Evaluation of the influence of physical and chemical parameters on water radiolysis simulations under MeV electron irradiation using Geant4-DNA *Wook Geun Shin*

Towards continuous integration testing of optical code *Daren Sawkey*

F113, Jefferson Lab 06:15 - 06:30

Validation of the Geant4 radioactive decay and emission of Auger electrons *Susanna Guatelli*

F113, Jefferson Lab 06:30 - 06:45

5D gamma conversion model: high energy tests *Denis Robert Leon Bernard*

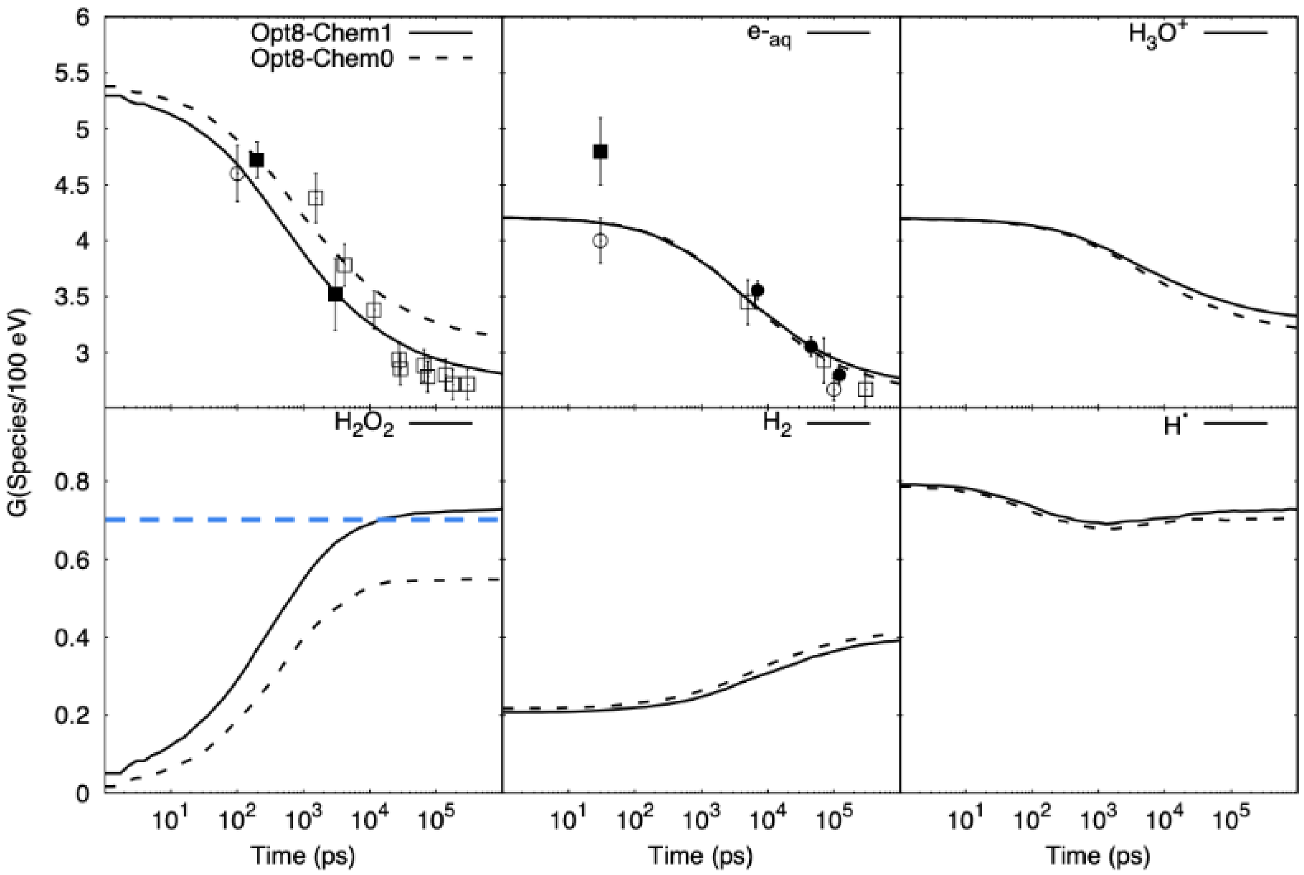
F113, Jefferson Lab 06:45 - 07:00

Discussion

F113, Jefferson Lab 07:00 - 07:30

Example dna/chem5

- J. Ramos-Méndez and B. Faddegon, Department of Radiation Oncology UCSF
- The example is a modified version of chem4.
- Geant4 modular list introducing two constructors:
  - G4EmDNAPhysics_option8
  - G4EmDNAChemistry_option1.
- Output: Tabulated data in ASCII format:
  - Time [ps] G-value (/eV) RMS Molecule's name.



For a comprehensive study on chemistry and physical parameters, see Wook-Geun's presentation in Parallel 8A

Validation of the Geant4 radioactive decay and emission of Auger electrons

