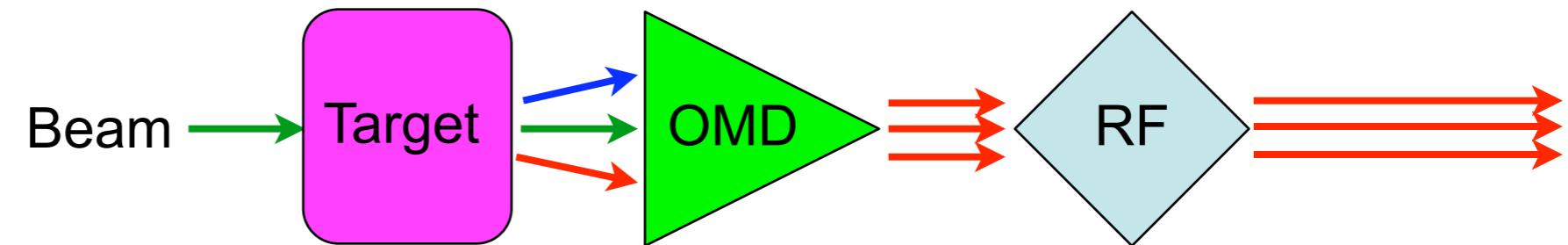


# Positron Source Modelling using Geant4

S. Riemann, A. Schälicke, A. Ushakov

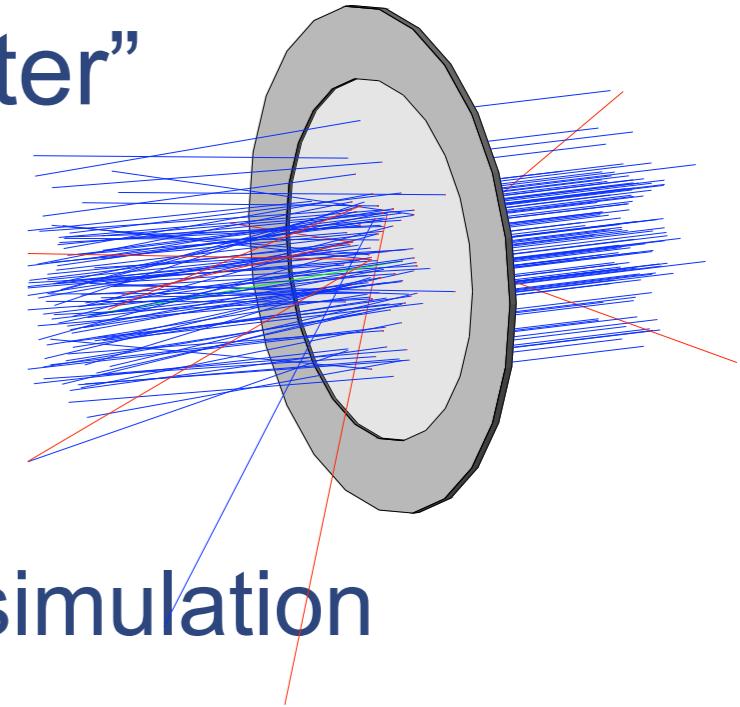
- Introduction
  - PPS Overview
  - Geant4 Overview
- PPS-Sim
  - Features
  - Results
- Live Demo
- Summary/Outlook

## Polarised Positron Source (for the ILC)



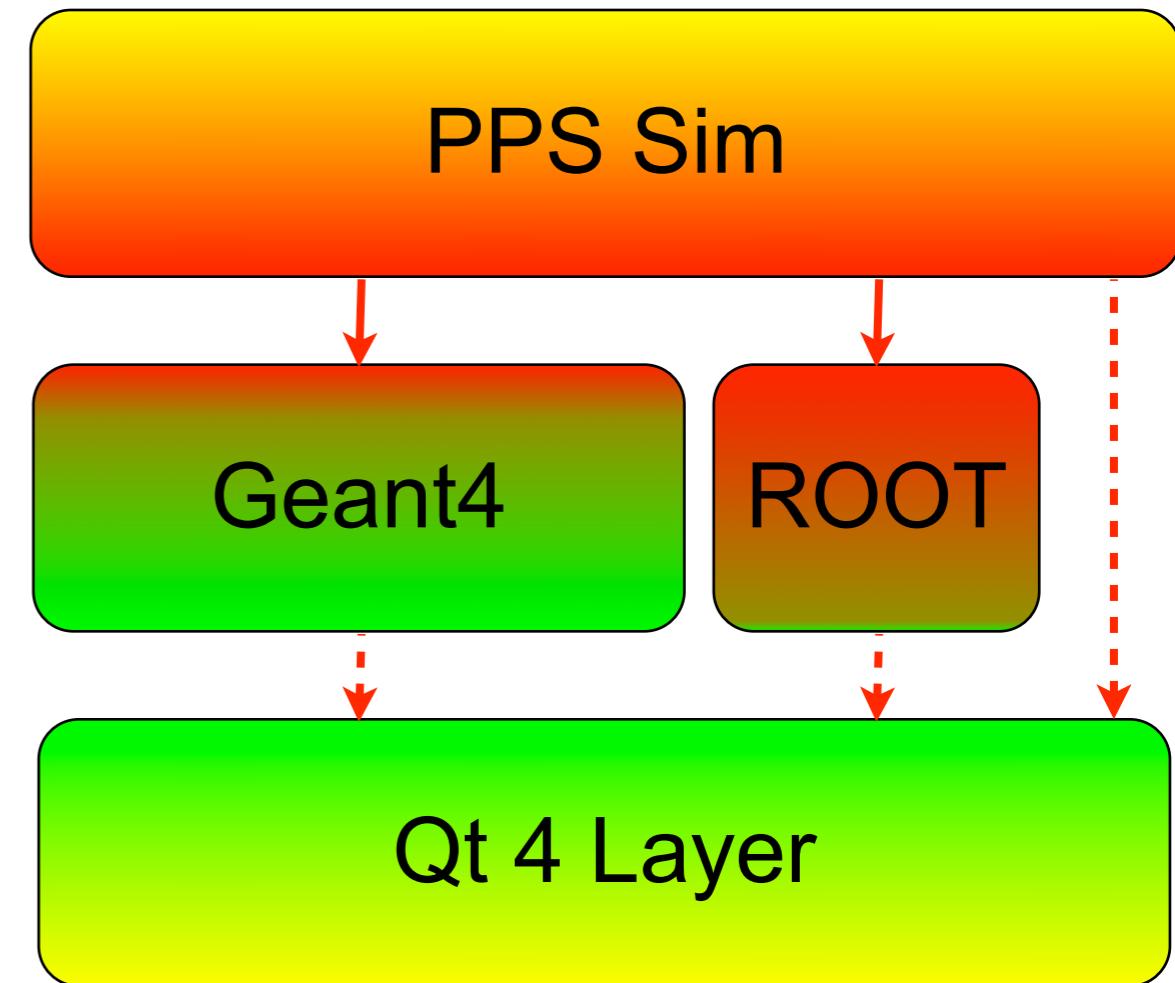
- Primary beam
  - Photons from Undulator
  - Electrons (conventional source)
  - Input file (Compton photons, Crystal target)  new
- Target
  - Ti wheel, Liquid Lead
- Positron Capture Optics (OMD)
  - AMD, QWT, Li-Lens
  - Solenoid B-field, RF E-field

