Coherent Vector Meson Photoproduction off Deuterium

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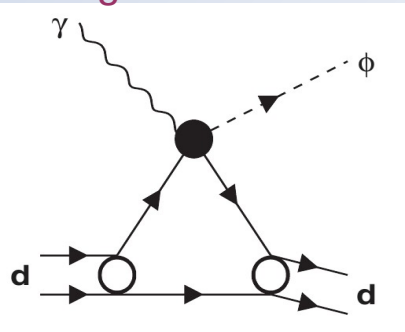
OUTLINE

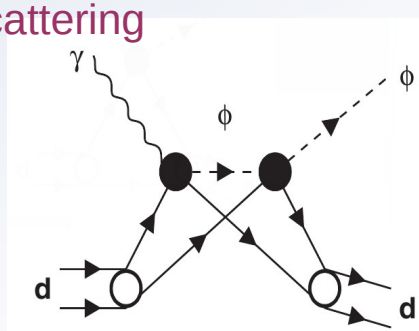
- Motivation
- A theoretical model
- PID Spectra
- Basic Cuts
- Global Plots: Data
- Acceptance
- Yield Extraction
- Preliminary Results
- ω - photoproduction
- Conclusion

MOTIVATION

Single scattering



Double scattering

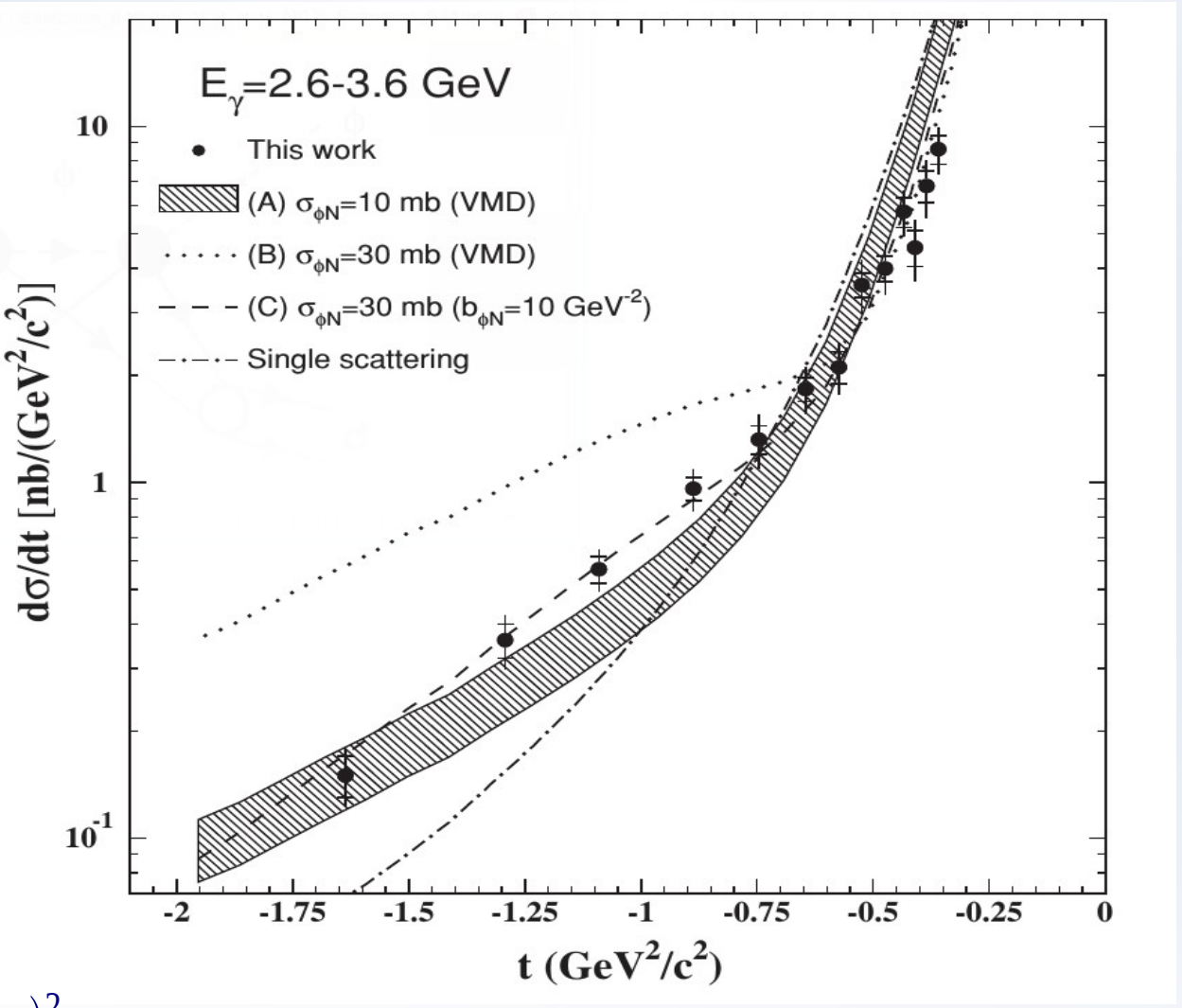


Reactions in interest

$$\gamma d \rightarrow \rho d \qquad \gamma d \rightarrow \omega d$$

Mandelstam ***t*** :

$$t = (P_\gamma - P_\rho)^2 = (P_{d_i} - P_{d_o})^2$$



T. Mibe *et al.* PHYSICAL REVIEW C 76, 052202(R) (2007)

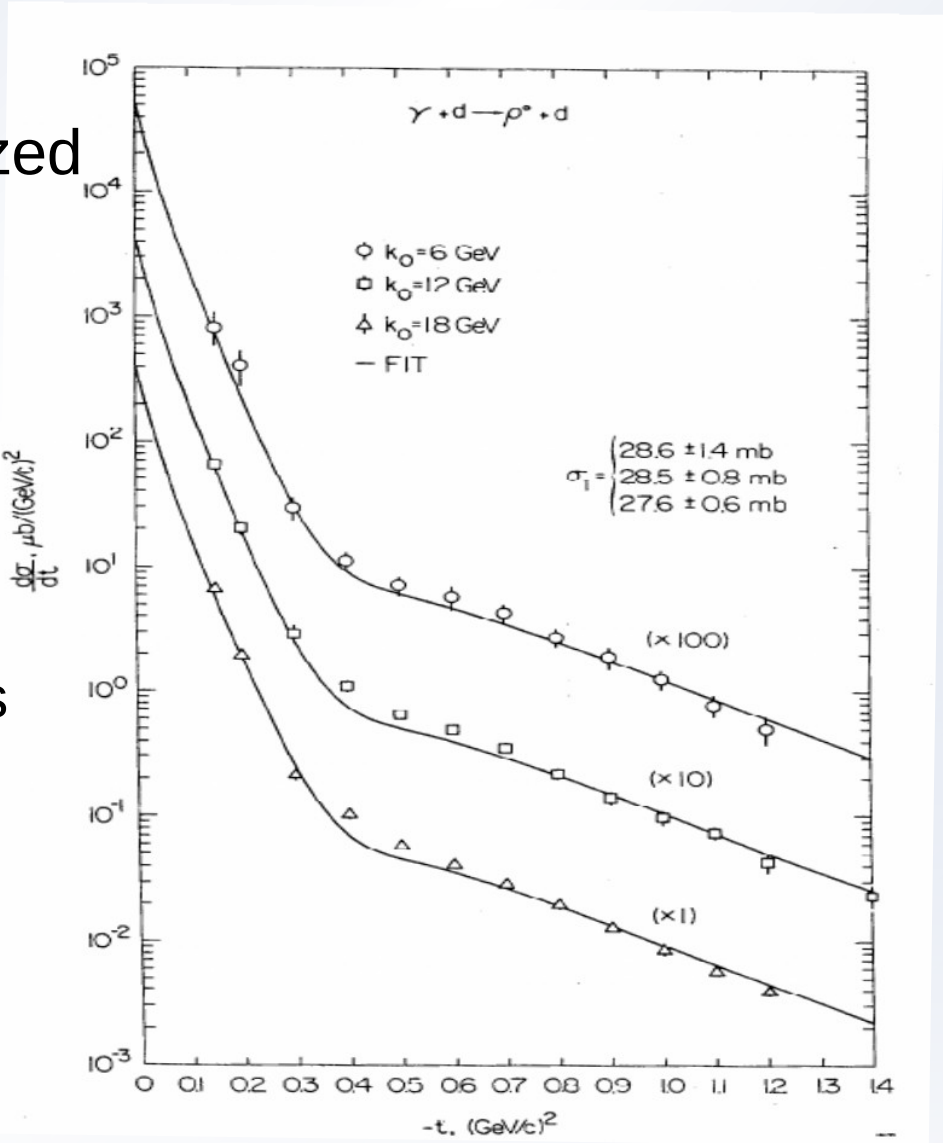
MOTIVATION

- These channels were never analyzed before for low E and higher t.

- SLAC:
  - E = 6, 12, 18 GeV
  - $|t|$ = [0.15,1.2] GeV^2/c^2
  - Fits based on Glauber Theory
  - Conclusion:
    Vector Dominance Model does not describe all photon-hadron interactions

- This reaction is a competing reaction with the d* process (dibaryon resonance)

$$\gamma d \rightarrow \pi d^{*} \rightarrow \pi^{+} \pi^{-} d$$

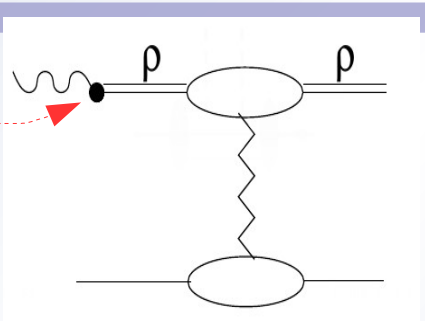


I. D. Overman, *"Coherent photoproduction of rho mesons from deuterium,"* US Atomic Energy Commission **SLAC-140, UC-34** (1971)

A THEORETICAL MODEL

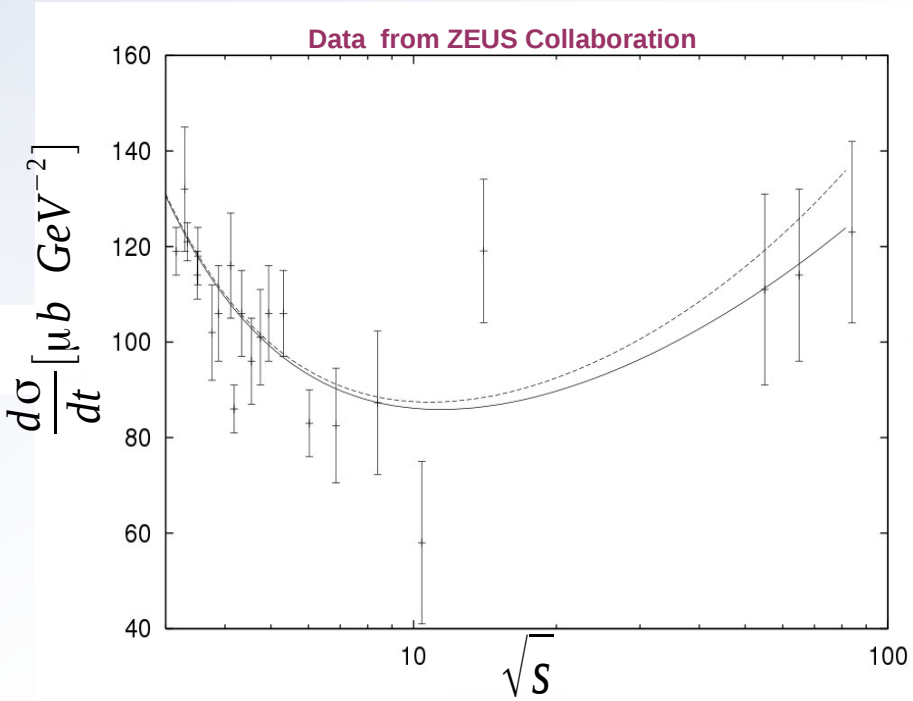
Simple version of VMD:

$$\frac{d\sigma}{dt}(\gamma\, p \to \rho\, p; t) = \alpha_{EM}\frac{4\pi}{\gamma_\rho^2}\frac{d\sigma}{dt}(\rho\, p \to \rho\, p; t)$$

