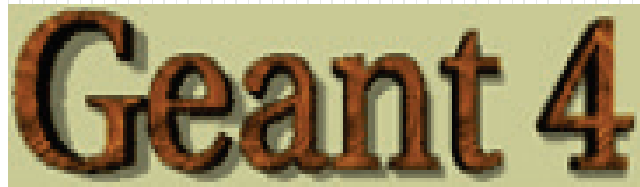


# Highlights of version 10.2 and 2016 work plan

V. Ivanchenko for Geant4 Collaboration

3 May 2016

The logo for Geant 4, featuring the text "Geant 4" in a stylized, brown, serif font with a slight shadow effect, set against a light green rectangular background.

# Outline

- Overview of 10.2 EM physics
  - EM standard
  - Some validation results
  - EM lowenergy
- EM standard plan for 2016
- EM low-energy plan for 2016

# EM standard developments for Geant4 10.2

- Completed migration of EM parameters management via `G4EmParameters` class
  - Essential for configuration of EM physics in MT mode
  - Added separate UI interfaces for  $e^+$ - and muons/hadrons
- PAI models configuration
  - provided possibility to be used for several different regions with different materials
  - New UI interface allowing configure PAI model on top of any Physics List (useful for ALICE)
- Improved ionisation processes
- Goudsmit-Saunderson msc model rewritten
  - Added extra EM physics constructor, so can be tried by LHC experiments
- Urban msc model – new optional lateral displacement sampling, added positron correction
- `G4hCoulombScatteringModel` for single scattering of muons/hadrons at highest energies

# Ionisation processes/models improvements

- Introduced lowest energy to ionisation processes, removed hidden tracking cuts from elastic scattering
  - Removed very low-energy electrons in LHC simulation but allowing to reduce the threshold for other applications
- Improved PAI models `G4PAIModel`, `G4PAIPhotModel`
  - Adding some CPU penalty compared with the Urban model, so should be applied only for specific sensitive volumes
  - PAI model provides stable energy deposition independently on step size
- Improved Urban model `G4UniversalFluctuations`
  - Mainly CPU performance
- Fixed density effect parameterisation for gasses and mixtures

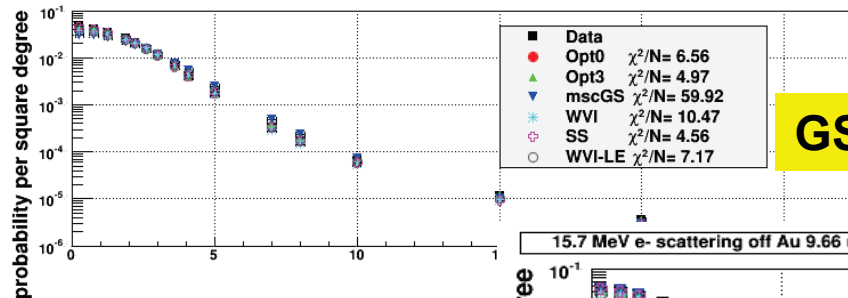
# Single and multiple scattering models

- **MultipleScattering models:**
  - **G4UrbanMscModel**
    - Since 10.0 we have only one version of the Urban model
    - For 10.1 the model was updated to improve CPU performance
    - For 10.2 a new correction factor for positrons was added and improved mechanism of lateral displacement was introduced
  - **G4WentzelVIModel**
    - Full single scattering option was added for small steps for 10.1
    - This model is used for muons/hadrons in Opt4 Physics List
  - **G4GoudsmithSoundersonModel**
    - **For 10.2 is completely rewritten**
    - Sampling according to EGSnrc prescriptions
    - Effective algorithms of sampling is introduced
    - CPU performance and accuracy become competitive to other models
- **Single scattering models:**
  - **G4eCoulombScatteringModel** – minor tuning
  - **G4hCoulombScatteringModel** - reviewed and updated for 10.2
  - **G4IonCoulombScatteringModel** – reviewed and fixed in 10.1.p02

