Toy MC analysis for BBC in magnetic field

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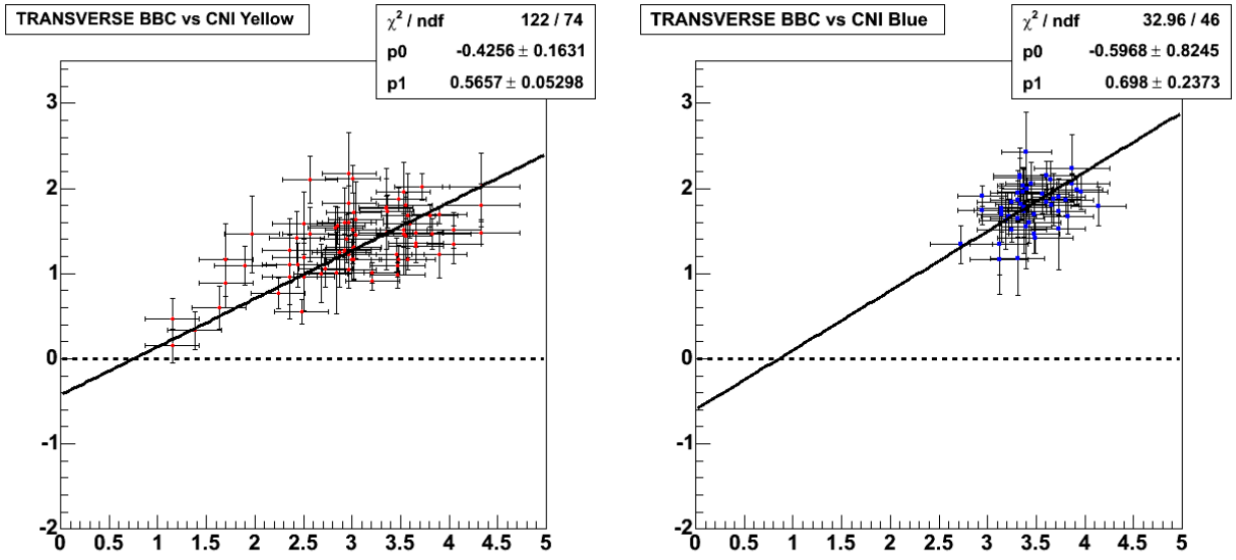
SPD Physics & MC meeting
17 April 2024

Motivation



(a) (b)

Figure 5.1: Correlation of the beam asymmetries measured by the RHIC *pC* CNI polarimeter [429, 430] and left (a) and right (b) STAR BBCs (in arbitrary units).

Figure from SPD CDR

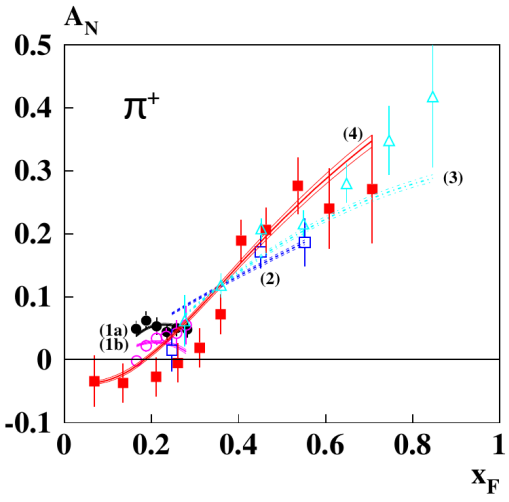
Observed effective analyzing power at RHIC at BBC is ~ 0.7%.

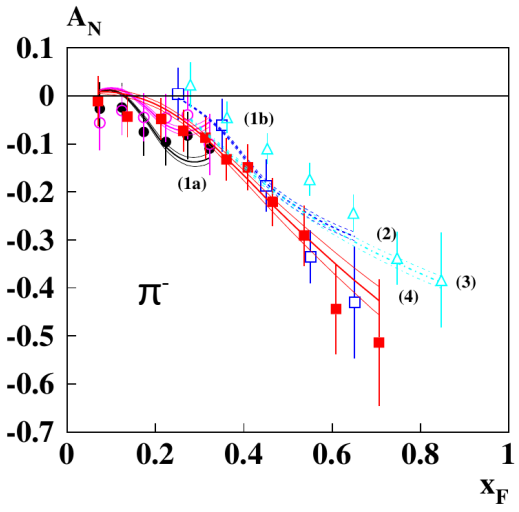
Plan

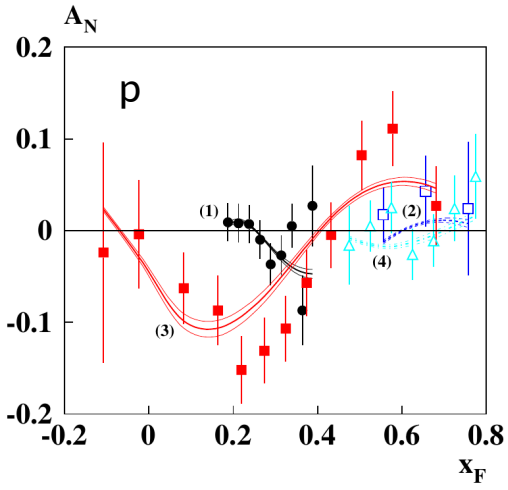
- Model for weighting data
- Event-wise weighting
- Track-wise weighting

Model for weighting

According to measurements, A_N depends on both pT and xF. It's not possible to get definite parameterization from data. Consequently, the CPQ model calculations by V. Abramov are used (J.Phys.Conf.Ser. 678 (2016) 1, 012039)



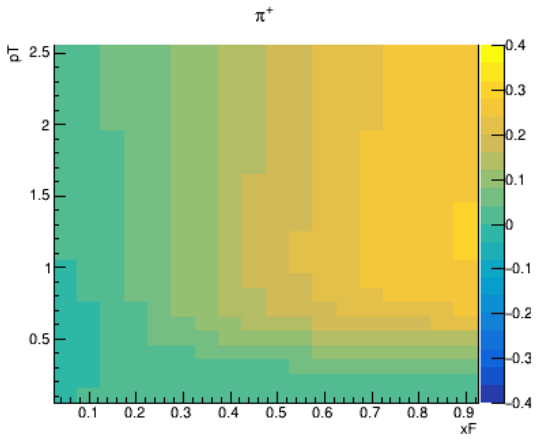


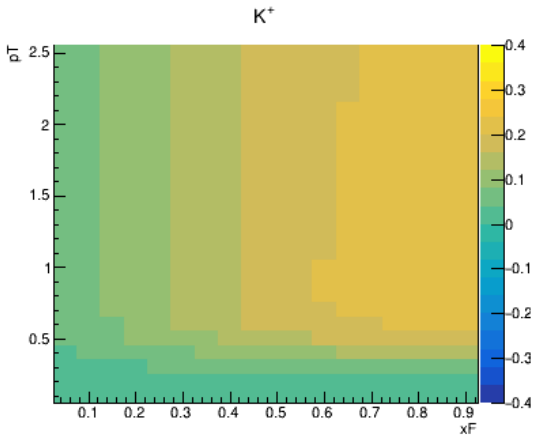


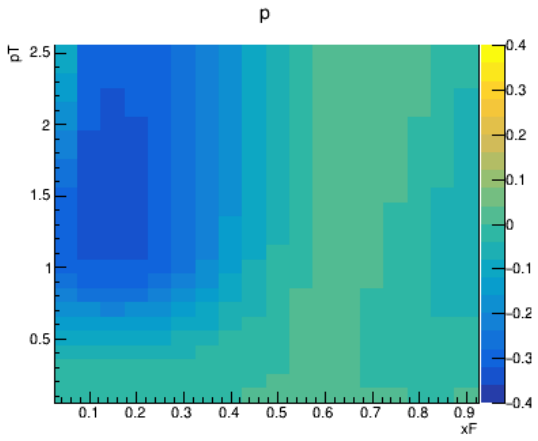
1. BRAHMS (200 GeV)
2. BRAHMS (64 GeV)
3. E704 (19.4 GeV)
4. FODS (8.77 GeV)

