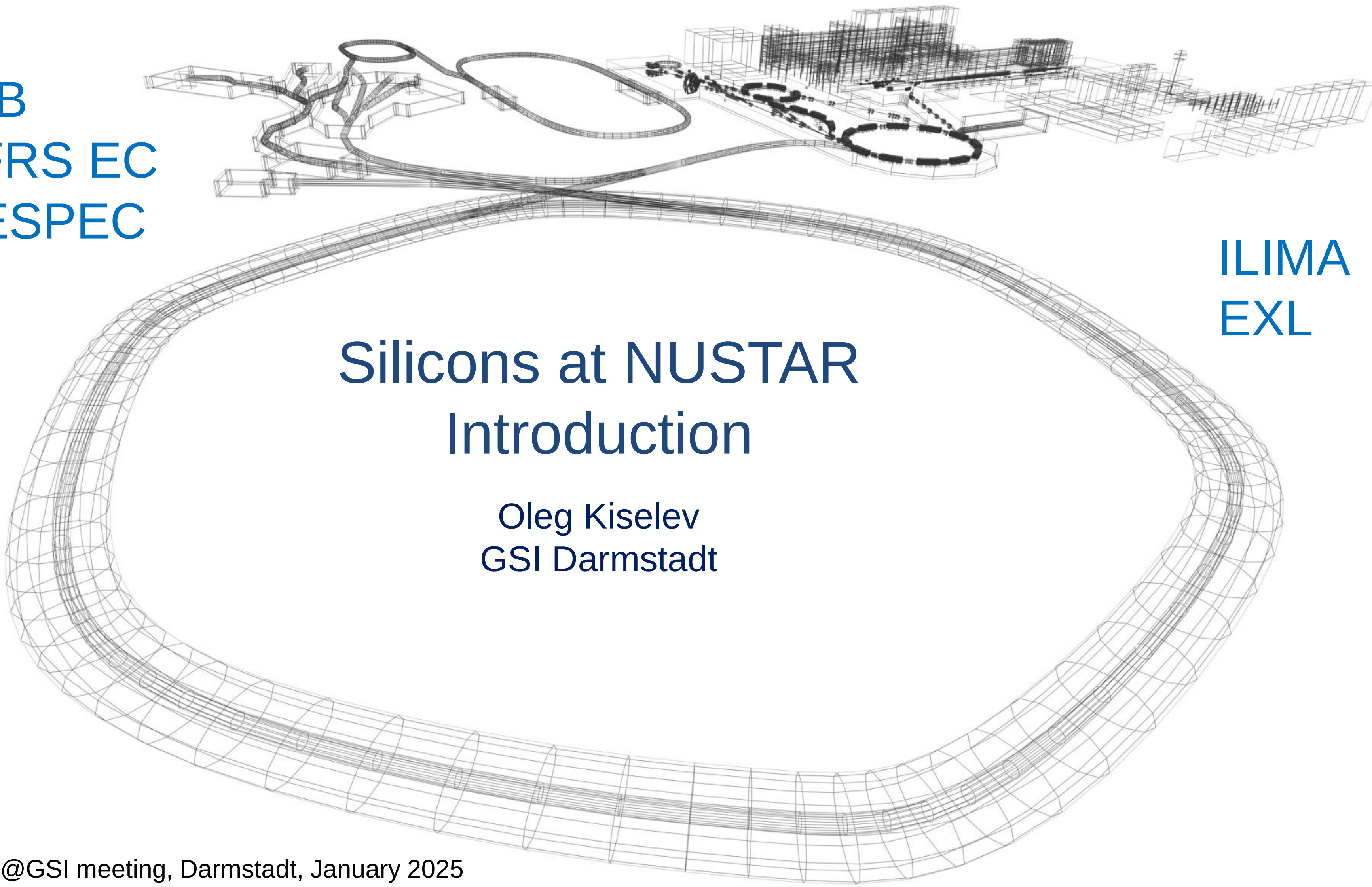
NUSTAR

R^{3}B
SFRS EC
DESPEC

ILIMA
EXL



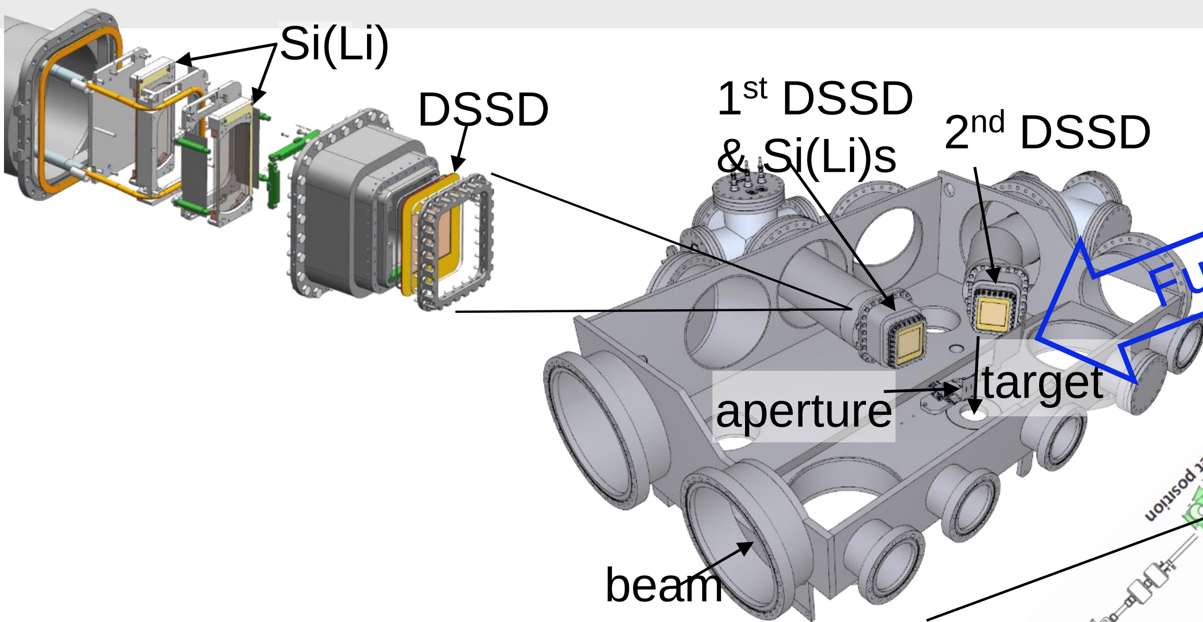
Silicons at NUSTAR Introduction

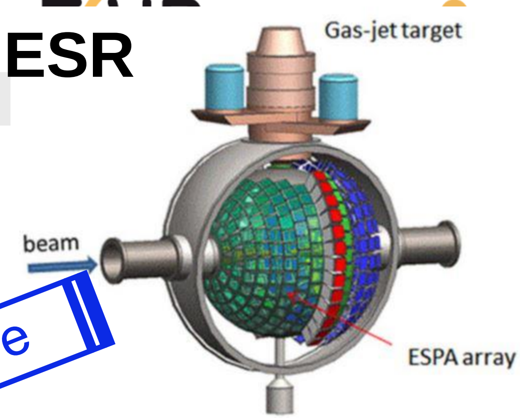
Oleg Kiselev
GSI Darmstadt

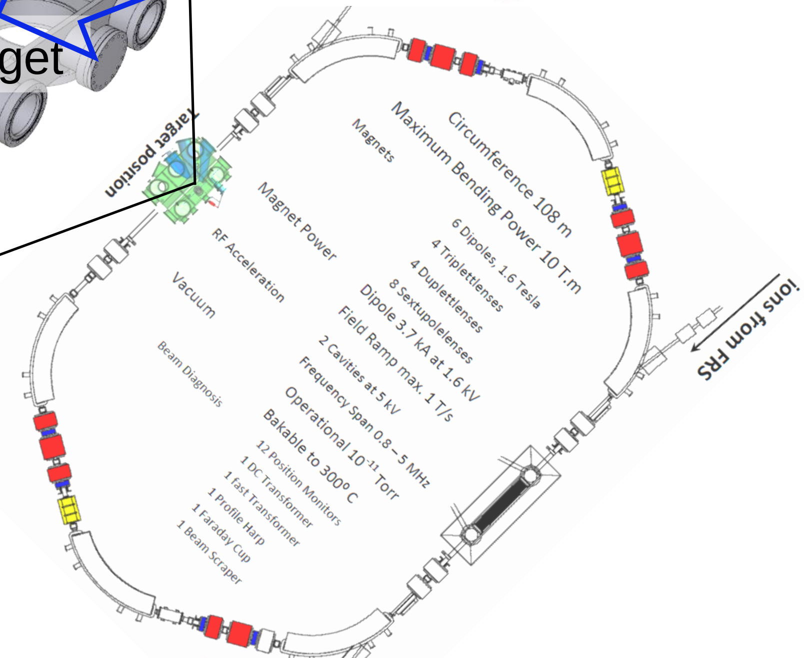
Silicons@GSI meeting, Darmstadt, January 2025

Internal Target Experiment

Experimental Setup for Internal Target at ESR







- **DSSD**: 128×64 strips, (6×6) cm², 285 µm thick, **dead layer of only 40 nm (extremely low energy threshold)**
- **Si(Li)**: 8 pads, (8×4) cm², 6.5 mm thick
- **DSSDs as active vacuum barrier/window**
- **UHV inside the chamber – backable detectors, cables**

Successful experiment in 2012, several high-level publications

