2016 RHO ANALYSIS EVENT SELECTION

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MOTIVATION

- Generalized Parton Distrubutions (GPDs) give insight into the 3D structure of hadrons
- Accessing GPDs can be done using deeply virtual vector meson production (DVMP)
  - DVMP is sensitive to higher order twist terms and chiral odd GPDs
- The 3D angular distribution can be shown from experimental results
  - Schilling-Wolf showed that Spin Density Matrix Elements (SDMEs) are parameters of the angular distributions
- In the Goloskokov-Kroll (GK) model, SDMEs are relate to GPDs
  - This allows for constrictions on the theoretical calculation of GPDs

$$
\begin{aligned}
\mathcal{W}^U(\Phi,\phi,\cos\Theta) &= \frac{3}{8\pi^2}\Big[\frac{1}{2}(1-r^{04}_{00})+\frac{1}{2}(3r^{04}_{00}-1)\cos^2\Theta \\
&- \sqrt{2}\mathrm{Re}\{r^{04}_{10}\}\sin 2\Theta\cos\phi - r^{04}_{1-1}\sin^2\Theta\cos 2\phi - \epsilon\cos 2\Phi\big(r^{1}_{11}\sin^2\Theta \\
&+ r^{1}_{00}\cos^2\Theta - \sqrt{2}\mathrm{Re}\{r^{1}_{10}\}\sin 2\Theta\cos\phi - r^{1}_{1-1}\sin^2\Theta\cos 2\phi\big) \\
&- \epsilon\sin 2\Phi\big(\sqrt{2}\mathrm{Im}\{r^{2}_{10}\}\sin 2\Theta\sin\phi + \mathrm{Im}\{r^{2}_{1-1}\}\sin^2\Theta\sin 2\phi\big) \\
&+ \sqrt{2\epsilon(1+\epsilon)}\cos\Phi\big(r^{5}_{11}\sin^2\Theta + r^{5}_{00}\cos^2\Theta - \sqrt{2}\mathrm{Re}\{r^{5}_{10}\}\sin 2\Theta\cos\phi \\
&- r^{5}_{1-1}\sin^2\Theta\cos 2\phi\big) + \sqrt{2\epsilon(1+\epsilon)}\sin\Phi\big(\sqrt{2}\mathrm{Im}\{r^{6}_{10}\}\sin 2\Theta\sin\phi \\
&+ \mathrm{Im}\{r^{6}_{1-1}\}\sin^2\Theta\sin 2\phi\big)\Big], \qquad (2.19)
\end{aligned}
$$

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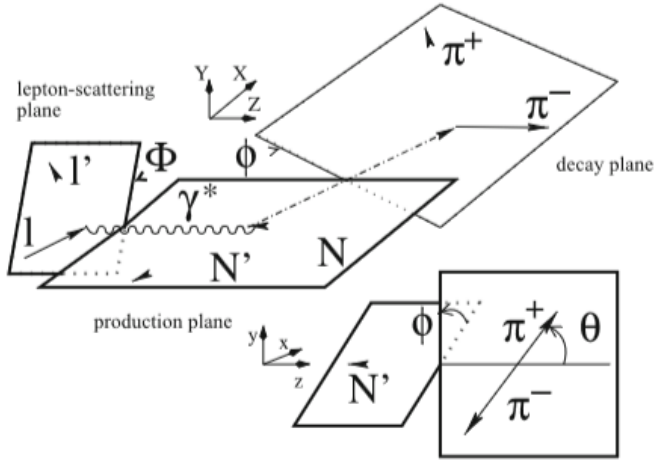
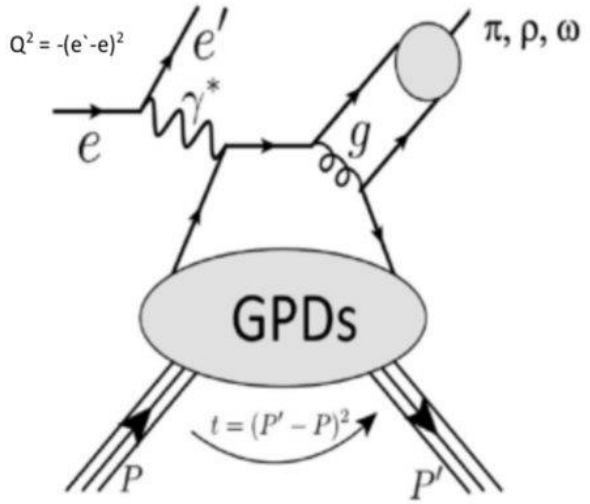
$$
\begin{aligned}
\mathcal{W}^L(\Phi,\phi,\cos\Theta) &= \frac{3}{8\pi^2}\Big[\sqrt{1-\epsilon^2}\big(\sqrt{2}\mathrm{Im}\{r^{3}_{10}\}\sin 2\Theta\sin\phi + \mathrm{Im}\{r^{3}_{1-1}\}\sin^2\Theta\sin 2\phi\big) \\
&+ \sqrt{2\epsilon(1-\epsilon)}\cos\Phi\big(\sqrt{2}\mathrm{Im}\{r^{7}_{10}\}\sin 2\Theta\sin\phi + \mathrm{Im}\{r^{7}_{1-1}\}\sin^2\Theta\sin 2\phi\big) \\
&+ \sqrt{2\epsilon(1-\epsilon)}\sin\Phi\big(r^{8}_{11}\sin^2\Theta + r^{8}_{00}\cos^2\Theta - \sqrt{2}\mathrm{Re}\{r^{8}_{10}\}\sin 2\Theta\cos\phi \\
&- r^{8}_{1-1}\sin^2\Theta\cos 2\phi\big)\Big]. \qquad (2.20)
\end{aligned}
$$





W. Augustyniak, et al. ,Spin Density Matrix Elements for exclusive ρ0 meson production using the 2012 COMPASS data,internal note, 2021.

COMPASS

- Data
  - Year 2016, period 09, slot 8
- Monte Carlo
  - HepGen, Lepto
- Channel: $\mu p \longrightarrow \mu' \rho^0 X \longrightarrow \mu' \pi^+ \pi^- X$
  - Where X is the proton, and it is identified through the missing mass
  - ρ^0 decays into $\pi^+ \pi^-$
  - Initial Cut: $Q^2 > 0.8\ GeV^2$

Coming from DVCS analysis of 2016 data
(J. V. Giarra, Deeply Virtual Compton Scattering at COMPASS, PhD thesis, 2022.)

MUON SELECTION

Incoming muon track (μ):

- first measured before the target ($Z_{tgt,min.}$=-318.5 cm)
- track crosses the full target length
- momentum: 140 GeV/c $< p_\mu <$ 180 GeV/c
- momentum error: $\Delta p_\mu \leq 0.025 \cdot p_\mu$
- meantime: -2 ns $< t_{track} <$ 2 ns
- hits in Beam Momentum Station (BMS): ≥ 3
- hits in Scintillation Fibre detectors (SCIFI): ≥ 2
- hits in Silicon strip detectors (SI): ≥ 3

Outgoing charged track (μ'):

- same charge as incoming muon
- rel. radiation length: $X/X_0 >$15
- first measured before and last after SM1: $Z_{first} <$ 350 cm and $Z_{last} >$ 350 cm
- track extrapolations are in the active hodoscope areas (PaHodoHelper::iMuPrim())

Vertex requirements:

- in target
  - -318.5 cm$< Z_{vtx} <$-78.5 cm
  - $R_{vtx} <$1.9 cm
  - $Y_{vtx} <$1.2 cm
- exactly one outgoing charged track

Coming from 2012 Rho analysis (W. Augustyniak, et al. ,Spin Density Matrix Elements for exclusive ρ^0 meson production using the 2012 COMPASS data,internal note, 2021.)

