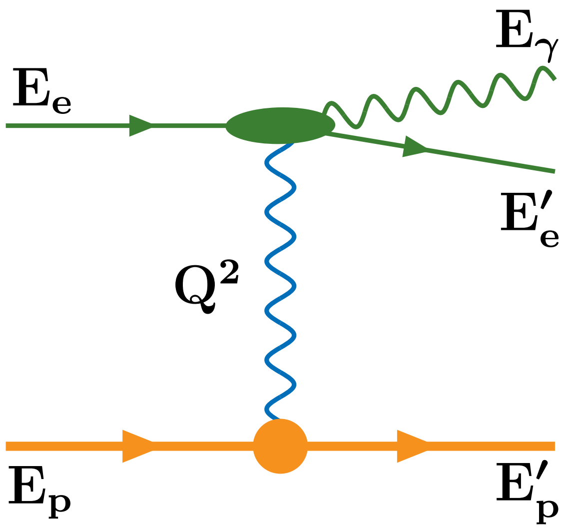
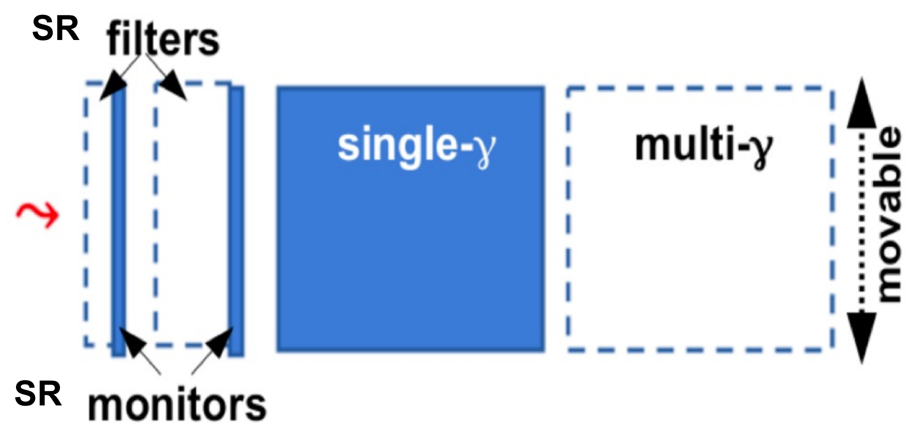
DSC-FBWD: High Rate Calorimeters

Krzysztof PIOTRZKOWSKI





ePIC Collaboration Meeting, 7/29/2023

Direct Photon Detection: Introduction

In principle, measurements of direct bremsstrahlung photons can provide very simple and precise EIC luminosity measurements, as a photon (geometrical) acceptance is almost 100% and one has to simply account for a photon energy threshold, which can be well calibrated.

However, using this simple method of photon counting is only possible at low luminosities. For the nominal L = 10^{34} $cm^{-2}s^{-1}$ about 23 hard photons on average will be emitted for each bunch crossing, forcing measurements of energy flow, which are more difficult.

