TASK #:07-048 SiGe and Advanced Mixed Signal Radiation

QUARTERLY TECHNICAL PROGRESS REVIEW

TASK # & TITLE:	**07-048 SiGe and Advanced Mixed Signal Radiation**
QUARTER:	**4Q FY07**
COORDINATING CENTER:	**GSFC**
PARTICIPATING CENTER/S:	**N/A**
PROGRAM AREA:	**NEPP**
TASK MANAGER:	**Drs. Paul Marshall & Ray Ladbury/GSFC**
FY07 FUNDING:	
CUSTOMER:	**OSMA/Brian Hughitt**

TASK DESCRIPTION

SiGe and Advanced Mixed Signal - Radiation

- SiGe microelectronics are a commercially available high-speed, mixed signal technology applicable to a diverse range of digital, RF, and mixed signal wideband systems. In FY04-06, we proved this technology is extremely well suited for space with respect to ionizing radiation and particle damage issues, but problems arise due to the extreme sensitivity to soft errors. Our research targets these issues using collaborative test chips (including DoD-funded hardening methods) to acquire radiation effects data and support device physics and circuit level modeling.

GOALS/OBJECTIVES

SiGe and Advanced Mixed Signal - Radiation

- FY07 activities involve test and modeling to characterize IBM 5HP 8HP and 9HP SiGe structures and devices, and other commercial processes (IHP)
- Modeling activities include 3-D device physics charge collection and TCAD simulations of circuit response in 5HP, 7HP, and 8HP SiGe HBT technologies
- We will generate and evaluate simulation based solutions to RHBD architectures and related test structures
- We will assess the temperature dependence of HBT concerns under cryo conditions
- Test activities will also characterize the companion CMOS circuits for these BiCMOS processes, as well as strained CMOS structures

DELIVERABLES

SiGe and Advanced Mixed Signal - Radiation

FY07 Deliverables	Quarter Due	Quarter Completed	Notes
Documentation of baseline (unhardened) technology performance in 3 generations of SiGe HBT from multiple foundries and including corresponding CMOS for BiCMOS processes	4Q07[1]		In progress from 1Q-4Q FY07
Documentation of improved SiGe HBT SEU/SET model(s) showing fidelity to laboratory test results	4Q07[1]		In progress from 1Q-4Q FY07
Report indicating techniques applicable to radiation hardening by design (RHBD) with application to 8HP SiGe	4Q07[1]		In progress from 1Q-4Q FY07
Documentation of improved SiGe HBT SEU on-orbit model for 5HP SiGe HBT based circuits	4Q07[1]		In progress from 1Q-4Q FY07

[1] *Each major deliverable for this task will be tracked with intermediate deliverable inputs (e.g., test reports, published papers) from GSFC and its University and other partners throughout each of the 4 quarters, and these will appear in the "Major Accomplishments" portion of the quarterly reports.*

SCHEDULE for FY07

SiGe and Advanced Mixed Signal - Radiation

	2006						2007					
FY06	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**
Test circuit development												
Ion, proton, laser testing												
Improved Models												
SEU/SET in HBT												
On-orbit for IBM 5HP												

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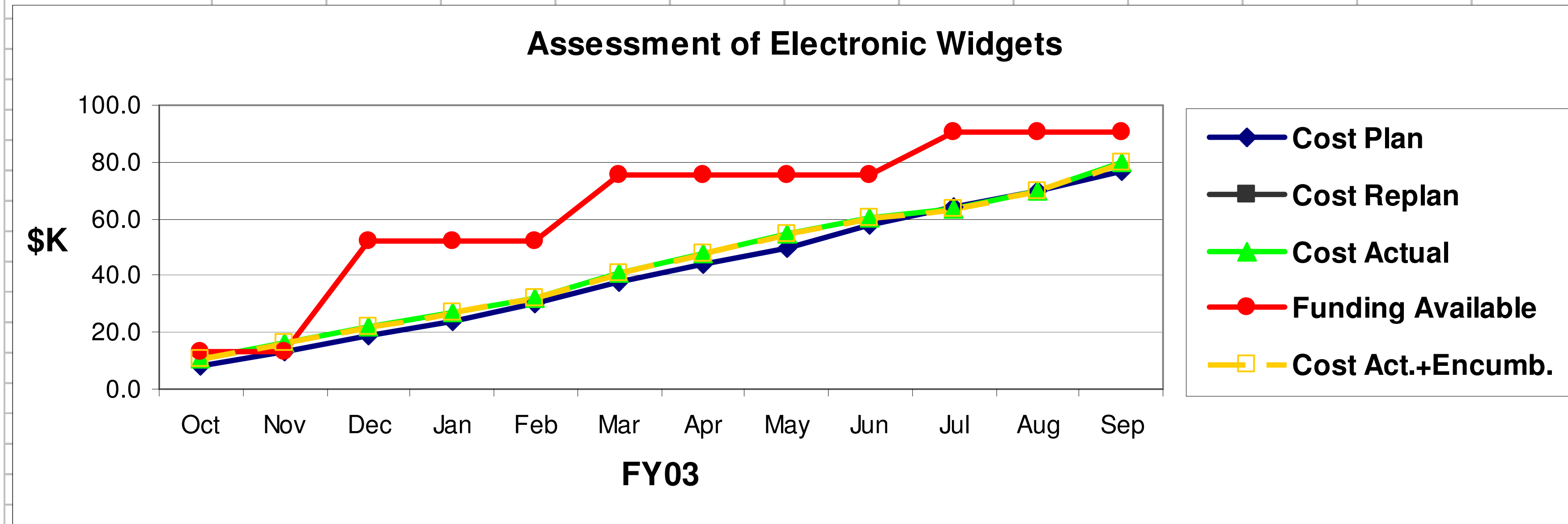
BUDGET/WORKFORCE

SiGe and Advanced Mixed Signal - Radiation



Assessment of Electronic Widgets 100774-1.2.ABC.0	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Cost Plan	8.0	13.0	19.0	24.0	30.0	38.0	44.0	50.0	58.0	64.0	70.0	77.0
Cost Replan												
Cost Actual	11.0	16.1	22.0	27.0	32.2	40.9	48.0	54.7	60.5	63.8	69.6	79.9
Cost Variance	3.0	3.1	3.0	3.0	2.2	2.9	4.0	4.7	2.5	-0.2	-0.4	2.9
Funding Available	12.9	12.9	51.9	51.9	51.9	75.3	75.3	75.3	75.3	90.7	90.7	90.7
Encumbrances	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cost Act.+Encumb.	11.0	16.1	22.0	27.0	32.2	40.9	48.0	54.7	60.5	63.8	69.6	79.9
WF Plan	0.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.30	0.30	0.30
WF Actual	0.39	0.34	0.34	0.36	0.33	0.33	0.33	0.31	0.24	0.23	0.31	0.32

MAJOR ACCOMPLISHMENTS THIS QUARTER

SiGe and Advanced Mixed Signal - Radiation

- **Georgia Tech highlights to advancing the SiGe task during 4th quarter FY07 are:**
  - **Circuit Design and Test Structure Tapeout**
    - **July 07 IBM 8HP**
      - **Std. M/S & Dual Interleaved 16-bit SR with ext. ring device RHBD**
      - **n-ring RHBD devices wired for laser testing (Tx level transients)**
      - **Inverse-mode ECL gate test structures for 12/07 microbeam**
    - **September 07 5AM (CRYO 3)**
      - **n-ring test structures + Op Amp with n-ring RHBD devices**
      - **Charge pumping test structures**
    - **October 07 IHP**
      - ***npn/pnp* RHBD structures (without DT) + RHBD ring oscillator**

MAJOR ACCOMPLISHMENTS THIS QUARTER (Cont.)

SiGe and Advanced Mixed Signal - Radiation

- Vanderbilt University highlights to advancing the SiGe task during the 4th quarter FY07 are:
  - Experiments
    - TPA transient testing at NRL (2-3 July 2007)
      - Obtained first IBM 5HP SiGe HBT transients
        - Nominal transients in active regions
        - Evidence of potential pushout for carrier generation outside trench. Spatially and energy dependent. Focus of EDL paper. J. A. Pellish, et al., "Non-linear spatiotemporal radiation effects in the IBM 5HP SiGe HBT," IEEE Electron Device Lett., in progress.
      - Used VU-implemented high-speed package
      - Leveraged CRYO-II DUTs from NASA-MSFC RHESE

MAJOR ACCOMPLISHMENTS THIS QUARTER (Cont.)

SiGe and Advanced Mixed Signal - Radiation

- Auburn University highlights to advancing the SiGe task during the 4th quarter FY07 are:
  - Analysis of microbeam testing results of shared dummy collector RHBD HBTs and 2x2 HBT arrays
  - 4x4 array HBT array constructed and simulated
    - Ion strike performed on different locations
    - Comparisons with 2x2, 3x3 and 4x4 are made
  - Hardening of a SiGe opamp circuit using dummy collector – circuit has been submitted
  - Presentation of dummy collector RHBD approach at NSREC

MAJOR ACCOMPLISHMENTS THIS QUARTER (Cont.)

SiGe and Advanced Mixed Signal - Radiation

- NASA/GSFC led highlights in 4Q07 are:
  - Contributed to final drafts of 12 accepted NSREC paper submissions.
  - Specified and acquired 2 additional 12.5 Gbit/s Anritsu Bit Error Rate Test (BERT) test sets for 1Q08 (and beyond use).
  - Completed final draft documentation of guidelines for Built in Self Test (BIST) architectures for autonomous SEE testing at GHz clock rates.
  - Worked closely with Georgia Tech, the Mayo Foundation, and OGA to disseminate findings of 5AM, 5HP, and 8HP radiation characteristics (emphasis on soft error rates and RHBD mitigation) to enable insertion of SiGe circuits to replace GaAs HBT circuits in flight COMMSEC hardware.
  - Analyzed data on SiGe OpAmp and conducted test (TAMU) to assess Analog Single Event Transients (ASETs) in very fast SiGe devices.
    - The TI POPA211 SiGe device tested is from the TI commercial BiCOM3HV (high voltage) process. Prototypes of this new high voltage process were tested at Texas A&M Cyclotron. High power supply current failures occurred. Currently the BiCom3HV process is in revision, at least in part because of this finding.
  - Prepared for proton and heavy ion testing for 4Q06.
    - Test samples are being prepared (with GT partner) from the following commercial technology flows. IBM 8HP SiGe, SemiSouth SiC, IBM 65nm CMOS, IBM 5AM SiGe, IBM 5AM SiGe CRYO I, ST SOI, IBM SiGe 8WL.

MAJOR ACCOMPLISHMENTS THIS QUARTER

SiGe and Advanced Mixed Signal - Radiation

10 Papers to appear in *IEEE Transactions of Nuclear Science, December 2007*

[1] Marco Bellini, Bongim Jun, Aravind C. Appaswamy, Peng Cheng, John D. Cressler, Paul W. Marshall, Badih El-Kareh, Scott Balster, and Hiroshi Yasuda, "The Effects of Proton Irradiation on the DC and AC Performance of Complementary (*npn* + *pnp*) SiGe HBTs on Thick-Film SOI" IEEE Nuclear and Space Radiation Effects Conference, 2007

[2] Peng Cheng, Bongim Jun, Akil Sutton, Chendong Zhu, Aravind Appaswamy,John D. Cressler, Ronald D. Schrimpf, and Daniel M. Fleetwood, "Probing Radiation- and Hot Carrier-Induced Damage Processes in SiGe HBTs Using Mixed-Mode Electrical Stress" IEEE Nuclear and Space Radiation Effects Conference, 2007

[3] Ryan M. Diestelhorst, Steven Finn, Bongim Jun, Akil K. Sutton, Peng Cheng, Paul W. Marshall, John D. Cressler, Ronald D. Schrimpf, Daniel M. Fleetwood, Hans Gustat, Bernd Heinemann,Gerhard G. Fischer, Dieter Knoll, and Bernd Tillack, "The Effects of X-Ray and Proton Irradiation on a 200 GHz / 90 GHz Complementary (*npn* + *pnp*) SiGe:C HBT Technology" IEEE Nuclear and Space Radiation Effects Conference, 2007

[4] Bongim Jun, Akil K. Sutton, Ryan M. Diestelhorst, Gregory J. Duperon, John D. Cressler, Jeffrey D. Black, Tim Haeffner, Robert A. Reed, Michael L. Alles, Ronald D. Schrimpf,Daniel M. Fleetwood, and Paul W. Marshall, "The Application of RHBD to n-MOSFETs Intended for Use in Cryogenic-Temperature Radiation Environments" IEEE Nuclear and Space Radiation Effects Conference, 2007

[5] Anuj Madan, Bongim Jun, Ryan M. Diestelhorst, Aravind Appaswamy, John D. Cressler, Ronald D. Schrimpf, Daniel M. Fleetwood, Tamara Isaacs-Smith, John R. Williams, and Steven J. Koester "Radiation Tolerance of Si/SiGe n-MODFETs" IEEE Nuclear and Space Radiation Effects Conference, 2007

[6] Laleh Najafizadeh, Bongim Jun, John D. Cressler, A.P. Gnana Prakash, Paul W. Marshall, and Cheryl J. Marshall, "A Comparison of the Effects of X-Ray and Proton Irradiation on the Performance of SiGe Precision Voltage References", IEEE Nuclear and Space Radiation Effects Conference, 2007

[7] Akil K. Sutton, Jonathan P. Comeau, Ramkumar Krithivasan, John D. Cressler, Jonathan A. Pellish, Robert A. Reed, Paul W. Marshall, Muthubalan Varadharajaperumal, Guofu Niu, and Gyorgy Vizkelethy, "An Evaluation of Transistor-Layout RHBD Techniques for SEE Mitigation in SiGe HBTs" IEEE Nuclear and Space Radiation Effects Conference, 2007