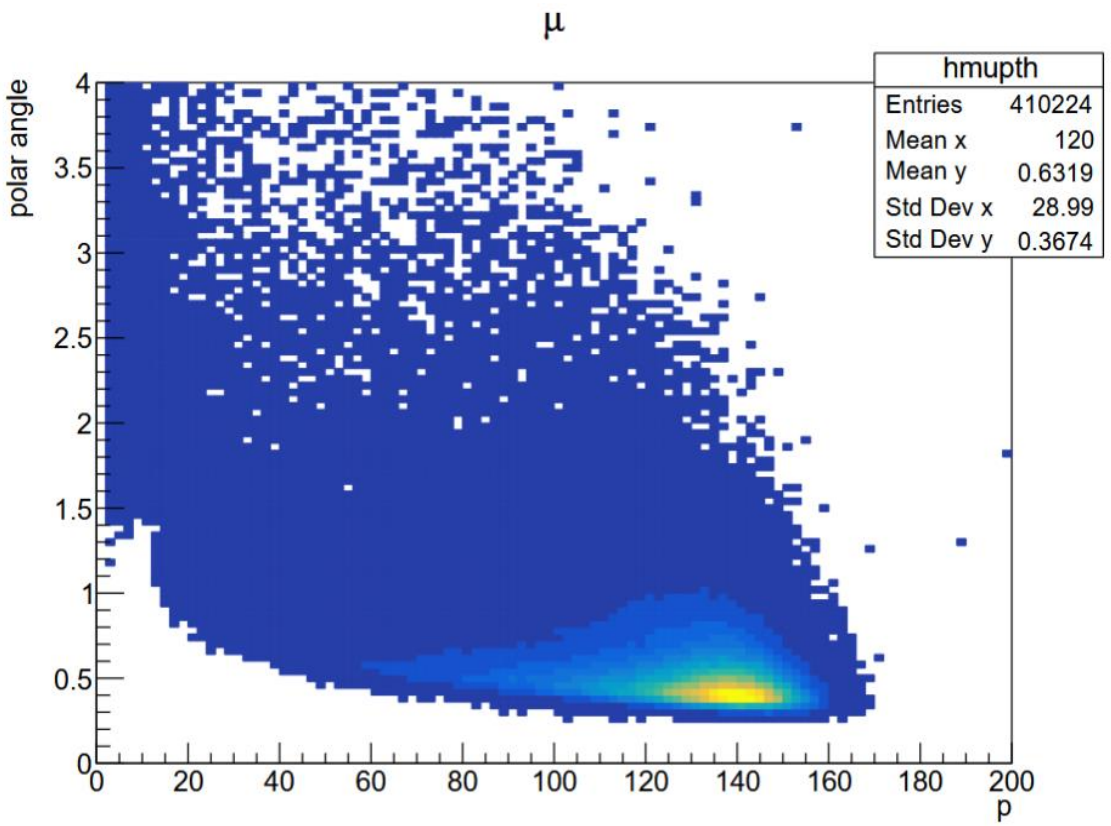
HADRON SELECTION

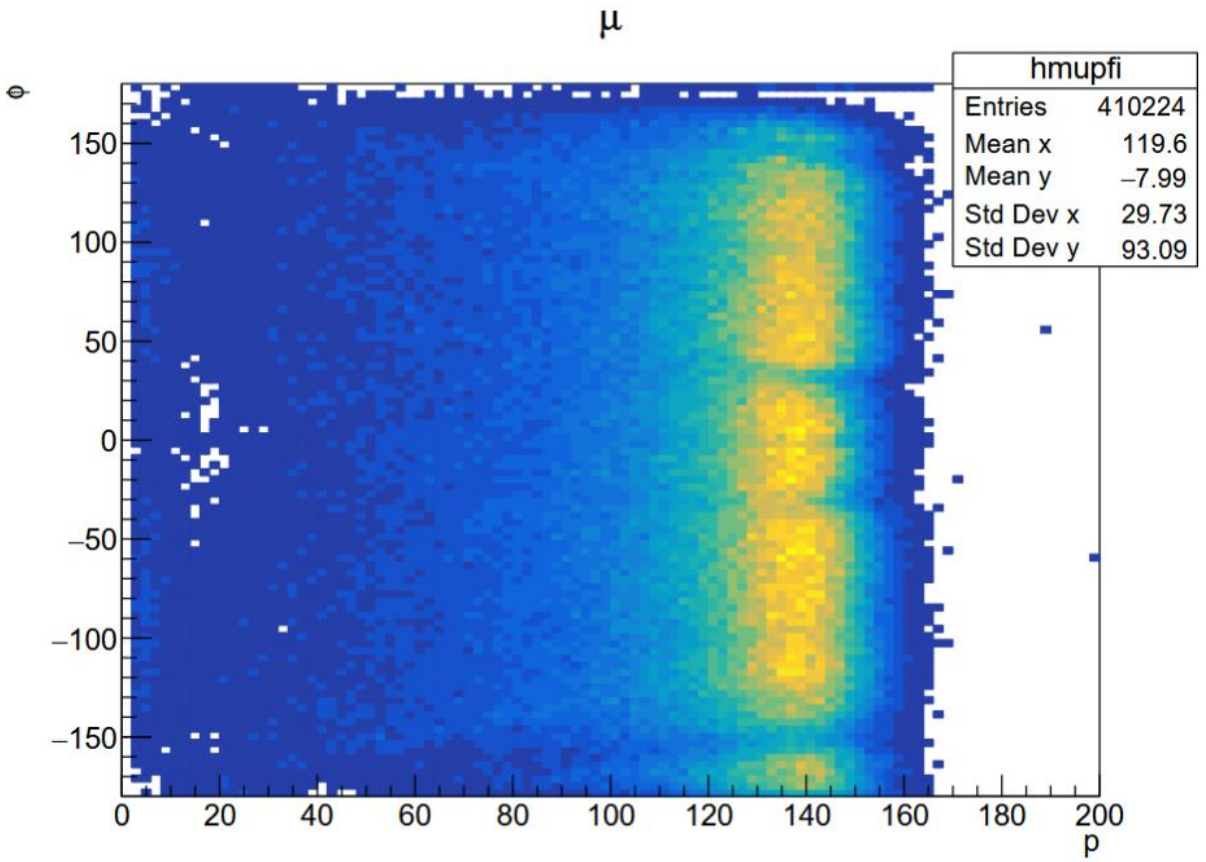
- Hadrons
  - Good fit quality of scattered hadron (π^+, π^- reconstruction, given by reduced χ^2 is required to be smaller than 10 (χ^2 <10).
    Track reconstruction quality χ^2 <10.
  - Penetration length of hadron track should be smaller than 10 radiation lengths.
  - Track starts before SM1, i.e. $Z_{first} < 350.0$ cm .

Proton is not identified

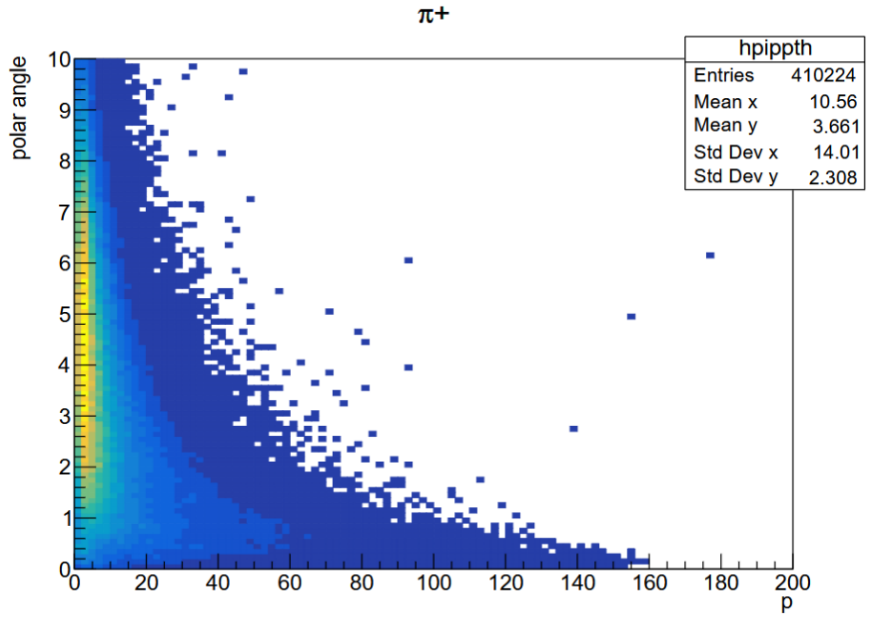
DATA PARTICLE KINEMATICS NO EXCLUSIVE CUTS