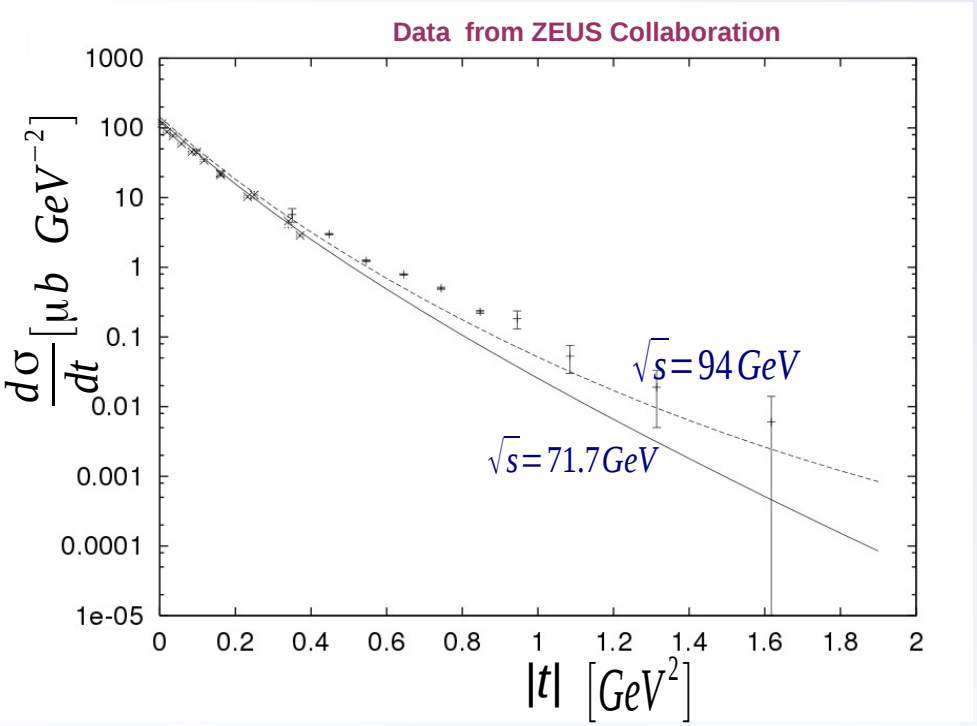


γ_ρ :rho-photon coupling obtained from $\rho \to e^+ e^-$

- Assuming coupling to ρ as same as π
- Pomeron and Regge exchange $(f_2,\ a_2)$
- Normalization factor 0.84



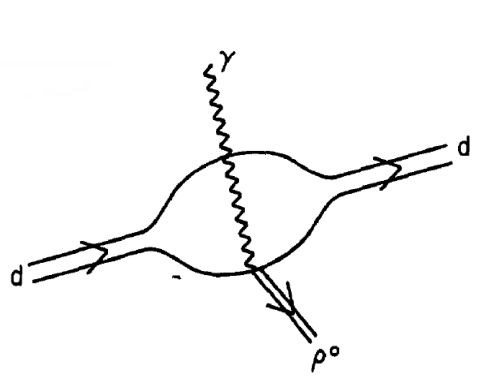
$d\sigma/dt \quad at \quad t=0$



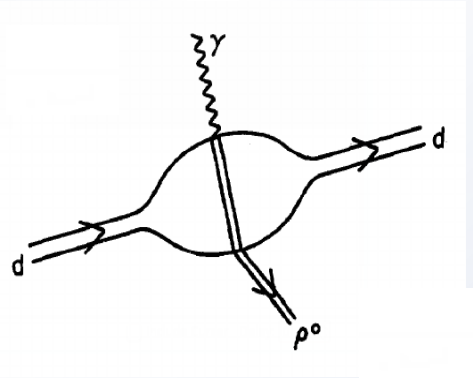
Idea taken from: *Applying Regge Theory* : P. Landshoff
http://www.indiana.edu/~jpac/Resources/Landshoff.pdf

A THEORETICAL MODEL

$\gamma d \to \rho d$



Single scattering



Double scattering

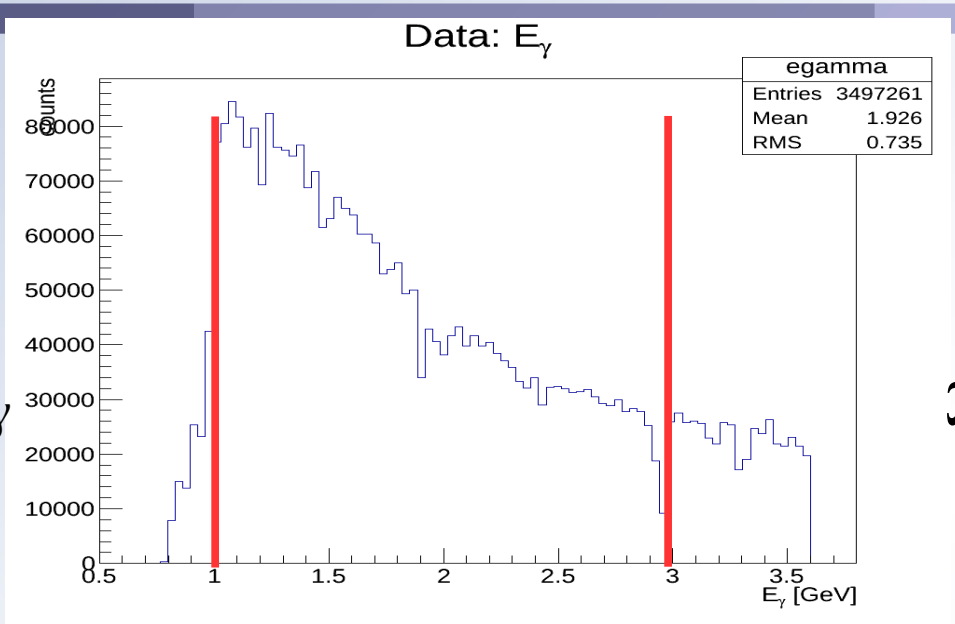
$F_{\gamma d \to \rho d}$ = single scattering term + double scattering term

VMD
Reggeon + Pomeron
Deuteron form factors

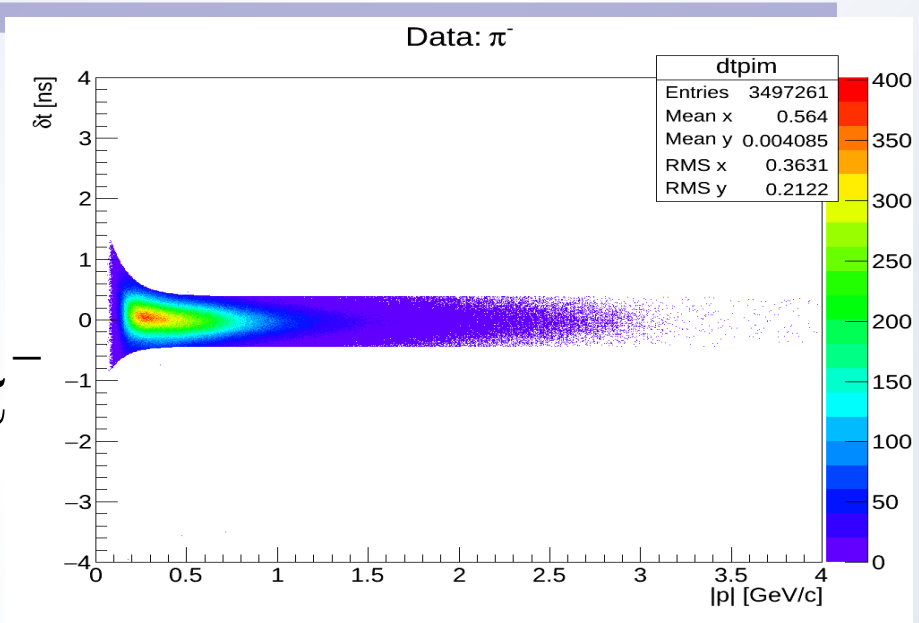
$$\frac{d\sigma}{dt}(\gamma d \to \rho d)_{theory}$$

PID SPECTRA (DATA)