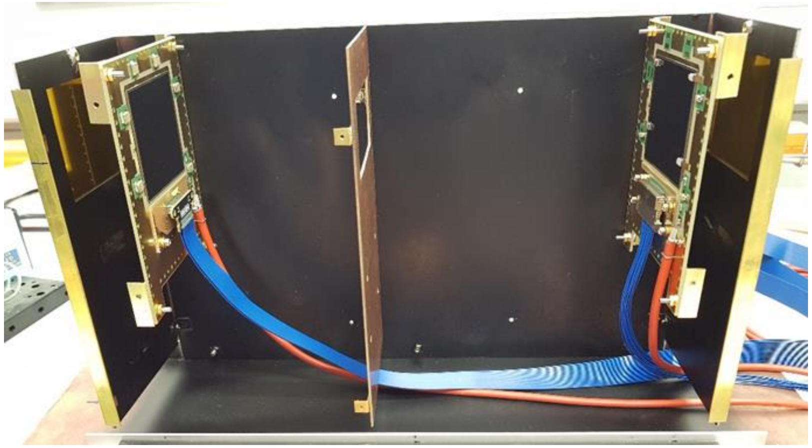
Further experiments and setup not funded

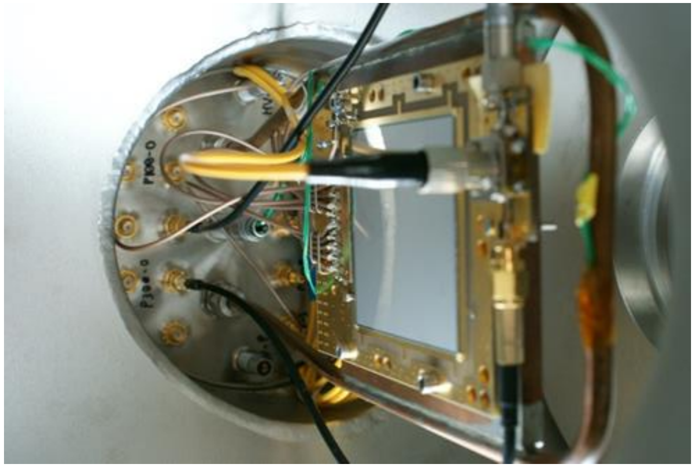
TOF Si planar detectors

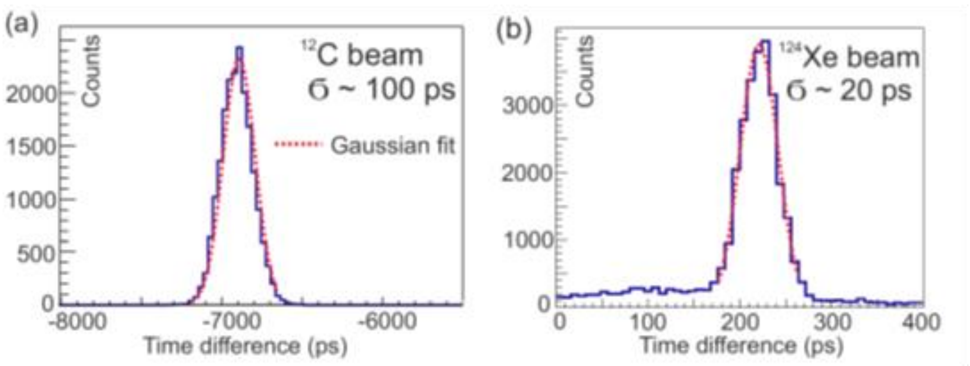
Measurement of TOF with large-size SSD

1. Thickness --------300 um
2. Strip pitch ------1 mm
3. Inter-strip gap --- 50 um

•Signals processed by front-end (PADI-X ASICs) and FPGA TDC –TAMEX2 boards (resolution 7 ps)
•Rate capability ~1 MHz/ch







Supposed to be a Russian In-Kind to FAIR, project stopped in 2022

SFRS EC, EXPERT setup

EXPERT (EXotic Particle Emission and Radioactivity by Tracking)

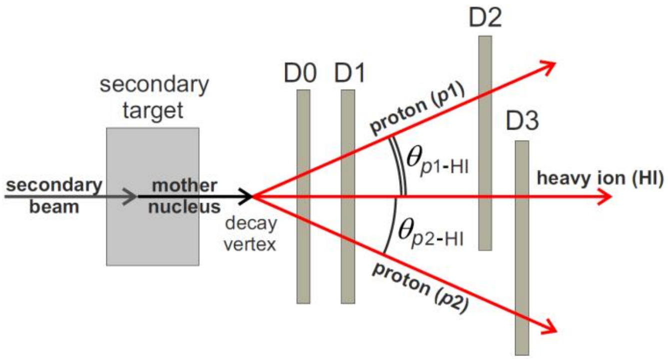
1 -- Si microstrip (or pixel detectors) tracking detectors;

