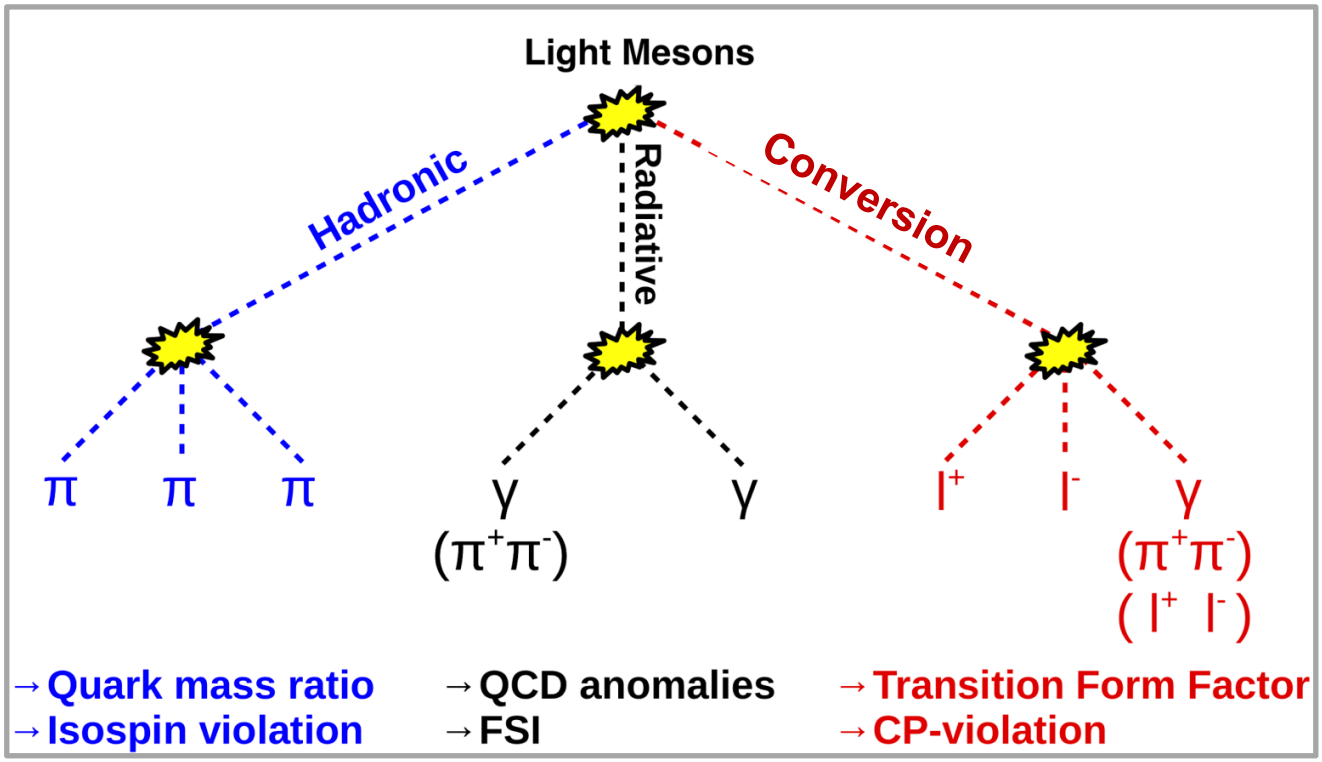
From Jülich to Jefferson Lab: Exploring the Nature of Matter

Deutsche Pysikerinnentagung 2018
Oldenburg (D)

Susan Schadmand, IKP

light meson decays



WASA-at-COSY: π, η

the orginal proposal for bringing WASA to COSY :

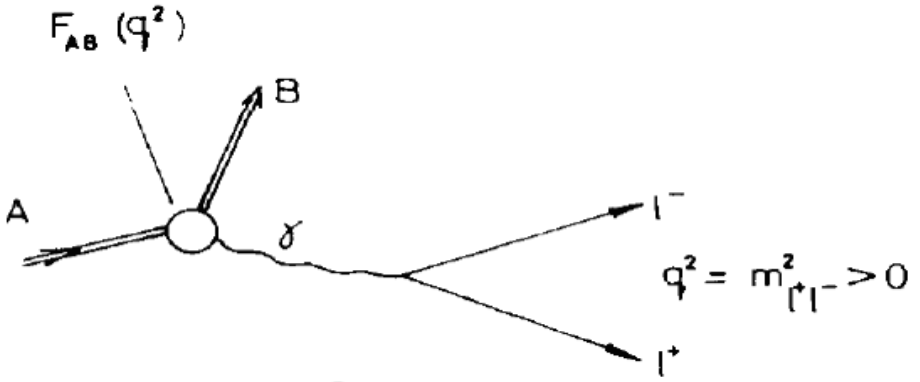
Proposal for the wide angle shower apparatus (WASA) at COSY-Julich: WASA at COSY
WASA-at-COSY Collaboration, e-Print: **nucl-ex/0411038**

CLAS: π, η, ω, η'

the orginal proposal:
CAA Photoproduction and Decay of Light Mesons in CLAS
https://wiki.jlab.org/lmd/

conversion decays

Transition Form Factors



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

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

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

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

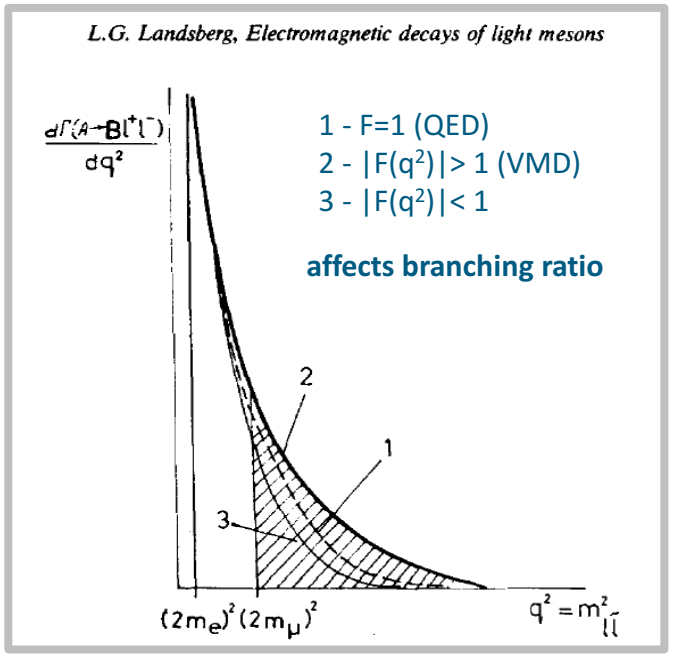
'standard' VMD, b~1.69/GeV^2

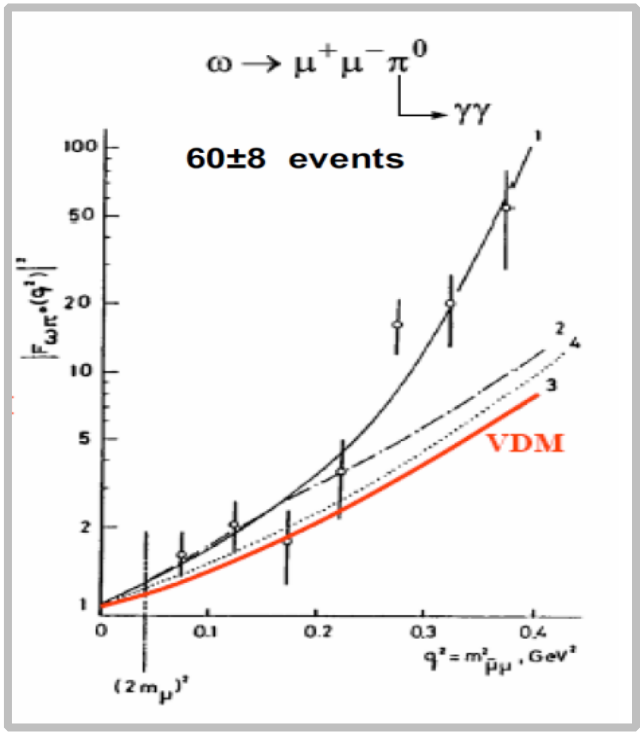
slope parameter

size (transition region)

