



GEANT4
A SIMULATION TOOLKIT

Hadronic Showers in Geant4 10.7.p02 (plus something on Ref05)

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CERN EP-SFT

Main Changes in Hadronics vs. 10.7.p01

- De-excitation

- Changed half-life time threshold for isomer production from **1 microsecond** to **1 nanosecond**
 - The goal is to avoid unphysical missing energy cases as reported by NA61/SHINE Collaboration

- Radioactive Decay

- Fixed bug in the track weight of secondaries when using Radioactive Decay in analogous mode with “external” biasing (e.g. generic biasing, GPS generator with weights, etc.)
 - In the method `G4RadioactiveDecayBase::DecayAnalog()`

- ParticleHP

- Fixed condition in `G4ParticleHPInelasticCompFS::CompositeApply()`

- Physics lists

- `G4HadronPhysicsShielding` : corrected parameters of the **M** variant
 - Transition between FTFP and BERT should be 9.5 – 9.9 GeV for pions, kaons protons and neutrons
 - `ShieldingM` is used by Mu2e

Crashes & Warnings

- No crashes
- No infinite loops
- No new warnings

Reproducibility

- All OK
 - Both usual tests and the new ones for tasking

Pion- showers: FTFP_BERT

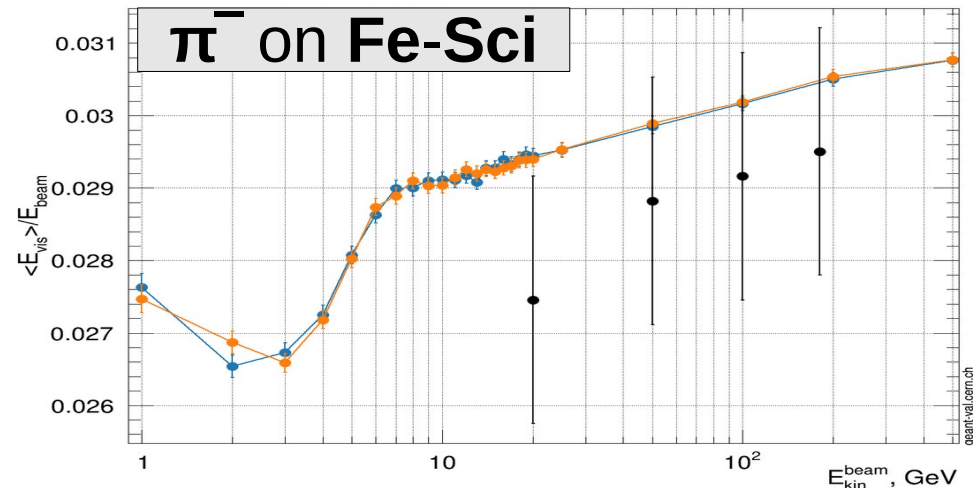
G4 10.7.p02

G4 10.7.p01

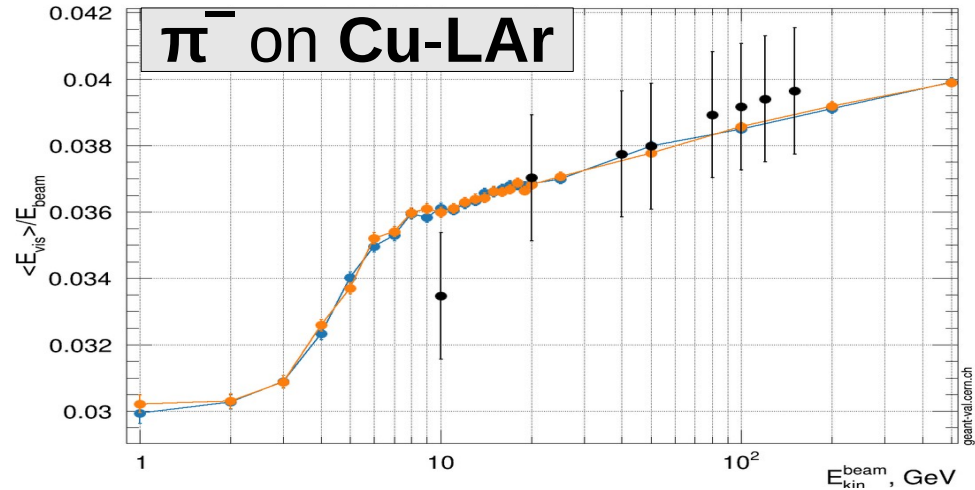
*Note : conventional Birks treatment
(easier and no experimental h/e to fit !)*

FTFP_BERT : Energy Response

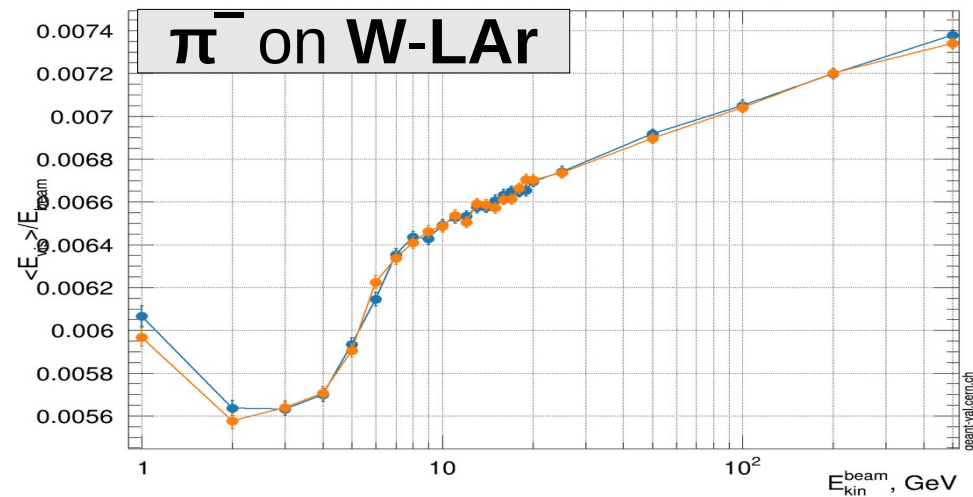
Energy response | Beam: pi- | Target: TileCal



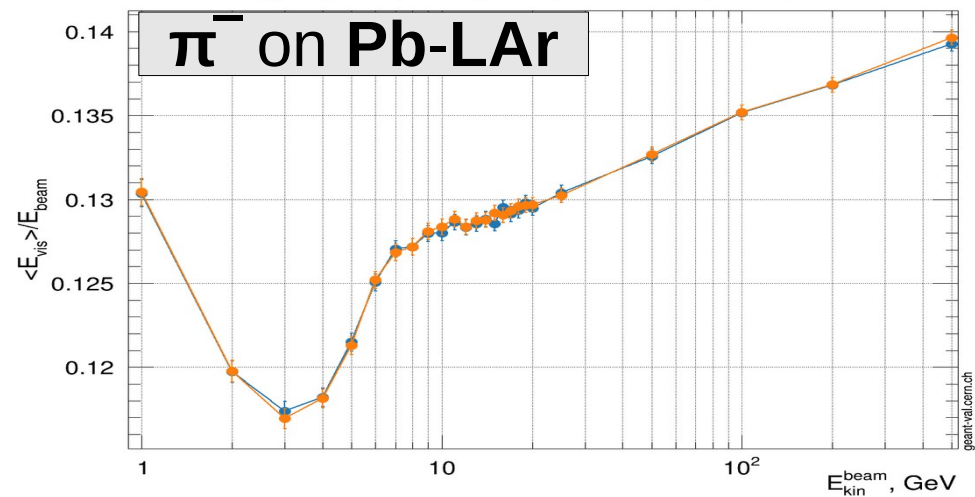
Energy response | Beam: pi- | Target: AtlasHEC



Energy response | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

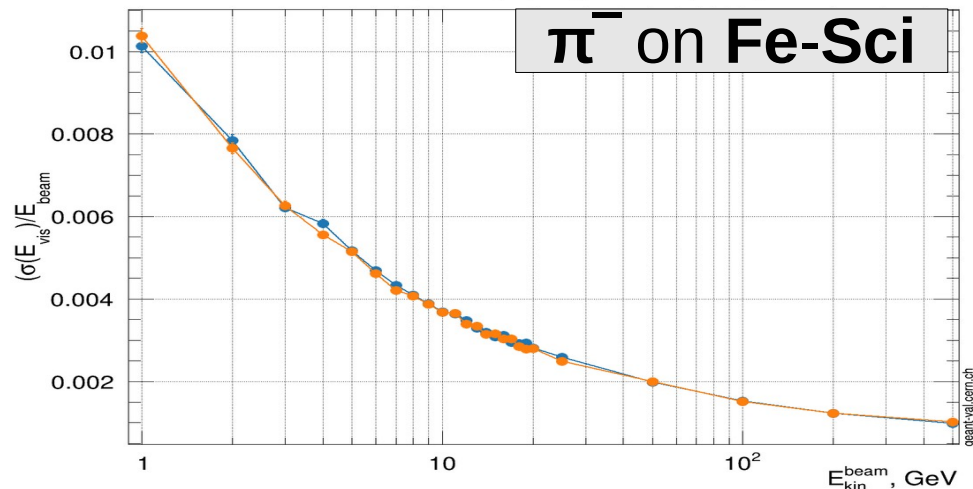


Energy response | Beam: pi- | Target: AtlasECAL | FTFP_BERT

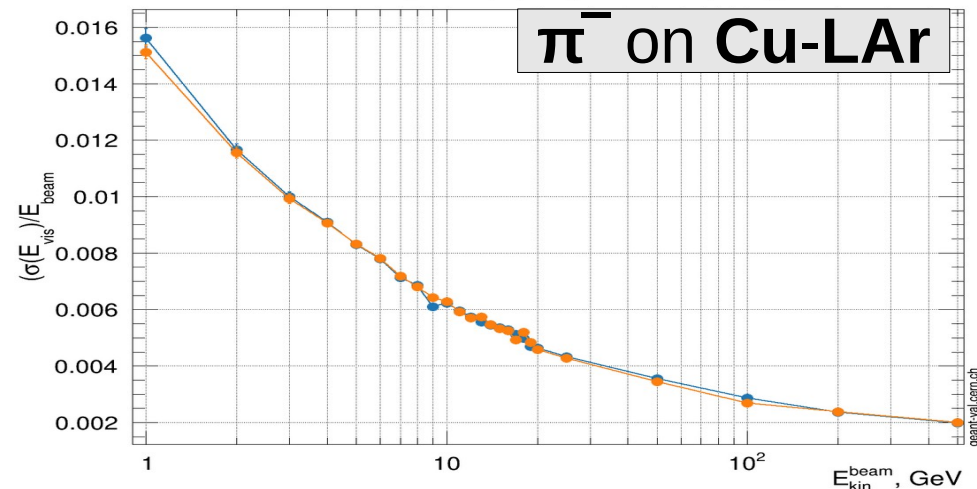


FTFP_BERT : Energy Width

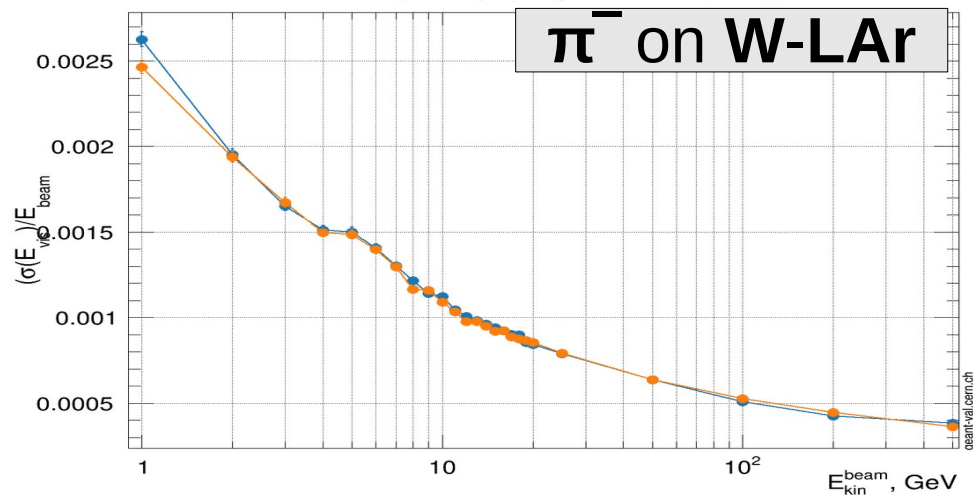
Normalized width | Beam: pi- | Target: TileCal | FTFP_BERT



