HSWG

CLAS Collaboration Meeting

JLab, June 15 2017

Hadron Spectroscopy 1

Remote connection: https://bluejeans.com/827115701

Convener: Marco Battaglieri (INFN-GE)

Location: CEBAF Center (Auditorium)

09:00 **Hadron Spectroscopy Working Group Business** *20'*
- Speaker: Marco Battaglieri (INFN-GE)
- Material: **Slides**

09:20 **The cross section measurement of the 3\pi final states from CLAS-g12** *20'*
- Speaker: Zulkaida Akbar (FSU)
- Material: **Slides**

09:40 **Photoproduction of 3pi with CLAS** *20'*
- Speaker: Paul Eugenio (Florida State University)
- Material: **Slides**

10:00 **Status update on the analysis of eta->pi+pi-X, X=pi0,g with CLAS** *20'*
- Speaker: Daniel Lersch (Juelich Research Center)
- Material: **Slides**

10:20 **Discussion** *10'*

10:30 **Coffee Break** *30'*

11:00 **JPAC report** *20'*
- Speaker: Cesar Fernandez-Ramirez (UNAM)
- Material: **Slides**

11:20 **Light meson decay** *20'*
- Speaker: Susan Schadmand (Forschungszentrum Juelich)
- Material: **Slides**

11:40 **CLAS12 MesonEx trigger studies** *20'*
- Speaker: Stefan Diehl (Giessen University)
- Material: **Slides**

12:00 **Near threshold J/psi photoproduction and study of LHCb pentaquarks with CLAS12** *20'*
- Speaker: Valery Kubarovsky (Jefferson Lab)
- Material: **Slides**

12:20 **Analysis reviews status** *40'*

Agenda

- ✳ CLAS6 data analysis: 3pi
- ✳ CLAS12 related studies
- ✳ LHCb pentaq proposal HSWG reviewed and submitted to PAC45
- ✳ Status of ongoing analysis

Activities

- ✳ Early results report (B.McKewon)
- ✳ Are we ready for physics? KPP data analysis showed that we can make it
- ✳ Make good use of JPAC results and support
- ✳ Any analysis ready for review has to give a presentation to the HSWG
- ✳ Analysis ready for a plenary presentation (e.g. Paul's $\gamma n \rightarrow p\pi^-$ Differential Cross Section Measurements with CLAS)

Talks

- ✳ Over all CLAS contributions, HSWG-related are 40%
- ✳ Regular interactions with the CSC
- ✳ List of possible topics/speakers on the latest CLAS results
- ✳ REMINDER: Communicate talks and proceedings to the CSC
- ✳ JSA-TFC funds $20k allocated for 2017

WG Reviews status

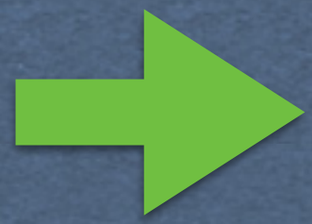
Polarized structure function sigmaLT from the single pi0 electroproducion on the proton in the resonance region
PI: Nick Markov
RC: V.Crede, Ralf Goethe, Yelena Prok
Started Sept 2014
Status: is moving forward

Measurement of Cross-Sections of exclusive pi^{0} Photo-production on Hydrogen from 1.1 GeV - 5.45 GeV using e+e-gamma
PI: Michael Kunkel
RC: Carlos Salgado (Chair), Lei Guo , Yordanka Ilieva
Status: 2nd round, healthy

DONE!

Cascade polarization in photoproduction
PI: J.Bono et al.
RC: A. D'Angelo (Chair), M.Kunkel, E Pasyuk
Status: 2nd round, healthy

Coherent omega-meson photoproduction off the deuteron
PI: T.Chetry
RC: B.McKinnon, P.Cole, N.Zachariou
Status: 1st round



Less than 6 months!

WG Reviews status

New since last meeting

Photoproduction of the 3π mesons in the reaction $\gamma p \rightarrow \pi+\pi+\pi-n$ with CLAS detector at 6 GeV/$c2$

PI:P.Eugenio

RC: D.Glazier (chair), A.Filippi, M.Dugger

Status: 1st round, waiting for response

Exclusive pi- Electroproduction off the Neutron in Deuterium in the Resonance Region

PI:Y.Tian

RC: Nikolay Markov (Chair), Mikhail Bashkanov , Eugene Isupov

Status: 1st round

In progress

Radiative decay of eta' to pi+ pi- gamma from g11 data set

PI:G. Mbianda Njencheu

RC: R. Schumacher,S.Schadmand,A.Celentano

Status: 1st round, stud graduated, revised note in prep

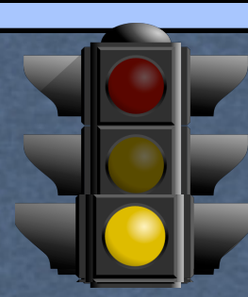
Polarization Observables T and F in the $\vec{p}(\vec{\gamma},\pi 0)p$ Reaction

PI:H.Jiang

RC: Barry Ritchie (Chair), Volker Crede , Bryan McKinnon

Status: Ist round, still waiting for response (was March?)

WG Reviews status



Measurement of Sigma in pi- photoproduction on the neutron from the g13b dataseta

PI: D.Sokhan (GlasgowU) et al.
RC: Eugene Pasyuk (Chair), Nicholas Zachariou , Paul Mattione
Started Jul 2016
Status: lost contact with the author after 1st round, RESUMED YESTERDAY!

Spin observables in eta meson photoproduction on the proton from FROST data

PI: R.Tucker (ArizonaU) et al.
RC: K.Livingston, J.Price, Xiangdong Wei
Sterted July 2016
Status: on-hold, still on-hold but authors are alive

Pentaquark search in g10 by using the MMSA method

PI: Kenneth Hicks et al.
RC: Stepan Stepanyan (Chair), Lei Guo , Bryan McKinnon
Started Aug 2015
Status: stopped communication from 6 months, NO progress

KLambda and KSigma from FROST

PI: N.Walforf et al.
RC: S.Strauch, M.Holtrop, P.Mattione,
Started May 2015
I round of comments in May 2015, waiting for a revise
Status: stalled for a long while, now it seems to be resurrected, unfortunately NO

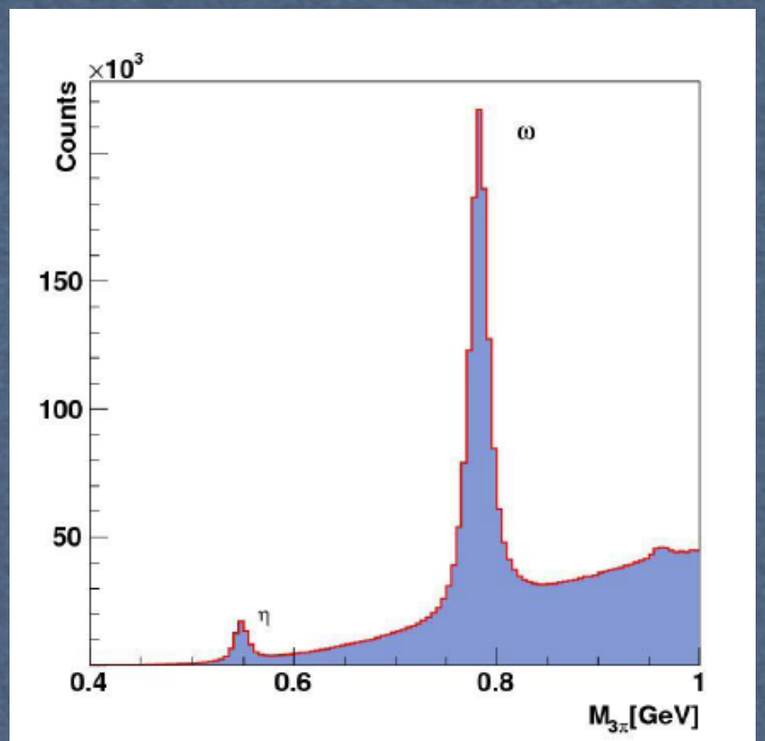
Exclusive Photo-Production Measurement of K +Sigma*- off Quasi-Free Neutrons in Deuterium

PI: H.Lu (SCU) et al.
RC: N.Zachariou, M.Dugger, D.MacGregor
Started in 2012 (!)
Status: resumed with reshuffled committee, still waiting …

Asked to SC/run-group to go trough the analysis and see if the latest issues have an easy fix H.Lu will work in the next few months

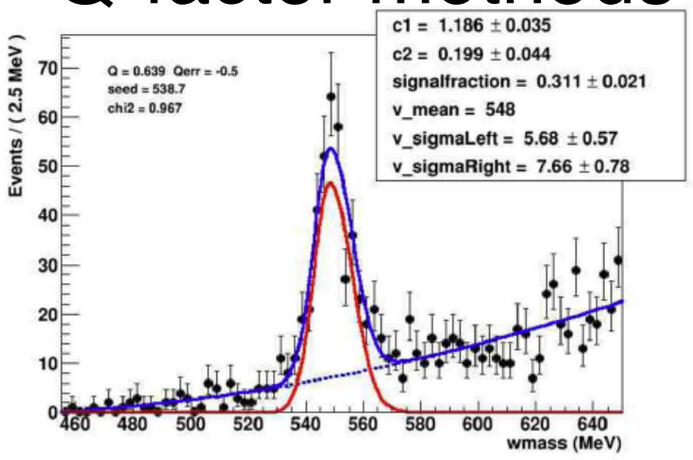
Photo-production of $\pi^+\pi^-\pi^0$ using CLAS-g12 at Jefferson Laboratory

