Update on crystal calorimetry
Integration of segmented crystal ECAL into IDEA concept

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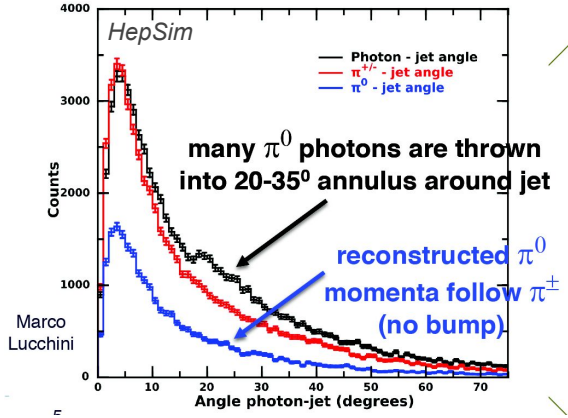
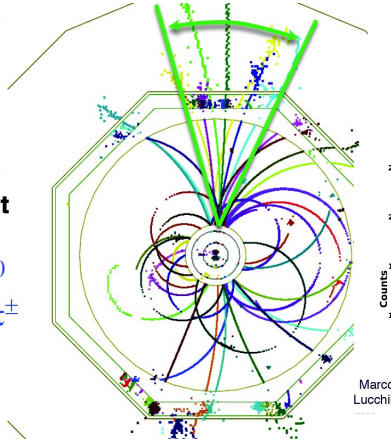
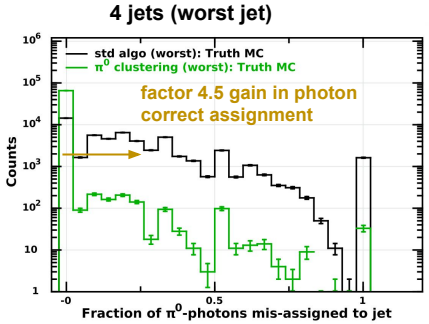
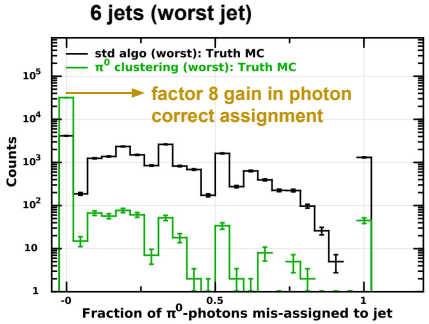
Crystal ECAL for enhanced PFA performance

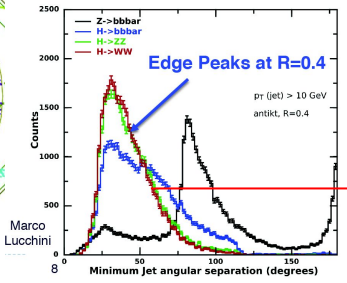
- **A high e.m. resolution ECAL enables efficient clustering of photons into π^0**
  - Jet clustering algorithms can then be fed with π^0's ,
    reducing the confusion term from photons scrambled among jets
- **Improvements in correct photon-to-jet assignment**
  enhance jet reconstruction,
  especially in 4 and 6 jet topologies







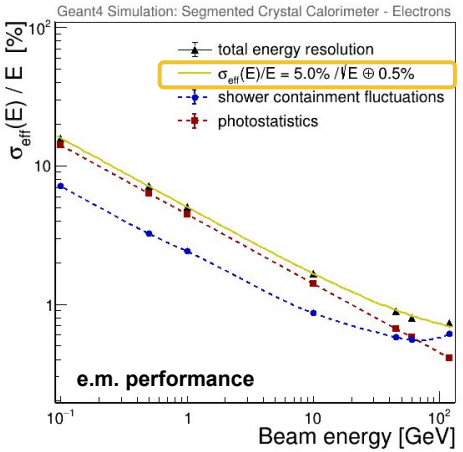




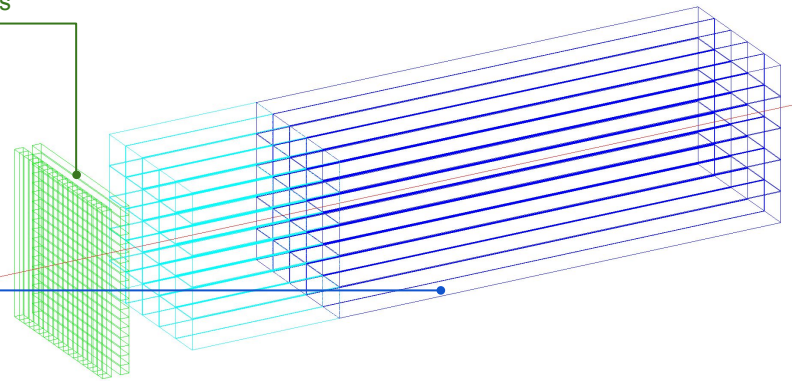
Roughly ⅓ of multi-jet (⅔ of) Higgs Physics impacted by low energy photon annulus

