Status of the ***EduGATE*** *Project*

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with contributions from

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(* See separate presentations)

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New Master Course at University of Wuppertal

(international / English)

→ Computer Simulation in Science ***CSIS***

Topic: *Imaging in Medicine*

→ Focus on
physical and computational background
of imaging In Medicine
including computer simulation

- *special topics: imaging for medical application*
- *Application of Simulation → System Design, etc.*
- *Image Reconstruction*
- *Image Analysis and Data Visualization*

New Master Course at University of Wuppertal

(international / English)

→ Computer Simulation in Science CSIS

- *Based to a large part on:*
- *GATE*
- *Root / C++*

But also:

- *Develop / use Python-based analysis interface including tools for image reconstruction.*

EduGATE – basic examples for educative purpose using the GATE simulation platform

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Abstract

EduGATE is a collection of basic examples to introduce students to the fundamental physical aspects of medical imaging devices. It is based on the GATE platform, which has received a wide acceptance in the field of simulating medical imaging devices including SPECT, PET, CT and also applications in radiation therapy. GATE can be configured by commands, which are, for the sake of simplicity, listed in a collection of one or more macro files to set up phantoms, multiple types of sources, detection device, and acquisition parameters. The aim of the EduGATE is to use all these helpful features of GATE to provide insights into the physics of medical imaging by means of a collection of very basic and simple GATE macros in connection with analysis programs based on ROOT, a framework for data processing. A graphical user interface to define a configuration is also included.

Keywords: Monte Carlo Simulation, GATE, PET, SPECT, Education, Imaging

EduGATE – einfache lehrreiche Beispiele zum Zweck der Ausbildung basierend auf der GATE Simulationsplattform

Zusammenfassung

EduGATE ist eine Sammlung einfacher basaler Beispiele für Studenten zur Einführung in die fundamentalen Aspekte der bildgebenden Systeme in der Medizin. Sie baut auf der GATE-Plattform auf, die im Feld der Simulation bildgebender Systeme besonders SPECT, PET, CT, ebenso auch Strahlentherapie eine weite Verbreitung gefunden hat. GATE wird gewöhnlich durch Kommandos gesteuert, die zur Vereinfachung in eine Reihe von Dateien (Makros) zusammengefasst sind und Phantome, verschiedene Typen an Quellen, Nachweisdetektor und Akquisitionsparameter beschreiben. Das Ziel, EduGATE zu entwickeln, war, diese vielfältigen, sehr nützlichen Eigenschaften zu nutzen, um mithilfe sehr einfacher GATE-Makros dem interessierten Nutzer Zugang zur Physik der medizinischen Bildgebung zu ermöglichen, verbunden mit einem Analyseprogramm basierend auf ROOT, einem Softwarepaket für Datenanalyse. Eine graphische Benutzerschnittstelle zur Definition der gewünschten Konfiguration ist eingeschlossen.

Schlüsselwörter: Monte-Carlo-Simulation, GATE, PET, SPECT, Bildgebung, Ausbildung

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http://journals.elsevier.de/zemedi

An article that describes EduGATe was published in 2012. Since then EduGATE several new examples have been added. Currently **9** basic modules have ben developed and tested, Two of which were available publically:

Gamma-Camera
Coincidance Channel

Installation of GATE / EduGATE project
on a cluster named " Compass"
using Easy-GATE-Installation-master

→

Students have easy access to GATE / EduGATE!

→ *Used during Lecture & Exercises*

Motivation to extend the EduGATE project & to teach it in an IEEE Short Course → Atlanta 2017 & Sydney 2018;

- GATE is *powerful* but also quite complex …

  → initially EduGATE was intended to provide very *simple introductory examples* to support newcomers using GATE

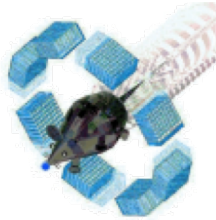
- the simple and very basic examples turned out to be useful during lectures
  → exposing basic detector & imaging physics