ZULKAIDA AKBAR

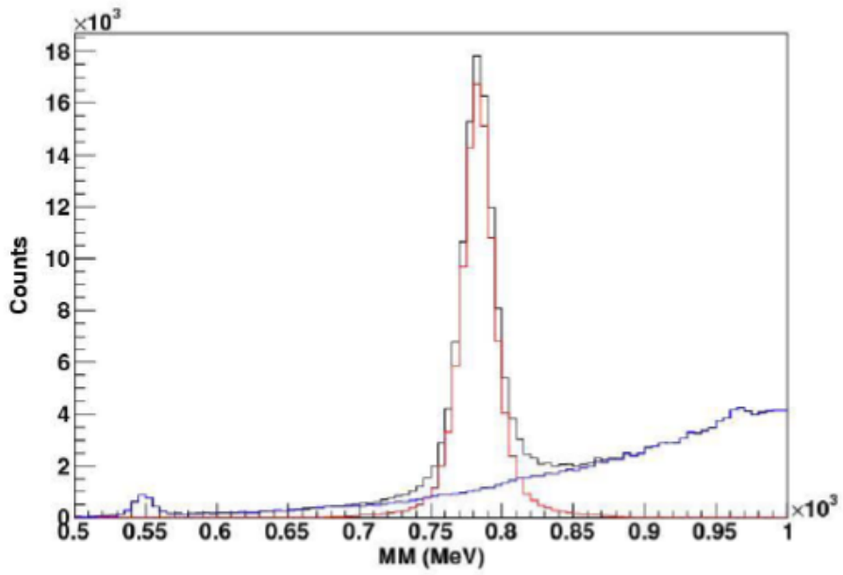


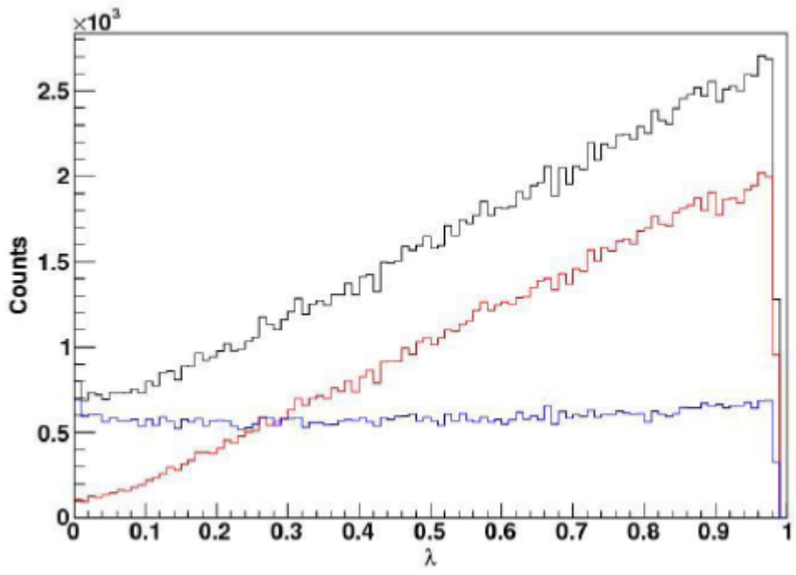
γp -> pω	γp -> $K^0\Sigma^+$	γp -> pη
High statistic isospin filter -> Benchmark measurement	Assess the validity of SU(3) quark model in describing resonance decay	Assess the validity of SU(3) quark model in describing resonance decay
Missing baryon resonance study through vector meson photo production	The strangeness production study through Isospin related channel	Testing the model of η photo production at higher energy using FESR by JPAC
	Missing baryon resonances study	
	There have been many attempts to measure the γp -> $K^0\Sigma^+$ cross section (not yet published)	

Q-factor methods

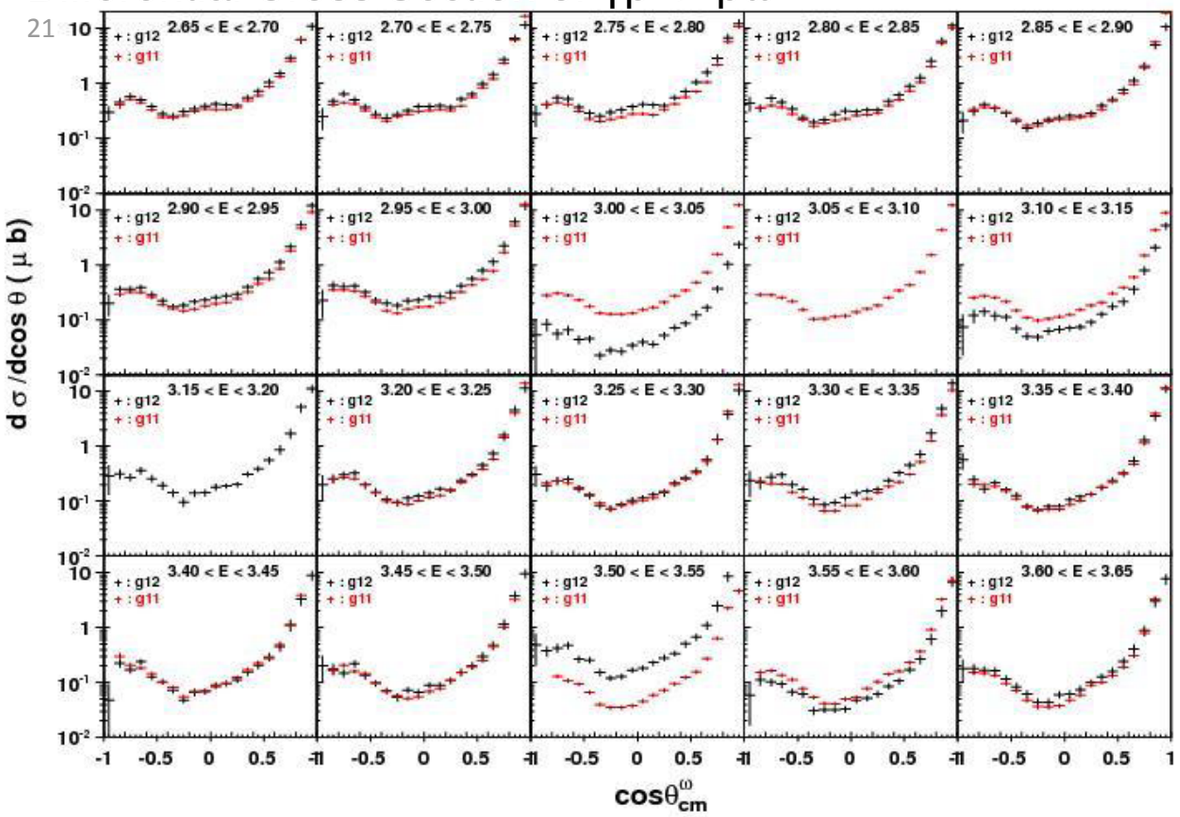


Fit example for an η event.

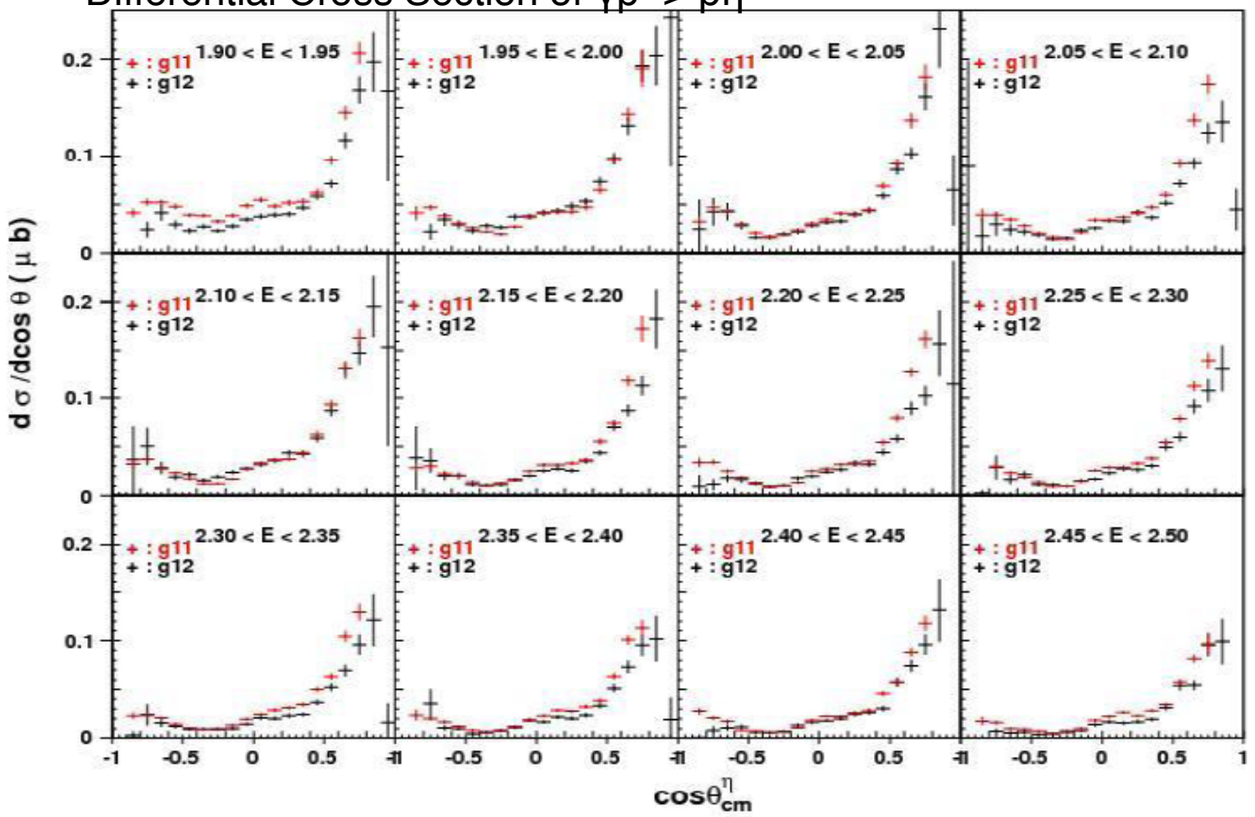




Differential Cross Section of γp -> pω



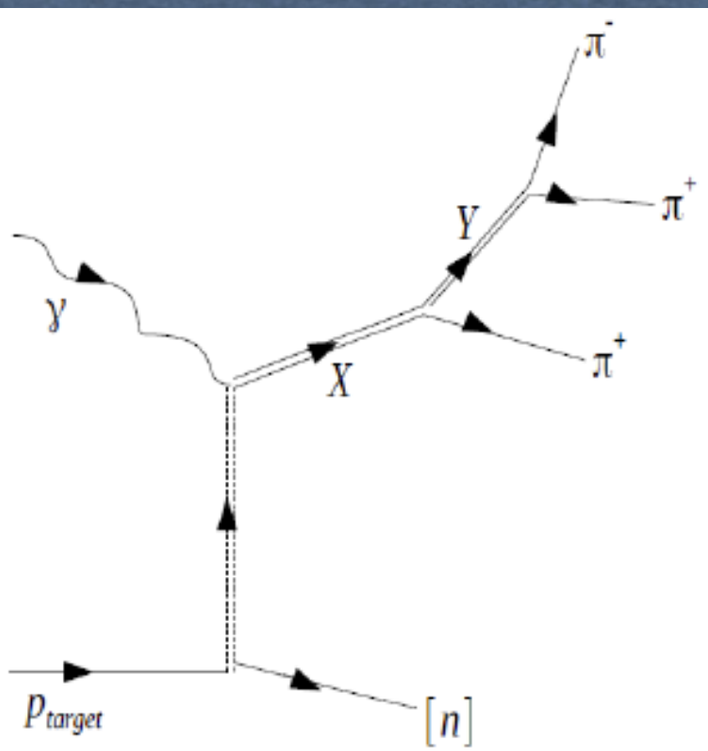
Differential Cross Section of γp -> pη



Run	Channel	Observable	Status	PIC
FROST	γp -> pω	E	Wide Collaboration review	Zulkaida Akbar
FROST	γp -> pω	Σ	Paper review	Priyashree Roy
g12	γp -> pω	Cross section	Analysis note in preparation	Zulkaida Akbar
g12	γp -> pη	Cross section	Analysis note in preparation	Zulkaida Akbar
g12	γp -> $K^0\Sigma^+$	Cross section	Analysis note in preparation	Kyle Romines/Zulkaida Akbar
g12	γp -> pφ	Cross section	Starting	Tianqi hu/Benjamin Gibson
g12	γp -> pω	SDME	Paused	Chris Zeoli/Zulkaida Akbar
g12	γp -> $p\pi^+\pi^-$	Cross section & Polarization observable	Will start in Fall	Zulkaida Akbar

