JÜLICH
FORSCHUNGSZENTRUM

Polarimetry Concept Based on Heavy Crystal Hadron Calorimeter

for the JEDI Collaboration | CALOR 2016 |

May 17, 2016 | Irakli Keshelashvili |

- Introduction
- JEDI Polarimetry Concept
- MC Simulations
- Laboratory and Beam Tests
- Outlook
- Summary

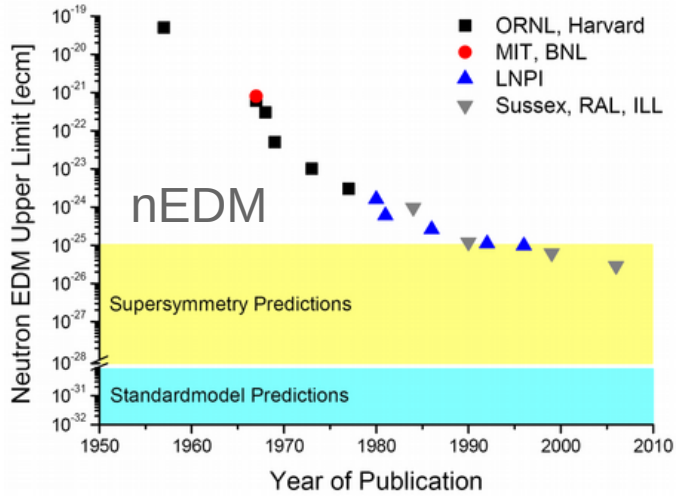
JEDI – Jülich Electric Dipole moment Investigation

Collaboration members: ***122***

Baryo genesis

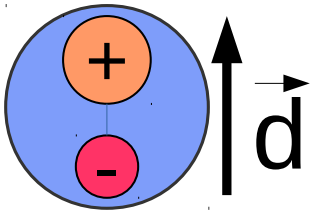
Standard Model

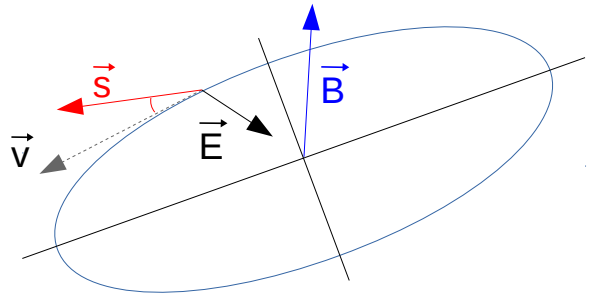
- not enough CP violation



Why Storage Ring?

Measuring EDM for Charged Pericles



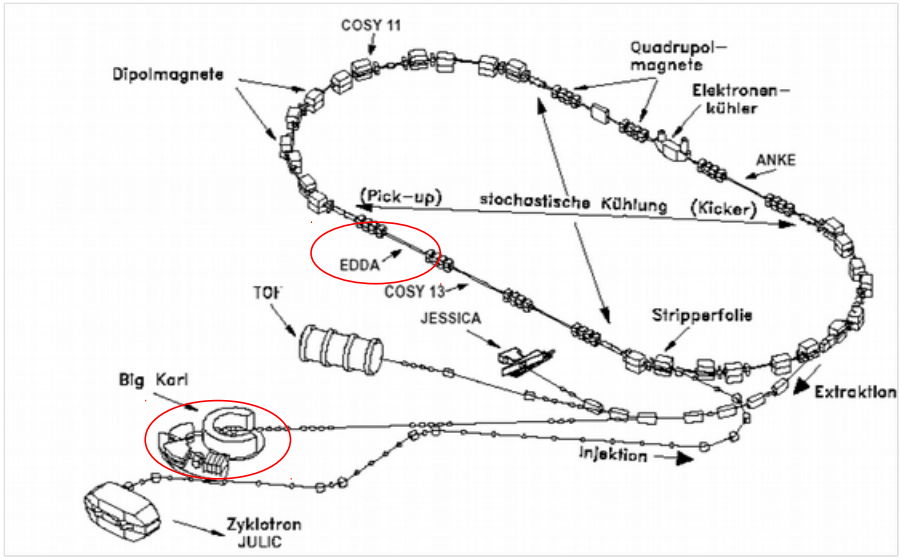


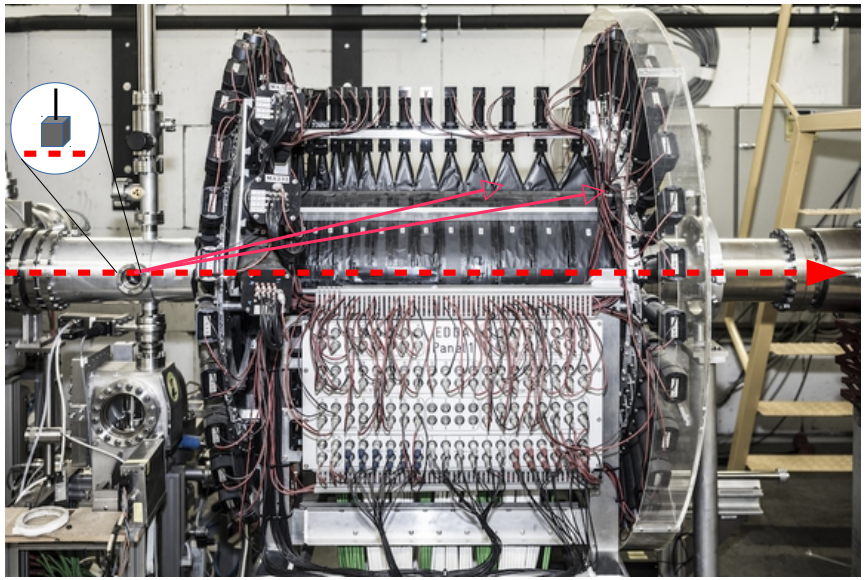
$$\frac{d\vec{s}}{dt} = \vec{d} \times \vec{E} + \vec{d} \times (\vec{v} \times \vec{B})$$

- Store polarized deuterons (COSY)
- Interact with an E-field (Wien-Filter)
- Analyze Polarization Build-up (this talk)

COSY (COoler SYnchrotron)

at Forschungszentrum Jülich (Germany)





- Energy range:
  - 0.045 – 2.8 GeV (p)
  - 0.023 – 2.3 GeV (d)
- Max. momentum ~ 3.7 GeV/c
- **Electron** and Stochastic cooling
- Internal and **external** beams
- High **polarisation** (p,d)
  - **Spin manipulation !!!**

srEDM – Precision Experiment

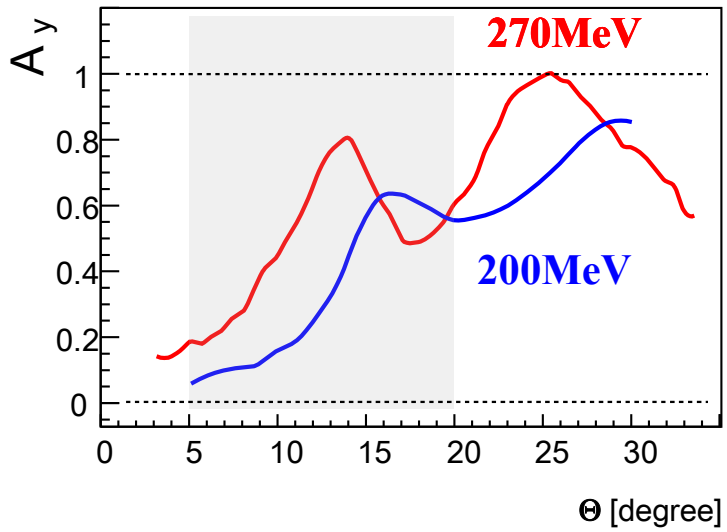
complementary

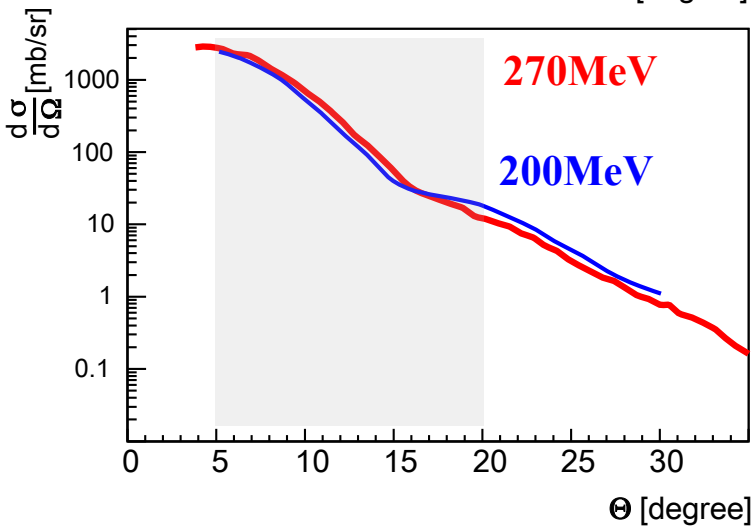
LHC – Energy Frontier

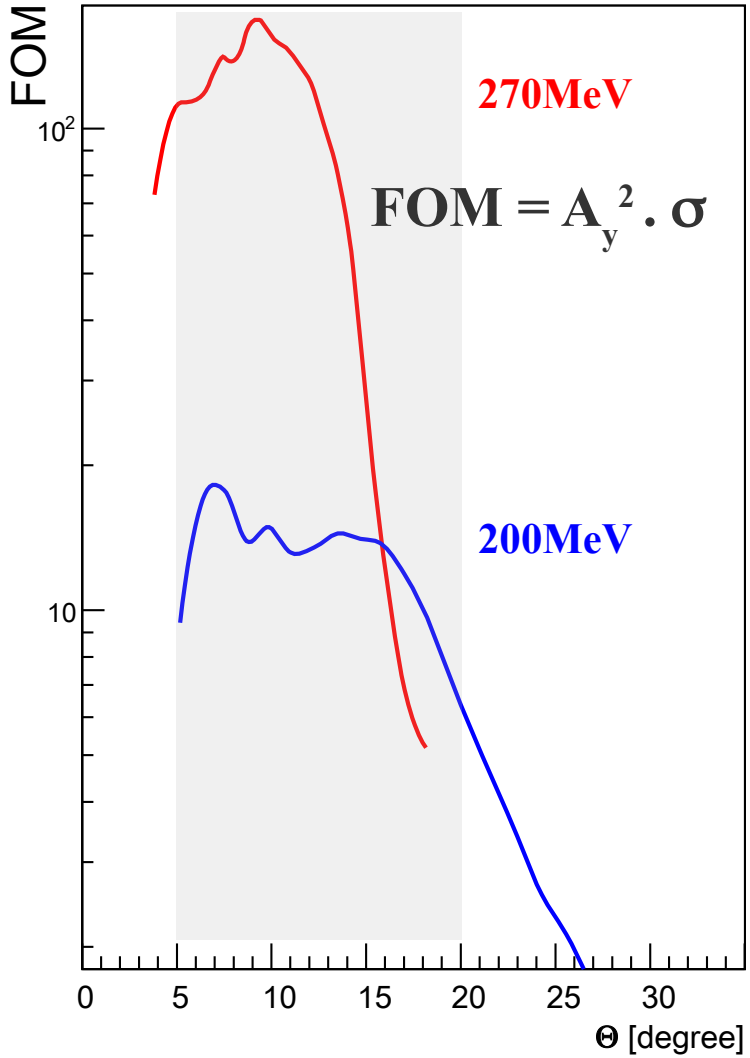
- Reaction with Large A_y: Best $dC \rightarrow dC$!!!
- Maximum Detection & Data Taking Efficiency !!!
- Full ϕ in Reasonable FOM(θ) region !!!
- No Magnetic / Electric Field !!!
- Stability – Long / Short Term !!!

