

Geant4 Overview and Kernel

Geant4 Tutorial @ Japan 2007
Geant4 Collaboration

KEK/CRC



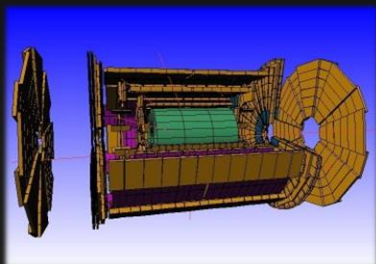
What is Geant4?

User applications

Basic Concept in Monte Carlo Simulation

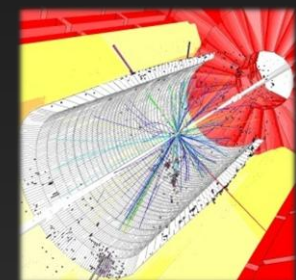
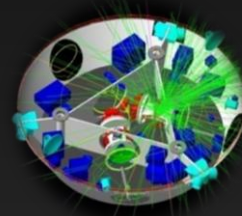
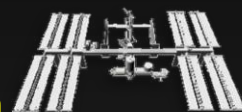
INTRODUCTION

What is Geant4?



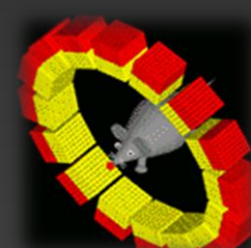
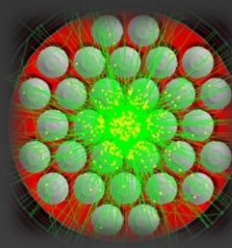
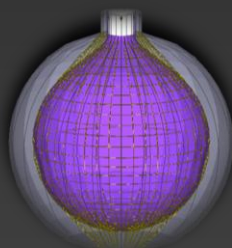
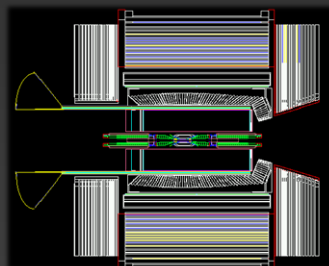
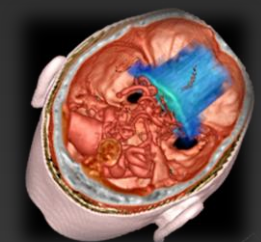
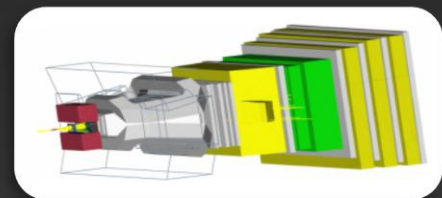
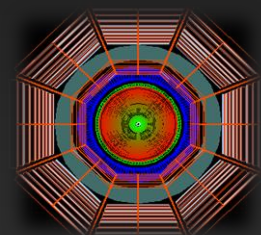
A world-standard toolkit for HEP detector simulation

- Successor of GEANT3
- A successful project to re-design a HEP software using an Object-Oriented approach (C++)
 - ✓ for LHC experiments

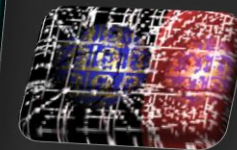
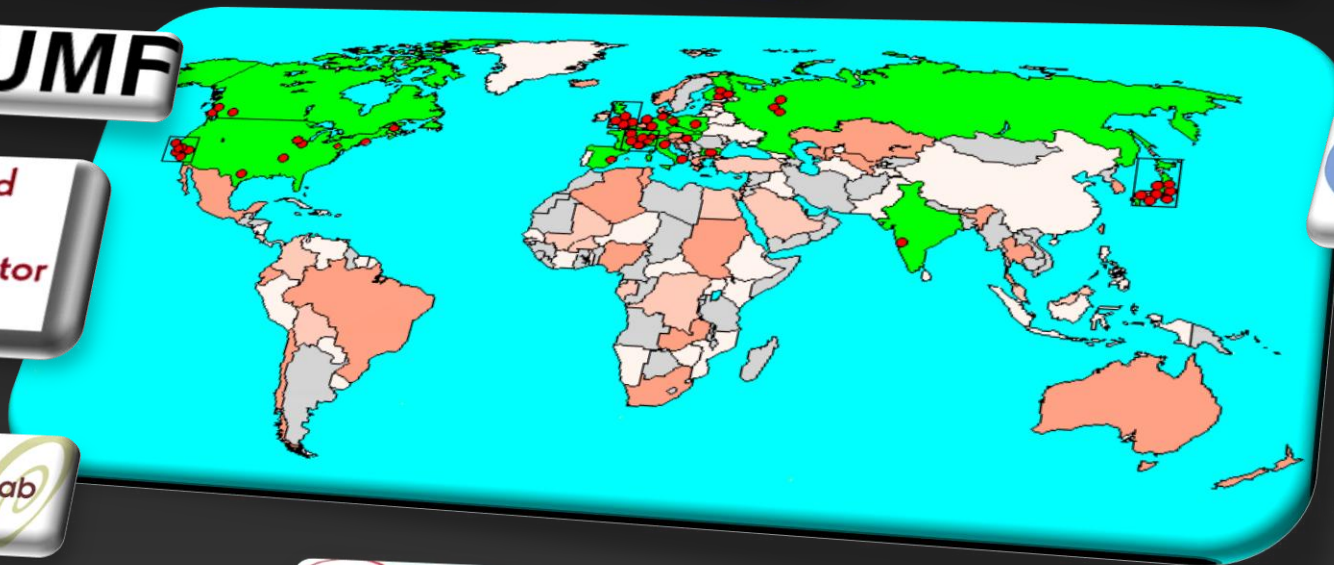
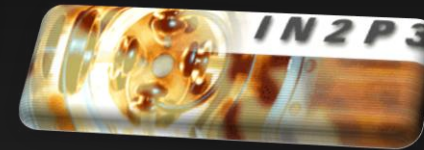


A large degree of functionality and flexibility

- Many application fields beyond HEP
- A variety of requirements from
 - ✓ HEP experiments, under ground experiments, cosmic ray physics, astrophysics, accelerator engineering, shielding studies, space science and medical applications



Geant4 Collaboration

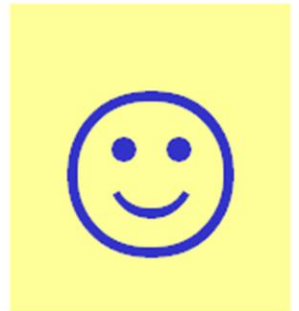


Collaborators also from non-member institutions, including
Budker Inst. of Physics
IHEP Protvino
MEPHI Moscow
Pittsburg University

Geant4 at the LHC Today

Now Geant4 has become the standard simulation for ATLAS, LHCb, and CMS

	ATLAS	CMS	LHCb
Transition to Geant4 (G3 stopped)	DC02 '04	Nov '03	May '04
Produced # of events in DC	12 M	40 M	80 M
CPU time (sec)/ event (2.8 Ghz)	600 (pp→Z→ee) 700 (SUSY)	200 (QCD jets) 60 (min bias)	22-65
Memory used	400 Mb	220 Mb	220 Mb
# of placed volumes	5 M	1.2 M	18 M



No memory leaks!!

⇒ Observations:

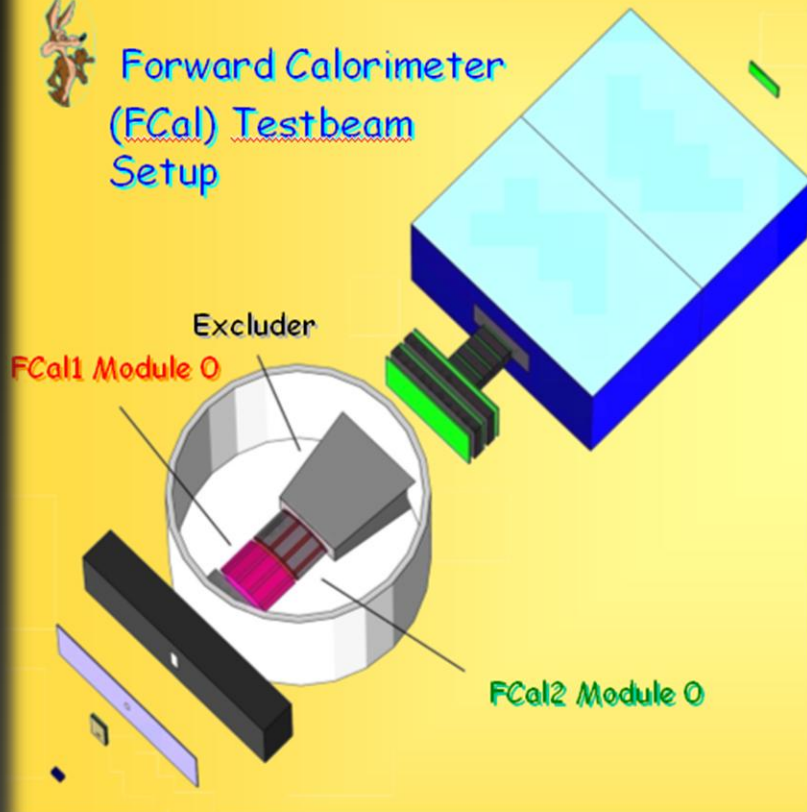
- Geant4 in production is running now very stable/very few problems ($\sim 10^{-5}$)
- Transition to Geant4 has been a very smooth process for all experiments



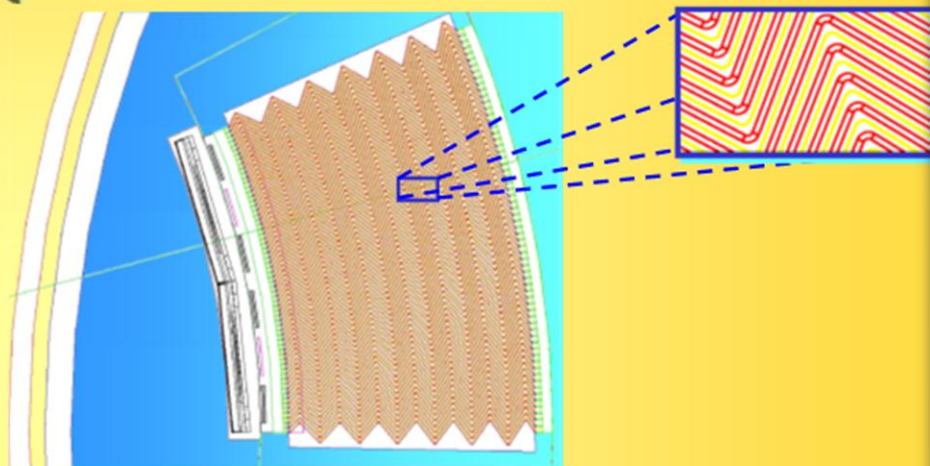
Geant4 Setups (2)



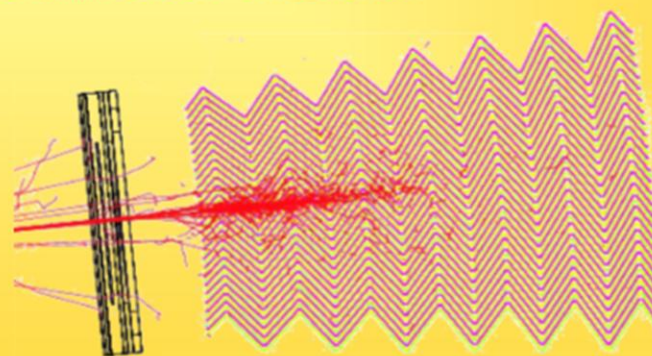
Forward Calorimeter
(FCal) Testbeam
Setup