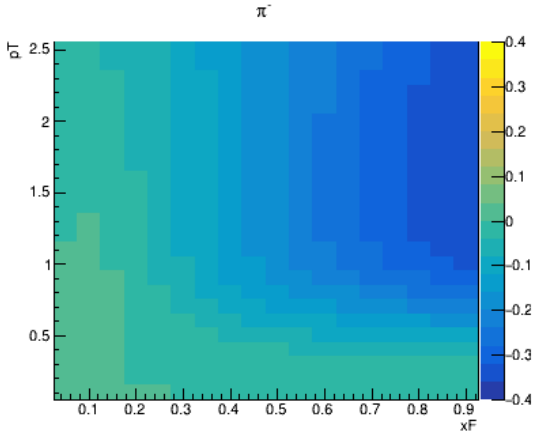
Kaons can be also taken into account but don't significantly affect the results (see talk by A. Terekhin).

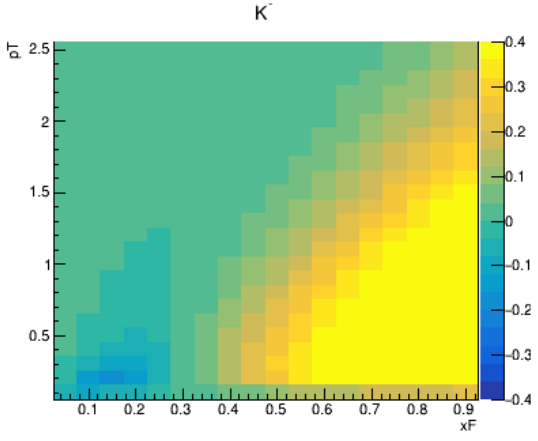
Model prediction grid (√s=27 GeV)









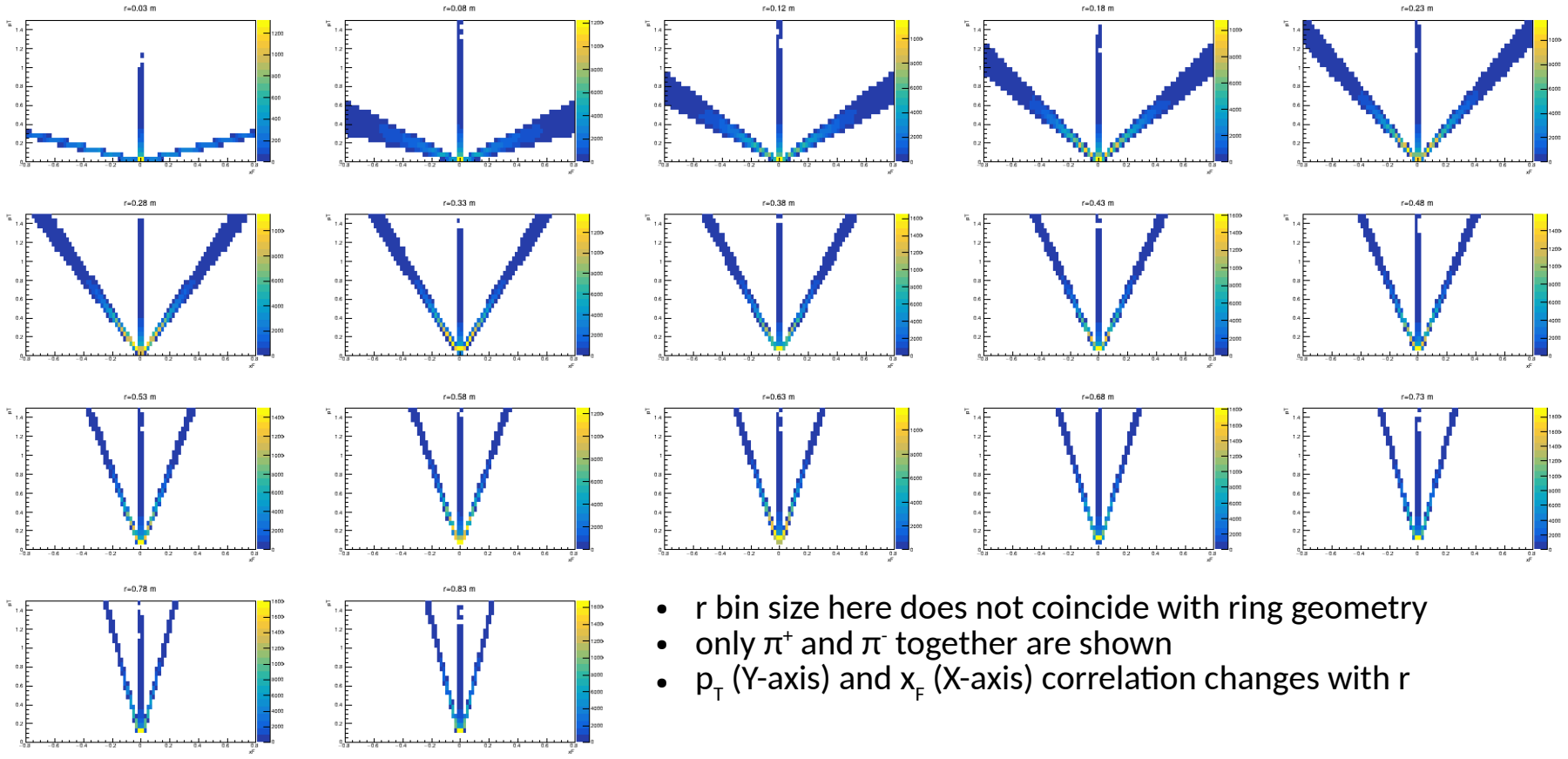


Thanks to Victor Abramov!