conversion decays

Transition Form Factors





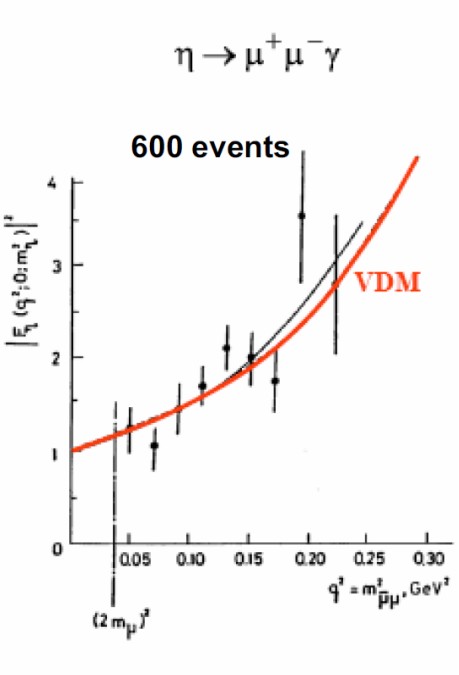
form factor: divide experimental q^2 distribution by QED

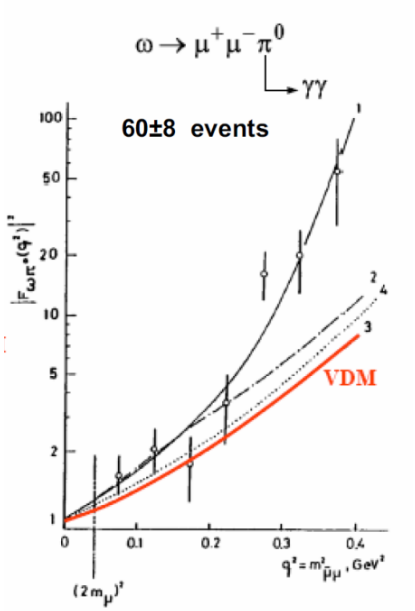
$$\Lambda \simeq m_\rho \ (\Lambda^{-2} = b_{AB})$$ 'standard' VMD, b~1.69/GeV^2

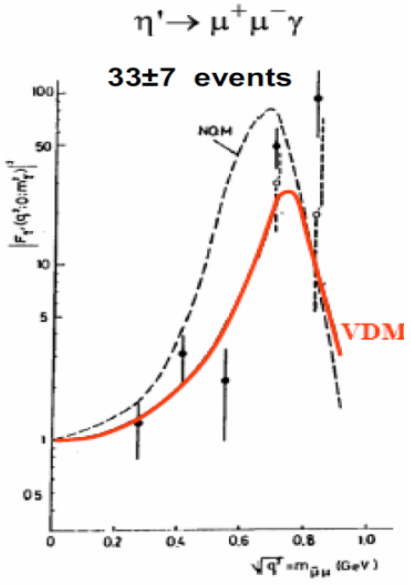
(old) world data set: conversion decays

L.G. Landsberg, Electromagnetic decays of light mesons

IHEP in 1978—1980 on the “Lepton-G” spectrometer







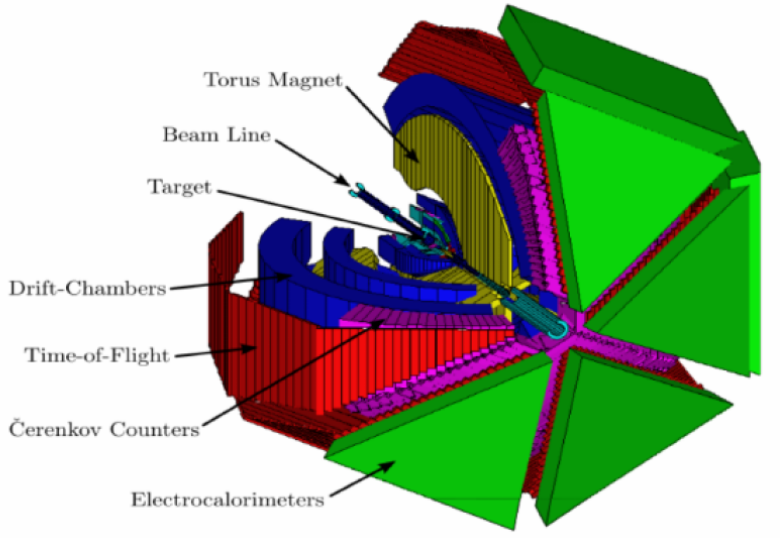
for ω meson, additional mechanisms apart from standard VMD ?

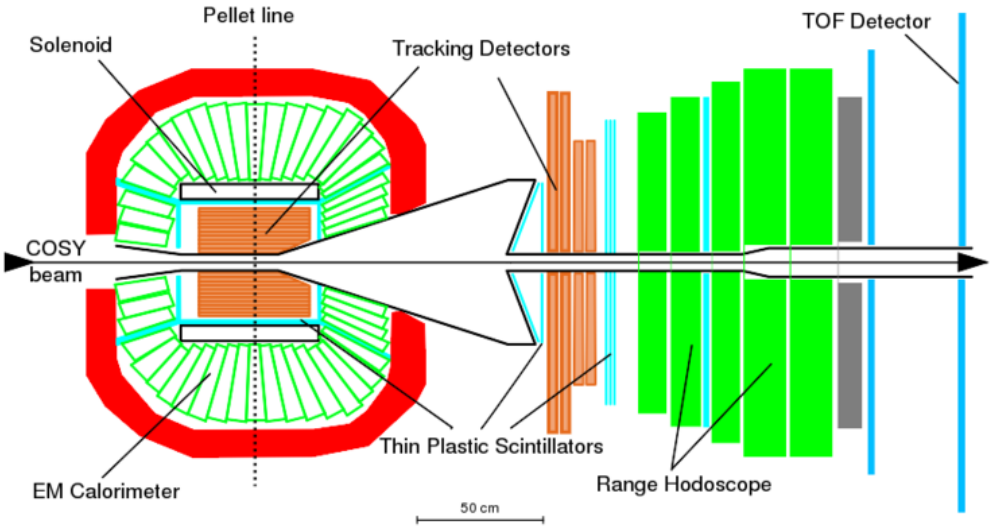
(black curves are fits to the data)

