On BBC performance in the magnetic field

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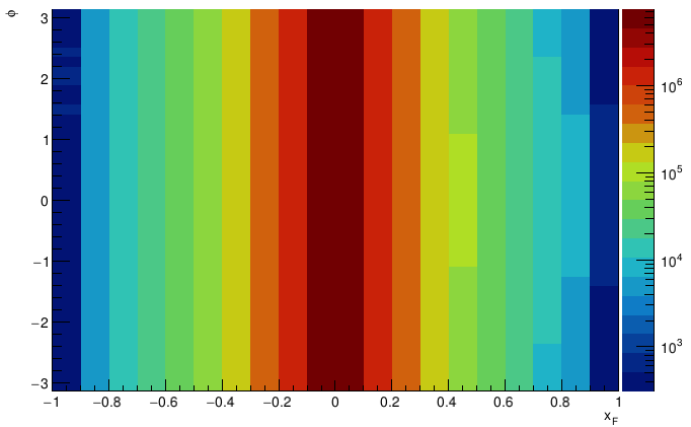
Motivation

- We can expect magnetic field to smear polarization effect for BBC.
- For the time of study **we don't have event generator for collisions of polarized particles**.
- Weighting procedure was used:
  - weight for event = a product of $(1 + A_N(x_F)*\cos(\varphi))$ for each track.
  - Weighting error is $\sigma^2 = (\text{sum } w)^2 / (\text{sum } w^2)$.
- Zhanibek has done such study in SpdRoot, but results seemed to have some artifacts.
- Here is generator-level investigation of possible reasons will be given.

Simulation details

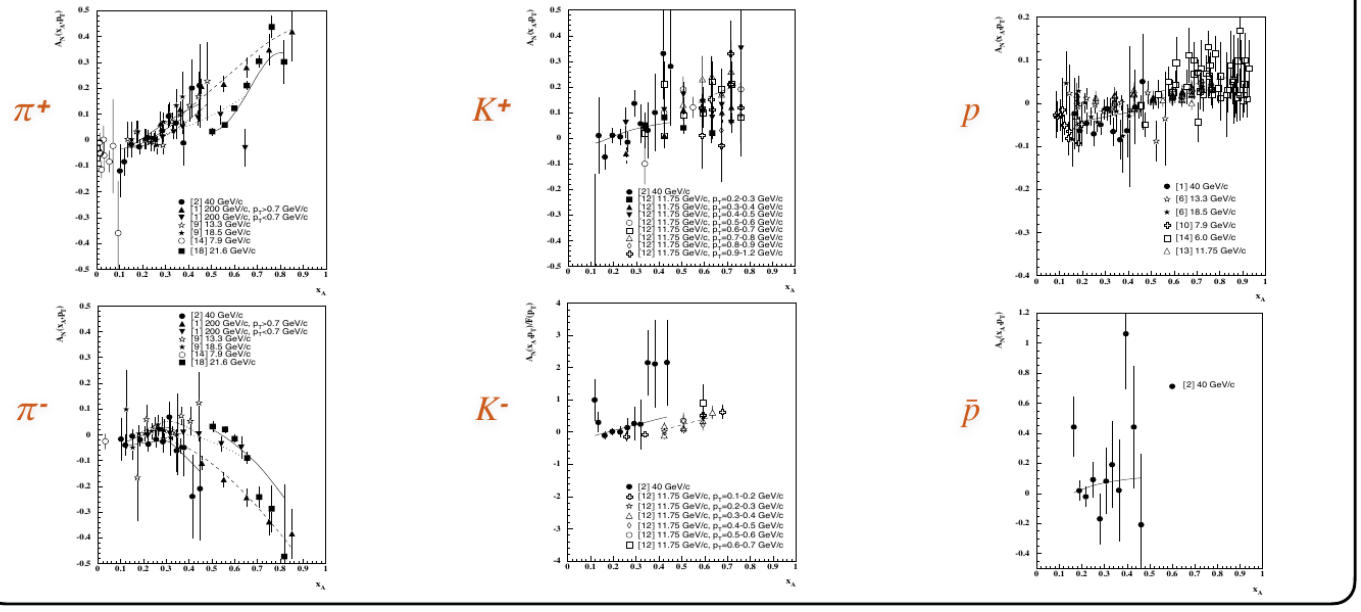
- Constant magnetic field of 1T, √s = 27 GeV.
- All tracks are analytically parameterized as helixes.
- Rough geometry dimensions are used. Time t = t(l, pz), the rotation angle is determined from x(t) and y(t). Track reaches BBC if when it paths trough BBC plane r_min < r < r_max.
- Two-dimensional histograms xF x φ for generated particles and for particles in BBC are filled and analyzed.
- Only charged asymmetries of charged pions are considered (**no weight modification due to kaons or protons**)
- For extraction of asymmetries the φ distribution is fitted in each x_F bin.



