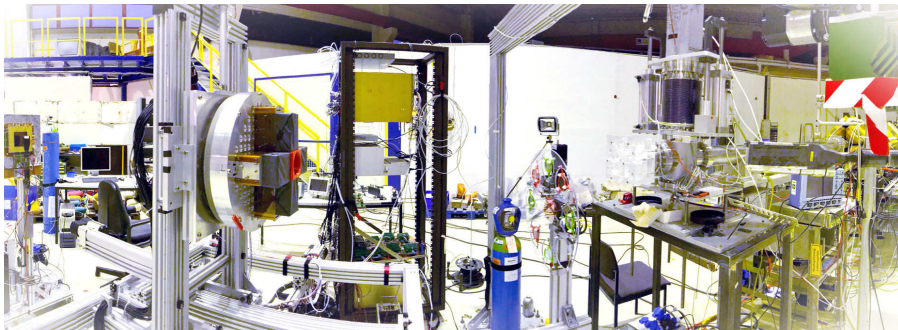




A NEW APPROACH: LYSO BASED POLARIMETRY FOR THE EDM MEASUREMENTS

Speaker: I. Keshelashvili

CALOR 2018 — University of Oregon, Eugene

May 24th, 2018 | Irakli Keshelashvili |

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^0 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.

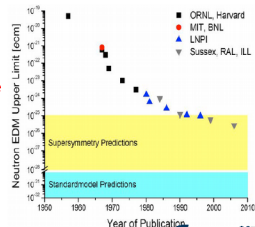
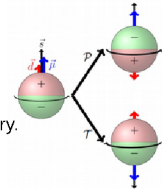
SM CP violation is enough to explain what has been observed in the K & B meson systems but orders of magnitude smaller than observed in the universe

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

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

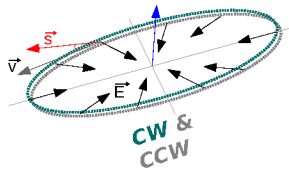
method differs strongly from nEDM



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

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

- a) Store longitudinally polarized **protons**
- b) Interact with a radial E-field
- c) Analyze Polarization Build-up (this talk)



**build-up of vertical
polarization**

$$\vec{s}_{\perp} \propto |\mathbf{d}|$$

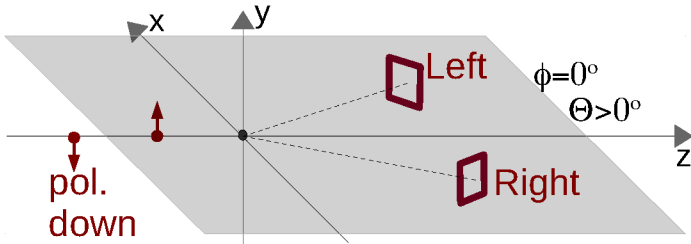
GENERAL FORMALISM

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

$$\sigma^{\text{pol}}(\theta, \phi) = \sigma_0(\theta) \left[1 + \frac{3}{2} PA_y(\theta) \cos \phi + \left\{ \frac{1}{3} \sum P_{ij} A_{ij} \right\} \right]$$

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

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



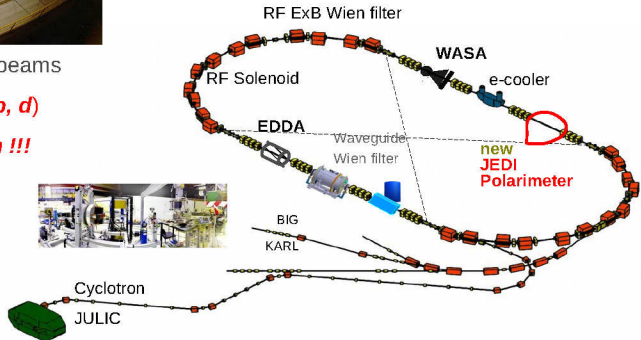
POLARIMETER SETUP @ COSY



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)

