Geant 4
Version 10.0-p01

Concluding Remarks

Makoto Asai (SLAC PPA/SCA)
on behalf of the SLAC Geant4 Team

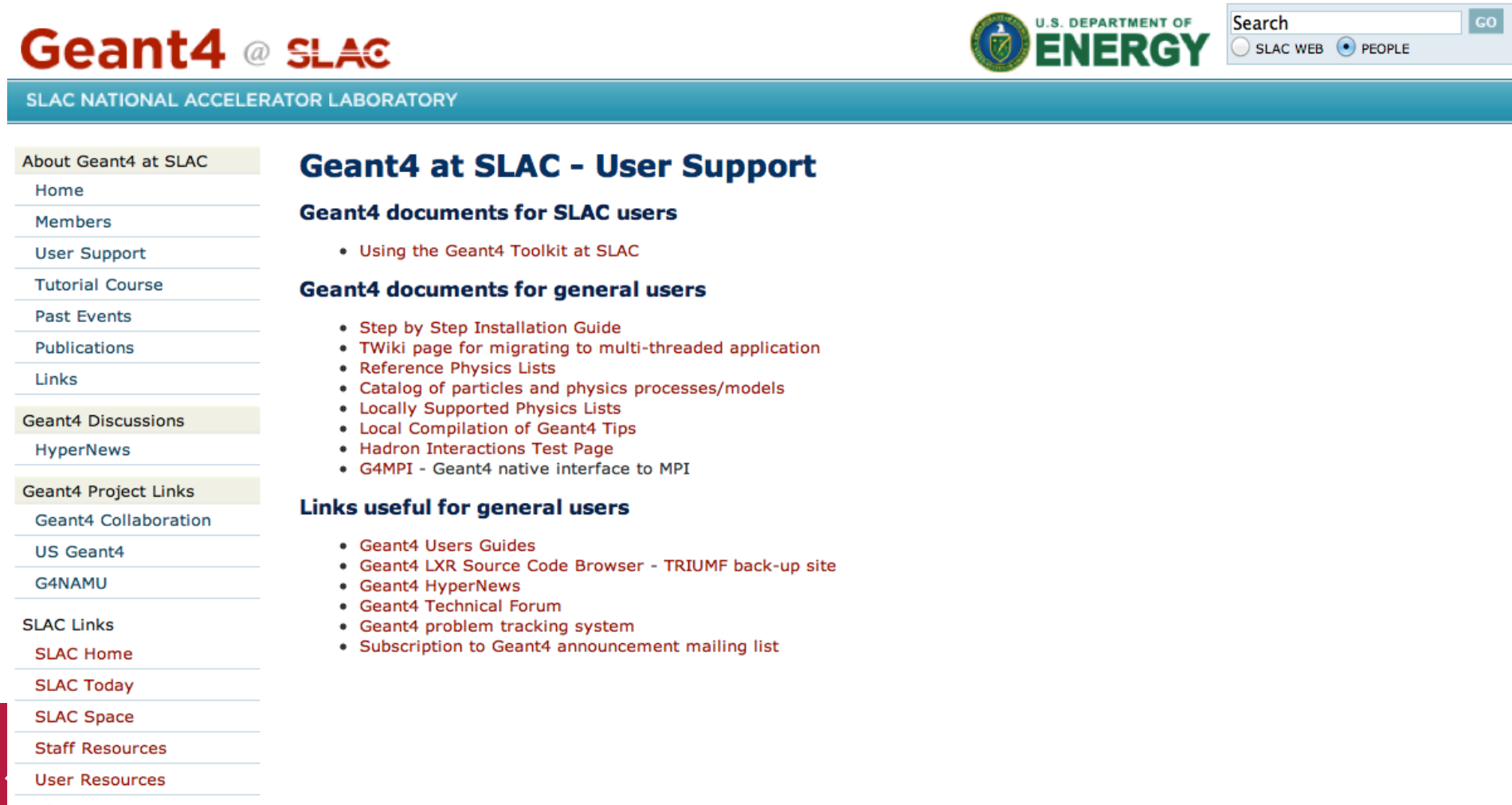
Concluding remarks

- The SLAC Geant4 team sincerely hope you could enjoy our tutorial and you found it informative and useful.
- Let me add a few more slides for
  - Following up
  - Introducing the SLAC Geant4 Team

Following up - 1

http://geant4.slac.stanford.edu/

- Please keep maintaining your Geant4 installation updated.
  - Irregular patch releases may be more important than regular releases.
  - Check our web page regularly to find release news, or register to Geant4 announcement mailing list.



Following up - 2

- If you have a question
  1. Look for our documents.
     - Users guides, Twiki pages, tips pages, examples and their READMEs
  2. Post your question on Geant4 HyperNews

     http://hypernews.slac.stanford.edu/HyperNews/geant4/cindex
     - Please make sure to do a bit of survey that no one has already asked the same question before.
  3. As the final method, write us a mail.
     - Avoid anonymous mail account such as hotmail, gmail, etc., if possible.
     - Mention you attended our SLAC Geant4 tutorial 2014.
  4. Or, catch us at meetings/conferences.
     - Apologies if we cannot recognize you…

Following up - 2

- If you have a question

Geant4 @ SLAC

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- US Geant4
- G4NAMU

SLAC Links
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- SLAC Today
- SLAC Space

Geant4 at SLAC - User Support

Geant4 documents for SLAC users

- Using the Geant4 Toolkit at SLAC

Geant4 documents for general users

- Step by Step Installation Guide
- TWiki page for migrating to multi-threaded application
- Reference Physics Lists
- Catalog of particles and physics processes/models
- Locally Supported Physics Lists
- Local Compilation of Geant4 Tips
- Hadron Interactions Test Page
- G4MPI - Geant4 native interface to MPI

Links useful for general users

- Geant4 Users Guides
- Geant4 LXR Source Code Browser - TRIUMF back-up site
- Geant4 HyperNews
- Geant4 Technical Forum
- Geant4 problem tracking system
- Subscription to Geant4 announcement mailing list

Following up - 3

- N

10th Geant4 Space Users Workshop

May 27-29, 2014
Jackson Center, Huntsville, AL

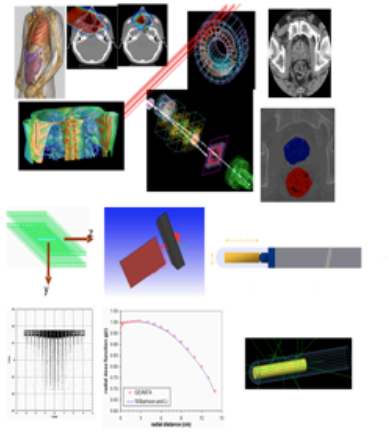
Geant4 Space Users Workshop
Home
Scientific program
Registration

News
- *Feb. 19, 2014* - First announcement
- *Mar. 8, 2014* - Second

G4NAMU

The Geant4 North American Medical User Organization

Home News Tutorials Links



What ...
G4NAMU was launched in May of 2005 to provide a meeting place for the rapidly growing Geant4 medical user community of North America. The purpose of G4NAMU is to bring this community together to share issues and advice, to develop regional collaboration and to communicate as a group to the Geant4 developers.

Who ...
G4NAMU's current membership includes 178 members from 86 institutions throughout North America.

While many G4NAMU resources are provided by the SLAC National Accelerator Laboratory's Geant4 team, G4NAMU is intended to be a consensus organization that evolves as needed by its members.

How ...
G4NAMU communicates through a mailing list, geant4-namu@slac.stanford.edu. The list is lightly moderated just to maintain focus and prevent spam.

- To join the list, send mail to perl@slac.stanford.edu
- Hints on using the mailing list

Latest News ...

G4NAMU at AAPM Charlotte

- G4NAMU members attending the American Association of Physicists in Medicine 54th Annual Meeting in Charlotte will meet on Sunday, July 29th from 6 - 8 PM.
- Location: Westin Charlotte Hotel (the AAPM Headquarters hotel across the street from the Convention Center). First Floor (also called Lobby Level): Providence Ballroom III
- We will have a few short presentations, and then plenty of time for discussions, over drinks and snacks.
- Everyone is welcome. You do not need to already be familiar with Geant4 or G4NAMU.
- See the Agenda Page for all the details.