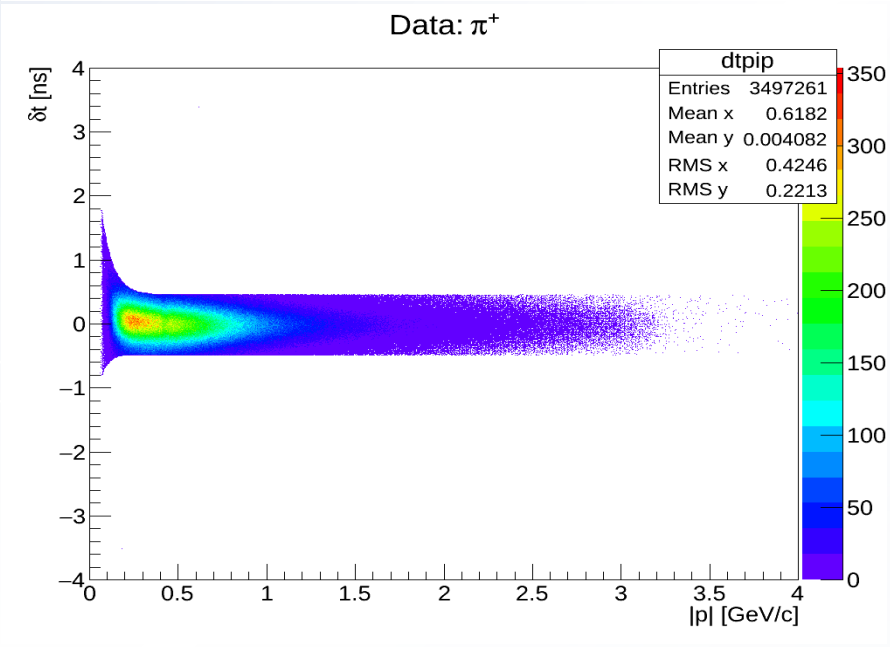
E_γ



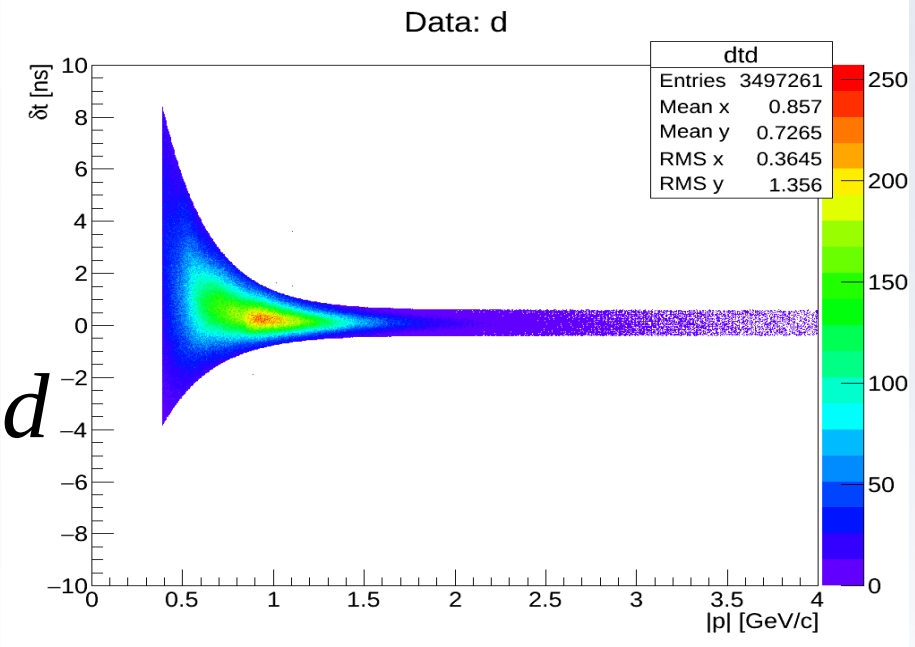
π^-



π^+

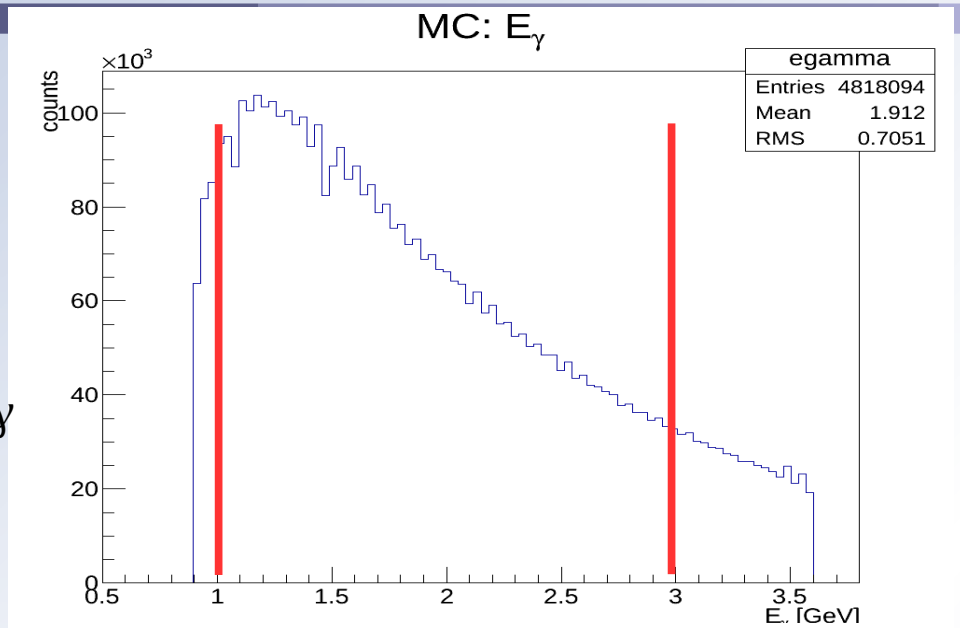


d

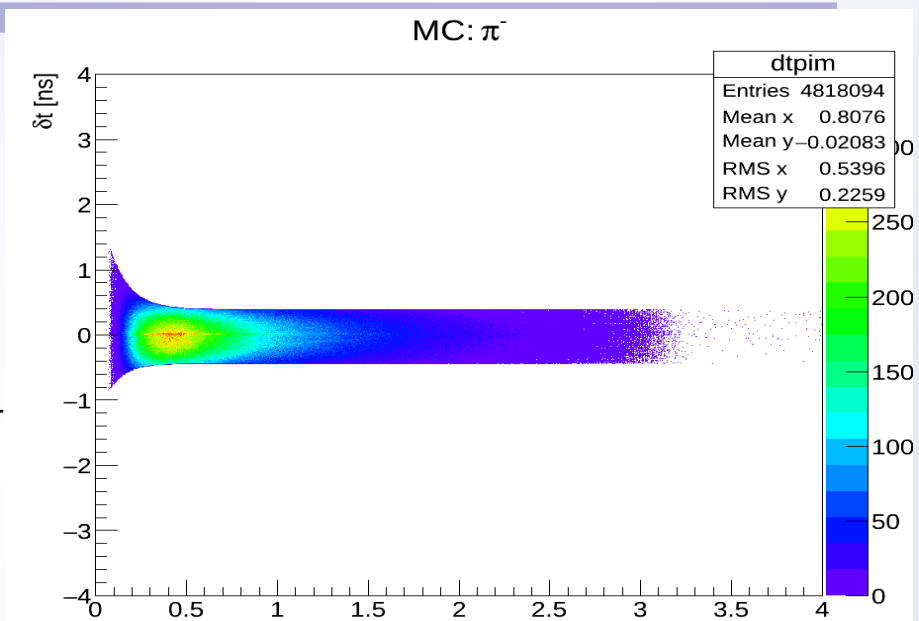


PID SPECTRA (MC)

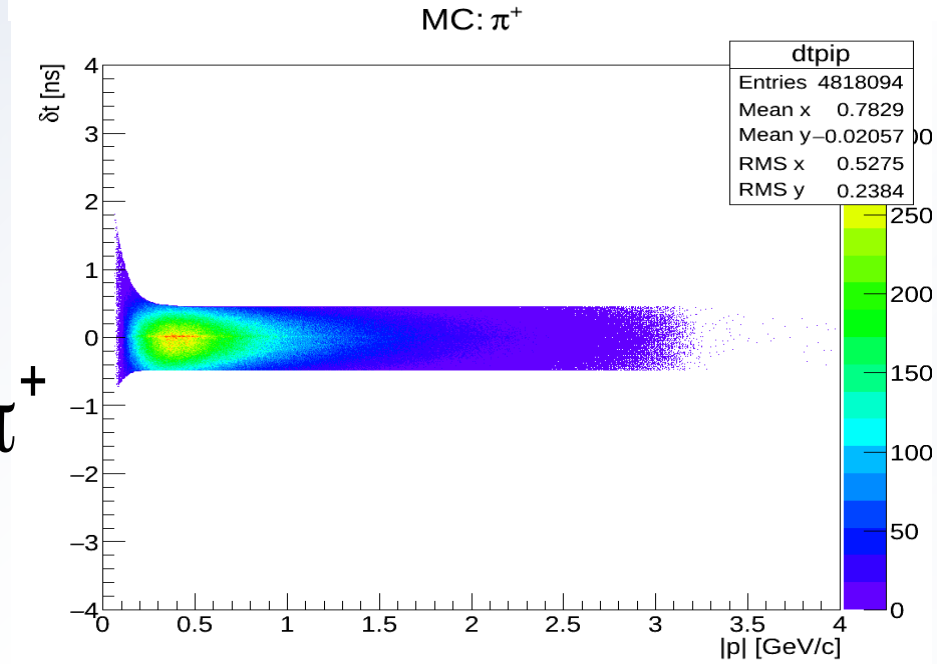
E_γ



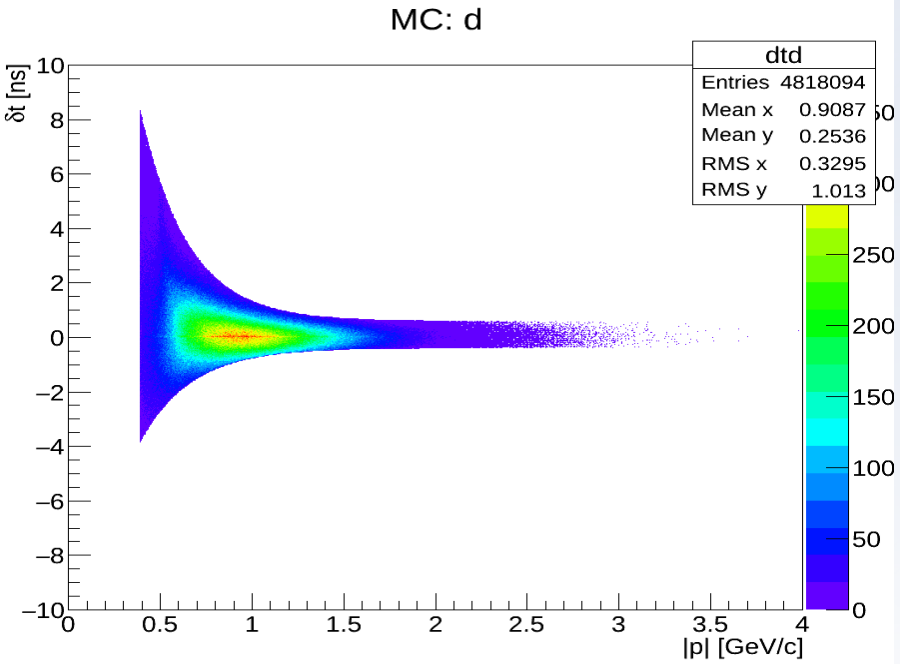
π^-



π^+



d



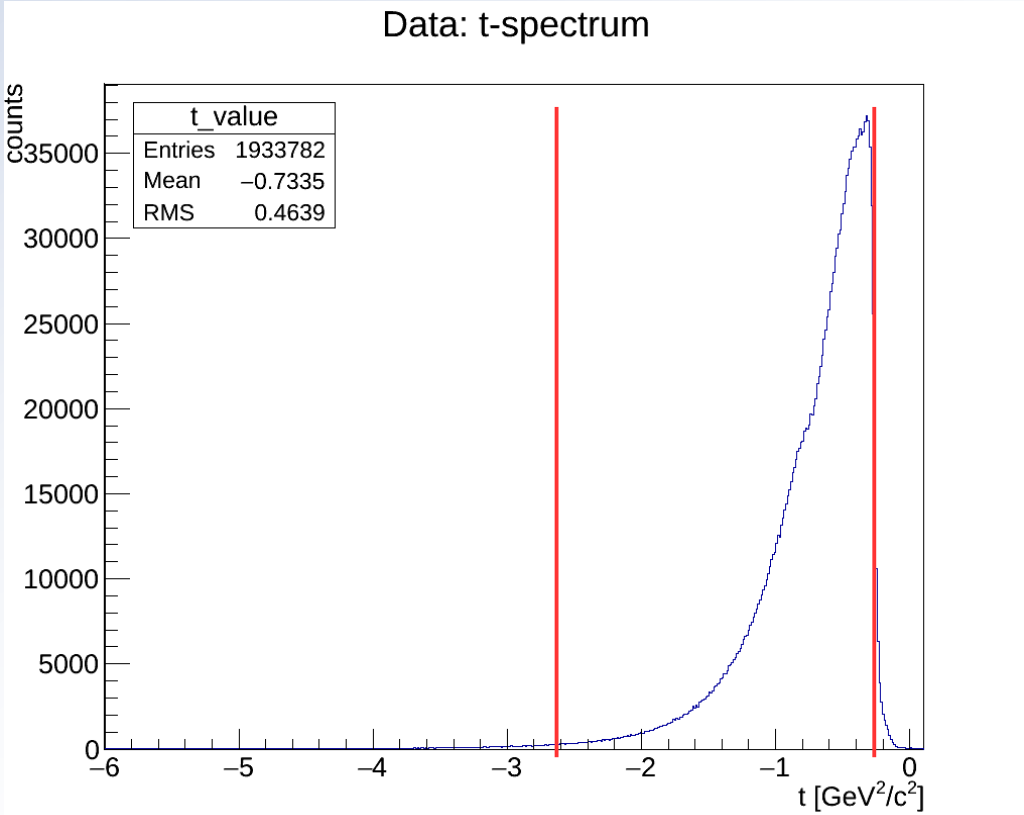
t-SPECTRUM

t-value calculated using:

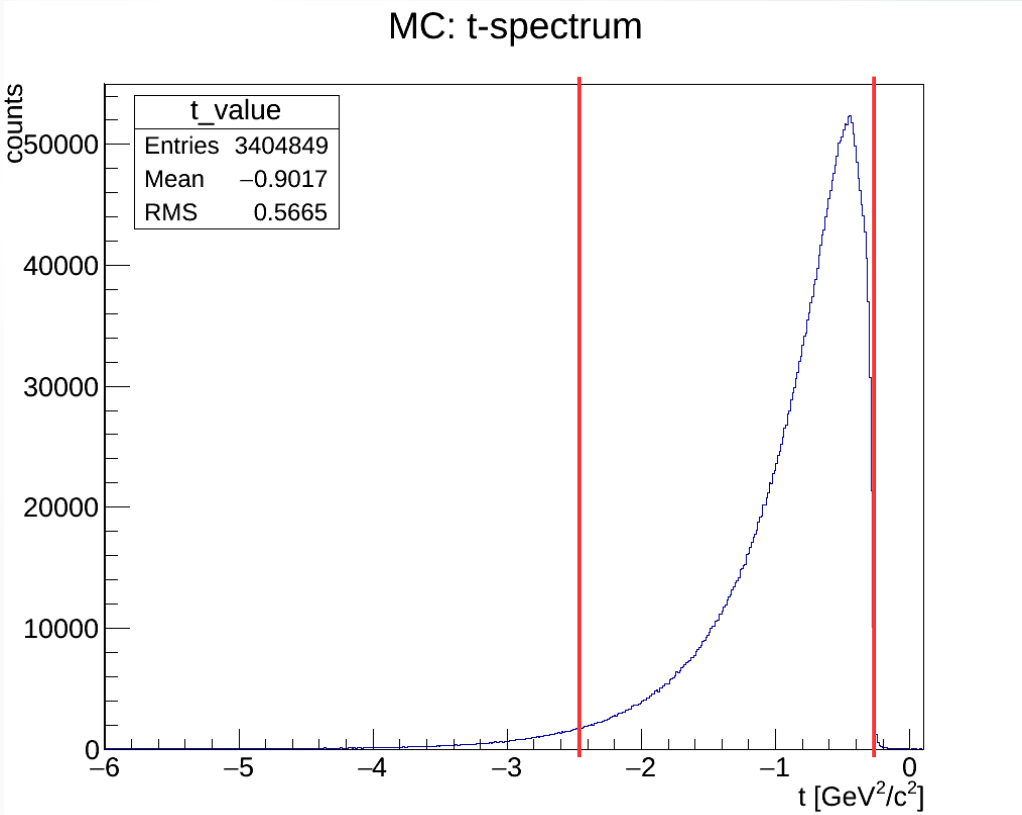
$$t = (P_\gamma - P_\rho)^2$$

$$-2.5 < t < -0.3$$

DATA

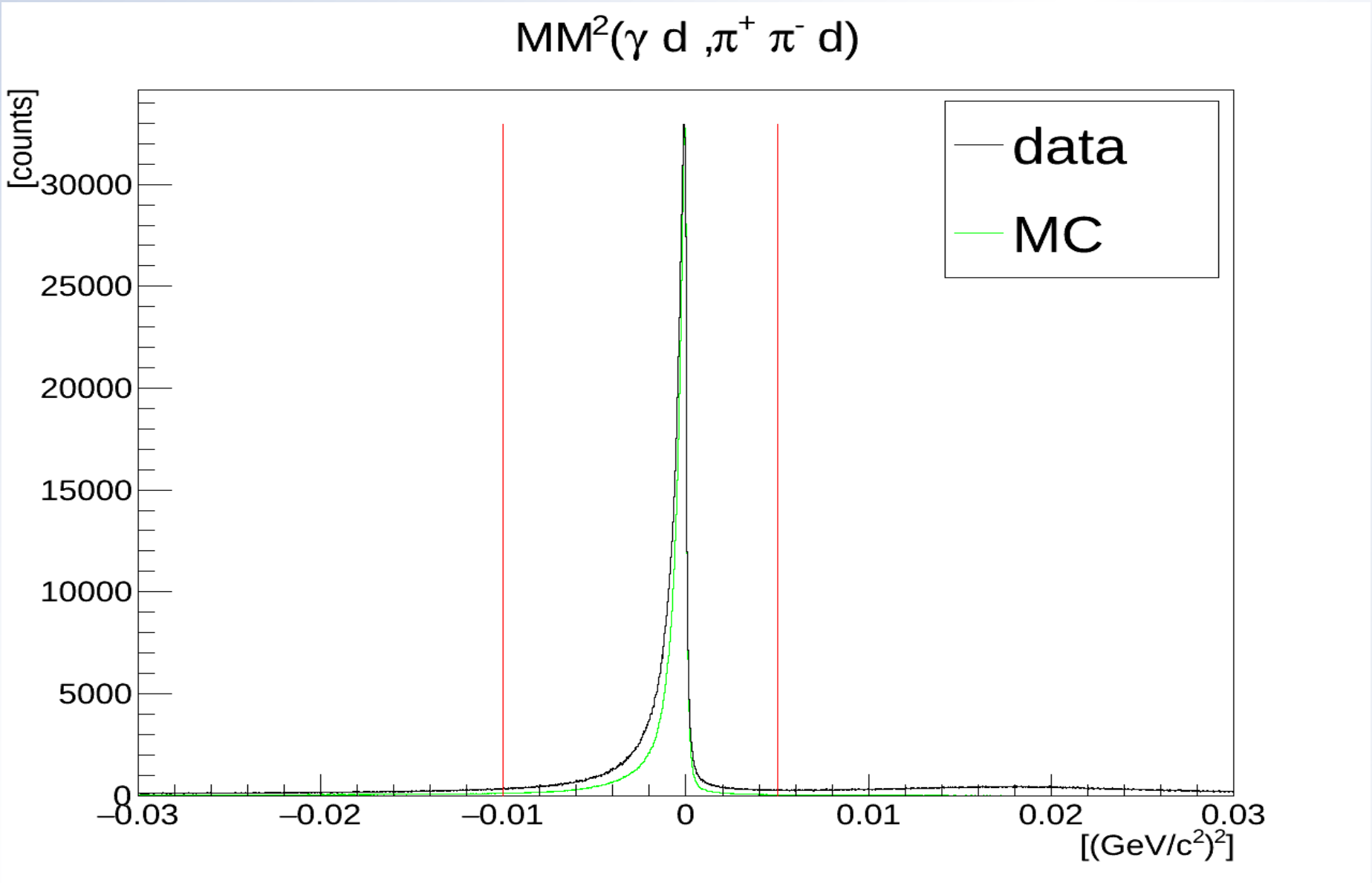


MC



Generated with *t-slope* = 1.5

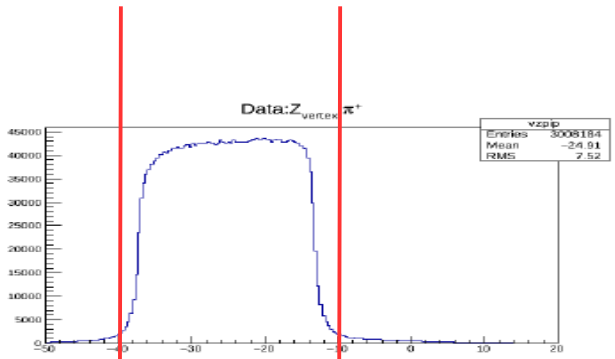
Missing Mass Squared CUT



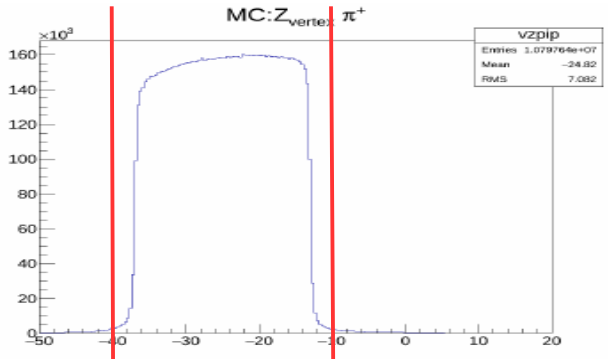
- *Scale normalized by peak height*

ZVERTEX CUT

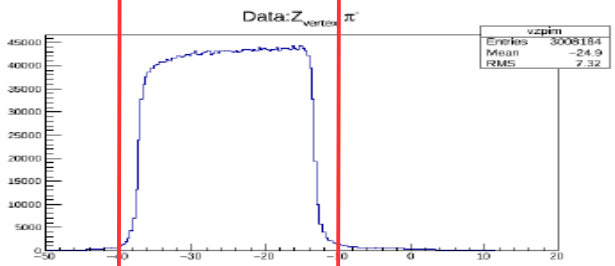
$-40\,cm < z_{vertex} < -10\,cm$



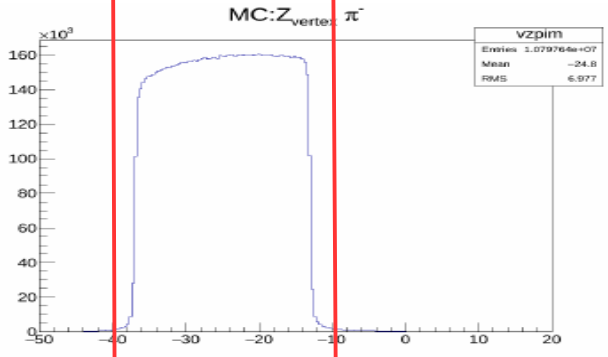
(a) $z_{vertex}(\pi^+)$



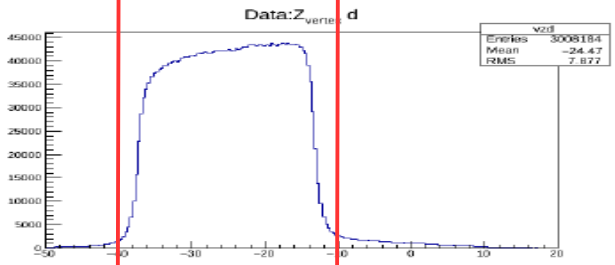
(b) $z_{vertex}(\pi^+)$



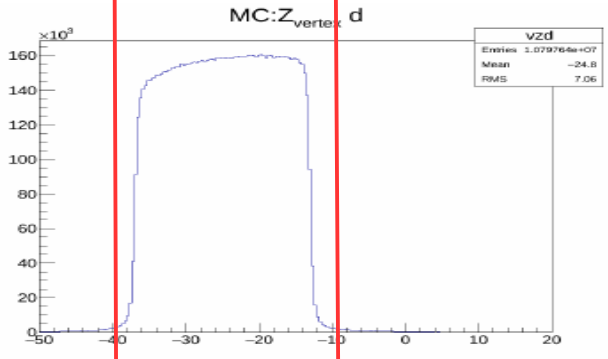
(c) $z_{vertex}(\pi^-)$



(d) $z_{vertex}(\pi^-)$



(e) $z_{vertex}(d)$



(f) MC $z_{vertex}(d)$

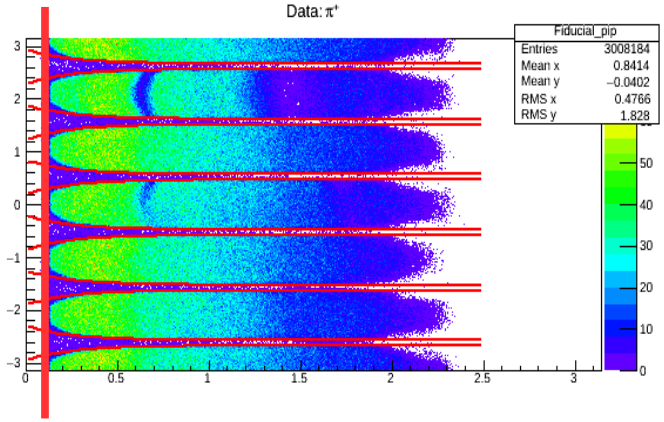
FIDUCIAL CUT

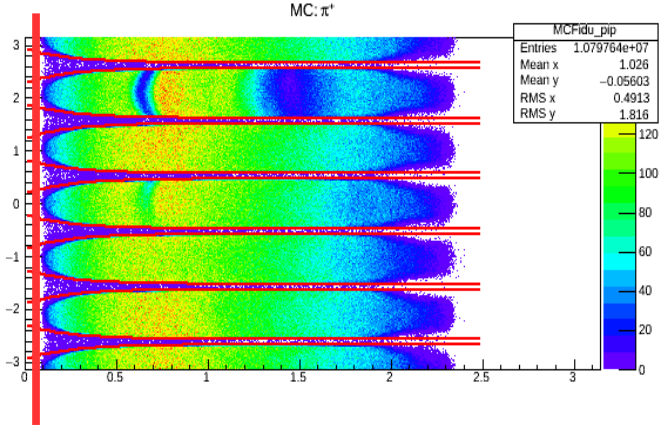
$\varphi = a e^{b\theta} + c$

$\theta\ [rad]$

$\varphi\ [rad]$

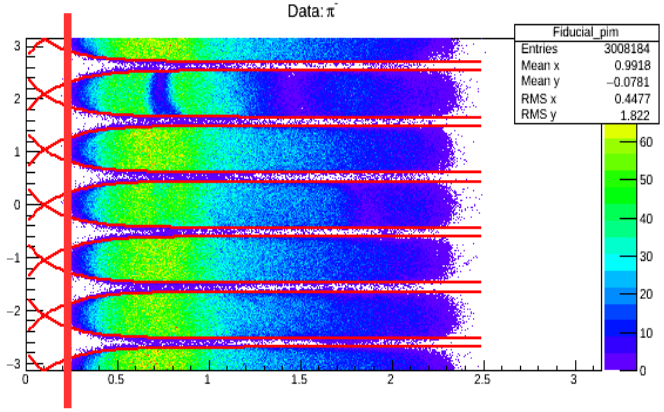
π^+

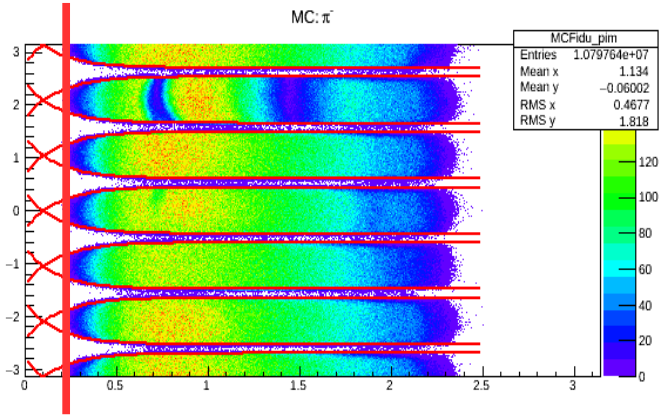




$\theta_{\pi^+} > 0.1$ [rad]