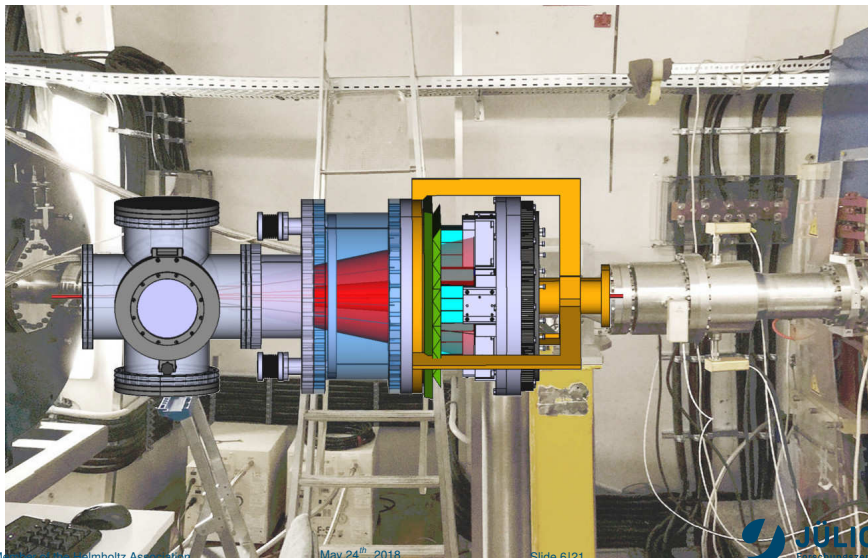
Max. momentum ~ 3.7 GeV/c

Electron & Stochastic cooling

Feed-forward machine

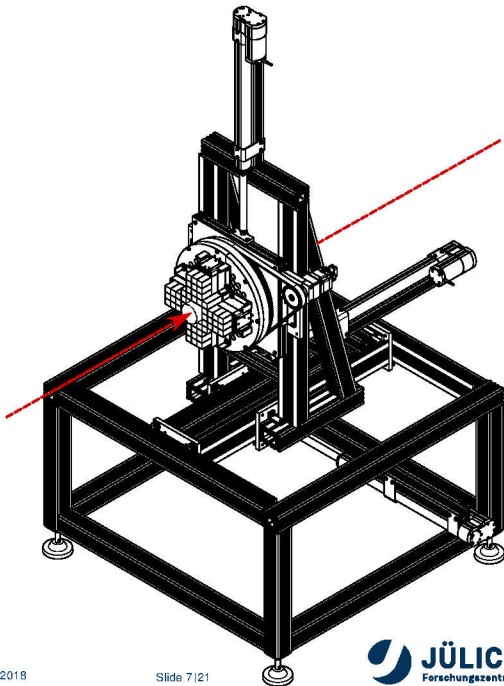
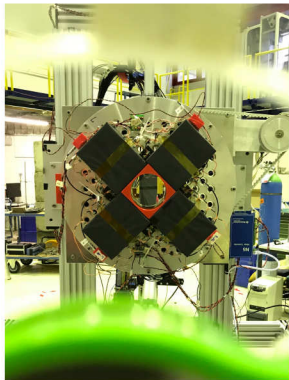
INTERNAL POLARIMETER

Prototype of the Calorimeter Part

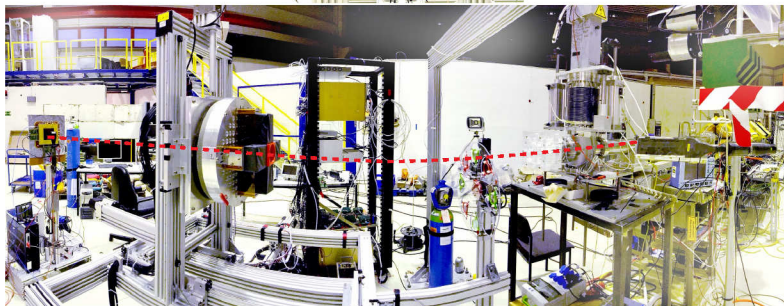
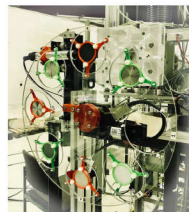
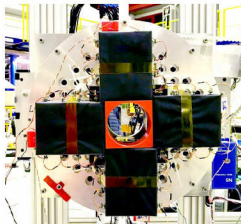
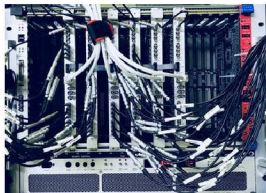


