Updated template fitting and systematic uncertainties

22 Sep 2021
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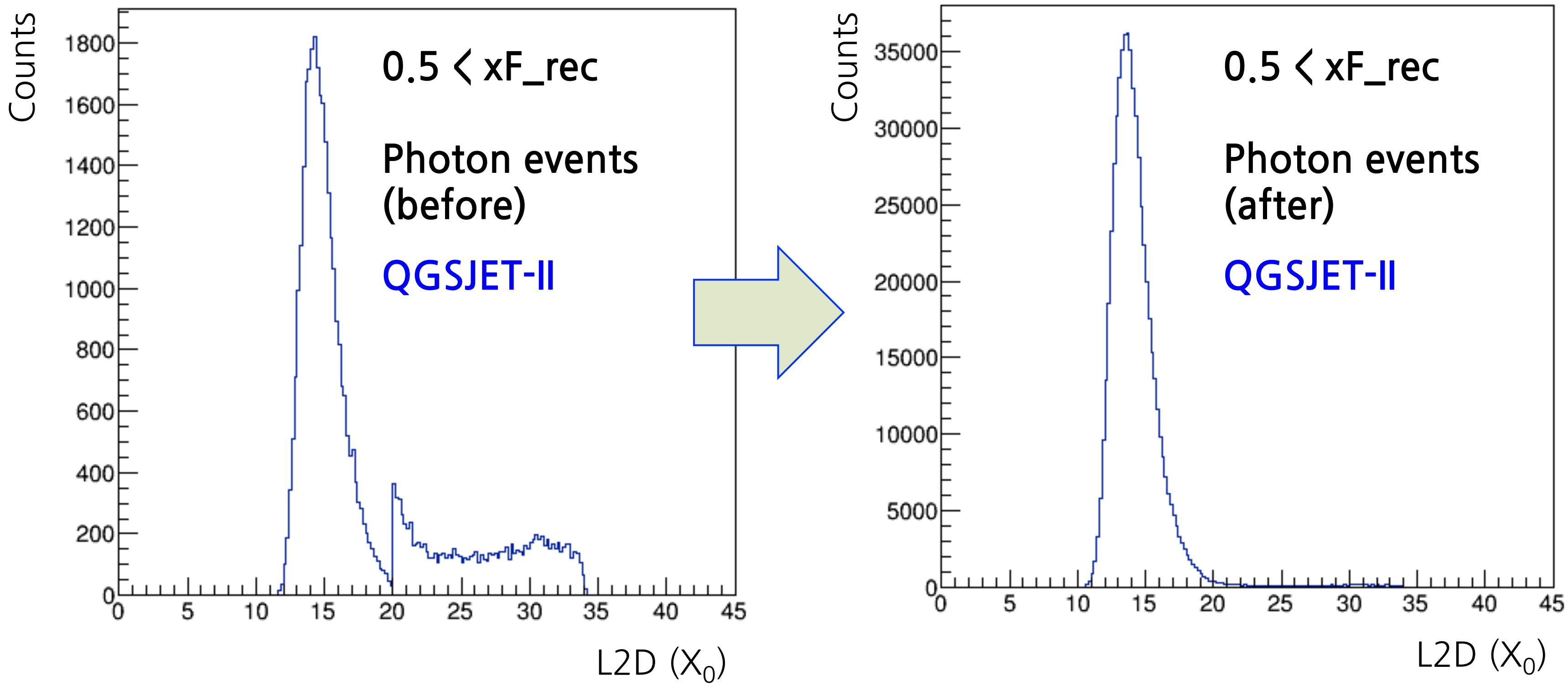
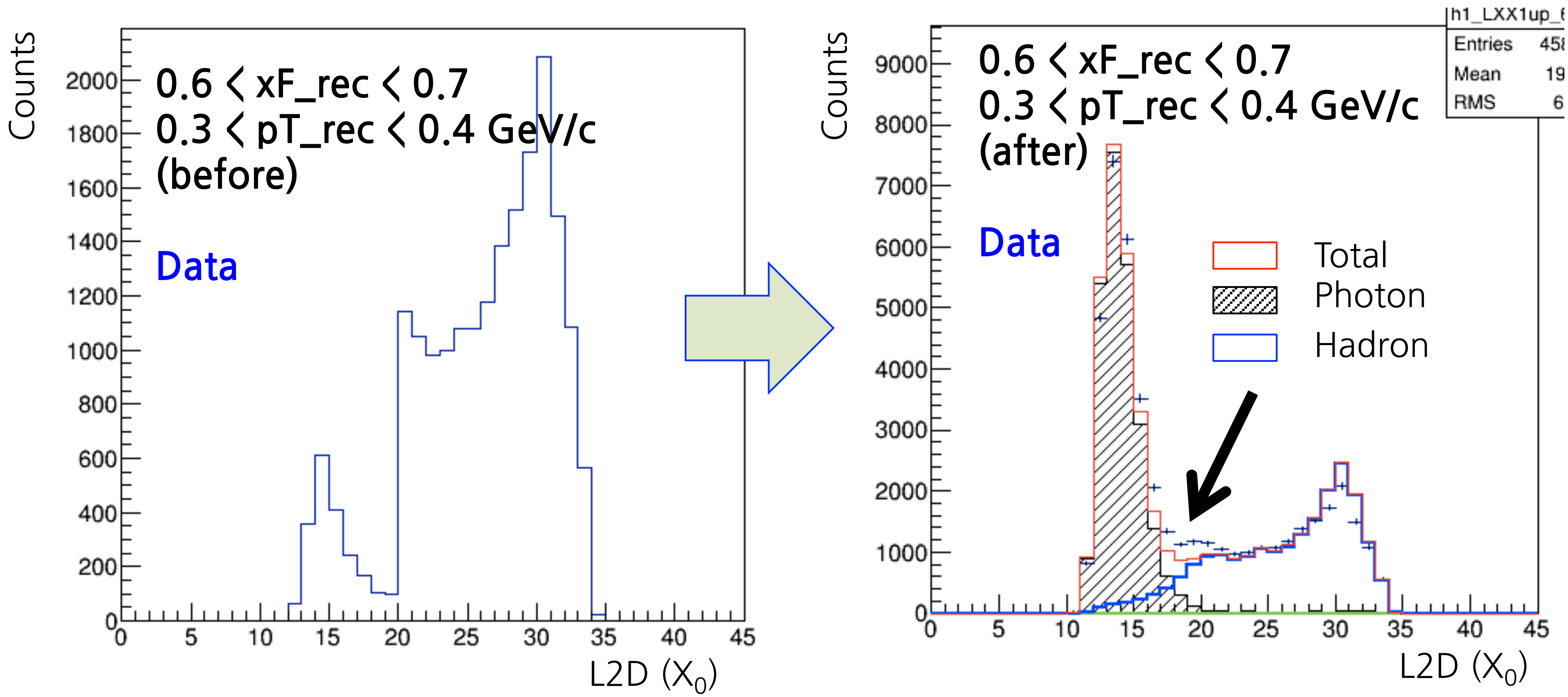
L2D distribution updated



