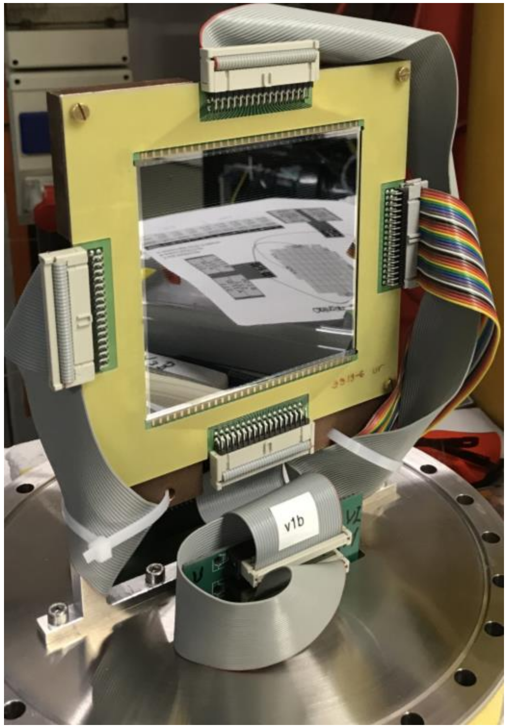
Tracking Detector WG: 2022 Status Report

Dominic Rossi

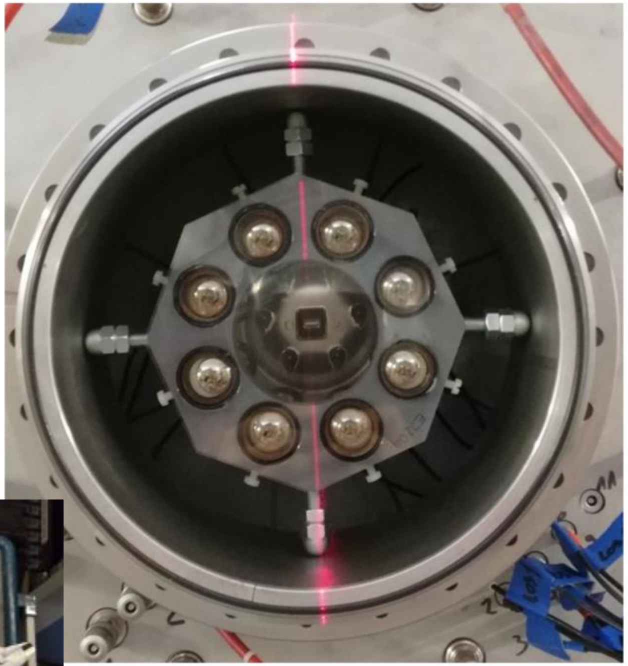


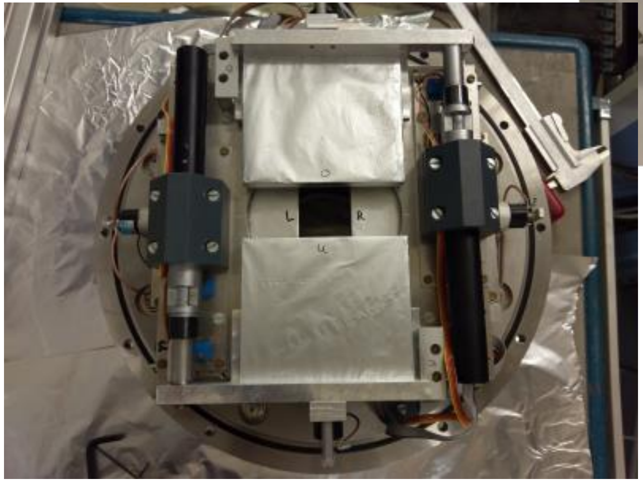
Overview

- Goal of this session:
  - Provide collaboration members preparing new proposals with up-to-date information on tracking detectors for >2023
  - Initiate discussion on non-deliverable Russian in-kind contributions (specifically: PAS)
  - Initiate discussion on 2023 setup

LOS, ROLU

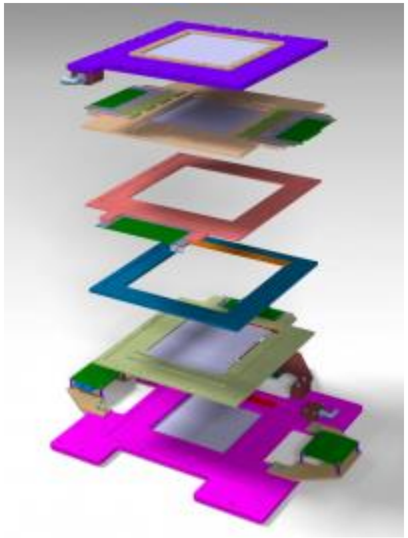
- Both detectors functional
- LOS: two geometries
  - PMTs parallel to beam: primarily for thin scintillator foils
  - PMTs orthogonal to beam: for thick (mm) scintillator foils
- Scintillator thickness needs to be communicated early to Tracking WG (purchase new foils, installation, testing)



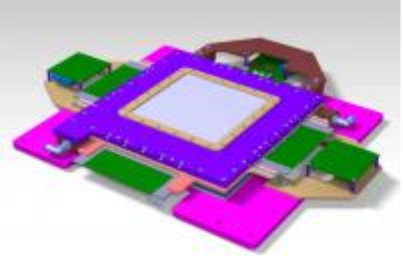


MWPC

- SOFIA MWPCs have been used in recent experiments for beam tracking (x,y positions)
- Thin detectors (small material budget), but need to be operated in air
- High reliability, quick setup → primary detector system for beam tuning in HTC, along with LOS and ROLU



- We use the SOFIA detectors for now, but R3B should consider building their own set of MWPCs for long-term use



MUSIC: what's new?

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- 2022 experiments: light ion-beams
  - s522: Z=6 (^{12,16}C), E_{inc}= 1.25 AGeV ;

    → high production of δe^- and small energy deposition (~6000 e^-/anode)
  - s509: Z=4-10 (Be-Ne), E_{inc}= 400 AMeV

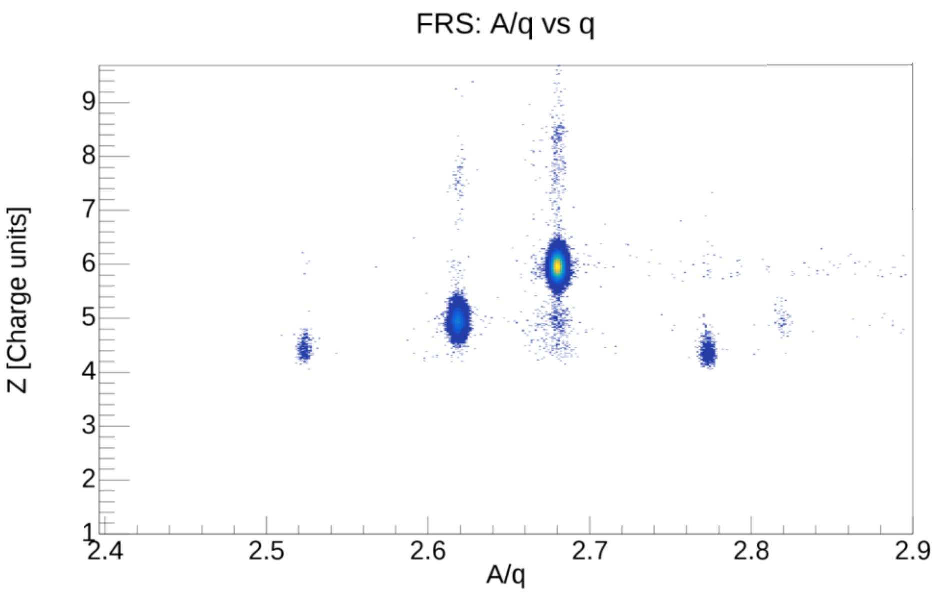
    → lower production of δe^- is expected because of the lower E_{inc} and therefore a better charge resolution
- ¼ of TWIN MUSIC
- new high-gain pre-amplifiers
- new firmware for MDPP16 electronics: sum of anode signals by 2, 4, 8, 16.