- **Geant4 Toolkit**  
“a toolkit for the simulation of  
the passage of particles through matter”
- Features include
  - powerful geometry package
  - electromagnetic and hadronic shower simulation
  - polarisation transfer in physics processes
  - particle and spin tracking in electromagnetic fields
  - visualisation (geometry, particles, energy deposition,...)
  - GUI (XM, Qt,...)
  - ...



- Idea: use Geant4 for modelling of PPS
  - start from positron production (target)
  - end after first accelerator structure
  - simplified geometry
  - aim: easy usage (also for non-G4 experts)
- graphical user interface (GUI)
  - visualisation
  - internal analysis
- allow for batch mode running
  - high statistics runs
  - configure via macro commands
  - post analysis

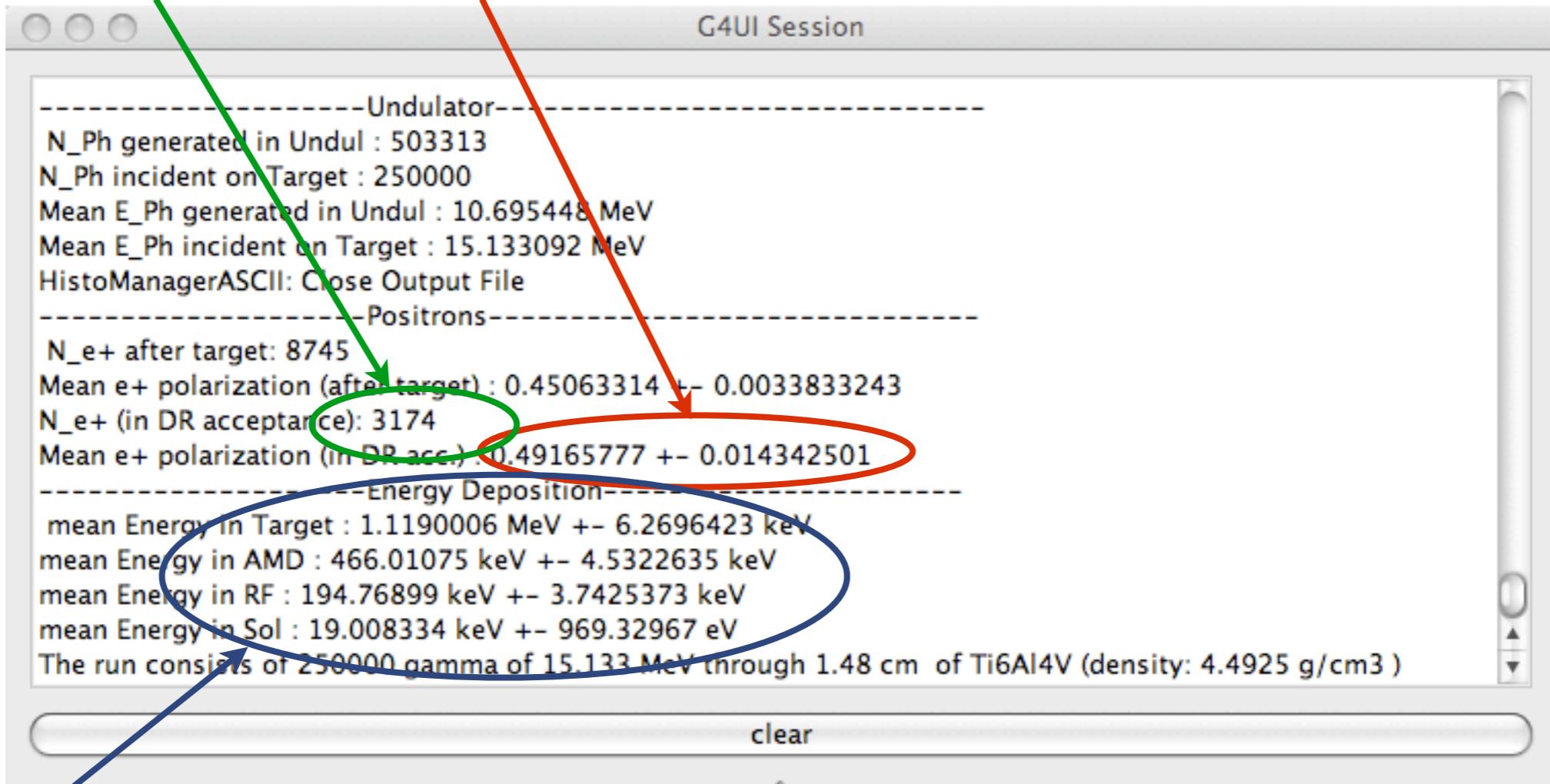
- Layout
  - use **Geant4** for:  
geometry, physics, UI
  - use **ROOT** for:  
data analysis, persistency
- Prerequisites
  - Geant4 9.2  
(incl. Qt4 binding)
  - ROOT 5.22  
(incl. Qt4 binding)
  - **Qt 4.2 or above**  
(4.4.x recommended)



- Tested:
  - Linux SL5 and OpenSuSE
  - MacOSX 10.5.x

- Input:
  - Beam, Target & OMD (free configurable)
- Output:
  - positron yield & polarisation (incl. DR acceptance)
  - beam properties (width, emittance, energy, ...)
  - total energy deposition in components
  - ...
- User interface:
  - GUI allows for setting of simulation parameter
  - visualisation of geometry & tracks
  - semi-automatic parameter scans (e.g. RF phase)
  - output as .root, .eps, .....