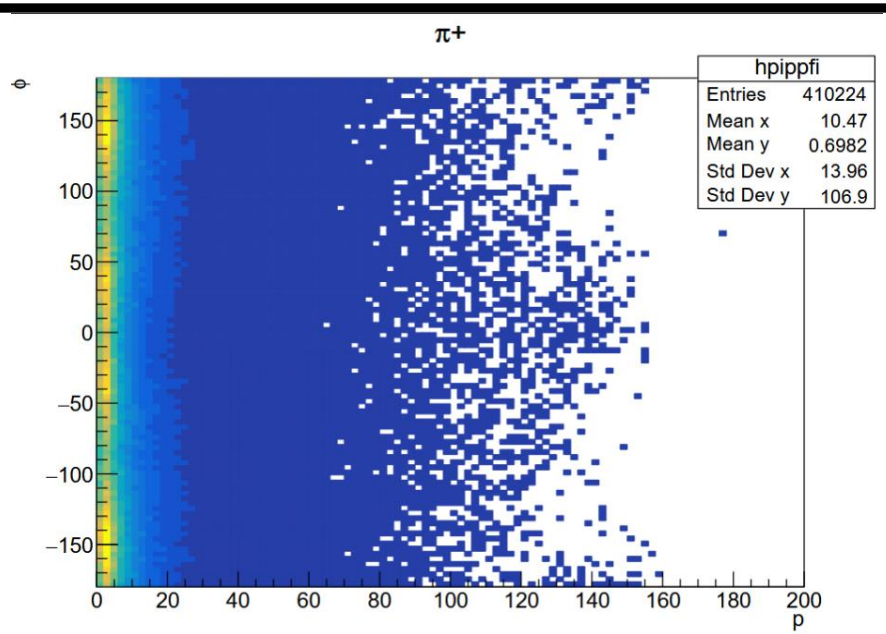
PARTICLE KINEMATICS: SCATTERED MUON

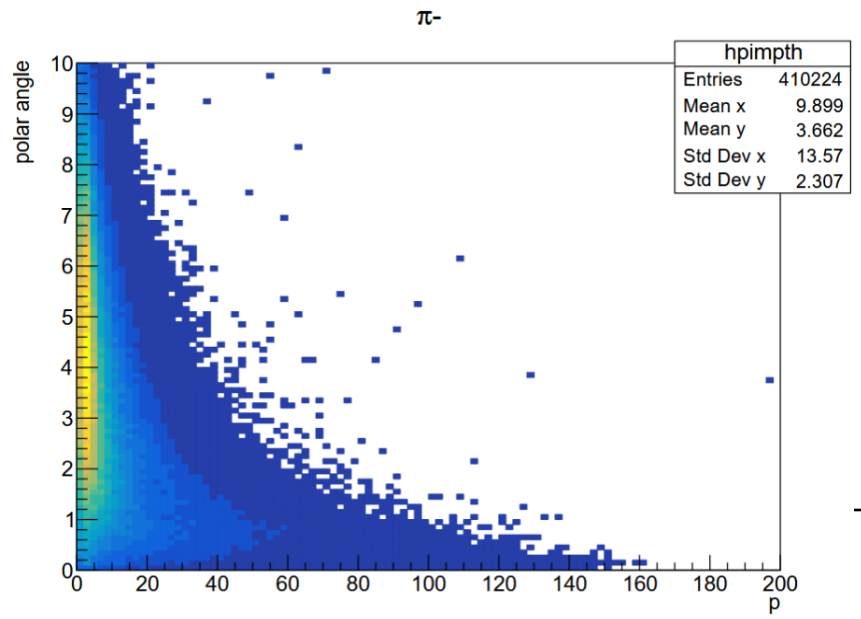


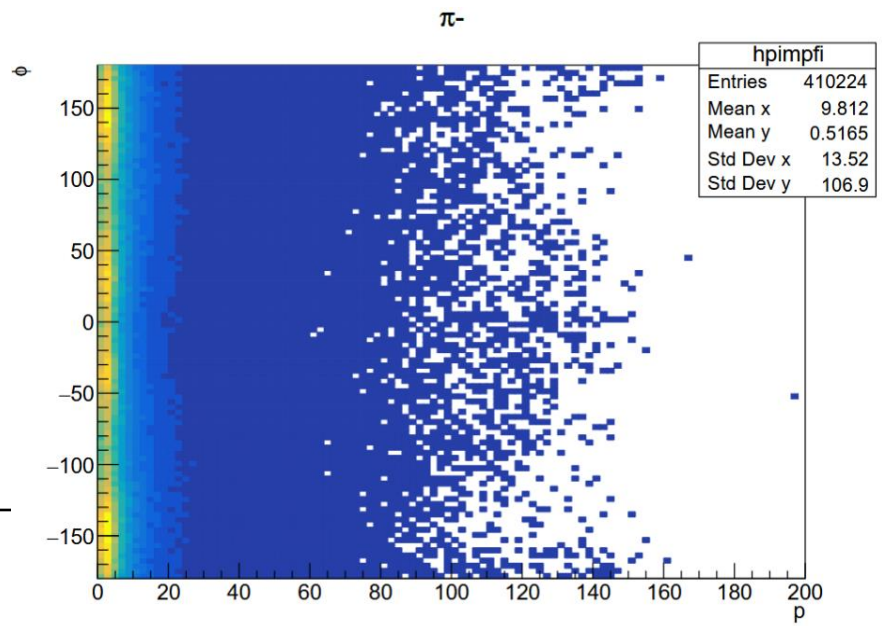


PARTICLE KINEMATICS: PION









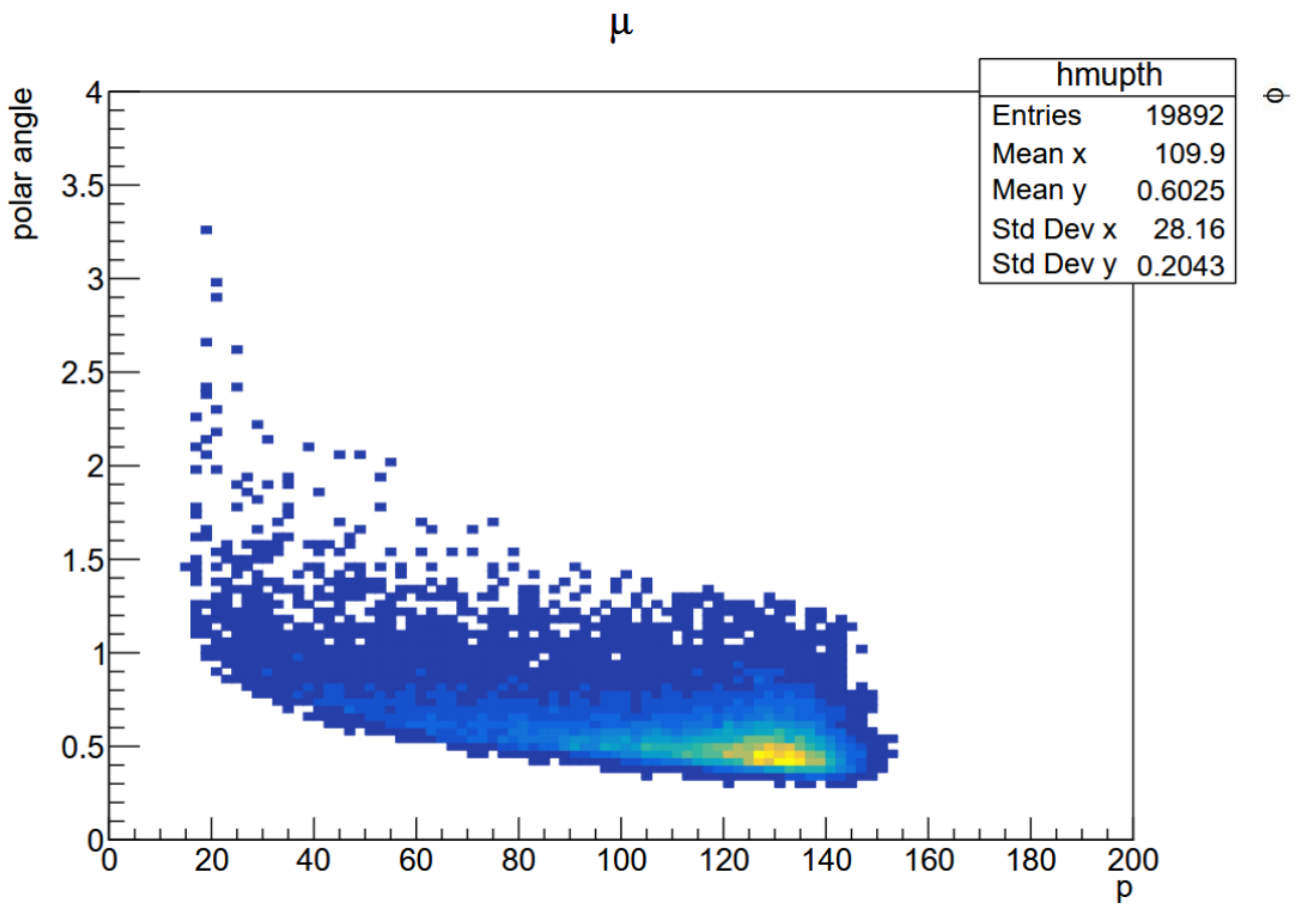
Coming from 2012 Rho analysis (W. Augustyniak, et al. ,Spin Density Matrix Elements for exclusive ρ^0 meson production using the 2012 COMPASS data,internal note, 2021.)

