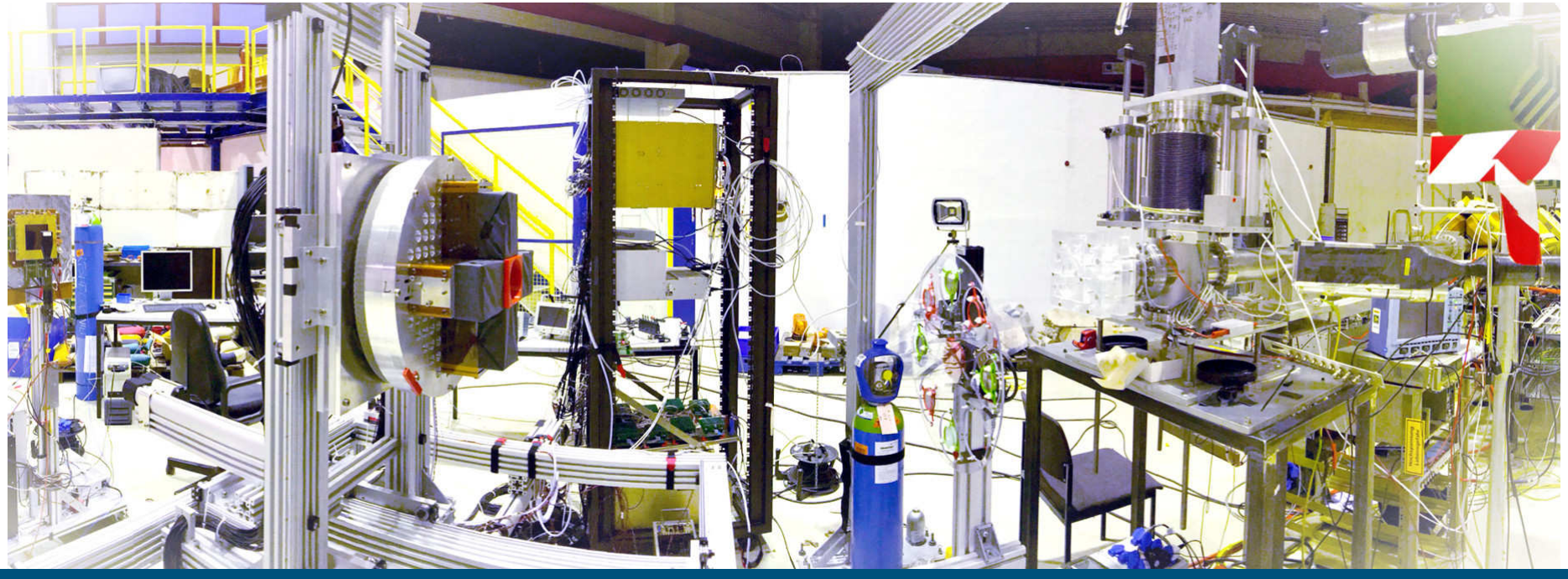


A NEW APPROACH: LYSO BASED POLARIMETRY FOR THE EDM MEASUREMENTS

Speaker: I. Keshelashvili

CALOR 2018 — University of Oregon, Eugene

OUTLINE

- Mission of ***Polarimetry***

  challenges for srEDM case

- **COSY** Accelerator Facility

  Spin gymnastic & operating polarimeters

- New Polarimeter Concept

  dedicated polarimeter for srEDM experiment

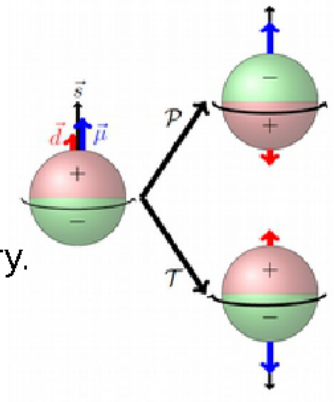
- Experimental Results

  4 beam time since CALOR 2016

- Summary

ELECTRIC DIPOLE MOMENT
of the elementary particles

In the **SM**, the **CP** violation originates from the complex phase in the Cabibbo-Kobayashi-Maskawa (***CKM***) matrix,
which couples the quarks' weak and the mass eigenstates, and the θ term in the QCD Lagrangian.



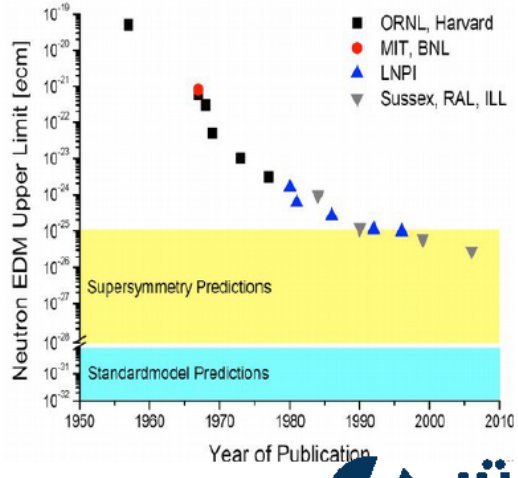
CP (K^o decays) violation means **T** is also violated assuming **CPT** symmetry.
The existence of a non-zero EDM is a violation of P and T simultaneously & the search for a EDM is a search for **CP** violation and a search for **direct T** symmetry violation.

SM CP violation is enough to explain what has been observed in the *K & B* meson systems but orders of magnitude smaller than observed in the universe

$$\eta = \frac{N_B - N_{\bar{B}}}{N_\gamma} = \sim 10^{-18}(SCM) \sim 6 \cdot 10^{-10}(BAU)$$

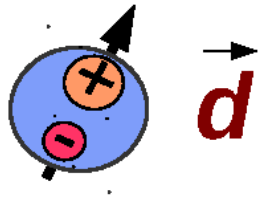
1967: Sacharov conditions for the Baryon Asymmetry of the Universe
1) At least one N_B violating process.
2) C and CP violation
3) Interactions outside of thermal equilibrium.

*Measurement of the non zero **EDM** → physics beyond **SM***



STORAGE RING – EDM

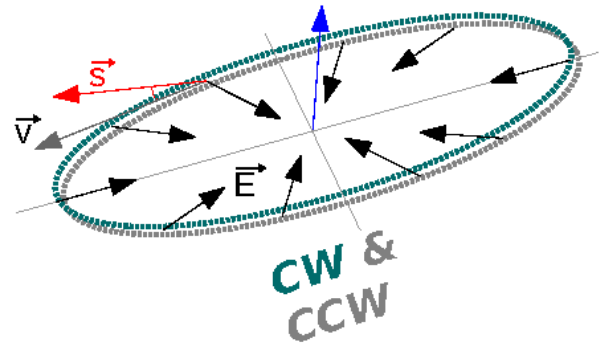
method differs strongly from nEDM



$\vec{d}$

For all ***EDM*** experiments
Interaction of ***d*** with ***E***
is necessary!

$$\frac{d\vec{s}}{dt} \propto d \cdot \vec{E} \times \vec{s}$$



a) Store longitudinally polarized ***protons***

b) Interact with a radial E-field

c) Analyze Polarization Build-up (this talk)

build-up of vertical polarization $\vec{s}_{\perp} \propto |d|$

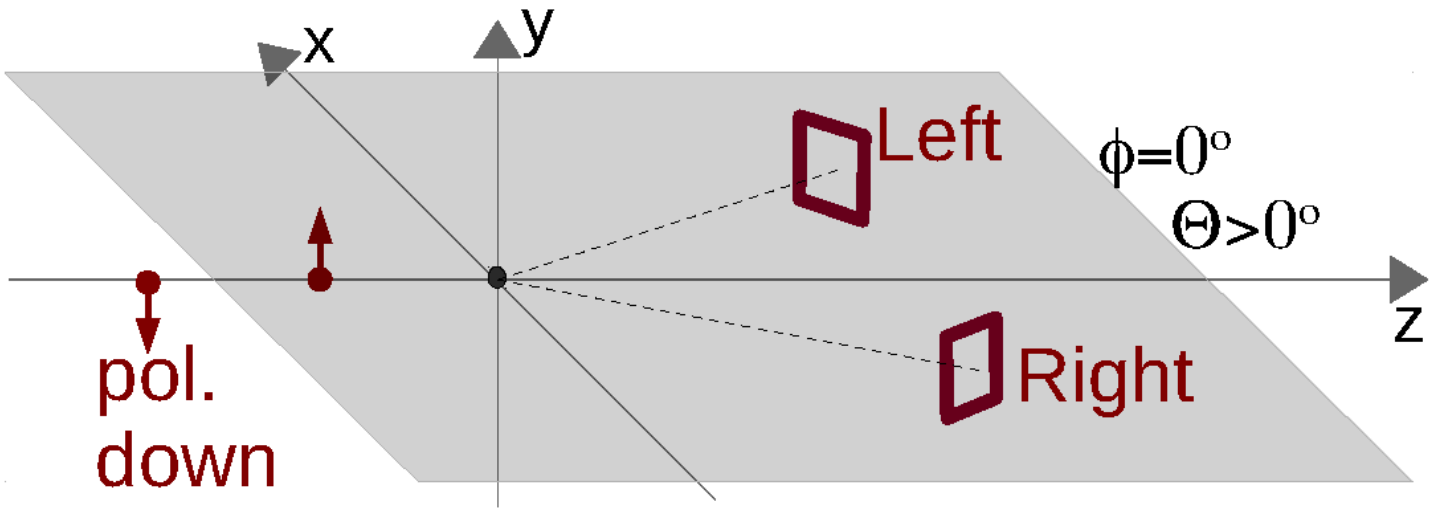
GENERAL FORMALISM

$$PA_y(\theta) = \frac{\sigma^L(\theta) - \sigma^R(\theta)}{\sigma^L(\theta) + \sigma^R(\theta)} \approx \frac{N^L(\theta) - N^R(\theta)}{N^L(\theta) + N^R(\theta)} \text{ – between } -1 : 1$$

$$\sigma^{\mathbf{pol}}(\theta, \phi) = \sigma_0(\theta)[1 + \tfrac{3}{2} PA_y(\theta) \cos\phi \quad + \{\tfrac{1}{3} \sum P_{ii} A_{ii}\} \ ]$$

$$CR(\theta) = \frac{\sqrt{N^{L\uparrow} N^{R\downarrow}} - \sqrt{N^{R\uparrow} N^{L\downarrow}}}{\sqrt{N^{L\uparrow} N^{R\downarrow}} + \sqrt{N^{R\uparrow} N^{L\downarrow}}} \approx PA_y \text{ – known } A_y : \text{calculate } P$$

$$FOM(\theta) = \sigma A_y^2 \text{ – max. } FOM : \text{monitor } \frac{d\vec{s}}{dt}$$



POLARIMETER SETUP @ COSY

Internal and **external** beams

High **polarization** (***p, d***)

Spin manipulation !!!

