ECAL-e NPOD studies

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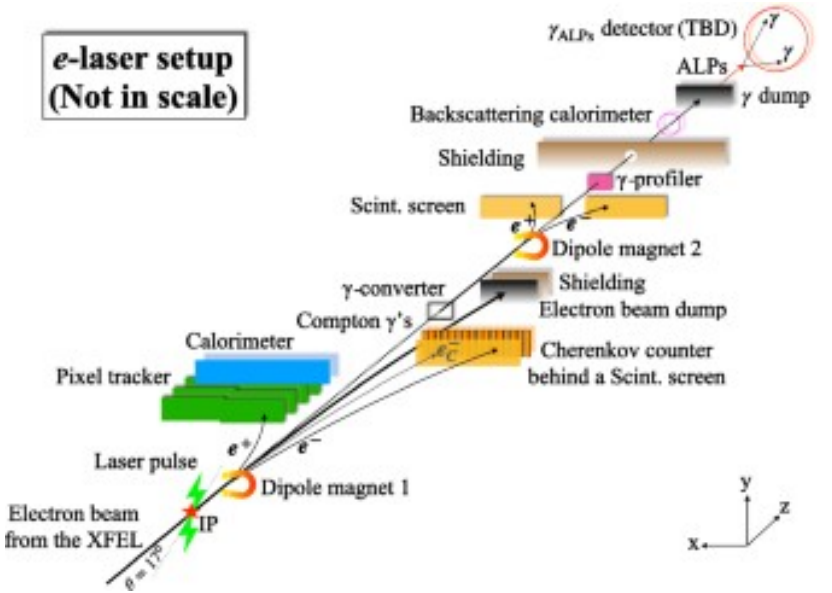
Plan de Recuperación, Transformación y Resiliencia

GENERALITAT VALENCIANA

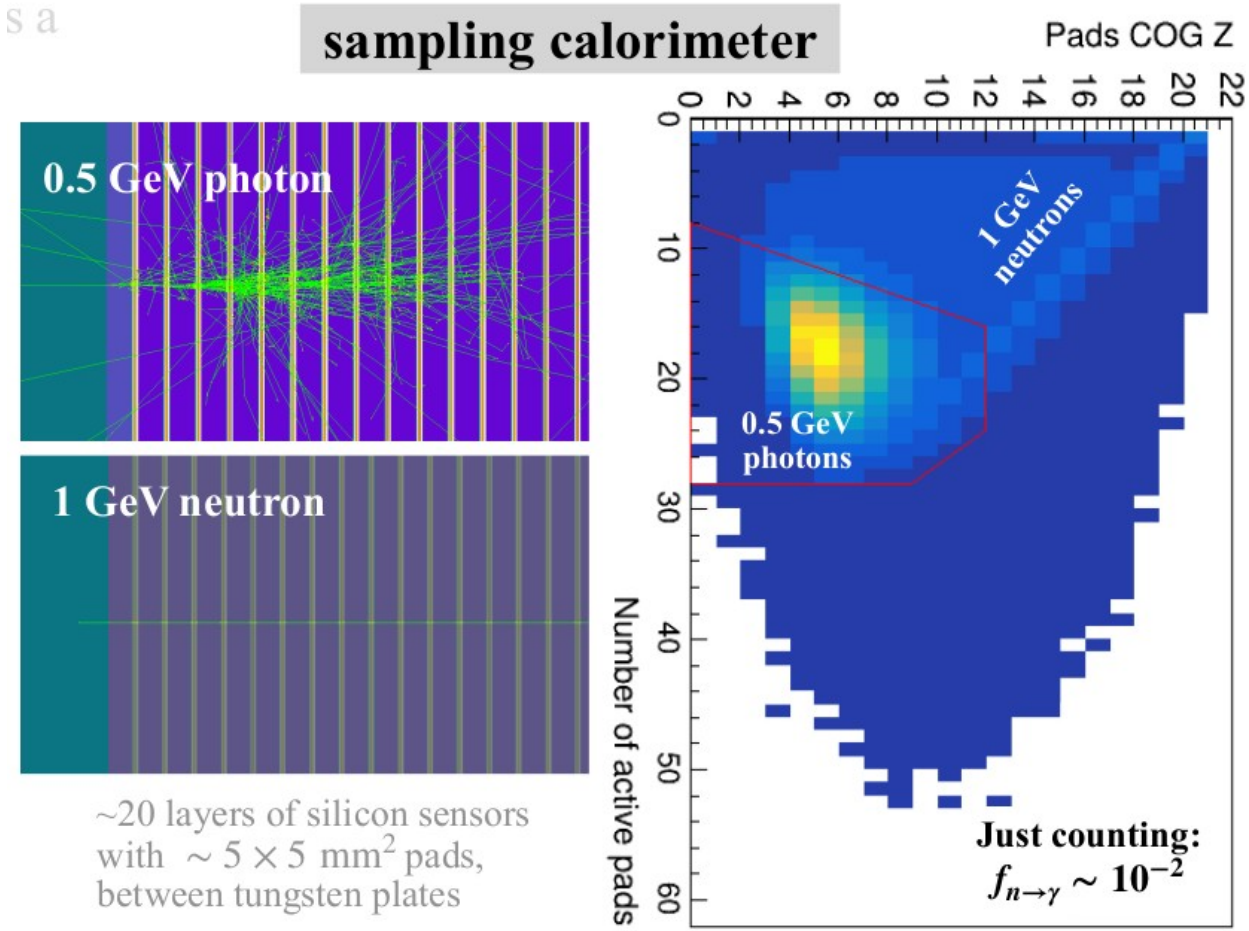
GVANEXT Fondos Next Generation en la Comunitat Valenciana

