Outline

- Calculated uncertainty in yield using the covariance matrix of the fit.
- Efficiencies corrected using randomly generated background.
- Pre-systematic analysis.

Event Selection

Reaction Filter Stage

$\gamma A \rightarrow \pi^+ \pi^- p (X)$

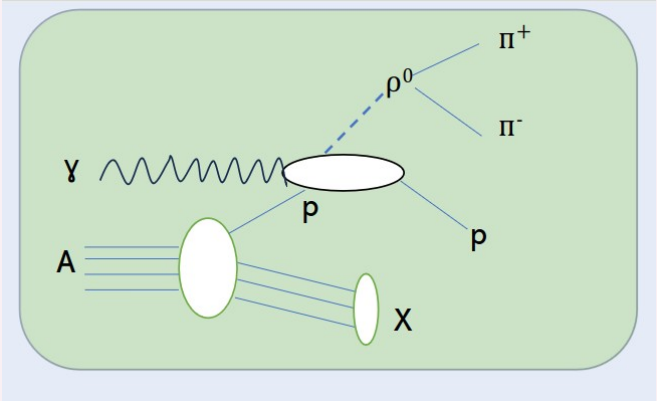
Flags: Vertex and Momentum constrained, 4 beam bunches on each sides of prompt peak, 2 Extra tracks and 5 extra shower: **B4F4T2S5**

DSelector Stage

Loose cuts

CL > 0.0001 , beam energy > 6.0 GeV, Extra tracks = 0, Missing Momentum < 350 MeV , 2 accidental peak on each side of prompt peak.

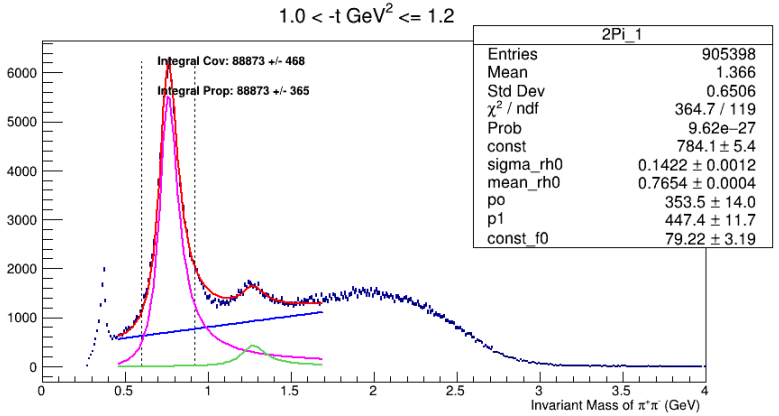
- **Base Criteria**
- Confidence Level > 0.001
- Beam Energy [6.5,10.8 GeV]
- Extra Tracks = 0
- Numbers of Shower = 5
- Proton Vertex [52,78] cm
- Missing Momentum < 300 MeV/c

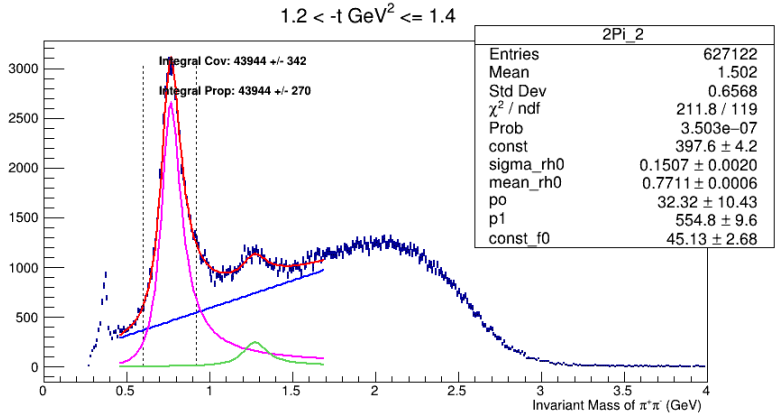


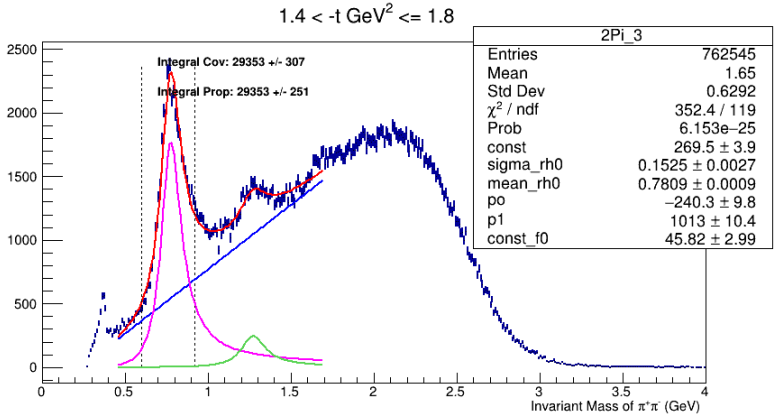
t_min	t_max	Proton angle
1	1.2	> 25 degree
1.2	1.4	> 25 degree
1.4	1.8	> 25 degree
1.8	2.6	> 25 degree
2.6	3.4	> 25 degree
3.4	4.6	> **20 degree**

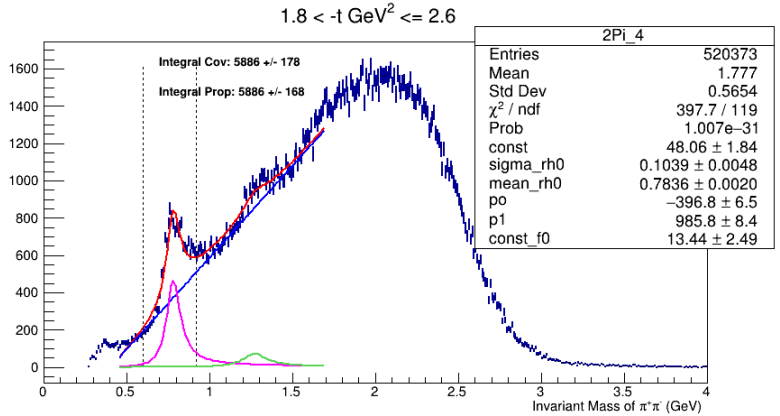
Selection cuts have been applied consistently to both data and reconstructed simulations.

Deuterium Data:







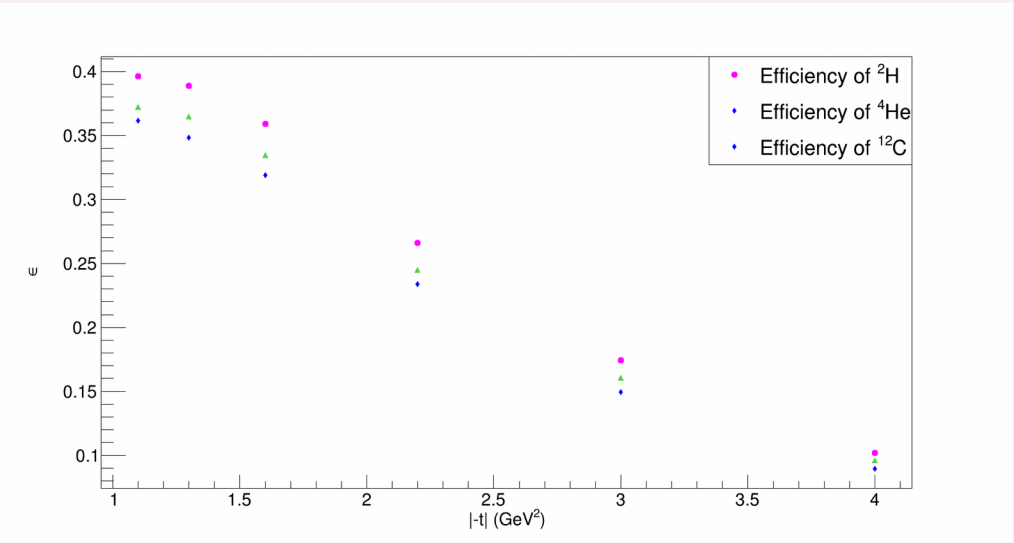


Uncertainty in Yield

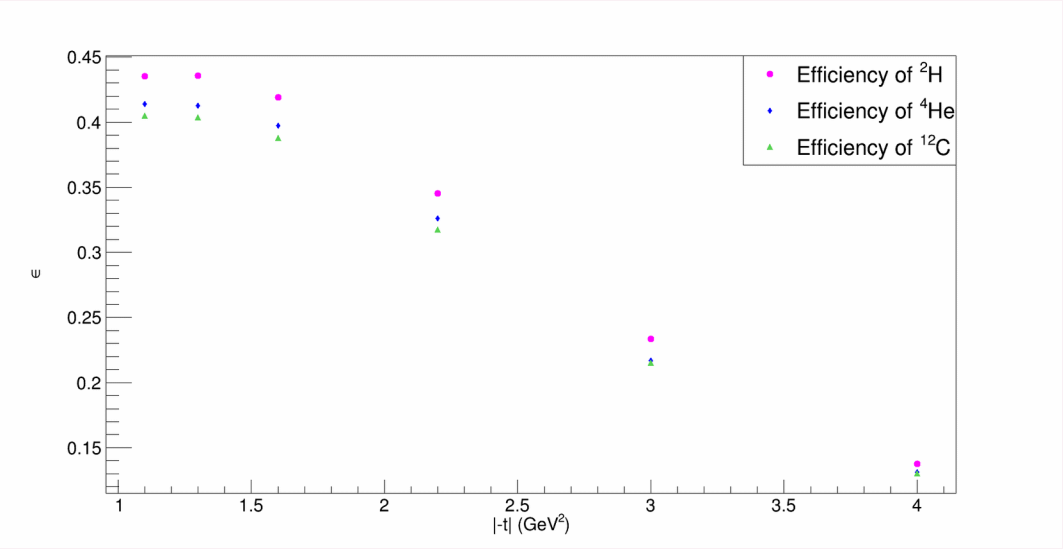
Table 3.1: Yields for each nucleus as a function of momentum transfer.

Nucleus	$\lvert -t \rvert (GeV^2)$					
	1 - 1.2	1.2 - 1.4	1.4 - 1.8	1.8 - 2.6	2.6 - 3.4	3.4 - 4.6
Deuterium	468 88873±365	342 43944±270	307 29353±251	178 5886±168	1068±59	288±32
Helium	490 91898±377	359 46425±279	326 33253±262	198 7950±176	1057±63	330±35
Carbon	465 81832±353	340 41237±261	312 31247±246	193 8579±165	1051±58	357±31

Efficiencies



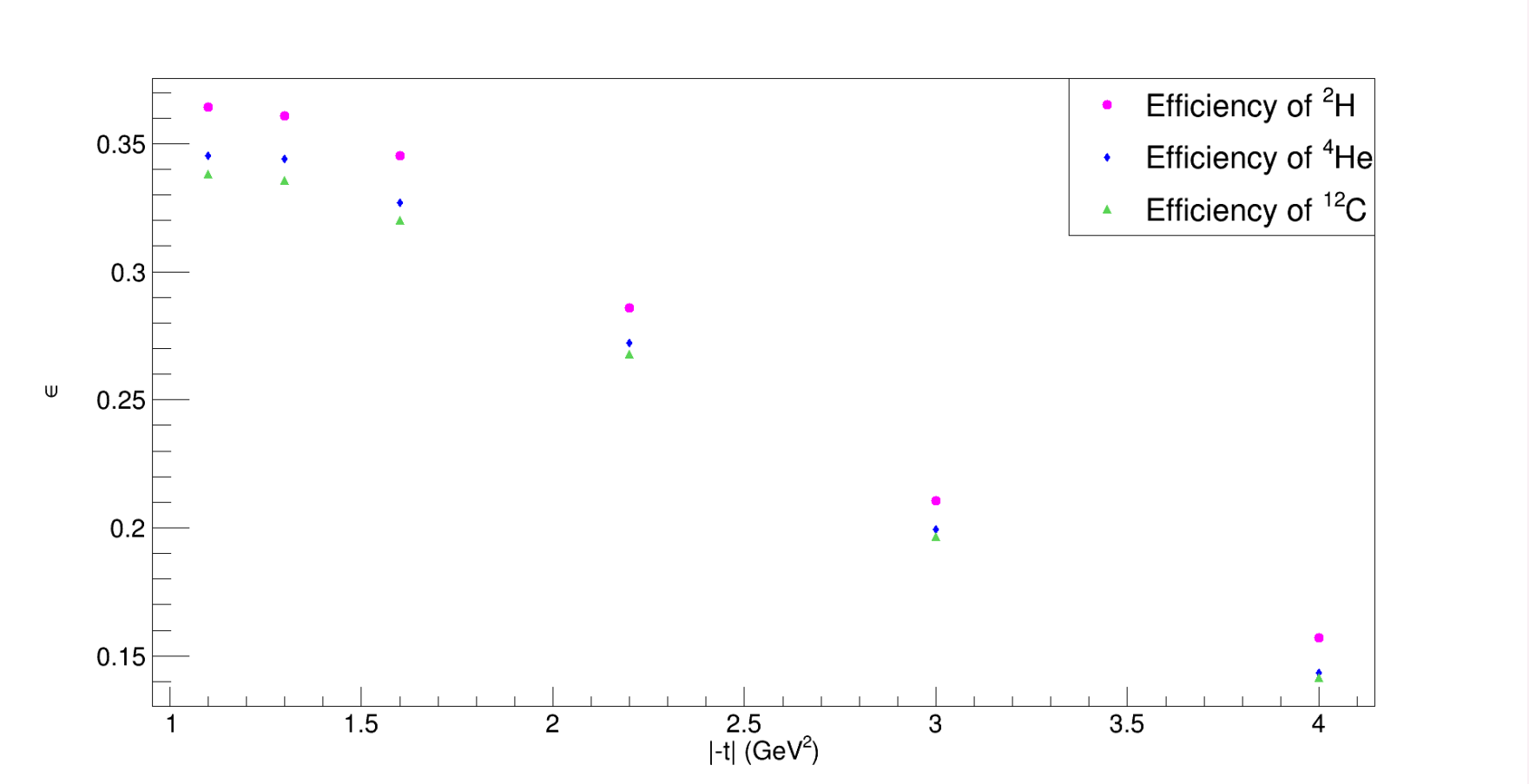
Truth Beam energy: No cut



Truth Beam energy >6.5 GeV

Beam contains no accidental peaks

Final Corrected efficiency



Truth Beam energy: >6.5 GeV and Accidental sideband subtraction

Formula

$$Luminosity = flux * \text{Target Length} * \text{Number Density}$$

$$\sigma = \frac{N_{signal}}{\mathcal{L} \times \epsilon \times B(\rho^0 \rightarrow \pi^+\pi^-)}$$

Nucleus	Tagged Photon Flux (10^{12})	Tagged Luminosity (pb^{-1}·nucleon)
Deuterium	13.17	33.98
Helium	30.8	63.80
Carbon	49.46	97.73

Table :Tagged flux and luminosity for each target, with beam photons having energies between 6.5 and 10.8 GeV