Weighting method and model

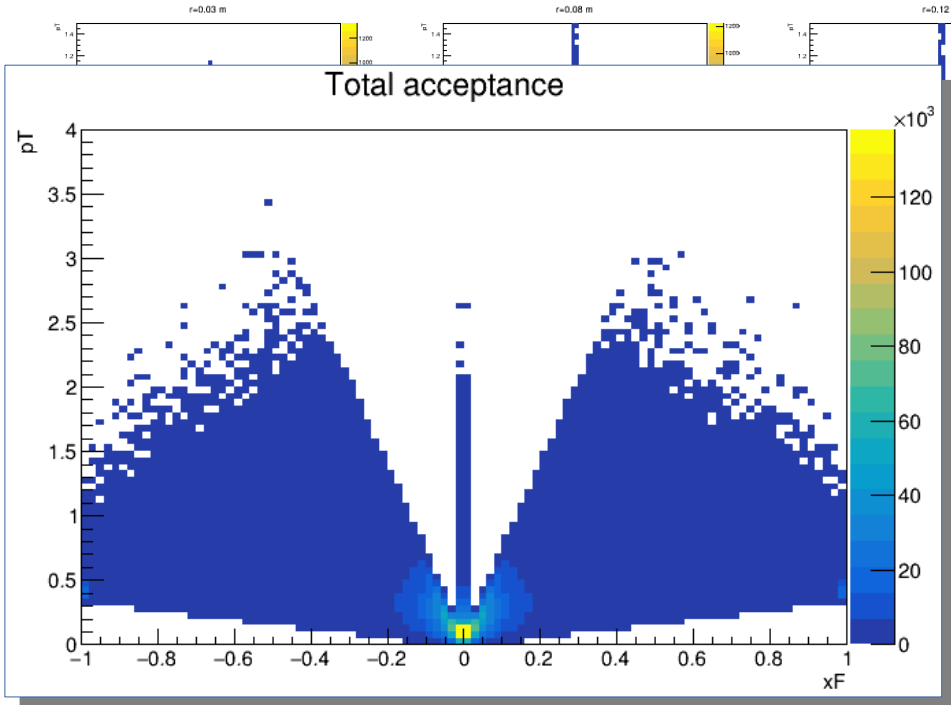
- We can expect magnetic field to smear polarization effect for BBC.
- Currently, we don't have event generator for collisions of polarized particles.
- Weighting procedures.
  - Approach 1: weight each track individually ($w = 1 + A_N(x_F)*\cos(\varphi)$) – will not take into account particle correlation in the event (**avoided previously**).
  - Approach 2: weight event (weight is given by a product of $(1 + A_N(x_F)*\cos(\varphi))$ for each track). Consistency check is required.
  - Weighting error is $\sigma^2 = (\text{sum } w)^2 / (\text{sum } w^2)$.
- Significant number of events is required. Toy MC of 500M events Is studied:
  - Pythia8 MB, $\sqrt{s} = 27$ GeV,
  - rough geometry, analytical track parameterization,
  - charged pion and proton tracks are weighted.

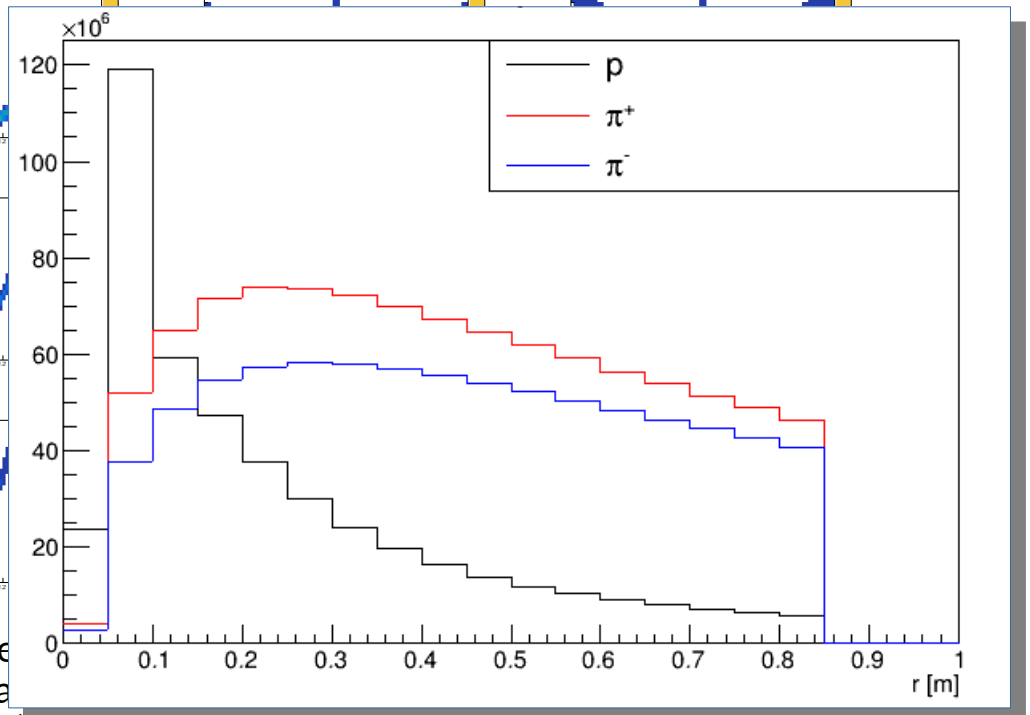
BBC kinematics in xF x pT in r bins



- r bin size here does not coincide with ring geometry
- only π^+ and π^- together are shown
- p_T (Y-axis) and x_F (X-axis) correlation changes with r

