R&D of Dark SHINE LYSO Crystal ECAL

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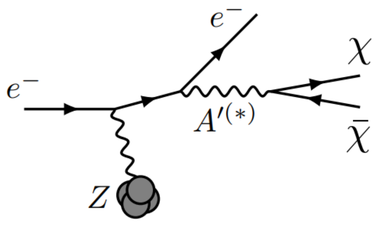
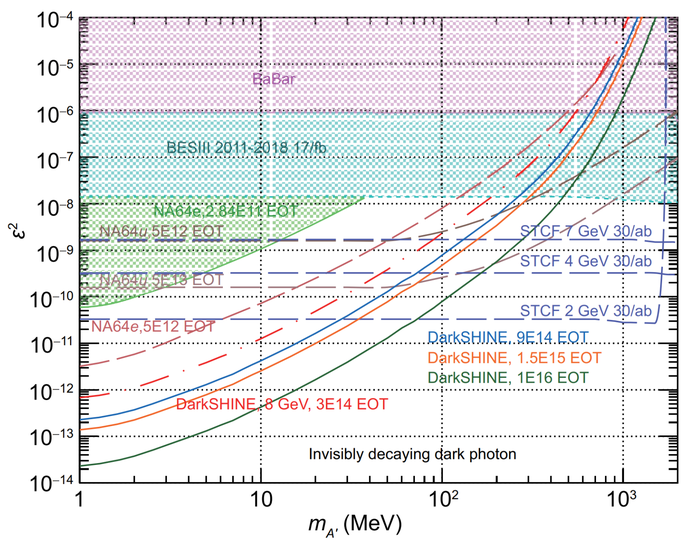
Introduction

A large amount of astronomical observations has strongly indicated the existence of dark matter. New physics theories beyond the Standard Model predict candidate particles for DM, with the "Dark Photon" being a prominent candidate.

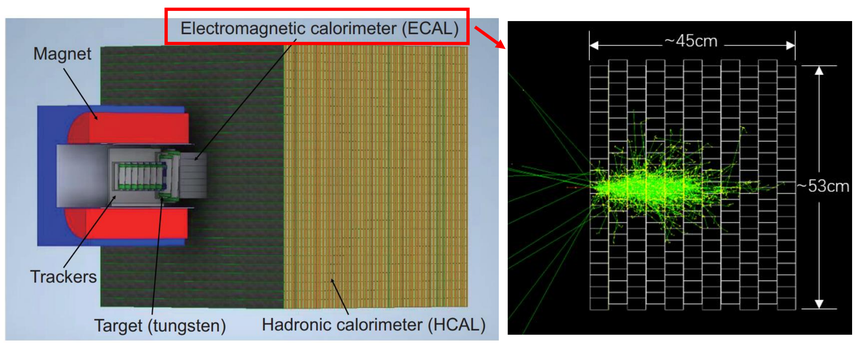
Dark SHINE is an experiment designed to detect the decay of dark photons into invisible light-mass DM particles (LDM). It relies on the Shanghai Hard X-ray Free Electron Laser (SHINE) facility, which is expected to employ an 8 GeV high-frequency single electron beam to collide with a target. By measuring the energy loss of recoiled electrons, DarkSHINE detector has excellent sensitivity for detecting dark photons with mass in MeV range.





LYSO Crystal ECAL for Dark SHINE

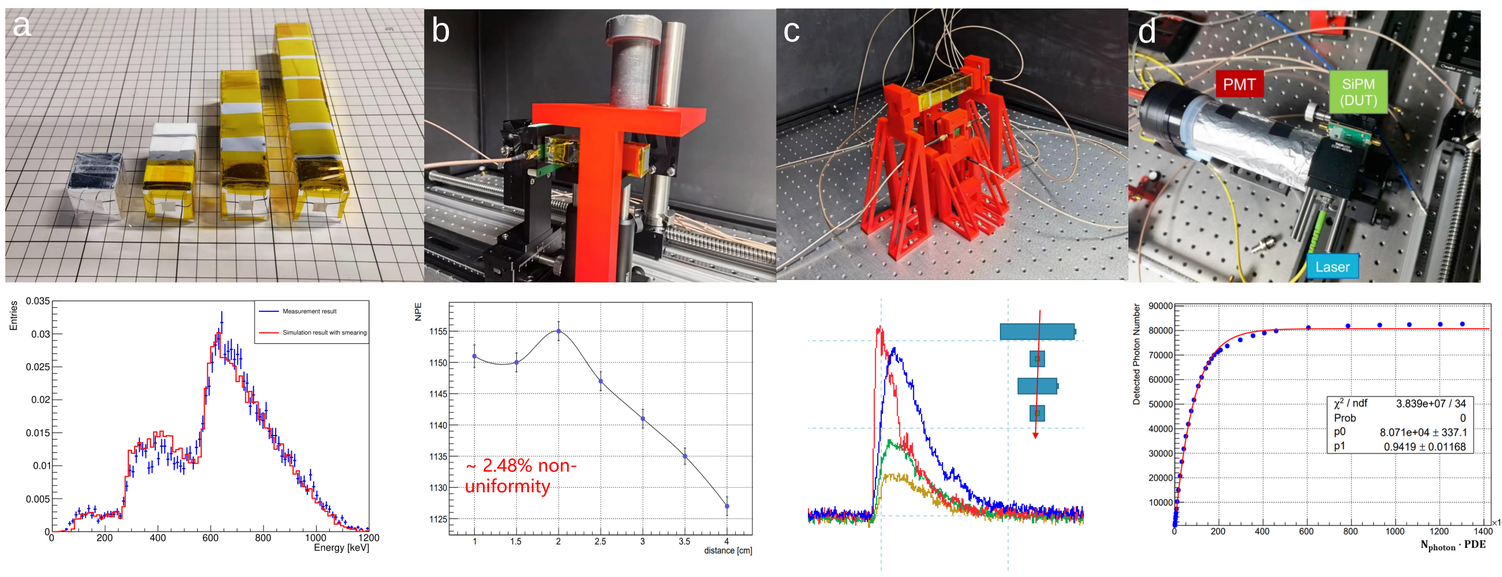
The ECAL in Dark SHINE is to precisely measure the energy of recoil electrons. Due to the high-frequency electron beams, the central region of the detector faces a significant level of radiation damage and pileup. And ECAL should also be large enough to contain all of the EM components. We have a homogenous LYSO crystal ECAL design which has excellent energy resolution, high radiation hardness, fast light decay time and high density.