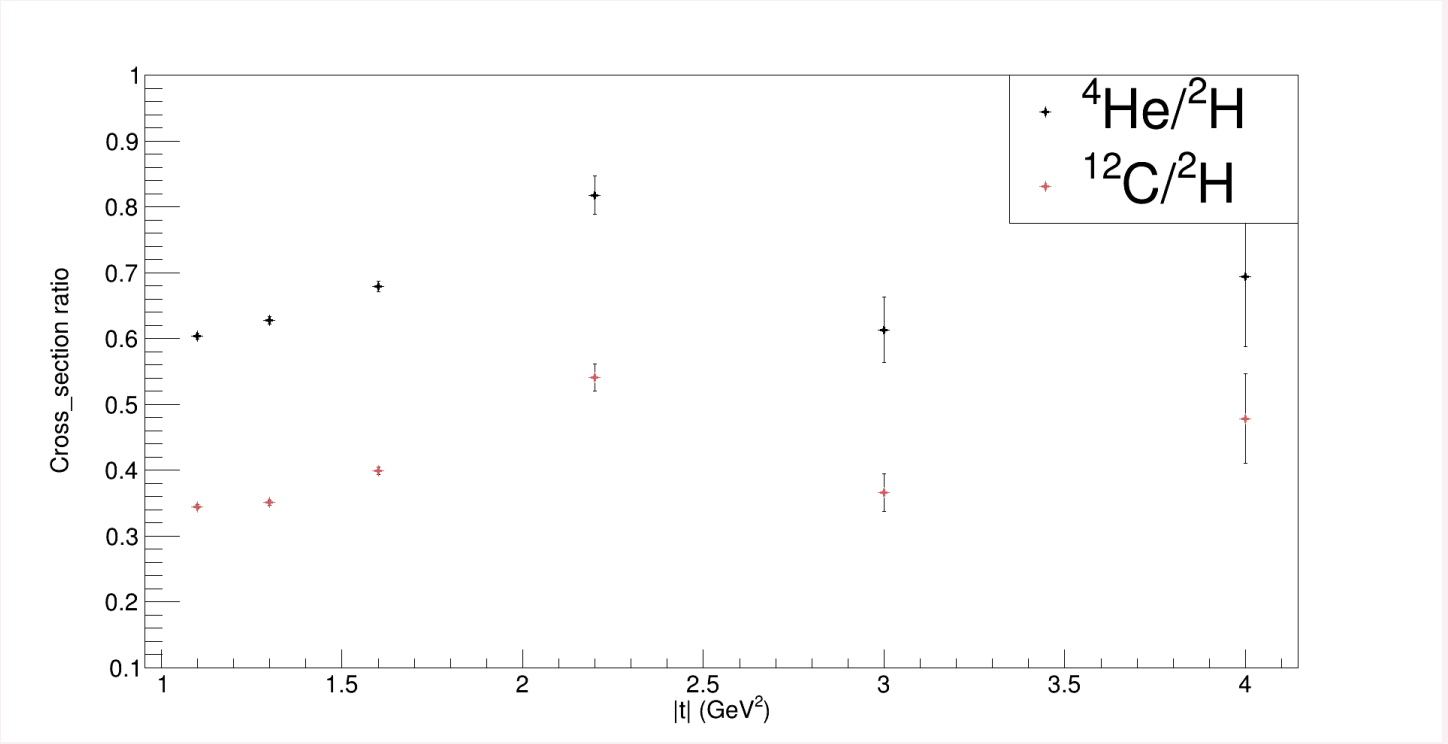
$$T(^4\text{He}) = \frac{\sigma_{(^4\text{He})}}{\sigma_{(^2\text{H})}}$$

$$T(^{12}\text{C}) = \frac{\sigma_{(^{12}\text{C})}}{\sigma_{(^2\text{H})}}$$

Number Density = $$\rho_N = \frac{N_{\text{Avogadro}}(\text{particle/mole}) \times \text{target mass density}(\text{gm/cm}^3)}{\text{atomic weight of proton}(\text{gm/mole})} \times \frac{1\text{cm}^2}{1 \times 10^{24}\ \text{barns}}$$

Source: Hao Li's Dissertation (Glue X)

Cross-Sectional Ratio.

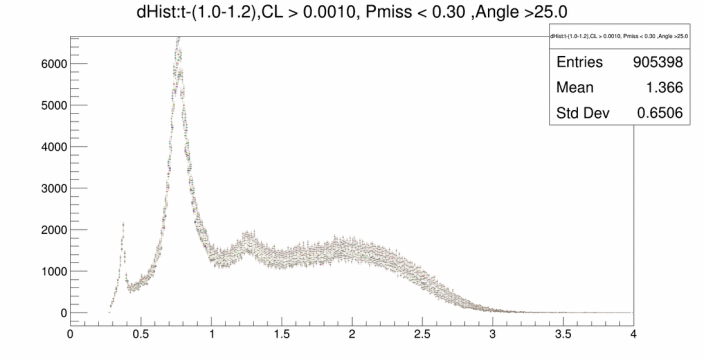


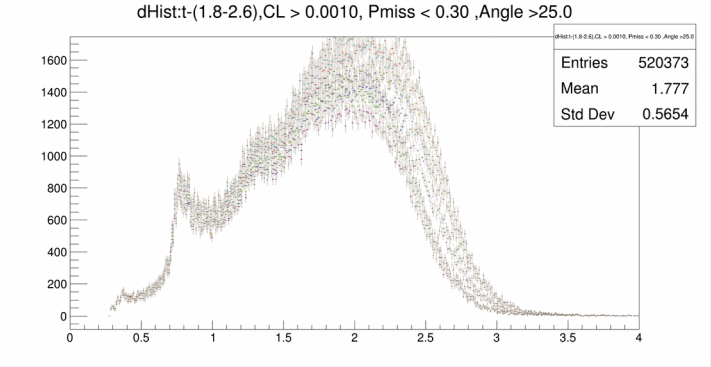
Only statistical uncertainties from data yields are considered for this calculation.

Systematic uncertainties: Event Selection.