# Hanson data for e- scattering off thin foil

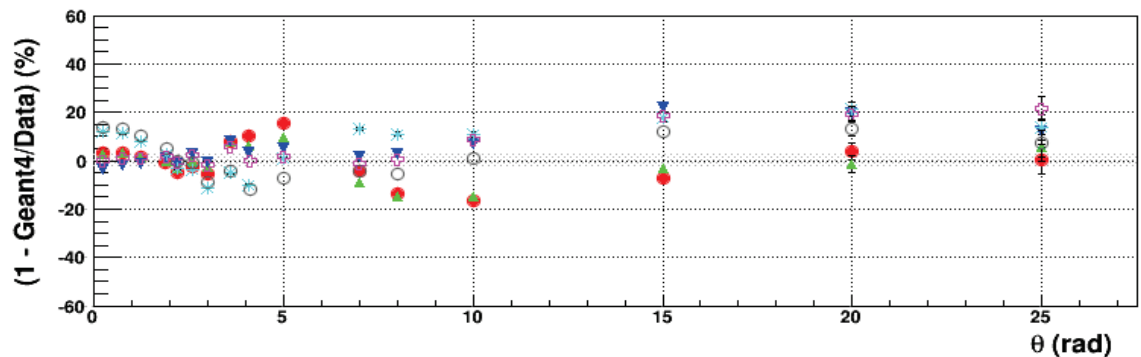
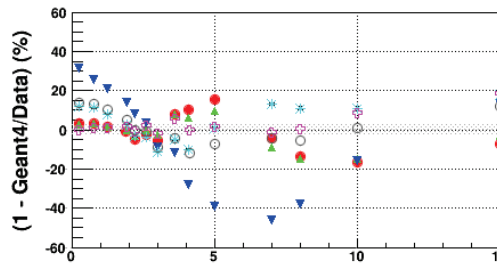
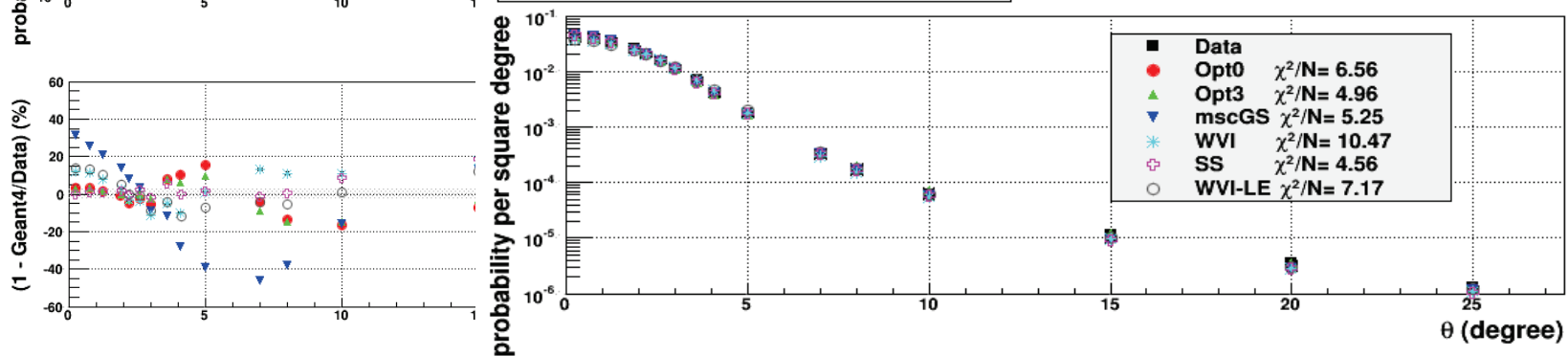
*Phys. Rev.* 84, p. 634-637, 1951.

