Coherent Vector -Meson Photoproduction off Deuterium: *g*10 Data

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CLAS COLLABORATION MEETING 2017

05 October, 2017

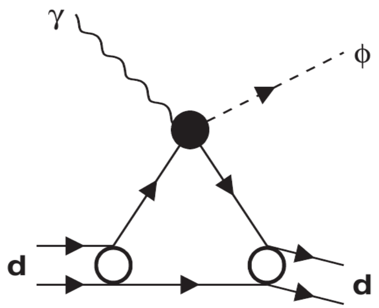
Outline

- $\gamma d \rightarrow \rho d$
  - PID
  - Yield Extraction
  - Results
- Updates on $\gamma d \rightarrow \omega d$
- Summary

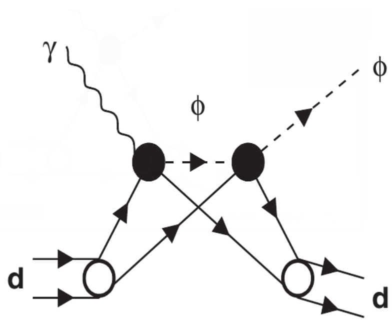
Motivation

$\gamma d \rightarrow \phi d$

Single scattering

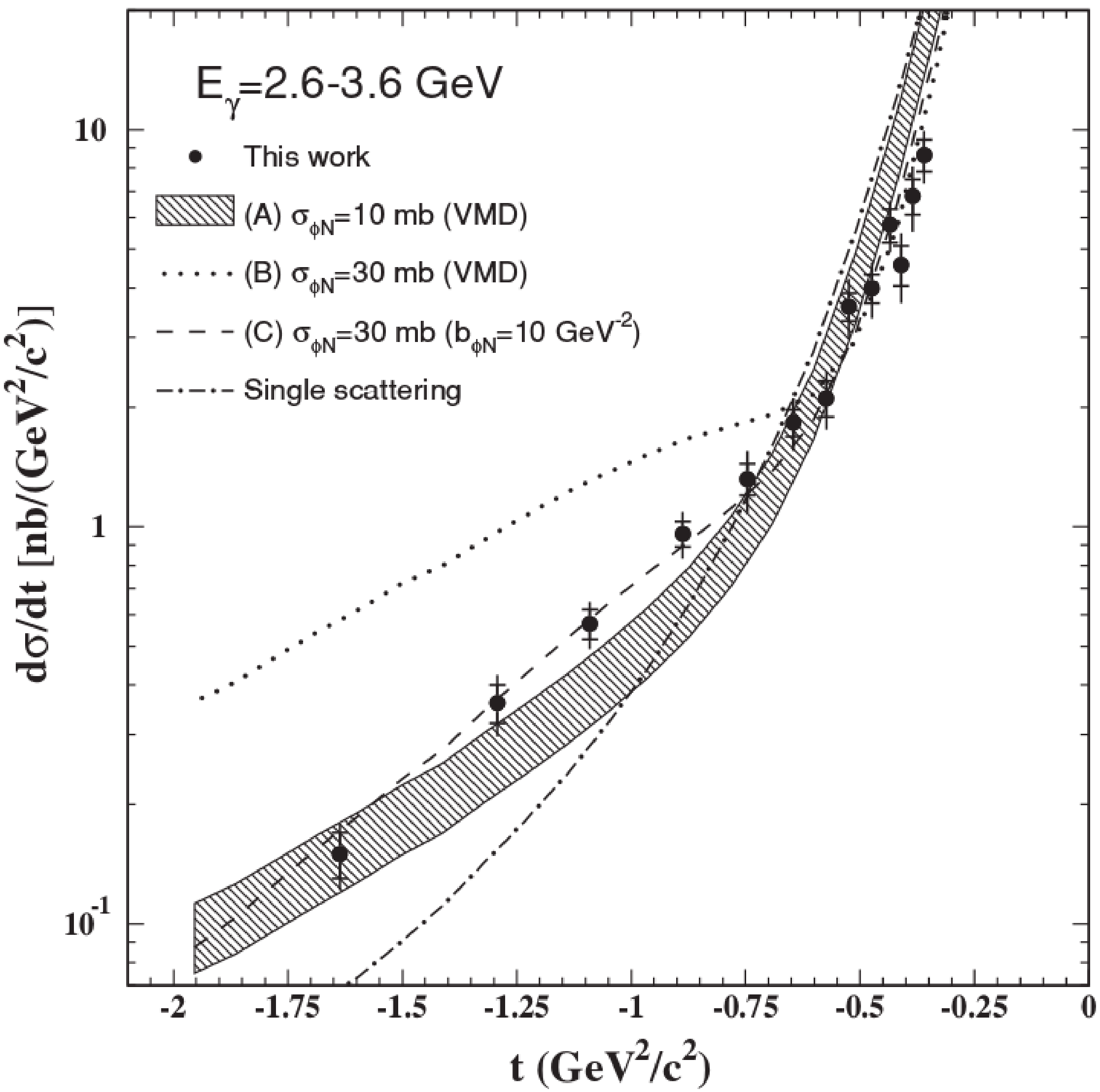


Double scattering



Mandelstam *t* :

$$t=\left(P_\gamma-P_\phi\right)^2=\left(P_{d_i}-P_{d_o}\right)^2$$

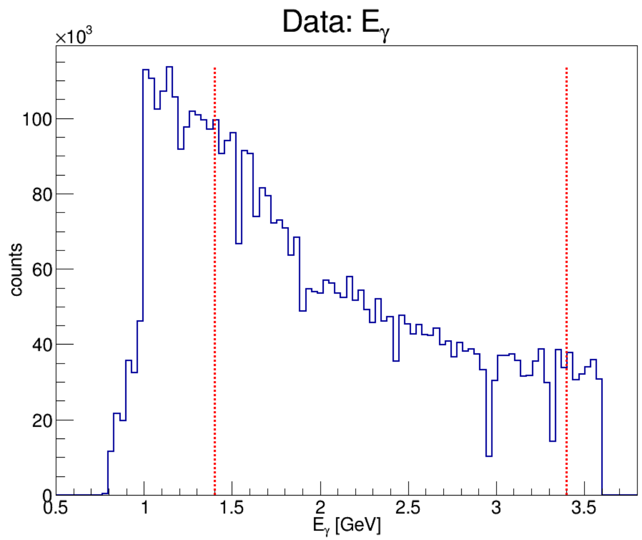


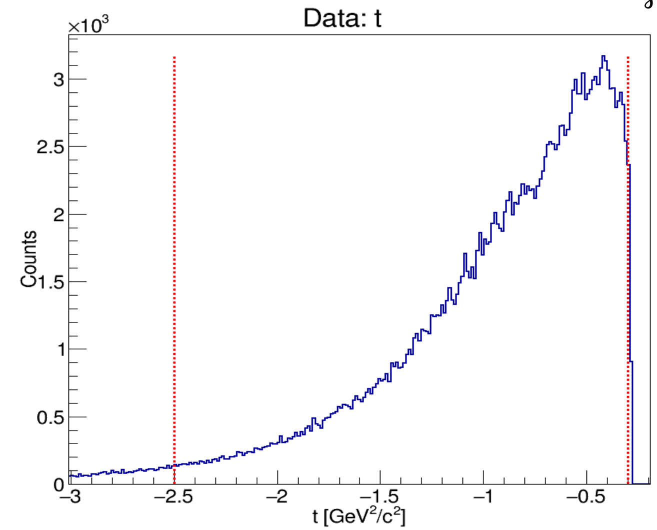
T. Mibe *et al.* PHYSICAL REVIEW C 76, 052202(R) (2007)

