Luminosity Spectrometer

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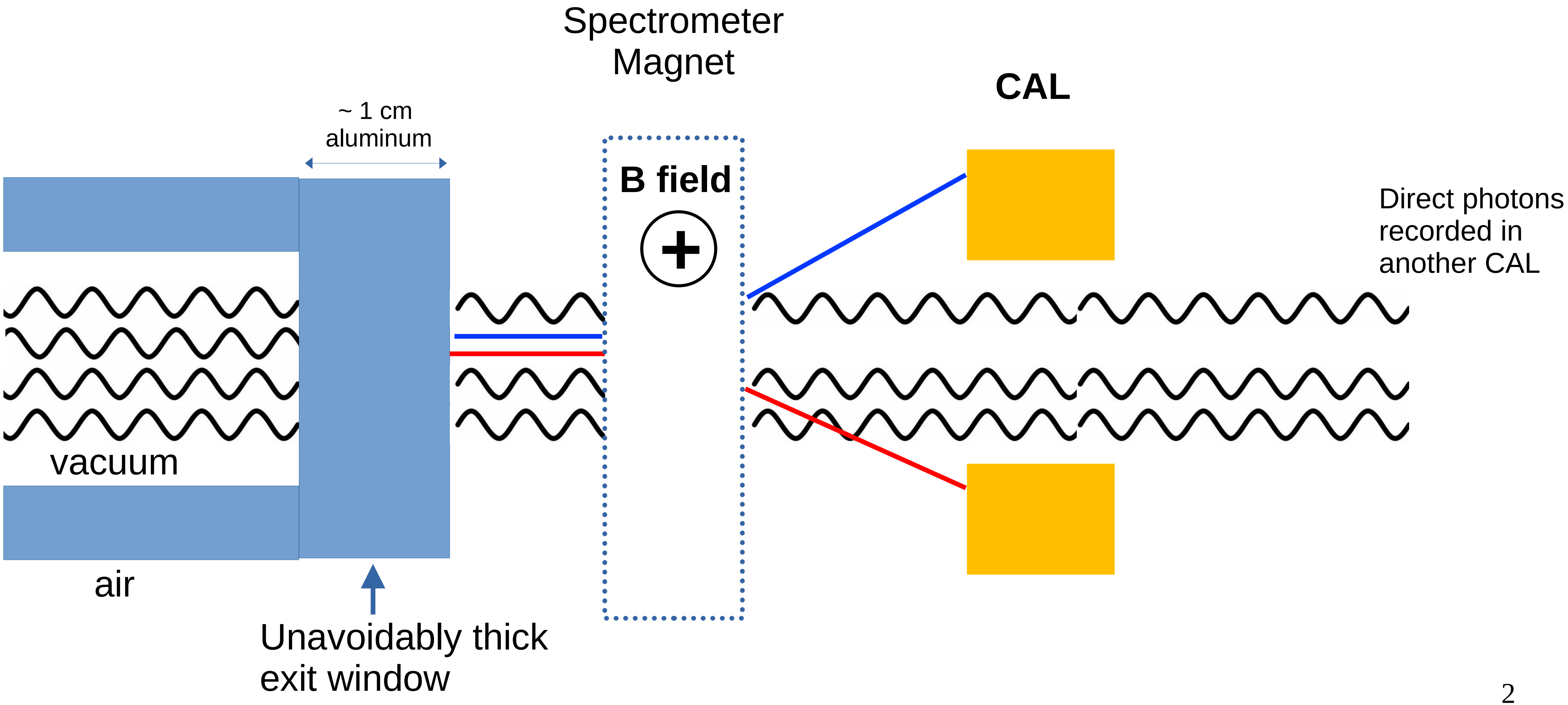
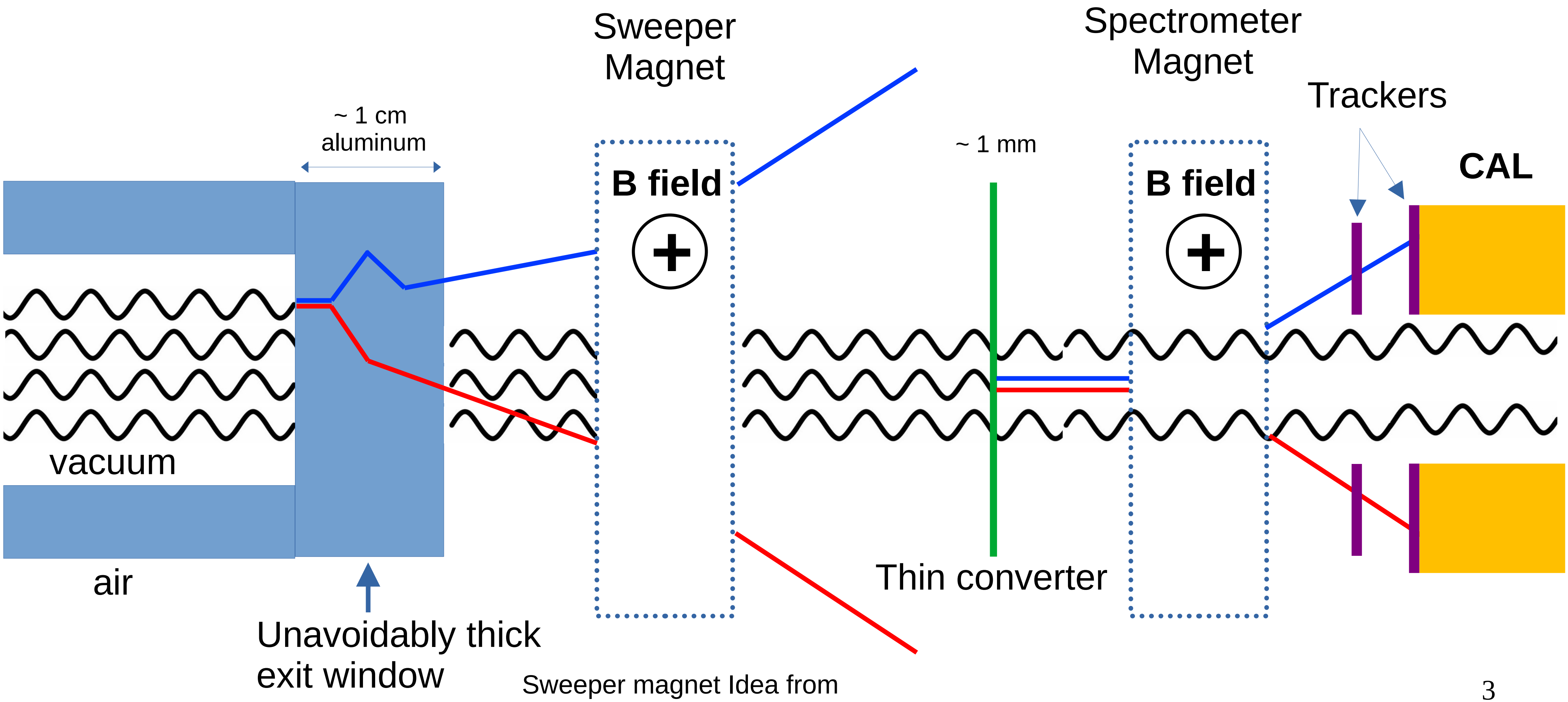
ePIC collaboration meeting Jan 2023

