Updates on Validation of Geant4 EM Physics

V.Ivanchenko
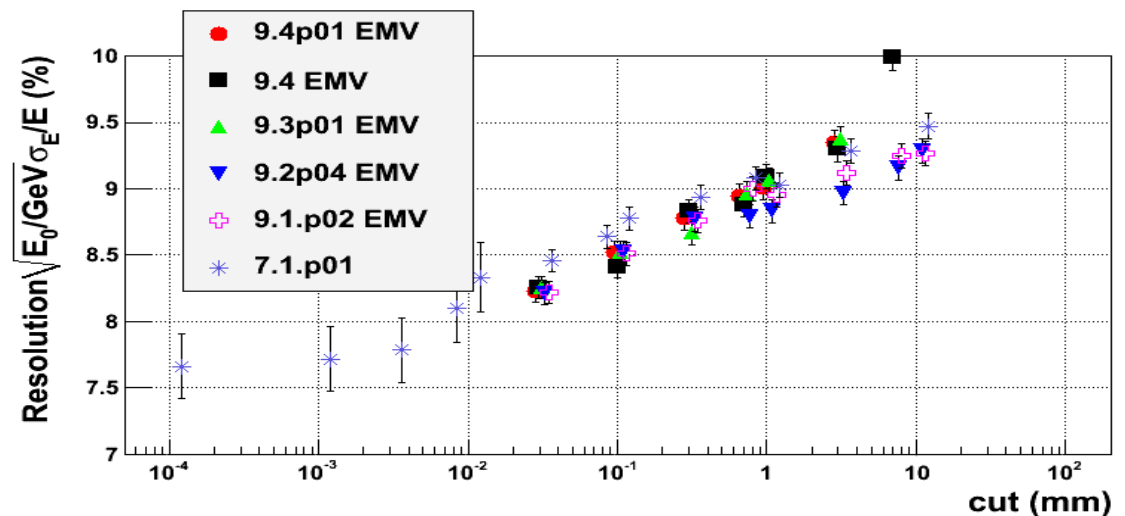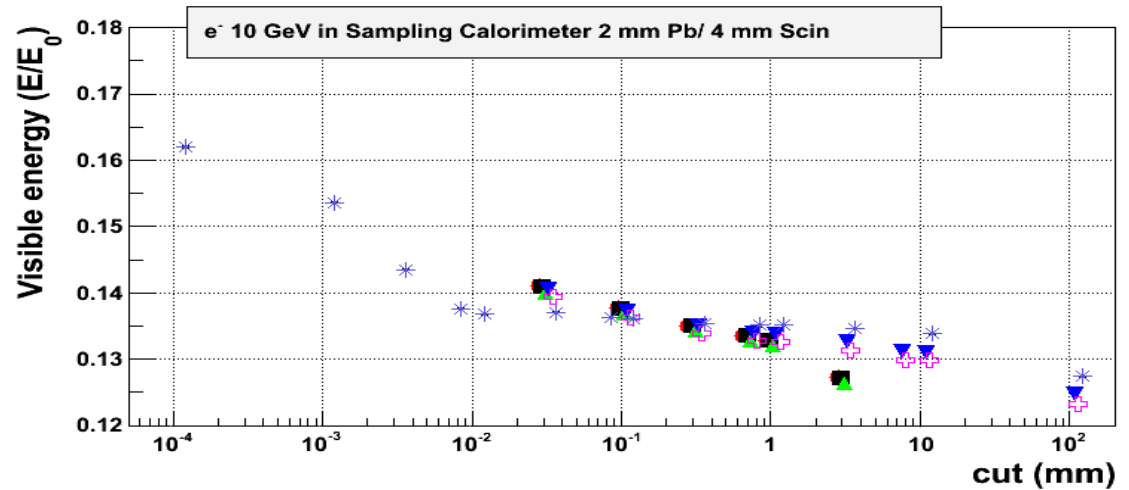for Geant4 EM standard group
Geant4 Technical Forum
3 March 2011

Introduction

- EM validation suite run for each reference version of Geant4
- Recent results (including 9.4p01) will be discussed
  - Calorimeter response
  - Tracker response
- Change in Multiple Scattering in Geant4 9.4