$\vec{d}C \rightarrow dC$ Elastic Scattering @ 270 *MeV*

Y. Satou et al., Phys. Lett. B 549, 307 (2002).

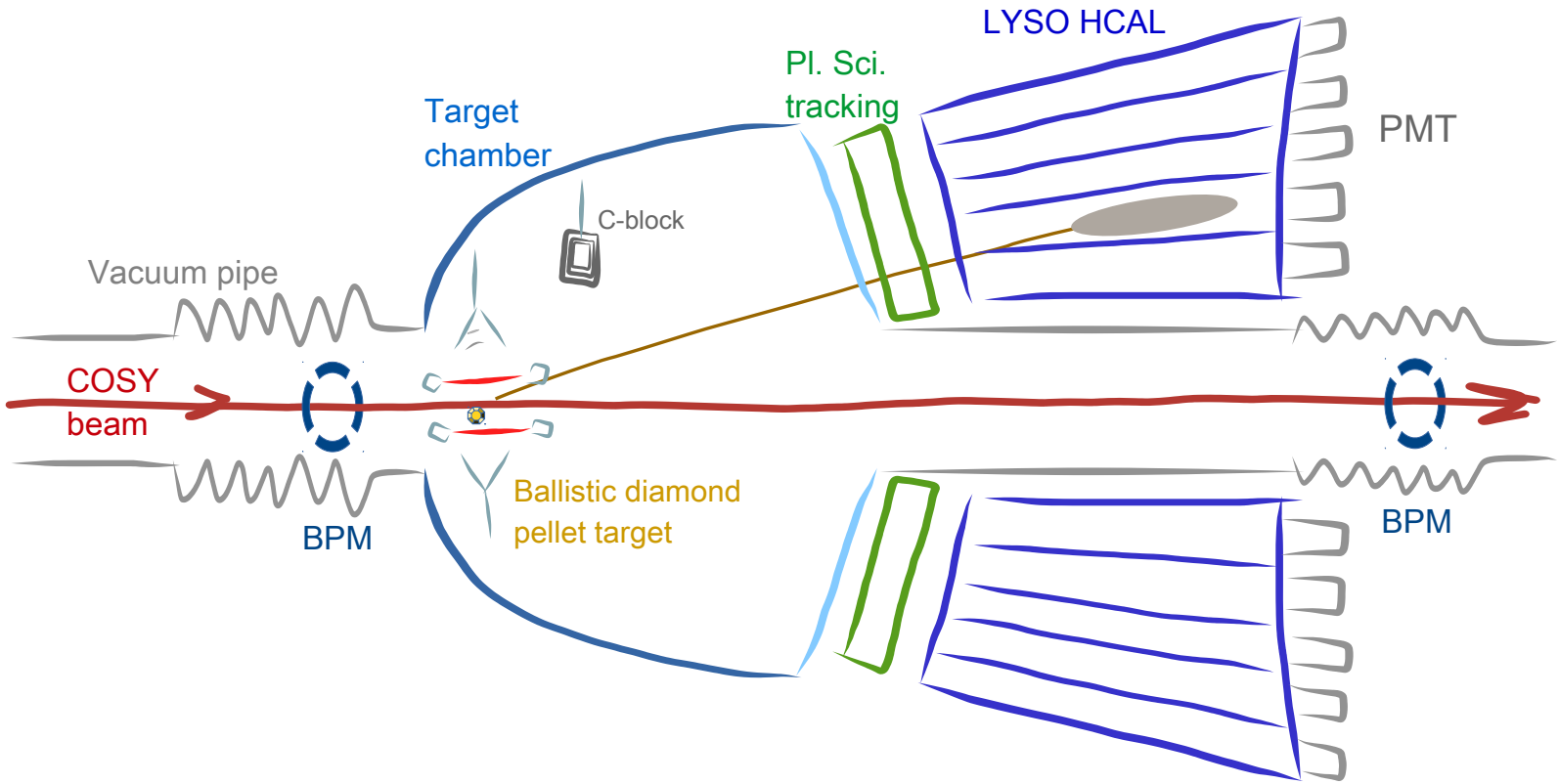






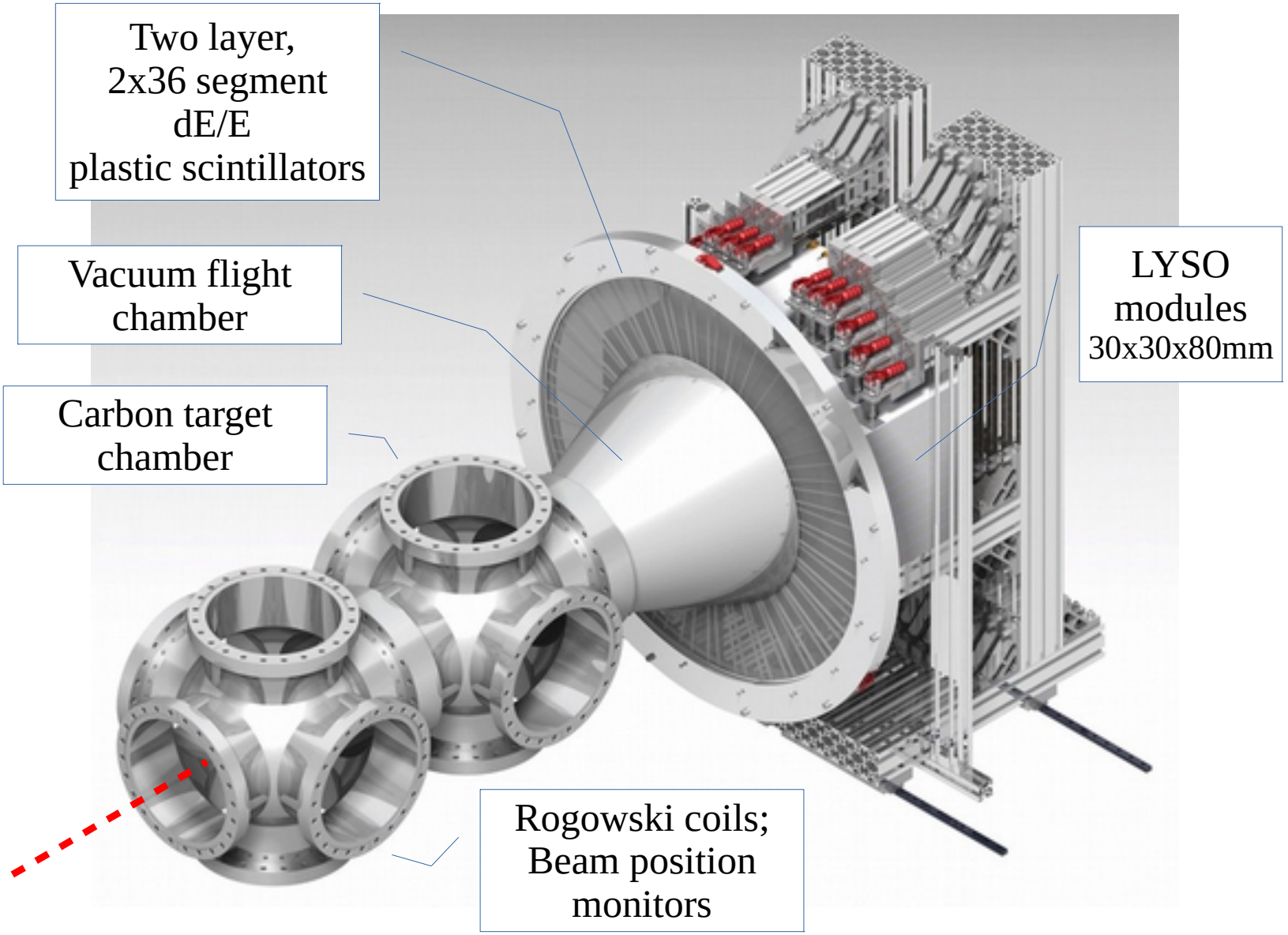
JEDI Polarimetry Concept

Optimized for $\vec{d}C \rightarrow dC$ Reaction



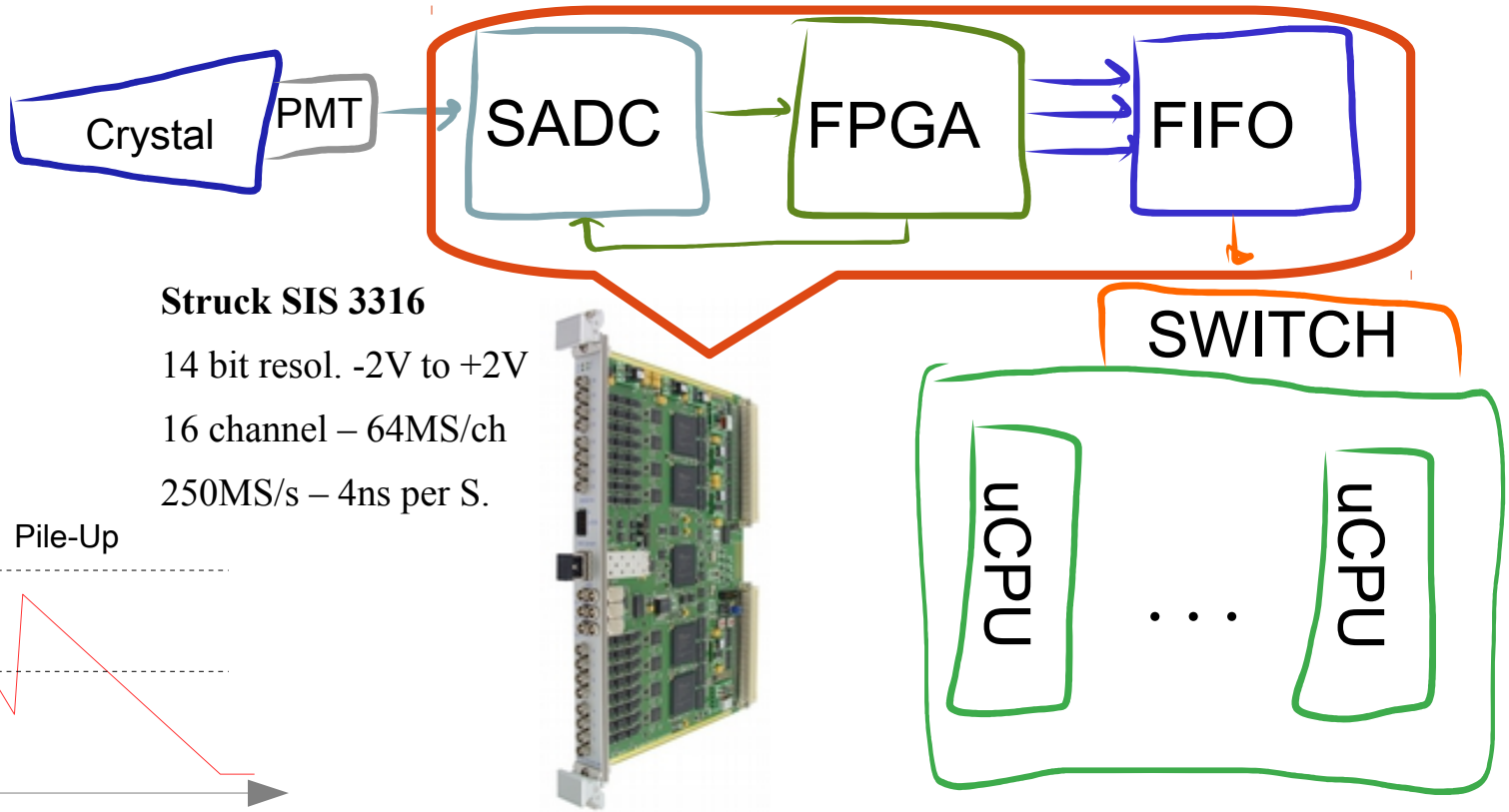
LYSO Based Polarimeter

Modular Setup / Easy Splitting



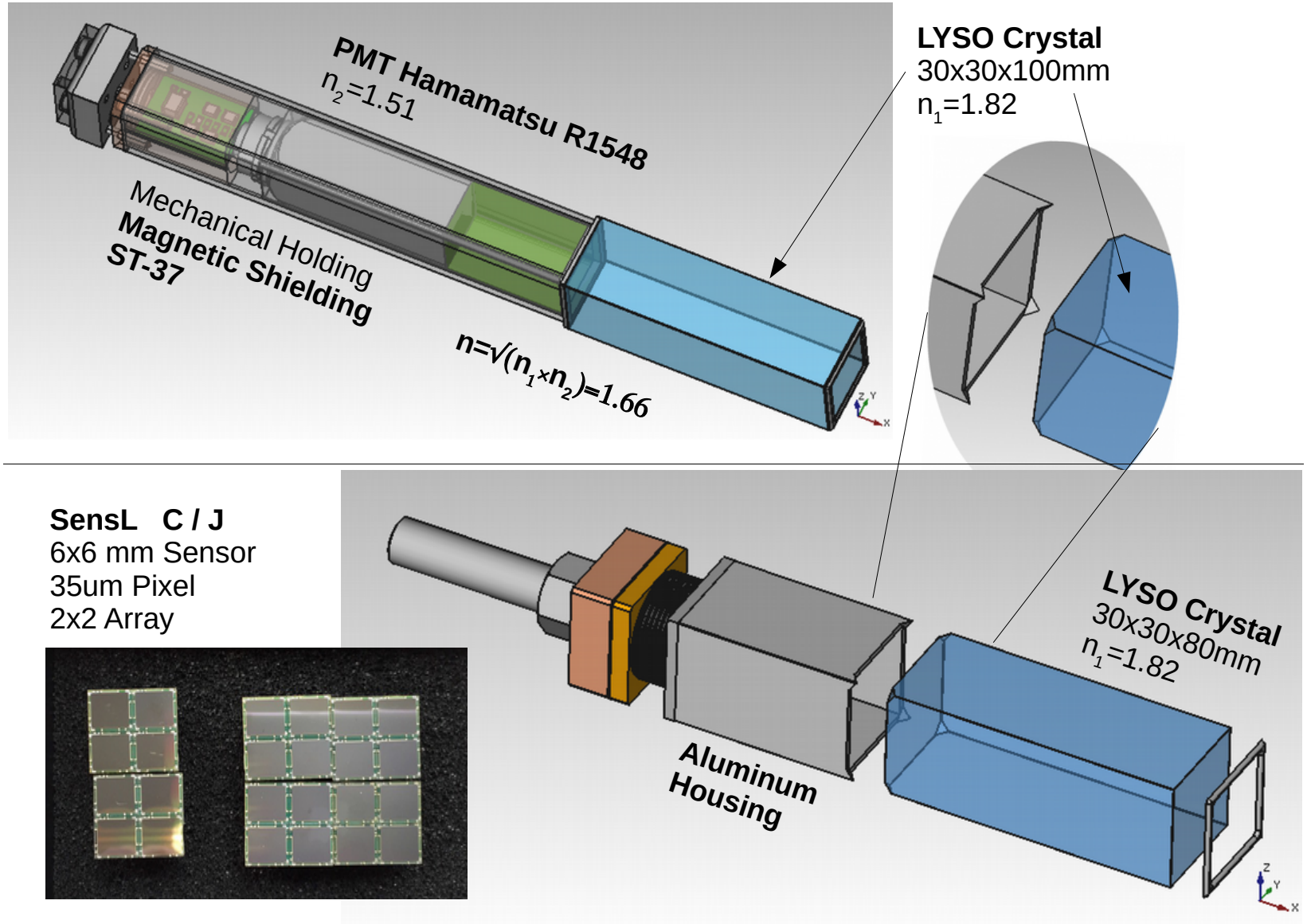
FADC Based DAQ

∼ 100 % Data Taking Efficiency



