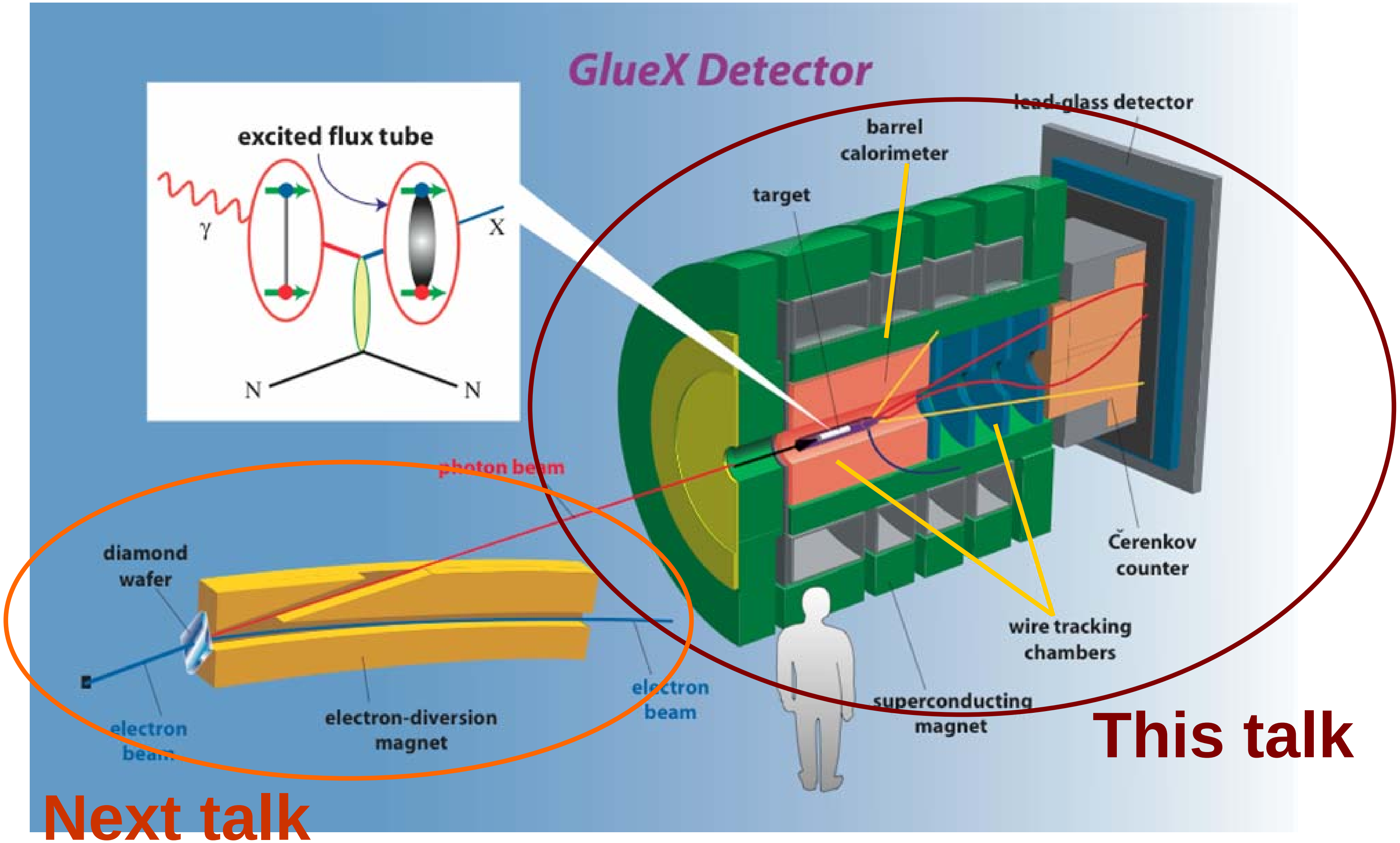
The GlueX Detector

Curtis A. Meyer



The GlueX Detector

This talk will start with the physics goals of GlueX and what GlueX has to be able to do to achieve them

Present the detector as a whole and what the components do individually and collectively.

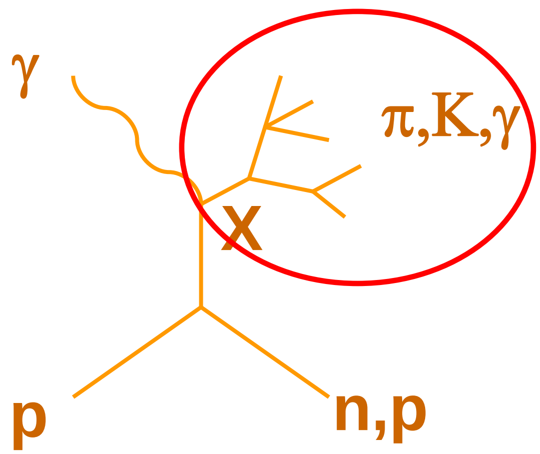
Show that the GlueX detector can achieve the physics goals.

Follow up talks will go into much more detail on each of the individual detectors elements.

Search for QCD Exotics

The GlueX Detector Design has been driven by the need to carry out Amplitude analysis.

π_1 η_1 η'_1 b_2 h_2 h'_2 b_0 h_0 h'_0



Photoproduction

$\eta_1 \rightarrow a^+_1\pi^- \rightarrow (\rho^o\pi^+)(\pi^-) \rightarrow \pi^+\pi^-\pi^+\pi^-$

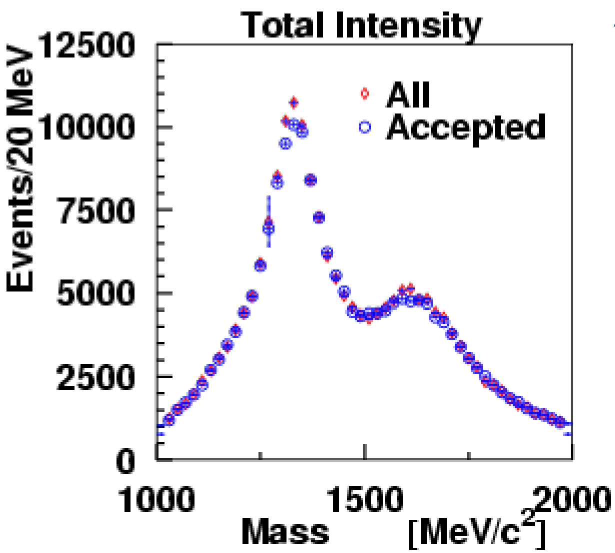
$h_0 \rightarrow b^o_1\pi^o \rightarrow (\omega\pi^o)\gamma\gamma \rightarrow \pi^+\pi^-\gamma\gamma\gamma\gamma\gamma\gamma$

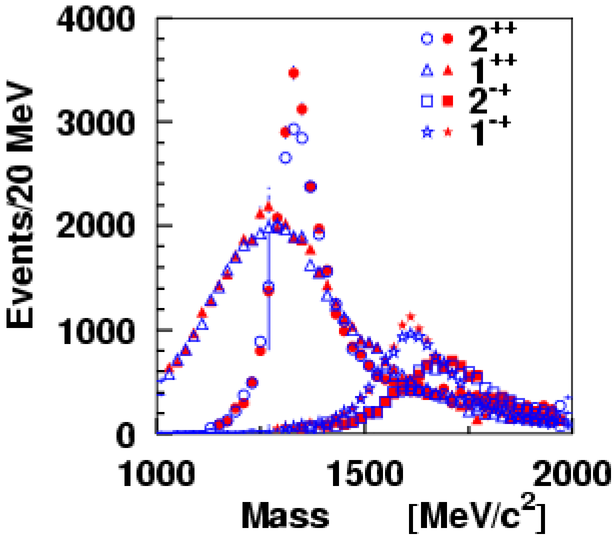
$h'_2 \rightarrow K^+_1K^- \rightarrow \rho^o K^+ K^- \rightarrow \pi^+\pi^- K^+K^-$

Final state particles

$\pi^\pm$ $K^\pm$ γ p   n K_L

Physics Requirements





A Good Partial Wave Analysis Requires:

Hermetic Detector for charged particles and photons.

Uniform, understood acceptance.

Excellent resolution to reduce backgrounds.

Linear polarized photons.

High statistics data sets.

Sensitive to many final states.

Rates

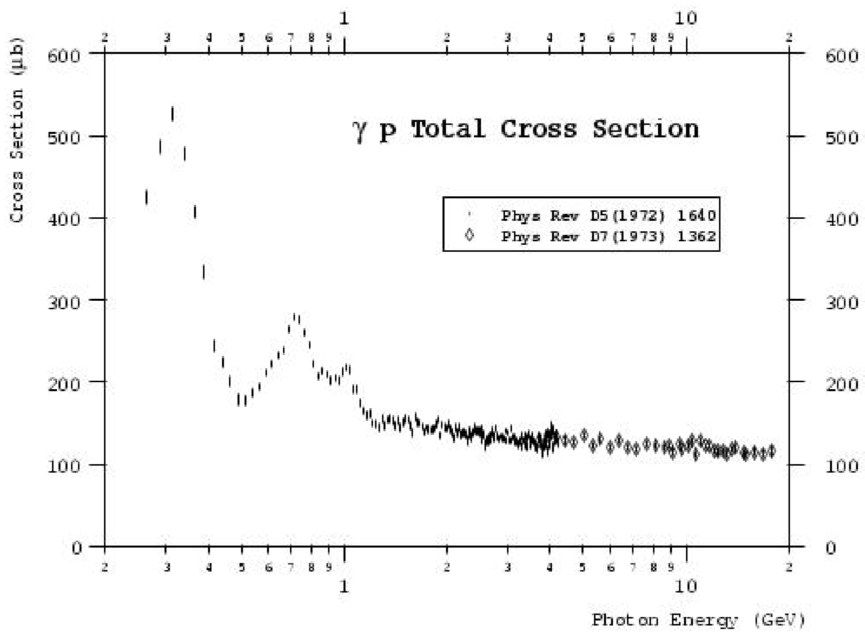
High statistics means high rates

Initially 10^7 tagged γ/s
Design detector for 10^8

At 10^7, the total hadronic rate is $\sim$ 37kHz
the tagged hadronic rate is $\sim$ 1.4kHz
At 10^8, the total hadronic rate is $\sim$ 370kHz
the tagged hadronic rate is $\sim$ 14kHz

JLab CLAS runs at 10^7 already.

