Update on BBC simulation in magnetic field

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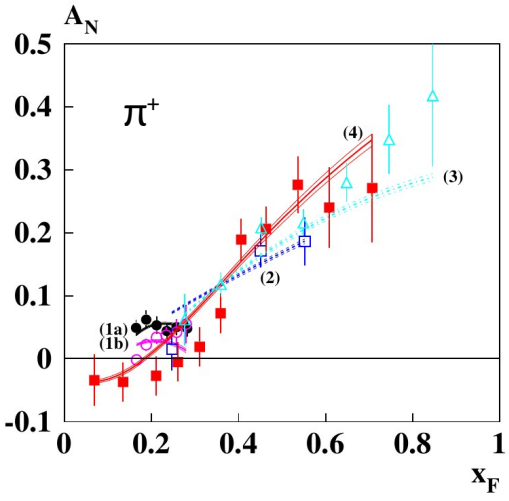
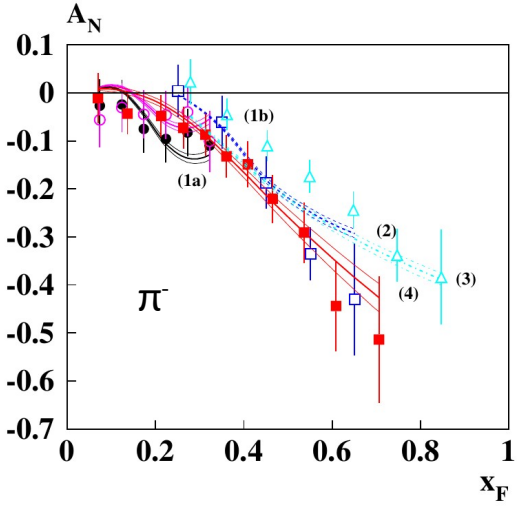
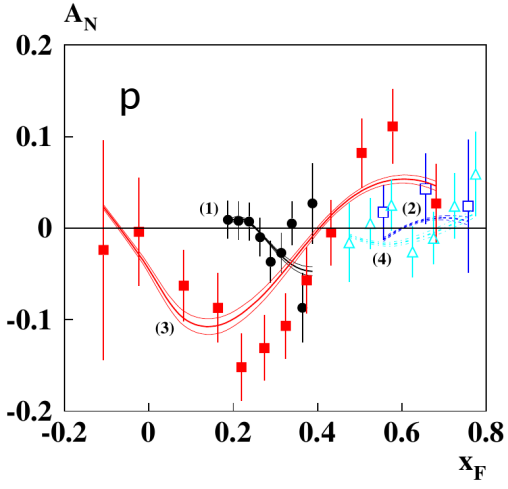
Model for weighting

According to measurements, A_N depends on **both p_T** and **x_F**. It's not possible to get definite parametrization from data. Consequently, the **chromomagnetic polarization of quarks (CPQ)** model calculations by V. Abramov are used (J.Phys.Conf.Ser. 678 (2016) 1, 012039)

