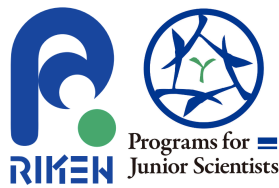


Multi-dimensional analysis for the transverse single spin asymmetry for very forward neutral pion production

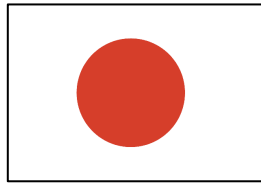
Minho Kim (RIKEN)

on behalf of the RHICf collaboration



September 7, 2022
The Physical Society of Japan

RHIC forward (RHICf) experiment



RIKEN (Y. Goto, I. Nakagawa, R. Seidl, M. H. Kim), **Nagoya Univ.** (Y. Iwano, H. Menjo, K. Sato, K. Ohashi), **Univ. of Tokyo** (T. Sako), **JAEA** (K. Tanida), **Waseda Univ.** (S. Torii), **Shibaura Inst. of Tech.** (K. Kasahara), **Tokushima Univ.** (N. Sakurai)



Korea Univ. (B. Hong), **Sejong Univ.** (Y. Kim, S. Oh, S. H. Lee)

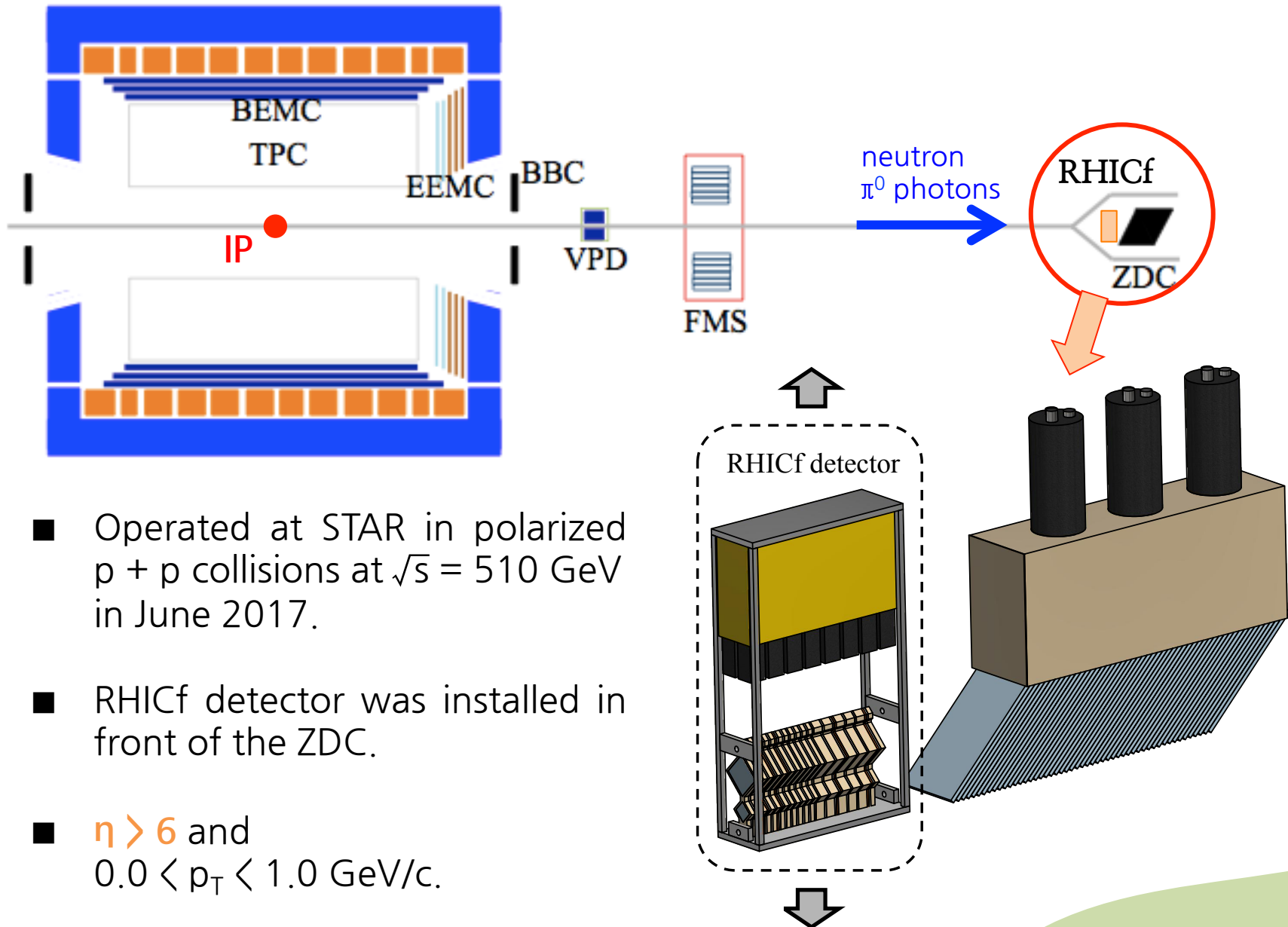


INFN (O. Adriani, E. Berti, L. Bonechi, R. D'Alessandro, A. Tricomi)