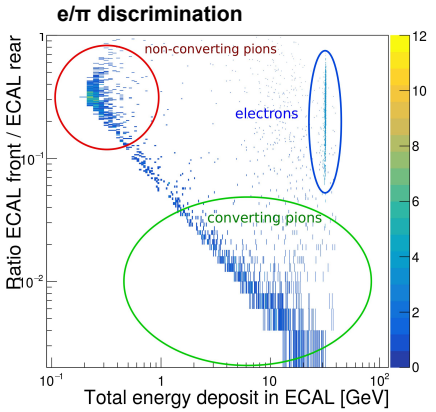
High precision segmented crystal ECAL

- ***SCEPCAL:***
  a **S**egmented **C**rystal **E**lectromagnetic **P**recision **C**alorimeter
- **Transverse and longitudinal segmentations** optimized for particle identification, shower separation and performance/cost
- Exploiting **SiPM readout** for contained cost and power budget



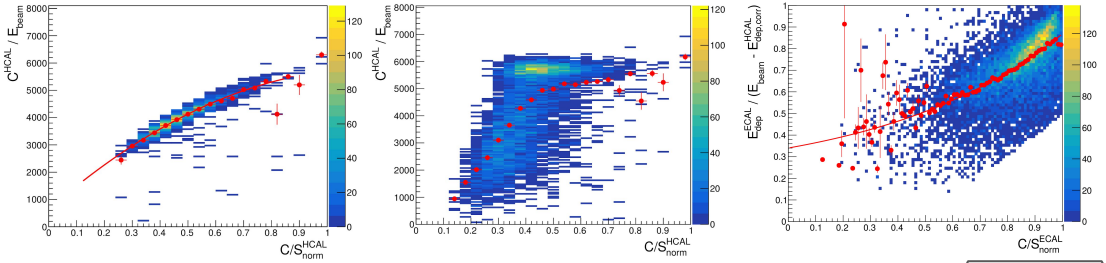
- **Timing layer** (σ_t < 30 ps)
  - LYSO:Ce crystals (~1X_0)
  - 3x3x54 mm³ active cell
  - 3x3 mm² SiPMs (15-20 um)
- **ECAL layer**
  - PbWO crystals
  - Front segment (~6X_0)
  - Rear segment (~16X_0)
  - 10x10x200 mm³ crystal
  - 5x5 mm² SiPMs (10-15 um)