Running at 10^7 for 1 year will exceed current photoproduction data by several orders of magnitude and will exceed current π data.



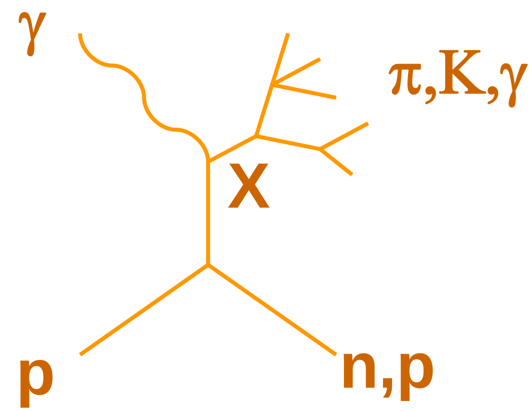
More on rates in the next presentation

Topologies

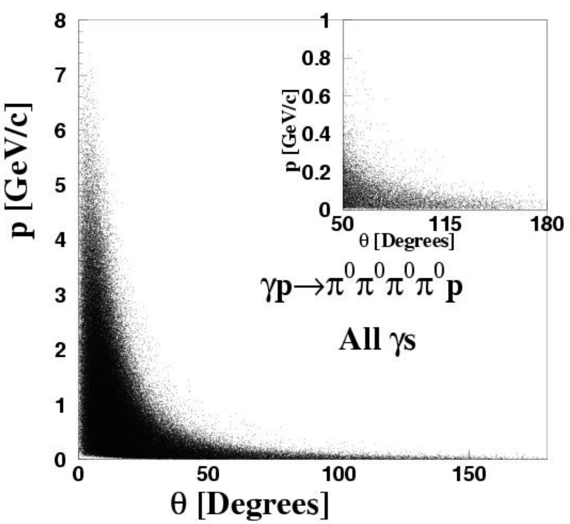
Incident 8-9 GeV γ
Lorentz boost

t-channel meson photoproduction

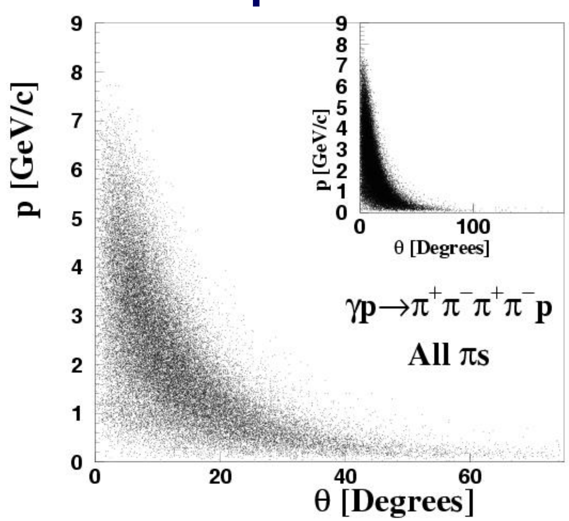
$$\sigma(t) \sim e^{-\alpha t}$$



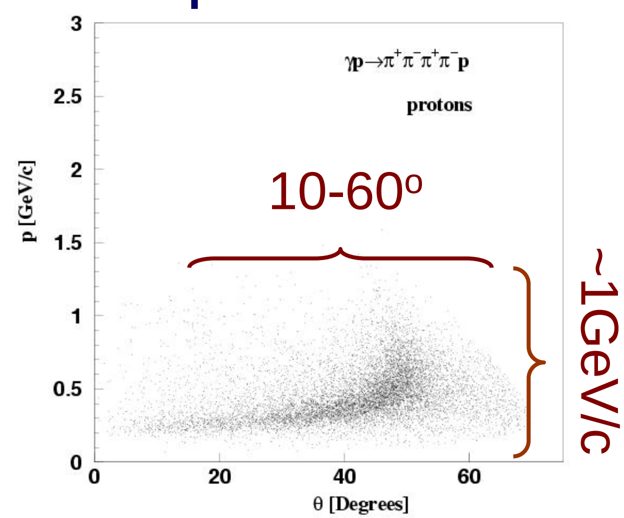
photons



pions



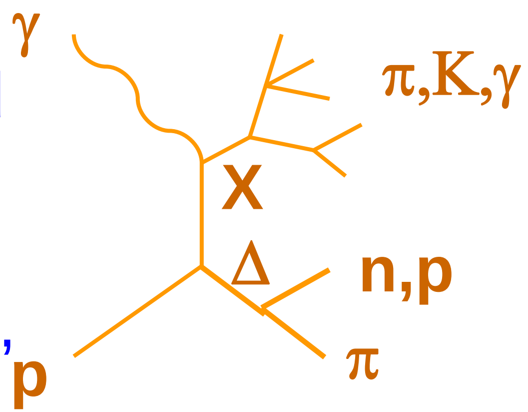
protons



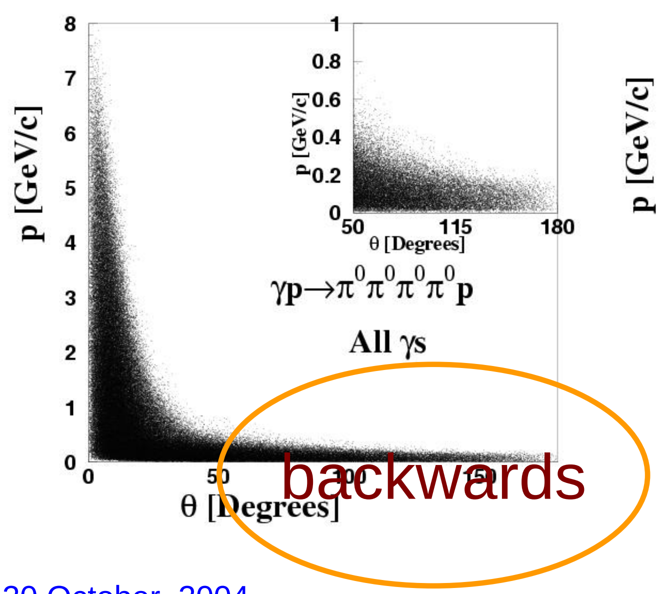
Background Topologies

Δ/N^* production is a significant background to the simple t-channel production.

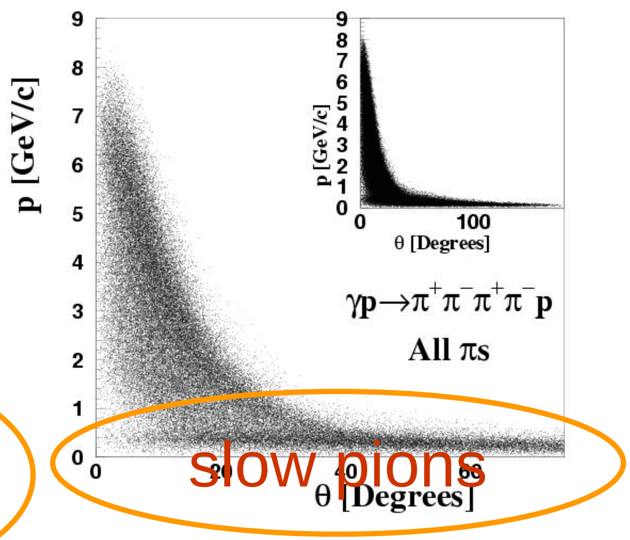
There is interesting physics in this channel, it is just more complicated to analyze.