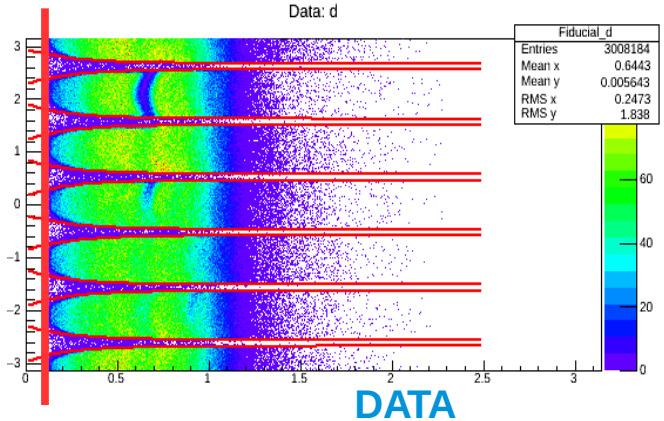
π^-



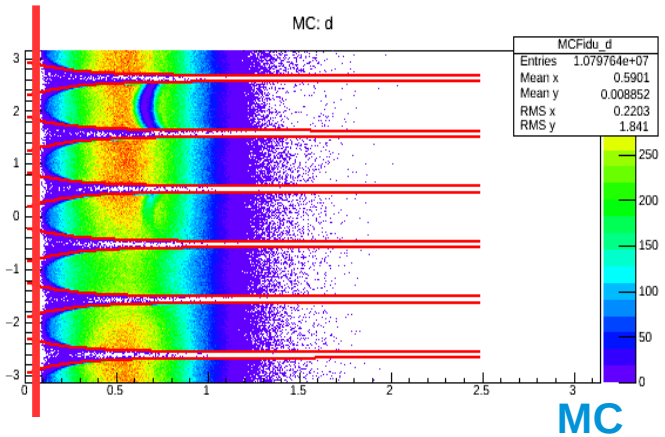


$\theta_{\pi^-} > 0.25$ [rad]

d



DATA



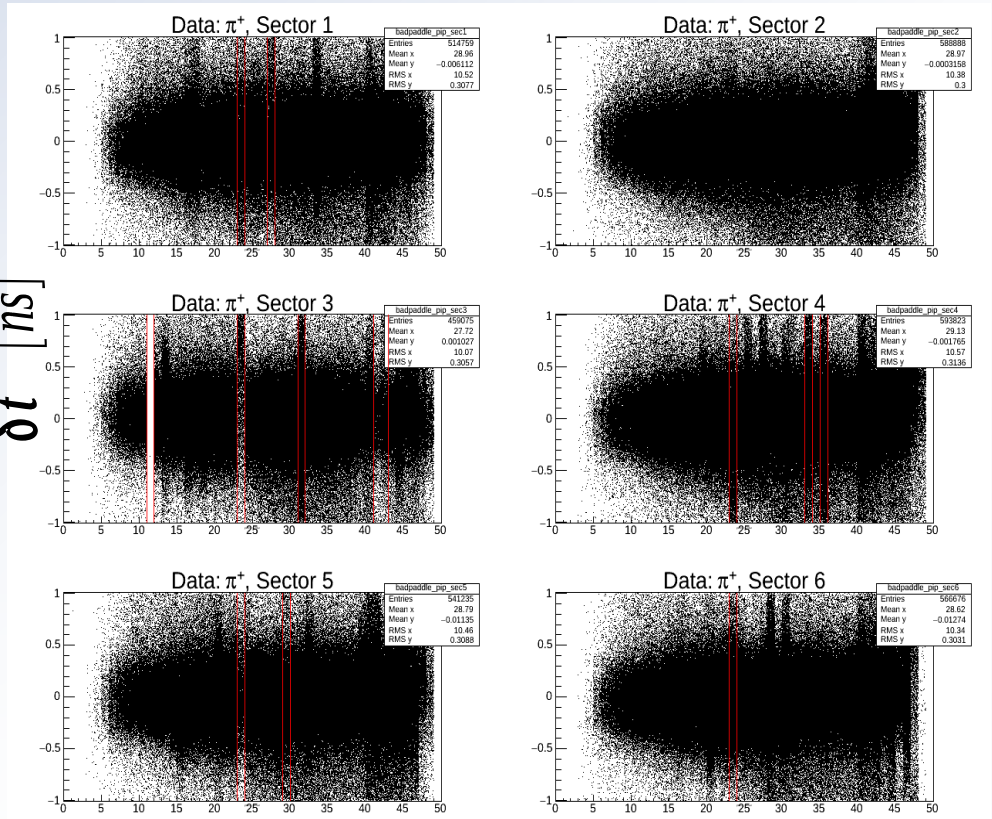
MC

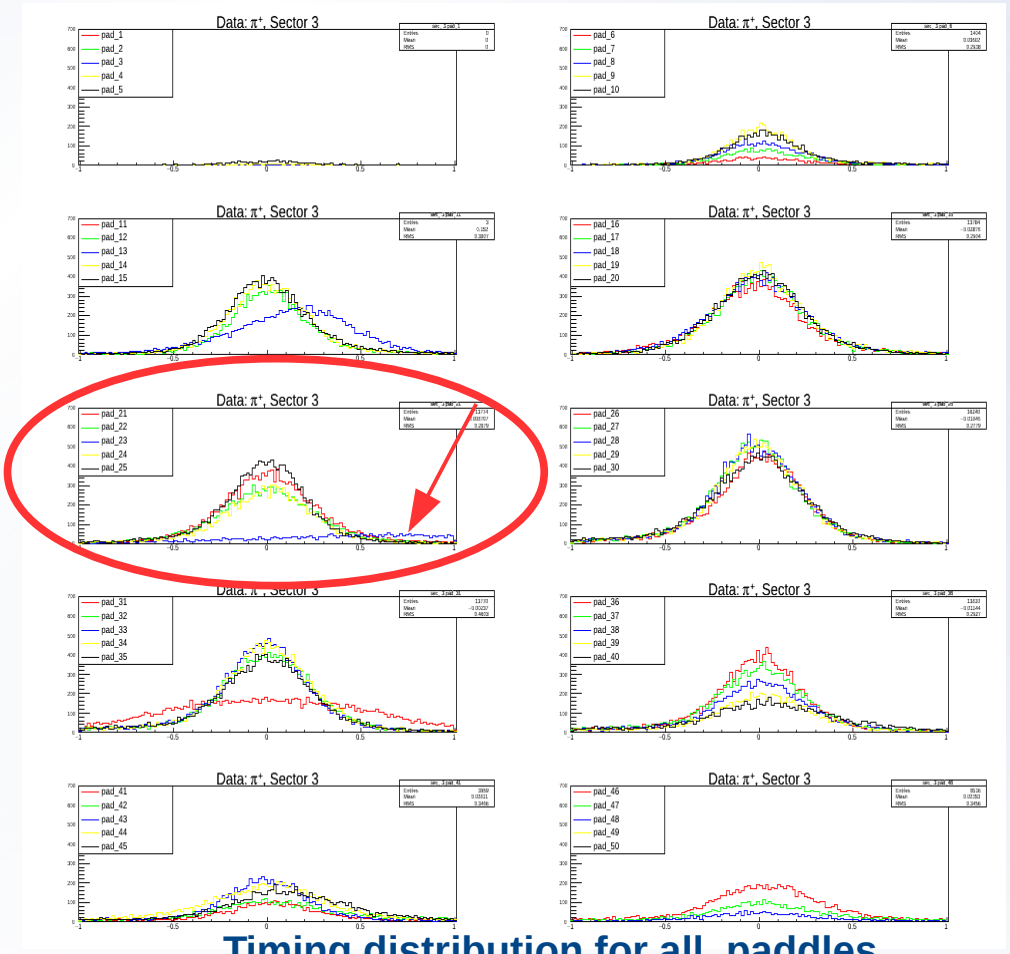
$\theta_d > 0.1$ [rad]

PADDLE CUT

- 48 paddles in total
- Bad paddles selected using accepted particle timing.

Particle	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
π^+	23, 27 ≥ 43	 ≥ 45	11, 23, 31 ≥ 40	23, 33, 35 ≥ 46	23, 29 ≥ 46	23 ≥ 45
π^-	23, 27 ≥ 41	 ≥ 41	11, 15, 16, 23, 34-36 ≥ 41	23, 27, 35 ≥ 43	20, 23, 29 ≥ 43	23 ≥ 42
d	23, 27 ≥ 35	23 ≥ 35	11, 22, 23 ≥ 35	23 ≥ 35	23 ≥ 35	23 ≥ 35





Timing distribution for all paddles in sector 3 for π^+

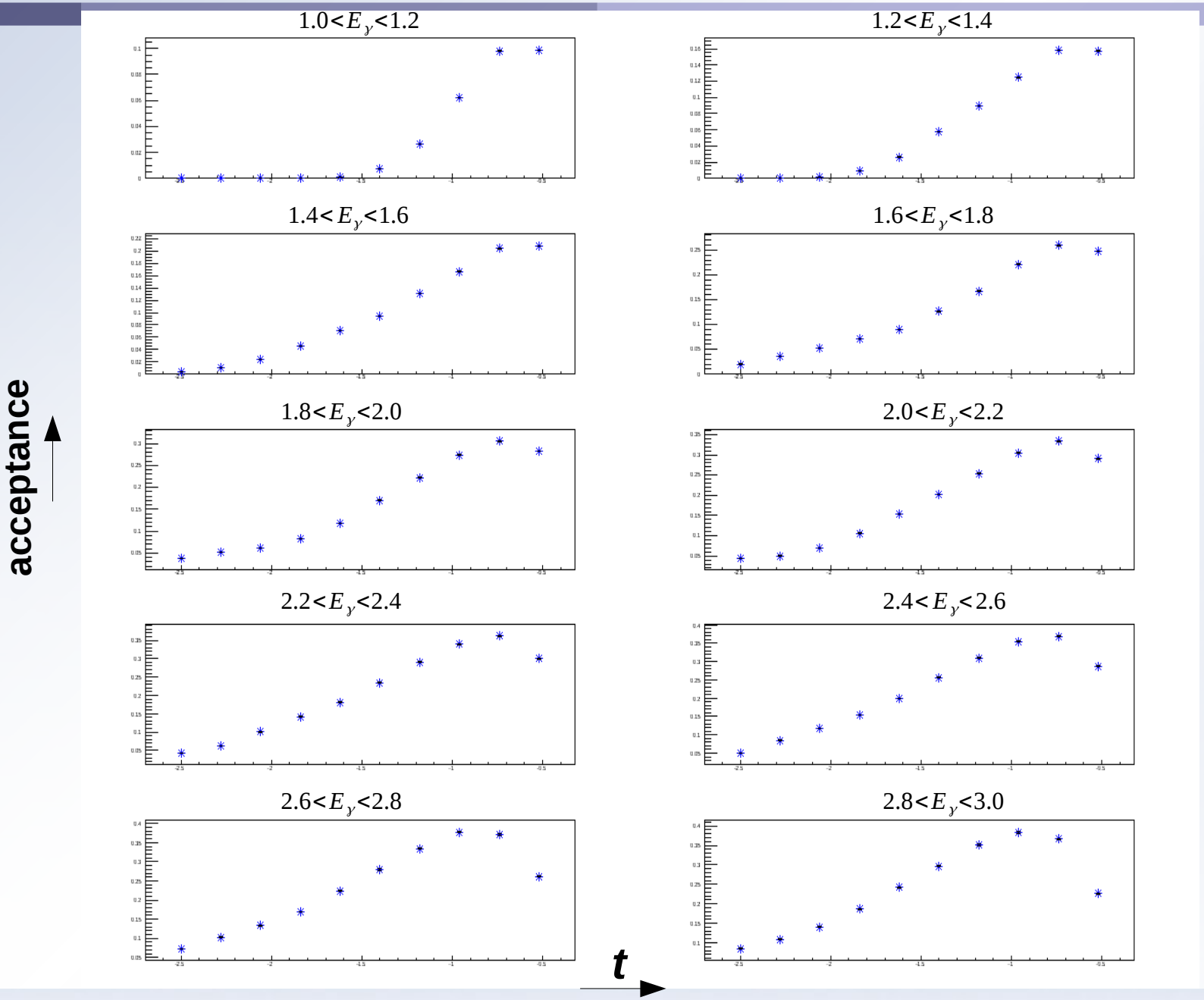
SUMMARY OF CUTS MADE

- Timing cuts made using momentum-dependent analysis
- $-40\,cm < z_{vertex} < -10\,cm$
- $-0.01 < MM^2 < 0.005 \quad [GeV^2/c^4]$
- Theta cut: $\theta_{\pi^-,d} > 0.1[rad]$ and $\theta_{\pi^+} > 0.25[rad]$
- Fiducial cuts applied $\varphi = a e^{b\theta} + c$
- Paddle Cuts

