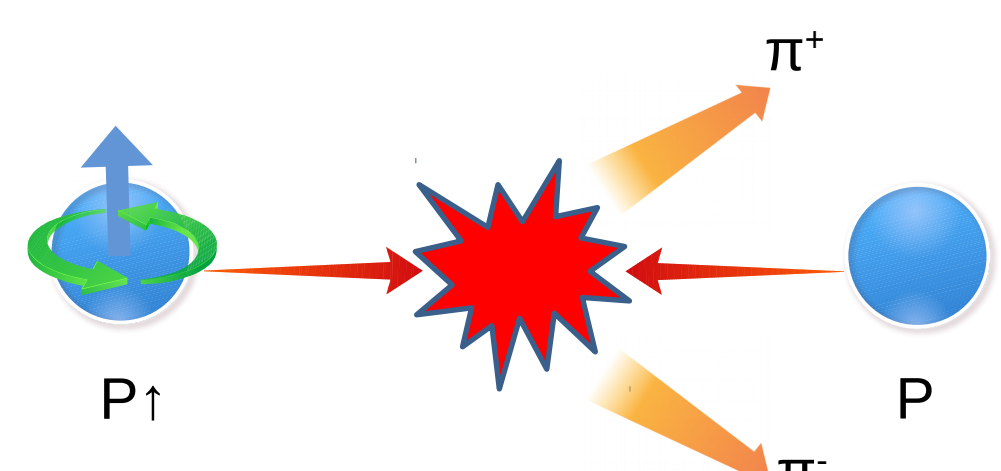


Transverse Spin Dependent Azimuthal Correlations of Charged Pion Pairs in $p^\uparrow + p$ Collisions at $\sqrt{s} = 510$ GeV Using Run 2017 Data



Motivation



Parton Distribution Function(PDFs)

Parton Distribution Function probe the internal structure of proton.

- Unpolarized PDF, $f_1(x)$
- Helicity PDF, $g_1(x)$
- Transversity PDF, $h_1^q(x)$

Unlike $f_1(x)$ and $g_1(x)$, $h_1^q(x)$ requires chiral-odd partner (Transverse Spin Dependent Fragmentation Function, $H_1^\zeta(z,M)$)

– Only the combination of both can be experimentally accessed through an asymmetry measurement.

Observable

The transversely polarized cross-section of hadron pairs in $p^\uparrow + p$ collision is given by

$$d\sigma_{UT} \propto \sin(\phi_{RS}) \int dx_a dx_b f_1(x_a) h_1(x_b) \frac{d\Delta\hat{\sigma}}{dt} H_1^\zeta(z, M)$$

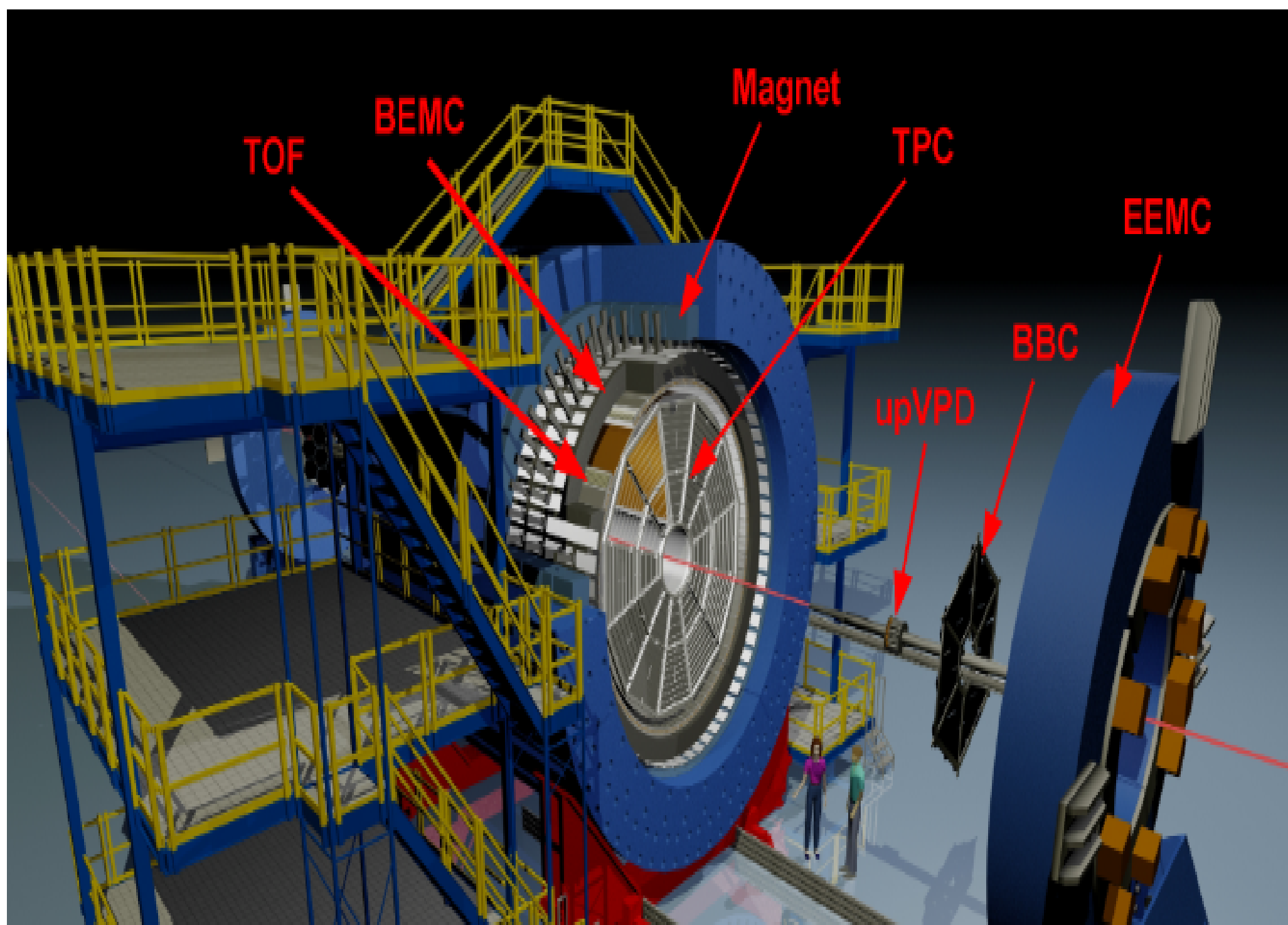
$\rightarrow \hat{\sigma}$ = polarized parton cross-section with four momentum transfer t
 $\rightarrow f_1(x_a)$ = unpolarized parton distribution function.

