Calorimeter Construction for Luminosity Monitoring

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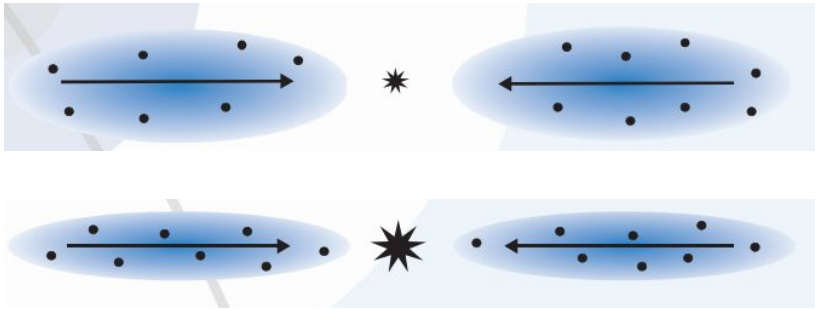
Luminosity Summary

- Luminosity ~ likelihood of collision occurring between particles.

$$L = \sigma R$$

- σ - cross section, R - rate.



- By measuring the rate of a process with a known cross section, can calculate luminosity

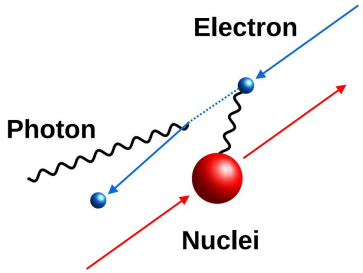
Source - https://cds.cern.ch/record/2800578/files/Cross%20Section%20and%20Luminosity%20Physics%20Cheat%20Sheet.pdf

Bremsstrahlung Process

- Braking radiation - electron slows down releasing a photon.

- Bremsstrahlung cross section known from QED.

- $\sigma_{eA} = Z_A^2 \sigma_{ep}$.



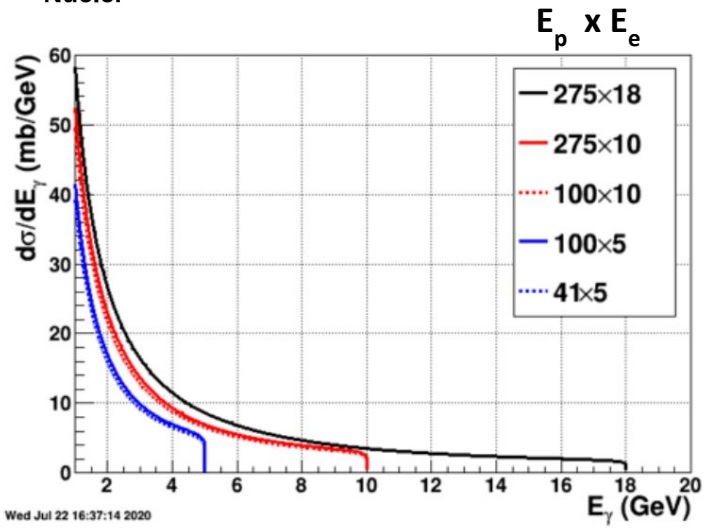
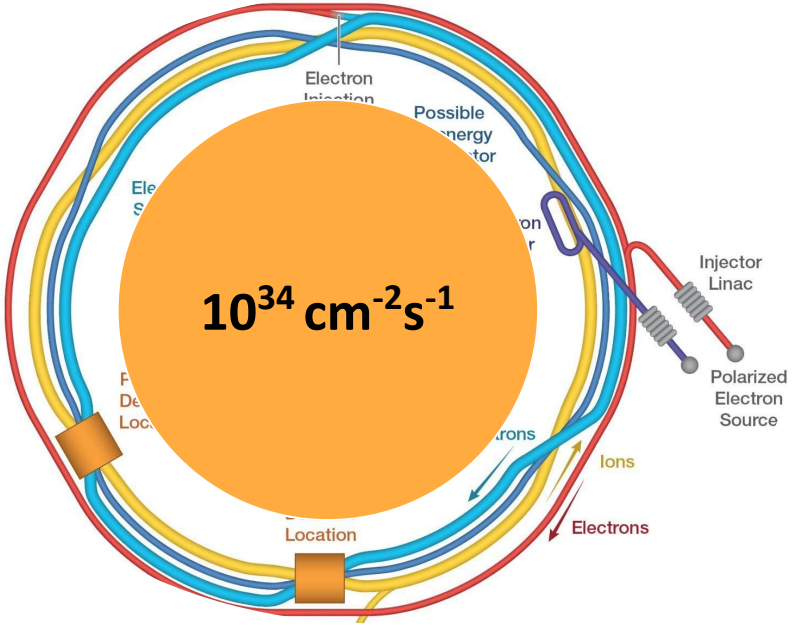