LHCb "simplified ECAL": Response with EMV option of EM physics

- Only "fast" EMV option is shown
- For given cut value calorimeter response is stable between Geant4 releases
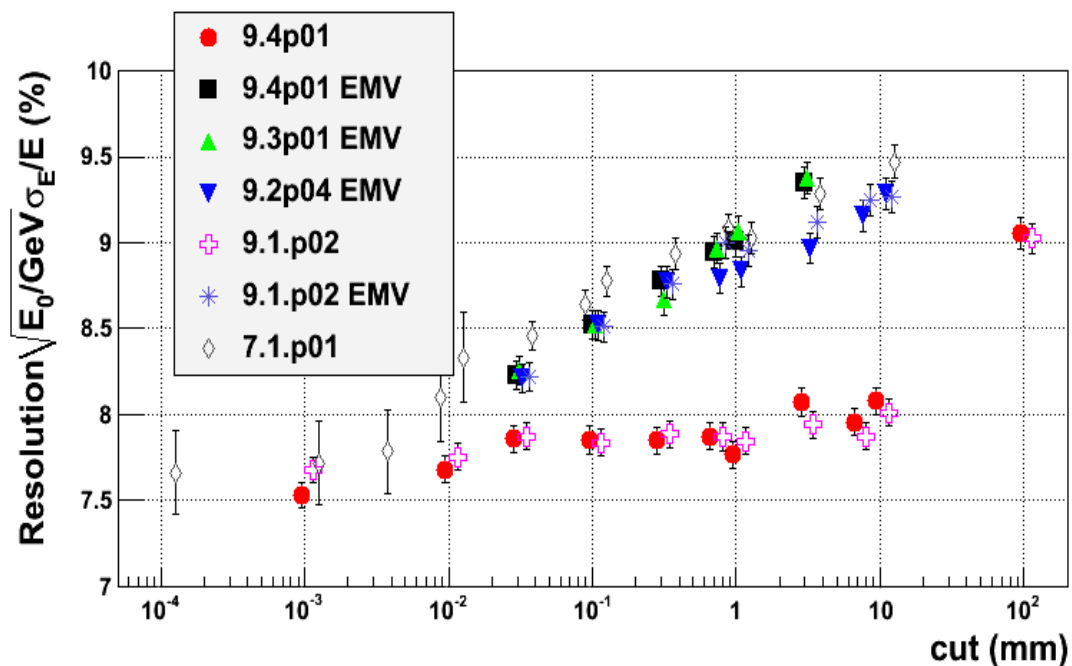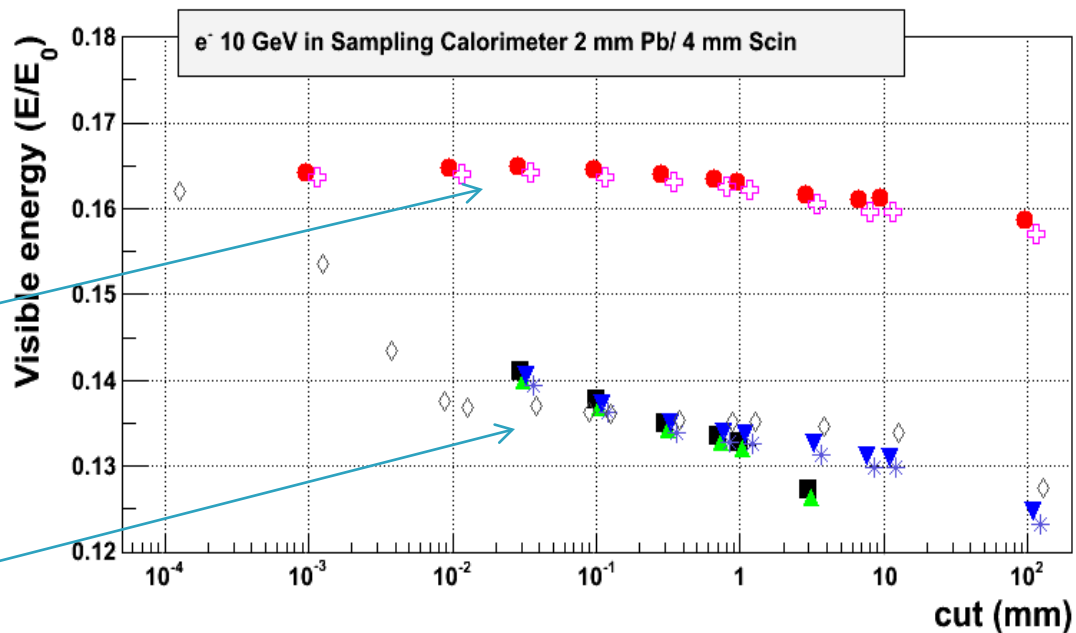- Cut dependence of the response is connected with simplified multiple scattering model

