# Single Coulomb Scattering process

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# Outline

- Motivation
- New classes
- Comparison results
- Problems and summary

# Motivation

- Elastic Coulomb scattering is an important process for particle transport
- Multiple scattering may fail at low dense media
  - beam transport in vacuum
  - space applications
- Provide an alternative to multiple scattering based as much as possible on theory
- In view of further development of combined scattering process per particle type

# New classes

- G4CoulombScattering – elastic process
  - standardSS, standardIG builders
- G4eCoulombScatteringModel
  - no nuclear recoil
  - main version, all plots below
- G4CoulombScatteringModel
  - Recoil nucleus is provided
  - Need more validation

# Physics

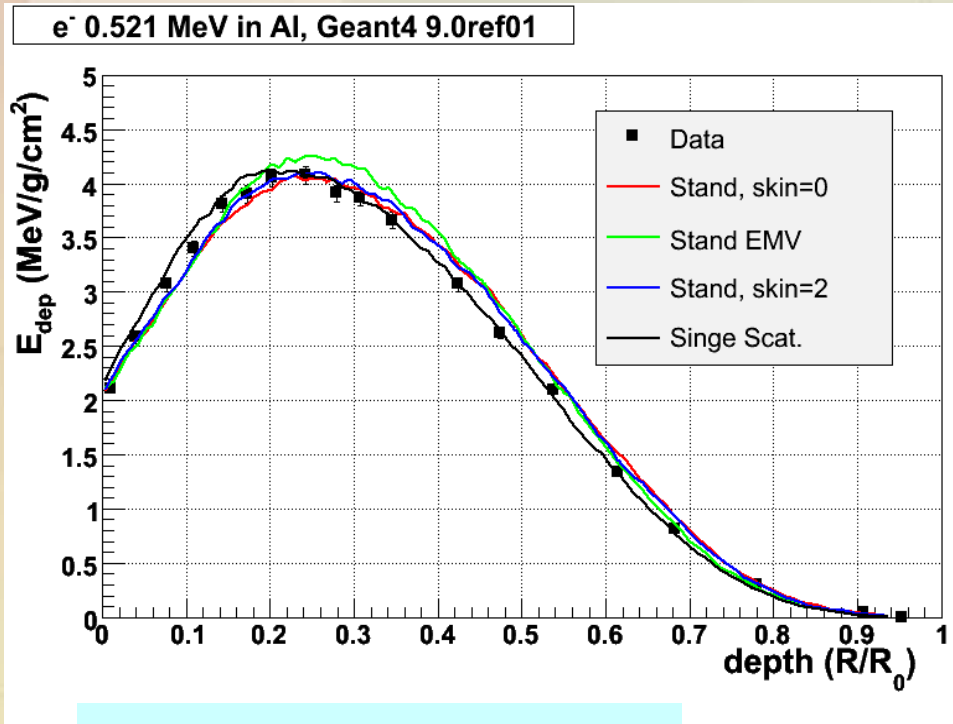
- Wentzel model with Bethe second order corrections to screening radius
  - J.M. Fernandez-Varea, R. Mayol, J. Baro, F. Salvat, NIM B73 (1993) 447
  - H.A. Bethe, Phys. Rev. 78 (1953) 1256
- Nuclear size corrections
  - A.V. Butkevich, R.P. Kokoulin, G.V. Matushko, S.P. Mikheyev, NIM A488 (2002) 282
- Scattering off electrons
  - $Z^2$ -> Z(Z + 1)
  - no conventional model
- Nuclear recoil
  - is not in any existing model

