# *The First Two Years of GlueX Physics*

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# Outline


1. Engineering Running
2. Initial Physics Running
3. Initial Hybrid Searches
4. GlueX Beam Requirements
5. Computing Needs
6. Summary

# Pre-Beam Engineering and Commissioning

This part of the commissioning process will take place between the time that the detector is installed and when beam is first delivered to Hall D.

- Magnet commissioning with installed detector.
- Data acquisition commissioning with full detector.
- Verify network connections and transfer capabilities.
- Cosmic and pulser data for most detector elements.
- Generate initial detector calibrations.

# Engineering Running and Commissioning

During the first six months of beam in HallD, commissioning of the experiment and engineering running of the detector will take place.

- The commissioning of the photon beam.
  - Commissioning of the tagger.
  - Beam line setup and commissioning.
  - Beam energy calibrations.
- Commissioning of the GlueX detector.
  - Commissioning of all detector elements.
  - Commissioning of the GlueX trigger.
  - Commissioning of the data acquisition system.
  - Commissioning of the offline software.
- Engineering Running
  - Readout and reconstruction of complete events.
  - Produce refined calibrations for the detector.

# Reproducing Known Physics

During the second six months of beam in HallD, GlueX activities will be focused on reproducing known physics using the GlueX detector. In particular, we will focus on the following:

- Polarization sensitive physics such as vector mesons.
- Study reconstruction of the same physics using several different final states.

# Vector Meson Photo-production

- Relatively large, and known cross sections for vector meson production.
- Angular distribution of decays measures polarization.
- Measure spin-density matrix elements.
- Should be able to measure the beam polarization.

| Light Vector Mesons | | |
|---|---|---|
| $\gamma p \to \rho(770) p$ | $20\mu b$ | $\rho \to \pi^+\pi^-$ |
| $\gamma p \to \omega p$ | $2\mu b$ | $\omega \to \pi^+\pi^-\pi^\circ, \pi^\circ\gamma$ |
| $\gamma p \to \phi p$ | $0.4\mu b$ | $\phi \to K^+K^-, K_S K_L, \pi^+\pi^-\pi^\circ$ |

# The $a_2(1320)$ Meson

The $a_2$ has a large production cross section and many well known decay channels. It also has a mass that makes it an ideal state in which to study the reconstruction of different final states of the same physics.

| | $\gamma p \to n a_2^+(1320) \quad \sim 1\,\mu b$ | |
|---|---|---|
| 70% | $a_2 \to (\rho\pi)^+ \to$ | $\pi^+\pi^+\pi^-$, $\pi^+\pi^\circ\pi^\circ$ |
| 14.5% | $a_2 \to \eta\pi^+ \to$ | $\pi^+\gamma\gamma$, $\pi^+\pi^+\pi^-\pi^\circ$, $\pi^+\pi^\circ\pi^\circ\pi^\circ$ |
| 4.9% | $a_2 \to K^+K_S \to$ | $K^+\pi^+\pi^-$, $K^+\pi^\circ\pi^\circ$ |
| 0.5% | $a \to \pi^+\eta\prime \to$ | $\pi^+\pi^+\pi^-\gamma\gamma$ |

These final states can fully exercise the GlueX detector with high statistics in a short period of time.

# The First Spectroscopy Using GlueX

During this period we will start our first searches for exotic hybrid mesons. We anticipate that the initial tagged photon rate will be $10^7\,\gamma/s$ and that during this period, we will start to push it up to as close to $10^8\,\gamma/s$ as we can get.

This rate is effectively limited by the level-3 trigger compute farm, which may also be being built up during this period. For rates of $10^7$, the level-3 trigger does nothing, while at $10^8$, it is removing about 75% of the level-1 data.

These searches will focus on three final states which can couple to several different exotic hybrids.

# Event Rate Estimates

The event rate, $\dot{N}_{evt}$ is given as:

$$\begin{aligned} \dot{N}_{evt} &= \sigma \cdot N_{targ} \cdot \dot{N}_{\gamma} \\ N_{evt} &= \dot{N}_{evt} \cdot \text{time} \end{aligned}$$

where $\sigma$ is the photo-production cross section,

- $N_{targ}$ is the number of scattering centers, $(1.26\, b^{-1})$.
- Assume initial photon rates, $\dot{N}_{\gamma}$ are $10^7\, s^{-1}$.
- Assume "time" is 26 weeks with 30% efficiency, $(5 \times 10^6\, s/yr)$.
- Assume overall event efficiency is 72%.

| $\sigma\, \mu b$ | $N_{\gamma}$ | Events | | |
|---|---|---|---|---|
| | | Trig. Rate | To Tape | Reconstructed |
| $1\, \mu b$ | $1 \times 10^7 \gamma/s$ | $12.6\, Hz$ | $6.3 \times 10^7\, \text{yr}^{-1}$ | $4.5 \times 10^7\, \text{yr}^{-1}$ |

# Exotic Hybrid Final States

The three channels, $\pi\pi\pi$, $\omega\pi\pi$ and $\eta\pi\pi$ are a good starting point for searches for exotic hybrids.