Basic idea of ZEUS spectrometer



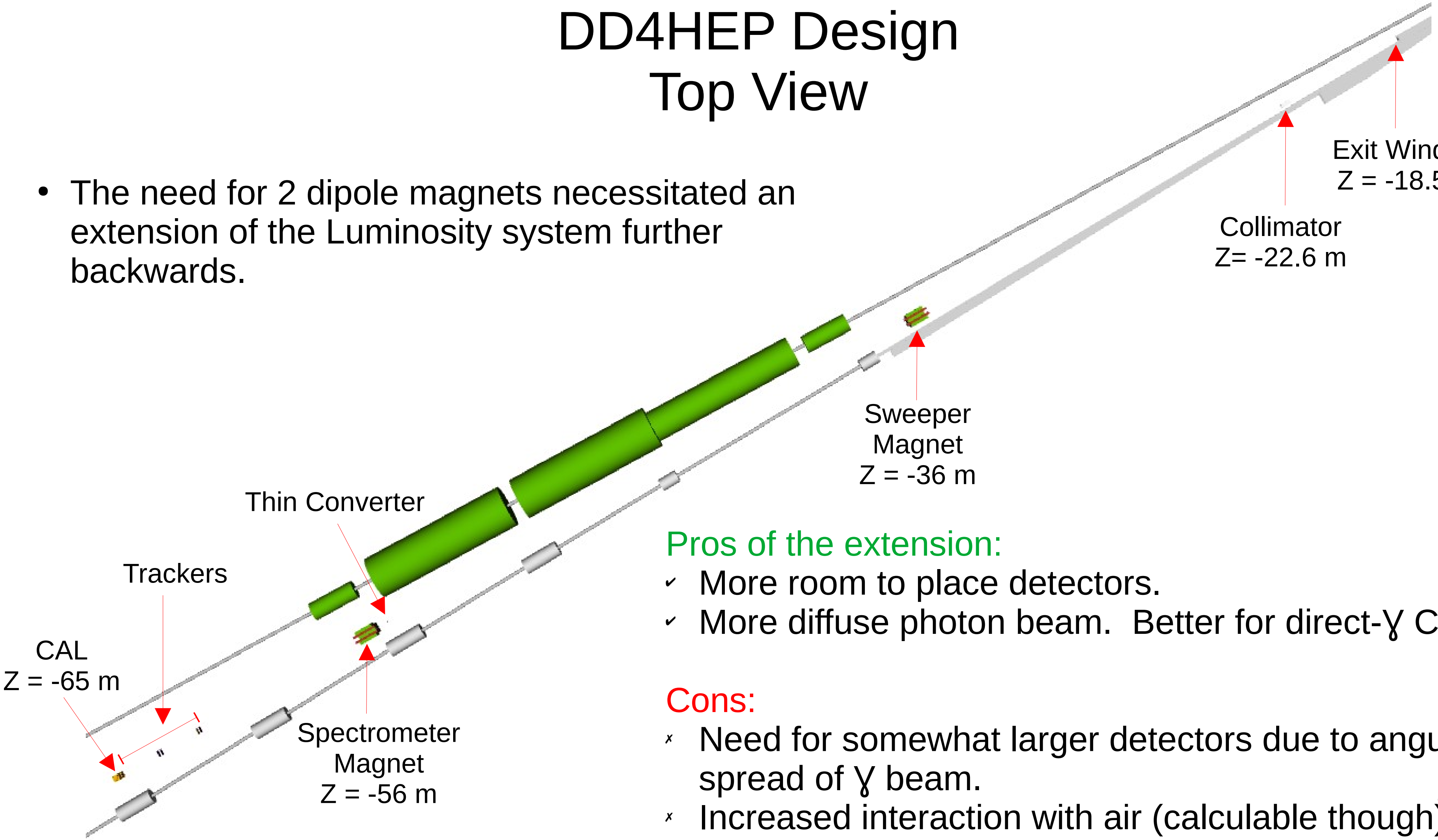
Basic idea of **ePIC** spectrometer



Sweeper magnet Idea from
Kzyrsztof Piotrzkowski

DD4HEP Design
Top View

- The need for 2 dipole magnets necessitated an extension of the Luminosity system further backwards.



