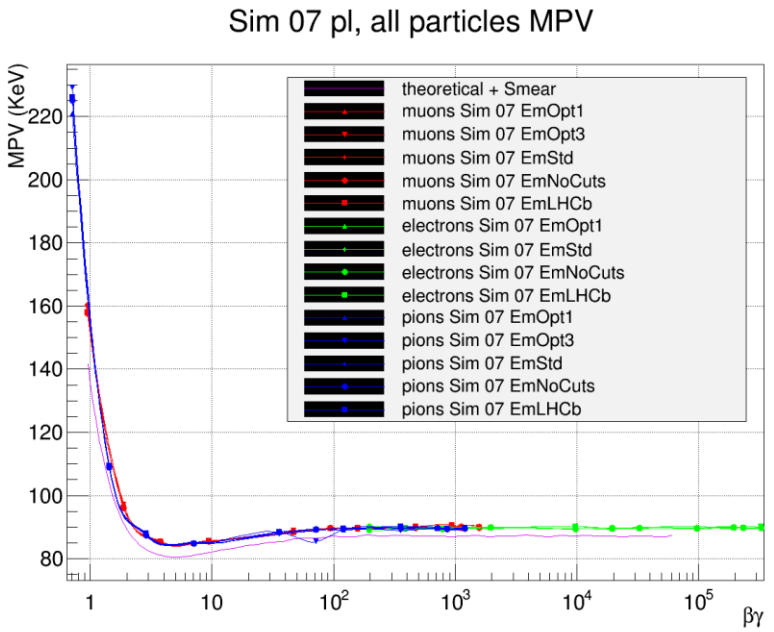
# LHCb Report - G4 Technical Forum

- Pre-production Physics List tests
- Recent productions used
  - Geant4 9.4.patch02
  - Electromagnetic: EmOption1 (with the ApplyCuts removed)
  - Hadronic: LHEP
- Scope of validations for future production
  - Use Geant4 9.5.patch02
  - Electromagnetic
    - EmOption1 (with the ApplyCuts removed) vs. EmStd, EmOpt1, EmOpt3, EmLHCb (private version prepared for us in 2011)
  - Hadronic:
    - LHEP vs. FTFP_BERT, GQSP_FTFP_BERT, QGSP_BERT_CHIPS

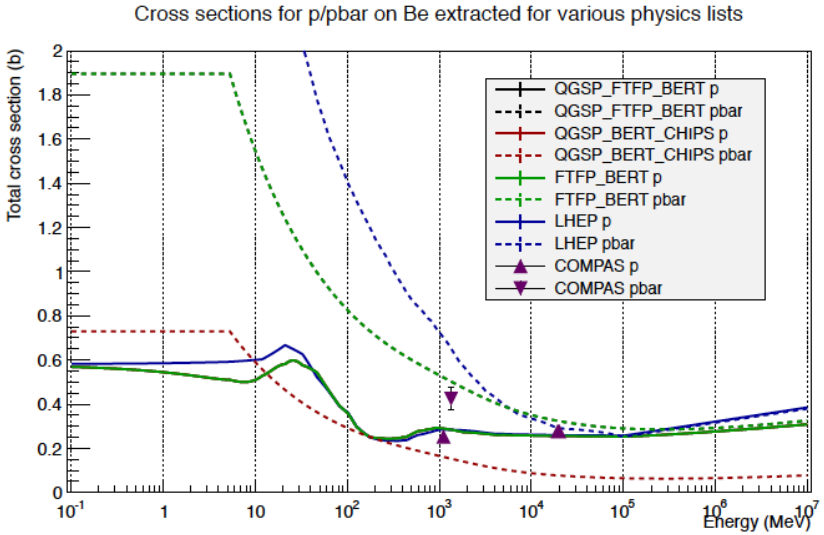
# Electromagnetic

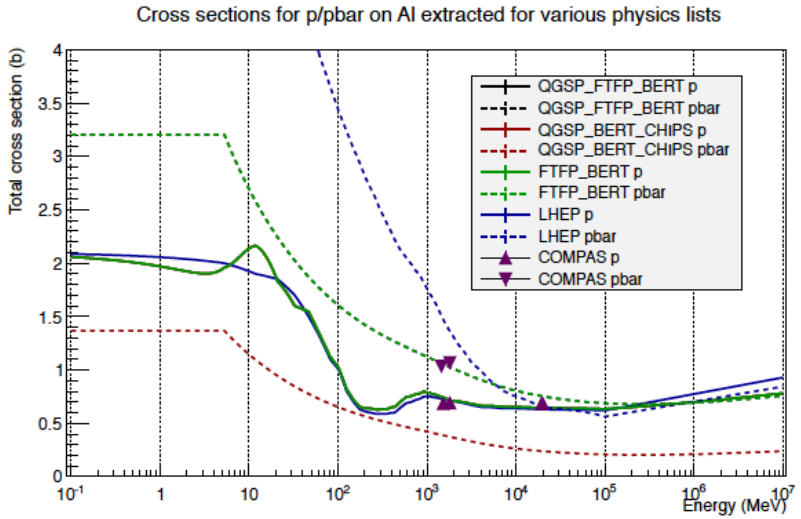
- Studied with full LHCb geometry, particle guns and min. bias samples
- Variations between all lists found to be very small
  - EmNoCuts, EmOpt1, EmStd, EmOpt3, EmLHCb
- No significant gain so conclusion to remain with current list
  - EmOption1/no ApplyCuts



