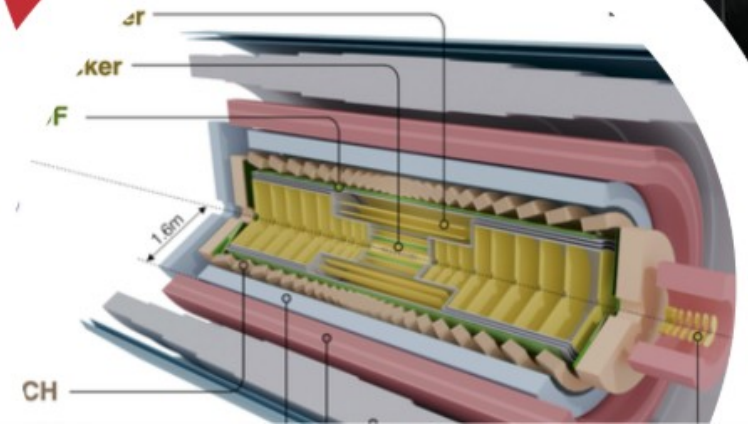
ALICE MEXICO
MID MEETING

The meeting is devoted to discuss the R&D activities of the muon identifier detector (MID) of ALICE 3



ACORDE Plastic Scintillator Prototype for the ALICE-3 MID: Current Status

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Benemérita Universidad Autónoma de Puebla

April 15th, 2026

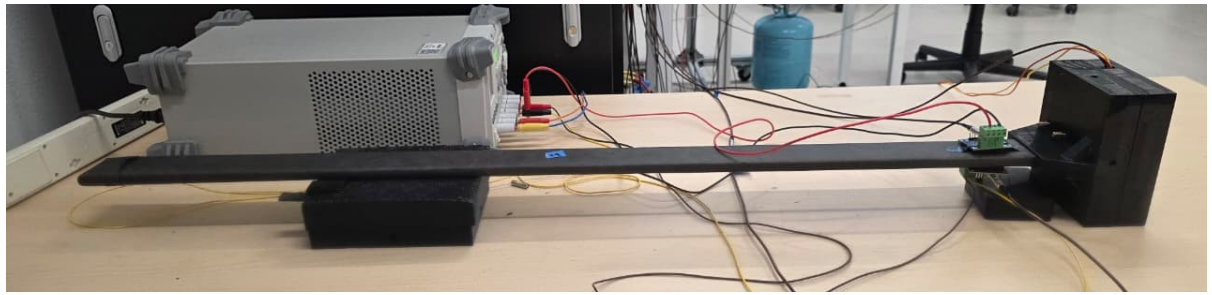
Outline

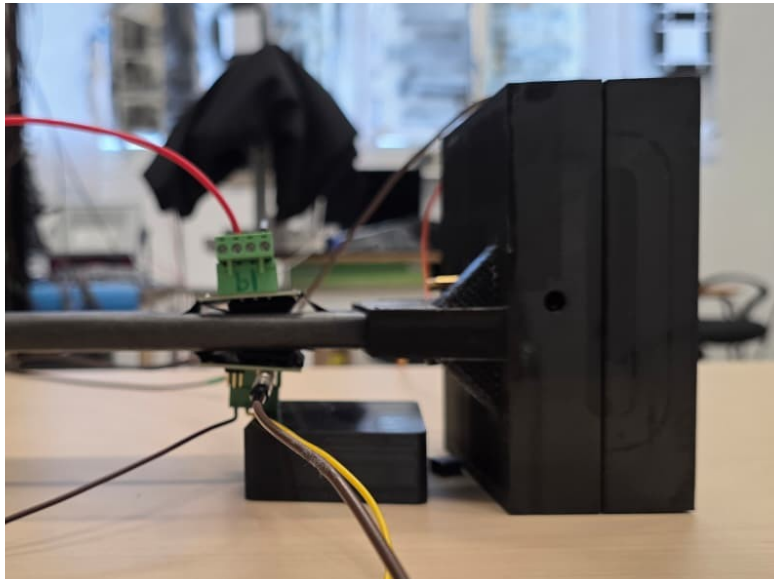
- Cosmics Rays Tests
- Test Beam 2025
- Radiation Campaign
- Plans

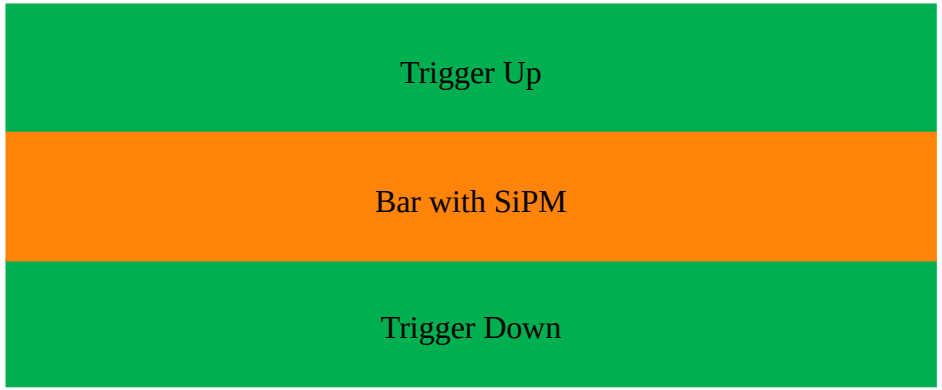
Cosmic Rays Tests

- All 40 plastic scintillator bars for the MID prototype have been polished and equipped with coupled WLS fibers.
- Bars are wrapped with reflective Mylar and light-tight Tyvek to optimize light collection and suppress external noise.
- Standard readout electronics are used for signal acquisition.
- Cosmic-ray measurements are ongoing. 30 bars have been characterized so far.
- Measurements are performed at three positions along each bar.

