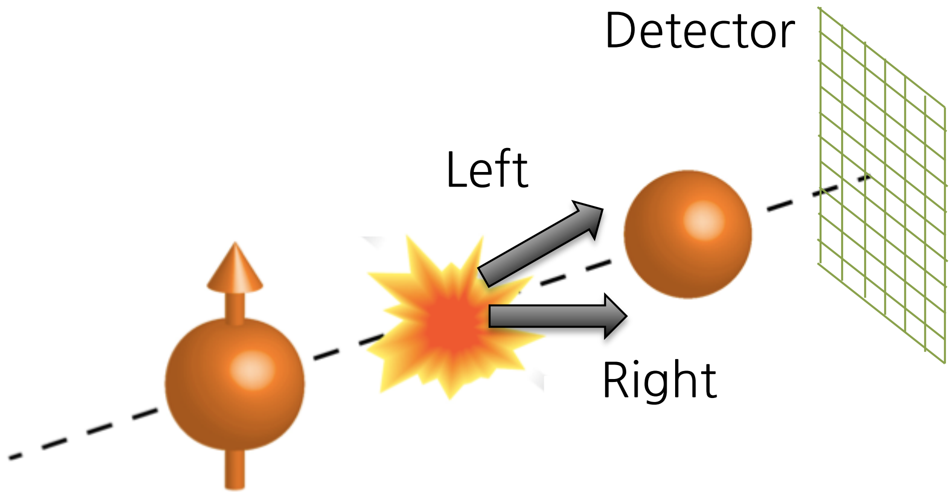
Status and plan for the RHICf 2017 data analysis

RHICf/ RHICf-II collaboration meeting

28 Jan 2022

Minho Kim

Transverse single spin asymmetry (A_N)



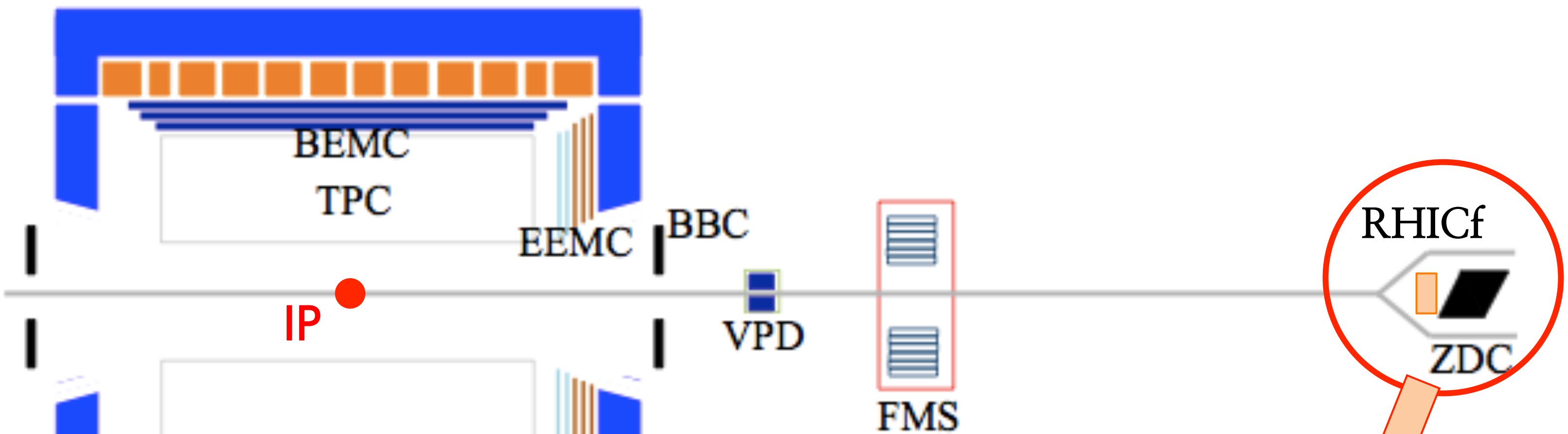
$$A_N = \frac{\sigma_L^{\uparrow} - \sigma_R^{\uparrow}}{\sigma_L^{\uparrow} + \sigma_R^{\uparrow}} = \frac{\sigma_L^{\uparrow} - \sigma_L^{\downarrow}}{\sigma_L^{\uparrow} + \sigma_L^{\downarrow}}$$

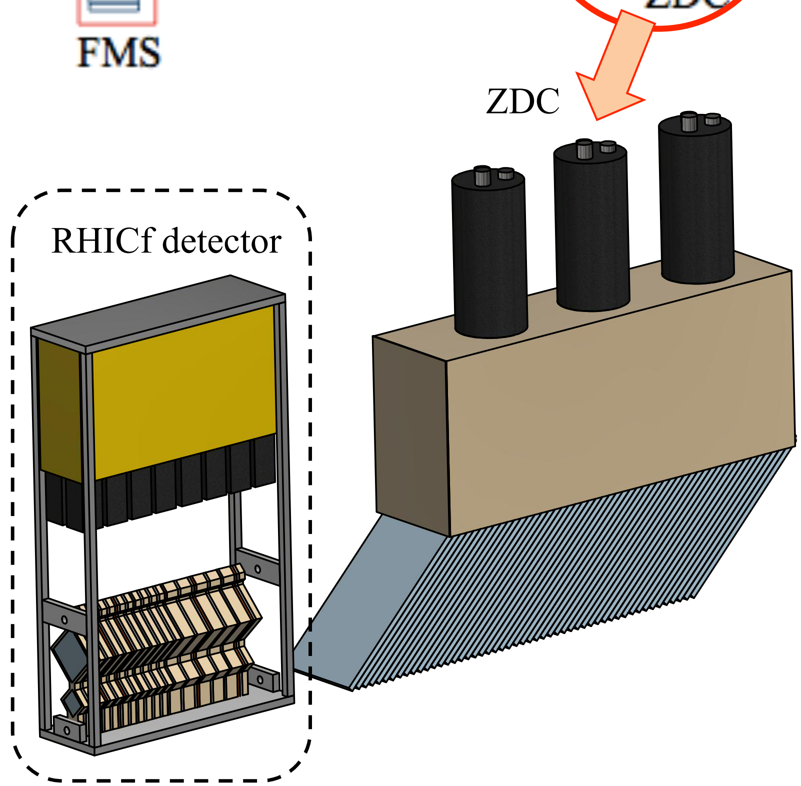
- In polarized p + p collision, A_N is defined by a left-right cross section asymmetry of a specific particle.

- A_N of very forward ($6 < \eta$) particle is a powerful tool to understand the spin-involved production mechanism from the view points of diffractive and non-diffractive interactions.

