Geant4 LowEn Validation subgroup

F. Di Rosa, G.A.P.Cirrone, Zhang Qiwei: validation of migrated photon processes

ORGANIZATION OF OUR WORK FOR PHOTON VALIDATION

1) Verification before of Validation

(A) Identification of data libraries for validation: Livermore, Ziegler, NIST, Sandia…. **DONE**

(B) Verification for migrated processes (migrated vs no migrated) for Livermore & Penelope **DONE**

(C) Verification for migrated processes: comparison with Standard physics processes **DONE**

2) Validation

Identification of the Libraries based on experimental data for COMPARISON to Geant4 (Validation) **DONE**

Identification of data libraries for validation (A)

- EPDL97 (Evaluated Photon Interaction Data Library) designed to meet the needs of users at Lawrence Livermore National Laboratory for use in photon transport calculations
  http://www-nds.iaea.org/epdl97/

- The National Institute of Standards and Technology (NIST) maintains a large number of databases about photon-atom interactions (Form Factors, Attenuation & Scattering Tables, NIST X-Ray and Gamma-Ray Attenuation Coefficients and Cross Section)
  http://physics.nist.gov/PhysRefData/contents.html

- Henke et al. provide tables of photoabsorption, scattering, transmission and reflection data
  http://henke.lbl.gov/optical_constants/

- Kissel et al. have compute ab initio the elastic scattering amplitudes to improve the photon-polarization informations, the scattering angular distributions and the form factor (These results have been used to improve the EPDL97 elastic (coherent) scattering data)
  http://physci.llnl.gov/Research/scattering/

Verification for migrated processes (B)

Comparison of Mean Free Path (MFP) for photoelectric, compton scattering, gamma conversion, rayleigh scattering
Elements/Compounds: H, Ne, Ag, Cu, Pb, Water

For the migrated processes: G4EMCalculator object

- G4LivermoreXxxModel.cc
- G4PenelopeXxxModel.cc

VS

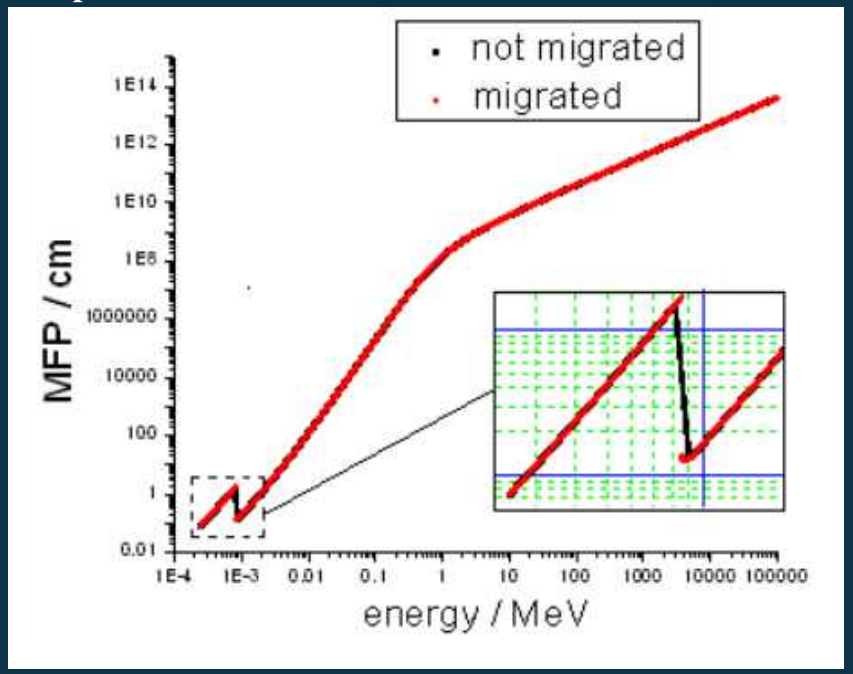
For no migrated processes: Changed the Geant4 Code Processes

- G4LowEnergyXxx.cc
- G4PeneleopeXxx.cc

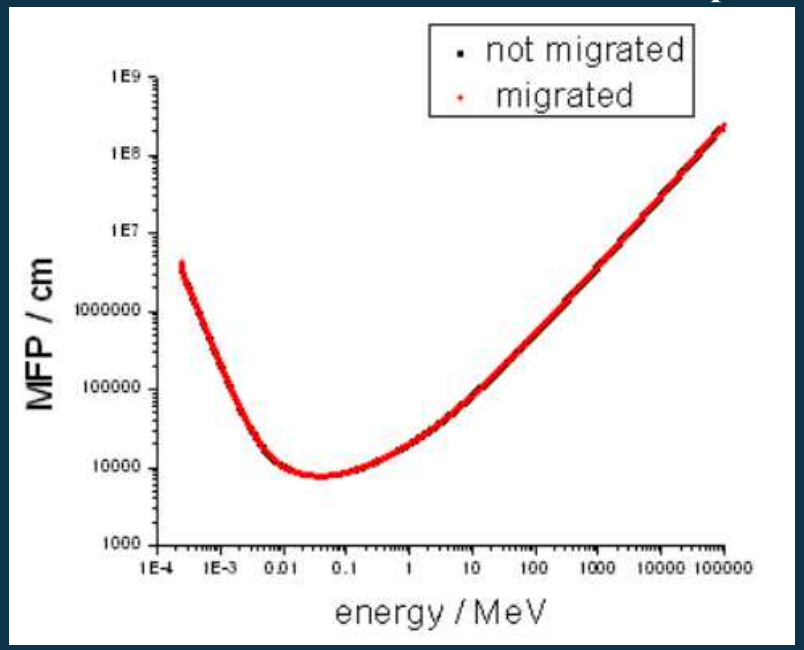
Comparison of MFP for Livermore model (Neon)

(B)

photoelettric

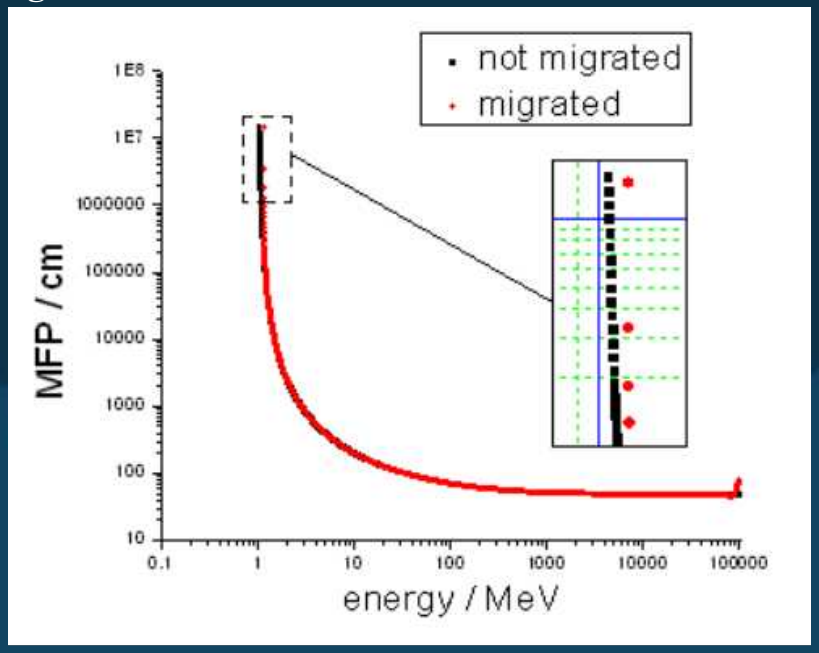


Compton

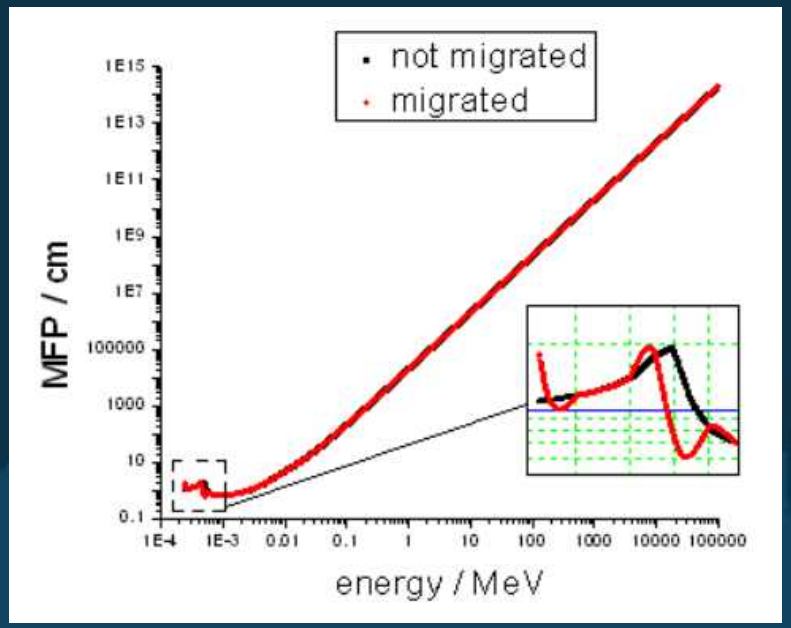


Comparison of MFP for Livermore model (Water)