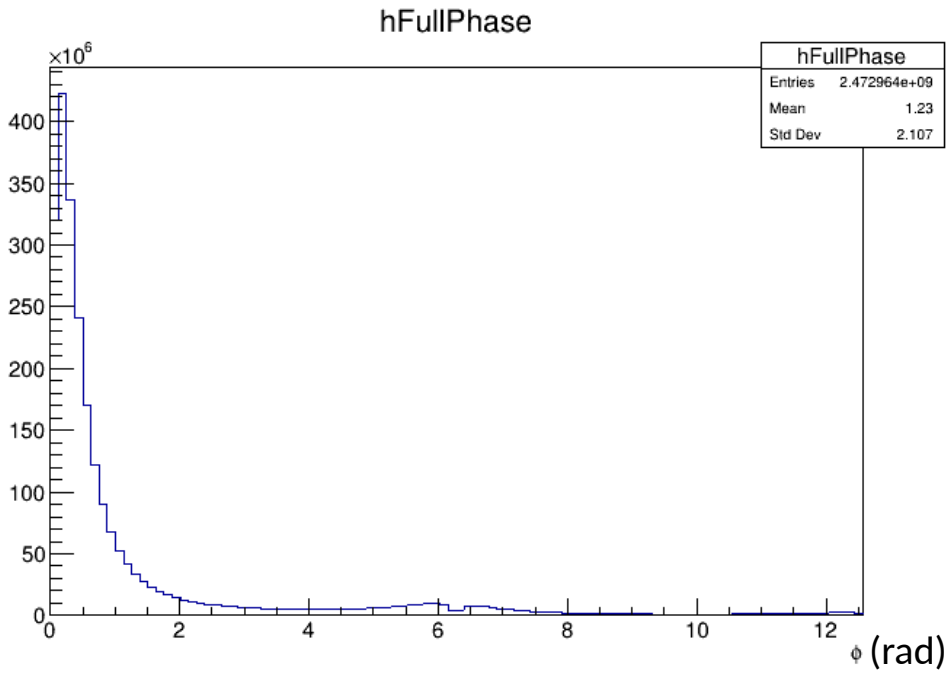
BBC kinematics in xF x pT in r bins

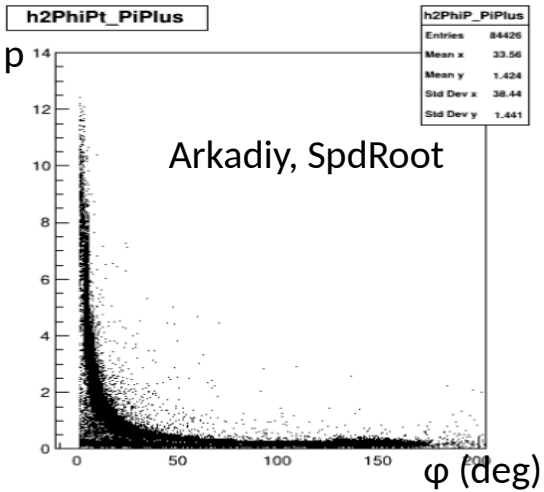


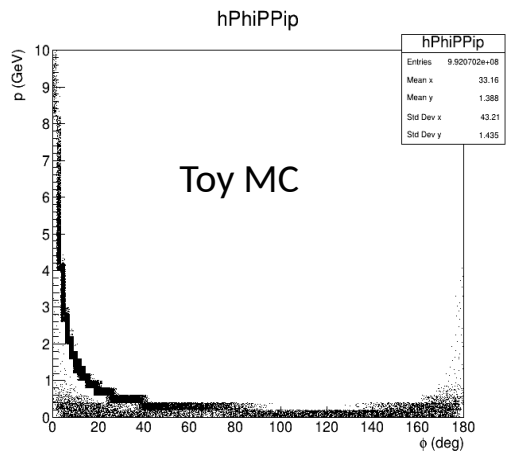


- only π^+ a
- p_T (Y-axis) and x_F (X-axis) correlation changes with r

Control plots

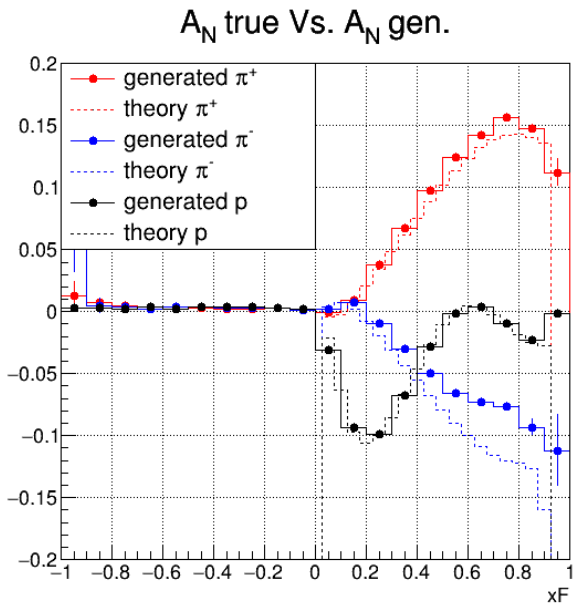


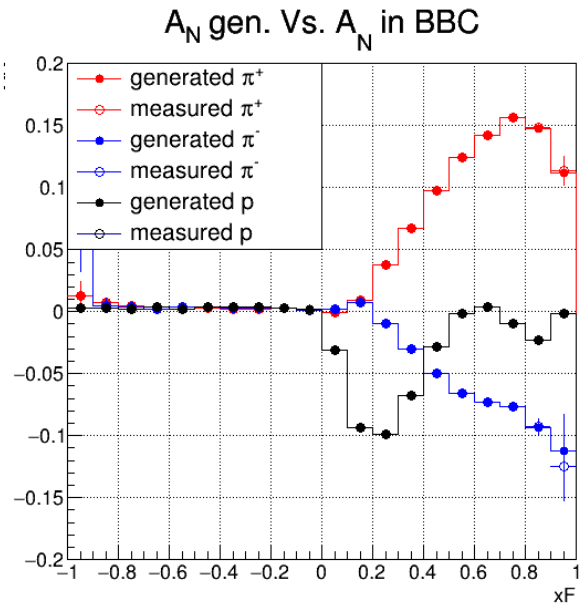


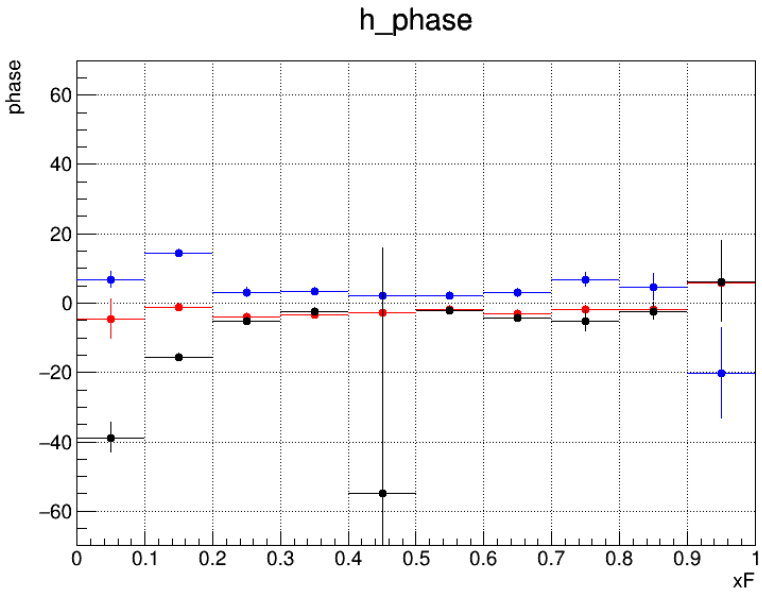


"Full" track rotation angle (rad, all charged particles) taken from helix parameterization (@27 GeV).

Event-wise weighting

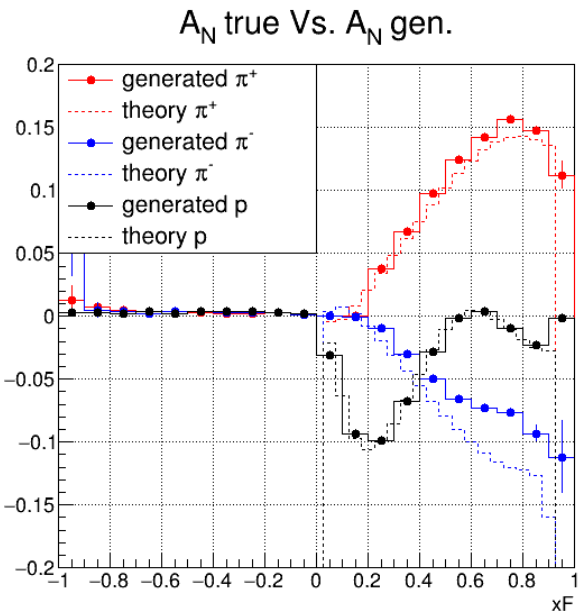


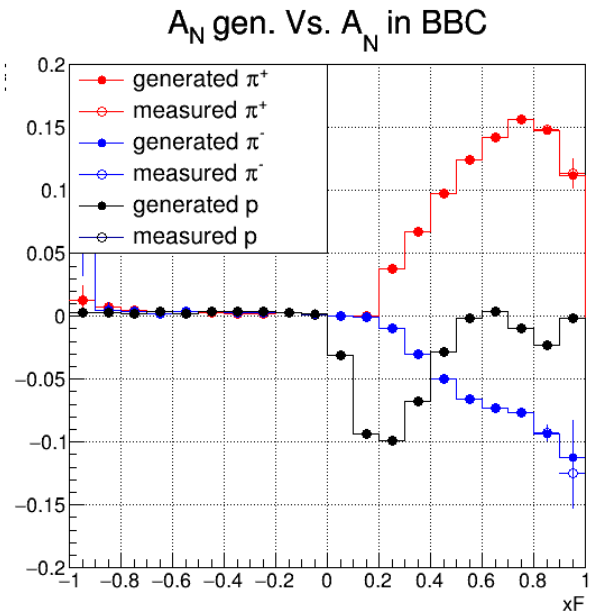


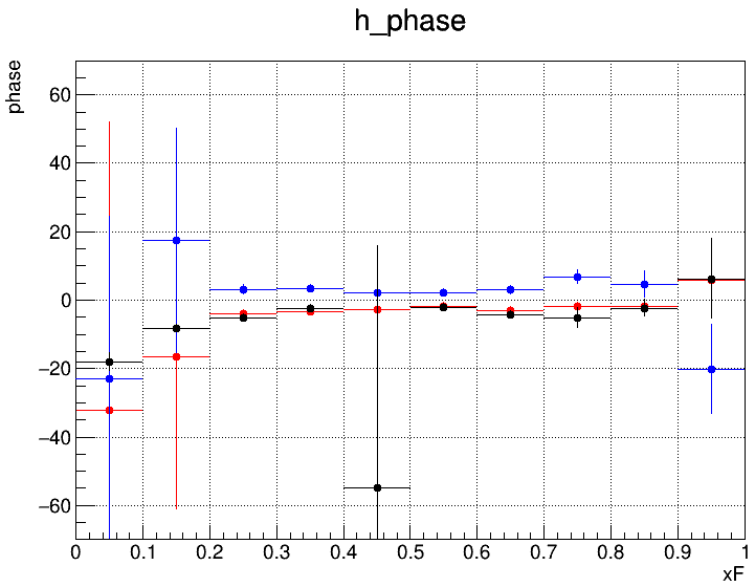


- Theory prediction are properly weighted in the acceptance region
- "Generated" asymmetry for π^- is **less than** the input one
- No visible difference between generated and asymmetry in BBC except for phase
- Strange phase behavior in the first xF bin (weighting artifact)