- confirmed by NA60 AA reactions, S. Damjanovic, PLB 677 (2009) 260
- confirmed by NA60 pA reactions, A.Uras, J.Phys. Conf.Ser.270(2011) 012038

different experimental approach: elementary reactions, using di-electrons

a tale of two experiments

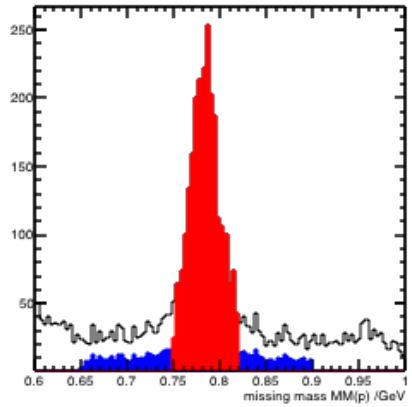


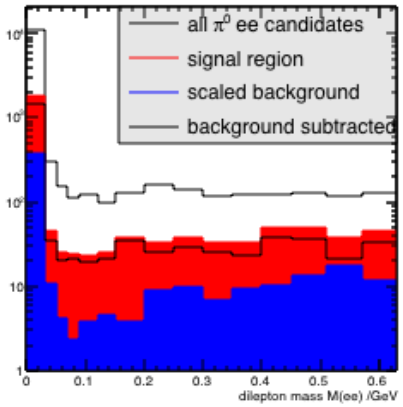


CLAS Jefferson Lab	experimental issue	WASA COSY-Jülich
$\gamma + p$ (g12 experiment)	• cross section • multipion background	$p + p$ (2010)
LH_2 target	external γ conversion	pellet target + beam pipe
Cerenkov Counters	dilepton identification	
EM calorimeter	photon detection	CsI EM Colrimeter

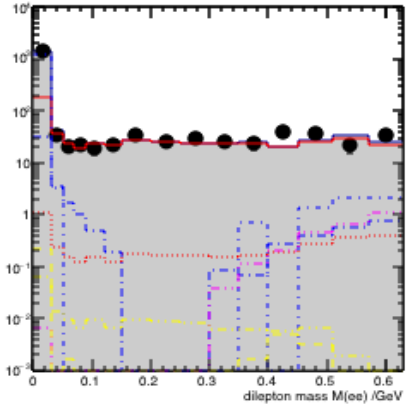
preliminary look at ω-π⁰ transition form factor

smooth background subtraction

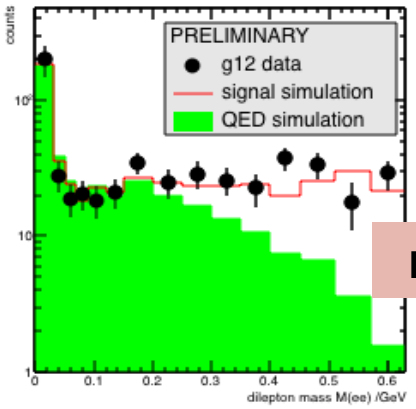




in-peak background



in-peak and smooth background subtracted



data / QED simulation

PRELIMINARY

simulations for n-peak background reveal:

- **external conversion** at small masses
- **combinatorics** at large masses
- influence of rho/omega dilepton decay

- effect of (strict) cut-based analysis
- **new analysis**
  - **statistics**
  - **combinatorics**

preliminary analysis:
so far, consistent with A2 result (and 'extended' VMD)

C. Terschlüsen and S. Leupold, Phys. Lett. B 691, 191 (2010)

JEFFERSON LAB

Virtual Tour

LOGISTICS

Transportation Information

Travel Accommodations

International Visitors

New Employees

AROUND TOWN

Newport News

Hampton

Williamsburg

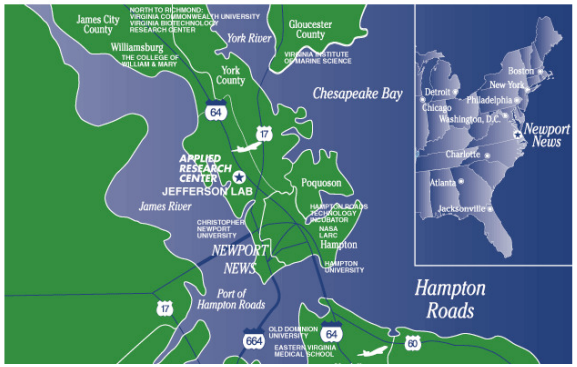
CAMPUS MAP | USER LIAISON | CONTACT US

VISITING JEFFERSON LAB

The Thomas Jefferson National Accelerator Facility (Jefferson Lab) is located at 12000 Jefferson Avenue in Newport News, Virginia. The main entrance to the facility is on Lawrence Drive.

DRIVING DIRECTIONS

12000 Jefferson Avenue, Newport News, VA 23606
Click HERE for Google Map Directions.



RESEARCH LINKS

Nuclear Physics Home

Accelerator Science Home

Theory Center Home

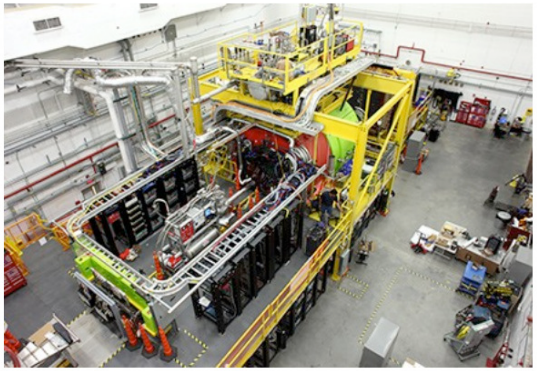
Experiment Information

Experiment Schedule

Publications Home

Research Highlights

RESEARCH HIGHLIGHTS



The newly upgraded Jefferson Lab CEBAF Accelerator opens door to strong force studies

Scientists have been rigorously commissioning the experimental equipment to prepare for a new era of nuclear physics experiments at the newly upgraded Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab in Newport News, Va. These activities have already led to the first scientific result, which demonstrates the feasibility of detecting a potential new form of matter.

