Implementation of the EPICS2017 database for photons in Geant4

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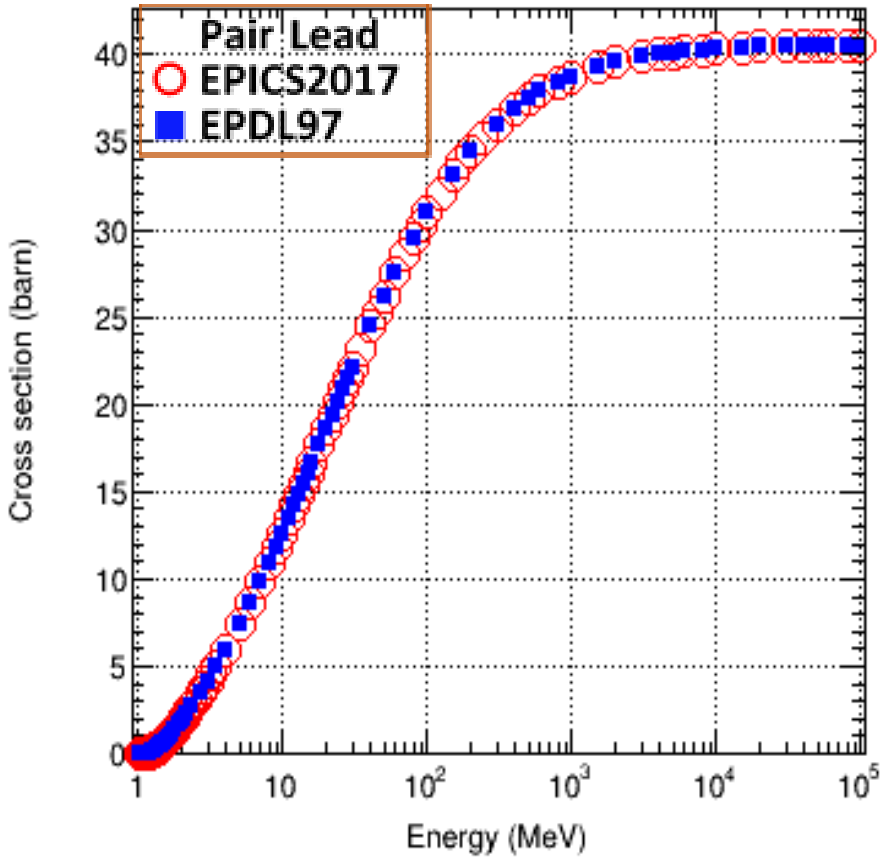
Context

- Livermore low-energy electromagnetic models uses EPDL97 database
- Database EPICS2017 (Electron Photon Interaction Cross Section library) contains physical data (cross section…) for electron and photon transport calculation
- Update of Livermore models using EPICS2017 database
- Physics processes relating to photons
  1) Gamma conversion → Already available in Geant4 10.7
  2) Compton effect
  3) Photoelectric effect → Soon available in Geant4 11
  4) Rayleigh scattering