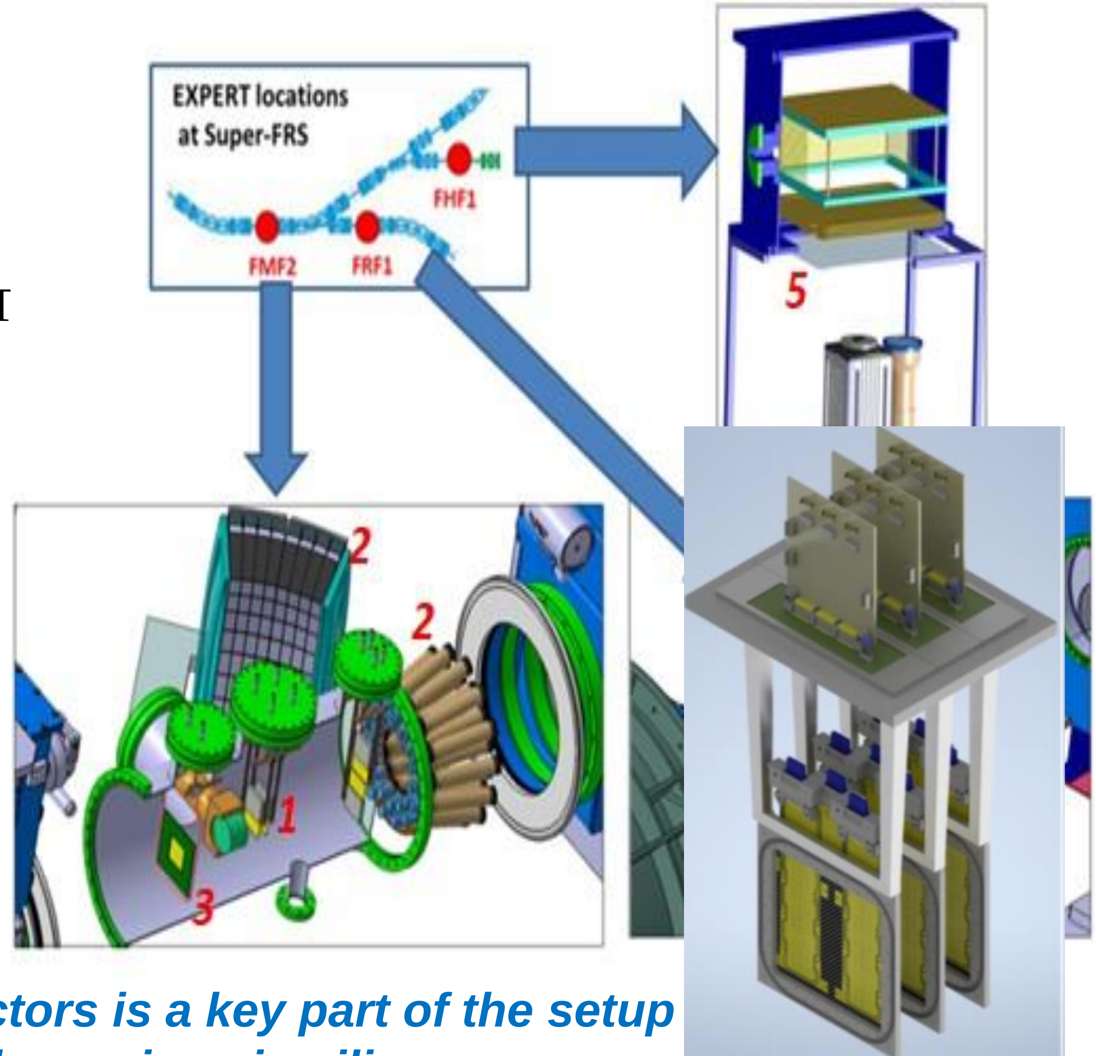
2 -- detector of gamma-rays GADAST

3 -- beam Si ToF detectors;

4 -- neutron detector NeuRad;

5 -- implantation-decay chamber with optical readout OTPC.





Si microstrip, in future pixel detectors is a key part of the setup
Tracking and PID of protons and heavy ions in silicons

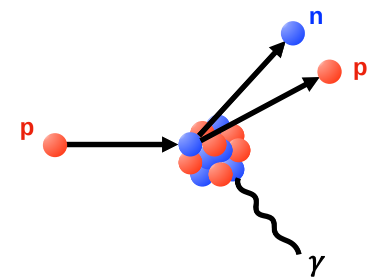
Tracking of protons with FOOT detectors at R3B

Valerii Panin for R3B collaboration

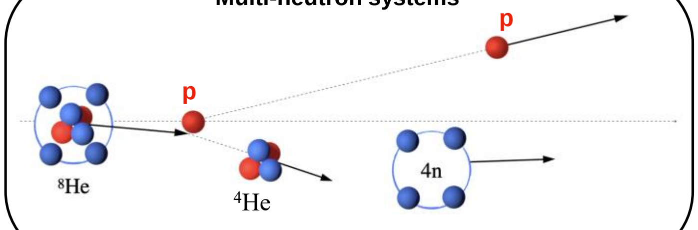
Silicons @ GSI: Kick-off event
GSI, January 31, 2025