ECALe studies for using it as NPOD detector

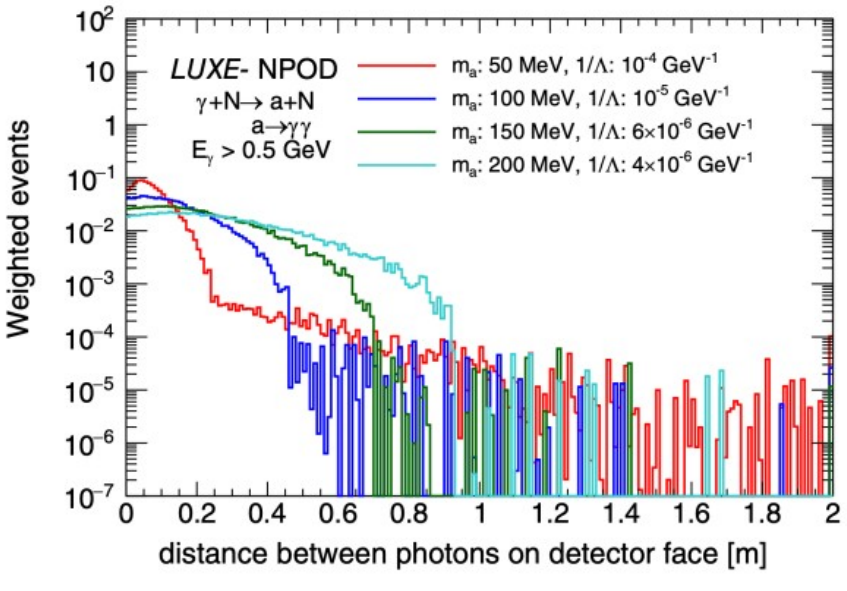
- The ECALe is not used during the e-laser mode… what about using it for NPOD?
- Idea first proposed during the Rehovot meeting in Nicolo's talk Q&A
  - First very raw draft of the idea done during the wine tasting that evening…
- The topic has been studied by KIT and they started optimizing the geometry. The goal is to include it in a LUXE-NPOD paper
  - More detailed studies on basic detector performance are needed
  - Hence: we (IFIC) started working on the topic this summer, together with KIT