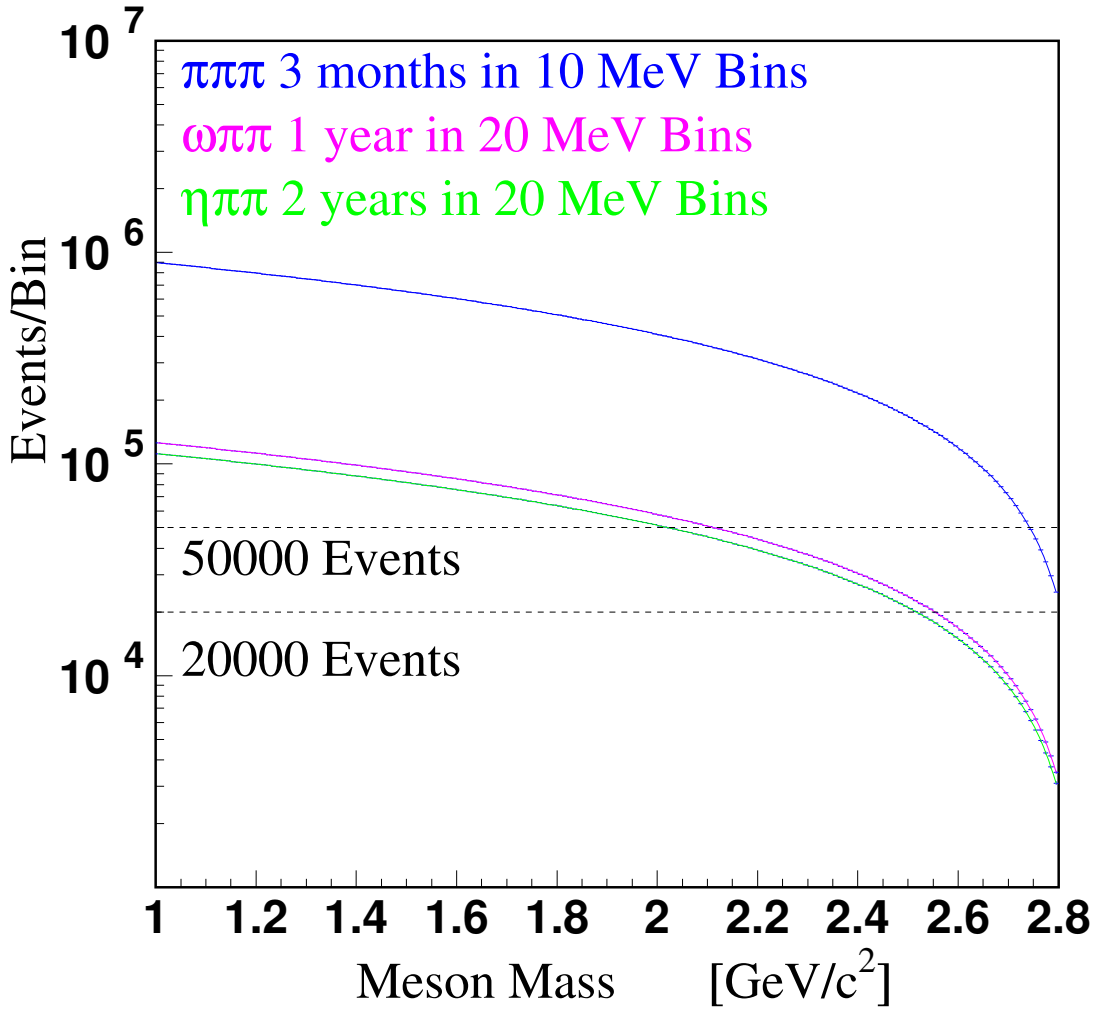
- The cross sections times branching fraction are reasonable.
- Multiple isospin states are available.
- Three particle final states allow *simplified* analysis.

| Reaction | $\sigma$ | | Fraction |
|---|---|---|---|
| $\gamma p \to p\pi\pi\pi$ | $10\mu b$ | | 1.0 |
| $\gamma p \to n\pi^+\pi\pi$ | $10\mu b$ | | 1.0 |
| $\gamma p \to p\pi\pi\omega$ | $0.2\mu b$ | $\omega \to 3\pi$ | 0.88 |
| $\gamma p \to n\pi^+\pi\omega$ | $0.2\mu b$ | $\omega \to 3\pi$ | 0.88 |
| $\gamma p \to p\pi\pi\eta$ | $0.2\mu b$ | $\eta \to \gamma\gamma$ | 0.37 |
| $\gamma p \to n\pi^+\pi\eta$ | $0.2\mu b$ | $\eta \to \gamma\gamma$ | 0.37 |

# Expected Events for Partial Wave Analysis

| Hybrid | $\pi\pi\pi$ | $\omega\pi\pi$ | $\eta\pi\pi$ |
|---|---|---|---|
| $h_0$ | | yes | |
| $\eta_1$ | | | yes |
| $\pi_1$ | yes | yes | |
| $h_2$ | yes | yes | |
| $b_2$ | | | yes |

At least 20,000 events are needed in a bin for partial wave analysis, while 50,000 is a much better number.