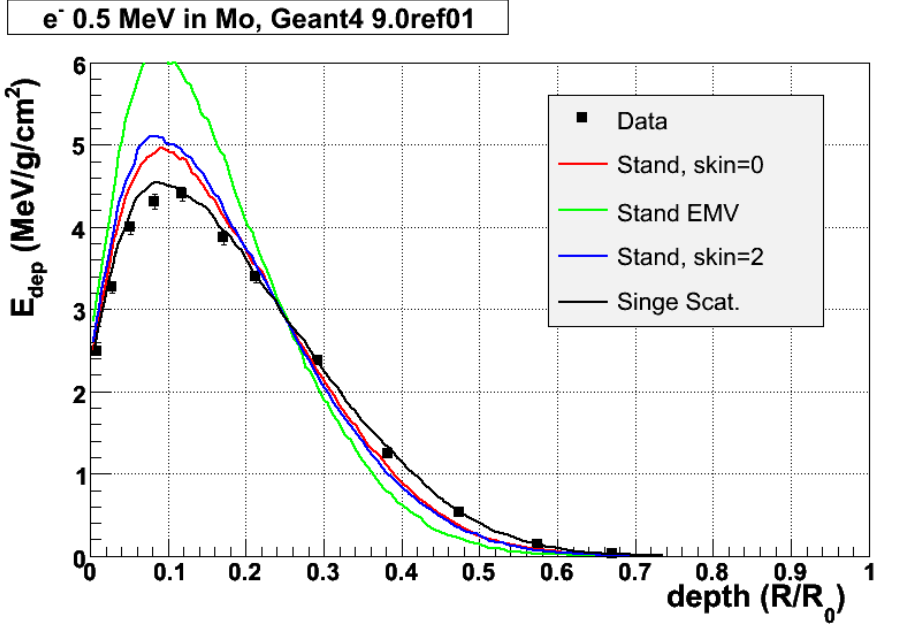
# Validation

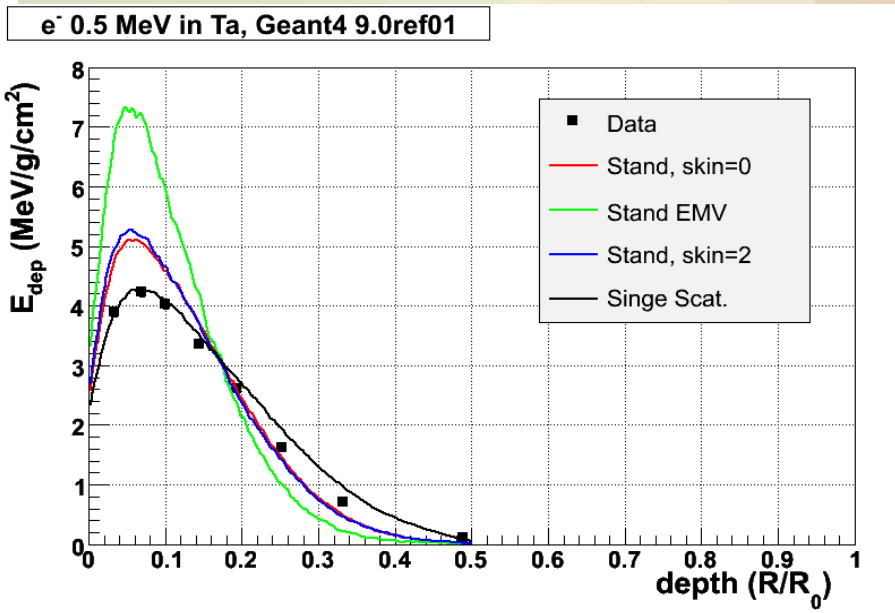
- Two new automatic tests:
  - Test37 – Sandia data for $e^-$ 0.5 MeV
    - Sandia report
  - Test41 – MuScat data for $\mu^+$ 172 GeV/c
    - D.Attwood et al., NIM B251 (2006) 41
- More tests will follow

