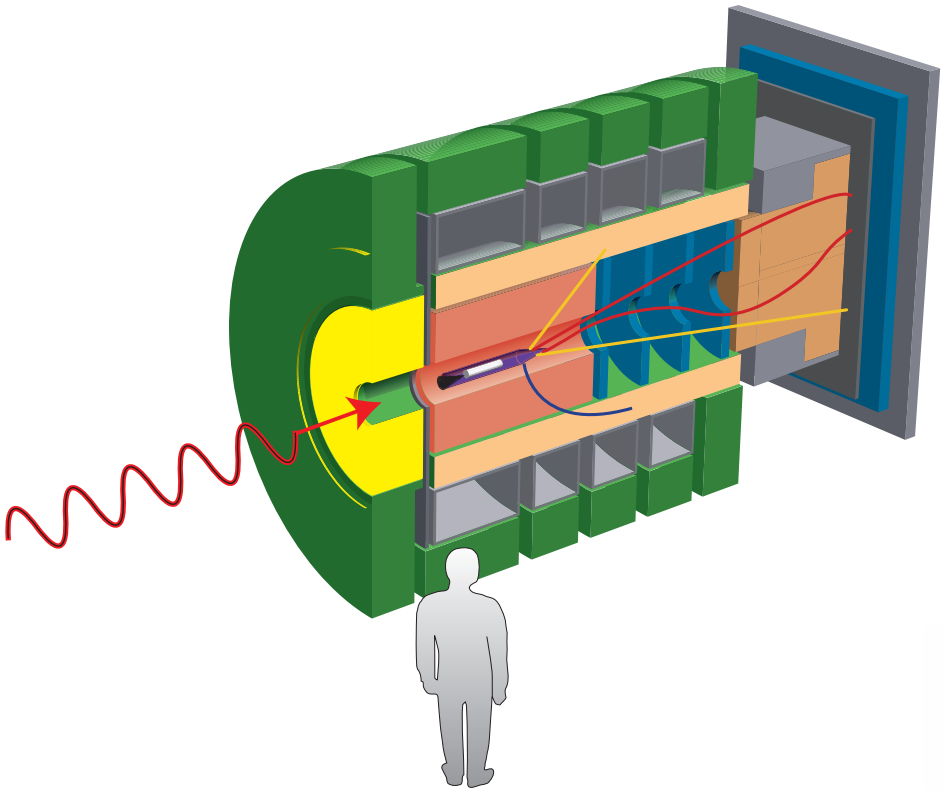
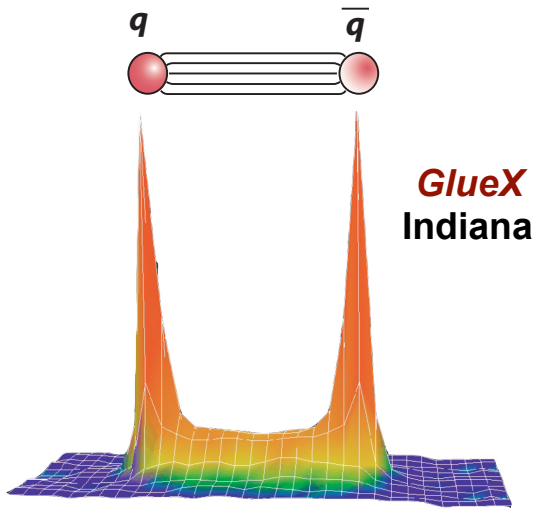
Mapping the Spectrum of Gluonic Excitations with Photons

The GlueX Project at Jefferson Lab





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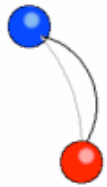
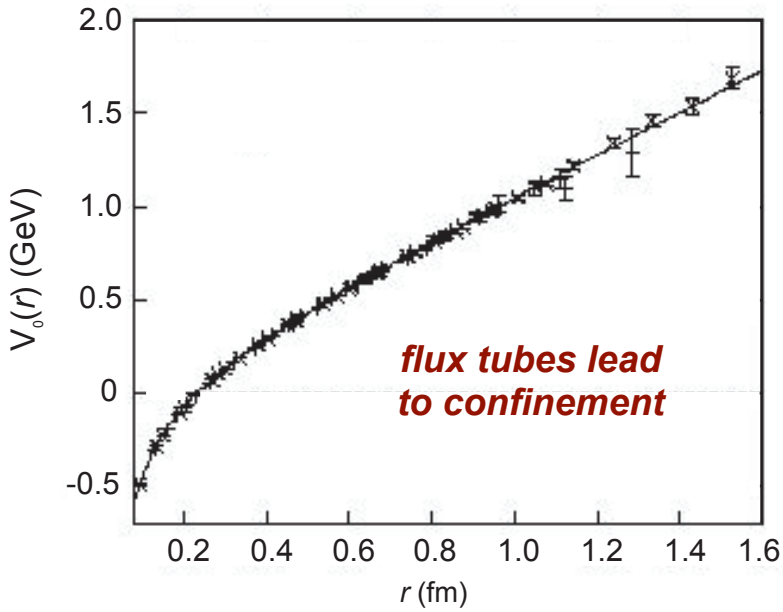
GlueX Collaboration Spokesperson
Indiana University and Jefferson Lab