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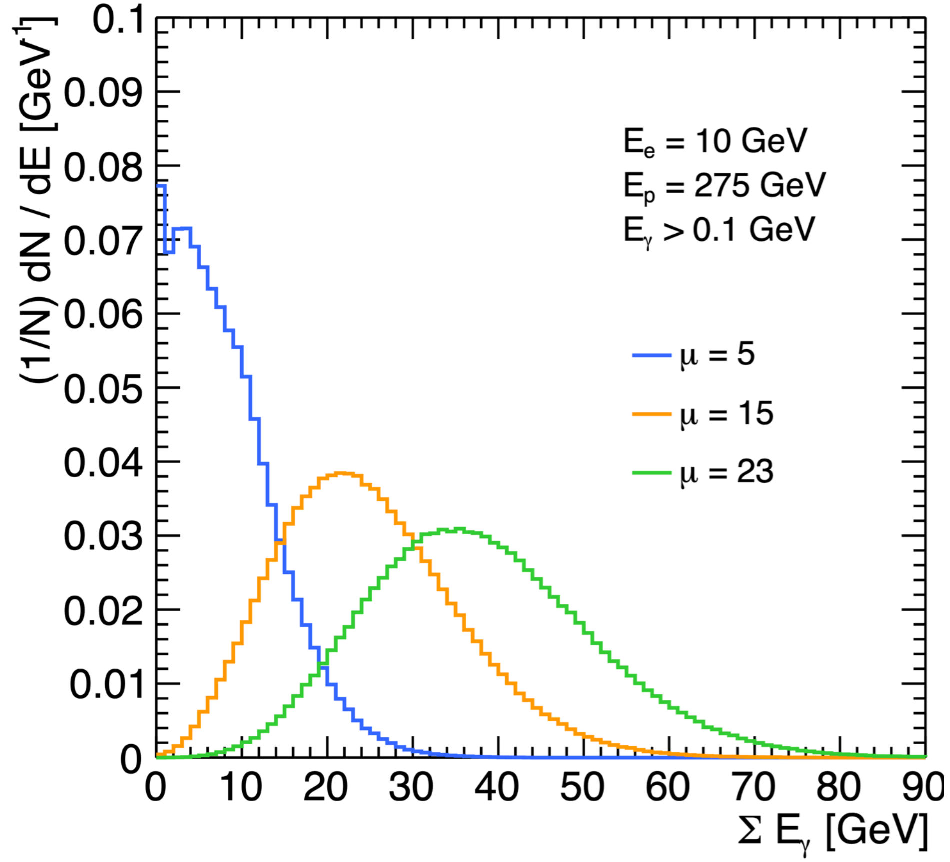
Therefore, **two** separate direct photon calorimeters are proposed: one with *excellent energy resolution* to be used only for **special luminosity calibration runs at low *L***, and one which is capable of withstanding *multi-GHz event rates* and be used for robust **luminosity monitoring** during the nominal EIC running.



Direct “Zero-degree” Photon Detection

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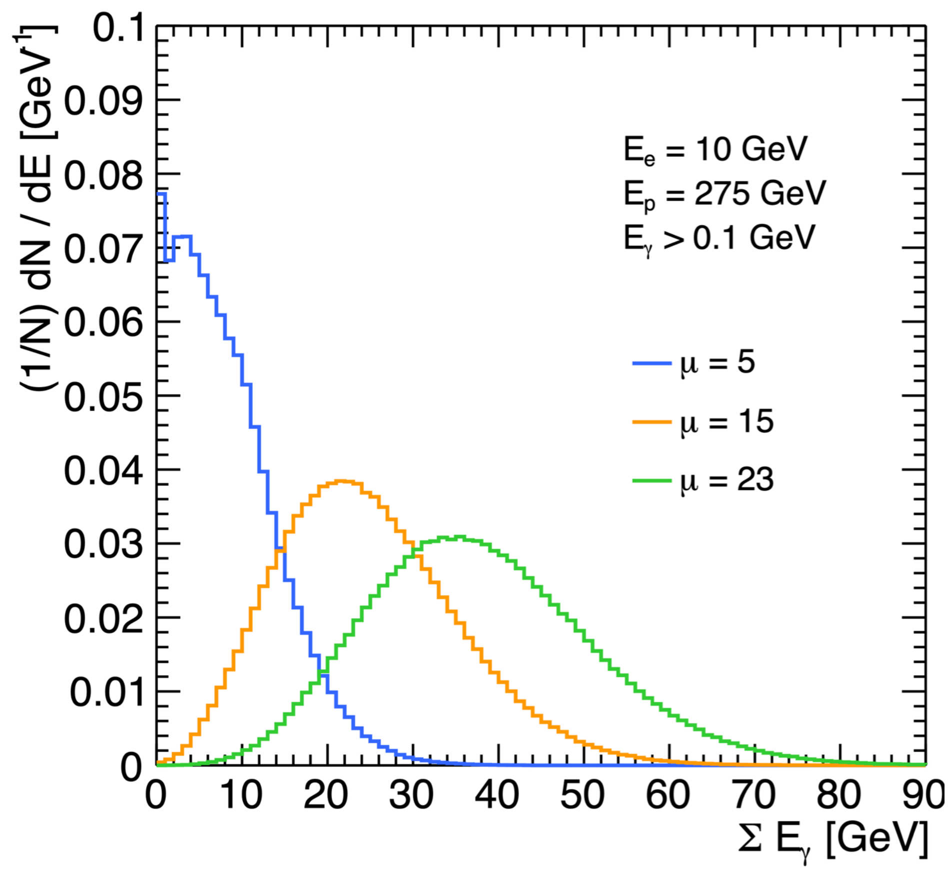
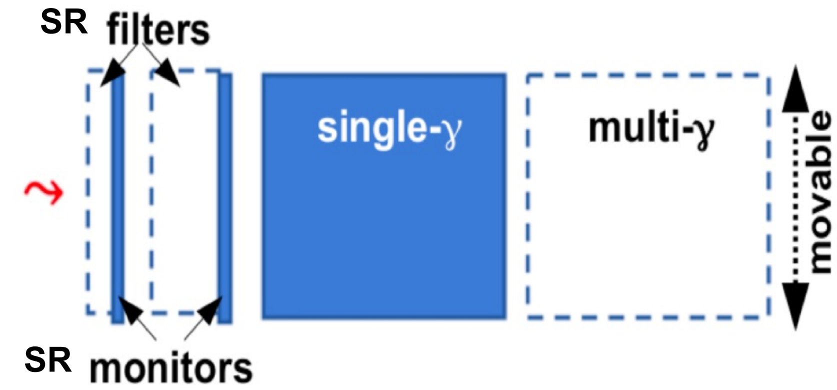


