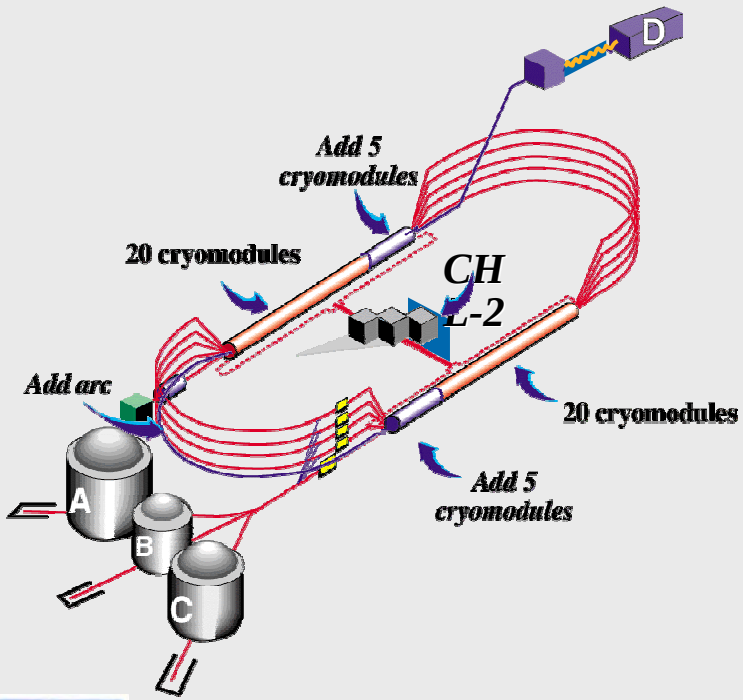
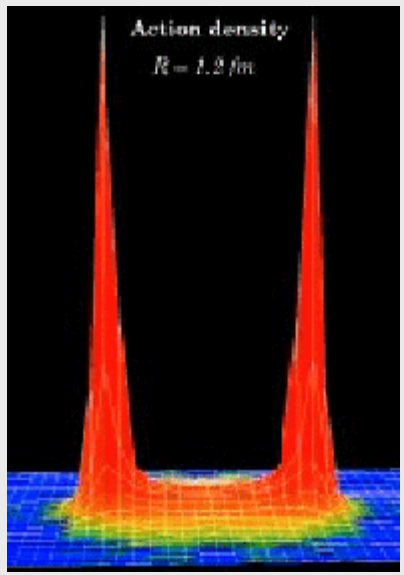
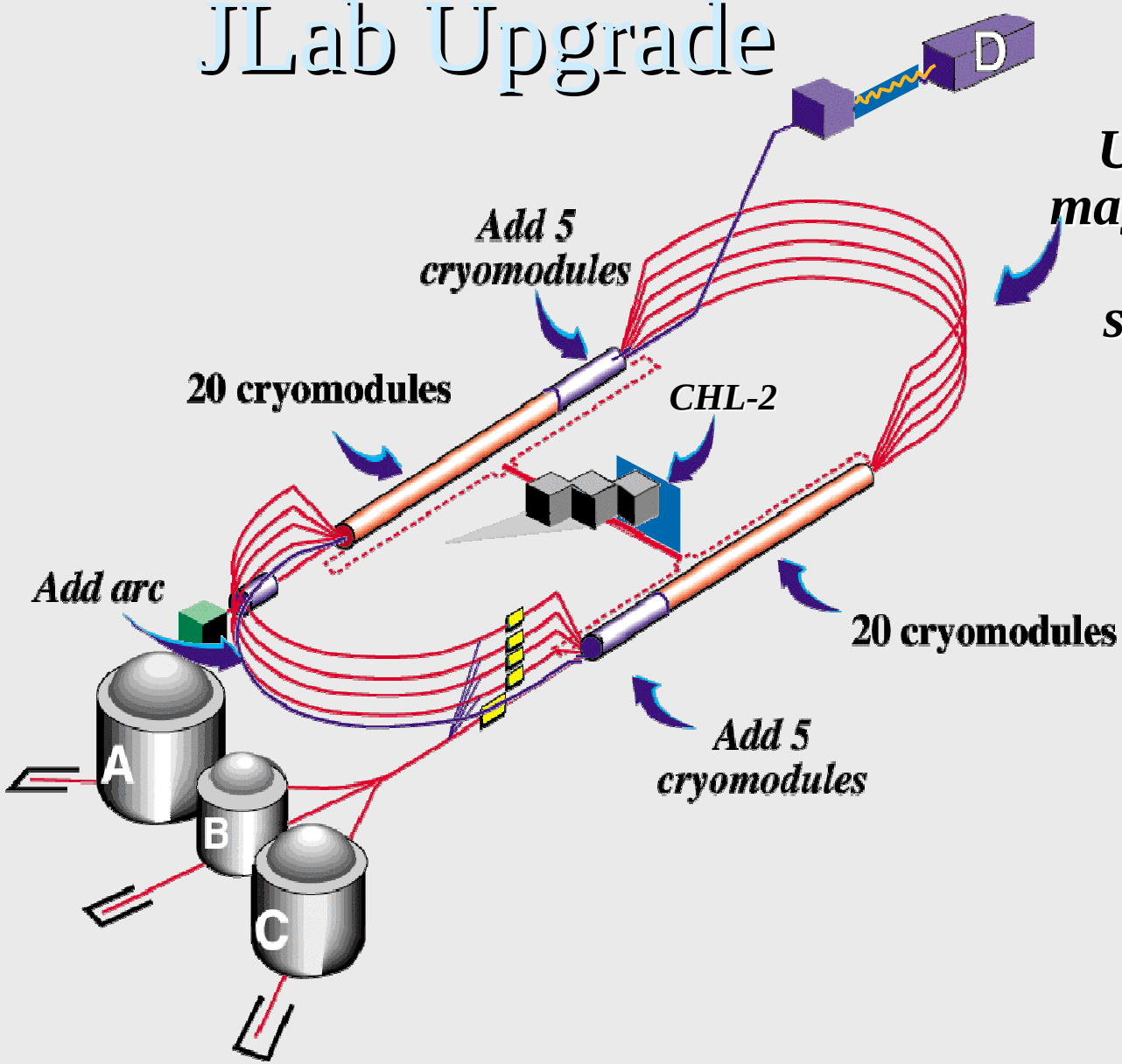
The GlueX Experiment

Curtis A. Meyer





JLab Upgrade



What's New: **The CEBAF Upgrade will take advantage of recent advances in computing power, combined with a doubling of the existing energy of the**
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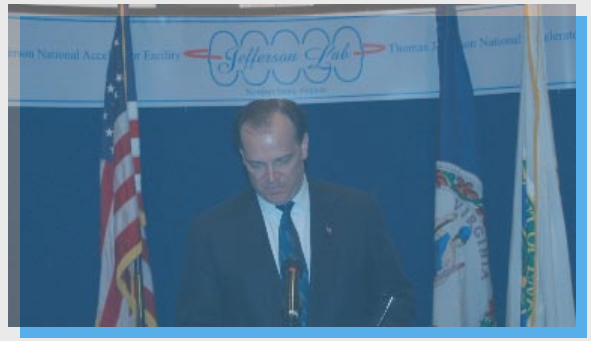
everbefore-

February 2006: Project Receives CD-1

Secretary of Energy Announces Approval and Funding for Facilities Upgrade at the Thomas Jefferson National Lab and Highlights Lab's Successful Education Programs