Energy range (min.-- max.):

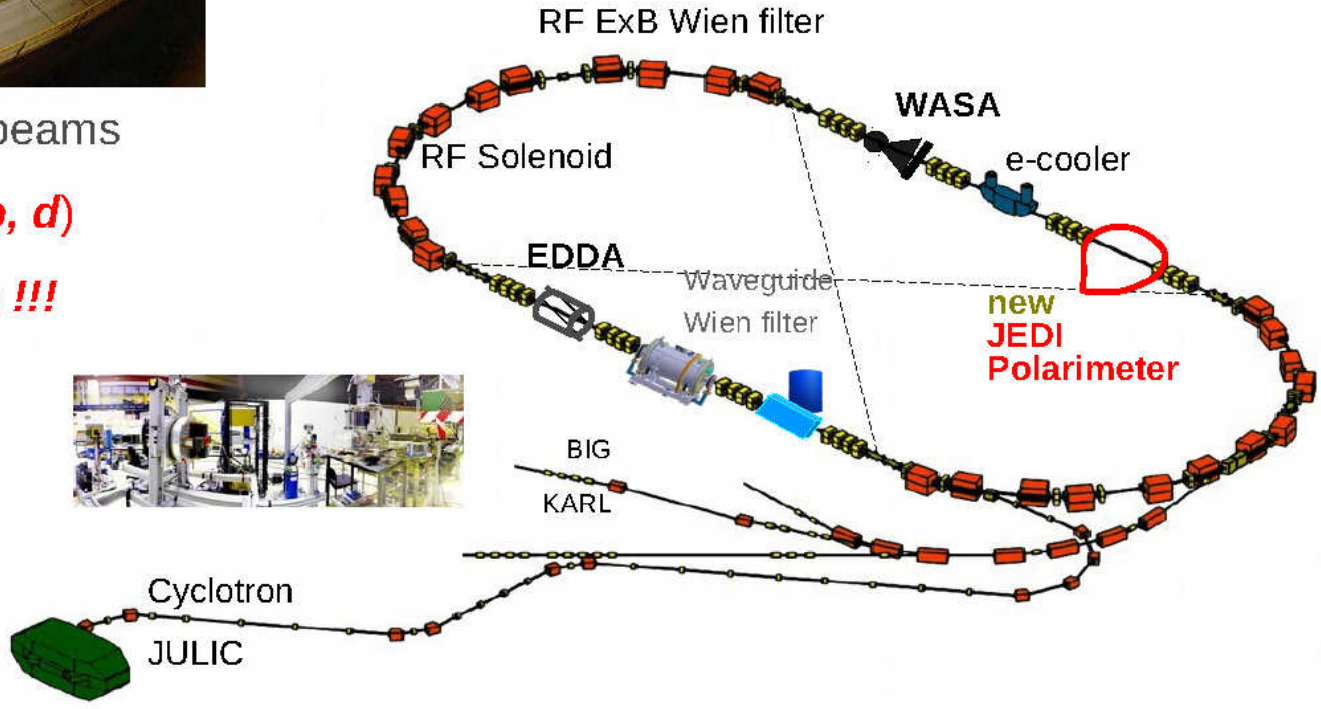
0.045 – 2.8 GeV (p)

0.023 – 2.3 GeV (d)

