Far Backwards Overview

Pair Spectrometer Calorimeter Design

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01/03/24

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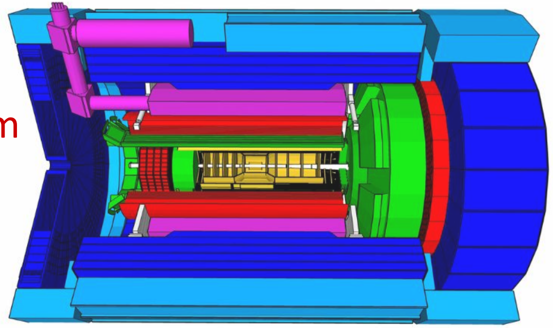
Supported by:
STFC Grants - ST/V001035/1, ST/W004852/1 and STFC Studentship - 2824381

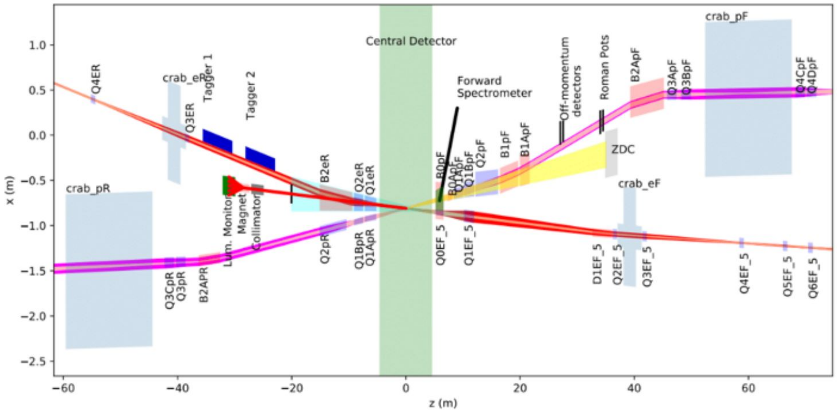
The Far Backwards Region

- Region covers - 5 m to - 60 m.
- A key goal is to determine luminosity.
- Peak luminosity of 10^{34} cm^{-2} s^{-1} .
- Requirement of 1% uncertainty for absolute luminosity and 10^{-4} relative uncertainty.

Ion Beam



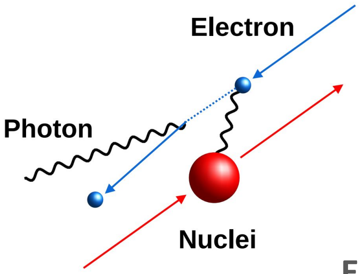
Electron Beam



Figures - EIC Yellow Report

Bremsstrahlung Process

- Luminosity is determined from cross section and rate.
- Bremsstrahlung cross section is well understood.
- System is required to measure rate of photons and electrons.



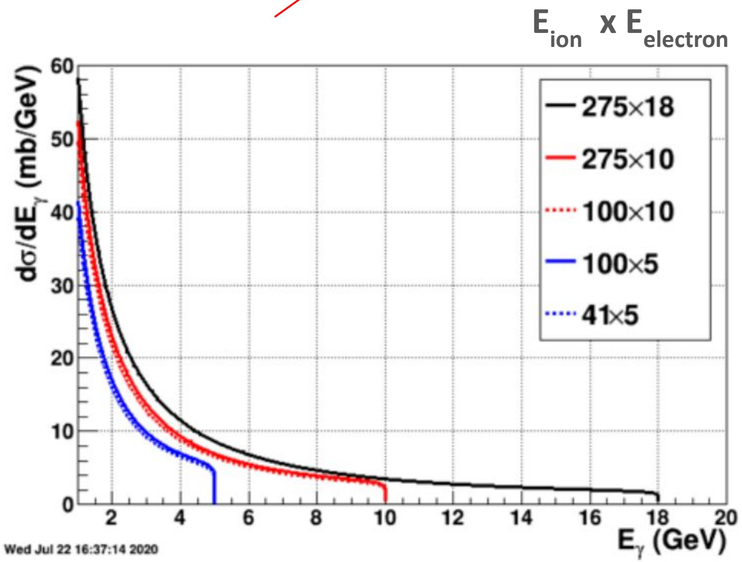


Figure - Dr. Dhevan Gangadharan, UoH.