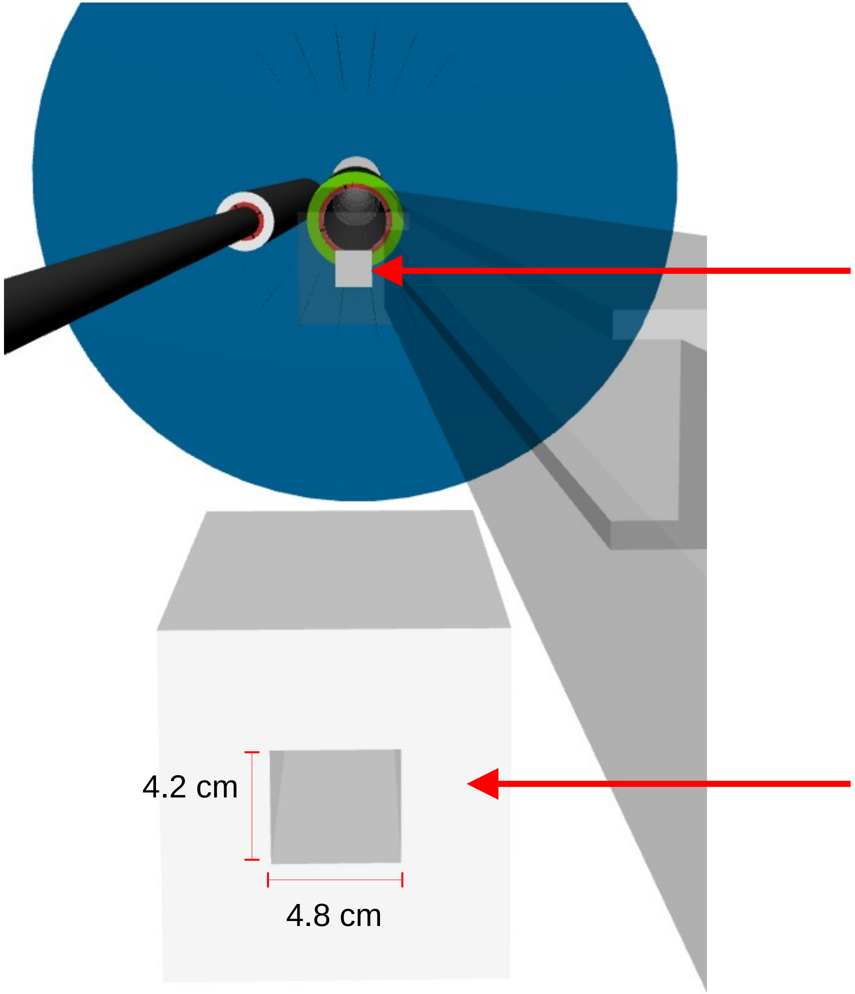
Pros of the extension:

- ✓ More room to place detectors.
- ✓ More diffuse photon beam. Better for direct-Ɣ CAL.

Cons:

- ✗ Need for somewhat larger detectors due to angular spread of Ɣ beam.
- ✗ Increased interaction with air (calculable though)

