Status of **FTF** Hadronic Showers in G4 10.3.ref07

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Introduction & Outline

Reminder: since last year, we have two versions of the G4 string models Fritiof (FTF) and Quark-String-Model (QGS):

1. **Production** (or **stable**) as in public releases G4 10.3.p0x
   good for hadronic showers
2. **Development** as in reference tags (including 10.4β)
   good for thin-target data

In this presentation:

- Changes in the FTF development after G4 10.3 up to now
- Status of FTF hadronic showers
- Curiosity: how the hadronic showers look like for
  FTF + QGS-string-fragmentation ?
- Conclusion & Outlook

G4 10.3.ref07

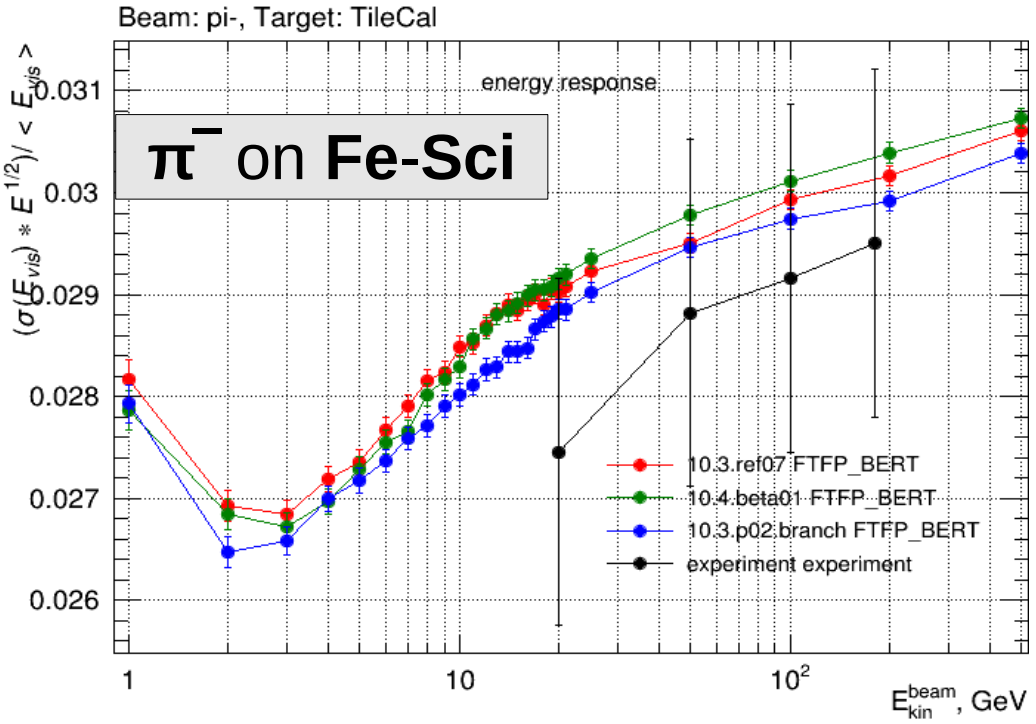
Changes in FTF model since G4 10.3

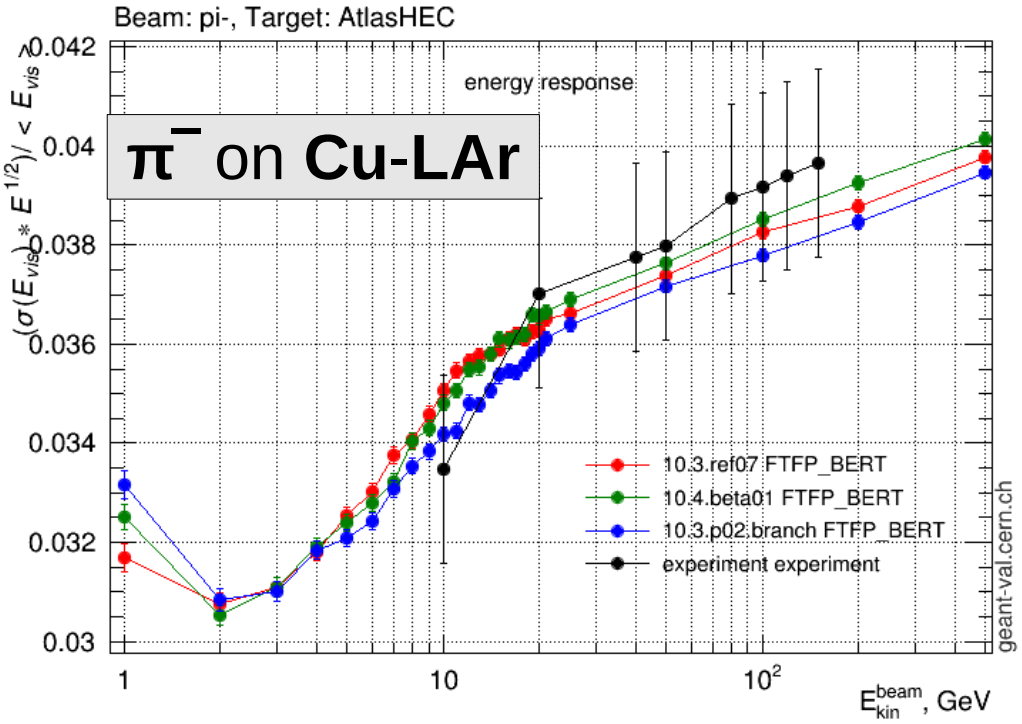
- First implementation of rotating strings with introduction of transverse-mass distribution of hadrons
  - In Lund string fragmentation
    - Not motivated by thin-target data, but to be able to describe the observed mass-dependent Pt-distribution of hadrons
  - Changes made in February 2017, included in G4 10.3.ref02 & 10.4β
  - Major improvements in FTF hadronic showers
    - Lower energy response (especially for heavy absorbers)
    - Wider showers
    - Not far from the hadronic showers of the FTF production version of G4 10.3
- Improved description of pion-nucleon, fixes in rotating strings, and introduction of smearing of resonance masses
  - Motivated by thin-target data (plus PANDA request for smearing)
  - Changes made in July 2017, included in G4 10.3.ref07

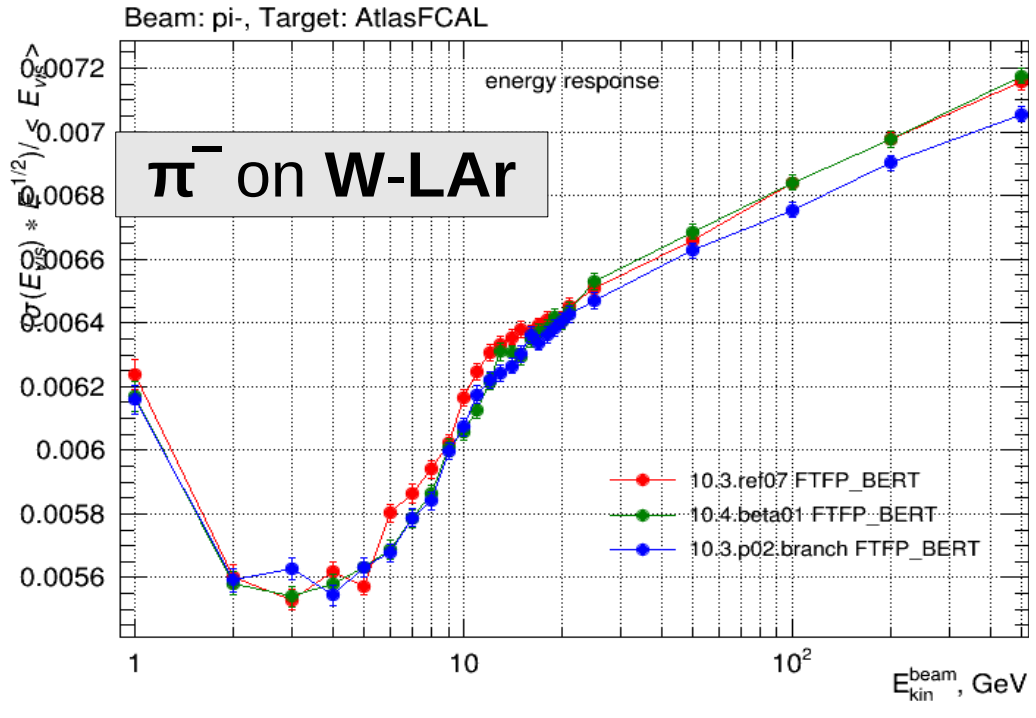
Pion showers: FTFP_BERT

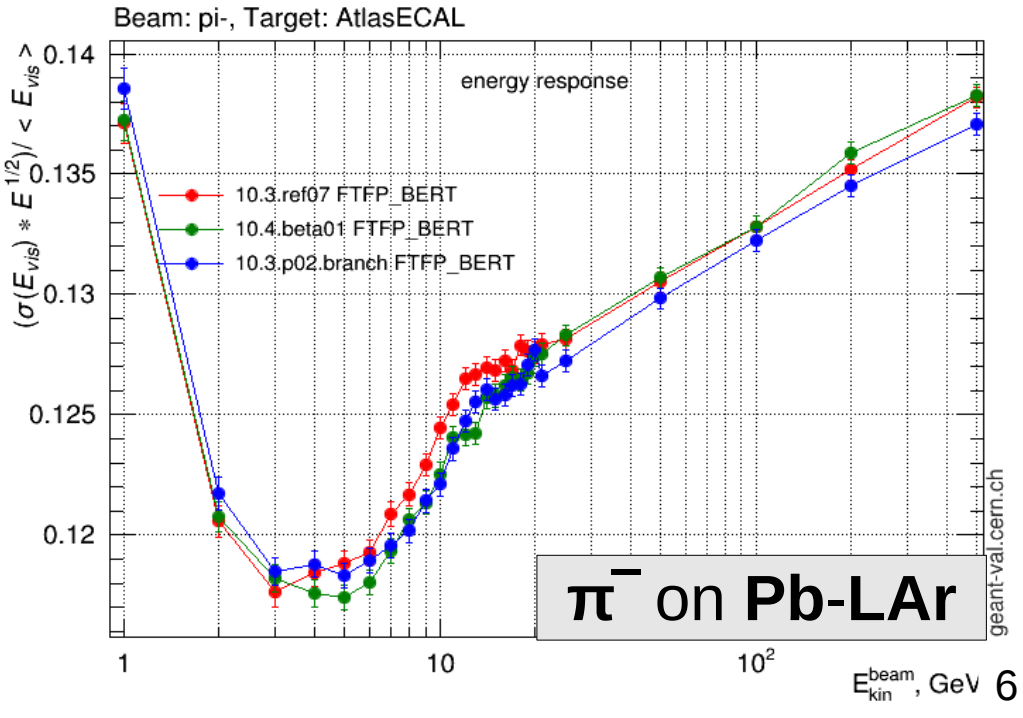
G4 10.3.ref07 ,
10.3.ref06 (= 10.4β) ,
10.3.p02