RHIC forward (RHICf) experiment

STAR experiment

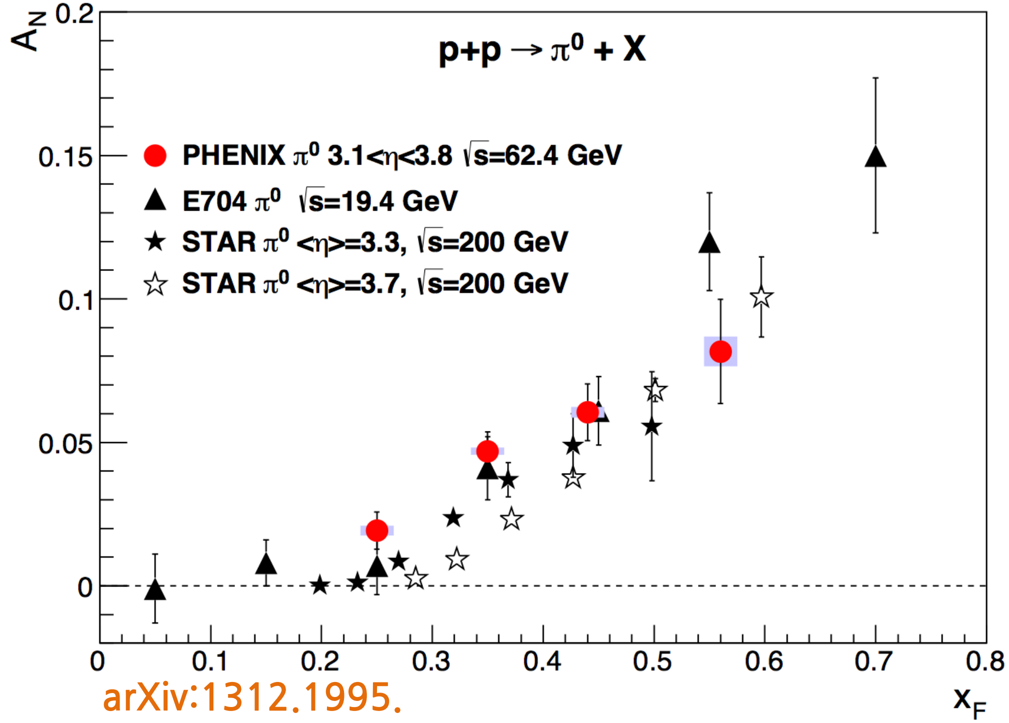




- 18 m away from IP.
- Very forward ($\eta > 6$) π^0 of
  $0.2 < x_F < 1.0$
  $0.0 < p_T < 1.0$ GeV/c.
- Operated in June, 2017 at RHIC STAR in polarized p + p collisions at 510 GeV.

A_N of the forward π^0

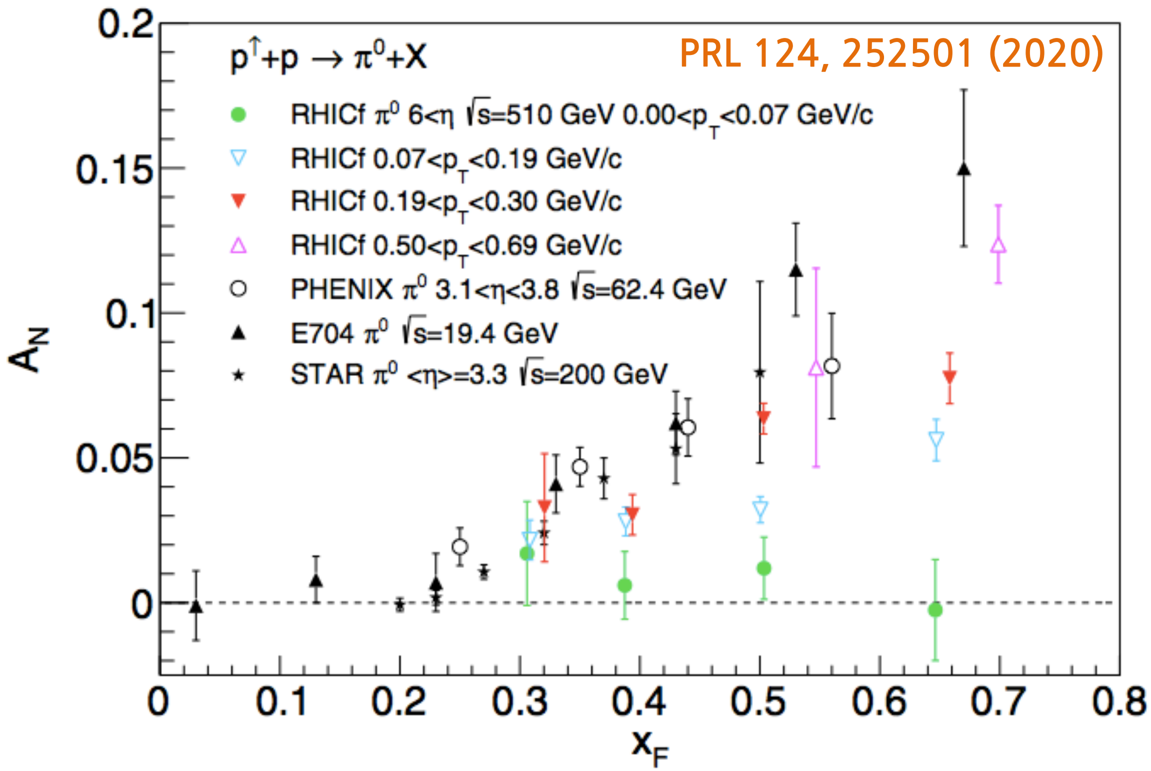
$2 < \eta < 4$



arXiv:1312.1995.

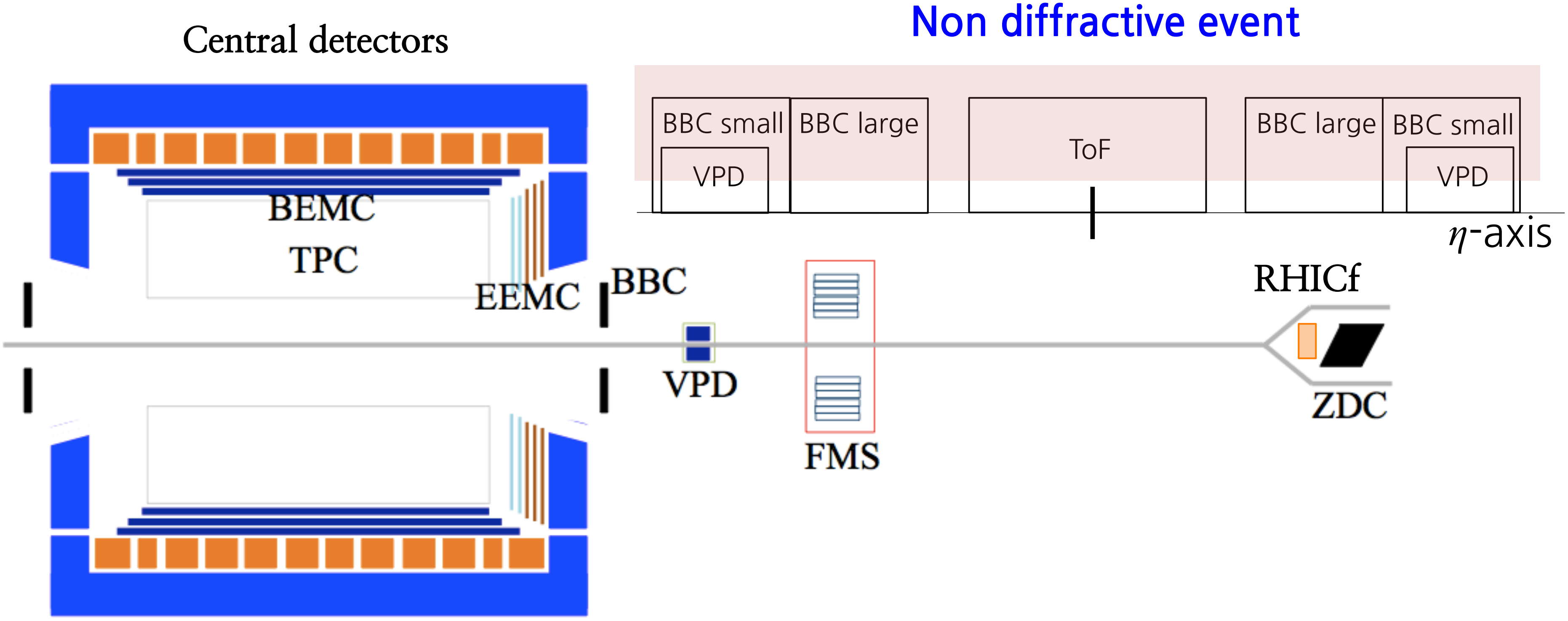
- Observed non-zero A_N of π^0 has been interpreted based on only quarks and gluons' degrees of freedom theoretically.
- To study a possible diffractive contribution to the π^0 A_N, the RHICf experiment has measured that of the very forward ($6 < \eta$) π^0 in June 2017.