gamma conversion



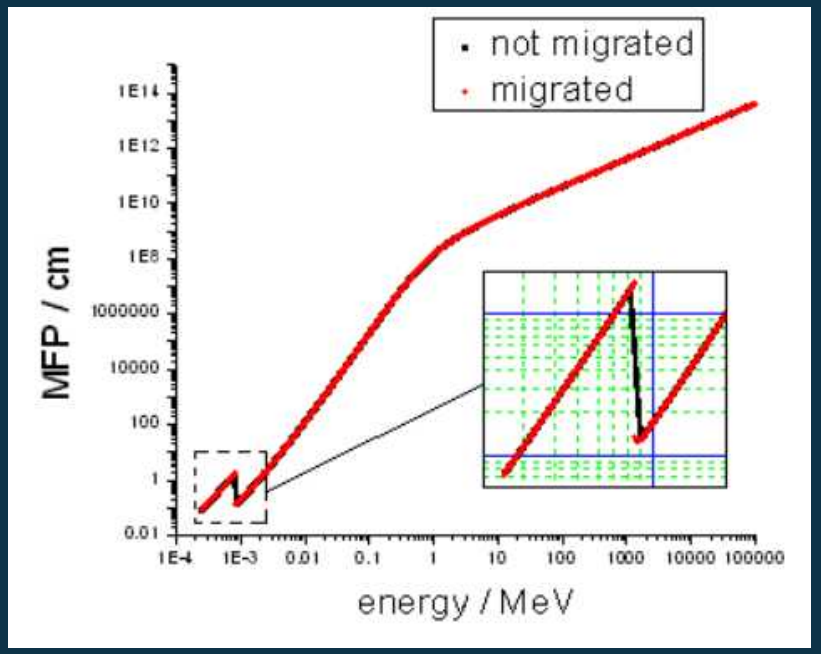
rayleigh



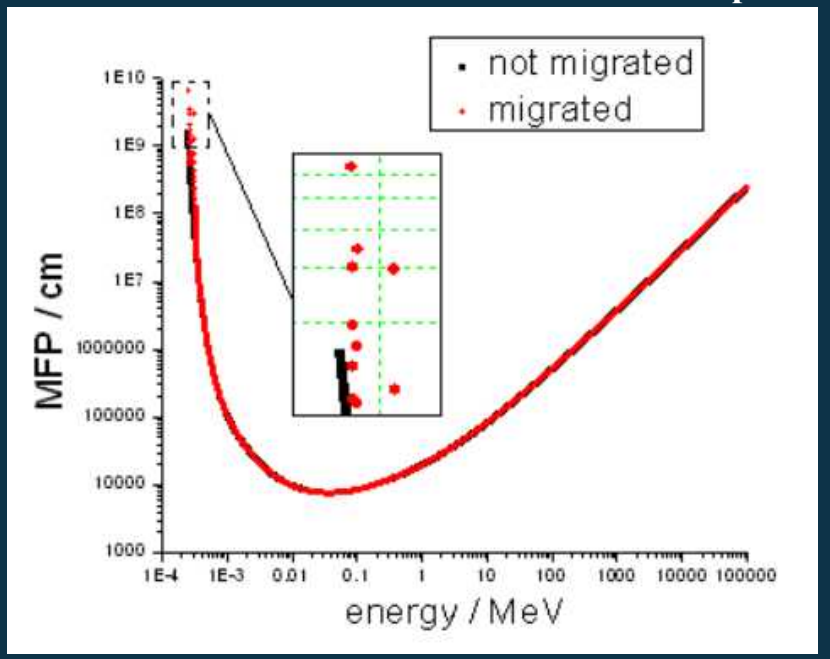
Comparison of MFP for Penelope model (Neon)

(B)

photoelettric

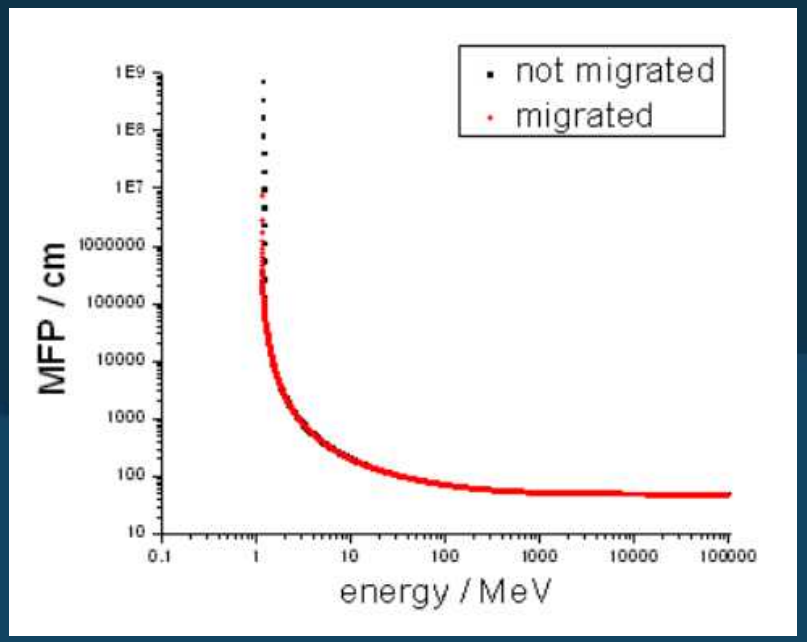


Compton

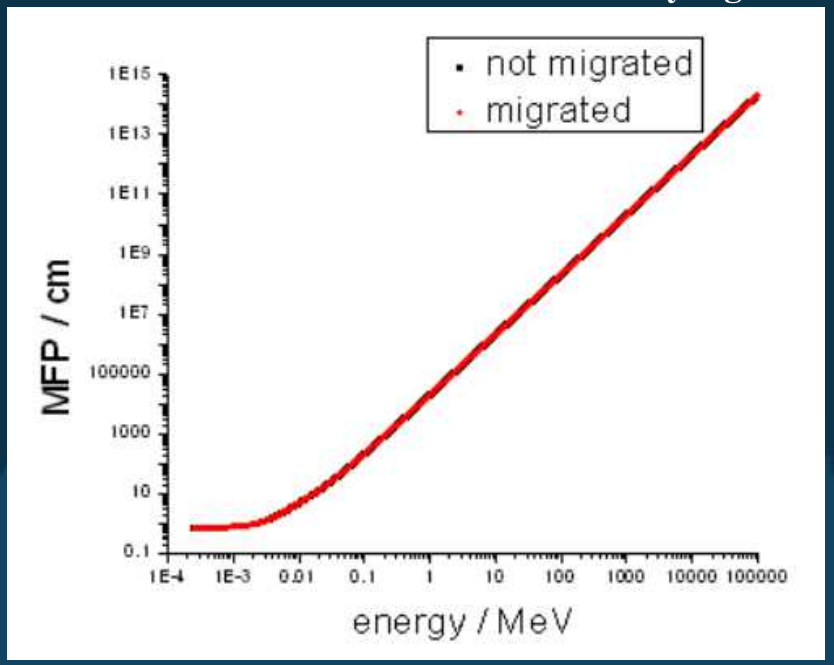


Comparison of MFP for Penelope model (Water)

gamma conversion



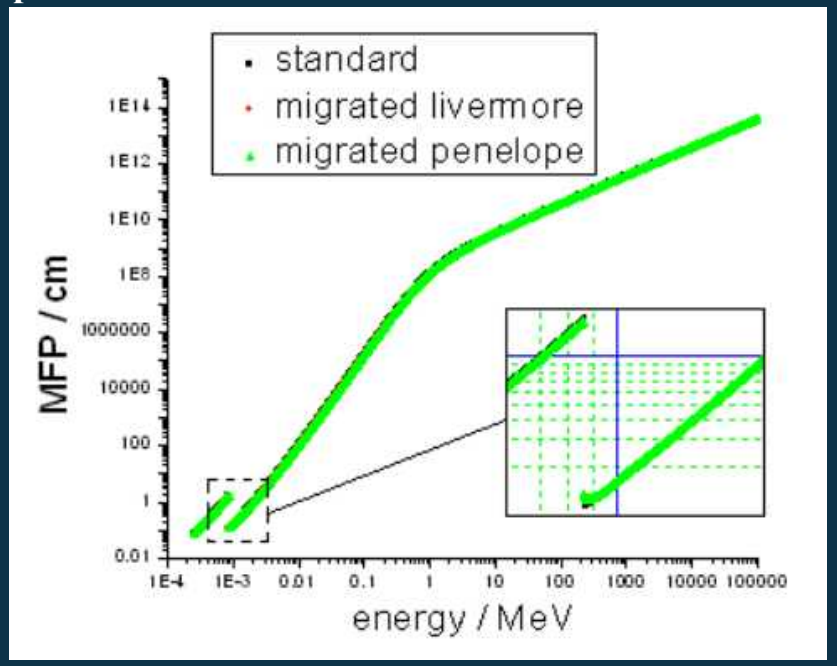
rayleigh



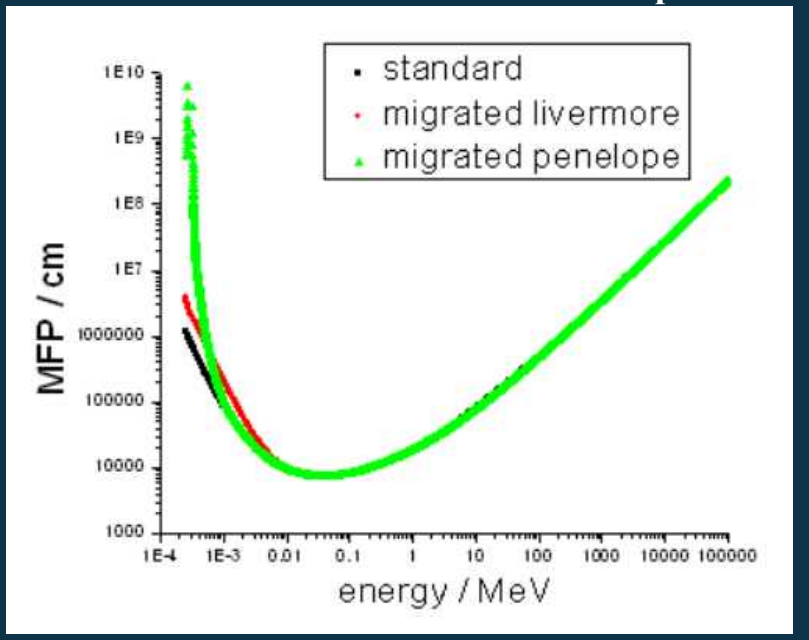
Comparison with Standard physics processes (Neon)

