Mapping Hybrid Mesons & Confinement in QCD

Outline:

1. What are hybrid mesons and how is their spectroscopy related to understanding confinement in QCD.

2. Why producing mesons with linearly polarized photons is expected to be rich in exotic hybrid mesons.

3. Why 9 GeV photons will be sufficient for the required mass reach and why electrons of 12 GeV in energy are essential.

4. Why an amplitude analysis is required to identify exotic hybrid, non-exotic hybrid and conventional meson nonets.

5. Why a solenoidal-based spectrometer with excellent acceptance, resolution and particle identification is required to do the spectroscopy.

6. Status of the GlueX project.

Presentation to PAC27

Alex R. Dzierba
Spokesperson - GlueX Collaboration

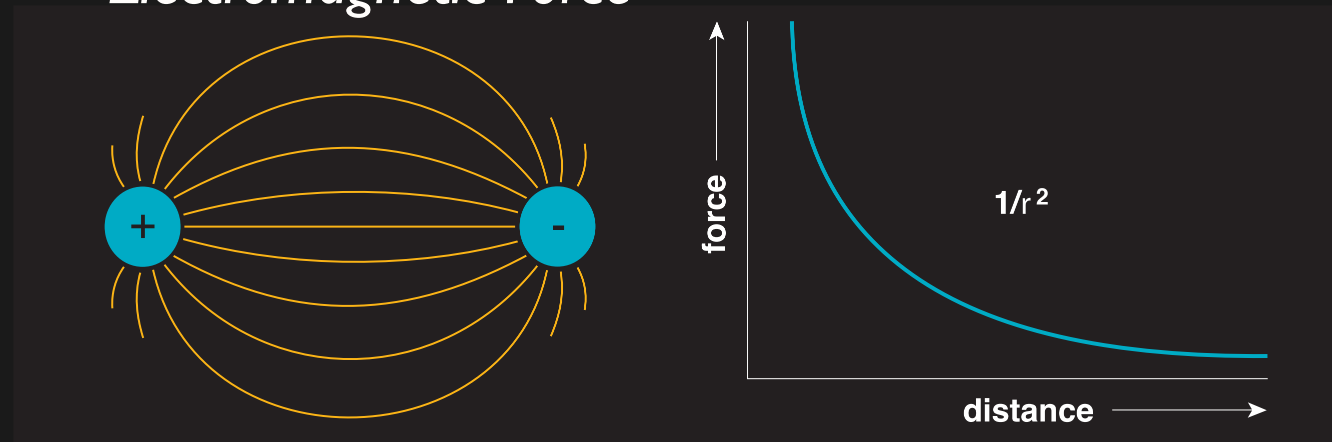
QED/QCD

QCD differs from QED:

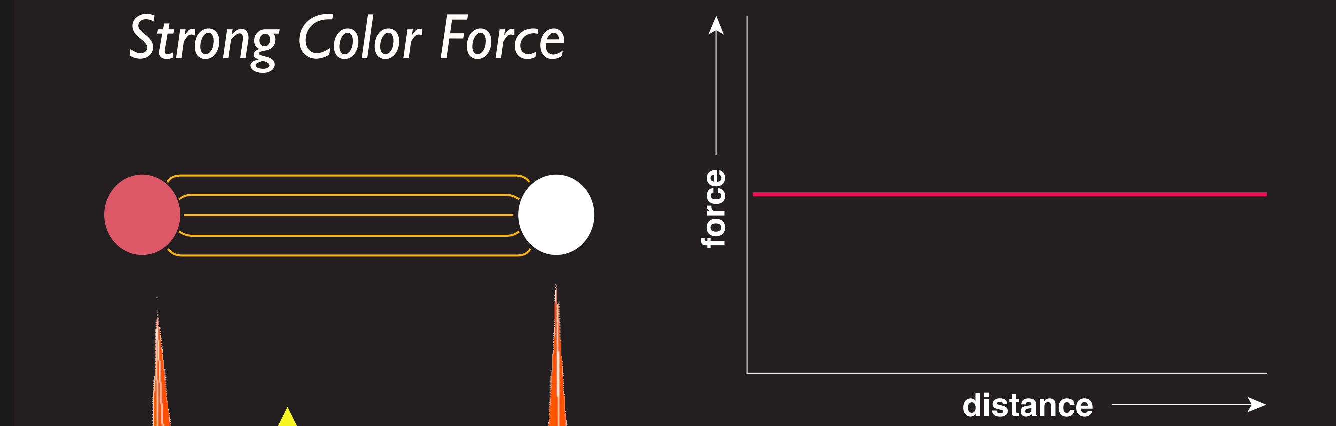
The field quanta interact and this leads to flux-tubes that are responsible for confinement

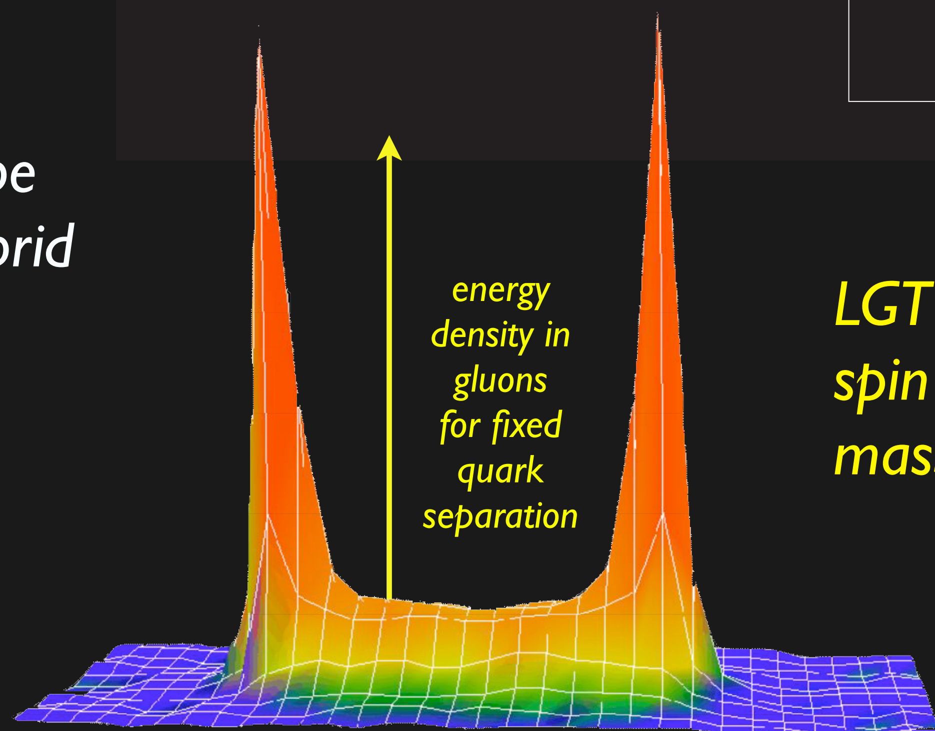
Excitations of the flux tube can give rise to exotic hybrid mesons

Electromagnetic Force



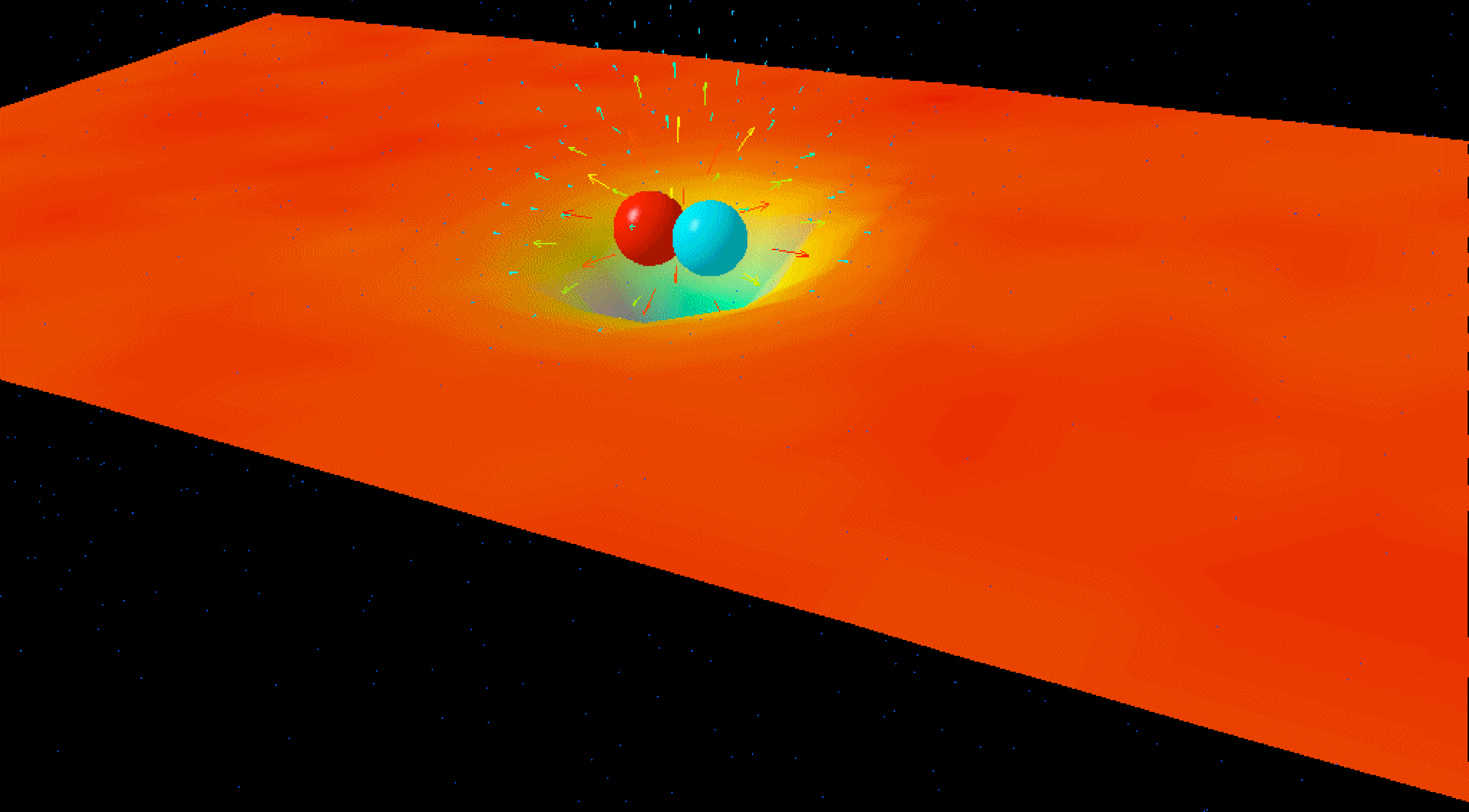
Strong Color Force





from G. Bali

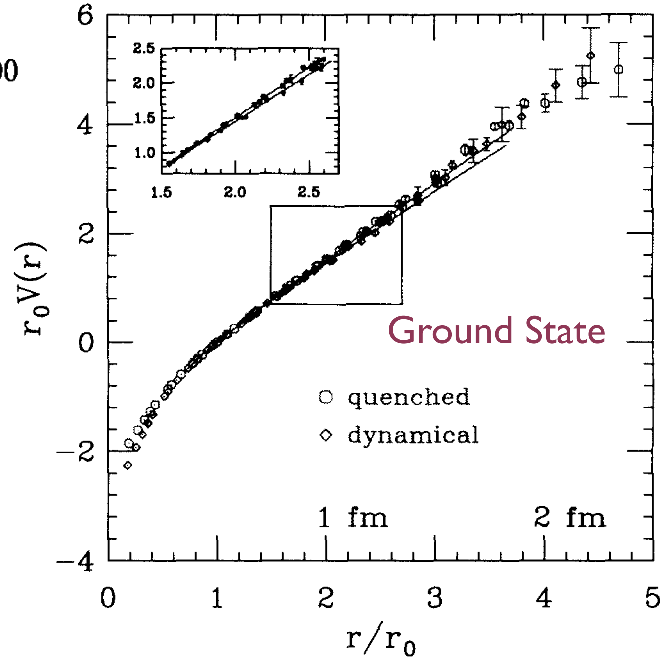
LGT predicts lightest spin one exotics with mass of 2 GeV from Derek Leinweber et al