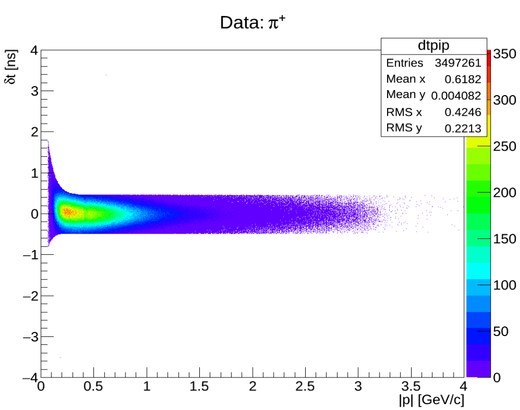
Particle Identification

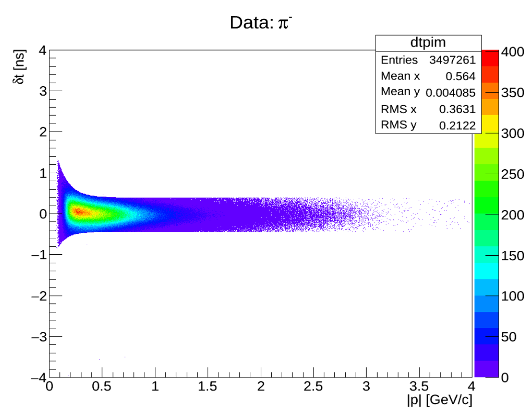
$\gamma\, d \rightarrow \rho\, d$

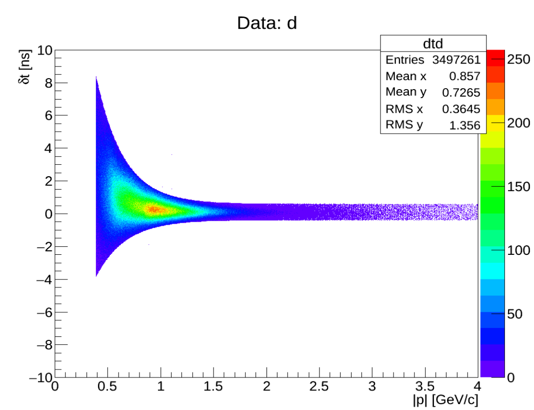
$t = (p_\gamma - p_\rho)^2$

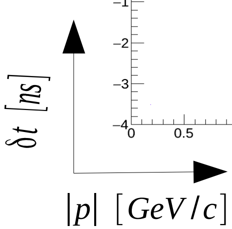








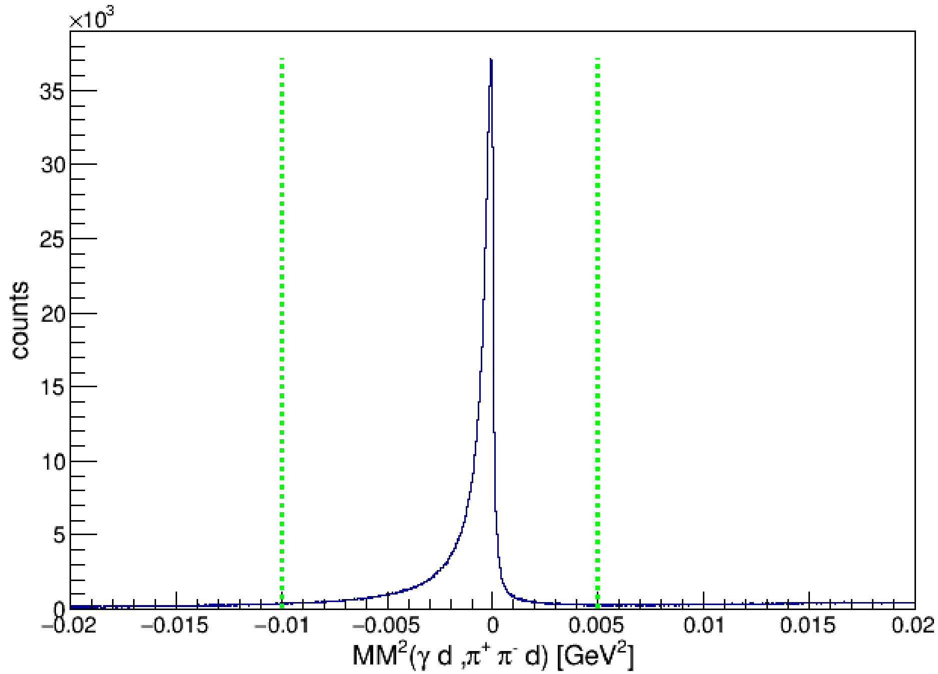


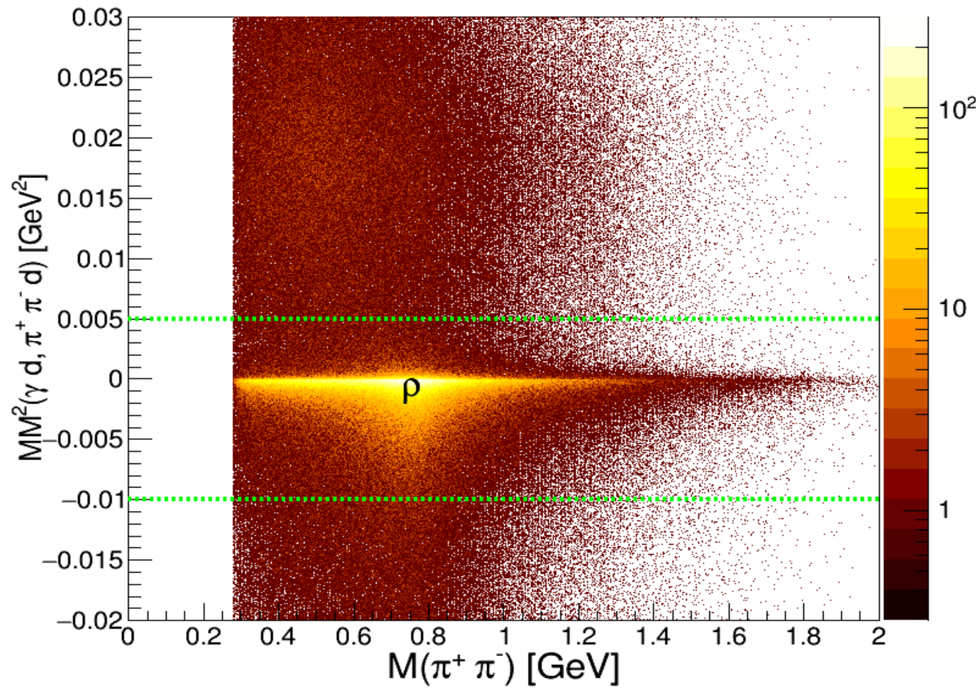


π^+ π^- d

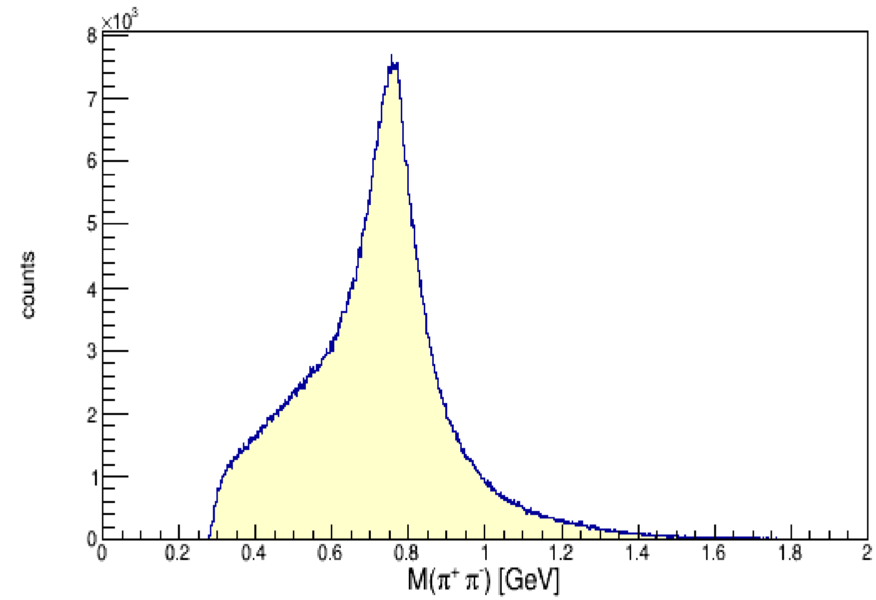
Global Spectrum

$\gamma\, d \rightarrow \rho\, d$





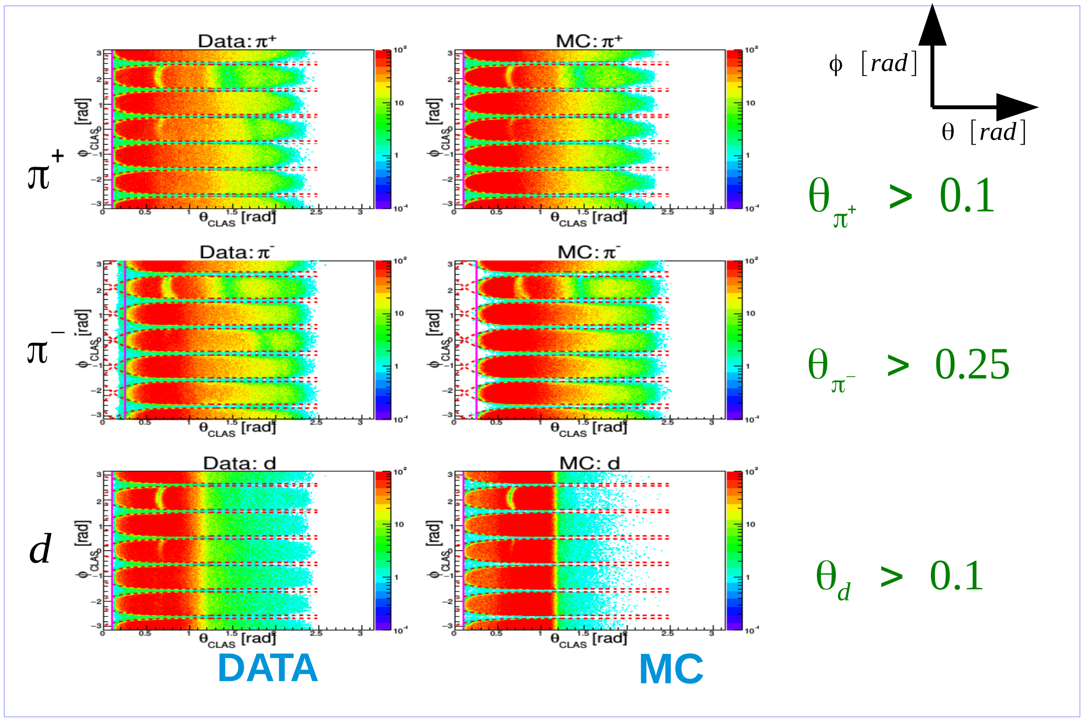
- $-0.01 < MM^2(\gamma d,\pi^+\pi^- d) < 0.005$ [GeV
- Signal over smooth background.
- Cuts applied to reduce background.