# Hadronic cross-sections

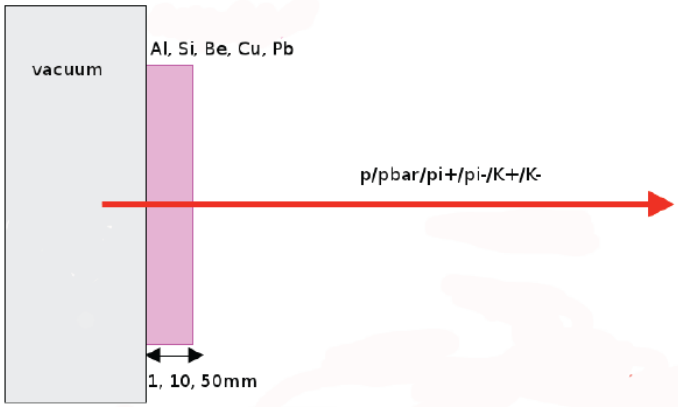
- Standalone tests of cross-sections (no detector geometry)
  - Protons, kaons, pions on Al, Si, Be
  - Anticipated to use FTFP_BERT as improved thin layer modelling of hadronic interactions (including $K^{\pm}$) and anti-baryons and light anti-ions, and CHIPS cross-sections.
  - Found (and G4 very quickly fixed – thanks!) LHEP cross-sections being used in FTFP_BERT for kaons



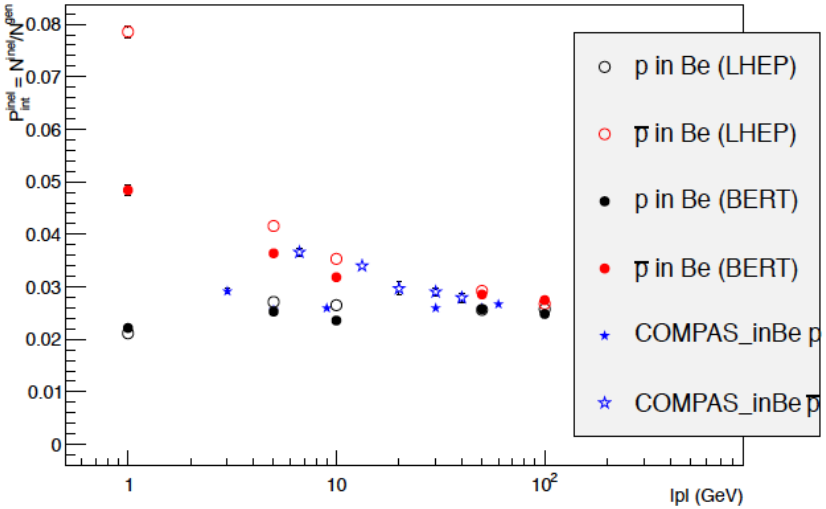



# Hadronic cross-sections

- Tests of inferred cross-sections (simplified geometry, but using LHCb simulation framework)
  - Protons, kaons, pions on Al, Si, Be




Inelastic cross-section (10mm Al)




- Particle guns:
  - $p$, $K^+$, $\pi^+$, $\bar{p}$, $\pi^-$, $K^-$
- Materials:
  - A, Si, Be, Cu, Pb
- Thicknesses:
  - 1mm, 10mm, 50mm

