R&D possible directions

Igal Jaeglé

Thomas Jefferson National Accelerator Facility

1st Workshop on New Light Physics and Photon-beam Experiments

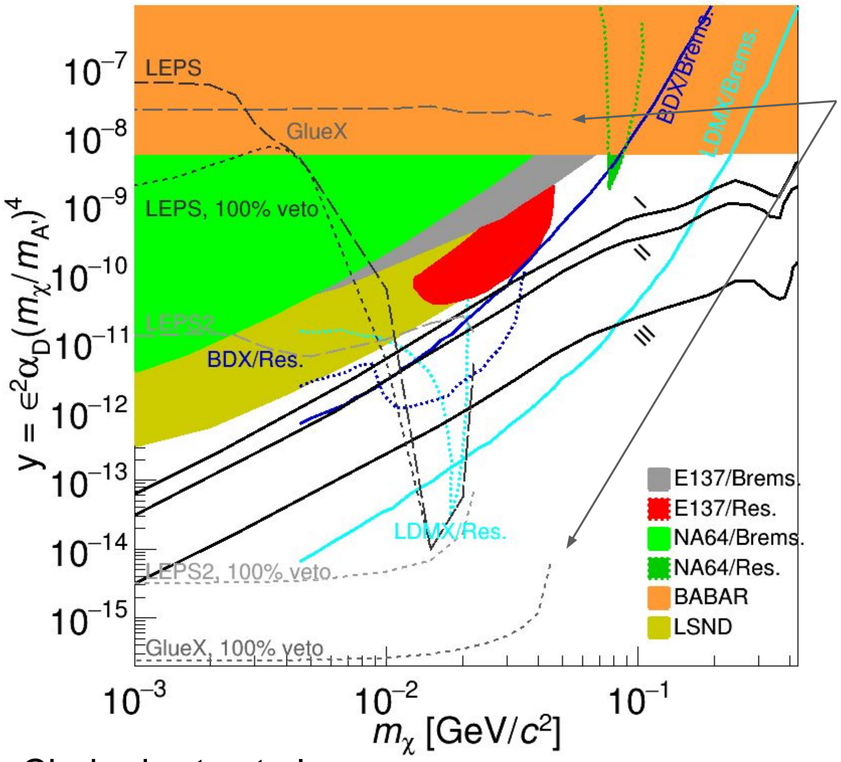
Monday March 08, 2021

Outline of this talk

- Introduction
- GlueX Beamline
- Cylindrical vertex detector
- Conclusion

Introduction

Photon-beam experiments are low-intensity experiments compared to electron & proton fixed-target experiments



- If electrons and photons are unambiguously distinguished i.e. photons can be vetoed
- $$\frac{U_\varepsilon}{U_\varepsilon^0} = \left(\frac{\mathcal{L}^0}{\mathcal{L}}\frac{\Delta_M}{\Delta_M^0}\frac{\epsilon^0}{\epsilon}\right)^{0.25}$$
    - $\mathcal{L}$ integrated luminosity
    - Δ_M resolution, number of background under the signal peak scales with mass resolution
    - ϵ detection efficiency

(GlueX sensitivity does not take into account ComptonCal i.e. angle between 0.2 and 0.8 degrees are covered)

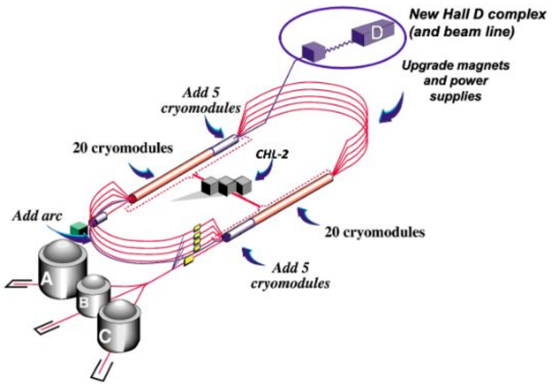
Chakrabarty et al.