Past tutorials

Geant4 @ SLAC

U.S. DEPARTMENT OF ENERGY

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Past Events

User meetings organized by SLAC Geant4 team

- G4NAMU meeting - July 29, 2012
- G4NAMU meeting - July 31, 2011
- 7th Geant4 Space Users Workshop - August 18-20, 2010 - co-organized with Boeing Co., NASA/JPL and Vanderbilt University
- G4NAMU meeting - July 18, 2010
- G4NAMU meeting - July 26, 2009
- G4NAMU meeting - July 27, 2008
- Symposium on Particle Beams in Cancer Management - April 18, 2008 - co-organized with Dept. of Radiation Oncology, Stanford Univ.
- 4th Geant4 Space Users Workshop - November 6-10, 2006 - co-organized with NASA/JPL
- 2nd Geant4 Space Users Workshop - May 10-12, 2004 - co-organized with Vanderbilt University
- 1st International Geant4 Users Workshop - February 18-20, 2002

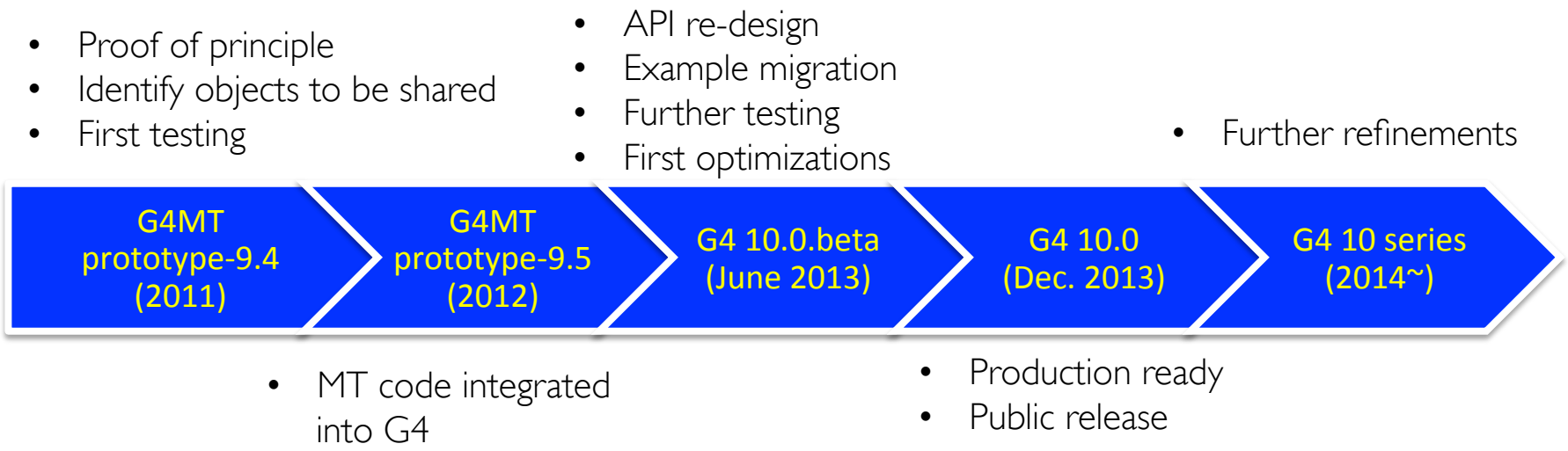
Geant4 tutorials conducted by SLAC Geant4 team

- Jefferson Lab, Virginia - July 9-13, 2012
- NASA/MSFC, Alabama - April 9-12, 2012
- University of Pennsylvania, Pennsylvania - May 14-18, 2011
- Oak Ridge N.L., Tennessee - March 8-11, 2011
- Texas A&M University, Texas - January 10-14, 2011
- Puebla, Mexico - June 14-18, 2010
- SLAC - November 02-06, 2009
- SLAC - May 14-18, 2007
- NASA JPL, California - November 10, 2006
- McGill University, Quebec, Canada - September 25-28,2006
- Jefferson Lab, Virginia - May 22-25, 2006
- SLAC - March 7-10, 2006
- Helsinki Institute of Physics, Finland - June 6-7, 2005
- ESA/ESTEC, Netherlands - March 3, 2005
- SLAC - March 8-10, 2004
- Vanderbilt University, Tennessee - January 12-14, 2004
- Fermilab, Illinois - October 27-29, 2003
- SLAC - February 18-20, 2002

For the complete list of past events, please visit Geant4 Collaboration web page.

Beyond Geant4 version 10.0

- Geant4 version 10 series will be improving at least for five or more years.
  - Performance improvements
  - Missing functionalities yet to be migrated to multithreading,
  - Additional APIs
  - Additional functionalities
  - New physics



SLAC Geant4 team

SLAC Geant4 team is actively involving to the international Geant4 collaboration.

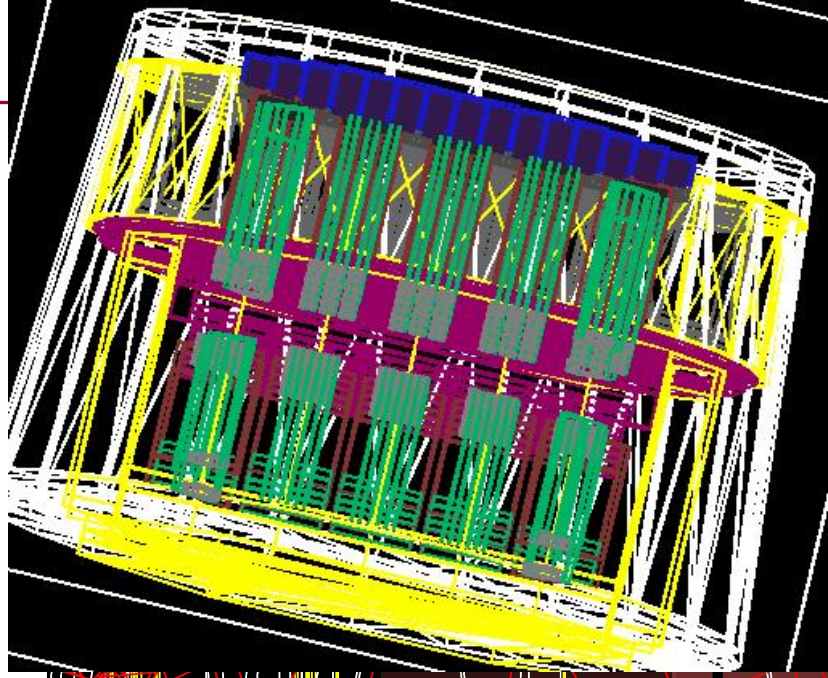
- Geant4 Kernel, hadronic physics, visualization and many other categories
- Computing and physics performance monitoring & improvements

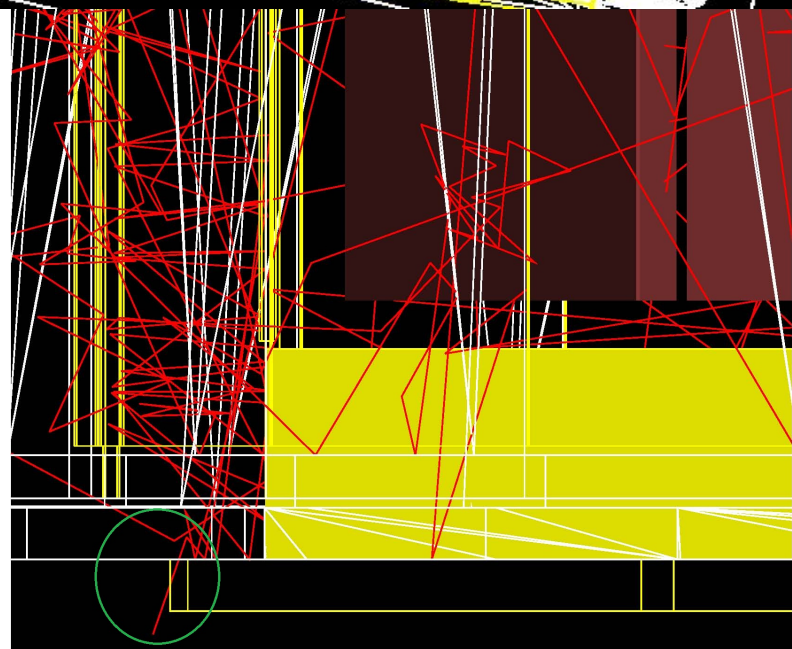
SLAC Geant4 team is extending Geant4 to meet the domestic needs.

- Channeling effect in atomic lattice
- Phonon transport in cryogenic crystal
- Neutrino physics

SLAC Geant4 team is collaborating with users.

- Thermal motion of atoms in vacuum cryostat
- Single molecule irradiation
- Electron / hole transport in semiconductor
- Activation
- Offering the best-of-the-world expertise on Geant4





Software quality assurance (http://code.google.com/p/gooda/)

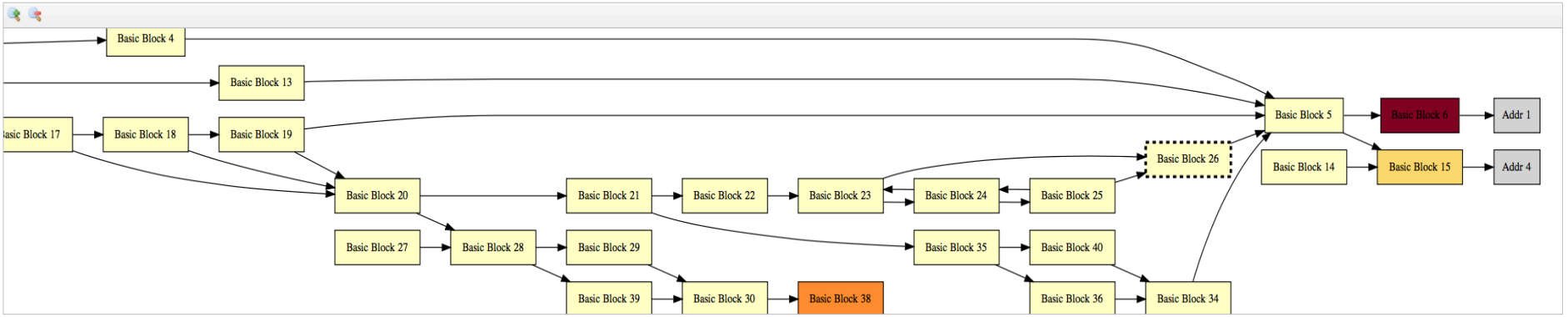
- SLAC is working with Google on performance measurements of Geant4-based application using Gooda tool, a PMU-based event data analysis package.

