

Development of LYSO detector modules for a charge-particle EDM polarimeter

on behalf of the JEDI collaboration



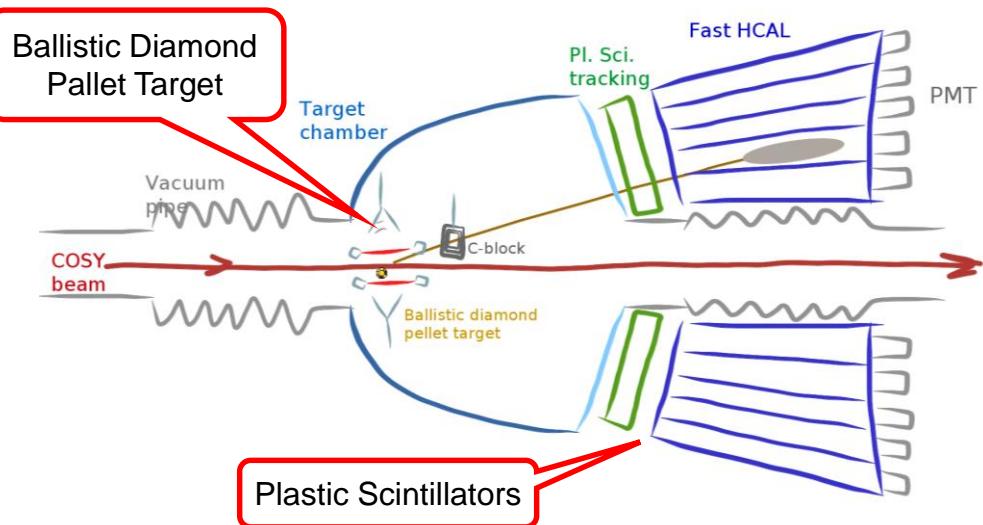
Dito Shergelashvili, PhD student @ SMART|EDM_Lab, TSU, Georgia

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

12th September 2018 | Ferrara

Steps in Polarimeter Design

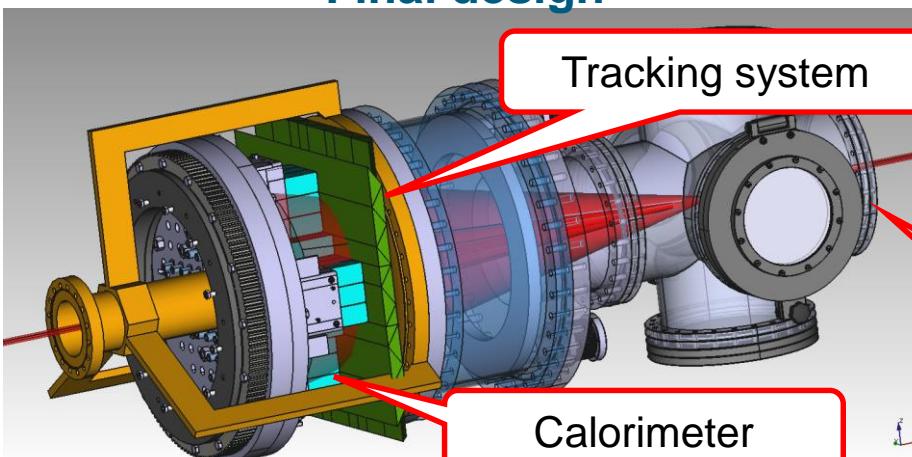
1st sketch



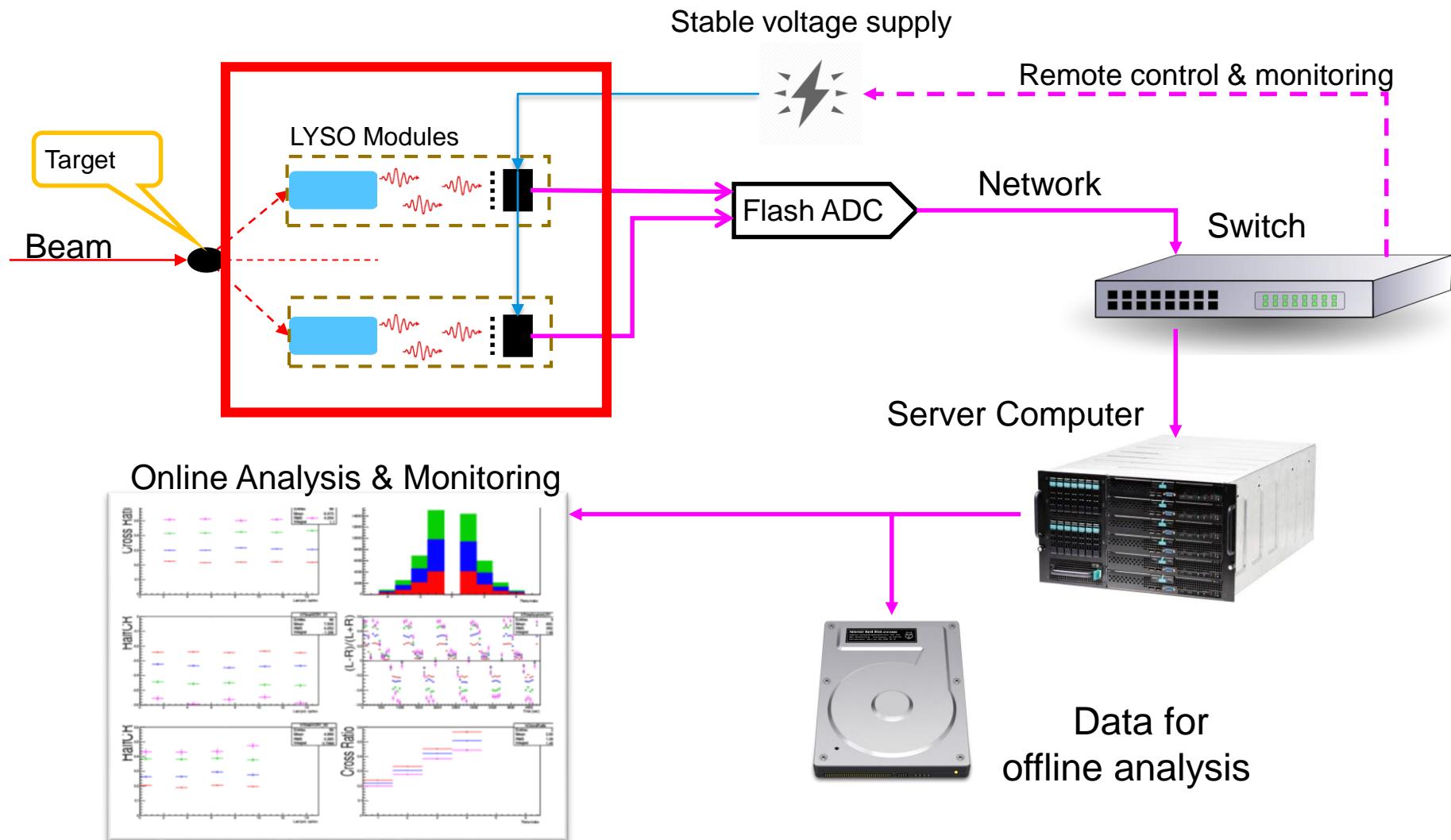
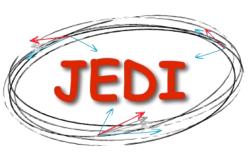
Requirements:

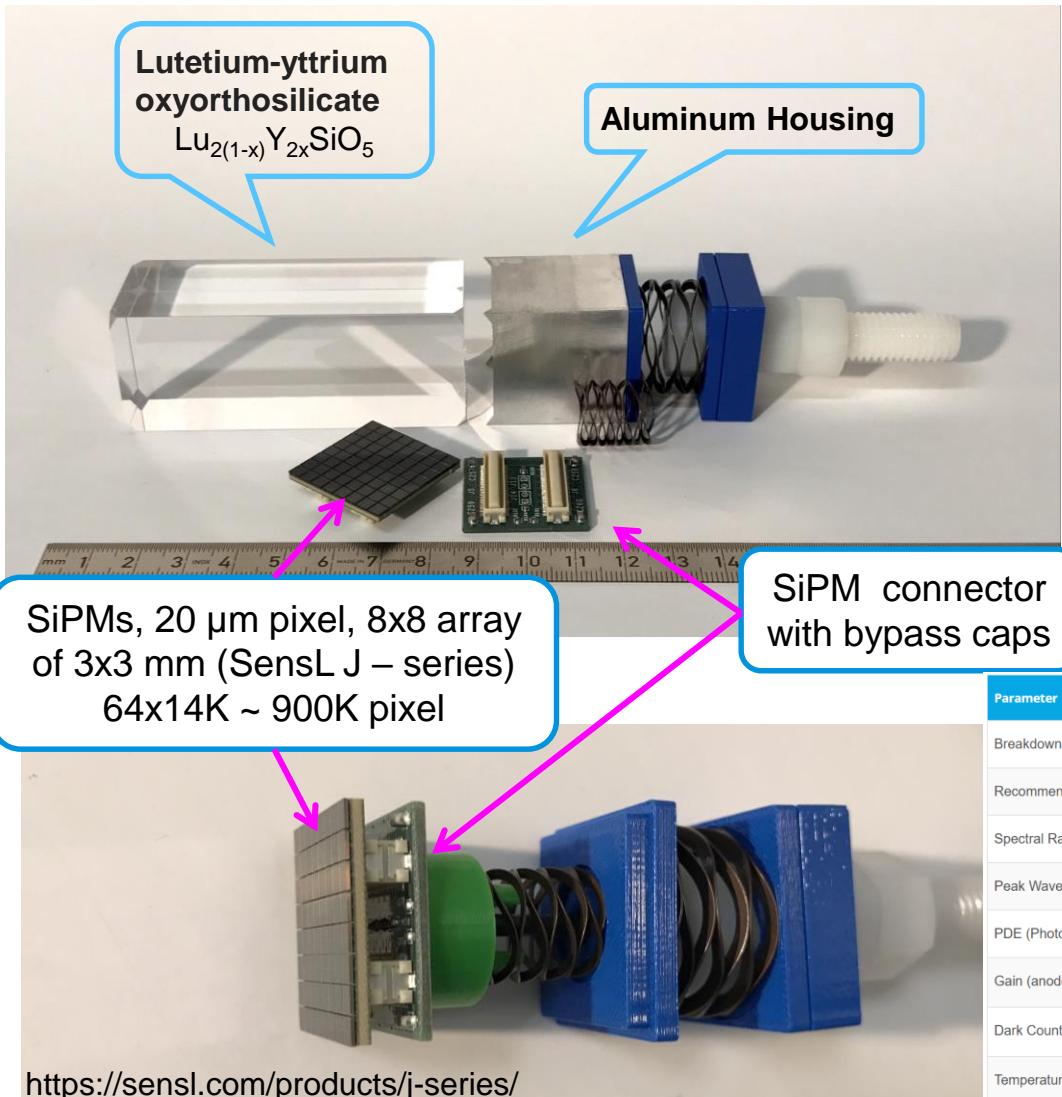
- High precision
- High efficiency
- High stability
- No magnetic / electric field
- Compact size

