Parallel 5A: New EM Validations Summary

28th Geant4 Collaboration Meeting
Hokkaido University, 2023

J. W. Archer, S. Guatelli

Contributions

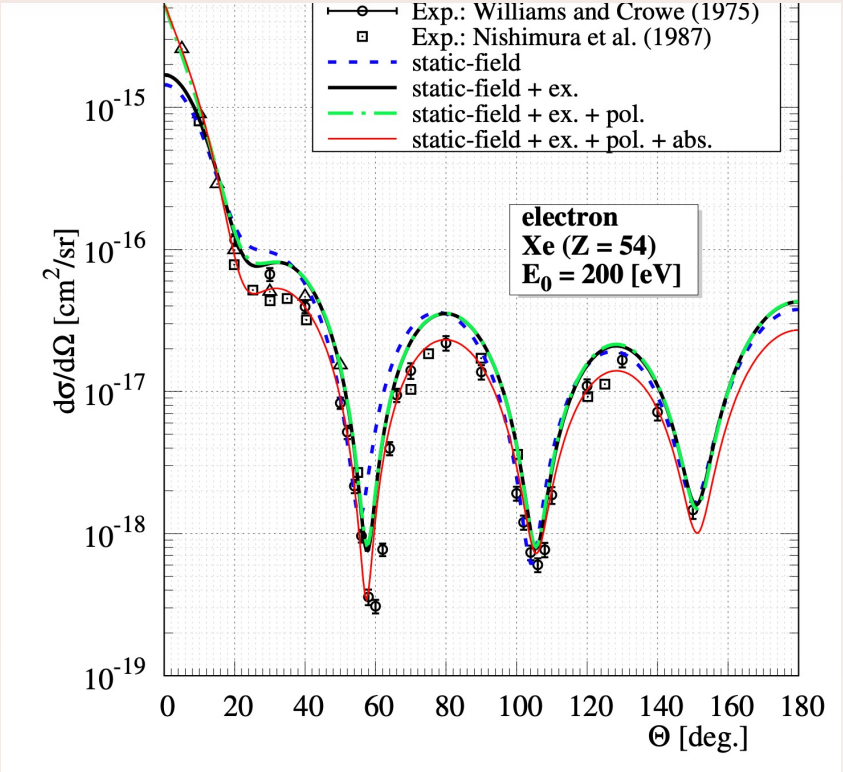
28th September 2023

14:00	**Model of the single Coulomb scattering of e-/e+ based on numerical DCS from DPWA** *Room A, Hokkaido University*	*Mihaly Novak* 14:00 - 14:15
	Bragg Peak validation *Room A, Hokkaido University*	*Miguel Antonio Cortes Giraldo* 14:15 - 14:30
	Validation of Geant4 fragmentation for incident alpha particles *Room A, Hokkaido University*	*David Bolst* 14:30 - 14:45
	Modelling the Response of CLLBC(Ce) and TLYC(Ce) SiPM-Based Radiation Detectors in Mixed Radiation Fields with G… *Jeremy Brown*	
15:00	**Calculation of early DNA damage in astronauts: update and future perspectives** *Room A, Hokkaido University*	*Jay Archer* 15:00 - 15:15
	Geant4 based Dose Planning Monte Carlo (DPM) *Room A, Hokkaido University*	*Mihaly Novak* 15:15 - 15:30

Model of the single Coulomb scattering of e-/e+ based on numerical DCS from DPWA

Contribution from M. Novak

- Differential cross-sections (DCS) computed for e^- and e^+s on free atoms
- Dirac-Fock (DF) Dirac Plane Wave Approximation (DPWA) DCS uses a point potential screened by electrons distributed according to a Dirac-Fock model



