Recent results from CCB

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CCB – Cyclotron Center of Bronowice*

- **Radiotherapy**

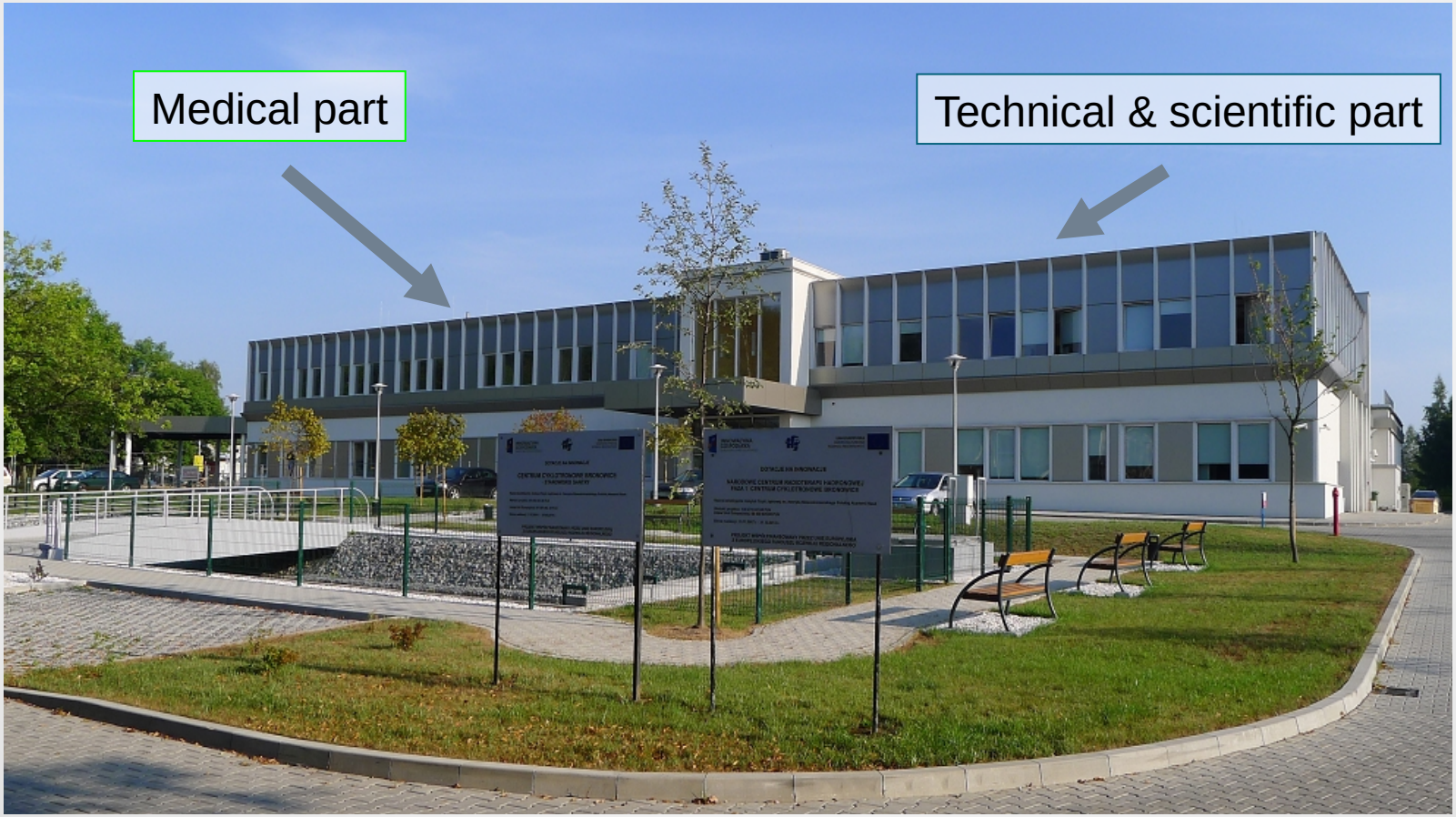
  (ocular radiotherapy, two gantry facilities)
- **Dosimetry**
- **Detector testing**

  (CALIFA, FAZIA, GARFIELD, KRAB**)
- **Fundamental physics**

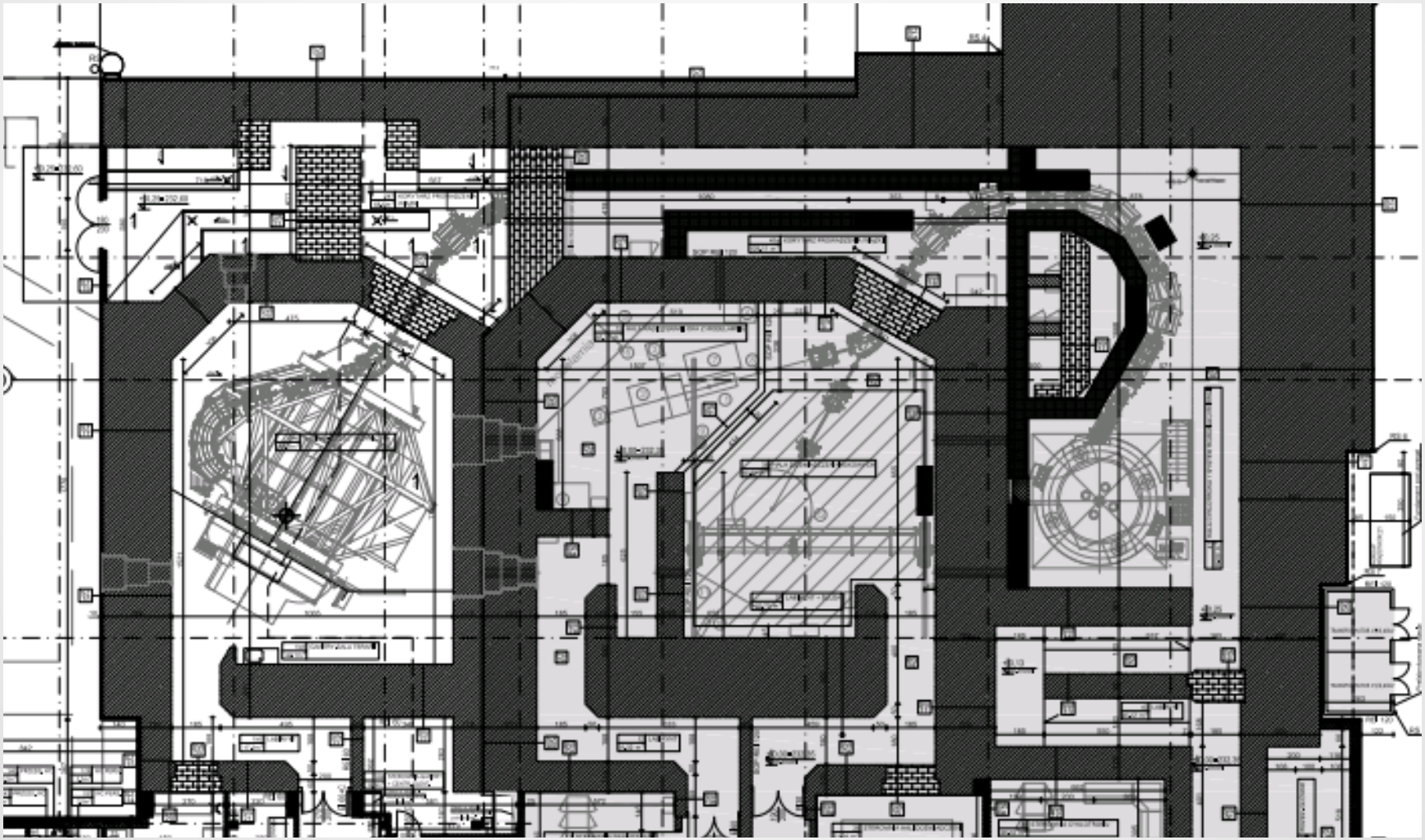
  (nuclear structure, spallation)

*) North-West district of Krakow
**) described below

CCB – Cyclotron Center of Bronowice



CCB – Cyclotron Center of Bronowice



Cyclotron: Proteus 235

Technical parameters

- Magnet Length Diameter: 435 cm
- Magnet height; 210 cm
- Magnet weight: 220 tons
- Magnetic Structure:4 spiral sectors
- Deep valley design
- Magnetic Field: 1,75 ÷ 2,35 T
- Main Coil Current: 0 ÷ 850 A
- Number of Harmonic Coils In central region: 4
- Number of Dees: 2 (α=30º)
- RF Generator Frequency: 106 MHz
- RF Generator Power: 100kW
- Dee voltage:
  - Central region: 50 kV
  - Extraction region: 120 kV

Beam

- Proton beams with energies from 70 to 230 MeV
- $\Delta E/E < 0.7$ %
- Beam intensity (at cyclotron output, E=230 MeV):

  from 0.1 nA ($6.6 \cdot 10^{8}$ *p*/s) to 600 nA* ($3.3 \cdot 10^{12}$ *p*/s)
- The beam energy can be changed smoothly using a graphit degrader. The change takes few seconds.
- Cyclotron frequency: 106 MHz (beam pulse every 10 ns).