visit: www.gluex.org



Lattice QCD tells us that the gluonic field between quarks is confined in flux tubes and their excitations can result in mesons with exotic quantum numbers. ***GlueX will use linearly polarized photons to map out the spectrum of exotic mesons.***



Open Science Grid

U.S. DEPARTMENT OF ENERGY

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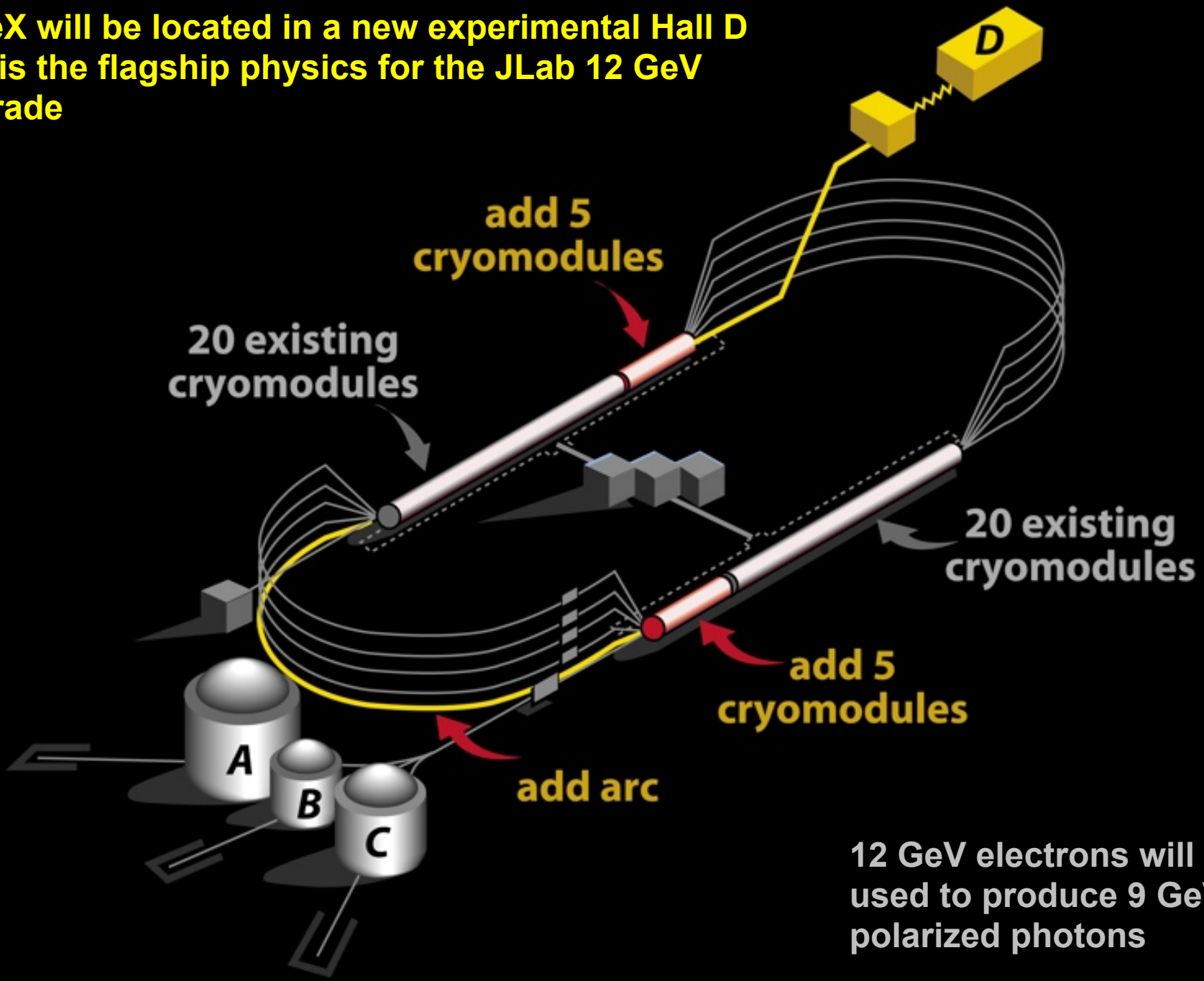
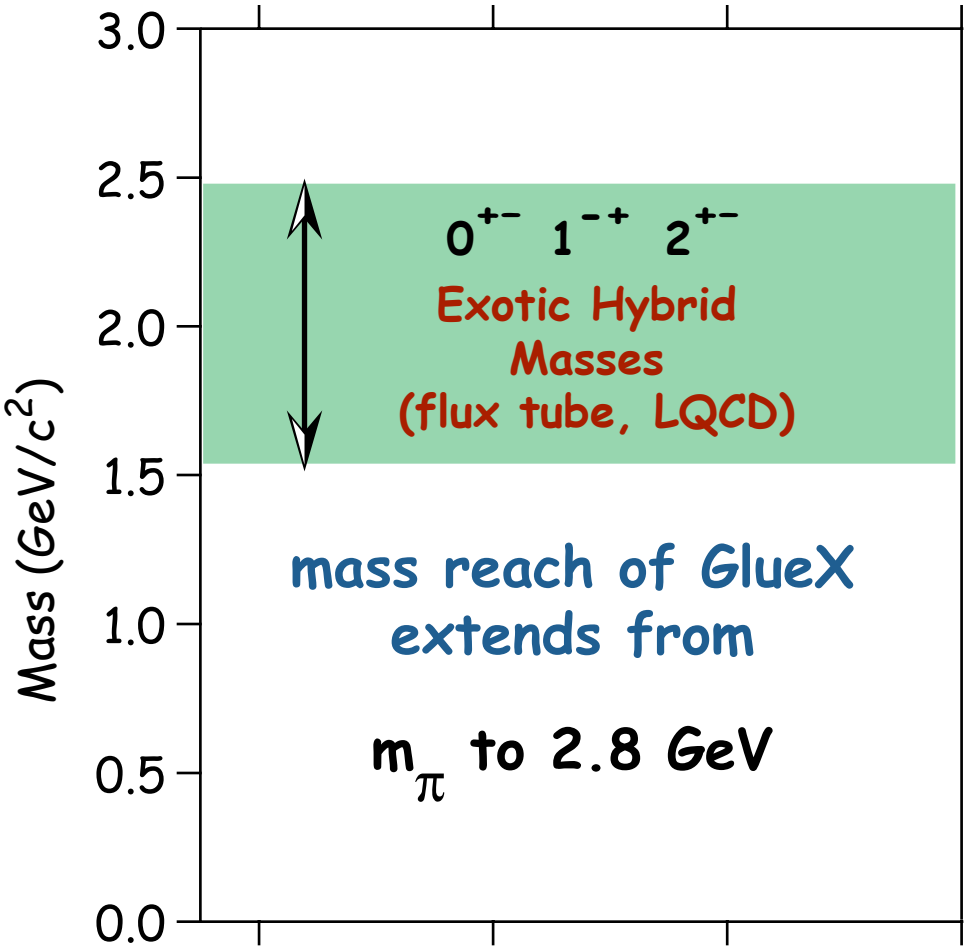
GlueX will be located in a new experimental Hall D and is the flagship physics for the JLab 12 GeV upgrade