Direct bremsstrahlung photon calorimeters are inevitably exposed to the direct synchrotron radiation, mostly originating in the electron beam ”separating” dipole B2eR. For a 18 GeV electron beam that requires using thick absorbers/filters to attenuate SR, at a cost of deteriorating the energy measurements. We therefore need to carefully study the optimal way of configuring such filters.

HRC DSC:

Y. Ali, A. Kowalewska, K. Piotrzkowski, M. Przybycien (AGH); J. Chwastowski (IFJ); J. Nam (Temple), I. Korover (MIT/Tel Aviv); N. Zachariou (x-link to PS DSC); J. Adam (x-link to High Rate Tracker DSC)



Our focus: Development of complete systems for direct photon measurements as well as for low-Q^2 electron energy measurements with calorimeters – great synergies are due to similar event rate challenges (except for Single-γ CAL)

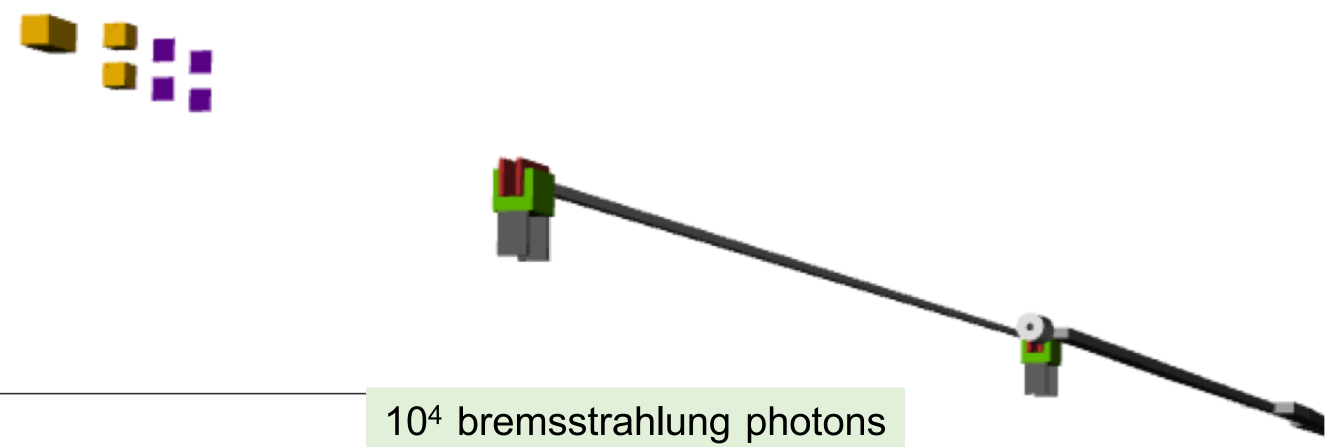
Important x-collaborations:

- Single-γ calorimeter developments vs. *Pair Spectrometer DSC*
- Simulations of electron trajectories/backgrounds vs. *High Rate Tracker DSC*