Electromagnetic Barrel Accordion Calorimeter



10 GeV Electron Shower



Heavy-Ion Collisions

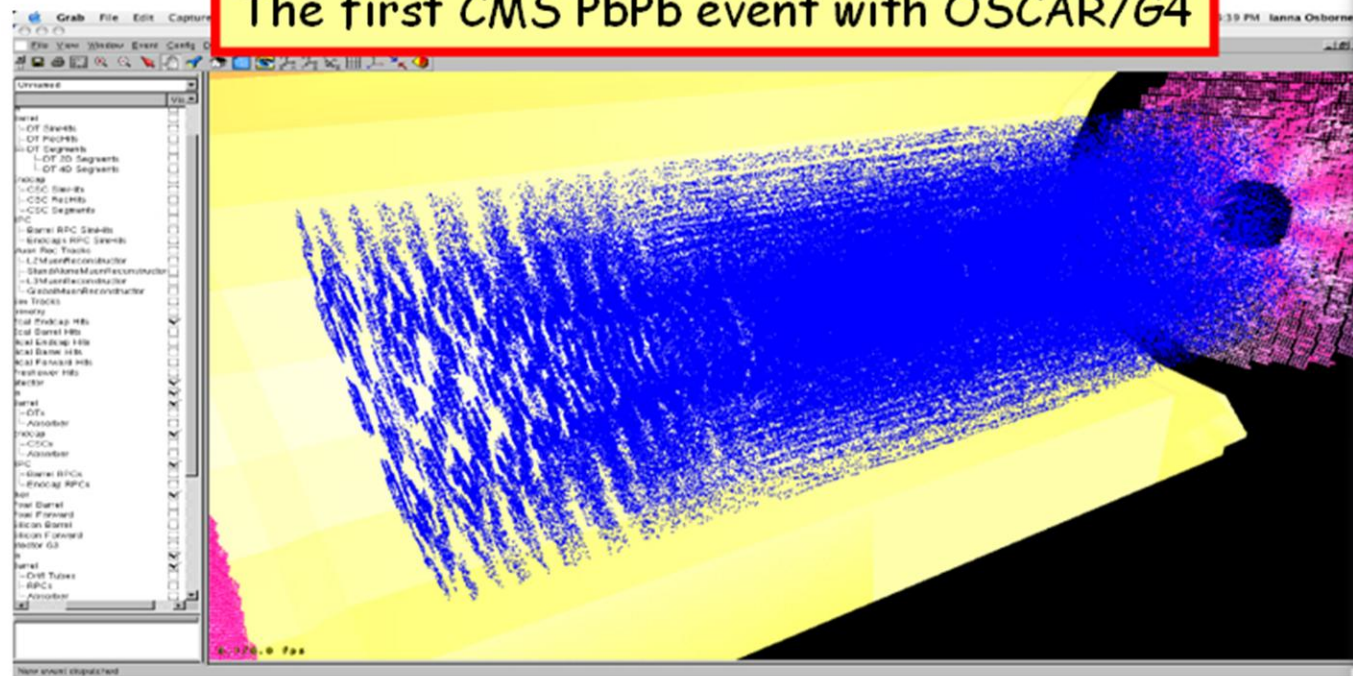
OSCAR/Geant4 can run full heavy ion events.

- Timing is good/Memory > 500 Mbyte (2GB memory machines used)
- Have now run > 100 events without problems

~ Timing for the first event with 55K generator tracks

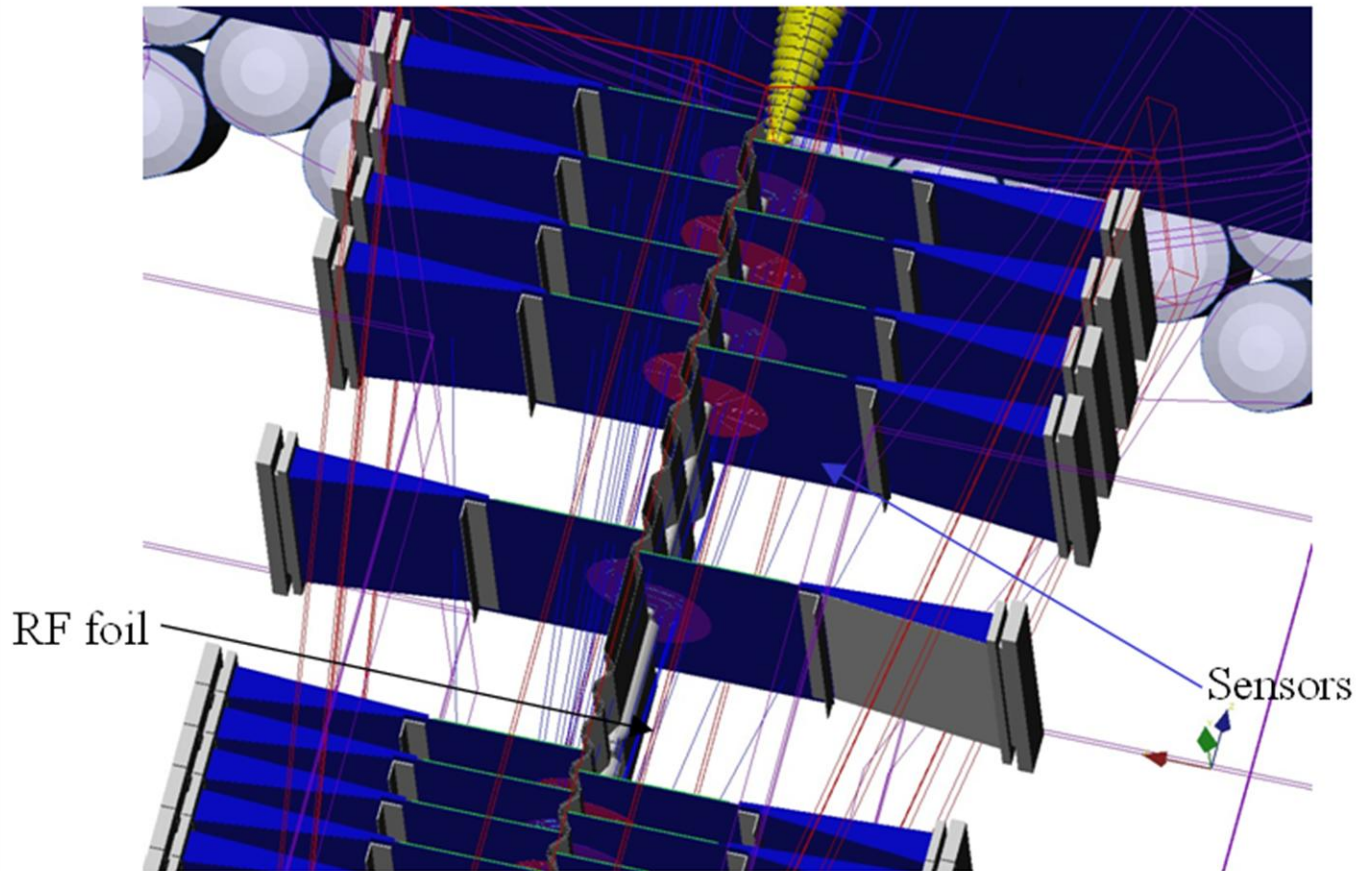
Program	CPU (2.8GHz) (min)
CMSIM	230
OSCAR 2_4_5	320
OSCAR 3_4_0	180

The first CMS PbPb event with OSCAR/G4



Albert De Roeck (CERN)28

Geant4 at the LHC Today



Complicated
geometry
Details are very
important

Geant4 can
handle it!!

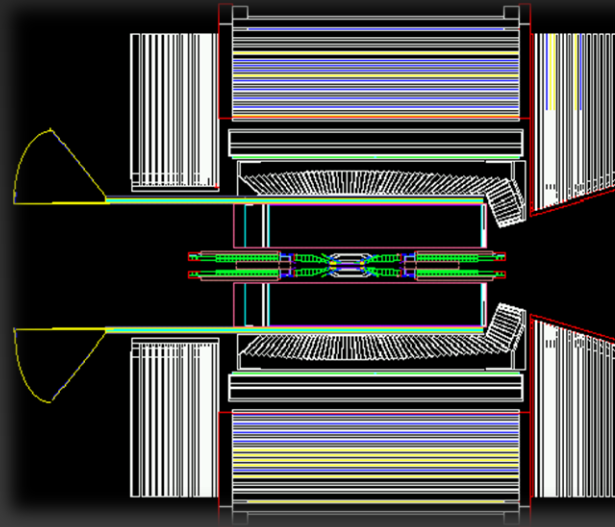
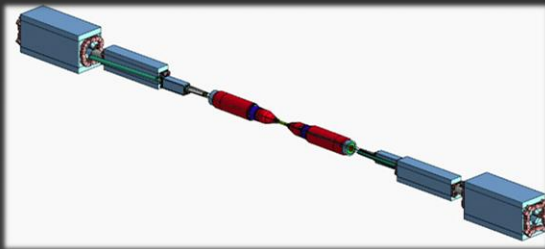
LHCb Vertex Locator description

Albert De Roeck (CERN)24

BaBar

BaBar at SLAC is pioneer in the use of Geant4

- Started in 2000
- Simulated 10^{10} events so far
- Produced at 20 sites in North America and Europe
- Current average production rate 6.1×10^7 events/week

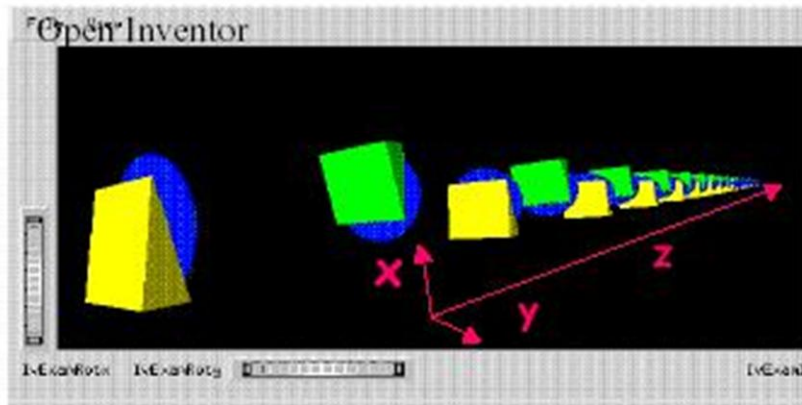


Geant4 for beam transportation

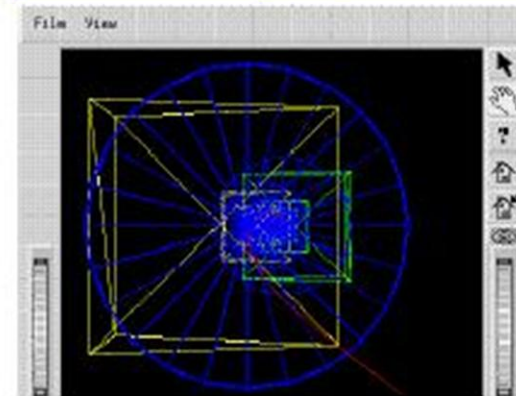
Example: Helical Channel

Published in proc. of PAC 2001
(Fermilab-Conf-01-182-T)

72 m long solenoidal + dipole field with wedge absorbers and thin cavities



$$B_{xy} = B_T \cos, \sin \left(\frac{2p}{L} z \right) \quad B_z = B_0$$

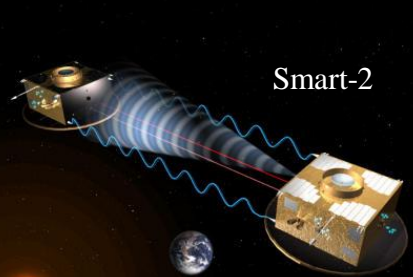


Other simulations:

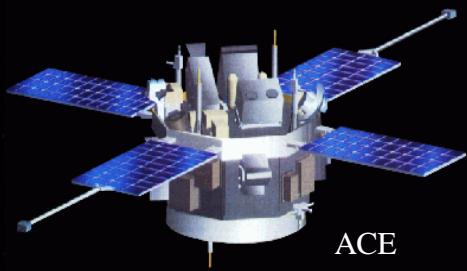
- Alternate Solenoid Channel (sFoFo), published in proceedings of PAC2001 and Feasibility Study II for a Neutrino Factory at BNL (2001)
- Bent Solenoid Channel, presented at Emittance Exchange Workshop, BNL 2000
- Low Frequency r.f. Cooling Channel, presented at International Cooling Experiment Workshop, CERN 2001
- Cooling Experiment (MICE) Simulation (in progress)

