# On BBC simulation in magnetic field

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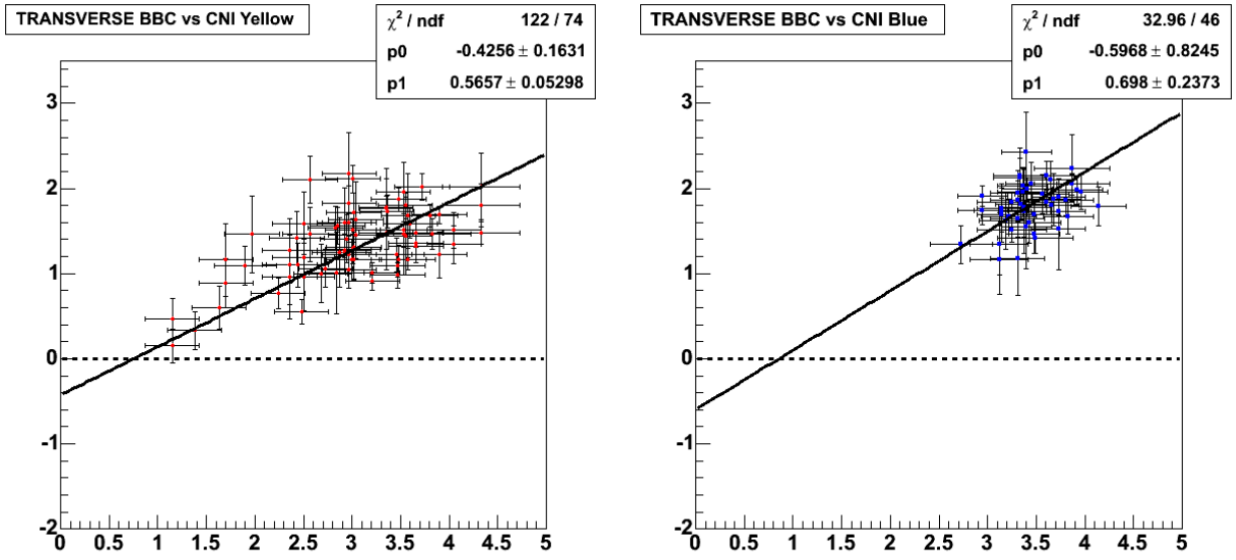
# Motivation



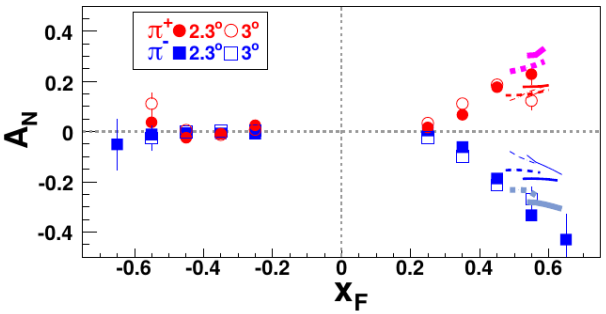

(a) (b)

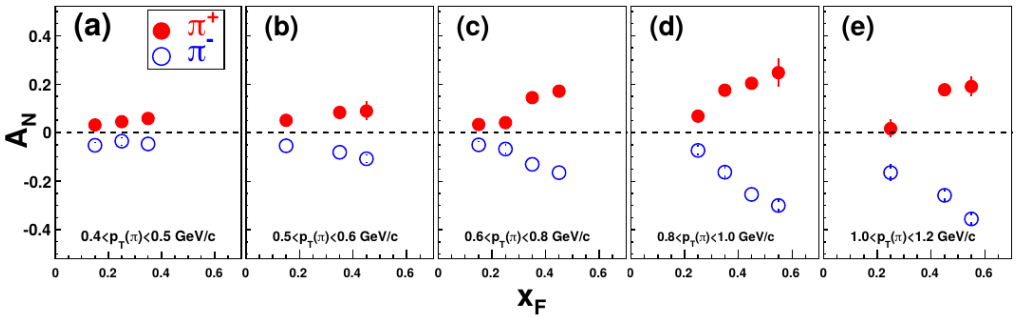
Figure 5.1: Correlation of the beam asymmetries measured by the RHIC *pC* CNI polarimeter [429, 430] and left (a) and right (b) STAR BBCs (in arbitrary units).

