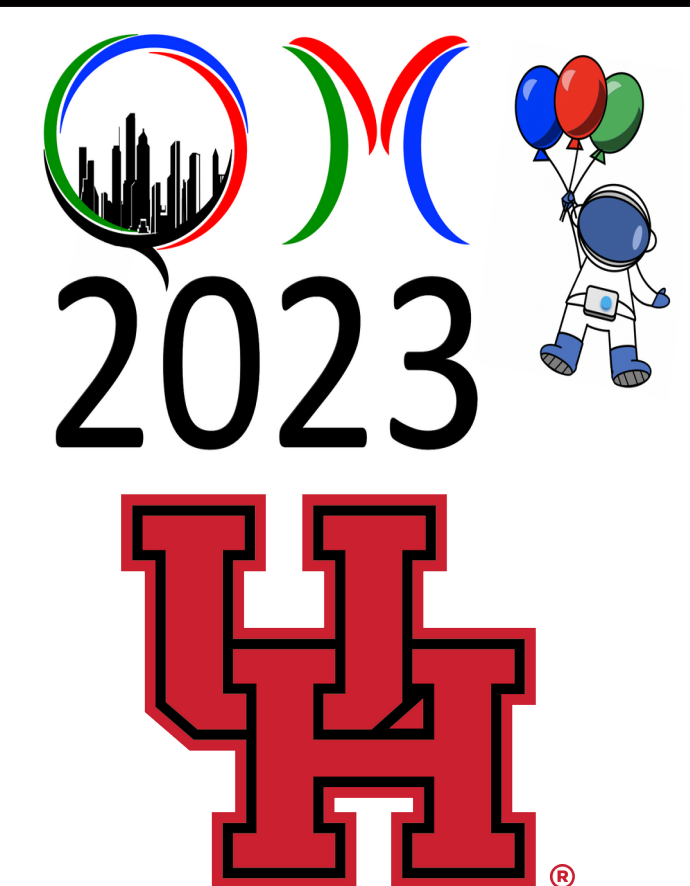# Simulation Studies of the
Pair Spectrometer Luminosity Detector
for the ePIC experiment at the EIC

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Detector Goal : Measure