Figure - Dr. Dhevan Gangadharan, UoH.

Lumi Requirements

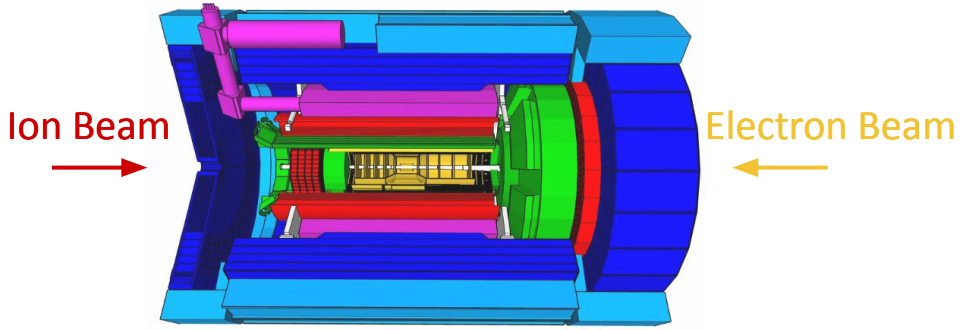
- Precision on absolute luminosity to 1%.
- Precision on relative luminosity to 10^{-4}.
- Complementarity and Redundancy.

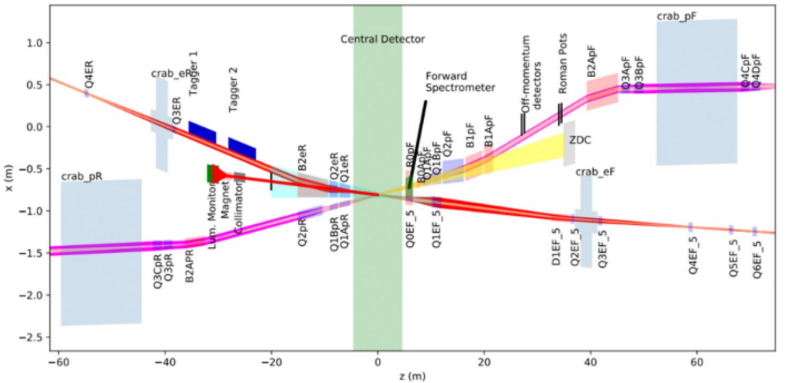


Far Backwards Region

- Luminosity is determined in the far backwards region:
- Low Q^2 Tagger.
- Direct Photon Detector.
- Pair Spectrometer.