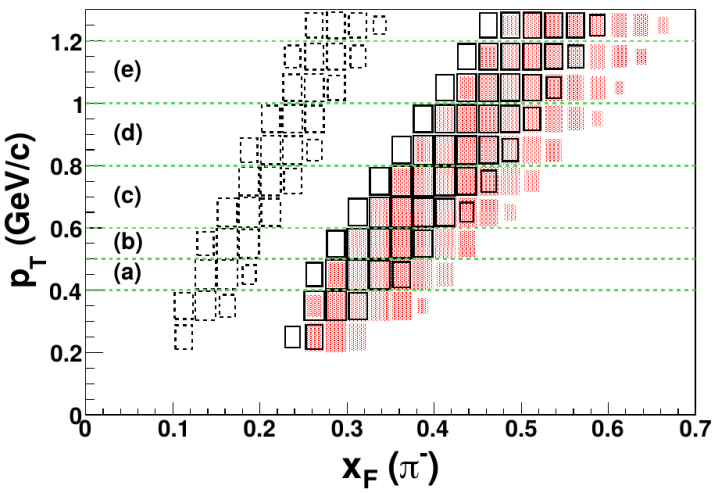
Figure from SPD CDR

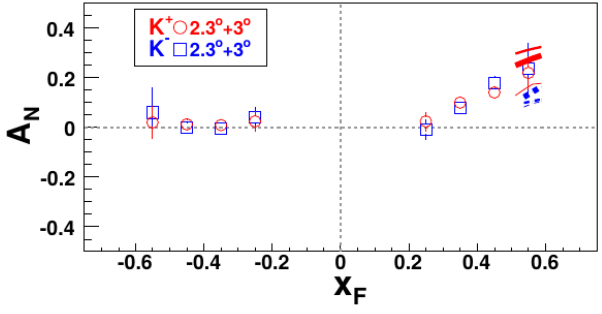
Observed effective analyzing power at RHIC at BBC is ~ 0.7%.

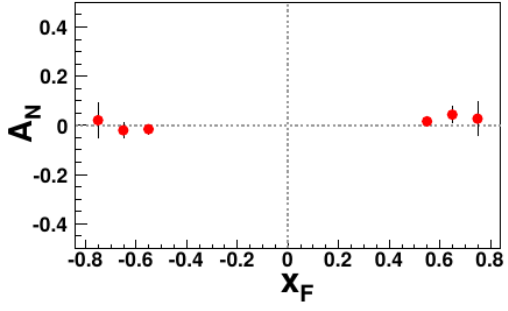
# BRAHMS (polarized pp, √s=62.4 GeV)




$A_N = A_N(x_F, p_T)$

$A_N$~0 for $x_F < 0.2$? To what precision?

# Other measurements

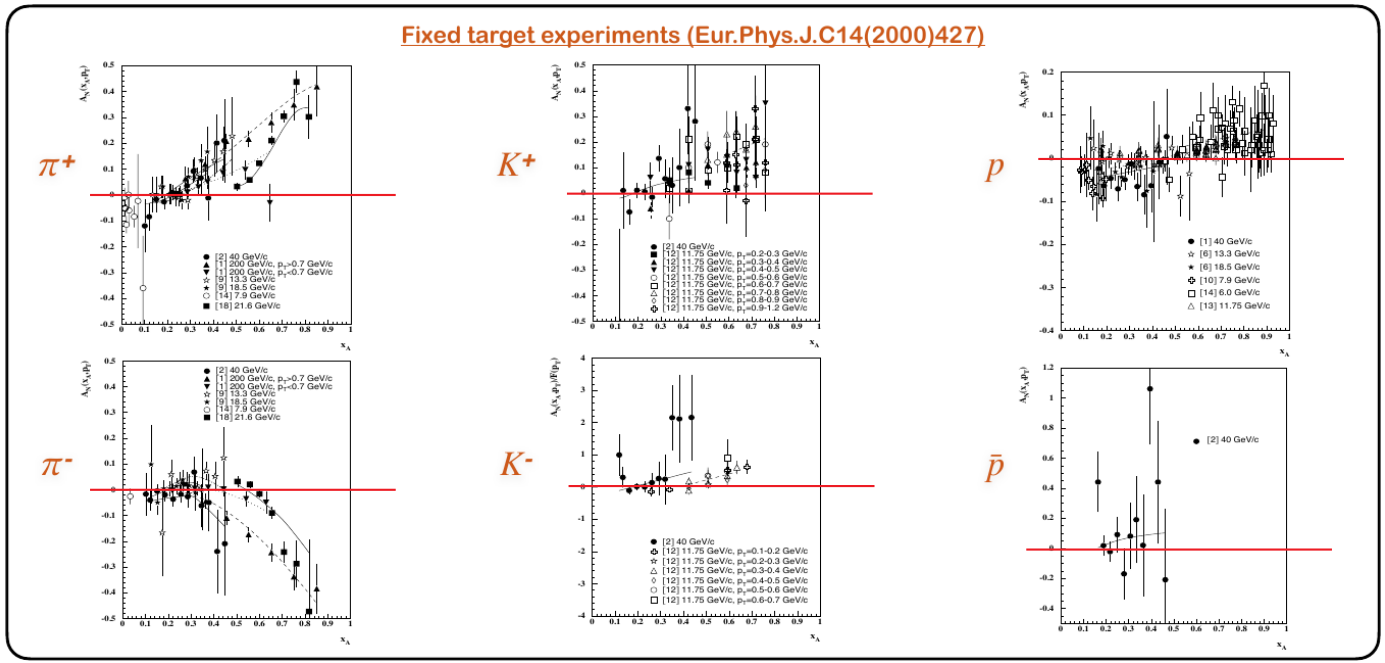
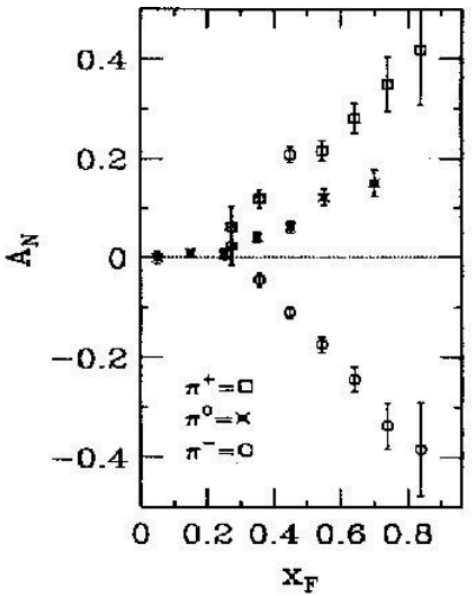