12 GeV electrons will be used to produce 9 GeV polarized photons

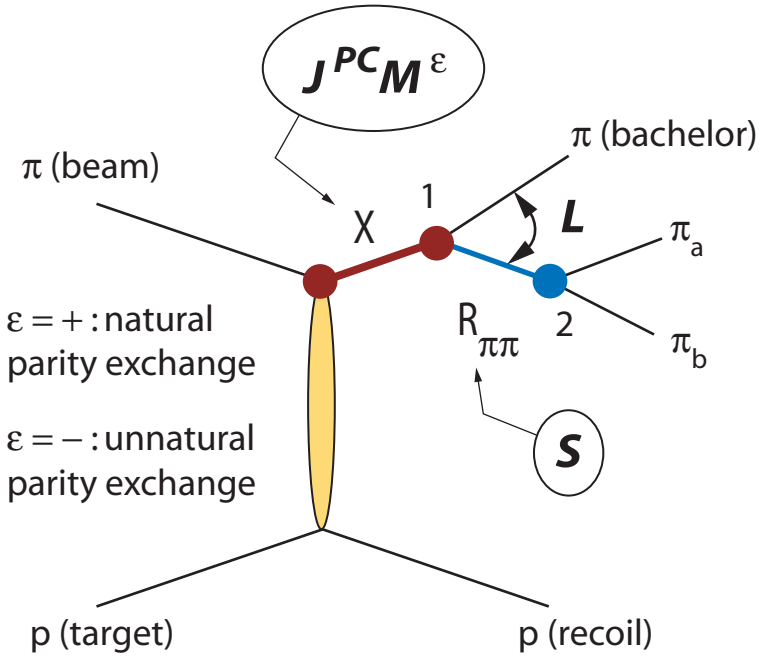
Mapping Exotics - Experiment Requirements