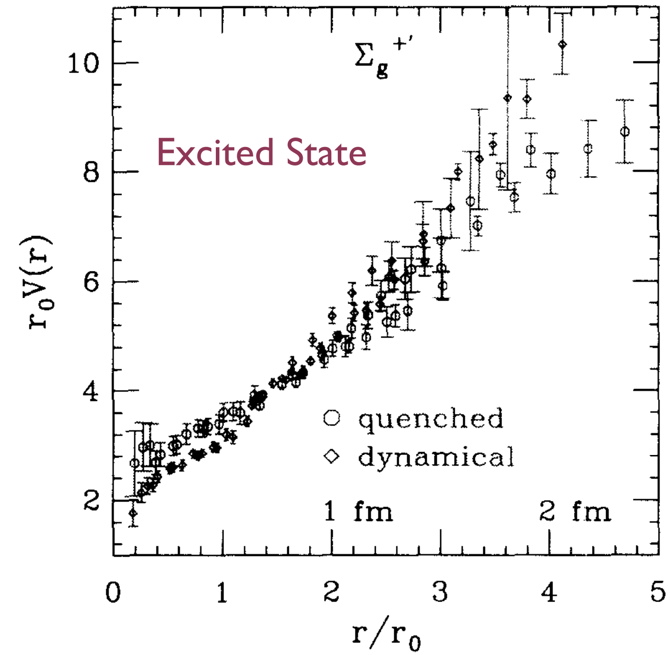


Static hybrid quarkonium potential with improved staggered quarks

MILC Collaboration

Nuclear Physics B (Proc. Suppl.) 119 (2003) 598–600





LQCD is setting the stage

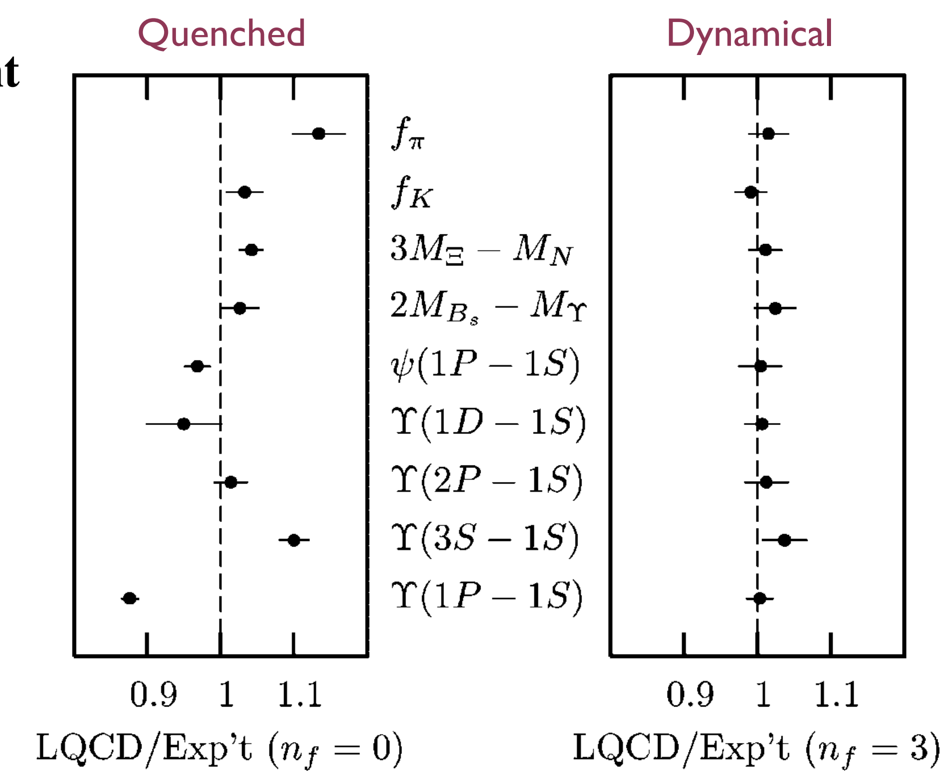
Now we need data

High-Precision Lattice QCD Confronts Experiment

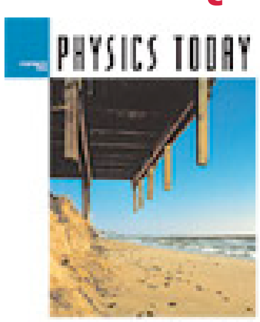
PHYSICAL REVIEW LETTERS

VOLUME 92, NUMBER 2 JANUARY 2004

HPQCD/UKQCD/MILC/Fermilab Collaboration



Lattice Quantum Chromodynamics Comes of Age

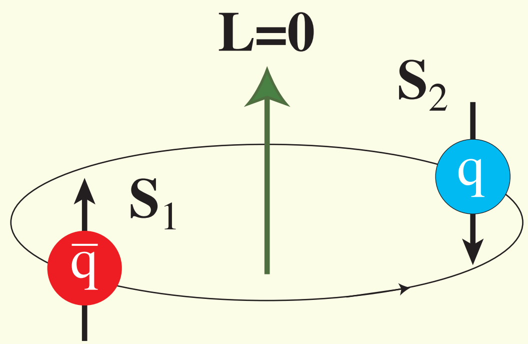


Carleton DeTar and Steven Gottlieb

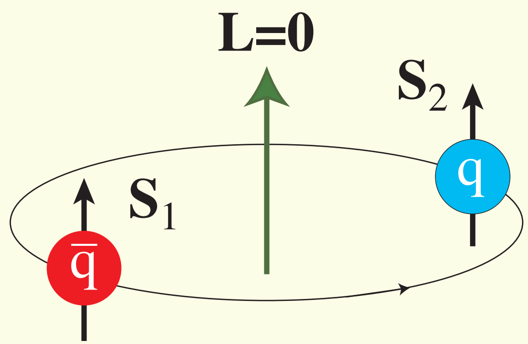
Feb 2004

Conventional Light Mesons

$$\vec{J} = \vec{L} + \vec{S}$$
$$P = (-1)^{L+1}$$
$$C = (-1)^{L+S}$$



$J^{PC} = 0^{-+}$: π, K

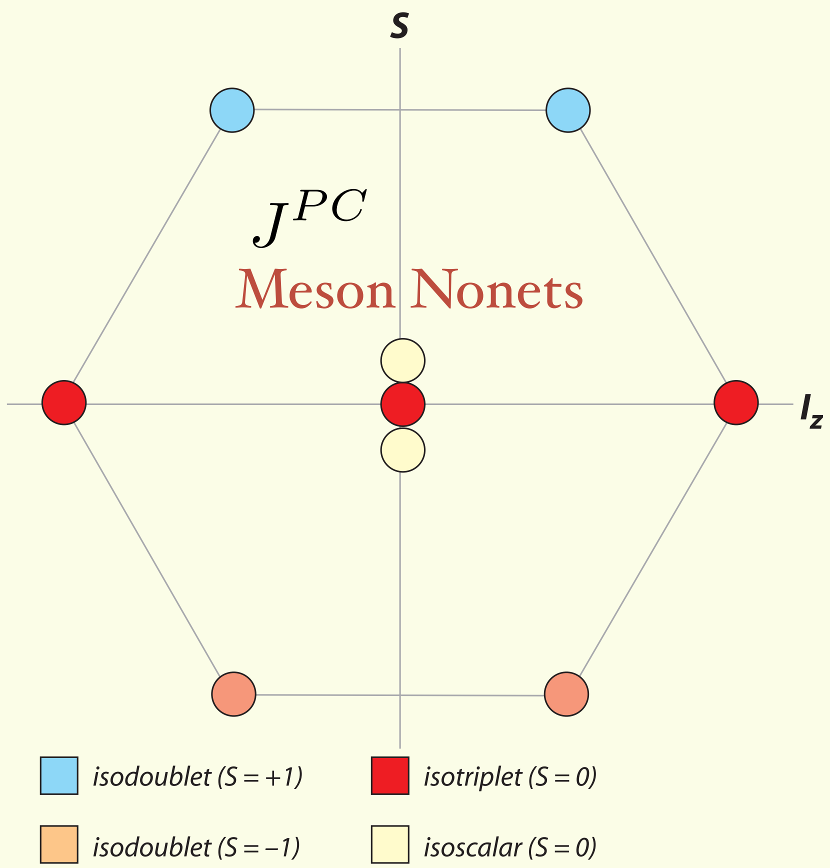


$J^{PC} = 1^{--}$: ρ, K^*, γ

Certain spin-parity combinations are not allowed - exotic:

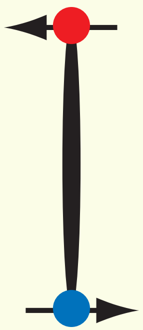
$$J^{PC} = 0^{--}, 0^{+-}, 1^{-+}, 2^{+-}$$

For light quarks (u, d, s) and fixed J, P and C we expect nonets of mesons:



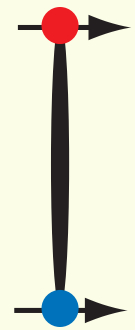
Excite the flux tube

Conventional mesons correspond to the flux tube in its ground state - gluonic degrees of freedom do not contribute.



$\vec{L} = 0, \ \vec{S} = 0$

$\pi, \ K$

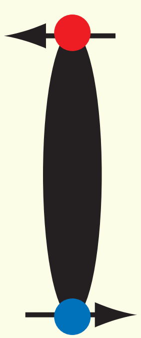


$\vec{L} = 0, \ \vec{S} = 1$

$\rho, \ K^*, \ \gamma$

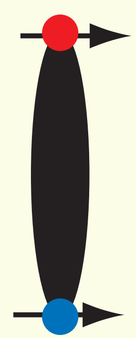
In its first excited state the flux tube has: $J^{PC} = 1^{+-} \ or \ 1^{-+}$

Now include the quantum numbers of the excited flux tube:



$\vec{L} = 0, \ \vec{S} = 0$

$J^{PC} = 1^{--} \ or \ 1^{++}$

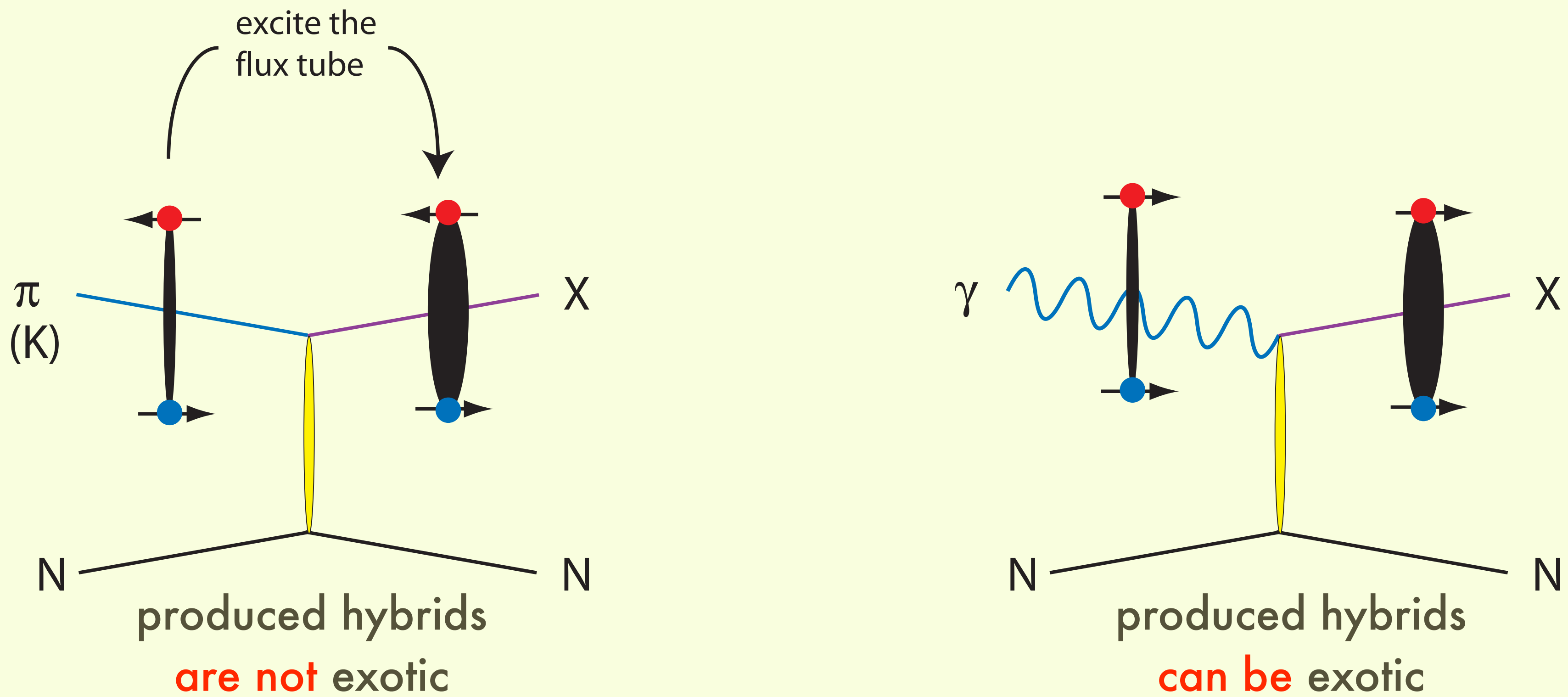


$\vec{L} = 0, \ \vec{S} = 1$

Exotic: $J^{PC} = 0^{+-}, 1^{-+}, 2^{+-}$

$J^{PC} = 0^{-+}, 1^{+-}, 2^{-+}$

Production with pions vs photons



Role of photoproduction in exotic meson searches

Adam P. Szczepaniak, Maciej Swat

Physics Letters B 516 (2001) 72–76

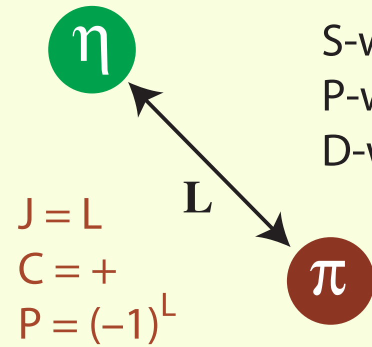
We have estimated the exotic meson photoproduction rate based on the existing data on hadronic production with pion beams. From the E852 $\pi^- p \to Xp \to \rho\pi p$ data it follows that the exotic production is suppressed by roughly a factor of 10 as compared to the $a_2(1320)$ production. We find, however, this is not the case in reactions with photon beams. Based on the rate estimate from the E852 data we conclude that in photoproduction the π_1 and a_2 production should be comparable.

Have Exotic Hybrids Been Detected?