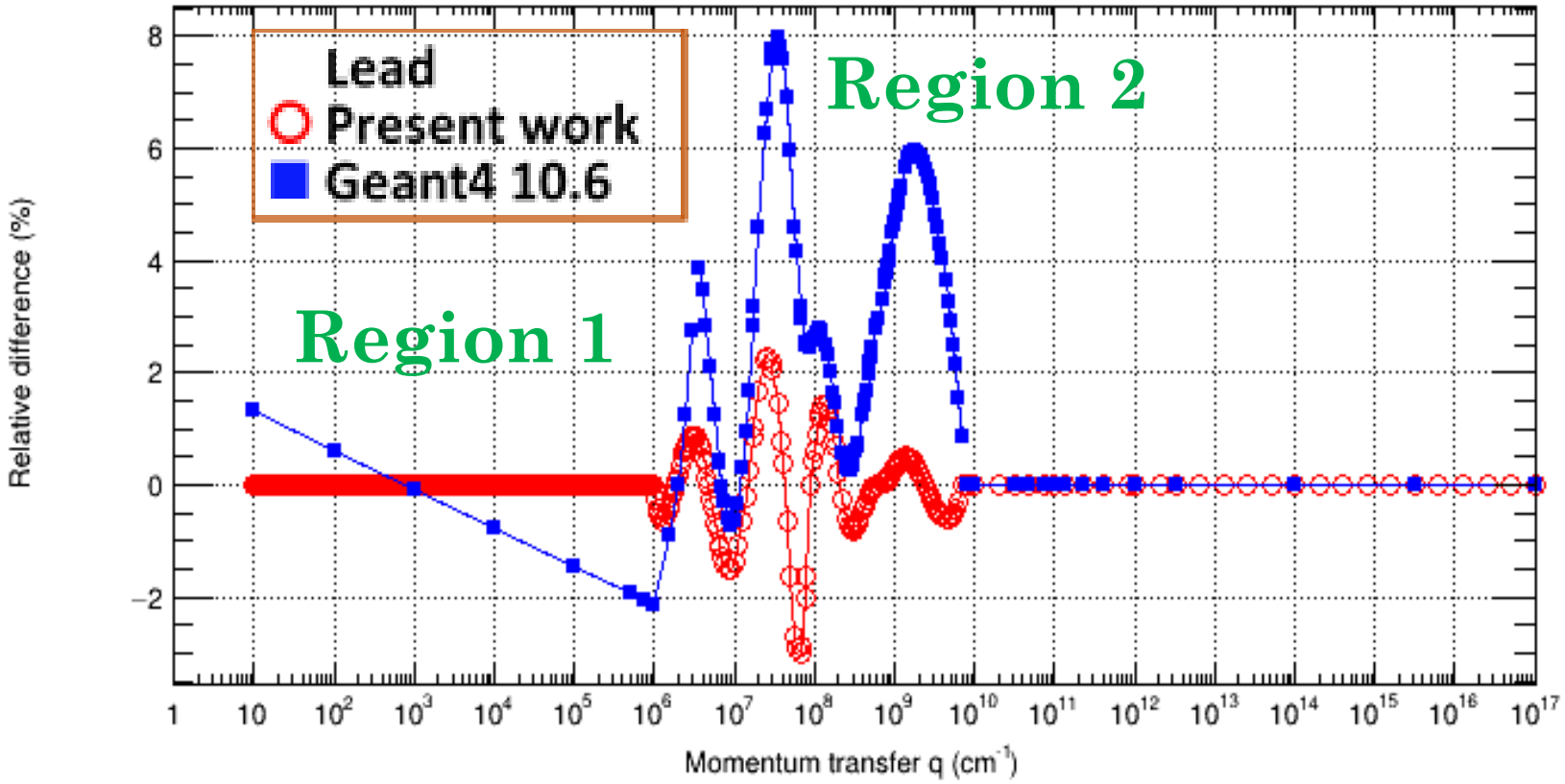
1) Gamma conversion

- Cross-sections are updated
- More data points in EPICS2017 ➔ linear interpolation
- Two models are already available in Geant4 10.7:
  - ***G4LivermoreGammaConversionModel***
  - ***G4LivermoreGammaConversion5DModel***



2) Compton effect

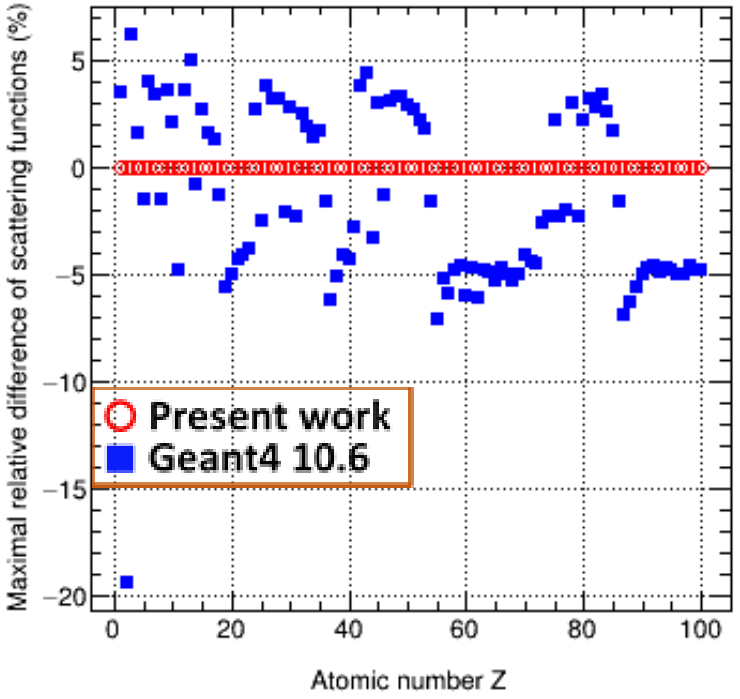
- Cross-sections and scattering functions are updated
- Parameterization of scattering functions is improved



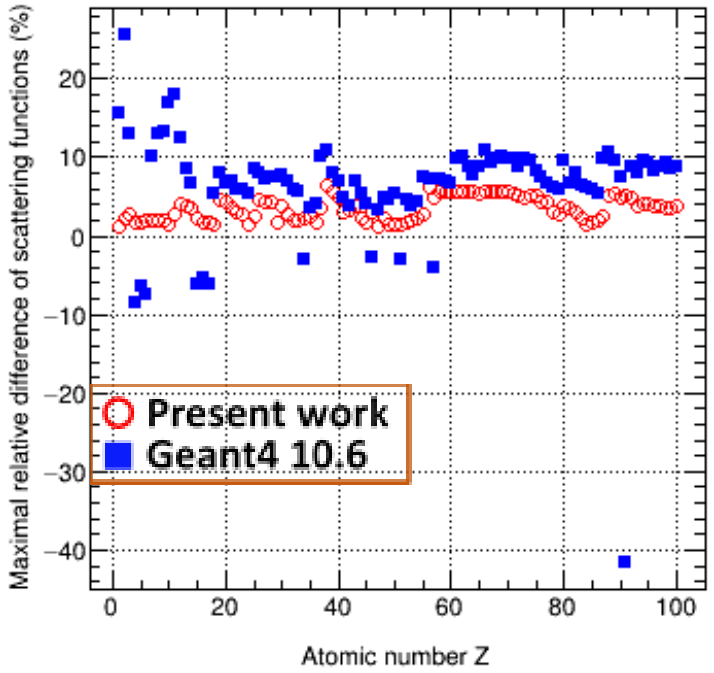
2) Compton effect

- Precision of parameterizations of scattering function is improved by a factor of:
  - ~1000 for low momentum transfer region
  - ~2.8 for high momentum transfer region