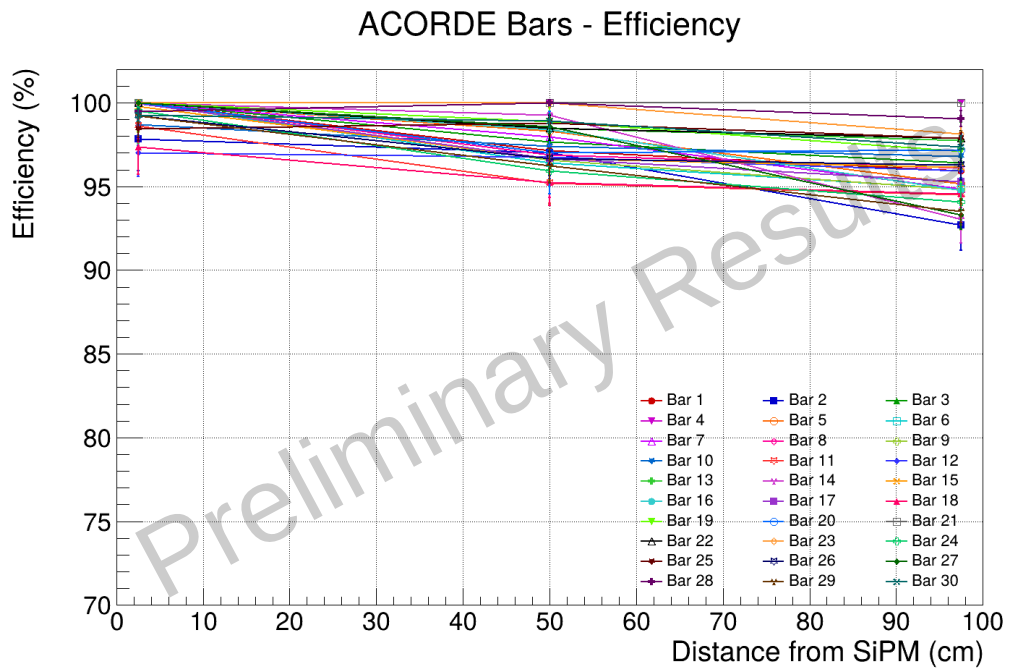
Cosmic Rays Tests – Setup

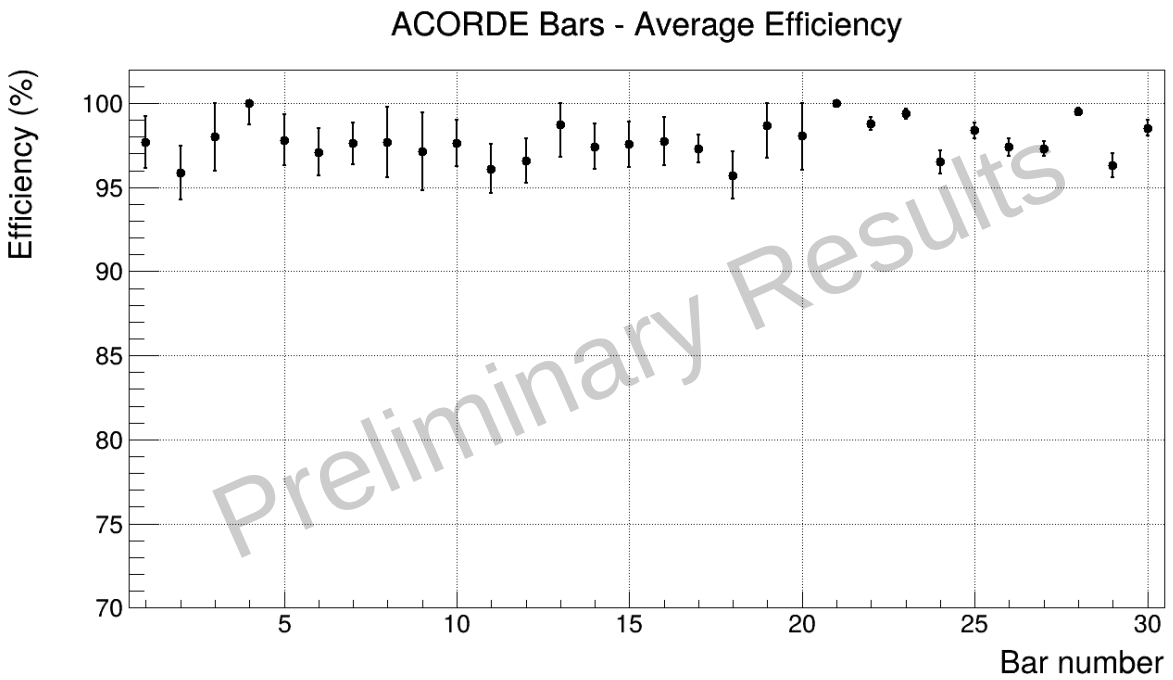






Cosmic Rays Tests – Preliminary Results





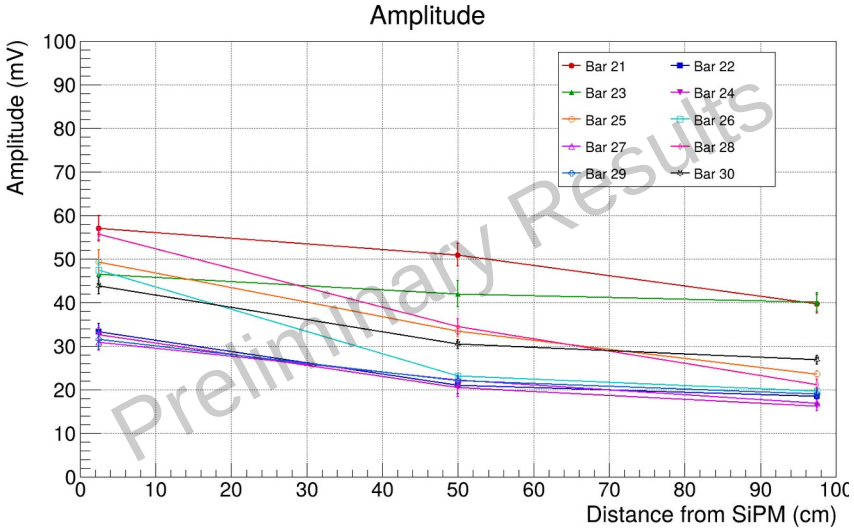
Efficiency > 93% at all positions along the bar