e^- 10 GeV in Sampling Calorimeter 2 mm Pb/ 4 mm Scin

Legend:
- 9.4p01 EMV
- 9.4 EMV
- 9.3p01 EMV
- 9.2p04 EMV
- 9.1.p02 EMV
- 7.1.p01

LHCb ECAL-like

Default

EMV

e⁻ 10 GeV in Sampling Calorimeter 2 mm Pb/ 4 mm Scin

▸ Default Physics List is about factor 2 slower than EMV

Legend:
- 9.4p01
- 9.4p01 EMV
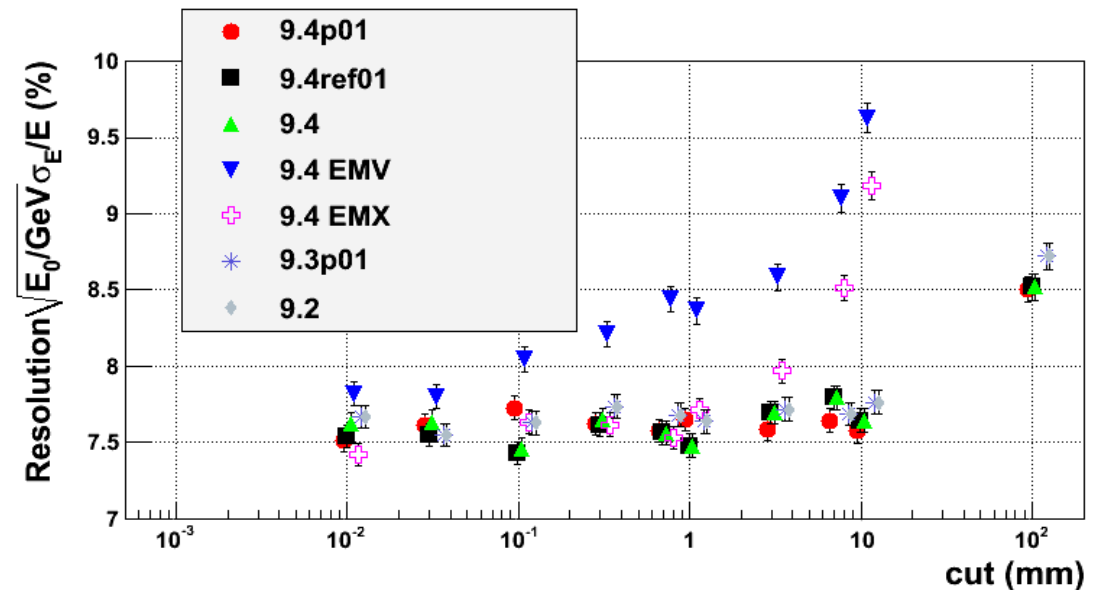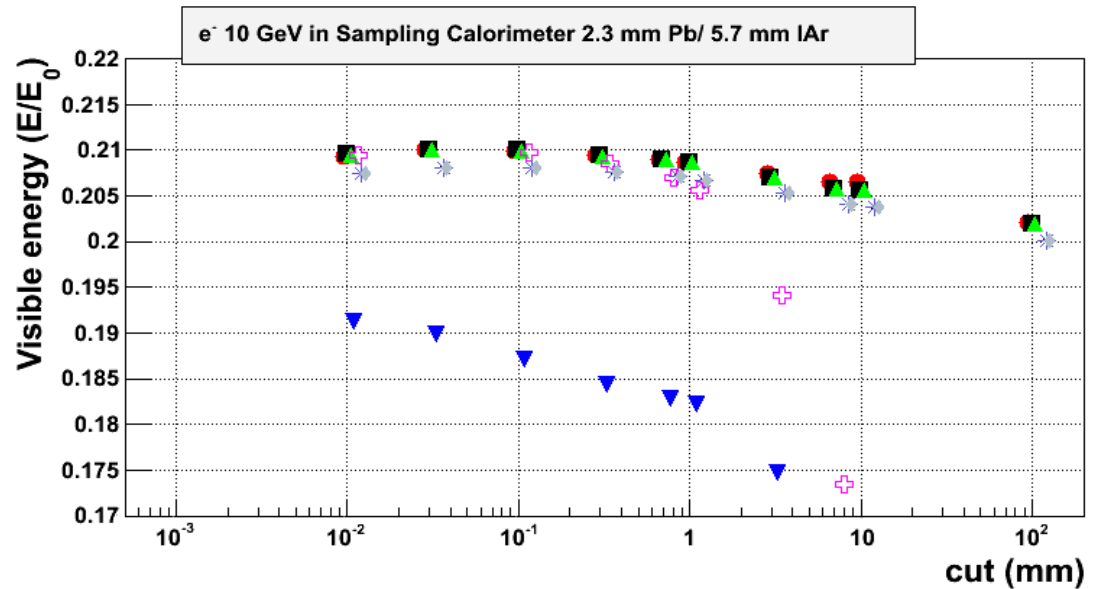- 9.3p01 EMV
- 9.2p04 EMV
- 9.1.p02
- 9.1.p02 EMV
- 7.1.p01

Issue of energy scale variation

- LHCb reported 15% variation in energy scale between G4 9.1 and 9.2(p3)
  - Our similar (simplified) setup shows good stability since G4 7.1 – if MSc choice is EMV (backward compatibility with 7.1 default)
- Can explain change only if EM Opt0 was used with G4 9.1
  - Action was needed to use EM-Opt1 instead – to maintain "old" choice
    - The revision of MSc and of the EM options were advertised and documented
- We will monitor carefully more LHCb test cases
  - Continue to check LHCb ECAL (previous plots)
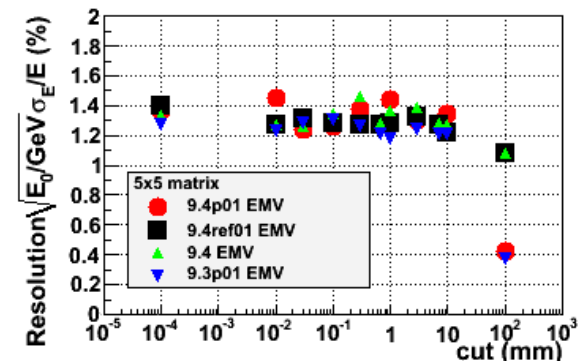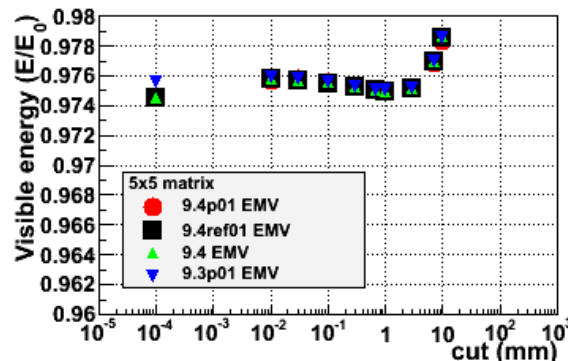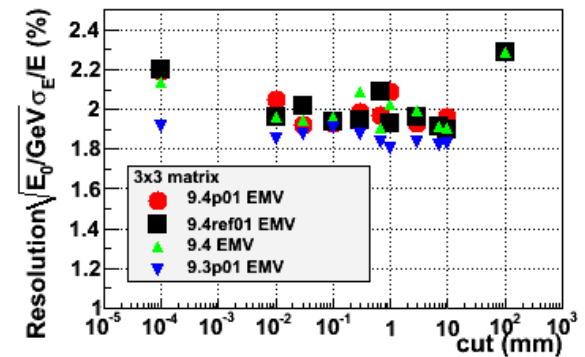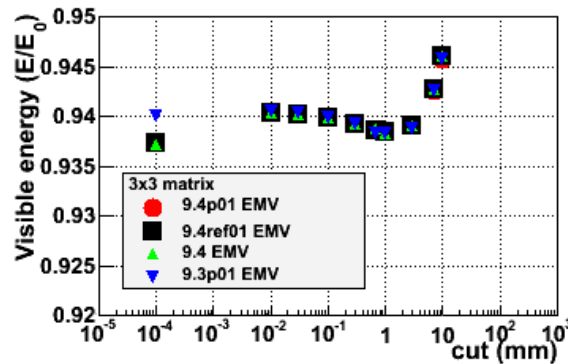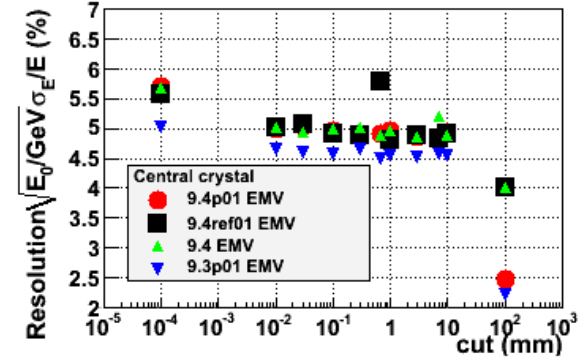 - To add test case for LHCb HCAL (simplified)