- **Cross section** measurement to study the origin of the ultra high energy cosmic rays ($E > 10^{18}$ eV).
 - Various models predict different acceleration mechanism of the ultra high energy cosmic rays.
 - Cross section data can constrain and tune the models.
- **Transverse single spin asymmetry** measurement to study the spin-involved particle production mechanism.

RHIC forward (RHICf) experiment

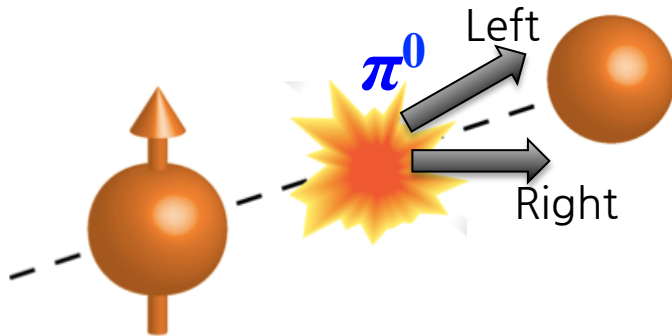
STAR experiment



- Operated at STAR in polarized $p + p$ collisions at $\sqrt{s} = 510$ GeV in June 2017.
- RHICf detector was installed in front of the ZDC.
- $\eta > 6$ and $0.0 < p_T < 1.0$ GeV/c.

Transverse single-spin asymmetry (A_N)

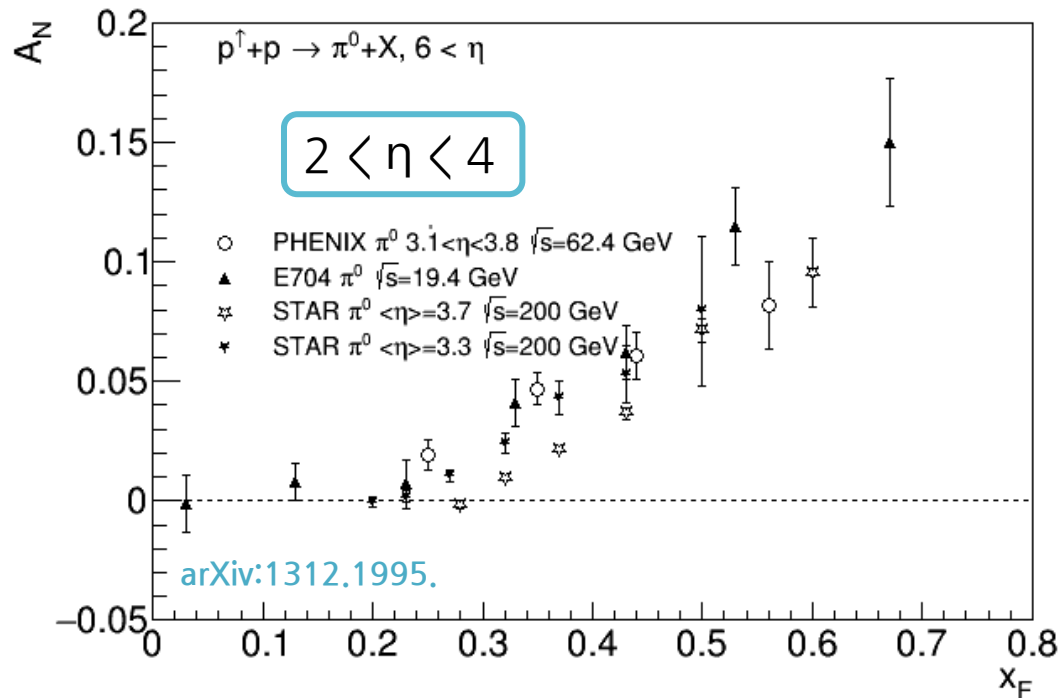
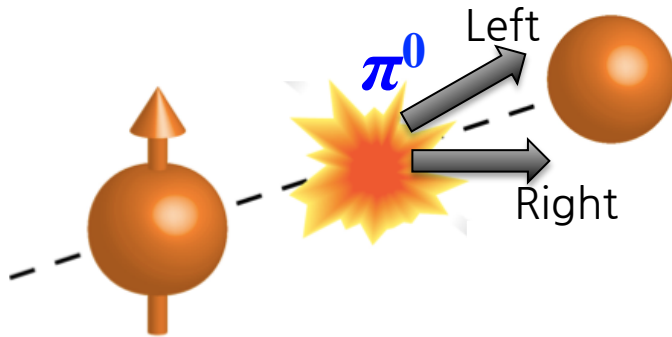
$$A_N = \frac{\sigma_L^\uparrow - \sigma_R^\uparrow}{\sigma_L^\uparrow + \sigma_R^\uparrow}$$