Figure from the talk by A. Korzenev




Phys. Lett., B261:201–206, 1991

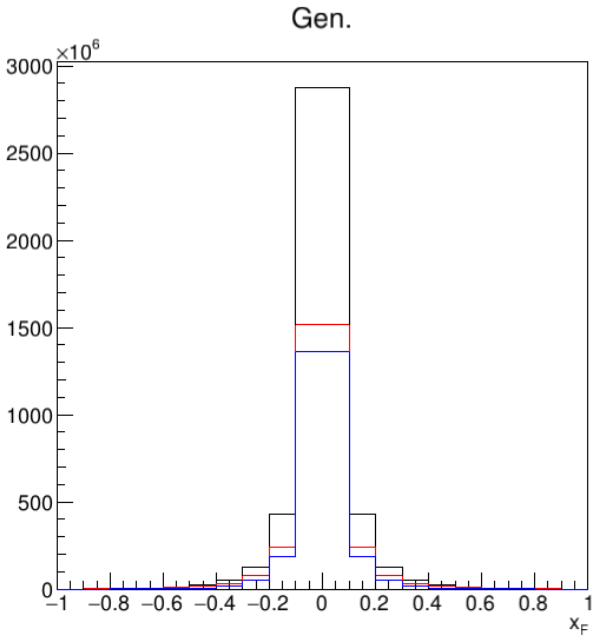
# Simulation method

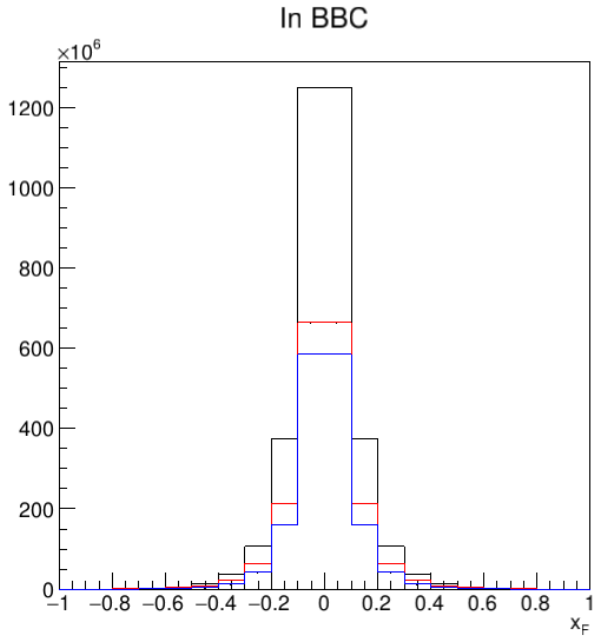
- We can expect magnetic field to smear polarization effect for BBC.
- For the time of study **we don't have event generator for collisions of polarized particles**.
- Weighting procedure:
  - weight for event = a product of $(1 + A_N(x_F)*\cos(\varphi))$ for each track;
  - weighting error in bins is $\sigma^2 = (\text{sum } w)^2 / (\text{sum } w^2)$ in each bin.
- Both **asymmetry value and phase** changes are important
- Here is **generator-level** studies are presented (require large statistics).

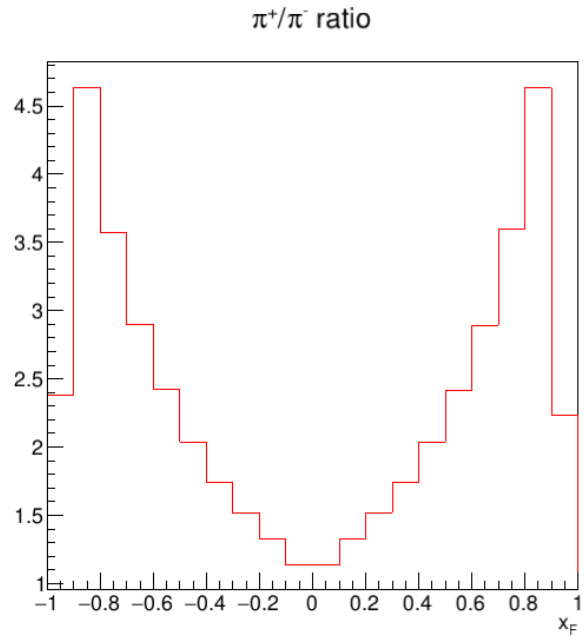
# Simulation details

- Pythia8 MB, $\sqrt{s} = 27$ GeV.
- Constant magnetic field of 1T, all tracks are analytically parameterized as helices.
- 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 $r\_min < r < r\_max$, rotation phase is determined.
- Two-dimensional histograms $x_F$ x $\varphi$ 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 $\varphi$ distribution is fitted in each $x_F$ bin.