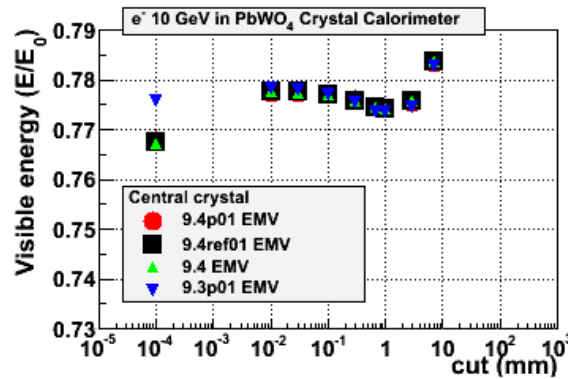# ATLAS barrel

- Visible energy and resolution are stable within 1 % since Geant4 8.3
- There is no change in the calorimeter response between 9.4 and 9.4p01

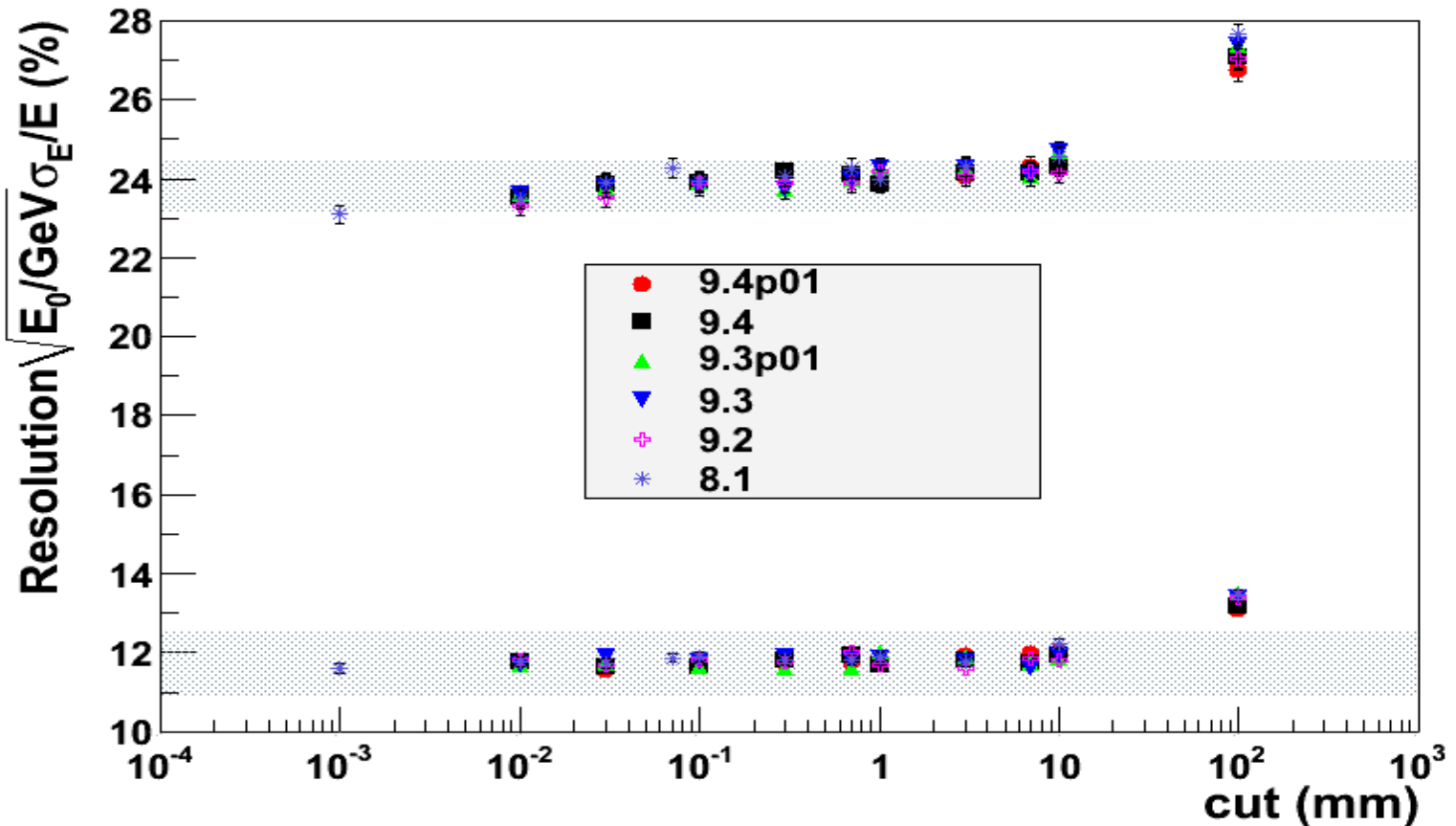e⁻ 10 GeV in Sampling Calorimeter 2.3 mm Pb/ 5.7 mm lAr

