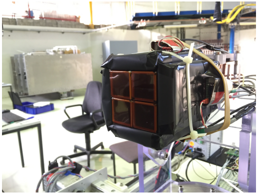
LYSO Crystal Testing for an EDM Polarimeter

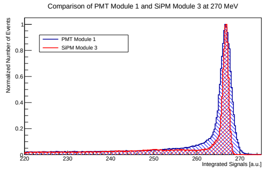
for the JEDI Collaboration | CALOR 16

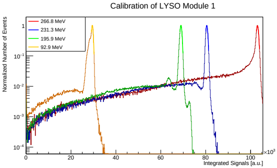
May 17, 2016 | Fabian Müller | IKP-2

Outline

- Introduction
- Experimental Setup
- Data Analysis
- Results
- Summary / Outlook

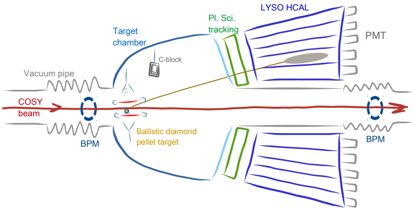




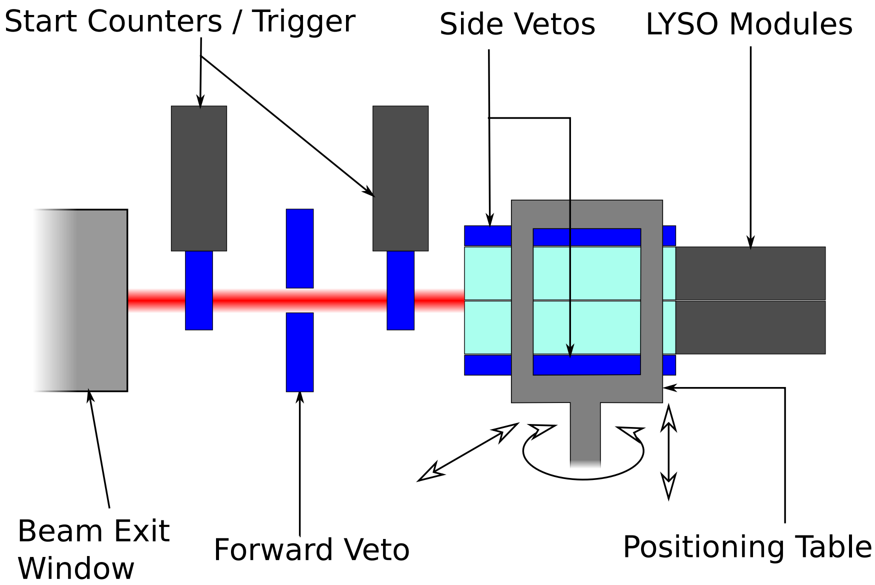


Introduction

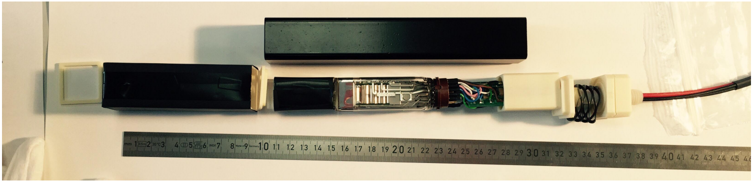
- External beam at the COSY accelerator facility in Jülich, Germany.
- LYSO crystals from two different manufacturer.
- PMT and Silicon PhotoMultiplier (SiPM).
- Deuteron beam (100MeV, 150MeV, 200MeV, 235MeV and 270MeV).
- Struck 14 bit, 250 MS/s Flash ADC.



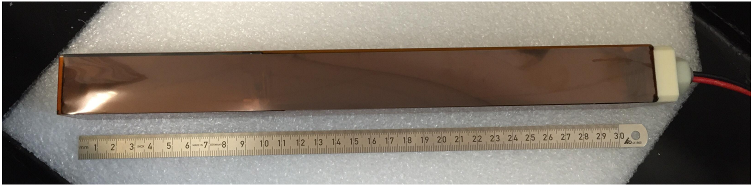
Model of the full EDM polarimeter built from LYSO detector modules.