15.7 MeV e- scattering off Au 9.66  $\mu\text{m}$ , Geant4 10.1p02

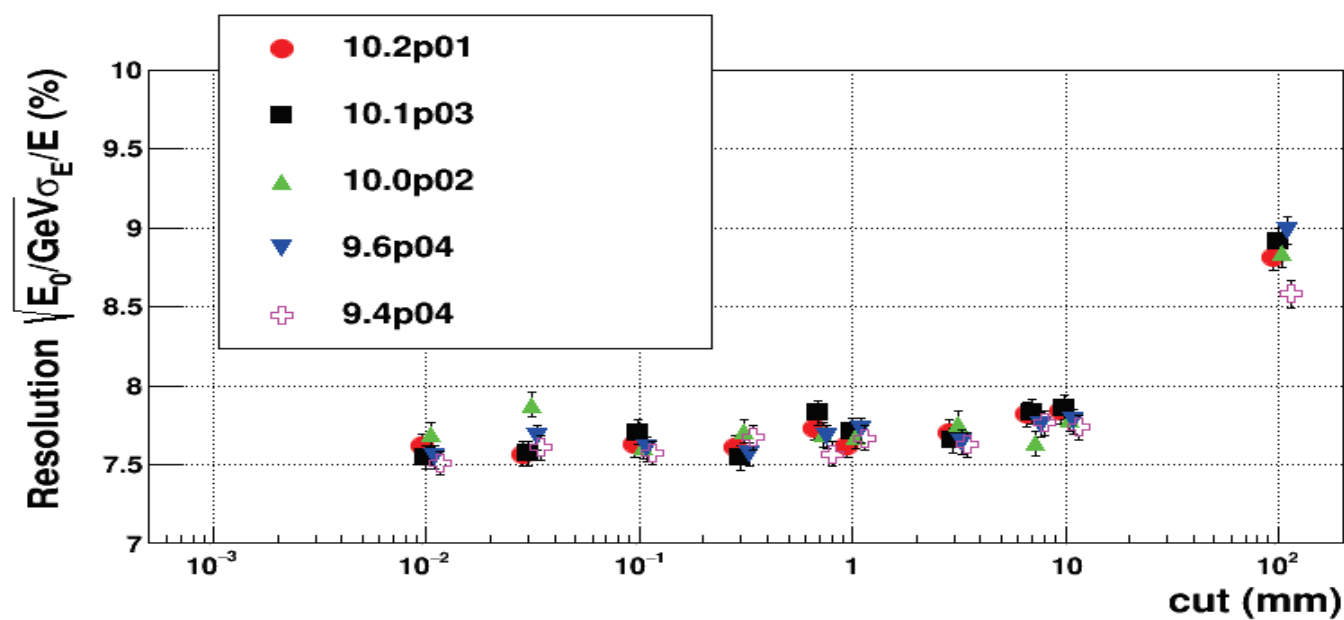
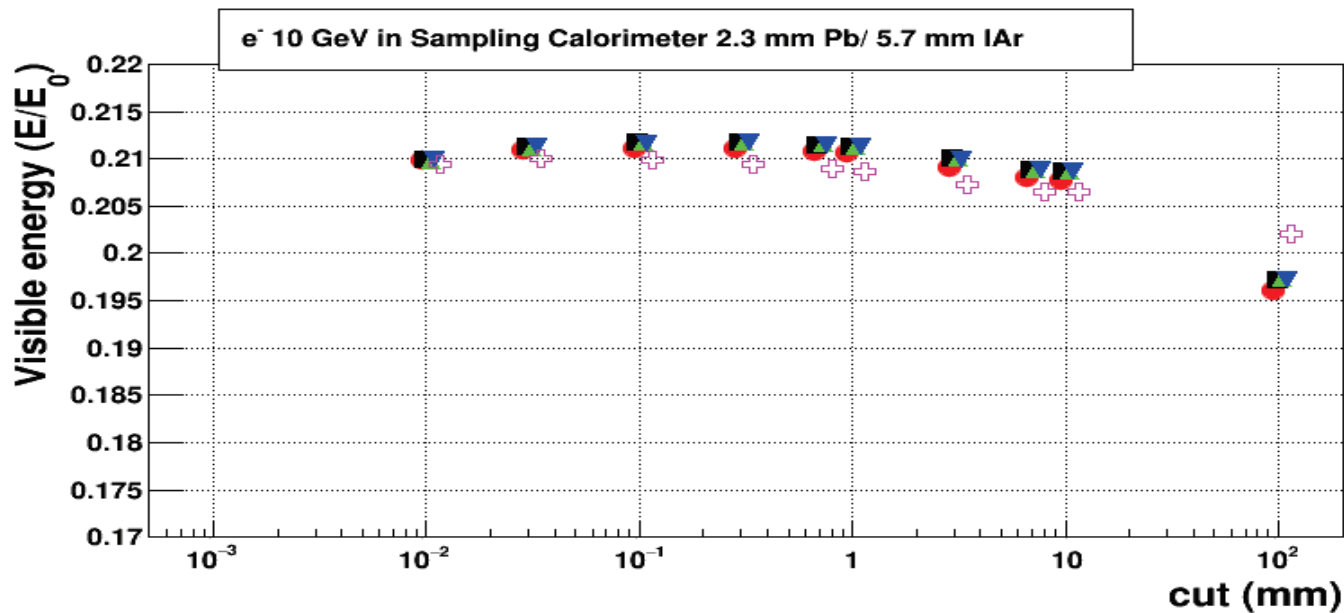