Using GATE to Educate → EduGATE

Note:You need a running Version of GATE to use: EduGATE

GATE_v7.2 or GATE_v8.0 {v8.1,2 not tested yet!}

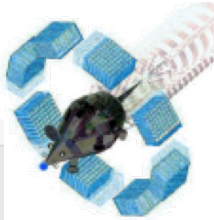
List of examples – EduGATE used during Lecture "Collection 2018+ "



(compatible with Gate; 8.0; Root 6)

- **Coin_Chan** → from a **coincidence channel** to a **PET** system
  Coin_Chan+ **extended version → to study "scatter" effects …**
- **Gamma_Camera** → basic imaging features of a **Gamma camera**
- **SPECT_to_Reco** → including **Reconstruction** from projections - **(based on /DL/GDL)**
  → (needs new Reco part, based on C++ / Python (Fiji)
- **Spectro** → analysing **Energy Spectra** of **radioactive Isotopes** → linking to the book „ -->Physics in Nuclear Medicine" of Cherry et al.:
- **Spectrometry_Gamma+** → actually **two** modules (**basic** & **extended**)
  → also linking to the book of Cherry et al. ()*
- **MR-PET+** → **available in two versions (Particle & Ion Sources)**
  → **explore the fate of Positron or Electron in a MR-system**
- **Attenuation** → a **Monte Carlo approach** …based on an "*unrealistic*" system
- **Cherenkov …** → **Optical Photons; Cherenkov & Scintillation → fast PET-Detectors**
- **MultiLayer_PET** → expectations for higher spatial resolution using 1 to 4 crystal layers

Ex.1 – EduGATE environment



file: Gamma_Camera.txt
with start-settings

→ large number of combinations

ViewPointThetaPhi: 0 90; 90 0; -90 0; 89 90;

VisuOnOff: novisu; visu;

Src_Act: 20 Bq; 50 Bq; 100 Bq; 1000 Bq; 10000 Bq; 0.1 MBq; 0.5

CameraType: camera_Tc; camera_I_131;

x_pos: 20.0; 15.0; 10.0;

CollMat: Lead; Vacuum; Air; Copper; Iron; Tungsten; Plexiglass;

CrysMat: NaI; BGO; LSO; GSO; PWO; LuAP; YAP; CZT;

PhanMat: Plexiglass; Water; Air; Vacuum; Lead; PVC; Copper;….;

PhanRmax: 50 mm; 52 ; 54 ;

PhanRmin: 49 mm; 49.99 mm; 49.9 mm; 49.5 mm;

SrcVolMat: Plexiglass; Air; Water; Vacuum; PVC;

SrcType: src_gamma_3_lim_ang; src_gamma_lim_ang;

Src_E: 140; 80; 364; 511; 1000; 2284;

E_blur: 0.1; 0.0; 0.05; 0;0.15; 0.20; 0.25;

SP_blur: 2.0; 0.5; 1.0; 1.5; 2.5; 3.0; 4.0; 5.0;

E_low: 5; 50; 100;