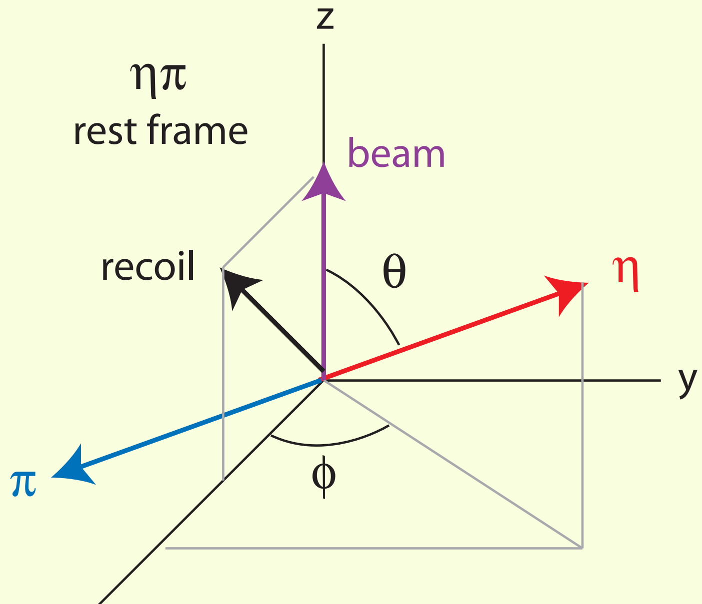
$\pi_1(1400)\ J^{PC} = 1^{-+}$

$$\pi^- p \rightarrow \eta \pi^0 n$$

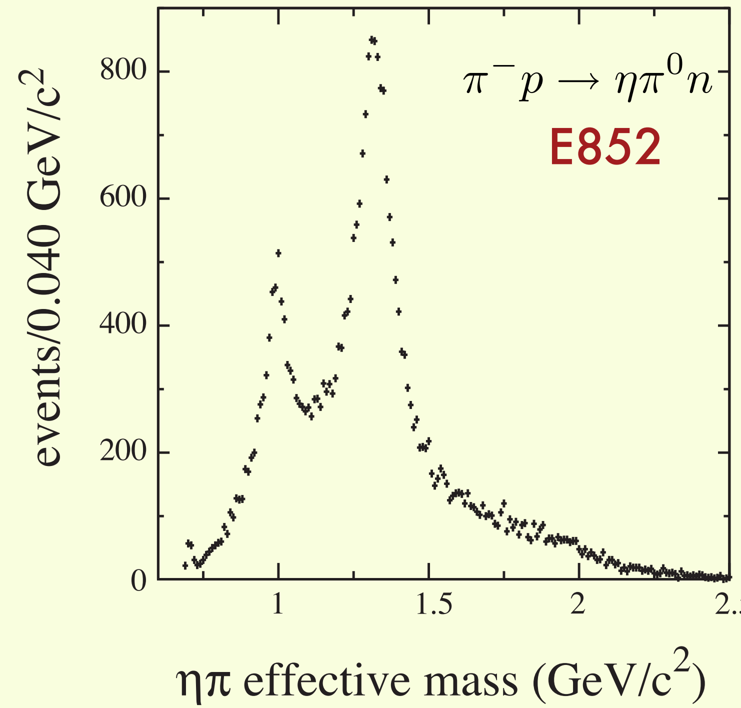
In late 70's - claim from IHEP/CERN



S-wave (L=0) ⟶ scalar - $a_0(980)$
P-wave (L=1) ⟶ exotic ?
D-wave (L=2) ⟶ tensor- $a_2(1320)$



Gottfried - Jackson Frame



$$\pi^- p \rightarrow \eta \pi^- p$$

Report of an exotic state by BNL E852 - confirmed by Crystal Barrel. This result was controversial.

$$\pi^- p \rightarrow \eta \pi^0 n$$

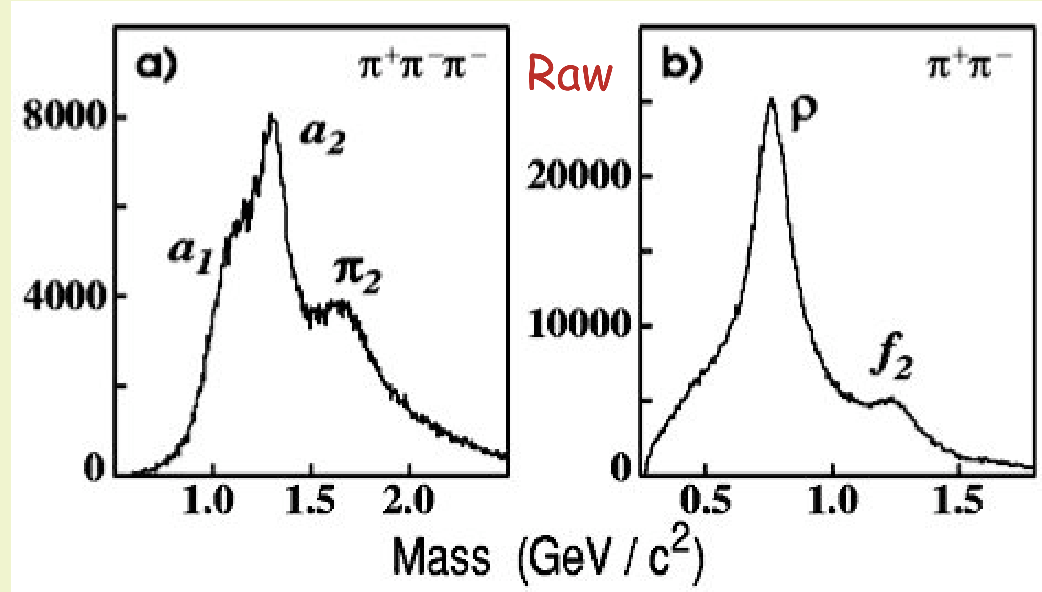
An analysis of this reaction indicates the presence of a P-wave but non-resonant.

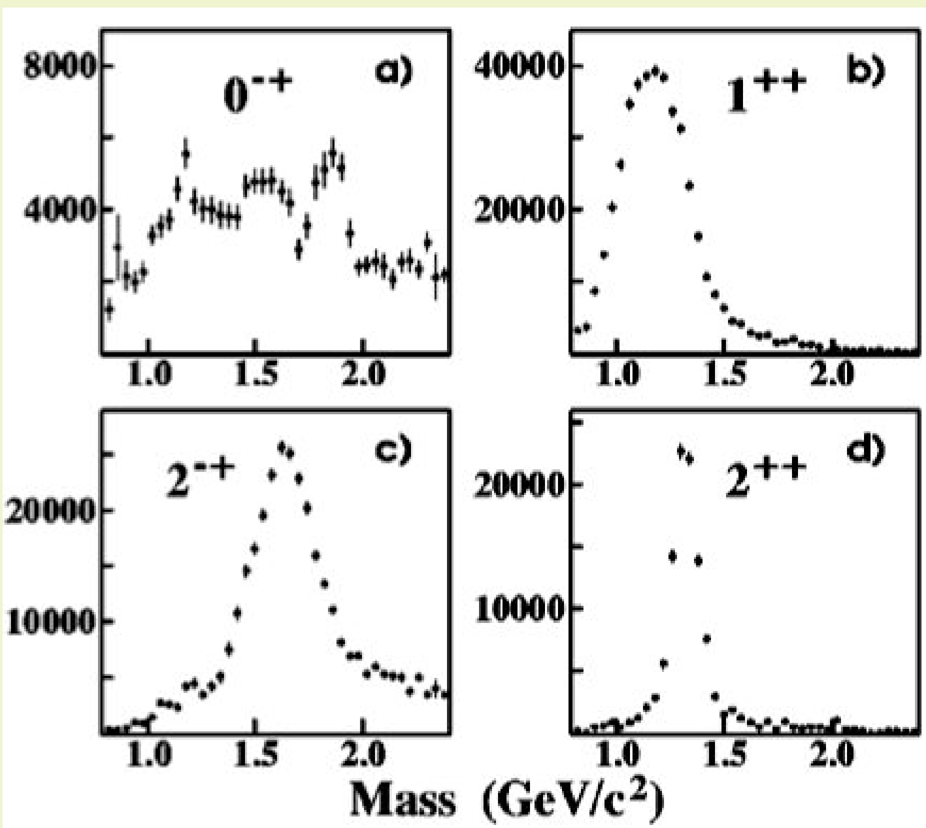
E852 Analysis

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

Based on 250,000 events

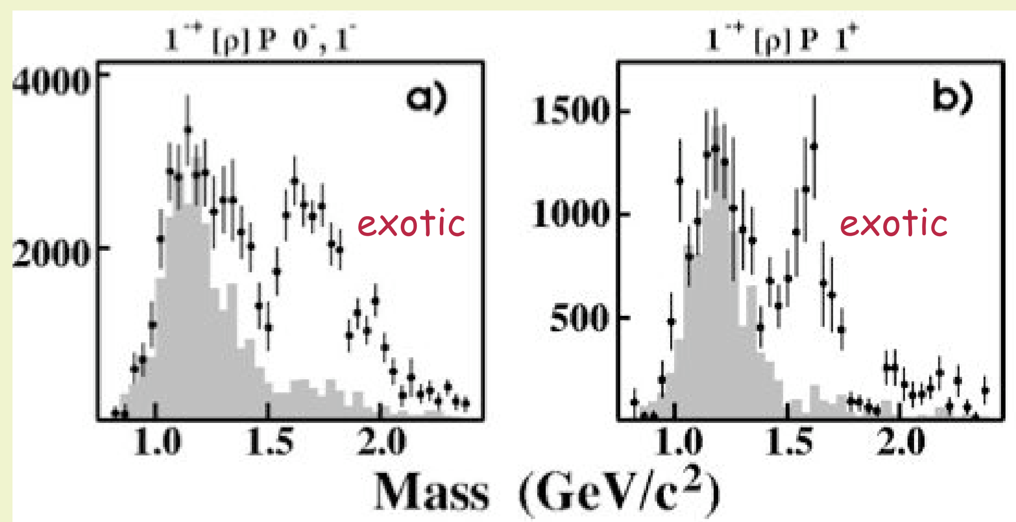
$$\boxed{\pi_1(1600)\ J^{PC} = 1^{-+}}$$





After PWA

Standard states observed in addition to a JPC exotic



High Statistics Analysis in Progress

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

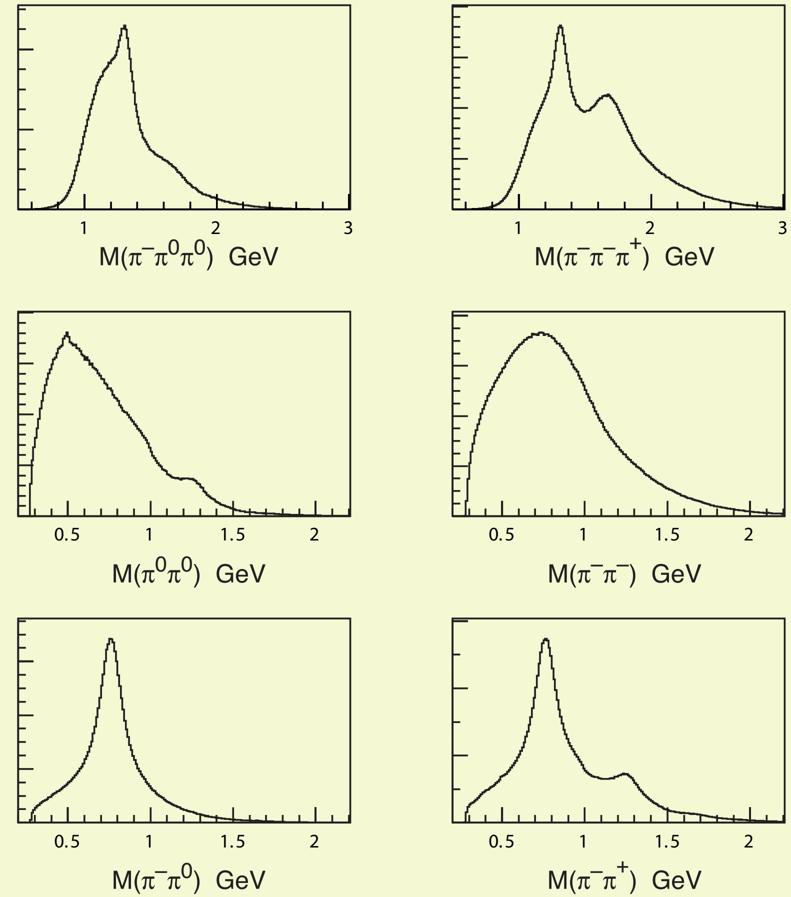
$$\pi^- p \rightarrow \pi^- \pi^0 \pi^0 p$$

Based on 10M events of each reaction

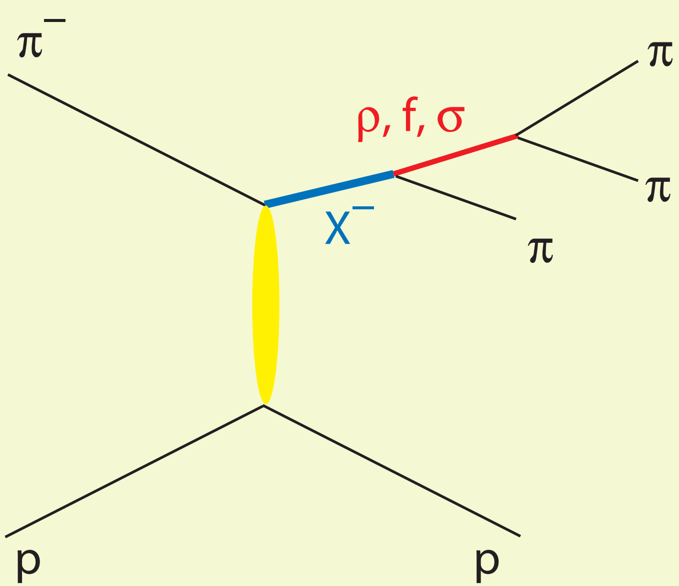
$$\pi_1(1600)\ J^{PC} = 1^{-+}$$

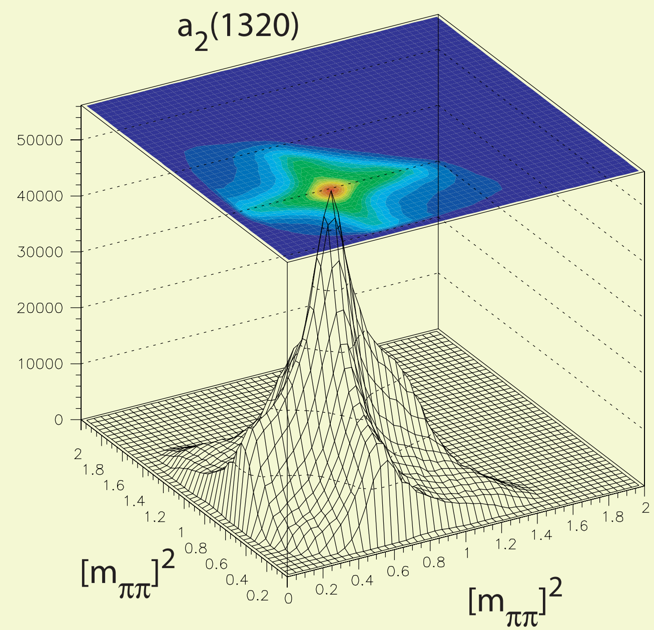
Evidence based on 250,000 events of:

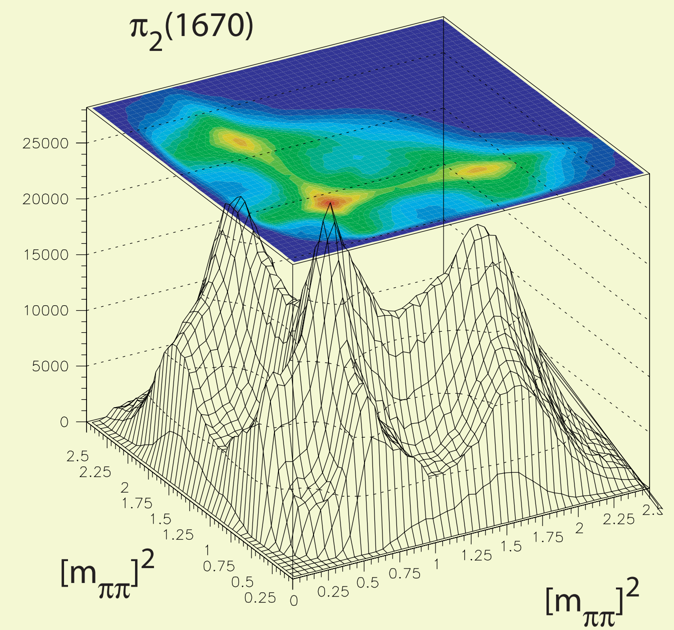
$$\pi^- p \rightarrow \pi^- \pi^- \pi^+ p$$



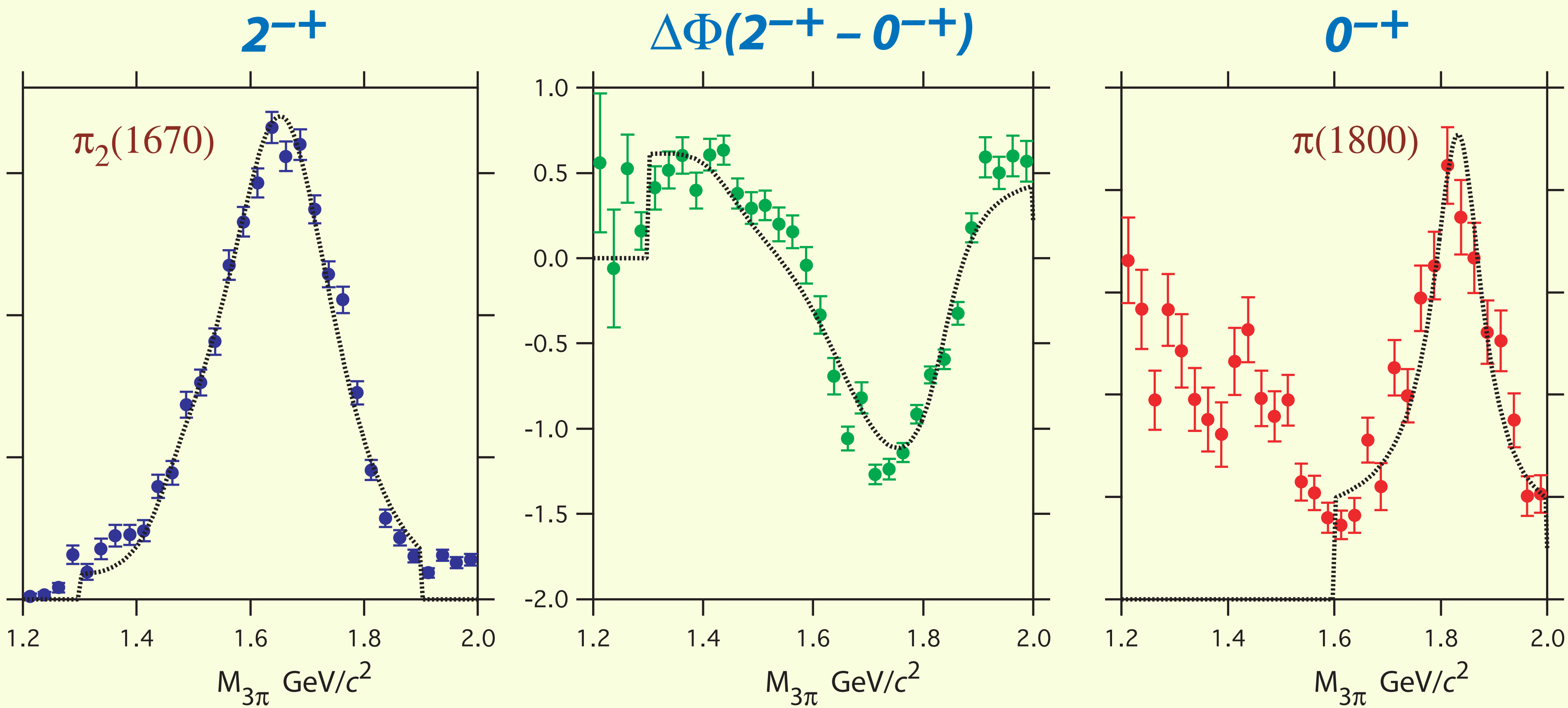
PWA based on the *isobar* model





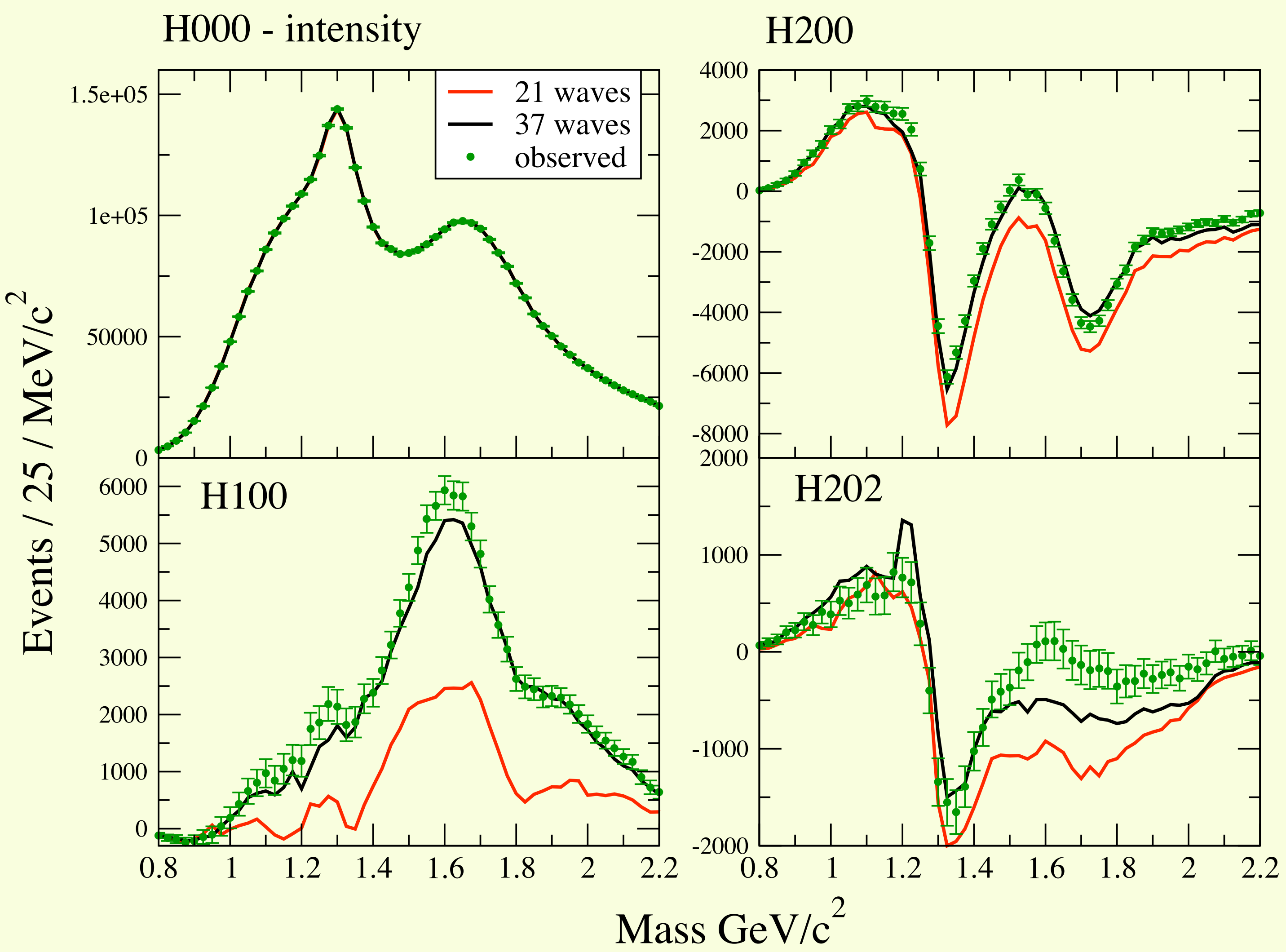


Amplitude & Phase of Two Established States



This shows the amplitudes and relative phase of two established states as described by two interfering Breit-Wigners with “blue-book” (PDG) parameters.

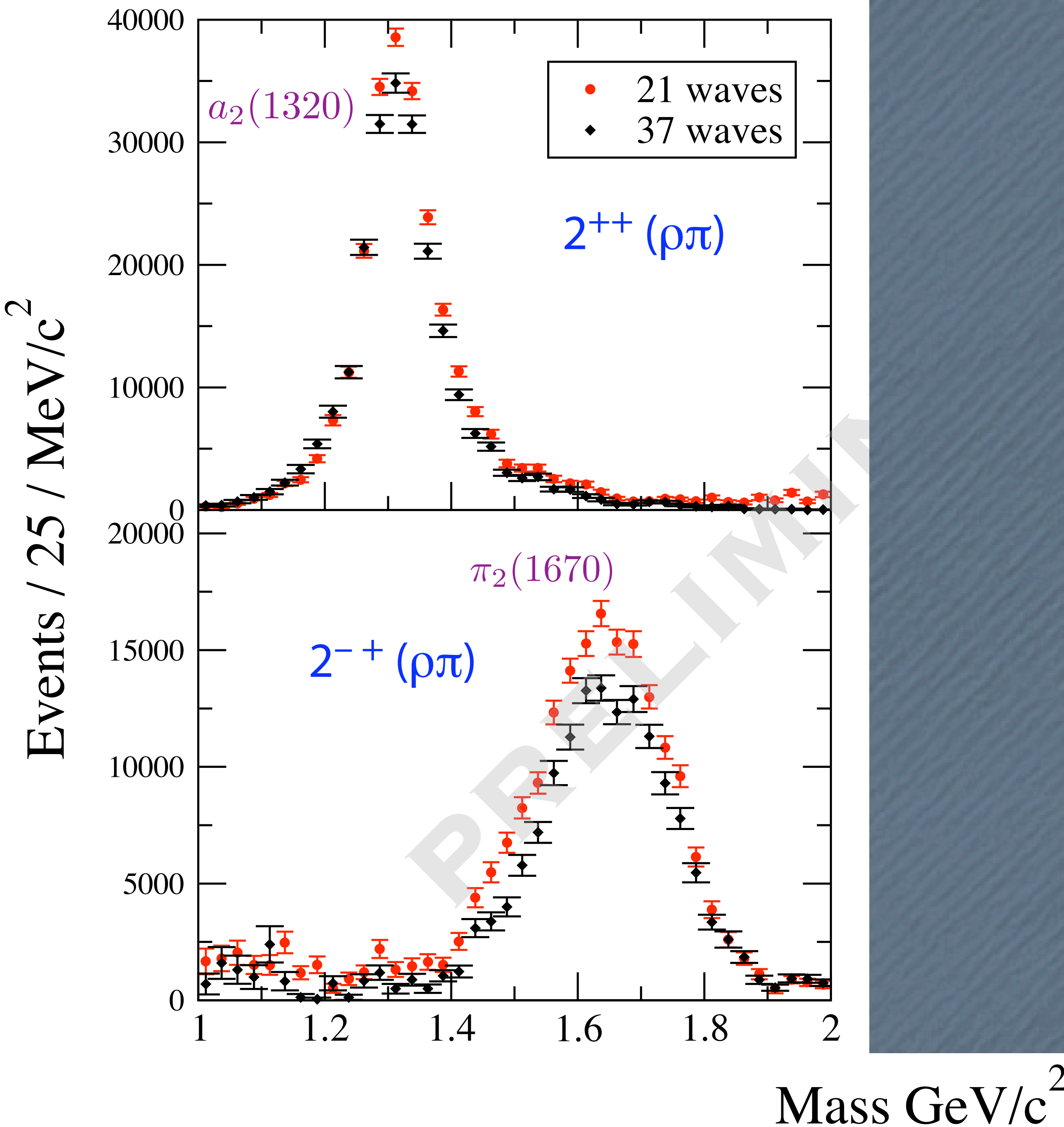
Using Moments as Arbiter



$$H^{\exp}_{LMN}(t, M_{3\pi}) = \sum_{j=1}^{N_{\text{data}}} D^{L}_{MN}(\alpha_j, \beta_j, \gamma_j)$$ from data