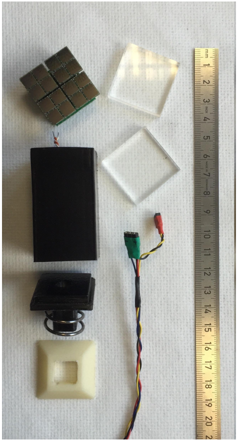
Start Counters / Trigger
Side Vetos
LYSO Modules
Beam Exit Window
Forward Veto
Positioning Table



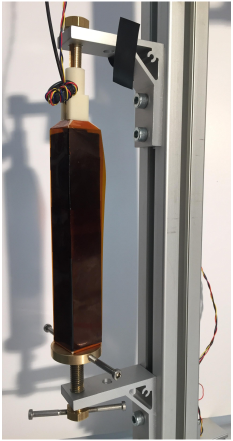
Open PMT module: Wrapped LYSO crystal, lightguide glued to dual channel PMT (Hamamatsu R1548-07), high voltage divider and 3D-printed tensioning device.



Finalized PMT module: PMT, lightguide and high voltage divider are inserted in a steel housing. Everything is tensed together by capton strips.

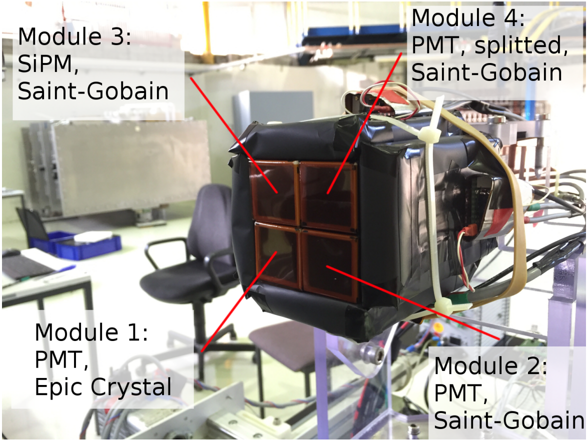


Open SiPM module without LYSO crystal: 4x4, 6mm SiPM array (SensL C-Series), 3D-printed ABS housing and tensioning device.



Closed SiPM Module: This module is clamped in the mounting device to apply a force to the tension spring.

Experimental Setup
Experiment

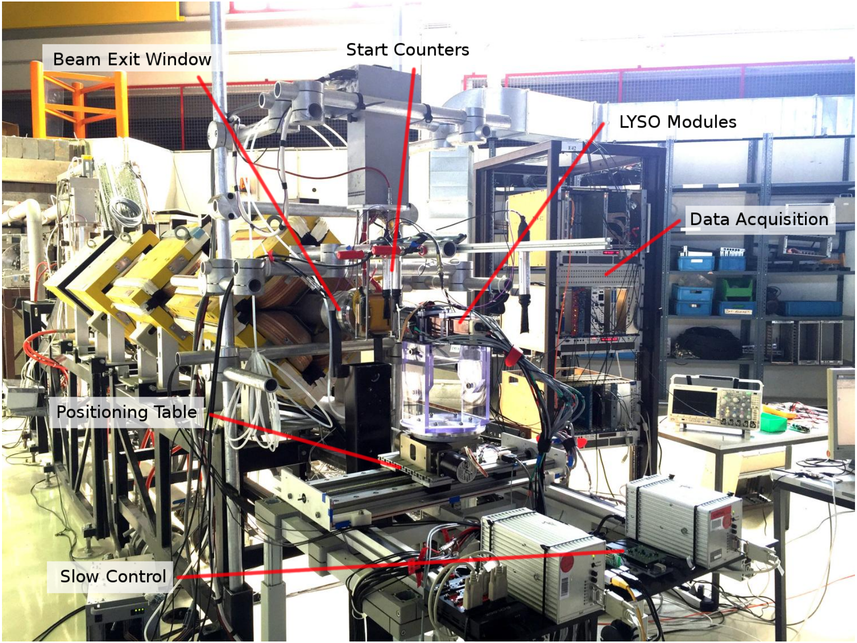


Manufacturer	Amount	Dimension [mm]	Module
Saint-Gobain	2	30 x 30 x 100	2 + 3
Saint-Gobain	2	15 x 30 x 100	4 (4.1 + 4.2)
Epic Crystal	1	30 x 30 x 100	1

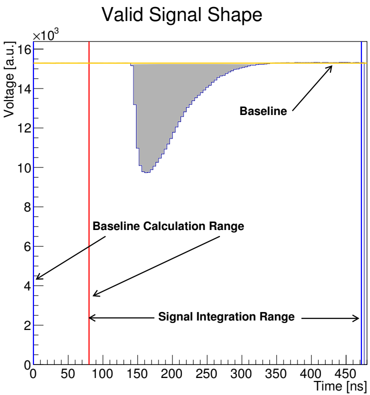
Overview of the LYSO crystals used in this experiment.