GS model has been significantly improved

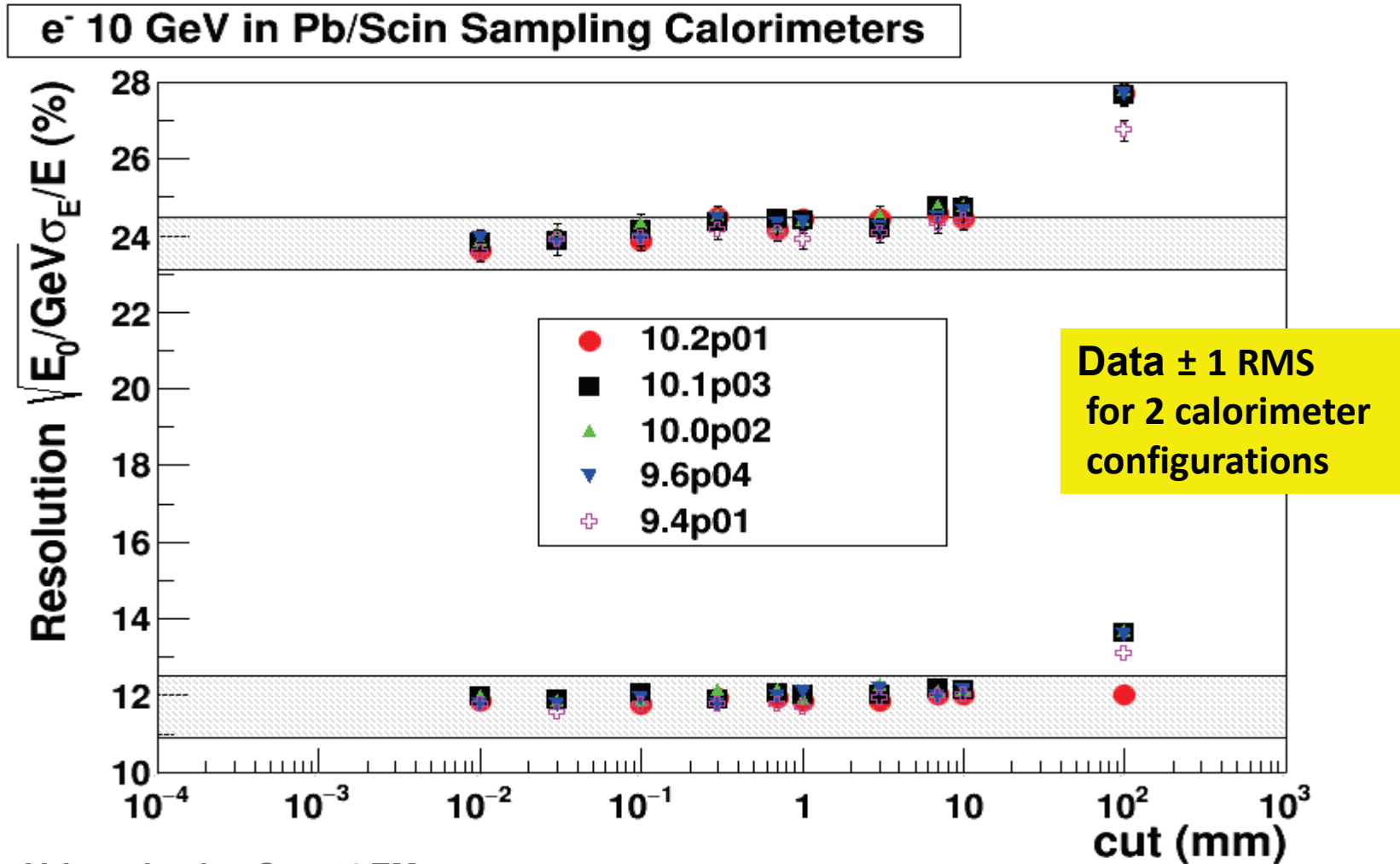
15.7 MeV e- scattering off Au 9.66  $\mu\text{m}$ , Geant4 10.2beta