  → better S/N ratio

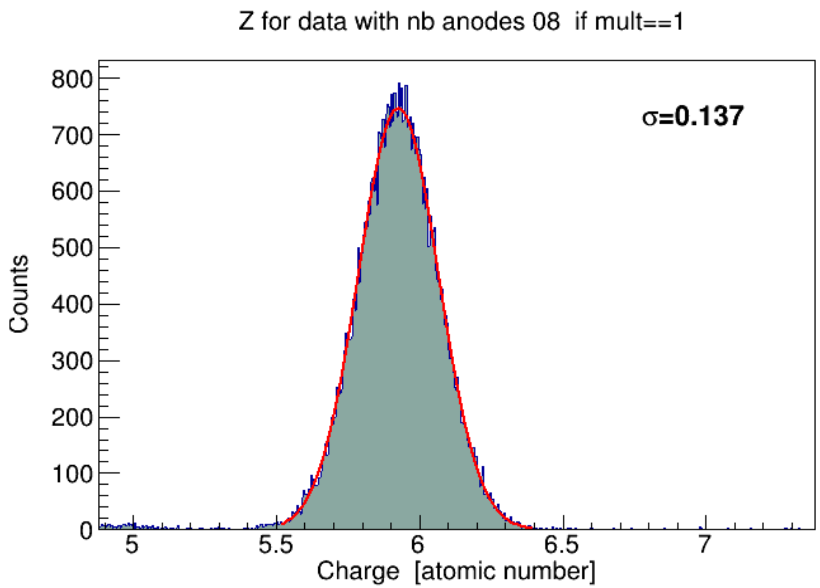
Courtesy of M. Duer and S. Velardita

MUSIC: Charge Identification

Online spectrum s522



Online spectrum ^{16}C data



Courtesy of M. Duer and S. Velardita

MUSIC: Noise

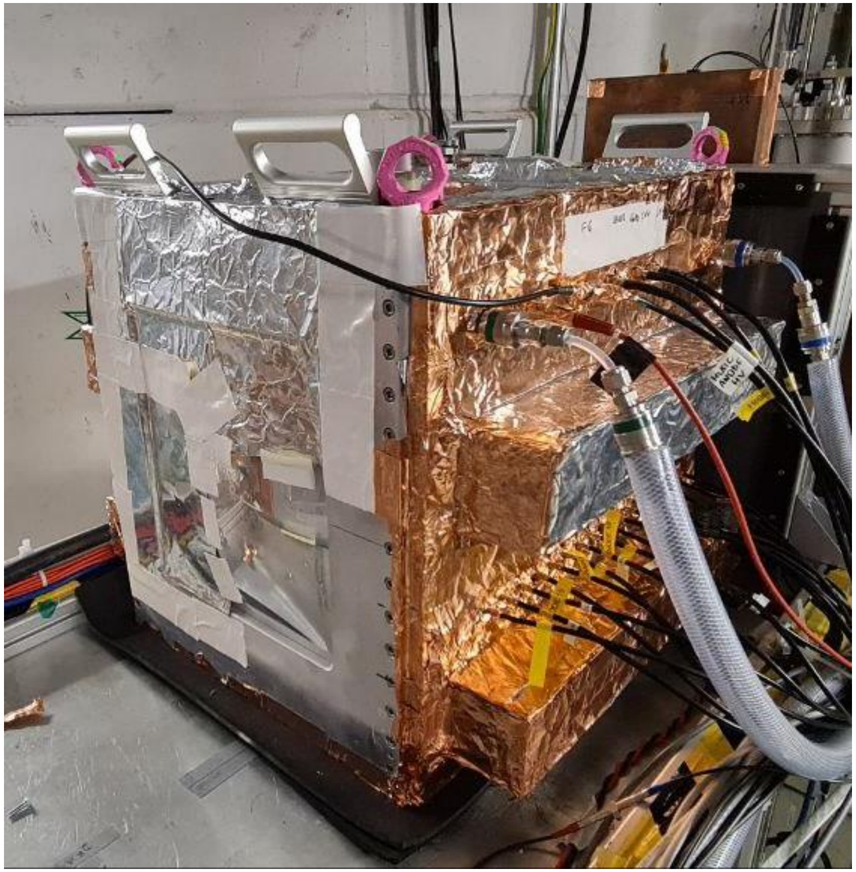
The windows are the weak spot for electromagnetic interferences.

Temporary solution, adopted for s522 and s509:

- shield of the window leaving open one quarter to let the beam pass, as shown in the picture

A permanent solution, change the windows:

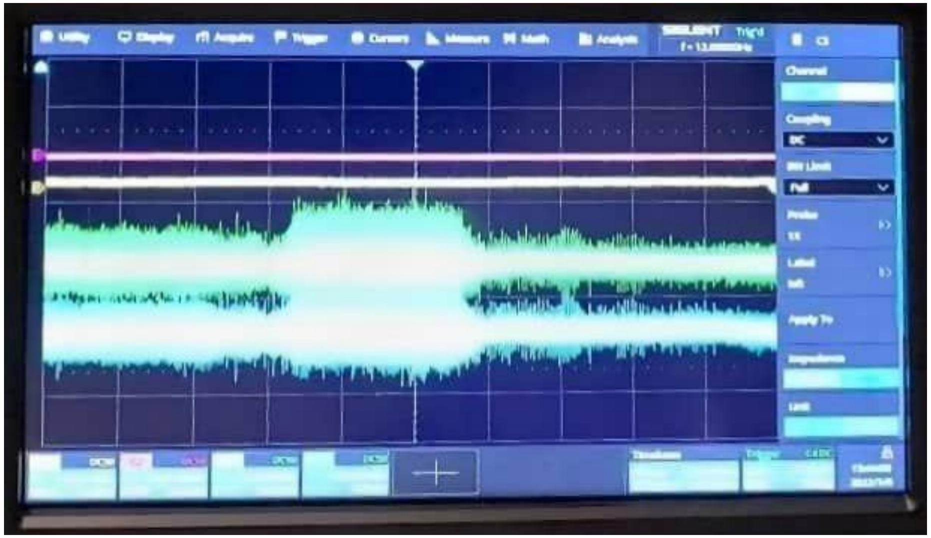
- switch to other metals with lower resistivity, e.g:
  - Silver
  - flash of Gold
  - or both, with an intermediate Chromium layer

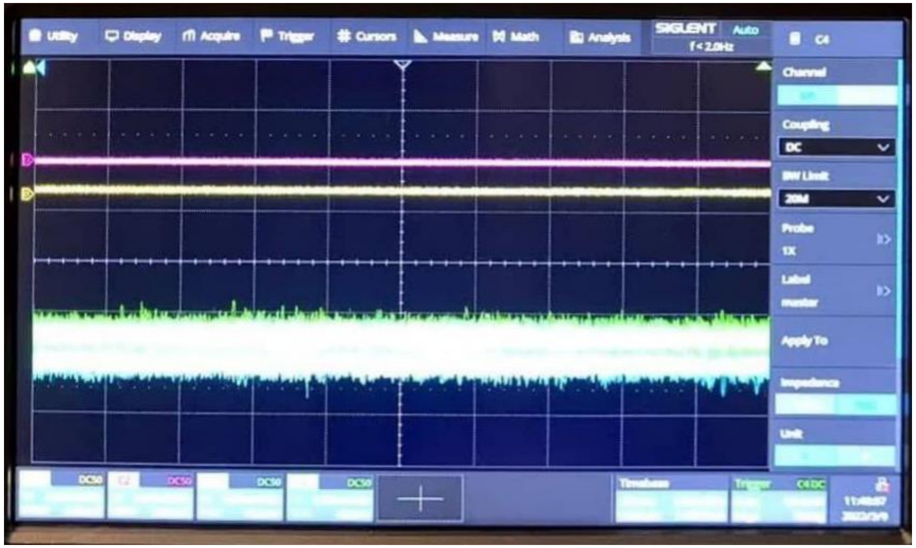


Courtesy of M. Duer and S. Velardita

MUSIC: Noise

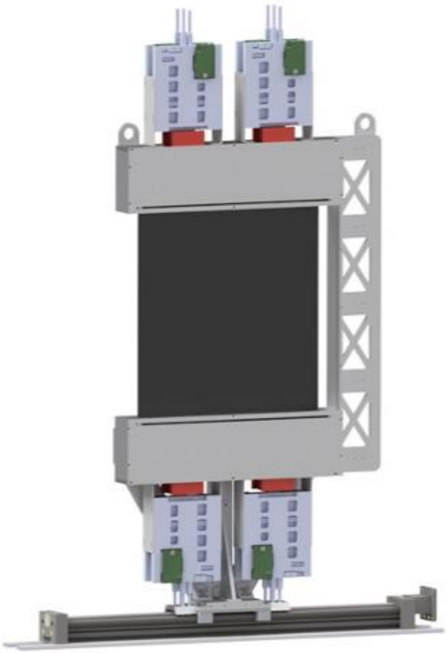
Before shielding the windows	After shielding the windows





Courtesy of M. Duer and S. Velardita

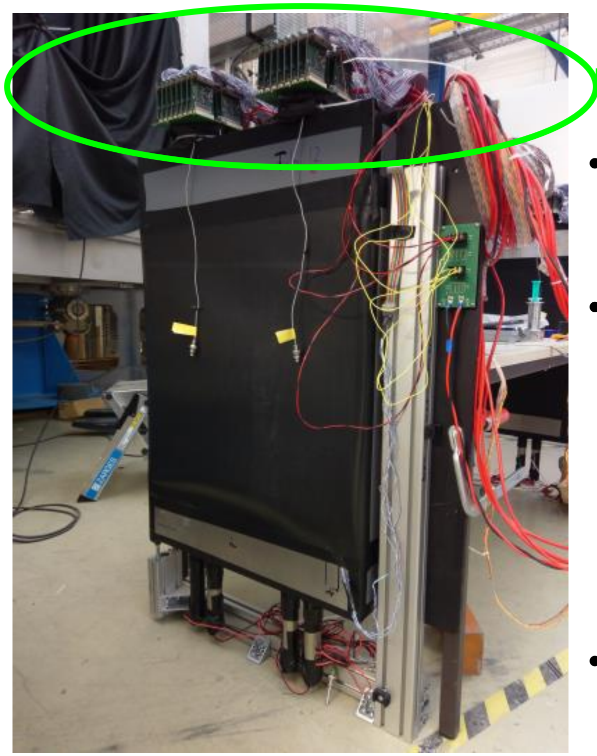
Fiber Detectors 30-33



- Consisting of 512 scintillating fibers
- Fiber thickness of 1mm
- Active area of ~50x50cm²
- Readout with 2 pairs of 2 multi-anode PMTs
- Per PMT, every Fiber is readout by 1 anode
- Electronics, combination of PADI and new clock-TDC (KILOM)

