SINGLE EVENT UPSET MECHANISMS FOR LOW-ENERGY-DEPOSITION EVENTS IN SiGe HBTs

By

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Thesis

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in

Electrical Engineering

December, 2007

Nashville, Tennessee

Approved,:

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ACKNOWLEDGEMENTS

This work would not have been possible without the generous support of the NASA Electronic Parts and Packaging (NEPP) group centered at NASA-GSFC. Their contributions into investigating the viability of new technologies for space applications are lauded.

Many people contributed to the success and completion of this work. I would like to thank my advisor, Dr. Robert Reed, for his tremendous patience, guidance, and understanding, and for introducing me into the Silicon Germanium world. Thanks also go to Dr. Ronald Schrimpf, another mentor, for inspiring in me the concept and opportunity of graduate education in semiconductor physics and the understanding of how research is done in an academic setting. I would also like to recognize and thank Dr. Andrew Sternberg and Jonathan Pellish for many hours of technical discussions and programming help. Thanks go to the members, past and present, of Vanderbilt University's Radiation Effects and Reliability Group for their empathy and support. Thank you to our collaborators from Dr. Guofu Niu's group at Auburn University and Dr. John Cressler's group at Georgia Institute of Technology, whose help was invaluable.

Finally, I would like to thank the people whose non - technical support, belief in the completion of this work, and shared revelry in its completion contributed to a sense of personal fulfillment: my parents, Henry and Cristina, my sister, Liana, and my friends from all my walks of life.

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CHAPTER I

INTRODUCTION

The focus of this work is to understand the charge collection response of SiGe (Silicon Germanium) HBTs (Heterojunction Bipolar Transistors) to ionizing radiation. The space environment is hostile; a primary reliability concern for microelectronics is the space radiation environment. Models developed to predict the interactions of radiation with electronic devices are used to understand the suitability of a candidate technology for space-based applications. These models are used to predict the fundamental physical mechanisms of the device response to radiation. An understanding of the physical mechanisms is necessary for the development of accurate models. For new technology, refinement of these models is required if they fail to predict behavior.

Inaccurate predictions by these models can have serious consequences on the control of spacecraft. It currently costs approximately $4,000 USD per pound to launch a commercial satellite into Low Earth Orbit (LEO) and approximately $10,000 USD per pound to launch a commercial satellite into Geo Transfer Orbit (GTO) [1]. Satellite survivability and robustness are fundamental in economically justifying their use for particular applications.

The interaction of microelectronic circuitry with ionized particles from Galactic Cosmic Rays was proposed 44 years ago [2]. It was theorized that the increase in transistor density, along with the decrease in device feature size, that electronics exposed to the cosmic ray environment would be affected by heavily ionizing tracks due to cosmic ray spallation reactions. Professionals in the radiation effects community have been trying to understand the subtle interactions of single particles with semiconductor devices since the late 1970's. Important questions that arise from the discovery of this effect are: is a lone, ionizing particle interaction with microelectronic devices important enough to worry about at mission level, and if it is, how often must we worry about them? Single event upsets (SEUs) have been credited for the need for continual maintenance of the TDRSS-1 satellite, and for causing mission threatening effects on the systems RAM manifesting themselves as errors in the attitude control system [3]. Don Vinson, a former ground controller of the satellite, said "If this [the repeated SEU's] keeps up, TDRS will have to be equipped with a joystick. [3]" The necessity for constant maintenance and potential failure highlights the need for a mission plan to deal with the adverse effects that these single ionizing particles can produce. Developing rate predictive methodology has been a goal of researchers since the realization that the phenomenon existed. Models have been proposed and refined.

Silicon Germanium (SiGe) Heterojunction Bipolar Transistors (HBTs) are a new candidate technology for high-speed digital, radio-frequency, and microwave applications. They have an intrinsically higher speed performance than standard silicon CMOS technology, while offering minimal additional process complexity. Their cost performance exceeds that of similarly suited Gallium Arsenide (GaAs) technology. SiGe HBTs have also been shown to be resistant to various types of ionizing radiation effects, making them a compelling candidates for space applications [4 -11]. Unfortunately, this technology is susceptible to SEU as seen, for example, in [12-16]. Space applications employing these circuits will require detailed analysis of the SEU susceptibility. This analysis is complicated by the complex charge collection response of SiGe HBTs to SEU.

Fig.1 shows heavy ion data collected on a string of shift registers fabricated using two different flip-flop architectures in IBM's 5AM SiGe HBT process [14]. These data are for neon, argon, and xenon ions incident at 0°, 45°, and 60°. The argon and xenon data are taken at the same angles as the neon data, with the first point being ions incident normal to the surface, the second point incident at 45°, and the third point incident at 60°.

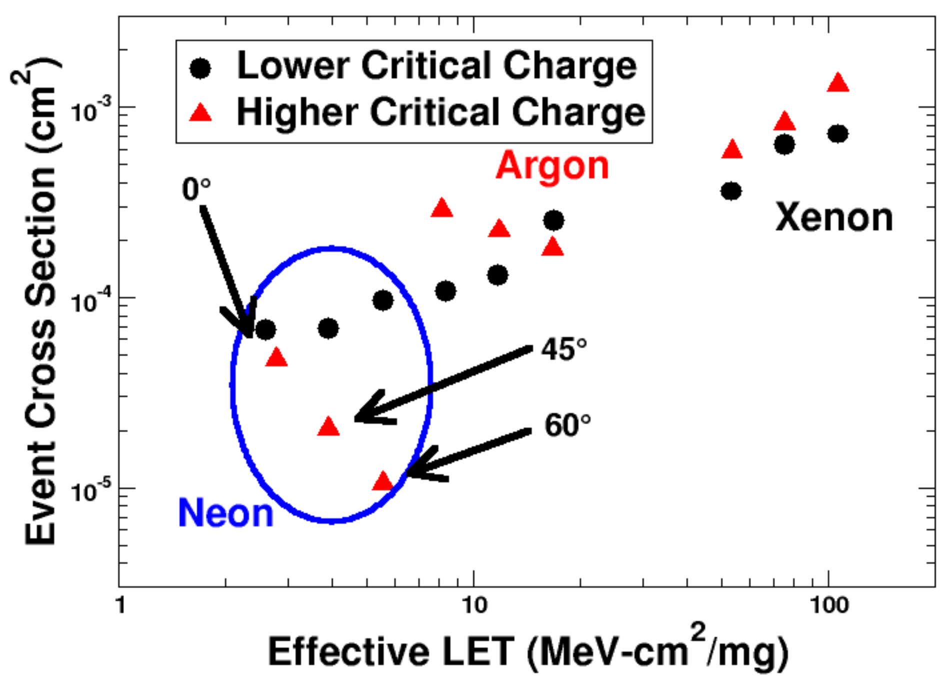

Figure 1: Cross section vs. Effective LET graph for two circuits [14].

In this plot, the conventional geometric considerations describing the sensitive volume as a Rectangular Parallelepiped (RPP) were assumed, e.g., the "Effective LET" is equal to the Linear Energy Transfer (LET) multiplied by the secant of the off-normal angle of incidence of the ion strikes. Given the assumptions of the "thin" RPP model, the measured cross section is expected to increase with effective LET. The data shown in Fig. 1 do not follow the trends expected from a typical RPP structure. Typically in this kind of graph, there is an onset value for LET where the cross section begins to increase, known as the "threshold LET". After this value, the cross section continues to rise as a function of the effective LET. There comes a point where an increase in effective LET no longer has significant impact on the cross section, the "knee" region. Following the "knee", the cross section is no longer affected by the increase in effective LET, and is at the "saturation" level. The data in Fig. 1 for the higher critical charge device clearly do not follow the trends assumed by the RPP model. From the graph, neither a consistent rise as a function of the effective LET, nor a saturation of the cross section are seen. A significant decrease in cross section with increasing effective LET is seen for neon ions for this circuit [14].

Two major aspects of SiGe HBTs that define the charge-collection mechanisms are the Deep Trench Isolation (DTI) geometry and the large area, reverse-biased, collector-substrate (subcollector) junction located about 3 μm below the silicon surface (Fig. 2) [16]. The DTI mitigates charge transport from the substrate following a single event, providing a well-defined region of maximum charge collection [16].

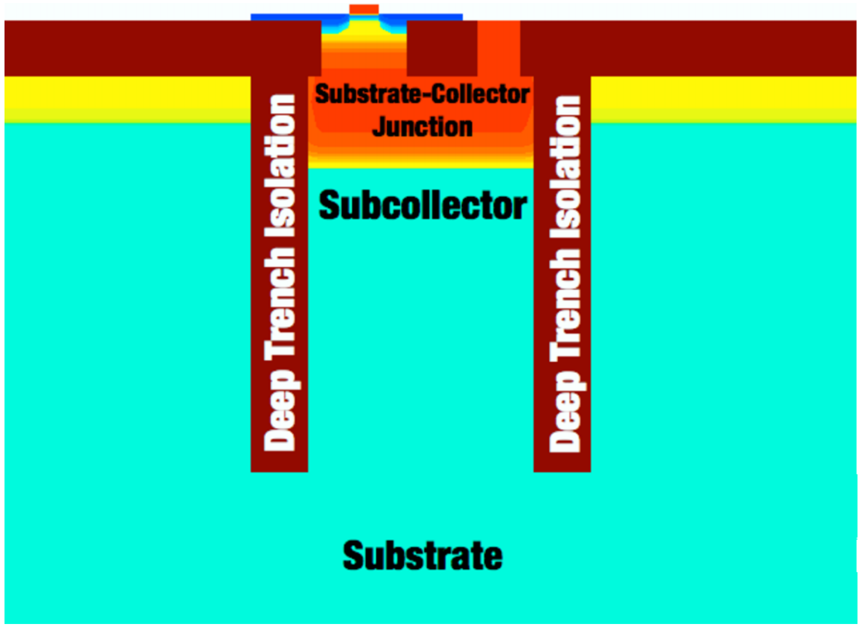

Figure 2: TCAD Cross Section of an IBM 5AM SiGe HBT.

In this work, ion microbeam measurements and TCAD simulations are used to investigate the impact of the DTI on charge collection for events crossing the subcollector junction, with a focus on lightly ionizing (low LET) ions at various angles of incidence relative to the normal of the die surface.

The DTI affects the charge collection from off-normal ion strikes, and in turn produces a “non-RPP" response. This work focuses on low LET events because the observed decrease in cross section with angle is most evident for neon ion strikes. A new technique for estimating the critical charge, Q_{crit}, for SiGe HBT circuits is proposed. The technique is based on comparing broad beam experimental results taken at various angles of incidence to TCAD simulations using those same incident angles. The insights gained through this work offer a new understanding of the mechanisms that will enable new error rate prediction techniques to be developed.

In Chapter II, a brief background on SEE and SiGe HBTs is given. Chapter III describes the experimental verification of atypical charge collection at off-normal angles. Chapter IV describes the simulation tool and methodology used for simulating charge collection from ion strikes. In Chapter V, a discussion of the simulation results is presented, along with a novel way to estimate critical charge for a SiGe HBT. Chapter VI concludes this work and summarizes its key points.

CHAPTER II

BACKGROUND

Single Event Effects

A Single Event Effect (SEE), with regards to electronics, is an effect caused by the loss of energy through interactions of a lone, energetic ion passing through the lattice of a semiconducting material [22]. As the ion loses energy in the semiconducting material, an ionization trail of electron-hole pairs is generated. The measurable effect of this charge generation and the resultant disturbance created by this charge on expected electronics behavior is categorized as a Single Event Effect (SEE).

Typically in the analysis of SEE's, the energetic particles of interest in the space environment are protons and "heavy" ($Z > 1$) ions. Protons result from solar activity and get trapped in the earth's magnetosphere [22]. "Heavy" ions can be spawned by solar activity or exist as Galactic Cosmic Rays (GCRs) [22]. This analysis will focus on the interaction of "heavy" ions with microelectronics.

Within the framework of SEE, there are several types of failures induced by these energetic particles, including but not limited to Single Event Upset (SEU), Single Event Transient (SET), Single Event Functional Interrupt (SEFI), Single Event Burnout (SEB), Single Event Gate Rupture (SEGR) and Single Event Induced Latchup (SEL) [22]. "Hard" or destructive errors to transistors or circuitry are caused by SEB, SEGR, and SEL; while "soft" errors caused by SEFI, SET, or SEU create transient errors that can be propagated through the circuitry or cause loss of information. This work focuses strictly on the single event induced reliability failure of SEU.

A SEU occurs when a highly ionizing particle passes through a semiconductor and generates a plasma track of liberated electron-hole pairs as a result of energy loss through a combination of elastic and inelastic collisions with the nuclei of the semiconductor and inelastic collisions with the bound electrons of the semiconductor [23]. The metric used for measuring Coulomb energy loss from the incident particle to the semiconductor is known as stopping power, or Linear Energy Transfer (LET) expressed in either MeV – cm^2 / mg or converted to pC/μm for a particular material. The charge generated by an ion event is determined by the particle's LET and its pathlength through silicon. The amount of charge needed to cause electronics to depart from their operation specifications is known as the critical charge and is not only device dependent, but also circuit-functional and circuit-topological dependent. If the charge collected, due to generation by a lone, ionizing particle, is greater than the critical charge, a SEU is recorded. Knowing the sensitivities of an electronic component to SEU allows forecasting of the performance of the component for different space environments, a process usually known as on-orbit rate prediction or rate prediction. Rate prediction of SEU and mitigation of SEU are often the goals of analyzing these physical mechanisms.

A traditional method of predicting SEU rates in space for a given technology utilizes a Rectangular Parallelepiped (RPP) geometric model to represent the sensitive volume (SV) of a device. The sensitive volume is used to determine how much energy is deposited from an ion event in a region of interest in a semiconductor device. The methods of obtaining the dimensions of the RPP have been refined and debated since its inception [25-31], but are typically defined by a combination of theory, technology process information, and experimental analysis. The charge collected from the energy deposited in the SV must be greater or equal to the critical charge of the device for a SEU to be recorded. In determining SEU sensitivity, it is important to couple how much charge is generated as a result of an ion strike and how much of the generated charge actually gets collected at a terminal of the device. Knowledge of the mechanisms that induce a SEU is essential in determining a predictable rate of upset for a given device.

Ground based SEU testing methodology utilizes the geometrical assumptions created by the RPP model to predict charge collection behavior for off-normal ion strikes. Typically, test data are plotted by assuming the "thin" RPP model in which inverse cosine scaling rules are used to normalize cross section data taken at off-normal angles [29]. Effective LET is defined as the LET divided by $\cos(\theta)$. Likewise the cross section is computed by normalizing the fluence for angle, i.e., "Effective" fluence is the actual beam fluence multiplied by $\cos(\theta)$.

Breakdowns in this the RPP model have been observed when the cross section varies for different particles that have the same effective LET. Five general explanations have been proposed in the literature: 1) energy loss of the ion before arriving at the surface of the device, changing its LET [25], 2) the device has significant collection depth so that the $\cos(\theta)$ correction to the cross section doesn't hold [33], 3) the warping of the equipotential lines makes the $\cos(\theta)$ correction for LET inappropriate [34], 4) different ions of the same LET have different track structures, and change the effective area of the device [35,26], and 5) the failure to account for resultant nuclear reaction products from ion events' interaction with metals used in interconnects on the top of the transistor [46-48] . These problems have been investigated, but not in the context of the unique geometry of deep trench-isolated SiGe HBTs.

Silicon Germanium HBTs

SiGe HBTs are the successors to standard Silicon bipolar technology. The theory of operation for a HBT was formulated by Kroemer by 1957 [17,18]. The process of epitaxially growing a SiGe base wasn't refined until approximately 20 years ago [19,20], and now SiGe HBTs are finding a growing place in today's market. One of the factors contributing to SiGe's growing market share is the relative ease with which the introduction of Ge in the base has been accomplished with traditional Si processing techniques. Another quality of SiGe is its ability to incorporate itself into traditional CMOS technology processes, thus being able to garner all the benefits of a mixed bipolar CMOS (BiCMOS) technology. Due to the roughly 4% lattice difference between Silicon and Germanium, compressive strain introduces a bandgap reduction of about 75 meV for every 10% of Germanium introduced [12]. Introducing an alloy of SiGe in the base of a bipolar transistor provides a valence band offset in the base (Fig. 3) that creates a drift field for the enhanced transport of electrons. Fig. 5 shows an energy band diagram comparison between a standard bipolar transistor (solid lines) and a SiGe HBT (dashed lines). The valence band offset in the base of the HBT represents itself as a narrowing of the energy bandgap in the base dependent on the germanium profile that is introduced.

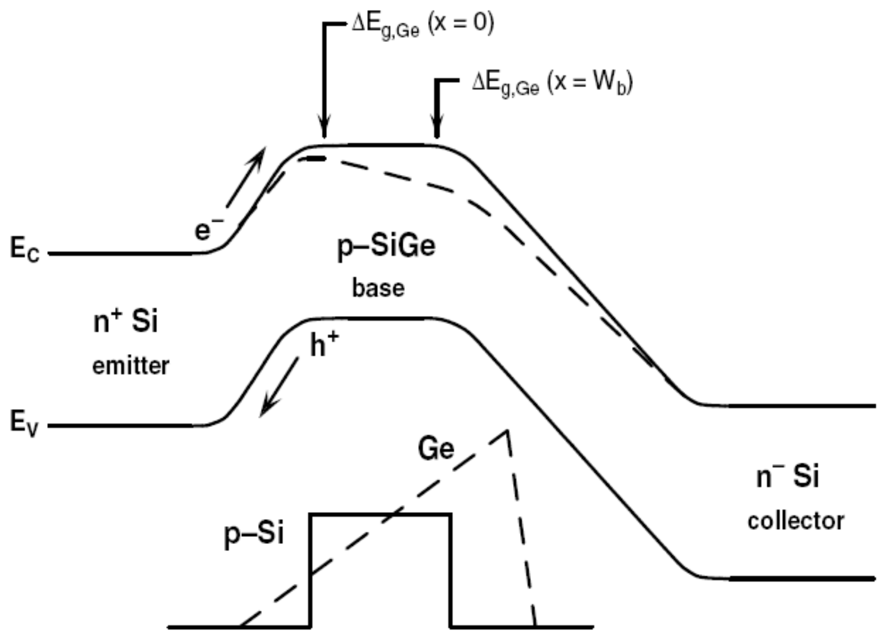

Figure 3: Energy band diagram comparison of a Si BJT (solid line) and SiGe HBT (dashed line) biased in forward active mode at low injection [12].

This drift field greatly reduces the base transit time by speeding up the electrons to near saturation velocity in the base [12], resulting in much greater AC performance than its silicon progenitor. SiGe also offers superior noise figure and linearity performance compared to standard bulk Si.

Not only are the AC characteristics enhanced through introduction of a SiGe base, but collector current density, current gain, and Early Voltage are improved as well. Germanium introduced into the base region of a bipolar transistor lowers the potential barrier of the injection of electrons from the emitter to the base, thus for an equivalent V_{BE} applied to a SiGe HBT, collector current density will increase, and given an equivalent base current the current gain will increase. The presence of Ge in the CB junction will also raise output resistance, elevating the Early Voltage.

SiGe technology is typically composed of these elements, some of which are illustrated in Fig. 6:

- A patterned subcollector (*n* for *npn*, *p* for *pnp*) on a doped substrate (generally p^-)
- Lightly doped collector epi
- Oxide lined, polysilicon backfilled deep trenches for inter-device, independent HBT isolation
- Oxide filled shallow trenches for intra-device isolation
- A collector sinker to the subcollector
- A SiGe epitaxial layer, consisting of a Si buffer, doped SiGe active layer, and a Si cap
- Self aligned emitter-base integration
- A selectively implanted collector (SIC) for tuning breakdown voltage and improving collector current density (J_C)
- Polysilicon extrinsic base contacts with self aligned extrinsic base implants to lower sheet resistance
- Silicided extrinsic base
- Heavily doped polysilicon emitter
- Back end metallization (Al or Cu) with tungsten (W) plugs connecting metal layers with oxide interlayer fill

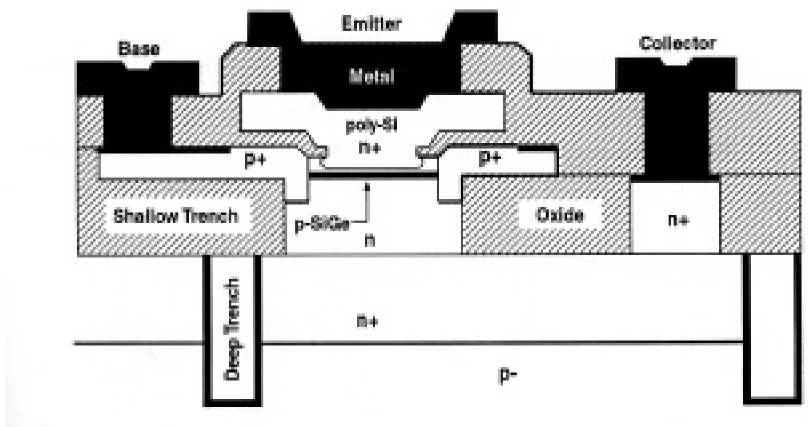

Figure 4: Example of a SiGe HBT cross section [12]

SiGe HBTs have been found to be quite tolerant to total ionizing dose (the amount of trapped charge accumulated over time found typically in the oxides and oxide interfaces of the device) and displacement effects (the result of lattice defects typically attributed to non-ionizing nuclear scattering reactions) [5-11], but are vulnerable to SEU [12-16]. Common elements seen in the SEU susceptibility of SiGe HBTs are a low threshold for upset (threshold LET), and increased susceptibility as operating speeds of the devices are increased [12-16, 39-41]. Circuit level mitigation techniques such as Current Shared Hardening architecture have been shown to not improve the SEU susceptibility as they did for previous technologies [39-40].

Two major aspects of SiGe HBTs that define the charge-collection mechanisms for SEE are the Deep Trench Isolation (DTI) geometry and the large area, reverse-biased collector-substrate (subcollector) junction located about 3 μm below the silicon surface (Fig. 2) [16]. DTI as a form of dielectric isolation has long been recognized as a method of not only integrating complementary transistors, but as a way to reduce the collector-substrate capacitances (C_{CS}) in bipolar technology [21]. Reduction of parasitic capacitances is essential for operation of high-frequency/high-speed technology. The reverse-biased subcollector junction is another form of isolation, with the bias typically at the lowest potential (for NPN) that can be supported to minimize substrate leakage currents. The DTI mitigates charge transport from the substrate following a single event, thereby providing a well-defined region of maximum charge collection [16].

Charge Collection

The “collection” of charge refers to the process through which charge generated by an ion event reaches a terminal of one of the devices in the circuit and generates a perturbation. Mechanisms responsible for collecting liberated charge include drift, diffusion, and field funneling.

An electric field exists at the junction of a *p* – doped region (an area doped with acceptors, elements that have less valence electrons than the material being doped) and an *n* – doped region (an area doped with donors, elements with more valence electrons than the material being doped). When these materials come into contact, the excess carriers from the two regions diffuse into each creating an electric field. The electric field is sufficient to repel the respective majority carriers that try to cross it from either type of doped material. This area is known as the depletion region because it is depleted of majority charge carriers.

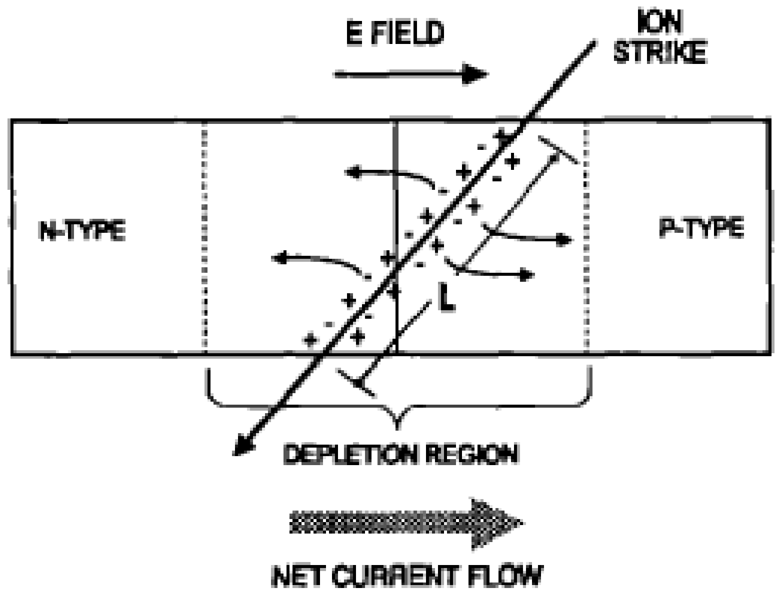

Figure 5: Example of drift charge collection induced by an ion strike through a depletion region [22].

Charge liberated in a depletion region will be collected via drift. From Fig. 3, the electrons get swept into the *n* – type region of the device, while the holes get swept into the *p* – type region of the device due to the electric field. Drifting charge is limited by the saturation velocity of the carriers, ensuring prompt charge collection.

Diffusion refers to the process in which charge liberated outside a junction randomly finds its way to interact with a junction and gets swept across a depletion region [22]. Once the liberated charge feels the effect of the electric field in the depletion region, the collection process is akin to drift collection. The junction where charge is being collected can be the junction the ion strike passes through, or a neighboring junction. Diffusive charge generally takes a much longer time to be collected than charge collected by drift.