A_N of the very forward π^0



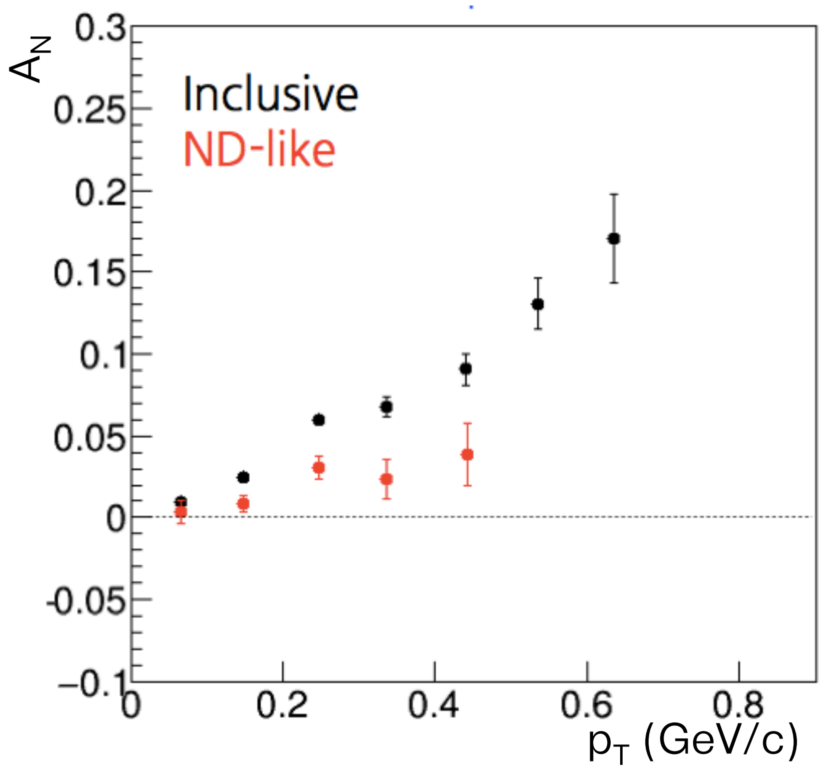
- At very low $p_T < 0.07$ GeV/c, the asymmetries are consistent with zero.
- As p_T increases, the asymmetries increase approximately reproducing that of the forward π^0.
- What makes the non-zero asymmetry of the very forward π^0?

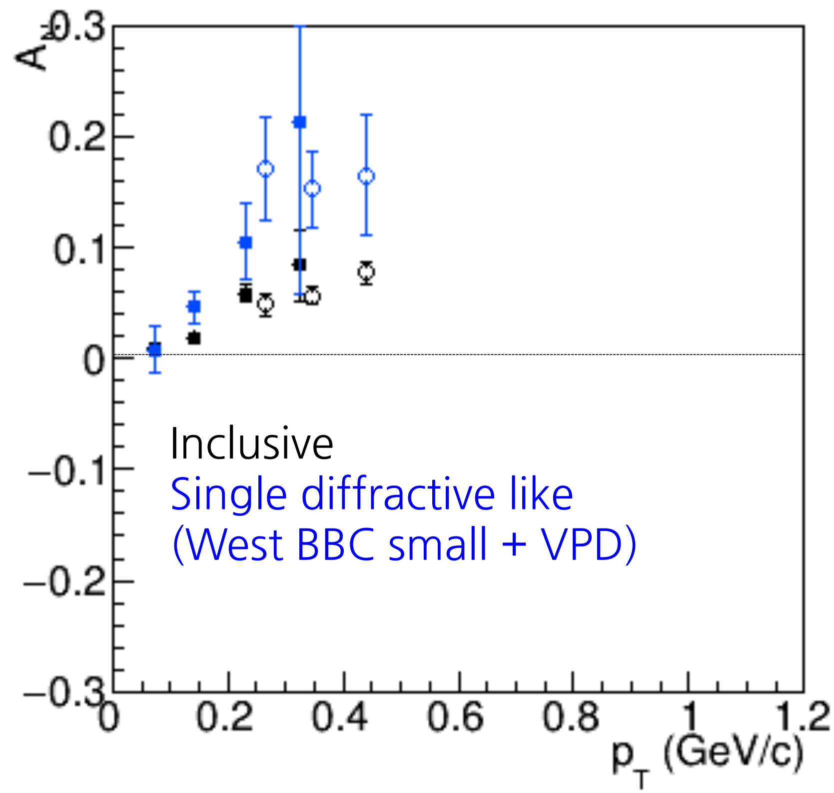
RHICf-STAR combined analysis



- Using STAR central detectors, BBC, and VPD, we can study the detector correlation or event type dependence for the very forward π^0 A_N.
- For example, there should be signals in the TOF, BBC, and VPD if a π^0 comes non-diffractive event.

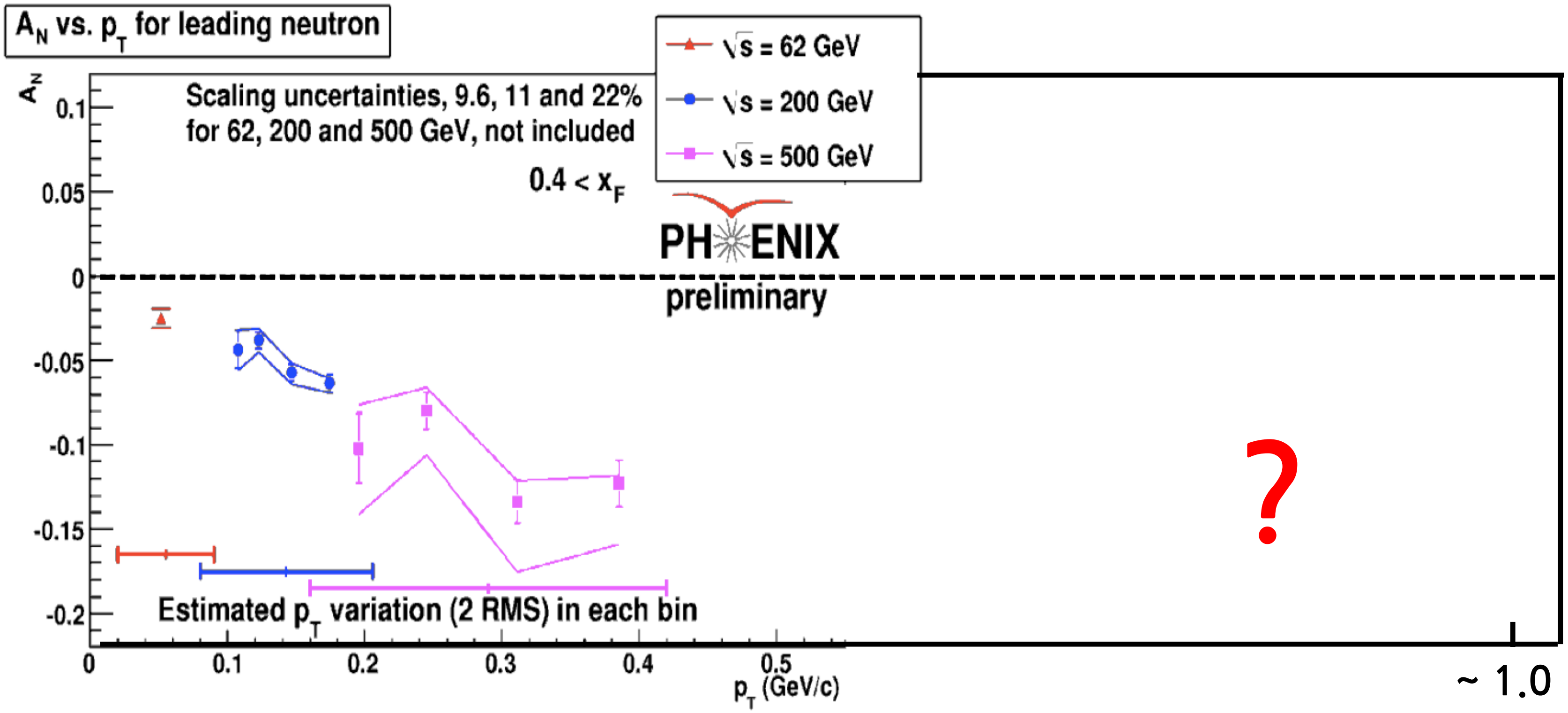
Intermediate results





- We can see a clear detector correlation for the very forward π^0 A_N.
- The combined analysis will be resumed in earnest in this year.