Event-wise weighting (flattened asymmetry in the first two xF bins)

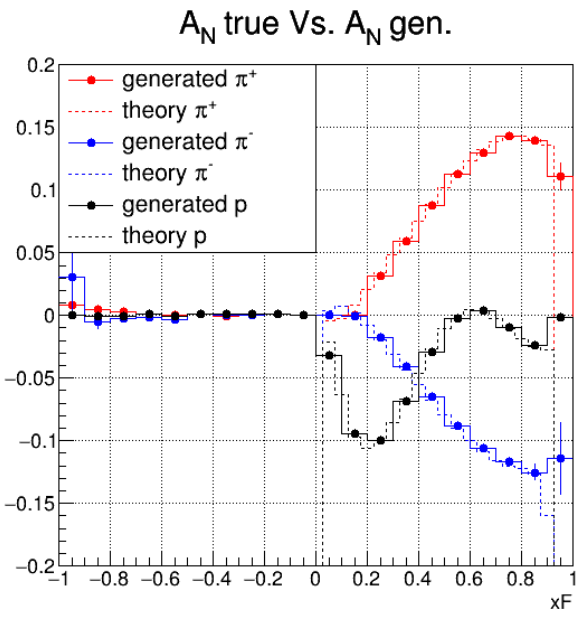


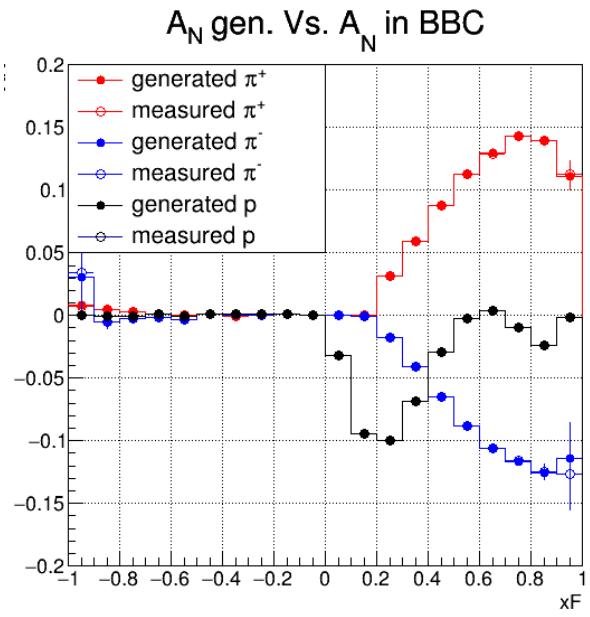


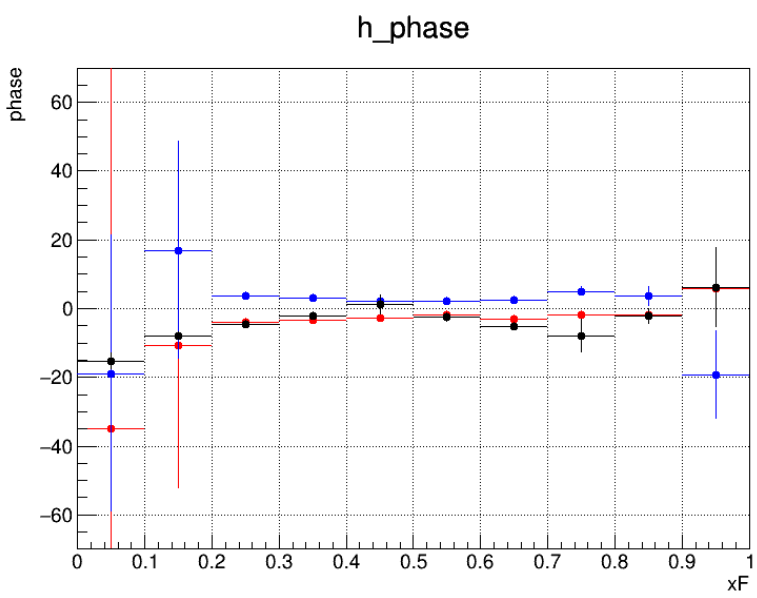


- Theory prediction are properly weighted in the acceptance region
- No asymmetry for pions for 0 < xF < 0.2 (**to be used later)**
- “Generated” asymmetry for π^- is **less than** the input one
- No visible difference between generated and asymmetry in BBC except for phase

Track-wise weighting (flattened asymmetry in the first two xF bins)