“Field funneling” or “funneling”, as it is sometimes referenced, refers to a phenomenon [24] in which the equipotential lines of the junction related to collection are spatially and temporally “pushed out”, extending the depletion region in which liberated charge can be promptly collected. Fig. 4 shows a simulation result for a normal ion strike pushing out the equipotential lines into the substrate. Note that the substrate bias before the ion strike is set at -5.2 V. The length of the funnel depends on the mobilities of the carriers in the two doped regions and the width of the depletion region after the funnel has collapsed. [45]

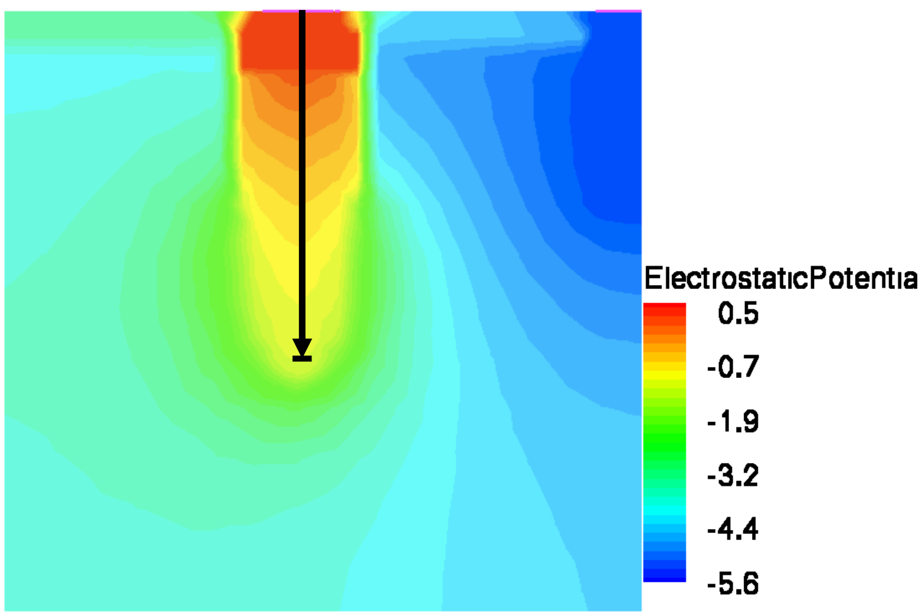

Figure 6: Example of equipotential line push out resultant from a single event. Note that the substate potential before the event was set at -5.2V. Arrow represents ion strike’s length, angle/position of incidence, and trajectory.

The geometry of the SiGe HBT, most notably the deep trench isolation (DTI), plays a major role in modulating the potential push out into the substrate. The DTI also limits how much charge can be collected, as diffusive collection is a probabilistic occurrence dependent on the solid angle between the point charge's location and the subcollector junction. The presence of the DTI could provide a masking effect for diffusive charge collection on the collector terminal of the HBT. Drift-collected charge also depends on the geometry of the HBT, especially for off-normal ion strikes. For an off-normal ion strike, the ion path may be truncated before it reaches the opposite end of the depletion region if it is too close to the DTI.

CHAPTER III

HEAVY ION MICROBEAM TESTING

Microbeam tests were performed on a single HBT to investigate the position-dependent, charge-collection response. These data show that charge collection does not conform to typical thin RPP assumptions. Figs. 13 and 14 show Ion Beam Induced Charge Collection (IBICC) microbeam data taken at Sandia National Laboratories' IBICC facility [37] on a SiGe 7HP HBT. The emitter, base, substrate and collector were each connected to separate probes (four probe IBICC technique [15]) and the induced charge generated by the ion strike was measured for each terminal. The emitter, base, and collector were all biased at 0V, while the substrate was biased at -5.2 V.

The die was etched to remove as much of the insulating overlayer as possible to ensure penetration of the ions through the subcollector junction. 36 MeV oxygen ions, with a peak LET of 7.5 MeV·cm^2/mg, were selected over other ions available at the facility because they offer the best combination of penetration depth and LET to provide high signal to noise ratio. To estimate the penetration depth of the oxygen ion of interest into silicon, SRIM® (the Stopping Range of Ions in Matter) was used. SRIM® is a set of computer programs that calculate the stopping and range of ions (up to 2 GeV/amu) into matter using a quantum mechanical treatment of ion-atom collisions [49]. SRIM® profiles of the oxygen ion of interest [16] display the Bragg peak in silicon occurring at a penetration depth of around 21 μm. Some dead overlayers remained, but enough were removed to ensure that the range of the oxygen ions into the silicon was in excess of 12 μm, sufficient for the investigation of the charge-collection mechanisms of interest.

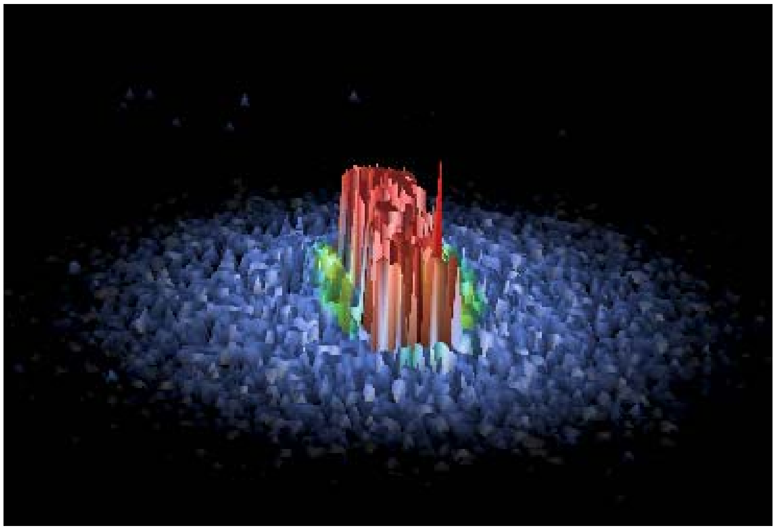

Figure 7: IBICC charge-collection data as a function of position for 36 MeV normally incident oxygen ions

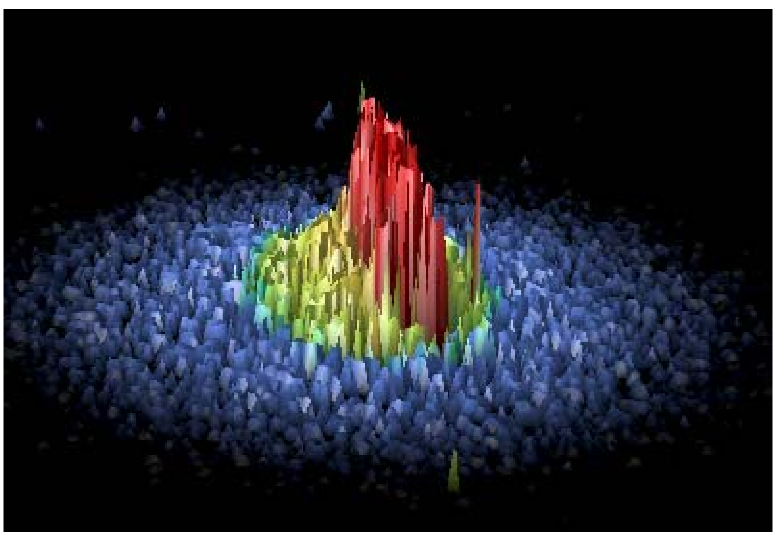

Figure 8: IBICC charge-collection data as a function of position for 36 MeV oxygen ions incident from ~15°

Figs. 7 and 8 show the microbeam data from normally incident ions, and ions incident at 15 degrees off normal. Fig. 7 is a 3D plot of the charge collection as a function of position for normally incident particles. The DTI outline is clearly displayed in the normally incident strikes by the “mesa” region surrounded by a region of low-level charge-collection events. For ionizing events that occur outside the trench, noticeably less charge is collected. The DTI forms a limiting boundary for large charge-collection events when ions are incident normal to the die.

Fig. 8 displays the microbeam data for a tilt angle of approximately 15°. The area of peak charge collection within the DTI is reduced with increased angle, evidenced by the area of the top of the “spike” for Fig. 8 versus the area of the top of the “mesa” of Fig. 7. From Fig. 8, an increase in area for low-level charge collection is displayed compared to Fig. 7.

Assuming the sensitive area is defined by the area confined by the DTI, and applying the assumption of the RPP model to the area, a tilt angle of 15° would lead to < 4% change in sensitive area. However, these data show a 25 to 30% decrease in the area for peak charge collection. The standard thin assumptions implied by assuming an RPP model do not apply to SiGe HBTs because of the failure of the cosine correction to describe how peak charge is collected for this technology.

CHAPTER IV

CHARGE COLLECTION SIMULATIONS

TCAD

Technology Computer Aided Design (TCAD) is a branch of electrical design automation (EDA) used to model semiconductor fabrication, predict transistor behavior, and capture the individual transistor behavior in an analytical model to feed into a circuit simulator as the next stage of design. TCAD utilizes finite element methods to solve partial differential equations (PDEs) used to model the physical behavior underlying transistor operation. Definition of the "mesh", the points used in the finite element calculations, coupled with the correct analytical physical models for the problem being solved is crucial to modeling the problem of interest.

In this work, the ISE, now Synopsys, TCAD 3D suite was used to simulate a SiGe HBT representative of the IBM 5AM process, and to model the trends seen both in the broadbeam and microbeam experiments. TCAD simulations of ion-induced charge collection in SiGe HBTs allow for a deeper understanding of the physical mechanisms involved. The TCAD tool is flexible enough to allow running great numbers of simulations where various properties of the ion strike can be controlled; in particular its' LET, its exact penetration point into the device, and the trajectories of the ions entering the device (the ion strikes' angle of penetration). Beam testing does not provide as much flexibility, so to fully develop trends in the change in charge collection with angled ion strikes, TCAD is needed.

During the course of this work, ISE was purchased by Synopsys, so reference will be made to the program names that ISE used even though they may change in the near future or may have changed already. The simulation tools from the suite used to simulate the device and how the ion strikes affected its electrical characteristics are DEVISE, MESH, and DESSIS. DEVISE is a tool in which materials, geometry, and doping are specified [38]. MESH is the program that defines the finite elements for solving the PDEs. DESSIS is the device simulation tool that is used to solve the physical behavior of the transistor.

Definition of Device for Simulation

This "deck", or device model, was created in the DEVISE tool as a series of cuboids with doping defined in specific regions as dictated by the process. All geometric and doping specifications for the deck are included in Appendix A. The deck was also used in [16] to investigate positional, normal-incident, ion strike charge collection and describes what SiGe HBT geometrical and material details that were used in the simulations. The area of the emitter for the device considered here, A_E, is equal to 0.5 μm^2, the area enclosed by the DTI is 10 μm^2 (2.5 μm x 4.0 μm), and the large area, reverse-biased collector-substrate (subcollector) junction is located about 3 μm below the silicon surface (Fig. 2) [16]. Important physical models to include in these simulations are the Phillips unified mobility model for bipolar devices, and bandgap narrowing due to heavy doping and bulk SRH recombination [16]. While the deck in [16] was created in

MESH it was adopted into DEVISE for this work. The mesh for this work was defined differently than the mesh in [16] to ensure electrical behavior consistent with the process, and to accommodate the angled ion strikes investigated. As the work in [16] was initially calibrated to process results, the initial goal of the deck used in this work was to ensure agreement with the deck in [16]. Gummel curves, representing bipolar transistor performance, for the two decks are presented in Fig. 9.

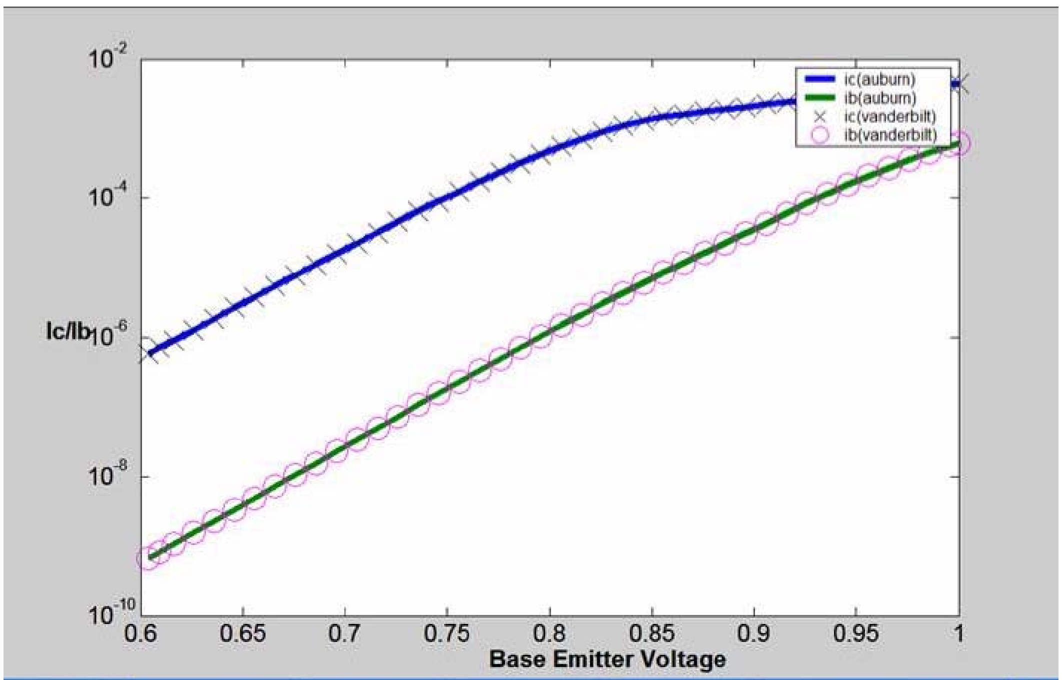

Figure 9: Comparison of Gummel curves between deck in [16] and this work

The largest area junction in the SiGe HBT is the subcollector junction. There is a significant disparity in the amount of dopants between the substrate doping and the subcollector doping. The disparity in dopant levels along with the different polarities of the doped areas will be manifested in the different mobilities of the majority carriers in the substrate and subcollector areas.

With the mobilities being so different, “funneling” will occur when an ion traverses the junction. Since the junction has the largest area of any of the junctions in the individual transistor, an ion event has the greatest probability of traversing it relative to the transistor’s other junctions. Due to the probability of an ion strike interacting with the substrate – subcollector junction and the high probability a “funnel” will result, this junction is of critical import to the charge collection of the SiGe HBT.

Utilizing the recognition of the critical junction for charge collection, simplification of the device being simulated to save computation time was now considered. A test was run using a diode identical to the collector – subcollector p-n junction, rather than the full HBT structure to see the difference in charge collection. A normally incident ion through the center of the emitter was used for this comparison. While the total difference in charge collection between the two cases was approximately 8%, simulation time was reduced from roughly 20 hours for the full device simulation to 1 hour of simulation time for this particular case. Subsequently, all results are based on diode structures.

Ion Strike Simulation Methodology

The purpose of these simulations was to investigate the role that device geometry had on the charge collection for ion strikes of different angles passing through the DTI enclosed substrate - subcollector junction. For the simulations run in this paper, a PERL script (Appendix A) that parses and refines the mesh along the ion track was used. It simplifies the process of creating ion track refinements for the various angled and positioned ion strikes used in simulation.

Instead of having to create hundreds of devices with unique meshing for each individual ion track, one device can be created and the meshing refinements for the ion strike can be tailored for each simulation. The script calls as its inputs a "track-file", which is a tab separated value file featuring 6 entries (*x*,*y*,*z*,*x'*,*y'*, and *z'*) of interest describing the geometrical trajectory and location of incidence for the ion strike, and "refine-size" which is the degree of refinement of the mesh desired around the ion track. These coordinated values given in the "track-file" correspond to the same geometrical mapping that is used in definition of the device. The script generates tetrahedrons and assigns them geometrical values based on the inputs into the script. After these tetrahedrons are created, the output file created by the script is concatenated with the original MESH file to include all the tetrahedronal refinements into the defined device so that defined and implements them into the MESH input file. Finally, after MESH is run, each instance of uniquely tailored meshing for each ion strike is defined, and the physical simulation of its properties is ready to begin. DESSIS introduces the ion strike as a transient event after the device has been biased in the off-state as described above. The results of the DESSIS simulations are traces of the current pulses on each terminal that follow an ion strike. The integration of these current pulses is the amount of charge collected on the respective terminals.

TCAD simulations at various angles, locations, and directions for 520 MeV neon ions (LET of 2.7 MeV·cm^2/mg, or 0.028 pC/ μm) were performed, with the LET corresponding to that of the broadbeam data presented in [14].

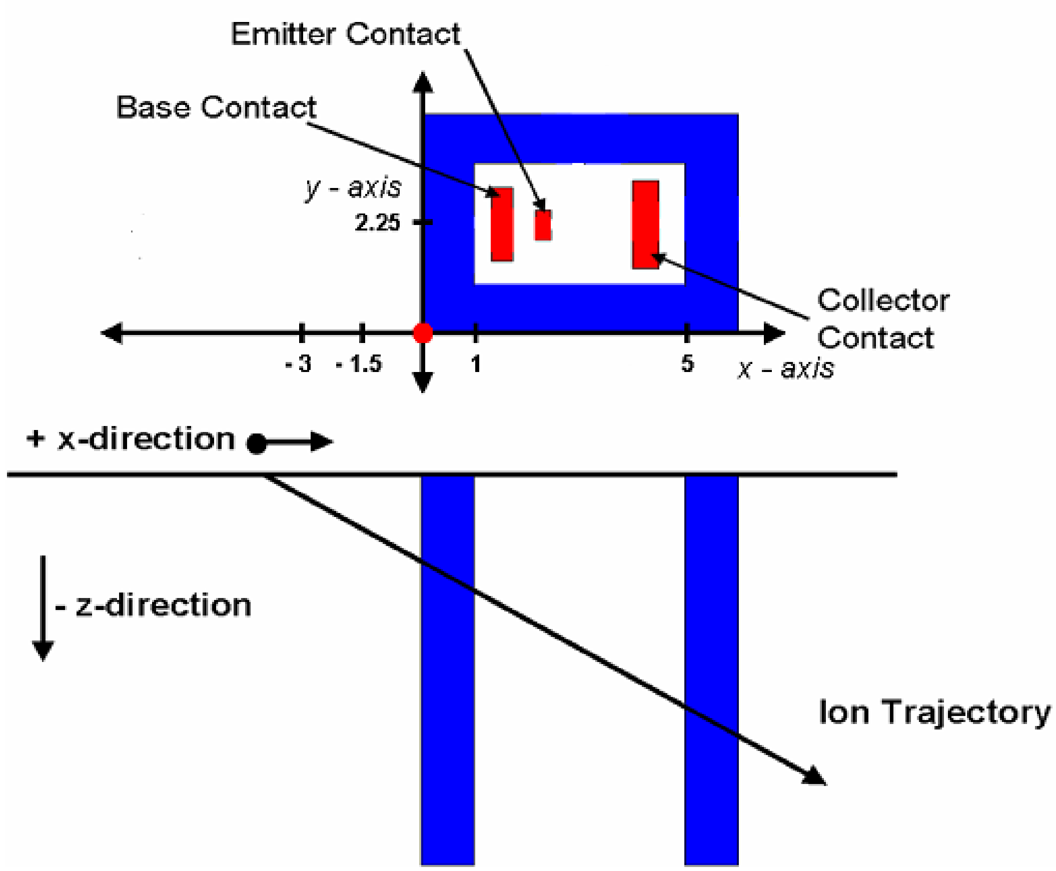

Figure 10: Top down view of ion strike locations and cross sectional view of ion trajectory with strike location. Note the origin of the coordinate system is the red dot.

A grid that contains points inside and outside the trench, which define the surface incident locations for each simulated ion event, is shown in Fig. 10. The x-axis is established by the outside border of the lower deep trench wall, when looking at the device with the base contact on one's left hand side as displayed in Fig. 10. The positive *x*-direction points from the base contact towards the collector contact (see Figs. 2, 10). The y-axis is perpendicular to the x-axis and is the outside border of the left most deep trench wall. The origin of the coordinate system is the red dot on Fig. 10. The *y*-direction is defined by the y-axis, positive numbers on the axis indicate a *y*-direction pointing from the lower deep trench wall to the upper deep trench wall in Fig. 10.

For each simulation, charge is generated between two points, one is a fixed *x*,*y* coordinate on the *xy* plane (*z* = 0), the other is a point defined by *x′*, *y′*, *z′* coordinated. For all simulations, *y′* = *y* and *x′* > *x*. Normal incidence refers to a normal to the *xy* plane. Off angle refers to an angle referenced to the normal.

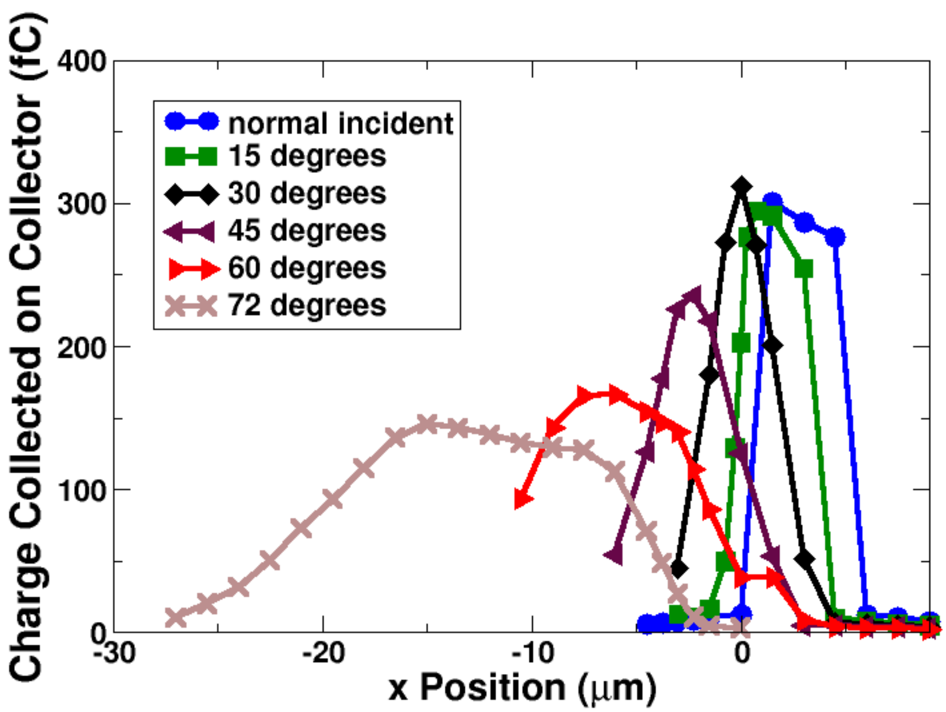

Figure 11: Simulation results of change in charge collection with angle. The enclosed trench area goes from 1 µm to 5 µm along x-axis. Ion events were incident at the *x*-position marks on curve, the *y*-position of the marks corresponds to how much charge was collected for each strike. Ions have trajectories in the positive *x*-direction on this graph.

Fig. 11 shows charge collection simulation results for ion strikes that originate at different points along the x-axis, at *y* = 2.25, for angles of 0°, 15°, 30°, 45°, 60° and 72°. In coordinate terms, if the left most ion strike occurs between (*x*, *y*, z) and (*x′*, *y′*, z'), where x’ > x, the subsequent ion strike in the group for a particular angle would occur between (*x*+*n*, *y*, z) and (*x*′+*n*, *y*′, z').

The angles used for simulation correspond to the angles used in broadbeam testing [13-15]. The “Effective LET” from Fig. 1 represents angles used in broadbeam testing from [14].

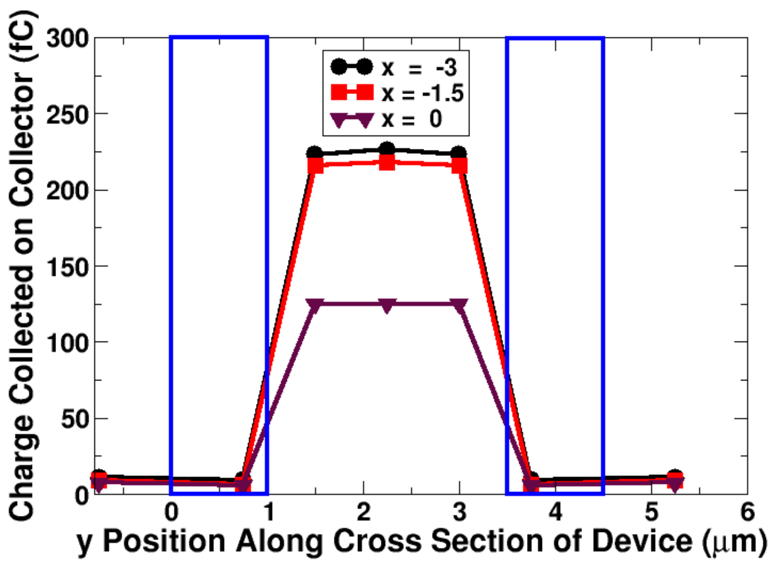

Figure 12: Simulation results of charge collection along *y* axis for 45° incident ion strikes along *x* axis, deep trench walls drawn to scale are identified by blue boxes on graphs.

