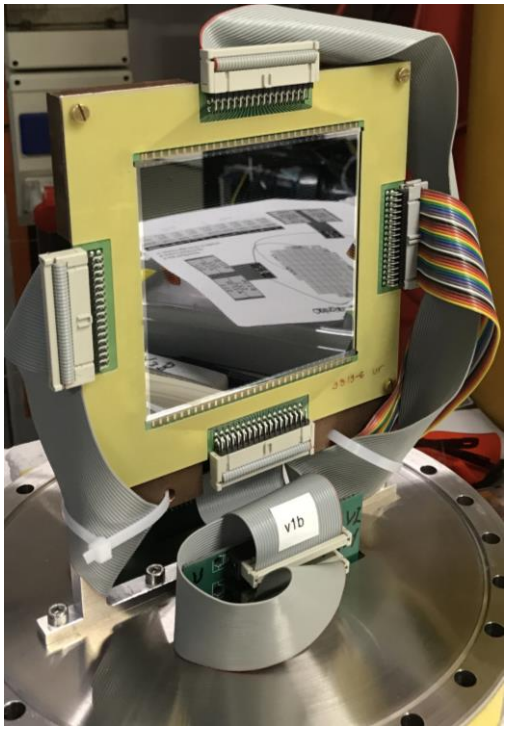
Tracking Detector WG Session

TECHNISCHE UNIVERSITÄT DARMSTADT

R3B Collaboration Meeting

Mainz, Nov. 8-9 2023

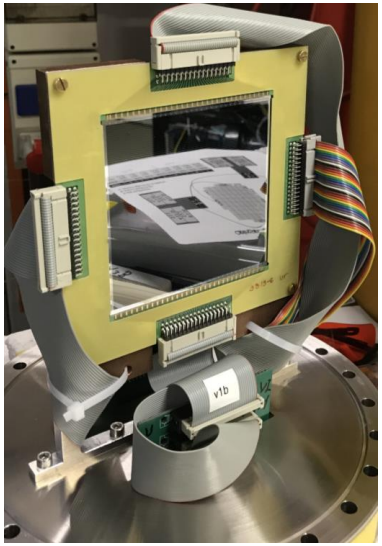
Dominic Rossi



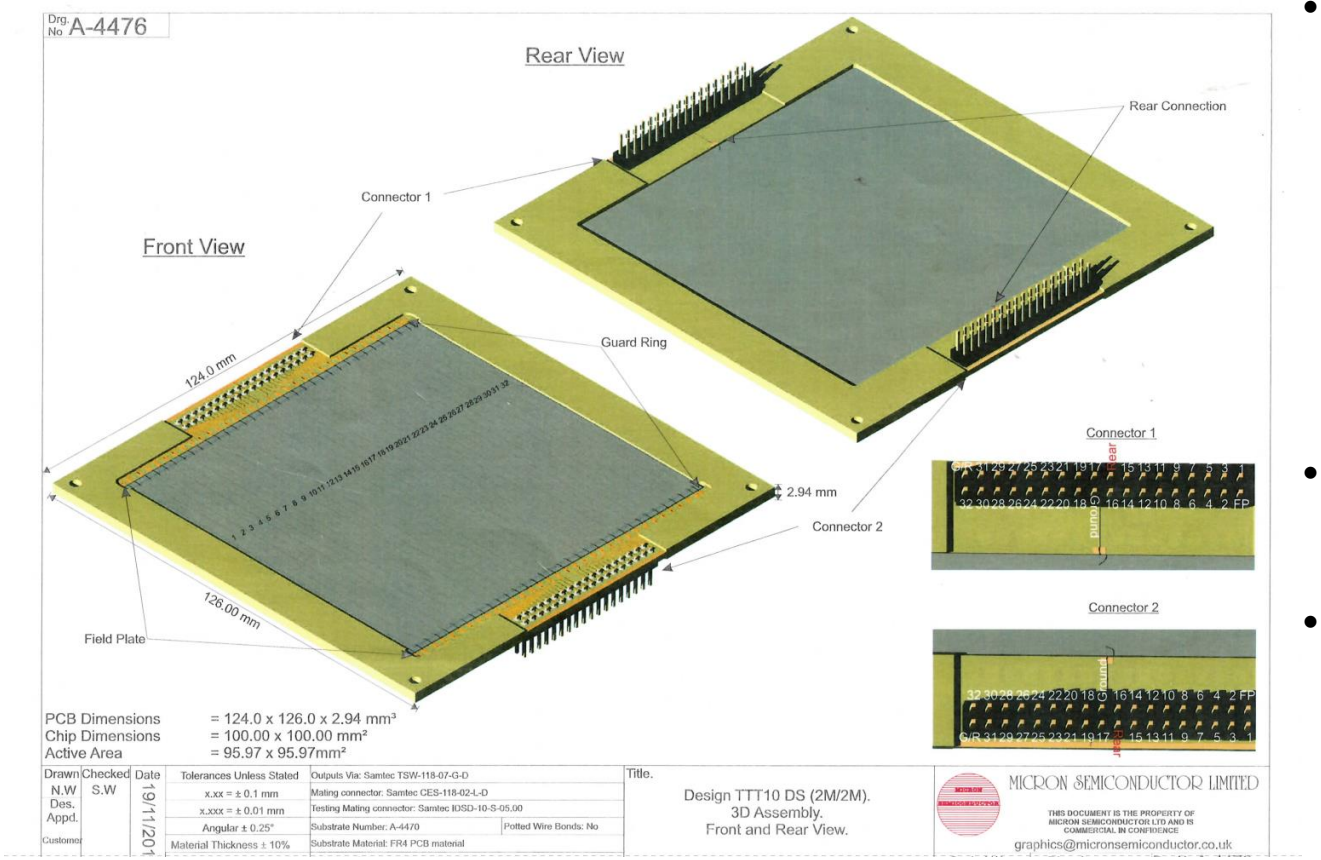
FAIR Phase 0 Research Program R3B

Introduction

- Short overview of ongoing activities:
  - TTT10 concept and testing (Wei Zhang)
  - Plans for X5 development
- PAS concept and TDR addendum (Deniz Savran)



Micron TTT10 Detectors



- One detector with a thickness of 500um (B-grade) and three with a thickness of 300um.
- 32 strips with a pitch width of 3mm.
- Dimensions: 10cm * 10cm