$$\sigma_{int} = P_{int} \cdot \frac{A}{\rho N_A \Delta x} \cdot 10^{-24}$$

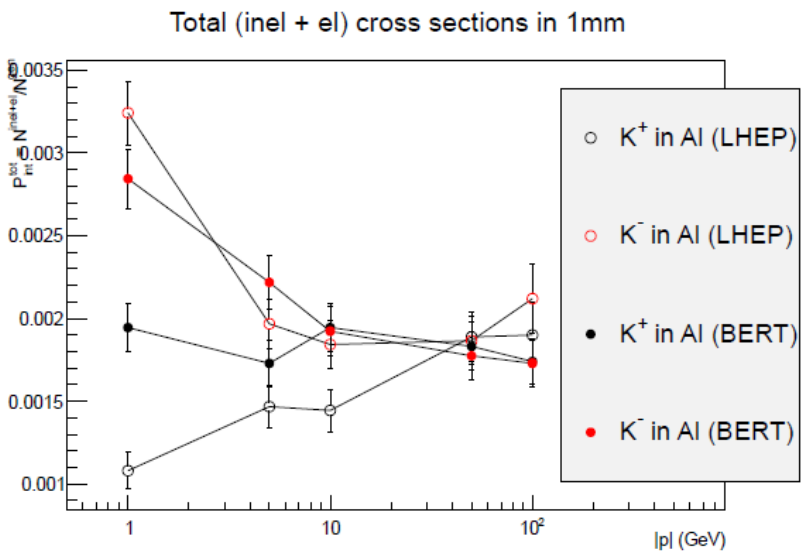
- $\Delta x \rightarrow$ thickness
- $\rho$ and $A$ of material
- $10^{-24} \rightarrow$ conversion to barn

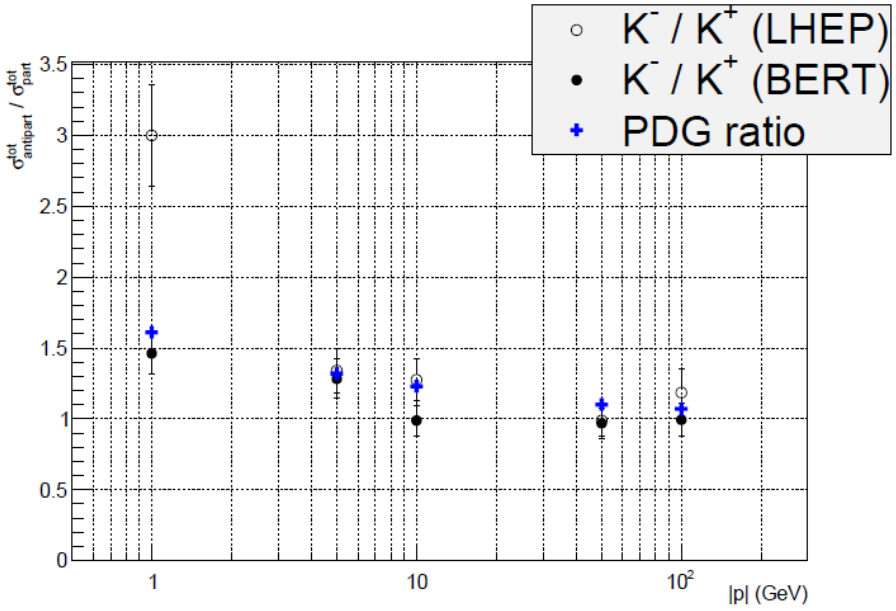
Valid for thin layers.

