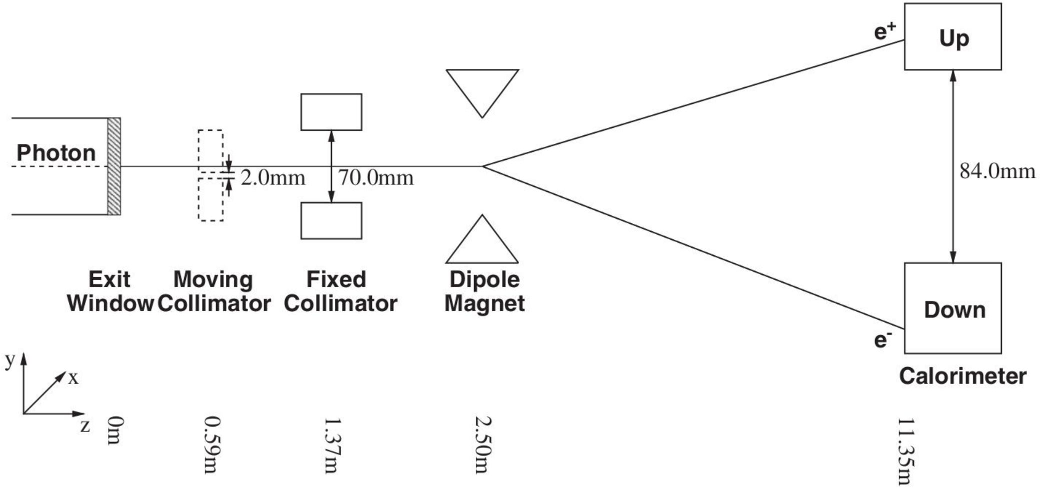
Pair Spectrometer Design

Far-backward lumi pair spectrometer DSC: Wiki page

Nick Zachariou, Dhevan Gangadharan, Bill Schmidke
May 16th 2023

Need to go beyond the ZEUS design

M. Helbich et al. / Nuclear Instruments and Methods in Physics Research A 565 (2006) 572–588



- A goal at the EIC is to measure the luminosity to ~1% accuracy.
- During ZEUS operations, it was 3.5% for the pair spectrometer.
- Most of that uncertainty arose from uncertainties in the acceptance at the CALs.
  That arose from upstream obstacles and the **thick exit window**

Systematics During HERA operations

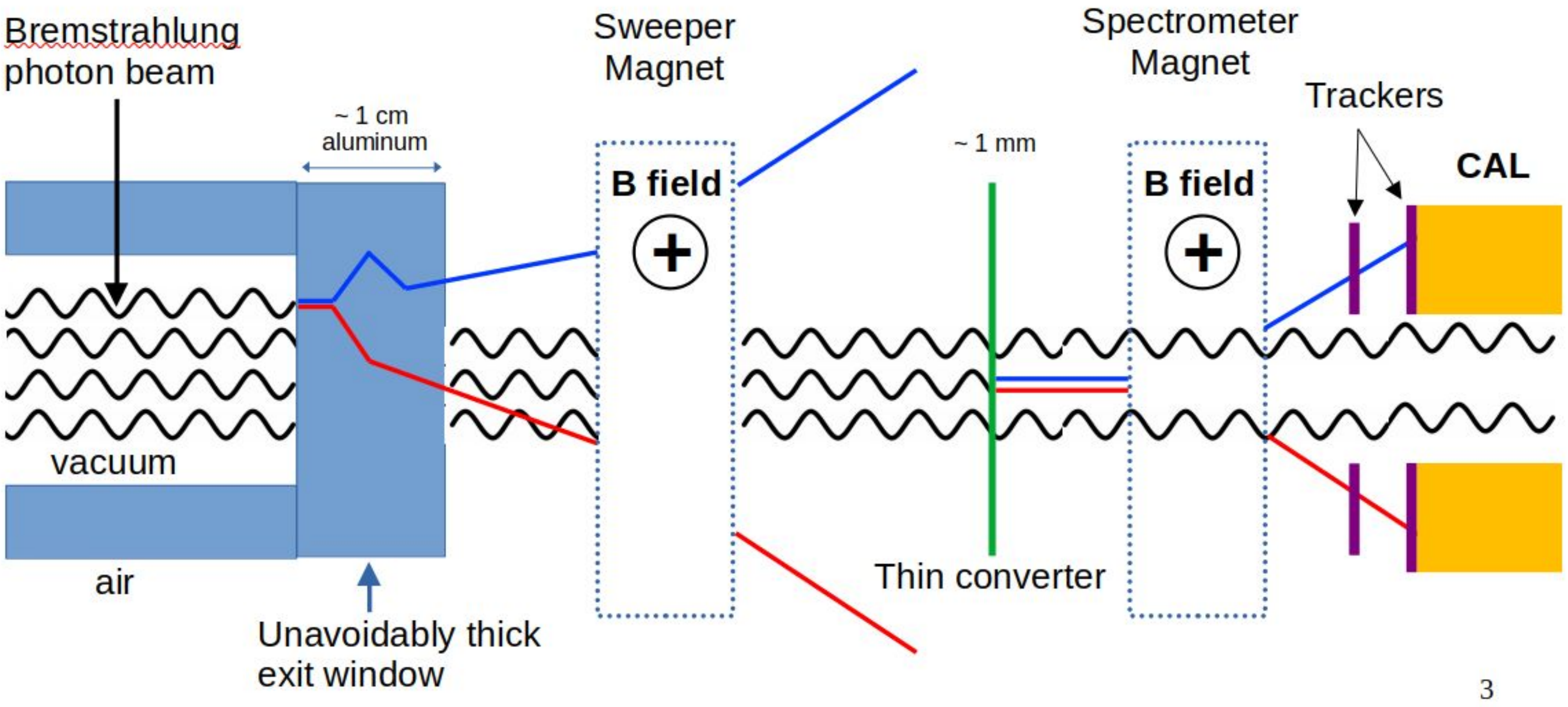
Cause	Uncertainty in luminosity
Vertical alignment and y_γ measurement	2.5%
Photon conversion rate	2%
Pile-up	0.5%
Deadtime measurement	0.5%
Theoretical Bethe–Heitler cross-section	0.5%
Dipole magnetic field	Small
Trigger threshold correction	Small
Total	3.5%