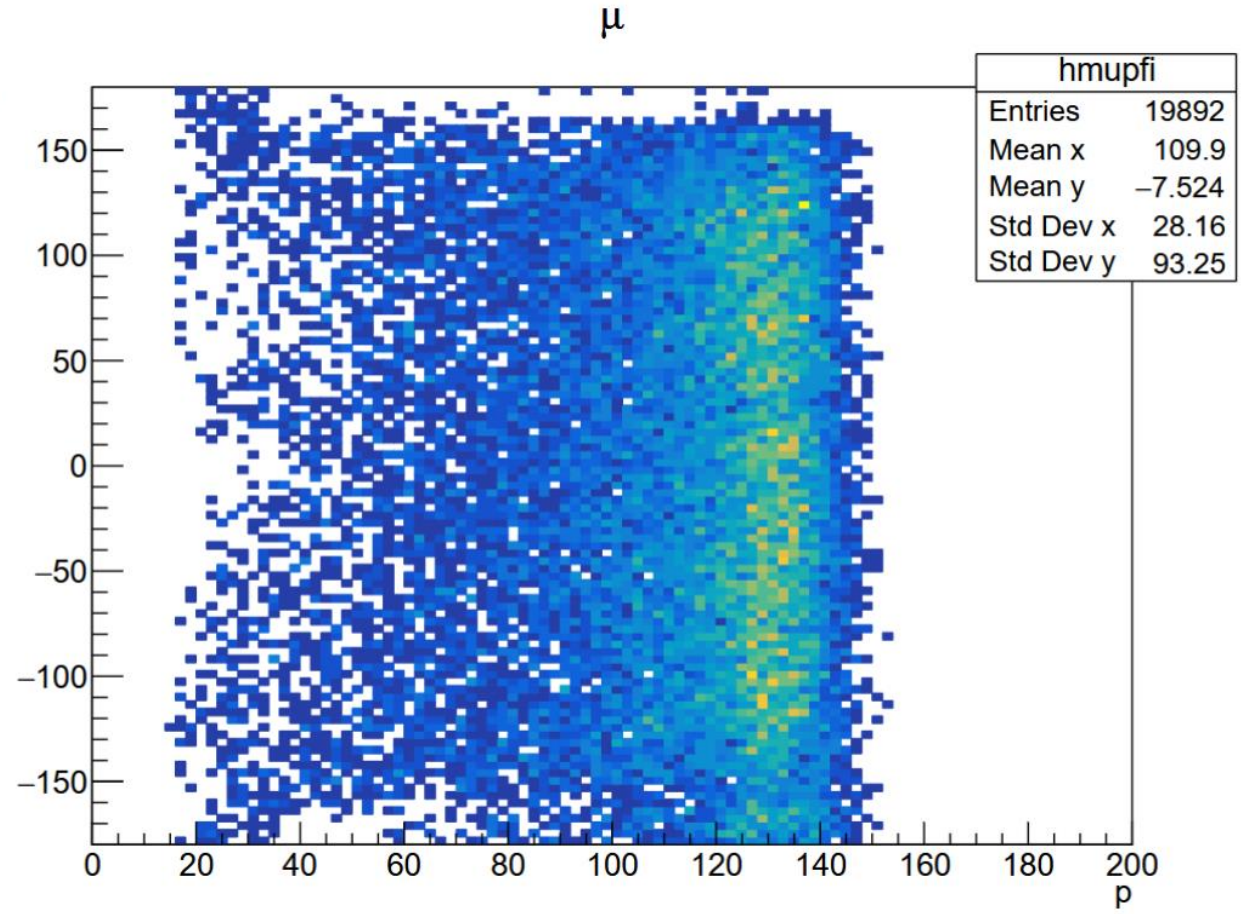
EXCLUSIVE CUTS

- $W > 5$ GeV
- $0.1 < y < 0.9$
- $1.0 < Q^2 < 10$ GeV
- $\nu > 20$ GeV
- $0.01 < p^2_T < 0.5$ $(GeV/C)^2$
- $0.5 <$ Invariant Mass < 1.1 GeV/C^2
- $-2.5 < E_{Miss} < 2.5$ GeV
- Momentum of $\rho^0 > 15$ GeV/C

DATA PARTICLE KINEMATICS EXCLUSIVE CUTS

PARTICLE KINEMATICS: SCATTERED MUON

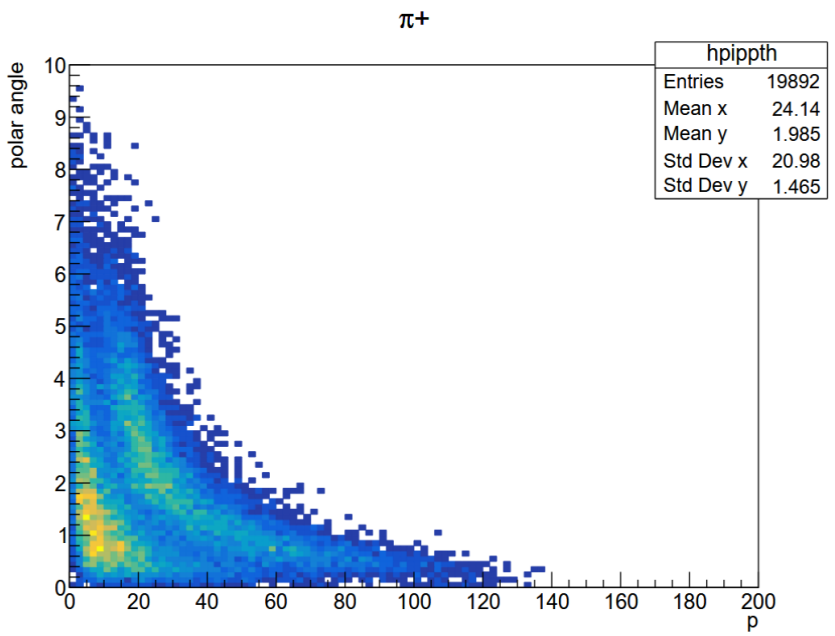


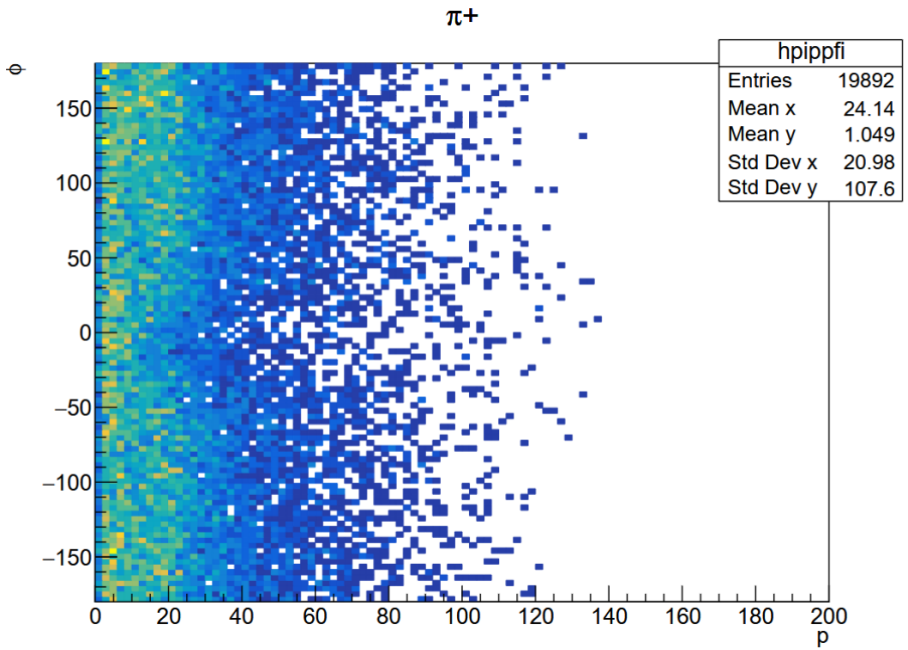


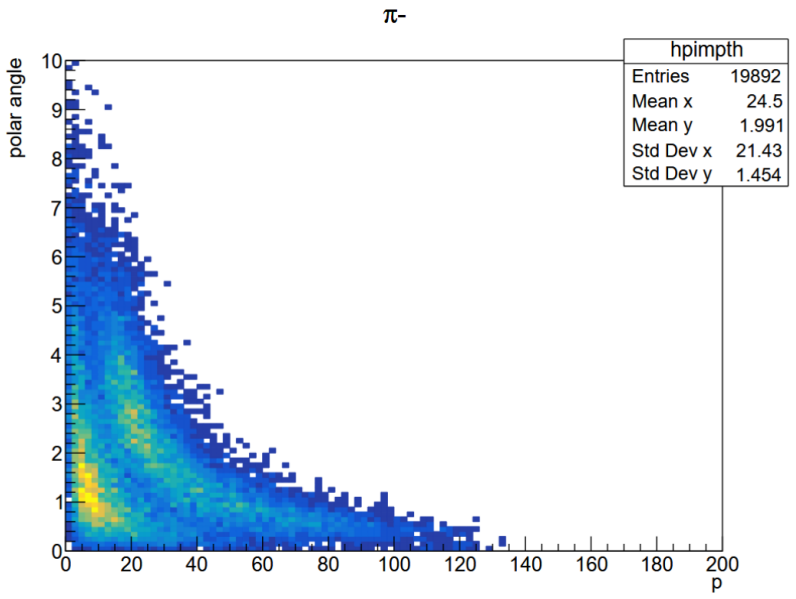
Cuts: W, y, Q2 ,ν, p2T, Invariant Mass, EMiss, Momentum of ρ0