Cuts Applied

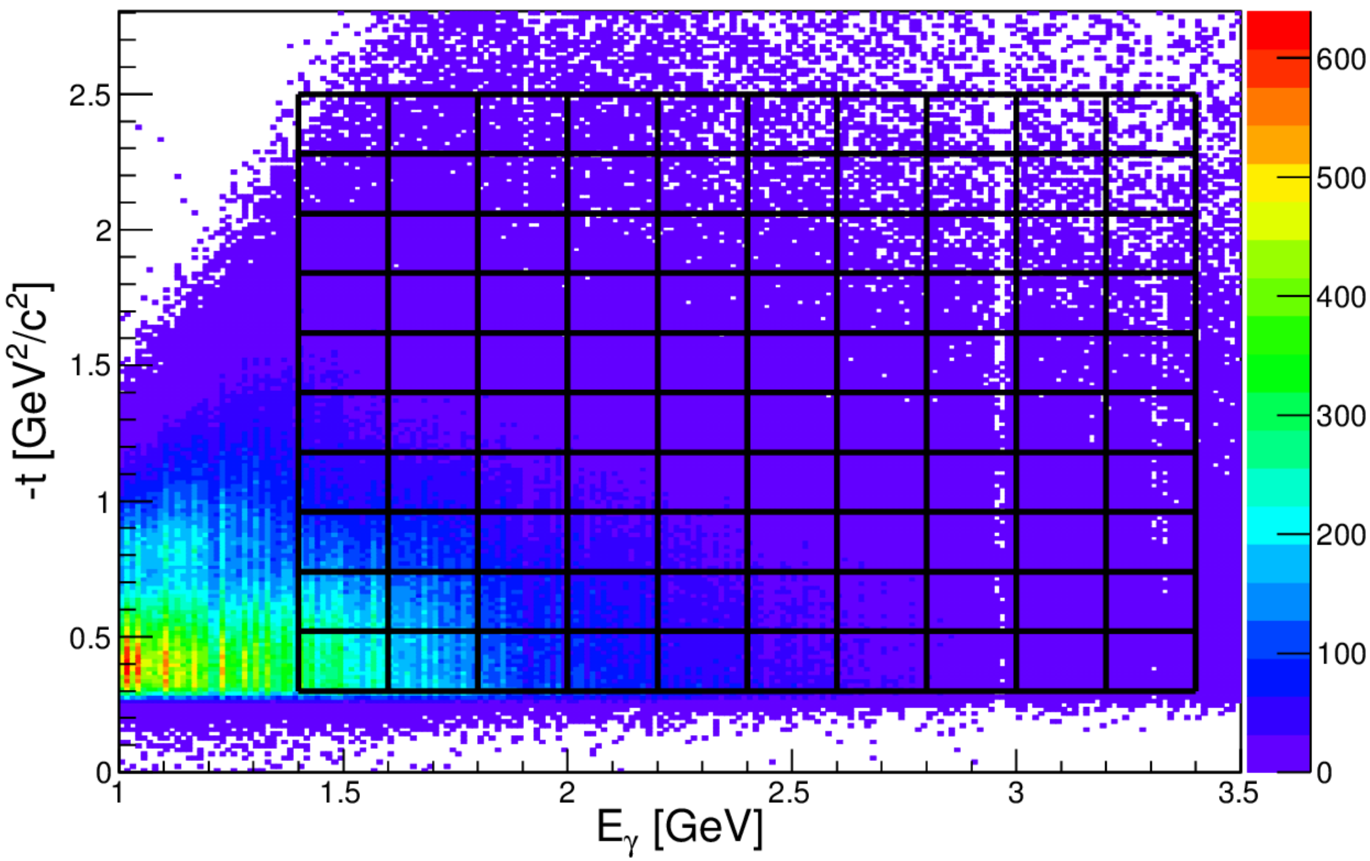
$\gamma\, d \rightarrow \rho\, d$

- Timing cuts made using momentum-dependent analysis
  - One “good photon”, $|\Delta t|<1$ ns
- -37 cm $< z_{vertex} < -13$ cm
- Fiducial cuts applied $\phi = a e^{b\theta} + c$
  - Minimum Theta Cut
- Minimum Momentum Cuts
- Missing mass Squared Cut.
- Bad SC Paddles removed.



Particle	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
π^+	23, 27 ≥ 43	≥ 45	11, 13, 23, 31 ≥ 40	23, 33, 35 ≥ 46	23, 29 ≥ 46	23 ≥ 45
π^-	23, 27 ≥ 41	≥ 41	11, 15, 16, 23, 31 34-36, ≥ 41	23, 27, 35 ≥ 43	20, 23, 29 ≥ 43	23 ≥ 42
d	23, 27 ≥ 35	23 ≥ 35	11, 22, 23, 31 ≥ 35	23 ≥ 35	23, 29 ≥ 35	23 ≥ 35

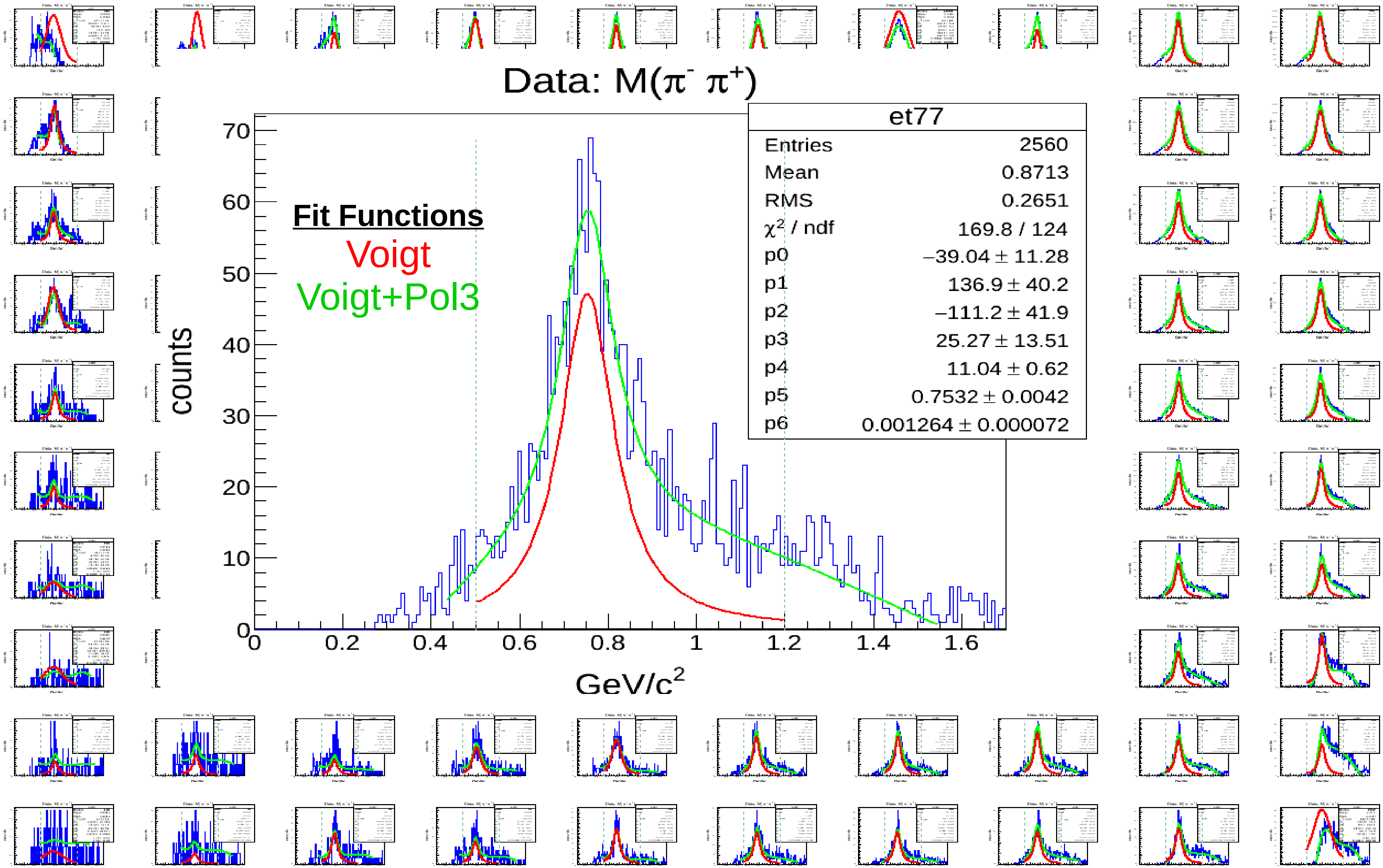
Binning



10 incident photon energy and 10 momentum transfer bins.