Slide: courtesy of Wei Zhang

Test at York — Setup

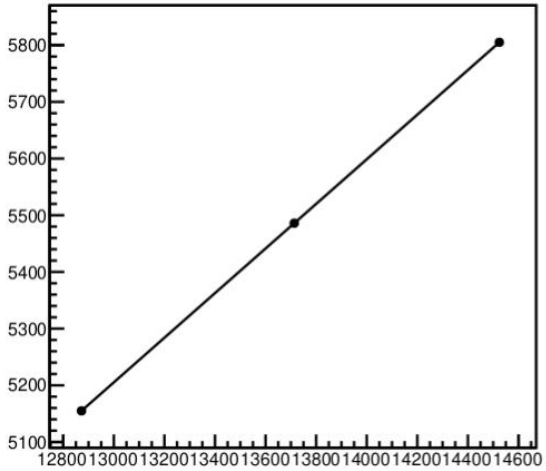
York vacuum chamber and triple-alpha source (^{239}Pu, ^{241}Am and ^{244}Cm)

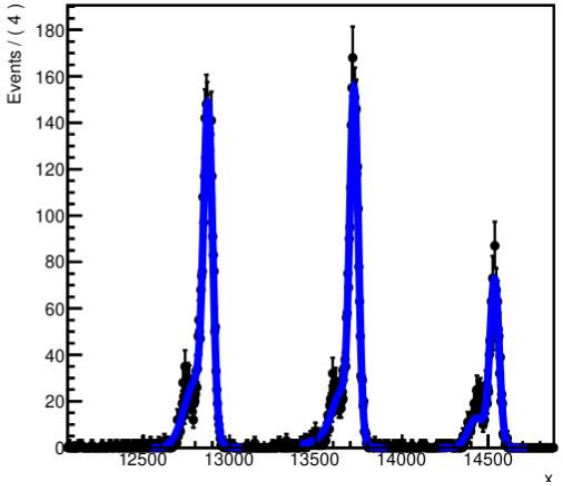
Rough vacuum: 0.1~0.3 mbar

- MHV-4 negative bias input
- Preamplifier MPR32 (25 MeV range)
- MDPP 32 SCP
- MVLC controller: Trigger IRQ(Interrupt requests) =1

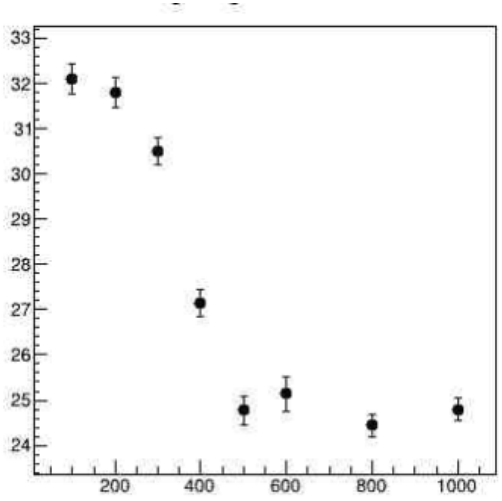
Slide: courtesy of Wei Zhang

Test Results





All channels have a good linearity in this energy domain.



Energy resolution FWHM (in keV, y-axis) values change with different shaping time setting (x-axis in the unit of 12.5ns), as shown in the figure above for the three alpha peaks and their average value.

The shaping time is set as 500(6.25us), but shorter values would work as well.

Slide: courtesy of Wei Zhang

Test Results — Strip-by-Strip Energy Resolution

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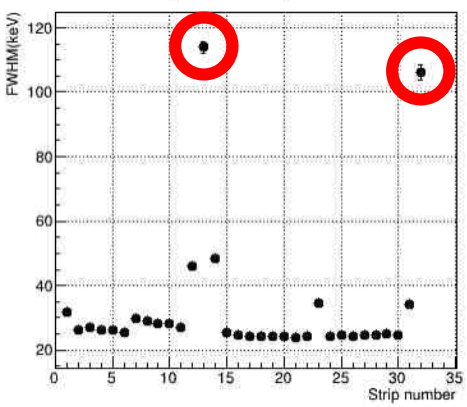
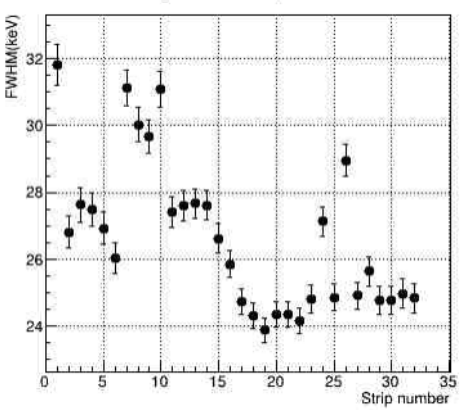
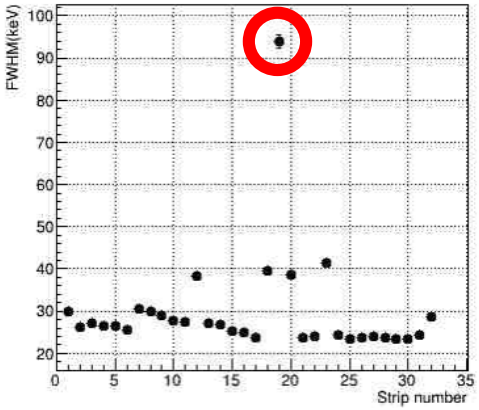
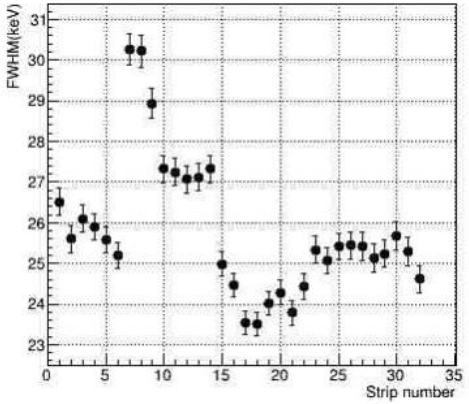
Three 300 um TTT10







500 um B-grade



One detector has a poor resolution (FWHM>100 keV) at strip no. 13 and 32; and the other one has a poor resolution at strip no.19.

A shorter shaping time (<2.5 us) can improve their performance.