Low momentum transfer region



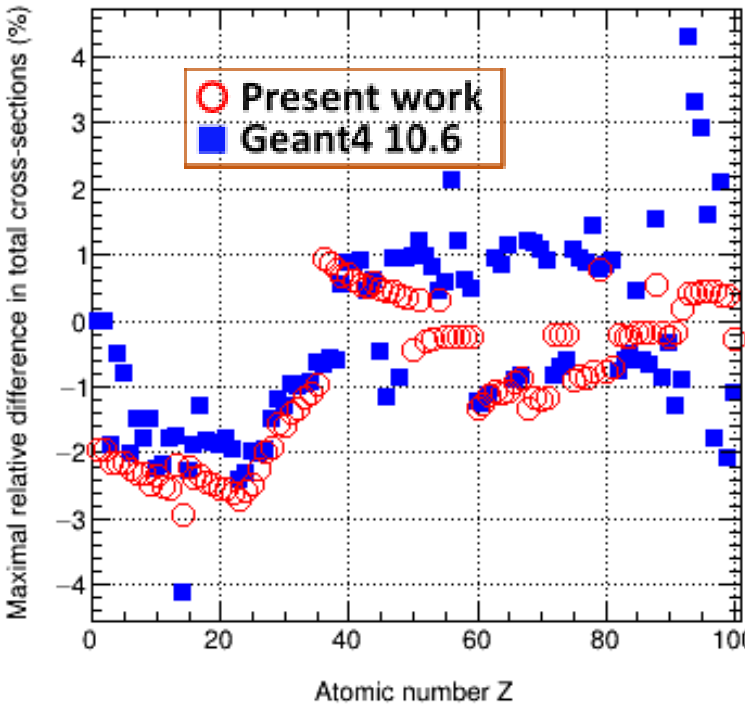
High momentum transfer region



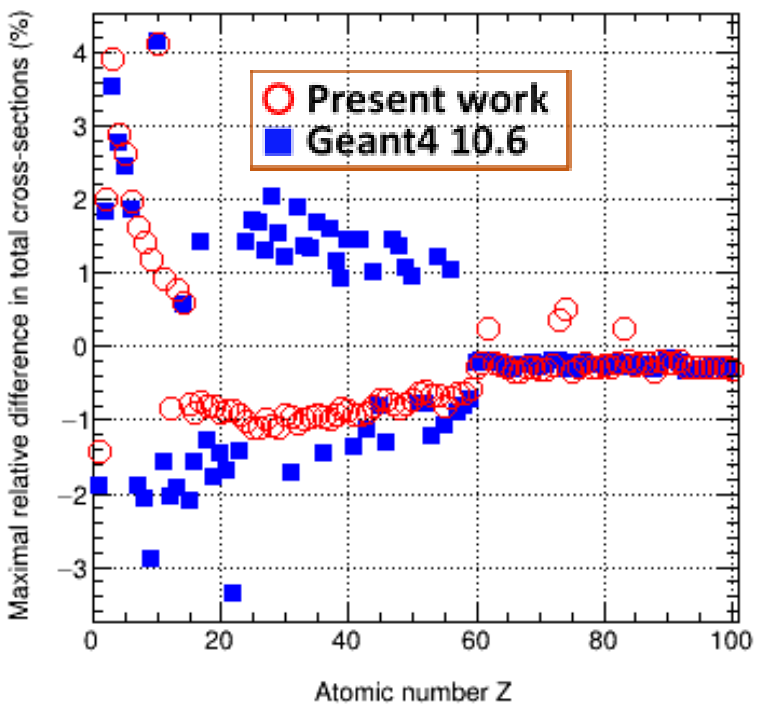
3) Photoelectric effect

- Total and subshell cross-sections are updated and reparameterized
- Precision of parameterizations for total cross-sections are improved by a factor of:
  - ~1.9 for low energy fit
  - ~1.3 for high energy fit