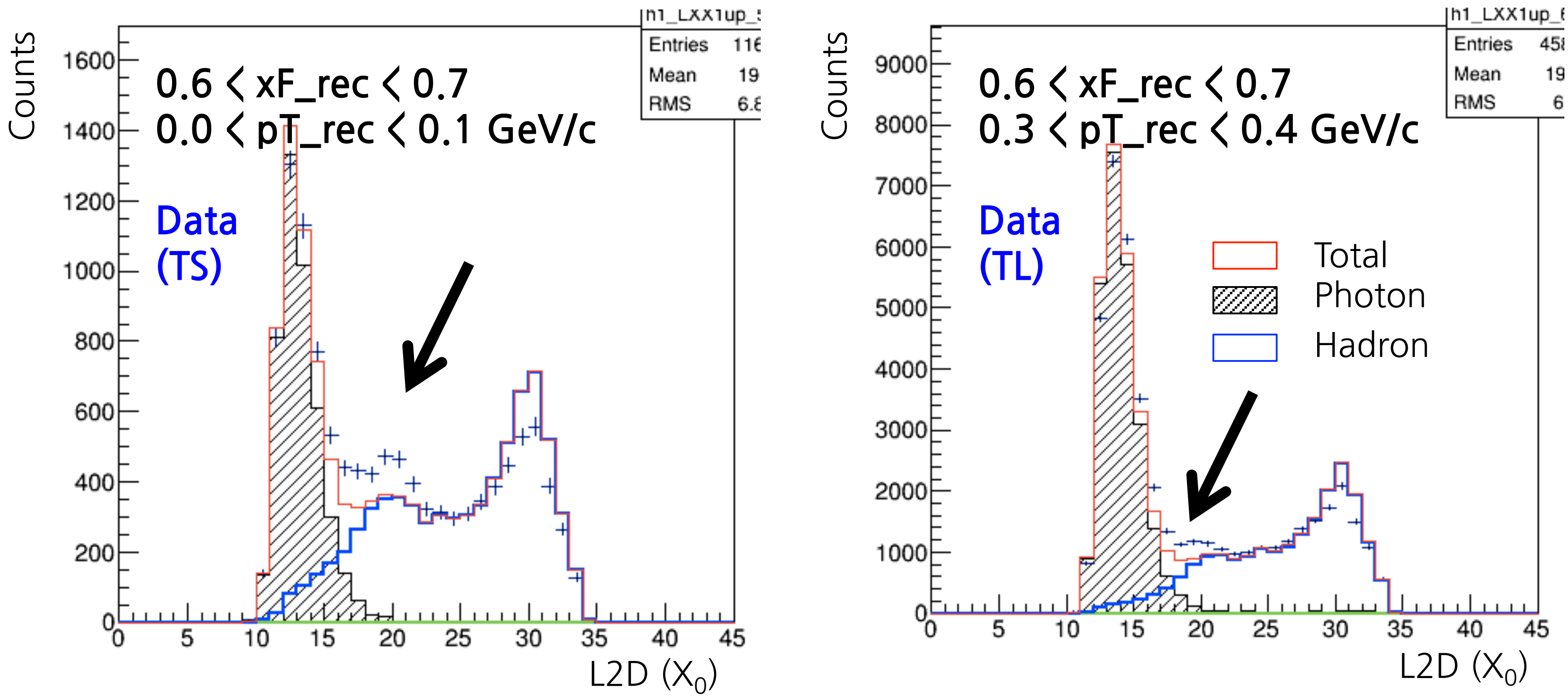
- After the photon energy is reconstructed by neutron energy conversion function, the peak at L2D = 20 in the photon event disappeared.
- Since the photon energy is reconstructed by neutron one, photon events in high x_F increased.

L2D distribution updated



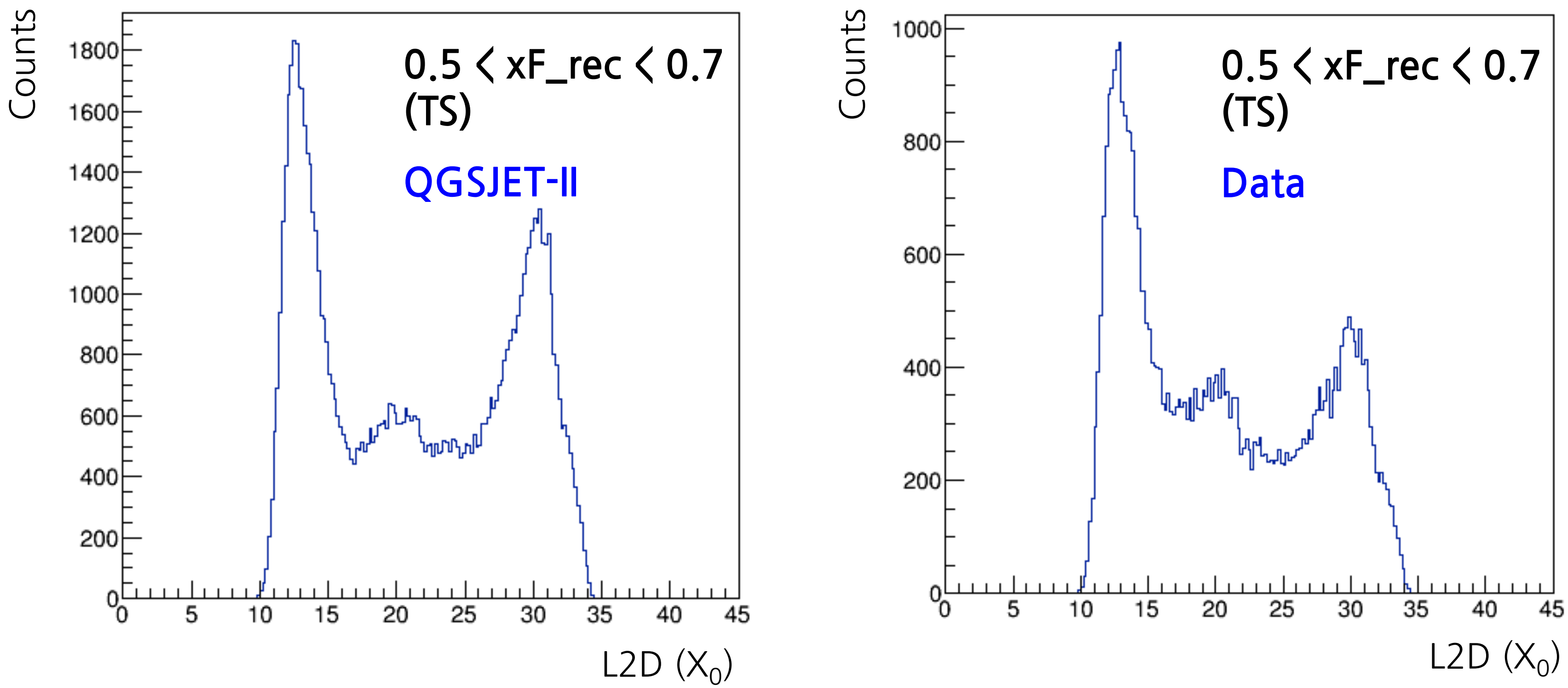
- The template fitting looks well proceeded only with the photon and hadron event.
- However, though the photon peak disappeared, we can see some inconsistency around L2D = 20.