Polarisation and Cross Section

- Polarisation is a key science requirement for the EIC.
- Polarised beams have a negligible effect on bremsstrahlung.
- Bremsstrahlung cross section with polarized beams for luminosity determination at the EIC

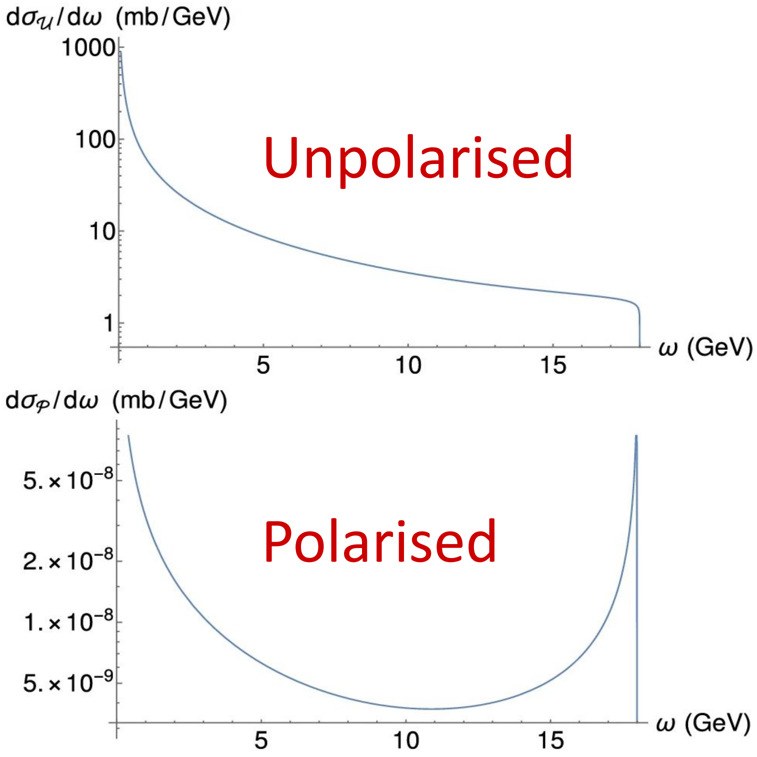
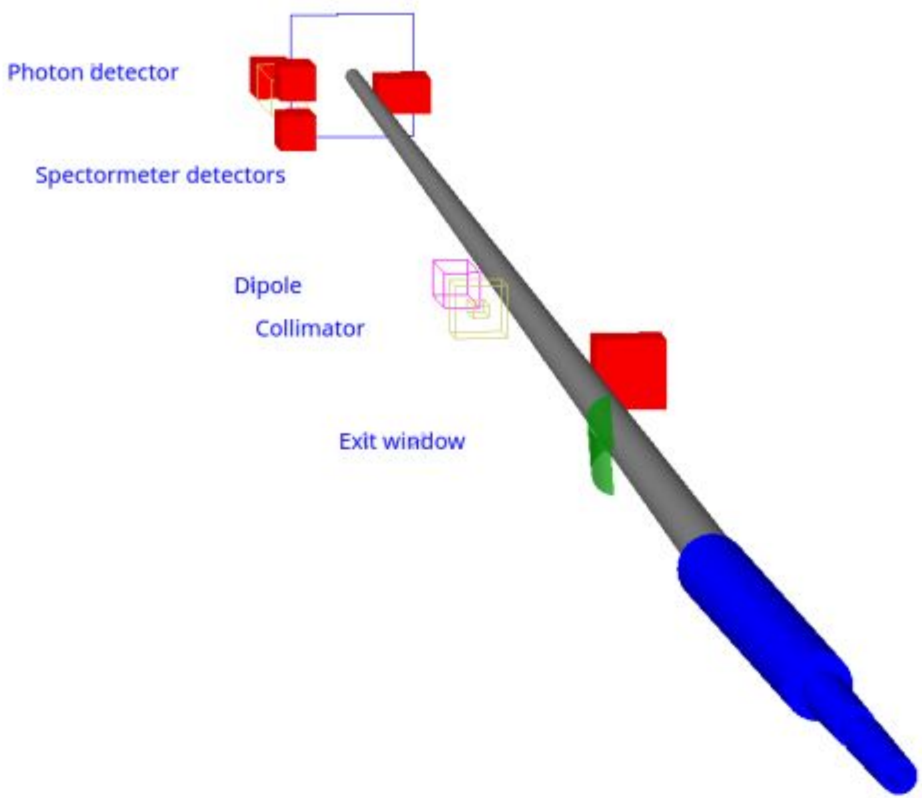


Figure - Dr. Dhevan Gangadharan, UoH.