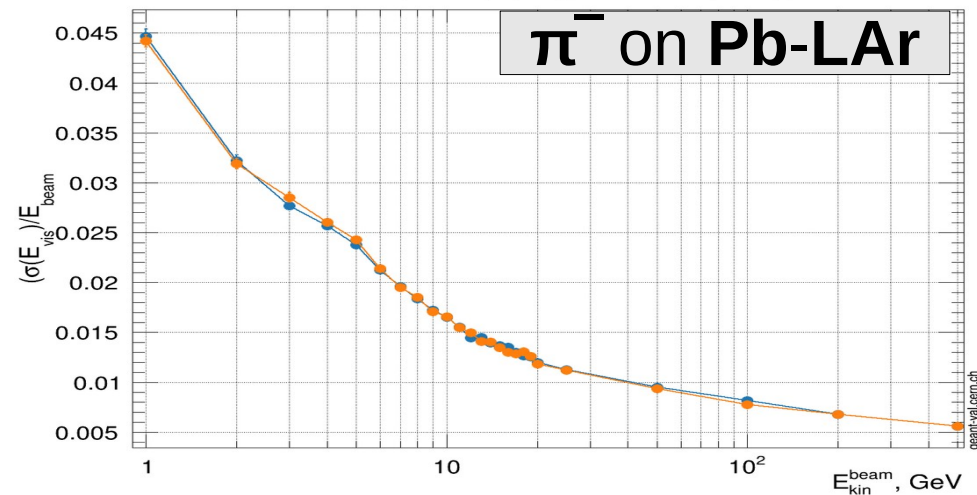
Normalized width | Beam: pi- | Target: AtlasHEC | FTFP_BERT



Normalized width | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

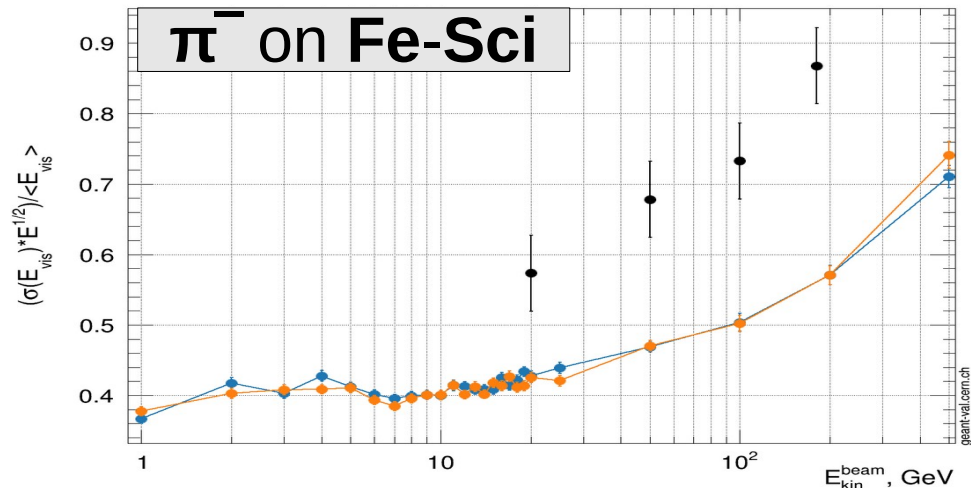


Normalized width | Beam: pi- | Target: AtlasECAL | FTFP_BERT

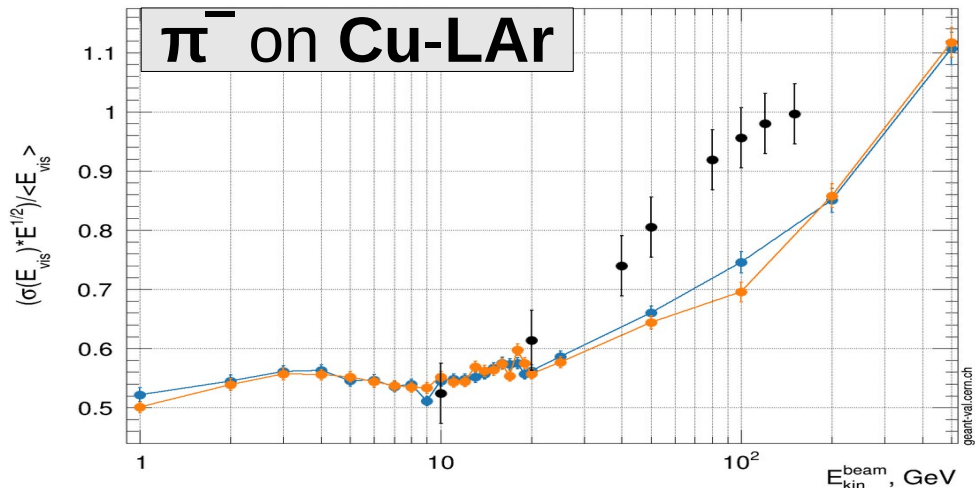


FTFP_BERT : Energy Resolution

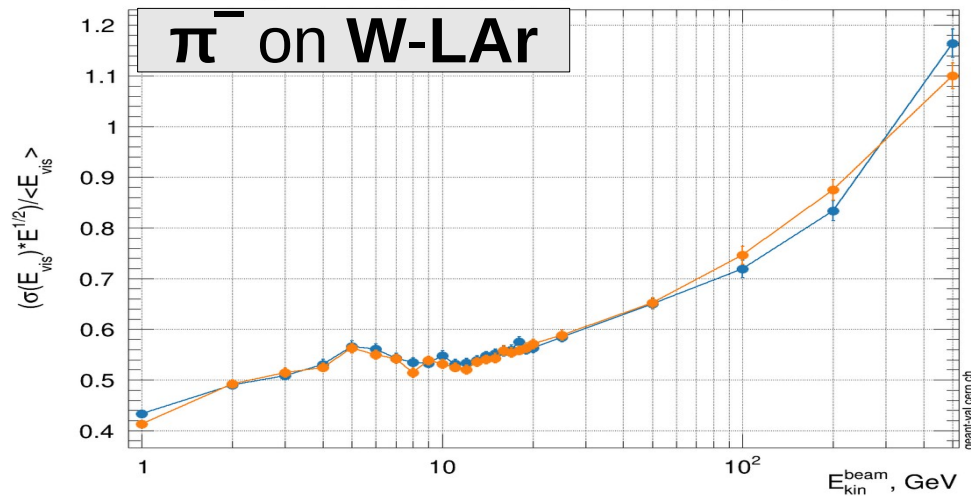
Energy resolution | Beam: pi- | Target: TileCal



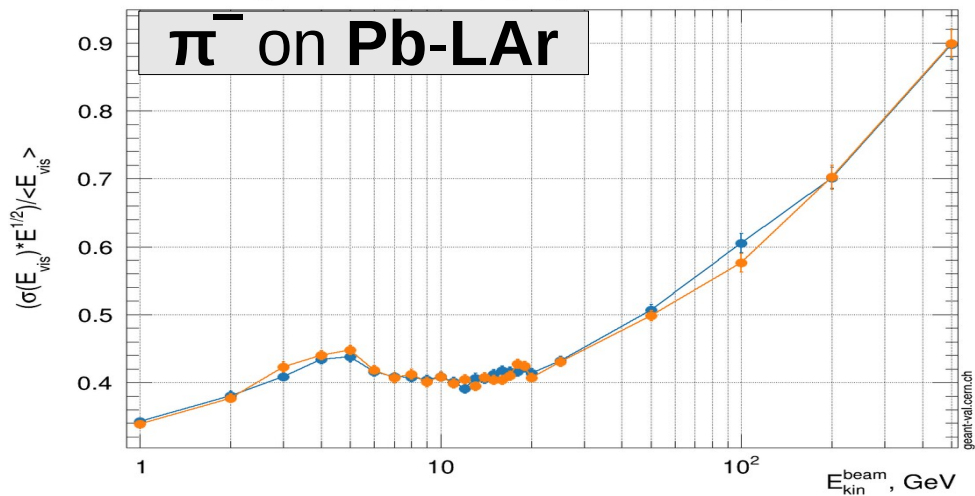
Energy resolution | Beam: pi- | Target: AtlasHEC