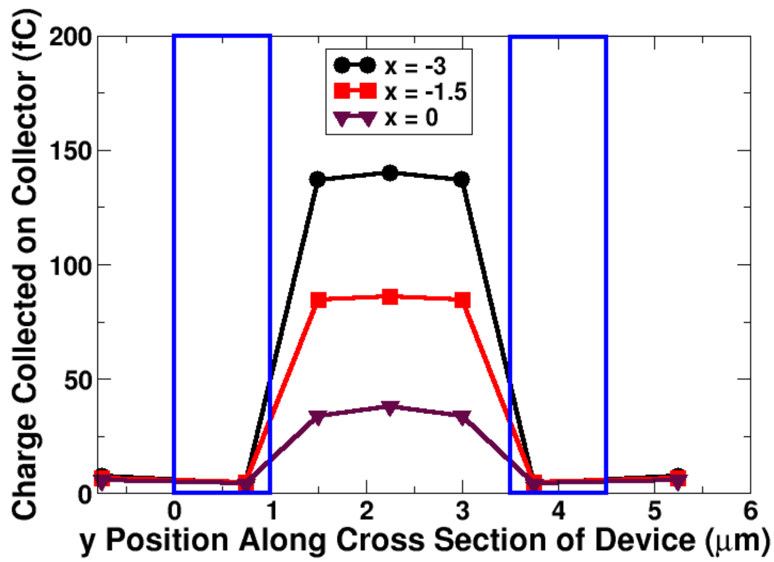

Figure 13: Simulation results of charge collection along *y* axis for 60° incident ion strikes along *x* axis, deep trench walls drawn to scale are identified by blue boxes on graphs.

Figs. 12 and 13 show a *y*-cut of the simulated charge-collection data for three fixed values of *x* at two angles, 45° (Fig. 13) and 60° (Fig. 14). The trajectory of the ion strikes in these graphs is the same as the ion strikes in Fig. 11; in Figs. 12 and 13 one can imagine the ion strikes going into the paper at the particular angle for each graph. The boxes on the graphs show the location and widths of the deep trench walls in the transistor. Showing different *x* positions on the same graph are used to see if the characteristics of the charge collection across the trench vary across "cut" lines. Two important characteristics of these results are: 1) limited charge collection for regions outside the DTI and 2) nearly constant charge collection for events inside the DTI.

Estimation of the Sensitive Area

The data in Figs. 11, 12, and 13 can be used to estimate the variation of the sensitive collection area vs. angle of incidence for various amounts of charge collection. For this analysis, we assume that the sensitive area is a rectangle. The length of the sides of the rectangle is determined from the data in Figs. 11, 12, and 13.

One dimension of the rectangle is simply the length of the area enclosed by the trench along the y-axis, i.e., 2.5 μm. The simulation results in Figs. 12 and 13, which support this assumption, shows very little charge collection for events outside the trench area. Events occurring inside the trench area have a charge-collection value that is essentially constant for a fixed value of *x*.

The value for the other side of the rectangle can be determined from the data in Fig. 11. The length is determined by selecting a value for the charge collected, then determining the distance over which this value is collected. For example, 150 fC of charge will be collected for an ion event incident at 60° between x = -8 μm and x = -2.5, μm, giving a length of 5.5 μm.

The sensitive area is then estimated by computing the product of the area of this rectangle and cos(θ). The cosine term is introduced to account for the reduction in the projected area with increasing angle.

The data in Fig. 11 show that the sensitive area's functional dependence on angle of incidence depends strongly on the critical charge of the circuit. From these simulations, as the angle of incidence of the ion strikes increases, the sensitive area for large charge-collection events is reduced and the area for lower level charge collection events increases. For example, from Fig. 11, comparing the 15° incident ion strikes with the 60° incident ion strikes, the 60° strikes do not have any that generate 200 fC while the 15° strikes have a range that does. The 60° strikes do have a greater range for which they can collect 150 fC of charge than the 15° strikes. In the next chapter we compare these simulation results to the broadbeam SEU data.

CHAPTER V

DISCUSSION OF CHARGE COLLECTION FROM OFF - NORMAL ION STRIKES

The schematic diagram in Fig. 14 shows that as the angle increases, the projected area of the sensitive volume decreases dramatically because of the truncation of charge collection by the deep trench walls. Case #1 shows the sensitive area for that particular angle is not significantly affected by the trench geometry. Case #2 shows that for that particular angle and strike direction, the peak charge collection occurs when the strike passes the corner of the junction and extends into the substrate, underneath the deep trench. This correlates to a dramatic reduction in the collection area for peak charge collection. Case #3 shows that at a more obtuse angle, a significant truncation results, all but eliminating the peak charge collection. This schematic diagram suggests that the projected area will change with angle, because peak charge, corresponding to the

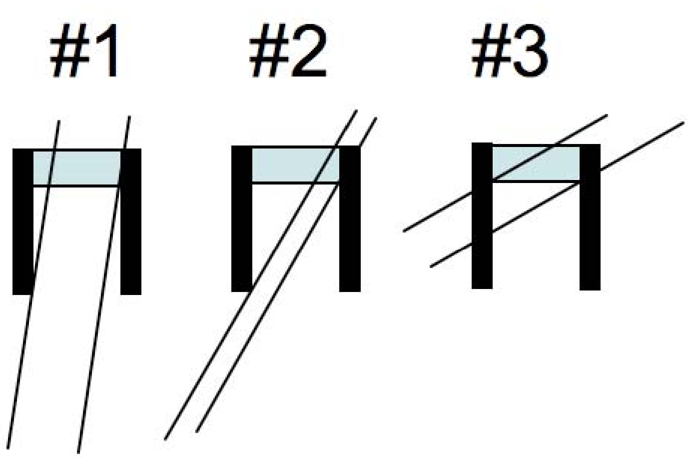

Figure 14: Examples of reduction of sensitive area with angular strikes.

mesa area in the microbeam data, is limited to long strikes that have the ability to collect charge by prompt collection. With a reduction in sensitive area, there is a corresponding reduction in SEU cross section.

Fig. 15, from [14], shows results of broadbeam testing on five different shift register designs with different values of critical charge implemented in the IBM 5AM technology. Quasi-mixed mode 3-D simulations [40,41] predict that the enhanced switching current and current-shared architecture would have similar critical charges for upset; while the dual interleaved and cross coupled NAND architectures would have similar but higher critical charges than the first two topologies. The baseline structure has the same circuit topology as that of the enhanced switching current architecture, but operates at lower current. The baseline structure is more susceptible to upset and has a lower critical charge than the enhanced switching current architecture configuration [41,14]. The figure plots the measured cross-section vs. angle, normalized to that at normal incidence. The typical thin RPP angle corrections were not applied to these data, i.e., these data are the number of upsets divided by the pure beam fluence, and are normalized to the cross section at zero degrees.

This plot also shows the cosine relationship implied by the RPP model. If the circuits were well-described by the RPP model, their cross sections should be larger than or equal to the cosine curve. The cross sections that fall below the cosine curve are decreasing relative to the normally incident cross section. This highlights the deviation from the RPP model. The sensitive area curves for the different amounts of critical charge should not be decreasing more than the cosine curve due to the finite area of the active silicon. The sensitive area curves should lie on top of, or be above the cosine curve if the RPP correction holds. At least two of these circuits, utilizing the deep trench isolated IBM 5AM SiGe HBT, do not conform to the traditional RPP model.

Fig. 16 shows the projected variation of the sensitive area with angle based on TCAD simulation results from Fig. 11. The results in Fig. 16 are normalized to the sensitive area of the set of normally incident ion strikes, where X is the area of the rectangle, θ is the angle of incidence, and Y is the value of the area of the rectangle at normal incidence, ie $X(\cos(\theta))/Y$. X can be thought of as the projected area of the "beam" onto the silicon surface of the transistor. $X(\cos(\theta))$ is this abstraction would then be the back projected area of the actual "beam", i.e. the perpendicular area between the "beam" extremes dictated by X. The abstraction of the "beam" concept in regards to the simulations is merely the distance between ion strikes that gives a specific collected charge. The specific collected charge term is determined by first fixing a value for the charge collection, and then determining these values.

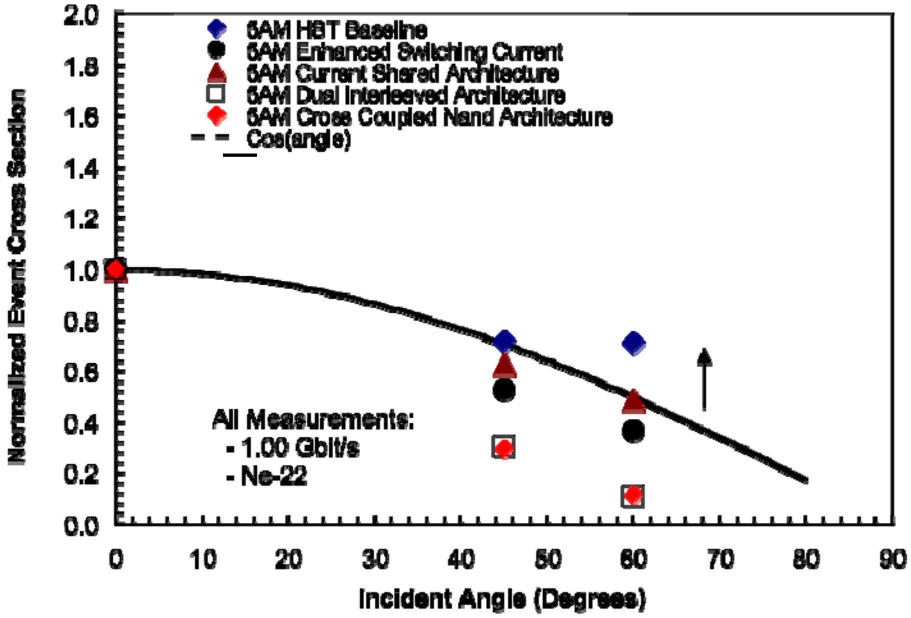

Figure 15: Broadbeam test data [3] showing the deviation from the cosine correction suggested in the traditional RPP model for IBM SiGe 5AM HBTs.

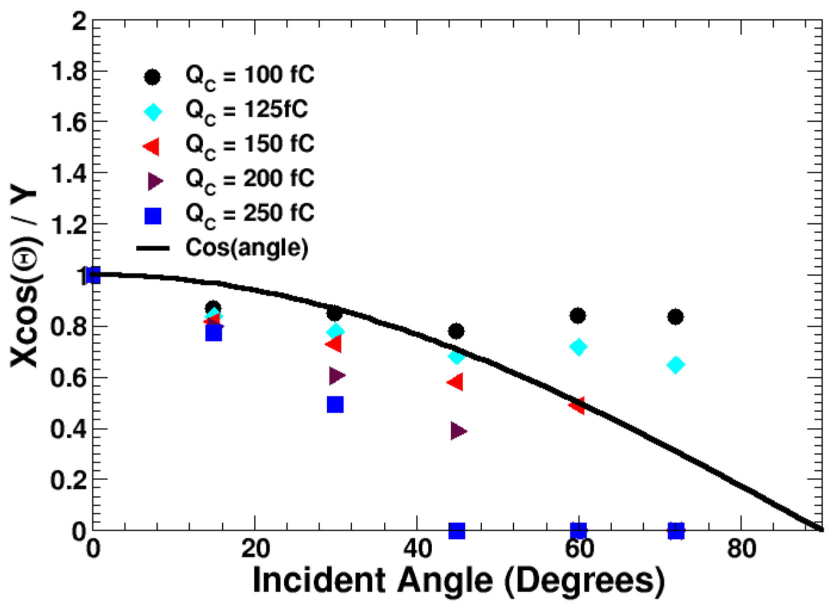

Figure 16: Simulation results showing the deviation from the cosine correction suggested in the traditional RPP model for IBM SiGe 5AM HBTs. These data are plotted in the same way as the experimental results in Fig.

15. The ordinate for Fig. 16 is then normalized sensitive area from simulation results on an individual transistor. The solid line is the cosine function. The trends in these simulated results agree with the trends seen in the measured data. For example, the circuit with the highest critical charge shows a significant deviation from the cosine curve.

The data show some interesting trends with regards to the charge collection mechanisms of the SiGe HBTs. For collecting larger amounts of charge, the angle of the ion strikes' penetration must be relatively acute. This observation follows the discussion from the schematic diagram in Fig. 14. A significant funnel is necessary for the highest collection of charge from ion events crossing the subcollector junction. As angle of incidence of the ion strikes becomes more obtuse, the amount of lower level charge collection events increases. The "peaks" in charge collection from Fig. 11 shift to the left for increasing angle, following the required geometric path lengths needed to traverse the subcollector junction. These observations culminate in the data suggesting that the untruncated ion charge collection path significantly contributes to the collected charge resulting from an ion strike. The critical charge of the circuit in question will determine how this mechanism manifests itself in the SEU data. If the circuit has a high critical charge (above ~200 fC) upsets will only be recorded at shallow angles relative to normally incident on the device because of the need for an uninterrupted charge collection path. If the circuit has a lower critical charge, collected charge from within the active area of the device, coupled with the collected diffusive charge, will be enough to record an upset. Lower critical charge circuits will behave more typically in accord with RPP assumptions, because no matter how the ion strike angle is tilted, upsets will still be recorded since the upset is not dependent on the ion charge collection path. Dielectric isolation that individualizes HBTs will mitigate charge collection from ion events by truncating the ion's path of generated charge.

Estimation of Critical Charge

The trends established in the broadbeam data and simulation results, shown in Figs. 15 and 16, are the basis for estimating critical charge. Data from broadbeam measurements, taken as in [14], and organized as in Fig. 15 establish the functional dependence of normalized event cross section with angle. The simulation data show how the dependence of cross section on angle changes for different amounts of collected charge. The functional dependencies are the manifestation of how the sensitive area is dictated by minimum path-length for upset at a particular LET as a function of angle. The individual normalized numbers at a particular angle are a ratio establishing the percentage of ion strikes that have a long enough path-length for upset at that angle, $X(\cos(\theta))$, to the 100% upset lengths at normal incidence, Y. If the functional dependence of critical charge on angle from the broadbeam data matches the functional dependence for a particular amount of collected charge as a function of angle from the simulation data, then an estimate of critical charge for the circuit is the value of charge collected from the simulation data.

The major benefit of this method for estimating critical charge is its independence of the need to define a sensitive volume for a device. No assumptions about a sensitive volume, such as how to account for diffusive collection of charge, have to be made. Broadbeam SEU testing at various angles coupled with numerous positionally-dependent, angled-ion strike simulations run on a calibrated TCAD device can be obtained. The functional dependencies of these two sets of data should have similar trends, and estimating the value for critical charge depends on finding equal functional dependencies. For the DTI-enclosed SiGe HBT, based on Figs. 15 and 16, the critical charge for the baseline circuit is approximately 100 fC, while that for the radiation hardened circuits is approximately 200 fC.

CHAPTER VI

CONCLUSIONS

SiGe HBT microbeam measurements and TCAD simulations were used to demonstrate the impact of the deep trench isolation on charge collection induced by single ion events. The DTI walls truncate the charge collection of angled ion strikes that cross the subcollector junction. The simulation and experimental data show that the variation of the sensitive area is not well-described by the RPP analysis method. Future charge collection models need to account for the truncation of the funnel, a consequence of the geometrical constraints imparted by deep trench dielectric isolation. At low energies, the effective cross section decreases with increasing effective LET for the circuits with higher critical charges. Charge collection is found to be angularly dependent for particular LETs, with strikes at obtuse angles having lower "peak" amounts of charge collected over a wider area.

The important SEU mechanisms for low energy deposition events in DTI isolated SiGe HBTs are: the truncation of the charge collection funnel by the DTI for off normal ion strikes, and the realization that diffusive charge collection from a truncated funnel ion strike can contribute to SEU. As the angle of penetration of the ion strikes becomes more obtuse, the segment of liberated charge resulting from the ion strike shortens between the two deep trenches. With the path length of liberated charge being shorter, less charge will be collected through drift and funneling mechanisms. SEUs are dependent on the critical charge of the circuit in which the technology is used. Since SEUs are directly related to cross section, the higher the critical charge, the greater the dependence of cross section on the truncation of the funnel length. A lower critical charge device may record SEU through diffusive charge collection alone, making the cross section increase even if the funnel is being truncated. The DTI mitigates charge collection from off normal ion strikes by truncating the funnel. Accounting for the DTI is necessary in any on orbit rate prediction methodology for DTI isolated SiGe HBTs.

A novel approach to the prediction of critical charge, independent of the RPP model, is presented. This predictive method utilizes the functional dependencies of data from calibrated TCAD simulations of charge collected from positionally-dependent, angular-ion strikes and from existing broadbeam data of normalized event cross sections as a function of angle of incidence.

Appendix A

FILES USED IN SIMULATION PROCESS

The following are a series of files used to represent the simulation process utilizing the TCAD tools. The PERL script parsing the refinements along the ion track used for simulation was developed by Dr. Andrew Sternberg, now of the Institute for Space Defense Electronics, for previous work and refined by Jonathan A. Pellish of the Vanderbilt University Radiation Effects and Reliability research group for this work. The TCAD files are an example of a set of one simulation run. Following the section titles will be a description of the code listed below it.

PERL script parsing code

This code parses the ion track, creating user defined tetrahedronal refinements around the track to be incorporated into the physical simulation of the SiGe HBT:

```
#!/usr/bin/env perl

# Jonathan Pellish
# jonny.pellish@vanderbilt.edu
# Version 1.0 on 08 May 2005
# Version 1.1 on 06 October 2005

# The copy module allows the script to copy files and even move
them around, but ours will be
# created in the current directory only.

print "track_mesh_strip.pl; v1.1; (c) J.A. Pellish\n";

#use File::Copy;
```

```
# The following Perl module is standard and provides the function
GetOptions function to
# process command-line switches with long names. In this case,
it's kind of overkill, but
# it's nice to have the code already built-in. The options it can
process range from switches
# that are Boolean or string or integer up to array variables for
repeating options or
# user-defined validation routines. Though it's possible to use
Getopt::Std, this solution
# is simpler and better suited.

use Getopt::Long;

GetOptions(       "track-file=s" => \$trk_file,       # Mandatory
string parameter, not :s
            "refine-size=s" => \$refine_size_1, # Refinement
width
            "help" => \$help_me);               # Given as --
option or not at all

$usage = "\nOptions:\n\t --track-file=TRACK_FILE_NAME\n\t --
refine-size=WIDTH_OF_REFINEMENT (nm)\n\t --help\n";

if ($help_me) {
      print "\nFor detailed information on the use of this
program, email jonny.pellish\@vanderbilt.edu\n";
      print "Make sure to define Refine_Block_1 in the
Definitions{} section of your MESH command file.\n\n";
      print "You can either use the C-preprocessor (cpp) or cut-
and-paste to get the refinement\n";
      print "placements into the Placements{} section of the MESH
command file.\n";
      print $usage;
      die "Good luck! Program exiting now.\n";
}
else {
      die "You need to supply an MRED track file.\n" unless
defined $trk_file;
      die "You need to supply a refinement size.\n" unless
defined $refine_size_1;
}

# Opening the MRED track data file stream.

unless (open (TRK_DATA, "< $trk_file")) {
      die "Cannot open MRED track file: $!";
}

# This loads the MRED track data into memory and closes the file
stream.

@track_data = <TRK_DATA>;
close(TRK_DATA);

# Open output file stream
open(OUT, "> cubic_msh.dat");
```

```
# You will need to define Refine_Block_1 in the Definitions{}
section of your MESH command file
$i = 0;
$max_element_size = 0.090;
$min_element_size = 0.090;

$min_length = 0.05;
# $refine_size_1 is defined as an option to the program

print "Printing file to TRACK_FILE stream....\n";

foreach $line (@track_data) {

    chomp($line); # Eats the newline character at the end of
$line. Better than chop().
    ($x1,$y1,$z1,$x2,$y2,$z2,$E,$sig)=split(' ',$line);

    $len=sqrt((($x1-$x2)*($x1-$x2))+(($y1-$y2)*($y1-$y2))+(($z1-
$z2)*($z1-$z2)));

# Case 1.  When the segment read in is less than min_length.

if($len>0.00 && $len<$min_length && $E>0.0){
      $lll=sqrt(($x1-$x2)**2 + ($y1-$y2)**2 + ($z1-$z2)**2);

      #put them in order
      if($x2<$x1){$tmp=$x1;$x1=$x2;$x2=$tmp;}
      if($y2<$y1){$tmp=$y1;$y1=$y2;$y2=$tmp;}
      if($z2<$z1){$tmp=$z1;$z1=$z2;$z2=$tmp;}
      $x1-=$refine_size_1;    $y1-=$refine_size_1;    $z1-
=$refine_size_1;
      $x2+=$refine_size_1;    $y2+=$refine_size_1;
      $z2+=$refine_size_1;

      print OUT "\tRefinement \"Refine Block $i\" {\n";
      print OUT "\t\tReference = \"Refine_Block_1\"\n";
      print OUT "\t\tRefineWindow = Cuboid [( $x1 $y1 $z1) , ($x2
$y2 $z2)]\n";
      print OUT "\t}\n";
      $i++;
} # end of Case 1

# Case 2.  When the length is longer than the minimum length

if($len>$min_length && $E>0.0){
      $u=0; # parametric variable
      $x0=$x1;$y0=$y1;$z0=$z1;

      # calculate l, m, and n, the equations for x, y, and z.
      $l=($x2-$x1)/$len; $m=($y2-$y1)/$len; $n=($z2-$z1)/$len;

      while ($u<($len-$min_length))
      {
            $u+=$min_length;
            $x=$x0+($l*$u);
            $y=$y0+($m*$u);
```

```
            $z=$z0+($n*$u);

            $X1=$x1; $Y1=$y1; $Z1=$z1; $X=$x; $Y=$y; $Z=$z;

            if($X<$X1){$tmp=$X1;$X1=$X;$X=$tmp;}
            if($Y<$Y1){$tmp=$Y1;$Y1=$Y;$Y=$tmp;}
            if($Z<$Z1){$tmp=$Z1;$Z1=$Z;$Z=$tmp;}
            $X1-=$refine_size_1; $Y1-=$refine_size_1; $Z1-
=$refine_size_1;
            $X+=$refine_size_1;     $Y+=$refine_size_1;
      $Z+=$refine_size_1;

            print OUT "\tRefinement \"Refine Block $i\" {\n";
            print OUT "\t\tReference = \"Refine_Block_1\"\n";
            print OUT "\t\tRefineWindow = Cuboid [( $X1 $Y1 $Z1)
, ($X $Y $Z)]\n";
            print OUT "\t}\n";
            $x1=$x;$y1=$y;$z1=$z;
            $i++;
      }

      if($u<($len-$min_length && $E>0.0)) # residual track left
at the end
      {
            #put them in order
            if($x2<$x){$tmp=$x;$x=$x2;$x2=$tmp;}
            if($y2<$y){$tmp=$y;$y=$y2;$y2=$tmp;}
            if($z2<$z){$tmp=$z;$z=$z2;$z2=$tmp;}
            $x-=$refine_size_1;     $y-=$refine_size_1;     $z-
=$refine_size_1;
            $x2+=$refine_size_1;    $y2+=$refine_size_1;
      $z2+=$refine_size_1;

            print OUT "\tRefinement \"Refine Block $i\" {\n";
            print OUT "\t\tReference = \"Refine_Block_1\"\n";
            print OUT "\t\tRefineWindow = Cuboid [( $x $y $z) ,
($x2 $y2 $z2)]\n";
            print OUT "\t}\n";
            $i++;
      }
    }
}

close(OUT);

print "There are $i blocks in your track mesh.\n";
```