Samer Bakr[1], Tibor Kibedi[2], David Bolst[1], Maarten Vos[3], Mohammed Alotiby[3,4], Alfonso Mantero[7], Anatoly Rosenfeld[1,10], Vladimir Ivanchenko[5,6], Sebastien Incerti[8,9], Susanna Guatelli[1,10]

[1] Centre for Medical Radiation Physics, University of Wollongong, Wollongong, Australia
[2] Department of Nuclear Physics, Research School of Physics, The Australian National University, Canberra, Australia
[3] Electronic Materials Engineering, Research School of Physics, The Australian National University, Canberra, Australia
[4] King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia
[5] Geant4 Associates International Ltd.
[6] Tomsk State University, Tomsk, Russia
[7] SWHARD s.r.l.
[8] CNRS/IN2P3, Centre d'Etudes Nucléaires de Bordeaux-Gradignan, Bordeaux, France
[9] Université de Bordeaux, Bordeaux, France
[10] Illawarra Health and Medical Research Institute, University of Wollongong, Wollongong, Australia

Benchmarking: radioisotopes

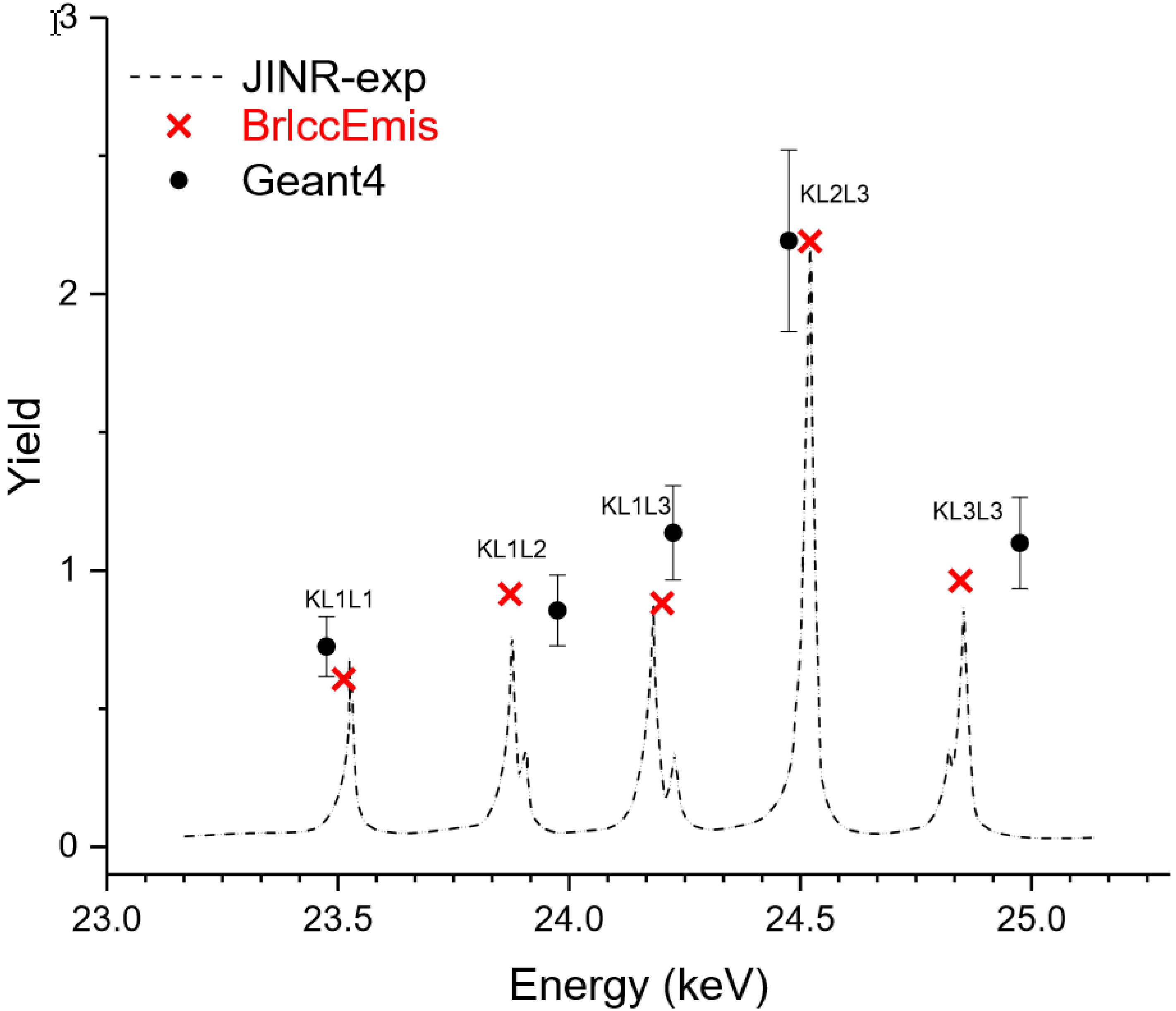
- I-123, I-124, I-125
  - widely used in nuclear medicine
- Cs-131
  - attractive radioisotope for brachytherapy of malignant tumours