(C)

photoelettric

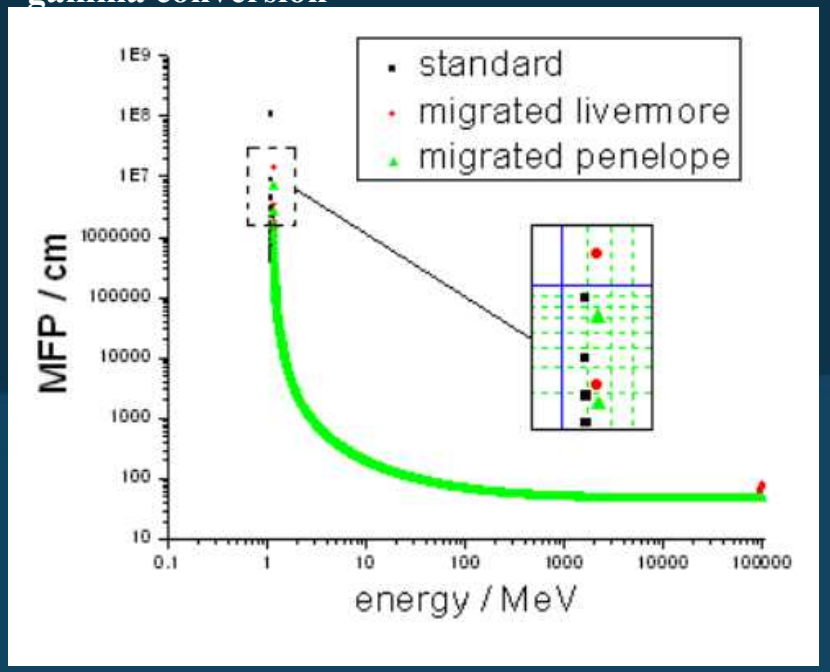


Compton

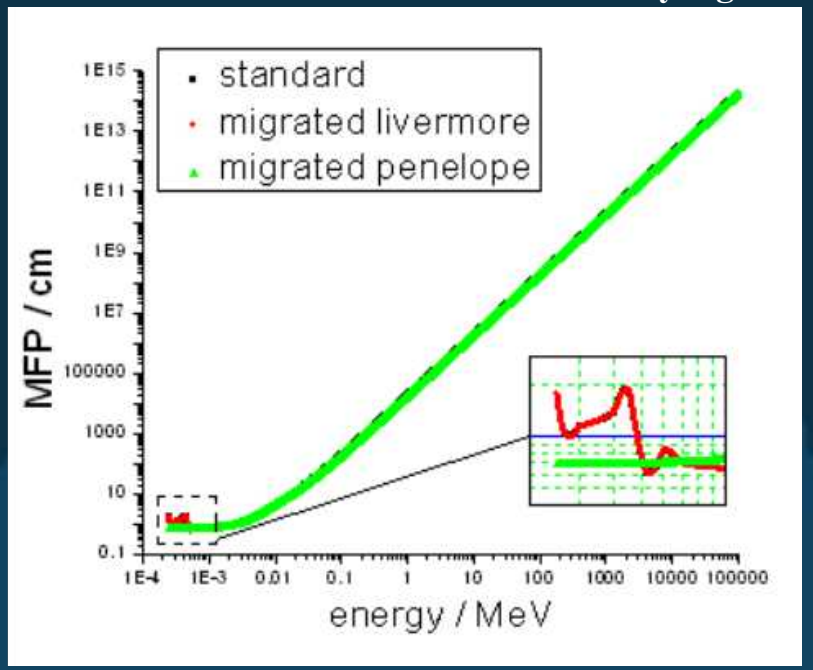


Comparison with Standard physics processes (Water)

gamma conversion



rayleigh



Identification of the Libraries based on experimental data for COMPARISON to Geant4 (Validation)

Identification

NIST and EPDL97 Libraries for all processes

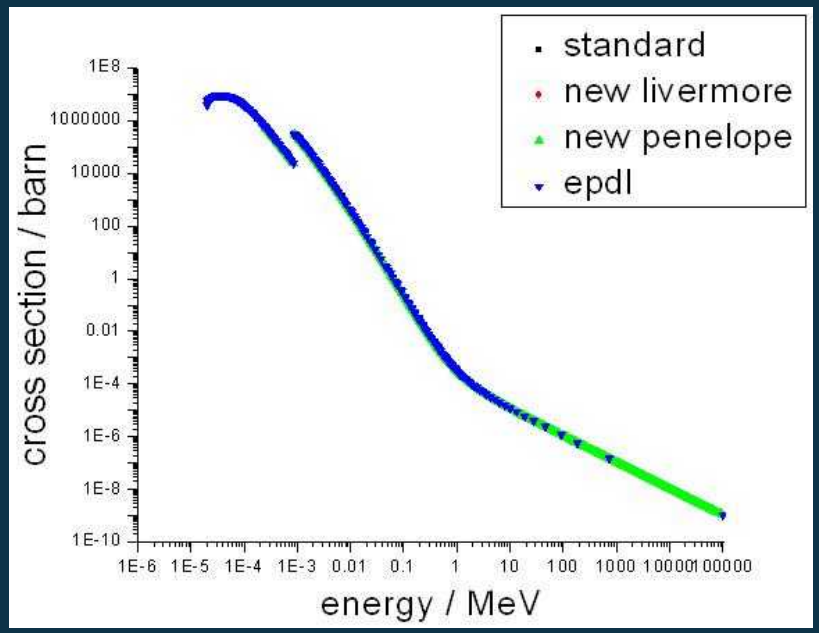
SANDIA Libraries only for photoelectric and compton processes

The next two slides are an quick example of comparison of simulation data vs Libraries

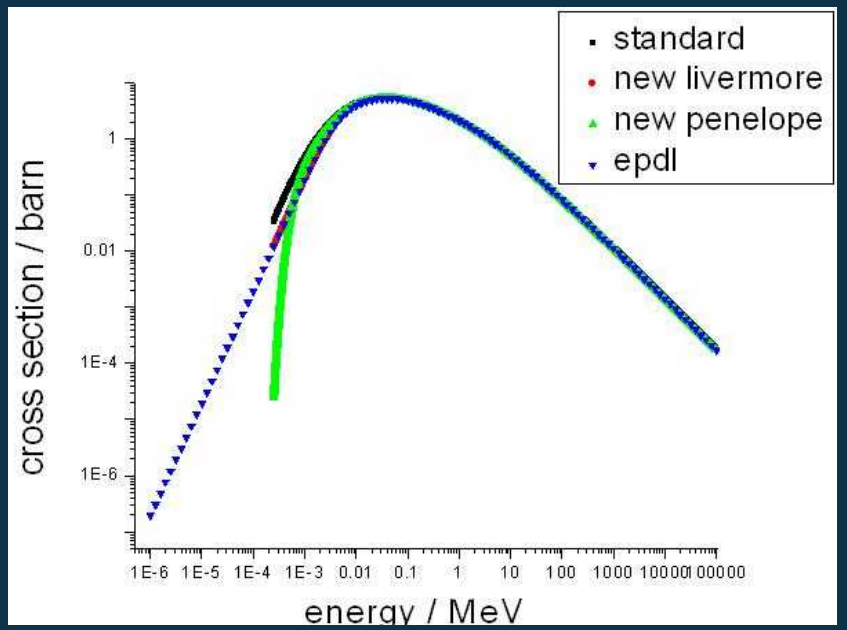
(1) Comparison of XS per Atom between epdl97 and Geant4 for an element (photoelectric and compton for Ne)

(2) Comparison of XS per Volume between epdl97 and Geant4 for a compound (gamma conversion and rayleigh Water)

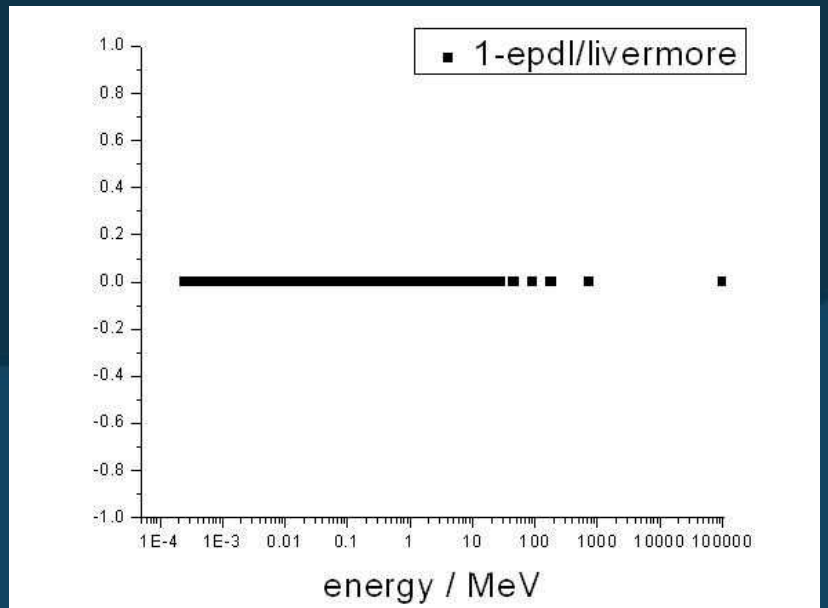
Comparison of XS per Atom between epdl97 and Geant4 (Ne)