Yield Extraction

$\gamma\, d \rightarrow \rho\, d$



Yield is extracted by taking integral of the Voigt function

Differential Cross-section

Preliminary

Differential cross-section,

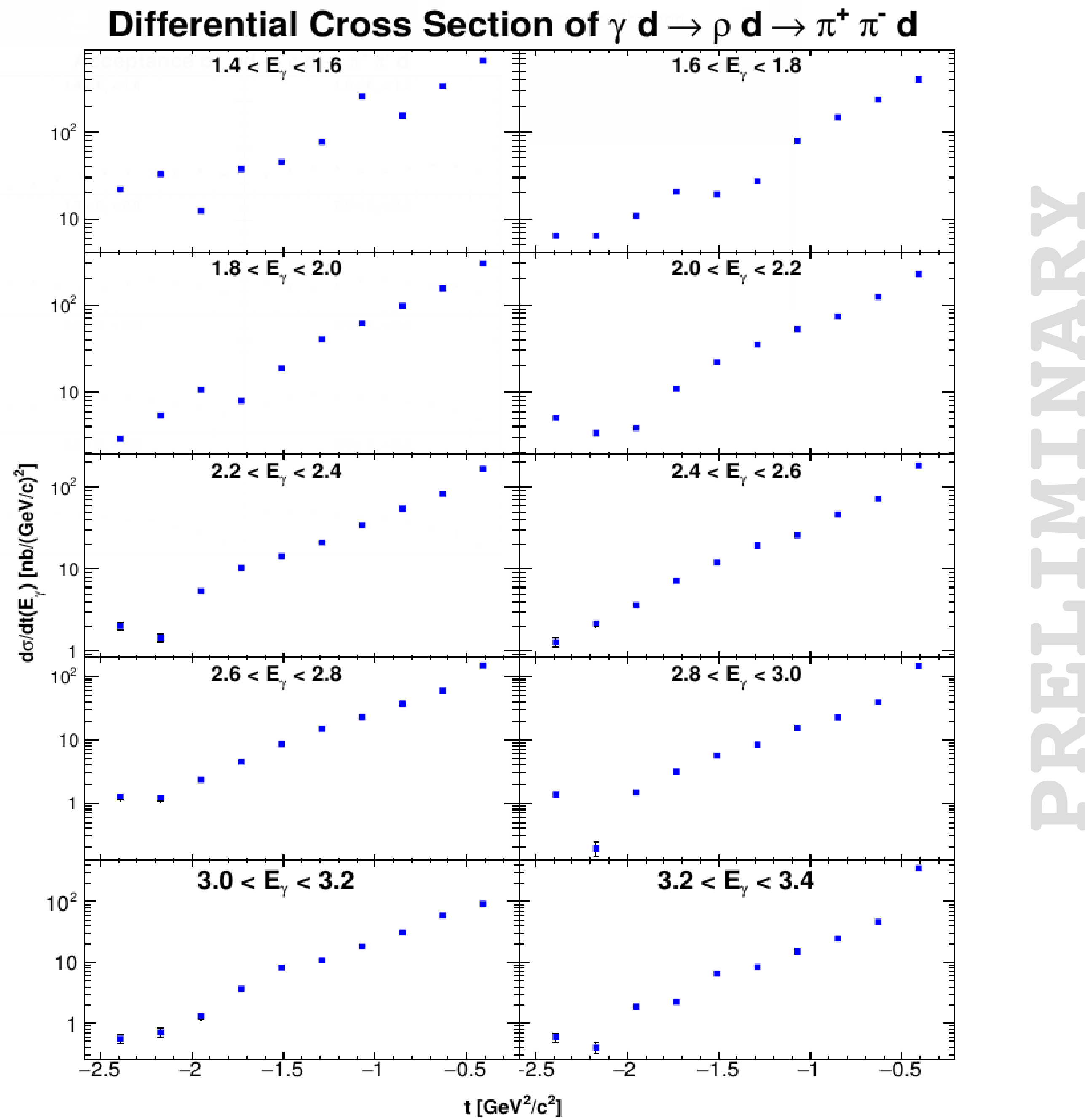
$$\frac{d\sigma}{dt} = \frac{Y_D}{\Delta t A \mathscr{L}}$$

A = Acceptance
Δt = Width of t-bin
Y_D = Signal Yield

Luminosity,

$$\mathscr{L}(E_\gamma) = \frac{\rho_T N_A l_T}{M_d} N_\gamma(E_\gamma)$$

$\rho_d = 0.169\, gcm^{-3}$
$l_d = 24\, cm$
$M_d = 2.014\, g\, mole^{-1}$
$N_\gamma(E_\gamma) =$ Photon Flux

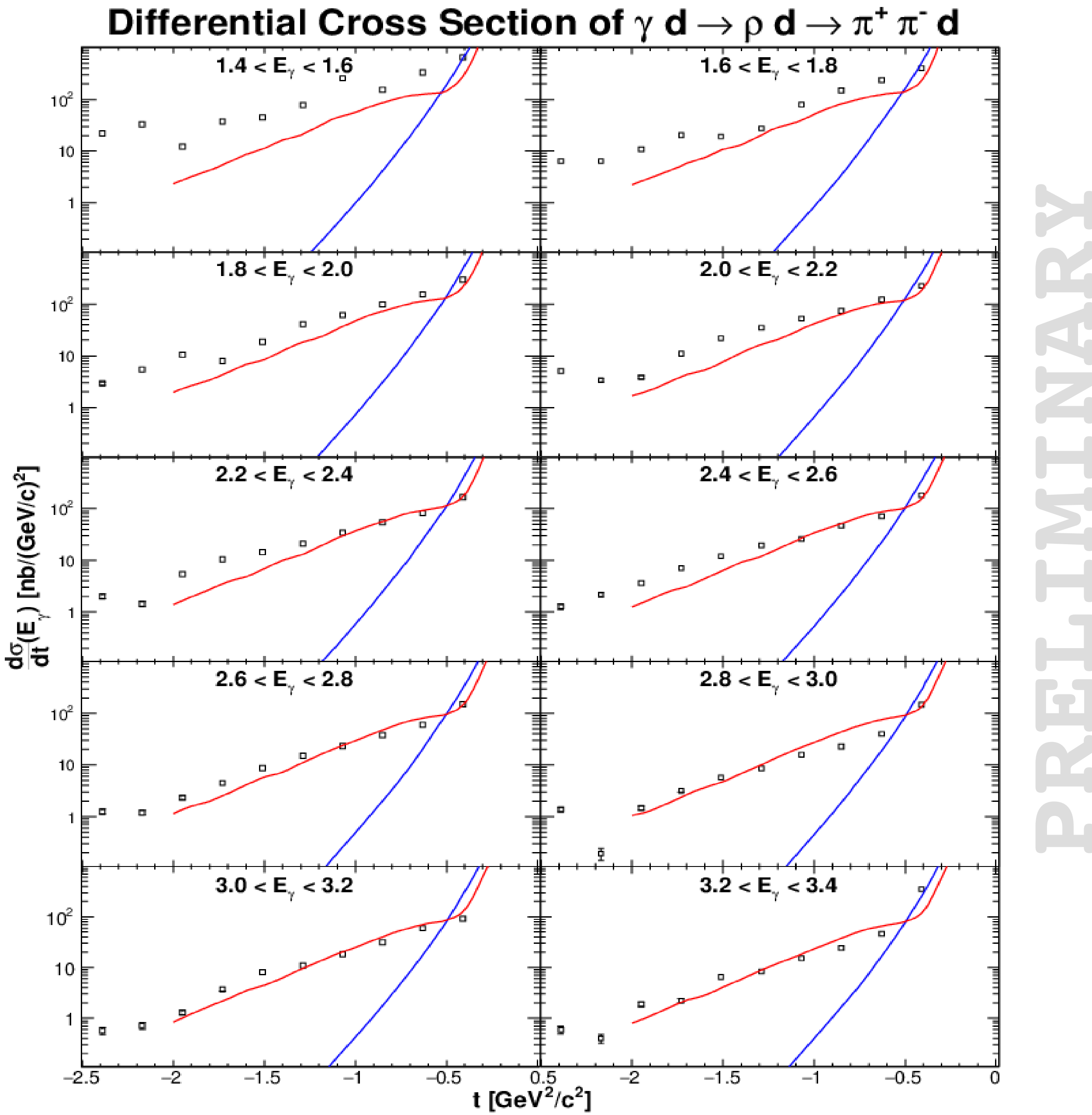


Differential Cross-section

Preliminary

- Calculations are provided by Dr. Sargsian (FIU)*.
- Production of ρ is within the Vector Dominance Model.
- Born Term Contribution: single scattering
- Final State Interaction included

Work in Progress!



