Electron Beam Excursion Detector

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Introduction

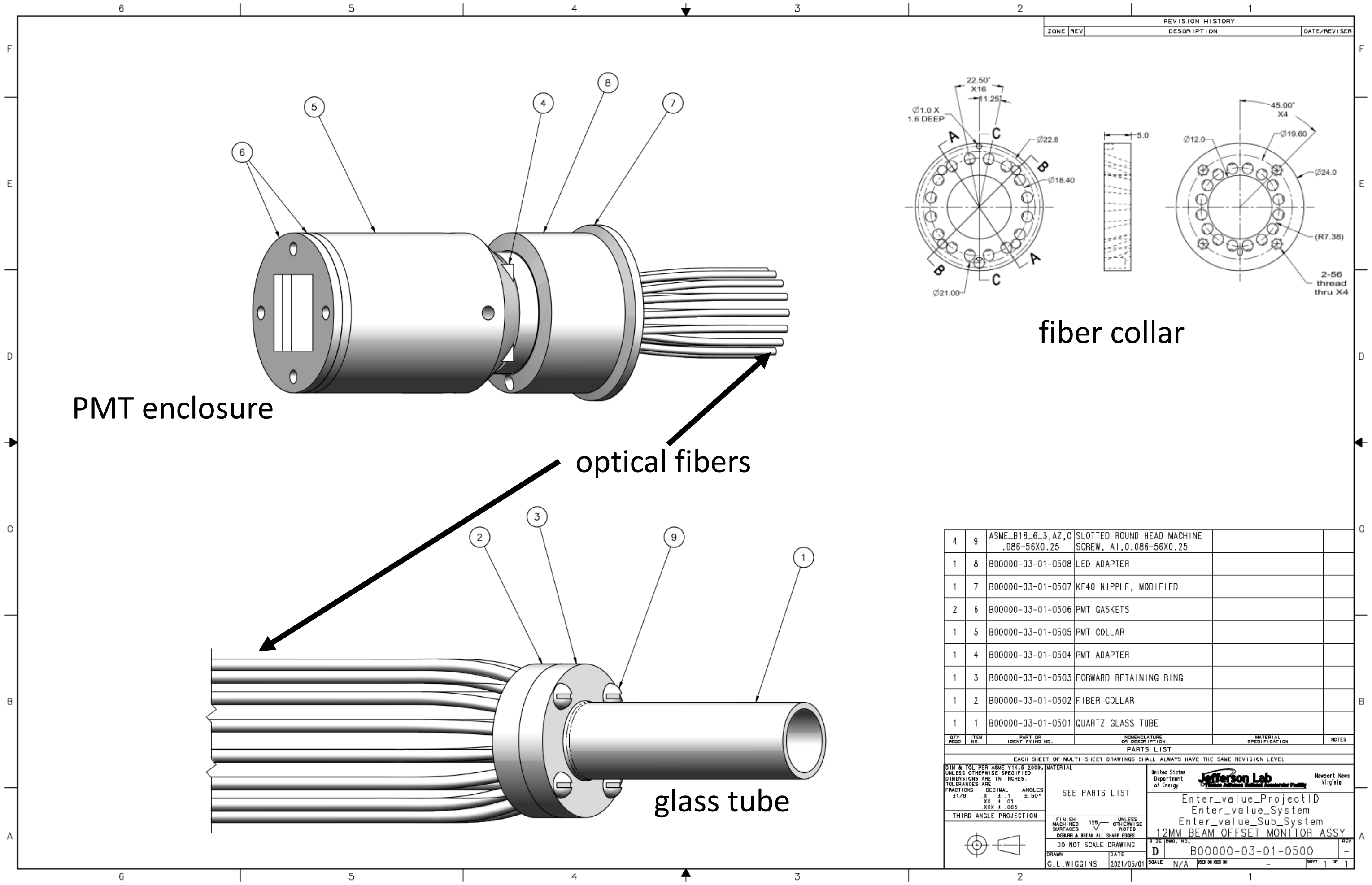
- In ERR-1 CPS write-up, we emphasized the need for FSD protection against beam excursions beyond 1mm at the radiator.
- The "comments" in the ERR-1 final report suggests that we use a Beam Offset Monitor (BOM) similar to the one used in Hall B to implement the electron beam position interlock in front of CPS.