# ATLAS barrel type simplified calorimeter results



# Resolution of ZEUS test beam calorimeters as function of cut in range





# EM low-energy developments for Geant4 10.2

- Monash gamma models updates
  - PDF function for the Compton model
  - New polarized Compton model
- Update of atomic de-excitation
  - New UI commands
  - New set of fluorescence line data by Bearden et al.
  - Auger cascade simulation
  - Fixed Penelope de-excitation
- ICRU'73 data for ion ionisation recomputed
- Significant update of DNA models
  - General paper on DNA: Phys. Medica 31 (2015) 861-874

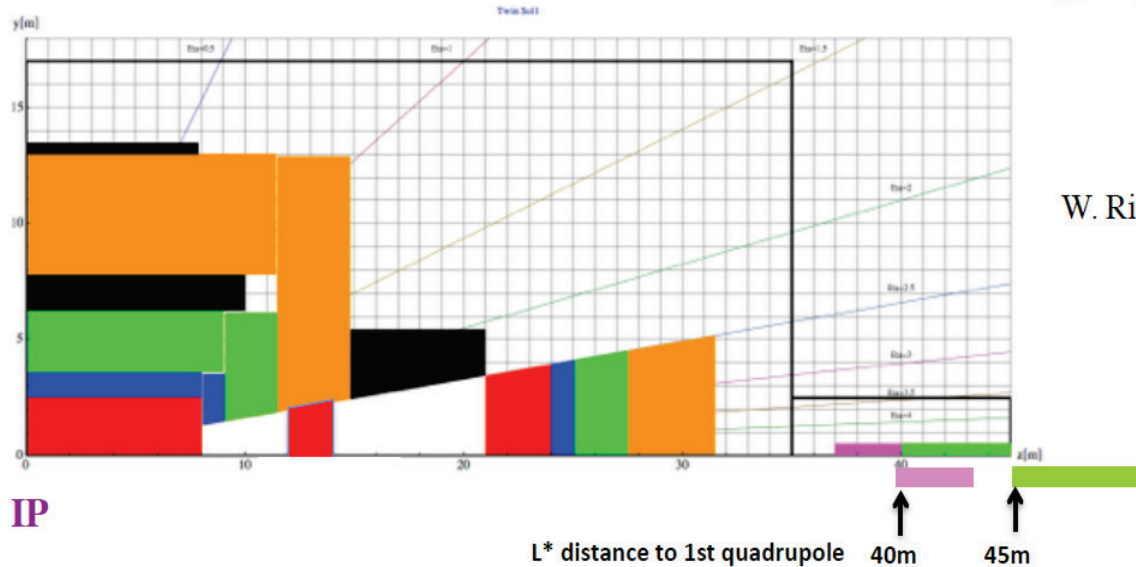
# Plan 2016 for EM standard physics

- Detailed plan is available in the web:  
[http://geant4.cern.ch/collaboration/working\\_groups/electromagnetic/plan2016.txt](http://geant4.cern.ch/collaboration/working_groups/electromagnetic/plan2016.txt)  
[http://geant4.cern.ch/support/planned\\_features.shtml](http://geant4.cern.ch/support/planned_features.shtml)
- Main topics of the plan:
  - Further EM infrastructure upgrade and migration to c++11
  - Extension of EM options for Physics Lists
  - Evaluation and tuning of multiple scattering and fluctuation models
    - Optimisation of Physics Lists
  - Extension of upper energy of EM models to 100 TeV
    - FCC requirement
  - Evaluation of PAI and XTR model for ALICE
  - Validation of EM physics
    - Focused on LHC experiments requirements
    - Coming test-beam results for LHC detectors upgrade

# Conceptual design of FCC detector



## FCC-hh interaction region and detector



W. Riegler et al.

- Baseline beam-pipe and detector is a combination of ATLAS, CMS, LHCb
- Requirements to Geant4 EM:
  - upper energy should be extended from 10 TeV to 100 TeV
  - High energy models should be reviewed and upgraded

# Plan 2016 for EM low-energy physics

- Detailed plan is available in the web:  
[http://geant4.cern.ch/support/planned\\_features.shtml](http://geant4.cern.ch/support/planned_features.shtml)
- Main topics of the plan:
  - Expansion of M-shell ionisation cross sections for protons and alpha for de-excitation module up to 1 GeV
  - Upgrade of Livermore ionisation model and provide sampling of secondary electrons below threshold
  - Update polarisation models
  - Monarsh models: provide new photoelectric model and extend PDF functions for the Compton model
  - Further developments on DNA models
    - Cross-section models for other biological materials and incident particles
    - New chemistry models
    - Updated LEPTS models