*) For security reasons, during long experimental runs the beam intensity is not allowed to exceed 20 nA

Detectors

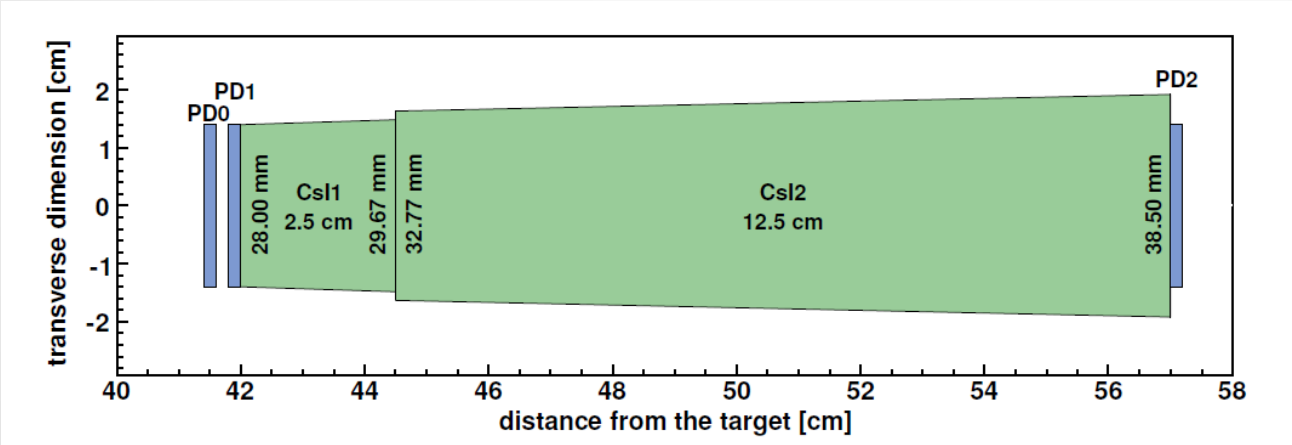
- BINA – light charged particles (nuclear force studies)
- KRATTA* – charged particles (nuclear reactions)
- HECTOR – gamma rays
- PARIS* – gamma rays

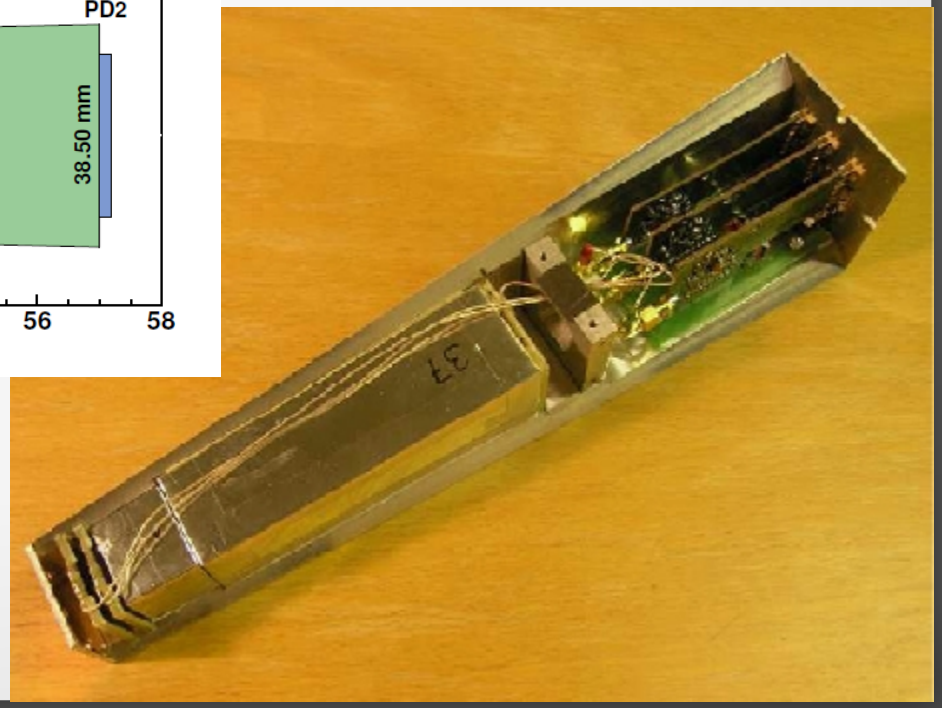
*) described below

KRATTA – Triple Telescope Array

Nuclear Instruments and Methods in Physics Research A 709 (2013) 120–128

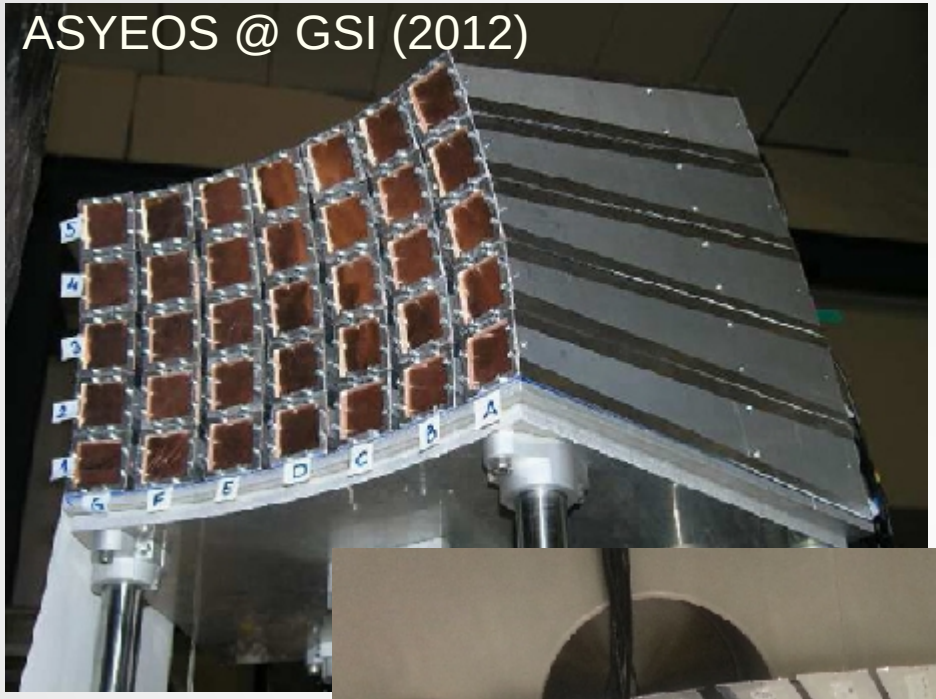
KRATTA is a versatile, low threshold, broad energy range system built to measure the energy, emission angle, and isotopic composition of light charged reaction products. It consists of 38 independent modules which can be arranged in an arbitrary configuration. A single module, covering actively about 4.5 msr of the solid angle at the optimal distance of 40 cm from the target, consists of three identical, 500 mm thick, large area photodiodes, used also for direct detection, and of two CsI(1500 ppm Tl) crystals of 2.5 and 12.5 cm length, respectively. All the signals are digitally processed.