- Comparison of Auger e^-, X and gamma rays, IC e^- yields w.r.t.
  - Other theoretical approaches
  - Experimental measurements in the case of I-125 and Cs-131

- rdecay01 example, Geant4 10.4

Cs-131-exp

G4.10.04

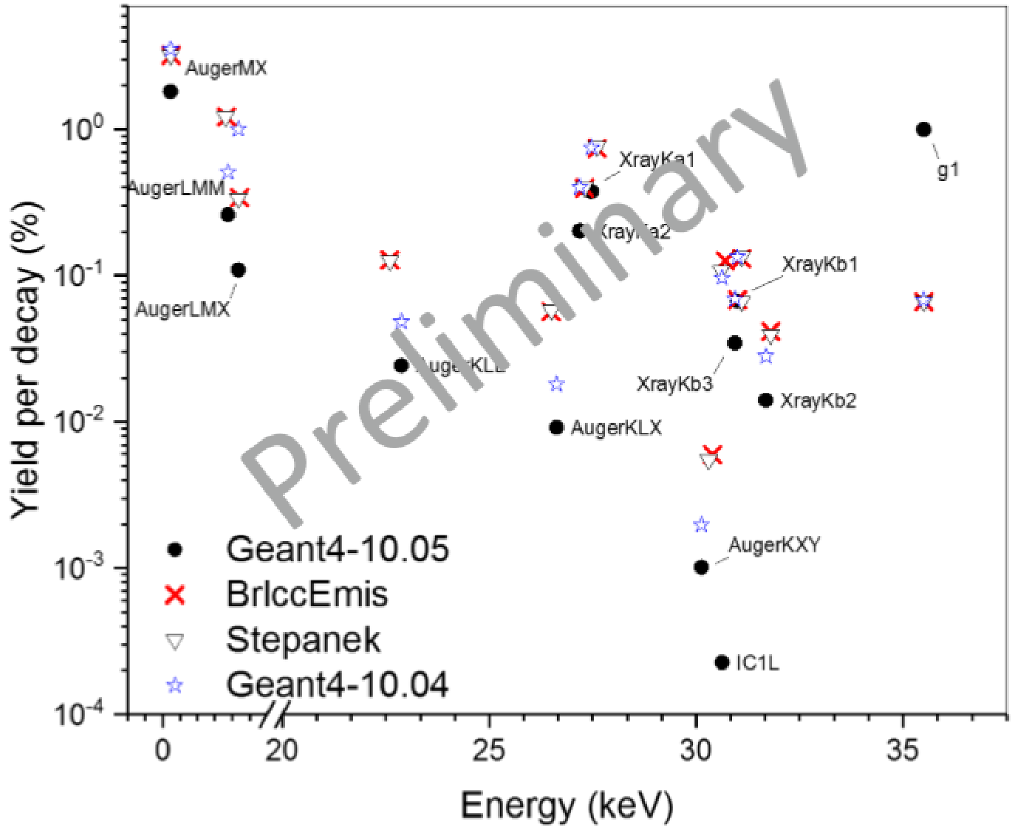


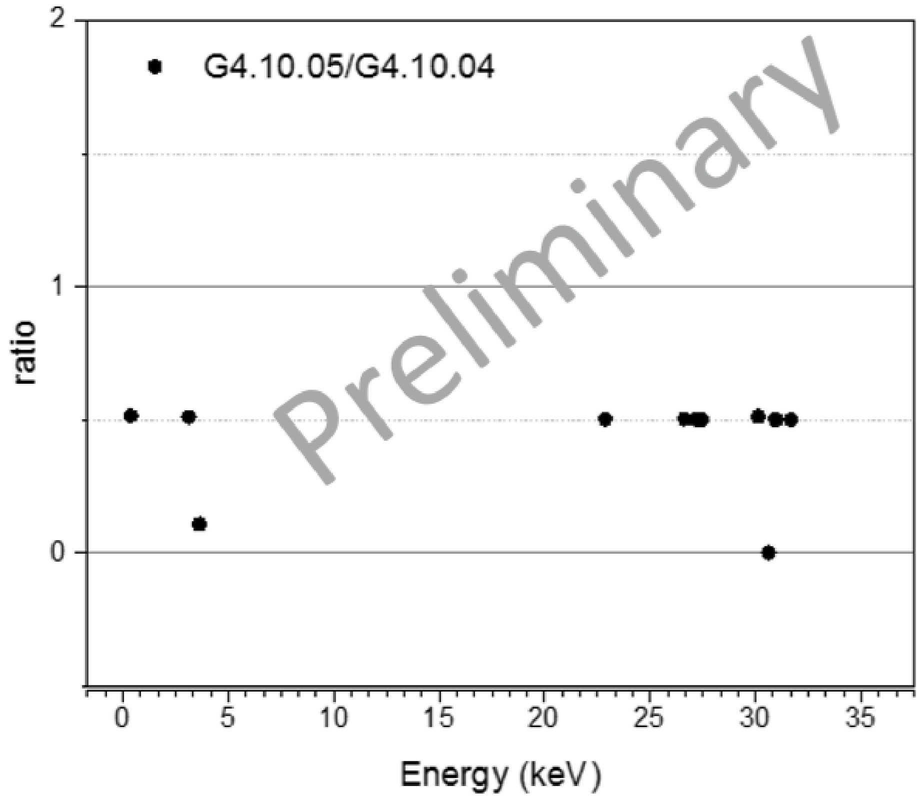
Geant4 results have a consistent energy shift of ~180 eV (BrIccEmis ~95 eV)

Regression testing

I-125

- Geant4 10.4 (RadioactiveDecay5.2) and 10.5 (RadioactiveDecay5.3)





5D γ conversion model: high energy tests

(80 GeV - 100 TeV)

Igor Semeniouk & Denis Bernard

LLR, Ecole Polytechnique and CNRS/IN2P3, France

`html`

24th Geant4 Collaboration meeting, 23-27 Sept. 2019, JLab

7

Context

$\gamma X \to e^+ e^- X$

- The Bethe-Heitler differential cross section (DCS) is five-differential
- G4BetheHeitler5DModel implemented in Geant4 release 10.5 in 2018
- Provides SampleSecondaries only