Slide: courtesy of Wei Zhang

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TTT10 In-Beam Box

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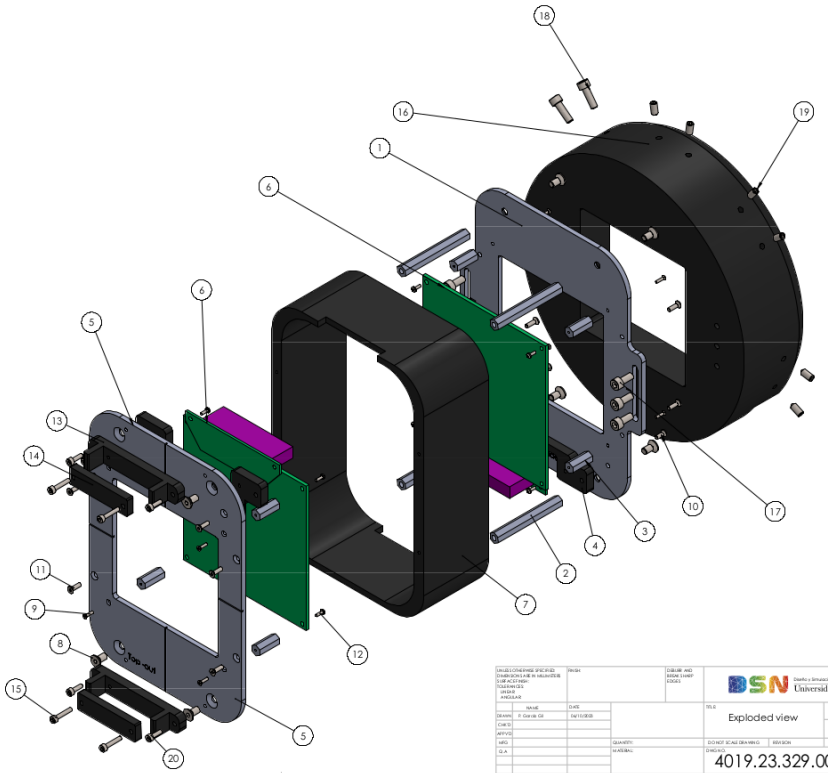
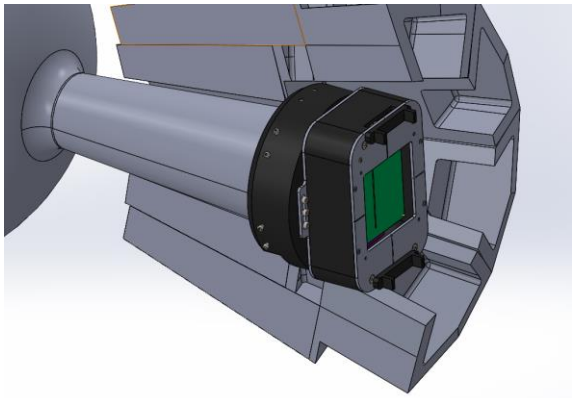
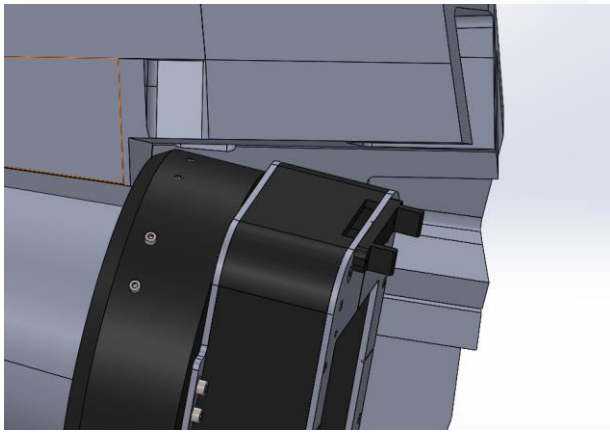
Design by Pablo and Enrique

N.º DE ELEMENTO	N.º DE PIEZA	CANTIDAD
1	4019.23.329.1000-BotomPlate-D	1
2	4019.23.329.4002-PlatesSep-D	4
3	4019.23.329.4000-BoardsSep-D	8
4	4019.23.329.4002-AdapterSep-D	2
5	4019.23.329.1001-TopPlate-D	1
6	TTT10 and adapter	2
7	4019.23.329.5000-Box-D	1
8	ISO 10642 - M5 x 10 - 10N	8
9	ISO 7046-1 - M2 x 8 - Z - 8N	8
10	ISO 10642 - M3 x 8 - 8N	2
11	ISO 10642 - M3 x 10 - 10N	10
12	ISO 7045 - M2 x 6 - Z - 6N	8
13	4019.23.329.3001-WiresHolderBase-D	2
14	4019.23.329.3002-WiresHoldeTop-D	2
15	ISO 4762 M3 x 16 - 16N	4
16	4019.23.329.5000-FlangeAttachment-D	1
17	ISO 4762 M5 x 12 - 12N	6
18	ISO 4762 M5 x 16 - 16N	4
19	DIN 916 - M5 x 10-N	6
20	ISO 4762 M3 x 10 - 10N	4







Slide: courtesy of Wei Zhang

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TTT10 In-Beam Box

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Design by Pablo and Enrique

The box will be brought to GSI by Pablo this week, will try to see if it fits with the Mesytec adapter and cables for TTT10 as well as with CEPA.

Slide: courtesy of Wei Zhang

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VME Crate Configuration for TTT10 at GSI

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PSP crate used currently including:

- Vme crate inc: Rio R4L-44, TRIVA, VULOM4B, MDPP-32
- Power supply for MPR-32 preamp
- Fan in-Fan out for input pulser

Slide: courtesy of Wei Zhang

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PSP X5 Development

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- X5 analysis in Sn experiments (s473, s515) difficult due to significant detector response most likely related to high rates (incomplete charge collection)
- Planned developments to improve high-rate performance:
  - Use mesytec MDPP-32 digitizers as alternative to FEBEX (4 MDPP-32 ordered and delivered)
  - Redesign of X5 PCB for improved shielding and connectors
    - 2 X5 300um and 1 X5 200um ordered without PCB
    - Search for alternative connectors, coax cables and feedthroughs to improve signal-to-noise ratio
- TTT10 operation during 2024 experiments to provide important insight into new readout
- Possible splitting of energy-loss and position measurements in one detector for high-rate experiments?