FTFP_BERT : Energy Response

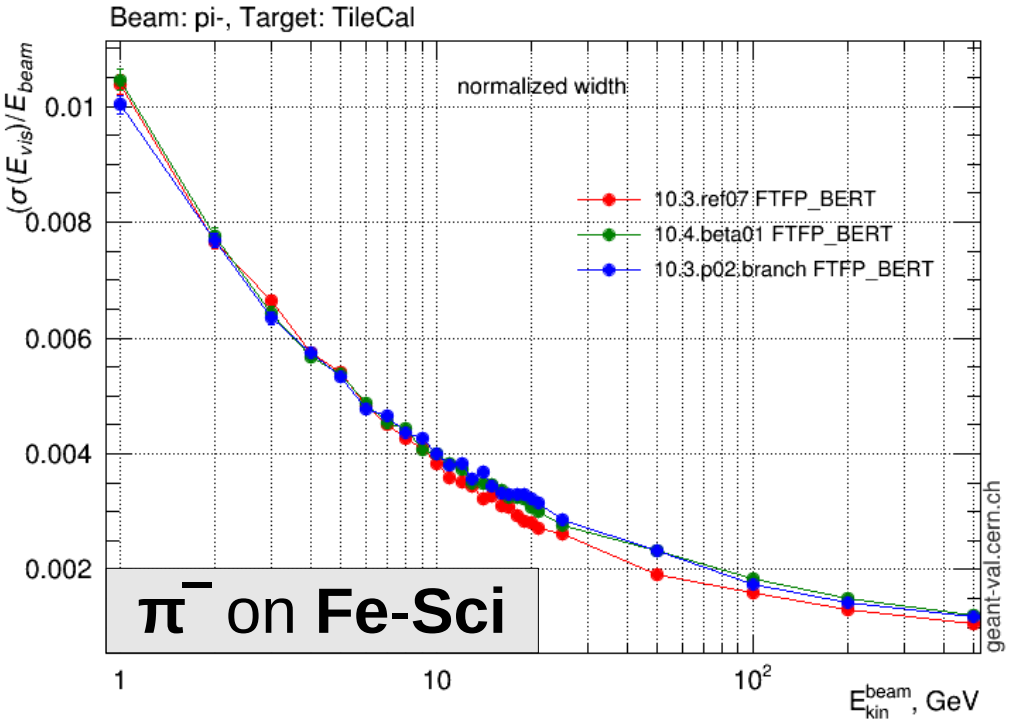


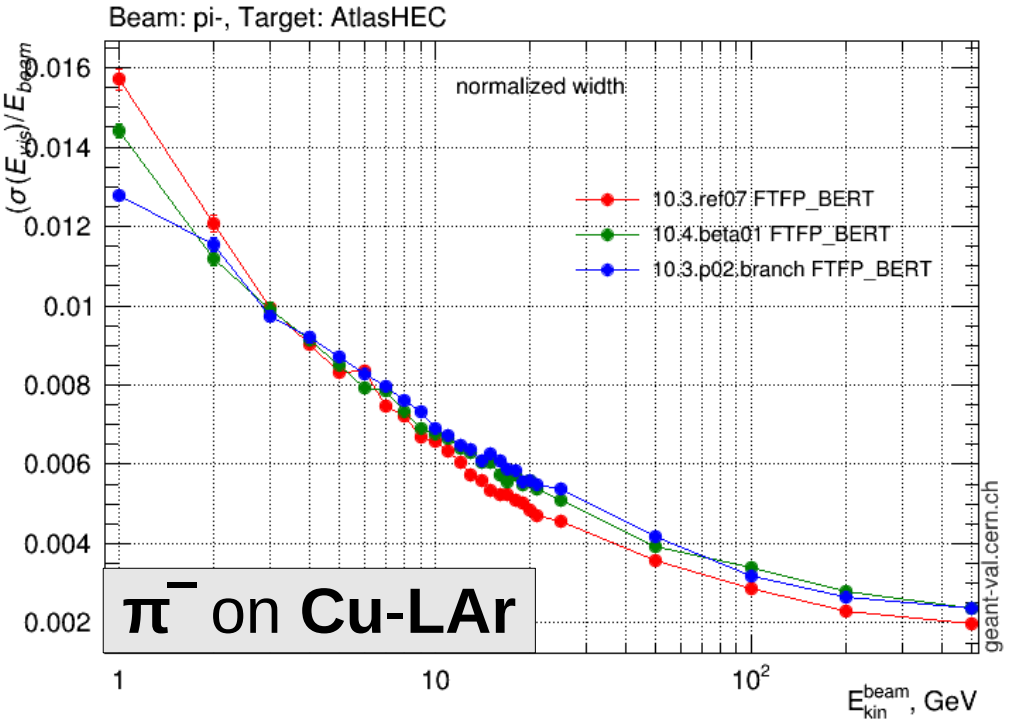


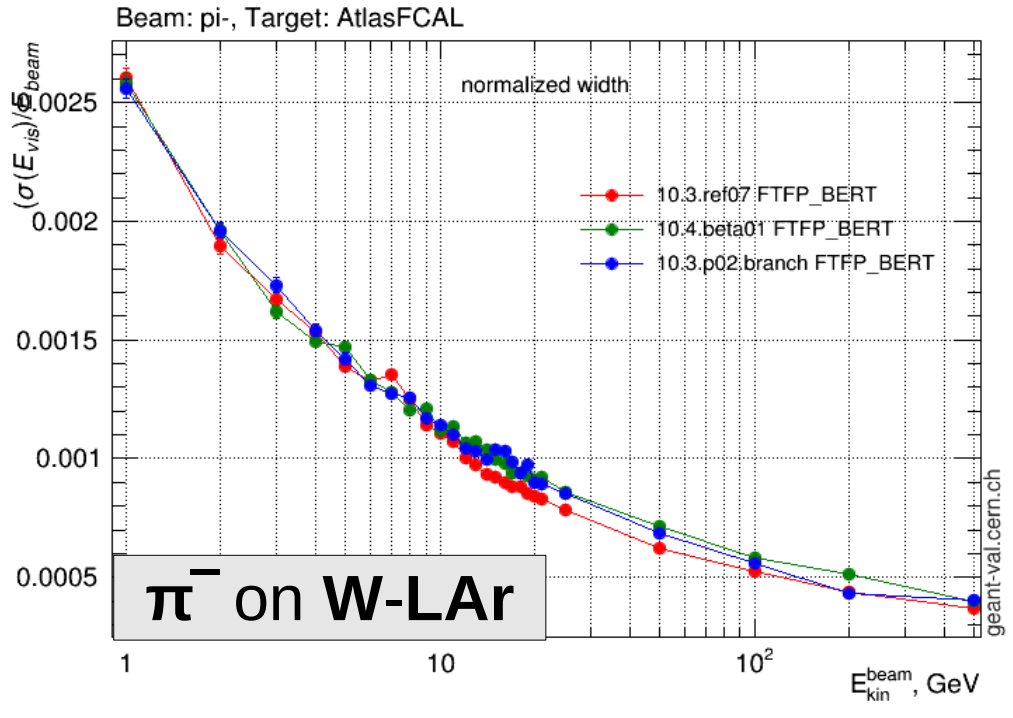


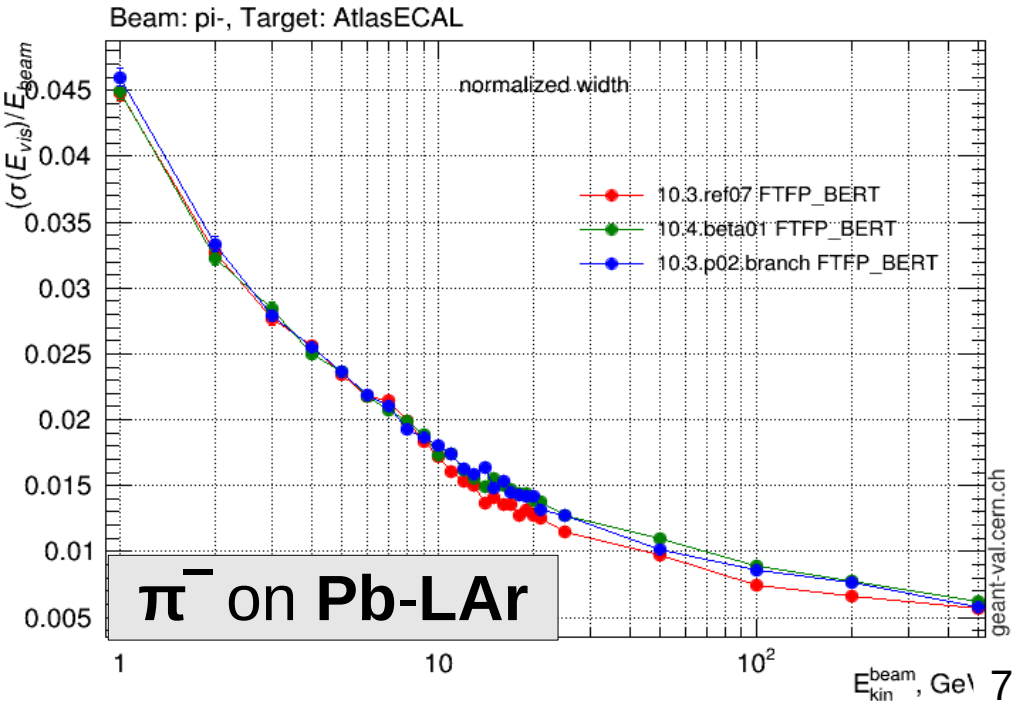


FTFP_BERT : Energy Width

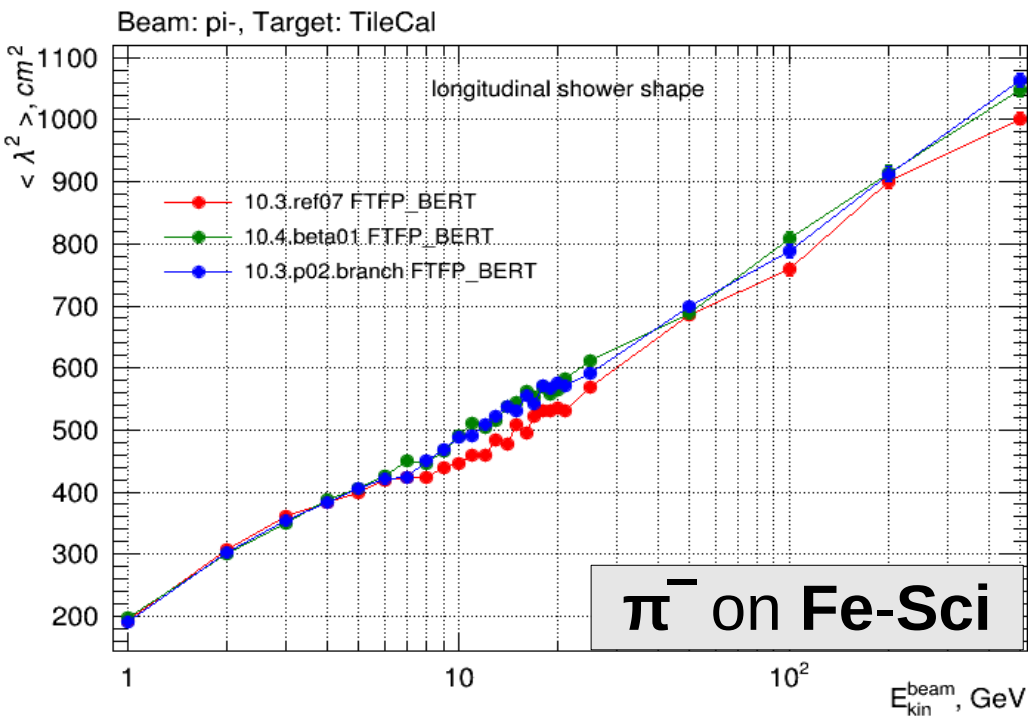


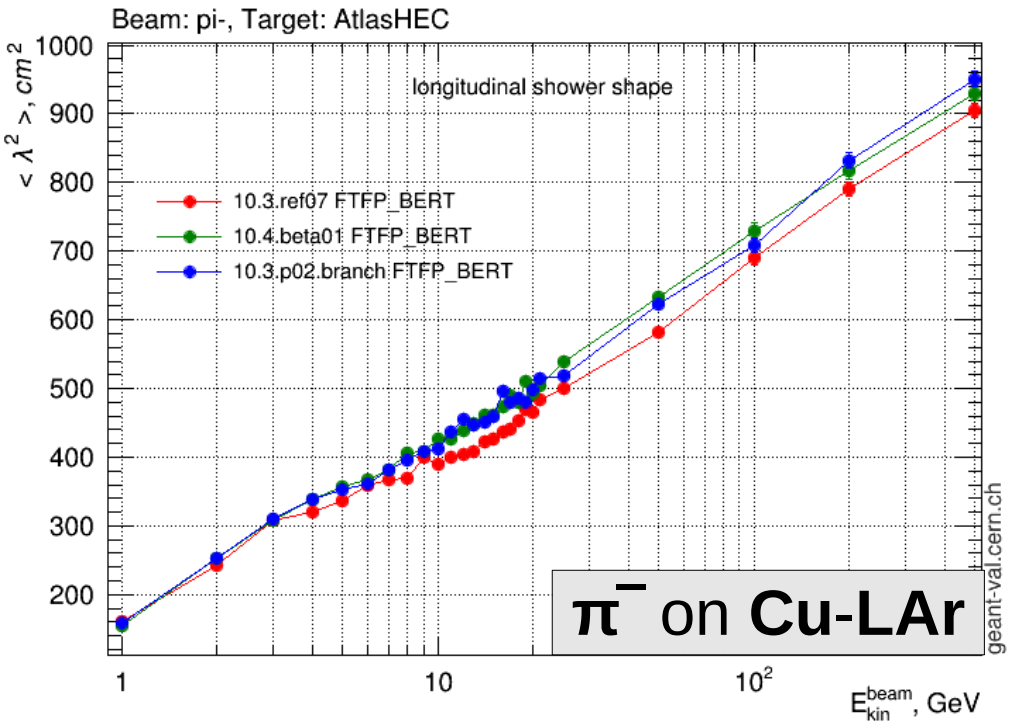


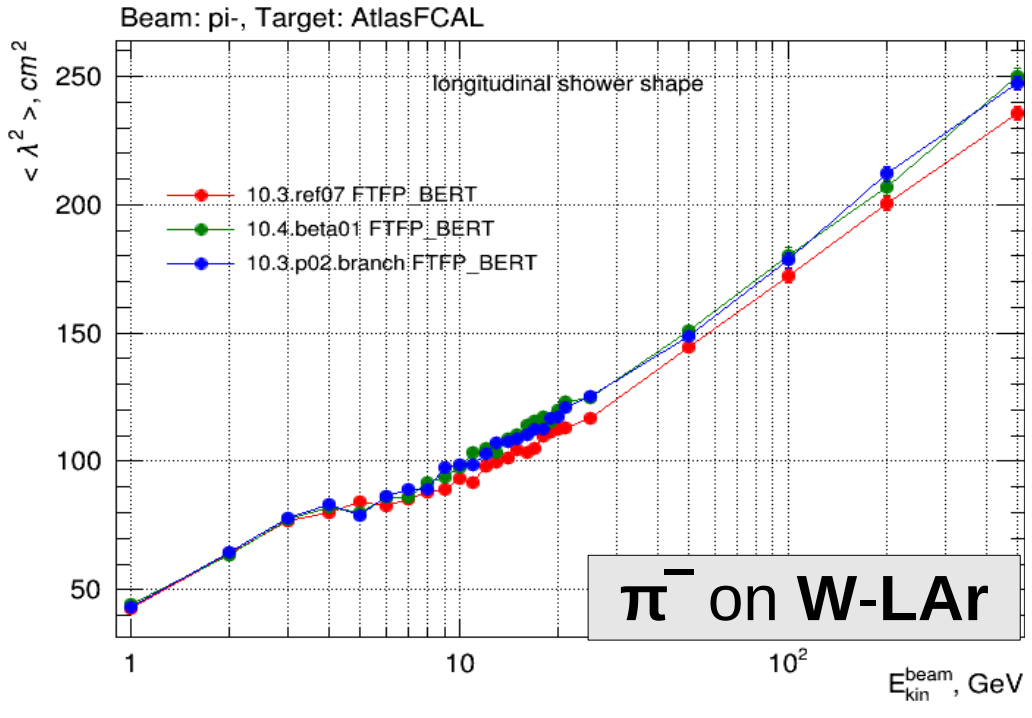


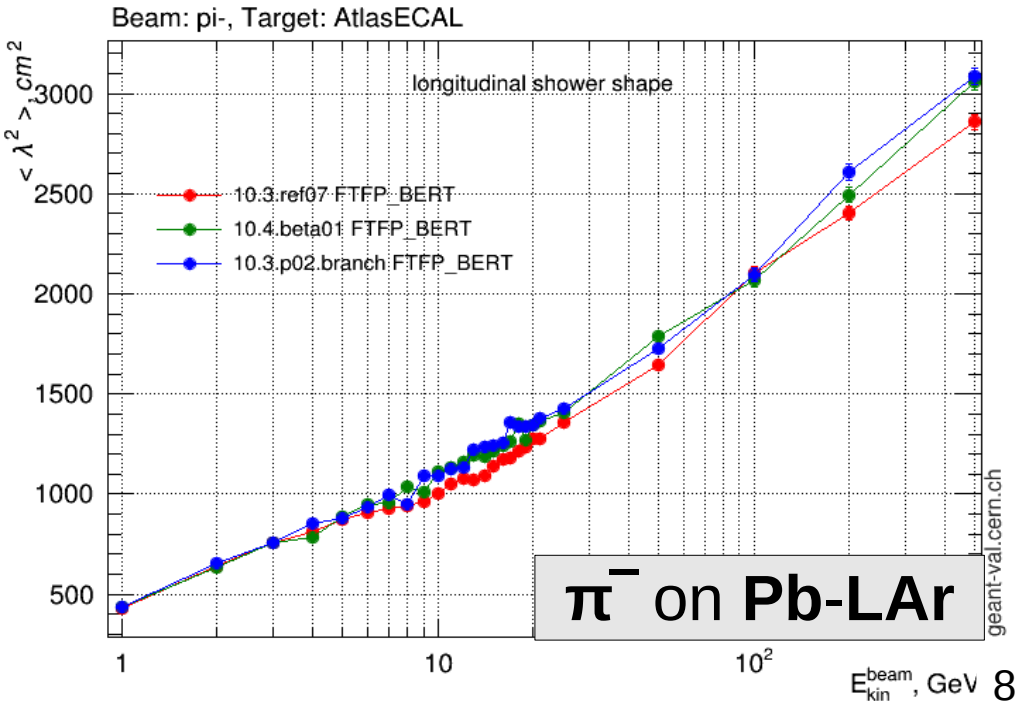


FTFP_BERT : Longitudinal Shape

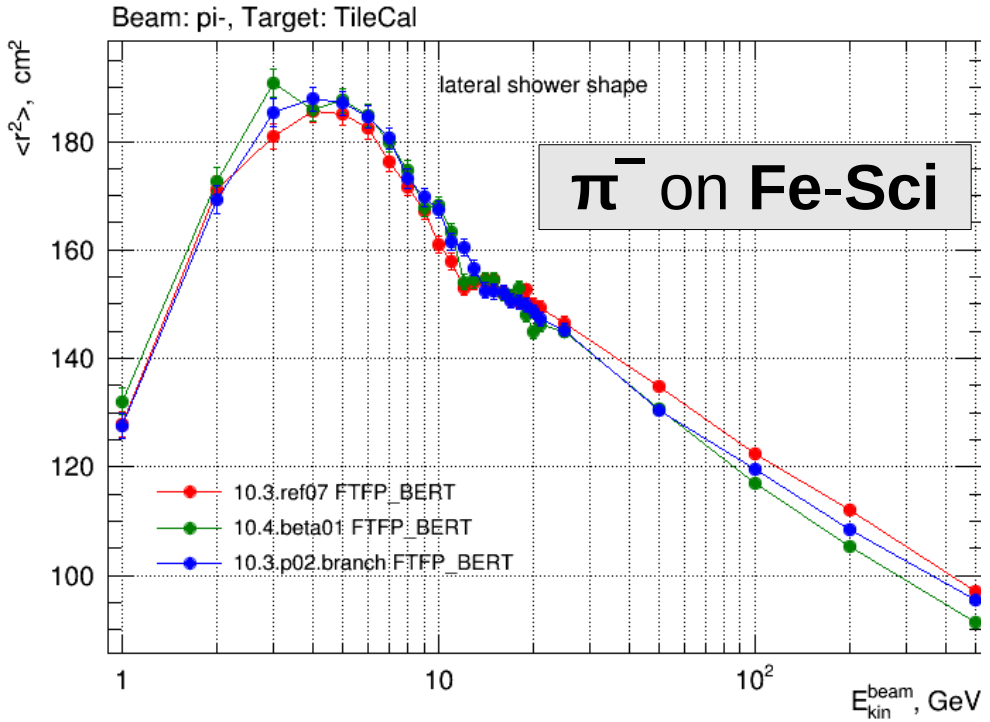


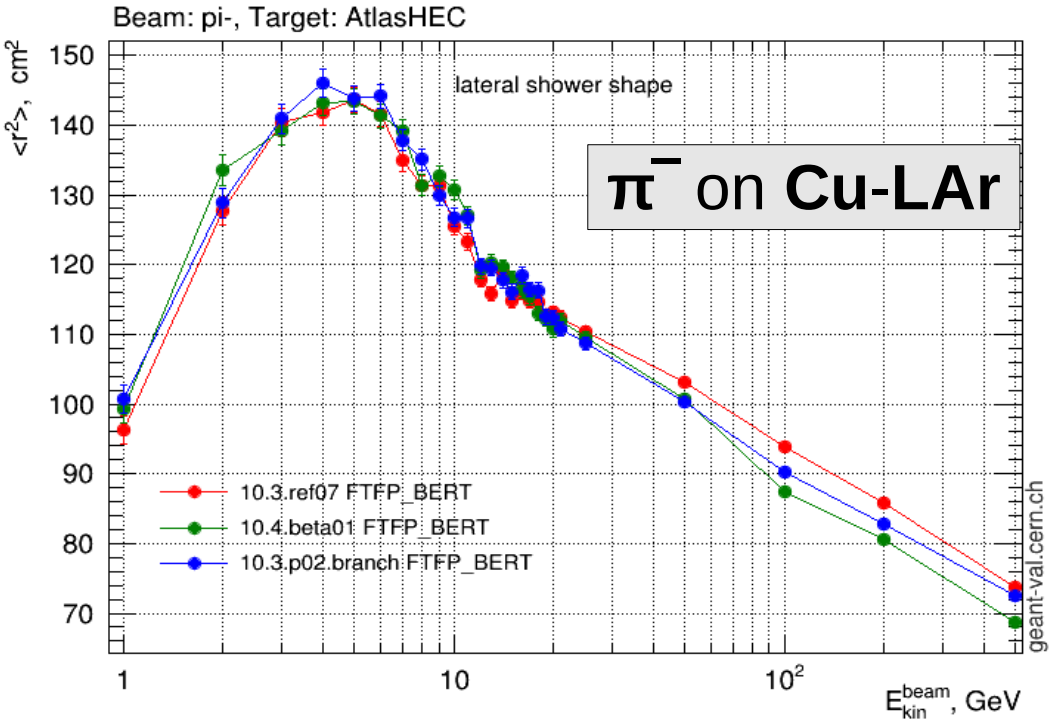


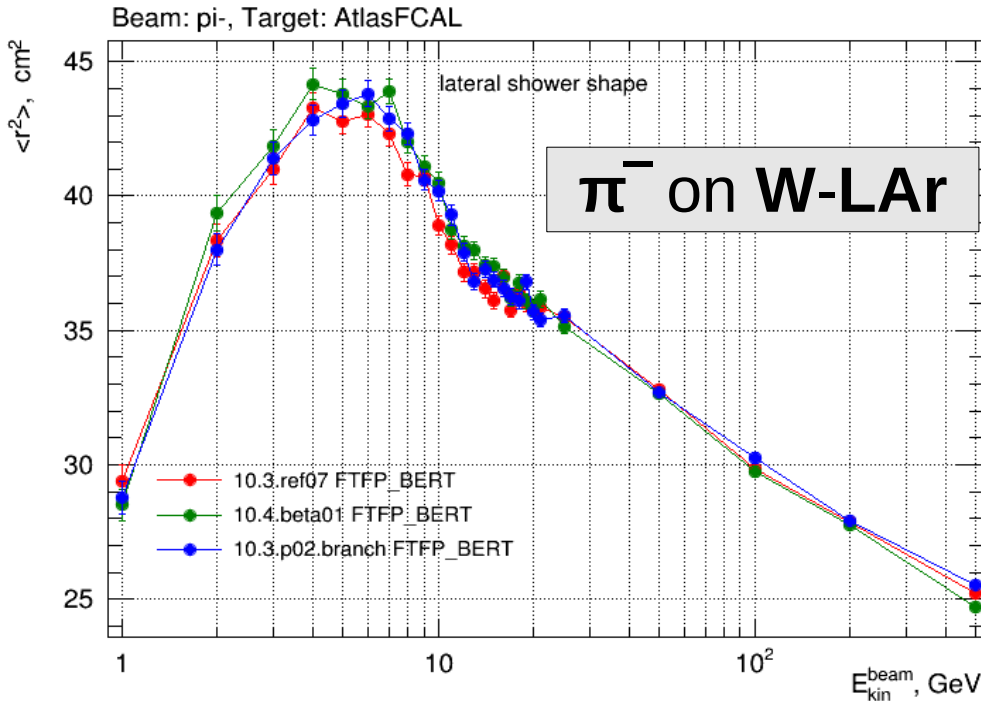


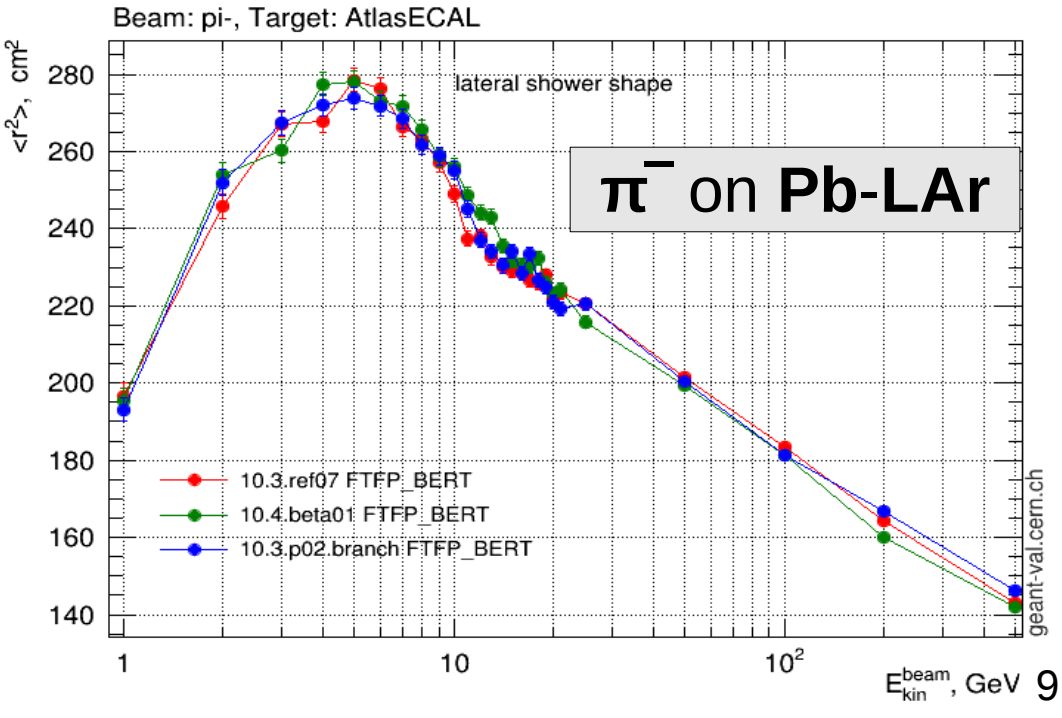


FTFP_BERT : Lateral Shape









Summary

FTFP_BERT hadronic showers : ref07 *vs.* ref06

- Energy response: lower for E ≥ 20 GeV for Fe & Cu (good)
  higher for E ≤ 20 GeV for W & Pb (bad)