Max. momentum ~ **3.7 GeV/c**

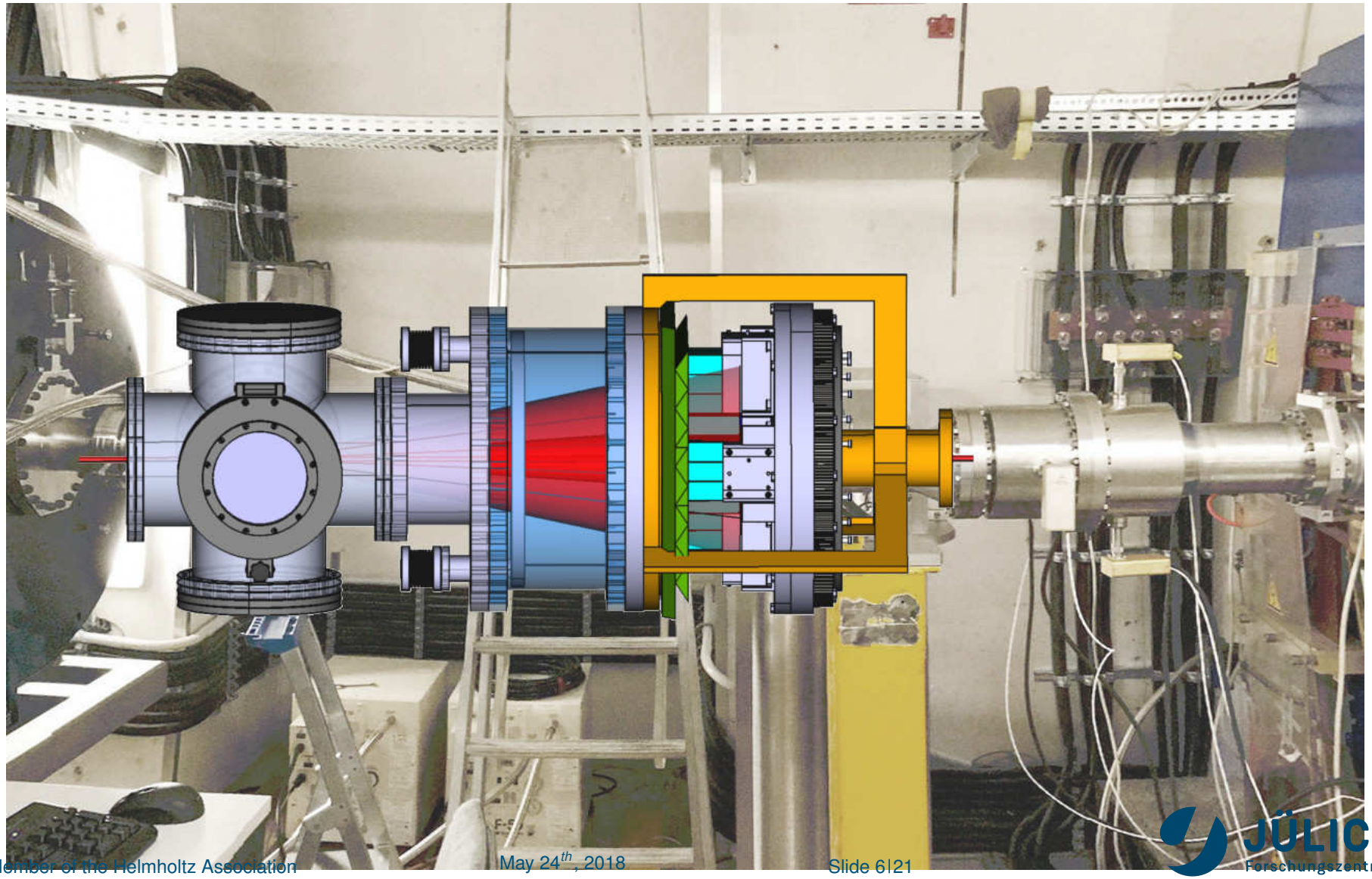
Electron & ***Stochastic*** cooling

Feed-forward machine



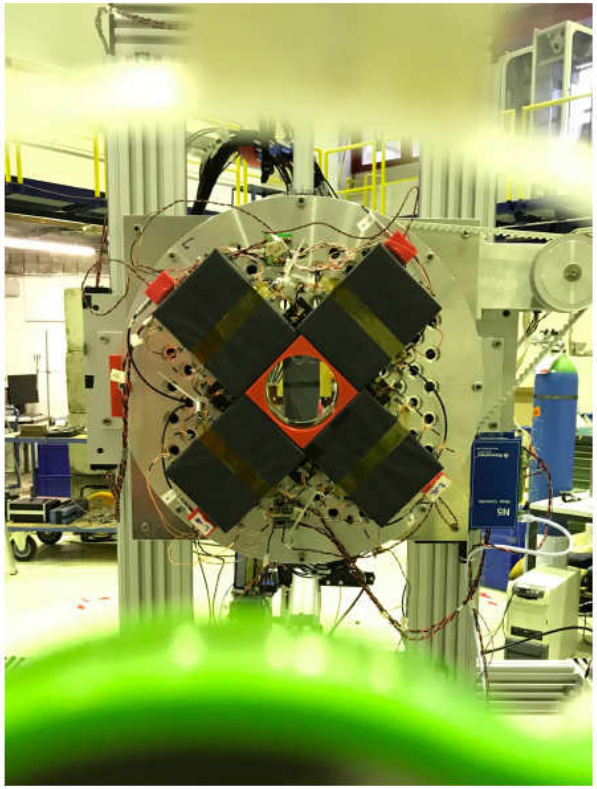
INTERNAL POLARIMETER

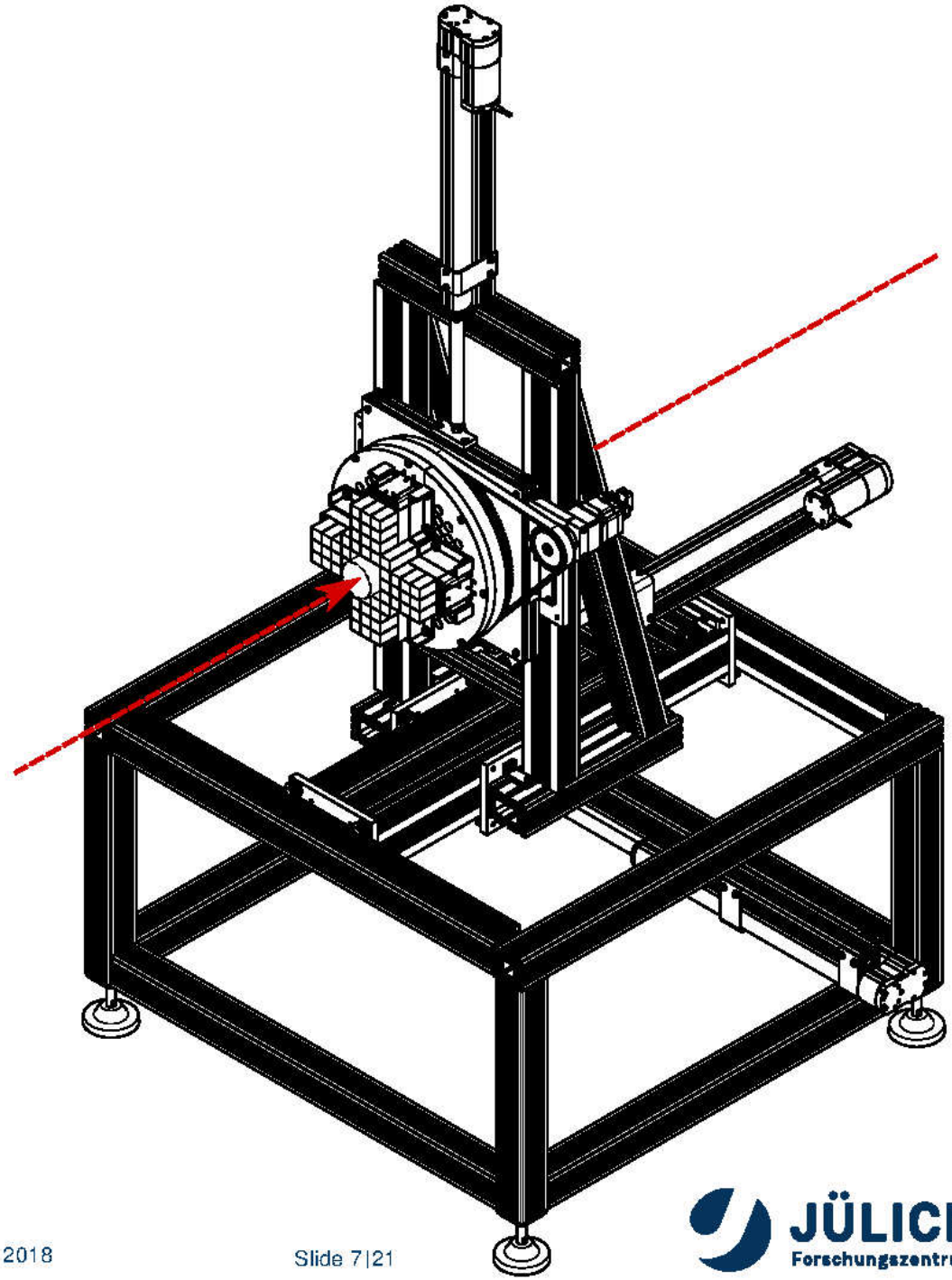
Prototype of the Calorimeter Part



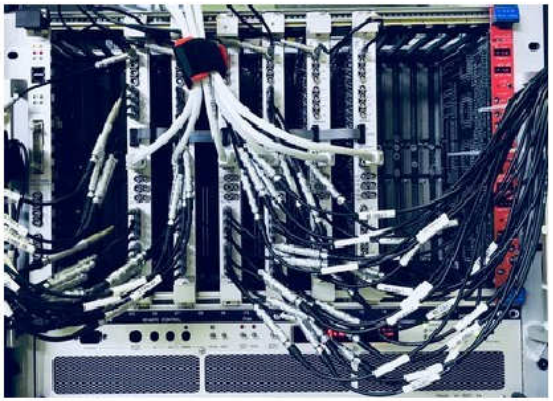
NEW SETUP

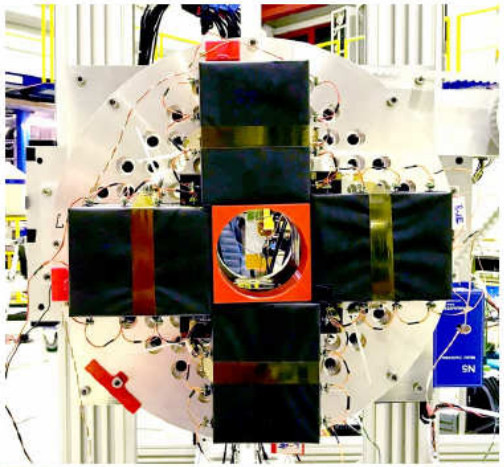
Test setup for polarimeter

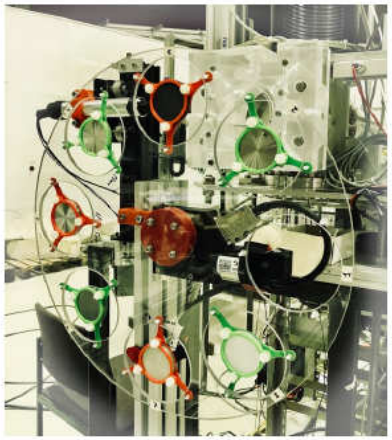