Courtesy of E. Lorenz

Fiber Detectors: Electronics



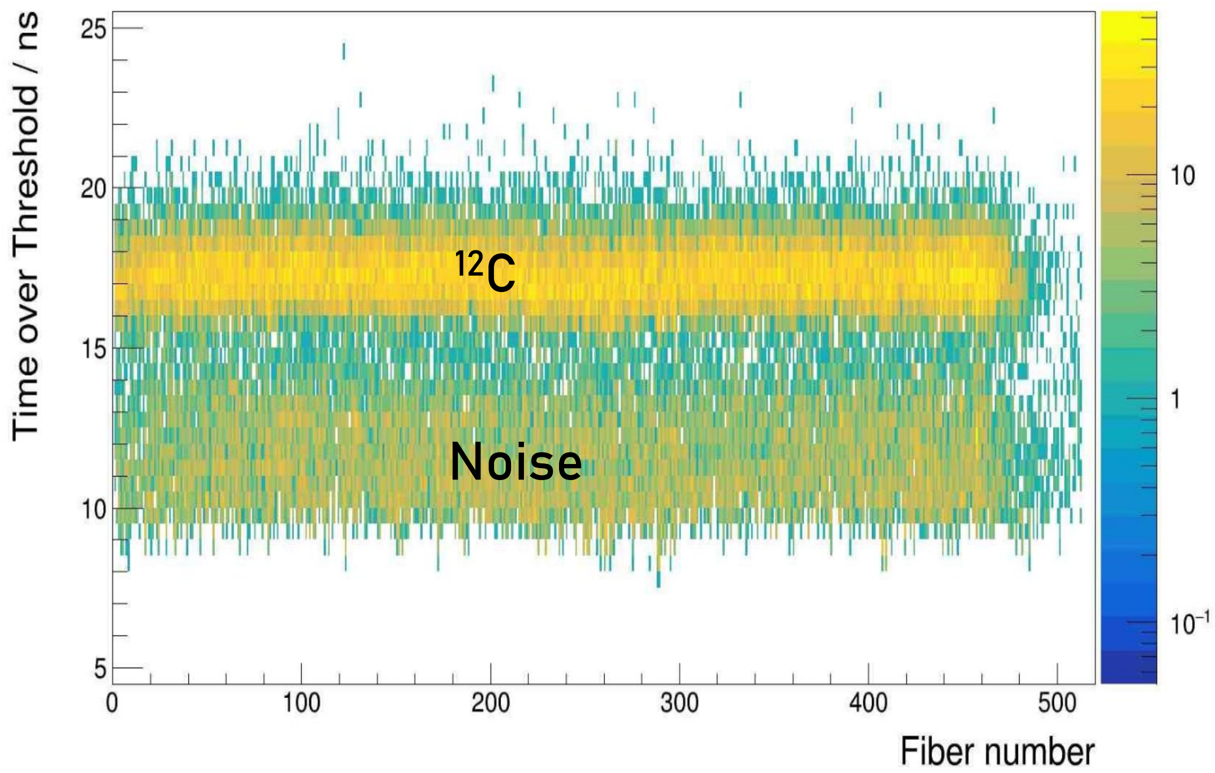
- MAPMT & SPMT readout to dual MAPMT
- Before: used CLK_TDC-128 electronics, 16 PADI cards per MAPMT, connected via twisted pair to FPGA-TDC

- Now: 8-channeled PADI-boards connected to a specially developed clock-TDC (KILOM)
- 2 PADI-KILOM for one MAPMT

Courtesy of E. Lorenz

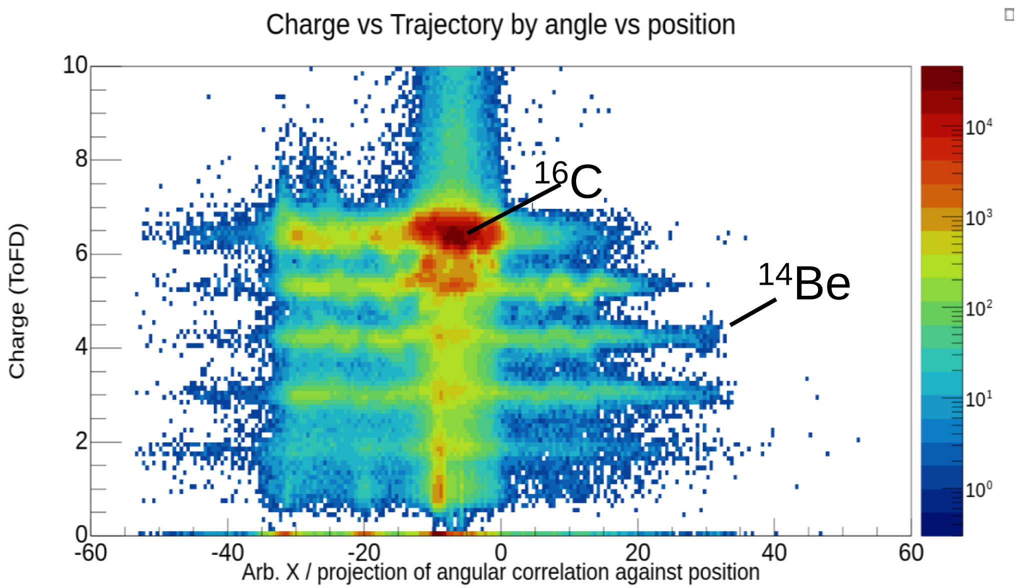
Fiber Detector Calibration

- Calibration with 12C sweep run
- Signals of all channels sit distinctly above noise

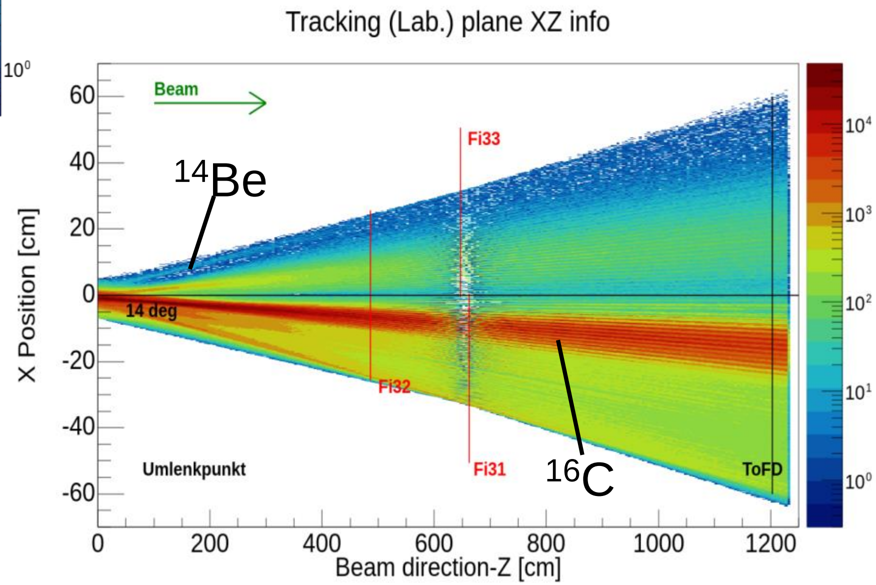


Courtesy of E. Lorenz

Fiber Detectors: PID



- PID of fragment. Q from ToFD. A/Q (on x-axis) correlation of bending angle against x-position on fibers. Projection on the main diagonal

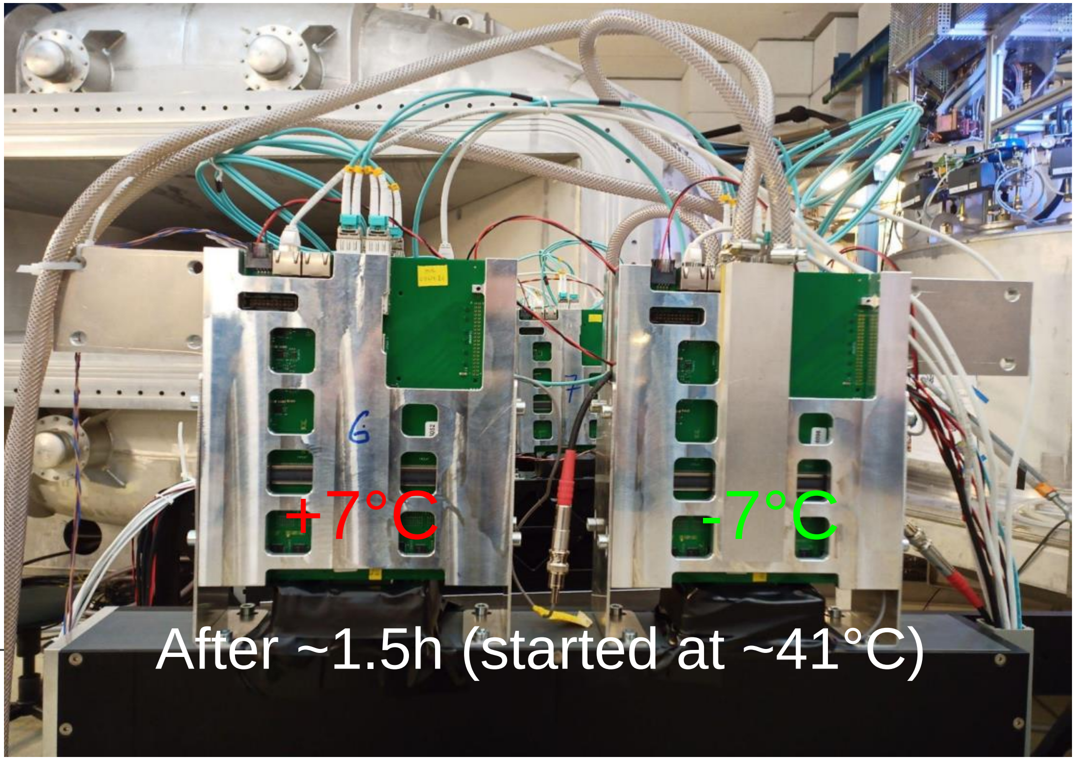


Tracking of fragment arm with Fibers and ToFD.