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PAS – Proton Arm Spectrometer

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- Activities since last R3B meeting:
  - Continuation of investigation into both PAS concepts (FIB and RPC), taking comments from past meeting into account
  - Full reset of project status: requires TDR addendum to present new PAS concept
  - Funding also re-established to full initial value, escalated to 2023 EUR value

- RPC concept:
  - Technical challenges still to be solved (RPC operation at low pressure)
  - Decision to pursue FIB concept for now, door open for possibility to pursue RPC concept for additional detector, if needed
- FIB concept: following presentation by Deniz Savran

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New concept for the Proton Arm Spectrometer (PAS)

T. Aumann[1,2], C. Caesar[2], E. Casarejos[3], D. Galaviz Redondo[4], P. Garcia Gil[3], H. Heggen[2], M. Heil[2], D. Körper[2], V. Panin[2], D. Rossi[1,2], D. Savran[2], H. Simon[2], and A. Zilges[5]

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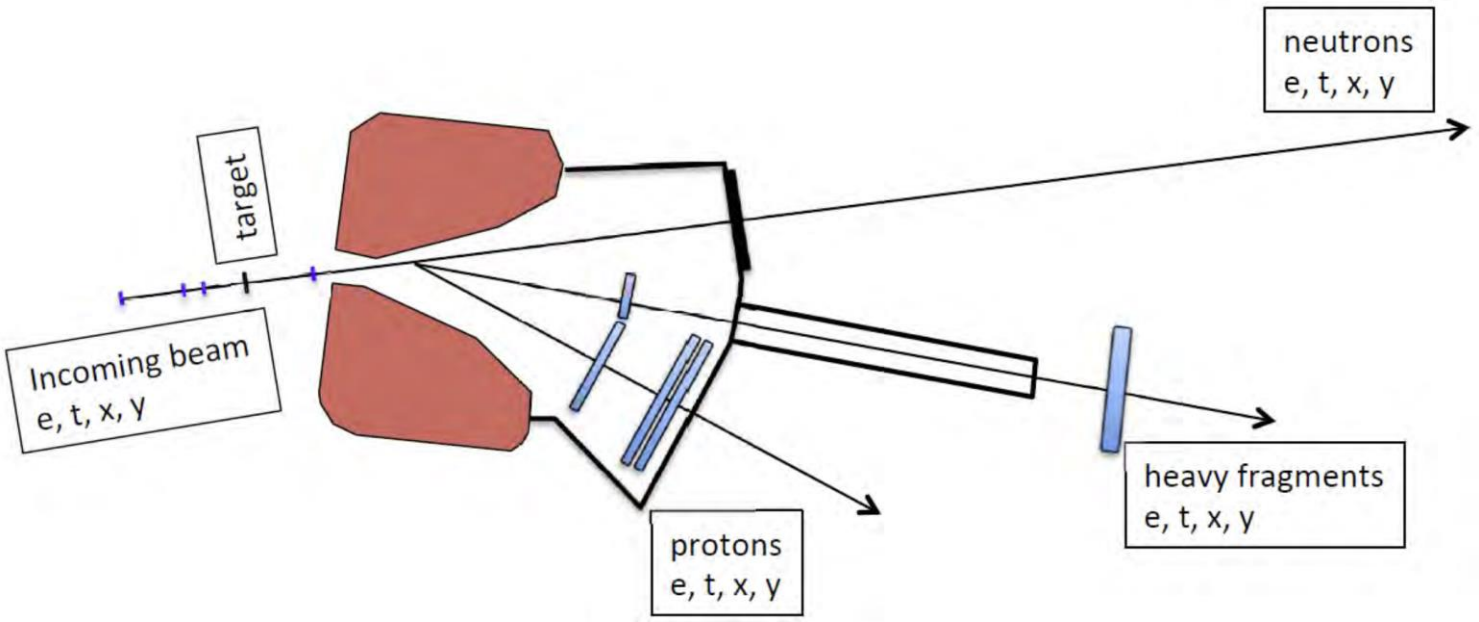
3 Dpt. of Mechanical Engineering - Faculty of Industrial Engineering Universidade de Vigo E-36310 Spain
4 LIP - Laboratory for Instrumentation and Experimental Particle Physics, Lisbon, Portugal
5 Institut für Kernphysik, Universität zu Köln, 50937 Köln, Germany

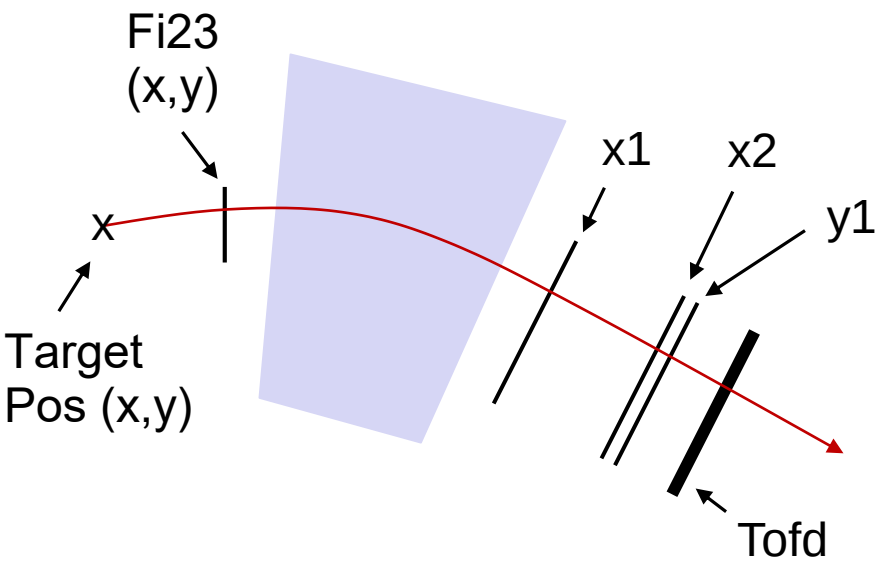
GSI

Proton Arm Spectrometer



PAS – Simulations (reminder from last meeting)

Geometry:



- Tracking of simulated events
- Simulate different thickness and granularity of PAS plains (Fi6x)
- Influence of detector in front of GLAD (Fi23)

Fi60 thickness	0.5 mm	1.0 mm	1.5 mm	2.0 mm
Δp/p in %	0.030	0.042	0.048	0.057

- Detector before Glad very important
- Impact of fiber thickness on momentum resolution less critical, up to 2mm possible

→ Use of 1.5 mm for sufficient light output and perfectly matches Hamamatsu SiPM array