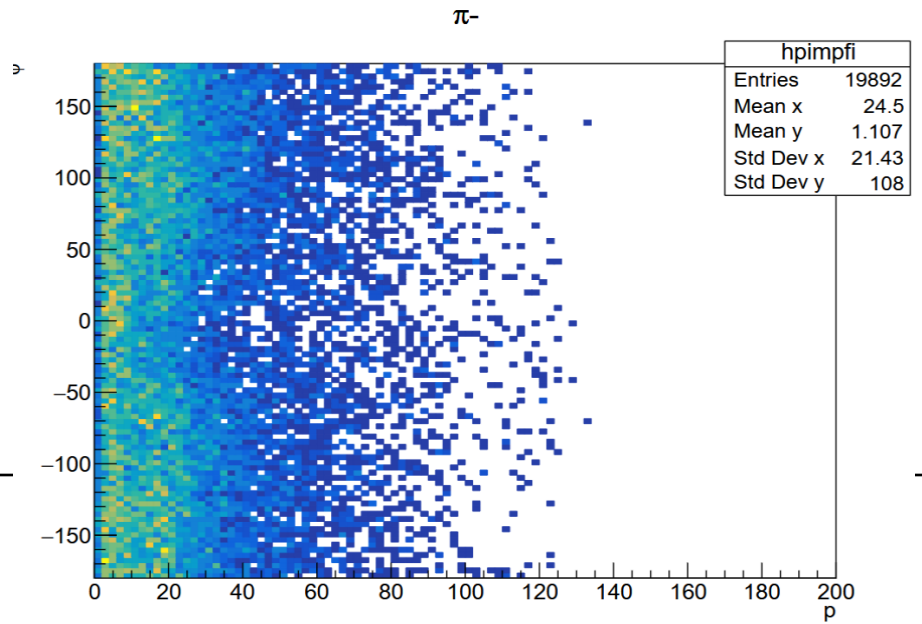
PARTICLE KINEMATICS: PION

Cuts: W, y, Q2 ,ν, $p2_T$, Invariant Mass, E_{Miss}, Momentum of ρ0





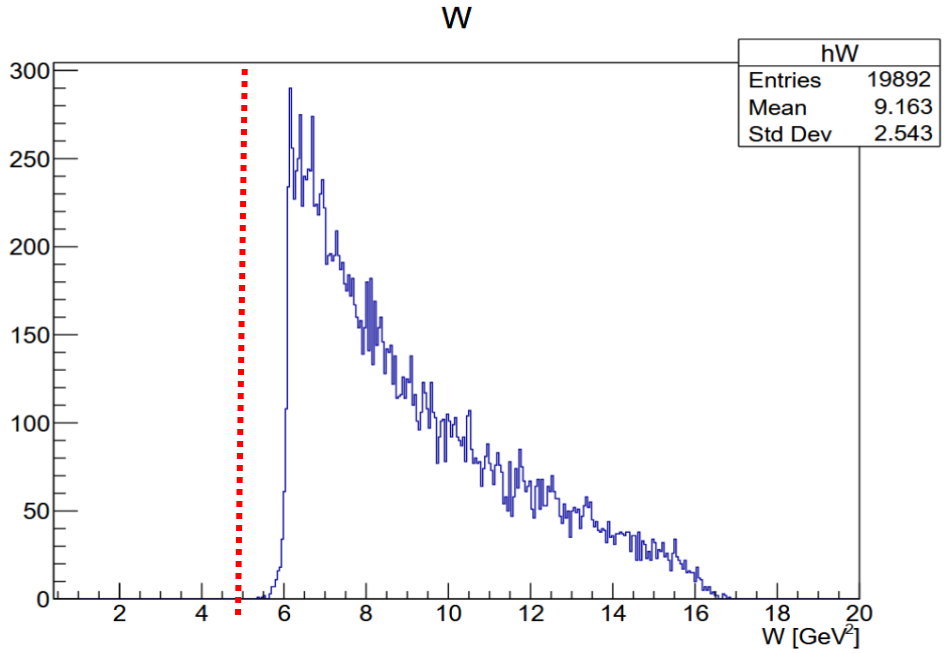


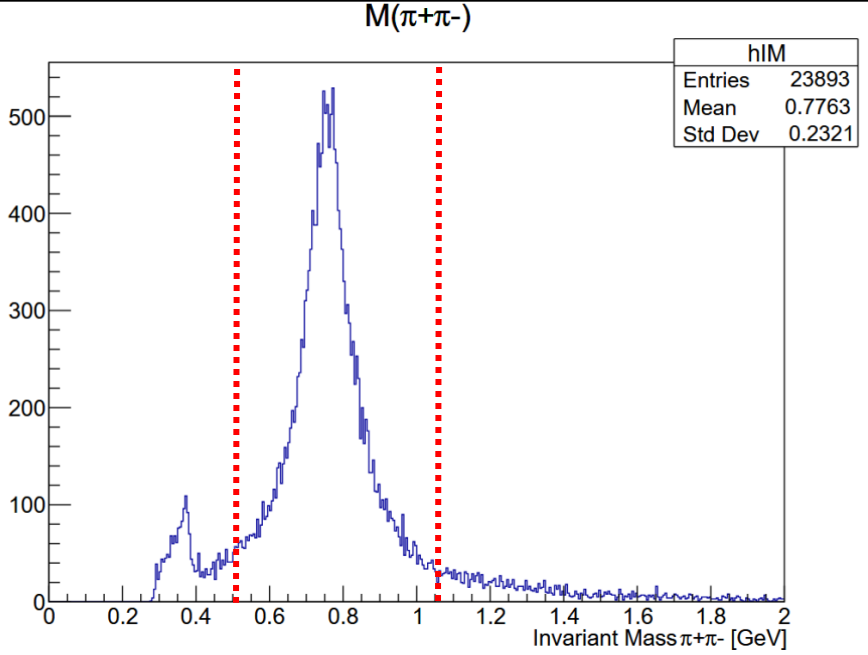


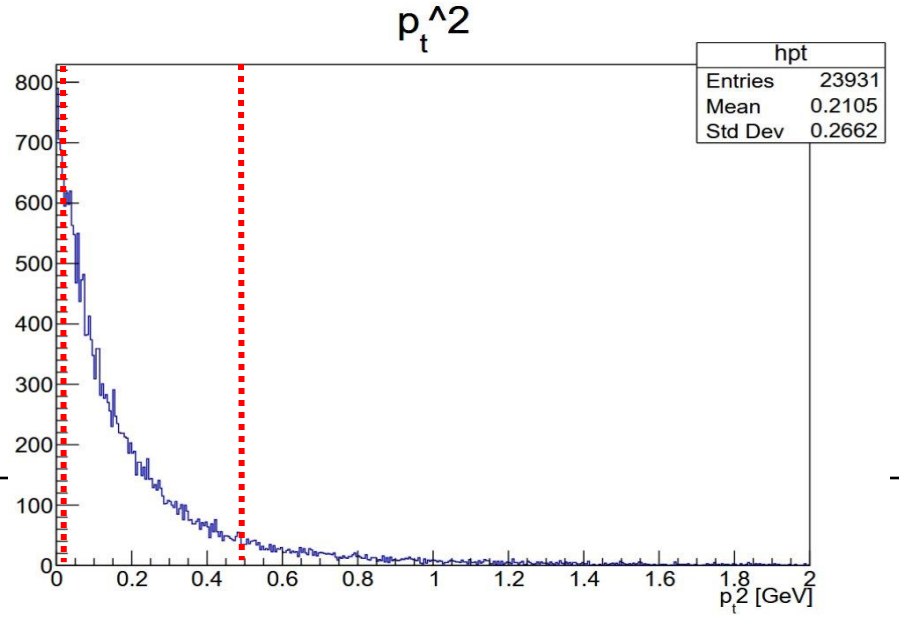
DATA EXCLUSIVE KINEMATICS

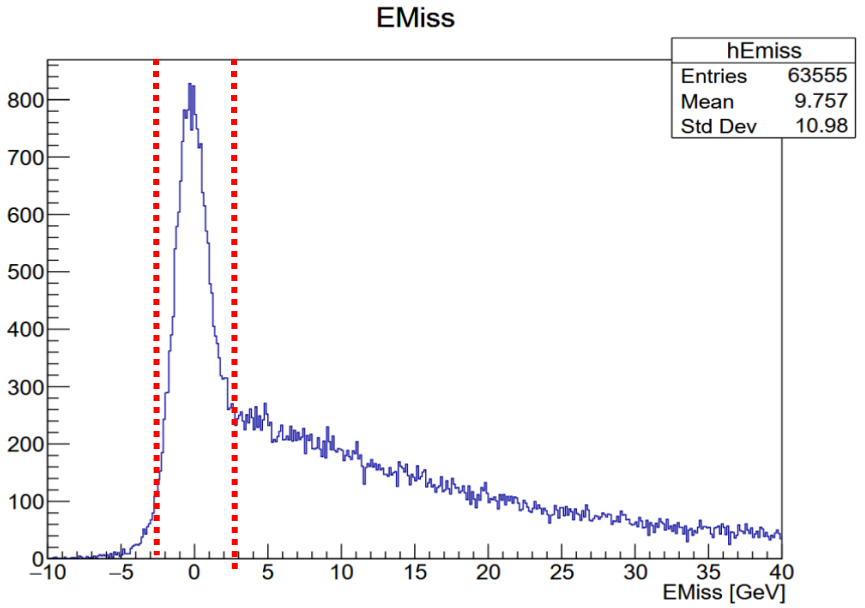
EXCLUSIVE KINEMATICS