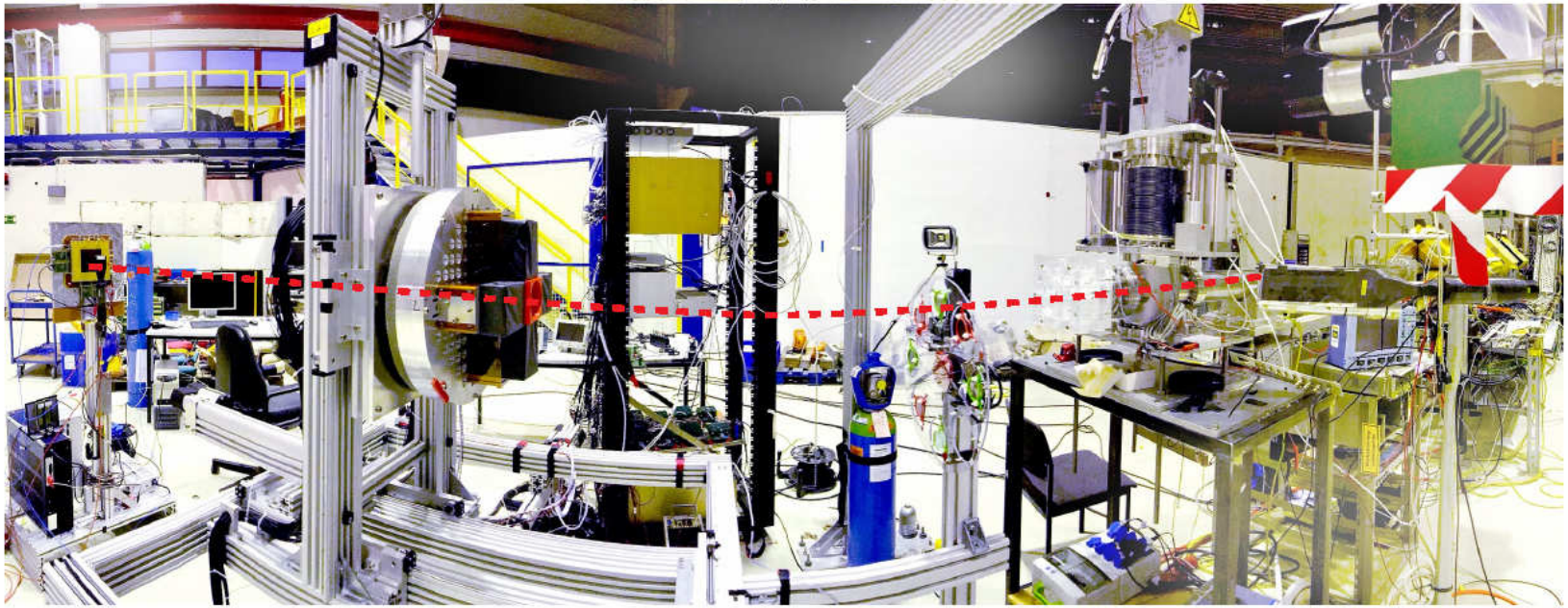


BIG KARL EXP. HALL

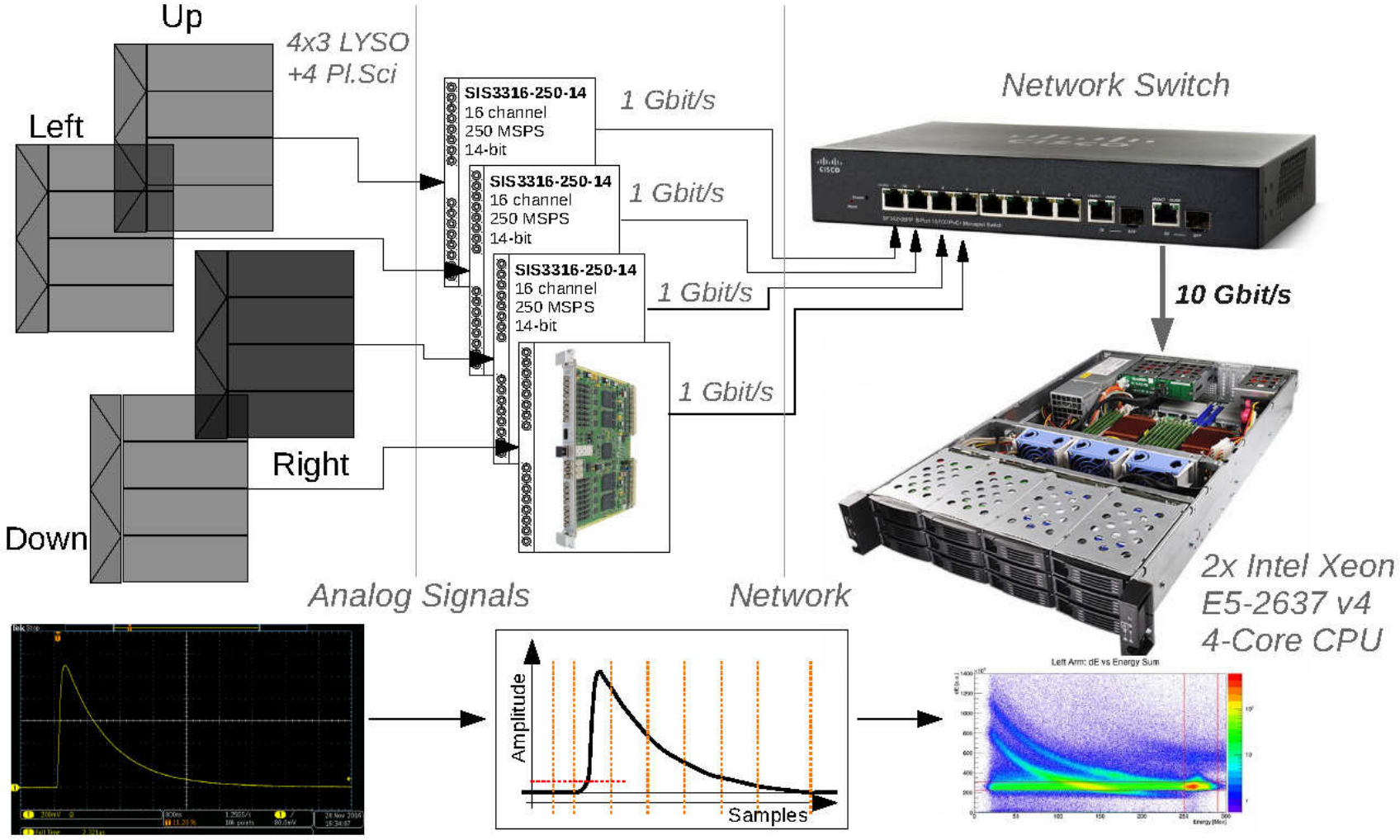






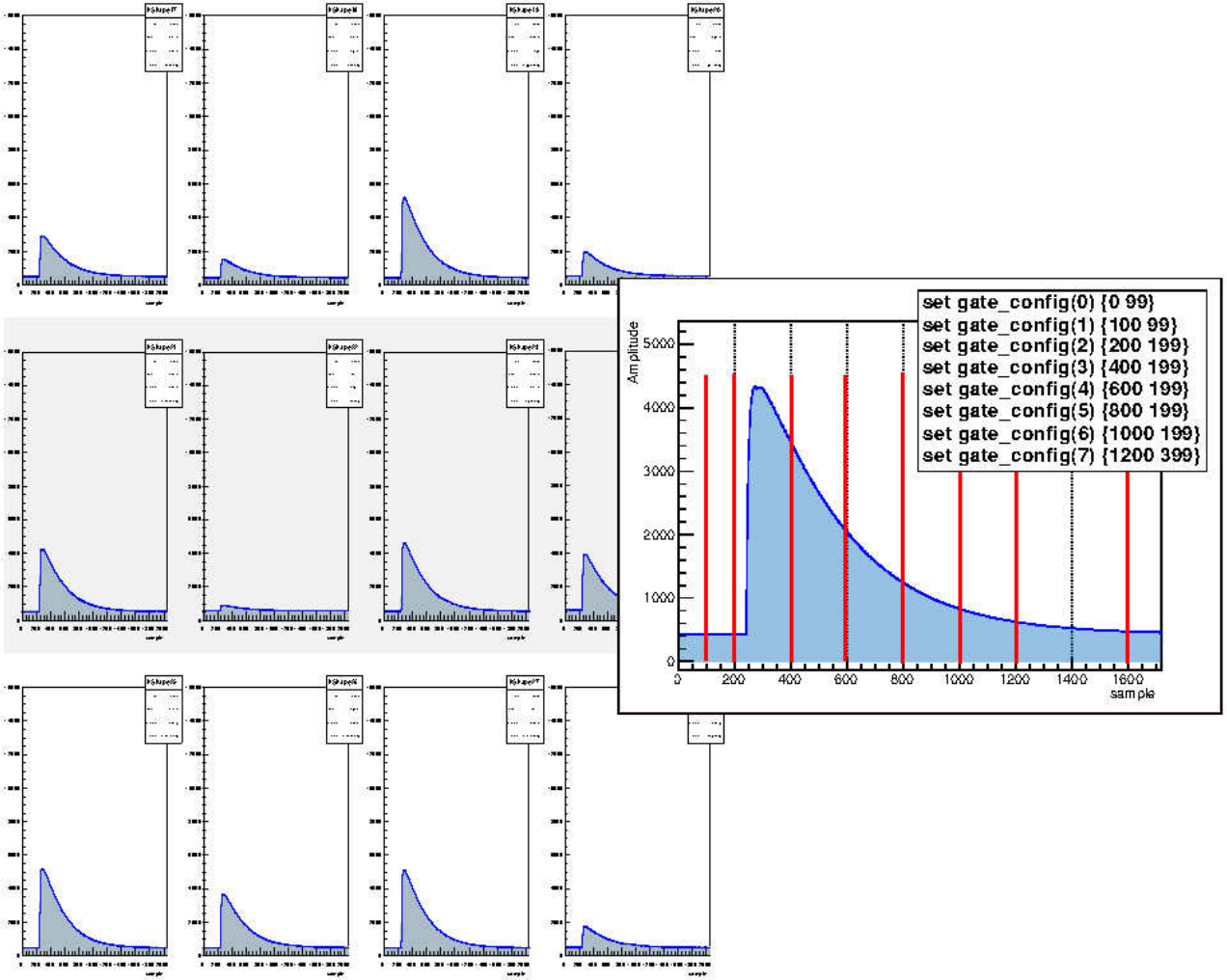


SADC BASED DAQ SYSTEM



SIGNAL SHAPES

Full signal shape vs 8 accumulator/integral region



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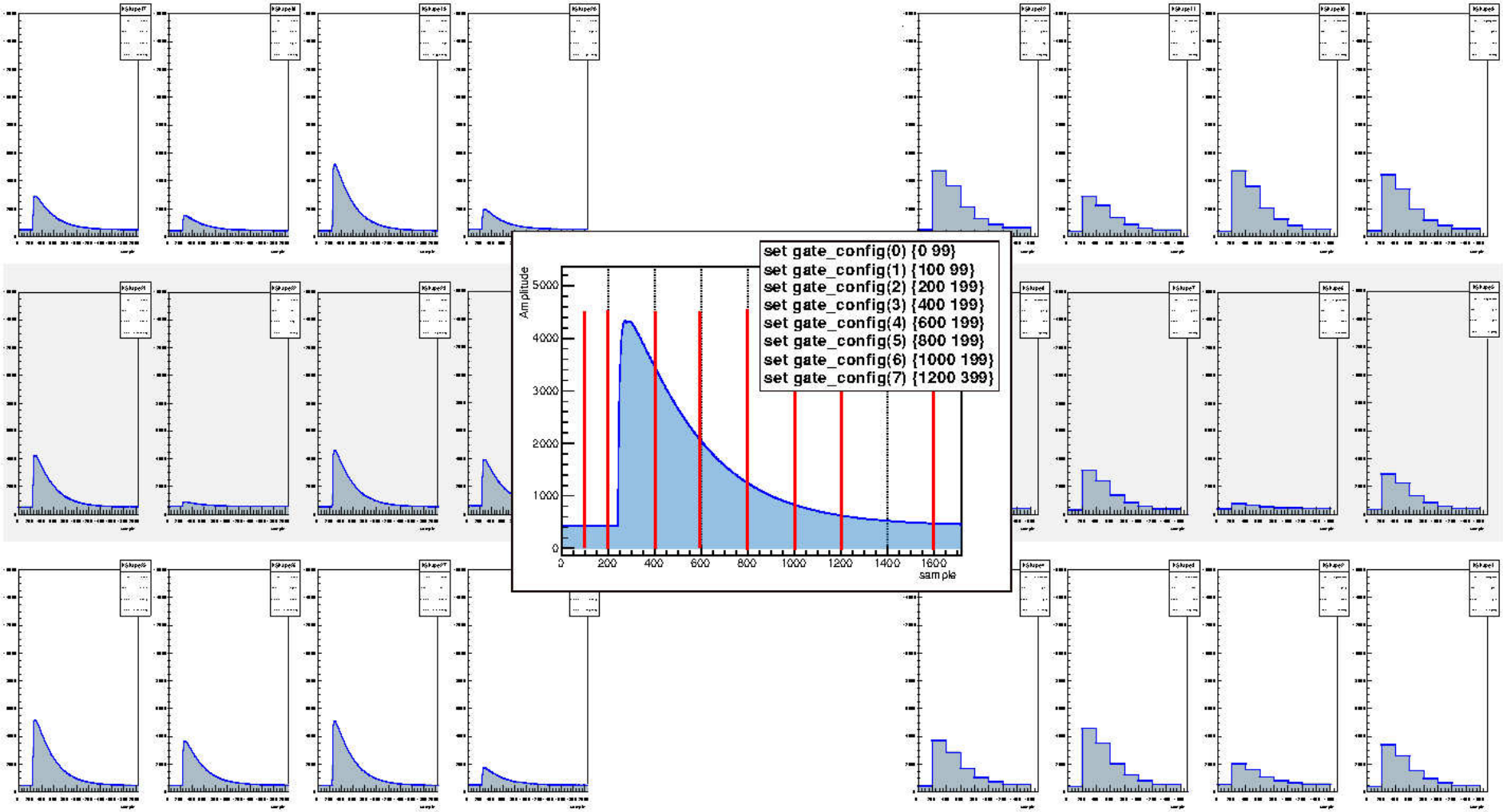
SIGNAL SHAPES

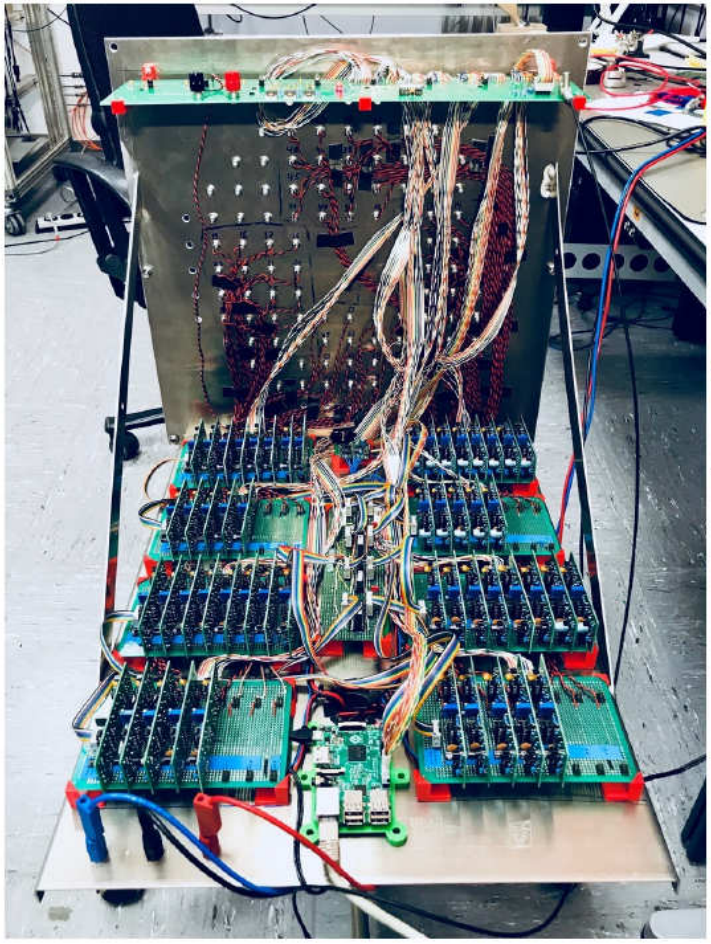
Full signal shape vs 8 accumulator/integral region