November 2003

12 GeV Upgrade
CD-0 Signing at
Jefferson Lab
April 19, 2004



Deputy Energy Secretary Kyle McSlarrow

The GlueX Collaboration

The search for gluonic excitations

Approximately 70 Collaborators

Members from seven countries

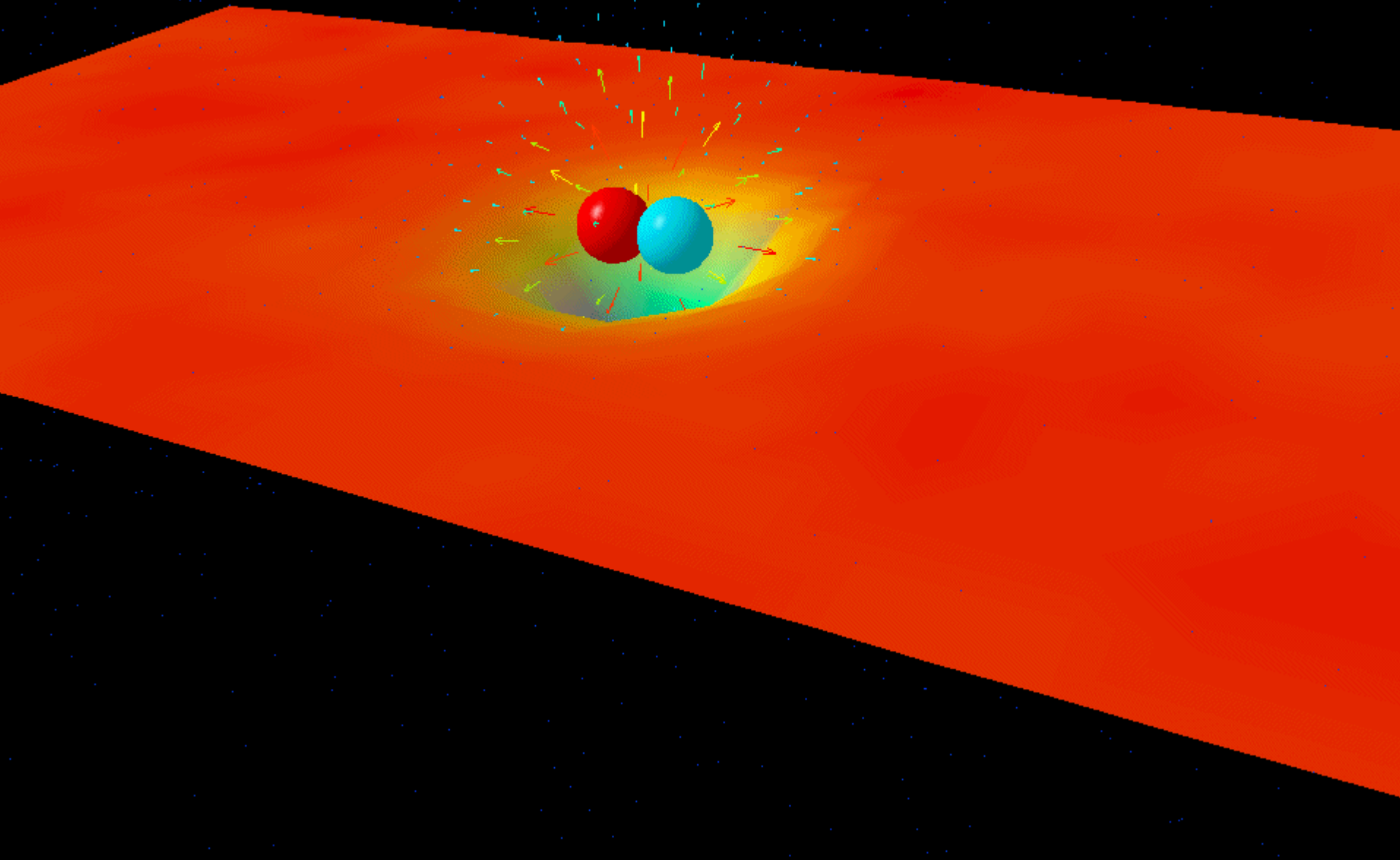
Active collaboration since 1998

New Members are very welcome

http://www.gluex.org/

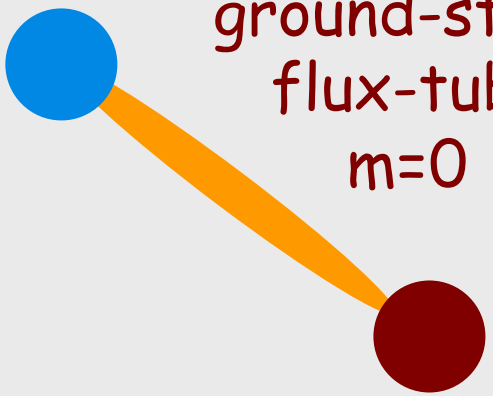
Spectrum

Flux Tubes



Hybrid Mesons

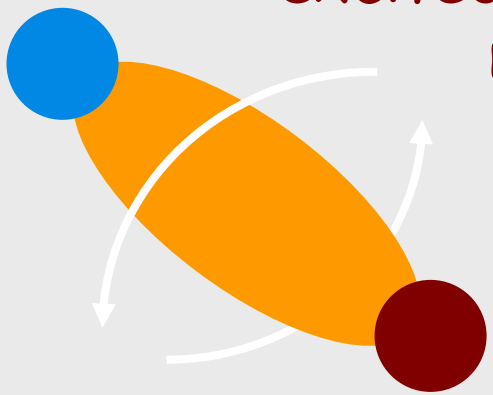
built on quark-model mesons



ground-state
flux-tube
m=0

normal mesons

$CP=\{(-1)^{L+S}\}\{(-1)^{L+1}\}$
$=\{(-1)^{S+1}\}$



excited flux-tube
m=1

1^{-+} or 1^{+-}

ρ,ω,ϕ

$S=0,L=0,m=1$

$J=1$ $CP=+$

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

(not exotic)

$S=1,L=0,m=1$

$J=1$ $CP=-$

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

$1^{-+},1^{+-}$

$2^{-+},2^{+-}$

exotic

Flux-tube Model

$m=0$ $CP=(-1)^{S+1}$

$m=1$ $CP=(-1)^{S}$

Hybrid Predictions

Flux-tube model: 8 degenerate nonets

$1^{++}, 1^{--}$ $0^{-+}, 0^{+-}, 1^{-+}, 1^{+-}, 2^{-+}, 2^{+-}$ **~1.9 GeV/c²**

S=0 S=1

Lattice calculations --- 1^{-+} nonet is the lightest

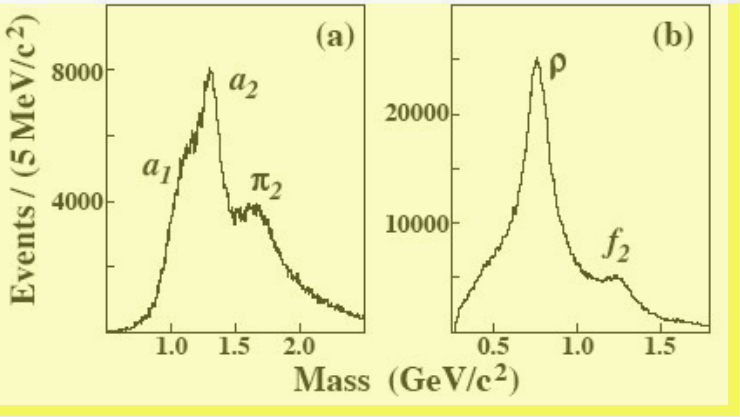
UKQCD (97)	1.87 ±0.20
MILC (97)	1.97 ±0.30
MILC (99)	2.11 ±0.10
Lacock(99)	1.90 ±0.20
Mei(02)	2.01 ±0.10
Bernard(04)	1.792±0.139