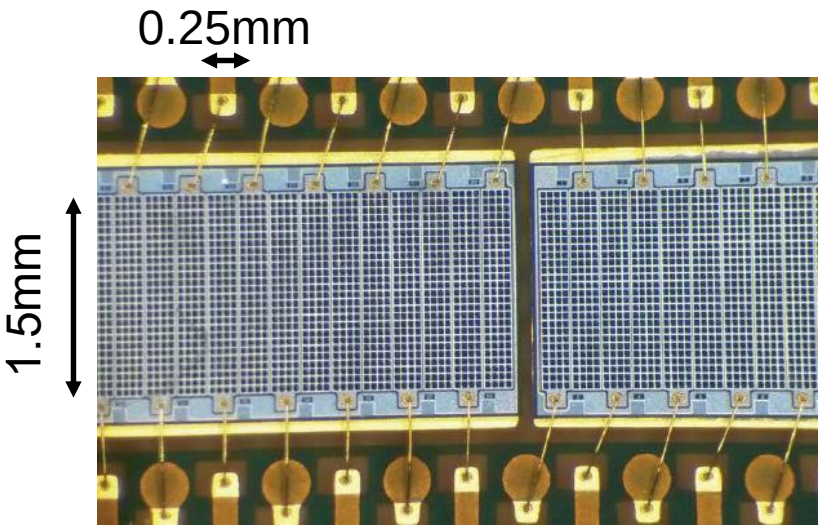
PAS – SiPM array and electronics

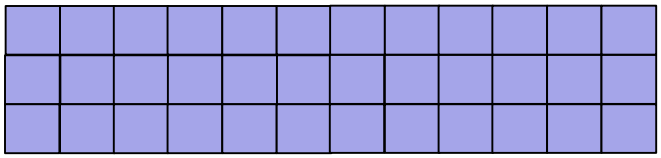
Hamamatsu 4 LHCb:

One-dimensional 128 ch array,
Channel size: 1.5mm x 0.25mm
Pixel size: 50x50 μm

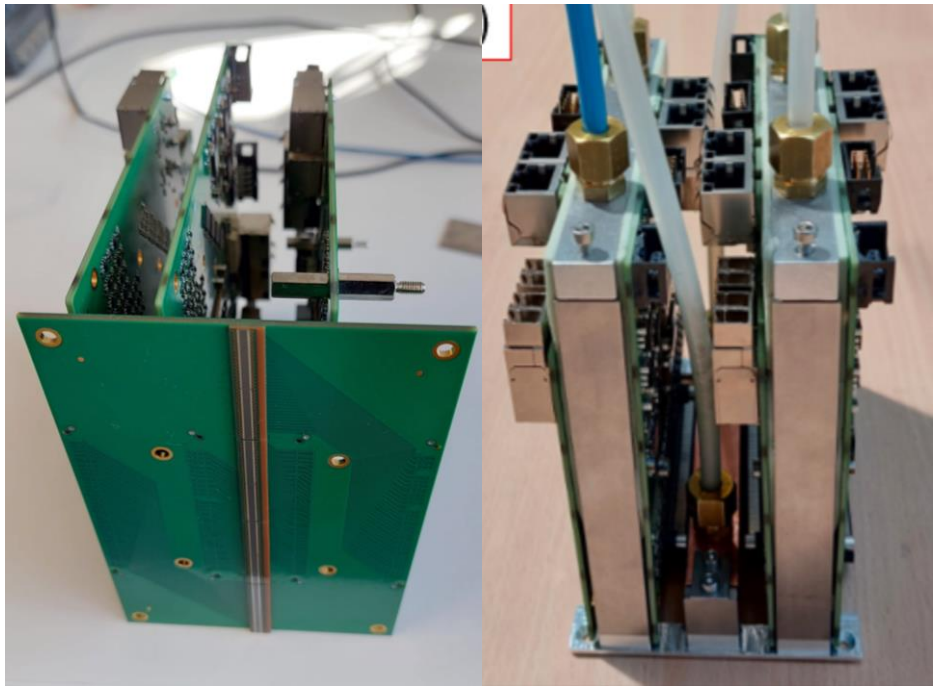
Readout: MPPC ROB3

Power supply for SiPM's
Clock TDC
128ch on one board



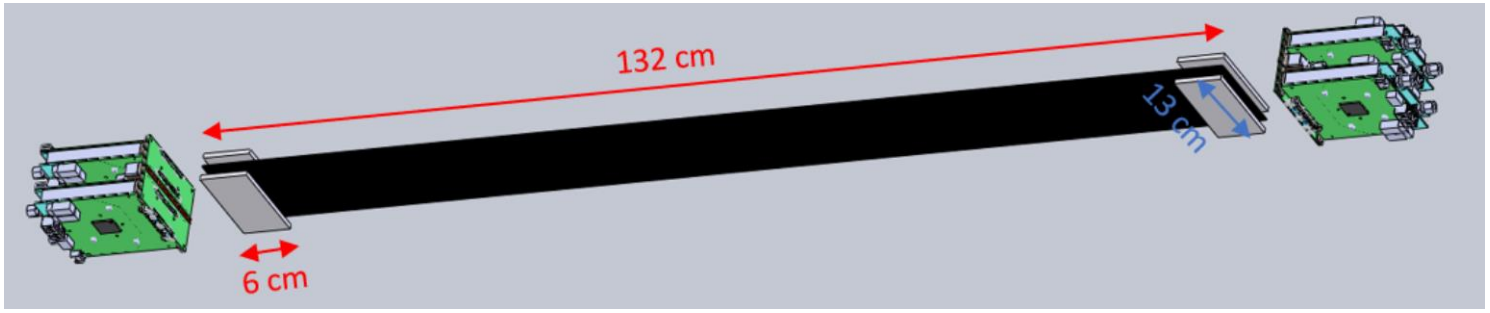


Fiber ribbon: 3x 0.5mm

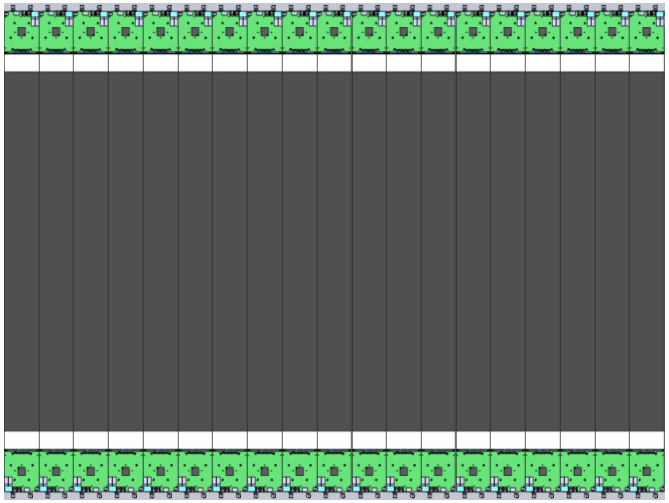


PAS – concept

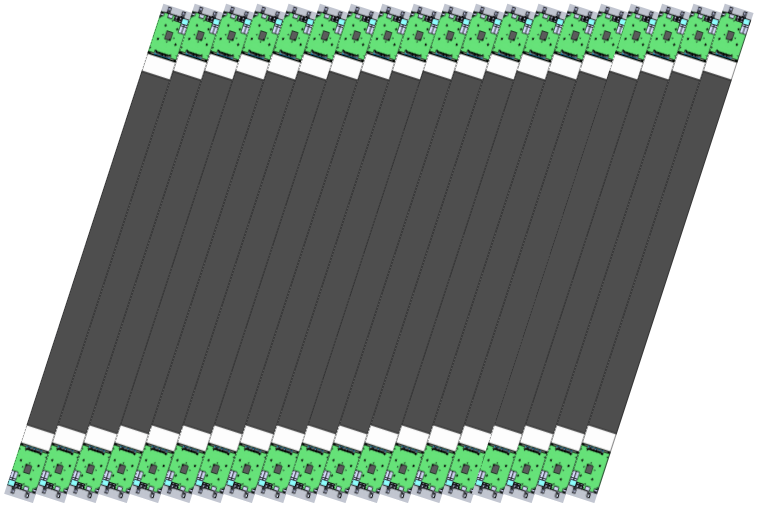
Basic building block 120cm x 12.8 cm module (512 channels SiPM on one board)



X1 and X2 plane



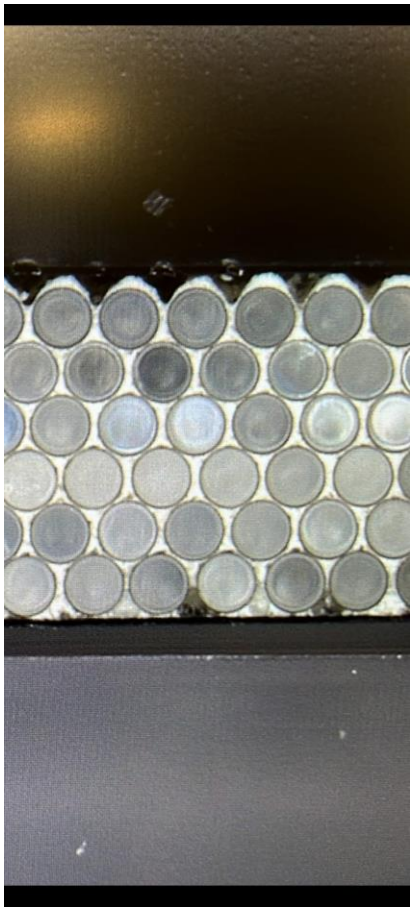
Y1 plane



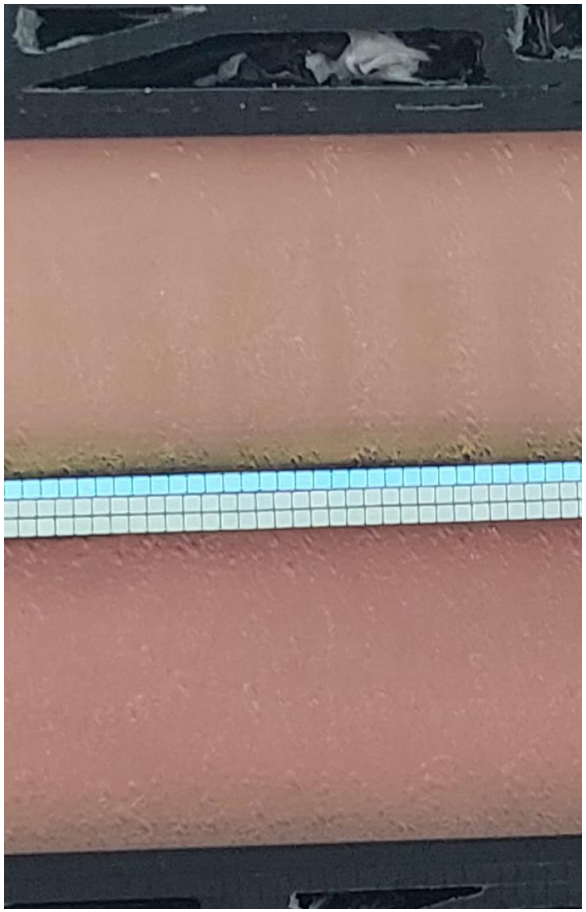
Two prototypes build

1.2 m long

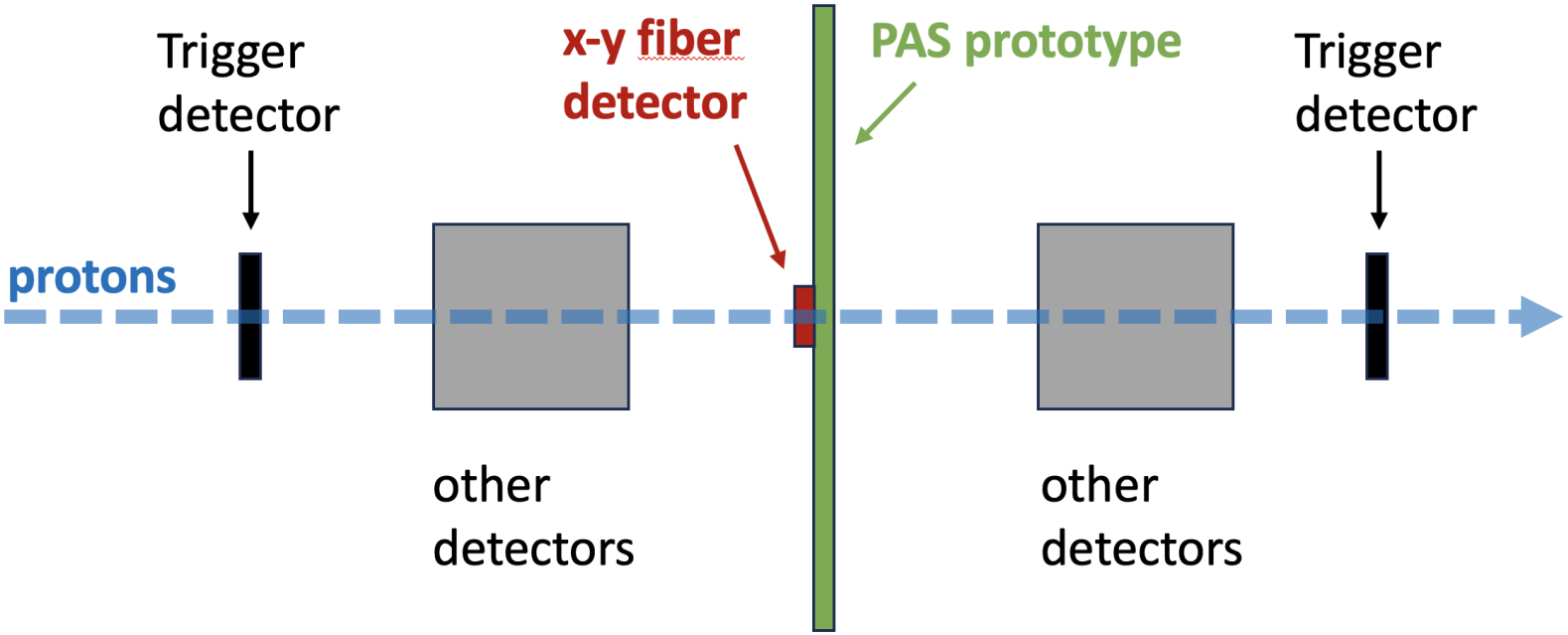
6x 0.25mm (LHCb)