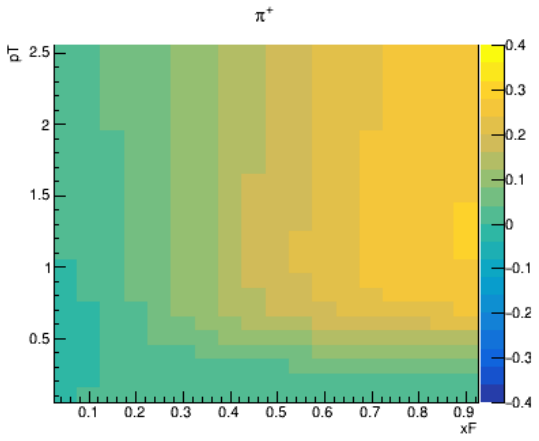


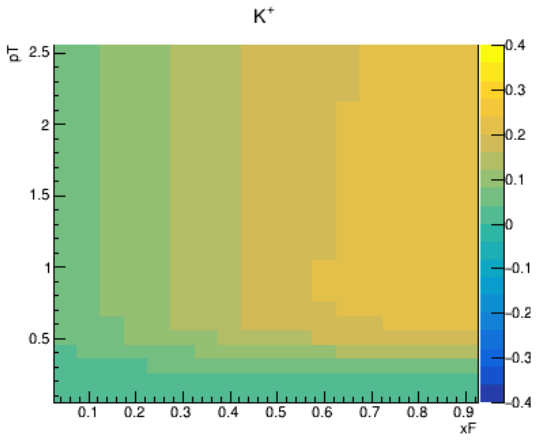


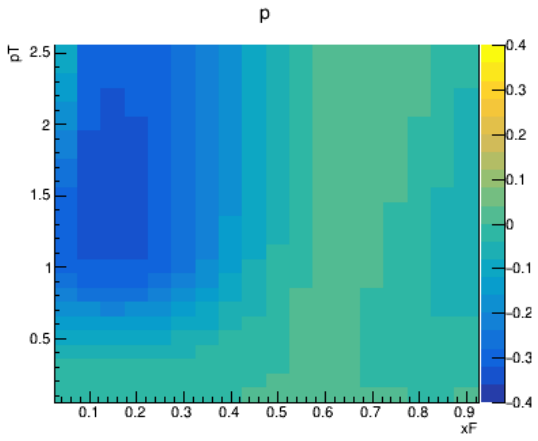


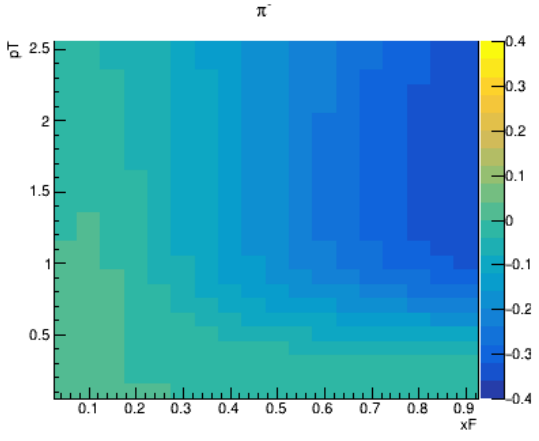
1. BRAHMS (200 GeV)
2. BRAHMS (64 GeV)
3. E704 (19.4 GeV)
4. FODS (8.77 GeV)

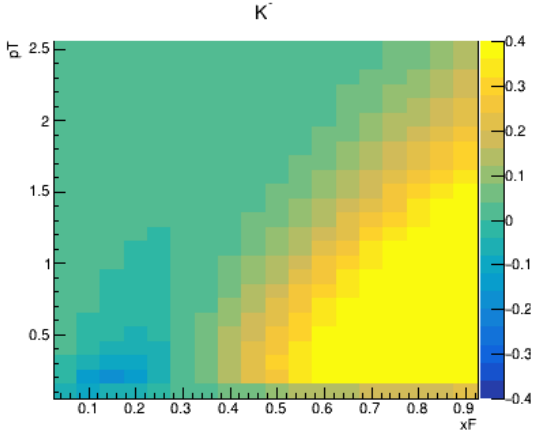
CPQ model prediction grid (√s=27 GeV)