Courtesy of E. Lorenz

Cooling of Readout Electronics

- New prototype for cooling system.
- Electronics remain at a mid-range temperature of 40° while covered.
- To be used when FIB detectors operated in vacuum.



Fiber temperatures (threshold = 90 deg)

Fib30	46.5 - 46.3 - 44.2 - 40.4 - 40.9 - 39.3 - 41.1 - 56.5
Fib31	27.7 - 28.3 - 45.5 - 26.5 - 33.2 - 30.3 - 26.2 - 31.0
Fib32	37.5 - 44.0 - 44.2 - 50.2 - 42.0 - 39.7 - 51.4 - 44.2
Fib33	41.8 - 46.0 - 30.6 - 25.5 - 48.7 - 51.2 - 46.5 - 49.7

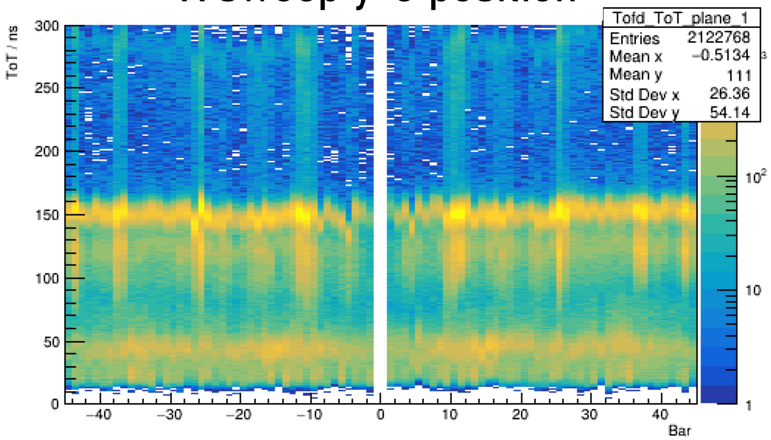
Courtesy of E. Lorenz

SiPM-FIB

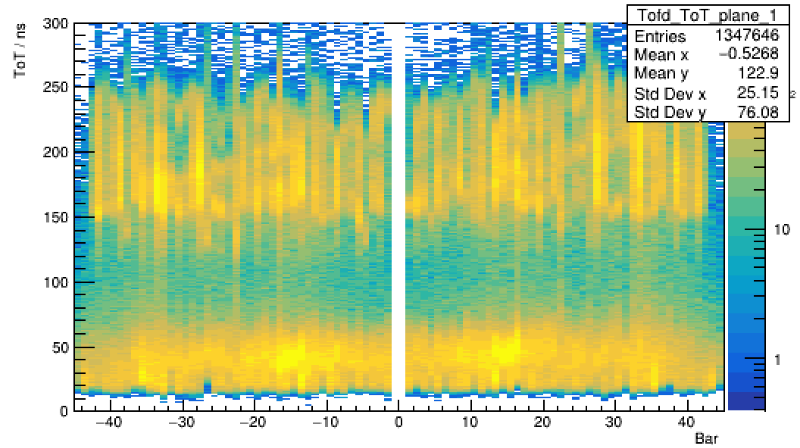
- Development work for thin FIB detector close to GLAD
- Proof-of-principle tests with ^{16}O@300 AMeV in 2021:
  - 500 um square fibers from Kuraray + 8x8 SiPM matrix from Hamamatsu + WASA readout board
- Testing during s522 test in March 2022:
  - Same as 2021, readout of 32 channels
- Testing during s522 main run:
  - 200 um square fibers from Kuraray + 2 8x8 SiPM matrices + GSI readout board (128 ch read out)
  - Correlations observed with drift chambers behind TOFD
- Future developments:
  - Use LHCb SiPM array (1D array with 128 ch.)
  - Build small SiPM-FIB detector (~10x10 cm^2)
  - Final detector: >40x40 cm^2

TOFD calibration for s522 and s509

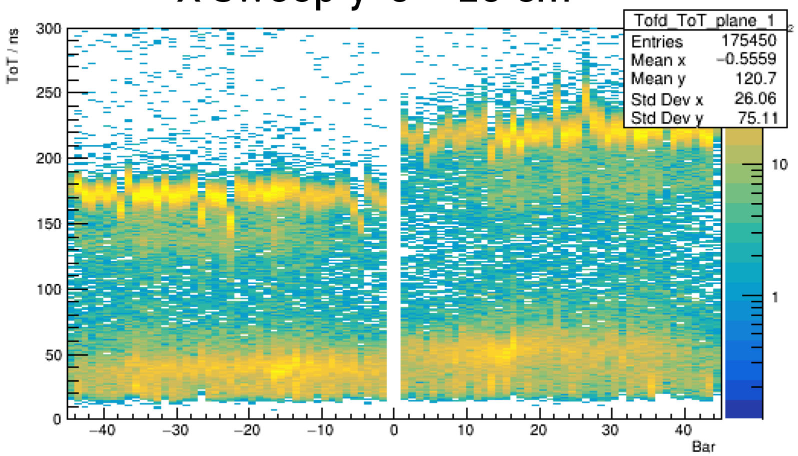
X sweep y=0 position

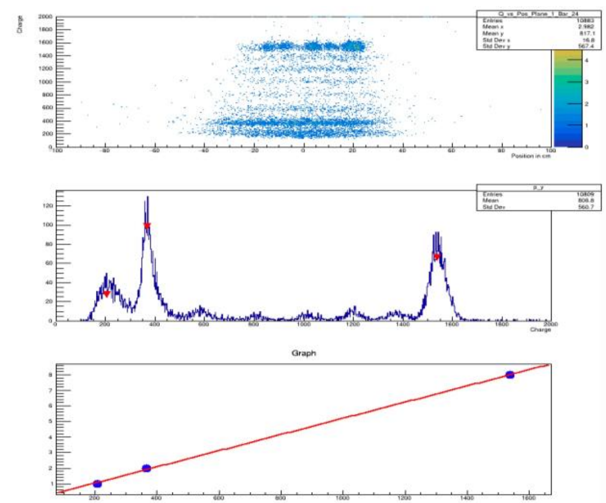


Meander run



X sweep y=0 + 20 cm





Courtesy of A. Lagni

TOFD Online Analysis Cal level: s522

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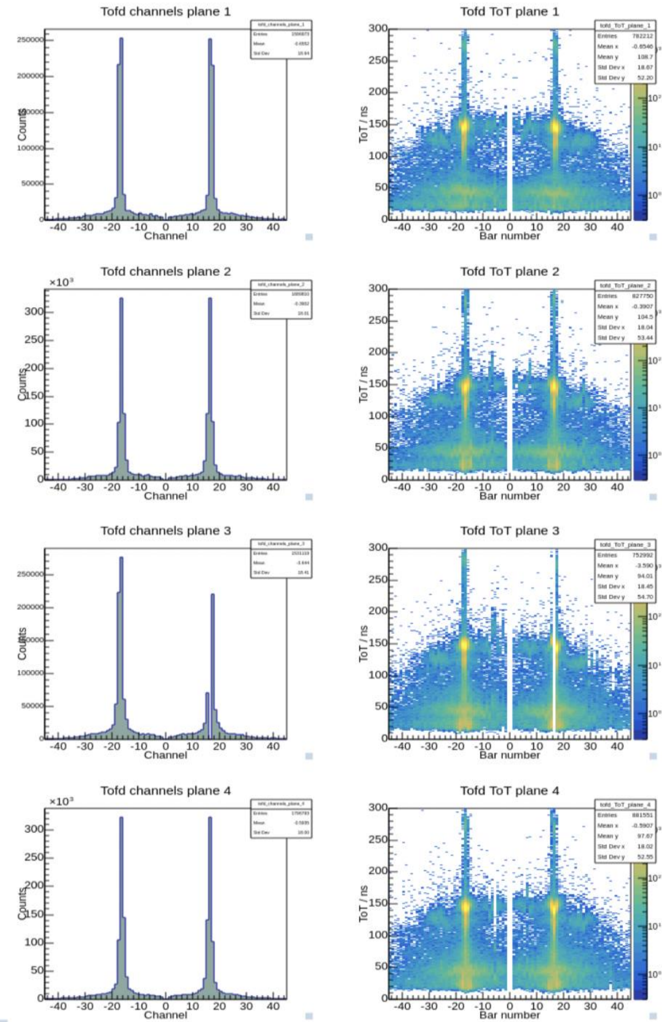
Online analysis s522:

- Beam spot of around 2 bars;
- ToT gain matched at 150;
- 16C centred at 15.02 deg bar 15-16 plane 1 & 3, 15 plane 2&4;
- 12C centred at 14.73 deg bar 17 plane 1&3, bar 16 plane 2&4;



Courtesy of A. Lagni

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TOFD Online Analysis Cal level: s522

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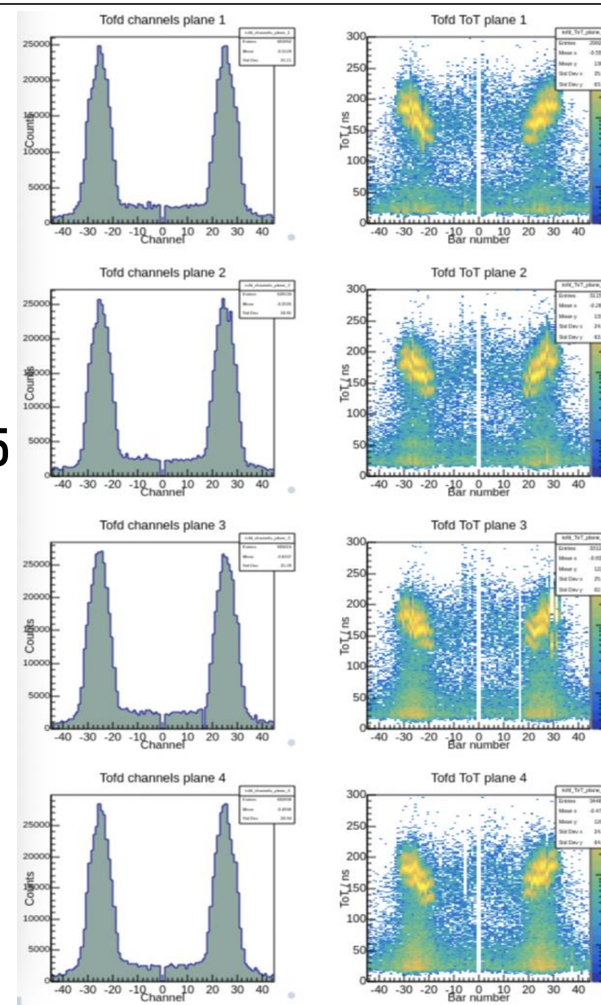
Online analysis s509:

22O

- From left to right: 14C, 13B, 16C, 18C+21N. For fine tuning: placed 13B, 16C (most intense) at 13.9°, 13.6° respectively -> TOFD bar = 22-23, 25 New reference 19N at 13.5° - > TOFD bar 25

21N

- From left to right: alfa, 10Be, 13B, 11Be, 12Be, 20C, 14Be. For fine tuning: place 11,12Be (most intense) at 14.2°, 13.1° respectively->TOFD bar 31.