3x 0.5mm



Prototype - test at Jülich with proton beam

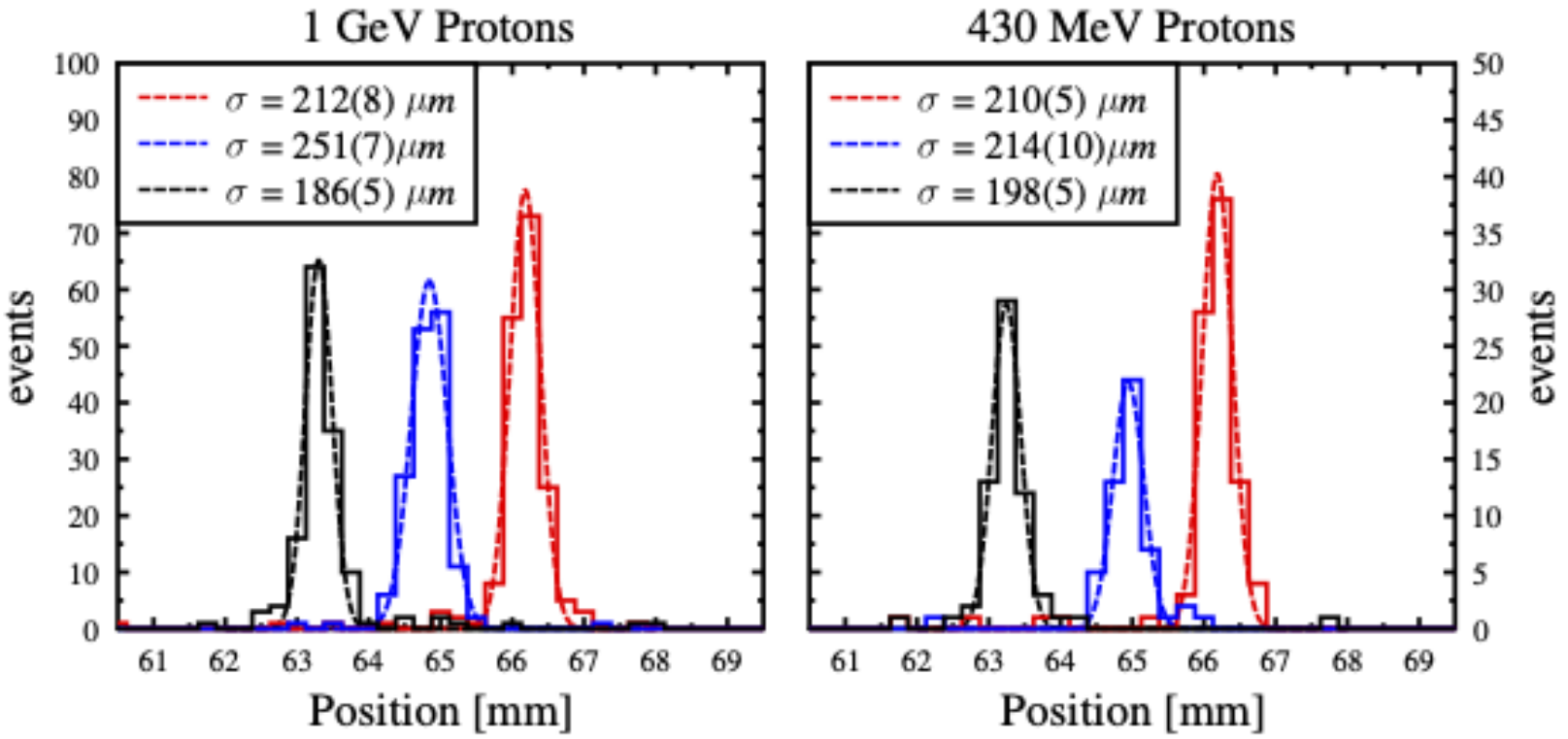


(at Jülich only single side readout due to limited available electronics)

- Variation of thresholds and voltage supply
- Efficiency of 98.8(5)% for 1 GeV protons and 99.0(3)% for 430 MeV protons

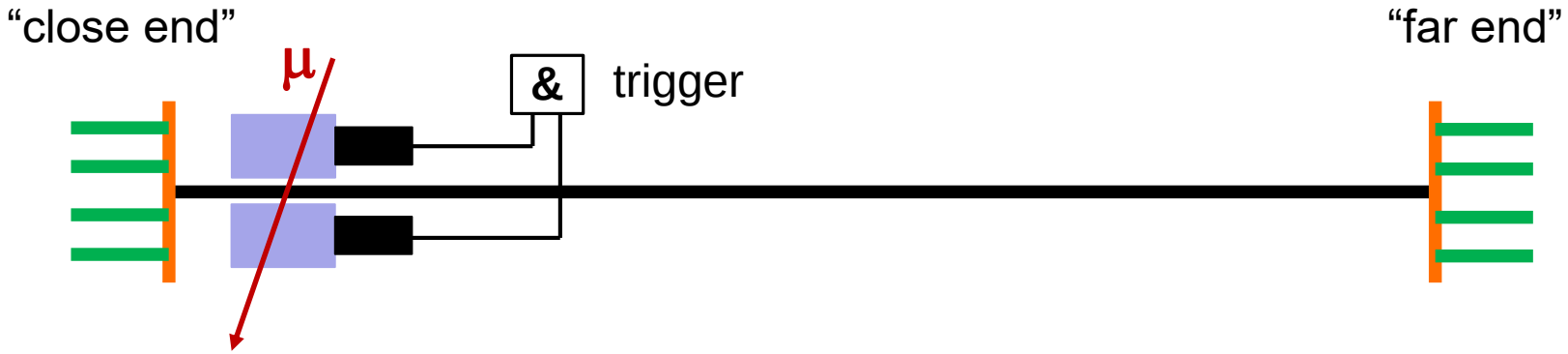
Prototype - test at Jülich with proton beam