Legend:
- 9.4p01
- 9.4ref01
- 9.4
- 9.4 EMV
- 9.4 EMX
- 9.3p01
- 9.2

CMS ECAL

- CMS ECAL response and resolution are very stable

- No change for 9.4p01

Comparison with ZEUS test beam data on sampling calorimeter

e⁻ 10 GeV in Pb/Scin Sampling Calorimeters

Legend:
- 9.4p01
- 9.4
- 9.3p01
- 9.3
- 9.2
- 8.1

x-axis: cut (mm)

y-axis: Resolution $\sqrt{E_0/\text{GeV}}\,\sigma_E/E$ (%)

Bernardi E et al. 1987 *Nucl. Instrum. Meth. A 262 229*
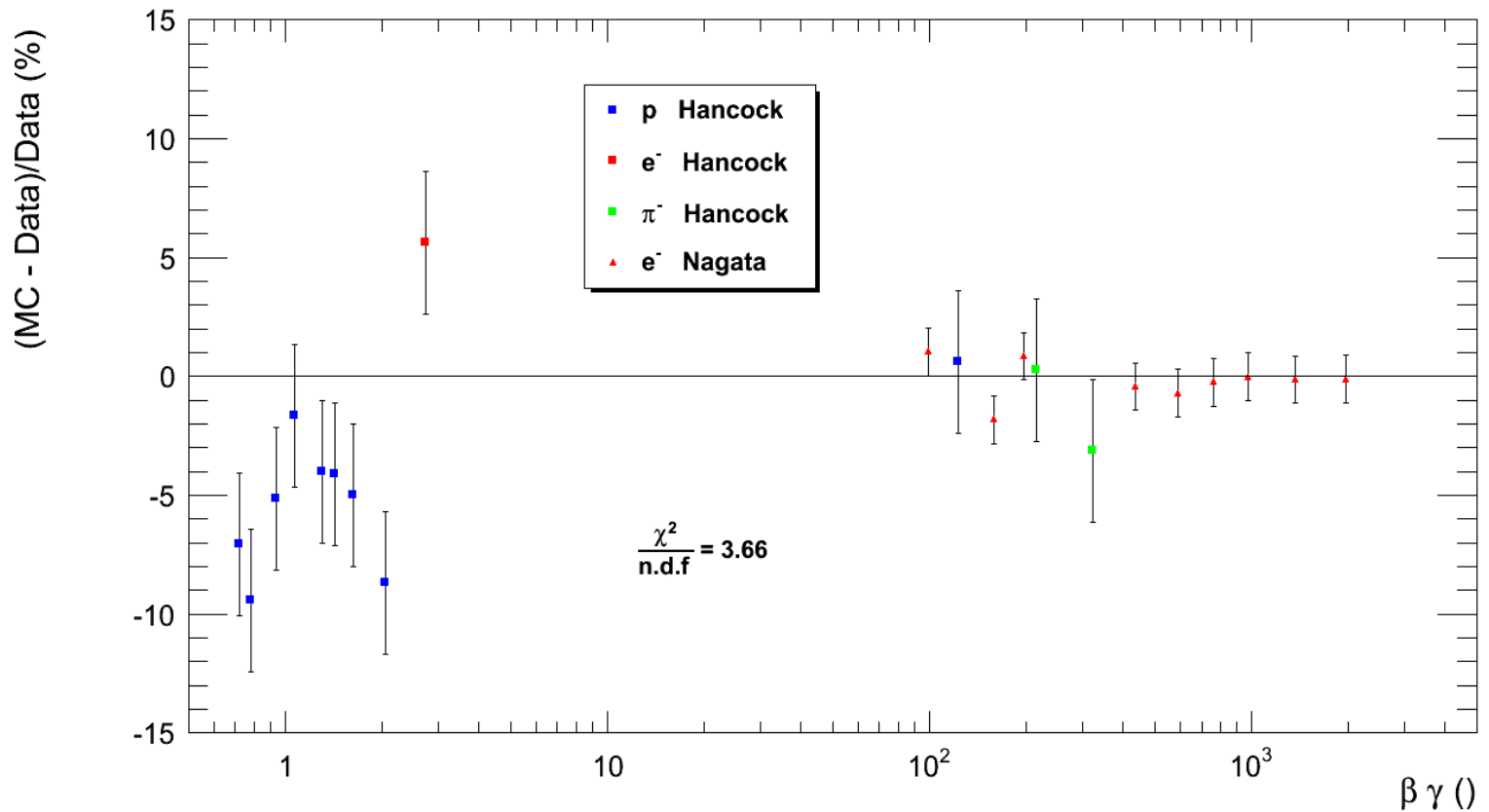
# Simulation versus data for thin targets

Accuracy of simulation of peak of energy deposition in 0.3 mm Silicon for 9.4p01

Comparison of Most Probable Energy Deposition Δ between GEANT4 9.4 and Bichsel data with Gauss fit, emstandard & Cut = 10 um

