

Development of LYSO Detector Modules for an EDM Polarimeter at COSY for the JEDI Collaboration

February 28, 2018 – DPG Spring Meeting

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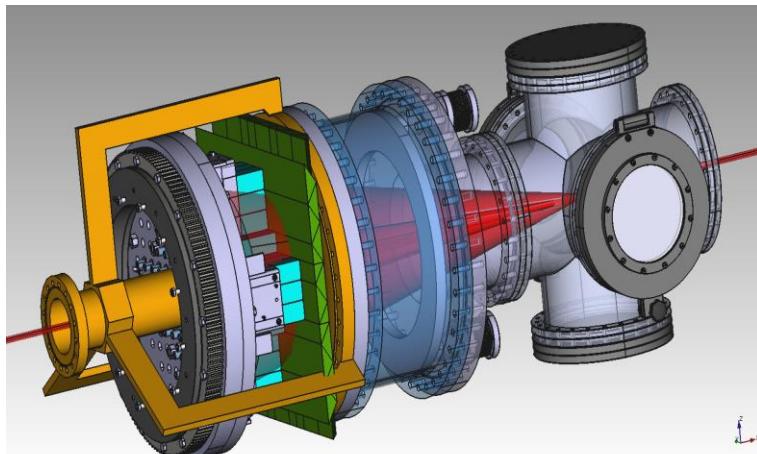
Supv: Dr. David Mchedlishvili @ TSU; Dr. Irakli Keshelashvili @ FZJ

Talk overview

- Objective
- LYSO Module Assembling
- Module Inspection and Tuning in the Lab
- Energy Resolution & Linearity Tests
- HV Power Supply
- Summary & Outlook



Latest concept of the JEDI* Polarimeter

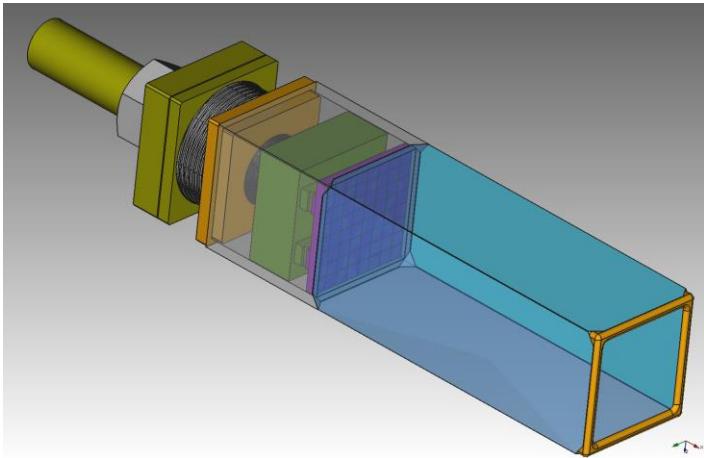


* JEDI – Juelich Electric Dipole moment Investigation

LYSO Modules Assembling



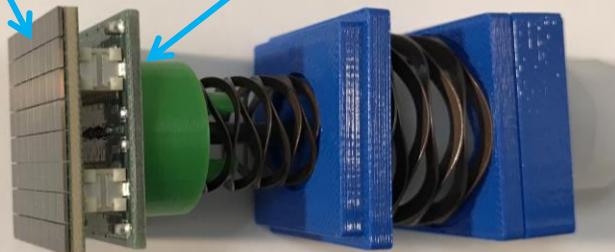
3D drawing of the module



Aluminum Housing

SiPMs, 20 μm pixel, 8x8 array
of 3x3 mm (SensL J – series)
64x14K ~ 900K pixel

SiPM connector
with bypass caps



Kapton tape



LYSO Modules Assembling



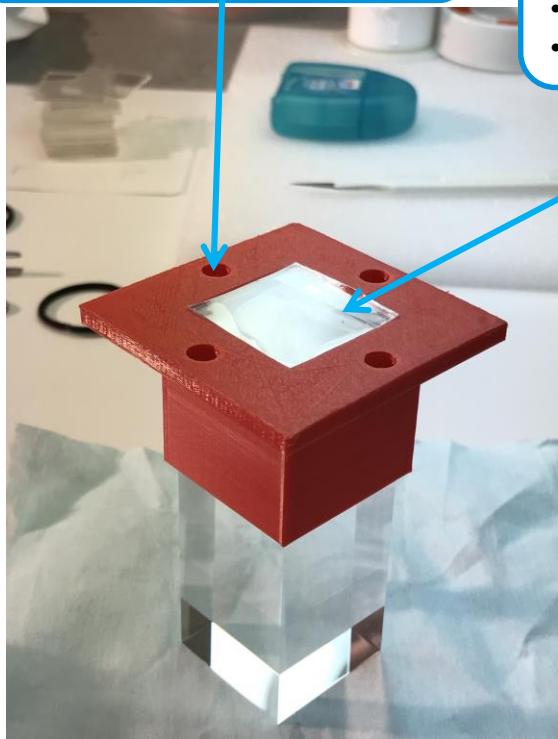
Two layers of foils:

- I - Four different inner layers (reflector)
- II - Tedlar (outer) foil (light tightness)



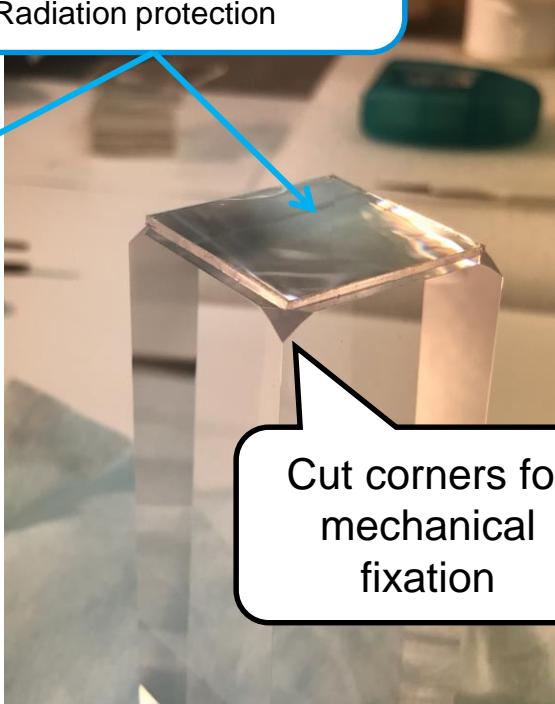
1. Teflon – 50 µm
2. Tyvek ~ 100 µm
3. Smooth Mylar - 25 µm
4. Wrinkled Mylar - 25 µm