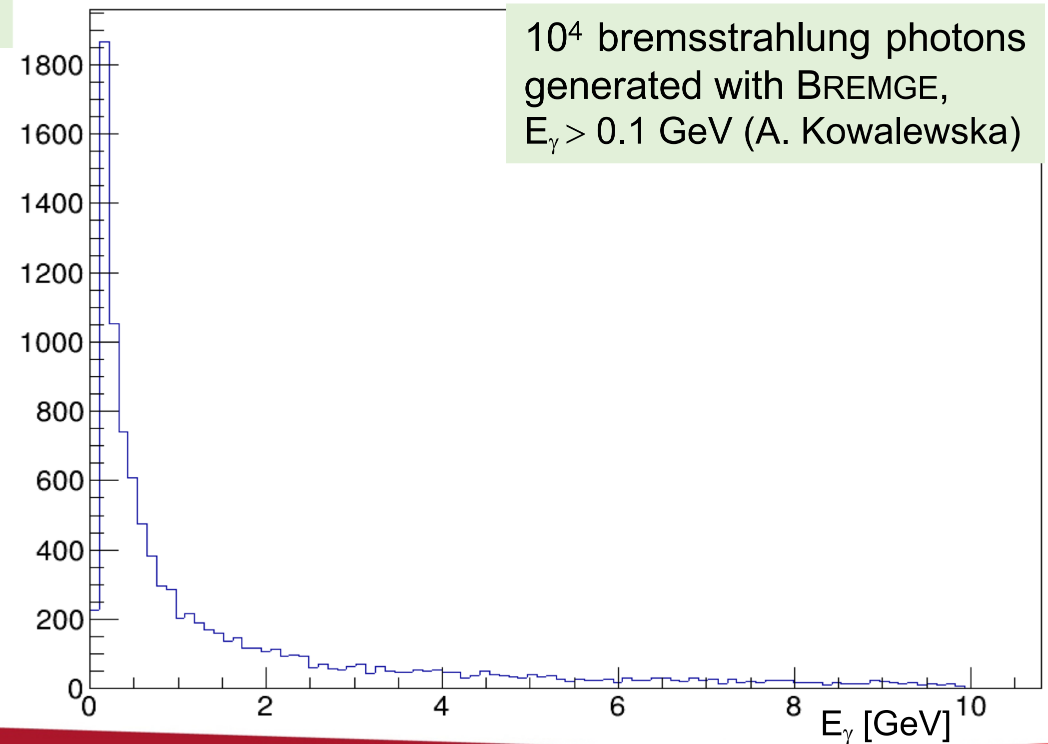
HRC "work environment"

Monte Carlo "warm-up exercise":

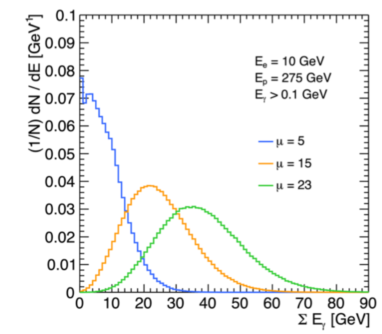
Simulations of a $PbWO_4$ calorimeter – one crystal block 10 cm x 10 cm x 20 cm, placed just behind PS, for studies of (unavoidable) bremsstrahlung energy deposits