Accuracy of simulation of FWHM of energy deposition in 0.3 mm Silicon for 9.4p01

Comparison of Full Width at Half Maximum w between GEANT4 9.4 and Bichsel data with Gauss fit, emstandard & Cut = 10 um
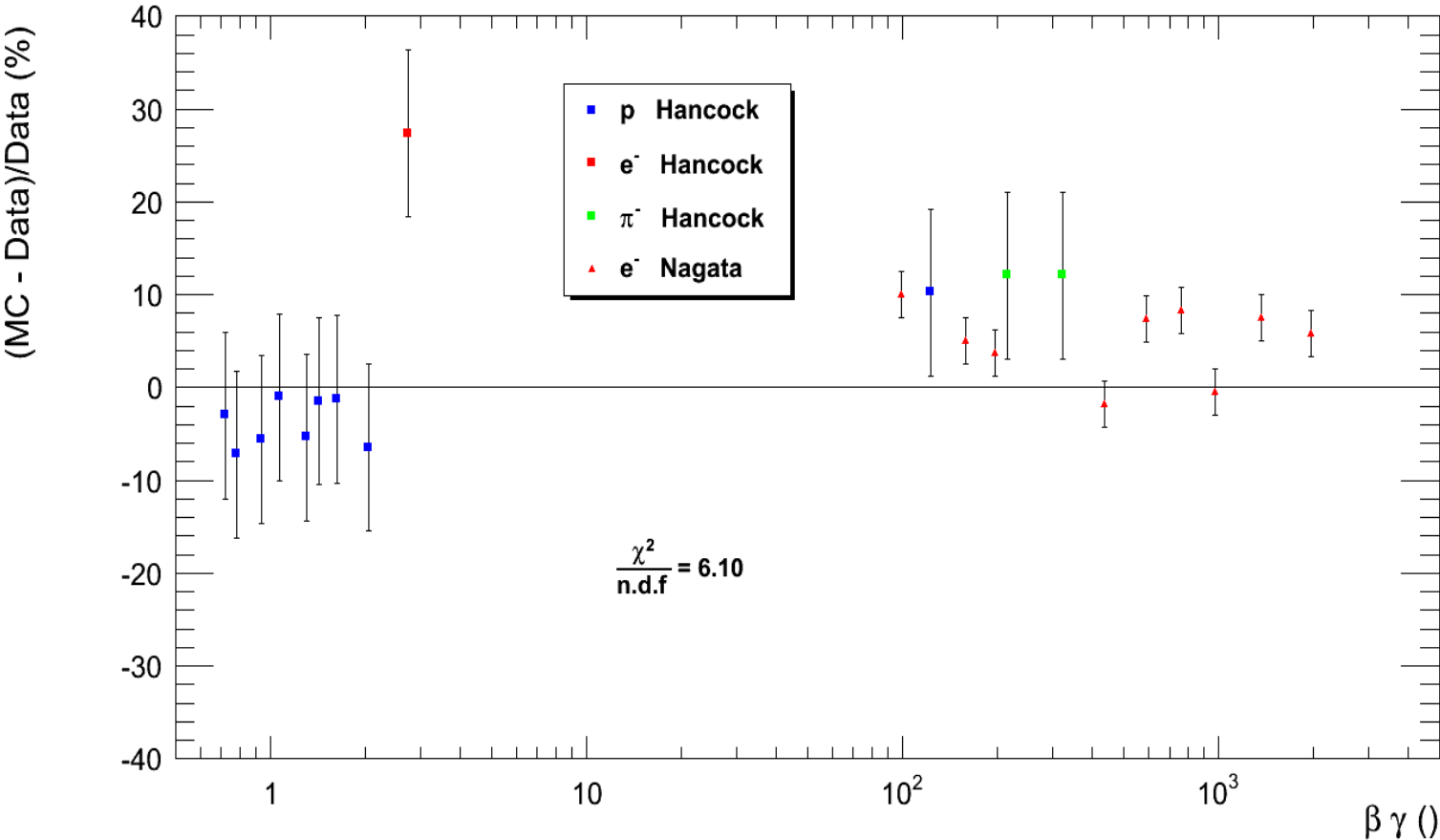
New Step limitation in Multiple Scattering for Muons

- In Geant4 9.4 a new combined model for muon multiple scattering was introduced
  - G4WentzelVIModel for small angles ($\theta < 0.2$ rad)
  - G4CoulombScattering for large angles
- In G4WentzelVIModel a new limitation of step size was added
  - Step is limited by $20*X_0$ (default value)
    - Value can be adjusted