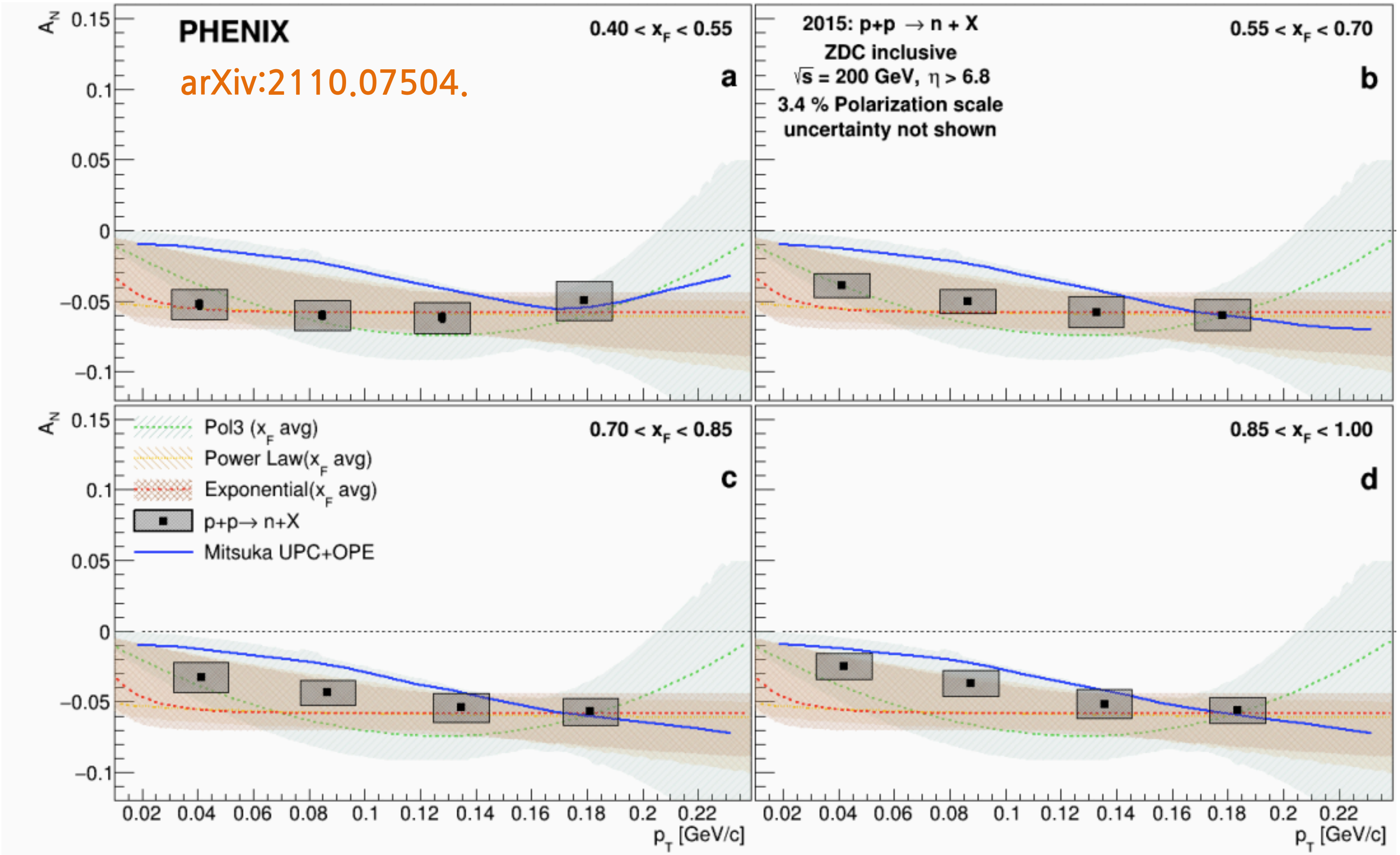
A_N of the very forward neutron



- $\sqrt{s}$ and p_T dependences of the neutron A_Ns were largely smeared by insufficient position resolution.

- RHICf experiment will show precise tendency of the neutron A_N as functions of both x_F and p_T.

A_N of the very forward neutron

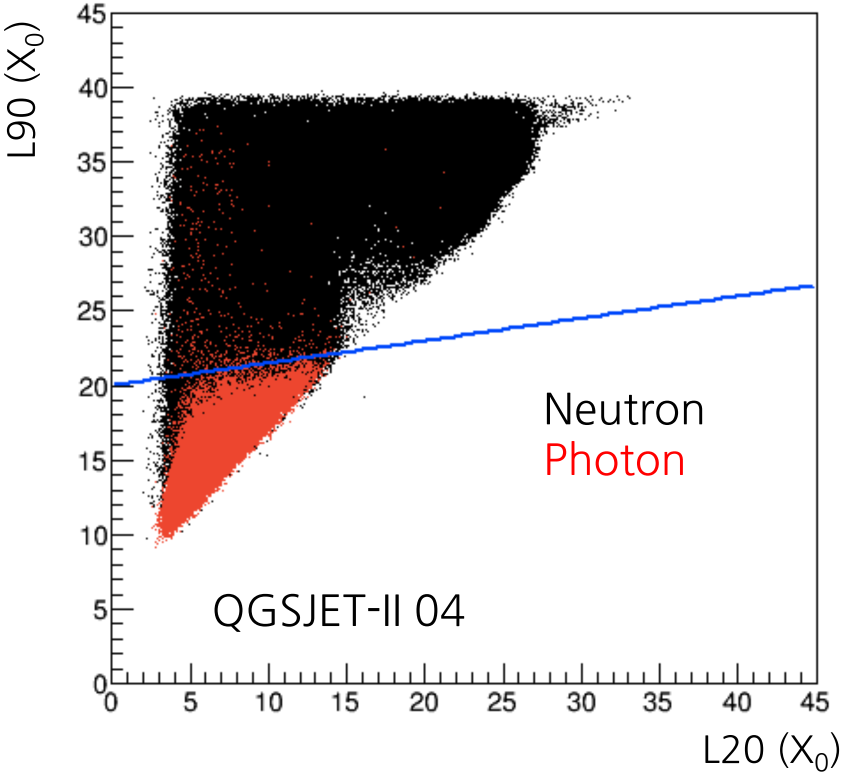


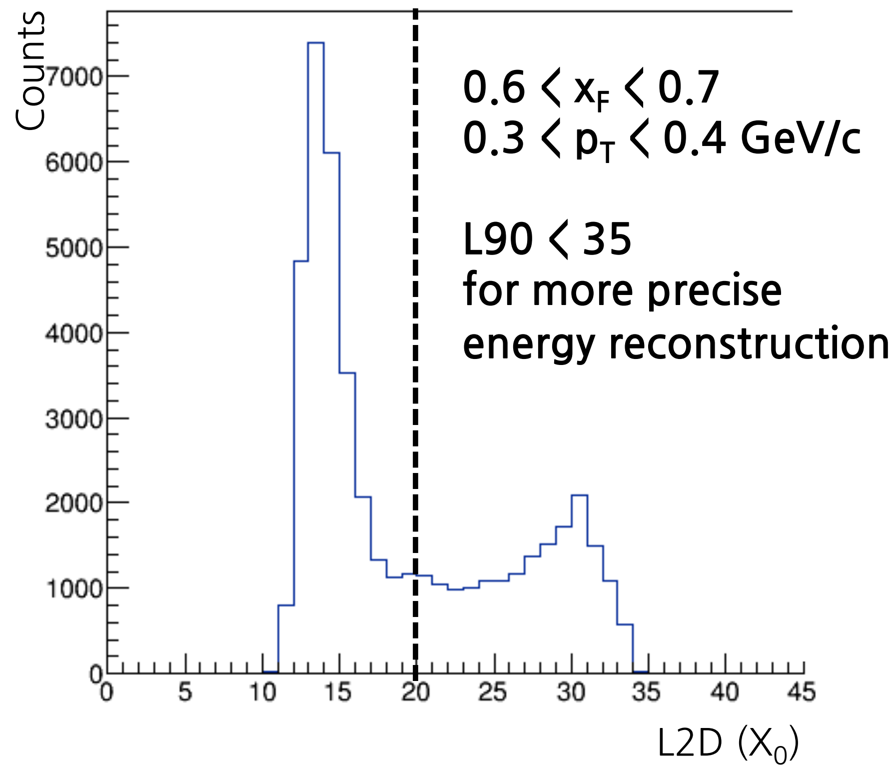
- The A_N slightly increases following the p_T axis except the lowest x_F region.