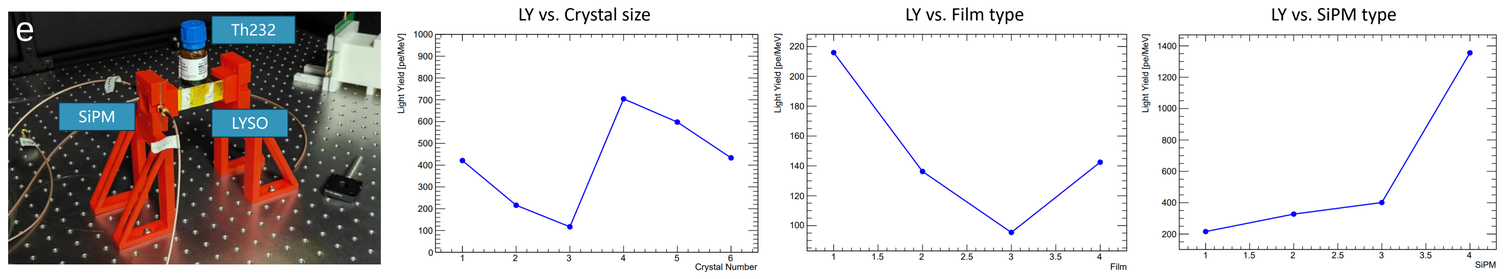
Key requirements
- ☐ Radiation hardness: $\sim 10^{13}\ n_{eq}$
- ☐ Large radiation length
- ☐ Fast signal

Unit Tests in Lab

Experiments based on LYSO and SiPM to research their properties.



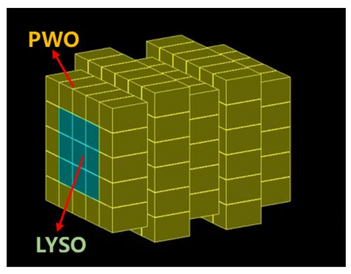
a. LYSO intrinsic radiation from $^{176}_{71}Lu \rightarrow {}^{176}_{72}Hf$
b. Uniformity test with $^{60}_{27}Co$ source
c. Cosmic ray test
d. SiPM dynamic range test

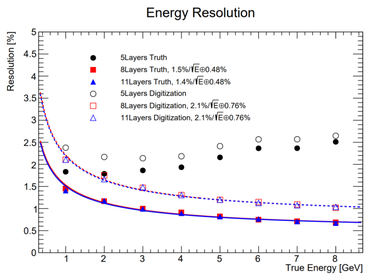


e. Light yield changed with crystal size, reflective film type and SiPM type

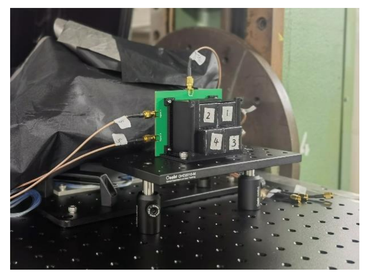
Crystal Module for Beamtest

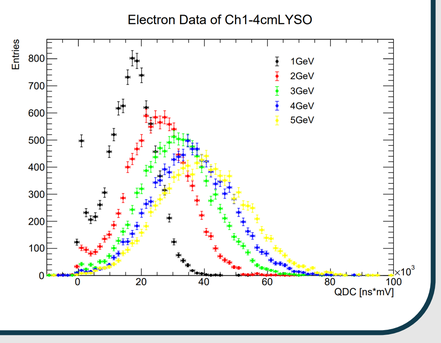
LYSO crystal module for beamtest
- $2.5 \times 2.5 \times 4cm^3$ LYSO&PWO
- Core: LYSO, good radiation hardness
- Outer: PWO, economical, high density





Beamtest of a 4-channel LYSO unit at DESY
- 1~5GeV electron beam
- $2.5 \times 2.5 \times 4/5cm^3$ LYSO
- HAMAMATSU S14160-3010PS





Summary & Prospect

- ➢ The LYSO crystal ECAL in Dark SHINE has a very good energy resolution, high radiation hardness, fast decay time and large radiation length. But radiation-resistant SiPMs are needed.
- ➢ We have performed many measurements for crystals and SiPMs. The light yield for one unit can be about 100~1400 pe/MeV with different couplings. The crystal response uniformity is good. And we also measured the dynamic range of SiPMs with large pixel densities.
- ➢ A LYSO/PWO hybrid crystal module is proposed for system performance validation. And we just performed a 4-channel LYSO unit beamtest at DESY.

Reference

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