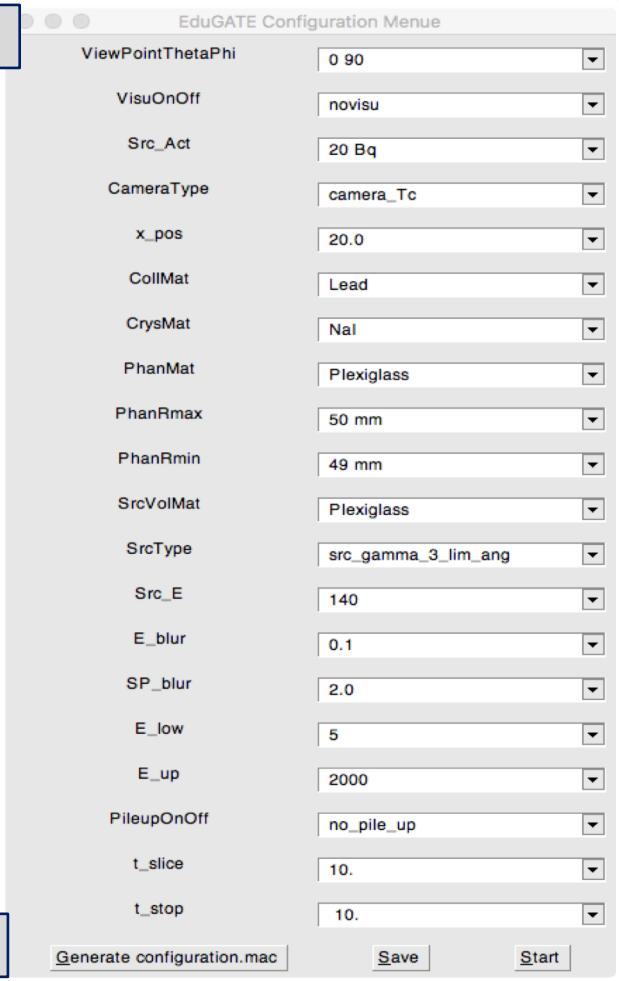
E_up: 2000; 100;

PileupOnOff: no_pile_up; pile_up;

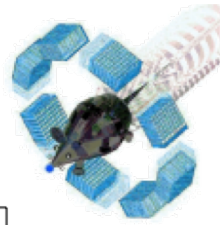
t_slice: 10.; 1.0; 0.1; 0.01; 0.001; 0.0001;

t_stop: 10.; 1.0; 0.1; 0.01; 0.001; 0.0001;