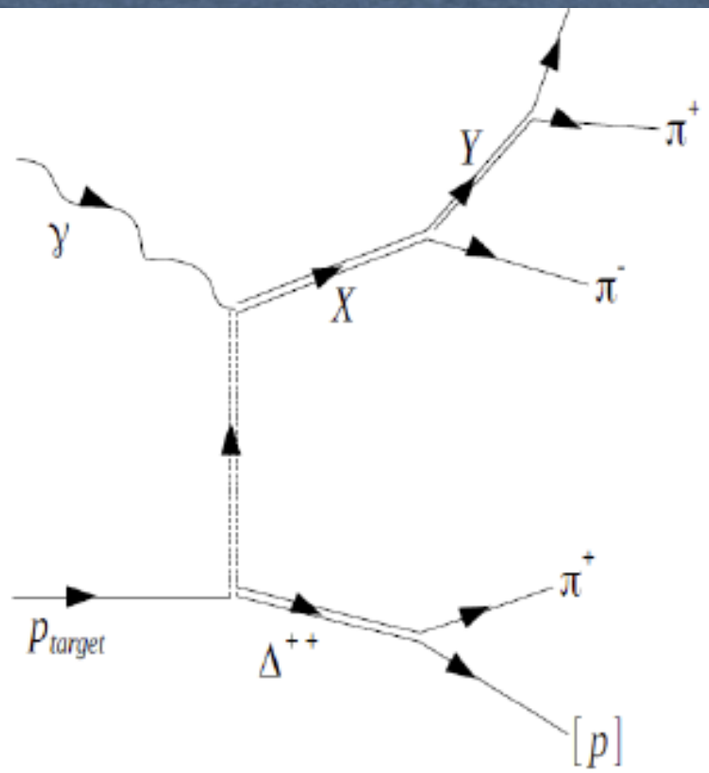
Photoproduction of 3π with CLAS

P. Eugenio
Florida State University



$\gamma p \rightarrow n\pi^+\pi^+\pi^-$

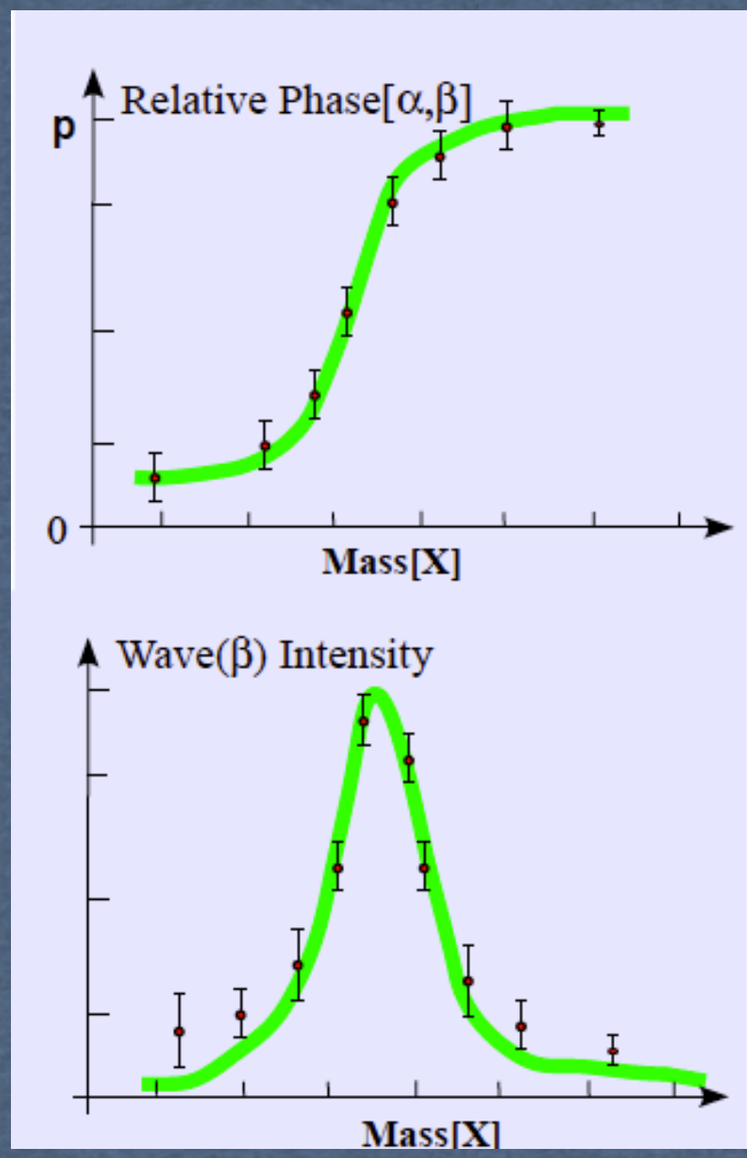
Form CLAS-g12 dataset (~25B events):
- **Three** charged pions selected
- **Neutron** is identified by energy and momentum conservation



$\gamma p \rightarrow \Delta^{++}\pi^+\pi^-\pi^-$

Form CLAS-g12 dataset (~25B events):
- **Four** charged pions selected
- **Proton** is identified by energy and momentum conservation

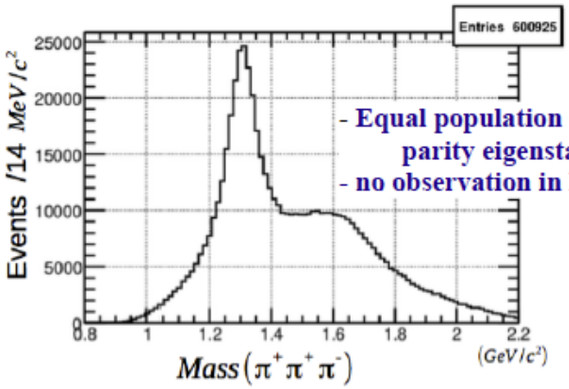
Partial Wave Analysis in the 3π sample



PWA Results: $n\pi^+\pi^+\pi^-$

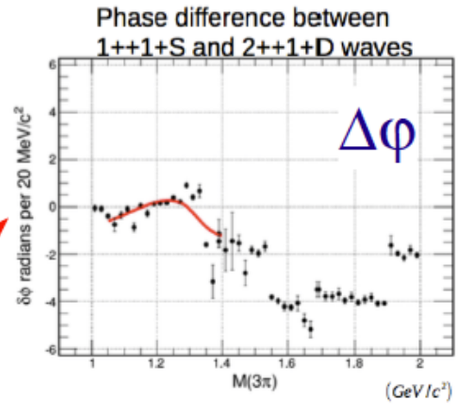
CLAS g12

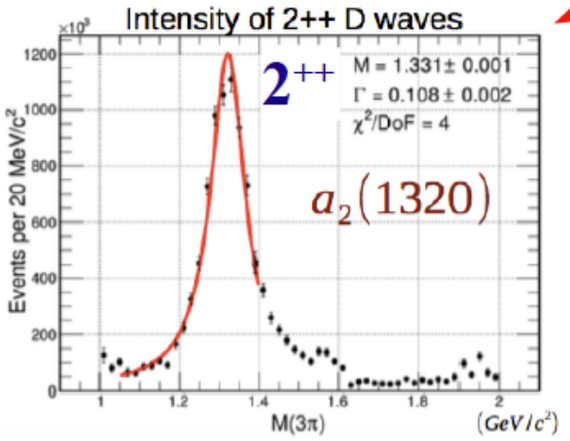
First observation of the $a_1(1260)$ in photoproduction

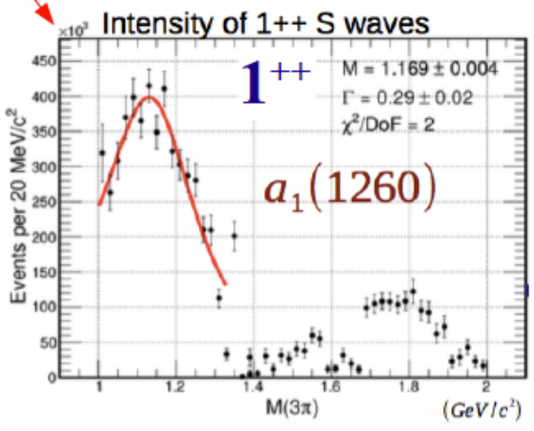


- Equal population of both parity eigenstates
- no observation in M=0 wave

PWA





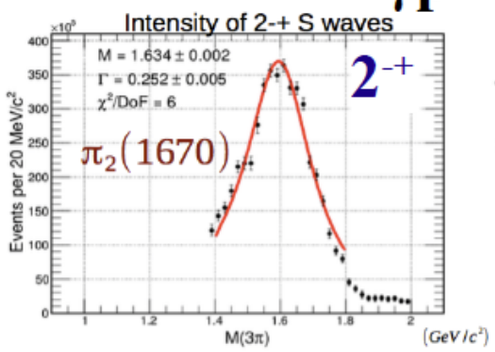


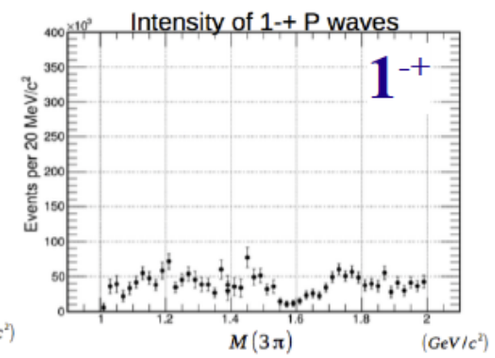
A. Tsaris (2016 FSU Dissertation)