Low energy fit

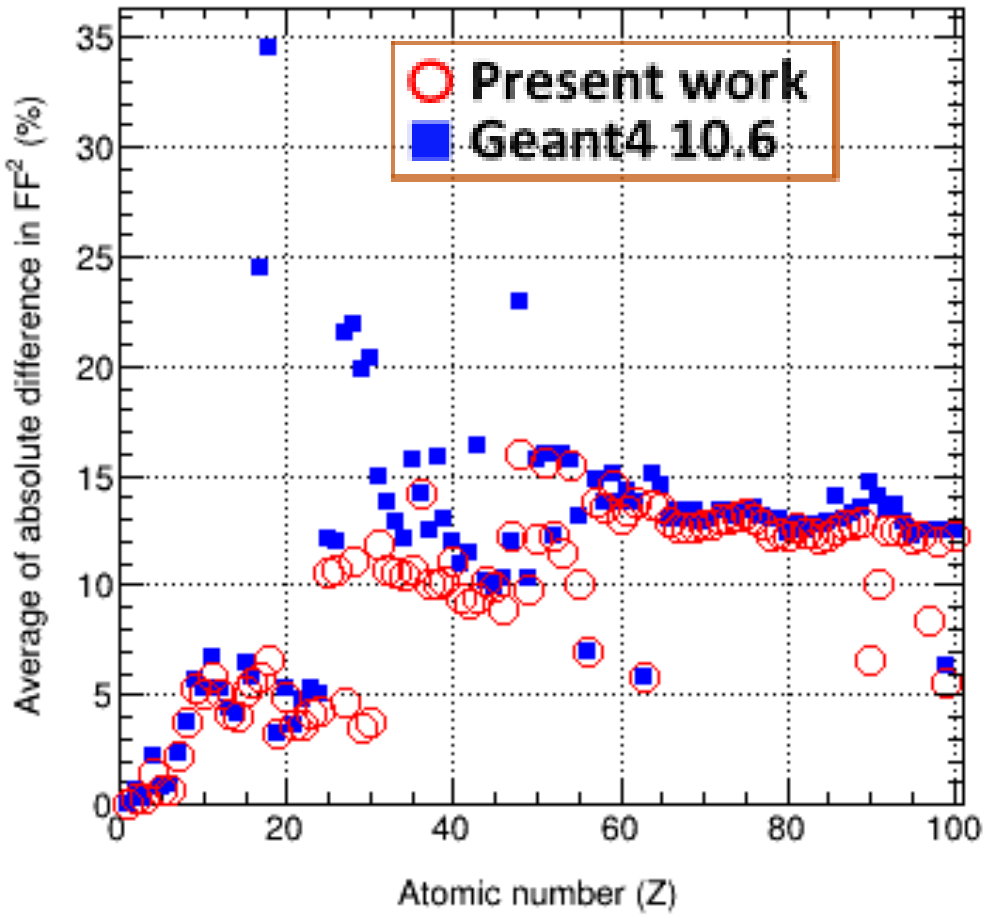


High energy fit



4) Rayleigh scattering

- Cross-sections and form factors are updated
- Precision of parameterization for form factors is improved by a factor of ~1.3

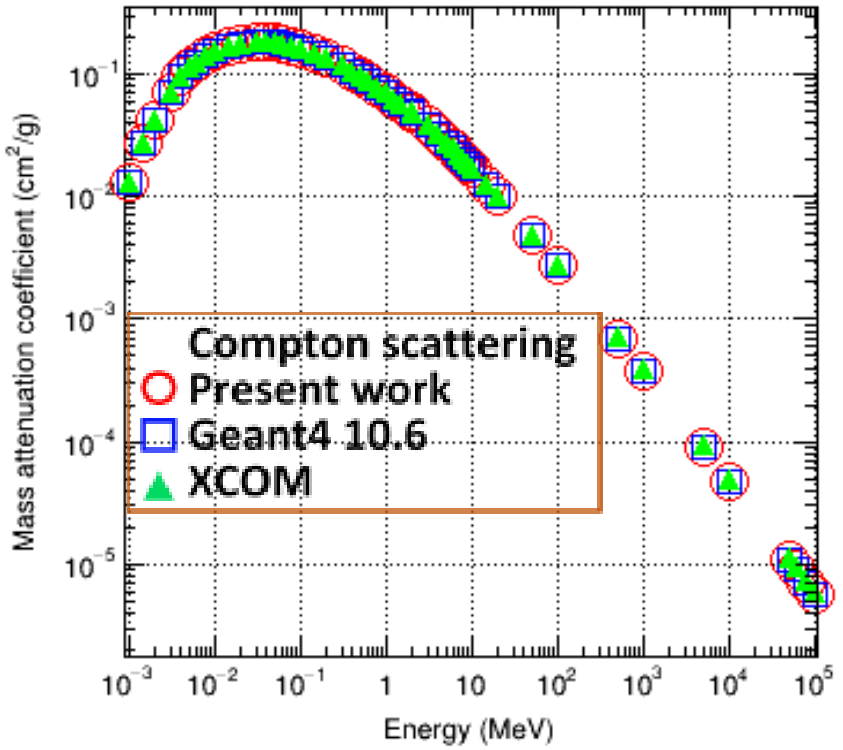


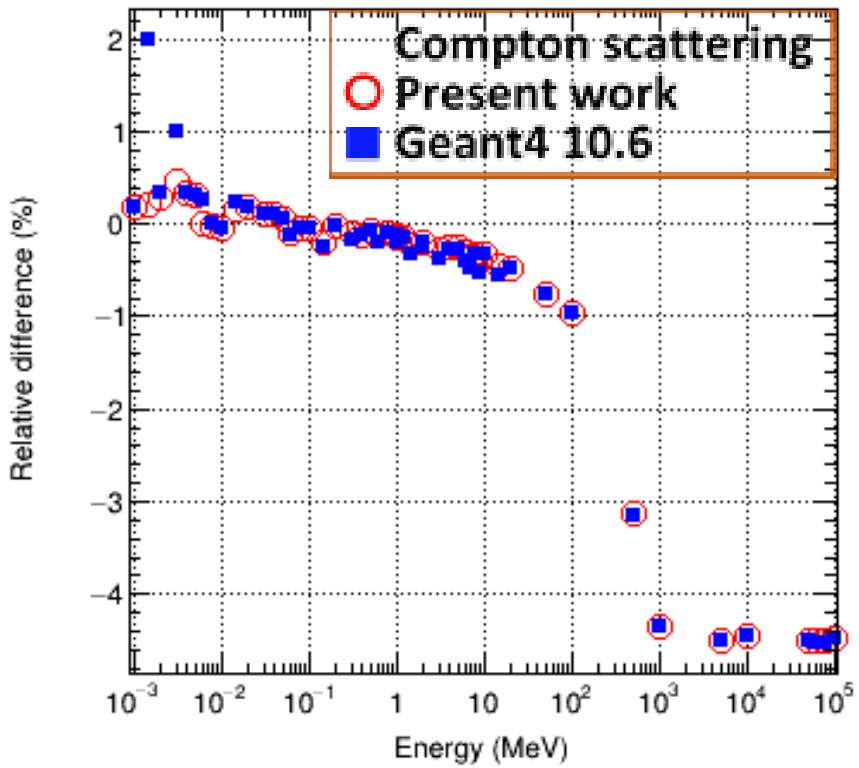
Comparative study: mass attenuation coefficient

