Differential η Meson Photo-production Cross Sections Off The Proton At Center Of Mass Energies Up To 4.75 GeV From The GlueX Experiment

$$\gamma + p \rightarrow \eta + p$$
$$\eta \rightarrow \gamma\gamma$$

Mahmoud Kamel

On behalf of the GlueX Collaboration

Introduction

- GlueX studies the light meson spectrum and searches for exotic and hybrid mesons. The production of the lightest multiplet of exotic mesons involves the same Regge exchanges that occur in the pseudoscalar mesons production like $\eta^{(\prime)}$ (Mathieu et al. 2017)

- The chosen reaction is one of the simplest final states in the GlueX experiment to test the Regge theory for s and t dependence.

- The forward cross section peak is due to mesons exchange ($S^{2\alpha(t)-2}$), while the backward cross section peak is due to baryons exchange ($S^{2\alpha(u)-2}$), where $\alpha(t)$ and $\alpha(u)$ are the so-called Regge trajectories (M. Guidal, J.M.Laget and M. Vanderhaeghen 1997).

- Previous cross section measurements are scarce for beam energies above 4.5 GeV. GlueX will provide the most extensive high statistics measurements currently available.

Data Selection

1) The nominal GlueX beam energy ($6.2 < E_\gamma < 11.6$ GeV): 20 % of GlueX-I data.

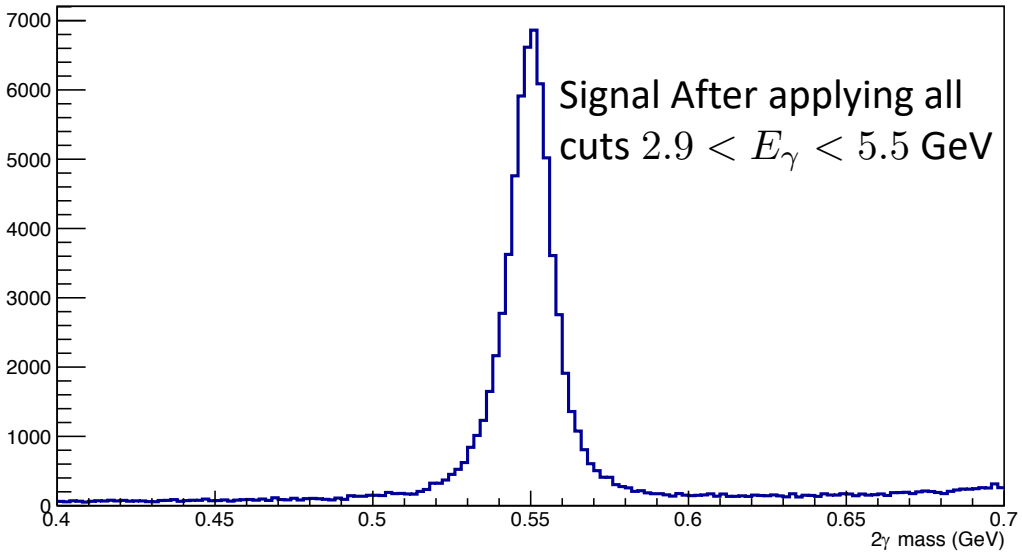
2) Low beam energy ($2.9 < E_\gamma < 5.9$ GeV): Short run dedicated for low energy data.

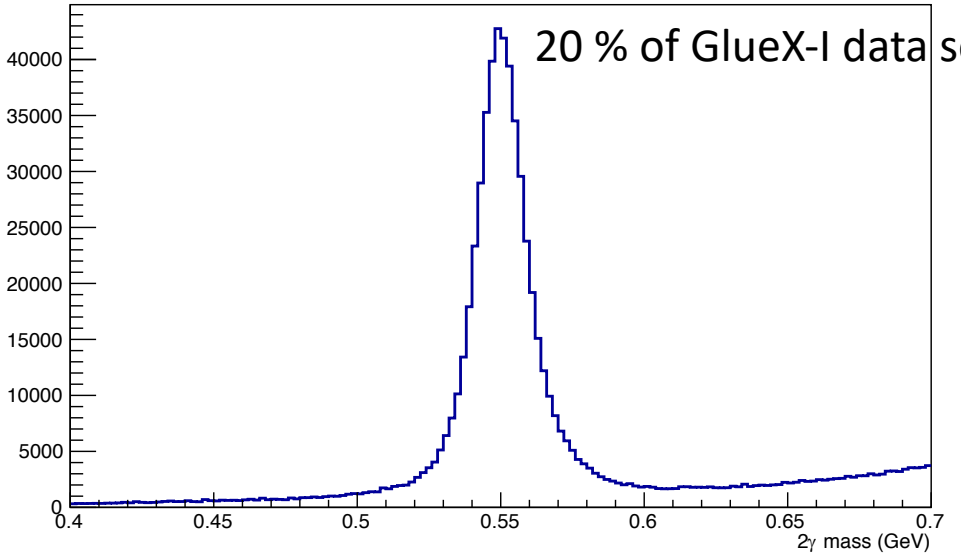
Similar Cuts were applied for both data sets:

1) KinFit $\chi^2 < 30$
2) Missing mass squared cut $|M_M^2| < 0.03 GeV^2$

3) Radial vertex cut $R < 1$ cm , and z-cut of $51 < Z < 79$ cm.

4) Recoil proton momentum > 350 MeV





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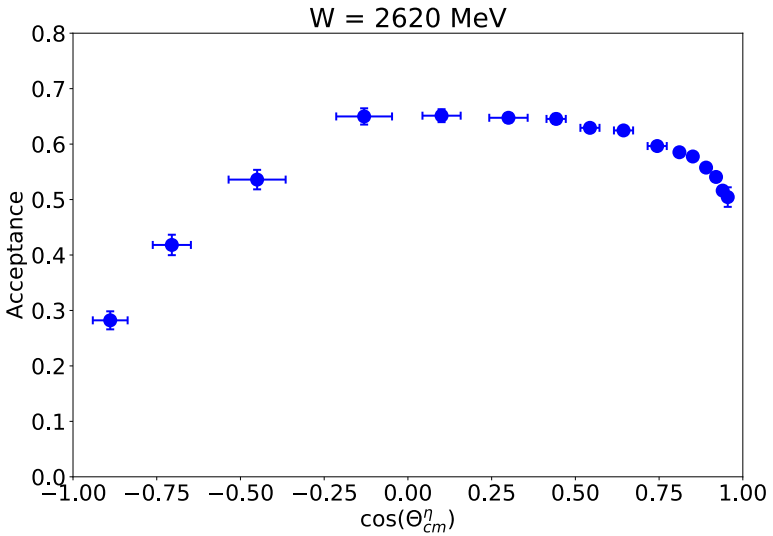
Acceptance

