



**GEANT4**  
A SIMULATION TOOLKIT

# Hadronic Showers in Geant4 **11.2.ref08**

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# Main Changes in Hadronics vs. G4 11.2.ref07 (1/2)

- **New hadronic datasets**

- G4ENSDFSTATE**3.0** , PhotonEvaporation**6.0** , RadioactiveDecay**6.0.1**
- Major work done by Laurent Desorgher
  - Scripts and tools are available: for the future, we want to share this effort among some interested people
- Some fixes are likely needed before the December release

- *hadronic/cross\_sections/*

- *G4InterfaceToXS* : renamed class name of the recently introduced *G4XSectionXS* class
- *G4ParticleInelasticXS*, *G4NeutronInelasticXS* : Coverity fixes; code clean-up

- *hadronic/models/util/*

- *G4IsotopeList* : added table with low-energy threshold energies per atomic number
- *G4NucleaRadii* : added two static functions to describe threshold shape by the old Gheisha

- *hadronic/models/abla/ & inclxx/*

- Coverity fixes

# Main Changes in Hadronics vs. G4 11.2.ref07 (2/2)

- *hadronic/models/de\_excitation/*
  - For pre-compound model, return to the original interval of applicability  $E_{ex}/A = (0.1 - 30)$  MeV
    - This is important: the changes in hadronic showers seen in Ref07 were due to  $E_{ex}/A = (0.1-3)$  MeV
  - *G4LevelReader* : added two new protections to handle broken files with gamma level data
    - A revised version of PhotonEvaporation6.0 is likely needed soon, before 11.3
  - *G4EvaporationProbability* : replaced *G4XSectionXS* with *G4InterfaceToXS*
    - Moreover, this class has been moved to *hadronic/cross\_sections/*
- *hadronic/models/particle\_hp/*
  - *G4CrossSectionHP* : fixed cross-section computation with Doppler broadening due to media temp.
    - This should fix some problems reported recently on the physics list QGSP\_BERT\_HP
- *hadronic/models/coherent\_elastic/*
  - *G4ChargeExchange* : implemented production and decay of  $\omega(780)$  and  $f_2(1270)$  for pion projectile; implemented decay of unstable isomers if recoil nucleus if not a natural isotope; addressing #2618
- *hadronic/models/pre\_equilibrium*
  - *G4(V)PreCompoundFragment* : replaced *G4XSectionXS* with *G4InterfaceToXS*

# Crashes & Warnings

- No crashes
- No infinite loops
- No new warnings

# Reproducibility

- OK in all cases

# Pion- showers: FTFP\_BERT

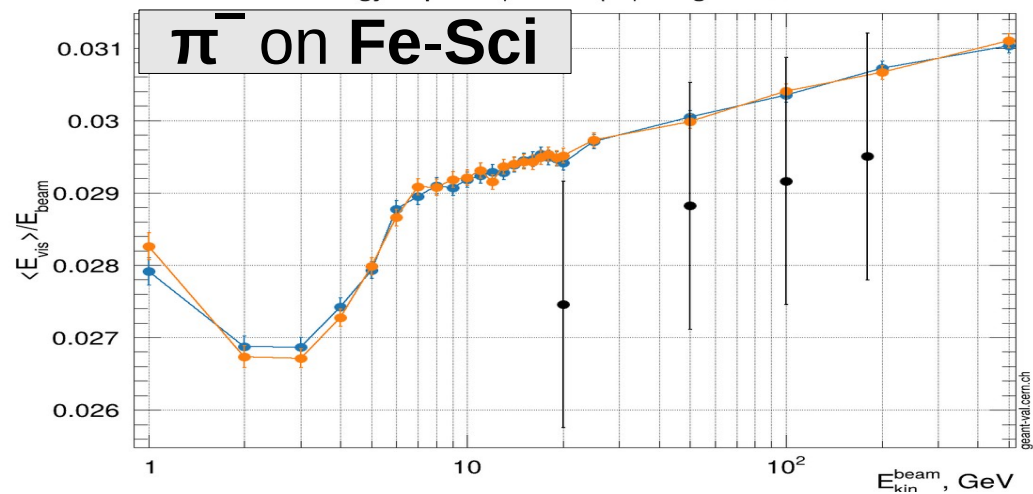
G4 11.2.ref06

G4 11.2.ref08

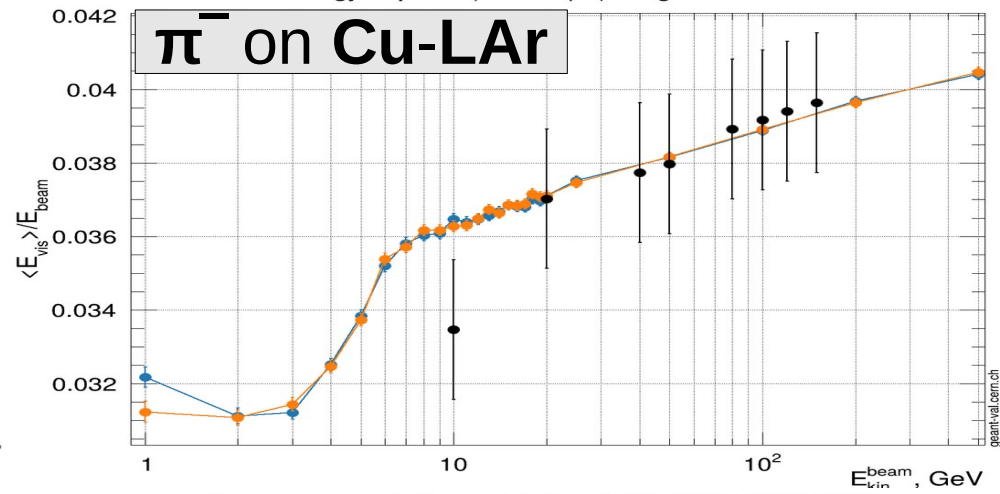
*Note : conventional Birks treatment  
(easier and no experimental h/e to fit !)*