DEVISE device definition file

This file geometrically and materially defines the device to be simulated.

```
(isedr:set-title "05x1_5HP_HBT")

(isegeo:set-default-boolean "ABA")


; Substrate Geometry
; ------------------

(isegeo:create-cuboid (position -10 -10 -25) (position 18 14.5 0)
"Silicon" "substrate_block")


; Deep Trench Oxide
; -----------------

(isegeo:create-cuboid (position 0 0 -8) (position 1 4.5 -1)
"Oxide" "deep_trench_1")
(isegeo:create-cuboid (position 1 3.5 -8) (position 6 4.5 -1)
"Oxide" "deep_trench_2")
(isegeo:create-cuboid (position 5 3.5 -8) (position 6 0 -1)
"Oxide" "deep_trench_3")
(isegeo:create-cuboid (position 5 1 -8) (position 1 0 -1) "Oxide"
"deep_trench_4")


; Shallow Trench and Surface Oxide
; --------------------------------

(isegeo:create-cuboid (position -10 -10 -1) (position 16 14.5 0)
"Oxide" "sti_oxide")


; Epitaxial Silicon Cuboids (active region)
; -----------------------------------------

(isegeo:create-cuboid (position 1.25 1.25 -1) (position 2.75 3.25
0) "Silicon" "epi_si_emitter-base")
(isegeo:create-cuboid (position 4 1.25 -1) (position 4.75 3.25 0)
"Silicon" "epi_si_collector")


; Silicon Germanium Base
; ----------------------

(isegeo:create-cuboid (position 0 0 0) (position 3.75 4.5 0.10)
"SiliconGermanium" "sige_base")


; Emitter Silicon
; ---------------

(isegeo:create-cuboid (position 1.75 1.75 0.10) (position 2.25
```

```
2.75 0.2695) "Silicon" "emitter_silicon")


; Contact Definitions
; -------------------

; Collector
(isegeo:imprint-rectangular-wire (position 4.2 1.3 0) (position
4.6 3.2 0))
(isegeo:define-contact-set "Collector" 4.0 (color:rgb 1 0 0)
"##")
(isegeo:define-3d-contact (find-face-id (position 4.4 2 0))
"Collector")

; Base
(isegeo:imprint-rectangular-wire (position 0 0 0.1) (position 1.0
4.5 0.1))
(isegeo:define-contact-set "Base" 4.0 (color:rgb 1 0 0) "##")
(isegeo:define-3d-contact (find-face-id (position 0.5 2.25 0.1))
"Base")

; Substrate
(isegeo:imprint-rectangular-wire (position 16 0 0) (position 18
4.5 0))
(isegeo:define-contact-set "Substrate" 4.0 (color:rgb 1 0 0)
"##")
(isegeo:define-3d-contact (find-face-id (position 17 2.25 0))
"Substrate")

; Emitter
(isegeo:imprint-rectangular-wire (position 1.80 1.80 0.2695)
(position 2.20 2.70 0.2695))
(isegeo:define-contact-set "Emitter" 4.0 (color:rgb 1 0 0) "##")
(isegeo:define-3d-contact (find-face-id (position 2 2 0.2695))
"Emitter")


; Doping Profiles
; ---------------

; Substrate
(isedr:define-constant-profile "substrate.profile"
"BoronActiveConcentration" 5e+15)
(isedr:define-refinement-window "substrate_window" "Cuboid"
(position -10 -10 -25) (position 18 14.5 -1))
(isedr:define-constant-profile-placement
"place.substrate.profile" "substrate.profile" "substrate_window")

; Substrate Plug
(isedr:define-constant-profile "substrate.plug.profile"
"BoronActiveConcentration" 1e+18)
(isedr:define-refinement-window "substrate_plug_window" "Cuboid"
(position 16 -10 -8) (position 18 14.5 0))
(isedr:define-constant-profile-placement
"place.substrate.plug.profile" "substrate.plug.profile"
"substrate_plug_window")
```

```
; Subcollector
(isedr:define-1d-external-profile "subcollector.profile"
"dopC.dat" "Scale" 1 "Range" 6.0460000e-1 2.8801759 "Erf"
"Factor" 0.01)
(isedr:define-refinement-window "subcollector_window" "Rectangle"
(position 0.8 0.8 -0.29) (position 5.2 3.7 -0.29))
(isedr:define-analytical-profile-placement
"place.subcollector.profile" "subcollector.profile"
"subcollector_window" "Negative" "NoReplace" "Eval")

; Epitaxial
(isedr:define-constant-profile "epitaxial.profile"
"PhosphorusActiveConcentration" 1e+16)
(isedr:define-refinement-window "epitaxial_window" "Cuboid"
(position -10 -10 -1.5) (position 16 14.5 0))
(isedr:define-constant-profile-placement
"place.epitaxial.profile" "epitaxial.profile" "epitaxial_window")

; Intrinsic Base
(isedr:define-1d-external-profile "intrinsic.base.profile"
"dopB.dat" "Scale" 1 "Range" 0 0.598 "Gauss" "Factor" 0)
(isedr:define-refinement-window "intrinsic_base_window"
"Rectangle" (position 0 0 0.2695) (position 3.75 4.5 0.2695))
(isedr:define-analytical-profile-placement
"place.intrinsic.base.profile" "intrinsic.base.profile"
"intrinsic_base_window" "Negative" "NoReplace" "Eval")

; Collector Contact
(isedr:define-constant-profile "collector.contact.profile"
"PhosphorusActiveConcentration" 1e+20)
(isedr:define-refinement-window "collector_contact_window"
"Cuboid" (position 4 1.25 -1.55) (position 4.75 3.25 0))
(isedr:define-constant-profile-placement
"place.collector.contact.profile" "collector.contact.profile"
"collector_contact_window")

; SIC
(isedr:define-1d-external-profile "base-collector.profile"
"dopD.dat" "Scale" 1 "Range" 0.0 0.598 "Gauss" "StdDev" 0)
(isedr:define-refinement-window "base-collector_window"
"Rectangle" (position 1.755 1.755 0.2695) (position 2.245 2.745
0.2695))
(isedr:define-analytical-profile-placement "place.base-
collector.profile" "base-collector.profile" "base-
collector_window" "Negative" "NoReplace" "Eval")

; Extrinsic Base
(isedr:define-gaussian-profile "extrinsic.base.profile"
"BoronActiveConcentration" "PeakVal" 1e+20 "PeakPos" 0 "StdDev"
0.06 "Gauss" "Factor" 0)
(isedr:define-refinement-window "extrinsic_base_window_1"
"Rectangle" (position 0 0 0.10) (position 1.50 4.5 0.10))
(isedr:define-refinement-window "extrinsic_base_window_2"
"Rectangle" (position 2.50 0 0.10) (position 3.75 4.5 0.10))
(isedr:define-refinement-window "extrinsic_base_window_3"
"Rectangle" (position 1.50 3.0 0.10) (position 2.50 4.5 0.10))
(isedr:define-refinement-window "extrinsic_base_window_4"
```

```
"Rectangle" (position 0 0 0.10) (position 2.50 1.5 0.10))
(isedr:define-analytical-profile-placement
"place.extrinsic.base.profile.1" "extrinsic.base.profile"
"extrinsic_base_window_1" "Negative" "NoReplace" "Eval")
(isedr:define-analytical-profile-placement
"place.extrinsic.base.profile.2" "extrinsic.base.profile"
"extrinsic_base_window_2" "Negative" "NoReplace" "Eval")
(isedr:define-analytical-profile-placement
"place.extrinsic.base.profile.3" "extrinsic.base.profile"
"extrinsic_base_window_3" "Negative" "NoReplace" "Eval")
(isedr:define-analytical-profile-placement
"place.extrinsic.base.profile.4" "extrinsic.base.profile"
"extrinsic_base_window_4" "Negative" "NoReplace" "Eval")

; Germanium Mole Fraction (in the base)
(isedr:define-1d-external-profile "mole.fraction" "xMol.xy"
"Scale" 1 "Range" 0.1646 0.2774 "Erf" "Factor" 0)
(isedr:define-refinement-window "germanium_window" "Rectangle"
(position 0 0 0.10) (position 3.75 4.5 0.10))
(isedr:define-analytical-profile-placement "place.mole.fraction"
"mole.fraction" "germanium_window" "Negative" "NoReplace" "Eval")

; Emitter
(isedr:define-1d-external-profile "emitter.profile" "dopA.dat"
"Scale" 1 "Range" 0.0 0.598 "Gauss" "Factor" 0)
(isedr:define-refinement-window "emitter_window" "Rectangle"
(position 1.75 1.75 0.2695) (position 2.25 2.75 0.2695))
(isedr:define-analytical-profile-placement
"place.emitter.profile" "emitter.profile" "emitter_window"
"Negative" "NoReplace" "Eval")


; Meshing Refinements
; -------------------

(isedr:define-refinement-size "default.msh" 3 3 3 1 1 1)
(isedr:define-refinement-function "default.msh"
"DopingConcentration" "MaxTransDiff" 1.0)
(isedr:define-refinement-window  "default_msh_window" "Cuboid"
(position -10 -10 -25) (position 18 14.5 0.2695))
(isedr:define-refinement-placement "place.default.msh"
"default.msh" "default_msh_window")

(isedr:define-refinement-size "base.msh" 2 2 0.1 1 1 0.01)
(isedr:define-refinement-function "base.msh"
"DopingConcentration" "MaxTransDiff" 1.0)
(isedr:define-refinement-window "base_msh_window" "Cuboid"
(position 0 0 0) (position 3.75 4.5 0.10))
(isedr:define-refinement-placement "place.base.msh" "base.msh"
"base_msh_window")

(isedr:define-refinement-size "emitter-base.msh" 2 2 0.1 1 1
0.01)
(isedr:define-refinement-function "emitter-base.msh"
"DopingConcentration" "MaxTransDiff" 1.0)
(isedr:define-refinement-window "emitter-base_msh_window"
"Cuboid" (position 1.55 1.55 0.15) (position 2.45 2.95 0.0))
```

```
(isedr:define-refinement-placement "place.emitter-base.msh"
"emitter-base.msh" "emitter-base_msh_window")

(isedr:define-refinement-size "base-collector.msh" 1 1 0.25 0.3
0.3 0.1)
(isedr:define-refinement-function "base-collector.msh"
"DopingConcentration" "MaxTransDiff" 0.7)
(isedr:define-refinement-window "base-collector_msh_window"
"Cuboid" (position 1.25 1.25 -0.1) (position 2.75 3.25 0.09))
(isedr:define-refinement-placement "place.base-collector.msh"
"base-collector.msh" "base-collector_msh_window")

(isedr:define-refinement-size "collector-substrate.msh" 2 2 0.5 1
1 0.1)
(isedr:define-refinement-function "collector-substrate.msh"
"DopingConcentration" "MaxTransDiff" 1.0)
(isedr:define-refinement-window "collector-substrate_msh_window"
"Cuboid" (position 1.25 1.25 -3) (position 5 3.25 -2))
(isedr:define-refinement-placement "place.collector-
substrate.msh" "collector-substrate.msh" "collector-
substrate_msh_window")


; Save Files
; ----------
(ise:save-model "05x1")
```

MESH refinement definition file

This file assigns the finite elements to the defined device for use in the partial differential equations describing the physical behavior of the SiGe HBT.

```
# 1 "05x1diode.cmd.tmpl"
# 1 "<built-in>"
# 1 "<command line>"
# 1 "05x1diode.cmd.tmpl"
Title "05x1_5HP_HBT"

Controls {

}Definitions {
        Constant "substrate.profile" {
                Species = "BoronActiveConcentration"
                Value = 5e+15
        }
        Constant "substrate.plug.profile" {
                Species = "BoronActiveConcentration"
                Value = 1e+18
        }
        AnalyticalProfile "subcollector.profile" {
        Function = SubMesh1d(datafile = "dopC.dat", scale = 1,
```

```
range = line[ (0.6046), (2.88018) ])
        LateralFunction = Erf(Factor = 0.01)
        }
        Constant "epitaxial.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+16
        }
        Constant "epitaxial1.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+16
        }
        Constant "epitaxial2.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+16
        }
        Constant "epitaxial3.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+16
        }
        Constant "epitaxial4.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+16
        }
        Constant "epitaxial5.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+16
        }
        Constant "epitaxial6.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+16
        }
        Constant "collector.contact.profile" {
                Species = "PhosphorusActiveConcentration"
                Value = 1e+20
        }
        Refinement "default.msh" {
                MaxElementSize = ( 10 10 10 )
                MinElementSize = ( 5 5 5 )
                RefineFunction = MaxTransDiff(Variable =
"DopingConcentration",Value = 1)
        }
        Refinement "default1.msh" {
                MaxElementSize = ( 3 3 3 )
                MinElementSize = ( 1 1 1 )
                RefineFunction = MaxTransDiff(Variable =
"DopingConcentration",Value = 1)
        }
        Refinement "base.msh" {
                MaxElementSize = ( 2 2 0.1 )
                MinElementSize = ( 1 1 0.01 )
                RefineFunction = MaxTransDiff(Variable =
"DopingConcentration",Value = 1)
        }
        Refinement "emitter-base.msh" {
                MaxElementSize = ( 2 2 0.1 )
                MinElementSize = ( 1 1 0.01 )
                RefineFunction = MaxTransDiff(Variable =
```

```
"DopingConcentration",Value = 1)
        }
        Refinement "base-collector.msh" {
                MaxElementSize = ( 1 1 0.25 )
                MinElementSize = ( 0.3 0.3 0.1 )
                RefineFunction = MaxTransDiff(Variable =
"DopingConcentration",Value = 0.7)
        }
        Refinement "collector-substrate.msh" {
                MaxElementSize = ( 2 2 0.5 )
                MinElementSize = ( 1 1 0.1 )
                RefineFunction = MaxTransDiff(Variable =
"DopingConcentration",Value = 1)
        }
        Refinement "Refine_Block_1" {
                MaxElementSize = (0.5 0.5 0.5)
                MinElementSize = (0.1 0.1 0.1)
        }
}

Placements {
        Constant "place.substrate.profile" {
                Reference = "substrate.profile"
                EvaluateWindow {
                        Element = Cuboid [( -34 -34 -35 ) , ( 40
38.5 -1 )]
                }
        }
        Constant "place.substrate.plug.profile" {
                Reference = "substrate.plug.profile"
                EvaluateWindow {
                        Element = Cuboid [( 16 -10 -8 ) , ( 18
14.5 0 )]
                }
        }
        AnalyticalProfile "place.subcollector.profile" {
                Reference = "subcollector.profile"
                ReferenceElement {
                        Element = Rectangle [( 0.8 0.8 -0.29 ) ,
( 5.2 3.7 -0.29 )]
                        Direction = negative
                }
        }
        Constant "place.epitaxial.profile" {
                Reference = "epitaxial.profile"
                EvaluateWindow {
                        Element = Cuboid [( -34 -34 -1.5 ) , ( 1
38.5 0 )]
                }
        }
        Constant "place.epitaxial1.profile" {
                Reference = "epitaxial1.profile"
                EvaluateWindow {
                        Element = Cuboid [( 5 -34 -1.5 ) , ( 16
38.5 0 )]
                }
        }
```

```
        Constant "place.epitaxial2.profile" {
                Reference = "epitaxial2.profile"
                EvaluateWindow {
                        Element = Cuboid [( 18 -34 -1.5 ) , ( 40
38.5 0 )]
                }
        }
        Constant "place.epitaxial3.profile" {
                Reference = "epitaxial3.profile"
                EvaluateWindow {
                        Element = Cuboid [( 16 14.5 -1.5 ) , ( 18
38.5 0 )]
                }
        }
        Constant "place.epitaxial4.profile" {
                Reference = "epitaxial4.profile"
                EvaluateWindow {
                        Element = Cuboid [( 16 -34 -1.5 ) , ( 18
-10 0 )]
                }
        }
        Constant "place.epitaxial5.profile" {
                Reference = "epitaxial5.profile"
                EvaluateWindow {
                        Element = Cuboid [( 1 -34 -1.5 ) , ( 5 1
0 )]
                }
        }
        Constant "place.epitaxial6.profile" {
                Reference = "epitaxial6.profile"
                EvaluateWindow {
                        Element = Cuboid [( 1 3.5 -1.5 ) , ( 5
38.5 0 )]
                }
        }
        Constant "place.collector.contact.profile" {
                Reference = "collector.contact.profile"
                EvaluateWindow {
                        Element = Cuboid [( 1.25 1.25 -1.55 ) , (
4.75 3.25 0 )]
                }
        }
        Refinement "place.default.msh" {
                Reference = "default.msh"
                RefineWindow = Cuboid [( -34 -34 -35 ) , ( 40
38.5 0.2695 )]
        }
        Refinement "place.default1.msh" {
                Reference = "default1.msh"
                RefineWindow = Cuboid [( -8 -6.75 -33 ) , ( 5 5.5
0.2695 )]
        }
        Refinement "place.base.msh" {
                Reference = "base.msh"
                RefineWindow = Cuboid [( 0 0 0 ) , ( 3.75 4.5 0.1
)]
        }
```

```
        Refinement "place.emitter-base.msh" {
                Reference = "emitter-base.msh"
                RefineWindow = Cuboid [( 1.55 1.55 0.15 ) , (
2.45 2.95 0 )]
        }
        Refinement "place.base-collector.msh" {
                Reference = "base-collector.msh"
                RefineWindow = Cuboid [( 1.25 1.25 -0.1 ) , (
2.75 3.25 0.09 )]
        }
        Refinement "place.collector-substrate.msh" {
                Reference = "collector-substrate.msh"
                RefineWindow = Cuboid [( 1.25 1.25 -3 ) , ( 5
3.25 -2 )]
        }
# 1 "cubic_msh.dat" 1
        Refinement "Refine Block 0" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 8.20684061984353 1.5 -
0.775244165751898) , (9.75 3 0.75)]
        }
        Refinement "Refine Block 1" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 8.16368123968706 1.5 -
0.800488331503795) , (9.70684061984353 3 0.724755834248102)]
        }
        Refinement "Refine Block 2" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 8.12052185953059 1.5 -
0.825732497255693) , (9.66368123968706 3 0.699511668496205)]
        }
        Refinement "Refine Block 3" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 8.07736247937412 1.5 -
0.850976663007591) , (9.62052185953059 3 0.674267502744307)]
        }
        Refinement "Refine Block 4" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 8.03420309921765 1.5 -
0.876220828759488) , (9.57736247937412 3 0.649023336992409)]
        }
        Refinement "Refine Block 5" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.99104371906118 1.5 -
0.901464994511386) , (9.53420309921765 3 0.623779171240512)]
        }
        Refinement "Refine Block 6" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.94788433890471 1.5 -
0.926709160263284) , (9.49104371906118 3 0.598535005488614)]
        }
        Refinement "Refine Block 7" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.90472495874824 1.5 -
0.951953326015181) , (9.44788433890471 3 0.573290839736716)]
        }
        Refinement "Refine Block 8" {
```

```
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.86156557859177 1.5 -
0.977197491767079) , (9.40472495874824 3 0.548046673984819)]
        }
        Refinement "Refine Block 9" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.8184061984353 1.5 -
1.00244165751898) , (9.36156557859177 3 0.522802508232921)]
        }
        Refinement "Refine Block 10" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.77524681827883 1.5 -
1.02768582327087) , (9.3184061984353 3 0.497558342481023)]
        }
        Refinement "Refine Block 11" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.73208743812236 1.5 -
1.05292998902277) , (9.27524681827883 3 0.472314176729126)]
        }
        Refinement "Refine Block 12" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.68892805796589 1.5 -
1.07817415477467) , (9.23208743812236 3 0.447070010977228)]
        }
        Refinement "Refine Block 13" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.64576867780942 1.5 -
1.10341832052657) , (9.18892805796589 3 0.42182584522533)]
        }
        Refinement "Refine Block 14" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.60260929765295 1.5 -
1.12866248627847) , (9.14576867780942 3 0.396581679473432)]
        }
        Refinement "Refine Block 15" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.55944991749648 1.5 -
1.15390665203036) , (9.10260929765295 3 0.371337513721535)]
        }
        Refinement "Refine Block 16" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.51629053734001 1.5 -
1.17915081778226) , (9.05944991749648 3 0.346093347969637)]
        }
        Refinement "Refine Block 17" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.47313115718354 1.5 -
1.20439498353416) , (9.01629053734001 3 0.320849182217739)]
        }
        Refinement "Refine Block 18" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.42997177702707 1.5 -
1.22963914928606) , (8.97313115718354 3 0.295605016465842)]
        }
        Refinement "Refine Block 19" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.3868123968706 1.5 -
```

```
1.25488331503795) , (8.92997177702707 3 0.270360850713944)]
        }
        Refinement "Refine Block 20" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.34365301671412 1.5 -
1.28012748078985) , (8.8868123968706 3 0.245116684962046)]
        }
        Refinement "Refine Block 21" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.30049363655765 1.5 -
1.30537164654175) , (8.84365301671412 3 0.219872519210149)]
        }
        Refinement "Refine Block 22" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.25733425640118 1.5 -
1.33061581229365) , (8.80049363655765 3 0.194628353458251)]
        }
        Refinement "Refine Block 23" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.21417487624471 1.5 -
1.35585997804554) , (8.75733425640118 3 0.169384187706353)]
        }
        Refinement "Refine Block 24" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.17101549608824 1.5 -
1.38110414379744) , (8.71417487624471 3 0.144140021954456)]
        }
        Refinement "Refine Block 25" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.12785611593177 1.5 -
1.40634830954934) , (8.67101549608824 3 0.118895856202558)]
        }
        Refinement "Refine Block 26" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.0846967357753 1.5 -
1.43159247530124) , (8.62785611593177 3 0.0936516904506601)]
        }
        Refinement "Refine Block 27" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 7.04153735561883 1.5 -
1.45683664105314) , (8.5846967357753 3 0.0684075246987624)]
        }
        Refinement "Refine Block 28" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.99837797546236 1.5 -
1.48208080680503) , (8.54153735561883 3 0.0431633589468647)]
        }
        Refinement "Refine Block 29" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.95521859530589 1.5 -
1.50732497255693) , (8.49837797546236 3 0.017919193194967)]
        }
        Refinement "Refine Block 30" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.91205921514942 1.5 -
1.53256913830883) , (8.45521859530589 3 -0.00732497255693076)]
        }
```

```
        Refinement "Refine Block 31" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.86889983499295 1.5 -
1.55781330406073) , (8.41205921514942 3 -0.0325691383088285)]
        }
        Refinement "Refine Block 32" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.82574045483648 1.5 -
1.58305746981262) , (8.36889983499295 3 -0.0578133040607262)]
        }
        Refinement "Refine Block 33" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.78258107468001 1.5 -
1.60830163556452) , (8.32574045483648 3 -0.0830574698126239)]
        }
        Refinement "Refine Block 34" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.73942169452354 1.5 -
1.63354580131642) , (8.28258107468001 3 -0.108301635564522)]
        }
        Refinement "Refine Block 35" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.69626231436707 1.5 -
1.65878996706832) , (8.23942169452354 3 -0.133545801316419)]
        }
        Refinement "Refine Block 36" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.6531029342106 1.5 -
1.68403413282021) , (8.19626231436707 3 -0.158789967068317)]
        }
        Refinement "Refine Block 37" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.60994355405413 1.5 -
1.70927829857211) , (8.1531029342106 3 -0.184034132820215)]
        }
        Refinement "Refine Block 38" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.56678417389766 1.5 -
1.73452246432401) , (8.10994355405413 3 -0.209278298572112)]
        }
        Refinement "Refine Block 39" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.52362479374119 1.5 -
1.75976663007591) , (8.06678417389766 3 -0.23452246432401)]
        }
        Refinement "Refine Block 40" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.48046541358472 1.5 -
1.78501079582781) , (8.02362479374119 3 -0.259766630075908)]
        }
        Refinement "Refine Block 41" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 6.43730603342825 1.5 -
1.8102549615797) , (7.98046541358472 3 -0.285010795827805)]
        }
        Refinement "Refine Block 42" {
                Reference = "Refine_Block_1"
```

```
		RefineWindow = Cuboid [( 6.39414665327178 1.5 -
1.8354991273316) , (7.93730603342825 3 -0.310254961579703)]
	}
	Refinement "Refine Block 43" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.35098727311531 1.5 -
1.8607432930835) , (7.89414665327178 3 -0.3354991273316)]
	}
	Refinement "Refine Block 44" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.30782789295884 1.5 -
1.8859874588354) , (7.85098727311531 3 -0.360743293083498)]
	}
	Refinement "Refine Block 45" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.26466851280237 1.5 -
1.91123162458729) , (7.80782789295884 3 -0.385987458835396)]
	}
	Refinement "Refine Block 46" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.2215091326459 1.5 -
1.93647579033919) , (7.76466851280237 3 -0.411231624587293)]
	}
	Refinement "Refine Block 47" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.17834975248943 1.5 -
1.96171995609109) , (7.7215091326459 3 -0.436475790339191)]
	}
	Refinement "Refine Block 48" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.13519037233296 1.5 -
1.98696412184299) , (7.67834975248943 3 -0.461719956091088)]
	}
	Refinement "Refine Block 49" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.09203099217649 1.5 -
2.01220828759488) , (7.63519037233296 3 -0.486964121842986)]
	}
	Refinement "Refine Block 50" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.04887161202002 1.5 -
2.03745245334678) , (7.59203099217649 3 -0.512208287594883)]
	}
	Refinement "Refine Block 51" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 6.00571223186355 1.5 -
2.06269661909868) , (7.54887161202002 3 -0.537452453346781)]
	}
	Refinement "Refine Block 52" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 5.96255285170708 1.5 -
2.08794078485058) , (7.50571223186355 3 -0.562696619098679)]
	}
	Refinement "Refine Block 53" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( 5.91939347155061 1.5 -
2.11318495060247) , (7.46255285170708 3 -0.587940784850576)]
```