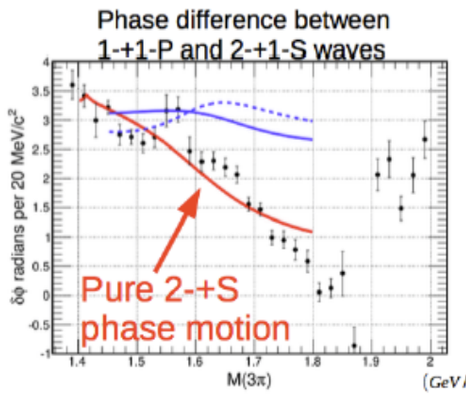
$\pi_2(1670)$ & Non-resonant 1^{-+} wave

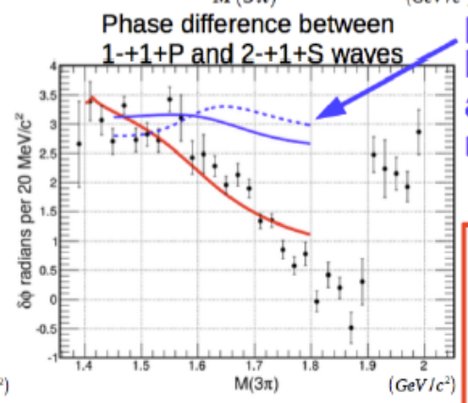
$\gamma p \rightarrow n\ \pi^+\pi^+\pi^-$

CLAS g12





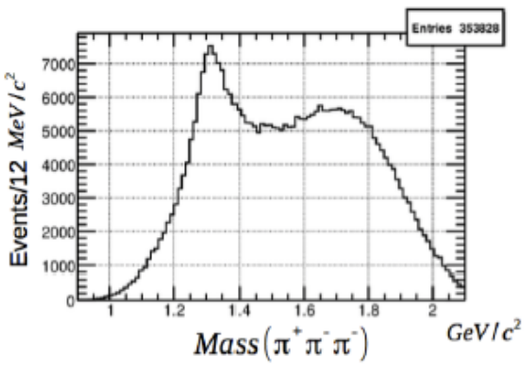


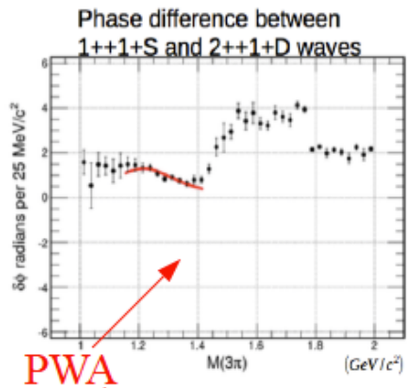


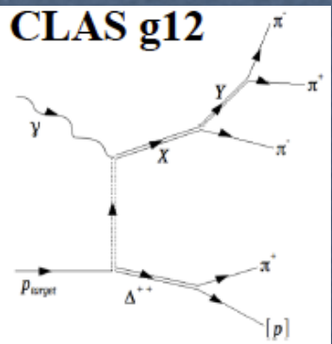
phase difference between 2-+S and a resonating 1-+P

The exotic 1-+ partial wave does not show resonant behavior

PWA Results: $\Delta^{++}\ \pi^+\pi^-\pi^-$



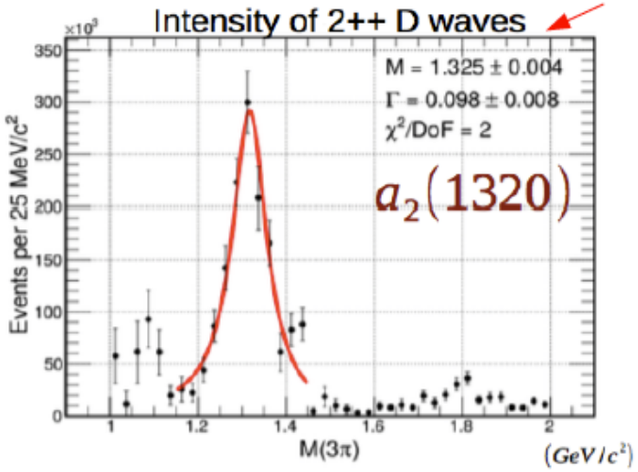


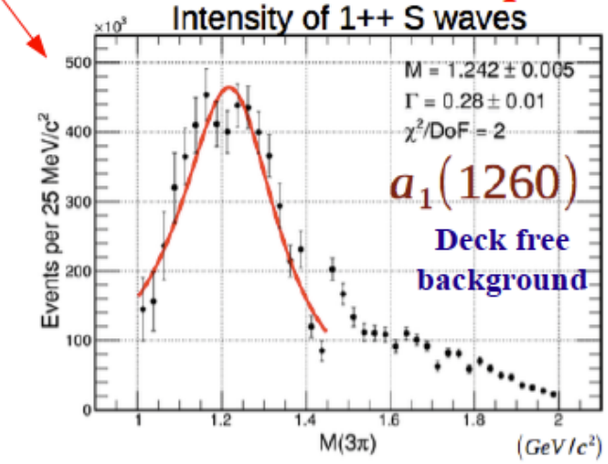


Confirmation of the $a_1(1260)$ in photoproduction

PWA

1^{-+} exotic wave was not required





- $\gamma p \rightarrow n\pi^+\pi^+\pi^-$:
  - The $a_2(1320)$ and the $a_1(1260)$ are observed
  - The $\pi_2(1670)$ is observed
  - The $J^{PC}=1^{-+}$ does not show resonant behavior and it is strongly consistent with a non-resonant non-interfering wave relative to a resonant $\pi_2(1670)$
- $\gamma p \rightarrow \Delta^{++}\pi^+\pi^-\pi^-$:
  - A first time PWA of the $\Delta^{++}3\pi$ system
  - The $a_2(1320)$ and the $a_1(1260)$ are observed
  - The $\pi_2(1670)$ is observed
- Analysis Review is underway :
  - written draft PRL for n3π
  - writing longer paper to include details of n3p and $\Delta^{++}3\pi$

Status Update on the Analysis of $\eta \to \pi^+\pi^-(X)$, $X = \pi 0/\gamma$ with CLAS

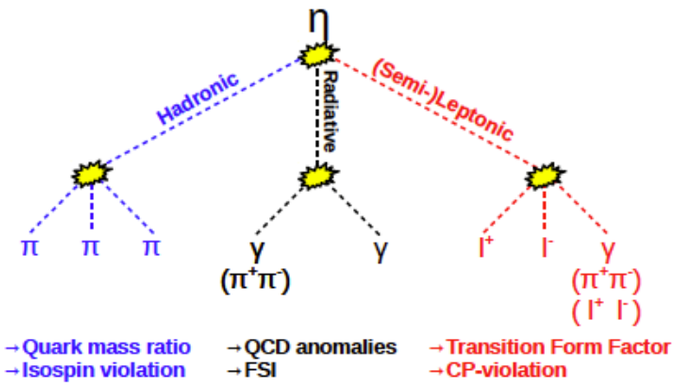
Daniel Lersch

One Meson, many Opportunities

Properties of the η-meson

m_η [GeV/c^2]	0.5478
Γ_η [keV]	(1.31 ± 0.05)
$\bar{\tau}$ [s]	$5 \cdot 10^{-19}$
J^{PC}	0^{-+}

- The η-meson is a *C*-, *P*-, *G*- and *CP*-eigenstate
- All strong and electromagnetic decays are forbidden to first order
- Access to rare decay processes



Today:

1.) Analysis Status of $\eta \to \pi^+\pi^-\pi^0$

2.) Set up Analysis for $\eta^{(\prime)} \to \pi^+\pi^-\gamma$ (Sorry, no update here)

- Parameterise decay width Γ:

$$\frac{d^2\Gamma}{dXdY} \propto (1 + aY + bY^2 + cX + dX^2 + eXY + fY^3 + gX^2Y + ...)$$

- **Dalitz Plot Analysis and determination of Q for $\gamma p \to p\eta[\eta \to \pi^+\pi^-\pi^0]$ with the CLAS G12 data set**

- Decay $\eta \to \pi^+\pi^-\pi^0$ is G-violating $\Rightarrow$ Forbidden to first order
- Decay is driven by isospin breaking part of strong interaction
  $\Rightarrow$ C is conserved
- Decay width: $\Gamma \propto Q^{-4}$

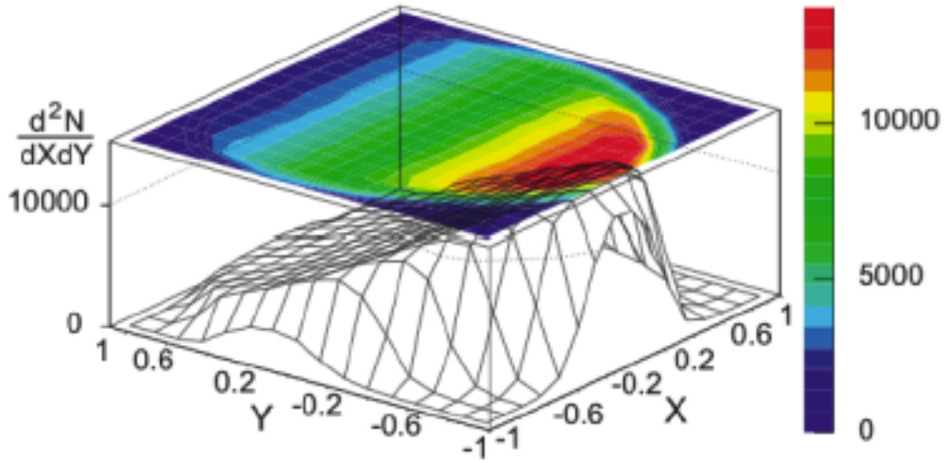
  with: $Q^2 = \left(\frac{m_s}{m_d}\right)^2 \times \left[1 - \left(\frac{m_u}{m_d}\right)^2\right]^{-1}$

$\Rightarrow$ **Determine decay width Γ $\Rightarrow$ Access to quark mass ratio**