# $x_F$ distribution and $\pi^+/\pi^-$ fraction



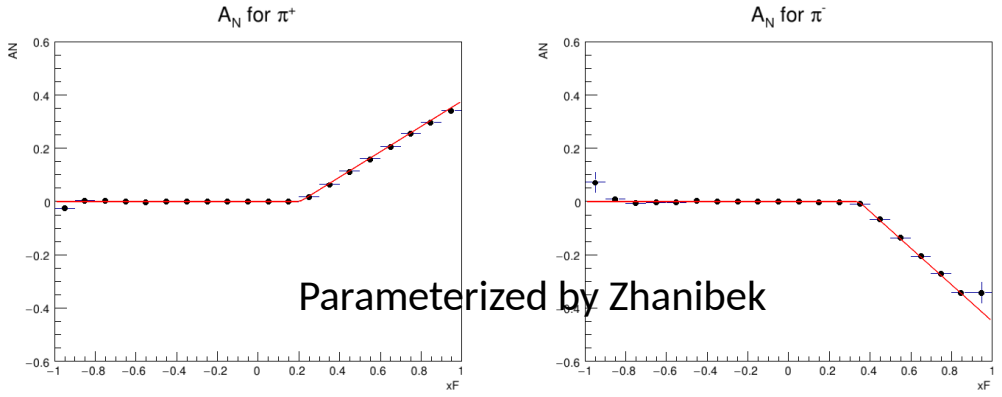



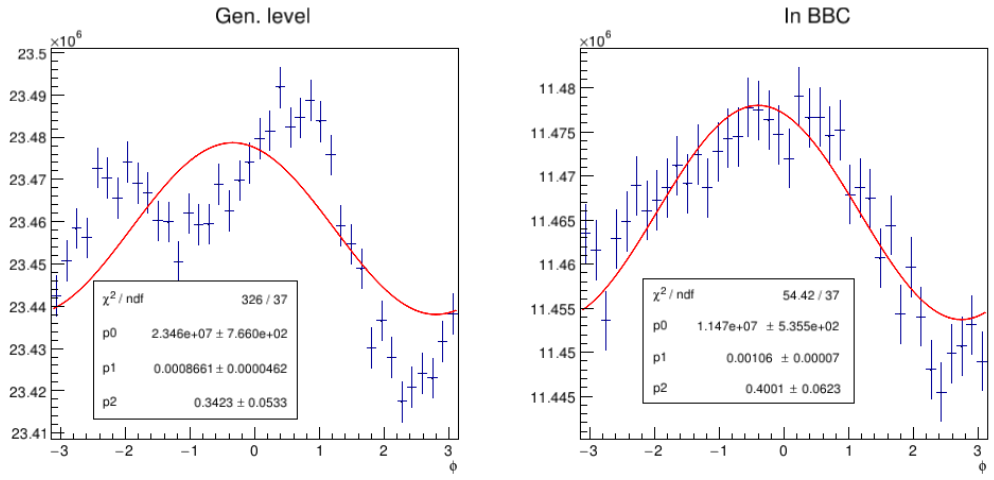

Central bins can be extremely important

# Simulation results

- The method gives pion asymmetries consistent with weighting function
- The model above gives weighting artifacts **~0.1%**, but not a **total asymmetry of ~1%.**
- We can't expect that the asymmetry seen at RHIC is caused mostly by charged pion asymmetry from xF>0.2 only.
- Current knowledge seems **too scarce** to make efforts to reproduce data with 1% total asymmetry (cocktail of pions, kaons, and protons with not well-measured asymmetries)
- Let's consider different xF values separately.



