

Montecarlo Methods for Medical Physics

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Summary of the Course

- Part1 (Apr 28)
 - General (and brief) introduction to Monte Carlo methods
 - Montecarlo methods in Medical Physics
- Part2 (May 3 – May5)
 - Introduction to the Geant4 toolkit
 - Fundamentals of a Geant4 application
 - Physics, Geometry, Particle Flux, Scoring
- Part3 (May 5 – Today)
 - Realisation of an example relevant to Medical Physics

Evaluation for the “Laboratory”

- Discussion of Geant4 example
 - G4 example relevant to Medical Physics
- Discussion of requirements and methods
 - Medical Physics “environment”
 - Geant4 modeling
 - “Basic” analysis of results
- Realization of “new” example – Laboratory
 - Might just be an improvement of an existing G4 example

Homework

- Review G4 web pages
- Find Appropriate documentation
- Find relevant Medical Physics examples
- Define your preferred project
 - Simple geometry
 - Particle distributions
 - Scoring needs

Part 2

Introduction to Geant4
G4 examples
G4 geometry
G4 particle generation
G4 scoring mechanisms

Outline of Part2

- General Introduction to G4
 - What is G4 ?
 - Review of user documentation
 - Geant4 as a toolkit
- Basics of OO programming
- Geant4 Kernel and basics of the toolkit
 - Run, Event, Step
 - Particle and Physics processes
 - User classes
- Introduction to G4 examples
- Brief explanation of major user classes
 - Physics List, Particle generator action, DetectorConstruction, SensitiveDetectors

The Geant4 toolkit

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Geant4

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.

[Getting started](#)

Get started

Everything you need to get started with Geant4.

[I'm ready to start!](#)

Download

Geant4 source code and installers are available for download, with source code under an [open source license](#).

Latest: [11.1.1](#)

Docs

Documentation for Geant4, along with tutorials and guides, are available online.

[Read documentation](#)

News

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23 Mar 2023

[2023 Planned Features](#)

03 Mar 2023

[Release 11.0.4](#)

10 Feb 2023

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

G4 Application Developer

🏠 Book For Application Developers



10.5

Search docs

Introduction

Getting Started with Geant4 - Running a Simple Example

Toolkit Fundamentals

Detector Definition and Response

Tracking and Physics

User Actions

Control

[Docs](#) » Geant4 Book For Application Developers

Geant4 Book For Application Developers

Scope of this manual

The User's Guide for Application Developers is the first manual the reader should consult when learning about GEANT4 or developing a GEANT4 -based detector simulation program. This manual is designed to:

- introduce the first-time user to the GEANT4 object-oriented detector simulation toolkit,
- provide a description of the available tools and how to use them, and
- supply the practical information required to develop and run simulation applications which may be used in real experiments.

This manual is intended to be an overview of the toolkit, rather than an exhaustive treatment of it. Related physics discussions are not included unless required for the description of a particular tool. Detailed discussions of the physics included in GEANT4 can be found in the [Physics Reference Manual](#). Details of the design and functionality of the GEANT4 classes can be found in the [User's Guide for Toolkit Developers](#).

Geant4 Cross Reference














Geant4 Cross Reference

[Cross-Referencing](#) [Geant4](#)
[Geant4/](#)

Version: [[ReleaseNotes](#)] [[1.0](#)] [[1.1](#)] [[2.0](#)] [[3.0](#)] [[3.1](#)] [[3.2](#)] [[4.0](#)] [[4.0.p1](#)] [[4.0.p2](#)] [[4.1](#)] [[4.1.p1](#)] [[5.0](#)] [[5.0.p1](#)] [[5.1](#)] [[5.1.p1](#)] [[5.2](#)] [[5.2.p1](#)] [[5.2.p2](#)] [[6.0](#)] [[6.0.p1](#)] [[6.1](#)] [[6.2](#)] [[6.2.p1](#)] [[6.2.p2](#)] [[7.0](#)] [[7.0.p1](#)] [[7.1](#)] [[7.1.p1](#)] [[8.0](#)] [[8.0.p1](#)] [[8.1](#)] [[8.1.p1](#)] [[8.1.p2](#)] [[8.2](#)] [[8.2.p1](#)] [[8.3](#)] [[8.3.p1](#)] [[8.3.p2](#)] [[9.0](#)] [[9.0.p1](#)] [[9.0.p2](#)] [[9.1](#)] [[9.1.p1](#)] [[9.1.p2](#)] [[9.1.p3](#)] [[9.2](#)] [[9.2.p1](#)] [[9.2.p2](#)] [[9.2.p3](#)] [[9.2.p4](#)] [[9.3](#)] [[9.3.p1](#)] [[9.3.p2](#)] [[9.4](#)] [[9.4.p1](#)] [[9.4.p2](#)] [[9.4.p3](#)] [[9.4.p4](#)] [[9.5](#)] [[9.5.p1](#)] [[9.5.p2](#)] [[9.6](#)] [[9.6.p1](#)] [[9.6.p2](#)] [[9.6.p3](#)] [[9.6.p4](#)] [[10.0](#)] [[10.0.p1](#)] [[10.0.p2](#)] [[10.0.p3](#)] [[10.0.p4](#)] [[10.1](#)] [[10.1.p1](#)] [[10.1.p2](#)] [[10.1.p3](#)] [[10.2](#)] [[10.2.p1](#)] [[10.2.p2](#)] [[10.2.p3](#)] [[10.3](#)] [[10.3.p1](#)] [[10.3.p2](#)] [[10.3.p3](#)] [[10.4](#)] [[10.4.p1](#)] [[10.4.p2](#)] [[10.4.p3](#)] [[10.5](#)] [[10.5.p1](#)]