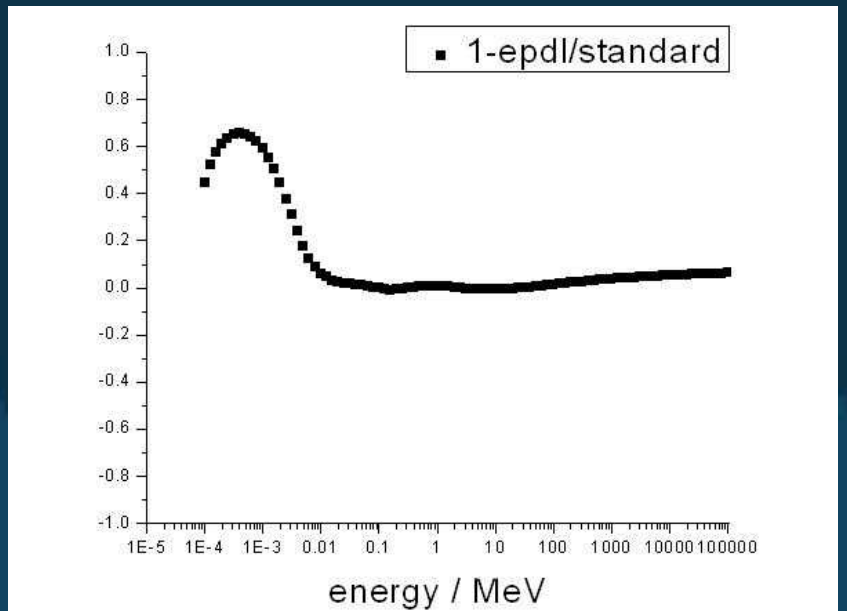


photoelectric

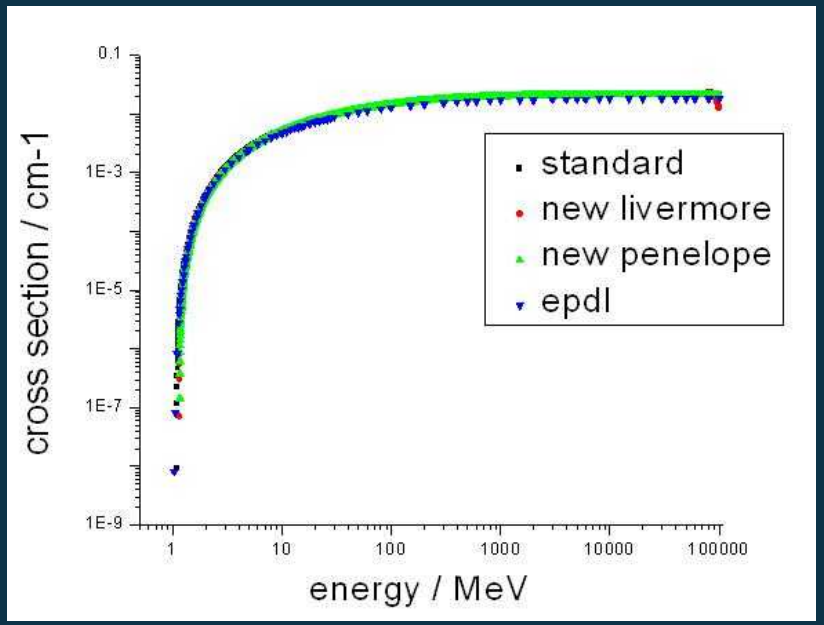


compton

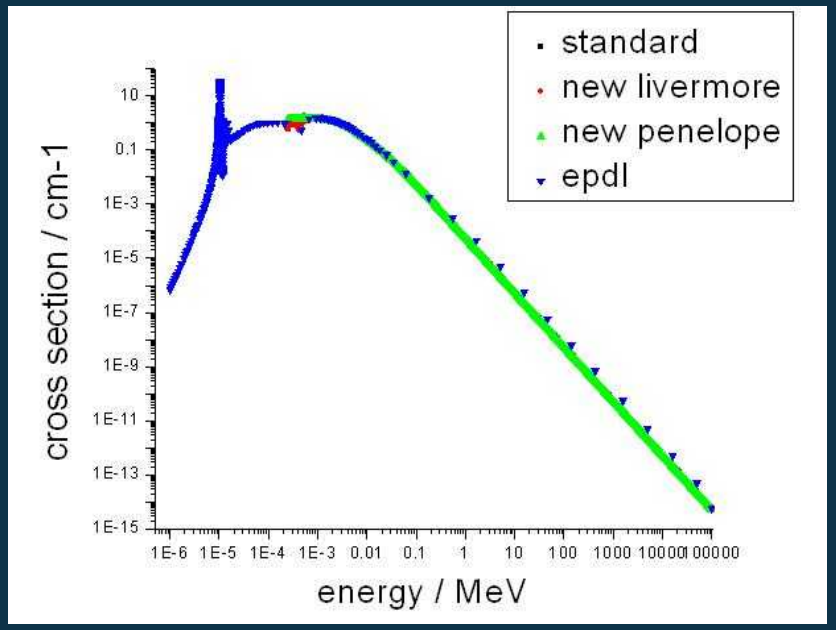




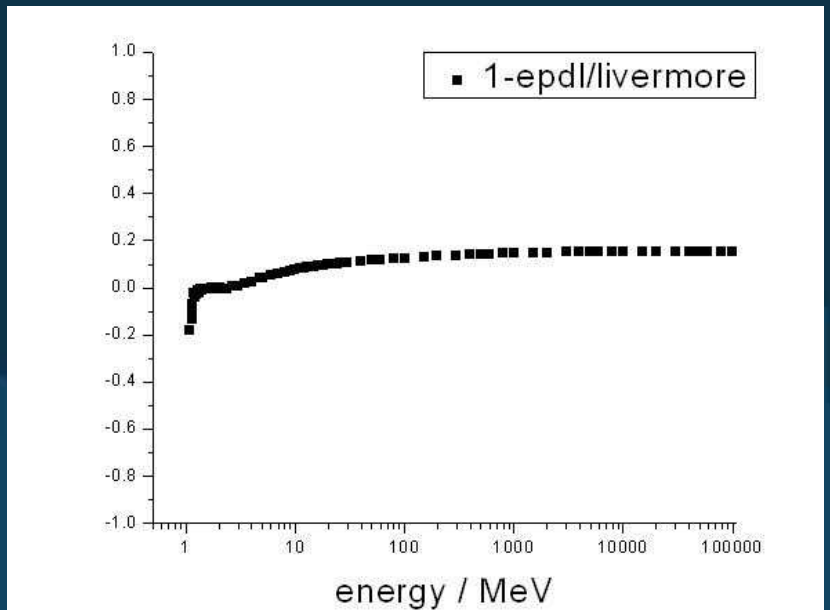
Comparison of XS per Volume between epdl97 and Geant4 (Water)

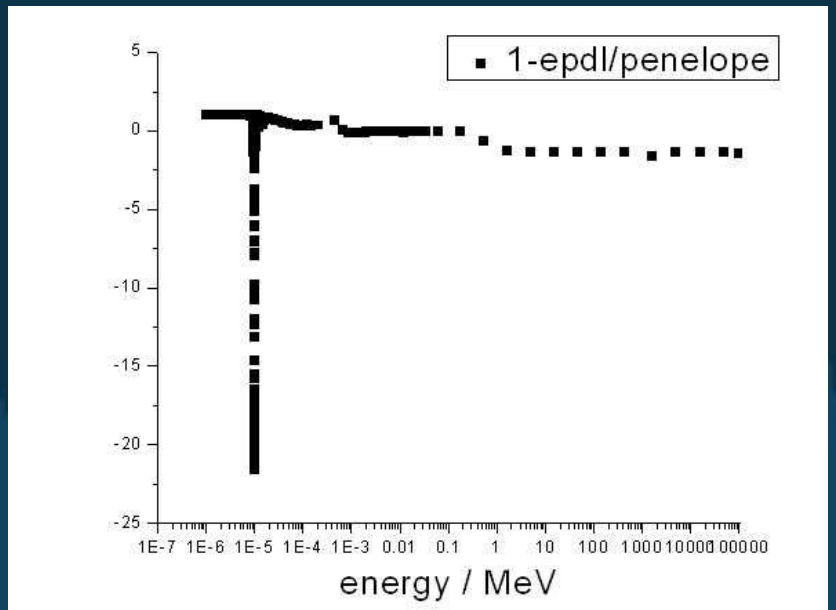


gamma conversion



rayleigh





NEXT STEPS

All data, plots and documentation will store in our workgroup website

We would like reorganize the test of the lowenergy source folder adding also the new test for the validation:
geant4-09-02-ref-xx/source/processes/electromagnetic/lowenergy/test

We are preparing our first test for automatic data production

Study of a Statistical tool to valuate the goodness of the comparison

Geant4 LowEn Validation subgroup

F. Di Rosa: validation for proton and ion LET

ORGANIZATION OF MY WORK FOR LET

1) LET for clinical proton beam

(1.A) Depth dose distribution vs Geant4 simulation data comparison **DONE**

(1.B) Implementation of LET calculation inside Hadrontherapy **DONE**

(1.C) Comparison with literature data **DONE**

2) LET for Carbon ion beam

(2.A) Depth dose distribution vs Geant4 simulation data comparison **DONE**

(2.B) Implementation of LET calculation inside Hadrontherapy

(2.C) Comparison with literature data

Working in progress

LOW ENERGY GROUP ACTIVITY - LET study

The LET calculation is an important and fundamental task for Radiobiology experiment, Radioprotection, TPS accurate dose distribution, RBE, LEM model, etc… etc…