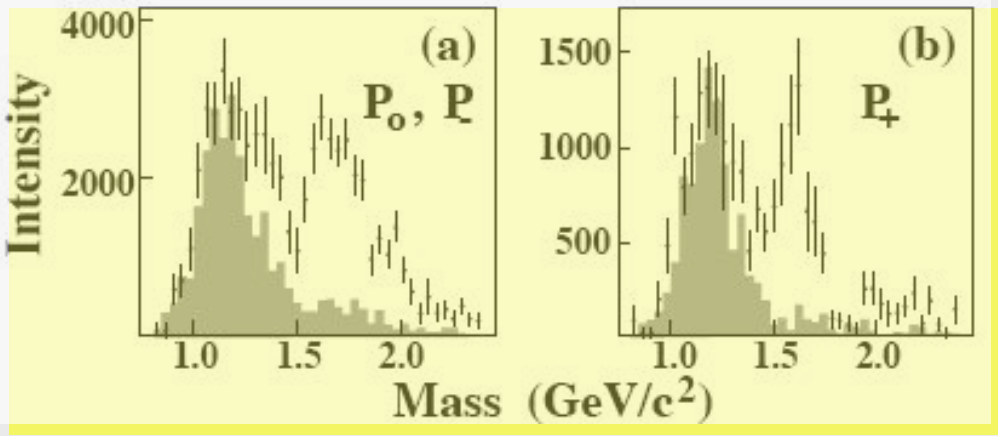
1^{-+}	1.9± 0.2
2^{+-}	2.0± 0.11
0^{+-}	2.3± 0.6

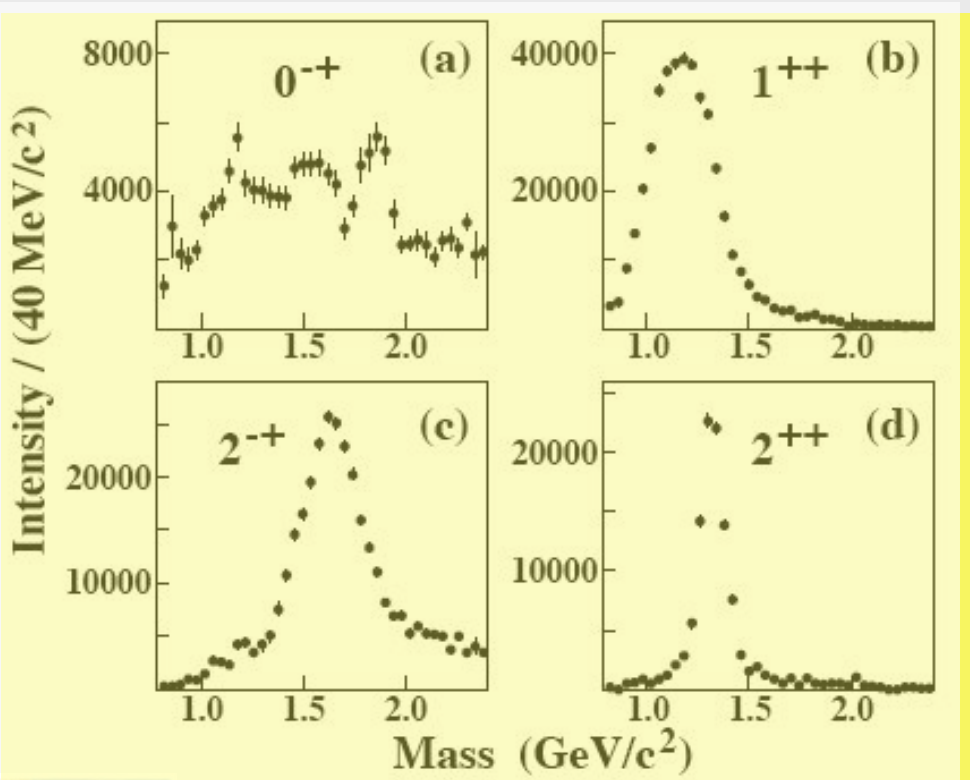
In the charmonium sector:

1^{-+}	4.39 ±0.08
0^{+-}	4.61 ±0.11

Splitting = 0.20







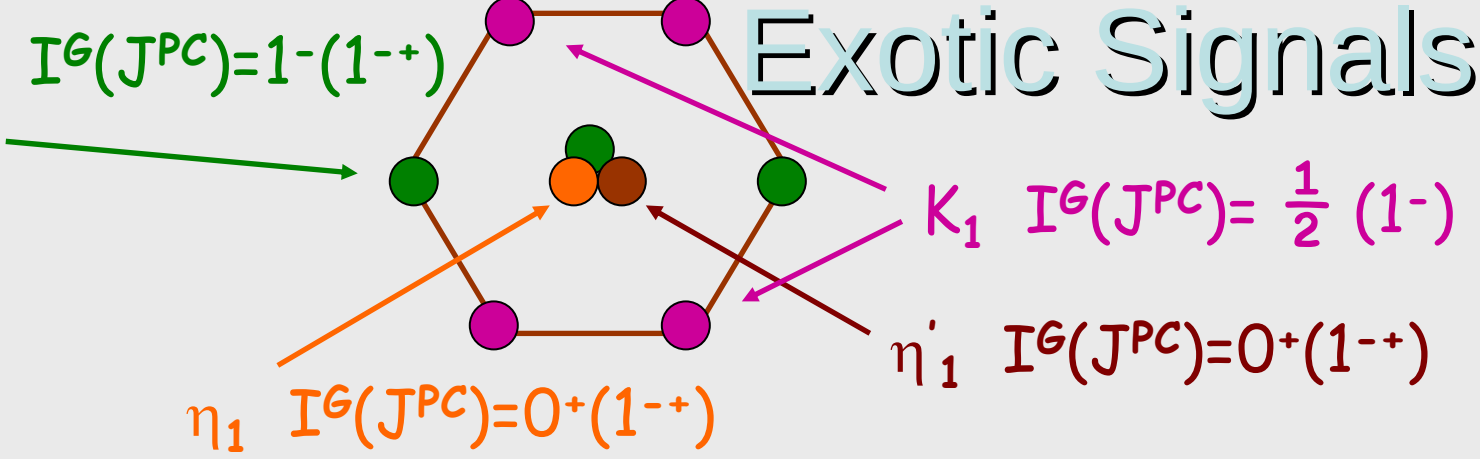
$\pi^- p \rightarrow n\, \pi^+ \pi^- \pi^-$

E852 (BNL): Exotic reported at a mass of 1.6 GeV

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

A new analysis with 10 times the statistics shows no exotic signal in $\rho\pi$.

Exotic Signals



$\pi_1(1400)$ Width ~ 0.3 GeV, Decays: only $\eta\pi$
weak signal in πp production (scattering??)
strong signal in antiproton-deuterium.