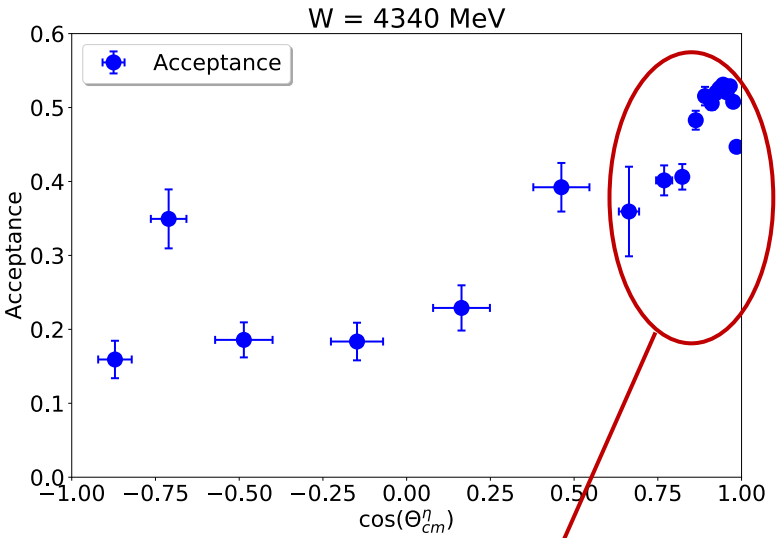
Acceptance is calculated using MC sample generated by standard GlueX generator for exclusive η photo-production with Regge model. The response of the GlueX detector is simulated with geant4.

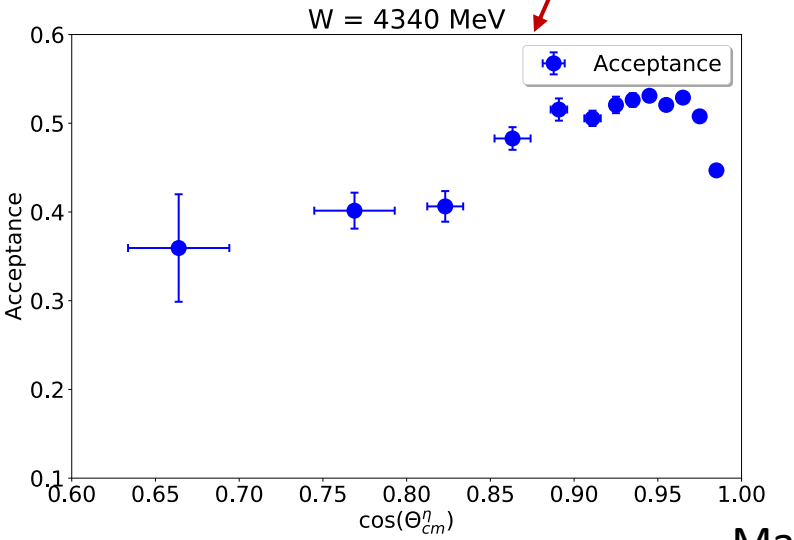
Acceptance = Reconstructed signal/ thrown sample

