Tagger Microscope:

a High-Resolution Hodoscope for the Photon Beamline of the GlueX Experiment

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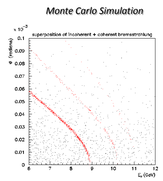
Abstract

In the constituent quark model (CQM), the quantum state of a meson (quark, anti-quark pair) is derived purely from the states of the two quarks. Current theoretical calculations predict that the "glue", which merely provides the binding of the quarks in the CQM, may be excited to produce a new kind of meson called a "hybrid". In a hybrid meson, the glue is in an excited state, and contributes extra angular momentum to the meson. This allows the meson to possess a combination of total angular momentum, parity and charge conjugation that is forbidden for quarkonium. These so-called "exotic" quantum numbers allow unambiguous identification of the new states. The GlueX experiment is designed to search for these exotic mesons and map out their spectrum.

In the GlueX experiment, a 12GeV electron beam passes through a 20μm thick diamond wafer and undergoes bremsstrahlung, producing a polarized photon beam directed at a liquid hydrogen target, where meson photo-production takes place. In order to constrain the reaction, it is crucial to know the energy of the photon that produced it. The instrument that provides this information is a magnetic spectrometer known as a photon tagger. The Nuclear Physics Group at UConn is constructing a special high resolution tagging detector called the "Tagger Microscope". This device is designed for: efficient running at several MHz, individual bunch identification, and robust operation in a difficult environment of stray magnetic fields and background radiation.

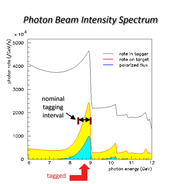
Linearly Polarized Photon Beam



Scatter plot of Bremsstrahlung emission angle versus energy for a diamond radiator and 12 GeV electron beam. Coherent (red dots) and incoherent (black dots) components are both present in the beam.

- 12 GeV endpoint
- 20 μm diamond radiator
- Linearly polarized (determined by diamond orientation)
- 3 μA electron beam
- Active beam-collimator alignment
  a.k.a. - "Active Collimator" (Tungsten)
- 3.5 mm diameter collimator (Nickel)
- Diamond radiator to collimator distance → 76m

✓ Leads to 10^8 γ/s on target (after the collimator)
✓ Initial energy range of interest 8.4 – 9 GeV



Design goal is to build an experiment with ultimate rate capability as high as 10^8 γ/s on target.

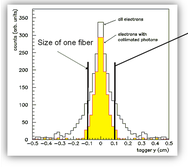
Photon Tagging

In order to identify the hybrid mesons among the other particles that are produced in the target, it is essential to know the energy and time for each photon which interacts with a proton in the liquid hydrogen target. "Tagging" of the photon energy is achieved by measuring the energy and time of the associated bremsstrahlung electron, which is accomplished using the "Tagger Microscope" (center panel).

Detector Construction

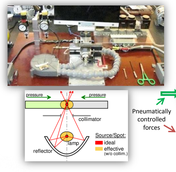
Scintillating Fiber (BCF-20)

- Multi-clad fiber
- Polystyrene core
- 2.7 ns decay time
- Trapping Efficiency 7.3%

