HARP-CDP results on Geant4 validation

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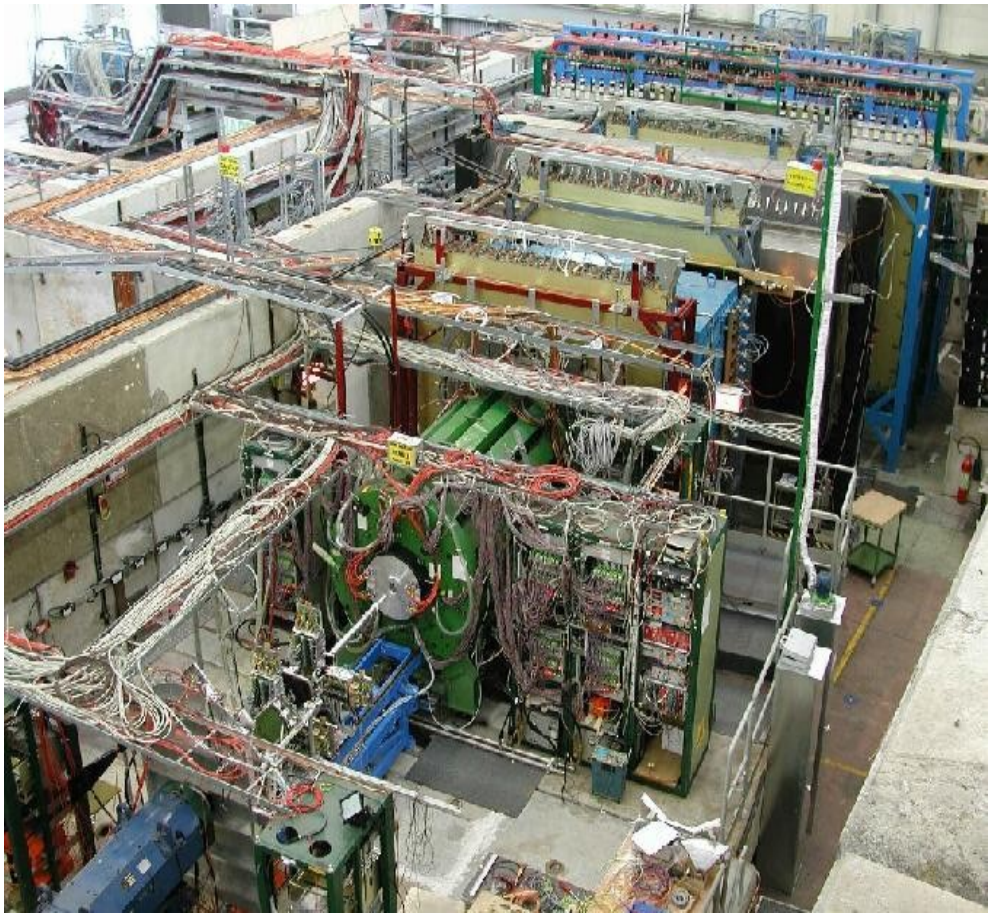
for the HARP-CDP group

LCG Physics Validation meeting 18 June 2008

The HARP experiment

- The hadron production experiment at CERN PS
- Data taken in 2001-2002
- Beam **p, $\pi^{\pm}$**, K, d
- Beam momenta **1.5-15** GeV/c
- Target nuclei from **H_2** to **Pb**



The comparison presented is based on the HARP-CDP analysis of p and $\pi^{\pm}$ interactions with Beryllium target at +8.9 and -8.0 GeV/c

The HARP experiment

For more details about HARP-CDP results, you are invited to attend a CERN Seminar by F. Dydak

Tuesday 24 June 2008
from 16:30 to 17:30 in the Main Auditorium

Validation conditions

- Geant4 version 4.9.1 (14 Dec 2007) was used
- Test program, derived from the G4 example hadr01, reproduced ideal HARP conditions
  - Beam particles bombard thin (5% λ) beryllium target
  - MC truth information of secondaries was collected
  - Angular distribution of MC output was compared with data
  - All standard physics lists were tested
- Only shape of distributions was compared. No comparison of absolute cross-sections was done yet
- We repeated few tests with the most up-to-date Geant4, version 4.9.1p02 (9 May 2008)

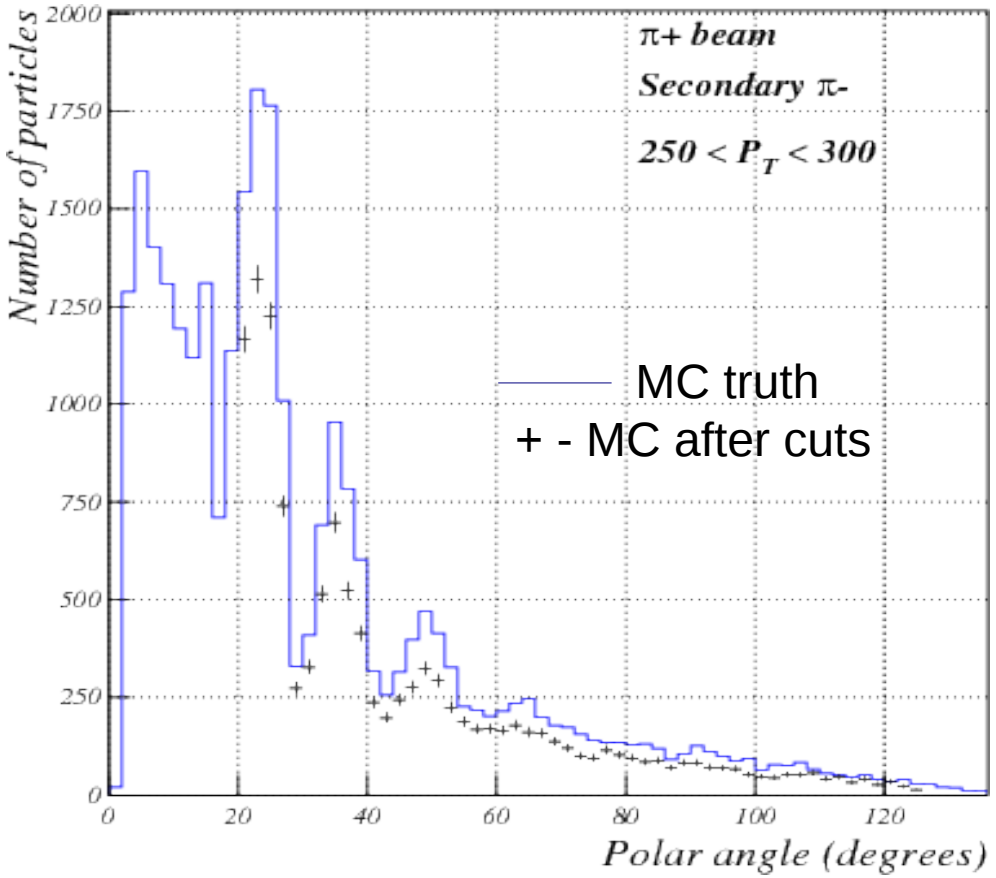
Geant4 physics lists

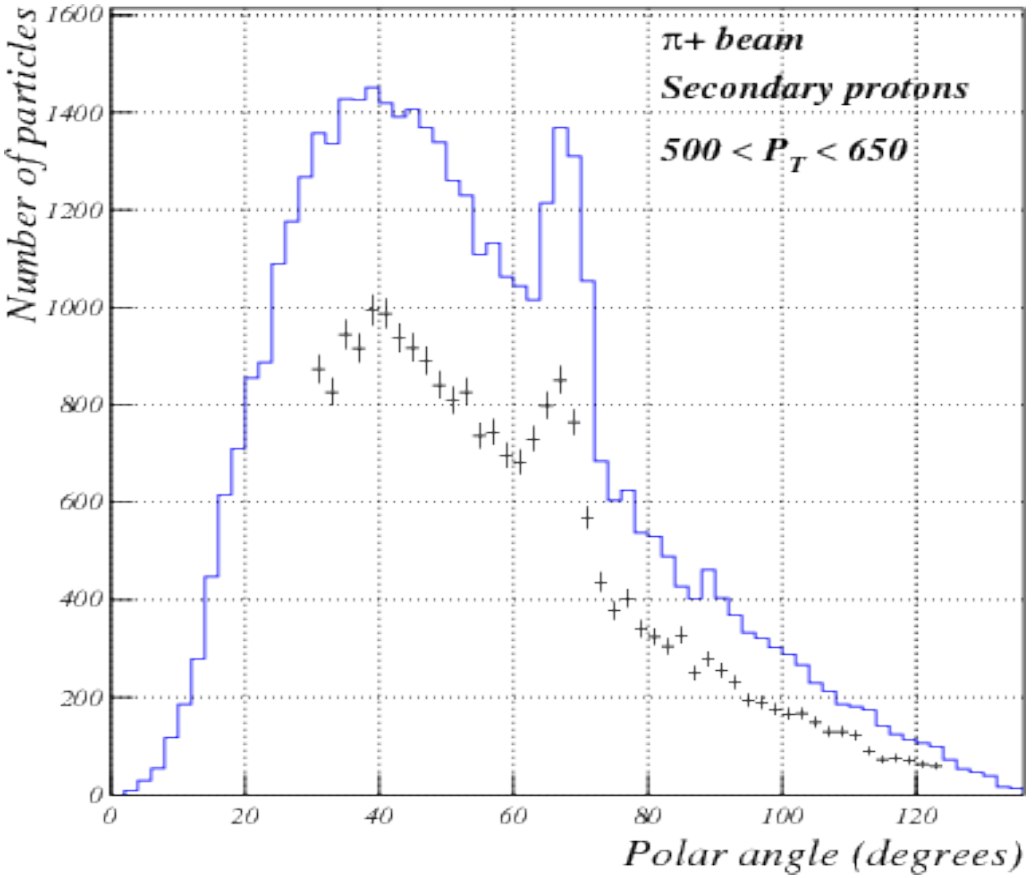
- Geant4 version 4.9.1 has 32 standard physics lists
- However part of them are using the same sets of models to simulate hadronic processes
- We selected 11 sets, which are different in the simulation of pN and πN interactions:

  LHEP, LHEP_PRECO_HP, QGSC, QGS_BIC, QGSP, QGSP_BERT, QGSP_BIC, QBBC, FTFC, FTFP, FTFP_BERT

- The difference is in choice of major building blocks of hadronic processes, and range of their applicability
  - Re-parametrized GHEISHA (separately for low and high energy)
  - Bertini and binary cascades
  - Quark-gluon and FRITIOF string models
  - Precompound model and CHIPS for nuclear deexitation

Acceptance and migration

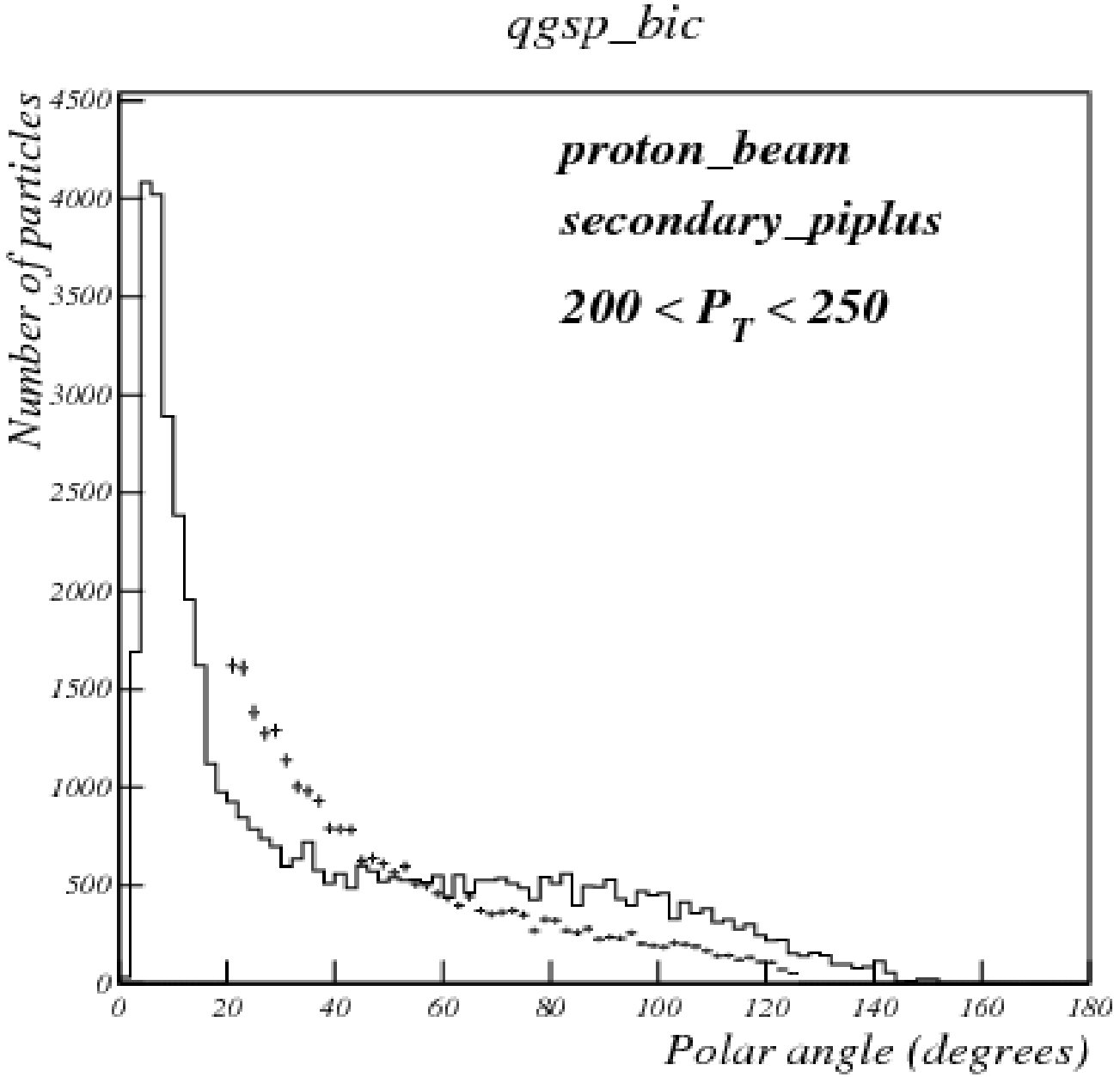




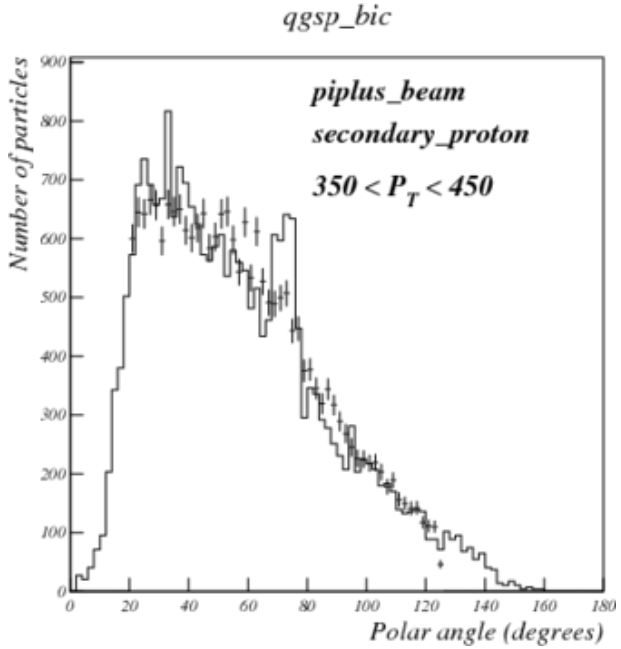
We consider the effect of acceptance correction and migration small enough, and compare data with MC truth directly

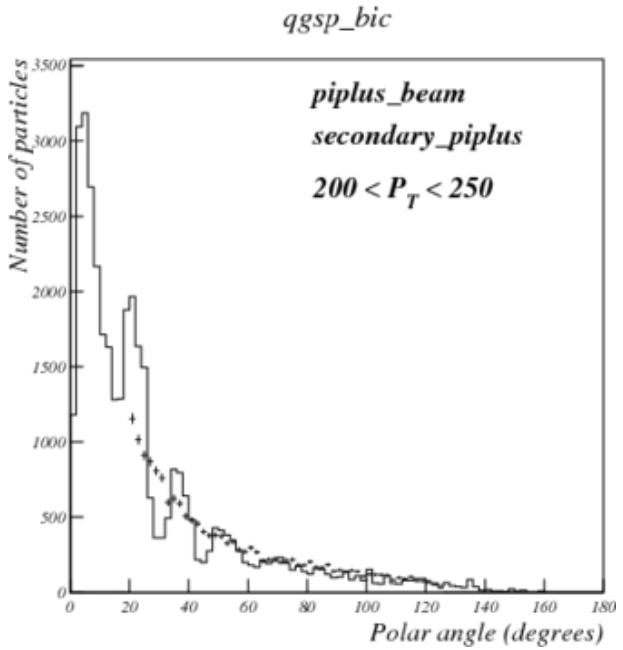
Kinematic region with unambiguous particle identification is chosen

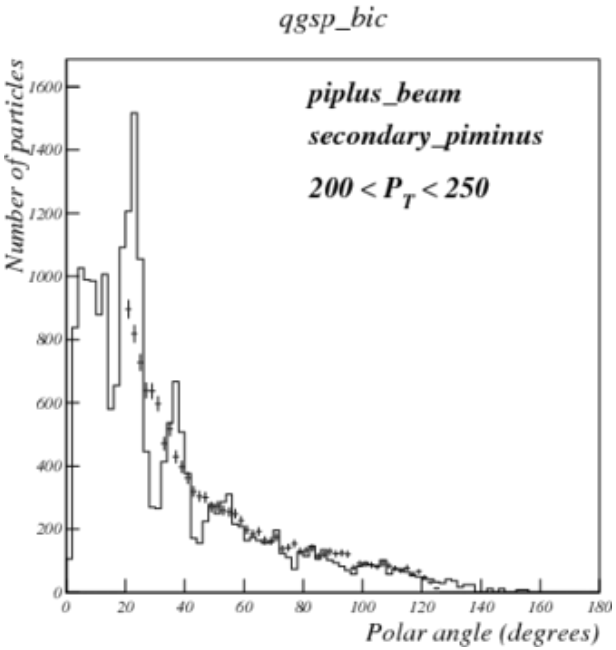
Comparison: QGSP_BIC (proton beam)

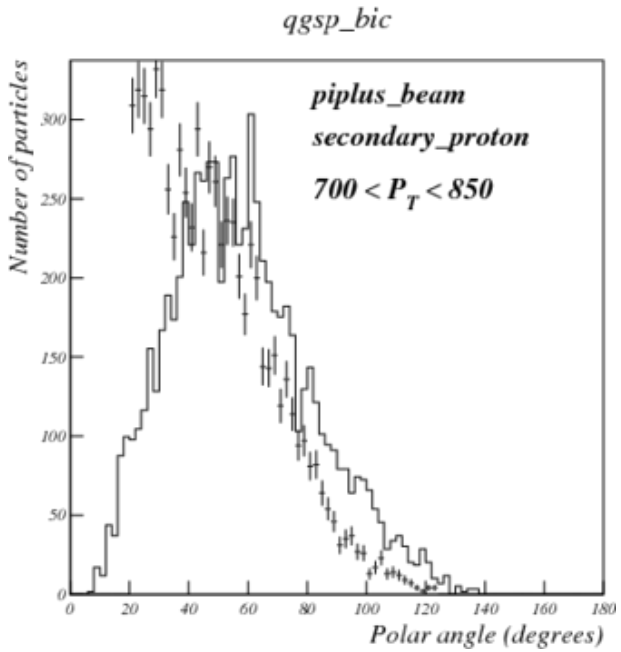


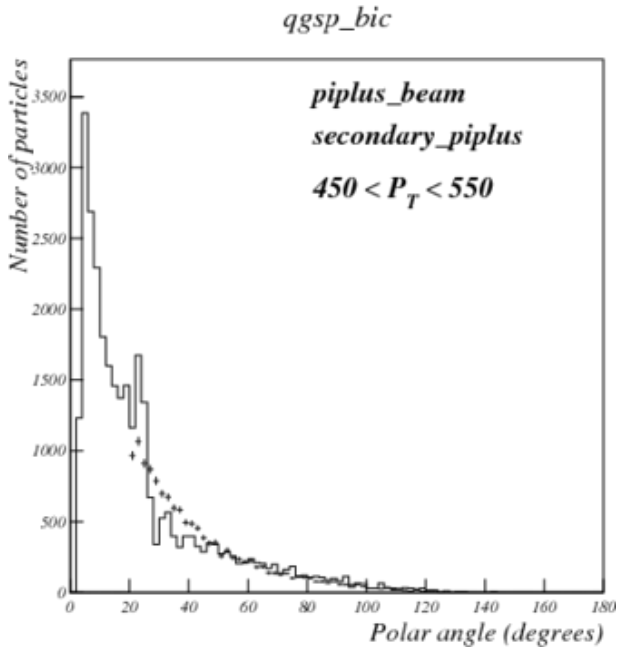
Comparison: QGSP_BIC (π^+ beam)

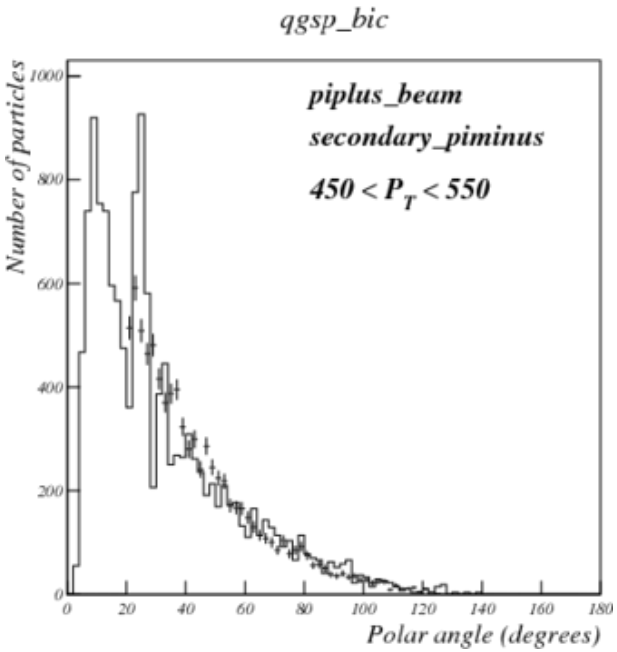




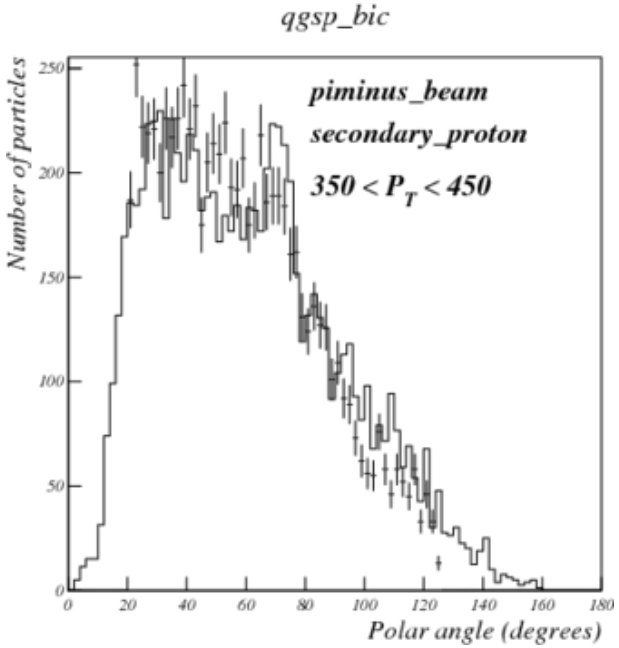


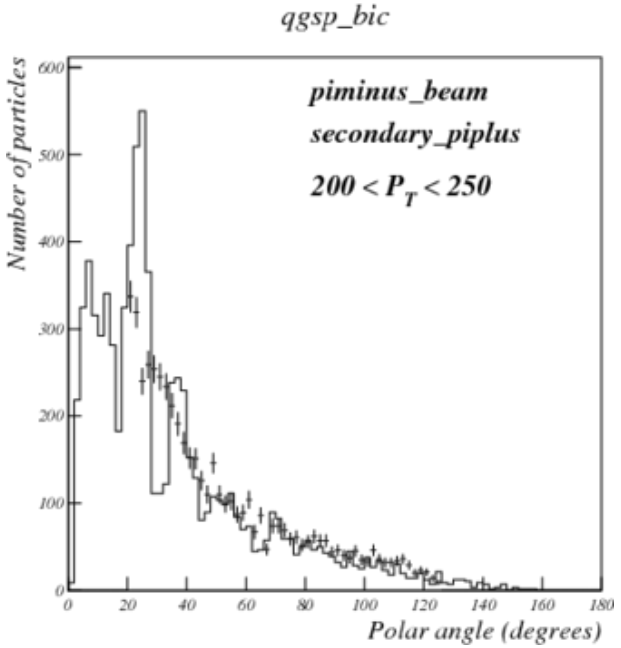


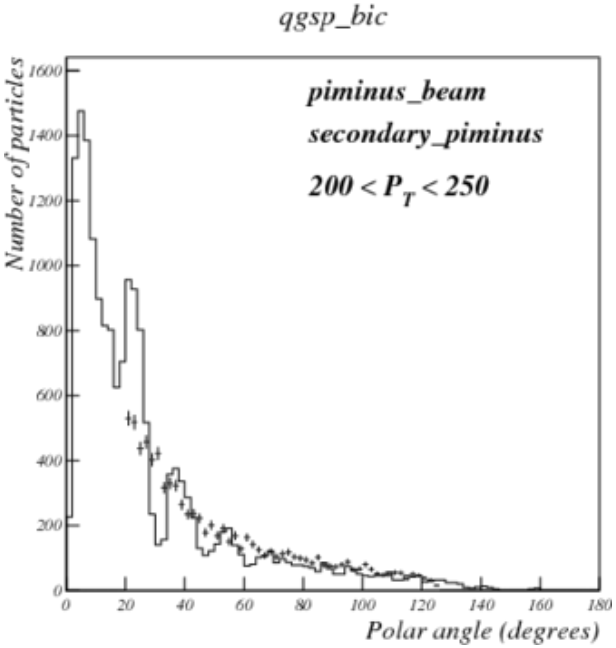


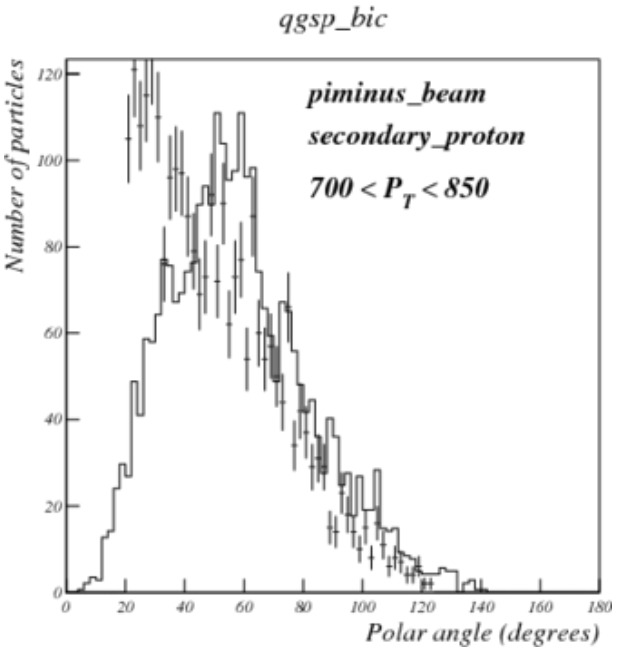


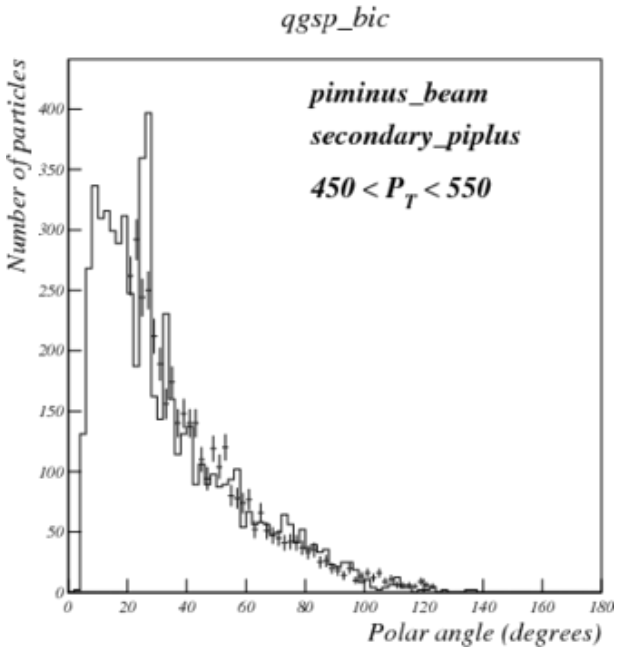
Comparison: QGSP_BIC (π^- beam)