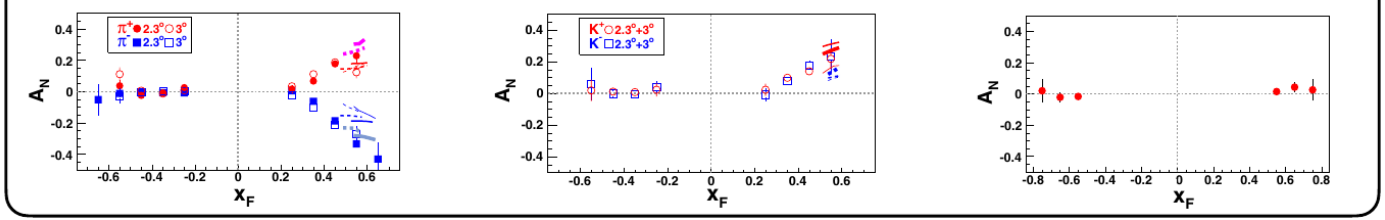
Measured asymmetries

Slide from A. Korzenev at SPD TB, 12.01.23

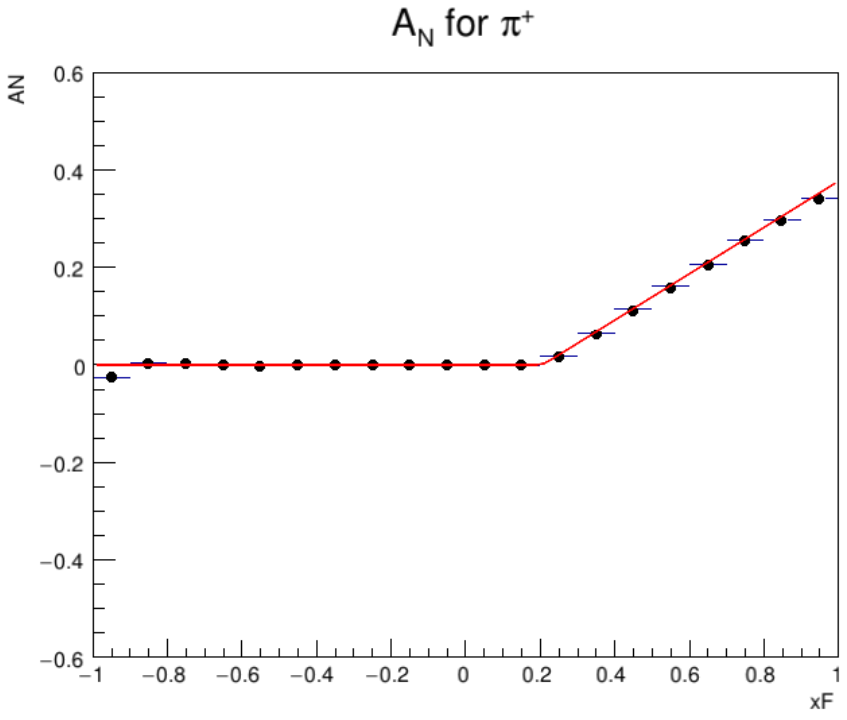
Fixed target experiments (Eur.Phys.J.C14(2000)427)

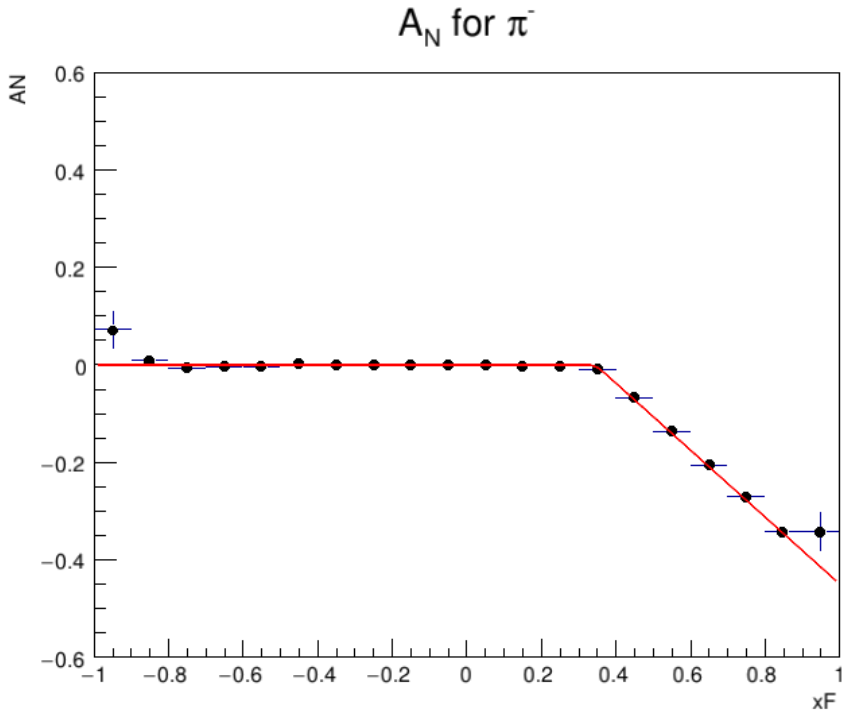


Collider experiment BRAHMS (Phys.Rev.Lett.101(2008)042001)