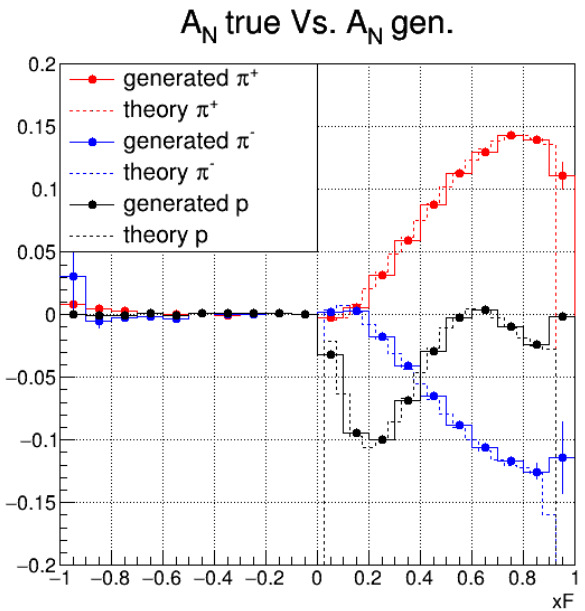


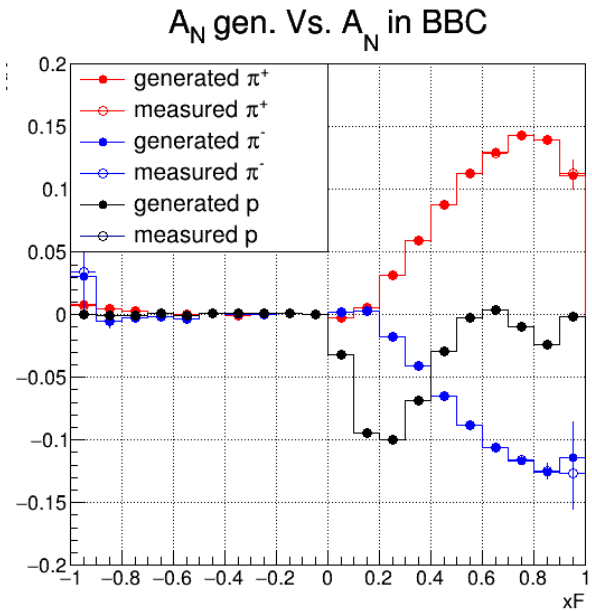


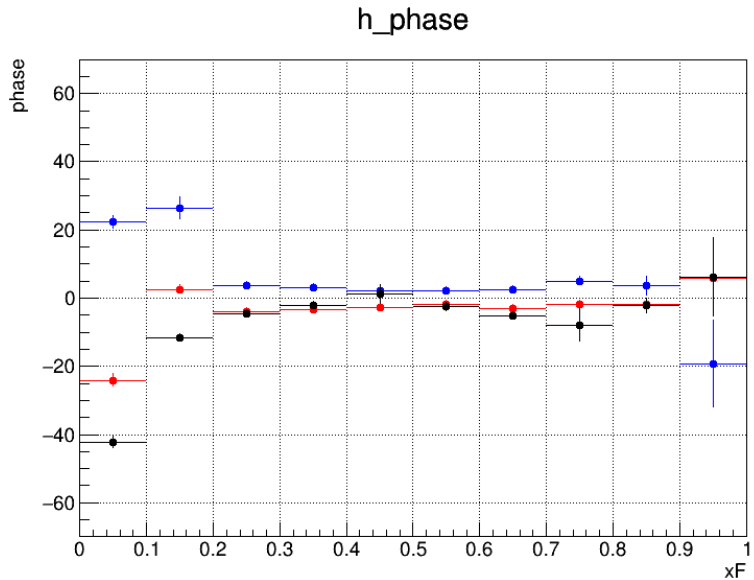


- Theory prediction are properly weighted in the acceptance region
- No asymmetry for pions for 0 < xF < 0.2 (**to be used later)**
- “Generated” asymmetry for π^- is **consistent** with the input one
- No visible difference between generated and asymmetry in BBC except for phase
- No notable difference with event-wise weighting

Track-wise weighting (flattened asymmetry in the first two xF bins)