The convolution of $h_1^q(x)$ and $H_1^\zeta(z, M)$ gives asymmetry A_{UT} , Single Spin Asymmetry, experimental observable which is proportional to differential cross-section

$$A_{UT} \cdot P \cdot \sin(\phi_{RS}) = \frac{\sqrt{N^\uparrow(\phi_{RS})N^\downarrow(\phi_{RS}+\pi)} - \sqrt{N^\downarrow(\phi_{RS})N^\uparrow(\phi_{RS}+\pi)}}{\sqrt{N^\uparrow(\phi_{RS})N^\downarrow(\phi_{RS}+\pi)} + \sqrt{N^\downarrow(\phi_{RS})N^\uparrow(\phi_{RS}+\pi)}}$$

STAR Experiment Solenoidal Track At RHIC

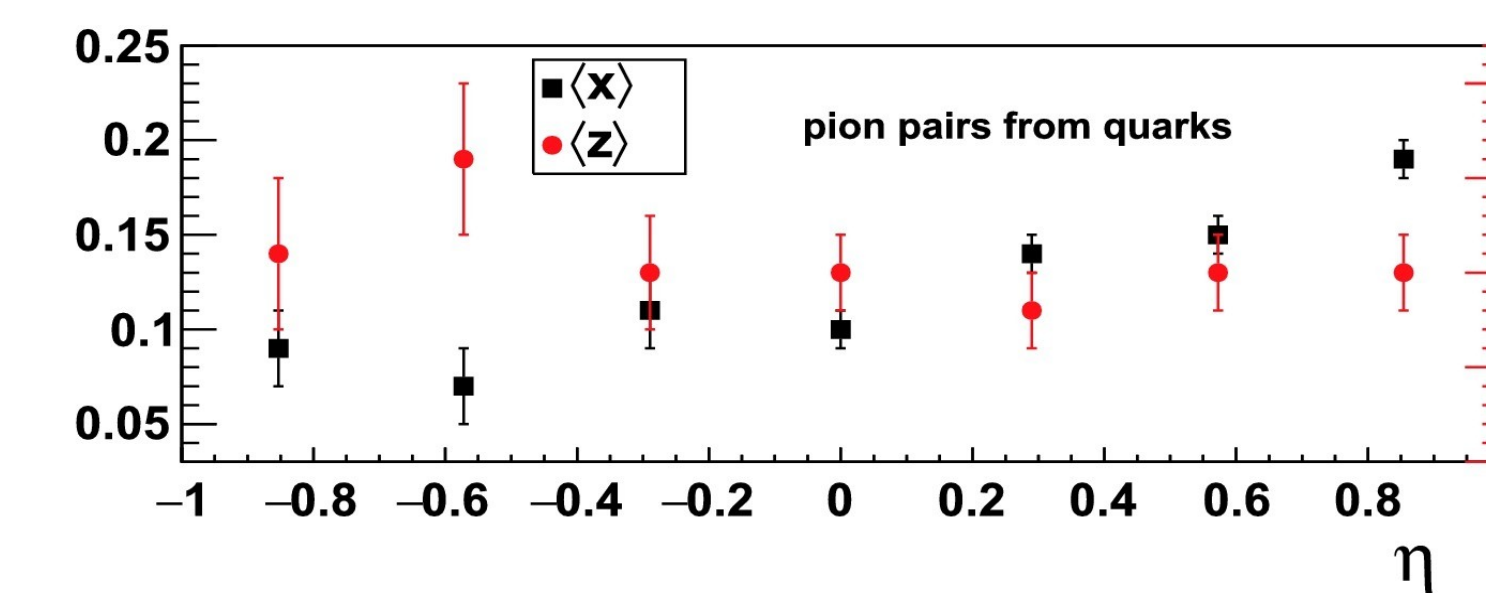
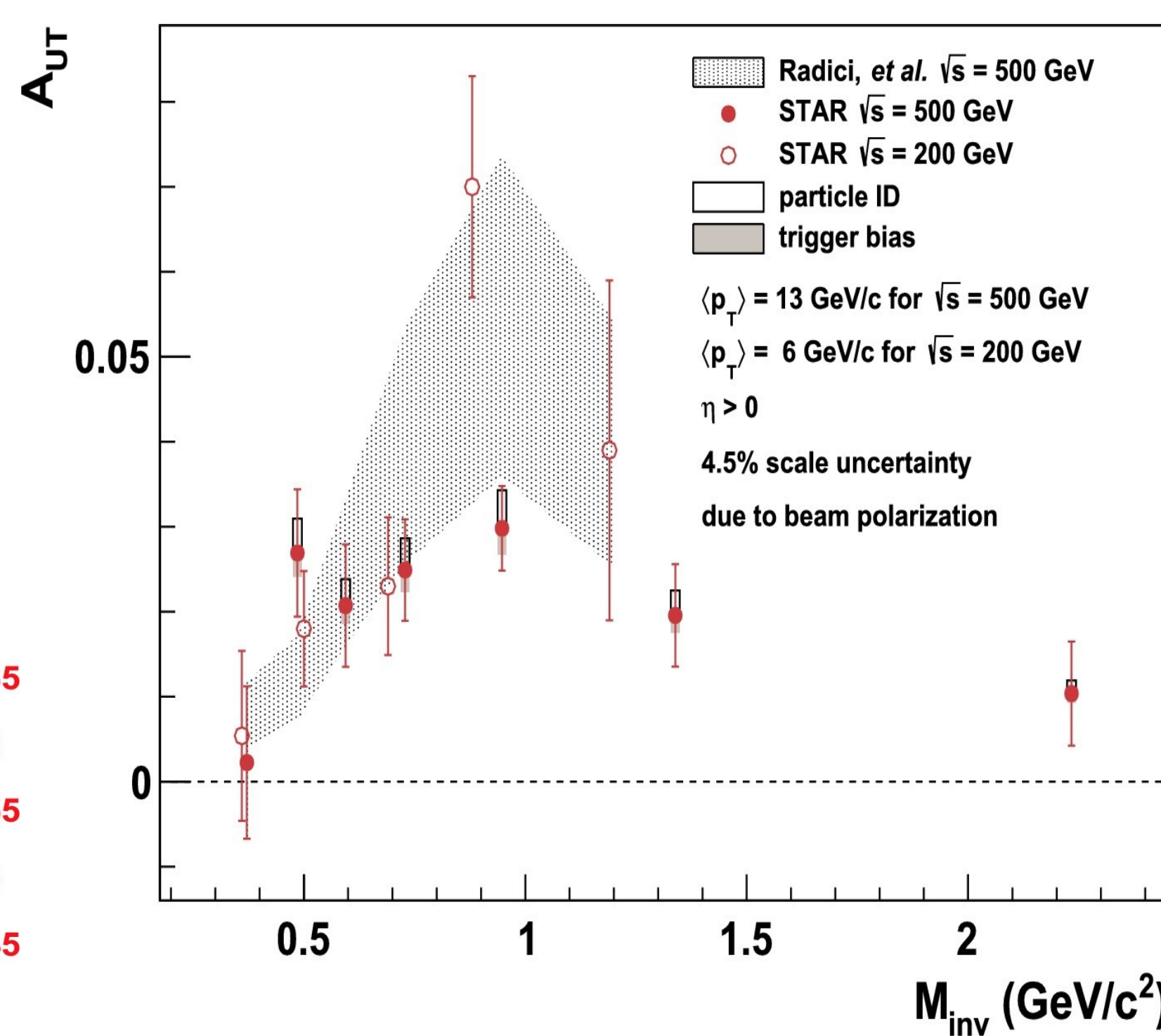
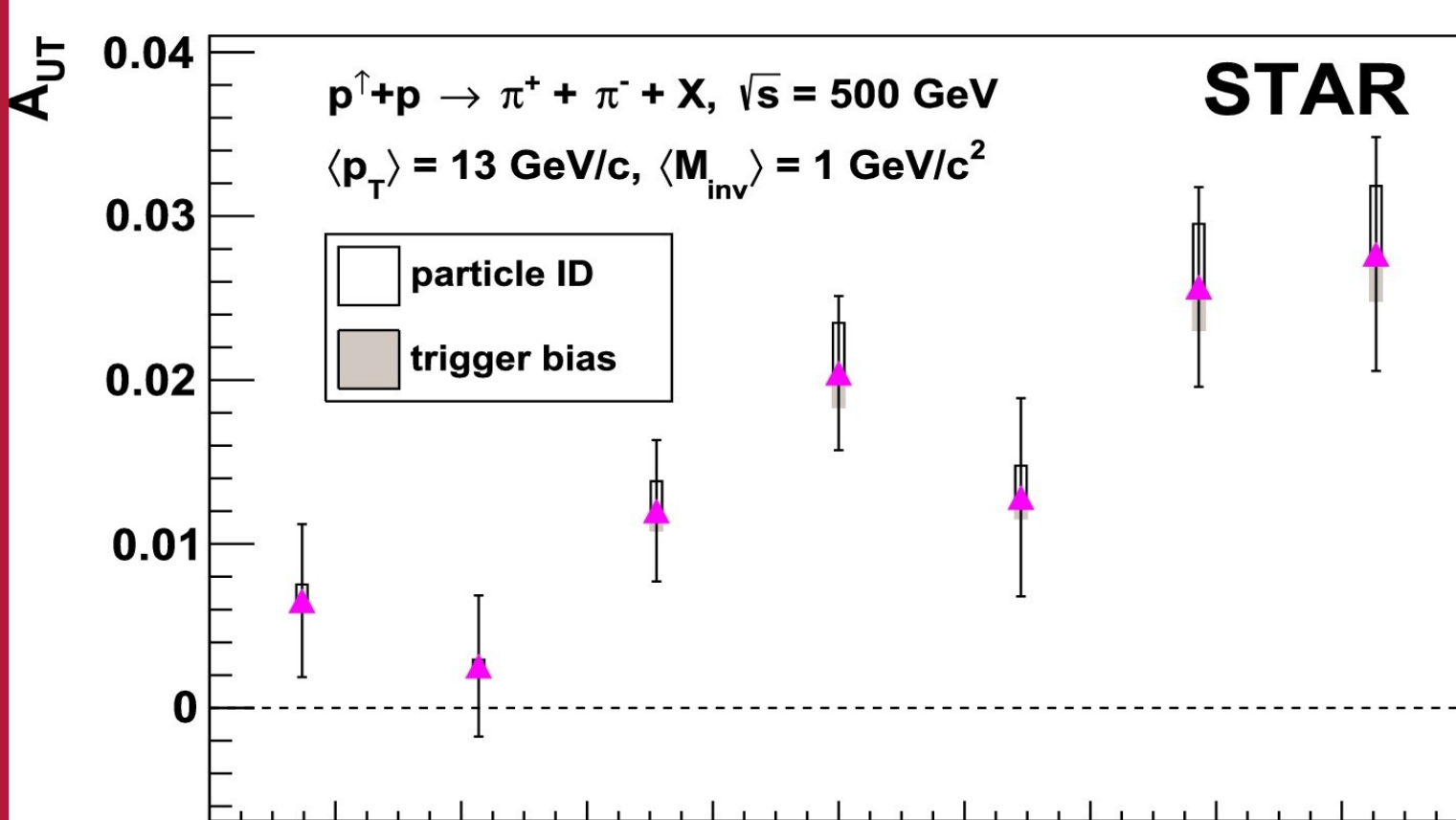
- Magnetic Field $B = 0.5$ T
- TPC, $|\eta| < 1$, $0 < \phi < 2\pi$
→ Tracking-momentum measurement
- Particle Identification based on energy loss dE/dx .
- BEMC/EEMC, $-1 < \eta < 2$, $0 < \phi < 2\pi$
→ Trigger on high- p_T charged particle
- TOF, $-1 < \eta < 1$, $0 < \phi < 2\pi$
→ Particle identification based on time of flight.
- ZDC/VPD
→ Monitors luminosity