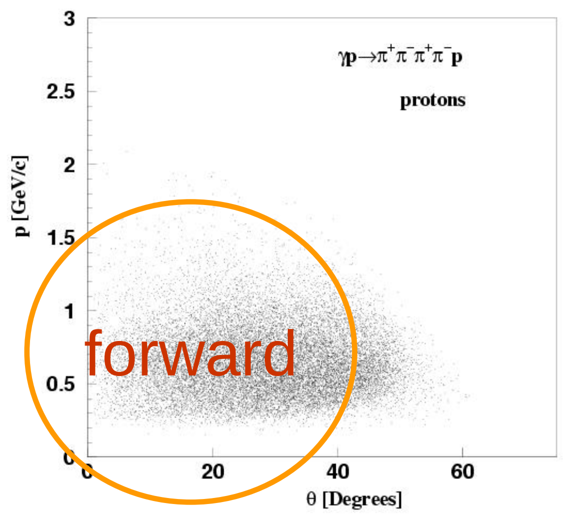
photons



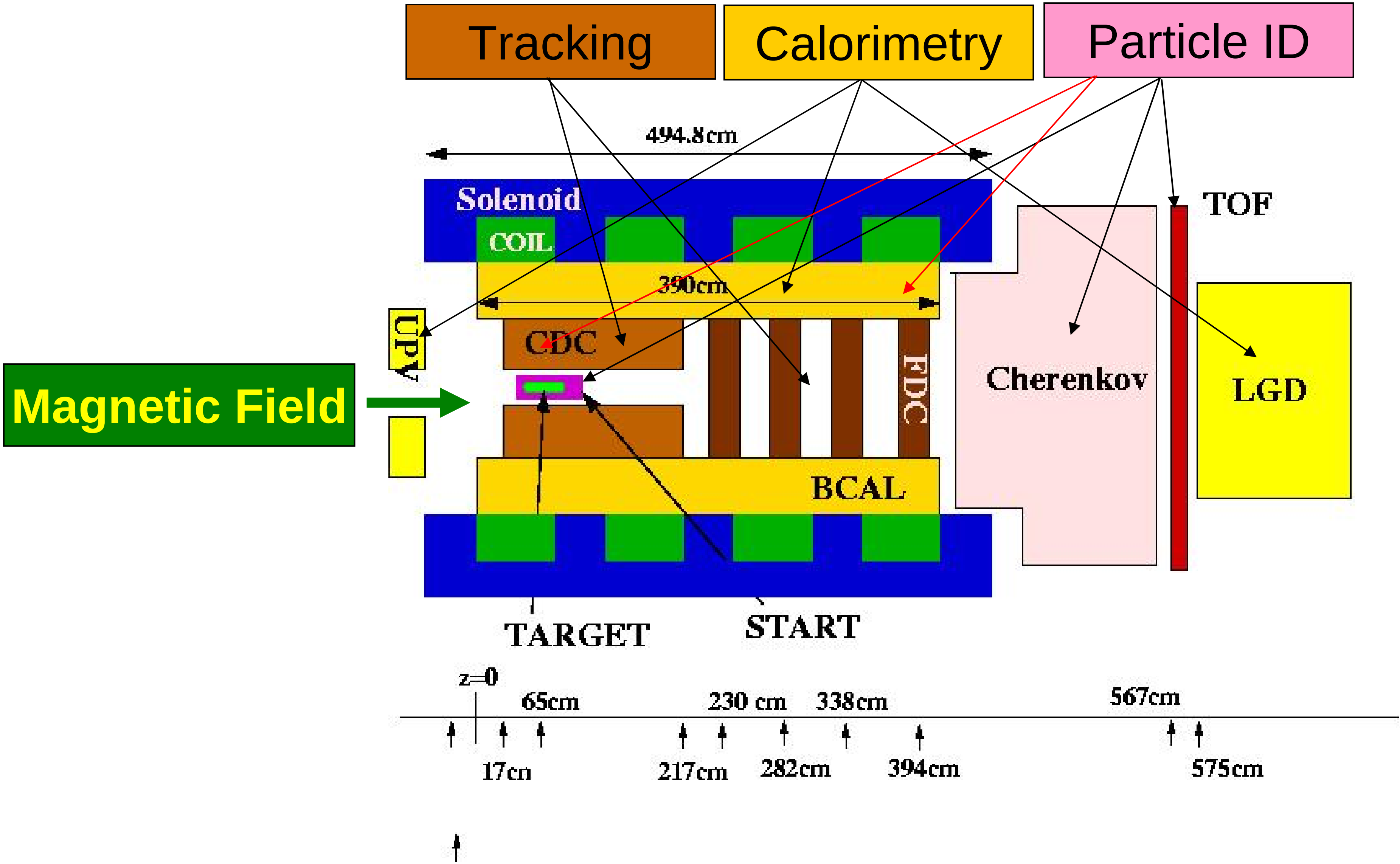
pions



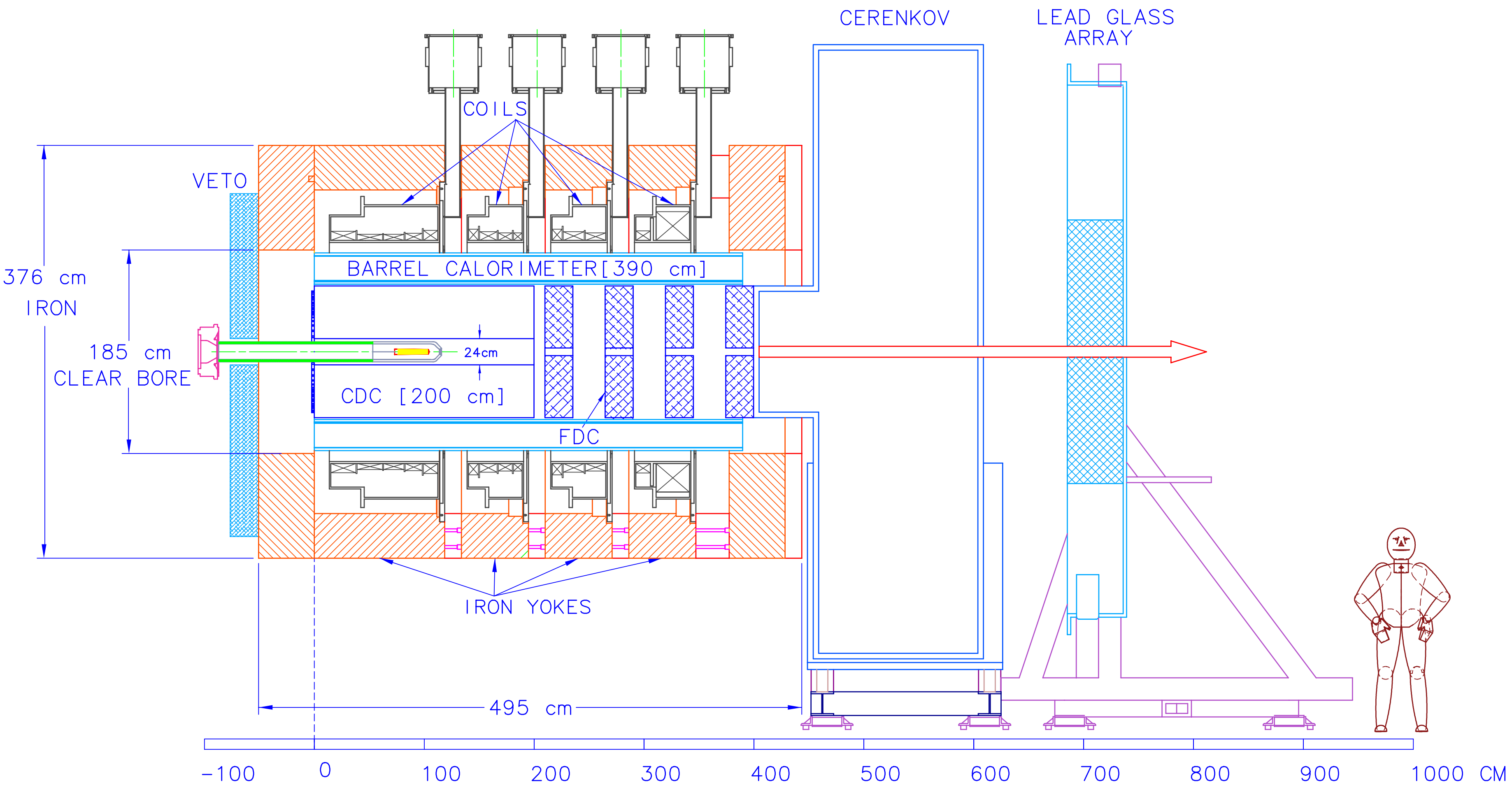
protons



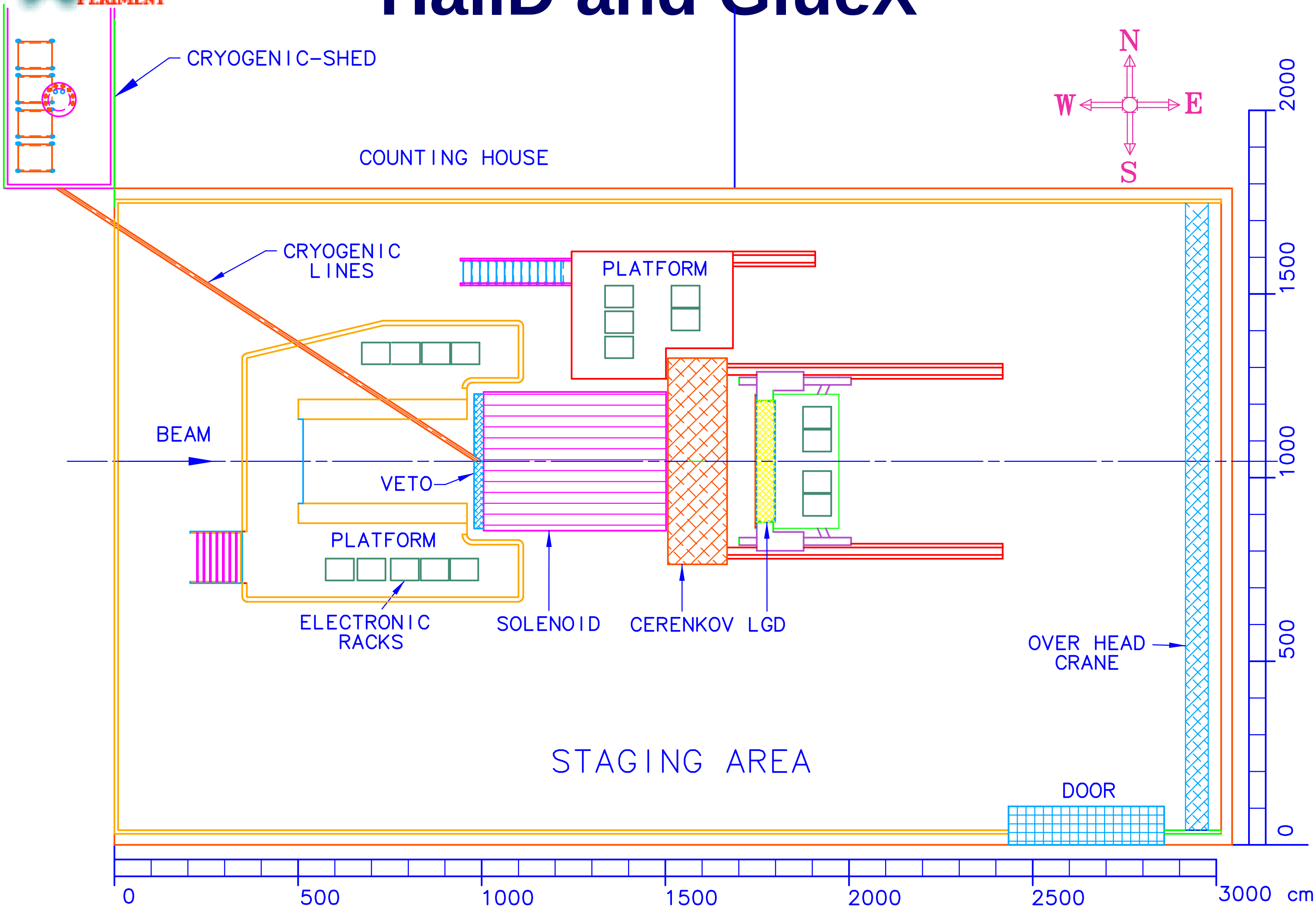
The GlueX Detector



The GlueX Detector

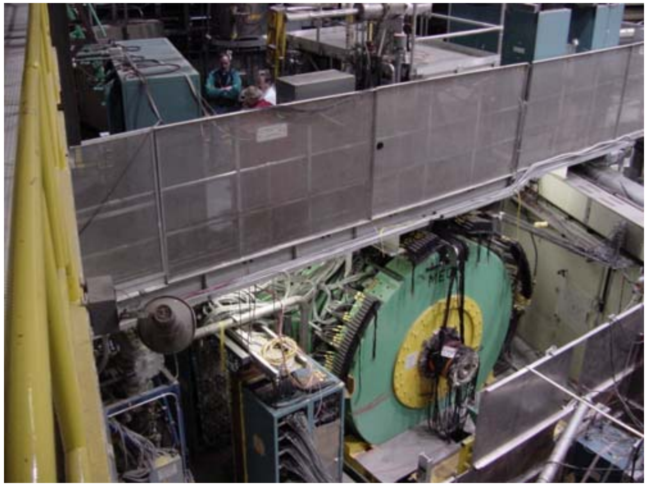


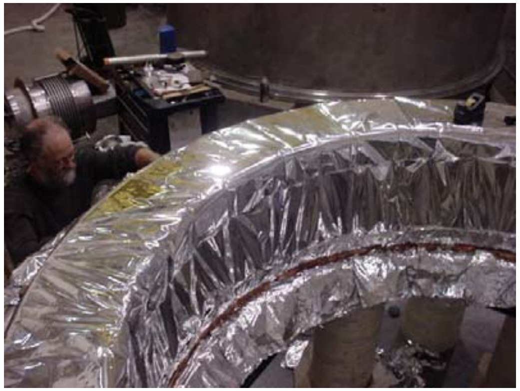
HallD and GlueX



The Solenoid

LASS Solenoid
Superconducting 2.24T
Used in Los Alamos MEGA Experiment.
Moved to IUCF for refurbishing Oct. 2003.