Luminosity monitoring system

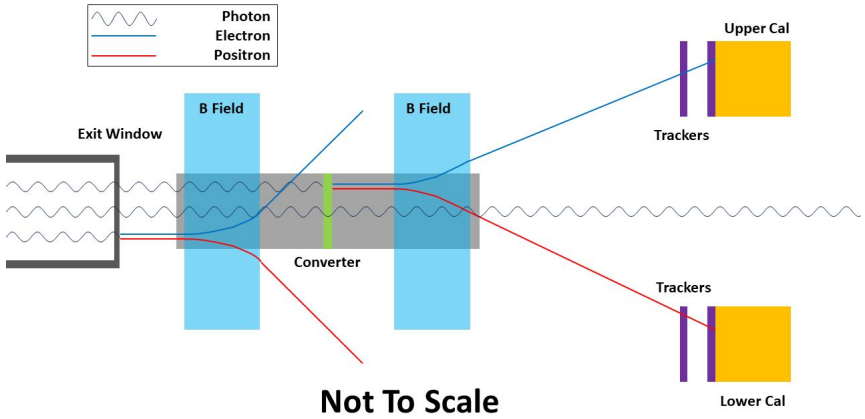


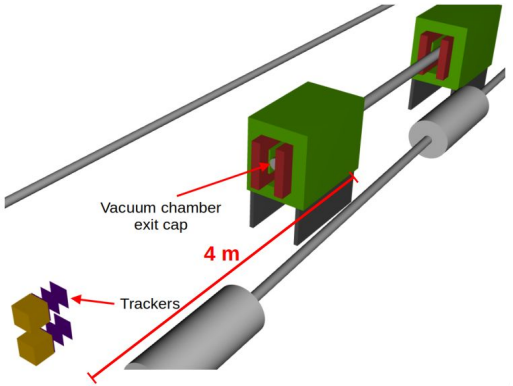


Figures - EIC Yellow Report

Pair Spectrometer

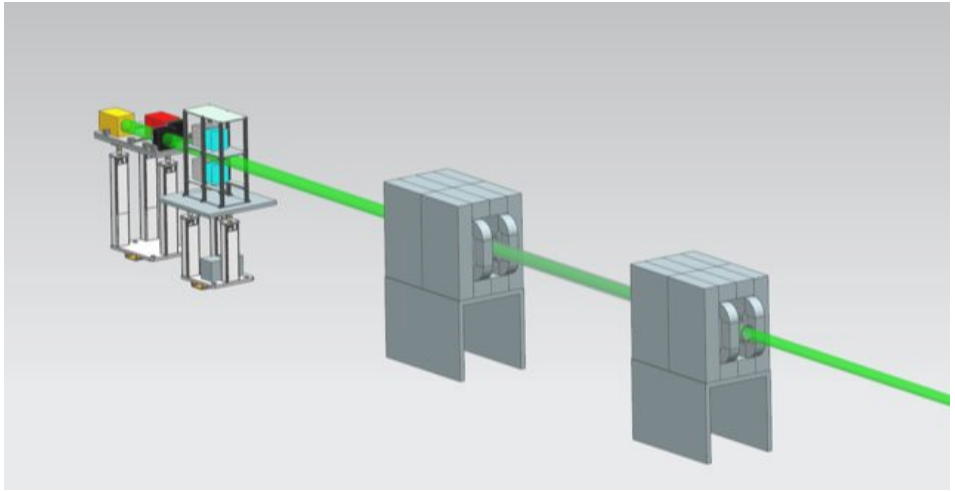
- Thin beryllium converter produces e+ e- pair from photon.
- Two detectors count rate of pairs.
- Less affected by high radiation.





PS Requirements

- Energy resolution < 15%/sqrt(E).
- Timing resolution on the order of 5 ns.
- 5σ gap between the calorimeter for the bremsstrahlung beam.
- Calibration during operation.



Pair Spectrometer Rates

- 1% of photons converted into pairs.
- Not all events will see hits in both detectors.
- Coincidence rate is high even with low conversion probability.