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 digits_hits/		2019-04-17 07:34:31	
 environments/		2019-04-17 07:34:33	
 error_propagation/		2019-04-17 07:34:32	
 event/		2019-04-17 07:34:32	
 examples/		2019-04-17 07:34:31	
 externals/		2019-04-17 07:34:32	
 g3tog4/		2019-04-17 07:34:32	
 geometry/		2019-04-17 07:34:32	
 global/		2019-04-17 07:34:33	
 graphics_reps/		2019-04-17 07:34:32	

To use Geant4, you have to...

- Geant4 is a toolkit. You have to build an application.
- To make an application, you have to
 - Define your geometrical setup
 - Material, volume
 - Define physics to get involved
 - Particles, physics processes/models
 - Production thresholds
 - Define how an event starts
 - Primary track generation
 - Extract information useful to you
- You may also want to
 - Visualize geometry, trajectories and physics output
 - Utilize (Graphical) User Interface
 - Define your own UI commands
 - etc.

User Classes needs

- Define material and geometry
 - G4VUserDetectorConstruction
- Select appropriate particles and processes and define production threshold(s)
 - G4VUserPhysicsList
- Define the way of primary particle generation
 - G4VUserPrimaryGeneratorAction
- Define the way to extract useful information from Geant4
 - G4UserSteppingAction, G4UserTrackingAction, etc.
 - G4VUserDetectorConstruction, G4UserEventAction, G4Run, G4UserRunAction
 - G4SensitiveDetector, G4VHit, G4VHitsCollection
 - G4PrimitiveScorers

Advanced Examples

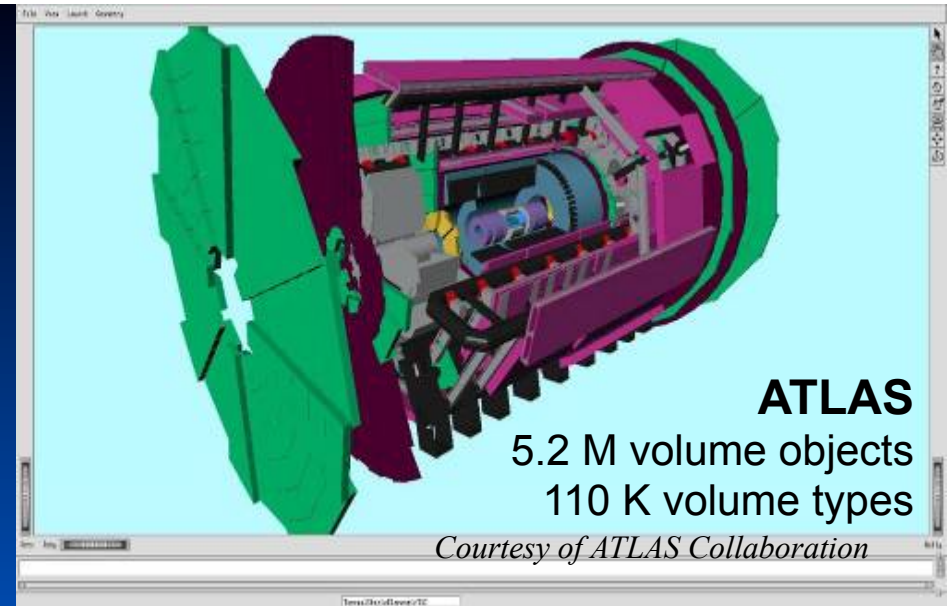
- air_shower
- ams_Ecal
- Brachytherapy
- ChargeExchangeMC
- composite_calorimeter
- eRosita
- Gammaknife
- gammaray_telescope
- hadrontherapy
- human_phantom
- iort_therapy
- IAr_calorimeter
- medical_linac
- microbeam
- microelectronics
- nanobeam
- purging_magnet
- radioprotection
- underground_physics
- xray_fluorescence
- xray_telescope

