Hadronic Showers in Geant4
11.3.ref00

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Fixed reproducibility violation

- In 11.3.cand01, found one reproducibility violation in QGSP_BIC_HP_EMZ
  - Rare, seen in 11.3.cand01 for the first time, but present in Geant4 since version 10.2
  - In the class *G4UAtomicDeexcitation* , there is a *std::vector<int> vacancyArray* which, in rare cases, can keep memory of previous events, therefore breaking reproducibility.
    - The problem arises in the method *G4UAtomicDeexcitation::GenerateParticles* when there is an early exit by the condition:
      if (Z < 6 || Z > 104) return;
      and the solution is to clear the vector at the beginning of the method
      (or, equivalently, in the above if-statement, before returning)
  - The fix was included in 11.3 a few days before the release.
    It should be applied to patches of previous versions as well, in particular 11.1 and 11.2

Note : during this debugging, done together with Mihaly, we have realised that in QGSP_BIC_HP instead of EM Opt0, the EM Opt4 (_EMZ) is silently and confusingly forced !
This was introduced in Geant4 10.5, in the following 3 physics lists:
QGSP_BIC_HP , QGSP_BIC_HPT , QGSP_BIC_AllHP

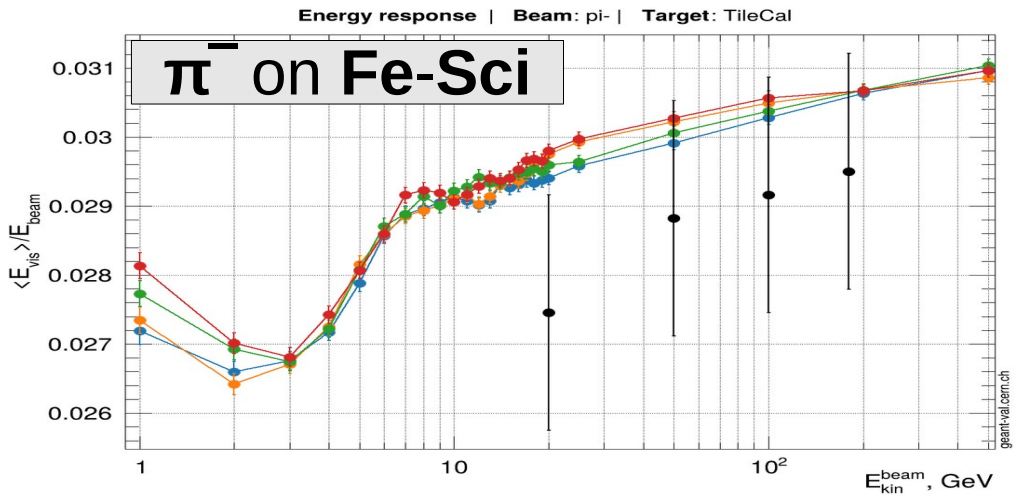
Pion− showers:

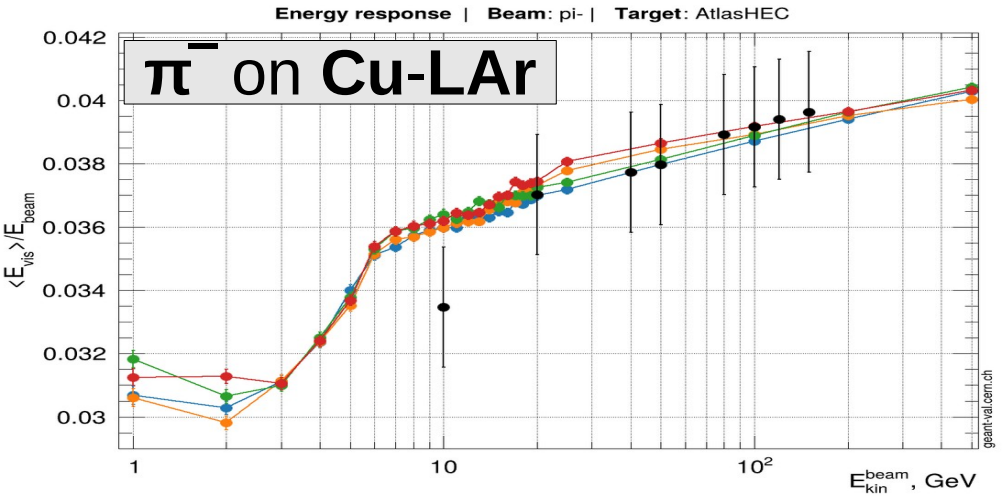
G4 11.3 FTFP_BERT
G4 11.2.p02 FTFP_BERT

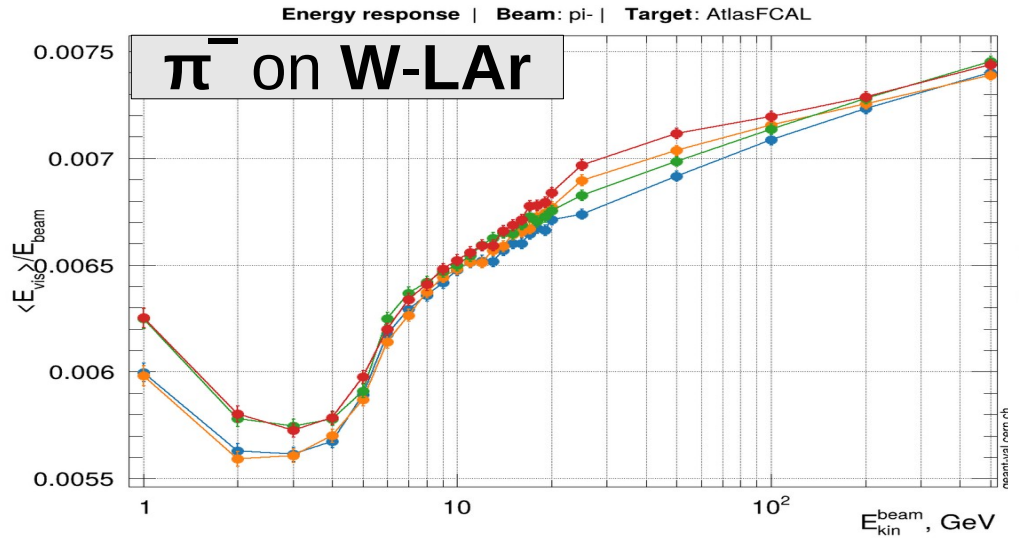
G4 11.3 QGSP_BERT
G4 11.2.p02 QGSP_BERT

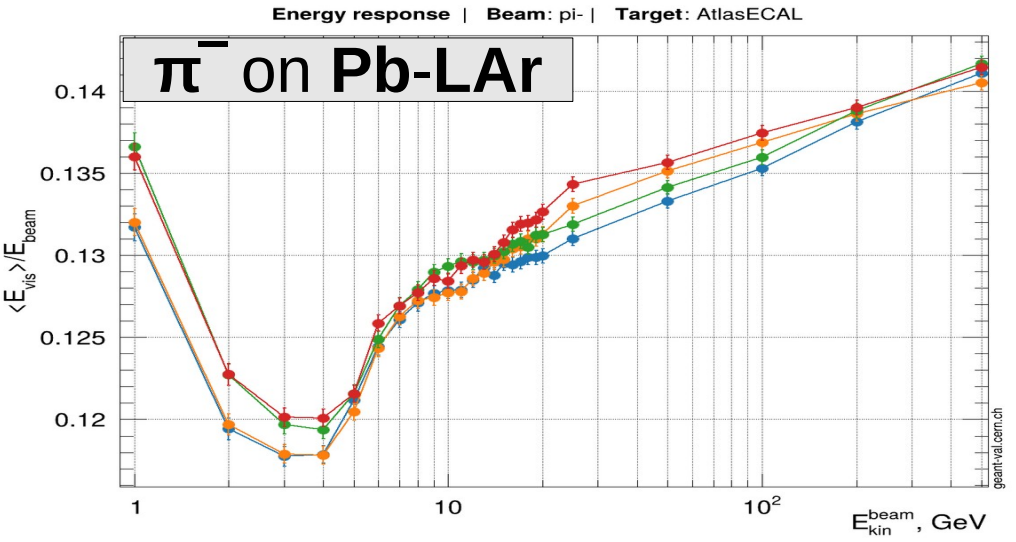
Note : conventional Birks treatment
(easier and no experimental h/e to fit !)