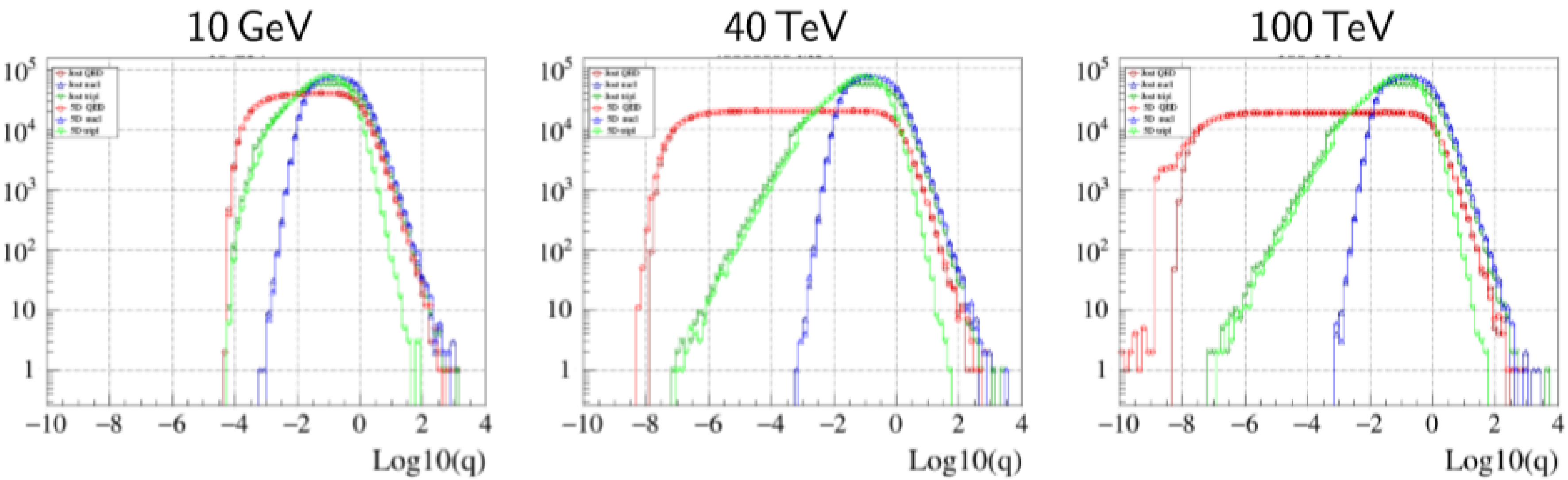
  (total cross section inherited from G4BetheHeitlerModel)

  ⇒ available through G4EmLowEPPhysics physics list ($E < 80\,\mathrm{GeV}$)
- Algorithm verified at much higher energies though

  (fortran demonstration model, Nucl. Instrum. Meth., A **899** (2018) 85)
- Mihaly Novak (Sept. 2019) solved the energy limit issue
- In this talk, preparatory high-energy tests that we have performed, end of 2018.

Recoil momentum

- The main limitation of the model is sampling very low recoil momentum q
- q plotted here is `PRec`, used in computing the DCS in G4BetheHeitler5DModel