luminosity by counting Bremsstrahlung photons produced at ePIC.

Dominant part of total inelastic cross section is QED Bremsstrahlung (BH), σ_{BH}, which is *precisely calculable*.
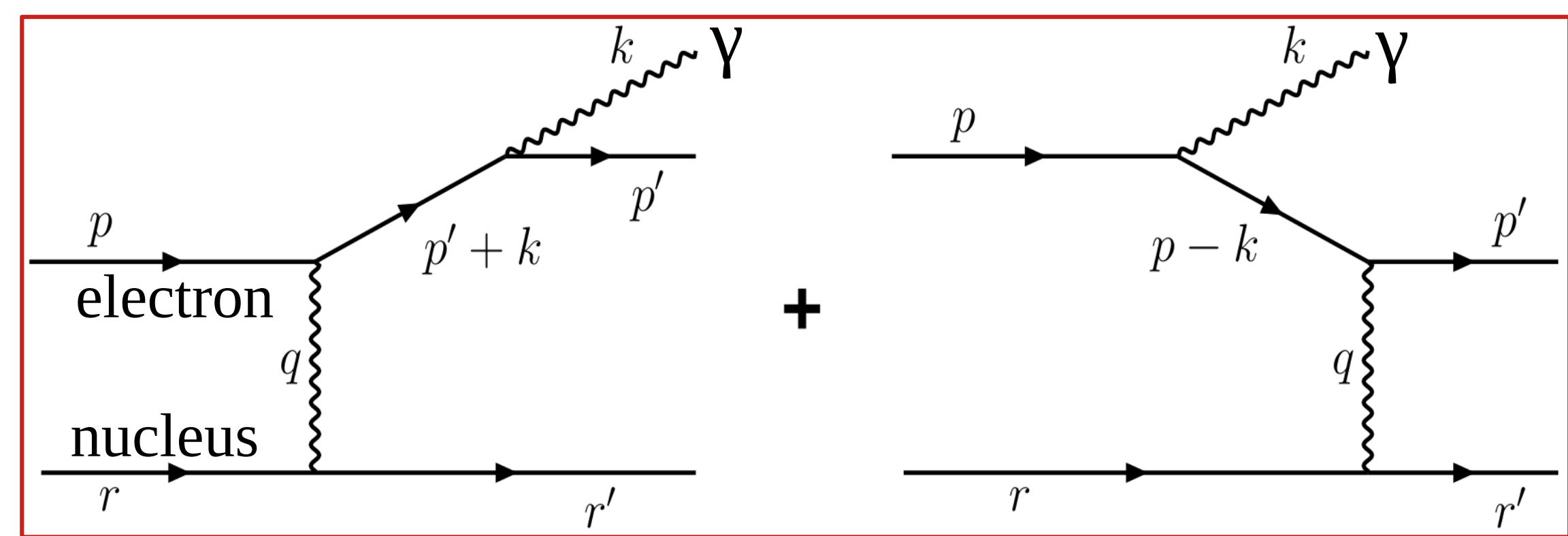