* *Coherent Photo- and Leptoproduction of Vector Mesons from Deuterium*, **Frankfurt et al**, Nucl.Phys. A622 (1997) 511-537

Motivation

Differential Cross Section for $\gamma d \to \omega d$ using CLAS at Jefferson Lab

Taya Chetry* and Kenneth Hicks†
Ohio University, Athens, Ohio 45701

(CLAS Collaboration)
(Dated: September 26, 2017)

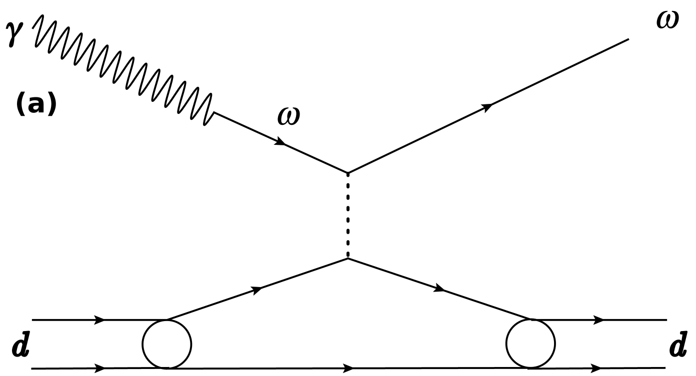
The cross section for the coherent ω-meson photoproduction off of deuteron have been measured for the first time as a function of the momentum transfer $t = (P_\gamma - P_\omega)^2$ and E_γ using the CLAS detector at the Thomas Jefferson National Accelerator Facility. The cross sections are calculated in the energy range $1.4 < E_\gamma < 3.4$ GeV. A rescattering model used for comparison is consistent with the data at low and intermediate momentum transfer regimes. For large $|t|$, discrepancy between data and the calculation suggests the need of the u-channel contribution to include the effects due to the large center of mass scattering angle. Due to limited world data on $\gamma d \to \omega d$, this measurement opens up the possibility to study ωN interaction at low energies and large $|t|$.

Almost ready!

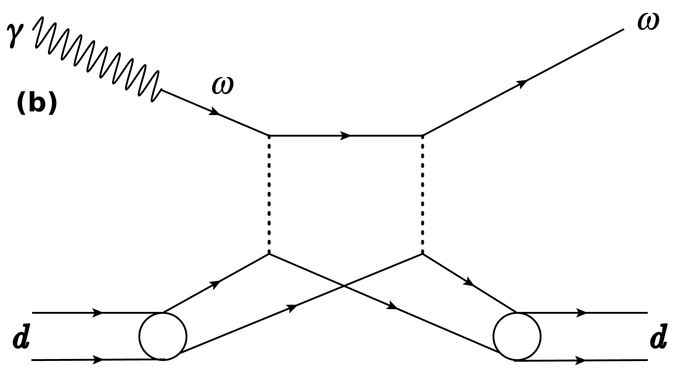
Updates

$\gamma\, d \rightarrow \omega\, d$

Single scattering

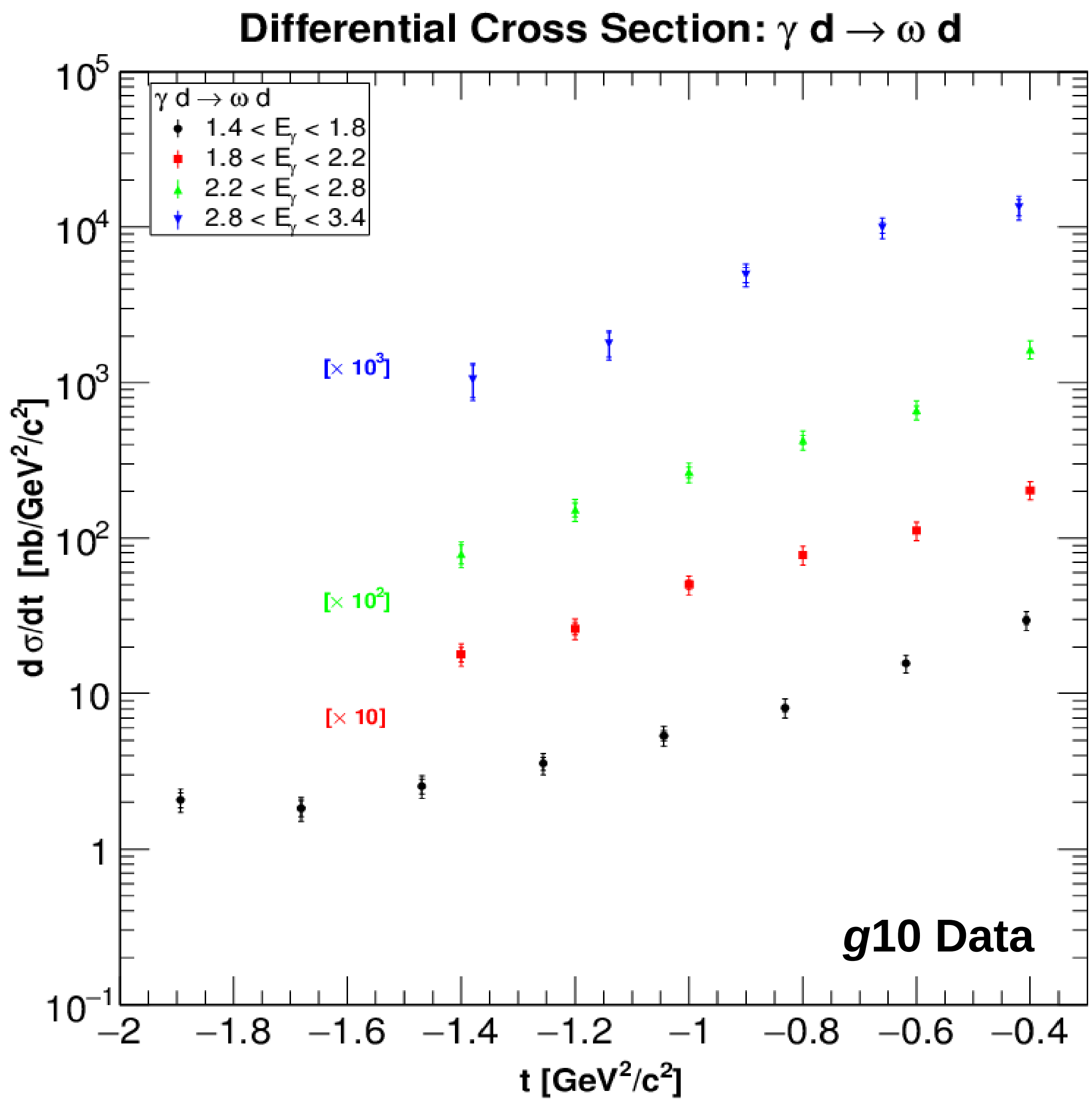


Double scattering



Mandelstam *t* :