Analysis procedure for the neutron A_N

Neutron candidate

Neutron candidate





- L90 > a*L20 + b is considered as neutron.
- Among a and b where the neutron purity is higher than 99%, they were fixed so that the (neutron efficiency) x (purity) reaches the maximum.
  → a = 0.15, b = 20
- While the L2D is defined by L90 - 0.15*L20, an event was considered as neutron one if L2D > 20.

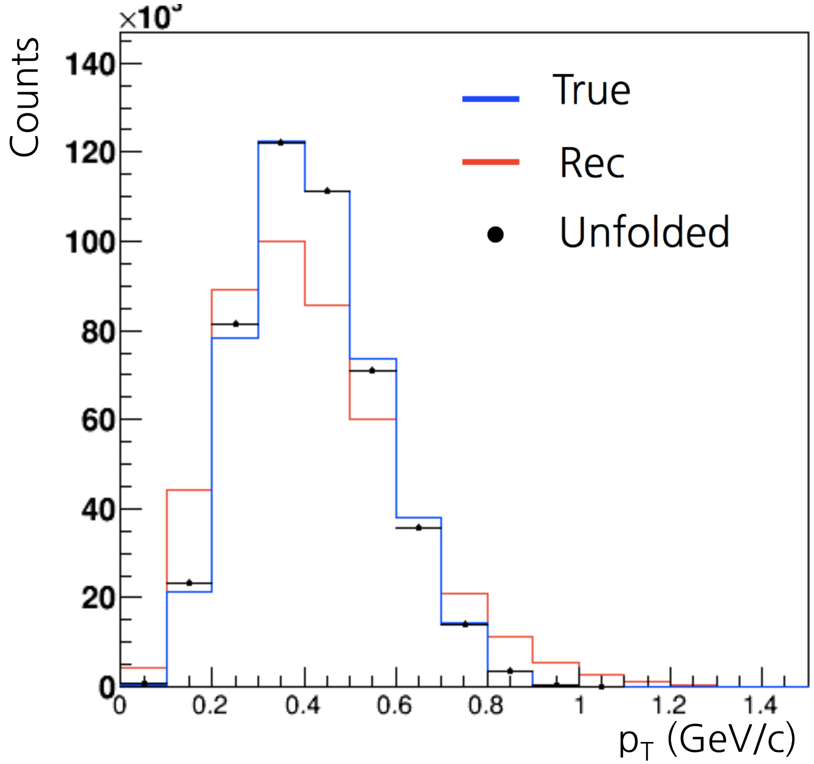
Analysis procedure for the neutron A_N

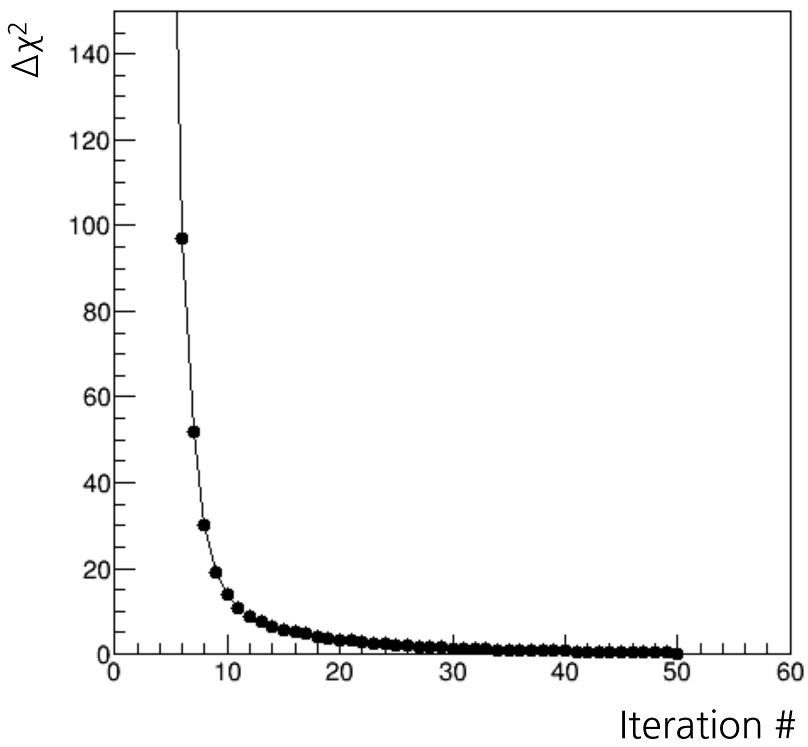
Neutron candidate

↓

x_F & p_T unfolding

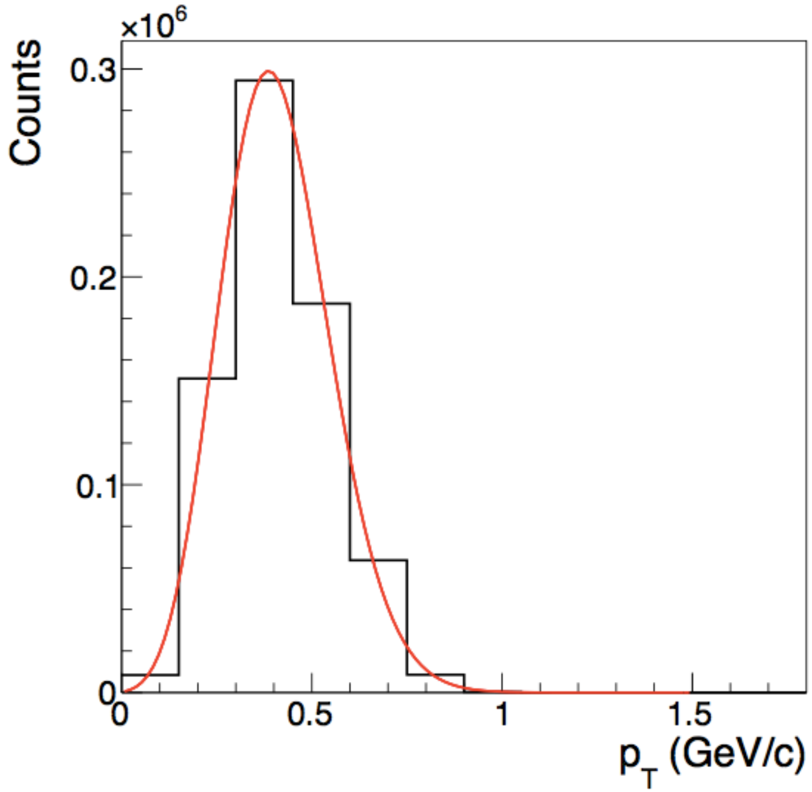
2D Bayesian unfolding

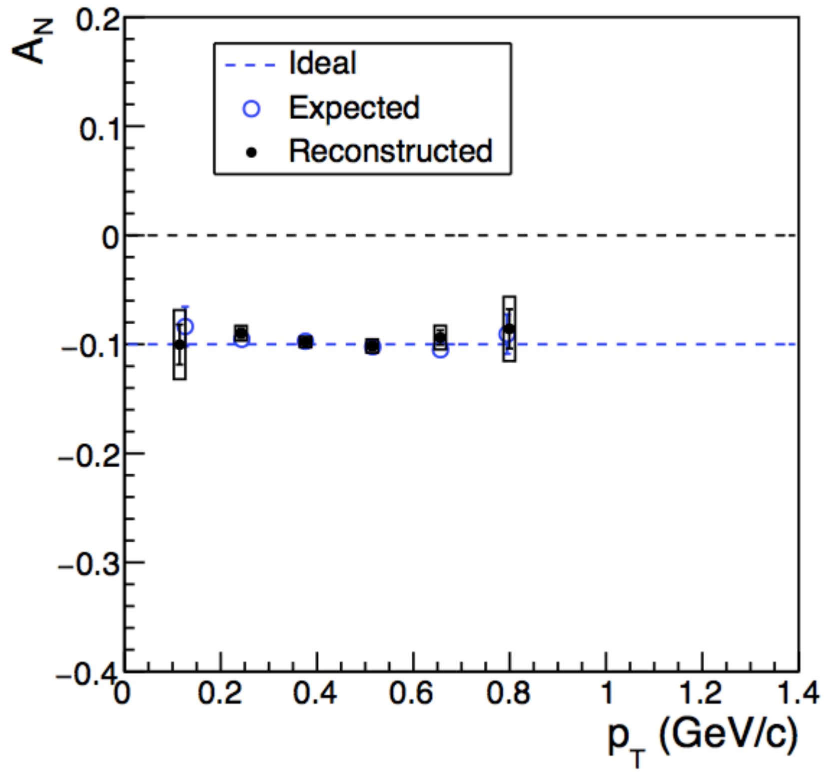




- Single neutrons of randomized energy and direction were generated for the 2D Bayesian unfolding.
- Number of iteration was done until the $\Delta\chi^2$ get smaller than 1.

Unfolding performance





- To estimate the ⟨x_F⟩ and ⟨p_T⟩, the unfolded distributions were fitted by a Gaussian-based function. The differences were less than 0.02 (GeV/c).
- The reconstructed A_Ns were consistent with the weighted input.