DD4HEP Design



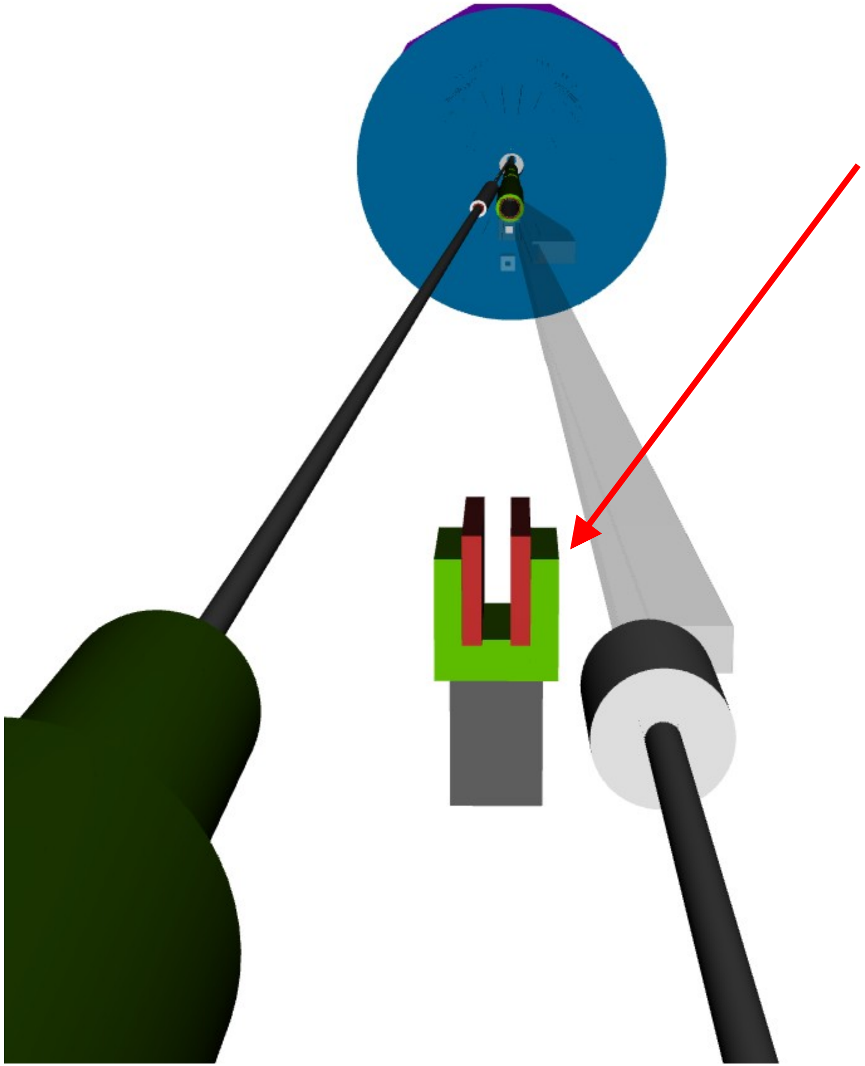
Exit Window

- Taken to be Aluminum, 1 cm thick
- Thickness and composition needs to be accurately known in order to account for the lost photons

Collimator

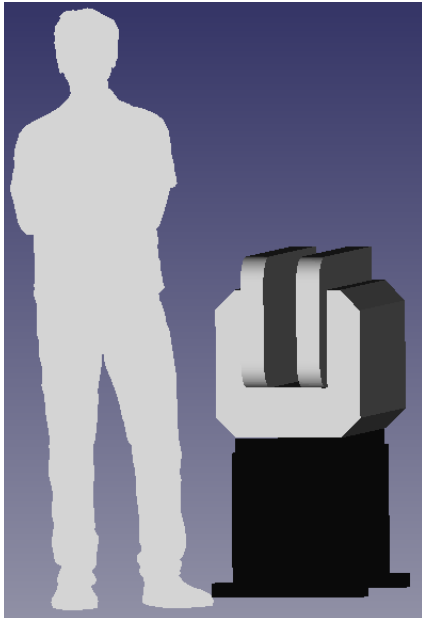
- Steel block to remove stray particles that may damage other components further downstream.
- Opening size defines phase space of measured photons: taken to be 5σ ~ ±2.4 cm.