[8] Tonmoy S. Mukherjee, Kevin T. Kornegay, Akil K. Sutton, Ramkumar Krithivasan, John D. Cressler, Guofu Niu, and Paul W. Marshall, "A Novel Circuit-Level SEU-Hardening Technique For Low-Voltage, Ultra-High-Speed SiGe HBT Logic Circuits" IEEE Nuclear and Space Radiation Effects Conference, 2007

[9] Jonathan A. Pellish, Robert A. Reed, Robert A. Weller, Marcus H. Mendenhall, Paul W. Marshall, Akil K. Sutton, Ramkumar Krithivasan, John D. Cressler, Ronald D. Schrimpf, Kevin M. Warren, Brian D. Sierawski, and Guofu Niu, "On-Orbit Event Rate Calculations for SiGe HBT Shift Registers", IEEE Nuclear and Space Radiation Effects Conference, 2007

[10] M. Varadharajaperumal, G. Niu, X. Wei, J. D. Cressler, R. A. Reed, and P. W. Marshall, "3D simulation of SER hardening of SiGe HBTs using Shared Dummy Collector", IEEE Nuclear and Space Radiation Effects Conference, 2007

MAJOR ACCOMPLISHMENTS THIS QUARTER

SiGe and Advanced Mixed Signal - Radiation

2 Papers presented at the Radiation Effects on Components and Systems*, September 2007*

[1] Laleh Najafizadeh, Akil Sutton, Bongim Jun, John D. Cressler, Tuan Vo, Omeed Momeni, Mohammad Mojarradi, Chandra Ulaganathan, Suheng Chen, Benjamin J. Blalock, Yuan Yao, Xuefeng Yu, Foster Dai, Paul W. Marshall, and Cheryl J. Marshall, “Radiation Response of SiGe BiCMOS Mixed-Signal Circuits Intended for Emerging Lunar Applications” Radiation Effects on Components and Systems

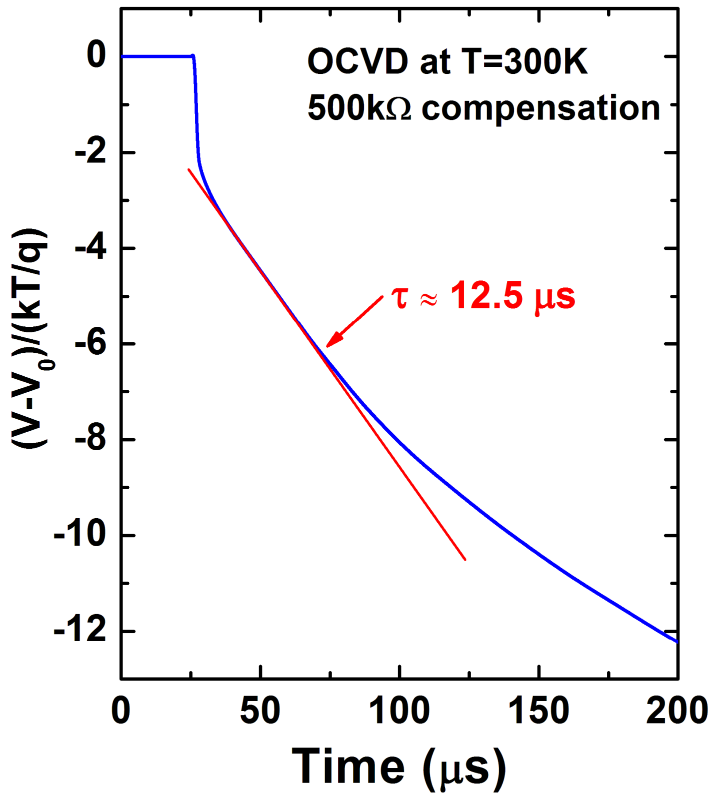
[2] Akil Sutton, A.P. Gnana. Prakash, John D. Cressler, Jessica Metcalfe, Johnathan A. Rice, Alex A. Grillo, Ashley Jones, Forest Martinez-McKinney, Paul Mekhedjian, Hartmut F.W. Sadrozinski, Abe Seiden, Edwin Spencer, Max Wilder, Gabriel Hare, Robert Hackenburg, James Kierstead, and Sergio Rescia, “Source Dependence and Technology Scaling Effects on the Radiation Tolerance of SiGe HBTs at Extreme Dose and Fluence Levels” Radiation Effects on Components and Systems

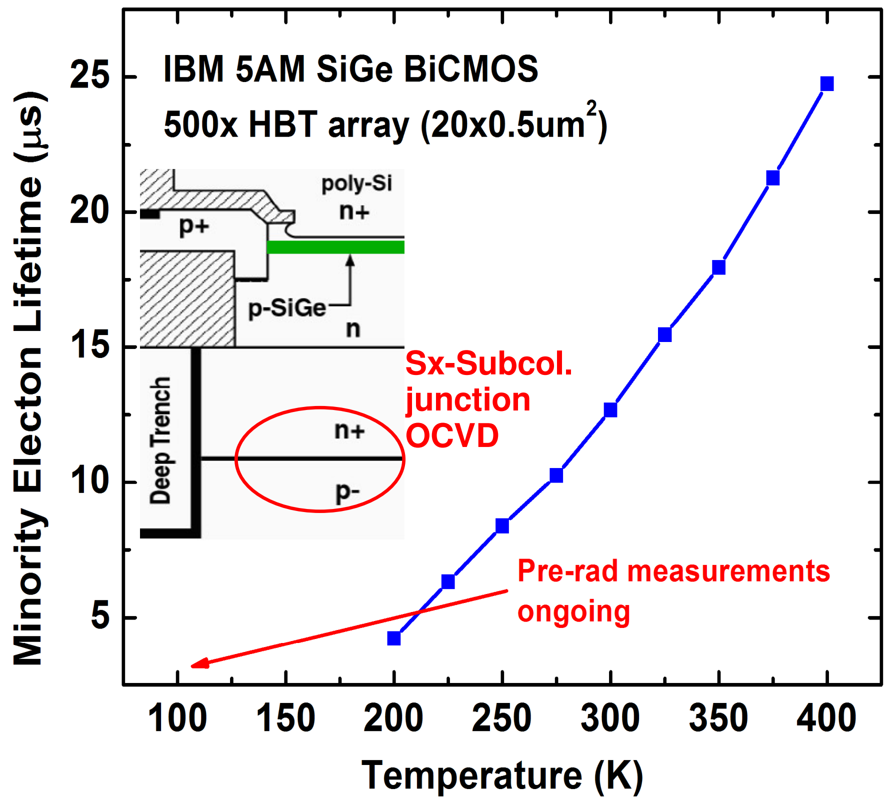
TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

63 MeV Proton Impact on Minority Carrier Lifetimes at 300K and 77K

- Test plans made for 11/07 UC Davis proton experiment
- Provides insight into substrate charge collection at 77K vs. 300K
- Uses compensated OCVD to extract bulk minority carrier lifetime from substrate-subcollector junction



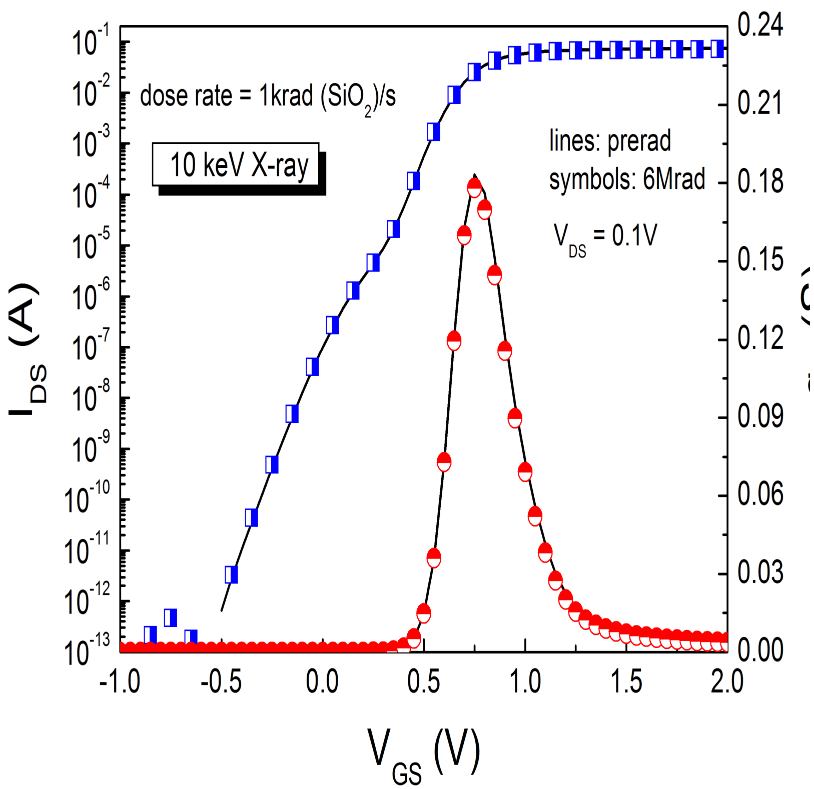


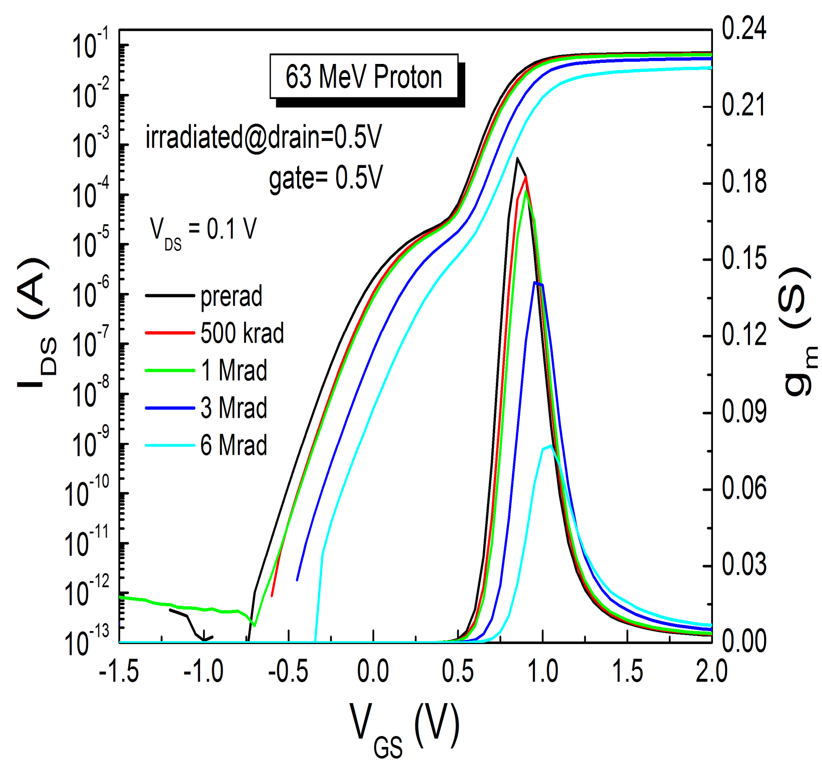
TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

Comparison of 10keV and 63 MeV Proton Irradiation on 4H SiC VJFETs

- Tolerant to x-ray exposure
- Degradation in threshold voltage, peak transconductance, and saturation current density attributed to displacement damage for 63MeV protons



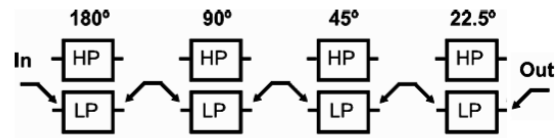


TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

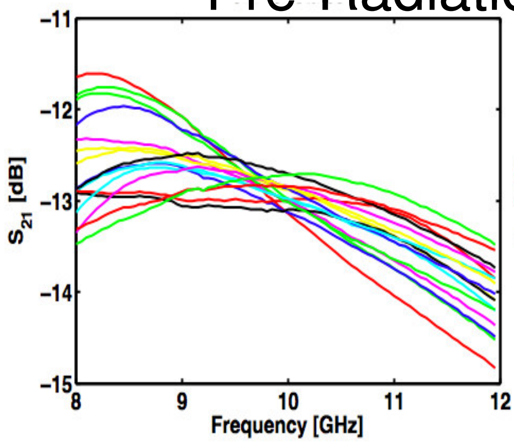
Phase Shifter Radiation Effects

- **CMOS and HBT 4-bit X-band Phase Shifters**
  - phased-array radar applications
  - switched hi-pass/lo-pass filter sections
  - 8 SPDT series switches
  - Compare MOS & HBT based response