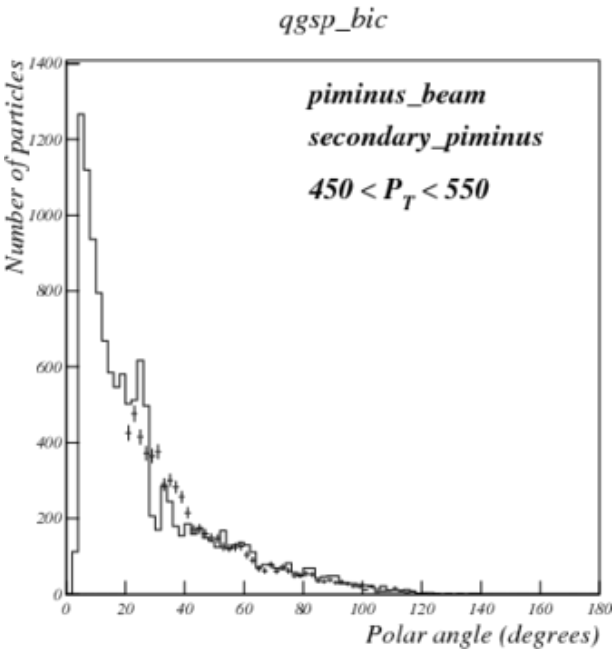




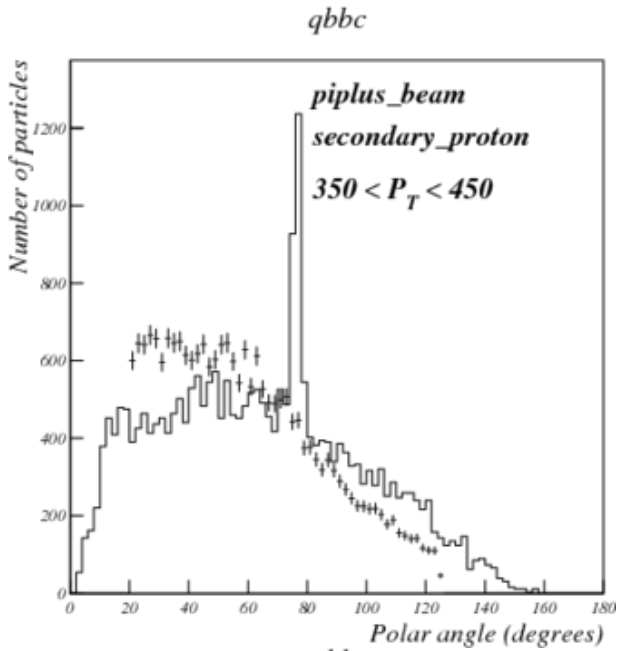


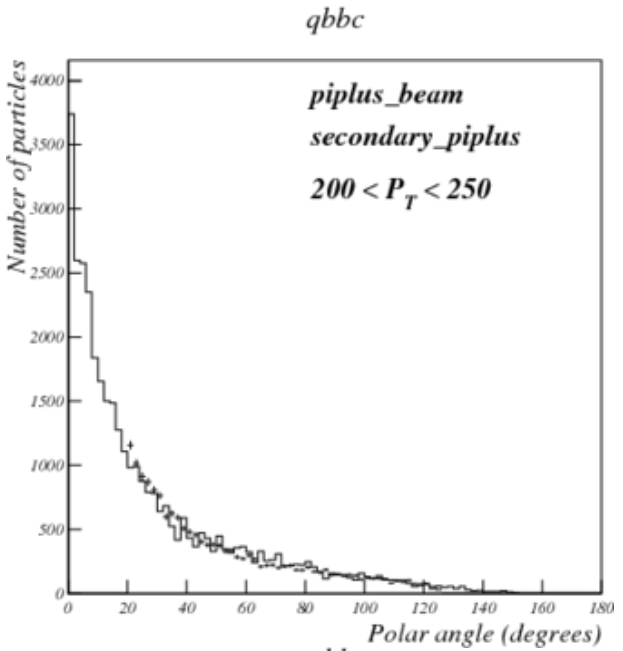


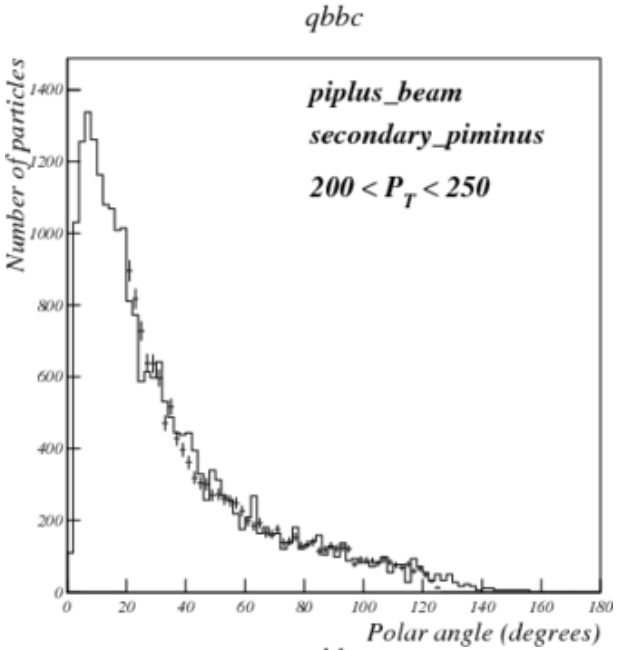


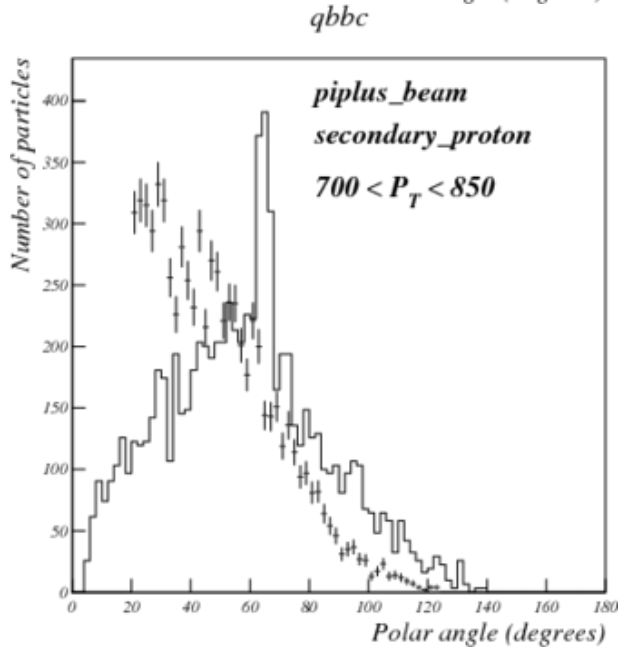


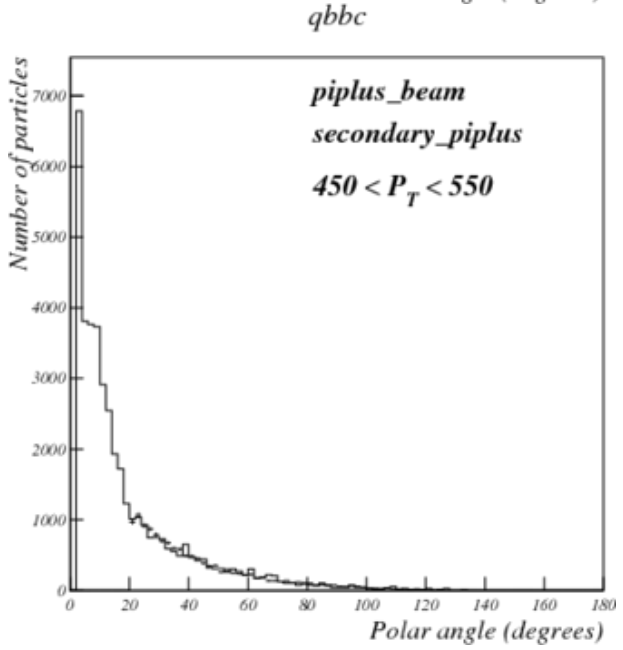
Comparison: QBBC (π^+ beam)

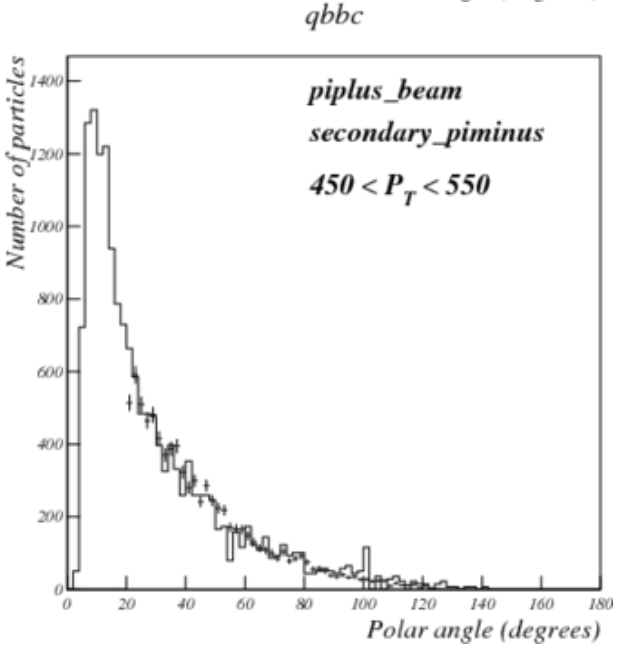




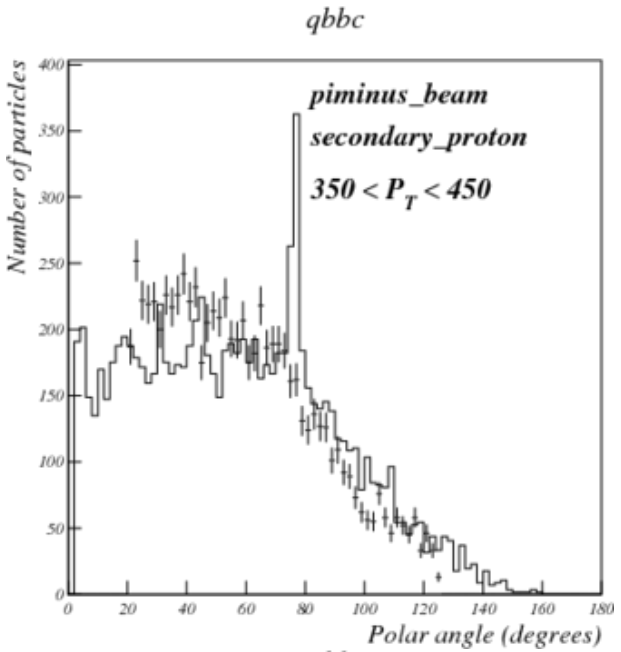


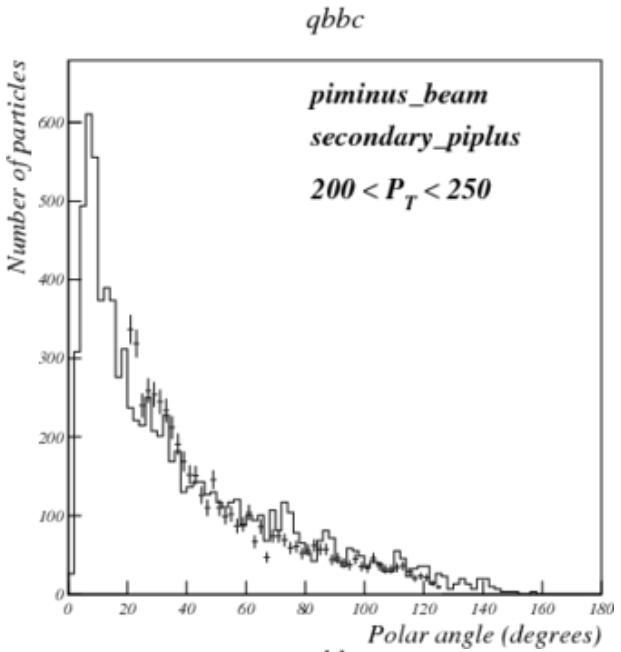


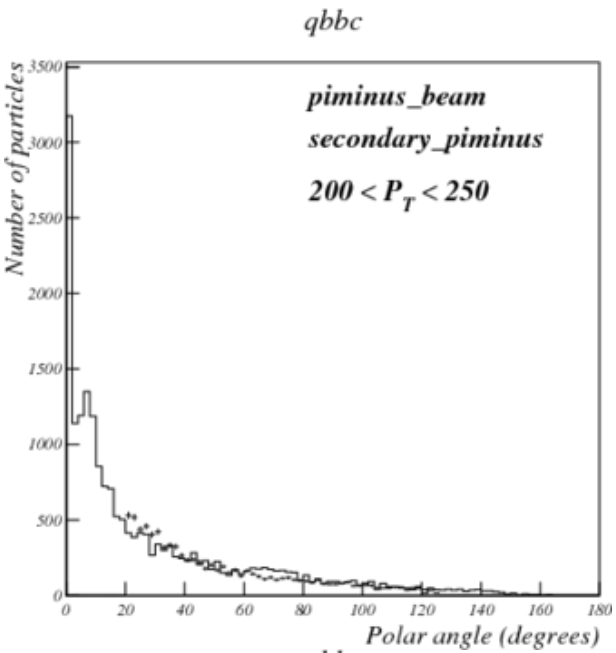


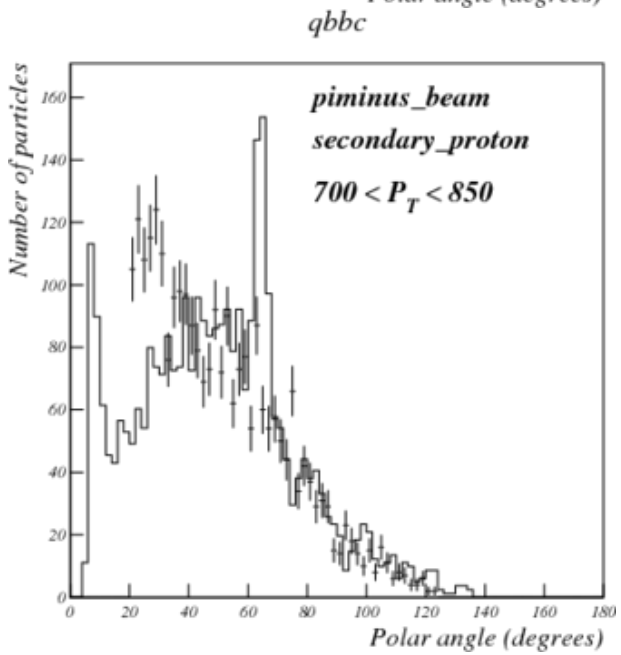


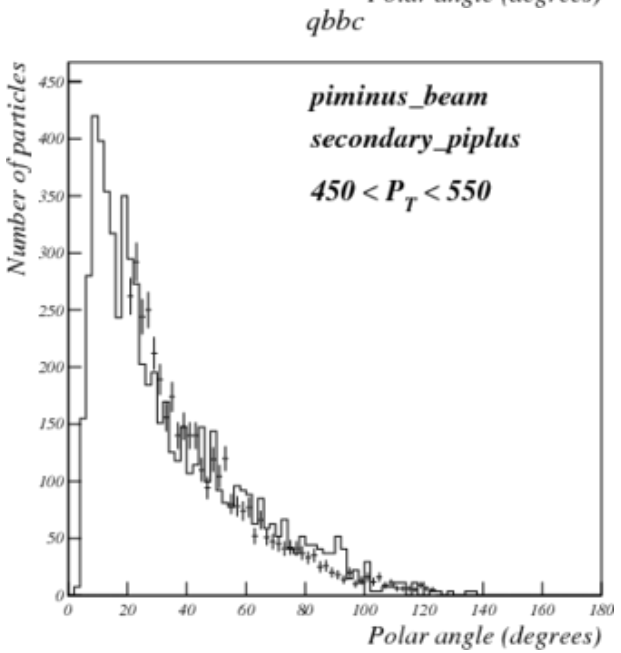
Comparison: QBBC (π^- beam)

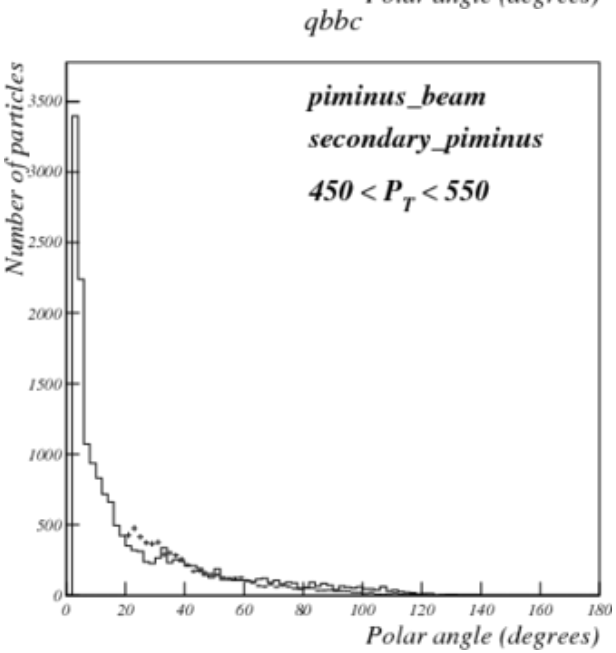




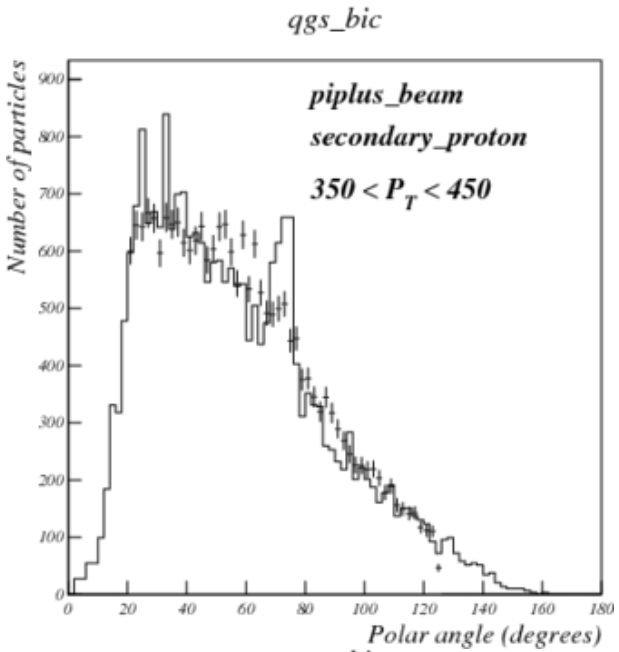


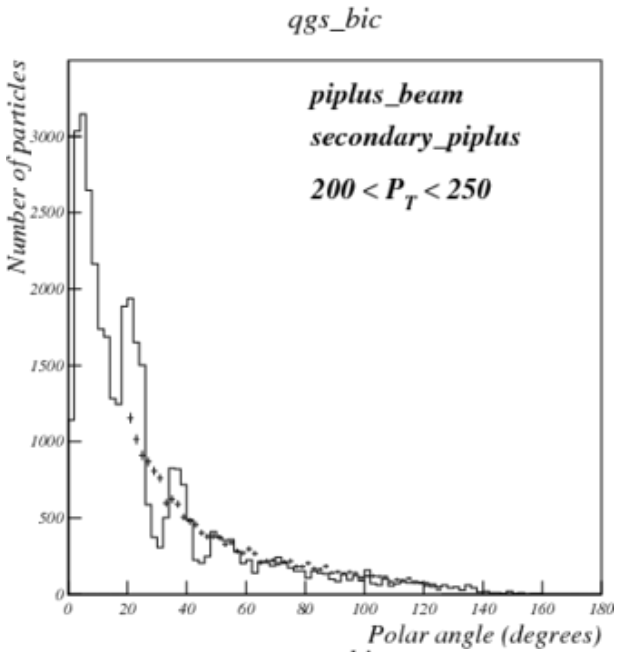


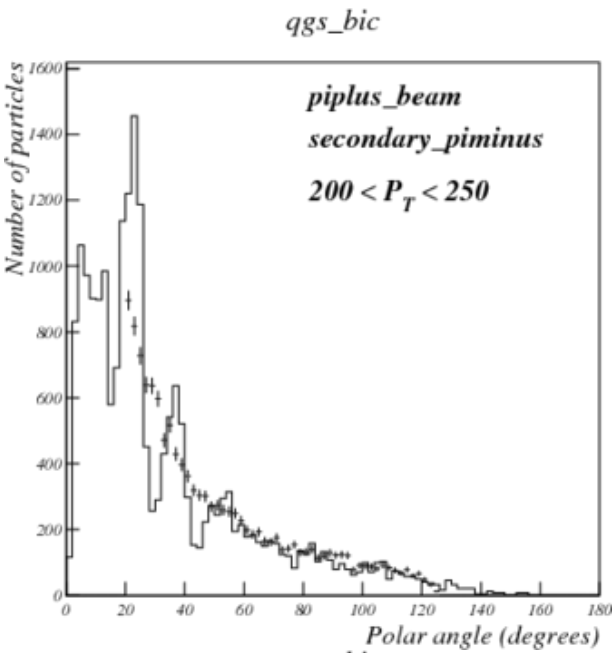


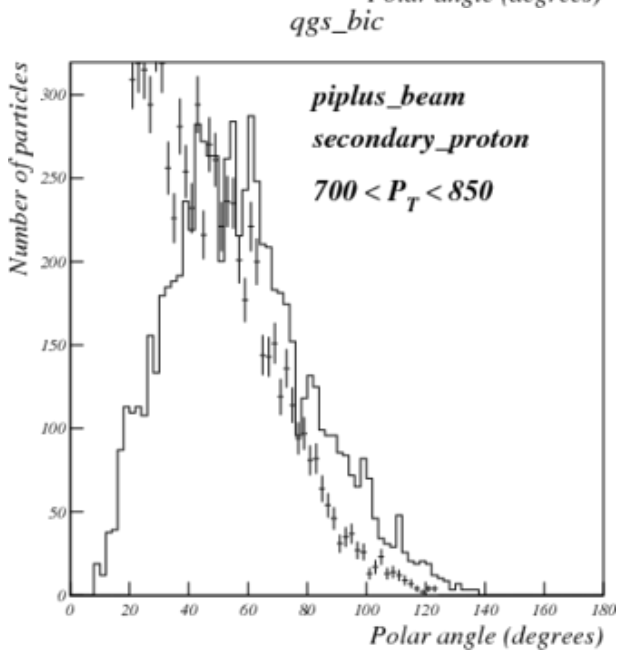


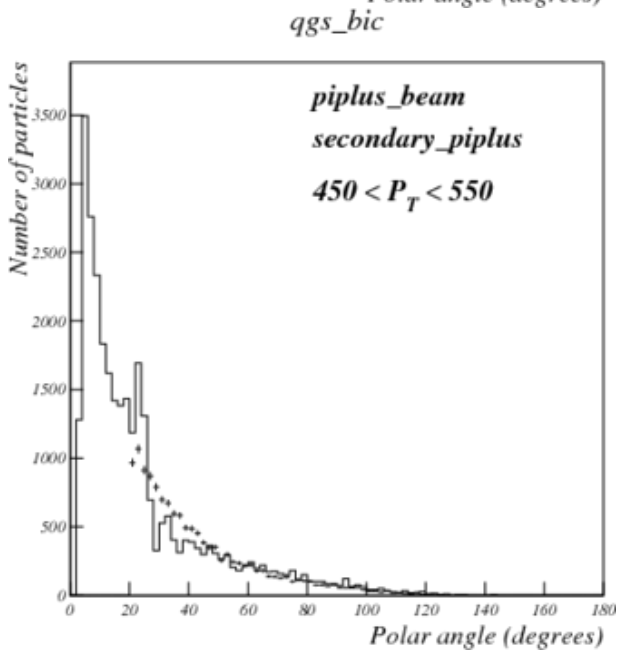
Comparison: QGS_BIC (π^+ beam)