Fig 1. Feymann diagram of Bremsstrahlung processes.

Requirements
• ~1% uncertainty for absolute luminosity
• Less than 10^{-4} for relative luminosity [1]

Average luminoisty
L = R_γ/σ_{BH} (cm^{-2} s^{-1}) ~ 10^{34} (10^2 times ZEUS-HERA) [1]

Major Challenges
1. Synchrotron radiation **2.** High rate BH radiation

Pair Spectrometer (PS) luminosity detector
• Indirectly measure R_γ (dN_γ/ dt) by $e^\pm$ pair conversions.
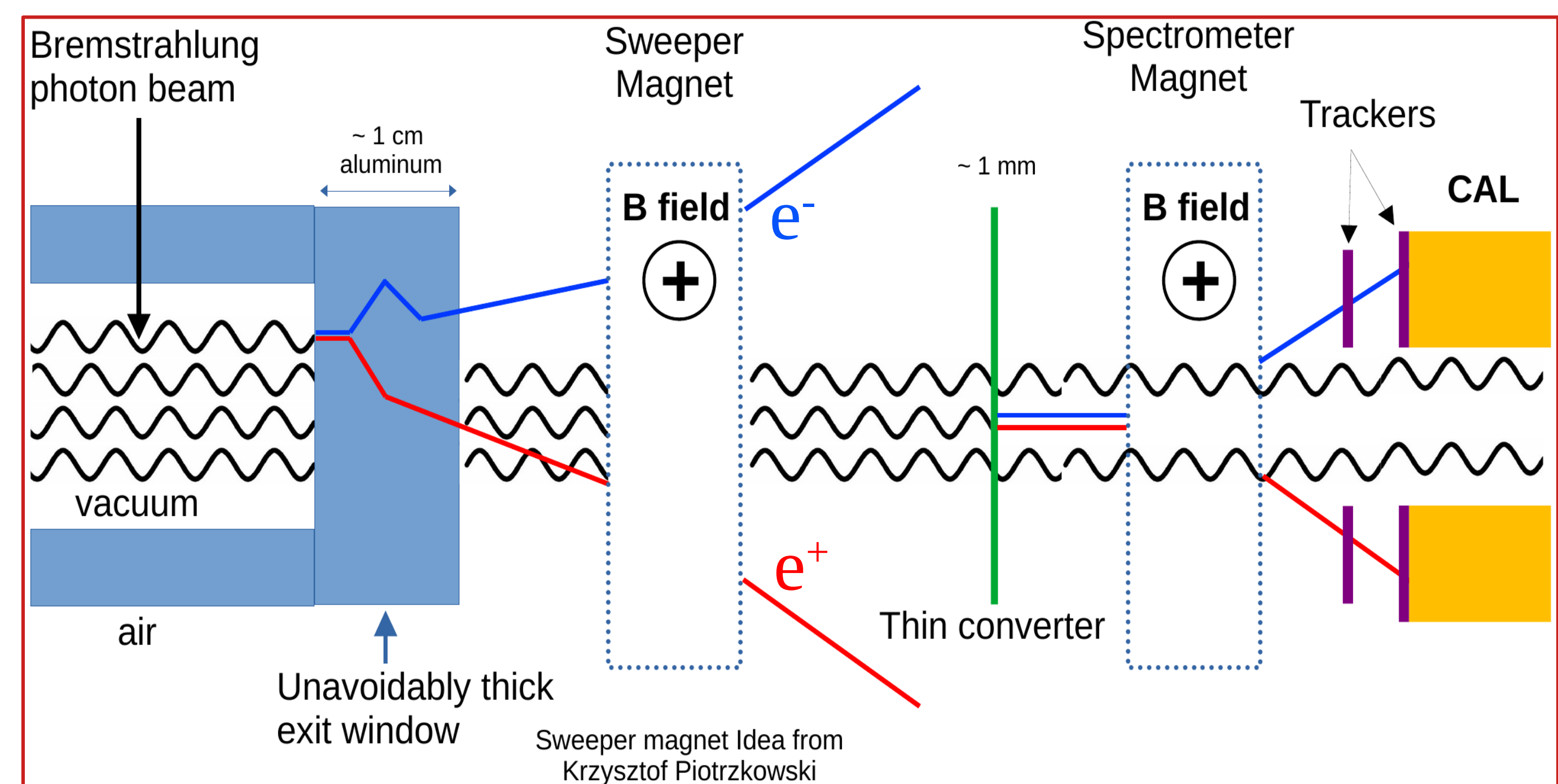• Deals with the major challenges