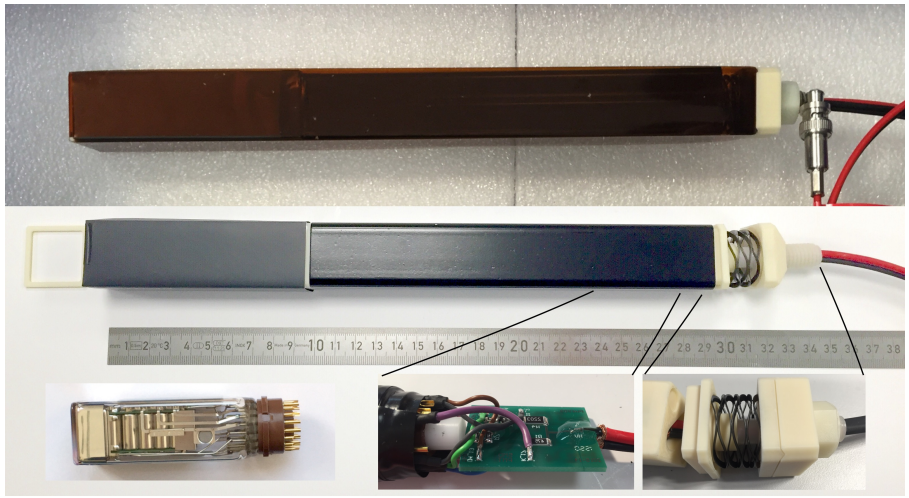
LYSO Modules

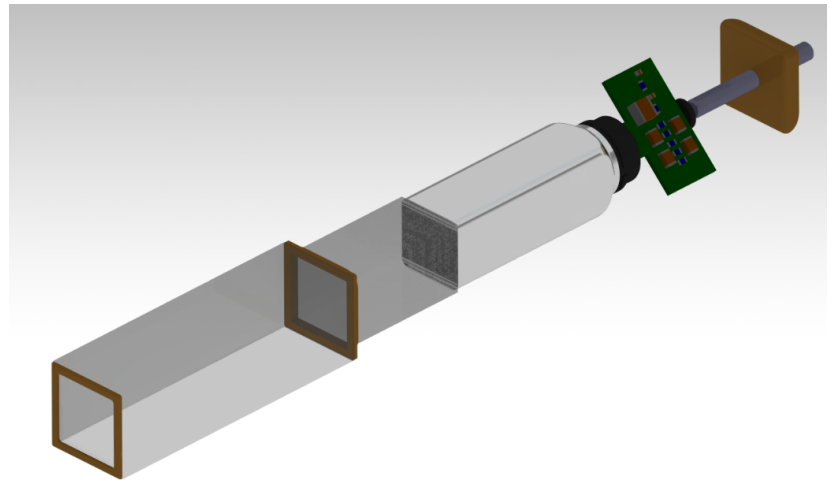
First and Second Generation

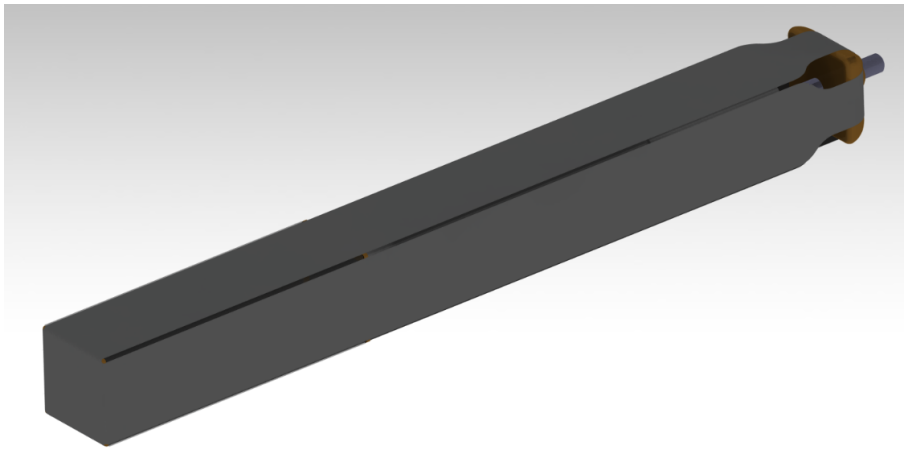


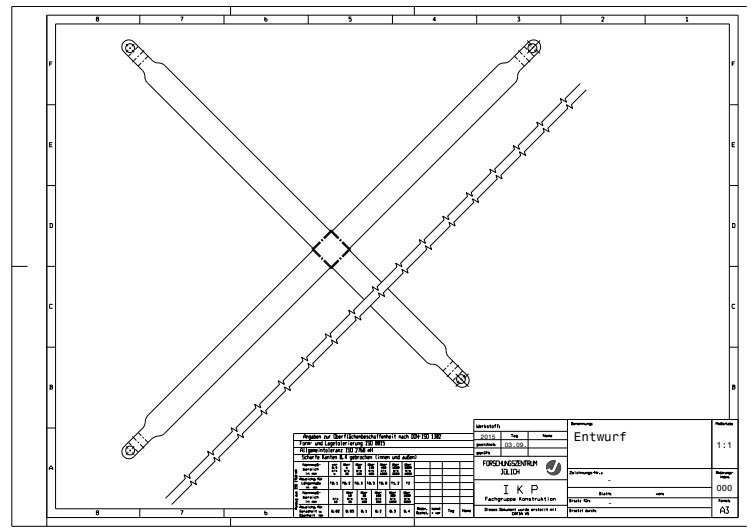
LYSO Module

Assembly and Mechanical Stability



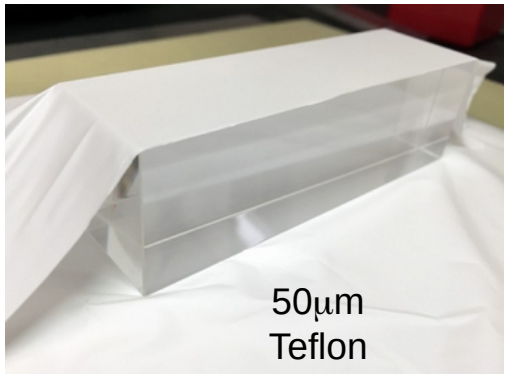


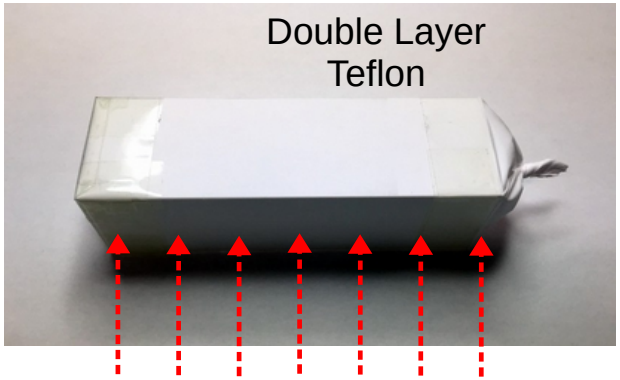




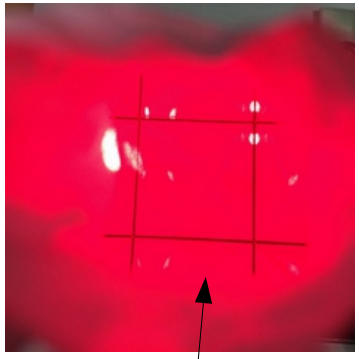
LYSO Crystal Wrapping

and Homogeneity Test

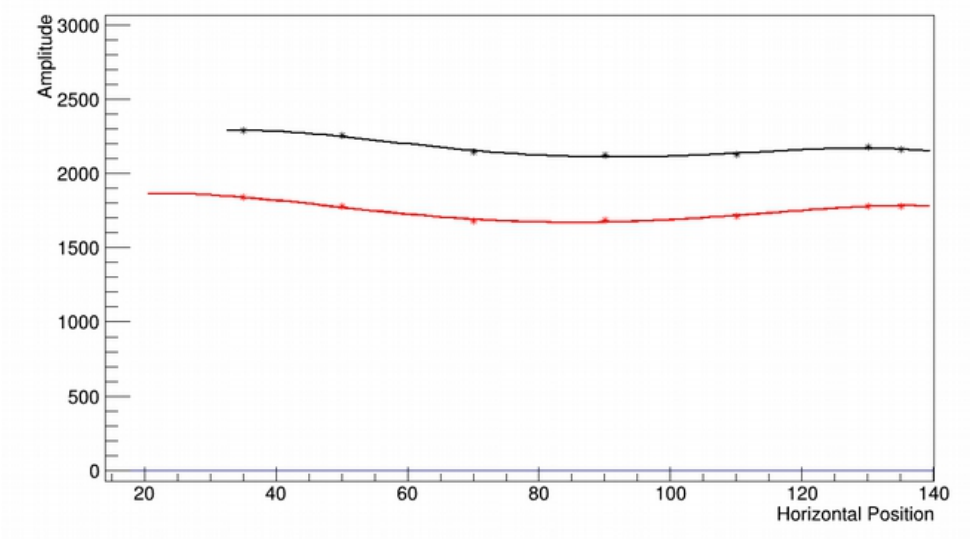