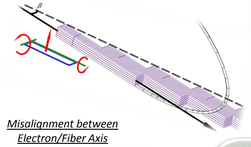


Fiber Splicing Unit

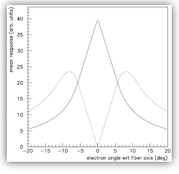
- Fuses Waveguide to SciFi



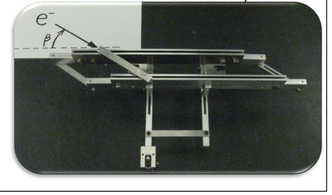
- *Splicing Collars*

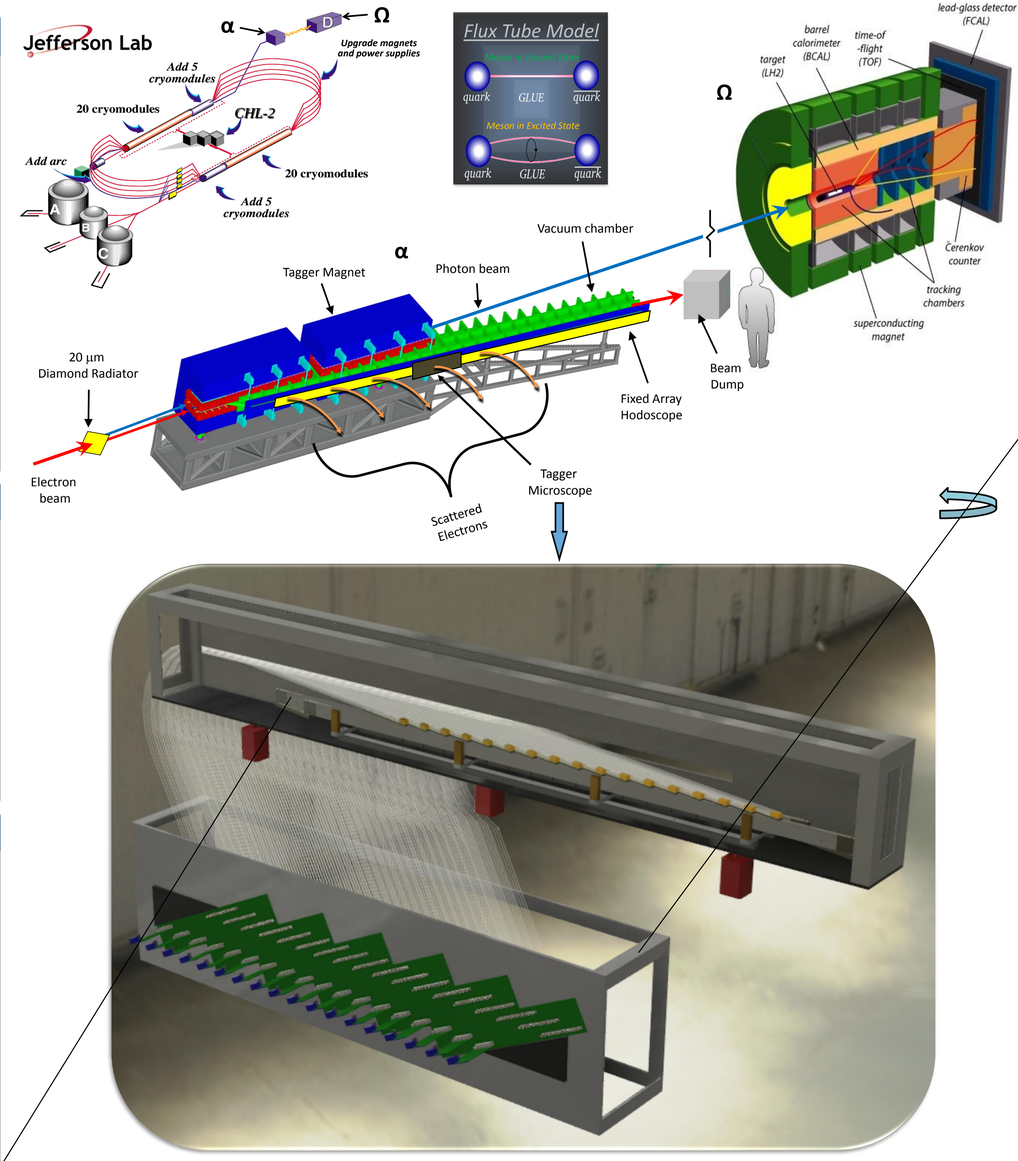


Misalignment between Electron/Fiber Axis

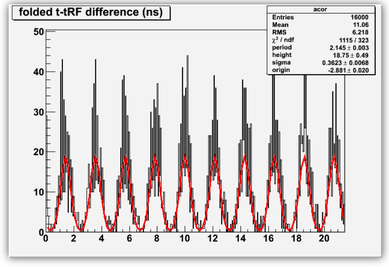


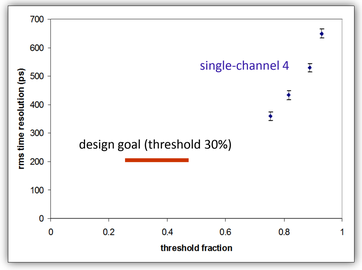
Beam's Eye View





Parasitic Beam Test Results from Hall B

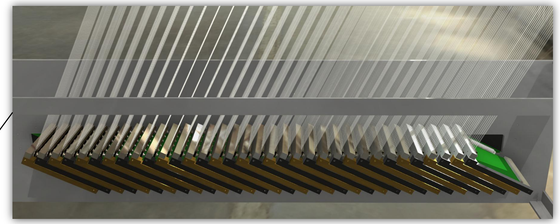




Electronics

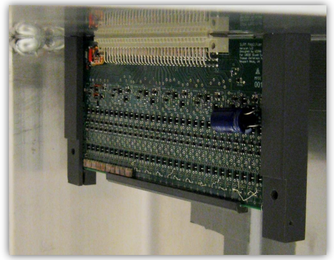
Specifications

- 200 ps time resolution
- 100 MHz bandwidth readout
- Individual photon counting pulse height resolution
- Low power consumption
- Radiation-resistant to gammas
- > 95% efficient at 4 MHz rate



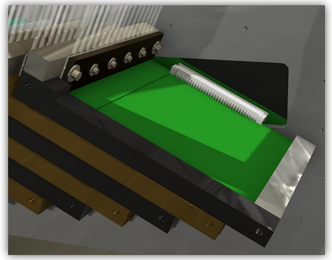
Layout Design

Prototype

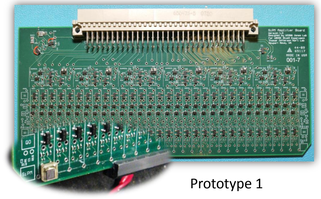


vs.

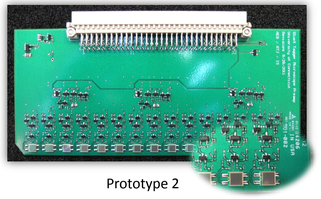
Full Scale Model



Preamplifier Board



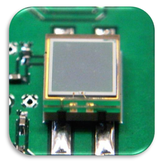
Prototype 1

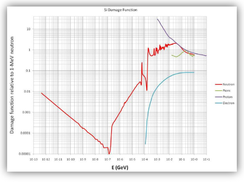


Prototype 2

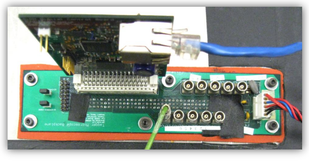
Silicon Photo-multipliers

- Hamamatsu
- 3 x 3 mm active area
- 14,400 pixels
- Spectral response range: 320 – 900 nm
- Peak sensitivity wavelength: 440 nm
  - BCF-20 SciFi emission peak: 492 nm
- Susceptible to neutron radiation damage





Backplane Board



Digital Board

References

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