Energy resolution | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

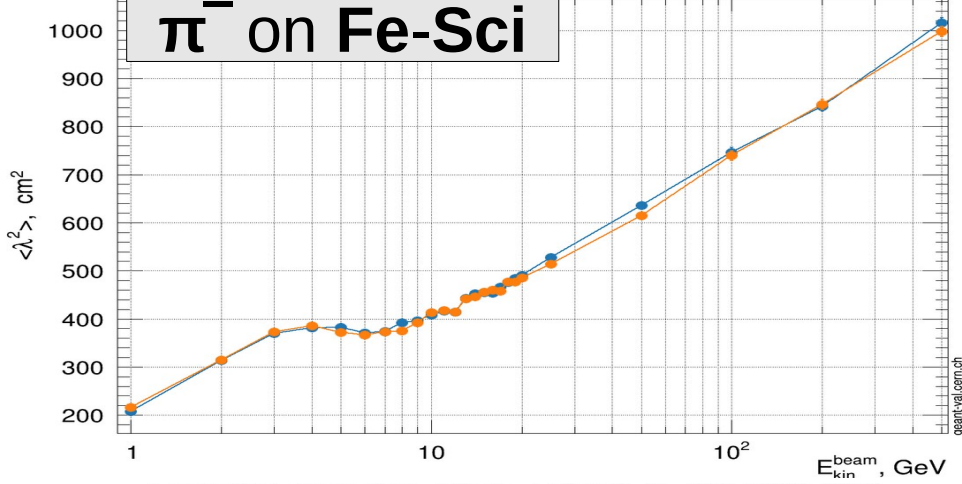


Energy resolution | Beam: pi- | Target: AtlasECAL | FTFP_BERT

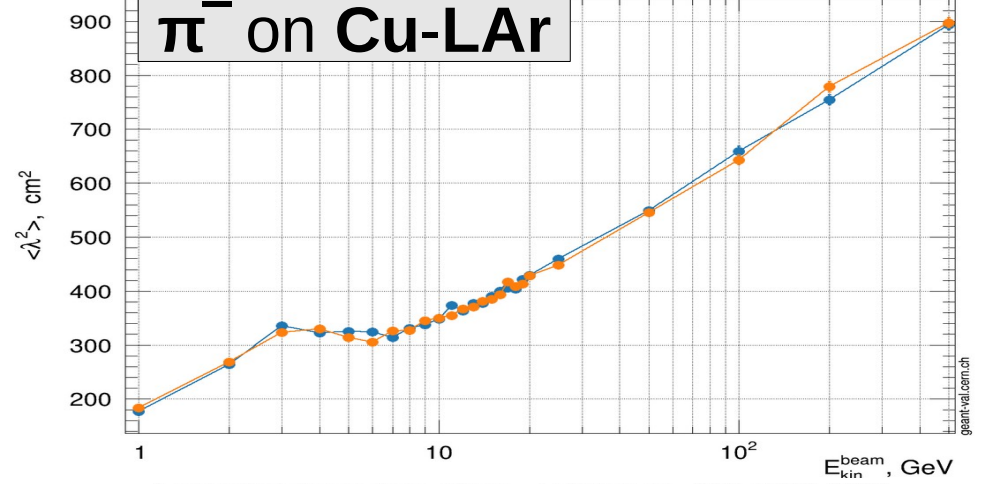


FTFP_BERT : Longitudinal Shape

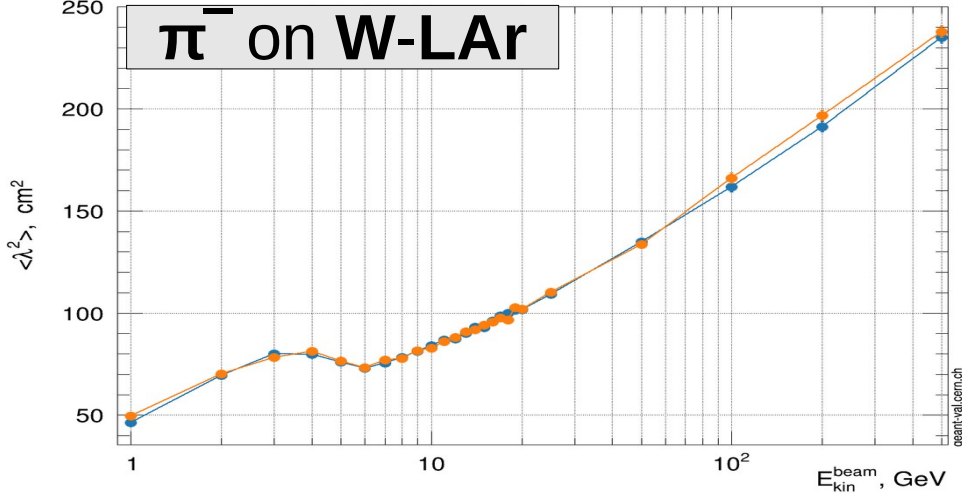
Longitudinal shower shape | Beam: pi- | Target: TileCal | FTFP_BERT



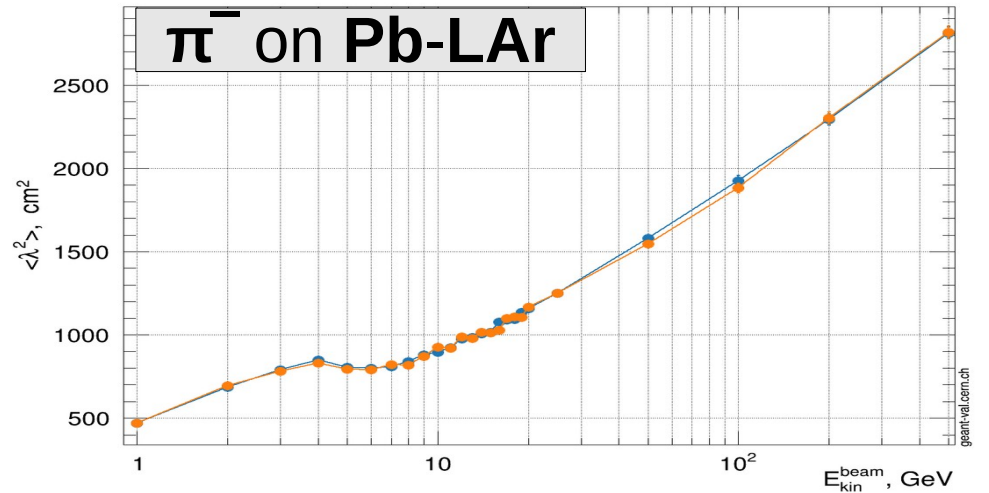
Longitudinal shower shape | Beam: pi- | Target: AtlasHEC | FTFP_BERT



Longitudinal shower shape | Beam: pi- | Target: AtlasFCAL | FTFP_BERT



Longitudinal shower shape | Beam: pi- | Target: AtlasECAL | FTFP_BERT



10.7.p01

10.7.p02

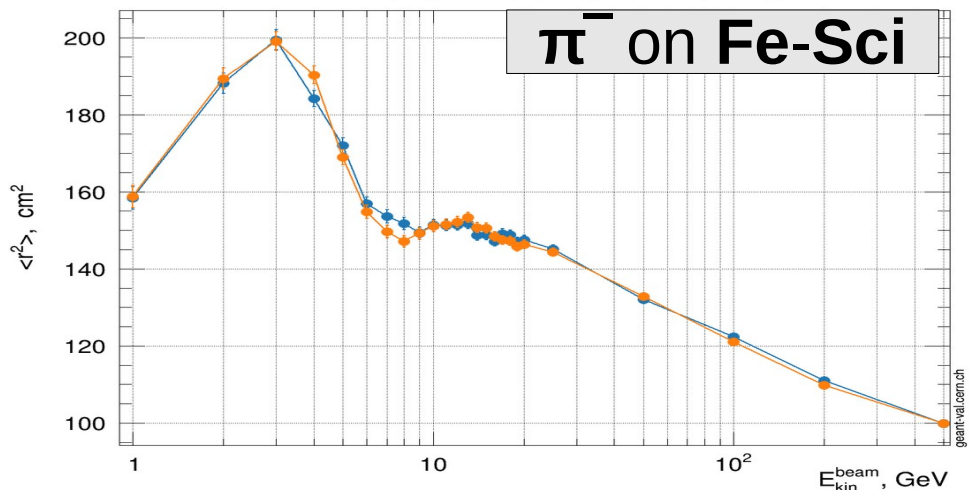
10.7.p01

10.7.p02

FTFP_BERT : Lateral Shape

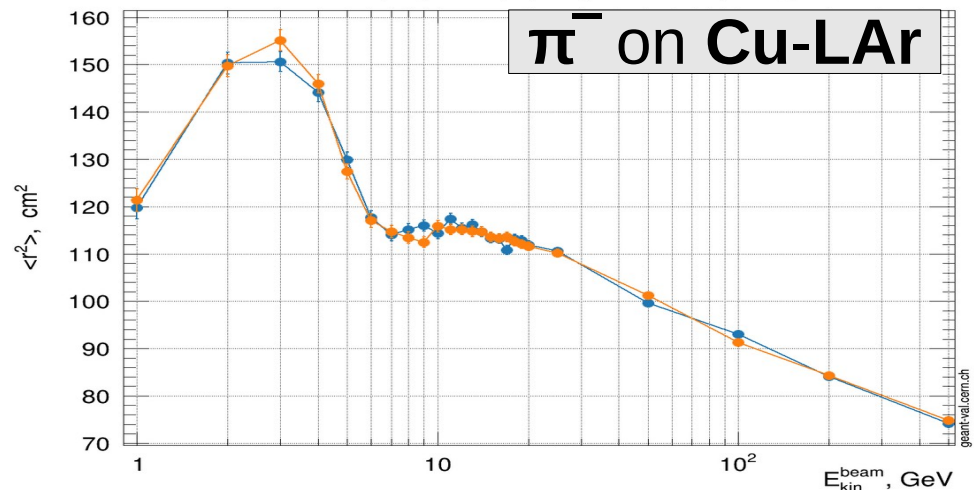
Lateral shower shape | Beam: pi- | Target: TileCal | FTFP_BERT

π^- on Fe-Sci



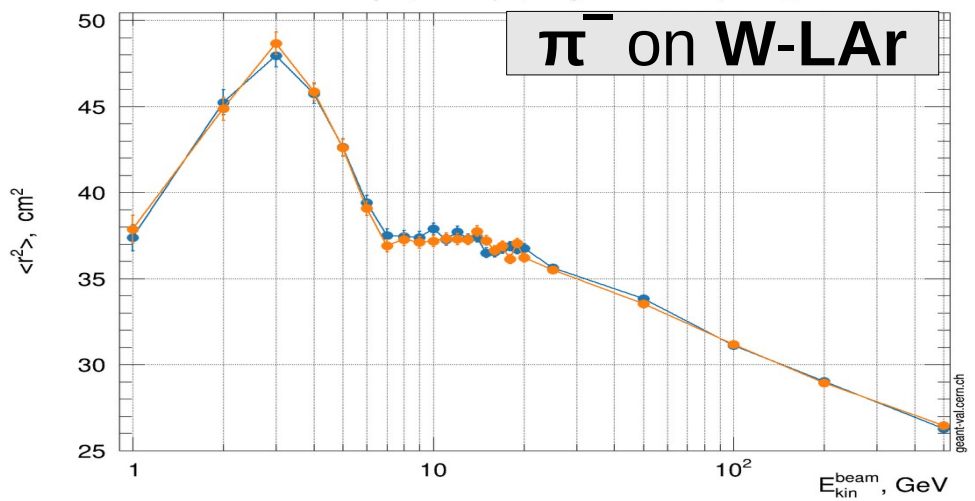
Lateral shower shape | Beam: pi- | Target: AtlasHEC | FTFP_BERT