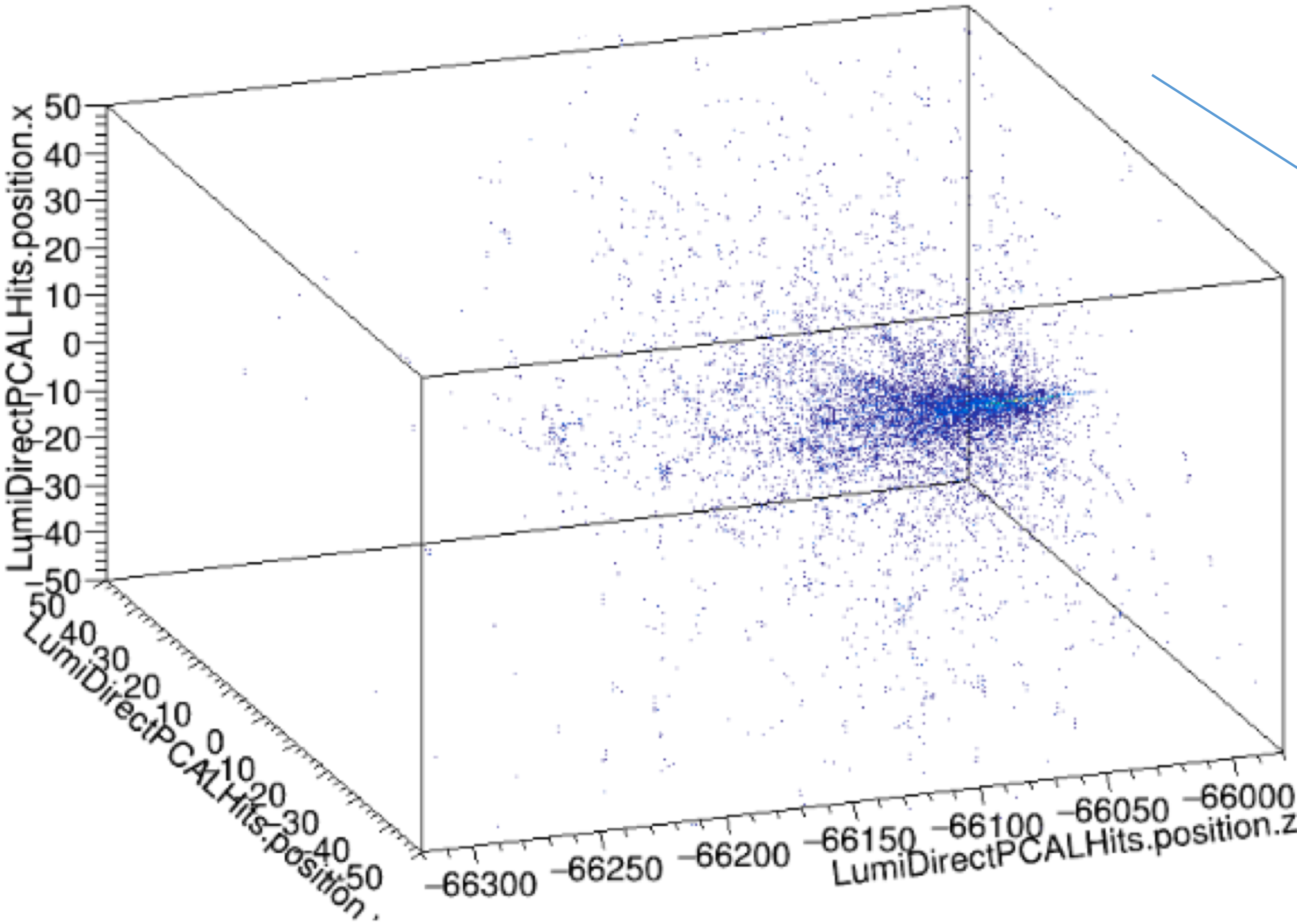
Photon hit position was "gaussian-smeared" laterally (with **σ = 1 cm**, both horizontally and vertically) to account for beam divergence and varying beam tilts over long time periods (+ possible calorimeter "lateral shifts", from time to time)

