Source Modelling using Geant4

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Outline

- Geant4 capabilities
  - Polarised processes
  - Magnetic field (T-BMT equation)
- Modelling
  - Geometry
  - Photon spectrum (Input)
  - Results
- Summery & Outlook

Geant4 in Source Simulation

Polarisation extension to Geant4

- 5 polarised processes (since Dec. 2006)
- 1 polarised process add Dec. 2007 (E166 needs)
- support for polarised media (for polarimetery)

Magnetic fields

- Runge-Kutta integrator
- equation of motion for magnetic field
- equation of motion for electric & magnetic field
  (new since Dec. 2007 release 9.1)
- T-BMT equation for spin transport

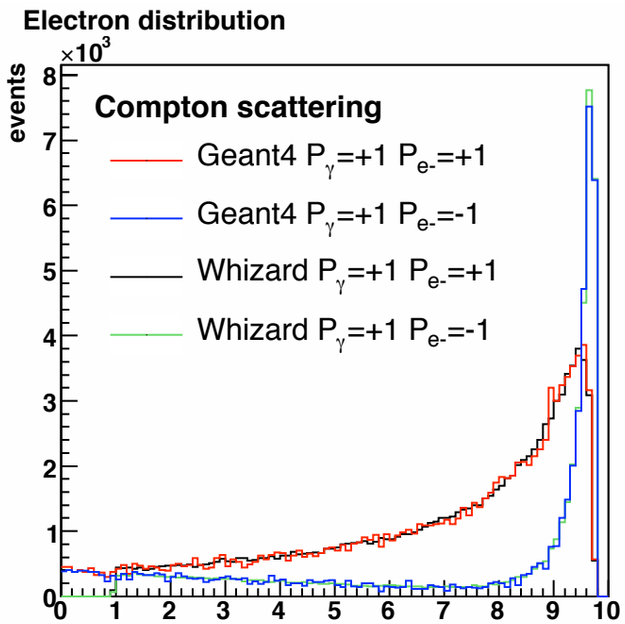
Polarised Geant4

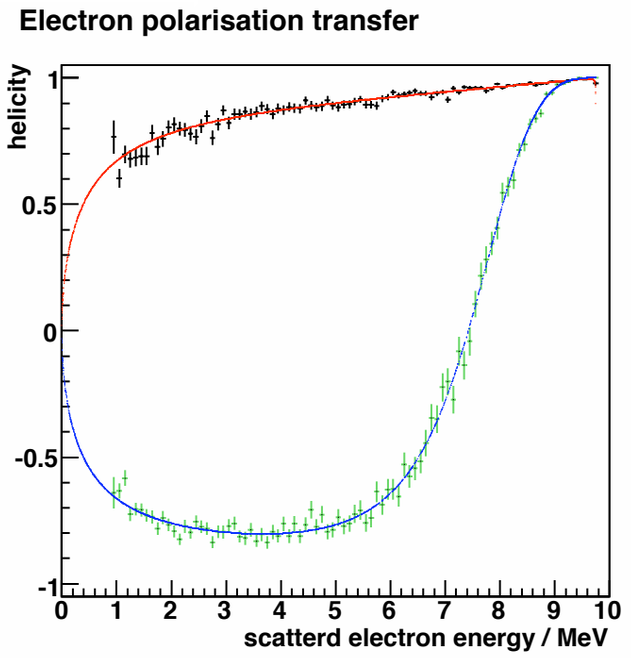
- Physics processes:
  - Pair production
  - Bremsstrahlung
  - Compton scattering
  - Moller/Bhabha scattering
  - Photo electric effect
- Implementation:
  - based on Stokes vectors
  - polarisation transfer
  - asymmetries (polarised target)

$$\frac{d\sigma\left(\xi^{(1)},\xi^{(2)},\xi^{(3)},\xi^{(4)}\right)}{d\Omega} = \Phi\left(\xi^{(1)},\xi^{(2)}\right) + A\left(\xi^{(1)},\xi^{(2)}\right)\cdot\xi^{(3)} + B\left(\xi^{(1)},\xi^{(2)}\right)\cdot\xi^{(4)} + {\xi^{(3)}}^{T} M\left(\xi^{(1)},\xi^{(2)}\right)\xi^{(4)}$$

Polarised Geant4

- well tested:
  - based on old publications (from 60')
  - independent recalculation of selected processes (P. Starovoitov)
  - comparison with EGS (where possible)
  - comparison with Whizard generator
  - data from E166 experiment