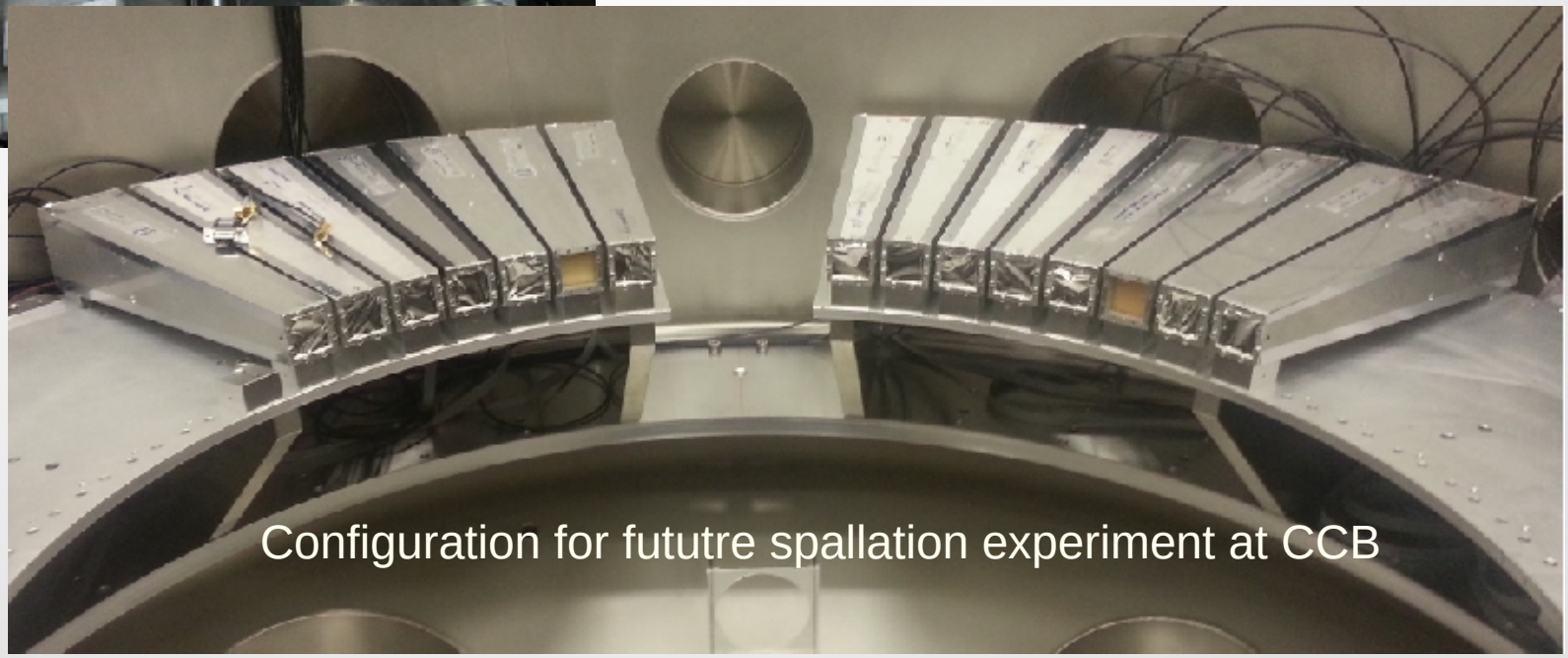




Energy range for protons: E <260 MeV

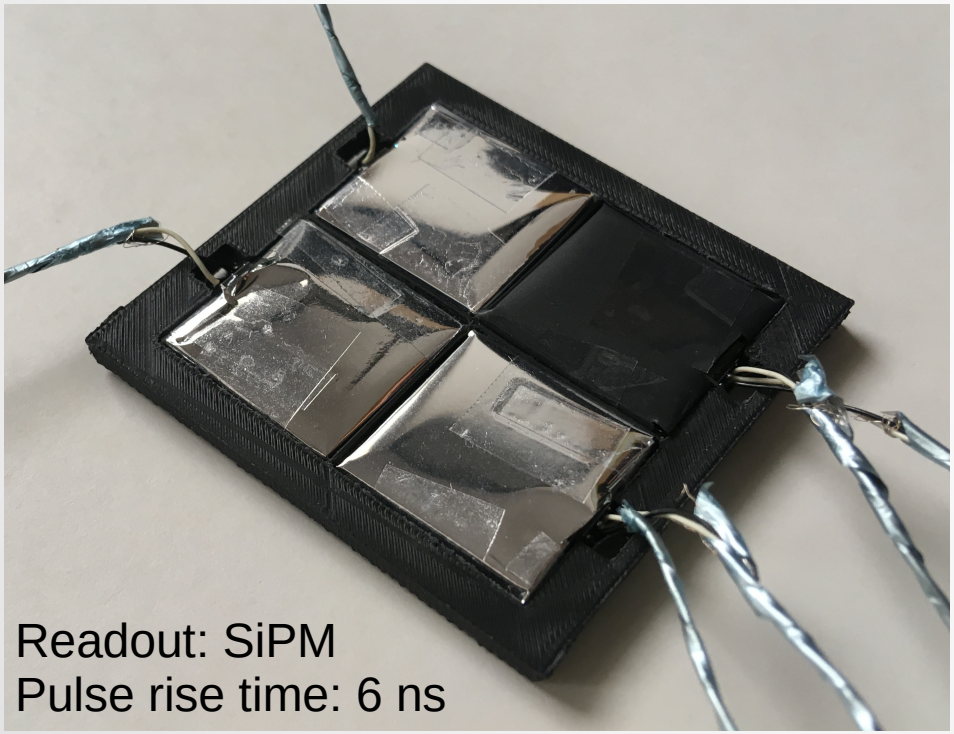
KRATTA


ASYEOS @ GSI (2012)

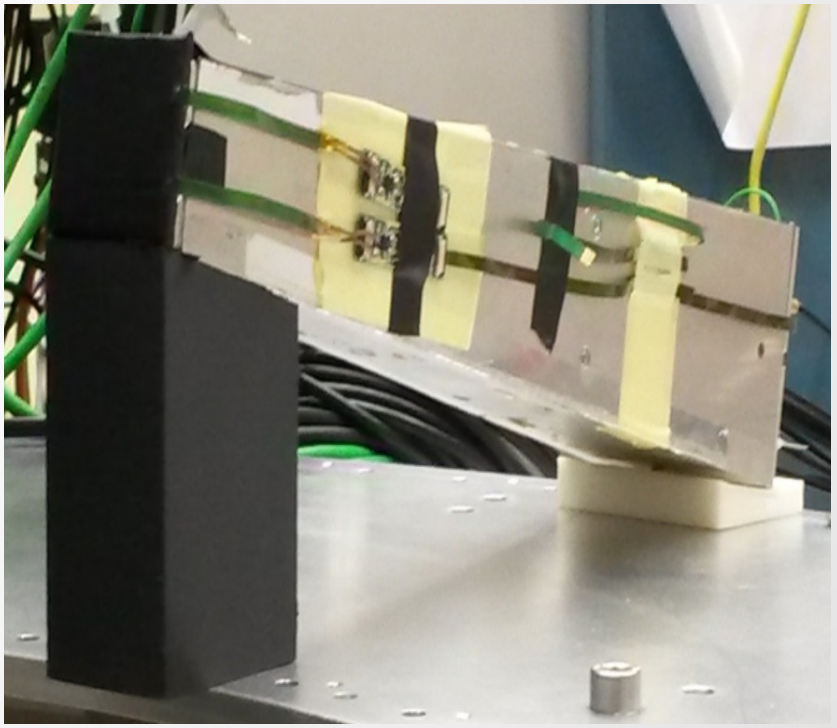

Configuration for fututre spallation experiment at CCB

KRATTA upgrade

To improve timing and granularity of KRATTA, in each module a 4-segment plastic detector was mounted on front of each KRATTA module.