Laboratory - 6

- Find the examples relevant to Medical Physics

Geometry

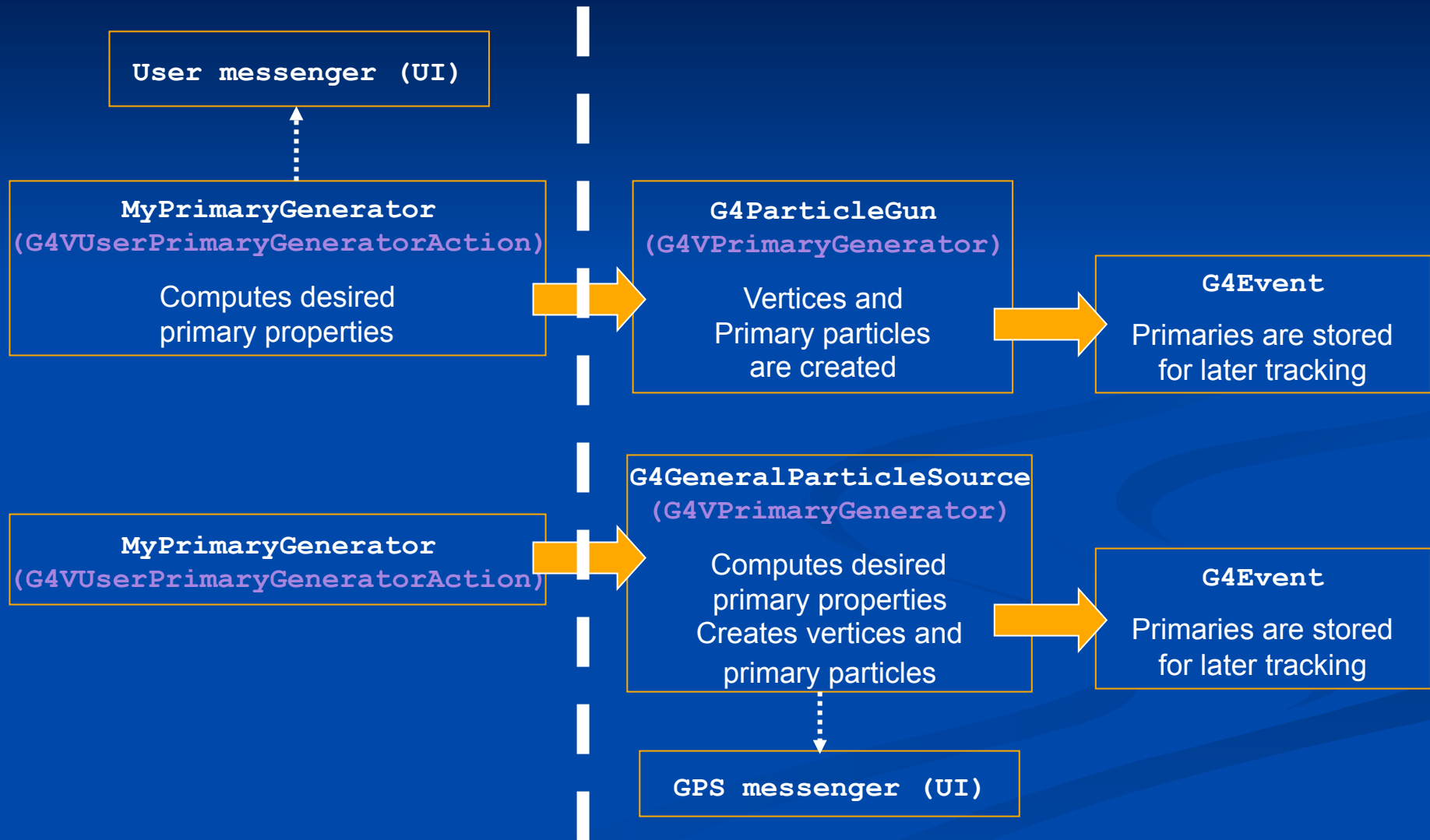
- Role
 - detailed detector description
 - efficient navigation
- Three conceptual layers
 - **Solid**: shape, size
 - **LogicalVolume**: material, sensitivity, daughter volumes, etc.
 - **PhysicalVolume**: position, rotation
- One can do fancy things with geometry...