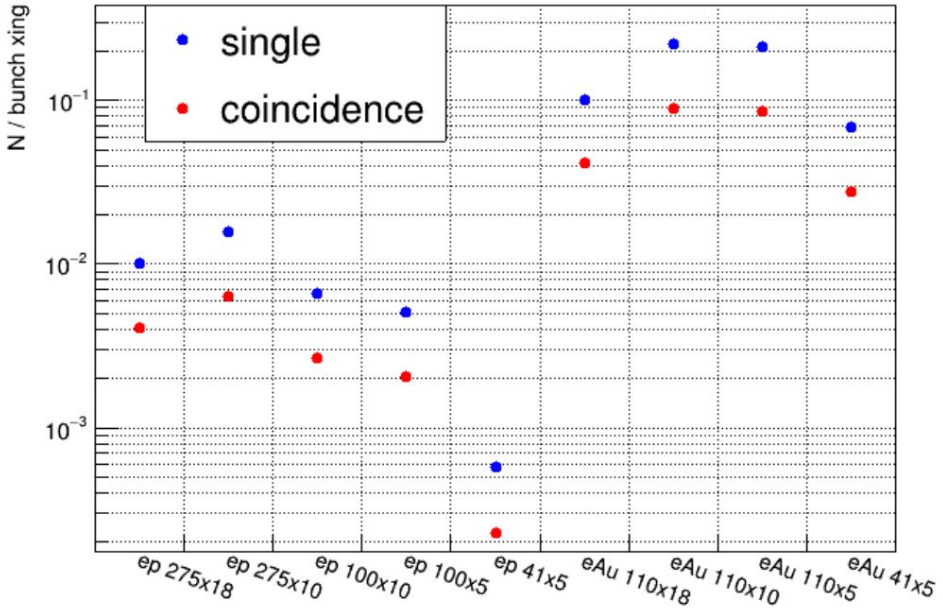
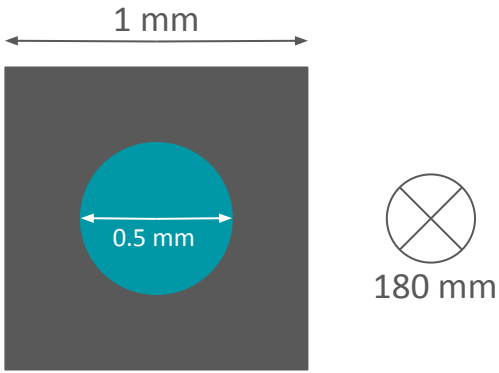


Figure - Dr. Dhevan Gangadharan, UoH.

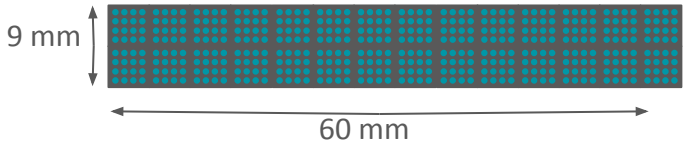
PS Calorimeter Design

- Spaghetti calorimeter design, plastic scintillating fibres in tungsten powder.
- Fibre diameter and spacing both 0.5mm.
- Volume ratio of 4:1, tungsten to fibre.

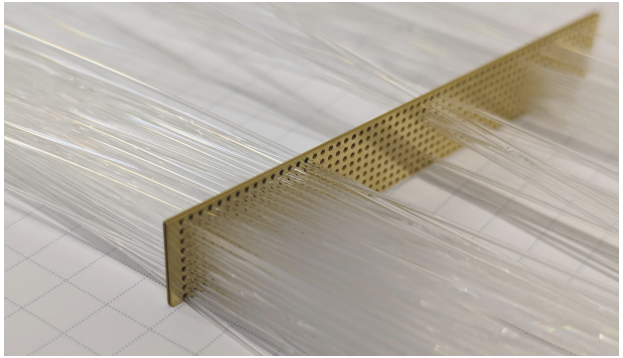


PS Calorimeter Design

- Tiles consisting of 448 fibres will be the base construction unit.