NOT A HYBRID

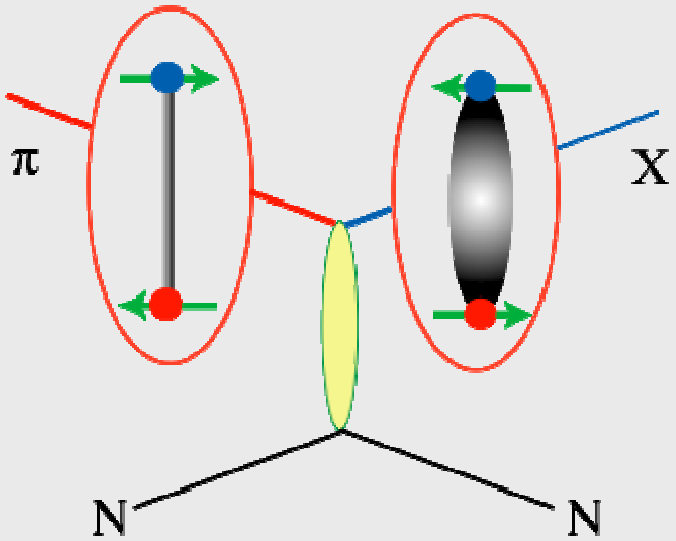
$\pi_1(1600)$ Width ~ 0.16 GeV, Decays $\rho\pi$,$\eta'\pi$,($b_1\pi$)
Only seen in πp production, (E852 + VES)

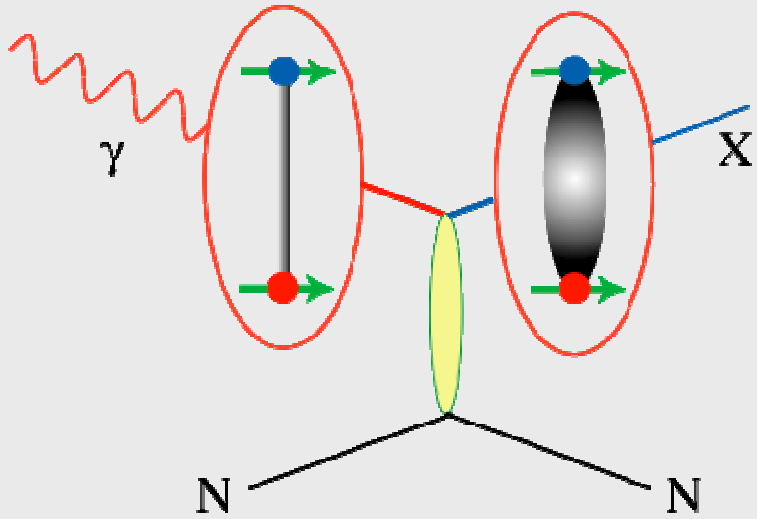
Does this exist?

$\pi_1(2000)$ Weak evidence in preferred hybrid modes $f_1\pi$ and $b_1\pi$

The right place. Needs confirmation.

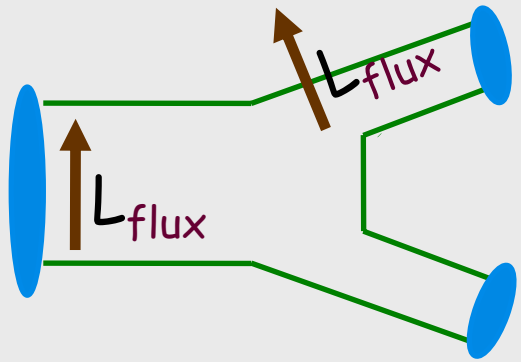
Photoproduction





More likely to find exotic hybrid mesons
using beams of photons

Hybrid Decays



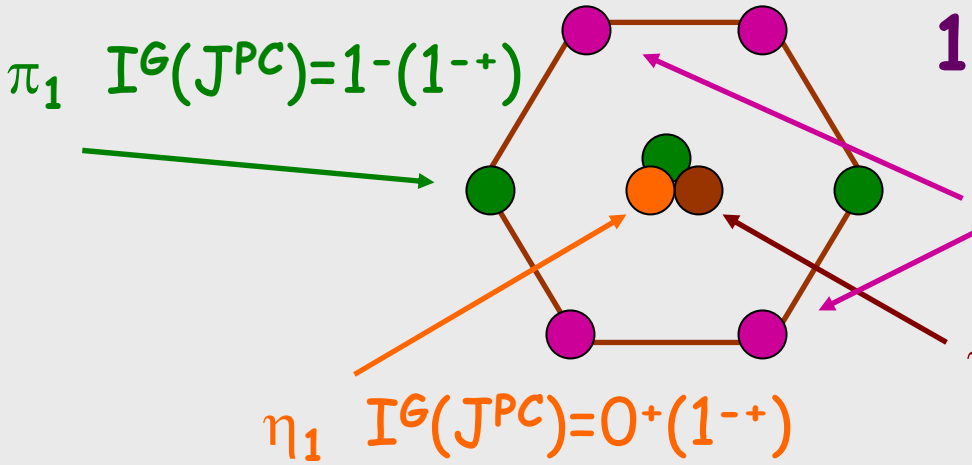
The angular momentum in the flux tube stays in one of the daughter mesons (L=1) and (L=0) meson.

Exotic Quantum Number Hybrids

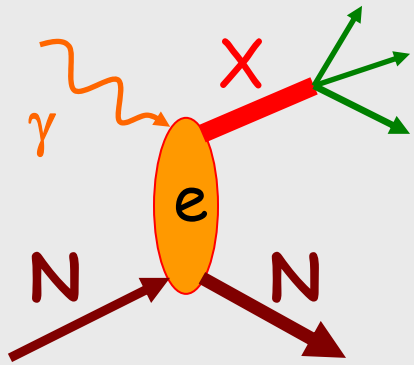
$\pi_1 \rightarrow \pi b_1$, πf_1 , $\pi\rho$, ηa_1	1:.25:.25:.20
$\eta_1 \rightarrow \pi(1300)\pi$, $a_1\pi$	1:1
$b_2 \rightarrow a_1\pi$, $h_1\pi$, $\omega\pi$, $a_2\pi$	1:1:0.5:0.25
$h_2 \rightarrow b_1\pi$, $\rho\pi$, $\omega\eta$	1:1:0.1
$b_0 \rightarrow \pi(1300)\pi$, $h_1\pi$	1:0.20
$h_0 \rightarrow b_1\pi$, $h_1\eta$	1:0.02

Mass and model dependent predictions

Exotics in Photoproduction



Need to establish nonet nature of exotics: π η η'

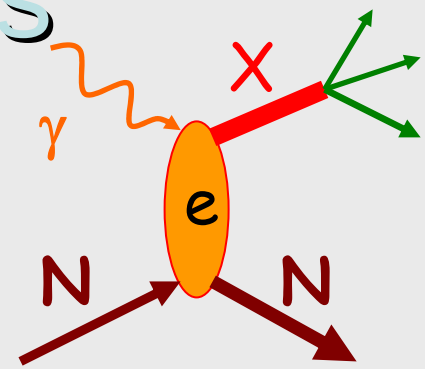


$\gamma \Leftrightarrow \rho, \omega, \phi$

Need to establish more than one nonet: 0^{+-} 1^{-+} 2^{+-}

0^{+-} and 2^{+-} Exotics

In photoproduction, couple to ρ, ω or ϕ?



b_0 $I^G(J^{PC})=1^+(0^{+-})$ $\omega a_1, \rho f_0, \rho f_1$

h_0 $I^G(J^{PC})=0^-(0^{+-})$ $\omega f_0, \omega f_1, \rho a_1$

h'_0 $I^G(J^{PC})=0^-(0^{+-})$ $\phi f_0, \phi f_1, \rho a_1$

K_0 $I(J^P)=\frac{1}{2}(0^+)$

"Similar to π_1"