- positron yield & polarisation

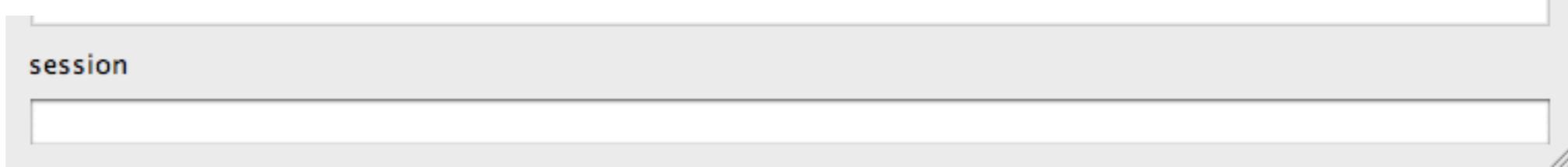


```
G4UI Session

-----Undulator-----
N_Ph generated in Undul : 503313
N_Ph incident on Target : 250000
Mean E_Ph generated in Undul : 10.695448 MeV
Mean E_Ph incident on Target : 15.133092 MeV
HistoManagerASCII: Close Output File
-----Positrons-----
N_e+ after target: 8745
Mean e+ polarization (after target) : 0.45063314 +- 0.0033833243
N_e+ (in DR acceptance): 3174
Mean e+ polarization (in DR acc.) : 0.49165777 +- 0.014342501
-----Energy Deposition-----
mean Energy in Target : 1.1190006 MeV +- 6.2696423 keV
mean Energy in AMD : 466.01075 keV +- 4.5322635 keV
mean Energy in RF : 194.76899 keV +- 3.7425373 keV
mean Energy in Sol : 19.008334 keV +- 969.32967 eV
The run consists of 250000 gamma of 15.133 MeV through 1.48 cm of Ti6Al4V (density: 4.4925 g/cm3 )

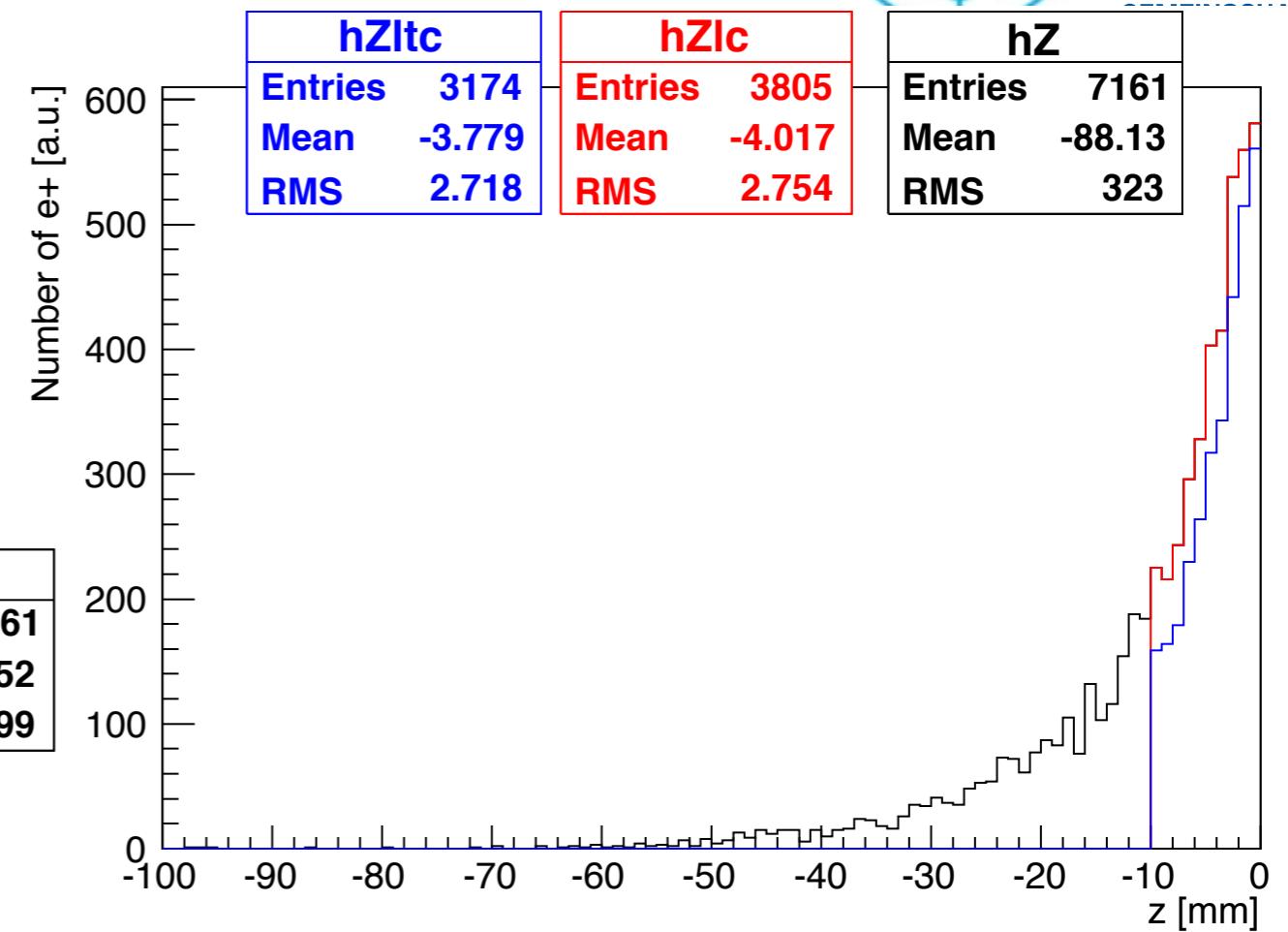
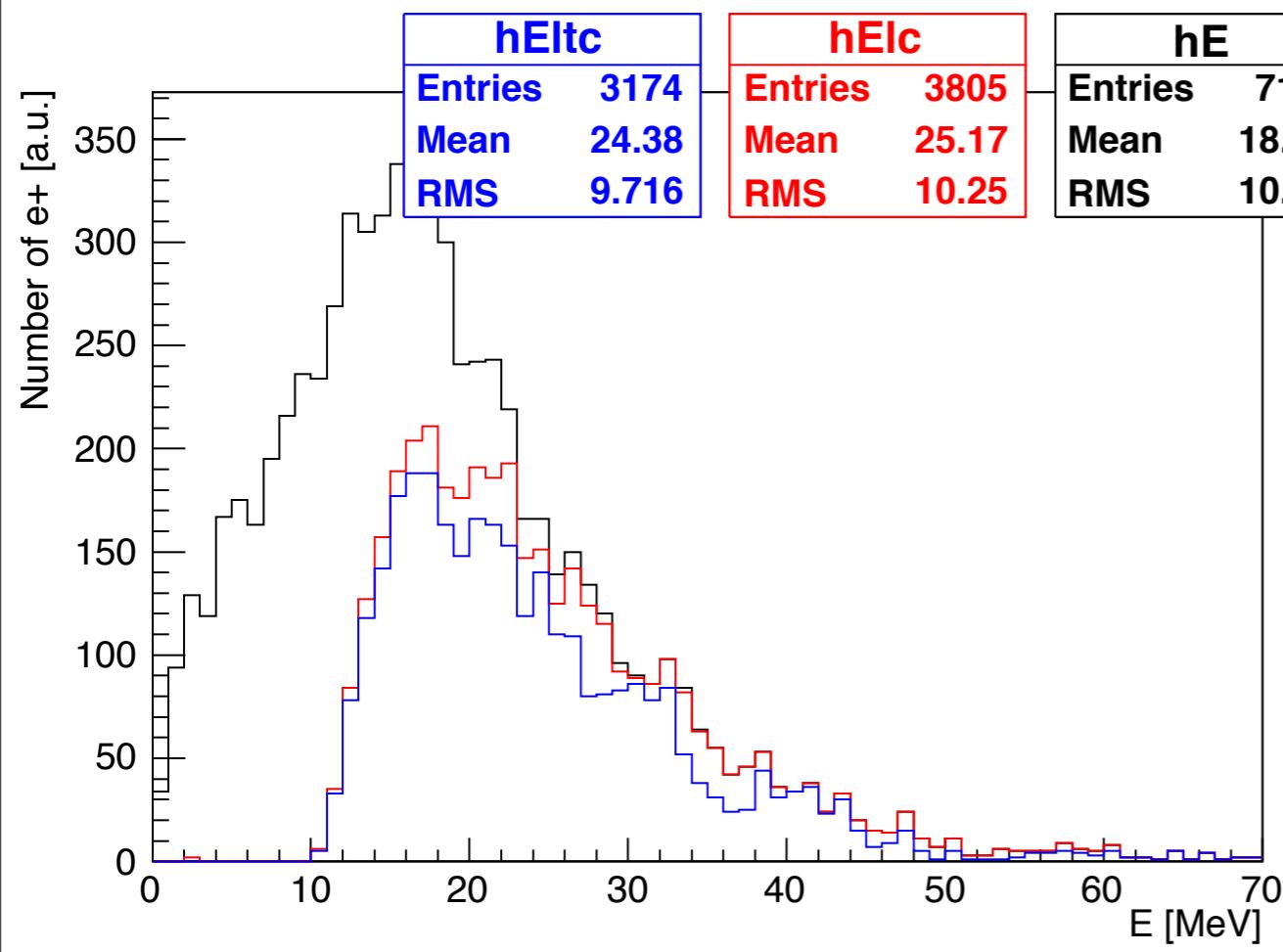
clear
```