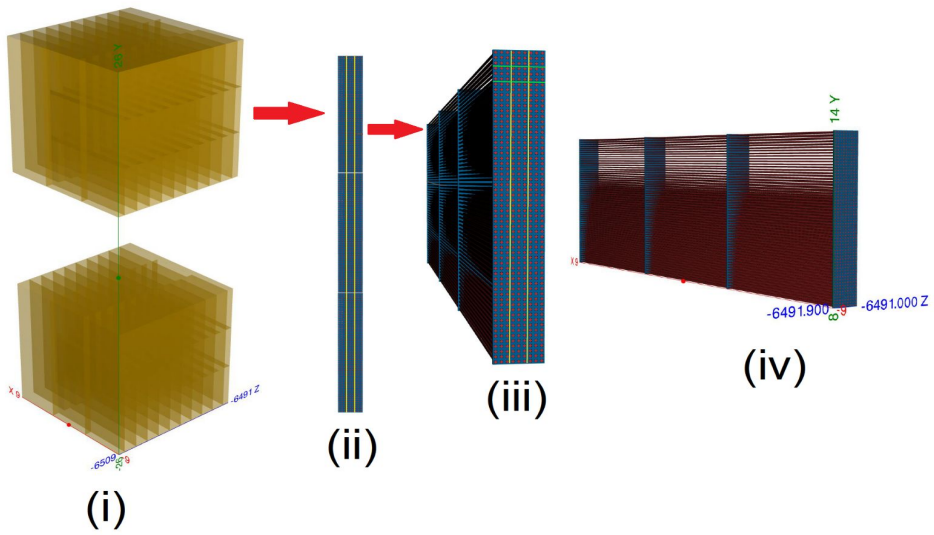
- Three tiles will be stacked to produce a 180 mm tall layer.



- Brass plates are used to keep the fibres in place

PS Calorimeter Design

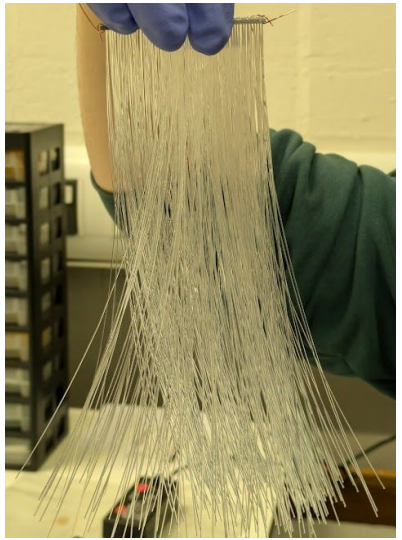
- Layers are alternated between X and Y to give positional information.
- Overall size of 18^3 cm^3.
- Calorimeter design may be used by the DPD and low Q^2 taggers.

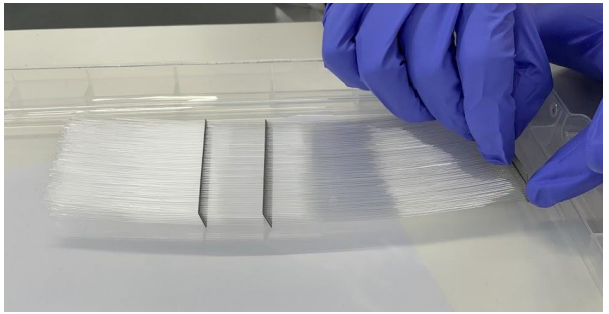


Density	9 g cm-3
Moliere Radius	15 mm
Mass	~ 60 kg

Construction Update

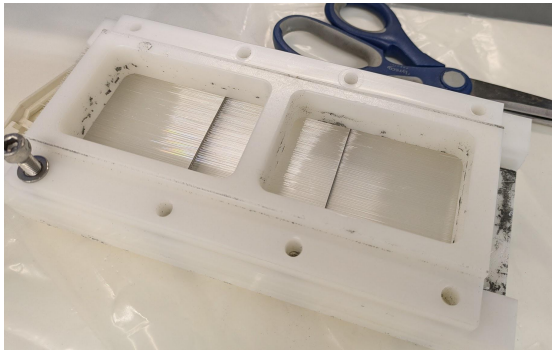
- Fibres are threaded through 4 brass meshes.
- Mesh holder is used to thread 95% of fibres.
- Final fibres must be done manually.