Low energy data set



High energy data set





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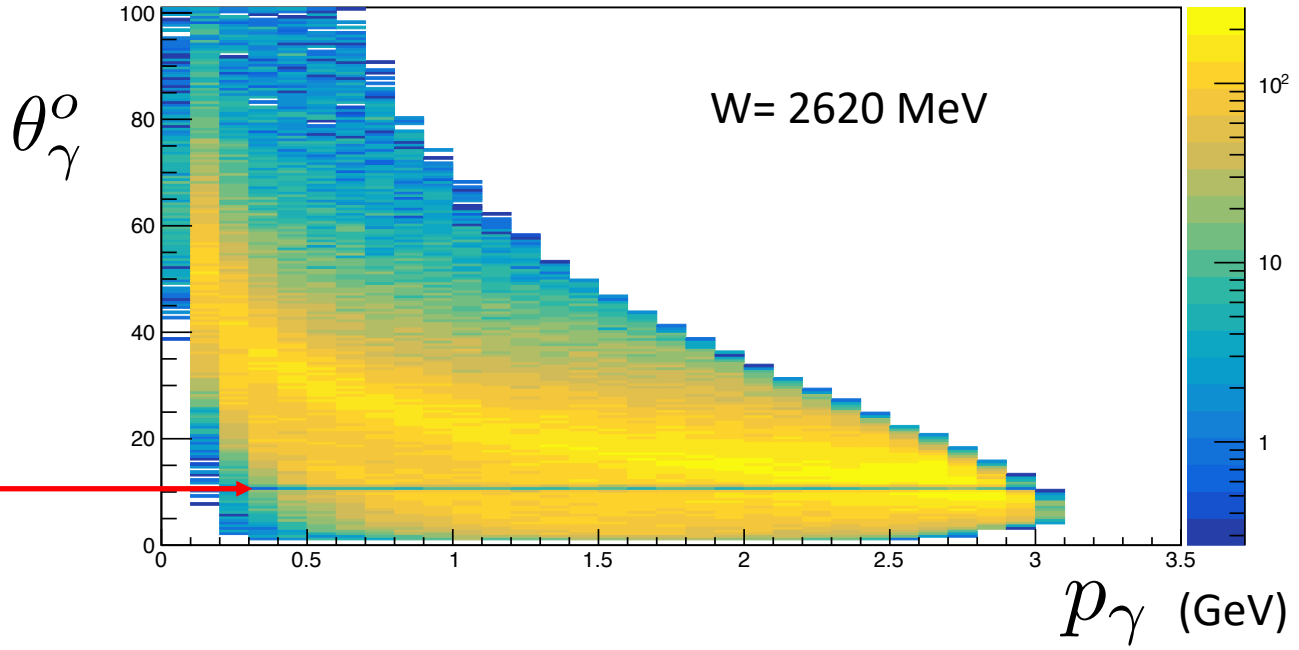
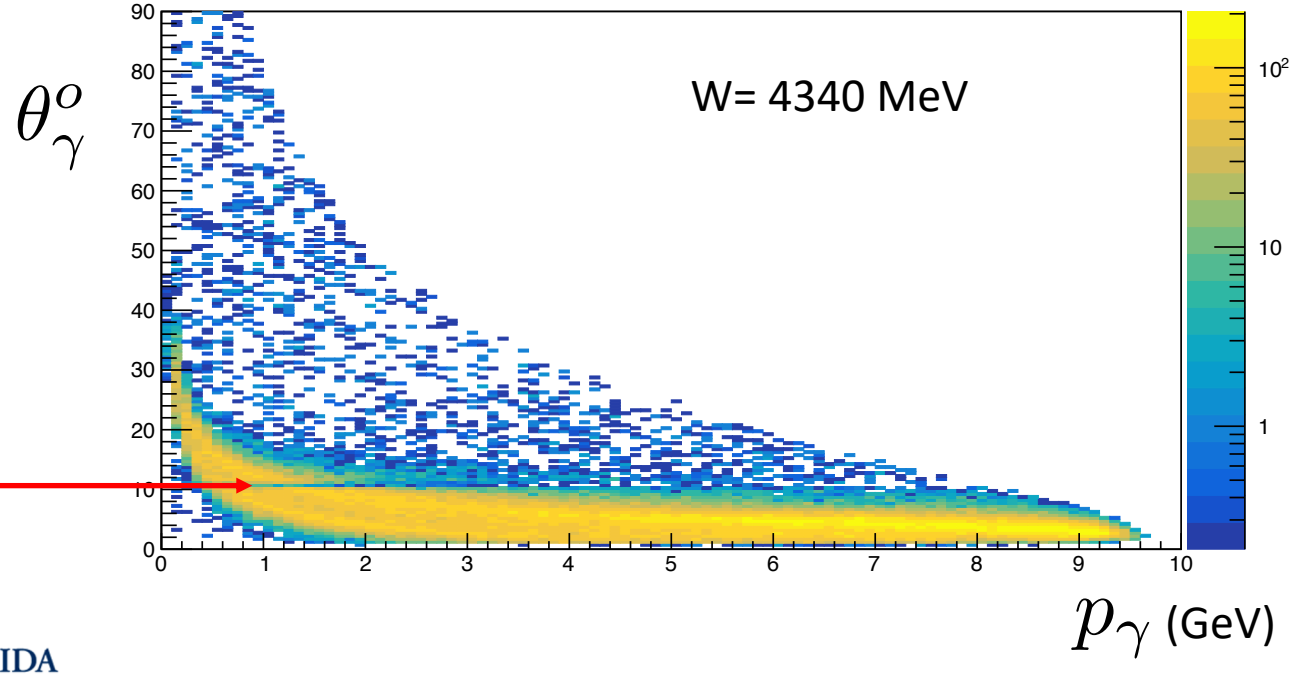
Why The Acceptance Differ?