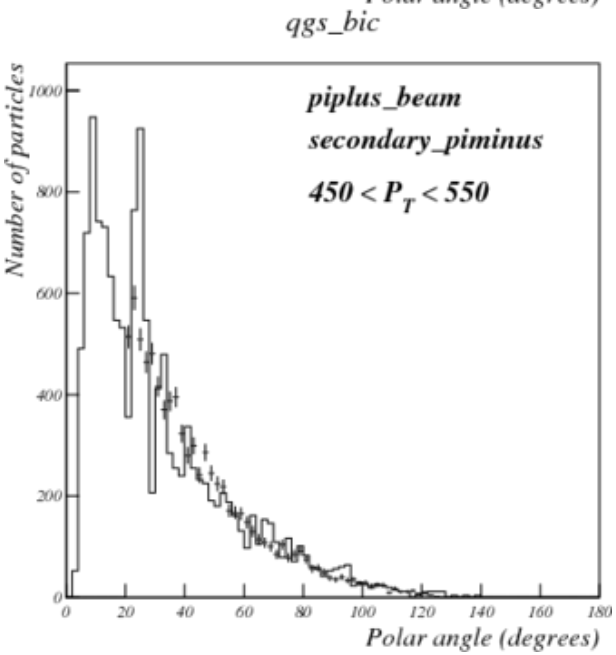




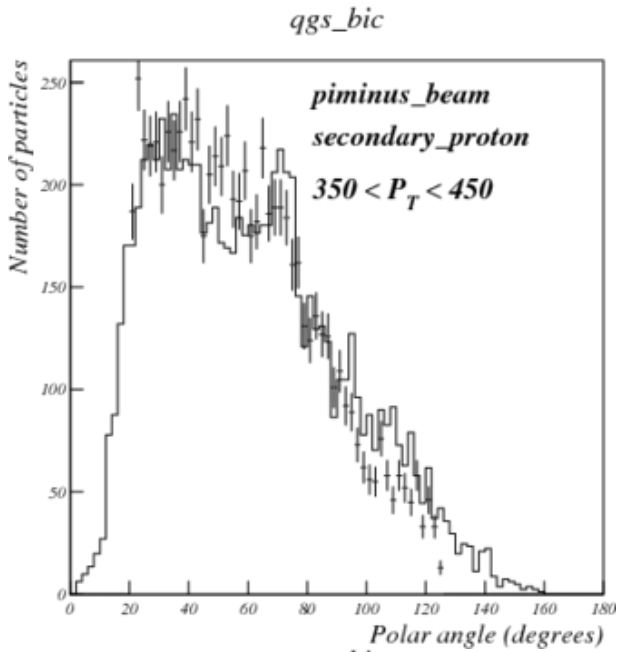


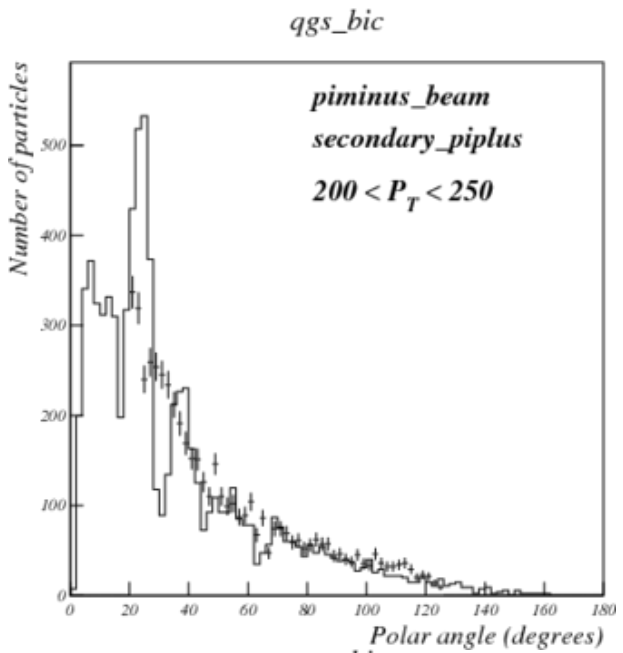


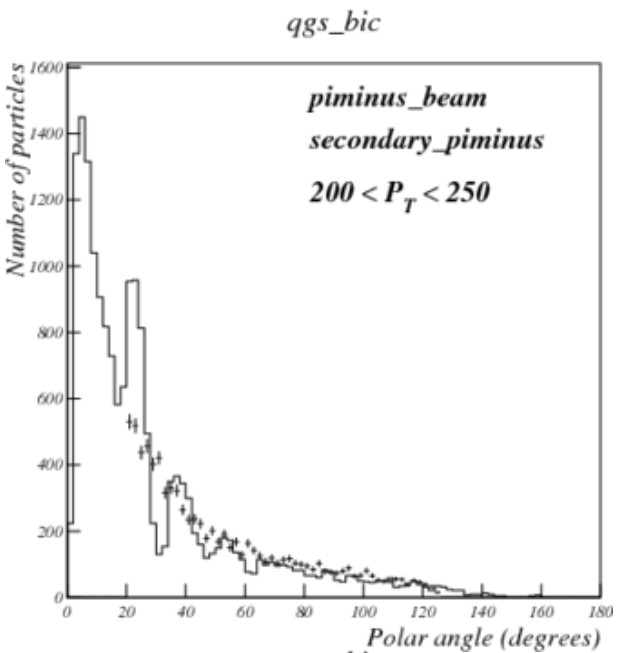


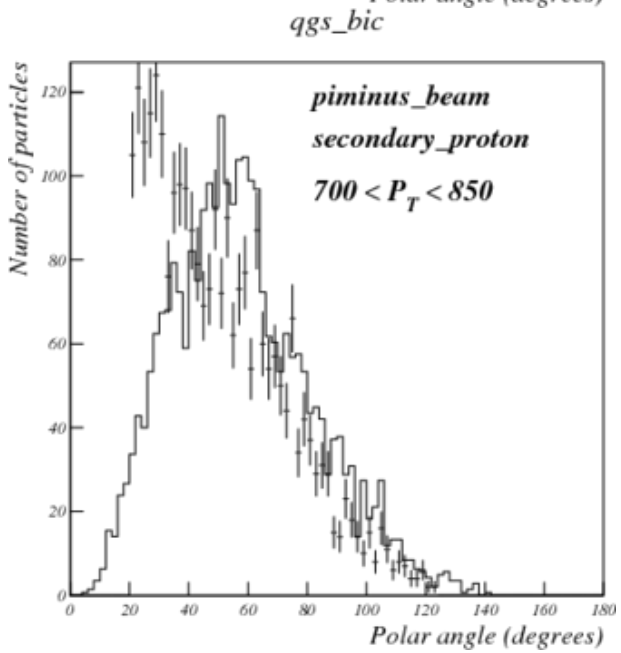


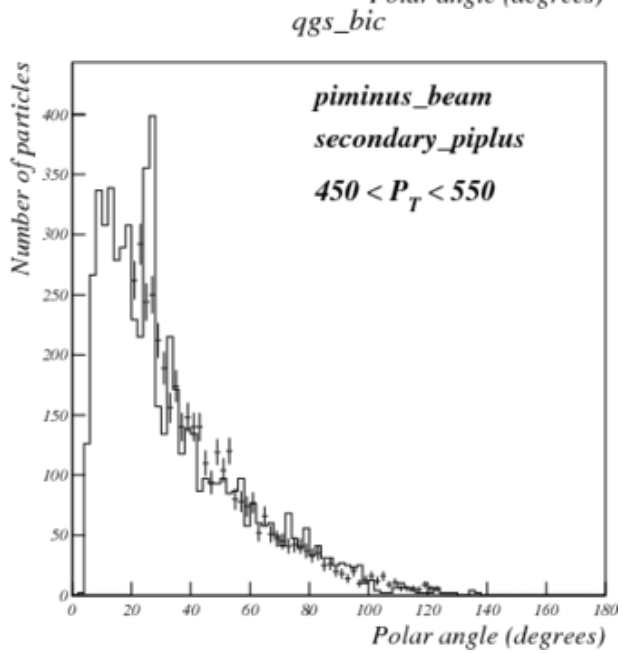
Comparison: QGS_BIC (π^- beam)

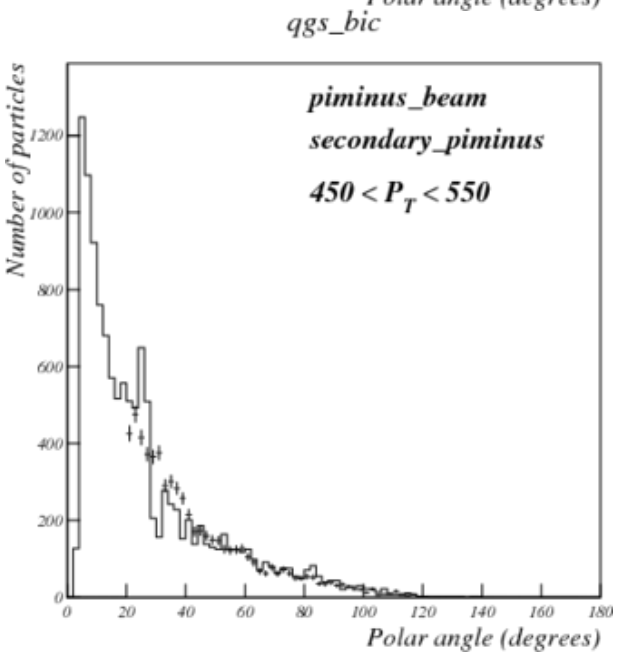




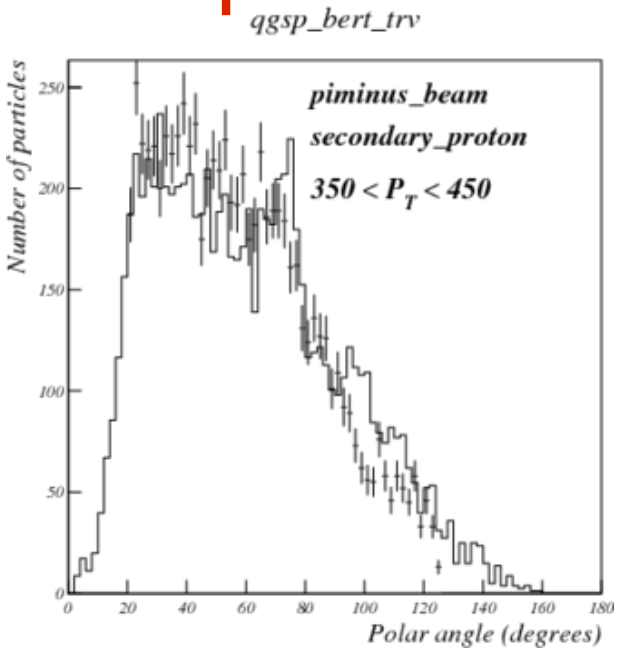


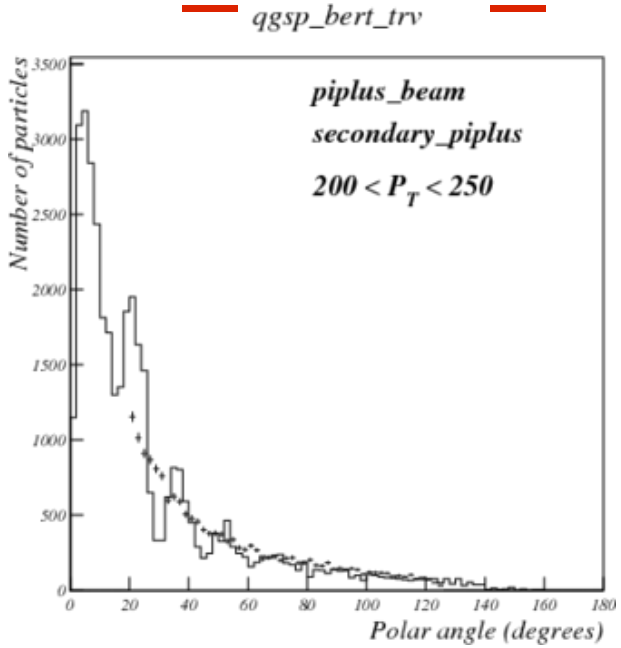


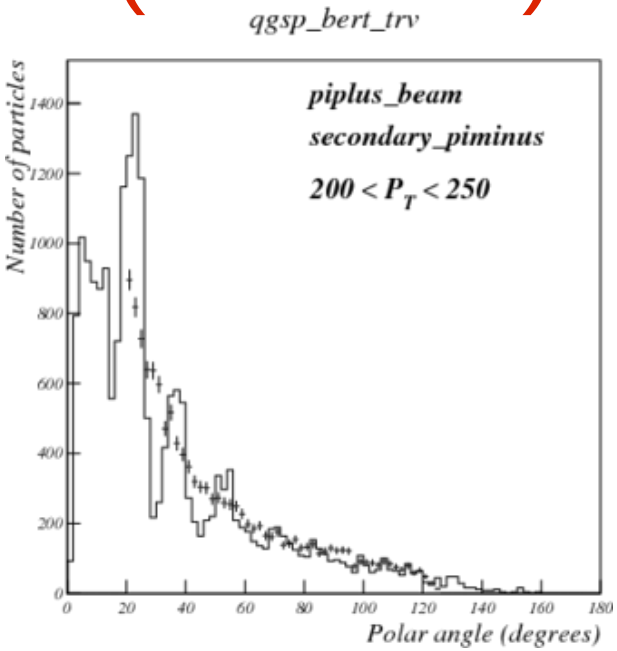


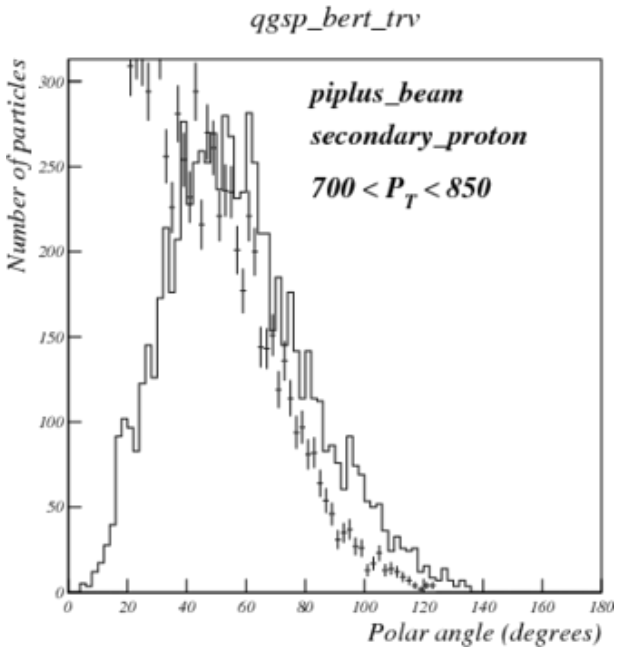


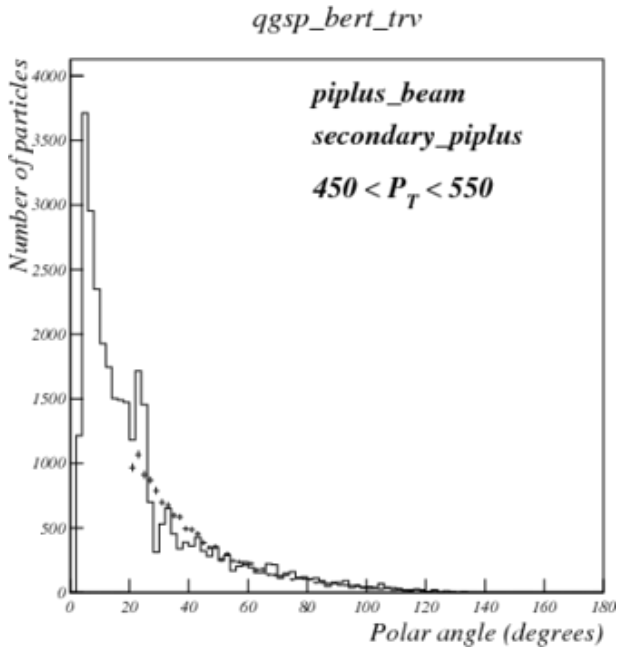
Comparison: QGSP_BERT_TRV (π^+ beam)

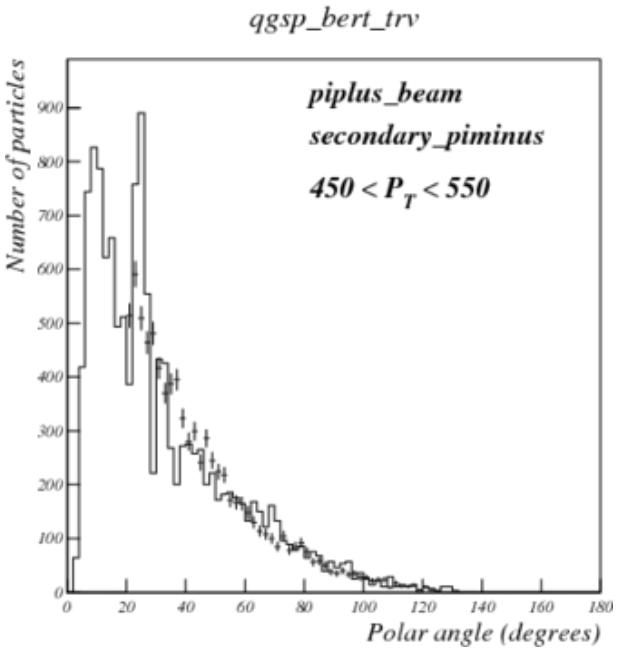




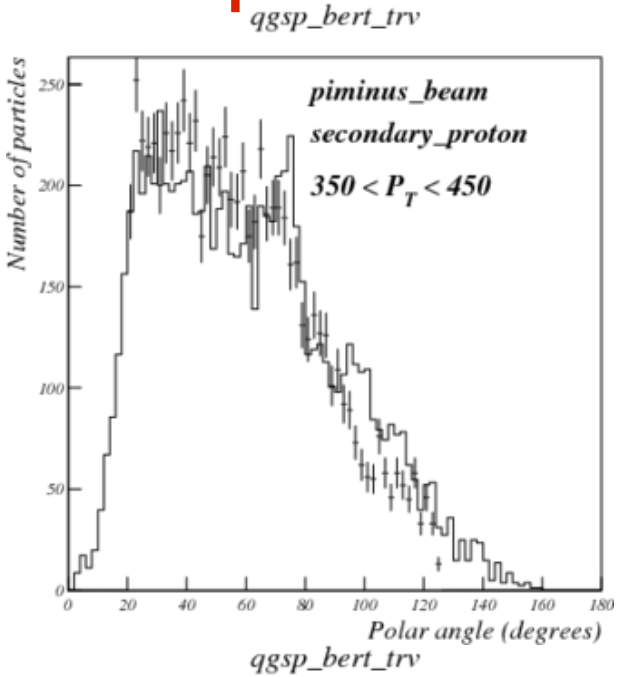


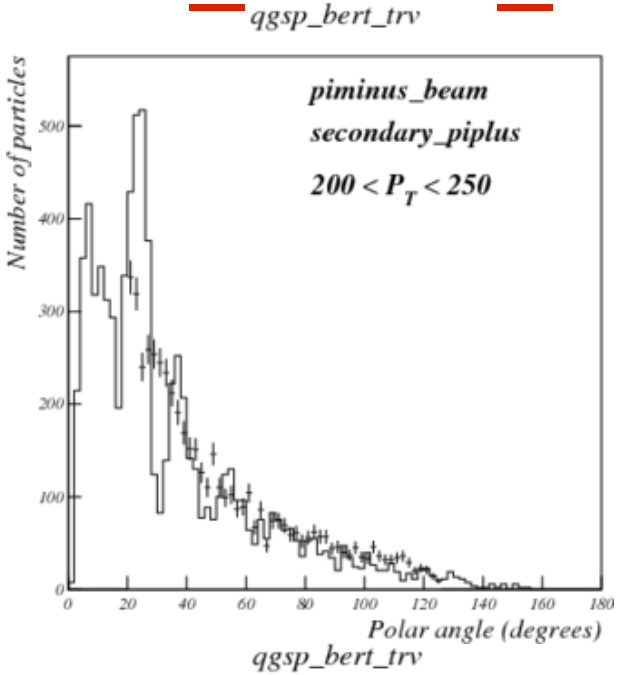


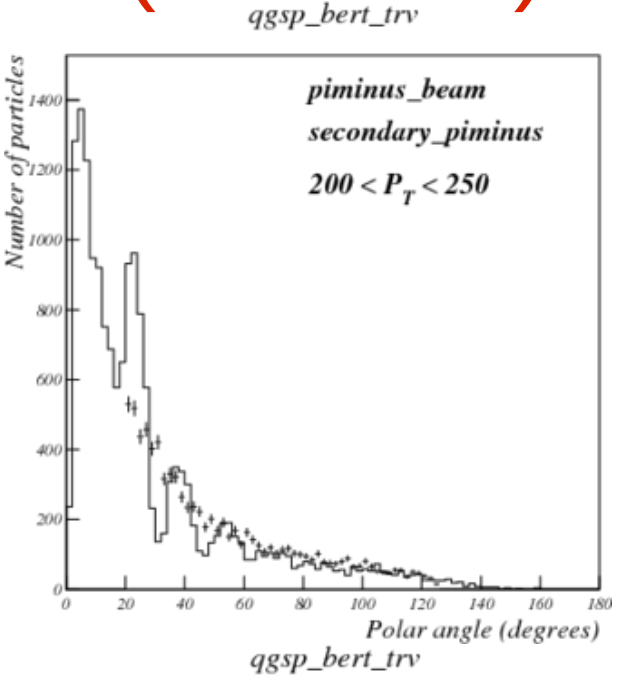


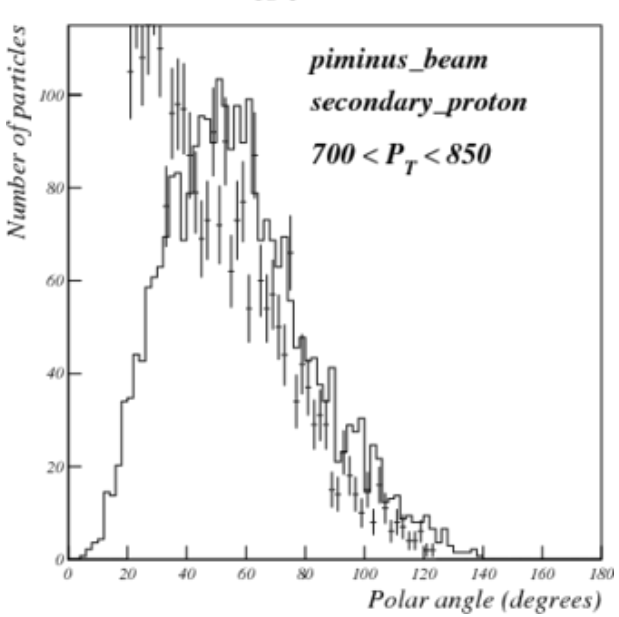


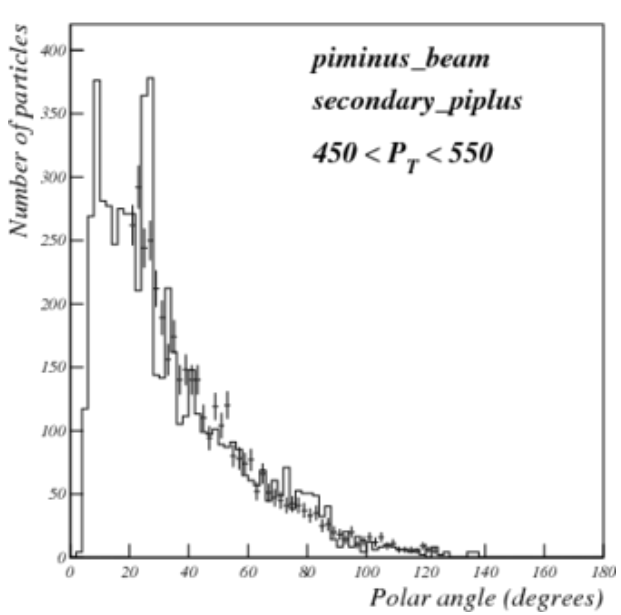
Comparison: QGSP_BERT_TRV (π^- beam)