PHYSICS

Nuclear Physics Home

Seminars and Colloquia

Current Experiments

Recent Results

Jefferson Lab Users Group

Technical Support Groups

TECHNICAL PAGES

Experimental Hall A

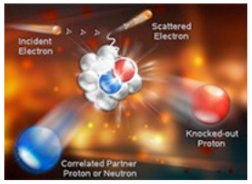
Experimental Hall B

HALL A | HALL B | HALL C | HALL D

EXPERIMENTAL NUCLEAR PHYSICS

Exploring the Nature of Matter

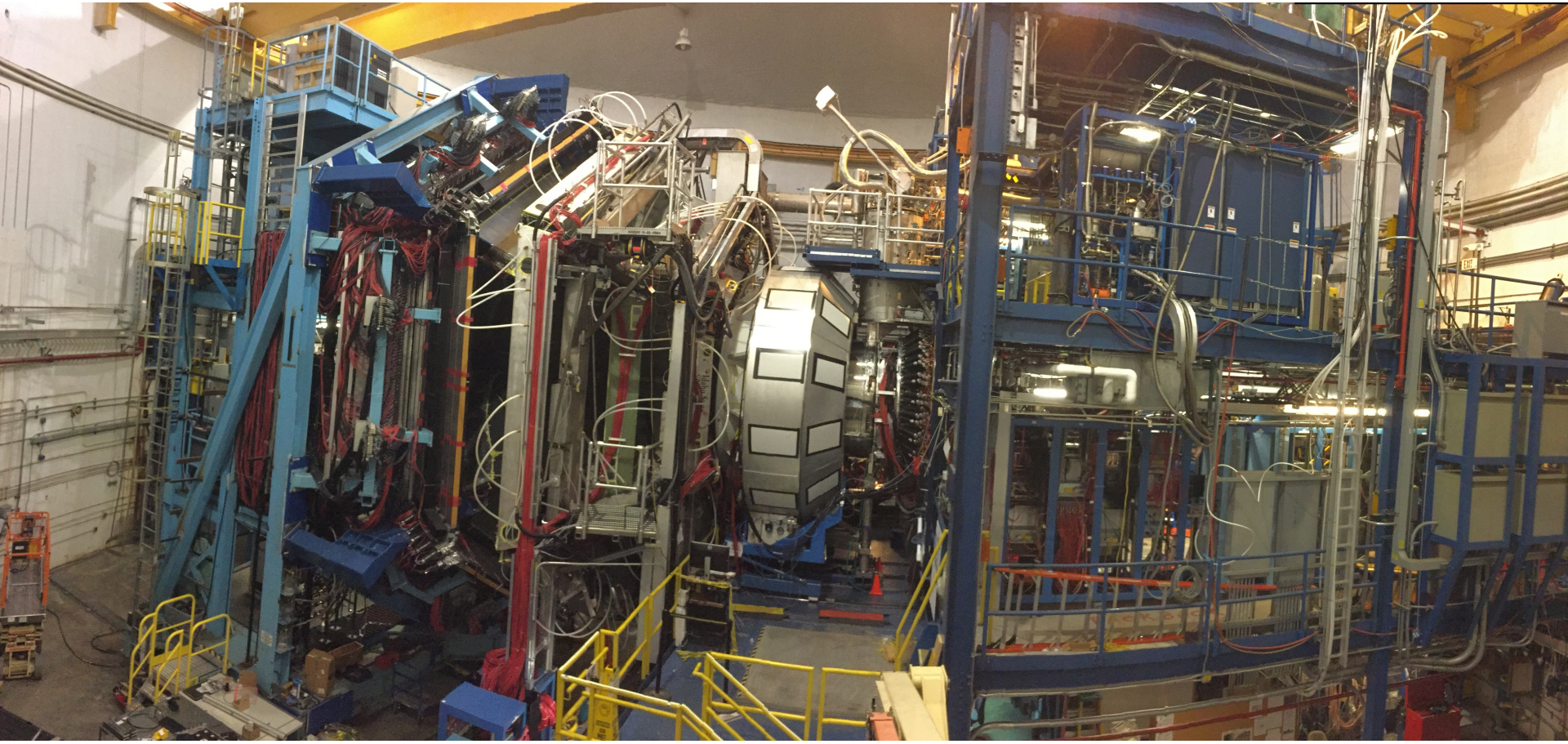
Scientists from across the country and around the world come to Jefferson Lab to advance mankind's understanding of the atom's nucleus. To probe nuclei, scientists use continuous beams of high-energy electrons from the lab's Continuous Electron Beam Accelerator Facility, or CEBAF, as well as technologically advanced targets, unique particle-detection systems and ultra-high-speed data acquisition equipment in CEBAF's four experimental halls.



RESEARCH

Nuclear and particle physicists from around the world come to Jefferson Lab to perform world-class research in the lab's four experimental halls. Learn about the research they conduct here and how they are making discoveries about the very heart of matter.

one of the first photos of the CLAS detector, all cabled up
(by Volker Burkert, Hall B leader)



CLAS - Shift Schedule - Log in - FAQ - Mailing Lists - Map - Speakers - SoS - Reviews - CLAS12

Today is

Sunday, September 30, 2018

Current shift status

Time: 05:28 EDT
Expert: Jixie Zhang
Worker: Mariana Khachatryan
RC: Latifa Elouadrhiri
PDL: Eugene Pasyuk
Schedule: RG-A

Display options

Start: 30 Sep 2018

End: 15 Mar 2019

Narrow search by name: Susan Schadmand

or by institute:

or by accelerator schedule:

Choose view:
schedule statistics
PDLs RCs

List | Reset form

or show the next two weeks

Log in

More resources

- Required training
- List of Institutional Contacts
- FAQ
- Service work & SoS
- Speakers Committee
- Paper and PAC Reviews
- Experiment Status Toolbar

Shift schedule from Sep 30, 2018 to Mar 15, 2019 for user Susan Schadmand

Important

Shift start time refers to the date in the left hand column of table
e.g. if the date is 01-January-2018:
Expert Owl starts at 00:00 and ends 08:00 on 01-January-2018
Expert Day starts at 08:00 and ends 16:00 on 01-January-2018
Expert Swing starts at 16:00 and ends 24:00 (midnight) on 01-January-2018
Worker Day starts at 07:00 and ends 15:00 on 01-January-2018
Worker Swing starts at 15:00 and ends 23:00 on 01-January-2018
Worker Owl starts at 23:00 and ends 07:00 on 02-January-2018 (the following calendar day)

Contact Shift Takers

Date	Expert Owl (00:00-08:00)	Expert Day (08:00-16:00)	Expert Swing (16:00-24:00)	Worker Day (07:00-15:00)	Worker Swing (15:00-23:00)	Worker Owl (23:00-07:00)	Accelerator Schedule/ Hall B Program
22-Oct-2018 Monday	SCAROLINA	Yordanka Ilieva	Raffaella De Vita	Susan Schadmand	INFNFE	Nathan Dzbenski	RG-A
23-Oct-2018 Tuesday	Yordanka Ilieva	Silvia Niccolai	UCONN	INFNFE	TEMPLE	Susan Schadmand	RG-A
24-Oct-2018 Wednesday	Yordanka Ilieva	Silvia Niccolai	UCONN	INFNFE	TEMPLE	Susan Schadmand	RG-A
25-Oct-2018 Thursday	Yordanka Ilieva	Silvia Niccolai	UCONN	INFNFE	TEMPLE	Susan Schadmand	RG-A
26-Oct-2018 Friday	Yordanka Ilieva	Silvia Niccolai	UCONN	INFNFE	TEMPLE	Susan Schadmand	RG-A
27-Oct-2018 Saturday	Francesco Bossu	Yuri Gotra	Silvia Niccolai	INFNFE	Hyon-Suk Jo	Susan Schadmand	RG-A
28-Oct-2018 Sunday	Francesco Bossu	Yuri Gotra	Silvia Niccolai	INFNFE	Hyon-Suk Jo	Susan Schadmand	RG-A
29-Oct-2018 Monday	Francesco Bossu	Yuri Gotra	Silvia Niccolai	INFNFE	Hyon-Suk Jo	Susan Schadmand	RG-A
30-Oct-2018 Tuesday	Francesco Bossu	Yuri Gotra	Silvia Niccolai	INFNFE	Hyon-Suk Jo	Susan Schadmand	RG-A

Found a total of 9 shifts spread over 9 days.

User info for Susan Schadmand:

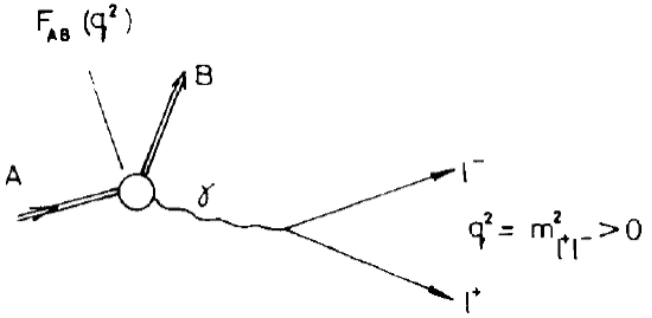
Full name: Susan Schadmand
Affiliation: JUELICH (Institute fur Kernphysik)
Email: s.schadmand@fz-juelich.de
Qualification: Novice/Worker

Stefan Leupold
Uppsala University

conversion decays

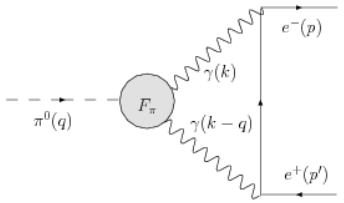
Reactions of hadrons with virtual photons