BCAL/FCAL Boundary



BCAL/FCAL Boundary

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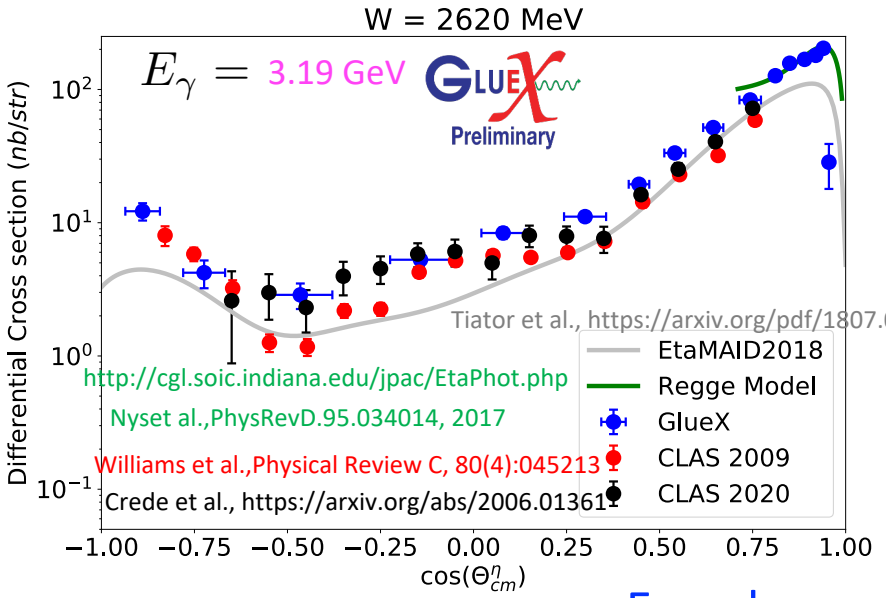
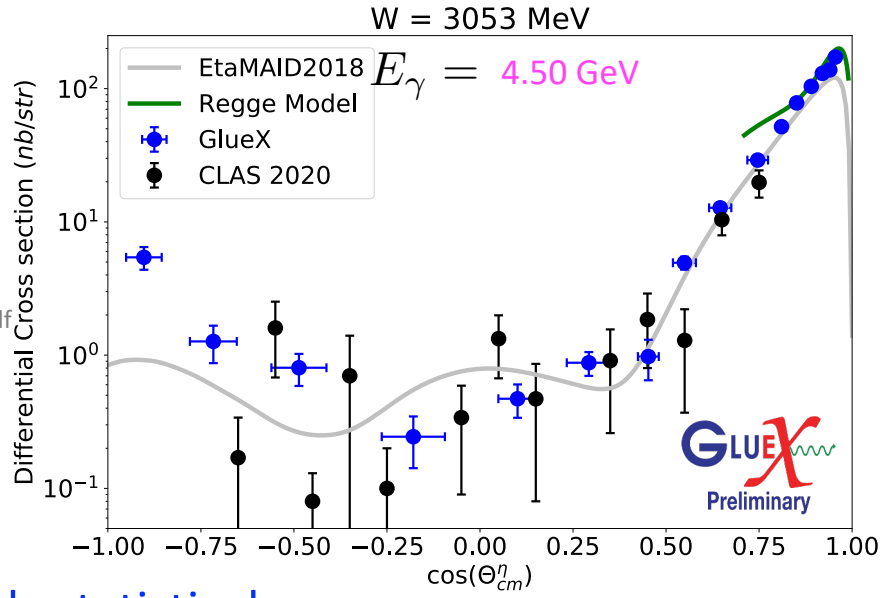
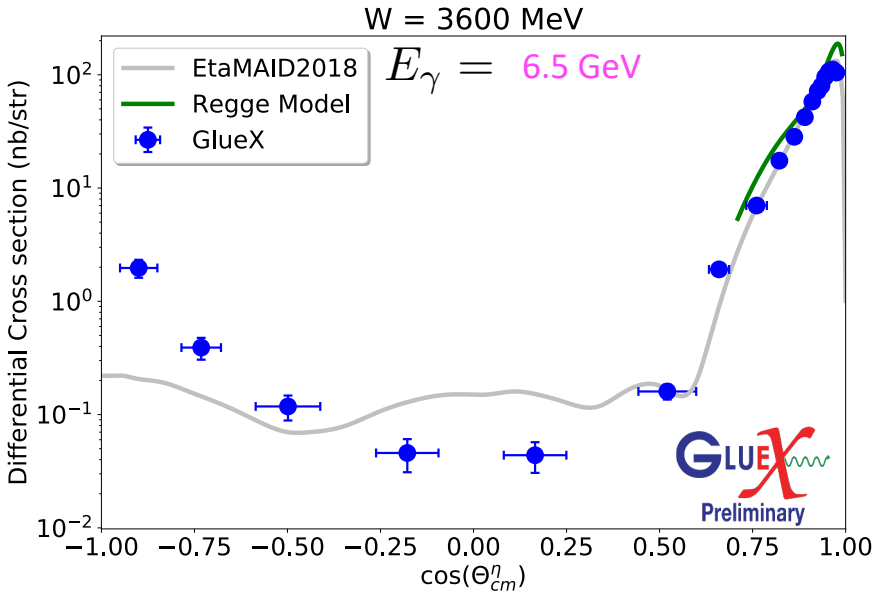
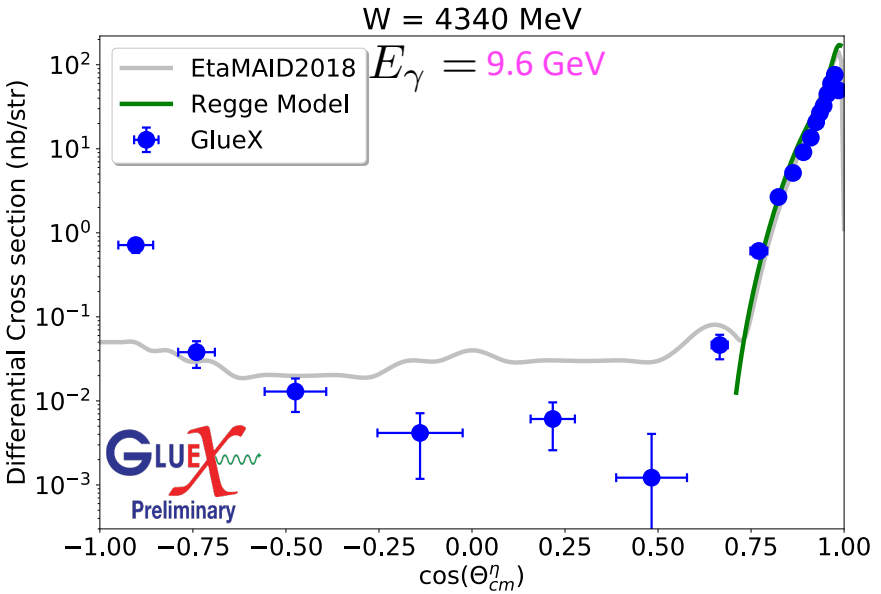
Differential Cross Sections ($\frac{d\sigma}{d\Omega}$)



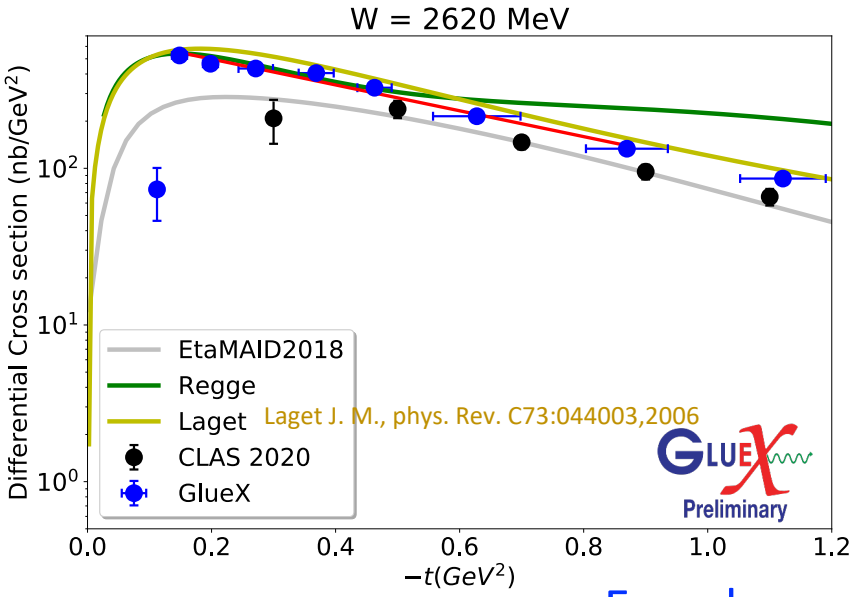


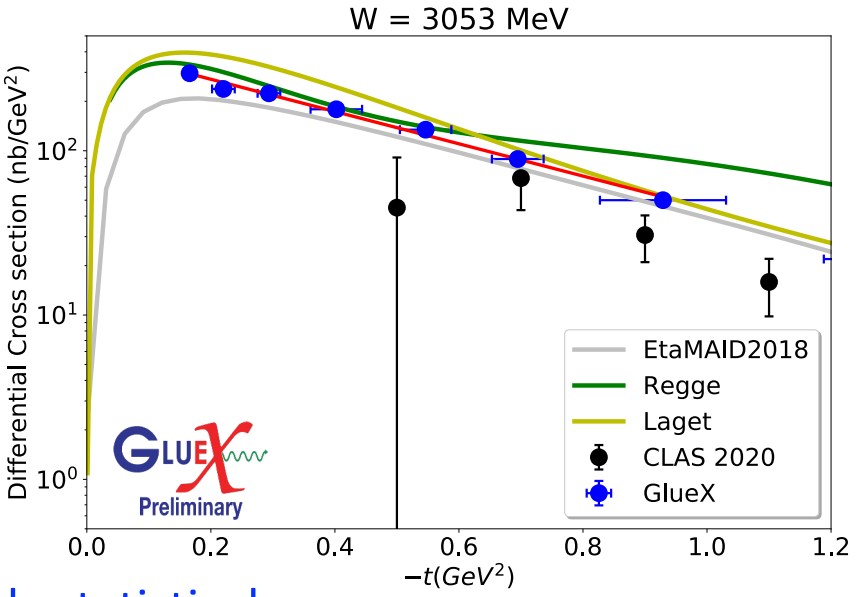
Error bars are only statistical





Differential Cross Sections ($\frac{d\sigma}{dt}$)