# FTFP\_BERT : Energy Response

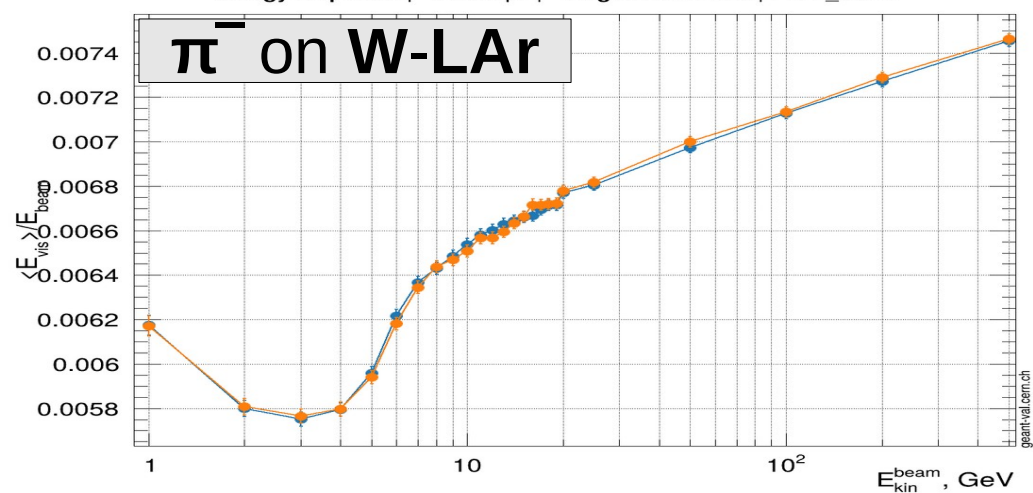
Energy response | Beam: pi- | Target: TileCal



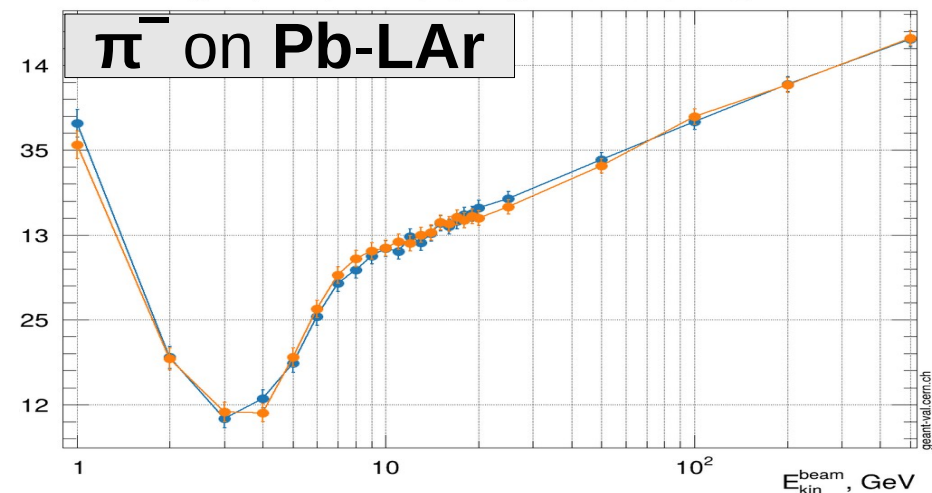
Energy response | Beam: pi- | Target: AtlasHEC