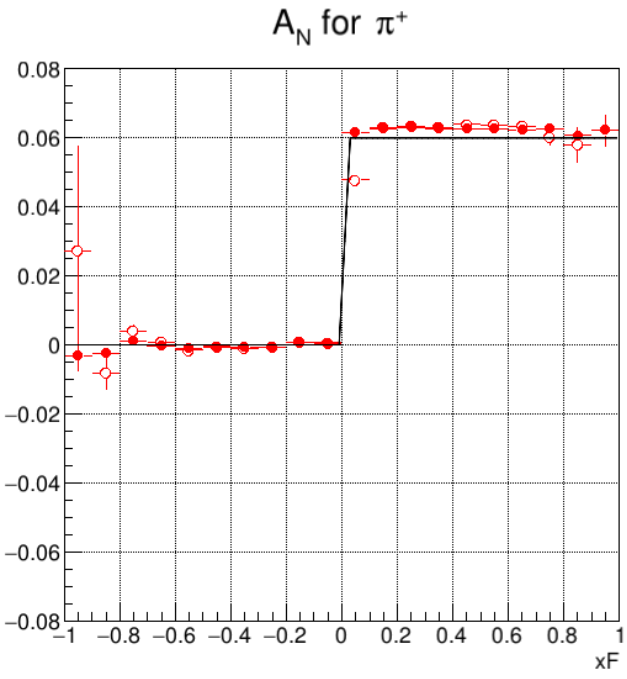

Parameterized by Zhanibek

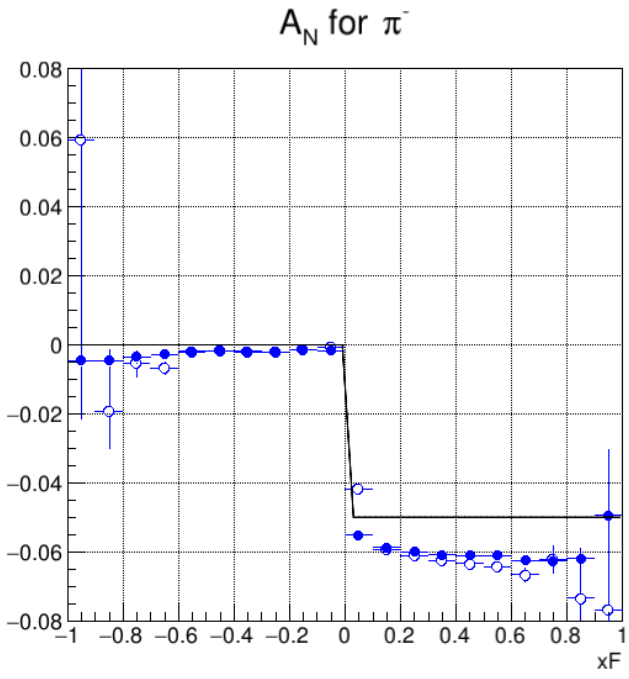


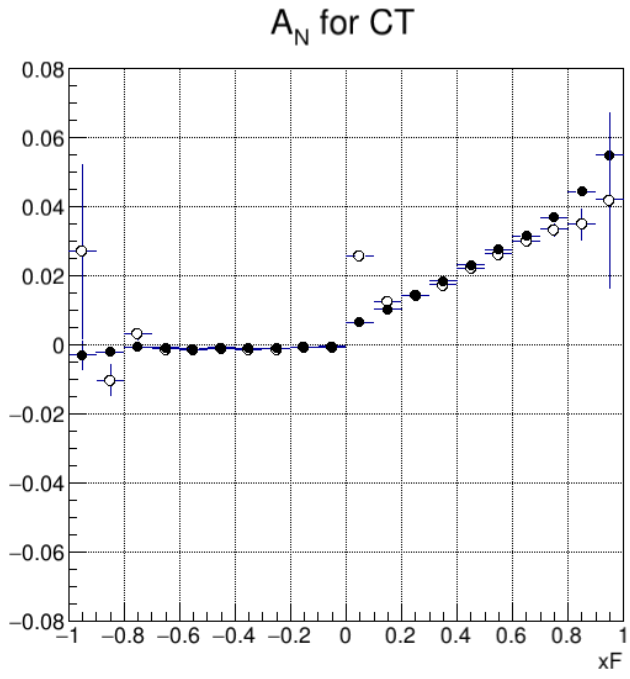
# Study update

- As the next model I considered **only pions** (CT below stands for all charged pions) from MB events and used **step-function** to weight $\pi^+$ and $\pi^-$ (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
- **New**: phase, kinematic constrains from radius in BBC