- Two goals:
  - Assess quantitatively the compatibility of implemented models versus models in Geant4 10.6
  - Demonstrate the accuracy and reliability of new cross-section data with respect to reference NIST-XCOM data
- Implemented models are tested:
  - ***G4LivermoreGammaConversionModel***
  - ***G4LivermoreComptonModel***
  - ***G4LivermorePhotoElectricModel***
  - ***G4LivermoreRayleighModel***
- Selected materials: beryllium, carbon, aluminum, silicon, germanium, iron, silver, cesium, gold, lead, uranium, water and ICRU compact bone
- Mass attenuation coefficients (total + partial) are calculated

Comparative study: mass attenuation coefficient

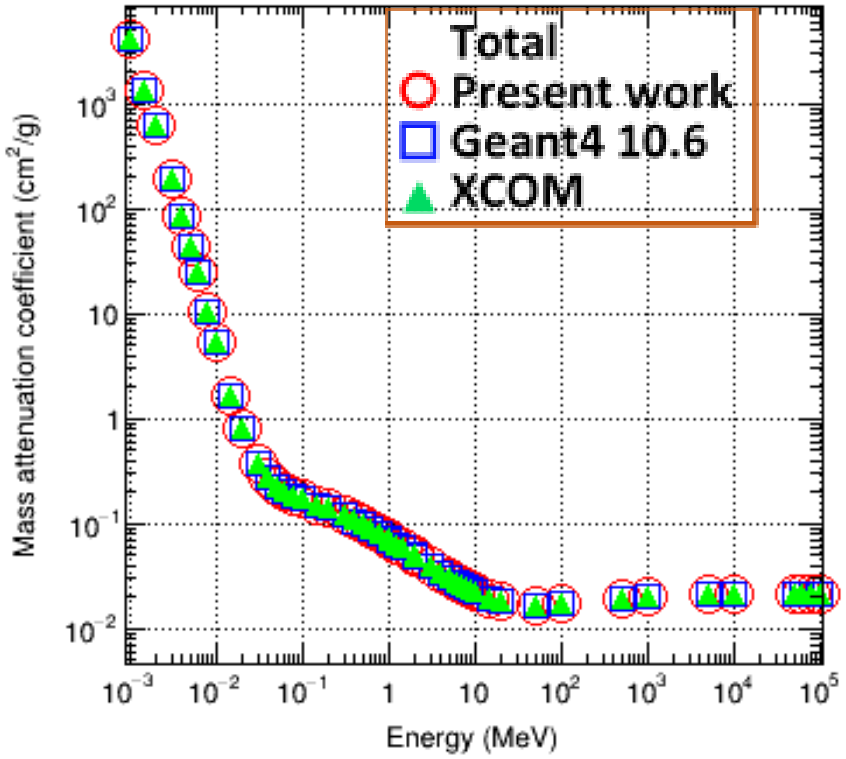
- Example: material = water, for Compton effect
- A good agreement with XCOM data was observed