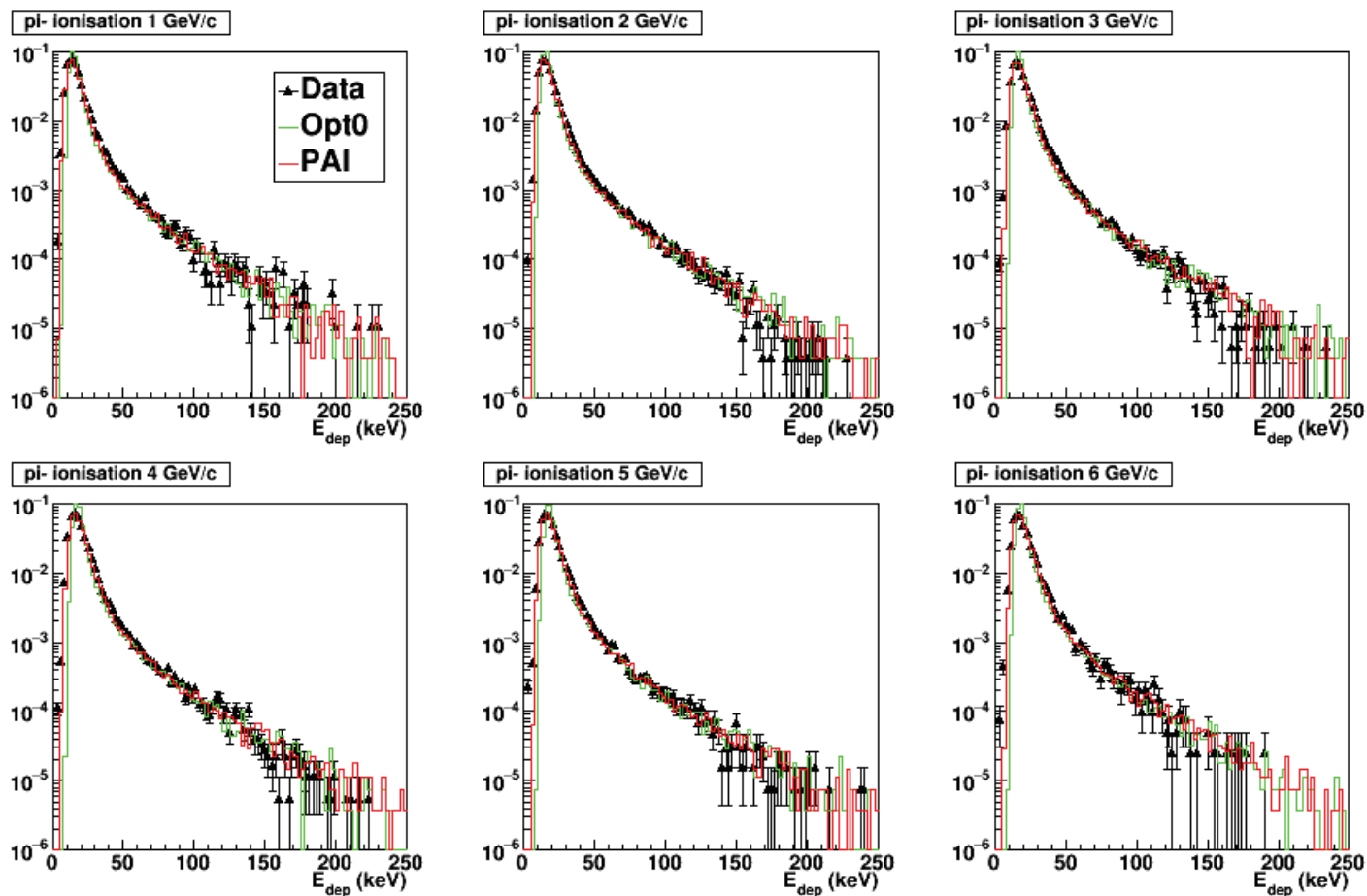
# Backup: validation results

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# Energy deposition in ALICE TPC test-beam

Nucl. Instr. Meth. A, 519, 508-517 (2004)

Pion beam, step limit 2 mm, Xe sensitive volume



# Thick target proton scattering benchmark

(B. Gottschalk et al., NIM B 74 (1993) 467)

160 MeV protons

Characheristic Angle Distribution for Aluminium