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

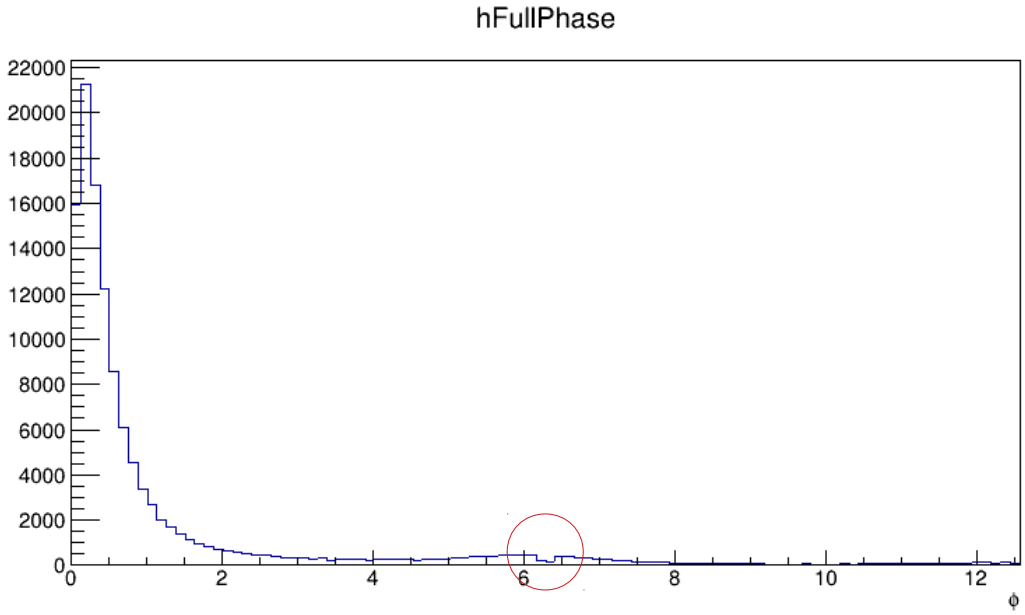


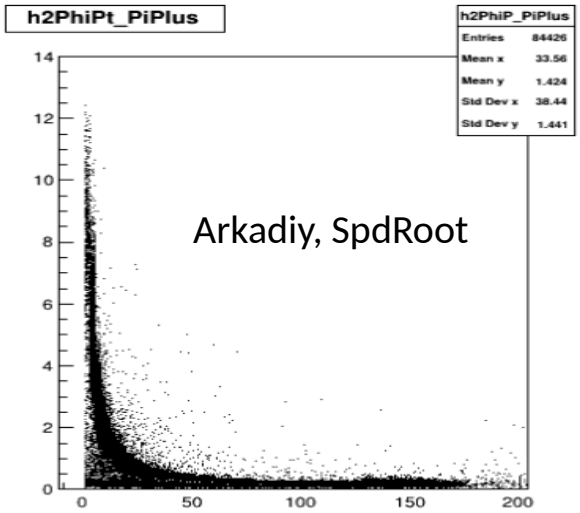



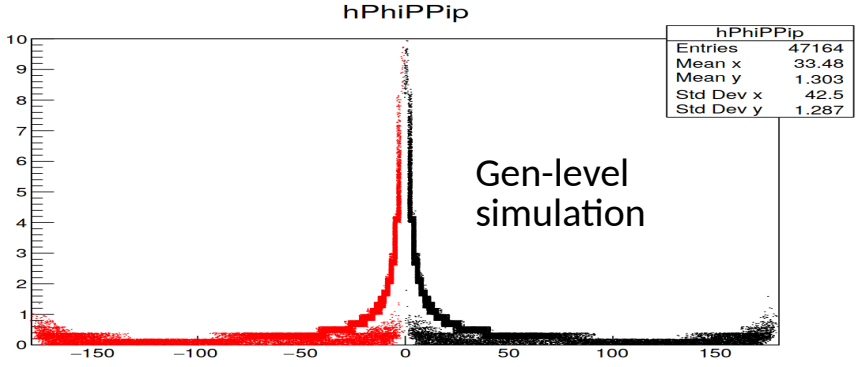




- Small correlation between $\pi^+$ and $\pi^-$ is notable
- Visible asymmetry in $0 < x_F < 0.1$ is reduced by ~ 20% for π+ and π- separately
- Visible asymmetry for CT in the same bin is larger than initial (see one of my previous talks)