NEW SETUP

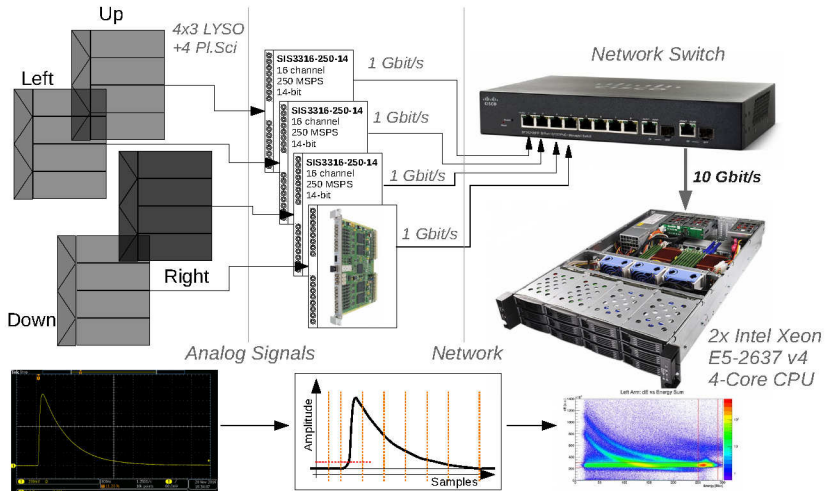
Test setup for polarimeter



BIG KARL EXP. HALL

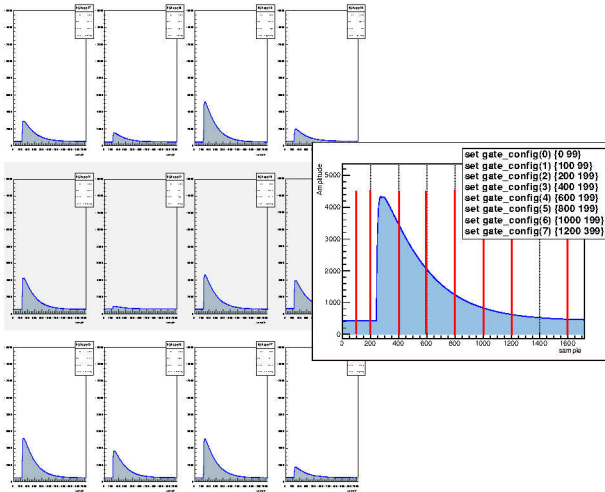


SADC BASED DAQ SYSTEM



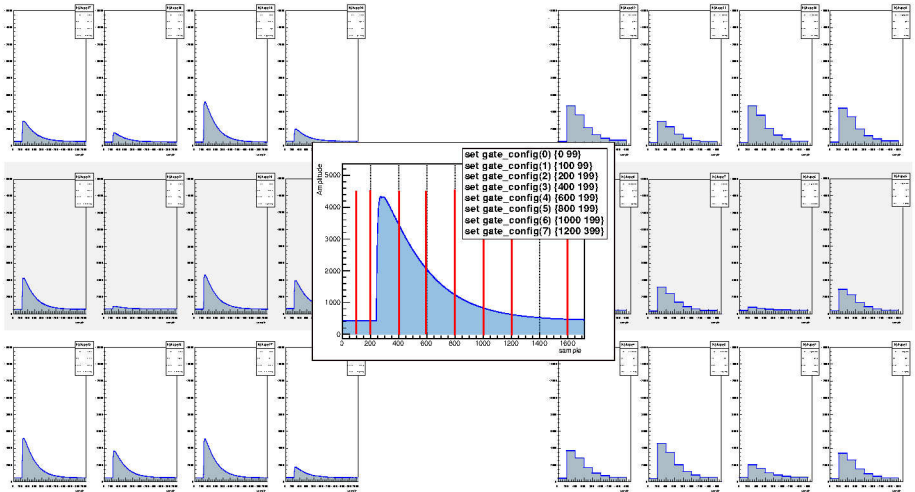
SIGNAL SHAPES

Full signal shape vs 8 accumulator/integral region



SIGNAL SHAPES

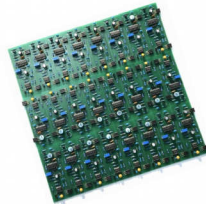
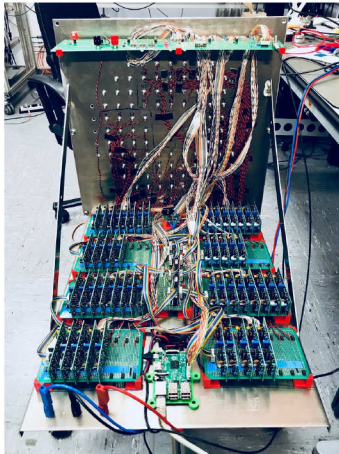
Full signal shape vs 8 accumulator/integral region



SIPM VOLTAGE SUPPLY

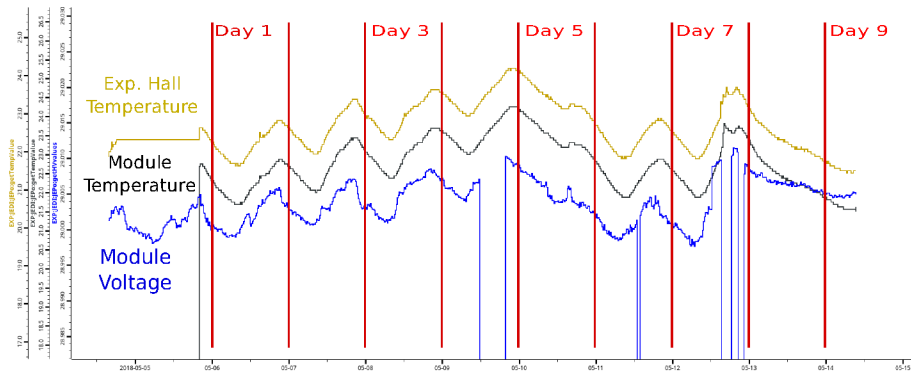
Very Good Long Term Stability $\sim 50\mu V_{pp}$