# Test37 results

**Integral dose is an important value for LHC – 3 % accuracy**

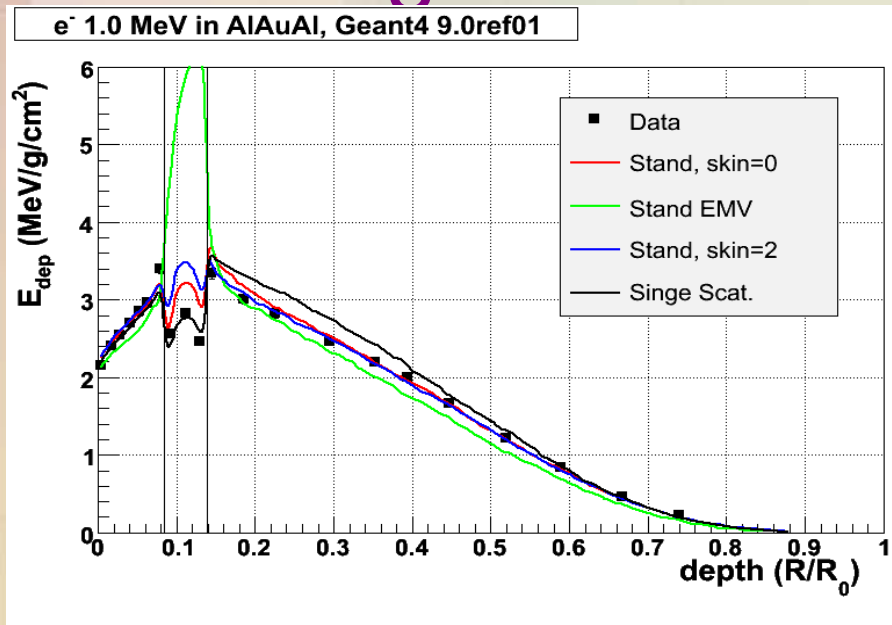