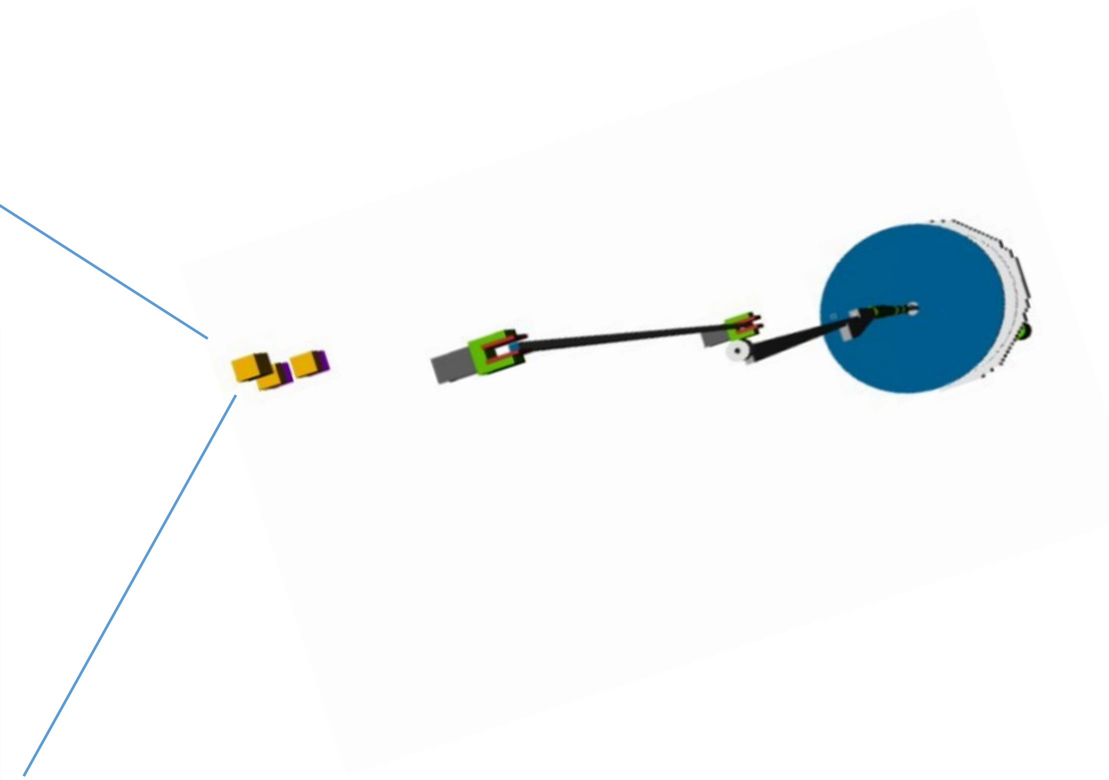


10^4 bremsstrahlung photons generated with BREMGE, $E_\gamma > 0.1$ GeV (A. Kowalewska)