Red lines show exclusive cuts



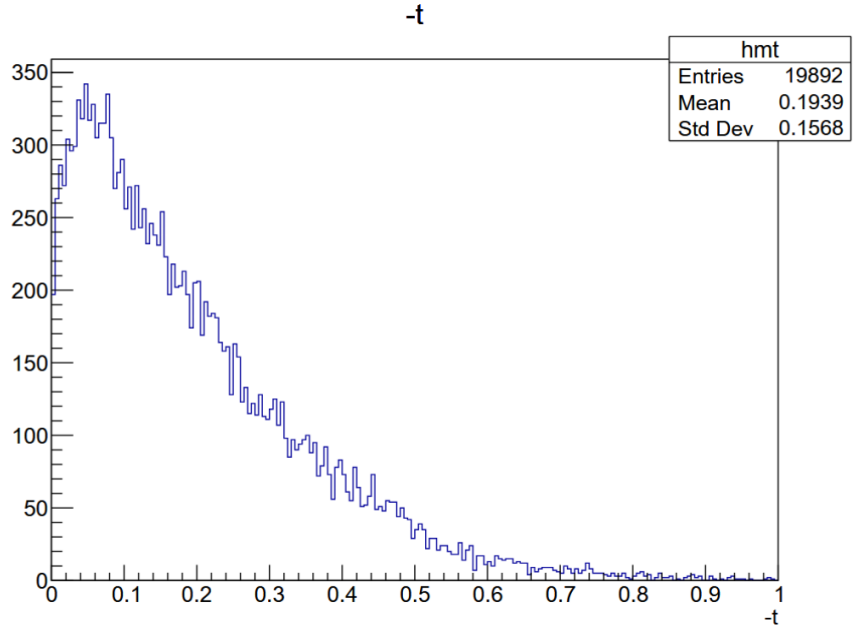


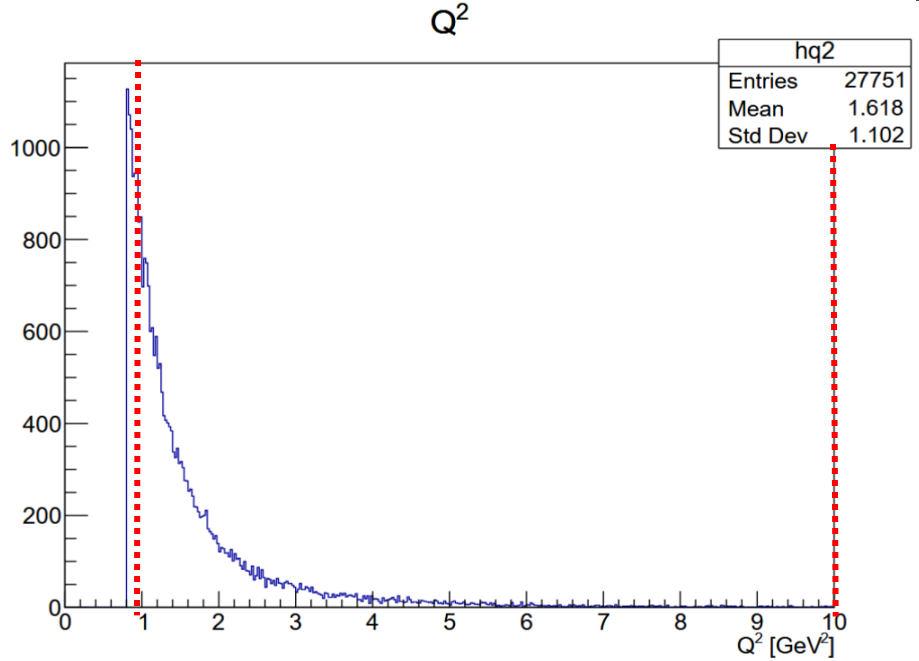


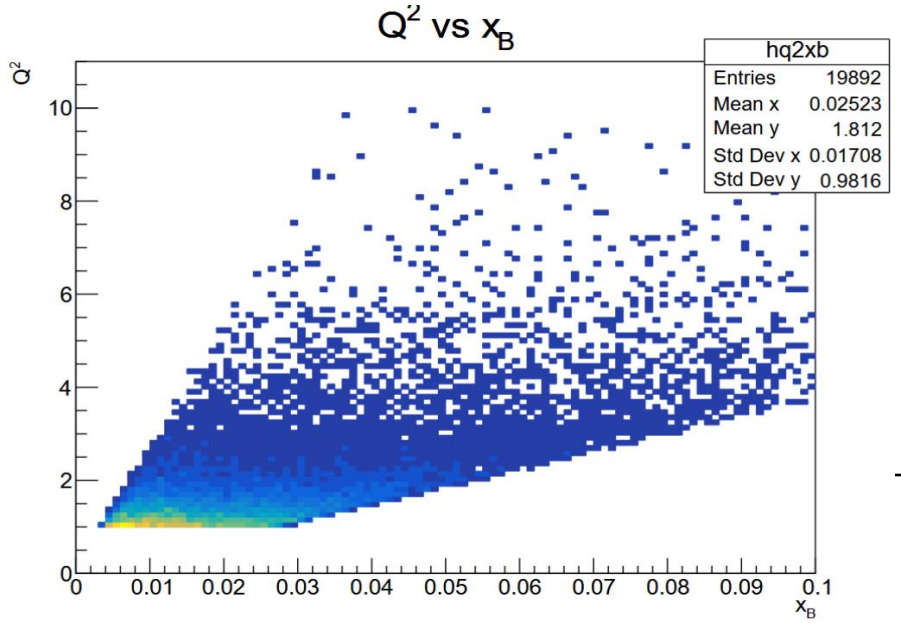


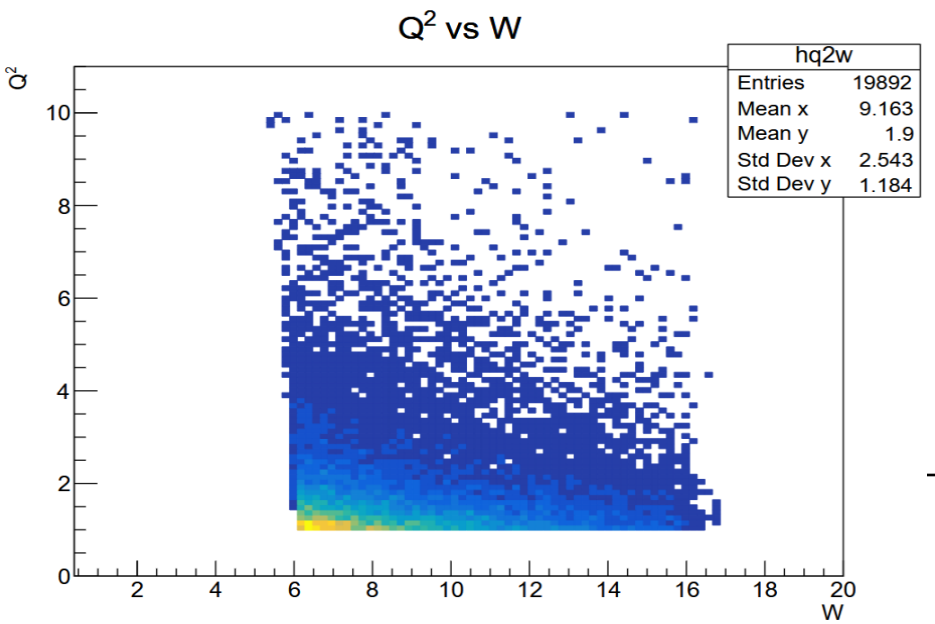
EXCLUSIVE KINEMATICS CONTINUED

Red lines show exclusive cuts



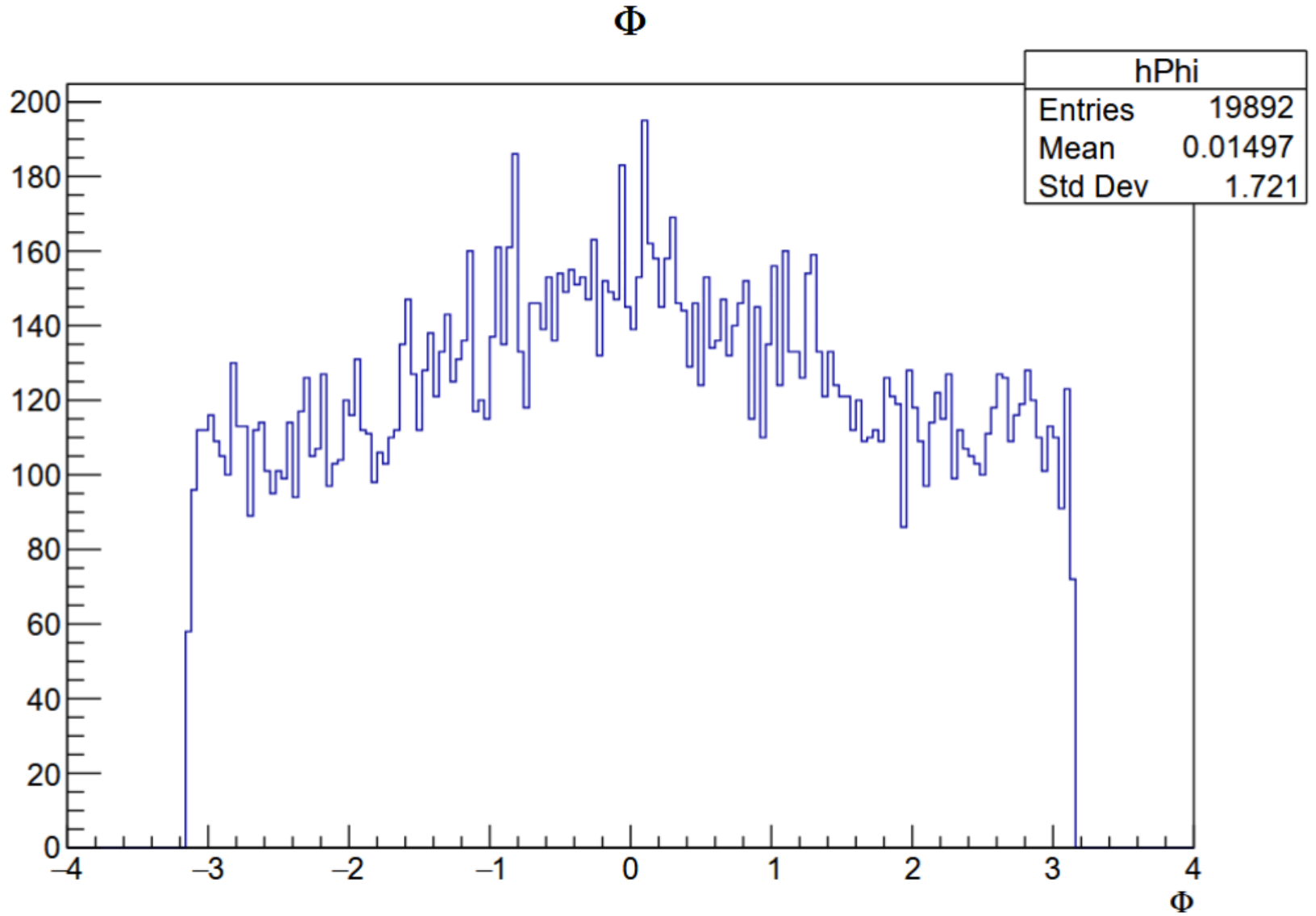


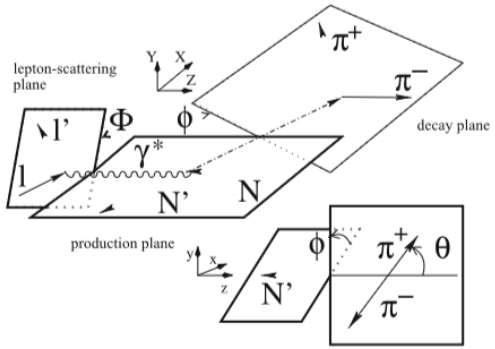




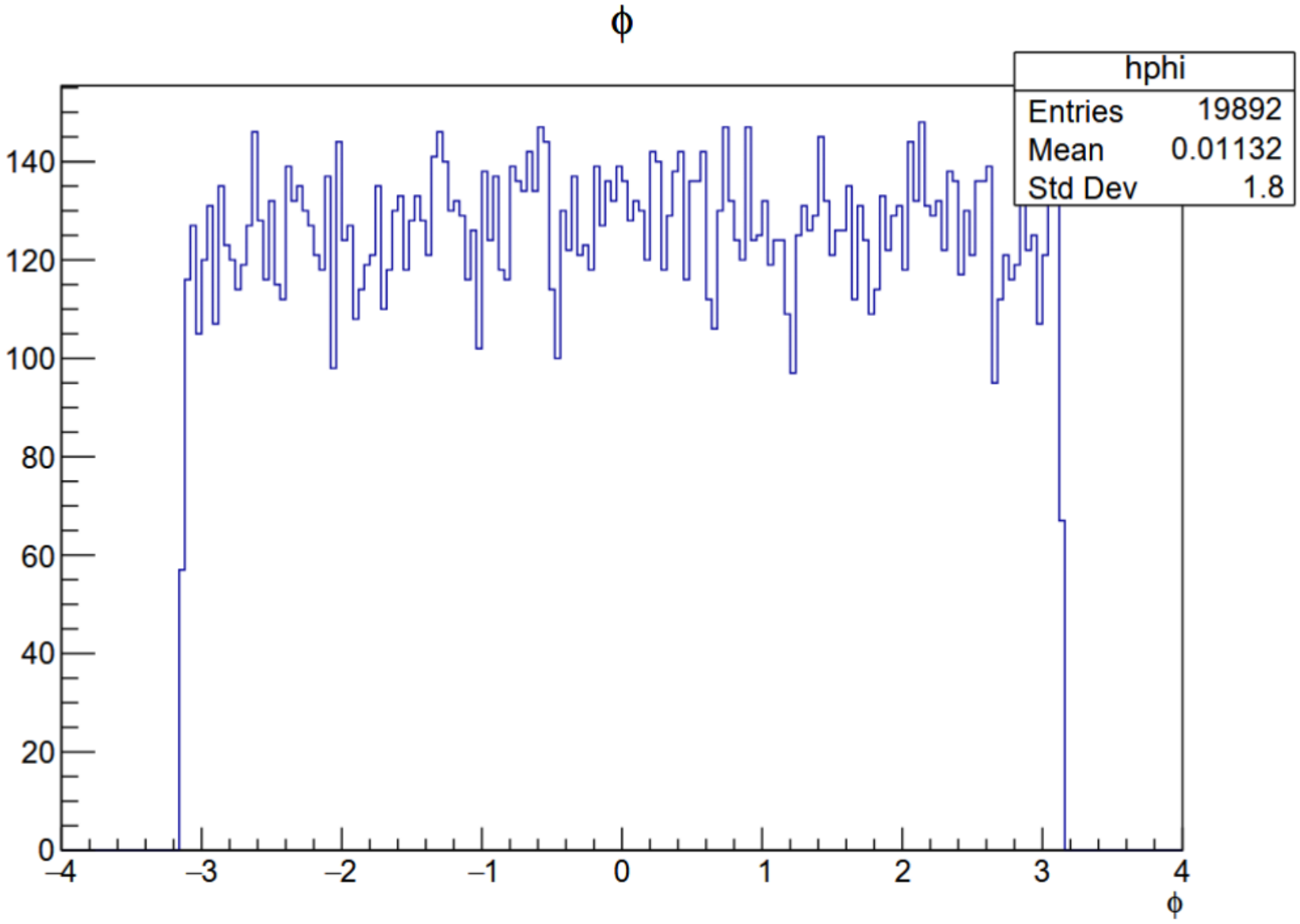