Energy Response

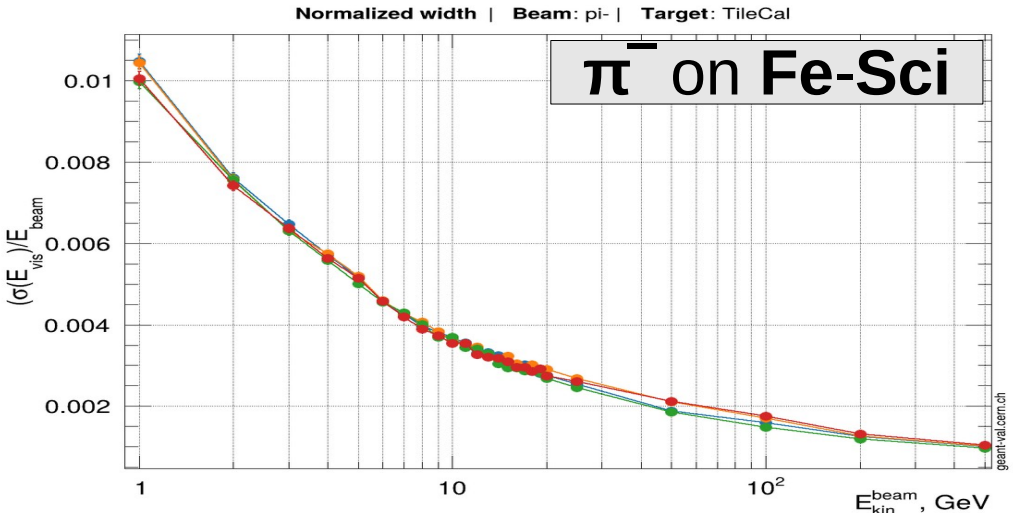


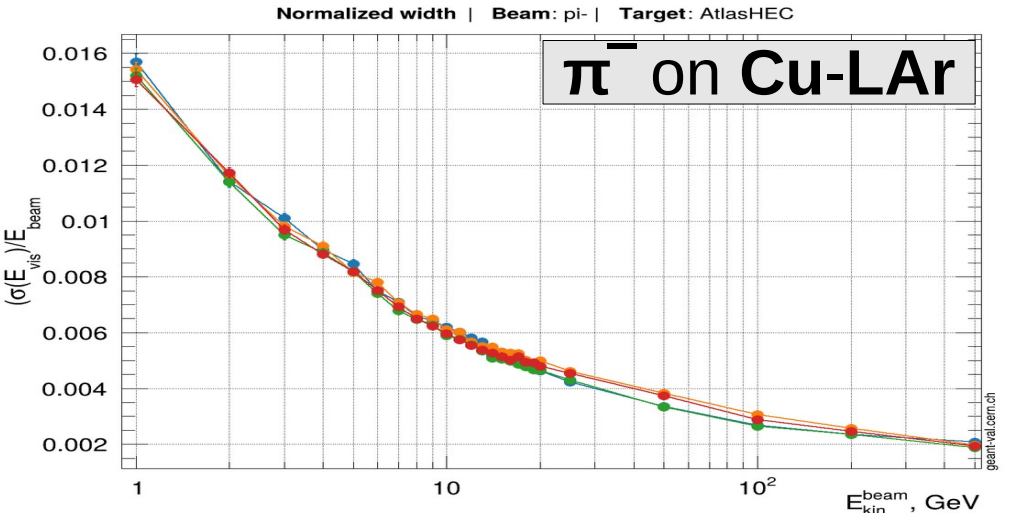


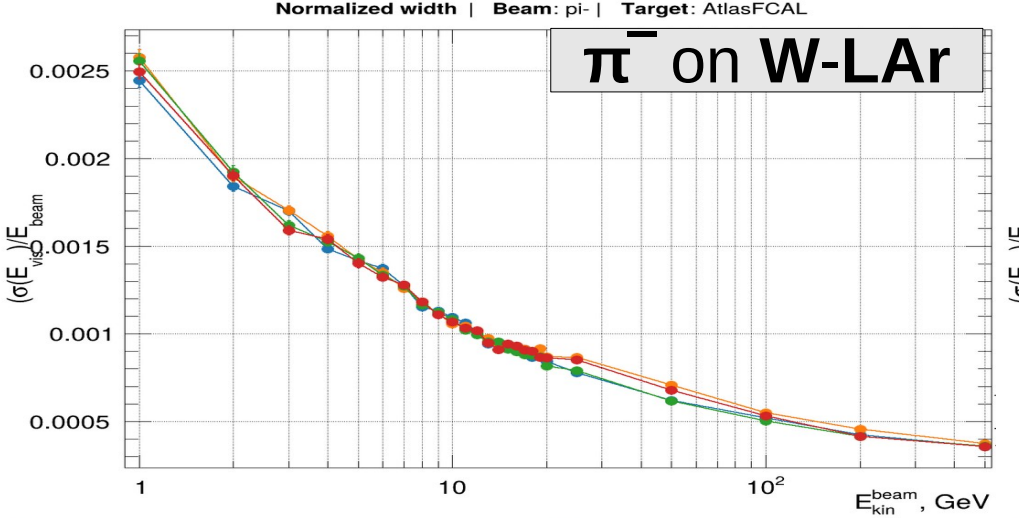


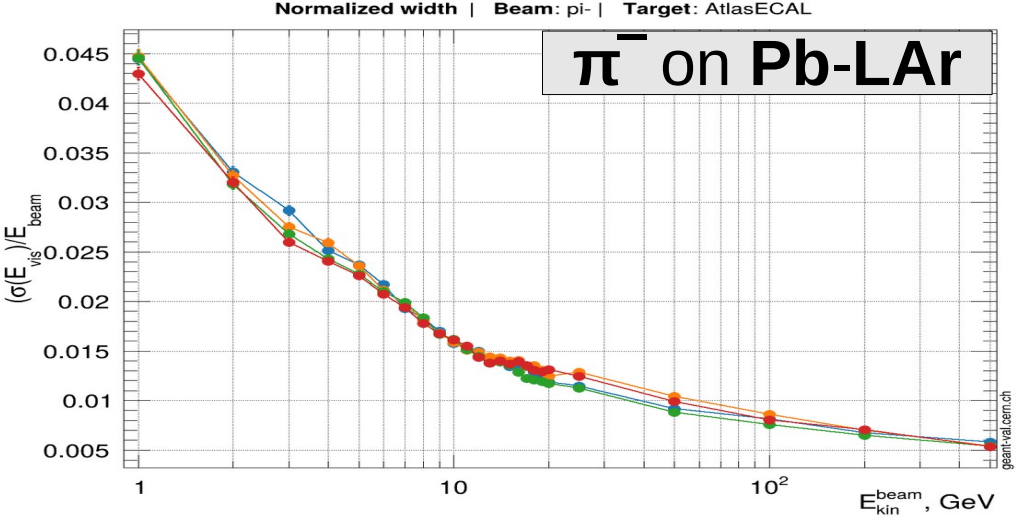


Energy Width