π^- on Cu-LAr



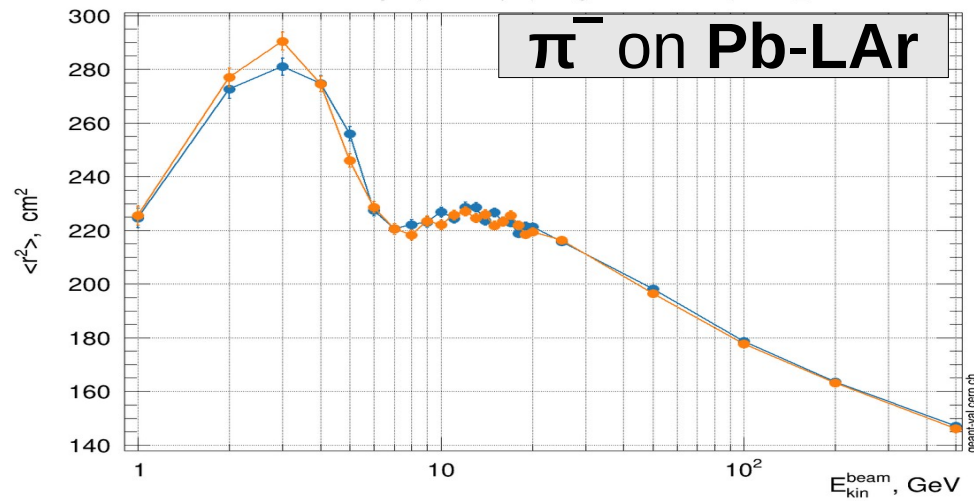
Lateral shower shape | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

π^- on W-LAr



Lateral shower shape | Beam: pi- | Target: AtlasECAL | FTFP_BERT

π^- on Pb-LAr



10.7.p01

10.7.p02

10.7.p01

10.7.p02

Conclusions

- **G4 10.7.p02**
 - No crashes, infinite loops, or new warnings
 - Reproducibility OK
 - Hadron showers
 - Similar to those of G4 10.7.p01

Back-up : Ref05

Reminder

- Hadron showers in G4 10.7.ref05 have
 - ~1% smaller visible energy
 - ~1-2% narrower showers
- with respect to those of G4 10.7.ref04
- Not clear the reason for these changes

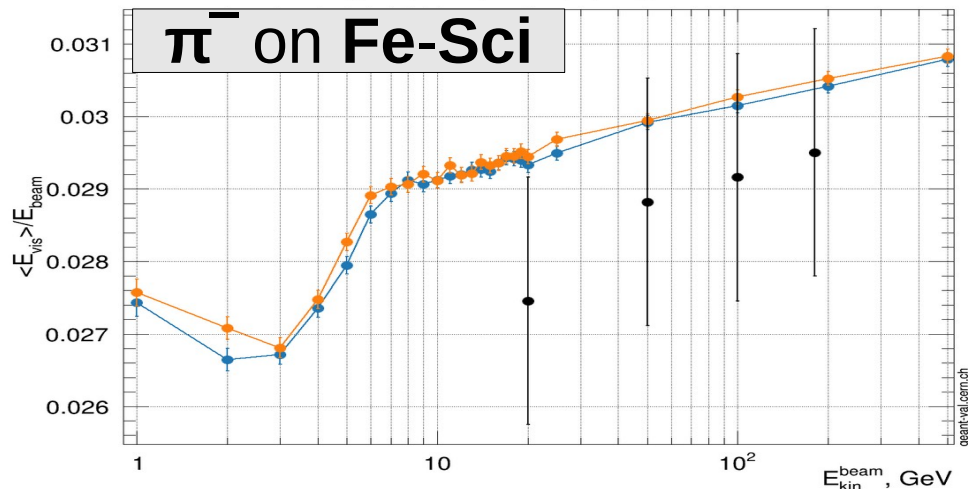
Pion- showers: FTFP_BERT

G4 10.7.ref05

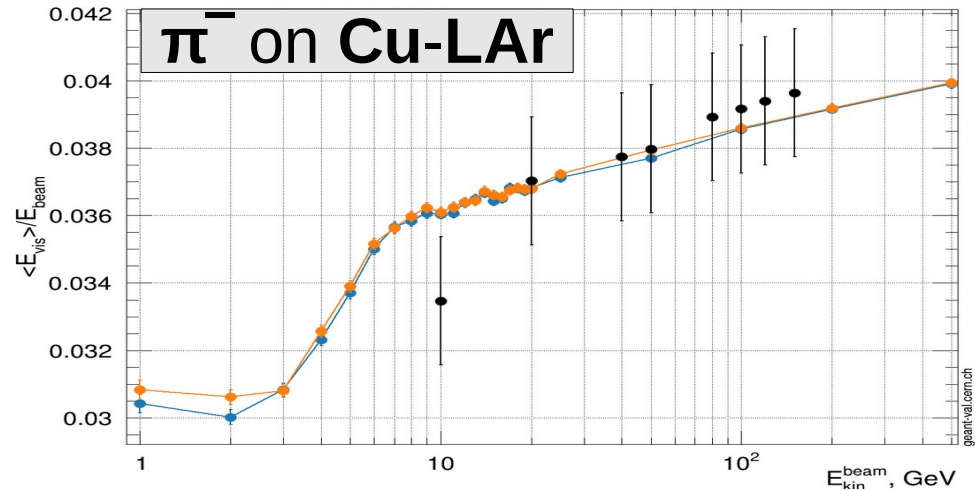
G4 10.7.ref04

FTFP_BERT : Energy Response

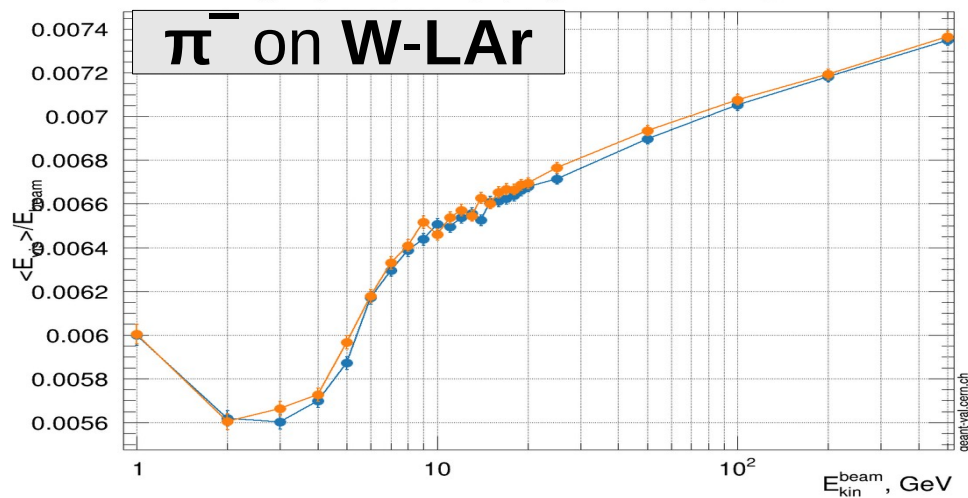
Energy response | Beam: pi- | Target: TileCal



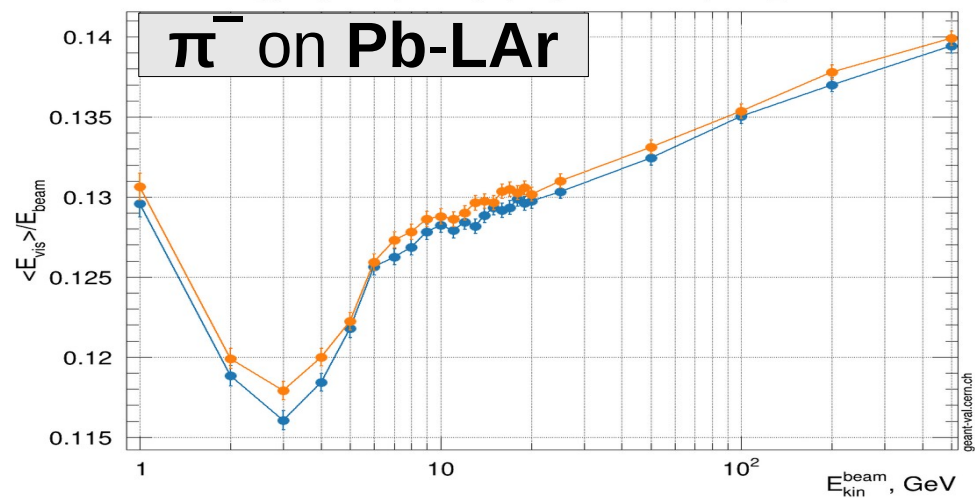
Energy response | Beam: pi- | Target: AtlasHEC



Energy response | Beam: pi- | Target: AtlasFCAL | FTFP_BERT



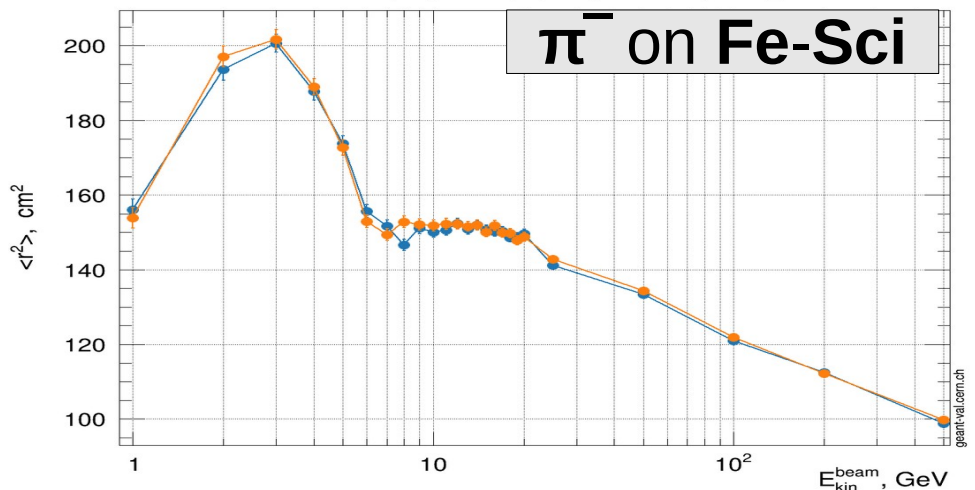
Energy response | Beam: pi- | Target: AtlasECAL | FTFP_BERT



FTFP_BERT : Lateral Shape

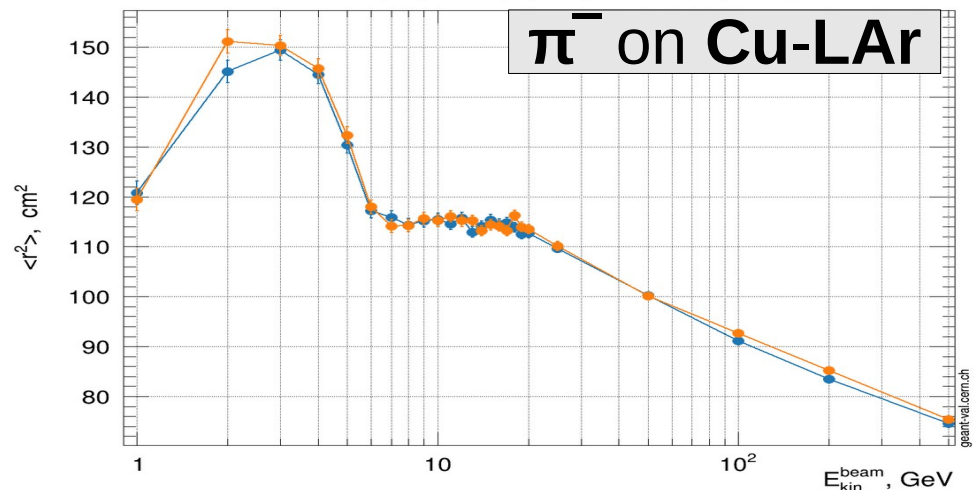
Lateral shower shape | Beam: pi- | Target: TileCal | FTFP_BERT