Energy response | Beam: pi- | Target: AtlasFCAL | FTFP\_BERT



Energy response | Beam: pi- | Target: AtlasECAL | FTFP\_BERT



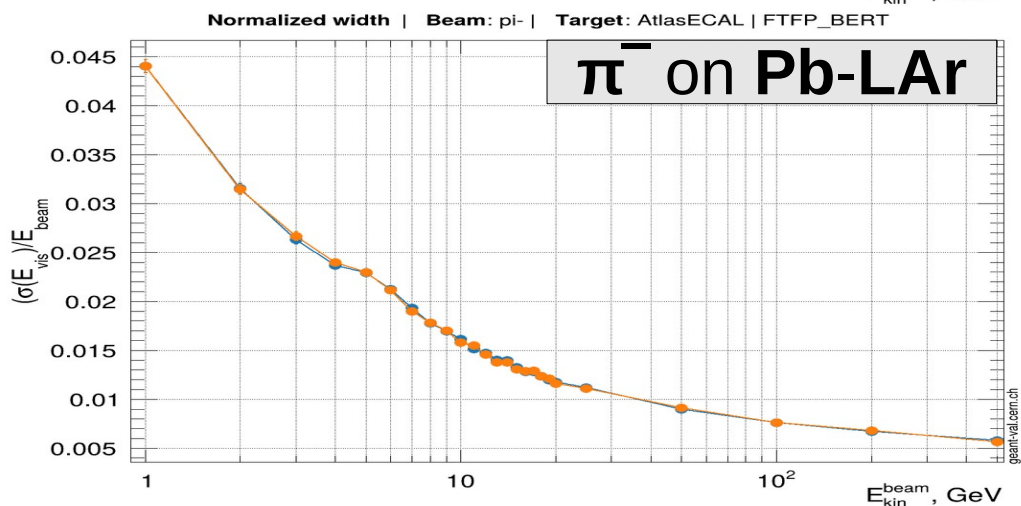
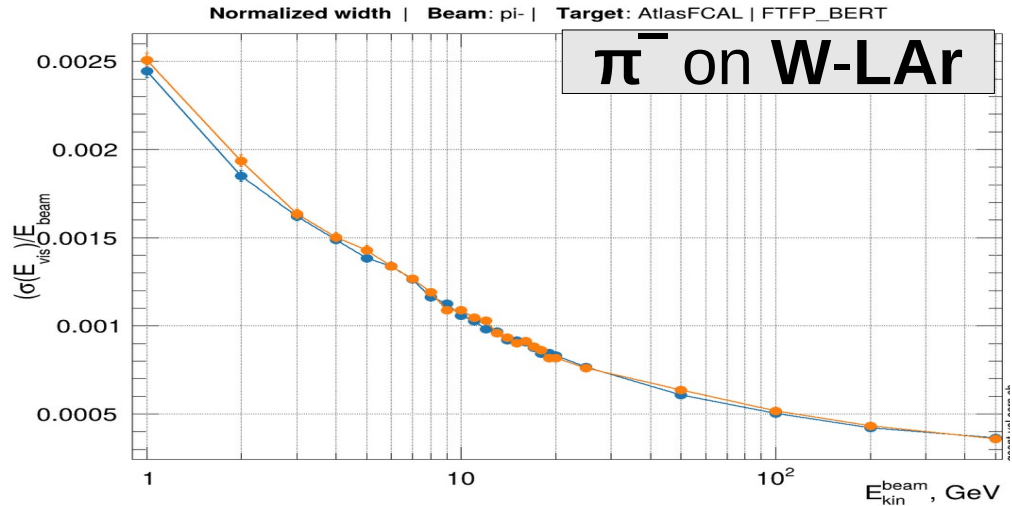
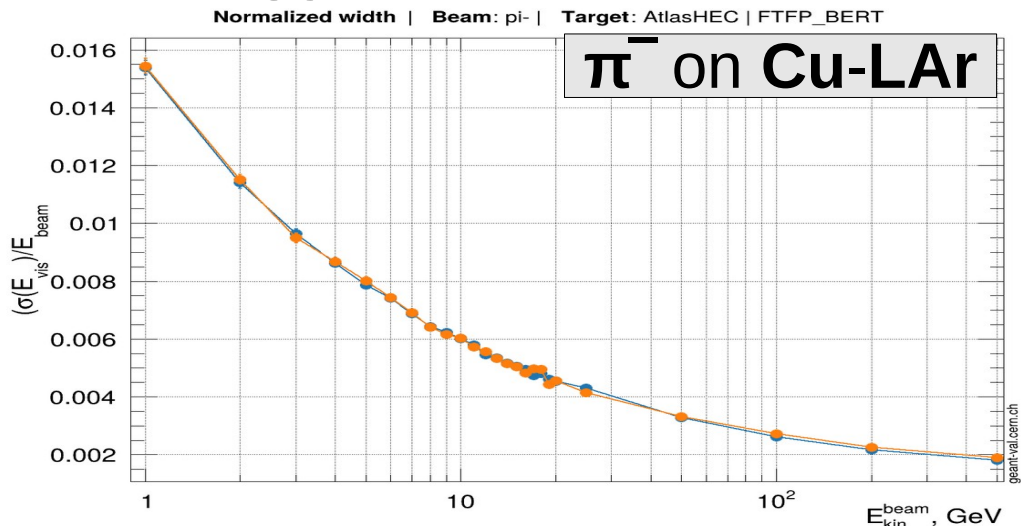
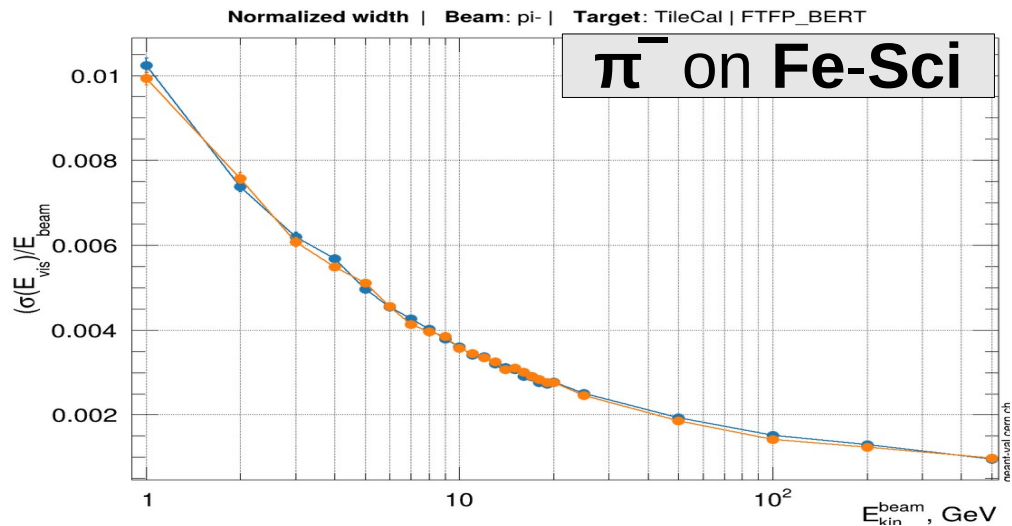
11.3.beta\_cand00