Sections of the FB Region

- Direct Photon Calorimeter.
- Pair Spectrometer.
- Low Q^2 Tagger.



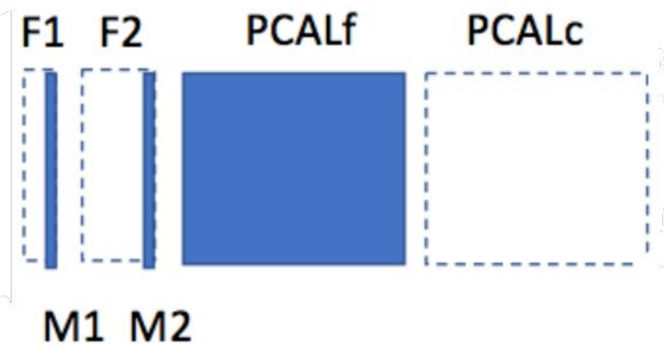
Figures - EIC Yellow Report

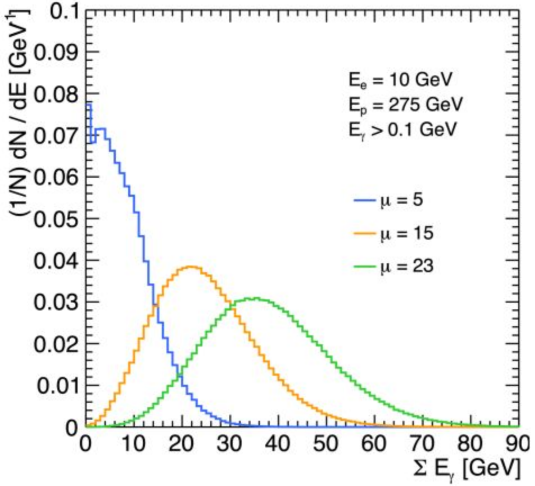
Direct Photon Calorimeter

- High resolution calorimeter to count the number of bremsstrahlung photons.

- Used successfully at HERA.

- Issues with higher rates at EIC:
- Up to 30 photons per bunch,
- Bunch spacing of 10 ns.





Figures - Dr. Krzysztof Piotrzkowski, AGH.

Low Q^2 Tagger

- Detects low Q^2 electrons from processes including bremsstrahlung.
- Two tagging stations off the electron beamline
- Provides a second luminosity measurement as well as information on other physics.

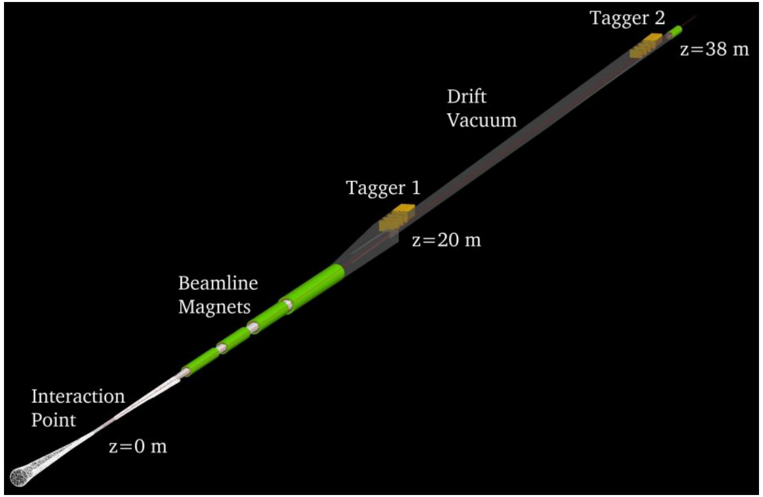
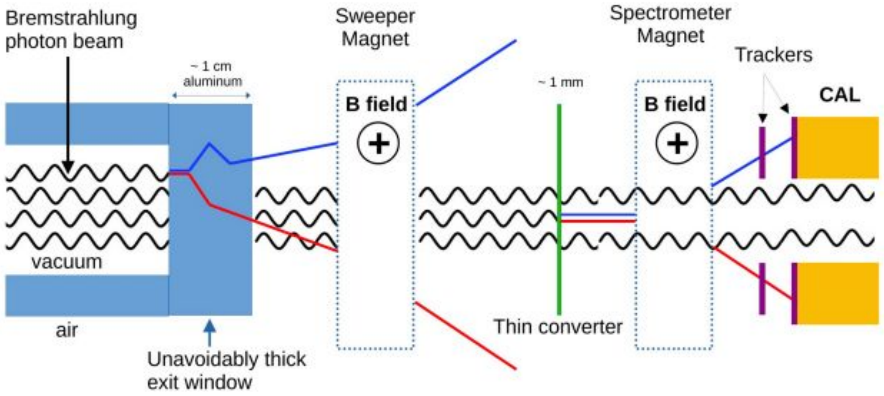