Analysis procedure for the neutron A_N

Neutron candidate

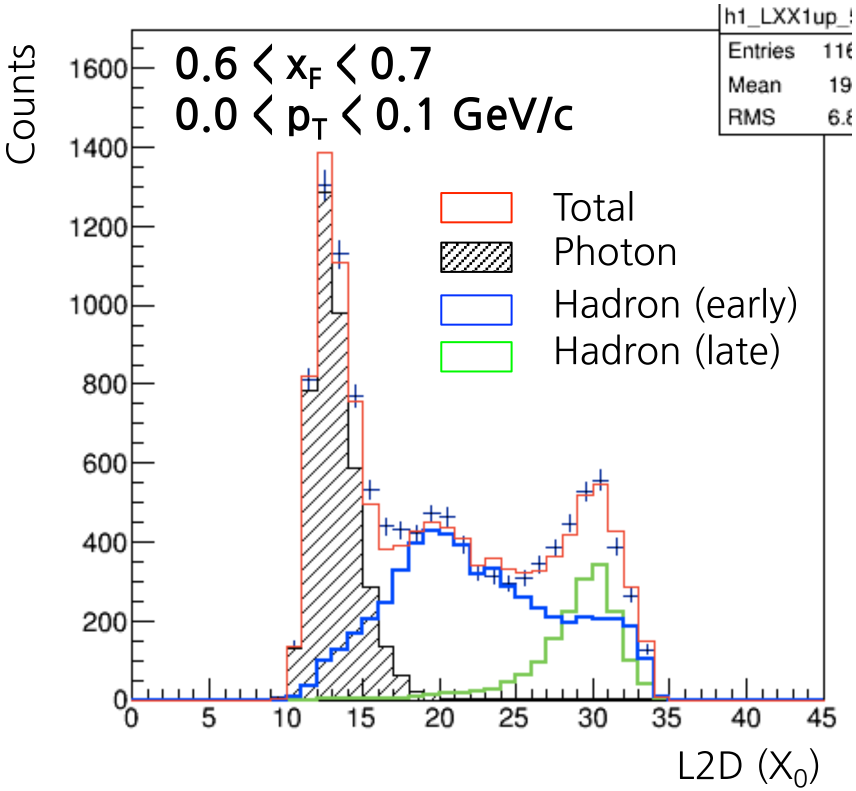
↓

x_F & p_T unfolding

↓

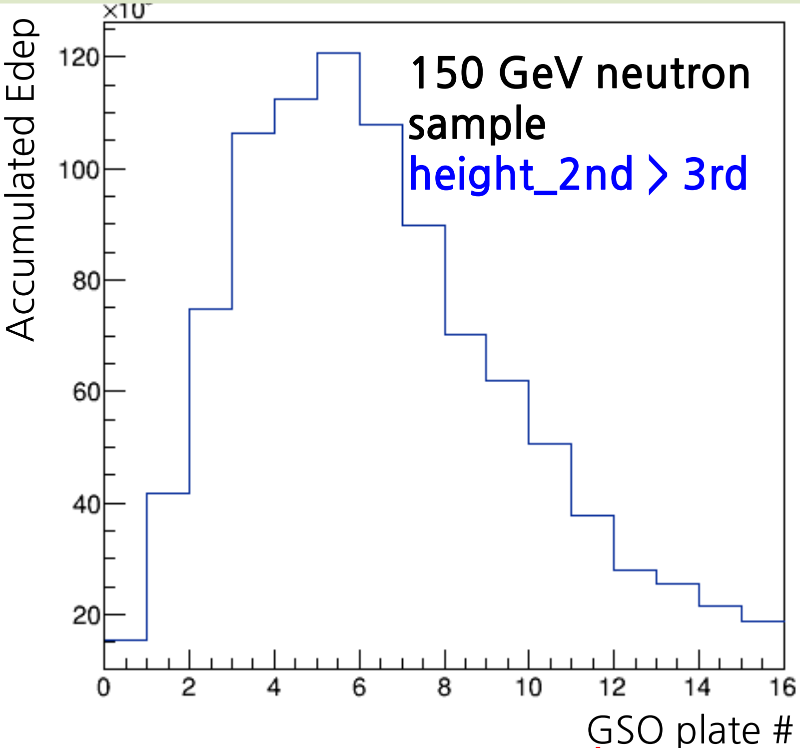
Background fraction
Background A_N

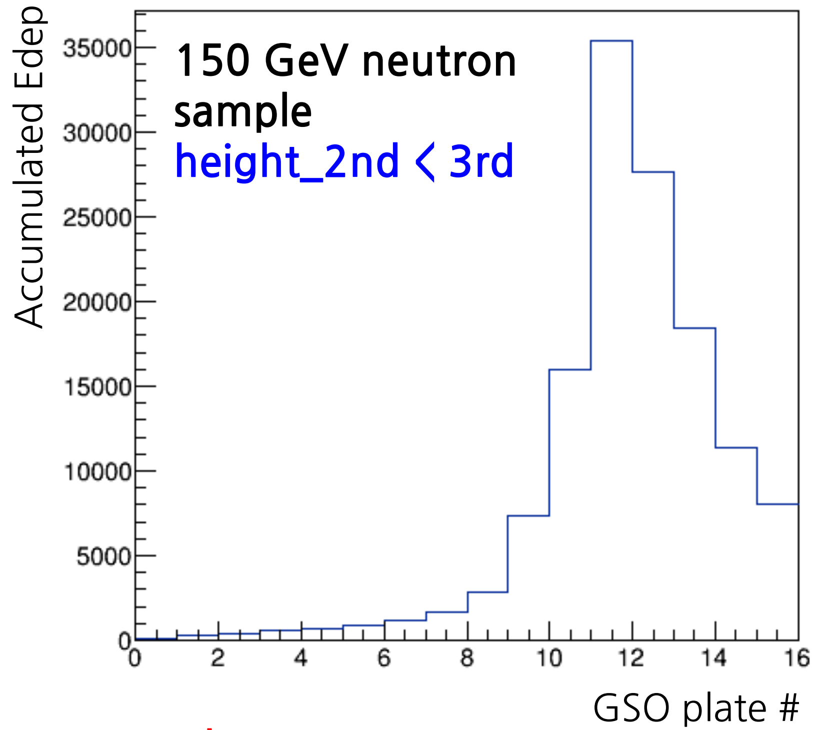
Background photon

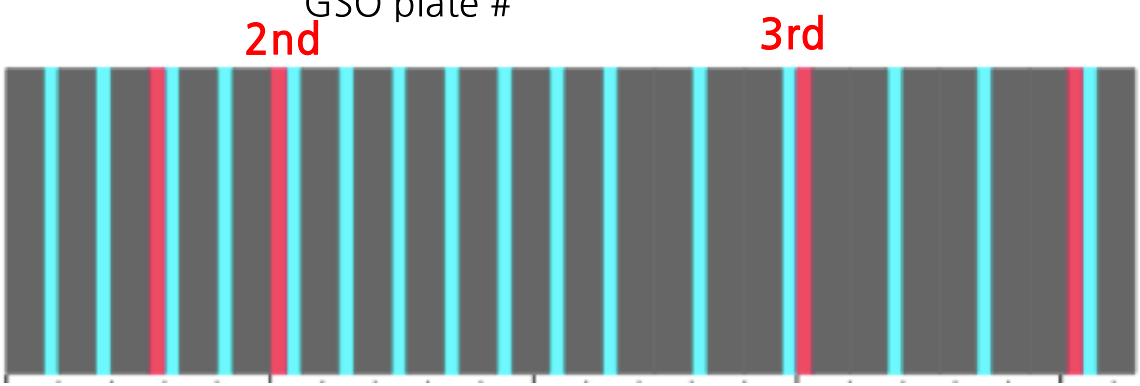


- Three samples (photon, early and late neutron shower of neutron) were used for the template fitting.
- Number of photon candidates in the up and down polarization events were counted to estimate the photon A_N.

Early and late shower development

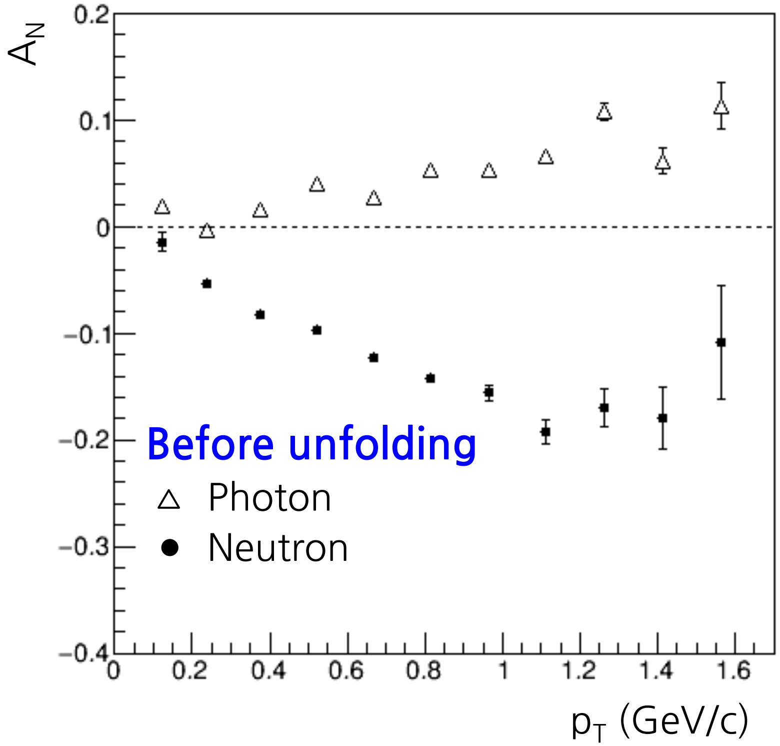






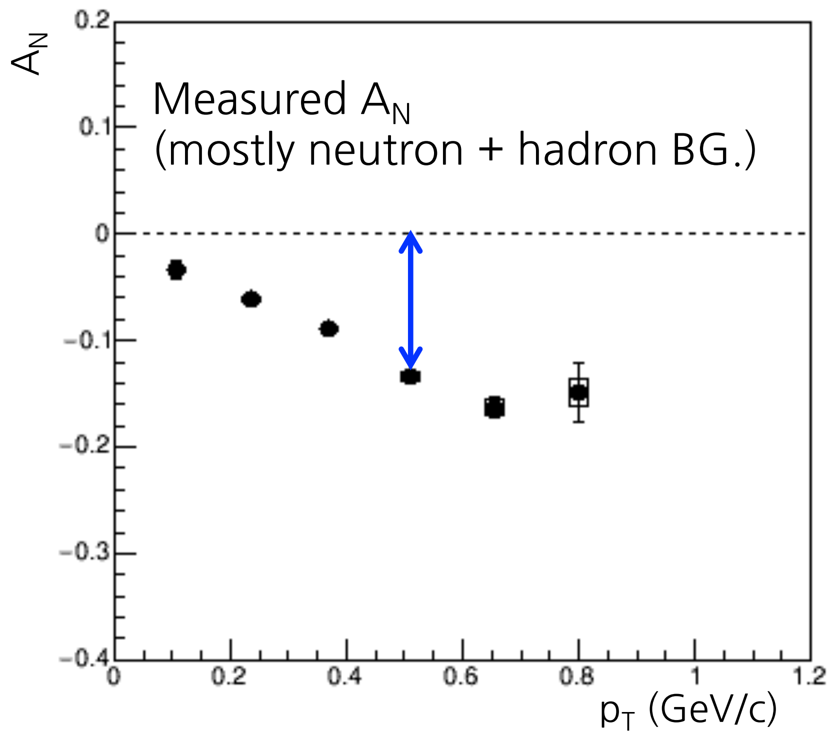