Final design

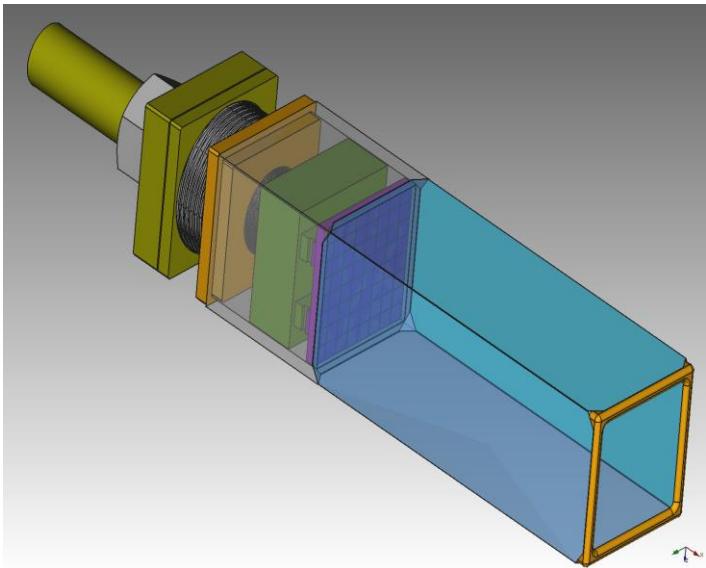


Polarimetry Overview



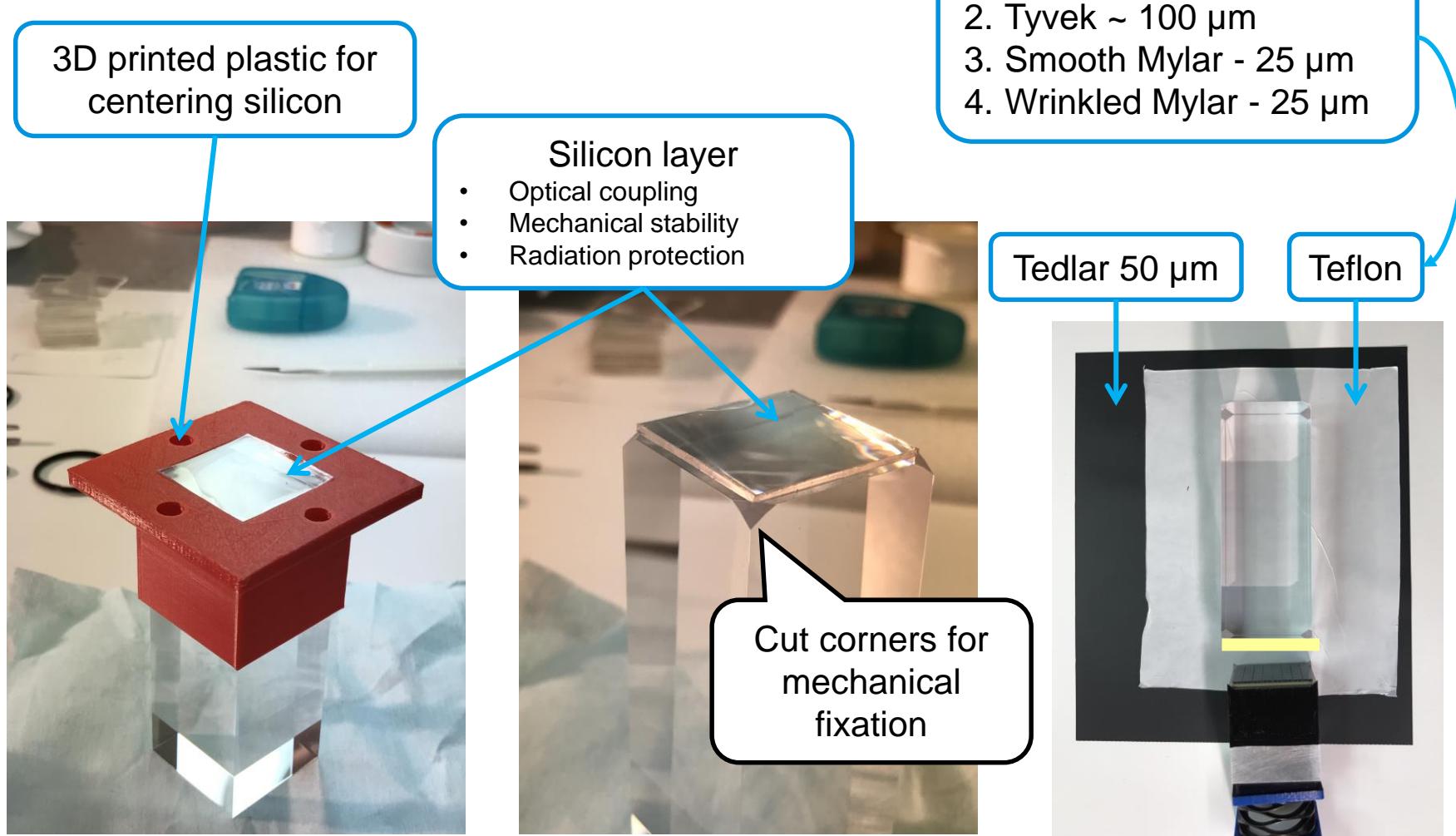


3D drawing

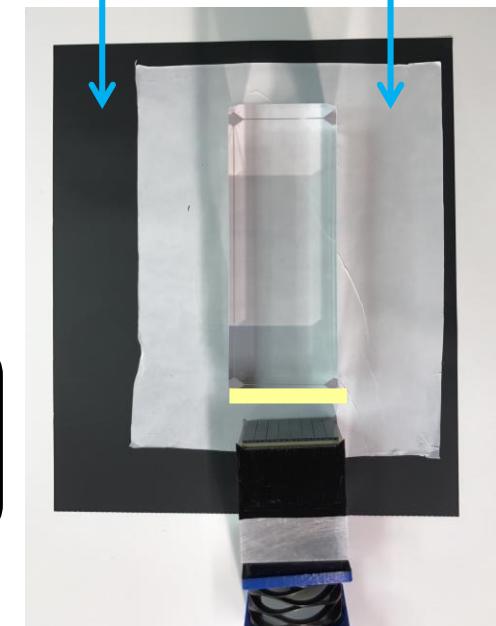
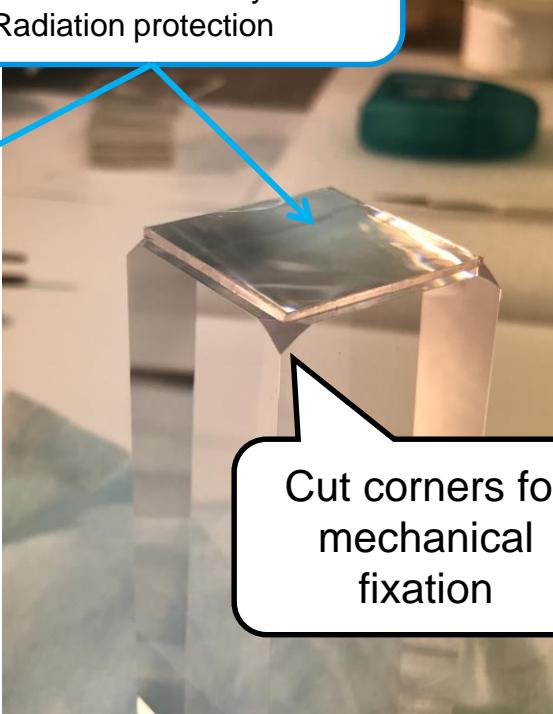
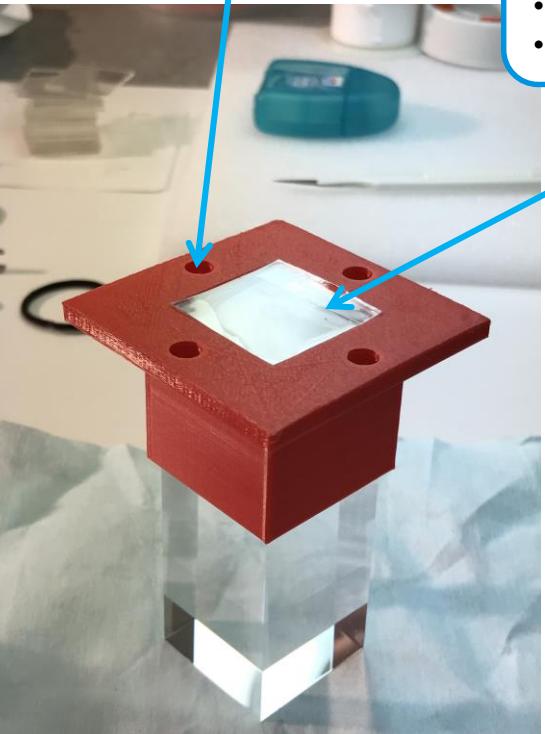