  - Less energy flow in mesons and more in baryons at high energies, and the opposite at lower energies
- Energy fluctuation: smaller (optimistic energy resolution) (bad)
  - Mainly due to the changes in the pion-nucleon parameters: reduced probabilities for quark-exchange (with and without excitation) and target diffraction (projectile diffraction remains switched off), and increased of "non-diffractive" interactions: this implies **less fluctuations in π° production**
- Longitudinal profile: shorter (not clear if it is good or bad)
  - Mainly due to switching off target diffraction in nucleon-nucleus interactions
- Lateral profile: wider for E ≥ 30 GeV for Fe & Cu (good)
  - Due to mainly two effects:
    1. Switching off target diffraction for nucleon-nucleus interactions
    2. Increased (reduced) energy flow in baryons (mesons) at high energies

Curiosity:
FTF + QGS-string-fragmentation
G4 10.3.ref07**a**

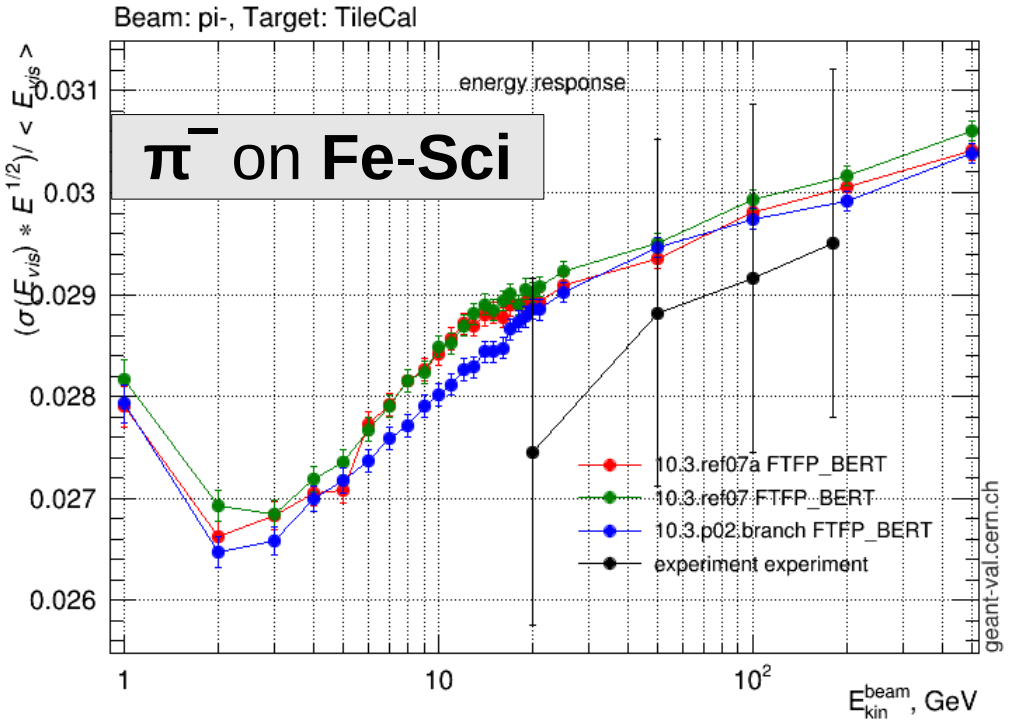
Special Version: G4 10.ref07**a**

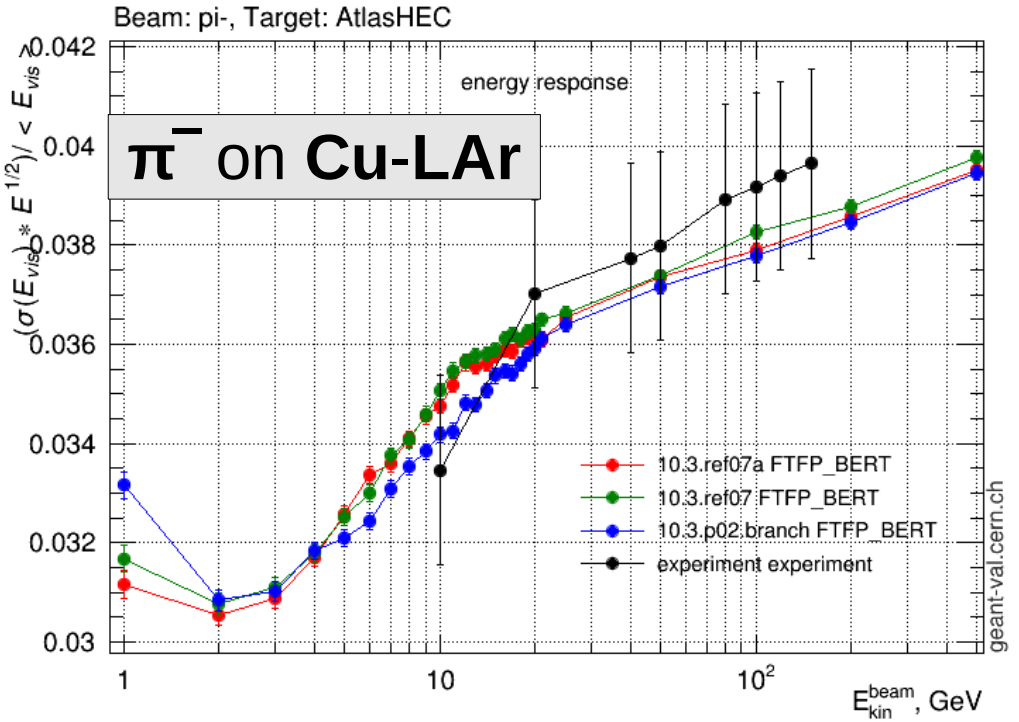
- V. Uzhinsky has found that, suprisingly, the combination
  FTF + QGS-string-fragmentation
  (instead of the usual FTF + Lund-string-fragmentation)
  describes well some difficult thin-target data...
- So, we want to see the effect on FTFP_BERT hadronic showers of such a combination
  - G4 10.3.ref07 as baseline
  - FTF + Lund-string-fragmentation replaced with:
    FTF + QGS-string-fragmentation in all FTF-based physics lists
  - For curiosity, we try also:
    QGS + Lund-string-fragmentation
    (instead of the usual QGS + QGS-string-fragmentation)
    in all QGS-based physics lists