11.2.ref08

11.3.beta\_cand00

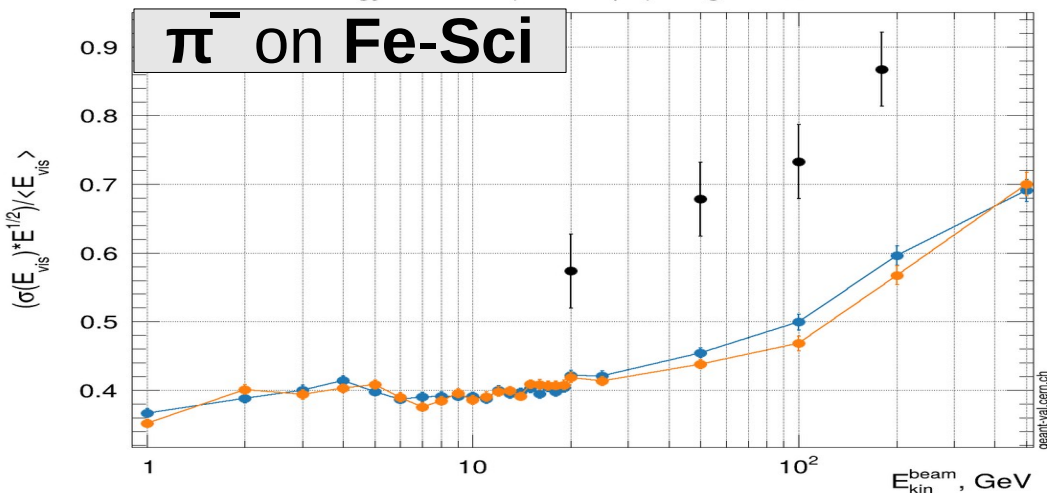
11.2.ref08

# FTFP\_BERT : Energy Width

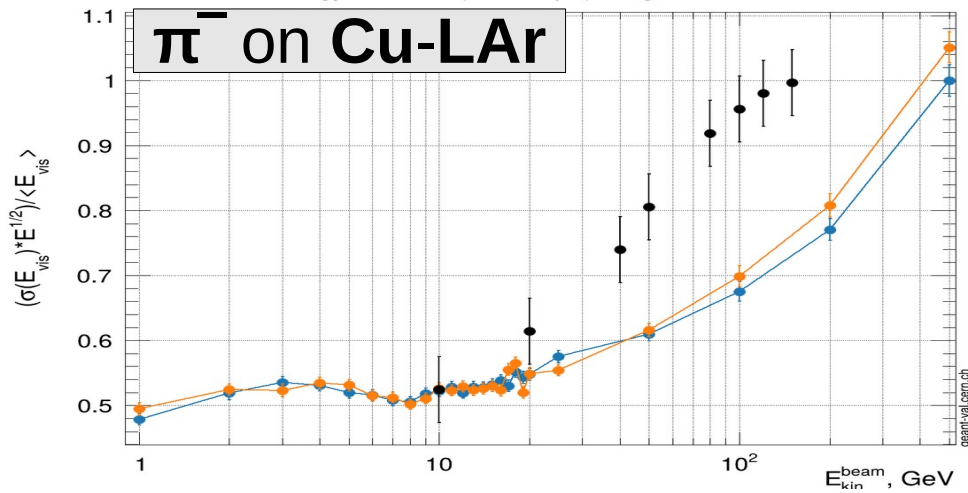


# FTFP\_BERT : Energy Resolution

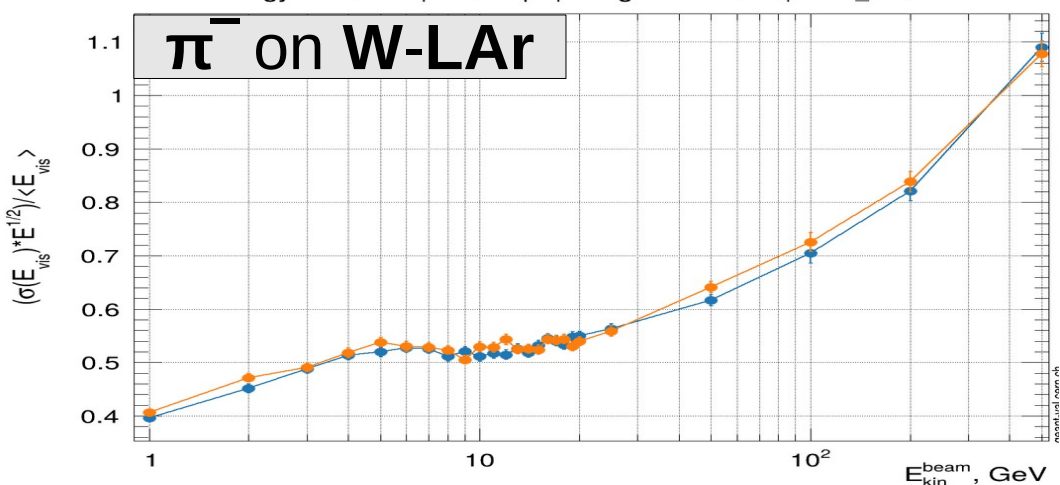
Energy resolution | Beam: pi- | Target: TileCal



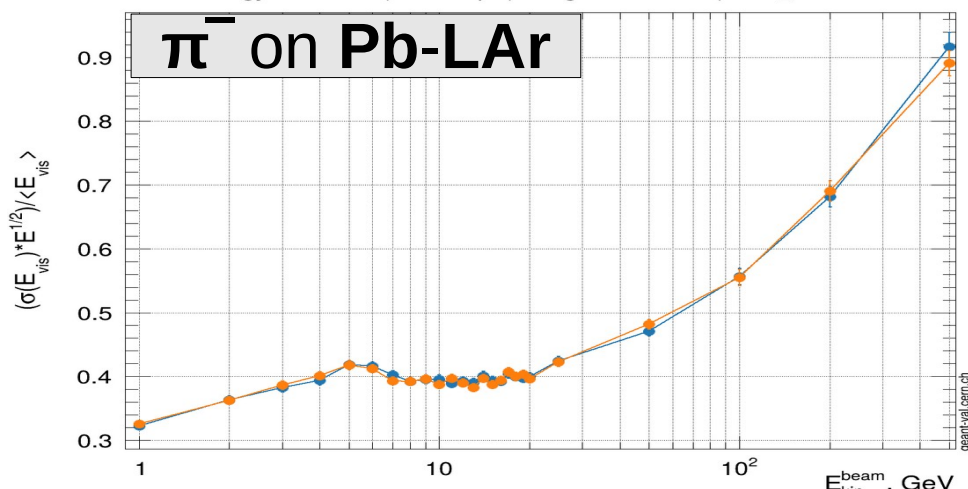
Energy resolution | Beam: pi- | Target: AtlasHEC