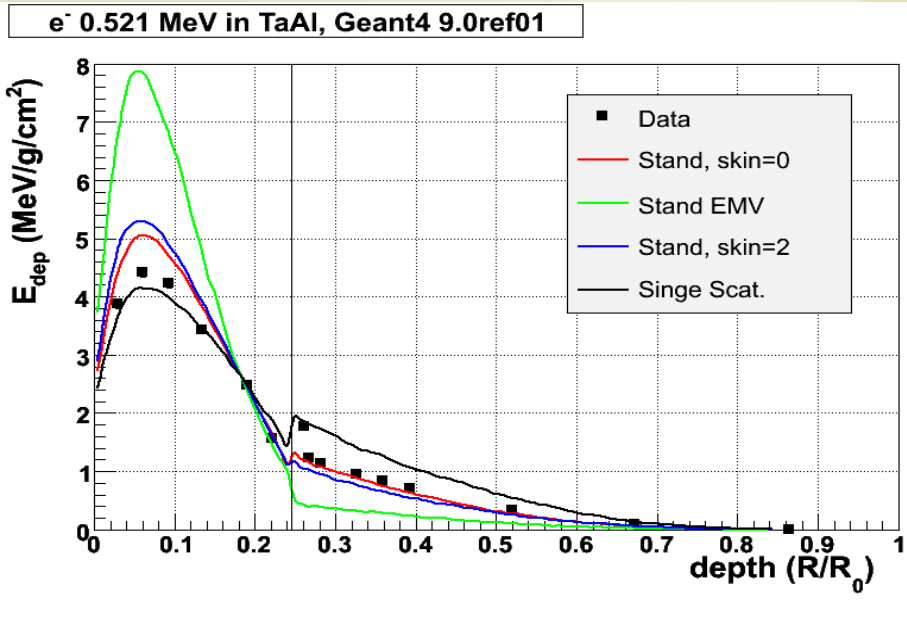



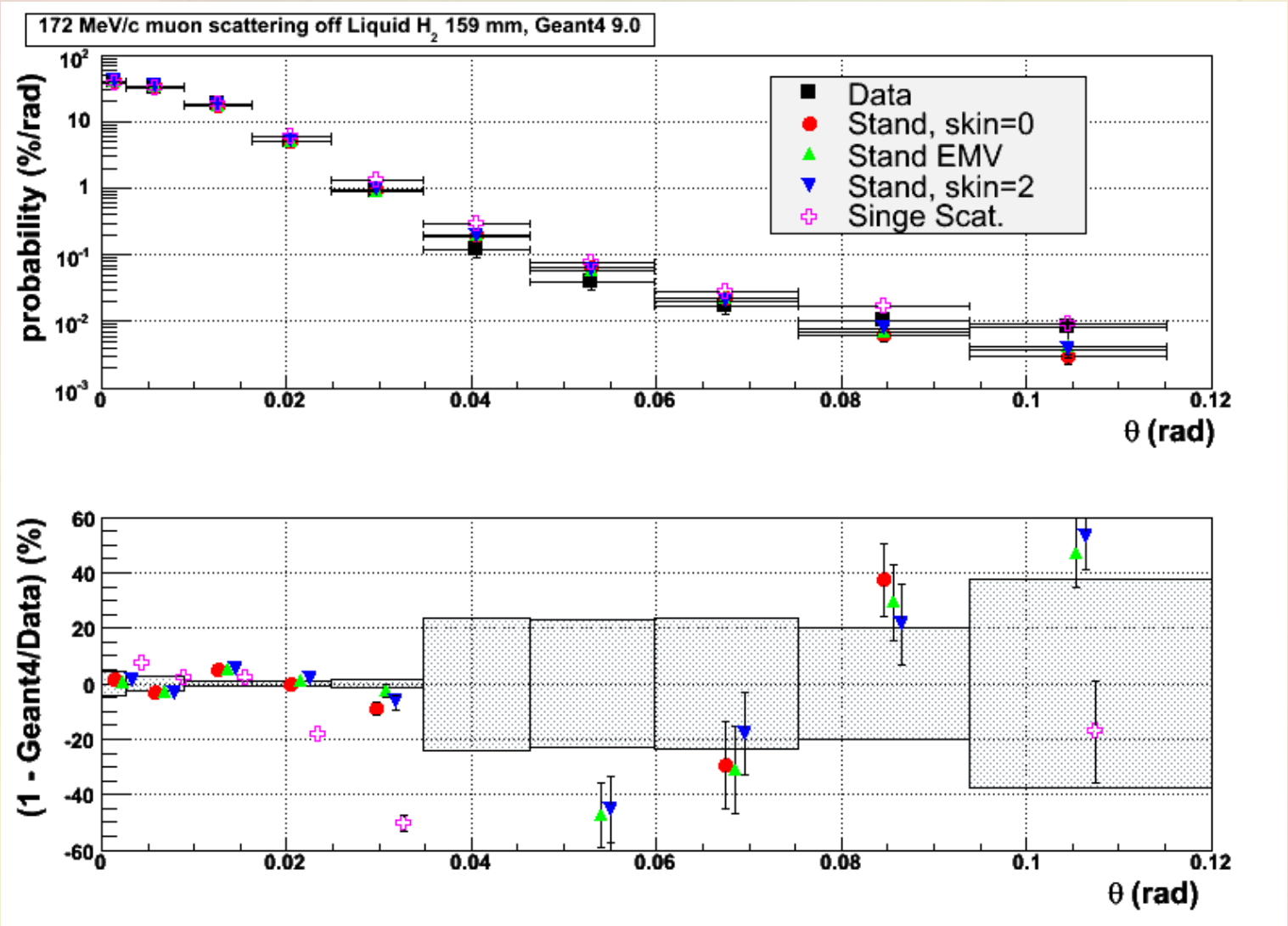

**Standard cut 0.7 mm**

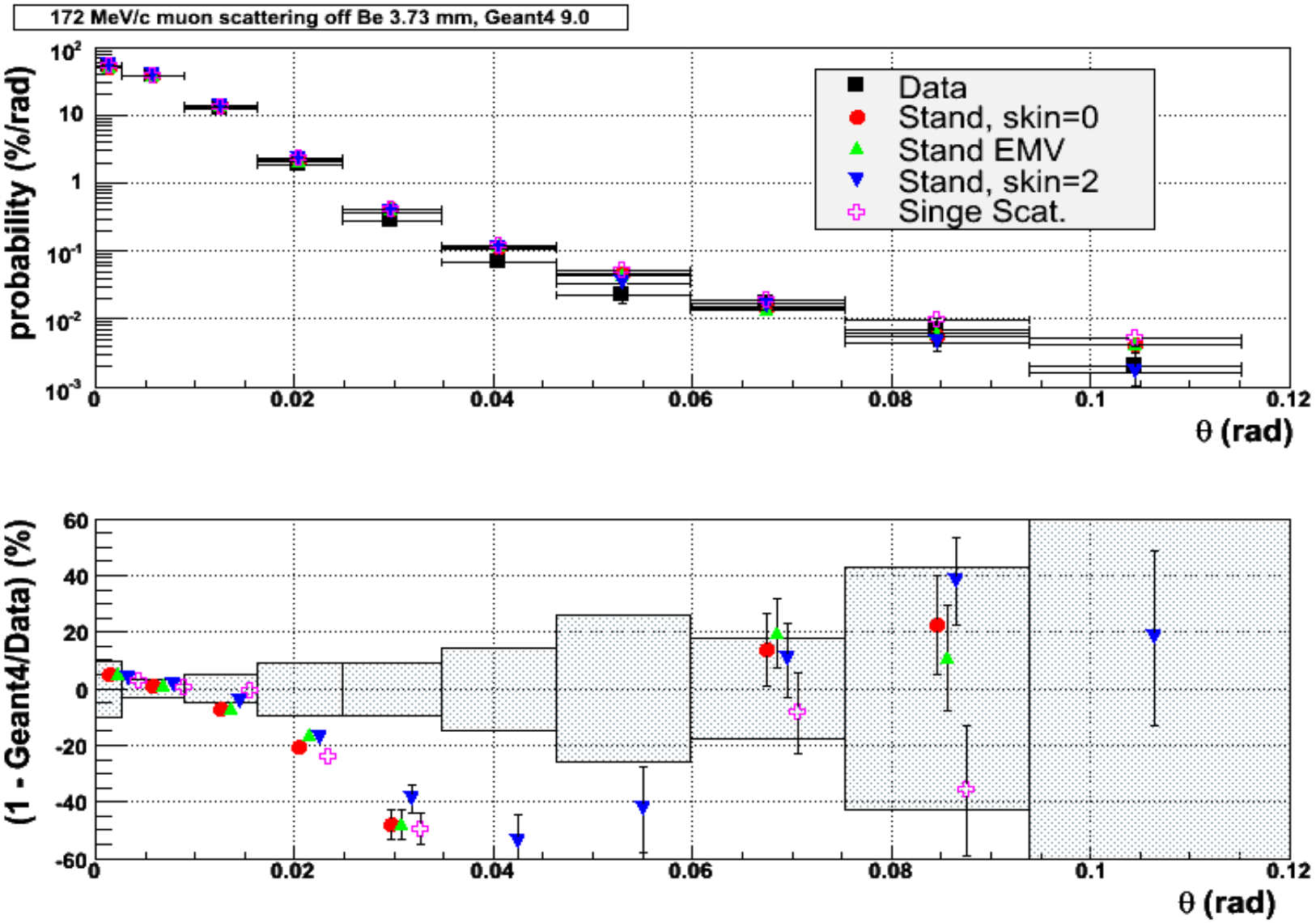