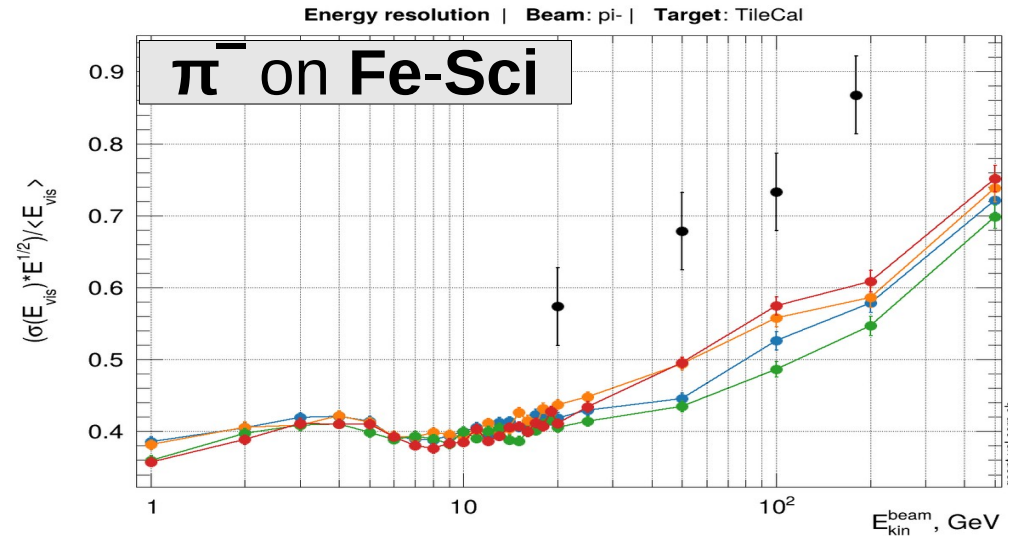


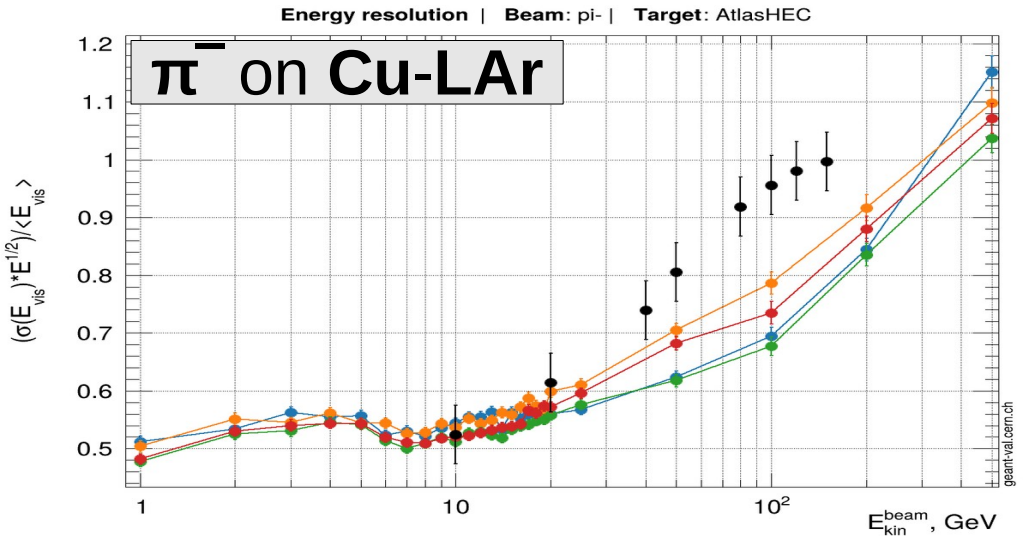


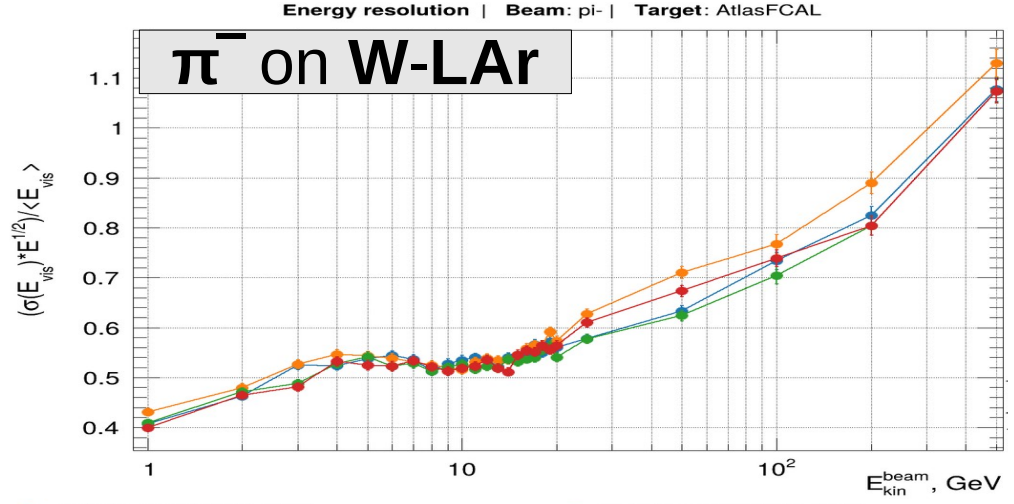


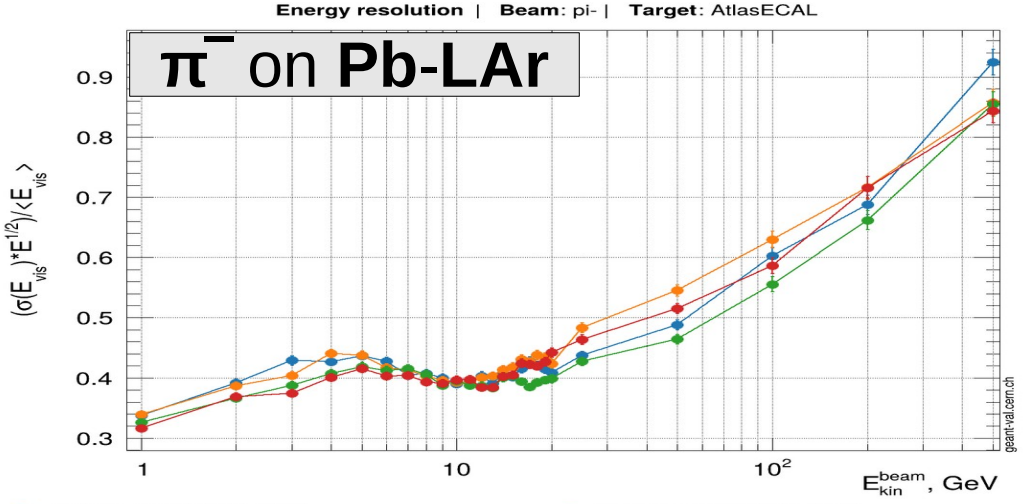


Energy Resolution

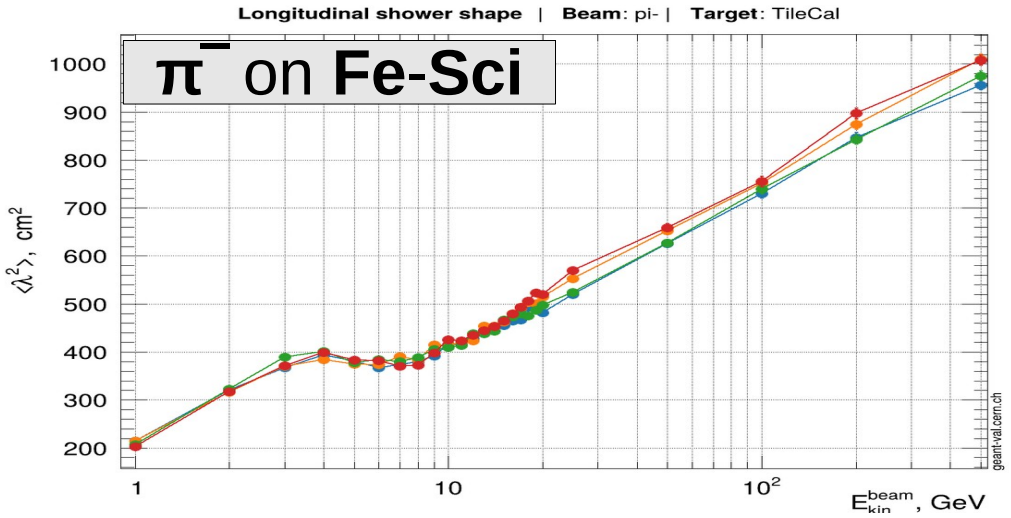