Previous Result

(L. Adamczyk *et al.* (STAR Collaboration), Transverse spin-dependent azimuthal correlations of charged pion pairs measured in $p^\uparrow + p$ collisions at $\sqrt{s} = 500$ GeV, Phys. Lett. B 780, 332 (2018))

Single Spin Asymmetry (A_{UT}) observed for several kinematic variables (x, z), pseudorapidity (η), Invariant mass (M_{inv}) and transverse momentum of Pion pair (p_T) for transverse $p^\uparrow + p$ collision at $\sqrt{s} = 500$ GeV for Run 2011 with integrated luminosity ≈ 25 pb $^{-1}$.



A_{UT} (top) and kinematic variables, $\langle x \rangle$ and $\langle z \rangle$ (bottom), plotted as a function of η for $\langle p_T \rangle = 13$ GeV/c for pion pairs.

A_{UT} as a function of invariant mass in the highest p_T bin consistent with STAR Run 6 ($\sqrt{s} = 200$ GeV) results and theoretical predictions

Track and Pair Selection

Vertex Selection	$ z\text{-vertex} < 90$ cm	Particle Momentum	> 2 GeV/c
Pseudorapidity	$-1 < \eta < 1$	Sigma Cut	$-1 \leq n\sigma_\pi \leq 2$
Pion Pair Momentum	≥ 3.75 GeV/c	Pion Separation	$\sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} \leq 0.7$