3D printed plastic for centering silicon



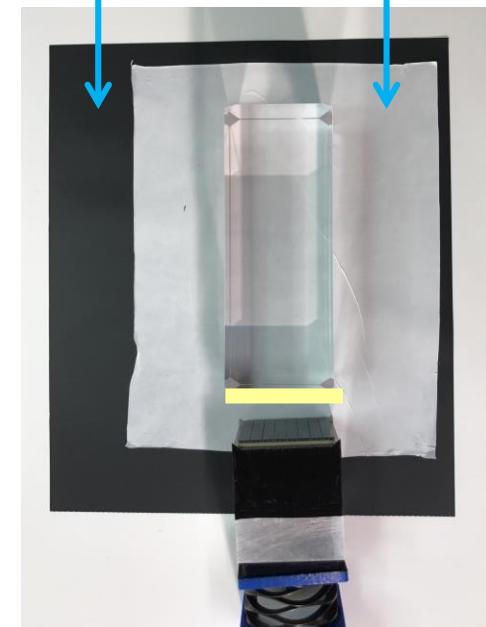
Silicon layer

- Optical coupling
- Mechanical stability
- Radiation protection



Tedlar 50 µm

Teflon



LYSO Modules Assembling

3rd hand during assembling



Ready for test



SiPM array



2 x 50 µm Teflon

2 x 50 µm Tedlar

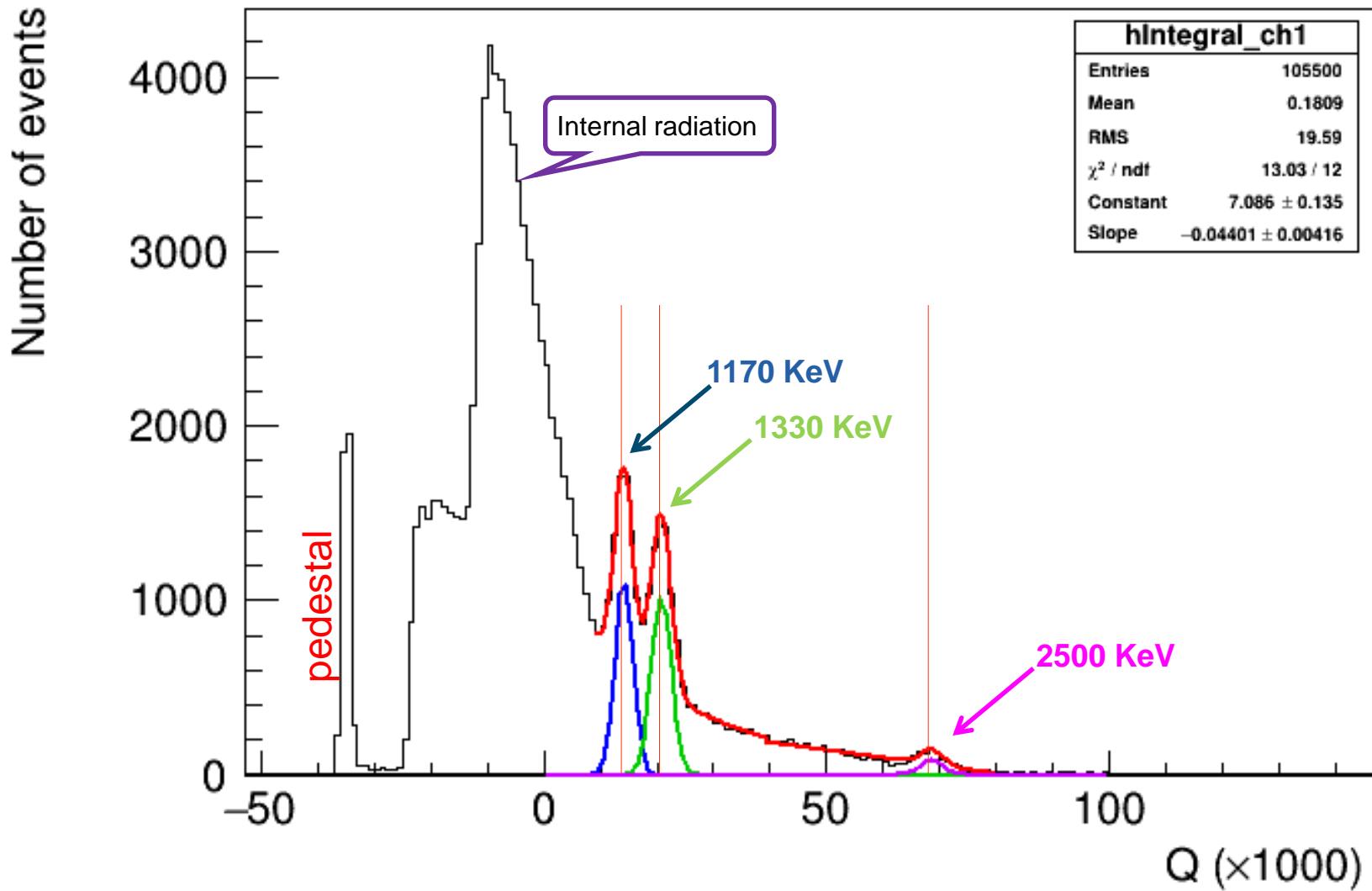
2 x 25 µm Kapton

Energy loss can be
estimated

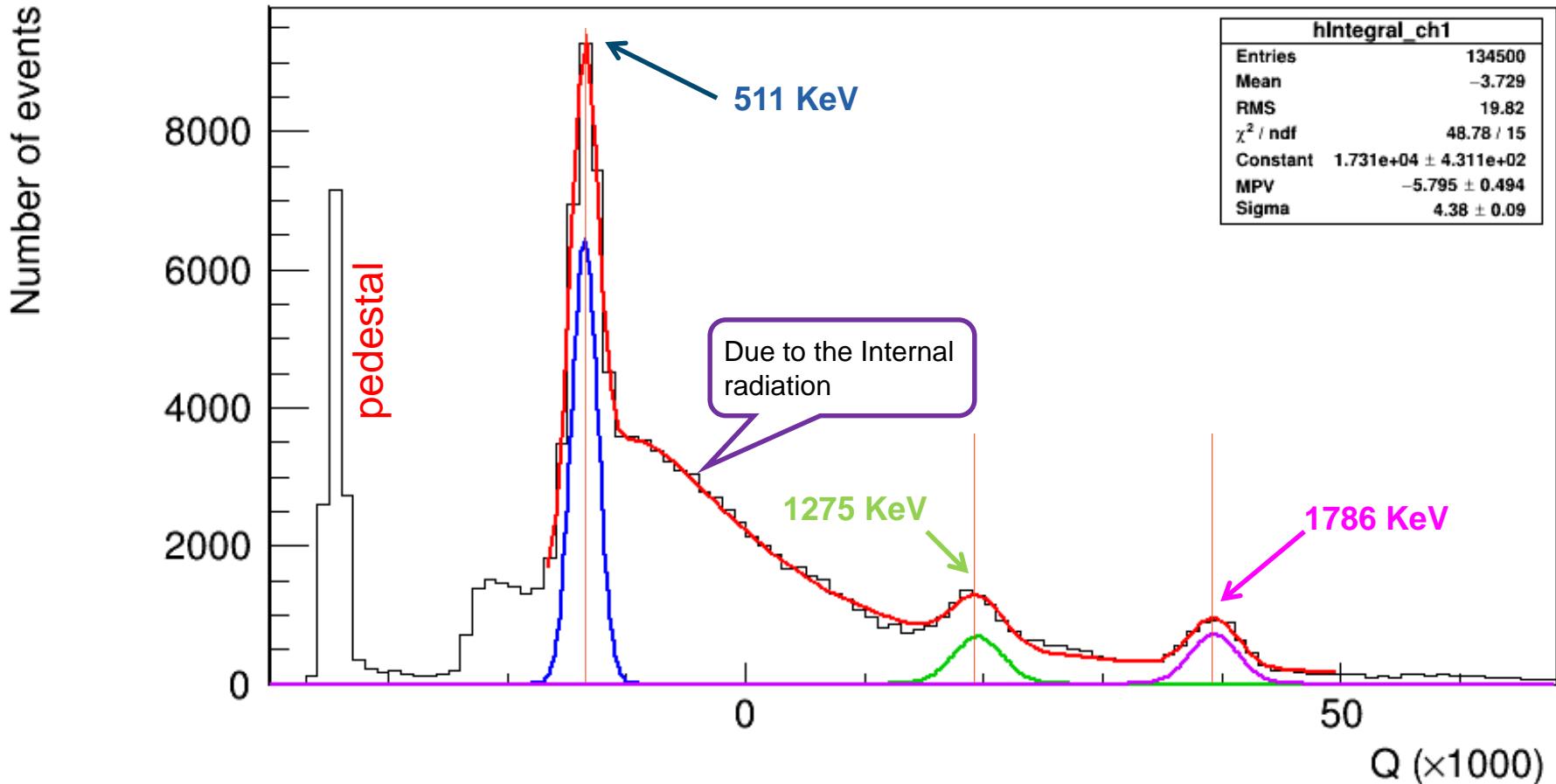
LYSO Modules Lab Tests Analysis



$^{60}\text{Co} + ^{176}\text{Lu}$, 30 V Supply, 4 mV threshold, Left Down 3rd Module

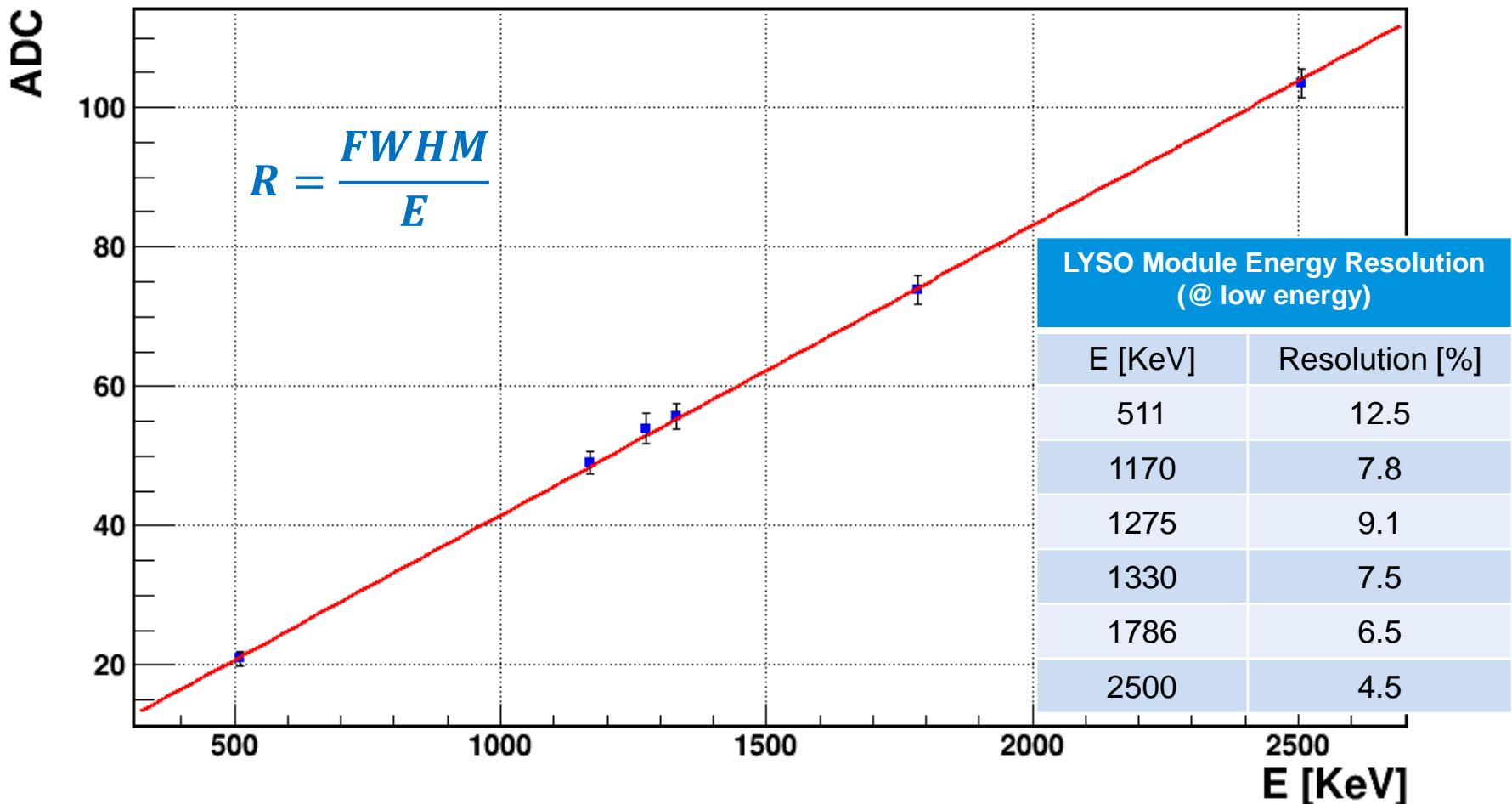


$^{22}\text{Na} + ^{176}\text{Lu}$, 30 V Supply, 4 mV threshold, Left Down 3rd Module