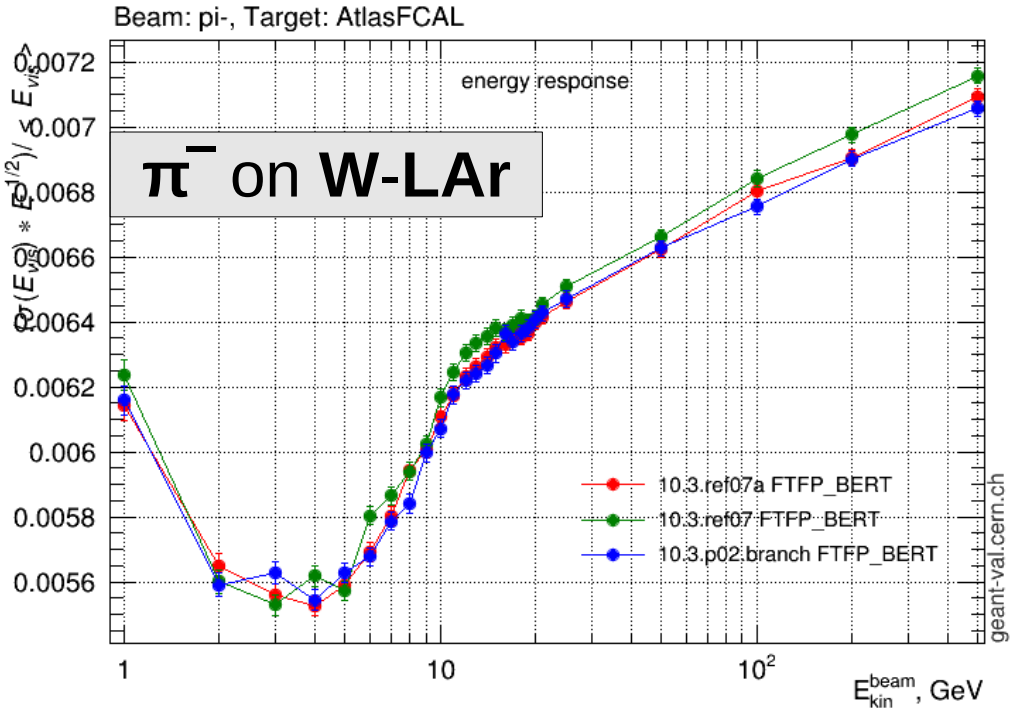
Pion showers: FTFP_BERT

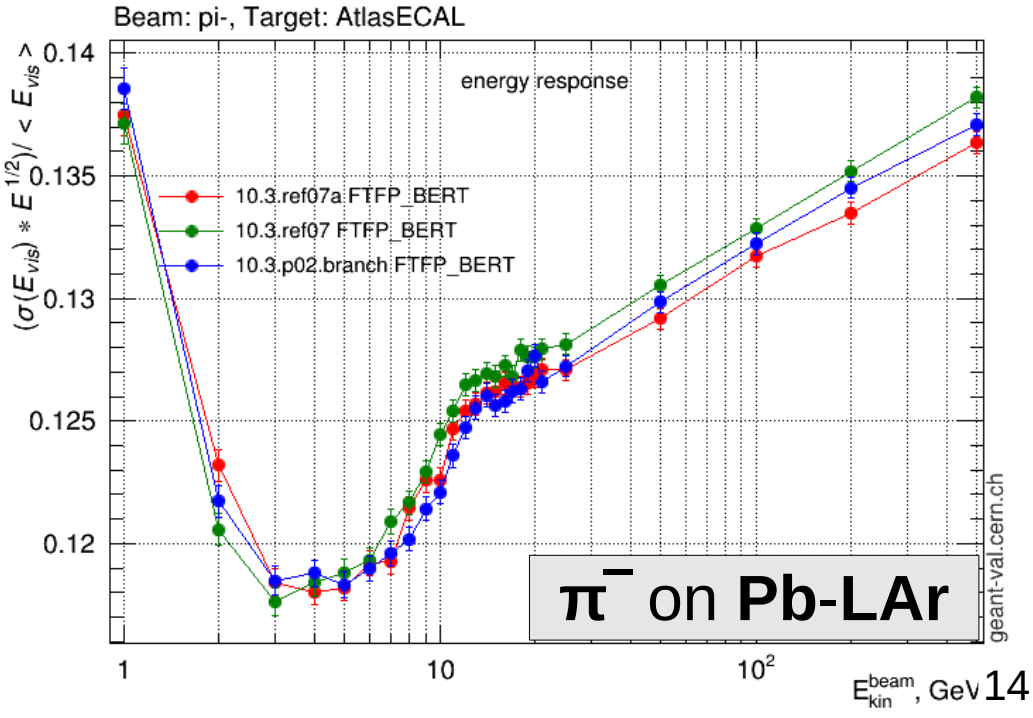
G4 10.3.ref07**a**
10.3.ref07
10.3.p02

FTFP_BERT : Energy Response

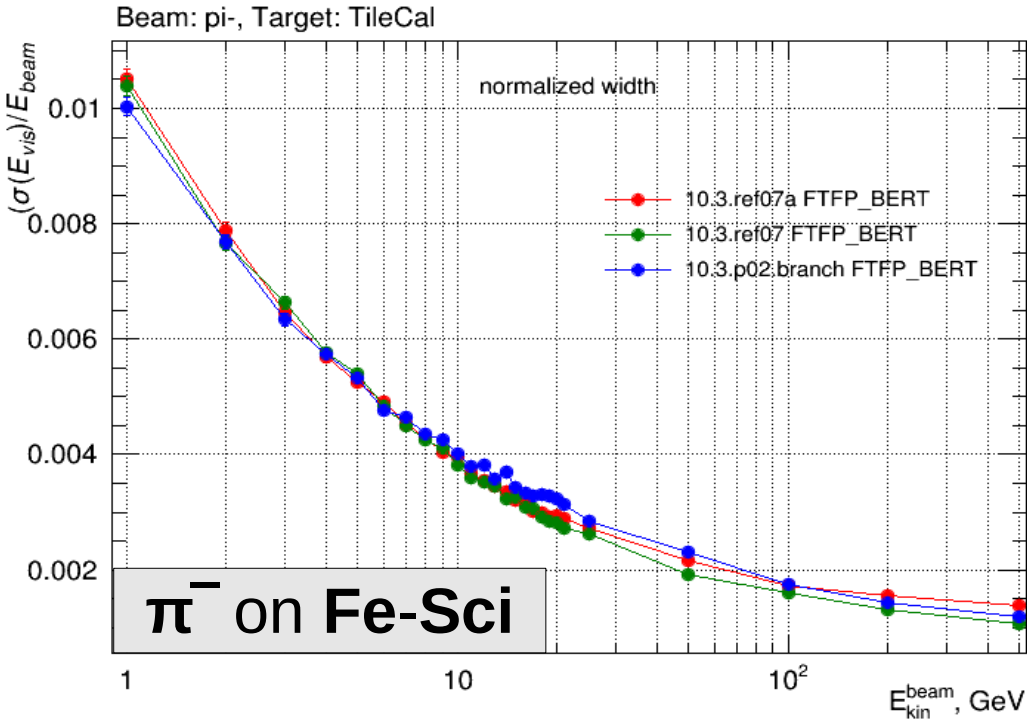


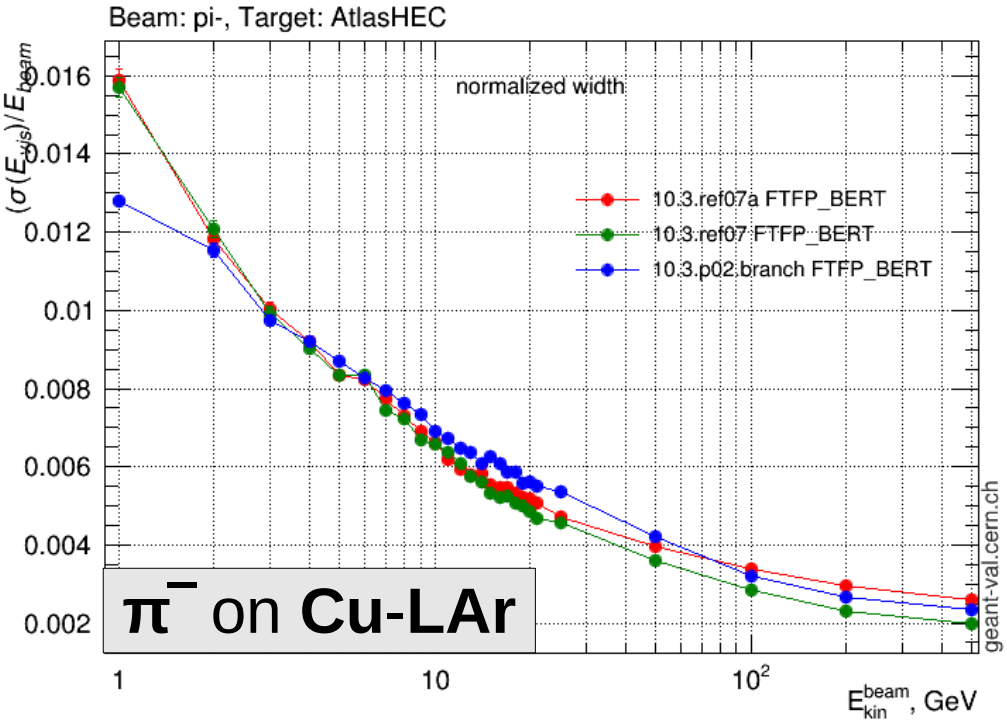


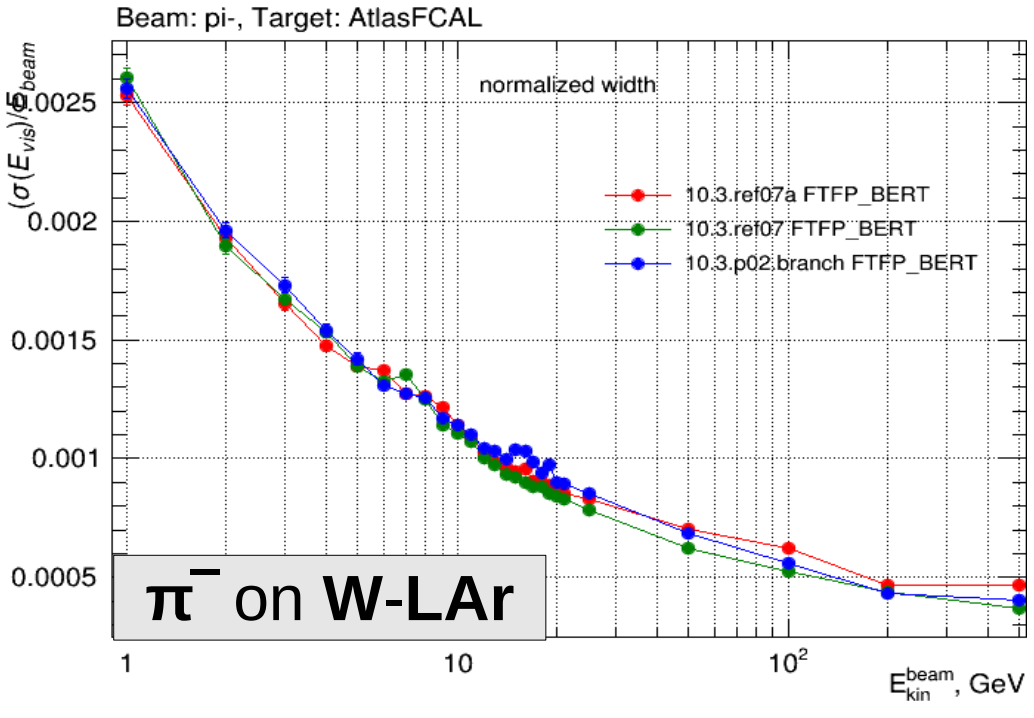


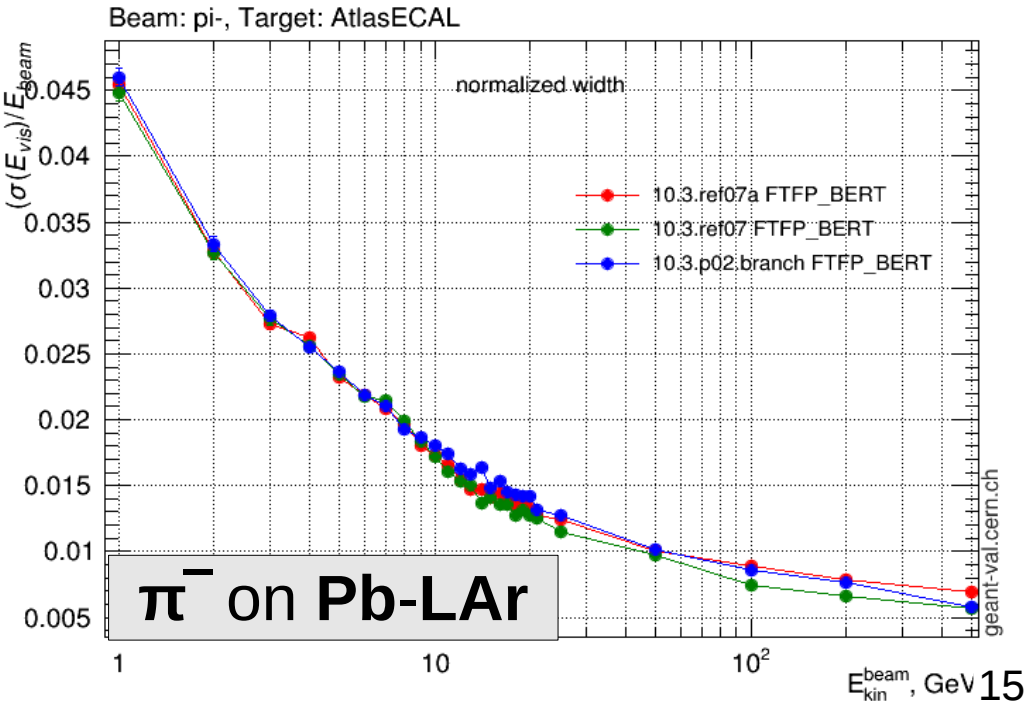


FTFP_BERT : Energy Width

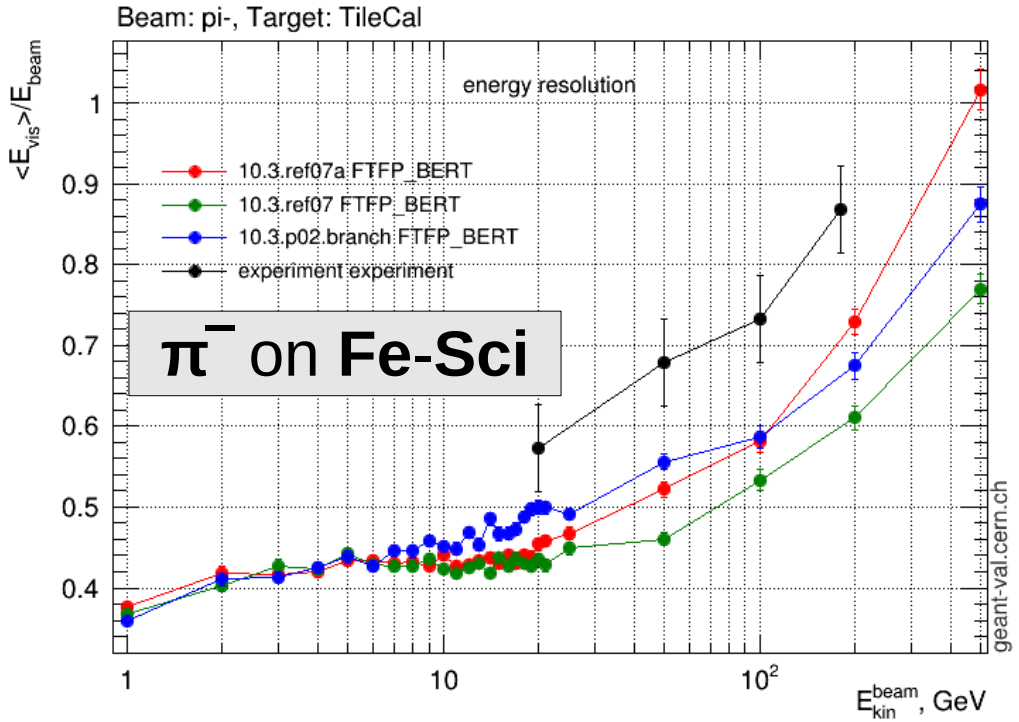


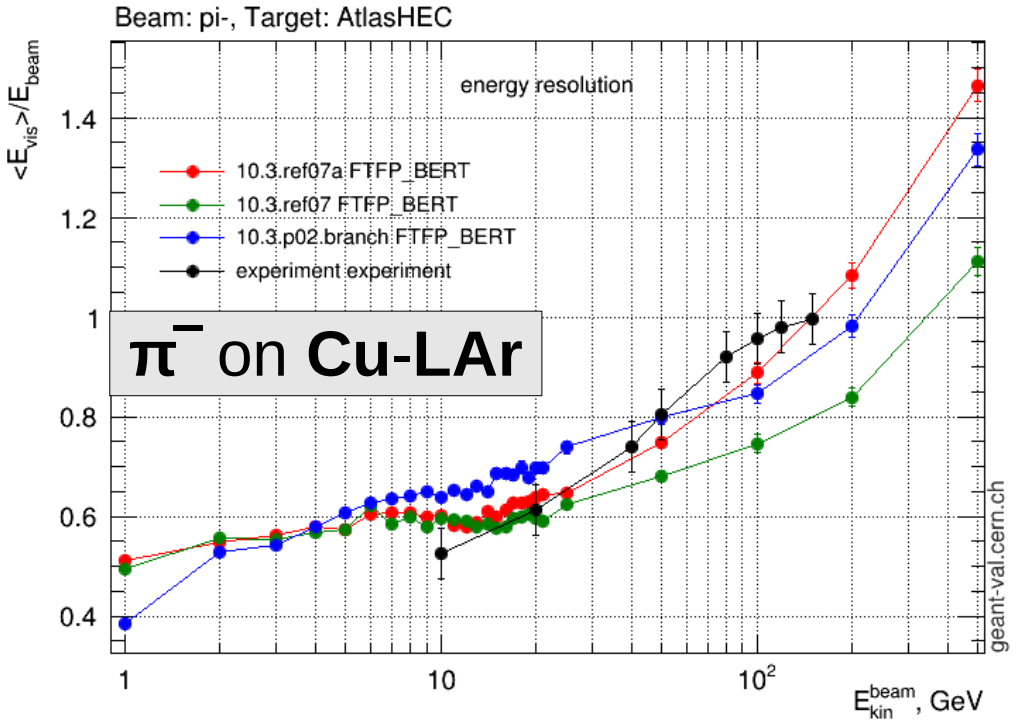


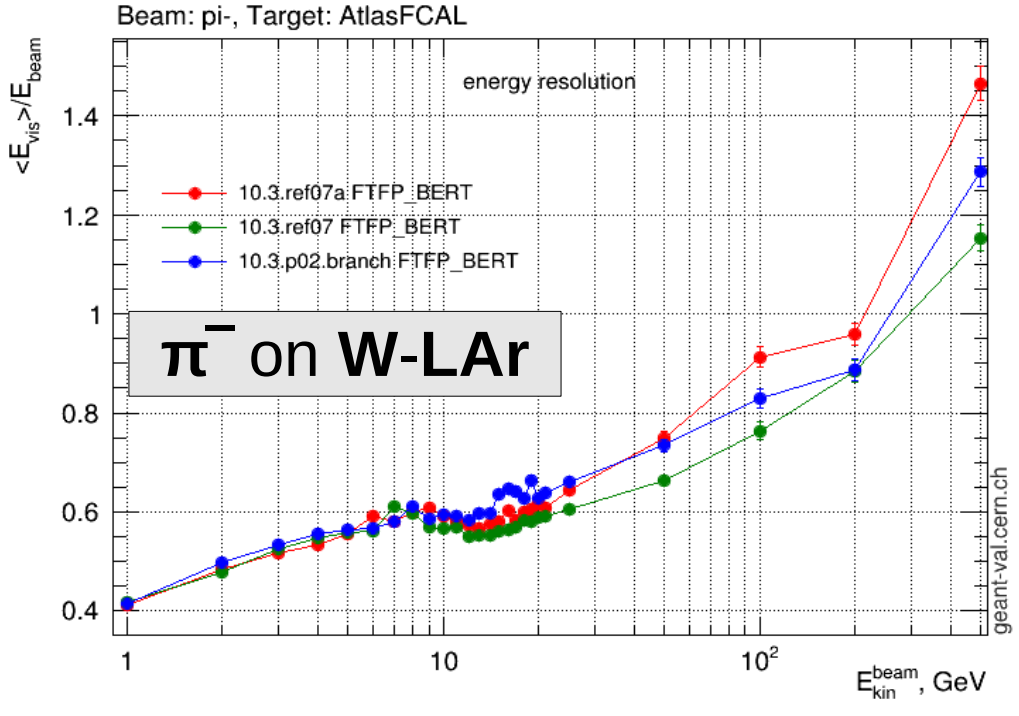


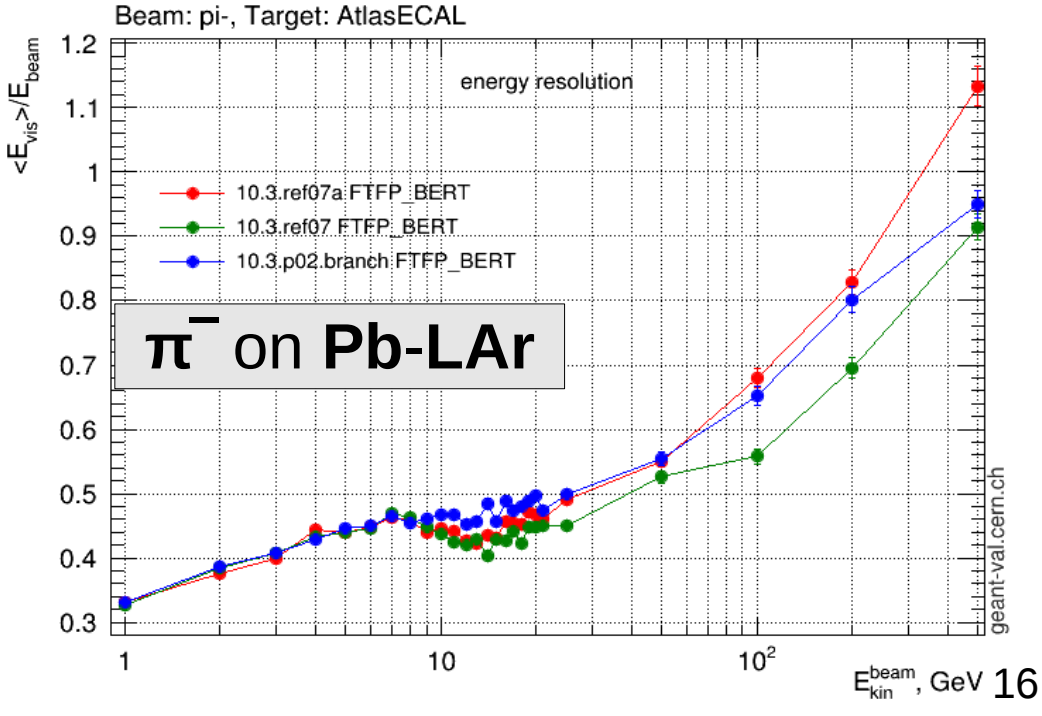


FTFP_BERT : Energy Resolution

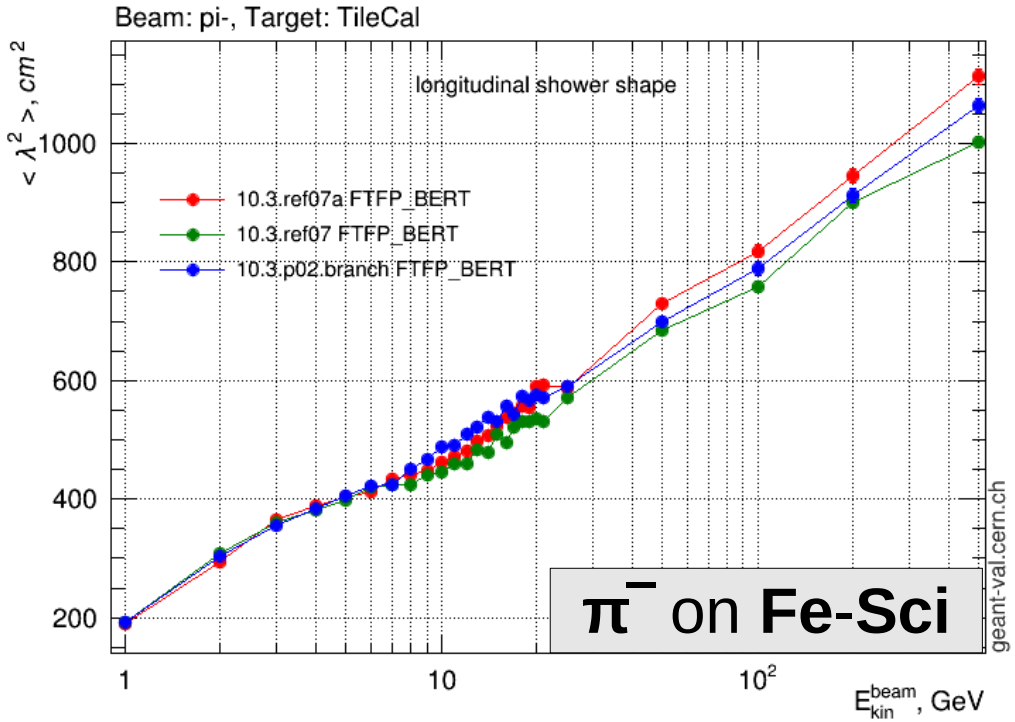


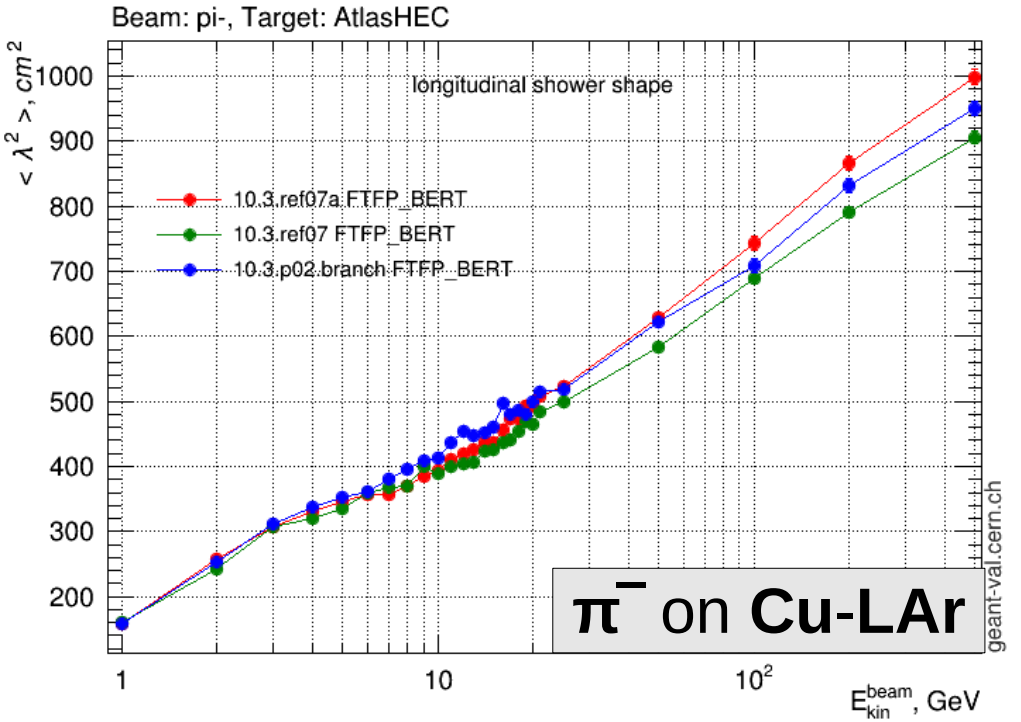


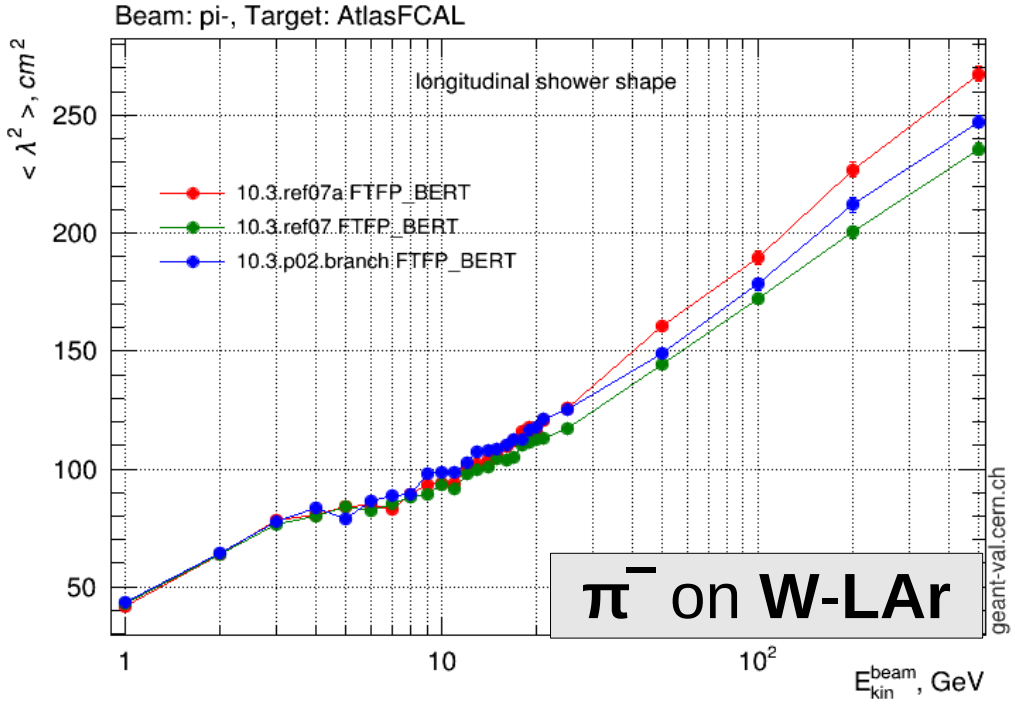


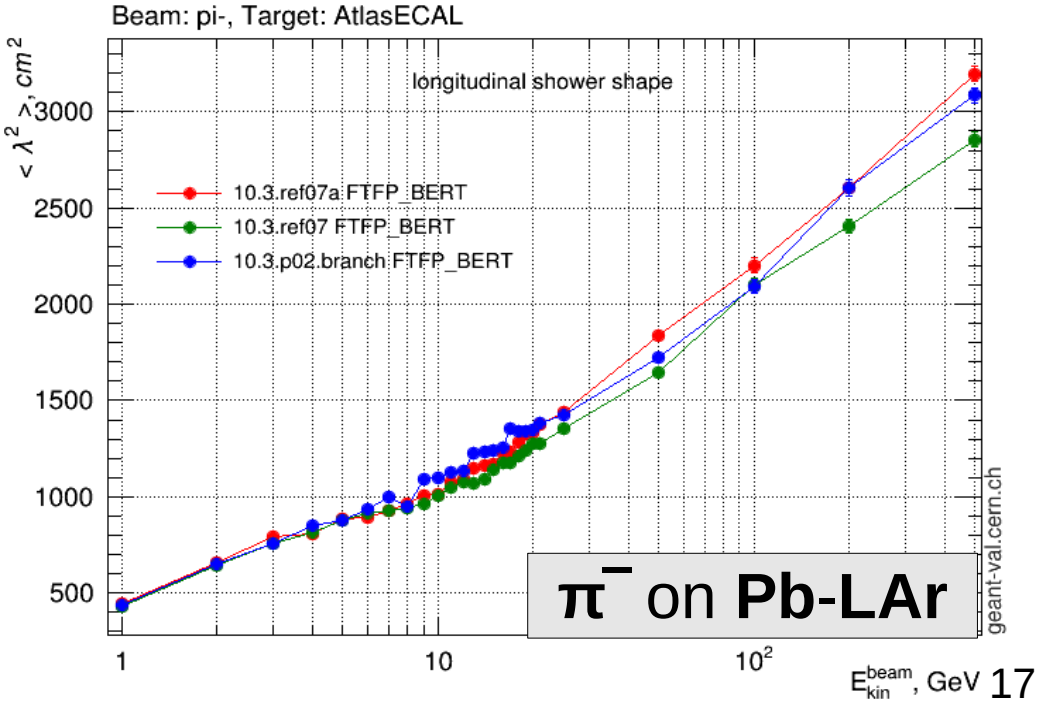


FTFP_BERT : Longitudinal Shape