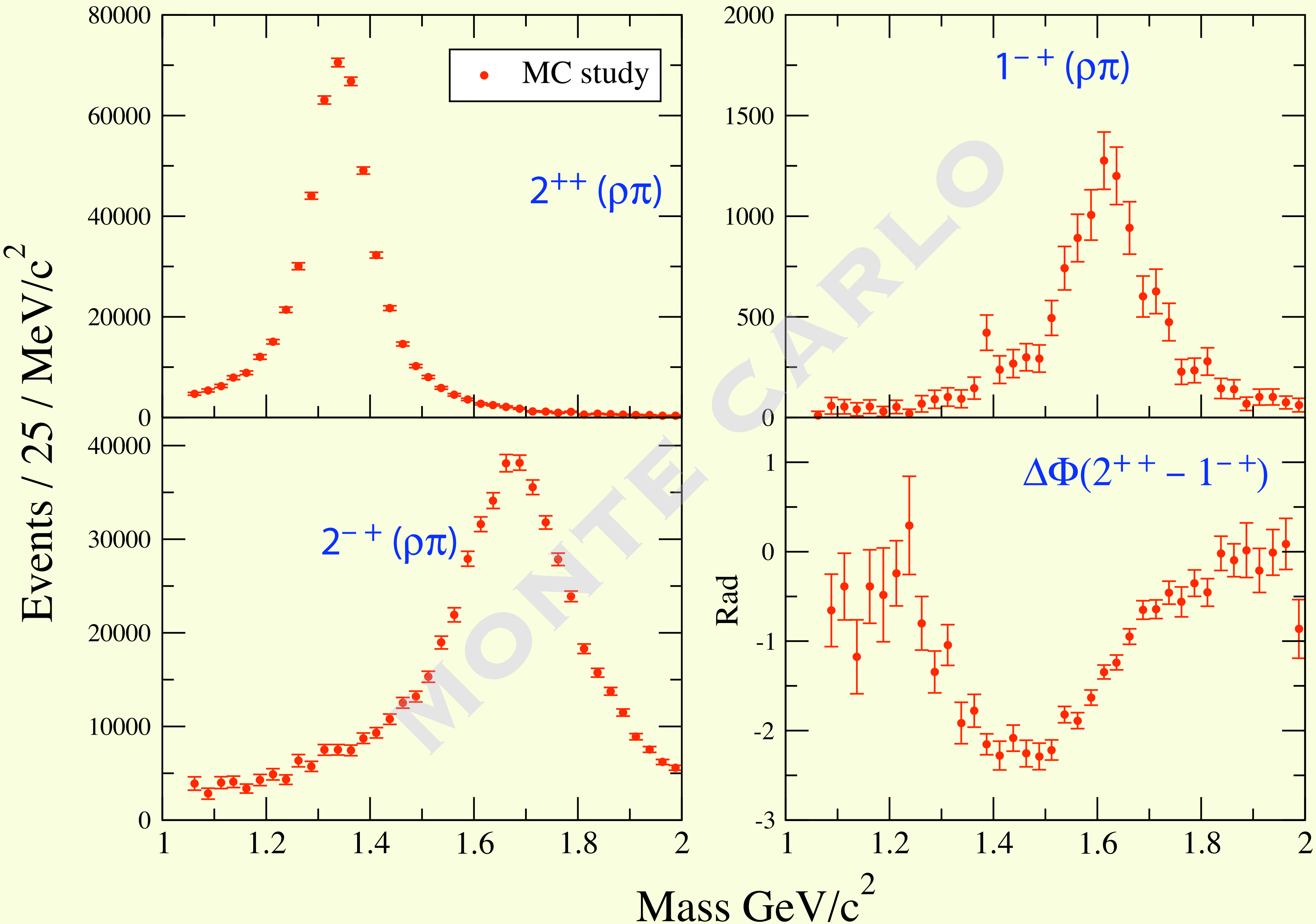
$$H^{\exp}_{LMN}(t, M_{3\pi}) = \frac{1}{N_{\text{raw}}} \sum_{j=1}^{N_{\text{acc}}} I(s_1, s_2, \alpha_j, \beta_j, \gamma_j) D^{L}_{MN}(\alpha_j, \beta_j, \gamma_j)$$ from PWA

Exotic Wave



Events / 25 / MeV/c^2
$a_2(1320)$
21 waves
37 waves
2^{++} ($\rho\pi$)
$\pi_2(1670)$
2^{-+} ($\rho\pi$)
Mass GeV/c^2

Monte Carlo



MC study
2^{++} (ρπ)
1^{-+} (ρπ)
2^{-+} (ρπ)
$\Delta\Phi(2^{++} - 1^{-+})$
Events / 25 / MeV/c^2
Rad
Mass GeV/c^2
MONTE CARLO

High Statistics, Resolution, Acceptance, PID are Key

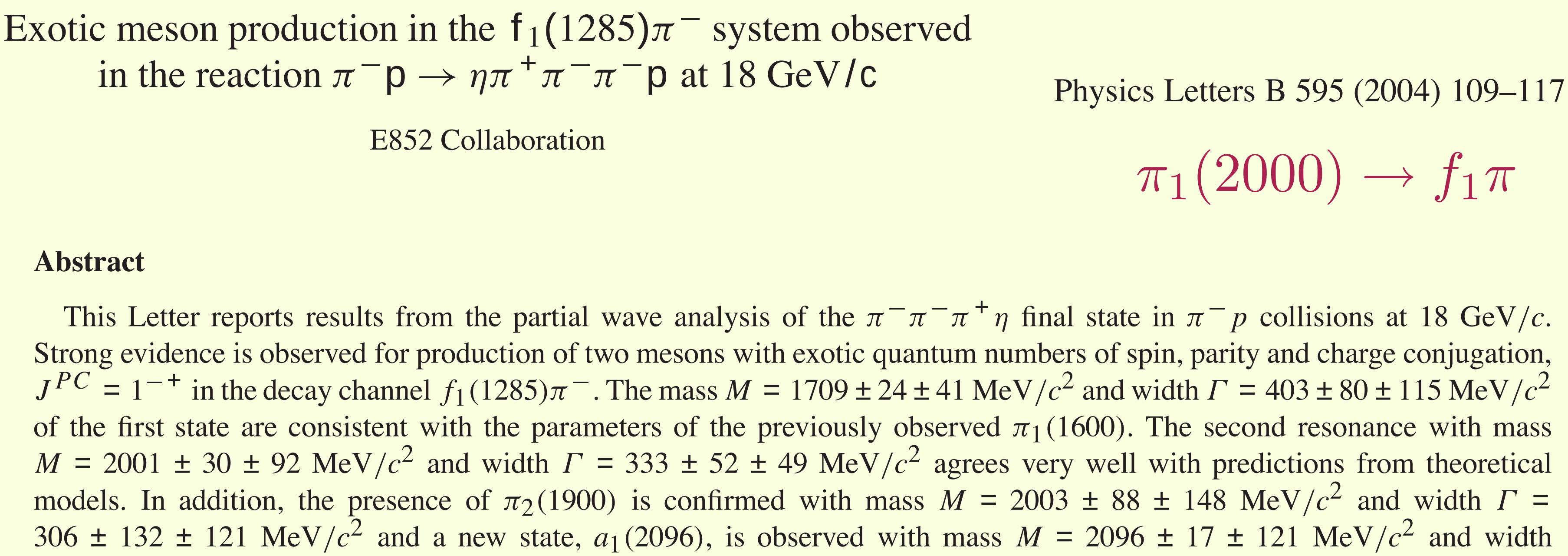
Is the $\pi_1(1600)$ real?

GlueX will resolve this issue with:

- superior statistics (more than 2-3 orders of magnitude compared to E852)
- superior acceptance (to eliminate leakage of one partial wave into another)
- resolution (which will eliminate background reactions with similar charged particle topologies)
- particle identification (which will eliminate background reactions with similar charged particle topologies - especially important when looking at channels with strangeness).

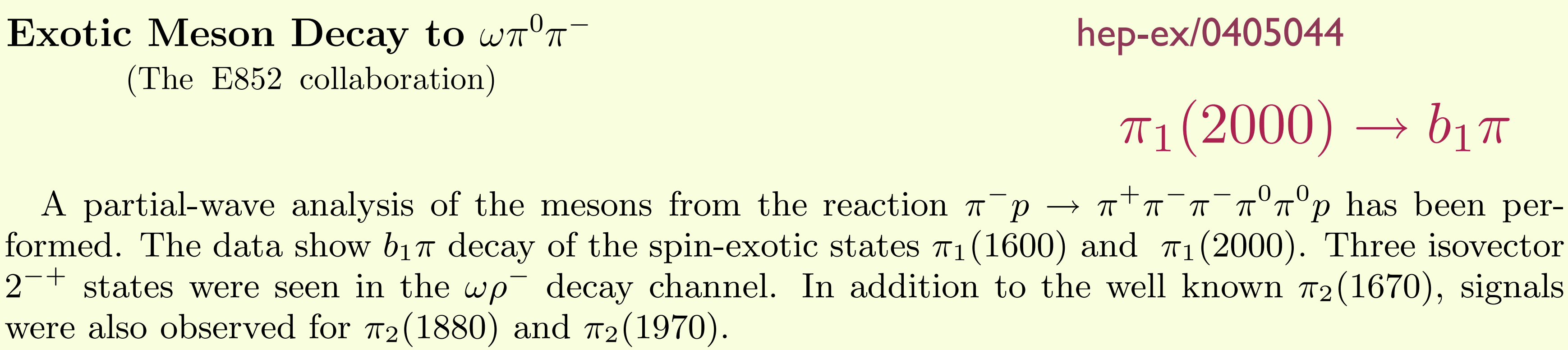
And models predict that if the $\pi_1(1600)$ is real it will be photoproduced with cross-sections comparable to that of the conventional mesons like the $a_2(1320)$ in contrast to E852 where the cross section is a few per-cent of the conventional mesons.

More From E852



Physics Letters B 595 (2004) 109–117

$\pi_1(2000) \to f_1\pi$



hep-ex/0405044

$\pi_1(2000) \to b_1\pi$

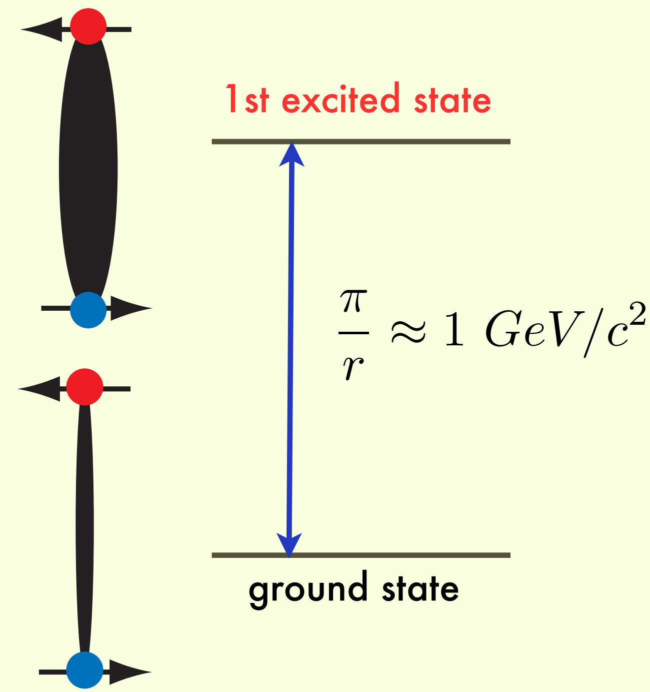
Encouraging! - These are more in line with what is expected from models and LQCD in terms of mass and decay modes. But the statistics are low (limiting the checks that should be done) but GlueX will confirm these states if they are real - not just these states but the nonets of exotics and in multiple decay channels.

Hybrid Masses

Lightest exotic hybrids from LQCD:

Author			1^{-+} Mass (GeV/c^2)	
Collab.	Year	Ref.	$u\bar{u}/d\bar{d}$	$s\bar{s}$
UKQCD	(1997)	[2]	1.87 ± 0.20	2.0 ± 0.2
MILC	(1997)	[3]	$1.97 \pm 0.09 \pm 0.30$	$2.170 \pm 0.080 \pm 0.30$
MILC	(1999)	[4]	$2.11 \pm 0.10 \pm (sys)$	
SESAM	(1998)	[5]	1.9 ± 0.20	
Mei& Luo	(2003)	[6]	$2.013 \pm 0.026 \pm 0.071$	
Bernard *et al.*	(2004)	[7]	1.792 ± 0.139	2.100 ± 0.120

Table 1: Recent results for the light-quark 1^{-+} hybrid meson masses.



Multiplet	J^{PC}	Mass (GeV/c^2)
π_1	1^{-+}	1.9 ± 0.2
b_2	2^{+-}	2.0 ± 0.11
b_0	0^{+-}	2.3 ± 0.6

$u\bar{u}/d\bar{d}$

Other multiplets - from LQCD expect these to be heavier for:

$s\bar{s} \approx\ 0.2 - 0.3\ GeV/c^2$

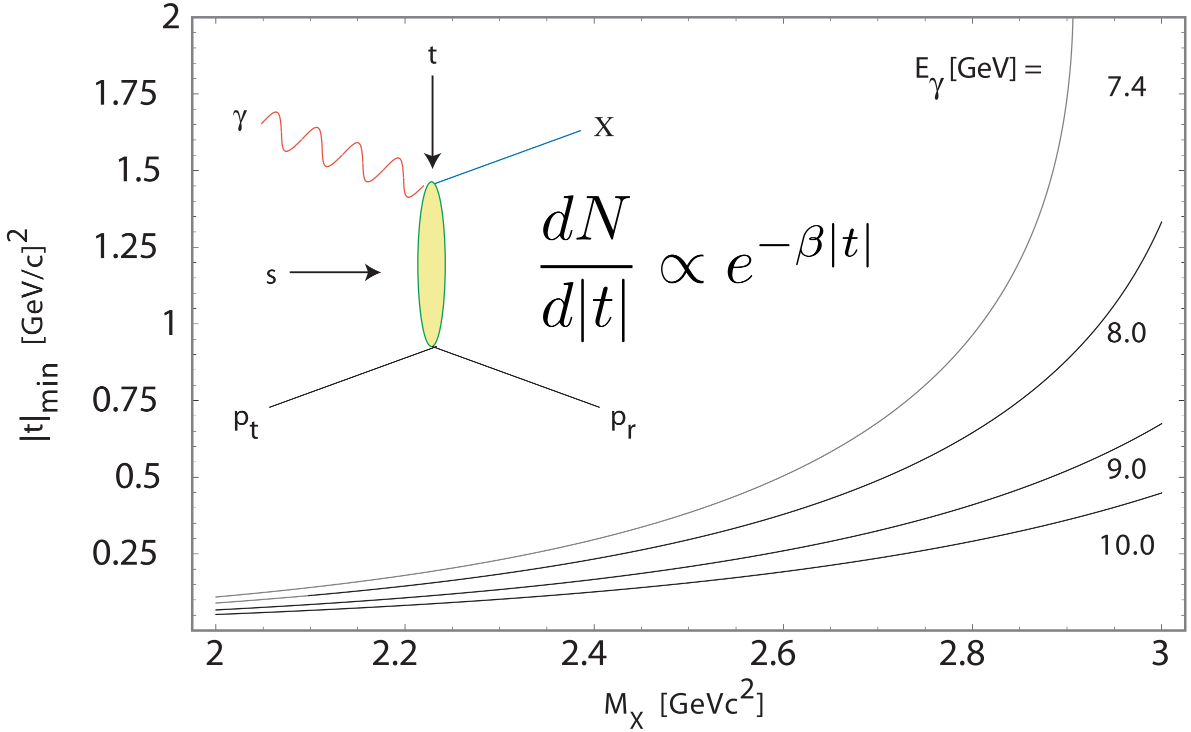
SESAM Collaboration

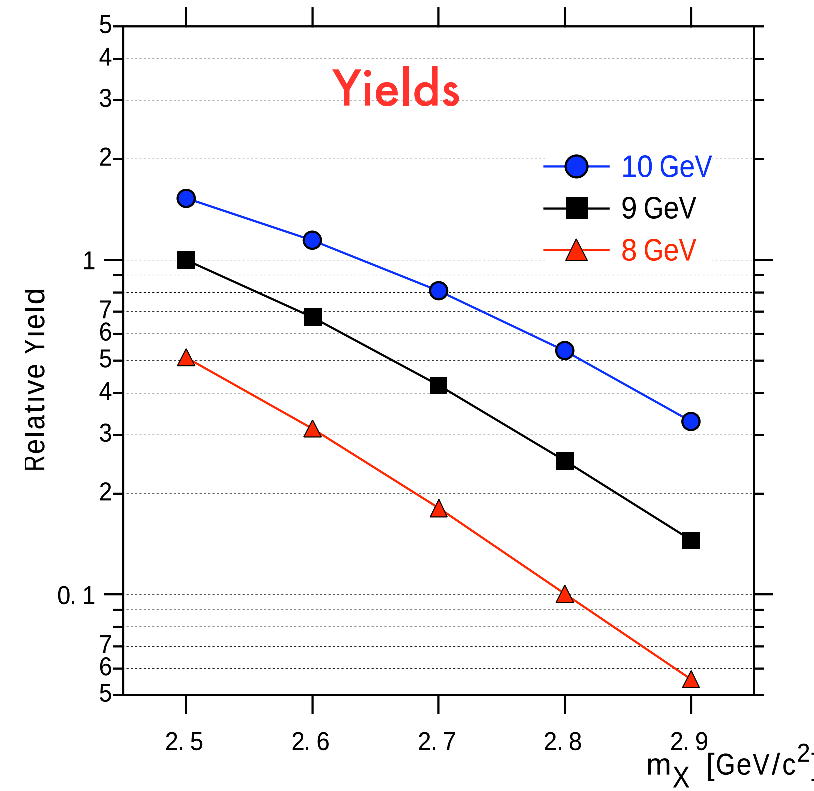
Conclusion: There is enough uncertainty in masses and widths - sensitivity is needed up to masses of about 2.8 GeV/c ^{2} so the mass reach should extend to 3 GeV/c ^{2}

Line shape and yields of higher-mass resonances

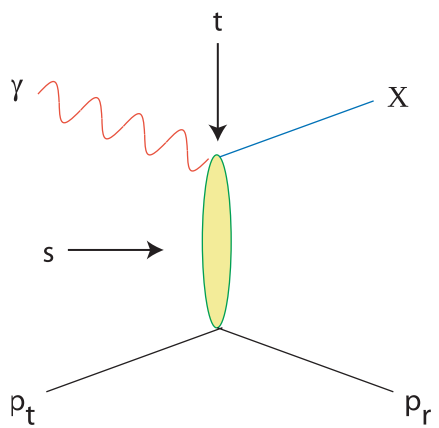
$$\gamma p \longrightarrow X p$$

$$N(m_X) = A \cdot BW(m_X) \cdot e^{-8|t|}$$

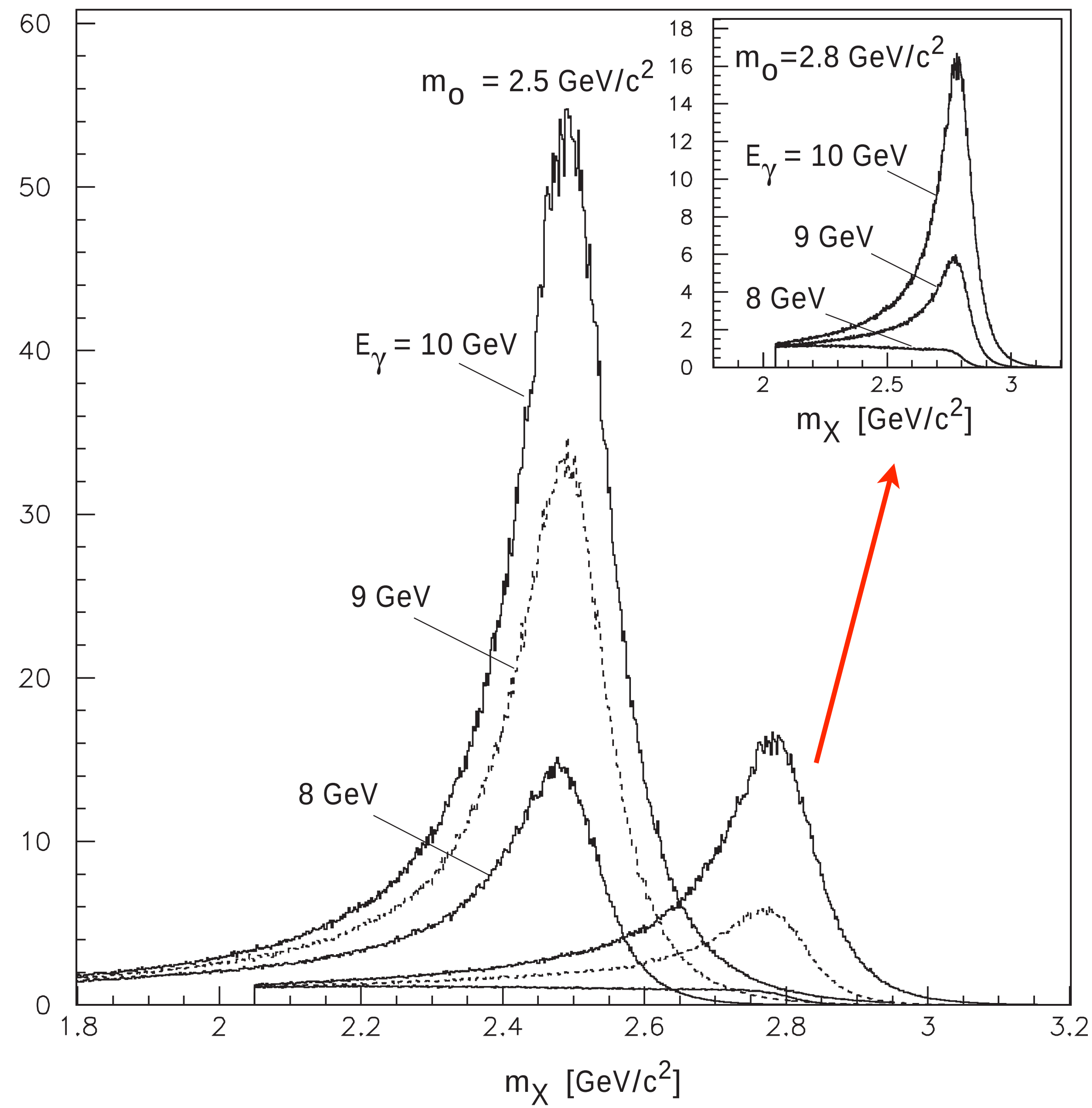




Line shape distortion



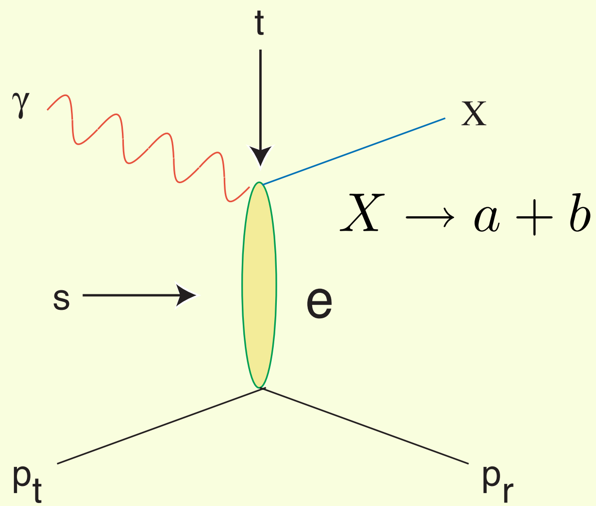
$$N(m_X) = A \cdot BW(m_X) \cdot e^{-8|t|}$$



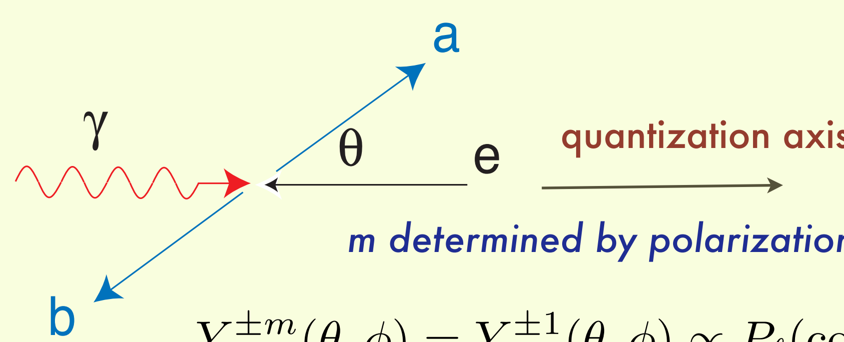
Conclusion:

9 GeV *photons suffice and well-matched to the solenoidal design of the GlueX detector.*

Why linear polarization?



assume that X decays into two spin-less mesons: a and b
and that e is also spin-less



m determined by polarization of photon

$$Y_\ell^{\pm m}(\theta,\phi) = Y_\ell^{\pm 1}(\theta,\phi) \propto P_\ell(\cos\theta) e^{\pm\phi}$$

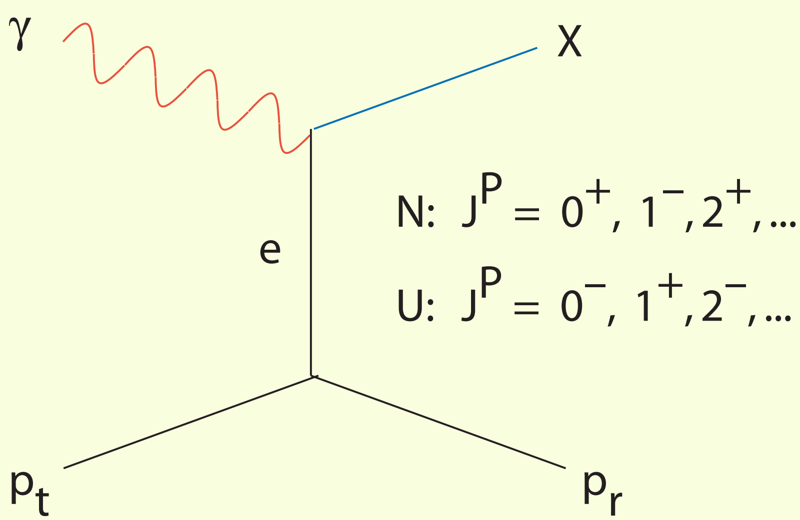
For circularly polarized photons: m = +1 or m = -1 ➡ $W(\theta,\phi) \propto |P_\ell(\cos\theta)|^2$

For unpolarized photons:
equal mixture of m = +1 and m = -1 ➡ $W(\theta,\phi) \propto |P_\ell(\cos\theta)|^2$

For x - linear polarization: ➡ $W(\theta,\phi) = |Y_\ell^{+1} - Y_\ell^{-1}|^2 \propto |P_\ell(\cos\theta)|^2 \sin^2\phi$

For y - linear polarization: ➡ $W(\theta,\phi) = |Y_\ell^{+1} + Y_\ell^{-1}|^2 \propto |P_\ell(\cos\theta)|^2 \cos^2\phi$

Why linear polarization?



Exotic Production:

Takes place via unnatural (U) parity exchange

Diffractive Production:

Through natural parity (N) exchange

Unpolarized or circular polarized photons cannot distinguish between U and N.

With longitudinal polarization one can distinguish by selection based on the angle the polarization vector makes with the production plane.