G4 Users Meeting, February 21st, 2002

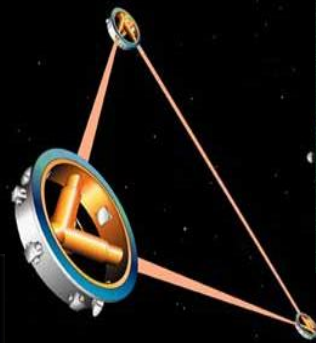
V. Dantel Elvira, Fermilab



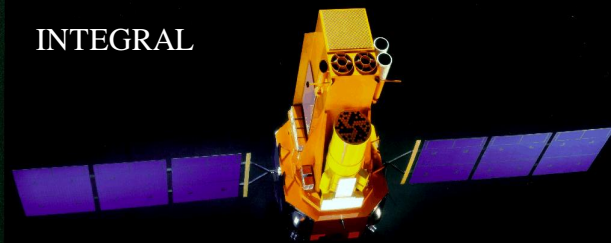
Smart-2



ACE



LISA

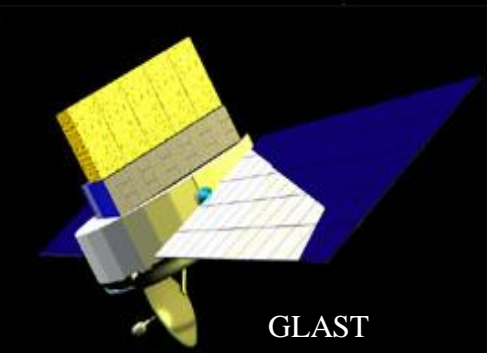


INTEGRAL

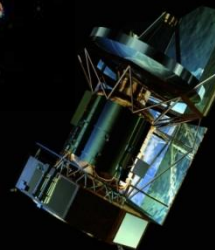
Cassini



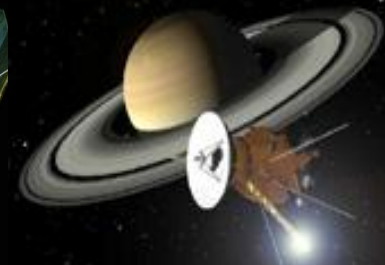
Bepi Colombo



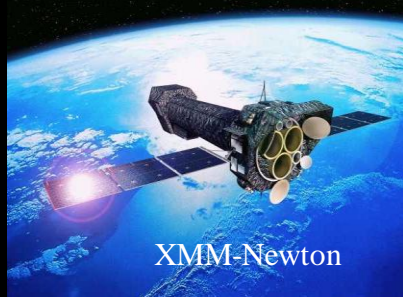
GLAST



Herschel



Astro-E2



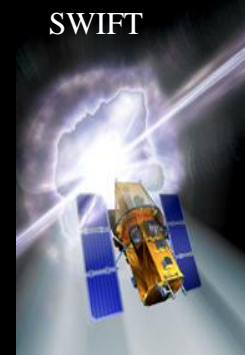
XMM-Newton



GAIA



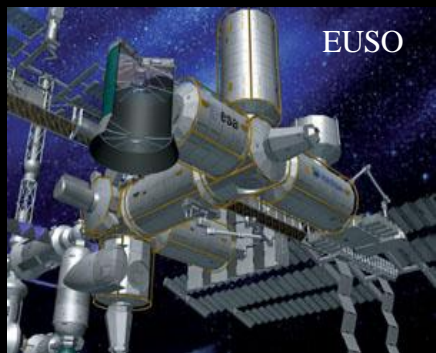
JWST



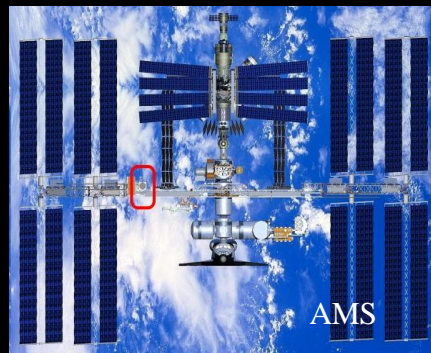
SWIFT



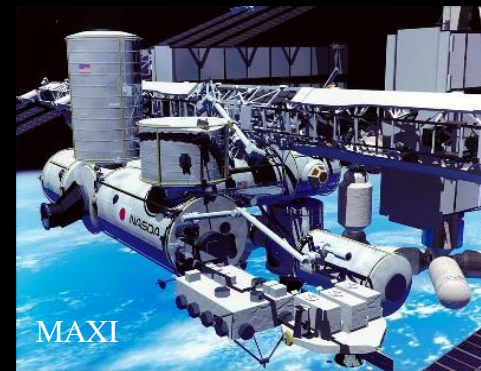
ISS Columbus



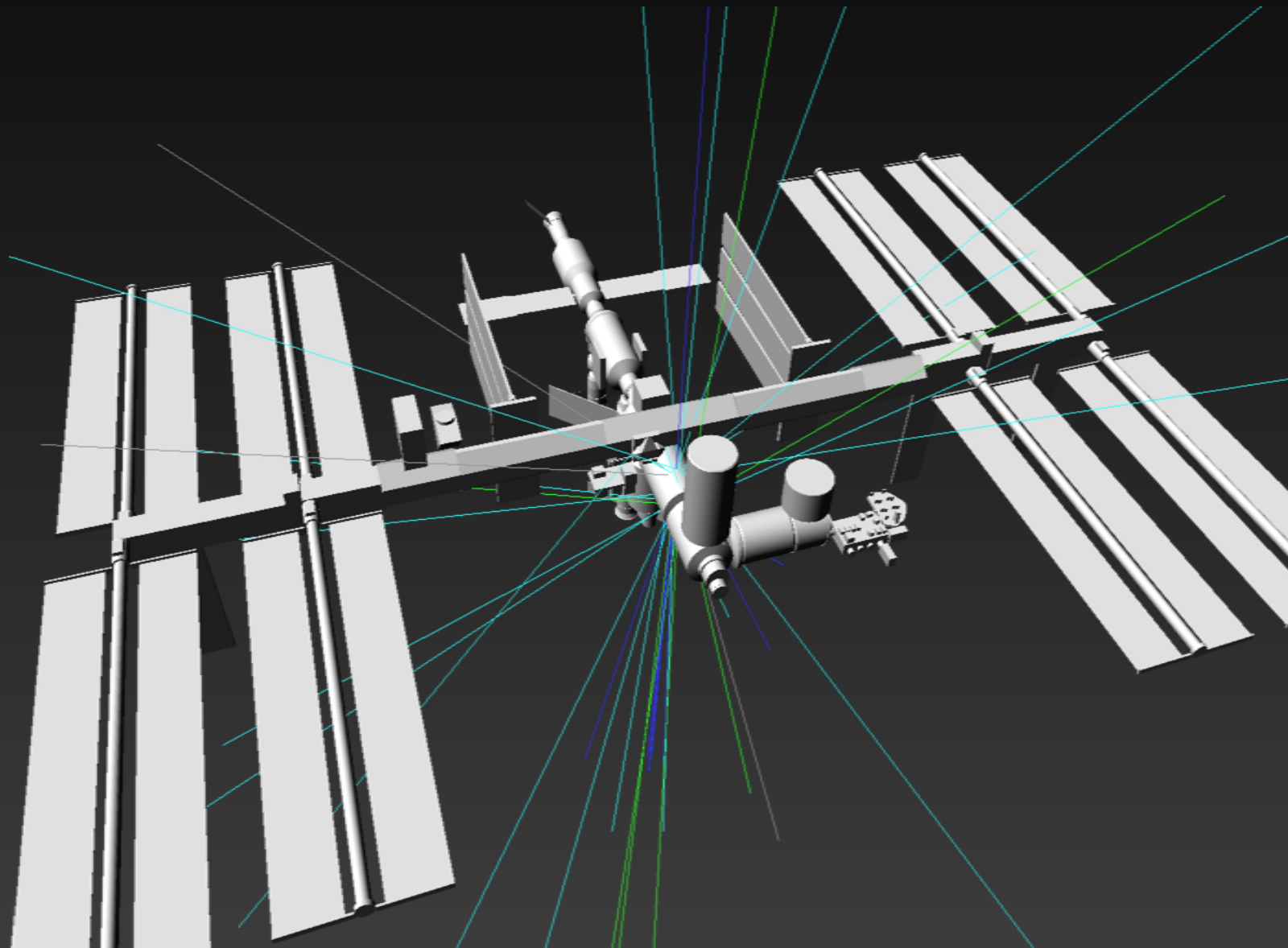
EUSO



AMS

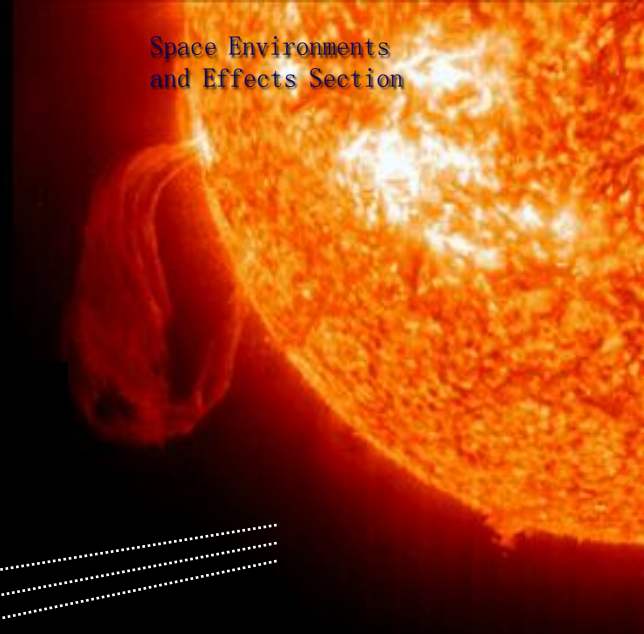
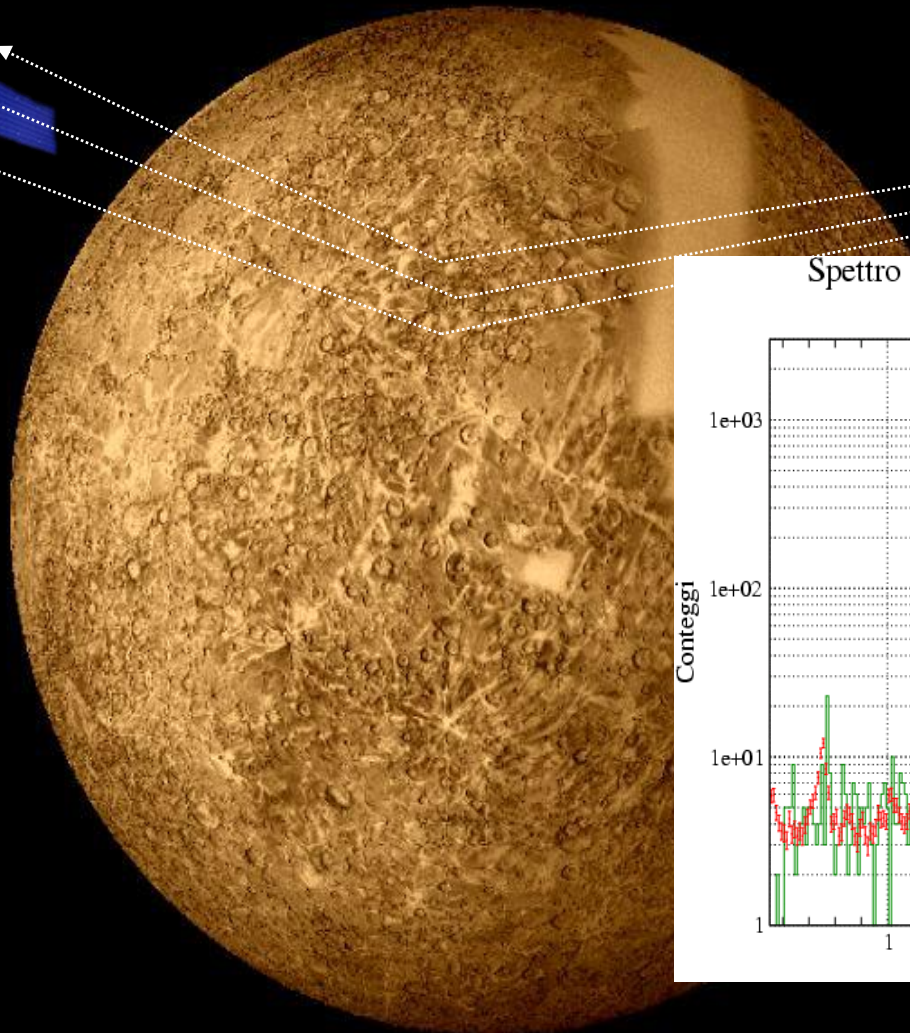
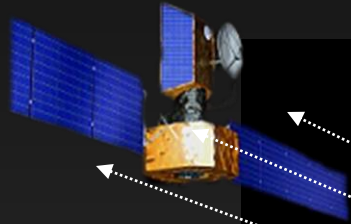


MAXI



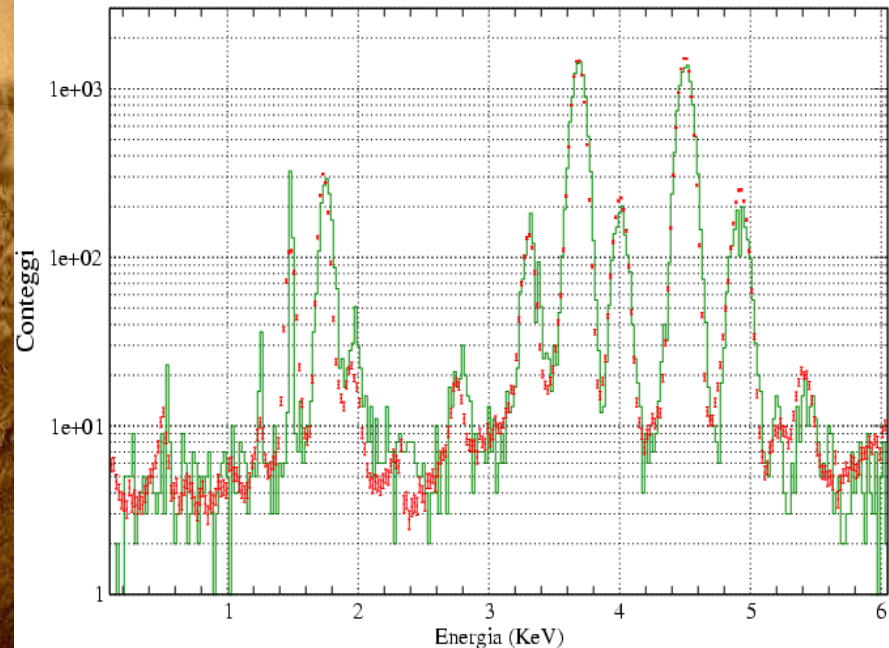
Bepi Colombo: X-Ray Mineralogical Survey of Mercury