Muon multiple scattering test at 7.195 GeV/c in Copper target

Probability for plane scattering angle θ_z: 7.195 GeV & emstandard_opt0

Probability for plane scattering angle θ_z: 7.195 GeV & emstandard_opt0

Opt0 – g4 9.4p01

Opt0 – g4 9.3
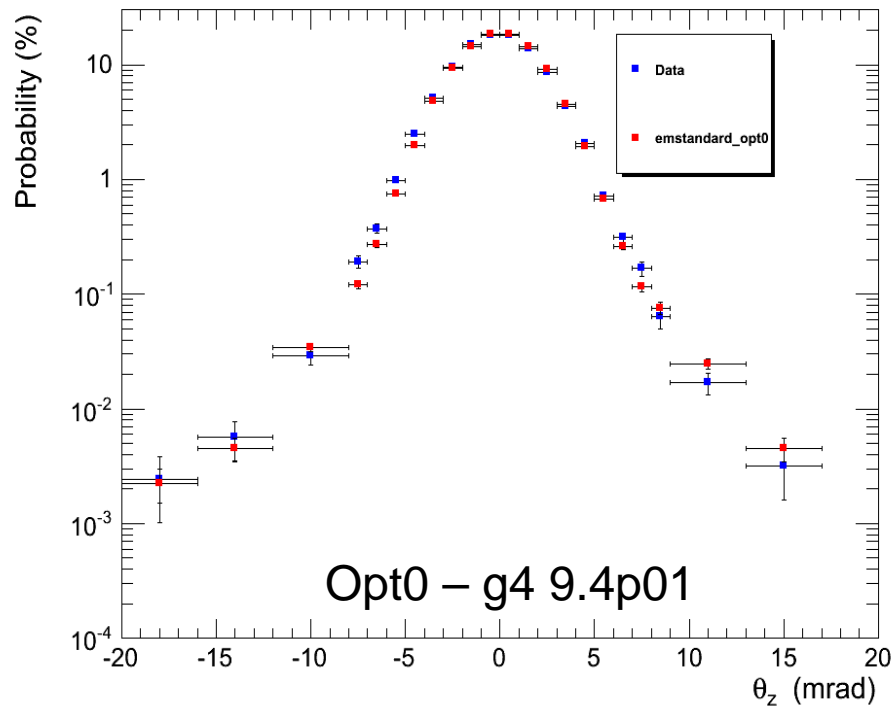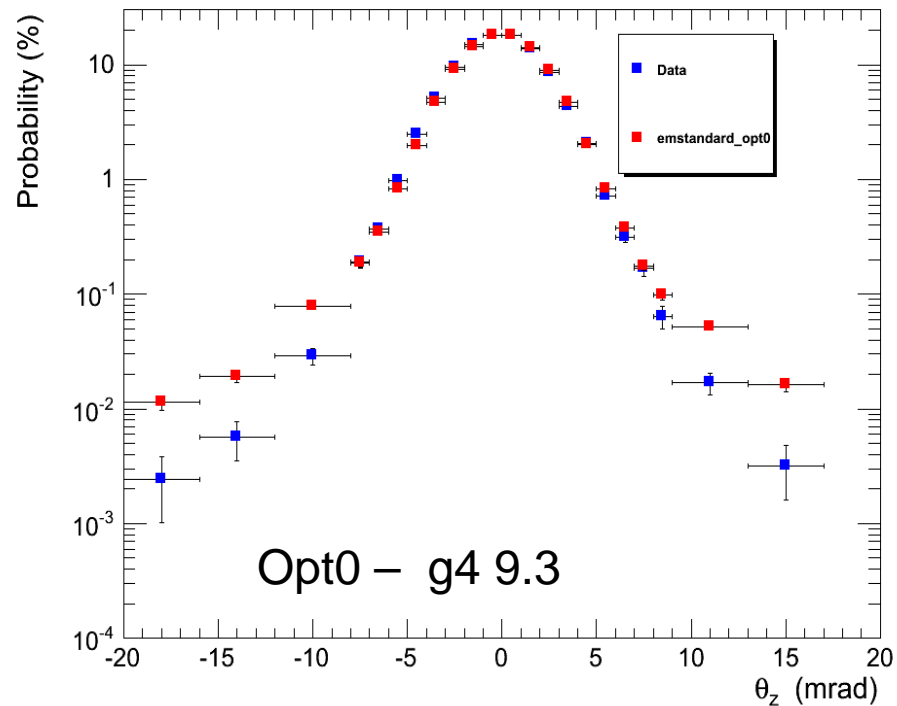
Akimenko S A et al 1986 Nucl. Instr. Meth. A 234 518