Problem at template fitting



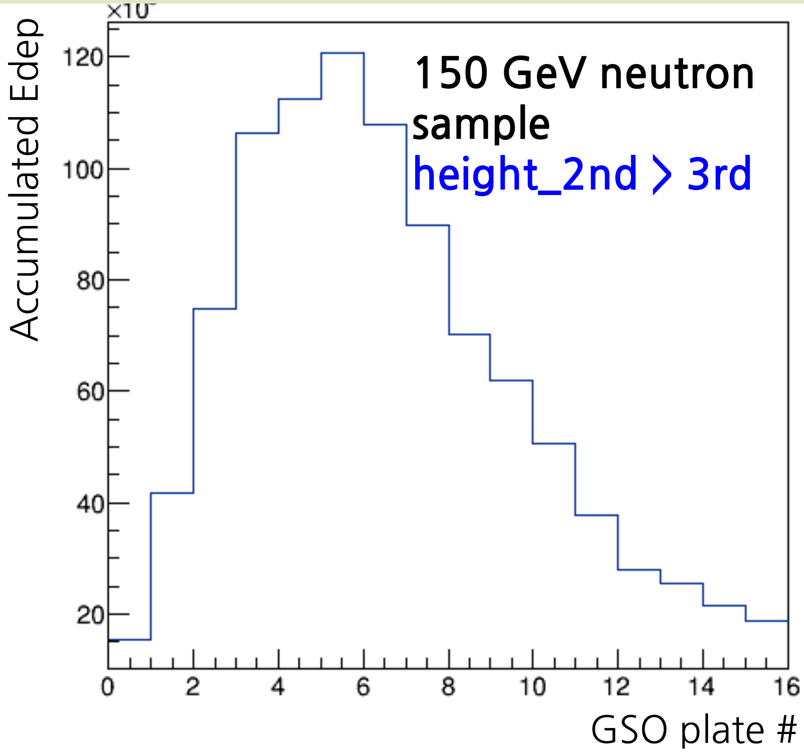
- The inconsistency gets more serious at TS.
- This means the previous peak around L2D = 20 is related with not only the photon events but also the neutron ones.

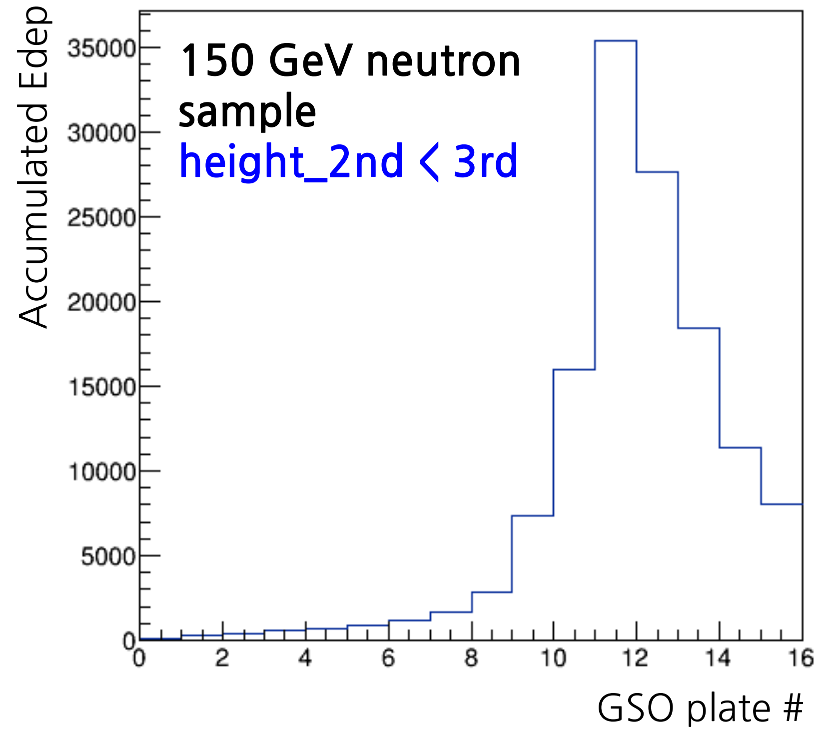
L90 distribution comparison

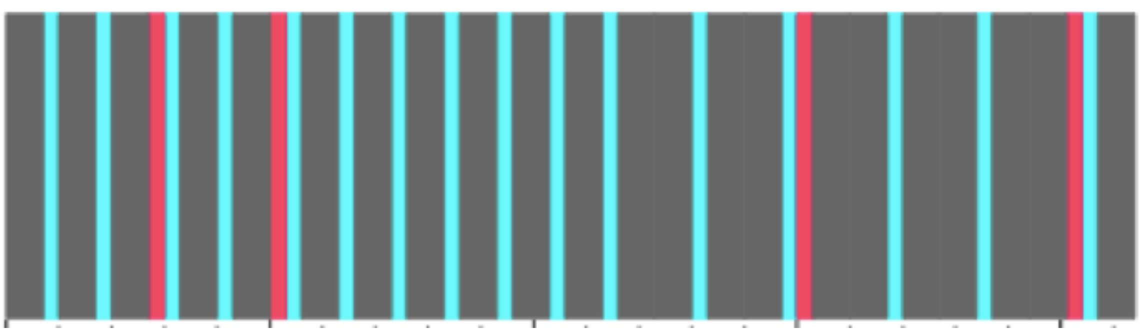


- Two neutron peaks can correspond to early and late shower development.
- It seems that the ratio of two events is different between simulation and data due to their different energy distributions.
- It is necessary to assign different weight for two types of shower developments.

