# Beam Offset Monitor for CPS

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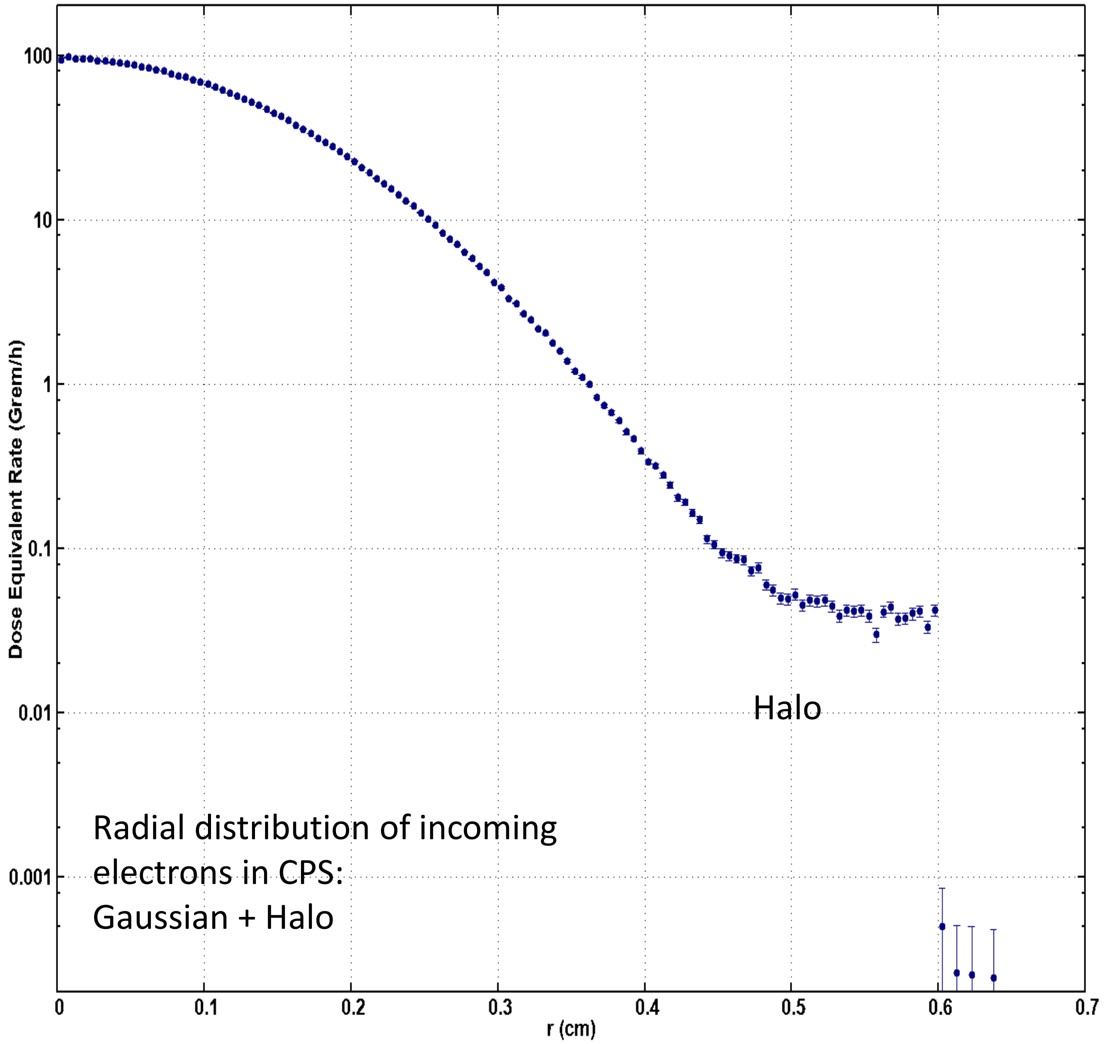
# Introduction

- "Comments" in the ERR-1 final report suggests that we use a Beam Offset Monitor (BOM) similar to the one used in Hall B to implement the electron beam position interlock in front of CPS.
    - Consider inclusion of a halo/beam offset monitor (similar to Hall B) near the CPS to monitor delivered electron beam quality and limit CPS face activation.
- Hall B has been using BOM for both electron and photon beams.
    - It is a quartz detector (fibers or a barrel) around the beam read out by a multianode PMT.
    - HPS and CLAS12 have been using the newer version BOM with a quartz barrel with a 10cm inner diameter and on-board electronics located close to the PMT.
    - In Hall B it is mostly useful for tuning and FSD.
        - It does not seem to be optimized to be sensitive to small beam motion in Hall B.
            - CLAS beam is very narrow with $\sigma$=150$\mu$m.
        - Catches sudden large beam excursions.
- BOM can also replace the collar that Pavel was suggesting to be used in conjunction with the ion chambers in FSD.
    - This way we will have two FSD inputs : an Ion Chamber and the BOM.
    - We can also implement a slow interlock based on the BPM redbacks in EPICS.