- total energy deposition  
in components



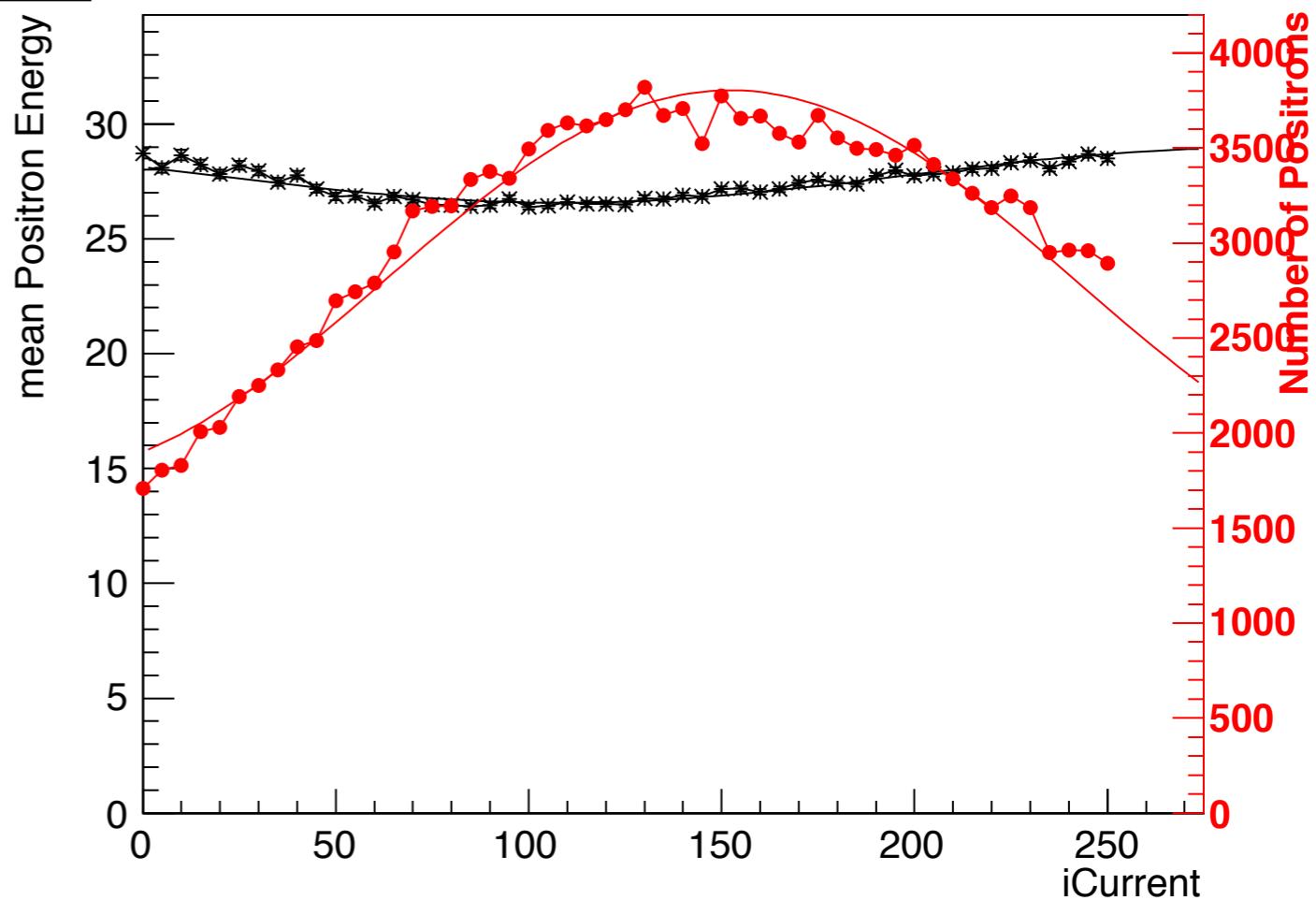
# Results

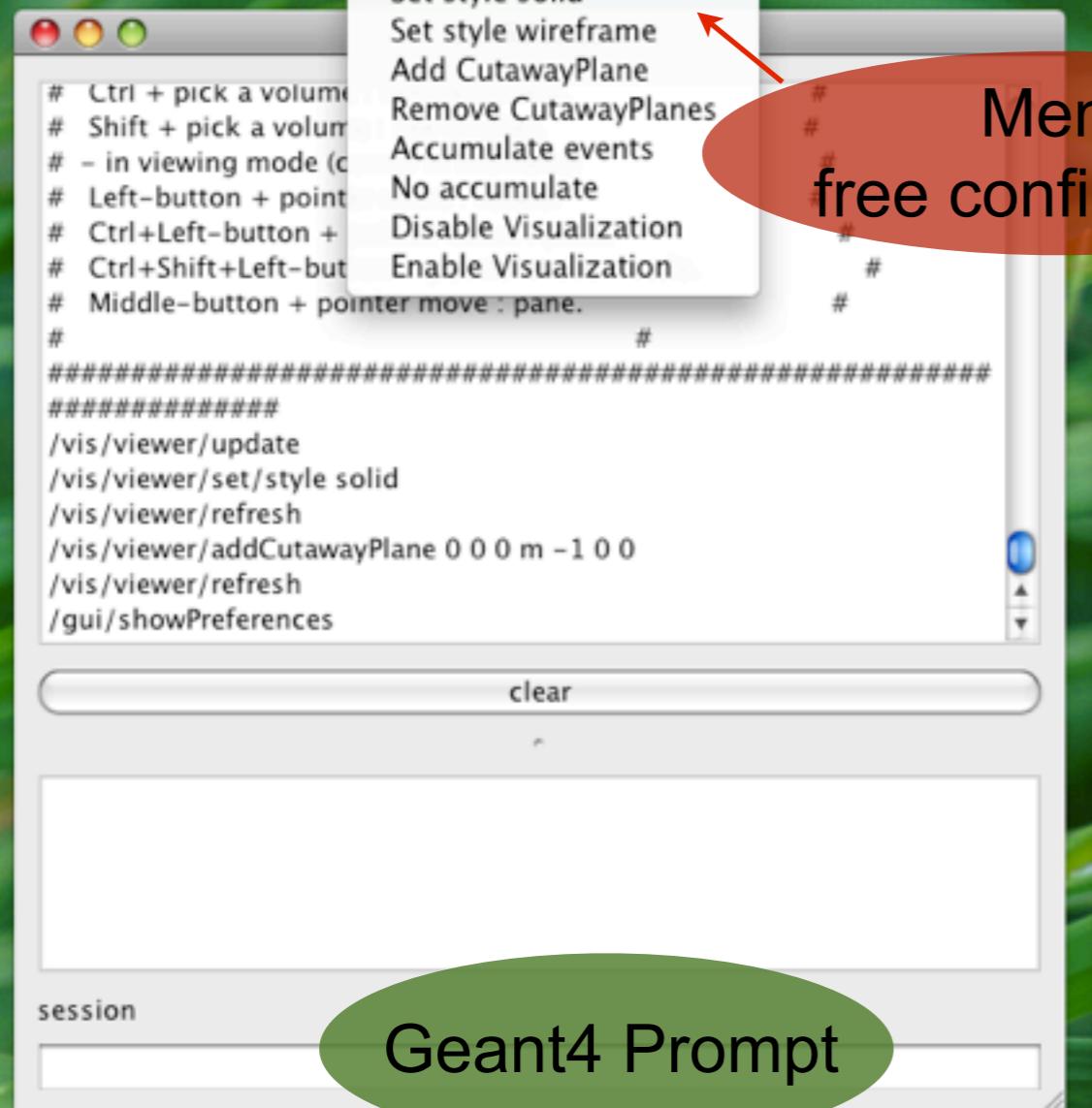
- Energy distribution
- Phase space