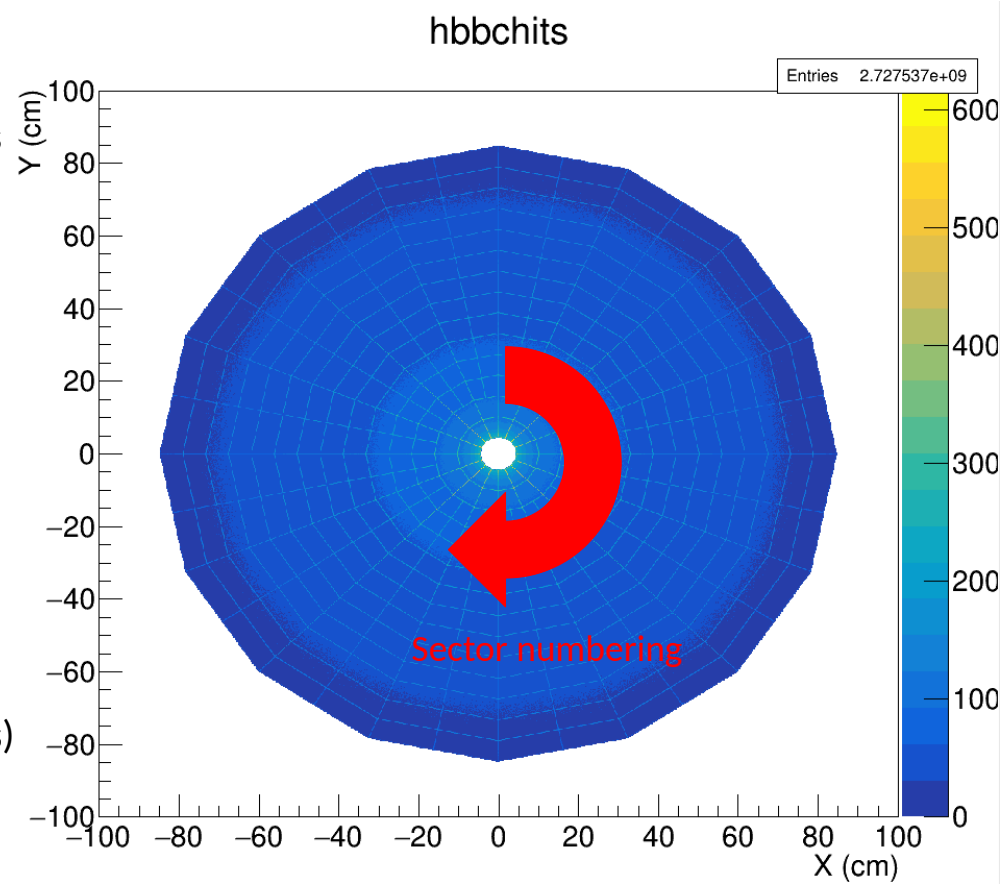
Thanks to Victor Abramov!

Overview

- We can expect magnetic field to **smear polarization effect for BBC or introduce phase bias**. We are interested in "visible A_N" in each BBC ring (each ring has different xF Vs. pT acceptance and momenta spectra and composition of charged particles).
- Currently, we don't have event generator for collisions of polarized particles, so the weighting procedure is used (requires a significant number of events for stable results).
  - *Track weighting*: weight each track individually ($w = 1 + A_N(x_F, p_T)*\cos(\varphi)$).
  - *Event weighting*: weight event (weight is given by a product of $(1 + A_N(x_F, p_T)*\cos(\varphi))$ for each track). It produces artifacts at low x_F.
- **Toy study**: 500M Pythia8 MB @27 GeV, analytical track parametrization, charged pion and proton tracks are weighted (my talk P&MC, 17.04.24)
- **First SpdRoot study:** P&MC 18.06.25
- **This talk**: the updated in SpdRoot simulation (dev, 4.1.7.5).

Simulation details

- **Production data**: PROD2025-020, 27 GeV, 40M events simulated and reconstructed with SpdRoot 4.1.7.4 development version.
- "Track weighting method" is used, secondaries are weighted based on the G1 particle
- Found simulation/reconstruction issues:
  - sometimes particle produces more than 1 BBC hit: allow one hit from one originating from one G1 particle per BBC tile; cases when two G1 particles cause hits in one tile are rare
  - possible slight displacement of tiles (see next slides) – to be studied.