Space Environments
and Effects Section

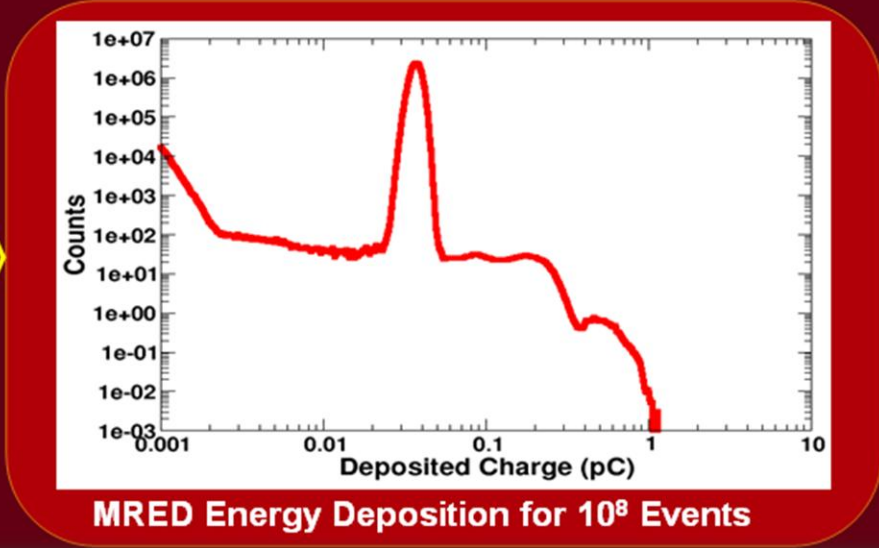
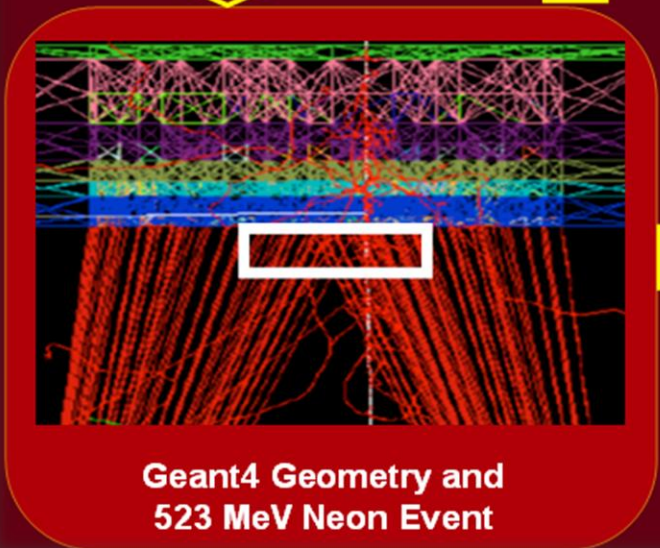
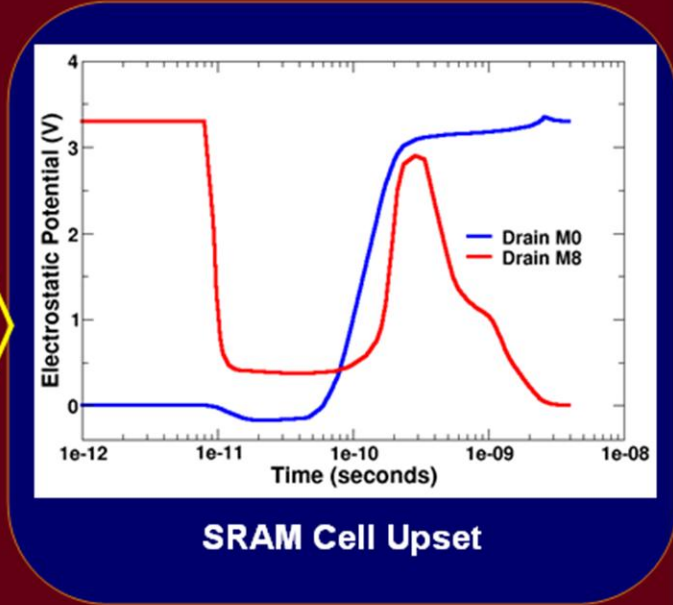
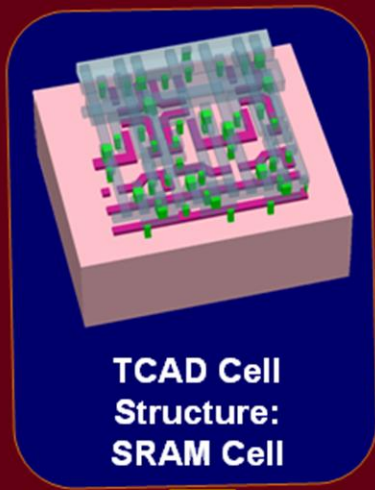


Spettro di Fluorescenza di Basalto Islandese Simulato

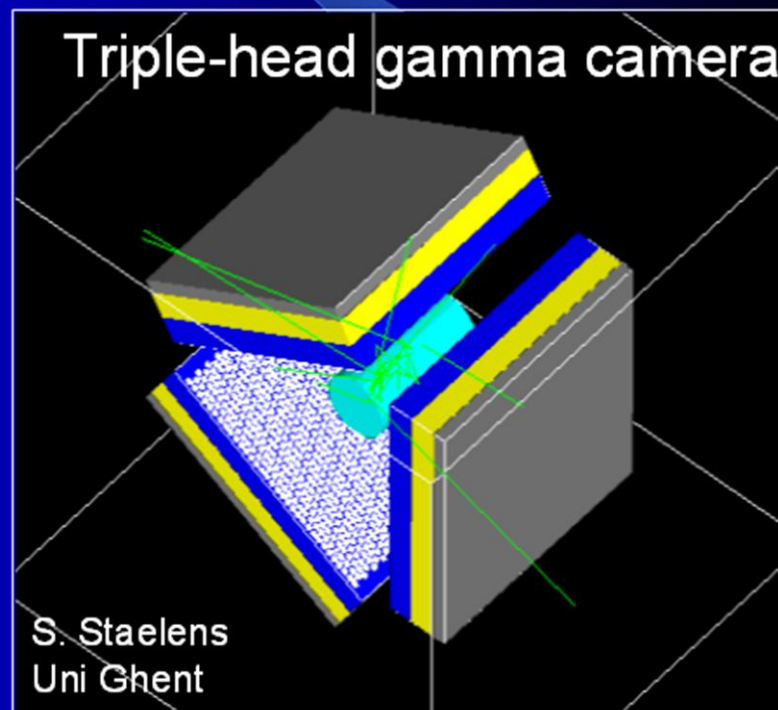
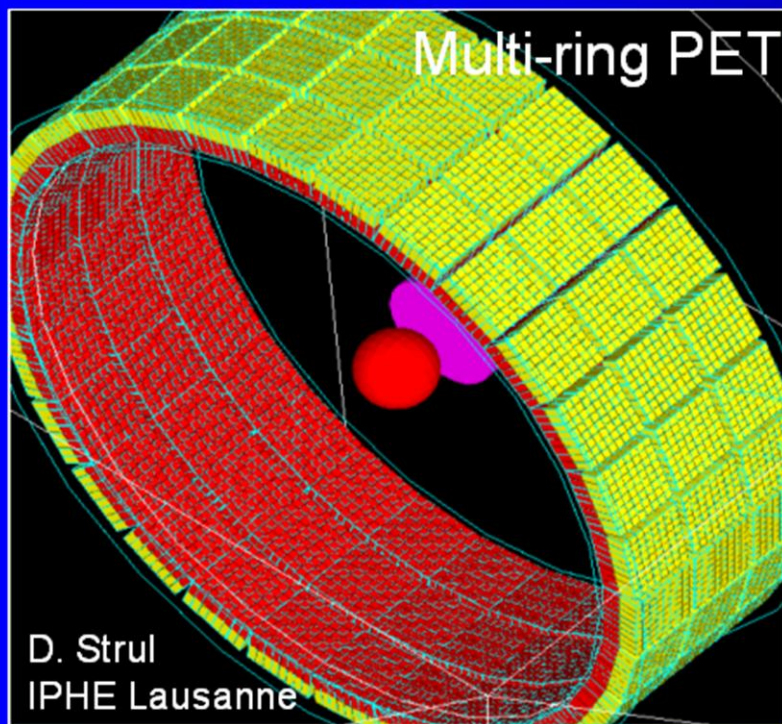
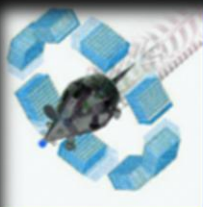
En. Incidente 6.5 KeV



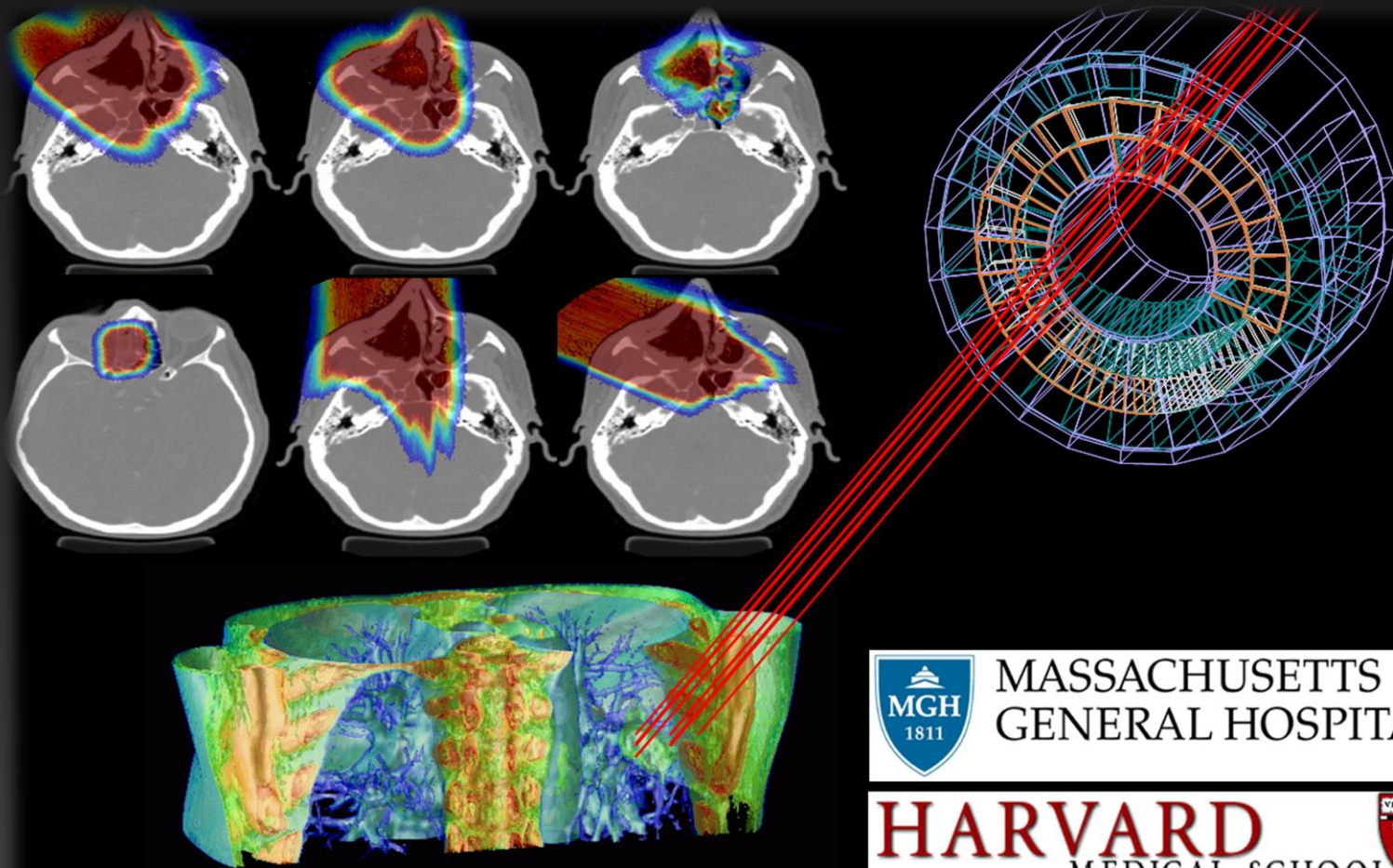
RADSAFE on SEE in SRAMs



Geometry examples of GATE applications



GEANT4 based proton dose calculation in a clinical environment: technical aspects, strategies and challenges