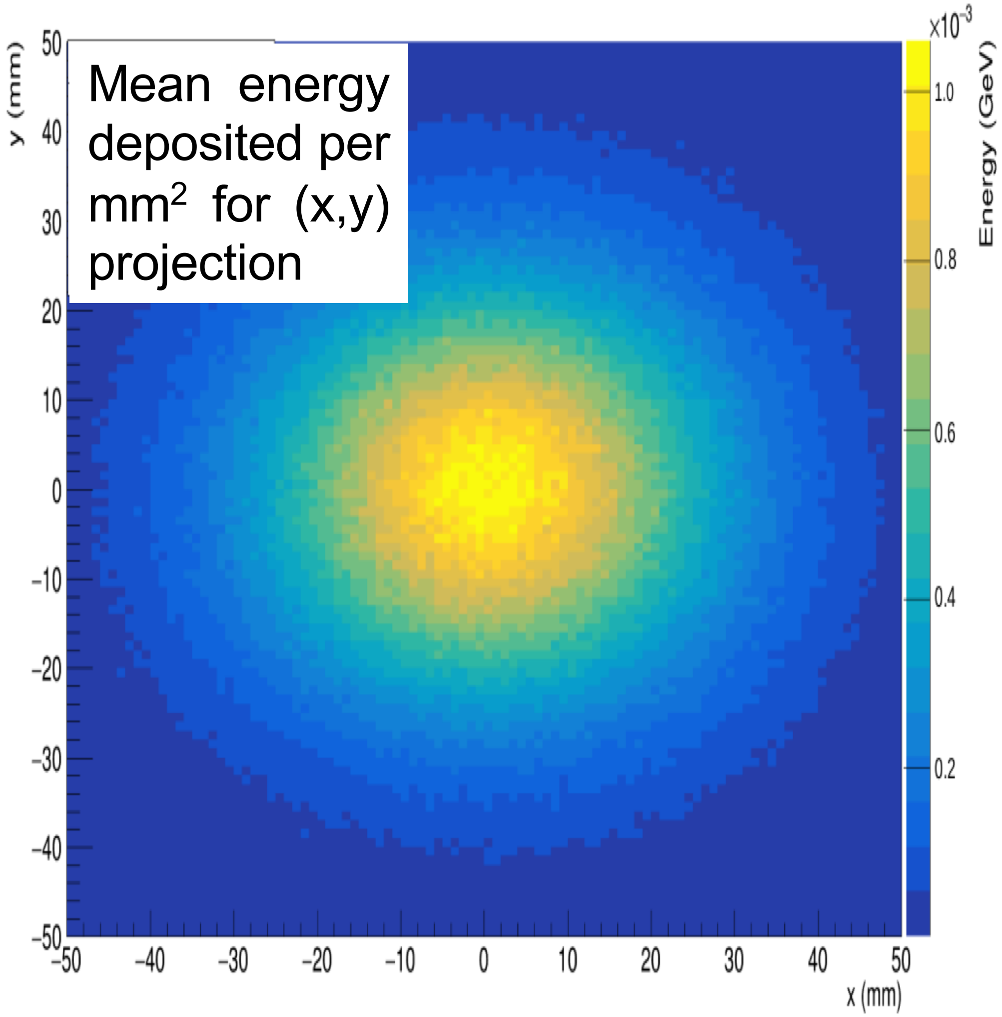
Simulations for $PbWO_4$

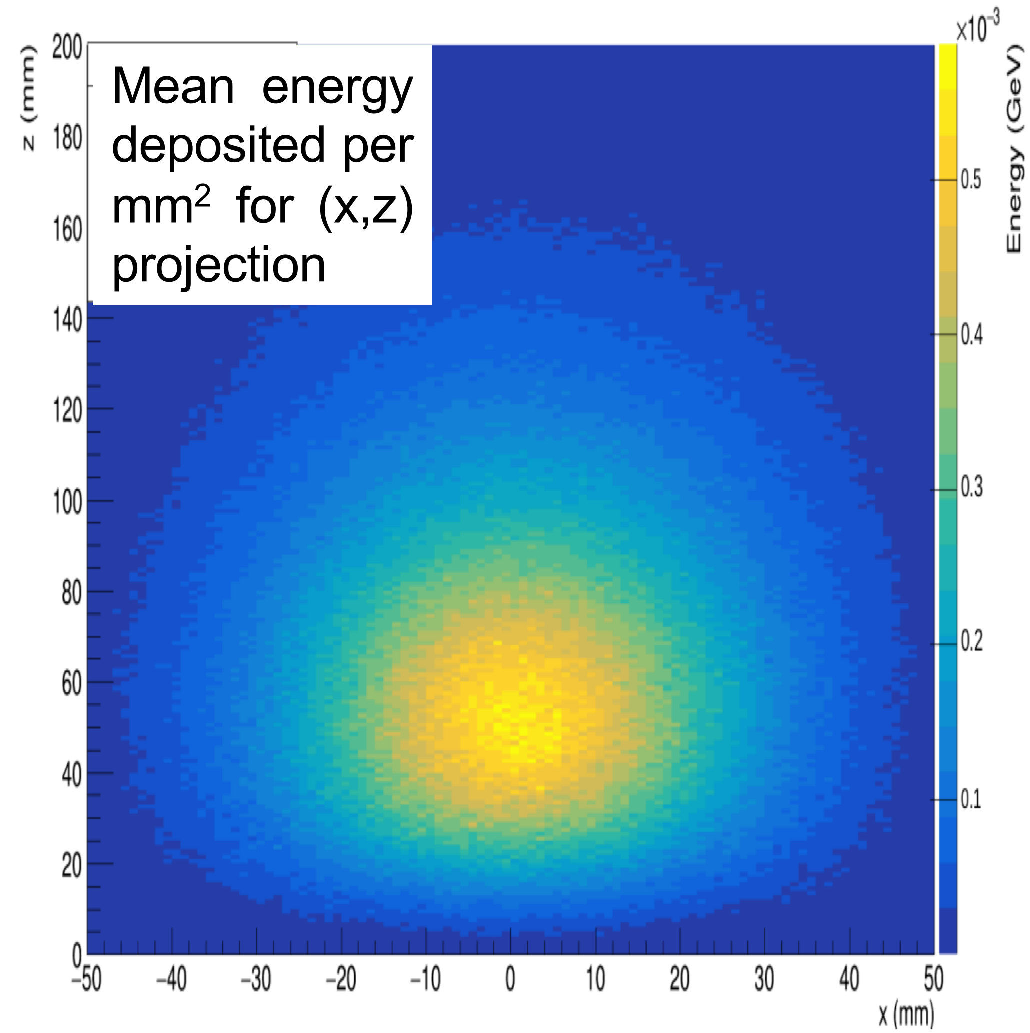




Absorbed doses for $PbWO_4$

10 GeV x 275 GeV





Y. Ali

Absorbed doses for $PbWO_4$

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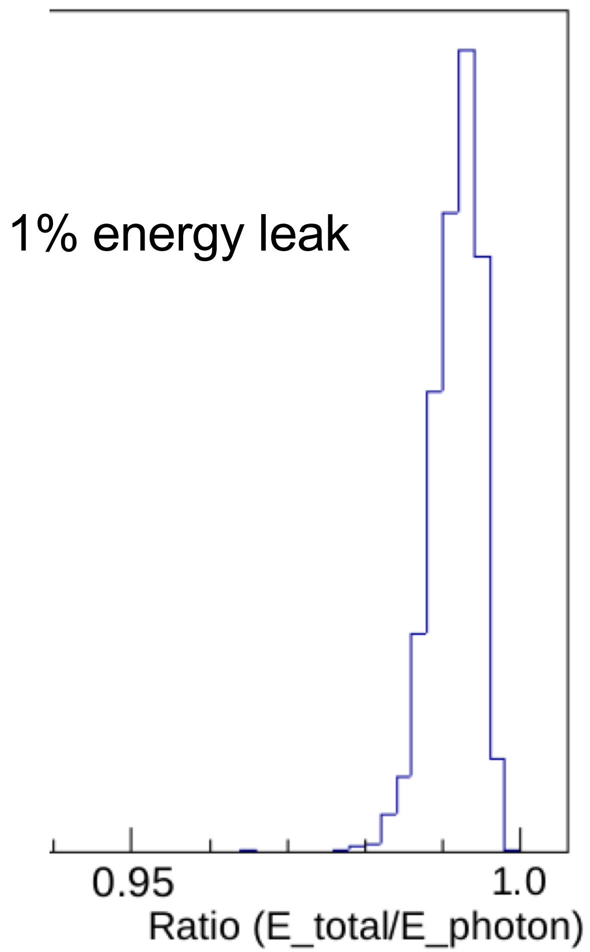