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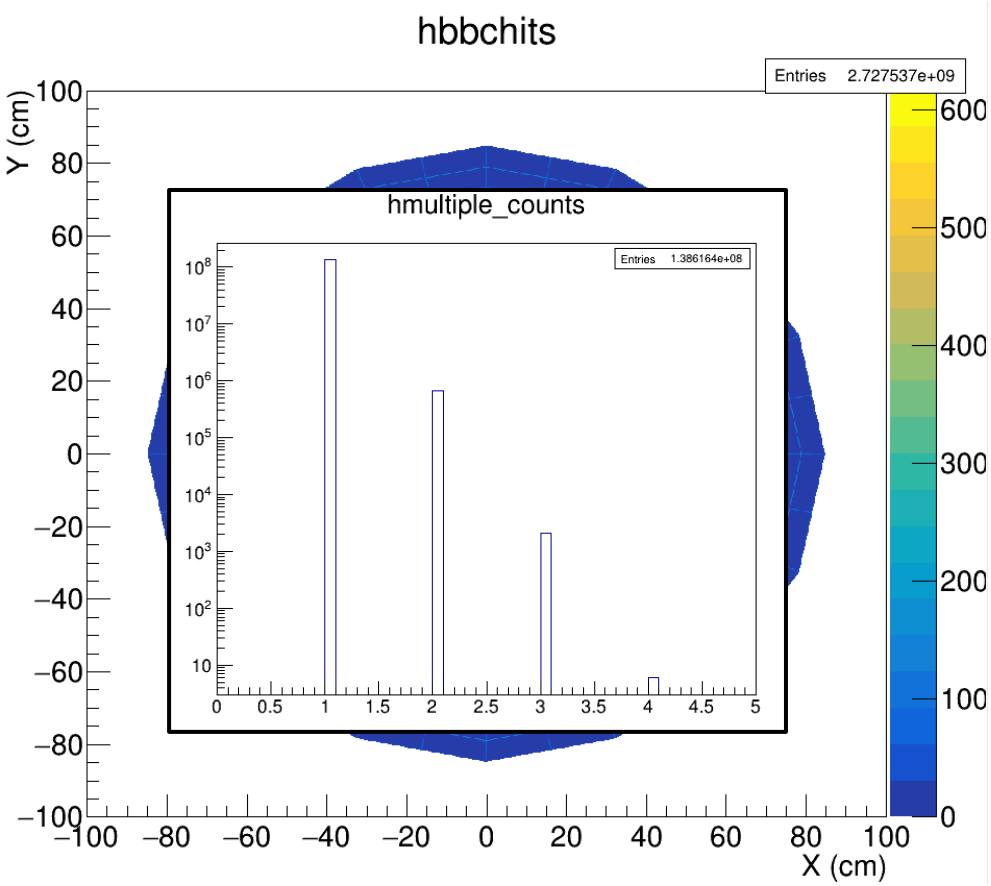
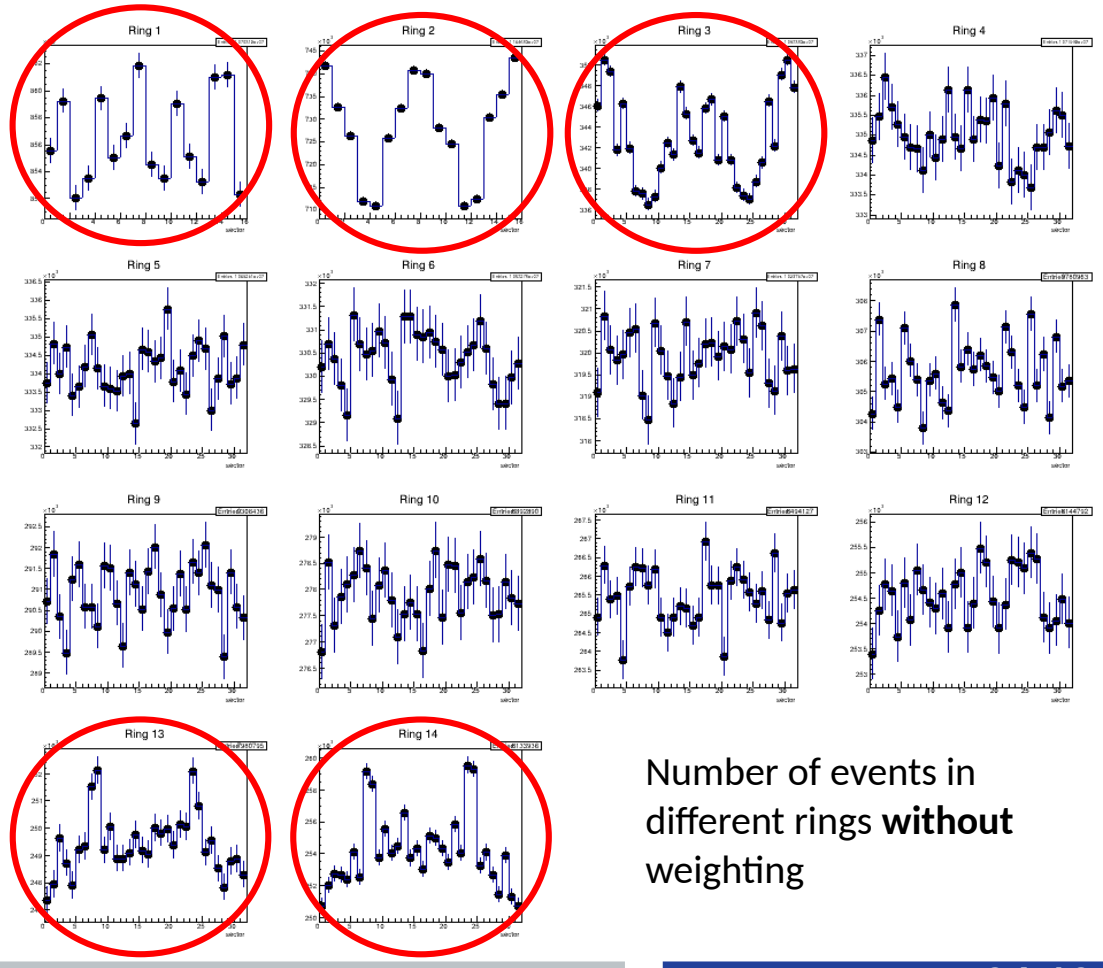