$\omega\pi$ $\omega a_1, \rho f_0, \rho f_1$ b_2 $I^G(J^{PC})=1^+(2^{+-})$

$\omega\eta, \rho\pi, \omega f_0, \omega f_1, \rho a_1$ h_2 $I^G(J^{PC})=0^-(2^{+-})$

$\phi\eta, \rho\pi, \phi f_0, \phi f_1, \rho a_1$ h'_2 $I^G(J^{PC})=0^-(2^{+-})$

K_2 $I(J^P)=\frac{1}{2}(2^+)$

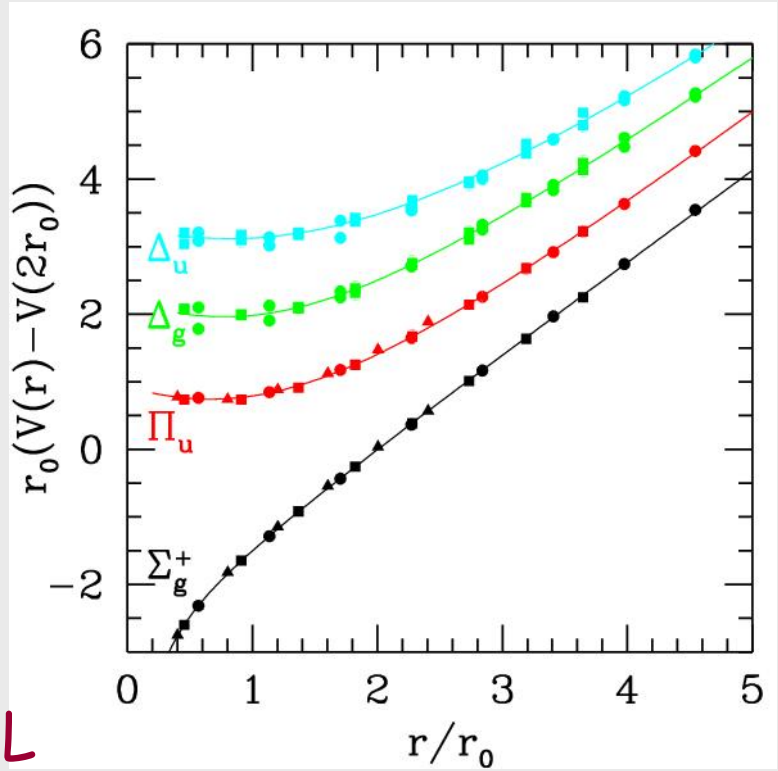
Kaons do not have exotic QN's

Exotics and QCD

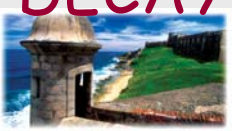
In order to establish the existence of gluonic excitations, We need to establish the nonet nature of the 1^{-+} state.

We need to establish other exotic QN nonets – the 0^{+-} and 2^{+-}.

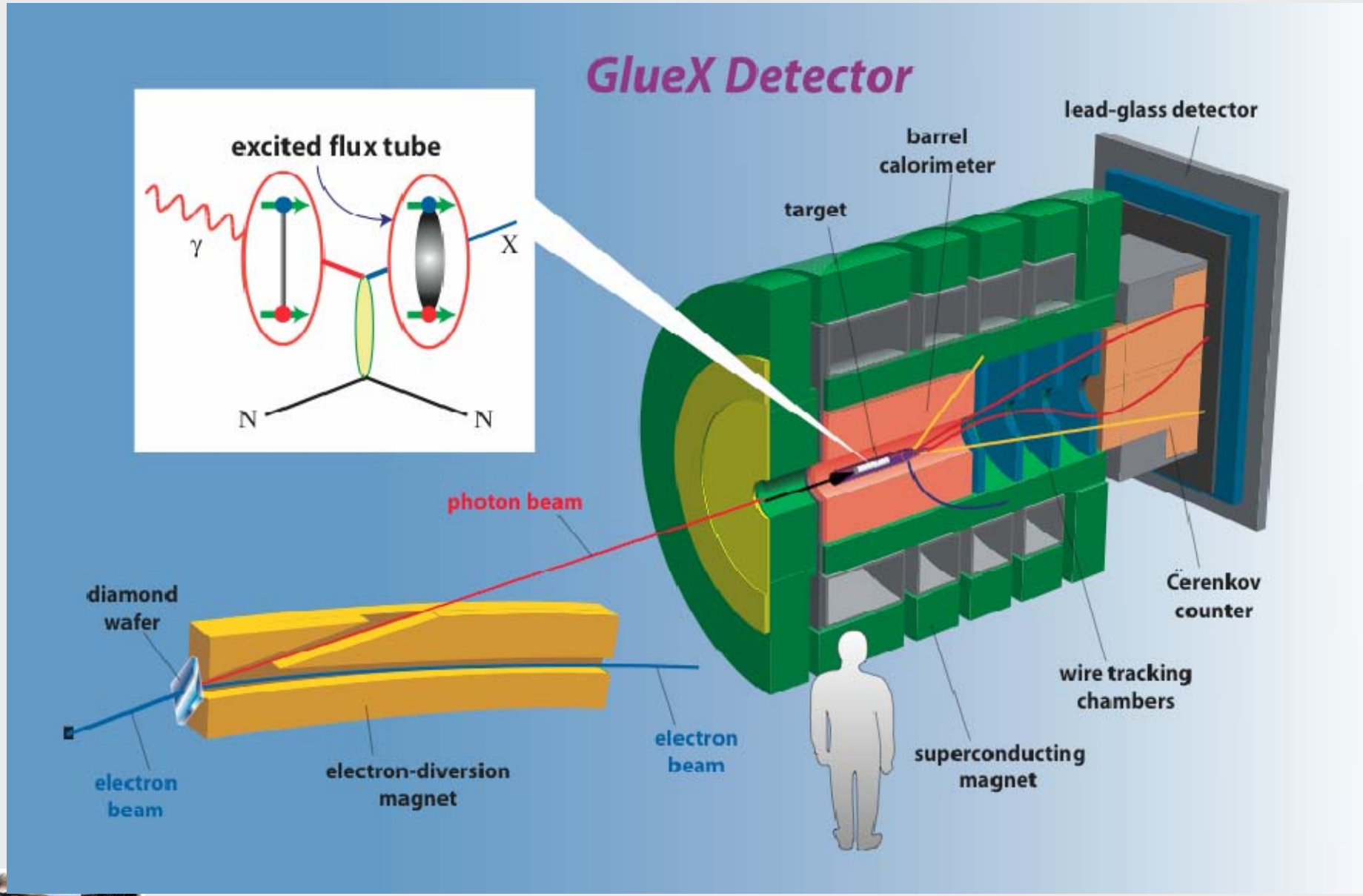
In the scalar glueball sector, the decay patterns have provided the most sensitive information. I expect the same will be true in the hybrid sector as well.



DECAY PATTERNS ARE CRUCIAL



The GlueX Experiment



Optimized for PWA

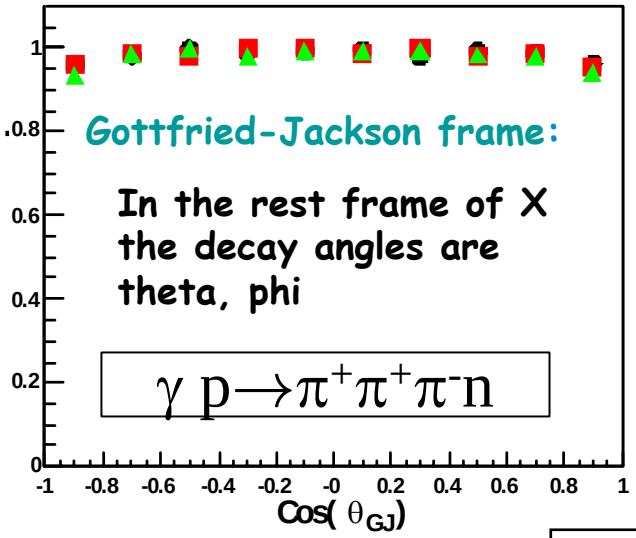
Nearly 4π acceptance for neutral and charged particles.