Parameter	Min.	Typ.	Max.	Units	Notes
Breakdown Voltage (V _{br})		24.5		V	
Recommended overvoltage (Voltage above V _{br})	+1		+6	V	
Spectral Range	200		900	nm	
Peak Wavelength		420		nm	
PDE (Photon Detection Efficiency)	50			%	35um microcell @ V _{br} + 6V and 420nm
Gain (anode to cathode readout)	6.3x10 ⁶				35um microcell @ V _{br} + 6V
Dark Count Rate	50			kHz/mm ²	@ V _{br} + 2.5V
Temperature dependence of V _{br}	21.5			mV/°C	

Module Assembly



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



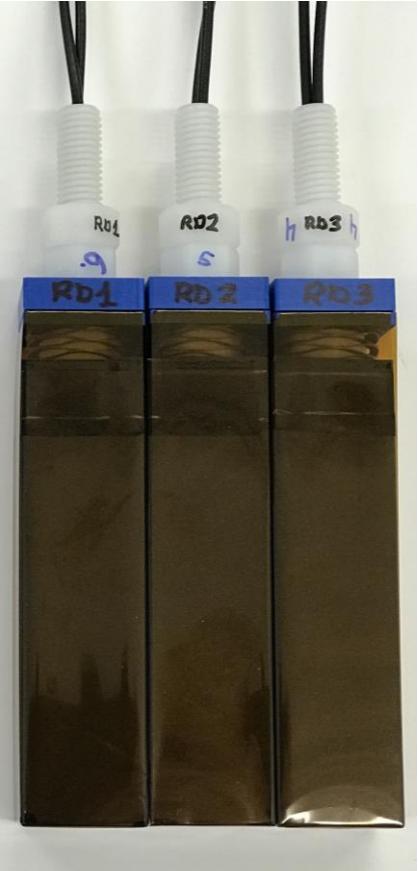
Module Assembly



3rd hand during assembling



Ready for test



Enough depth to stop
270 MeV deuterons

SiPM array



2 x 50 µm Teflon

2 x 50 µm Tedlar

2 x 25 µm Kapton

Energy loss can be
estimated



Stand-alone test bench for LYSO lab tests



Redpitaya

- ✓ FPGA based 2 ch 125 MS/s DAC and function generator
- ✓ Linux on board
- ✓ C/C++ compiler
- ✓ Communication via LAN