$\Downarrow$

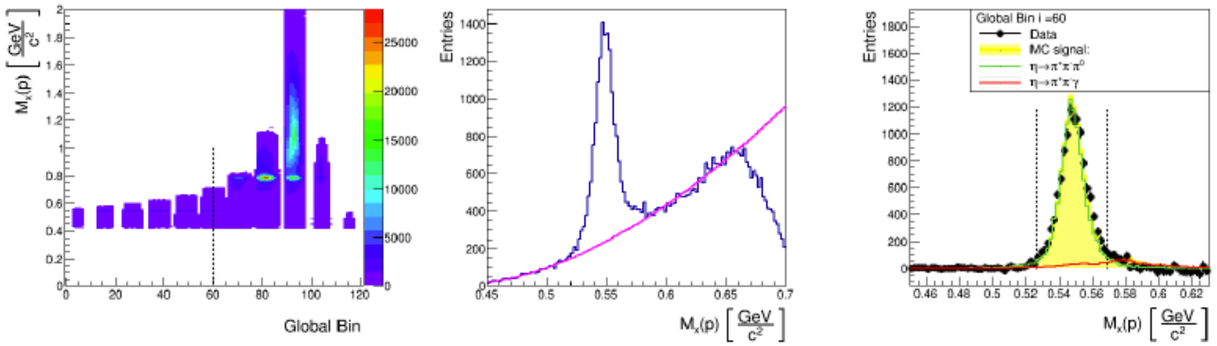
a) Measure $\Gamma(\eta \to \pi^+\pi^-\pi^0)$, e.g. via $\frac{\Gamma(\eta \to \pi^+\pi^-\pi^0)}{\Gamma(\eta \to \gamma\gamma)}$

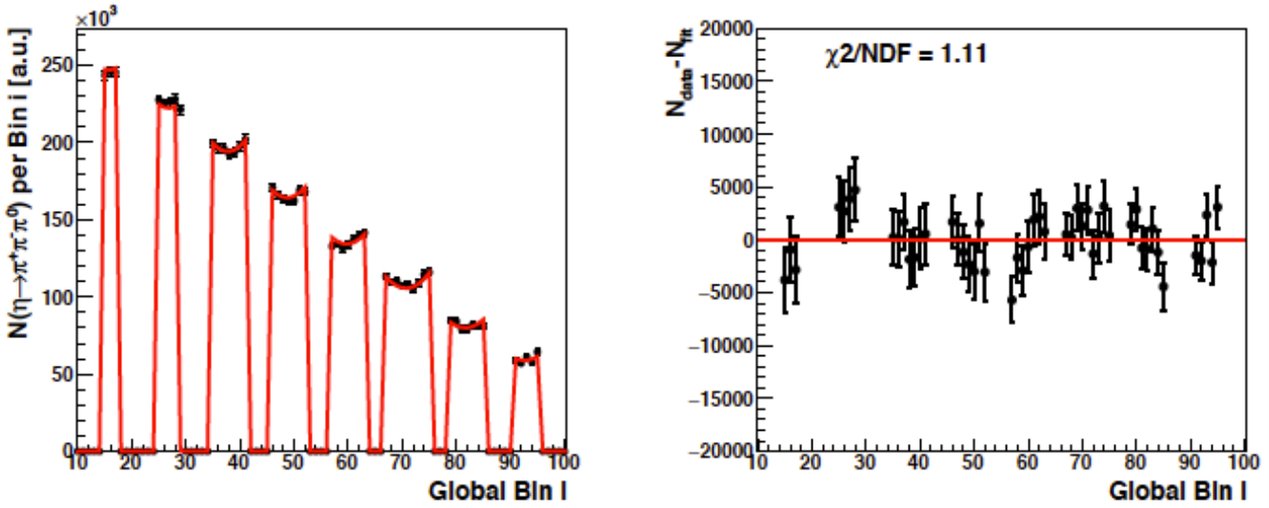
b) Dalitz Plot Analysis



(a) KLOE coll., *JHEP*, 05, (2008)

Background Handling and Determination of $N^0(\eta \to |\pi^+\pi^-\pi^0)$





Determining Systematic Errors: Procedure

1. Do analysis with analysis parameter $p_1, .., p_N$ (e.g. kinematic fit probability)
   $\Rightarrow$ Obtain reference data set with result(s): $R \pm \Delta R$
2. Redo analysis:
   a) Vary parameter p_i (e.g. beam energy) within interval $[p_{i1}, p_{ik}]$
   b) Keep remaining parameters $p_{j \neq i}$ fixed

   $\Rightarrow$ Obtain sub-data sets $i_1, .., i_k$ with result(s): $R_{im} \pm \Delta R_{im},\ m = 1, .., k$
3. Are sub-data sets $i_1, .., i_k$ statistically uncorrelated?

   Yes: Errors ΔR_{im} are (statistically) uncorrelated and can be treated independently
   No: Errors ΔR_{im} are (statistically) correlated and have to be corrected:
   $\Delta R_{im} \mapsto \sqrt{|\Delta R^2 - \Delta R_{im}^2|}$

   $\Rightarrow$ Fit a straight line to $R_{im} \pm \Delta R_{im}$ and determine error σ_i from that fit
4. Repeat steps 1.-3. for remaining parameter

$\Rightarrow$ Analysis of $\eta \to \pi^+\pi^-\pi^0$:

- Refined analysis and background fitting procedure (not shown here)
- Study of reconstruction-related systematics $\Rightarrow$ Suspicion on influence of fitting procedure itself:
  i) Fixing Parameters c,e and g to 0
  ii) Neglecting DP bins < 20 show large impact on parameters b and f $\Leftrightarrow$ Background handling in this region
- Asymmetry is not affected by i)/ii) $\Leftrightarrow$ Hint for other systematic influences
- **Goal:** Have Analysis and systematic studies finished until next collaboration meeting

$\Rightarrow$ Analysis of $\eta^{(\prime)} \to \pi^+\pi^-\gamma$:

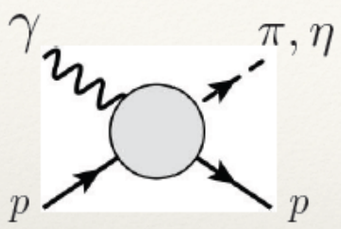
- Set up preliminary reconstruction plan
- Determination of α-parameter ongoing

JPAC Report

(Summer'17 Edition)

César Fernández-Ramírez
Instituto de Ciencias Nucleares
Universidad Nacional Autónoma de México

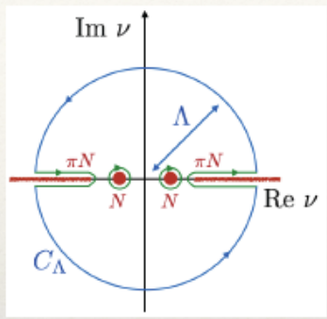
Finite Energy Sum Rules



$$\int_0^\Lambda \text{Im } A_i(\nu,t)\nu^k d\nu = \beta_i(t)\frac{\Lambda^{\alpha_i(t)+k}}{\alpha_i(t)+k+1} + \dots$$

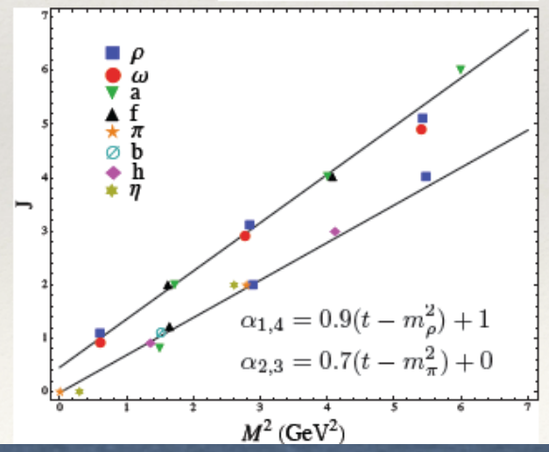
$S_i(t,k)$

$\nu = (s-u)/2$



High-energy residue prediction
from low-energy data

$$\widehat{\beta}_i(t) = S_i(t,k)\frac{\alpha_i(t)+k+1}{\Lambda^{\alpha_i(t)+k}}$$
$$= \beta_i(t) + \mathcal{O}(1/\Lambda)$$



Joint Physics Analysis Center (2017)

Indiana University
Geoffrey Fox
Emilie Passemar
Adam Szczepaniak
Vincent Mathieu
Andrew Jackura
Nathan Sherril

Jefferson Lab
Victor Mokeev
Vladiszlav Pauk
Alessandro Pilloni

George Washington University
Michael Döring
Ron Workman

Bonn Universität
Misha Mikhashenko

U Nacional Autónoma de México
César Fernández-Ramírez
Jorge Silva Castro

California State University
Peng Guo

JGU-Mainz Universität
Igor Danilkin

Ghent Universiteit
Jannes Nys

Universidad de Valencia
Astrid Hiller Blin

Collaborating with: CLAS & GlueX (JLab), COMPASS & LHCb (CERN), MAMI (Mainz), BESIII (Beijing), KLOE (Frascati), BELLE II (KEK), BABAR (SLAC)

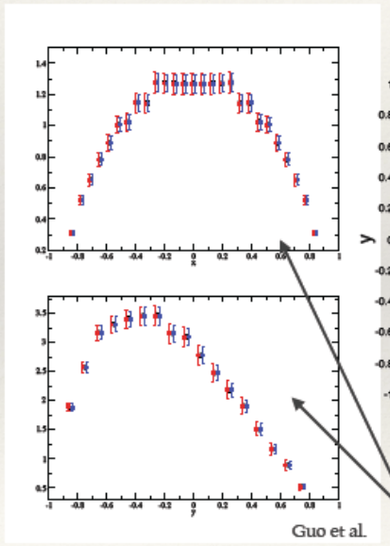
Code: Faculty / Staff
Postdoc
PhD student