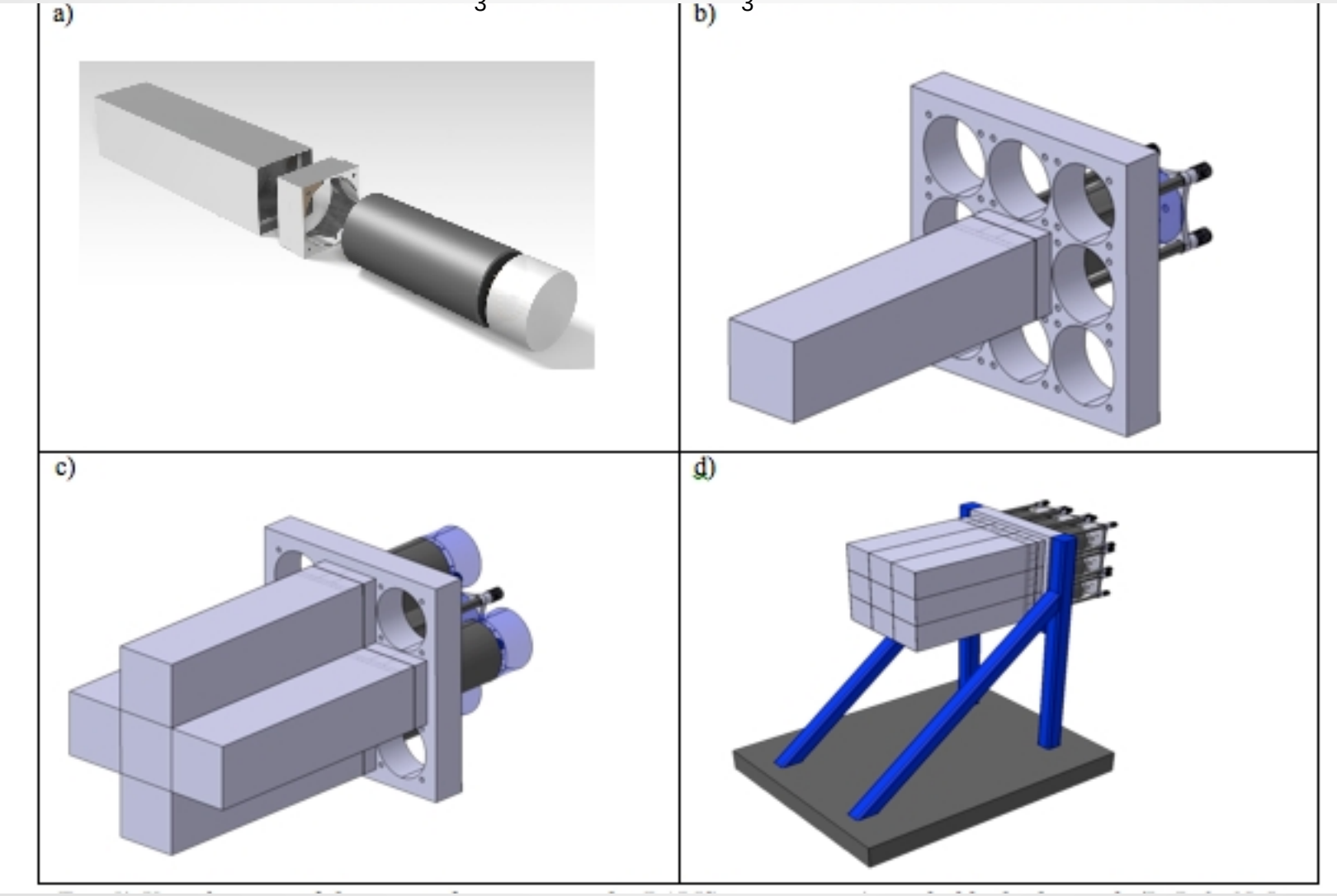
Readout: SiPM
Pulse rise time: 6 ns



PARIS

Cluster of phoswich detectors for gamma energy measurements

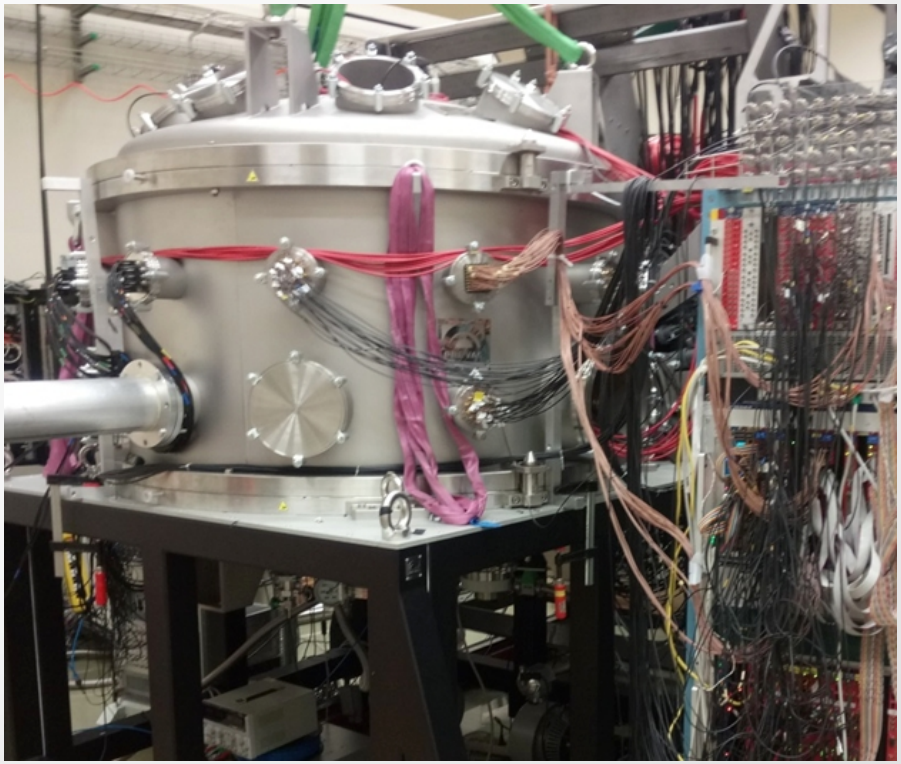
$LaBr_3$ + NaI or $CeBr_3$ + NaI



Scattering chamber

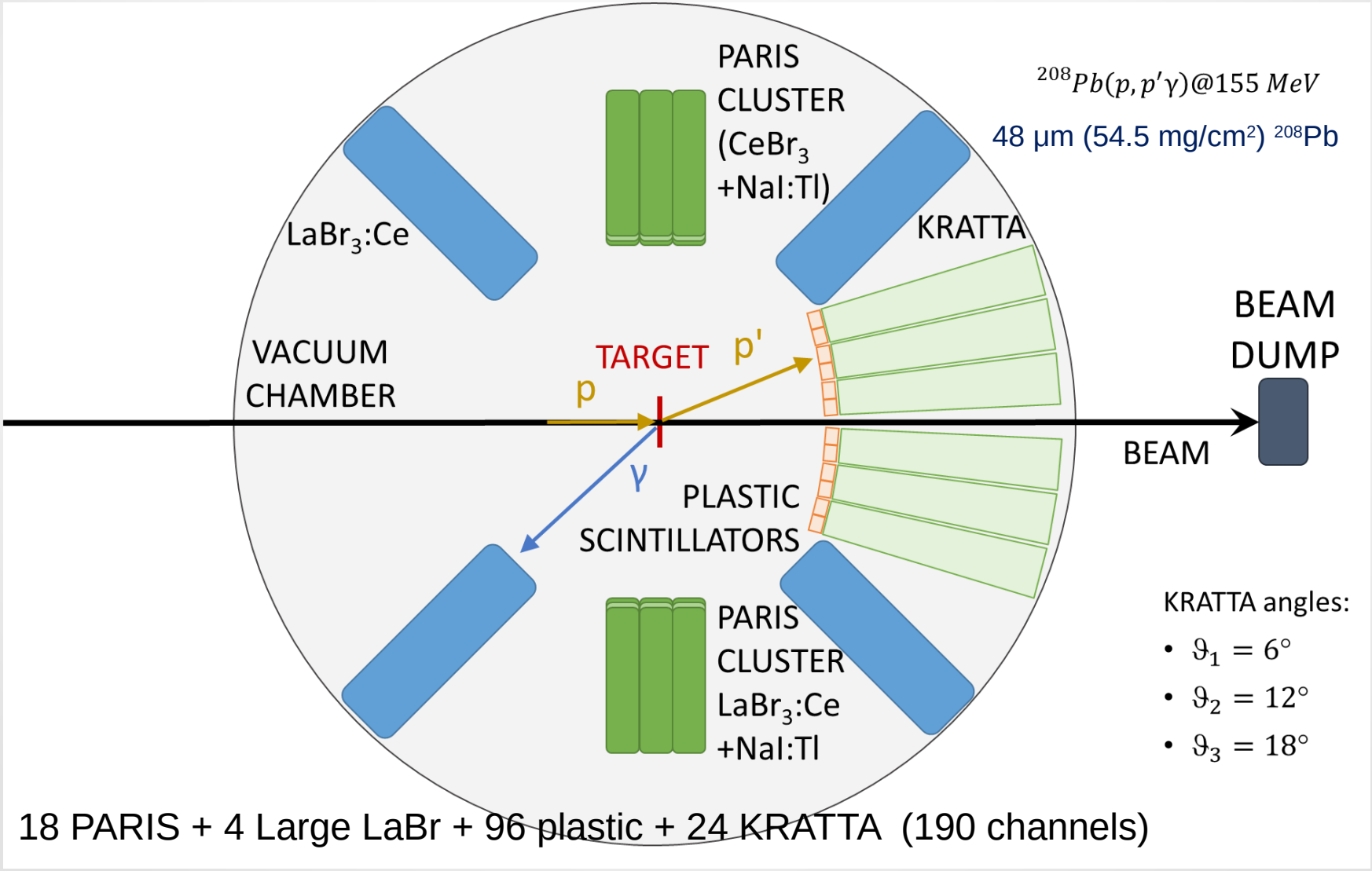
Large, multipourpose scattering chamber

(Diameter: 1,5 m, height 1 m)