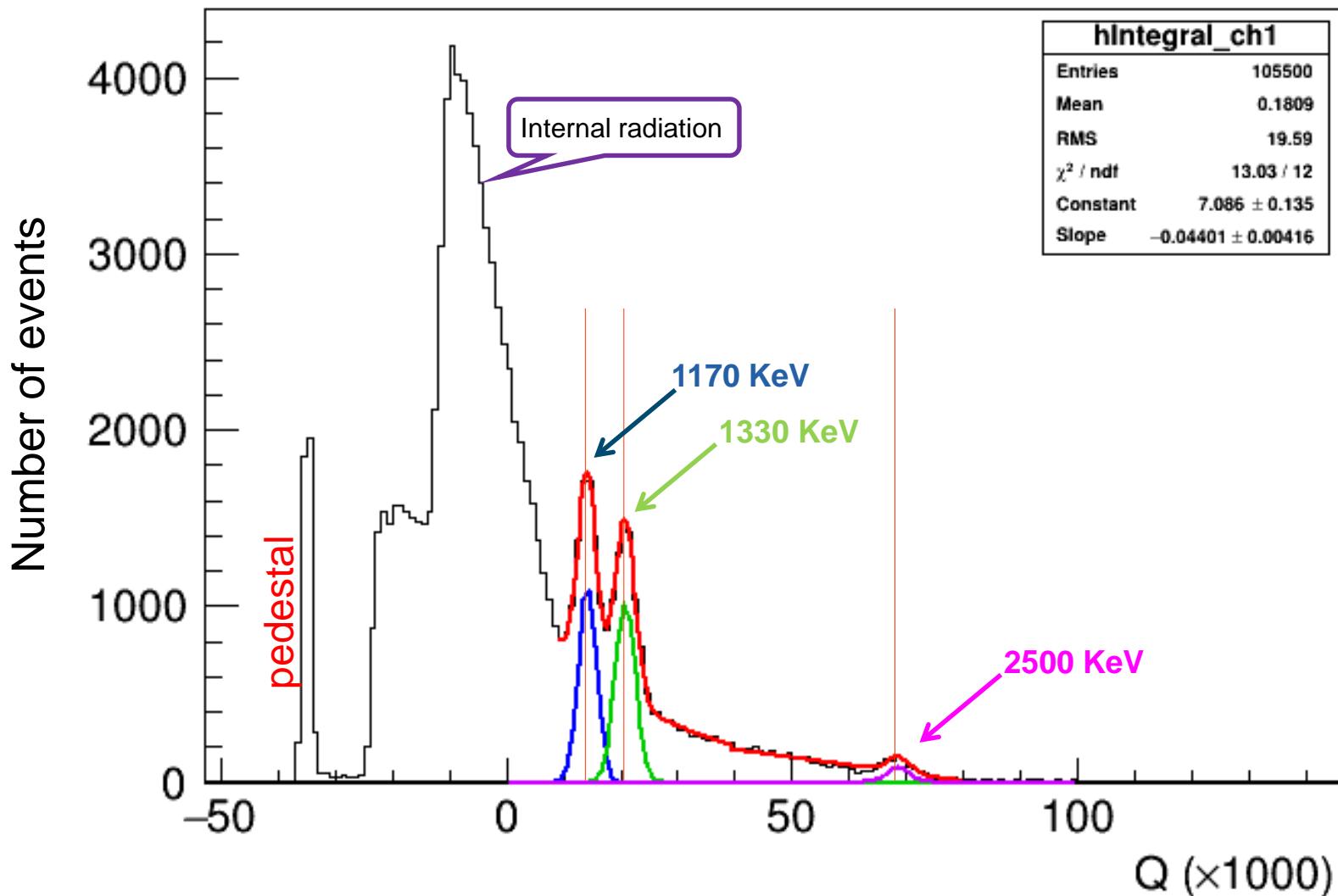
Raspberry Pi

- ✓ Root based online analysis software



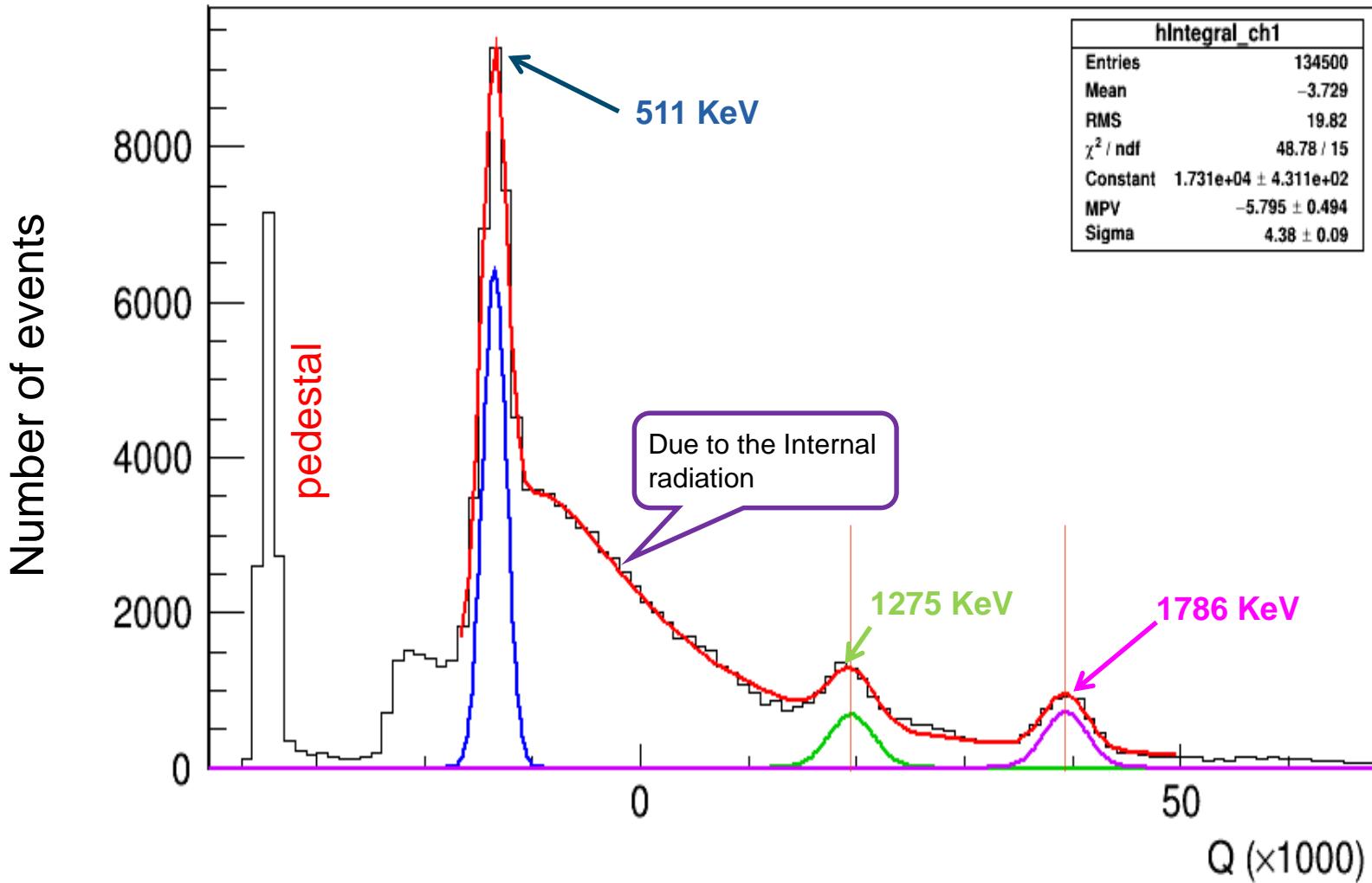
LYSO Test Data

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



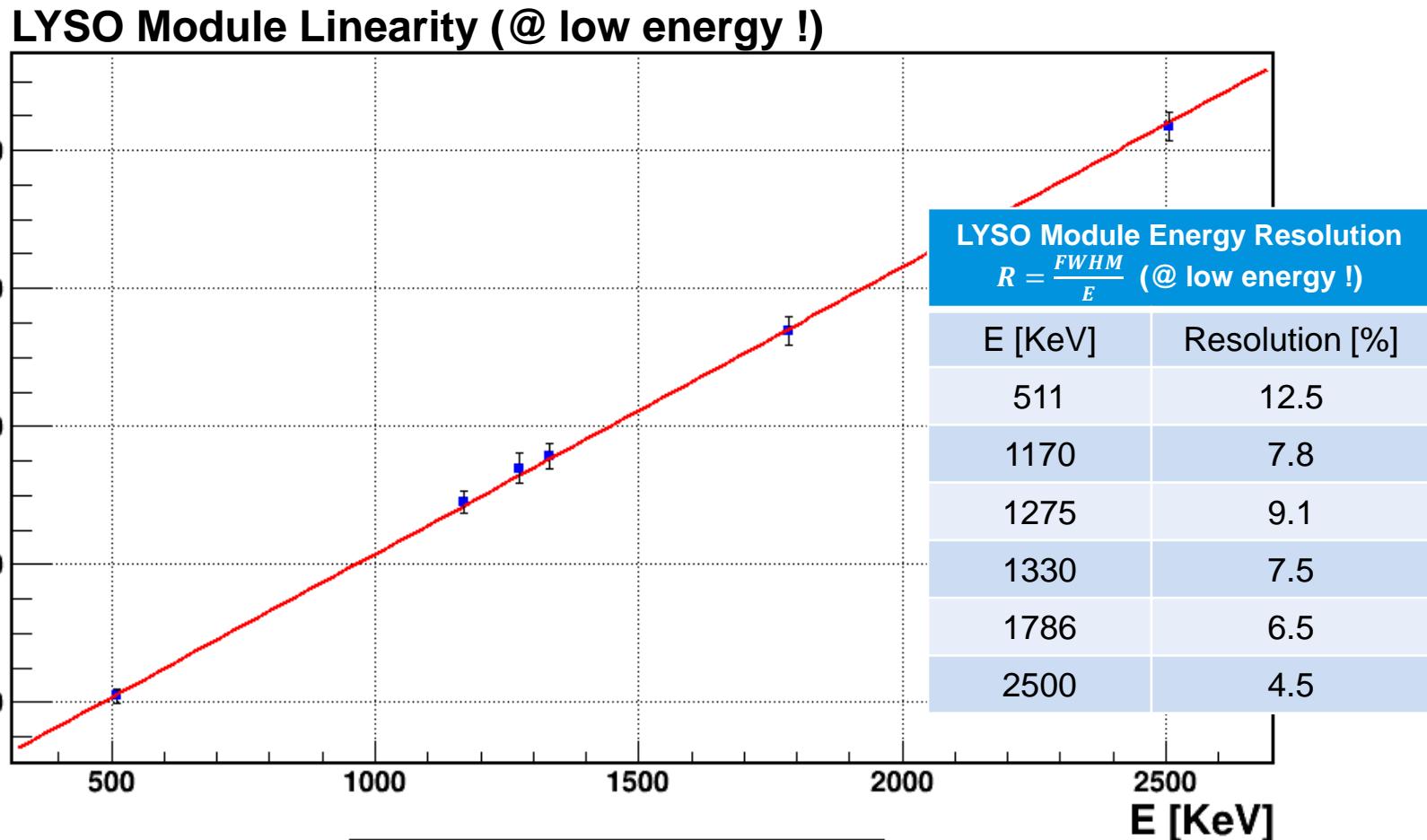
LYSO Test Data

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

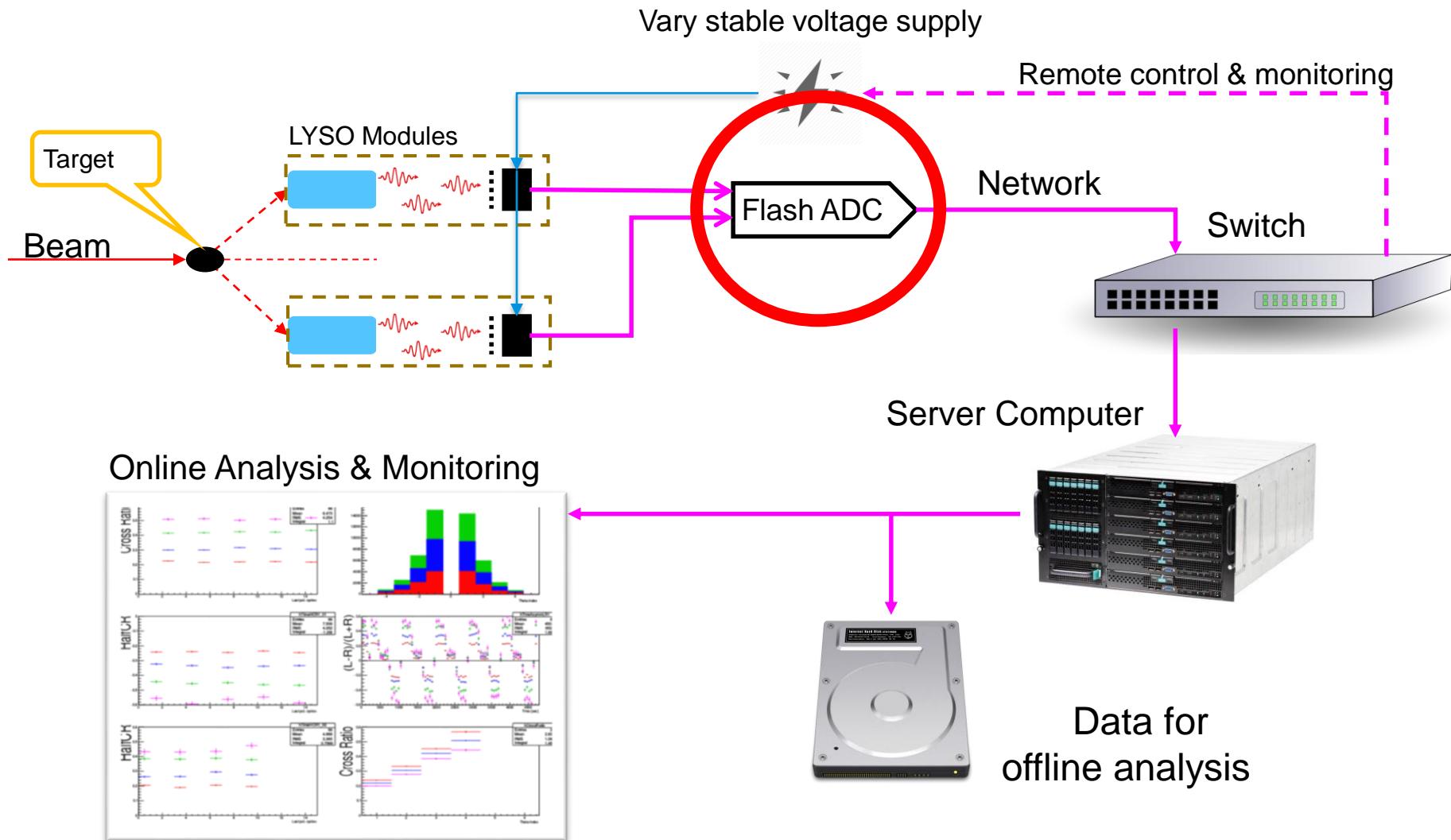


LYSO Module Linearity

ADC



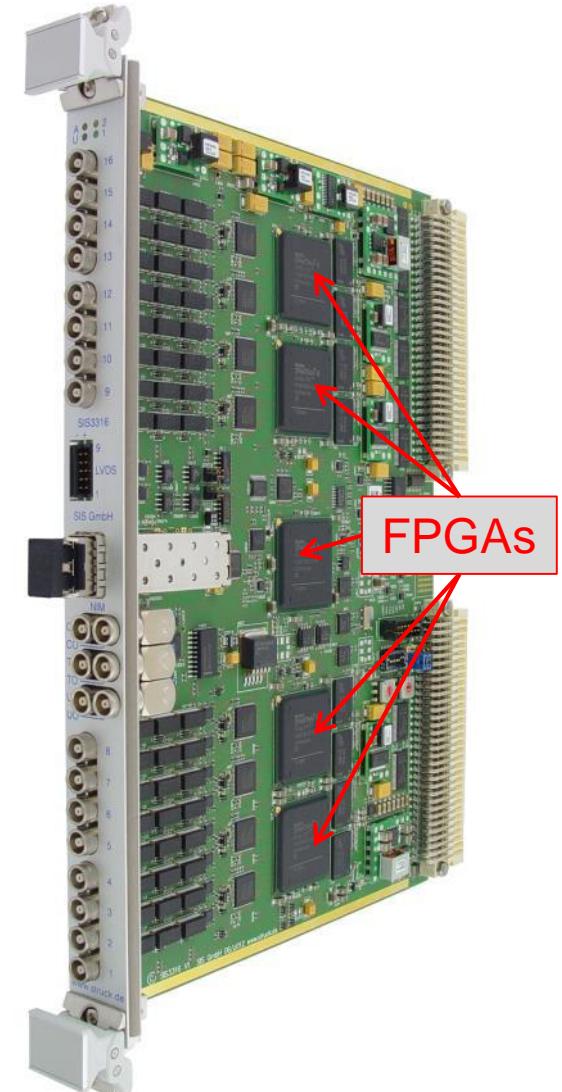
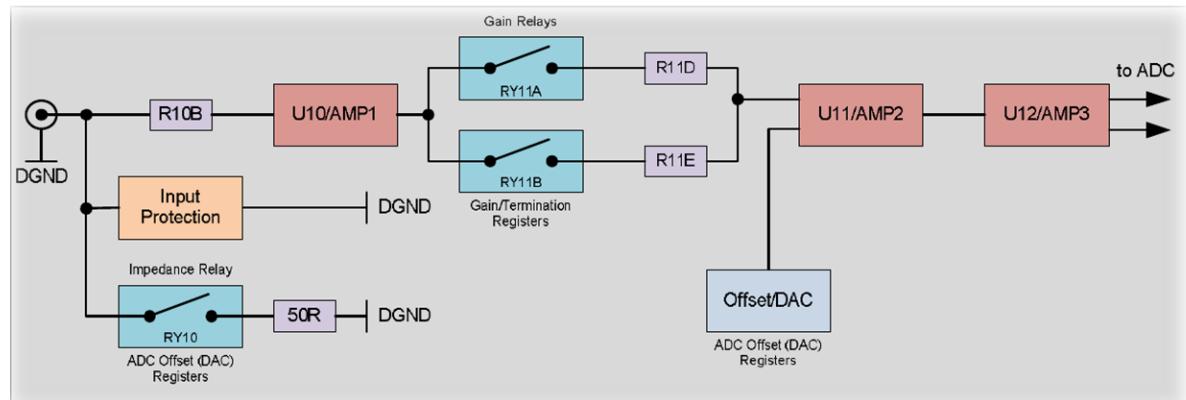
Polarimetry Overview: FADC