Two types of shower development

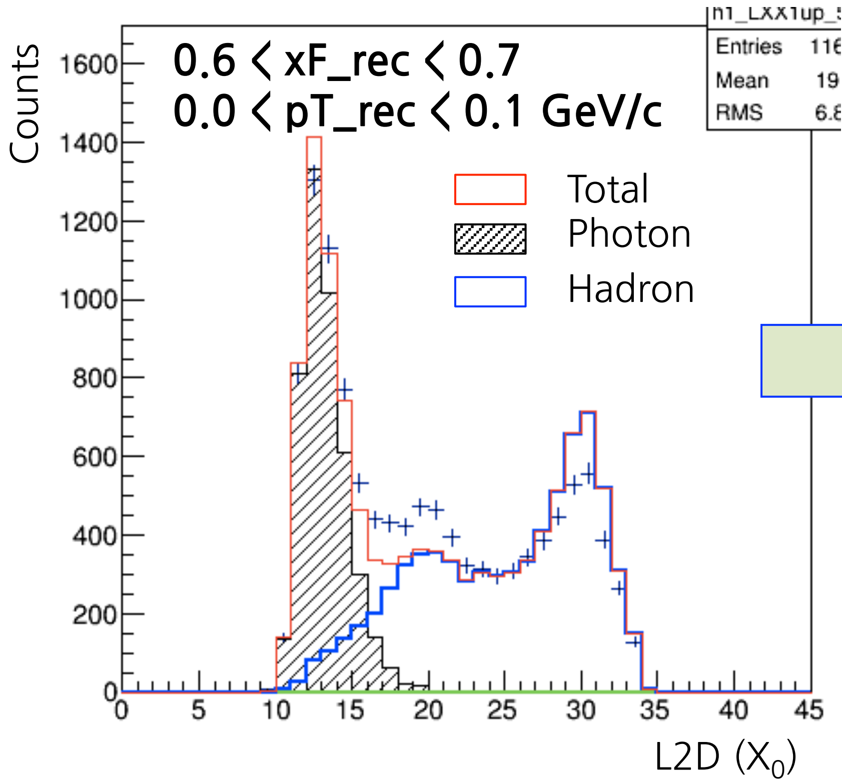


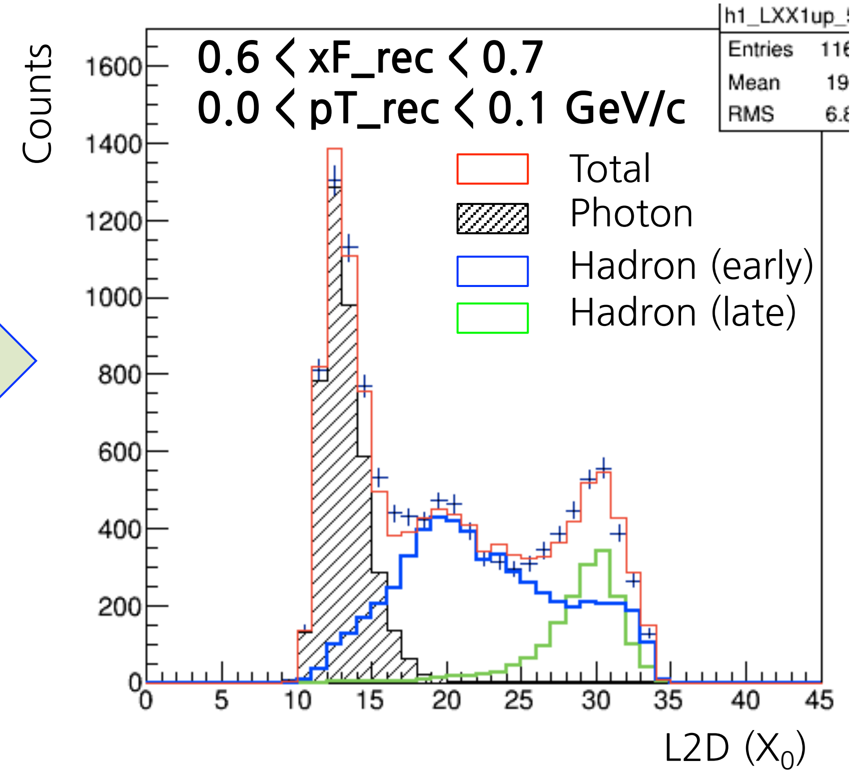




- We can separate the early and late shower developments by comparing the peak heights of 2nd and 3rd GSO bar layers.

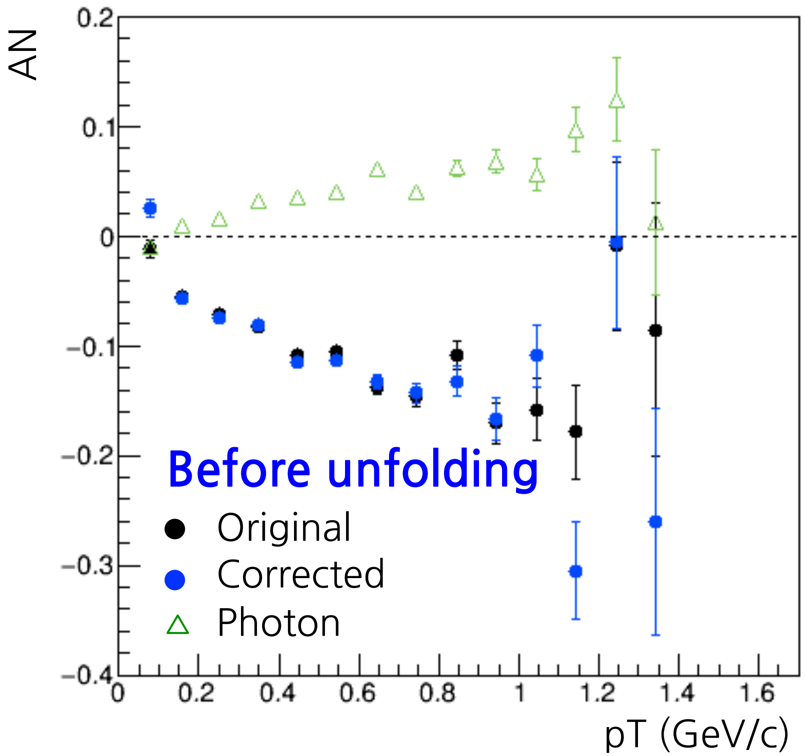
Improved template fitting

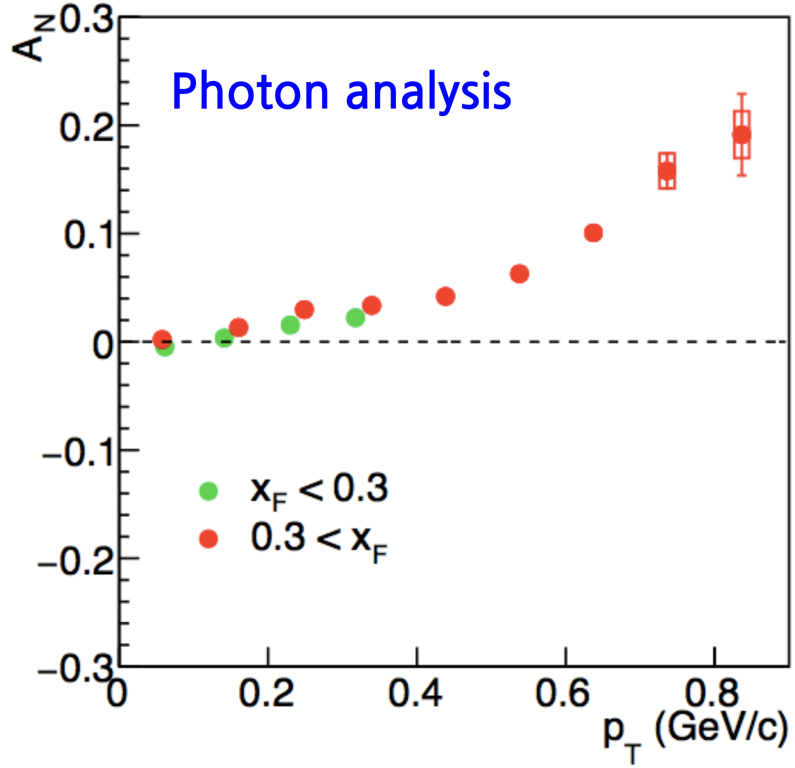




- One can see the template fitting result has been improved.
- For more precise energy reconstruction and unfolding, only the events of early shower development was counted with a L2D cut of L2D > 21.
- Photon contamination is less than 5%.