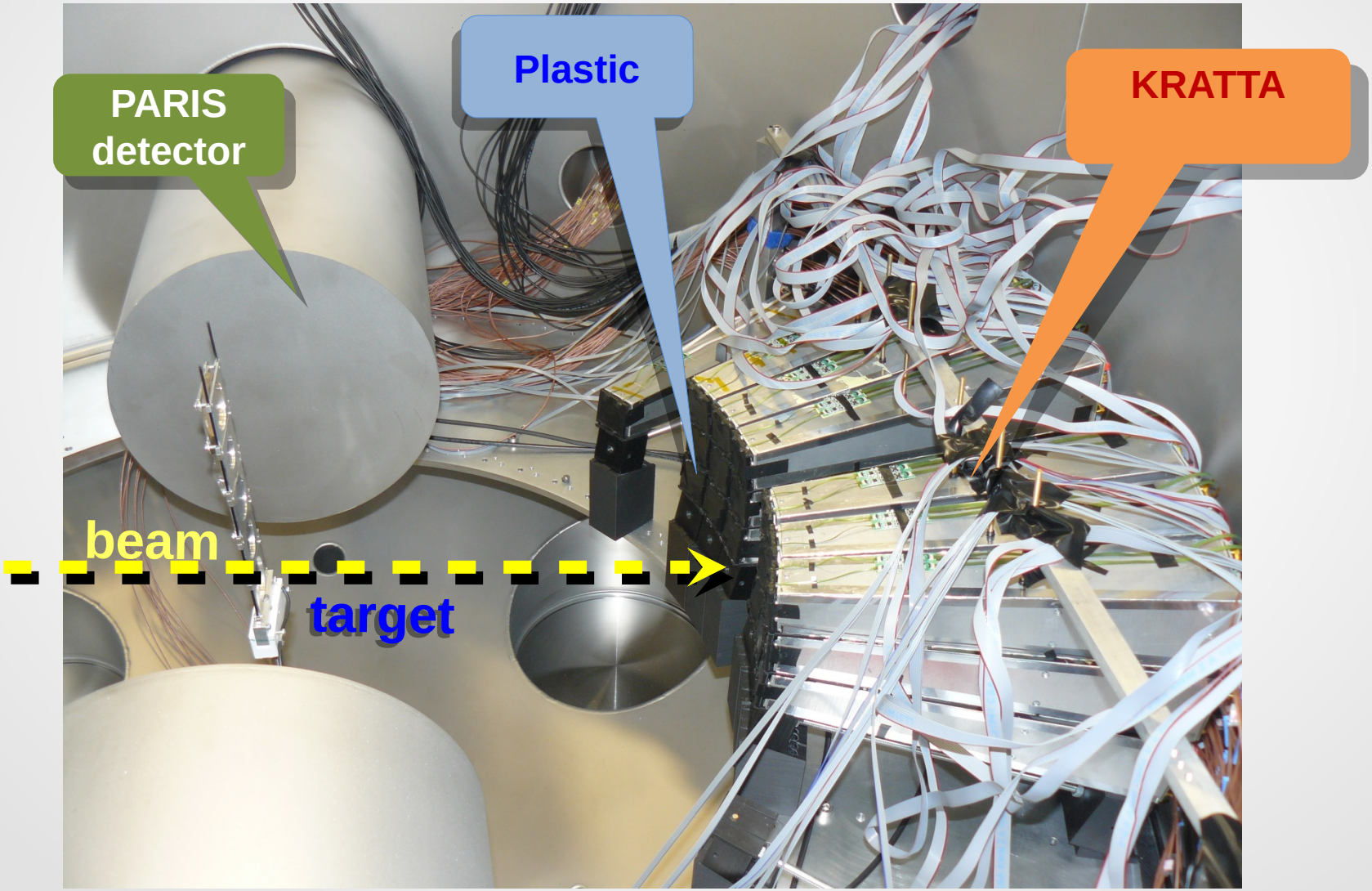
^{208}Pb (p, p’ ɣ) @ E=155 MeV

Studies of resonance states in nuclei using high-energy proton beam in p,p’ reactions



18 PARIS + 4 Large LaBr + 96 plastic + 24 KRATTA (190 channels)

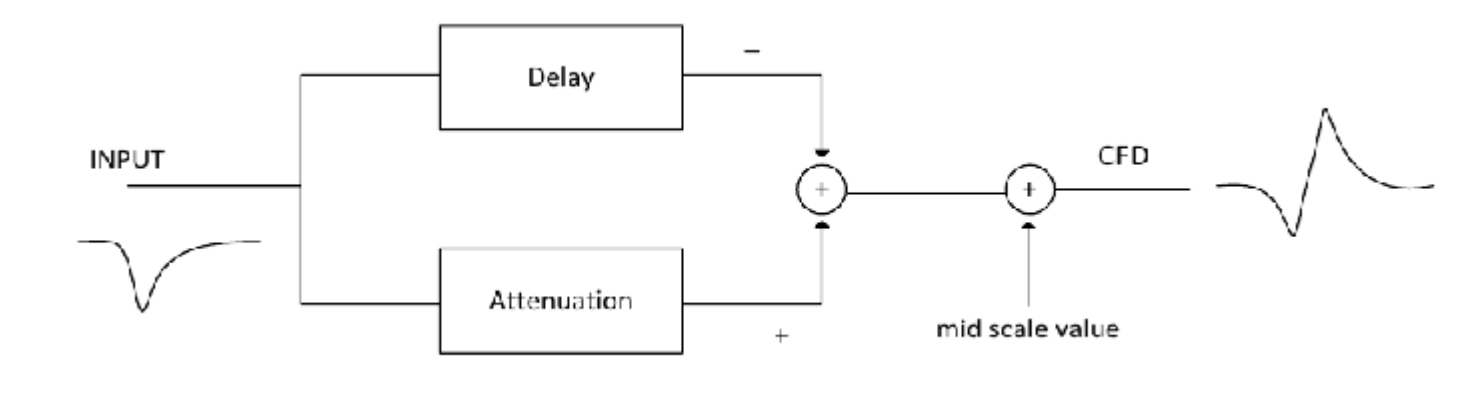
Experimental setup

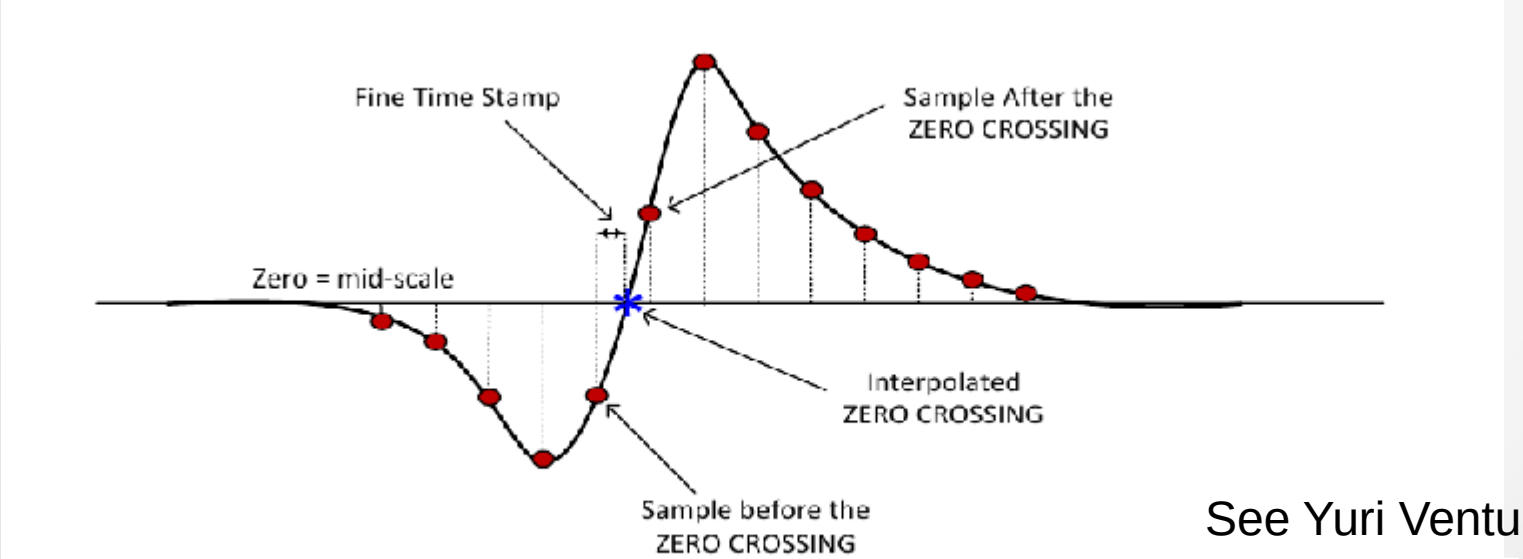


Electronics

- Digital signal processing:
  - **KRATTA:** 9xV1724 digitizer
    - sampling: 100 MHz
    - Buffer size: 512 (PD0) or 1024 (PD1,PD2) samples
    - Firmware: standard (waveforms)
  - **PARIS:** 2xV1730B digitizer
    - sampling: 500 MHz
    - Buffer size: 500 samples
    - Firmware: PSD (time,long,short + waveforms)
  - **PLASTIC:** 6xV812 CFD + 3xV775 TDC