# Test37 for multi-layer configurations



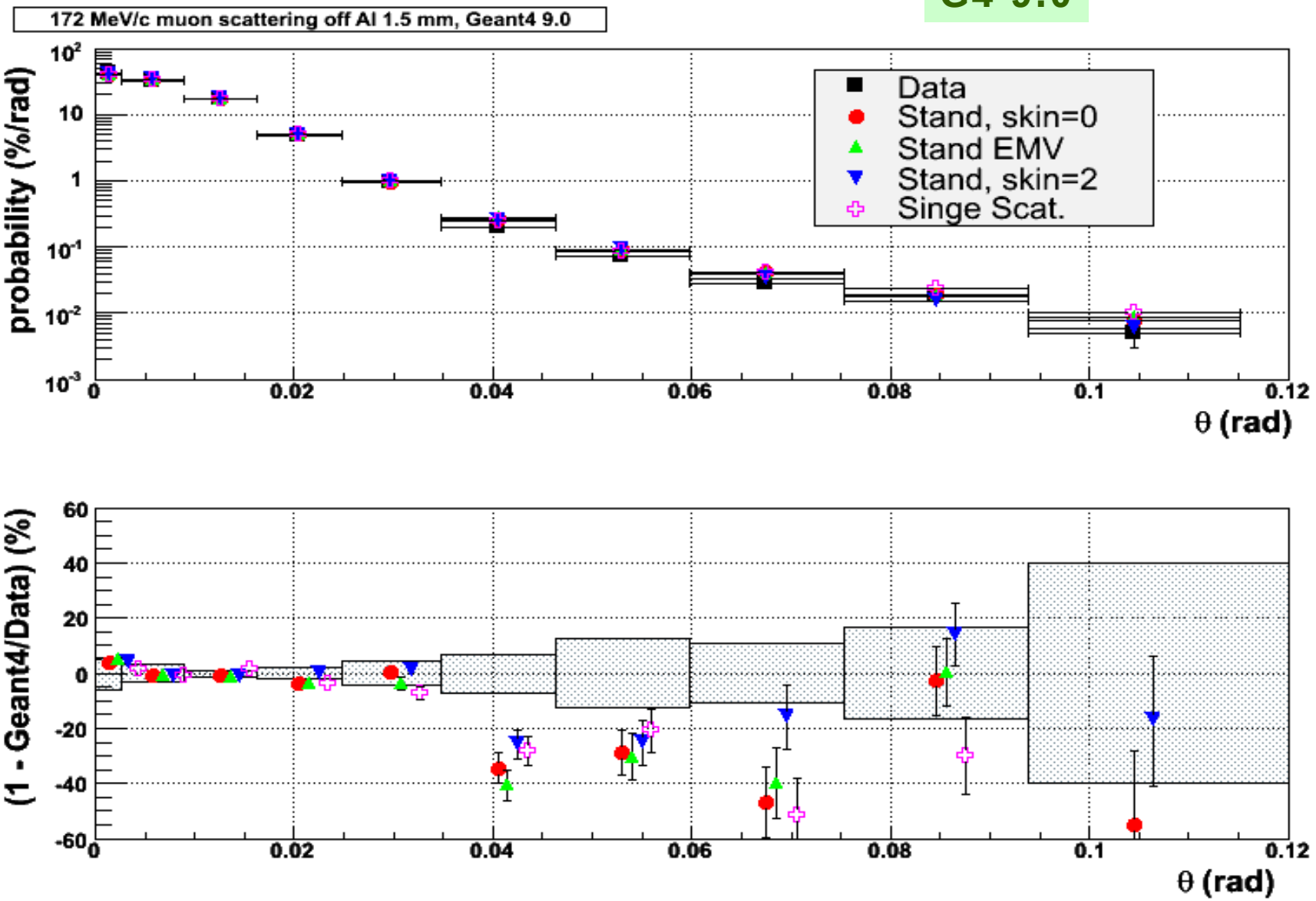




- EMV shows significant deviation from the data
- Single scattering model overestimates dose deposition in the last layer and provide slightly longer distribution in dense media