Struck SIS3316 FADC

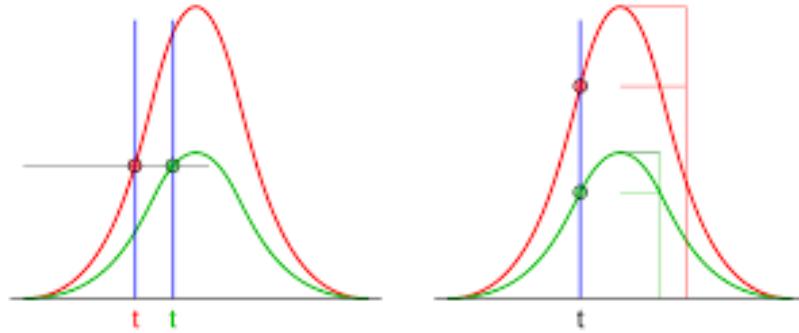


- 16 channels per module
- 250 MS/s per channel
- 125 MHz analog bandwidth
- 14-bit resolution
- Offset DACs
- Internal/External clock
- Readout in parallel to acquisition
- **Capable of working in a chain**
- Built-in hardware features (Pile-up detection, averaging and more)
- Self triggering

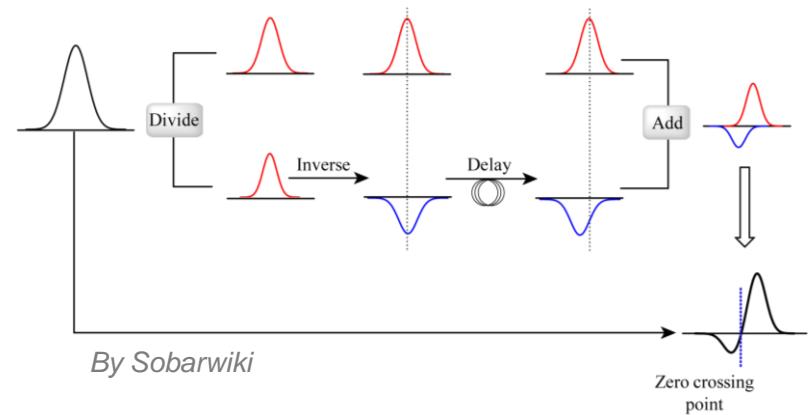


Struck SIS3316 FADC: Time Resolution

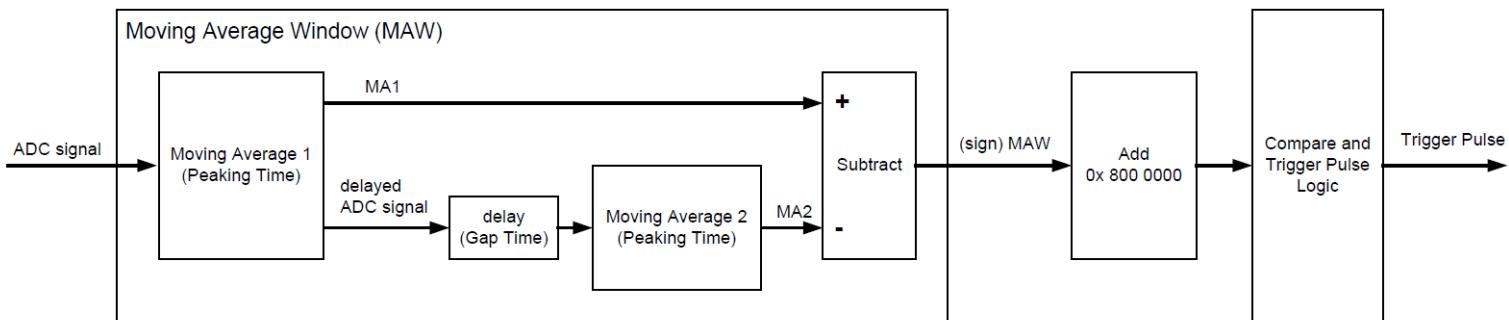
Amplitude threshold trigger vs CFD trigger