# Phase

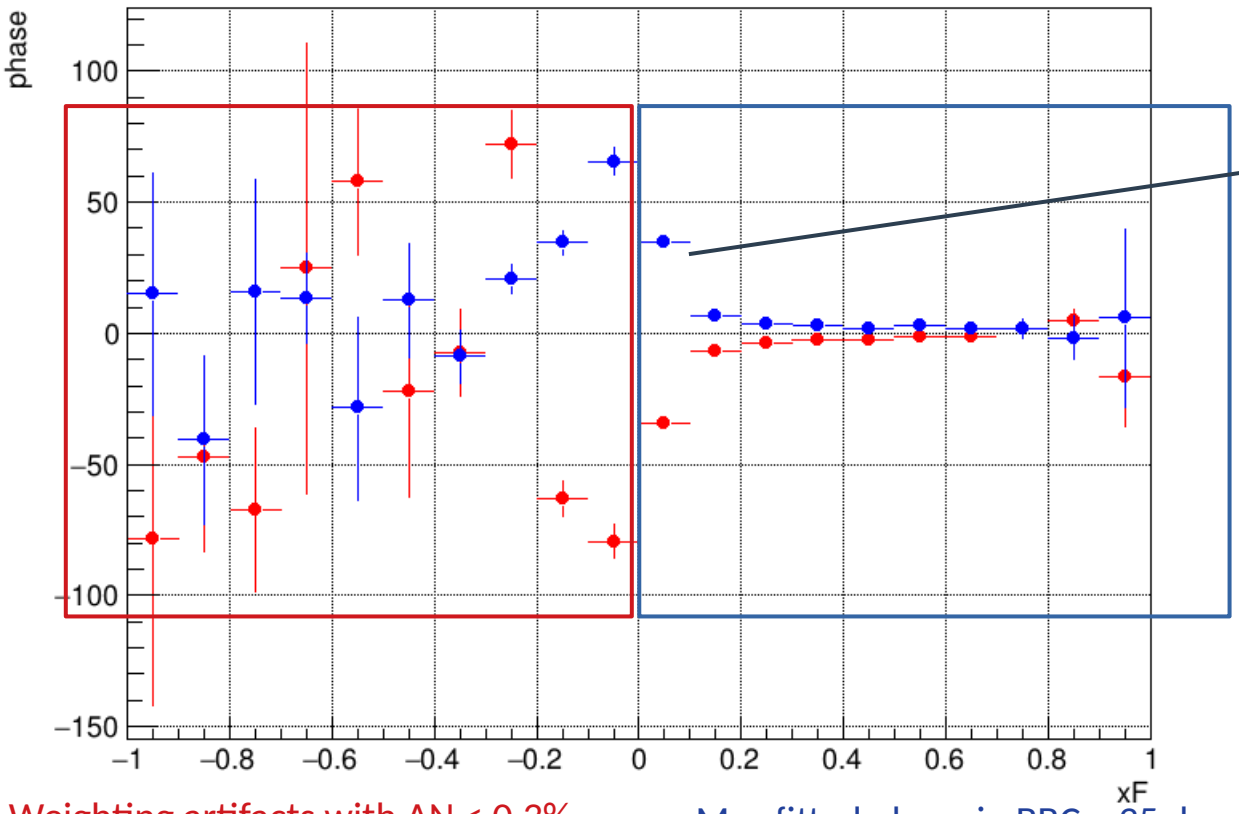



- “Full” track rotation angle (rad, all charged particles) taken from helix parameterization (@27 GeV).
- Track rotation angle depends on $p_T$ and $p_L$ (xF)

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

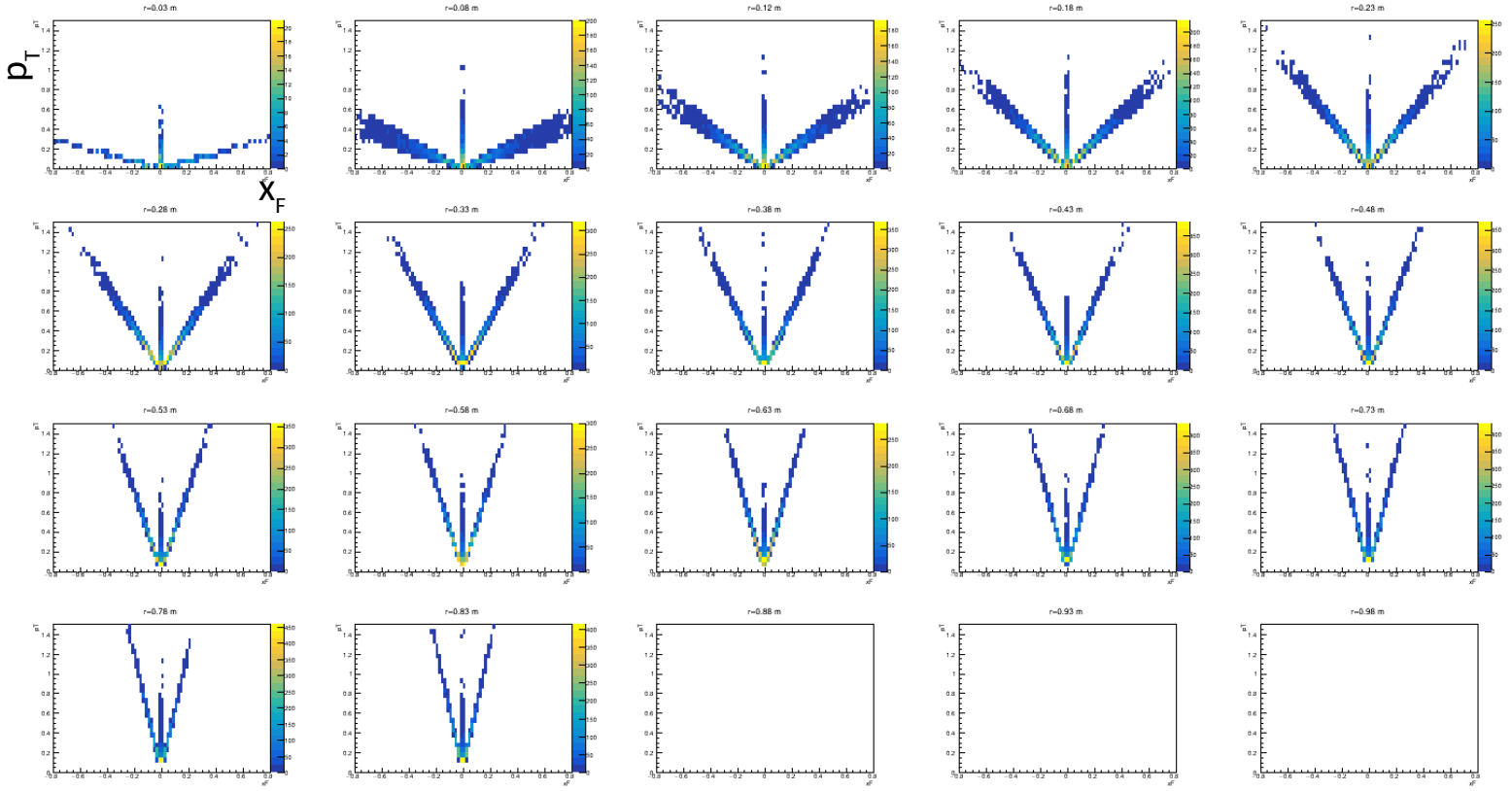



Impact on determination of reaction plane ?