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        }
        Refinement "Refine Block 54" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.87623409139414 1.5 -
2.13842911635437) , (7.41939347155061 3 -0.613184950602474)]
        }
        Refinement "Refine Block 55" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.83307471123767 1.5 -
2.16367328210627) , (7.37623409139414 3 -0.638429116354371)]
        }
        Refinement "Refine Block 56" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.7899153310812 1.5 -
2.18891744785817) , (7.33307471123767 3 -0.663673282106269)]
        }
        Refinement "Refine Block 57" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.74675595092473 1.5 -
2.21416161361006) , (7.2899153310812 3 -0.688917447858167)]
        }
        Refinement "Refine Block 58" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.70359657076826 1.5 -
2.23940577936196) , (7.24675595092473 3 -0.714161613610064)]
        }
        Refinement "Refine Block 59" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.66043719061179 1.5 -
2.26464994511386) , (7.20359657076826 3 -0.739405779361962)]
        }
        Refinement "Refine Block 60" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.61727781045532 1.5 -
2.28989411086576) , (7.16043719061179 3 -0.764649945113859)]
        }
        Refinement "Refine Block 61" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.57411843029885 1.5 -
2.31513827661765) , (7.11727781045532 3 -0.789894110865757)]
        }
        Refinement "Refine Block 62" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.53095905014238 1.5 -
2.34038244236955) , (7.07411843029885 3 -0.815138276617654)]
        }
        Refinement "Refine Block 63" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.48779966998591 1.5 -
2.36562660812145) , (7.03095905014238 3 -0.840382442369552)]
        }
        Refinement "Refine Block 64" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.44464028982944 1.5 -
2.39087077387335) , (6.98779966998591 3 -0.86562660812145)]
        }
        Refinement "Refine Block 65" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.40148090967297 1.5 -
2.41611493962525) , (6.94464028982944 3 -0.890870773873347)]
        }
        Refinement "Refine Block 66" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.3583215295165 1.5 -
2.44135910537714) , (6.90148090967297 3 -0.916114939625245)]
        }
        Refinement "Refine Block 67" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.31516214936003 1.5 -
2.46660327112904) , (6.8583215295165 3 -0.941359105377143)]
        }
        Refinement "Refine Block 68" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.27200276920356 1.5 -
2.49184743688094) , (6.81516214936003 3 -0.96660327112904)]
        }
        Refinement "Refine Block 69" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.22884338904709 1.5 -
2.51709160263284) , (6.77200276920356 3 -0.991847436880938)]
        }
        Refinement "Refine Block 70" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.18568400889062 1.5 -
2.54233576838473) , (6.72884338904709 3 -1.01709160263284)]
        }
        Refinement "Refine Block 71" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.14252462873415 1.5 -
2.56757993413663) , (6.68568400889062 3 -1.04233576838473)]
        }
        Refinement "Refine Block 72" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.09936524857768 1.5 -
2.59282409988853) , (6.64252462873415 3 -1.06757993413663)]
        }
        Refinement "Refine Block 73" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.05620586842121 1.5 -
2.61806826564043) , (6.59936524857768 3 -1.09282409988853)]
        }
        Refinement "Refine Block 74" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 5.01304648826474 1.5 -
2.64331243139232) , (6.55620586842121 3 -1.11806826564043)]
        }
        Refinement "Refine Block 75" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.96988710810827 1.5 -
2.66855659714422) , (6.51304648826474 3 -1.14331243139232)]
        }
        Refinement "Refine Block 76" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.9267277279518 1.5 -
```

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2.69380076289612) , (6.46988710810827 3 -1.16855659714422)]
        }
        Refinement "Refine Block 77" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.88356834779533 1.5 -
2.71904492864802) , (6.4267277279518 3 -1.19380076289612)]
        }
        Refinement "Refine Block 78" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.84040896763886 1.5 -
2.74428909439991) , (6.38356834779533 3 -1.21904492864802)]
        }
        Refinement "Refine Block 79" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.79724958748239 1.5 -
2.76953326015181) , (6.34040896763886 3 -1.24428909439991)]
        }
        Refinement "Refine Block 80" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.75409020732592 1.5 -
2.79477742590371) , (6.29724958748239 3 -1.26953326015181)]
        }
        Refinement "Refine Block 81" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.71093082716945 1.5 -
2.82002159165561) , (6.25409020732592 3 -1.29477742590371)]
        }
        Refinement "Refine Block 82" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.66777144701298 1.5 -
2.8452657574075) , (6.21093082716945 3 -1.32002159165561)]
        }
        Refinement "Refine Block 83" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.62461206685651 1.5 -
2.8705099231594) , (6.16777144701298 3 -1.3452657574075)]
        }
        Refinement "Refine Block 84" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.58145268670004 1.5 -
2.8957540889113) , (6.12461206685651 3 -1.3705099231594)]
        }
        Refinement "Refine Block 85" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.53829330654357 1.5 -
2.9209982546632) , (6.08145268670004 3 -1.3957540889113)]
        }
        Refinement "Refine Block 86" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.4951339263871 1.5 -
2.94624242041509) , (6.03829330654357 3 -1.4209982546632)]
        }
        Refinement "Refine Block 87" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.45197454623063 1.5 -
2.97148658616699) , (5.9951339263871 3 -1.44624242041509)]
        }
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        Refinement "Refine Block 88" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.40881516607416 1.5 -
2.99673075191889) , (5.95197454623063 3 -1.47148658616699)]
        }
        Refinement "Refine Block 89" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.36565578591769 1.5 -
3.02197491767079) , (5.90881516607416 3 -1.49673075191889)]
        }
        Refinement "Refine Block 90" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.32249640576122 1.5 -
3.04721908342268) , (5.86565578591769 3 -1.52197491767079)]
        }
        Refinement "Refine Block 91" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.27933702560475 1.5 -
3.07246324917458) , (5.82249640576122 3 -1.54721908342268)]
        }
        Refinement "Refine Block 92" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.23617764544828 1.5 -
3.09770741492648) , (5.77933702560475 3 -1.57246324917458)]
        }
        Refinement "Refine Block 93" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.19301826529181 1.5 -
3.12295158067838) , (5.73617764544828 3 -1.59770741492648)]
        }
        Refinement "Refine Block 94" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.14985888513534 1.5 -
3.14819574643028) , (5.69301826529181 3 -1.62295158067838)]
        }
        Refinement "Refine Block 95" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.10669950497887 1.5 -
3.17343991218217) , (5.64985888513534 3 -1.64819574643028)]
        }
        Refinement "Refine Block 96" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.0635401248224 1.5 -
3.19868407793407) , (5.60669950497887 3 -1.67343991218217)]
        }
        Refinement "Refine Block 97" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 4.02038074466593 1.5 -
3.22392824368597) , (5.5635401248224 3 -1.69868407793407)]
        }
        Refinement "Refine Block 98" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.97722136450946 1.5 -
3.24917240943787) , (5.52038074466593 3 -1.72392824368597)]
        }
        Refinement "Refine Block 99" {
                Reference = "Refine_Block_1"
```

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                RefineWindow = Cuboid [( 3.93406198435299 1.5 -
3.27441657518976) , (5.47722136450946 3 -1.74917240943787)]
        }
        Refinement "Refine Block 100" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.89090260419652 1.5 -
3.29966074094166) , (5.43406198435299 3 -1.77441657518976)]
        }
        Refinement "Refine Block 101" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.84774322404005 1.5 -
3.32490490669356) , (5.39090260419652 3 -1.79966074094166)]
        }
        Refinement "Refine Block 102" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.80458384388358 1.5 -
3.35014907244546) , (5.34774322404005 3 -1.82490490669356)]
        }
        Refinement "Refine Block 103" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.76142446372711 1.5 -
3.37539323819735) , (5.30458384388358 3 -1.85014907244546)]
        }
        Refinement "Refine Block 104" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.71826508357064 1.5 -
3.40063740394925) , (5.26142446372711 3 -1.87539323819735)]
        }
        Refinement "Refine Block 105" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.67510570341417 1.5 -
3.42588156970115) , (5.21826508357064 3 -1.90063740394925)]
        }
        Refinement "Refine Block 106" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.6319463232577 1.5 -
3.45112573545305) , (5.17510570341417 3 -1.92588156970115)]
        }
        Refinement "Refine Block 107" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.58878694310123 1.5 -
3.47636990120494) , (5.1319463232577 3 -1.95112573545305)]
        }
        Refinement "Refine Block 108" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.54562756294476 1.5 -
3.50161406695684) , (5.08878694310123 3 -1.97636990120494)]
        }
        Refinement "Refine Block 109" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.50246818278828 1.5 -
3.52685823270874) , (5.04562756294476 3 -2.00161406695684)]
        }
        Refinement "Refine Block 110" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.45930880263181 1.5 -
3.55210239846064) , (5.00246818278828 3 -2.02685823270874)]
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        }
        Refinement "Refine Block 111" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.41614942247534 1.5 -
3.57734656421253) , (4.95930880263181 3 -2.05210239846064)]
        }
        Refinement "Refine Block 112" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.37299004231887 1.5 -
3.60259072996443) , (4.91614942247534 3 -2.07734656421253)]
        }
        Refinement "Refine Block 113" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.3298306621624 1.5 -
3.62783489571633) , (4.87299004231887 3 -2.10259072996443)]
        }
        Refinement "Refine Block 114" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.28667128200593 1.5 -
3.65307906146823) , (4.8298306621624 3 -2.12783489571633)]
        }
        Refinement "Refine Block 115" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.24351190184946 1.5 -
3.67832322722012) , (4.78667128200593 3 -2.15307906146823)]
        }
        Refinement "Refine Block 116" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.20035252169299 1.5 -
3.70356739297202) , (4.74351190184946 3 -2.17832322722012)]
        }
        Refinement "Refine Block 117" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.15719314153652 1.5 -
3.72881155872392) , (4.70035252169299 3 -2.20356739297202)]
        }
        Refinement "Refine Block 118" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.11403376138005 1.5 -
3.75405572447582) , (4.65719314153652 3 -2.22881155872392)]
        }
        Refinement "Refine Block 119" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.07087438122358 1.5 -
3.77929989022771) , (4.61403376138005 3 -2.25405572447582)]
        }
        Refinement "Refine Block 120" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 3.02771500106711 1.5 -
3.80454405597961) , (4.57087438122358 3 -2.27929989022771)]
        }
        Refinement "Refine Block 121" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.98455562091064 1.5 -
3.82978822173151) , (4.52771500106711 3 -2.30454405597961)]
        }
        Refinement "Refine Block 122" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.94139624075417 1.5 -
3.85503238748341) , (4.48455562091064 3 -2.32978822173151)]
        }
        Refinement "Refine Block 123" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.8982368605977 1.5 -
3.8802765532353) , (4.44139624075417 3 -2.35503238748341)]
        }
        Refinement "Refine Block 124" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.85507748044123 1.5 -
3.9055207189872) , (4.3982368605977 3 -2.3802765532353)]
        }
        Refinement "Refine Block 125" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.81191810028476 1.5 -
3.9307648847391) , (4.35507748044123 3 -2.4055207189872)]
        }
        Refinement "Refine Block 126" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.76875872012829 1.5 -
3.956009050491) , (4.31191810028476 3 -2.4307648847391)]
        }
        Refinement "Refine Block 127" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.72559933997182 1.5 -
3.9812532162429) , (4.26875872012829 3 -2.456009050491)]
        }
        Refinement "Refine Block 128" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.68243995981535 1.5 -
4.00649738199479) , (4.22559933997182 3 -2.4812532162429)]
        }
        Refinement "Refine Block 129" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.63928057965888 1.5 -
4.03174154774669) , (4.18243995981535 3 -2.50649738199479)]
        }
        Refinement "Refine Block 130" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.59612119950241 1.5 -
4.05698571349859) , (4.13928057965888 3 -2.53174154774669)]
        }
        Refinement "Refine Block 131" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.55296181934594 1.5 -
4.08222987925049) , (4.09612119950241 3 -2.55698571349859)]
        }
        Refinement "Refine Block 132" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.50980243918947 1.5 -
4.10747404500238) , (4.05296181934594 3 -2.58222987925049)]
        }
        Refinement "Refine Block 133" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.466643059033 1.5 -
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4.13271821075428) , (4.00980243918947 3 -2.60747404500238)]
        }
        Refinement "Refine Block 134" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.42348367887653 1.5 -
4.15796237650618) , (3.966643059033 3 -2.63271821075428)]
        }
        Refinement "Refine Block 135" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.38032429872006 1.5 -
4.18320654225808) , (3.92348367887653 3 -2.65796237650618)]
        }
        Refinement "Refine Block 136" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.33716491856359 1.5 -
4.20845070800997) , (3.88032429872006 3 -2.68320654225808)]
        }
        Refinement "Refine Block 137" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.29400553840712 1.5 -
4.23369487376187) , (3.83716491856359 3 -2.70845070800997)]
        }
        Refinement "Refine Block 138" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.25084615825065 1.5 -
4.25893903951377) , (3.79400553840712 3 -2.73369487376187)]
        }
        Refinement "Refine Block 139" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.20768677809418 1.5 -
4.28418320526567) , (3.75084615825065 3 -2.75893903951377)]
        }
        Refinement "Refine Block 140" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.16452739793771 1.5 -
4.30942737101756) , (3.70768677809418 3 -2.78418320526567)]
        }
        Refinement "Refine Block 141" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.12136801778124 1.5 -
4.33467153676946) , (3.66452739793771 3 -2.80942737101756)]
        }
        Refinement "Refine Block 142" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.07820863762477 1.5 -
4.35991570252136) , (3.62136801778124 3 -2.83467153676946)]
        }
        Refinement "Refine Block 143" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 2.0350492574683 1.5 -
4.38515986827326) , (3.57820863762477 3 -2.85991570252136)]
        }
        Refinement "Refine Block 144" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.99188987731183 1.5 -
4.41040403402515) , (3.5350492574683 3 -2.88515986827326)]
        }
```

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        Refinement "Refine Block 145" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.94873049715536 1.5 -
4.43564819977705) , (3.49188987731183 3 -2.91040403402515)]
        }
        Refinement "Refine Block 146" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.90557111699889 1.5 -
4.46089236552895) , (3.44873049715536 3 -2.93564819977705)]
        }
        Refinement "Refine Block 147" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.86241173684242 1.5 -
4.48613653128085) , (3.40557111699889 3 -2.96089236552895)]
        }
        Refinement "Refine Block 148" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.81925235668595 1.5 -
4.51138069703275) , (3.36241173684242 3 -2.98613653128085)]
        }
        Refinement "Refine Block 149" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.77609297652948 1.5 -
4.53662486278464) , (3.31925235668595 3 -3.01138069703274)]
        }
        Refinement "Refine Block 150" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.73293359637301 1.5 -
4.56186902853654) , (3.27609297652948 3 -3.03662486278464)]
        }
        Refinement "Refine Block 151" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.68977421621654 1.5 -
4.58711319428844) , (3.23293359637301 3 -3.06186902853654)]
        }
        Refinement "Refine Block 152" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.64661483606007 1.5 -
4.61235736004033) , (3.18977421621654 3 -3.08711319428844)]
        }
        Refinement "Refine Block 153" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.6034554559036 1.5 -
4.63760152579223) , (3.14661483606007 3 -3.11235736004034)]
        }
        Refinement "Refine Block 154" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.56029607574713 1.5 -
4.66284569154413) , (3.1034554559036 3 -3.13760152579223)]
        }
        Refinement "Refine Block 155" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.51713669559066 1.5 -
4.68808985729603) , (3.06029607574713 3 -3.16284569154413)]
        }
        Refinement "Refine Block 156" {
                Reference = "Refine_Block_1"
```