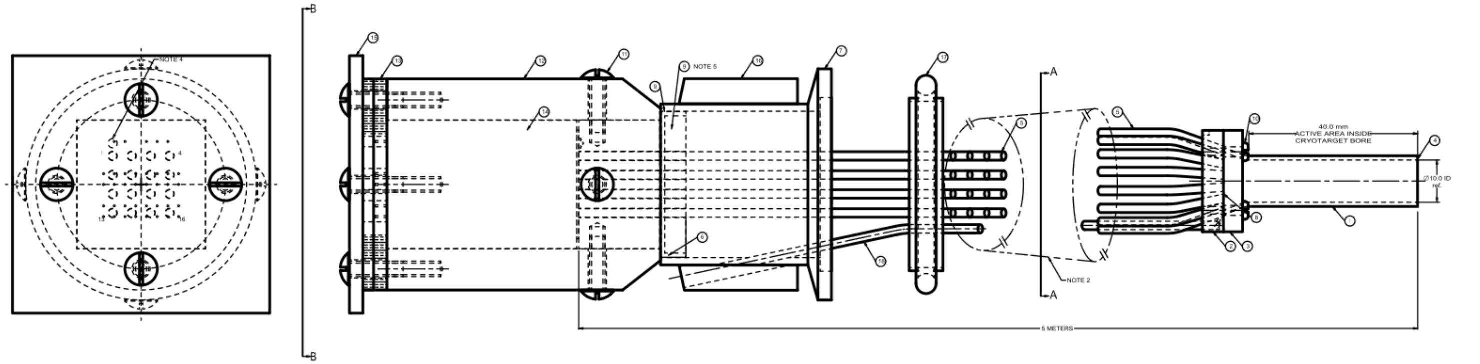
  Consider inclusion of a halo/beam offset monitor (similar to Hall B) near the CPS to monitor delivered electron beam quality and limit CPS face activation.

- We previously considered putting a fused silica detector with a very narrow hole around the beam to generate FSD signal due to beam excursion.
  - The rates would be too large to run in counting mode.
  - Radiation dose rate was extremely large, would kill the quartz detector in a couple of days.
- Currently considering using a narrow carbon ring upstream of CPS to create high counting rate and then detected the rate due to poor beam conditions.
  - Still keep a CEBAF standard ion chamber located near the beam pipe.
    - It is not clear if the ion chambers will provide enough sensitivity and sufficiently short latency.
  - In addition, use a quartz barrel detector, similar to Hall B BOM, to detect the elevated rates just upstream of the ring.

Hall B BOM

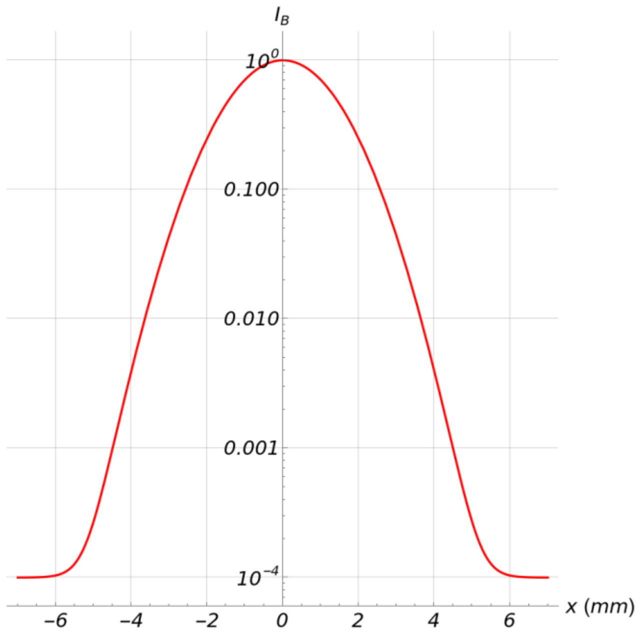
- The borosilicate tube with ID of 10 cm and OD of 12 cm is in front of the CLAS target cell.
  - Reflective surface at the downstream end of the tube.
- Sixteen five-meter-long optical fibers bring the light to the CLAS target cart where the PMT is located.
  - Needs a transition from vacuum to air 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.