Fig 2. ePIC PS Luminosity Detector pictorial representation.

Pair Spectrometer Calorimeter

Requirements and Design

1. Insight into the acceptance and fairly good energy resolution
2. Radiation hardness & low integration time (< 10 ns bunch spacing)
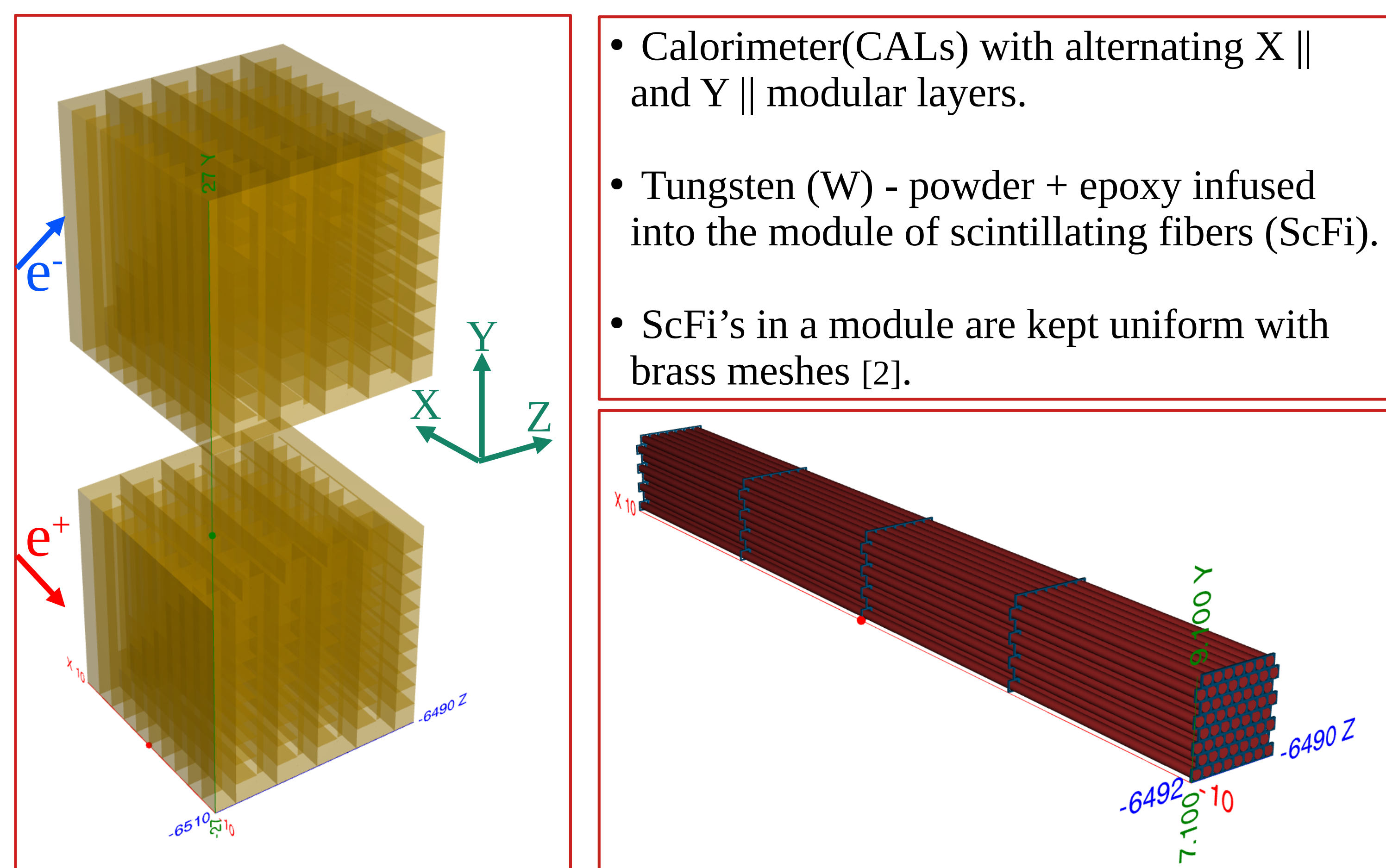3. Track shower profile for improved pile up (multiple $e^\pm$ hits) treatment

• Calorimeter(CALs) with alternating X || and Y || modular layers.

• Tungsten (W) - powder + epoxy infused into the module of scintillating fibers (ScFi).

• ScFi's in a module are kept uniform with brass meshes [2].

Fig 3. The Modular and Fiber Structure of W-Scfi CALs without W powder.