Figure - Dr. Simon Gardiner, UoG.

Pair Spectrometer

- Thin beryllium converter produces e+ e- pair from photon.
- Two detectors count rate of pairs
- Less affected by high radiation.
- 5σ gap between the calorimeter for the bremsstrahlung beam.



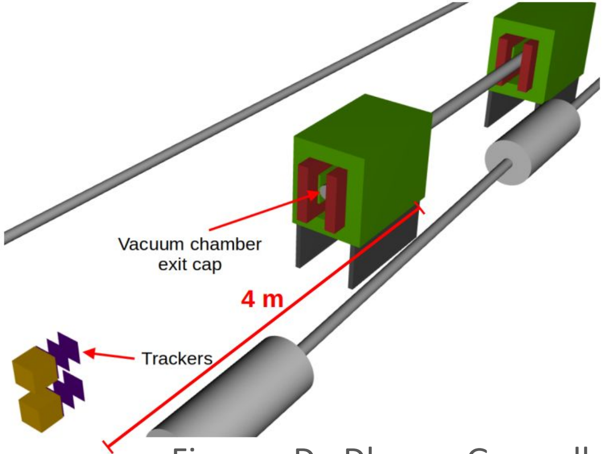


Figure - Dr. Dhevan Gangadharan, UoH.

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.

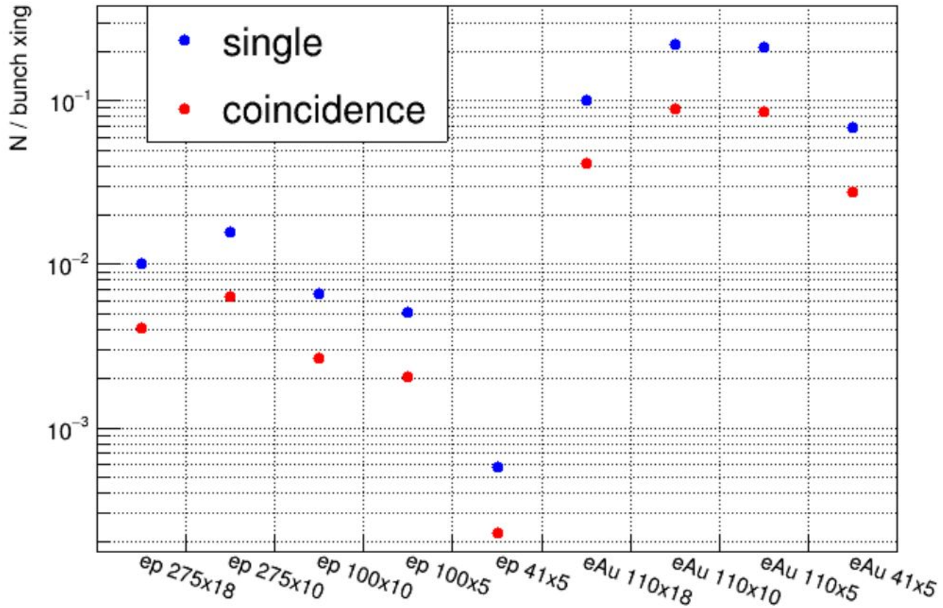
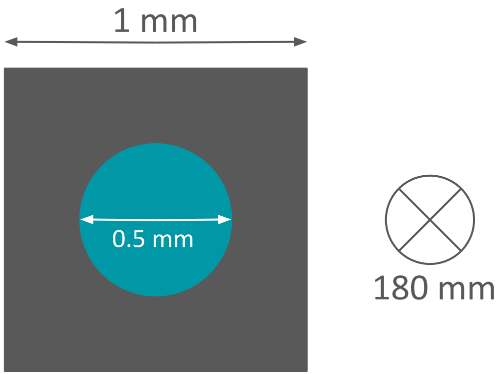


Figure - Dr. Dhevan Gangadharan, UoH.