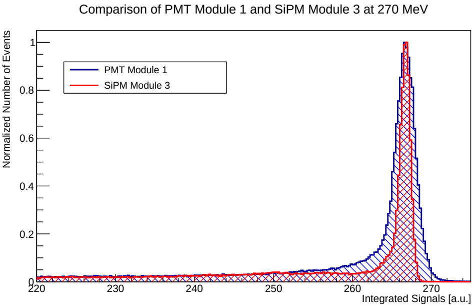
Experimental Setup

Experiment



Data Analysis
Typical Spectra

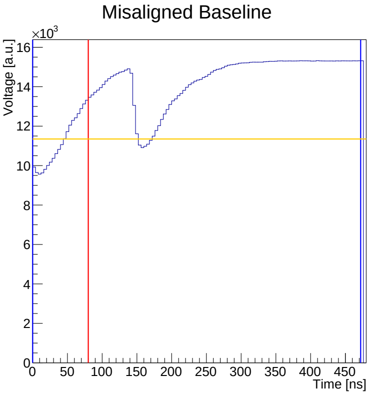


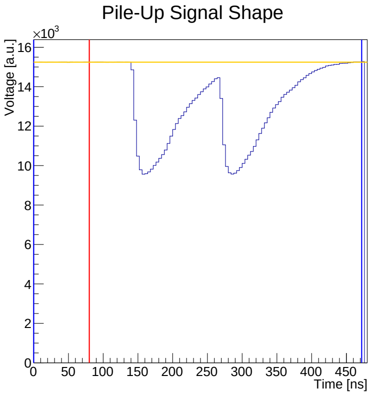


- Baseline = $\langle$*Baseline Calculation Range*$\rangle$
- $E_{dep} \sim$ Shaded Area

- The integrated signals have been used to create spectra for the individual modules.
- These spectra show the energy distribution of the registered particle.

Data Analysis
Cuts





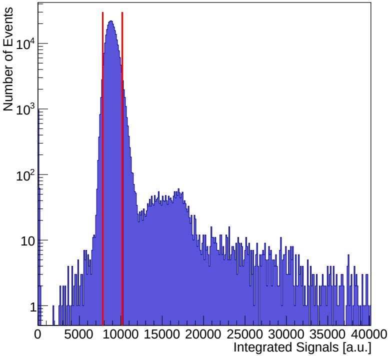
- Calculate χ^2 in the *Baseline Calculation Range* to exclude events with a misaligned baseline

- Count peaks to exclude pile-up events

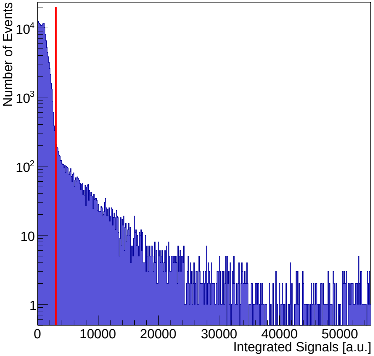
Data Analysis

Cuts

Cut on Start Counters



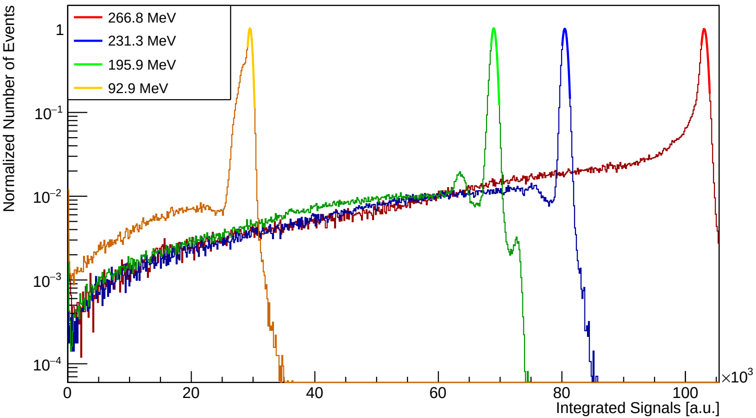
Cut on Side-Vetos



- Cut on the spectra of the start counters in order to exclude events with *head on* pile-up
- Cut on the spectra of the side vetos to exclude break-up events where a particle escaped the LYSO crystal