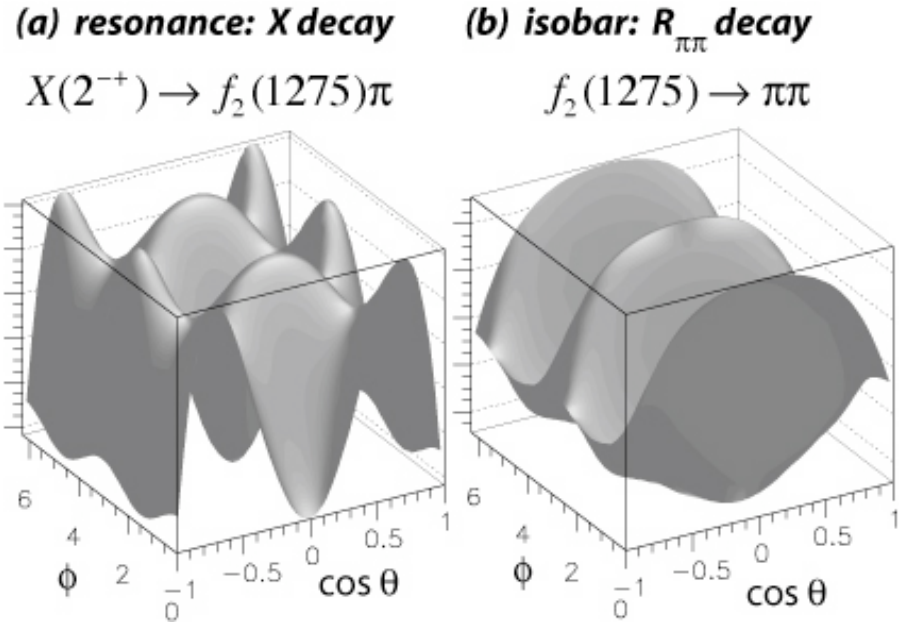


- Linearly polarized photons of sufficient energy - 9 GeV
- Amplitude analysis to identify quantum numbers of produced states
  - adequate detector (acceptance & resolution)
  - statistics
  - analysis tools

The Amplitude Analysis of Very Large Data Sets is the Unique Challenge for GlueX

Example: Amplitude Analysis of the 3π System





*The analysis is based on the **isobar model** that assumes an intermediate 2π resonance*

$$I(m_{3\pi}, t, \tau) = \eta(\tau) \sum_{\varepsilon} \left| \sum_{b} a_b^{\varepsilon}(m_{3\pi}, t) A_b^{\varepsilon}(\tau) \right|^2$$

acceptance — $\eta(\tau)$

production — $a_b^{\varepsilon}(m_{3\pi}, t)$

decay — $A_b^{\varepsilon}(\tau)$

observed intensity — $I(m_{3\pi}, t, \tau)$

spin variables: J, M, S — ε, b

kinematic variables $\tau = \{\theta_{GJ}, \phi_{GJ}, \theta_H, \phi_H, m_{\pi\pi}\}$

The Fitting Challenge

$$I(m_{3\pi}, t, \tau) = \eta(\tau) \sum_{\varepsilon} \left| \sum_{b} a_b^{\varepsilon}(m_{3\pi}, t) A_b^{\varepsilon}(\tau) \right|^2$$

the fit parameters

Do unbinned maximum likelihood fit for n events:

Calculation of L can be done over parallel machines

$$L = \frac{e^{-\mu}\mu^n}{n!} \prod_{i=1}^{n} \frac{I(\tau_i)}{\int \eta(\tau) I(\tau) d\tau}$$