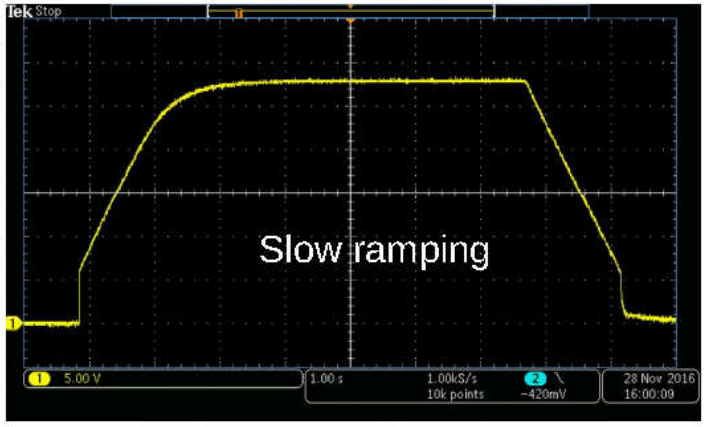


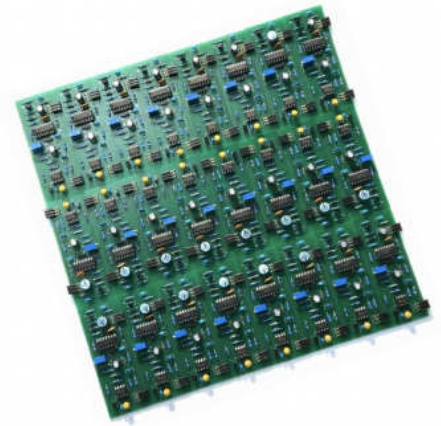
SIPM VOLTAGE SUPPLY

Very Good Long Term Stability $\sim 50\mu V_{pp}$

Entirely SmartLab and Agruni contribution

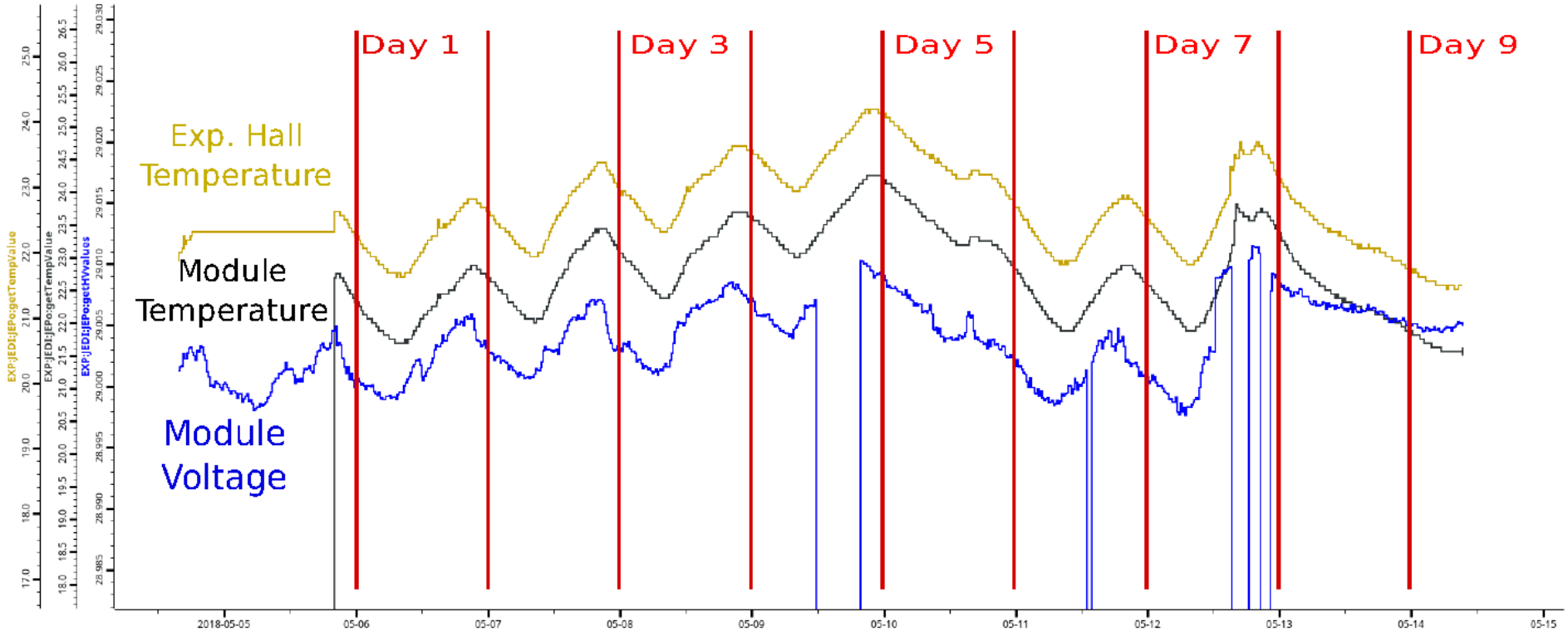






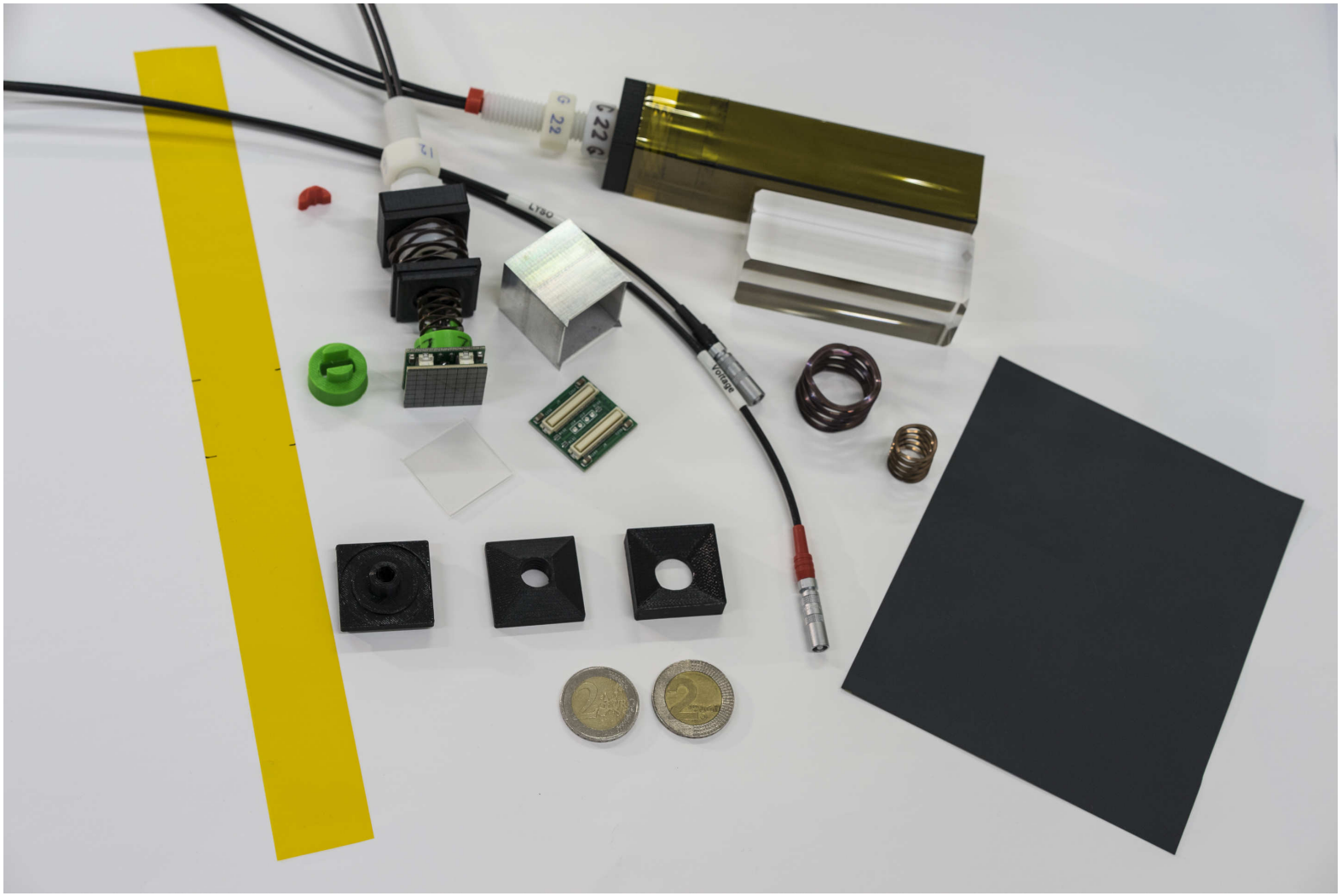
VOLTAGE MONITORING

Monitoring of all channels



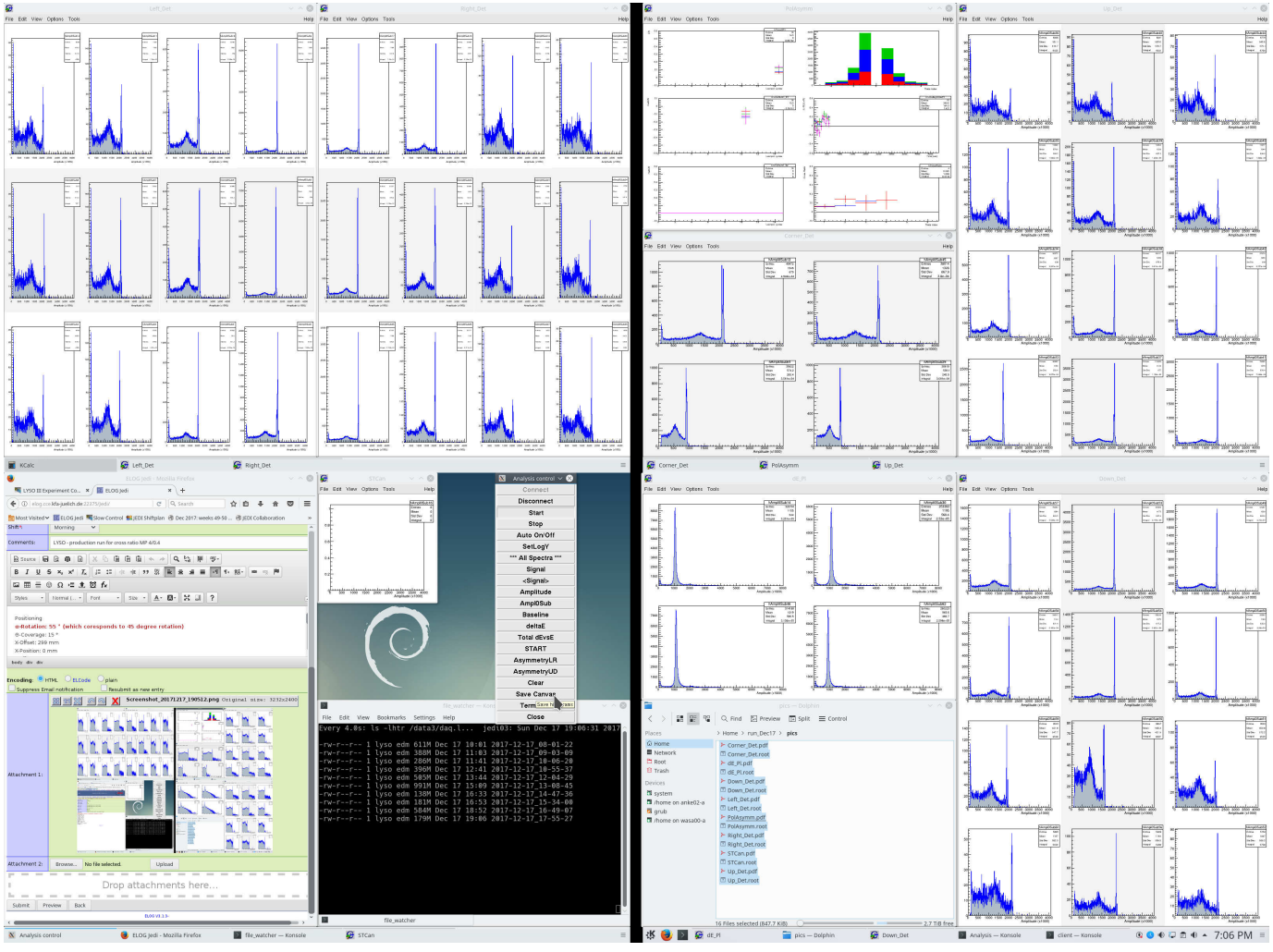
LYSO MODULE