Cycles Samples — Enter search term

address	princ_l#	disassembly	unhalted_core_cycles		uops_retired:stall_cycles		instruction_retired	uops_retired:any		load_latency		instruction_starvation		bandwi
			249801	(100%)	183440	(73%)	81361	96333	157004	(62%)	102099	(40%)	3478	(1%
0x30ce8	521	Basic Block 26 <0x30b2b>	268	(0%)	146	(54%)	95	105			20	(7%)		
0x30ce8	521	lea 0x0(,%rax,8),%r8	139	(0%)	102	(73%)	32	38			20	(14%)		
0x30cef	521	null												
0x30cf0	521	lea 0x8(,%rax,8),%r9	80	(0%)	37	(46%)	48	60						
0x30cf7	521	null												
0x30cf8	521	jmpq 30b2b	50	(0%)	7	(14%)	16	8						
0x30cfd	521	Basic Block 27 <0x30d00>												
0x30cfd	521	nopl (%rax)												
0x30d00	521	Basic Block 28 <0x30ed9…	7463	(2%)	5649	(75%)	3111	3133	3478	(46%)	4929	(66%)	129	
0x30d00	521	movq %xmm0,-0x8(%rsp)	805	(0%)	548	(68%)	317	286	99	(12%)	378	(46%)	20	
0x30d06	521	mov -0x8(%rsp),%rax	805	(0%)	716	(88%)	206	264	10	(1%)	566	(70%)	20	
0x30d0b	521	mov %rax,%rcx	566	(0%)	438	(77%)	190	173	70	(12%)	298	(52%)		
0x30d0e	521	shr $0x34,%rcx	517	(0%)	373	(72%)	222	271	30	(5%)	149	(28%)		
0x30d12	521	sub $0x3ff,%ecx	119	(0%)	88	(73%)	32	60						
0x30d18	521	cvtsi2sd %ecx,%xmm4	199	(0%)	95	(47%)	40	60			20	(10%)		
0x30d1c	521	mov $0x800ffffffffffff…	1232	(0%)	957	(77%)	484	505	60	(4%)	765	(62%)	30	
0x30d23	521	null												
0x30d26	521	and %rcx,%rax	10	(0%)				8						
0x30d29	521	mov $0x3fe00000000000…												
0x30d30	521	null												
0x30d33	521	or %rcx,%rax												

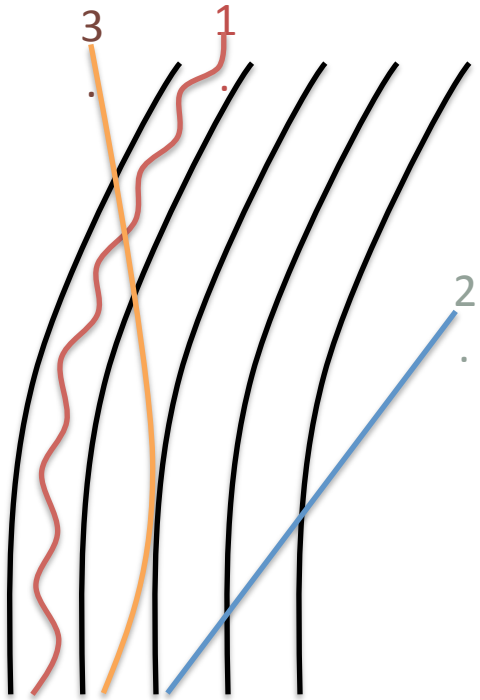
Cycles Samples — Enter search term

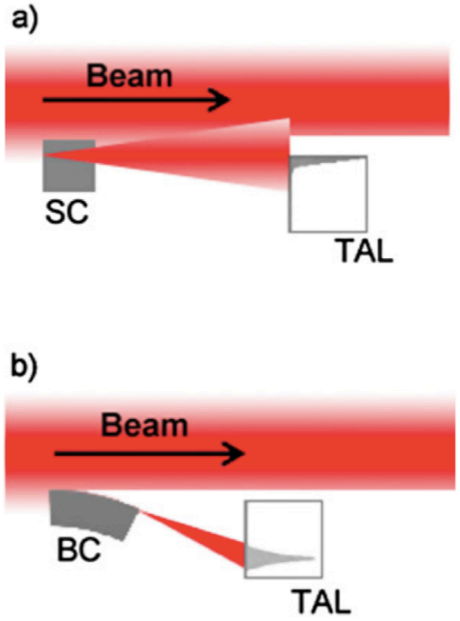
line number	source	unhalted_core_cycles		uops_retired:stall_cycles		instruction_retired	uops_retired:any		load_latency		instructi
		249801	(100%)	183440	(73%)	81361	96333	157004	(62%)	102099	(40%)
513	G4double y;										
514	if(theEnergy <= edgeMin) {	43596	(17%)	35500	(81%)	5730	7862	24814	(56%)	19478	(44%)
515	lastIdx = 0;	636	(0%)	519	(81%)	63	120	308	(48%)	318	(50%)
516	y = dataVector[0];	1202	(0%)	1082	(90%)	111	158	4035	(335%)	924	(76%)
517	} else if(theEnergy >= edgeMax) {	3170	(1%)	2353	(74%)	651	738	1113	(35%)	1520	(47%)
518	lastIdx = numberOfNodes-1;										
519	y = dataVector[lastIdx];										
520	} else {										
521	lastIdx = FindBin(theEnergy, lastIdx);	109860	(43%)	76853	(69%)	45196	54010	65906	(59%)	41559	(37%)
522	y = Interpolation(lastIdx, theEnergy);	84798	(33%)	61193	(72%)	29102	32887	59616	(70%)	35646	(42%)
523	}										
524	return y;										
525	}	6539	(2%)	5941	(90%)	508	557	1034	(15%)	2554	(39%)
526											
527	//----------										
528											
529	G4double G4PhysicsVector::FindLinearEnerg…										
530	{										
531	if(1 >= numberOfNodes) { return 0.0; }										
532	size_t n1 = 0;										
533	size_t n2 = numberOfNodes/2;										
534	size_t n3 = numberOfNodes - 1;										

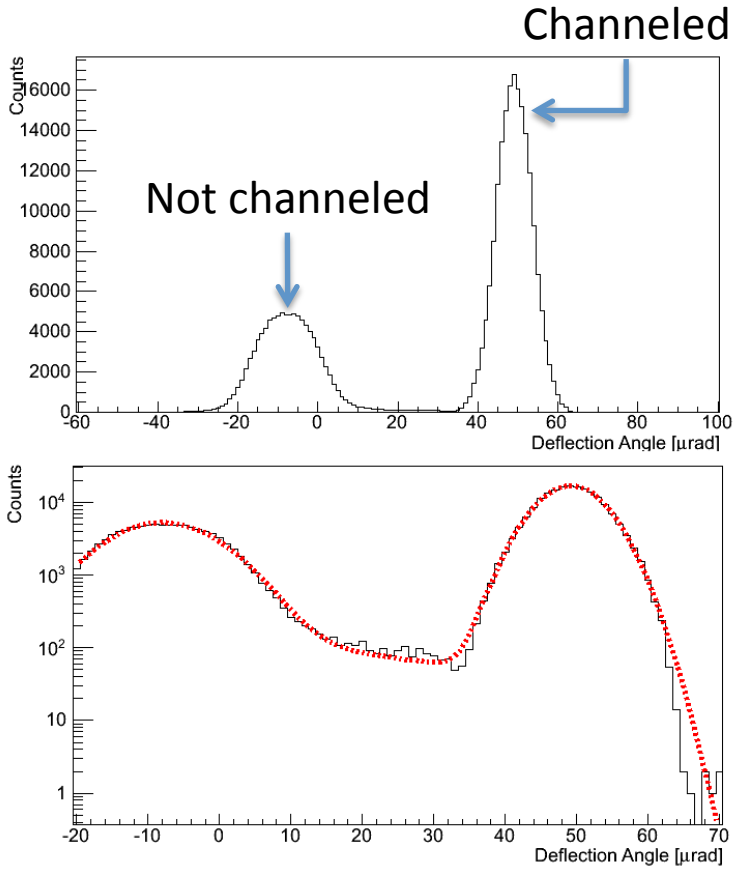


Bent crystal as a collimator

- Bent crystal can be used as a collimator to deflect particles of beam halo.
- This study will be extended for T-513 experiment at SLAC LCLS ESTB







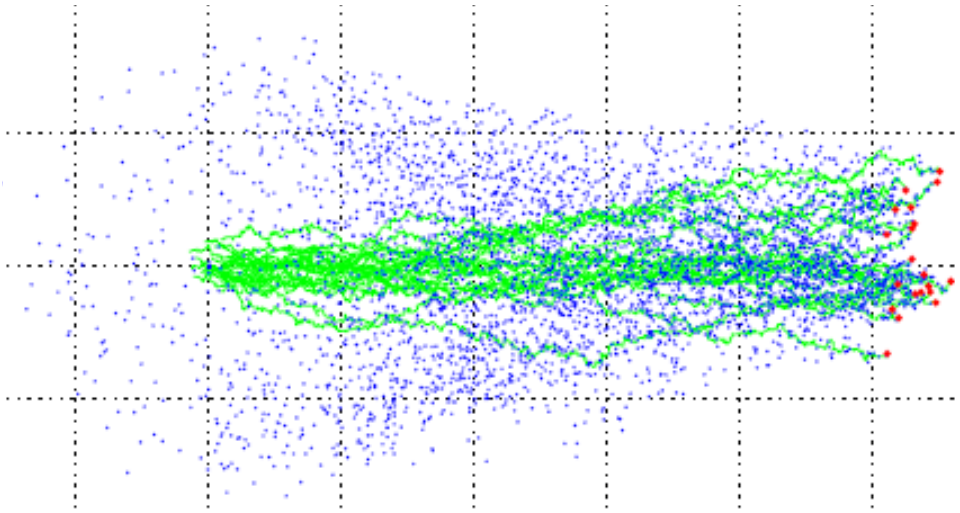
Enrico Bagli (INFN/Ferrara and SLAC)