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                RefineWindow = Cuboid [( 1.47397731543419 1.5 -
4.71333402304793) , (3.01713669559066 3 -3.18808985729603)]
        }
        Refinement "Refine Block 157" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.43081793527772 1.5 -
4.73857818879982) , (2.97397731543419 3 -3.21333402304793)]
        }
        Refinement "Refine Block 158" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.38765855512125 1.5 -
4.76382235455172) , (2.93081793527772 3 -3.23857818879982)]
        }
        Refinement "Refine Block 159" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.34449917496478 1.5 -
4.78906652030362) , (2.88765855512125 3 -3.26382235455172)]
        }
        Refinement "Refine Block 160" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.30133979480831 1.5 -
4.81431068605552) , (2.84449917496478 3 -3.28906652030362)]
        }
        Refinement "Refine Block 161" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.25818041465184 1.5 -
4.83955485180741) , (2.80133979480831 3 -3.31431068605552)]
        }
        Refinement "Refine Block 162" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.21502103449537 1.5 -
4.86479901755931) , (2.75818041465184 3 -3.33955485180741)]
        }
        Refinement "Refine Block 163" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.1718616543389 1.5 -
4.89004318331121) , (2.71502103449537 3 -3.36479901755931)]
        }
        Refinement "Refine Block 164" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.12870227418243 1.5 -
4.91528734906311) , (2.6718616543389 3 -3.39004318331121)]
        }
        Refinement "Refine Block 165" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.08554289402596 1.5 -
4.94053151481501) , (2.62870227418243 3 -3.41528734906311)]
        }
        Refinement "Refine Block 166" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 1.04238351386949 1.5 -
4.9657756805669) , (2.58554289402596 3 -3.44053151481501)]
        }
        Refinement "Refine Block 167" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.999224133713015 1.5 -
4.9910198463188) , (2.54238351386949 3 -3.4657756805669)]
```

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        }
        Refinement "Refine Block 168" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.956064753556544 1.5 -
5.0162640120707) , (2.49922413371301 3 -3.4910198463188)]
        }
        Refinement "Refine Block 169" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.912905373400074 1.5 -
5.0415081778226) , (2.45606475355654 3 -3.5162640120707)]
        }
        Refinement "Refine Block 170" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.869745993243603 1.5 -
5.0667523435745) , (2.41290537340007 3 -3.5415081778226)]
        }
        Refinement "Refine Block 171" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.826586613087132 1.5 -
5.09199650932639) , (2.3697459932436 3 -3.5667523435745)]
        }
        Refinement "Refine Block 172" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.783427232930661 1.5 -
5.11724067507829) , (2.32658661308713 3 -3.59199650932639)]
        }
        Refinement "Refine Block 173" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.74026785277419 1.5 -
5.14248484083019) , (2.28342723293066 3 -3.61724067507829)]
        }
        Refinement "Refine Block 174" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.697108472617719 1.5 -
5.16772900658209) , (2.24026785277419 3 -3.64248484083019)]
        }
        Refinement "Refine Block 175" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.653949092461248 1.5 -
5.19297317233399) , (2.19710847261772 3 -3.66772900658209)]
        }
        Refinement "Refine Block 176" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.610789712304777 1.5 -
5.21821733808588) , (2.15394909246125 3 -3.69297317233399)]
        }
        Refinement "Refine Block 177" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.567630332148306 1.5 -
5.24346150383778) , (2.11078971230478 3 -3.71821733808588)]
        }
        Refinement "Refine Block 178" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.524470951991836 1.5 -
5.26870566958968) , (2.06763033214831 3 -3.74346150383778)]
        }
        Refinement "Refine Block 179" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.481311571835365 1.5 -
5.29394983534158) , (2.02447095199184 3 -3.76870566958968)]
        }
        Refinement "Refine Block 180" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.438152191678894 1.5 -
5.31919400109348) , (1.98131157183536 3 -3.79394983534158)]
        }
        Refinement "Refine Block 181" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.394992811522424 1.5 -
5.34443816684538) , (1.93815219167889 3 -3.81919400109348)]
        }
        Refinement "Refine Block 182" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.351833431365953 1.5 -
5.36968233259727) , (1.89499281152242 3 -3.84443816684538)]
        }
        Refinement "Refine Block 183" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.308674051209482 1.5 -
5.39492649834917) , (1.85183343136595 3 -3.86968233259727)]
        }
        Refinement "Refine Block 184" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.265514671053011 1.5 -
5.42017066410107) , (1.80867405120948 3 -3.89492649834917)]
        }
        Refinement "Refine Block 185" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.222355290896539 1.5 -
5.44541482985297) , (1.76551467105301 3 -3.92017066410107)]
        }
        Refinement "Refine Block 186" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.179195910740068 1.5 -
5.47065899560486) , (1.72235529089654 3 -3.94541482985297)]
        }
        Refinement "Refine Block 187" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.136036530583599 1.5 -
5.49590316135676) , (1.67919591074007 3 -3.97065899560486)]
        }
        Refinement "Refine Block 188" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.0928771504271282 1.5 -
5.52114732710866) , (1.6360365305836 3 -3.99590316135676)]
        }
        Refinement "Refine Block 189" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.0497177702706573 1.5 -
5.54639149286056) , (1.59287715042713 3 -4.02114732710866)]
        }
        Refinement "Refine Block 190" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( 0.00655839011418635 1.5
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-5.57163565861246) , (1.54971777027066 3 -4.04639149286056)]
        }
        Refinement "Refine Block 191" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.0366009900422846 1.5
-5.59687982436435) , (1.50655839011419 3 -4.07163565861246)]
        }
        Refinement "Refine Block 192" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.0797603701987555 1.5
-5.62212399011625) , (1.46339900995772 3 -4.09687982436435)]
        }
        Refinement "Refine Block 193" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.122919750355226 1.5 -
5.64736815586815) , (1.42023962980124 3 -4.12212399011625)]
        }
        Refinement "Refine Block 194" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.166079130511697 1.5 -
5.67261232162005) , (1.37708024964477 3 -4.14736815586815)]
        }
        Refinement "Refine Block 195" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.209238510668168 1.5 -
5.69785648737195) , (1.3339208694883 3 -4.17261232162005)]
        }
        Refinement "Refine Block 196" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.252397890824639 1.5 -
5.72310065312385) , (1.29076148933183 3 -4.19785648737195)]
        }
        Refinement "Refine Block 197" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.29555727098111 1.5 -
5.74834481887574) , (1.24760210917536 3 -4.22310065312385)]
        }
        Refinement "Refine Block 198" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.338716651137581 1.5 -
5.77358898462764) , (1.20444272901889 3 -4.24834481887574)]
        }
        Refinement "Refine Block 199" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.381876031294052 1.5 -
5.79883315037954) , (1.16128334886242 3 -4.27358898462764)]
        }
        Refinement "Refine Block 200" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.425035411450523 1.5 -
5.82407731613144) , (1.11812396870595 3 -4.29883315037954)]
        }
        Refinement "Refine Block 201" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.468194791606994 1.5 -
5.84932148188334) , (1.07496458854948 3 -4.32407731613144)]
        }
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        Refinement "Refine Block 202" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.511354171763465 1.5 -
5.87456564763523) , (1.03180520839301 3 -4.34932148188334)]
        }
        Refinement "Refine Block 203" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.554513551919936 1.5 -
5.89980981338713) , (0.988645828236535 3 -4.37456564763523)]
        }
        Refinement "Refine Block 204" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.597672932076406 1.5 -
5.92505397913903) , (0.945486448080064 3 -4.39980981338713)]
        }
        Refinement "Refine Block 205" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.640832312232877 1.5 -
5.95029814489093) , (0.902327067923594 3 -4.42505397913903)]
        }
        Refinement "Refine Block 206" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.683991692389348 1.5 -
5.97554231064283) , (0.859167687767123 3 -4.45029814489093)]
        }
        Refinement "Refine Block 207" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.727151072545819 1.5 -
6.00078647639472) , (0.816008307610652 3 -4.47554231064283)]
        }
        Refinement "Refine Block 208" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.77031045270229 1.5 -
6.02603064214662) , (0.772848927454181 3 -4.50078647639472)]
        }
        Refinement "Refine Block 209" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.813469832858761 1.5 -
6.05127480789852) , (0.72968954729771 3 -4.52603064214662)]
        }
        Refinement "Refine Block 210" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.85662921301523 1.5 -
6.07651897365042) , (0.686530167141239 3 -4.55127480789852)]
        }
        Refinement "Refine Block 211" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.899788593171701 1.5 -
6.10176313940232) , (0.64337078698477 3 -4.57651897365042)]
        }
        Refinement "Refine Block 212" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -0.942947973328172 1.5 -
6.12700730515421) , (0.600211406828299 3 -4.60176313940232)]
        }
        Refinement "Refine Block 213" {
                Reference = "Refine_Block_1"
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                RefineWindow = Cuboid [( -0.986107353484643 1.5 -
6.15225147090611) , (0.557052026671828 3 -4.62700730515421)]
        }
        Refinement "Refine Block 214" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.02926673364111 1.5 -
6.17749563665801) , (0.513892646515357 3 -4.65225147090611)]
        }
        Refinement "Refine Block 215" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.07242611379758 1.5 -
6.20273980240991) , (0.470733266358886 3 -4.67749563665801)]
        }
        Refinement "Refine Block 216" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.11558549395406 1.5 -
6.22798396816181) , (0.427573886202415 3 -4.70273980240991)]
        }
        Refinement "Refine Block 217" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.15874487411053 1.5 -
6.2532281339137) , (0.384414506045944 3 -4.72798396816181)]
        }
        Refinement "Refine Block 218" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.201904254267 1.5 -
6.2784722996656) , (0.341255125889473 3 -4.7532281339137)]
        }
        Refinement "Refine Block 219" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.24506363442347 1.5 -
6.3037164654175) , (0.298095745733002 3 -4.7784722996656)]
        }
        Refinement "Refine Block 220" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.28822301457994 1.5 -
6.3289606311694) , (0.254936365576532 3 -4.8037164654175)]
        }
        Refinement "Refine Block 221" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.33138239473641 1.5 -
6.3542047969213) , (0.211776985420061 3 -4.8289606311694)]
        }
        Refinement "Refine Block 222" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.37454177489288 1.5 -
6.37944896267319) , (0.16861760526359 3 -4.8542047969213)]
        }
        Refinement "Refine Block 223" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.41770115504935 1.5 -
6.40469312842509) , (0.125458225107119 3 -4.87944896267319)]
        }
        Refinement "Refine Block 224" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.46086053520582 1.5 -
6.42993729417699) , (0.0822988449506479 3 -4.90469312842509)]
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	}
	Refinement "Refine Block 225" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.50401991536229 1.5 -
6.45518145992889) , (0.039139464794177 3 -4.92993729417699)]
	}
	Refinement "Refine Block 226" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.54717929551876 1.5 -
6.48042562568079) , (-0.00401991536229396 3 -4.95518145992889)]
	}
	Refinement "Refine Block 227" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.59033867567524 1.5 -
6.50566979143268) , (-0.0471792955187649 3 -4.98042562568079)]
	}
	Refinement "Refine Block 228" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.63349805583171 1.5 -
6.53091395718458) , (-0.0903386756752358 3 -5.00566979143268)]
	}
	Refinement "Refine Block 229" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.67665743598818 1.5 -
6.55615812293648) , (-0.133498055831707 3 -5.03091395718458)]
	}
	Refinement "Refine Block 230" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.71981681614465 1.5 -
6.58140228868838) , (-0.176657435988178 3 -5.05615812293648)]
	}
	Refinement "Refine Block 231" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.76297619630112 1.5 -
6.60664645444028) , (-0.219816816144649 3 -5.08140228868838)]
	}
	Refinement "Refine Block 232" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.80613557645759 1.5 -
6.63189062019217) , (-0.262976196301119 3 -5.10664645444028)]
	}
	Refinement "Refine Block 233" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.84929495661406 1.5 -
6.65713478594407) , (-0.30613557645759 3 -5.13189062019217)]
	}
	Refinement "Refine Block 234" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.89245433677053 1.5 -
6.68237895169597) , (-0.349294956614061 3 -5.15713478594407)]
	}
	Refinement "Refine Block 235" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -1.935613716927 1.5 -
6.70762311744787) , (-0.39245433677053 3 -5.18237895169597)]
	}
	Refinement "Refine Block 236" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -1.97877309708347 1.5 -
6.73286728319977) , (-0.435613716927001 3 -5.20762311744787)]
        }
        Refinement "Refine Block 237" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.02193247723994 1.5 -
6.75811144895166) , (-0.478773097083472 3 -5.23286728319977)]
        }
        Refinement "Refine Block 238" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.06509185739641 1.5 -
6.78335561470356) , (-0.521932477239943 3 -5.25811144895166)]
        }
        Refinement "Refine Block 239" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.10825123755289 1.5 -
6.80859978045546) , (-0.565091857396414 3 -5.28335561470356)]
        }
        Refinement "Refine Block 240" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.15141061770936 1.5 -
6.83384394620736) , (-0.608251237552885 3 -5.30859978045546)]
        }
        Refinement "Refine Block 241" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.19456999786583 1.5 -
6.85908811195926) , (-0.651410617709356 3 -5.33384394620736)]
        }
        Refinement "Refine Block 242" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.2377293780223 1.5 -
6.88433227771116) , (-0.694569997865827 3 -5.35908811195926)]
        }
        Refinement "Refine Block 243" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.28088875817877 1.5 -
6.90957644346305) , (-0.737729378022298 3 -5.38433227771116)]
        }
        Refinement "Refine Block 244" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.32404813833524 1.5 -
6.93482060921495) , (-0.780888758178769 3 -5.40957644346305)]
        }
        Refinement "Refine Block 245" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.36720751849171 1.5 -
6.96006477496685) , (-0.82404813833524 3 -5.43482060921495)]
        }
        Refinement "Refine Block 246" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.41036689864818 1.5 -
6.98530894071875) , (-0.867207518491711 3 -5.46006477496685)]
        }
        Refinement "Refine Block 247" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.45352627880465 1.5 -
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7.01055310647065) , (-0.910366898648181 3 -5.48530894071875)]
        }
        Refinement "Refine Block 248" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.49668565896112 1.5 -
7.03579727222254) , (-0.953526278804652 3 -5.51055310647065)]
        }
        Refinement "Refine Block 249" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.53984503911759 1.5 -
7.06104143797444) , (-0.996685658961123 3 -5.53579727222254)]
        }
        Refinement "Refine Block 250" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.58300441927407 1.5 -
7.08628560372634) , (-1.03984503911759 3 -5.56104143797444)]
        }
        Refinement "Refine Block 251" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.62616379943054 1.5 -
7.11152976947824) , (-1.08300441927407 3 -5.58628560372634)]
        }
        Refinement "Refine Block 252" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.66932317958701 1.5 -
7.13677393523014) , (-1.12616379943054 3 -5.61152976947824)]
        }
        Refinement "Refine Block 253" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.71248255974348 1.5 -
7.16201810098203) , (-1.16932317958701 3 -5.63677393523014)]
        }
        Refinement "Refine Block 254" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.75564193989995 1.5 -
7.18726226673393) , (-1.21248255974348 3 -5.66201810098203)]
        }
        Refinement "Refine Block 255" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.79880132005642 1.5 -
7.21250643248583) , (-1.25564193989995 3 -5.68726226673393)]
        }
        Refinement "Refine Block 256" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.84196070021289 1.5 -
7.23775059823773) , (-1.29880132005642 3 -5.71250643248583)]
        }
        Refinement "Refine Block 257" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.88512008036936 1.5 -
7.26299476398963) , (-1.34196070021289 3 -5.73775059823773)]
        }
        Refinement "Refine Block 258" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.92827946052583 1.5 -
7.28823892974152) , (-1.38512008036936 3 -5.76299476398963)]
        }
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        Refinement "Refine Block 259" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -2.9714388406823 1.5 -
7.31348309549342) , (-1.42827946052583 3 -5.78823892974152)]
        }
        Refinement "Refine Block 260" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.01459822083877 1.5 -
7.33872726124532) , (-1.4714388406823 3 -5.81348309549342)]
        }
        Refinement "Refine Block 261" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.05775760099524 1.5 -
7.36397142699722) , (-1.51459822083877 3 -5.83872726124532)]
        }
        Refinement "Refine Block 262" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.10091698115171 1.5 -
7.38921559274912) , (-1.55775760099524 3 -5.86397142699722)]
        }
        Refinement "Refine Block 263" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.14407636130819 1.5 -
7.41445975850101) , (-1.60091698115171 3 -5.88921559274912)]
        }
        Refinement "Refine Block 264" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.18723574146466 1.5 -
7.43970392425291) , (-1.64407636130819 3 -5.91445975850101)]
        }
        Refinement "Refine Block 265" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.23039512162113 1.5 -
7.46494809000481) , (-1.68723574146466 3 -5.93970392425291)]
        }
        Refinement "Refine Block 266" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.2735545017776 1.5 -
7.49019225575671) , (-1.73039512162113 3 -5.96494809000481)]
        }
        Refinement "Refine Block 267" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.31671388193407 1.5 -
7.51543642150861) , (-1.7735545017776 3 -5.99019225575671)]
        }
        Refinement "Refine Block 268" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.35987326209054 1.5 -
7.5406805872605) , (-1.81671388193407 3 -6.01543642150861)]
        }
        Refinement "Refine Block 269" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.40303264224701 1.5 -
7.5659247530124) , (-1.85987326209054 3 -6.0406805872605)]
        }
        Refinement "Refine Block 270" {
                Reference = "Refine_Block_1"
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                RefineWindow = Cuboid [( -3.44619202240348 1.5 -
7.5911689187643) , (-1.90303264224701 3 -6.0659247530124)]
        }
        Refinement "Refine Block 271" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.48935140255995 1.5 -
7.6164130845162) , (-1.94619202240348 3 -6.0911689187643)]
        }
        Refinement "Refine Block 272" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.53251078271642 1.5 -
7.6416572502681) , (-1.98935140255995 3 -6.1164130845162)]
        }
        Refinement "Refine Block 273" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.57567016287289 1.5 -
7.66690141601999) , (-2.03251078271642 3 -6.1416572502681)]
        }
        Refinement "Refine Block 274" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.61882954302937 1.5 -
7.69214558177189) , (-2.07567016287289 3 -6.16690141601999)]
        }
        Refinement "Refine Block 275" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.66198892318584 1.5 -
7.71738974752379) , (-2.11882954302937 3 -6.19214558177189)]
        }
        Refinement "Refine Block 276" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.70514830334231 1.5 -
7.74263391327569) , (-2.16198892318584 3 -6.21738974752379)]
        }
        Refinement "Refine Block 277" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.74830768349878 1.5 -
7.76787807902759) , (-2.20514830334231 3 -6.24263391327569)]
        }
        Refinement "Refine Block 278" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.79146706365525 1.5 -
7.79312224477948) , (-2.24830768349878 3 -6.26787807902759)]
        }
        Refinement "Refine Block 279" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.83462644381172 1.5 -
7.81836641053138) , (-2.29146706365525 3 -6.29312224477948)]
        }
        Refinement "Refine Block 280" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.87778582396819 1.5 -
7.84361057628328) , (-2.33462644381172 3 -6.31836641053138)]
        }
        Refinement "Refine Block 281" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.92094520412466 1.5 -
7.86885474203518) , (-2.37778582396819 3 -6.34361057628328)]
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        }
        Refinement "Refine Block 282" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -3.96410458428113 1.5 -
7.89409890778708) , (-2.42094520412466 3 -6.36885474203518)]
        }
        Refinement "Refine Block 283" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.0072639644376 1.5 -
7.91934307353897) , (-2.46410458428113 3 -6.39409890778708)]
        }
        Refinement "Refine Block 284" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.05042334459407 1.5 -
7.94458723929087) , (-2.5072639644376 3 -6.41934307353897)]
        }
        Refinement "Refine Block 285" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.09358272475054 1.5 -
7.96983140504277) , (-2.55042334459407 3 -6.44458723929087)]
        }
        Refinement "Refine Block 286" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.13674210490701 1.5 -
7.99507557079467) , (-2.59358272475054 3 -6.46983140504277)]
        }
        Refinement "Refine Block 287" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.17990148506349 1.5 -
8.02031973654657) , (-2.63674210490701 3 -6.49507557079467)]
        }
        Refinement "Refine Block 288" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.22306086521996 1.5 -
8.04556390229846) , (-2.67990148506349 3 -6.52031973654657)]
        }
        Refinement "Refine Block 289" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.26622024537643 1.5 -
8.07080806805036) , (-2.72306086521996 3 -6.54556390229846)]
        }
        Refinement "Refine Block 290" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.3093796255329 1.5 -
8.09605223380226) , (-2.76622024537643 3 -6.57080806805036)]
        }
        Refinement "Refine Block 291" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.35253900568937 1.5 -
8.12129639955416) , (-2.8093796255329 3 -6.59605223380226)]
        }
        Refinement "Refine Block 292" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.39569838584584 1.5 -
8.14654056530606) , (-2.85253900568937 3 -6.62129639955416)]
        }
        Refinement "Refine Block 293" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.43885776600231 1.5 -
8.17178473105795) , (-2.89569838584584 3 -6.64654056530606)]
        }
        Refinement "Refine Block 294" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.48201714615878 1.5 -
8.19702889680985) , (-2.93885776600231 3 -6.67178473105796)]
        }
        Refinement "Refine Block 295" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.52517652631525 1.5 -
8.22227306256175) , (-2.98201714615878 3 -6.69702889680985)]
        }
        Refinement "Refine Block 296" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.56833590647172 1.5 -
8.24751722831365) , (-3.02517652631525 3 -6.72227306256175)]
        }
        Refinement "Refine Block 297" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.61149528662819 1.5 -
8.27276139406555) , (-3.06833590647172 3 -6.74751722831365)]
        }
        Refinement "Refine Block 298" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.65465466678467 1.5 -
8.29800555981745) , (-3.11149528662819 3 -6.77276139406555)]
        }
        Refinement "Refine Block 299" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.69781404694114 1.5 -
8.32324972556934) , (-3.15465466678467 3 -6.79800555981745)]
        }
        Refinement "Refine Block 300" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.74097342709761 1.5 -
8.34849389132124) , (-3.19781404694114 3 -6.82324972556934)]
        }
        Refinement "Refine Block 301" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.78413280725408 1.5 -
8.37373805707314) , (-3.24097342709761 3 -6.84849389132124)]
        }
        Refinement "Refine Block 302" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.82729218741055 1.5 -
8.39898222282504) , (-3.28413280725408 3 -6.87373805707314)]
        }
        Refinement "Refine Block 303" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.87045156756702 1.5 -
8.42422638857694) , (-3.32729218741055 3 -6.89898222282504)]
        }
        Refinement "Refine Block 304" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.91361094772349 1.5 -
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8.44947055432883) , (-3.37045156756702 3 -6.92422638857694)]
        }
        Refinement "Refine Block 305" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.95677032787996 1.5 -
8.47471472008073) , (-3.41361094772349 3 -6.94947055432883)]
        }
        Refinement "Refine Block 306" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -4.99992970803643 1.5 -
8.49995888583263) , (-3.45677032787996 3 -6.97471472008073)]
        }
        Refinement "Refine Block 307" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.0430890881929 1.5 -
8.52520305158453) , (-3.49992970803643 3 -6.99995888583263)]
        }
        Refinement "Refine Block 308" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.08624846834937 1.5 -
8.55044721733643) , (-3.5430890881929 3 -7.02520305158453)]
        }
        Refinement "Refine Block 309" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.12940784850584 1.5 -
8.57569138308832) , (-3.58624846834937 3 -7.05044721733643)]
        }
        Refinement "Refine Block 310" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.17256722866231 1.5 -
8.60093554884022) , (-3.62940784850584 3 -7.07569138308832)]
        }
        Refinement "Refine Block 311" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.21572660881879 1.5 -
8.62617971459212) , (-3.67256722866231 3 -7.10093554884022)]
        }
        Refinement "Refine Block 312" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.25888598897526 1.5 -
8.65142388034402) , (-3.71572660881879 3 -7.12617971459212)]
        }
        Refinement "Refine Block 313" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.30204536913173 1.5 -
8.67666804609592) , (-3.75888598897526 3 -7.15142388034402)]
        }
        Refinement "Refine Block 314" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.3452047492882 1.5 -
8.70191221184781) , (-3.80204536913173 3 -7.17666804609592)]
        }
        Refinement "Refine Block 315" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.38836412944467 1.5 -
8.72715637759971) , (-3.8452047492882 3 -7.20191221184781)]
        }
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        Refinement "Refine Block 316" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.43152350960114 1.5 -
8.75240054335161) , (-3.88836412944467 3 -7.22715637759971)]
        }
        Refinement "Refine Block 317" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.47468288975761 1.5 -
8.77764470910351) , (-3.93152350960114 3 -7.25240054335161)]
        }
        Refinement "Refine Block 318" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.51784226991408 1.5 -
8.80288887485541) , (-3.97468288975761 3 -7.27764470910351)]
        }
        Refinement "Refine Block 319" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.56100165007055 1.5 -
8.8281330406073) , (-4.01784226991408 3 -7.30288887485541)]
        }
        Refinement "Refine Block 320" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.60416103022702 1.5 -
8.8533772063592) , (-4.06100165007055 3 -7.3281330406073)]
        }
        Refinement "Refine Block 321" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.64732041038349 1.5 -
8.8786213721111) , (-4.10416103022702 3 -7.3533772063592)]
        }
        Refinement "Refine Block 322" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.69047979053997 1.5 -
8.903865537863) , (-4.14732041038349 3 -7.3786213721111)]
        }
        Refinement "Refine Block 323" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.73363917069644 1.5 -
8.9291097036149) , (-4.19047979053997 3 -7.403865537863)]
        }
        Refinement "Refine Block 324" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.77679855085291 1.5 -
8.95435386936679) , (-4.23363917069644 3 -7.4291097036149)]
        }
        Refinement "Refine Block 325" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.81995793100938 1.5 -
8.97959803511869) , (-4.27679855085291 3 -7.45435386936679)]
        }
        Refinement "Refine Block 326" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.86311731116585 1.5 -
9.00484220087059) , (-4.31995793100938 3 -7.47959803511869)]
        }
        Refinement "Refine Block 327" {
                Reference = "Refine_Block_1"
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                RefineWindow = Cuboid [( -5.90627669132232 1.5 -
9.03008636662249) , (-4.36311731116585 3 -7.50484220087059)]
        }
        Refinement "Refine Block 328" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.94943607147879 1.5 -
9.05533053237439) , (-4.40627669132232 3 -7.53008636662249)]
        }
        Refinement "Refine Block 329" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -5.99259545163526 1.5 -
9.08057469812628) , (-4.44943607147879 3 -7.55533053237439)]
        }
        Refinement "Refine Block 330" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.03575483179173 1.5 -
9.10581886387818) , (-4.49259545163526 3 -7.58057469812628)]
        }
        Refinement "Refine Block 331" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.0789142119482 1.5 -
9.13106302963008) , (-4.53575483179173 3 -7.60581886387818)]
        }
        Refinement "Refine Block 332" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.12207359210467 1.5 -
9.15630719538198) , (-4.5789142119482 3 -7.63106302963008)]
        }
        Refinement "Refine Block 333" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.16523297226114 1.5 -
9.18155136113388) , (-4.62207359210467 3 -7.65630719538198)]
        }
        Refinement "Refine Block 334" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.20839235241762 1.5 -
9.20679552688577) , (-4.66523297226114 3 -7.68155136113388)]
        }
        Refinement "Refine Block 335" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.25155173257409 1.5 -
9.23203969263767) , (-4.70839235241762 3 -7.70679552688577)]
        }
        Refinement "Refine Block 336" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.29471111273056 1.5 -
9.25728385838957) , (-4.75155173257409 3 -7.73203969263767)]
        }
        Refinement "Refine Block 337" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.33787049288703 1.5 -
9.28252802414147) , (-4.79471111273056 3 -7.75728385838957)]
        }
        Refinement "Refine Block 338" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.3810298730435 1.5 -
9.30777218989337) , (-4.83787049288703 3 -7.78252802414147)]
```