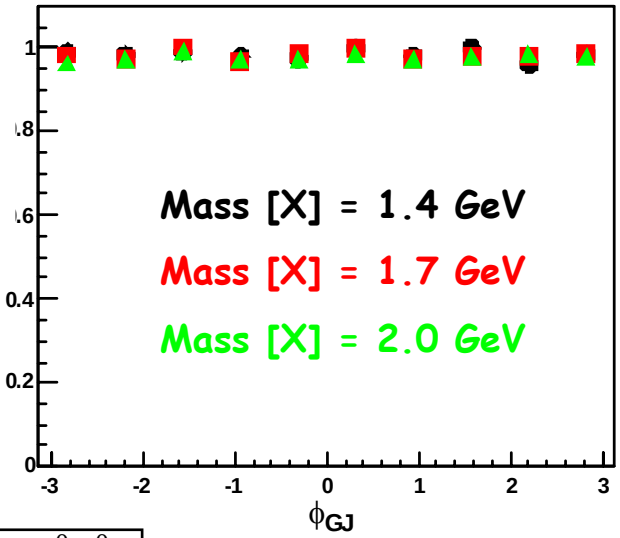
Linearly polarized photons with energy optimized for hybrid searches.

Uniform acceptance in the variables appropriate for Partial Wave Analysis.

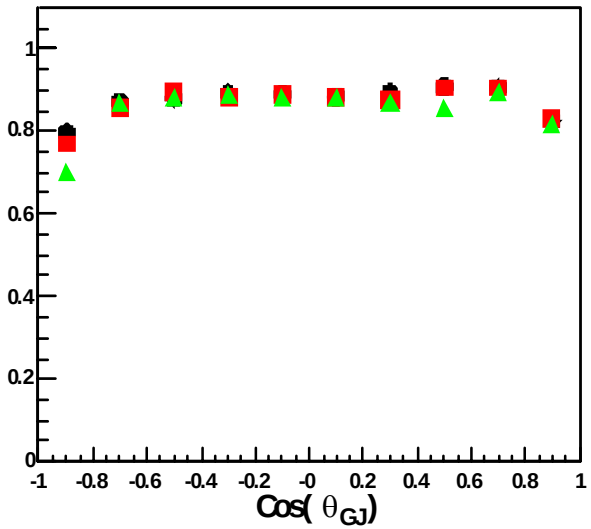
PWA Leakage studies have been performed using Monte Carlo.

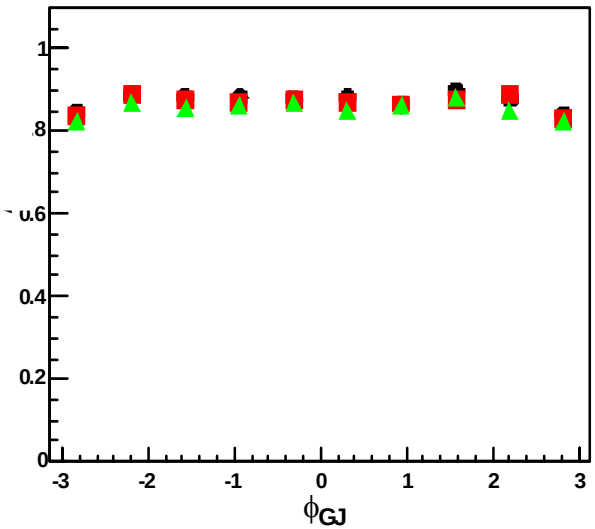
Acceptance





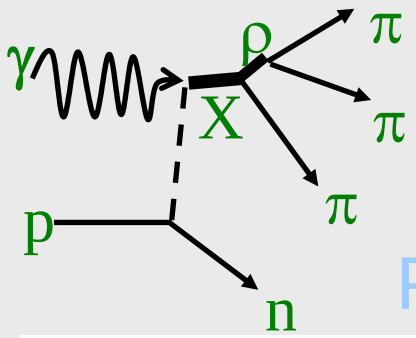
$\gamma p \rightarrow Xn \rightarrow \eta\pi^0\pi^0 n$