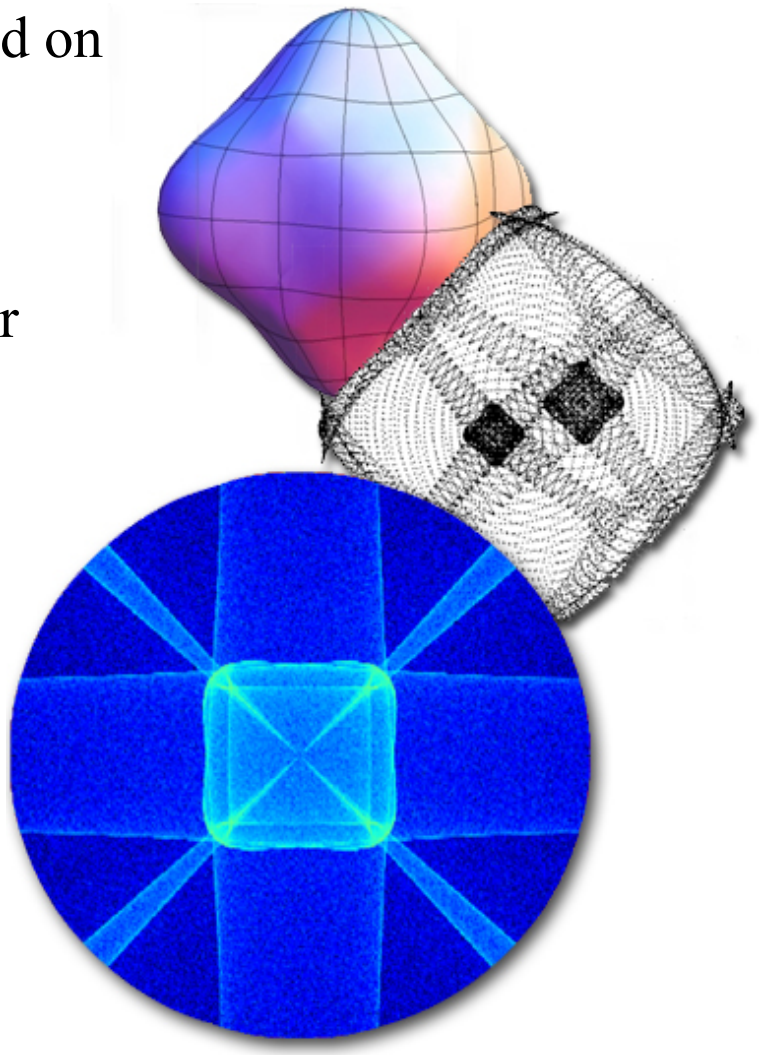
- W. Scandale et al., Phys. Lett. B 680 (2009) 129

Condensed Matter Physics in Geant4

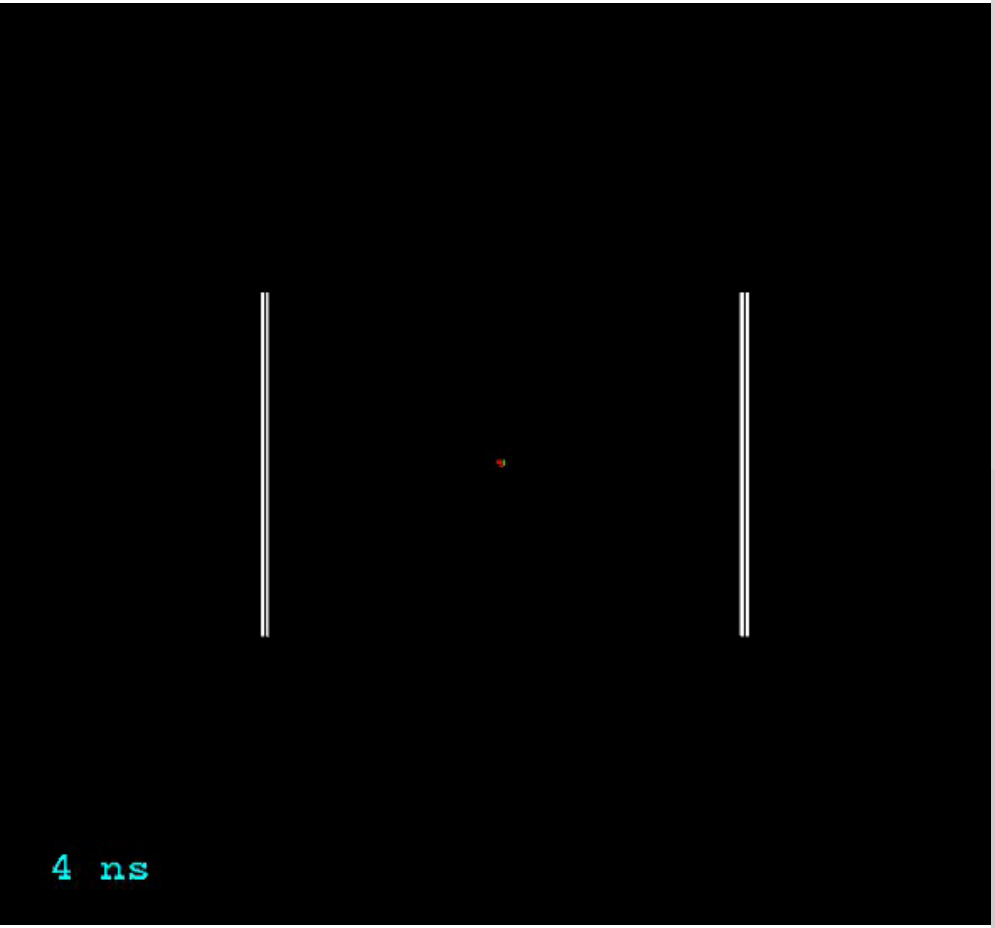
- Phonon propagation, including focusing based on elasticity tensor (right)

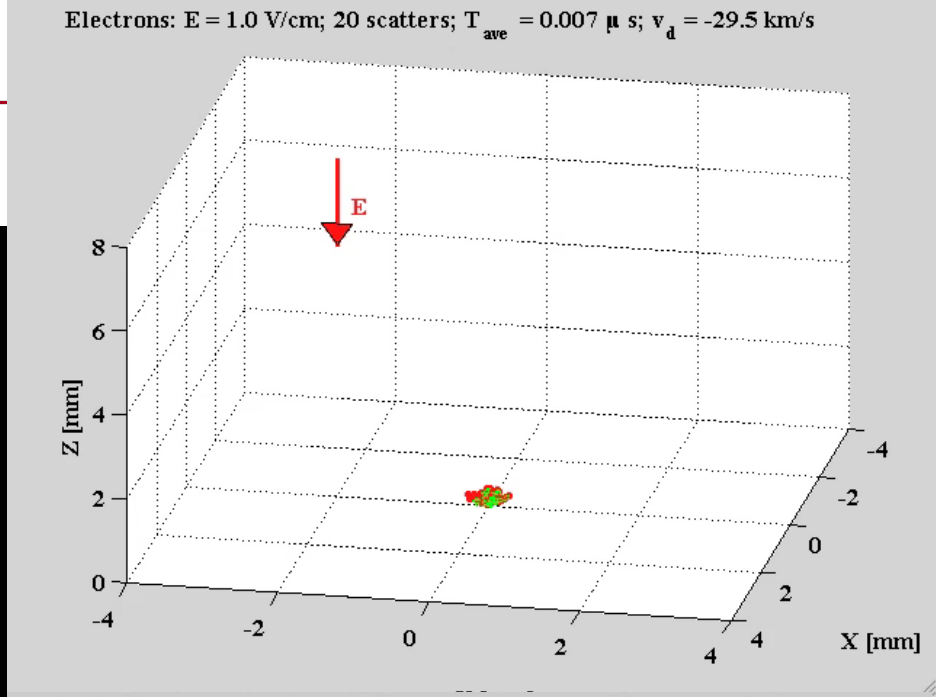
- e-/h+ transport, including conduction band anisotropy and Luke-Neganov emission, under development (below)

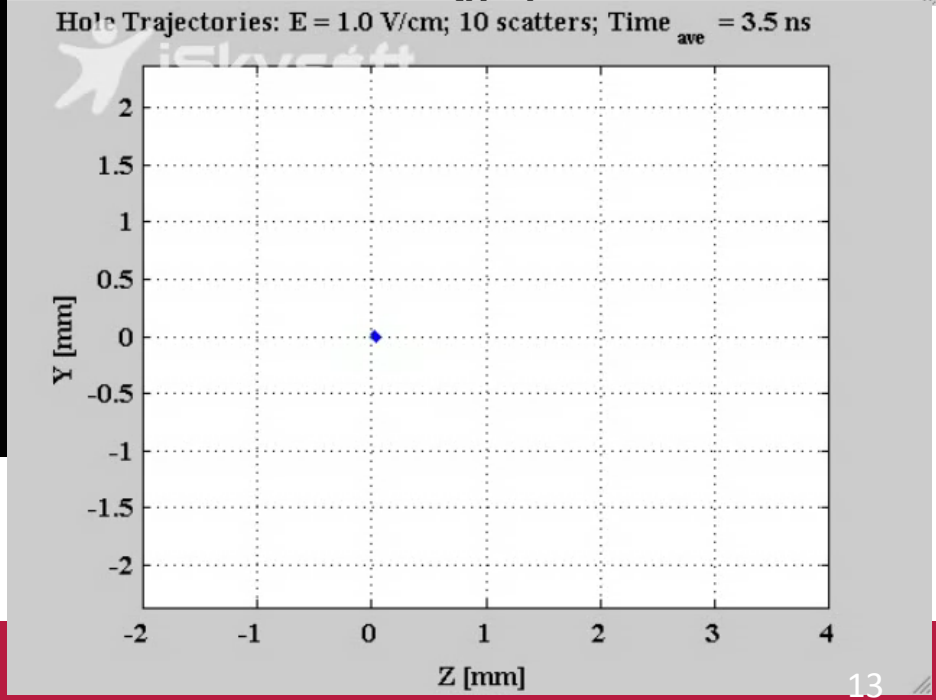




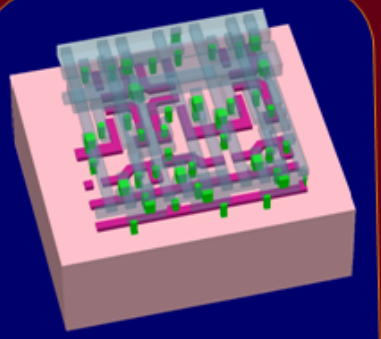
e-/h propagation with Luke phonon emission in Ge crystal