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

A_N for forward π^0 production

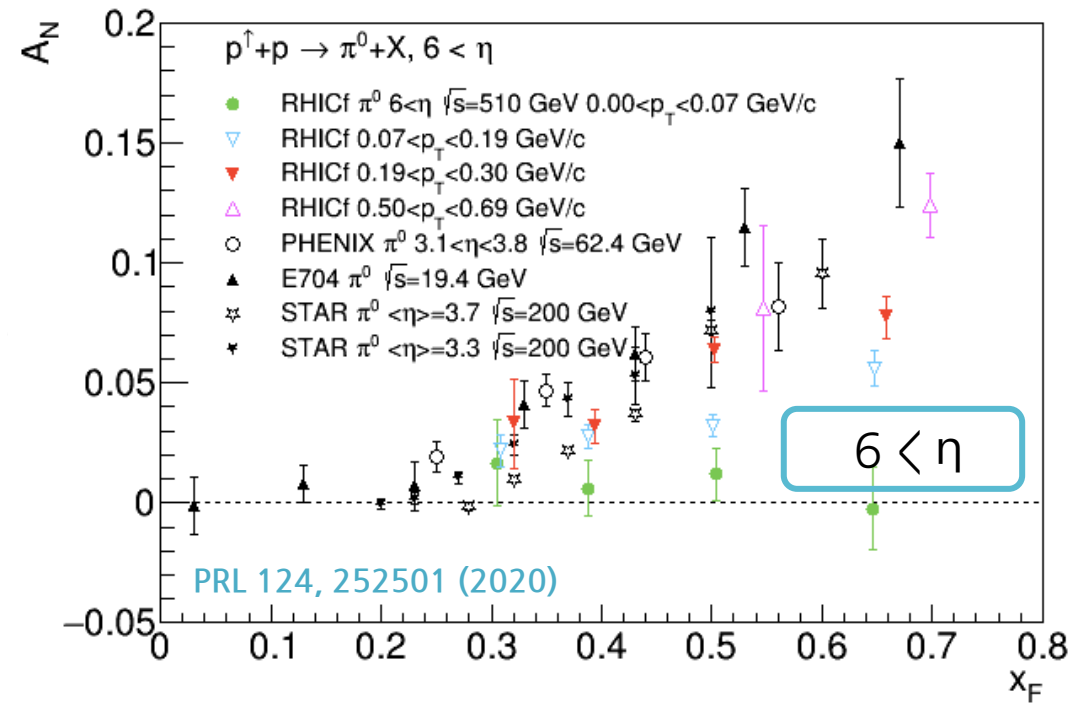
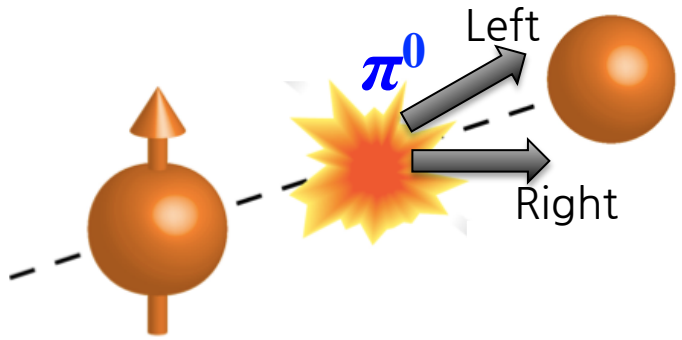
$$A_N = \frac{\sigma_L^\uparrow - \sigma_R^\uparrow}{\sigma_L^\uparrow + \sigma_R^\uparrow}$$