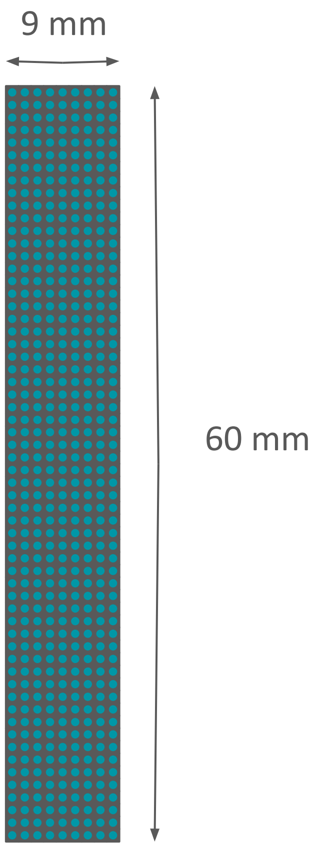
PS Calorimeter Design

- Spaghetti calorimeter design, plastic scintillating fibres in tungsten powder.
- Powder density approximately 11 g cm^{-3}.
- Fibre diameter and spacing both 0.5mm.
- Volume ratio of 4:1, tungsten to fibre.



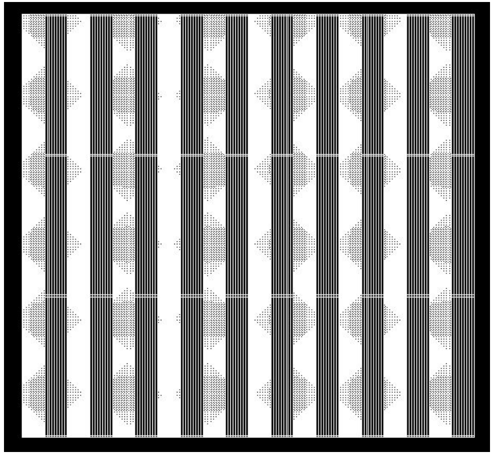
PS Calorimeter Design

- Tiles consisting of 540 fibres will be the base construction unit.
- 3 tiles will be stacked to produce a 180 mm tall layer.
- This tile size limits the siPM size options.



PS Calorimeter Design

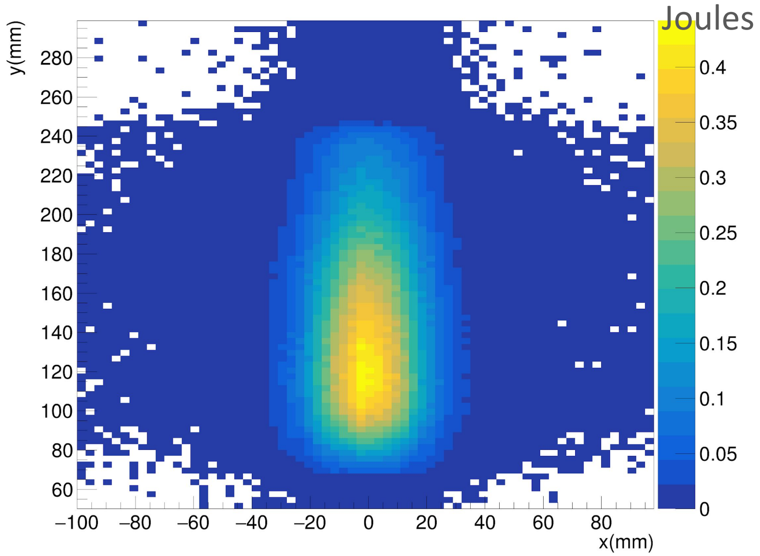
- Spaghetti calorimeter design, plastic fibres in tungsten powder.
- Layers are alternated between X and Y to detector shower profile.
- Overall size of 18^3 cm^3.