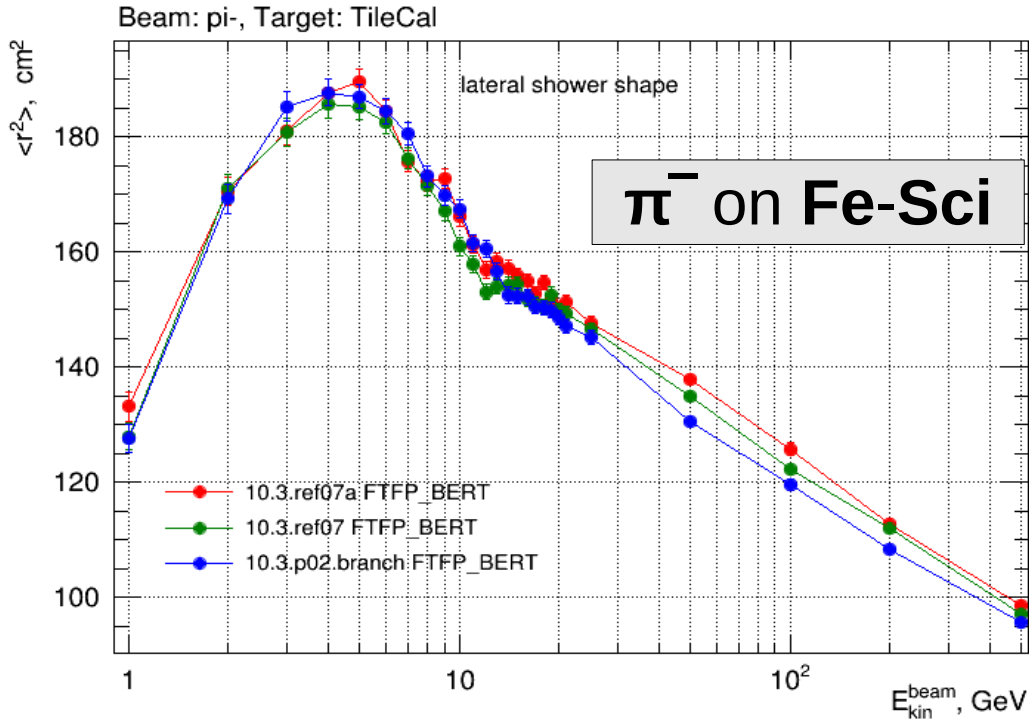


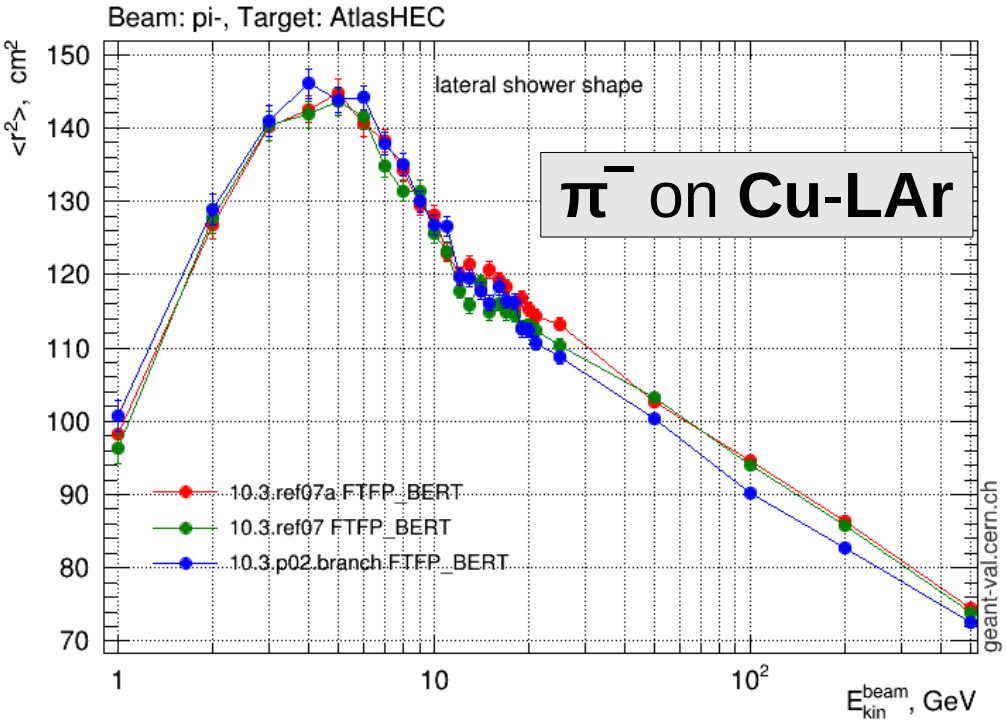


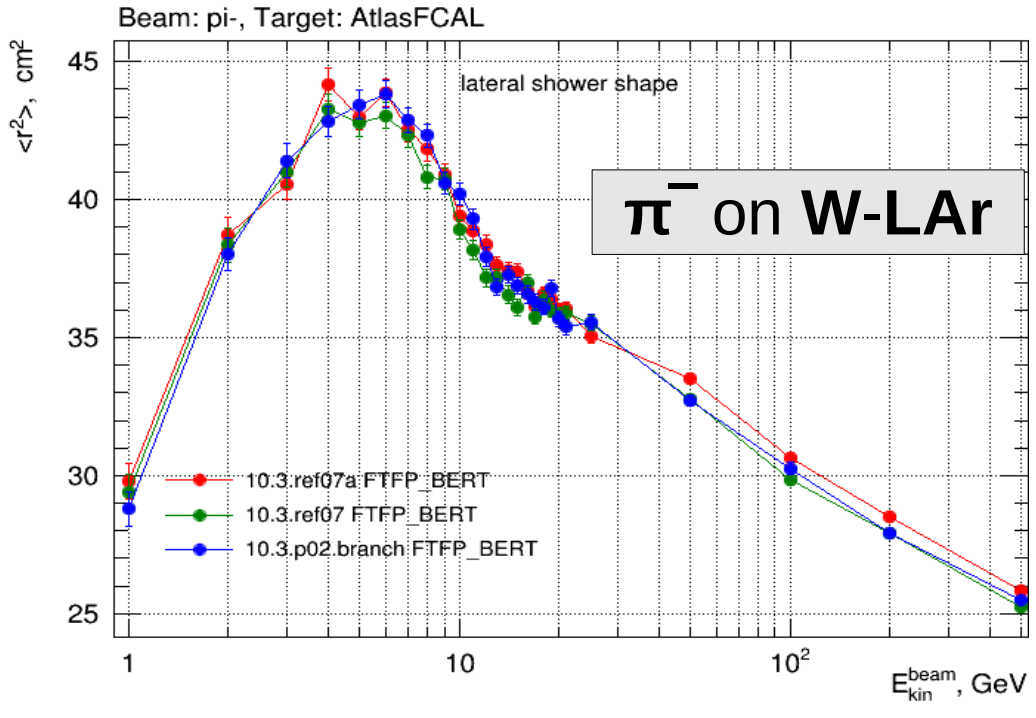


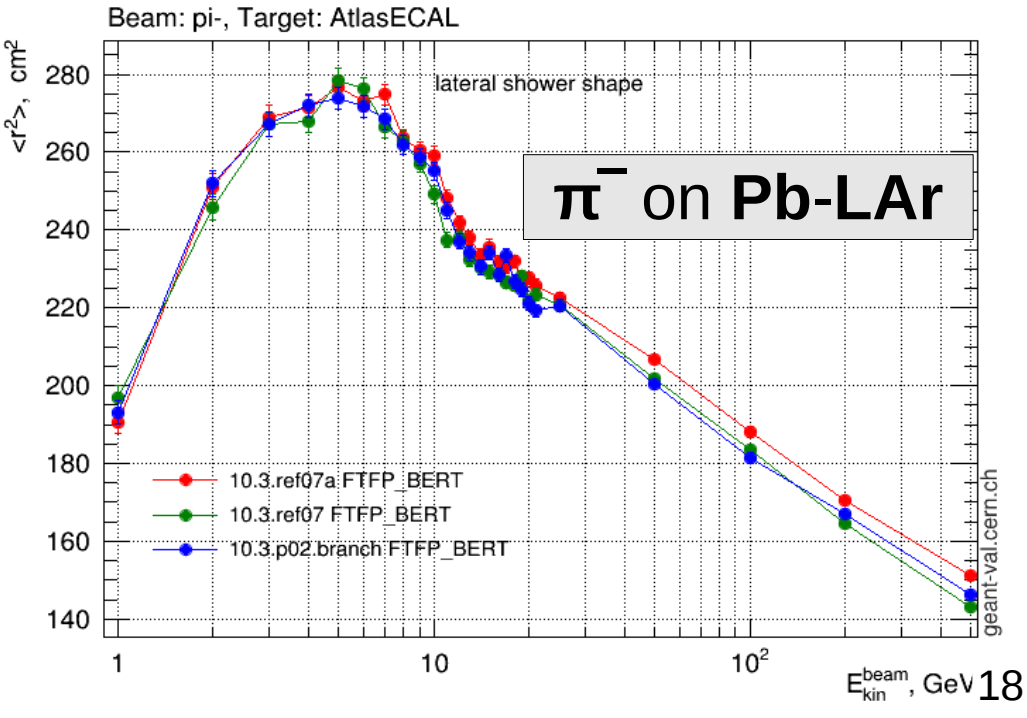


FTFP_BERT : Lateral Shape









Summary on G4 10.3.ref07**a**

- Hadronic showers of FTFP_BERT with special combination **FTF + QGS-string-fragmentation**
  - Lower energy response (good)
    - Exception: TileCal below ~20 GeV
  - More energy fluctuations (i.e. more pessimistic energy resolution) (good)
  - Longer showers (not clear if it is good or bad)
  - Wider showers (good)
  - Overall, hadronic showers are even better than those the stable, production version (as in G4 10.3.p02) of FTF (with Lund-frag.)
    - But the description of most thin-target data is worse !