π^- on Fe-Sci



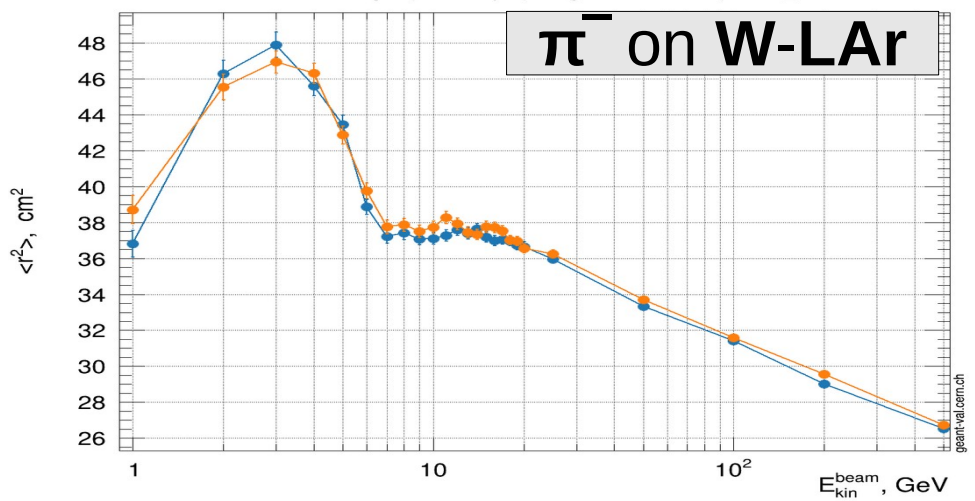
Lateral shower shape | Beam: pi- | Target: AtlasHEC | FTFP_BERT

π^- on Cu-LAr



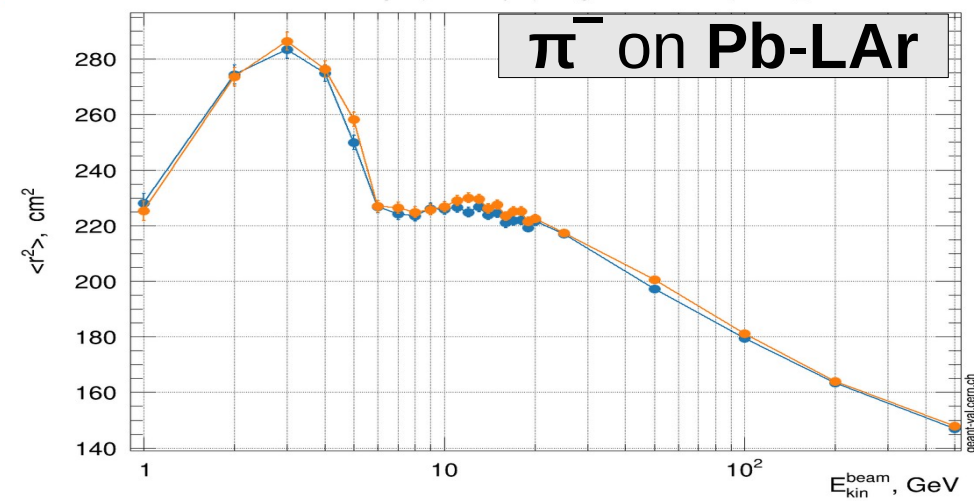
Lateral shower shape | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

π^- on W-LAr



Lateral shower shape | Beam: pi- | Target: AtlasECAL | FTFP_BERT

π^- on Pb-LAr



Bug introduced in Ref03 and then fixed in Ref05

- A bug was introduced in G4 10.7.ref**03** in the method:
 - **G4ionEffectiveCharge::EffectiveChargeSquareRatio**but the changes in hadronic showers with respect to 10.7.ref02 were overlooked and not reported (my fault!)
- The bug was then fixed in G4 10.7.ref**05**
- Because of this bug, there are two equivalent classes of hadronic showers which differ by **~1% in energy response** and **~1-2% in lateral shower shapes**
 - 10.7.{ p01 , p02 , ref00 , ref01 , ref02 , ref05 } OK !
 - 10.7.{ ref03 , ref04 } Buggy !

Pion- showers: FTFP_BERT

G4 10.7.ref03

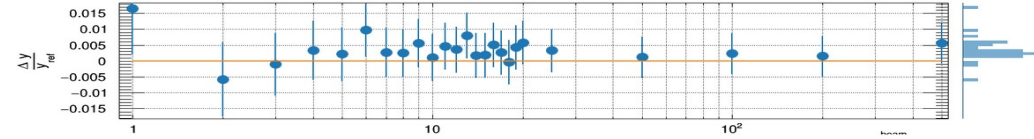
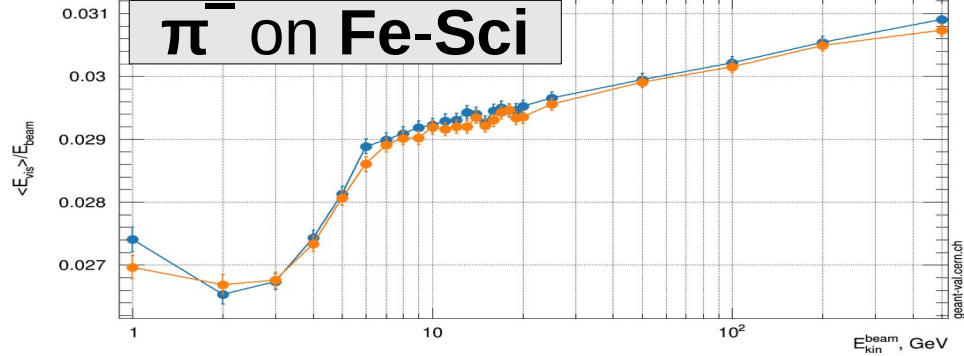
G4 10.7.ref02

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

FTFP_BERT : Energy Response

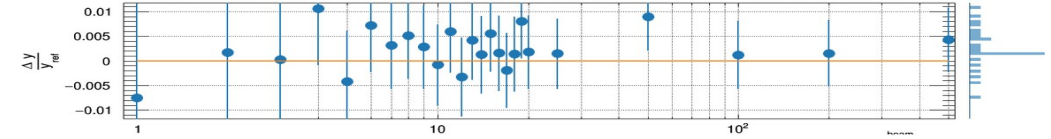
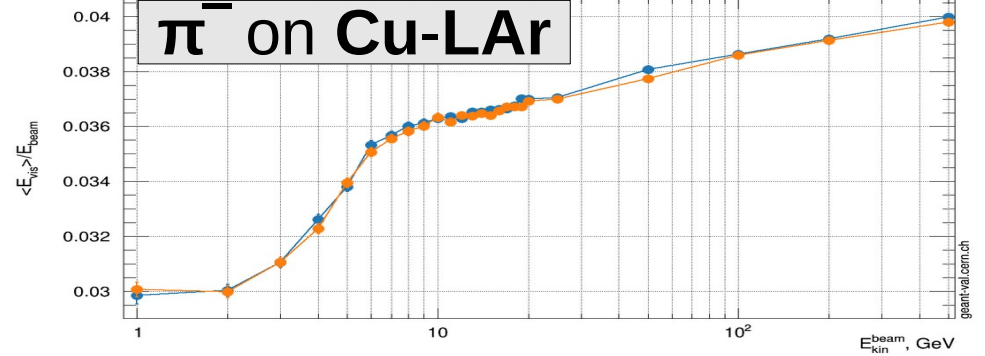
Energy response | Beam: pi- | Target: TileCal | FTFP_BERT | $\chi^2/n.d.f. = 0.328034$

π^- on Fe-Sci



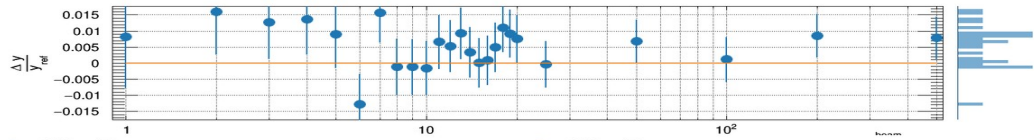
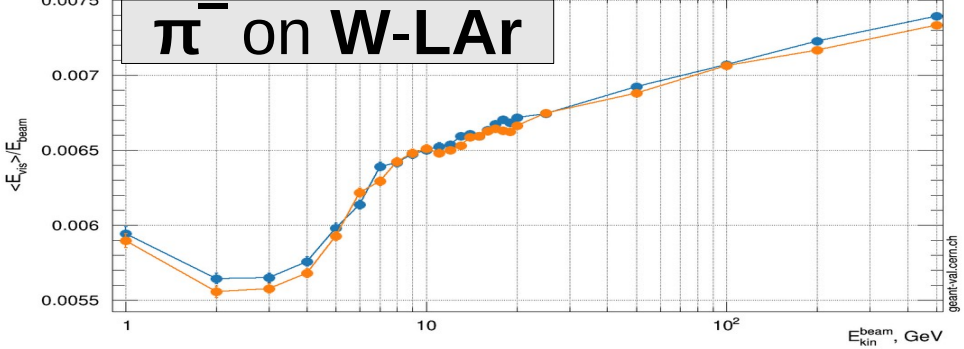
Energy response | Beam: pi- | Target: AtlasHEC | FTFP_BERT | $\chi^2/n.d.f. = 0.390291$

π^- on Cu-LAr



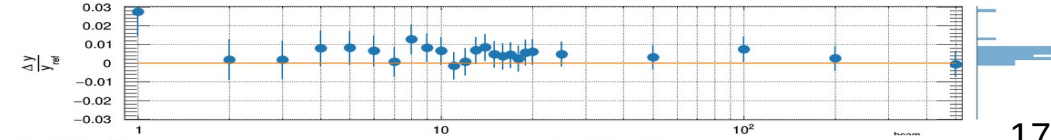
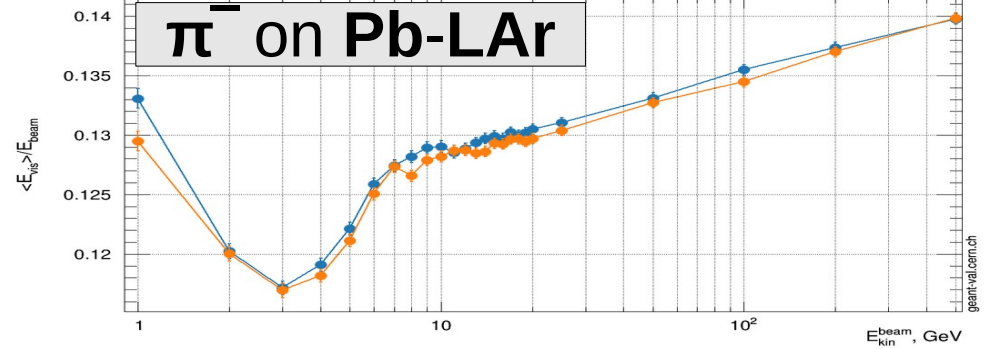
Energy response | Beam: pi- | Target: AtlasFCAL | FTFP_BERT | $\chi^2/n.d.f. = 1.00744$