Density	9 g cm-3
Moliere Radius	15 mm

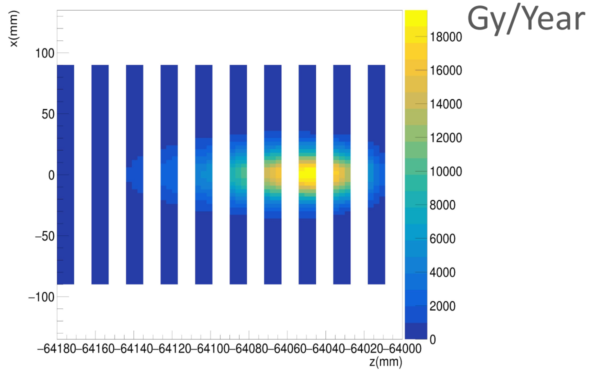
Pair Spectrometer Dose

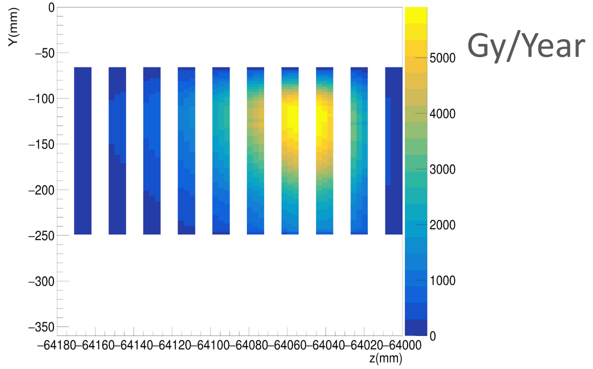
- Beam angle in Y seen in dose in Y fibres.
- Energy deposition is concentrated in certain regions.
- Energy deposition is shown for one day.



Pair Spectrometer Dose

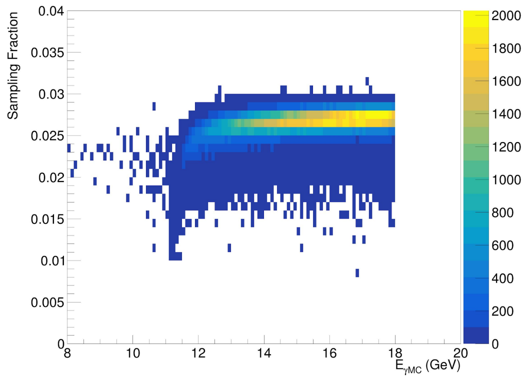
- Beam angle in Y seen in dose in Y fibres.
- X Fibres see a very high dose concentrated in the centre.
- No neutron dose calculations available yet.

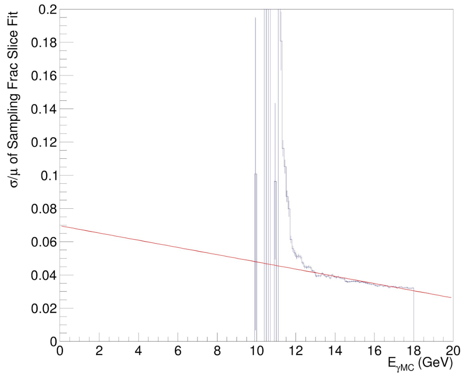




Sampling Fraction + ERes

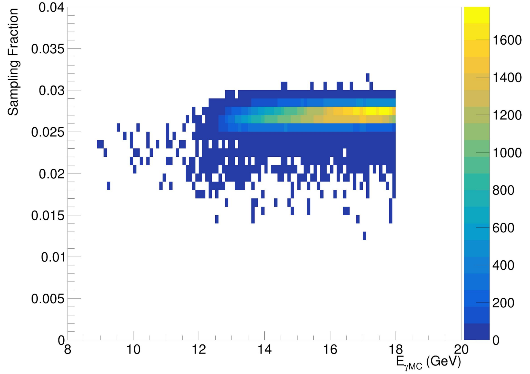
- Coincidence values shown here.
- Coincidence acceptance is between 10 - 18 GeV.
- Sampling fraction is ~3%, energy resolution is ~6%.