Entirely SmartLab and Agruni contribution



VOLTAGE MONITORING

Monitoring of all channels

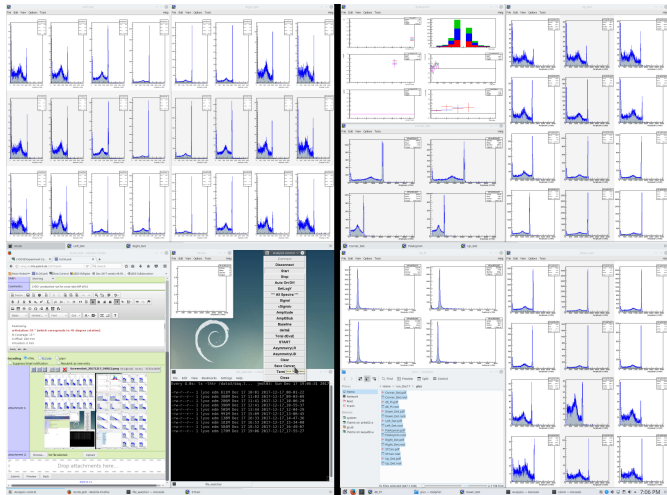


New improved mechanics and electronic components



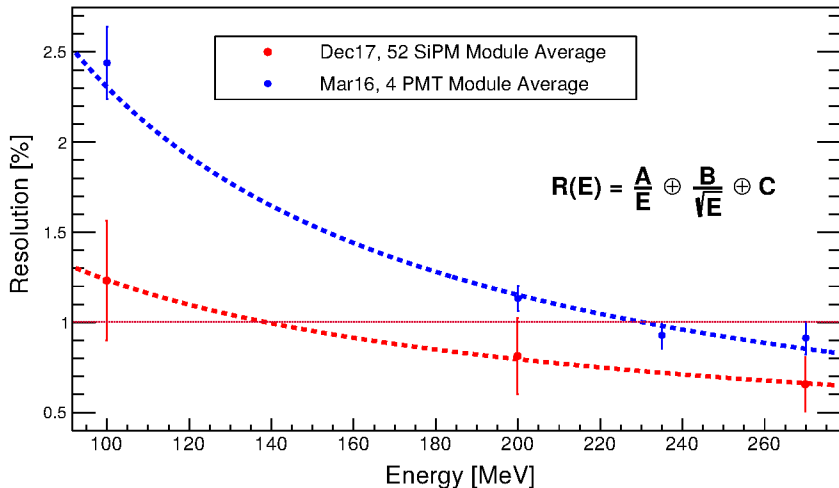
Slide 13|21

Monitoring of all amplitudes



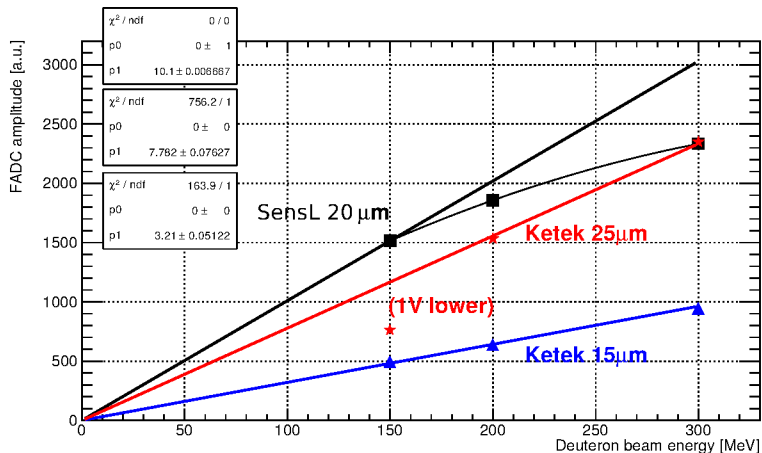
LYSO-SIPM RESOLUTION

from F. Mueller



LYSO-SIPM LINEARITY

from F. Mueller



SLOW CONTROL SYSTEM

Controls all movements

Firefox File Edit View History Bookmarks Tools Window Help

LYSO III Experiment Control

raspi02.lkp.kfa-juelich.de

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LYSO III Experiment Status

Actuators

- α -Rotation: online
- Start Counter: online