$$t=\left(P_{\gamma}-P_{\omega}\right)^2=\left(P_{d_i}-P_{d_o}\right)^2$$



Theory Paramaters

$$\frac{d\sigma}{dt} = \sigma_0 e^{-bt}$$

$\sigma_{\omega N}$

$$\alpha = \frac{Re(A)}{Im(A)}$$

$b_{\gamma N}$, $b_{\omega N}$

$d\sigma/dt|_{t=0;\ \gamma N}$

$\alpha_{\gamma N}$, $\alpha_{\omega N}$

Calculation based on VMD
(provided by M. Sargsian, FIU)*

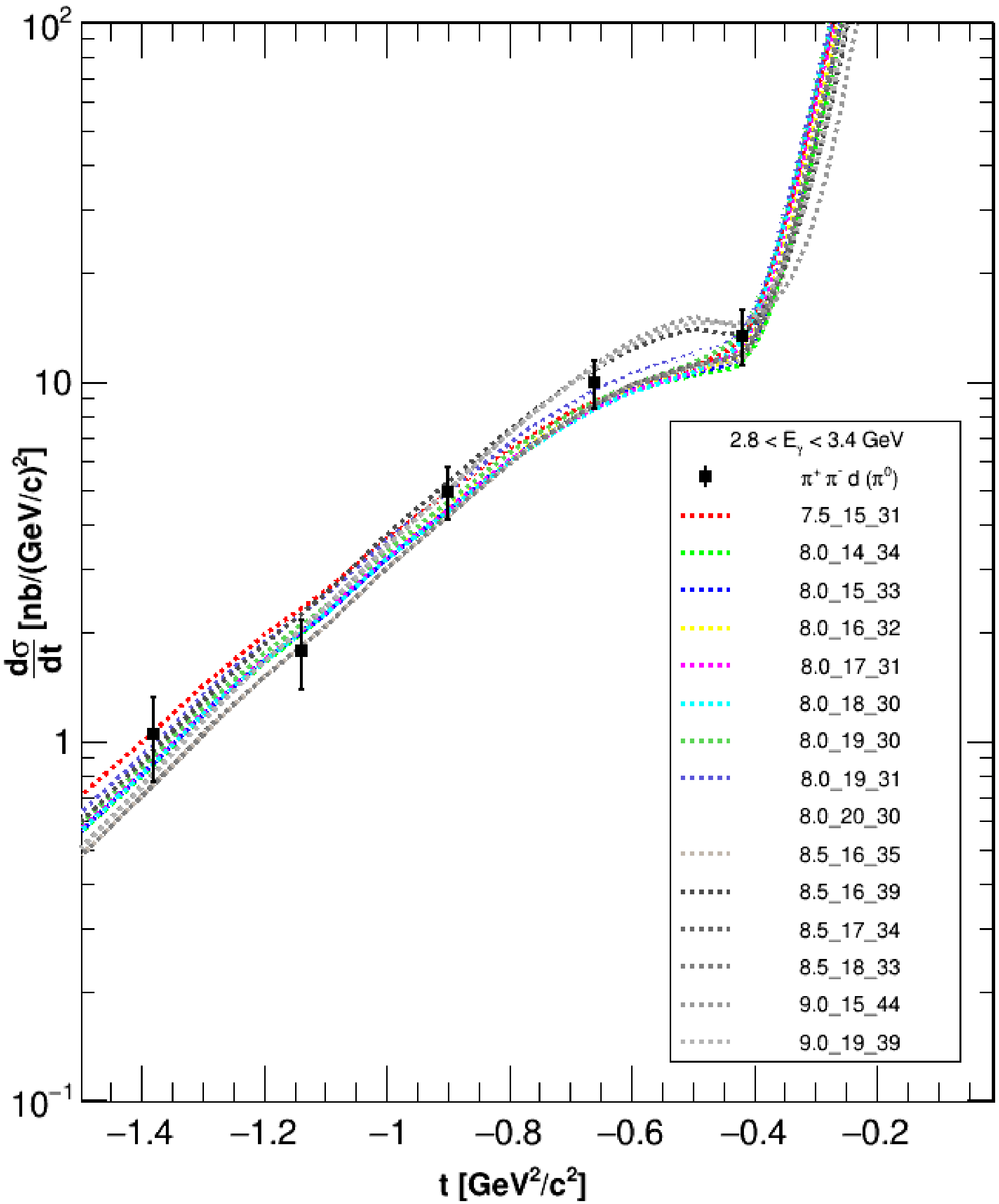
$\frac{d\sigma}{dt}$ → Comparison with Data

$\sigma_{\omega N}$

* **Frankfurt et al**, Nucl.Phys. A622 (1997) 511-537

Comparison

$\gamma\, d \rightarrow \omega\, d$



$\alpha_{\gamma N} = \alpha_{\omega N} = -0.4$

$b_{\gamma N} = b_{\omega N}$ $[GeV^{-2}]$	$\frac{d\sigma}{dt}\big\vert_{t=0,\gamma N}$ $[\mu b/GeV^2]$	$\sigma_{\omega N}$ $[mb]$	χ^2/NDF
7.5	15	31	1.13
8.0	14	34	1.15
8.0	15	33	1.01
8.0	16	32	0.96
8.0	17	31	1.00
8.0	18	30	1.15
8.0	19	30	0.91
8.0	19	31	0.87
8.0	20	30	1.03
8.5	16	35	1.11
8.5	16	39	1.00
8.5	17	34	1.05
8.5	18	33	1.07
9.0	15	44	0.99
9.0	19	39	0.89
9.0	20	38	0.87

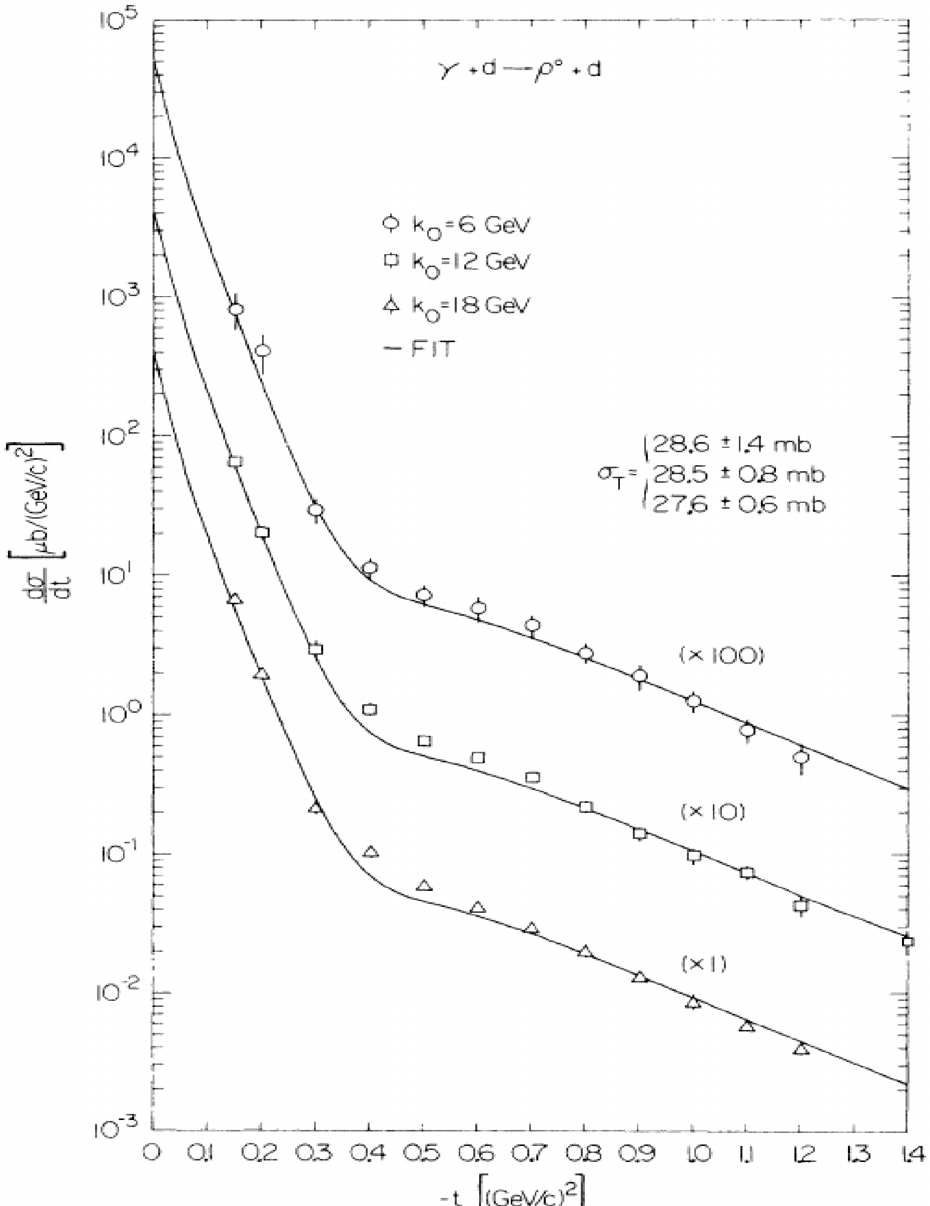
Summary

- The cross-section data provides sensitivity to the nucleon-scattering data in relatively low energy and high momentum transfer range mentioned.
- $\frac{d\sigma}{dt} \propto e^{-b|t|} \rightarrow$ as expected for a diffractive process.
- Rho analysis Note: soon to be submitted. With rho, the trio of vector meson will be complete!
- Omega paper almost done:
  - Tweaking with the theory parameters.
  - Quote $\sigma_{\omega N}$
  - Soon to be submitted to the *ad-hoc* committee.