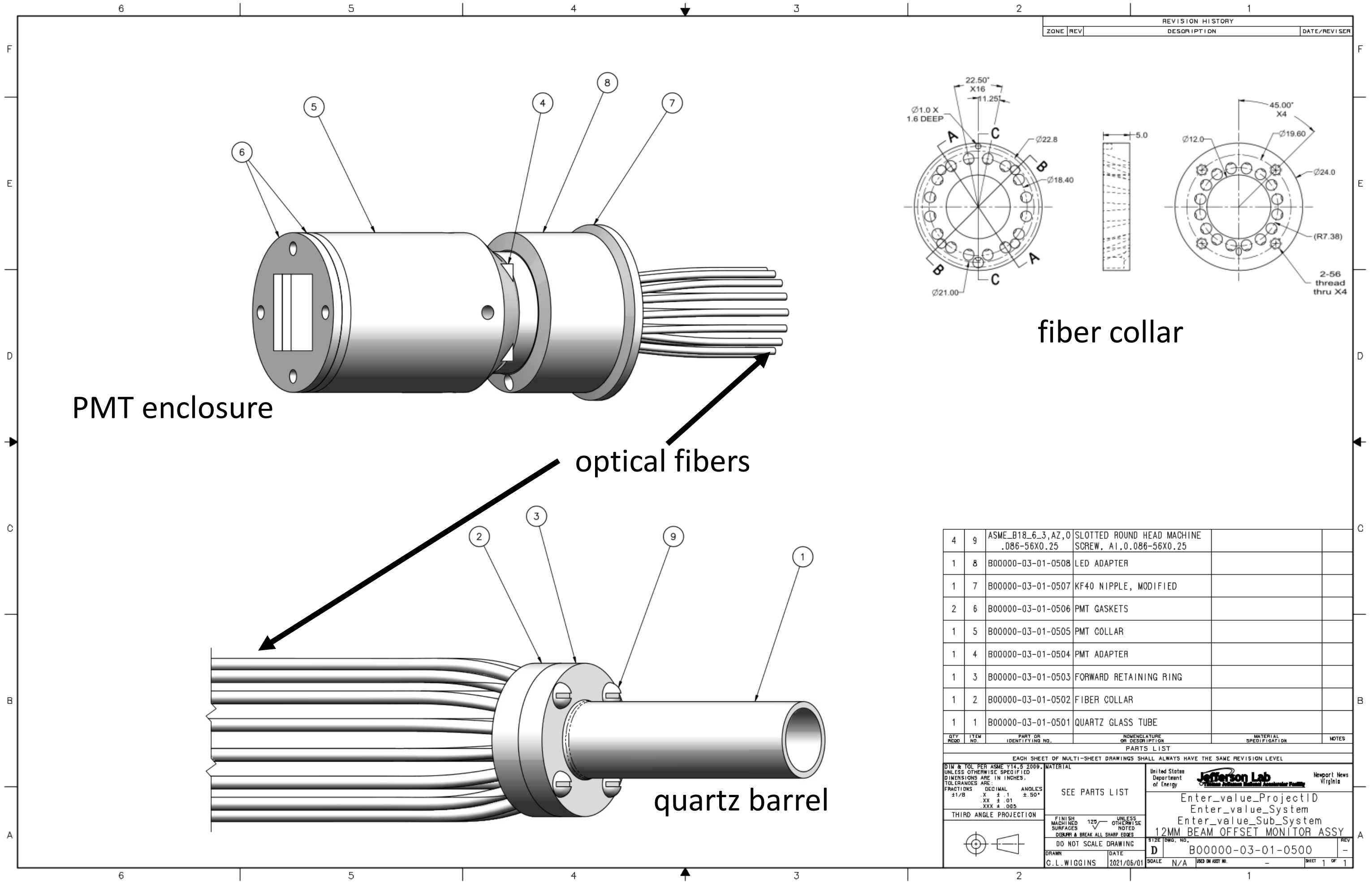
# Requirements for BOM

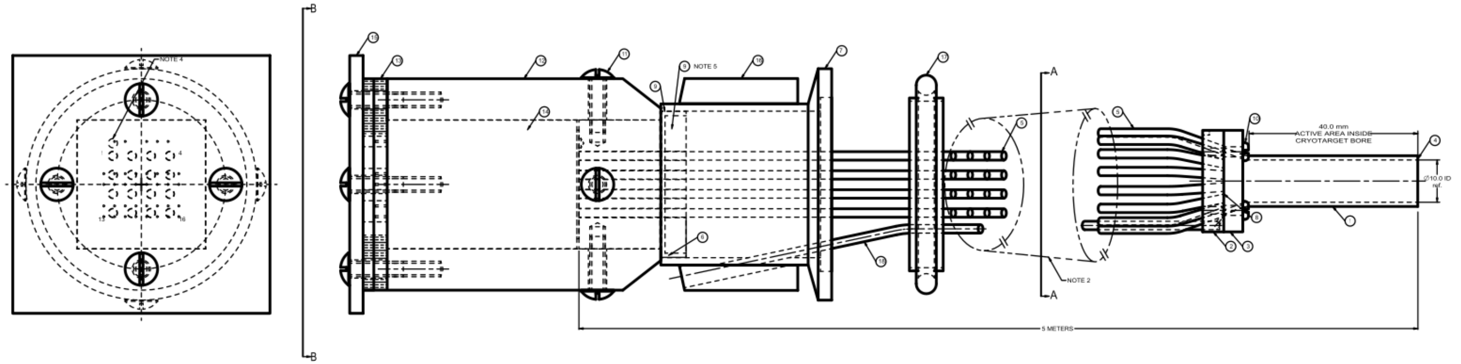
- Help tune KLF electron beam by scanning the beam over the CPS entrance.
  - The total rate in BOM should be dependent on the radial offset of the beam from the BOM center.
- Sensitivity to 1mm beam motion in order to implement FSD during CPS operations.
  - BOM beam opening cannot be much wider than R=5mm with $\sigma$=1.2mm beam and ~$10^{-4}$ level of beam halo.
  - FSD card with an appropriate input will be needed in the tagger hall.
  - Possibility to change FSD thresholds to be able to deal with beam halo and backgrounds from the beam.
- BOM part that is sensitive to the electrons needs to be in front part of the CPS radiator inside vacuum.
- Radiation hardness is essential as it is going to be close to the electron beam and to the CPS.
- It would be good if it can provide information on the electron beam position.
  - This would require azimuthally segmented quartz around the beam.



# Hall B Design

- The quartz barrel/tube with ID of 10cm and 12cm OD is in the area of the CLAS target cell (the target is inside BOM).
  - Reflective surface at the downstream end of the tube.
- Sixteen five-meter-long optical fibers bring the light to the CLAS target cart where the PMT is located.
  - Needs a transition from vacuum to air where the PMT is located.
  - Needs to stay light-tight.
- There is a board designed by Ben Raydo to discriminate the BOM signals and send them to the FSD board.
  - EPICS IOC runs on the same board.
  - The board is near the PMT itself.