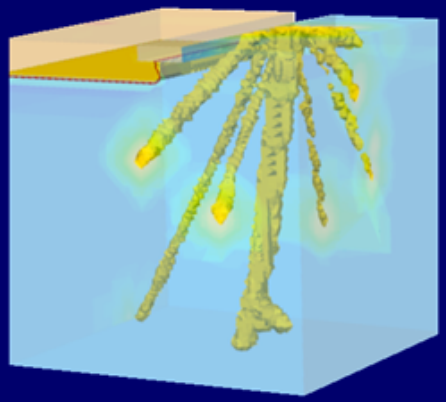




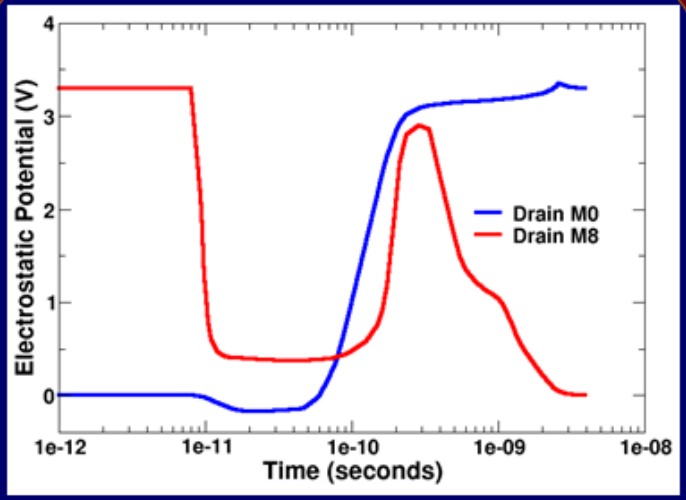
RADSAFE on SEE in SRAMs



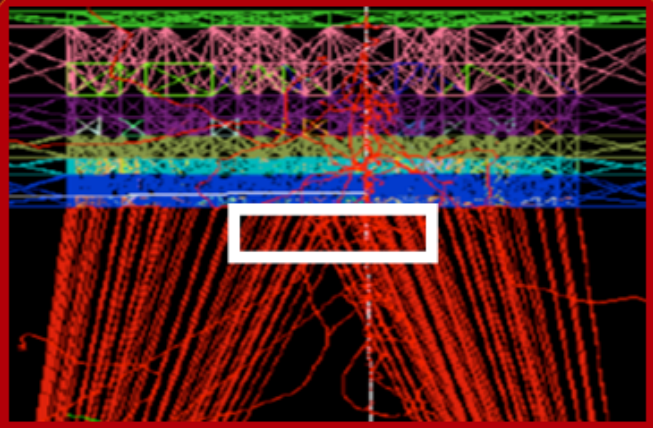
TCAD Cell Structure: SRAM Cell



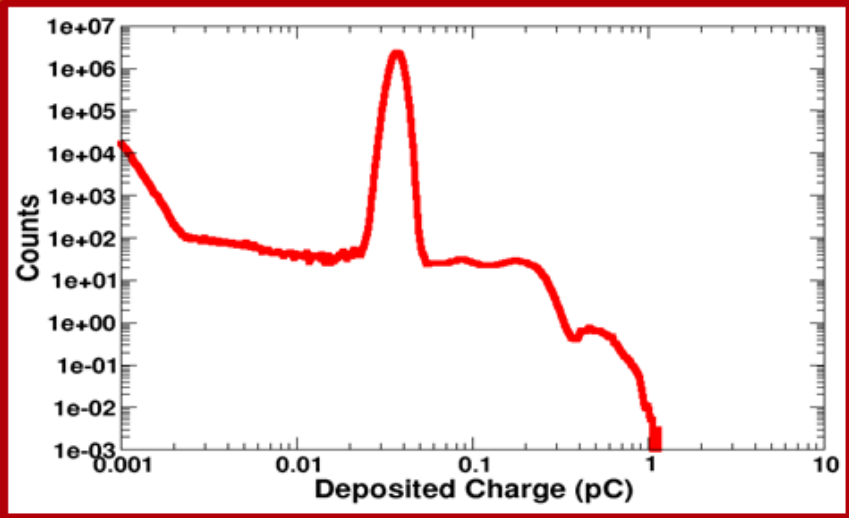
Single Charge Deposition in TCAD: Ne+W Event



SRAM Cell Upset



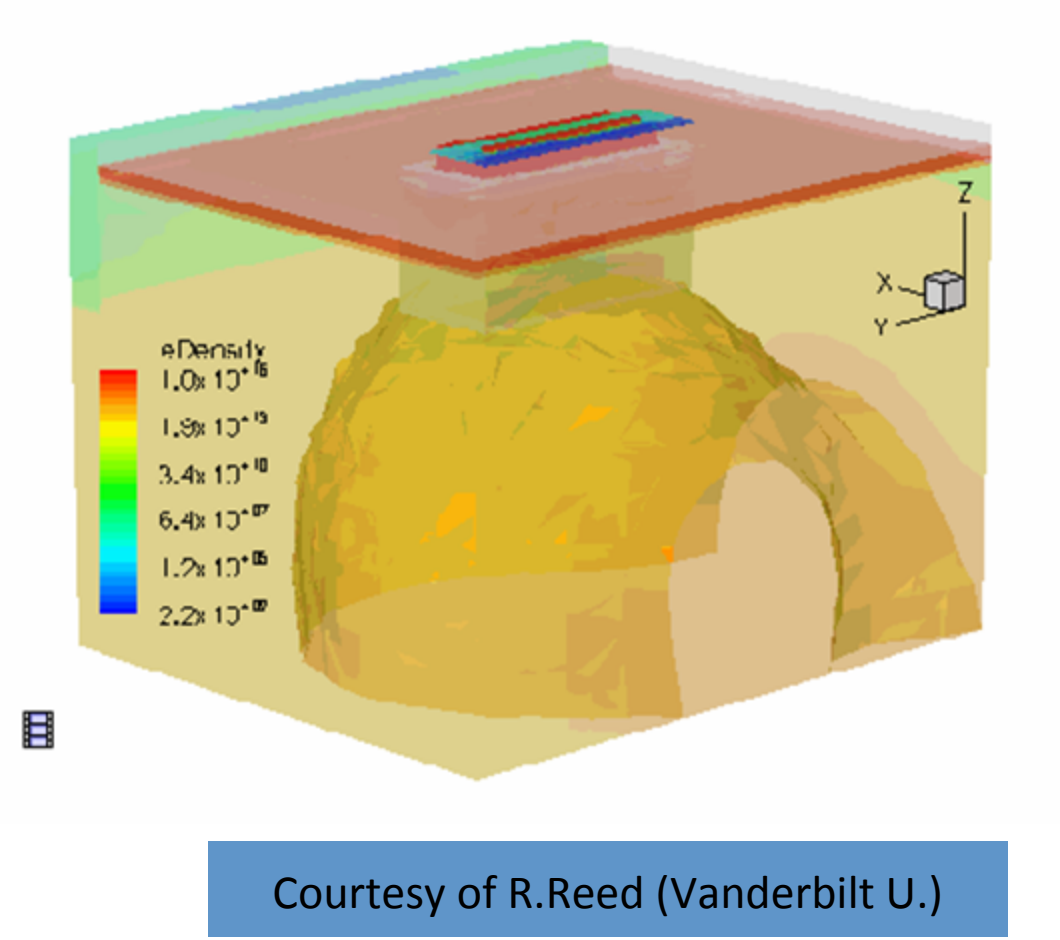
Geant4 Geometry and 523 MeV Neon Event

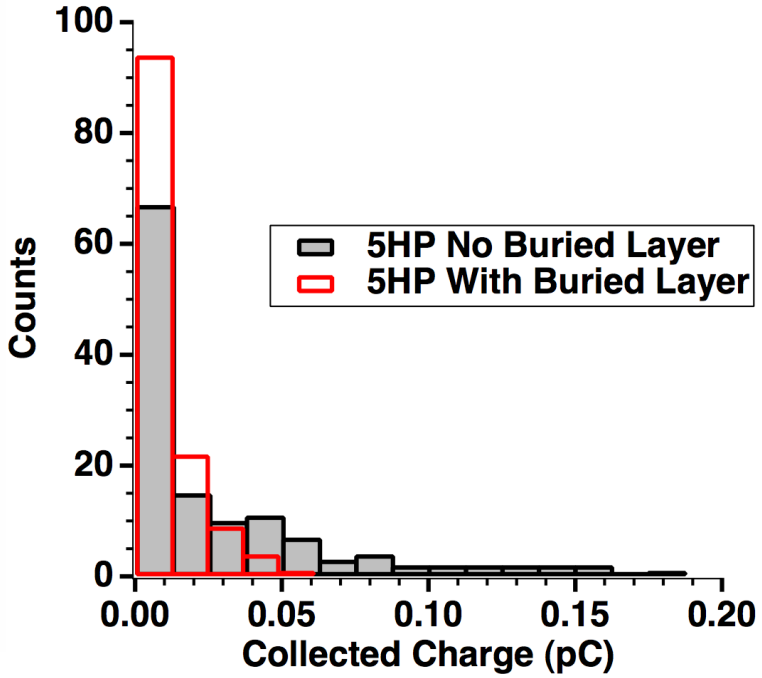


MRED Energy Deposition for 10^8 Events

Simulation of Radiation Events

- 63-MeV proton incident on a SiGe Heterojunction Bipolar Transistor (HBT)
- Iso-charge surfaces following a nuclear reaction





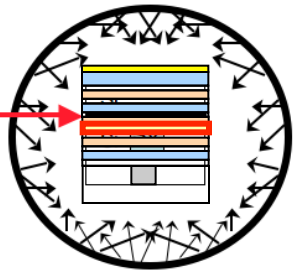
Courtesy of R.Reed (Vanderbilt U.)