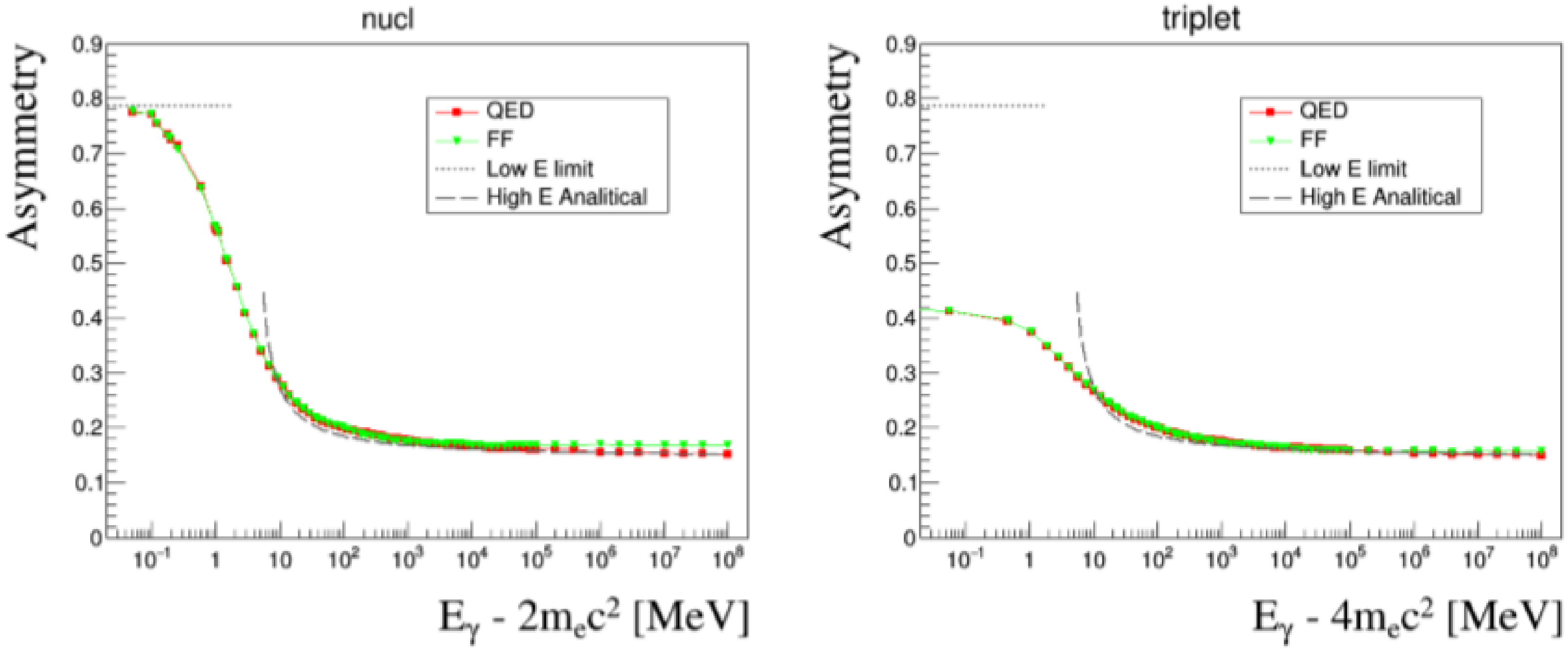
$\log_{10}(q/(\mathrm{MeV}/c))$ distributions for γ-ray conversions on Argon

- Jost QED
- Jost nucl
- Jost tripl
- 5D QED
- 5D nucl
- 5D tripl

- QED (isolated targets)
- Nuclear (same form-factor for G4BetheHeitler5DModel and Jost)
- Triplet (same form-factor for G4BetheHeitler5DModel and Jost)