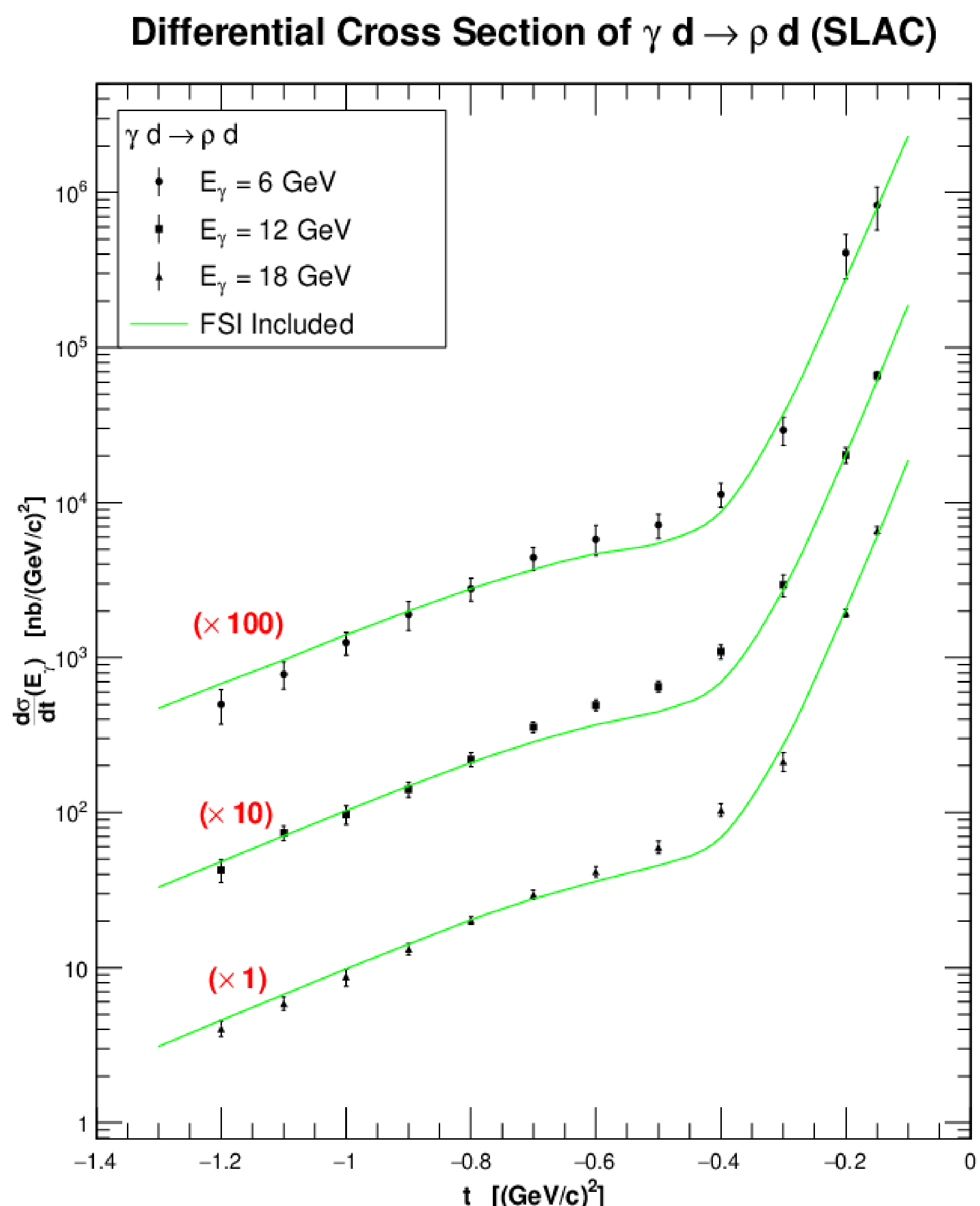
Extras

SLAC ρ Data

Back-up



R.L.Anderson et al, Phys. Rev. D. **4**, 3245, 1971



Using Calculations provided by M.Sargsian

Diffractive DCS

Differential cross-section,

$$\frac{d\sigma}{dt} = \frac{Y_D}{\Delta t A \mathscr{L}} \times \frac{\Gamma_\omega}{\Gamma_{\omega\to\pi^+\pi^-\pi^0}} \times \gamma_{corr}$$

A = Acceptance
Δt = Width of t-bin
Y_D = Signal Yield
γ_{corr} = Photon Multiplicity Correction factor

Luminosity,

$$\mathscr{L}(E_\gamma) = \frac{\rho_T N_A l_T}{M_d} N_\gamma(E_\gamma)$$

$\rho_d = 0.169\ g cm^{-3}$
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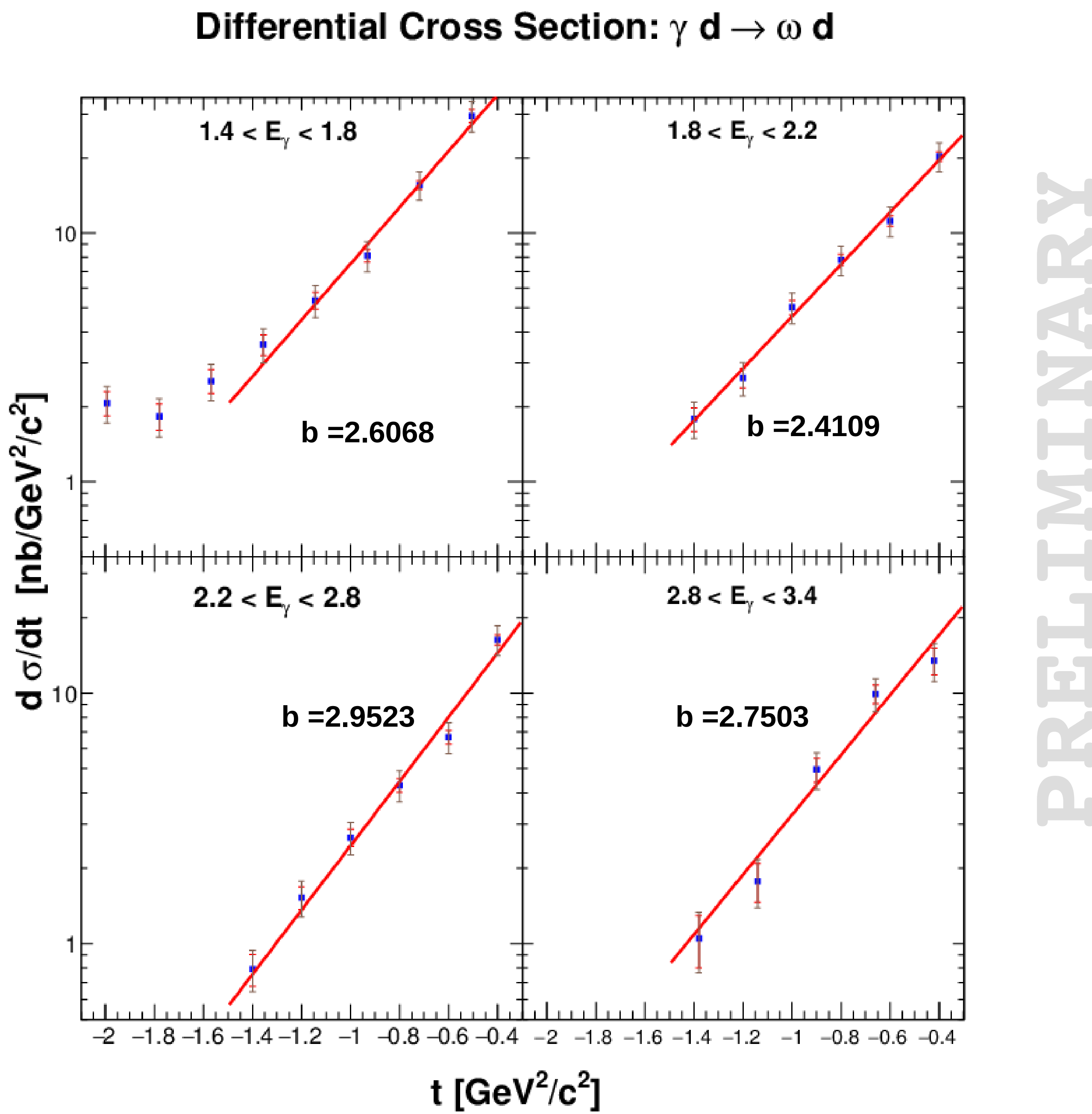
$N_\gamma(E_\gamma) =$ Photon Flux

$$\frac{d\sigma}{dt} \propto e^{-b|t|}$$



Previous Studies

Back-up

Group	E_γ [GeV]	t [GeV/c^2]	Comments
Gupta *et. al.* [SLAC] Phys. Rev. D 14, 42 (1976)	5.5	-	Low statistics. No mass fit was possible
Morris *et. al.* [NINA] Nuclear Physics B119 (1977)	3.9	-	*Total Cross-section measured: 1.4 ± 0.5 μb *Coupling constant ratio (rho/omega) measured