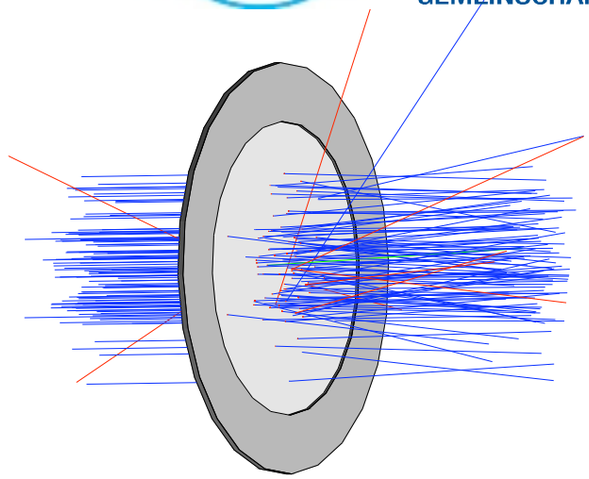


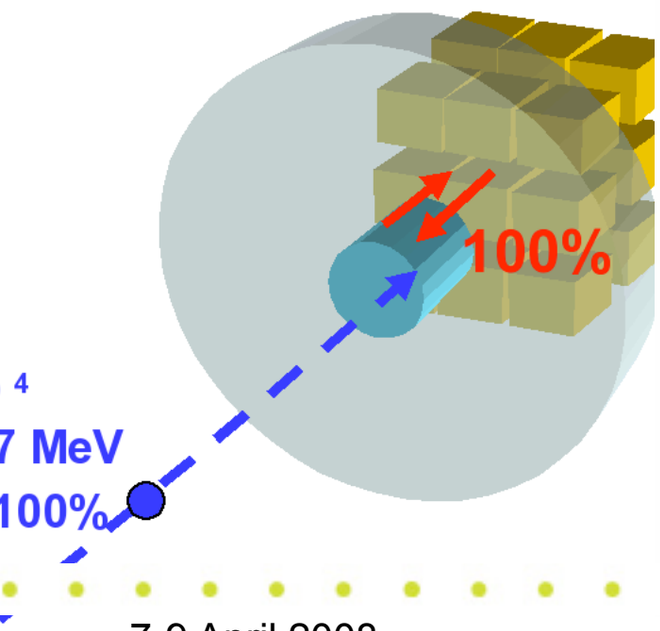


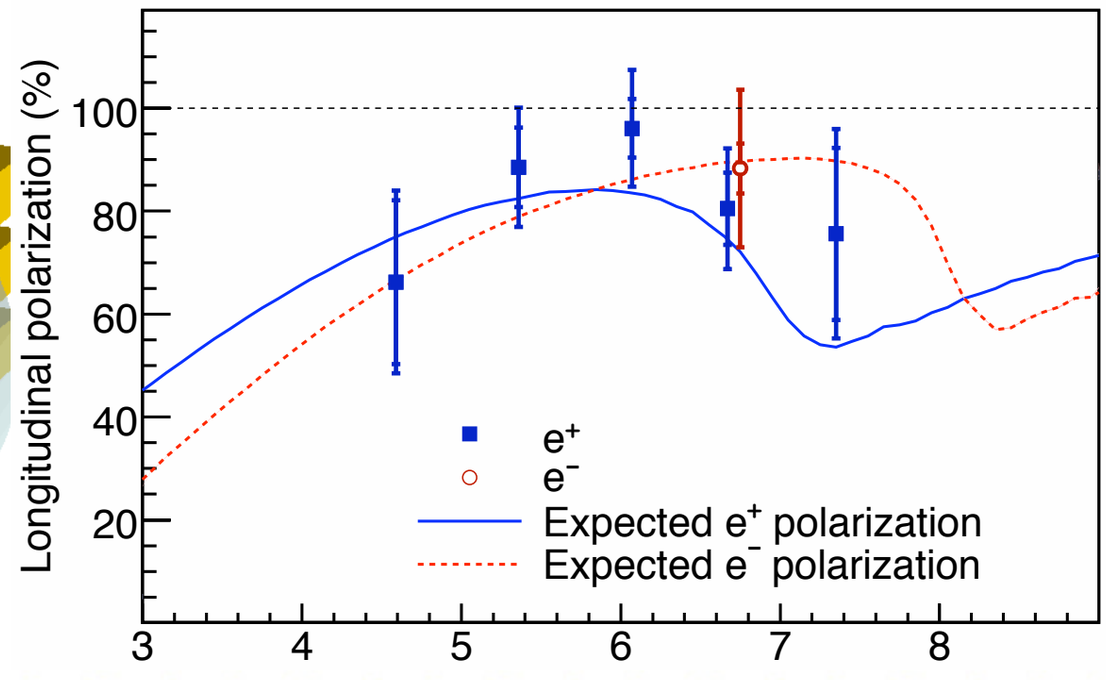
- further documentation:
  - Geant4 Physics reference manual
  - K. Laihem, A.S., P. Starovoitov, arXiv:0712.2336, DESY 07-202.

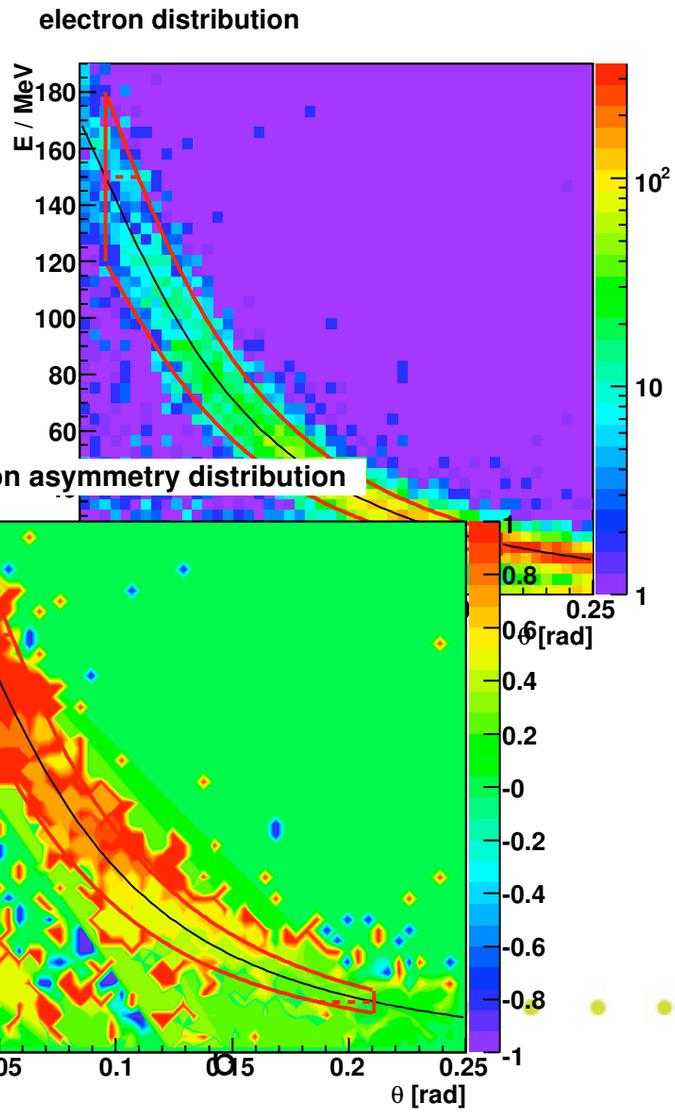
Polarised Geant4

- Applications:
  - E166 experiment
    - Analysing power
    - Expected Positron polarisation
  - ILC Polarised Positron Source
  - ILC Low Energy Polarimeter