Problems below $q < 10^{-8}\mathrm{MeV}/c$

Polarisation Asymmetry

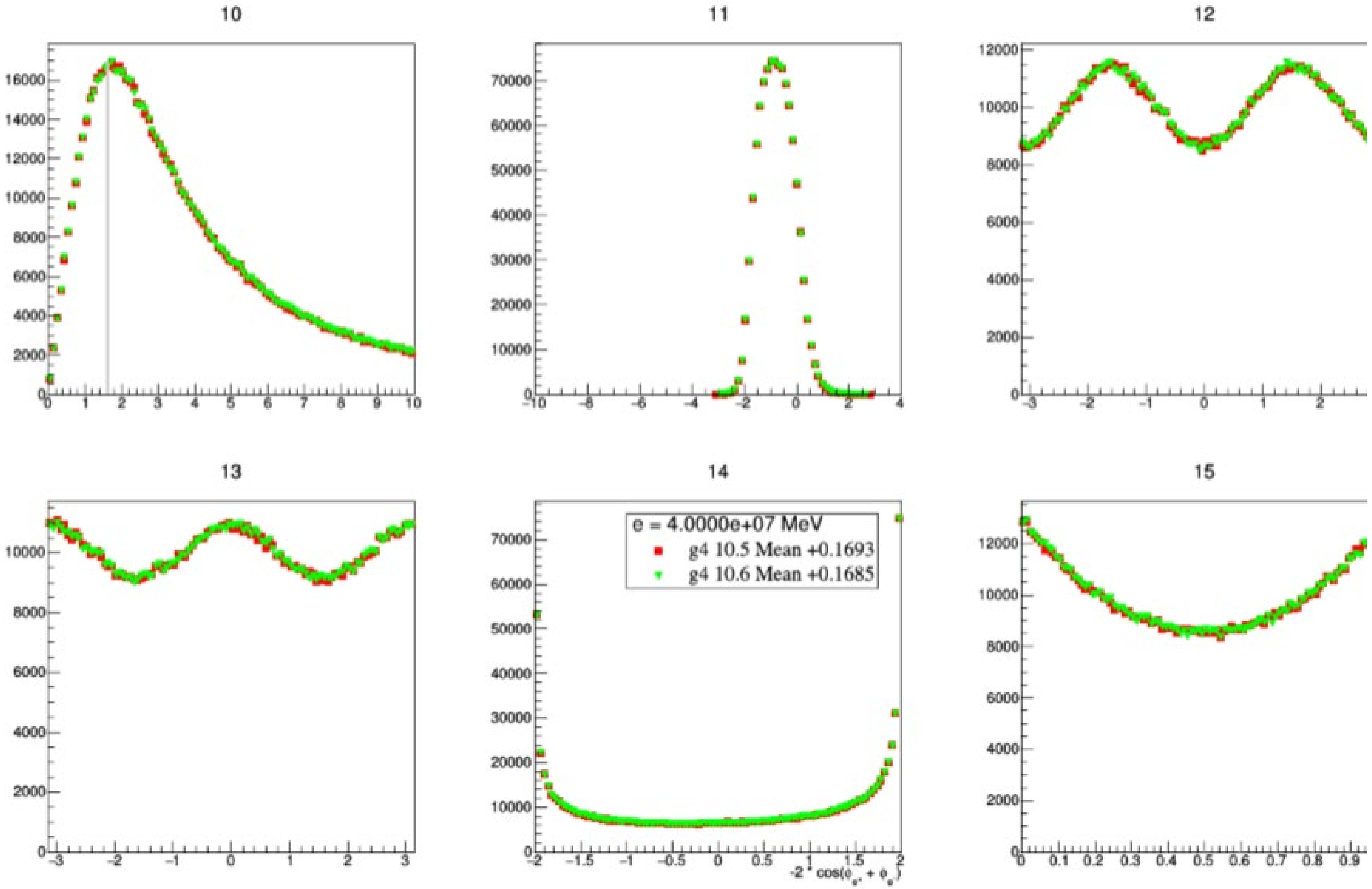


Polarisation asymmetry as a function of available energy, compared to asymptotic expressions

- Nice agreement at high energy and for nuclear low energy
- Disagreement for triplet low energy
  - was already seen in fortran Nucl. Instrum. Meth., A **899** (2018) 85)
    - approximations done for calculation low-energy asymptote illegitimate for triplet ?

Bethe-Heitler approximate for low-energy triplet conversion anyway (2 diagrams missing)

Direct check, nuclear, 40 TeV on atomic Argon



TestEm15

Thanks to Mihaly Novak

Conclusion

- G4BetheHeitler5DModel verified up to 100 TeV

  Means only that it does sample Bethe-Heitler differential cross section.

- We had to modify the code to obtain these results:
  - Exfiltrate `PRec` out of G4BetheHeitler5DModel
  - For small angles:
    obtain θ_{+-} from arcsin(cross product) instead of arcos(dot product)

- Model can't sample events with $q < 10^{-8}\mathrm{MeV}/c$ correctly, something which would happen
  - for conversions on isolated targets and $E > 40\,\mathrm{TeV}$

  (same was seen in `double precision` fortran Nucl. Instrum. Meth., A **899** (2018) 85)

- Users who would run TestEm15 out-of-the-box on high-energy conversions on isolated targets will have surprises.