Spectroscopy of exotic nuclei

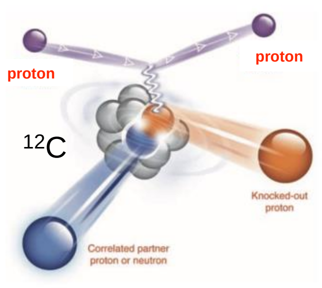
(p,2p) and (p,pn) reactions



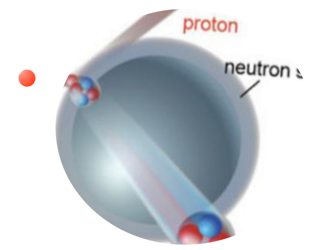
Multi-neutron systems



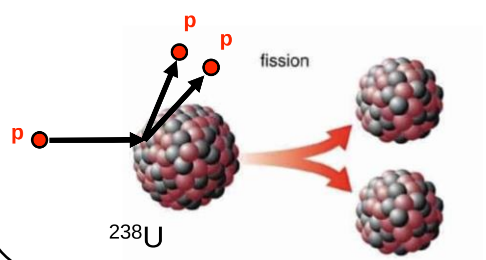
SRC pairs in nuclei

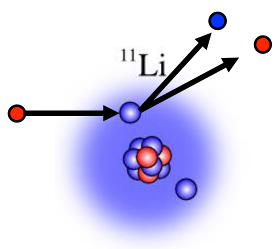


R^3B physics with quasi-free scattering



(p,2p)-induced fission





FOOT silicons for R^{3}B target recoil tracking

IDE1140 ASIC

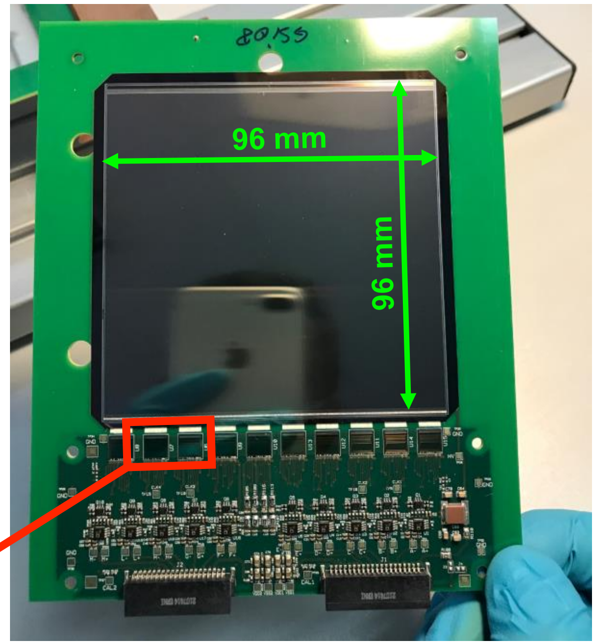
64 channel CSA

Input charges: -200 fC to +200 fC

Shaping time: 6.5-μs

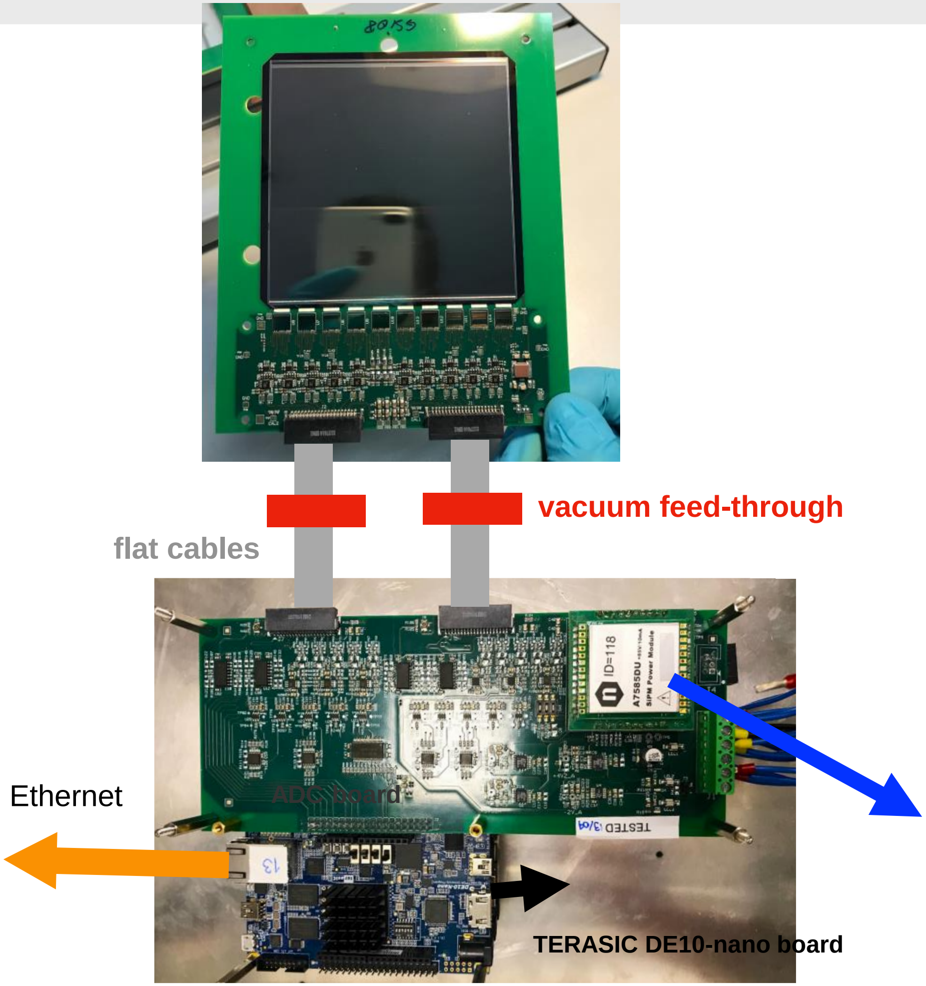
Power: 20 mW power (can work in vacuum without cooling)

Full readout cycle (default) ~80 us



Sensor type:	single-sided HAMAMATSU
Dimension:	96 x 96 mm^2
Thickness	150 μm
Implant pitch	50 μm
Readout pitch	150 μm, 640 ch
Total number of readout strips	640
Operational trigger rate	Up to ~6 kHz
Charge-sensitive ASIC	IDE1140 (VA140) (IDEAS, Norway)
Readout:	ADC board (Perugia) + de10nano FPGA

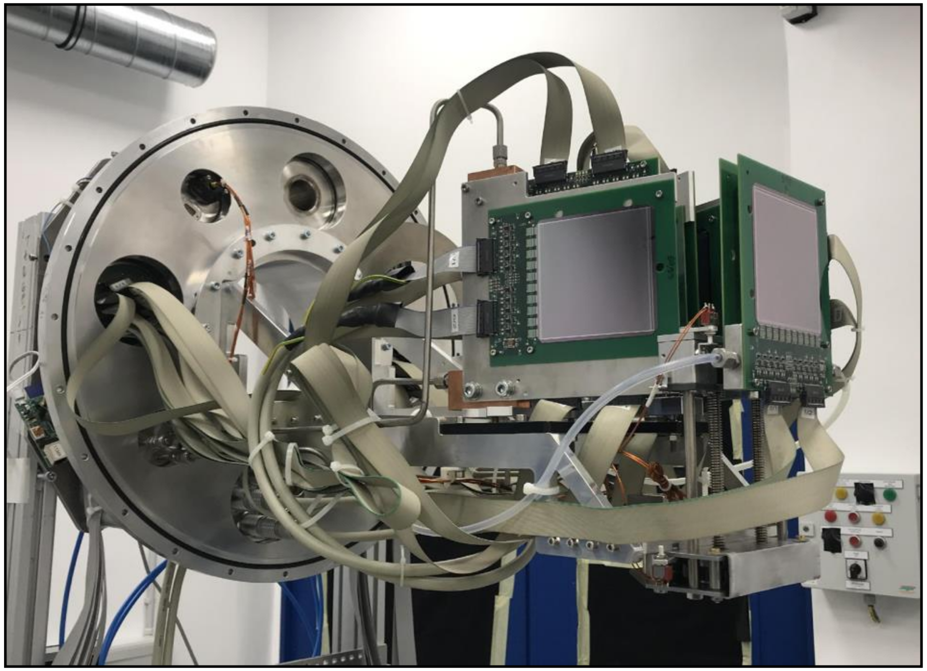
FOOT readout electronics



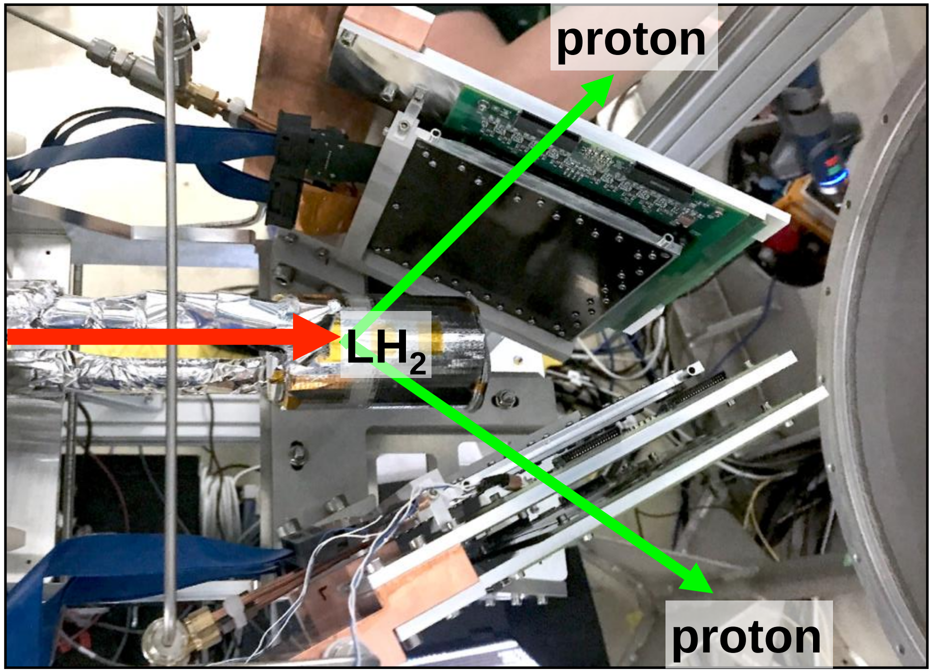
- Adopting readout solution from Perugia group
- Custom ADC board (provided by Perugia)
  - One ASIC per single 12-bit ADC
- Commercial FPGA: TERASIC DE10-nano with custom-made firmware (B. Löher)
  - Steering ADC board and ASICs
  - Communication and readout (DRASI)
  - Implemented Rataclock-timestamp receiver and sender (for local loopback)
- Addition modifications on the FE board to mitigate baseline drift at high trigger rates (K. Koch and N. Kurz)

CAEN DC power unit
to control bias voltage on the sensor
(operated by external ARDUINO)