T-BMT equation

- Particle trajectories in electrical and magnetic field
- Spin precession according to T-BMT equation

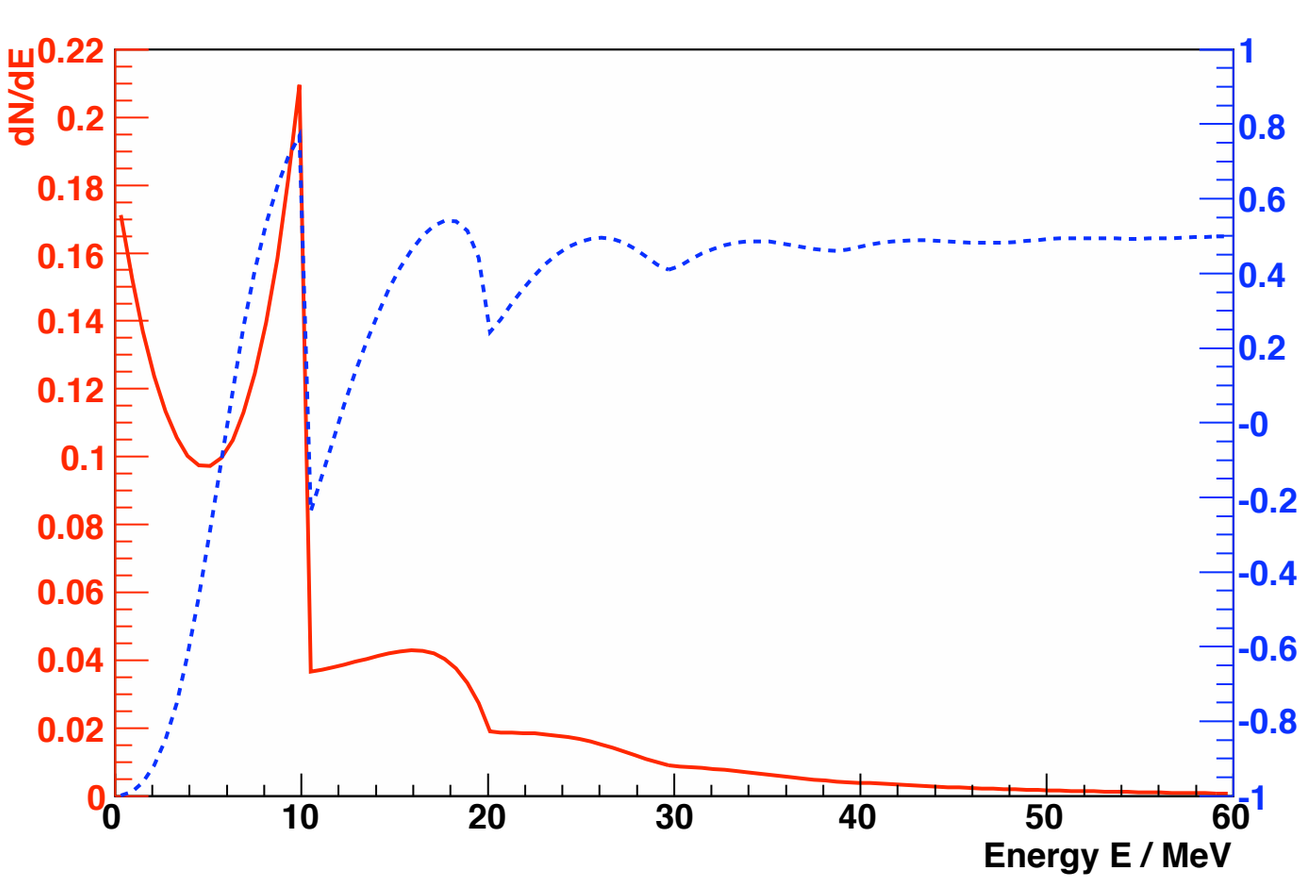
$$\frac{d\boldsymbol{S}}{dt} = -\frac{e}{m\gamma}\left[(\gamma a+1)\boldsymbol{B}_T + (a+1)\boldsymbol{B}_L - \gamma\left(a+\frac{1}{\gamma+1}\right)\beta\boldsymbol{e}_v \times \frac{\boldsymbol{E}}{c}\right] \times \boldsymbol{S}$$