Energy resolution | Beam: pi- | Target: AtlasFCAL | FTFP\_BERT



Energy resolution | Beam: pi- | Target: AtlasECAL | FTFP\_BERT



11.3.beta\_cand00

11.2.ref08

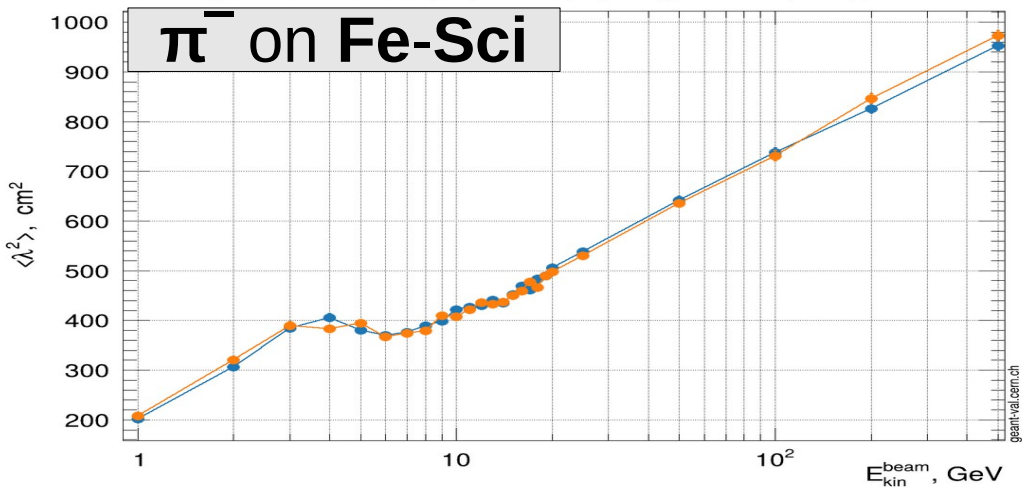
11.3.beta\_cand00

11.2.ref08

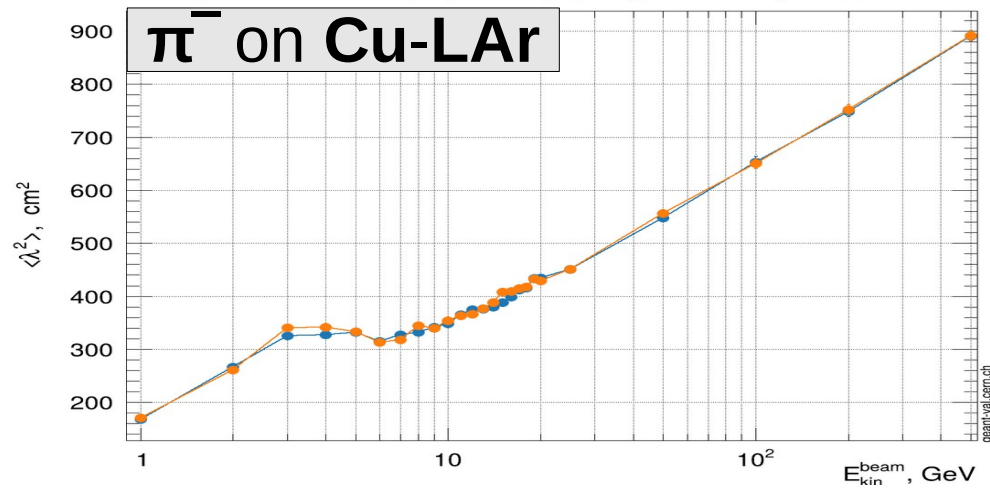


# FTFP\_BERT : Longitudinal Shape

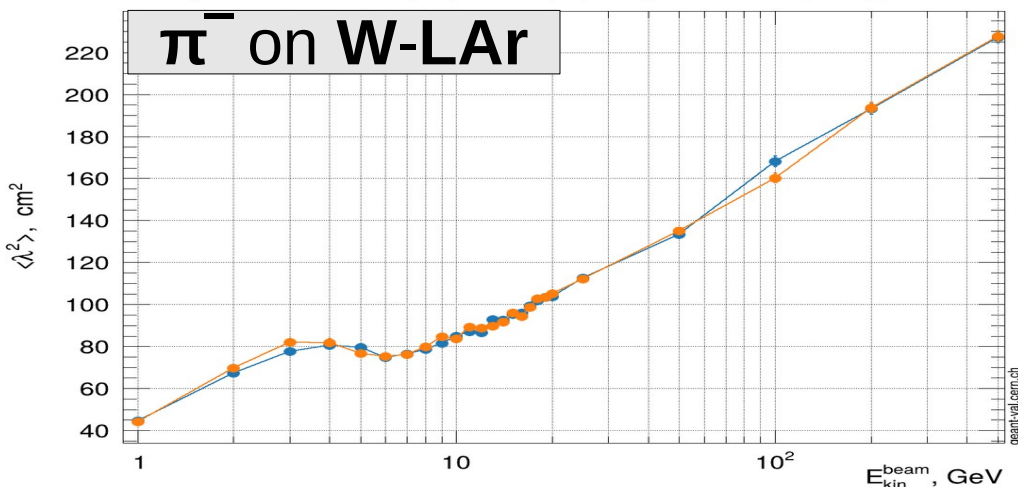
Longitudinal shower shape | Beam: pi- | Target: TileCal | FTFP\_BERT