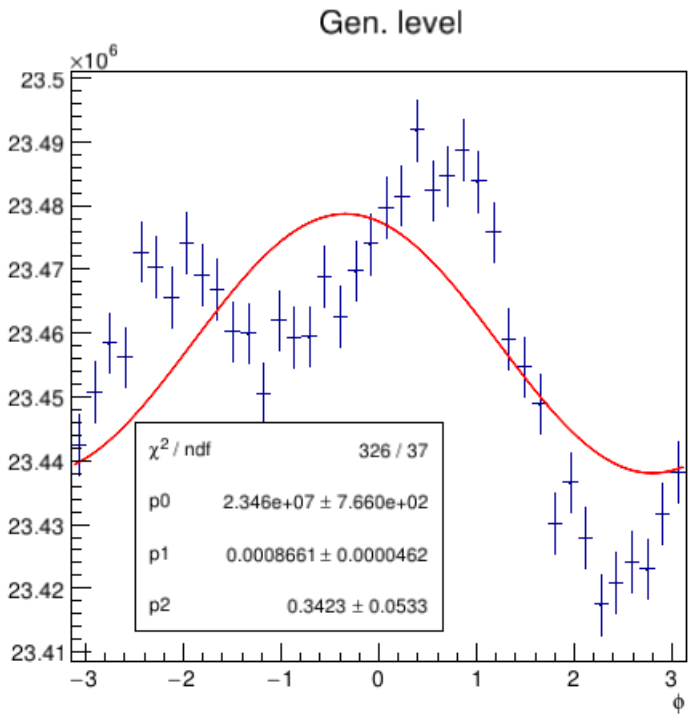


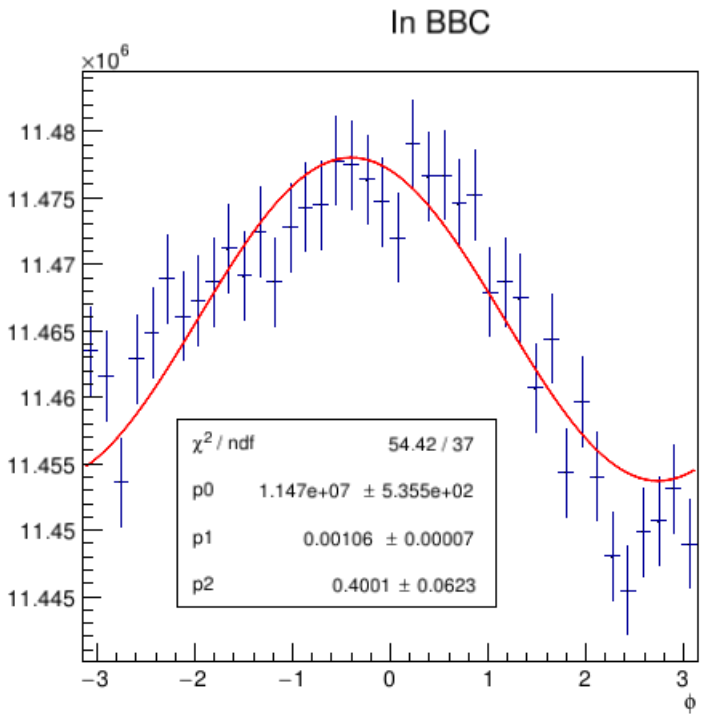
Consistency check for pions



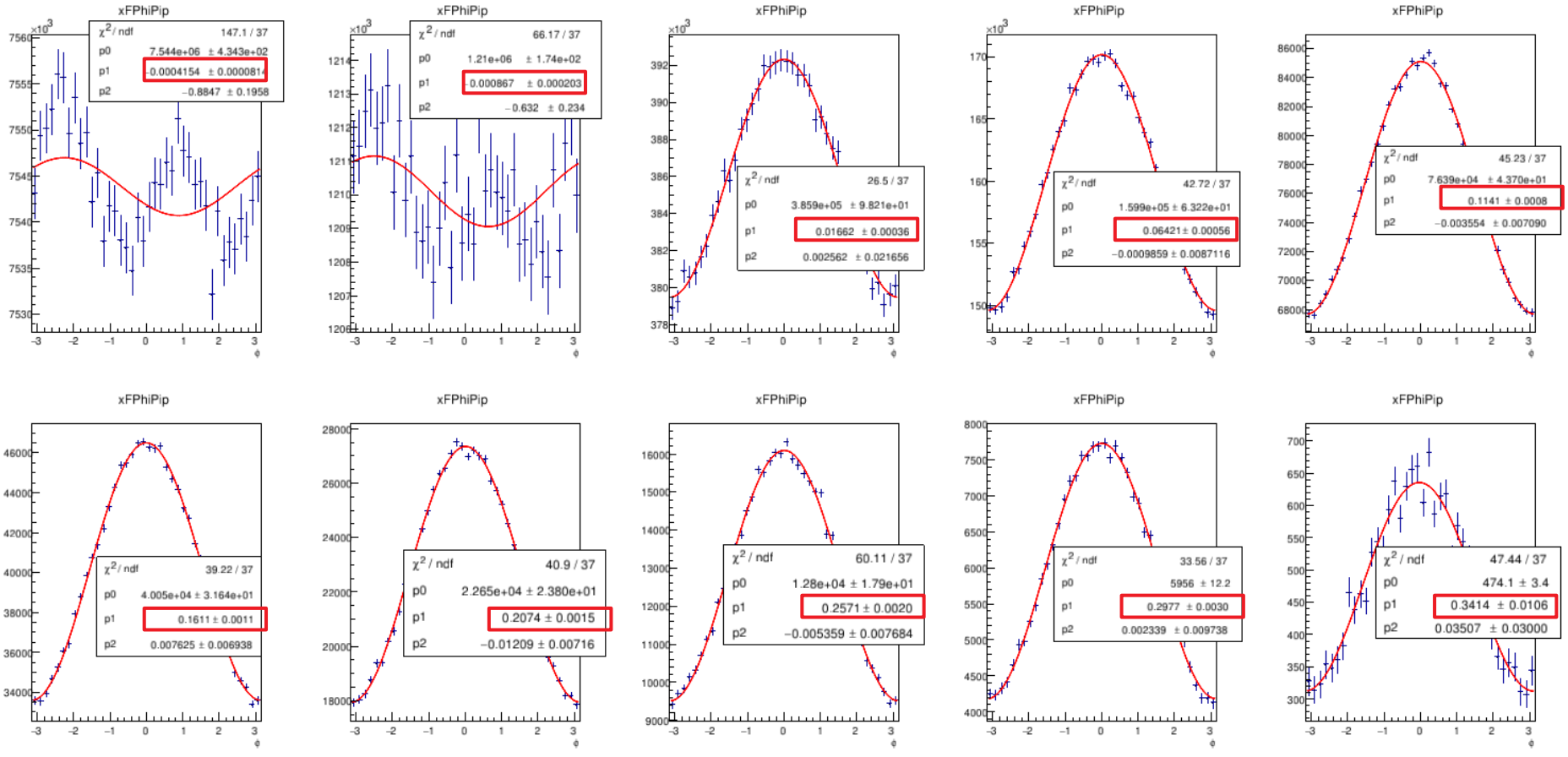


Integral distributions of generated events and tracks in BBC

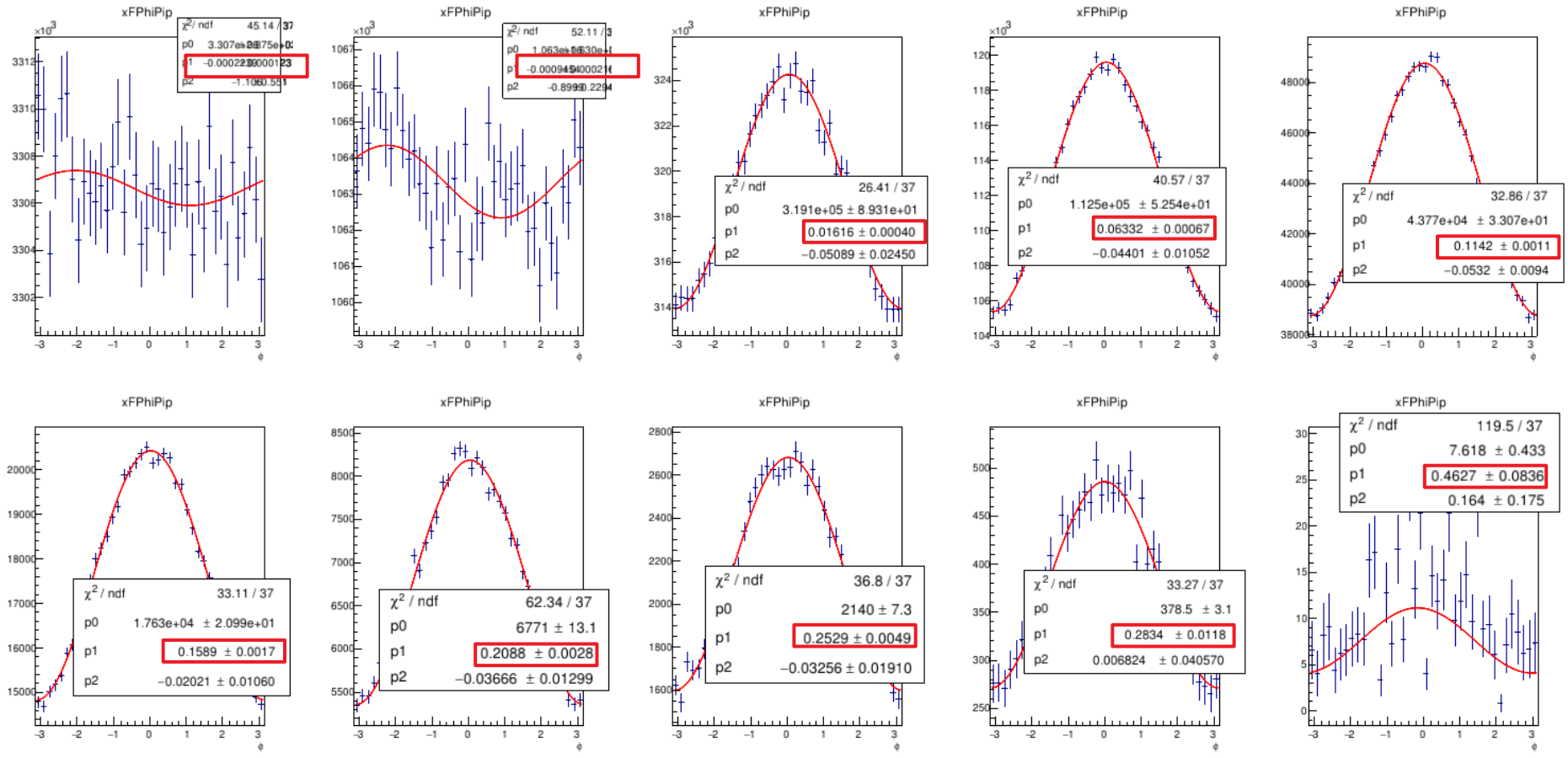




Generated tracks in x_F bins



Tracks in BBC in x_F bins



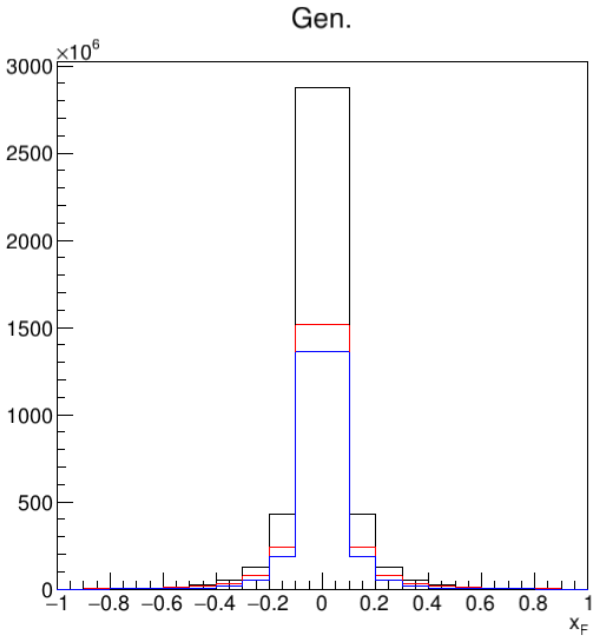
Summary

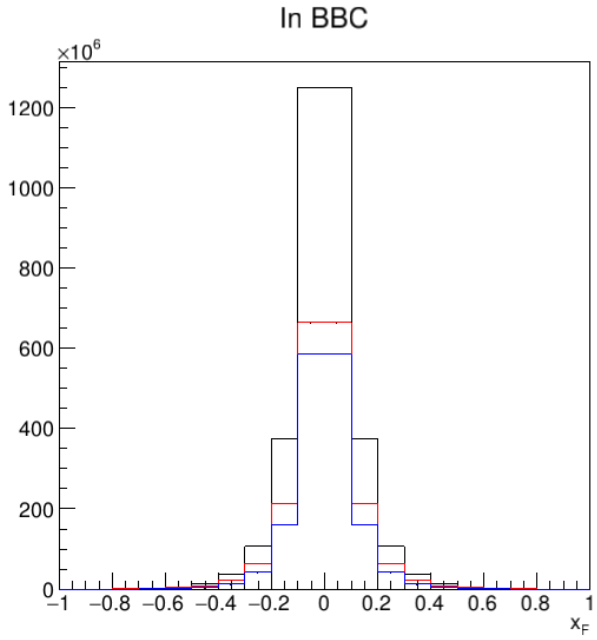
- A simple model and weighting procedure are studied at $\sqrt{s} = 27$ GeV:
  - There are **notable artifacts** of the weighting procedure in the regions with no asymmetry ($0 < x_F < 0.2$).
  - The asymmetry for $x_F > 0.2$ is almost the same for BBC and generated events.
  - Considering that we do not expect asymmetry in the region where we have artifacts, BBC should perform well in the magnetic field.

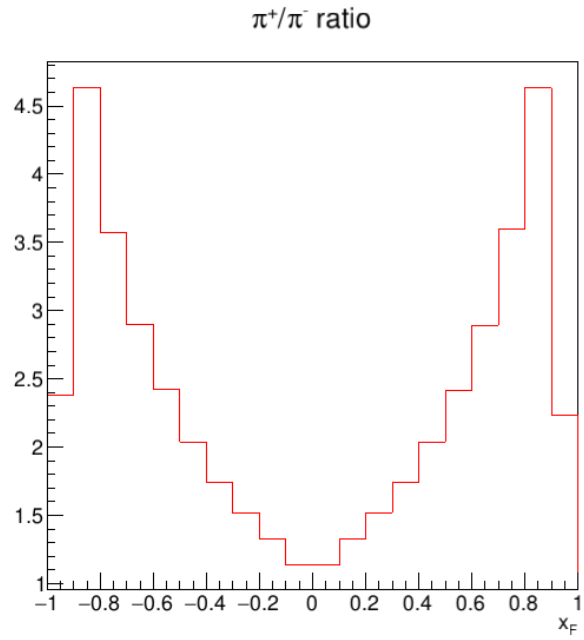
Study update

- The model above gives weighting artifacts ~0.001, but not a **total asymmetry of 1%.**
- I tried tried experiment with weighing events based on the transverse momenta of quark generated by Pyhtia8 – difficult to get consistent results.
- Current knowledge seems **too scarce** to make efforts to reproduce data with 1% asymmetry (cocktail of pions, kaons, and protons with not well-measured asymmetries)
- As the next model I considered **only pions** (CT below stands for all charged pions) from MB events and used **step-function** to weight π^+ and π^- (same weighting method):
  - $A_N(\pi^+)$ = 2% and $A_N(\pi^-)$ = -1% for $x_F>0$, both zero for $x_F<0$
  - $A_N(\pi^+)$ = 6% and $A_N(\pi^-)$ = -5% for $x_F>0$, both zero for $x_F<0$
  - $A_N(\pi^-)$ = -5% for $x_F>0$, zero for $x_F<0$
- Statistics ~10^9 Pythia8 events