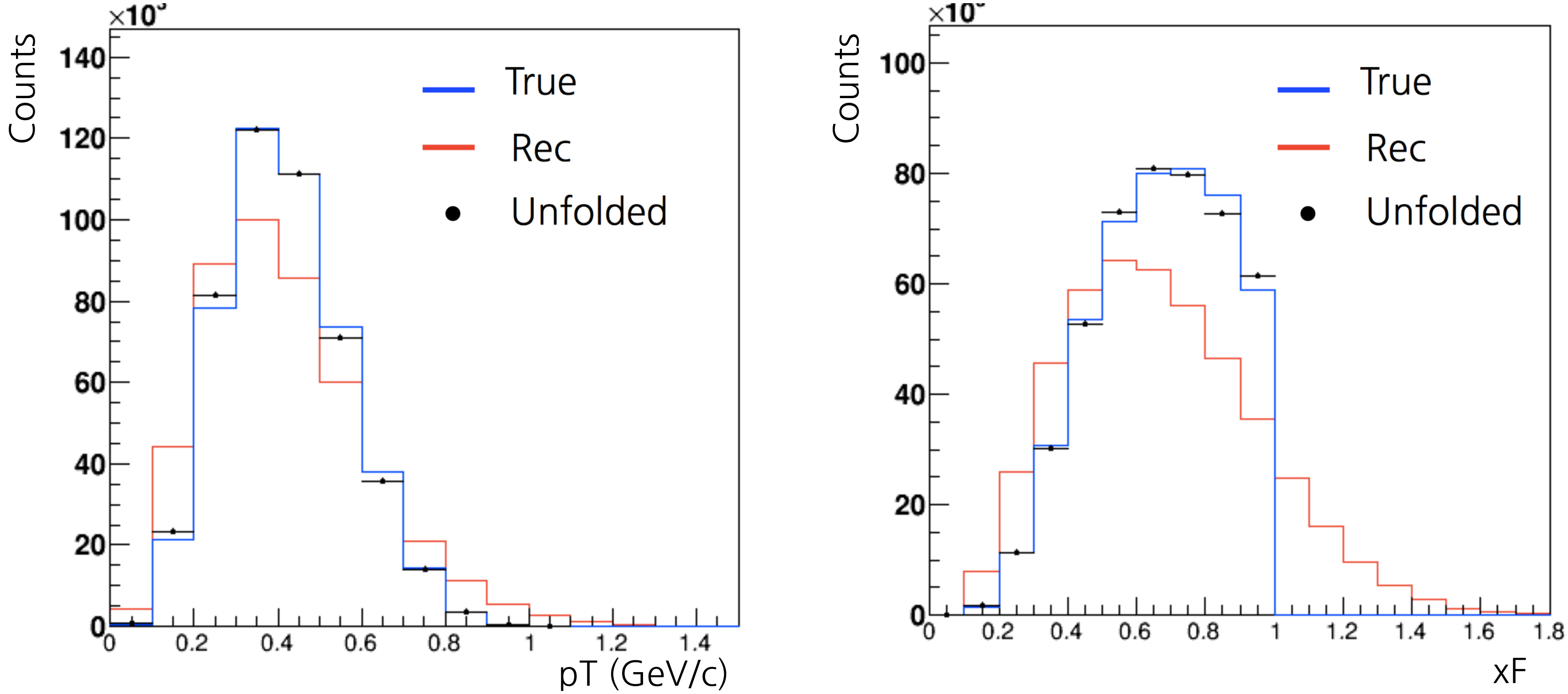
Photon asymmetry





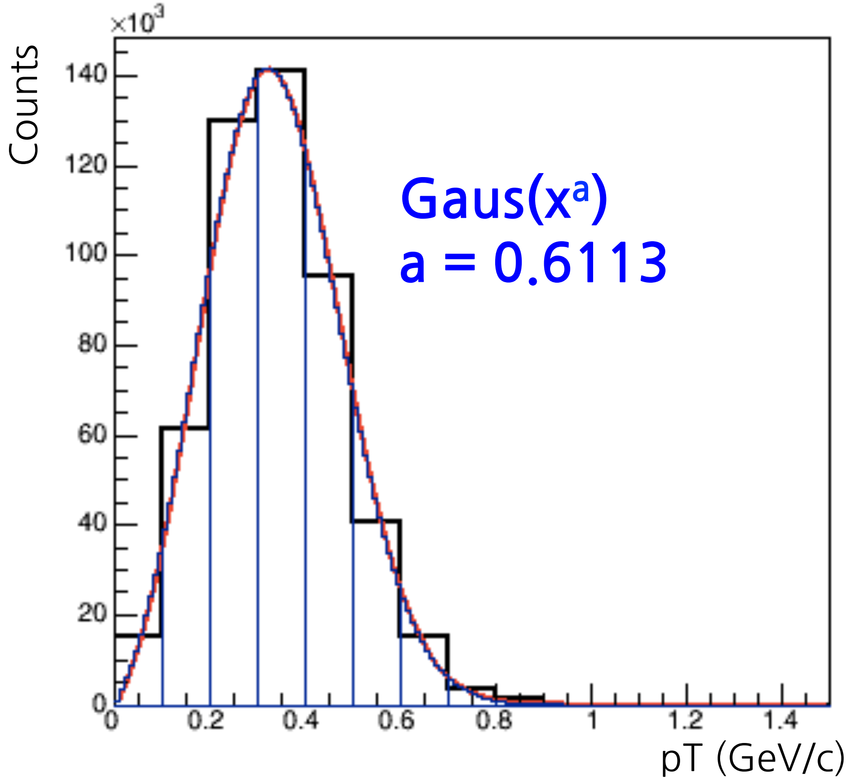
- Photon contamination already includes the non-zero asymmetry of π^0.
- If we count only the number of hadrons in the template fitting, we can be free from the photon asymmetry contamination.

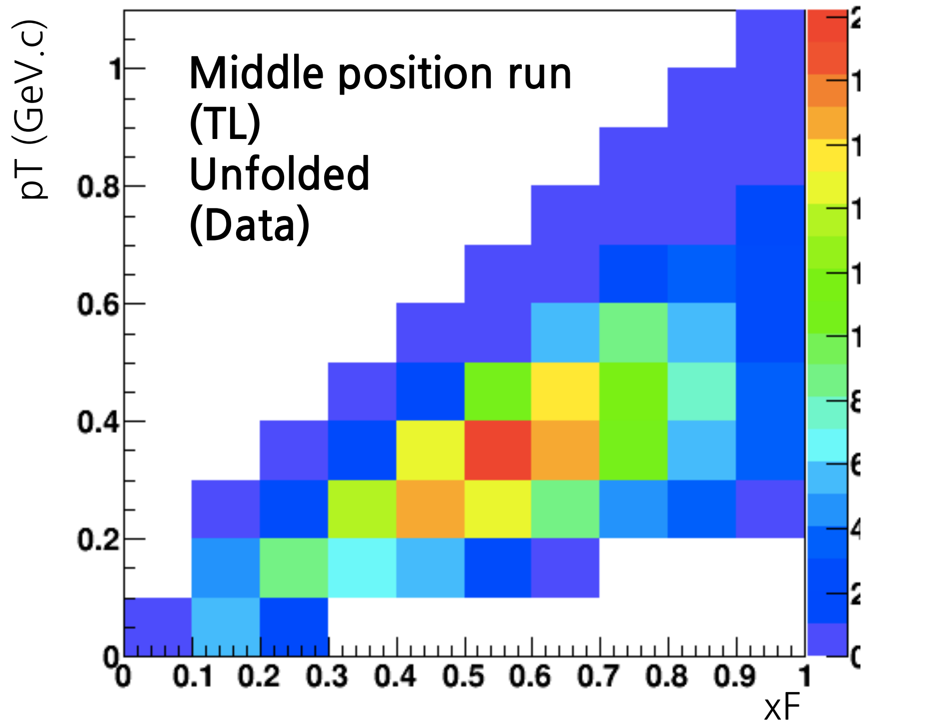
2D (x_F, p_T) Bayesian unfolding



- Single neutrons with randomized energy and direction were uniformly generated (flat distribution).
- Number of iteration was done until the $\Delta\chi^2$ get smaller than 1, it was 18 for simulation (10 times higher statistics than data) and 27 for data.
- Statistical fluctuation of each bin was considered as systematic uncertainty of unfolding.