Results
Calibration

Calibration of LYSO Module 1

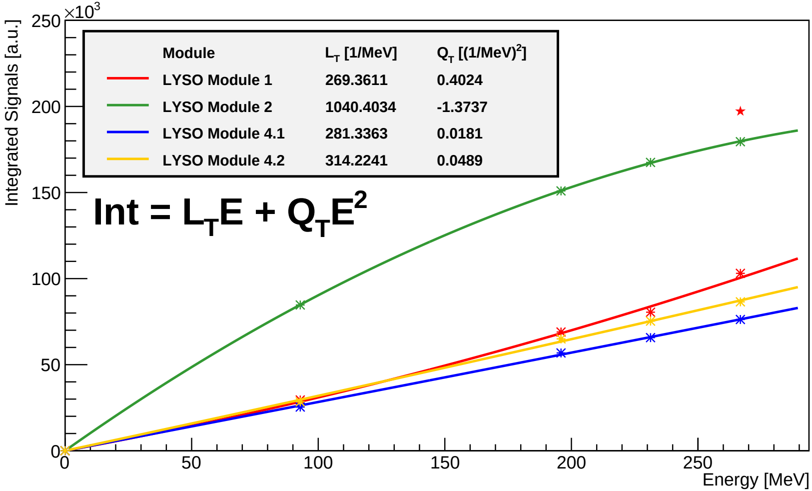


Beam Energy [MeV]	Effective Beam Energy [MeV]
100	92.90
200	195.90
235	231.26
270	266.75

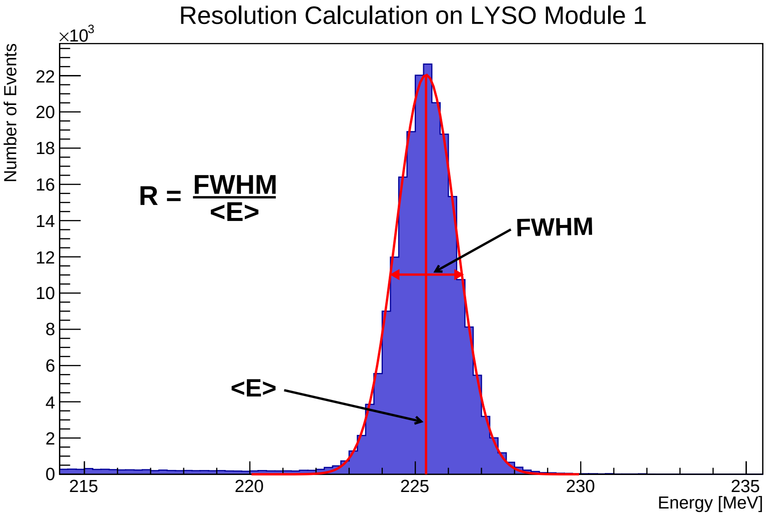
Effective beam energy due to energy losses in the beam path. Taken from a GEANT4 simulation.

Results
Calibration

Calibration of LYSO Modules



The red star denotes the data from the SiPM module 3.



Resolution Calculation on LYSO Module 1
×10^3
Number of Events
22
20
18
16
14
12
10
8
6
4
2
0
215
220
225
230
235
Energy [MeV]
R = FWHM / <E>
FWHM
<E>