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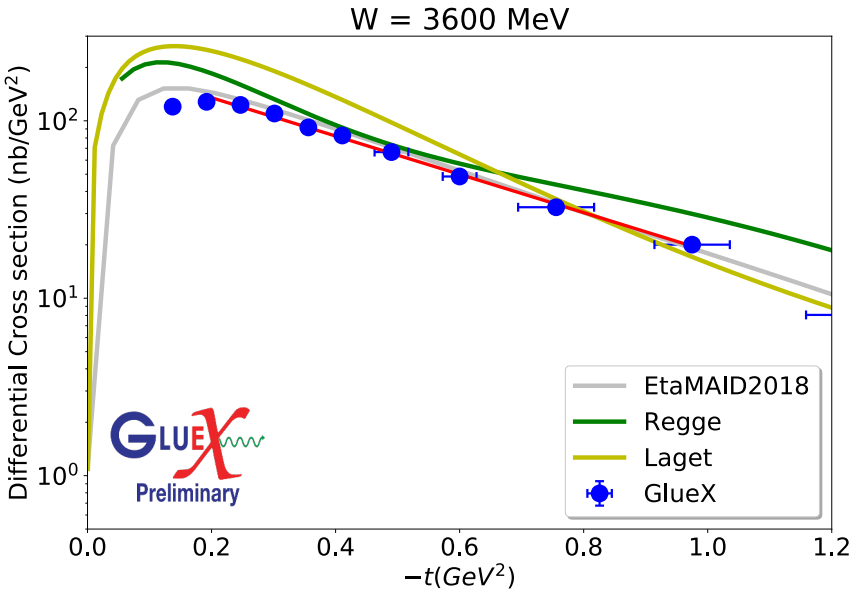
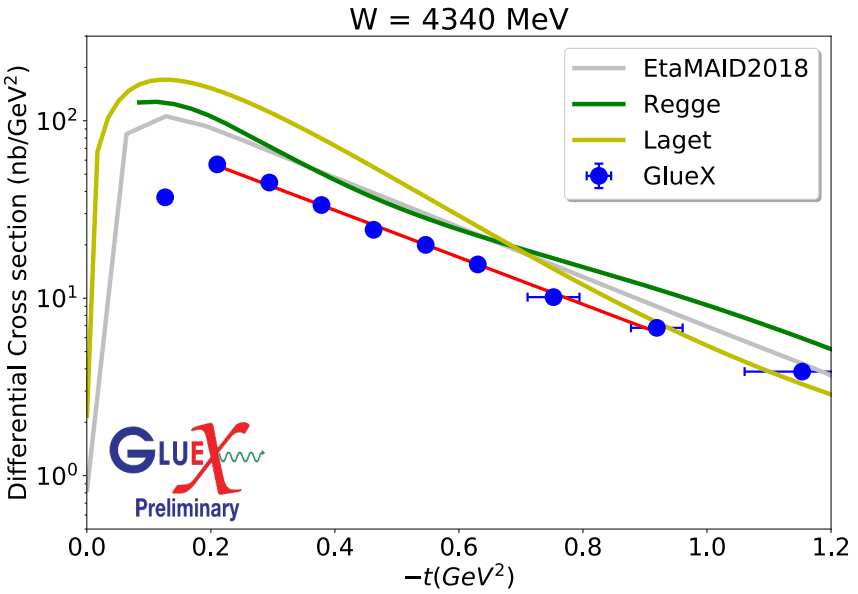




Extracted Fit Parameters & Regge Trajectories

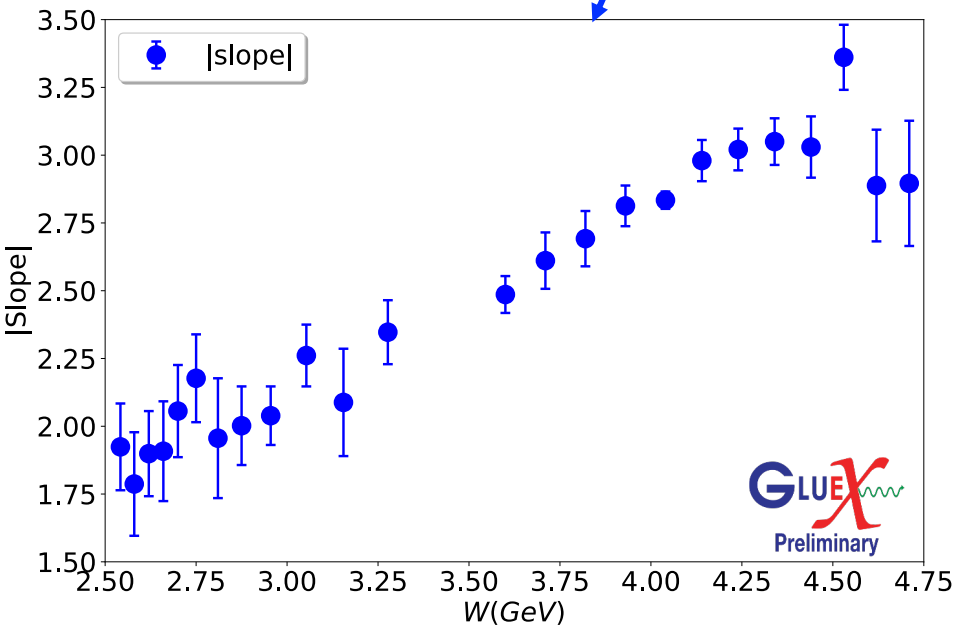
$$\frac{d\sigma}{dt} \propto \left(\frac{s}{s_0}\right)^{2(\alpha' t+\alpha_0)-2}$$