ANGLES FOR ANGULAR DISTRUBUTIONS

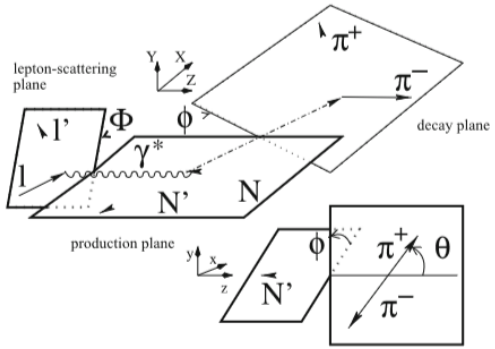
All Exclusive Cuts





All Exclusive Cuts





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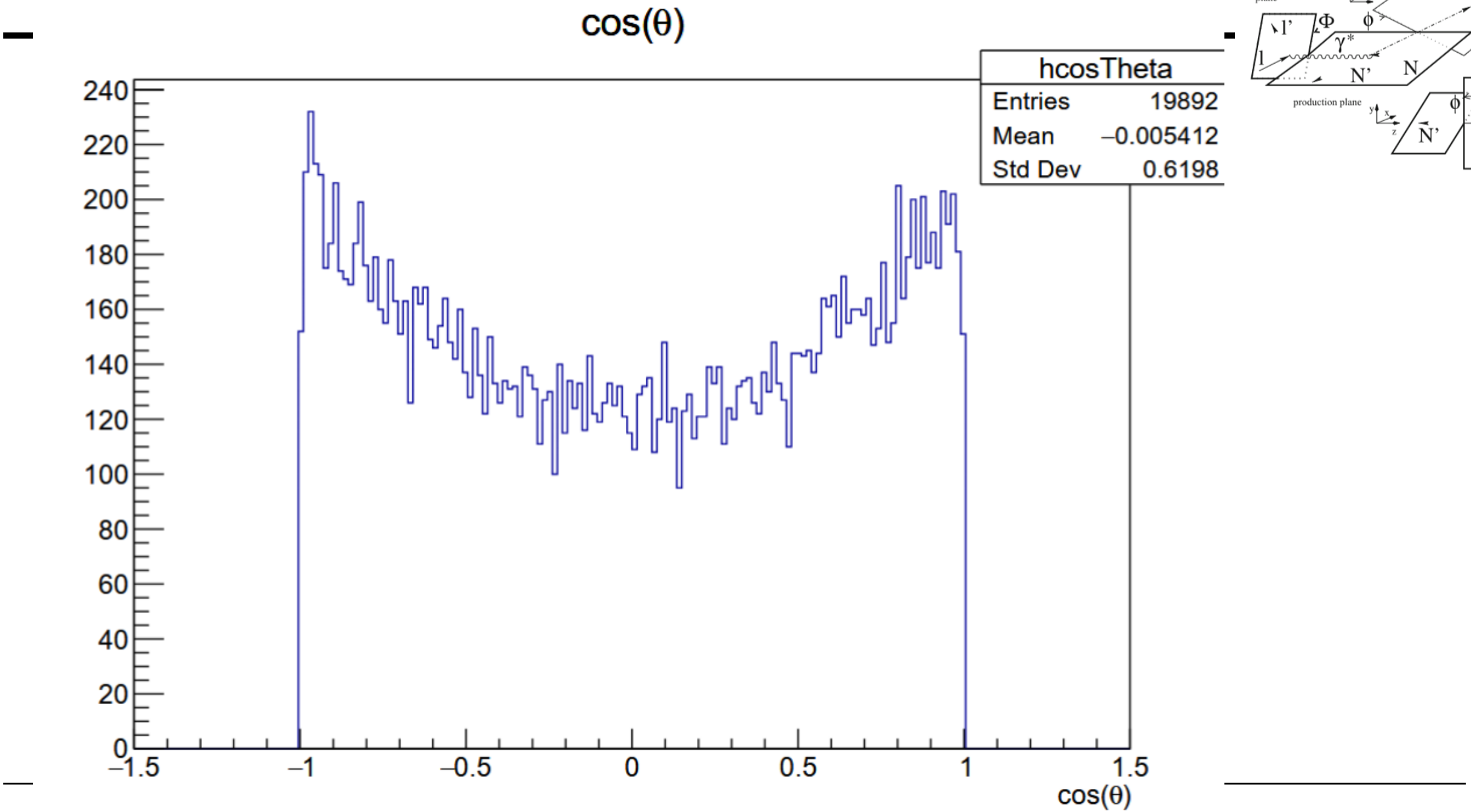
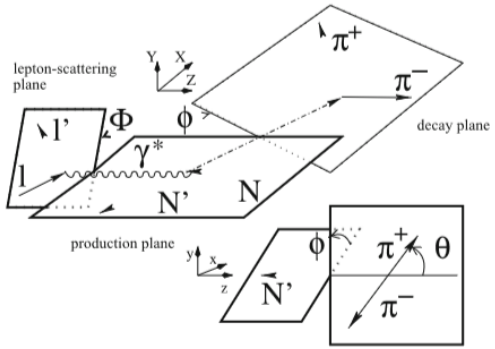
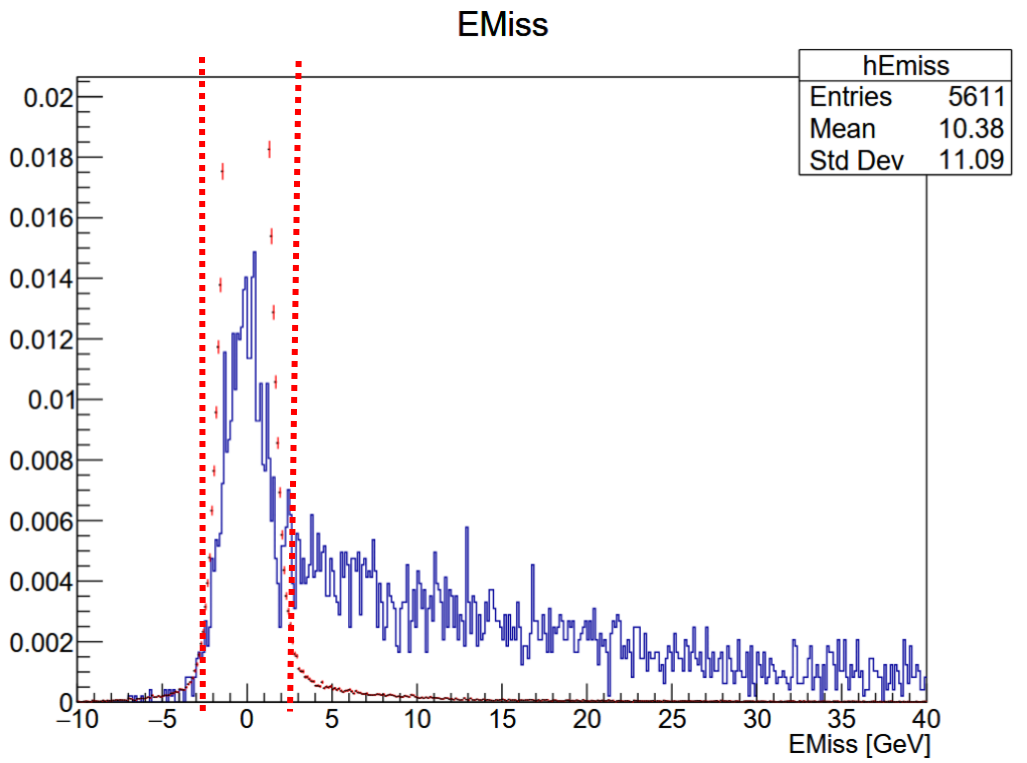




NEXT STEPS

- Showing of the comparison to the Monte Carlo and experimental data
  - Done for HepGen
  - Still need to compare lepto

- Extracting SDMEs from the angular distribution
  - Using the maximum likelihood method
  - Code is written and extraction has been attempted



$$-\ln L(\mathcal{R}) = -\sum_{i=1}^{N} \ln \frac{\mathcal{W}^{U+L}(\mathcal{R}; \Phi_i, \phi_i, \cos\Theta_i)}{\tilde{\mathcal{N}}(\mathcal{R})}$$