Systematics Post HERA operations

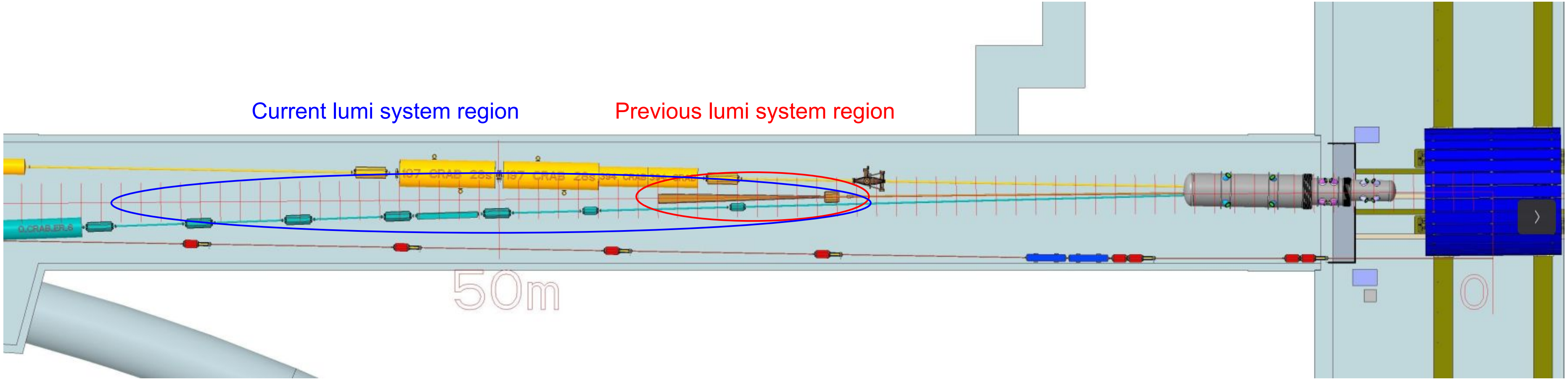
NIM A 744 (2014) 80-90

Source of systematics	Photon calorimeter	Spectrometer	
		2005/2006 $e^{-}p$	2006/2007 $e^{+}p$
Common systematics	1.6	1.6	1.5
Photon conversion In the beam exit window		0.7	0.7
Rms-cut correction		0.5	
Pedestal shifts	1.5		
Photon rate			0.6
Pile-up	0.5		
Sum	2.2	1.8	1.8