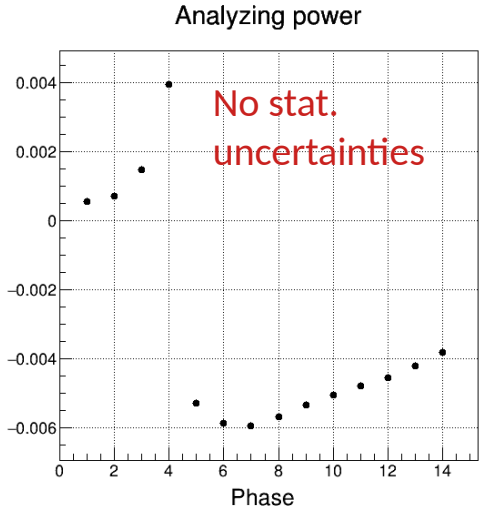
Hitmaps

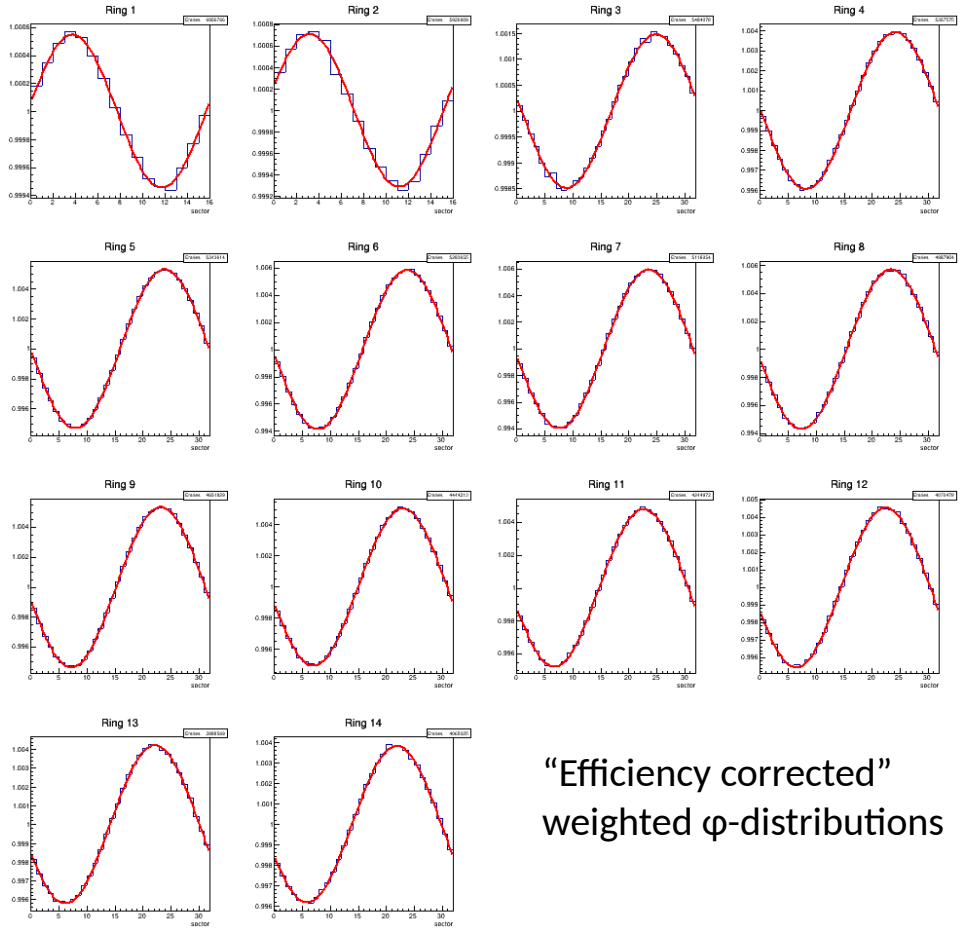
- Histograms now are filled based on ring and tile number
- Hitmaps for unweighted events show structures on the level of 1% (the most probable reason – slight displacement of tiles due to numerical approximations when constructing geometry), being investigated with Arkadiy
- The raw counts should be efficiency corrected before extracting asymmetry. Here efficiency is taken as ~ $1/N_{uw}$ in for each tile (absolute scale ignored)
- Without the correction for efficiency results no meaningful results can be obtained



Number of events in different rings **without** weighting

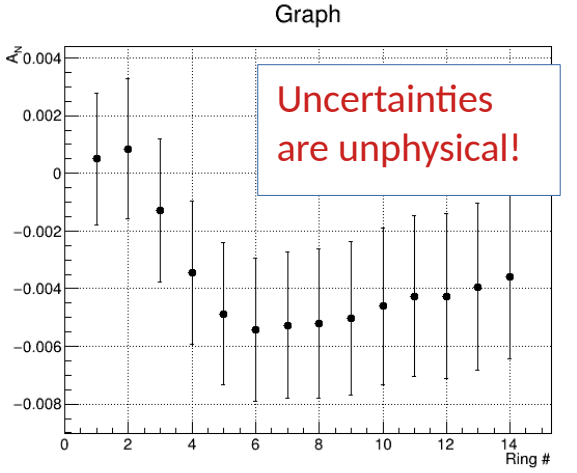
Fits to the “efficiency corrected” yields