π^- on W-LAr



Energy response | Beam: pi- | Target: AtlasECAL | FTFP_BERT | $\chi^2/n.d.f. = 0.678439$

π^- on Pb-LAr



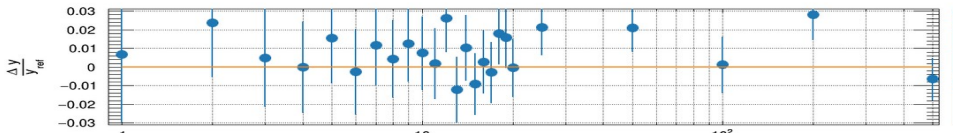
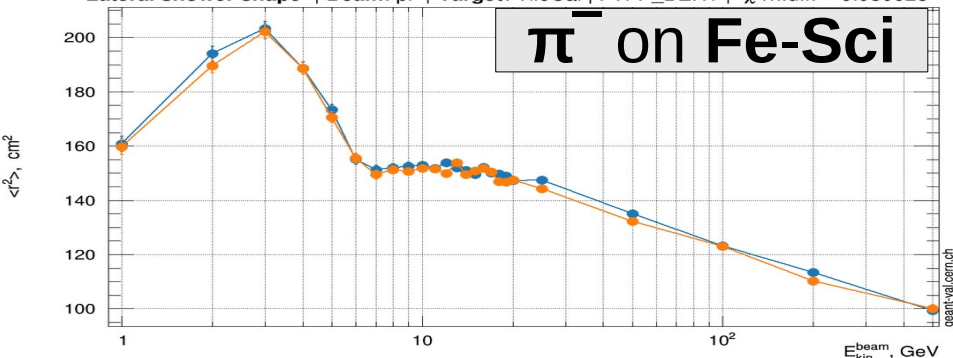
10.7.ref03 10.7.ref02

10.7.ref03 10.7.ref02

FTFP_BERT : Lateral Shape

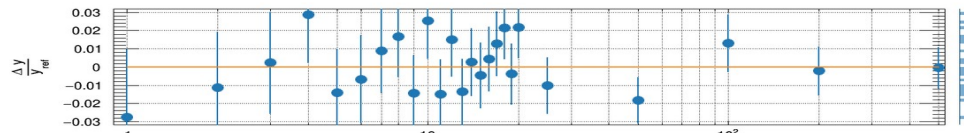
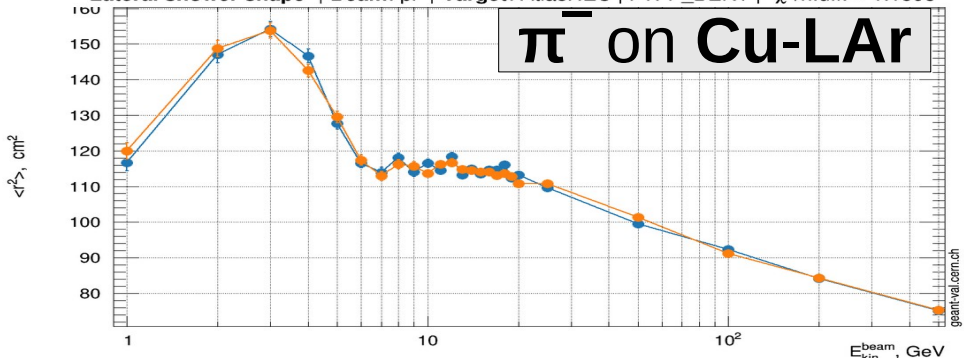
Lateral shower shape | Beam: pi- | Target: TileCal | FTFP_BERT | $\chi^2/n.d.f. = 0.980028$

π^- on Fe-Sci



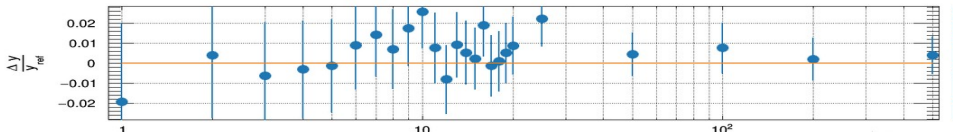
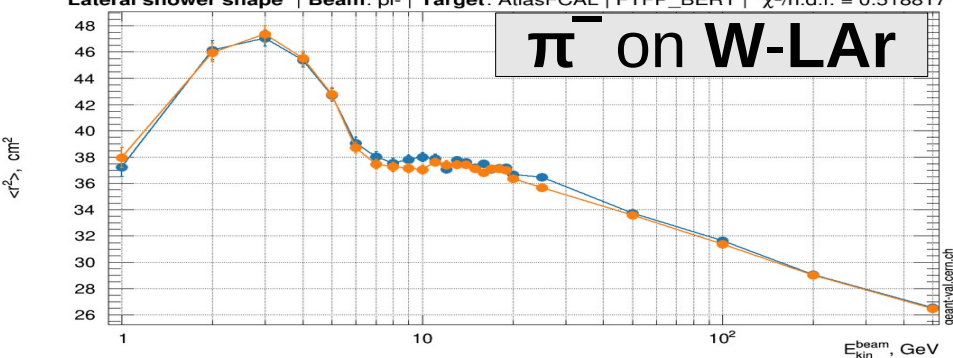
Lateral shower shape | Beam: pi- | Target: AtlasHEC | FTFP_BERT | $\chi^2/n.d.f. = 1.1595$

π^- on Cu-LAr



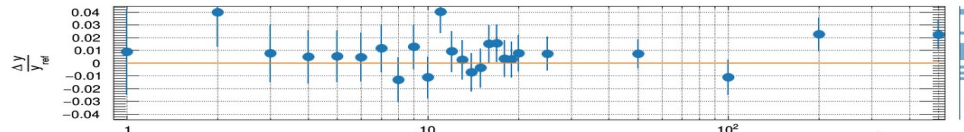
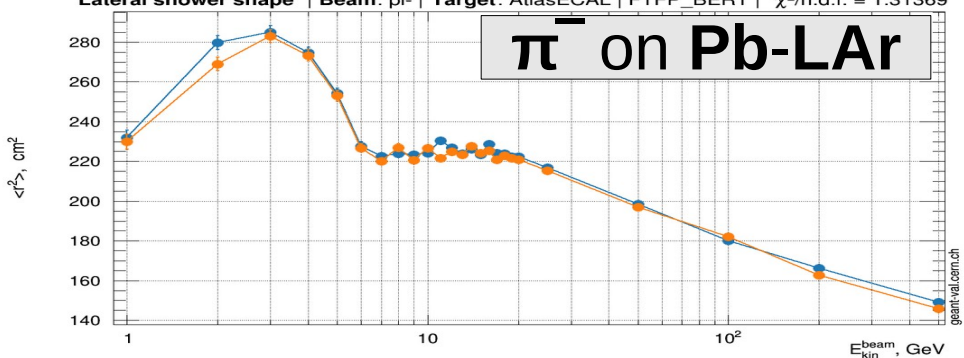
Lateral shower shape | Beam: pi- | Target: AtlasFCAL | FTFP_BERT | $\chi^2/n.d.f. = 0.518817$

π^- on W-LAr



Lateral shower shape | Beam: pi- | Target: AtlasECAL | FTFP_BERT | $\chi^2/n.d.f. = 1.31369$

π^- on Pb-LAr



Pion- showers: FTFP_BERT

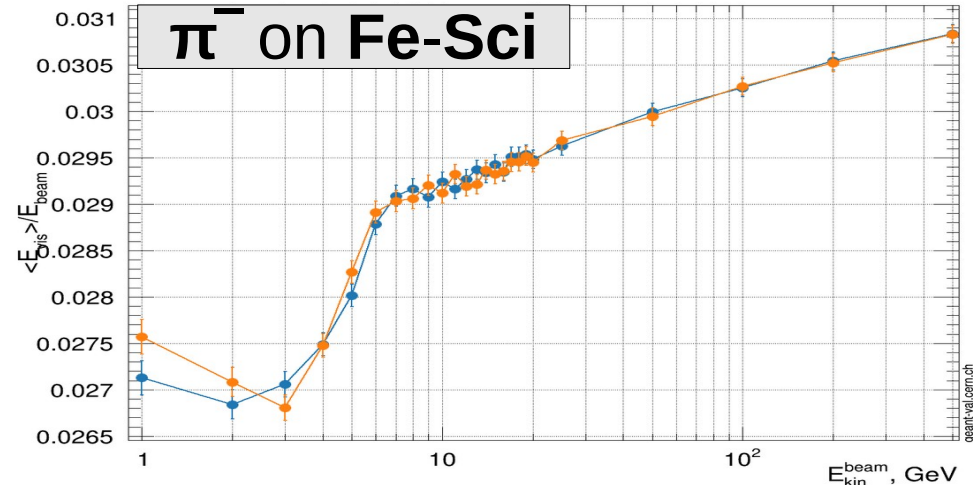
G4 10.7.ref05a as Ref05 but without bug-fix

G4 10.7.ref04

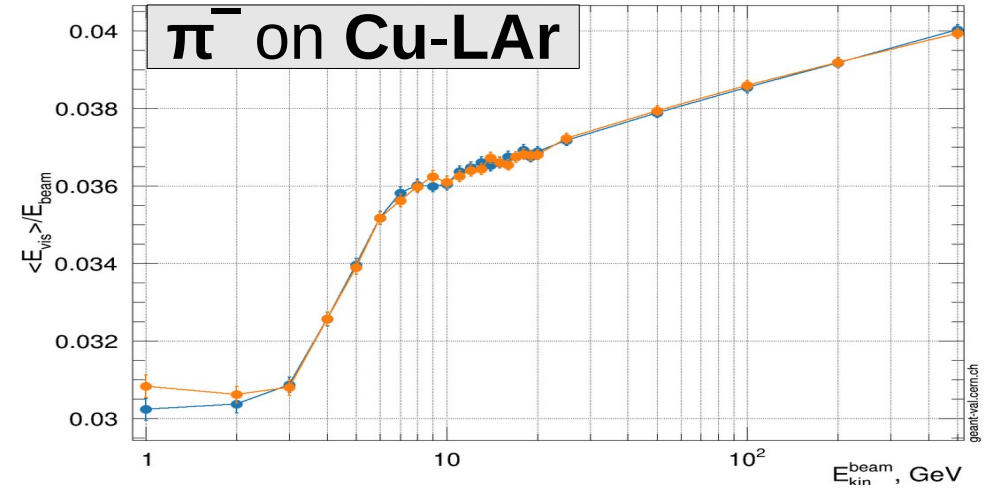
*Note : conventional Birks treatment
(easier and no experimental h/e to fit !)*