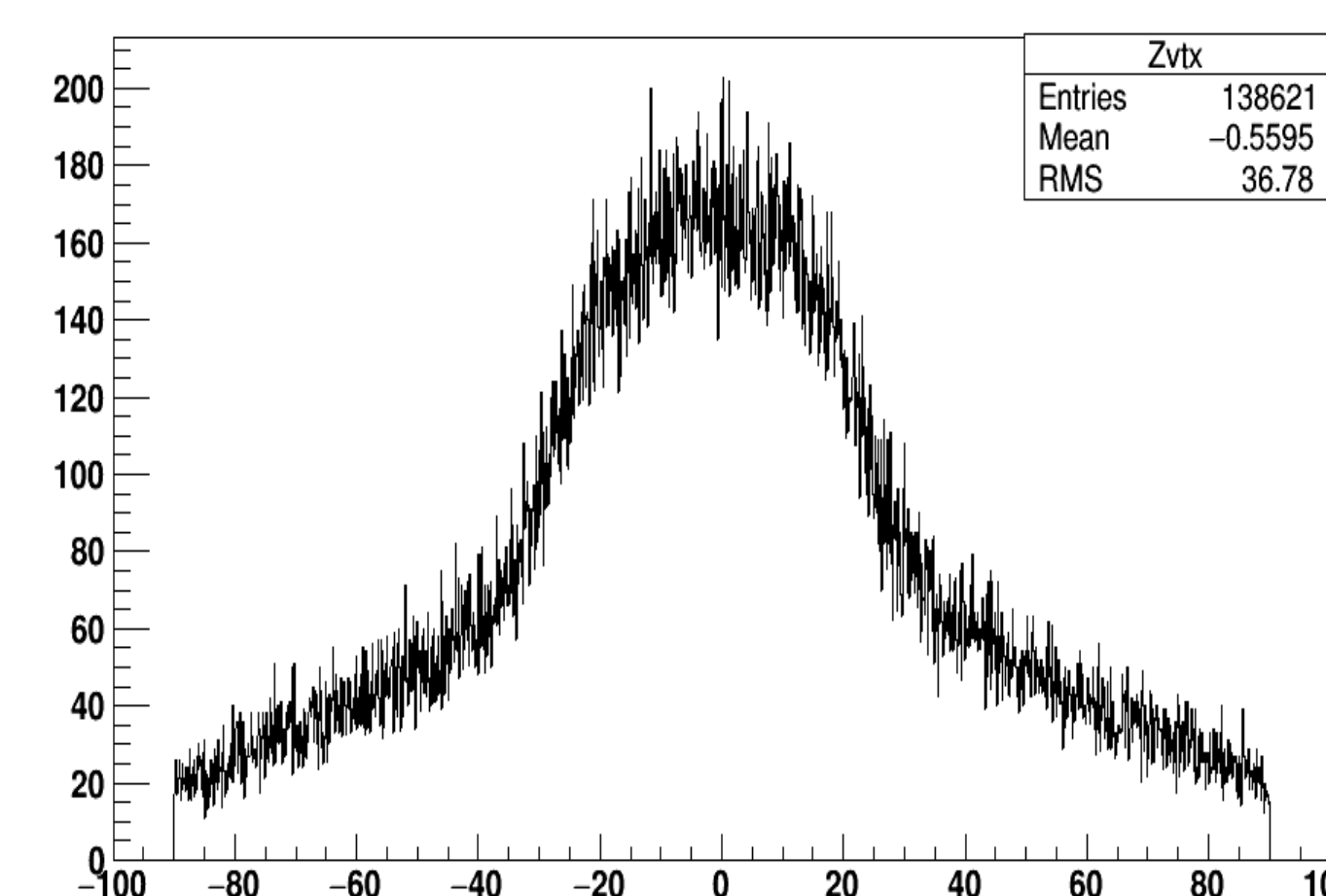
Status of Run 2017 Analysis

- Small Sample of data set has been looked at (less than 1 %)
- Only limited selection cuts are applied to the plots.

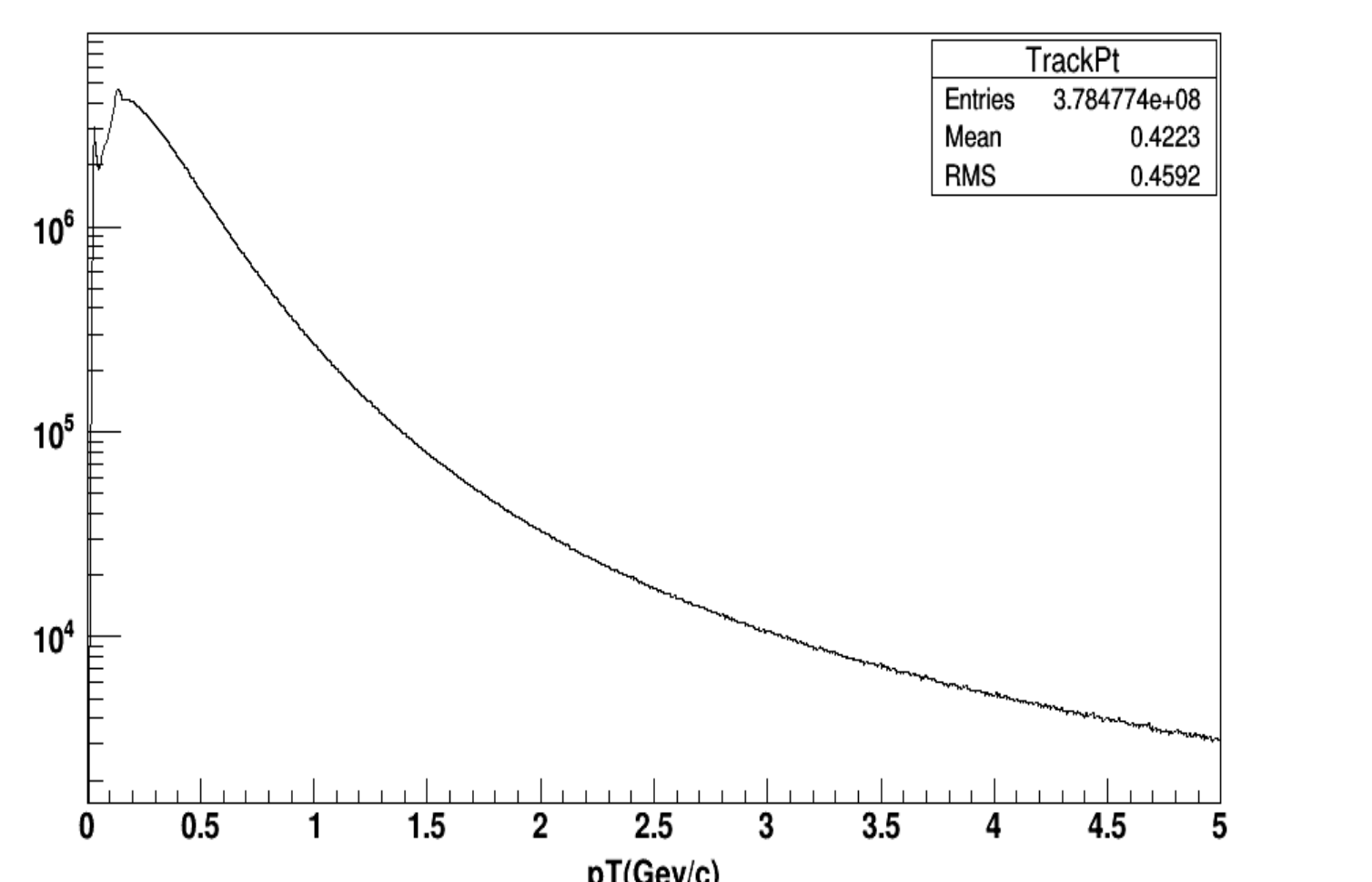
Track Selection

Z-vertex	± 90 cm	nHitMin	5
Sigma cut	$-2 < n\sigma_\pi < 2$	nHitMax	100
Pseudorapidity	$-1 < \eta < 1$	nHitsPossMin	5
TOF cut	< 0.03 (only if available)	FitRatio	0.52