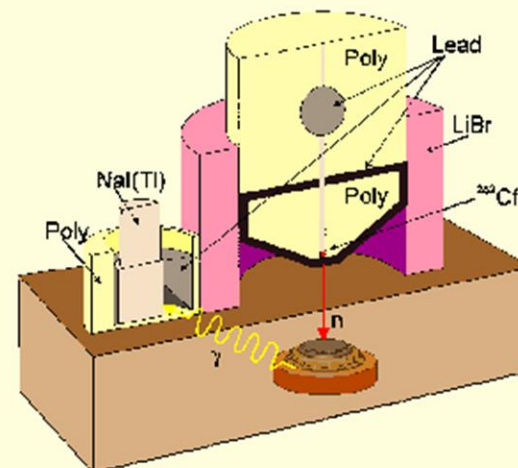
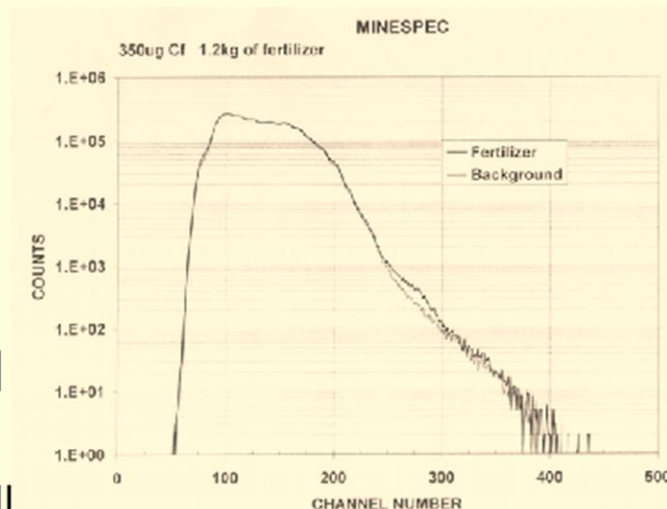
 MASSACHUSETTS
GENERAL HOSPITAL

HARVARD
MEDICAL SCHOOL 



Thermal Neutron Activation

- TNA detects explosive by properties of constituents
 - High concentration of N
 - Does not ID explosive
- Can confirm presence of all surface laid or shallow AT mines in few seconds to 1 minute
- AT up to 20 cm deep and large AP mines in < 5 minutes



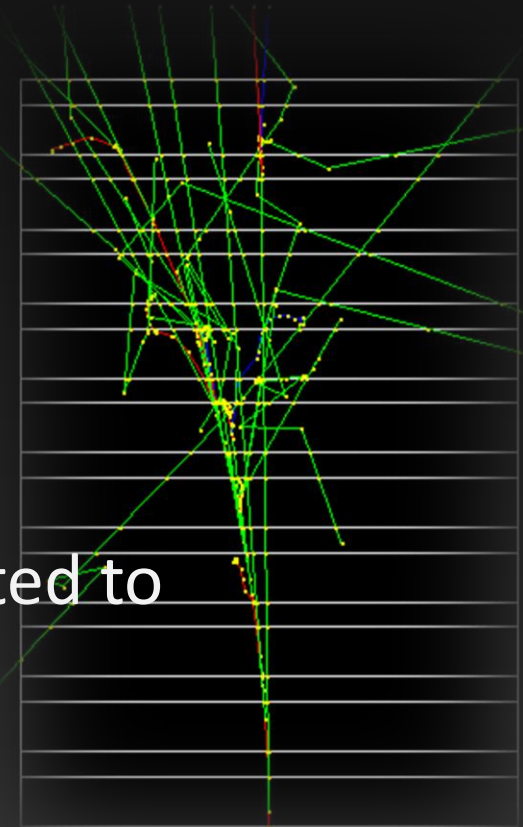
Defence Research Establishment Suffield • Centre de recherches pour la défense, Suffield

A. A. Faust, Geant4 User's Workshop, SLAC 2002 02 21

GEometry ANd Tracking

General characteristics of detector simulation programs:

- specifying the *geometry* of a detector
- *transporting (tracking)* particles injected to the detector
- simulating the particle interactions in matter based on the *Monte Carlo technique*



MC Simulation – *Exponential law*

$f(x)$: probability of **not** having interaction
after a distance x

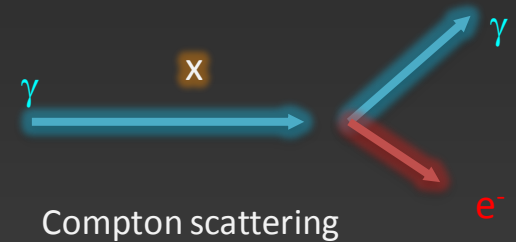
Microscopically,

$w dx$: prob. of having interaction in $[x, x+dx]$

- $w = N_{at} \sigma$: # atoms/unit x cross section
- $\lambda = 1/w$: *interaction length / lifetime*

$$f(x+dx) = f(x) (1-w dx)$$

$$f(x) = \exp(-x/\lambda)$$



MC Simulation – *How to randomize*

Interaction Probability in $[x, x+dx]$:

$$P(x)dx = f(x) w dx$$

✓ $P(x)$: Probability density function

$$1 = \int_0^{\infty} P(x)dx = \int_0^{\infty} f(x)w dx = \int_0^{\infty} \frac{1}{\lambda} \exp\left(-\frac{x}{\lambda}\right) dx = \int_0^1 dr$$

$$r = \exp\left(-\frac{x}{\lambda}\right), \quad dr = -\frac{1}{\lambda} \exp\left(-\frac{x}{\lambda}\right) dx$$

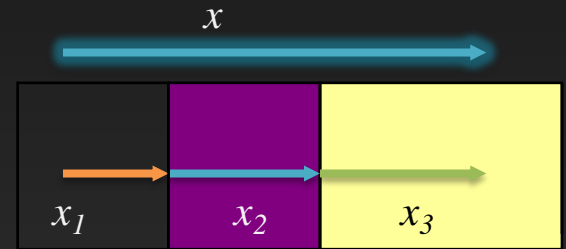
Interaction Point (x) can be generated by

$$n_{\lambda} = x/\lambda = -\ln(r), \quad \text{with } r \text{ uniform in } [0, 1]$$

Practically, ...

- λ and x are dependent of materials
- One can define the *number of interaction length* :

$$n_\lambda = \frac{x_1}{\lambda_1} + \frac{x_2}{\lambda_2} + \frac{x_3}{\lambda_3}$$



- n_λ is independent of materials !

In a MC program,

- sample n_λ at origin of the track (*fate*) : $n_\lambda = -\ln(r)$
- update elapsed n_λ along the track : $n_\lambda = n_\lambda - d\lambda_i / \lambda_i$
- generate an interaction when $n_\lambda = 0$
- n_λ is managed by each process

Basic concepts

KERNEL STRUCTURE

KERNEL STRUCTURE

Terminology a.k.a. Jargons



Analogy to the real HEP experiment / the real world (OO)

Run, Event, Track, Step, Step Point

- XXXManager, XXXUserAction,...

DetectorConstruction

- LogicalVolume, PhysicalVolume, Parameterized, ...

Primary, Vertex

- PrimaryGeneratorAction, ParticleGun, ...

Process

- At rest, Along Step, Post Step
- PhysicsList, ...
- ParticleDefinition, Dynamic Particle, ...
- Cut = Production Threshold

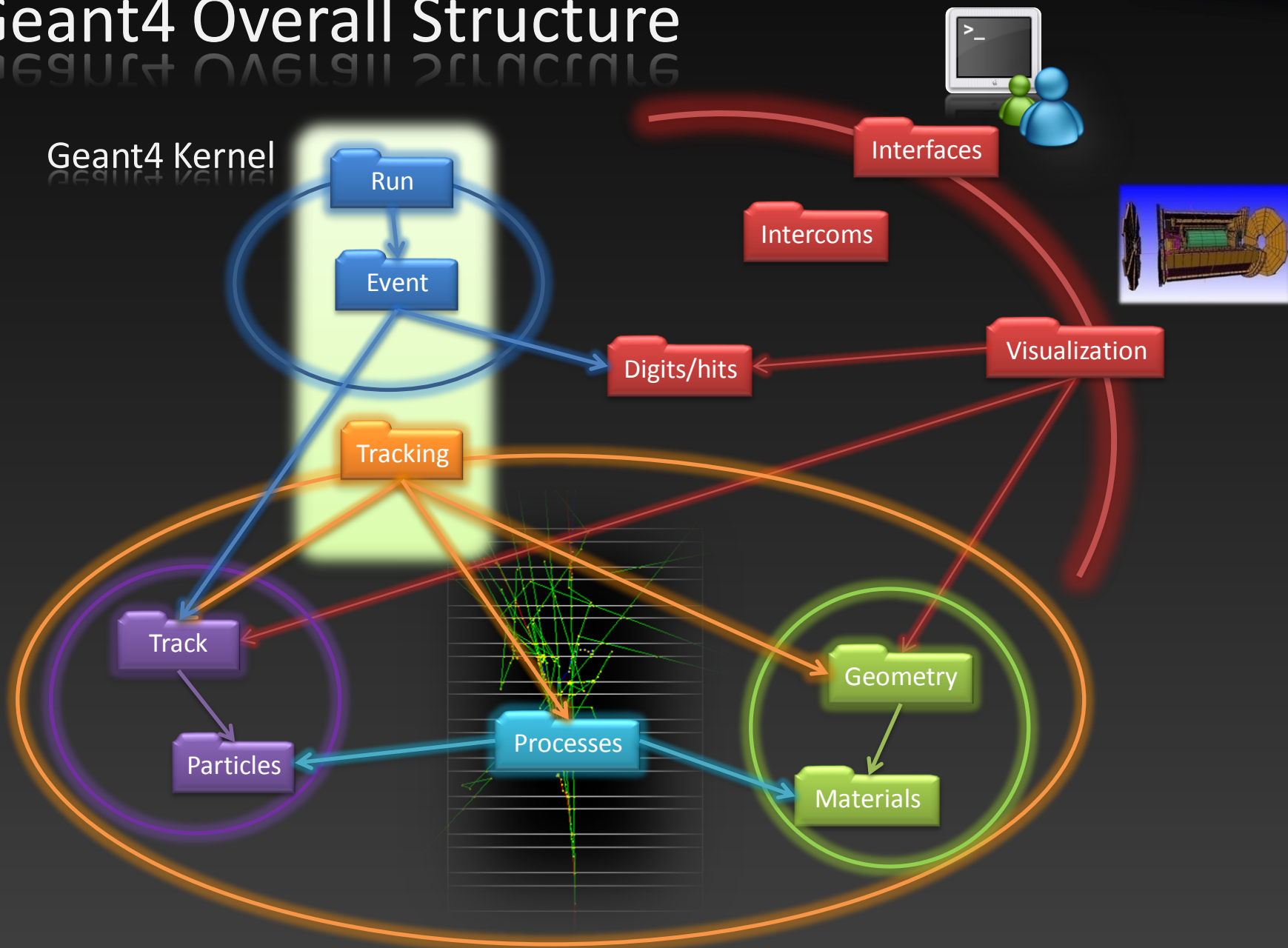
Sensitive Detector, Hit, Hits Collection

Trajectory / Trajectory Point

...



Geant4 Overall Structure



Run in Geant4

G4RunManager class manages processing a run.

- A run is represented by **G4Run** class, which has summary results of each run.
- Within a run, users **cannot** change
 - ✓ detector setup
 - ✓ settings of physics processes
- Conceptually, a run is a collection of “*events*” (**G4Event**).
- **G4UserRunAction** class is an optional user hook.

A run of Geant4 is started by saying “*Beam On*”.

- Practically, we call “*run beam on*” as executing a UI command “*/run/beamOn*”.
- At the beginning of a run, geometry is optimized for navigation and cross section tables are calculated according to materials in the geometry.

Event in Geant4

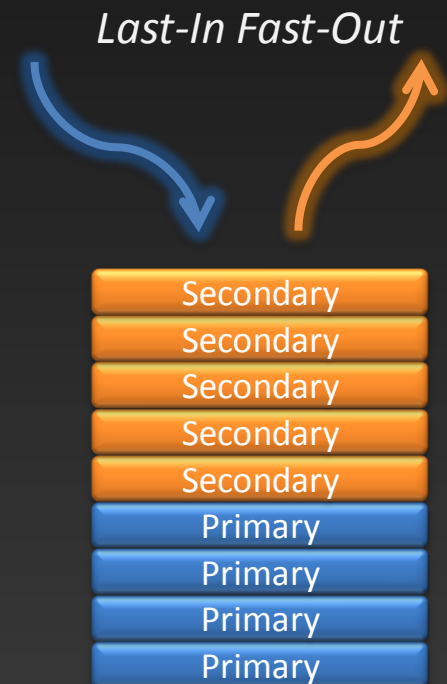
An event is the basic unit of simulation.