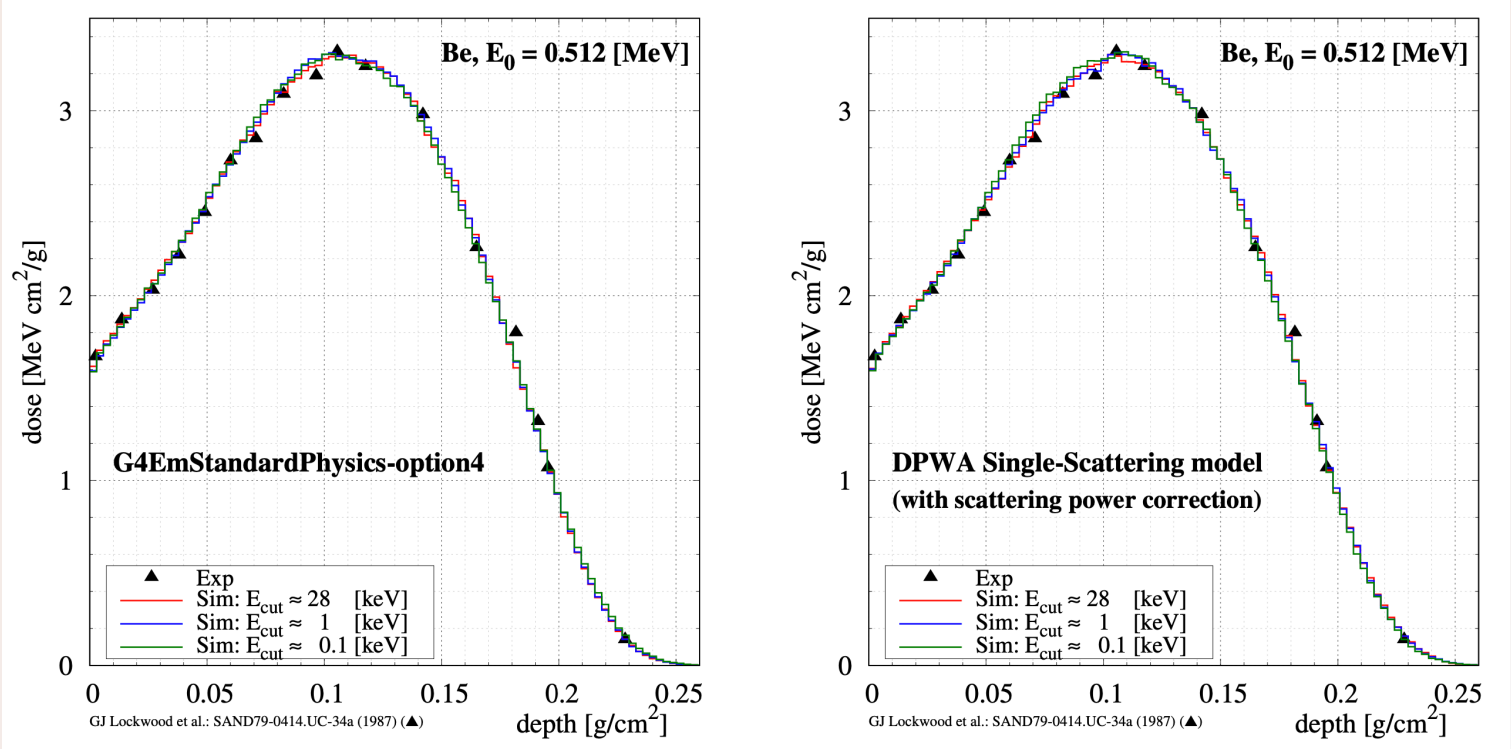
- Corrections to static field applied using:
  - *Exchange correction*
  - *Polarisation*
  - *Absorption*
- Implemented in the *G4eDPWACoulombScatteringModel* class

Model of the single Coulomb scattering of e-/e+ based on numerical DCS from DPWA

Contribution from M. Novak

The DCS and single scattering model available since 10.7

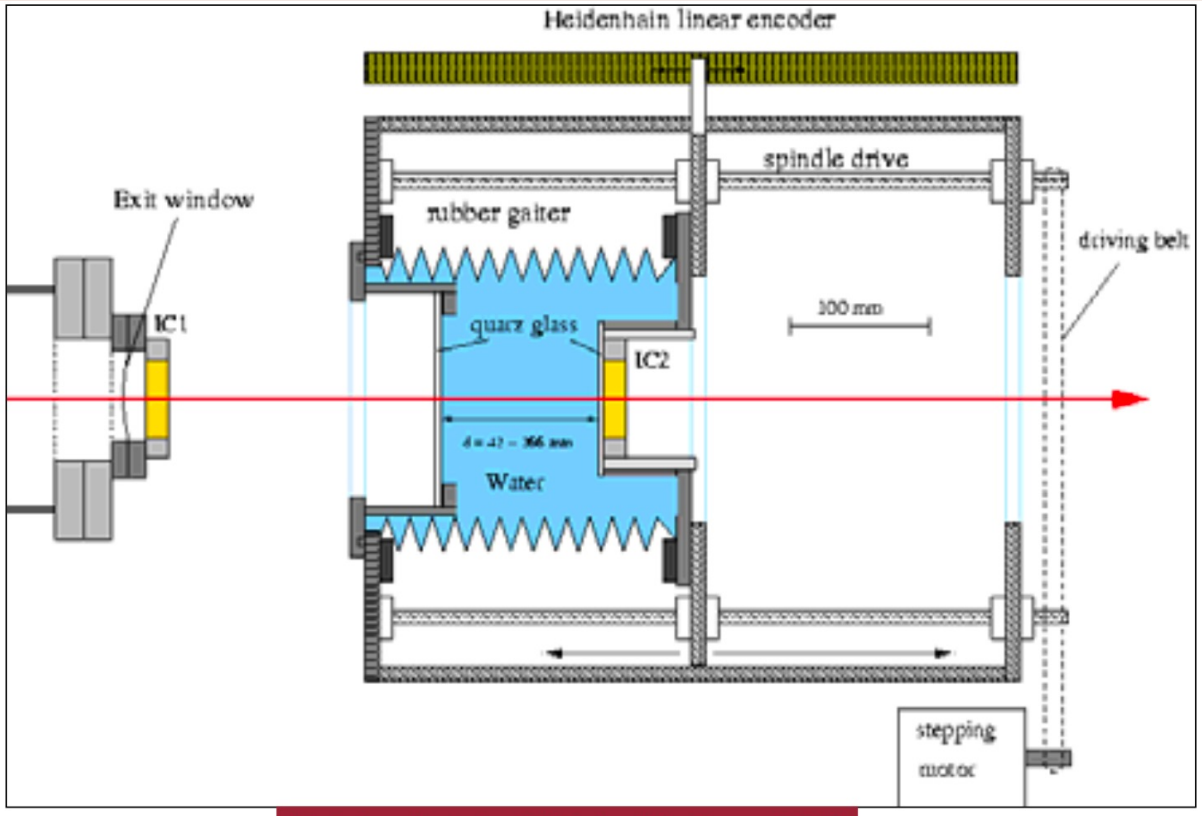
- Found good agreement with depth-dose profile of electrons in all materials independent of production cuts with *scattering power correction*