⟨p_T⟩ estimation

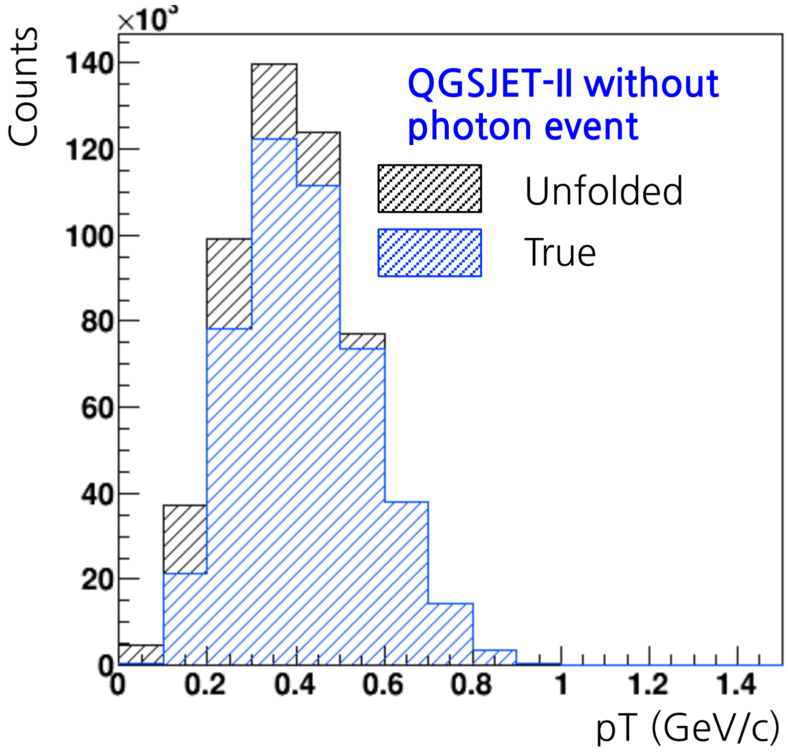


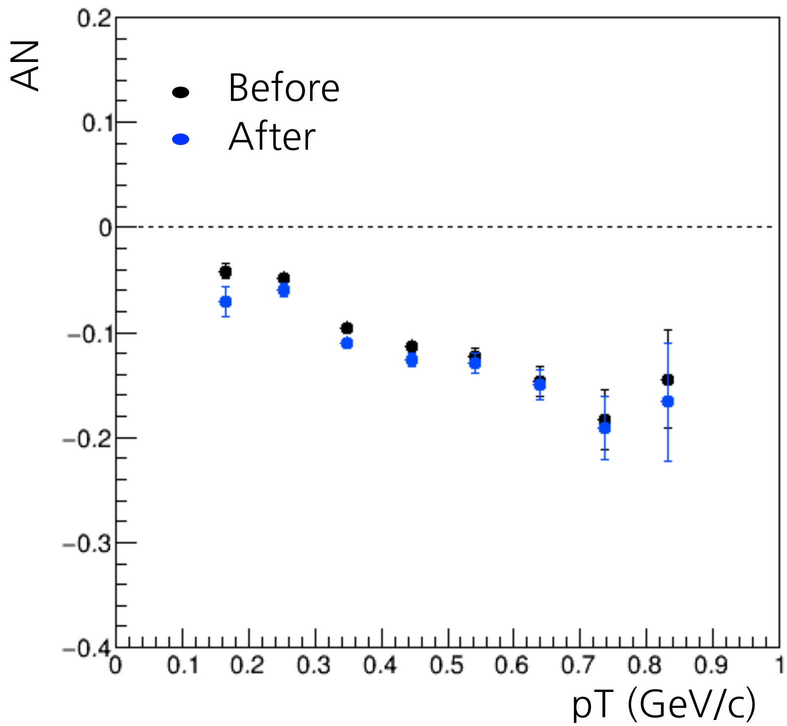


- x_F vs p_T map was projected to the p_T axis to estimate the overall p_T distribution.

- The ⟨p_T⟩ was calculated using the Gaussian-based function which fit the p_T distribution.

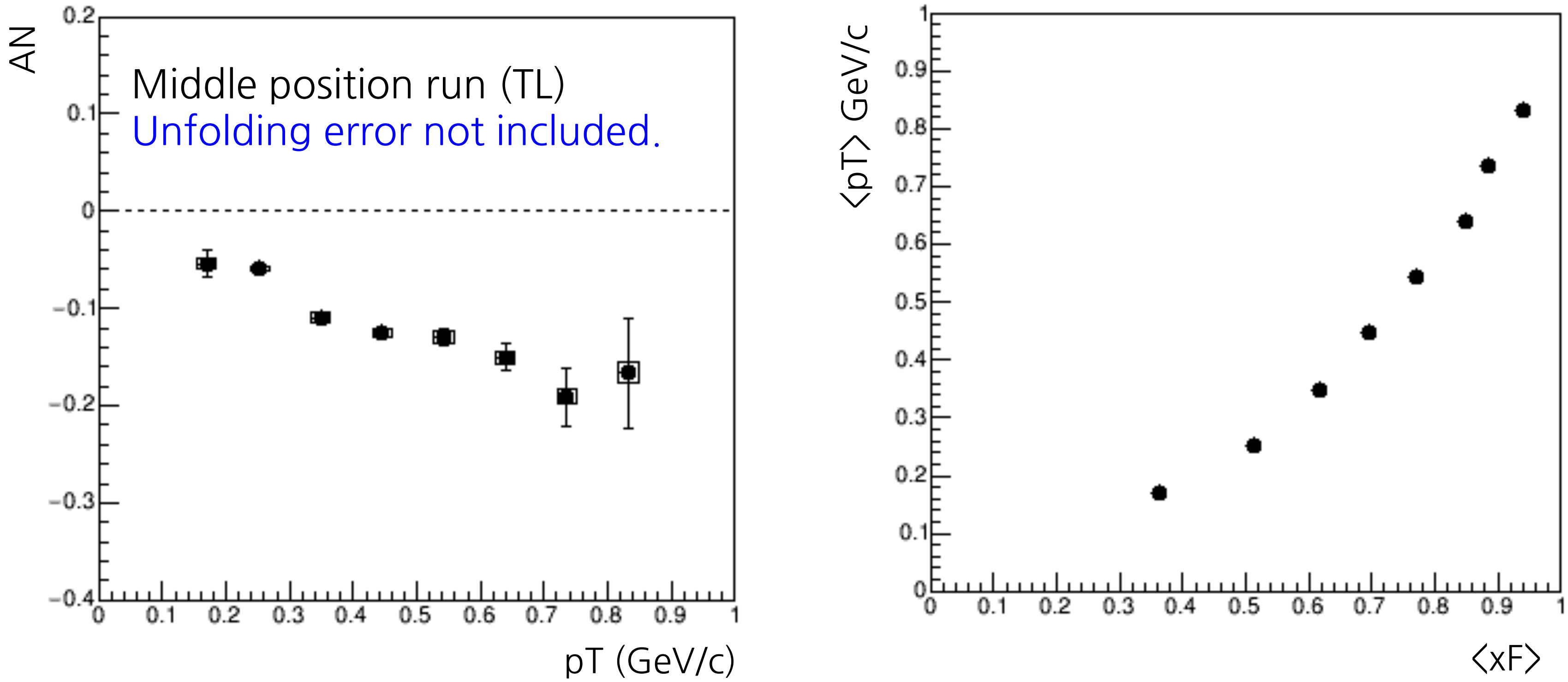
Background A_N subtraction





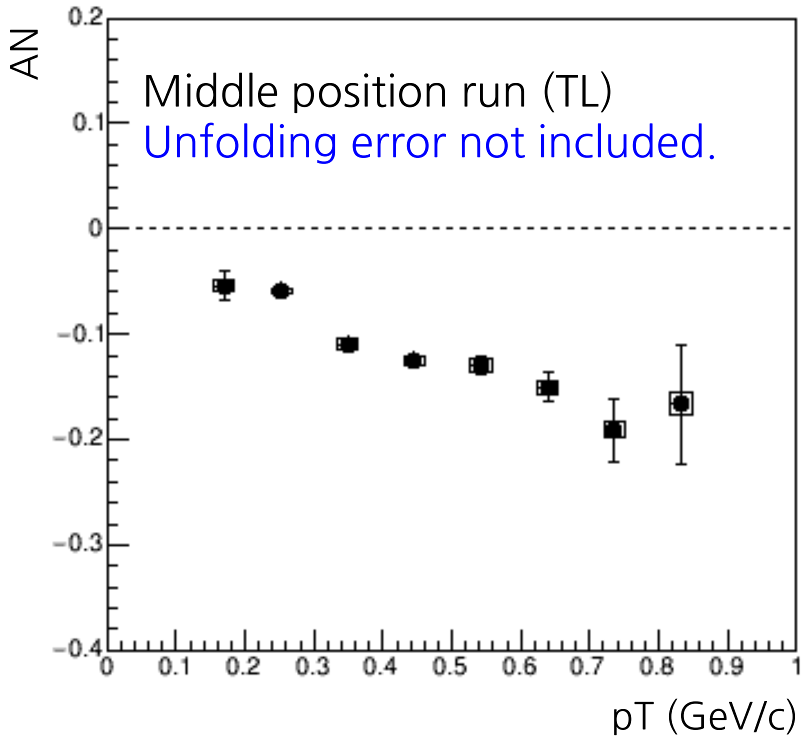
- QGSJET-II sample "without photon" was unfolded by neutron flat distribution.
- Fraction of unfolded to true neutron distribution of each bin was considered as the background fraction.
- It was assumed that the background A_N was zero.