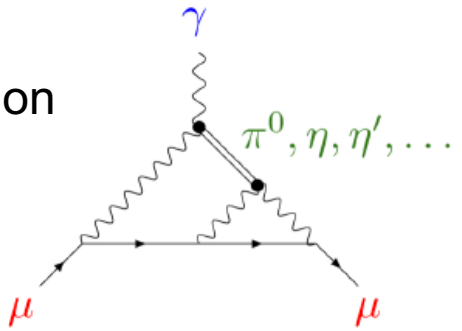
- intrinsic structure of hadrons
  - transition form factors
  - validity of vector meson dominance



- background for physics beyond the standard model
  - rare decays
    - eg $\pi \to ee$
  - g-2 anomalous magnetic moment of the muon
    - light-by-light scattering

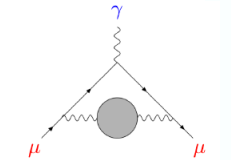
g-2 measurements: Fermilab and J-PARC

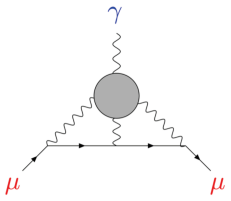


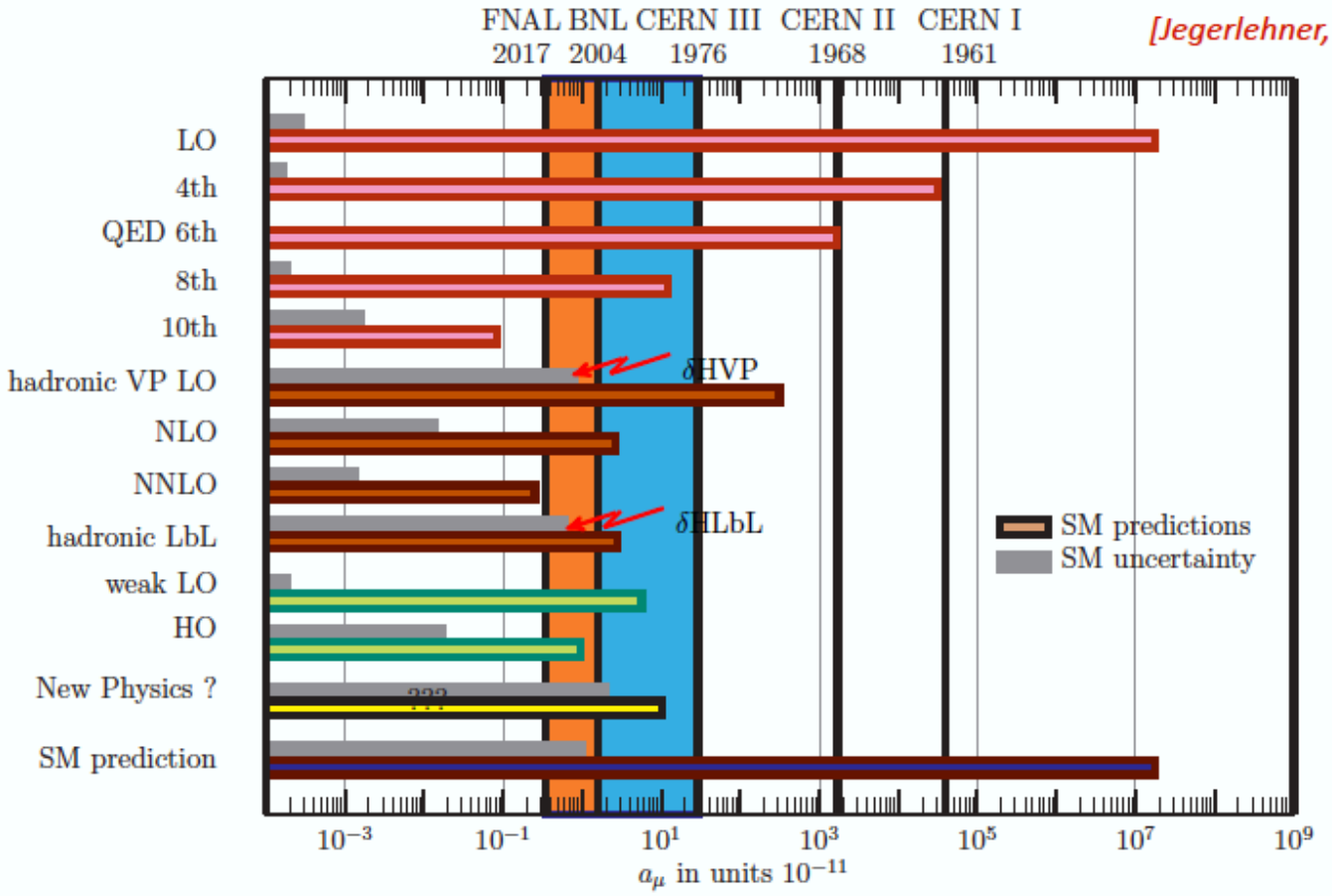


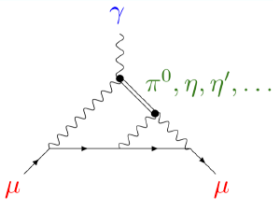
theory confronts experiment

Role of hadronic decays for g-2



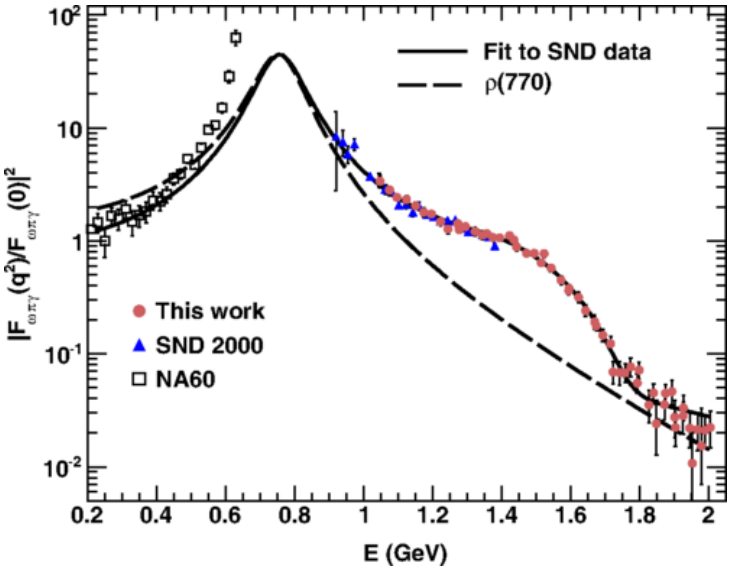




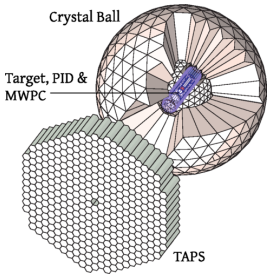


status of the ω-π transition form factor

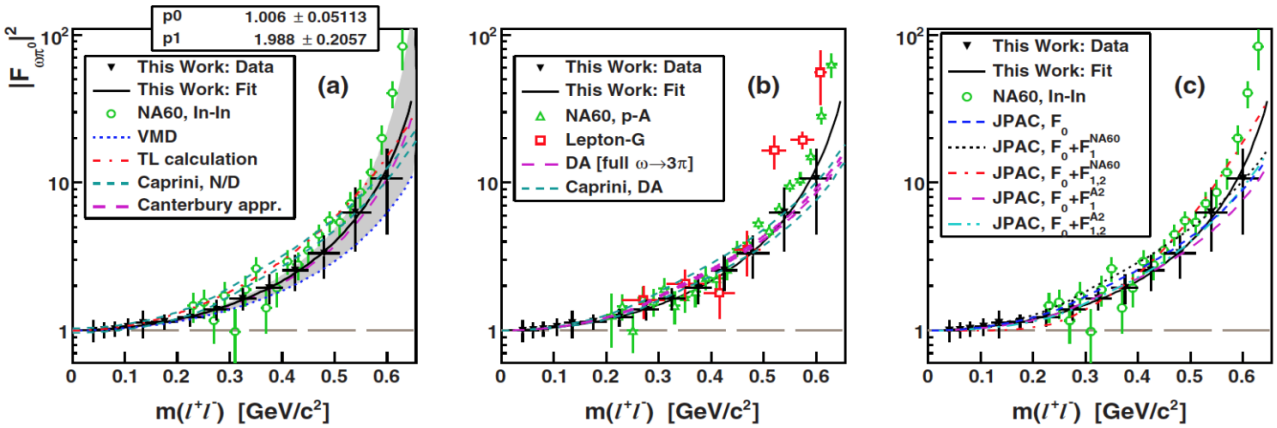
M. N. Achasov *et al.*, Phys. Rev. D 94, (2016) 112001