Going beyond the ZEUS design

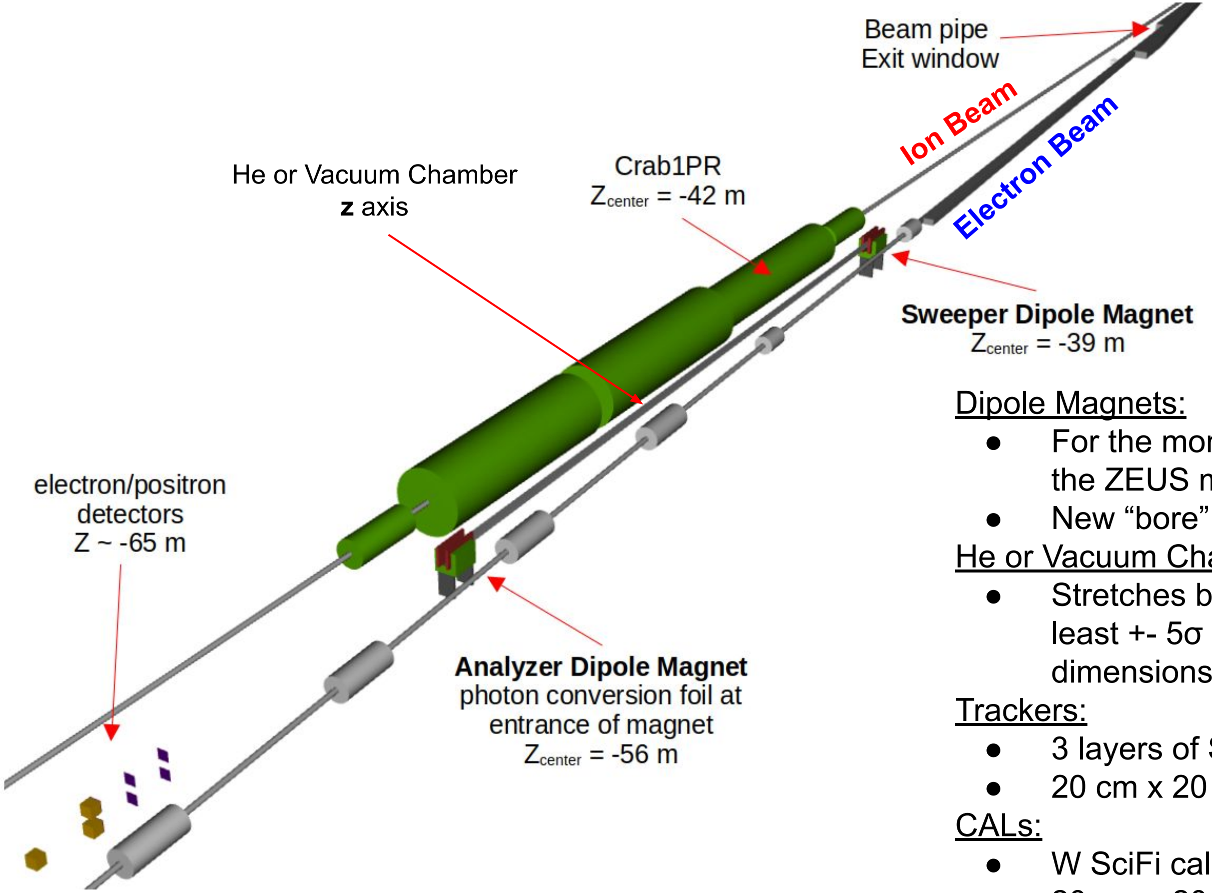


Going beyond the ZEUS design



- This engineer's drawing was provided by Karim Hamdi.
- The beamline magnets up to about Z=-65 m were transcribed from this drawing and placed into the DD4Hep ePIC repository.
- We can coordinate with the designer to get the exact placements of the beamline magnets and then adjust the locations of our Lumi system as needed.

Going beyond the ZEUS design



<u>Dipole Magnets:</u>
- For the moment, dimensions are assumed to be those of the ZEUS magnet: 44 cm (X) x 44 cm (Y) x 78cm (Z).
- New “bore” magnets are anticipated (next slide).

<u>He or Vacuum Chamber:</u>
- Stretches between dipole magnets and should allow at least +- 5σ photon beam clearance in transverse dimensions: 12 cm x 12 cm.

<u>Trackers:</u>
- 3 layers of Si sensors for the top and bottom arms
- 20 cm x 20 cm for each layer.

<u>CALs:</u>
- W SciFi calorimeters for the top and bottom arms.
- 20 cm x 20 cm x 20 cm each.

Dipole magnet requirements

A document has been prepared for these magnets.

Sweeper Dipole Magnet Requirements:

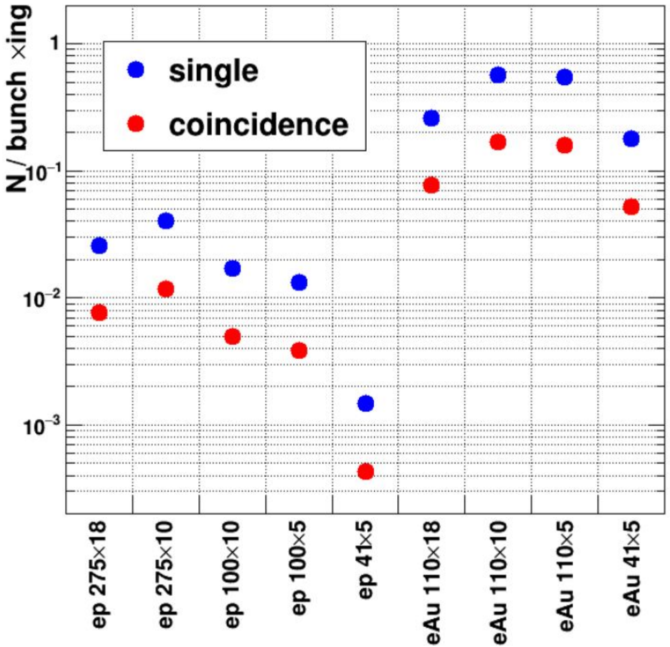
- Horizontal (x direction) field with an integrated B_x*dz of at least 0.3 T*m.
- Square bore hole of at least 8 cm in total width. This allows for a +- 5-sigma clearance of the photon beam at its location Z = -39 m. Largest anticipated electron beam divergence used for this calculation: 211e-6 rad. Bore diameter = 2 * (5 sigma) * (211e-6 rad) * (39 m)
- Not necessary to have a highly uniform field. This magnet just sweeps unwanted electrons away.
- Magnet's exterior dimensions should be small enough to allow it to fit in between electron and ion beam pipes, while being centered at X=0
- Fringe fields need to be smaller than 10 Gauss at a horizontal distance of 47 cm from the magnet's longitudinal axis, which is approximately the distance between the Z-axis and the electron beam line at Z = -39 m (IP6 coordinate system). This will ensure negligible impact on the electron beam. Magnetic shielding might be an option to help us reach this level.

Analyzer Dipole Magnet Requirements:

- Variable horizontal B field with an integrated B_x*dz ranging from at least 0.1 to 0.4 T*m. A wider range and larger mean would be highly beneficial however, as it allows for a more compact layout.
- Square bore hole of at least 12 cm in total width. Similar to the sweeper, this allows for a +- 5-sigma clearance at its location Z = -56 m.
- Field should be as uniform as possible in the bore region over the desired range of Bx*dz.
- Field polarity should be reversible for systematic studies.
- Magnet's exterior dimensions should be small enough to allow it to fit in between electron and ion beam pipes, while being centered at X=0
- Fringe fields need to be smaller than 10 Gauss at a horizontal distance of 84 cm from the magnet's longitudinal axis, which is approximately the distance between the Z-axis and the electron beam line at Z = -56 m (IP6 coordinate system). This will ensure negligible impact on the electron beam. Magnetic shielding might be an option to help us reach this level.

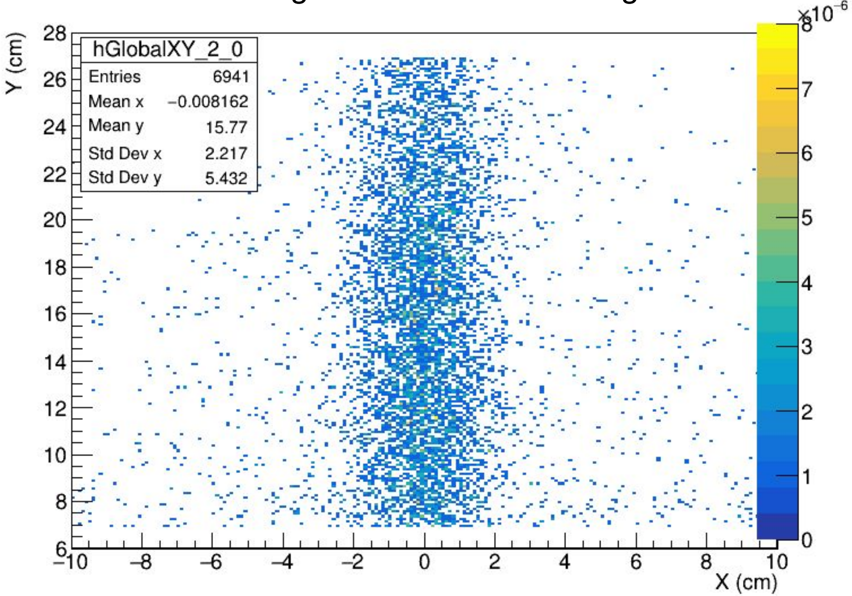
Expected Rates

Overall rates given current design



Differential rates for ep 275x18 (top trackers):
N “singles” / mm2 / bunch xing

Includes beam effects



CALs:

- Moliere radius defines the granularity of the readout (~ 2 cm). Two CALs of 20cm x 20cm yields 200 readout channels.
- Differential rate per 2cm x 2cm readout channel:
  For ep 275x18 it is < 1e-3 per bunch xing.
  For eA 110x10 it is < 2e-2 per bunch xing.

Trackers:

- Rates per pixel are tiny. MAPS sensors with small material budget and ~1 μsec integration times might be feasible.

Backup slides

Tracker Acceptances