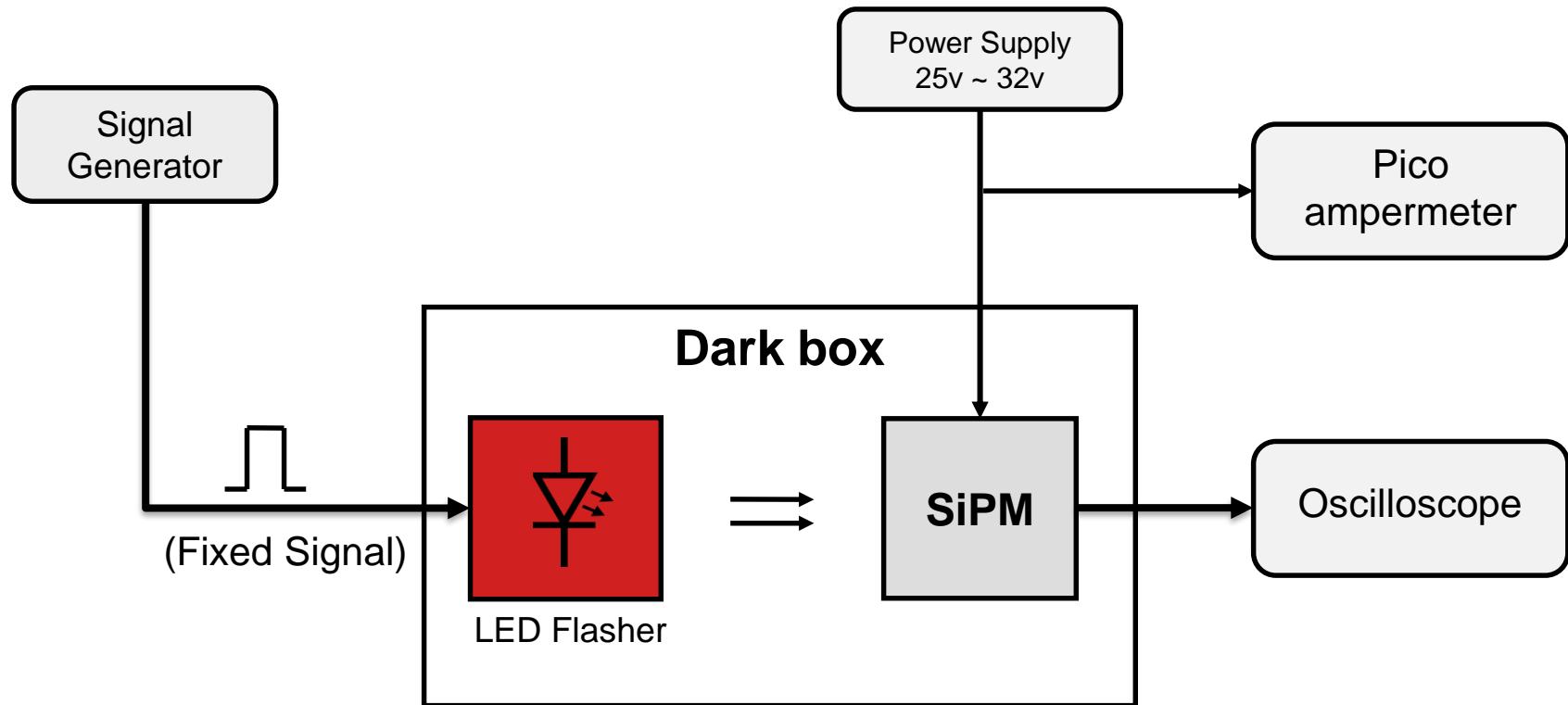


LYSO Modules Lab Tests Analysis

LYSO Module Linearity (@ low energy !)



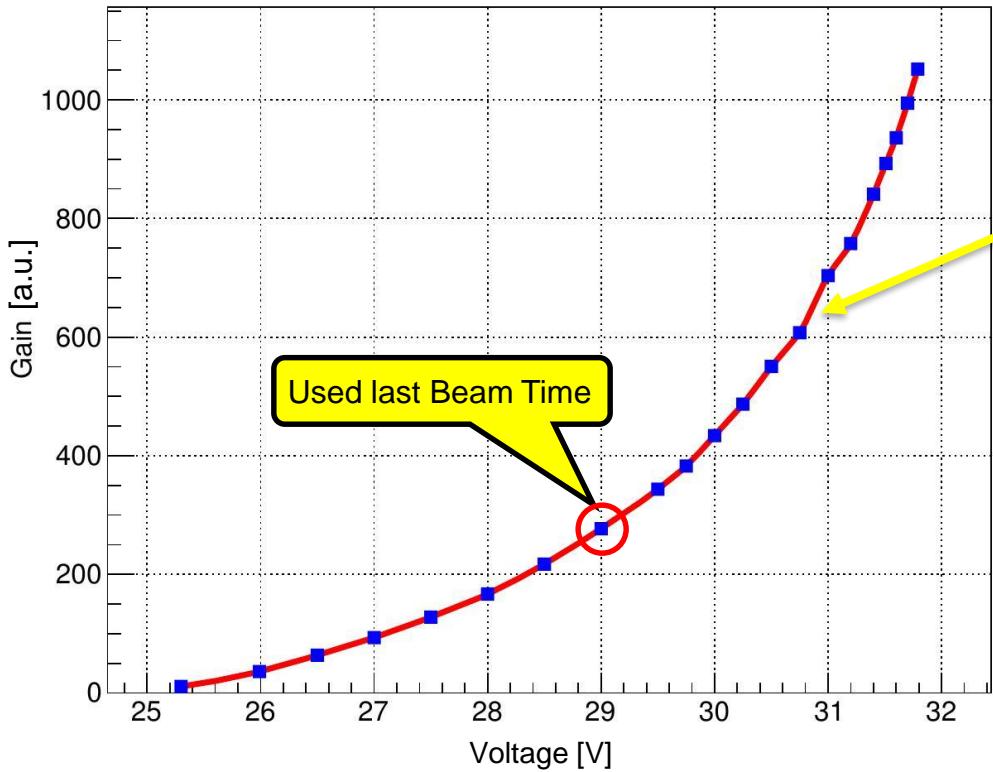
SiPM Lab Test



Test Procedure

- ✓ Functionality test
- ✓ Dark current monitoring using pico-ampermeter @1kHz & @10kHz with constant 1V pk-pk output
- ✓ Signal shape monitoring

SiPM Gain vs Voltage



1mV variation ~ 0.02...0.05 % in gain

Gain variation is directly related to energy resolution

LYSO energy resolution ~ 1%

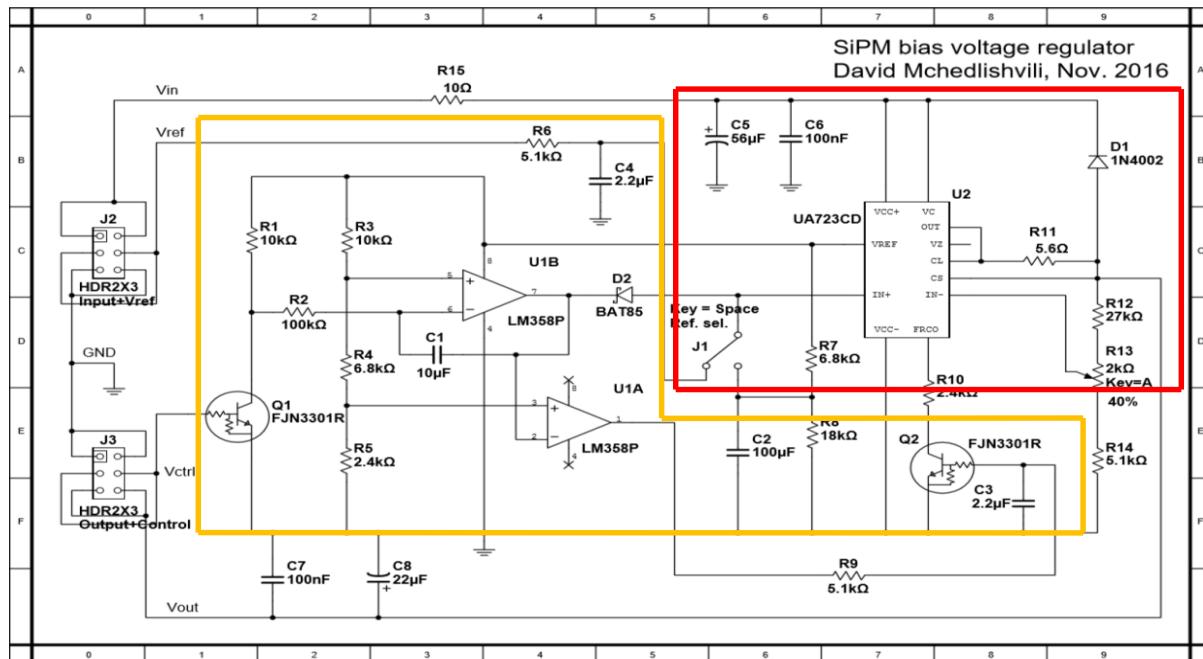


Max. accepted ΔV ~ 10mV

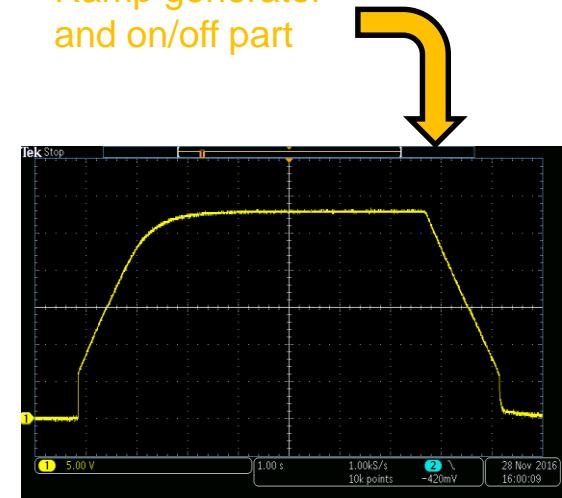
Development of a new voltage source

Basic requirements:

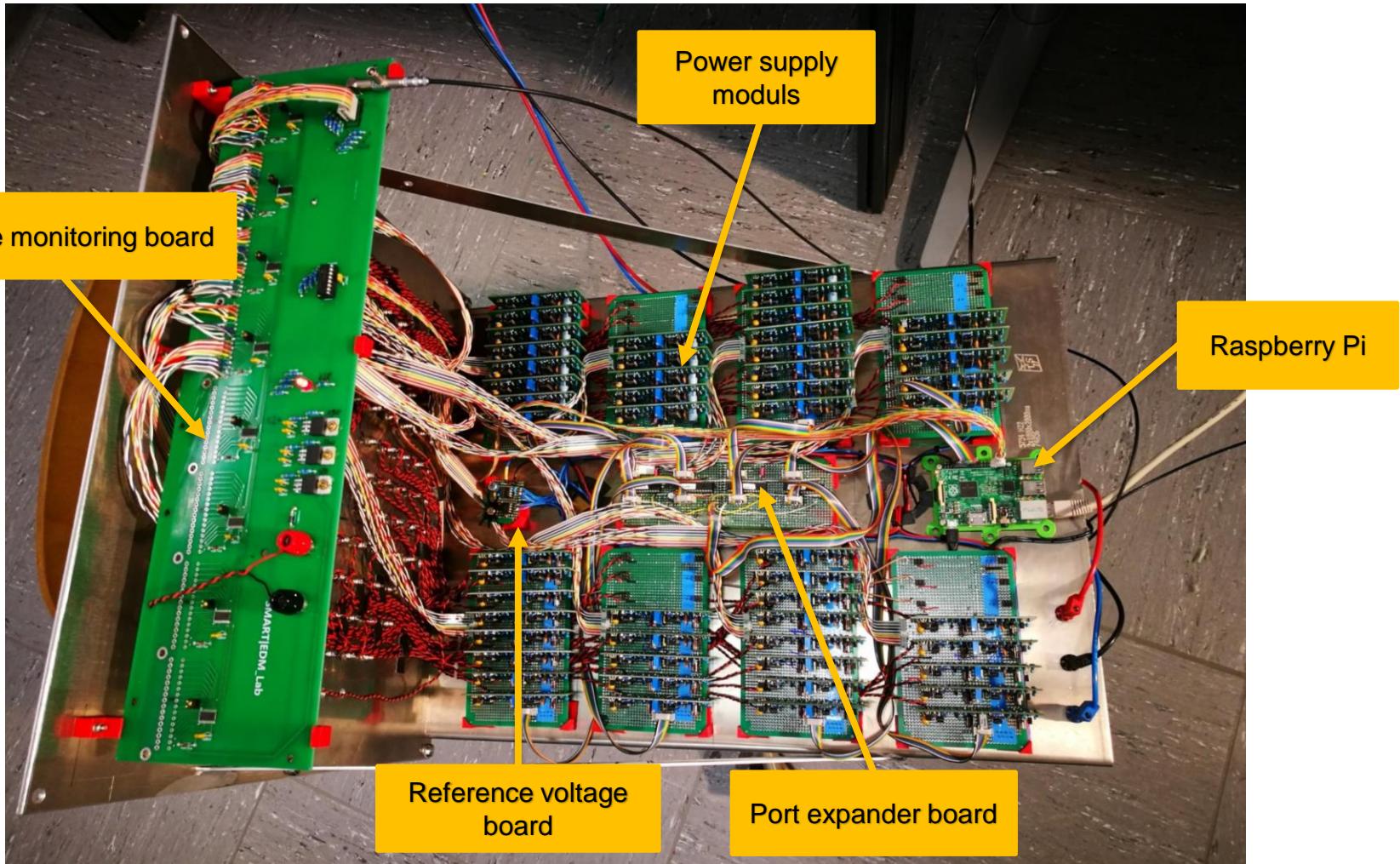
- Modular design
- High output stability (*temperature, long/short term, low noise*)
- Remote on/off capability (*currently organized using Raspberry Pi*)
- Voltage adjustment (*currently only manual*)



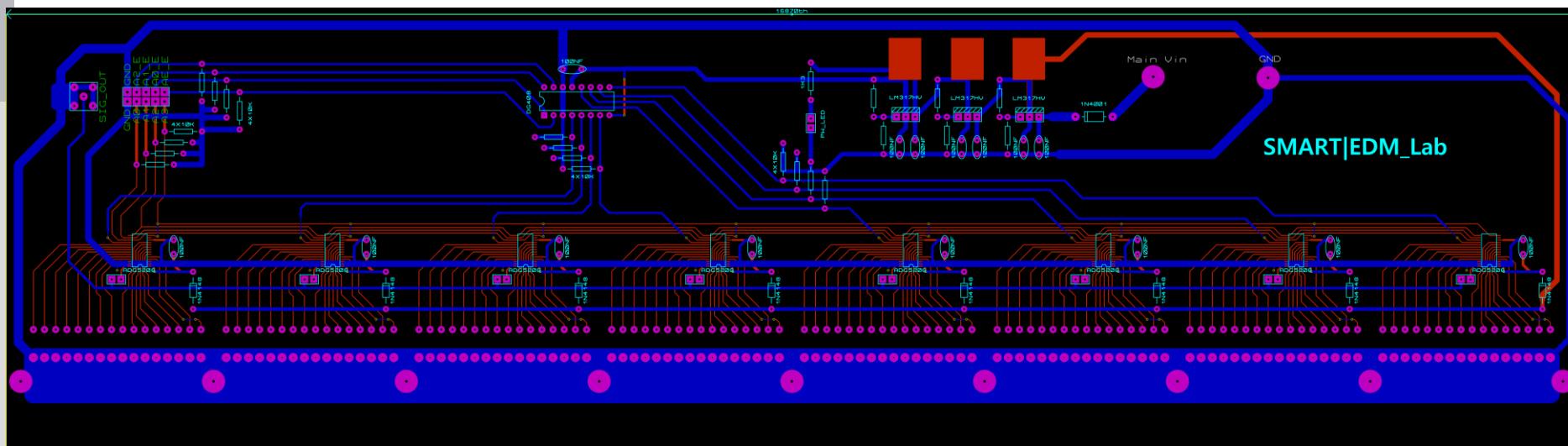
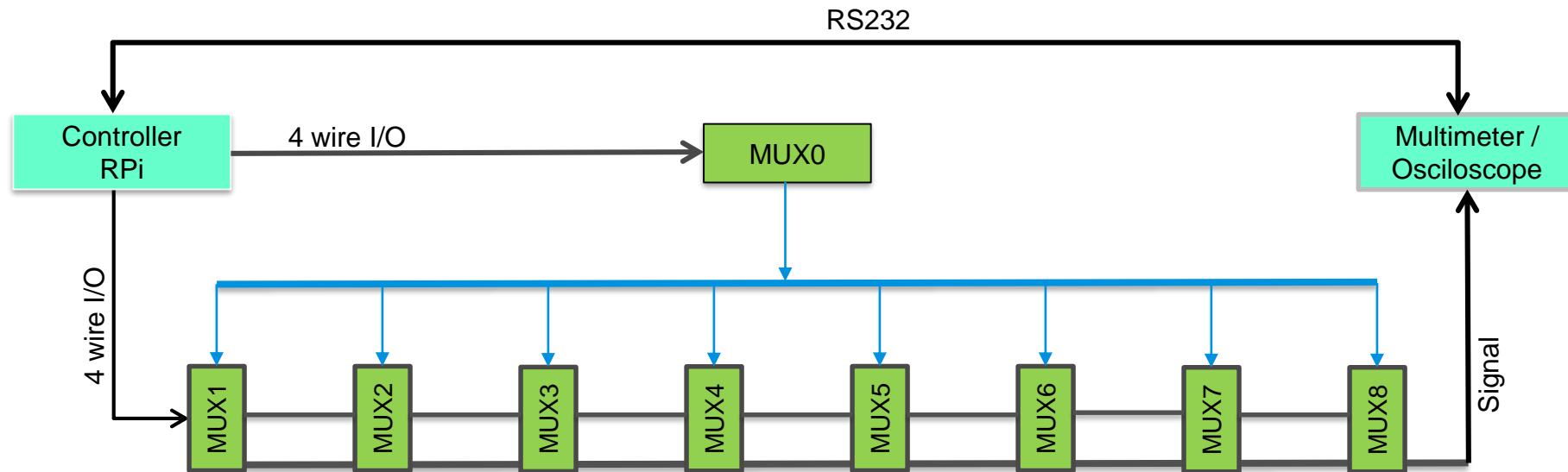
- Linear voltage regulator part
- Ramp generator and on/off part