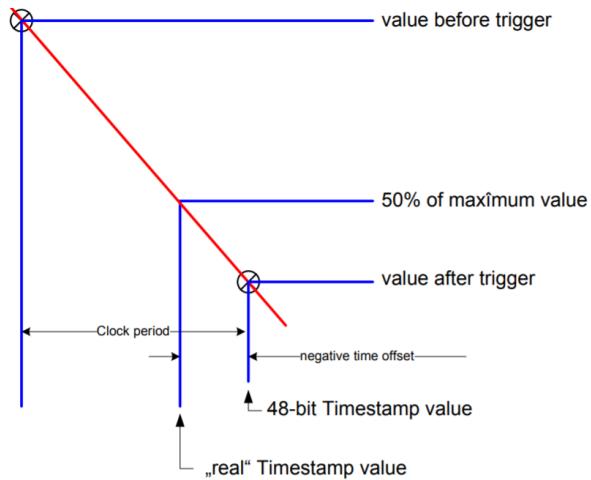
CFD Principle



CFD in FADC

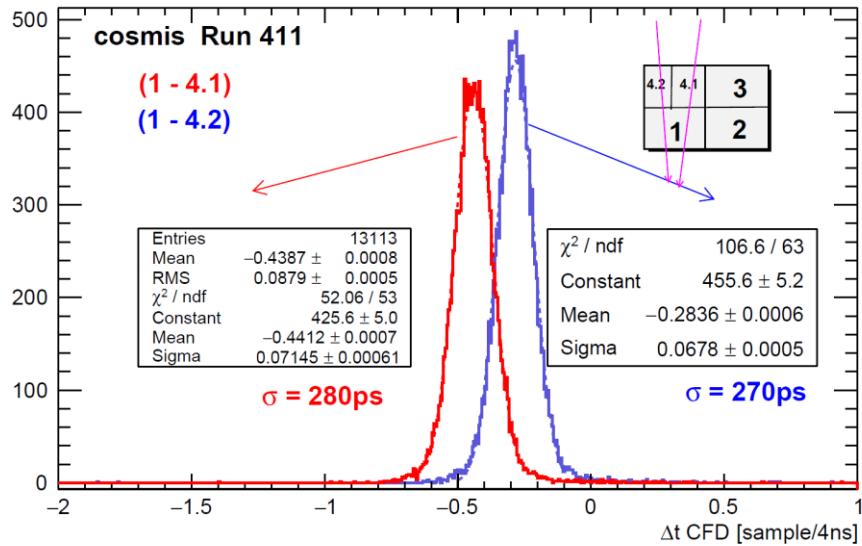


Struck SIS3316 FADC: Time Resolution

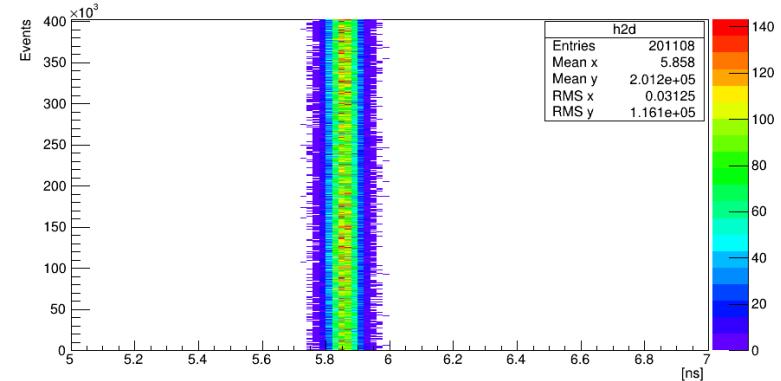
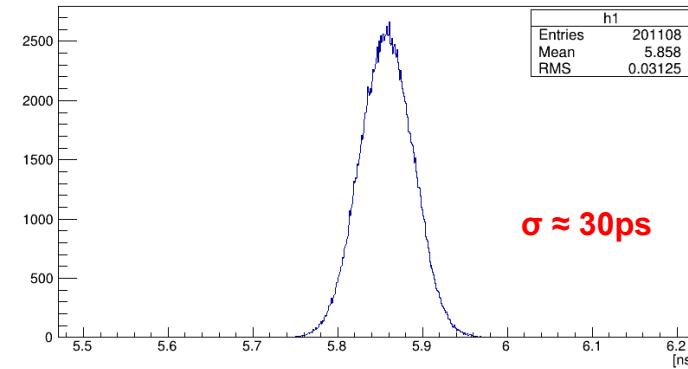


250 MS/s = 4 ns Timestamps

Cosmic Run with PMT & LYSO

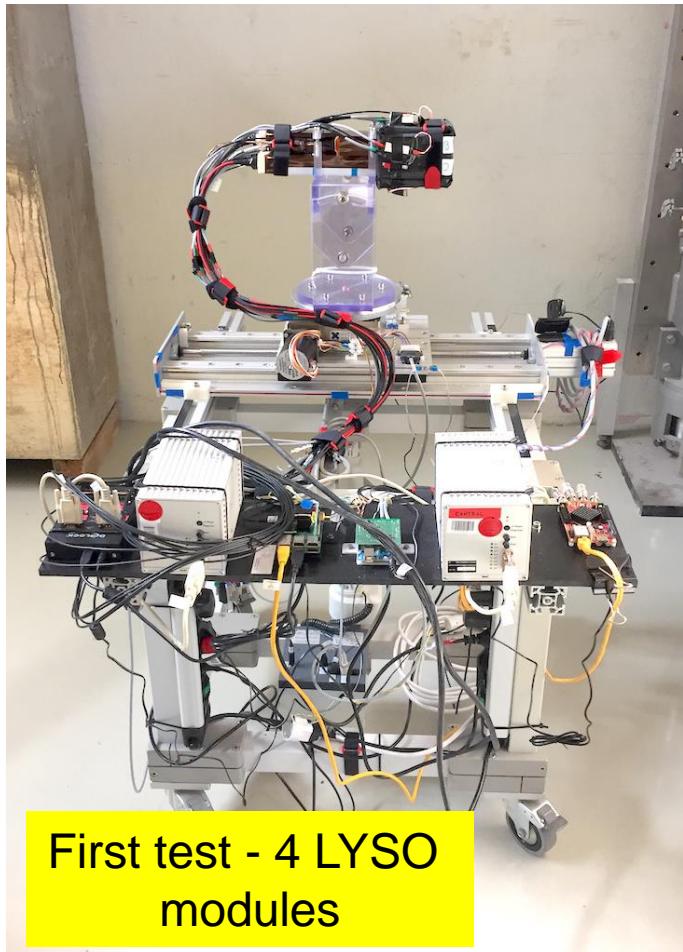


Signal delay in 1m BNC cable

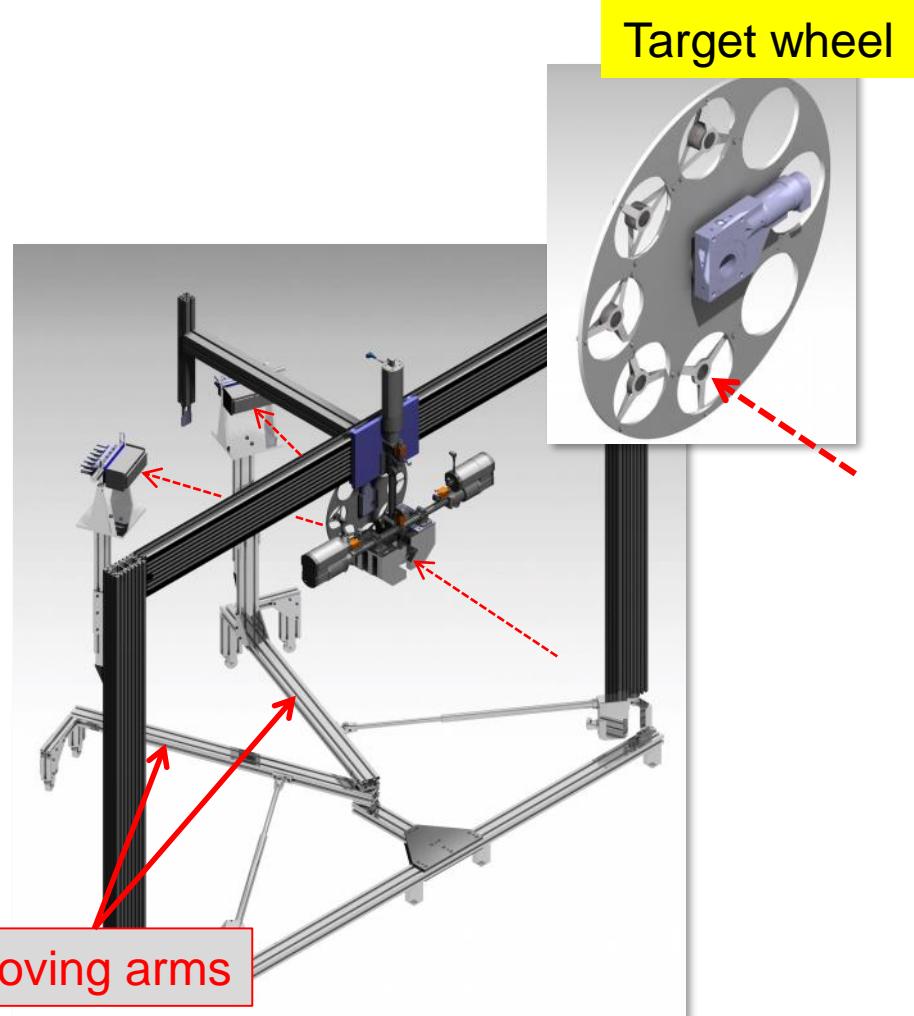


History of polarimetry

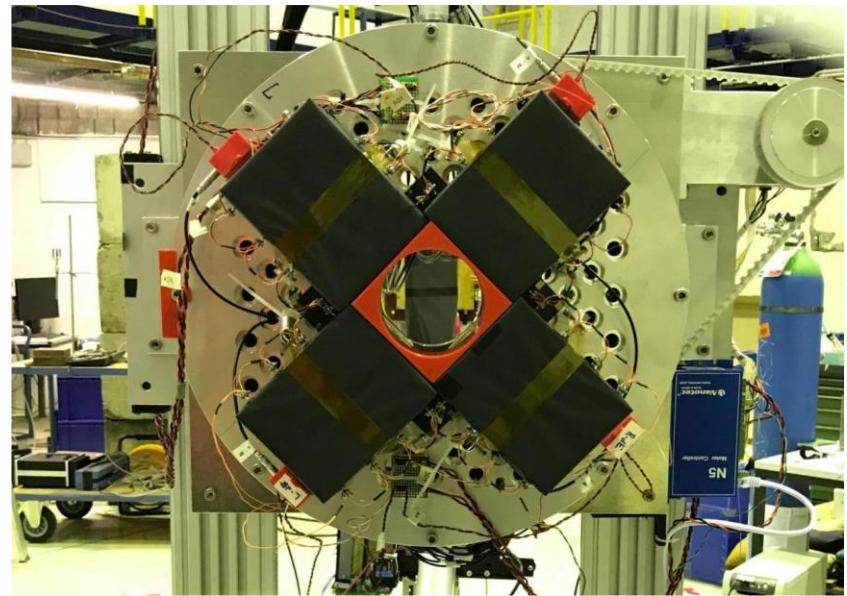
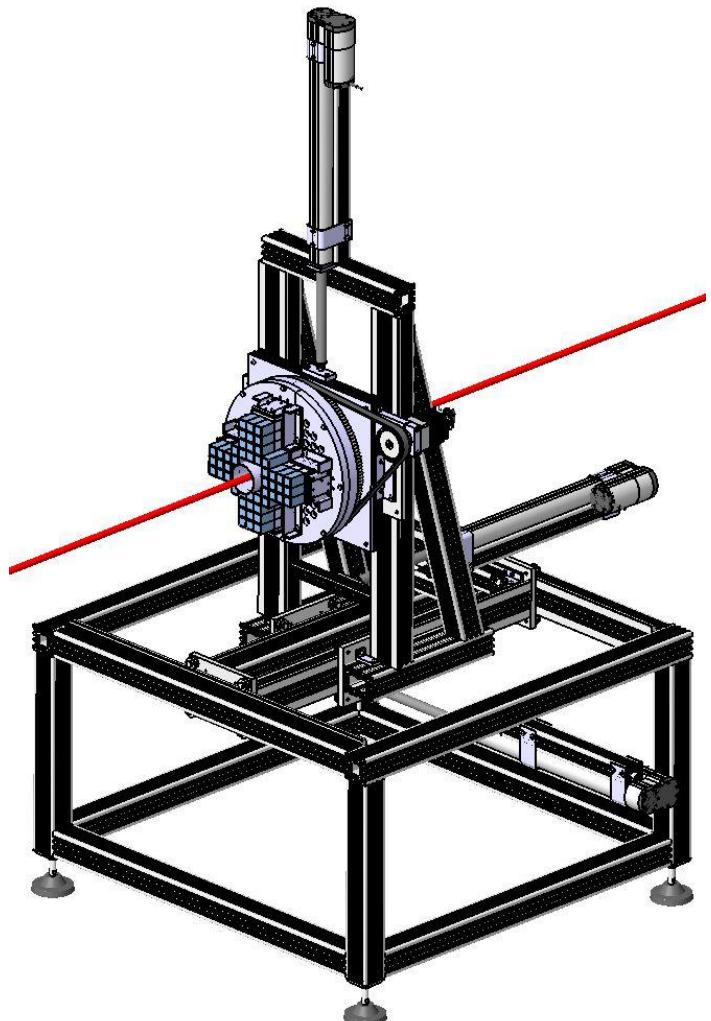
1st test with COSY beam