Digital CFD applied in V1730 digitizer

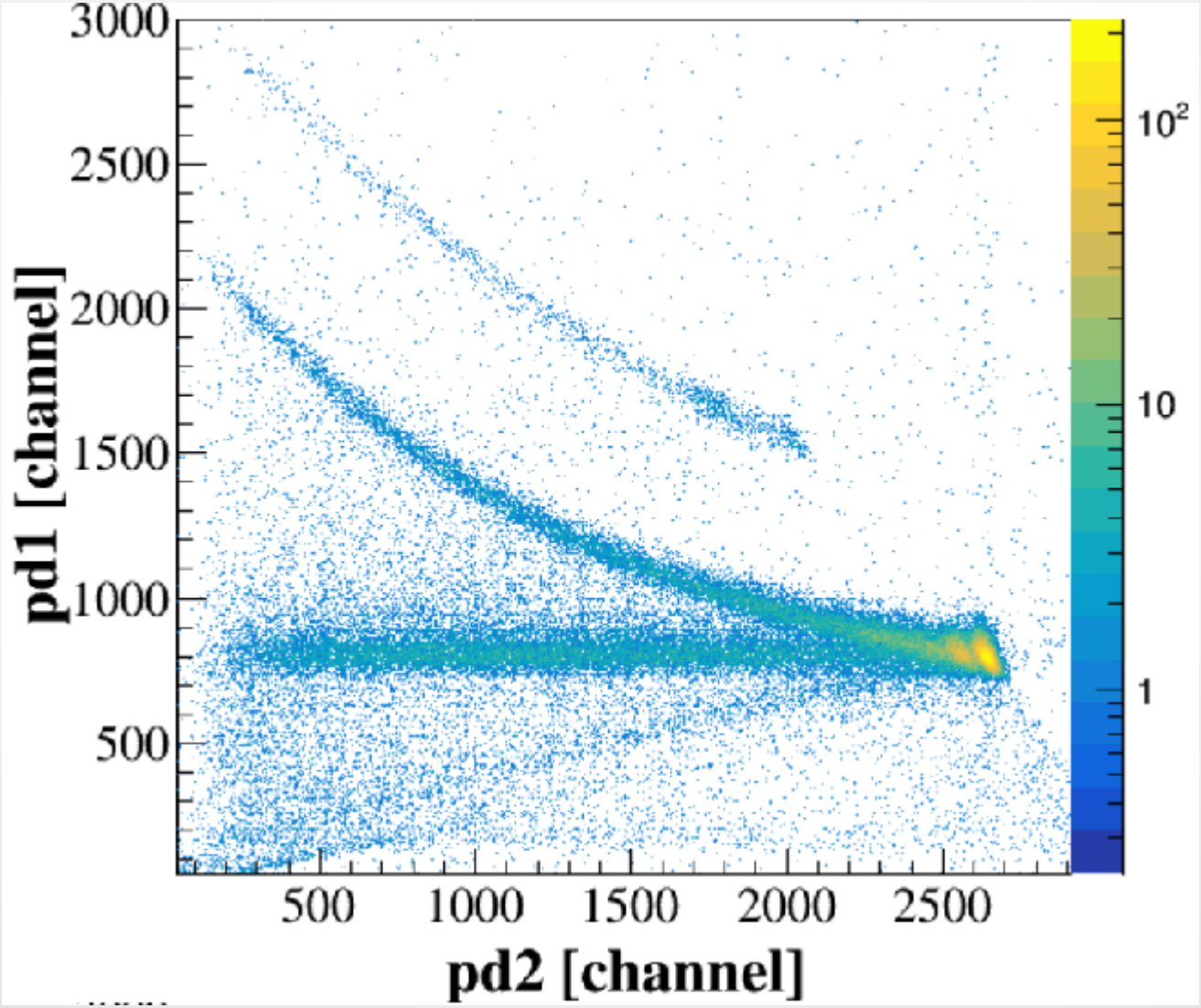




See Yuri Venturini talk fot details

User Manual UM2580
DPP-PSD
Digital Pulse Processing for Pulse Shape Discrimination
Rev. 8 - September 29th, 2016 (CAEN)

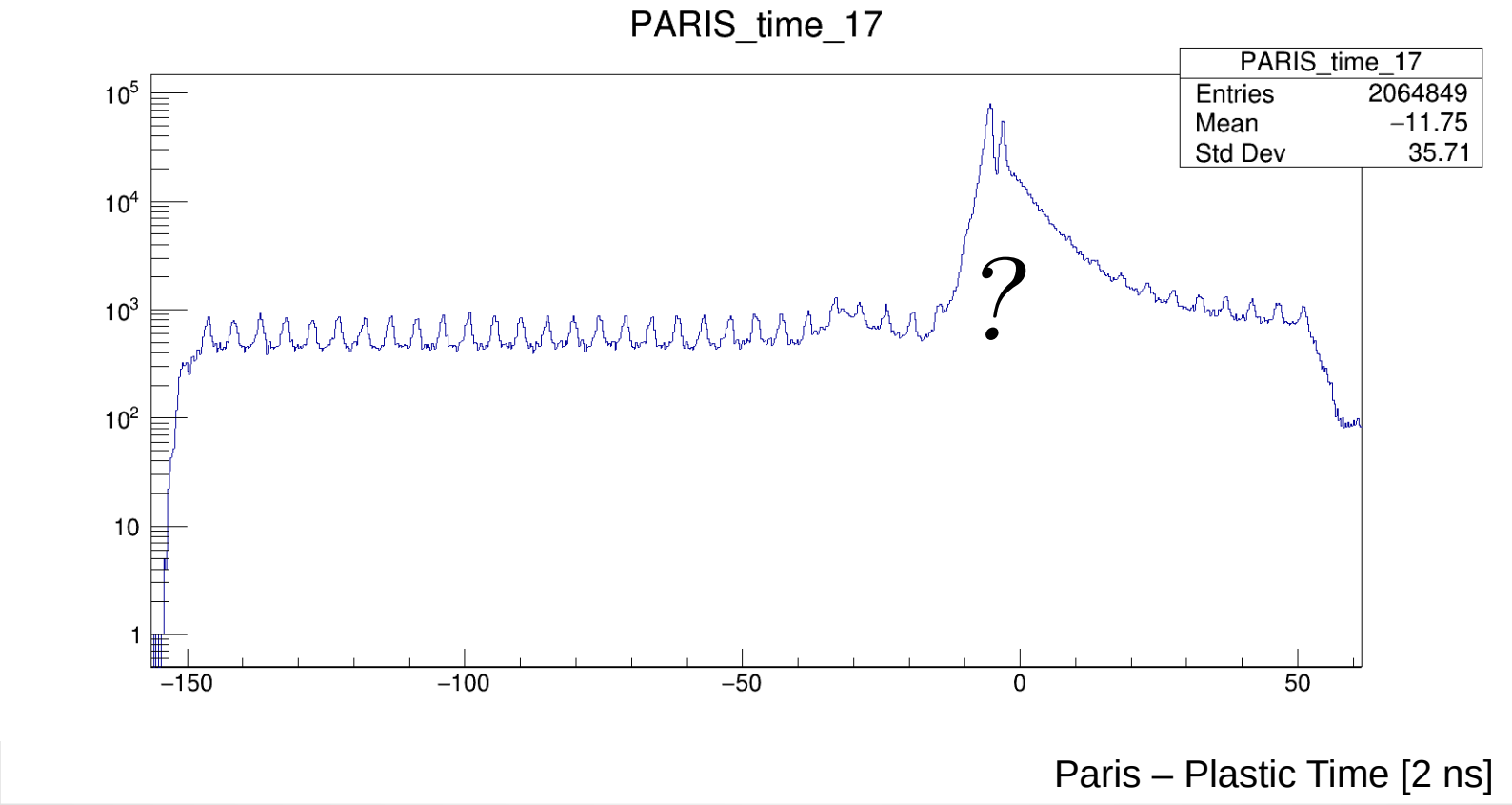
KRATTA performance



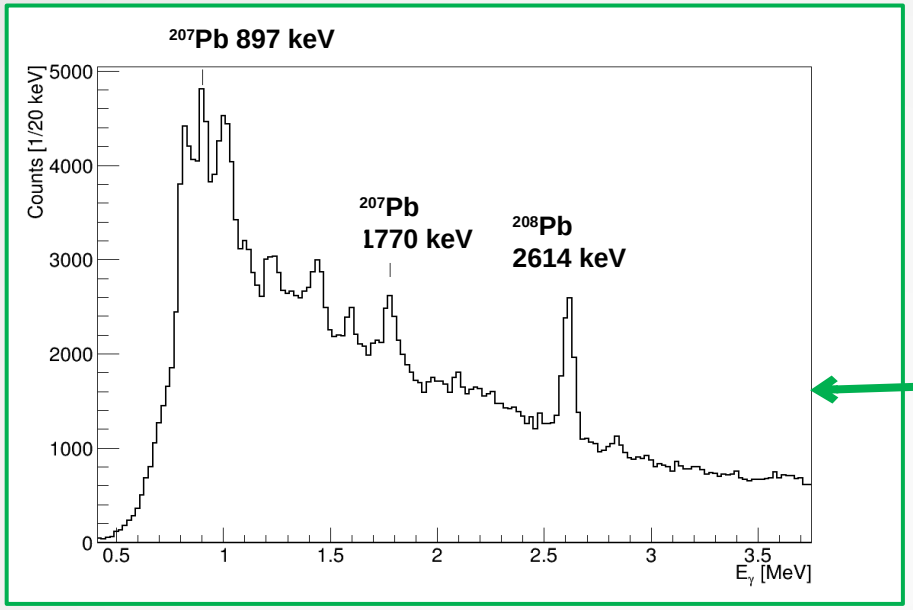
Time measurement

Gamma – proton time difference

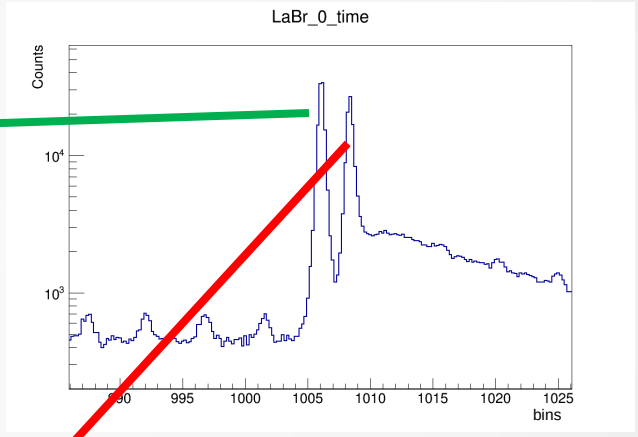
Plastic OR (protons) is connected to one channel of V1730B digitizer. The other channels are connected to PARIS (gamma) detectors. Fine Time Tag in V1730B is used to get time interval between them