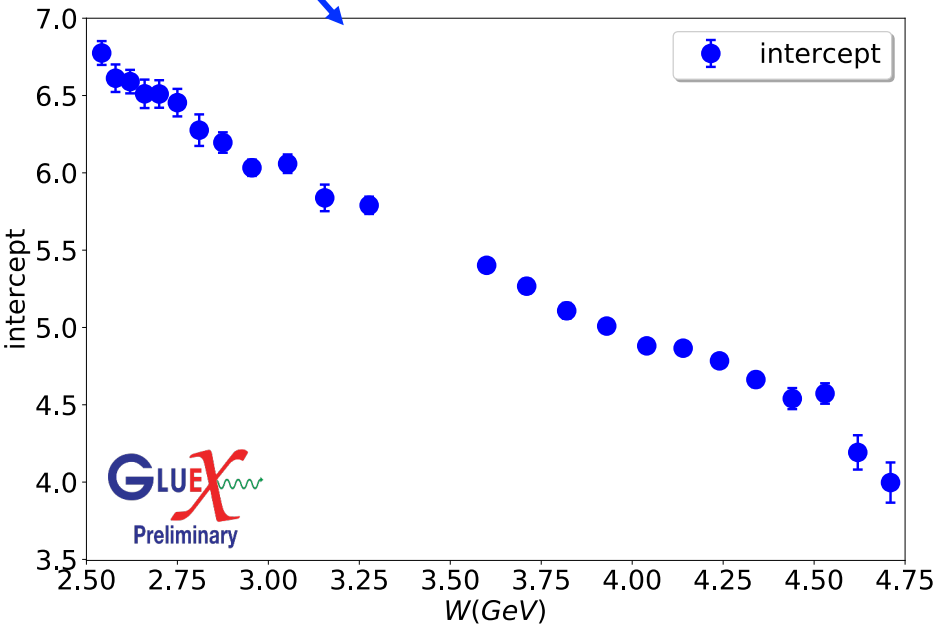
Conventional assumption s_0 = 1 GeV^2

$$\log\left(\frac{d\sigma}{dt}\right) \propto C_0 + C_1\alpha' t$$

where $C_1 = 2\log\left(\frac{s}{s_0}\right)$

$$C_0 = C_1(\alpha_0 - 1)$$

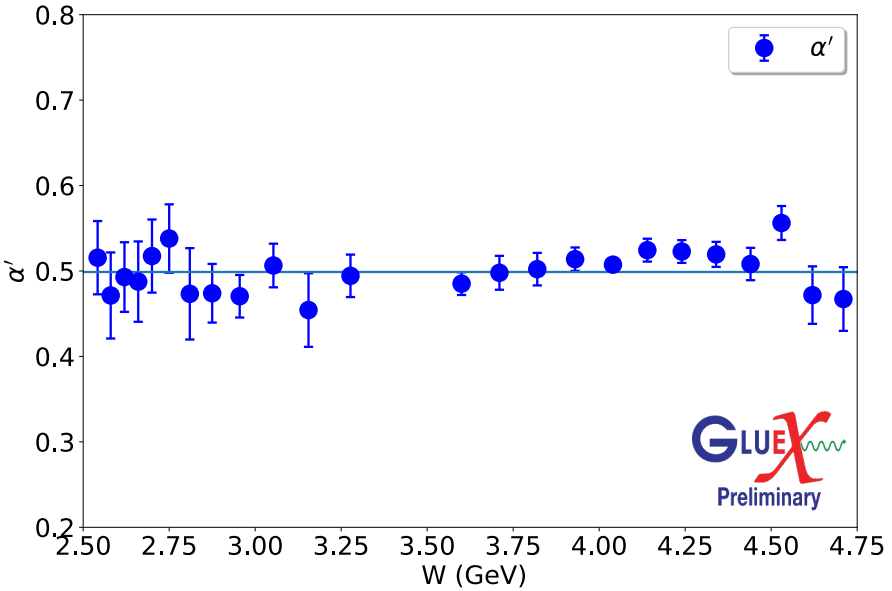


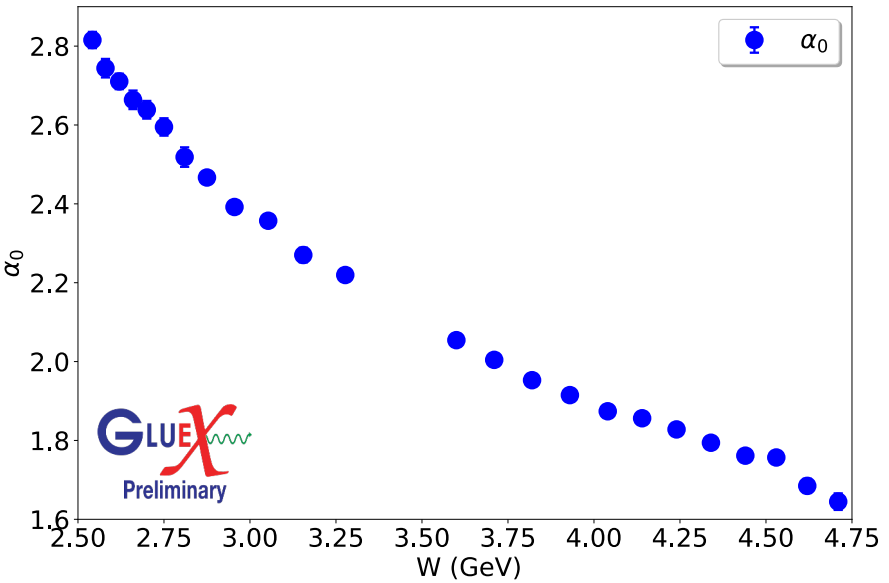


Extracted Fit Parameters & Regge Trajectories

α' = |slope|/C_1
= 0.5 ± 0.01

$$\alpha_0 = \frac{C_0}{C_1} + 1$$



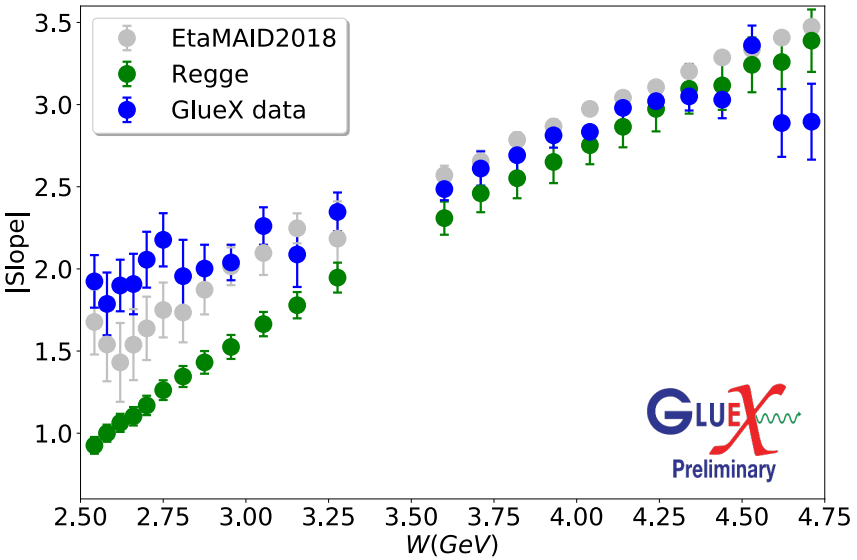


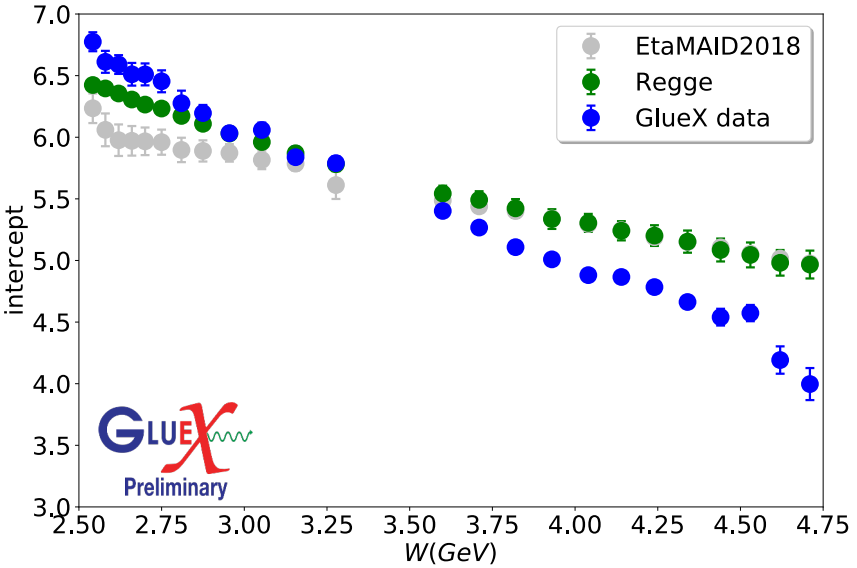