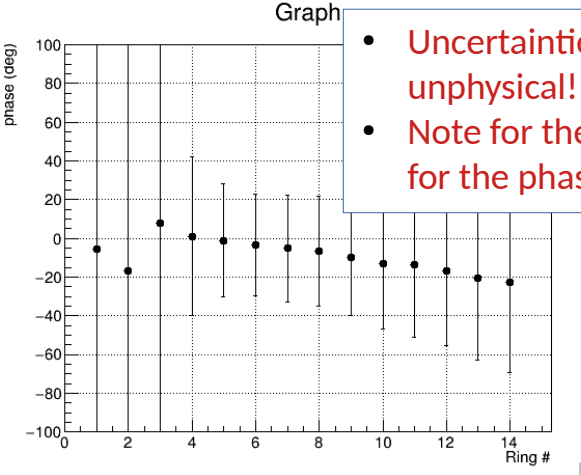


“Efficiency corrected” weighted φ-distributions

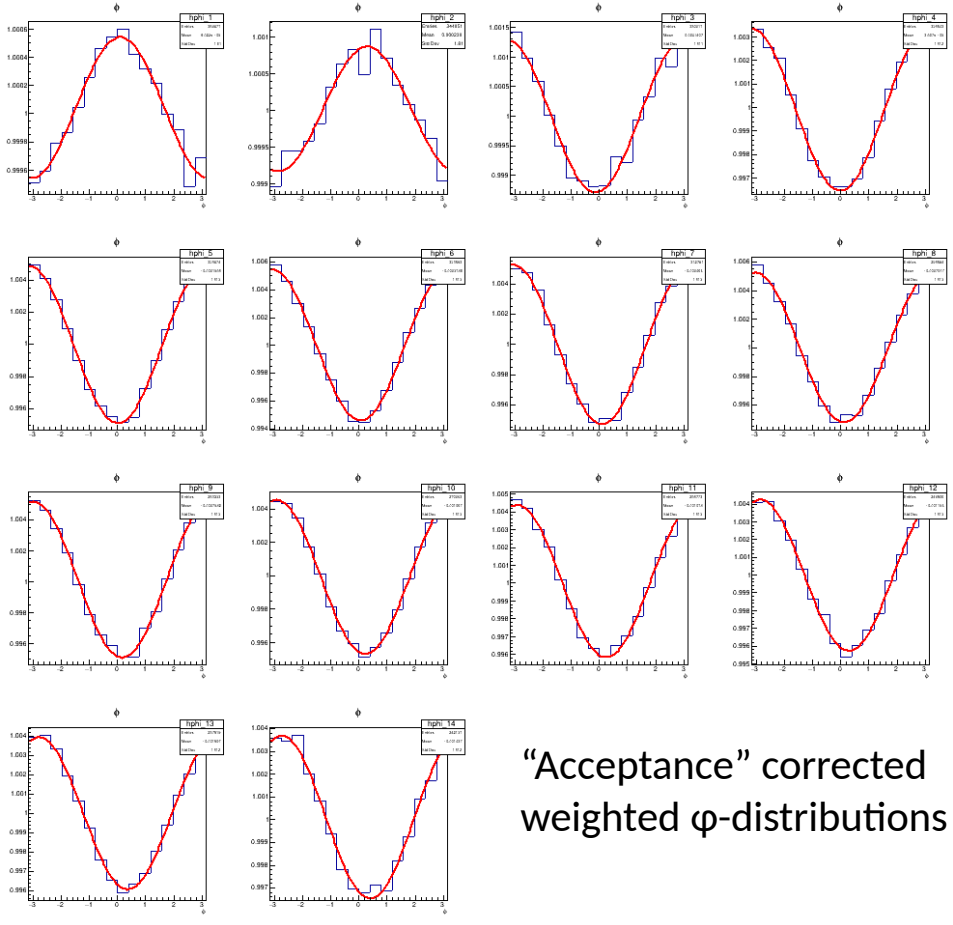
Fits to the “efficiency corrected” yields (previous talk, P&MC 18.06.25)



Uncertainties are unphysical!



- Uncertainties are unphysical!
- Note for the difference for the phase definition!



“Acceptance” corrected weighted φ-distributions

On the beam polarization determination

For online monitoring:

- beam polarization and phase can be first determined in each ring separately
- results can me merged using inverse variance method, phases should be corrected for the φ_0 individual for each ring (precision can be studies with a toy MC)
- “calibration” run with known beam conditions may be necessary to get asymmetries and phase shifts in the ring
- the asymmetries and phase shifts dependence on energy in unclear (to be studied, e.g. at 10 GeV collisions, but new input from Victor Abramov is required)

Summary

- More realistic BBC simulation shows the same results as the previous one (A_N ~ 0.5%, but depends on the ring number).
- The structures in tile counts within a single ring are to be understood (tile precise alignment is being checked)
- The BBC performance for online monitoring can be already estimated at the maximum energy.
- The energy dependence of the magnetic field effects should be studied.