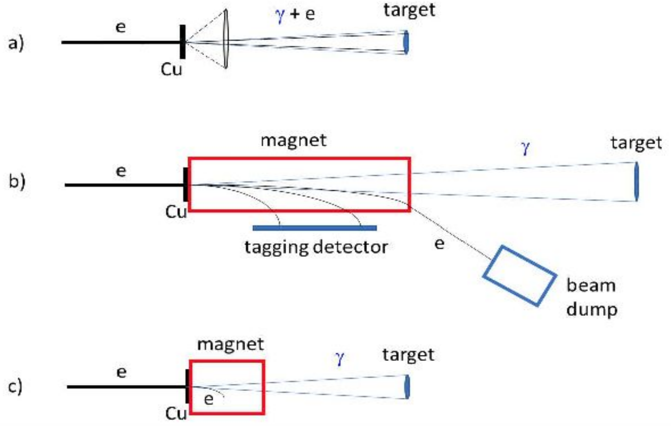
Compact Photon Source, arxiv1912.07355

In 2025, current Hall D tagger will be replaced by Compact Photon Source (CPS) for the KLF experiment (JLab C2–12–19–001)

- Un-tagged photon-beam with 10^{12} photon/s (currently photon flux is 10^{8} photon/s) needed to produce Kaon beam (arxiv:2002.04442)

- KLF experiment will run for 3 years, so one could think of removing the Kaon target and directly use the high-intensity un-tagged photon-beam

