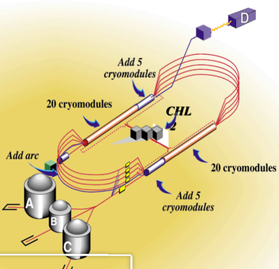
The GlueX Experiment in Hall-D

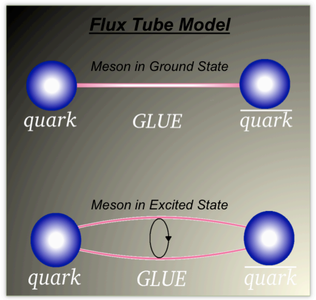


Exotic Hybrid Mesons

The observed spectrum of quark + (anti)quark states (mesons) is well described by the constituent quark model. In this model, the quantum state of the meson is derived purely from the states of the two quarks.

Recent theoretical calculations, however, predict that the gluons that bind the quarks together (the "glue") may also contribute to the quantum numbers of the meson.

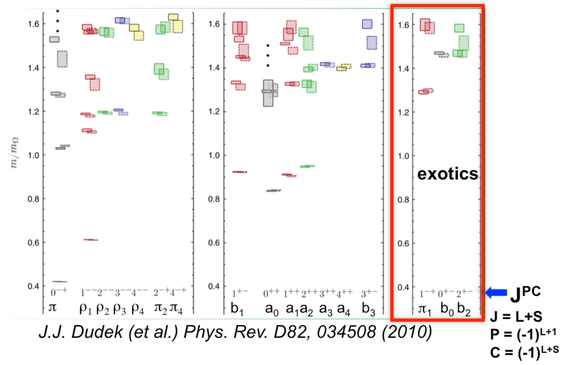
In these so called "hybrid" mesons, the glue is thought to be in an excited state such that it carries one unit of angular momentum.



With the glue acting as a 3rd contributor, quantum states can be obtained that are forbidden with only the two quarks contributing. These states are referred to as "exotic".

The goal of the GlueX experiment is to measure and map out the spectrum of these hybrid mesons in the light quark sector (*u, d*). The experiment will initially focus on the exotic states as these will be easier to distinguish.

Theoretical Predictions



J.J. Dudek (et al.) Phys. Rev. D82, 034508 (2010)

Early motivation for the GlueX experiment was provided by the Flux Tube model. In this model the gluons exchanged between the two quarks to form the binding can be thought to form a tube of relatively constant energy density. In the lowest excited state of the tube, it can carry one unit of angular momentum (picture a jump rope).

More recently, with the development of both high performance computing facilities and the field of Lattice QCD (LQCD), calculations have been made that confirm predictions of the flux tube model for their existence and range of expected masses.

The above diagram indicates results of a LQCD calculation. It indicates that the exotic hybrid with the lowest mass ($J^{PC}=1^{-+}$) would be about 1.3 times as heavy as Ω baryon or about 2 GeV/c².

Model predictions indicate that hybrids would decay preferentially into an L=1 and L=0 meson. This tends to lead to more complicated decay chains that end up with 5 or more particles in the final state. The difficulty in reconstructing these high-multiplicity events could be a contributing factor for the sparse experimental evidence of exotic hybrids to date.

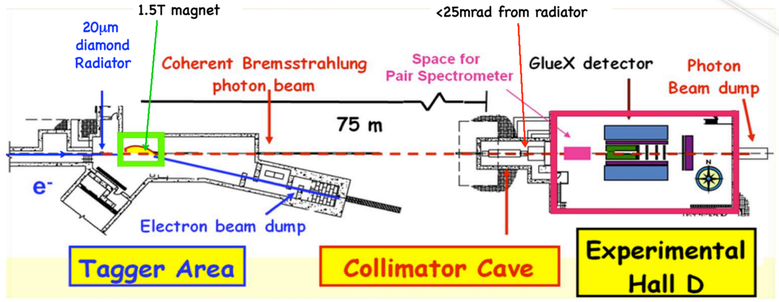
$$\gamma p \to p\pi_1 \searrow \quad \pi_1 \to b_1\pi \searrow \quad b_1 \to \omega\pi \searrow \quad \omega \to \pi\pi\pi$$

Production of exotic hybrids should be enhanced using a real photon (γ) beam as it will carry one unit of angular

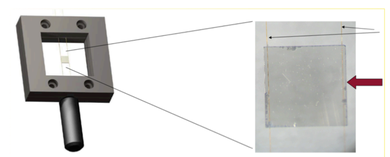
polarized photon beam produced using coherent bremstrahlung.

Linearly polarized photons

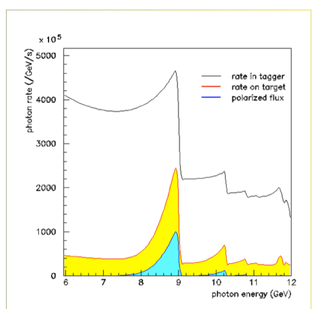
- Diamond ~20μm thick
- Coherent Bremsstrahlung
  - θ<25μr
  - collimator at 80m
- Range: 8.4 – 9GeV (coherent peak)
- Polarization: 40%
- Tagging
  - $\sigma_E/E \approx 10^{-3}$
  - 100 MHz in the peak



Top view of the photon beam line

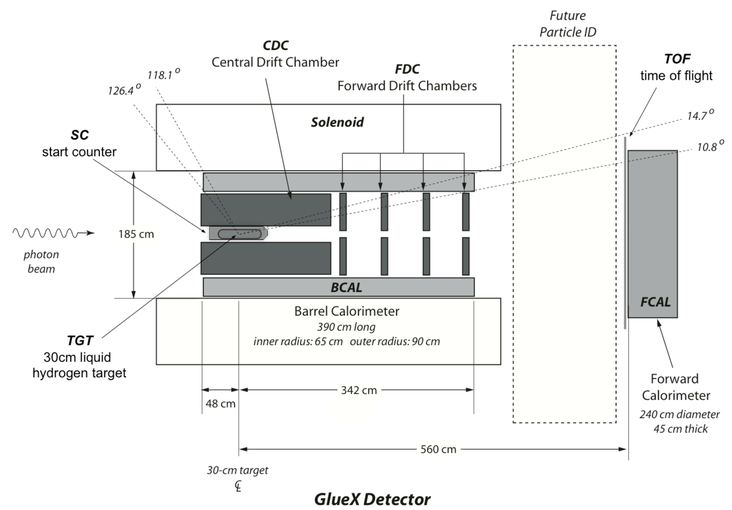


Picture of a 4mm x 4mm x 300μm diamond crystal with CAD rendering of mounting apparatus. This was produced using one of several techniques for making very thin crystals in order to meet the GlueX requirements.



Coherent bremsstrahlung spectrum

GlueX Detector



GlueX Detector

Schematic of the GlueX detector as viewed from the side

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