Photoproduction of ω mesons off protons and neutrons

Eur. Phys. J. A (2015) 51: 6

Back-up

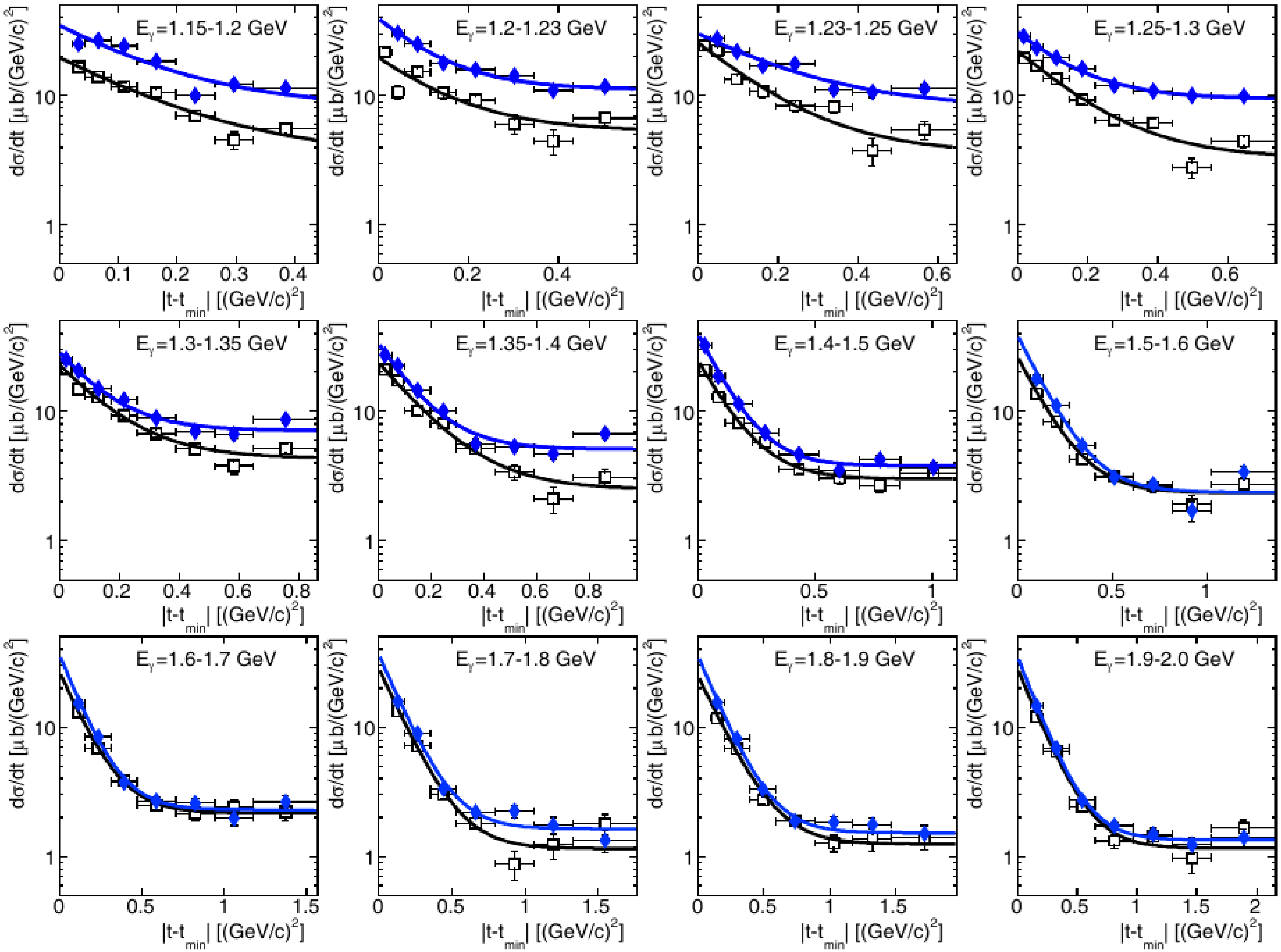


Fig. 11. (Color online) Differential cross-section *versus* the momentum transfer to the nucleon for ω mesons produced off the bound proton (open squares) and for ω mesons produced off the free proton (blue diamonds).

Photoproduction of ω mesons off protons and neutrons

Eur. Phys. J. A (2015) 51: 6

Back-up

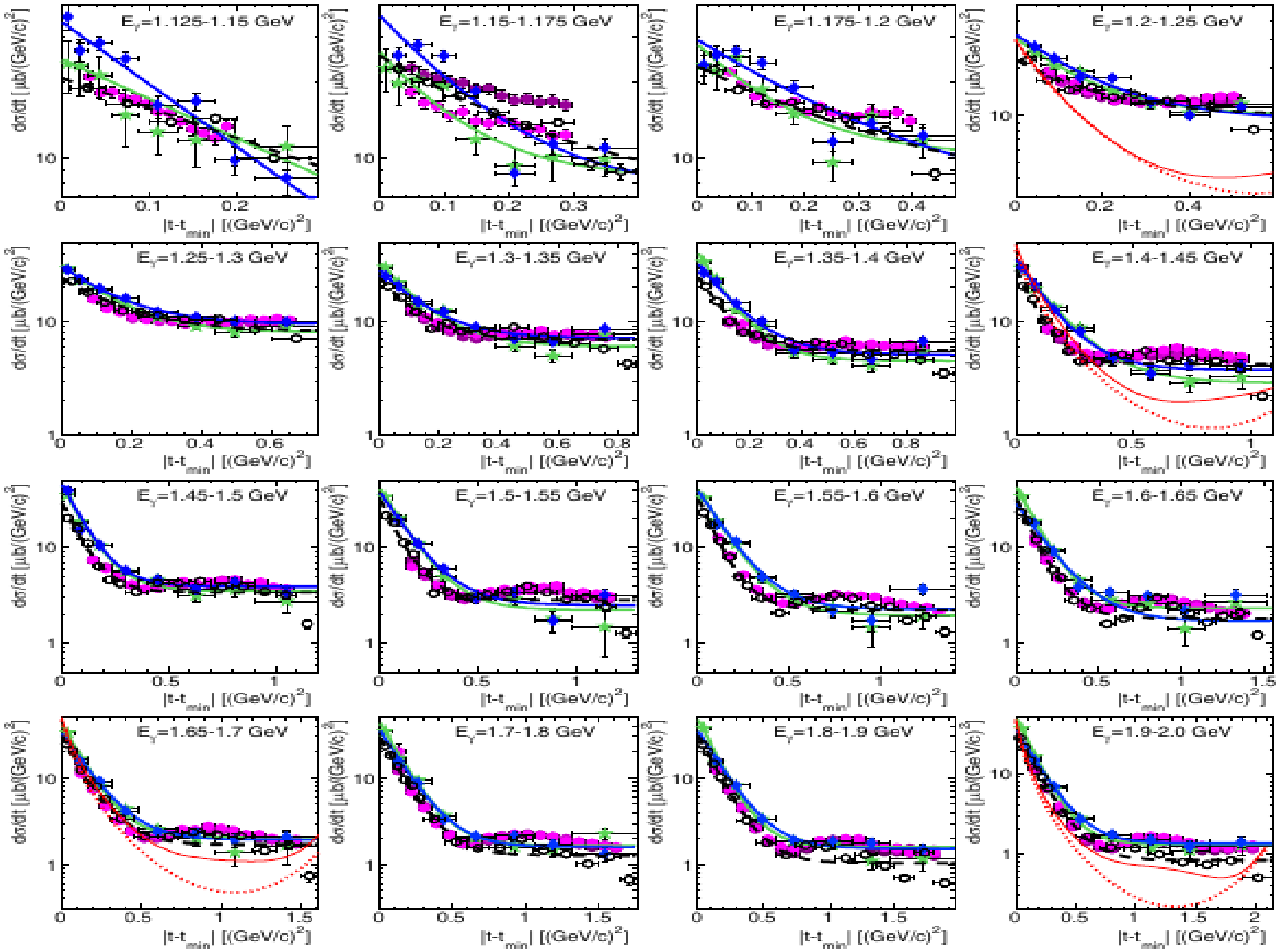


Fig. 9. (Color online) Differential cross-sections of ω mesons produced off the free proton *versus* the momentum transfer to the nucleon, t. The results of this work from the exclusive analysis (blue diamonds) and from the inclusive analysis (green stars) are compared to results from SAPHIR (open circles) [3] and CLAS (magenta circles) [4]. Since the incident energy binning of the present work does not coincide with that in [4] several CLAS data sets are shown for the incident energy intervals given in this figure. The lines are fits to the CBELSA/TAPS data (solid) and SAPHIR data (black dashed) according to eq. (6). For four incident beam energies theoretical curves are shown calculated with (red solid line) and without (red dotted line) N^* contributions [33].