- In polarized $p + p$ collision, A_N is defined as a left-right cross section asymmetry of a specific particle.
- Finite A_N for **forward** ($2 < \eta < 4$) π^0 production has been understood in **quarks and gluons' degrees of freedom**.
 - Intrinsic transverse momentum in the initial state proton.
 - Correlation between the proton spin and the

A_N for very forward π^0 production

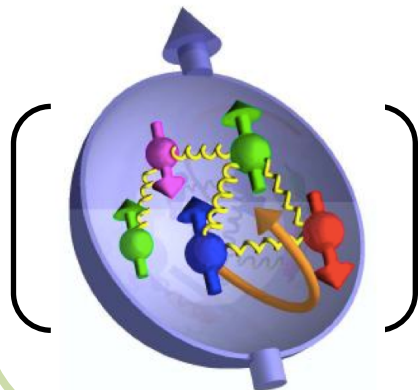
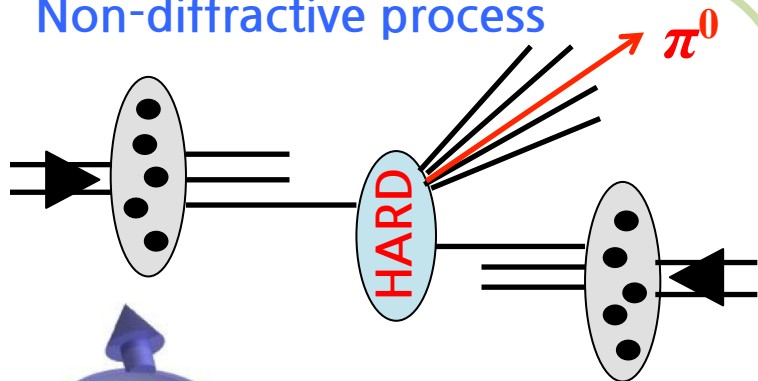
$$A_N = \frac{\sigma_L^\uparrow - \sigma_R^\uparrow}{\sigma_L^\uparrow + \sigma_R^\uparrow}$$



- Finite A_N for **very forward** π^0 production showed a possible contribution from the **diffractive process**.
- While p_T increases, A_N of very forward π^0 follows that of forward π^0 .
 - They “may” have a common production mechanism.
 - They “may” originate from different process.

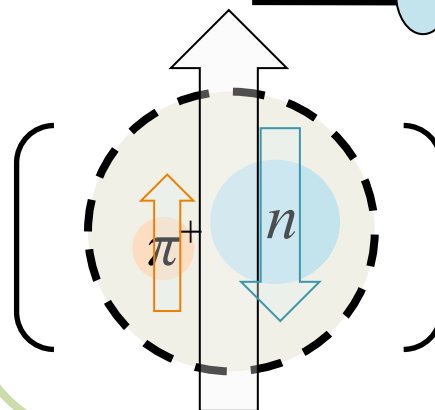
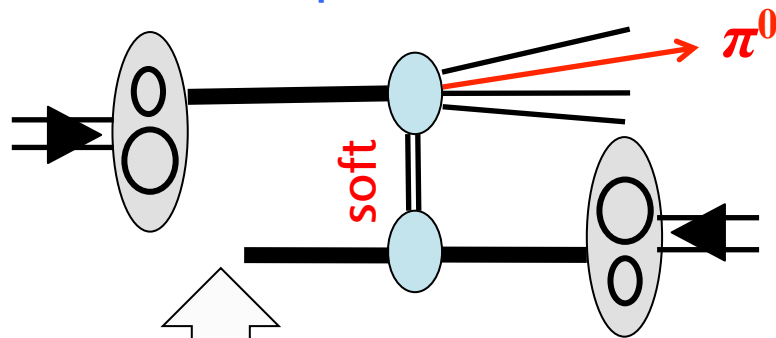
Non-diffractive vs Diffractive process