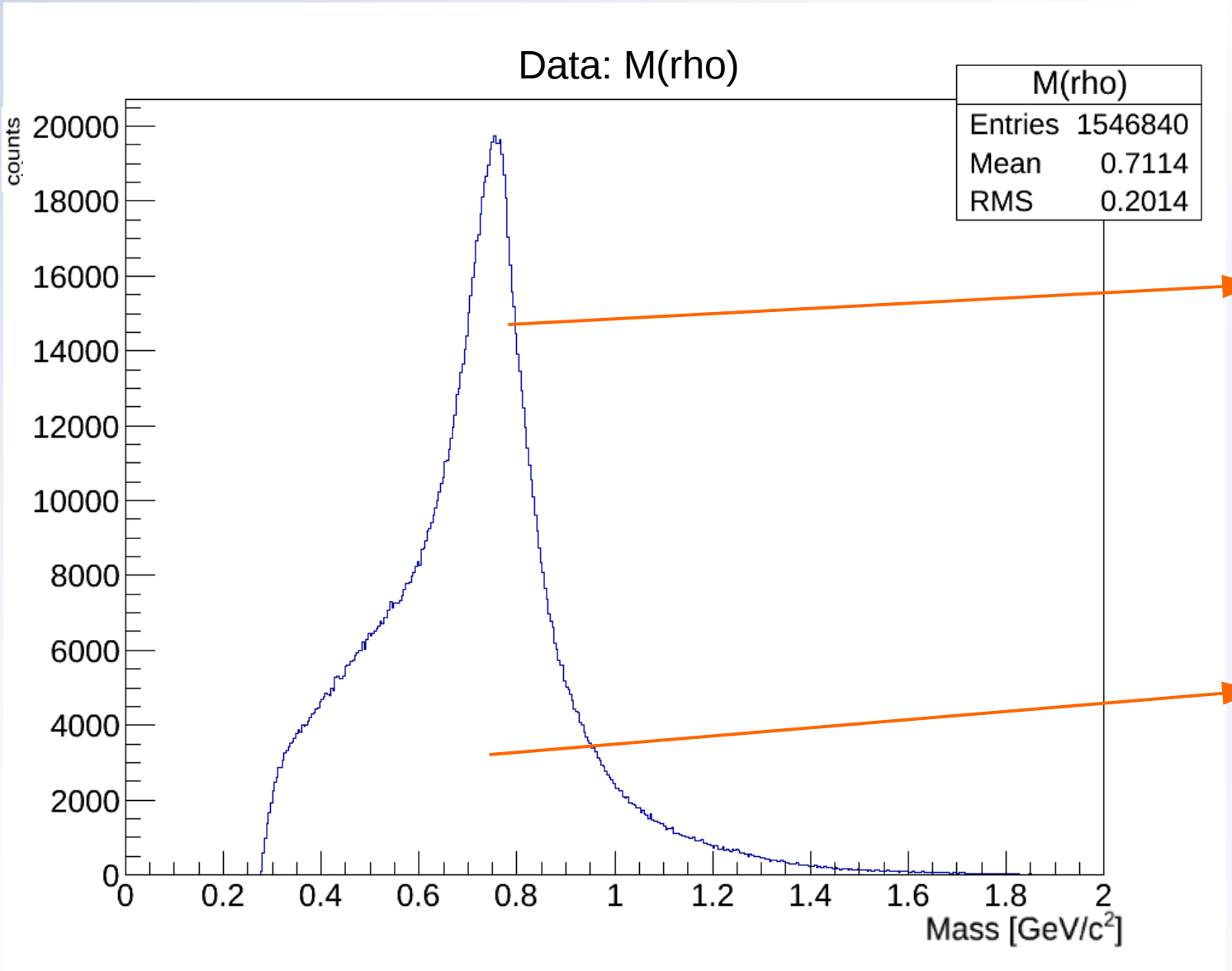
Particle	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
π^+	23, 27 ≥ 43	≥ 45	11, 23, 31 ≥ 40	23, 33, 35 ≥ 46	23, 29 ≥ 46	23 ≥ 45
π^-	23, 27 ≥ 41	≥ 41	11, 15, 16, 23, 34-36 ≥ 41	23, 27, 35 ≥ 43	20, 23, 29 ≥ 43	23 ≥ 42
d	23, 27 ≥ 35	23 ≥ 35	11, 22, 23 ≥ 35	23 ≥ 35	23 ≥ 35	23 ≥ 35

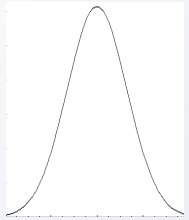
- Energy range: $1.0 < E_\gamma < 3.0 \quad [GeV]$
- *t*- range: $-2.5 < t < -0.3 \quad [GeV^2/c^2]$

ACCEPTANCE


1.0<E_γ<1.2
1.2<E_γ<1.4
1.4<E_γ<1.6
1.6<E_γ<1.8
1.8<E_γ<2.0
2.0<E_γ<2.2
2.2<E_γ<2.4
2.4<E_γ<2.6
2.6<E_γ<2.8
2.8<E_γ<3.0
acceptance
t

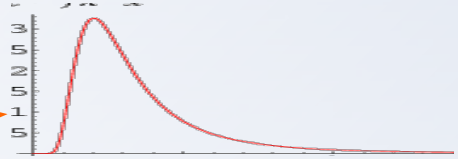
GLOBAL SPECTRUM





$\rho - signal$

+

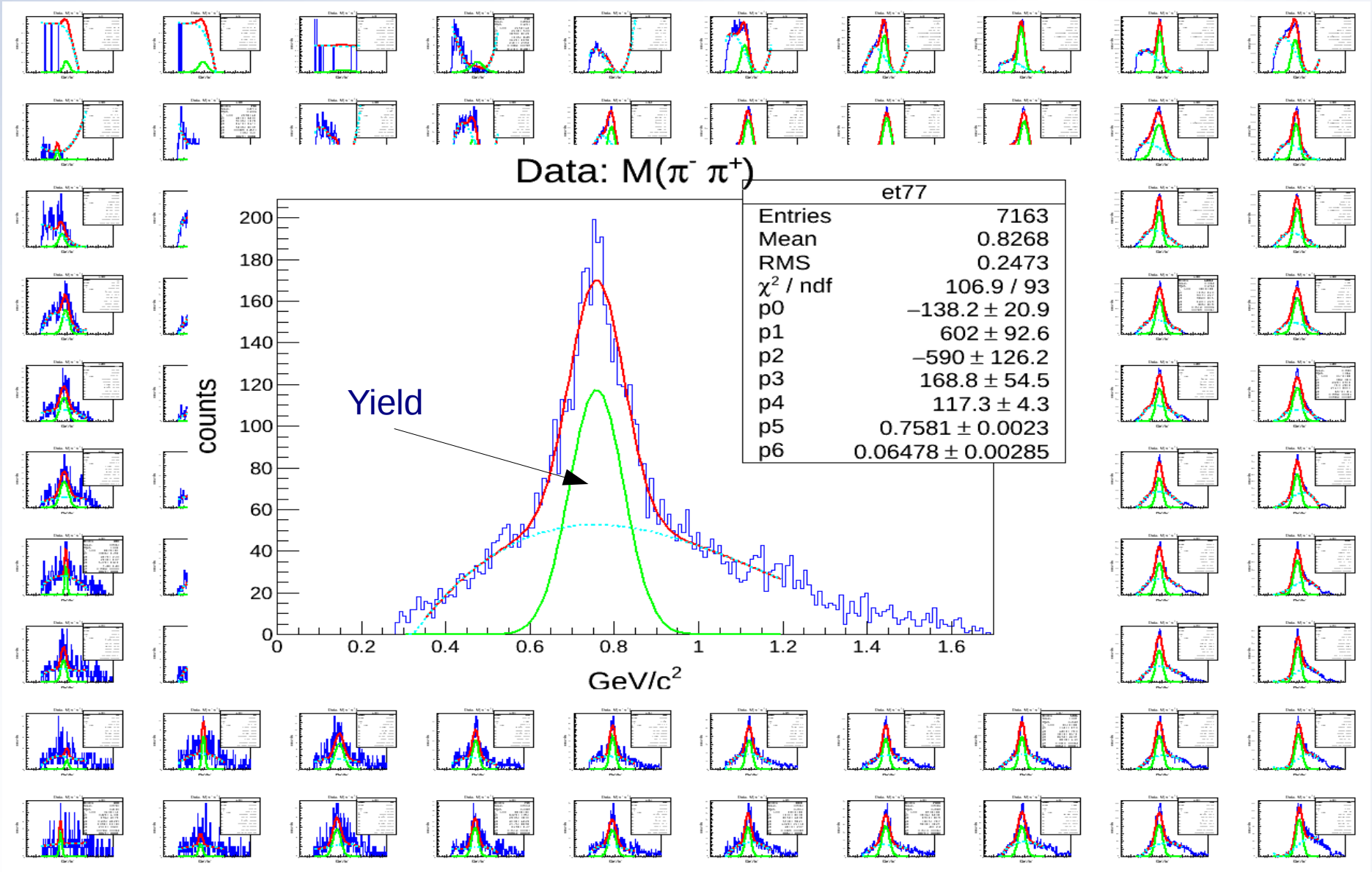


background

$$f_{bckg}(x) = \frac{a}{\frac{[b(x+c)]}{e^{a/[b(x+c)]} - 1}}$$

$$f_{bckg}(x) = a + bx + cx^2 + dx^3$$

YIELD EXTRACTION



$$M_\rho \equiv M_\rho\left(E_\gamma, |t|\right)$$

DIFFERENTIAL C-SECTION: *preliminary*

Differential cross-section,

$$\frac{d\sigma}{dt} = \frac{Yield}{(\delta t)\,\epsilon\, L(E_\gamma)}$$

$\epsilon \equiv$ *Detector Acceptance* $\sim 16\ \%$

$\delta t = 0.22\, GeV^2/c^2$

Luminosity,

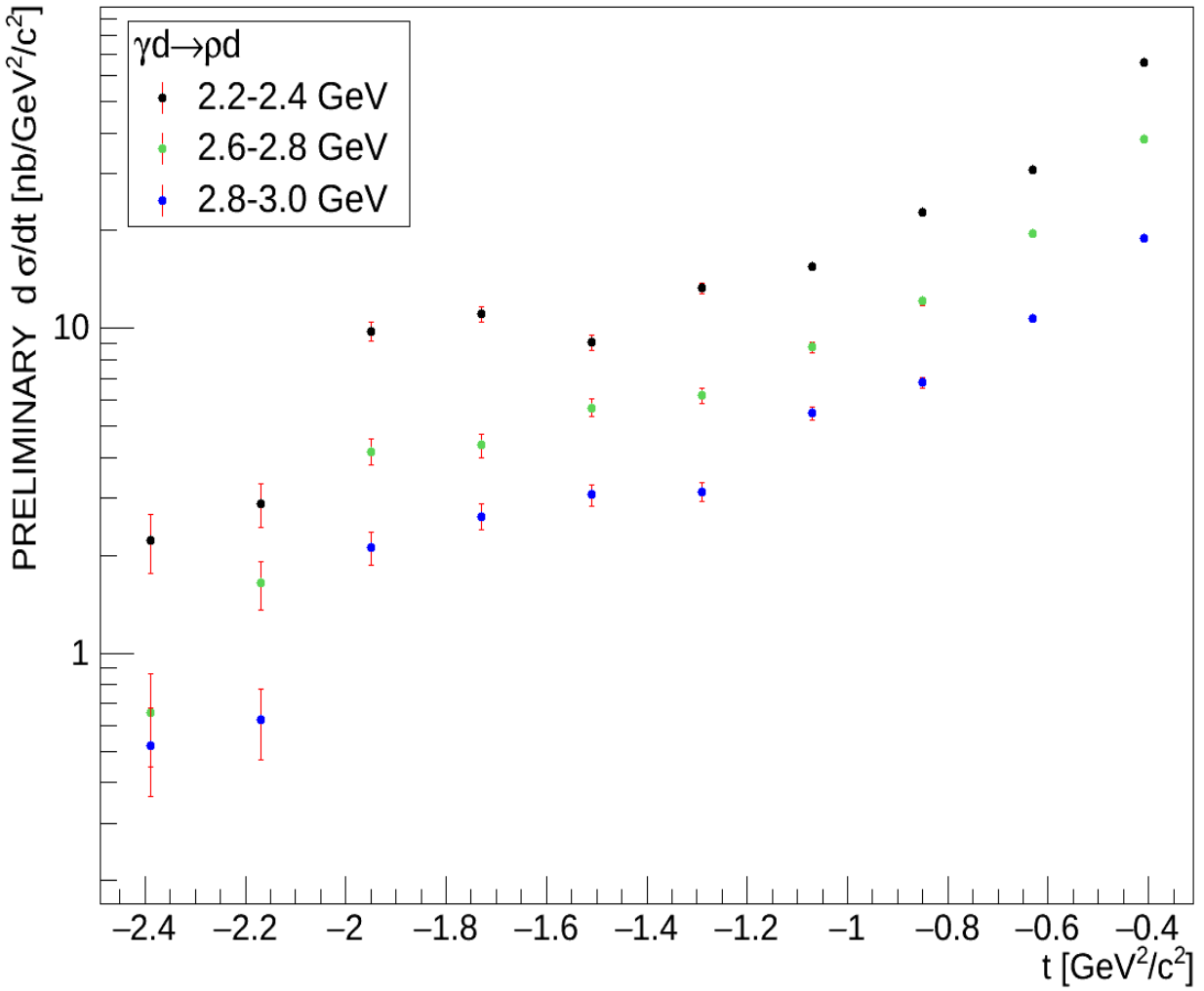
$$L(E_\gamma) = \frac{\rho_d N_A l_d}{M_d} N_\gamma(E_\gamma)$$