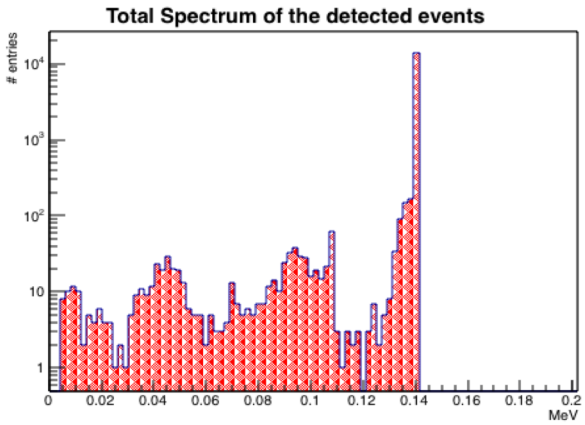
default selections

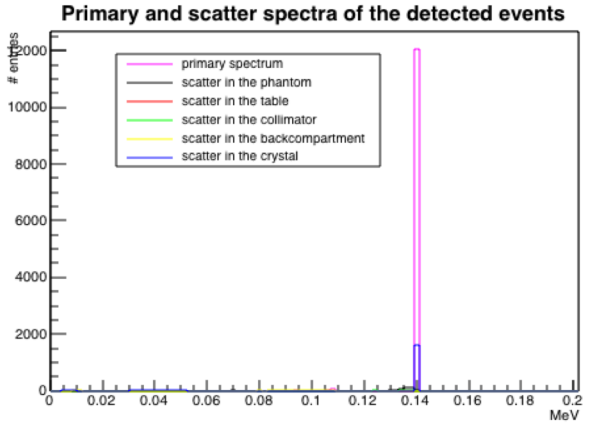


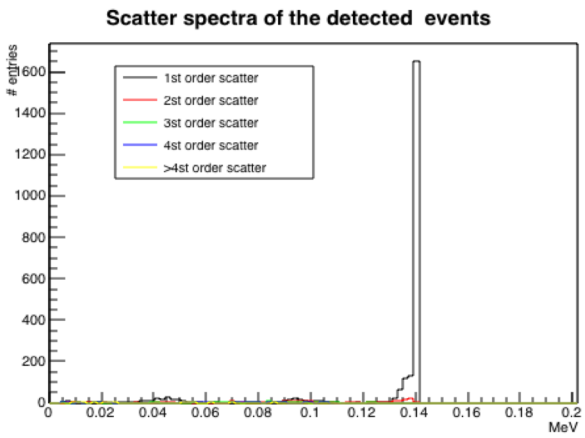
ROOT – Based Analysis

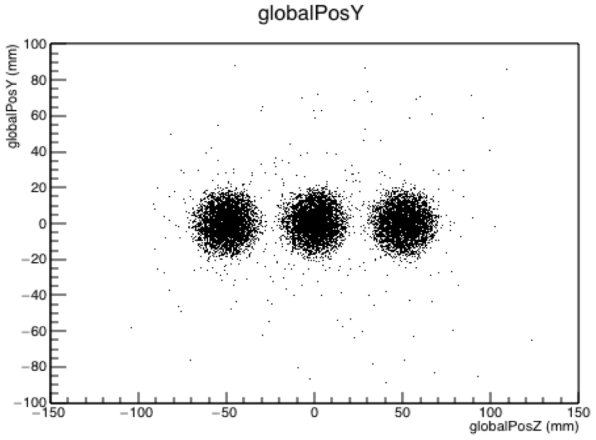


Perfect Energy Resolution,
blurring: 0.0%!



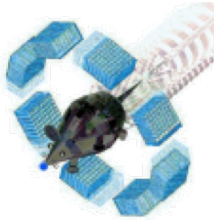






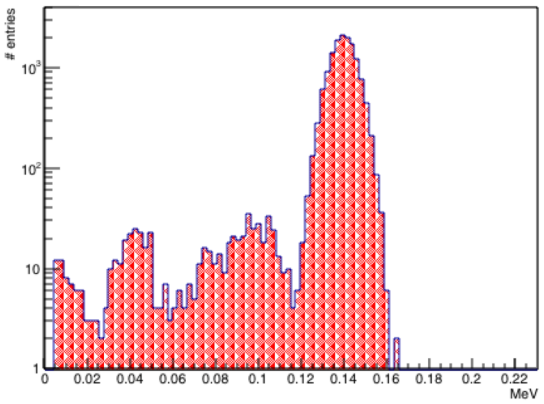
GC_camera_Tc_Lead_NaI_Plexiglass_Plexiglass_src_gamma_3_lim_ang_140_0.1 MBq_no_pile_up_0.0_2.0_5_2000_1.0_10..root

ROOT – Based Analysis

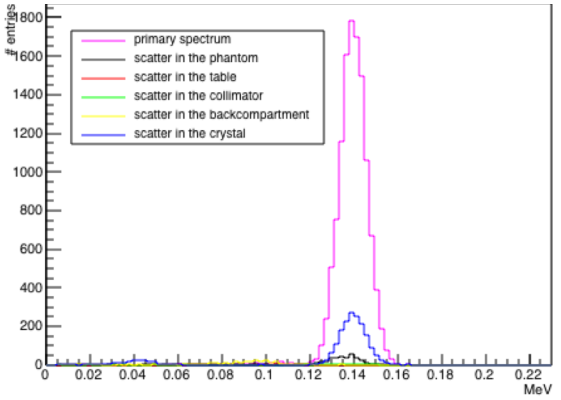


Limited Energy Resolution,
blurring: 10.0%!