normalization determined using N Monte Carlo events

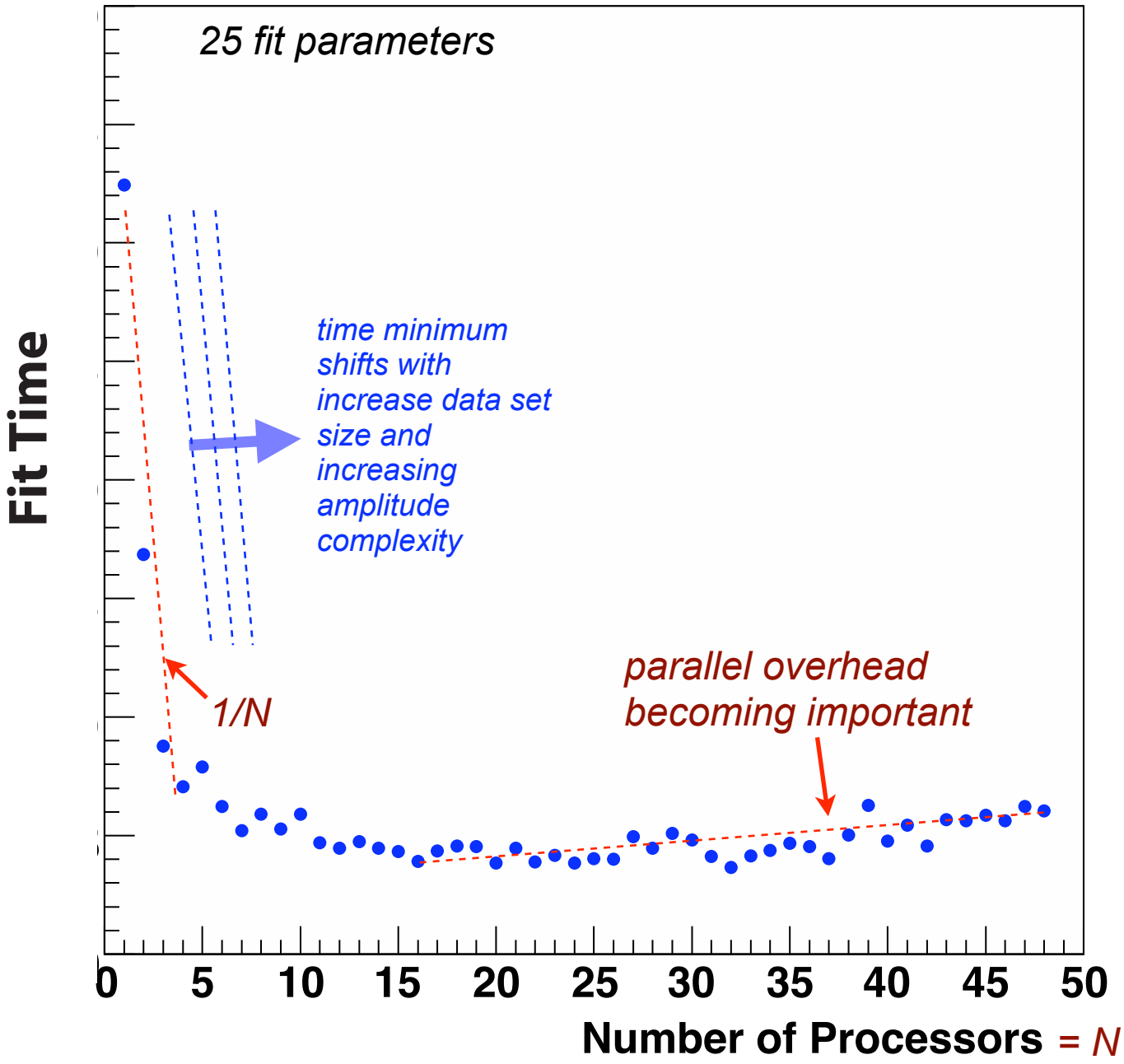
Minimize – ln(L)

$$-\ln L \propto -\sum_{i=1}^{n} \ln \left(\sum_{bb'} a_b a_{b'}^* A_b A_{b'}^* \right) + \sum_{bb'} a_b a_{b'}^* \left(\frac{1}{N} \sum_{i=1}^{N} A_b A_{b'}^* \right)$$

for a given fit these are fixed: so compute & cache - a simplification arising from the isobar model assumption and its inherent factorization.