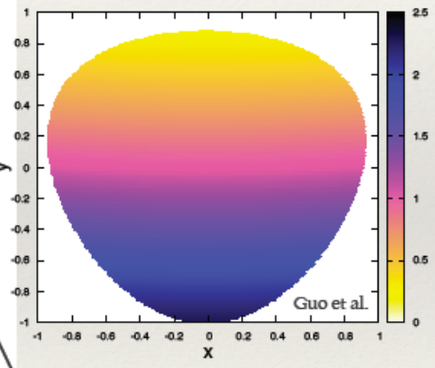
$\eta \to 3\pi$

Two different approaches ⇒ model dependencies and systematics under control

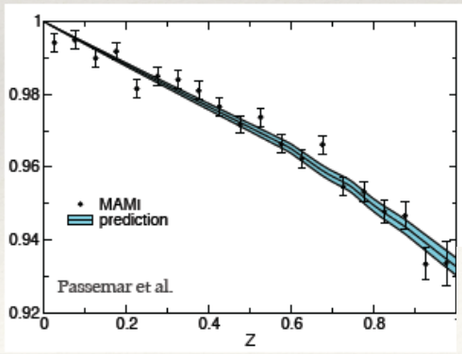
Guo *et al.* PRD 92 (2015) 054016 , PLB 771 (2017) 497

Colangelo, Lanz, Leutwyler, Passemar, PRL 118 (2017) 022001





Latest KLOE data

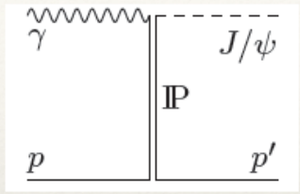


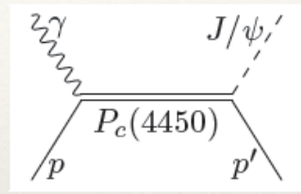
Pentaquark Photoproduction

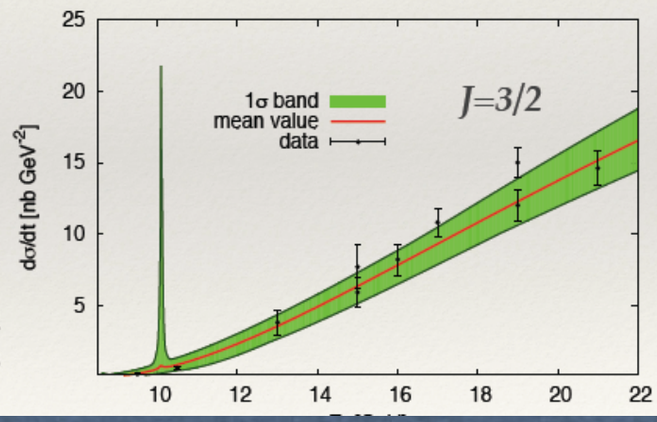
Model for J/Ψ photoproduction

Pomeron + Resonance

- High-energy dominated by Pomeron exchange
- Resonance added as a Breit-Wigner
- We assume vector meson dominance (we do not know the em couplings)







Hiller Blin *et al.*, PRD 94 (2016) 034002

F-R, Hiller Blin, Pilloni, arXiv:1703.06928

Light Meson Decays

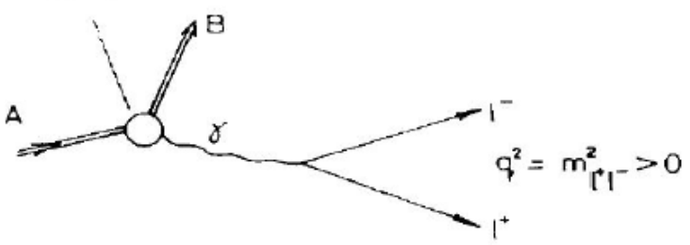
status of LMD group

Susan Schadmand, IKP
Hadron spectroscopy session
CLAS collaboration meeting
June, 2017

meson decay	physics	people	data	status	publication
$\pi \to \gamma e^+e^-$	transition form factor, Me+e- (dark photon)	Michael Kunkel	g12	PhD 2014, ODU	pi0 cross section in preparation
$\eta' \to \gamma e^+e^-$	transition form factor	Michaela Schever	g12	Master 2015, RWTH Aachen	----------→ CLAS1
$\eta \to \gamma e^+e^-$	transition form factor				
$\omega \to \pi^0 e^+e^-$	transition form factor	Susan Schadmand	g12	this talk	
$\eta \to \pi^0 e^+e^-$	C violation				
$\eta' \to \pi^+\pi^-\gamma$	box anomaly upper limit branching ratio	Georgie Mbianda Njencheu	g11	PhD 2017, ODU	analysis report in preparation
		Daniel Lersch	g12		
$\eta \to \pi^+\pi^-\gamma$	box anomaly	Torri Roark	g11		
		Daniel Lersch	g12		
$\varrho \to \pi^+\pi^-\gamma$		Tyler Viducic	g11 ?		
$\eta, \omega, \phi \to$ $^{+}\pi^{-}$ L.G.	Dalitz plot analysis η ω ϕ	Daniel Lersch, (Diane Schott) Carlos Salgado + , Chris Pederson	g11/g12	DL: see talk this meeting	
$\frac{d\Gamma(A \to B}{dq^2}$ $\pi^+\pi^-\eta$	Dalitz plot analysis pi+ pi- correlation	Sudeep Ghosh	g12, (g11)		analysis report in preparation

transition form factor

$F_{AB}(q^2)$



$$\frac{d\Gamma(A \to B\, l^+l^-)}{dq^2 \cdot \Gamma(A \to B\gamma)} = |F_{A\to B}(q^2)|^2 \cdot |\mathrm{QED}|$$

form factor: divide experimental q^2 distribution by QED

$F_{AB}(q^2) = [1 - q^2/\Lambda^2]^{-1}$ (single) pole approximation

$$F_{AB}(q^2) \simeq 1 + q^2[\mathrm{d}F_{AB}/\mathrm{d}q^2]|_{q^2\simeq 0} = 1 + q^2 b_{AB} = 1 + \tfrac{1}{6}q^2\langle r^2_{AB}\rangle$$

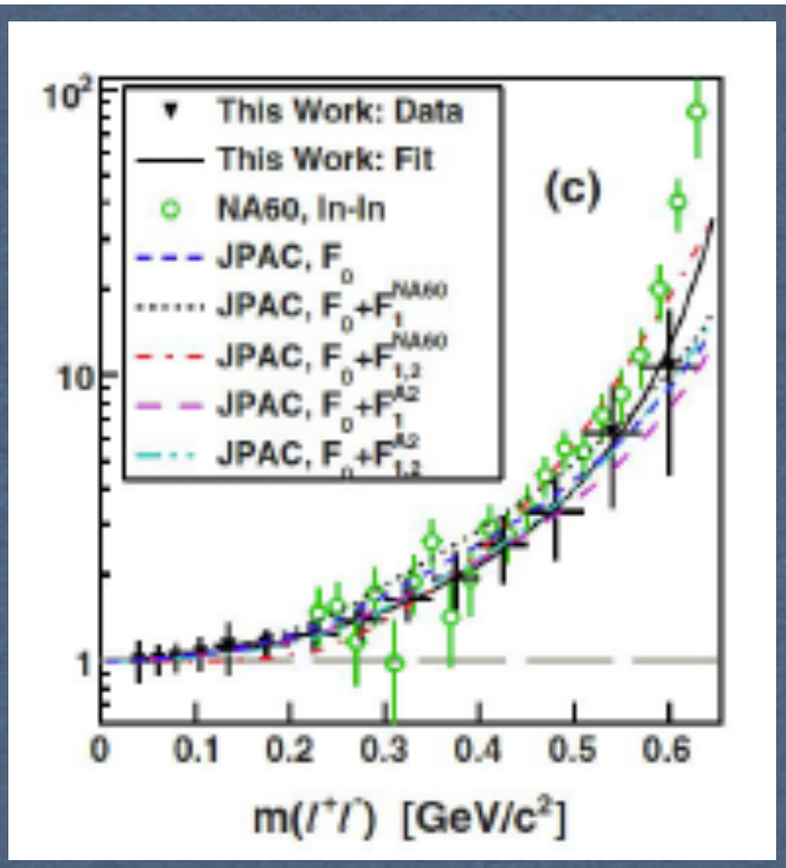
$\Lambda \simeq m_\rho$ $(\Lambda^{-2} = b_{AB})$

'standard' VMD

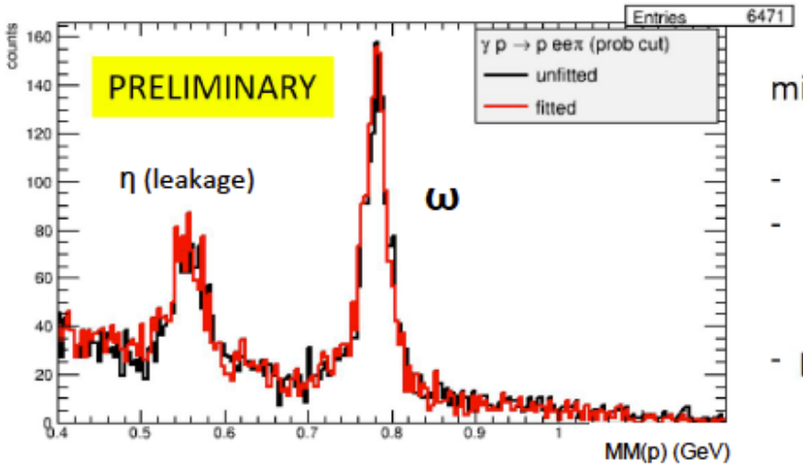
slope parameter

size (transition regio

ω-π transition form factor



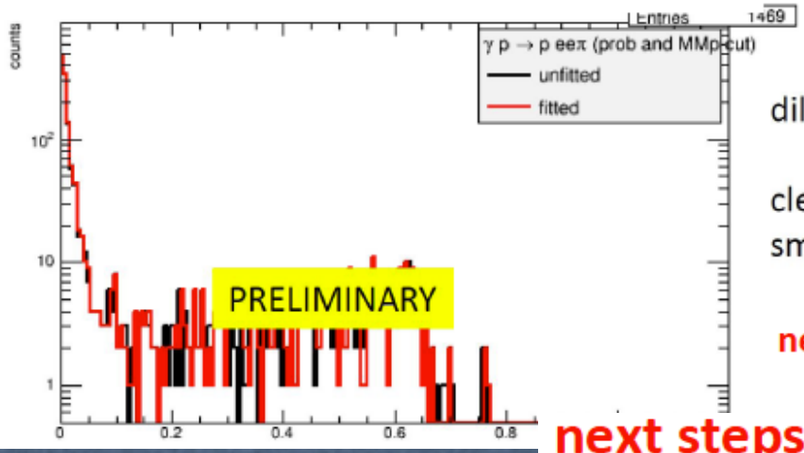
CLAS g12 dileptons



missing mass (p)

- smooth background
- in-peak background:
  competing decays
  photon external conversion
- peaking background?