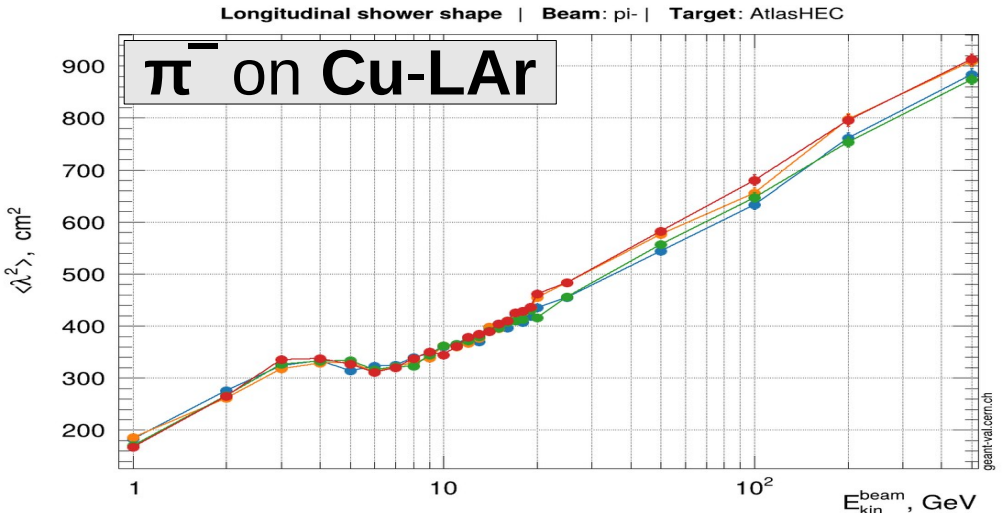


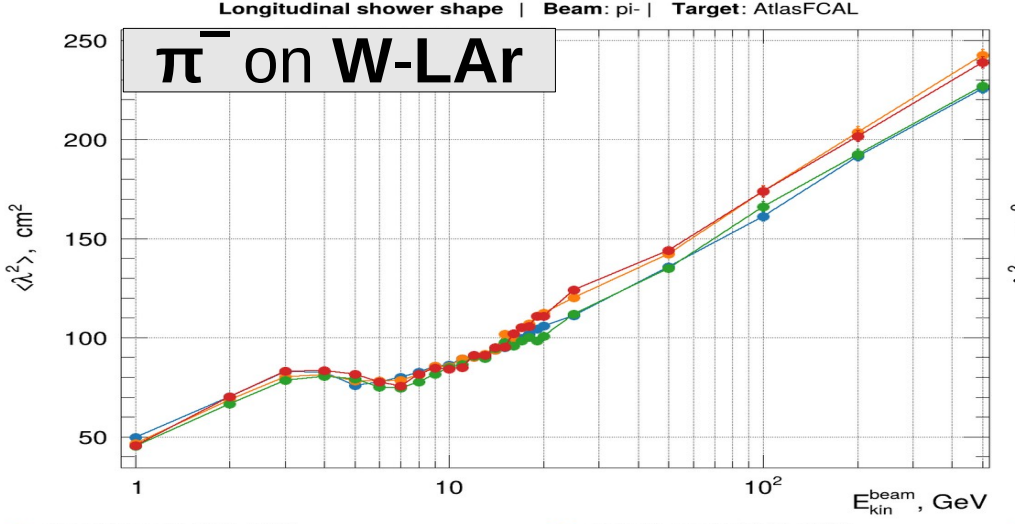


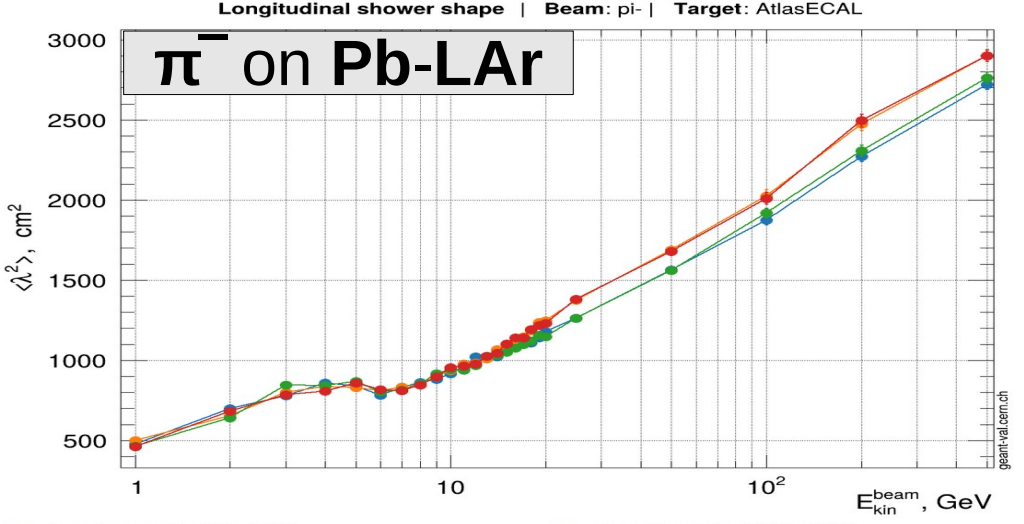


Longitudinal Shape

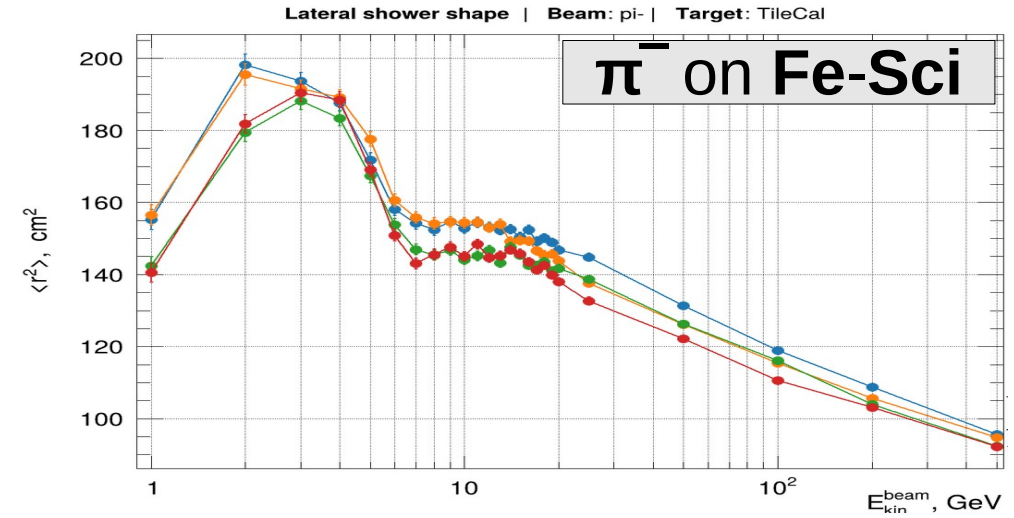


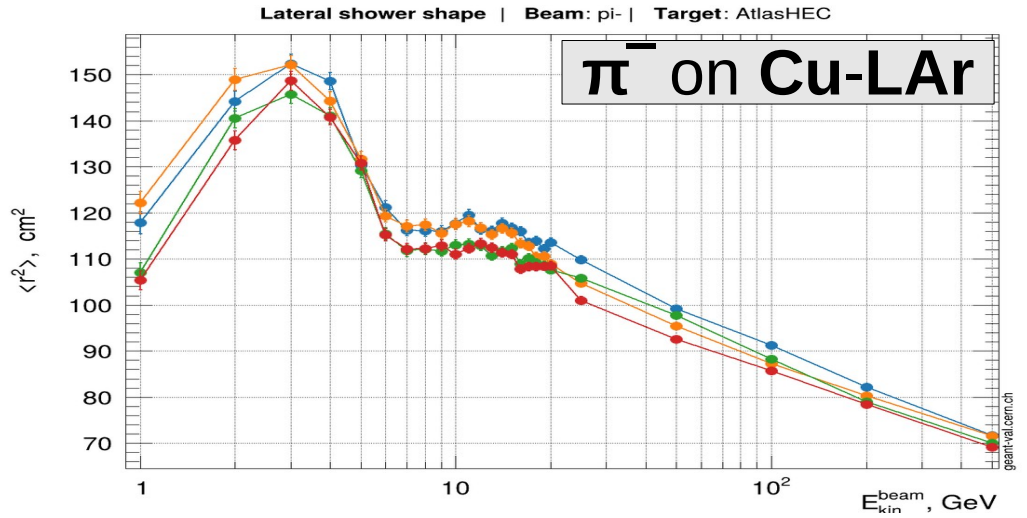