Non-diffractive process

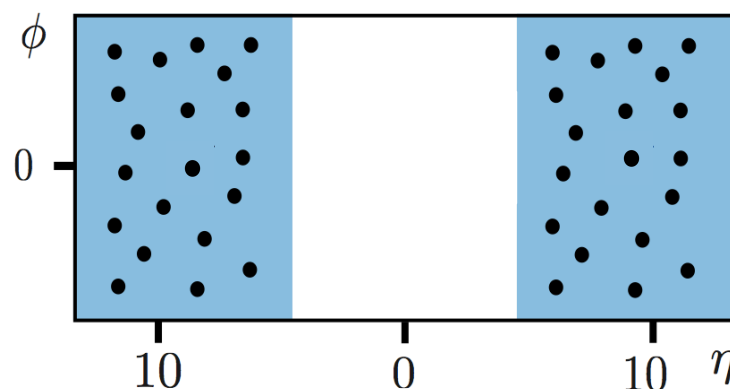
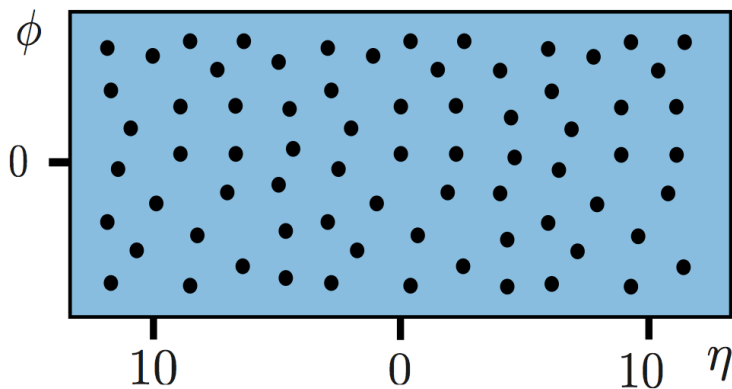