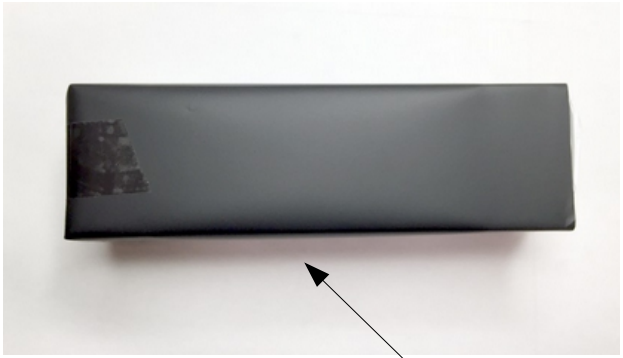


270 MeV deuteron beam



Laser
reflection

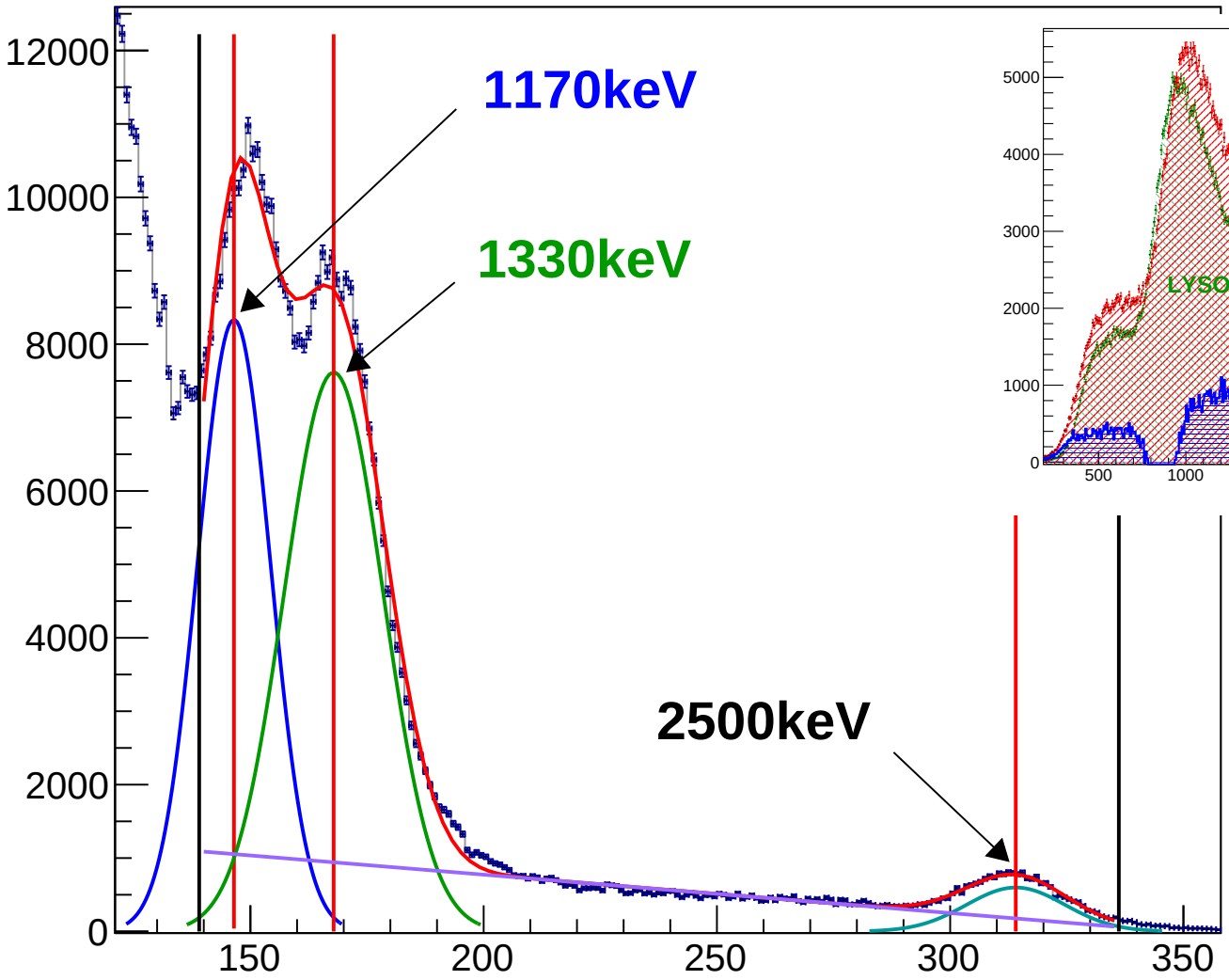


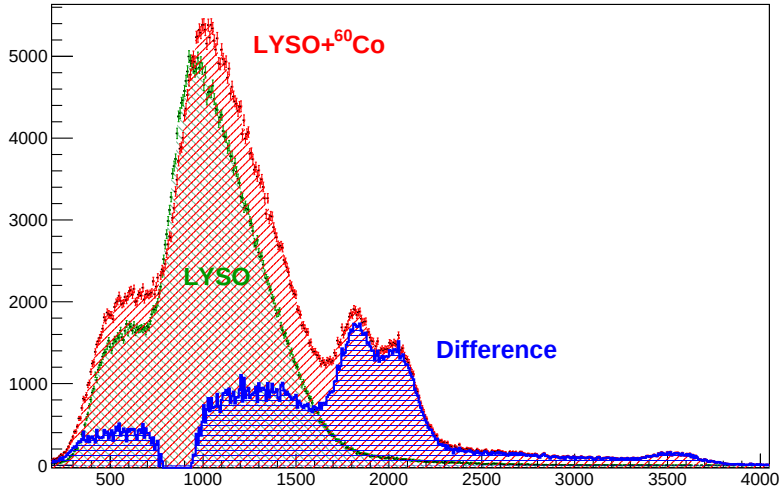


50μm Tedlar

LYSO (^{176}Lu) + ^{60}Co Tests

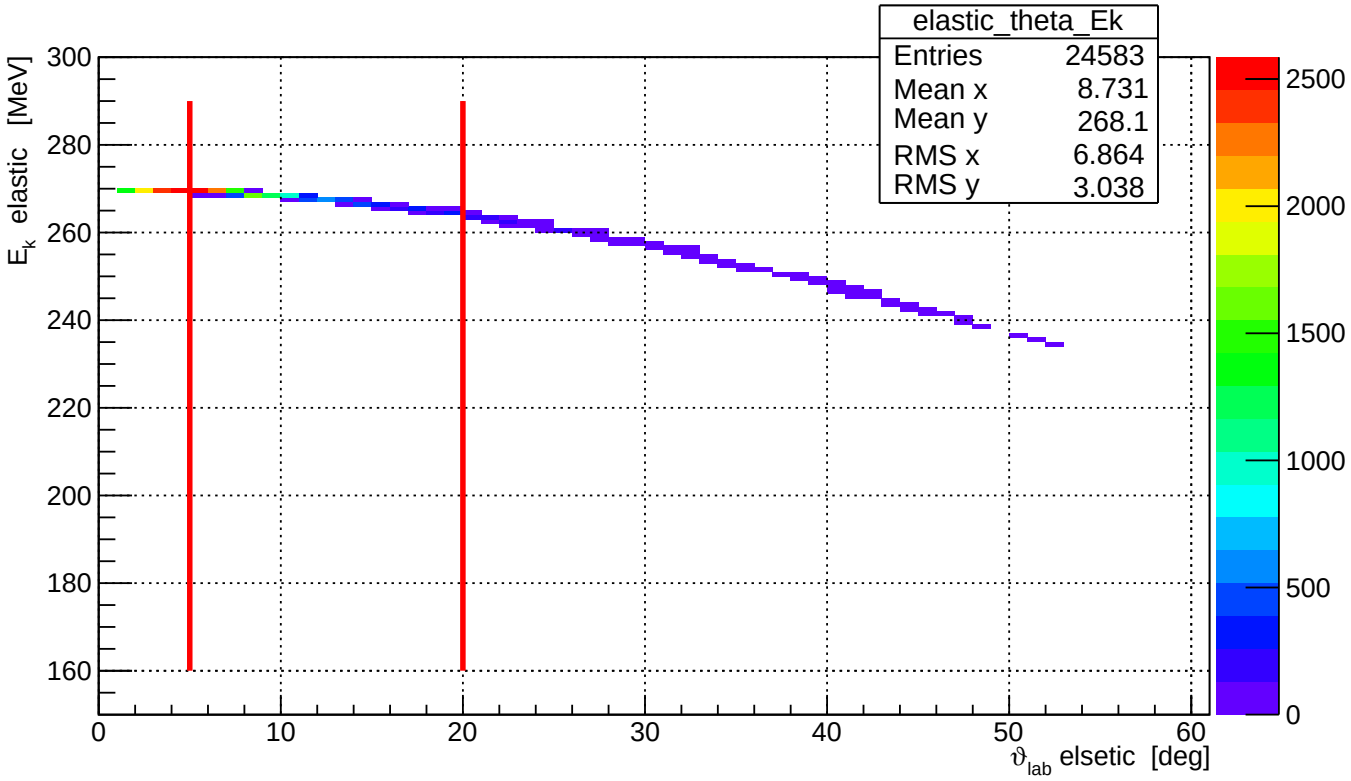
8 % Resolution at 2.5 MeV Photons

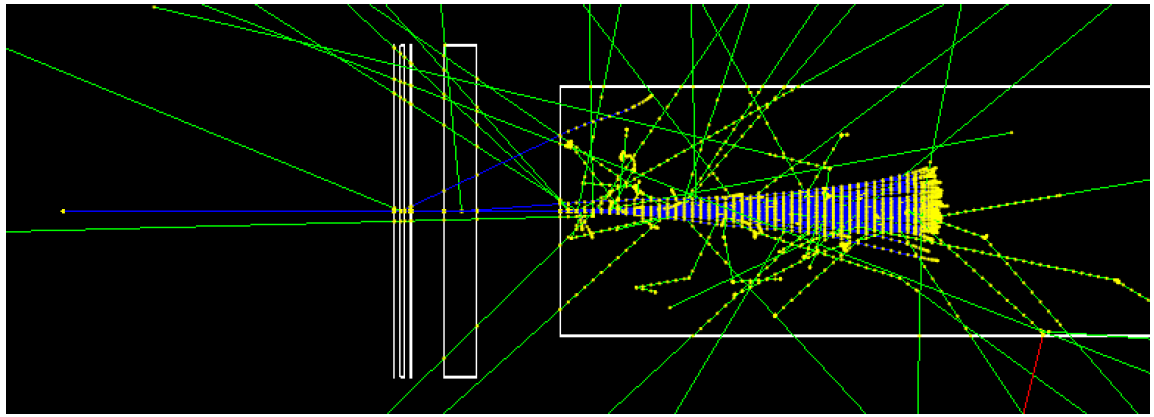




G4: Elastic $dC \rightarrow dC$ Scattering

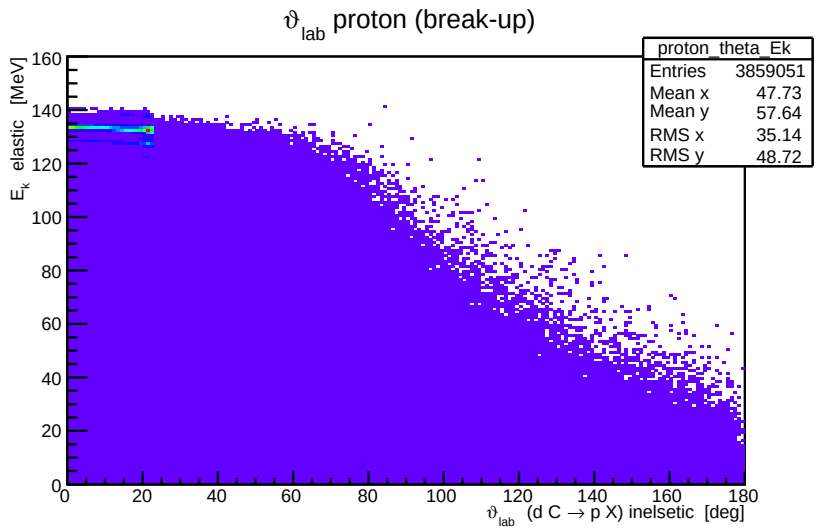
Very Clear Signature

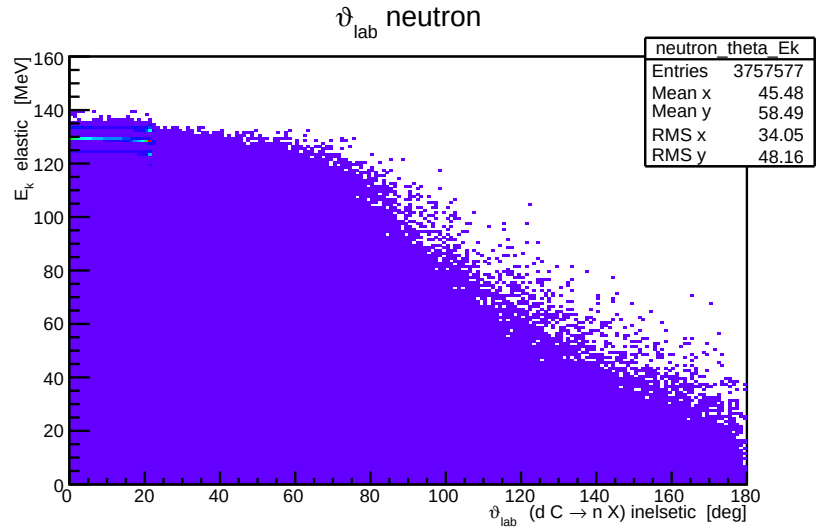