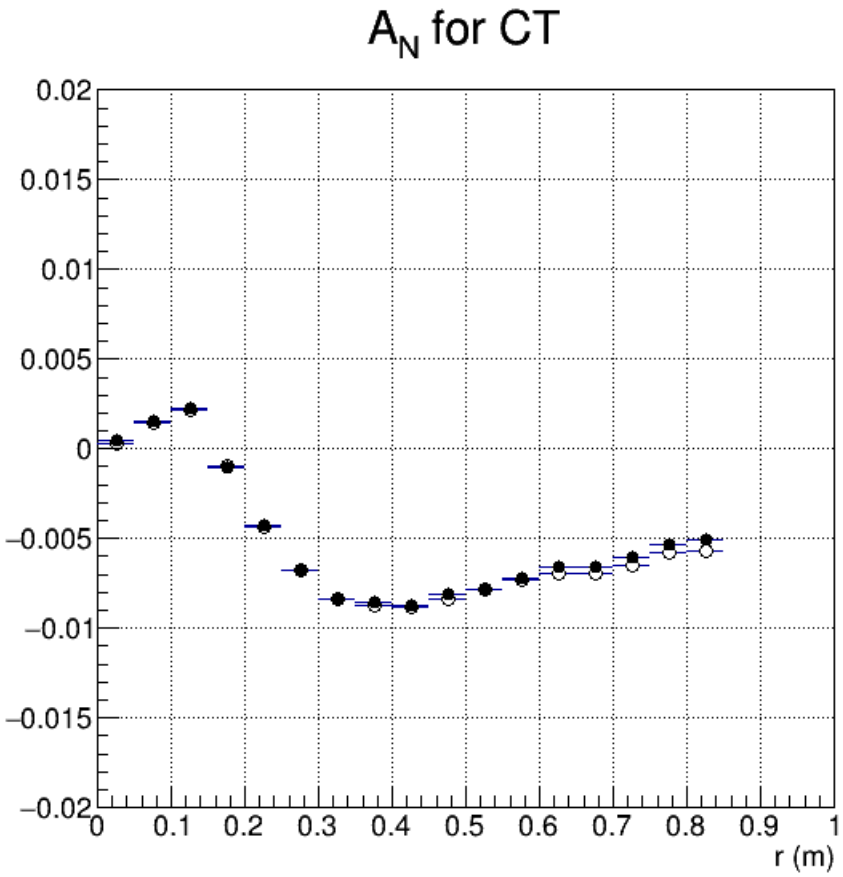


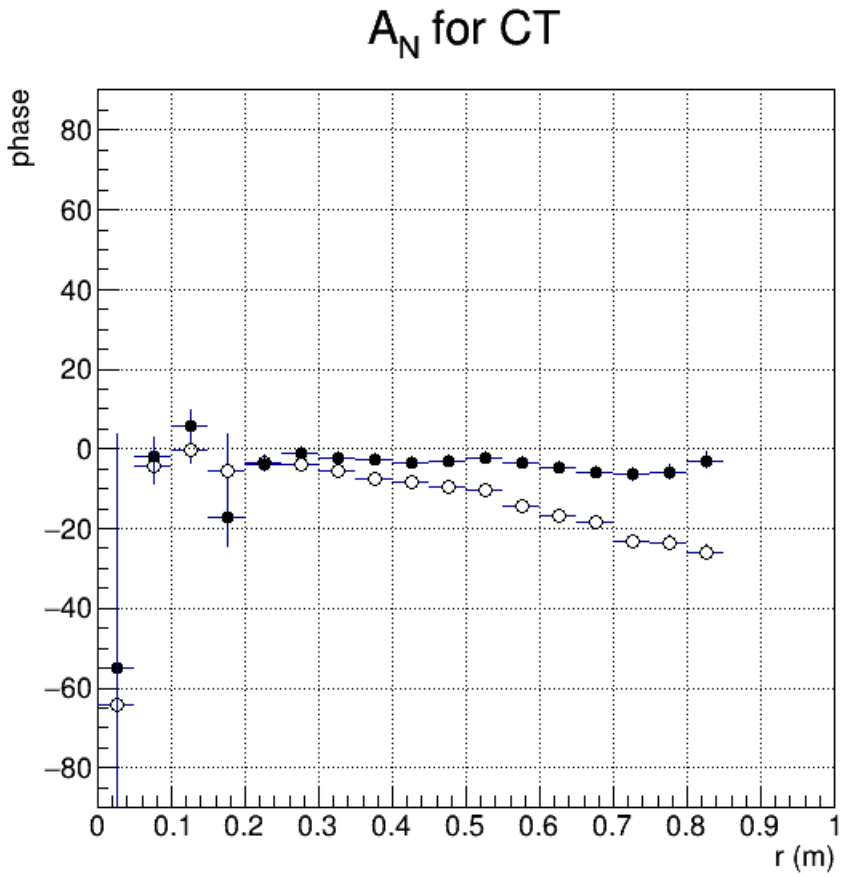




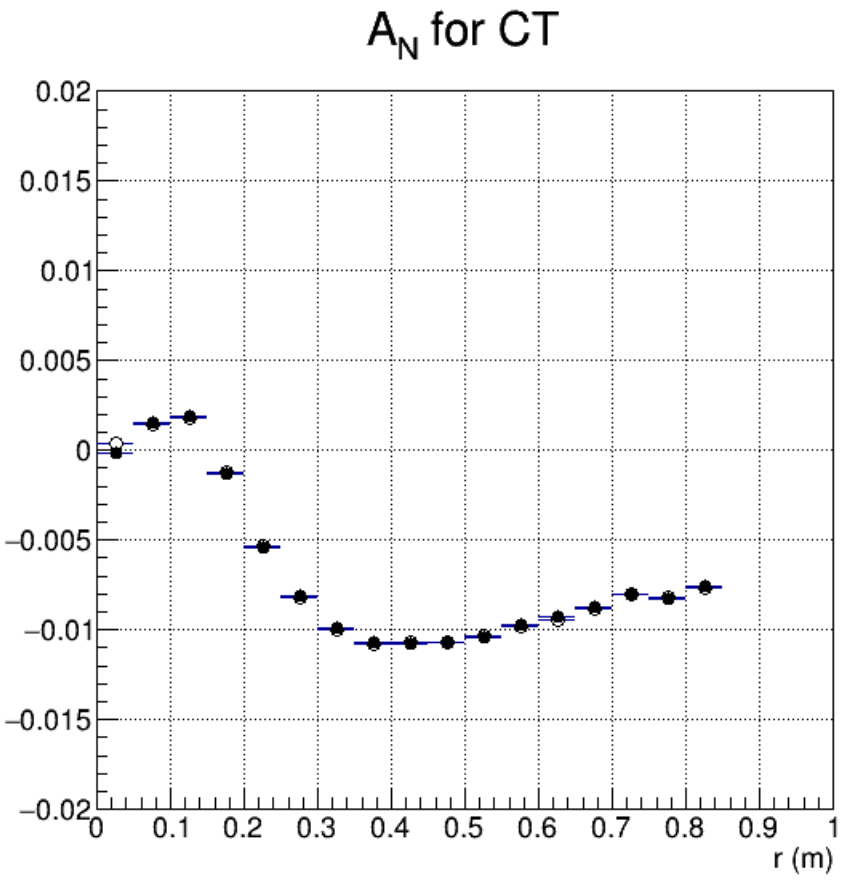
- Theory prediction are properly weighted in the acceptance region
- "Generated" asymmetry for π^- is **consistent** with the input one
- No visible difference between generated and asymmetry in BBC except for phase
- No notable difference with event-wise weighting except for the phase in the first two bins