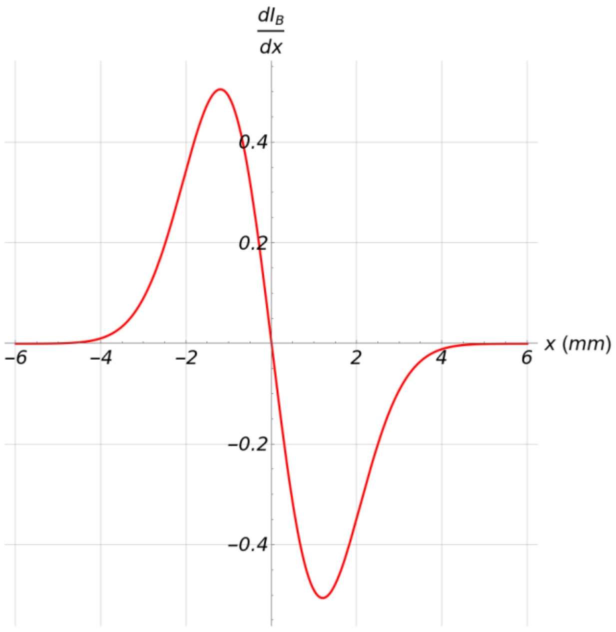


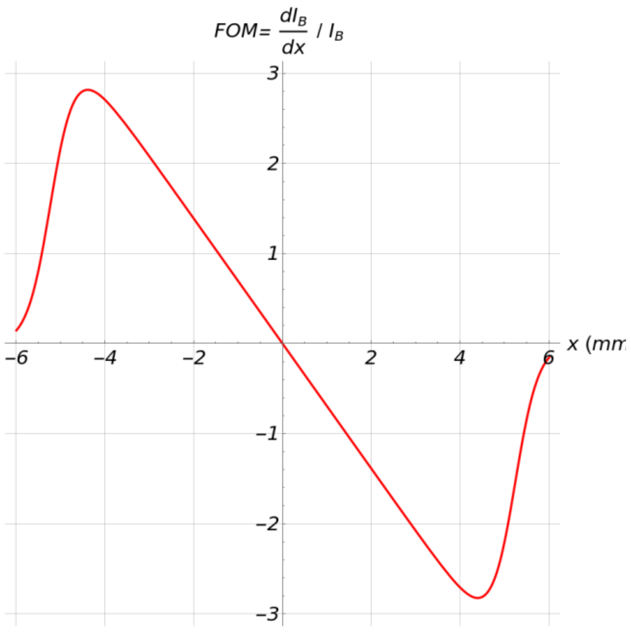


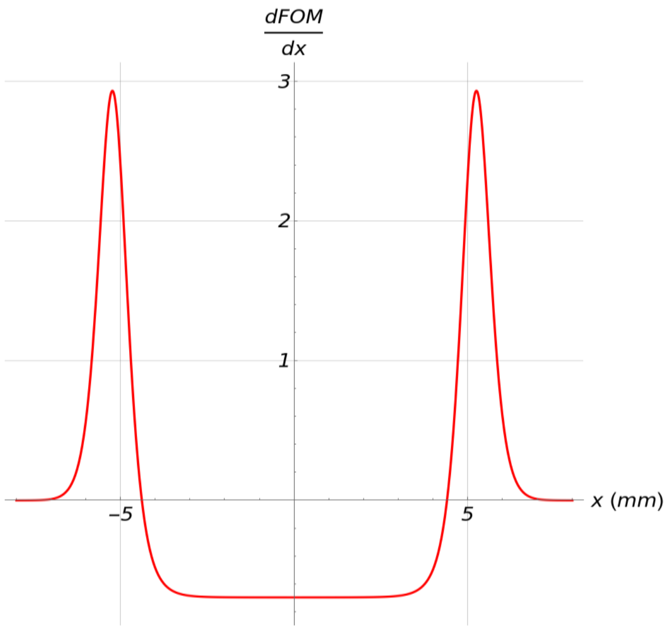
Ring Size and Material

- Assume nominal beam with σ=1.2 mm and a 10^{-4} level of beam halo.
  - Consider unitless beam intensity $I_B = 0.0001 + e^{-\frac{x^2}{2\sigma^2}}$.
  - The most sensitive area (steepest slope or the maximum of the derivative of I) is
    x = ±σ = ±1.2 mm.
  - The optimal ring position in terms of FOM="relative derivative" is at x=±4.39 mm, i.e. R=4.39 mm .
    - Considering the 2D beam intensity , the optimal value would be smaller R≈4 mm.
    - For σ=1 mm beam width, the optimal ring radius would be R=3.66 mm.
    - For a 10^{-5} halo, the optimal rind radius would be R=5 mm.
- The ring needs to be thin enough not to create too much radiation dose and counting rates at the nominal beam positions.
  - Use less dense material for low radiation dose at the nominal position
    - Carbon or Beryllium
  - The rates need to be high enough to prevent FSD trips due to statistical fluctuations.
    - Copper ring would be great if the rates and the radiation can be tolerated.