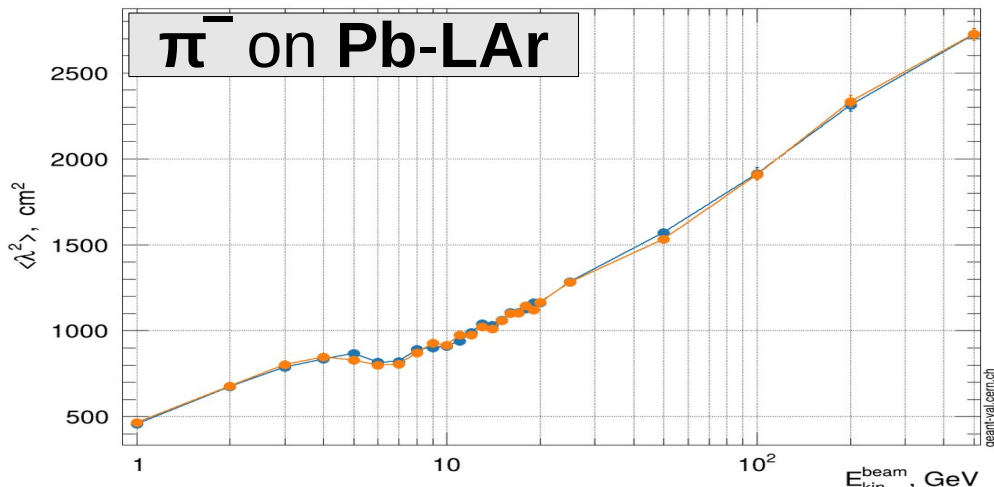
Longitudinal shower shape | Beam: pi- | Target: AtlasHEC | FTFP\_BERT



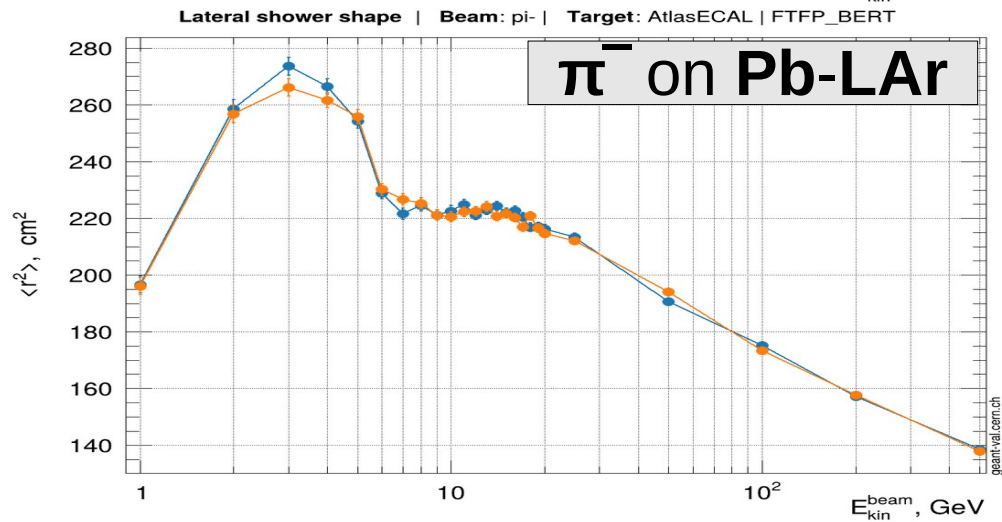
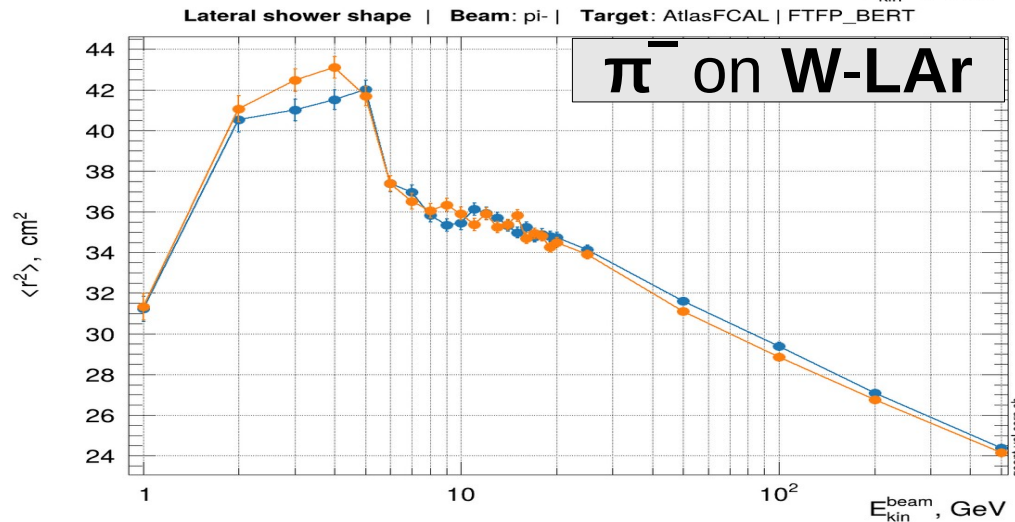