# The Requirements on The Delivered Beam

During initial running, the requirements placed on the beam into HallD will steadily increase until we reach those necessary for physics running.

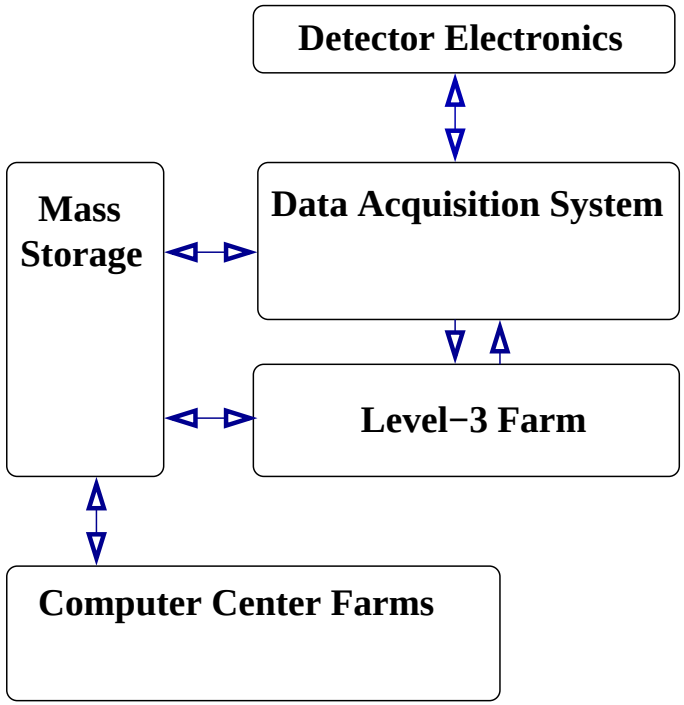
| | Engineering Running | Initial Physics | Hybrid Searches |
|---|---|---|---|
| Min. Energy | 10 GeV | 11 GeV | 12 GeV |
| Min. Current | 1 $nA$ | 1 $nA$ | 1 $nA$ |
| Avg. Current | $1 - 300\,nA$ | $\sim 300\,aA$ | $0.3 - 3\,\mu A$ |
| Max. Emitance | $50\,\text{mm}\cdot\mu r$ | $20\,\text{mm}\cdot\mu r$ | $10\,\text{mm}\cdot\mu r$ |
| Max. Energy Spread | $< 0.5\%$ | $< 0.5\%$ | $< 0.5\%$ |
| Max. Halo Fraction | $< 10^{-4}$ | $< 10^{-5}$ | $< 10^{-5}$ |
| Max. $e^-$ Polarization | *unspecified* | *unspecified* | $< 1\%$ |

Minimum current is required for beam-line setup. Average current is required for normal running and is expected to vary in engineering. The rate during hybrid searches is dependent on the level-3 trigger in GlueX.

# Computer Resource Needs

As with the beam-line requirements, the computing needs of the GlueX experiment will also evolve through the first two years of running.

- Networks
- Storage
- Trigger Farms
- Compute Farms



# Engineering Resource Needs

During this period, we anticipate that the compute needs will be low. We anticipate that networks will be in place early. Sporadic reconstruction will handle burst of data and calibration work.

| | Pre-Beam | Engineering |
|---|---|---|
| Networks | Connected | Full Rate |
| Trigger Farm | | Head Nodes |
| Storage | $\sim$ 1 *Tb* | $\sim$ 5 *Tb* |
| Compute Farms | Minimal | Sporadic Reconstruction |

# Physics Resource Needs

During this period, we anticipate quickly building up to the full compute needs of the GlueX experiment. We would like to be able to reconstruct all events, effectively in real time as well as carrying out physics analysis of those data.

| | Initial | Hybrids |
|---|---|---|
| Networks | Full Rate | Full Rate |
| Trigger Farm | Head Nodes | Adding Nodes |
| Storage | $\sim$ 100 *Tb* | $\sim$ 1000 *Tb* |
| Compute Farms | Dedicated Reconstruction (10% level) | Dedicated Reconstruction (100% level) |

# Summary

The three-part program outlined in allows us to commission the GlueX detector and beam line and understand how all it's parts works together. It should then provide calibrations.

We then identify a known physics where the data can be collected reasonably quickly and comparisons to known results can be made. This allows us to verify that all parts of the detector can work together.

Finally, we have a longer-term piece of physics that carries out a major initial search for exotic hybrids, but is limited to a small number of final states.