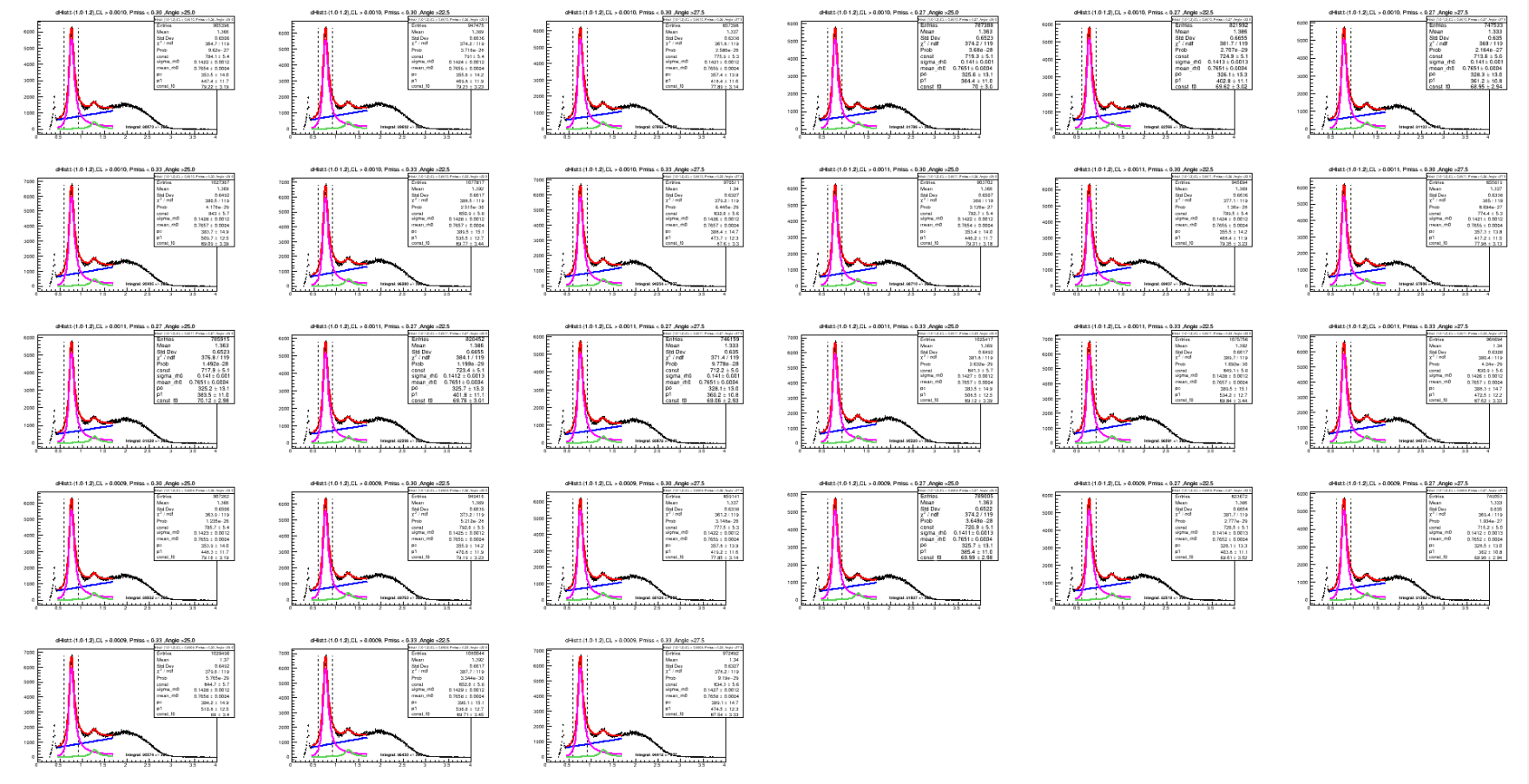
t_min	t_max	Proton angle	Confidence level	Missing Momentum
1.0	1.2	> (**25**, 27.5, 22.5) degree	> (**0.001**, 0.0011, 0.0009)	< (**300**, 270, 330) MeV
1.2	1.4	> (**25**, 27.5, 22.5) degree	> (**0.001**, 0.0011, 0.0009)	< (**300**, 270, 330) MeV
1.4	1.8	> (**25**, 27.5, 22.5) degree	> (**0.001**, 0.0011, 0.0009)	< (**300**, 270, 330) MeV
1.8	2.6	> (**25**, 27.5, 22.5) degree	> (**0.001**, 0.0011, 0.0009)	< (**300**, 270, 330) MeV
2.6	3.4	> (**25**, 27.5, 22.5) degree	> (**0.001**, 0.0011, 0.0009)	< (**300**, 270, 330) MeV
3.4	4.6	> (**20**, 27.5, 22.5) degree	> (**0.001**, 0.0011, 0.0009)	< (**300**, 270, 330) MeV

Missing Momentum :
270 → 290 MeV
330 → 310 Mev

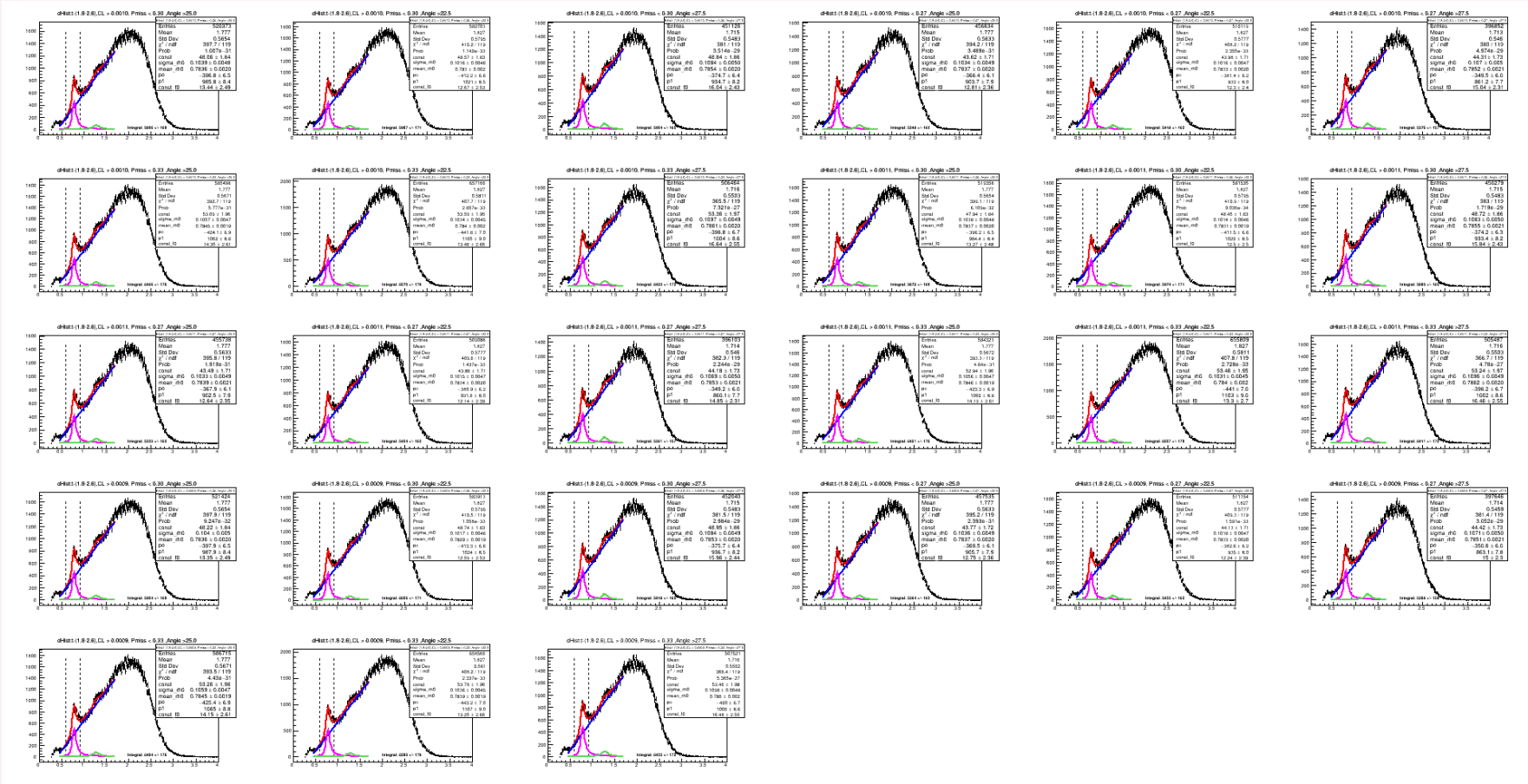




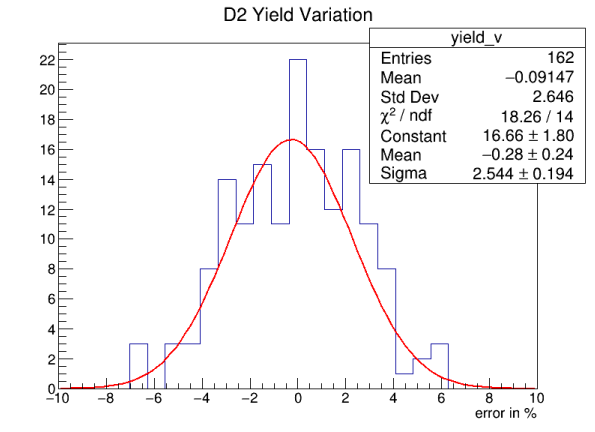
Data: Invariant Mass distribution of Carbon for (1.0 < t < 1.2)