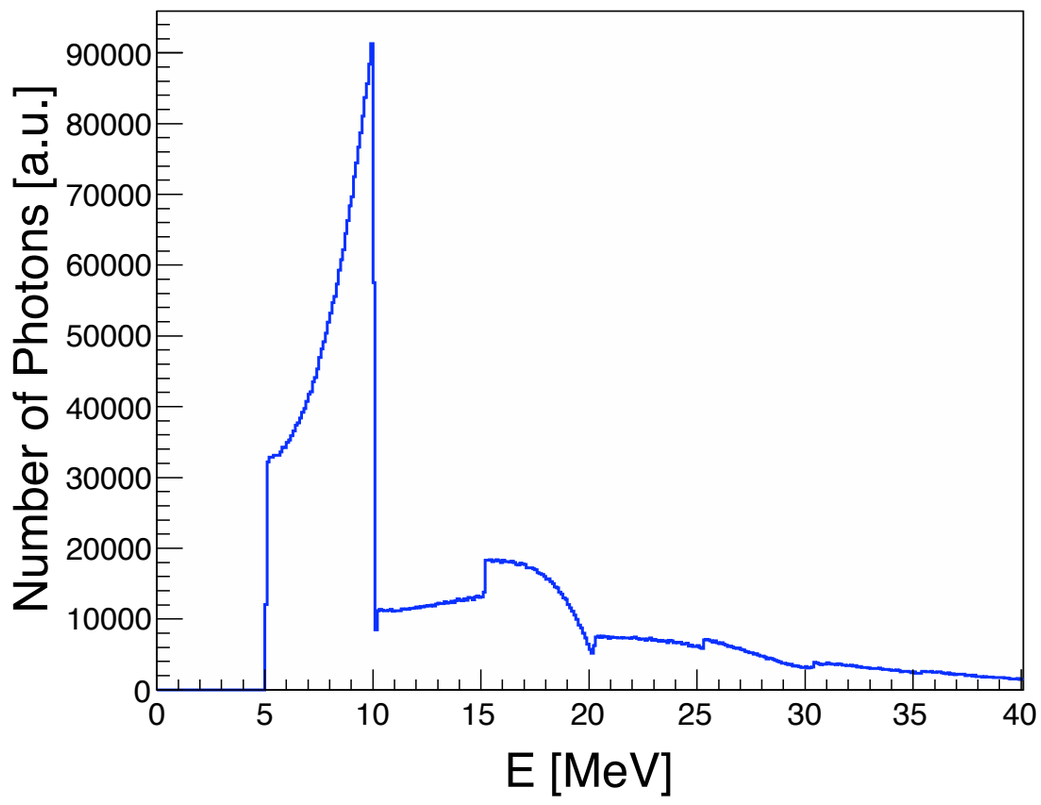
- E-field dependence not included in Geant4 yet

Source Modelling

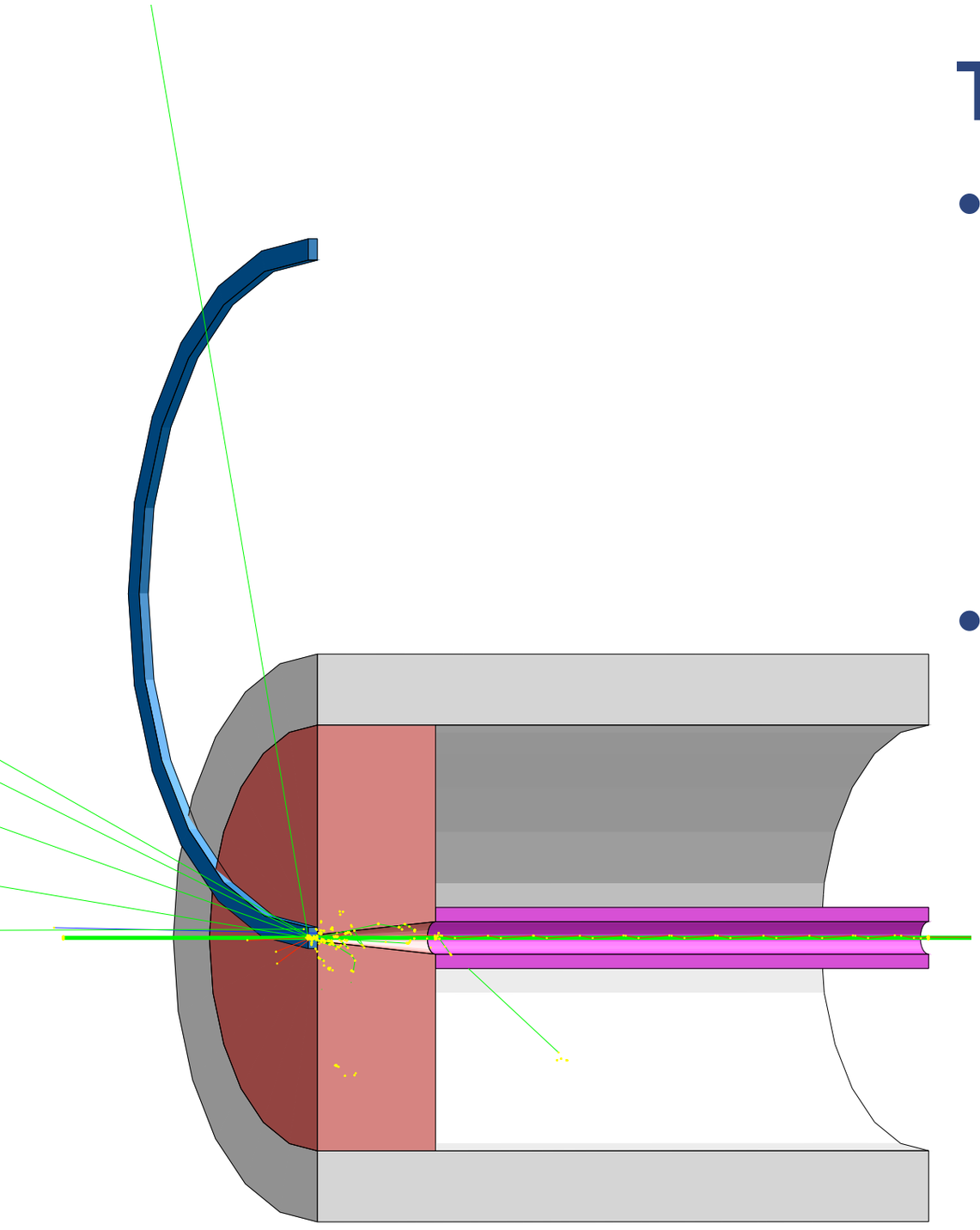
Undulator (inside G4 or independent ROOT script)