New improved mechanics and electronic components



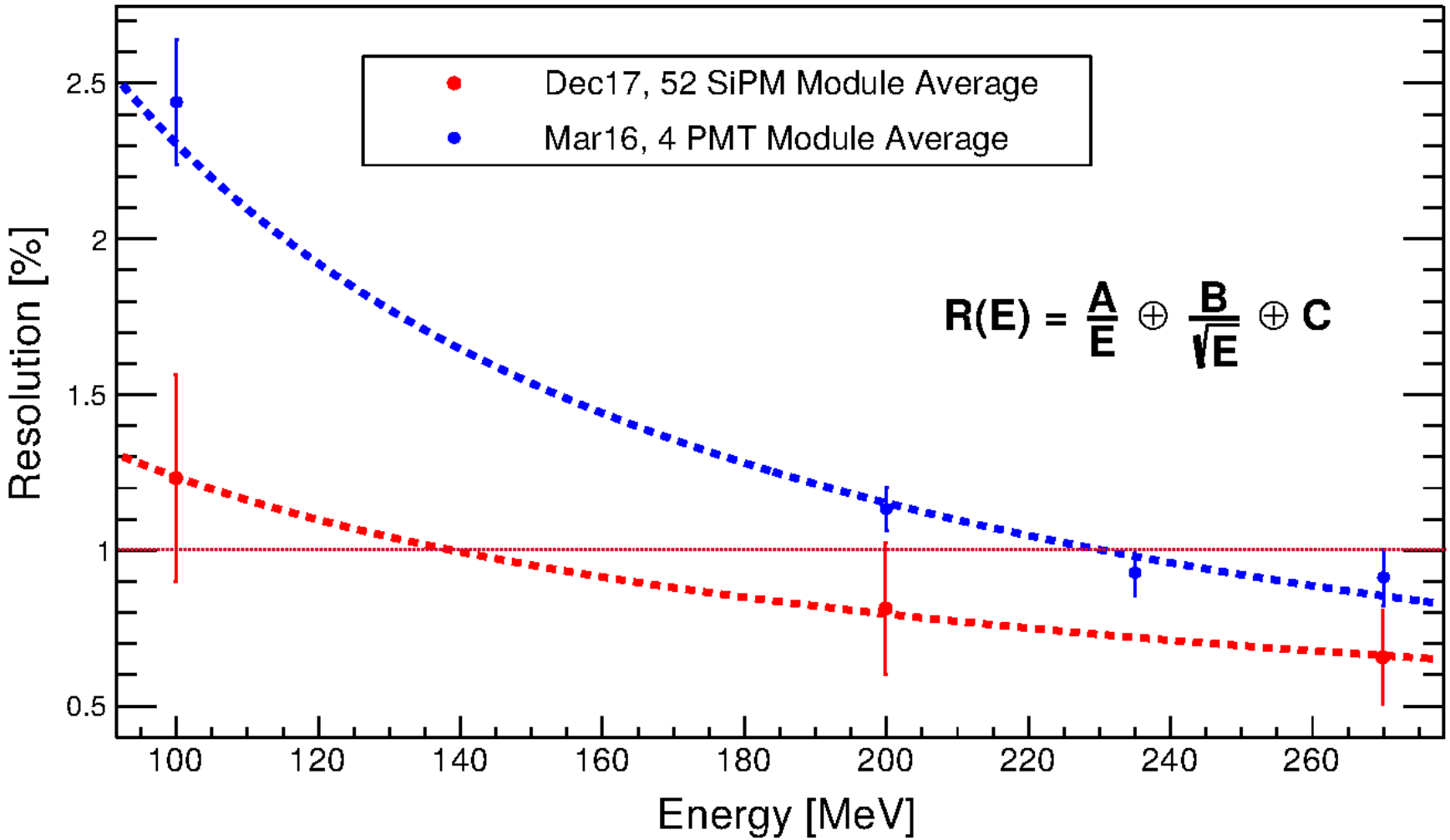
ONLINE MONITORING SYSTEM

Monitoring of all amplitudes



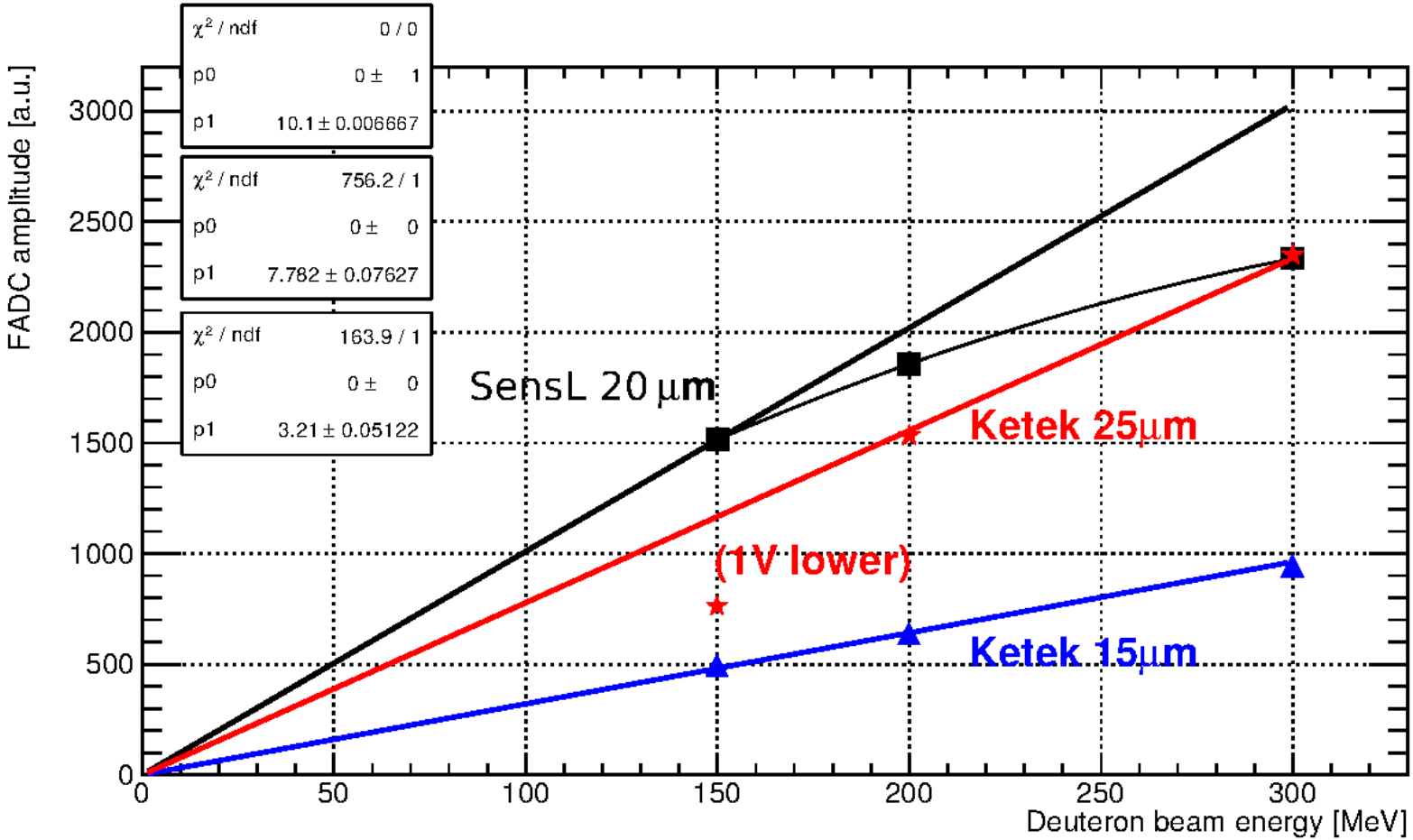
LYSO-SIPM RESOLUTION

from F. Mueller



LYSO-SIPM LINEARITY

from F. Mueller



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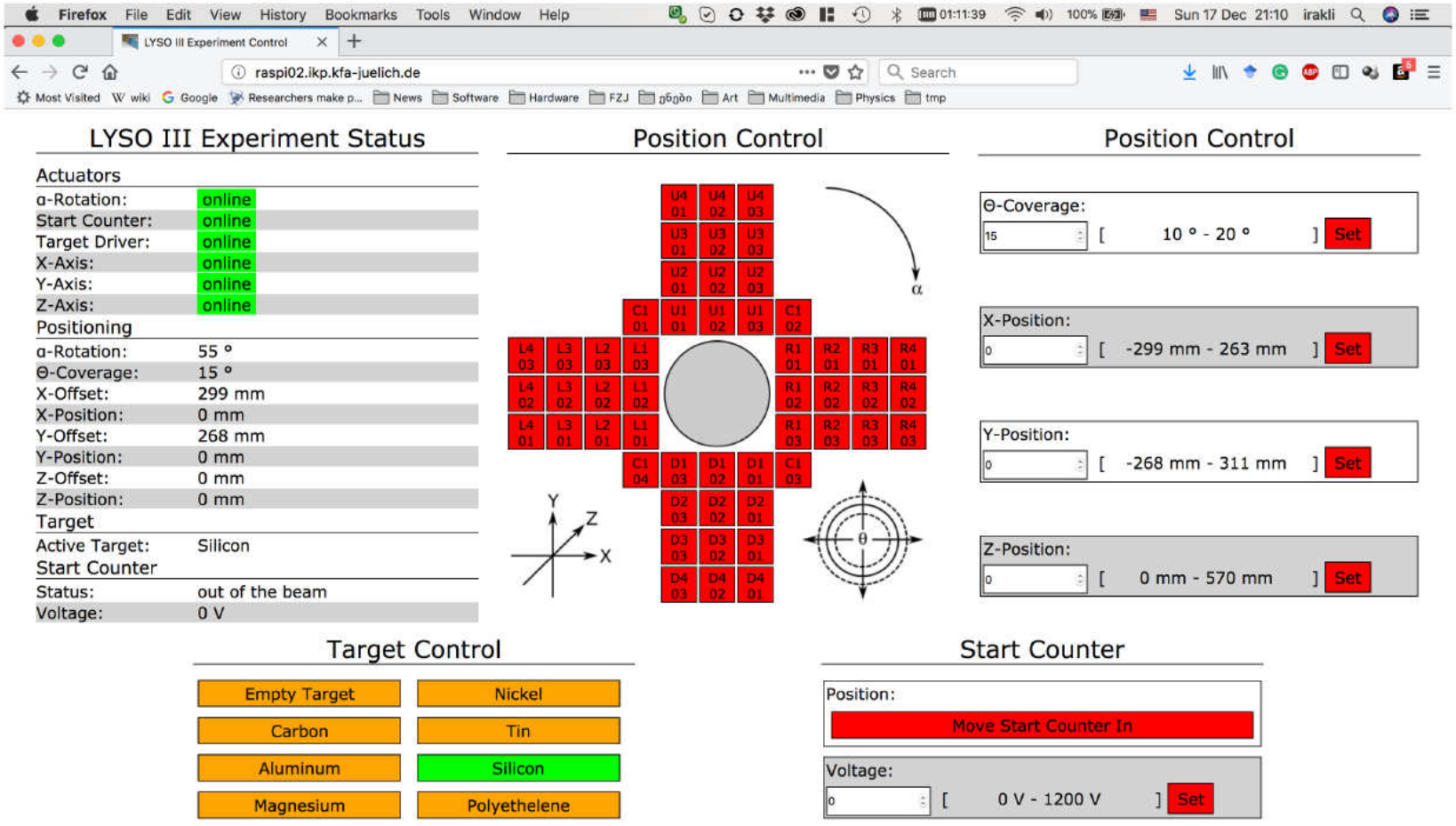
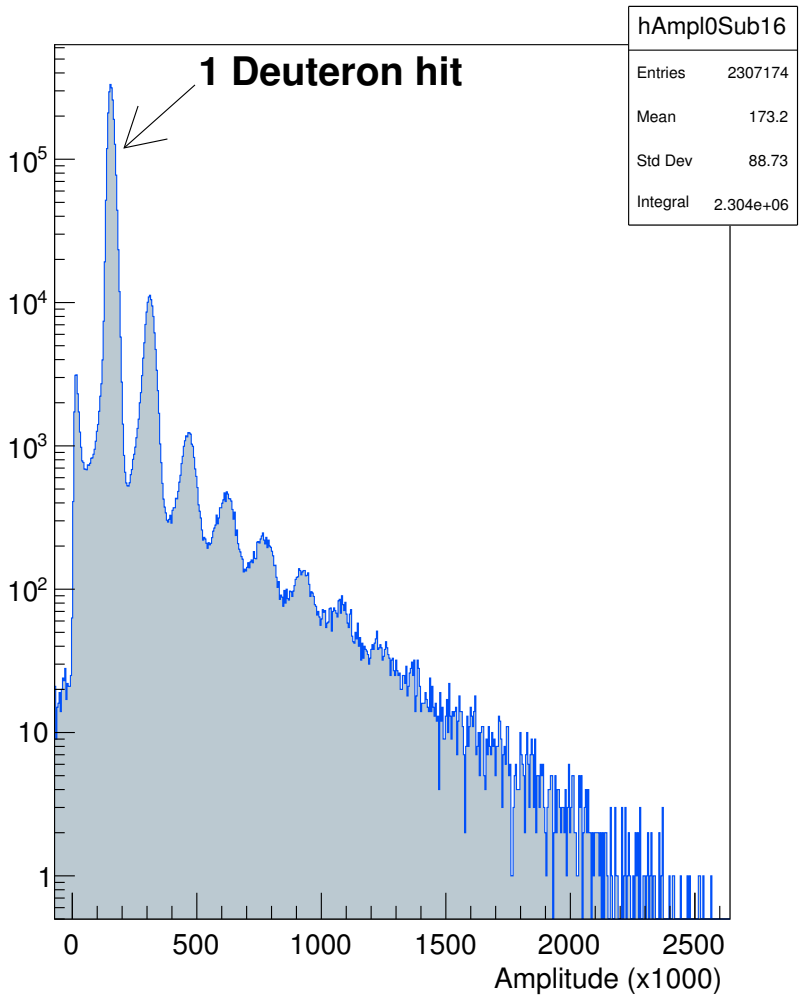
SLOW CONTROL SYSTEM