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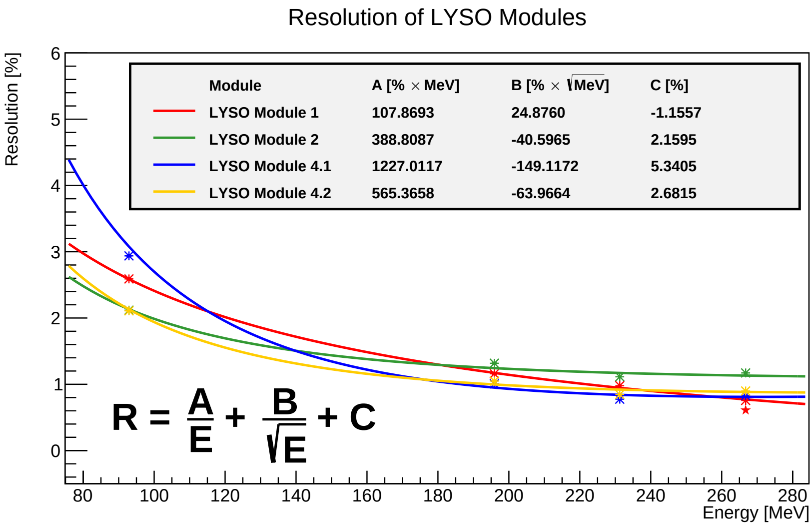

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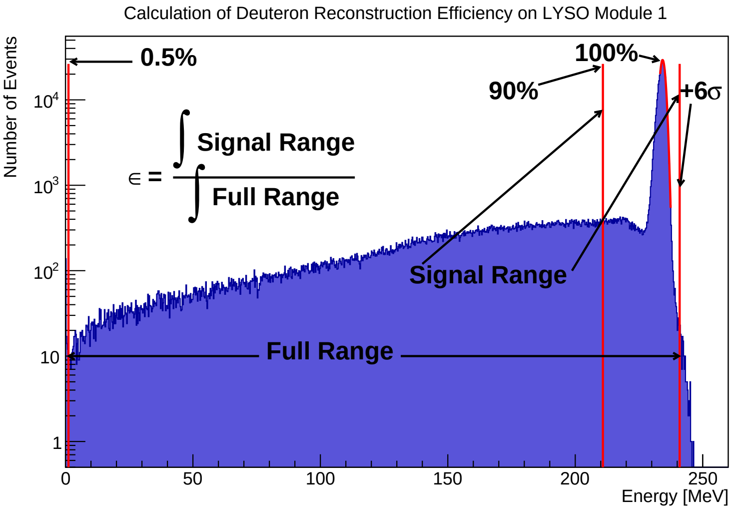
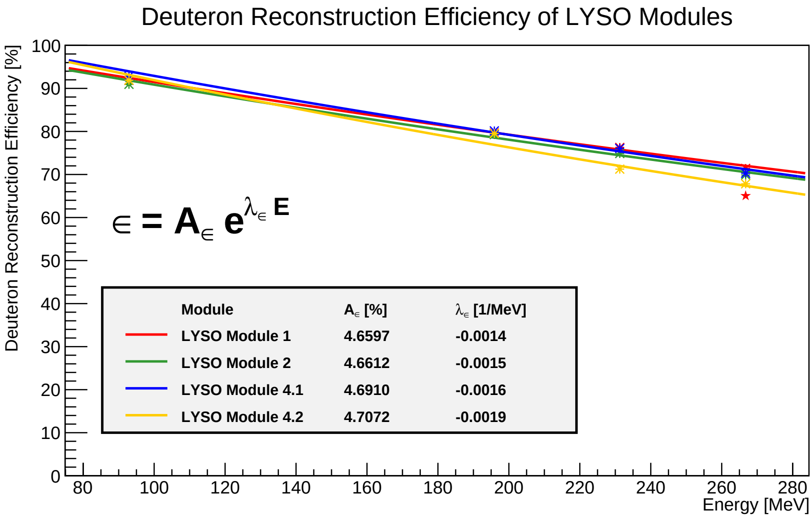


Calculation of Deuteron Reconstruction Efficiency on LYSO Module 1
Number of Events
Energy [MeV]
0.5%
100%
90%
+6σ
∈ = ∫ Signal Range / ∫ Full Range
Signal Range
Full Range

Results

d-Reconstruction Efficiency



The red star denotes the data from the SiPM module 3.

Summary

- A deuteron beam with five different energies up to 270MeV was used to examine the LYSO modules.
- The energy calibration of the modules was well described by a second order polynomial with a small quadratic term.
- The resolution of the LYSO modules lies below 3% for all tested energies and below 1% for the target energy of 270MeV.
- A deuteron reconstruction efficiency over 65% have been achieved in the whole energy spectrum.
- The SiPM readout promises good results without the need for an active amplification circuit and high voltage.
- All test will be repeated with a more sophisticated experimental setup, new generation of SiPMs and a larger number of LYSO crystals.