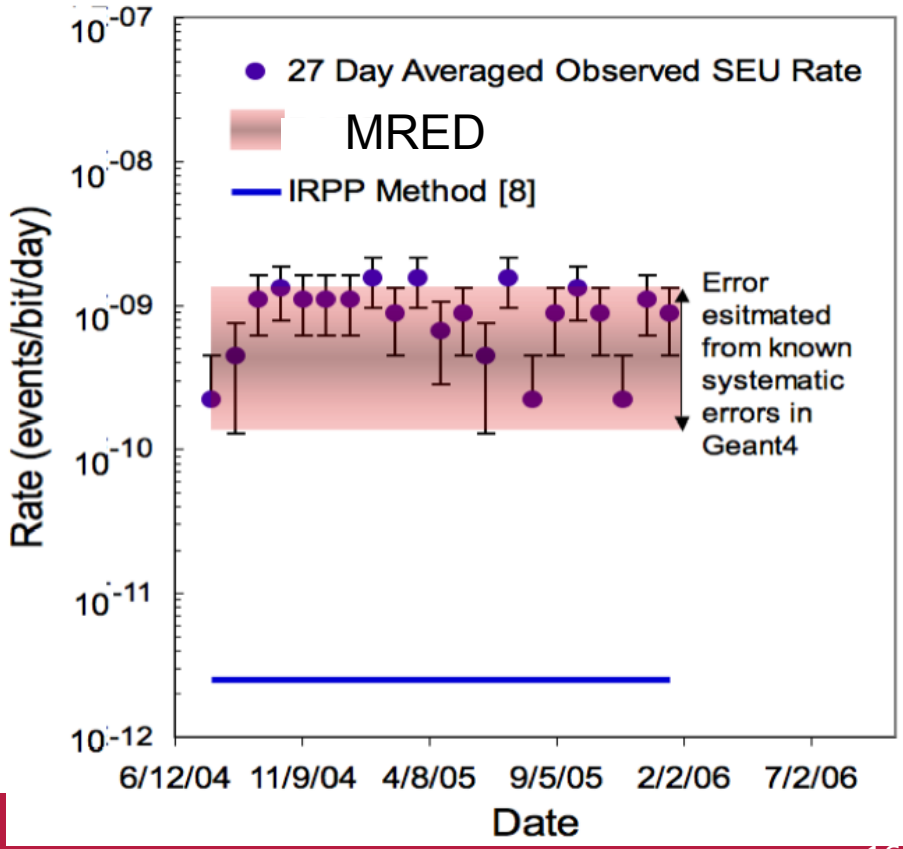
Observed and Predicted SEU Rate for an SRAM

- SRAM used on NASA spacecraft
- Observed Average SEU Rate:
  - $1x10^{-9}$ Events/Bit/Day
- Vendor predicted rate:
  - $2x10^{-12}$ Events/Bit/Day
  - Classical Method nearly a factor 500 lower than observed rate
- MRED rate (includes reaction products):
  - Between $1.3x10^{-10}$ and $1.3x10^{-9}$ Errors/Bit/Day

Courtesy of R.Reed (Vanderbilt U.)

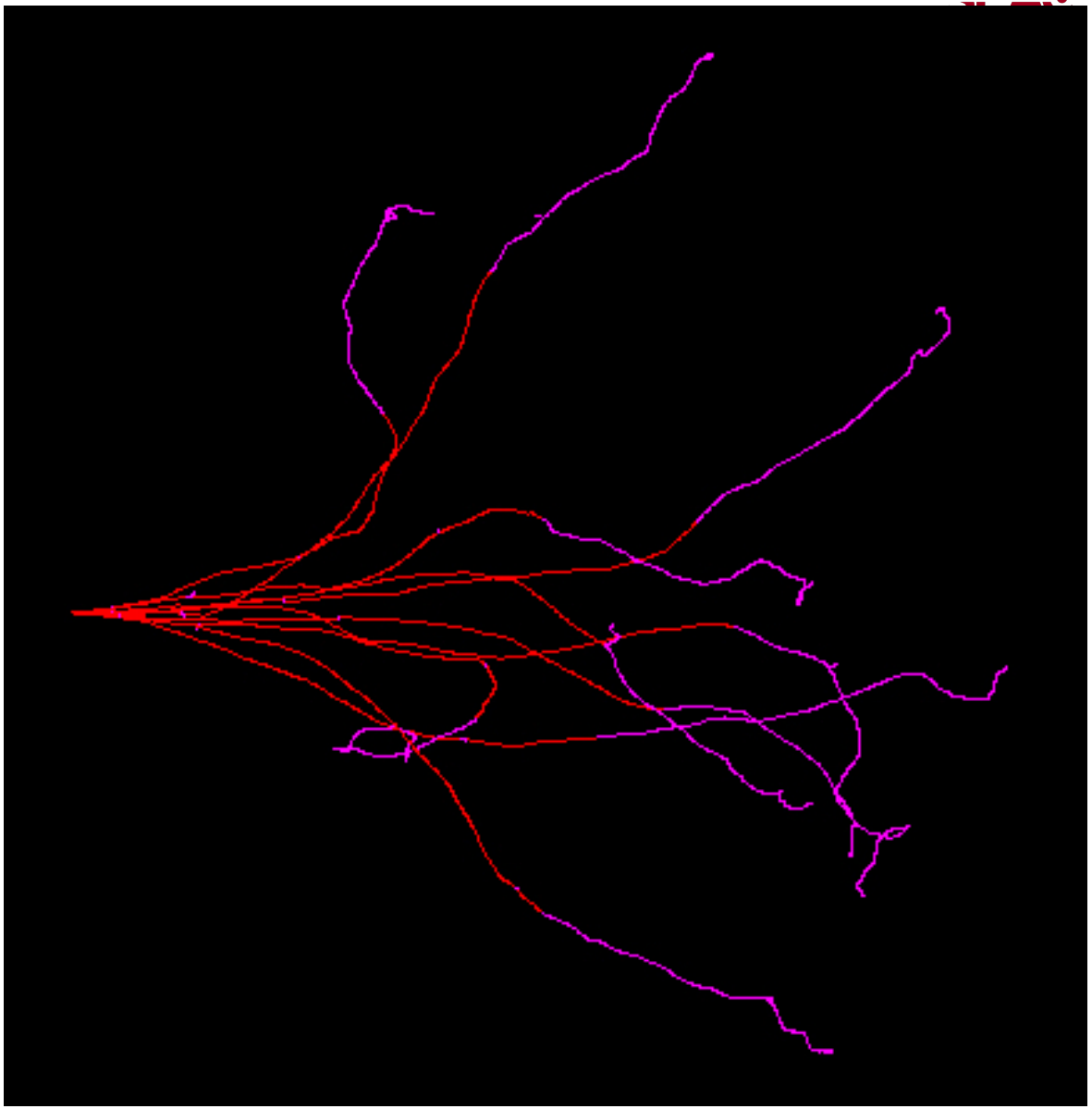
Multi-layered Stack



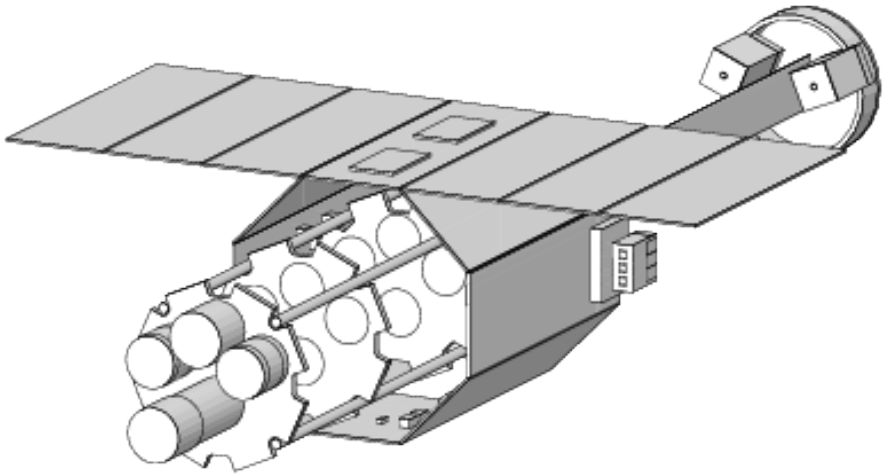


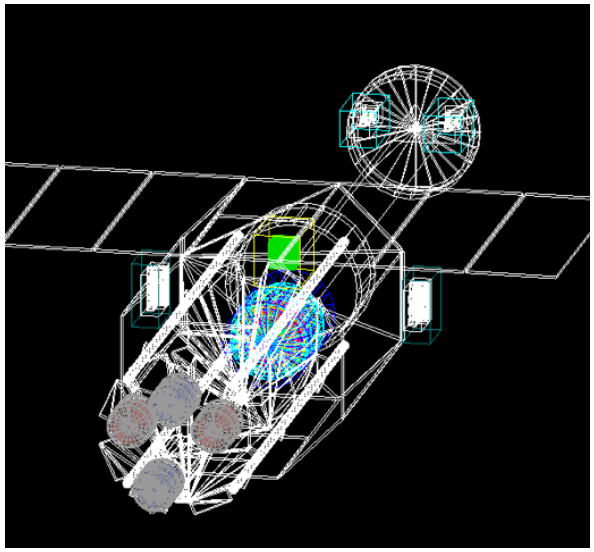
Connecting Geant4 and Fortran Penelope code