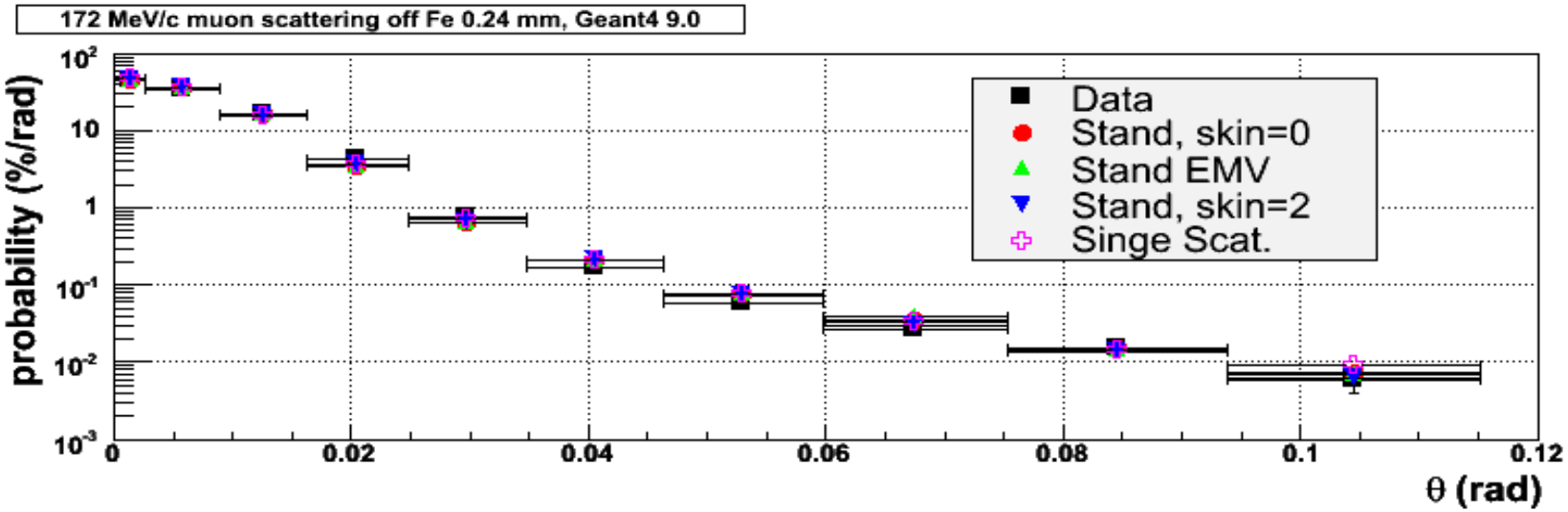

172 MeV/c muon scattering off Liquid H2 159 mm, Geant4 9.0
probability (%/rad)
Data
Stand, skin=0
Stand EMV
Stand, skin=2
Singe Scat.
θ (rad)
(1 - Geant4/Data) (%)
θ (rad)

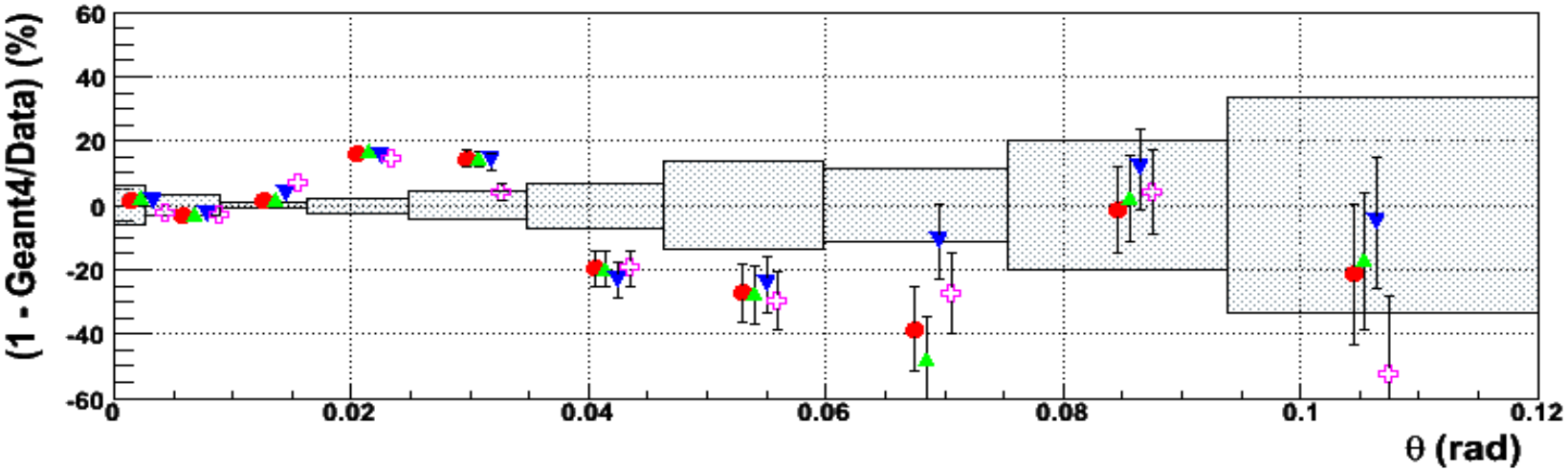

172 MeV/c muon scattering off Be 3.73 mm, Geant4 9.0
probability (%/rad)
Data
Stand, skin=0
Stand EMV
Stand, skin=2
Singe Scat.
θ (rad)
(1 - Geant4/Data) (%)
θ (rad)

**G4 9.0**


172 MeV/c muon scattering off Al 1.5 mm, Geant4 9.0
probability (%/rad)
Data
Stand, skin=0
Stand EMV
Stand, skin=2
Singe Scat.
θ (rad)
(1 - Geant4/Data) (%)
θ (rad)

# G4 9.0


172 MeV/c muon scattering off Fe 0.24 mm, Geant4 9.0
probability (%/rad)
Data
Stand, skin=0
Stand EMV
Stand, skin=2
Singe Scat.
θ (rad)


(1 - Geant4/Data) (%)
θ (rad)

# Problems and plans

- Scattering off electrons
- Nuclear recoil
- We need more tests
- We need to introduce cut in range for nuclear recoil
  - May be used in other G4 models
- Combine models per particle type