Resolution comparable with ZEUS
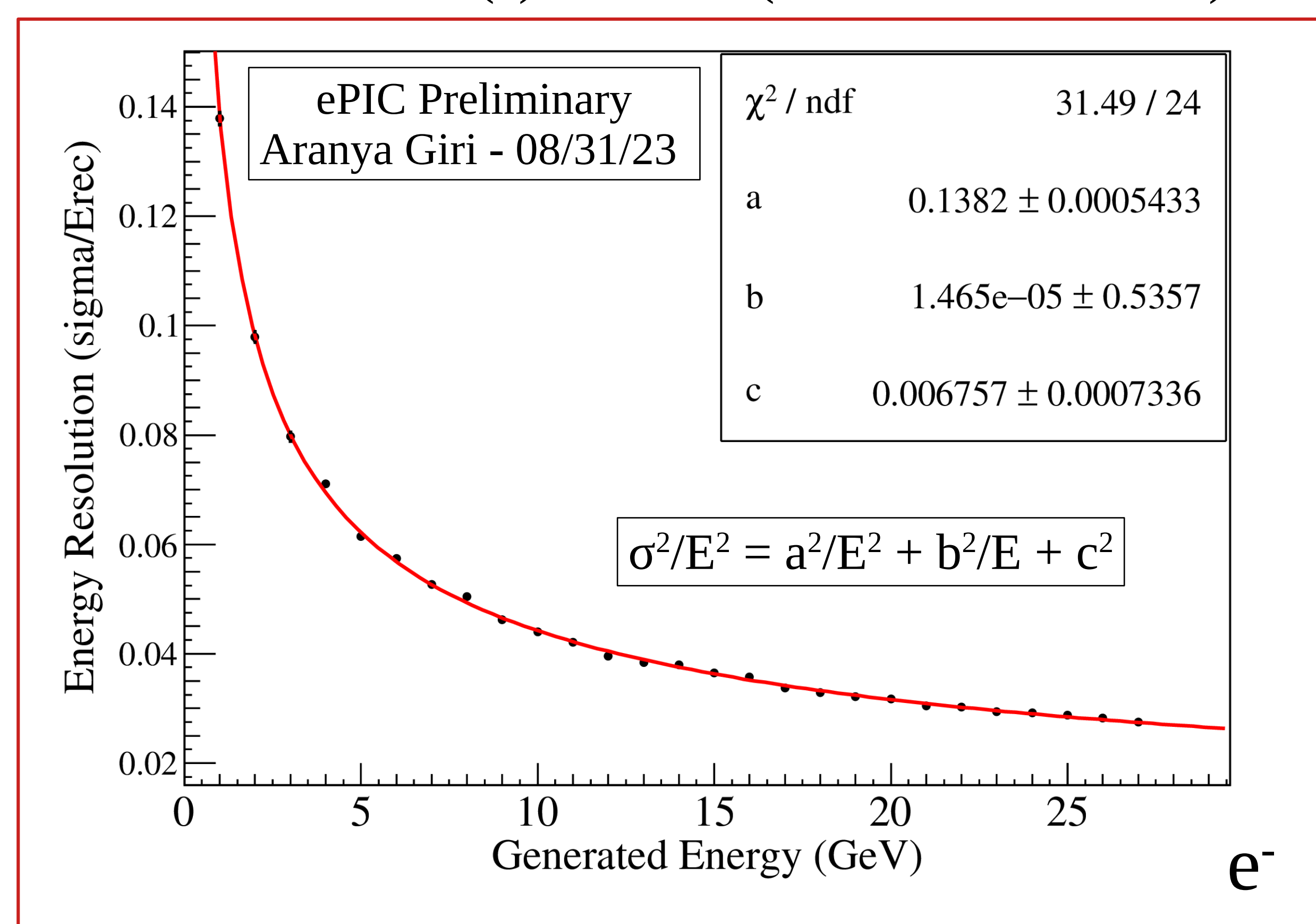• Stochastic Term (a) – 13.5 % (for ZEUS – 13% [3])

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χ^2 / ndf		31.49 / 24
a		0.1382 ± 0.0005433
b		1.465e−05 ± 0.5357
c		0.006757 ± 0.0007336

$\sigma^2/E^2 = a^2/E^2 + b^2/E + c^2$

Fig 5. Standalone energy resolution of PS CALs, e^- hit directly at a CAL.