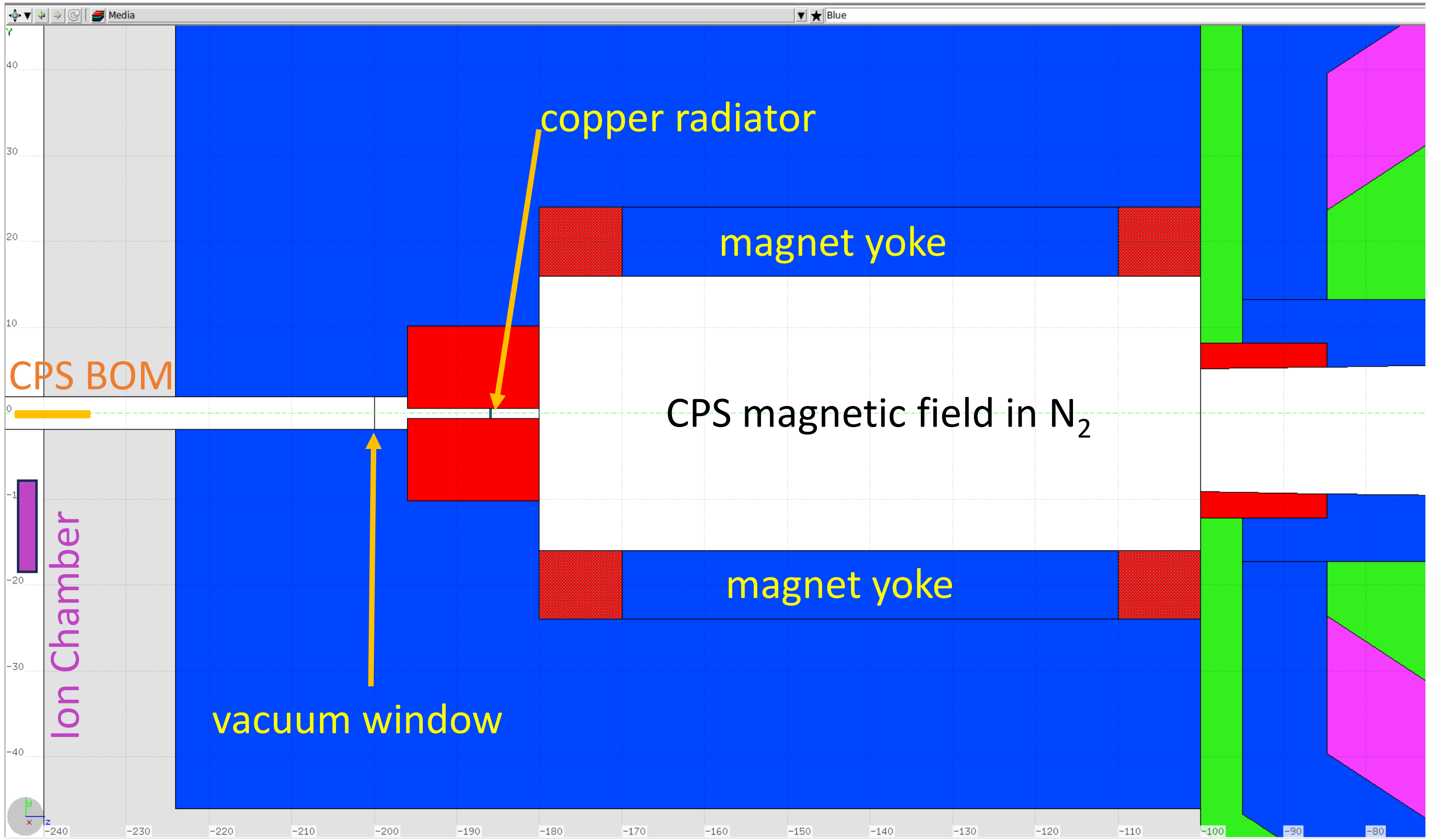


# CPS and BOM

- We could make a BOM very similar to Hall B version.
- Quartz barrel with an inner radius of 4mm or 5mm, an outer radius 6mm or 7mm, and a length of ~10cm.
- Optical fibers with 2mm diameter to transport Cherenkov light to outside of the vacuum to the MAPMT would be much shorter than 5m used in CLAS.
    - We will need a fiber vacuum feedthrough at the entrance of CPS.
- The electronics board with discriminators will need to be further away from the CPS and the beamline.
    - Optical fiber to the FSD board.
        - Needs coordination with accelerator people.
    - This board will also house the EPICS IOC for scaler readout.
    - Needs some work by Ben Raydo.

Snapshot from FLUKA model KLCPS78, view from beam-right



# Adaptation for Hall D

- Assume a Gaussian main beam profile with $\sigma$=1.2mm beam, and a ~$10^{-4}$ level of beam halo w.r.t. Gaussian peak height.
- Calculate integrals of the beam profile distribution within the quartz ring representing the cross section of the tube for different beam offsets and tube sizes.
- Call the photon production rate when assuming only Gaussian beam and a infinitely large quartz plate without a beam hole covering the full beam as the "reference rate".
  - The length of the tube will control the real rate and the "reference rate".
    - The real rate will depend on the lightguide geometry and on the thresholds chosen.
    - Preliminary estimate shows that 4cm IR quartz tube will produce >1K optical photons per beam electron. The rates might be too high.
- The relative rate with respect to the "reference rate" at nominal beam positions is minimal at around IR=4.5mm.
  - The tube wall thickness is assumed to be 2mm for all IR.
- With IR=4mm and quartz tube wall thickness of 2mm :
  - beam offset of 1mm yields factor x2 change in the reference rate.
  - beam offset of 2mm yields an order of magnitude change in the reference rate.
  - IR=5mm does not seem to provide sufficient sensitivity to 1mm beam offset.
- Although we could see halo $10^{-5}$ in GlueX with a wire scan, we may not be able to monitor it to that level without the tagger during KLF.
  - We need to design for halo level of $10^{-4}$.
  - For $10^{-5}$ halo level the optimal radius of the quartz tube would be IR=5mm.