Higher p_T

Diffractive process



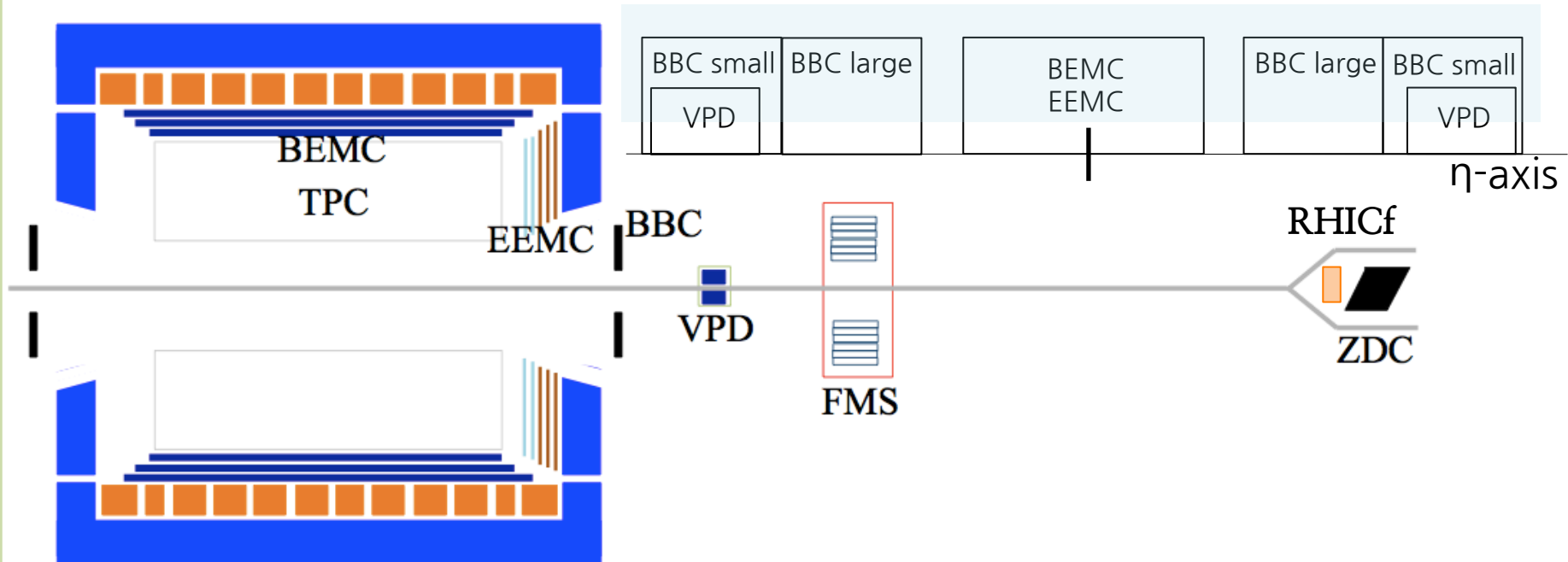
Lower p_T



Multi-dimensional analysis

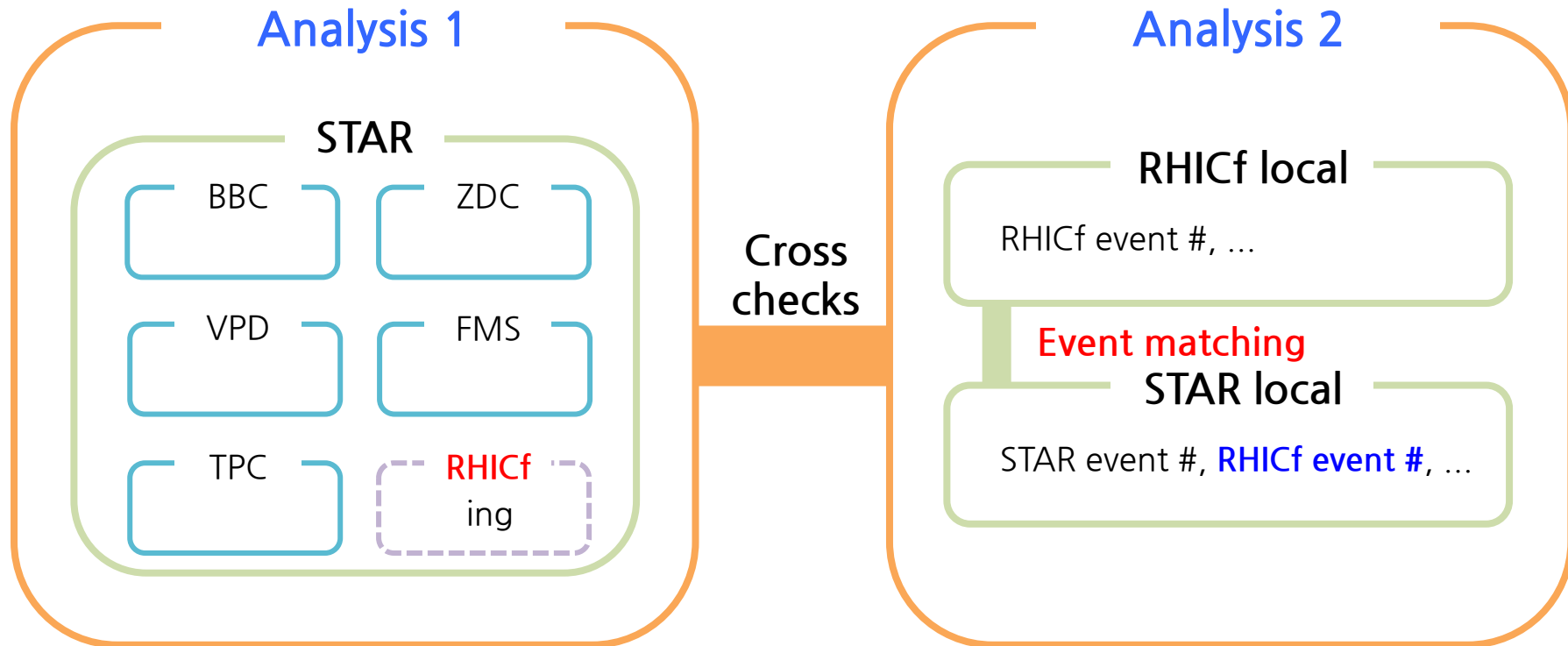
STAR experiment

Non-diffractive event



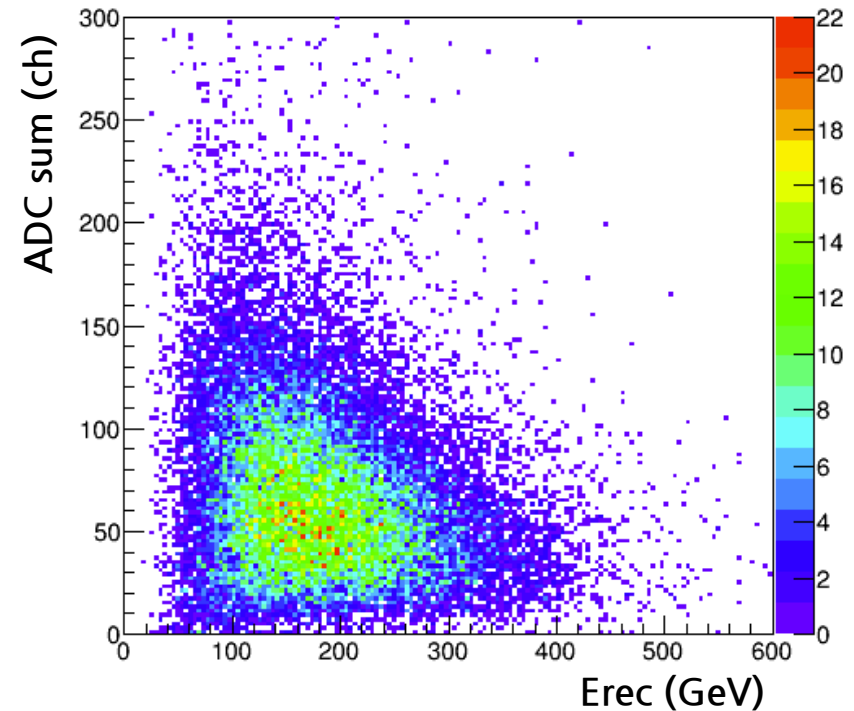
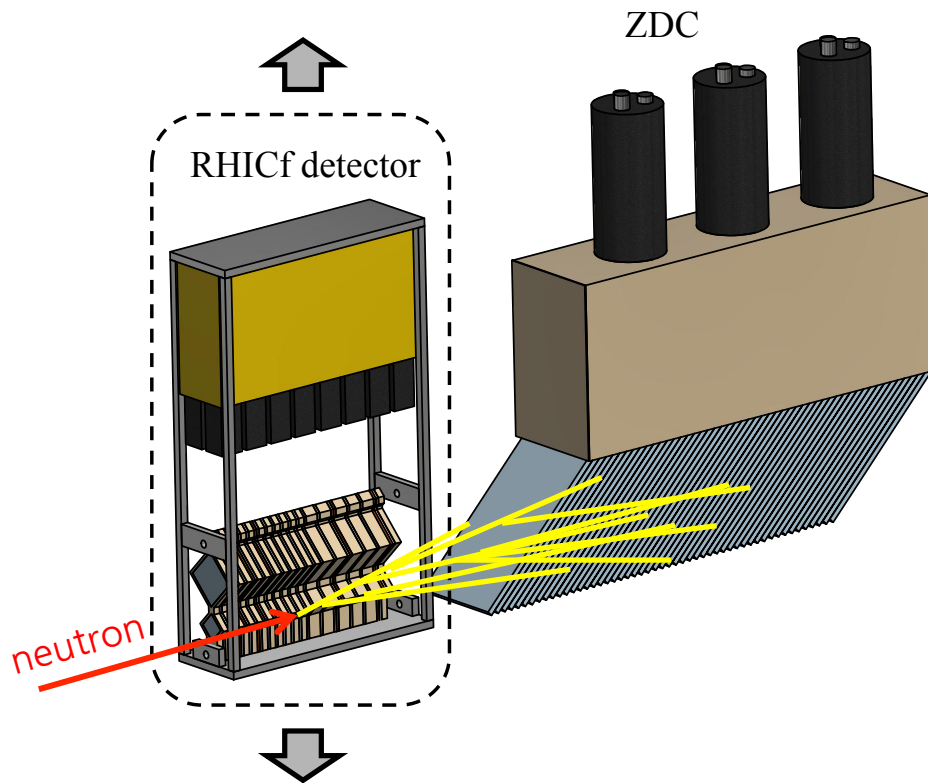
- Using STAR calorimeters, it is possible to estimate the **existence of the rapidity gap** to study the detector correlation of the A_N of very forward π^0 .
- For example, there should be signals in all of the STAR detectors if the non-diffractive process is generated.

Analysis strategy



- To proceed the RHICf-STAR combined analysis, RHICf library is being written in STAR.
- The combined analysis can also be done with two RHICf and STAR local files.
- Two analyses will be compared to convince that the RHICf library is properly added in STAR.