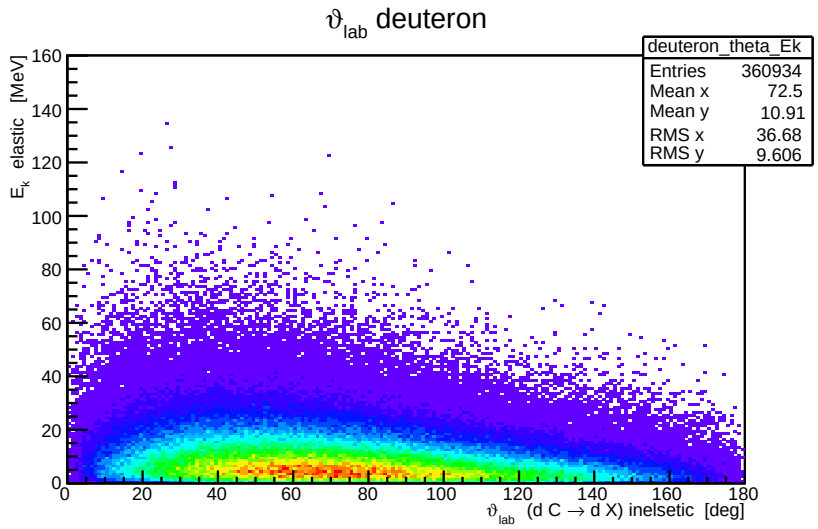


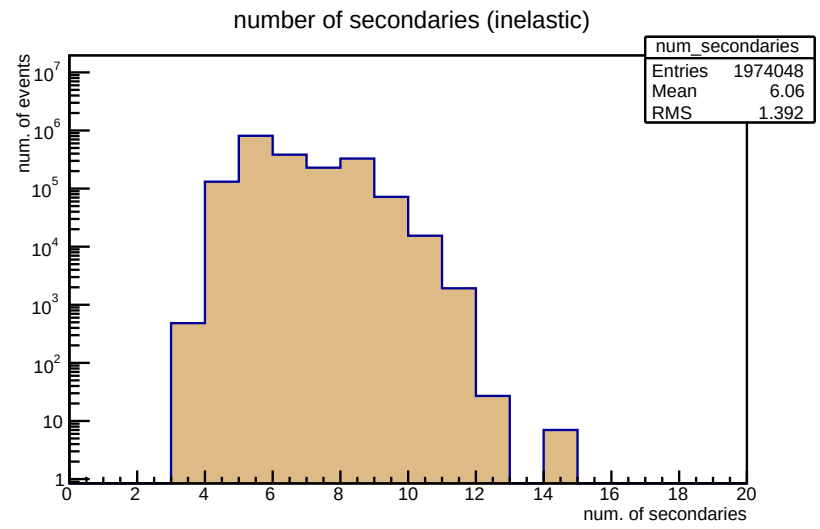
G4: Inelastic $dC \rightarrow X$ Simulation

Far Below Elastic E-Spectrum



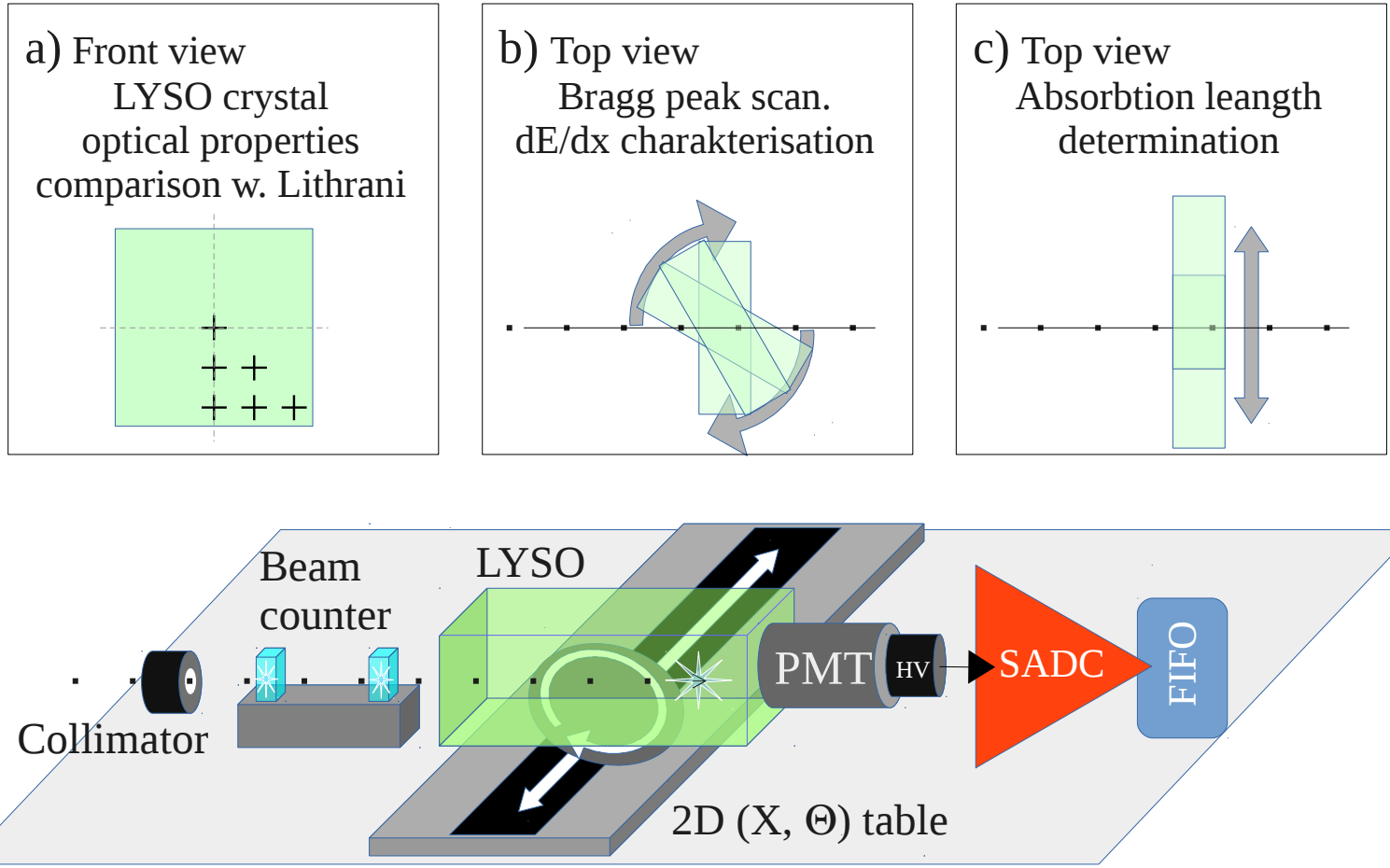






Prototype Test – BIG KARL Area

External Proton and Deuteron Beam



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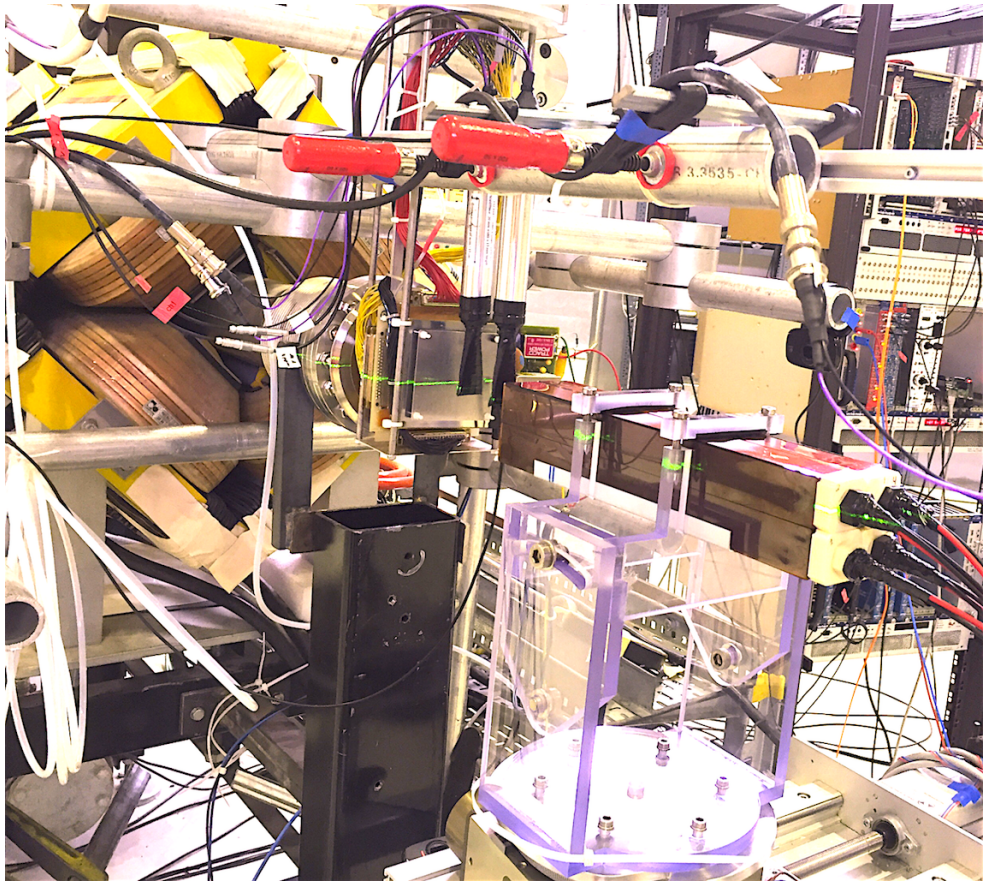
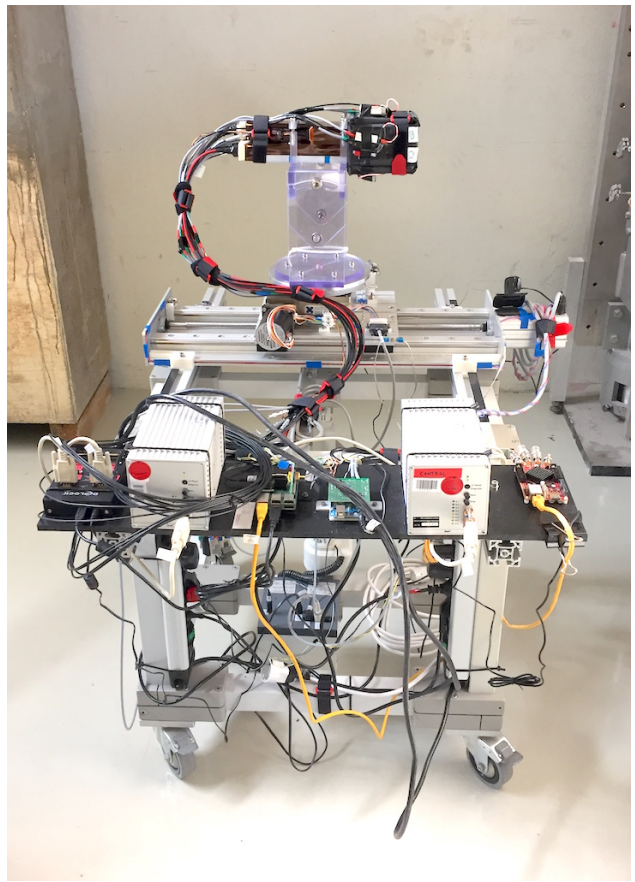
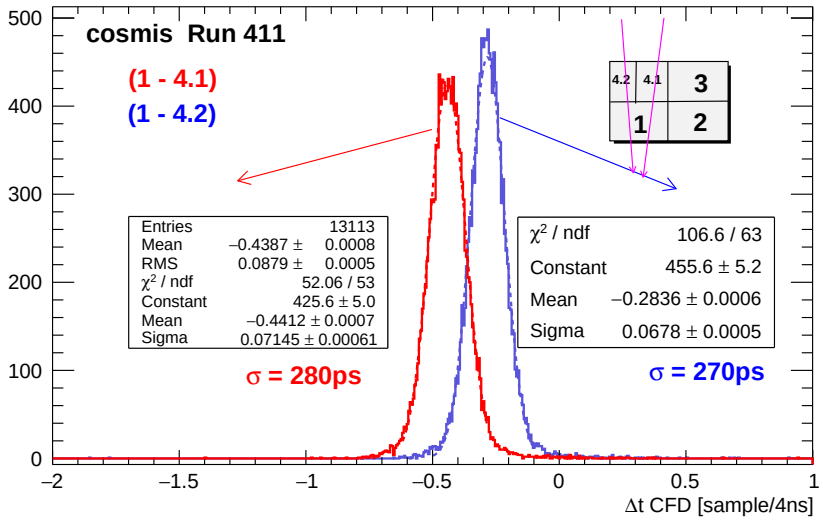