S. Prakhov (A2 Collaboration at MAMI)
Phys. Rev. C 95, 035208



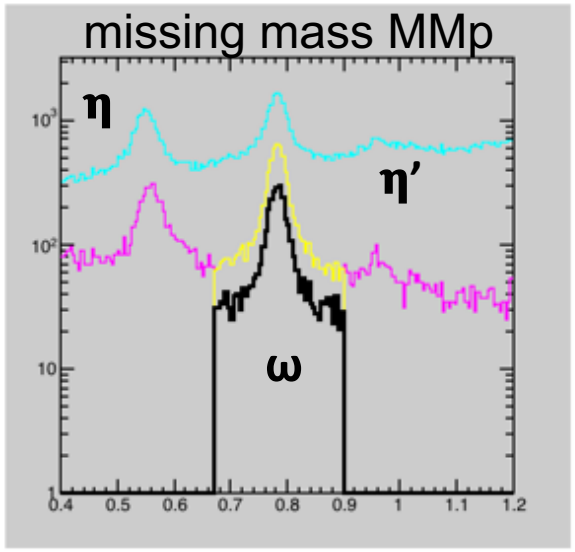
$\Lambda^{-2}=(1.99\pm0.21_{tot})$ GeV^{-2}
1100 overall statistics

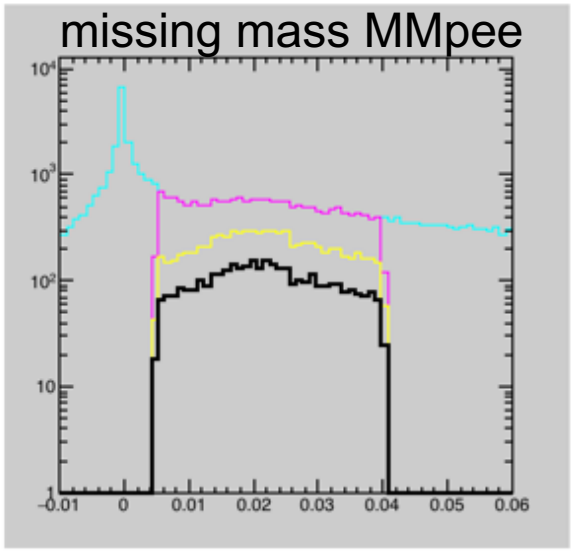


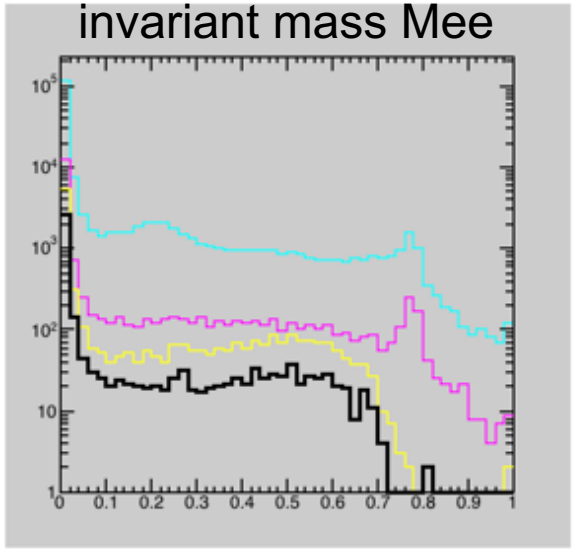
conclusion:

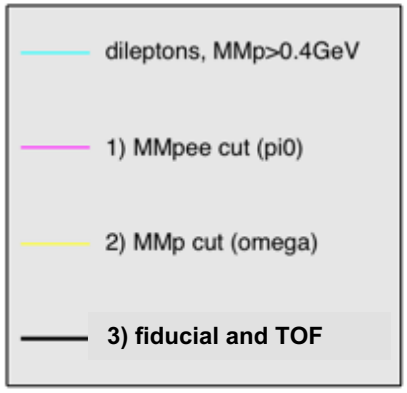
- A2 results are in better agreement with theoretical calculations, compared to earlier experiments
- statistical accuracy of the present data points at large m (ee) masses does not allow a final conclusion

analysis strategy cut-based analysis









e^+e^- detection
and missing particle

missing pion:
- missing mass is pion
- missing energy finite

ω→πee

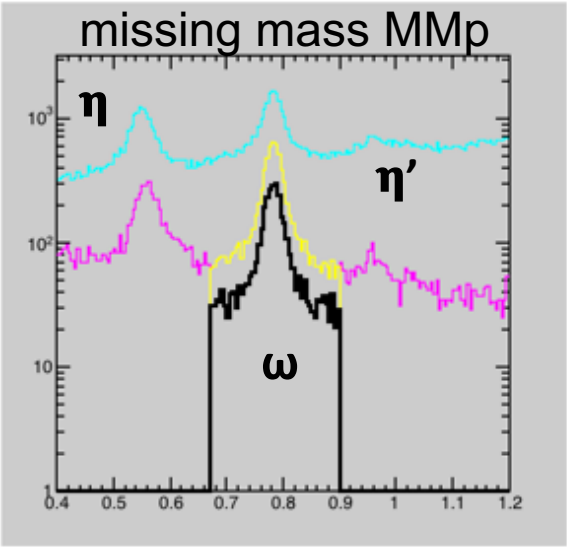
missing photon:
- missing mass zero
- missing energy finite

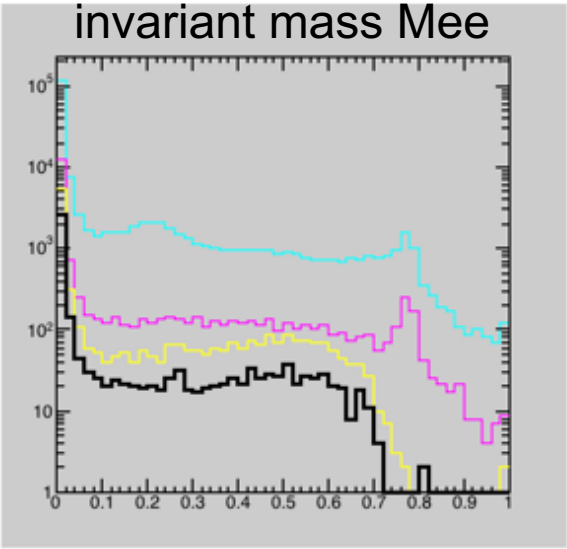
η(´)→γee

missing nothing:
- missing mass zero
  missing energy zero

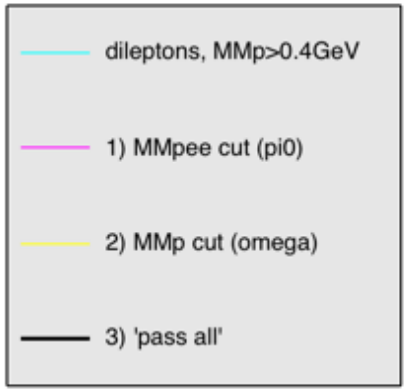
ρ/ω→ee

analysis strategy cut-based analysis





- smooth background
  ← subtract via MMp spectrum
- in-peak background (competing decays)
  ← simulations
- photon conversion from $\pi \rightarrow \gamma\gamma$ (small ee masses)
  ← simulations



experimental challenge p+p reactions

method:
reconstruct meson mass peak, use full final state information

2 types of background:

1. multi-pion background
   meson production cross sections

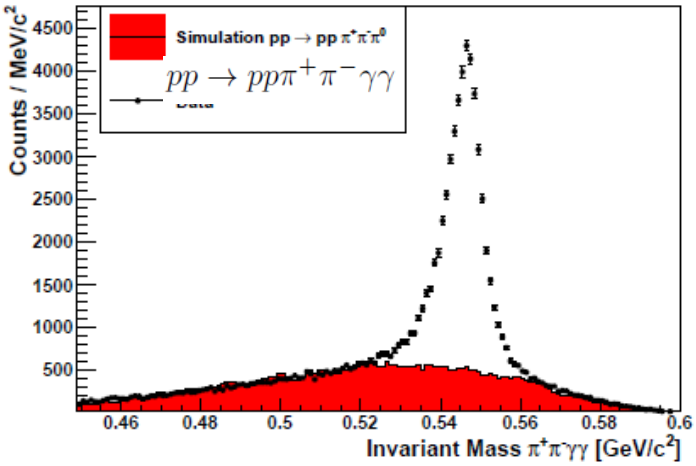
→ smooth background under meson mass peak
example:

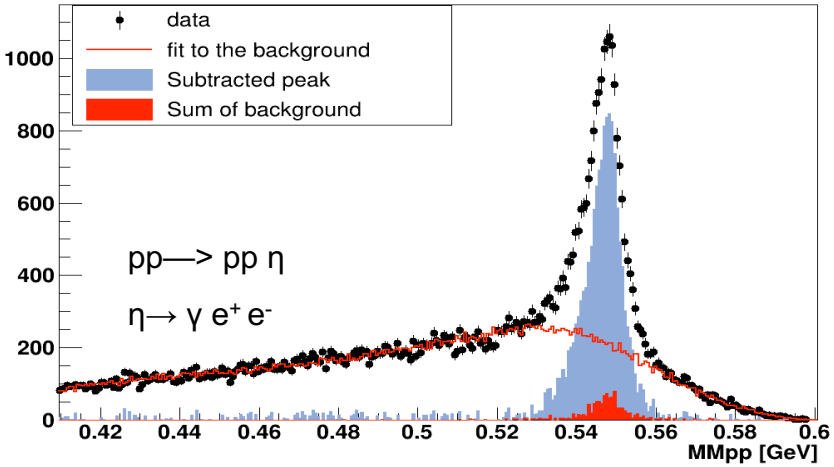
- signal $\eta \to \pi^+\pi^-\pi^0$ decay
- background direct $\pi^+\pi^-\pi^0$ production

2.) competing meson decays
relative branching ratios

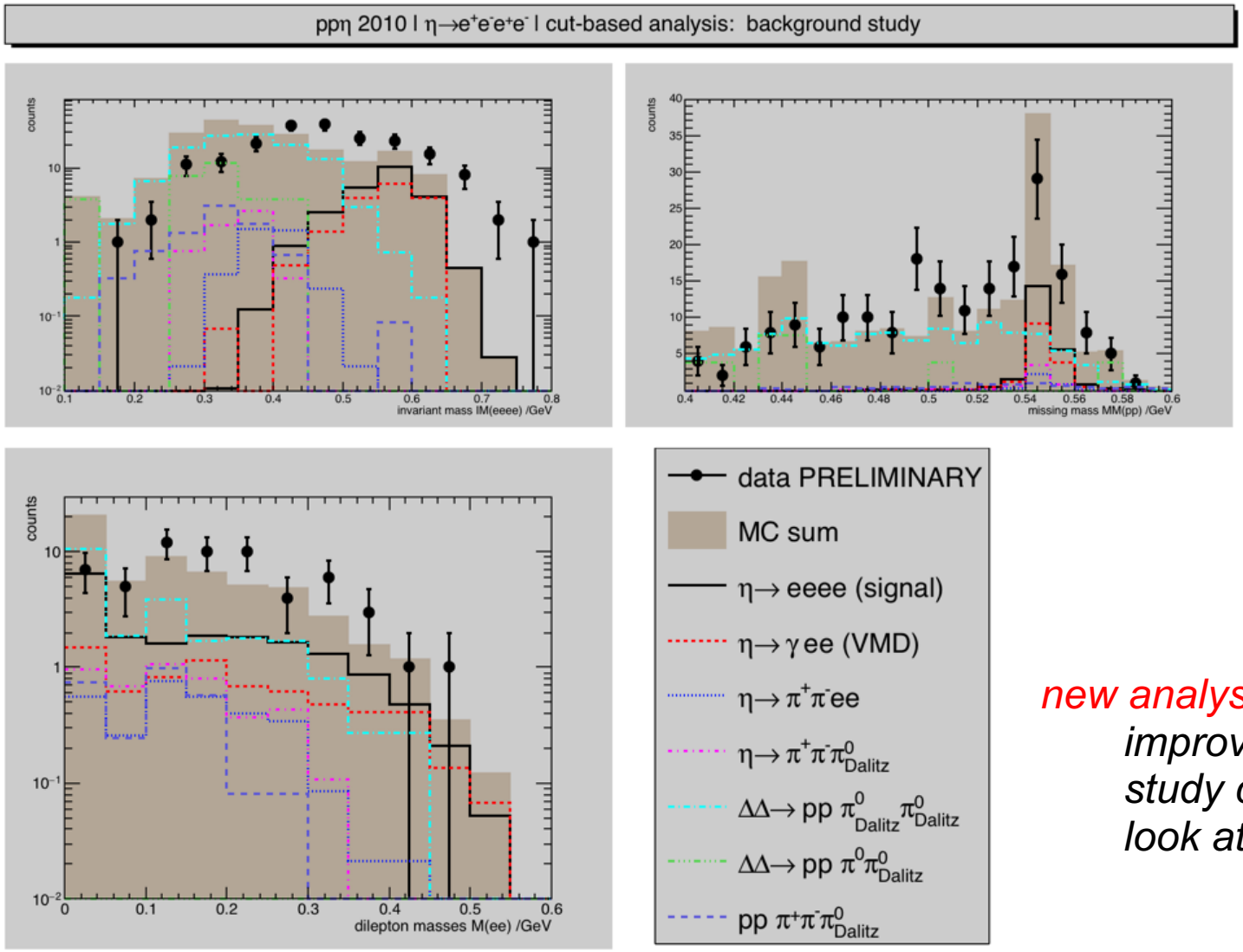
→ peaked background at the meson mass peak
subtract via simulations
example:

- signal $\eta \to e^+e^-\gamma$ decay
- background (eg) from $\eta \to \gamma\gamma$ decay





status analysis η→eeee



new analysis:

improve statistics

study combinatorics

look at pp pi0 data?