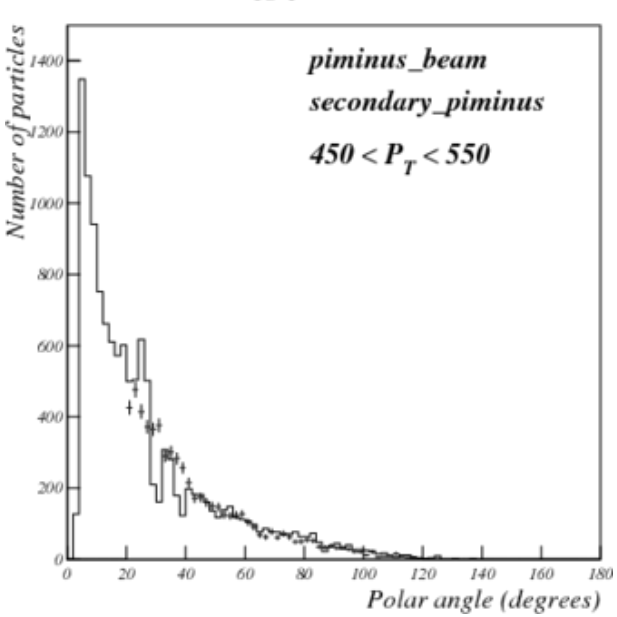




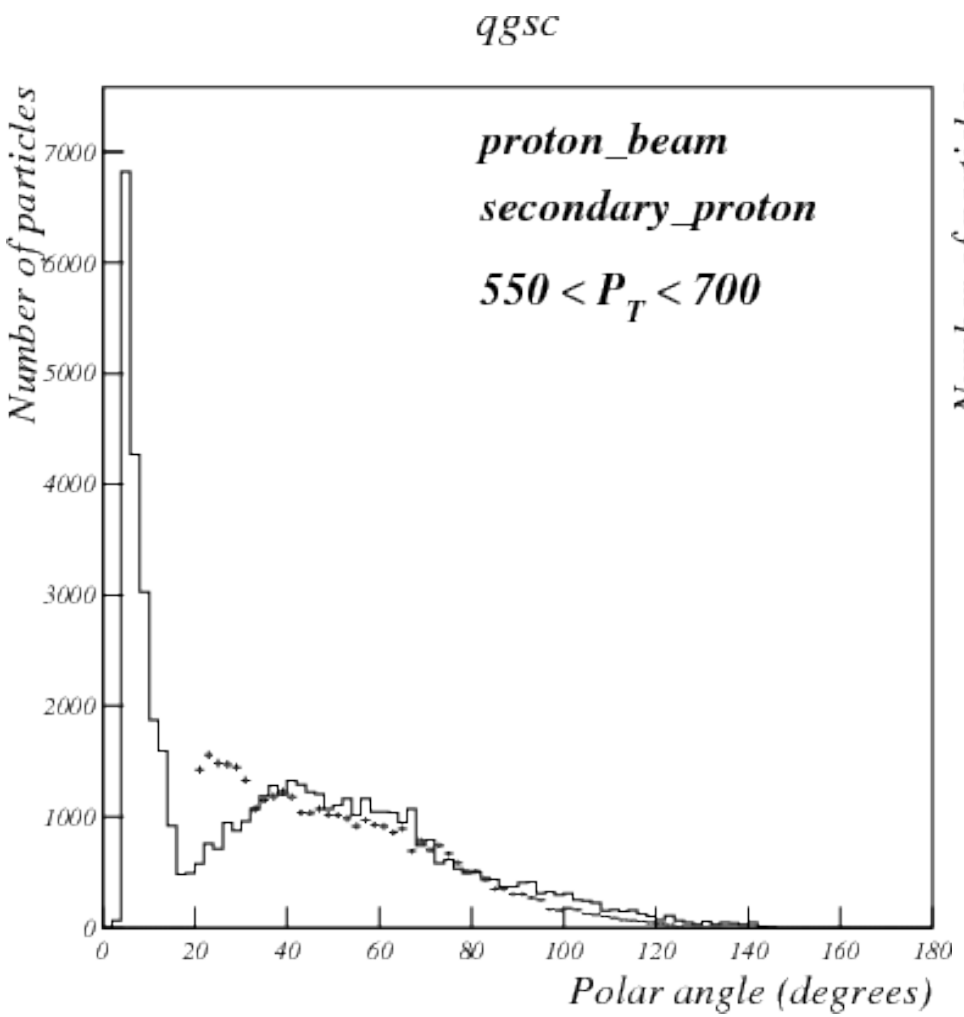


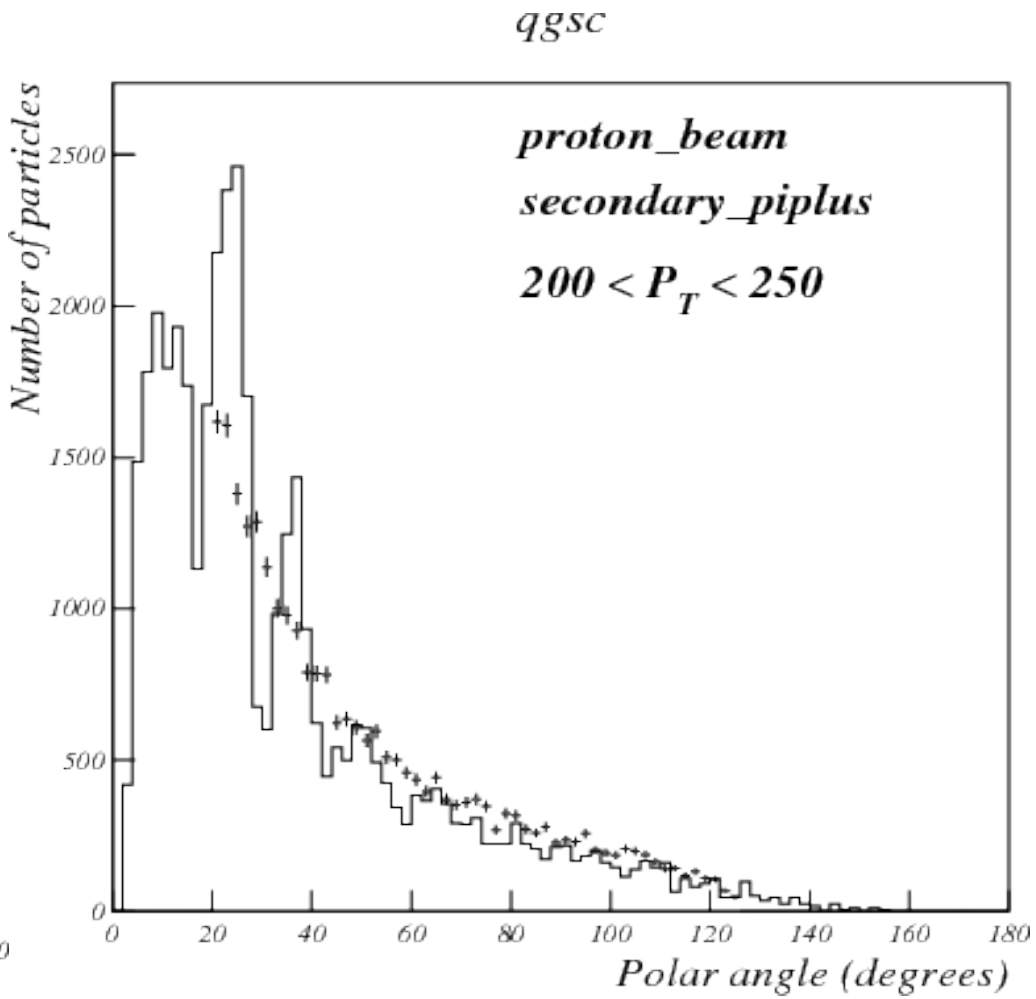




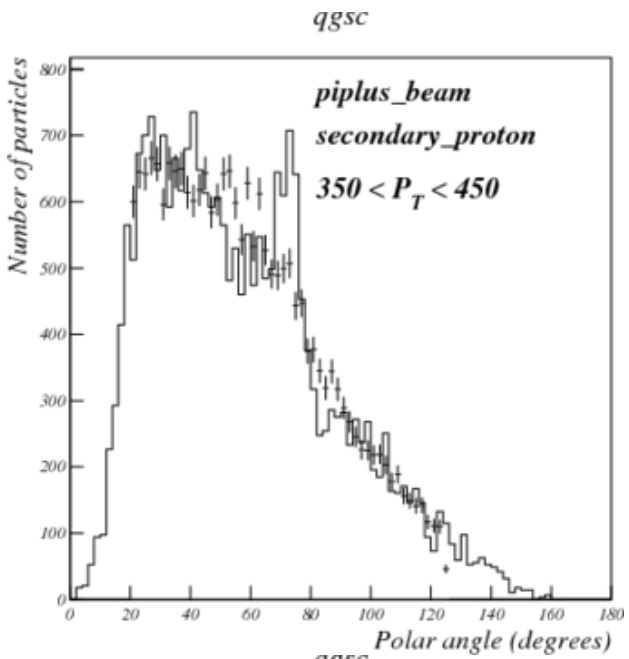


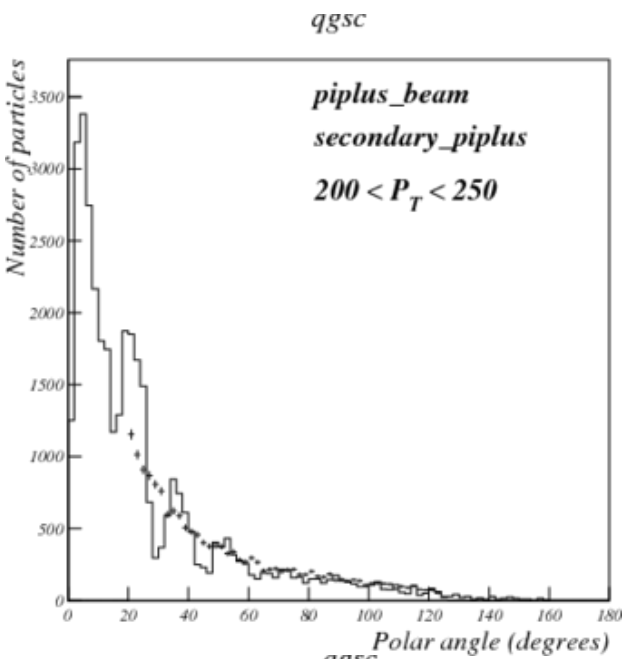
Comparison: QGSC (proton beam)

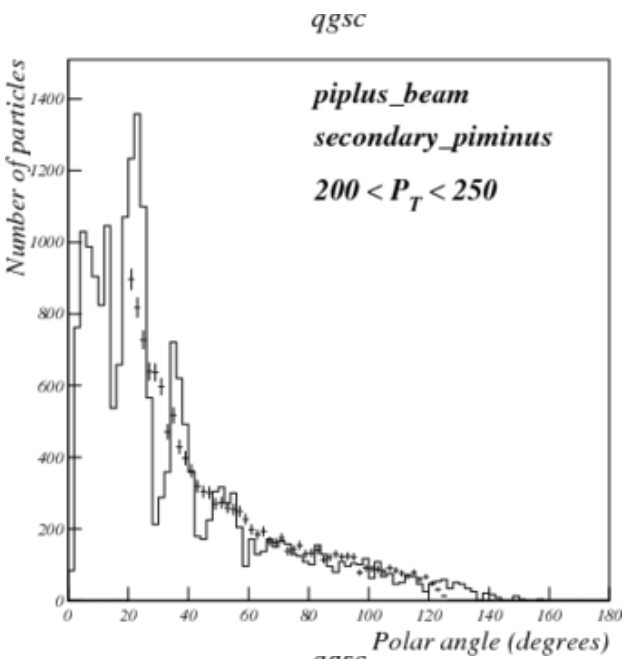


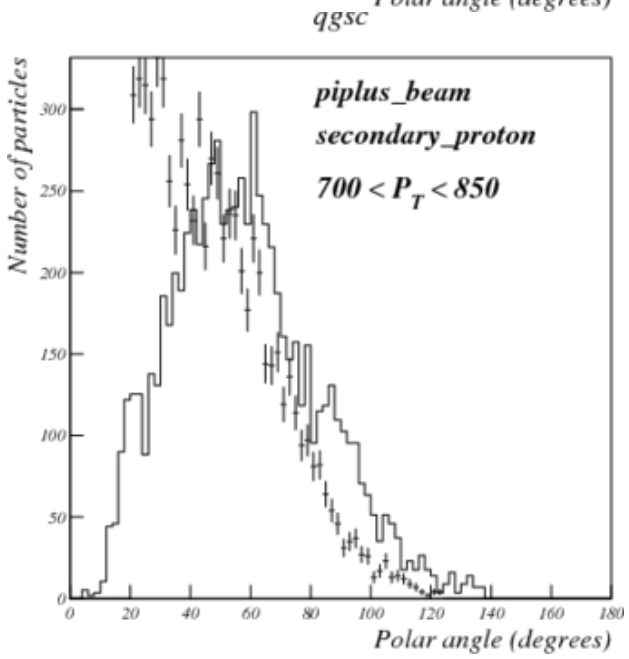


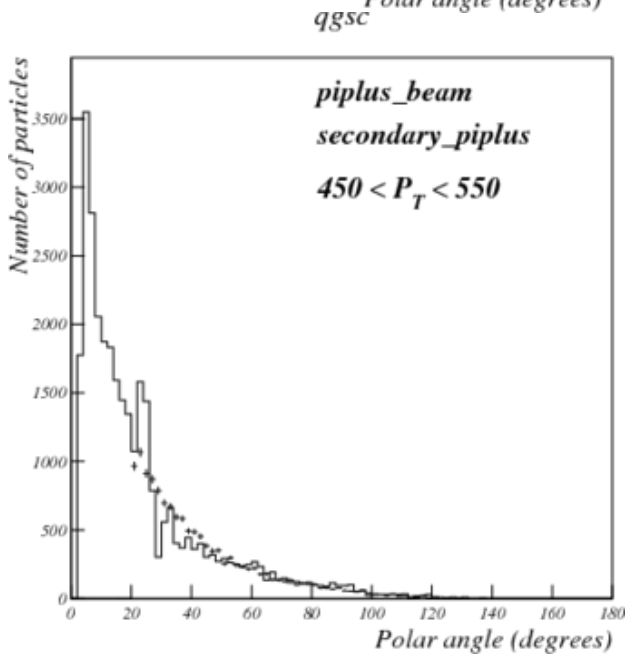
Comparison: QGSC (π^+ beam)

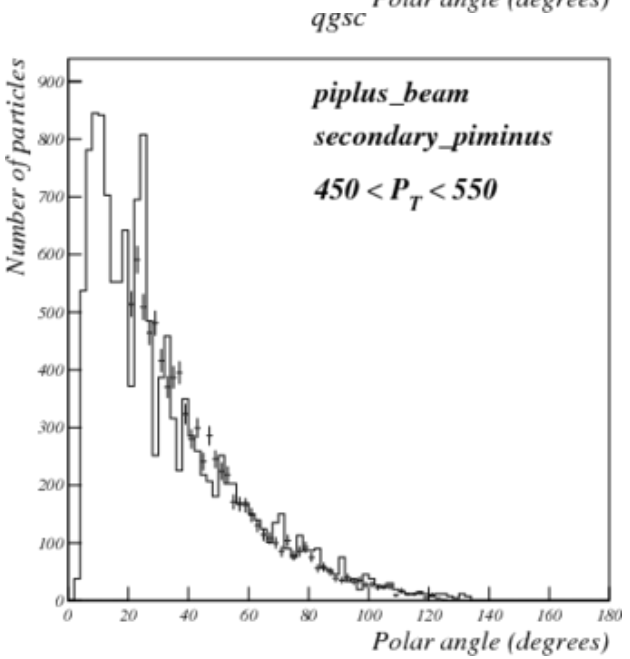




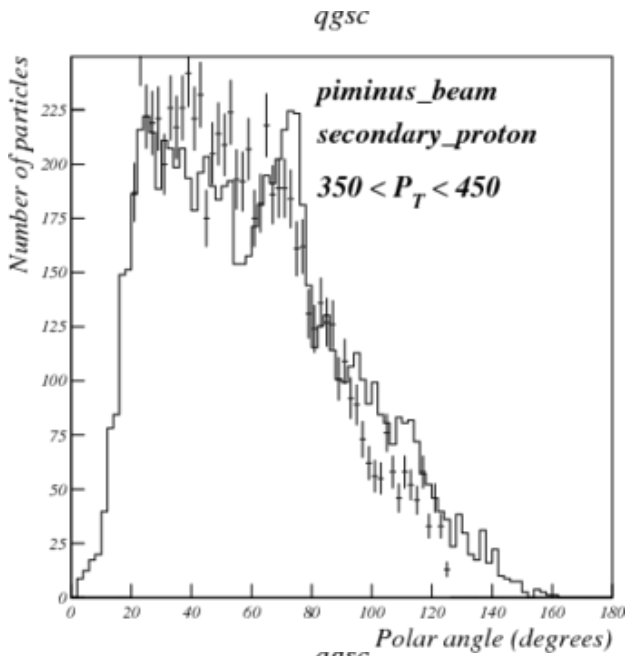


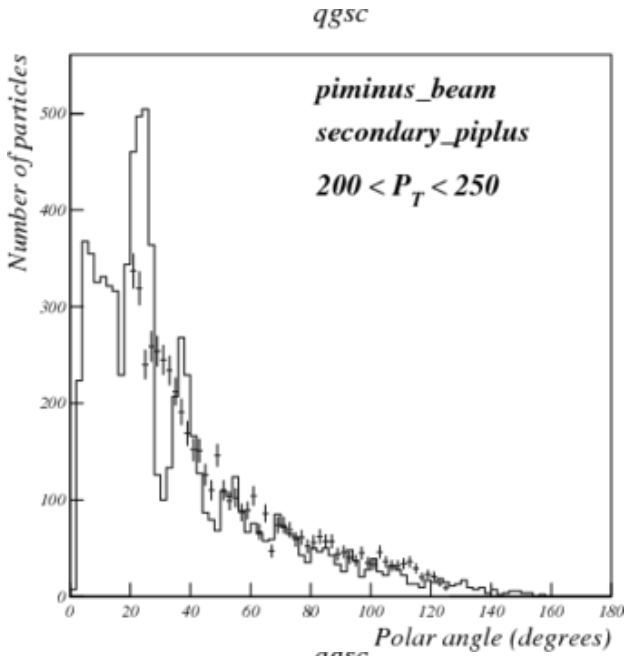


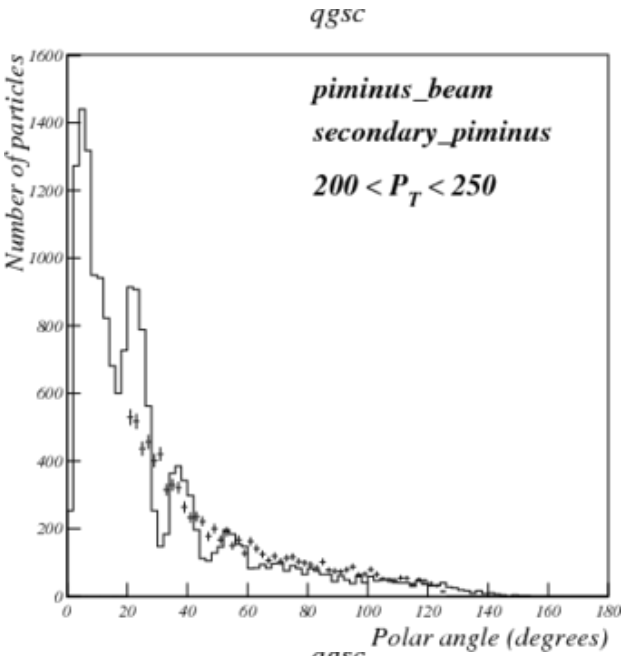


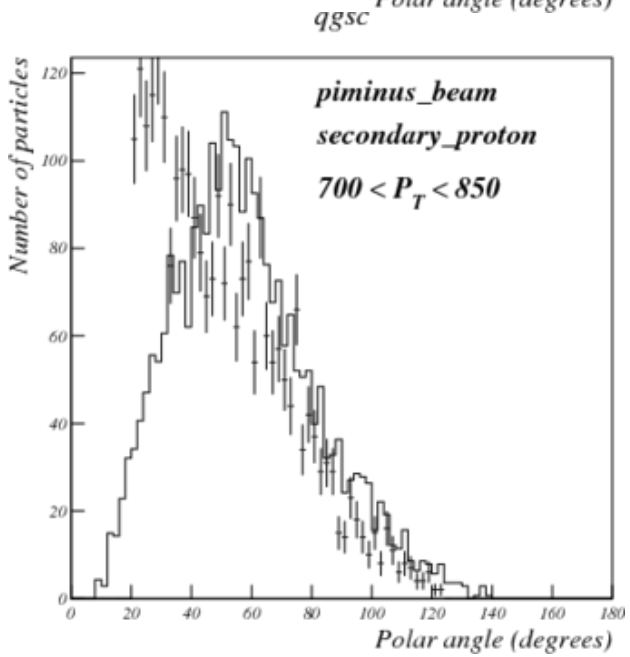


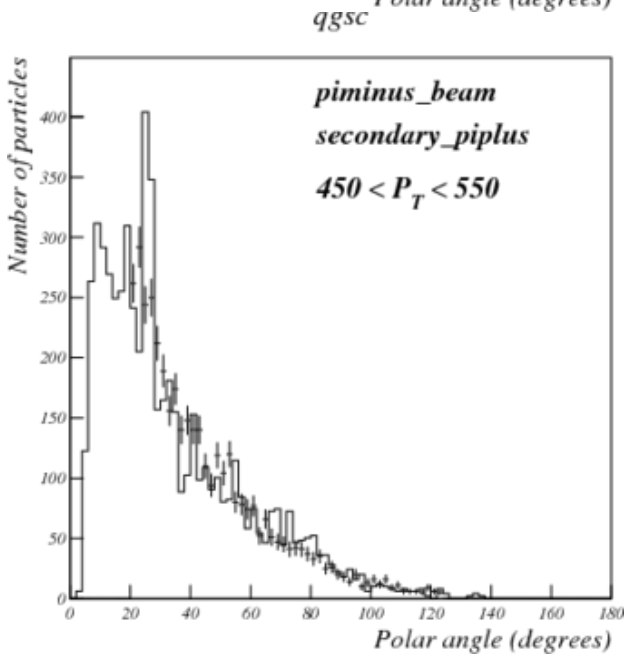
Comparison: QGSC (π^- beam)

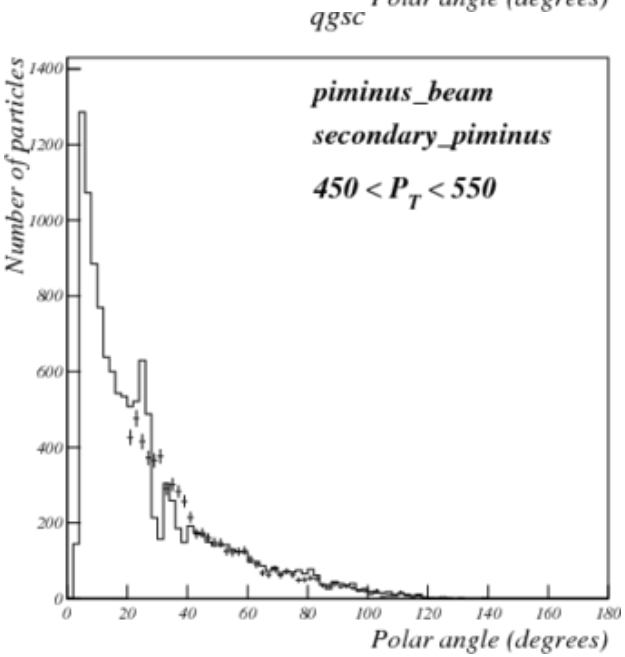




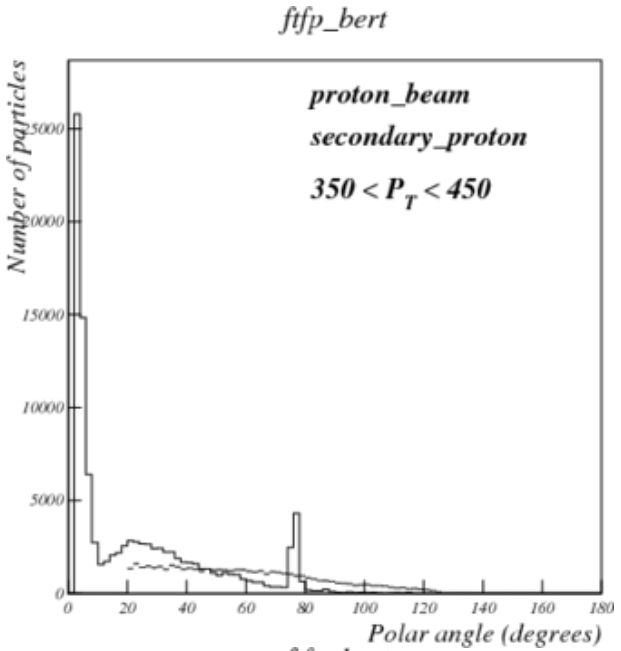


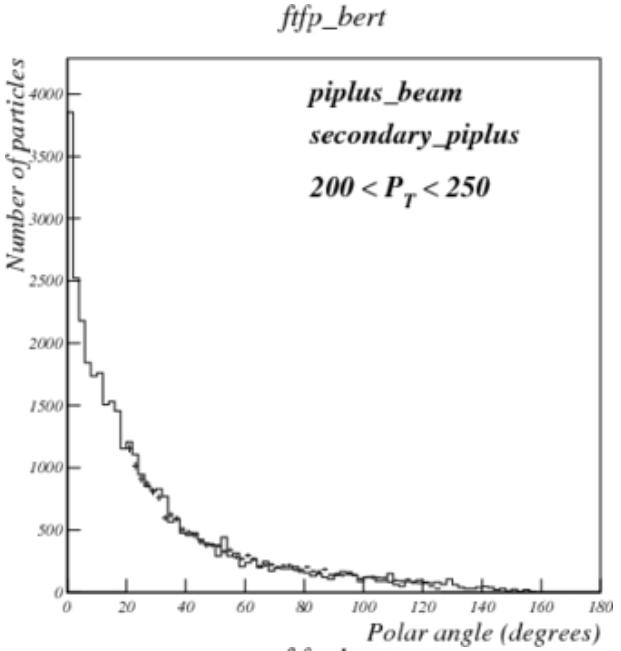


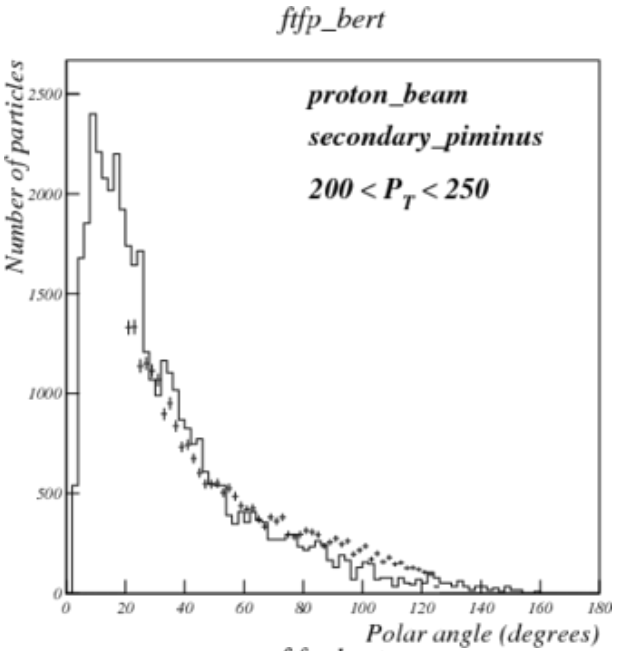


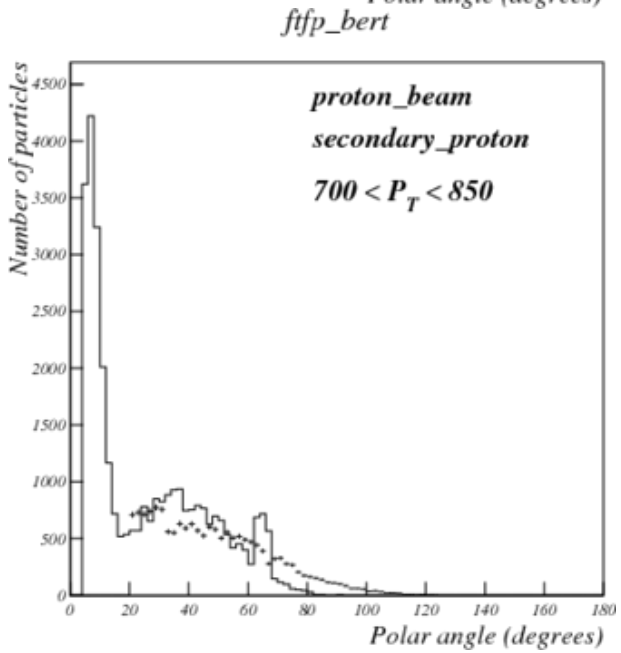


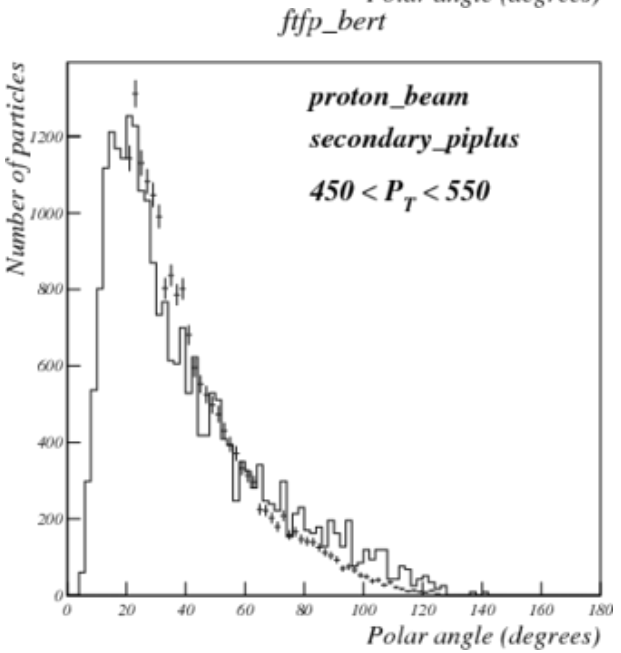
Comparison: FTFP_BERT (proton beam)