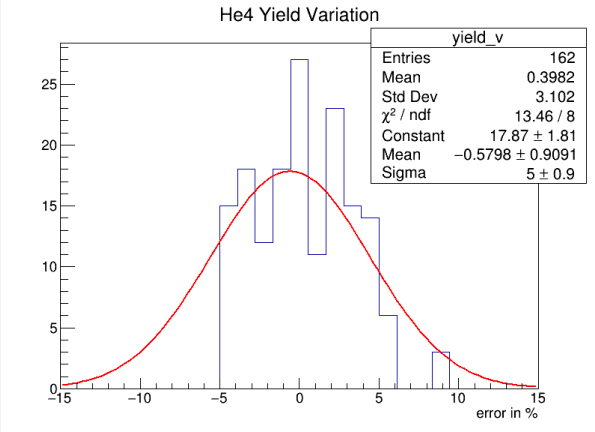


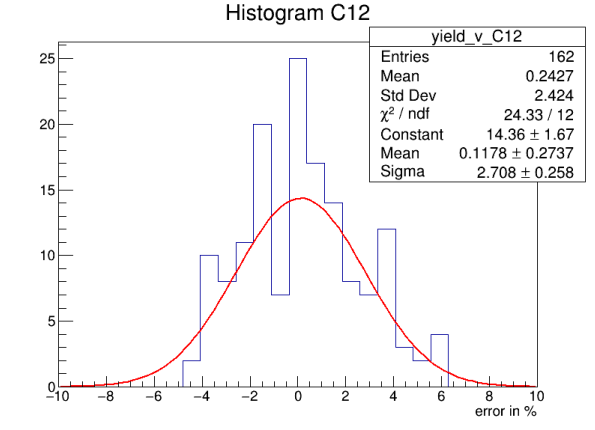
Data: Invariant Mass distribution of Carbon for (1.8 < t < 2.6)