Bragg Peak Validation: G4Med LightIonBraggPeak test

Contribution from M. A. Cortés-Giraldo

- A G4Med test benchmarking the Bragg peak in water against experimental data by Schardt et. al. using relative ionization measurements



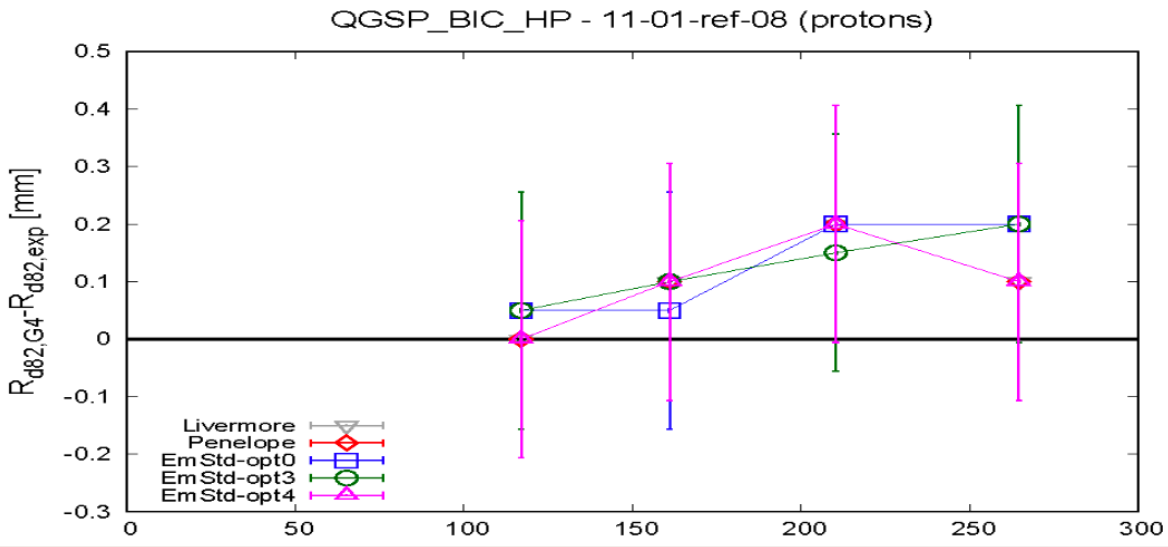
D. Schardt *et al.*, GSI Scientific Report 2007