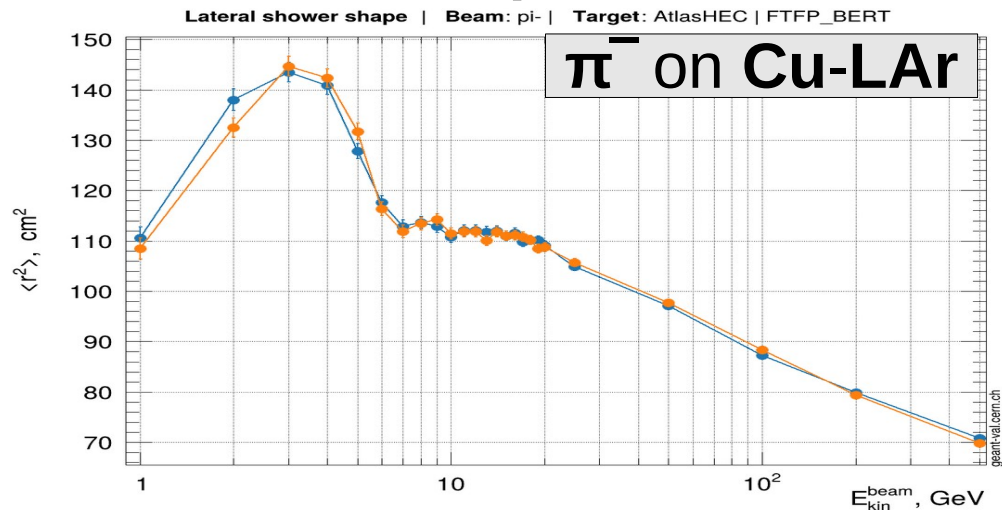
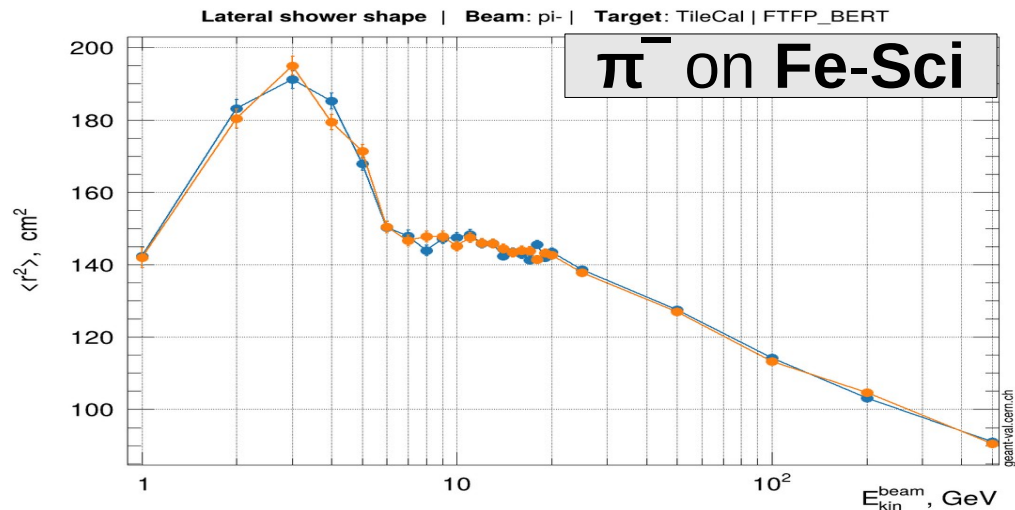
Longitudinal shower shape | Beam: pi- | Target: AtlasFCAL | FTFP\_BERT