FTFP_BERT : Energy Response

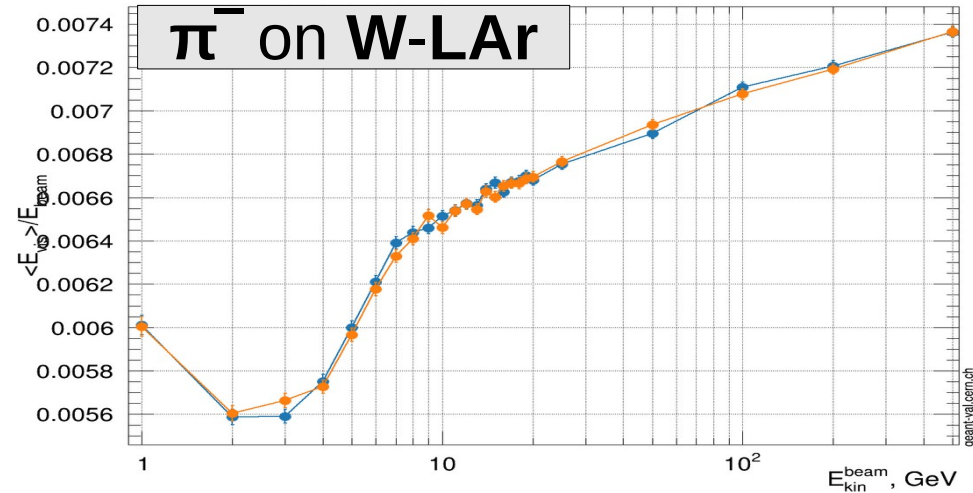
Energy response | Beam: pi- | Target: TileCal | FTFP_BERT



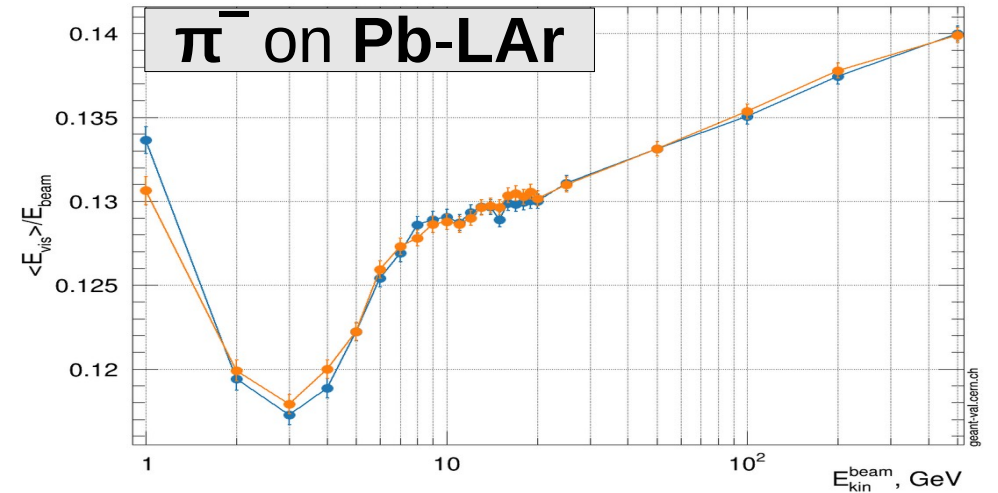
Energy response | Beam: pi- | Target: AtlasHEC | FTFP_BERT



Energy response | Beam: pi- | Target: AtlasFCAL | FTFP_BERT



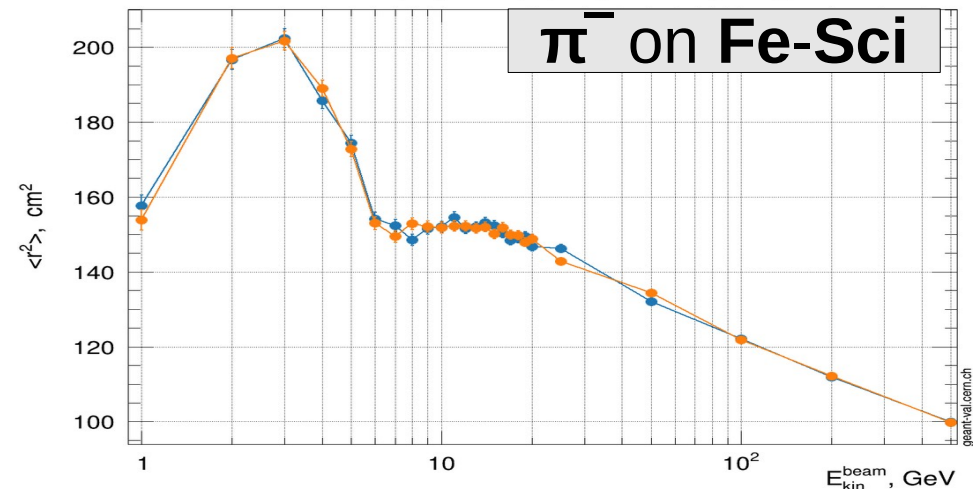
Energy response | Beam: pi- | Target: AtlasECAL | FTFP_BERT



FTFP_BERT : Lateral Shape

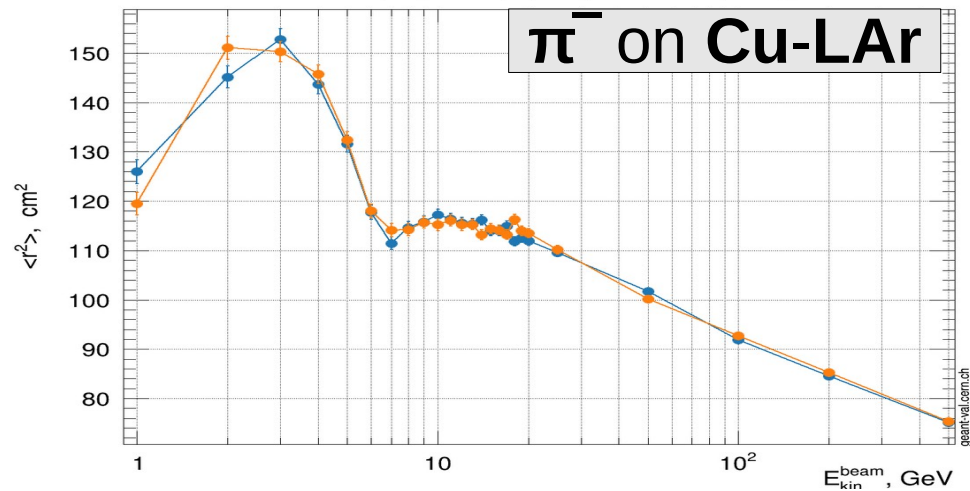
Lateral shower shape | Beam: pi- | Target: TileCal | FTFP_BERT

π^- on Fe-Sci



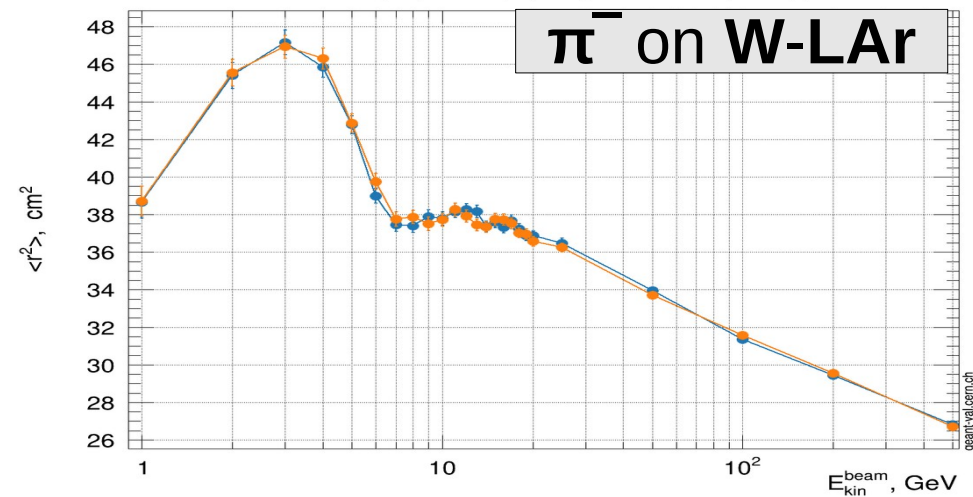
Lateral shower shape | Beam: pi- | Target: AtlasHEC | FTFP_BERT

π^- on Cu-LAr



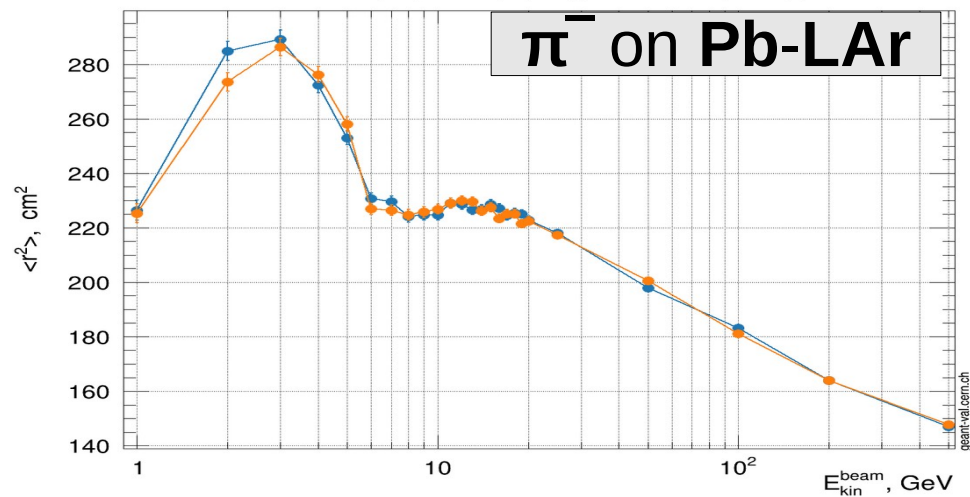
Lateral shower shape | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