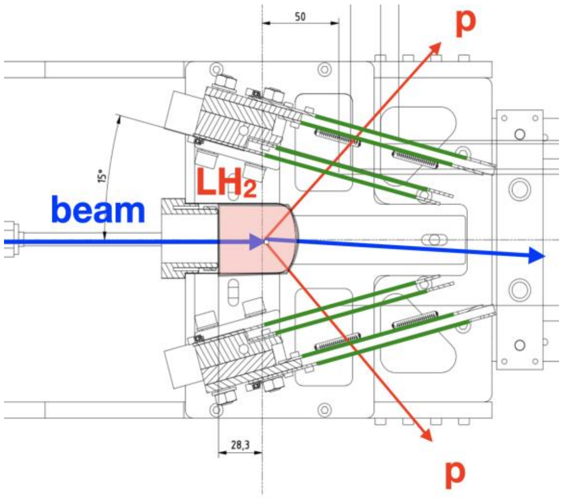
Recoil tracker array with 10 FOOTs

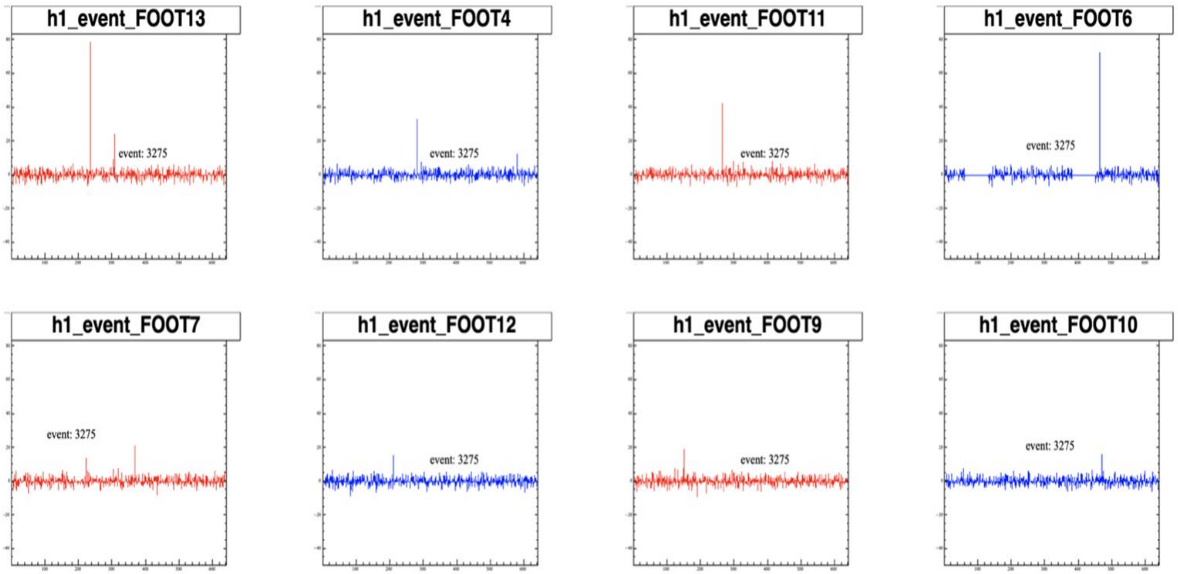


Liquid-hydrogen target + two-arm FOOT configuration

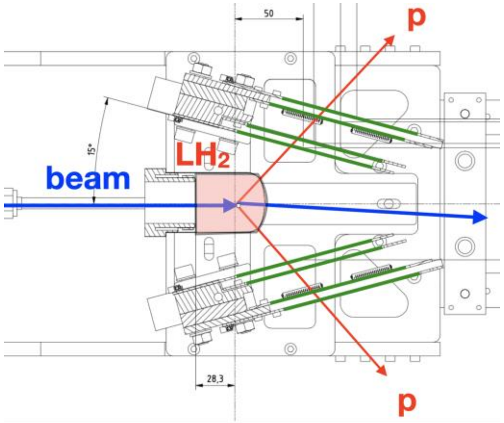


Two-track coincidence

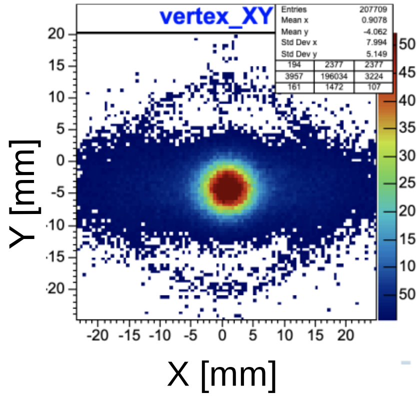




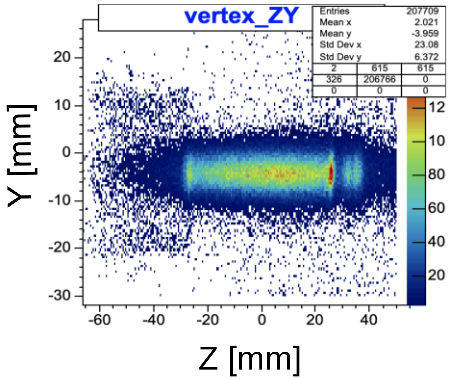
2024 experiments: ^{10,12,14,16}C beams @ ~500 MeV/u