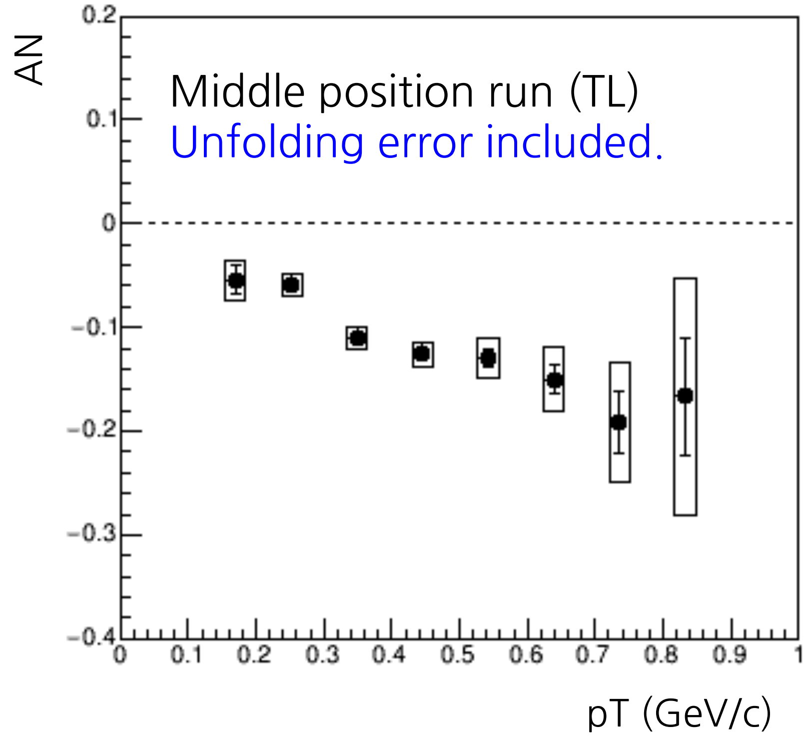
Neutron A_N as a function of p_T



- As it was expected, the A_N increases as a function of p_T.

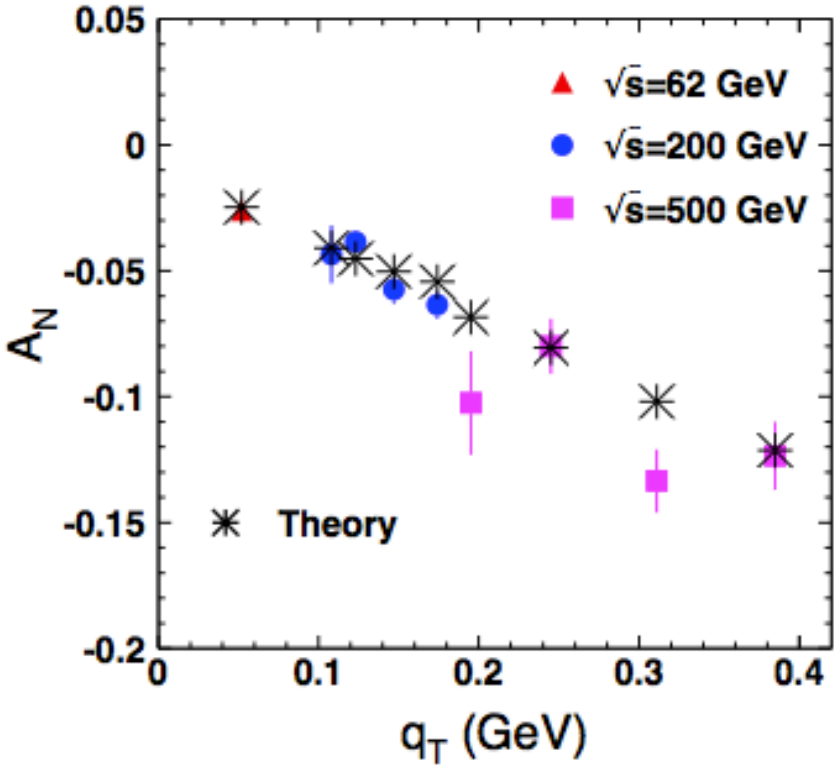
Neutron A_N as a function of p_T

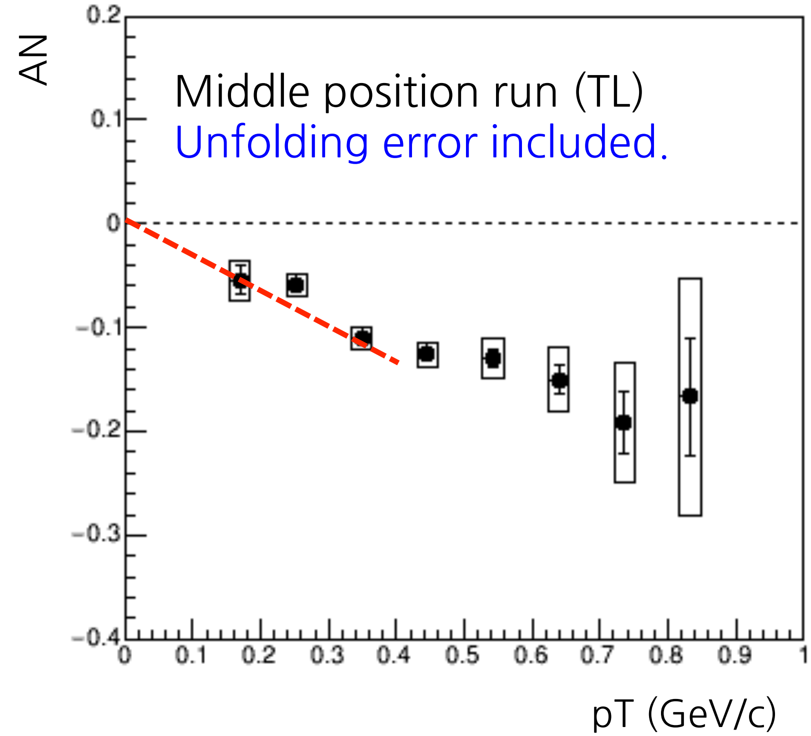




- As it was expected, the A_N increases as a function of p_T.
- Statistical uncertainty of unfolding is numerically ~ 2 x$\sqrt{N}$.