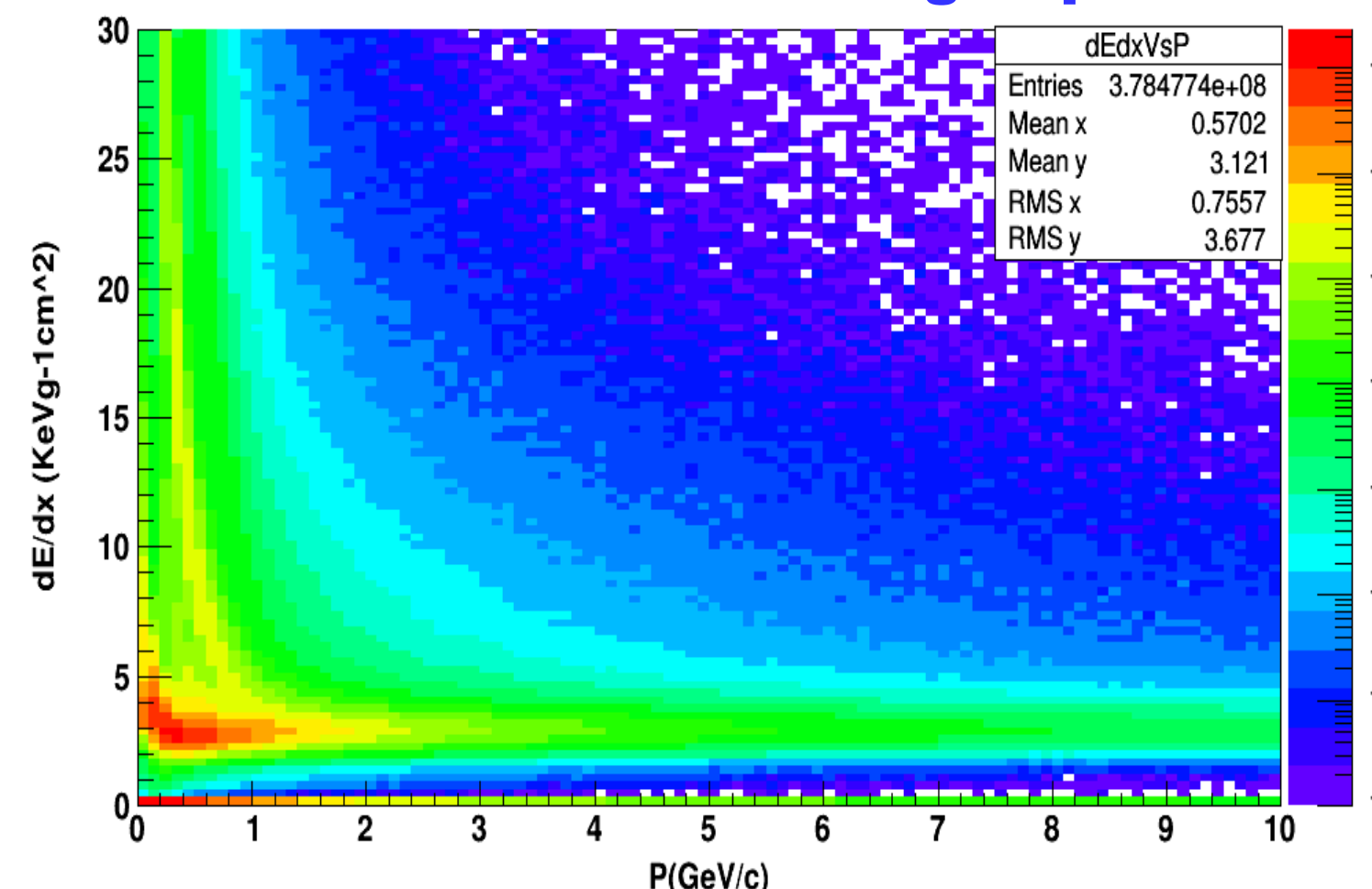
Z-vertex distribution



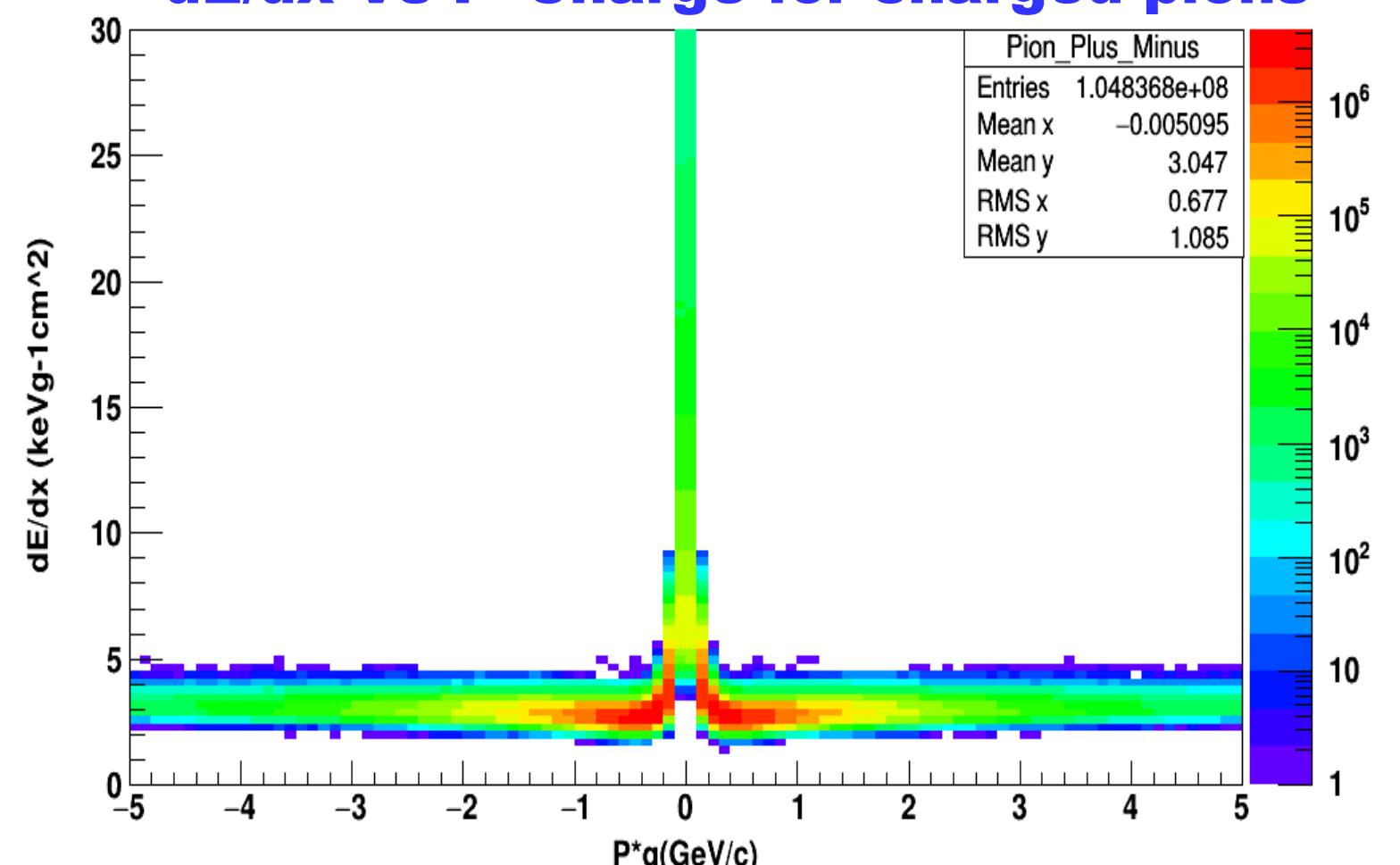
Track Tras. Momentum Distribution



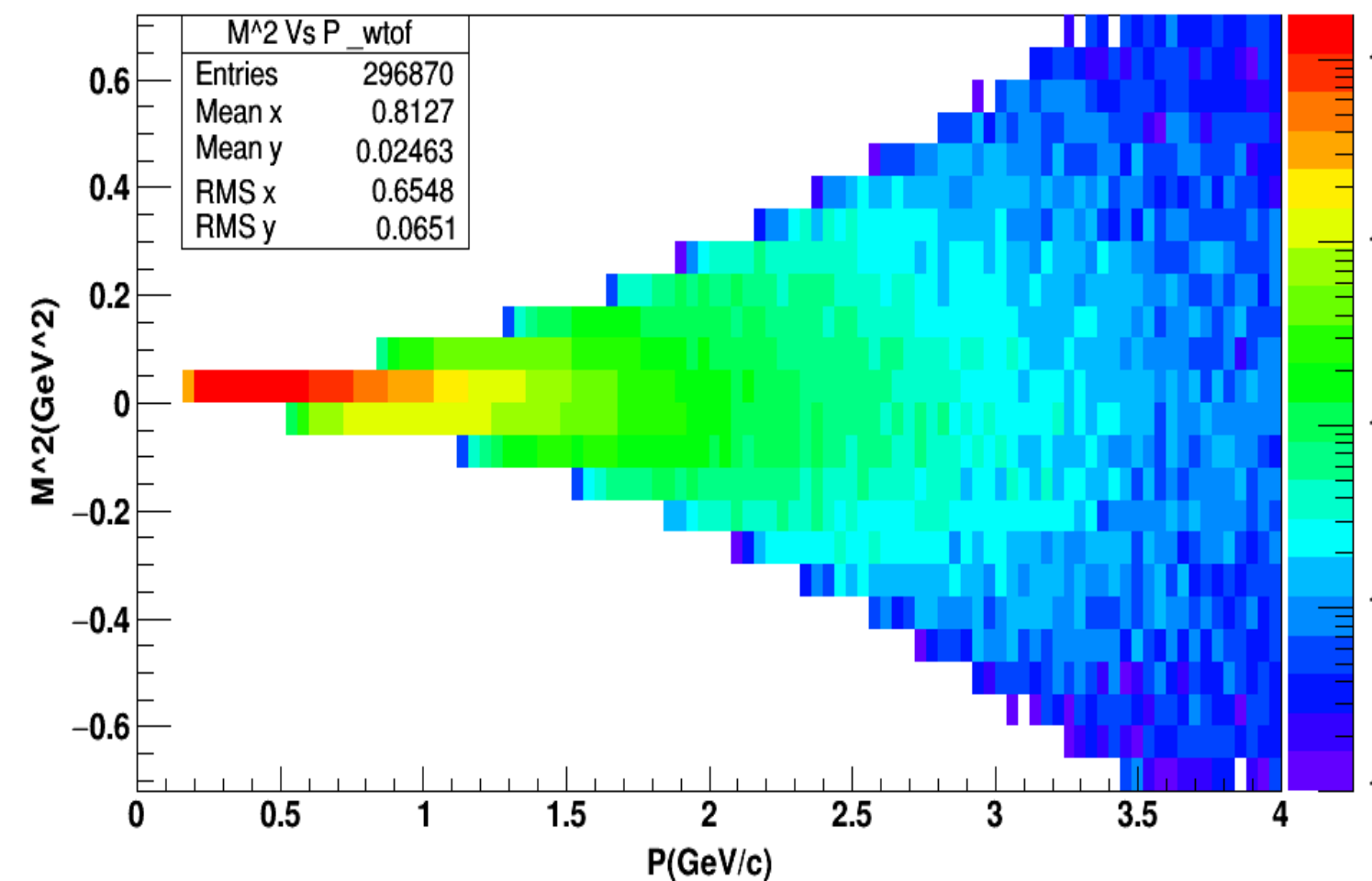
dE/dx Vs P for all charged particle



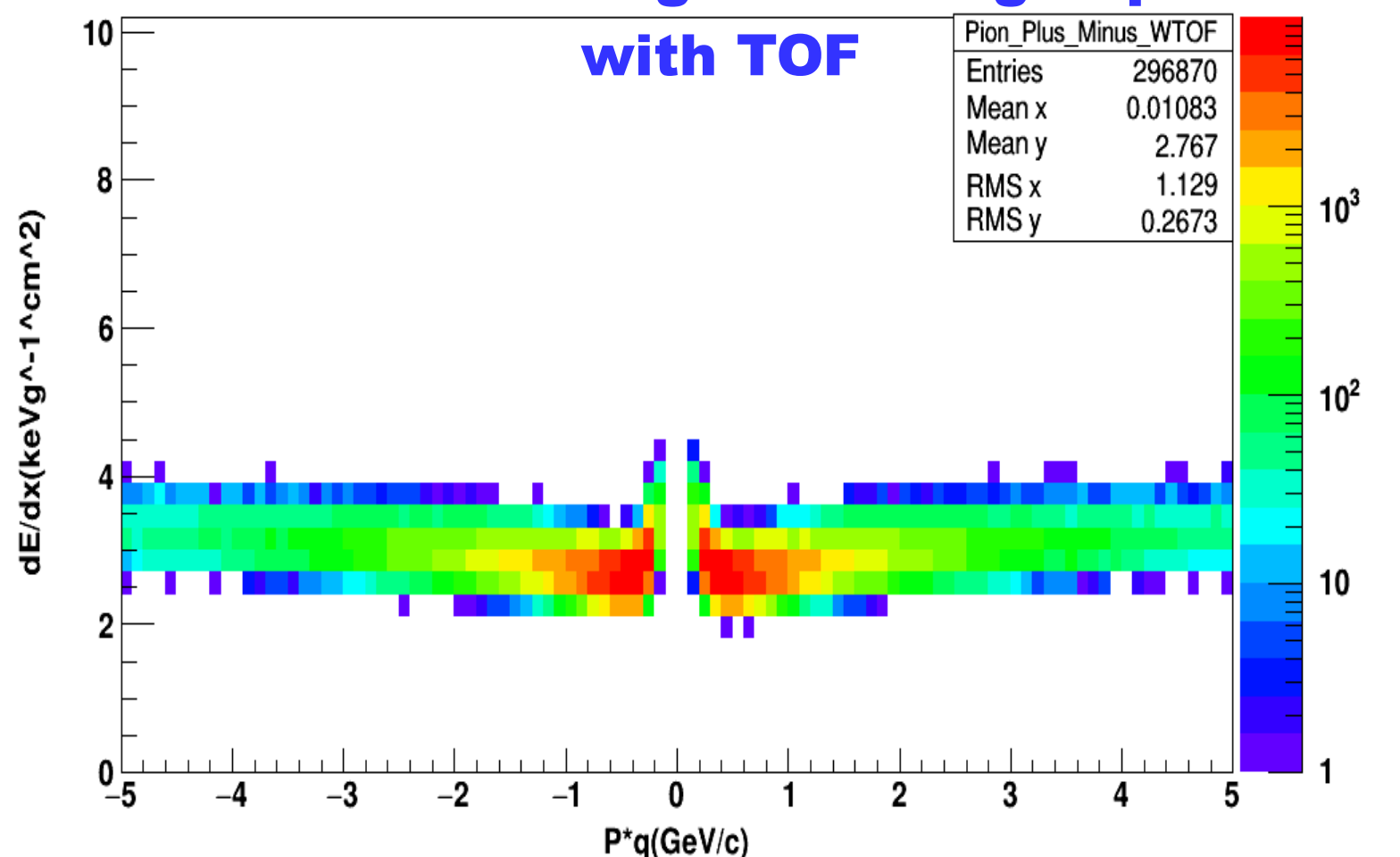
dE/dx Vs P*Charge for charged pions



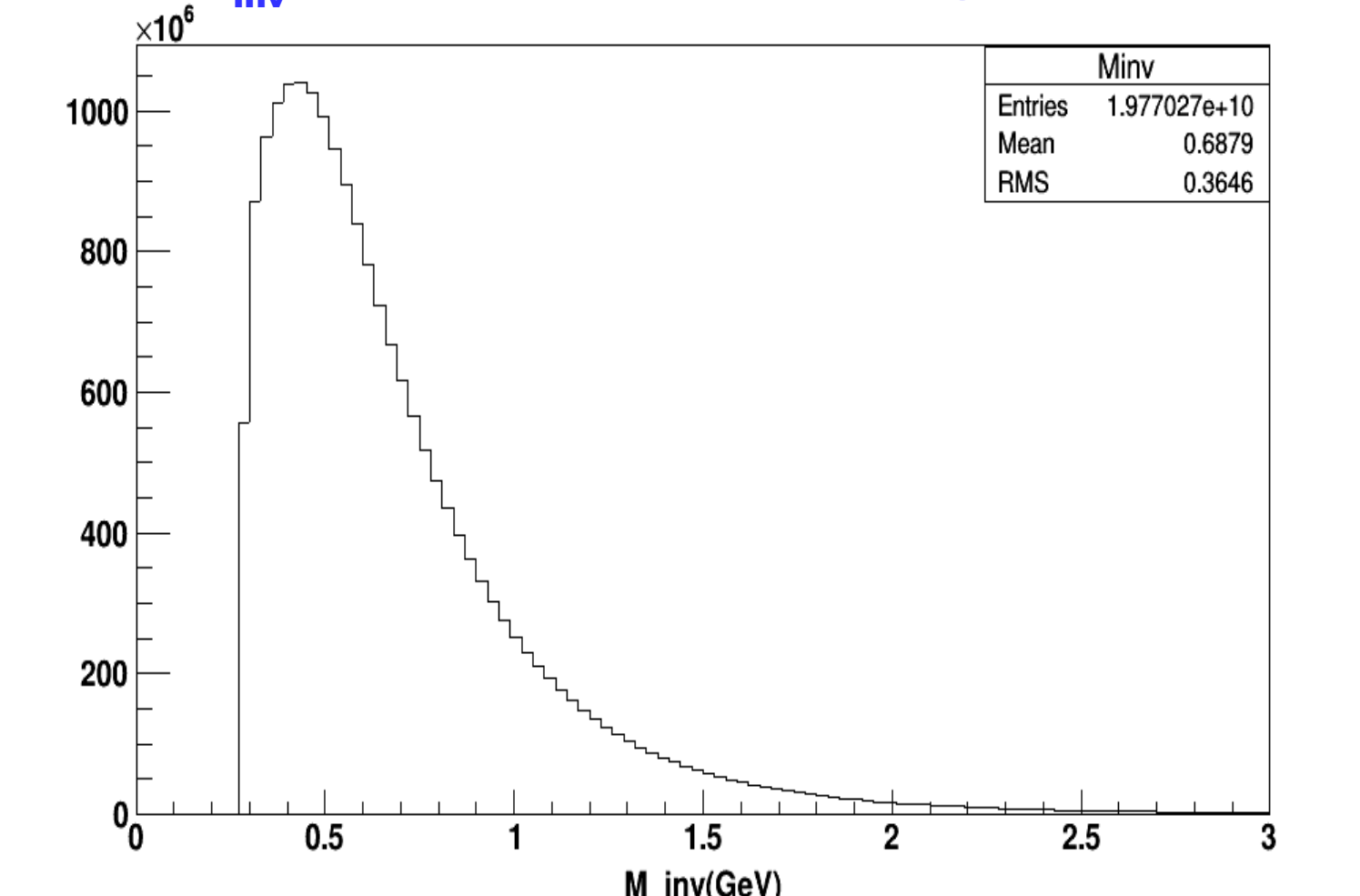
M^2 Vs P for charged pions with TOF



dE/dx Vs P*Charge for charged pions with TOF