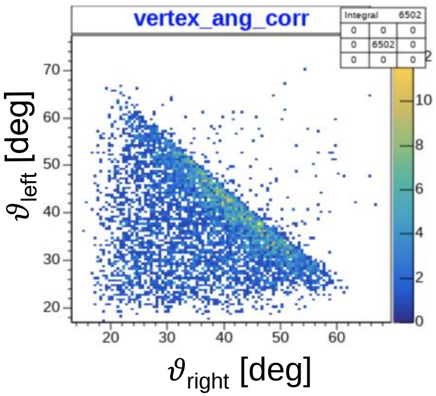
Target vertex



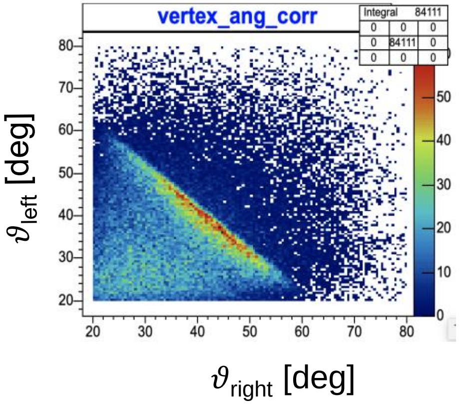
Target vertex



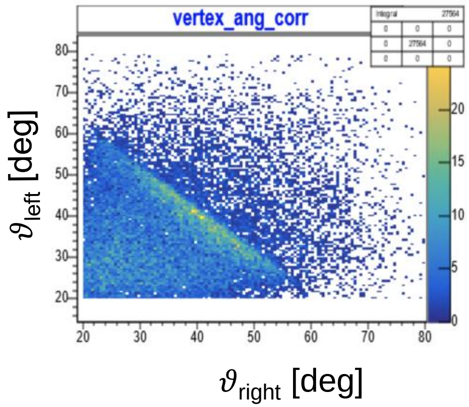
^{10}C beam



^{14}C beam

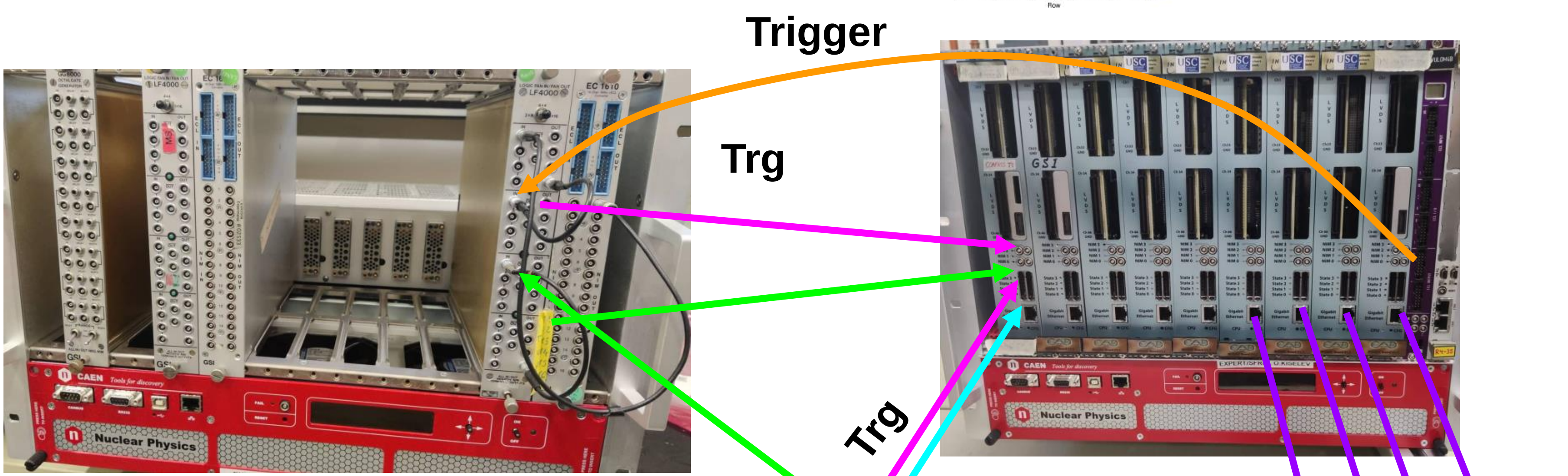


^{16}C beam



Martin Bajzek, GSI/University of Gießen

Current DAQ Setup



- **Rio4 ->VME controller configures pulser**
- **VULOMB 4B->Generate Pulse trigger signal**
- **EXPLODER->Timestamping WR**
- **ECL to NIM convertor**
- **FiFo->Distributes trigger and TS to MOSAICs**

DAQ Status

- Integration into GSI DAQ system drasi with libraries from ALICE ITS2
  - Synchronisation with White Rabbit protocol
- Zero-suppressed efficient output format
- Each electronic readout board (**MOSAIC**) reads up to 6 sensor chips
- Dedicated unpacking software (compressed binary file → ROOT)
- **External** trigger mode (due to stamp latching), internal mode not actively supported
- Noisy pixel masking
- Readout (event) rate of up to 100 kHz, depends on payload
- Software and FW public: https://git.gsi.de/m.bajzek

Figure taken from: S.N.Yilmaz - Development of Si-detectors for Super-FRS EC

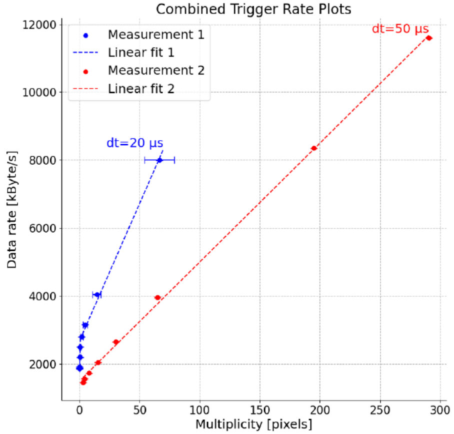


Fig. 3: *Data rate output of an ALPIDE chip vs. hit multiplicity, for two different manual deadtimes (dt) on a 100 kHz Poisson distributed trigger.*

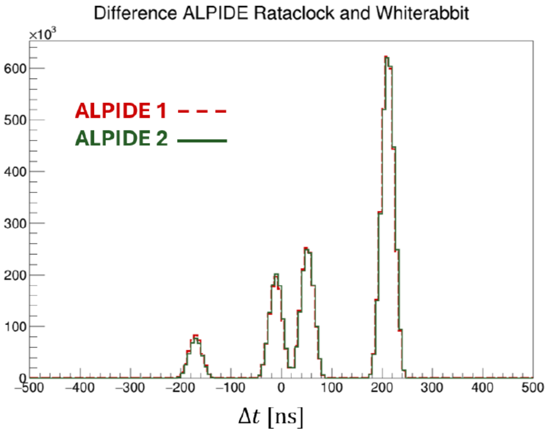


Figure adobe taken from: S. N. Yilmaz - Development of Si-detectors for Super-FRS EC

Analysis framework

- Object-oriented framework for offline analysis (hosted on github)
- New detector system - analysis framework speeds things up
- Multi-stage:
  - Clustering
  - Alignment
  - Tracking
- Each stage outputs results in ROOT format
- Able to impose variety of conditions (cuts):
  - Cluster size
  - Events with data in all detectors
  - Hit multiplicity


```
TRIGGER          = 1
EVENTNO          = 9006262
ALPIDE1T_HI      = 341327
ALPIDE1T_LO      = 3456274074
ALPIDE1PRECHIP   = 9
ALPIDE1PRECHIPv  = 1,
                   255, 255, 255, 255, 255, 255, 255, 255
ALPIDE1REGION    = 9
ALPIDE1REGIONv   = 255,
                   1, 255, 255, 255, 255, 7, 255, 255
ALPIDE1ENCODER_ID = 9
ALPIDE1ENCODER_IDv = 0,
                   0, 5, 5, 5, 5, 0, 14, 14
ALPIDE1ADDRESS   = 9
ALPIDE1ADDRESSv  = 0,
                   0, 244, 245, 246, 247, 0, 372, 373
ALPIDE1HITMAP    = 9
ALPIDE1HITMAPv   = 0,
                   0, 0, 0, 0, 0, 0, 0, 0
ALPIDE1CHIP      = 6
ALPIDE1CHIPv     = 1,
                   1, 1, 1, 1, 1
ALPIDE1ROW       = 6
ALPIDE1ROWv      = 122,
                   122, 123, 123, 186, 186
ALPIDE1COL       = 6
ALPIDE1COLv      = 42,
                   43, 43, 42, 252, 253
```


...

Pixels hit

clustering


```
T_HI            = 341327
T_LO            = 3456274074
CL_NUM          = 9
ALPIDE_ID       = 1,
                  1, 2, 2, 3, 4, 5, 6, 6
CL_SIZE         = 4,
                  2, 2, 2, 3, 2, 2, 3, 3
CL_uCOL         = 42.5,
                  252.5, 48, 257.5, 275.667, 279,
                  260.5, 60.6667, 265.667
CL_uROW         = 122.5,
                  186, 108.5, 173, 166.333, 168.5,
                  173, 95.6667, 164.333
CL_uCOL_SIG     = 0.5,
                  0.5, 0, 0.5, 0.471405, 0,
                  0.5, 0.471405, 0.471405
CL_uROW_SIG     = 0.5,
                  0, 0.5, 0, 0.471405, 0.5,
                  0, 0.471405, 0.471405
_N              = 23
_COLV           = 42,
                  43, 42, 43, 253, 252, 48, 48, 258, 257, 275,
                  276, 276, 279, 279, 261, 260, 61, 60, 61
_ROWV           = 122,
                  122, 123, 123, 186, 186, 108, 109, 173, 173, 166,
                  166, 167, 168, 169, 173, 173, 95, 96, 96
```

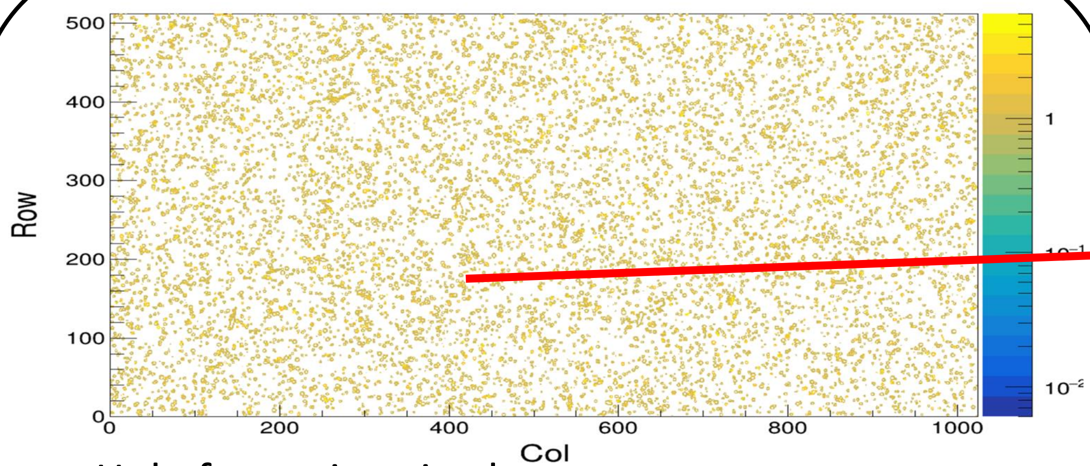

tracking

alignment


```
T_HI          = 372980
T_LO          = 3562545281
N_HITS        = 5
Z             = 0,
                120, 20, 100, 50
X             = 10.9358,
                10.9315, 10.9466, 10.9398, 10.9125
Y             = 13.1434,
                13.1257, 13.137, 13.1286, 13.1029
CL_SIZE       = 2,
                2, 5, 2, 2
X0            = 10.935
Y0            = 13.1339
PHI_X         = -3.01808e-05
PHI_Y         = -0.000109985
```