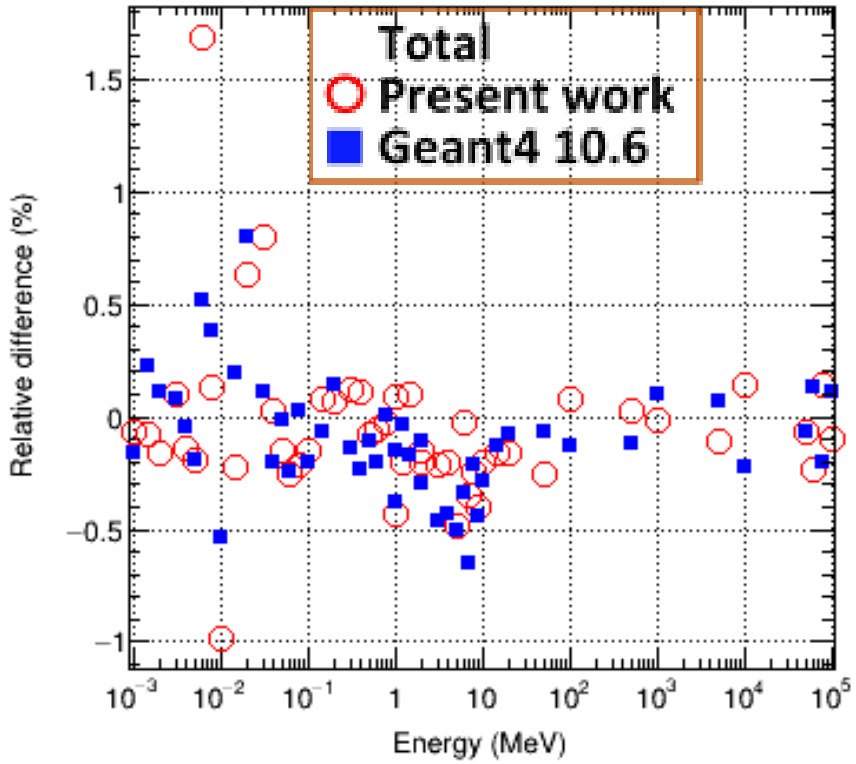




Comparative study: mass attenuation coefficient

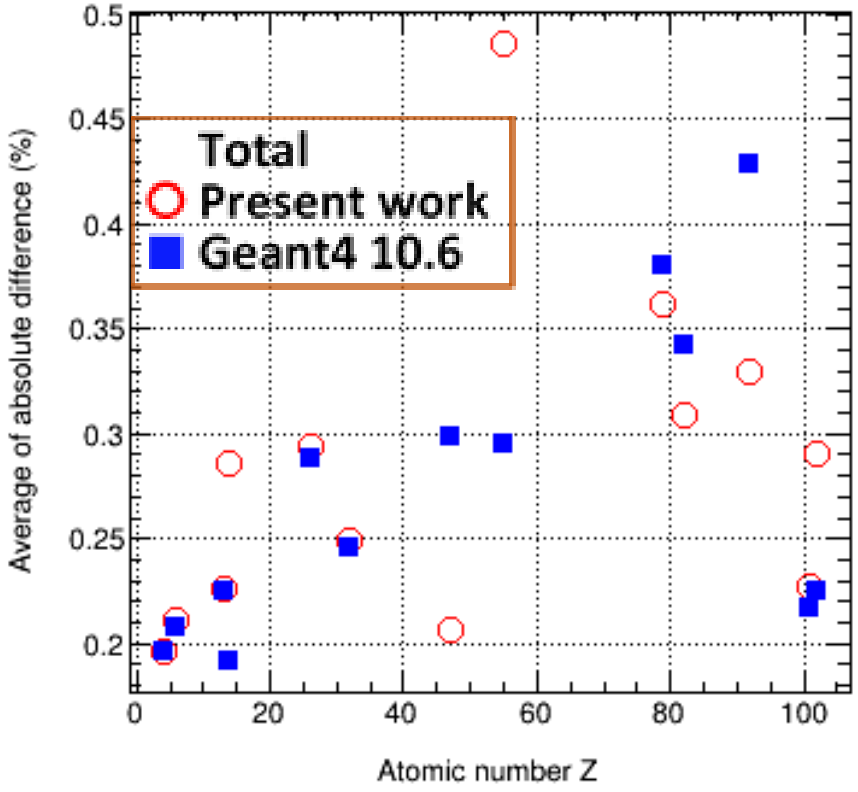
- Example: material = water, for total (all processes)
- A good agreement with XCOM data was observed