The Solenoid

Clear Bore: 185.4 cm diameter
Magnet Length: 495.3 cm
Solenoid Field: 22.4 kG
Uniformity: +- 3% in clear bore
+- 1% on axis

4 superconducting coils

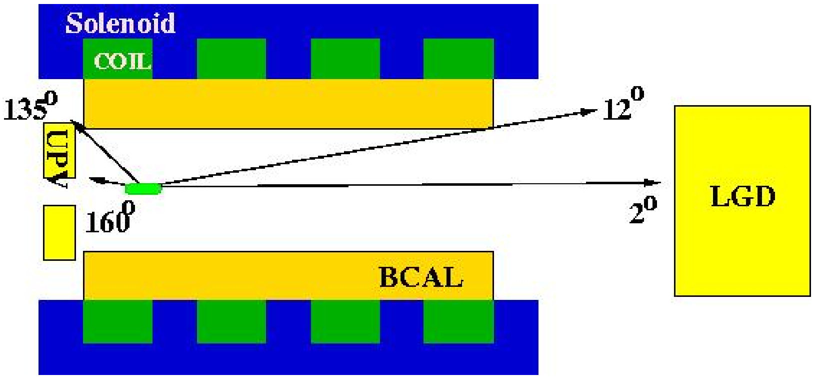
- coils 1 & 2 are complete
  - new gauges, insulation
  - leaks and plumbing fixed
  - pressure tested.

Coils 3 & 4 are waiting for contract completion

Magnet Review

- Magnet Assessment at LANL
- "looks very good" March 2001.
- Now have experience from 2 coils
- Interim assessment later this year

Calorimetry



Forward Calorimeter LGD

Existing lead glass detector
~2500 blocks
$\sigma_E/E \leq 0.036+0.073/E^{1/2}$
$\sim$ 100 MeV $\leq$ $E\gamma \leq$ 8 GeV

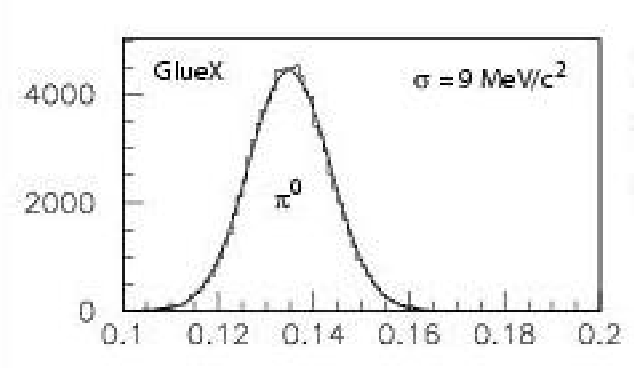
Barrel Calorimeter BCAL

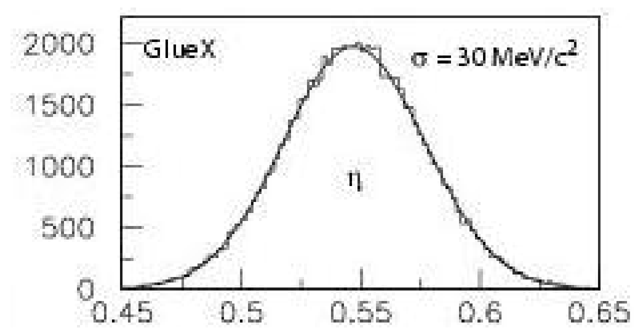
Lead-scifiber sandwich
4m long cylinder
$\sigma_E/E \leq 0.020+0.05/E^{1/2}$
~20MeV $\leq E_\gamma \leq \sim$ 3 GeV
200ps timing resolution
z-position of shower
time-of-flight

Upstream Photon Veto UPV

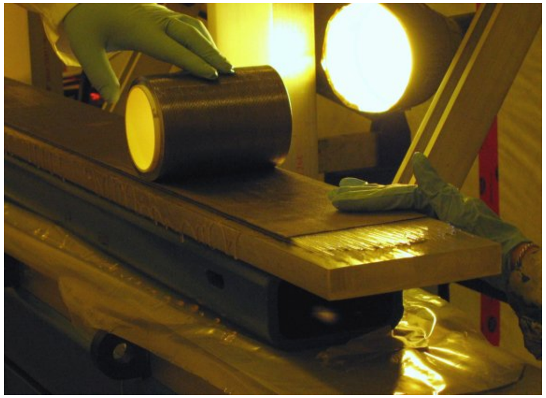
Veto photons
~20MeV $\leq E_\gamma \leq$ 300 MeV

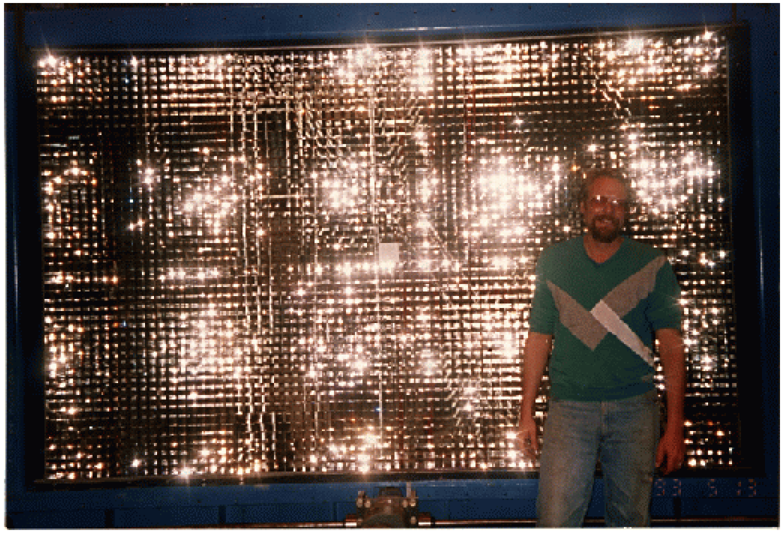
Expected π^o and η resolutions



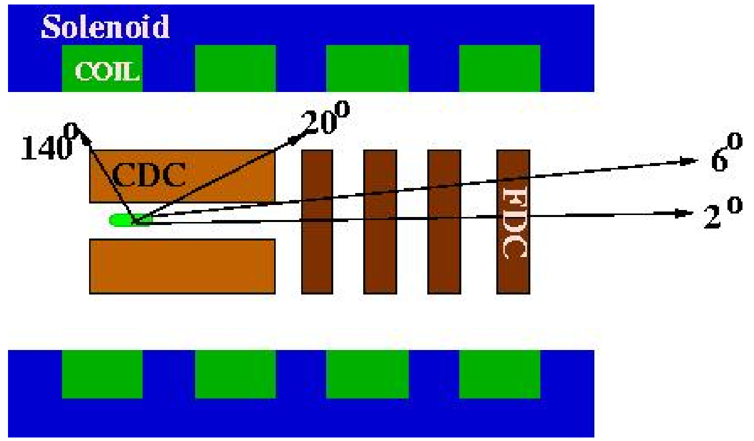


Calorimetry



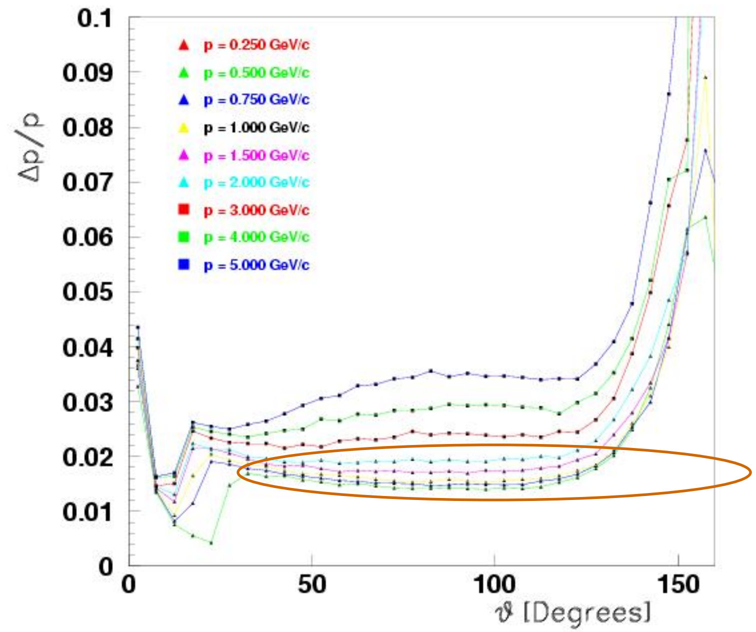


Tracking



Forward Region FDC

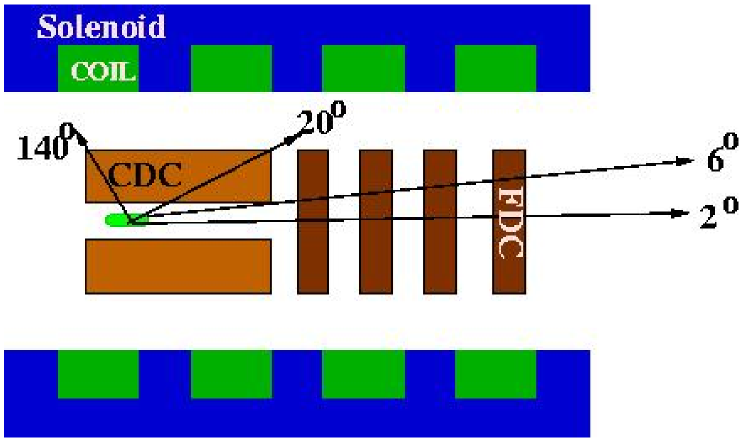
4 packages of planar drift chambers
- anode + cathode readout
- six planes per package
- σ_{xy}=150μm
- active close to the beam line.