Longitudinal shower shape | Beam: pi- | Target: AtlasECAL | FTFP\_BERT



# FTFP\_BERT : Lateral Shape



Pion- showers: QGSP\_BIC  
QGSP\_INCLXX

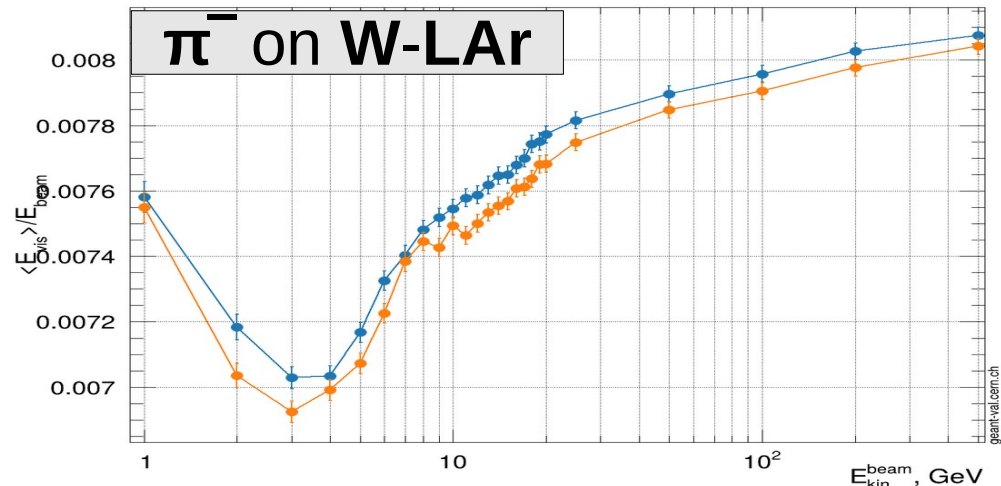
G4 11.2.ref06

G4 11.2.ref08

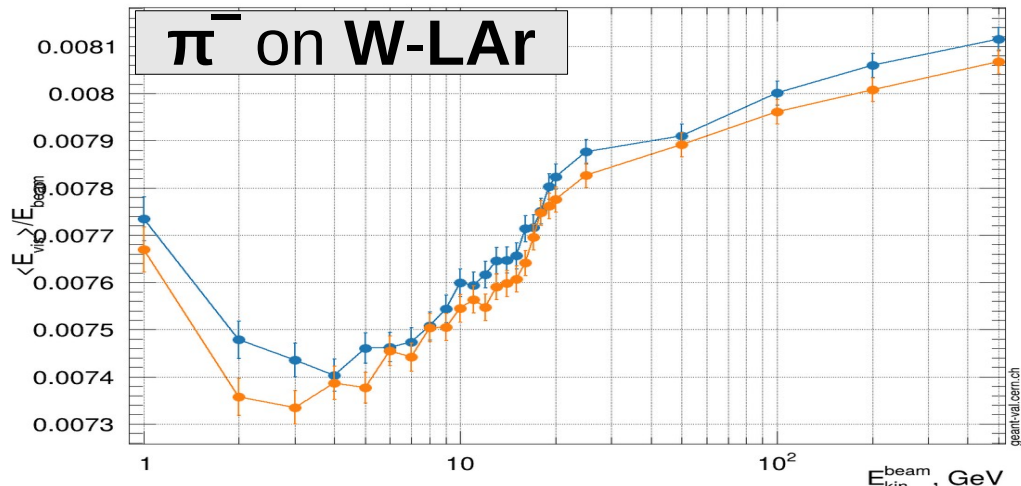
*Note : conventional Birks treatment  
(easier and no experimental h/e to fit !)*

# Energy Response & Lateral Shape in Tungsten

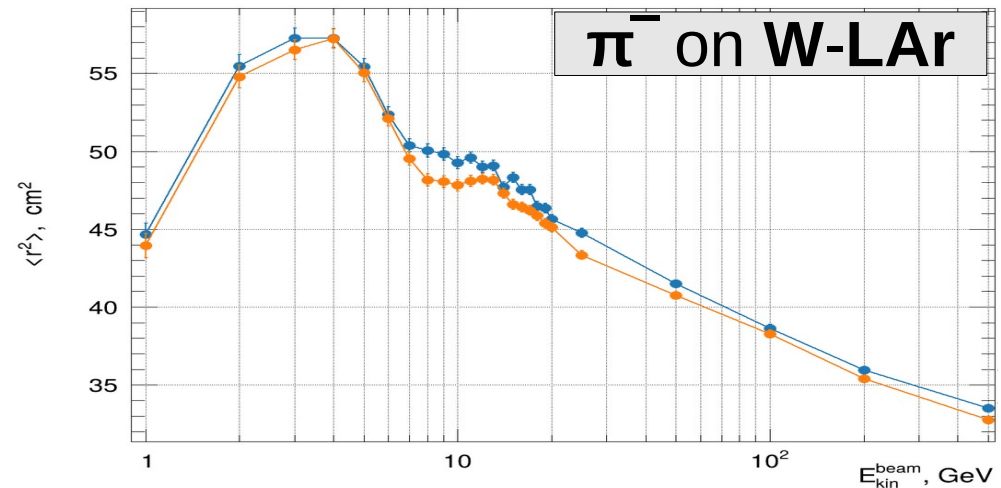
Energy response | Beam: pi- | Target: AtlasFCAL | QGSP\_BIC



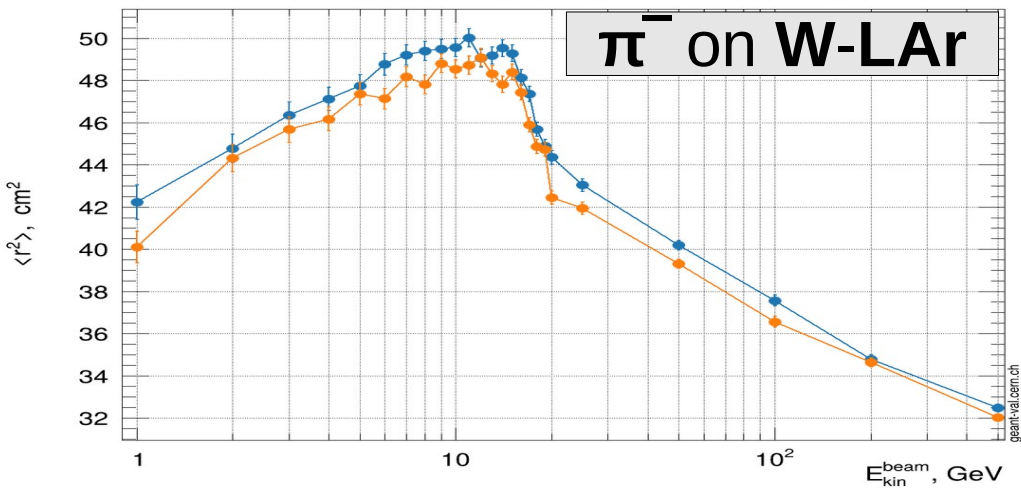
Energy response | Beam: pi- | Target: AtlasFCAL | QGSP\_INCLXX



Lateral shower shape | Beam: pi- | Target: AtlasFCAL | QGSP\_BIC



Lateral shower shape | Beam: pi- | Target: AtlasFCAL | QGSP\_INCLXX



# Conclusions

- **G4 11.2.ref08**

- No crashes, no infinite loops, no new warnings

- Reproducibility is fine in all cases

- Hadron showers:

- For nearly all reference physics lists (FTFP\_BERT, QGSP\_BERT, *etc.*), the pion showers of Ref08 are similar to those of Ref06

- The changes seen in Ref07 have been understood (due to the change of applicability range of Precompound, from [100 keV, 30 MeV]/nucleon to [100 keV, 3 MeV]/nucleon ) and fixed in Ref08 (by rolling back the original range [100 keV, 30 MeV]/nucleon )

- For QGSP\_BIC and QGSP\_INCLXX - only in Tungsten - some changes in the energy response and lateral shower shapes:

- ~1% lower energy response in Ref08 with respect to Ref06
- ~2% narrower lateral showers in Ref08 with respect to Ref06

likely due to the effect of the new hadronic datasets in nuclear de-excitation (whereas BERT has its own de-excitation that does not use those datasets)