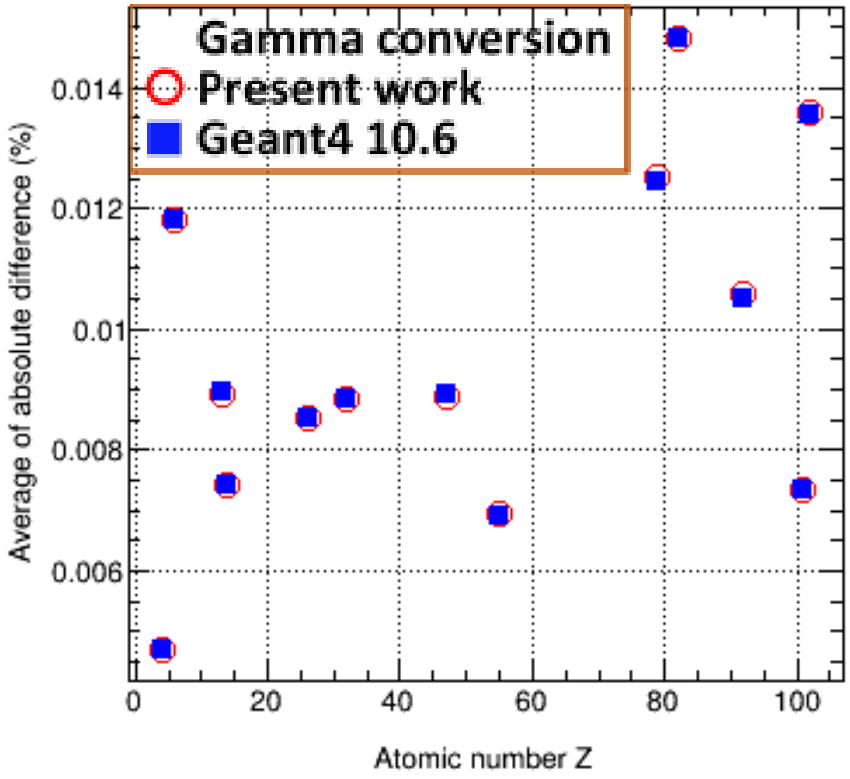




Comparative study: mass attenuation coefficient

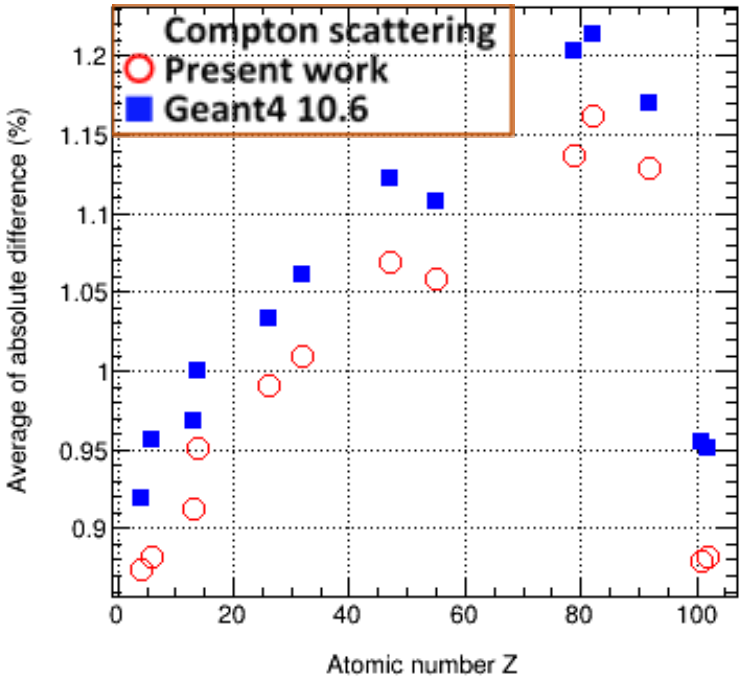
- Average of absolute relative difference on all the energy points is calculated for the selected materials

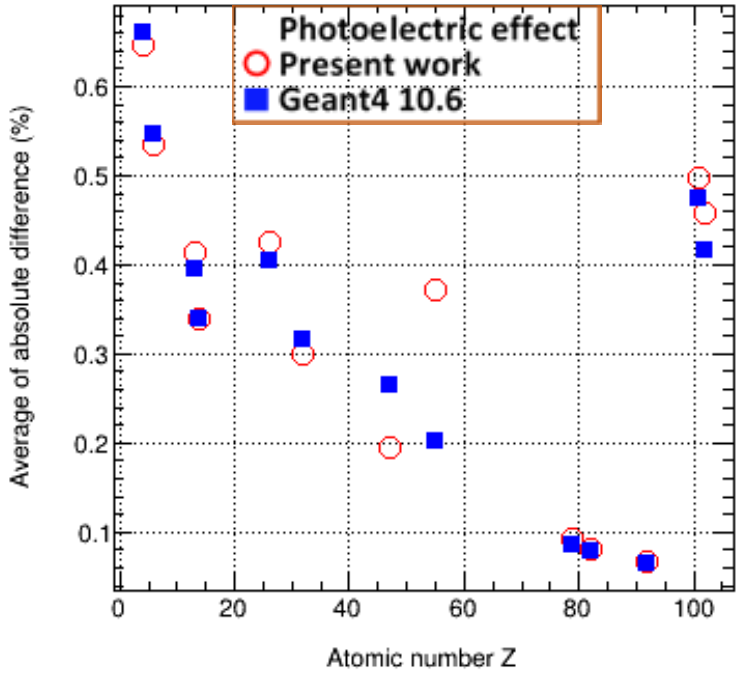


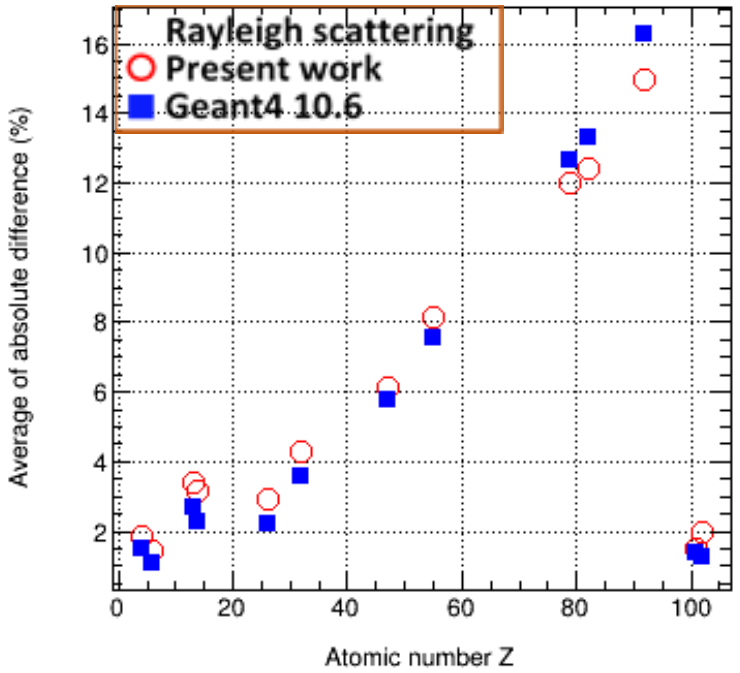


Comparative study: mass attenuation coefficient

- A good agreement with XCOM data was observed
- Compatibility between updated models and Geant4 10.6