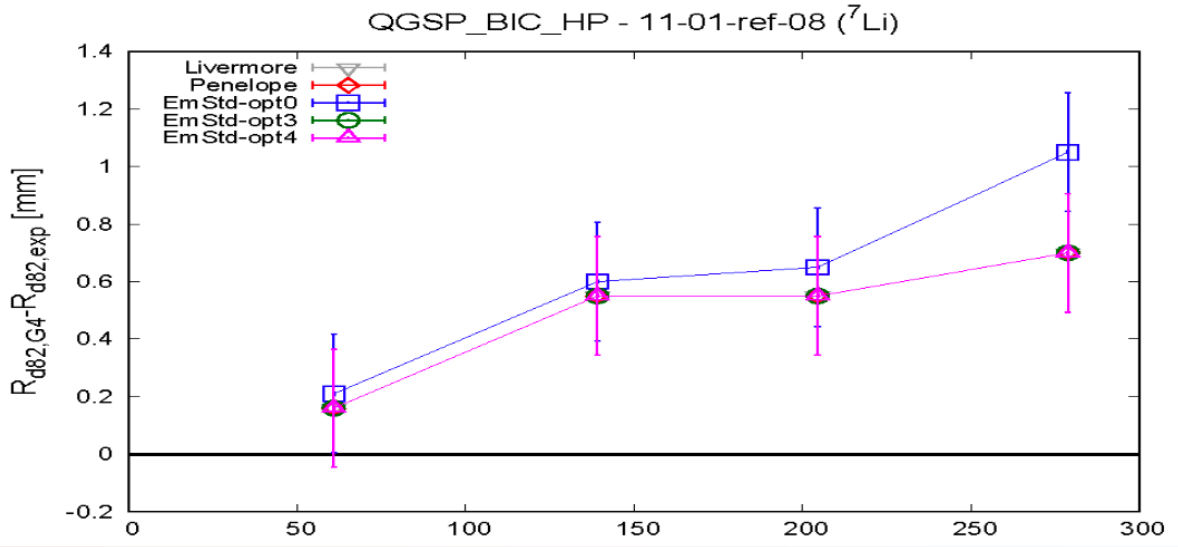
- Range reported here as the depth at 82% of the maximum distal to the Bragg peak

Bragg Peak Validation: G4Med LightIonBraggPeak test

Contribution from M. A. Cortés-Giraldo

- Ranges benchmarked using 10.05, 11.00.p01, 11.01-ref-08 using Livermore, Penelope, EmStd-opt0, EmStd-opt3, EmStd-opt4
  - 10.05-ref-00: opt3 and opt4 gives better agreement
  - 11.00-p01: Penelope and Livermore gives better agreement
  - 11.01-ref-08: Livermore, Penelope, opt3, opt4 gives best agreement

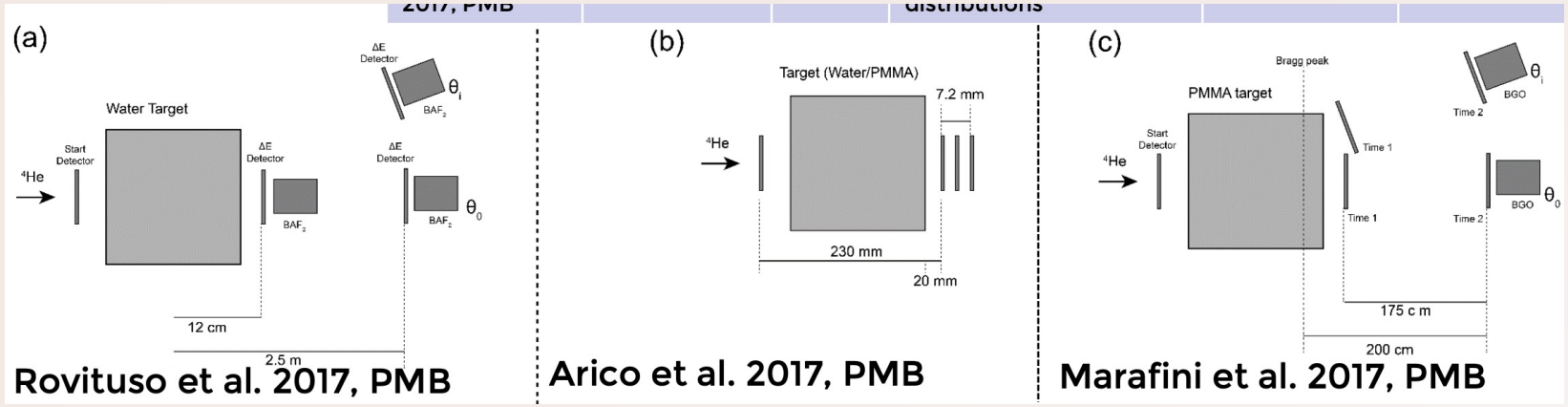




Validation of helium radiotherapy

Contribution from D. Bolst

- Increase in interest in helium radiotherapy
- More localized than protons and less fragments than carbon ions
- Benchmarking physics in Geant4 11.0 (BIC, QMD, INCL) against 3 studies:



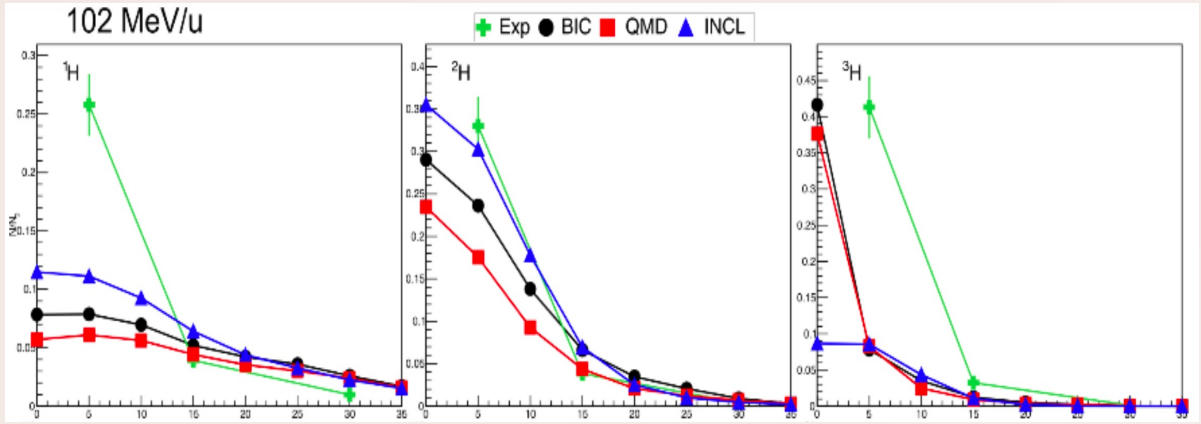
- Comparison of angular distributions, energy distributions and fragment yields

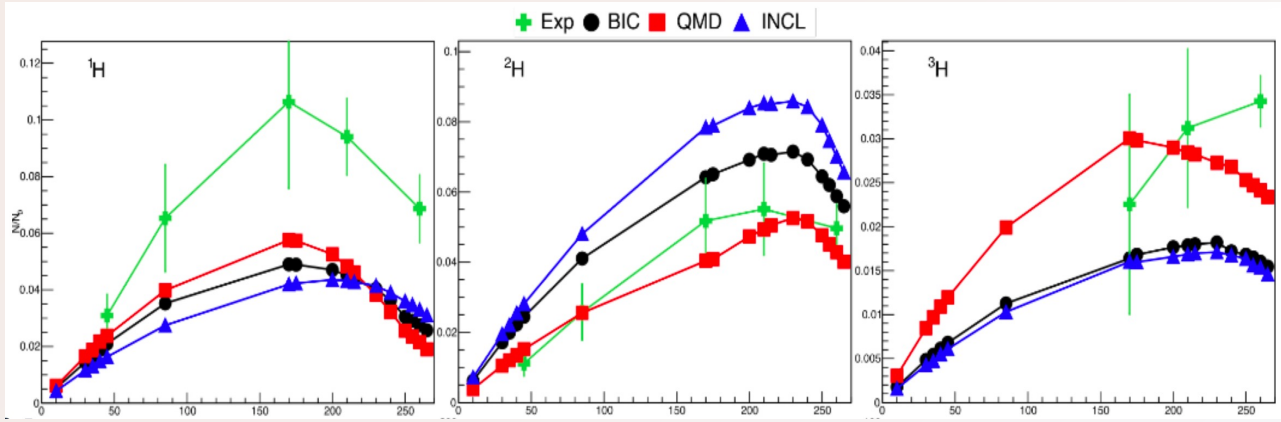
Validation of helium radiotherapy

Contribution from D. Bolst

Large deficiencies in the angular distribution in the forward direction for all physics models

QMD gives best agreement (when distinguishing isotopes) but *doesn't mean that they are being distributed the best*