Central Region CDC

cylindrical straw-tube chamber
- 23 layers from 14cm to 58cm
- 6° stereo layers
- $\sigma_{r\phi}$=150μm $\sigma_z \sim$ 2mm
- minimize downstream endplate
- dE/dx for p<450 MeV/c ← Necessary for protons

Tracking



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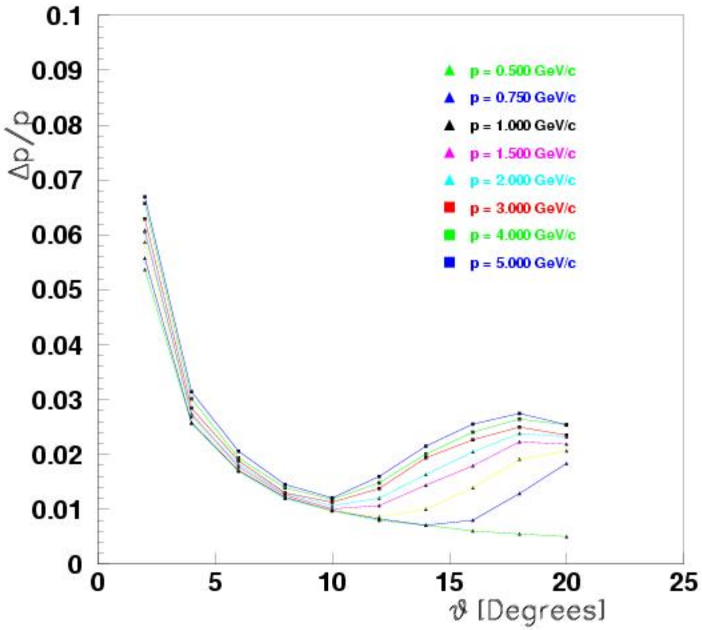

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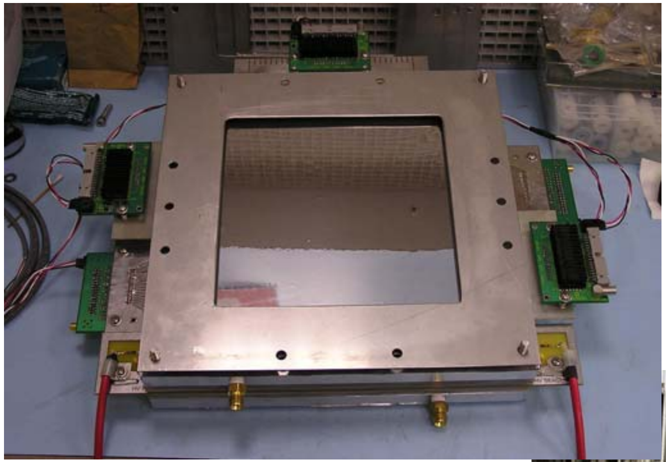
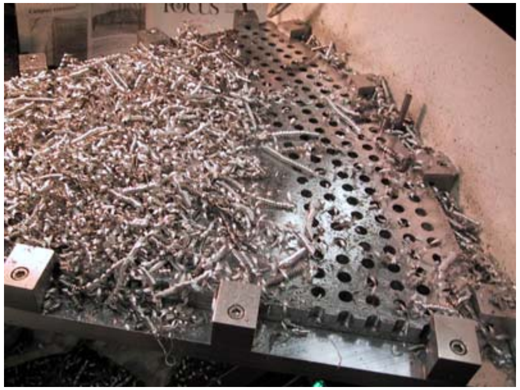
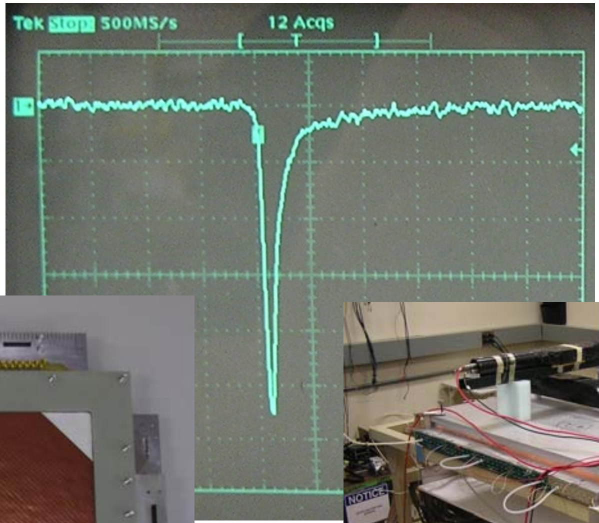
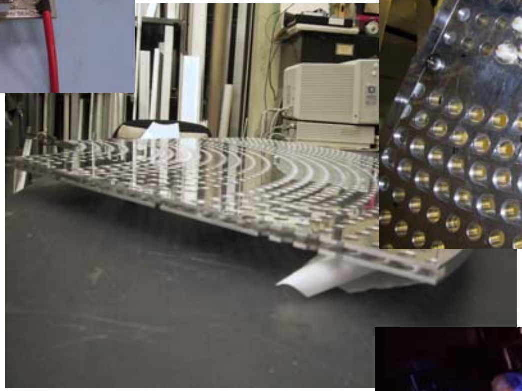
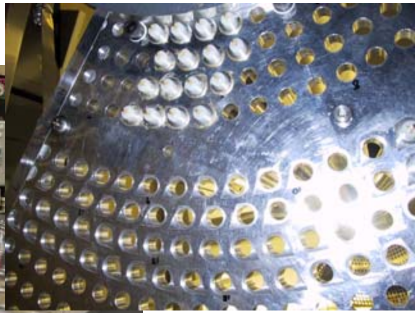
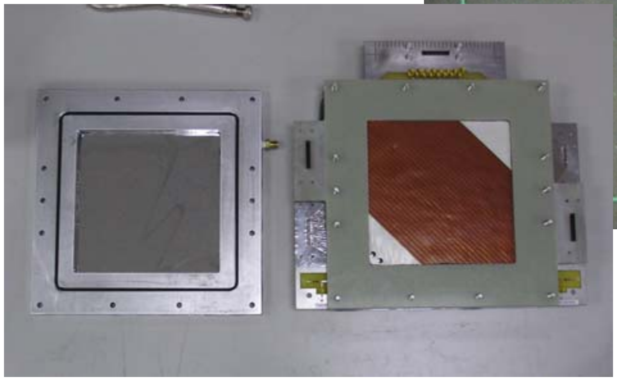


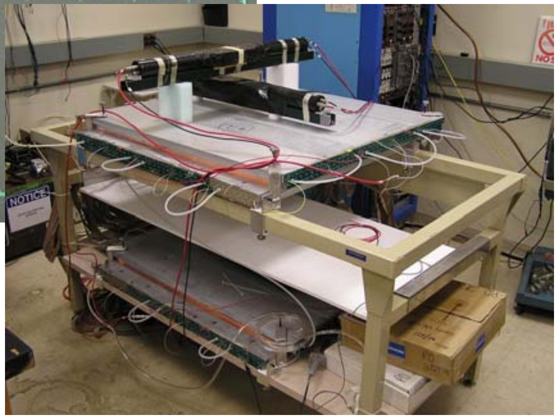












Particle Identification

Time-of-flight Systems

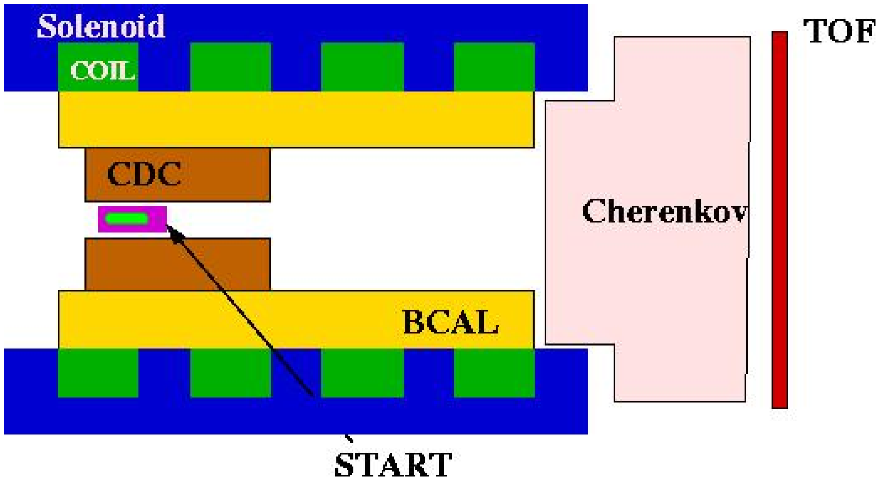
Forward tof ~80ps
BCAL ~200ps
Start counter