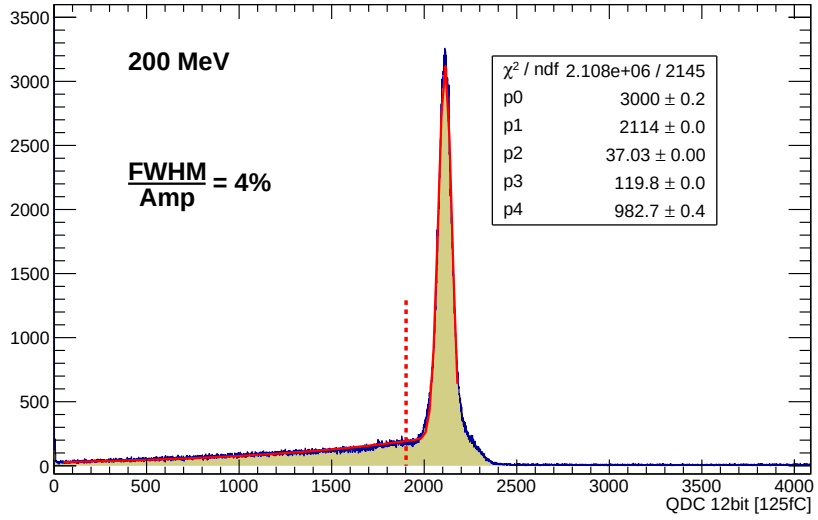


Time Resolution

Cosmic and External Beam

- Time Resolution with 250 MS/s Far Below 1 ns
- QDC Energy Resolution at 200 MeV roughly 4 %
- Deuteron Reconstruction Efficiency at 80 % (Threshold 90 %)

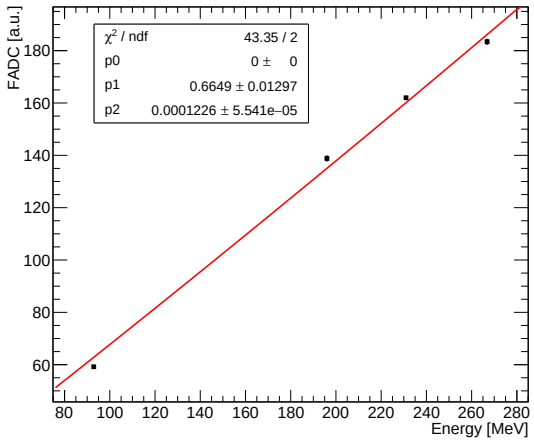


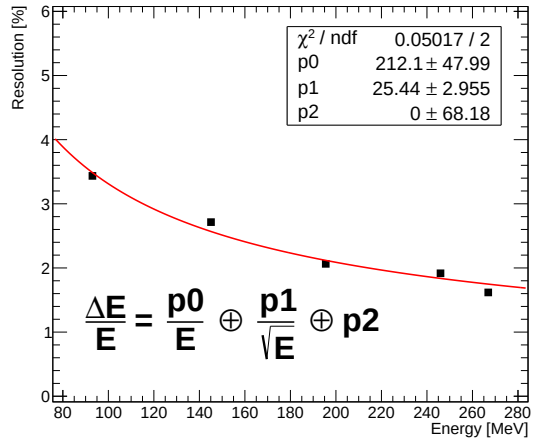


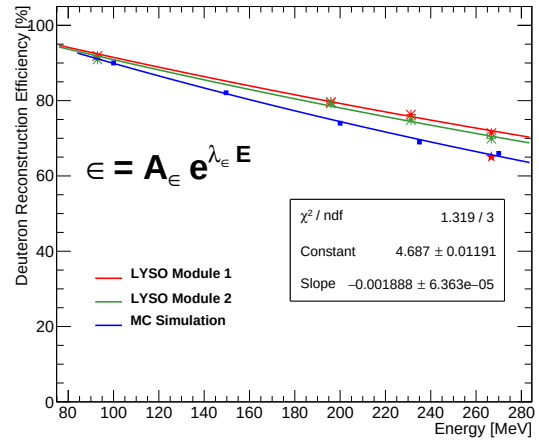
Prototype Characterization

Using External Beam

- Incident *vs* Reconstructed $d - T_{kin}$
- Reconstructed Energy Resolution *vs* Incident $d - T_{kin}$
- Deuteron Identification Efficiency
- Bragg Peak, Absorption λ, Radiation Hardness