not background subtracted
not acceptance corrected



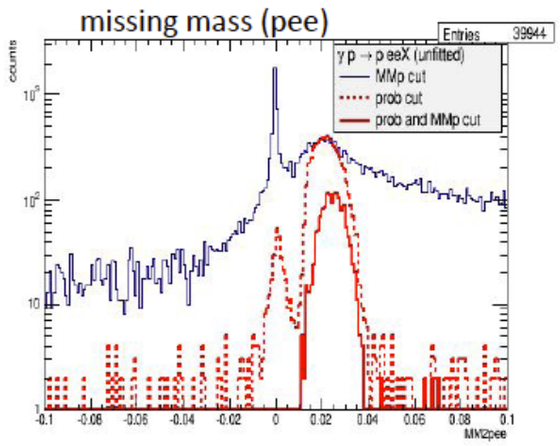
dilepton mass

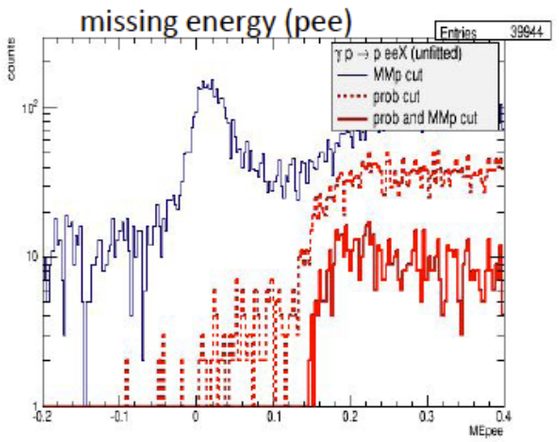
clearly dominated by background
small masses: external conversion

next step: background study

next steps

- more simulations for background
- different methods:
  - cut based analysis
  - kinematic fit
  - qfactor background subtraction ⇦
- compare/combine methods (⇨ systematic errors)
- acceptance correction
- extract transition form factor





CLAS g12 dileptons kinematics

analysis strategy:
e+e- detection
and missing particle

missing pion: **ω→πee**
- missing mass is pion mass
- missing energy

missing photon: **η(′)→γee**
- missing mass zero
- missing energy

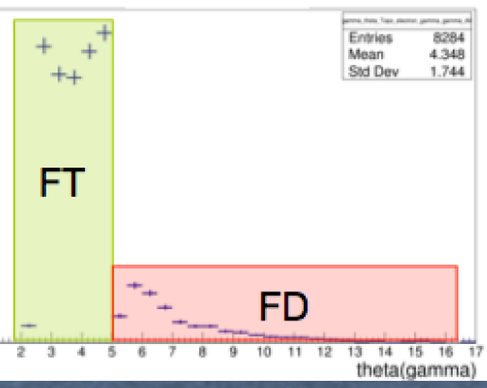
missing nothing: **ρ/ω→ee**
- missing mass and nergy zero

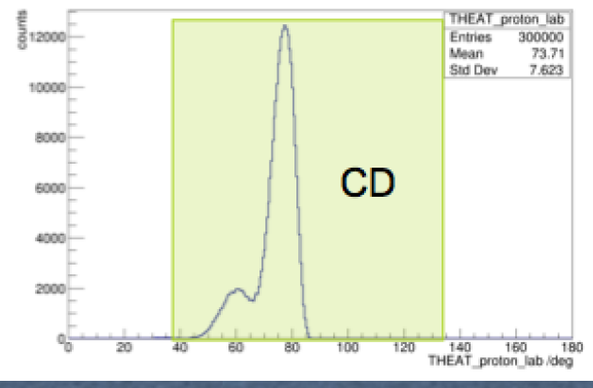
CLAS12 MesonEx trigger studies

Stefan Diehl

2nd Physics Institute, Justus-Liebig-University Giessen

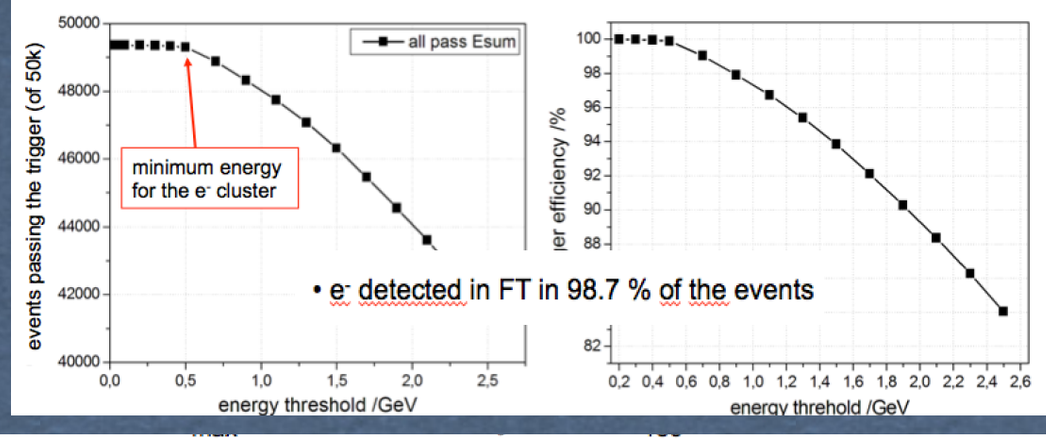
Trigger conditions for e p → e ' p π⁰



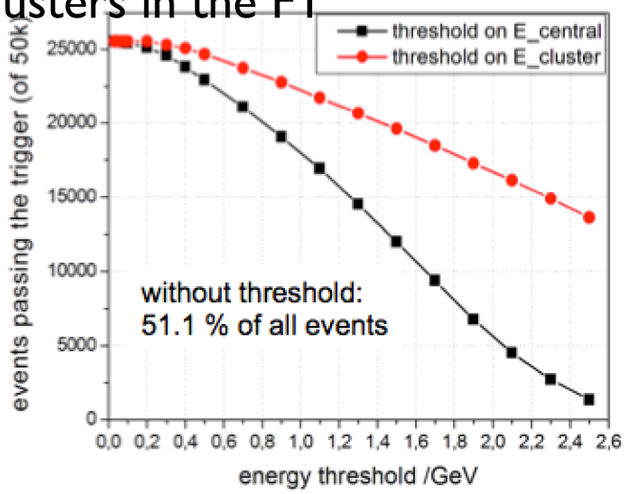


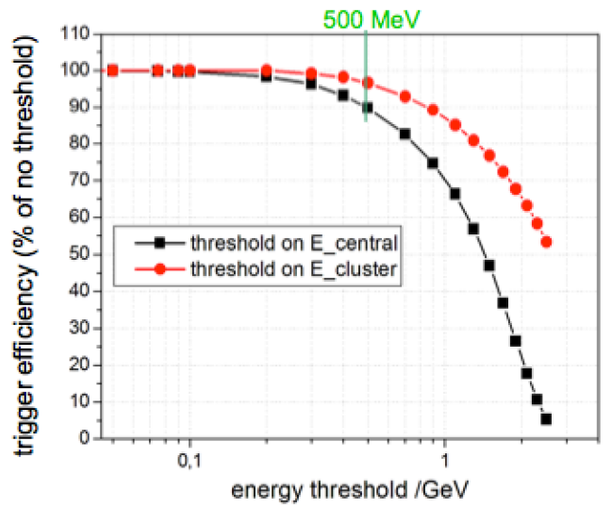
Energy sum of the reconstructed clusters