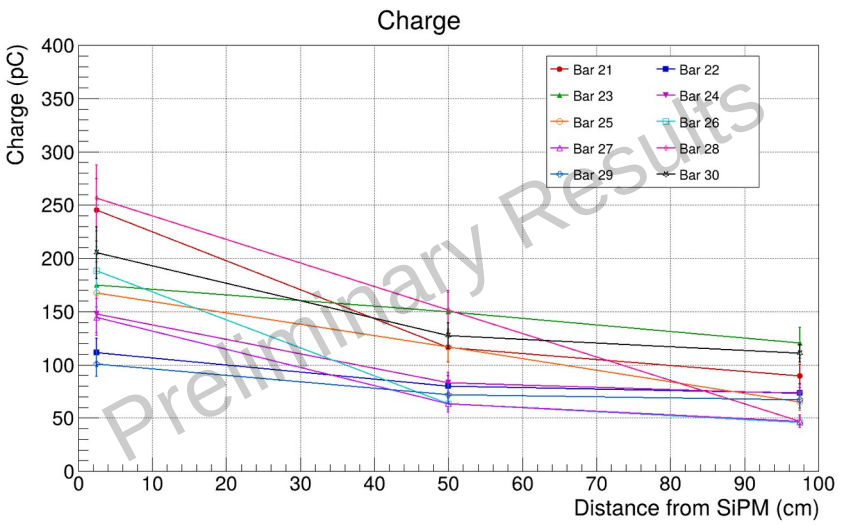
Average efficiency across all the bars > 95%

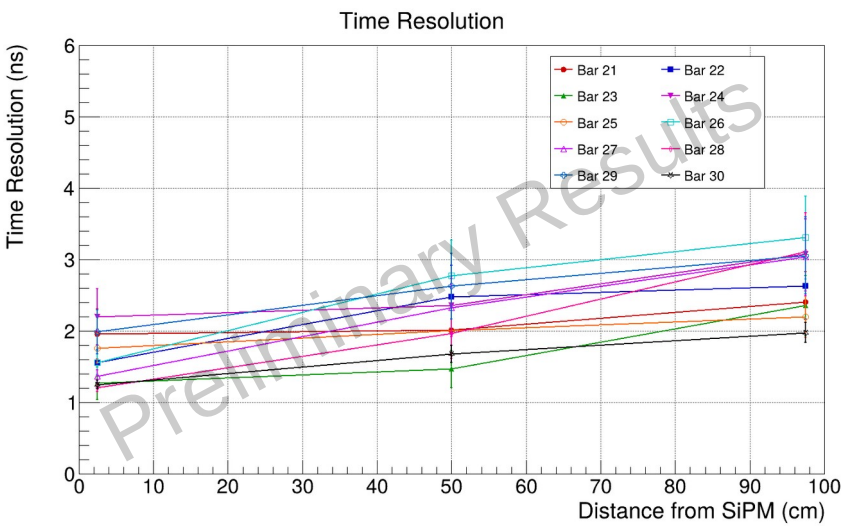
UNAM Prototype:

Efficiency > 98 %

Cosmic Rays Tests – Preliminary Results

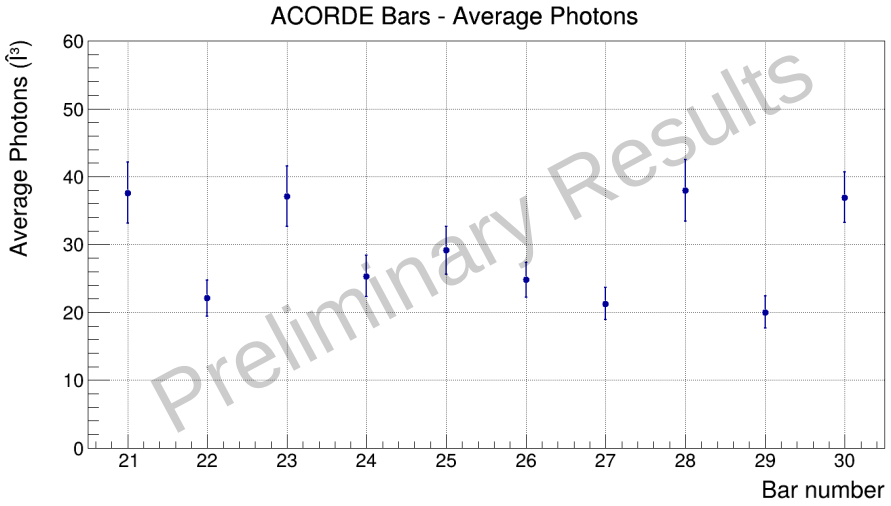






Time resolution: 1.2 – 3.5 ns

Average number of photons (γ): ≈ 30



Test Beam 2025

Period: July 30 to August 13, 2025

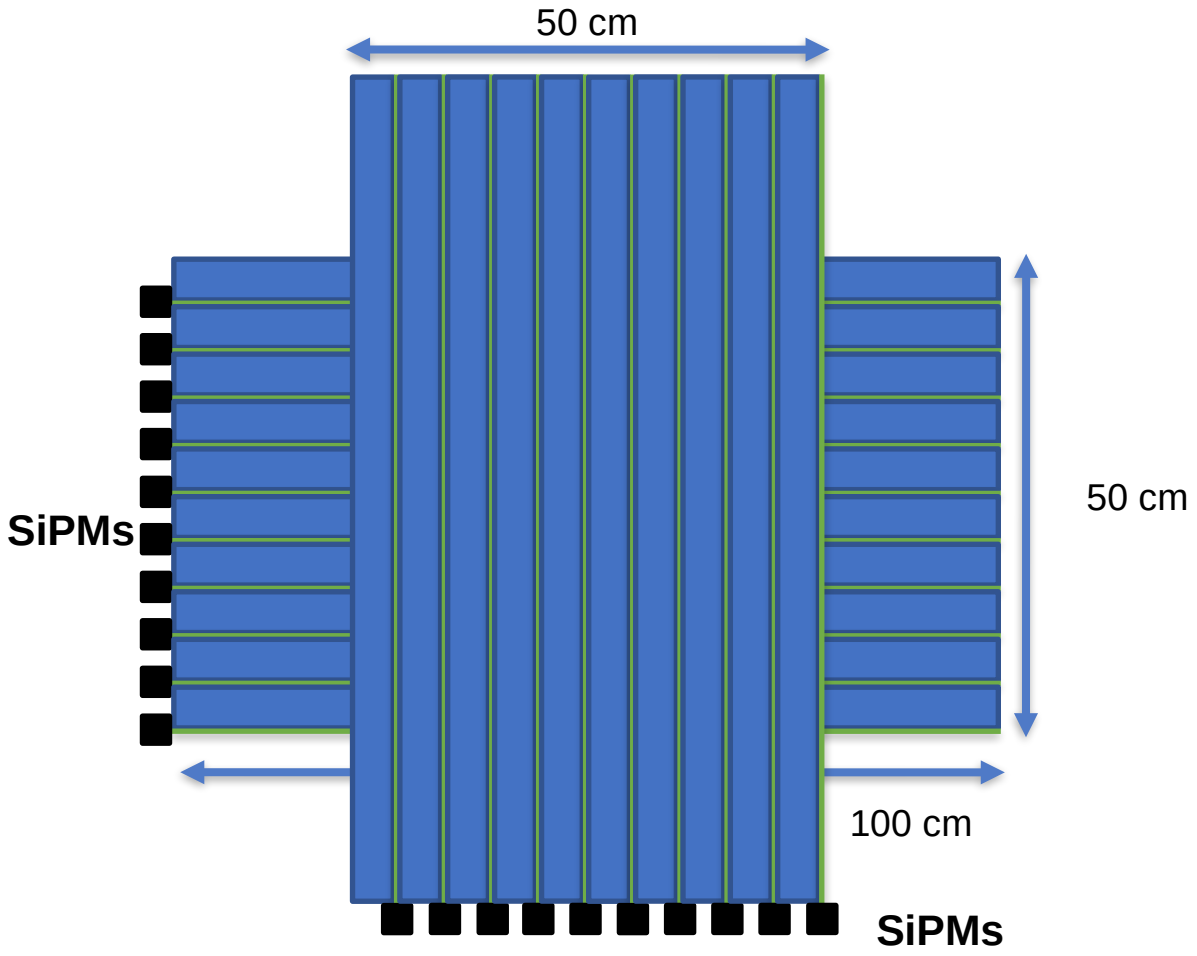
Location: T10 beamline at the CERN PS facility

Prototype:

- Two layers of ten plastic scintillator bars each
- Bar dimensions: 100 × 5 × 1 cm³
- SiPMs: SensL C-series, both 6×6 mm² and 3×3 mm²
- One SiPM per bar
- Three Kuraray Y-11(200) WLS fibers per bar

Tests performed:

- Efficiency and energy scan in two orientations: vertical, and horizontal
- Efficiency and energy scan in different sectors in the arrangement.
- Absorber scan with pions and muons at different beam energies



Assembling

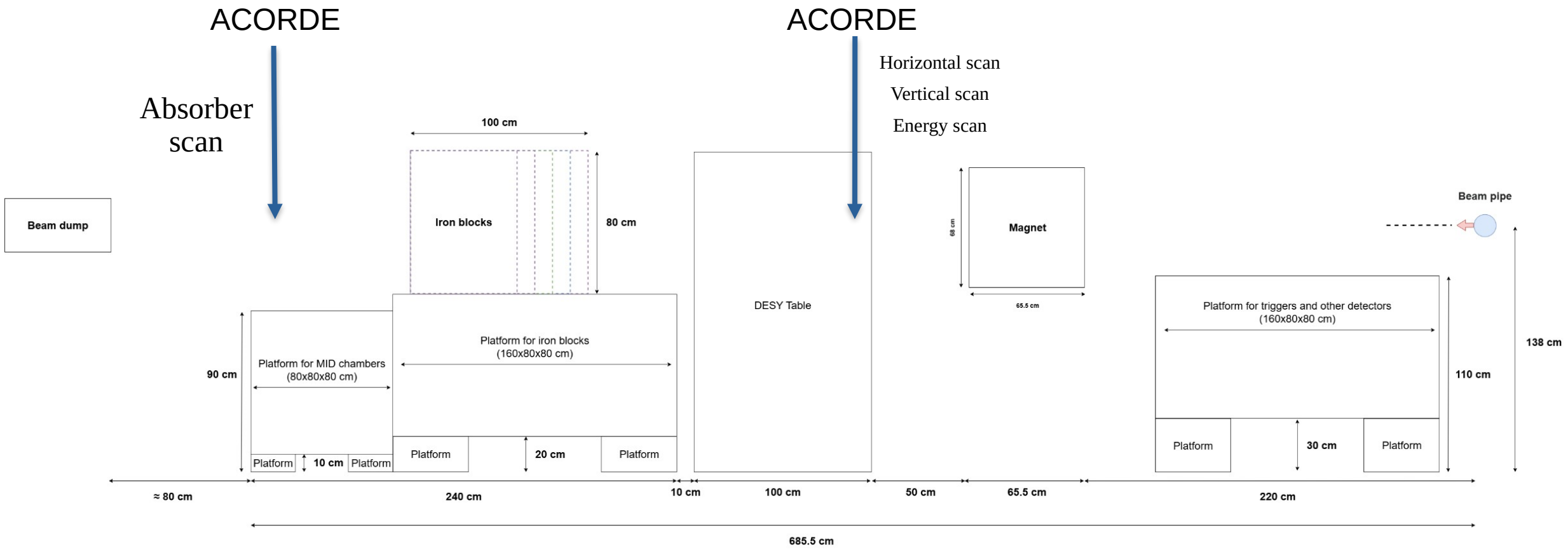
Assembly components:

- Three WLS fibers attached to one of the edges of each bar.
- One layer of Mylar reflective film.
- Three layers of Tyvek black paper.

Mechanical structure:

- 3D-printed housing
- Protects the SiPMs from external light.
- Allows alignment of the SiPMs with the ends of the WLS fibers.
- Gap between the bars of ≈ 2.5 mm

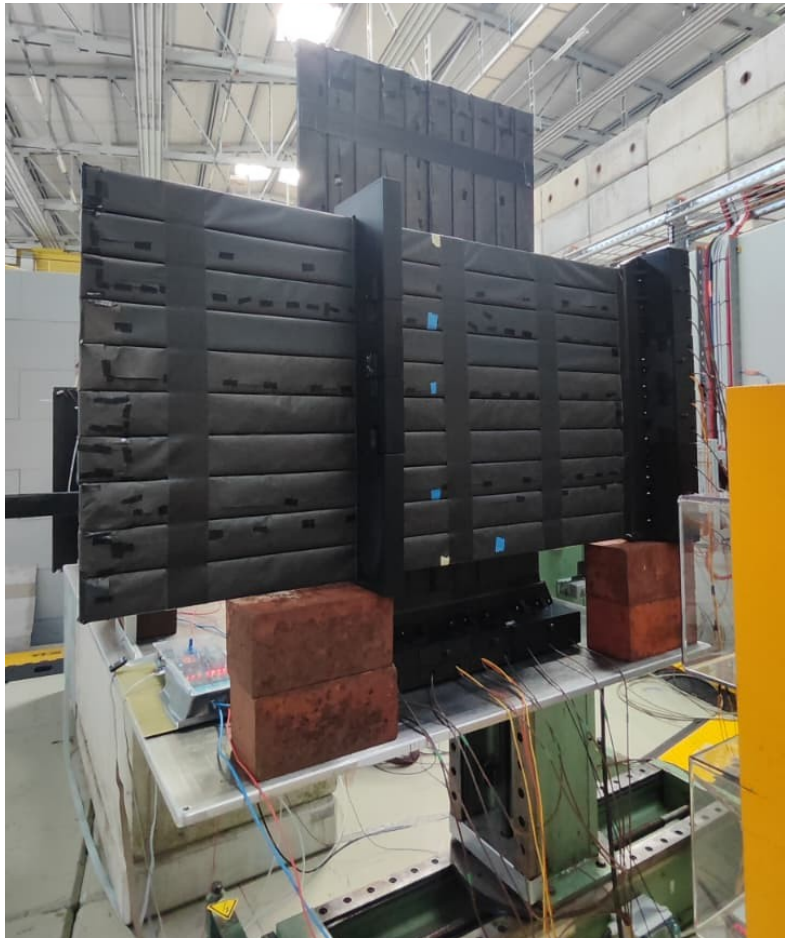
Test Beam 2025 – Setup



Test Beam 2025 – Setup

Test Beam 2025 – ACORDE Prototype

Prototype installed on the DESY table



Prototype installed behind the absorber

Test Beam 2025 – Preliminary Results

Scans Performed

Vertical Scan
Horizontal Scan
Energy Scan

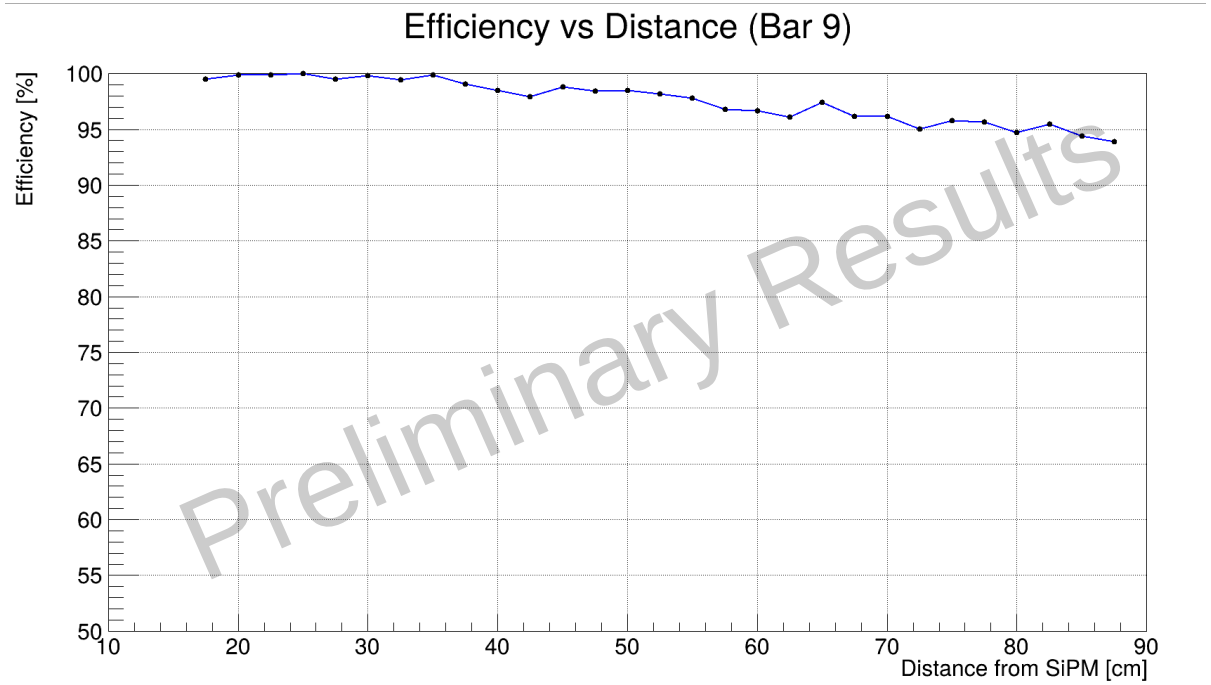
						(0, 66.5)	(5, 66.5)								SiPMs
				(-25, 61.5)	(-20, 61.5)	(-15, 61.5)	(-10, 61.5)	(-5, 61.5)	(0, 61.5)	(5, 61.5)	(10, 61.5)	(15, 61.5)	(20, 61.5)					Bar 1
				(-25, 56.5)	(-20, 56.5)	(-15, 56.5)	(-10, 56.5)	(-5, 56.5)	(0, 56.5)	(5, 56.5)	(10, 56.5)	(15, 56.5)	(20, 56.5)					Bar 2
				(-25, 51.5)	(-20, 51.5)	(-15, 51.5)	(-10, 51.5)	(-5, 51.5)	(0, 51.5)	(5, 51.5)	(10, 51.5)	(15, 51.5)	(20, 51.5)					Bar 3
				(-25, 46.5)	(-20, 46.5)	(-15, 46.5)	(-10, 46.5)	(-5, 46.5)	(0, 46.5)	(5, 46.5)	(10, 46.5)	(15, 46.5)	(20, 46.5)					Bar 4