- Target Driver: online
- X-Axis: online
- Y-Axis: online
- Z-Axis: online

Positioning

- α -Rotation: 55 °
- Θ -Coverage: 15 °
- X-Offset: 299 mm
- X-Position: 0 mm
- Y-Offset: 268 mm
- Y-Position: 0 mm
- Z-Offset: 0 mm
- Z-Position: 0 mm

Target

- Active Target: Silicon
- Start Counter
- Status: out of the beam
- Voltage: 0 V

Position Control

Position Control

Θ -Coverage: 15 [10 ° - 20 °] Set

X-Position: 0 [-299 mm - 263 mm] Set

Y-Position: 0 [-268 mm - 311 mm] Set

Z-Position: 0 [0 mm - 570 mm] Set

Target Control

Empty Target	Nickel
Carbon	Tin
Aluminum	Silicon
Magnesium	Polyethylene

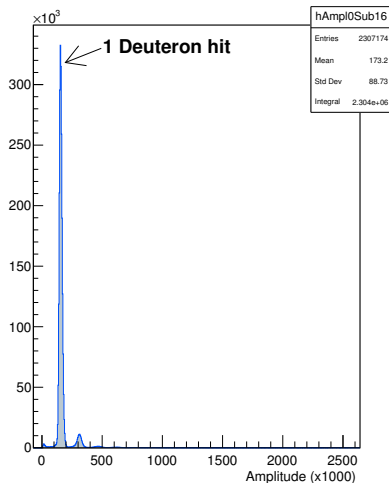
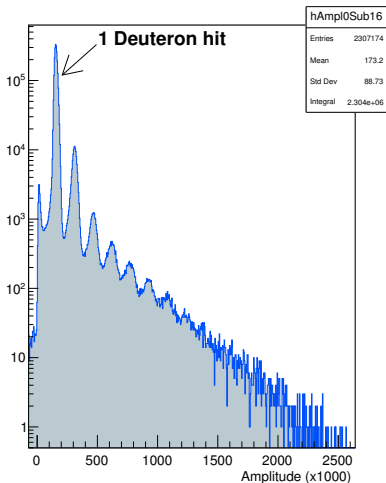
Start Counter

