ρ^0 Photoproduction off Protons in CLAS6

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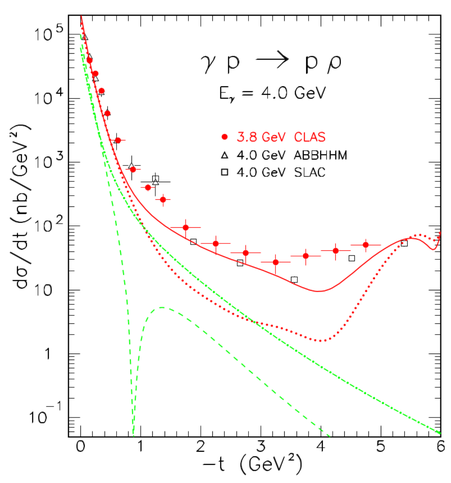
Motivation

Vector meson production may provide insight in many areas of nuclear physics:

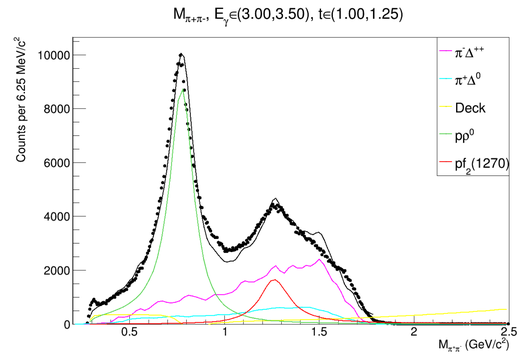
- Photon-Hadron interactions (Constituent Counting Rules)
- Short Range Correlations (high -t,s)
- Glueballs (2^{++} candidate along Pomeron trajectory)
- Gravitational Form Factors
  - Light (e.g. ρ): quark part of GFF
  - Heavy (e.g. J/ψ): gluon part of GFF

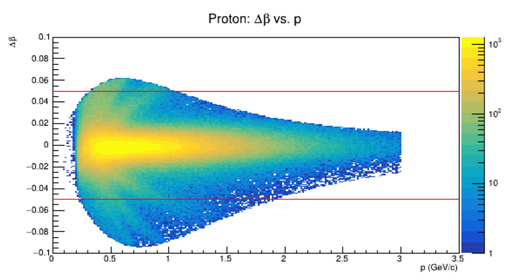
ρ^0 cross section data are sparse!

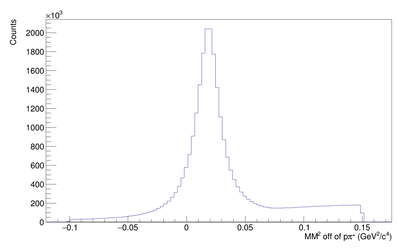


Analysis Methodology

- Skim for $\gamma p \rightarrow p\pi^+X$
- Require M^2_X between -0.1 and 0.15 (GeV^2/c^4)
- Fit $M_{\pi\pi}$ to obtain yields
- **$d\sigma/dt$** = yield / (efficiency * luminosity * δt)



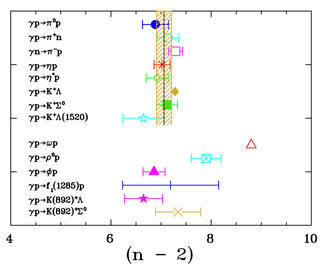




Constituent Counting Rules

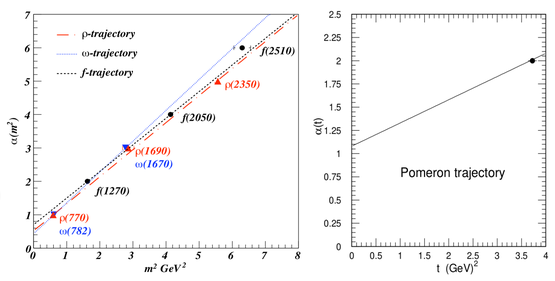
Question: how does γ interact with hadrons?

- $d\sigma/dt[90°] \sim s^{-(n-2)}$ for large s
- n: number of constituents or elem. fields in reaction
- e.g.: γ+p $\rightarrow$ ρ^0+p:
- **n = (0,1,2) + 3 + 2 + 3 = (8,9,10) → n-2 = (6,7,8)**
- No constituent? Point-like? Quark-antiquark?



Regge Theory

- $S_{fi} = \delta_{fi} + i(2\pi)^4\delta^{(4)}(P_f - P_i)T_{fi}$, $T_{fi} = T_\ell(s,t)$
- $T_\ell(s,t) \sim (2\ell+1)\ f_\ell(t)\ P_\ell(\cos\theta)$
- f_ℓ has singularities like $r(t) / [\ell - \alpha(t)]$
- $\alpha(t) = \alpha(0) + \alpha' t \rightarrow$ "Regge Trajectory"
- For $s >> |t|$, $d\sigma/dt \sim (s/s_0)^{2(\alpha-1)} e^{-b|t|}$, $b=2\alpha' \ln(s/s_0)$
- **b(s): "t-slope"**