Towards continuous integration of optical code

Geant4 Collaboration Meeting, Jefferson Lab

September 27, 2019

Daren Sawkey

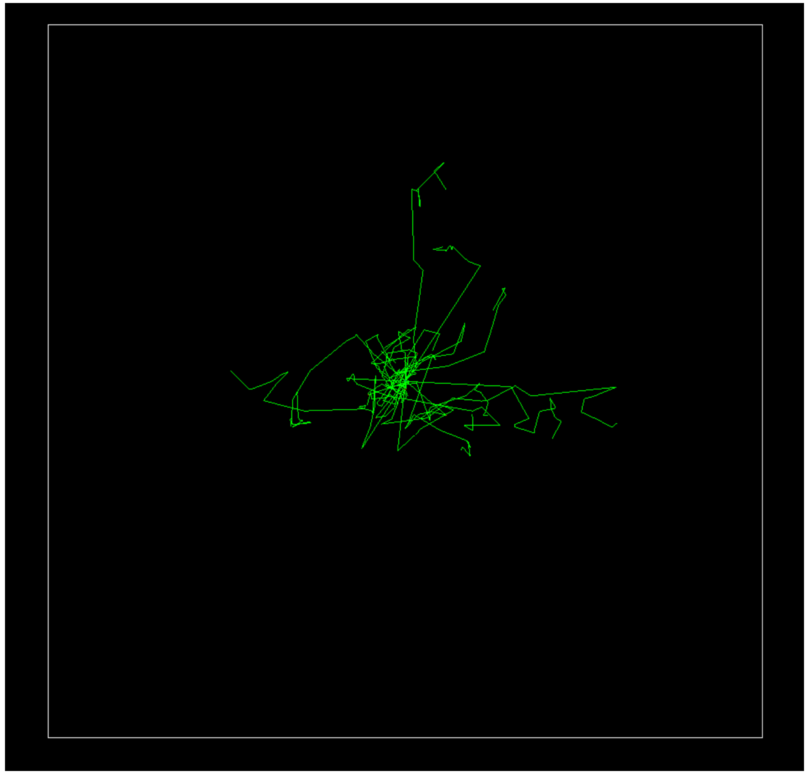
Varian Medical Systems

Examples

- All the macros run
- Example OpNovice2 (new in 10.5)
- Test using macro: great for Discourse
- In particular modular physics list

```
G4VModularPhysicsList* physicsList = new FTFP_BERT;
G4OpticalPhysics* opticalPhysics = new G4OpticalPhysics();
physicsList->RegisterPhysics(opticalPhysics);
```

- Basis for the tests



Scintillation

scintillation.mac

```
/opnovice2/boxProperty FASTCOMPONENT 0.000002 1.0 0.000008 1.3
/opnovice2/boxProperty SLOWCOMPONENT 0.000002 0.1 0.000003 0.2 …
/opnovice2/boxConstProperty FASTTIMECONSTANT 20   ## ns
/opnovice2/boxConstProperty SLOWTIMECONSTANT 100
/opnovice2/boxConstProperty SCINTILLATIONYIELD 5000.0
/opnovice2/boxConstProperty YIELDRATIO 0.5
/opnovice2/boxConstProperty RESOLUTIONSCALE 1
/opnovice2/boxConstProperty FASTSCINTILLATIONRISETIME 3
/opnovice2/boxConstProperty SLOWSCINTILLATIONRISETIME 10

/process/optical/scintillation/setYieldFactor 10
/process/optical/scintillation/setExcitationRatio .5
/process/optical/scintillation/setByParticleType false
/process/optical/scintillation/setTrackInfo      false
/process/optical/scintillation/setFiniteRiseTime true
/process/optical/scintillation/setStackPhotons   true

/process/optical/scintillation/setTrackSecondariesFirst true
```