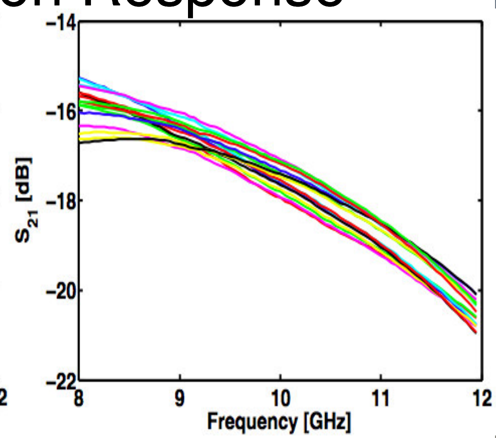


Phase Shifter Topology

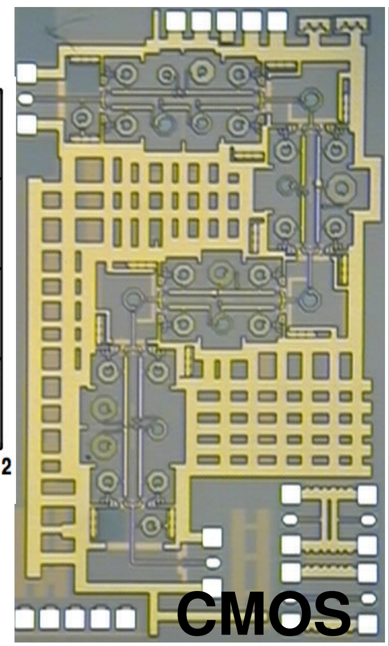
Pre-Radiation Response

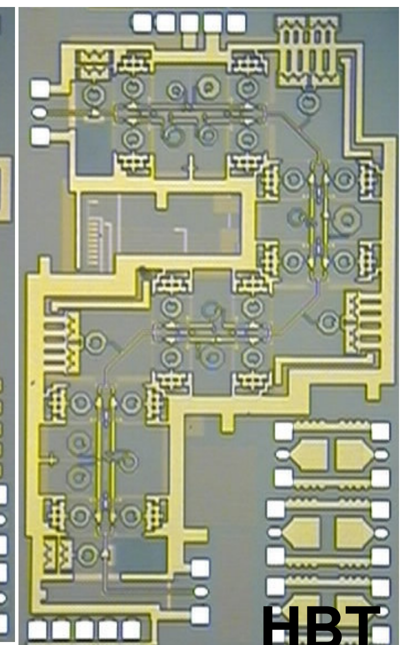


HBT Shifter



MOS Shifter



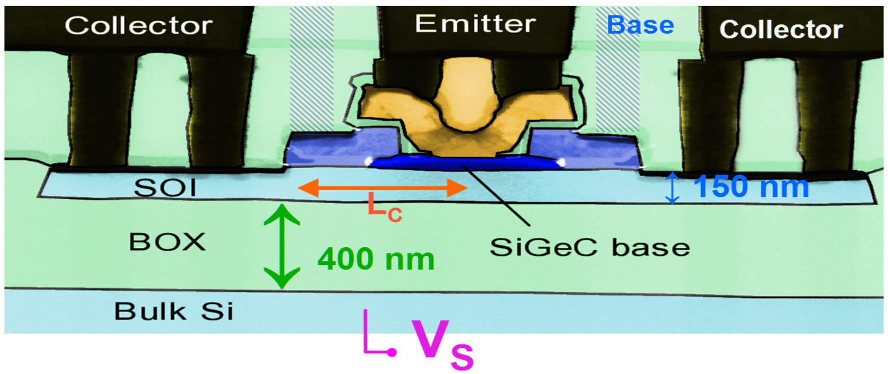


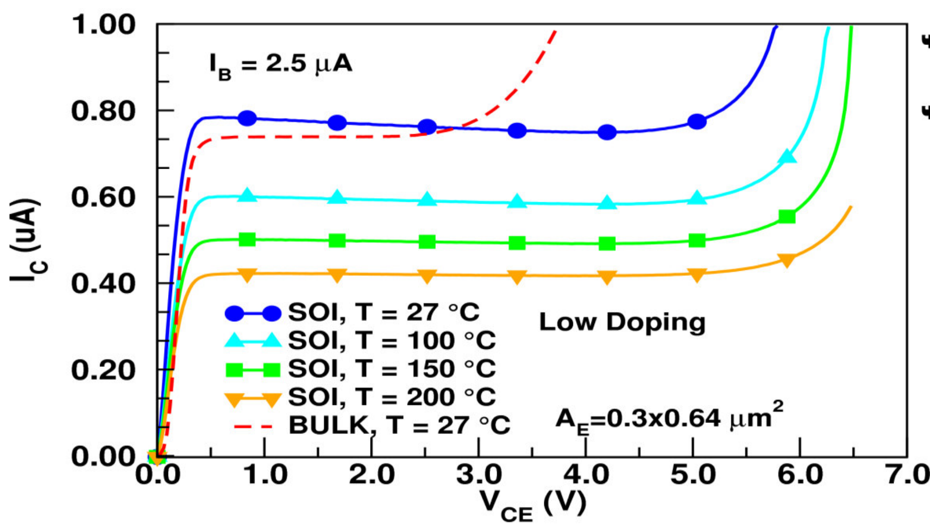
TECHNICAL HIGHLIGHTS

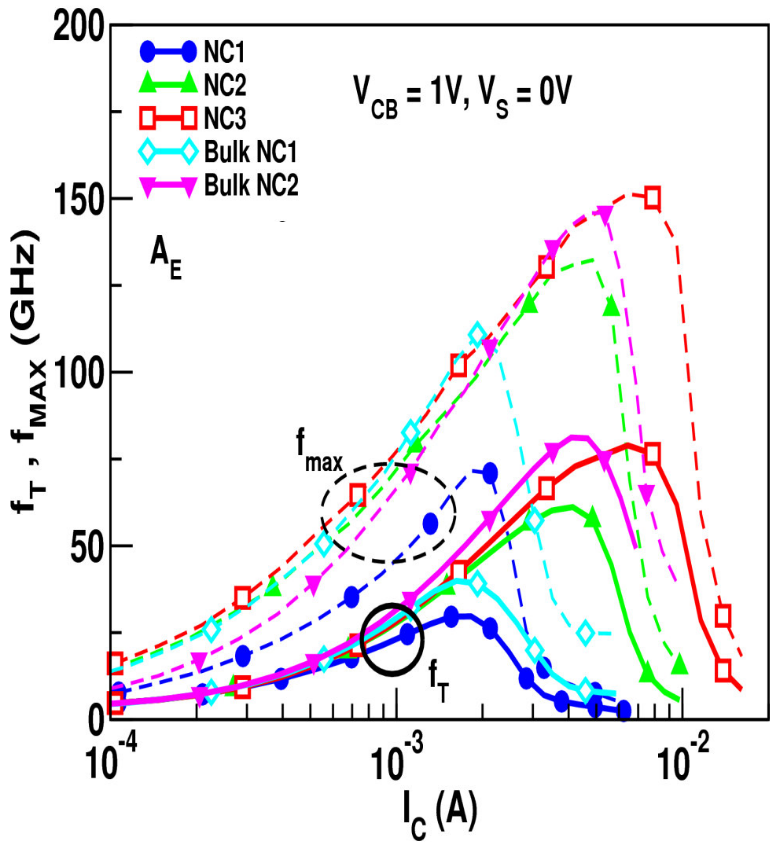
SiGe and Advanced Mixed Signal - Radiation

ST Microelectronics SOI Platform

- Laterally Optimized for *ac* Performance
- Target for Reliability, Radiation and Cryogenic Assessment







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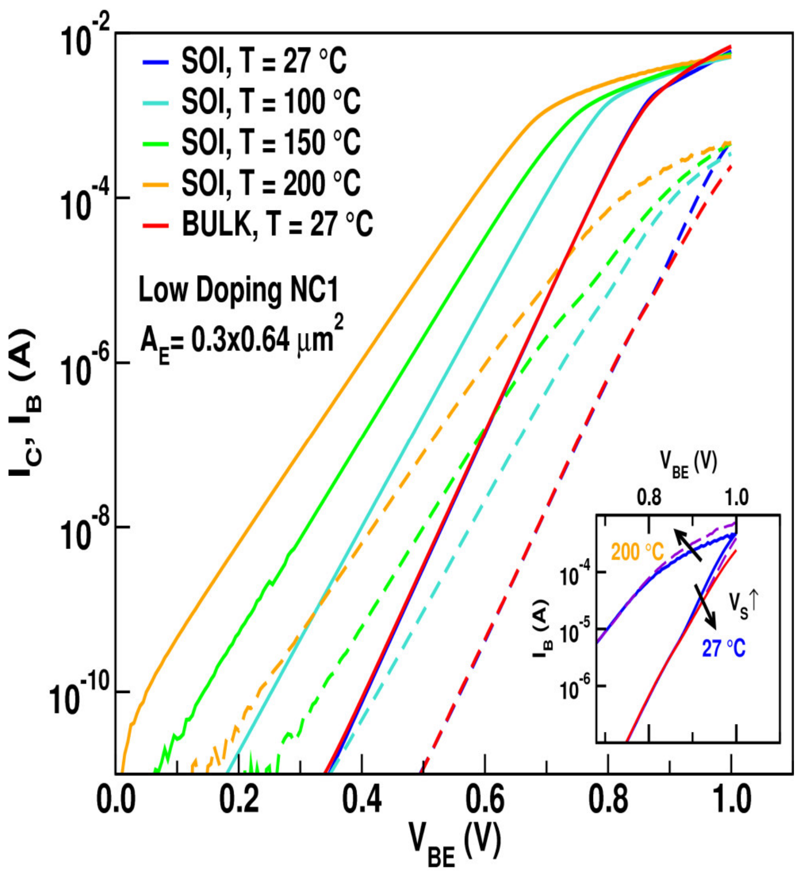
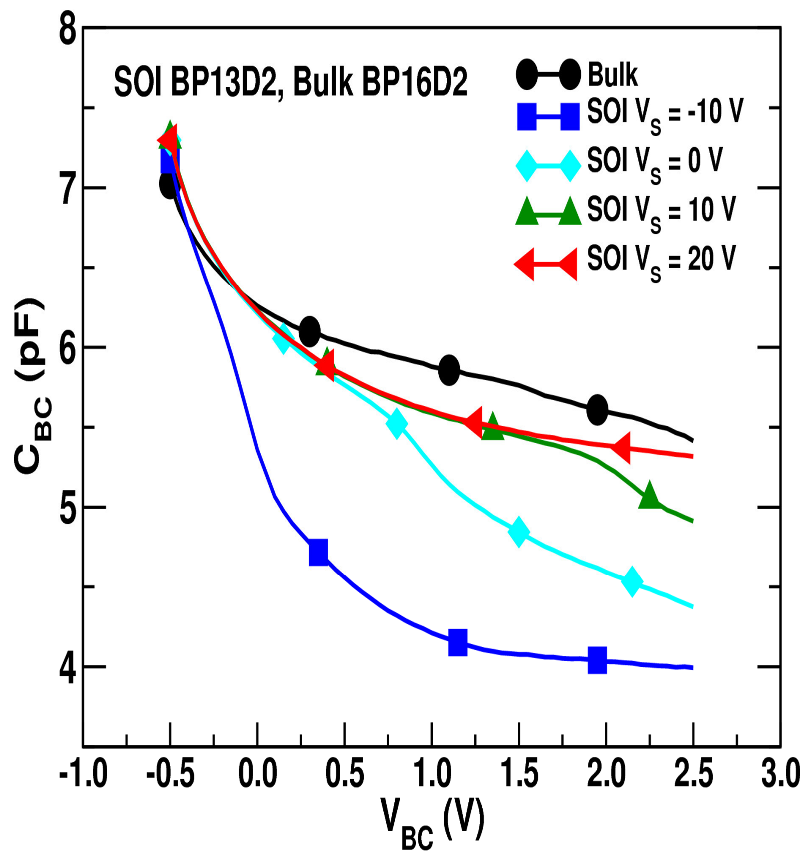
TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

8 MeV Electrons and 63 MeV Protons on ST HBT-on-SOI

- Compare SOI and Bulk versions of the same device
- Test possible Doping Deactivation effects on FD SOI device





TECHNICAL HIGHLIGHTS

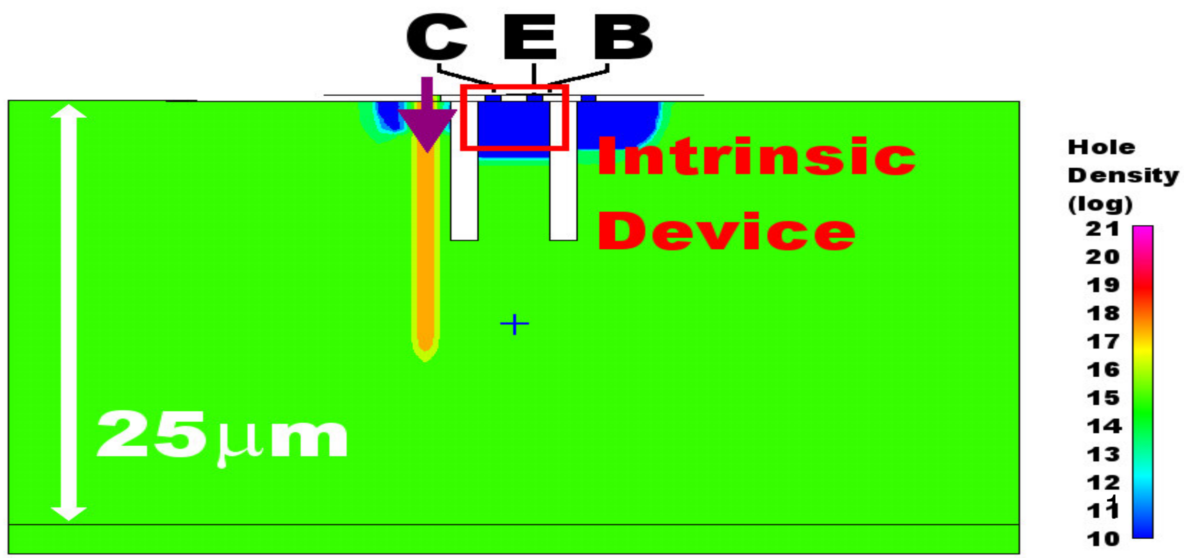
SiGe and Advanced Mixed Signal - Radiation