DD4HEP Design



Sweeper Magnet

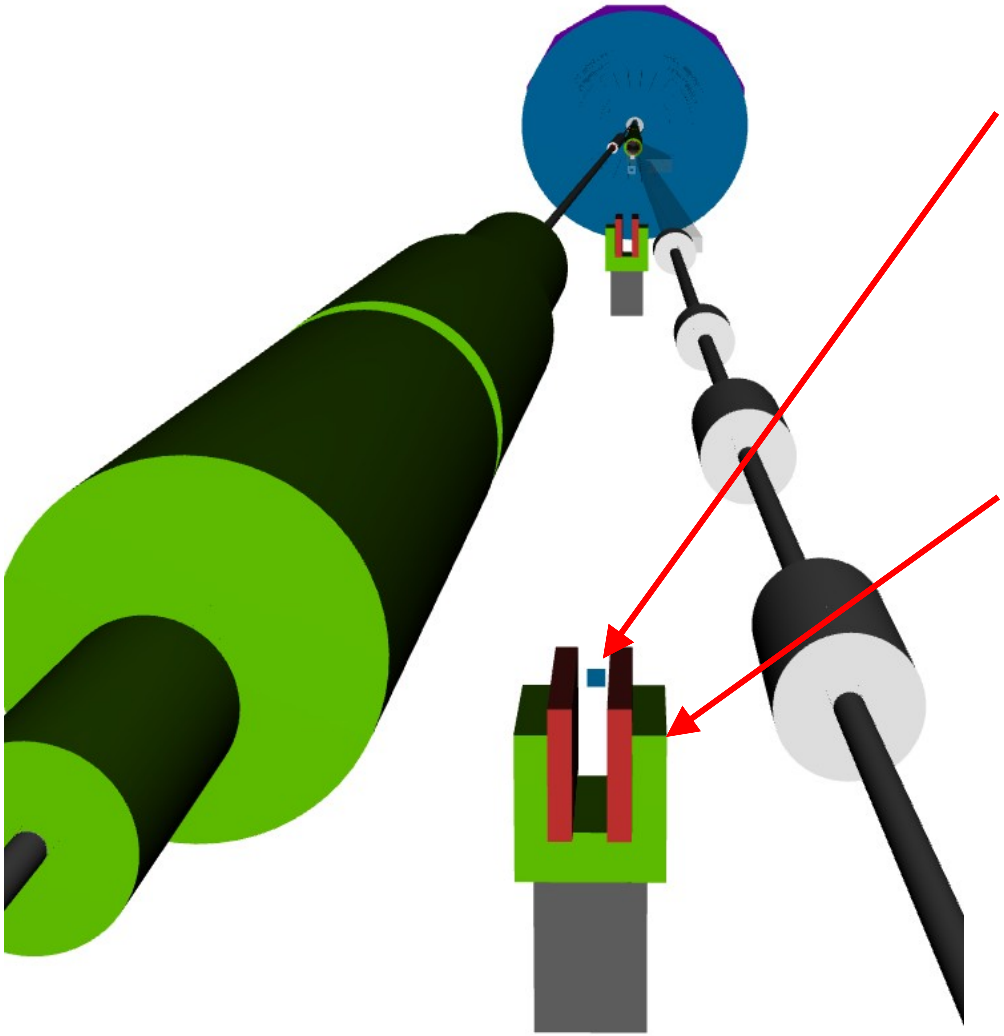
- Taken to be the same as the ZEUS design
- Dimensions extracted from a CAD drawing.
  - 10 cm opening (~±10σ photon beam) .
  - 0.5 T horizontal B field (electrons go up and down)
- Still need to ensure fringe field < 10 Gauss @ electron beam.