- Note: no results available for the combination **QGS + Lund-string-fragmentation**
  - Due to technical problems: crashes at exit during the destruction of objects...

Conclusion & Outlook

Conclusion & Outlook

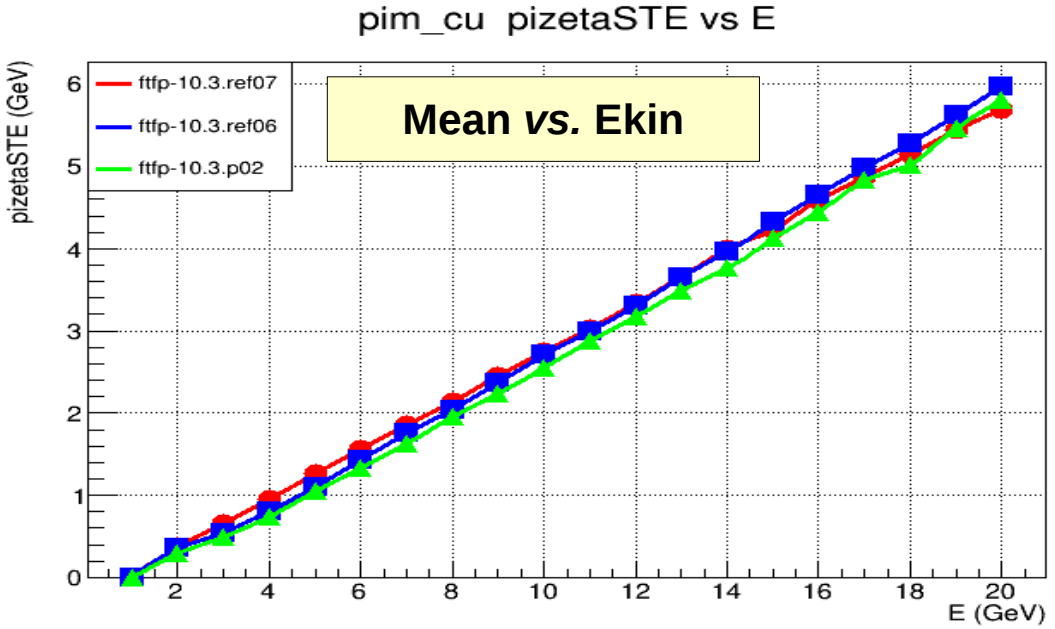
- Progress has been made this year to reduce the “gap” between development *vs.* production versions of FTF
  - Hadronic showers now (10.3.ref07 *vs.* 10.3.p02) are closer to each other now than they were before (10.3.ref01 *vs.* 10.3)
  - Still the development version produces showers with higher energy response than the production ones
- Not clear whether we could/should merge the two FTF versions for the coming release 10.4
  - Likely FTF will remain similar as it is right now for the release...
- QGS Status
  - No changes up to now (i.e. as it was in 10.3.ref01)