Exchange of two Reggeons with linear trajectories $\alpha_i(t) = \alpha_i(0) + \alpha_i' t, i = 1, 2$

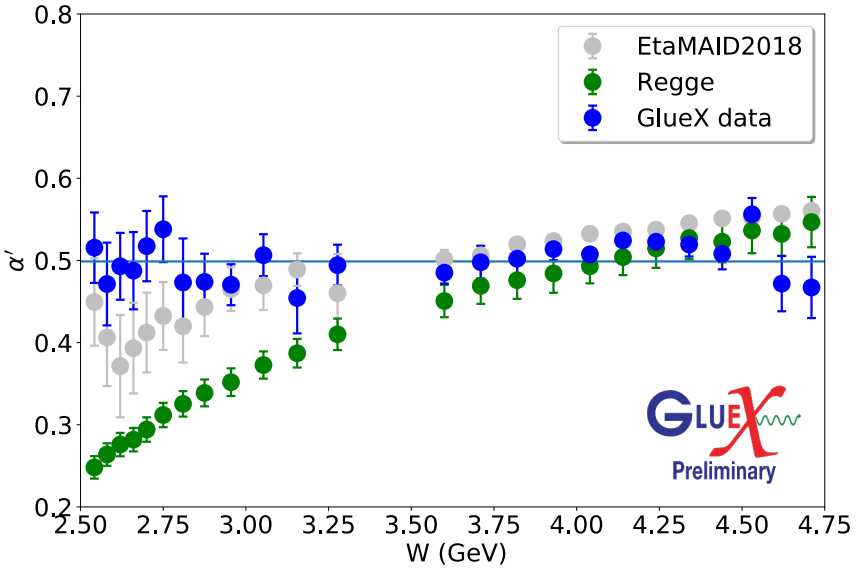
Gives Regge cut with a linear trajectory $\alpha_c(t) = \alpha_c(0) + \alpha_c' t$

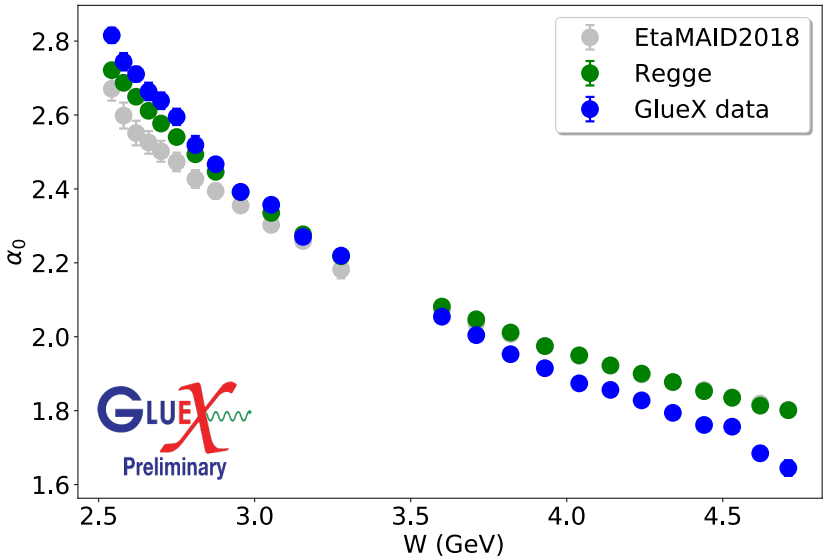
with $\alpha_c' = \frac{\alpha_1' \alpha_2'}{\alpha_1' + \alpha_2'}$, and $\alpha_c(0) = \alpha_1(0) + \alpha_2(0) - 1$

Extracted Fit Parameters & Regge Trajectories









Summary

Eta photo-production differential cross sections have been measured over large beam energy range $2.9 < E_\gamma < 11.6$ GeV.