Doing the fits on Parallel Processors

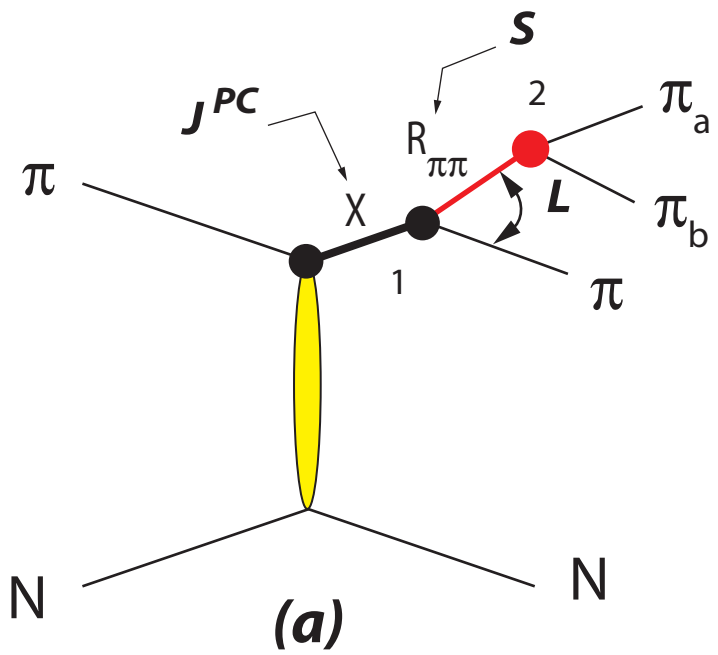
$\chi_{c0} \rightarrow KK\pi\pi$ (13 Amplitudes, 1K Events)

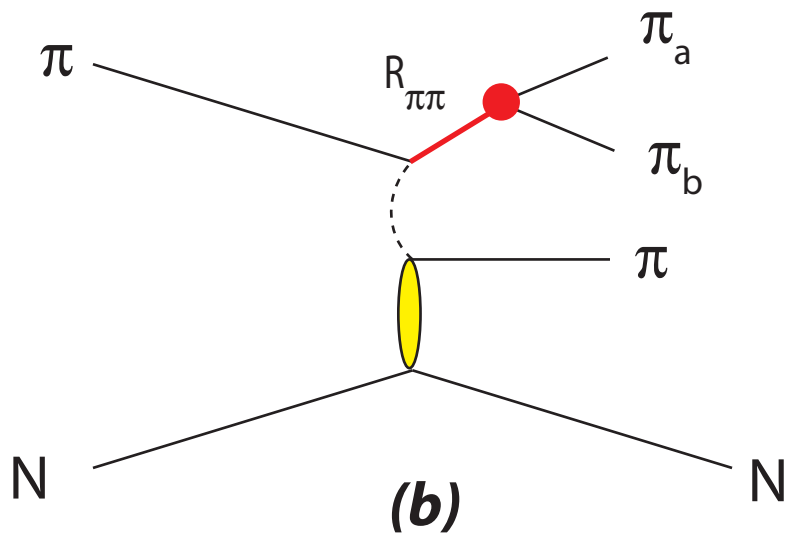


exercise using CLEO data using 110 processor cluster using small (1K) event samp

Example: Going Beyond the Isobar Model

This involved exploring physics that break factorization:





Isobar Model: ***Data from Brookhaven E852 have been analyzed using this model.***

Other Mechanisms: ***The so-called 'Deck Model' is one of several that will be studied.***