$\rho_d = 0.169\, gcm^{-3}$

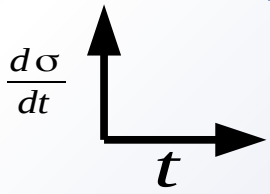
$l_d = 24\, cm$

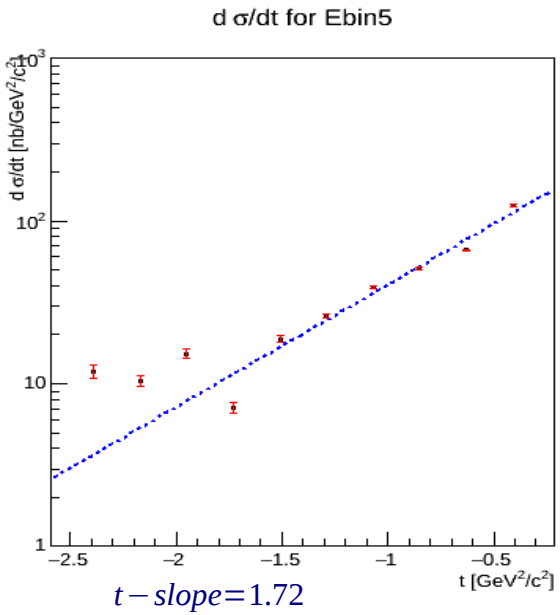
$M_d = 2.014\, g\, mole^{-1}$

$L(E_\gamma) \sim 5.3 - 2.3\, pb^{-1}$

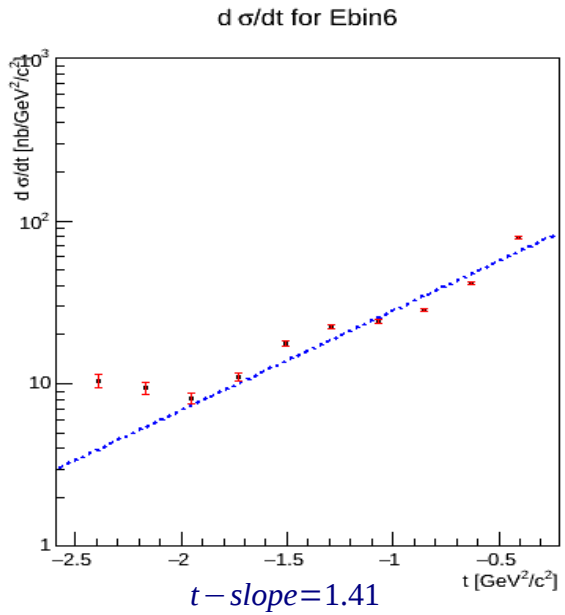


DIFFERENTIAL C-SECTION(fits): *preliminary*

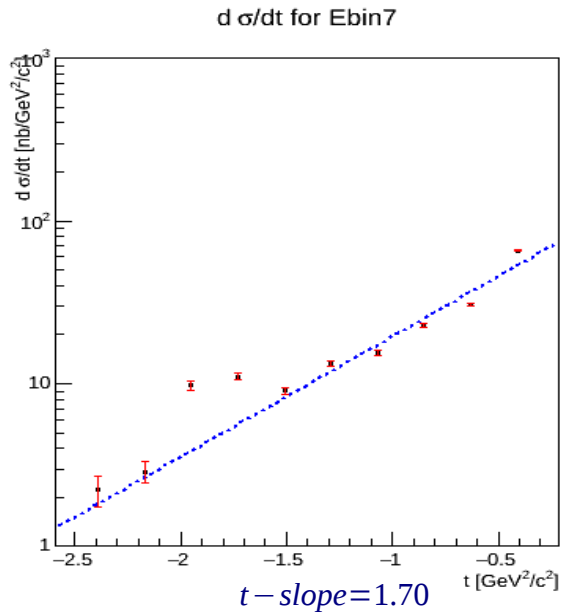




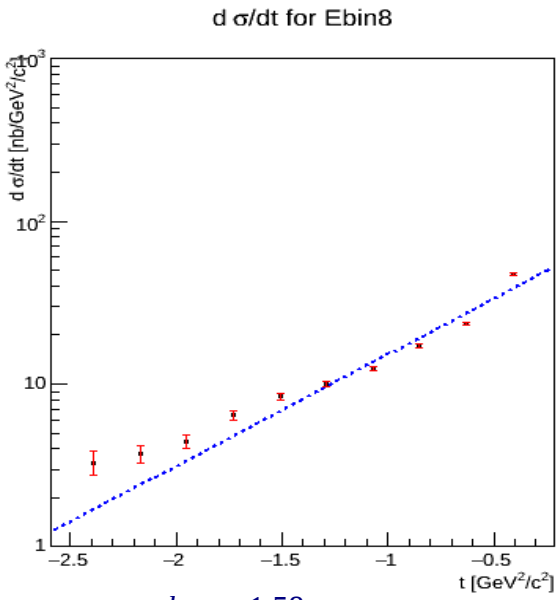
$t-slope=1.72$



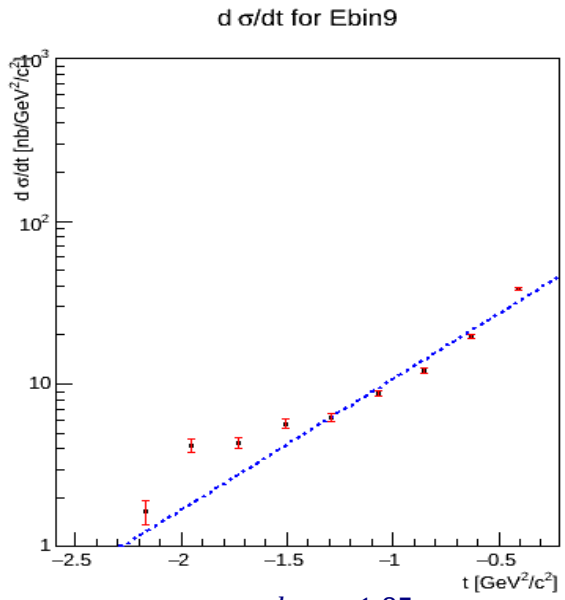
$t-slope=1.41$



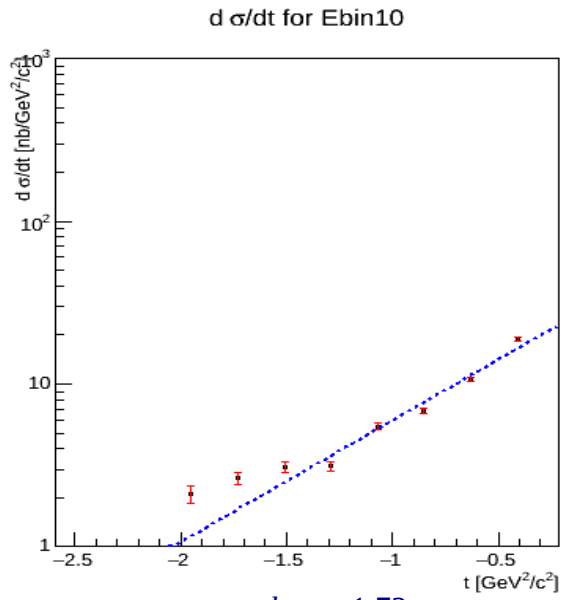
$t-slope=1.70$



$t-slope=1.58$

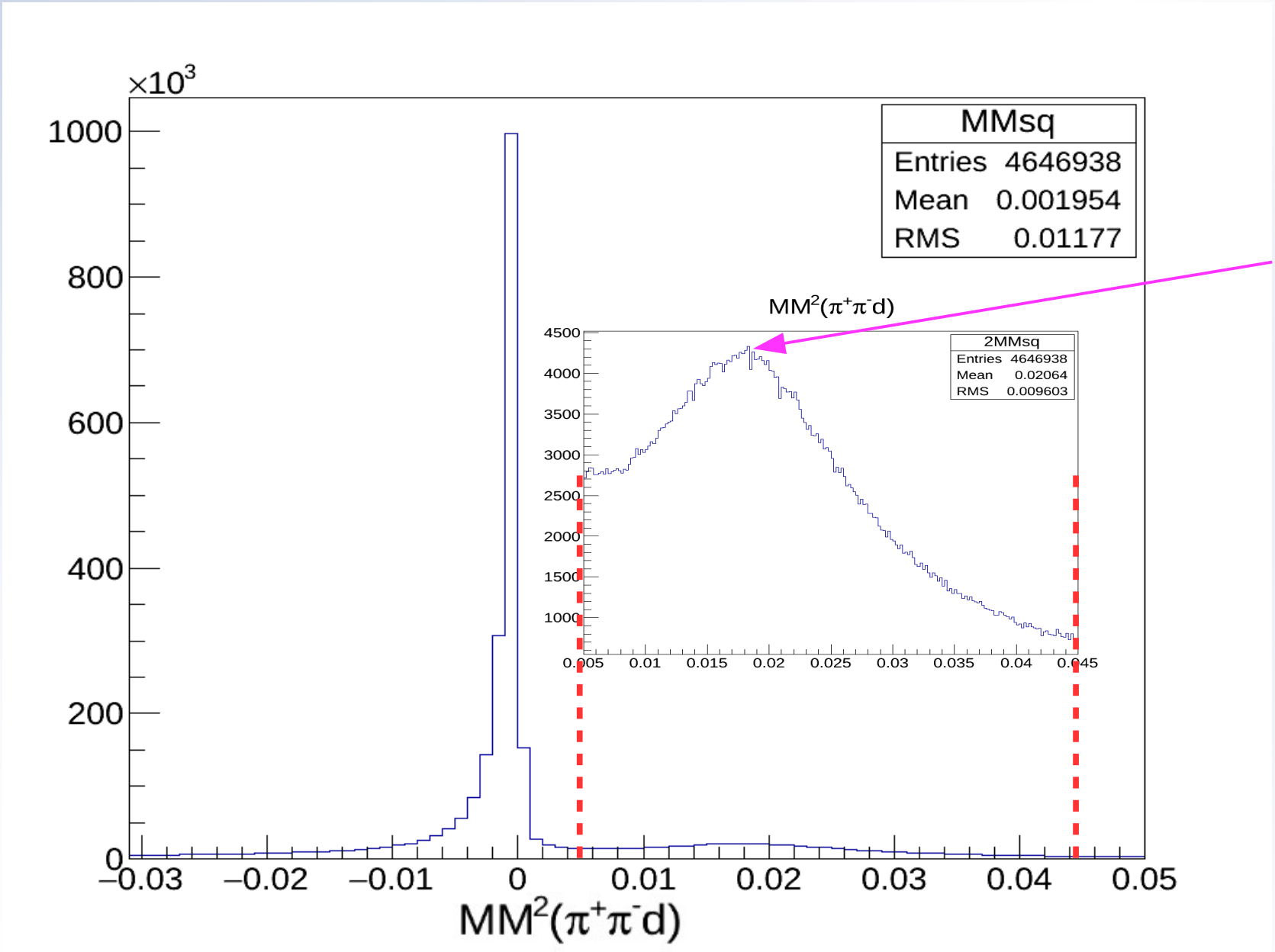


$t-slope=1.85$



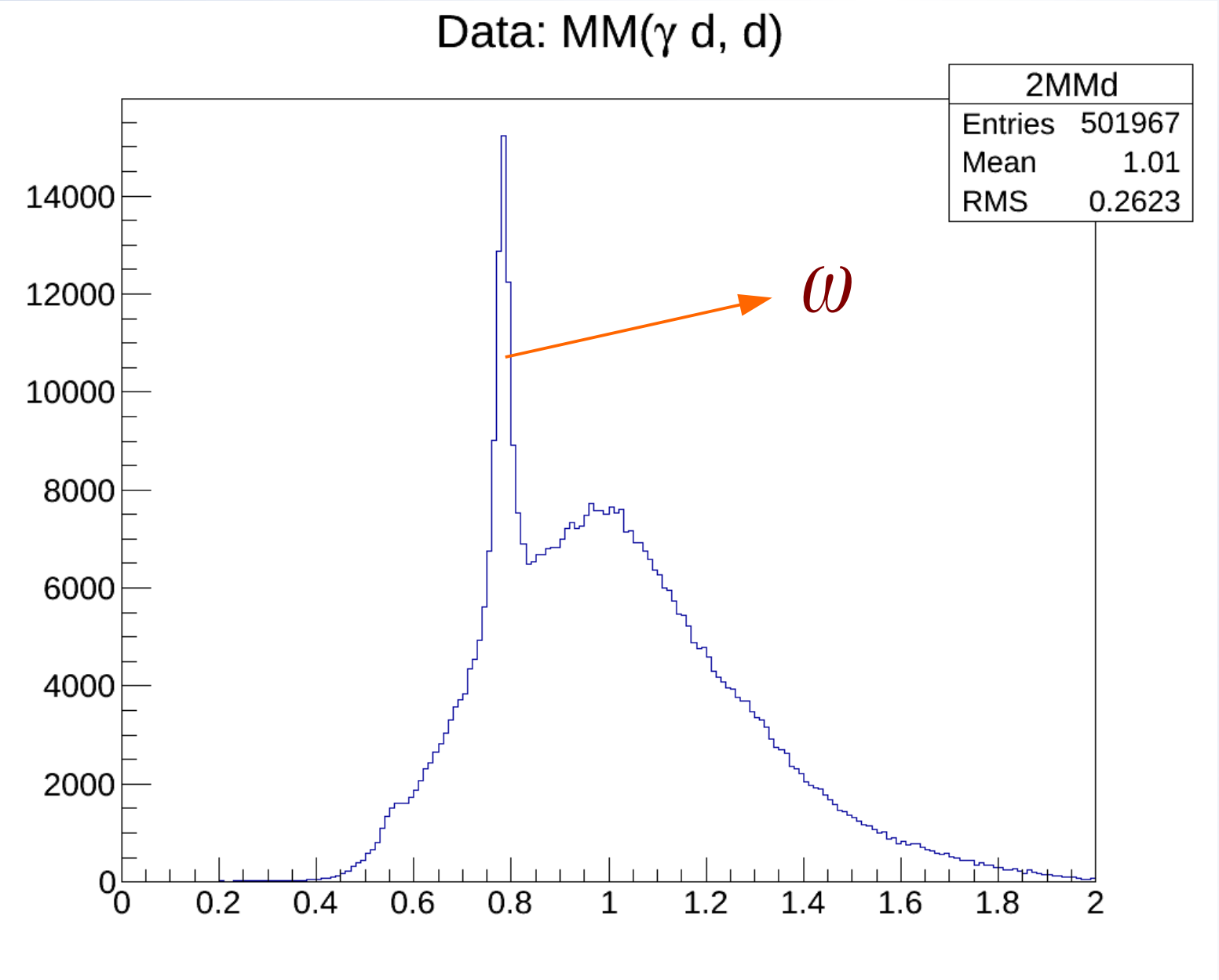
$t-slope=1.72$

ω- PHOTOPRODUCTION



Missing π^0

ω- PHOTOPRODUCTION

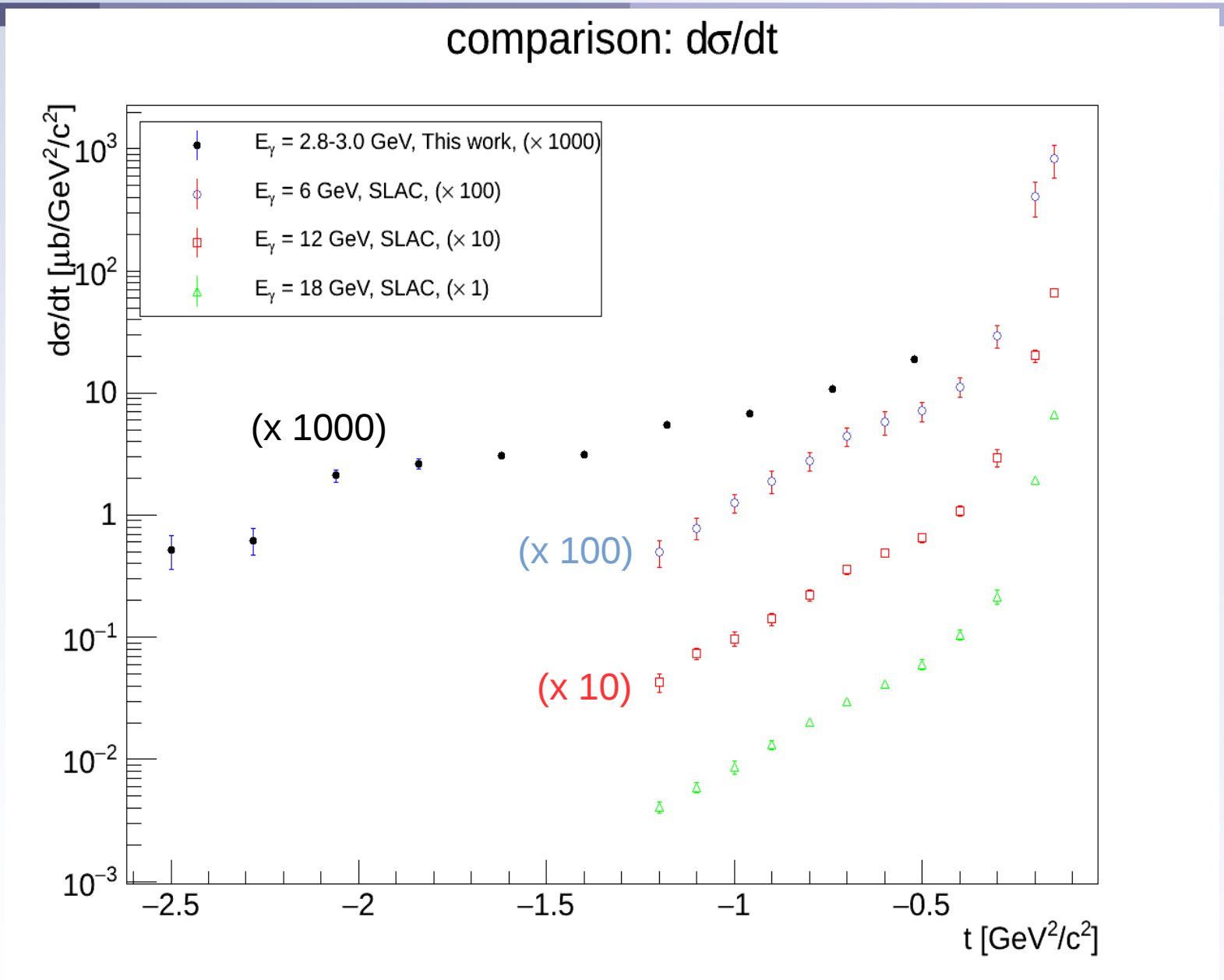


CONCLUSION

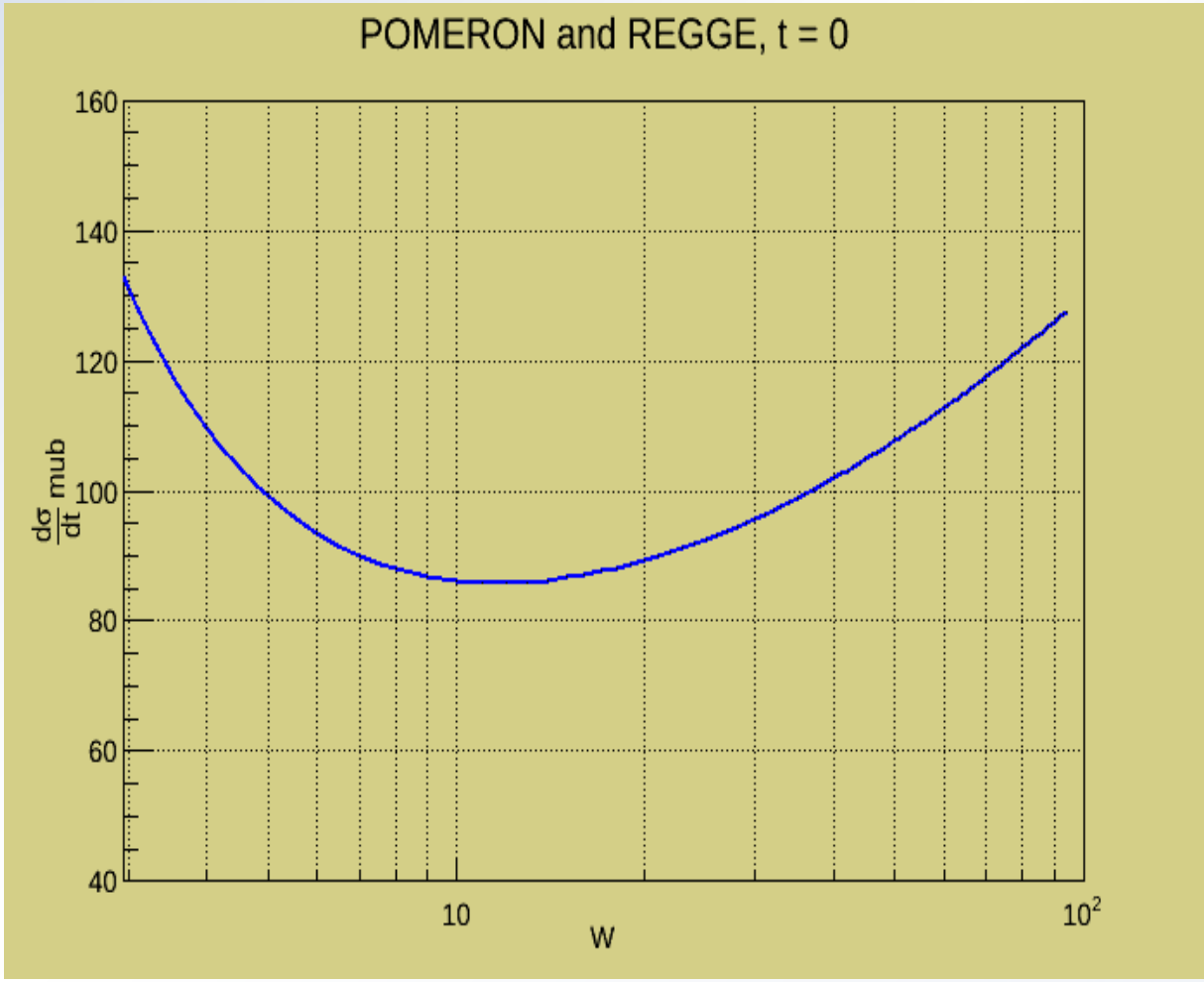
- The cross-section data provides sensitivity to the nucleon-scattering data for higher |*t*|-values.
- Understanding this reaction channel will help understand its interference in the d* resonance
  - $\gamma d \rightarrow \pi d^{*} \rightarrow \pi^{+} \pi^{-} d$
- Omega photoproduction: interesting channel worth pursuing
- Next steps would include:
  - Study of |*t*|-slope dependence in MC
  - Study of systematic uncertainties
  - Comparison with a model

BACK-UPs

BACK-UP
DIFFERENTIAL C-SECTION (comparison): *preliminary*



BACK-UP
SOFT POMERON



$$T_{\mathrm{SOFT}}(s,t) = iF(t)G_{\rho}(t)\left[A_{P_1}(\alpha'_{P_1}\,s)^{\alpha_{P_1}(t)-1}e^{-\frac{1}{2}i\pi(\alpha_{P_1}(t)-1)} + A_R(\alpha'_R s)^{\alpha_R(t)-1}e^{-\frac{1}{2}i\pi(\alpha_R(t)-1)}\right]$$

Formula from : ArXiv:hep-ph/9912312v1 12 Dec 1999

BACK-UP
SOFT+HARD POMERON