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        }
        Refinement "Refine Block 339" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.42418925319997 1.5 -
9.33301635564526) , (-4.8810298730435 3 -7.80777218989337)]
        }
        Refinement "Refine Block 340" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.46734863335644 1.5 -
9.35826052139716) , (-4.92418925319997 3 -7.83301635564526)]
        }
        Refinement "Refine Block 341" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.51050801351291 1.5 -
9.38350468714906) , (-4.96734863335644 3 -7.85826052139716)]
        }
        Refinement "Refine Block 342" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.55366739366938 1.5 -
9.40874885290096) , (-5.01050801351291 3 -7.88350468714906)]
        }
        Refinement "Refine Block 343" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.59682677382585 1.5 -
9.43399301865286) , (-5.05366739366938 3 -7.90874885290096)]
        }
        Refinement "Refine Block 344" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.63998615398232 1.5 -
9.45923718440475) , (-5.09682677382585 3 -7.93399301865286)]
        }
        Refinement "Refine Block 345" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.6831455341388 1.5 -
9.48448135015665) , (-5.13998615398232 3 -7.95923718440475)]
        }
        Refinement "Refine Block 346" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.72630491429527 1.5 -
9.50972551590855) , (-5.1831455341388 3 -7.98448135015665)]
        }
        Refinement "Refine Block 347" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.76946429445174 1.5 -
9.53496968166045) , (-5.22630491429527 3 -8.00972551590855)]
        }
        Refinement "Refine Block 348" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.81262367460821 1.5 -
9.56021384741235) , (-5.26946429445174 3 -8.03496968166045)]
        }
        Refinement "Refine Block 349" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.85578305476468 1.5 -
9.58545801316425) , (-5.31262367460821 3 -8.06021384741235)]
        }
        Refinement "Refine Block 350" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.89894243492115 1.5 -
9.61070217891614) , (-5.35578305476468 3 -8.08545801316425)]
        }
        Refinement "Refine Block 351" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.94210181507762 1.5 -
9.63594634466804) , (-5.39894243492115 3 -8.11070217891614)]
        }
        Refinement "Refine Block 352" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -6.98526119523409 1.5 -
9.66119051041994) , (-5.44210181507762 3 -8.13594634466804)]
        }
        Refinement "Refine Block 353" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.02842057539056 1.5 -
9.68643467617184) , (-5.48526119523409 3 -8.16119051041994)]
        }
        Refinement "Refine Block 354" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.07157995554703 1.5 -
9.71167884192374) , (-5.52842057539056 3 -8.18643467617184)]
        }
        Refinement "Refine Block 355" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.1147393357035 1.5 -
9.73692300767563) , (-5.57157995554703 3 -8.21167884192374)]
        }
        Refinement "Refine Block 356" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.15789871585997 1.5 -
9.76216717342753) , (-5.6147393357035 3 -8.23692300767563)]
        }
        Refinement "Refine Block 357" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.20105809601644 1.5 -
9.78741133917943) , (-5.65789871585997 3 -8.26216717342753)]
        }
        Refinement "Refine Block 358" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.24421747617292 1.5 -
9.81265550493133) , (-5.70105809601644 3 -8.28741133917943)]
        }
        Refinement "Refine Block 359" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.28737685632939 1.5 -
9.83789967068322) , (-5.74421747617292 3 -8.31265550493133)]
        }
        Refinement "Refine Block 360" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.33053623648586 1.5 -
9.86314383643512) , (-5.78737685632939 3 -8.33789967068322)]
        }
        Refinement "Refine Block 361" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.37369561664233 1.5 -
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9.88838800218702) , (-5.83053623648586 3 -8.36314383643512)]
        }
        Refinement "Refine Block 362" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.4168549967988 1.5 -
9.91363216793892) , (-5.87369561664233 3 -8.38838800218702)]
        }
        Refinement "Refine Block 363" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.46001437695527 1.5 -
9.93887633369082) , (-5.9168549967988 3 -8.41363216793892)]
        }
        Refinement "Refine Block 364" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.50317375711174 1.5 -
9.96412049944272) , (-5.96001437695527 3 -8.43887633369082)]
        }
        Refinement "Refine Block 365" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.54633313726821 1.5 -
9.98936466519461) , (-6.00317375711174 3 -8.46412049944272)]
        }
        Refinement "Refine Block 366" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.58949251742468 1.5 -
10.0146088309465) , (-6.04633313726821 3 -8.48936466519461)]
        }
        Refinement "Refine Block 367" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.63265189758115 1.5 -
10.0398529966984) , (-6.08949251742468 3 -8.51460883094651)]
        }
        Refinement "Refine Block 368" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.67581127773762 1.5 -
10.0650971624503) , (-6.13265189758115 3 -8.53985299669841)]
        }
        Refinement "Refine Block 369" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.7189706578941 1.5 -
10.0903413282022) , (-6.17581127773762 3 -8.56509716245031)]
        }
        Refinement "Refine Block 370" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.76213003805056 1.5 -
10.1155854939541) , (-6.2189706578941 3 -8.59034132820221)]
        }
        Refinement "Refine Block 371" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.80528941820704 1.5 -
10.140829659706) , (-6.26213003805056 3 -8.6155854939541)]
        }
        Refinement "Refine Block 372" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.84844879836351 1.5 -
10.1660738254579) , (-6.30528941820704 3 -8.640829659706)]
        }
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        Refinement "Refine Block 373" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.89160817851998 1.5 -
10.1913179912098) , (-6.34844879836351 3 -8.6660738254579)]
        }
        Refinement "Refine Block 374" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.93476755867645 1.5 -
10.2165621569617) , (-6.39160817851998 3 -8.6913179912098)]
        }
        Refinement "Refine Block 375" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -7.97792693883292 1.5 -
10.2418063227136) , (-6.43476755867645 3 -8.7165621569617)]
        }
        Refinement "Refine Block 376" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.02108631898939 1.5 -
10.2670504884655) , (-6.47792693883292 3 -8.74180632271359)]
        }
        Refinement "Refine Block 377" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.06424569914586 1.5 -
10.2922946542174) , (-6.52108631898939 3 -8.76705048846549)]
        }
        Refinement "Refine Block 378" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.10740507930233 1.5 -
10.3175388199693) , (-6.56424569914586 3 -8.79229465421739)]
        }
        Refinement "Refine Block 379" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.1505644594588 1.5 -
10.3427829857212) , (-6.60740507930233 3 -8.81753881996929)]
        }
        Refinement "Refine Block 380" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.19372383961527 1.5 -
10.3680271514731) , (-6.6505644594588 3 -8.84278298572119)]
        }
        Refinement "Refine Block 381" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.23688321977174 1.5 -
10.393271317225) , (-6.69372383961527 3 -8.86802715147308)]
        }
        Refinement "Refine Block 382" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.28004259992822 1.5 -
10.4185154829769) , (-6.73688321977174 3 -8.89327131722498)]
        }
        Refinement "Refine Block 383" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.32320198008469 1.5 -
10.4437596487288) , (-6.78004259992822 3 -8.91851548297688)]
        }
        Refinement "Refine Block 384" {
                Reference = "Refine_Block_1"
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                RefineWindow = Cuboid [( -8.36636136024116 1.5 -
10.4690038144807) , (-6.82320198008469 3 -8.94375964872878)]
        }
        Refinement "Refine Block 385" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.40952074039763 1.5 -
10.4942479802326) , (-6.86636136024116 3 -8.96900381448068)]
        }
        Refinement "Refine Block 386" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.4526801205541 1.5 -
10.5194921459845) , (-6.90952074039763 3 -8.99424798023257)]
        }
        Refinement "Refine Block 387" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.49583950071057 1.5 -
10.5447363117364) , (-6.9526801205541 3 -9.01949214598447)]
        }
        Refinement "Refine Block 388" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.53899888086704 1.5 -
10.5699804774883) , (-6.99583950071057 3 -9.04473631173637)]
        }
        Refinement "Refine Block 389" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.58215826102351 1.5 -
10.5952246432402) , (-7.03899888086704 3 -9.06998047748827)]
        }
        Refinement "Refine Block 390" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.62531764117998 1.5 -
10.6204688089921) , (-7.08215826102351 3 -9.09522464324017)]
        }
        Refinement "Refine Block 391" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.66847702133645 1.5 -
10.645712974744) , (-7.12531764117998 3 -9.12046880899207)]
        }
        Refinement "Refine Block 392" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.71163640149292 1.5 -
10.6709571404959) , (-7.16847702133645 3 -9.14571297474396)]
        }
        Refinement "Refine Block 393" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.7547957816494 1.5 -
10.6962013062478) , (-7.21163640149292 3 -9.17095714049586)]
        }
        Refinement "Refine Block 394" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.79795516180587 1.5 -
10.7214454719997) , (-7.2547957816494 3 -9.19620130624776)]
        }
        Refinement "Refine Block 395" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.84111454196234 1.5 -
10.7466896377516) , (-7.29795516180587 3 -9.22144547199966)]
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        }
        Refinement "Refine Block 396" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.88427392211881 1.5 -
10.7719338035035) , (-7.34111454196234 3 -9.24668963775155)]
        }
        Refinement "Refine Block 397" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.92743330227528 1.5 -
10.7971779692554) , (-7.38427392211881 3 -9.27193380350345)]
        }
        Refinement "Refine Block 398" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -8.97059268243175 1.5 -
10.8224221350072) , (-7.42743330227528 3 -9.29717796925535)]
        }
        Refinement "Refine Block 399" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.01375206258822 1.5 -
10.8476663007591) , (-7.47059268243175 3 -9.32242213500725)]
        }
        Refinement "Refine Block 400" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.05691144274469 1.5 -
10.872910466511) , (-7.51375206258822 3 -9.34766630075915)]
        }
        Refinement "Refine Block 401" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.10007082290116 1.5 -
10.8981546322629) , (-7.55691144274469 3 -9.37291046651105)]
        }
        Refinement "Refine Block 402" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.14323020305763 1.5 -
10.9233987980148) , (-7.60007082290116 3 -9.39815463226294)]
        }
        Refinement "Refine Block 403" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.1863895832141 1.5 -
10.9486429637667) , (-7.64323020305763 3 -9.42339879801484)]
        }
        Refinement "Refine Block 404" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.22954896337058 1.5 -
10.9738871295186) , (-7.6863895832141 3 -9.44864296376674)]
        }
        Refinement "Refine Block 405" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.27270834352705 1.5 -
10.9991312952705) , (-7.72954896337058 3 -9.47388712951864)]
        }
        Refinement "Refine Block 406" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.31586772368352 1.5 -
11.0243754610224) , (-7.77270834352705 3 -9.49913129527054)]
        }
        Refinement "Refine Block 407" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.35902710383999 1.5 -
11.0496196267743) , (-7.81586772368352 3 -9.52437546102243)]
        }
        Refinement "Refine Block 408" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.40218648399646 1.5 -
11.0748637925262) , (-7.85902710383999 3 -9.54961962677433)]
        }
        Refinement "Refine Block 409" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.44534586415293 1.5 -
11.1001079582781) , (-7.90218648399646 3 -9.57486379252623)]
        }
        Refinement "Refine Block 410" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.4885052443094 1.5 -
11.12535212403) , (-7.94534586415293 3 -9.60010795827813)]
        }
        Refinement "Refine Block 411" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.53166462446587 1.5 -
11.1505962897819) , (-7.9885052443094 3 -9.62535212403002)]
        }
        Refinement "Refine Block 412" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.57482400462234 1.5 -
11.1758404555338) , (-8.03166462446587 3 -9.65059628978192)]
        }
        Refinement "Refine Block 413" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.61798338477881 1.5 -
11.2010846212857) , (-8.07482400462234 3 -9.67584045553382)]
        }
        Refinement "Refine Block 414" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.66114276493528 1.5 -
11.2263287870376) , (-8.11798338477881 3 -9.70108462128572)]
        }
        Refinement "Refine Block 415" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.70430214509175 1.5 -
11.2515729527895) , (-8.16114276493528 3 -9.72632878703762)]
        }
        Refinement "Refine Block 416" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.74746152524822 1.5 -
11.2768171185414) , (-8.20430214509175 3 -9.75157295278952)]
        }
        Refinement "Refine Block 417" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.79062090540469 1.5 -
11.3020612842933) , (-8.24746152524822 3 -9.77681711854141)]
        }
        Refinement "Refine Block 418" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.83378028556116 1.5 -
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11.3273054500452) , (-8.29062090540469 3 -9.80206128429331)]
        }
        Refinement "Refine Block 419" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.87693966571764 1.5 -
11.3525496157971) , (-8.33378028556116 3 -9.82730545004521)]
        }
        Refinement "Refine Block 420" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.92009904587411 1.5 -
11.377793781549) , (-8.37693966571764 3 -9.85254961579711)]
        }
        Refinement "Refine Block 421" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -9.96325842603058 1.5 -
11.4030379473009) , (-8.42009904587411 3 -9.87779378154901)]
        }
        Refinement "Refine Block 422" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.006417806187 1.5 -
11.4282821130528) , (-8.46325842603058 3 -9.9030379473009)]
        }
        Refinement "Refine Block 423" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.0495771863435 1.5 -
11.4535262788047) , (-8.50641780618705 3 -9.9282821130528)]
        }
        Refinement "Refine Block 424" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.0927365665 1.5 -
11.4787704445566) , (-8.54957718634352 3 -9.9535262788047)]
        }
        Refinement "Refine Block 425" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.1358959466565 1.5 -
11.5040146103085) , (-8.59273656649999 3 -9.9787704445566)]
        }
        Refinement "Refine Block 426" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.1790553268129 1.5 -
11.5292587760604) , (-8.63589594665646 3 -10.0040146103085)]
        }
        Refinement "Refine Block 427" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.2222147069694 1.5 -
11.5545029418123) , (-8.67905532681293 3 -10.0292587760604)]
        }
        Refinement "Refine Block 428" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.2653740871259 1.5 -
11.5797471075642) , (-8.7222147069694 3 -10.0545029418123)]
        }
        Refinement "Refine Block 429" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.3085334672823 1.5 -
11.6049912733161) , (-8.76537408712587 3 -10.0797471075642)]
        }
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        Refinement "Refine Block 430" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.3516928474388 1.5 -
11.630235439068) , (-8.80853346728234 3 -10.1049912733161)]
        }
        Refinement "Refine Block 431" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.3948522275953 1.5 -
11.6554796048199) , (-8.85169284743882 3 -10.130235439068)]
        }
        Refinement "Refine Block 432" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.4380116077518 1.5 -
11.6807237705718) , (-8.89485222759529 3 -10.1554796048199)]
        }
        Refinement "Refine Block 433" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.4811709879082 1.5 -
11.7059679363237) , (-8.93801160775176 3 -10.1807237705718)]
        }
        Refinement "Refine Block 434" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.5243303680647 1.5 -
11.7312121020756) , (-8.98117098790823 3 -10.2059679363237)]
        }
        Refinement "Refine Block 435" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.5674897482212 1.5 -
11.7564562678275) , (-9.0243303680647 3 -10.2312121020756)]
        }
        Refinement "Refine Block 436" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.6106491283776 1.5 -
11.7817004335794) , (-9.06748974822117 3 -10.2564562678275)]
        }
        Refinement "Refine Block 437" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.6538085085341 1.5 -
11.8069445993313) , (-9.11064912837764 3 -10.2817004335794)]
        }
        Refinement "Refine Block 438" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.6969678886906 1.5 -
11.8321887650832) , (-9.15380850853411 3 -10.3069445993313)]
        }
        Refinement "Refine Block 439" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.7401272688471 1.5 -
11.8574329308351) , (-9.19696788869058 3 -10.3321887650832)]
        }
        Refinement "Refine Block 440" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -10.7832866490035 1.5 -
11.882677096587) , (-9.24012726884705 3 -10.3574329308351)]
        }
        Refinement "Refine Block 441" {
                Reference = "Refine_Block_1"
```

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		RefineWindow = Cuboid [( -10.82644602916 1.5 -
11.9079212623389) , (-9.28328664900353 3 -10.382677096587)]
	}
	Refinement "Refine Block 442" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -10.8696054093165 1.5 -
11.9331654280908) , (-9.32644602916 3 -10.4079212623389)]
	}
	Refinement "Refine Block 443" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -10.9127647894729 1.5 -
11.9584095938427) , (-9.36960540931647 3 -10.4331654280908)]
	}
	Refinement "Refine Block 444" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -10.9559241696294 1.5 -
11.9836537595946) , (-9.41276478947294 3 -10.4584095938427)]
	}
	Refinement "Refine Block 445" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -10.9990835497859 1.5 -
12.0088979253465) , (-9.45592416962941 3 -10.4836537595946)]
	}
	Refinement "Refine Block 446" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -11.0422429299424 1.5 -
12.0341420910984) , (-9.49908354978588 3 -10.5088979253465)]
	}
	Refinement "Refine Block 447" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -11.0854023100988 1.5 -
12.0593862568503) , (-9.54224292994235 3 -10.5341420910984)]
	}
	Refinement "Refine Block 448" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -11.1285616902553 1.5 -
12.0846304226022) , (-9.58540231009882 3 -10.5593862568503)]
	}
	Refinement "Refine Block 449" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -11.1717210704118 1.5 -
12.109874588354) , (-9.62856169025529 3 -10.5846304226022)]
	}
	Refinement "Refine Block 450" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -11.2148804505682 1.5 -
12.1351187541059) , (-9.67172107041176 3 -10.609874588354)]
	}
	Refinement "Refine Block 451" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -11.2580398307247 1.5 -
12.1603629198578) , (-9.71488045056823 3 -10.6351187541059)]
	}
	Refinement "Refine Block 452" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -11.3011992108812 1.5 -
12.1856070856097) , (-9.75803983072471 3 -10.6603629198578)]
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        }
        Refinement "Refine Block 453" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.3443585910376 1.5 -
12.2108512513616) , (-9.80119921088118 3 -10.6856070856097)]
        }
        Refinement "Refine Block 454" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.3875179711941 1.5 -
12.2360954171135) , (-9.84435859103765 3 -10.7108512513616)]
        }
        Refinement "Refine Block 455" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.4306773513506 1.5 -
12.2613395828654) , (-9.88751797119412 3 -10.7360954171135)]
        }
        Refinement "Refine Block 456" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.4738367315071 1.5 -
12.2865837486173) , (-9.93067735135059 3 -10.7613395828654)]
        }
        Refinement "Refine Block 457" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.5169961116635 1.5 -
12.3118279143692) , (-9.97383673150706 3 -10.7865837486173)]
        }
        Refinement "Refine Block 458" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.56015549182 1.5 -
12.3370720801211) , (-10.0169961116635 3 -10.8118279143692)]
        }
        Refinement "Refine Block 459" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.6033148719765 1.5 -
12.362316245873) , (-10.06015549182 3 -10.8370720801211)]
        }
        Refinement "Refine Block 460" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.6464742521329 1.5 -
12.3875604116249) , (-10.1033148719765 3 -10.862316245873)]
        }
        Refinement "Refine Block 461" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.6896336322894 1.5 -
12.4128045773768) , (-10.1464742521329 3 -10.8875604116249)]
        }
        Refinement "Refine Block 462" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.7327930124459 1.5 -
12.4380487431287) , (-10.1896336322894 3 -10.9128045773768)]
        }
        Refinement "Refine Block 463" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.7759523926024 1.5 -
12.4632929088806) , (-10.2327930124459 3 -10.9380487431287)]
        }
        Refinement "Refine Block 464" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.8191117727588 1.5 -
12.4885370746325) , (-10.2759523926024 3 -10.9632929088806)]
        }
        Refinement "Refine Block 465" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.8622711529153 1.5 -
12.5137812403844) , (-10.3191117727588 3 -10.9885370746325)]
        }
        Refinement "Refine Block 466" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.9054305330718 1.5 -
12.5390254061363) , (-10.3622711529153 3 -11.0137812403844)]
        }
        Refinement "Refine Block 467" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.9485899132282 1.5 -
12.5642695718882) , (-10.4054305330718 3 -11.0390254061363)]
        }
        Refinement "Refine Block 468" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -11.9917492933847 1.5 -
12.5895137376401) , (-10.4485899132282 3 -11.0642695718882)]
        }
        Refinement "Refine Block 469" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.0349086735412 1.5 -
12.614757903392) , (-10.4917492933847 3 -11.0895137376401)]
        }
        Refinement "Refine Block 470" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.0780680536976 1.5 -
12.6400020691439) , (-10.5349086735412 3 -11.114757903392)]
        }
        Refinement "Refine Block 471" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.1212274338541 1.5 -
12.6652462348958) , (-10.5780680536976 3 -11.1400020691439)]
        }
        Refinement "Refine Block 472" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.1643868140106 1.5 -
12.6904904006477) , (-10.6212274338541 3 -11.1652462348958)]
        }
        Refinement "Refine Block 473" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.2075461941671 1.5 -
12.7157345663996) , (-10.6643868140106 3 -11.1904904006477)]
        }
        Refinement "Refine Block 474" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.2507055743235 1.5 -
12.7409787321515) , (-10.7075461941671 3 -11.2157345663996)]
        }
        Refinement "Refine Block 475" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.29386495448 1.5 -
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12.7662228979034) , (-10.7507055743235 3 -11.2409787321515)]
        }
        Refinement "Refine Block 476" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.3370243346365 1.5 -
12.7914670636553) , (-10.79386495448 3 -11.2662228979034)]
        }
        Refinement "Refine Block 477" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.3801837147929 1.5 -
12.8167112294072) , (-10.8370243346365 3 -11.2914670636553)]
        }
        Refinement "Refine Block 478" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.4233430949494 1.5 -
12.8419553951591) , (-10.8801837147929 3 -11.3167112294072)]
        }
        Refinement "Refine Block 479" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.4665024751059 1.5 -
12.867199560911) , (-10.9233430949494 3 -11.3419553951591)]
        }
        Refinement "Refine Block 480" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.5096618552624 1.5 -
12.8924437266629) , (-10.9665024751059 3 -11.367199560911)]
        }
        Refinement "Refine Block 481" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.5528212354188 1.5 -
12.9176878924148) , (-11.0096618552624 3 -11.3924437266629)]
        }
        Refinement "Refine Block 482" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.5959806155753 1.5 -
12.9429320581667) , (-11.0528212354188 3 -11.4176878924148)]
        }
        Refinement "Refine Block 483" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.6391399957318 1.5 -
12.9681762239186) , (-11.0959806155753 3 -11.4429320581667)]
        }
        Refinement "Refine Block 484" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.6822993758882 1.5 -
12.9934203896705) , (-11.1391399957318 3 -11.4681762239186)]
        }
        Refinement "Refine Block 485" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.7254587560447 1.5 -
13.0186645554224) , (-11.1822993758882 3 -11.4934203896705)]
        }
        Refinement "Refine Block 486" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.7686181362012 1.5 -
13.0439087211743) , (-11.2254587560447 3 -11.5186645554224)]
        }
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        Refinement "Refine Block 487" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.8117775163577 1.5 -
13.0691528869262) , (-11.2686181362012 3 -11.5439087211743)]
        }
        Refinement "Refine Block 488" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.8549368965141 1.5 -
13.0943970526781) , (-11.3117775163577 3 -11.5691528869262)]
        }
        Refinement "Refine Block 489" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.8980962766706 1.5 -
13.11964121843) , (-11.3549368965141 3 -11.5943970526781)]
        }
        Refinement "Refine Block 490" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.9412556568271 1.5 -
13.1448853841819) , (-11.3980962766706 3 -11.61964121843)]
        }
        Refinement "Refine Block 491" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -12.9844150369835 1.5 -
13.1701295499338) , (-11.4412556568271 3 -11.6448853841819)]
        }
        Refinement "Refine Block 492" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.02757441714 1.5 -
13.1953737156857) , (-11.4844150369835 3 -11.6701295499338)]
        }
        Refinement "Refine Block 493" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.0707337972965 1.5 -
13.2206178814376) , (-11.52757441714 3 -11.6953737156857)]
        }
        Refinement "Refine Block 494" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.113893177453 1.5 -
13.2458620471895) , (-11.5707337972965 3 -11.7206178814376)]
        }
        Refinement "Refine Block 495" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.1570525576094 1.5 -
13.2711062129414) , (-11.613893177453 3 -11.7458620471895)]
        }
        Refinement "Refine Block 496" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.2002119377659 1.5 -
13.2963503786933) , (-11.6570525576094 3 -11.7711062129414)]
        }
        Refinement "Refine Block 497" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.2433713179224 1.5 -
13.3215945444452) , (-11.7002119377659 3 -11.7963503786933)]
        }
        Refinement "Refine Block 498" {
                Reference = "Refine_Block_1"
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                RefineWindow = Cuboid [( -13.2865306980788 1.5 -
13.3468387101971) , (-11.7433713179224 3 -11.8215945444452)]
        }
        Refinement "Refine Block 499" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.3296900782353 1.5 -
13.372082875949) , (-11.7865306980788 3 -11.8468387101971)]
        }
        Refinement "Refine Block 500" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.3728494583918 1.5 -
13.3973270417008) , (-11.8296900782353 3 -11.872082875949)]
        }
        Refinement "Refine Block 501" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.4160088385482 1.5 -
13.4225712074527) , (-11.8728494583918 3 -11.8973270417008)]
        }
        Refinement "Refine Block 502" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.4591682187047 1.5 -
13.4478153732046) , (-11.9160088385482 3 -11.9225712074527)]
        }
        Refinement "Refine Block 503" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.5023275988612 1.5 -
13.4730595389565) , (-11.9591682187047 3 -11.9478153732046)]
        }
        Refinement "Refine Block 504" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.5454869790177 1.5 -
13.4983037047084) , (-12.0023275988612 3 -11.9730595389565)]
        }
        Refinement "Refine Block 505" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.5886463591741 1.5 -
13.5235478704603) , (-12.0454869790177 3 -11.9983037047084)]
        }
        Refinement "Refine Block 506" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.6318057393306 1.5 -
13.5487920362122) , (-12.0886463591741 3 -12.0235478704603)]
        }
        Refinement "Refine Block 507" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.6749651194871 1.5 -
13.5740362019641) , (-12.1318057393306 3 -12.0487920362122)]
        }
        Refinement "Refine Block 508" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.7181244996435 1.5 -
13.599280367716) , (-12.1749651194871 3 -12.0740362019641)]
        }
        Refinement "Refine Block 509" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.7612838798 1.5 -
13.6245245334679) , (-12.2181244996435 3 -12.099280367716)]
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        }
        Refinement "Refine Block 510" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.8044432599565 1.5 -
13.6497686992198) , (-12.2612838798 3 -12.1245245334679)]
        }
        Refinement "Refine Block 511" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.847602640113 1.5 -
13.6750128649717) , (-12.3044432599565 3 -12.1497686992198)]
        }
        Refinement "Refine Block 512" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.8907620202694 1.5 -
13.7002570307236) , (-12.347602640113 3 -12.1750128649717)]
        }
        Refinement "Refine Block 513" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.9339214004259 1.5 -
13.7255011964755) , (-12.3907620202694 3 -12.2002570307236)]
        }
        Refinement "Refine Block 514" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -13.9770807805824 1.5 -
13.7507453622274) , (-12.4339214004259 3 -12.2255011964755)]
        }
        Refinement "Refine Block 515" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.0202401607388 1.5 -
13.7759895279793) , (-12.4770807805824 3 -12.2507453622274)]
        }
        Refinement "Refine Block 516" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.0633995408953 1.5 -
13.8012336937312) , (-12.5202401607388 3 -12.2759895279793)]
        }
        Refinement "Refine Block 517" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.1065589210518 1.5 -
13.8264778594831) , (-12.5633995408953 3 -12.3012336937312)]
        }
        Refinement "Refine Block 518" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.1497183012082 1.5 -
13.851722025235) , (-12.6065589210518 3 -12.3264778594831)]
        }
        Refinement "Refine Block 519" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.1928776813647 1.5 -
13.8769661909869) , (-12.6497183012082 3 -12.351722025235)]
        }
        Refinement "Refine Block 520" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.2360370615212 1.5 -
13.9022103567388) , (-12.6928776813647 3 -12.3769661909869)]
        }
        Refinement "Refine Block 521" {
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		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.2791964416777 1.5 -
13.9274545224907) , (-12.7360370615212 3 -12.4022103567388)]
	}
	Refinement "Refine Block 522" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.3223558218341 1.5 -
13.9526986882426) , (-12.7791964416777 3 -12.4274545224907)]
	}
	Refinement "Refine Block 523" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.3655152019906 1.5 -
13.9779428539945) , (-12.8223558218341 3 -12.4526986882426)]
	}
	Refinement "Refine Block 524" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.4086745821471 1.5 -
14.0031870197464) , (-12.8655152019906 3 -12.4779428539945)]
	}
	Refinement "Refine Block 525" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.4518339623035 1.5 -
14.0284311854983) , (-12.9086745821471 3 -12.5031870197464)]
	}
	Refinement "Refine Block 526" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.49499334246 1.5 -
14.0536753512502) , (-12.9518339623035 3 -12.5284311854983)]
	}
	Refinement "Refine Block 527" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.5381527226165 1.5 -
14.0789195170021) , (-12.99499334246 3 -12.5536753512502)]
	}
	Refinement "Refine Block 528" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.581312102773 1.5 -
14.104163682754) , (-13.0381527226165 3 -12.5789195170021)]
	}
	Refinement "Refine Block 529" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.6244714829294 1.5 -
14.1294078485059) , (-13.081312102773 3 -12.604163682754)]
	}
	Refinement "Refine Block 530" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.6676308630859 1.5 -
14.1546520142578) , (-13.1244714829294 3 -12.6294078485059)]
	}
	Refinement "Refine Block 531" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.7107902432424 1.5 -
14.1798961800097) , (-13.1676308630859 3 -12.6546520142578)]
	}
	Refinement "Refine Block 532" {
		Reference = "Refine_Block_1"
		RefineWindow = Cuboid [( -14.7539496233988 1.5 -
```

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14.2051403457616) , (-13.2107902432424 3 -12.6798961800097)]
        }
        Refinement "Refine Block 533" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.7971090035553 1.5 -
14.2303845115135) , (-13.2539496233988 3 -12.7051403457616)]
        }
        Refinement "Refine Block 534" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.8402683837118 1.5 -
14.2556286772654) , (-13.2971090035553 3 -12.7303845115135)]
        }
        Refinement "Refine Block 535" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.8834277638683 1.5 -
14.2808728430173) , (-13.3402683837118 3 -12.7556286772654)]
        }
        Refinement "Refine Block 536" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.9265871440247 1.5 -
14.3061170087692) , (-13.3834277638683 3 -12.7808728430173)]
        }
        Refinement "Refine Block 537" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -14.9697465241812 1.5 -
14.3313611745211) , (-13.4265871440247 3 -12.8061170087692)]
        }
        Refinement "Refine Block 538" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.0129059043377 1.5 -
14.356605340273) , (-13.4697465241812 3 -12.8313611745211)]
        }
        Refinement "Refine Block 539" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.0560652844941 1.5 -
14.3818495060249) , (-13.5129059043377 3 -12.856605340273)]
        }
        Refinement "Refine Block 540" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.0992246646506 1.5 -
14.4070936717768) , (-13.5560652844941 3 -12.8818495060249)]
        }
        Refinement "Refine Block 541" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.1423840448071 1.5 -
14.4323378375287) , (-13.5992246646506 3 -12.9070936717768)]
        }
        Refinement "Refine Block 542" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.1855434249636 1.5 -
14.4575820032806) , (-13.6423840448071 3 -12.9323378375287)]
        }
        Refinement "Refine Block 543" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.22870280512 1.5 -
14.4828261690325) , (-13.6855434249636 3 -12.9575820032806)]
        }
```