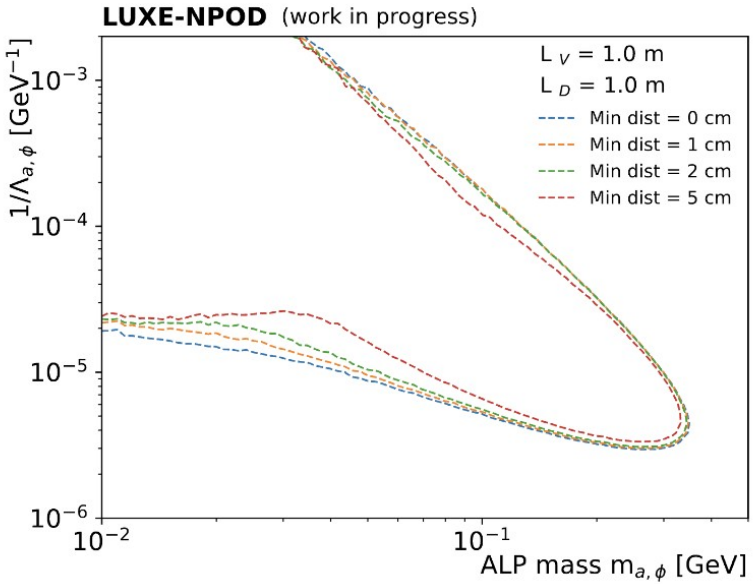
Challenge: bkg rejection

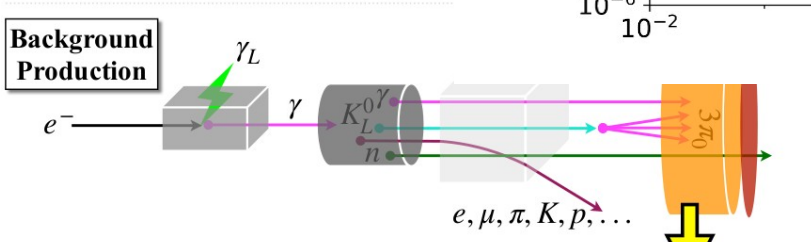


Challenge: 2 photon reconstruction



NPOD signal – phase 1 (350TW)





- $E_\gamma > 0.5$ GeV
- $\sigma_t \sim \mathcal{O}(100$ ps$)$
- $\sigma_r \sim \mathcal{O}(100\ \mu$m$)$
- $\sigma_\theta \sim \mathcal{O}(10$ mrad$)$

Can it be bkg-free?

IFIC involvement

KIT, Weizmann, DESY

- Are working on the NPOD design (beamline, dump, overall geometries and overal detector requirements)
- The ECALe is one of the proposed solutions → with extended geometry in “X”.
- **IFIC role:** Missing studies, what are the basic performance key numbers of such calorimeter with the “NPOD” geometry ?

Started in August-September

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Newly created repositories and framework for studies

- Study based on ILCSoft – LCIO tools (and DD4SIM)
  - à la CALICE (which is what I- Adrian - know best... so we can have quick results) – but it will be also very similar to the final LUXE software framework
- ECAL-lcio https://github.com/airqui/ECALe-lcio

Started in August-September

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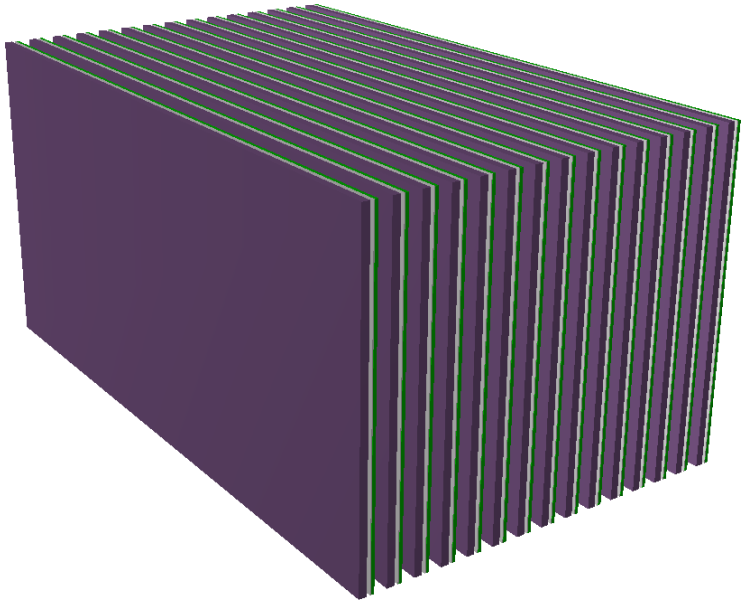
ECAL-lcio https://github.com/airqui/ECALe-lcio

- Generation
  - Using ddsim (DD4HEP).
  - Generating realistic sensors with dead areas was very challenging... I decided to simulate full detector size sensors (36x18cm^2) and pixelize them in a later stage
  - 4.2mm W + CF + readout module with Si.