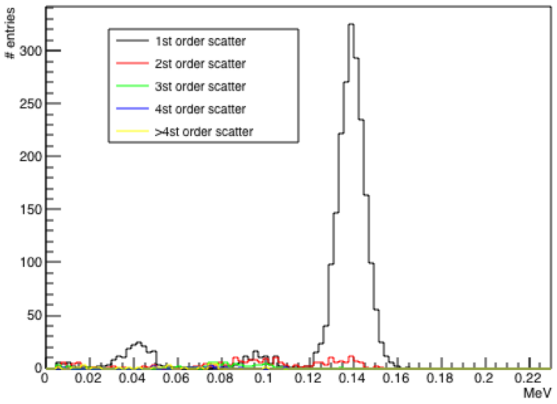
Total Spectrum of detected events



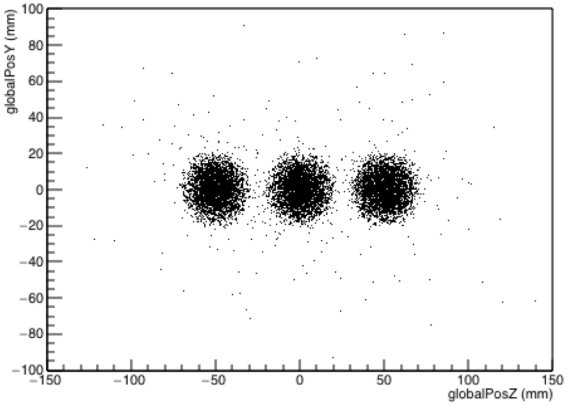
Primary and scatter spectra of detected events



Scatter spectra of detected events

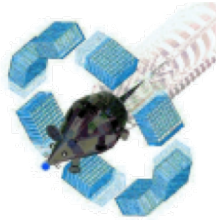


globalPosY

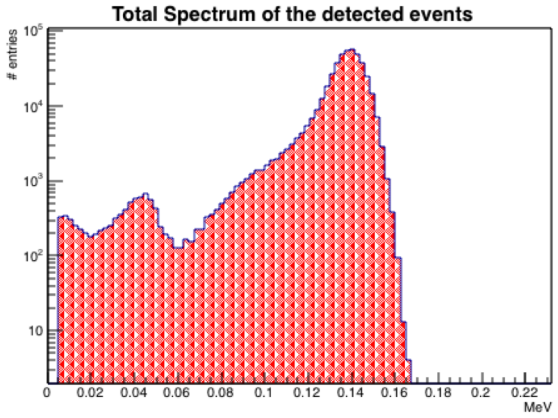


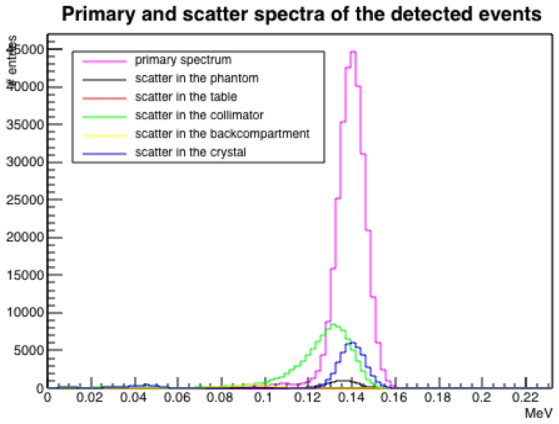
GC_camera_Tc_Lead_NaI_Plexiglass_Plexiglass_src_gamma_3_lim_ang_140_0.1 MBq_no_pile_up_0.1_2.0_5_2000_1.0_10..root

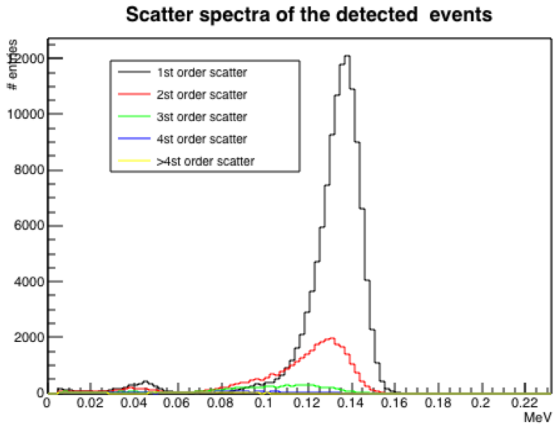
ROOT – Based Analysis

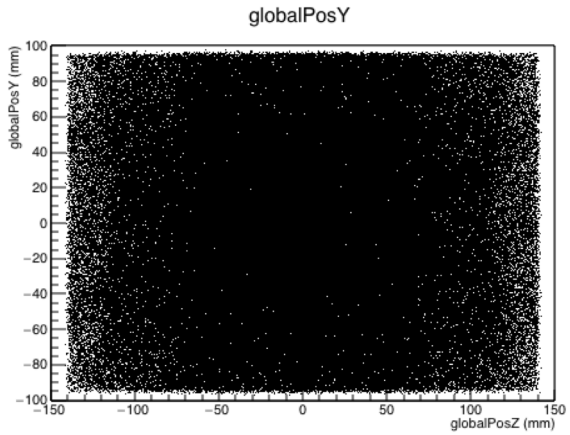


Collimator Material Copper
--→ No Imaging possible!!