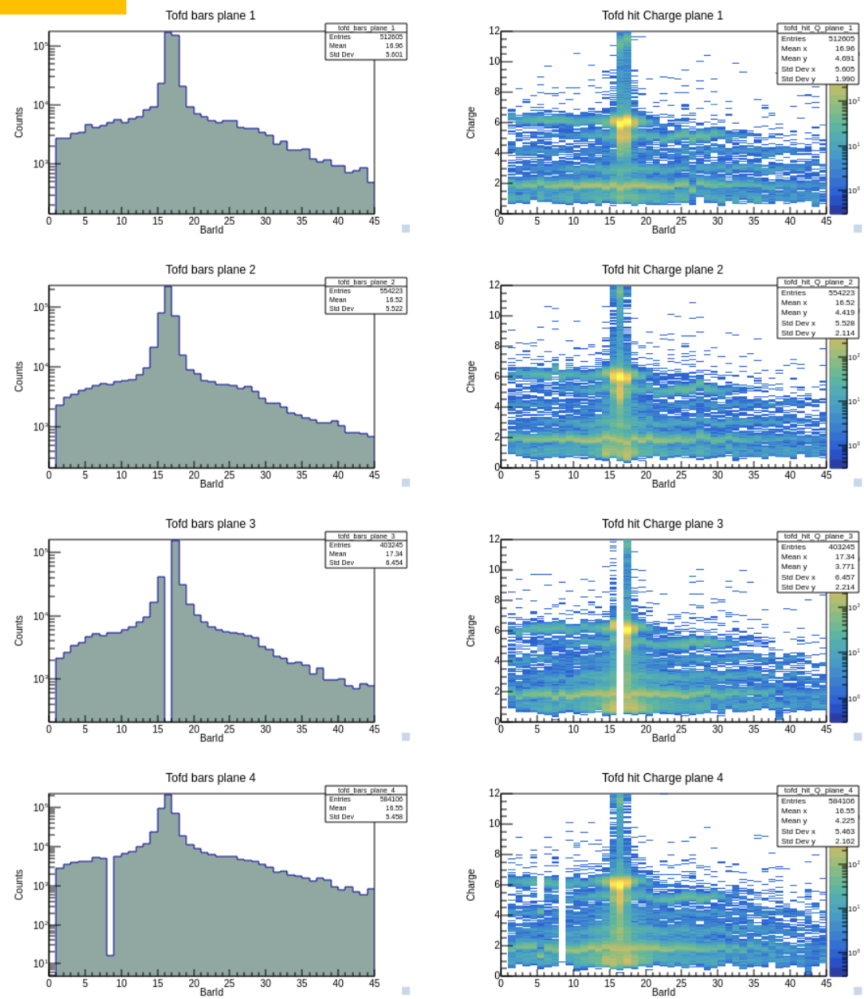


Courtesy of A. Lagni

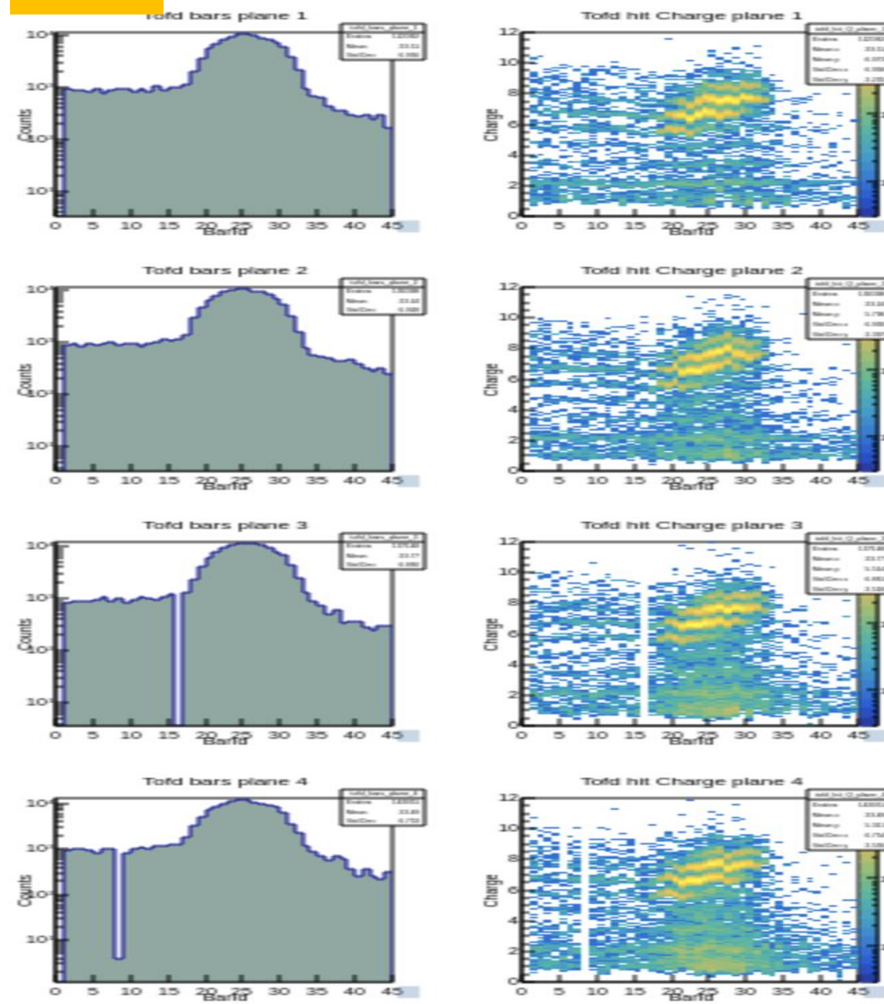
FAIR Phase 0 Research Program R3B

TOFD Online Analysis Hit level

s522

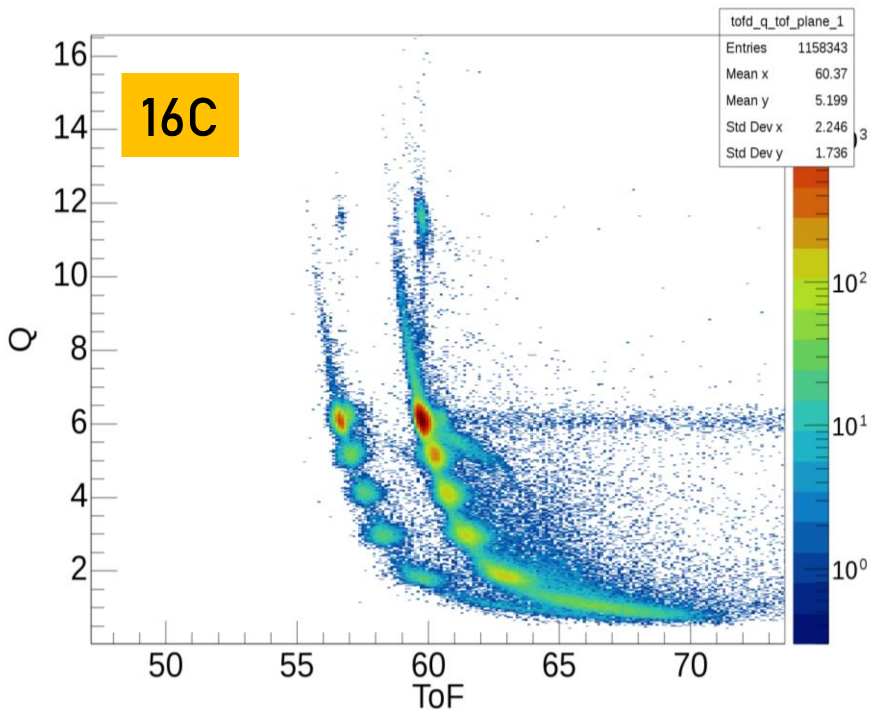


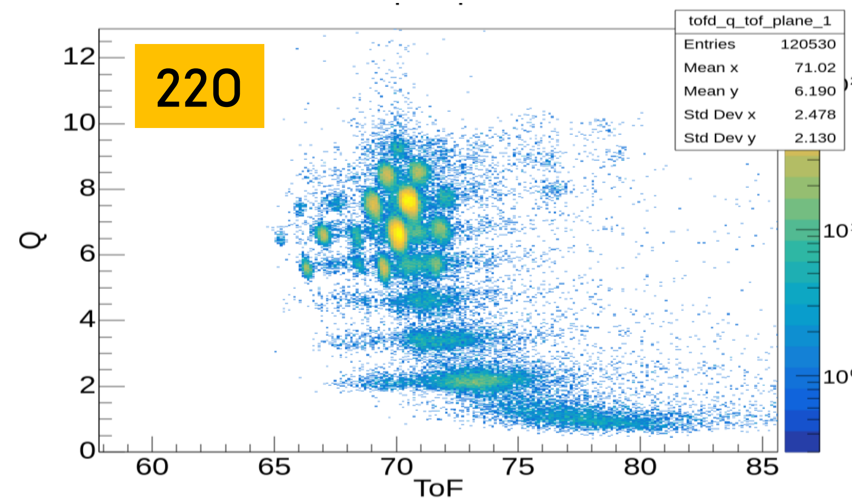
s509

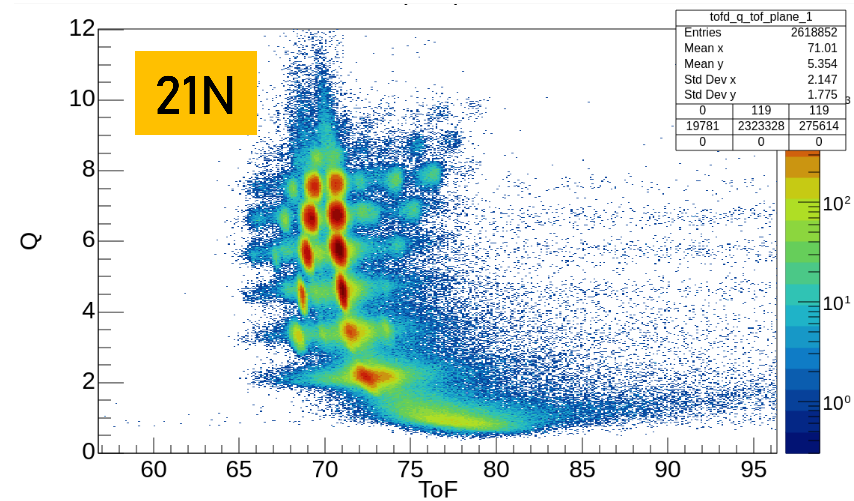


Courtesy of A. Lagni

TOFD online analysis Q vs. TOF







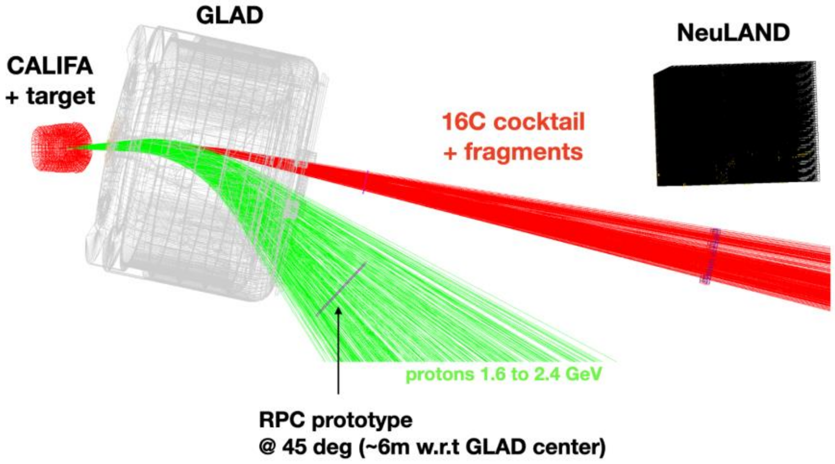
Courtesy of A. Lagni

TOFD plans for 2023

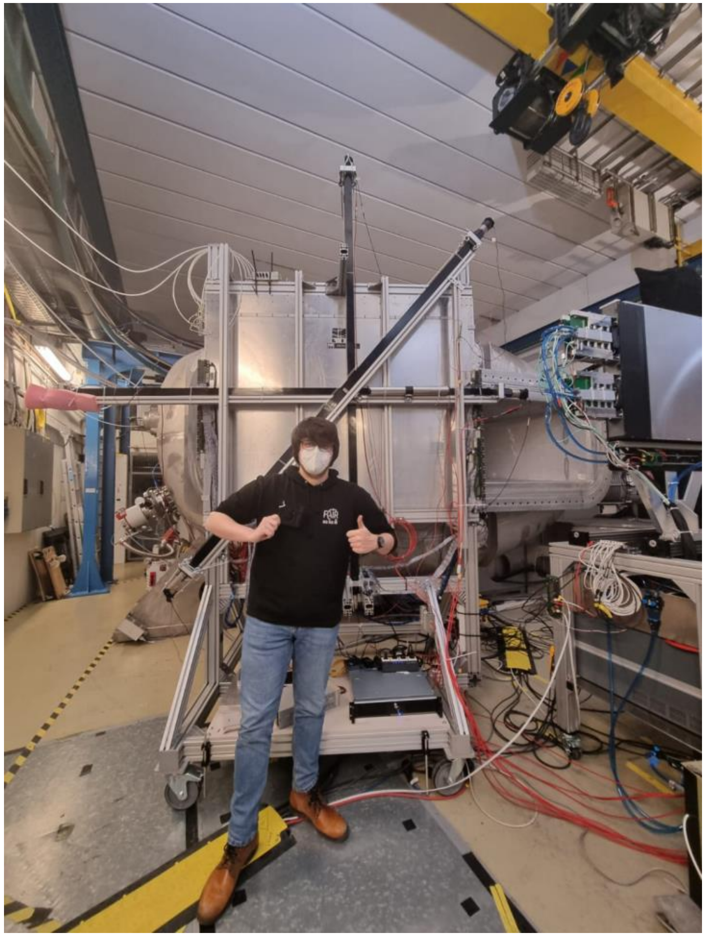
- Solve HV connector/cable situation
  - Change connectors to Redel type (same as NeuLAND)

  - Either keep same HV power supplies with CAEN A996 connectors
  - Or purchase new ISEG system directly with Redel connectors
- Fix cable routing between HV/electronics and TOFD (mechanical forces on cables/connectors)

Resistive Plate Chamber Detector at R3B



- Gaseous detector;
- Proposed to measure forward emitted Protons;
- Active area of 1500x1200 mm² = 1,8 m²
- Good time resolution, ≈ 50 ps σ
- Good efficiency > 95 %