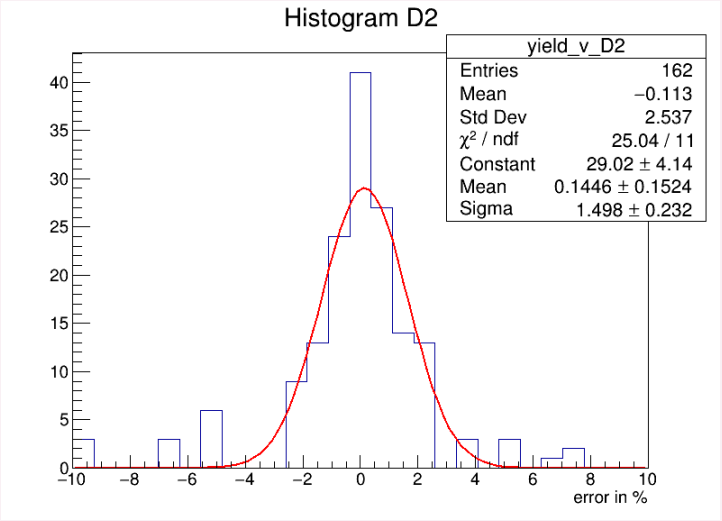
Yield Variation

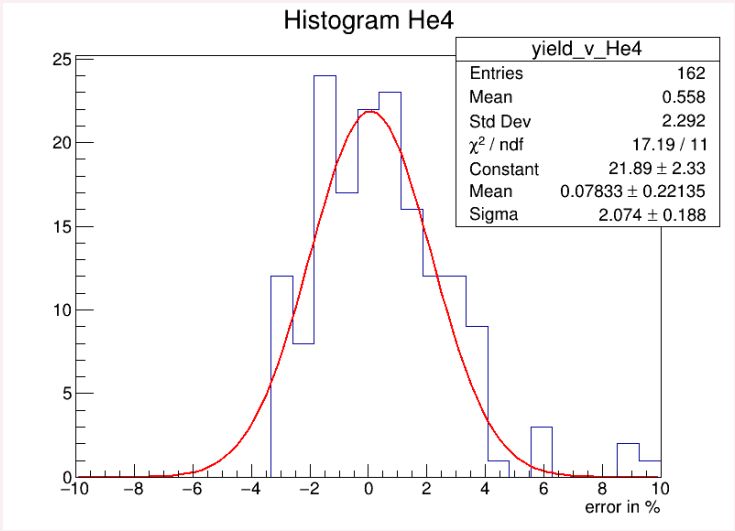


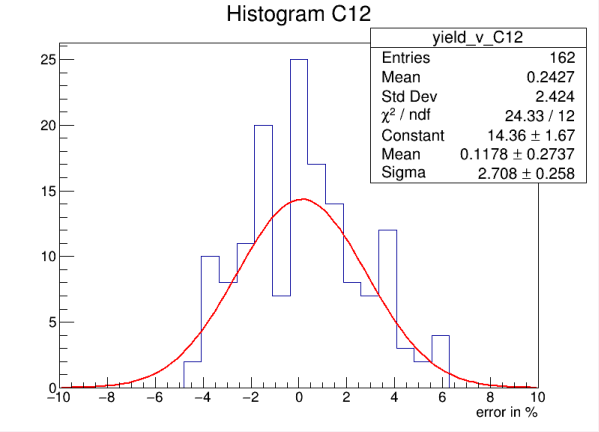




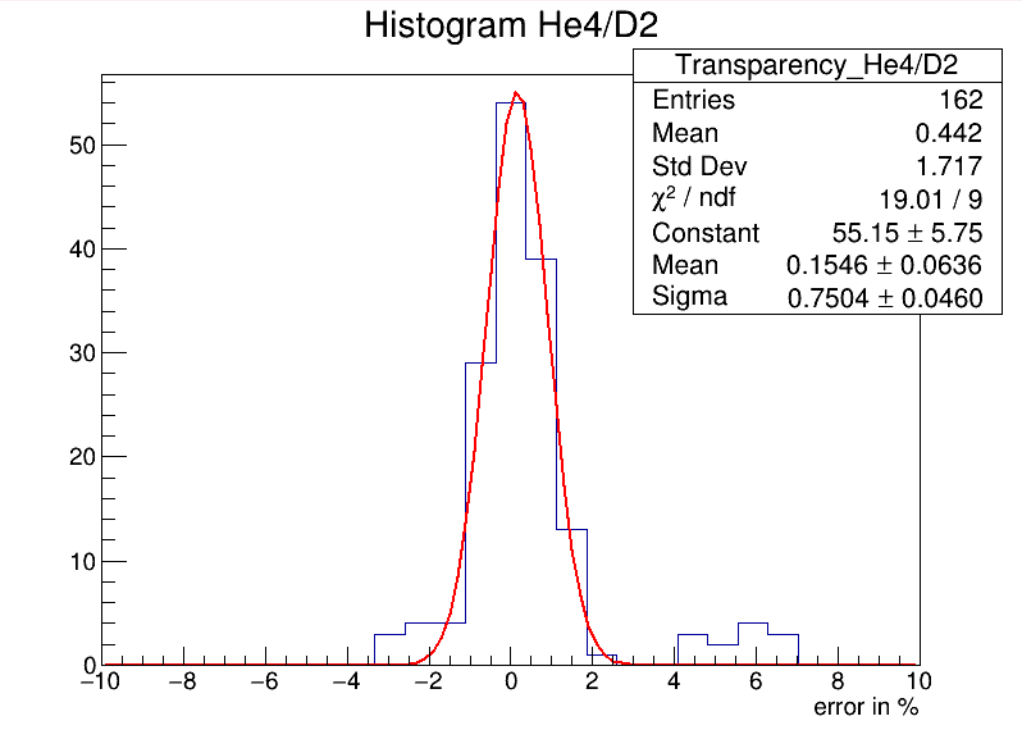
Cross-Section Variation

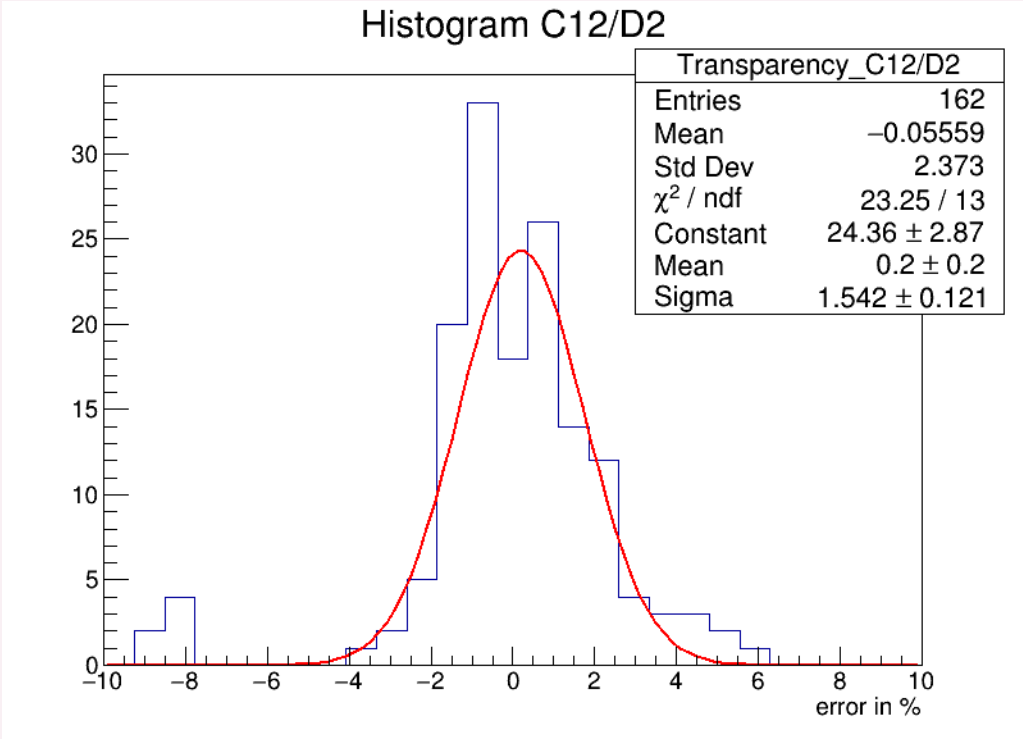






Transparency Variation



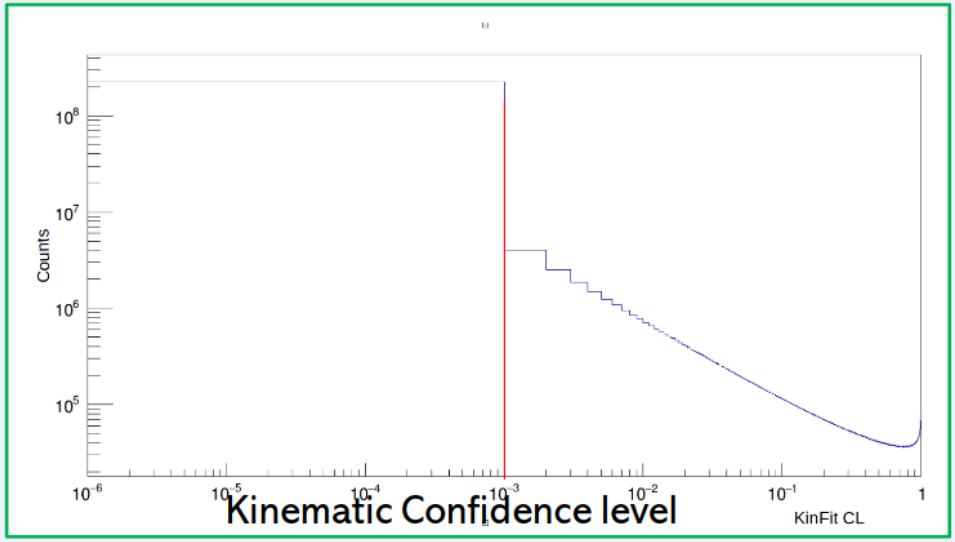


PID Selection Timing Cuts

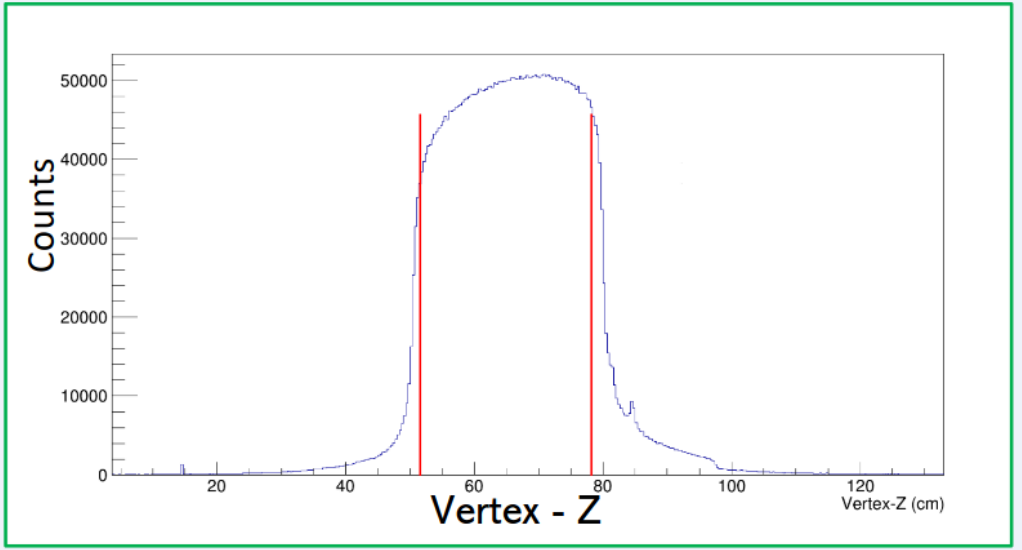
Particle ID	Timing Offset			
	BCAL/RF	TOF/RF	FCAL/RF	SC/RF
Charged Pions	± 1.0 ns	± 0.5 ns	± 2.0 ns	± 2.5 ns
Protons	± 1.0 ns	± 0.6 ns	± 2.0 ns	± 2.5 ns

Particle ID	CDC dE/dx Cut (keV/cm)	Combined dE/dx Cut (FDC,SC,TOF)
Charged Pions	$(< 3 + \exp(-7\,\|\mathbf{p}\|) + 6.2$	Not applied
Protons	$(> 2.25 + \exp(-4\,\|\mathbf{p}\|) + 1$	Not applied