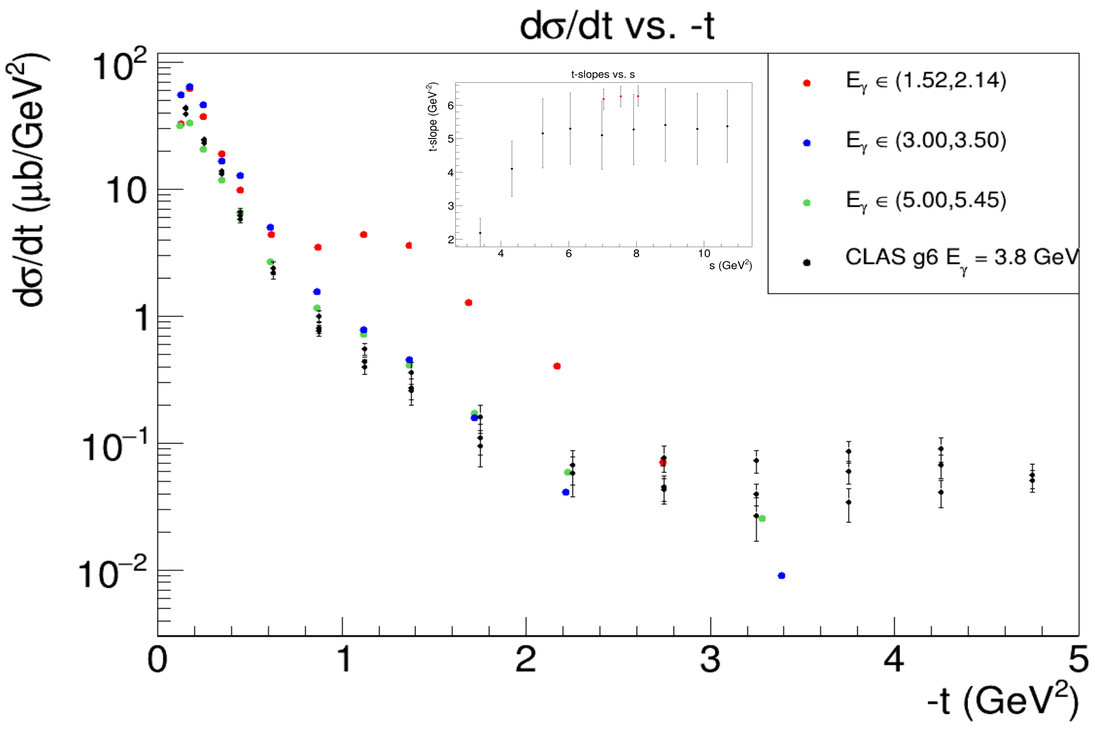


Experimental Objectives

- Determine **$d\sigma/dt$** over range of -t,s wider than previous measurements
- Determine t-slopes b(s) ← **$d\sigma/dt$** $\sim e^{-bt}$ for small -t
- Estimate n ← $\mathbf{d\sigma/dt}|_{90°} \sim s^{-(n-2)}$

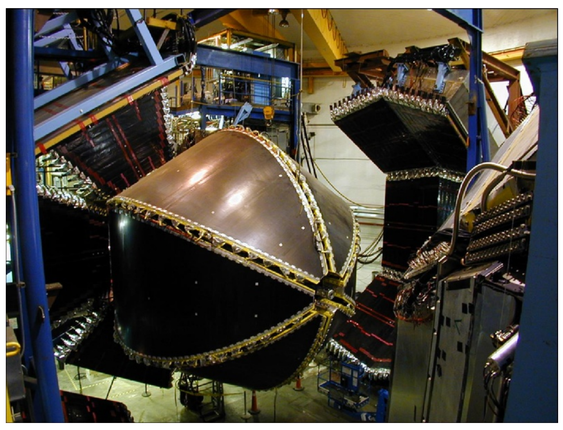
Preliminary Results

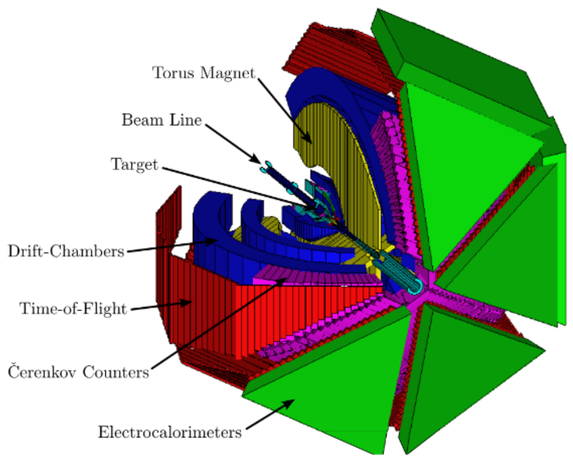
- **$d\sigma/dt$** results similar to previous measurements (for similar E_γ)
- t-slopes determined over wider s-range w.r.t. world data
- n-estimation is in progress!



CLAS6 Detector

- CLAS Detector housed in Hall B
- Data from g12 run period (Apr 2008 to Jun 2008)
- Photon beam with energies up to 5.7 GeV
- 40 cm long ℓH_2 target





Outlook

More improvements to come!

- Efficiency estimation
  - **$d\sigma/dt$** → weight the generator → efficiency → **$d\sigma/dt$** → ...
- Background Contributions ($\pi\Delta$, Deck, other resonances)
  - More stats, data-driven $\pi\Delta$ constraints
- Kinematic Fitting
- Systematic Uncertainties

References

- "Gravitational form factors of the proton from near-threshold vector meson photoproduction"
  - **Chin.Phys.C 48 (2024) 5**
- "High Energy Behaviour of Light Meson Photoproduction"
  - **Phys.Rev.C 103 (2021) 5**
- "Exclusive Meson Photo- and Electro-production, a Window on the Structure of Hadronic Matter"
  - **Prog.Part.Nucl.Phys. 111 (2020)**
- "Photoproduction of the rho0 meson on the proton at large momentum transfer"
  - **Phys.Rev.Lett. 87 (2001)**