Position: Move Start Counter In

Voltage: 0 [0 V - 1200 V] Set

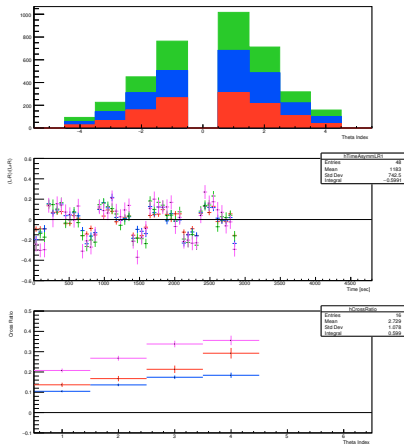
START COUNTER

Clearly seen deuteron pile-ups



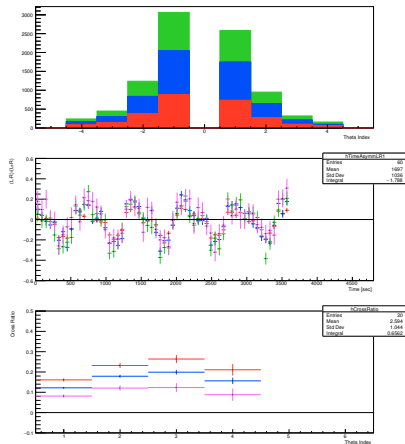
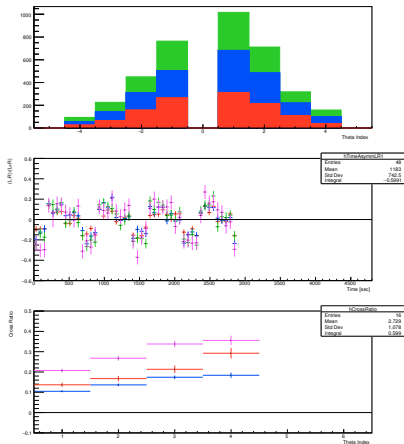
ASYMMETRY

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



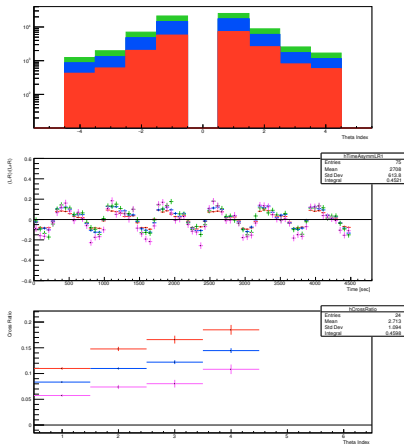
ASYMMETRY

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



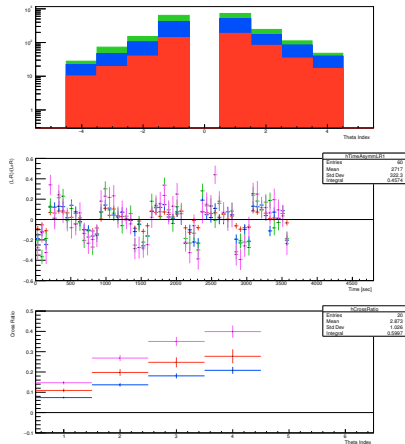
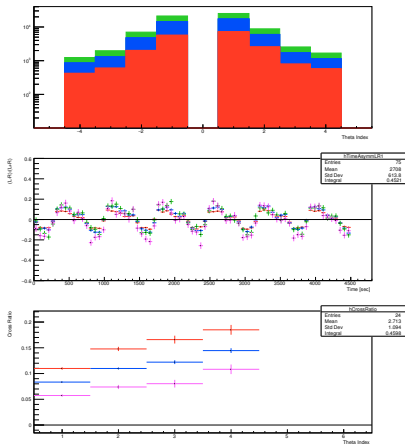
ASYMMETRY

Different target materials (left Nickel; right Tin)



ASYMMETRY

Different target materials (left Nickel; right Tin)



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**