				(-25, 41.5)	(-20, 41.5)	(-15, 41.5)	(-10, 41.5)	(-5, 41.5)	(0, 41.5)	(5, 41.5)	(10, 41.5)	(15, 41.5)	(20, 41.5)					Bar 5
				(-25, 36.5)	(-20, 36.5)	(-15, 36.5)	(-10, 36.5)	(-5, 36.5)	(0, 36.5)	(5, 36.5)	(10, 36.5)	(15, 36.5)	(20, 36.5)					Bar 6
				(-25, 31.5)	(-20, 31.5)	(-15, 31.5)	(-10, 31.5)	(-5, 31.5)	(0, 31.5)	(5, 31.5)	(10, 31.5)	(15, 31.5)	(20, 31.5)					Bar 7
				(-25, 26.5)	(-20, 26.5)	(-15, 26.5)	(-10, 26.5)	(-5, 26.5)	(0, 26.5)	(5, 26.5)	(10, 26.5)	(15, 26.5)	(20, 26.5)					Bar 8
(-45, 21.5)	(-40, 21.5)	(-35, 21.5)	(-30, 21,5)	(-25, 21.5)	(-20, 21.5)	(-15, 21.5)	(-10, 21.5)	(-5, 21.5)	(0, 21.5)	(5, 21.5)	(10, 21.5)	(15, 21.5)	(20, 21.5)	(25, 21.5)	(30, 21.5)			Bar 9
				(-25, 16.5)	(-20, 16.5)	(-15, 16.5)	(-10, 16.5)	(-5, 16.5)	(0, 16.5)	(5, 16.5)	(10, 16.5)	(15, 16.5)	(20, 16.5)					Bar 10
									(0, 11.5)	(5, 11.5)								
									(0, 6.5)	(5, 6.5)								
				Bar 20	Bar 19	Bar 18	Bar 17	Bar 16	Bar 15	Bar 14	Bar 13	Bar 12	Bar 11	SiPMs				

Horizontal scan was performed on bar 9.

Vertical scan was performed on bar 14.

Energy scan was performed on the sectors marked in green.