- We can separate the early and late shower developments by comparing the peak heights of 2nd and 3rd GSO bar layers.

Background photon A_N



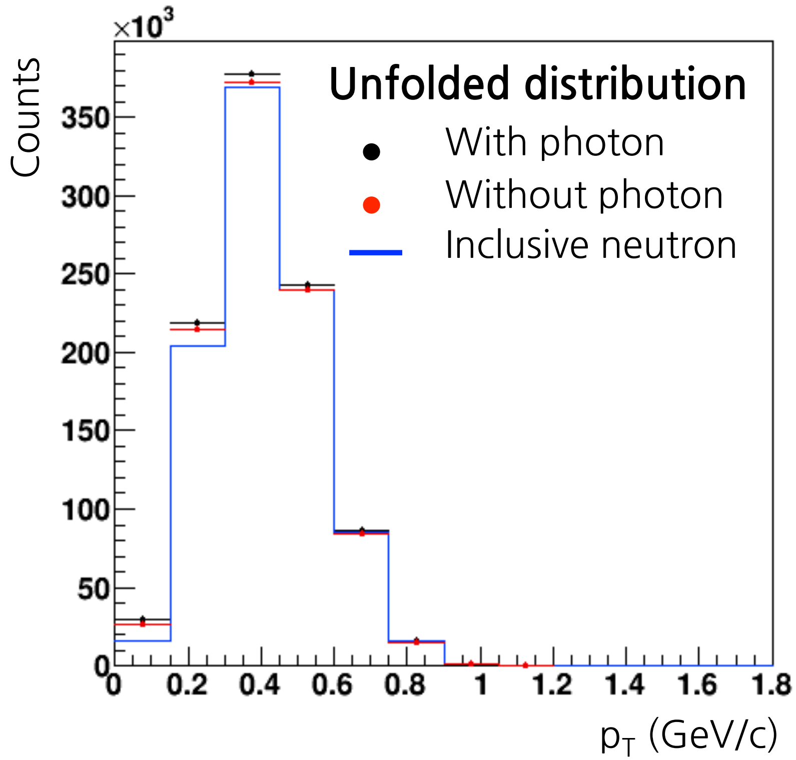
- We don't know how much photon A_N is smeared to each x_F and p_T bins while the unfolding is proceeded.
- Difference between the maximum and minimum photon A_N was considered as a source of the systematic uncertainties.

Background hadron A_N



- Background hadron mainly includes the proton and charged pions.
- We can not estimate the background hadron A_N.
- Differences between 0 and measured (neutron + background hadron) asymmetries were assigned as a source of the systematic uncertainties.