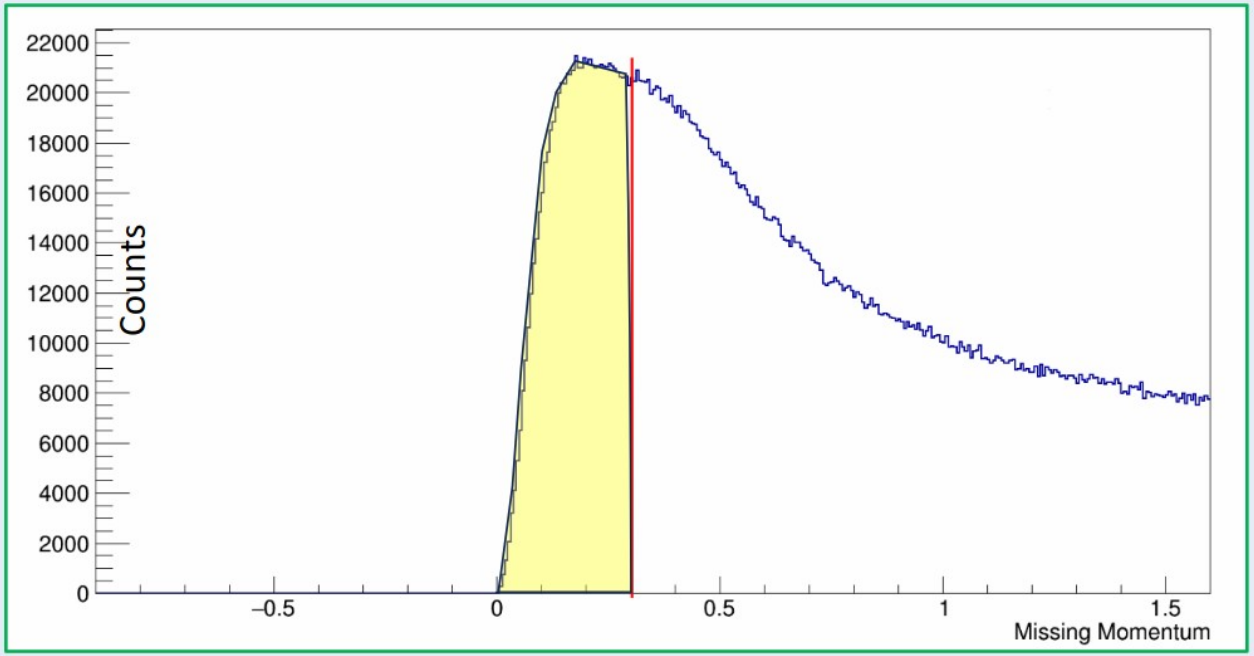
Kinfit and vertex cut



Plot: Kinematic Fit for confidence level



Missing Momentum



Plot: Missing Momentum distribution.

$$P_{\text{miss}} = (E_{\text{miss}}, \vec{p}_{\text{miss}})$$

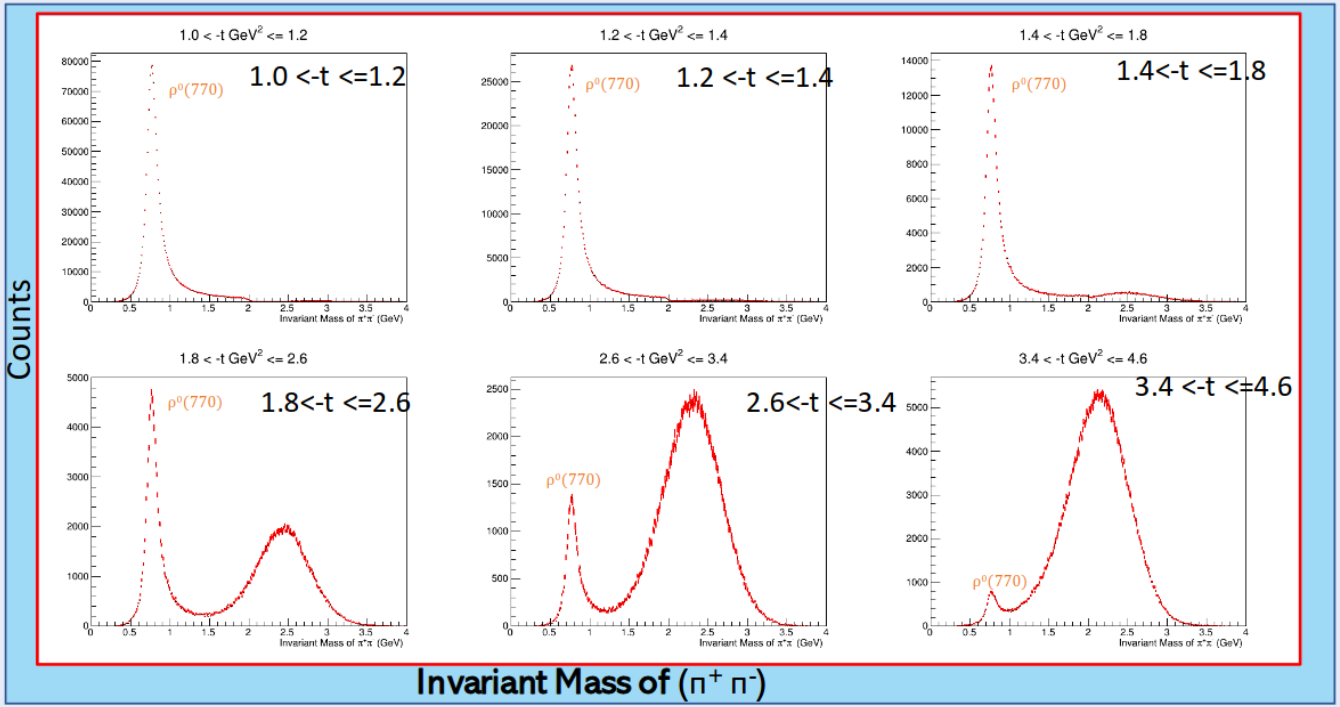
$$P_{\text{miss}} = (P_{\pi^+} + P_{\pi^-} + P_p - P_\gamma)$$

P_γ : Four momentum of the photon beam,

$P_{\pi^+}, P_{\pi^-}, P_p$: Four momenta of detected final state particles.

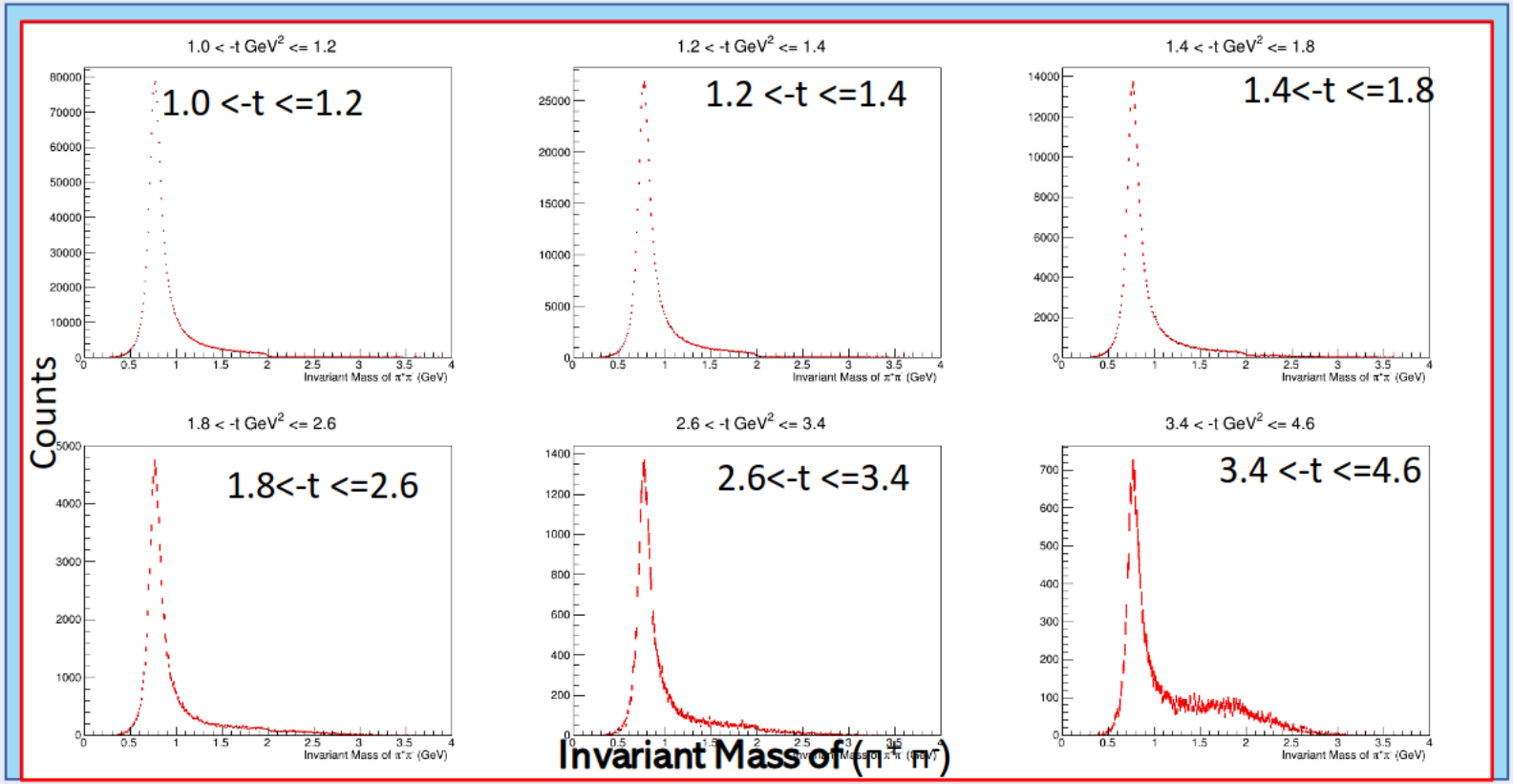
- Looking for events only for the mean-field region.
- Selecting missing momentum less than 300 MeV to remove events originating from the Short-Range Correlation(SRC) region.