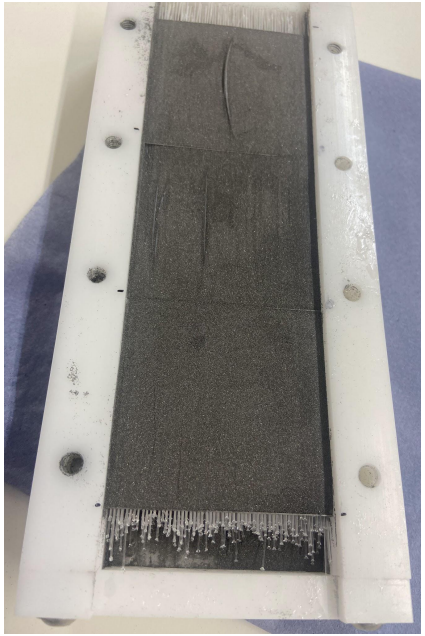


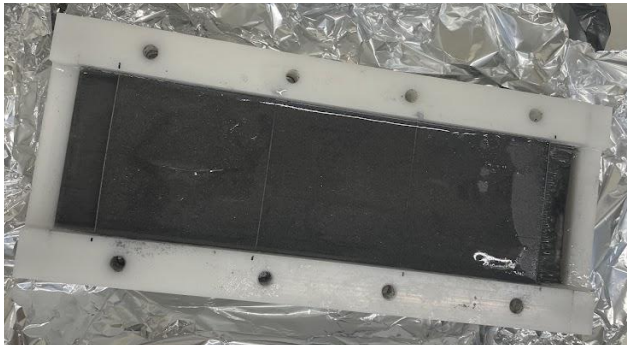


Construction Update

- Fibres and meshes are placed in the mould.
- Mould is filled with tungsten powder.
- Epoxy is poured over the top.
- Baked at 60° for two hours.





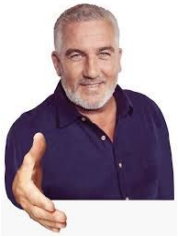


Construction Update

- After being freed from the mould, some sides need grinding down.

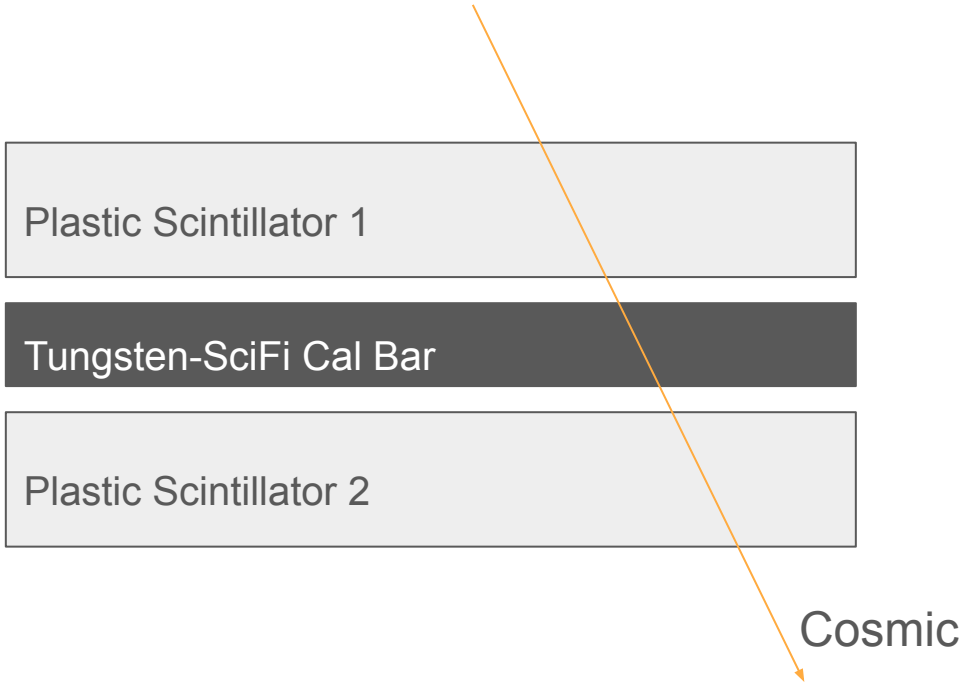
- Light transmission through fibres is mostly maintained.

- After machining ~ 0.9 kg.