π^- on W-LAr



Lateral shower shape | Beam: pi- | Target: AtlasECAL | FTFP_BERT

π^- on Pb-LAr



Pion- showers: FTFP_BERT

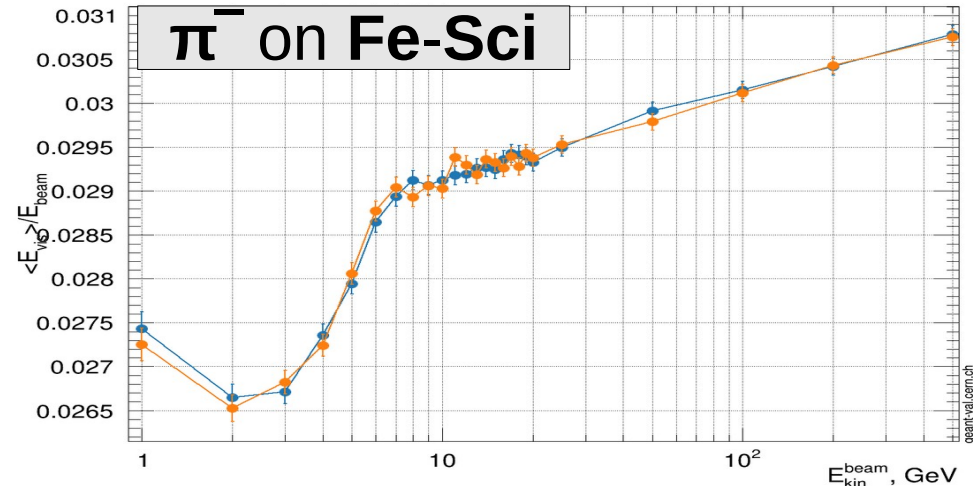
G4 10.7.ref05

G4 10.7.ref04a as Ref04 but with bug-fix

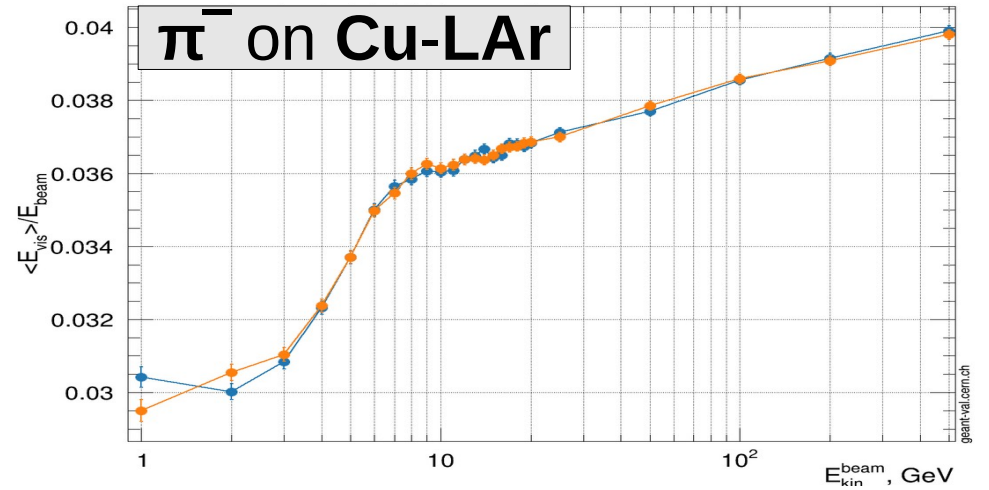
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FTFP_BERT : Energy Response

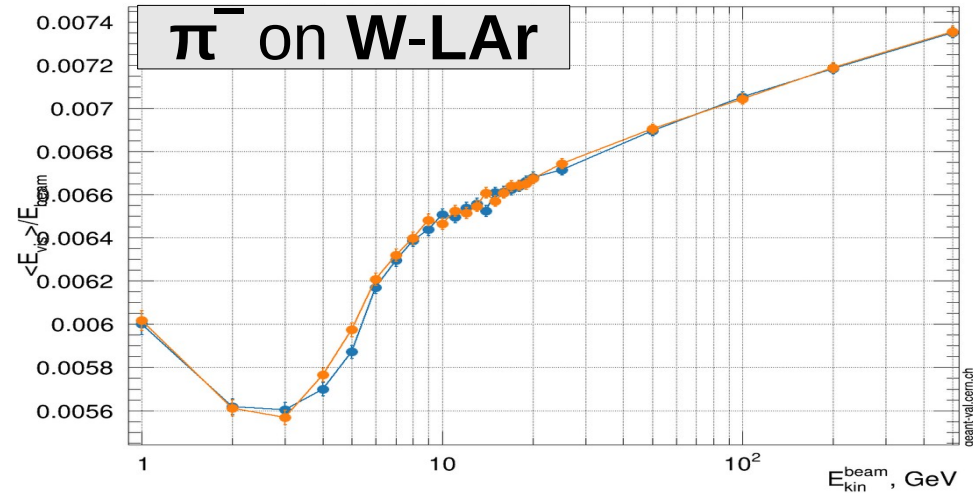
Energy response | Beam: pi- | Target: TileCal | FTFP_BERT



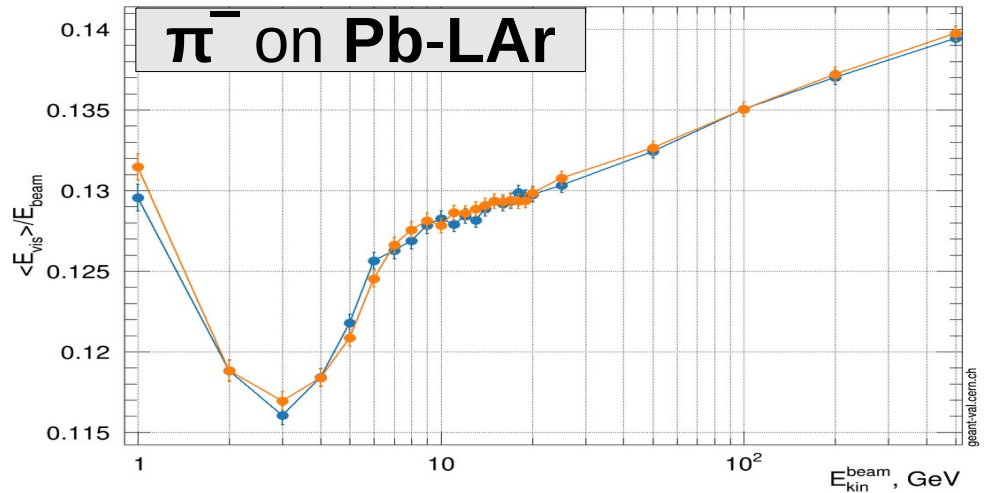
Energy response | Beam: pi- | Target: AtlasHEC | FTFP_BERT



Energy response | Beam: pi- | Target: AtlasFCAL | FTFP_BERT



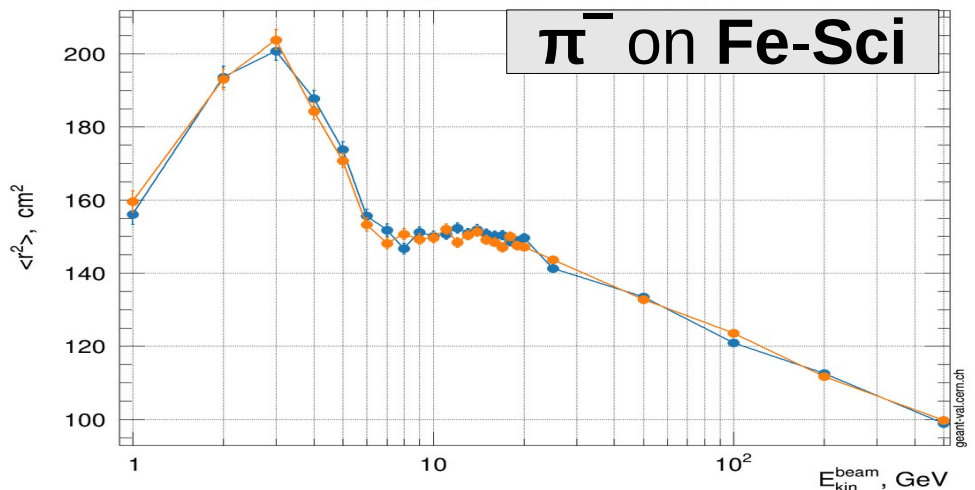
Energy response | Beam: pi- | Target: AtlasECAL | FTFP_BERT



FTFP_BERT : Lateral Shape

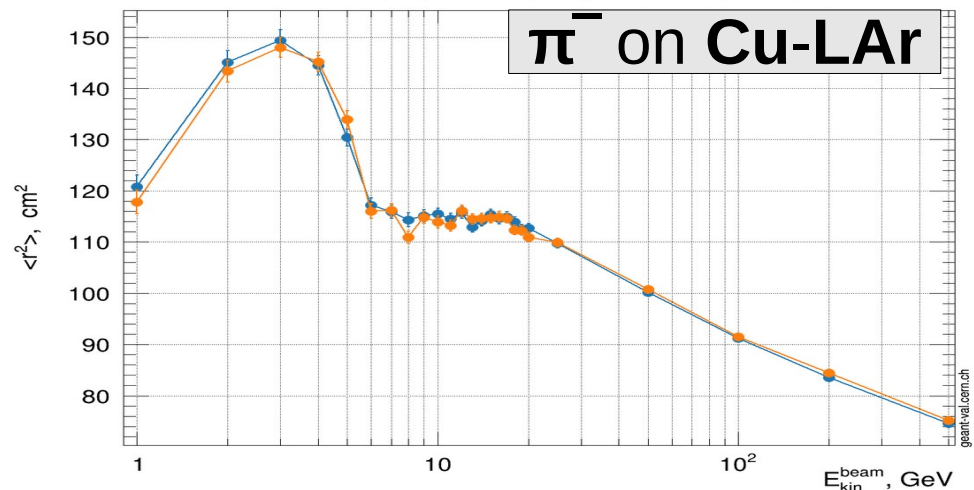
Lateral shower shape | Beam: pi- | Target: TileCal | FTFP_BERT

π^- on Fe-Sci



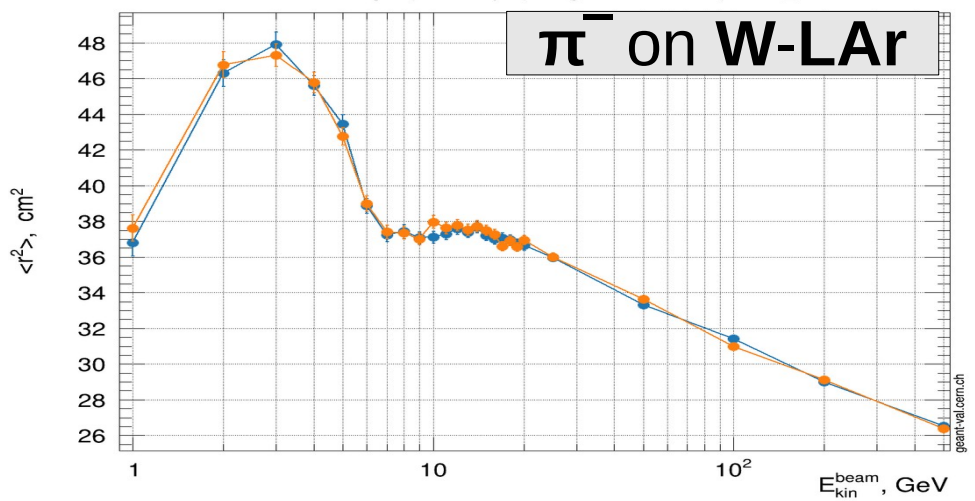
Lateral shower shape | Beam: pi- | Target: AtlasHEC | FTFP_BERT

π^- on Cu-LAr



Lateral shower shape | Beam: pi- | Target: AtlasFCAL | FTFP_BERT

π^- on W-LAr



Lateral shower shape | Beam: pi- | Target: AtlasECAL | FTFP_BERT

π^- on Pb-LAr