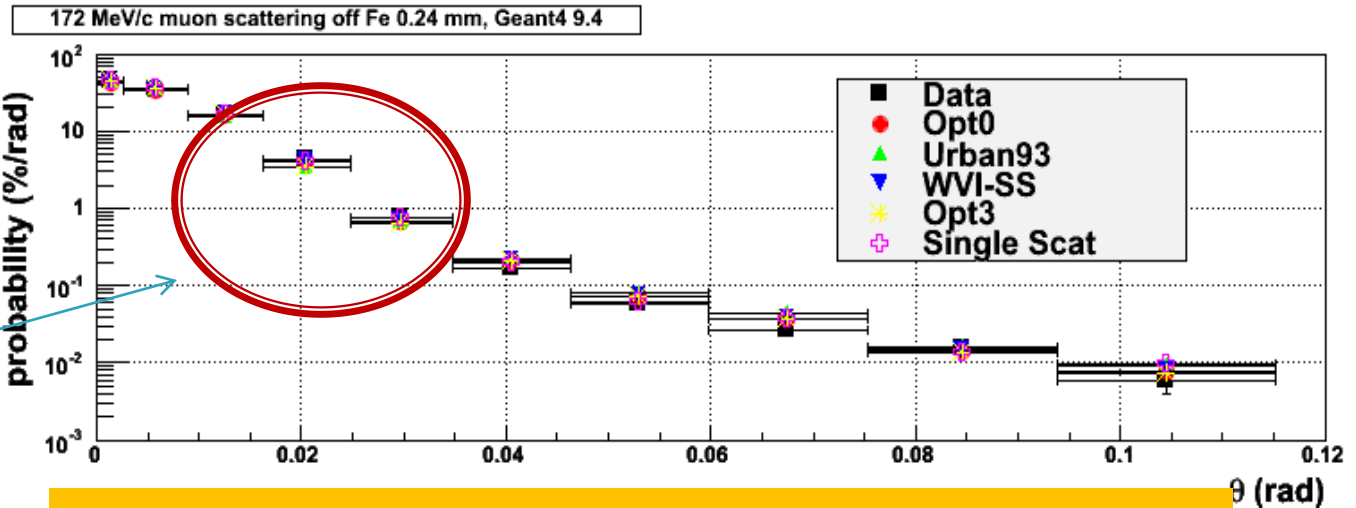V.Ivanchenko   13

Conclusions

- Results of Geant4 EM testing suite for 9.4p01 are the same as for 9.4
- Default and EMV EM physics providing significantly different visible energy in sampling calorimeters
  - depending on sampling fraction of the calorimeter
- Sampling calorimeter response is stable for many years within 1% if the same EM Physics List configuration and the same cut are used
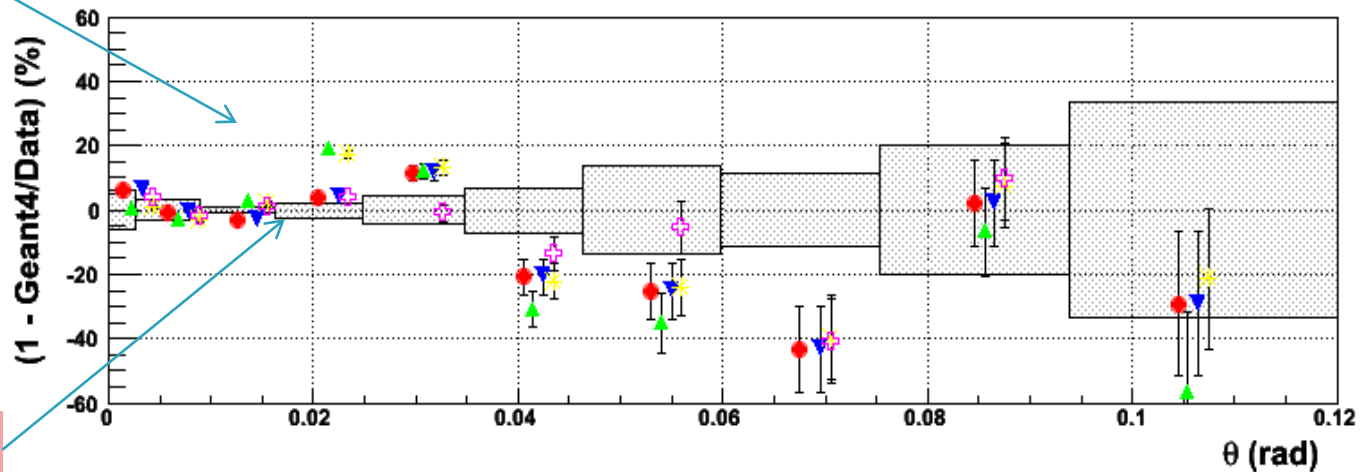
Backup slides: muon and hadron multiple scattering

MuScat Test Results 172 MeV/c

172 MeV/c muon scattering off Fe 0.24 mm, Geant4 9.4

Data
Opt0
Urban93
WVI-SS
Opt3
Single Scat

Improved area
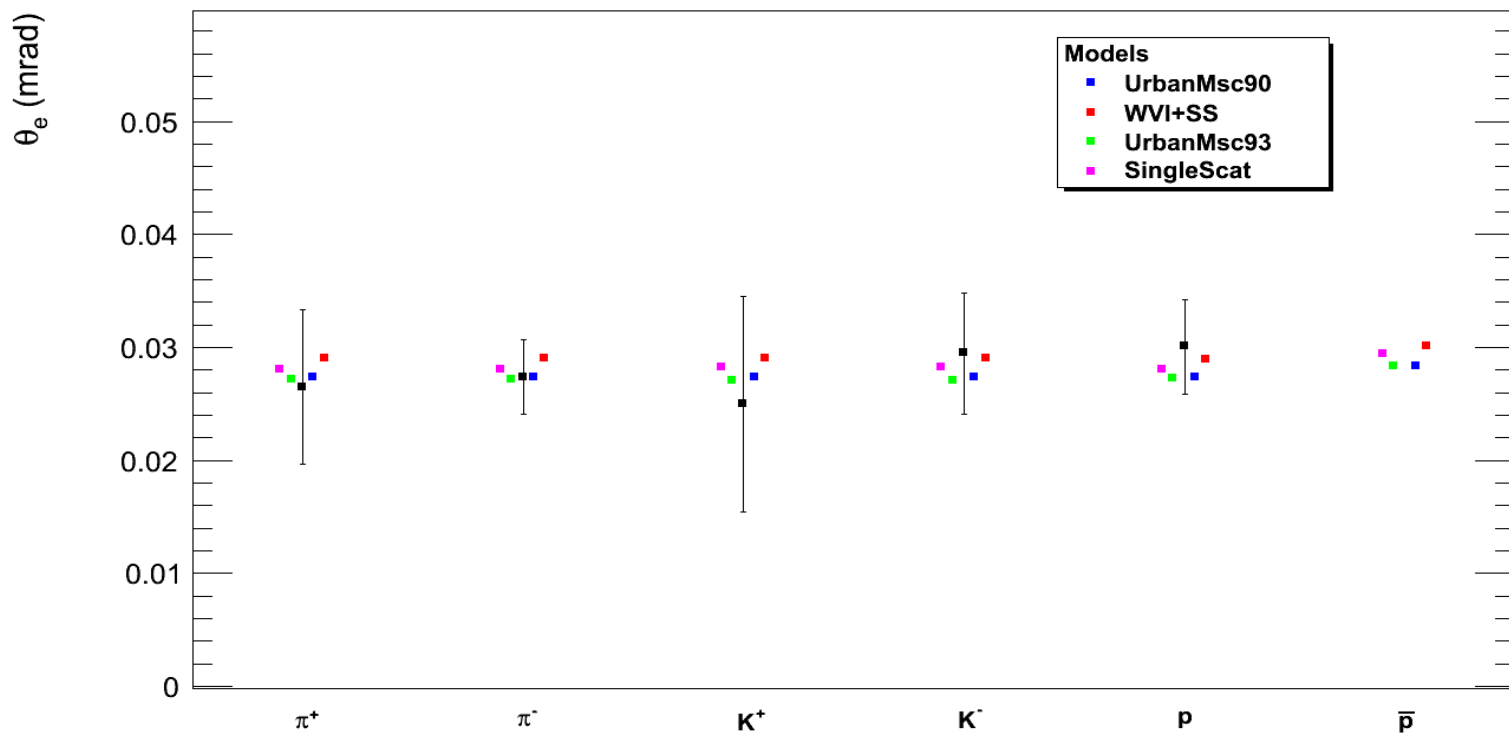
Urban model

MuScat data D.Attwood et al., NIM B251 (2006) 41

WentzelVI model

Hadron multiple scattering test at 175 GeV in Lead target

Comparison of GEANT4 and data θ_e: **Pb & 175 GeV**

Shen G et al 1979 Phys. Rev D 20 1584