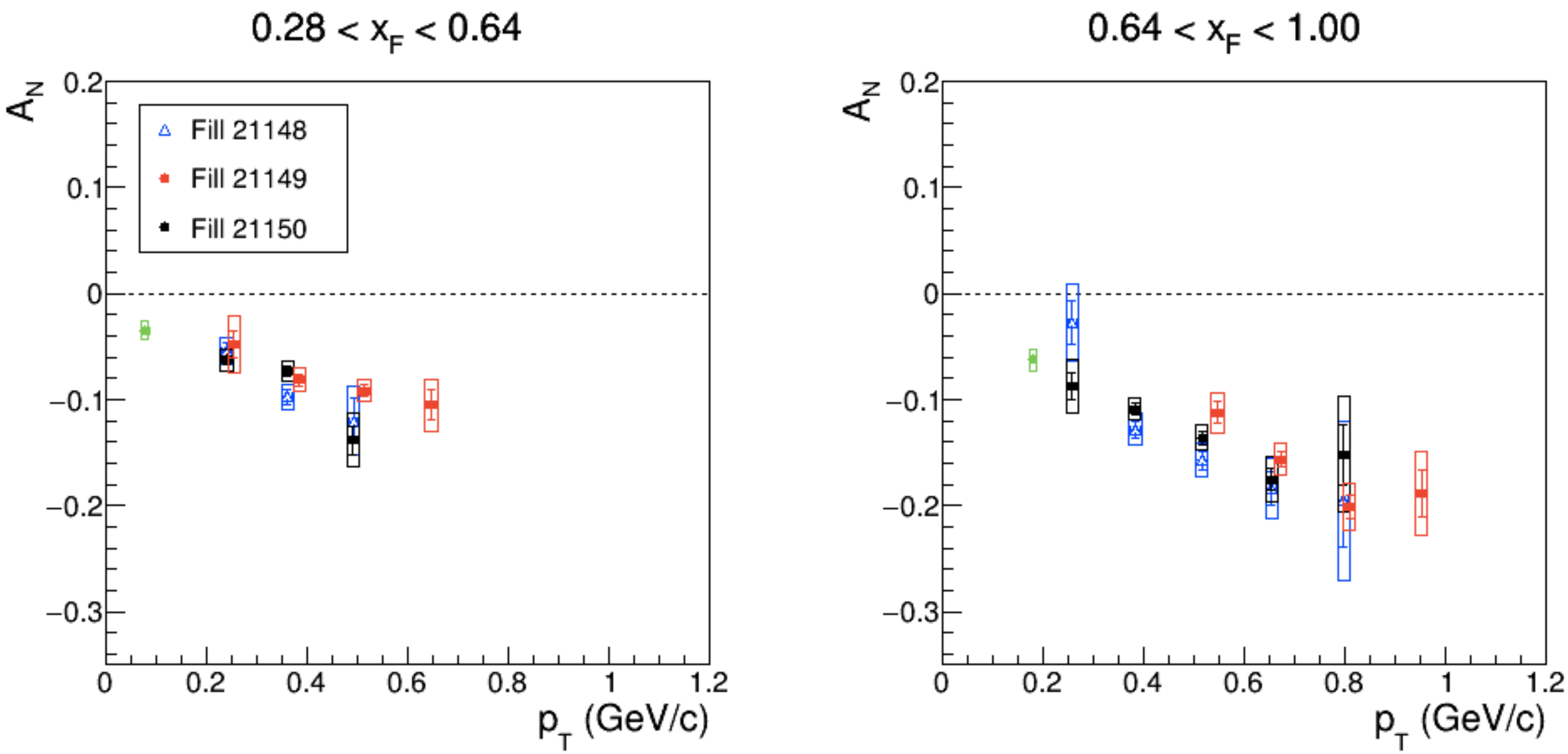
Background ratio



- Three QGSJET-II 04 samples (with and without photon events, and inclusive neutron) were unfolded to estimate the background fraction.

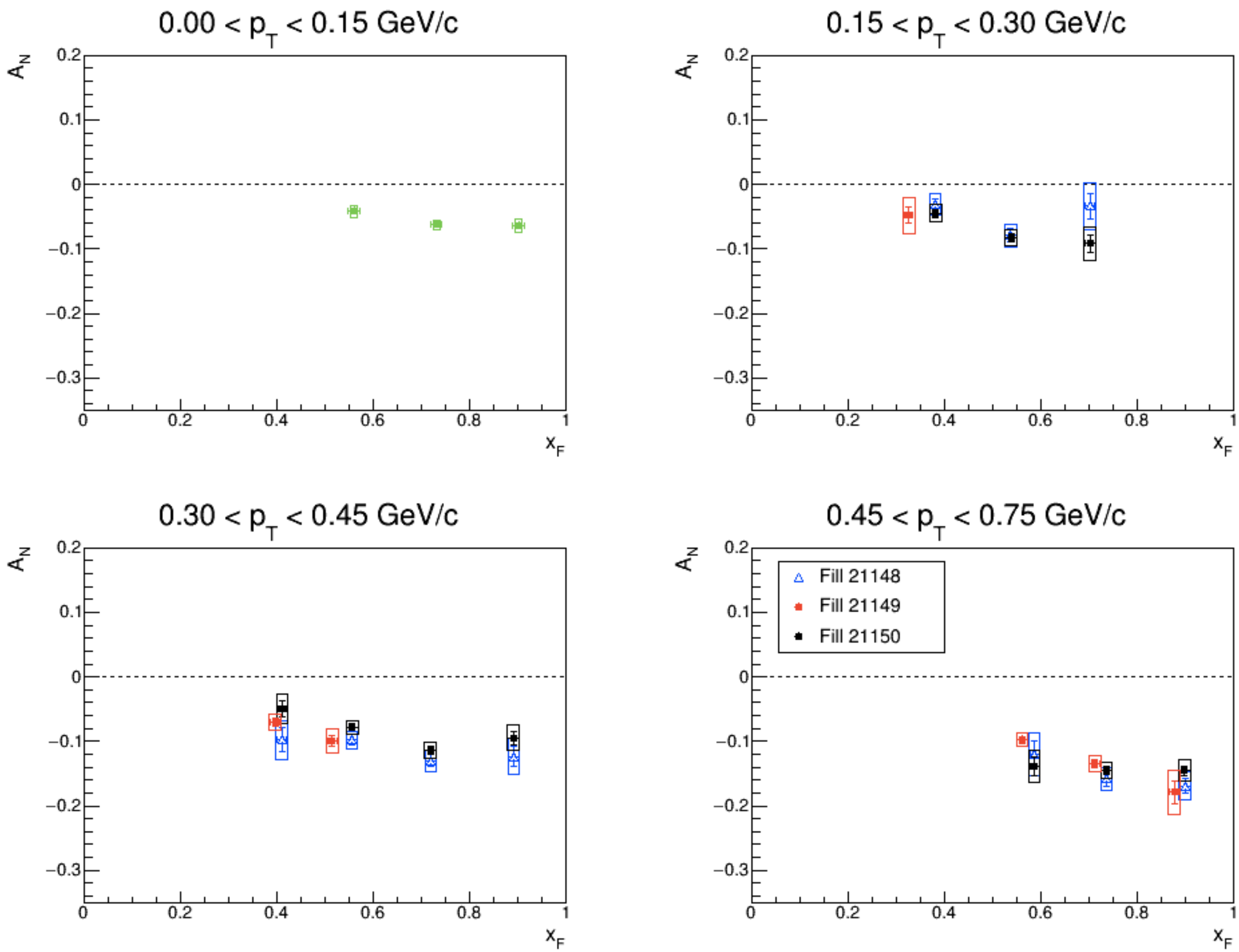
- Difference between • and • : Background photon ratio.
  Difference between • and — : Background hadron ratio.

Neutron A_N as a function of p_T



- In short kinematic ranges, the data points were consistent with each other within the uncertainties.
- Systematic uncertainties by the beam center, background AN subtraction, polarization, and unfolding were included currently.
- A_N uncertainty by the kinematic smearing needs to be included.

Neutron A_N as a function of x_F



TODO list

- RHICf-STAR combined analysis.
- Finalize the RHICf standalone neutron analysis.
- RHICf-II experiment preparation.