x_F distribution and π^+/π^- fraction





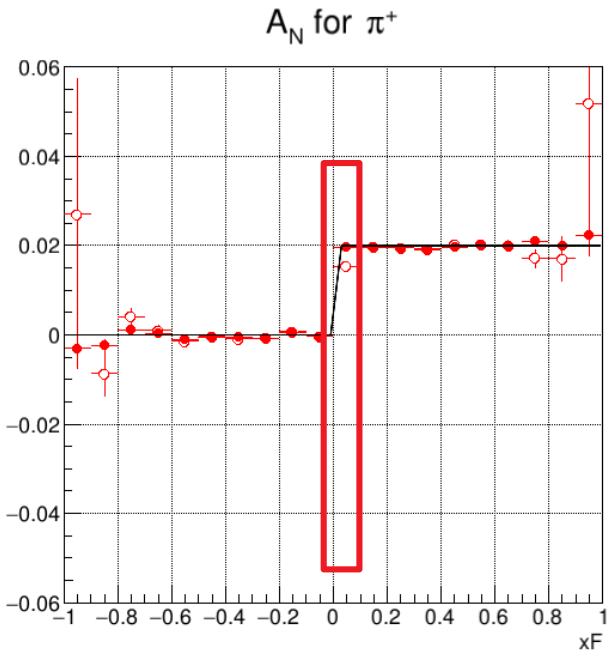


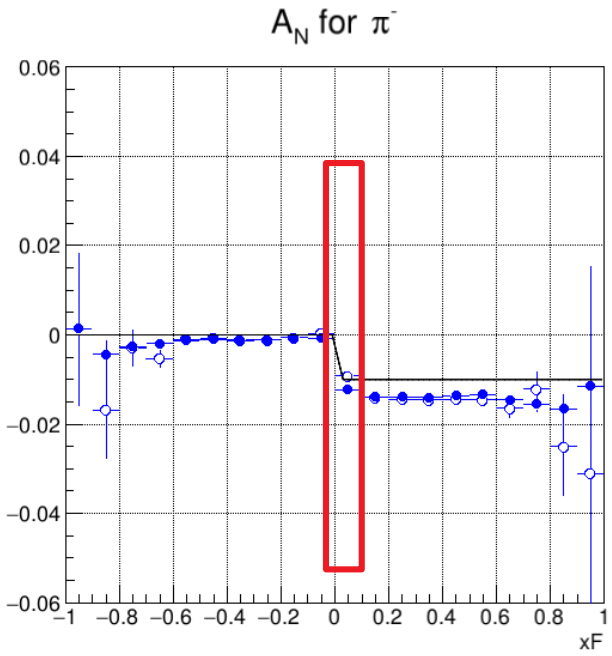
Central bins can be extremely important

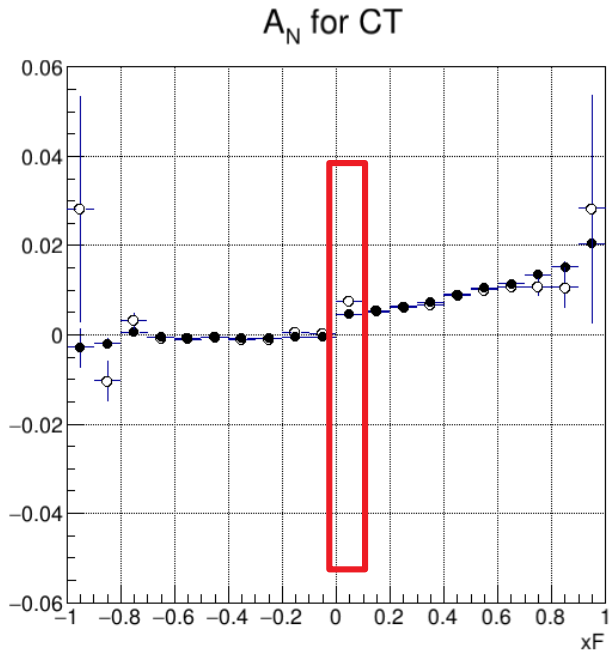
Cases

- $A_N(\pi^+)$ = 2% and $A_N(\pi^-)$ = -1% for $x_F>0$, both zero for $x_F<0$
- $A_N(\pi^+)$ = 6% and $A_N(\pi^-)$ = -5% for $x_F>0$, both zero for $x_F<0$
- $A_N(\pi^-)$ = -5% for $x_F>0$, zero for $x_F<0$