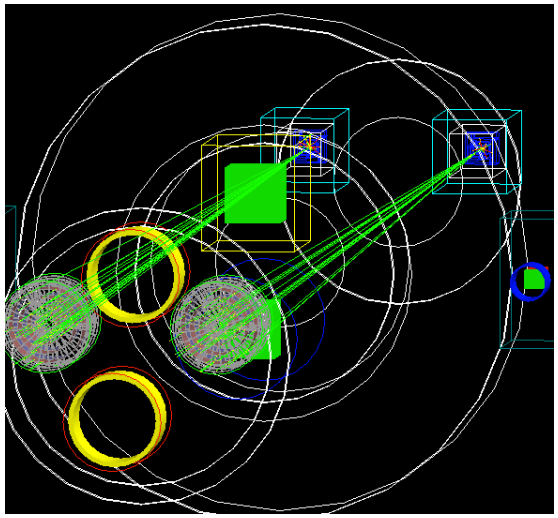
- Geant4 physics takes care of tracking electrons down to 500 keV (red lines), and then Penelope physics (including its native multiple scattering) takes care of them down to 50 eV (purple lines).
- Everything is inside Geant4 framework. Penelope Fortran code is wrapped in G4VProcess base class.

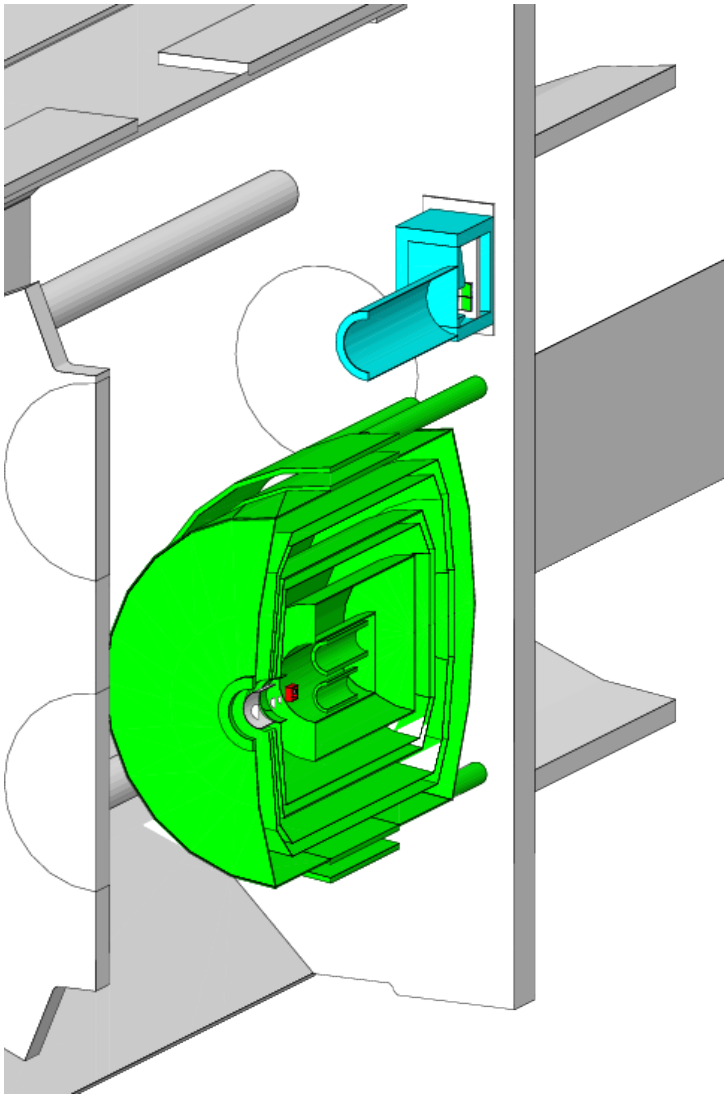


ASTRO-H (1)





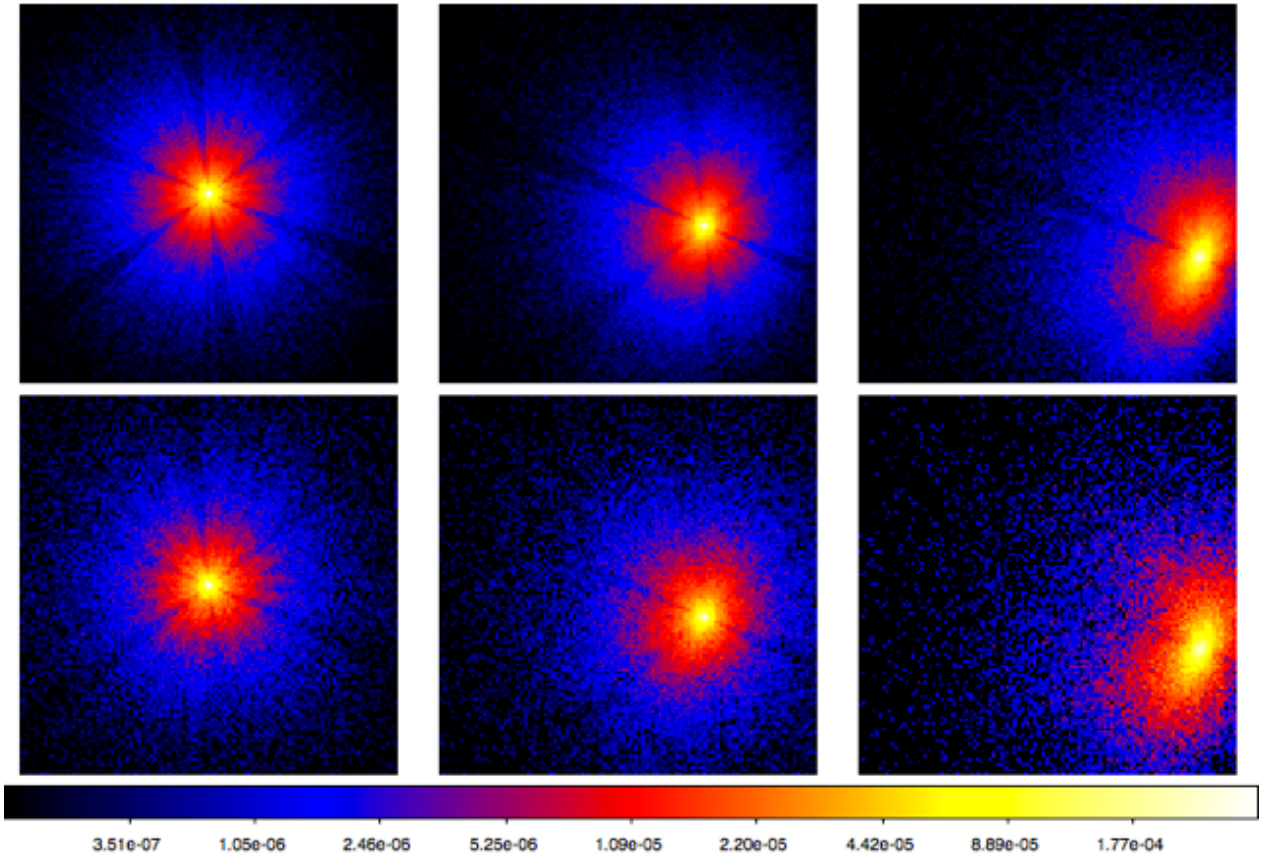




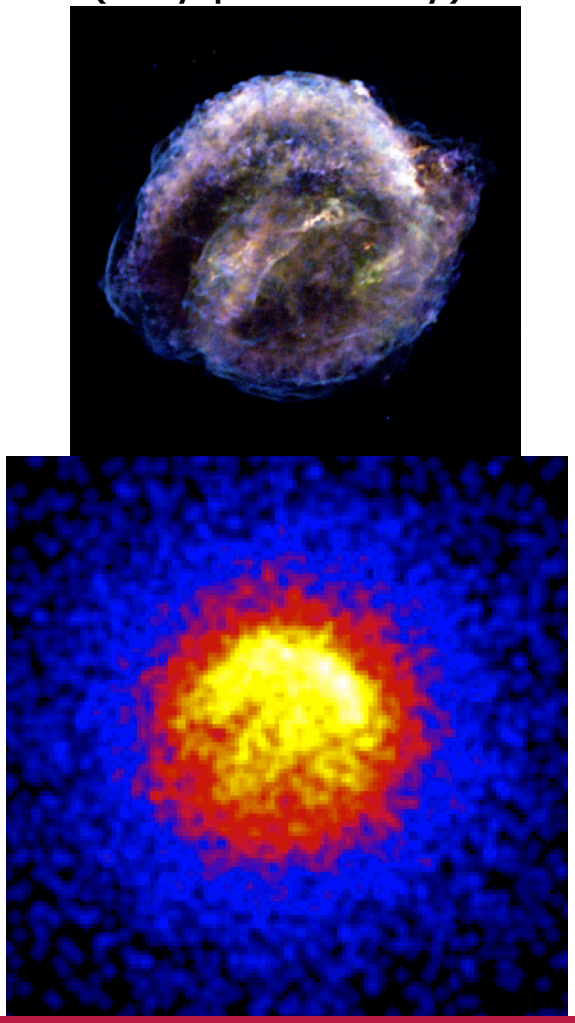
SXI and SXS

ASTRO-H (2)