SEU 3D Simulations

- Fast 3D solver with Mixed-Mode Simulation Capability
- Ideal for SEU Ion Strike Simulations
- *dc* Calibrated 3D model for IBM HBT-on-SOI

Thin-Film HBT-on-SOI

Bulk HBT



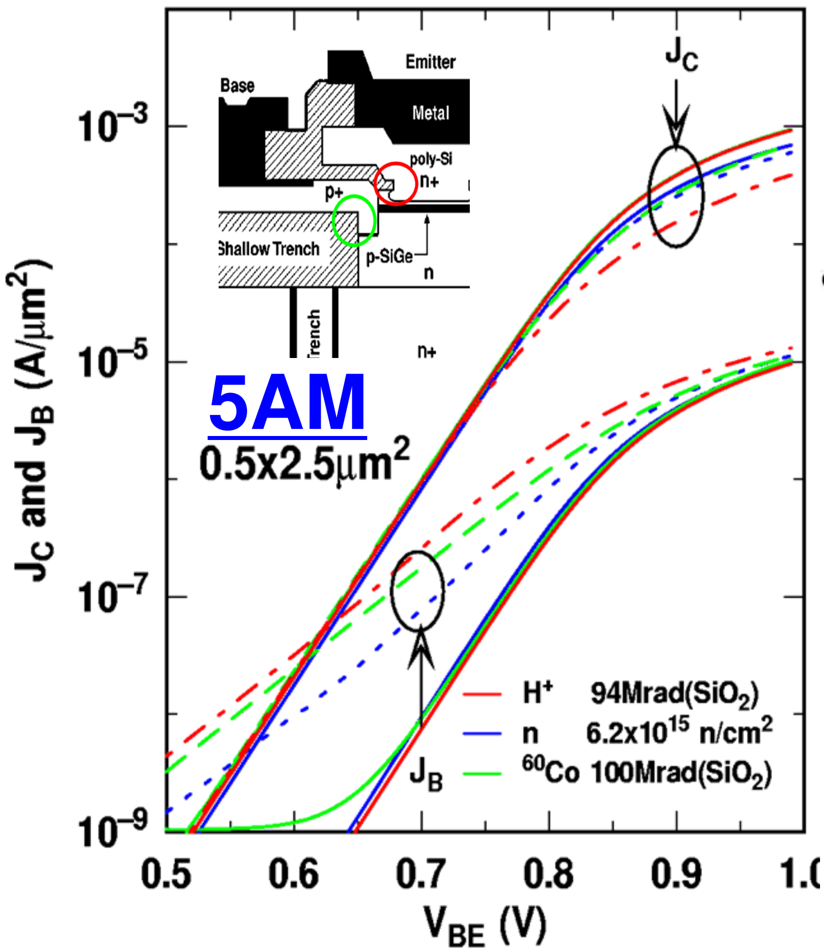
CFDRC NanoTCAD Simulator

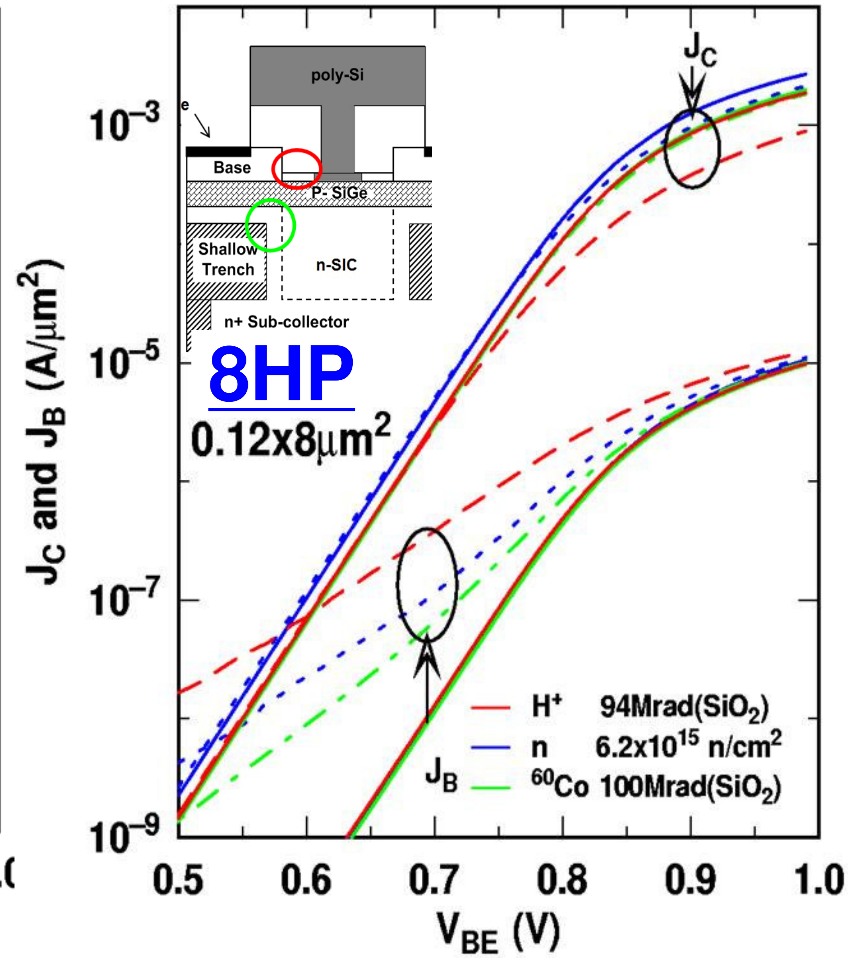
TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

High Dose Source Dependence and Technology Comparison (UCSC)

- Reduced gamma ΔJ_B in 8HP (raised ext. base + thinner STI)
- ΔJ_C at high injection → non ideal increase in resistance



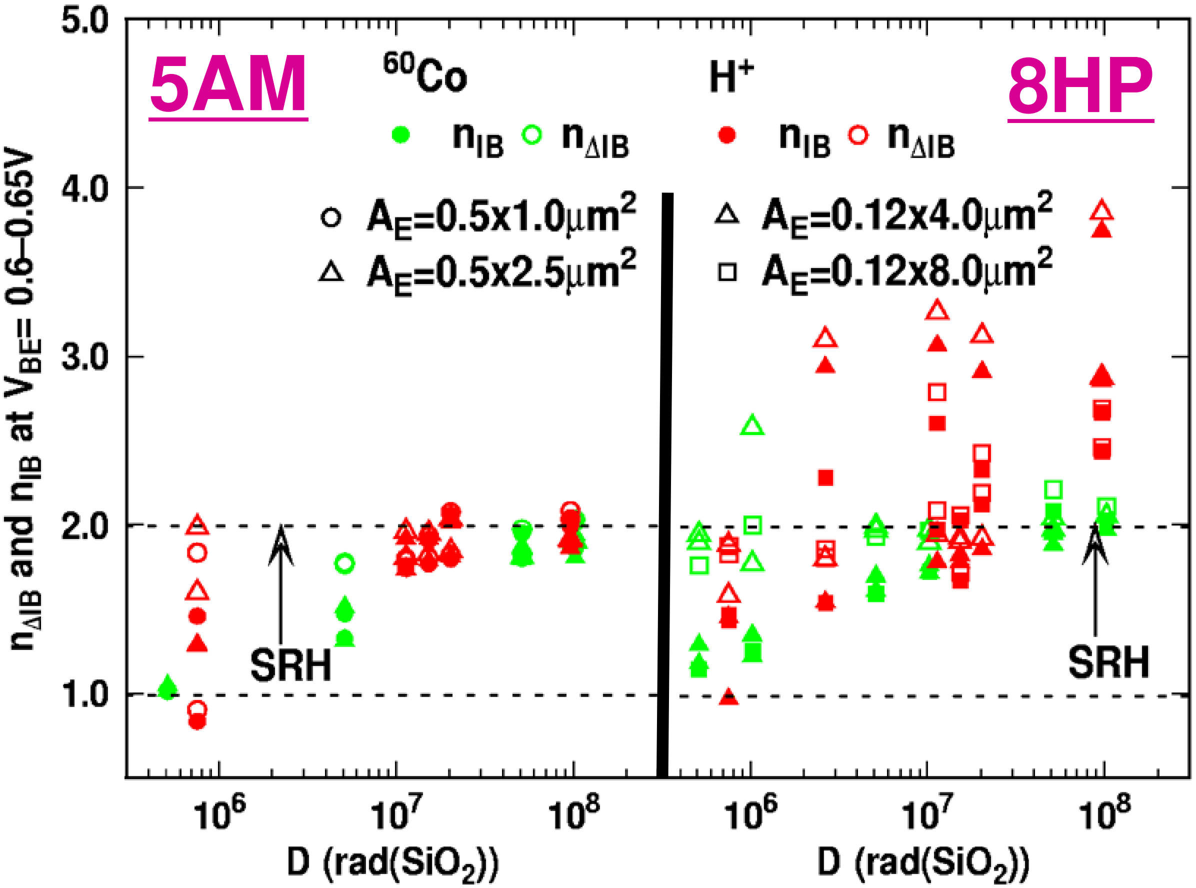


TECHNICAL HIGHLIGHTS

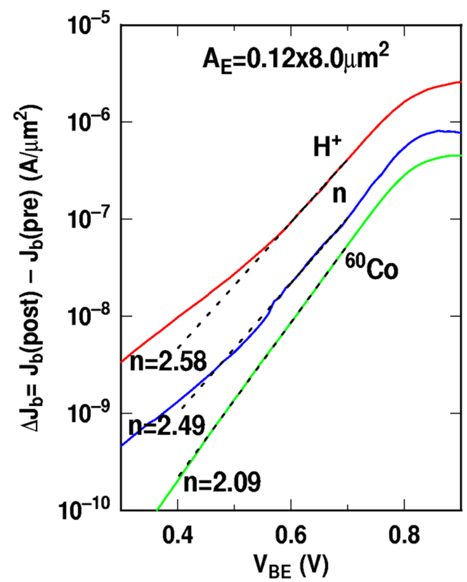
TECHNICAL HIGHLIGHTS

High Dose Source Dependence and Technology Comparison (UCSC)

- 5AM: *all sources*: $1<n_{IB}<2$ (SRH G/R)
- 8HP: *proton and neutron only:* $n_{IB}>2$ (SRH G/R + tunneling)



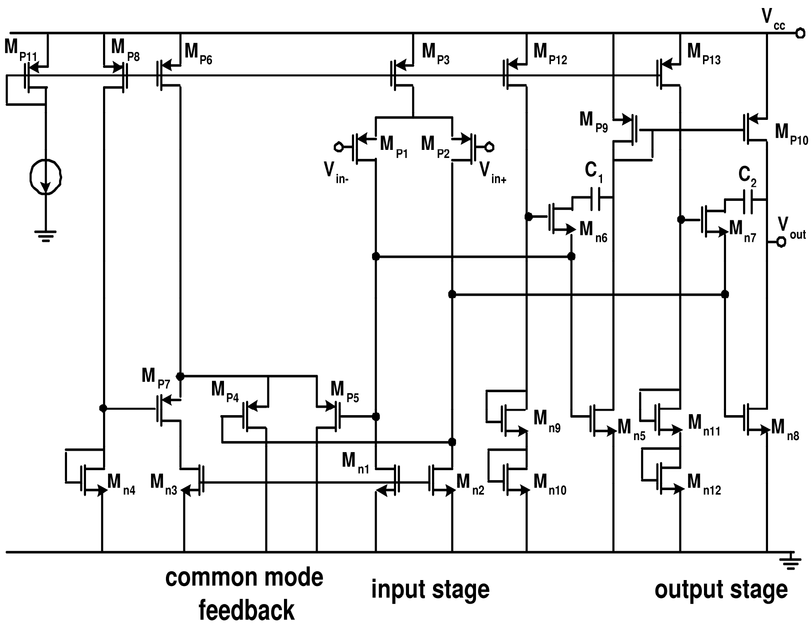
$$\Delta I_B = \Delta I_{B0} e^{\frac{qV_{BE}}{n\Delta_{IB}kT}}$$