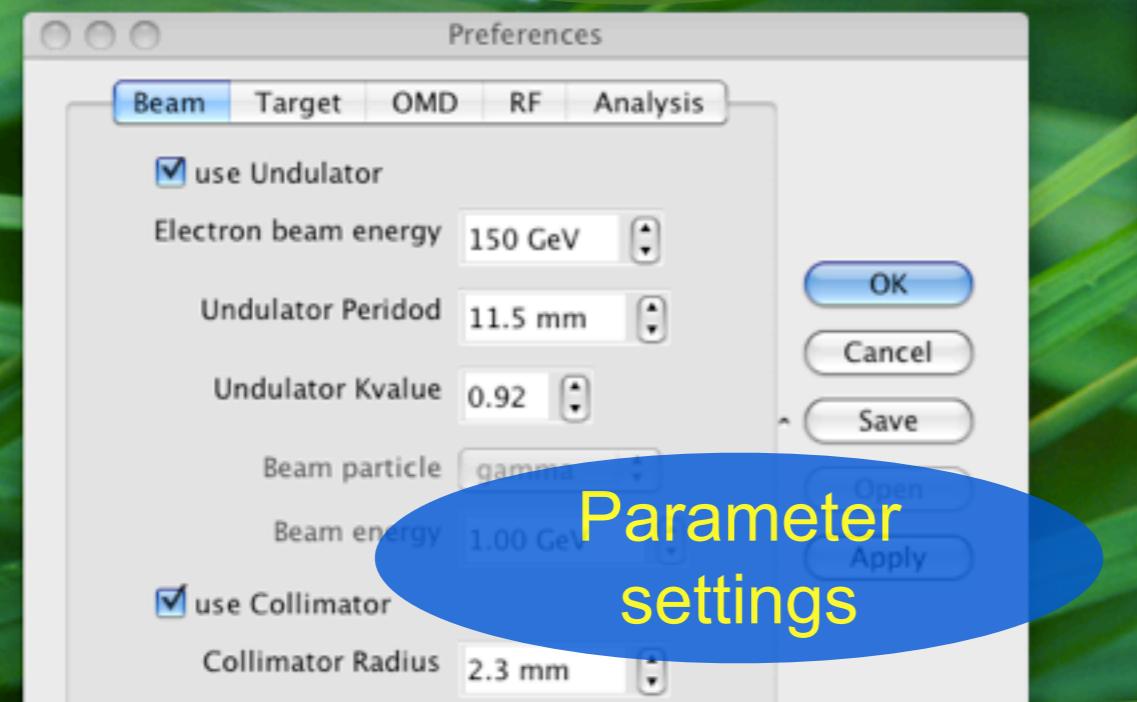
- (almost) arbitrary scans, e.g.
  - RF phase
  - target thickness
  - lens current  
(liquid Lithium)
  - field strength,  
OMD length  
(quarter wave trans.)
  - ....