Cherenkov Detector

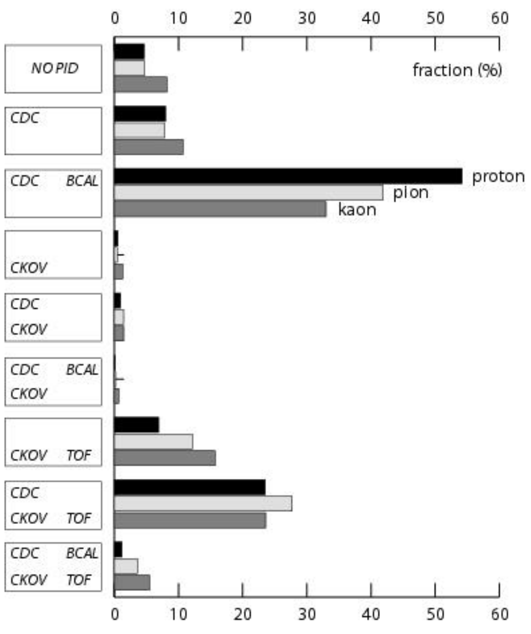
DIRC π K p separation

dE/dx Information

The CDC will do dE/dx
p<450 MeV/c

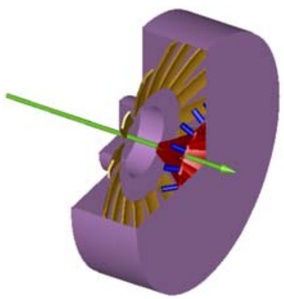


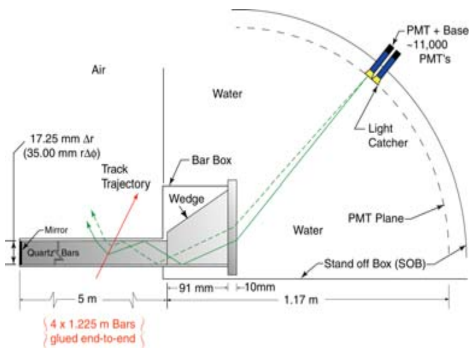
$$\gamma p \rightarrow K^* K^* p \rightarrow K^+ K^- \pi^+ \pi^- p$$

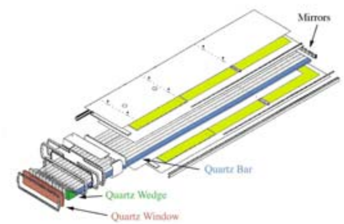


Particle Identification

The documentation discusses both a DIRC design and an atmospheric pressure Gas Cherenkov design. We do not believe that the latter will satisfy the physics requirements of GlueX.



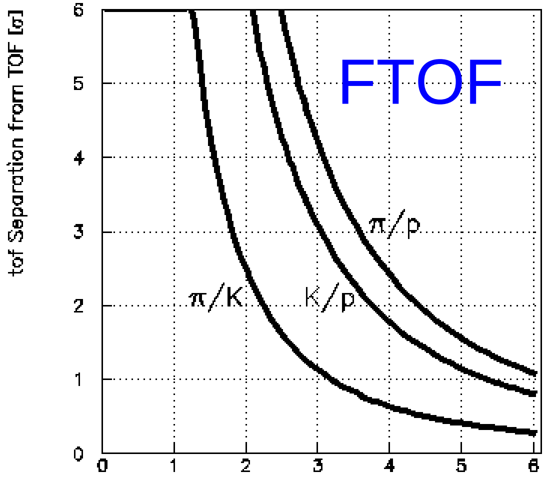


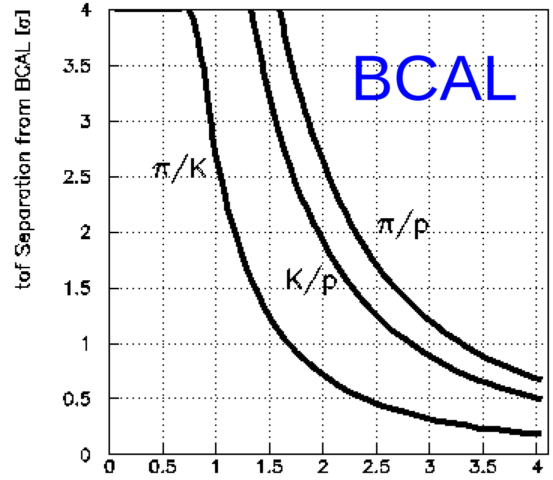


The DIRC design will accomplish the physics goals of the GlueX experiment.

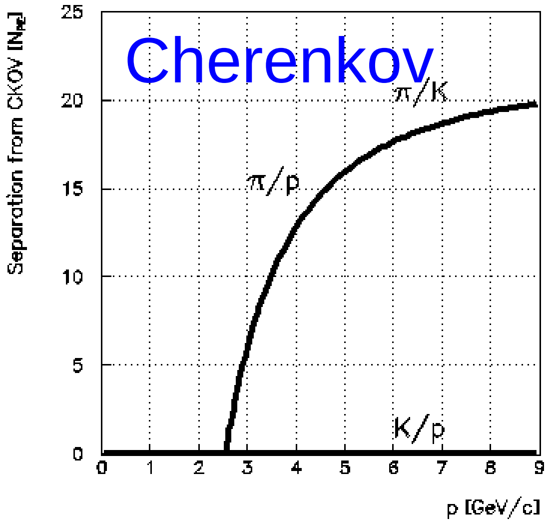
There are collaborators interested in pursuing the DIRC design and construction.

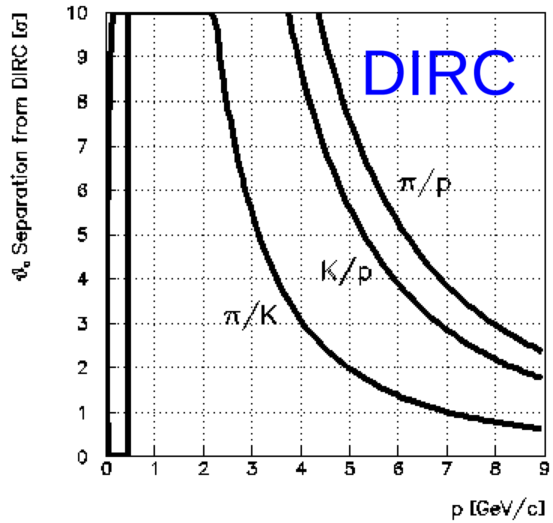
Particle Identification

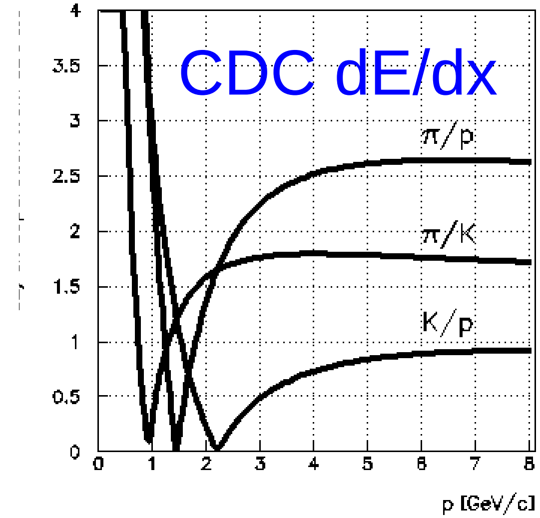




Separation from individual systems







Acceptance

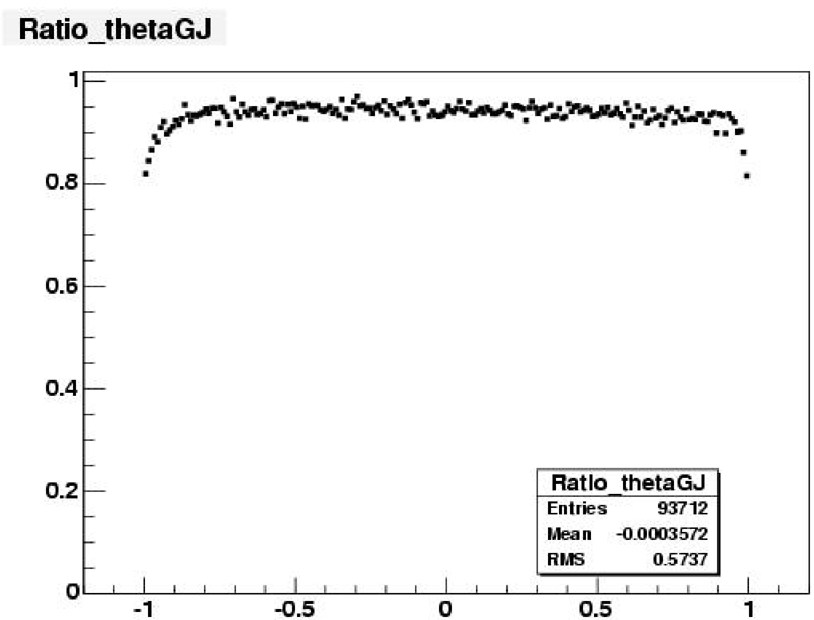
$\gamma\, p \to \eta_1\, p \to \pi^+\pi^- 4\gamma\, p$