G4EventManager class manages processing an event.

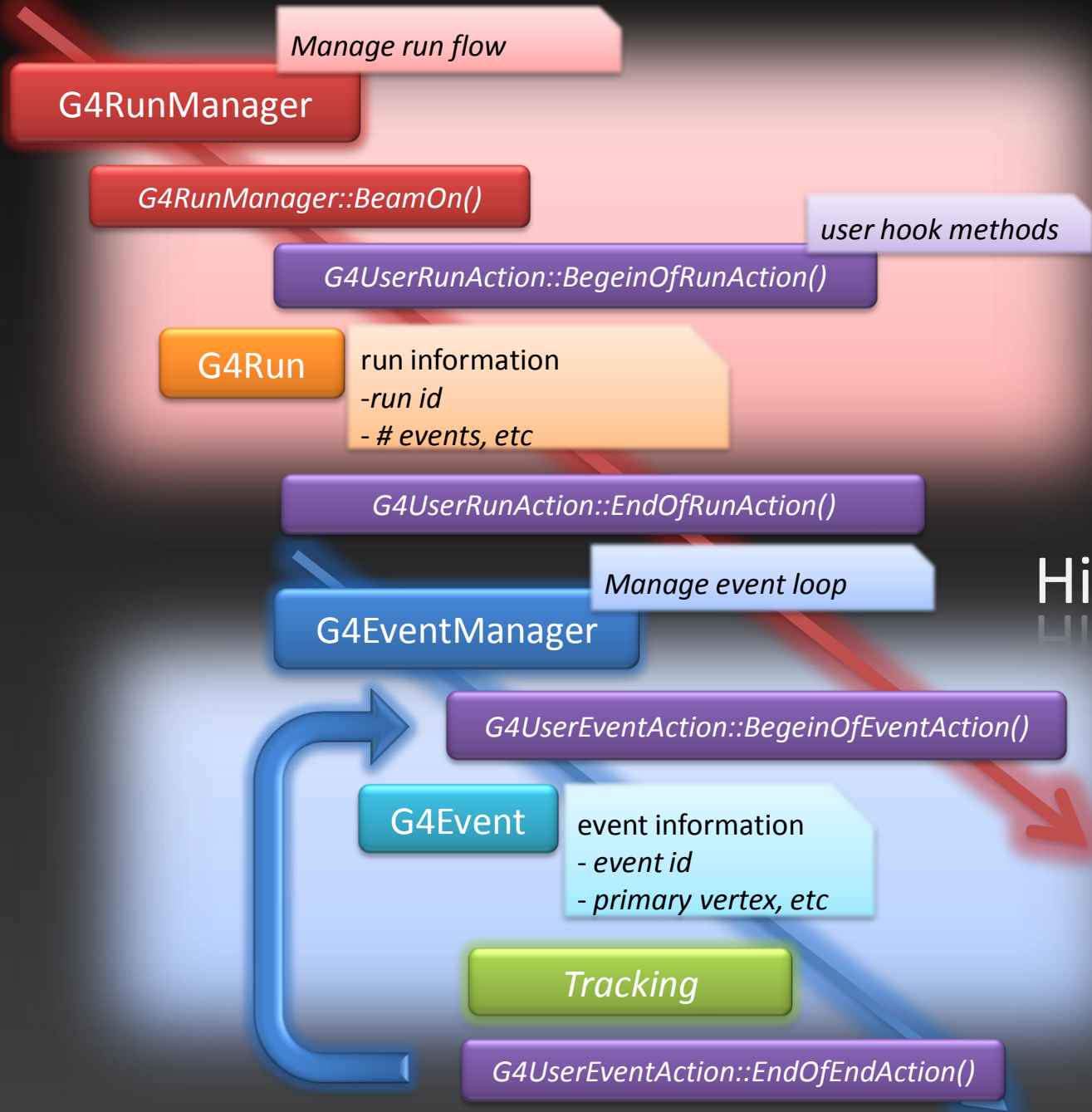
- At the beginning of processing, primary tracks are generated and pushed into a *stack*.
- A track is popped up from the stack one by one and “*tracked*”.
 - ✓ Resulting secondary tracks are also pushed into the stack.
- When the stack is empty, event processing is over.
- **G4UserEventAction** is an optional user hook.

G4Event class represents an event.

- List of primary vertices and particles (as input)
- Hits and Trajectory collections (as output)

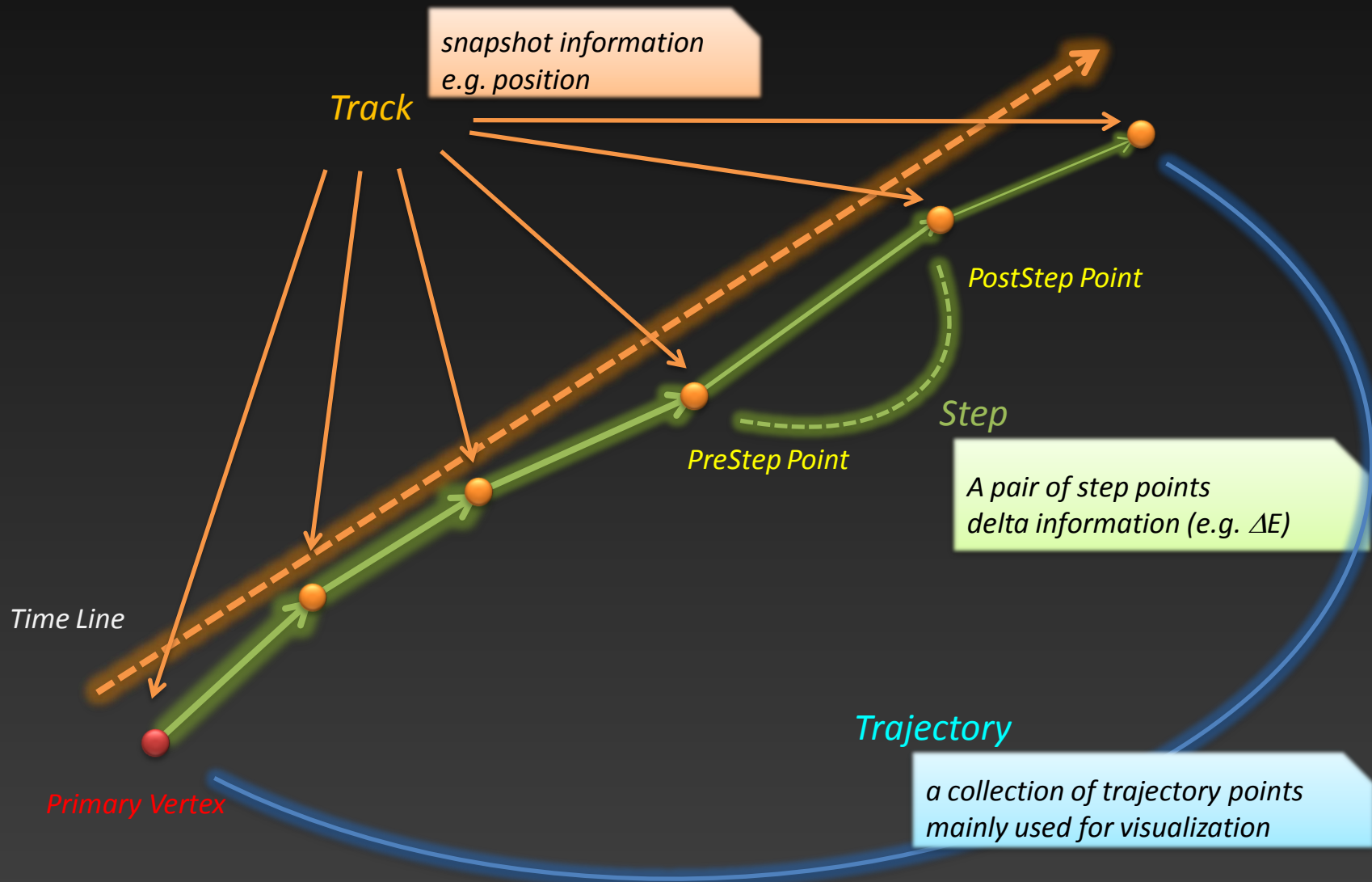


Track Stack



Run/Event Hierarchy/Flow

Tracking a particle, Track, Step, Step Point, and Trajectory



Track in Geant4

Track is a *snapshot* of a particle.

- It has physical quantities of **current instance only**, being updated by steps.
- No track object persists at the end of event.
 - ✓ For recording tracks, use *trajectory* objects.

G4TrackingManager manages processing a track

- A track is represented by **G4Track** class.
- **G4UserTrackingAction** is an optional user hook.

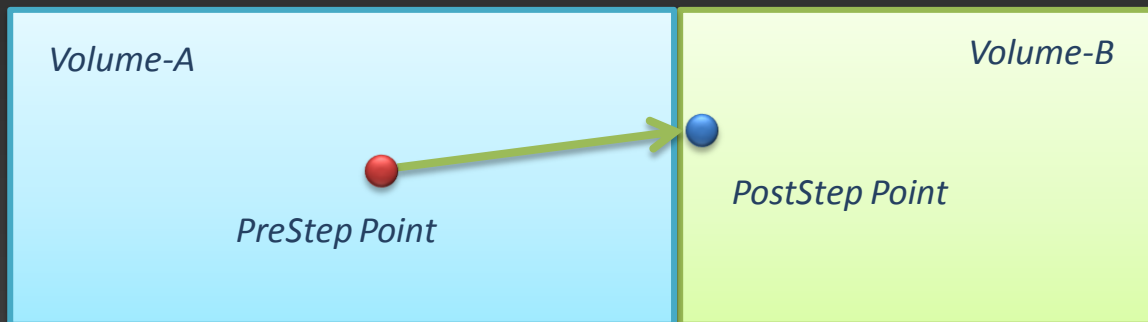
Step/Step Point in Geant4

Step has *two points* (**G4StepPoint**, *pre-/post- step point*) and also “*delta*” information of a particle

- energy loss, TOF spent by the step, etc.
- In case a step is limited by a volume boundary, the *post-step point* physically stands on the boundary, but *logically belongs to the next volume*.
 - ✓ Boundary processes such as transition radiation or refraction require material information in both volumes

G4SteppingManager class manages processing a step

- a step is represented by **G4Step** class.
- **G4UserSteppingAction** is an optional user hook.



Trajectory and Trajectory Point

G4Trajectory class copies some of **G4Track** information.

G4TrajectoryPoint class copies some of **G4Step** information.

- Track does not keep its trace.
- G4Trajectory has a collection of G4TrajectoryPoint.
- Given G4Trajectory/G4TrajectoryPoint objects persist until the end of an event.
- **G4Event** has a collection of G4Trajectory objects.
 - ✓ `/tracking/storeTrajectory` must be set to 1.
- They are mainly used for visualization.

Track status

At the end of each step, the state of a track may be changed.

- The user can also change the status in *UserSteppingAction/UserStackingAction*.
- Statuses shown in *blue* are artificial, i.e. Geant4 kernel does not set them.

fAlive

- Continue the tracking.

fStopButAlive

- The track has *come to zero kinetic energy*, but still “AtRest” process to occur.

fStopAndKill

- The track has lost its identity because it has decayed, interacted or *gone beyond the world boundary*.
- *used for forcedly killing an unnecessary track*

fKillTrackAndSecondaries

- Kill the current track and also associated secondaries.

fSuspend

- Suspend processing of the current track and push it and its secondaries to the stack.

fPostponeToNextEvent

- Postpone processing of the current track to the next event.
- Secondaries are still being processed within the current event.

Step status

Step status is attached to G4StepPoint to indicate why that particular step was determined.

- Use “*PostStepPoint*” to get the status of *this step*.
- “*PreStepPoint*” has the status of *the previous step*.