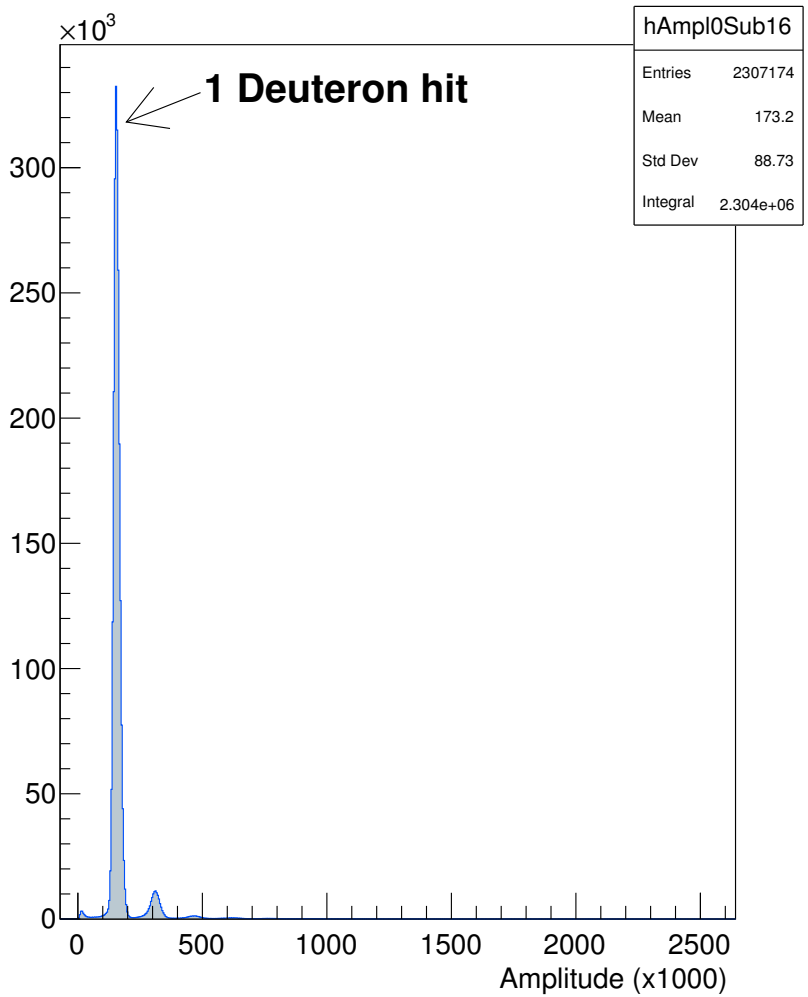
Controls all movements



START COUNTER

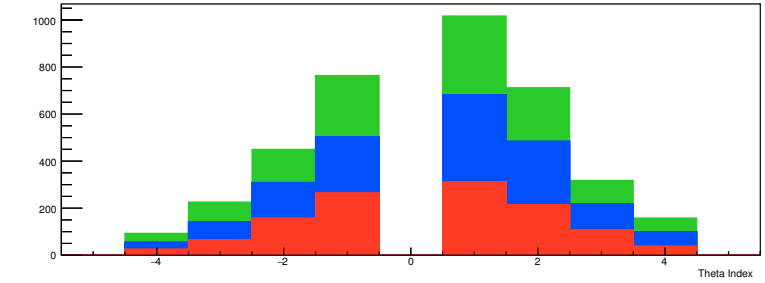
Clearly seen deuteron pile-ups

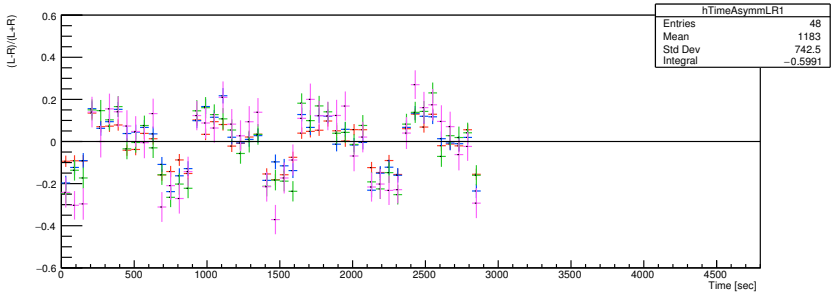


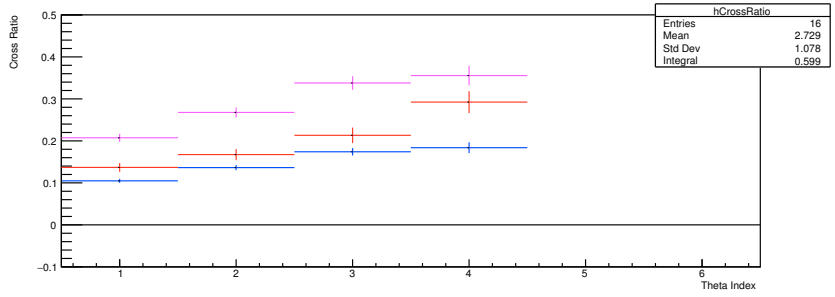


ASYMMETRY

Carbon at $\Theta_{max} = 10^o$ and $\Theta_{max} = 15^o$







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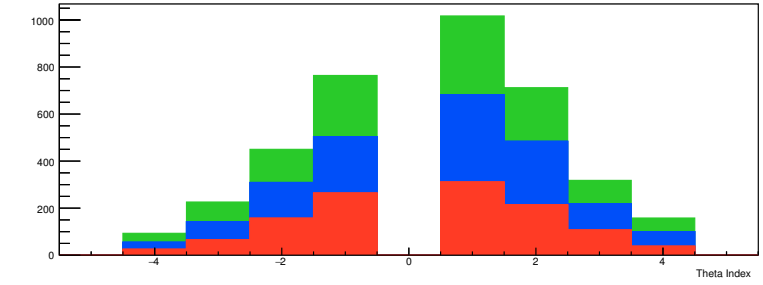
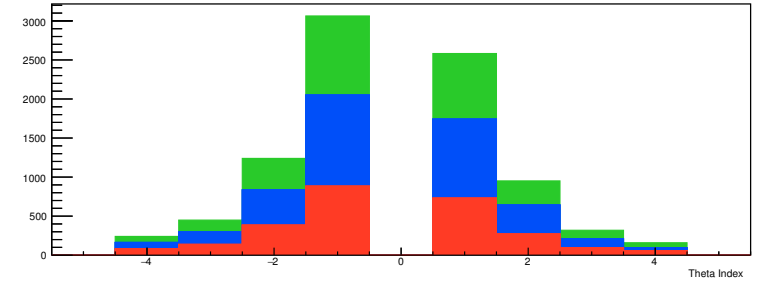
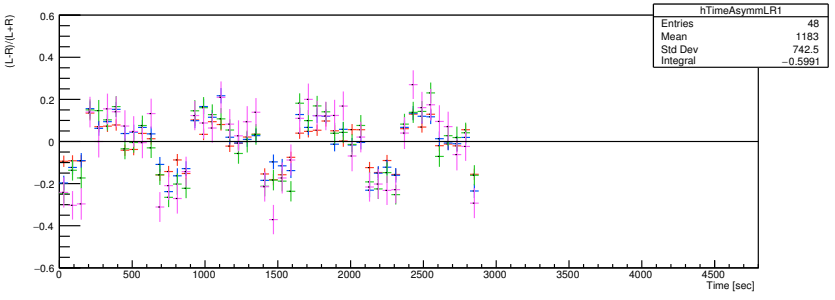
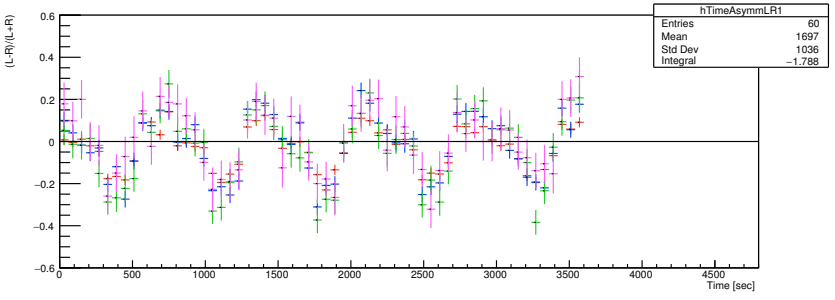
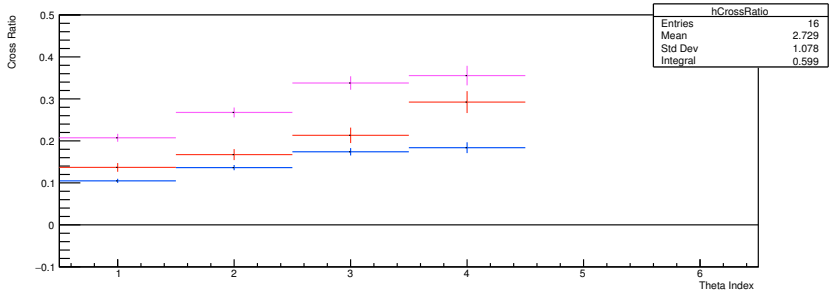
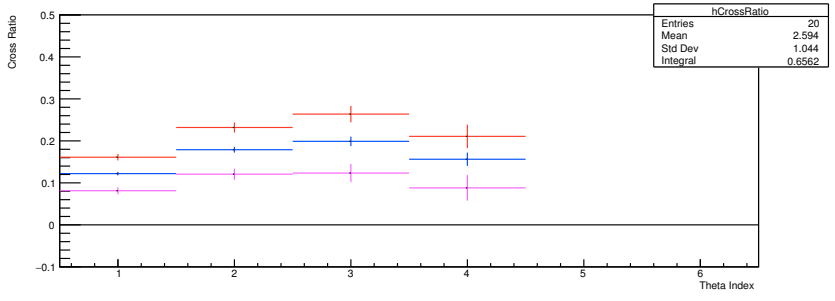






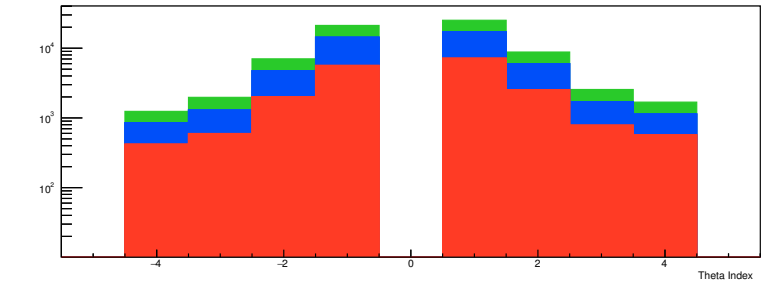


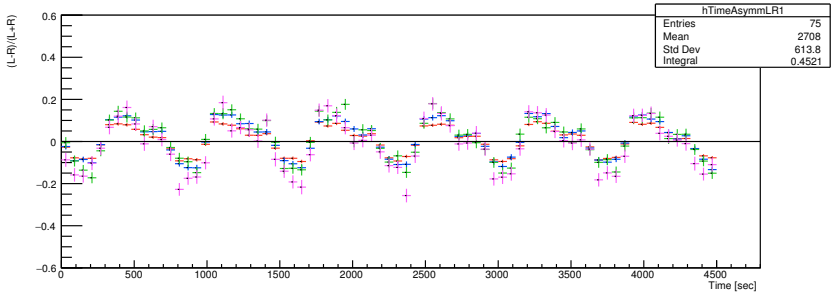


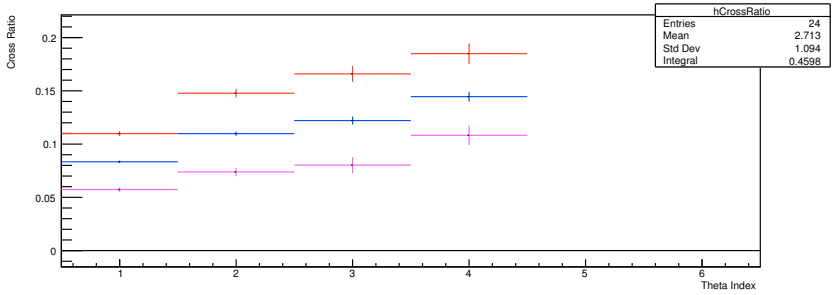


ASYMMETRY