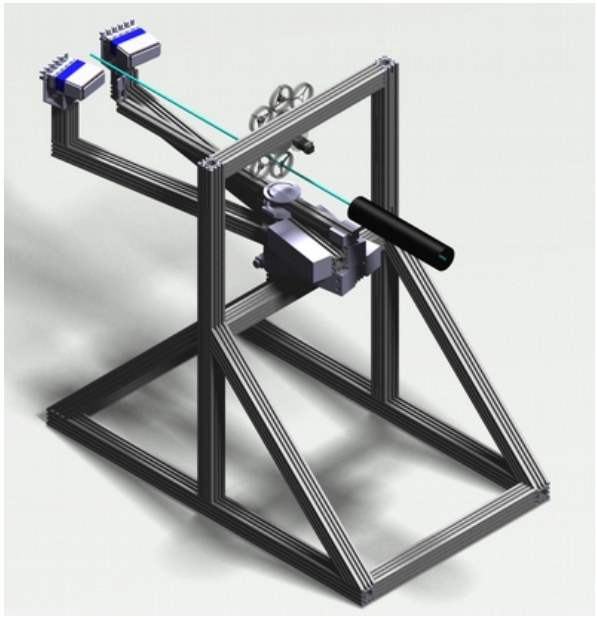


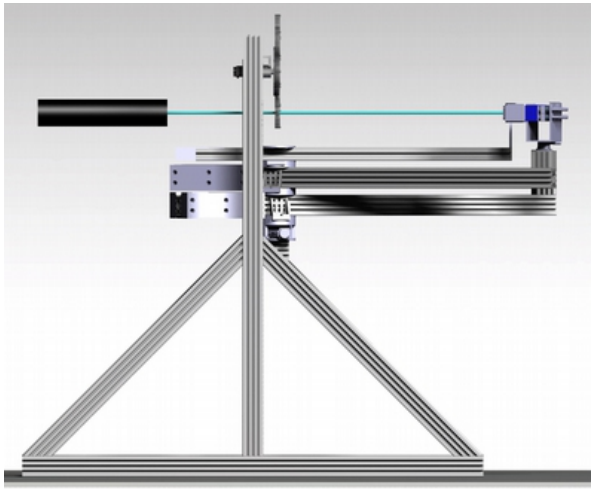


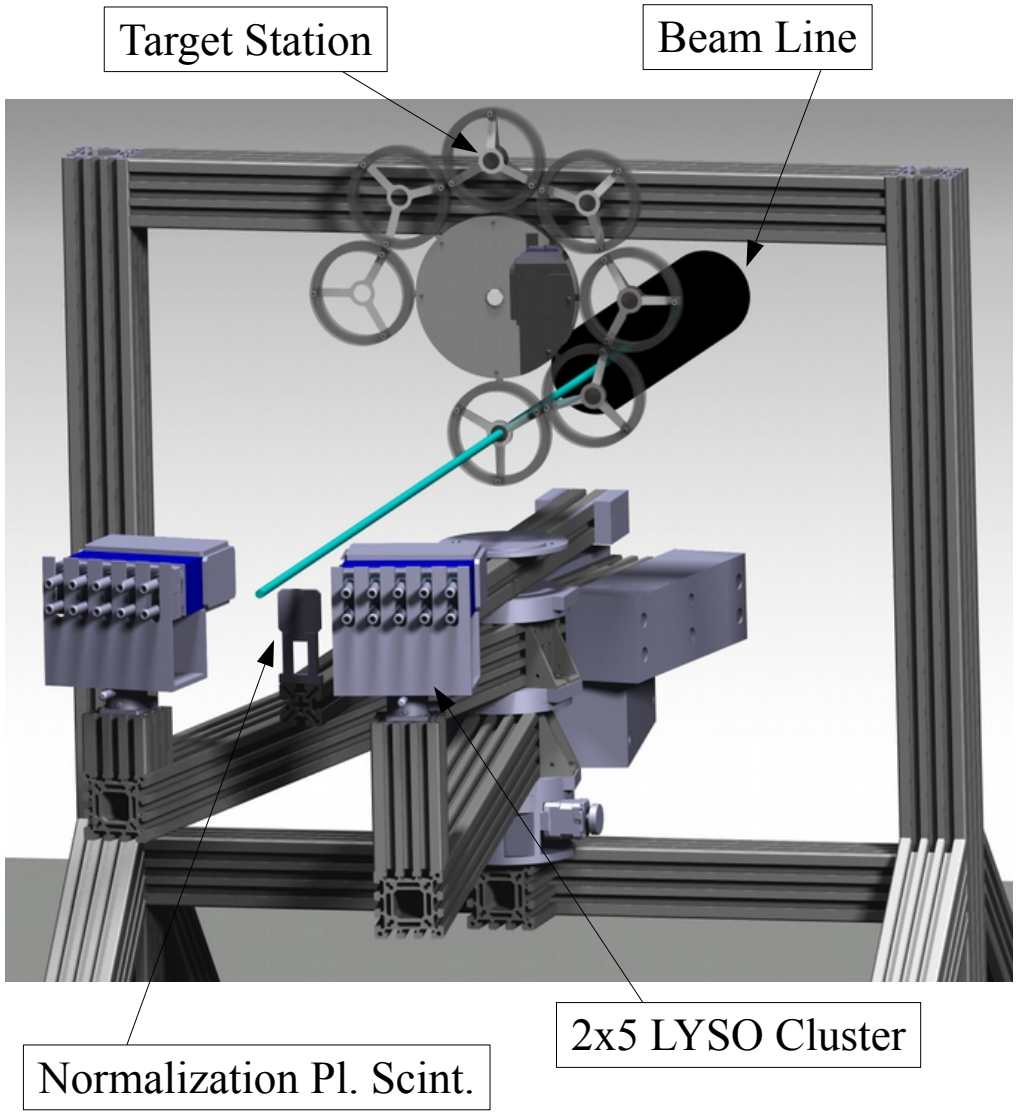


Next with 2x10 LYSO Modules

Polarized Deuteron Beam / 6 Different Targets





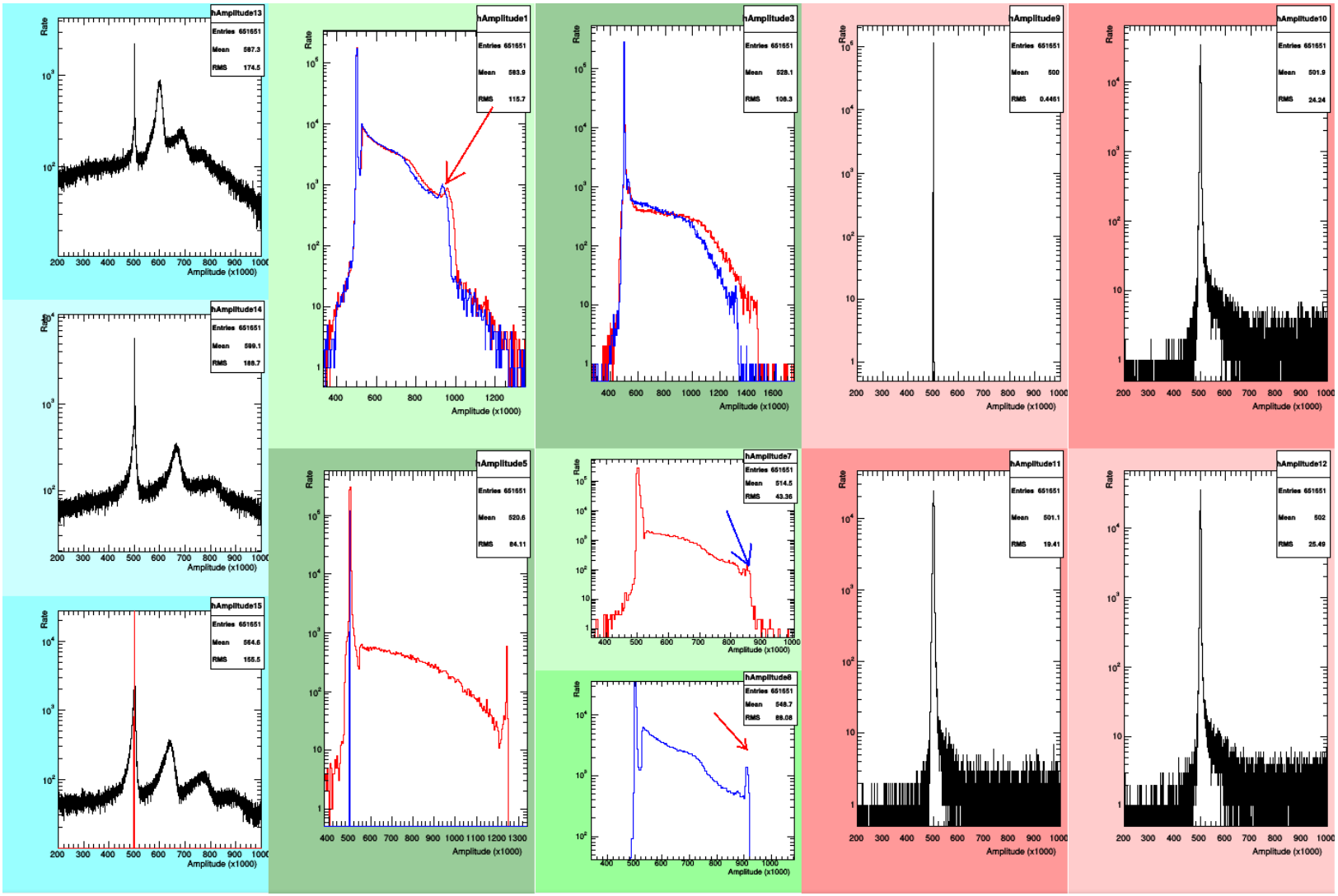


Summary

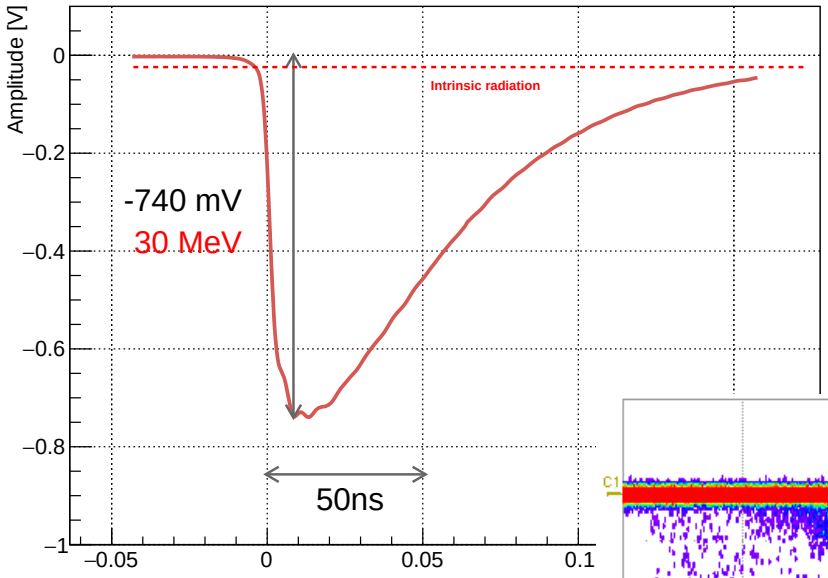
- Direct shot of protons and deuterons on LYSO
  Unpolarized deuteron and proton of:
  100, 150, 200, 235, **270 MeV**
- LYSO module development and mechanical construction:
  LYSO (2 types), PMT (2 types) and
  SiPM/MPPC (KETEK, SensL)
- **2 (+2)** LYSO crystals will be tested:
  Saint–Gobain (EU) 2x(30*x*30*x*100*mm*)
  EPIC–Crystals (China) 1x(30*x*30*x*100*mm*)
  Saint–Gobain 2x(15*x*30*x*100*mm*)
- **2x 10x LYSO modules** in readout with polarized deuterons
  Analyzing power / FOM comparison of different targets