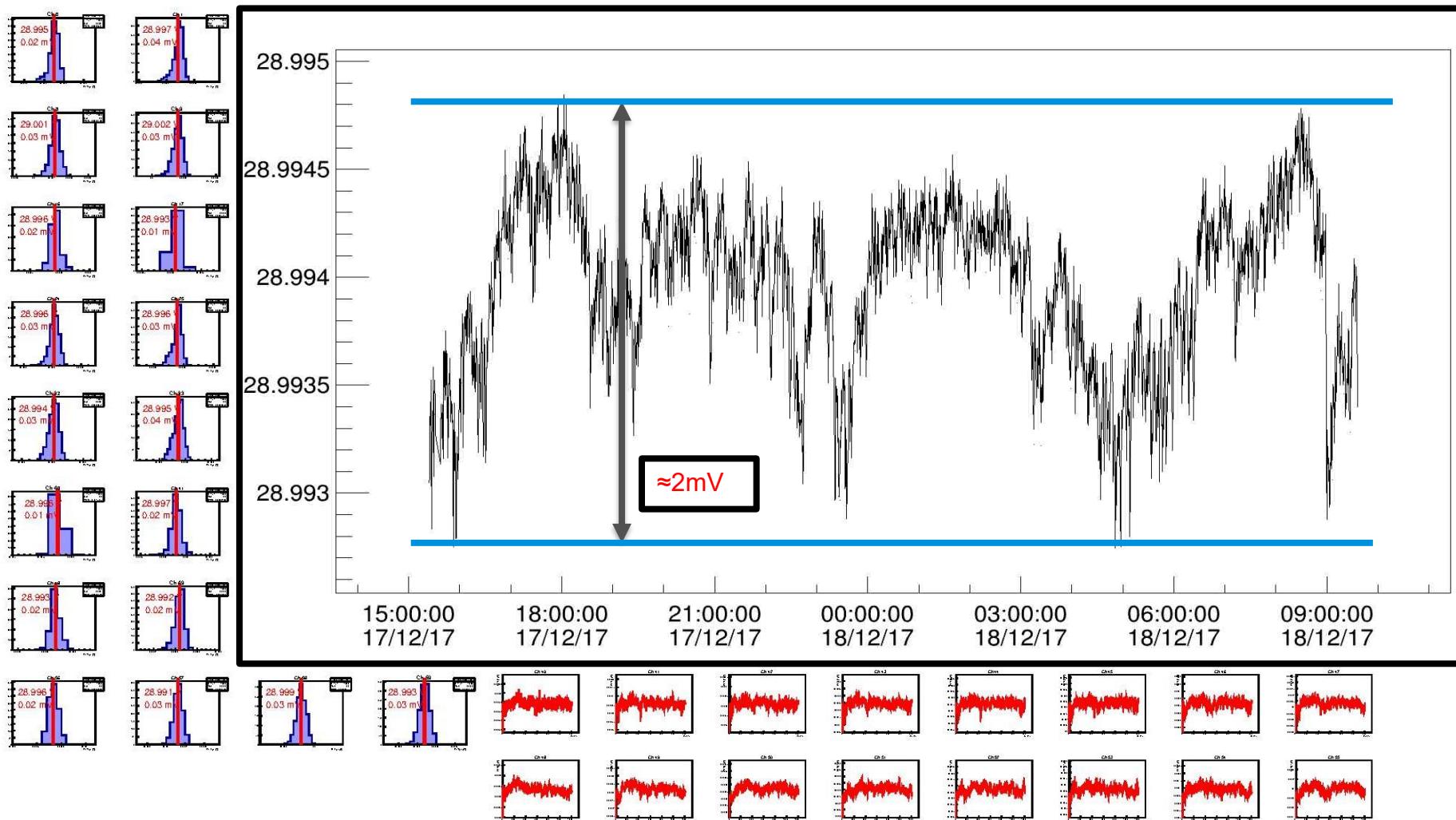
64 channel power supply with voltage monitoring



Voltage monitoring for 128 Ch



Signal shapes





Summary

- ✓ LYSO module **assembling** and **testing** procedure
- ✓ 52 module were assembled and **tested successfully**
- ✓ First version of modular voltage supply for SiPMs was successfully tested
- ✓ 128 channels voltage monitoring system was made

Outlook

Upgrade HW/SW packages for the read out system

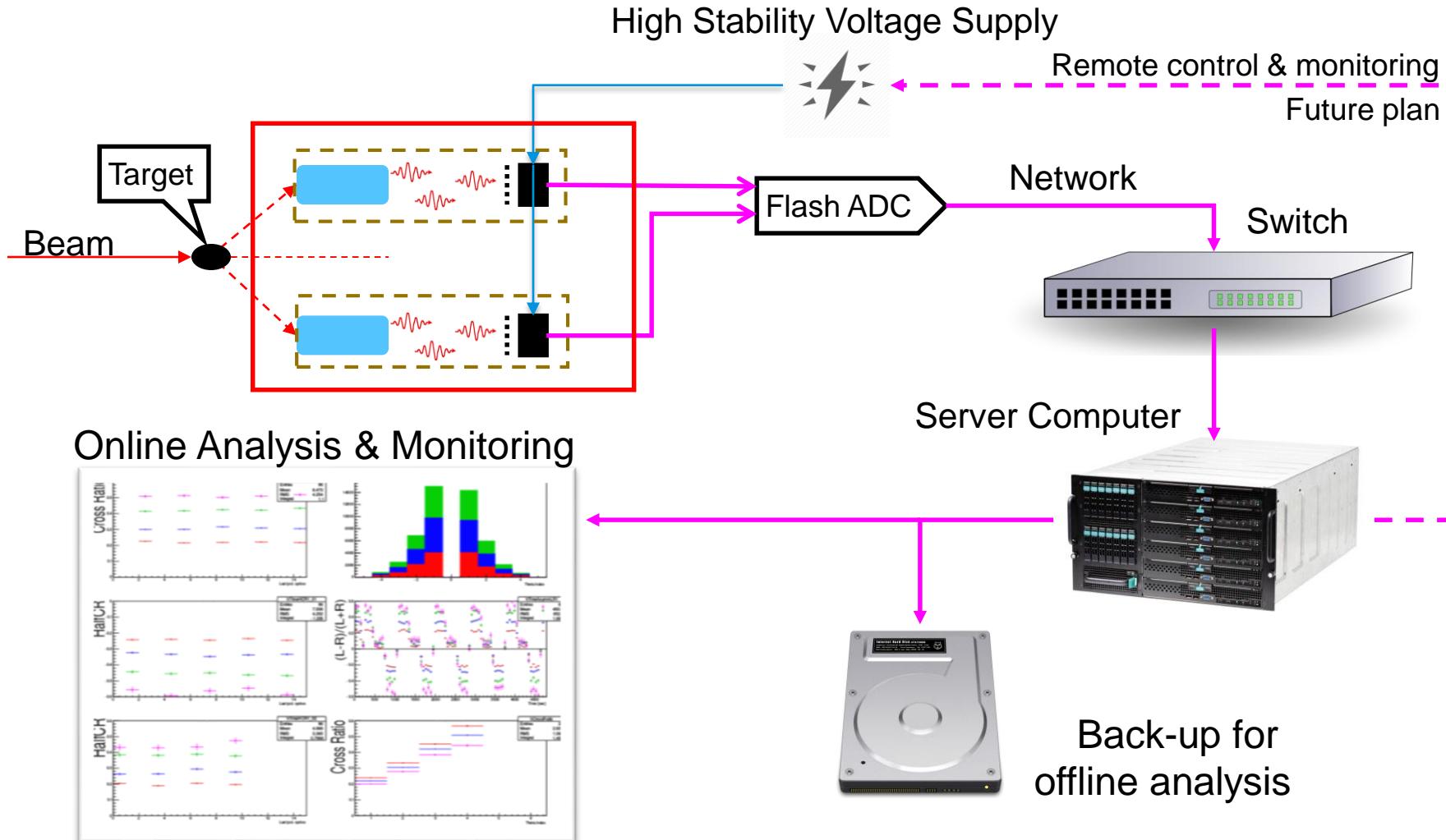
- Analyze already taken data
- Further development of online analysis and readout system
- Flash ADC configuration set-up (user friendly ☺)
- Implementation of a triangular scintillator bars for particles tracking

This work was supported by the Shota Rustaveli National Science Foundation (SRNSF)