Partial Wave Analysis

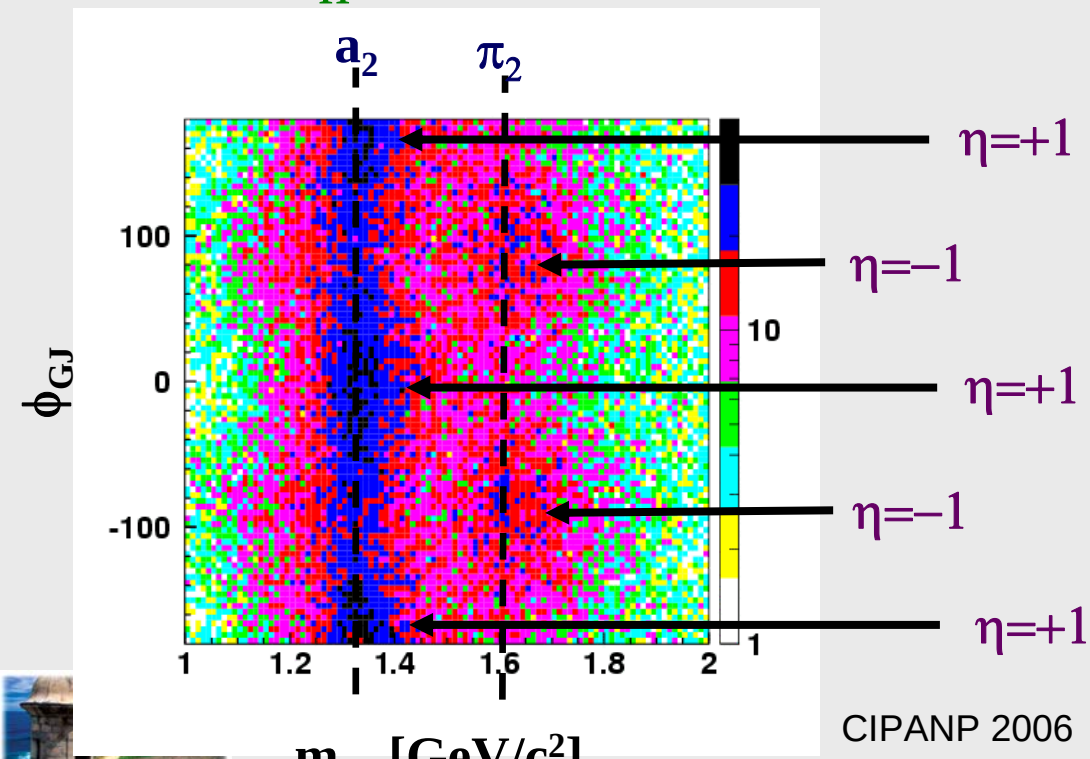
Double blind studies of 3π final states

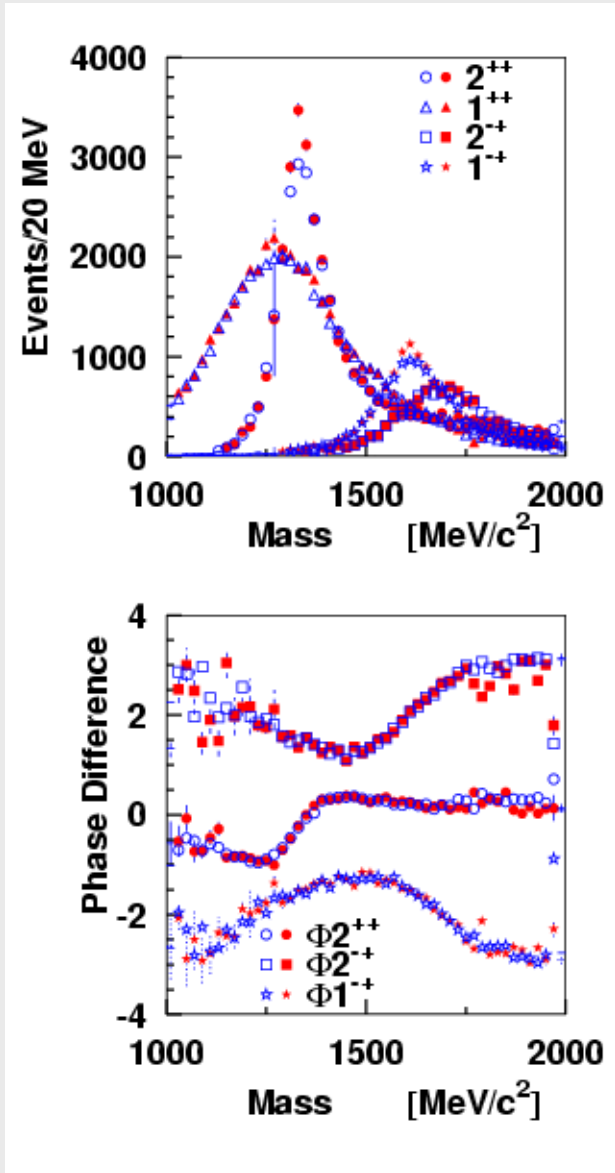


GlueX Monte Carlo

$\gamma p \rightarrow \pi_1^+ n \rightarrow \pi^+\pi^+\pi^- n$

Polarization $\rightarrow \pi^+\pi^0\pi^0 n$





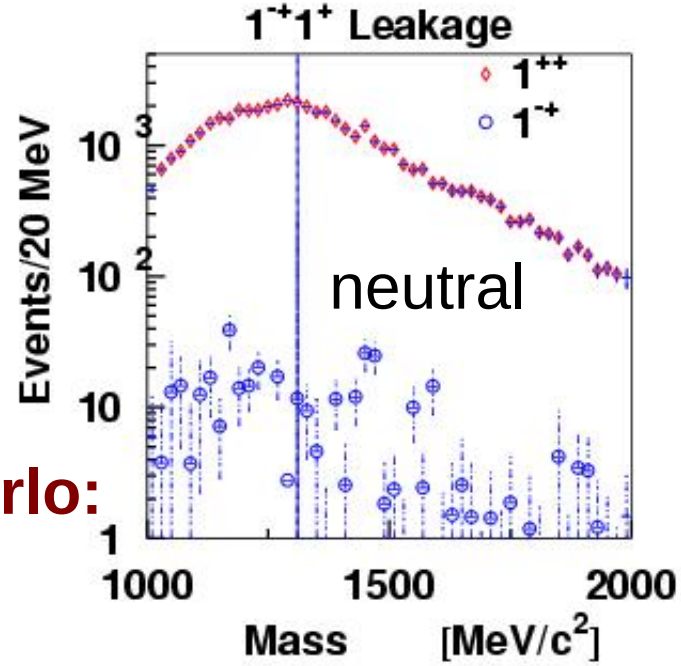
Leakage

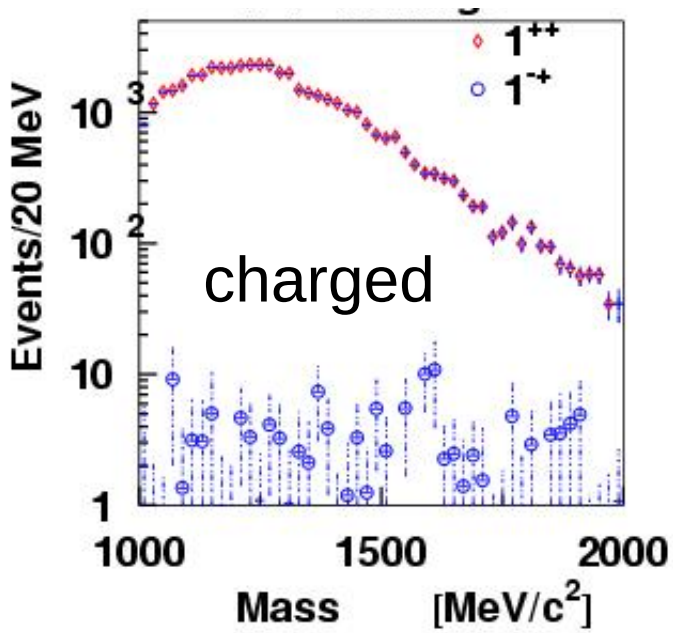
If your acceptance is not well understood, The PWA can “leak” one wave into another.

Break the GlueX detector in Monte Carlo:

- distort B-field
- degrade resolution
- change hole sizes
- distort beam energy

Largest leakage is ~ 1/2% of a strong signal. $\mathbf{a_1(1^{++}) \leftrightarrow \pi_1(1^{-+})}$





Partial Wave Analysis

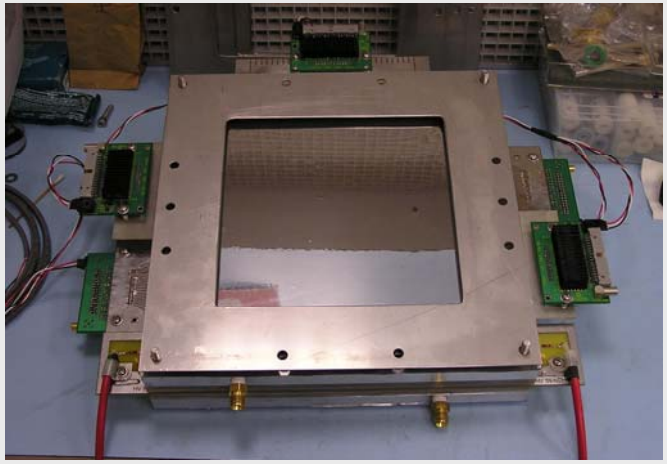
Have been able to pull out signals that are ~1% of a strong signal using PWA.

It is extremely difficult to produce leakage that is as large as 1%.

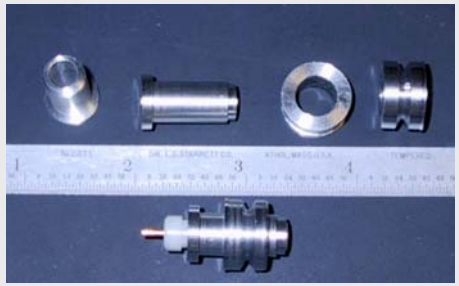
Assuming a good theoretical understanding, if hybrids are present at ~1% of normal mesons strength, this detector will be able to find them.