$A_N(\pi^+)$ = 2% and $A_N(\pi^-)$ = -1% for x_F>0, both zero for x_F<0



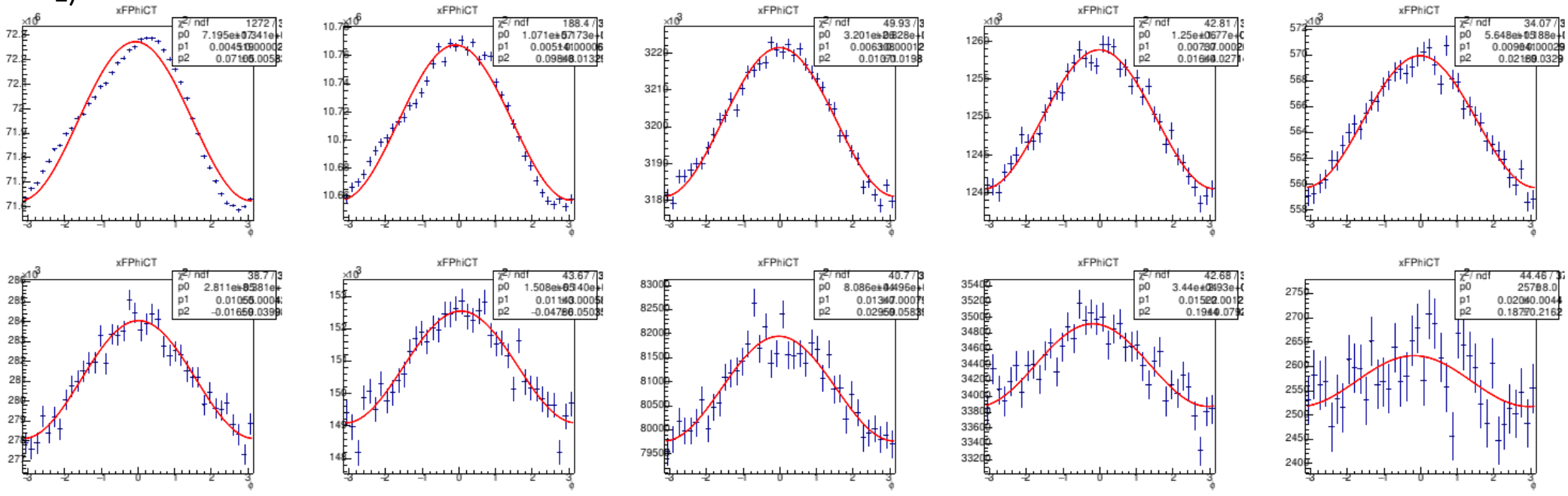




- Small correlation between π^+ and π^- is notable
- Visible asymmetry in $0 < x_F < 0.1$ is reduced by ~ 20% for π+ and π- separately
- Visible asymmetry for CT in the same bin is larger than initial (see next slides)

$A_N(\pi^+)$ = 2% and $A_N(\pi^-)$ = -1% for x_F>0, both zero for x_F<0

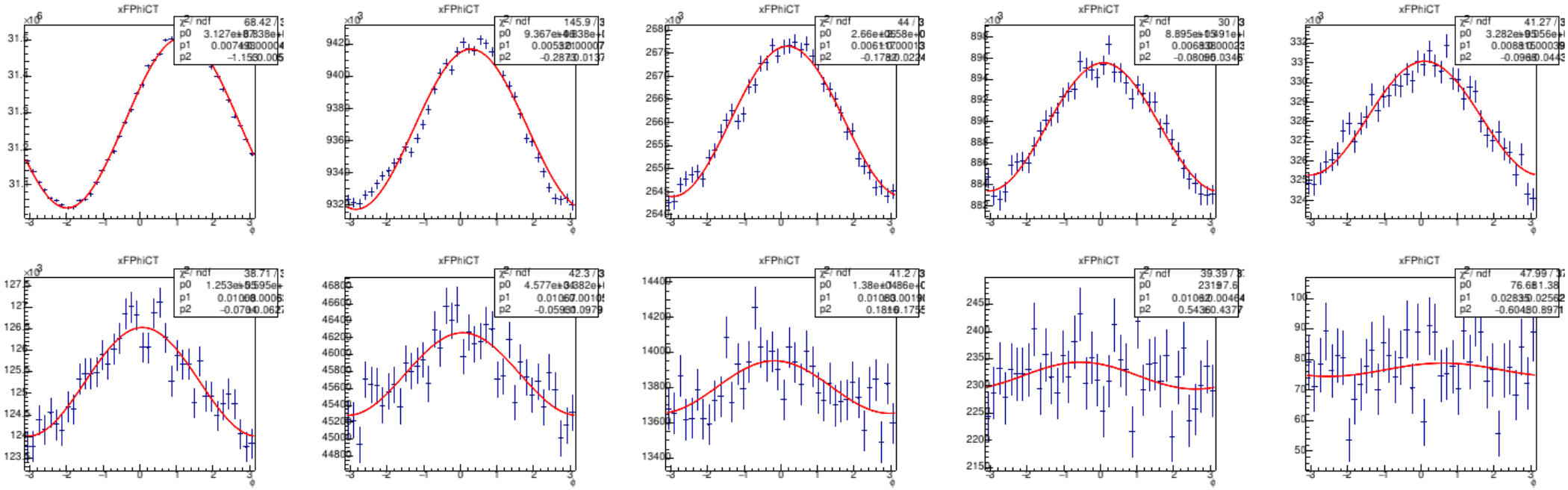
Tracks (π^+ and π^- **together**) **before** propagation to BBC (10 bins for 0 < xF < 1)



- There are deviations in shape for the first two figures, but generally figures are Ok.

$A_N(\pi^+)$ = 2% and $A_N(\pi^-)$ = -1% for x_F>0, both zero for x_F<0

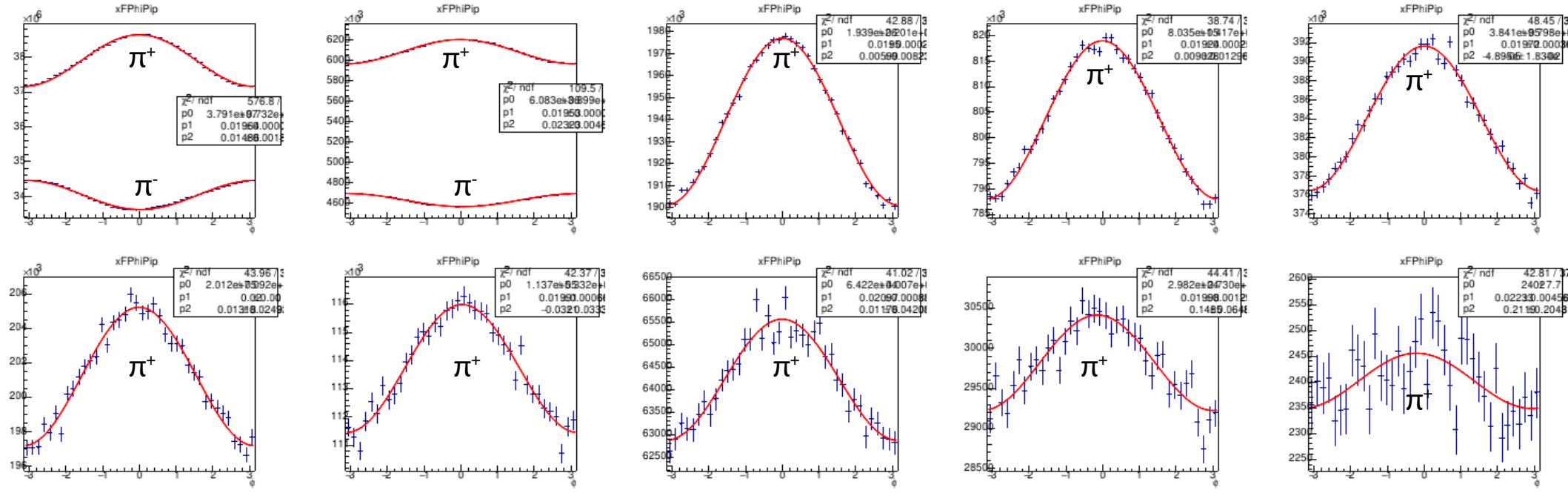
Tracks (π^+ and π^- **together**) **after** propagation to BBC (10 bins for 0 < xF < 1)