LET calculation for clinical proton beams

Very important LowEnergy Physics processes

Monte Carlo calculation vs others MC codes, i.e. Geant 3.21 (*)

Implementation inside Hadrotherapy example

LET model calculation for carbon ions

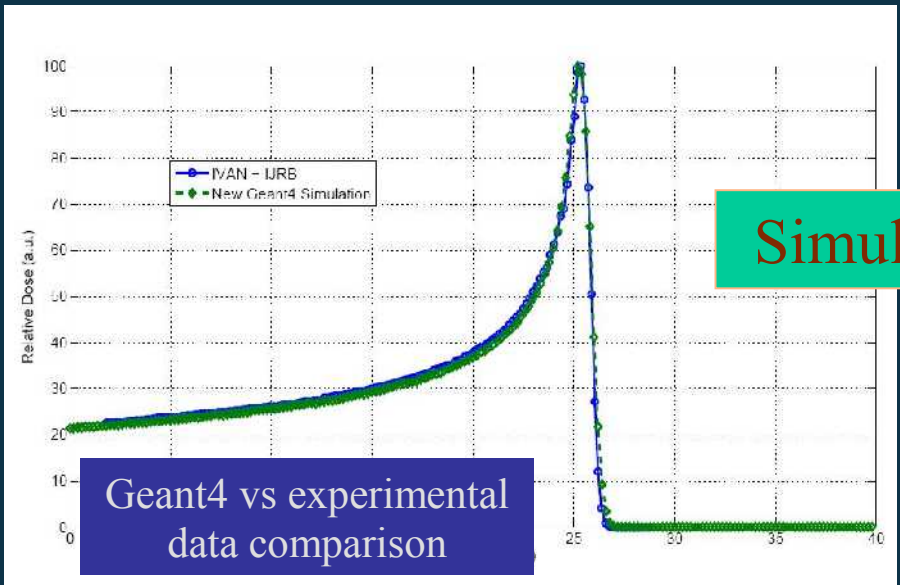
Very important Multifragmentation contributions

Monte Carlo calculation vs others MC codes, i.e. SHIELD-HIT (**)

Implementation in a new example

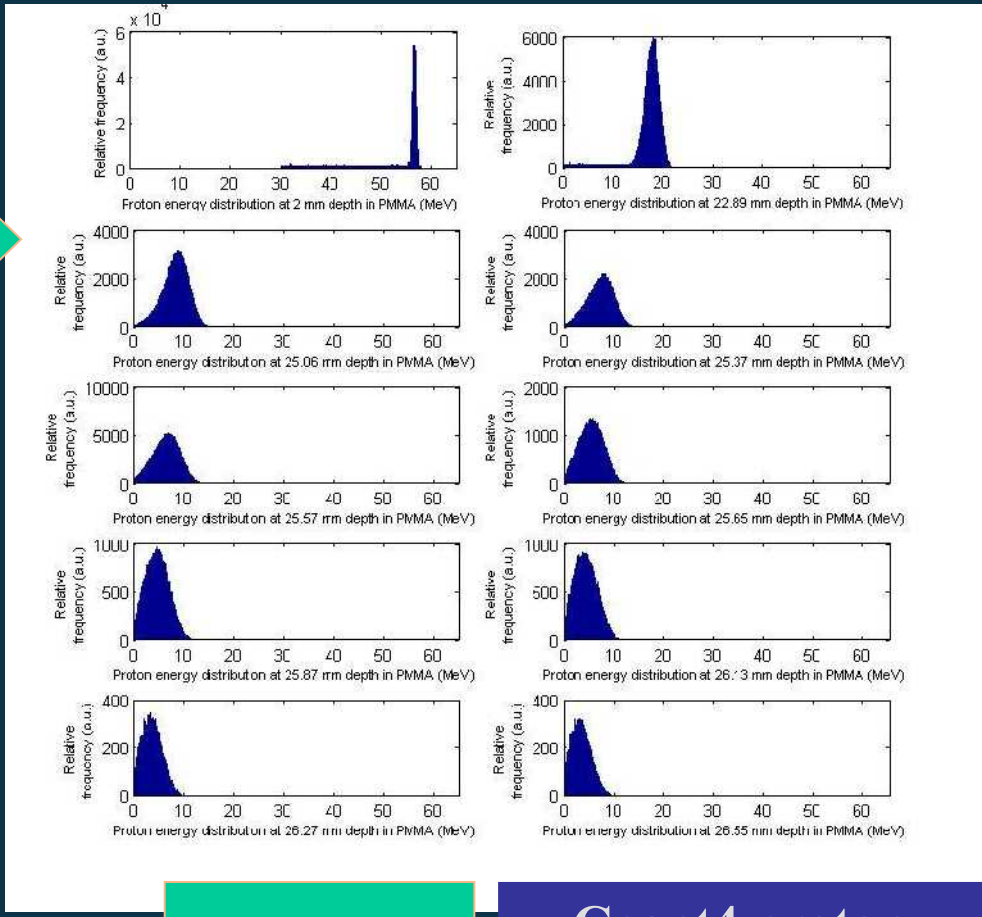
(*) J. J. Wilkens and U. Oelfke - Medical Physics, Vol. 30, No. 5, May 2003
(**) Kempe, Medical Physics, Vol. 34, No. 1, January 2007

LET calculation for clinical proton beams (1.A) + (2.B)

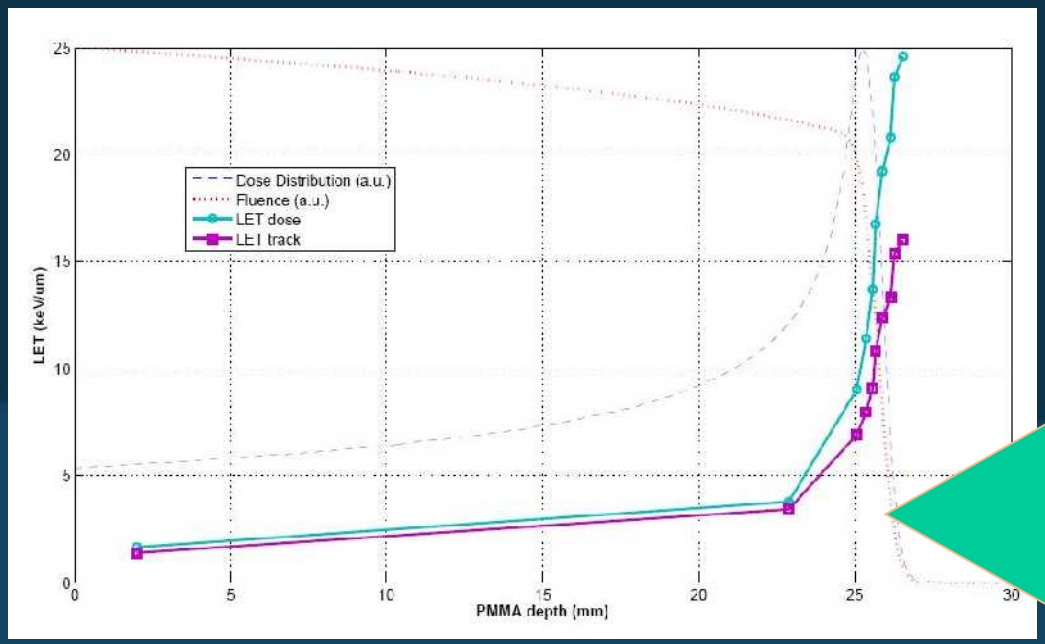


Geant4 vs experimental data comparison

Simulation



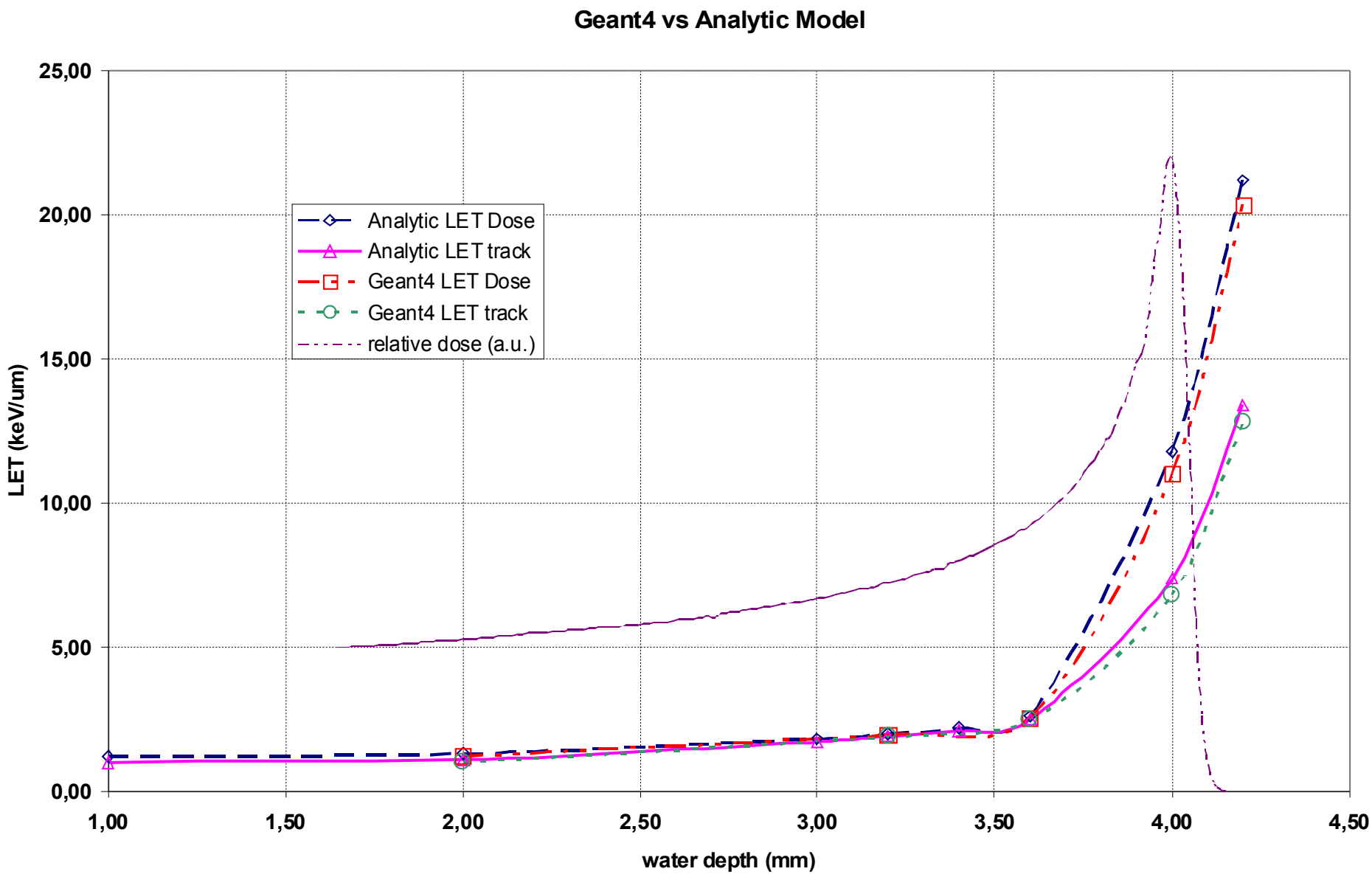
Geant4 proton depth kinetic energy simulation