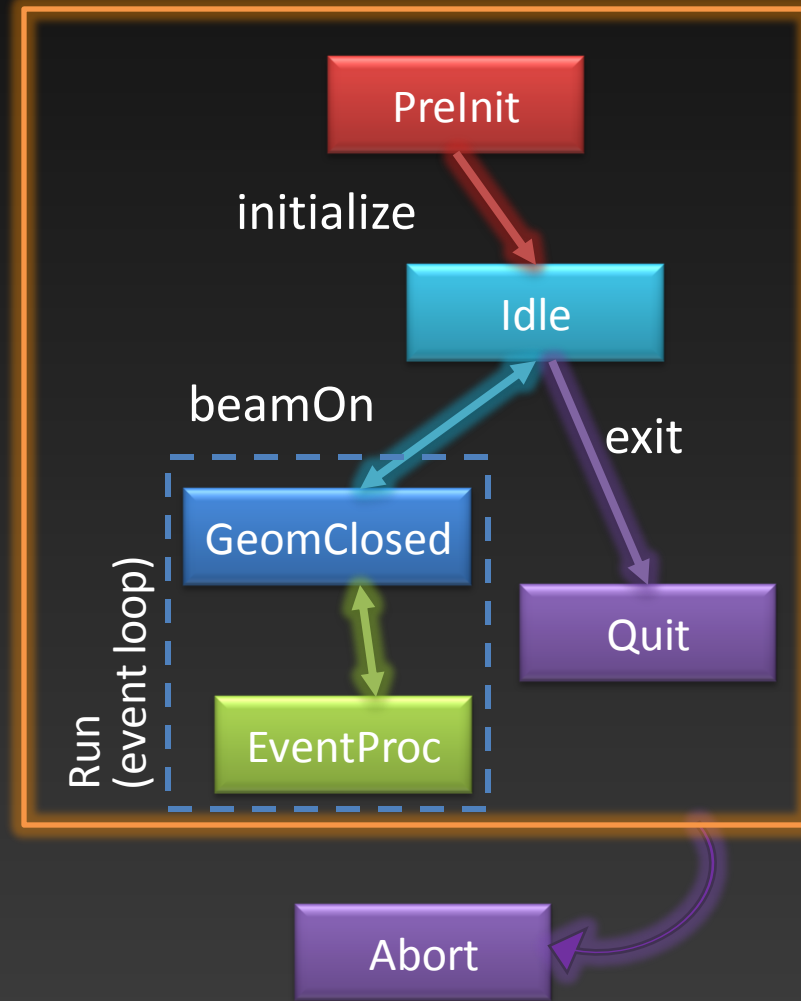
- `fWorldBoundary`
 - ✓ Step reached the world boundary
- `fGeomBoundary`
 - ✓ Step is limited by a volume boundary except the world
- `fAtRestDoItProc`, `fAlongStepDoItProc`, `fPostStepDoItProc`
 - ✓ Step is limited by a AtRest, AlongStep or PostStep process
- `fUserDefinedLimit`
 - ✓ Step is limited by the user Step limit
- `fExclusivelyForcedProc`
 - ✓ Step is limited by an exclusively forced (e.g. shower parameterization) process
- `fUndefined`
 - ✓ Step not defined yet

- If you want to identify *the first step in a volume*, pick `fGeomBoundary` status *in PreStepPoint*.
- If you want to identify *the step getting out of a volume*, pick `fGeomBoundary` status *in PostStepPoint*.

Geant4 as a state machine

Geant4 has *6 application states*.

- **G4State_Preinit**
 - ✓ Material, Geometry, Particle and/or Physics Process need to be initialized/defined
- **G4State_Idle**
 - ✓ Ready to start a run
- **G4State_GeomClosed**
 - ✓ Geometry is optimized and ready to process an event
- **G4State_EventProc**
 - ✓ An event is processing
- **G4State_Quit**
 - ✓ (Normal) termination
- **G4State_Abort**
 - ✓ A fatal exception occurred and program is aborting



Documentations

User support process

License

USER SUPPORT

Geant4 Web Pages

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Geant 4

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Search Geant4

Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high energy nuclear and accelerator physics, as well as studies in medical and space science. The two main reference papers for Geant4 are published in *Nuclear Instruments and Methods in Physics Research A* 506 (2003) 250-303, and *IEEE Transactions on Nuclear Science* 53 No. 1 (2006) 270-278.

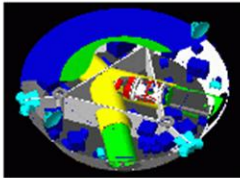
Reference

Applications



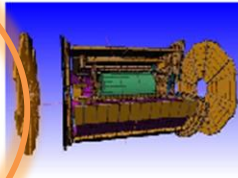
A sampling of applications, technology transfer and other uses of Geant4

User Support



Getting started, [user guides](#) and information for developers

Results & Publications



Validation of Geant4, results from experiments and publications

Collaboration



Who we are: collaborating institutions, [members](#), organization and legal information

News

- 18 September 2007 - GDML 2.10.0 released.
- 28 August 2007 - Patch-01 to release 9.0 is available from the [download area](#).
- 17 August 2007 - Patch-01 to release 8.3 is available from the [archive download area](#).
- 23 March 2007 - [2007 planned developments](#).

Events

- [5th Geant4 Space Users' Workshop](#), University of Tokyo, Tokyo (JP), 13-15 February 2008.
- [Past events](#)

<http://geant4.web.cern.ch/geant4>

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Last updated: 04 Oct 2007

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Geant4 Documents

Geant4 User's Guide for Application Developers

Geant4 Collaboration
Version: geant4 9.0
29 June, 2007

Table of Contents

- [1. Introduction](#)
 - [1.1. Scope of this manual](#)
 - [1.2. How to use this manual](#)
- [2. Getting Started with Geant4 - Running a Simple Example](#)
 - [2.1. How to Define the main\(\) Program](#)
 - [2.1.1. A Sample main\(\) Method](#)
 - [2.1.2. G4RunManager](#)
 - [2.1.3. User Initialization and Action Classes](#)
 - [2.1.4. G4UImanager and UI Command/Submission](#)
 - [2.1.5. G4cout and G4cerr](#)
 - [2.2. How to Define a Detector Geometry](#)
 - [2.2.1. Basic Concepts](#)
 - [2.2.2. Create a Simple Volume](#)
 - [2.2.3. Choose a Solid](#)
 - [2.2.4. Create a Logical Volume](#)
 - [2.2.5. Place a Volume](#)
 - [2.2.6. Create a Physical Volume](#)
 - [2.2.7. Coordinate Systems and Rotations](#)
 - [2.3. How to Specify Materials in the Detector](#)
 - [2.3.1. General Considerations](#)
 - [2.3.2. Define a Simple Material](#)
 - [2.3.3. Define a Molecule](#)
 - [2.3.4. Define a Mixture by Fractional Mass](#)
 - [2.3.5. Define a Material from the Geant4 Material Database](#)
 - [2.3.6. Print Material Information](#)
 - [2.4. How to Specify Particles](#)
 - [2.4.1. Particle Definition](#)
 - [2.4.2. Range Cuts](#)
 - [2.5. How to Specify Physics Processes](#)
 - [2.5.1. Physics Processes](#)
 - [2.5.2. Managing Processes](#)

Introduction of Geant4

Installation Guide

User's Guide: For Application Developers

- *You must read it!!*

User's Guide: For Toolkit Developers

Physics Reference Manual

Software Reference Manual

Installation Guide

<http://geant4.web.cern.ch/geant4/G4UsersDocuments/UsersGuides/InstallationGuide/html/index.html>

List of *required* software

- C++ compiler, **CLHEP**, GNU make, Geant4 toolkit
- choices for visualization software

How to install on **Linux**

Tips for installing on **Windows**

SLAC team provides a good practical installation guide:

<http://geant4.slac.stanford.edu/installation/>

In the practical viewpoint, we recommend Geant4 on



Application Developer Guide

[http:// geant4.web.cern.ch/geant4/G4UsersDocuments/
UsersGuides/ForApplicationDeveloper/html/index.html](http://geant4.web.cern.ch/geant4/G4UsersDocuments/UsersGuides/ForApplicationDeveloper/html/index.html)

Most important document both for novice & advanced users.

- Step-by-step tutorial for novice users
- Describes how to set up and run a simulation application with a lot of example codes
- *You should read this first if you are new to G4.*

Intended as an overview of the toolkit, not an exhaustive treatment. For more details:

- *Physics Reference Manual*
- *Toolkit Developers Guide*

Physics Reference Manual

<http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/PhysicsReferenceManual/html/PhysicsReferenceManual.html>

Dedicated to the detail description of the physics model used in each Geant4 interaction process.

- separate physics topics from how to use the toolkit
- Dedicated to physics models, theories, etc
 - ✓ There are no C++ codes.
 - ✓ *You should read this when you start to wonder what is going on behind the scene.*

LXR Code Browser

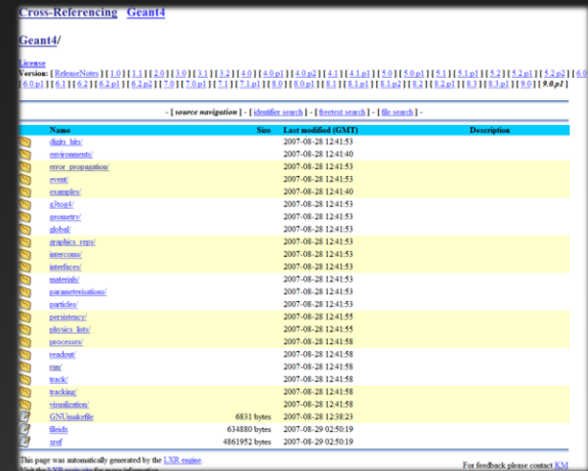
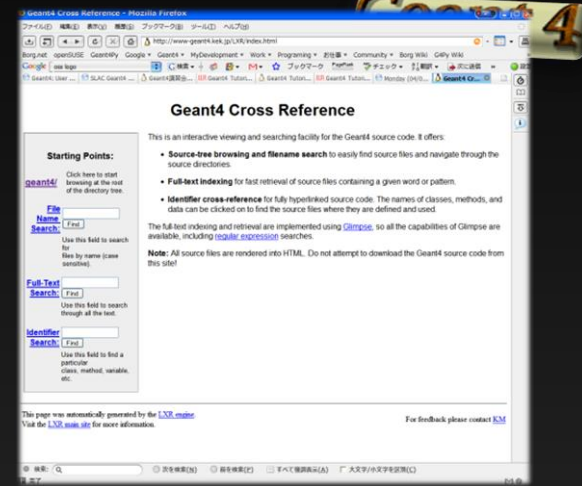
<http://www-geant4.kek.jp/LXR/>

Search the entire Geant4 source trees by

- *filename* (e.g. *G4Track.hh*)
- *text*
- *identifier*

Source files fully hyper-linked to classes and methods;

- tells where classes and methods are defined
- also where they are referenced



```
150 JustWarning,
151 "Geant4 kernel is not PreInit or Idle state : Method ignored.");
152
153 if (verboseLevel > 1) {G4cerr << "Current application state is "
154 << stateManager->GetStateString(currentState) << G4endl;
155 return;
156 }
157
158 // The world volume MUST NOT have a region defined by the user
159 if (worldVol->GetLogicalVolume()->GetRegion() != 0)
160 {
161     if (worldVol->GetLogicalVolume()->GetRegion() != "defaultRegion")
162     {
163         G4cerr << "The world volume has a user-defined region <"
164 << worldVol->GetLogicalVolume()->GetRegion() << "SetVolume ("
165 << " " << G4endl;
166         @ExceptionHandler("RunManager::DefineWorldVolume",
167 "RUN:WorldUserDefinedRegion",
168 FatalException,
169 "World would have a default region assigned by RunManagerKernel.");
170     }
171 }
172
173 // Remove old world logical volume from the default region, if exist
174 if (defaultRegion->GetNumberOfRootVolumes() != 0)
175 {
176     if (defaultRegion->GetNumberOfRootVolumes() > size_t(1))
177     {
178         @ExceptionHandler("RunManager::DefineWorldVolume",
179 "DefaultRegionHasMoreThanOneVolume",
180 FatalException,
181 "Default world region should have a unique logical volume.");
182     }
183 }
184
185 #define iterator @LogicalVolume*::iterator lVitr
186 #define defaultRegion @RunManager::DefineWorldVolume()
187 #define defaultRegion @RunManager::DefineWorldVolume()
188 if (verboseLevel > 1) {G4cout
189 << "Obsolete world logical volume is removed from the default region." << G4endl;
190 }
```

User Supports

Geant4 Collaboration offers extensive user supports.

- Technical Forum
- Users workshops and Tutorial courses
- HyperNews and mailing list
- Problem tracking system
- Daily “private” communications

Technical Forum

The Technical Forum is open to all interested parties

- To be held at least 4 times per year

The purpose of the forum is to:

- Achieve, as much as possible, a mutual understanding of the needs and plans of users and developers.
- Provide the Geant4 Collaboration with the clearest possible understanding of the needs of its users.
- Promote the exchange of information about physics validation performed by Geant4 Collaborators and Geant4 users.
- Promote the exchange of information about user support provided by Geant4 Collaborators and Geant4 user communities.

Geant4 Users/Collaboration Workshop and Tutorials

Users/Collaboration workshops were held.

- Catania - Oct. 2004
- Bordeaux - Nov.2005
- Lisbon - Oct. 2006
- Manchester - Sep. 2007
- **Kobe - Sep. 2008**

Local workshops/tutorials were organized various places *for different user communities*.

- SLAC/FNAL/ Jefferson : users workshops, tutorials
- NASA/ESA : space users workshops
- KEK : users workshops, tutorials
- IN2P3: tutorials
- INFN : tutorials
- IEEE/MIC : tutorials
- ...