Point source on HXI
Left; center; right - 0arcmin; 2arcmin; 4arcmin
top; bottom - 10keV; 30keV

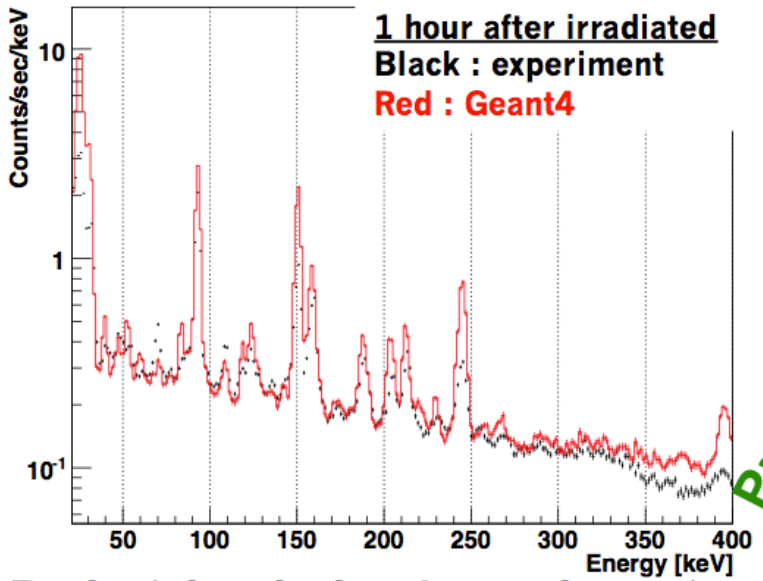


Kepler SNR on HXI
(very preliminary)

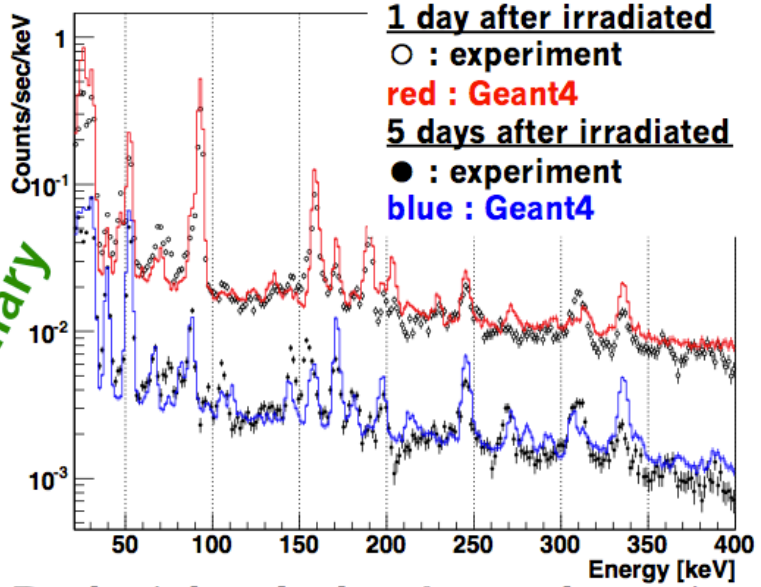


Time evolution of the activation background

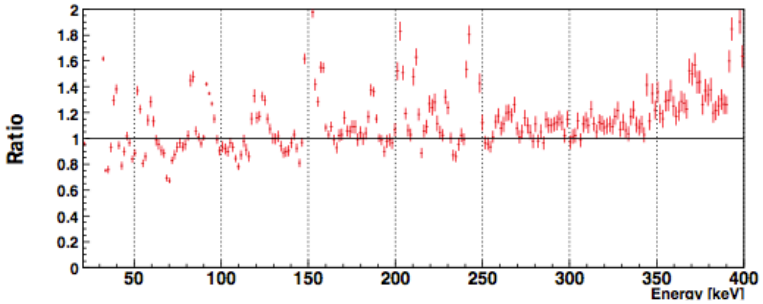
Comparison with Geant4



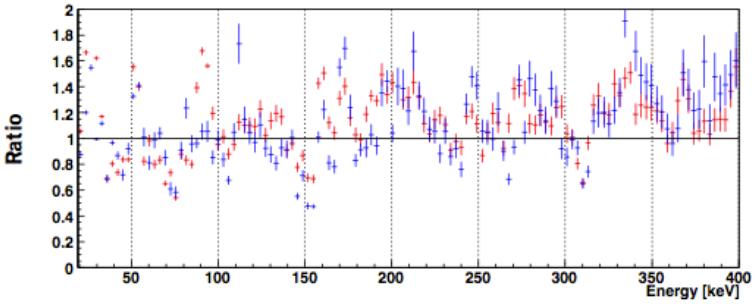
Preliminary



Ratio (simulation/experiment)



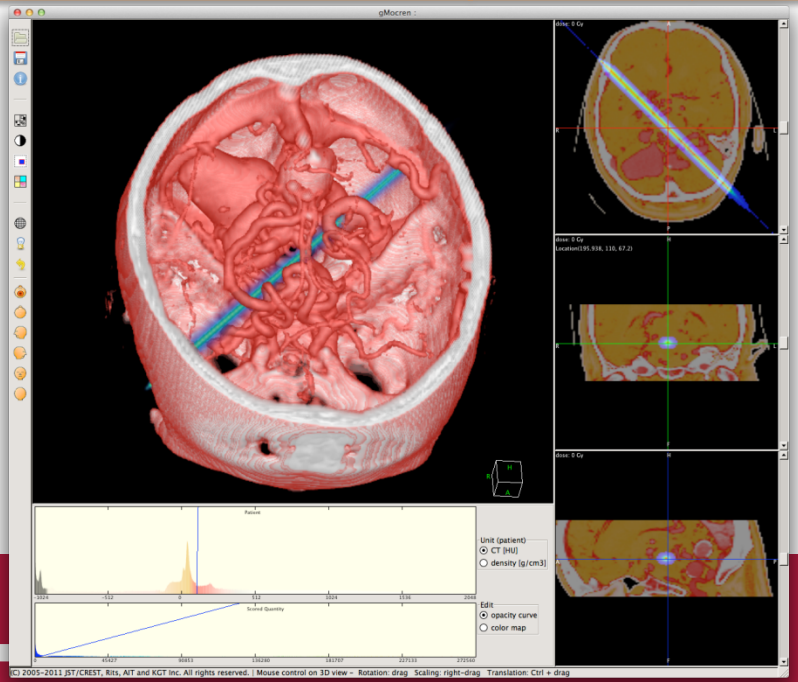
Ratio (simulation/experiment)



❖ Simulation results agrees with experimental data within a factor of two in terms of the line intensities

Investment for the future
– Low energy EM physics ported to GPU

Primary	Phantom	Time/History CPU (sec)	Time/History GPU (sec)	CPU/GPU
20 MeV electron	Water	1.06E-03	2.52E-05	42.1
20 MeV electron (e-spread)	Lung	1.20E-03	2.67E-05	44.9
20 MeV electron (e-spread)	Bone	9.76E-4	2.54E-05	38.4
6 MeV photon	Water	4.47E-04	1.12E-05	39.9
6 MV photon (e-spread)	Lung	3.52E-04	9.16E-06	38.4
6 MV photon (e-spread)	Bone	3.59E-04	9.00E-06	39.9
18 MV photon (e-spread)	Lung	4.05E-04	1.12E-05	36.2
18 MV photon (e-spread)	Bone	4.29E-04	1.17E-05	36.7



Observed GPU speed up over a single-thread CPU: ~40x

Left: Irradiation of 50 million 6 MeV monochromatic photons calculated by GPGPU (not for real treatment use, demonstration purposes only !)

Collaboration of SLAC, Stanford ICME and KEK with support of NVIDIA

SLAC Geant4 team

Geant4 @ SLAC

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Members of SLAC Geant4 team and their commitments and roles in Geant4 collaboration

Member List

Makoto Asai
asai@slac.stanford.edu
Working Groups: Run Event & Detector Response, Track & Particle, Geometry, Generic Process, Intercoms, Visualization, Documentation
Other roles: Spokesperson, Chair of Steering Board, Oversight Board

Andrea Dotti
adotti@slac.stanford.edu
Working Groups: Run Event & Detector Response, Hadronics, Testing & Q/A, Physics List
Other role: Steering Board

Michael Kelsey
kelsey@slac.stanford.edu
Working Group: Hadronics, Documentation
Other role: Steering Board

Tatsumi Koi
tkoi@slac.stanford.edu
Working Group: Hadronics, Physics List

Richard Mount
rmount@slac.stanford.edu
Other role: Oversight Board

Joseph Perl
perl@slac.stanford.edu
Working Groups: Visualization, Documentation

Dennis Wright
dwright@slac.stanford.edu
Working Groups: Hadronics, Documentation, Physics List
Other role: Steering Board

- Covers most of the Geant4 categories
- Is happy to organize Geant4 tutorial
  - At SLAC or preferably at your place
- Is willing to collaborate with you !!

Geant 4

Version 10.0-p01

Thank you for your attendance.
Let's keep in touch.