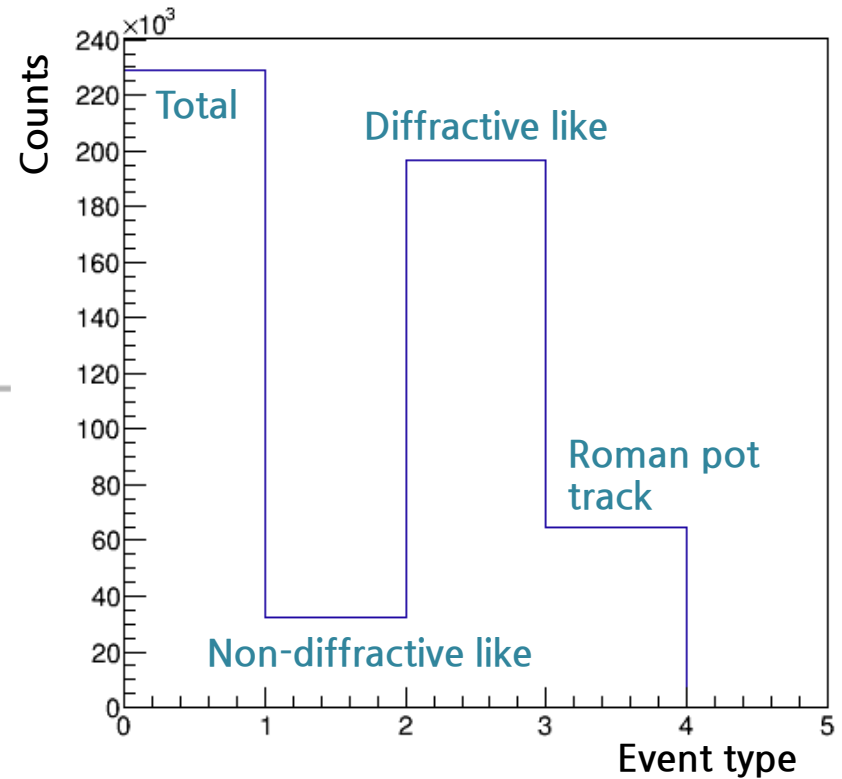
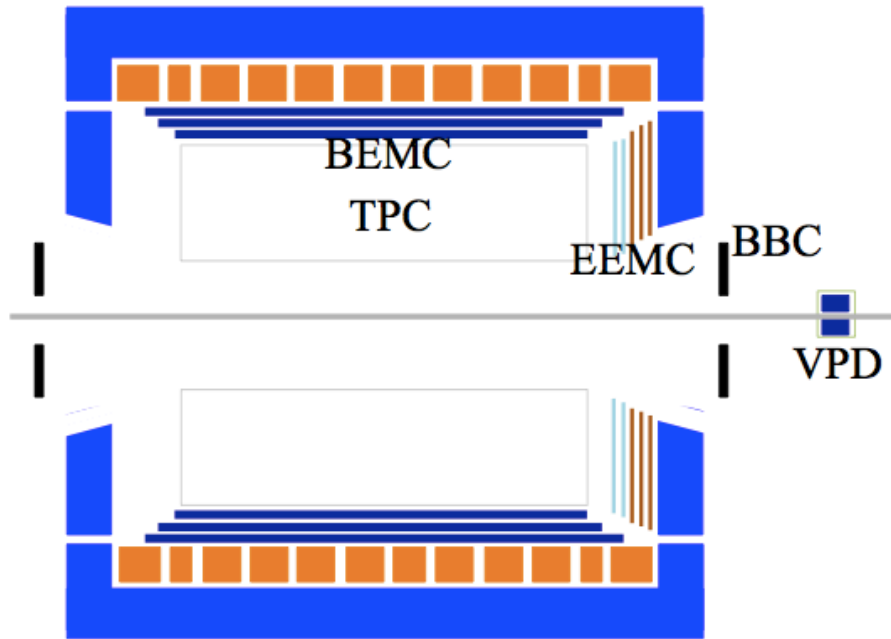
Event matching



- Since the interaction length of the RHICf detector is insufficient ($1.6 \lambda_I$) for the neutron measurement, longitudinal shower leakage of the RHICf detector is compensated by the ZDC.
- Clear correlation between the RHICf and ZDC makes us convince that the event matching works well.

Sensitivity study

STAR experiment



- Sensitivity of the RHICf event to each process can be studied by checking the signals of each detector.
- We will approach the each process more carefully and also should refer to the detector performance estimated by the simulation.

Summary and plan

- Finite A_N for very forward π^0 production was firstly observed by the RHICf experiment.
- We're preparing a multi-dimensional analysis (RHICf-STAR combined analysis) to investigate the origin of the A_N for very forward π^0 production.
- Full-scale analysis will be started within this winter season. → We will show an interesting analysis progress or preliminary in the next meeting!!