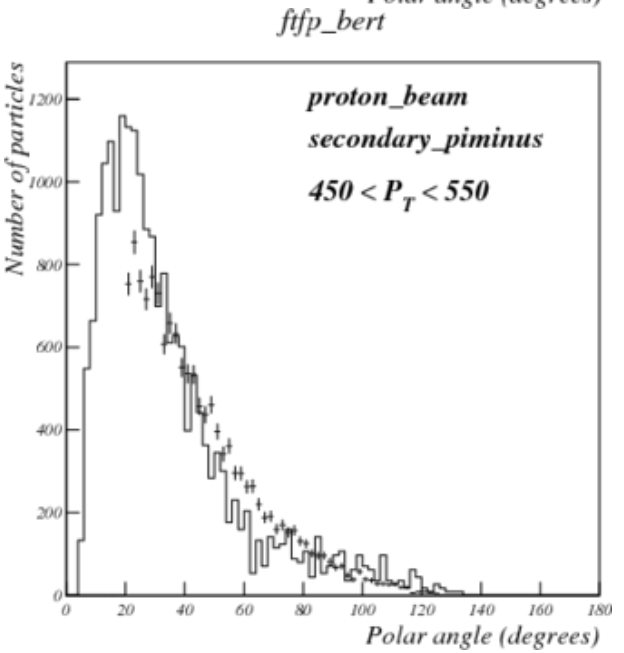




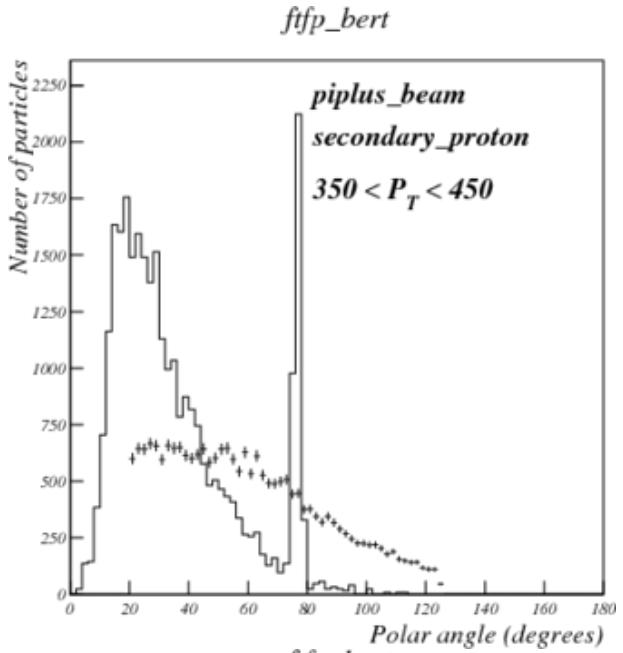


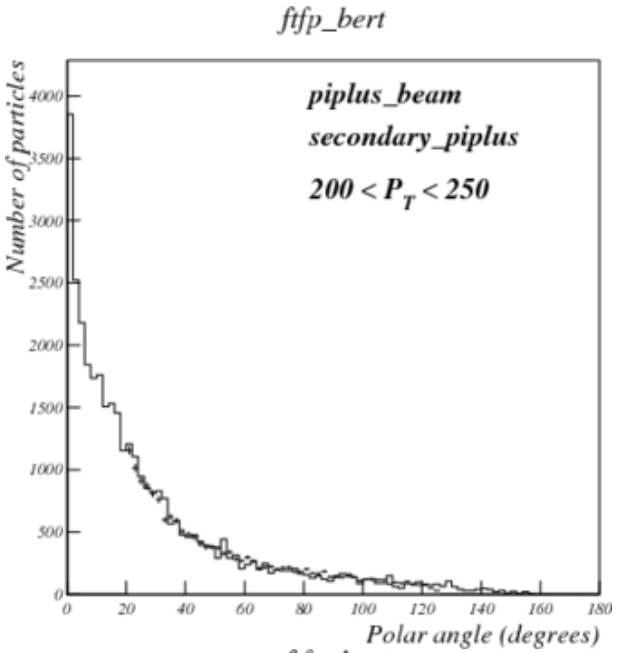


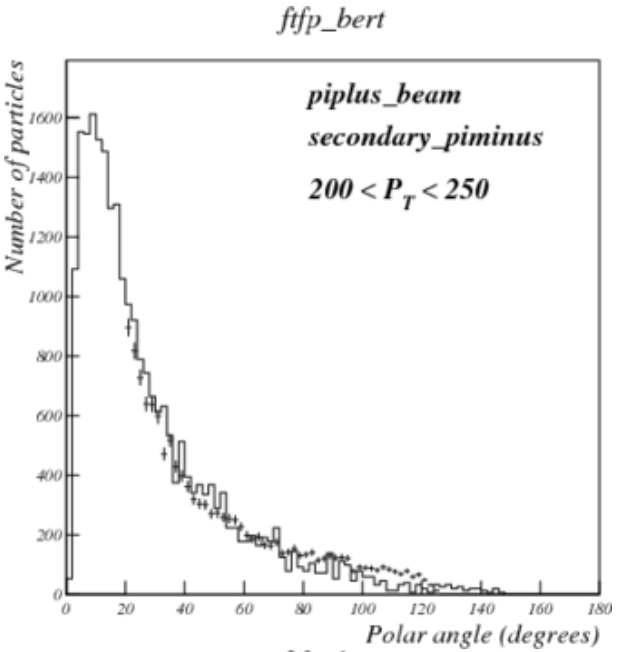


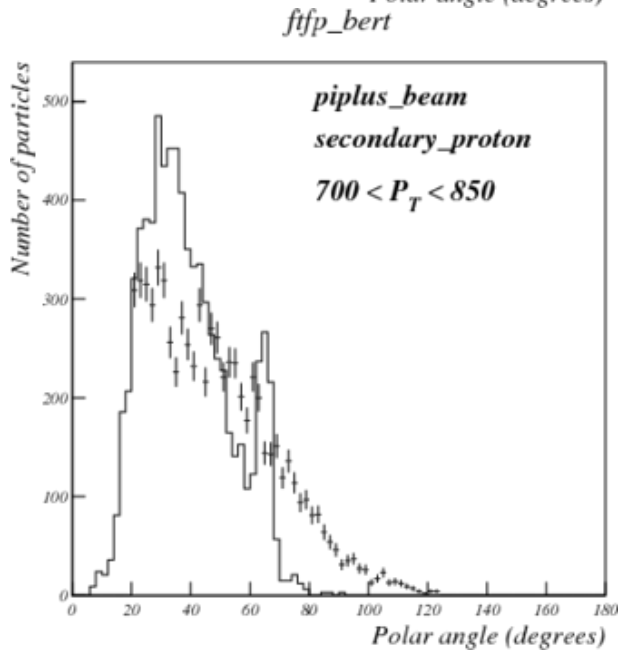


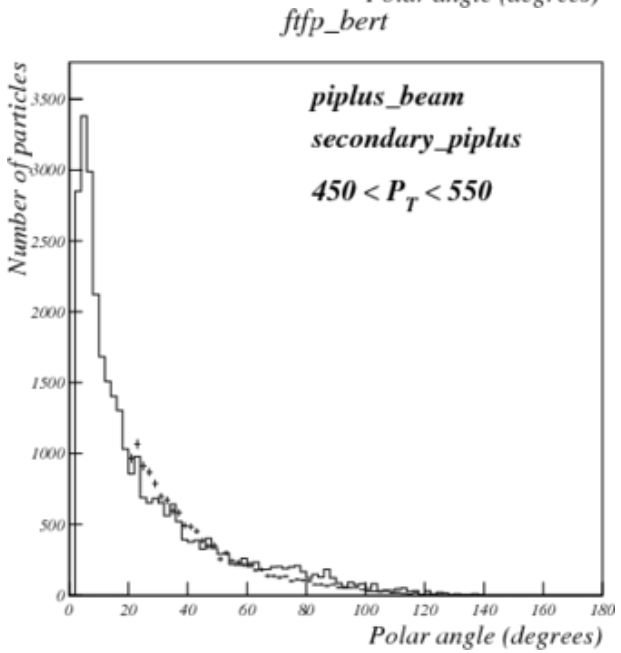
Comparison: FTFP_BERT (π^+ beam)

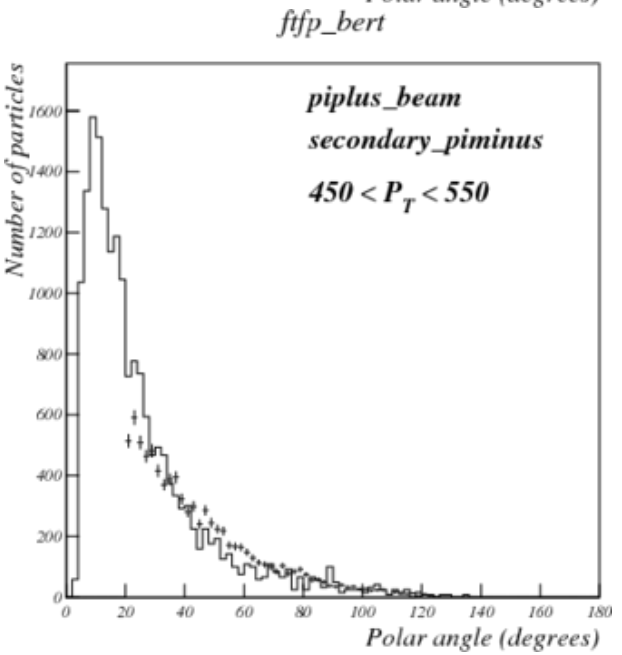




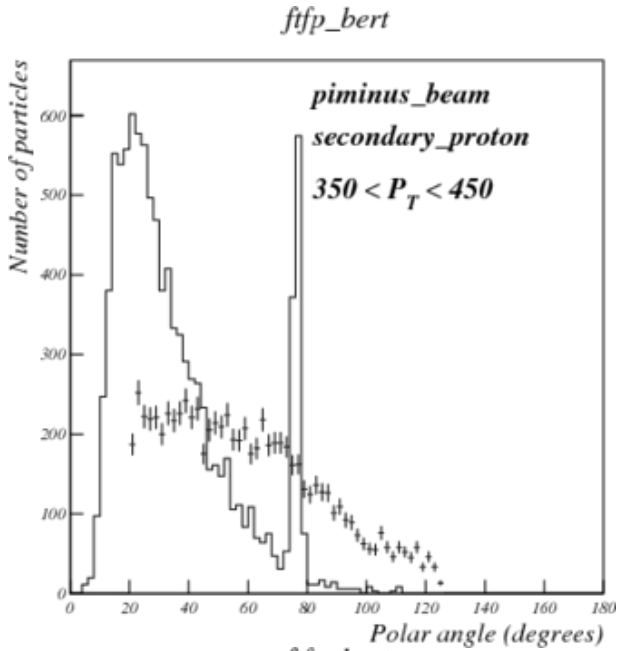


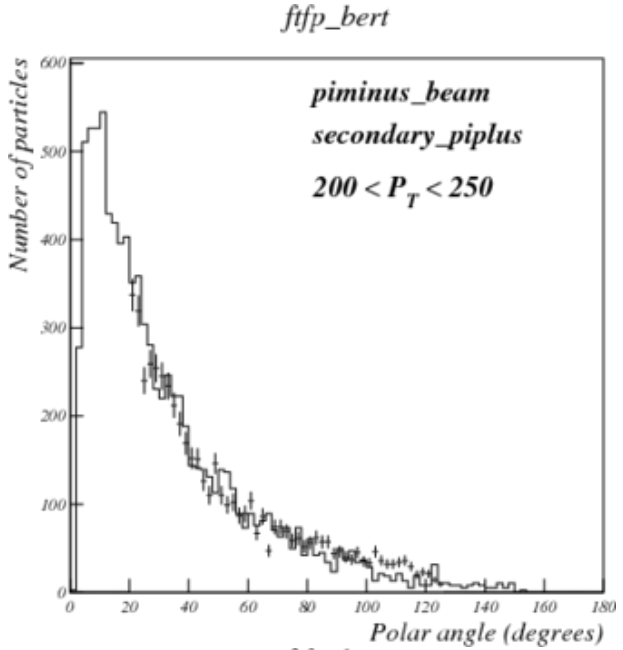


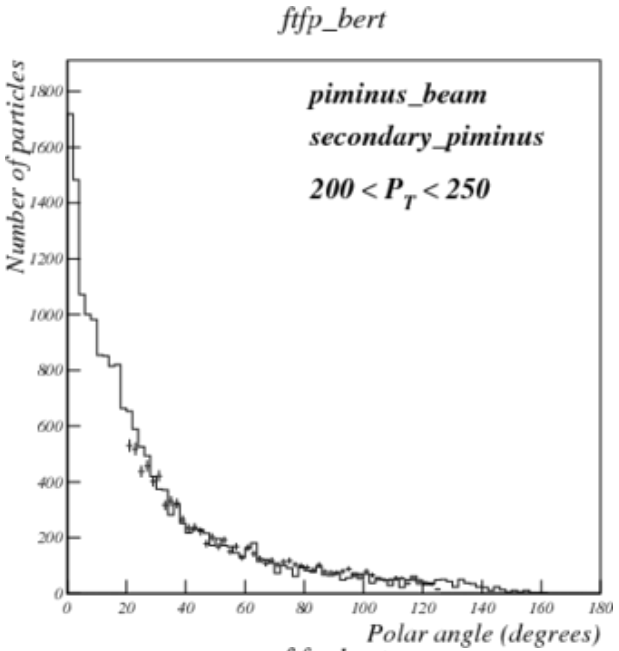


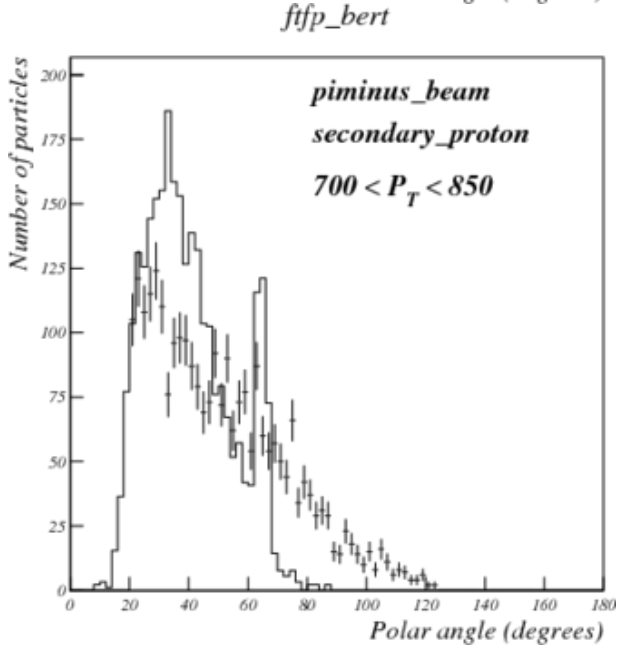


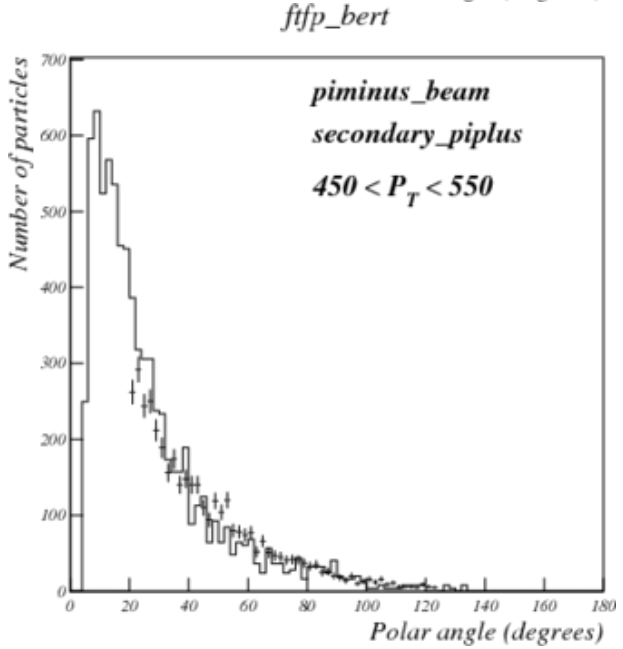
Comparison: FTFP_BERT (π^- beam)

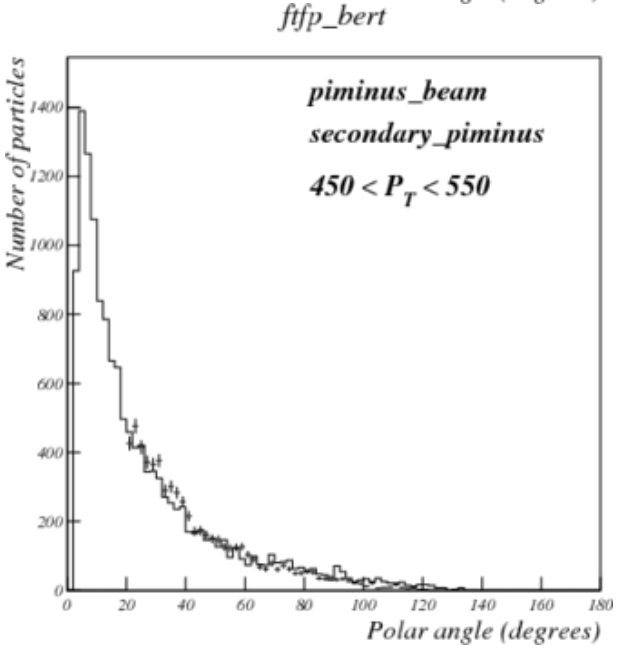




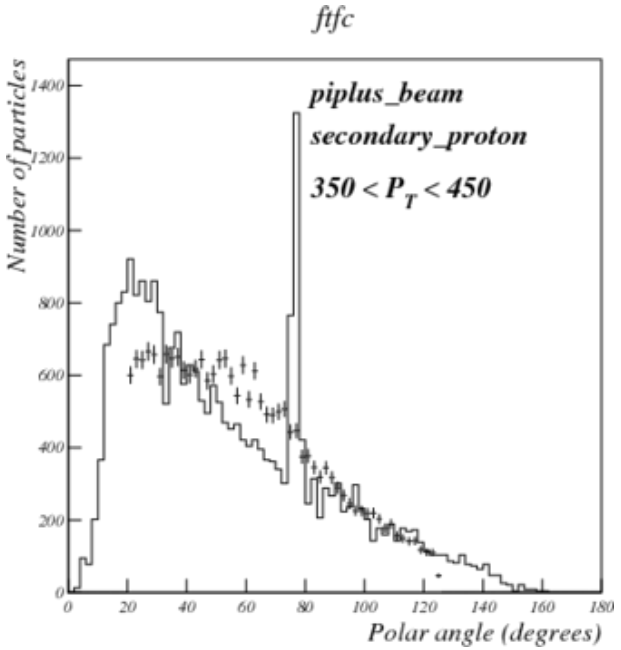


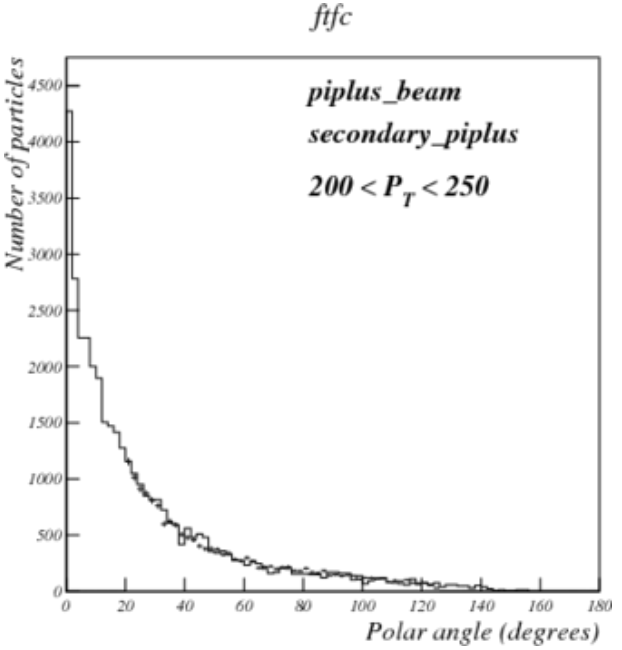


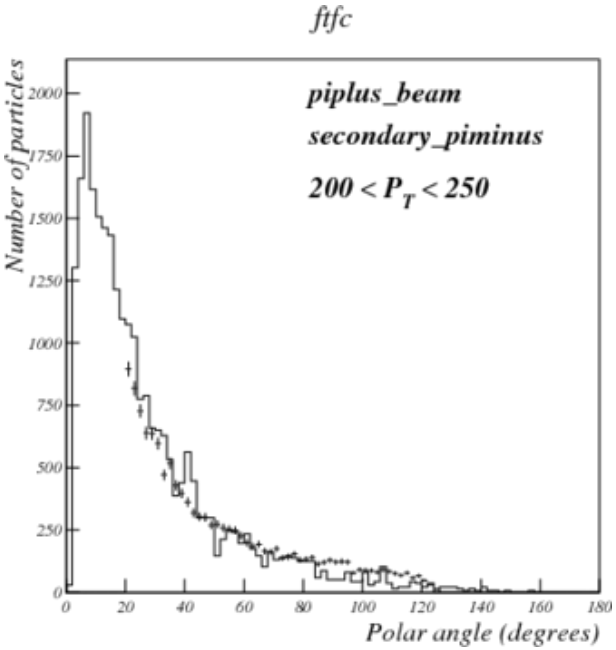


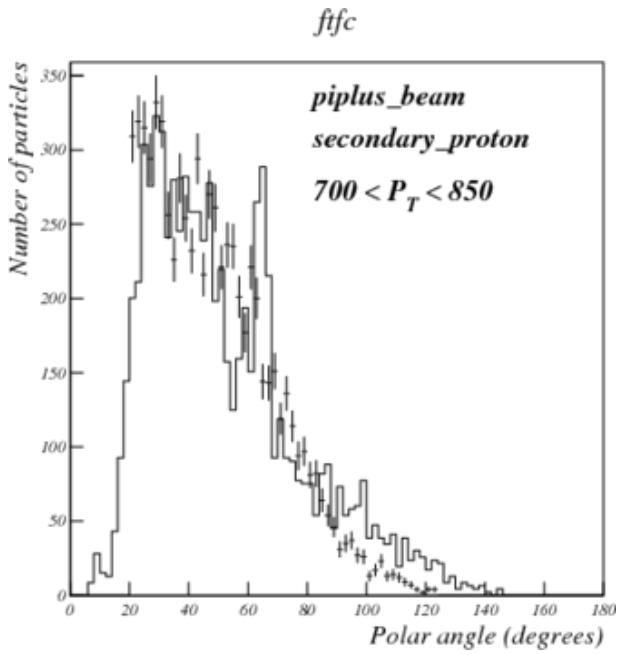


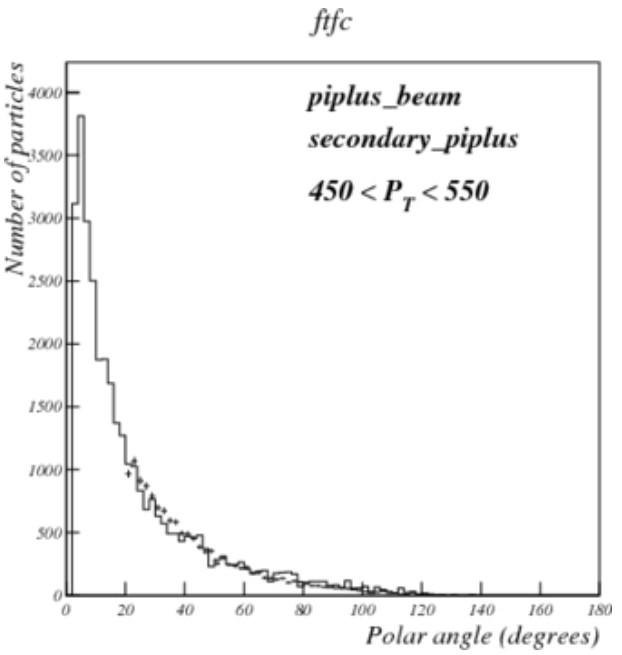
Comparison: FTFC (π^+ beam)