M_inv Distribution for charged pions



Eta Distribution for charged pions

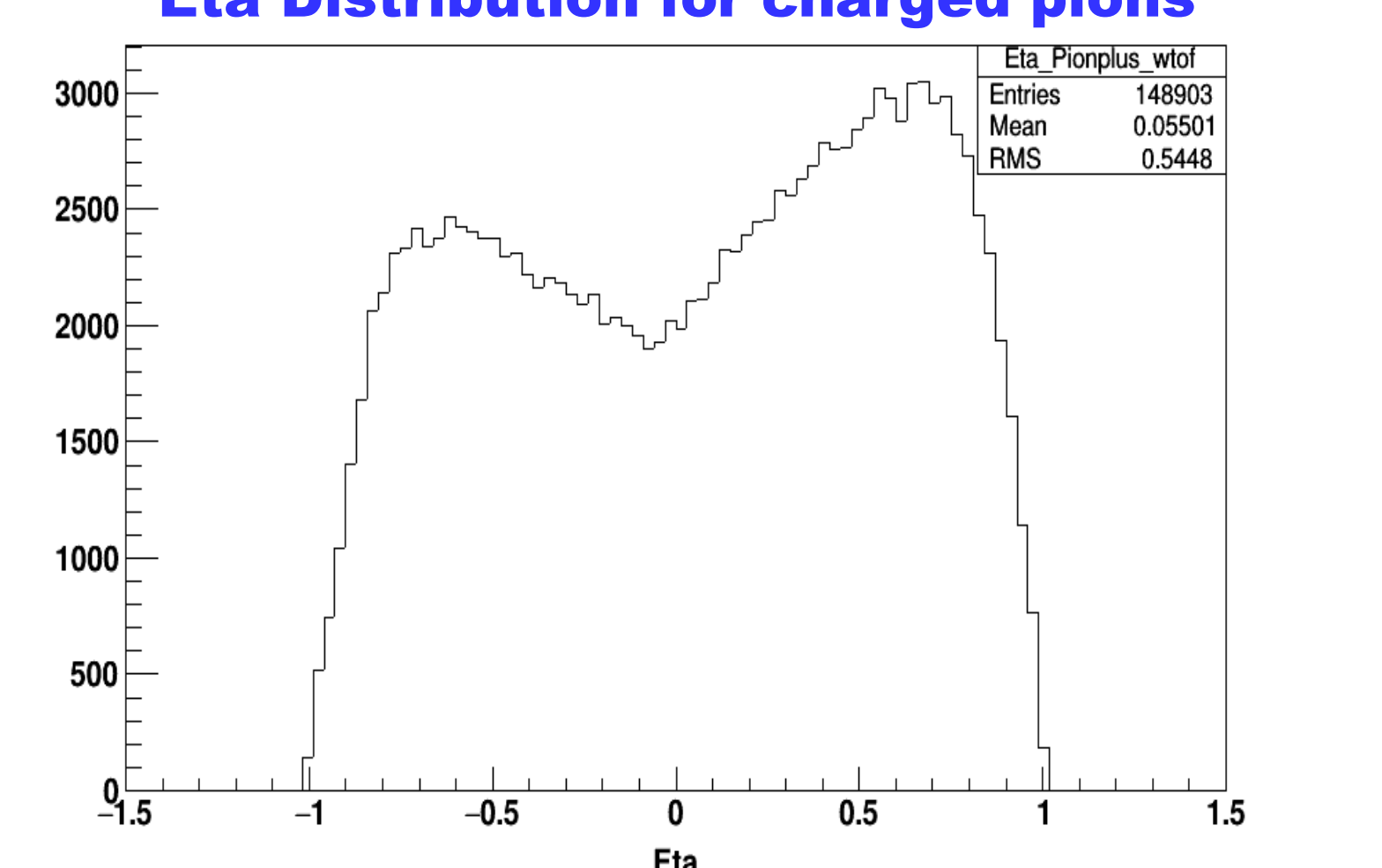
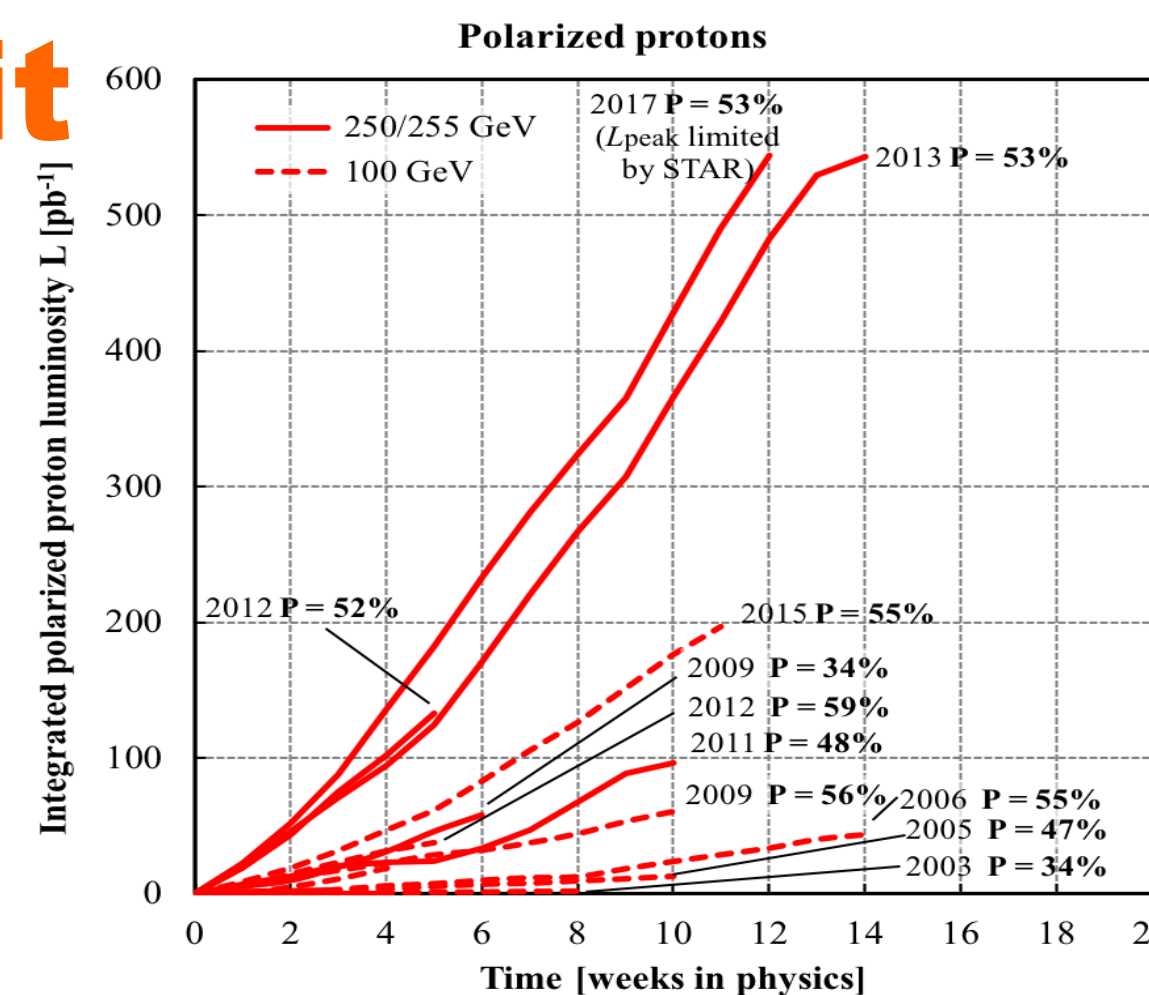


Figure of Merit

Integrated Luminosity (L_{11}) ≈ 25 pb $^{-1}$
Integrated Luminosity (L_{17}) ≈ 350 pb $^{-1}$
 $FOM_{11} = P_{11}^2 * L_{11} \approx 7$
 $FOM_{17} = P_{17}^2 * L_{17} \approx 105$

- The Run 2017 FOM is projected to be about 15 times larger than Run 2011.



Summary

- A_{UT} was observed for transverse $p^\uparrow + p$ collision in 2011 data consistent with results from Run 2006 and theoretical prediction.
- Significant asymmetry for higher η , where x (momentum fraction of parent proton carried by parton) is high; near mass of ρ meson (as predicted by IFF model) and higher p_T .
- Plots are produced for pion identification with small sample of Run 2017 data to test analysis code.
- Run 2017 data is projected to improve our statistical precision by roughly a factor of $(\sqrt{FOM_{17}/FOM_{11}})$ 4.
- Outcome of Run 2017 analysis will help to improve our understanding of transversity PDF $h_1^q(x)$ through a dedicated measurement of the respective di-hadron cross-section.
- Measurement of A_{UT} can be used to test the universality of IFF in SIDIS, e^+e^- and $p+p$ process.