2nd Iteration

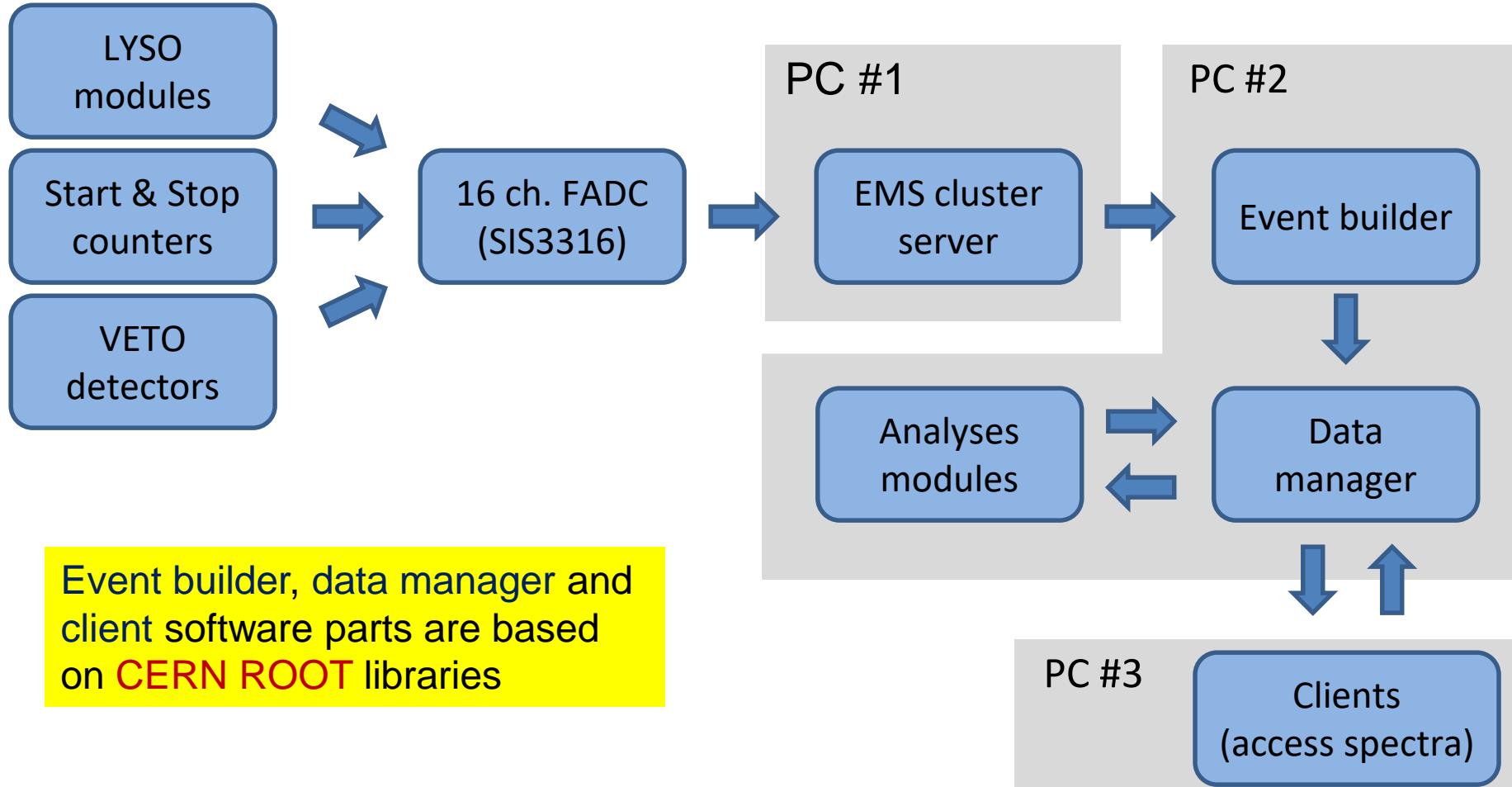


Current test setup

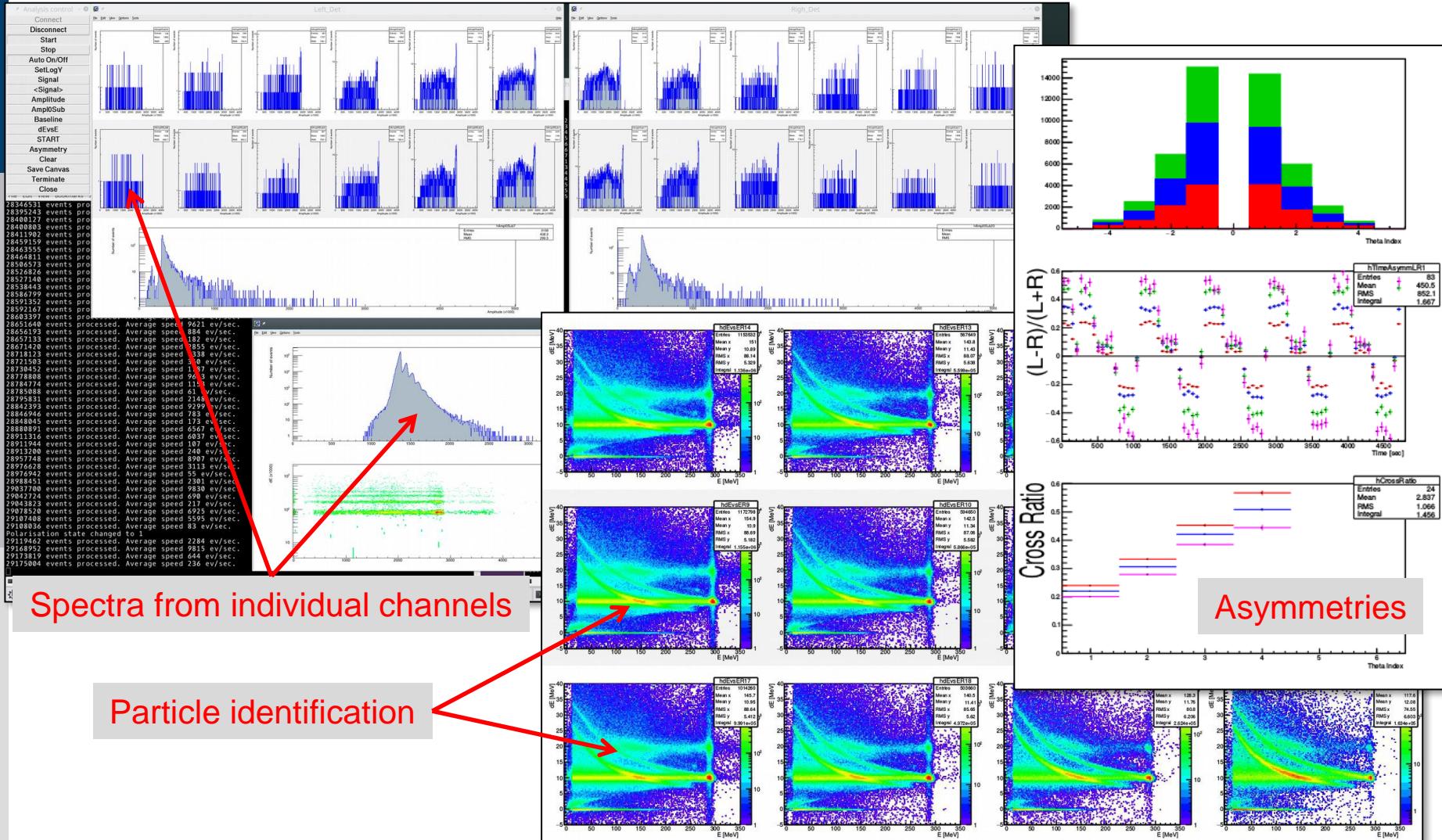
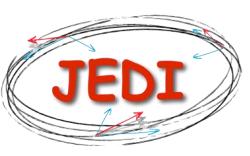


- Flench for up 120 LYSO modules
- X, Y, Z movement with rotation
- Temperature sensor
- Target wheel