- The shape in the first bin is notably different

$A_N(\pi^+)$ = 2% and $A_N(\pi^-)$ = -1% for x_F>0, both zero for x_F<0

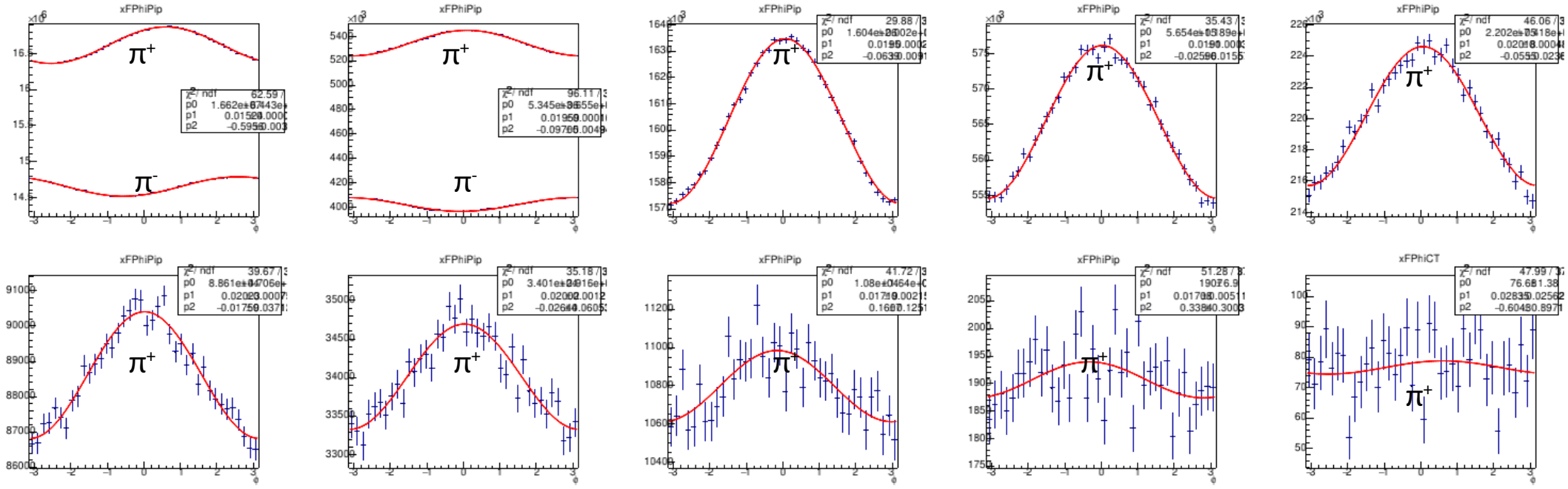
Tracks (π^+ and π^- **separately**) **before** propagation to BBC (10 bins for 0 < xF < 1)



- There is compensation of π^+ and π^- asymmetries

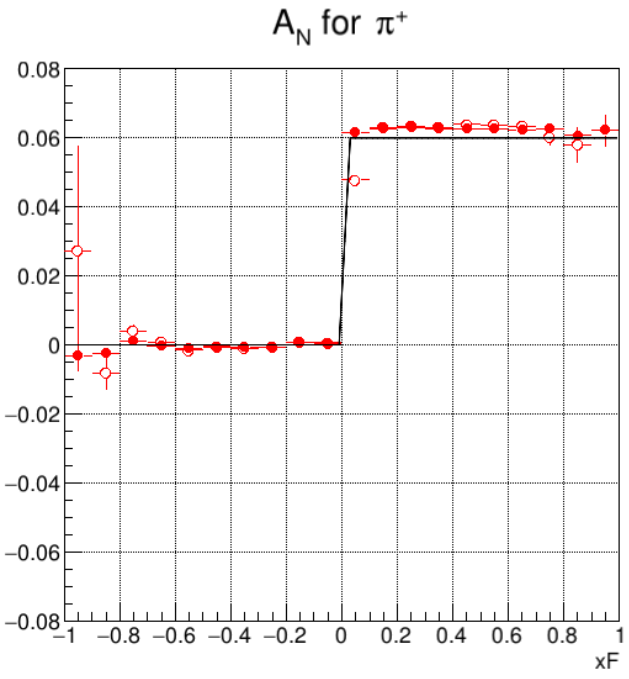
$A_N(\pi^+)$ = 2% and $A_N(\pi^-)$ = -1% for x_F>0, both zero for x_F<0

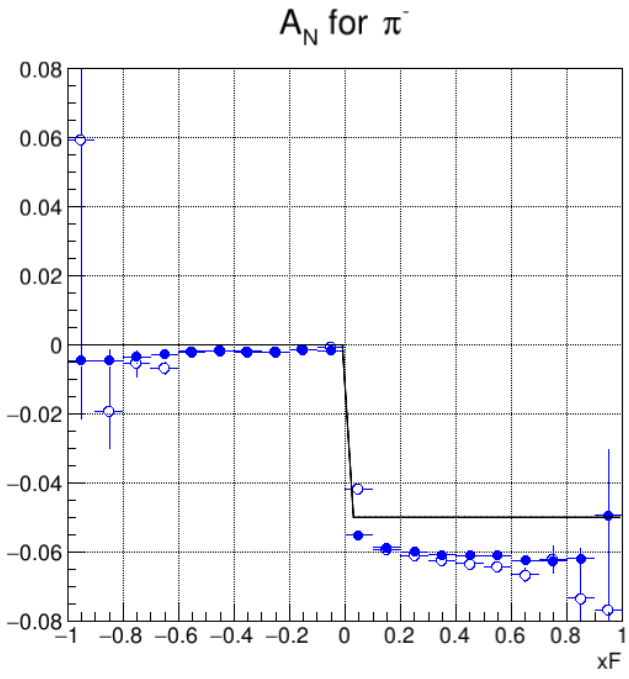
Tracks (π^+ and π^- **separately**) **after** propagation to BBC (10 bins for 0 < xF < 1)