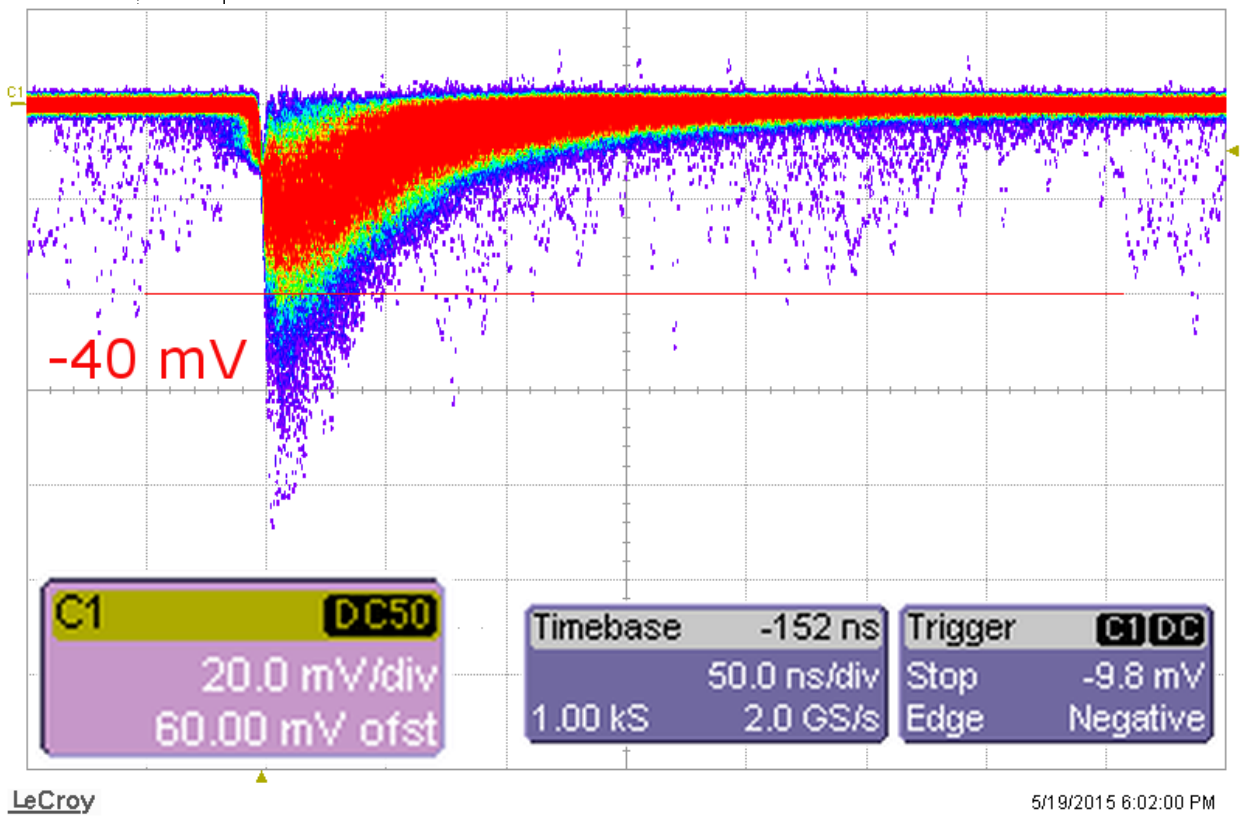
Carbon Scattering

Ellastic to Inelastic Ration



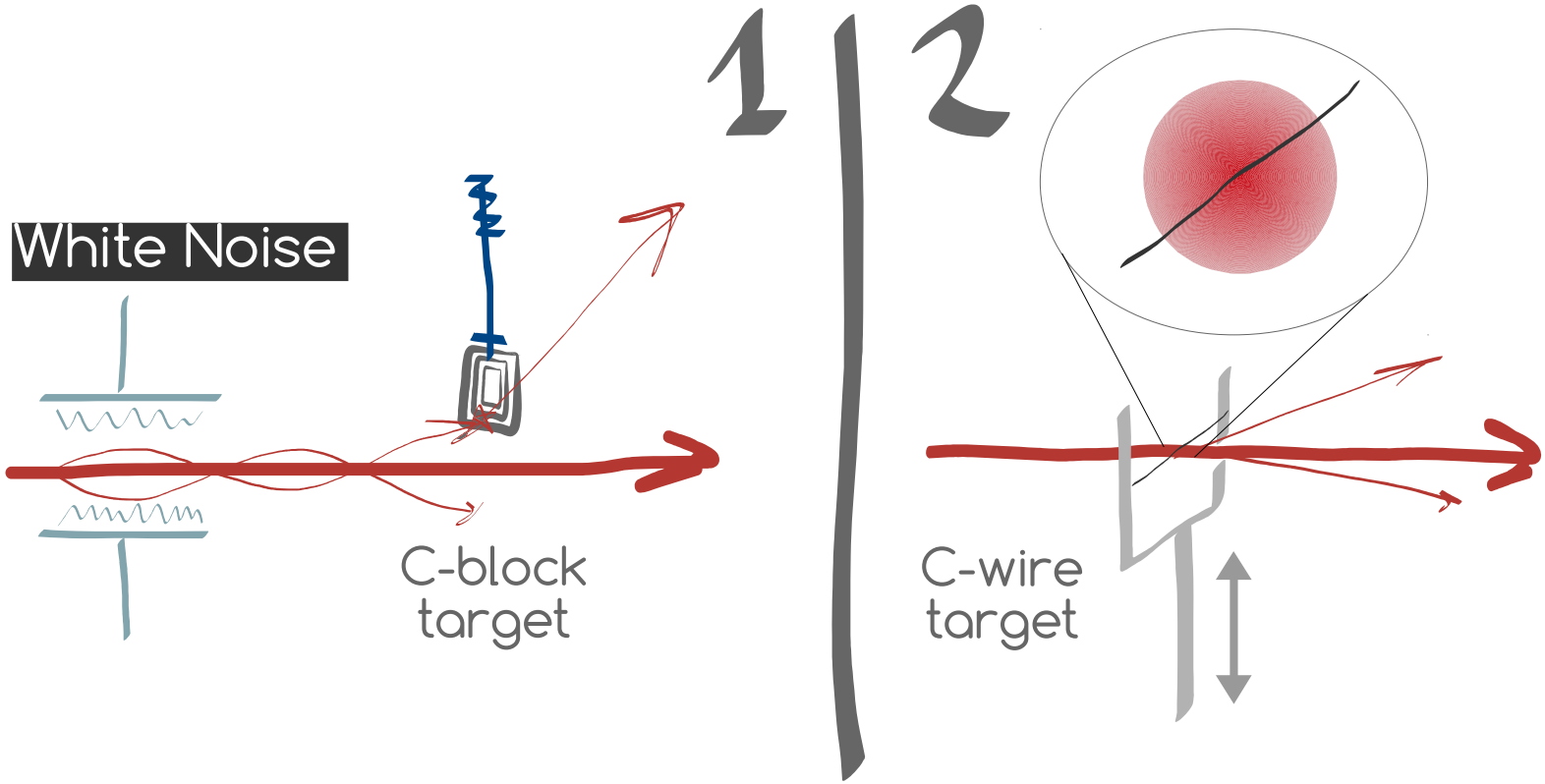
Cosmic Signal vs Intrinsic Radiation





EDDA@COSY Targets

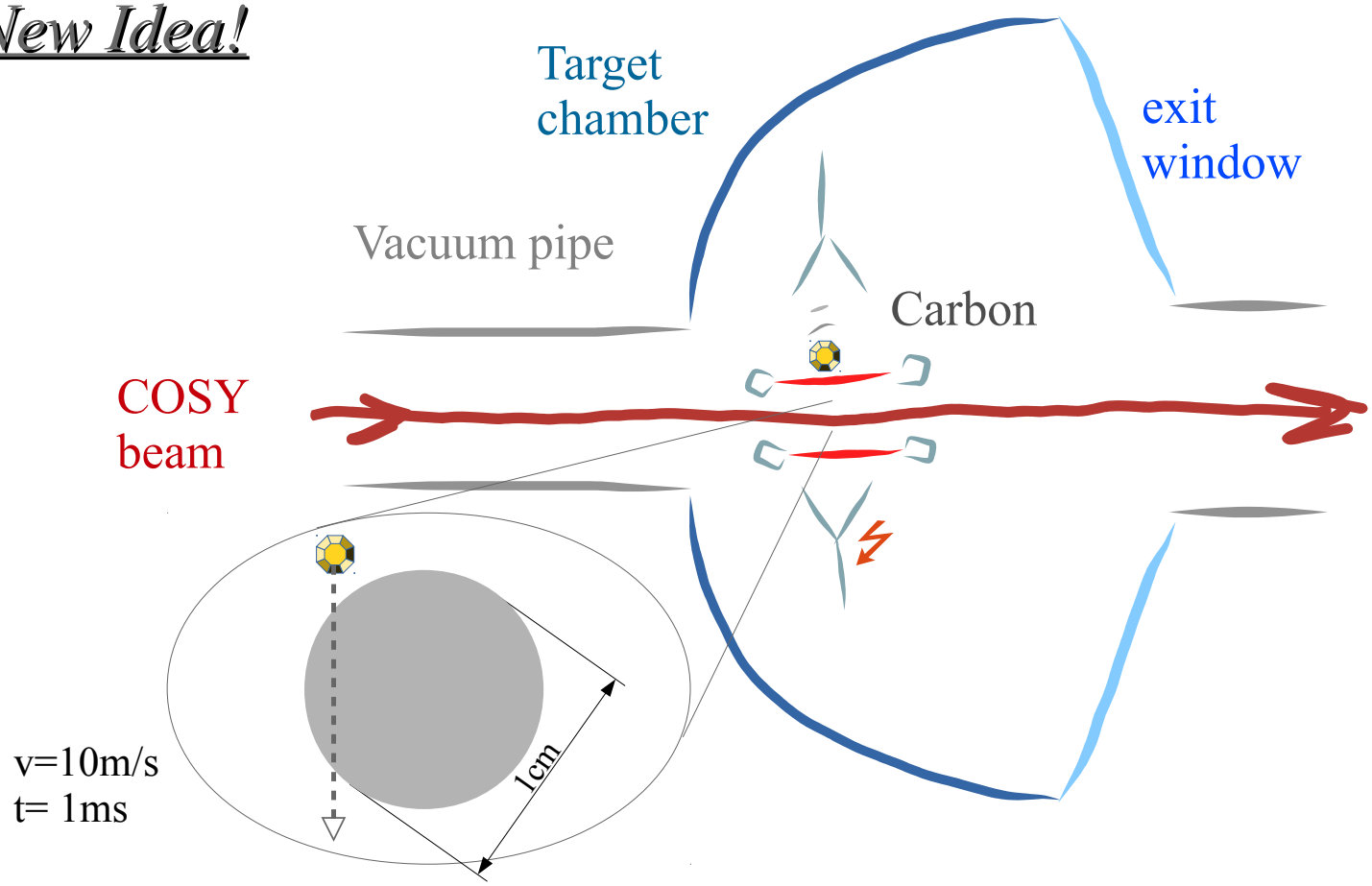
Optimized for $\vec{d}C \rightarrow dC$ Reaction



JEDI Polarimetry Concept

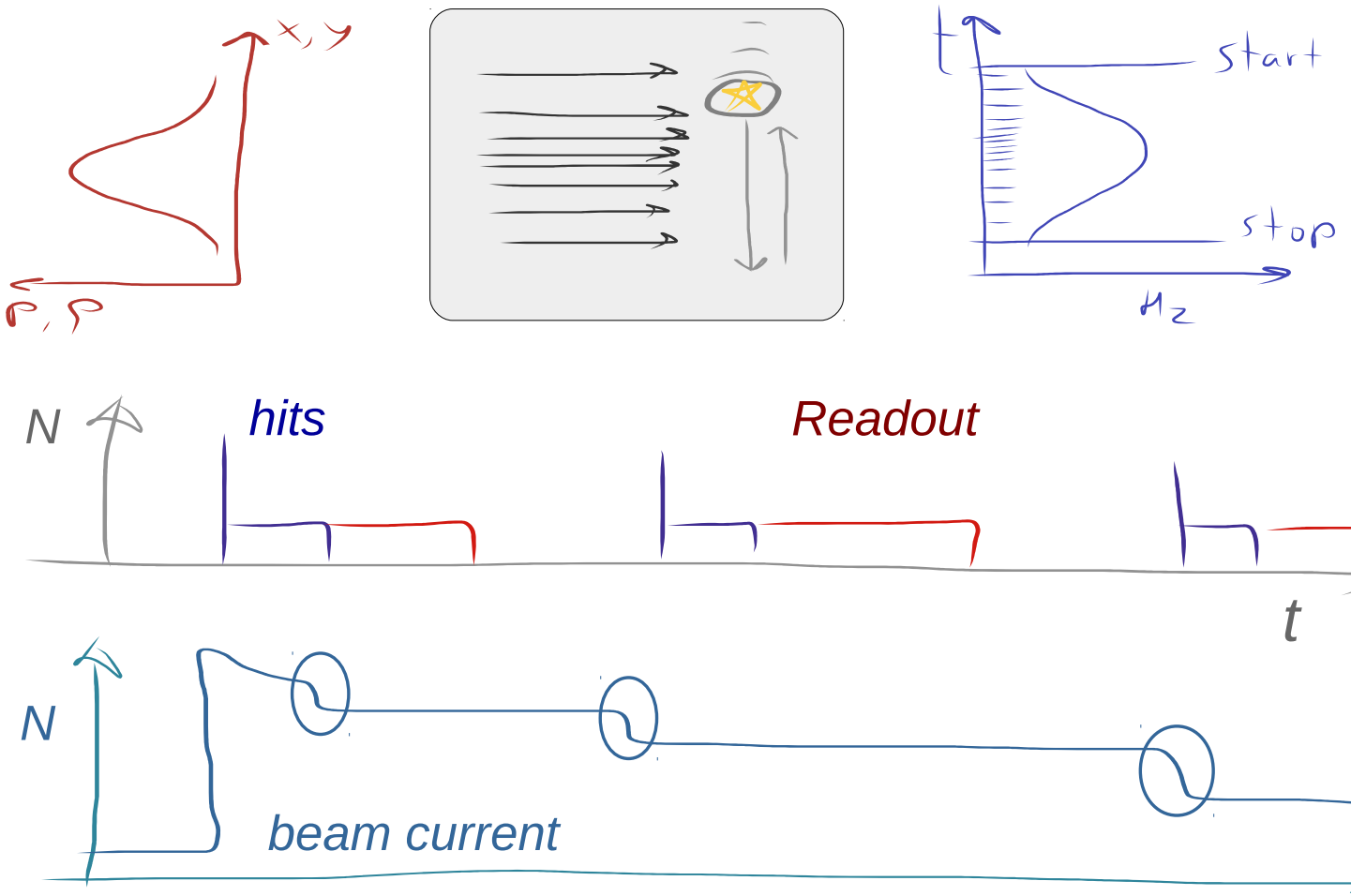
JüDiT – Jülich BallisticDiamond Pellet Target

New Idea!



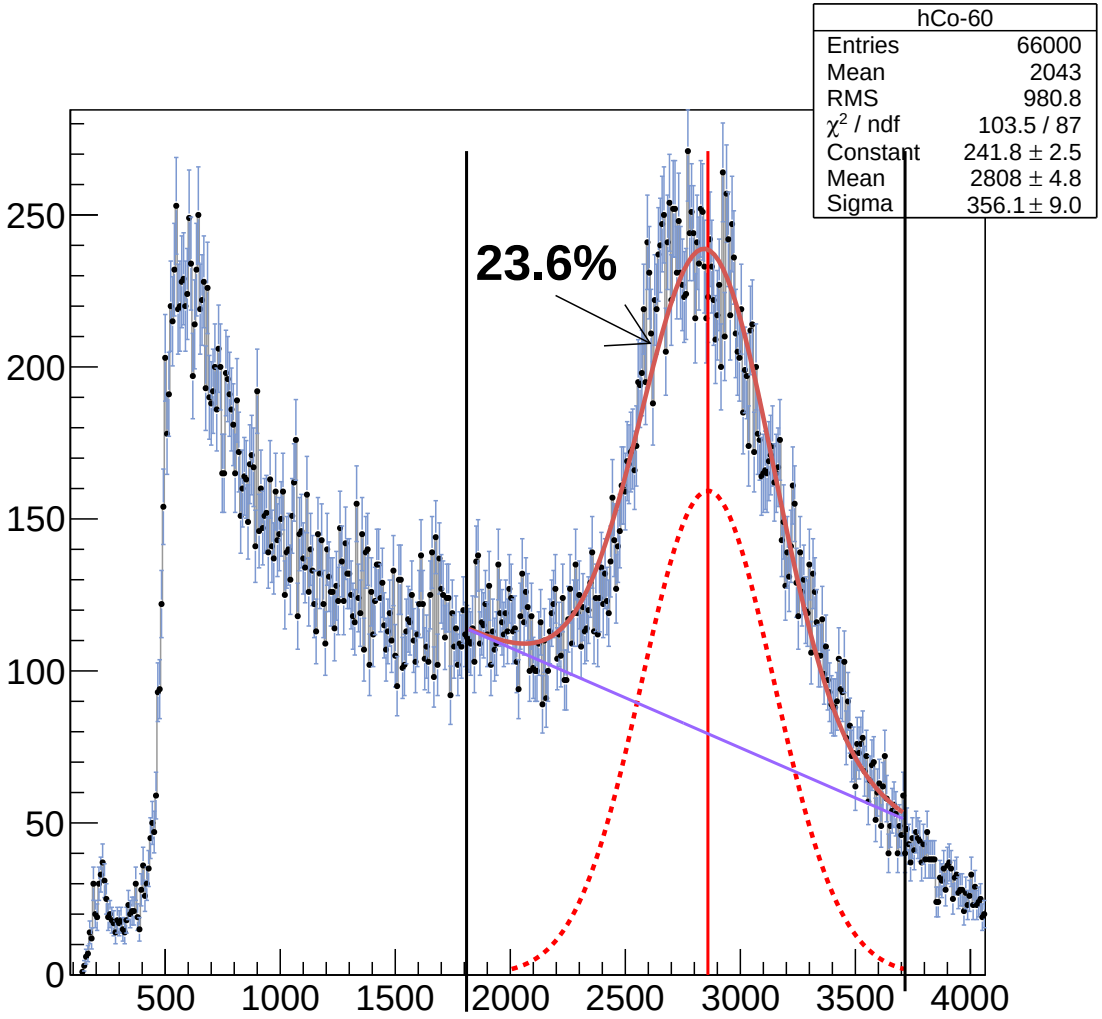
JEDI Polarimetry Concept

Variable Effective Target Thickness



Cosmic Calibration

K. Nowakowski, C. Dziwok



G4: Cosmic Simulation

P. Maanen, LYSO $30x30x100mm$ **with** 0^o, 45^o, 90^o