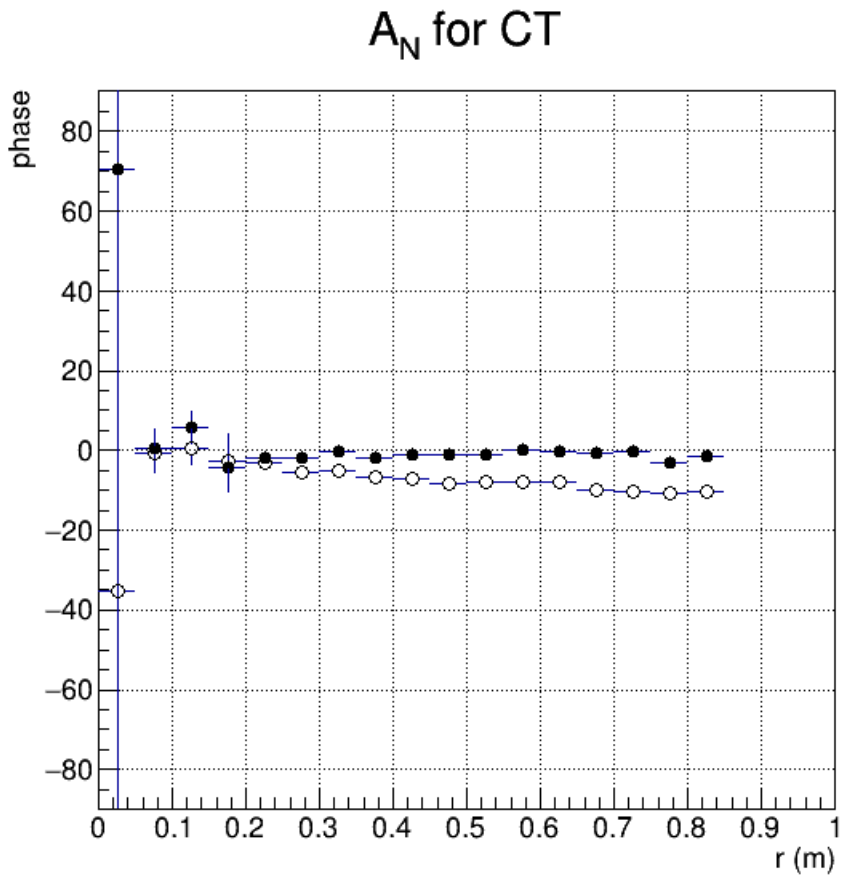
Event-wise weighting



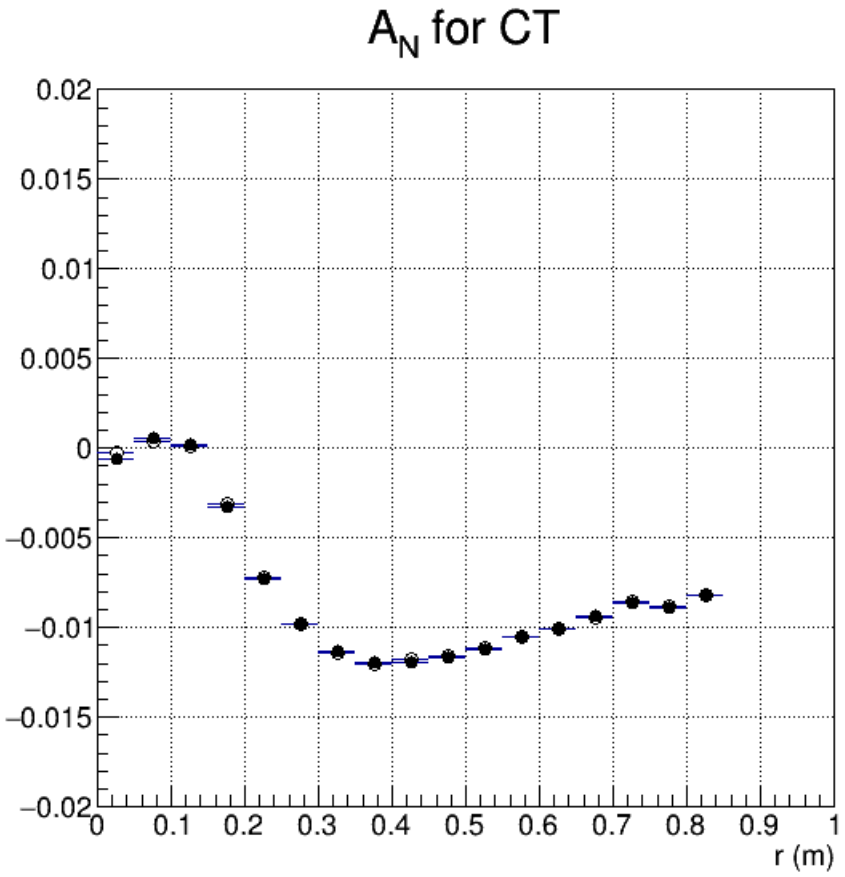


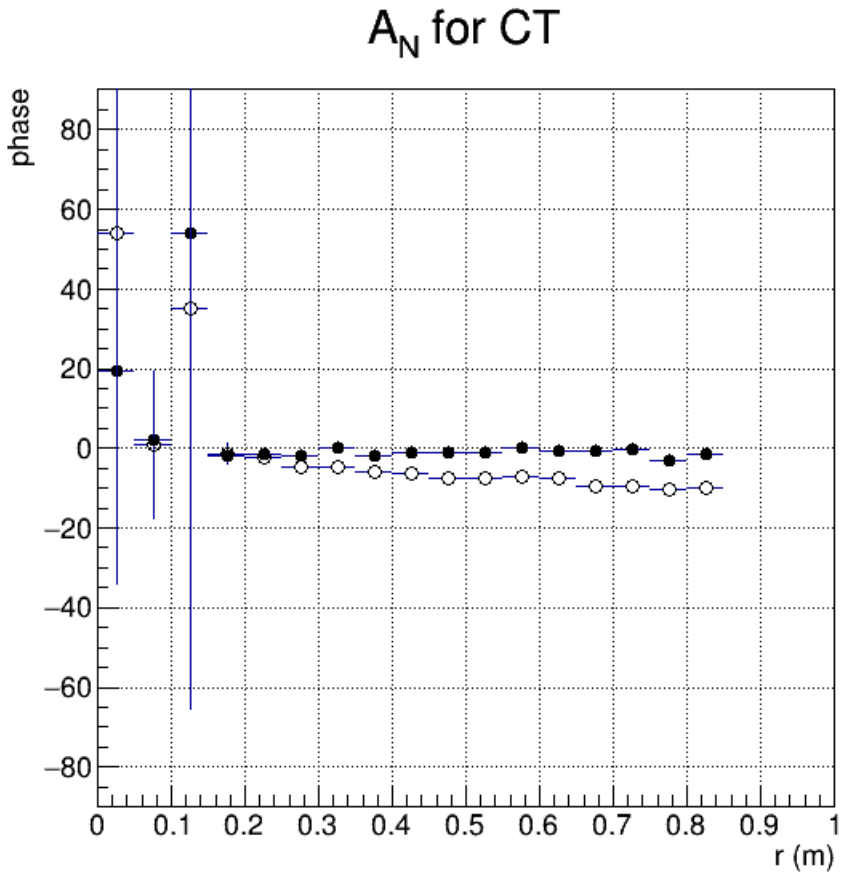
Event-wise weighting (flattened asymmetry in the first two xF bins)



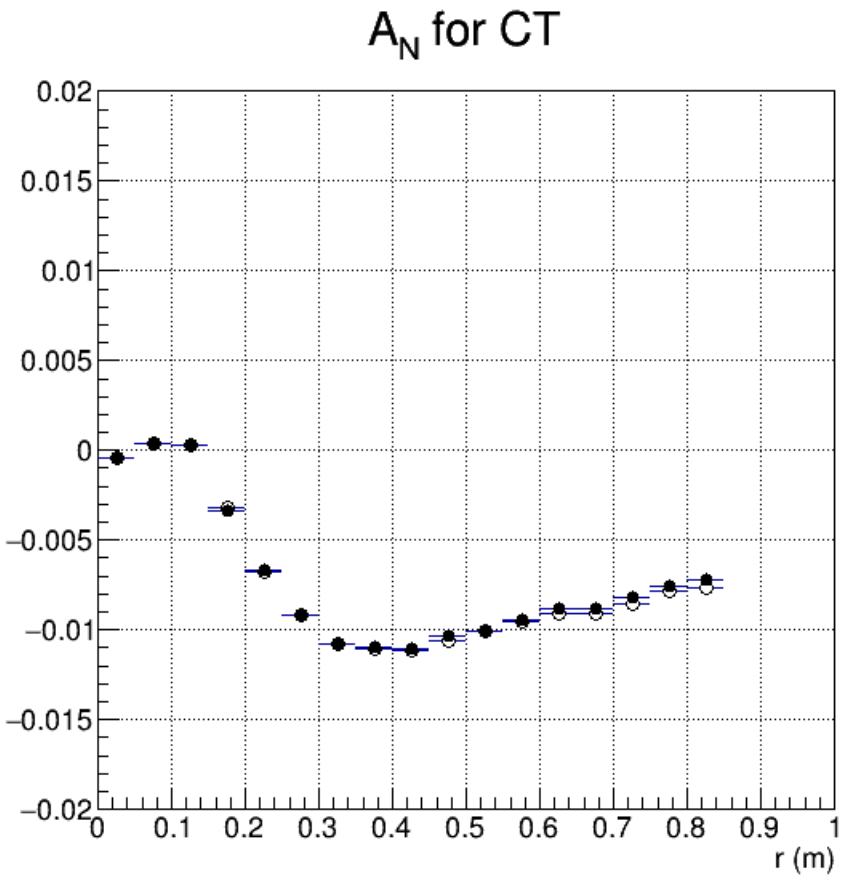


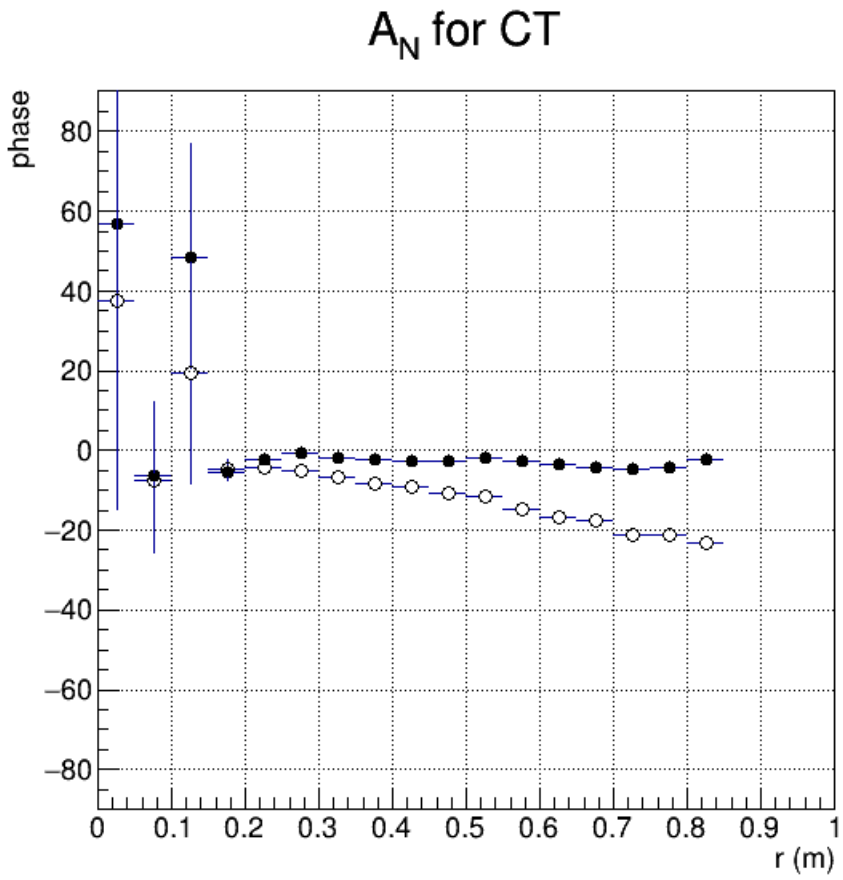
Track-wise weighting (flattened asymmetry in the first two xF bins)





Track-wise weighting





Summary

- Event-wise weighting results in small artifacts and small xF and individual asymmetries. If pion asymmetry is removed for low xF no notable differences are seen compared to track-wise weighting. **Track-wise weighting seem to be preferable.**
- Given CPQ model predictions a total asymmetry of the order of **1 percen**t is expected. The visible asymmetry and phase (up to 20 deg.) in BBC **depend on radius of the BBC ring** and **model prediction (especially at low xF)**.
- There is also an estimate for total asymmetry: ~0.7, $\Delta\varphi$~5 deg. **This is to be checked**.
- We can make a rough estimation for the time required to measure the beam asymmetry with given precision.
- The calculations can be cross checked with SpdRoot simulations once production data are available via track-wise weighting.
- Lower collision energies should be studied.
- Analysis of **elastic pp scattering in BBC** is of particular interest as the phase shift should be negligible.