GlueX Data Rates

$$\sigma_{\gamma p}^{total}(E_\gamma \ @ \ 9 \ GeV) = 120 \ \mu b$$

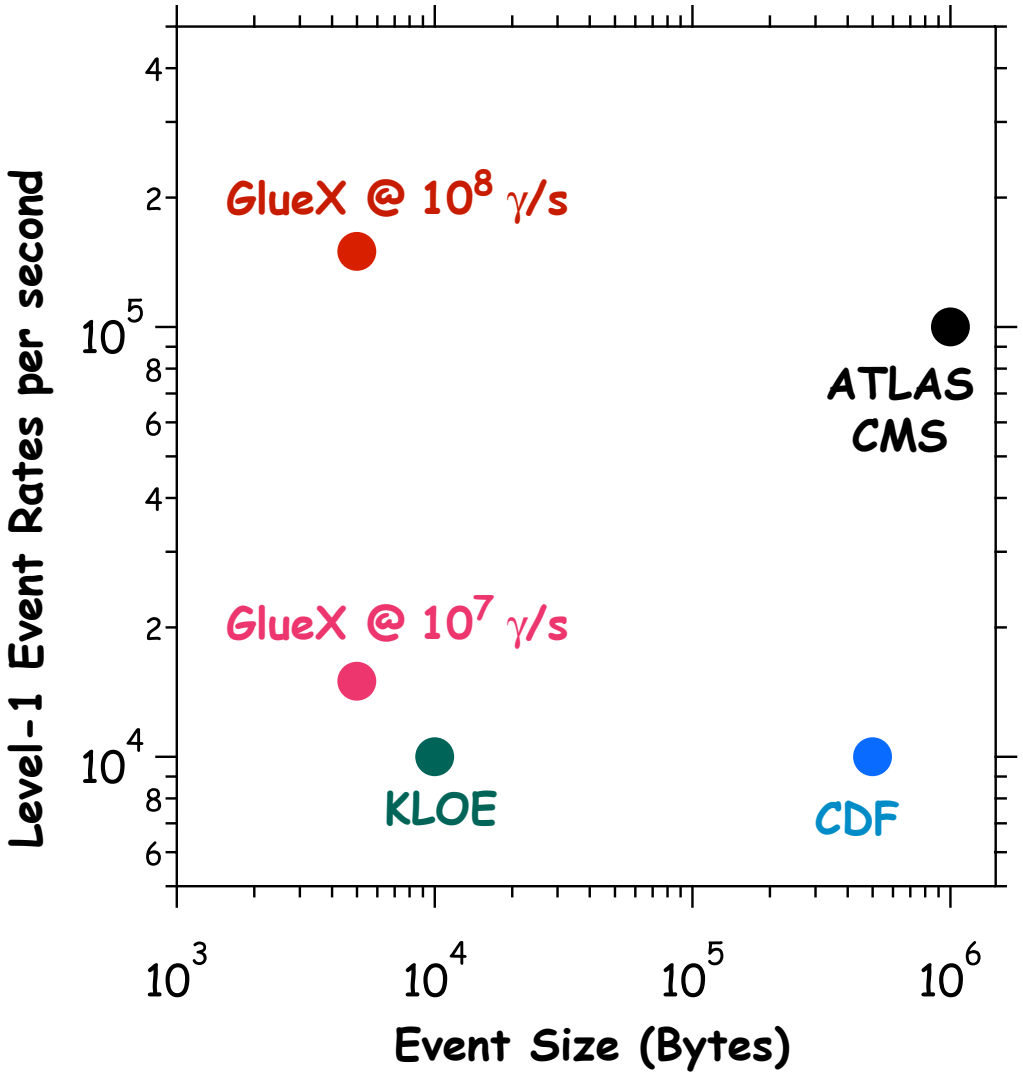
$$10^7 \ \gamma/s \text{ on } 30 \text{ cm } LH_2 \ \Rightarrow 15 \ kHz$$

$$\text{event size} = 5 \ kB$$

This implies recording data at 100 MByte/s and collecting 1 PByte of data per year

$$10^8 \ \gamma/s \text{ on } 30 \text{ cm } LH_2 \ \Rightarrow 150 \ kHz$$

Level-3 trigger will reduce the recording rate to 15 kHz or 100 MByte/s



Prepare for GlueX Challenge - Use Existing Data

Collaborative Research:
Open Access Amplitude Analysis on a Grid

A. R. Dzierba, G. C. Fox, M. R. Shepherd and A. P. Szczepaniak
Indiana University, Bloomington, IN
C. A. Meyer
Carnegie Mellon University, Pittsburgh, PA
R. T. Jones
University of Connecticut, Storrs, CT
J. J. Dudek
Old Dominion University, Norfolk, VA

submitted - September 2006

Data from existing experiments E852 at BNL and CLAS at JLab will be used in developing the Amplitude Analysis Toolkit

Sample sizes:
E852 - tens of GB (10 TB raw)
CLAS - factor 10 larger

Start using OSG in Summer 2007 for a 3-year period.

The proposal requests funding for four postdoctoral fellows to work on: (1) phenomenology; (2) GRID; and (3) tools for fitting.

Grid Implementation

Our Grid strategy will build on Open Science Grid (OSG) software and hardware. JLab has committed to use and support this approach and Indiana University is an active existing partner. OSG provides core middle ware and leaves application specific software to the individual experiments.