CAD drawing obtained from Yulia Furletova

Implemented in DD4HEP by Justin Chan

DD4HEP Design



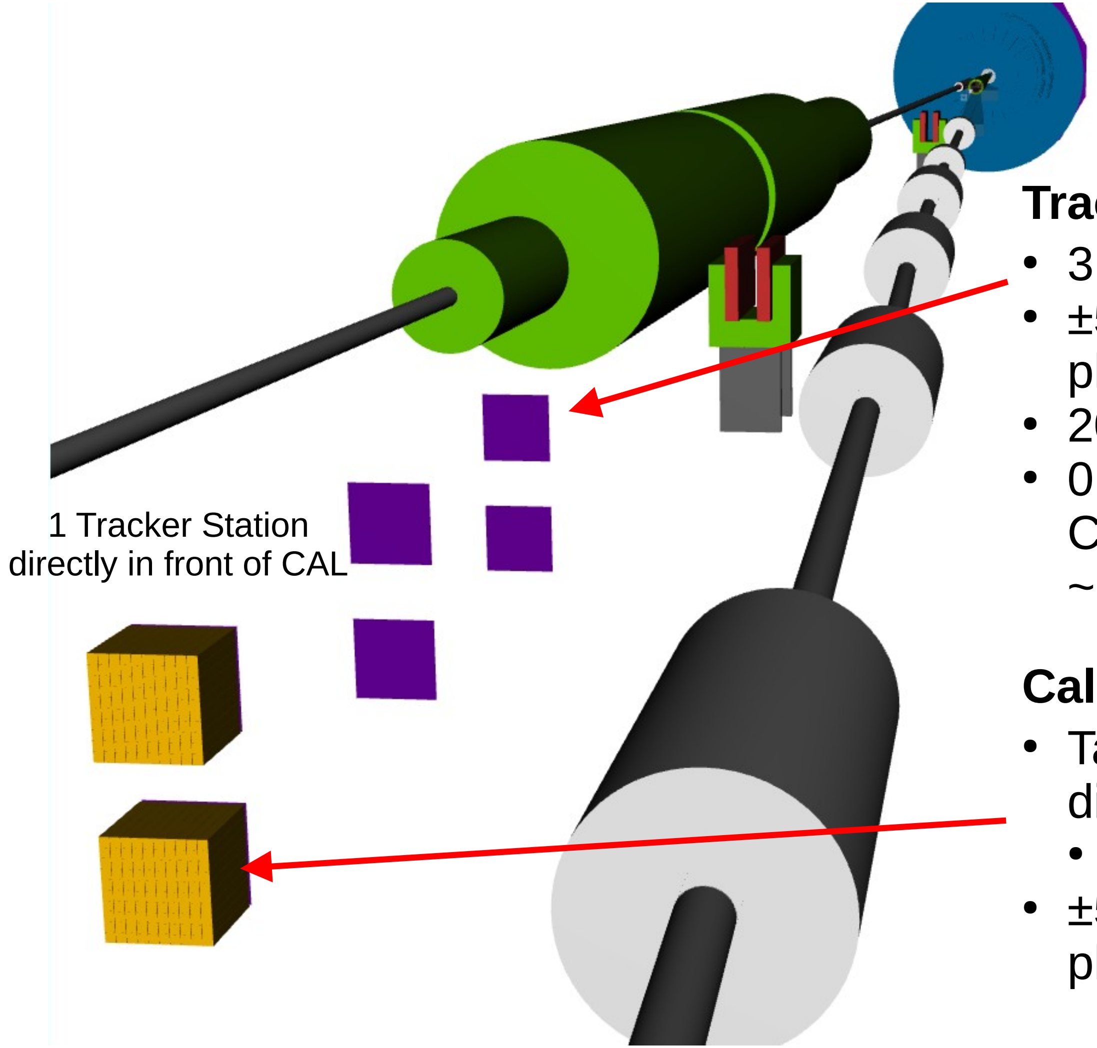
Converter

- Taken to be Aluminum, **1 mm thin**
- Thickness and composition needs to be accurately known in order to account for the conversions

Spectrometer Magnet

- Taken to be the same as the Sweeper Magnet: 0.5 T horizontal B field.
- Placed just after the converter.
- 10 cm opening also provides ~±10sigma clearance for direct-ɣ beam.

DD4HEP Design



Trackers

- 3 stations with a top & bottom plane each.
- ±5σ gap between top and bottom for direct photon passage.
- 20 cm x 20 cm transverse dimensions
- 0.3 mm SiliconOxide (sensor) + 0.14 mm Copper (ASIC+cooling approximation): ~1% $\boldsymbol{X}_0$