HyperNews User Forum

Geant4 HyperNews Index - Windows Internet Explorer

http://geant4-hn.slac.stanford.edu:5090/Geant4-HyperNews/index

[[Membership](#) | [Subscriptions](#) | [Recent Index](#) | [Search](#) | [Geant4 Home](#) | [Feedback](#) | [Help](#)]

Geant 4

[Geant4](#) HyperNews Forums

Search postings:

Welcome to the Geant4 HyperNews system.

The Geant4 collaboration welcomes user participation in this forum through the exchange of questions about and experiences with the Geant4 toolkit. When possible, developers will monitor these contributions and provide assistance. To report a problem or program error please use the Geant4 Problem Reporting System.

The following list is a short guide to what you can do from this page:

- To read a forum, click on the title of the forum in one of the available indices. Available indices include a [Time Ordered Index](#), and a [Recent Post Index](#).
- To post a new message (start a new thread) in a forum, click on the Add Message button at the bottom of the forum page. One can also use [email](#).
- To create a membership, follow the directions [here](#).
- To edit your membership information in the system, go to the [Membership](#) page.
- To subscribe (once you are a member) to any forum or to see what forums you are currently subscribed to, go to the [Central HyperNews Subscription Page](#). You can also see who else is subscribed to a forum from there.
- To search the messages in the HyperNews system, go to the [HyperNews Search Page](#).
- To request a new forum be created, use the [Request a New Forum](#) page.

Categorized Index of Forums

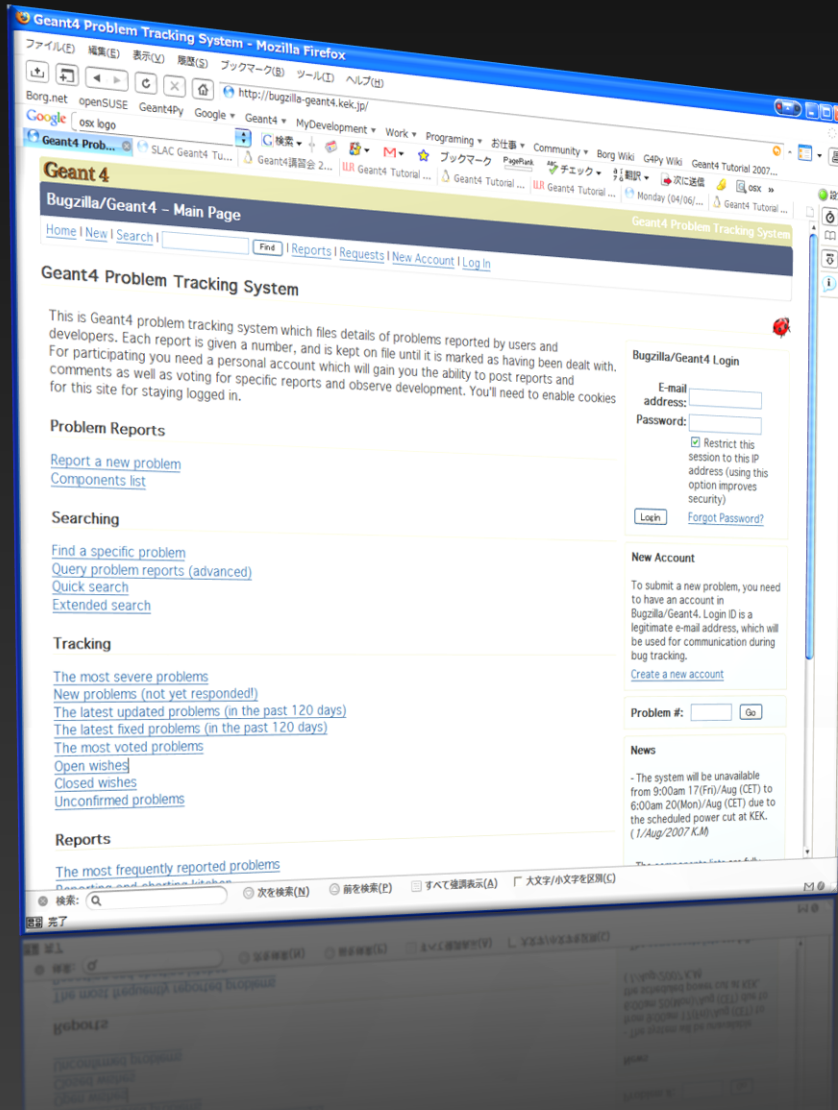
[Applications](#)

<http://geant4-hn.slac.stanford.edu:5090/Geant4-HyperNews/index>

Discuss problems with other users, post questions for experts, etc.

- 18 forums roughly based on Geant4 categories
- 4 forums for specific application areas (education, medicine, space, industry)
- New forums may be requested by users

Geant4/Bugzilla



<http://bugzilla-geant4.kek.jp/>

Geant4 Problem Tracking System
based on **Bugzilla**

- Archives and tracks details of problems reported by users and developers

Geant4 Reference Papers

The two main reference papers for Geant4:

Geant4—a simulation toolkit

Nuclear Instruments and Methods in Physics Research Section A: Volume 506, Issue 3, 1 July 2003, Pages 250-303

Geant4 developments and applications

Nuclear Science, IEEE Transactions Publication Date: Feb. 2006 Volume: 53, Issue: 1, Part 2 On page(s): 270- 278

INTRODUCTION
The ScienceDirect TOP25 Hottest Articles is a free quarterly service from ScienceDirect. When you subscribe to the ScienceDirect TOP25, you'll receive an e-mail every three months listing the ScienceDirect users' 25 most frequently downloaded journal articles, from any selected journal among more than 2,000 titles in the ScienceDirect database, or from any of 24 subject areas.

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Agostinelli, S.; Allison, J.; Amako, K.; Apostolakis, J.; Araujo, H.; Arce, P.; Asai, M.; Axen, D.; Banerjee, S.; Barrand, G.; Behner, F.; Bellagamba, L.; Boudreau, J.; Broglio, L.; Brunengo, A.; Burk...
- Geant4—a simulation toolkit** * Article
Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 506, Issue 3, 1 July 2003, Pages 250-303
Agostinelli, S.; Allison, J.; Amako, K.; Apostolakis, J.; Araujo, H.; Arce, P.; Asai, M.; Axen, D.; Banerjee, S.; Barrand, G.; Behner, F.; Bellagamba, L.; Boudreau, J.; Broglio, L.; Brunengo, A.; Burk...
- Radiation pneumonitis and pulmonary fibrosis in non-small-cell lung cancer: Pathway, function, prediction, and prevention** * Article
*International Journal of Radiation Oncology*Biological Physics, Volume 63, Issue 1, 1 September 2005, Pages 5-24*
Mehta, V.
- The American Society for Therapeutic Radiology and Oncology (ASTRO) evidence-based review of the role of radiotherapy for brain metastases** * Article
*International Journal of Radiation Oncology*Biological Physics, Volume 63, Issue 1, 1 September 2005, Pages 37-46*
Mehta, M.P.; Tsao, M.; Whelan, T.J.; Morris, D.E.; Hayman, J.A.; Flickinger, J.C.; Mills, M.; Rogers, C.L.; Souhami, L.
- CT-based definition of thoracic lymph node stations: An atlas from the University of Michigan** * Article

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SCIENTISTS PAPERS INSTITUTIONS JOURNALS COUNTRIES HOME
in-cites - July 2005
Clicking URL: <http://www.in-cites.com/hotpapers/2005/july05-eng.html>

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Published in the Last 2-years for Engineering

Previous | Field Menu 2005 | Field Menu 2005 | Field Menu 2005
"Science Hot" Papers in Science, Published Since 2003

Engineering
(Sorted by citations, 3 of 120)

1 Citations: 133
Title: GEANT4: SIMULATION TOOLKIT
Authors: AGOSTINELLI S; ALLISON J; AMAKO K; APOSTOLAKIS J; ARAUJO H; ARCE P; ASAI M; AXEN D; BANERJEE S; BARRAND G; BEHNER F; BELLAGAMBA L; BOUDREAU J; BROGLIO L; BRUNENGO A; BURKHARDT H; CHADUVI S; CHIMA J; CHYTRACEK R; COOPERMAN G; COSMO G; DESTYARENKO P; DELL'ACQUA A; DEPOLA G; DIETRICH D; ENAMI R; FELICIELLO A; FERLIGSON C; FESFELDT H; FOLGER G; FOPPIANO P; FORTI A; GARELLI S; GIANI S; GIANNITRACCHI R; GIBIN D; GADENNE J; GONCALVES I; HASEL G; GREENHALGH G; GREENE W; GRIECHNE V; GROSSHEIM A; GUATELLI S; GUMPLINGER P; HARATSU R; HASHIMOTO K; HASUI H; HEIKKINEN A; HOWARD A; IVANCHENKO V; JOHNSON A; JONES P; KALENBERG J; KANKIA R; KAWABATA M; KAWABATA Y; KAWARITSU M; KELLER S; KENT P; KIMURA A; KODAMA T; KONOLINER R; KOSSOV M; KURASHIGE H; LAMAMNA E; LAMPERT T; LARA V; LEFEBURE V; LEI F; LIENDL M; LOCKMAN W; LONGO F; MANNI S; MARINI M; MEDENHOFER C; DE MENTANA M; MENDIMOTO K; DE MONTENAPOLI M; MANGARATI M; MANTALLO R; NIEMINEN P; NISHIMURA T; OHTSUBO K; OKAMURA H; OMAE S; OOHATA Y; PAECH K; PERL J; PFEIFFER A; PISA M; RANARD P; RYBIN A; SADDOLFO S; DI SALVO E; SARTIN G; SASANI T; SAVVAS H; SAWADA Y; SCHERER S; SELB S; SPROTENGO V; SMITH D; STAROV M; STOECKER H; SUDRANO J; TAKAHASHI M; TANAKA S; TCHERNIAK E; TERRANI E; THORAND M; TRUSCOTT P; UNO H; URBAN L; URBAN F; VERDERI M; WALKER W; WANDER W; WEBER H; WELTICH J; WENIG T; WILLIAMS D; WISLANT O; YAMADA T; YOSHIDA M; ZSCHIECHE D

Source: NUCL INSTRUM METH PHYS RES A 506: (3) 250-303 JUL 1 2003
Address: European Org Nucl Res CERN, CH-1211 GENEVA, SWITZERLAND
ESA, ESTEC, Noordwijk, Netherlands.
Jefferson Lab, Newport News, VA, USA.
TRIUMF, Vancouver, BC V6T 2A3, Canada.
CERN, ATLAS Collaborat, Geneva, Switzerland.
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Brookhaven Natl Lab, Upton, NY 11973 USA.
IKF, Budapest, Hungary.
Univ Calabria, Calabria, Italy.
Univ Cordoba, Cordoba, Spain.

The Geant4 License

The collaboration presets *the Geant4 license*.

- *Makes clear the user's wide-ranging freedom to use, extend or redistribute Geant4, even as part of some for-profit venture.*
- The license was released along with the latest Geant4 release 8.1.
- Simple enough that you can read and understand it.

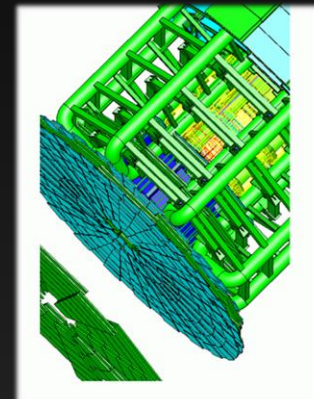


<http://cern.ch/geant4/license/>

Flexibility of Geant4

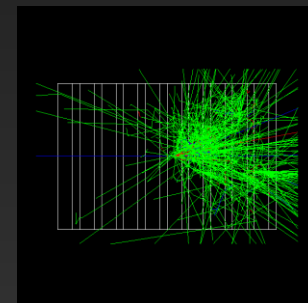
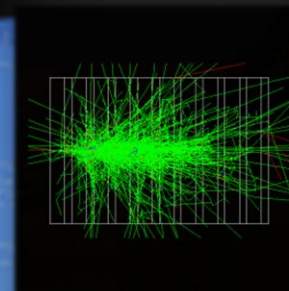
Many types of geometry descriptions

- CSG solids, BREP and boolean solids
- Placement, replica, divided, parameterized, reflected and grouped
- XML description



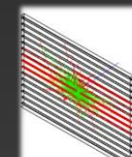
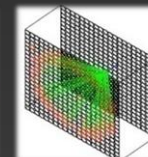
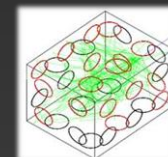
Wide coverage of physics processes

- EM, hadron, ion, optical photon, decay, shower parameterization event biasing, and your own processes
- Model mixture of theory-driven, data-driven and parameterized



Everything is open to the user

- Choice of physics processes/models
- Choice of analysis/user interface/visualization technologies



Geant4 is a tool kit, NOT a simulation black box!!