- Energy distribution
- angle distribution
- correlation between energy & angle





Source modelling

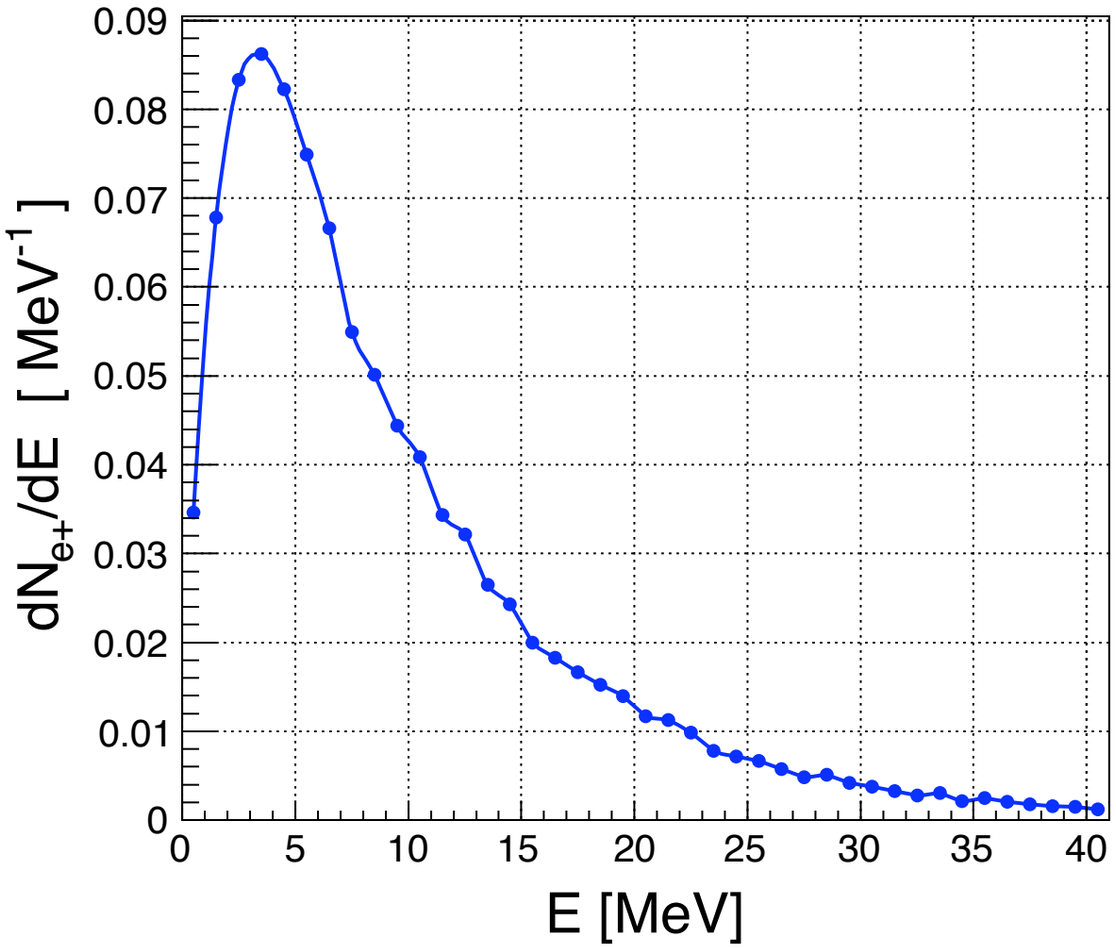


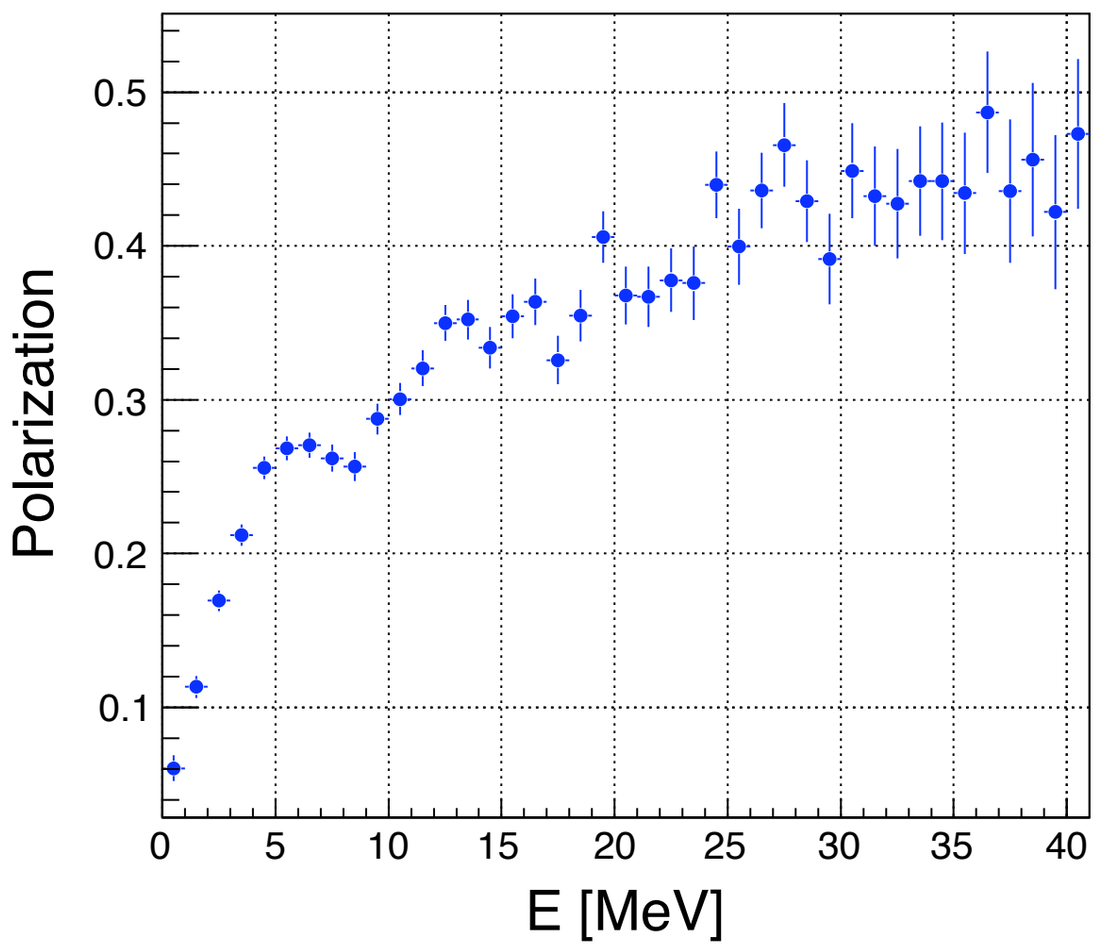
Target & Capture section

- simple Geometry
  - Target