FTFP_BERT closer to data for protons

# Hadronic cross-sections

- Asymmetries between particle/antiparticle
  - Protons, kaons, pions, on …

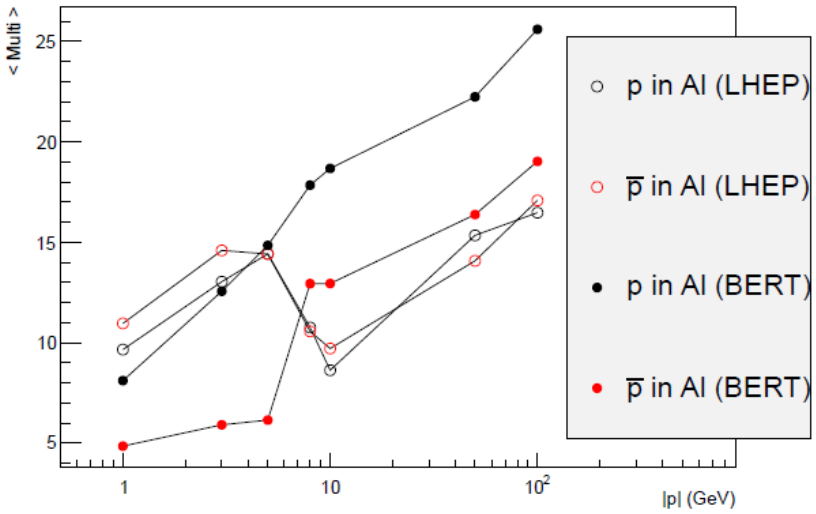


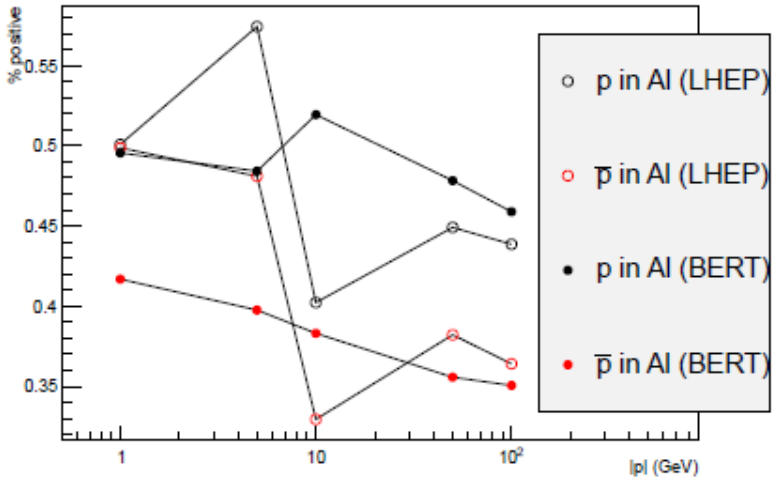
# Hadronic interactions

- Studied for kaons, protons, similar conclusions, FTFP_BERT more reasonably behaved

Inclusive particle multiplicities




Positive fraction



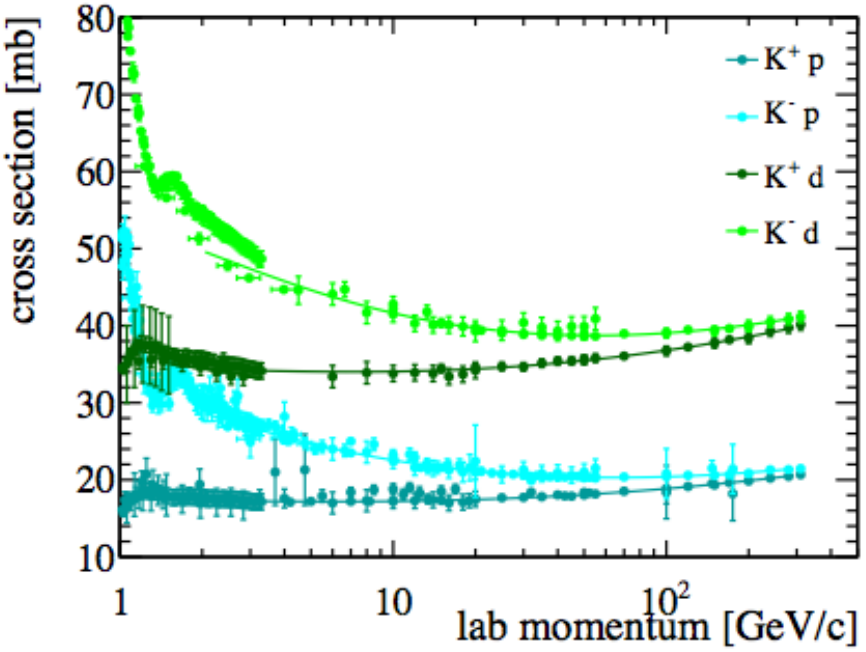

Positive

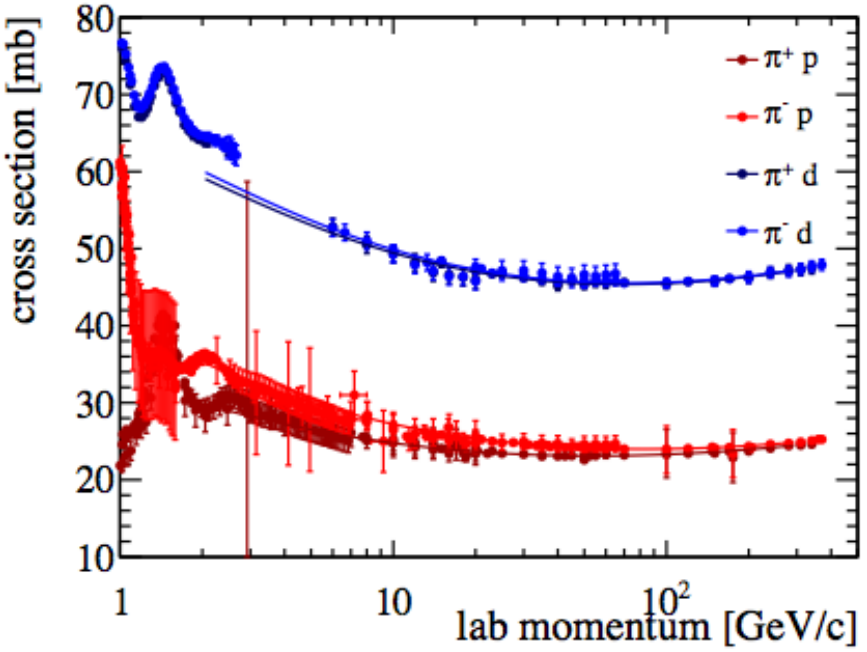
# Kaon and pion cross-section asymmetries