Boolean operations



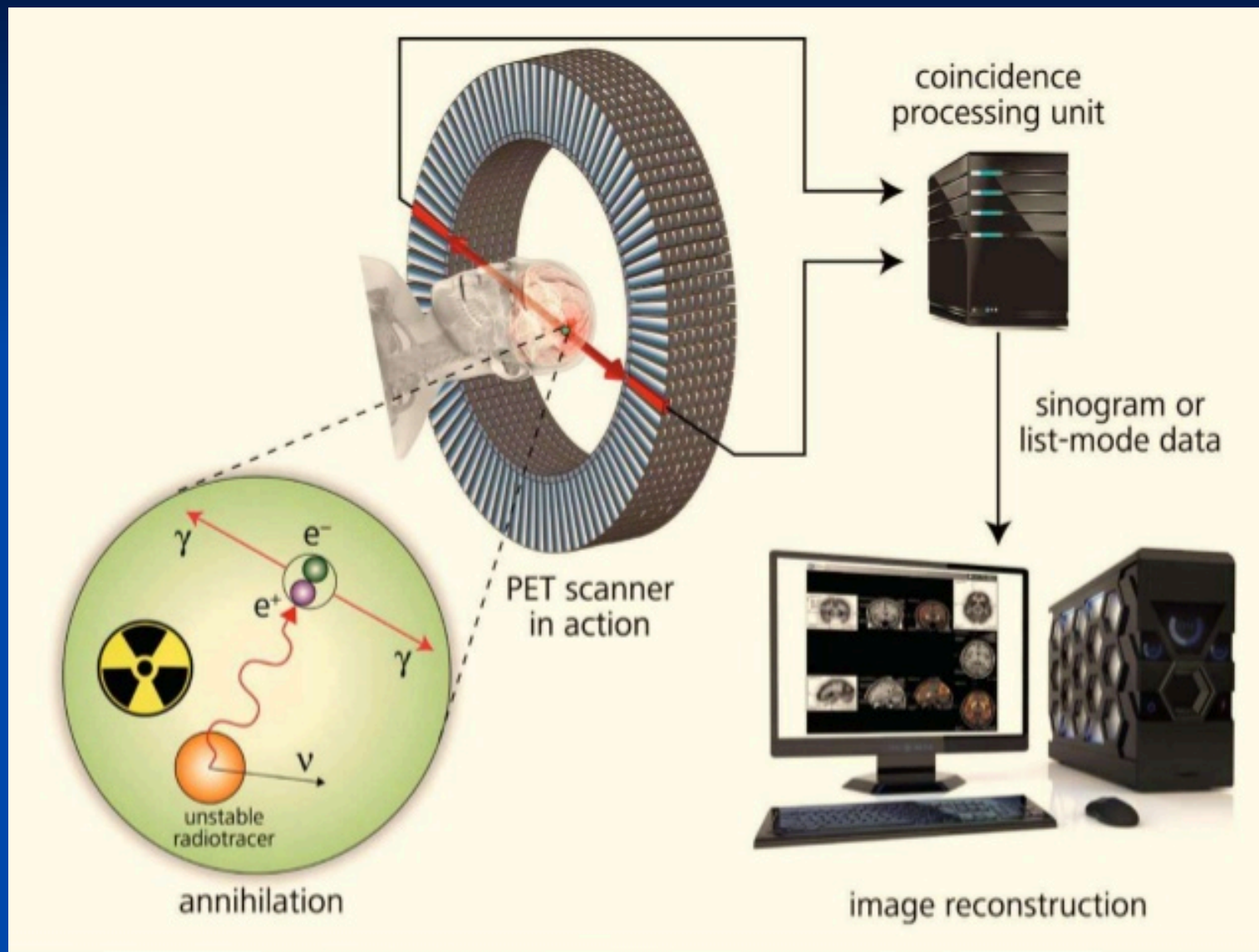
GPS vs G4ParticleGun



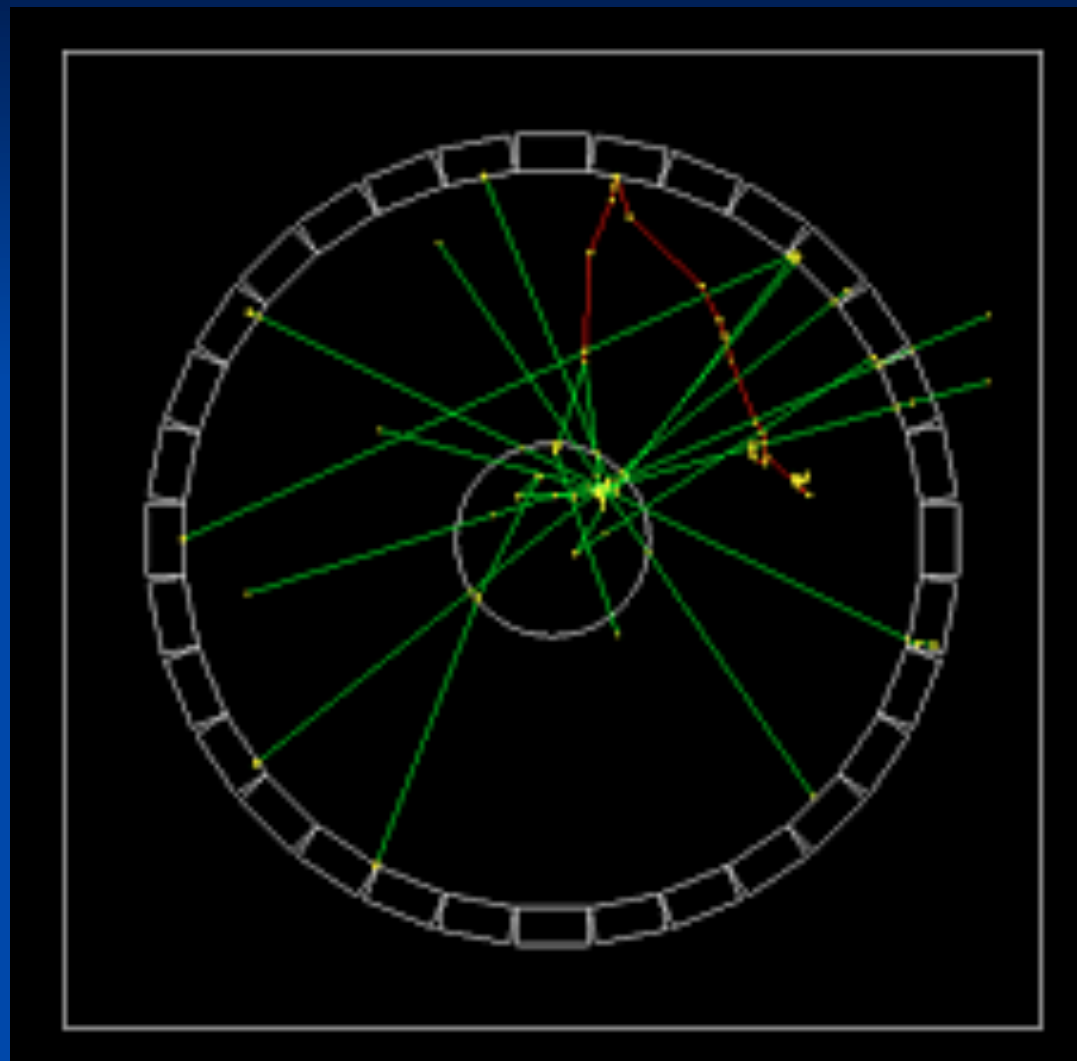
Laboratory – 7 – 8 – 9

- Find the materials in G4 example basic B3
- Identify the geometrical shapes and positions used in G4 example B3
- Check the usage of particle generation method in G4 example B3

The PET scanners



The PET scanner



Laboratory - 10

- What do we need to know more?

Extract useful information

- Given geometry, physics and primary track generation, Geant4 does proper physics simulation “silently”.
 - You have to add a bit of code to **extract information useful to you**.
- There are three ways:
 - Use user hooks (G4UserTrackingAction, G4UserSteppingAction, etc.)
 - You have full access to almost all information
 - Straight-forward, but do-it-yourself
 - Use Geant4 scoring functionality
 - Assign **G4VSensitiveDetector** to a volume
 - **Hit** is a snapshot of the physical interaction of a track or an accumulation of interactions of tracks in the sensitive (or interested) part of your detector.
 - **Hits collection** is automatically stored in G4Event object, and automatically accumulated if **user-defined Run** object is used.
 - Use user hooks (G4UserEventAction, G4UserRunAction) to get event / run summary
 - Using the **G4 primitive scorers**

Laboratory - 11

- Check the Scoring mechanism in example B3

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Final laboratory

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