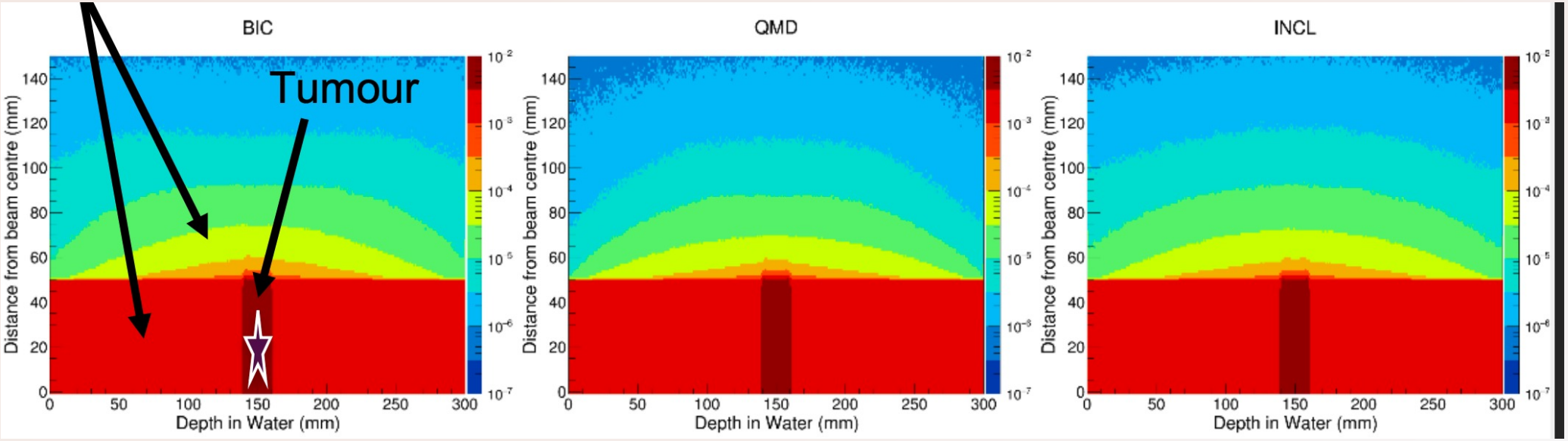




Validation of helium radiotherapy

Contribution from D. Bolst

Out of field dose distributions produced by models differ up to ~100% among the models alone



Modelling the Response of CLLBC(Ce) and TLYC(Ce) SiPM-Based Radiation Detectors in Mixed Radiation Fields with Geant4

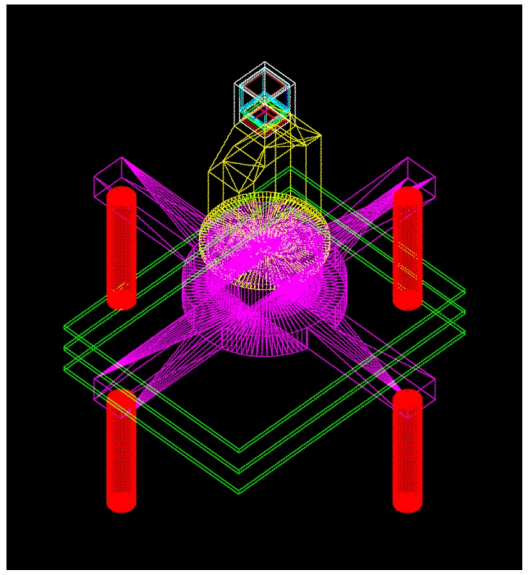
Contribution from J. M. C. Brown

$$^{6}Li + n \rightarrow {}^{4}He + {}^{3}H,\ Q = 4.8\ \text{MeV}$$

- CLLBC(Ce) and TLYC(Ce) are scintillators which are capable of measuring mix gamma ray neutron fields

1/2-inch RMD Inc. Crystals

Implemented Geant4 Geometry



- Characterised using Am-241, Cs-137, Co-60, Eu-152, and Cf-252 in Geant4 10.7 with QGSP_BIC_HP_EMZ physics
- Birk's constant and decay times determined:

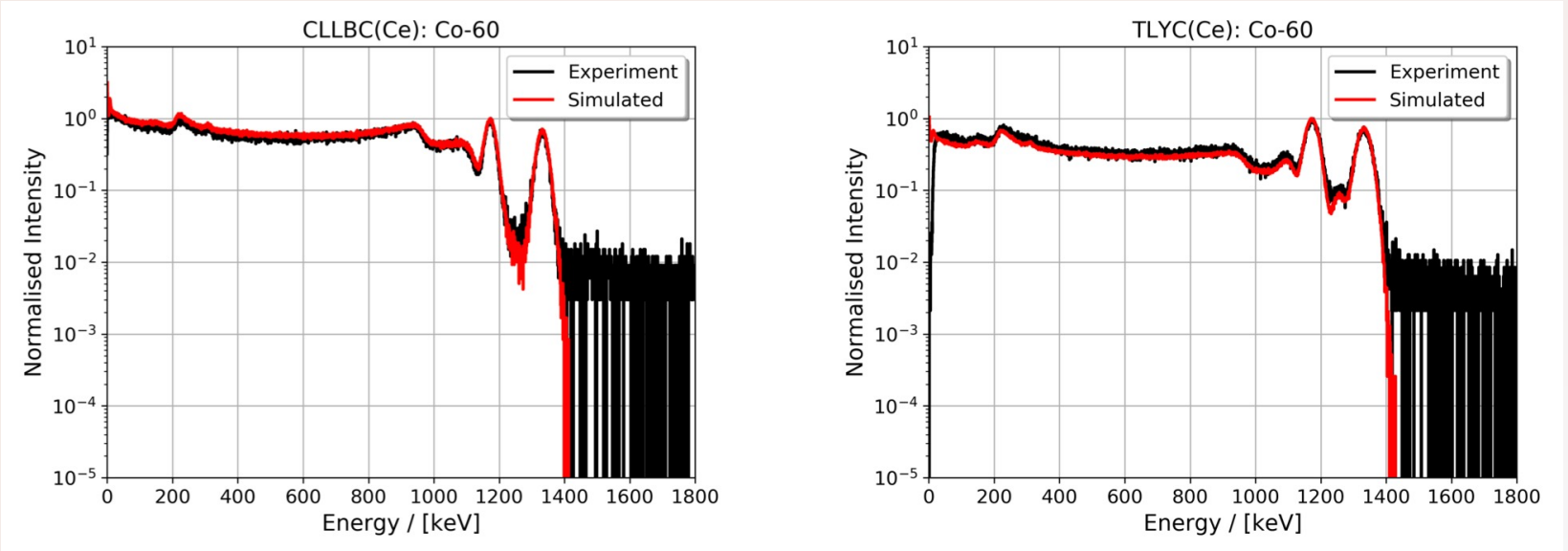
Material	Ref. Index	Optical Yield	Decay Times (ns)	Res Scale (@ 662 keV) Birks Con. (mm/keV)
CLLBC(Ce)	1.9	50k per MeV	130 (0.825) 784 (0.175)	2.167 3.85
TLYC(Ce)	2.4	29k per MeV	71 (0.323) 537 (0.677)	2.345 14.2