GlueX data provide more coverage in the very small (large) angles than previous experiments.

The data show that at W< 3.2 GeV (E_γ < 5 GeV), and W> 4.0 GeV (E_γ > 8 GeV), there are two different Regge particles that have been exchanged during the production.

In general Regge model agrees with the data for small (-t < 0.5 GeV^2) up to W = 2.875 GeV, while EtaMAID2018 underestimate the cross section for the same range and the Laget model overestimate it.

As W increases the EtaMAID calculations are in a relatively good agreement (within 10 %) with the GlueX data up to W = 3.71 GeV. For W > 3.82 GeV, EtaMAID2018 is overestimating eta photo-production cross sections.

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Back up

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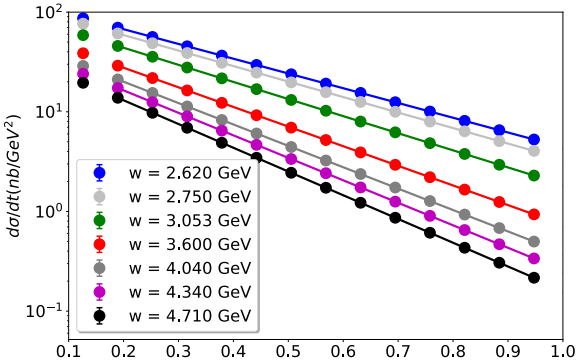
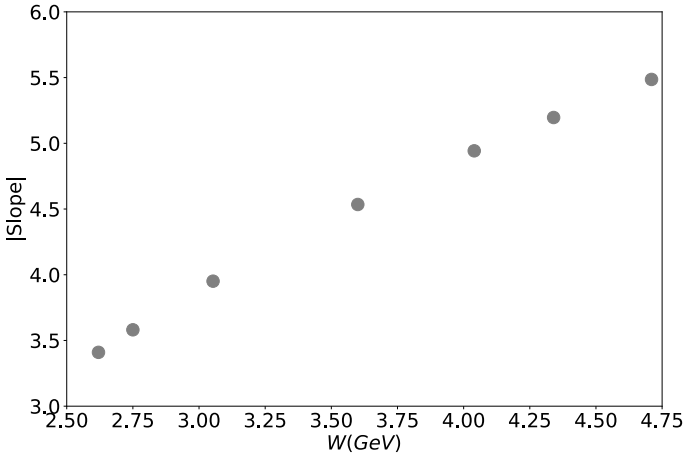
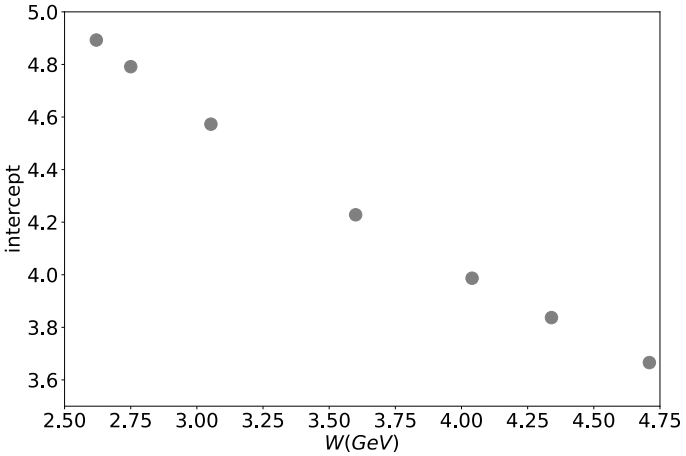
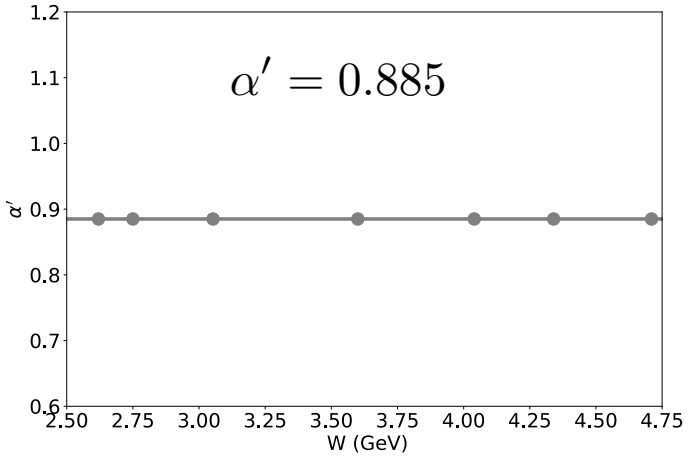
Toy model: Single Regge exchange using ρ trajectory parameters.

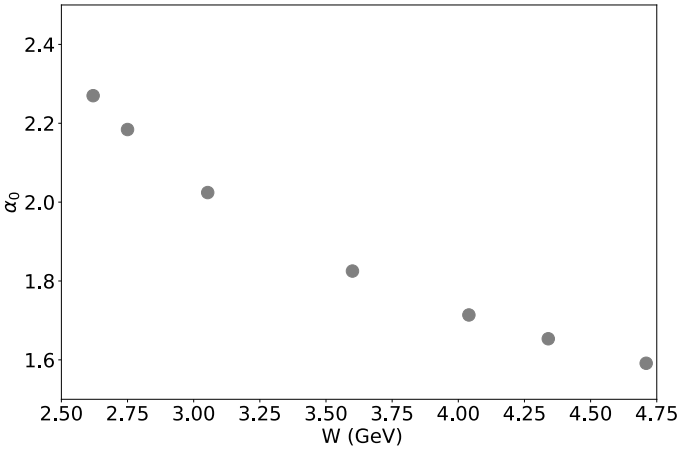
$$\frac{d\sigma}{dt} = 1000 s^{2(0.885t+0.477)-2}$$











Single Meson propagator

$$\frac{1}{t - M^2} \Rightarrow \left(\frac{s}{s_0}\right)^{\alpha(t)-1} \frac{\pi\,\alpha'}{\sin[\pi\alpha(t)]} \frac{\mathcal{S} + e^{-i\pi\alpha(t)}}{2} \frac{1}{\Gamma(\alpha(t))},$$