Graph

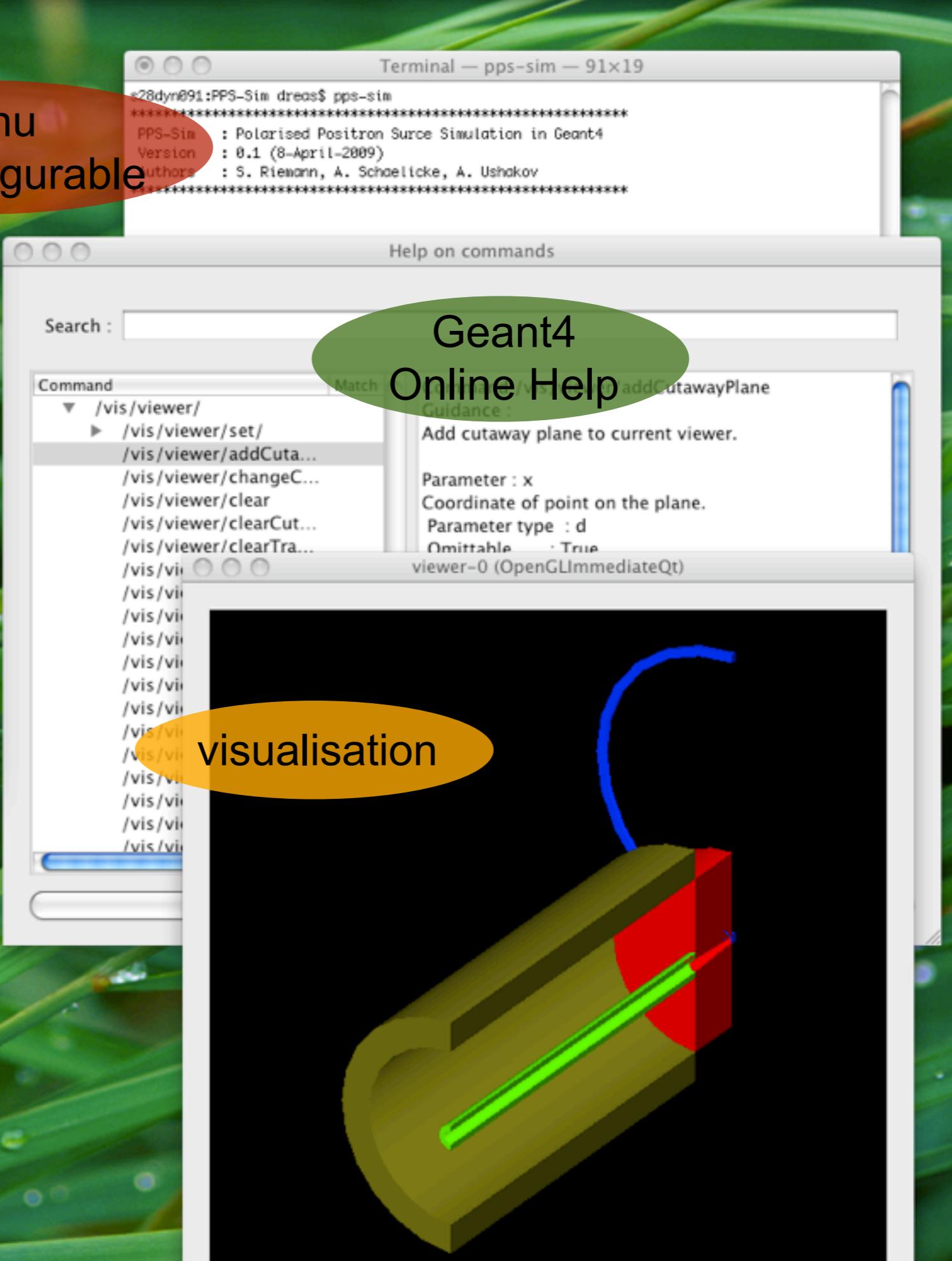




Geant4 Prompt



Parameter  
settings



Menu  
free configurable

Geant4  
Online Help

visualisation

## G4UI Session

N<sub>e+</sub> after target: 662  
 Mean e+ polarization (after target) : 0.46943857 +- 0.012203364  
 N<sub>e+</sub> (in DR acceptance): 212  
 Mean e+ polarization (in DR acc.) : 0.5096635 +- 0.055309366  
 iAngle : 345  
 -----Energy Deposition-----  
 mean Energy in Target : 1.1286344 MeV +- 22.102176 keV  
 mean Energy in AMD : 467.1731 keV +- 15.941289 keV  
 mean Energy in RF : 200.89736 keV +- 13.147376 keV  
 mean Energy in Sol : 20.585068 keV +- 3.7232789 keV