Pile-up treatment
• 3D shower profile from alternating layers

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hEnergyProfileYZ
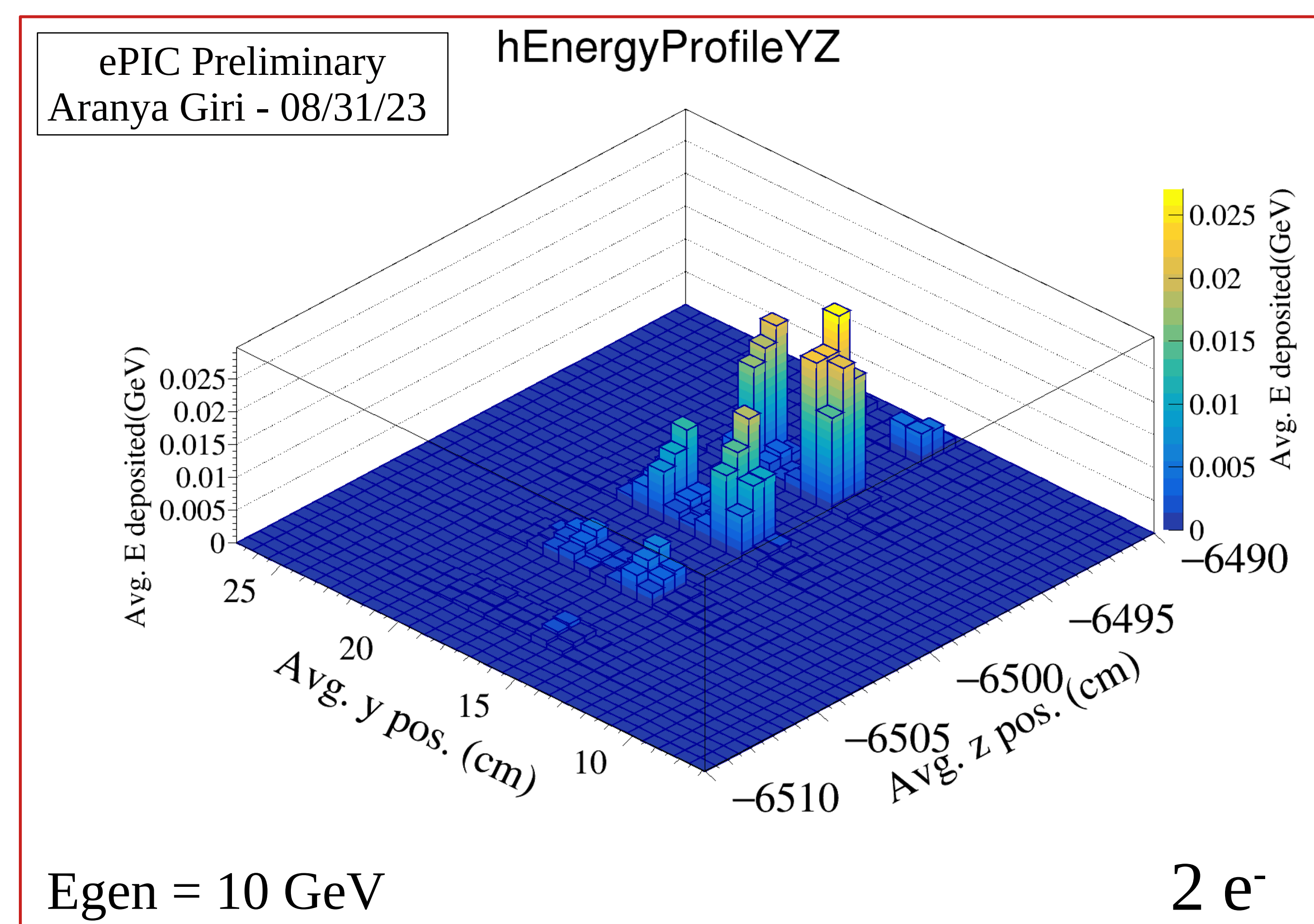
Egen = 10 GeV   2 e^-

Fig 4. Shower energy profile of 2 e^- from all the X || layers, e^- were separated 3 cm along Y-axis.