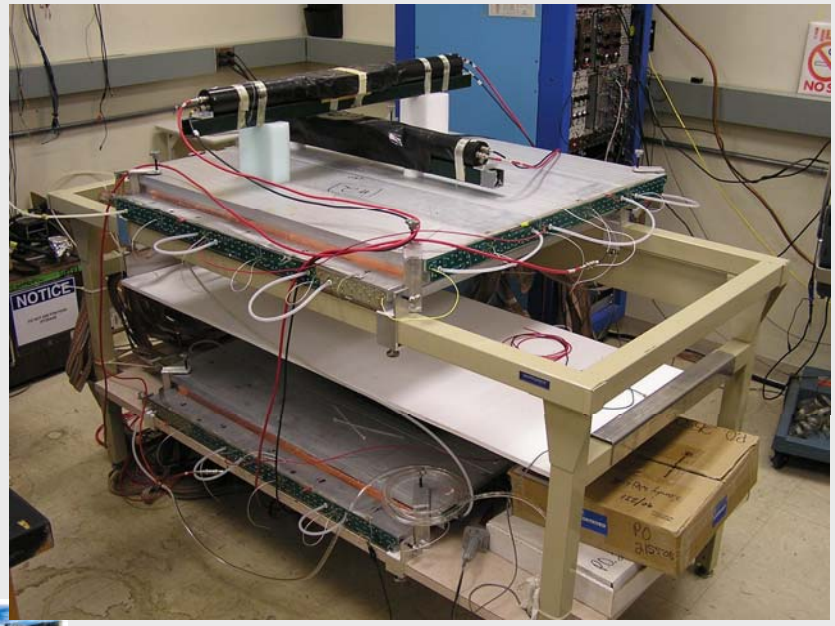
Studies are currently being redone with detector software.

Detector R&D Work



Drift Chambers





Solenoid Refurbishment

LASS Solenoid

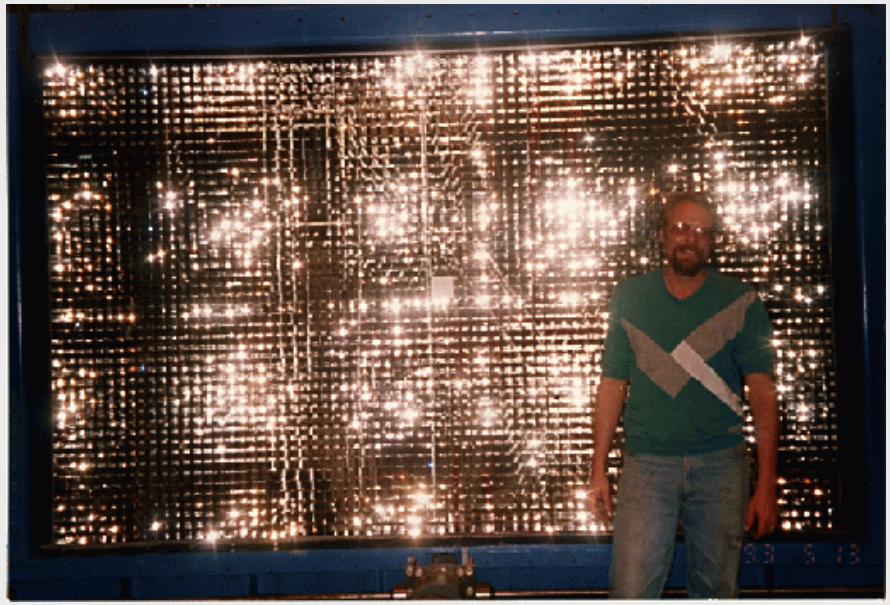
Superconducting 2.5T

Used in Los Alamos MEGA Experiment.

Moved to IUCF for refurbishing.

Calorimeters

Existing Pb-Glass for Forward



Barrel Calorimeter Pb-SciFib

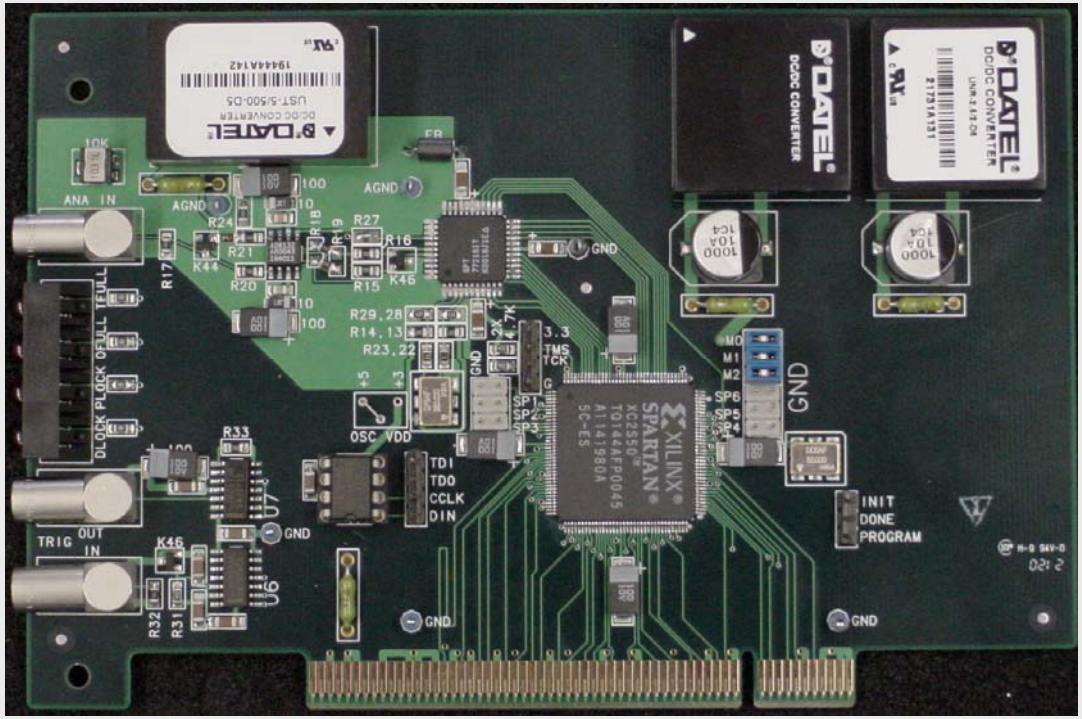
Beam tests fall 2006

Backwards Veto

Electronics

The F1TDC

Flash ADC System



Detector Reviews

July 2003: Held a 2-day review of GlueX Electronics

October 2004: Held a 2-day review of the GlueX Detector.

November 2004: Solenoid Assessment

January 2006: Tagger Review

Analysis Preparation

From the very start, the GlueX Collaboration has had an active theory group. It is well recognized that theorists need to be closely integrated into the analysis from the start.

The theoretical underpinnings of Partial Wave Analysis need to Be looked at closely now that large data sets are becoming available. What exactly are the model assumptions and how do they affect The results.

The scale of data from GlueX will be comparable to LHC experiments. However, the needs are different – GRID technologies will be crucial. Also, the tools to parallelize the analysis of 100,000,000 event data sets are being developed.

Summary

The GlueX Collaboration is moving forward!

The DOE 20-year plan and CD0 have opened the door to a great deal of interest by new groups in GlueX.

The Collaboration is pressing forward with detector R&D coupled with external reviews of what we are doing.

The Collaboration is working hard to make sure that analysis issues due to the large data sets are in hand.

We are paying close attention to the theoretical underpinnings of PWA to make sure that what comes out of GlueX is a clear answer.