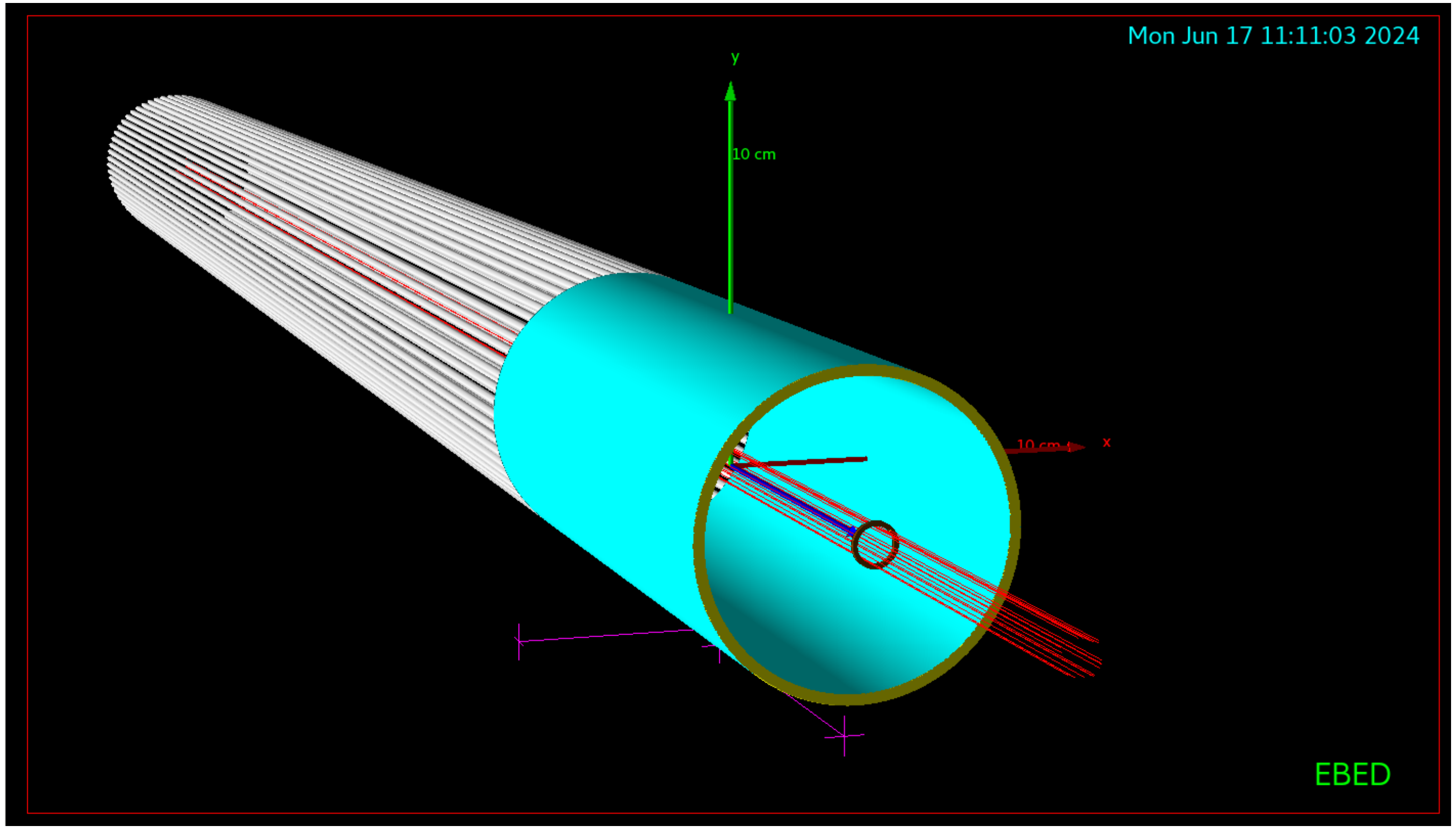






GEANT4 Model

- Created a standalone GEANT4 model.
- Carbon ring with IR=4.5mm and with both thickness and width of 1mm.
- Fused silica tube with IR=37.5 mm and OR=40 mm.
  - The tube size is picked from what is available at www.heraeus-conamic.com.
  - z-length of 20 cm to keep the plastic fibers away from the beam.
  - Radiation hard fused silica can be ordered from Heraeus.
- The 64 optical fibers with 2mm diameter that transport Cherenkov light to the outside of the vacuum to the MAPMT would be much shorter than 5 m used in CLAS.
  - An optical fiber to the FSD board.
    - Needs coordination with accelerator people.
- Still need to evaluate the counting rate in the PMT itself.
  - Requires modeling of the optical photons in GEANT4, which is mostly done.



- Power deposited in the carbon ring is on the order of $P_R \approx 5W - 10W$, according to GEANT4.
  - The ring may get heated to ≈1000^{O} C if attached by four 1mm carbon sticks.
  - We will need to consider heat dissipation.
- Dose rate in the quartz tube is D≈20 Rad/hr, based on Geant4
  - accumulated dose over 10000 hours would be ~0.2 x 10^6 Rad.
  - Fused silica can handle >10^6 Rad dose without significant deterioration.
  - MOLLER is considering using fused silica with dopants that will allow for doses 10^9 Rad (Yang et al, NIM A 2023, Vol 1055, Page 168523).
- e^+ and e^- track rate passing through the quartz tube is ~2 MHz.
  - Factor of x2.7 change in the rates for 1mm beam motion.

CPS and the Excursion Detector

- The thin carbon ring should not be too deep into the shielding to allow for high sensitivity for Ion Chamber.
- Quartz tube should be a few millimeters upstream of the ring.
- An Ion Chamber can be mounted in front of the CPS upstream shielding.
- The electronics board with discriminators will need to be further away from the CPS and the beamline.
    - Optical fiber from electronics 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.

- ***At this time, it would be good to check with FLUKA simulations if the radiation rate with 1mm x 1mm copper ring will be problematic for the magnet coils.***
    - Be- or C-ring with the same thickness would create less radiation.

Snapshot from FLUKA model KLCPS80, view from beam-right