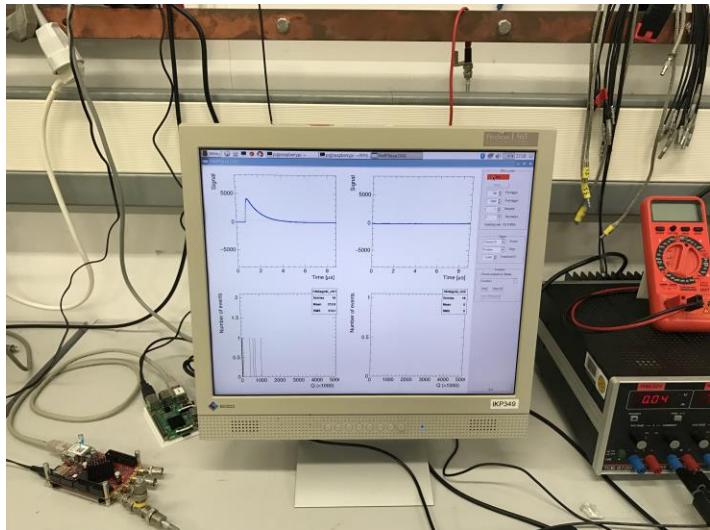


Appendix

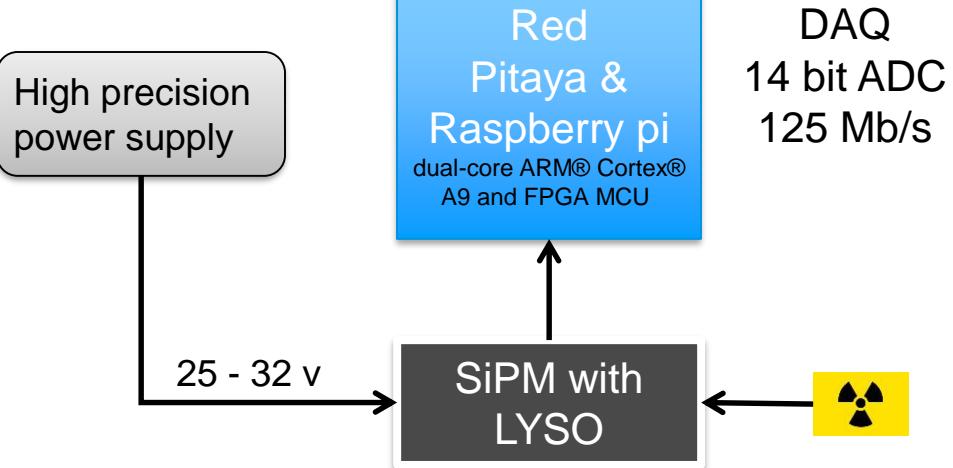
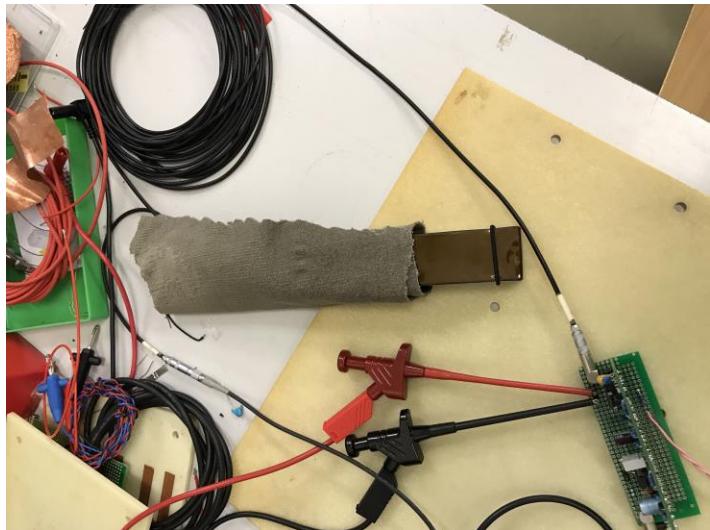
Polarimetry Overview



LYSO Modules Lab Tests

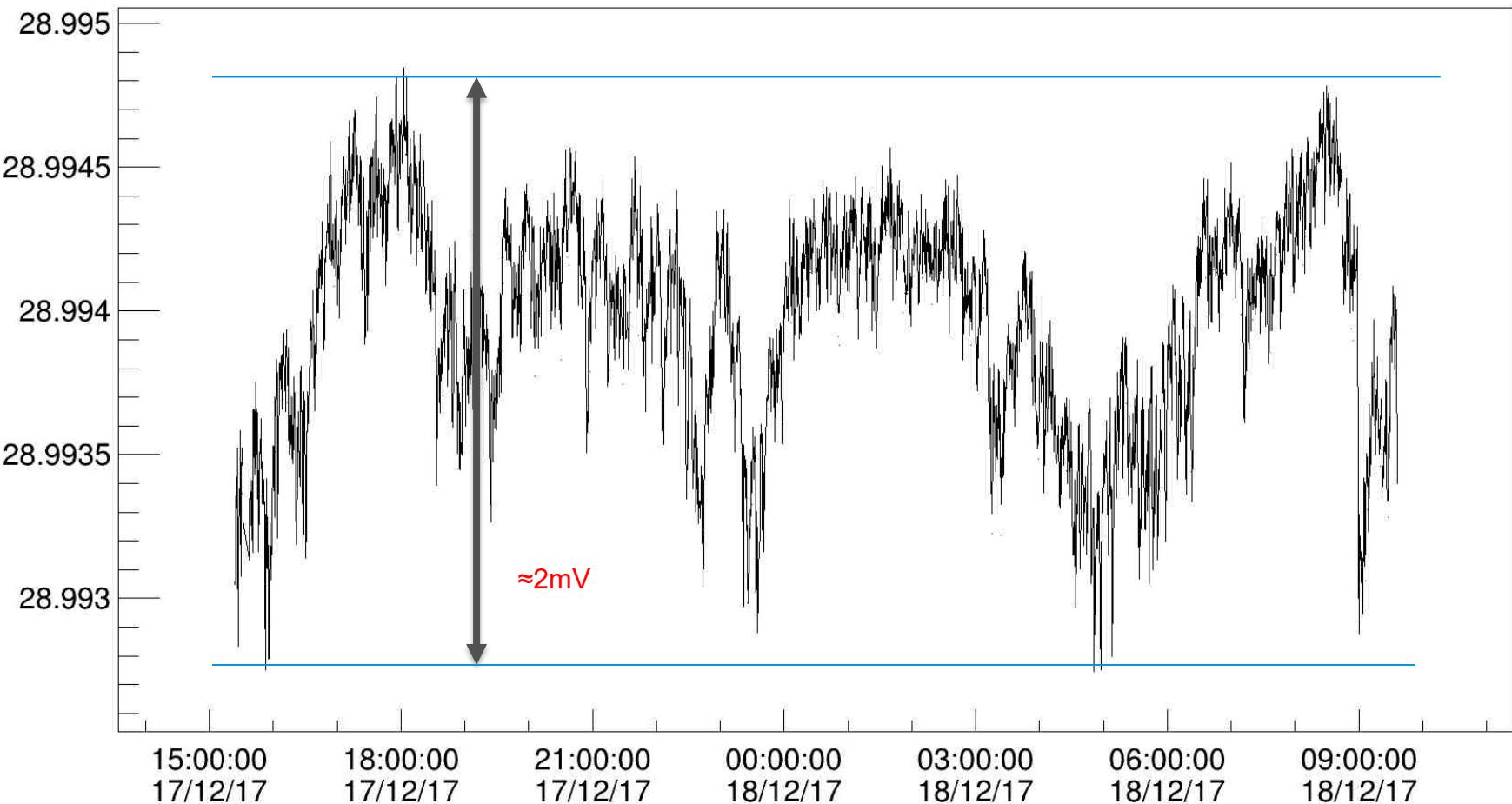


- Light Tightness
- Measurements of ^{22}Na , ^{60}Co , ^{176}Lu (internal)
- Optimal supply voltages
- Signal offset (current leakage)



Signal shapes

Signal from one channel



Struck innovation system: SIS3316 flash ADC

Features/Properties:

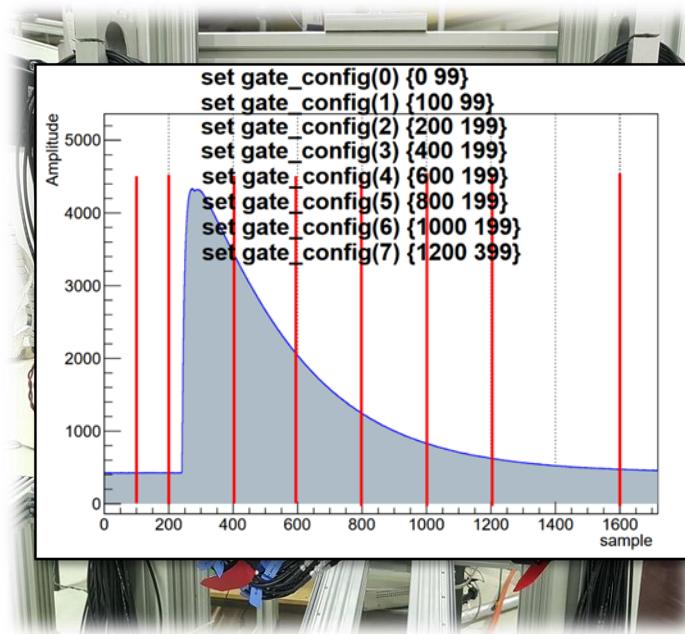
- 16 channels
- 250 MS/s per channel = **4ns between timestamps**
- 14-bit resolution
- 64 MSamples memory/channel
- ...



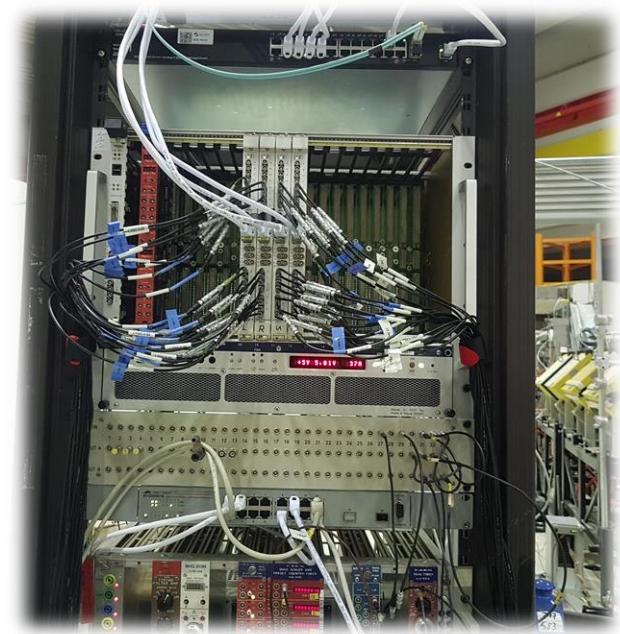
Data traffic:

1 sample = 2 Byte 1700 sample = 3.4 KB 40KHz ~ 1Gb/s **limit!**

Module side



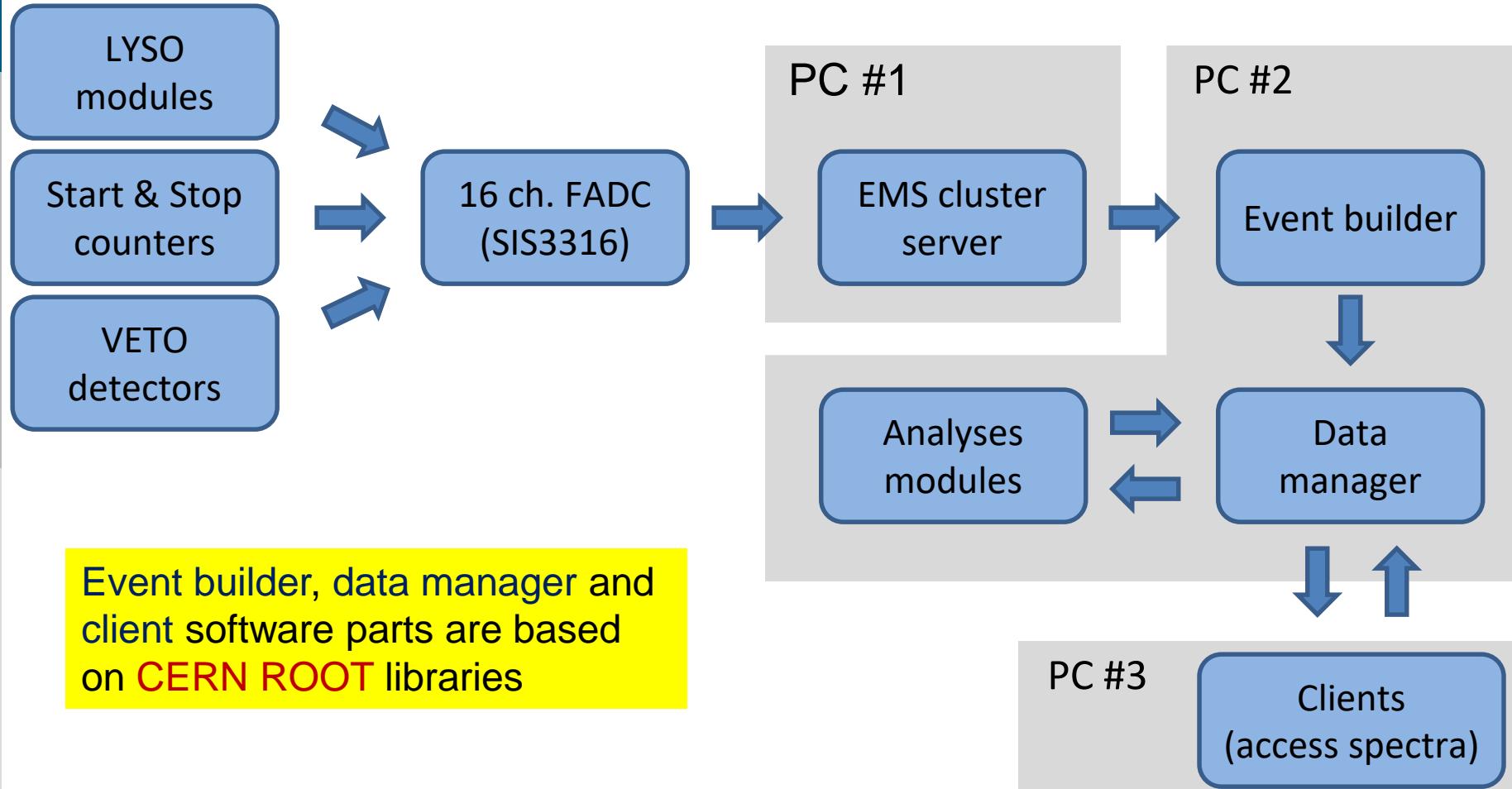
Flash ADC side



Data acquisition software



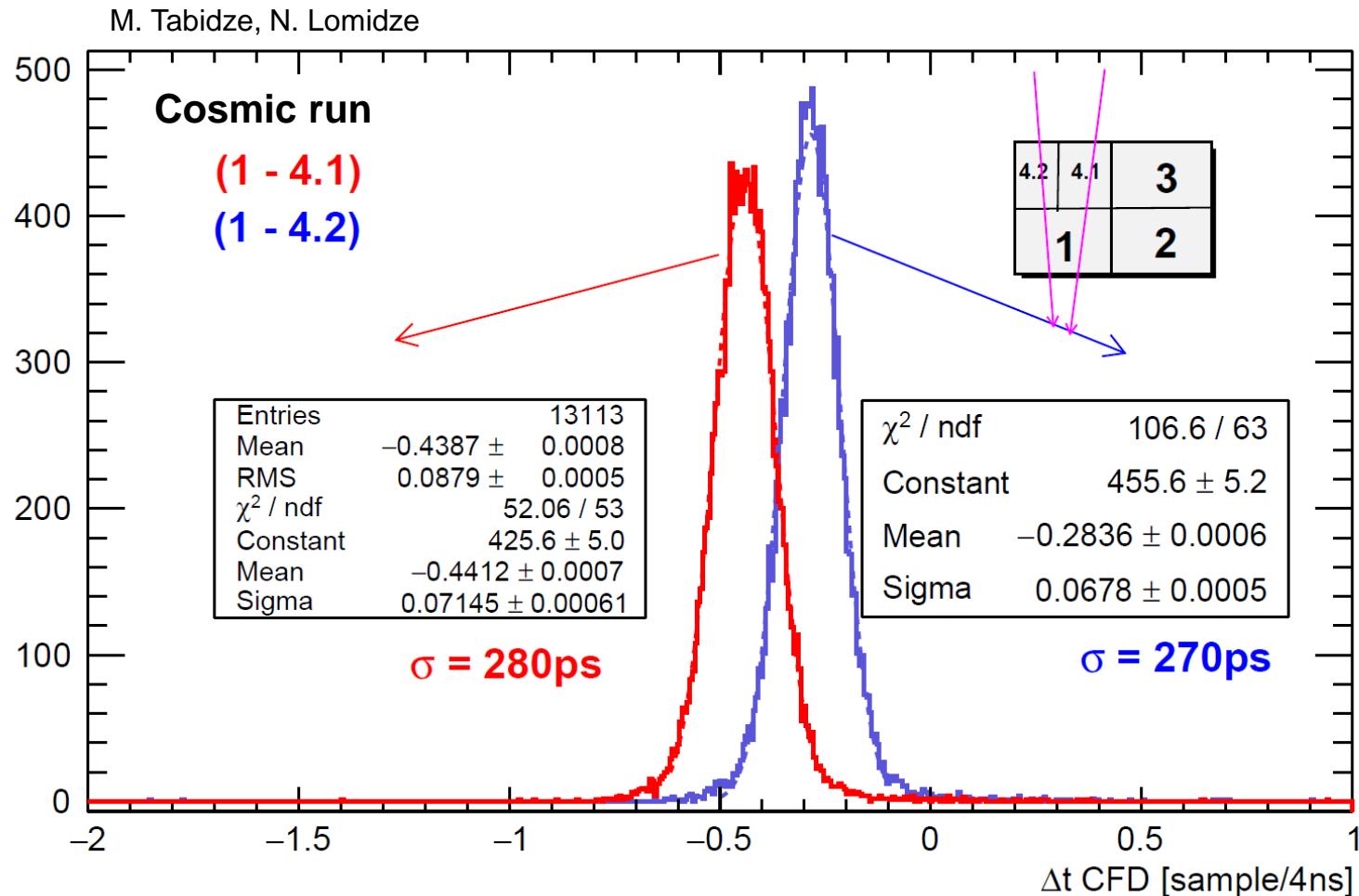
Developing at SMART|EDM_Lab



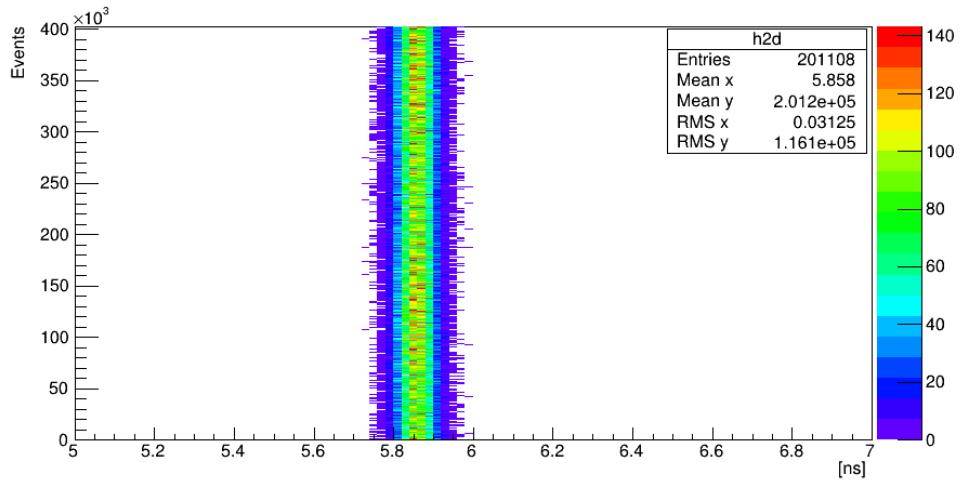
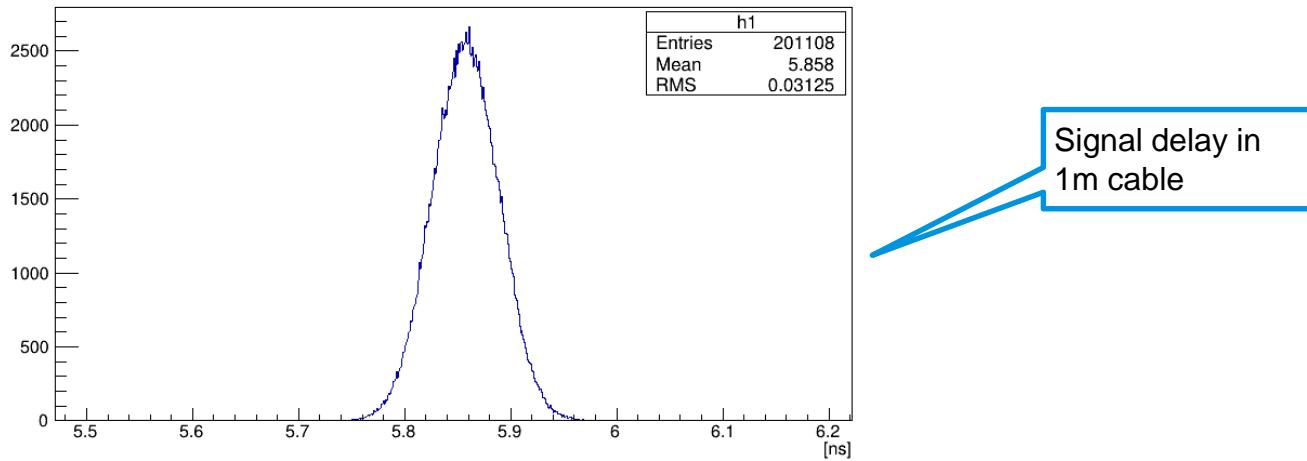