Test Beam 2025 – Preliminary Results

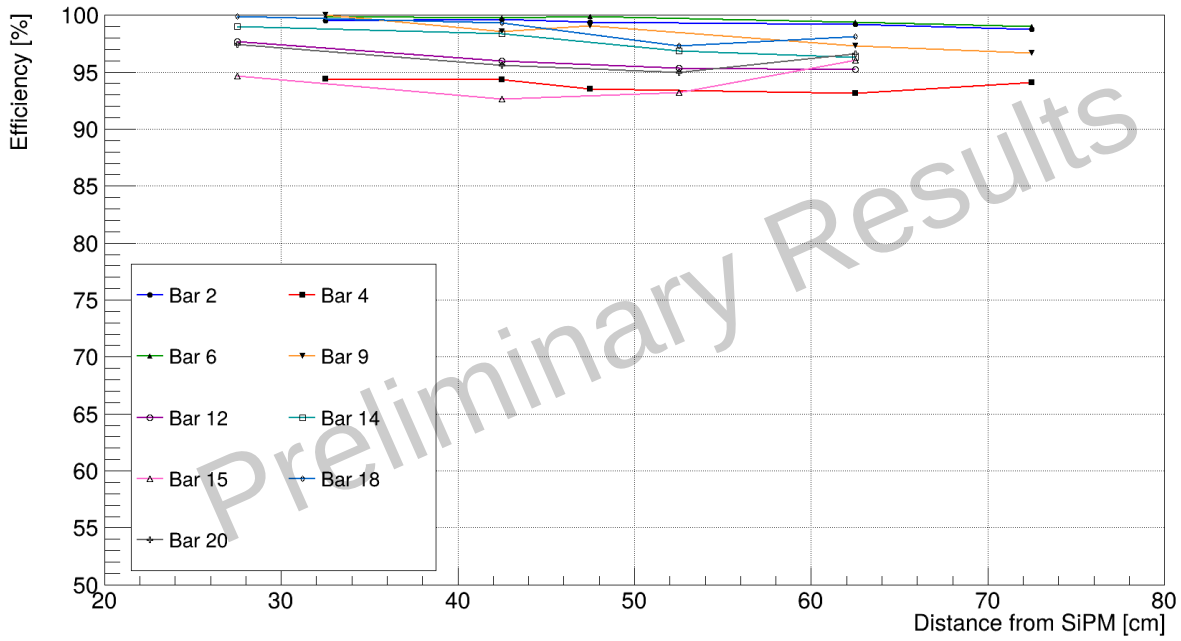


Horizontal Scan with Pions @ 6 GeV

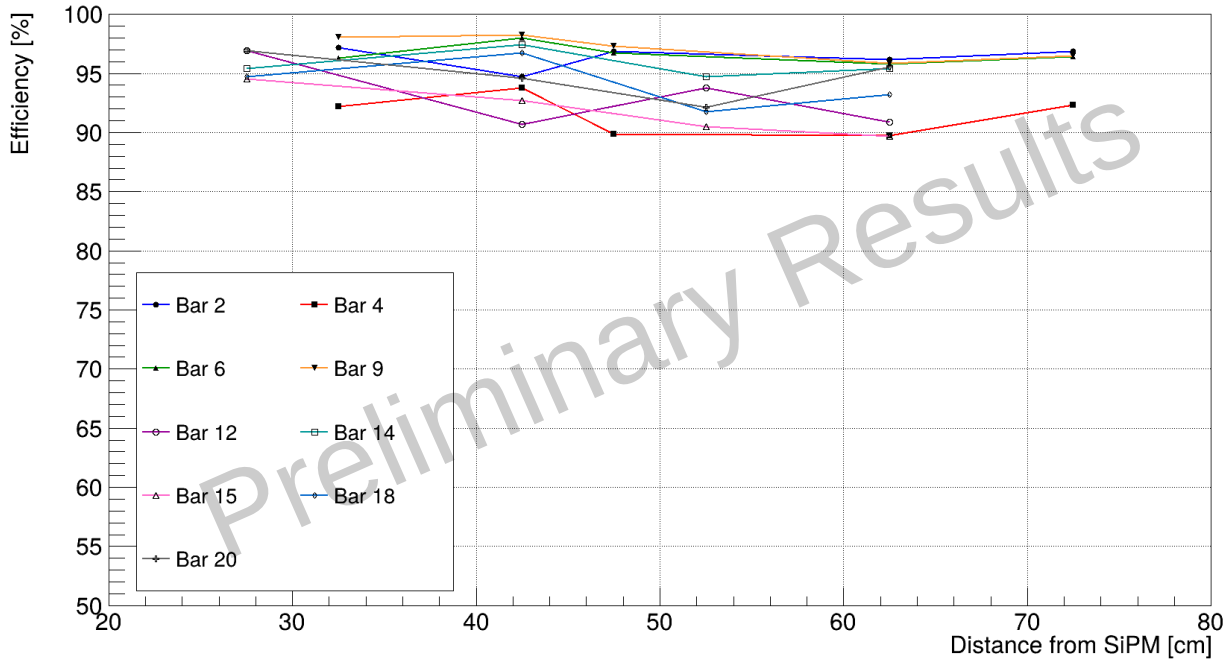
Vertical Scan with Pions @ 6 GeV

In the horizontal scan, the efficiency slightly decreases with distance. In the vertical scan, however, the efficiency drops in the middle of the bar and then increases again. This behavior might be related to coupling issues between the SiPMs and the WLS fibers. We are currently working on improving the assembly method to minimize human errors during coupling.