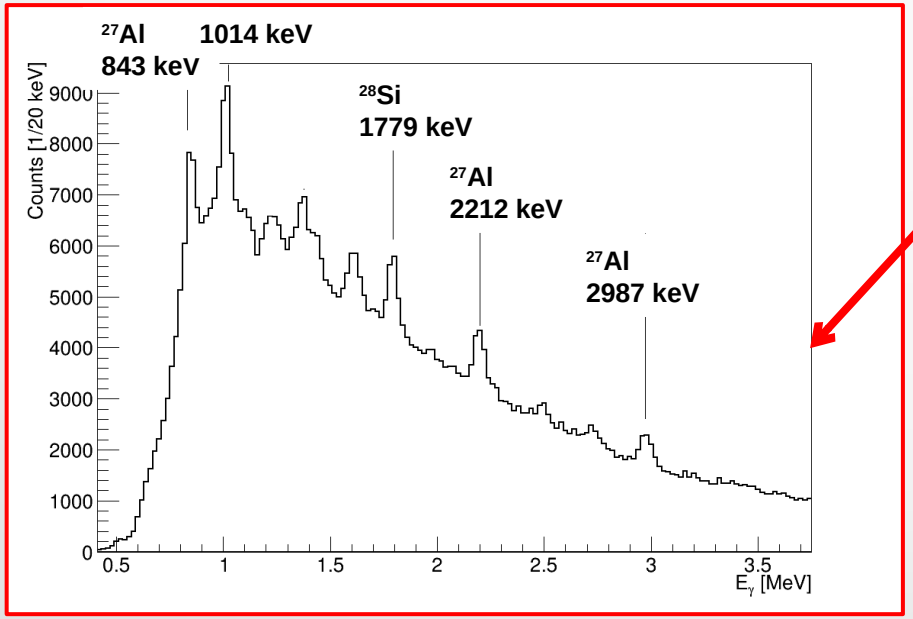


Time measurement



Reaction on ^{208}Pb target





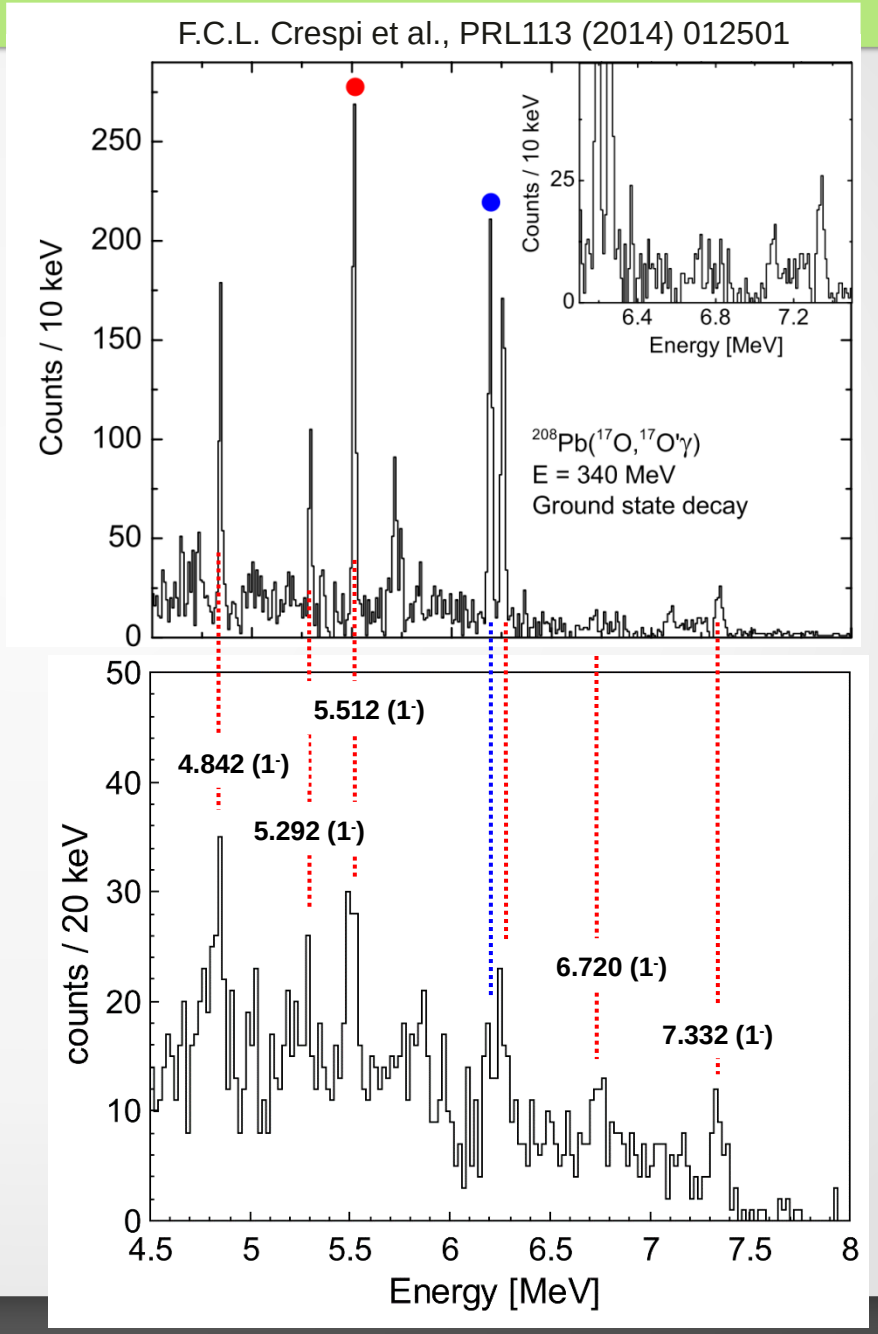
Reaction on other target (?)

Physics

^{208}Pb gamma structure in Pygmy region

(Analysis done by Mateusz Krzysiek)

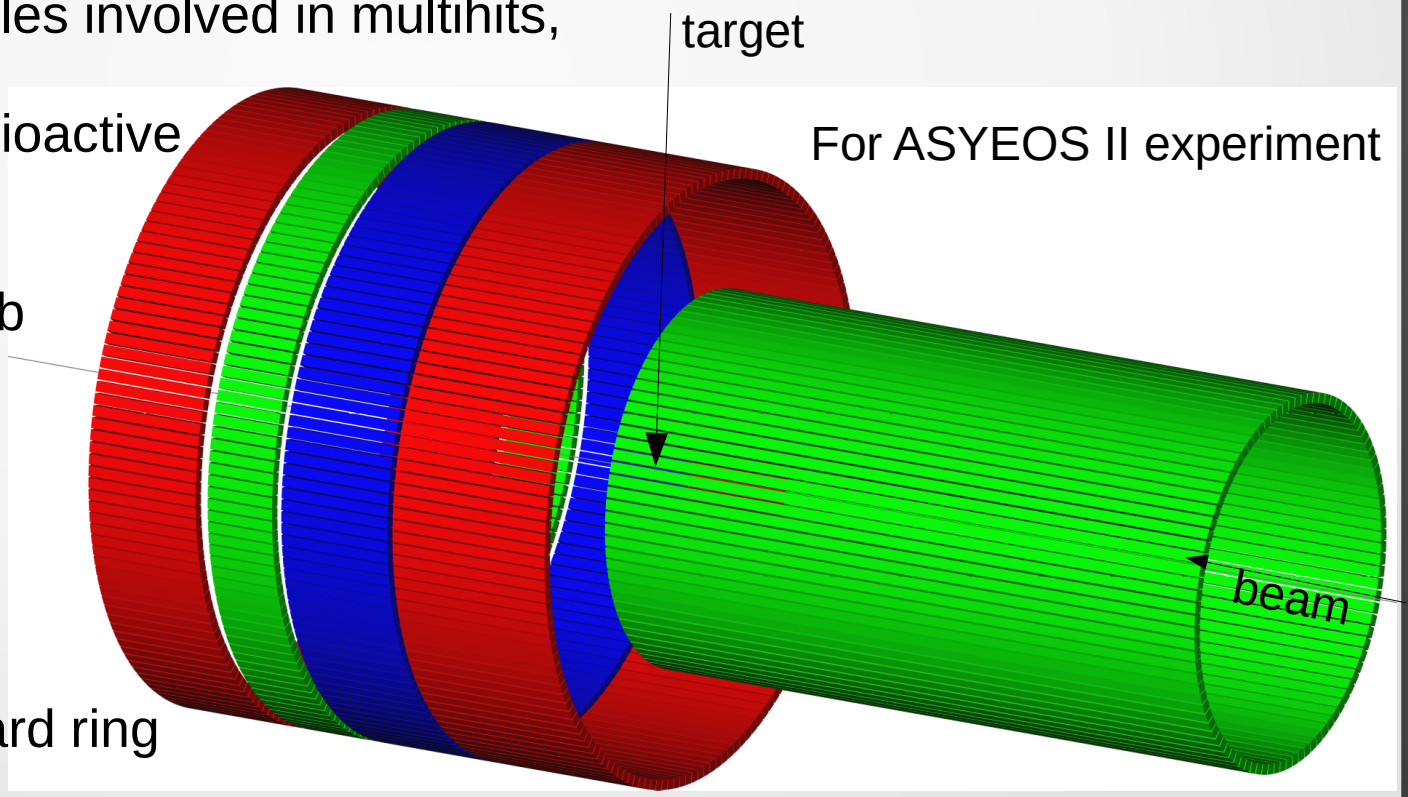
Data analysis is in progress...