pass trigger if $E_{sum} > E_{thr}$

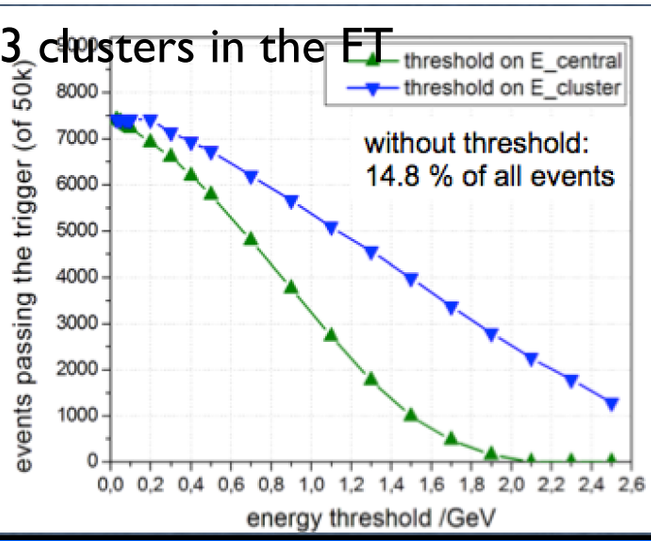


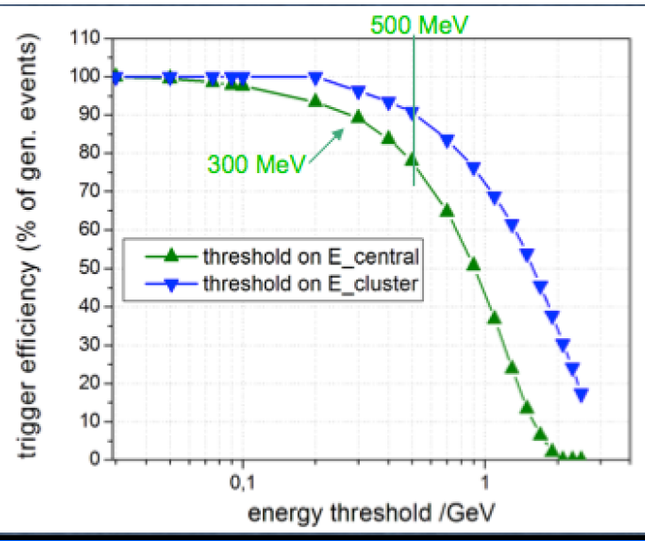
2 clusters in the FT



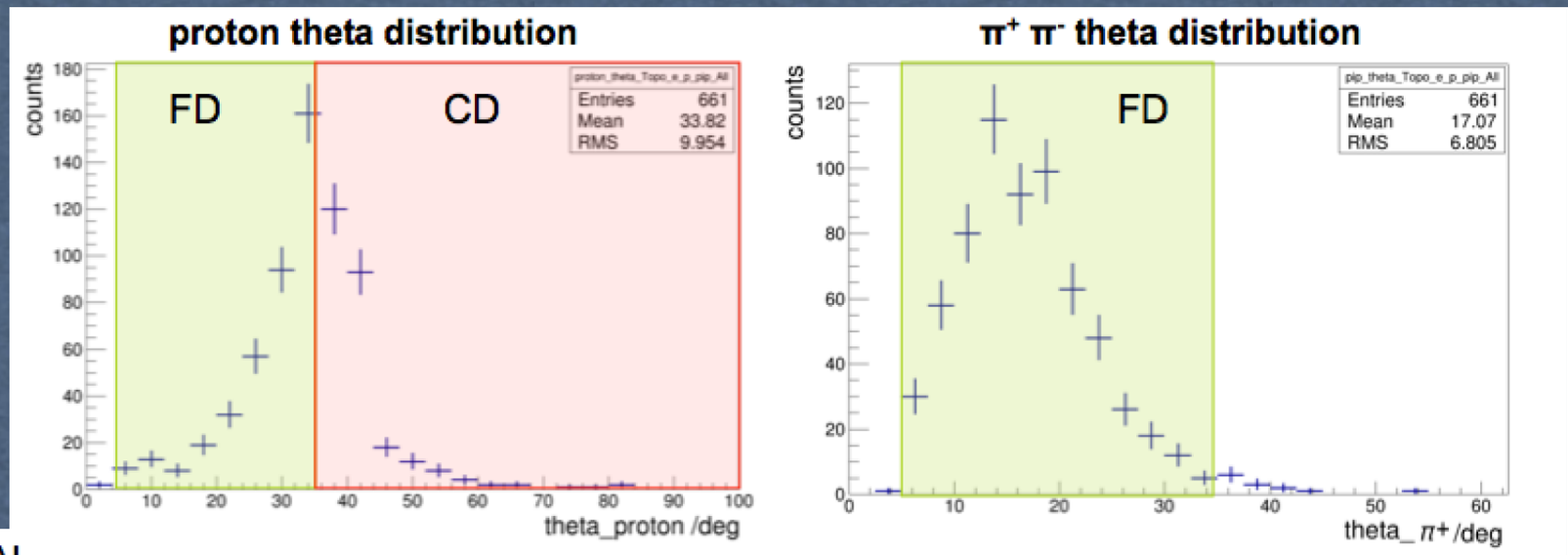


3 clusters in the FT

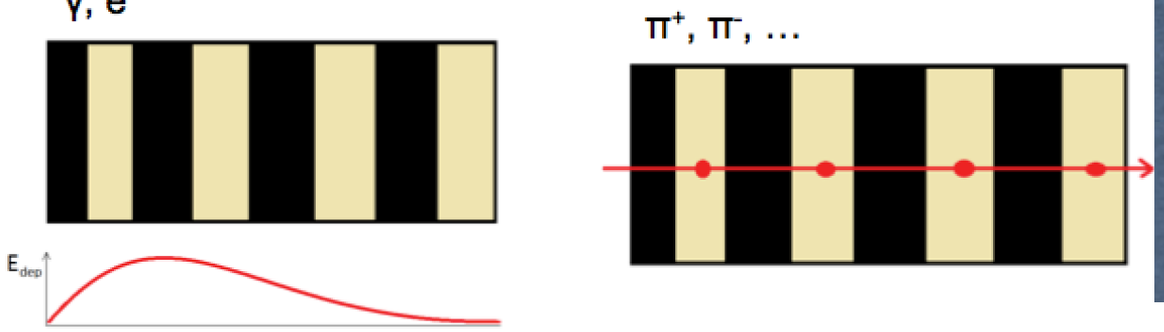




Trigger conditions for e p → e ‘ p π⁺ π⁻



Compare energy deposition in different layers of the ECAL



- Trigger studies have been performed based on events reconstructed from MC simulations
- Trigger simulation on this level is nicely working
- A cut on the number of clusters in the FT with a relatively low threshold for each cluster is an effective trigger for e p → e ‘ p π^0
- Reduction of the trigger cluster definition to the hit level will be investigated
- **Next step:** Move to a time based trigger simulation based on the gemc output (directly implementable to the FPGA)

Near threshold J/ψ production and study of the LHCb pentaquarks with CLAS12

Valery Kubarovsky

Approved J/Ψ Photoproduction Experiments at Jlab

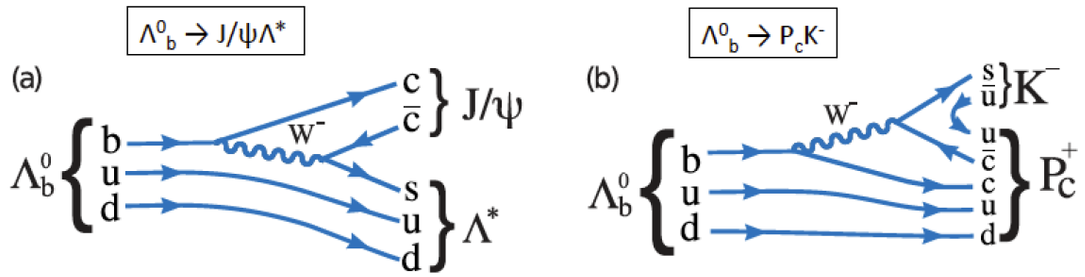
- PR12-12-001: Hall-B, untagged technique
- PR12-12-006: Hall-A
- PR12-16-007: Hall-C (Search for the LHCb pentaquarks)

New proposal – JLAB PAC45

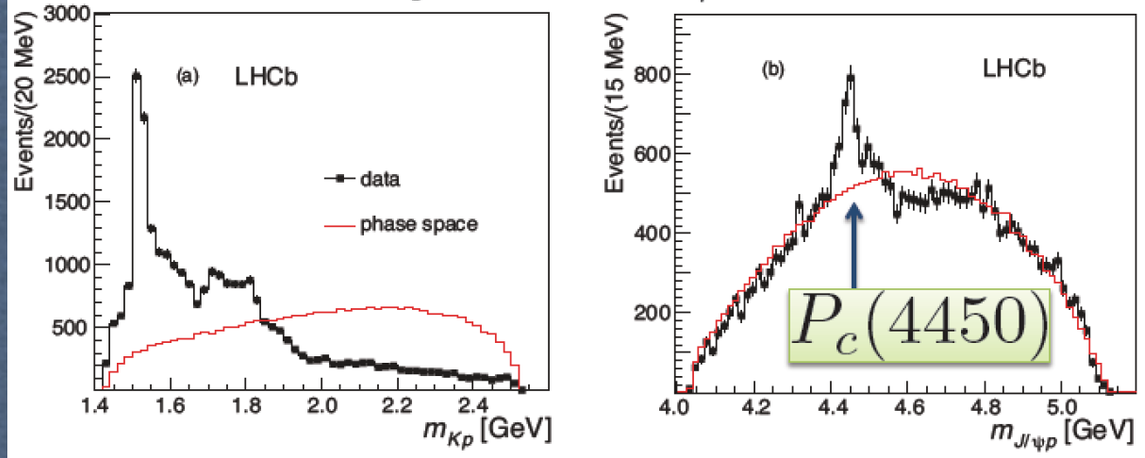
- Extends measurements of approved CLAS12 experiment E12-12-001 by including $J/\psi \to \mu^+\mu^-$ decay mode
- Will study pentaquarks with hidden charm using tagged (E12-12-005, MesonX) and untagged (E12-12-001) photoproduction with CLAS12

LHCb: Background and Signal

$$\Lambda_b^0 \to K^- J/\psi p$$

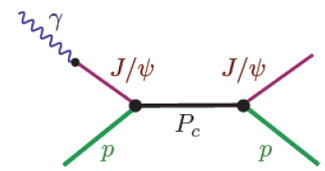


$$\Lambda_b^0 \to K^- J/\psi p$$



Pentaquark photoproduction

- It was shown that the vector dominance model works for the s-channel photoproduction of hidden-charm pentaquark.



$$\sigma(W) = \frac{2J+1}{4}\frac{4\pi}{k^2}\frac{\Gamma^2/4}{(W-M_c)^2+\Gamma^2/4} Br(P_c \to \gamma + p)\, Br(P_c \to J/\psi + p)$$

$$\sigma \sim Br^2(P_c \to J/\psi p)$$

$$\Gamma(P_c \to \gamma + p) = \frac{3\Gamma_{ee}(J/\psi)}{\alpha M(J/\psi)} \sum_L f_L \left(\frac{k}{p}\right)^{2L+1} \Gamma_L(P_c \to J/\psi + p)$$

$$1.5 \times 10^{-30}\,\mathrm{cm}^2 < \frac{\sigma_{max}[\gamma + p \to P_c(4380) \to J/\psi + p]}{Br^2[P_c(4380) \to J/\psi + p]} < 47 \times 10^{-30}\,\mathrm{cm}^2$$

$$1.2 \times 10^{-29}\,\mathrm{cm}^2 < \frac{\sigma_{max}[\gamma + p \to P_c(4450) \to J/\psi + p]}{Br^2[P_c(4450) \to J/\psi + p]} < 36 \times 10^{-29}\,\mathrm{cm}^2$$

$$\sigma(W) \sim \frac{\Gamma^2/4 \cdot Br^2(P_c \to J/\psi + p)}{(W-M_c)^2 + \Gamma^2/4}$$

CLAS12 performance – untagged photoproduction

$$ep \to (e')p'l^+l^-;\ l = e, \mu$$

- Recoil proton and decay leptons are detected
- Kinematics of the scattered electron will be reconstructed in the missing momentum analysis requires missing transvers momentum to be ~0
- Acceptance covers the mass range of charmed pentaquarks

- From the two gluon exchange prediction for cross section, we expect total of 45 J/ψ detected per day in the whole energy rage
- Expected total number of P_c4450 pentaquarks 98 per day

Compared to -

- The Hall-C E12-16-007 with the same cross section formalism will detect 70 pentaquarks per day
- The Hall-A experiment E12-12-006 with future SoLID detector expects ~42 J/ψ per day
- With current luminosity Hall-D Gluex experiments expects 5-10 J/ψ per day

CLAS12 performance – tagged photoproduction

- About x10 lower photon flux, but …
- Multiple final states to measure J/ψ photoproduction
- Excellent mass resolutions:
  - J/ψ as sharp peak either in the invariant mass of decay leptons (ΔM~15 MeV) or in the electron-proton missing mass (ΔM~7 MeV)
  - Pentaquarks will be reconstructed in the missing mass analysis of the scattered electron (W-distribution) (ΔM~5 MeV)

$$ep \to e'p'l^{+(-)},\ l^{-(+)};\ l = e, \mu$$

Detection efficiency ~28%

$$ep \to e'l^+l^-(p');\ l = e, \mu$$

Detection efficiency ~18%