- LHEP physics list used previously gave ~acceptable kaon asymmetry, but problematic pion asymmetry
- Study using $D^0 \rightarrow K\pi$ from semileptonic B decay
  - Extract interaction asymmetry from “reconstructible” efficiency
  - Compare with estimate of asymmetry from PDG and material map

# Interaction asymmetry from PDG

Kaon and pion cross sections on proton and deuterium




- Data from PDG (Compas group in Protvino)
- See http://pdg.lbl.gov/2012/hadronic-xsections/hadron.html
- Or PDG p.447-454

# Kπ asymmetry in PDG and data

preliminary

Uncertainty mainly from material budget knowledge.

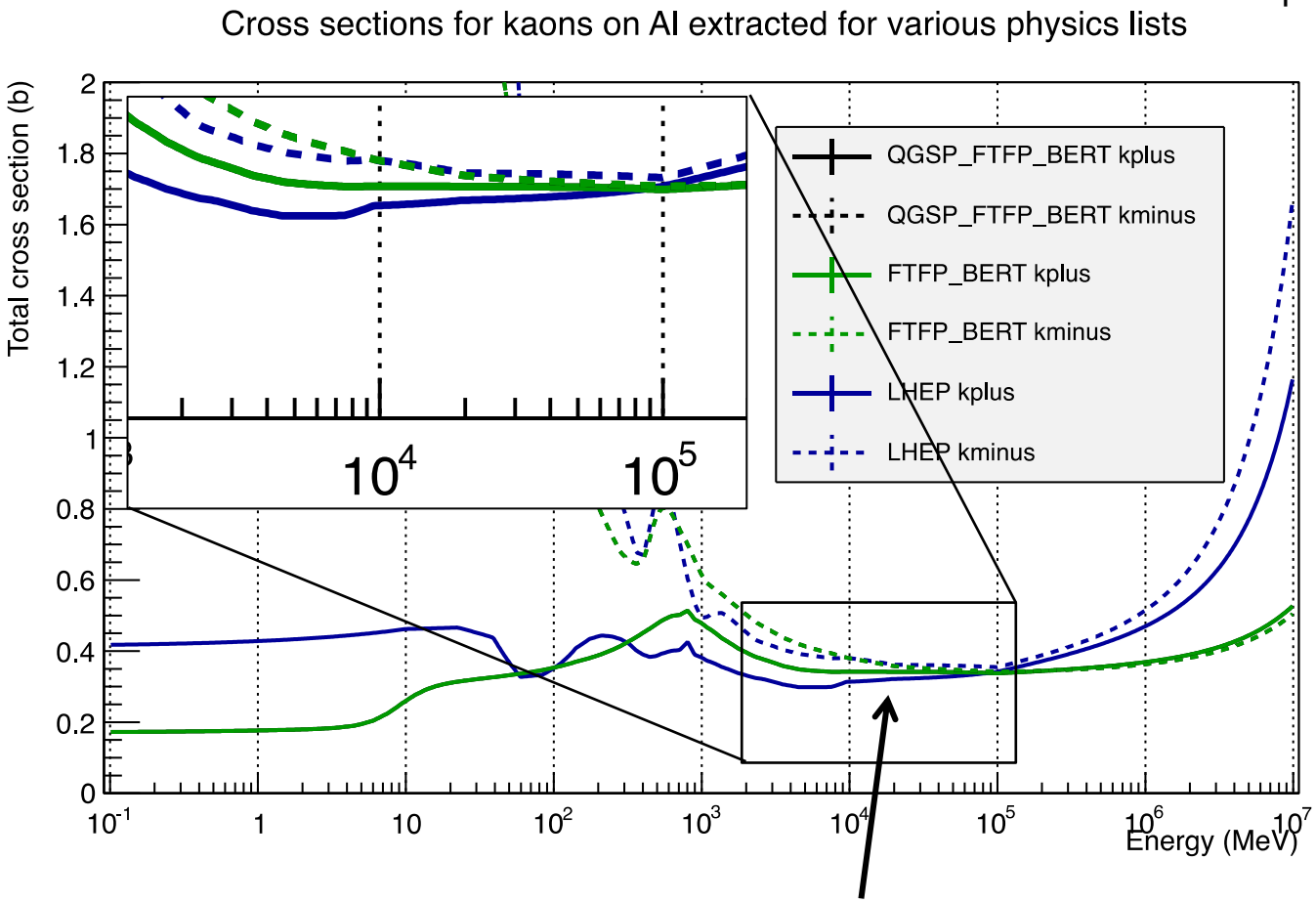
Data plot removed after the meeting, was not an “officially approved” result. Will be updated when an equivalent version becomes available.