  - AMD
  - first accelerator structures
- simple Field
  - OMD field
  - Solenoid field
  - time dependent electrical field

Results

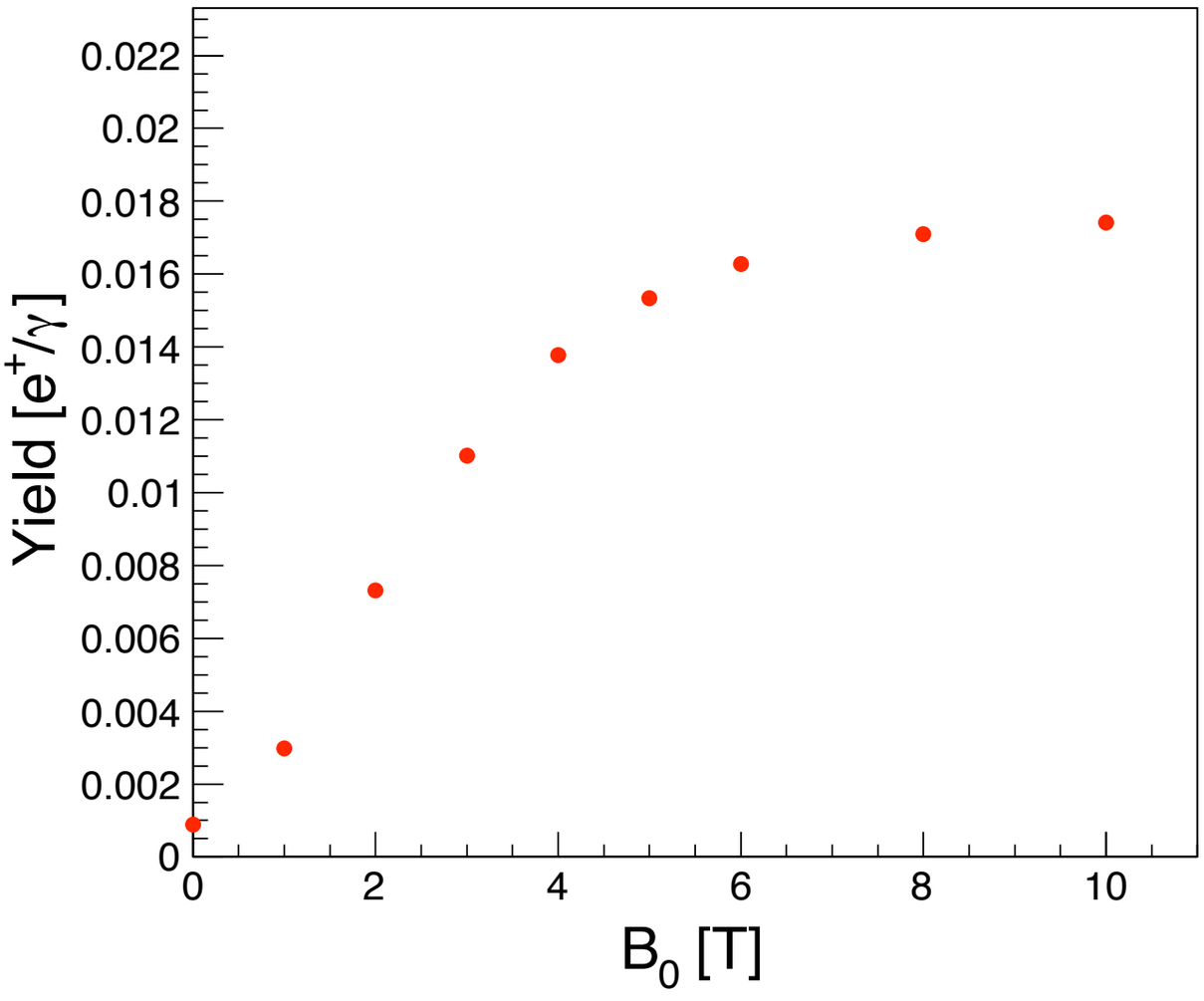
- Energy and polarisation spectrum of produced positrons