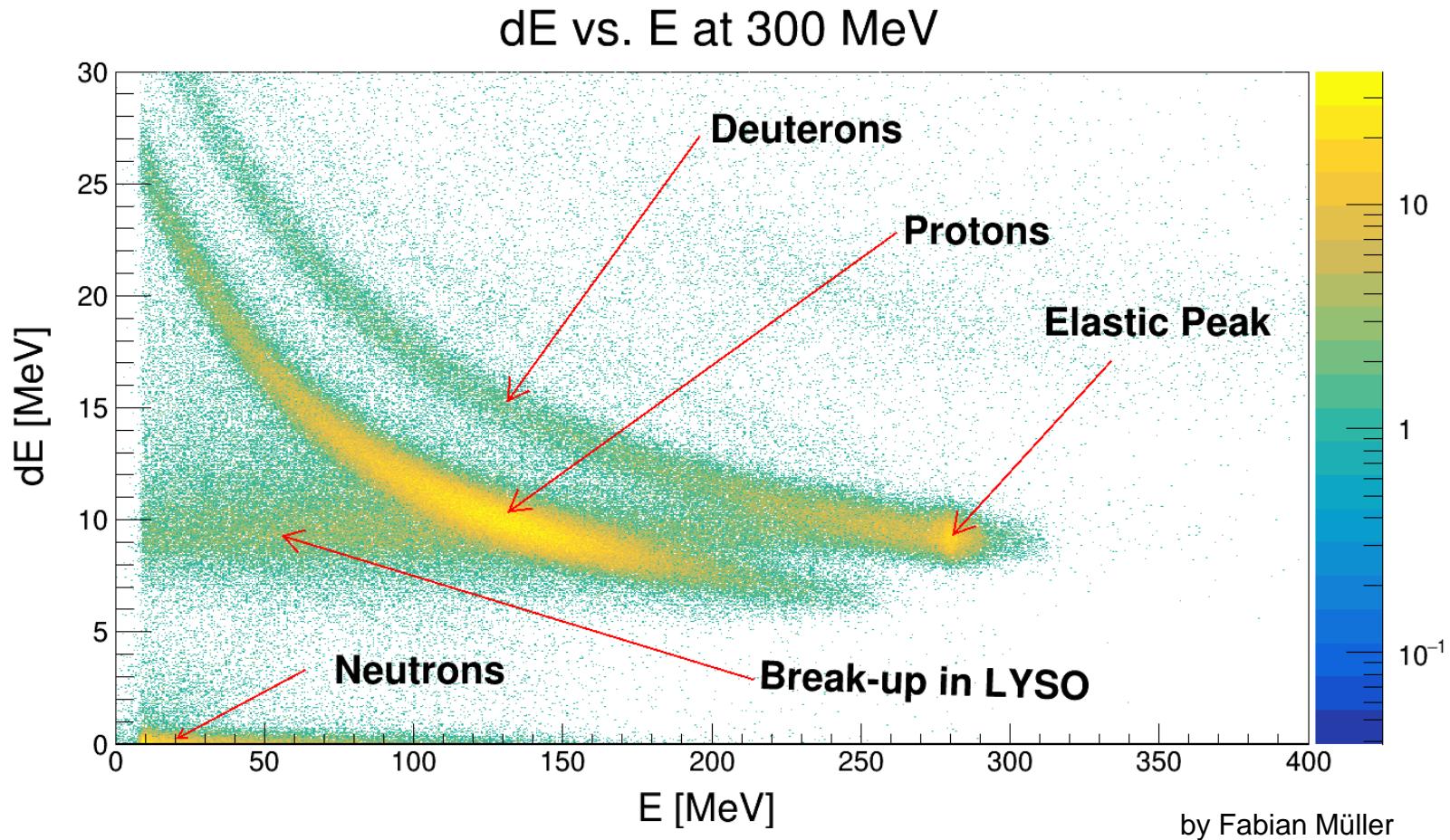
DAQ & online analysis



Online analysis results

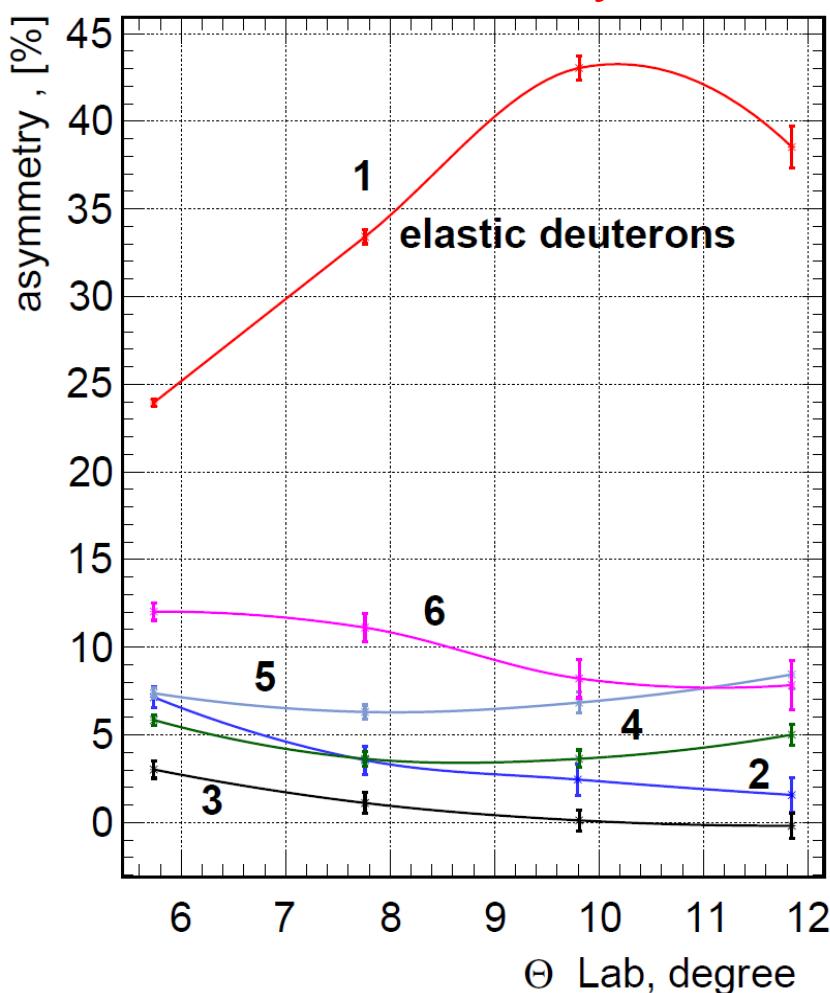
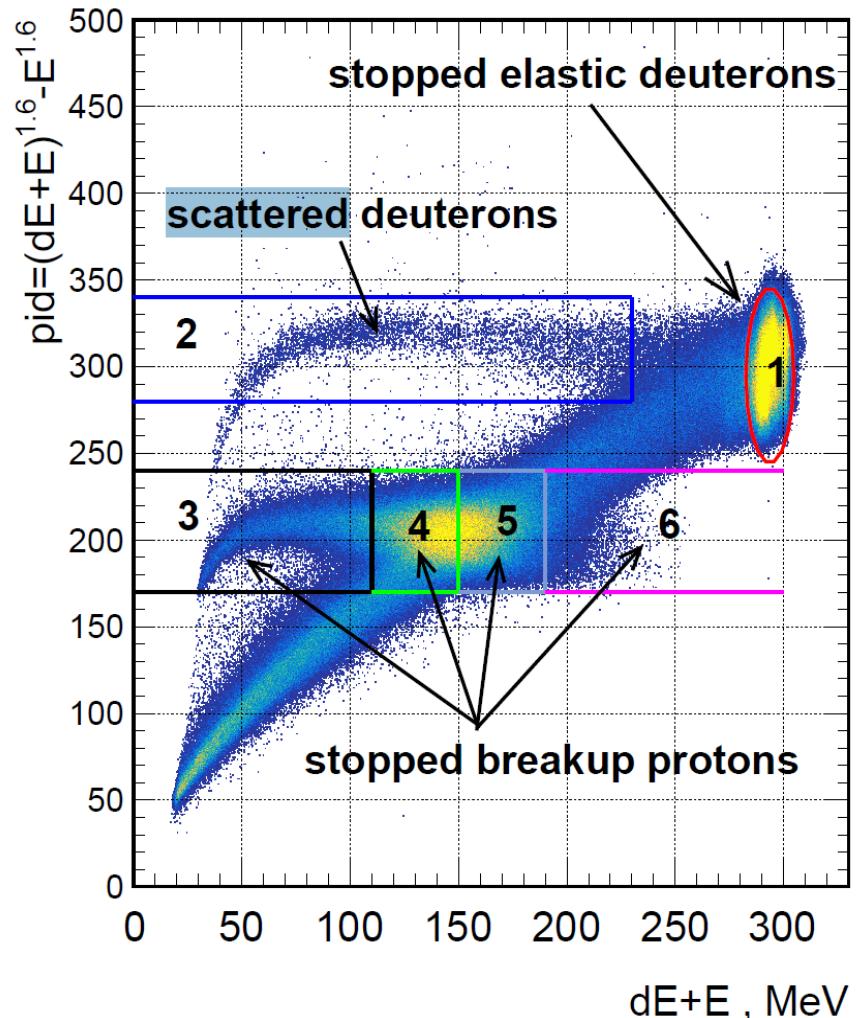


Particle Identification: Deuteron beam, carbon target



Particle Identification: Deuteron beam, carbon target

Preliminary!





Summary

- ✓ LYSO module assembling and testing procedure
- ✓ More than 50 module were assembled and tested successfully
- ✓ First version of 64 ch voltage supply built and tested
- ✓ Independent 128 ch voltage monitoring system developed – Data taken during recent test-experiments
- ✓ 5 successful beam times with extracted beam

Outlook

- Further SW/HW development: improve parallelism, implement new tracking system, create GUI interface, ...
- Installing the polarimeter on the COSY ring in 2019
- Building the pallet target chamber

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