PHYSICAL REVIEW D, VOLUME 61, 114008

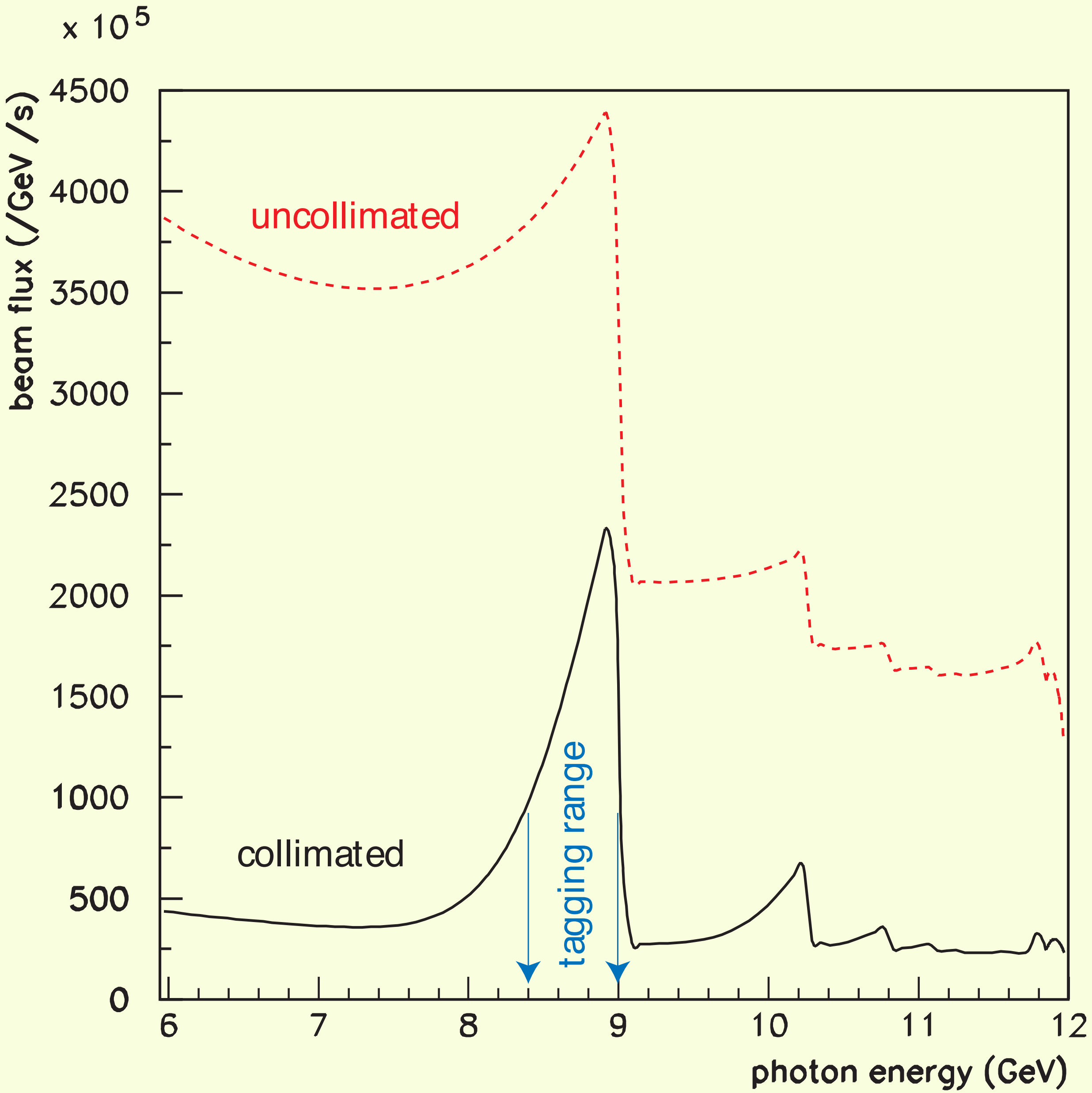
Andrei V. Afanasev
Adam P. Szczepaniak

Charge exchange $\rho^0\pi^+$ photoproduction and implications for searches for exotic mesons

We analyze the processes $\vec{\gamma}+p\rightarrow\rho^0\pi^+n$ at low momentum transfer focusing on the possibility of the production of an exotic $J^{PC}=1^{-+}$ meson state. In particular we discuss polarization observables and conclude that linear photon polarization is instrumental for separating the exotic wave.

Coherent Bremsstrahlung and Collimation

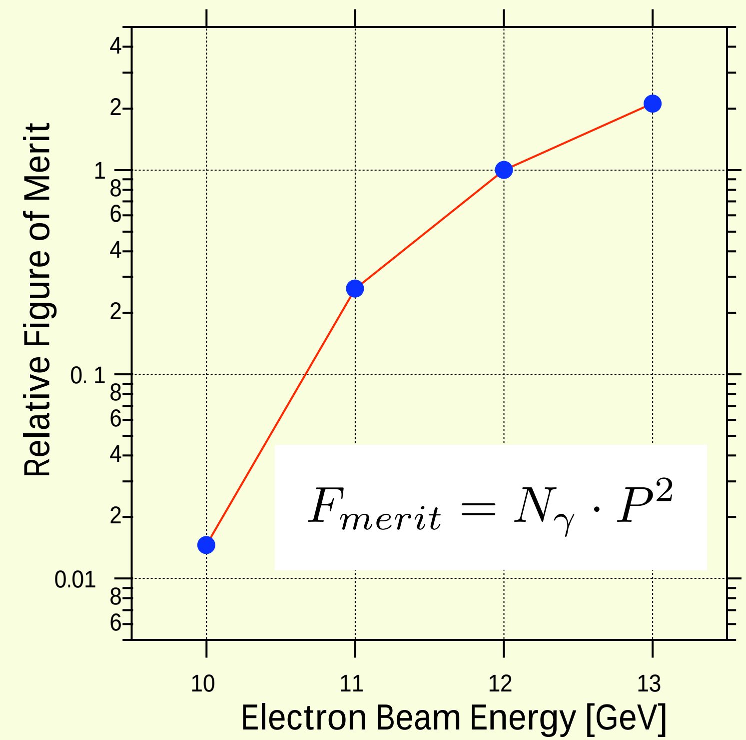
Provides Linear Polarization



electron beam energy	10 GeV	11 GeV	12 GeV	13 GeV
electron beam current	4.3 μA	3.5 μA	3.0 μA	2.5 μA
N_γ in peak	32 M/s	67 M/s	100 M/s	130 M/s
peak polarization	0.14	0.28	0.41	0.48
average polarization	0.08	0.24	0.37	0.47
peak tagging efficiency	0.25	0.43	0.50	0.57
average tagging efficiency	0.15	0.29	0.41	0.51
power on collimator	4.4 W	4.4 W	4.5 W	4.5 W
power on target	510 mW	610 mW	730 mW	850 mW
total hadronic rate	370 K/s	370 K/s	370 K/s	370 K/s
tagged hadronic rate	5 K/s	10 K/s	16 K/s	21 K/s
relative figure of merit	0.015	0.263	1.0	2.118

fixed → (total hadronic rate)

Fix Photon Energy at 9 GeV
Vary the Electron Energy



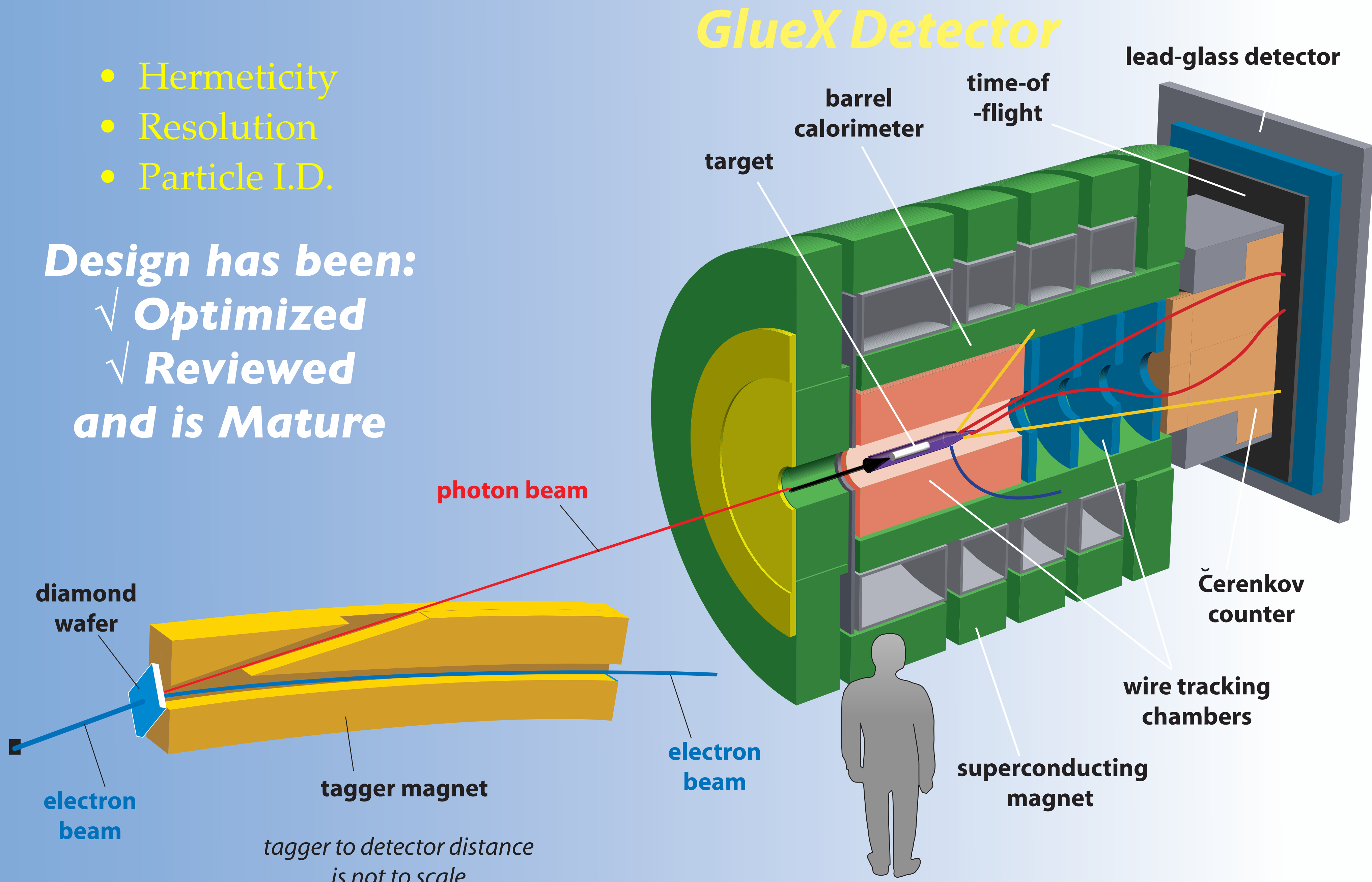
Conclusion:

12 GeV electrons essential and
13 GeV would be better!

Optimized for doing amplitude analyses

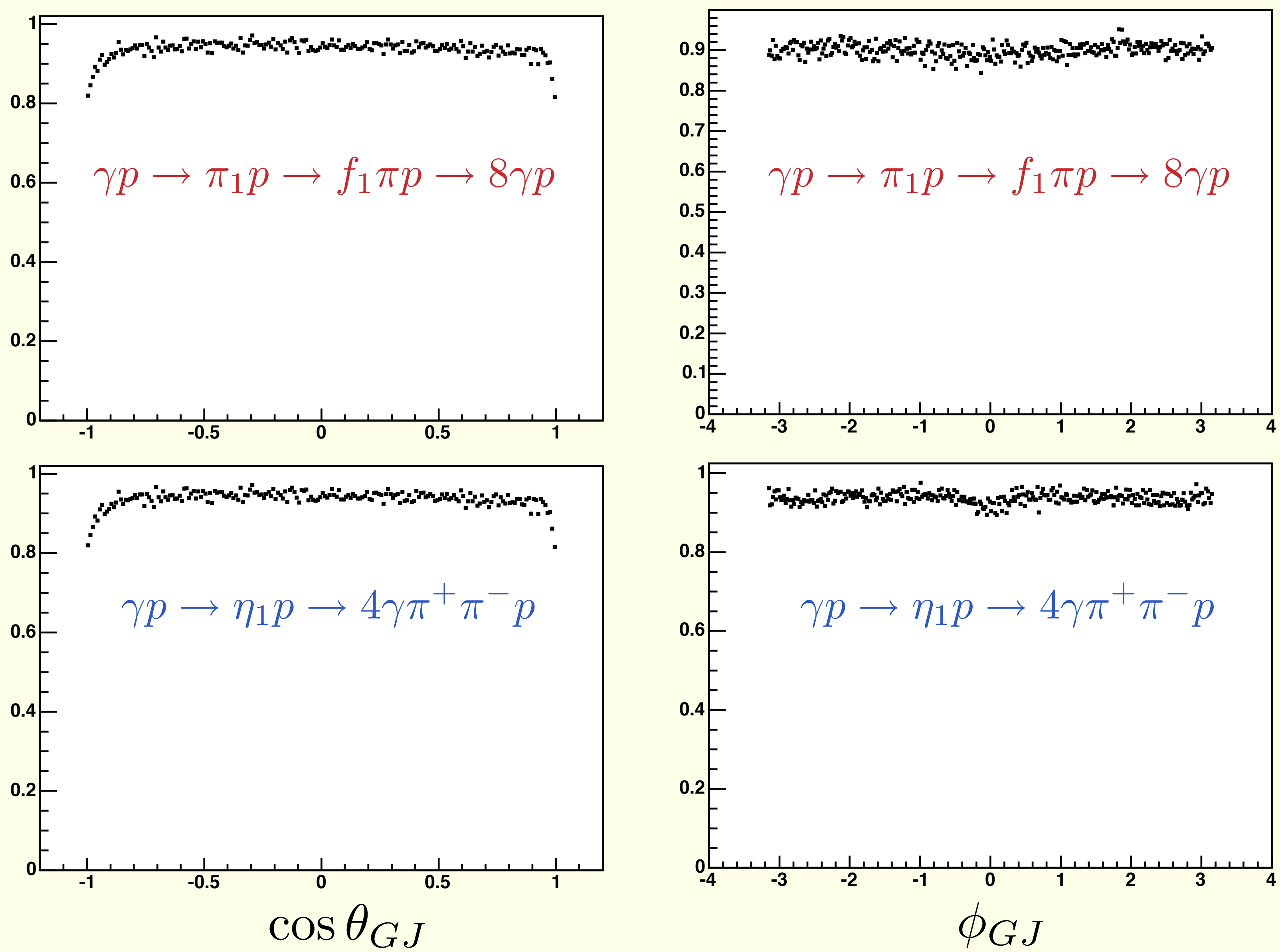
- Hermeticity
- Resolution
- Particle I.D.

Design has been:
√ Optimized
√ Reviewed
and is Mature



Collaboration has been carrying out R&D for last 5 years

Acceptance in Relevant Decay Angles



Exotic Hybrid Spectroscopy

GlueX seeks to map nonets of exotics (not just find one state) and determine branching ratios.