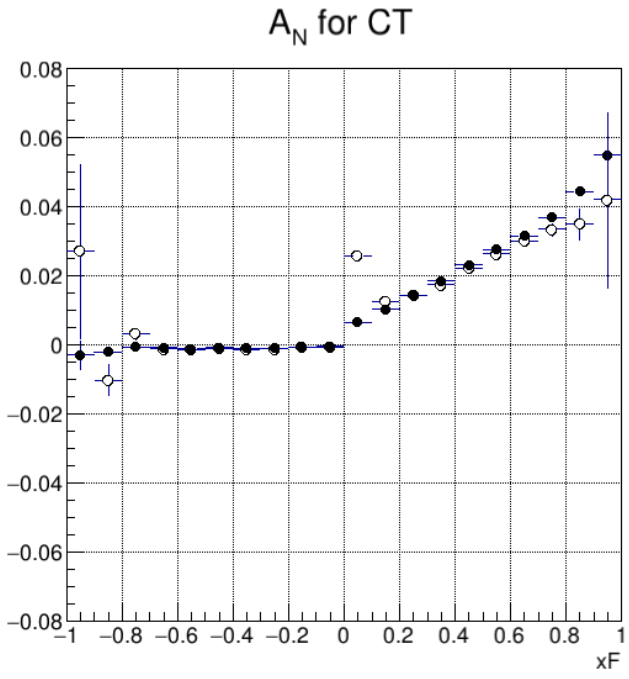


- For the first bin there is only **partial compensation** of π^+ and π^- asymmetries

$A_N(\pi^+)$ = 6% and $A_N(\pi^-)$ = -5% for x_F>0, both zero for x_F<0

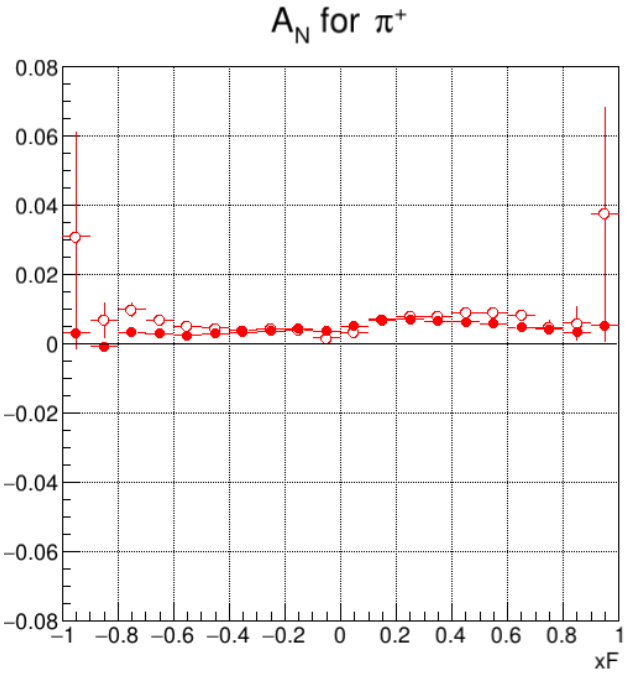


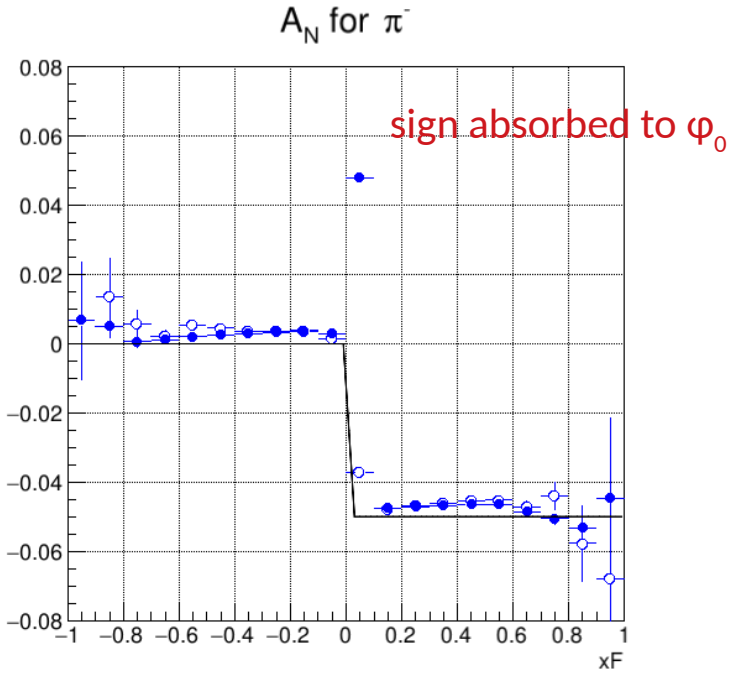


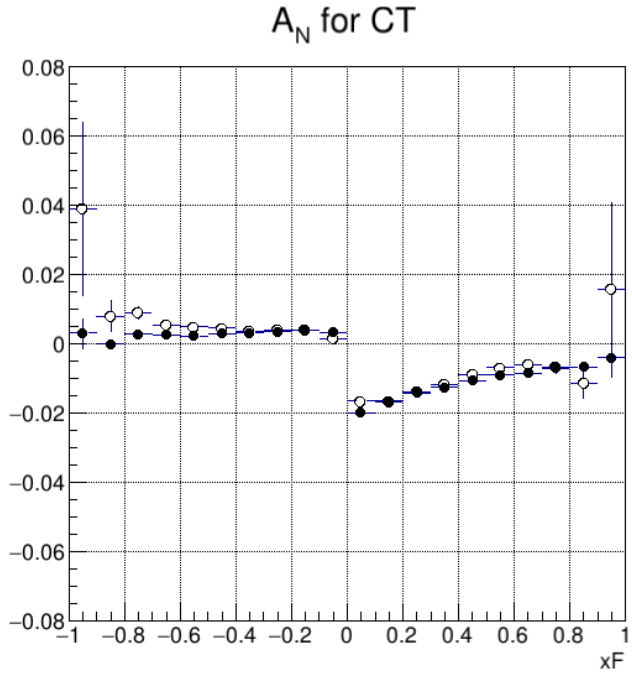


- π^- asymmetry is large than weighting functions
- Generally, situation is very similar to the previous case

$A_N(\pi^+)$ = 0% and $A_N(\pi^-)$ = -5% for x_F>0, both zero for x_F<0







Summary

- If total asymmetry of 1% comes mostly from the **same sign** of particles in **central xF bins**, we can expect 20-30% lower value to observed in BBC. If it is result of **compensation of opposite charges**, it might be even bigger. If it comes **not from central bins** then the observed asymmetry should not be affected by the magnetic field.
- Weighting is not perfect method. Is there any way to improve the analysis?
- What about lower energies?
- This calculation has not been cross-checked with SpdRoot yet.