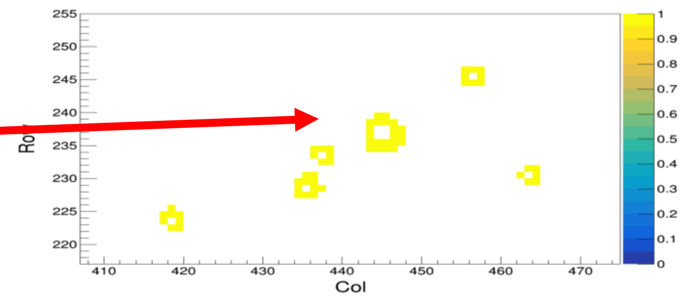
Luke Rose, University of York

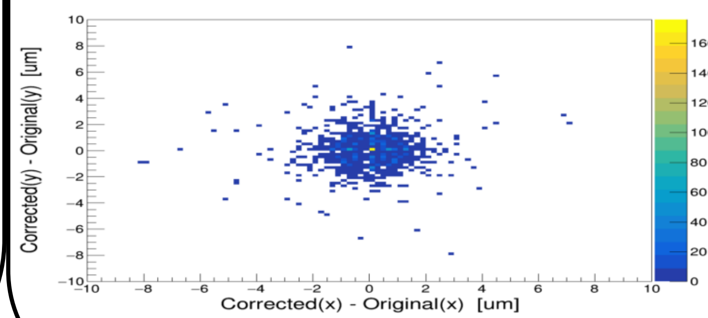
S091 Observations-Cluster Holes



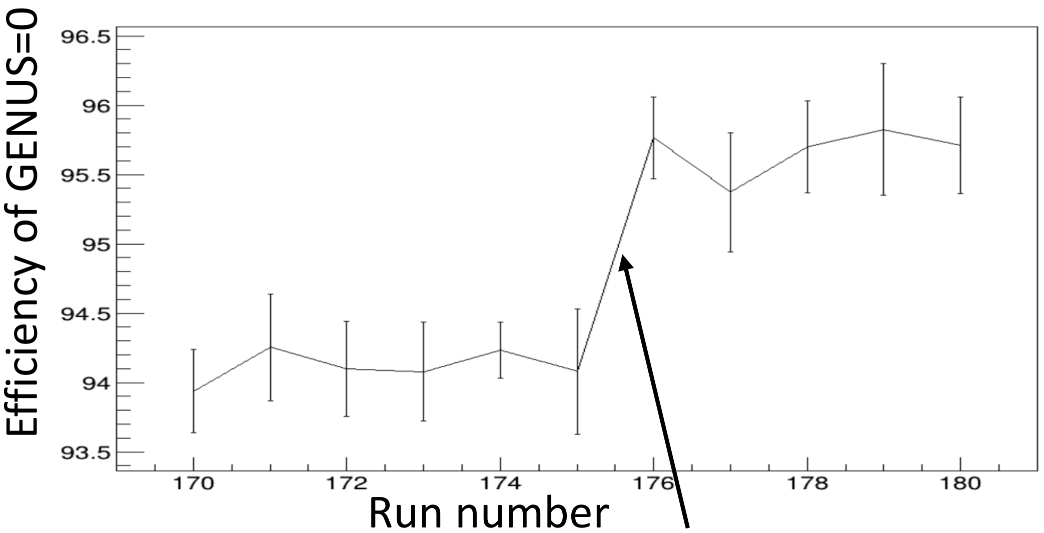
- Hole formations in clusters
  - Masked pixels
  - Time at which trigger comes->Can be manipulated to screen out delta electrons, possibly.

Some clusters contain holes





S091- How often does this happen?



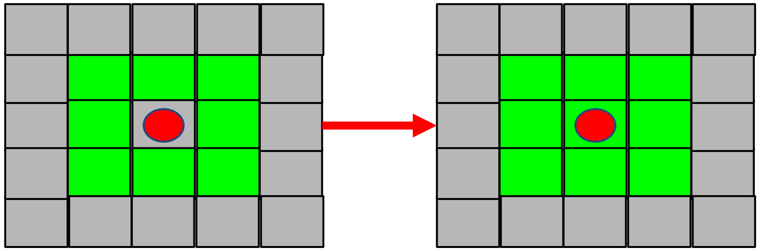
Trigger conditions changed (TRLO file modified) changes the percentage of clusters with genus>0

- There are Genus>0 clusters that do not come from region with masked pixels.
- Happend between 3-6% of the data depending on TRLO.
- More testing needed.

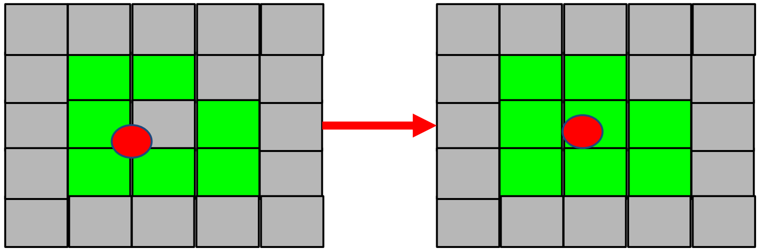
Cluster reconstruction-filling

Centroid is NOT shifted

Symmetric

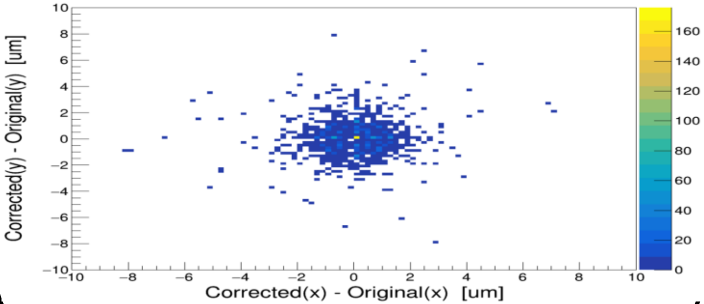


NON-Symmetric



Centroid is shifted

Cluster genus can be filled and then centroid recalculated. This will effect all non symmetric clusters



R3B-TRT device
Stage 1 and Stage 2 assembly stations at Daresbury Lab

Stefanos Paschalis
University of York

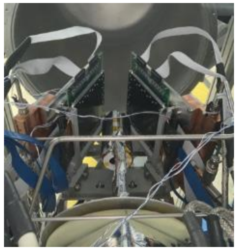
31st Jan 2025

Timeline of the TRT device

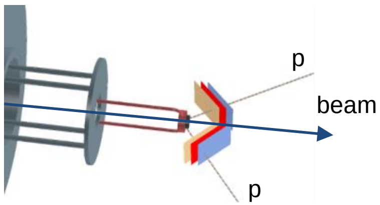
R3B Target Recoil Tracker - Project Timeline for Stage 1 and 2

in-beam test
single-sensor telescope
3x1.5 cm^2

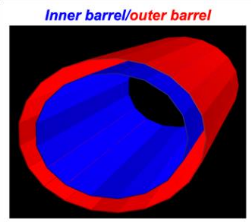
p,pd experiment
Two Stage 1 modules
partially populated