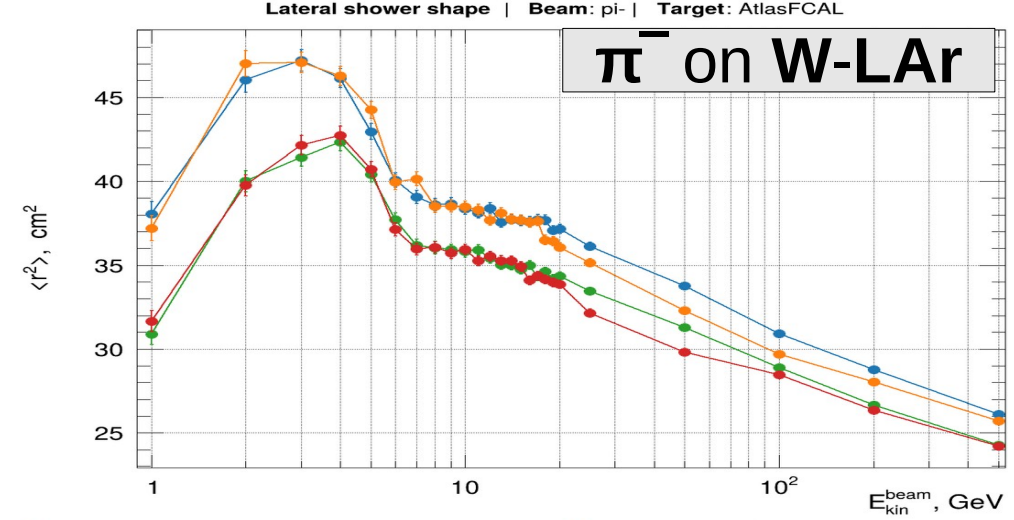


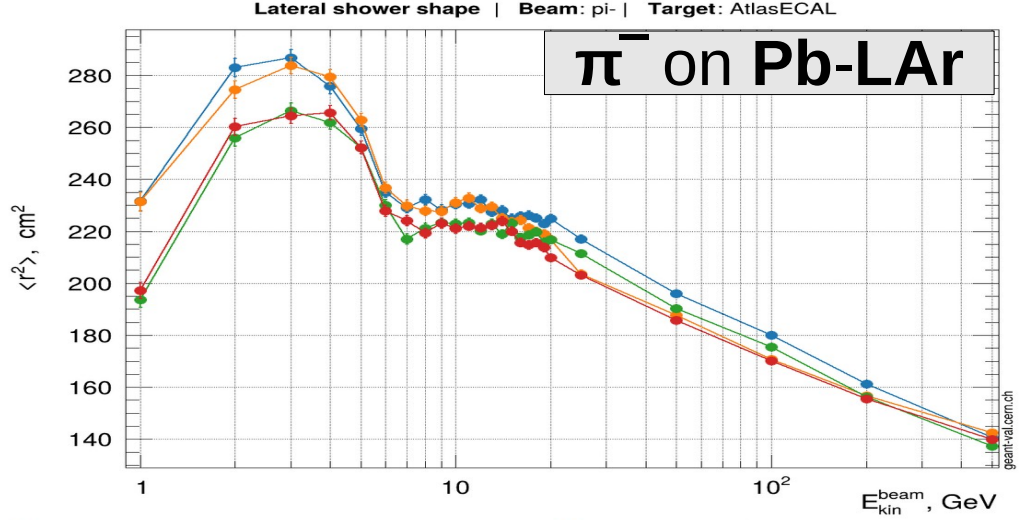


Lateral Shape









Hadronic showers

- For nearly all physics lists, hadronic showers in G4 **11.3** have
  ~ 1-2% higher energy response and
  ~ 5% narrower lateral showers
  than those of G4 11.2
  - Due to the improvement in the angular emission of ≥ 4 bodies in BERT, reducing the differences between this model and FTFP
  - QGSP_BERT showers with respect to FTFP_BERT ones in G4 11.3 :
    - ~ 1-2% higher energy response
    - **~ 10% wider (*i.e.* less optimistic) energy resolution**
    - ~ 5% longer showers
    - ~ 4% narrower showers