  - V. Uzhinsky will be back at CERN from 1st September until the end of the year, with the plan to improve QGS (but it is not clear how much of this development can be included in the release...)

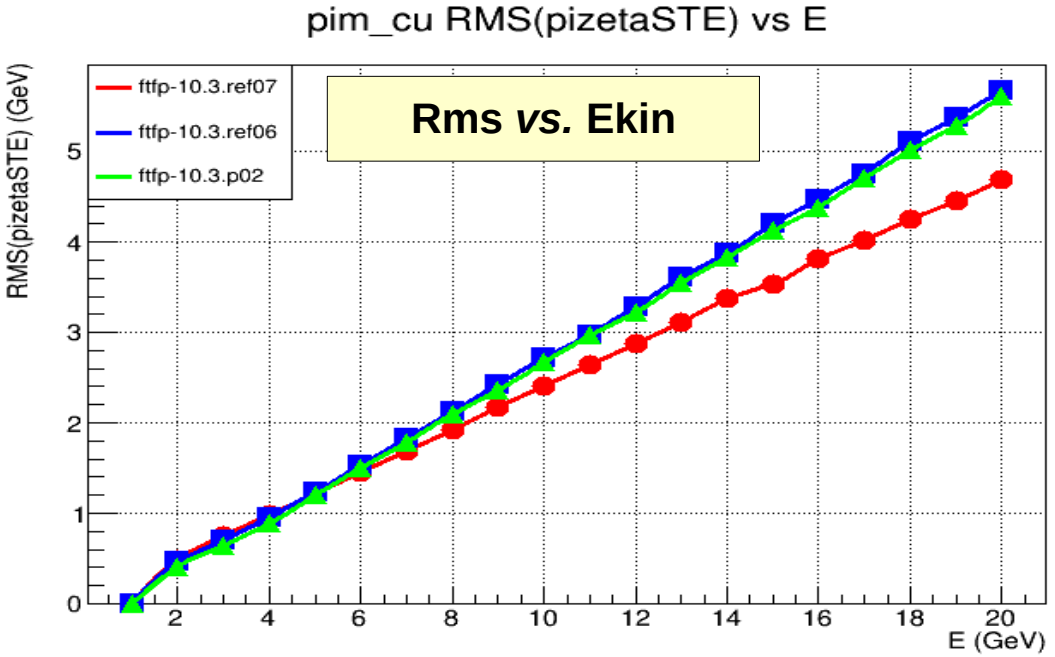
Back up

Model-level Energy Flow

π° + η + η' Energy Flow

π^- on Cu





- The higher the **mean** value of the energy flow in **π° + η + η'** in hadron-nucleus collisions, the higher the EM component of hadronic showers, so the higher the mean energy response in calorimeters (under-compensating)

- The lower the **r.m.s.** value of the energy flow in **π° + η + η'** in hadron-nucleus collisions, the smaller the fluctuations in the EM component of hadronic showers, which is the dominant component in the energy response **fluctuations**