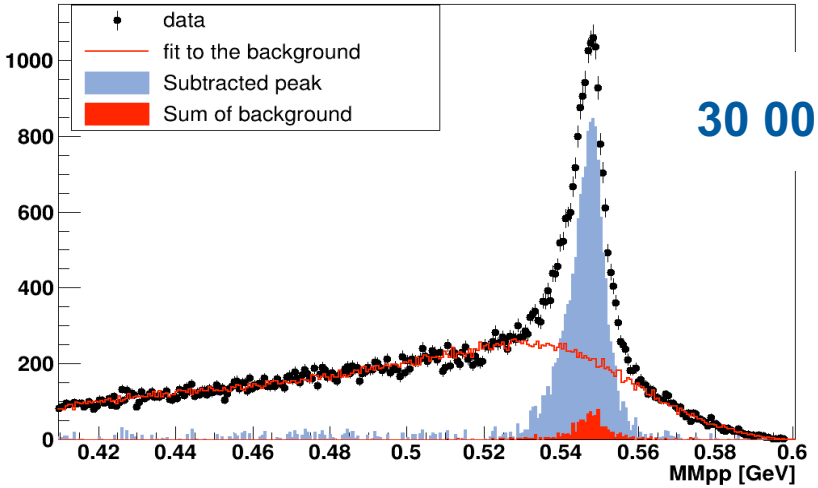
summary meson transition form factors

results coming up from the experiments
CLAS g12 and WASA at COSY:

$\eta \rightarrow \gamma\, e^+ e^-$ benchmark channel
$\eta \rightarrow e^+ e^- e^+ e^-$ double VMD ?

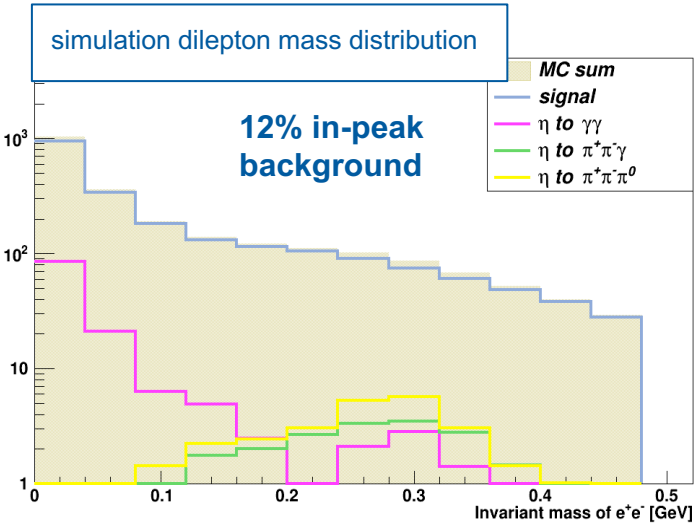
ω-π^0 transition form factor solve the puzzle?

conversion decay η→ γ e^+ e^-



30 000 η→ γ e^+ e^-

pp—> pp η (2010 data set)
Ankita Goswami
preliminary



'benchmark decay'

analysis: new base class for pp eta analyses

- full particle multiplicities
- improved particle id (neural networks)
- kinematic fit

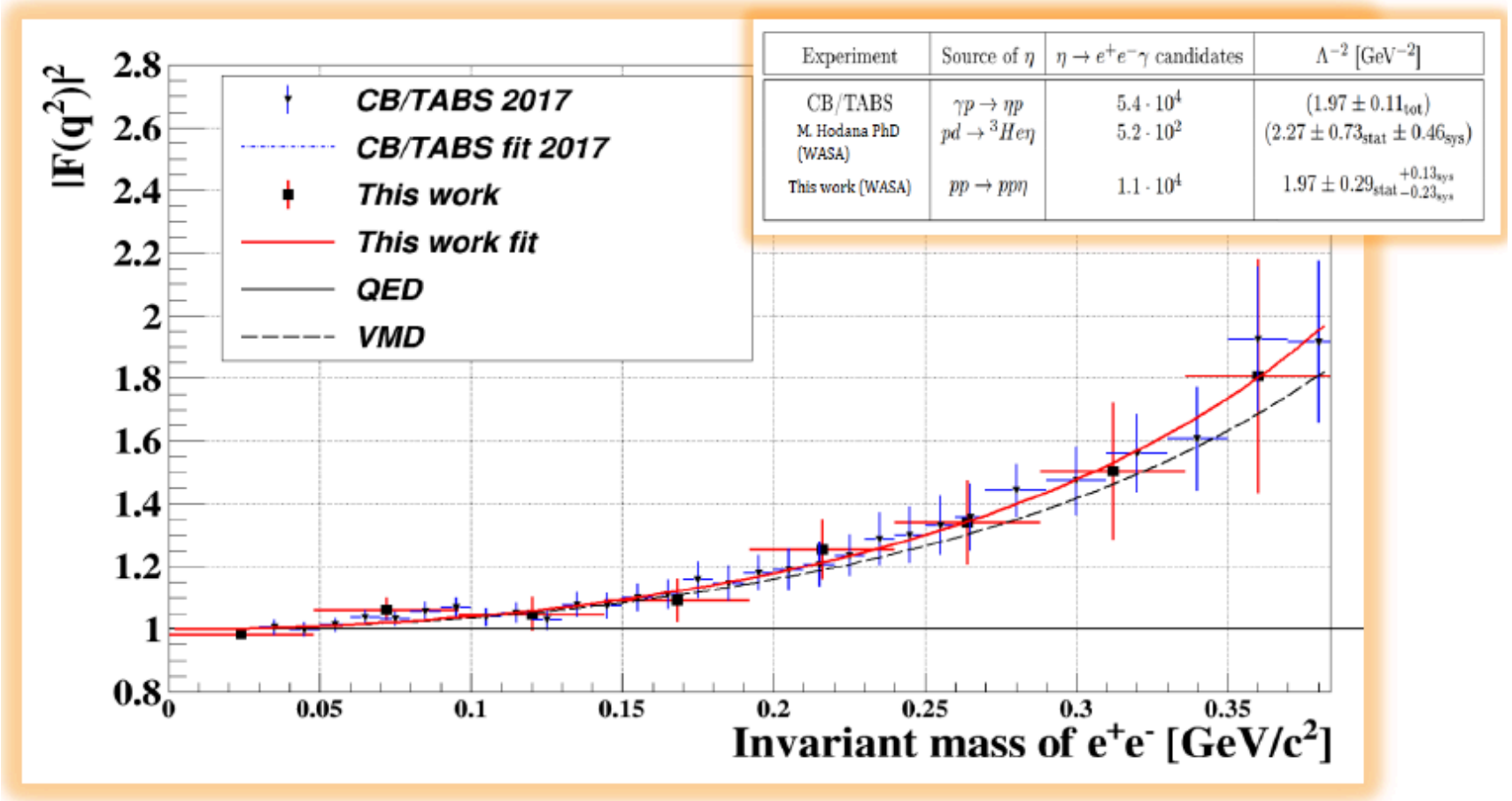
→ can improve the efficiency and signal/background

- in parallel, look at **η→ eeee**

further: *study in γ p—> p η(') and ω with CLAS/JLab*

conversion decay η→ γ e^+ e^-

pp—> pp η (2012 data set)
Damian Pszczel, preliminary



Experiment	Source of η	$\eta \to e^+e^-\gamma$ candidates	Λ^{-2} [GeV^{-2}]
CB/TABS	$\gamma p \to \eta p$	$5.4 \cdot 10^4$	$(1.97 \pm 0.11_{\text{tot}})$
M. Hodana PhD (WASA)	$pd \to {}^3He\eta$	$5.2 \cdot 10^2$	$(2.27 \pm 0.73_{\text{stat}} \pm 0.46_{\text{sys}})$
This work (WASA)	$pp \to pp\eta$	$1.1 \cdot 10^4$	$1.97 \pm 0.29_{\text{stat}}{}^{+0.13_{\text{sys}}}_{-0.23_{\text{sys}}}$