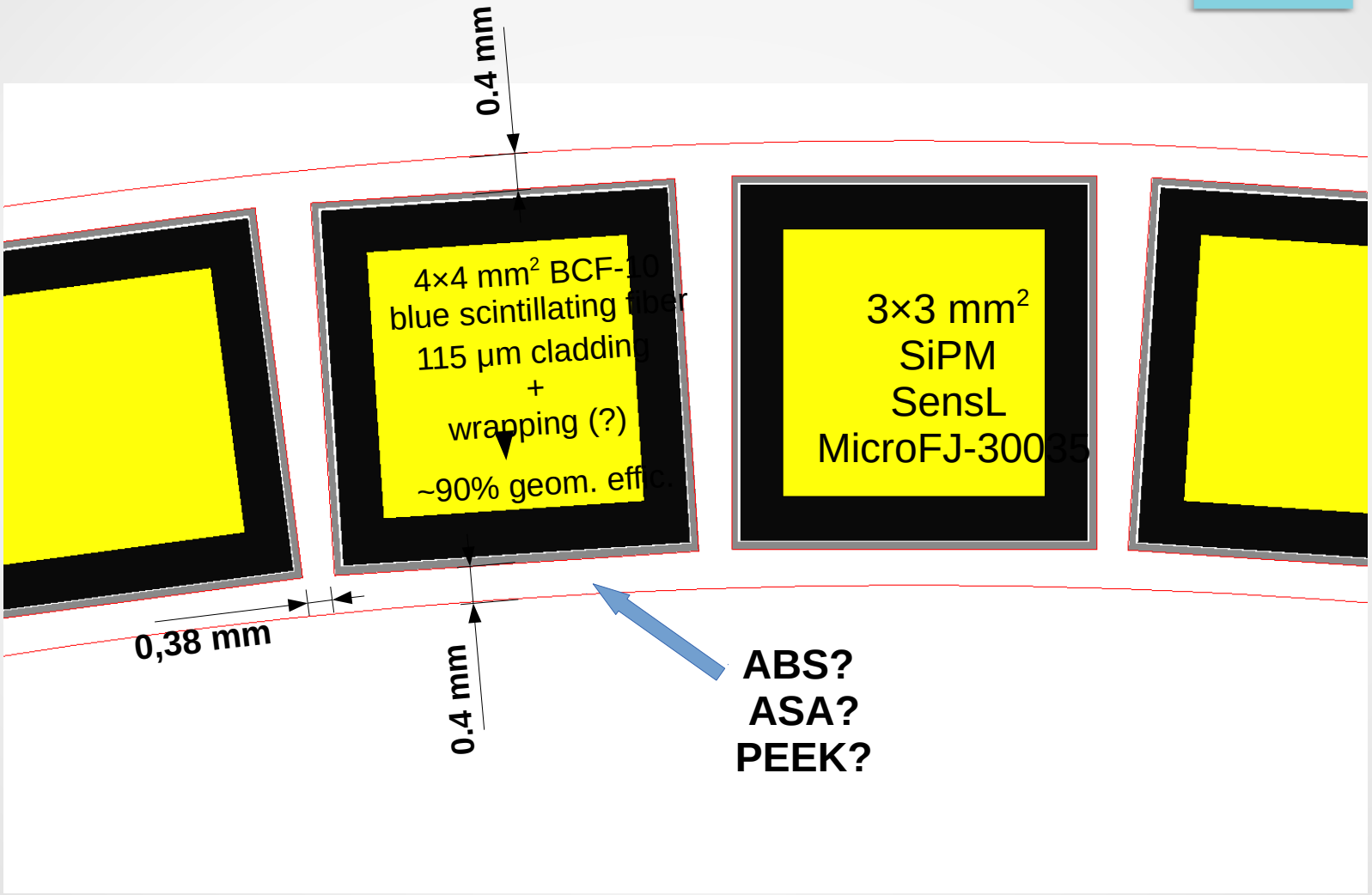
KRAB – a new detector build at IFJ

Multiplicity Trigger & Reaction Plane detector

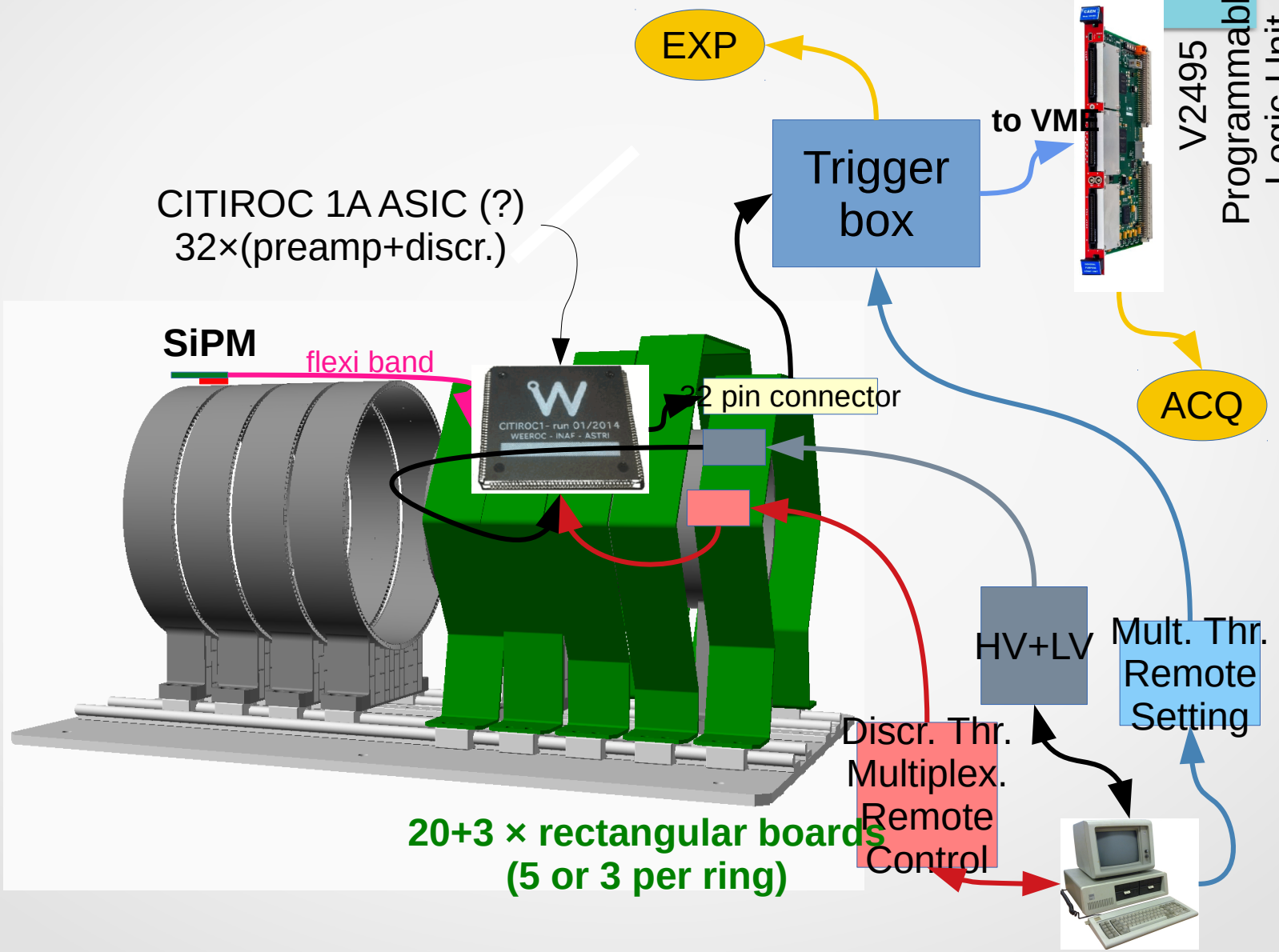
- 5 rings of 4x4 mm^2 fast scintillating fibers (e.g. BCF-10) read out by SiPMs
- covers angles from 30^o to 165^o,
- segmentation assures more or less uniform count rates for Au+Au at 1 AGeV,
- geometrical efficiency ~87%
- ~10% of charged particles involved in multihits,
- ~5% multihit probability
- sufficiently large for radioactive beams
- sufficiently small and lightweight not to disturb neutrons
- min radius - 7 cm,
- max radius - 12 cm
- length 43 cm
- 160 segments in forward rings
- 96 segments in backward ring
- 736 channels



Ring segments



Schematic view of KRAB



Conclusions

- CCB is a new facility for nuclear research available to all investigators all over the world.
- Proton beams from 70 to 230 MeV, large scattering chamber and a variety of detectors are available.
- The first full-scale experiment performed this year provided valuable data and proved good performance of the applied ingrediences.
- Electronic front-end basing on V1730 digitizers give a good time resolution (~100 – 200 ps) which allowed to separate true coincidences from background.
- Despite of some technical problems the physical data are of good quality. We may claim to be ready to make a real research.

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