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</layer>
```

Started in August-September

ECAL-lcio https://github.com/airqui/ECALe-lcio

- Pixelization
  - 500um thick Hammatsu sensors including 10um gap between pads and the 300um gap in the edges of the gap.

Started in August-September

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ECAL-lcio https://github.com/airqui/ECALe-lcio

- Digitization+MIPcalibration
  - MIP calculation using muons.
- Not totally dummy digitization using:
  - 1/10 on the MIP S/N for the charge measurement
  - 1/5 on the MIP S/N on the self trigger measurement
  - Cut on 0.5MIP

Started in August-September

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ECAL-lcio https://github.com/airqui/ECALe-lcio

- Clustering
  - Started to look at Arbor (discussions and help from Manqi Ruan) but still not a working version for us https://github.com/airqui/ECALe-Arbor → postponed effort ?
- Using the NearestNeightbourg approach
  - From MarlinReco software, tuned and adapted to us.
- Analysis
  - https://github.com/almanzam218/ECAL_Sim_Analysis
  - Done: MIP calculation, Energy Resolution, Linearity,
  - WIP: clustering and two-Photon separation (Shan), background rejection (Melissa & Jesús)

Energy Resolution / Linearity

Estimated with gun electrons.

Different “classical” (no ML) clustering techniques being used and optimized:

~~- ARBOR (ParticleFlow) Not trivial to optimize~~ (still not fully understood)

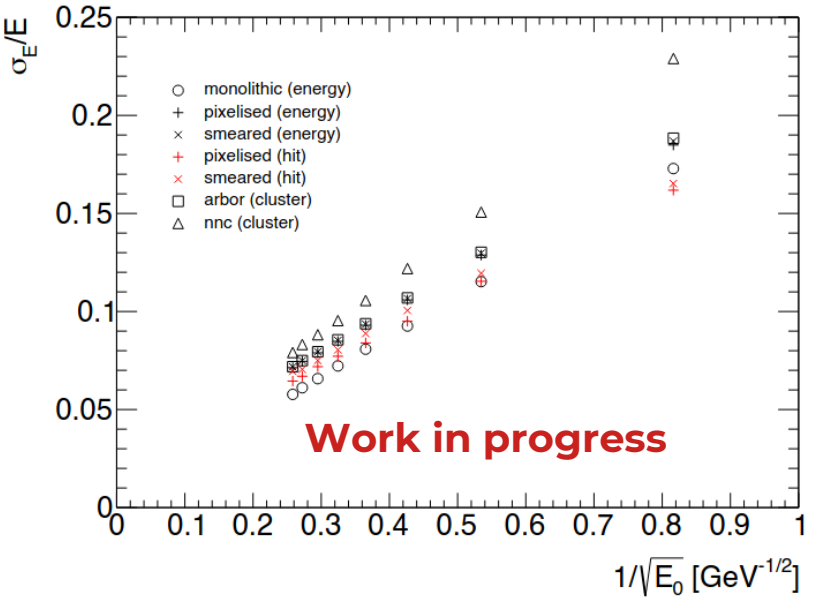
- NNC – Near Neighbour Clustering

Energy Resolution / Linearity

Isolated simulation of ECAL-E in ddsim

Single particle:

- Gun positioned at (z) 1000 mm away from the front
- Transverse distribution (x/y) with sigma of 20 mm



Clustering of two photons – reconstruction of ALP decay vertex

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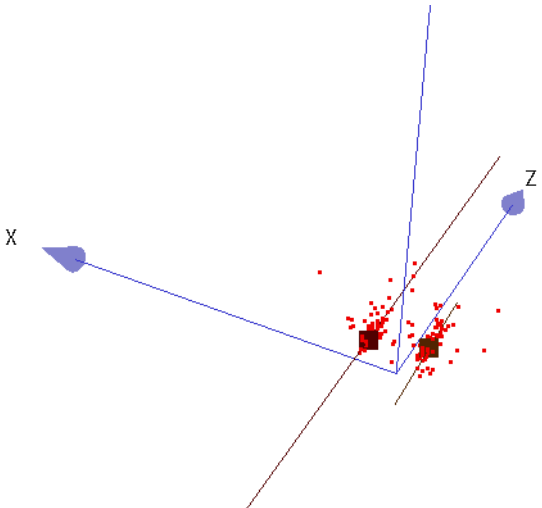
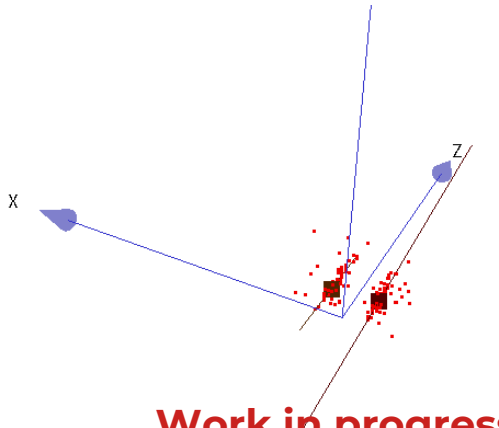