LET Calculation

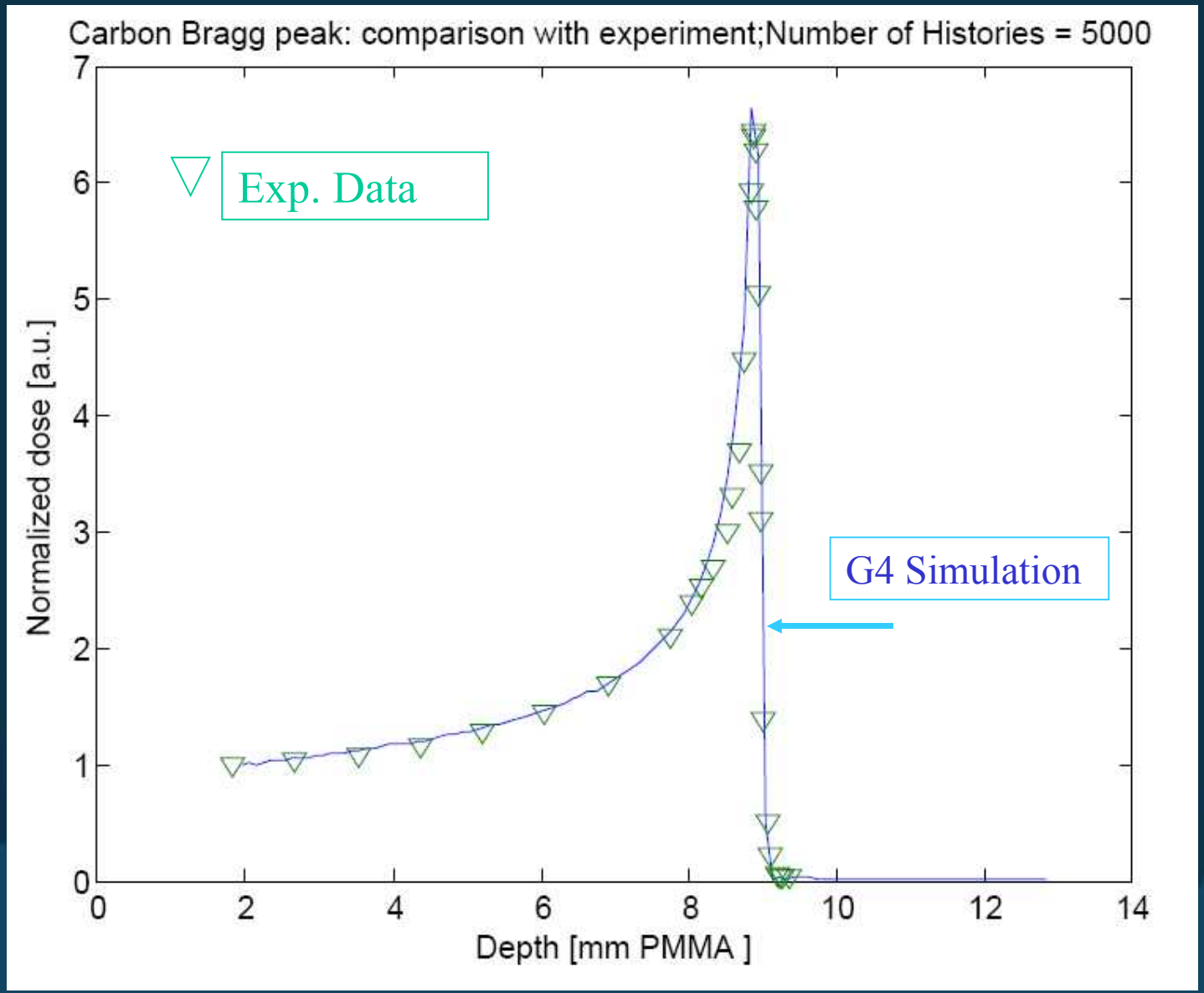
Comparison with literature data (1.C)

J. J. Wilkens and U. Oelfke - Medical Physics, Vol. 30, No. 5, May 2003

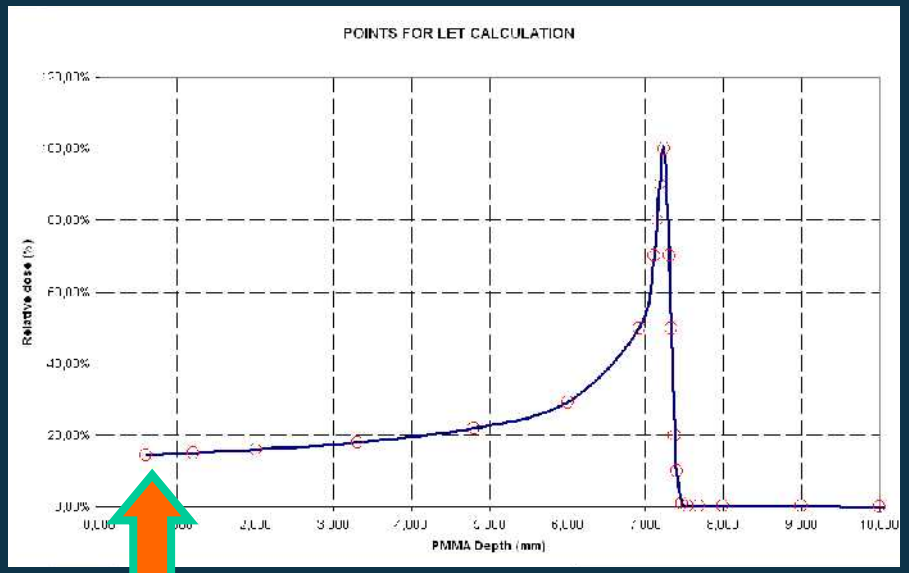


LET model calculation for carbon ions

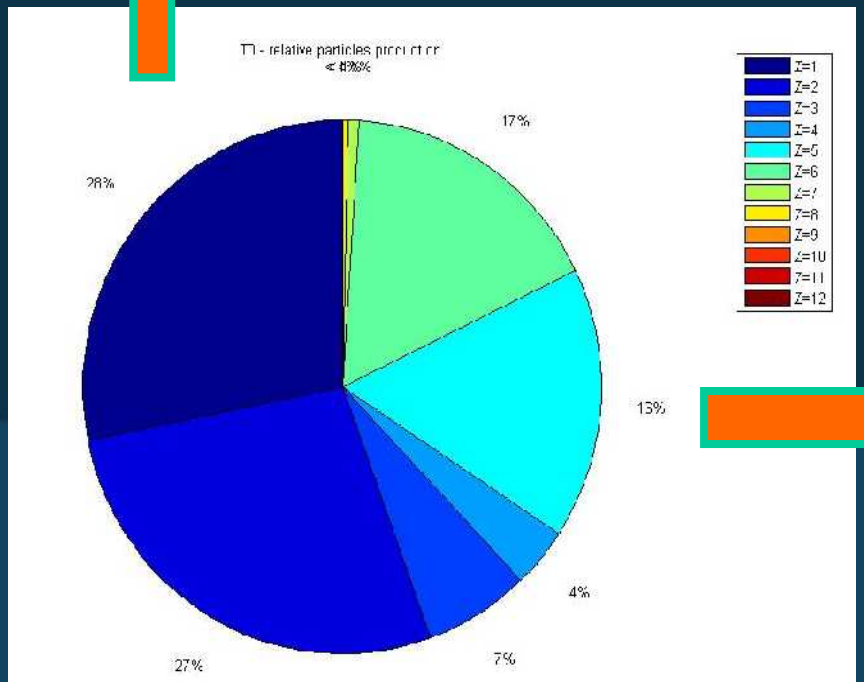
(2.A) Depth dose distribution vs Geant4 simulation data comparison