Mostly lateral energy leaks can be easily fixed by making a larger detector but the highest average density of deposited energy reaches **12 MeV/cm^3** per event which results in maximal absorbed dose of **550 Mrad** for 100 fb^{-1} of *ep* collisions

Conclusion: $PbWO_4$ is an option only for short calibration runs at (very) low luminosity – note the heat of about **0.6 W** generated inside the crystal, for *ep* collisions at 10^{34} cm^{-2}s^{-1}, and above **10 W** for *eAu*

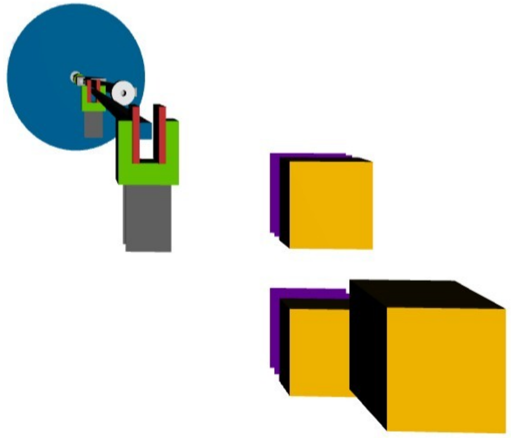
Fiber calorimeters

Base-line HRC detector choice:

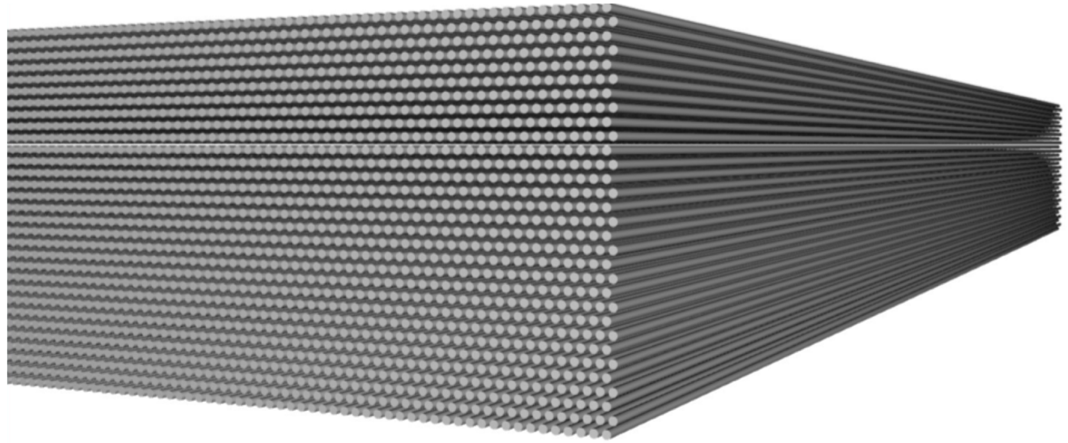
1. **Quartz fiber/tungsten spaghetti** calorimeter for energy flow – maximal **radiation hardness**

2. **Sci fiber/tungsten spaghetti** calorimeter for single photon measurements – maximal **energy resolution**

Similar situation for low-Q^2 ECALs



Underway: simulations of 12 cm x 12 cm x 24 cm (tilted) fiber calorimeters to study bremsstrahlung energy deposits for quartz and scintillator cases



Next steps

Simulate “honeycomb segmentation” with regular hexagon “fiber cells” of varying size:

- study fiber light outputs as a function of fiber type and size + cell size + *calorimeter tilt*

- optimize energy resolutions, including effects of the SR filters

- compare detector performances for different types of photosensors

10 degree