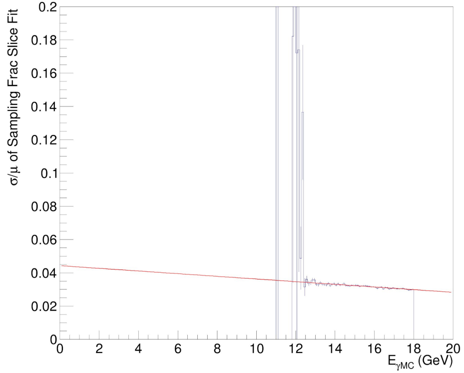




Sampling Fraction + ERes

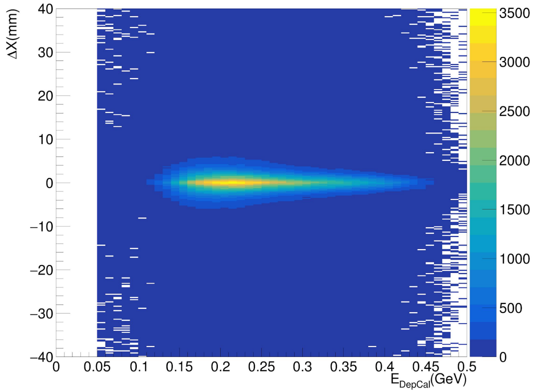
- Coincidence values shown here.
- Plots show effect of ignoring outer cm of each cal.
- Negligible effect on sampling fraction, whilst energy resolution is improved to ~5%.

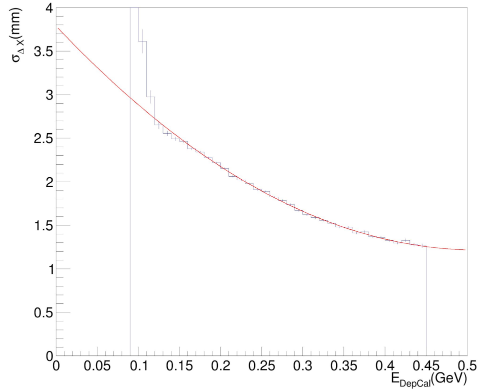




Position Resolution

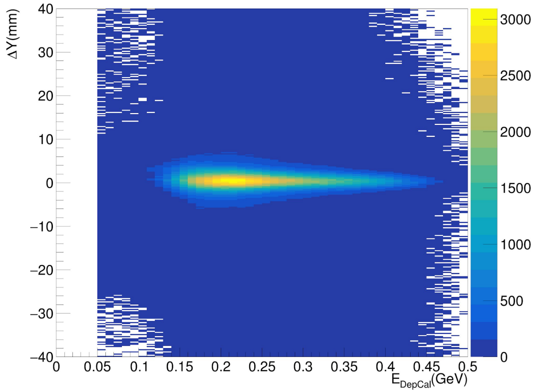
- Difference between reconstructed impact position and actual.
- Shown for top calorimeter, x aligned fibres.
- Assuming SiPM size of 3mm.

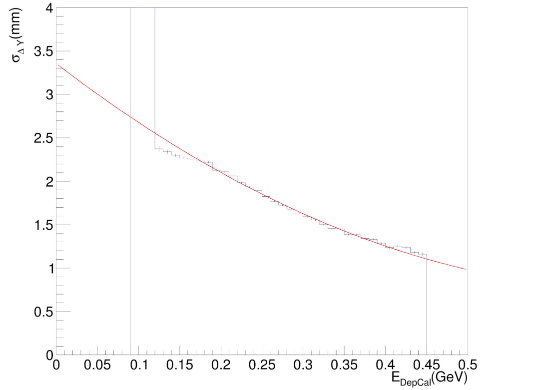




Position Resolution

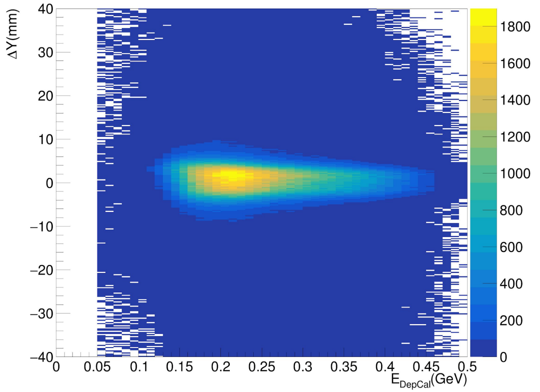
- Difference between reconstructed impact position and actual.
- Shown for top calorimeter, y aligned fibres.
- Assuming SiPM size of 3mm.