Very High

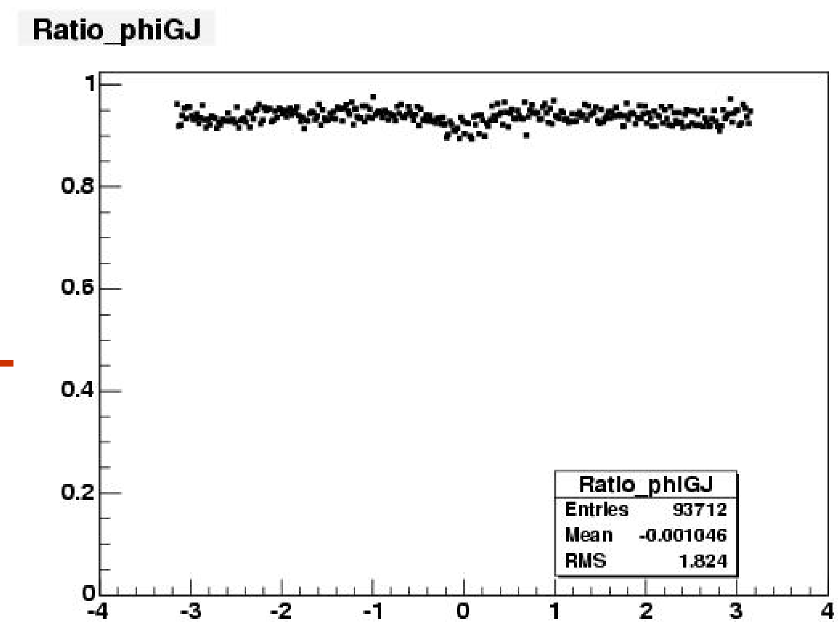
$\varepsilon_\pi \sim$ **0.99**

$\varepsilon_\gamma \sim$ **0.98**

Very uniform over PWA angles



Acceptance



$\cos\theta_{GJ}$ ϕ_{GJ}

Acceptance

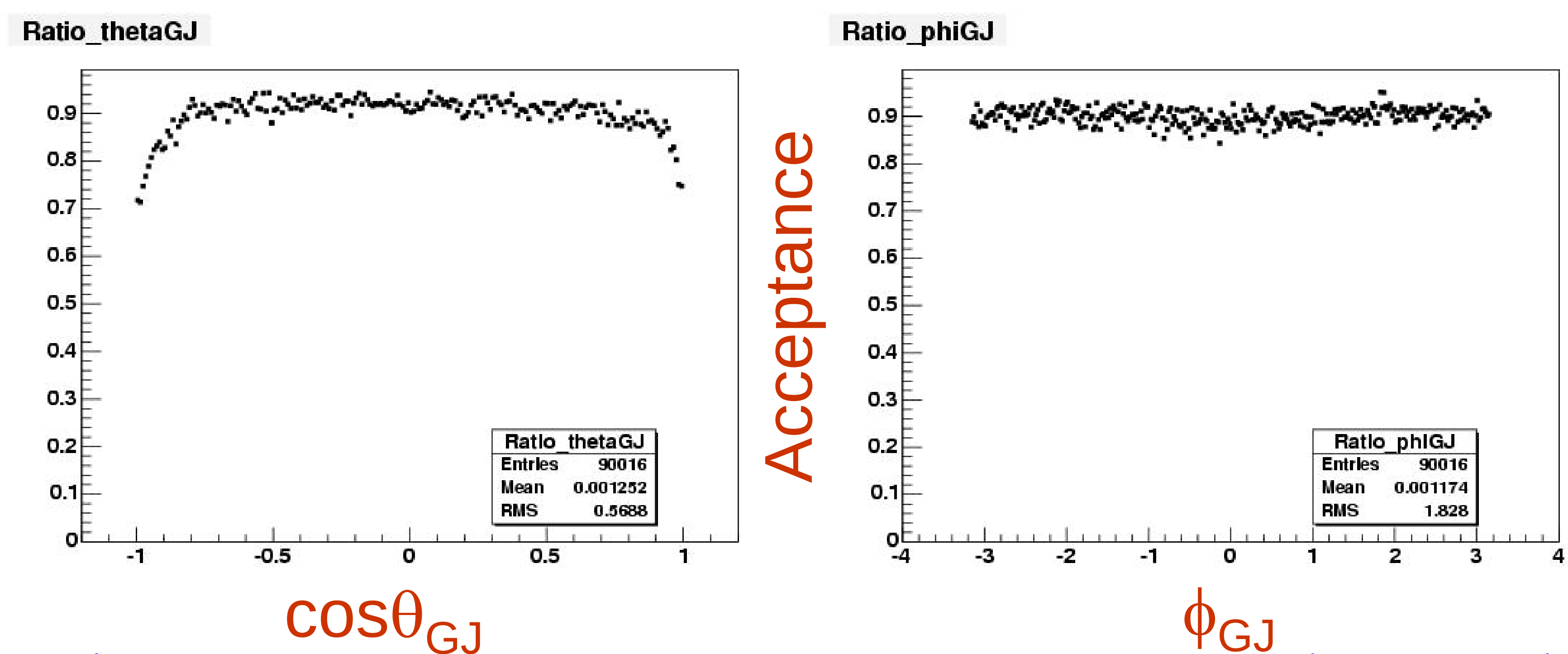
$\gamma\, p \rightarrow \eta_1\, p \rightarrow 8\gamma\, p$

Very High

$\varepsilon_\pi \sim$ **0.99**

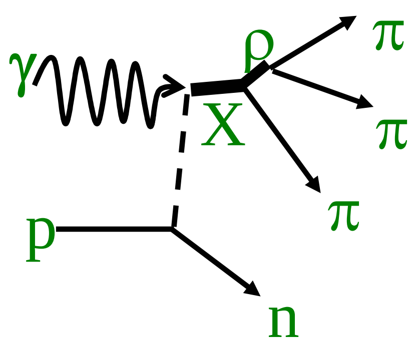
$\varepsilon_\gamma \sim$ **0.98**

Very uniform over PWA angles



Partial Wave Analysis

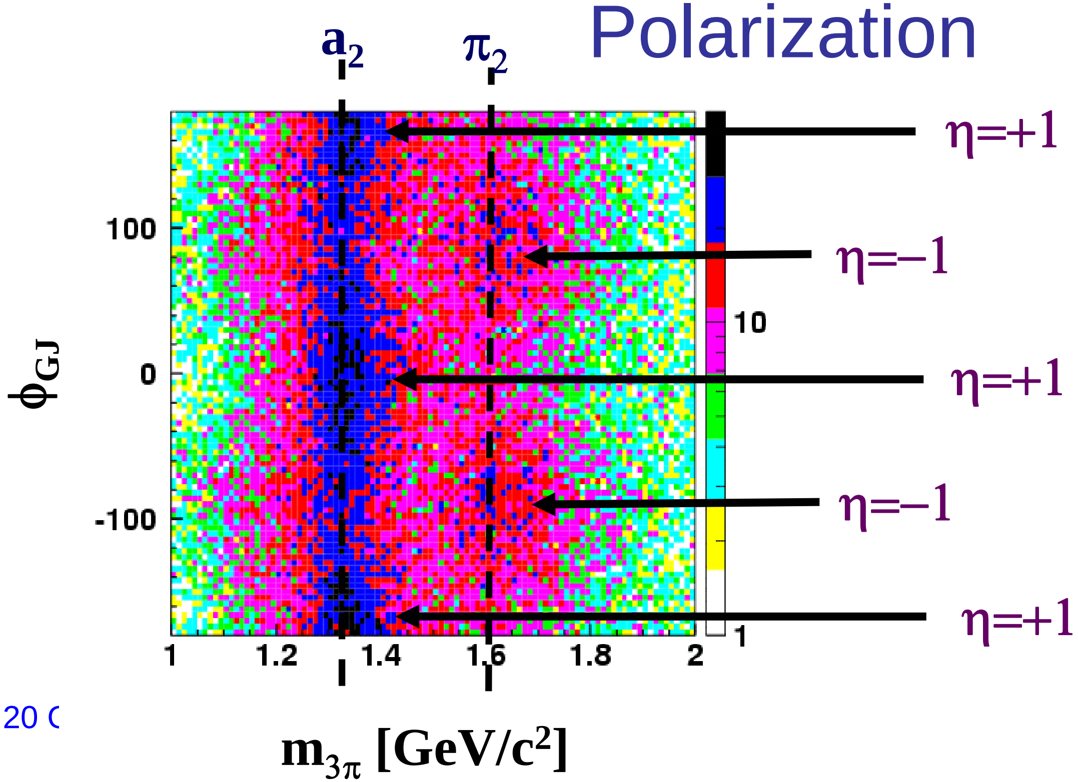
Double blind studies of 3π final states

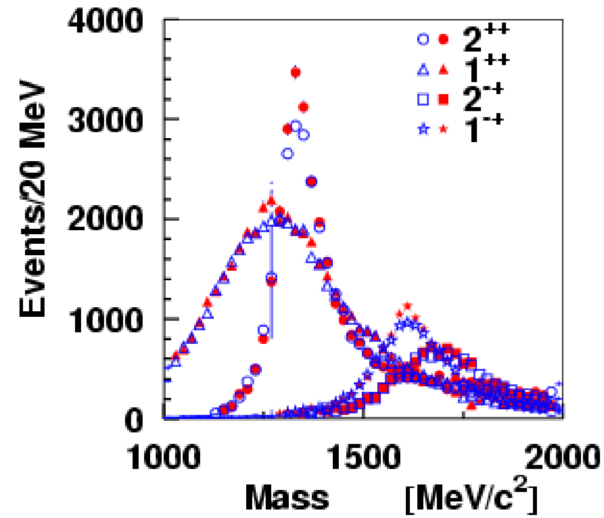


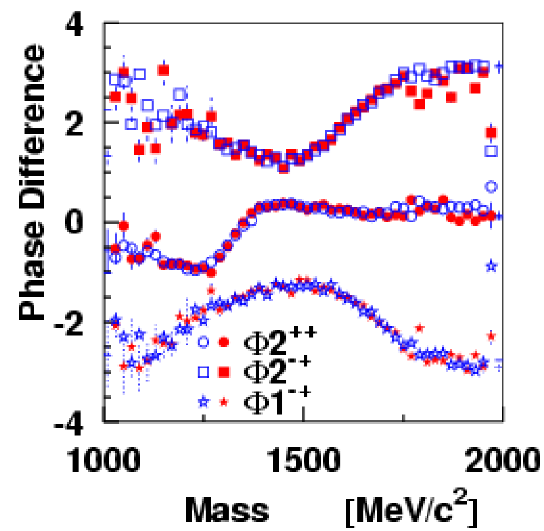
GlueX Monte Carlo

$$\gamma\, p \rightarrow \pi_1^+ n \rightarrow \pi^+\pi^+\pi^- n$$
$$\rightarrow \pi^+\pi^0\pi^0 n$$