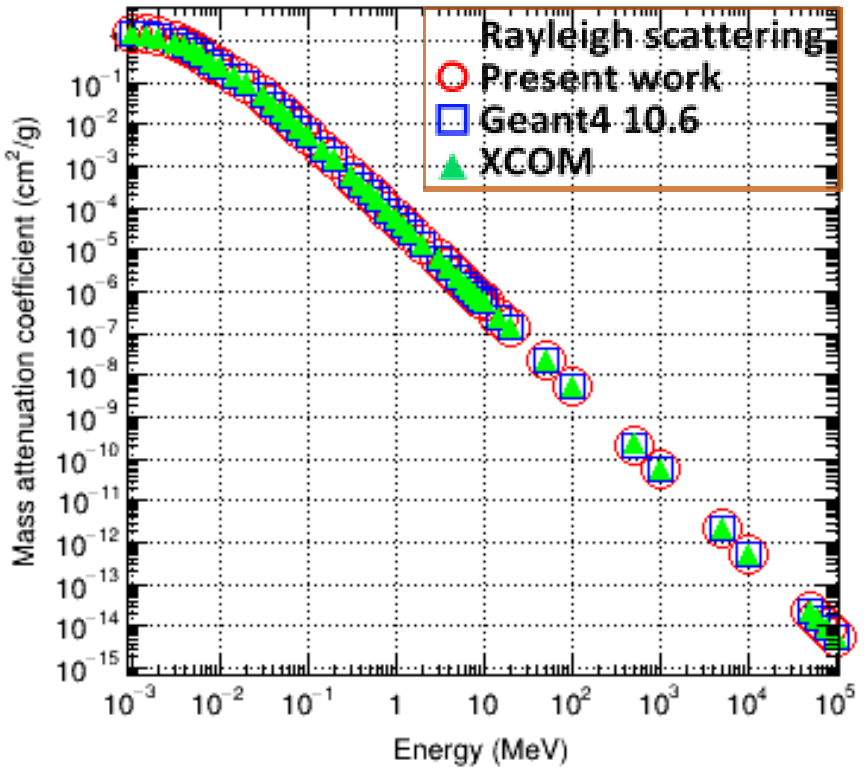


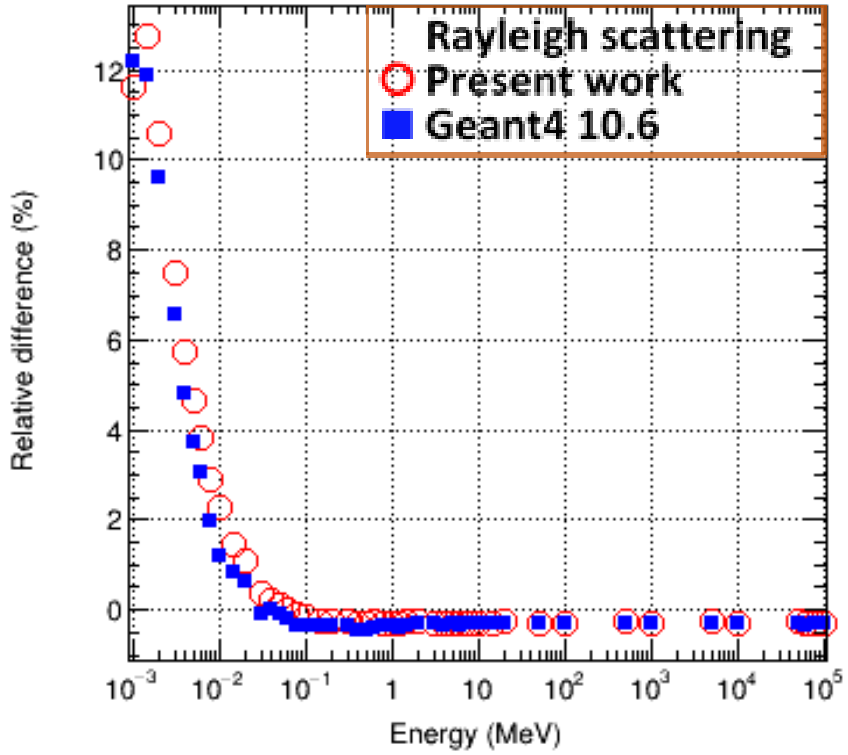


Conclusion

- Implementation for four photon processes:
  - Gamma conversion
  - Parameterization for scattering functions of Compton effect by a factor of:
    - ~1000 for low momentum region
    - ~2.8 for high momentum region
  - Parameterization for total cross sections of Photoelectric effect
    - ~1.9 for low energy fit
    - ~1.3 for high energy fit
  - Parameterization for form factors of Rayleigh scattering
    - ~1.3
- The implementation is soon available in Geant4 11

Thanks for listening


Rayleigh scattering
Present work
Geant4 10.6
XCOM
Mass attenuation coefficient (cm²/g)
Energy (MeV)


Rayleigh scattering
Present work
Geant4 10.6
Relative difference (%)
Energy (MeV)