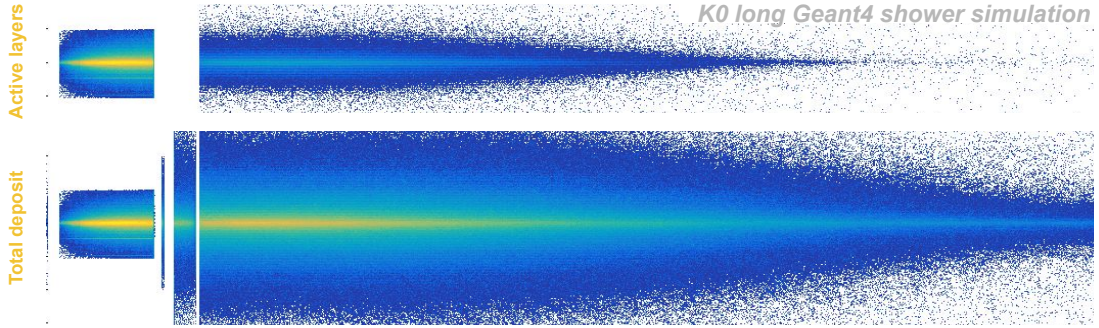




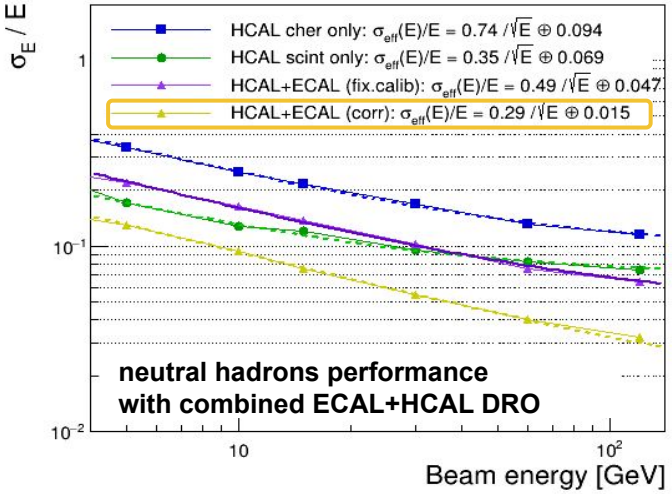
Exploring combined performance with a DRO HCAL

Calculate and apply **HCAL DRO correction** → Events with energy deposit in the ECAL require correction → Calculate and apply **ECAL DRO correction**





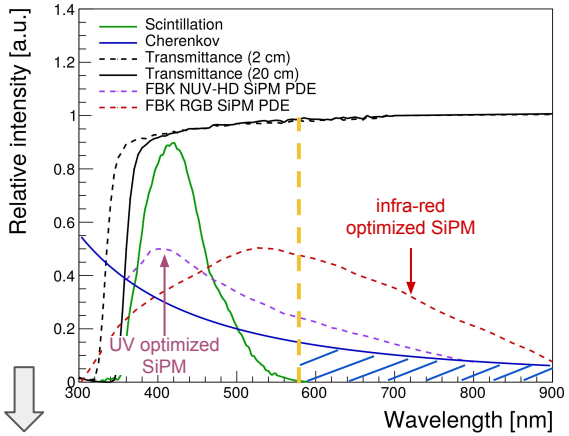
- Possibility of **integration with a dual readout HCAL**
- Excellent resolution for hadrons maintained: **~29%/√E ⊕ 1.5%**



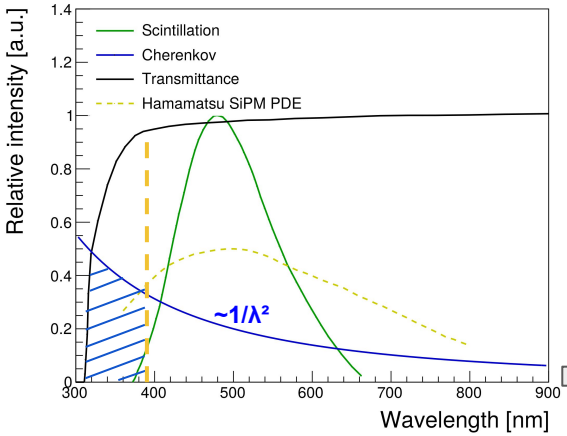
Optimization of dual readout with crystals

- In the last decade, **huge developments in photodetectors** extending sensitivity in both the UV and infrared region with Silicon Photomultipliers and increasing PDE
- At least two crystal candidates for a compact, cost-contained ECAL with DRO capabilities:
  - **PWO** (e.g. CMS) and **BGO** (e.g. L3)
  - **Crystal quality has improved** since then (e.g. ~2x increase in PWO-II light yield for PANDA ECAL)
  - Crystal segmentation increases light collection efficiency

PWO



BGO



Look at Cherenkov photons in either the UV (BGO) or infrared region (PWO) ***[ongoing simulation studies]***

~10% of signal from Cherenkov in CMS ECAL: increasing due to radiation damage that filters out the UV scintillation component!
N Akchurin et al 2008 J. Phys.: Conf. Ser.110 092034

Cherenkov signal detected and exploited for timing applications even for electrons from 511 keV ɣ-rays!
Stefan Gundacker et al., 2020 Phys. Med. Biol.65 025001

Open items, needs and plans

- **Demonstration and optimization of the dual readout crystal response**
  - Comparison of BGO and PWO
  - SiPMs with filters
  - “Dual SiPM” method (2 SiPMs with PDE peaking in different wavelength ranges)

- **Implementation of a segmented crystal geometry in full simulation**
  - Optimization of PFA algorithms for unequal longitudinal segmentation
  - Optimization of PFA for a high sampling fraction ECAL
  - Evaluation of the π^0 clustering approach impact on PFA jet reconstruction