Scoring plane at z=9410mm gives $A_{k\pi}$=0.93±0.08%
→ add 0.08% as systematic

- All details described in internal note LHCb-INT-2012-027
  - https://cds.cern.ch/record/1482647?ln=en
- Data above PDG predictions. Translates into (30±20)% more material.

# Geant cross sections for kaons

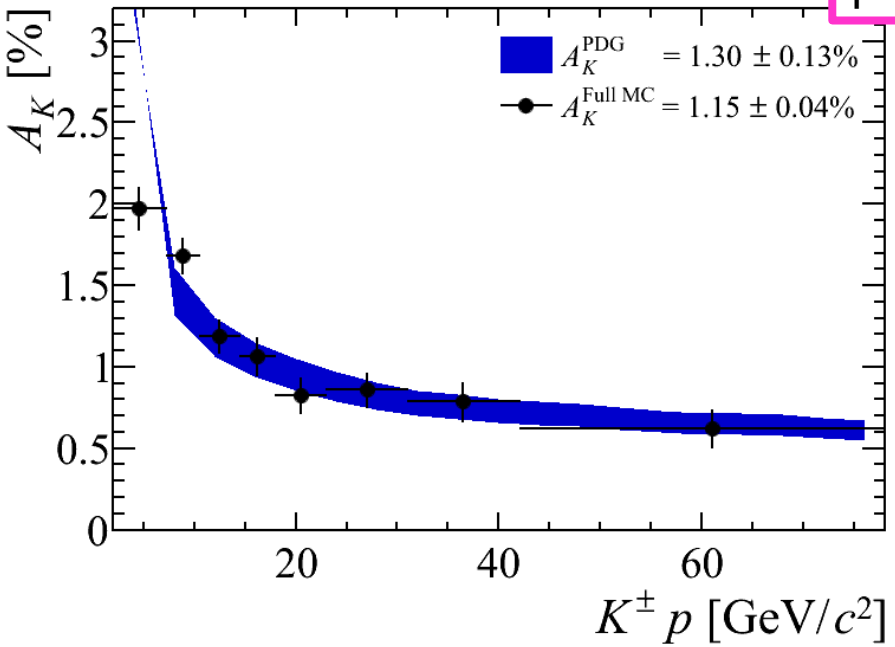
Same kaon cross-sections as previously shown