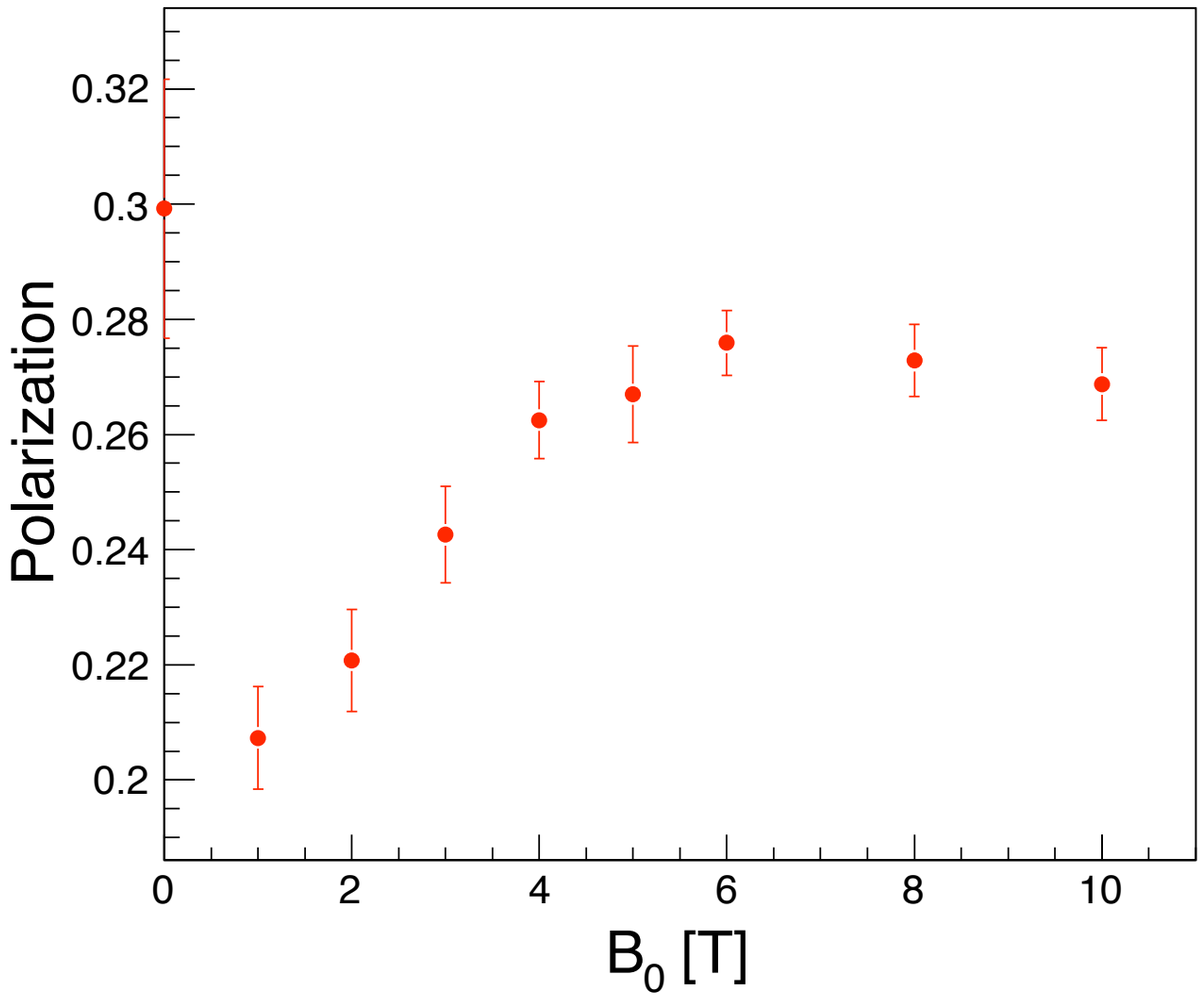




Results

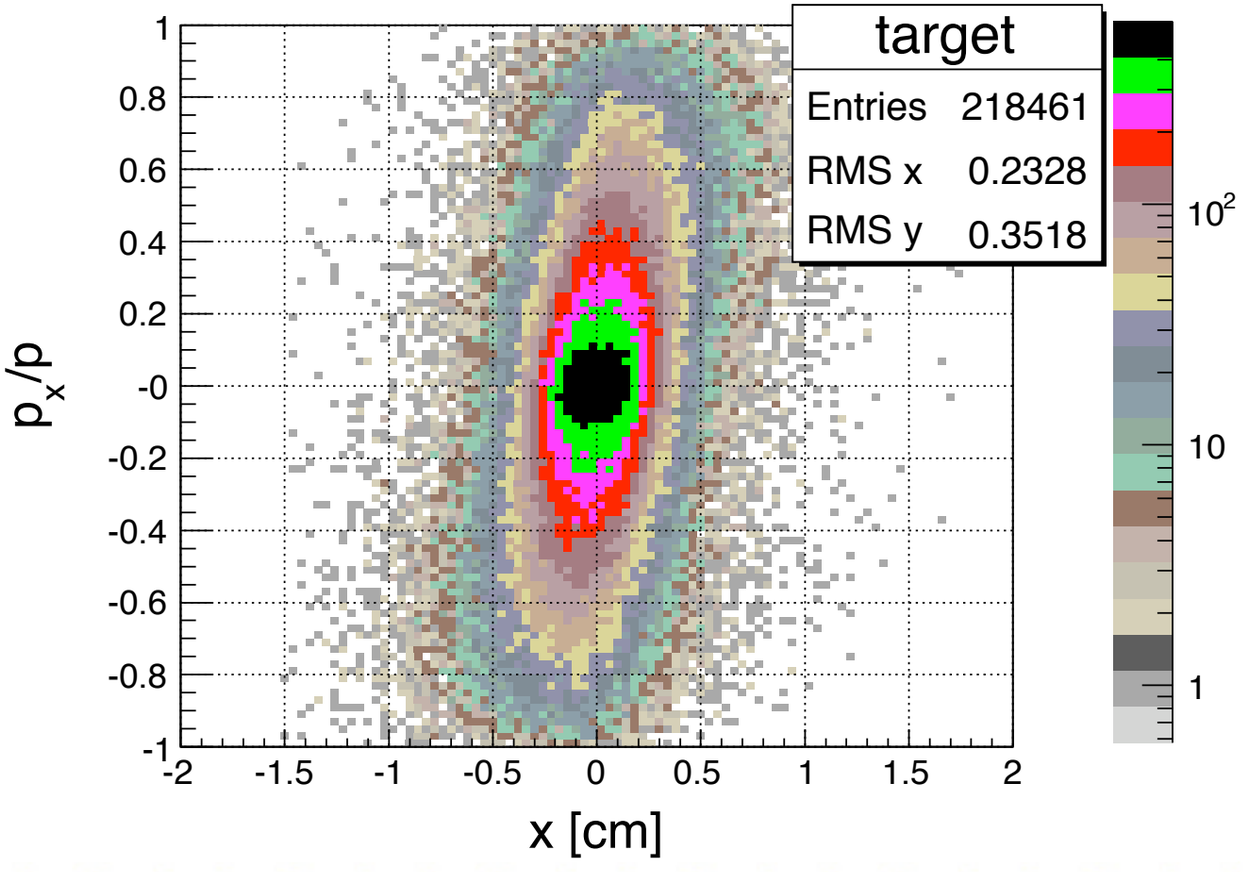
- Positron yield and polarisation depending on magnetic field