Invariant Mass distribution of Reconstructed MC



Plot: Invariant Mass distribution of simulated events for helium targets before applying angular cuts on proton candidate

Invariant mass distribution after applying angular cuts on proton



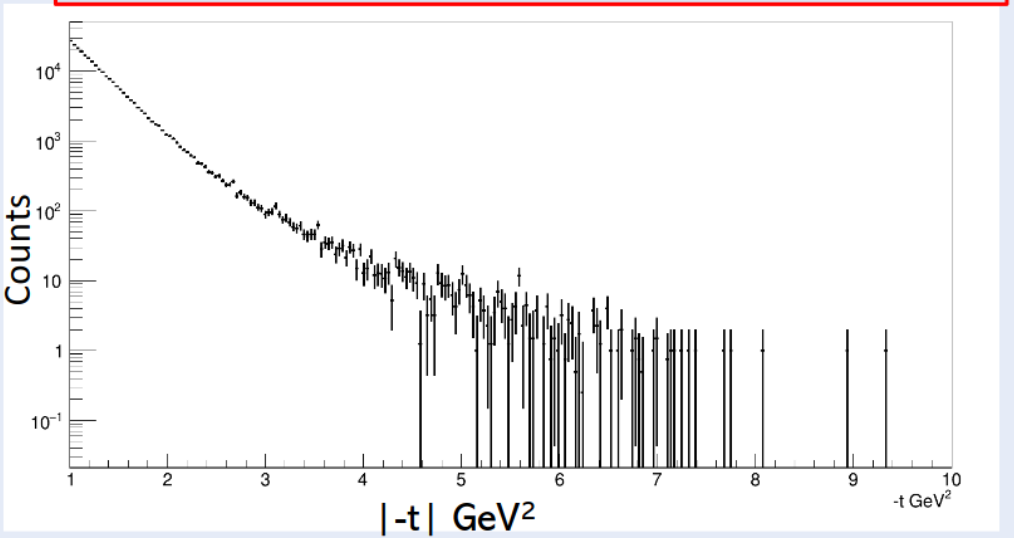
Plot: Invariant mass distribution of simulated events for helium targets after applying selection cuts on proton candidate

$$(\gamma A \rightarrow \pi^+\pi^- pX)$$

Mandelstam Variable "t" is defined in terms of beam photon and the final-state particles

$$t = -(P_\gamma - P_{\pi^+\pi^-}),$$

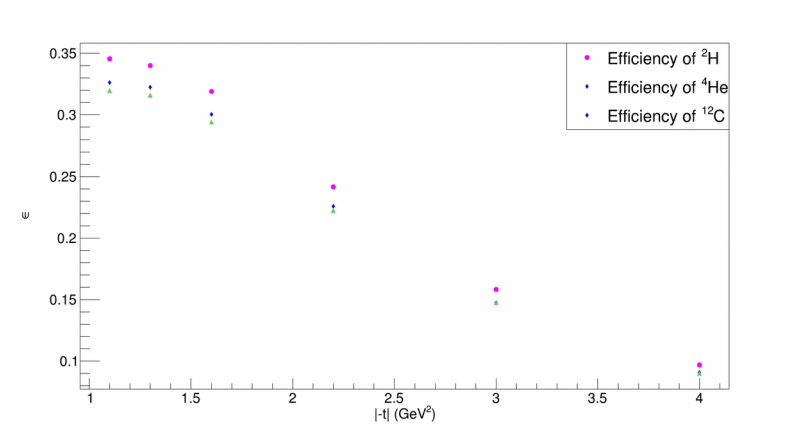
|-t| GeV² for θproton > 20⁰ & 0.6 < $M_{\Pi+\Pi-}$< 0.92 GeV



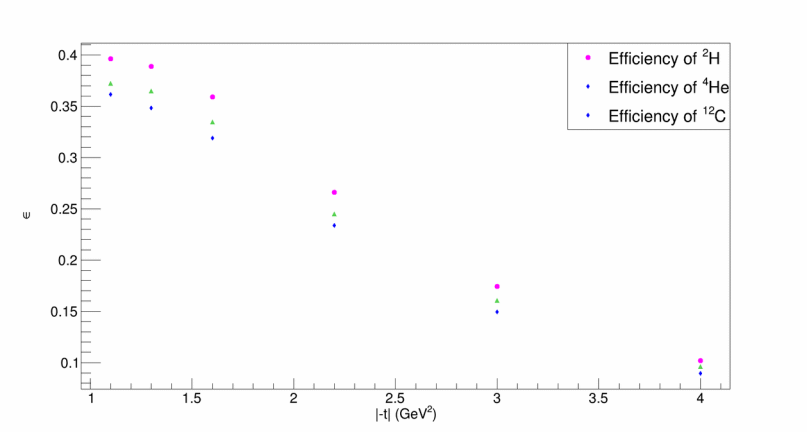
S.N	|-t| GeV² Range
1	1.0 < |-t| GeV² ≤ 1.2
2	1.2 < |-t| GeV² ≤1.4
3	1.4 < |-t| GeV² ≤1.8
4	1.8 < |-t| GeV² ≤2.6
5	2.6 < |-t| GeV² ≤3.4
6	3.4 < |-t| GeV² ≤4.6

Results: before and after TOF MC improvement

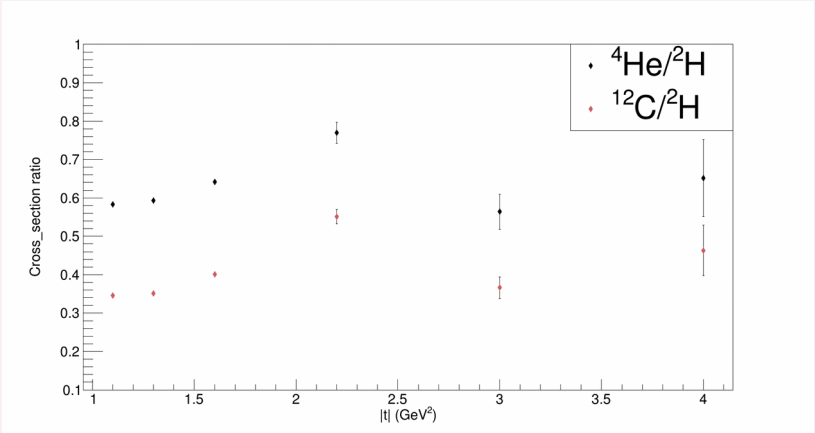
Efficiency: Before



Efficiency:After



Cross-section ratio: Before



Cross-Section ratio: After