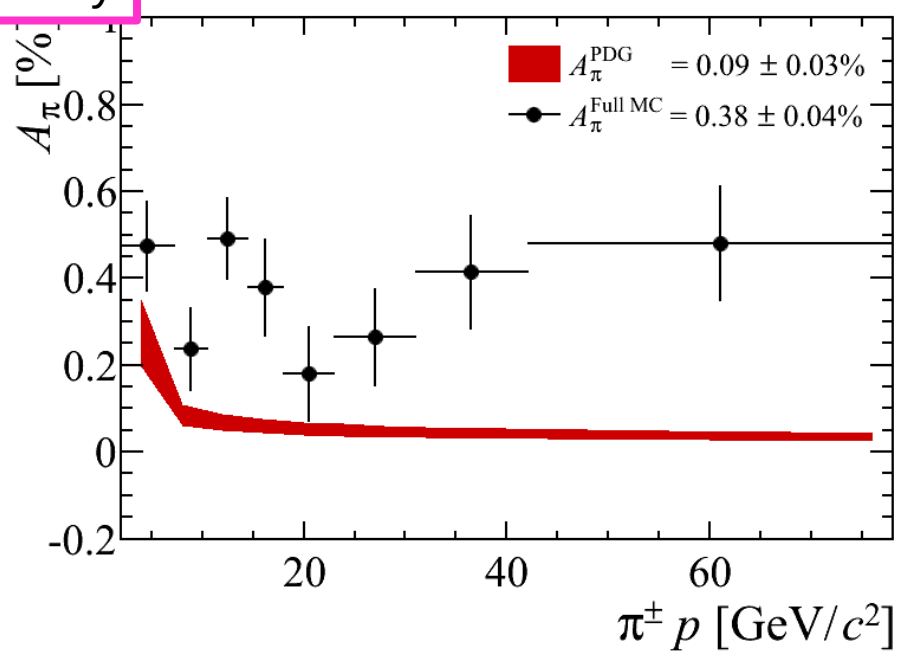



Worry: kaon cross sections slightly lower for FTFP_BERT compared to LHEP

# MC11 (LHEP) asymmetries

preliminary

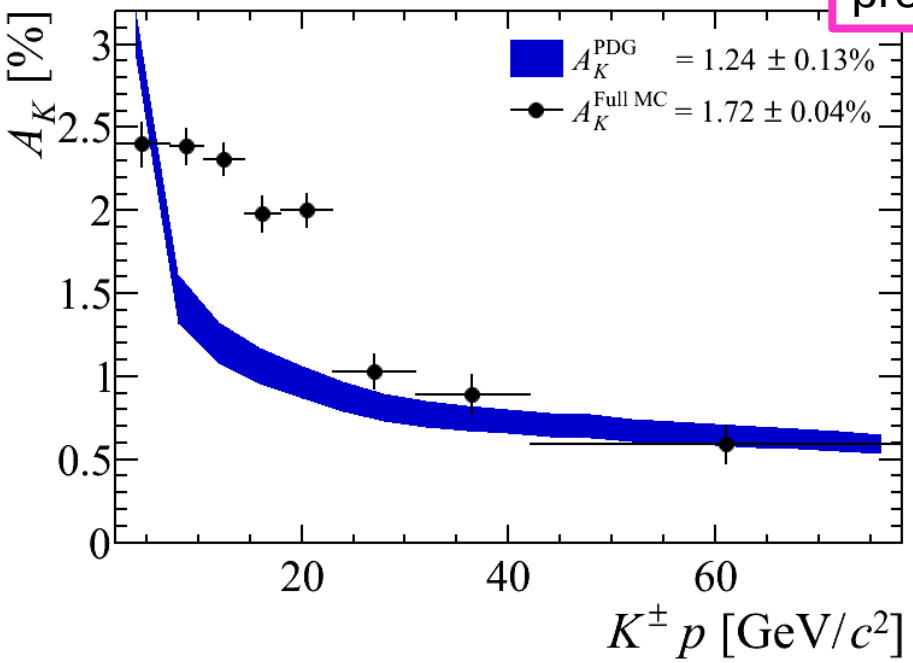


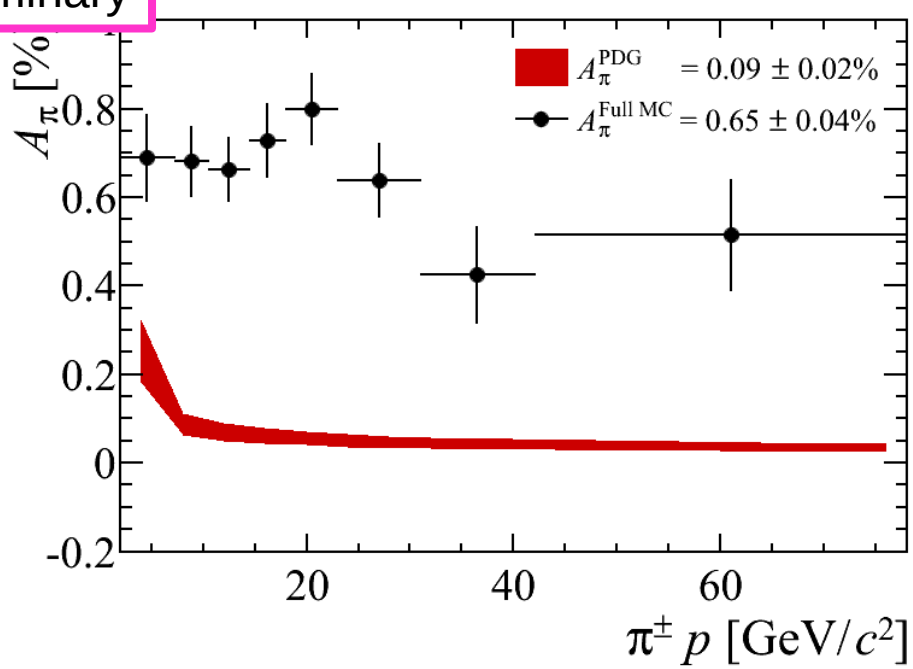




- From previous 9.4.patch02 production setup in LHCb (LHEP list)
  - Kaon asymmetry looks ok.
  - Pion asymmetry way off.