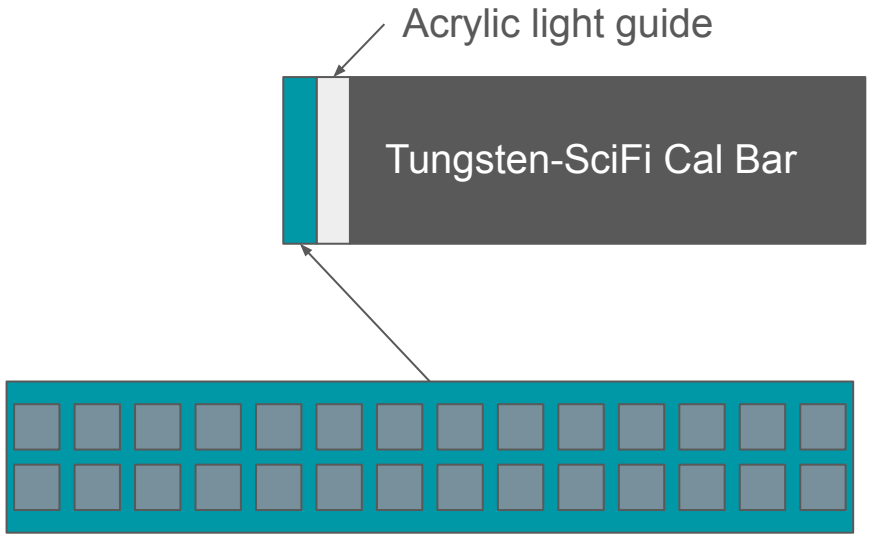
Module Testing

- As of now five modules have been produced.
- Initial testing is underway at York with cosmics.
- Tests of module uniformity have also been performed.



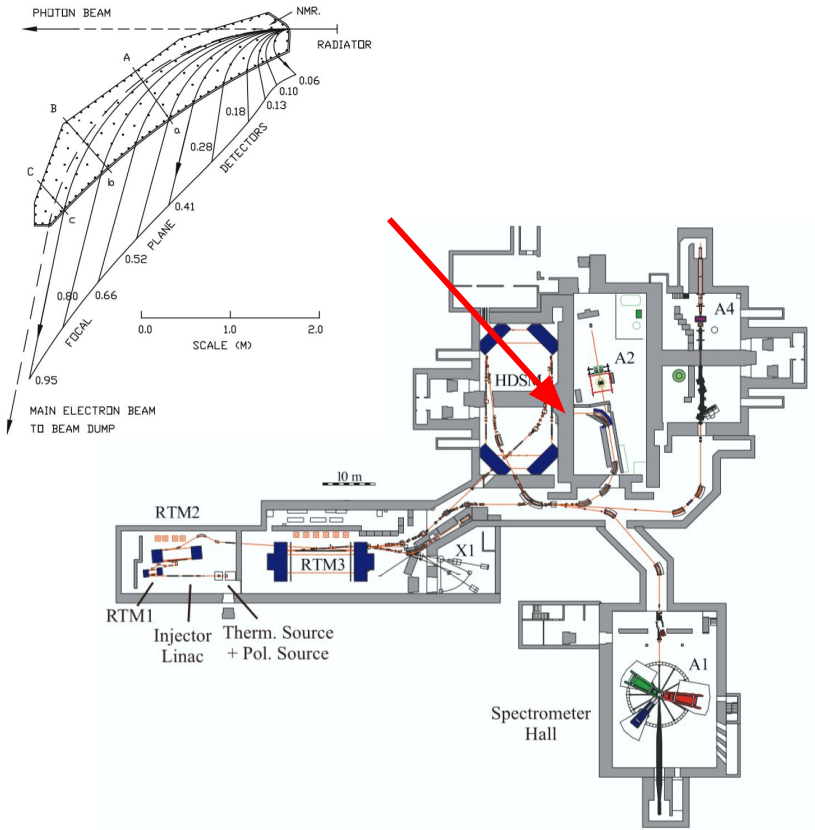
Module Testing

- As of time of writing, 5 modules have been constructed.
- PCBs are currently being populated with siPMs for readout.
- These will be tested at Mainz 2nd - 6th of December.