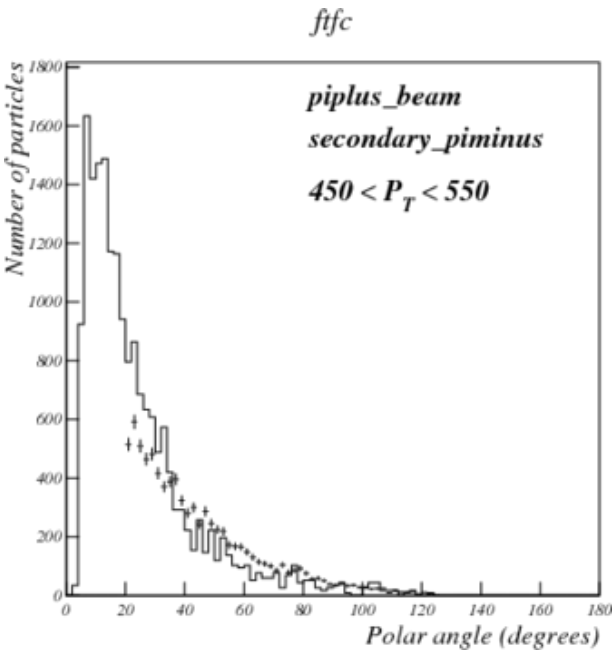




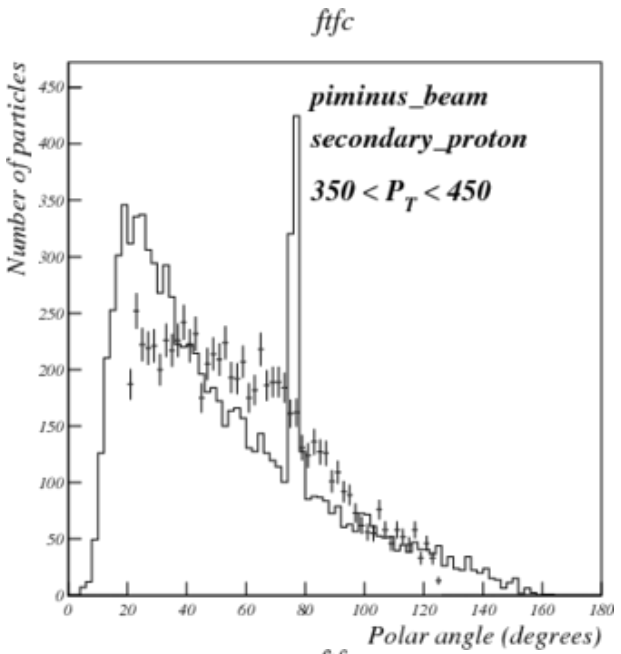


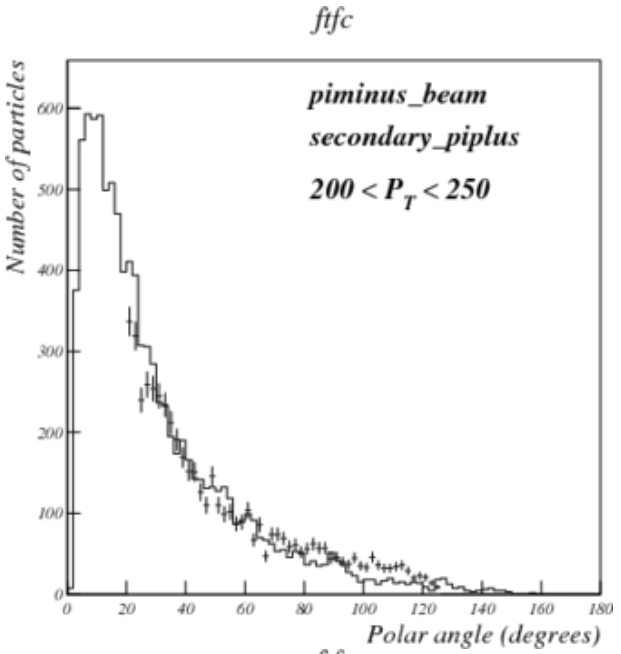


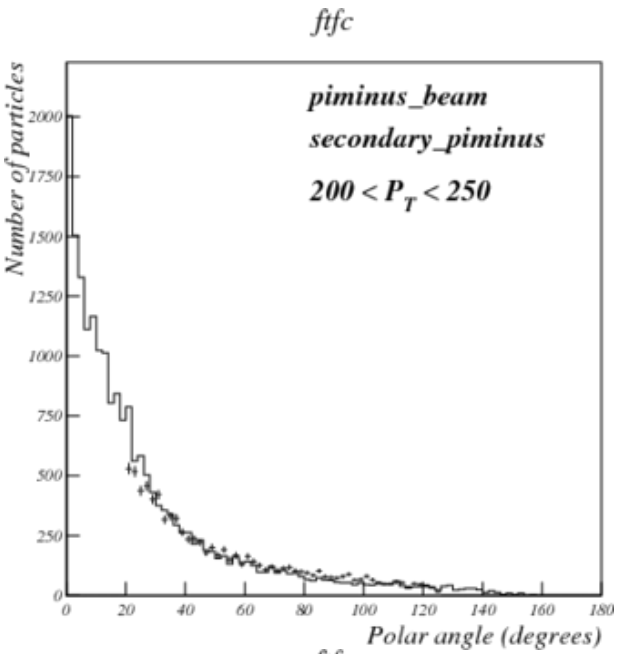


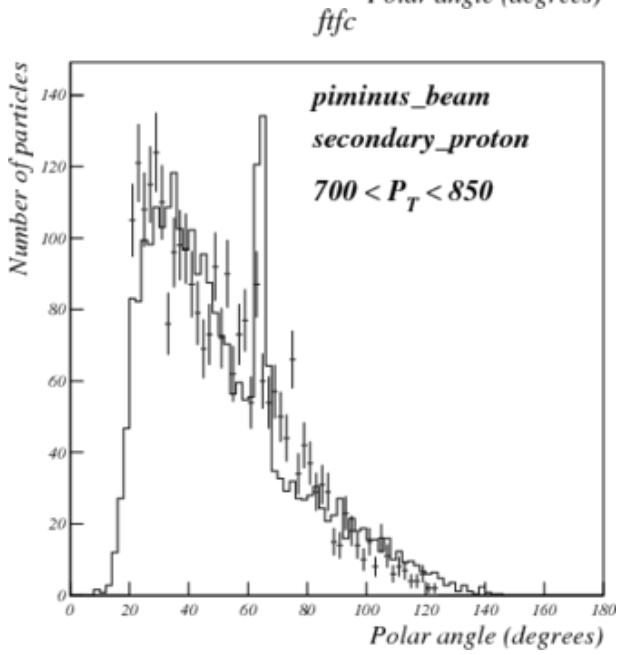


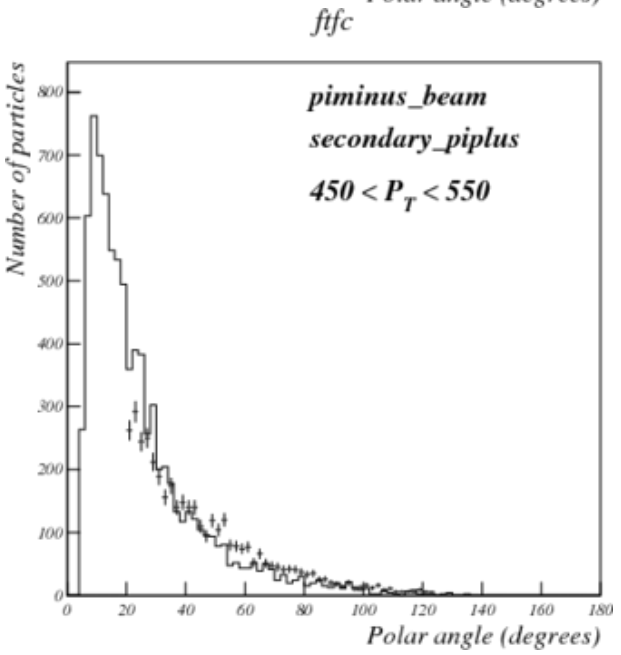
Comparison: FTFC (π^- beam)

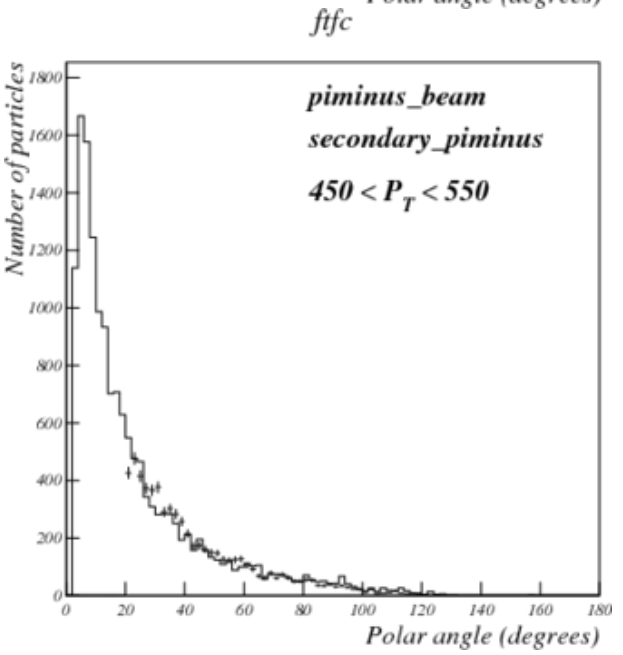




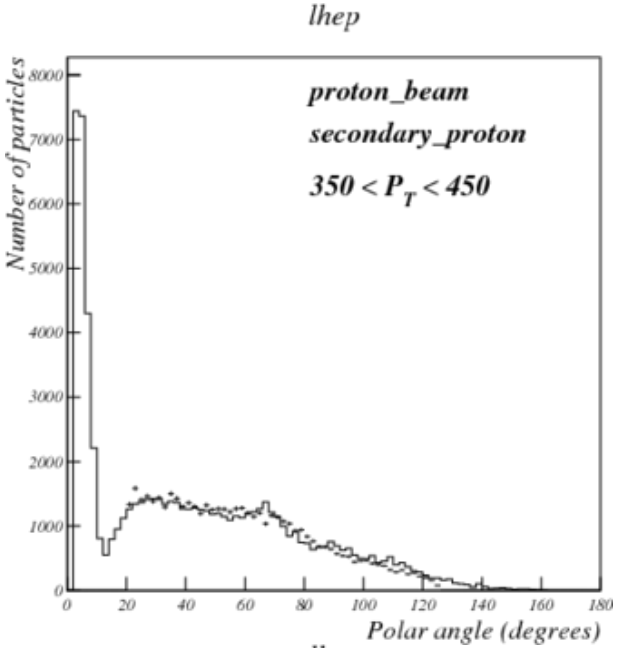


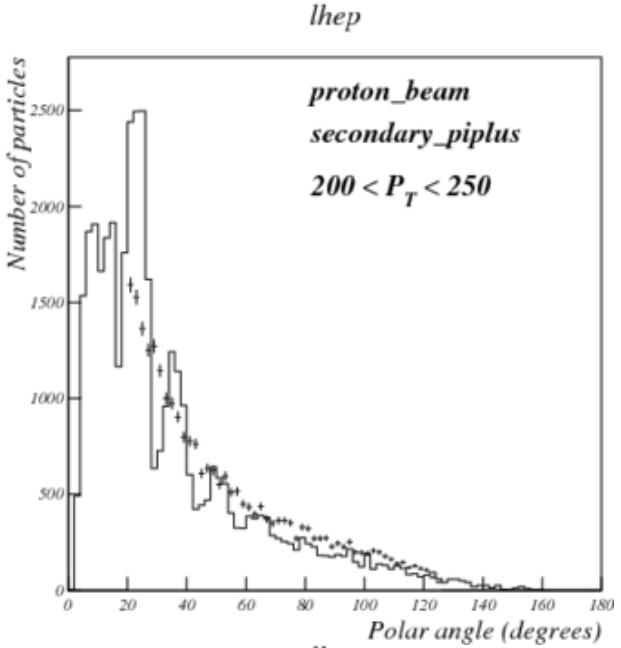


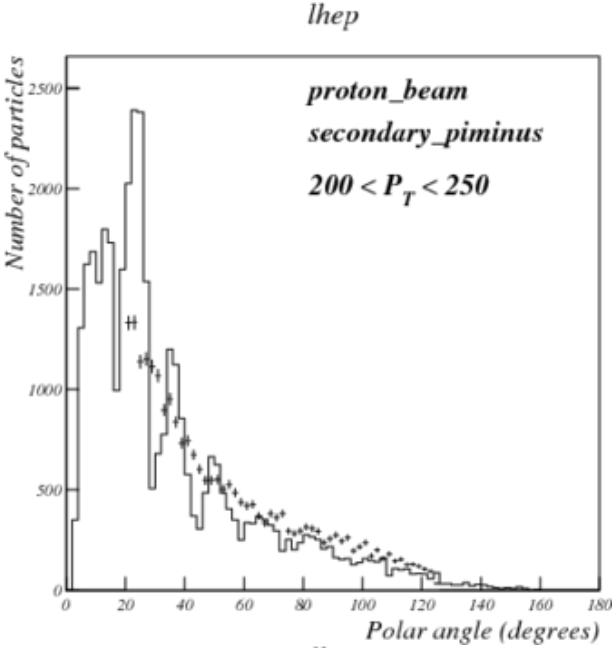


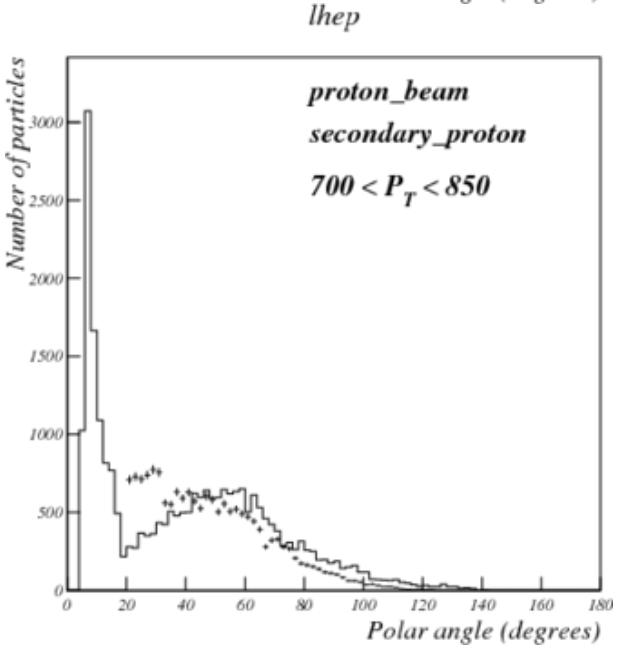


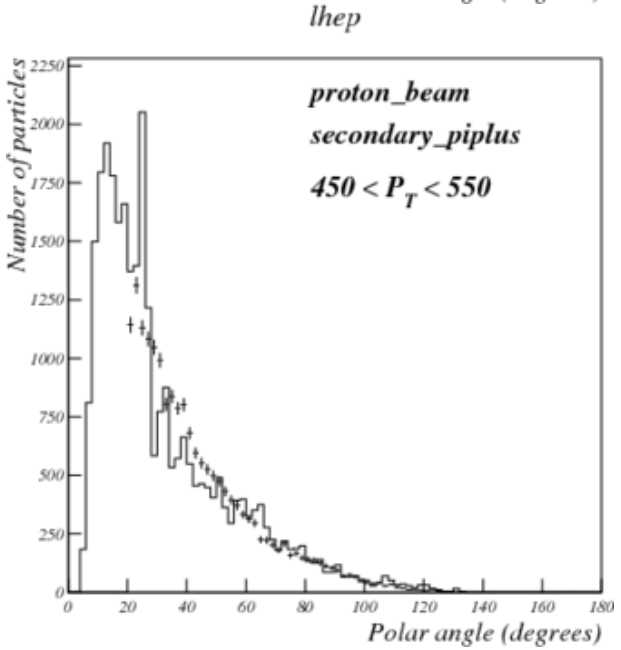
Comparison: LHEP (proton beam)

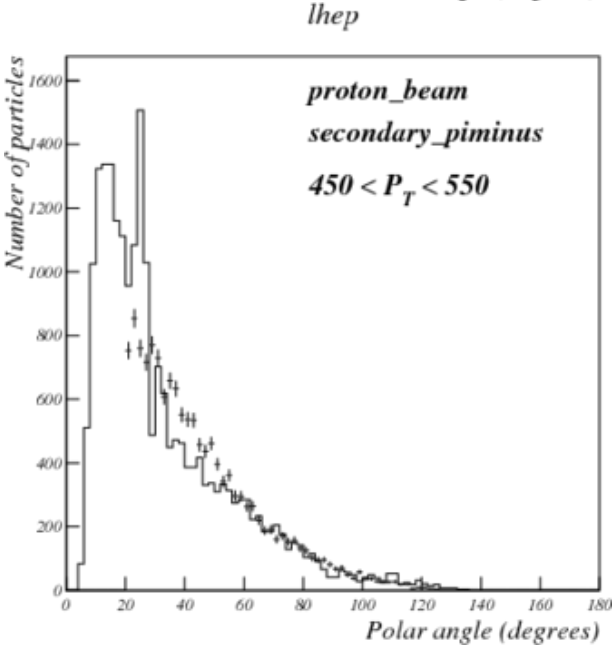




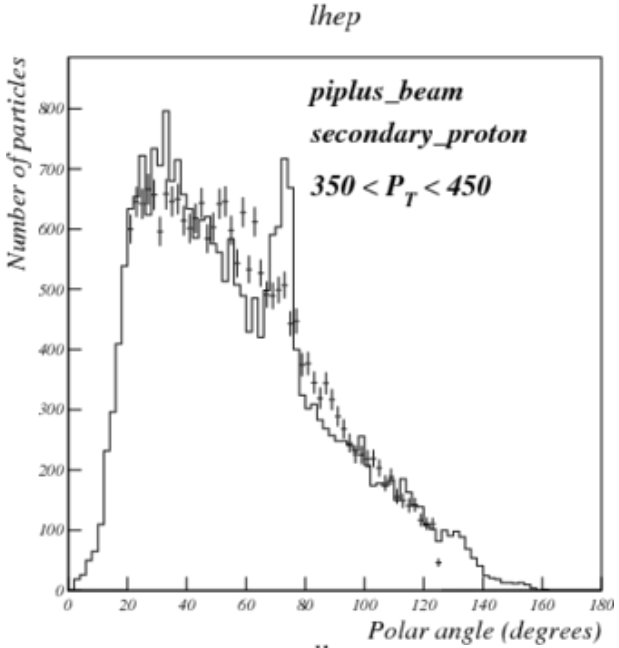


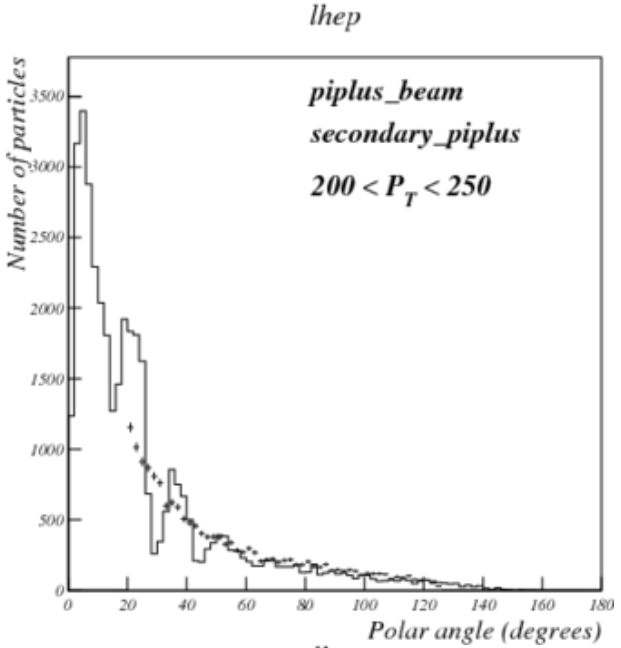


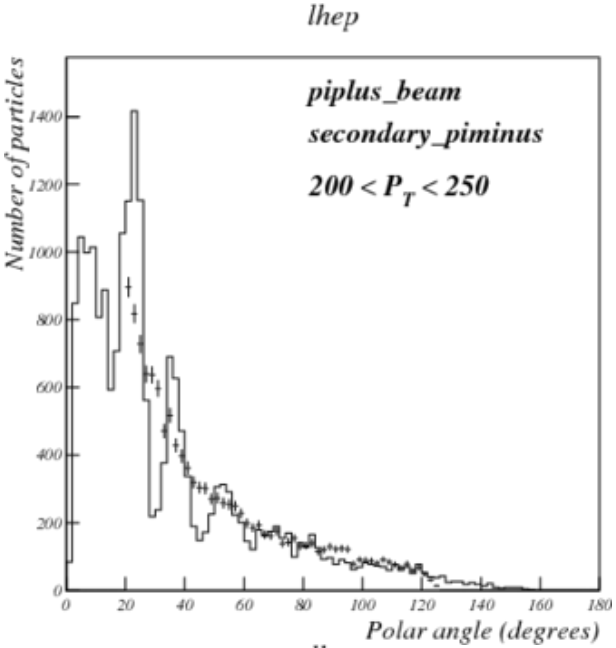


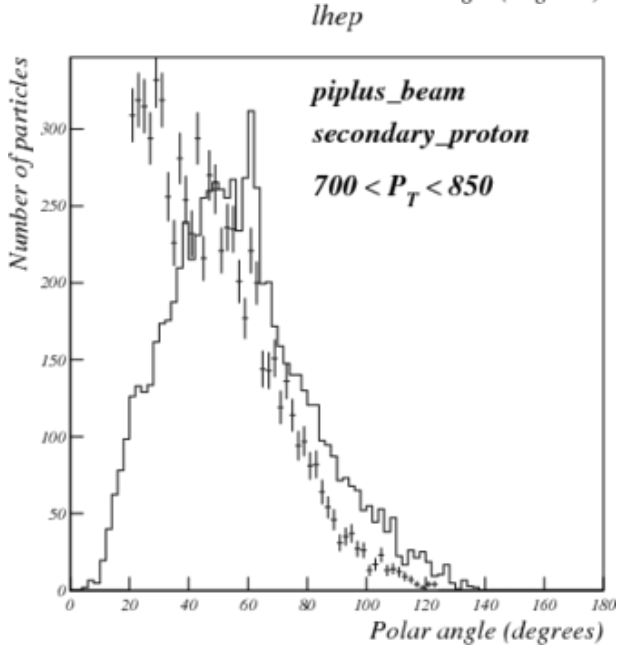


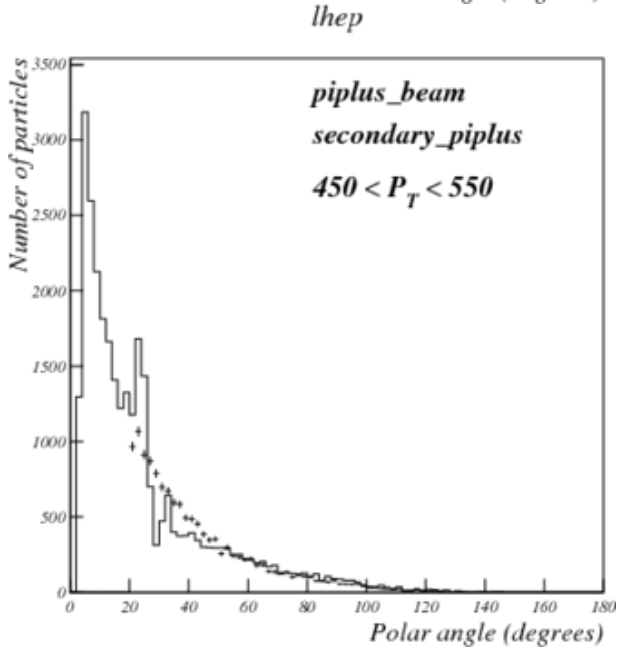
Comparison: LHEP (π^+ beam)