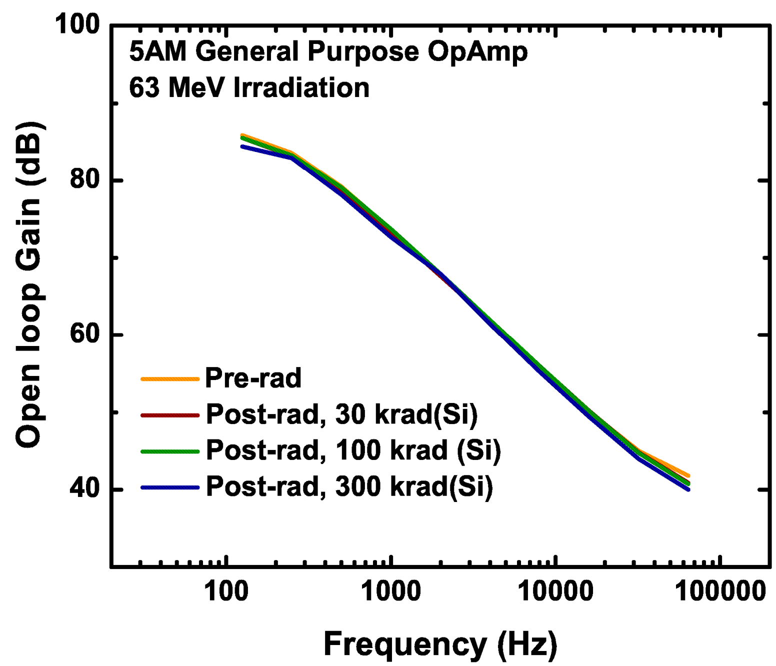


TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

Effects of 63 MeV Proton Irradiation on Op Amp



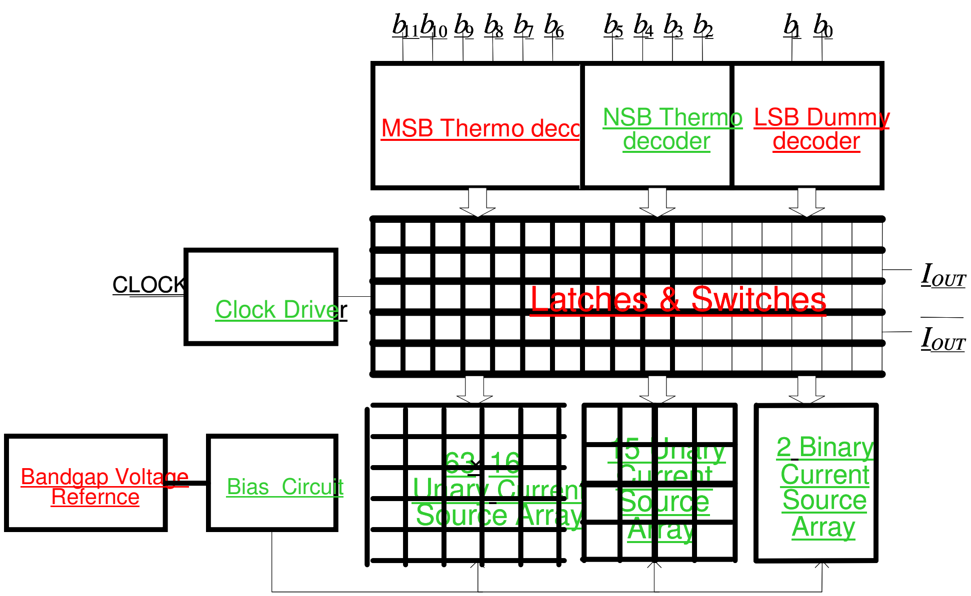


TECHNICAL HIGHLIGHTS

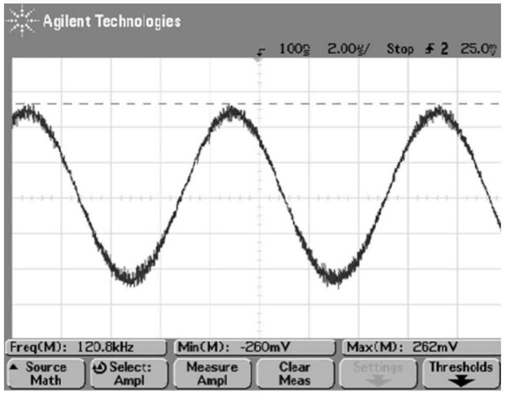
SiGe and Advanced Mixed Signal - Radiation

Effects of 63 MeV Proton Irradiation on DAC

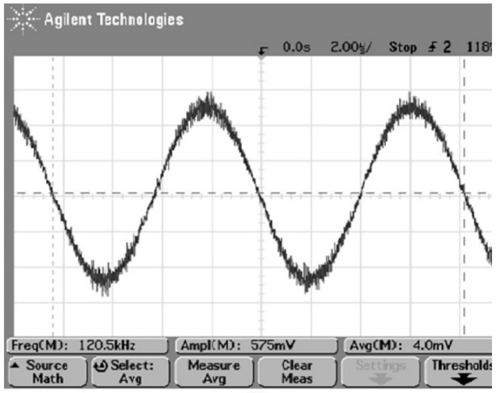
- Digital to analog converters are widely used in mixed-signal circuits
- Segmented current steering topology was implemented
- The DAC was irradiated to total dose level of 300 krad(Si)
- Circuit performance changes negligibly after irradiation



Pre-rad



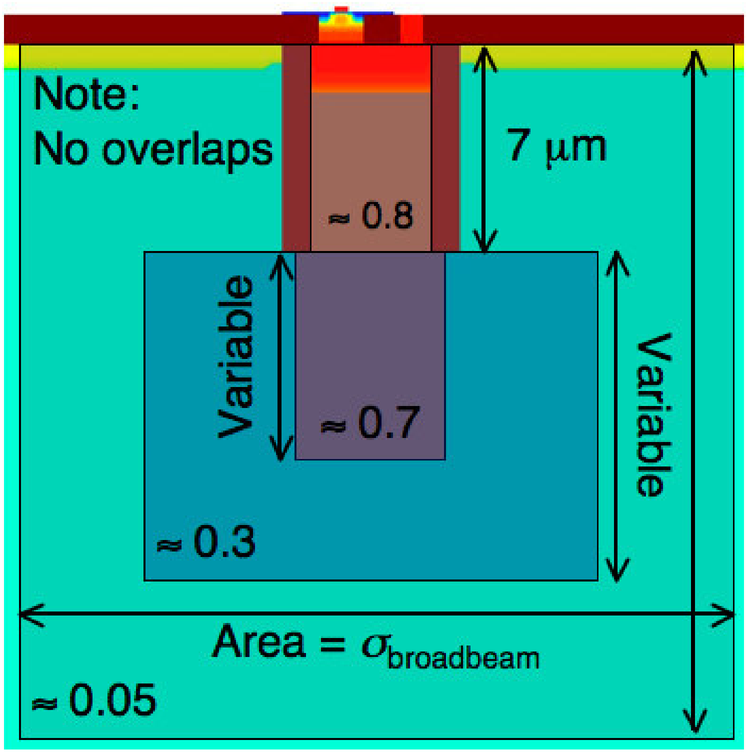
Post-rad



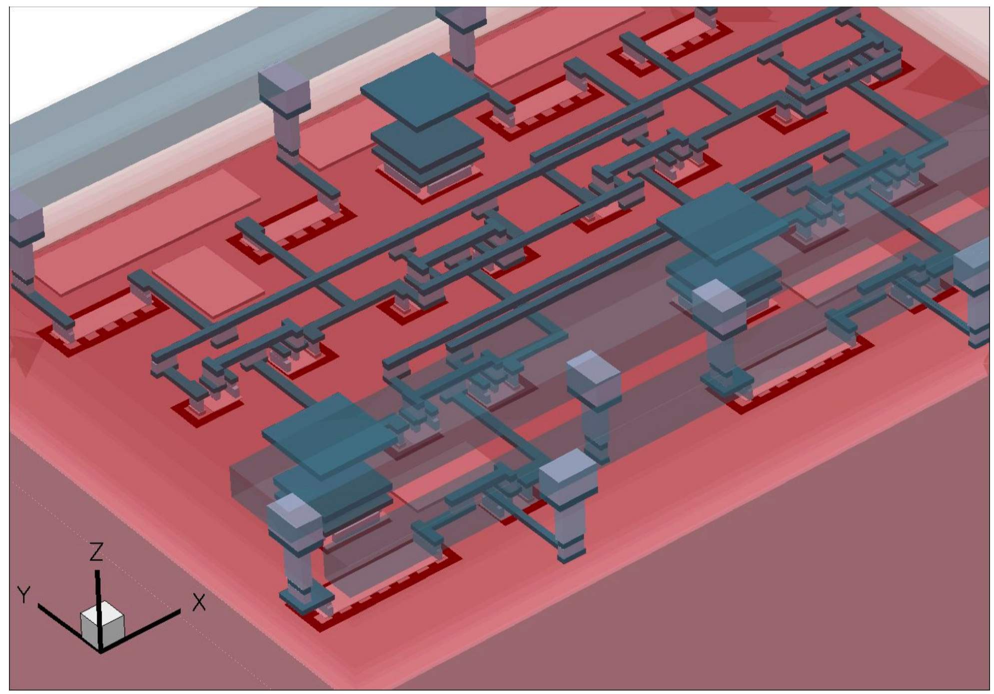
TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

IBM 5HP SiGe HBT Rate Calculation



Fiducial Volume Model Updated from 2007/Q3

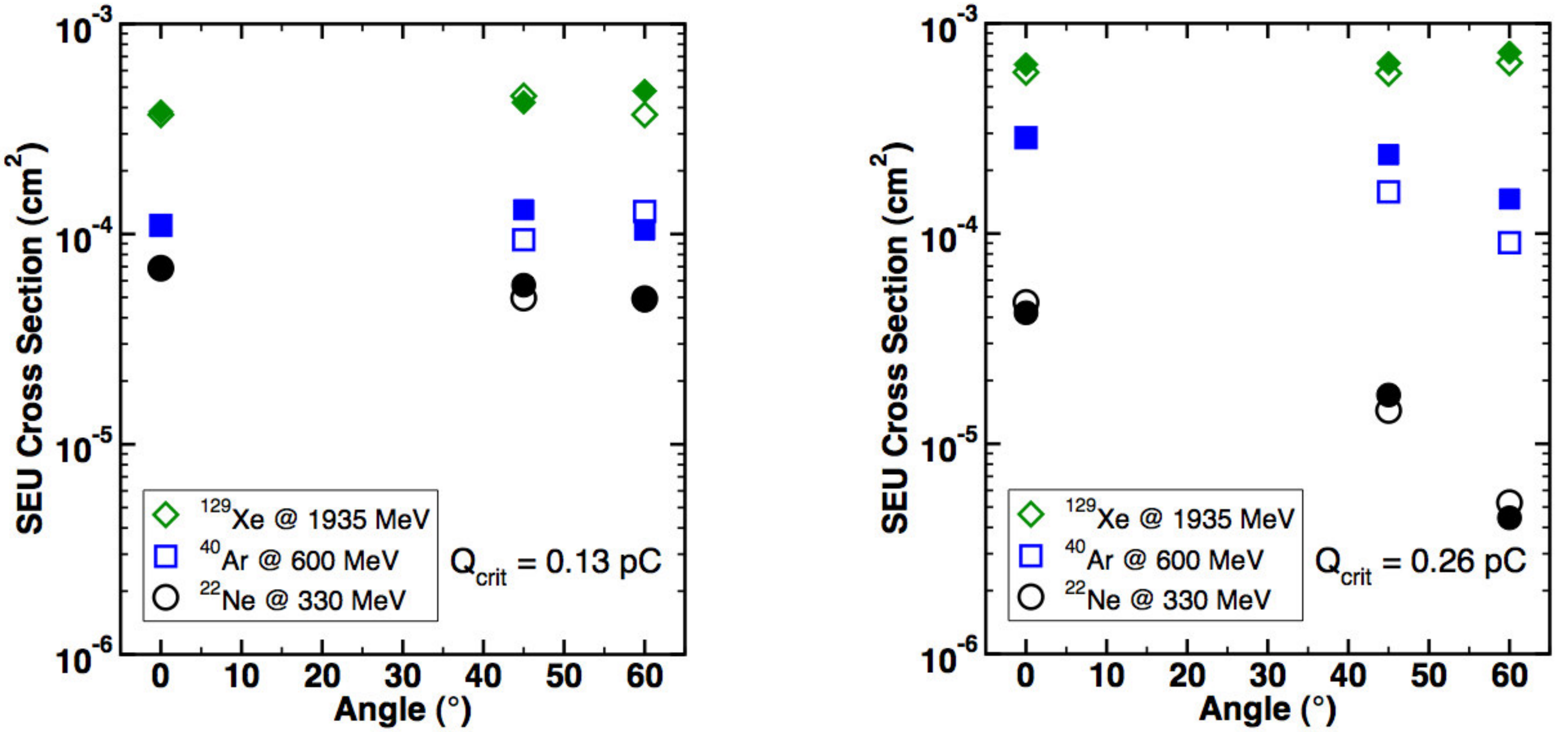


Virtualized 3-D Model of Shift Register Stage – used for radiation transport modeling

TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

IBM 5HP SiGe HBT Rate Calculation



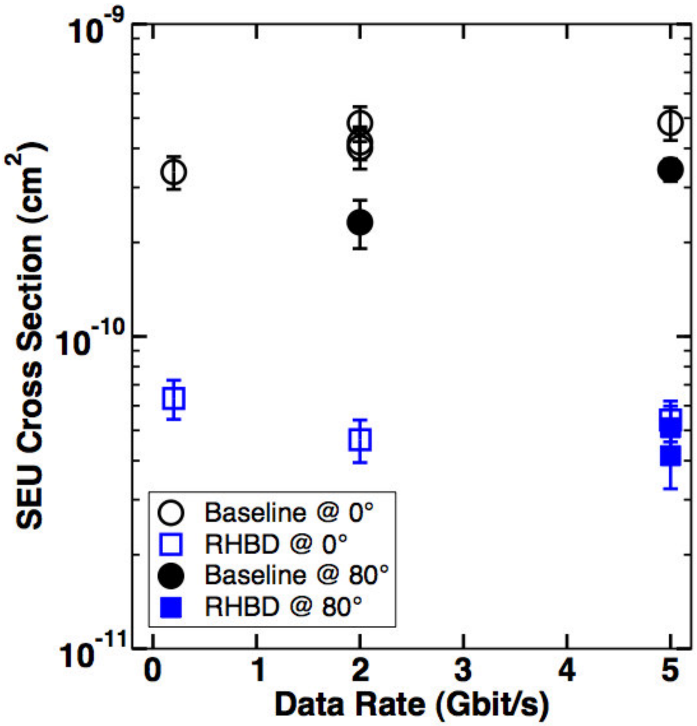
Fiducial volume model calibrated to heavy ion data

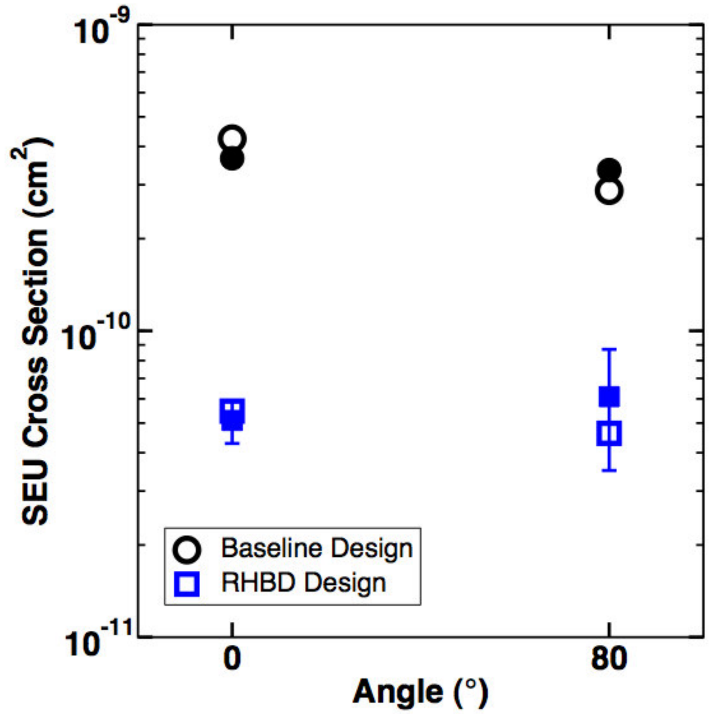
Open symbols are data after P. W. Marshall, *et al.*, *IEEE Trans. Nucl. Sci.*, vol. 52, pp. 2446-2454, Dec. 2005.

TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

IBM 5HP SiGe HBT Rate Calculation



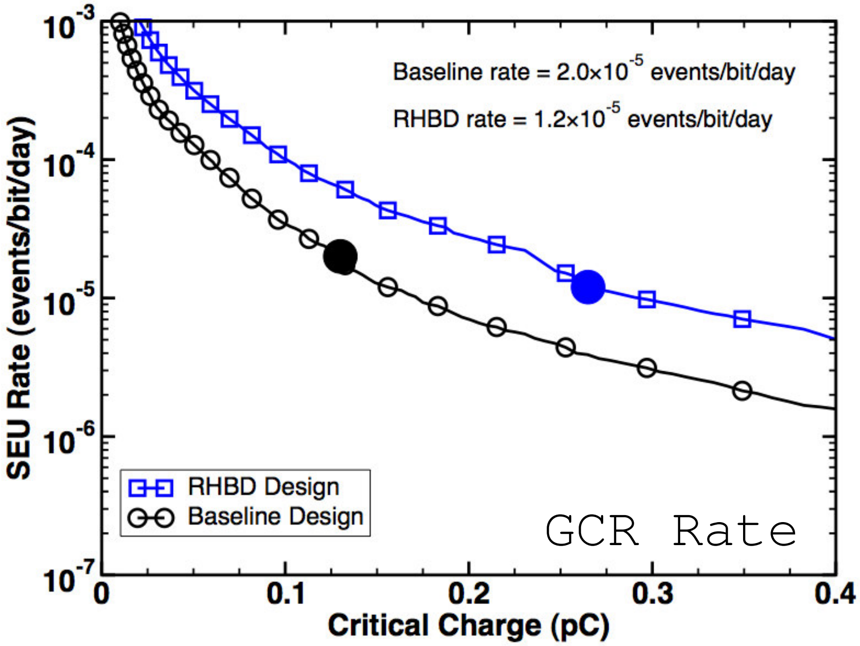


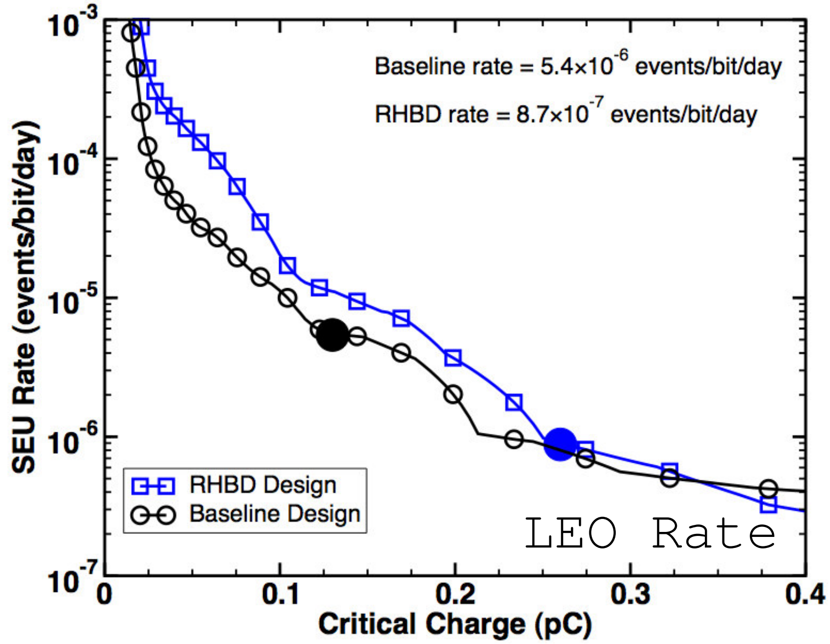
- Gathered 63 MeV proton data (2007/Q2) on the CREST macro and used it to validate the fiducial volume model for use in low-earth orbit rate calculations
- Open symbols in right-hand chart are averaged data points from left hand chart.

TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

IBM 5HP SiGe HBT Rate Calculation





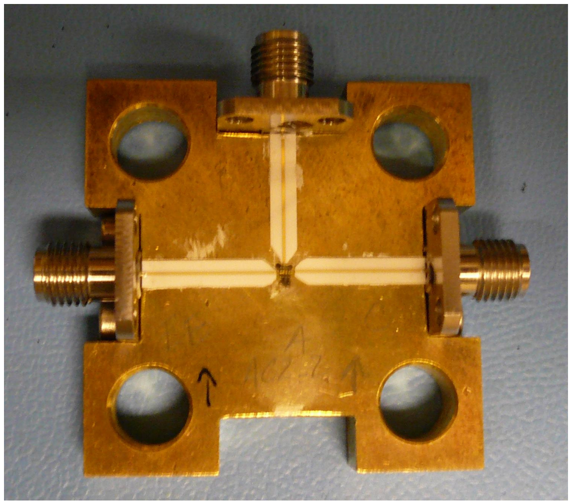
Evaluated rate for each part based on the calibrated Q_{crit} from the heavy ion and proton validations

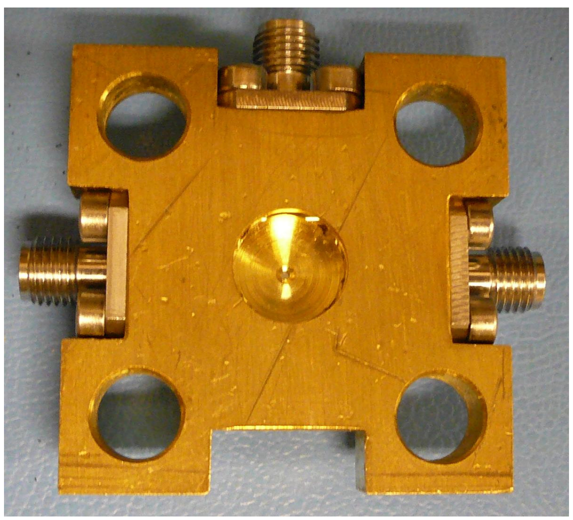
Q_{crit}(baseline) = 0.13 pC; Q_{crit}(RHBD) = 0.26 pC

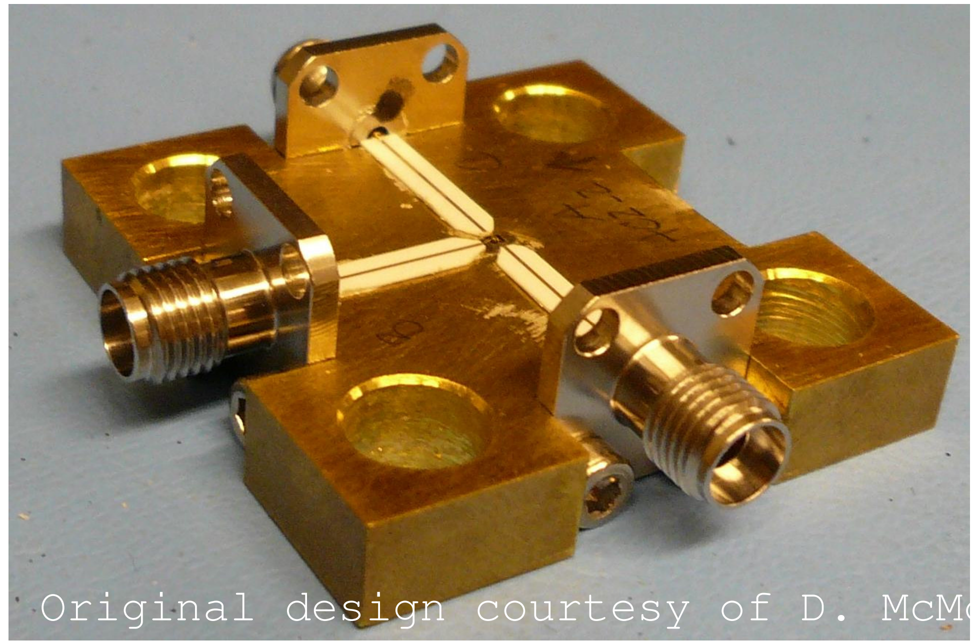
TECHNICAL HIGHLIGHTS

<u>SiGe and Advanced Mixed Signal - Radiation</u>

VU High-Speed Package

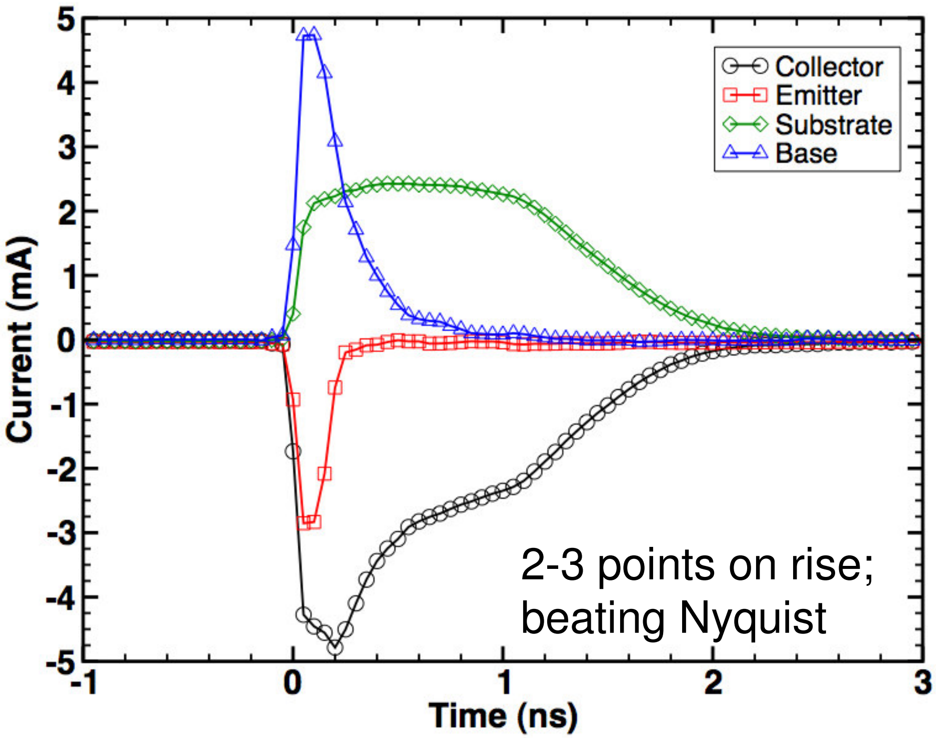


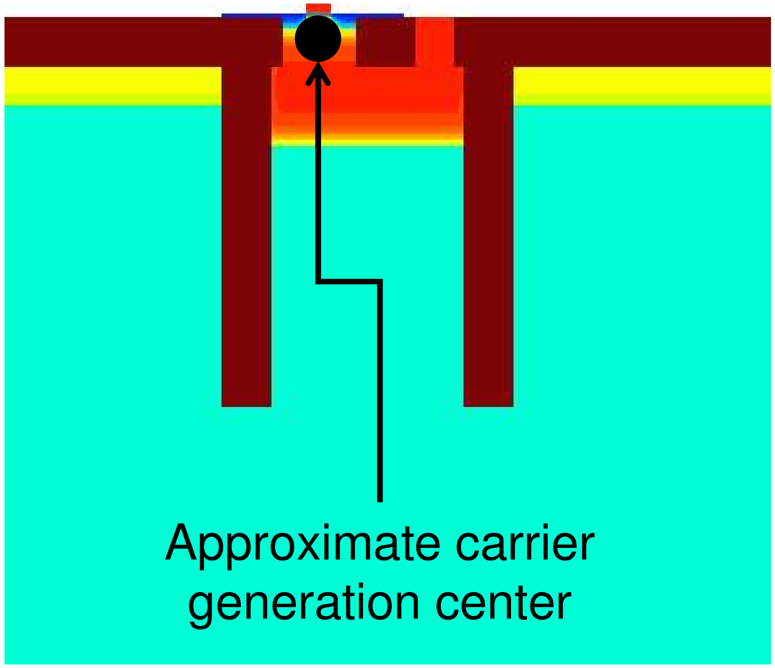




- Up to 4 high-speed connections
- Currently uses 2.92 mm F launchers (40 GHz)
- Microstrip transmission lines facillitate signal routing
- Backside tap for two-photon laser irradiation
- Low cost: manufactured in physics machine shop (approximately $400)