Additional Benefit : Distinguishing background hadrons
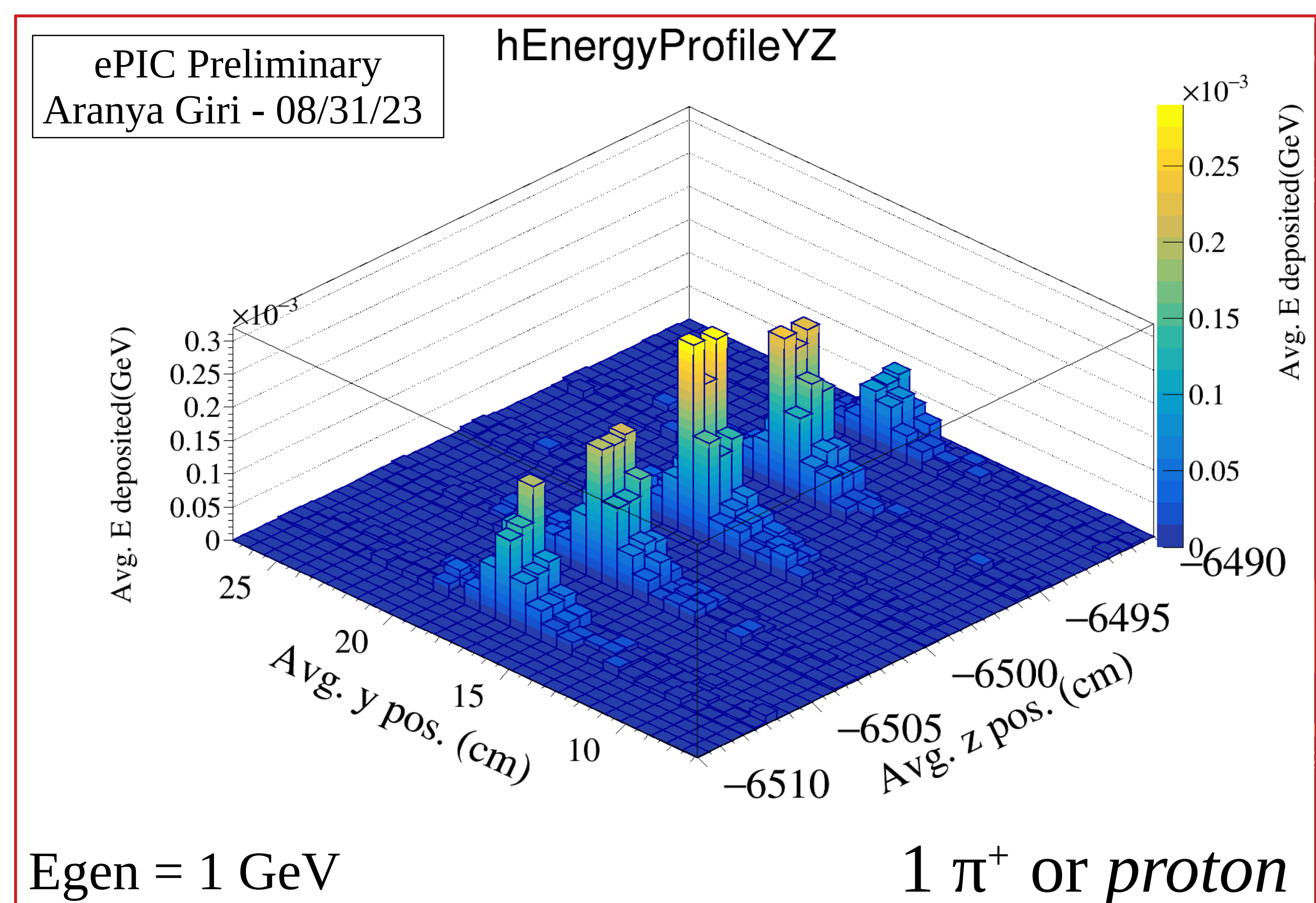• Energy deposition along z doesn't diminish like for e^-

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hEnergyProfileYZ

Egen = 1 GeV   1 π^+ or *proton*

Fig 6. π^+ energy deposition profile from all the X || layers.

Current Status

• The pair spectrometer luminosity detector has been implemented in DD4hep (geant4 based detector simulation package) to perform simulations.
• XY || design of pair spectrometer calorimeter show promising results with energy resolution, pile up treatment and distinguishing background from $e^\pm$ hits.
• Optimization of calorimeter design is still in progress in coordination with University of York (UK) group.

References

1) Nucl. Phys. A 1026 (2022) 122447
2) O D Tsai et al 2012 J. Phys.: Conf. Ser. 404 012023
3) Nucl. Instrum. Meth. A565: 572-588,2006