Time Resolution Analysis (SW CFD)

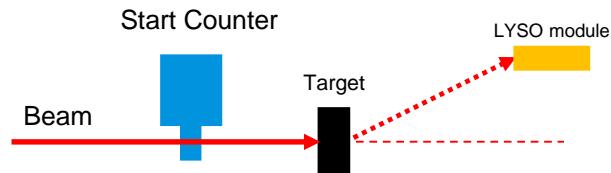
Cosmic Run with PMT & LYSO



Time Resolution Analysis (HW CFD)



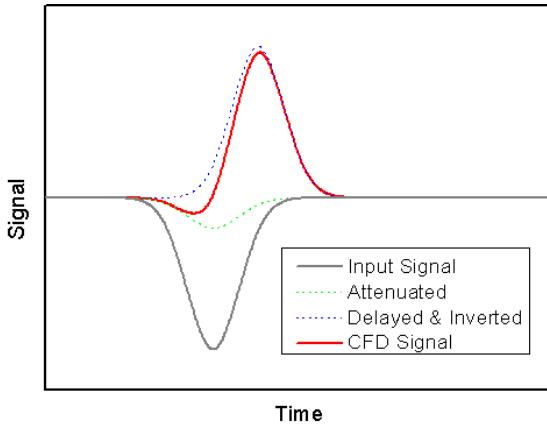
Deuteron TOF between start counter and detector



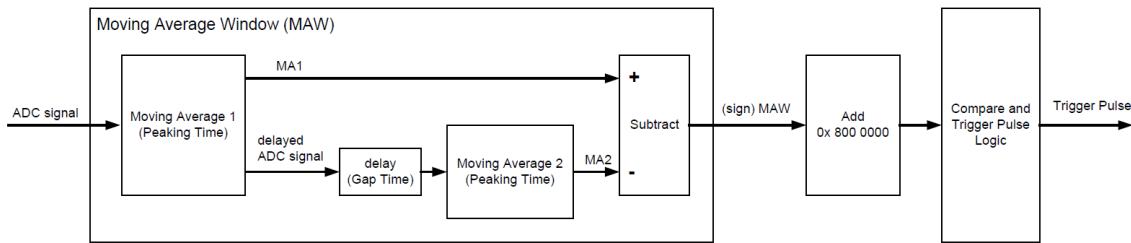
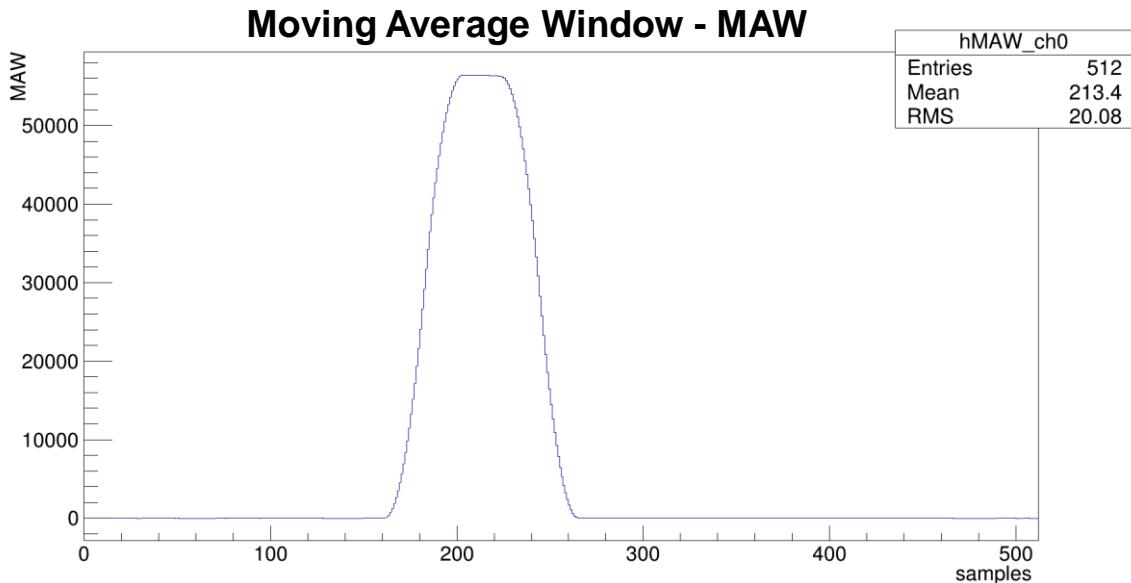
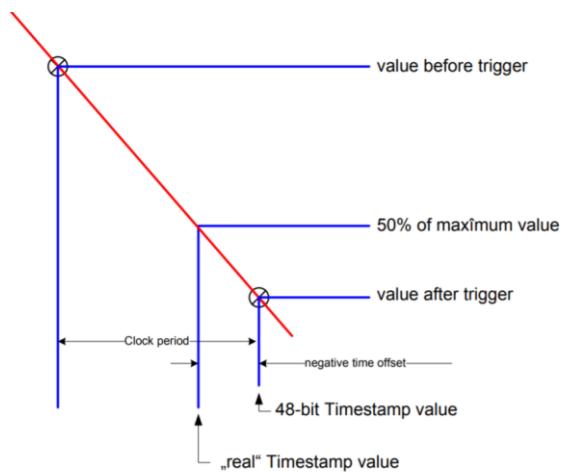
Time Resolution Analysis



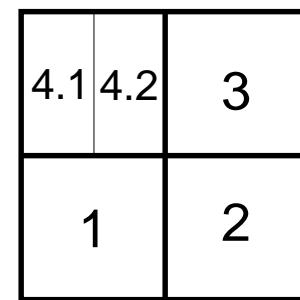
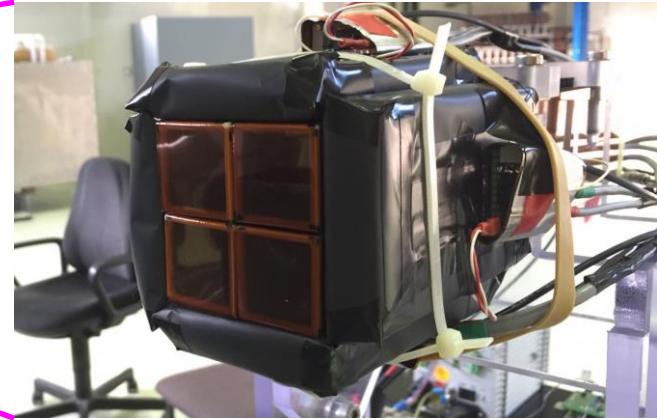
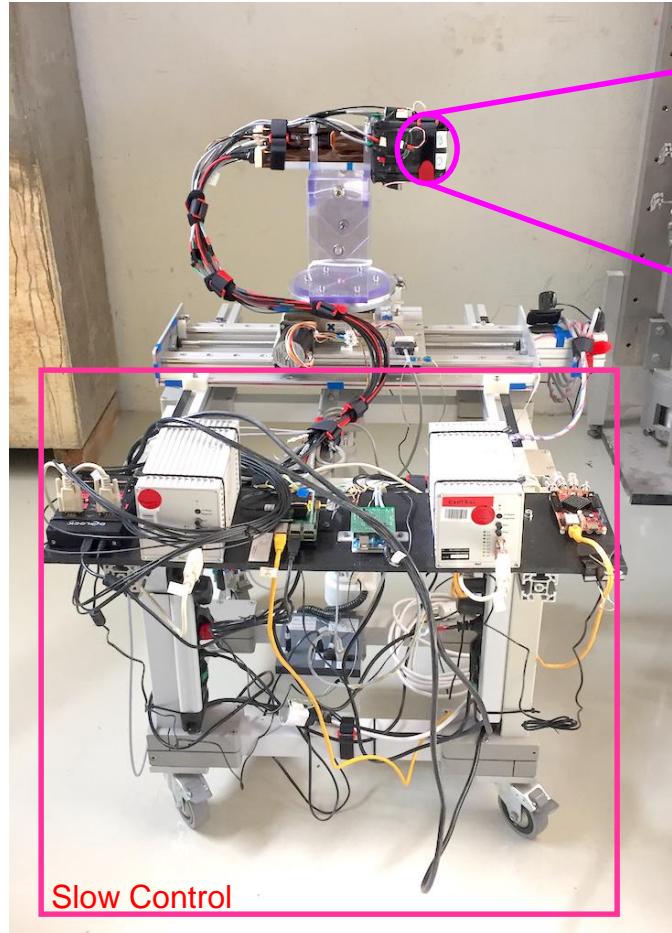
1. Software based Constant Fraction Discriminator (CFD)



2. Built-in feature (Hardware CFD)



1st Set-up for COSY Beam Time



First Test on LYSO – Bragg peak