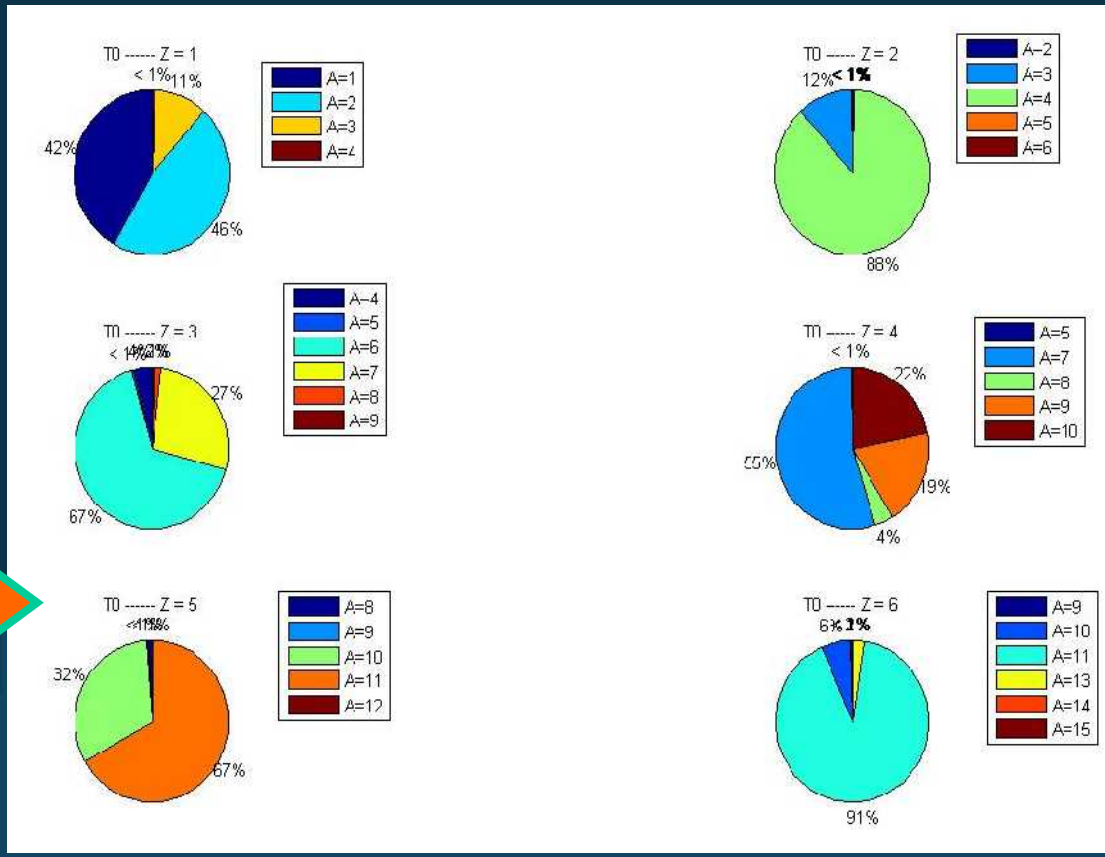


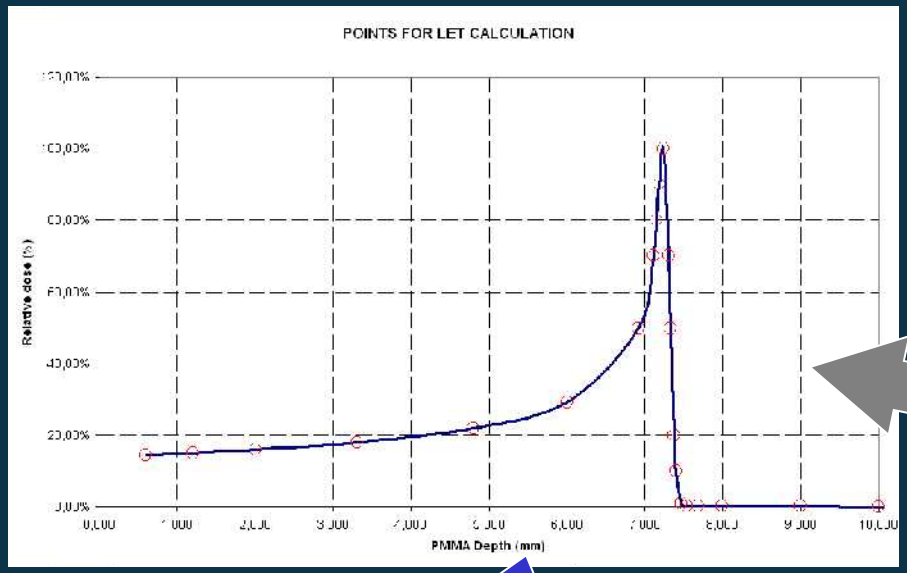
Multifragmentation contributions



EXAMPLE OF ION AND ISOTOPIES PRODUCTION AT FIRST PMMA DEPTH POSITION FOR LET CALCULATION



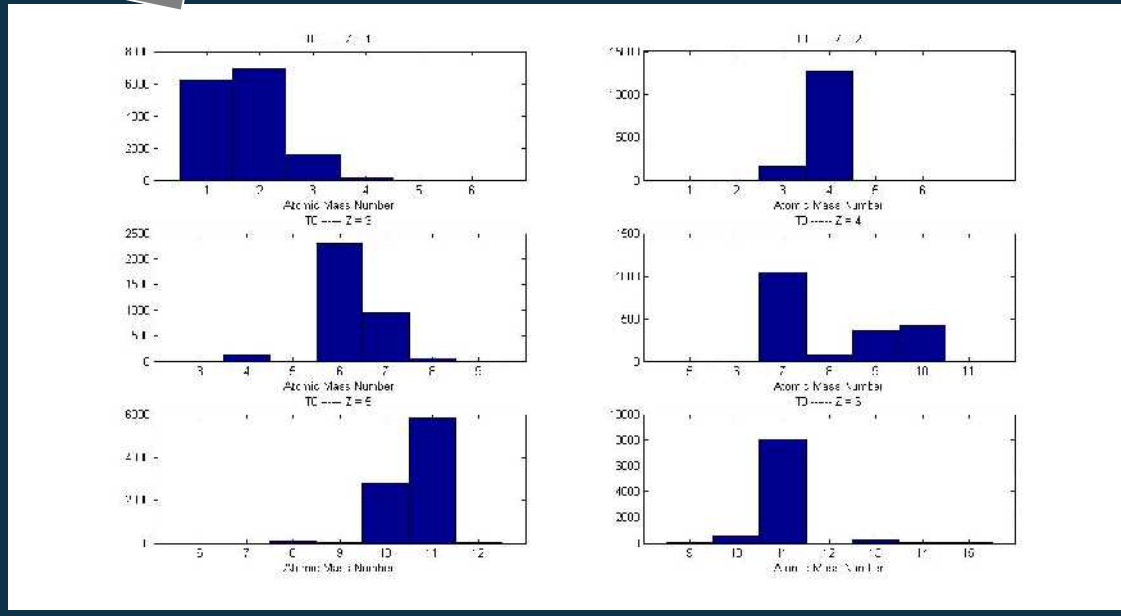


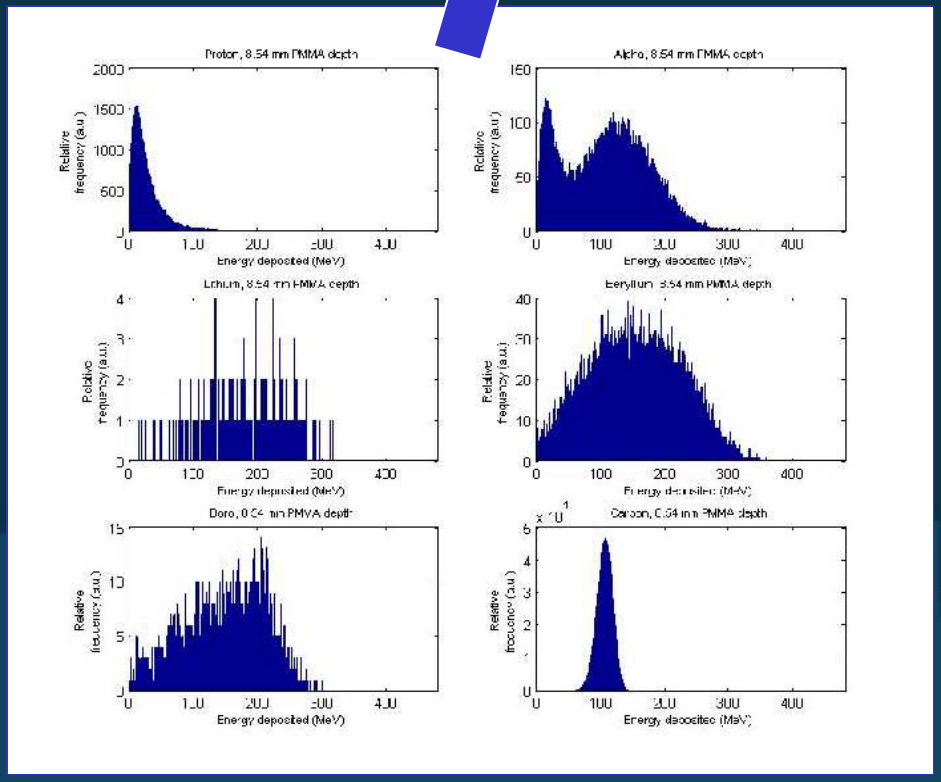


Points for LET calculations:

1) Secondary particles

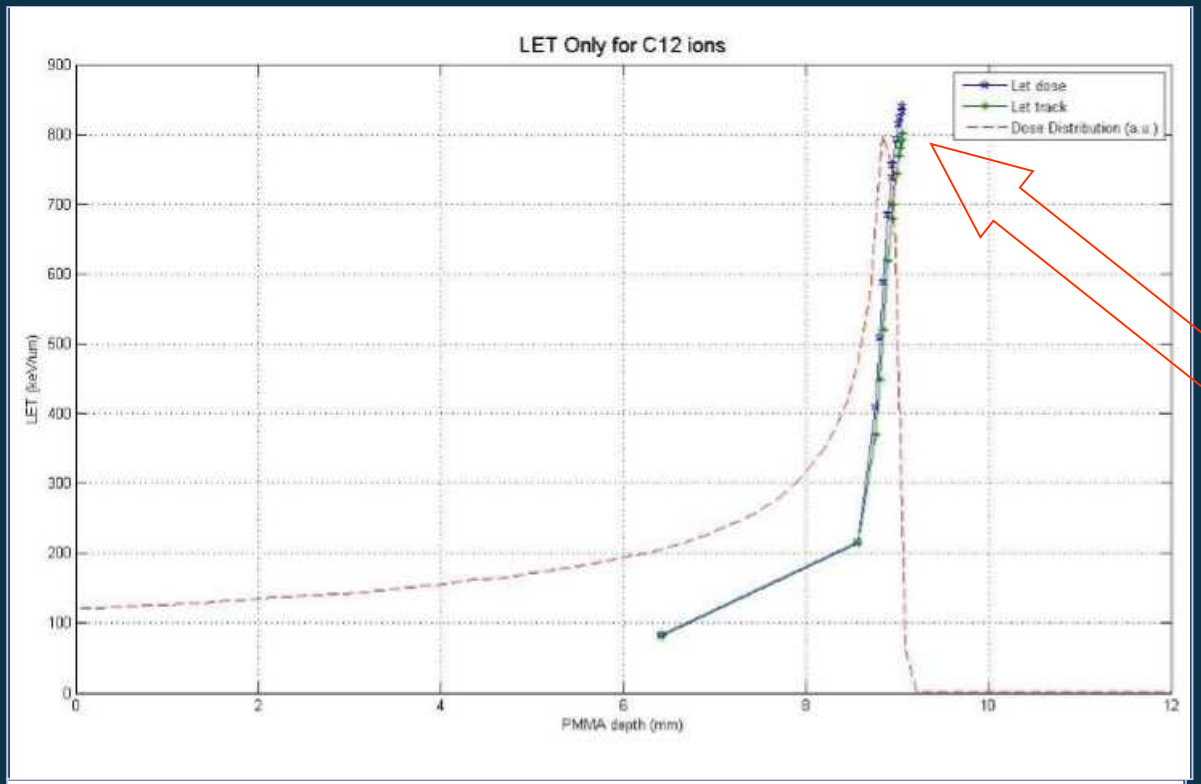
2) Kinetic energy spectra of these particles



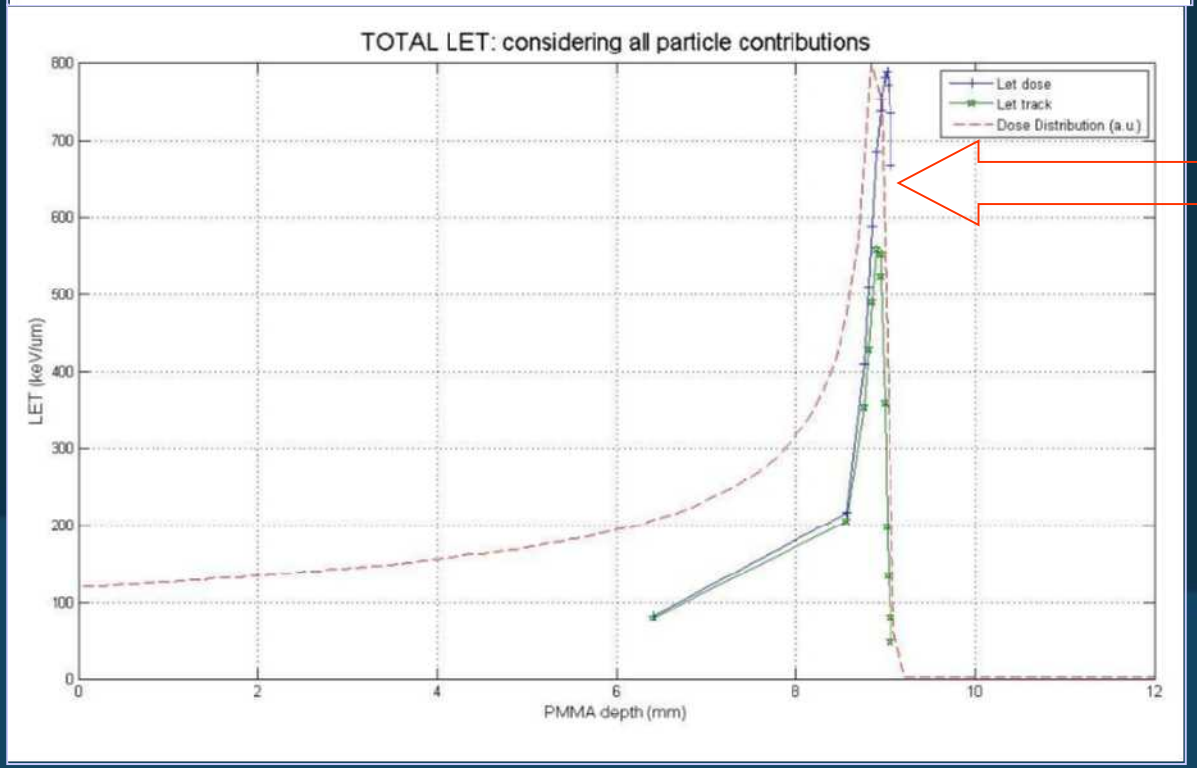


LET calculation for carbon ions

LET calculation for carbon ions

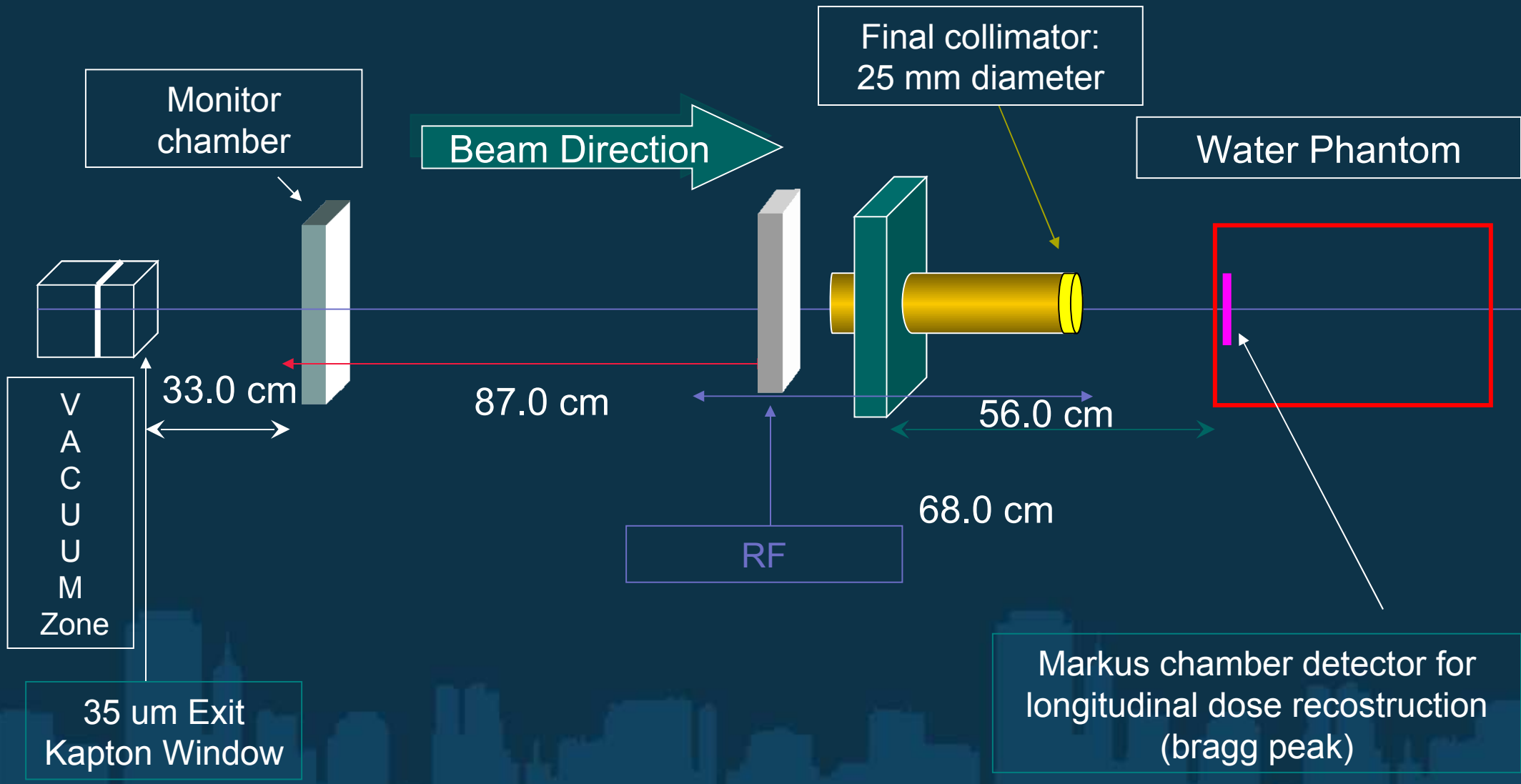


Without Multifragmentation contributions (only primary Carbon ion)



Multifragmentation contributions

SPIN-OFF OF ION LET CALCULATION: Ripple Filter (RF) for Carbon ion



Schematic irradiation procedure

SPIN-OFF OF ION LET CALCULATION: Ripple Filter (RF) for Carbon ion

Depth dose reconstruction for carbon ions in water: COMPARISON Experimental data vs G4 Simulation