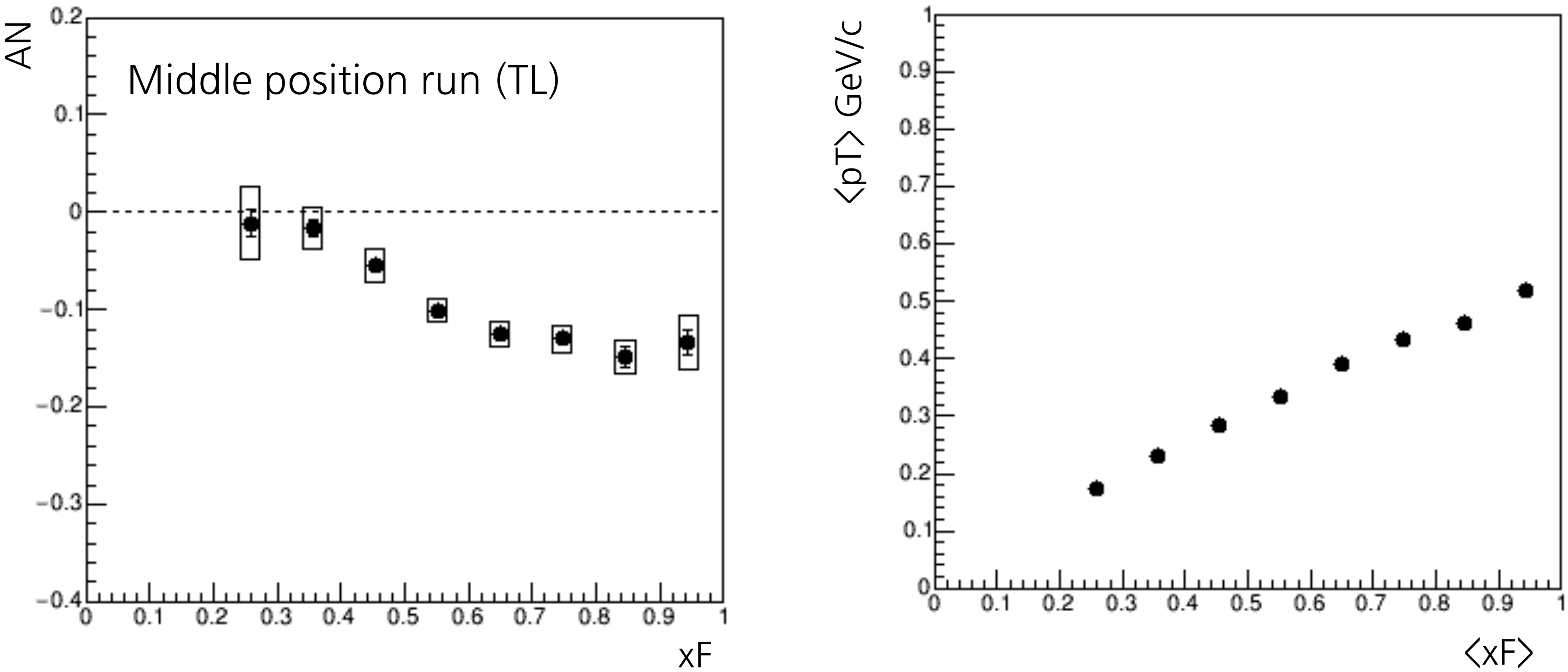
Neutron A_N as a function of p_T





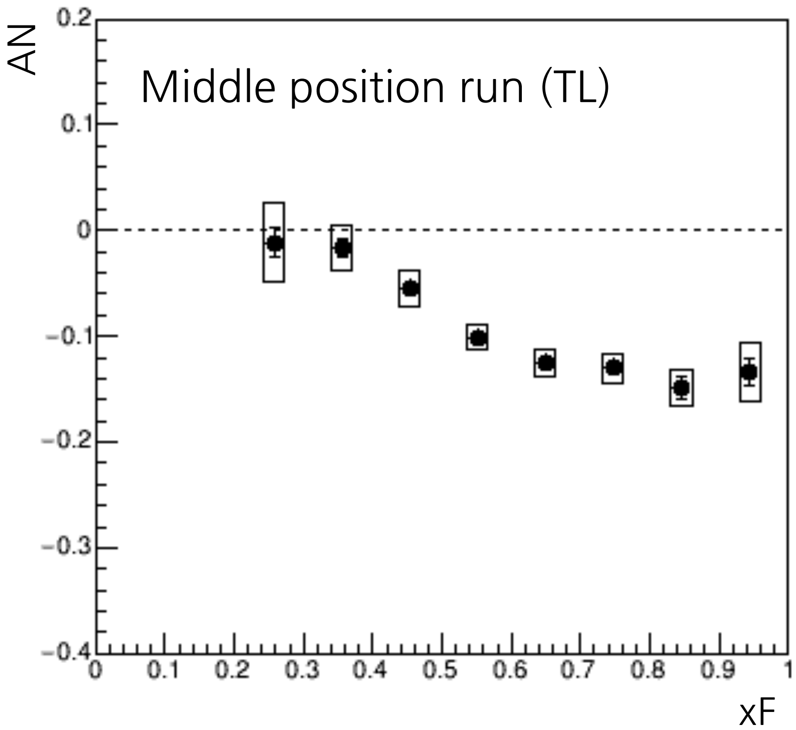
- As it was expected, the A_N increases as a function of p_T.
- Statistical uncertainty of unfolding is numerically ~ 2 x$\sqrt{N}$.
- The RHICf data looks consistent with previous results.
  ($\langle x_F \rangle_{PHENIX}$ = 0.7~0.8 and $\langle x_F \rangle_{RHICf}$ = 0.3~0.6)

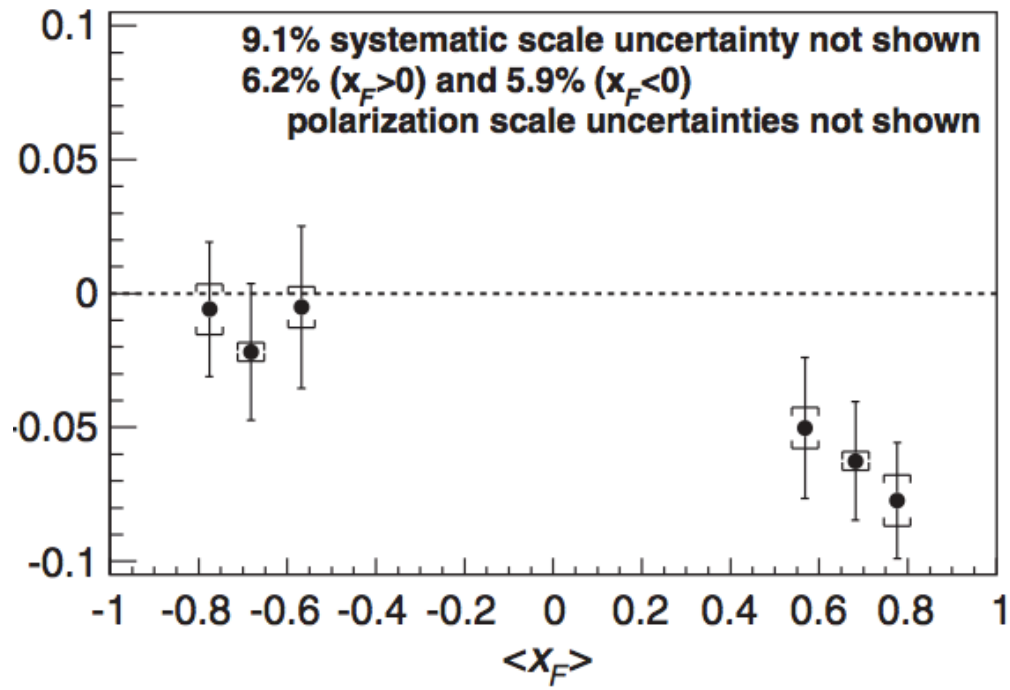
Neutron A_N as a function of x_F



- Increasing neutron A_N as a function of p_T is also shown in x_F plot because bigger x_F makes bigger p_T.

Neutron A_N as a function of x_F





- Increasing neutron A_N as a function of p_T is also shown in x_F plot because bigger x_F makes bigger p_T.
- The RHICf data looks have bigger A_N than previous results. ($\langle p_T \rangle_{PHENIX} < 0.2$ GeV/c and $\langle p_T \rangle_{RHICf} > 0.2$ GeV/c)