Polarization



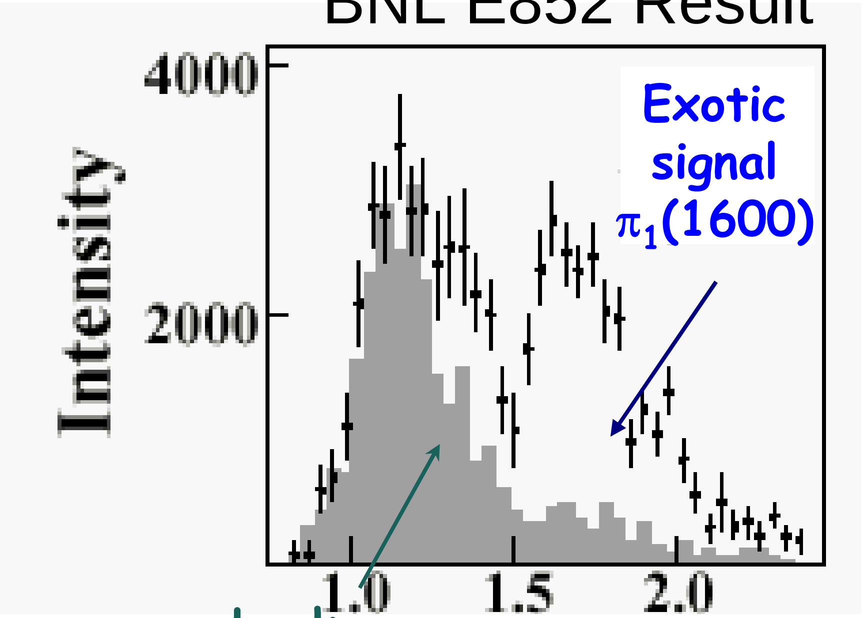




Leakage

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

BNL E852 Result



Leakage from non-exotic wave
due to imperfectly understood acceptance

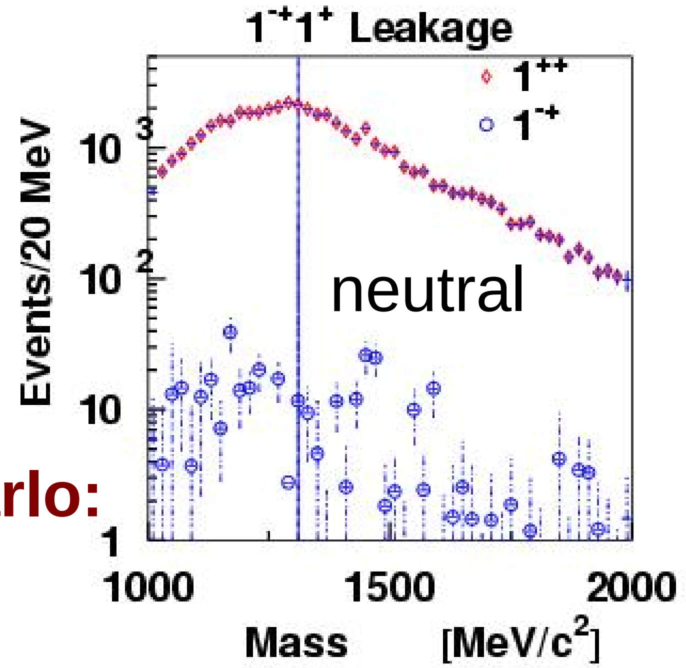
Leakage

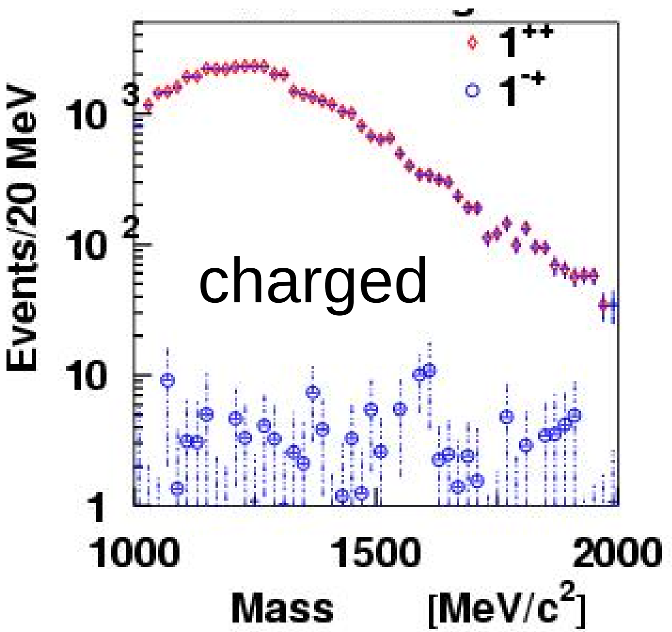
If your acceptance is not well understood, The PWA can "leak" one wave into another.

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. **$a_1(1^{++}) \leftrightarrow \pi_1(1^{-+})$**





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.

Summary

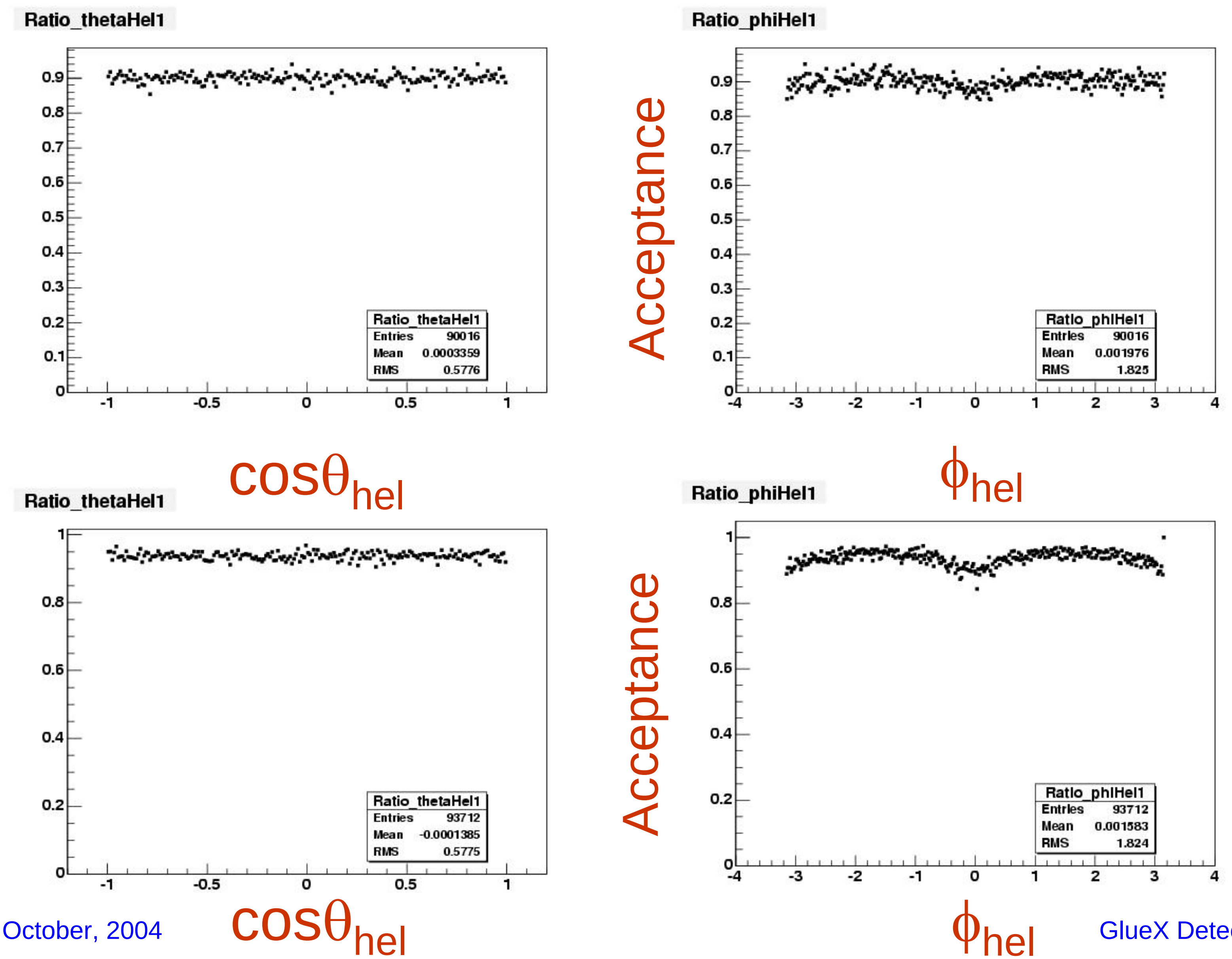
The combination of detector elements with their resolution requirements allows us achieve the GlueX physics goals.

The GlueX Detector has been optimized for Partial Wave analysis, and the design has been tested by carrying out these analyses on simulated data.

You will see that the status of all the detectors in the following talks. Some exist, most are in R&D, with all stages of R&D.

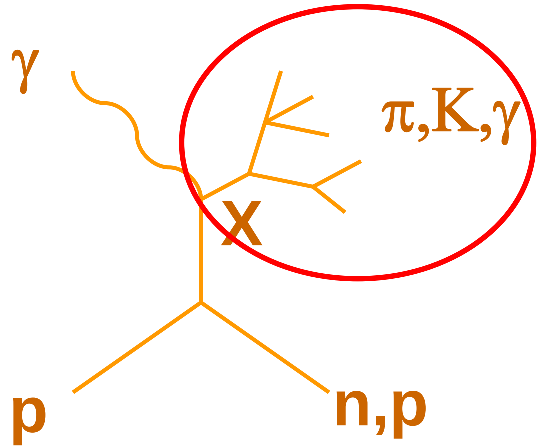
The collaboration is satisfied with the very recent DIRC design for the Cherenkov detector.

Acceptance


Ratio_thetaHel1
Ratio_phiHel1
Acceptance
Ratio_thetaHel1
Entries 90016
Mean 0.0003359
RMS 0.5776
Ratio_phiHel1
Entries 90016
Mean 0.001976
RMS 1.825
cosθhel
φhel
Ratio_thetaHel1
Ratio_phiHel1
Acceptance
Ratio_thetaHel1
Entries 93712
Mean -0.0001385
RMS 0.5775
Ratio_phiHel1
Entries 93712
Mean 0.001583
RMS 1.824
cosθhel
φhel

Search for QCD Exotics

The GlueX Detector Design has been driven by the need to carry out Amplitude analysis.



Photoproduction

$\pi_1 \to \pi b_1\ ,\ \pi f_1\ ,\ \pi\rho\ ,\ \eta a_1$	1:.25:.25:.20
$\eta_1 \to \pi(1300)\pi\ ,\ a_1\pi$	1:1
$\eta'_1 \to K_0K,\ K_1K$	
$b_2 \to a_1\pi\ ,\ h_1\pi\ ,\ \omega\pi\ ,\ a_2\pi$	1:1:0.5:0.25
$h_2 \to b_1\pi\ ,\ \rho\pi\ ,\ \omega\eta$	1:1:0.1
$h'_2 \to K_1K, \phi\eta$	
$b_0 \to \pi(1300)\pi\ ,\ h_1\pi$	1:0.20
$h_0 \to b_1\pi\ ,\ h_1\eta$	1:0.02
$h'_0 \to K_1K,\ h'_1\eta$	

$$\left.\begin{array}{l} \eta_1 \to a_1\pi \to (\rho\pi)(\pi) \to \pi\pi\pi\pi \\ h_0 \to b_1\pi \to (\omega\pi)\pi \to \pi\pi\pi\pi\pi \end{array}\right\} \quad \pi^0 \to \gamma\,\gamma$$

Final State Particles

$\pi^{\pm}\ K^{\pm}\ K_L\ \gamma\ n\ p$