Exotic hybrids will be the initial focus - these states cannot mix with conventional mesons and these are also more likely to have rich decay modes into 2 and up to 6 stable particles including charged and neutral π and K mesons.

Particle	J^{PC}	Total Width (MeV/c^2) [8]	[9]	Most Likely Decays
π_1	1^{-+}	$81-168$	117	$b_1\pi$, $\rho\pi$, $\eta(1295)\pi$
η_1	1^{-+}	$59-158$	107	$a_1\pi$, $\pi(1300)\pi$
η_1'	1^{-+}	$95-216$	172	$K_1(1400)K$, $K_1(1270)K$, K^*K
b_0	0^{+-}	$247-429$	665	$\pi(1300)\pi$, $h_1\pi$
h_0	0^{+-}	$59-262$	94	$b_1\pi$
h_0'	0^{+-}	$259-490$	426	$K(1460)K$, $K_1(1270)K$
b_2	2^{+-}	$5-11$	248	$a_2\pi$, $a_1\pi$, $h_1\pi$
h_2	2^{+-}	$4-12$	166	$b_1\pi$, $\rho\pi$
h_2'	2^{+-}	$5-18$	79	$K_1(1400)K$, $K_1(1270)K$, $K_2^*(1430)K$

Table 3: Exotic quantum number hybrid width and decay predictions.

GlueX has excellent acceptance, resolution and particle ID for these modes and it will be essential to measure these branching ratios.

Hybrid and Light Quark Spectroscopy (II)

Non-exotic hybrids will be mapped as well and this requires an understanding of the conventional spectrum as well. It will also be essential to measure branching ratios – essential information lies in the pattern of decays.

Particle	J^{PC}	Total Width MeV [8]	[9]	Large Decays
ρ	1^{--}	$70-121$	112	$a_1\pi$,$\omega\pi$, $\rho\pi$
ω	1^{--}	$61-134$	60	$\rho\pi$, $\omega\eta$, $\rho(1450)\pi$
ϕ	1^{--}	$95-155$	120	$K_1(1400)K$, K^*K, $\phi\eta$
a_1	1^{++}	$108-204$	269	$\rho(1450)\pi$, $\rho\pi$, K^*K
h_1	1^{++}	$43-130$	436	K^*K, $a_1\pi$
h_1'	1^{++}	$119-164$	219	$K^*(1410)K$,K^*K
π	0^{-+}	$102-224$	132	$\rho\pi$,$f_0(1370)\pi$
η	0^{-+}	$81-210$	196	$a_0(1450)\pi$, K^*K
η'	0^{-+}	$215-390$	335	K_0^*K,$f_0(1370)\eta$, K^*K
b_1	1^{+-}	$177-338$	384	$\omega(1420)\pi$,K^*K
h_1	1^{+-}	$305-529$	632	$\rho(1450)\pi$, $\rho\pi$, K^*K
h_1'	1^{+-}	$301-373$	443	$K^*(1410)K$, $\phi\eta$, K^*K
π_2	2^{-+}	$27-63$	59	$\rho\pi$,$f_2\pi$
η_2	2^{-+}	$27-58$	69	$a_2\pi$
η_2'	2^{-+}	$38-91$	69	K_2^*K, K^*K

Table 4: Non-exotic quantum number hybrid width and decay predictions.

Strangeonium Spectroscopy

$$\gamma \Rightarrow s\bar{s}$$

Strangeonium is the bridge between the lighter quark sector and charmonium and photoproduction will be rich in producing strangeonium.

Only 5 strangeonium states are well-established.

Look for decay modes:

$$s\bar{s} \longrightarrow \phi\eta$$

$$s\bar{s} \longrightarrow \phi\eta'$$

$$s\bar{s} \longrightarrow \phi\phi$$

$$s\bar{s} \longrightarrow K^*\bar{K}$$

$$s\bar{s} \longrightarrow K^*\bar{K}^*$$

$$s\bar{s} \longrightarrow K_1\bar{K}$$

$$s\bar{s} \longrightarrow K_2\bar{K}$$

Baryon Spectroscopy

GlueX is an 'electronic bubble chamber.' The interplay between excited meson and baryon resonance production - with excellent acceptance for both - will be studied.

GlueX will also search in the hyperon and cascade sectors - with the potential to determine spin/parity of these states.

Although current evidence for S = +1 baryons seems problematic, GlueX can (and will) study final states such as:

$$\gamma p \to K^+ K^- \pi^+ n$$

$$\gamma p \to K^* (K^+ n)$$

$$\gamma p \to \phi \Delta$$

$$\gamma p \to a_2 \Delta$$

Australia

Mexico

Russia

GlueX Collaboration

Canada

United Kingdom

100 Physicists
28 Institutions
7 Countries

+ an active theory group

Greece

USA

GlueX Management

GlueX Organization Chart

- *Each institution has written an MOU with the collaboration*
- *Procedures for admitting new collaborating institutions and removal of collaborating institutions are in place*

Executive Group (EG)

Spokesperson
Alex Dzierba
Deputy Spokesperson
Curtis Meyer
Hall D Group Leader
Elton Smith

- *Spokesperson elected by Collaboration for four-year tem*
- *Deputy selected by Spokesperson and confirmed by CB*
- *Hall D Leader appointed by JLab management*

Collaboration Board (CB)

Chair
George Lolos
Members
Dan Carman
Paul Eugenio
Richard Jones
Jim Kellie
Adam Szczepaniak

- *Members elected for two-year terms*
- *Chair selected by CB members*

Technical Review Commmittee

***Spokesperson** (Chair)*
Deputy Spokesperson
Hall D Group Leader
+ Coordinators of Working Groups shown below

Working Groups

Civil	Magnet	Beam	Detector	Electronics	Software	PWA
*** E. Smith**	*** P. Brindza**	*** J. Kellie**	*** C. Meyer**	*** P. Smith**	*** D. Lawrence**	***A. Szczepaniak**
P. Brindza	*E. Scott*	*R. Jones*	*W. Boeglin*	*D. Abbott*	*D. Abbott*	*P. Eugenio*
E. Scott		*D. Sober*	*D. Carman*	*F. Barbosa*	*E. Brash*	*C. Meyer*
E. Wolin			*S. Denisov*	*C. Cuevas*	*P. Eugenio*	*S. Teige*
			P. Eugenio	*D. Doughty*	*G. Fox*	
			G. Lolos	*E. Jastrzembski*	*R. Jones*	
			R. Mitchell	*J. Pinfold*	*Z. Papandreou*	
			Z. Papandreou	*T. Smith*	*S. Philpott*	
			S. Spanier	*E. Wolin*	*E. Wolin*	
			S. Teige			

*** coordinators**

more members will be added to the working groups

Reviews of GlueX/Hall D

Cassel Committee
December, 1999

David Cassel	Cornell University
Frank Close	Rutherford Laboratory
John Domingo	Jefferson Laboratory
William Dunwoodie	Stanford Linear Accelerator
Donald Geesaman	Argonne National Laboratory
David Hitlin	California Institute of Technology
Martin Olsson	University of Wisconsin
Glenn Young	Oak Ridge National Laboratory

GlueX Electronics
July, 2003

John Domingo	Jefferson Lab
Andy Lankford	U California - Irvine
Glenn Young	Oak Ridge National Lab

GlueX Detector
October, 2004

Mike Albrow	Fermilab
Jim Alexander	Cornell University
William Dunwoodie	Stanford Linear Accelerator
Bernhard Mecking	Jefferson Lab

Magnet Review
November, 2004

John Alcorn	LASS engineer, Jefferson Lab engineer (retired)
Bob Kephart	Fermilab
Claus Rode	Jefferson Lab

GlueX and Upgrade Presentations and Reviews

JLab PAC
NSAC
APS Town Meeting

Lehman Review for Upgrade & GlueX - 2005

GlueX Review

Mike Albrow, Jim Alexander, Bill Dunwoodie, Bernhard Mecking

November 9, 2004

From the Introduction

The Committee was satisfied overall with the detector concepts and the strategy the Collaboration has taken with respect to detector design. Designs are well based on prior experience which is either from local experiments (CLAS), or from elsewhere (LASS,KLOE), and on proven technology, which includes existing devices (LGD, magnet), or existing infrastructure (DAQ). Local experience with photon beams is also an important element which allows reliable estimates of rates and backgrounds.

The Committee was also impressed at the amount of R&D the Collaboration has managed to achieve over a period of years in which the prospects have been so uncertain. This speaks to strong physics motivation, coherent leadership, and a vibrant sociology within the Collaboration.

The committee raised a number of concerns about several of the sub-systems and the collaboration is now addressing these. The committee also urged the laboratory to move rapidly on confirming a Hall-D coordinator.

Closing: GlueX Goals and 6 Years of Preparation

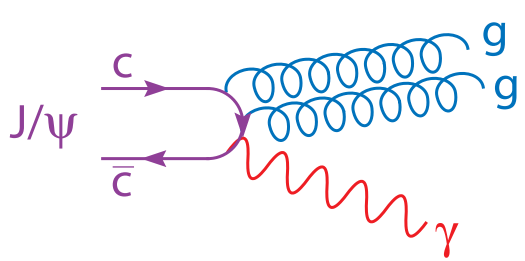
The main goal of GlueX addresses a fundamental physics issue and GlueX has significant discovery potential. And the recent progress in LQCD provides the stage on which to understand the results from GlueX. LQCD results on exotics and their masses and decays should come about the same time as results from GlueX.

The science goals have always included mapping the spectrum of exotic hybrids, non-exotic hybrids, strangeonium and light quark mesons and the interplay of baryon and meson resonances. The physics is rich and the detector is versatile. And the detector has been continually optimized in performance and cost - each subsystem has and continues to undergo this optimization.

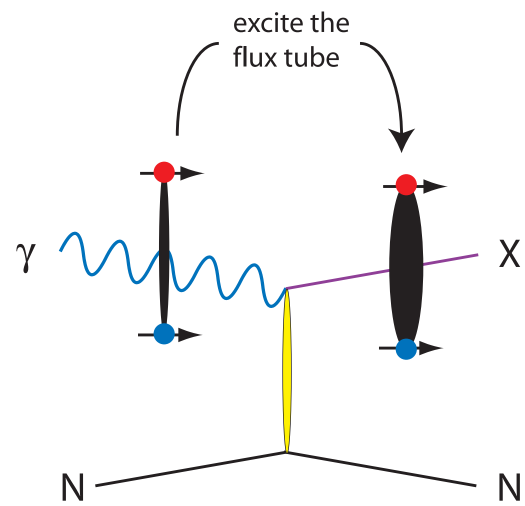
The collaboration has been active since late 1997 evolving a science plan and a detector design. The collaboration requested external reviews of the science and detectors in 1999 (Cassel committee), 2003 (electronics), 2004 (detector and magnet). The collaboration has responded to issues raised by those committees. Between 2000 and 2003 the collaboration presented the science program and technique to town meetings, NSAC and PAC's. This program has also been described in a series of Design Reports starting in 1999 and the next version - ver 5 - is in preparation.

Closing: Preparing for the Analysis

A careful amplitude analysis requires software and phenomenology tools which are being developed for the high statistics 3π analysis now in progress. These include understanding the limitations of the isobar model, isobar parameterization, constructing Deck effect amplitudes, optimizing the PWA fitters to run on multiple processors and developing visualization software. We are collaborating with physicists from CLEO-c who will be analyzing 1 billion J/ψ decays on seeking funding for developing analysis tools.



Gluonic excitations: Glueballs



Gluonic excitations: Exotic Hybrids

QCD and the Role of Gluonic Excitations

Links

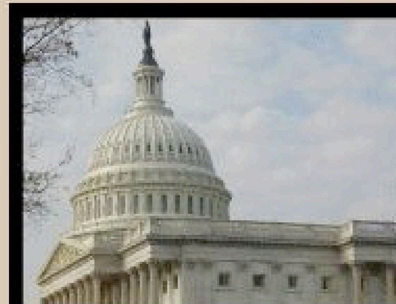
- Charge
- Organizers
- Feb. Pre-meeting
- Agenda
- Registration
- Abstracts
- Participants Links
- Directions to SURA
- Poster

Related Links

- SURA
- Cornell LEPP
- CLEO-c
- Jefferson Lab
- GlueX

QCD and the Role of Gluonic Excitations

Theoretical and Experimental Issues
April 28-30, 2005
SURA Headquarters, Washington, D.C.



SURA Headquarters
1201 New York Ave NW Suite 430
Washington, DC 20005 USA

One of the outstanding questions in physics is to understand the mechanisms behind confinement of quarks. A series of new experiments, including the GlueX at JLab, CLEO-c at Cornell, or PANDA at GSI have been recently advanced to focus on this issue by searching for new kind of hadronic matter: hadrons with gluonic excitations. On the theory side progress in lattice gauge algorithms and available computer power have been providing new insights and stimulated development of phenomenological models. When confronting the new, high statistics data new challenges will emerge associated with amplitude analysis and their interpretation.

A small workshop to address these issues will be held in the SURA headquarters in Washington DC on February 10 to 12. The main goal of this workshop is to formulate the questions, which will be addressed at more depth at a second meeting to be held at SURA on April 29-30. The workshops will have three working groups, one on glueballs, one on hybrids and one on theoretical and phenomenological issues.

http://www.jlab.org/intralab/calendar/archive05/qcd/

Closing: The Collaboration and Outside Support

All the new GlueX collaborators are new to JLab expanding the User community base. And they bring expertise from the high energy community (CLEO - FNAL - ATLAS - IHEP). The collaboration has also recruited several outstanding young physicists (postdocs and assistant professors) guaranteeing future leadership as the detector continues to be optimized and then later assembled, commissioned and operated continuing on to analysis and physics publications.

GlueX R&D has already resulted in five publications in Nucl Instr and Meth.

GlueX institutions have provided significant external support by way of manpower, infrastructure and startup funds. This was essential for our program of R&D. The collaboration successfully acquired the superconducting solenoid from MEGA (built for LASS) and now being refurbished for GlueX along with the 3000-element lead glass detector built for E852 at BNL.

So Let's Get Moving !