## -----Run Summary-----

The run consists of 20000 gamma of 14.992 MeV through 1.48

**Geant4 output**  
 (e.g. energy deposition)

session

## About PPS Sim

## PPS Sim G4

Polarised Positron Source Simulation in Geant4

Version 0.1

Authors: S. Riemann, A. Schälicke, A. Ushakov  
DESY, Zeuthen, Germany

Ok

## Terminal — pps-sim — 91x19

59.1522 percent of e+ are out of transv. and long. DR acceptance

tag=iAngle#

value=345#

212 : 24.6416 +- 0.551981

FCN=161.707 FROM MIGRAD STATUS=CONVERGED

EDM=7.45058e-12 STRATEGY= 1 EXPONENTIAL MATERIAL ACCURATE

STEP FIRST

EXT PARAMETER NO. NAME VALUE ERROR SIZE DERIVATIVE

1 p0 1.85434e+01 1.84651e-01 6.05036e-05 -1.33478e-04

2 p1 1.08273e+01 2.64165e-01 9.00113e-05 -2.56887e-04

3 p2 -6.33418e+01 1.13032e+00 7.82783e-03 -1.96041e-07

FCN=51.5481 FROM MIGRAD STATUS=CONVERGED 75 CALLS 76 TOTAL

EDM=4.22859e-11 STRATEGY= 1 ERROR MATRIX ACCURATE

STEP FIRST

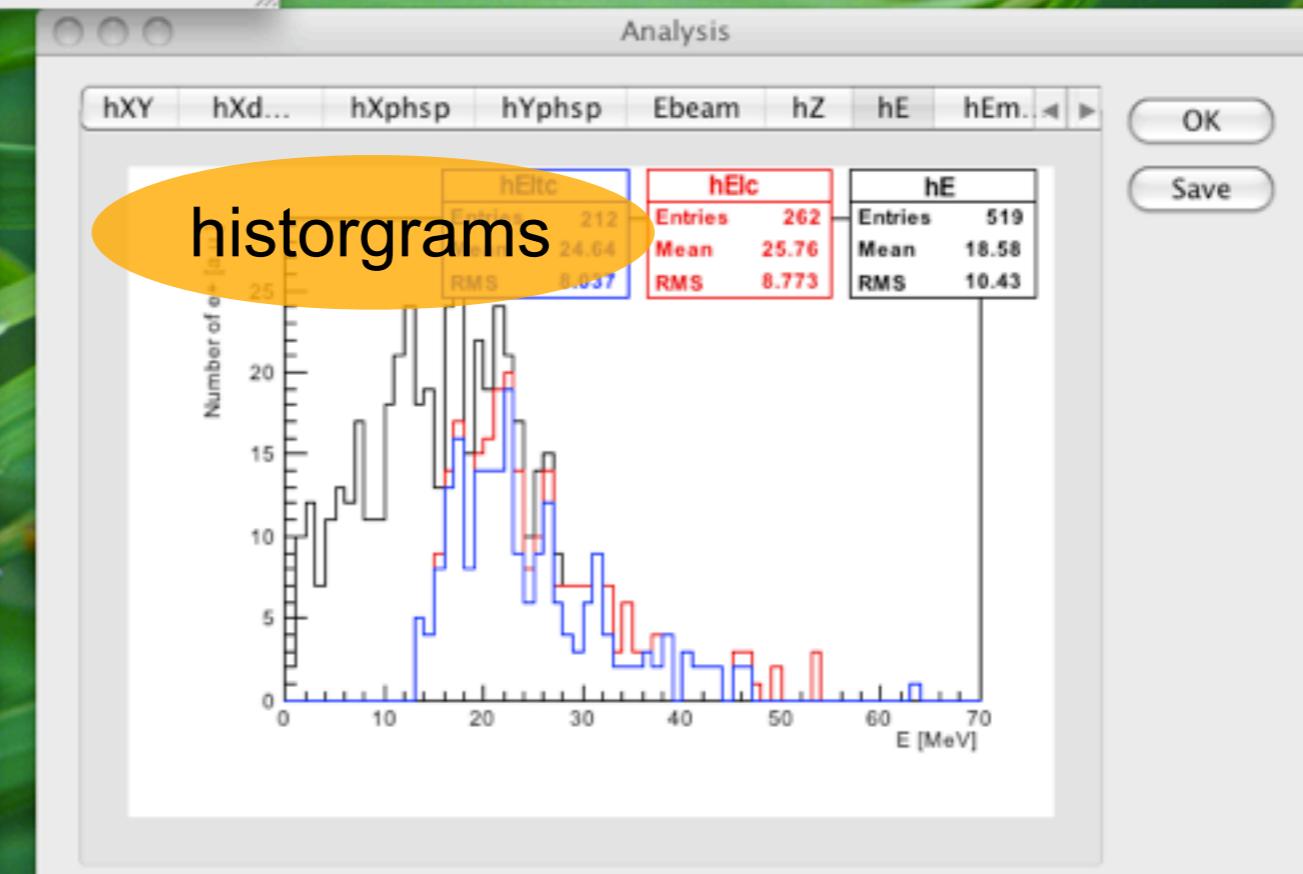
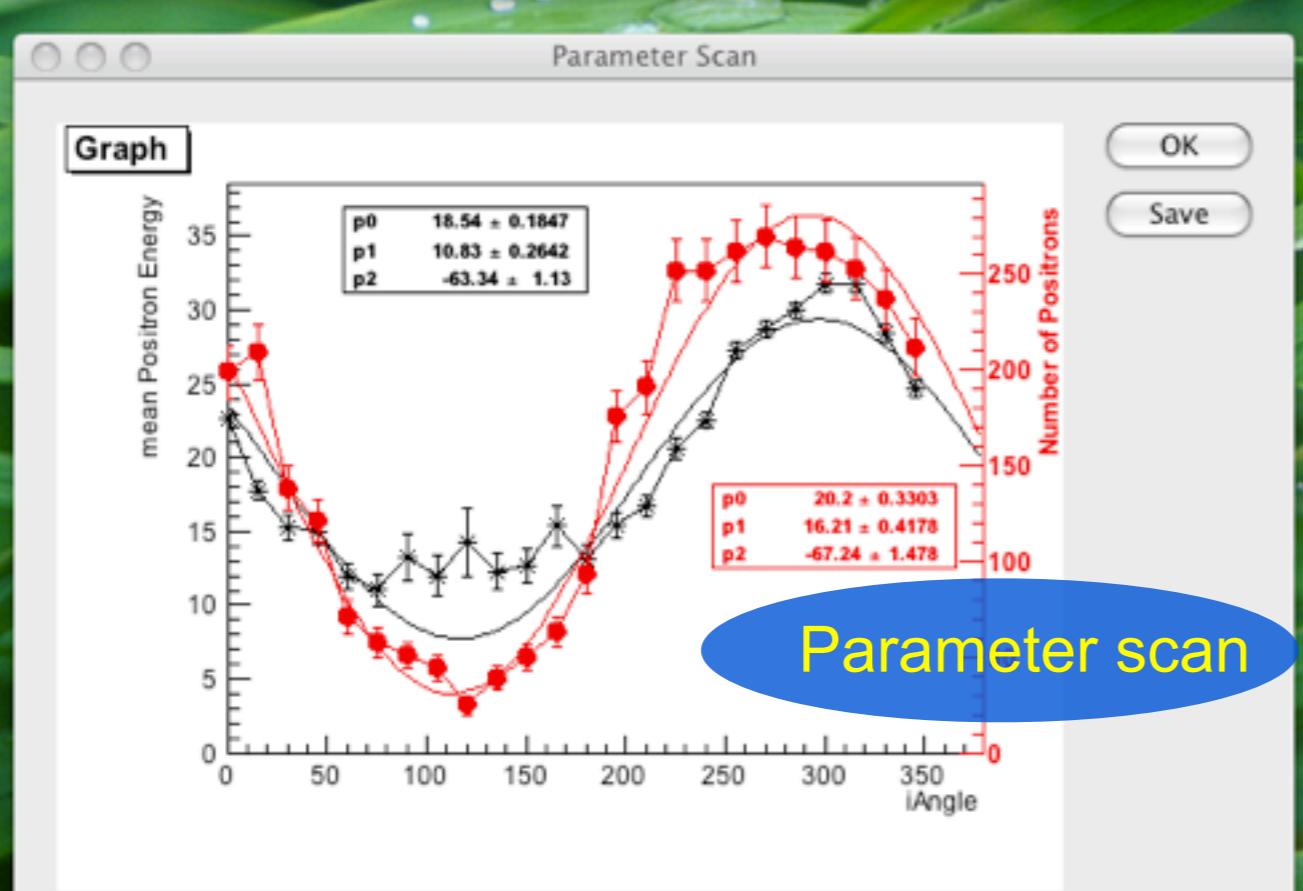
VALUE ERROR SIZE DERIVATIVE

2.81998e+01 3.38255e-01 5.89556e-05 3.55539e-05

1.62106e+01 4.17770e-01 7.17402e-05 -1.06939e-04

-6.72356e+01 1.47810e+00 5.22130e-03 -5.60456e-06

**ROOT output**  
 (e.g. fit results)



- **PPS-Sim**
  - exploitation of the Geant4 toolkit
  - provides Qt GUI for easy usage
  - allows batch runs for high statistics accumulation
  - uses ROOT for data analysis and persistency
- **Features**
  - e+ production: Undulator, Conventional
  - capture: AMD, QWT, Li-Lens
  - acceleration: RF & solenoid incl. spin tracking
- **Public available**
  - web page : [pps-sim.desy.de](http://pps-sim.desy.de)

- model improvements
  - extend beyond 1st accelerator section
  - include detailed energy deposition (scoring)
  - add alternative e+ production mechanism  
(e.g. Compton, CBS) (help welcome)
- UI improvements
  - simplify physics settings
  - allow speed improvements  
(e.g. no tracking of lost particles)
- other program improvements
  - multi processor (core) support
  - reduce dependencies on Qt