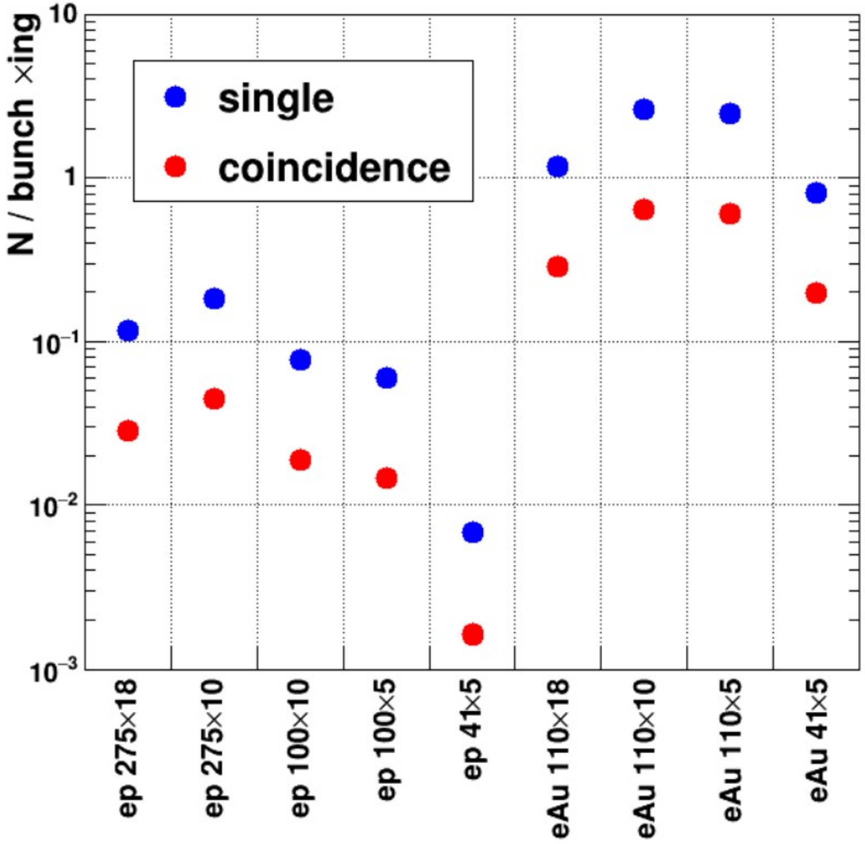
Calorimeter

- Taken to be PbWO4 with same module dimensions as scattered electron CAL
  - 2 cm x 2 cm x 20 cm.
- ±5σ gap between top and bottom for direct photon passage.

Expected Rates of electrons at spectrometer CALs

Bethe-Heitler formula for unpolarized ep Bremstrahlung

$$\frac{d\sigma}{dE_\gamma} = 4\alpha Z^2 r_e^2 \frac{E'_e}{E_\gamma E_e}\left(\frac{E_e}{E'_e} + \frac{E'_e}{E_e} - \frac{2}{3}\right)\left(\ln \frac{4E_p E_e E'_e}{m_p m_e E_\gamma} - \frac{1}{2}\right)$$



- Bremstrahlung σ is much larger for eAu than ep, but the bunch luminosity will be lower for eAu.
- These rates depend also on the design (acceptance) of the spectrometer CALs as well as the converter thickness.
- This plot assumed a 1 cm thick converter.
- With new design, it could be 1 mm or less (1/10th the rate).
- **Pileup greatly suppressed with new design!**

See Bill Schmidke's talk

Planned simulation studies before collaboration meeting

- Acceptance mapping of new design.
- Energy resolutions of CAL and trackers with and without beam effects.

Cross-calibration synergy with low-Q2 tagger

- Special low-luminosity runs are planned to cross calibrate spectrometer CAL and taggers: full detection of bremstrahlung process e+p → e+p+ɣ

Summary

- New luminosity spectrometer design implemented in DD4HEP.
- With new design (sweeper magnet + thin converter), pileup greatly suppressed.

Next steps

- Check the fringe-field strength of Lumi dipole magnets to confirm < 10 Gauss @ beams.
- Optimize placements/sizes of trackers and CAL.

Backup

Bethe-Heitler

$$\frac{d\sigma}{dE_\gamma} = 4\alpha Z^2 r_e^2 \frac{E_e'}{E_\gamma E_e}\left(\frac{E_e}{E_e'} + \frac{E_e'}{E_e} - \frac{2}{3}\right)\left(\ln\frac{4E_p E_e E_e'}{m_p m_e E_\gamma} - \frac{1}{2}\right)$$