Modelling the Response of CLLBC(Ce) and TLYC(Ce) SiPM-Based Radiation Detectors in Mixed Radiation Fields with Geant4

Contribution from J. M. C. Brown

Simulation matched well with measured intensities

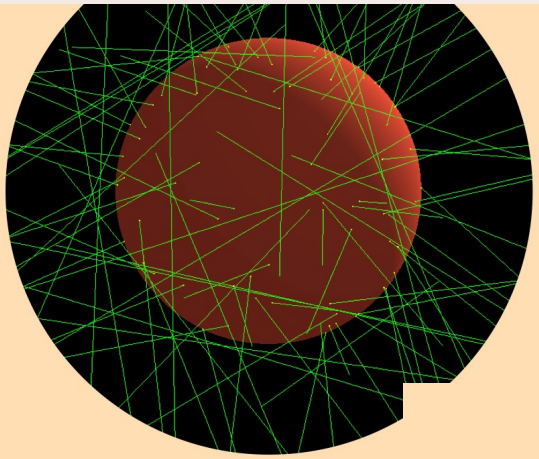
- Some discrepancies due to electronics (sum peaks) and scatter
- High level of correlation in gamma ray photopeak FHWM
- High level of correlation in neutron centroid and FWHM



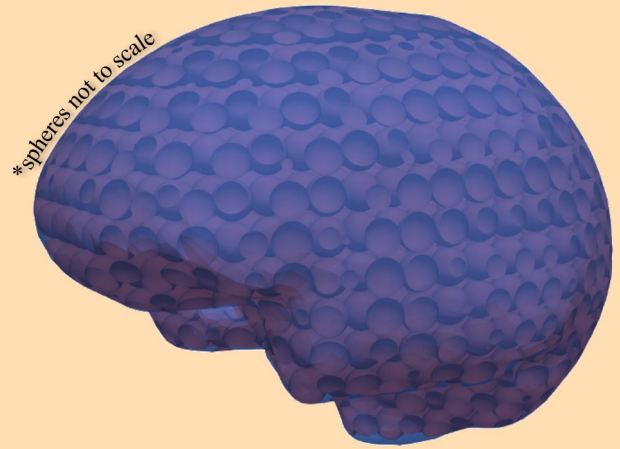
Calculation of early DNA damage in astronauts: update and future perspectives

Contribution from J. Archer

- Multi-scale simulation developed



- Radiation from galactic cosmic ray (GCR) protons and backscattered lunar radiation considered on cellular scale in human phantom
- DNA damage simulated using full human cell model
- Combined condensed history and track structure physics list implemented due to the particles outside energy range of Geant4-DNA models



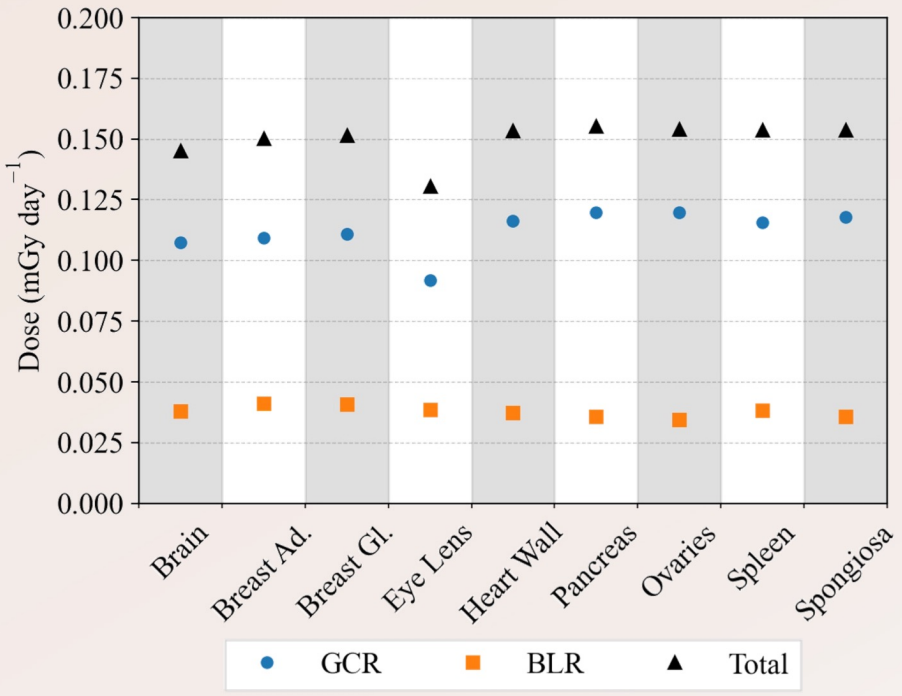
- 10 um lattice of virtual scoring spheres