```
        Refinement "Refine Block 544" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.2718621852765 1.5 -
14.5080703347844) , (-13.72870280512 3 -12.9828261690325)]
        }
        Refinement "Refine Block 545" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.315021565433 1.5 -
14.5333145005363) , (-13.7718621852765 3 -13.0080703347844)]
        }
        Refinement "Refine Block 546" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.3581809455894 1.5 -
14.5585586662882) , (-13.815021565433 3 -13.0333145005363)]
        }
        Refinement "Refine Block 547" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.4013403257459 1.5 -
14.5838028320401) , (-13.8581809455894 3 -13.0585586662882)]
        }
        Refinement "Refine Block 548" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.4444997059024 1.5 -
14.609046997792) , (-13.9013403257459 3 -13.0838028320401)]
        }
        Refinement "Refine Block 549" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.4876590860588 1.5 -
14.6342911635439) , (-13.9444997059024 3 -13.109046997792)]
        }
        Refinement "Refine Block 550" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.5308184662153 1.5 -
14.6595353292958) , (-13.9876590860588 3 -13.1342911635439)]
        }
        Refinement "Refine Block 551" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.5739778463718 1.5 -
14.6847794950476) , (-14.0308184662153 3 -13.1595353292958)]
        }
        Refinement "Refine Block 552" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.6171372265283 1.5 -
14.7100236607995) , (-14.0739778463718 3 -13.1847794950476)]
        }
        Refinement "Refine Block 553" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.6602966066847 1.5 -
14.7352678265514) , (-14.1171372265283 3 -13.2100236607995)]
        }
        Refinement "Refine Block 554" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.7034559868412 1.5 -
14.7605119923033) , (-14.1602966066847 3 -13.2352678265514)]
        }
        Refinement "Refine Block 555" {
                Reference = "Refine_Block_1"
```

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                RefineWindow = Cuboid [( -15.7466153669977 1.5 -
14.7857561580552) , (-14.2034559868412 3 -13.2605119923033)]
        }
        Refinement "Refine Block 556" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.7897747471541 1.5 -
14.8110003238071) , (-14.2466153669977 3 -13.2857561580552)]
        }
        Refinement "Refine Block 557" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.8329341273106 1.5 -
14.836244489559) , (-14.2897747471541 3 -13.3110003238071)]
        }
        Refinement "Refine Block 558" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.8760935074671 1.5 -
14.8614886553109) , (-14.3329341273106 3 -13.336244489559)]
        }
        Refinement "Refine Block 559" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.9192528876236 1.5 -
14.8867328210628) , (-14.3760935074671 3 -13.3614886553109)]
        }
        Refinement "Refine Block 560" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -15.96241226778 1.5 -
14.9119769868147) , (-14.4192528876236 3 -13.3867328210628)]
        }
        Refinement "Refine Block 561" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.0055716479365 1.5 -
14.9372211525666) , (-14.46241226778 3 -13.4119769868147)]
        }
        Refinement "Refine Block 562" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.048731028093 1.5 -
14.9624653183185) , (-14.5055716479365 3 -13.4372211525666)]
        }
        Refinement "Refine Block 563" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.0918904082494 1.5 -
14.9877094840704) , (-14.548731028093 3 -13.4624653183185)]
        }
        Refinement "Refine Block 564" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.1350497884059 1.5 -
15.0129536498223) , (-14.5918904082494 3 -13.4877094840704)]
        }
        Refinement "Refine Block 565" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.1782091685624 1.5 -
15.0381978155742) , (-14.6350497884059 3 -13.5129536498223)]
        }
        Refinement "Refine Block 566" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.2213685487188 1.5 -
15.0634419813261) , (-14.6782091685624 3 -13.5381978155742)]
```

```
        }
        Refinement "Refine Block 567" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.2645279288753 1.5 -
15.088686147078) , (-14.7213685487188 3 -13.5634419813261)]
        }
        Refinement "Refine Block 568" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.3076873090318 1.5 -
15.1139303128299) , (-14.7645279288753 3 -13.588686147078)]
        }
        Refinement "Refine Block 569" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.3508466891883 1.5 -
15.1391744785818) , (-14.8076873090318 3 -13.6139303128299)]
        }
        Refinement "Refine Block 570" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.3940060693447 1.5 -
15.1644186443337) , (-14.8508466891883 3 -13.6391744785818)]
        }
        Refinement "Refine Block 571" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.4371654495012 1.5 -
15.1896628100856) , (-14.8940060693447 3 -13.6644186443337)]
        }
        Refinement "Refine Block 572" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.4803248296577 1.5 -
15.2149069758375) , (-14.9371654495012 3 -13.6896628100856)]
        }
        Refinement "Refine Block 573" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.5234842098141 1.5 -
15.2401511415894) , (-14.9803248296577 3 -13.7149069758375)]
        }
        Refinement "Refine Block 574" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.5666435899706 1.5 -
15.2653953073413) , (-15.0234842098141 3 -13.7401511415894)]
        }
        Refinement "Refine Block 575" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.6098029701271 1.5 -
15.2906394730932) , (-15.0666435899706 3 -13.7653953073413)]
        }
        Refinement "Refine Block 576" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.6529623502836 1.5 -
15.3158836388451) , (-15.1098029701271 3 -13.7906394730932)]
        }
        Refinement "Refine Block 577" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.69612173044 1.5 -
15.341127804597) , (-15.1529623502836 3 -13.8158836388451)]
        }
        Refinement "Refine Block 578" {
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                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.7392811105965 1.5 -
15.3663719703489) , (-15.19612173044 3 -13.841127804597)]
        }
        Refinement "Refine Block 579" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.782440490753 1.5 -
15.3916161361008) , (-15.2392811105965 3 -13.8663719703489)]
        }
        Refinement "Refine Block 580" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.8255998709094 1.5 -
15.4168603018527) , (-15.282440490753 3 -13.8916161361008)]
        }
        Refinement "Refine Block 581" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.8687592510659 1.5 -
15.4421044676046) , (-15.3255998709094 3 -13.9168603018527)]
        }
        Refinement "Refine Block 582" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.9119186312224 1.5 -
15.4673486333565) , (-15.3687592510659 3 -13.9421044676046)]
        }
        Refinement "Refine Block 583" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.9550780113789 1.5 -
15.4925927991084) , (-15.4119186312224 3 -13.9673486333565)]
        }
        Refinement "Refine Block 584" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -16.9982373915353 1.5 -
15.5178369648603) , (-15.4550780113789 3 -13.9925927991084)]
        }
        Refinement "Refine Block 585" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.0413967716918 1.5 -
15.5430811306122) , (-15.4982373915353 3 -14.0178369648603)]
        }
        Refinement "Refine Block 586" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.0845561518483 1.5 -
15.5683252963641) , (-15.5413967716918 3 -14.0430811306122)]
        }
        Refinement "Refine Block 587" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.1277155320047 1.5 -
15.593569462116) , (-15.5845561518483 3 -14.0683252963641)]
        }
        Refinement "Refine Block 588" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.1708749121612 1.5 -
15.6188136278679) , (-15.6277155320047 3 -14.093569462116)]
        }
        Refinement "Refine Block 589" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.2140342923177 1.5 -
```

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15.6440577936198) , (-15.6708749121612 3 -14.1188136278679)]
        }
        Refinement "Refine Block 590" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.2571936724742 1.5 -
15.6693019593717) , (-15.7140342923177 3 -14.1440577936198)]
        }
        Refinement "Refine Block 591" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.3003530526306 1.5 -
15.6945461251236) , (-15.7571936724742 3 -14.1693019593717)]
        }
        Refinement "Refine Block 592" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.3435124327871 1.5 -
15.7197902908755) , (-15.8003530526306 3 -14.1945461251236)]
        }
        Refinement "Refine Block 593" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.3866718129436 1.5 -
15.7450344566274) , (-15.8435124327871 3 -14.2197902908755)]
        }
        Refinement "Refine Block 594" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.4298311931 1.5 -
15.7702786223793) , (-15.8866718129436 3 -14.2450344566274)]
        }
        Refinement "Refine Block 595" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.4729905732565 1.5 -
15.7955227881312) , (-15.9298311931 3 -14.2702786223793)]
        }
        Refinement "Refine Block 596" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.516149953413 1.5 -
15.8207669538831) , (-15.9729905732565 3 -14.2955227881312)]
        }
        Refinement "Refine Block 597" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.5593093335694 1.5 -
15.846011119635) , (-16.016149953413 3 -14.3207669538831)]
        }
        Refinement "Refine Block 598" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.6024687137259 1.5 -
15.8712552853869) , (-16.0593093335694 3 -14.346011119635)]
        }
        Refinement "Refine Block 599" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.6456280938824 1.5 -
15.8964994511388) , (-16.1024687137259 3 -14.3712552853869)]
        }
        Refinement "Refine Block 600" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.6887874740389 1.5 -
15.9217436168907) , (-16.1456280938824 3 -14.3964994511388)]
        }
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        Refinement "Refine Block 601" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.7319468541953 1.5 -
15.9469877826425) , (-16.1887874740389 3 -14.4217436168907)]
        }
        Refinement "Refine Block 602" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.7751062343518 1.5 -
15.9722319483944) , (-16.2319468541953 3 -14.4469877826425)]
        }
        Refinement "Refine Block 603" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.8182656145083 1.5 -
15.9974761141463) , (-16.2751062343518 3 -14.4722319483944)]
        }
        Refinement "Refine Block 604" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.8614249946647 1.5 -
16.0227202798982) , (-16.3182656145083 3 -14.4974761141463)]
        }
        Refinement "Refine Block 605" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.9045843748212 1.5 -
16.0479644456501) , (-16.3614249946647 3 -14.5227202798982)]
        }
        Refinement "Refine Block 606" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.9477437549777 1.5 -
16.073208611402) , (-16.4045843748212 3 -14.5479644456501)]
        }
        Refinement "Refine Block 607" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -17.9909031351342 1.5 -
16.0984527771539) , (-16.4477437549777 3 -14.573208611402)]
        }
        Refinement "Refine Block 608" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -18.0340625152906 1.5 -
16.1236969429058) , (-16.4909031351342 3 -14.5984527771539)]
        }
        Refinement "Refine Block 609" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -18.0772218954471 1.5 -
16.1489411086577) , (-16.5340625152906 3 -14.6236969429058)]
        }
        Refinement "Refine Block 610" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -18.1203812756036 1.5 -
16.1741852744096) , (-16.5772218954471 3 -14.6489411086577)]
        }
        Refinement "Refine Block 611" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -18.16354065576 1.5 -
16.1994294401615) , (-16.6203812756036 3 -14.6741852744096)]
        }
        Refinement "Refine Block 612" {
                Reference = "Refine_Block_1"
```

```
                RefineWindow = Cuboid [( -18.2067000359165 1.5 -
16.2246736059134) , (-16.66354065576 3 -14.6994294401615)]
        }
        Refinement "Refine Block 613" {
                Reference = "Refine_Block_1"
                RefineWindow = Cuboid [( -18.249859416073 1.5 -
16.2499177716653) , (-16.7067000359165 3 -14.7246736059134)]
        }
# 180 "05x1diode.cmd.tmpl" 2
}
```

DESSIS physical simulation file

This file defines the physics to be solved in the simulation including the physical models to use for solving the problem, the biasing of the device, the specification of the ion strike energy and timing, and how to output the results.

```
File {
      Grid = "05x1big60_msh.grd"
      Doping = "05x1big60_msh.dat"
      Plot = "60west1-1.dat"
      Current = "60west1-1.plt"
      Parameter = "silicon_mat.par"
}

Electrode {
      {Name = "Base"      Voltage = 0.0}
      {Name = "Emitter"   Voltage = 0.0}
      {Name = "Collector" Voltage = 0.0}
      {Name = "Substrate" Voltage = 0.0}
}

Physics {
      Mobility( PhuMob(Phosphorus) Highfieldsaturation )
      EffectiveIntrinsicDensity( BandGapNarrowing(OldSlotBoom) )
      HeavyIon(
            Direction = (0.87,0,-0.5)
            Location = (-3,2.25,0.10)
            Time = 5e-12
            Wt_hi = 0.1
            Length = 30
            LET_f = 0.027948
            Gaussian
            PicoCoulomb
      )
}
```

```
Physics ( Material = "Silicon") {
      Recombination( SRH(DopingDependance) )
}

Physics ( MaterialInterface="Oxide/Silicon" ) {
      Recombination( surfaceSRH )
}

Plot {
      eDensity
      hDensity
      eMobility
      hMobility
      ElectricField
      Potential
      SRHRecombination
      SurfaceRecombination
}

Math {
      NotDamped=20
      Iterations=10
      NewDiscretization
      Extrapolate
      Derivatives
      RelErrControl
      RecBoxIntegr
      Method=Blocked
      Transient=BE
}

Solve
{
      Coupled{Poisson}
      Coupled{Poisson Electron Hole}
      Quasistationary
                (Goal {Name="Substrate" Voltage = -5.2 }
                )
                { Coupled {Poisson Electron Hole}
                }
      NewCurrentFile=SEU_
      Transient (
            InitialTime = 0.0
            FinalTime = 5e-6
            InitialStep = 1e-14
            MaxStep = 1e-6
            Increment = 1.10
      )
      { Coupled { Poisson Electron Hole } }
}
```

REFERENCES

[1] B.D. Watts, The Military Use of Space: A Diagnostic Assessment, Washington D.C: Center for Strategic and Budgetary Assessment, February 2001.

[2] J.T. Wallmark, S.M. Marcus, "Minimum size and maximum packaging density of non-redundant semiconductor devices," *Proc. IRE*, vol. 50, pp. 286-298, March 1962.

[3] S.F. Odenwald, The 23rd Cycle *Learning to Live with a Stormy Star*, New York, Columbia University Press, 2001.

[4] D.L. Hansen, S. Pong, P. Rosenthal, and J. Gorelick, "Total Ionizing Dose Testing of SiGe 7HP discrete Heterojunction Bipolar Transistors for ELDRS Effects," *Proc. IEEE Radiation Effects Data Workshop*, pp. 215-220, 2007.

[5] J.A. Babcock, J.D. Cressler, L.S. Vempati, S.D. Clark, R.C. Jaeger, and D.L. Harame, "Ionizing radiation tolerance of high-performance SiGe HBTs grown by UHV/CVD," *IEEE Trans. Nucl. Sci.*, vol. 42, pp. 1558-1566, 1995.

[6] G. Banerjee, G. Niu, J.D. Cressler, S.D. Clark, M.J. Palmer, and D.C. Ahlgren, "Anomalous dose rate effects in gamma irradiated SiGe heterojunction bipolar transistors," *IEEE Trans. Nucl. Sci.*, vol. 46, pp. 1620-1626, 1999.

[7] N. van Nonno, R. Lucas, and D. Thornberry, "Total dose hardness of a commercial SiGe BiCCMOS technology," in *Proceedings of the 5th European Conference on Radiation and its Effects on Components and Systems (RADECS)*, Abbaye de Fontevraud, 1999, pp. K21-22.

[8] J. Rolden, W.E. Ansley, J.D. Cressler, S.D. Clark, and D. Nguyen-Ngoc, "Neutron radiation tolerance of advanced UHV/CVD SiGe HBT BiCMOS technology," *IEEE Trans. Nucl. Sci.*, vol. 44, pp. 1965-1973, 1997.

[9] J. Rolden, G.F. Niu, W.E. Ansley, J.D. Cressler, and S.D. Clark, "An investigation of the spatial location of proton-induced traps in SiGe HBTs," *IEEE Trans. Nucl. Sci.*, vol. 45, pp. 2424-2430, 1998.

[10] G.F. Niu, G. Banerjee, J.D. Cressler, J. Rolden, and S.D. Clark, "Electrical probing of surface and bulk traps in proton-irradiated gate-assisted lateral p-n-p transistors," *IEEE Trans. Nucl. Sci.*, vol. 45, pp. 2361-2366, 1998.

[11] S. Zhang, G. Niu, J.D. Cressler, S.D. Clark, and D.C. Ahlgren, "The effects of proton irradiation on the RF performance of SiGe HBTs," *IEEE Trans. Nucl. Sci.*, vol. 46, pp. 1716-1721, 1999.

[12] J.D. Cressler and G. Niu, Silicon – Germanium Heterojunction Bipolar Transistors, Boston: Artech House, 2003.

[13] P.W. Marshall, et al., "Single Event Effects in Circuit-Hardened SiGe HBT Logic at Gigabit per Second Data Rates," *IEEE Trans. Nucl. Sci.*, vol. 47, no.6, pp. 2669-2674, December 2000.

[14] P.W. Marshall, et al., "Autonomous Bit Error Rate Testing at Multi-Gbit/s Rates Implemented in a 5 AM SiGe Circuit for Radiation Effects Self Test (CREST)" *IEEE Trans. Nucl. Sci.*, vol. 52, no.6, pp. 2446-2454, December 2005.

[15] R.A. Reed, P.W. Marshall, J.C. Pickel, M.A. Carts, B. Fodness, G. Niu, K. Fritz, G. Vizkelethy, P.E. Dodd, T. Irwin, J.D. Cressler, R. Krithivasan, P. Riggs, J. Prairie, B. Randall, B. Gilbert, and K.A. LaBel, "Heavy-Ion Broad-Beam and Microprobe Studies of Single Event Upsets in 0.20 μm SiGe Heterojunction

Bipolar Transistors and Circuits," *IEEE Trans. Nucl. Sci.*, vol. 50, no. 6, pp. 2184-2190, 2003.

[16] M. Varadharajaperumal, G. Niu, R. Krithivasan, J.D. Cressler, R.A. Reed, P.W. Marshall, G. Vizkelethy, P.E. Dodd, and A.J. Joseph, "3-D Simulation of Heavy-Ion Induced Charge Collection in SiGe HBTs," *IEEE Trans. Nucl. Sci.*, vol. 50, no. 6, pp. 2191-2198, 2003.

[17] H. Kroemer, "Zur theorie des diffusions und des drifttransistors, part III," *Arch. Elektr. Ubertragung*, vol. 8, pp. 499-504, 1954.

[18] H. Kroemer, "Theory of a wide-gap emitter for transistors," *Proc. IRE*, vol. 45, pp. 1535-1537, 1957.

[19] C.A. King, J.L. Hoyt, C.M. Gronet, J.F. Gibbons, M.P. Scott, and J. Turner, "$Si/Si_{1-x}/Ge_x$ heterojunction bipolar transistors produced by limited reaction processing," *IEEE Electron Device Lett.*, vol. 10, no. 2, pp. 52-54, Feb. 1989.

[20] G.L. Patton, D.L. Harame, J.M.C. Stork, B.S. Meyerson, G.J. Scilla, E. Ganin, "Graded-SiGe-base, poly-emitter heterojunction bipolar transistors," *IEEE Electron Device Lett.*, vol. 10, no. 12, pp. 534-536, Dec. 1989.

[21] U.S. Davidsohn and F. Lee, "Dielectric Isolated Integrated Circuit Substrate Process," *Proc. of the IEEE*, vol. 57, no. 9, pp. 1532-1537, September 1969.

[22] L.W. Massengill *SEU Modeling and Prediction Techniques* Snowbird, UT ser. NSREC Short Course, ch.3, pg. 226-319, July 1993.

[23] F. Wrobel, "Fundamentals on Radiation-Matter Interaction," IEEE 2005 RADECS Conference Short Course.

[24] C. Hsieh, P.C. Murley, and R.R. O'Brien, "A Field-Funneling Effect on the Collection of Alpha-Particle Generated Carriers in Silicon Devices," *IEEE Elec. Dev. Lett.*, vol. EDL-2, no. 4, pp. 103-105, 1981.

[25] E.L. Petersen, J.C. Pickel, J.H. Adams, Jr., E.C. Smith, "Rate Prediction for Single Event Effects – a Critique," *IEEE Trans. Nucl. Sci.*, vol. 39, no. 6, pp. 1577-1599, December 1992.

[26] E.L. Petersen, J.C. Pickel, E.C. Smith, P.J. Rudeck, J.R. Letaw, "Geometrical Factors in SEE Rate Calculations," *IEEE Trans. Nucl. Sci.*, vol. 40, no. 6, pp. 1888-1909, December 1993.

[27] J.C. Pickel, J.T. Blandford, Jr., "Cosmic Ray Induced Errors in MOS Memory Cells," *IEEE Trans. Nucl. Sci.*, vol. NS-25, no. 6, pp. 1166-1171, December 1978.

[28] J.C. Pickel, J.T. Blandford, Jr., "Cosmic Ray Induced Errors in MOS Devices," *IEEE Trans. Nucl. Sci.*, vol. NS-27, no. 2, pp. 1006-1014, April 1980.

[29] L.W. Connell, P.J. McDaniel, A.K. Prinja, F.W. Sexton, "Modeling the Heavy Ion Upset Cross Section," *IEEE Trans. Nucl. Sci.*, vol. 42, no. 2, pp. 73-82, April 1995.

[30] P.J. McNulty, W.J. Beauvais, and D.R. Roth, "Determination of SEU Parameters of NMOS and CMOS SRAMs," *IEEE Trans. Nucl. Sci.*, vol. 38, no. 6, pp. 1463-1470, December 1991.

[31] P.J. McNulty, W.G. Abdel-Kader, and J.E. Lynch, "Modeling charge collection and single event upsets in microelectronics," *Nucl. Instr. and Methods*, vol. B61, no. 52, pp. 52-60, 1991.

[32] J.N. Brandford, “A distribution function for ion track lengths in rectangular volumes,” *J. Appl. Phys.*, vol. 50, no. 6, pp. 3799-3801, June 1979.

[33] F.W. Sexton, J.S. Fu, R.A. Kohler, and R. Koga, “SEU Characterization of a Hardened CMOS 64K and 256K SRAM,” *IEEE Trans. Nucl. Sci.*, vol. 36, no. 6, pp. 2311-2317, 1989.

[34] K.W. Golke, “Determination of Funnel Length from Cross Section versus LET Measurements,” *IEEE Trans. Nucl. Sci.*, vol. 40, no. 6, pp. 1910-1917, Dec. 1993.

[35] W.J. Stapor, P.T. McDonald, A.R. Knudson, and A.B. Campbell, “Charge Collection in Silicon for Ions of Different Energy but Same Linear Energy Transfer (LET),” *IEEE Trans. Nucl. Sci.*, vol. 35, no. 2, pp. 1585-1590, 1988.

[36] L.W. Connell and F.W. Sexton, “Further Development of the *H*eavy *I*on *C*ross Section for Single Event *Up*set: Model (HICUP),” *IEEE Trans. Nucl. Sci.*, vol. 42, no. 6, pp. 2026-2034, December 1995.

[37] K.M. Horn, B.L. Doyle, F.W. Sexton, J.S. Laird, A. Saint, M. Cholewa, and G. Legge, “Ion Beam Induced Charge Collection (IBICC) Microscopy of ICs: Relation to single event upset (SEU),” *Nucl. Instr. and Methods B*, vol. 77, pp. 355-361, 1993.

[38] “Synopsys, Inc.” Mountain View, CA 94043 (USA). [Online]. Available: http://www.synopsys.com

[39] G. Niu, R. Krithivasan, J.D. Cressler, P.W. Marshall, C. Marshall, R.A. Reed, and D.L. Harame, “Modeling of Single-Event Effects in Circuit-Hardened High-Speed SiGe HBT Logic,” *IEEE Trans. Nucl. Sci.*, vol. 48, no. 6, pp. 1849-3114, 2001.

[40] G. Niu, R. Krithivasan, J.D. Cressler, P.A. Riggs, B.A. Randall, P.W. Marshall, R.A. Reed, and B. Gilbert, "A Comparison of SEU Tolerance in High-Speed SiGe HBT Digital Logic Designed with Multiple Circuit Architectures," *IEEE Trans. Nucl. Sci.*, vol. 49, no. 6, pp. 3107-3114, 2002.

[41] R. Krithivasan, G. Niu, J.D. Cressler, S.M. Currie, K.E. Fritz, R.A. Reed, P.W. Marshall, P.A. Riggs, B.A. Randall, and B. Gilbert, "An SEU Hardening Approach for High-Speed SiGe HBT Digital Logic," *IEEE Trans. Nucl. Sci.*, vol. 50, no. 6, pp. 2126-2134, 2003.

[42] J.R. Hauser, S.E. Diehl-Nagle, A.R. Knudson, A.B. Campbell, W.J. Stapor, and P. Shapiro, "Ion Track Shunt Effects in Multi-Junction Structures," *IEEE Trans. Nucl. Sci.*, vol. NS-32, no. 6, pp. 4115-4121 (1985).

[43] G.C. Messenger and M.S. Ash, Single Event Phenomena, New York: Chapman & Hall, 1997.

[44] F.B. McLean and T.R. Oldham, "Charge Funneling in N- and P-Type Si Substrates," *IEEE Trans. Nucl. Sci.*, vol. NS-29, no. 6, pp. 2018-2023, December 1982.

[45] C. Hu, "Alpha-Particle-Induced Field and Enhanced Collection of Carriers," IEEE Electron Device Letters, vol. EDL-3, no.2, pp. 31-34, (1982).

[46] C. L. Howe, R.A. Weller, R.A. Reed, R.D. Schrimpf, L.W. Massengill, K.M. Warren, D. R. Ball, M.H. Mendenhall, K.A. LaBel, J.W. Howard Jr., "Monte Carlo Study of Radiation-Induced Energy Deposition in Scaled Microelectronic Structures," IEEE Trans. Nucl. Sci., vol. 53, pp. 2182-2188, (2005).

[47] A.S. Kobayashi, D. R. Ball, R.A. Reed, K.M. Warren, M.H. Mendenhall, R.D. Schrimpf, R.A. Weller, " The Effect of Metallization Layers on Single Event

Susceptibility," IEEE Trans. Nucl. Sci., vol. 53, pp. 2189-2193, (2005).

[48] K.M. Warren, R.A. Weller, R.A. Reed, D.R. Ball, M.L. Alles, L.W. Massengill, R.D. Schrimpf, M.H. Mendenhall, C.L. Howe, B.D. Olson, N.F. Haddad, S.E. Doyle, D. McMorrow, J.S. Melinger, W.T. Lotshaw, "The Contributions of Nuclear Reactions to the Single Event Upset Cross-Section Measurements in a High-Density SEU Hardened SRAM Technology," IEEE Trans. Nucl. Sci. vol. 53, pp. 2125-2131, (2005).

[49] "J.F. Ziegler", [Online]. Available: http://www.srim.org/SRIM/SRIMINTRO.htm