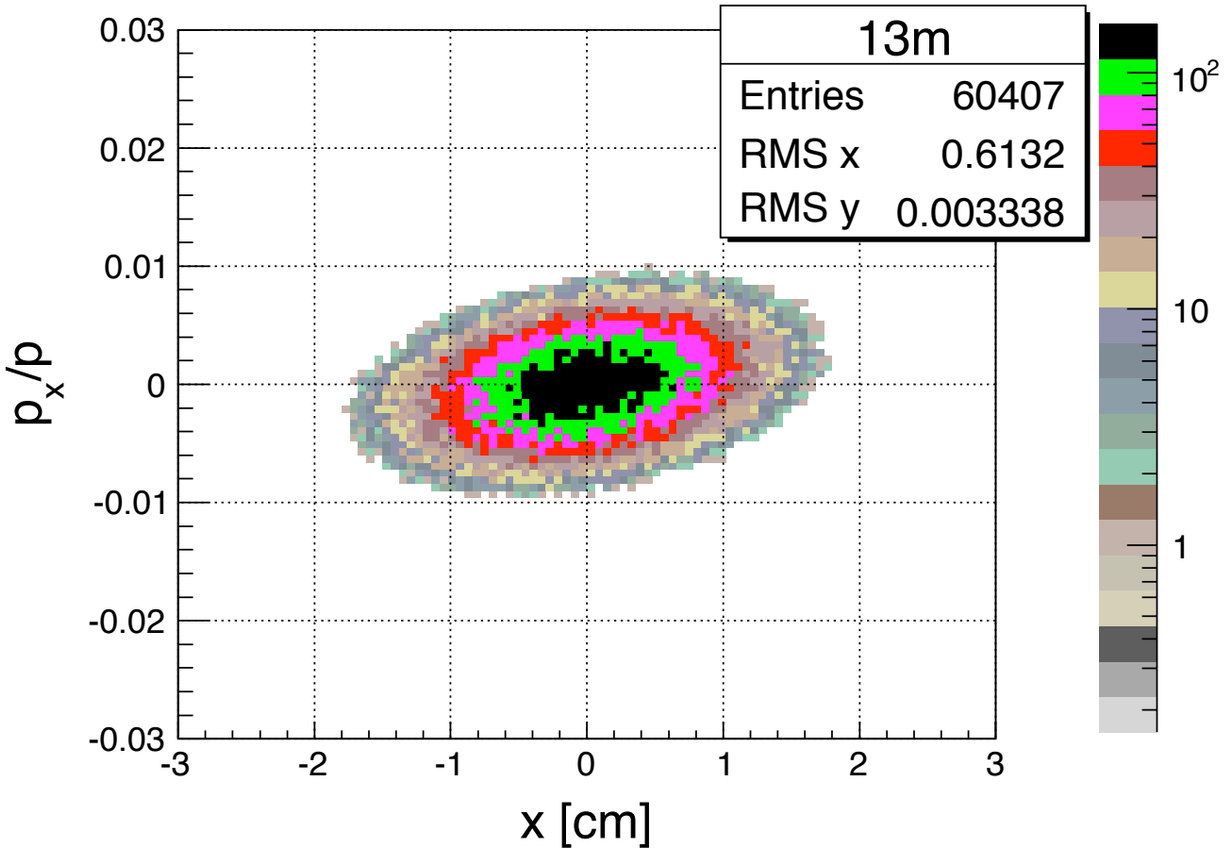




Results

- Phase space distribution of positrons
  - after Production target
  - after first accelerator structures (120MeV) (including DR acceptance cut)





Summary & Outlook

Summary

- Geant4 provides powerful tool for target simulations
- T-BMT already included (w/o electrical field)
- developed for E166 needs but also applicable to ILC setup

Outlook

- Publication on G4 Polarisation (over due!)
- Extension of simulation scope (perhaps using a polarised version of ASTRA)
- continue discussion with other groups doing “start to end” simulations ...