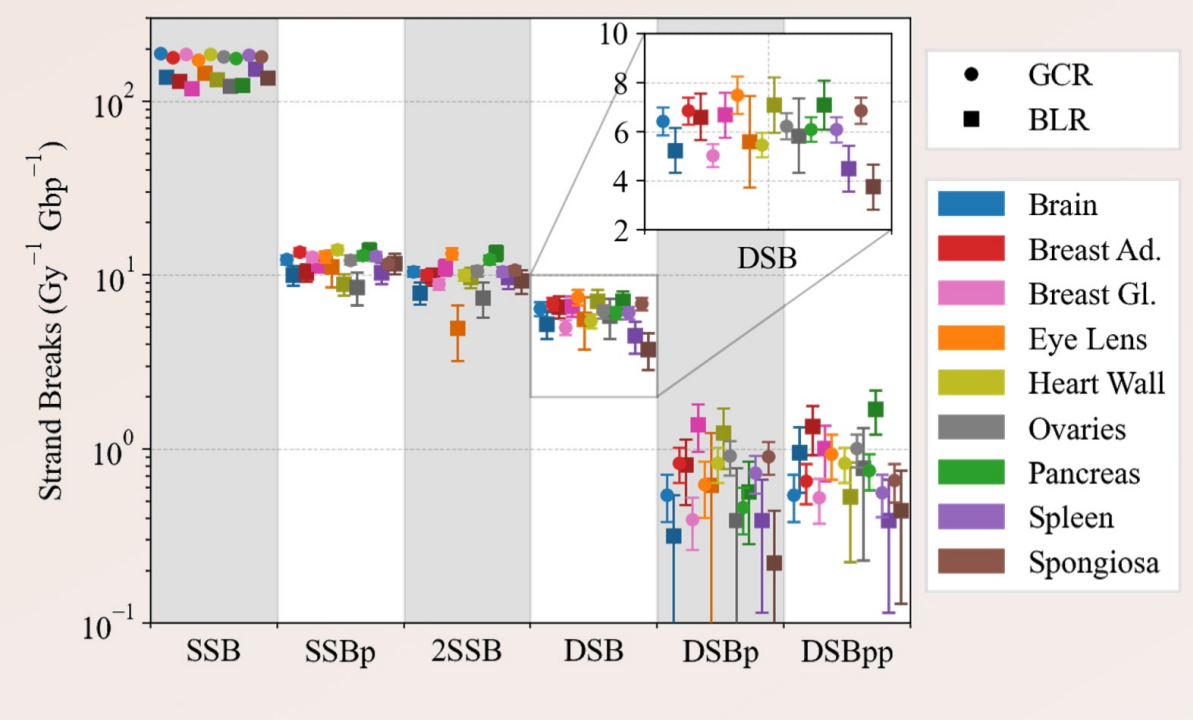
Calculation of early DNA damage in astronauts: update and future perspectives

Contribution from J. Archer

- BLR significant contribution to dose

- Strand break yields in organs of interest





Geant4 based Dose Planning Monte Carlo (DPM)

Contribution from M. Novak

- Fast and accurate 3D dose simulation in highly granular geometries
- Highly optimised for voxelised geometries
- Transport of γ and e^-/e^+ allows for steps across multiple boundaries
  - Woodcock tracking of γ
  - A special msc which is a pure discrete process for e^-/e^+
- Great reduction of e^-/e^+ steps without loss of accuracy
- prototype for providing a Monte Carlo simulator for photon and electron real-time (< 1 s) radiotherapy treatment

DPM described in:

DPM, a fast, accurate Monte Carlo code optimized for photon and electron radiotherapy treatment planning dose calculations

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Geant4 based Dose Planning Monte Carlo (DPM)

Contribution from M. Novak

- Great consistency with existing DPM study and G4
- Significant improvement in execution times