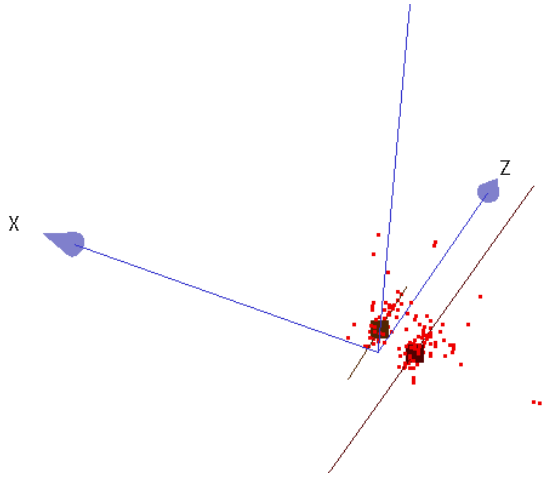
- First look at Two Photon simulations (single photon files with event-basis merging)
- We optimized the NNC and it looks promising for the two photon reconstruction
  - Two photons separated 70\pm 30mm in the entry point
  - Efficiency of clsutering (i.e. ==2 clusters) >98%





Work in progress



Particle Identification studies

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- For the NPOD, it is required an effective neutron (bkg) – gamma separation.
- Code adapted to create training ntuples from our simulation.
- PID working with 3 categories.
- Produced samples:
  - 0.5-10GeV single photons
  - 0.5-10GeV single neutrons
  - 0.5-10GeV single pi-
- Training about to start.

Figures of merit

- Photon vs n/pi- ID efficiency / purity (to be produced)
- Energy resolution (single particle)
- Pointing resolution? What is the exact definition? For what energy ?
- Minimum distance (front panel of the ECAL) for separation of two photons? At what energy? Angle?

- Still working on a full understanding of what are the expectations / assumptions / hopes for these numbers.

Short + medium term plans

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- Work in progress (see Melissa's and Shan's talks)
- Discussion in the SAS meeting (30th Sept ?)
- Basic ECALe performance figure of merits to be used in the NPOD paper lead by KIT ?

- Future plans, Optimization of detector layout. My intuition says that the ECALe is not compact enough… and not granular enough!
  - Timing was not discussed here…
  - Repeat all the analysis with a ECALp-like geometry (i.e. smaller moliere radius)
  - And optimize the ECALe layout (tungsten repartition etc)
  - Pad size ? What about a digital solution, à la CALICE or even à la CMOS… ?
  - Shan & Melissa!

- At the simulation level we can imagine a more ideal detector!…. And maybe use this for future proposals!

extra