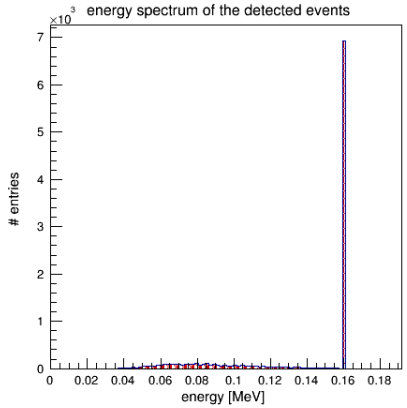


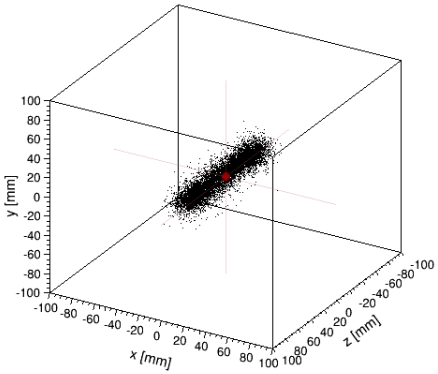




GC_camera_Tc_Copper_NaI_Plexiglass_Plexiglass_src_gamma_3_lim_ang_140_0.1 MBq_no_pile_up_0.1_2.0_5_2000_1.0_10..root

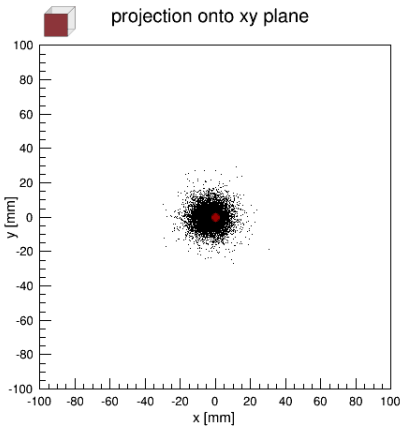
Magnetic field in z direction

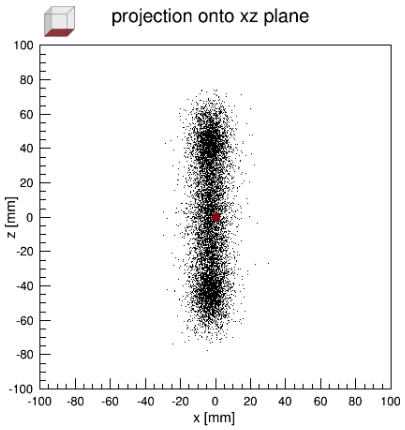


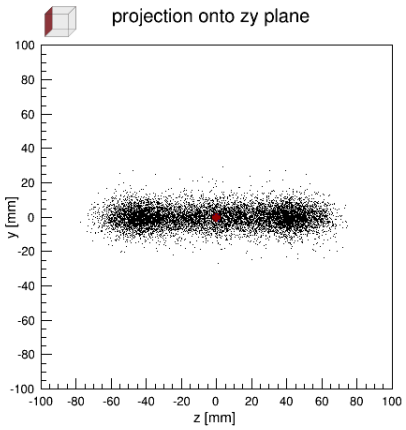


- particle: e-
- camera type: cube
- crystal material: Air
- source energy: 160 keV
- source activity: 100 Bq
- source type: beam (y)
- $B_{0,x}$: 0.0 T
- $B_{0,y}$: 0.0 T
- $B_{0,z}$: 0.5 T

source position







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