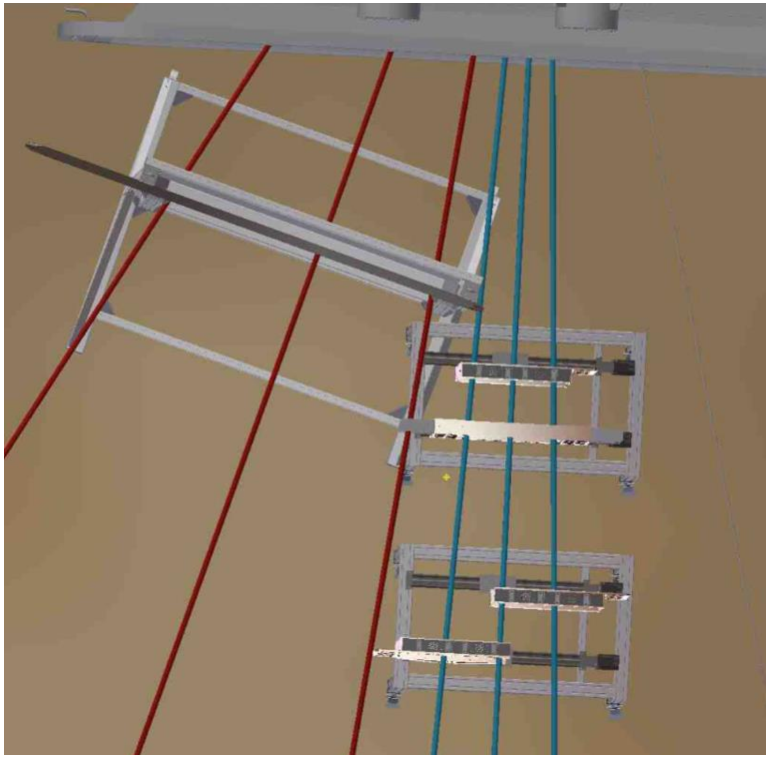
Courtesy of M. Xarepe

RPC Project

The RPC arrived on the 29/11/2021

Since then:

- Integrated into R^3B Cave and DAQ
- R3BRoot software developed
- Electronic resolution between RPC and LOS was reduced to around 38 ps
- Participated in the test beam time and two experiments, S522 and S509



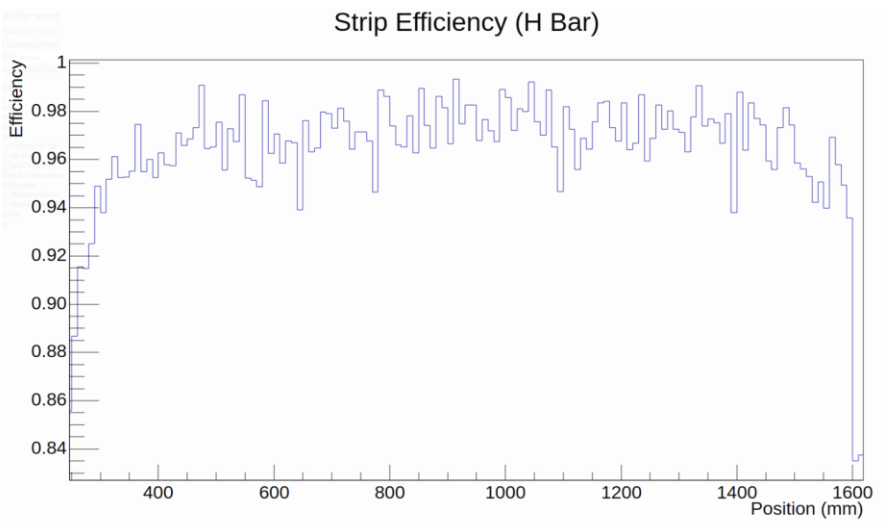
Daniel Körper CAD design

Courtesy of M. Xarepe

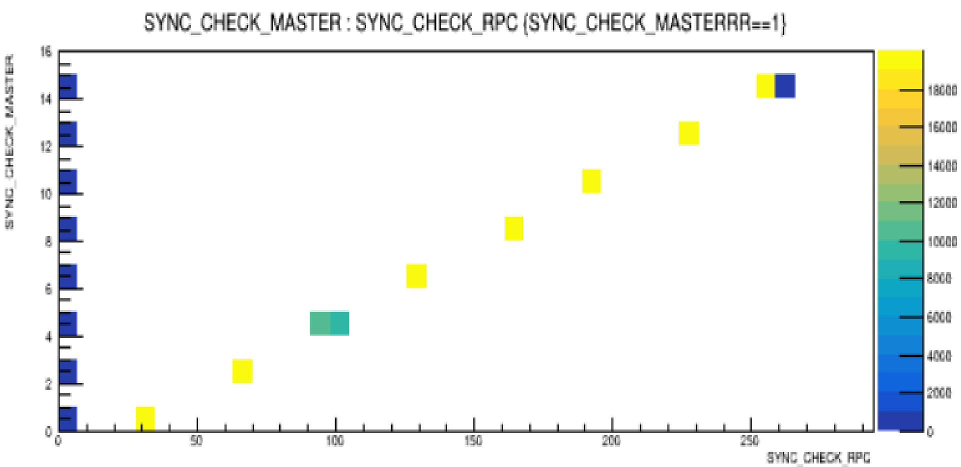
RPC Performance in S522

Detector and DAQ have been stable;

- RPC efficiency higher than 96%;



- Sync check passed, except for the spurious empty events;

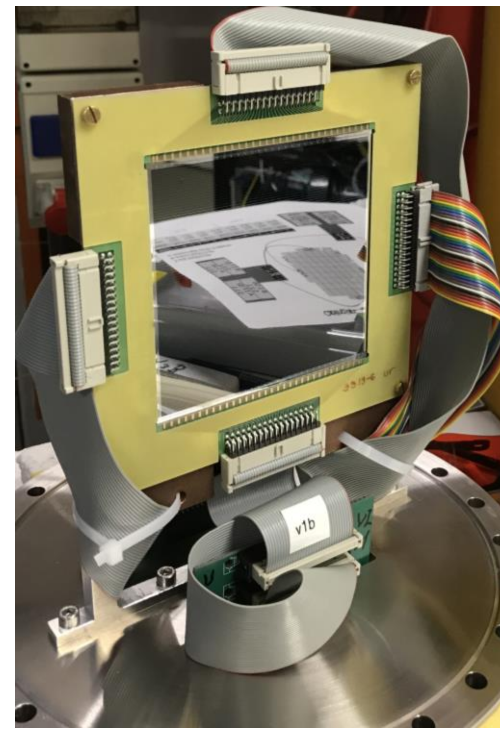


Courtesy of M. Xarepe

PSP X5 Detectors

- Double-sided silicon strip detector with resistive surface
- Active area 9.57cm x 9.57 cm
- 32 strips on each side
- 128 channels
- Read-out at both ends/across the strip

- Use for beam tracking and PID



Courtesy of E. Kudaibergenova

Performance in s515

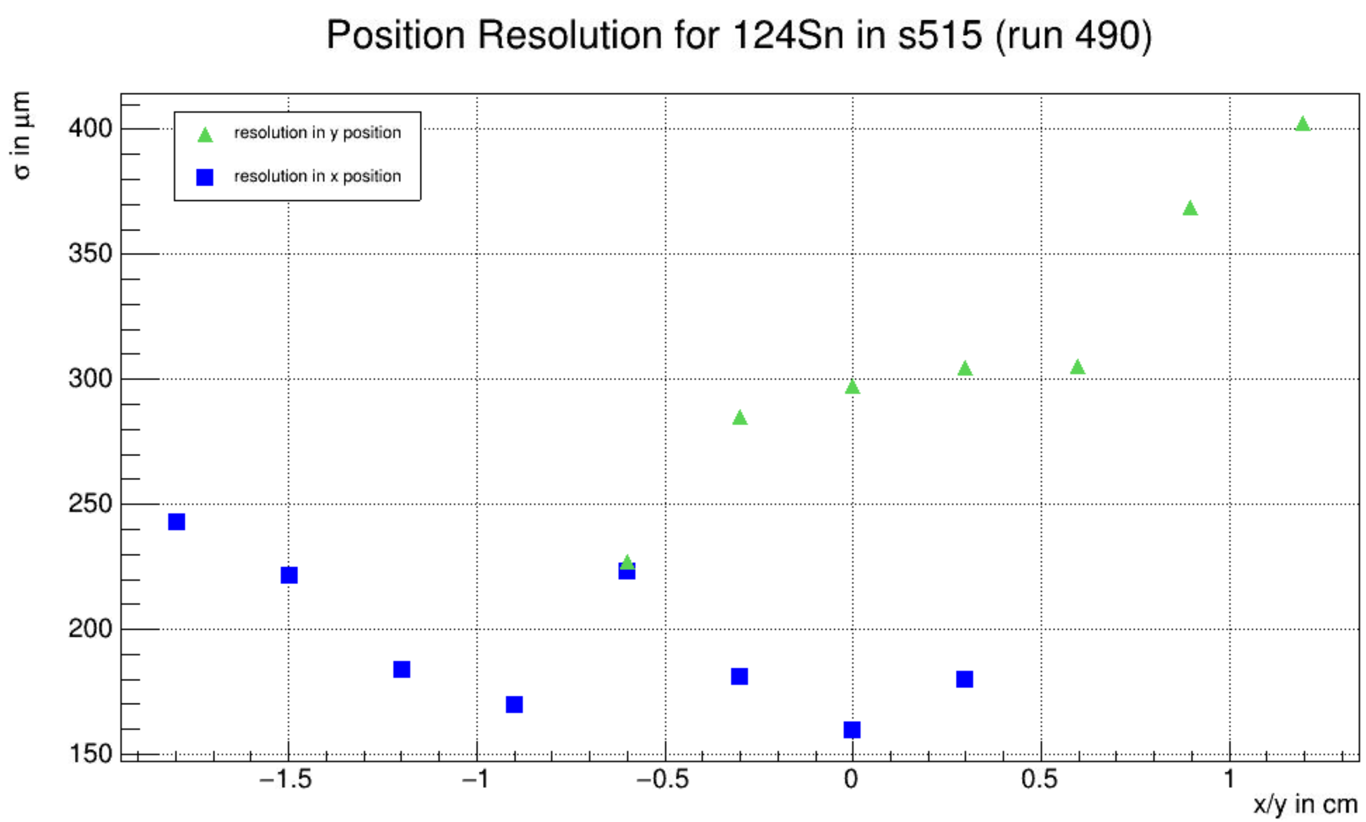
- In s515 two PSP detectors were installed:
- PSP1 (3319-6) and PSP2(3319-8): both were new and never used before.
- Because of a high leakage current PSP1 (3319-6) was replaced by the one from s473 experiment (2433-21).
- The other one could not be replaced.