Weighting artifacts with AN < 0.3%

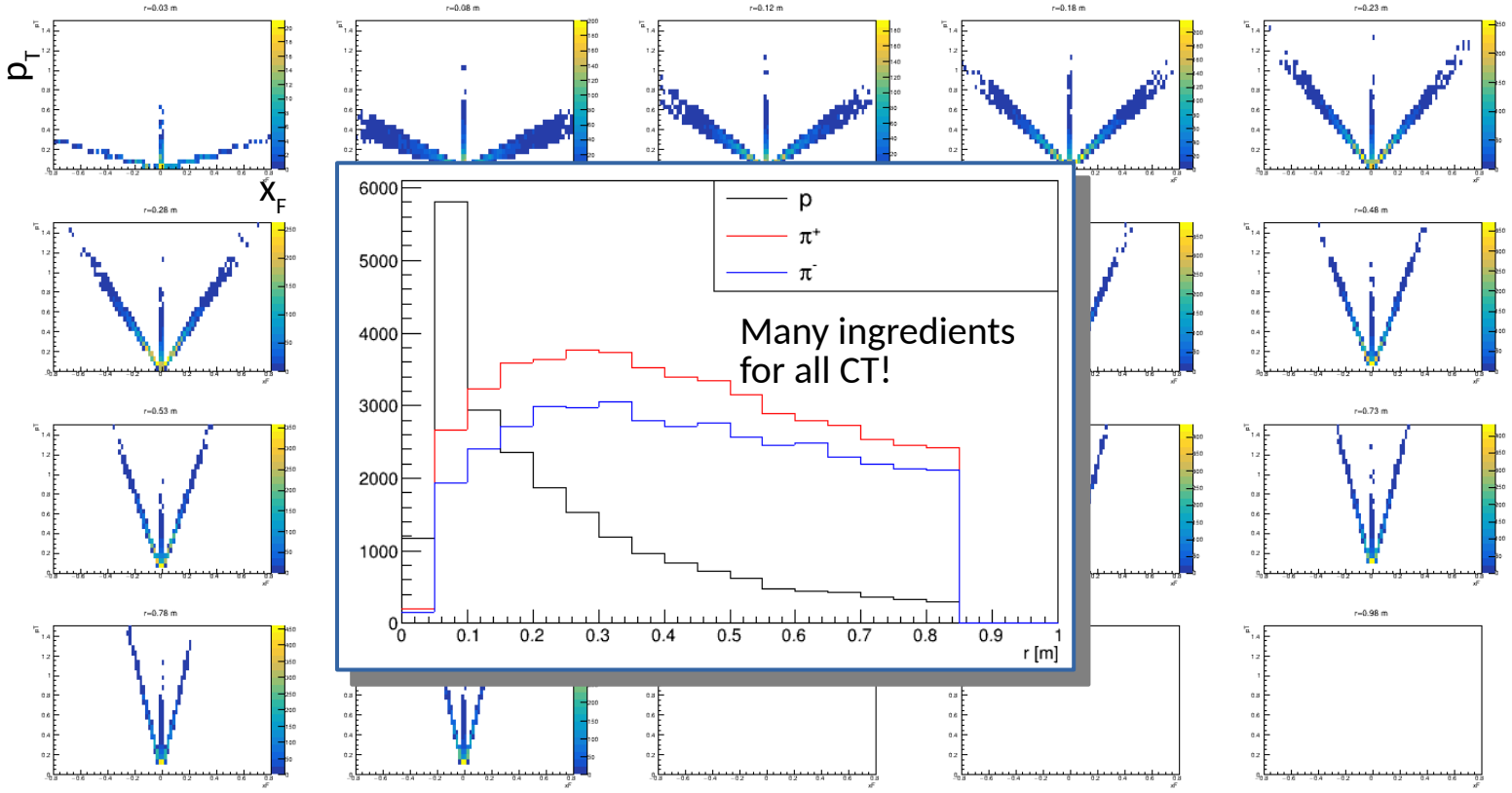
Max fitted phase in BBC ~ 35 deg for 0 < xF < 0.1, small for the other bins

# $x_F$ Vs. $p_T$ correlation in $r_{BBC}$ bins




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

# $x_F$ Vs. $p_T$ correlation in $r_{BBC}$ bins




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

# Summary

- Total analyzing power of ~1% can not be explained by nonzero charged pion asymmetry for $x_F > 0.2$ only.
- For the analyzing power there are effects in the magnetic field that decrease and increase it's value.
- If events at small $0 < x_F < 0.2$ notably contribute to asymmetry, a phase shift can be expected. Due to different $x_F$ and $p_T$ correlations the phase may depend on the ring number.
- Magnetic field should affect reconstruction of reaction plane in ion collisions.
- What about lower energies?
- Effect of the vertex smearing has been ignored so far.
- We don't have a good understanding to get quantitative results. Elaborate model calculations by V. Abramov (presented by Arkadiy in the absence of magnetic field)?