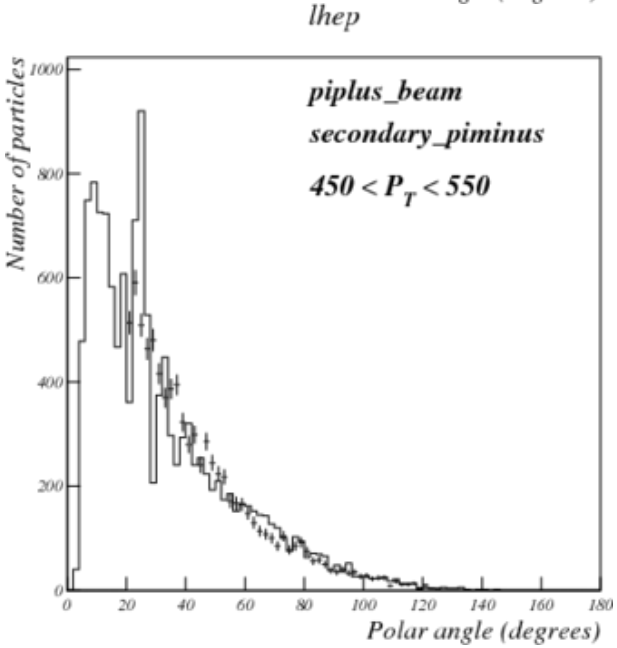




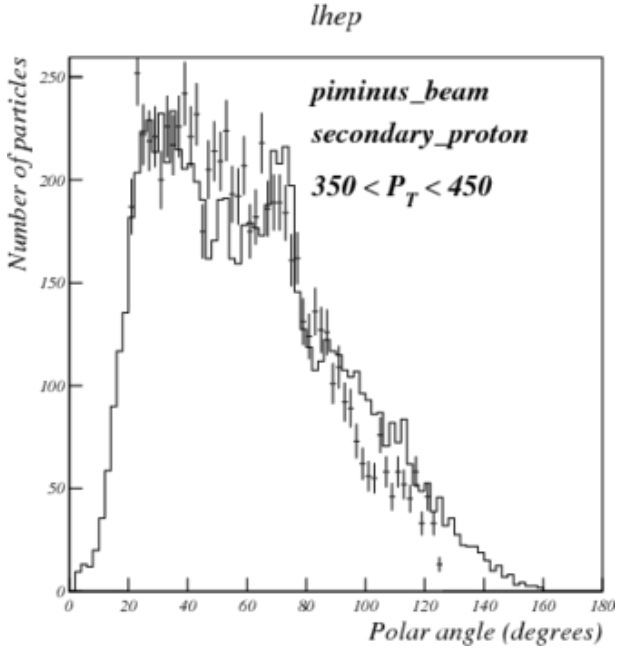


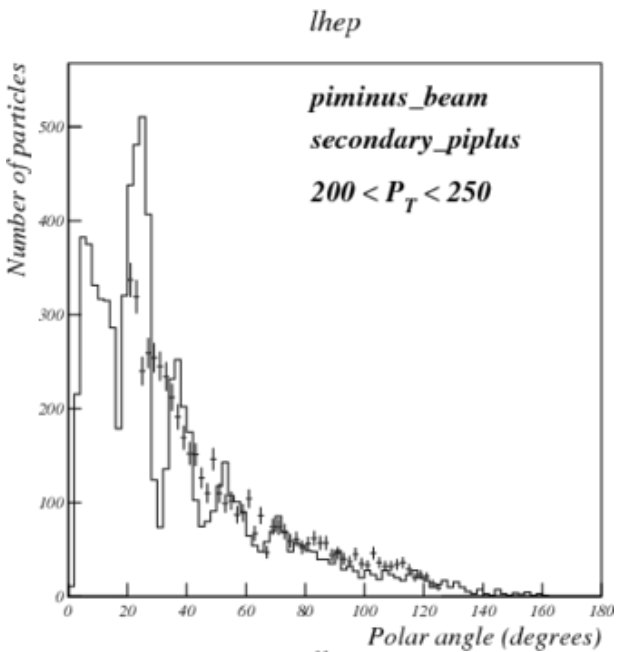


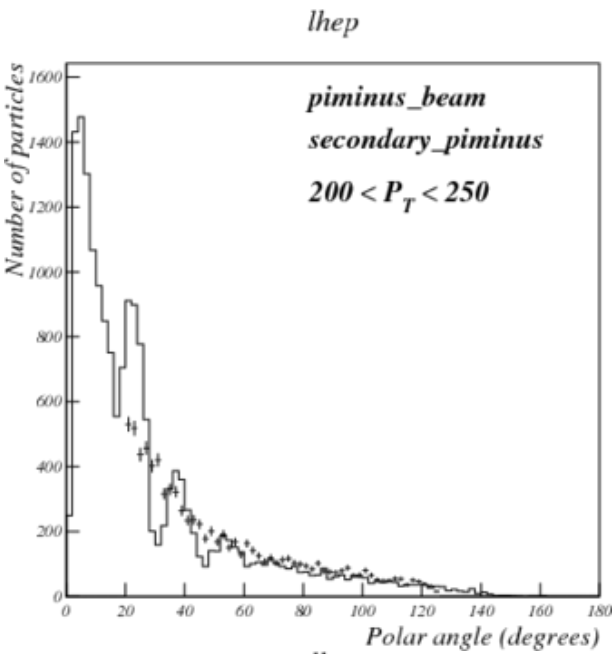


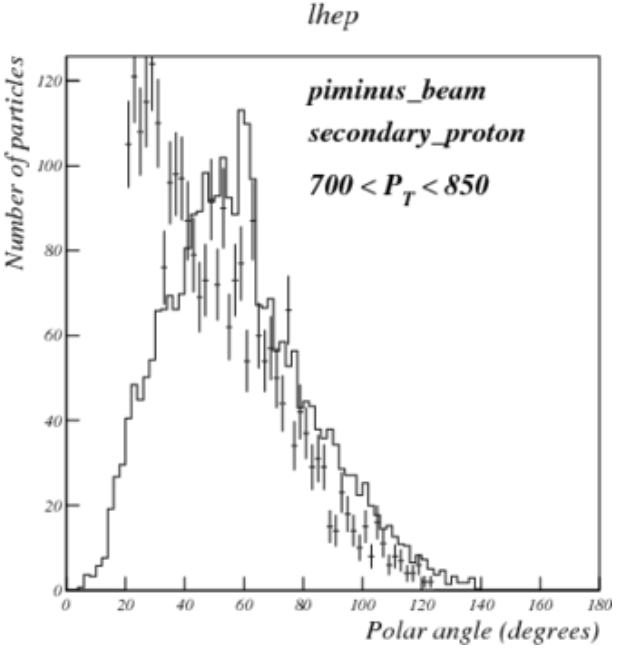


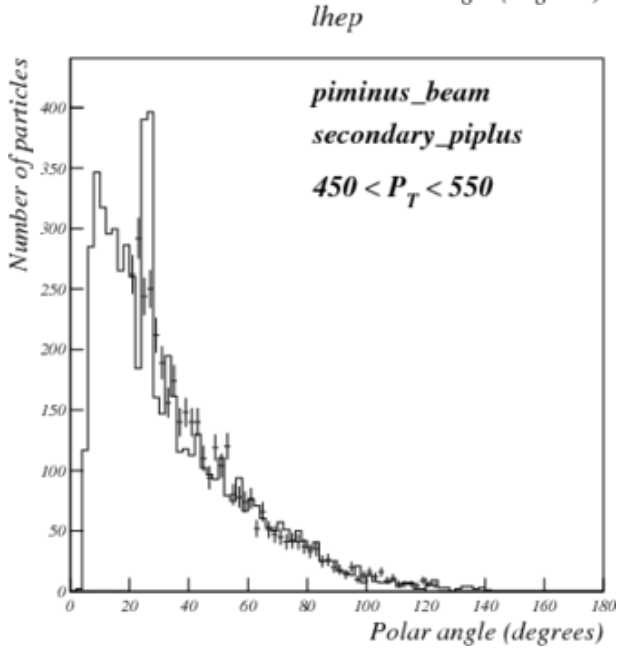
Comparison: LHEP (π^- beam)

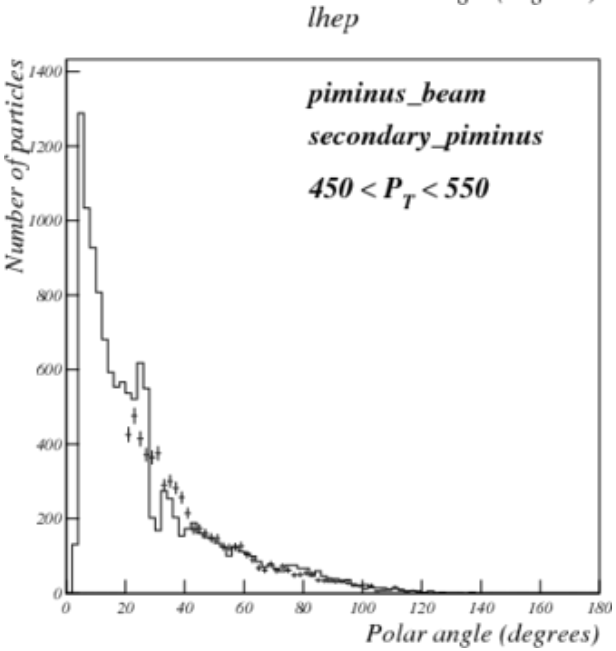










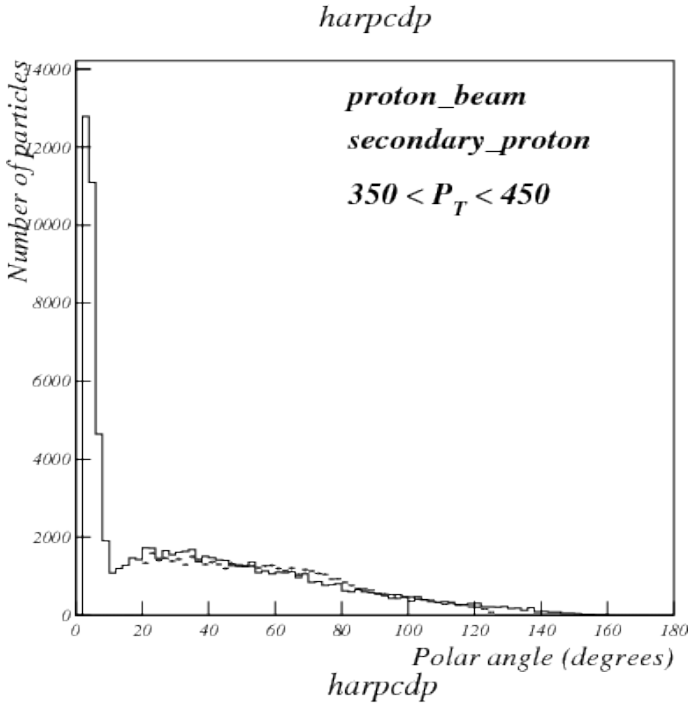


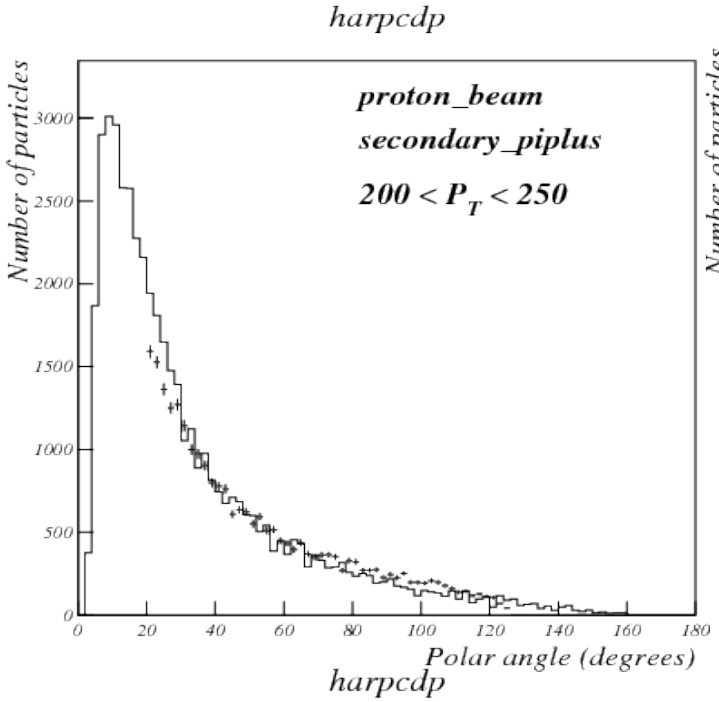
HARP-CDP physics list

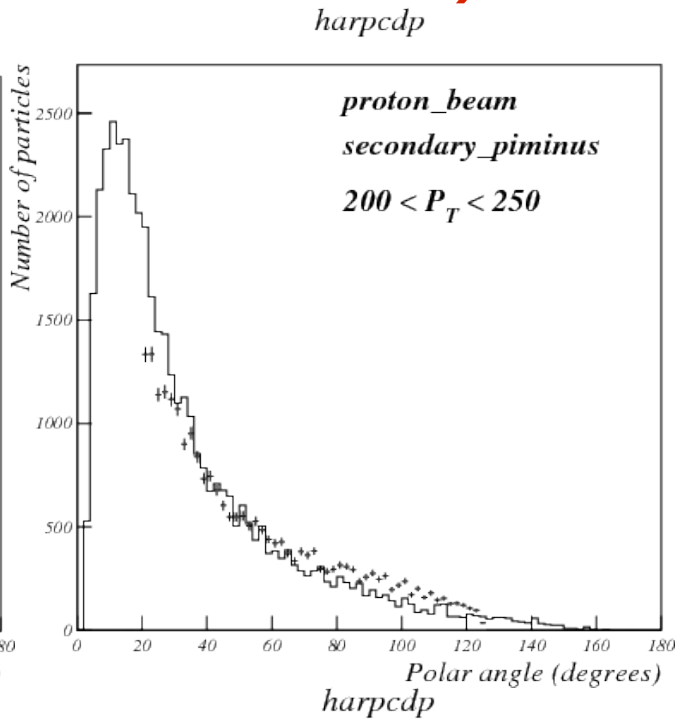
To reproduce the data, new HARP-CDP physics list has been prepared

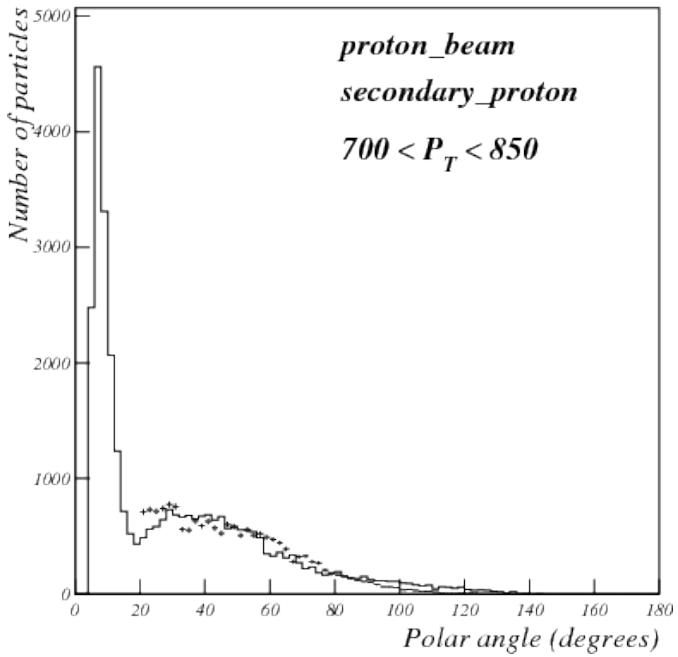
- Based on QBBC
- FRITIOF string model is used instead of QGSM for E > 6 GeV
- Bertini cascade is used for pions below 6 GeV
- Binary cascade is used for protons below 6 GeV
- Quasielastic channel is disabled

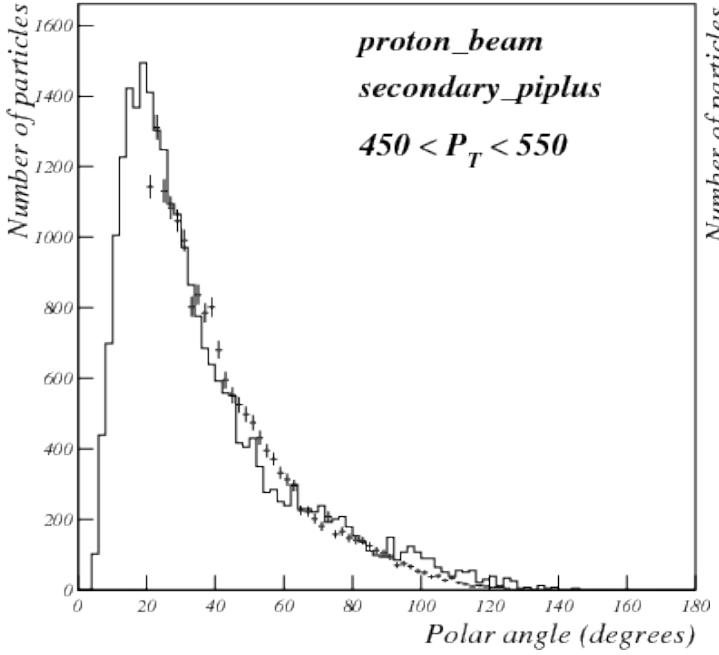
Comparison: HARPCDP (proton beam)

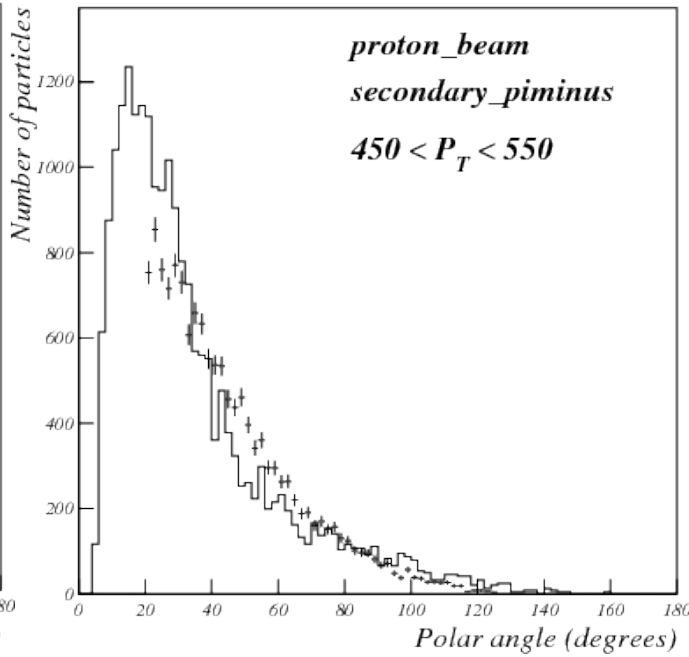




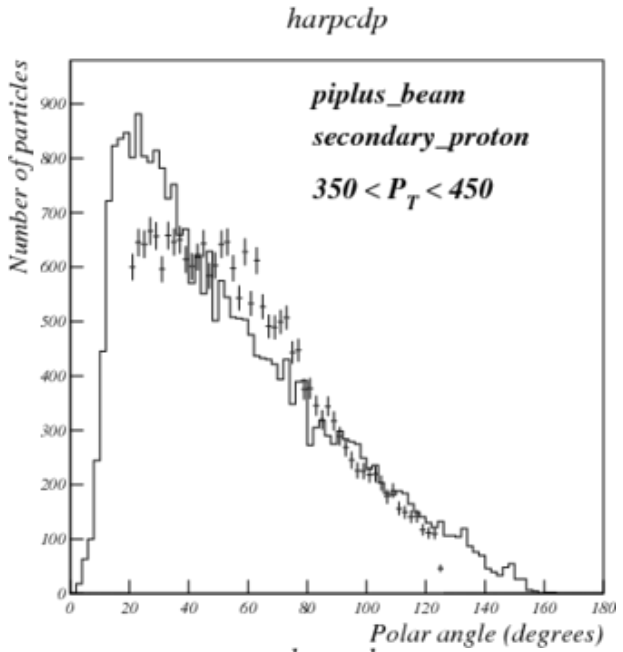


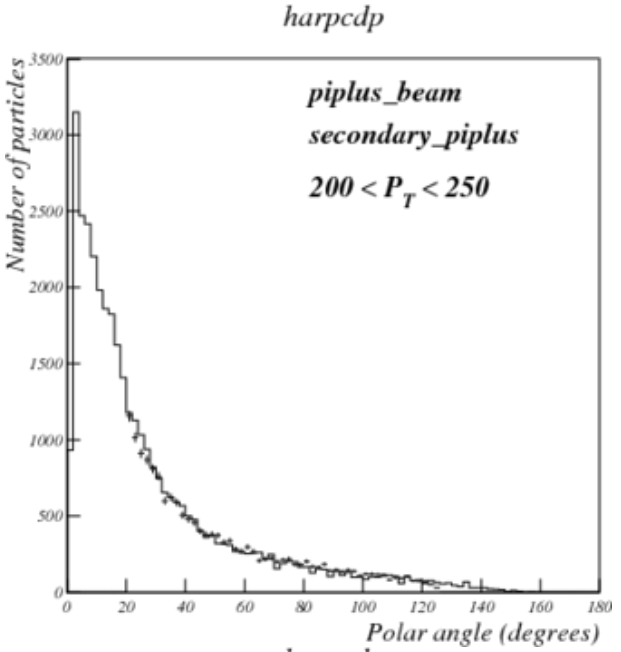


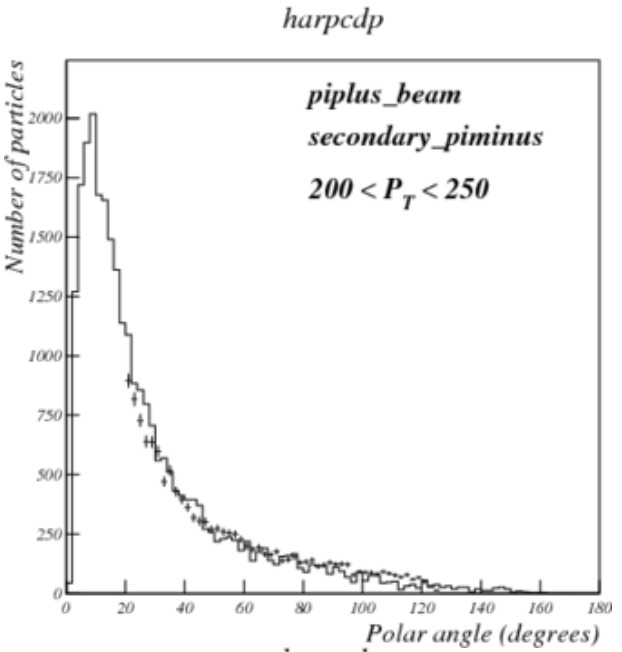


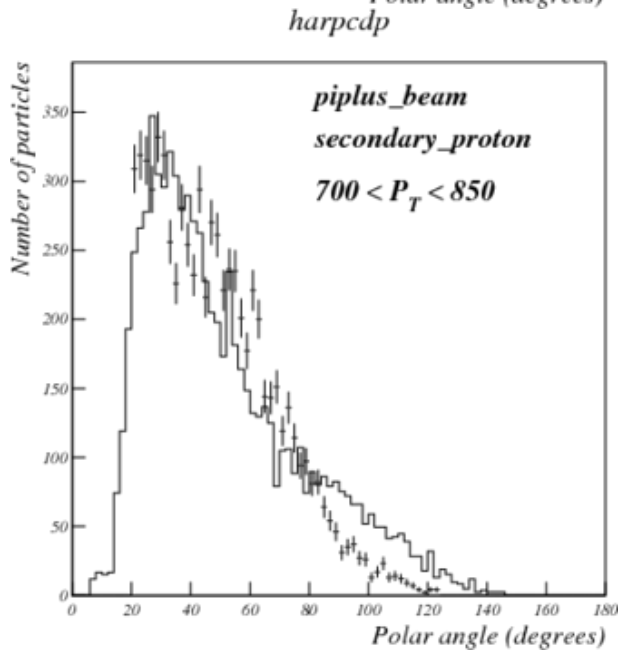


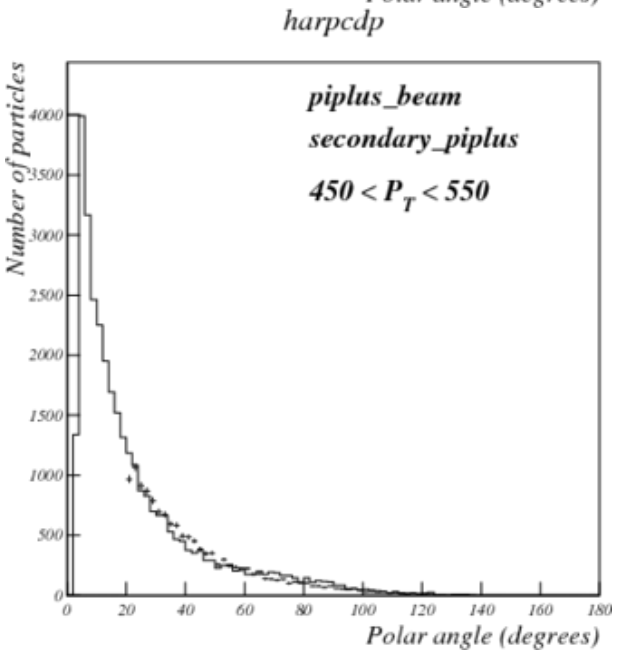
Comparison: HARPCDP (π^+ beam)