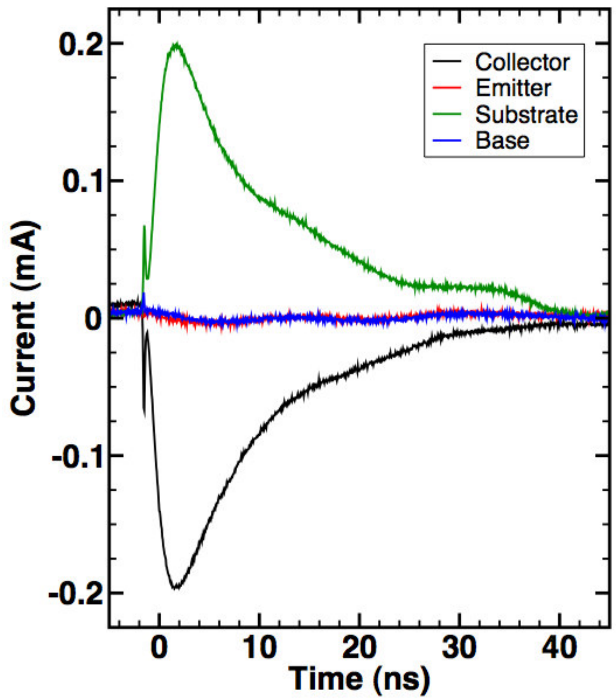
IBM 5HP SiGe HBT Transient Testing

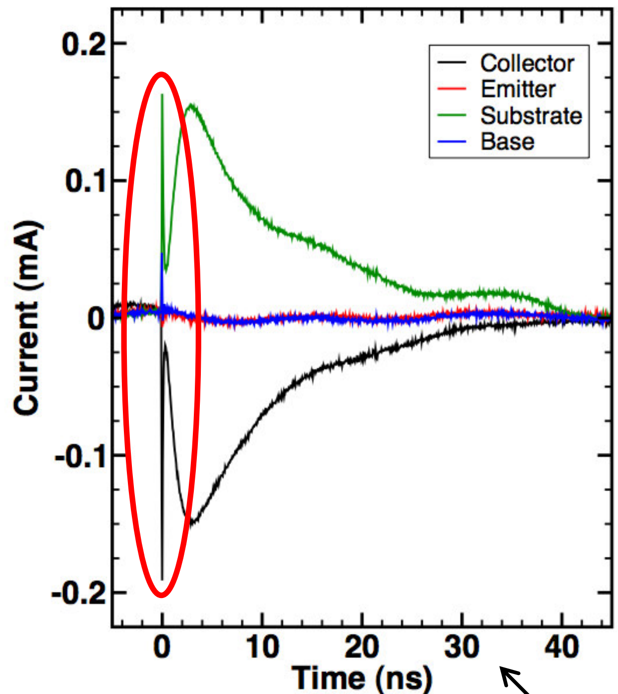




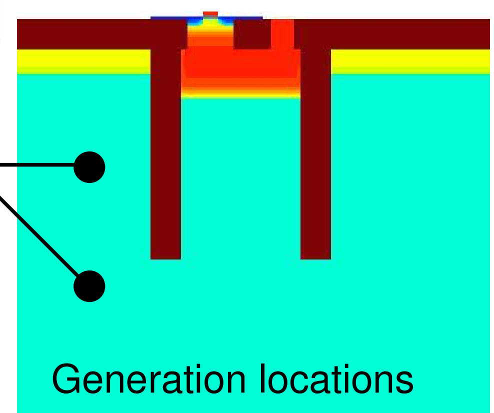
- Two-photon absorption using high-speed package; 12 GHz Tek 6124C digital real-time oscilloscope (AFOSR DURIP leverage)
- 25 mV laser control voltage; OD-0 filter
- Peak collector terminal current (FWHM = 1 ns)

IBM 5HP SiGe HBT Transient Testing





- 25 mV control voltage
- OD-0 filter
- Two different locations

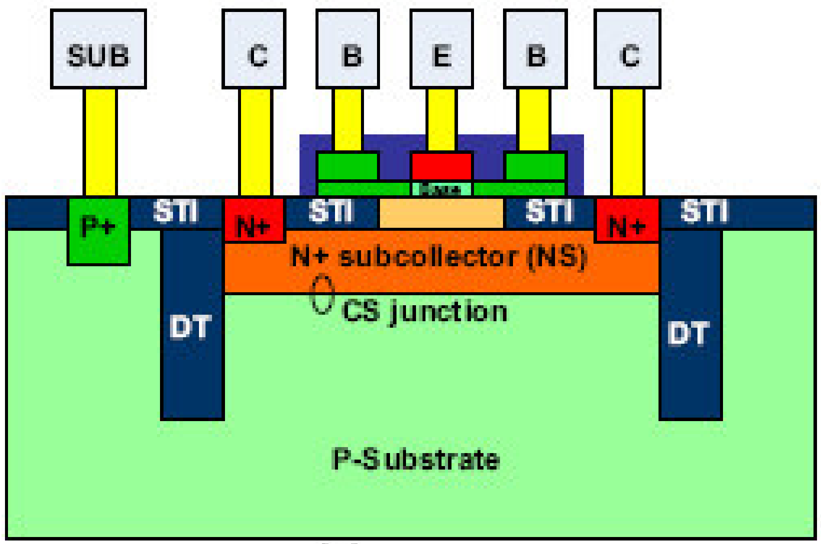


- Note the displacement current peak in the right-hand figure; signals potential pushout
- Spatially- and energy-dependent effect

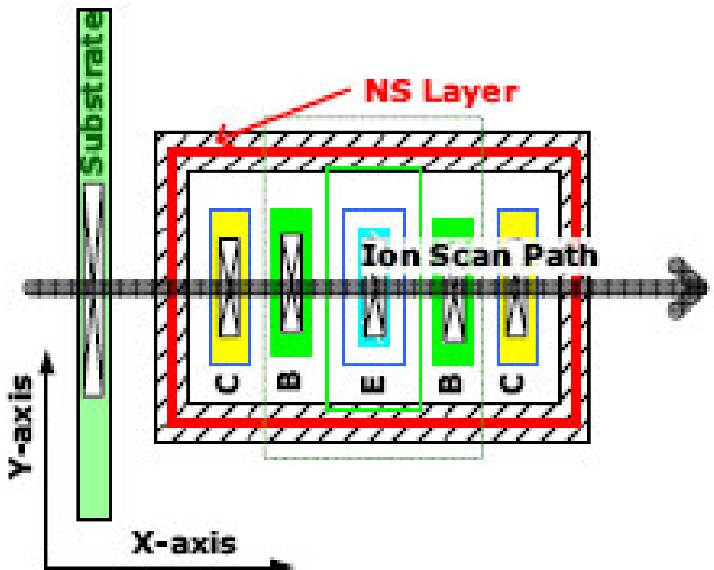
TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

Single HBT Structure (Regular)



(a)



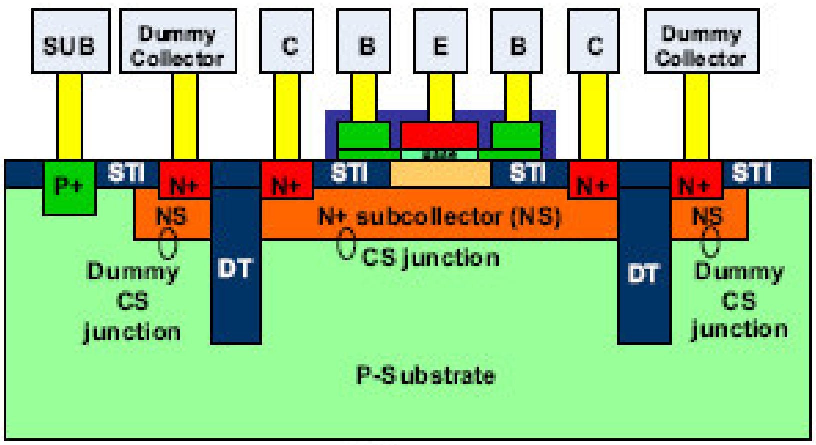
(b)

TECHNICAL HIGHLIGHTS

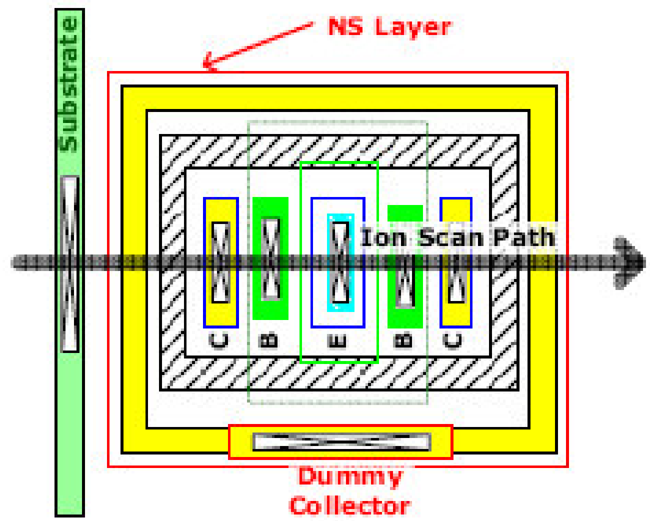
SiGe and Advanced Mixed Signal - Radiation

Single HBT (Hardened with outside DT ring)

- No real area penalty as devices must be apart by a few microns anyway to satisfy design rules
- Layout changes only - RHBD



(a)



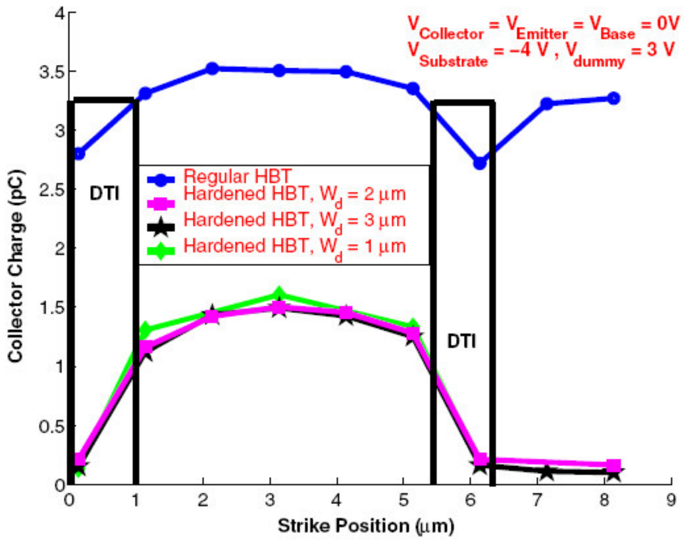
(b)

TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

Normal Strike on Single HBT, Dummy Ring Requirement

- Dummy collector width varied from 1um to 3um
- Little difference is observed
- 1um wide dummy collector is sufficient
- 1um spacing is naturally available as device spacing is often larger than this (design rules)
- This indicates we do not need to add extra space for this dummy collector – little or no area penalty



TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

Mechanism: Complete Suppression of Diffusive Charge Collection

- **Dummy collector placed around DT suppresses diffusive charge collection nearly completely**
- **Shorter duration will benefit analog circuit – reduced SET expected**

Normal strike

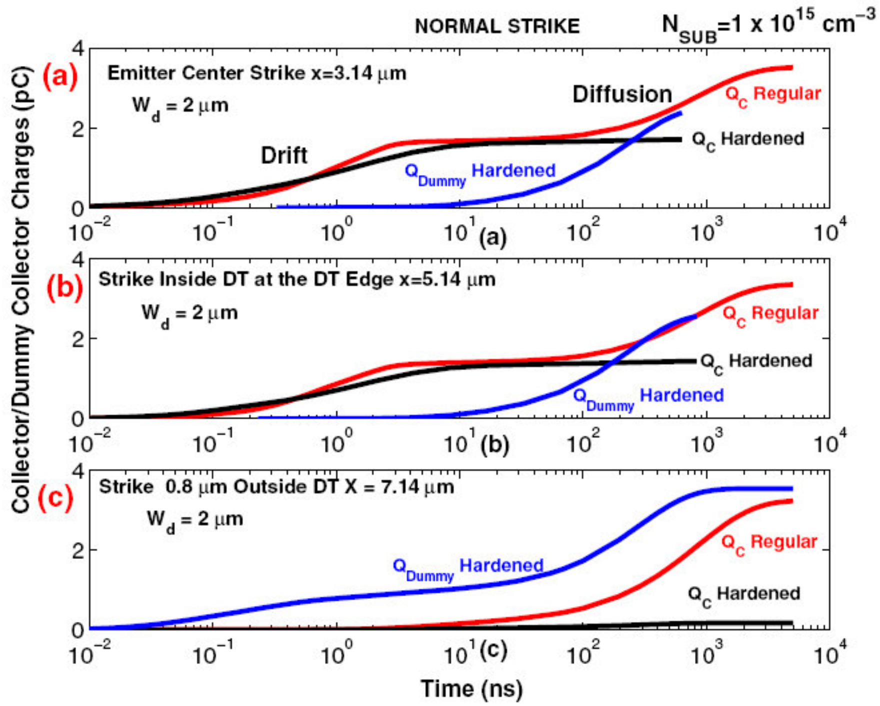


Fig. 5. Charge collection characteristics comparison for ion strike at (a) emitter center, (b) DT edge and (c) outside DT between the regular and hardened HBT.

TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

Angle Strike Mechanism

- **Diffusion charge collection suppressed**
- **Much shorter duration of charge collection**

Angled strike

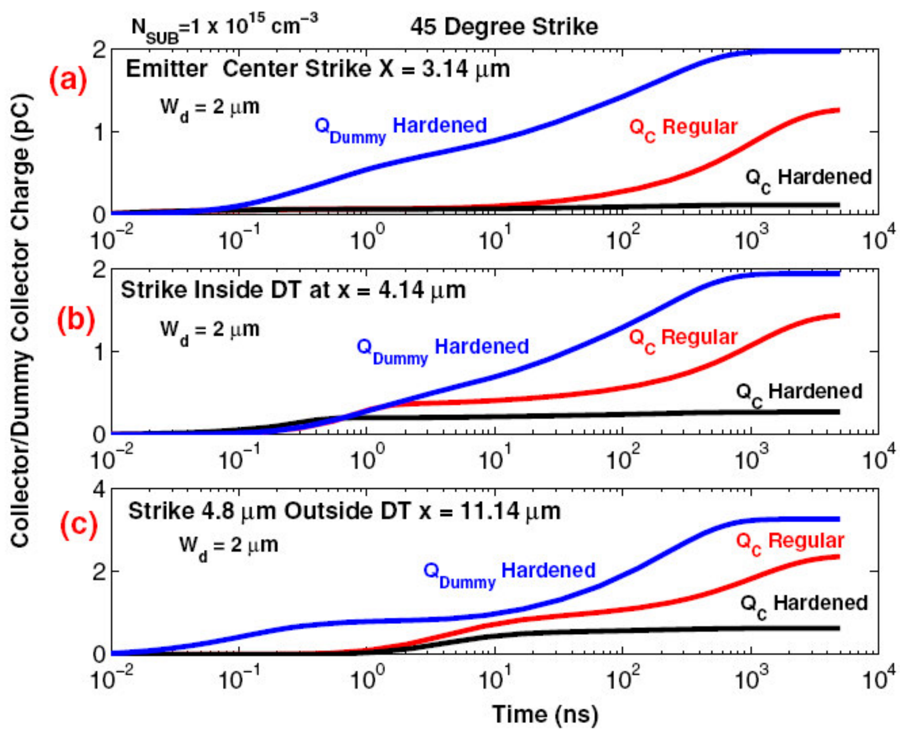


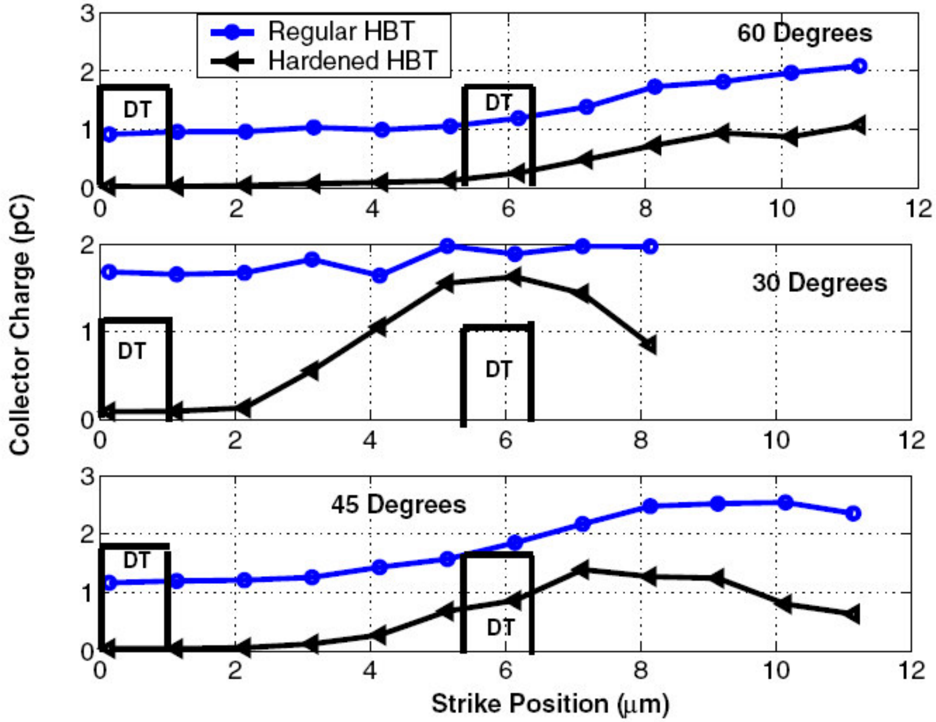
Fig. 7. Charge collection characteristics comparison for ion strike at (a) emitter center, (b) DT edge and (c) outside DT between the regular and hardened HBTs for $\theta = 45°$.

TECHNICAL HIGHLIGHTS

<u>**SiGe and Advanced Mixed Signal - Radiation**</u>

Single HBT Comparison for Angled Strike

- **Effective for all angles**
- **Overall cross section significantly reduced for 45 and 30 degrees of incidence**



TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

Multiple HBT arrays (2x2, 3x3, 4x4)

- **Charge collection by stuck device decreases with increasing array size due to more charge sharing**
- **Even for 4x4, each device collects considerable charge in regular HBTs**
- **Hardened HBTs collect much less charge (except for the struck HBT)**
- **For angle strikes in multiple HBT arrays, RHBD is effective in reducing charge collection by all HBTs**

TECHNICAL HIGHLIGHTS

3x3 HBT Array (normal, 30 and 45 degrees)

- **Significant reduction in all HBTs but the struck HBT for inside DT strike**
- **Significant reduction in all HBTs for outside DT strike**

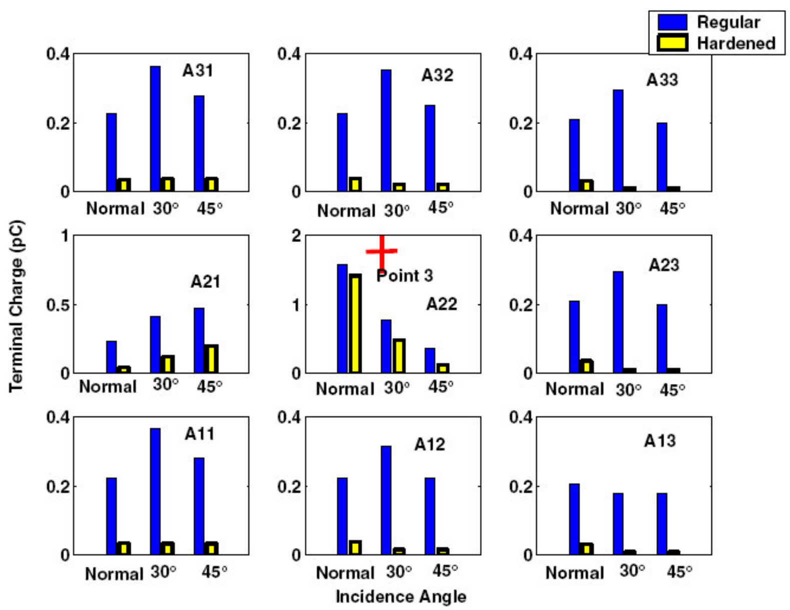


Fig. 15. Total charge comparison between 3x3 regular and hardened HBT arrays for normal, 30° and 45° ion strikes at point 3. The red cross indicates that the device A22 is hit by the ion.

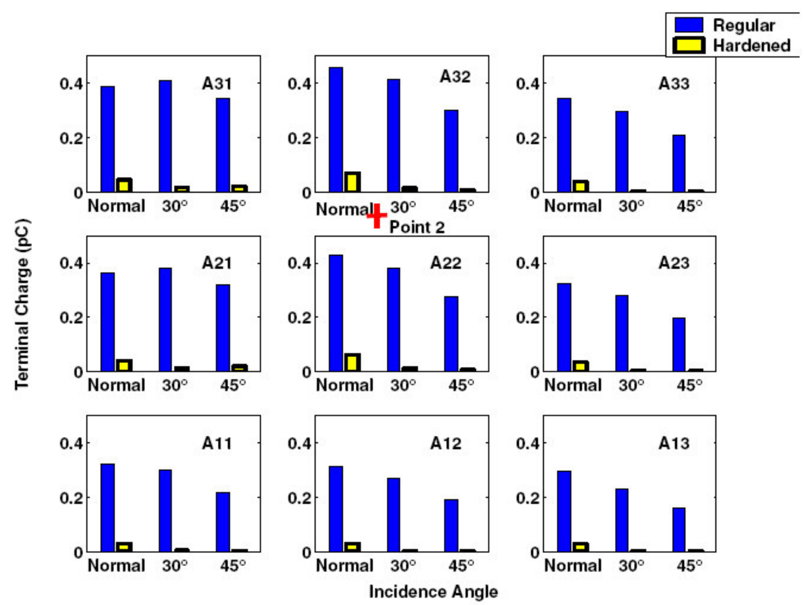


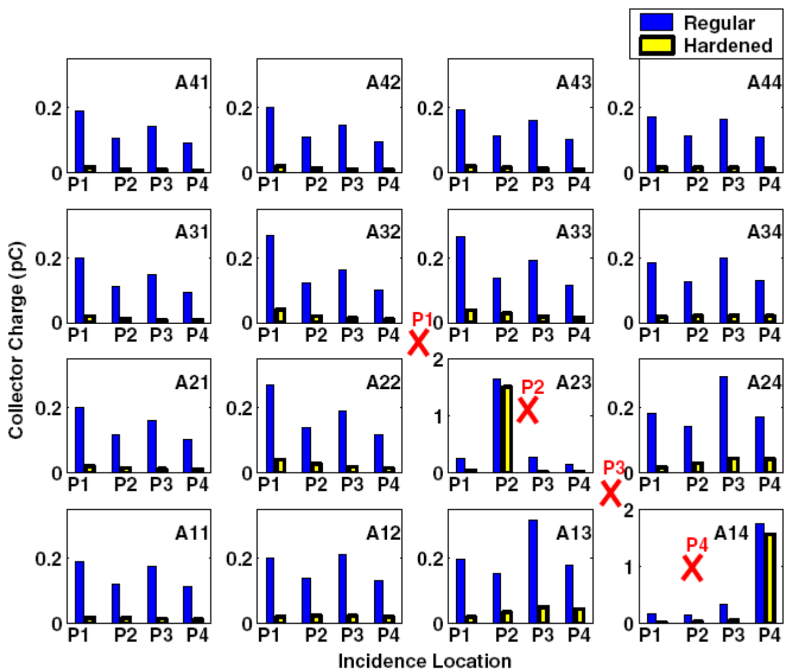
Fig. 16. Total charge comparison between 3x3 regular and hardened HBT arrays for normal, 30° and 45° ion strikes at point 2. The red cross indicates that the ion strike position is located between A32 and A22.

TECHNICAL HIGHLIGHTS

SiGe and Advanced Mixed Signal - Radiation

4x4 HBT Array

- **Normal incidence, 4 strike points**
- **RHBD not effective for only A23 HBT for P2 strike, and A14 HBT for P4 strikes**
- **All other HBTs collect much less charge**



ig. 17. Total charge comparison between 4x4 regular and hardened HBT arrays for 4 incident points.

PLANS FOR NEXT QUARTER

SiGe and Advanced Mixed Signal – Radiation

- Upcoming Experiments and Plans:
  - November 07 63MeV Proton Experiment
    - SEU at 300K and 77K on 16-bit SR
    - CMOS & HBT 4-bit X-band Phase Shifters
    - 4H-SiC VJFET at 300K and 77K
    - Passive elements on 5AM CRYO I (R,L,C)
    - Substrate lifetime at 300K and 77K
    - 65nm MODFET
    - ST Microelectronics SiGe HBT on SOI
  - December 07 Microbeam Experiment
    - Inverse-mode ECL Gates
    - TRIBICC on RHBD op-amp
  - NRL Laser Experiment
    - n-ring test structures

PLANS FOR NEXT QUARTER, cont.

SiGe and Advanced Mixed Signal – Radiation

- **SiGe HBT transient testing (NASA-MSFC RHESE leverage)**
  - **Second round of laser testing 2007-2008 Q1/Q2**
  - **Microbeam testing in 2007-2008 Q2**
- **Submit first round of SiGe transient testing to EDL for publication**
- **Investigate influence of substrate tap location in SiGe HBTs using DUTs from CRYO-II; slated for both TPA and microbeam testing (NASA-MSFC RHESE leverage)**
- **Begin to build burst error model for IBM 5HP SiGe HBT; logical extension of NSREC 2007 work. Attempt to submit to NSREC 2008.**
- **IBM 8HP SiGe HBT microbeam testing 2007-2008 Q24x4 HBT array angle simulation**
- **Mixed-mode simulation of the SiGe opamp circuit we have hardened with and without hardening**

Partnering

SiGe and Advanced Mixed Signal – Radiation

- Work partners
  - University partners: Vanderbilt University, Georgia Institute of Technology, and Auburn University
  - Industry partners: IBM, Jazz Semiconductor, National, BAE, TI, IHM
  - Others include The Mayo Foundation, The Naval Research Lab, OGAs

- Primary NEPP leverage is with the RADSAFE task with Vanderbilt

- Other significant leveraging includes:
  - DARPA/DTRA Radiation Hardening by Design Program (Boeing)
  - NASA's Code T Extreme Environments Program (Cryo SiGe)
  - DoD via Vanderbilt-led Multidisciplinary University Research Initiative (MURI)
  - OGA interests in high speed technologies via collaborations with Mayo and NRL
  - DTRA/NRL developments in 2-photon absorption for SiGe

PROBLEMS AND CONCERNS

SiGe and Advanced Mixed Signal – Radiation

- Plans for GSFC testing of 3D SOI high speed registers have been delayed due to poor yield of Lincoln Labs FD-SOI. Another fab run is planned.