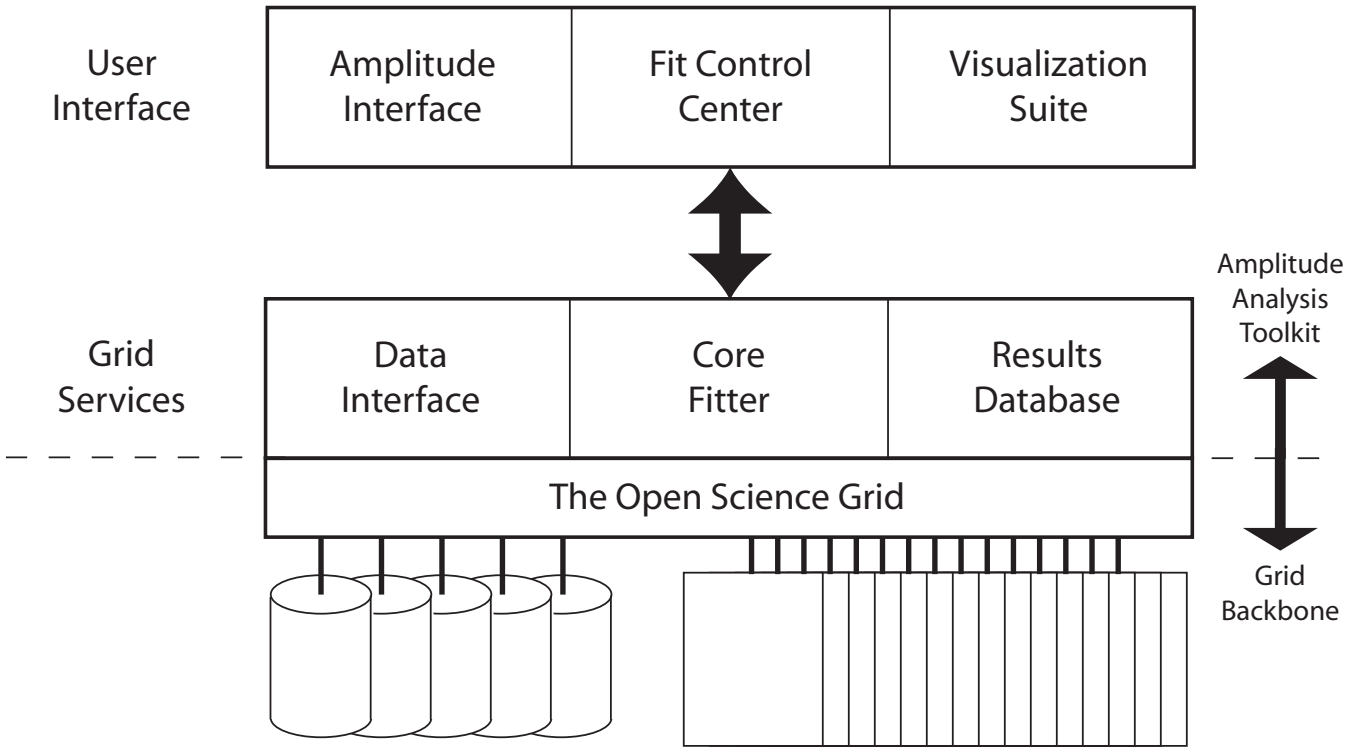
Jefferson Lab

Jefferson Lab Contribution: The Jefferson Lab Computing Center supports the lab's physics requirements to store and analyze data for the scientific program, and fully intends to support the computing model in this proposal. Specifically we plan to establish an infrastructure for sharing compute and storage resources within the GlueX collaboration based on the OSG consortium's Virtual Data Toolkit. Jefferson Lab will serve as the collaboration's Virtual Organization Registration Authority for DoE Science Grid certificates, to provide authentication and authorization for access to these resources. The laboratory will work with the collaborating institutions in this proposal to support this computing model using OSG, as well as investigate enhancements to Jefferson Lab's resources to interface OSG middle-ware with the Grid services of Jefferson Lab and GlueX.

Open Science Grid

OSG and GlueX: The amplitude analysis toolkit design was developed in consultation with the OSG management. We plan to make its distributed resources accessible as sites on the OSG infrastructure, depend on the OSG supported reference software stack, and plans to work with the OSG on the common and experiment specific services needed by amplitude analysis applications.

Physics at the Information Frontier (PIF)



Data Production for Hall-D and the 12 GeV upgrade

Based on a discussion between:
Roy Whitney, Graham Heyes, Andy Kowalski and Elton Smith

prepared in 2005
add two year delay

Year	Raw /yr	Prod /yr	Sim Raw	Sim Prod	work/Cache			Sim CPU	Raw Prod CPU	Sim Prod CPU
					CLAS	GLUEX	total			
2013	1	1	1	1		1.2	1.2	700	250	250
2012	1	0.5	1	1		0.8	0.8	700	200	250
2011	0.7	0.3	1	1	0.7	0.5	1.2	700	200	250
2010	0.3	0.3	0.5	0.5	0.5	0.3	0.8	350	200	100
2009	0.3	0.3	0.1	0.1	0.28	0.1	0.38	100	200	50
2008	0.3	0.3			0.15		0.15		200	
2007	0.3	0.3			0.12		0.12		150	
2006	0.3	0.3			0.1		0.1		125	
2005	0.2	0.2			0.07		0.07		100	
2004	0.2	0.2			0.04		0.04		100	

Notes:

_ All data numbers are in PB except when otherwise stated.

_ All CPU numbers assume 2008 hardware, i.e. already scaled from present and are a count of CPU's not boxes, quad-CPU boxes count as 4 not 1.

_ In 2005 we have approx. 200 CPUs but the 2008 hardware scaling factor brings this down to 100.

GlueX Computing Environment

Main storage - at JLab