Different target materials (left Nickel; right Tin)







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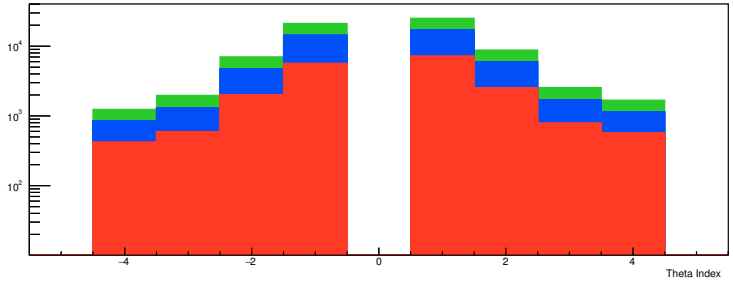
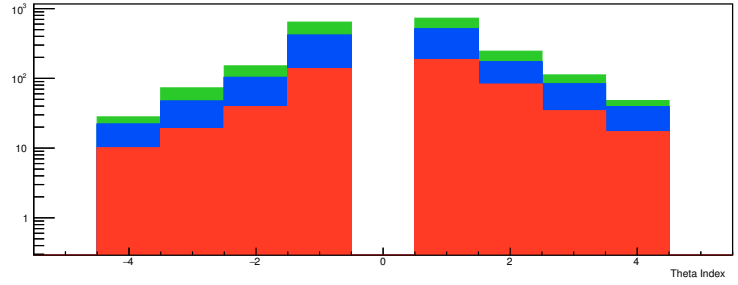
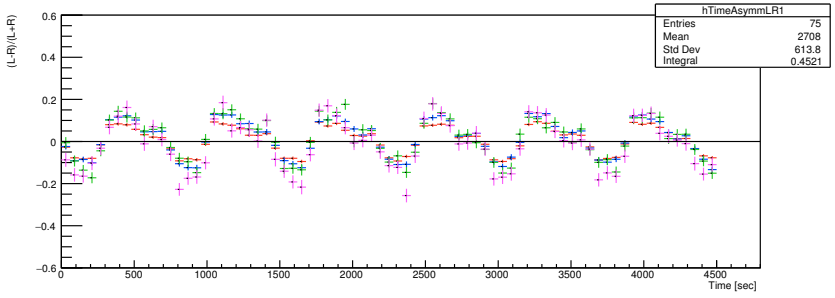
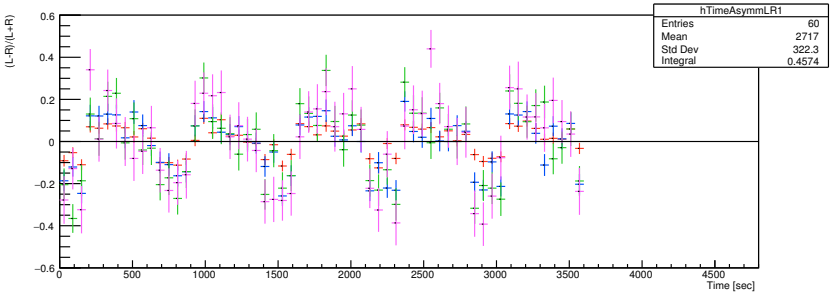
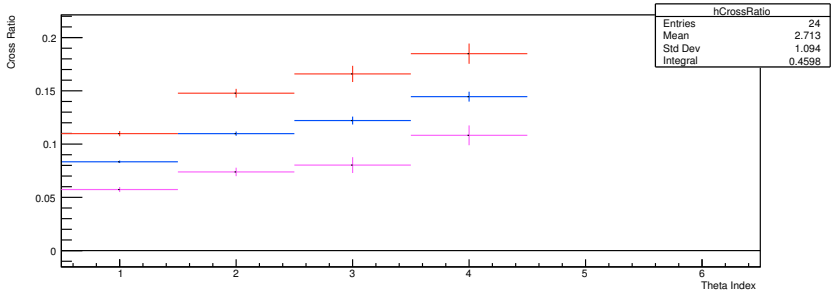
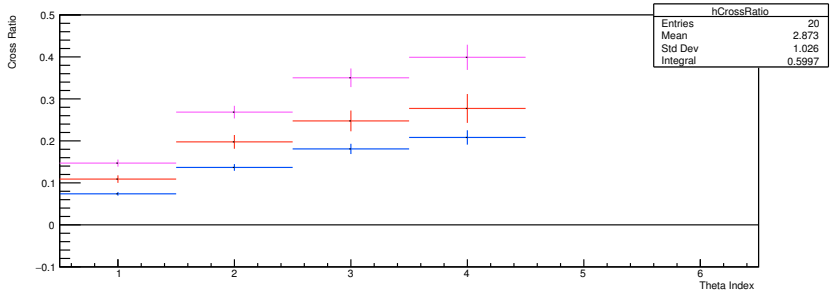






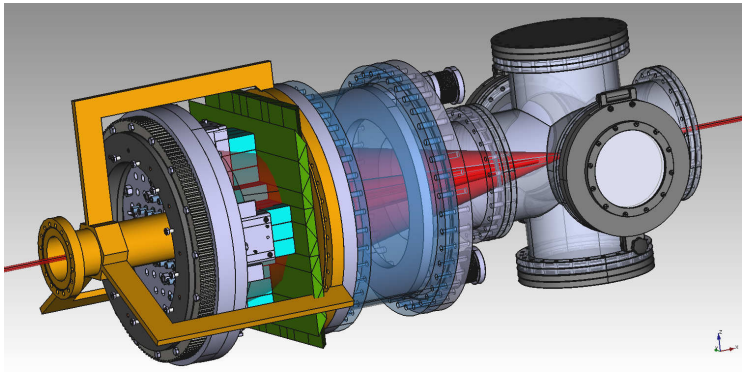






SUMMARY

- We have functional online polarimeter –needs further software development!
- Mechanical support & slow control shows excellent performance



- New DAQ system reached its max. designed data transfer of 400 MB/s
- We have assembled and tested new LYSO and SiPM vendors **in total 48+4 Modules**
- **Next major step is to install a tracking system made with the triangular scintillator bar**