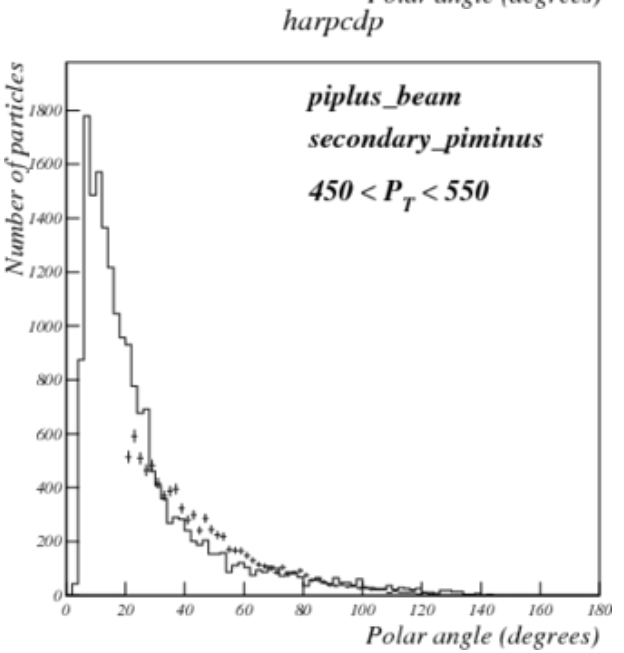




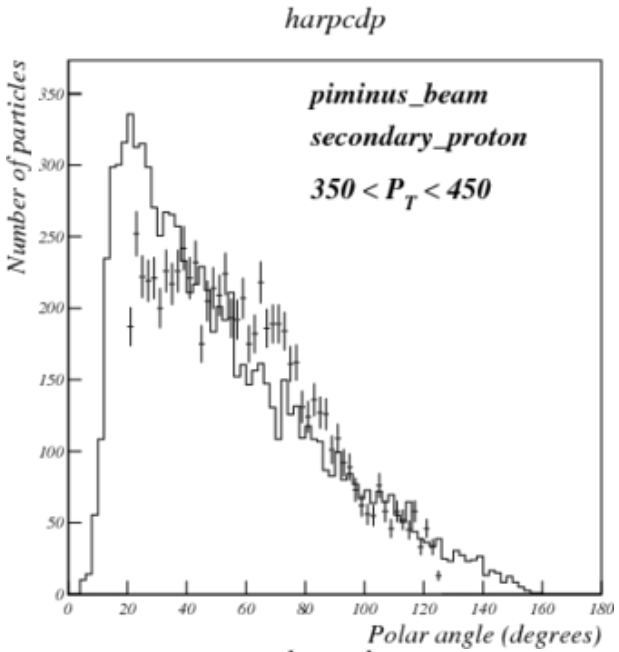


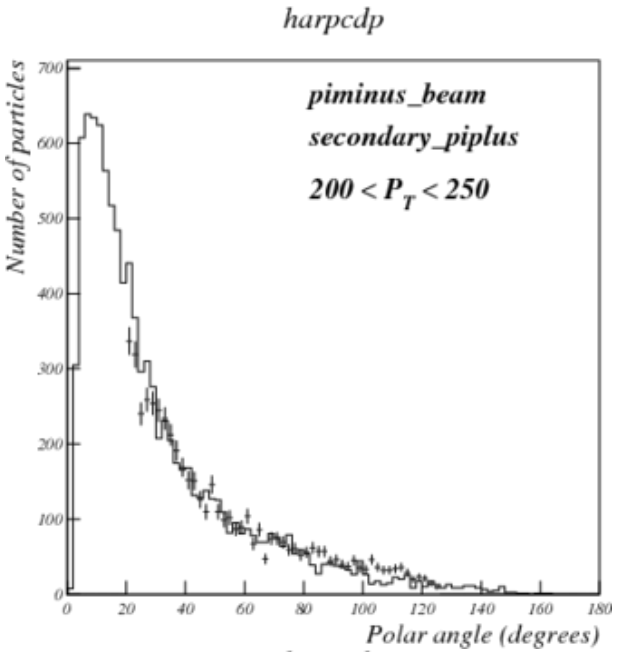


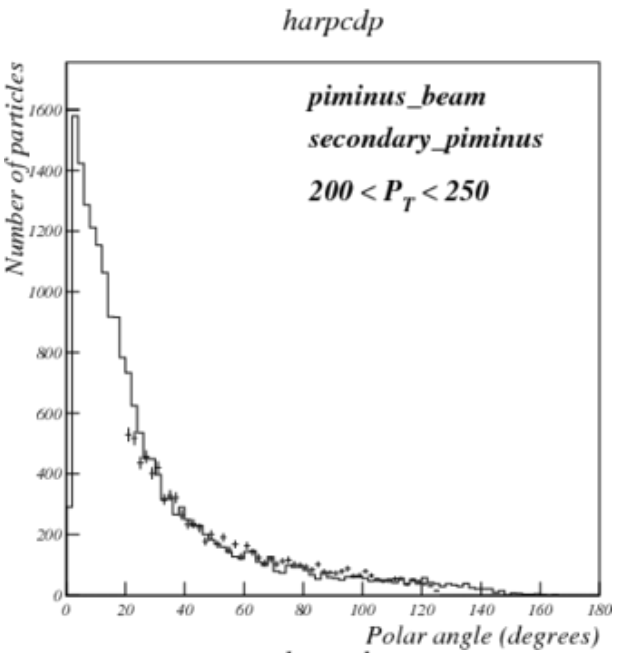


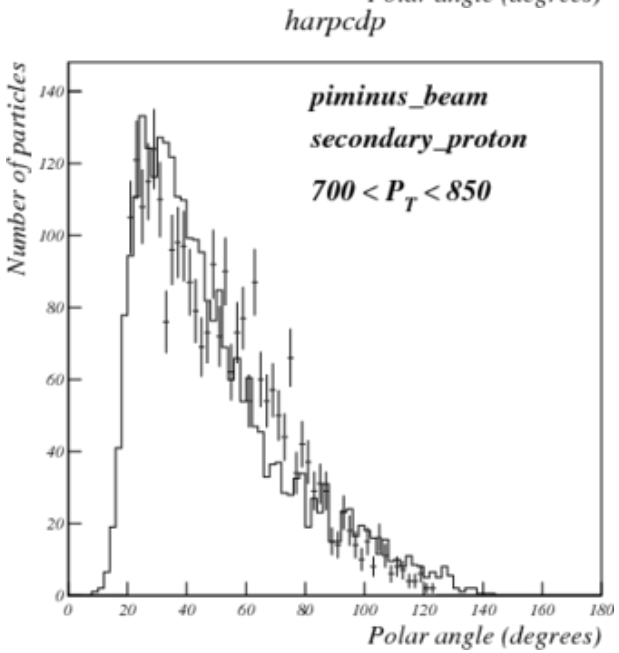


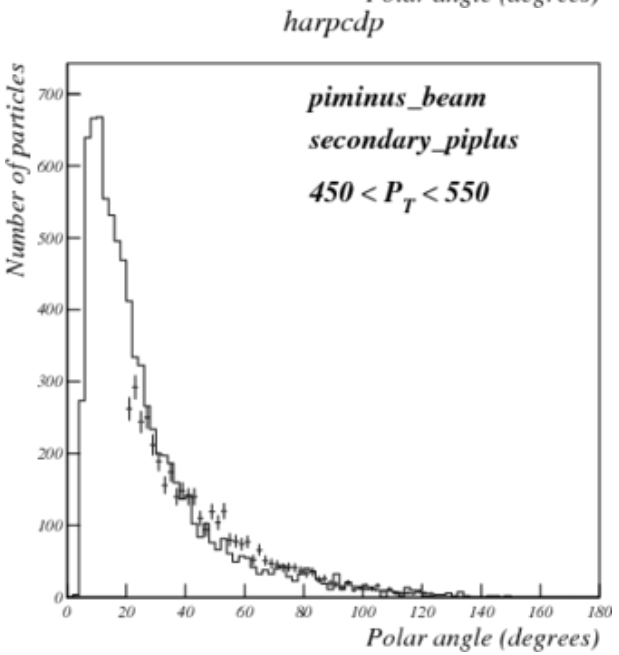
Comparison: HARPCDP (π^- beam)

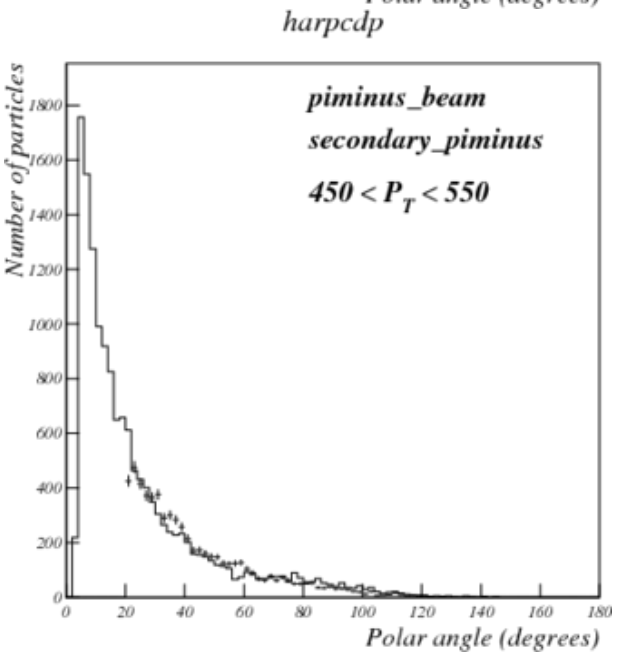












Comparison with Geant4 version 4.9.1p02

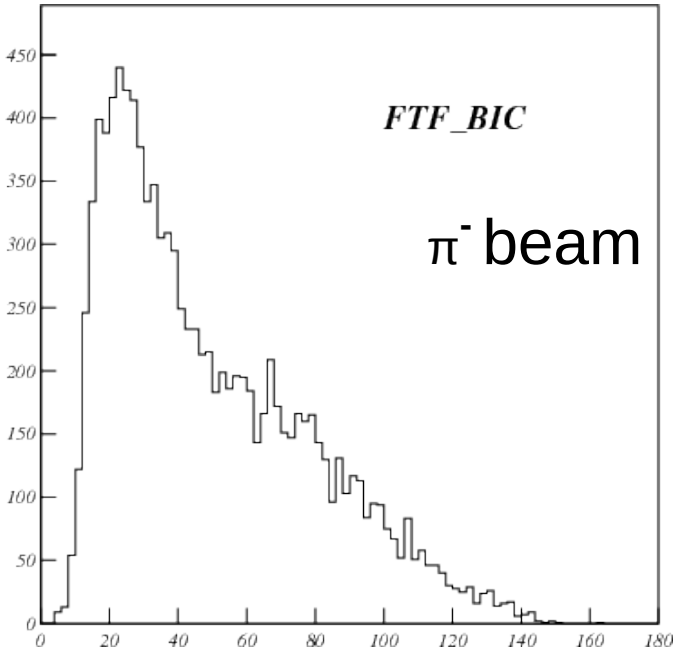
- Significant improvement in some physics lists
- Unphysical elastic peak disappeared:

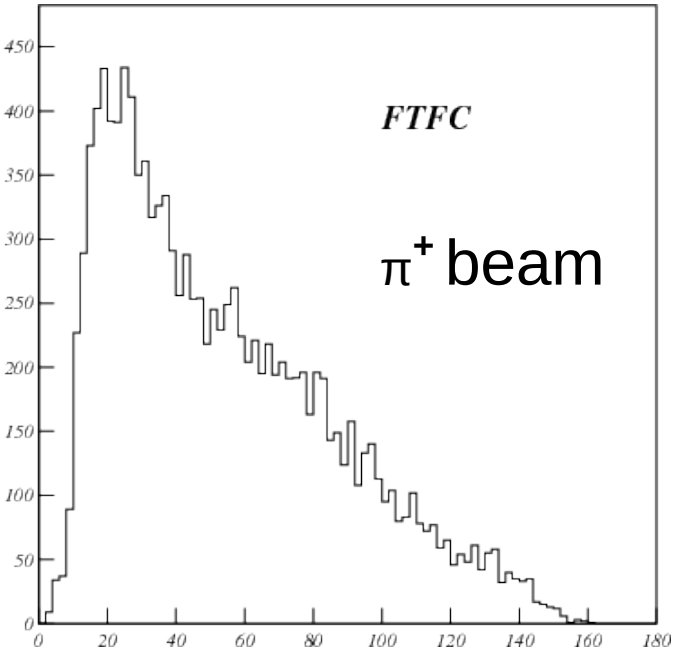
  FTP_BIC, FTFC, FTFP, QBBC, QGSC_BERT

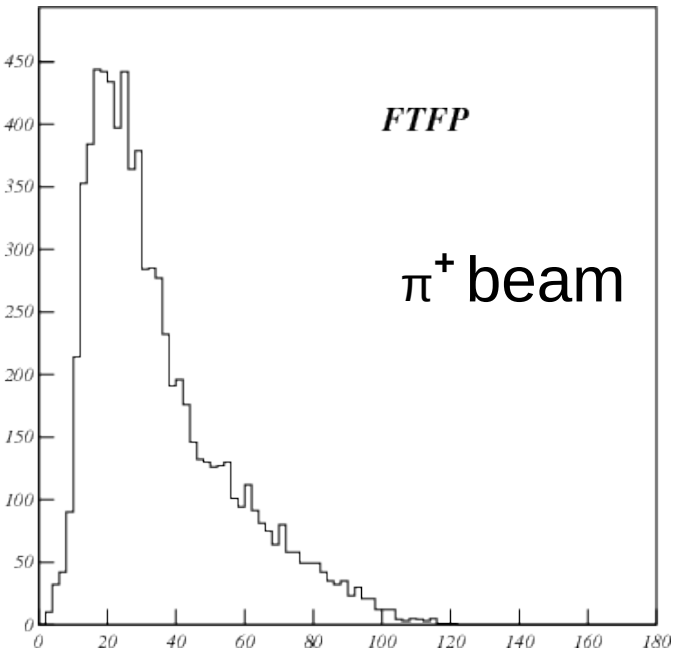
- The peak is still present:

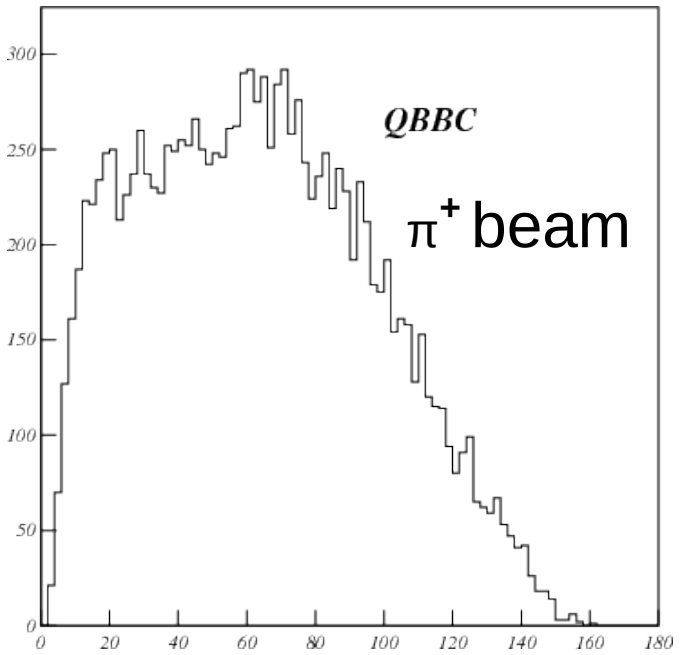
  QGS_BIC, QGSC, QGSP_BERT, QGSP_BERT_TRV, QGSP_BIC, QGSP

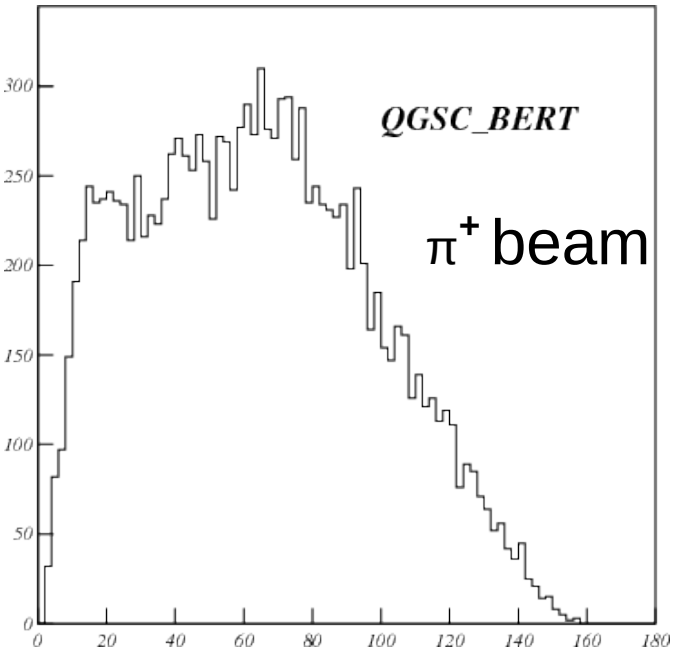
Improved since 4.9.1 (secondary protons)



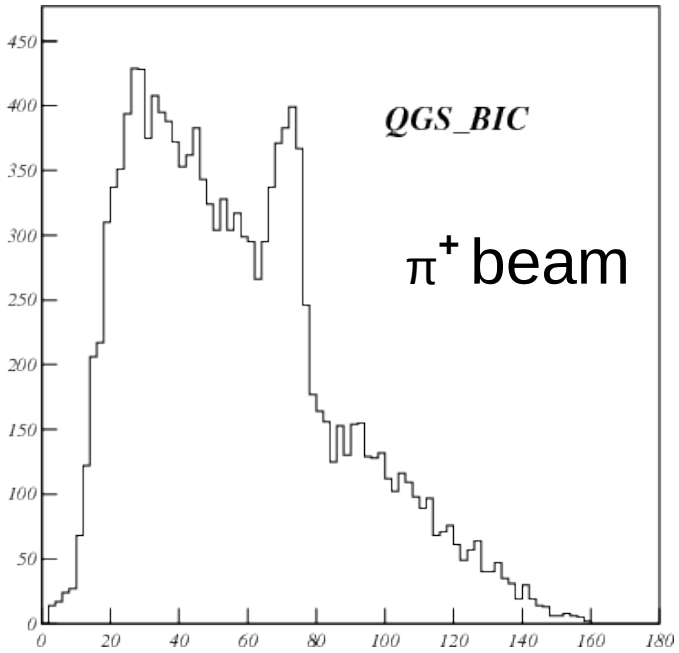


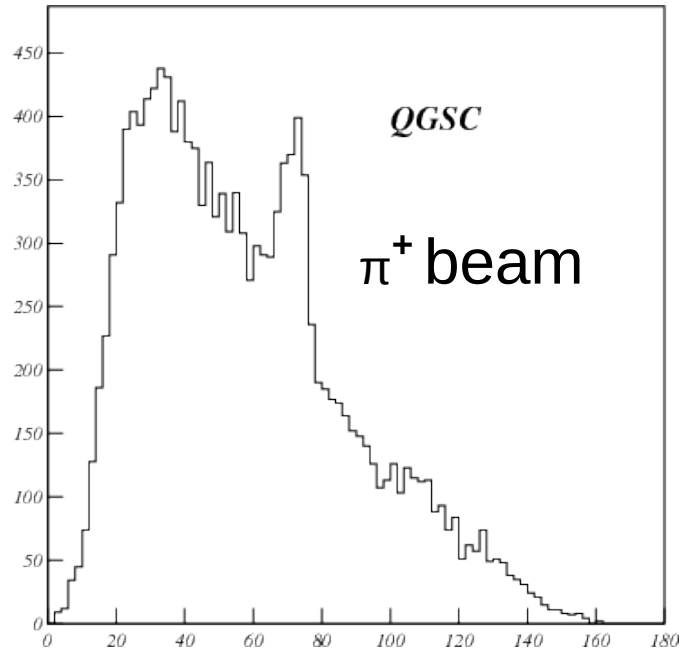


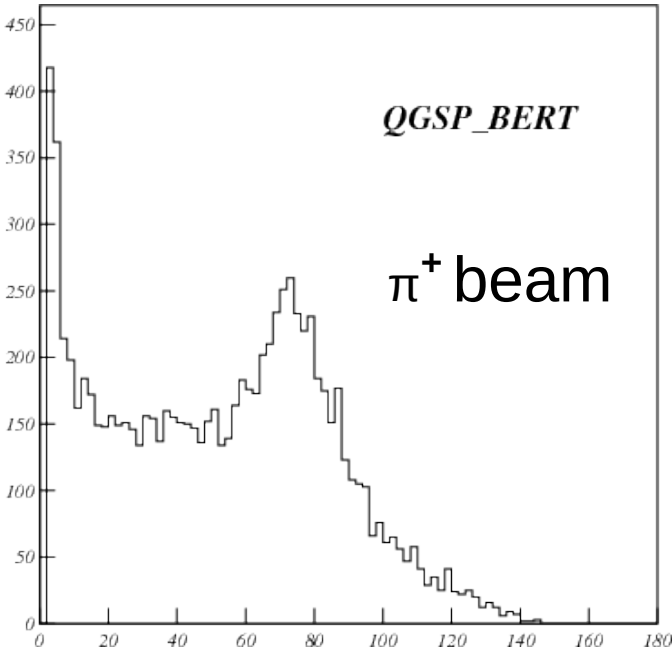


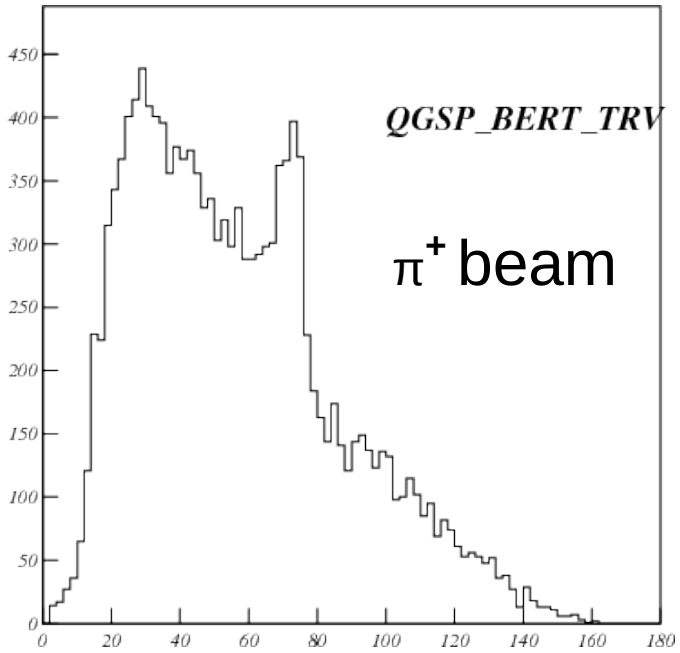


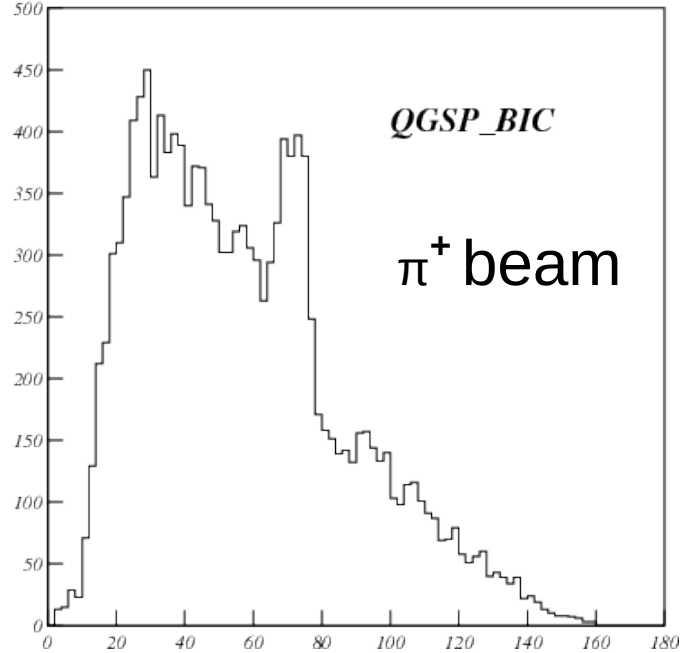
Did not improve since 4.9.1 (secondary protons)

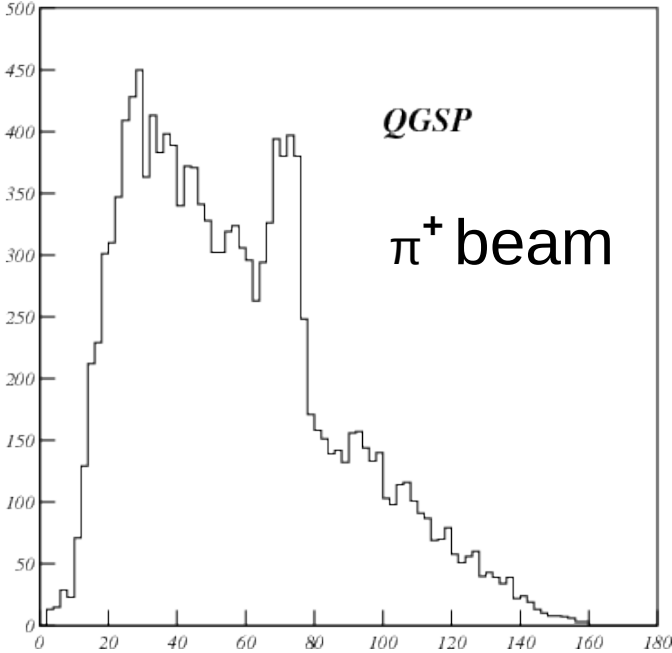












Summary

- Geant4 predictions on hadron production by protons and pions at 8.9 GeV/c has been compared with experimental data

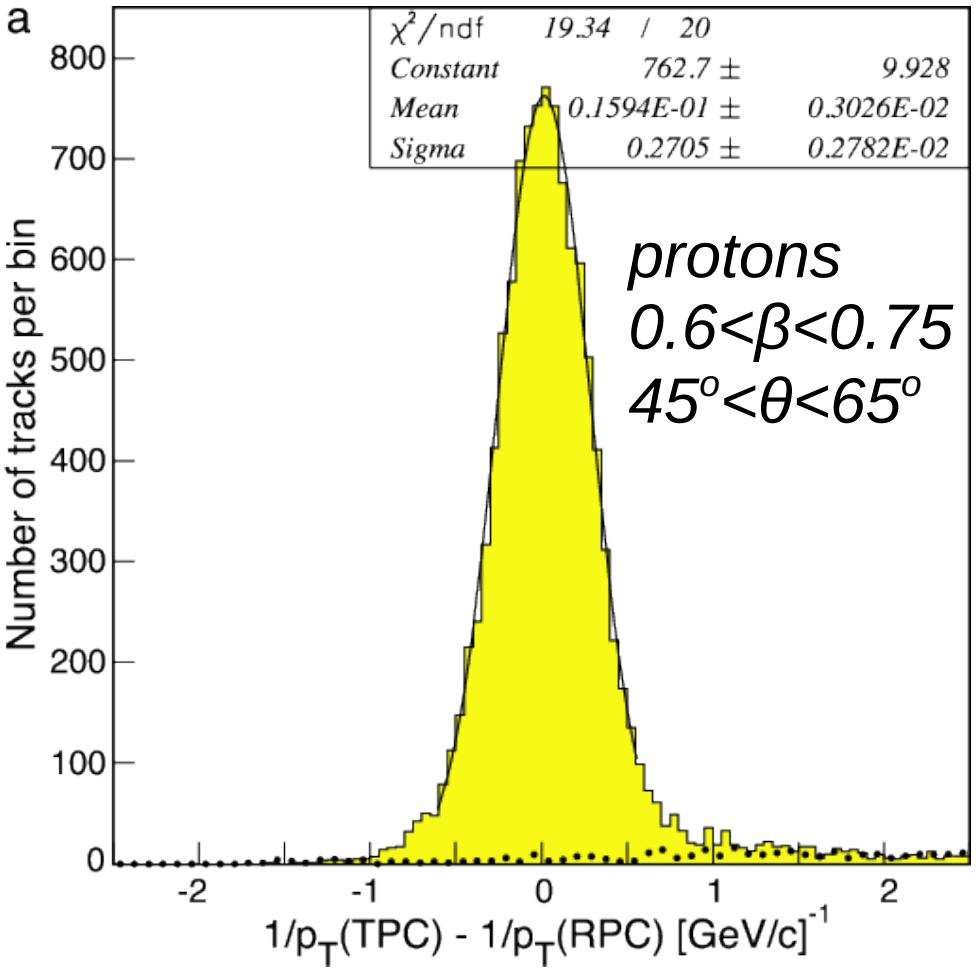
- Significant disagreements in shape of polar angle distributions have been found for all standard physics lists

- Major problems are
  - an unphysical peak for secondary protons near 70^{o}
  - an unphysical diffraction-like pattern for secondary pions
- Situation partially improved in the recent version 4.9.1p02

backup

The HARP large angle spectrometer performance

- $0.20 < \sigma(1/P_T) < 0.25$ (GeV/c)$^{-1}$
- TOF resolution 175 ps
- dE/dx resolution 16% for tracks longer than 300 mm



Particle identification