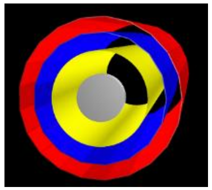
Stage 1
Two detector arms
with 6 modules



Stage 2
Full Barrel
with 2 layers



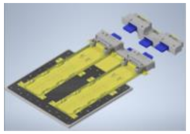
Far-future Stage
A layer of fully flexible Silicon wafer (current R&D by ALICE) fitted inside the barrel geometry
synergies (ALICE3 + EIC)



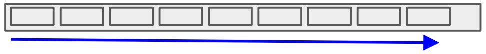
2023/4 — 2025/6 — 2027

Past

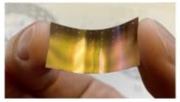
R&D and in-beam test with **ALICE** and **AMBER** collaborations

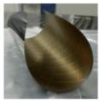


9x9 cm^2 18-sensor

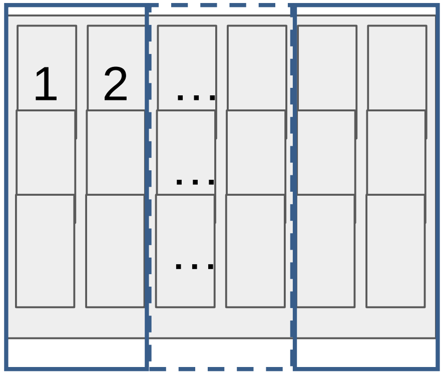


9 x 3 cm = 27 cm

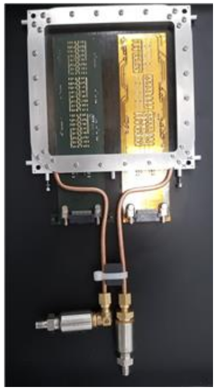




Stage 1 assembly:
CMM machine at Daresbury Lab
(Morrall, Labiche, Rose…)

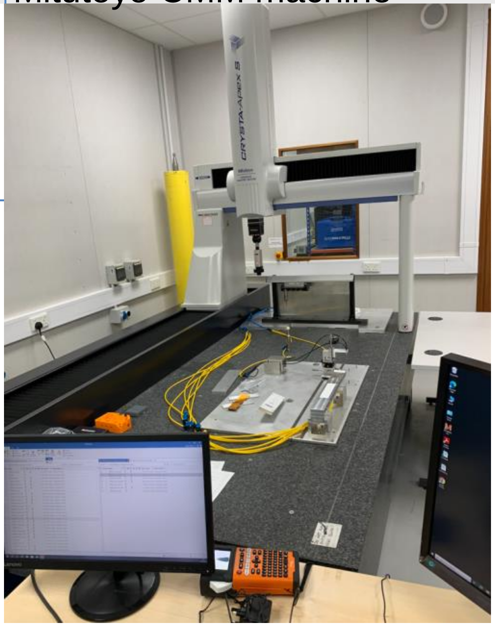


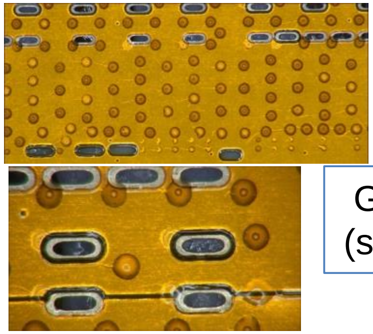
9x9 cm^2
3xFPCs



Trials with Cu and Al FPCs

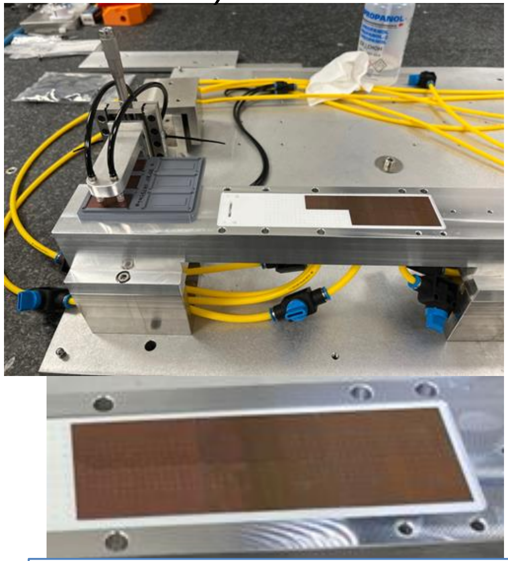
Mitutoyo CMM machine



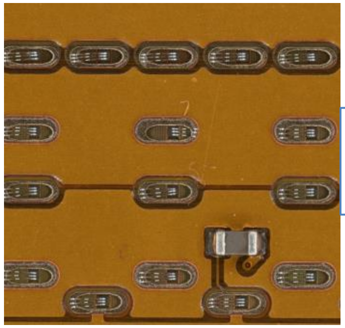


Glue-mask (stencil) trials

Jigs (mostly copied from **INFN Turin** and AMBER)



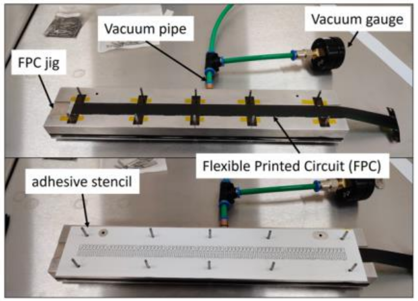
2 rows of 3 ALPIDE chips aligned on the jig



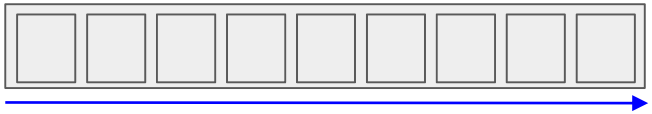
Wirebonding at GSI

Stage 2 assembly:
ALICIA machine at Daresbury Lab
(DGS group: Borri, Buckland, Sutowski, Rose…)

Prototyping jigs
(while final jigs are arriving)

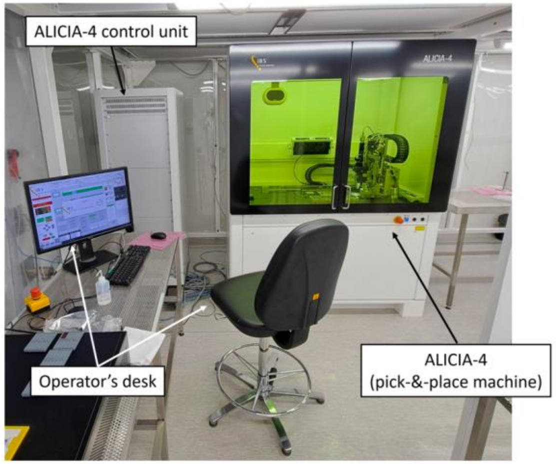


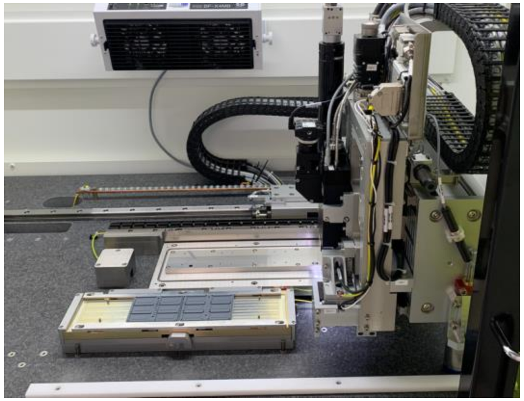
stencil



3 x 9 cm = 27 cm

ALICIA installed and operational





Jigs and FPCs
based on ALICE design

10 FPCs Stage 2 prototypes produced
(Cu based)