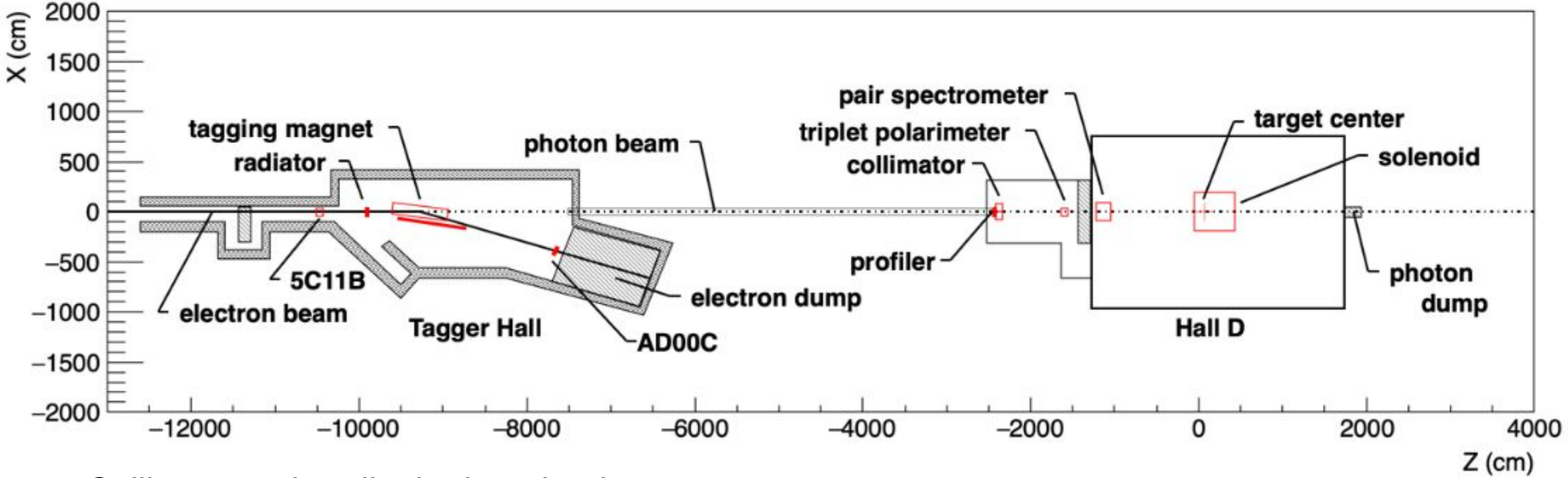




Jefferson Lab

GlueX beamline, arxiv2005.14272

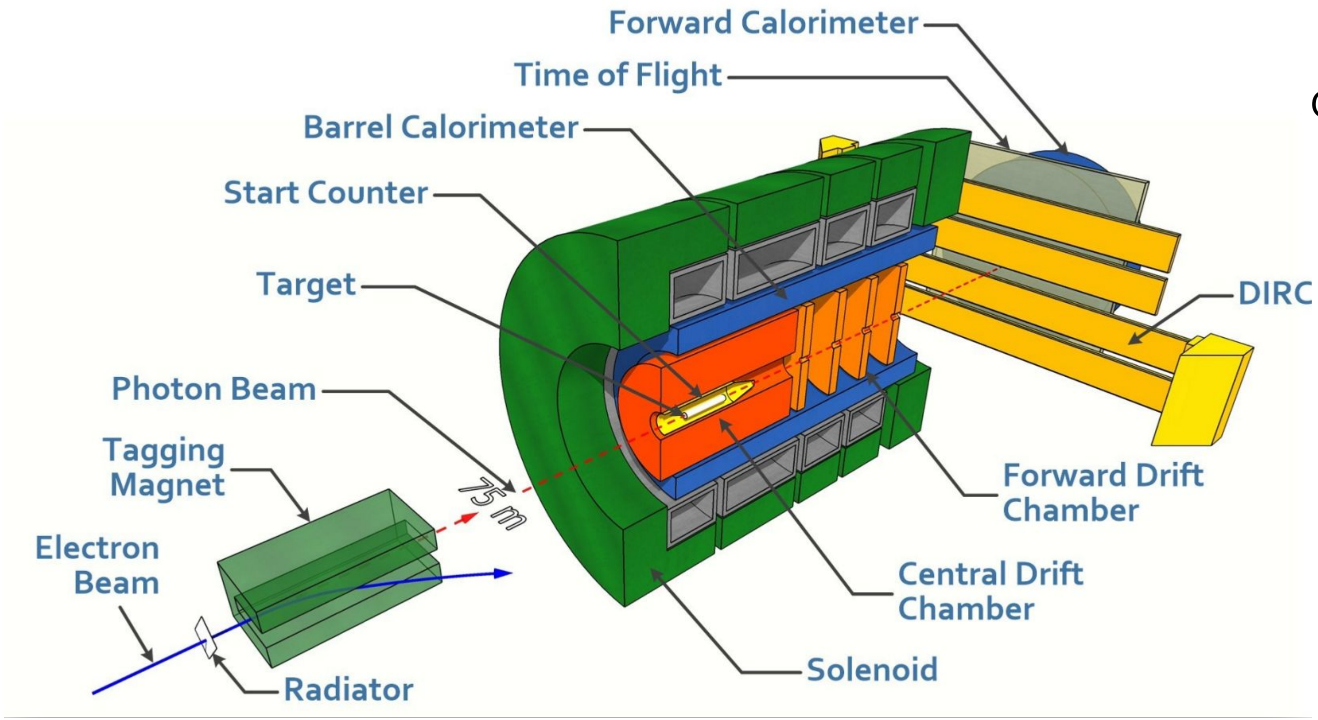
If so, one will need to upgrade the GlueX beamline and in particular



- Collimator to handle the heat load
- Pair spectrometer to measure the flux
- Target => gaseous target (e.g. electron target) to stay within DAQ capability => integrated luminosity will not be dramatically improved
- GlueX setup (e.g. replaced FDC by planar GEMs)
- Photon dump

Cylindrical vertex detector: common denominator

Cylinder of 30 cm length and 1.5 cm width placed between target and Start Counter (SC)



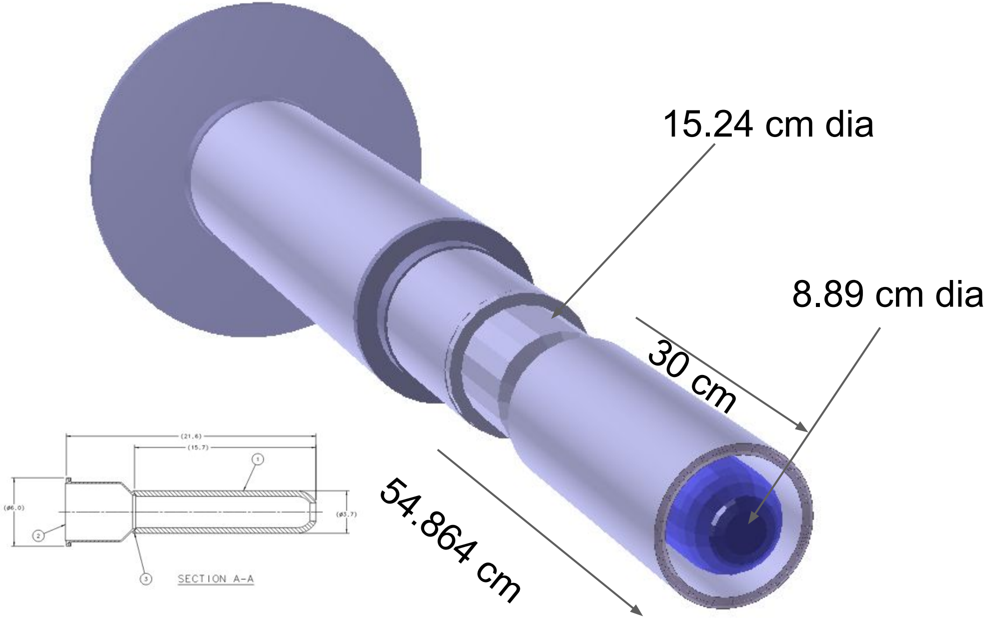
Old idea recently revived by:

- GlueX
- KLF

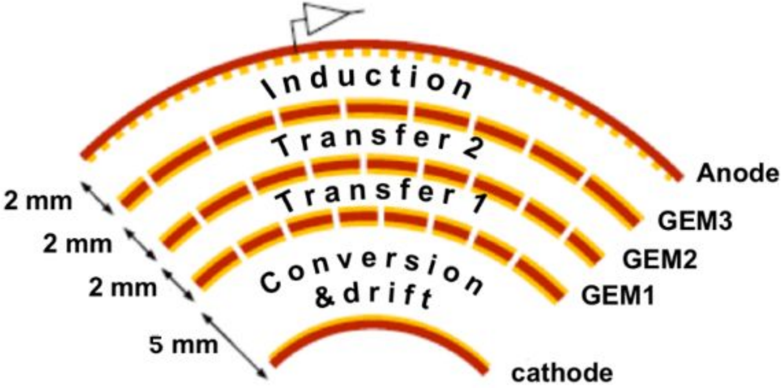
Goal: add up to three points to the track
=> improved resolution

Cylindrical vertex detector: dimension and basic performance requirements

Cylinder of 30 cm length and 1.5 cm width



BES-III CGEM module (arxiv:1803.07258)
1 point = 1 module



- Inner radius 4.5 cm - outer radius 6.8 cm if SC support structure kept
- Spatial resolution: 100 um
- Rate: 32kHz (derived from data SC rate)
- 2023 (during FCAL upgrade) or 2025 (switch to ^{7}KLF experiment)

Jefferson Lab

CGEM vs. uRWELL

Discussion summary with CGEM & uRWELL expert, Kondo Gnanvo (UVa)

- CGEM, arxiv:1803.07258
  - 3 points = 3 x (3 x Thick GEM) ~ 3 x 1.5 cm
  - Spatial resolution of 100 um easily achievable
  - 5 to 10 ns time resolution, resolution driven by the drift gap height
  - Maximum rate MHz/cm^2

- uRWELL, arxiv:1903.11017
  - 3 points = 3 x (uRWELL) ~ 3 x 0.5 cm ~ 0.5 to 1% X_0 radiation length
  - Spatial resolution of 100 um easily achievable
  - 5 to 10 ns to resolution
  - More suited for our low rate and space constraint between target & SC
  - Maximum rate 100kHz/cm^2
  - G. Kondo (UVa), Temple Uni, & Florida Tech are building first cylindrical prototype for IEC, ready by end of 2021 (https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF5_IF0_Gnanvo_Hohlmann_Posik_Surrow-044.pdf)

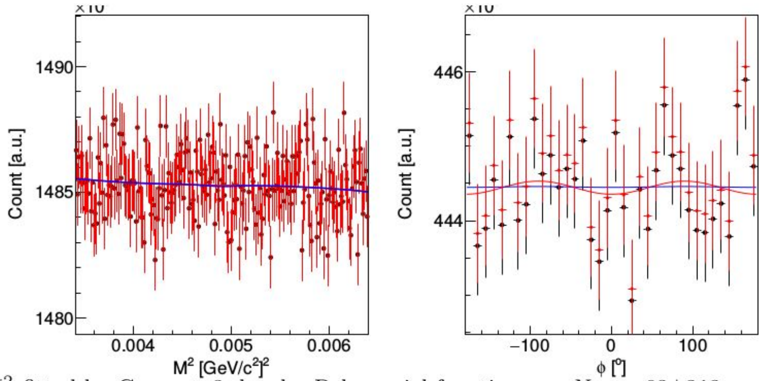
Beam and target polarizations

Single vs. multiple fits:

- Adding constraint to fit can improve yield extraction in a bump search, e.g. gamma $e^- \rightarrow A' e^-$

Combining a bump hunt in the invariant or missing mass with the beam-asymmetry

- 70 MeV dark photon
- 150 MeV^2 experimental resolution
- $P_\gamma = 0.4$ and $\Sigma_\gamma = 0.6$
- One month beam-time with a photon-flux of 5x10$^7 \gamma/s$



- M^2 fitted by Gauss + 3rd order Polynomial function => N_{sig}=-63±313
- ϕ fitted by $N_{bkg} + N_{sig}(1 - P_\gamma \Sigma_\gamma cos\phi)$ => N_{sig}=10±10
- N_{sig} common parameters => N_{sig}=23±109 for a combined fit

Jefferson Lab

Conclusion

- We have a couple of months to determine if uRWELL can a good candidate
- GDH sum rule with circularly polarized beam and transversely polarized nucleon target will take data after 2023
- We have a couple of years to think seriously if it is worse using directly CPS or un-tagged photon-beam