Position resolution (with respect to 200 x 200 μm^2 pixels of x-y detector)



Prototype - test setup at GSI

- Use thick scintillators above + below in coincidence to trigger on muons
- Trigger defines 100% efficiency

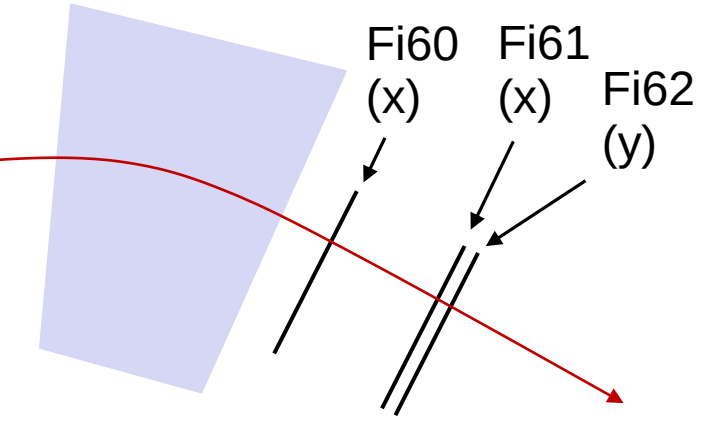


- Efficiency for far end side: 97.2(8)%
- Coincidence efficiency: 95.8(9)%

Cost estimate for full device

item	choice	single price	module[kEur]
Scintillating Fiber	Kuraray SCSF-78SJ 0.5mm SQ	3.77 Eur/m	4.9
Photo Sensor	Hamamatsu S13552; 1d MPPC array	289 Eur/128ch	2.3
Photo Sensor PCB	SciFi FEB512	236 Eur/ per 4 MPPCs	0.5
Readout Electronics	MPPC ROB3 (PreAmp+FPGA TDC)	776 Eur/128ch	6.2
Power supply for MPPC	Hamamatsu C14156	57Eur/MPPC ROB3	0.5
Cooling and support			1.5
costs for one module			15.9

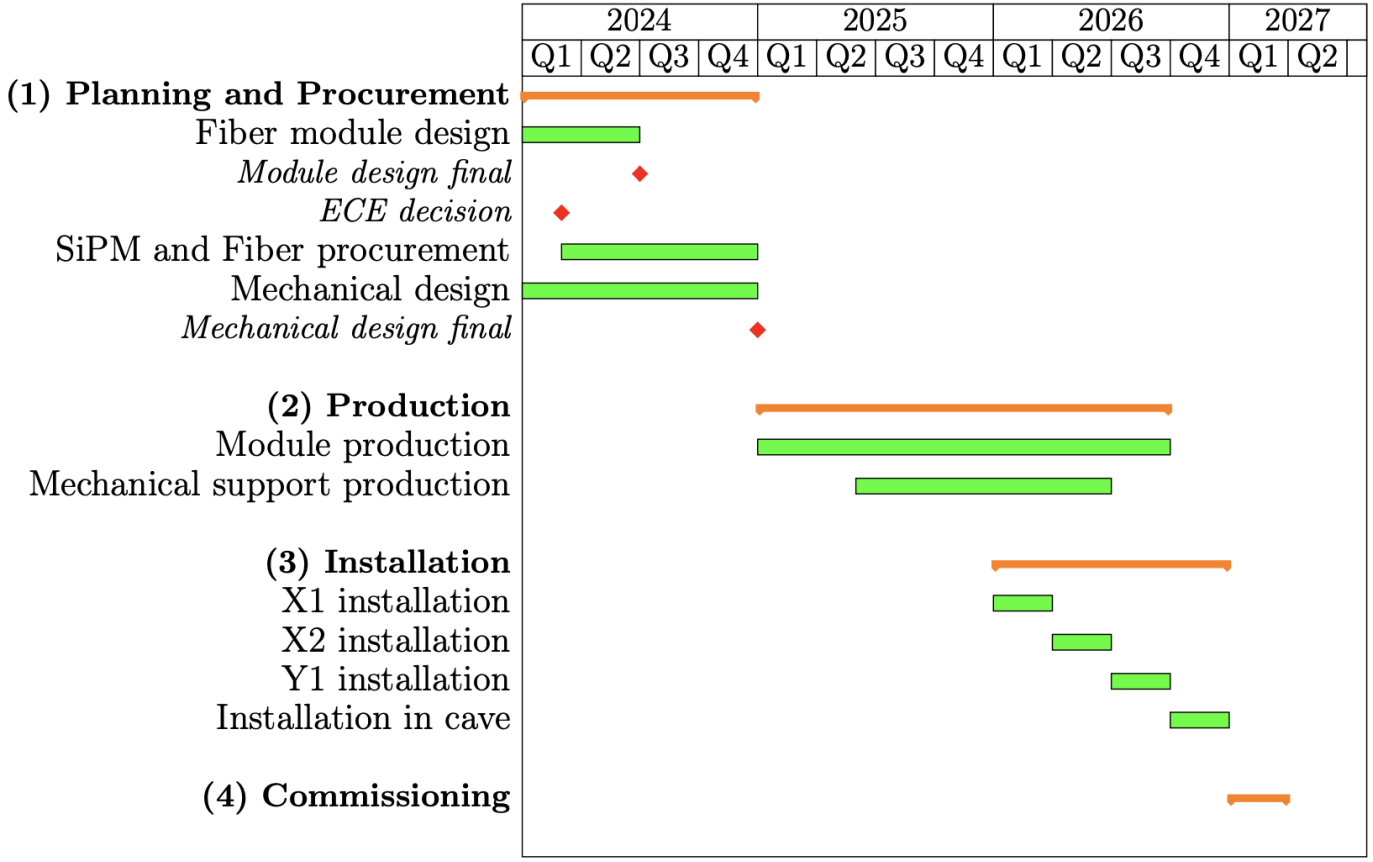
3 detector systems based on 120cm x 12.8cm modules:



item	price [kEur]
x1 plane - 15 modules	238.5
x2 plane - 19 modules	302.1
y1 plane - 21 modules	333.9
holding structures and mechanics	50
feedthroughs	2
DAQ equippement incl. PC and cables	14
LV supplies and distribution	12
Infrastructure for production and storage	20
cooling units	15
total costs	987.5

987.5 kEur

Timeline



→ Requires to hand in the TDR addendum end of next week

→ We need a decision end of this week