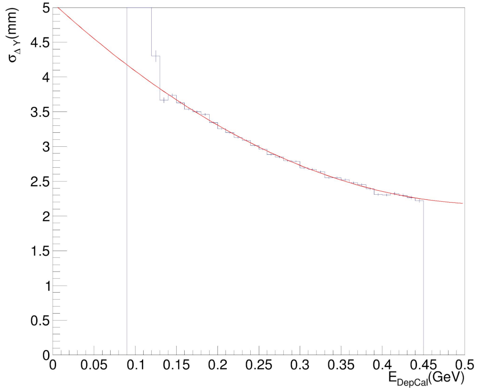




SiPM Size/Readout

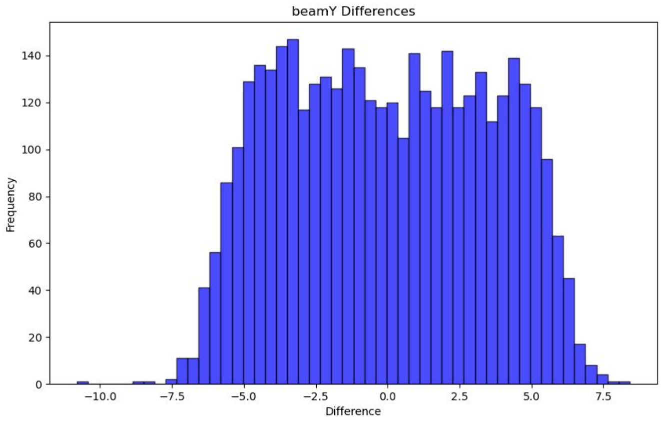
- Shows plots for y fibres from previous slides using 9mm SiPM.
- Position resolution increase of 50%.
- Greatly decreases SiPM count.





ML Position Resolution

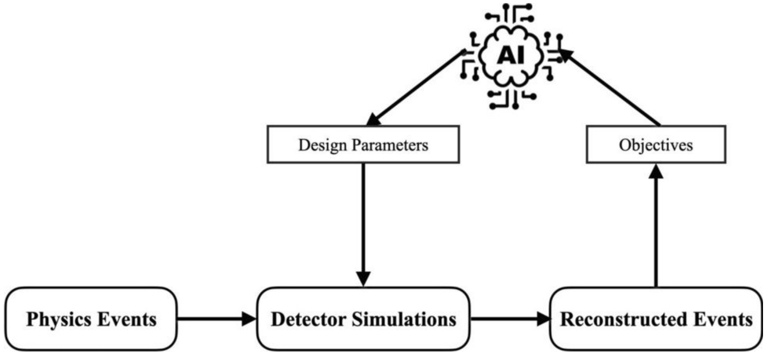
- Simple neural network can be used to predict impact position.
- Resolution is much greater in x direction than y.
- Y resolution comparable to conventional techniques.



Method	Conventional	ML
Energy Resolution (%)	5	0.0242
X Position Resolution (mm)	3.5	0.00623
Y Position Resolution (mm)	3.5	3.54
X Angle Resolution (°)	N/A	0.00613
Y Angle Resolution (°)	N/A	0.600

ML Assisted Design

- Machine learning can assist in detector design.
- C. Fanelli *et al* used ML algorithms for optimising dRICH design.
- Allows for multiple objectives (cost, resolutions etc.) to be optimised simultaneously.



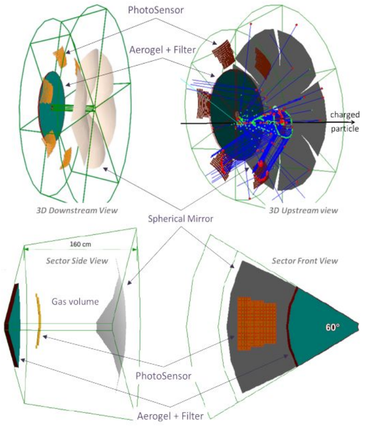


Figure - Dr Cristiano Fanelli, W&M.

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.

- There is great potential for machine learning algorithms in all parts of detector design and operation.