# Sim08 (LHEP) asymmetries

preliminary

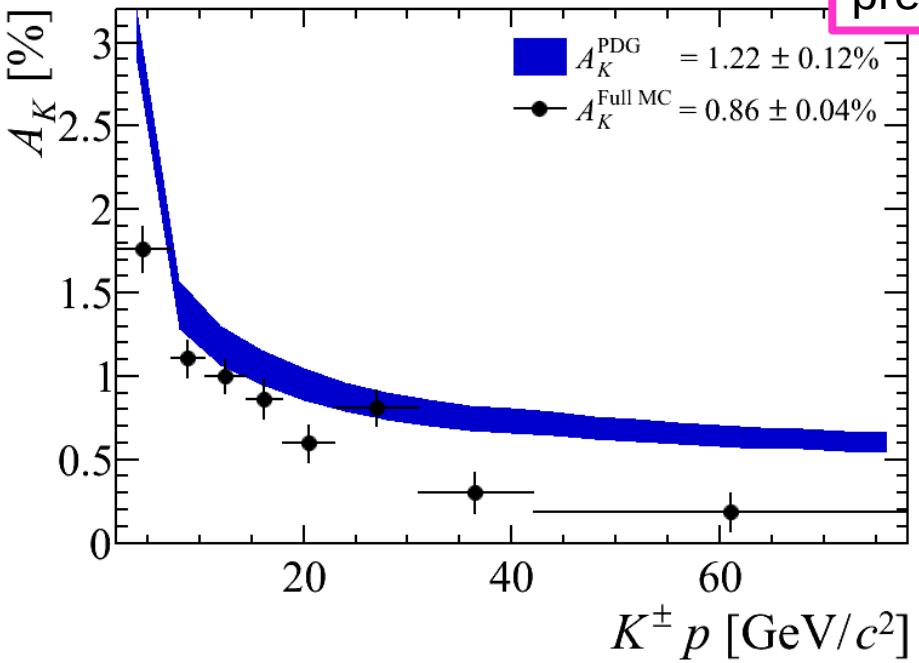


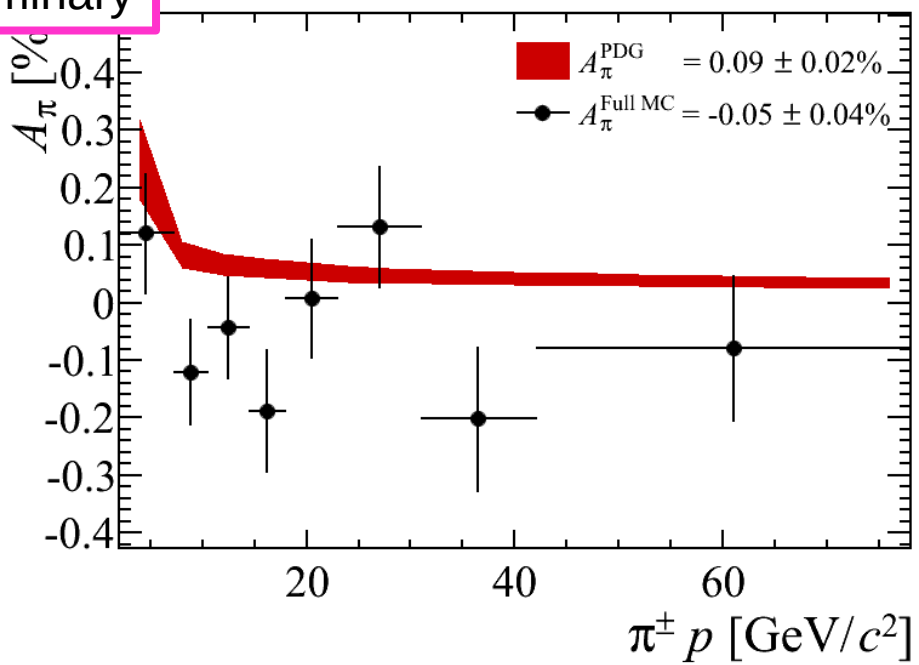




- Using 9.5.patch02 setup in LHCb (LHEP list)
  - Nominally unchanged G4 physics
- Kaon asymmetry for low momentum now too high
- Pion asymmetry further off
- At one level, should not worry as we will not use this PL, but…

# Sim08 (FTFP_BERT) asymmetries

preliminary




- Using 9.5.patch02 setup in LHCb (FTFP_BERT list)
- Kaon asymmetry too low (esp. for high momentum).
- Pion asymmetry is ok now (note changed $A_\pi$ scale cf. previous slide)

# Summary

- Pre-production tests completed, MC production to start tomorrow
- G4 9.5.patch02, FTFP_BERT, EmOpt1 (no ApplyCuts)
- Thanks to G4 team
  - for rapid fix of CHIPS cross-section in FTFTP_BERT for kaons
  - (Witek et al.) in advance for investigation of crashes
- Thanks to collaborators for most material today
  - Jeroen van Tilburg (Physikalisches Institut Heidelberg)
  - Jimmy McCarthy, Pete Griffith, Luca Pescatore (Birmingham)
  - Gloria