A2 MAMI Tests

- Modules will be placed in the A2 tagger at Mainz.
- Placement of the modules will give information on electron energies (~ 400 MeV).
- Full energy will likely not be captured but detector response can be studied.



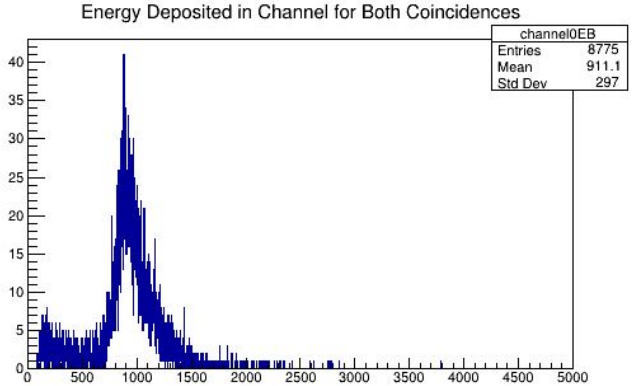
Summary

- The far backwards region is a critical part of the ePIC detector and the scientific program of the EIC, by providing the ability to measure luminosity to a high degree of accuracy.

- The pair spectrometer allows for a complimentary measurement of luminosity, especially relevant at the high luminosities reached by the EIC.

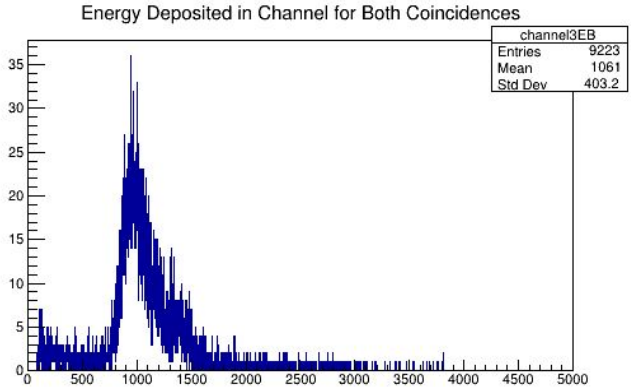
- PS system is progressing well and is on track to meet requirements.

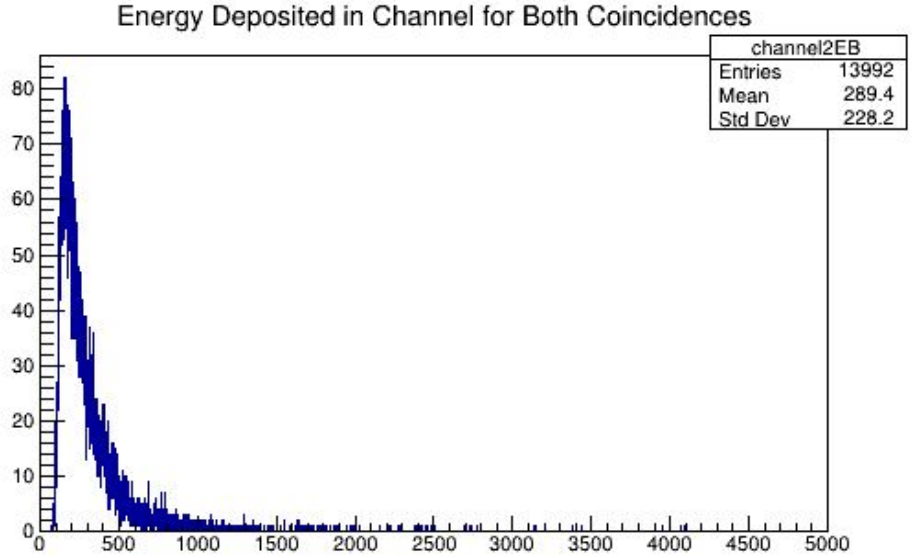
Module Testing



Plastic Scintillator 1

Plastic Scintillator 2





Tungsten-SciFi Cal Bar