type	p
thickness	313 um
Strip width	2.99 mm
Depletion voltage	75 V
Operation voltage	105 V

Table 1. PSP(2433-21) information

Courtesy of E. Kudaibergenova

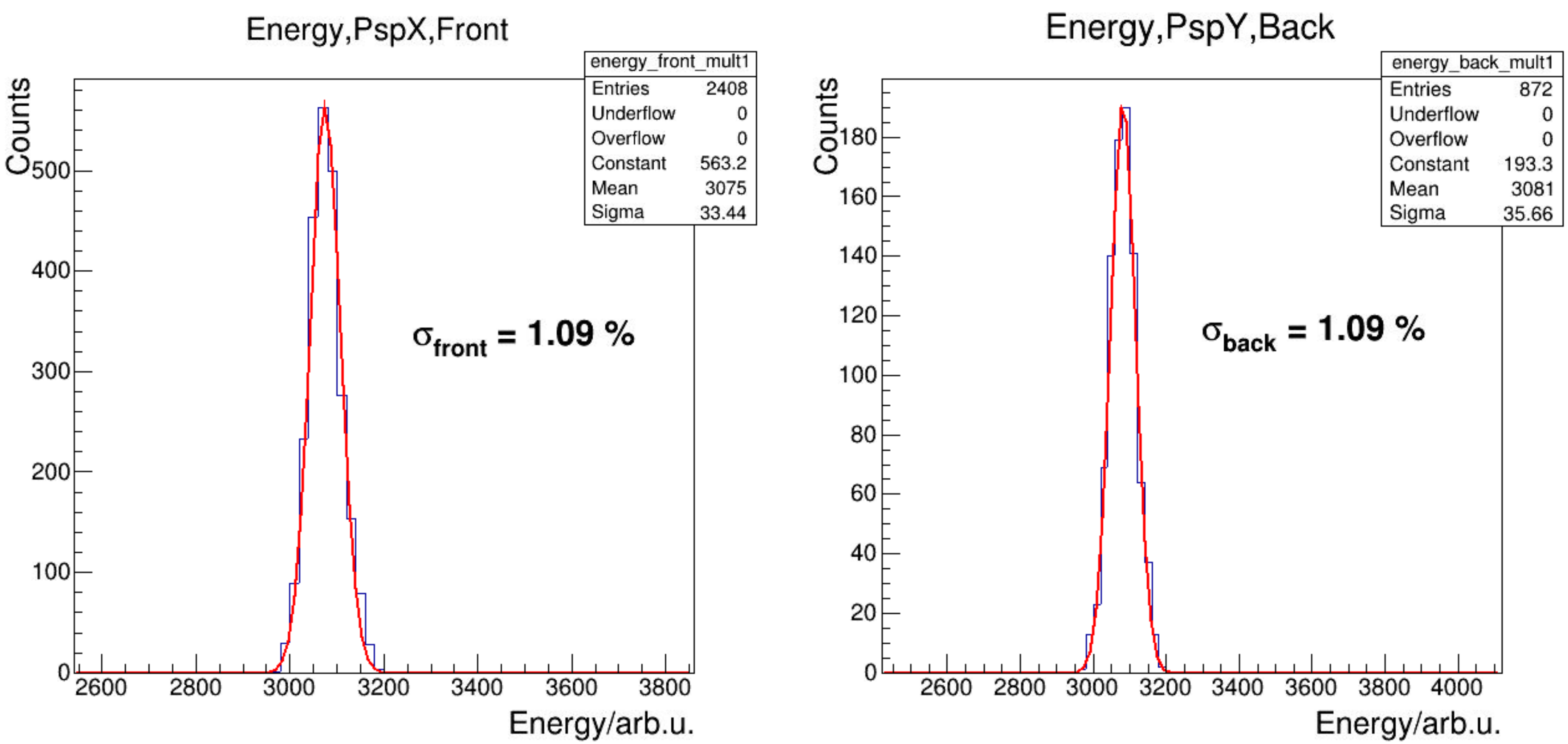
PSP X5 Position Resolution



The x resolution (back) is better than y resolution (front)

Courtesy of E. Kudaibergenova

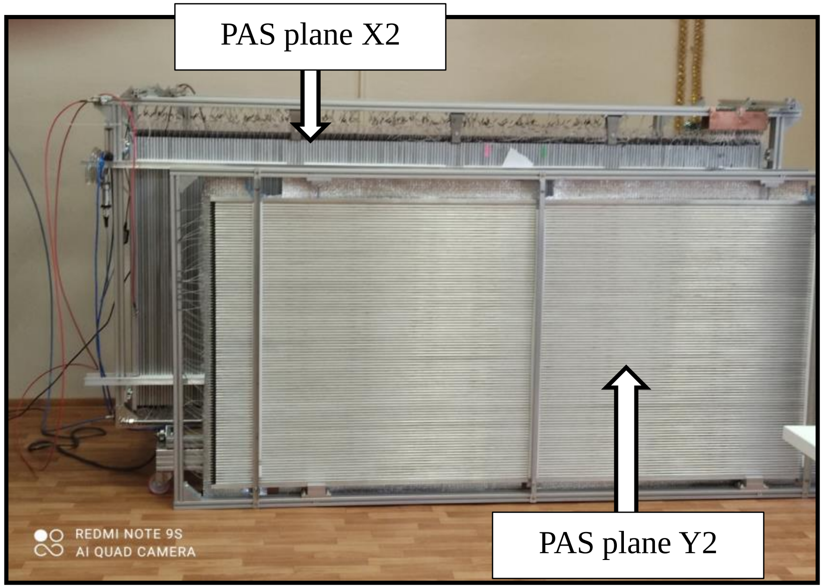
PSP X5 Energy Resolution

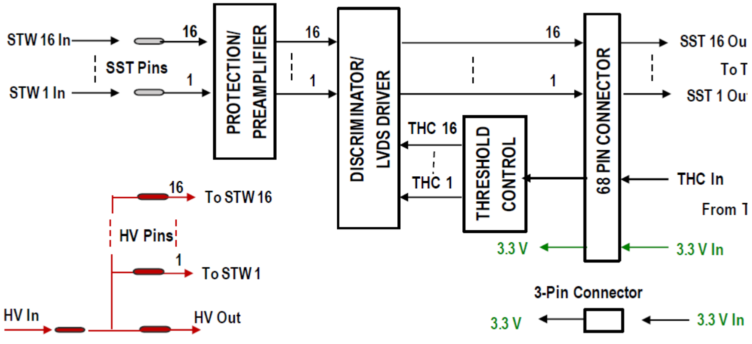


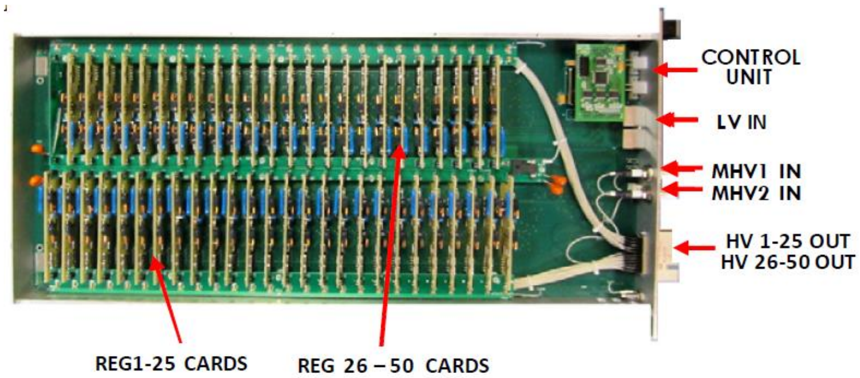
Proton-Arm Spectrometer Status

Status of project:

- STW X2 and Y2 built
- Gas distribution system built
- Front-end card ASD16 design completed and prototype built
- High-voltage module HVDB-16 design completed and prototype built







Proton-Arm Spectrometer Status

Status of project:

- Russian In-Kind contribution to R3B → project put on hold
- Unclear if device will be delivered at all in the future

- We need to search for alternatives/workarounds for >2025 (previously expected completion date of PAS) IF proton detection needed in experiments
- For instance, use of RPC, SOFIA TOF wall or Proton Drift Chambers could be considered as workaround

Summary

Detectors available for:

- Beam tracking (LOS, ROLU, MWPC, MUSIC, PSP X5)
- Fragment tracking (FIB, TOFD, PSP X5)
- Fast proton detection (RPC)

- Important to define setup as early as possible