Test Beam 2025 – Preliminary Results



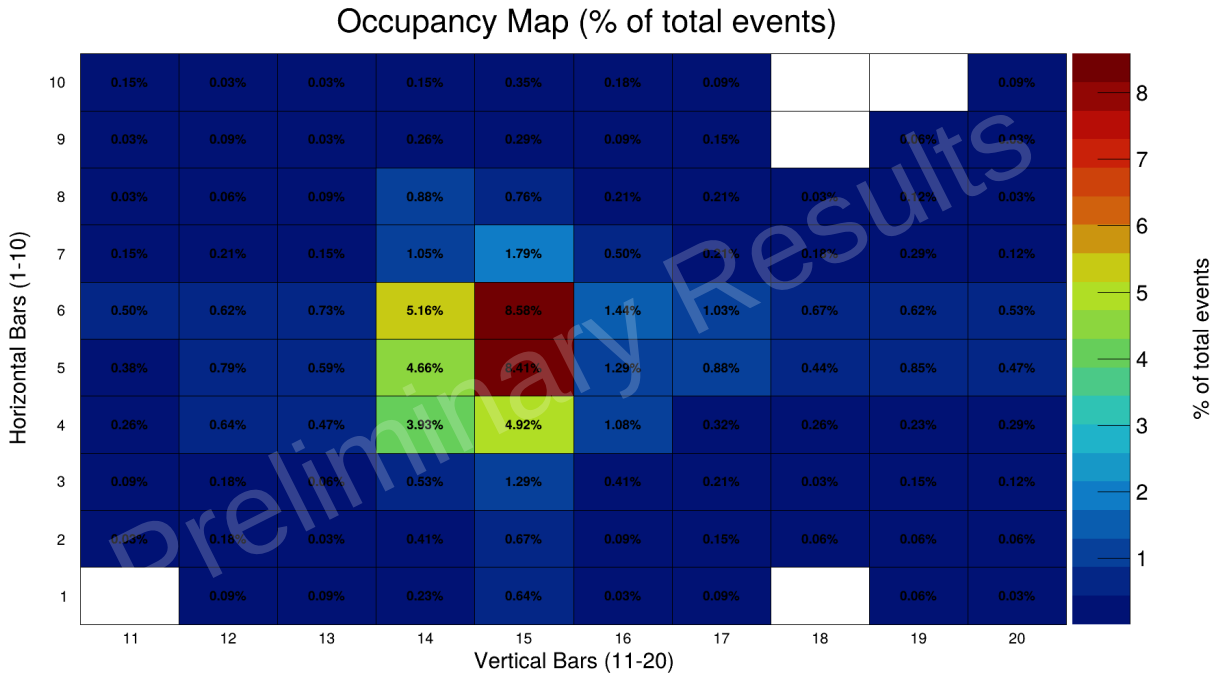
Efficiency with Pions @ 6 GeV

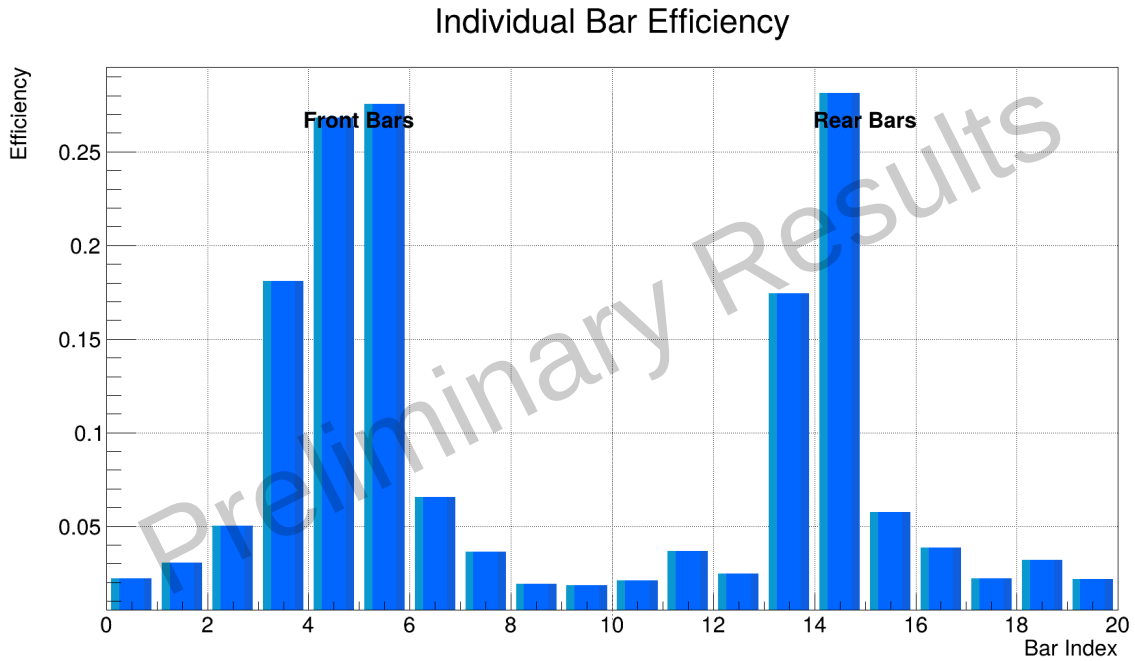


Efficiency with Pions @ 3 GeV

The efficiency of each bar is slightly different, indicating that the coupling was not performed uniformly across all bars. This will be improved in the next prototypes. Another source of error is that the trigger behind the bars was wider than the bar itself. For this reason, the efficiency decreases at lower energies, as the beam spot becomes wider. This effect can be corrected through simulations, and we are currently working on it.

Test Beam 2025 – Preliminary Results





The beam was centered between bars 14 and 15 horizontally, and between bars 4, 5, and 6 vertically.

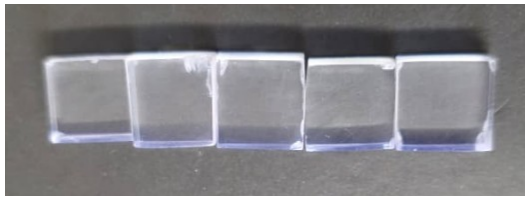
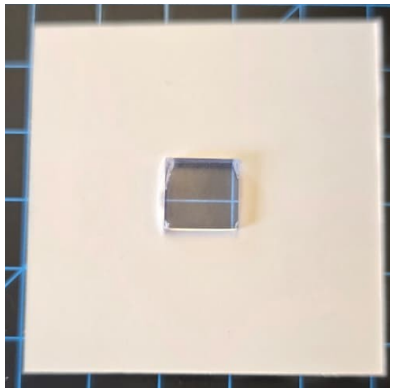
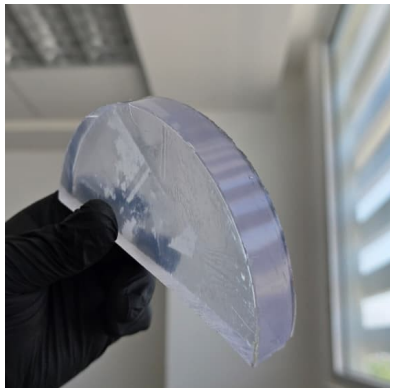
Data analysis of the absorber scan is still in progress. The module efficiency is around 85% without applying the acceptance factor. Simulations are ongoing.

For comparison, the UNAM module exhibits 94% efficiency after simulation corrections.

Radiation Campaign (IRRAD)

- Samples from ACORDE scintillator and two custom-made plastic scintillators (BUAP group) will be tested starting May 6th.
- All samples are being prepared with dimensions of 10 × 10 × 5 mm^3.
- ACORDE samples are already prepared.
- Custom-made plastic samples are currently being cut and polished.




Plans

Full MID Chamber Prototype

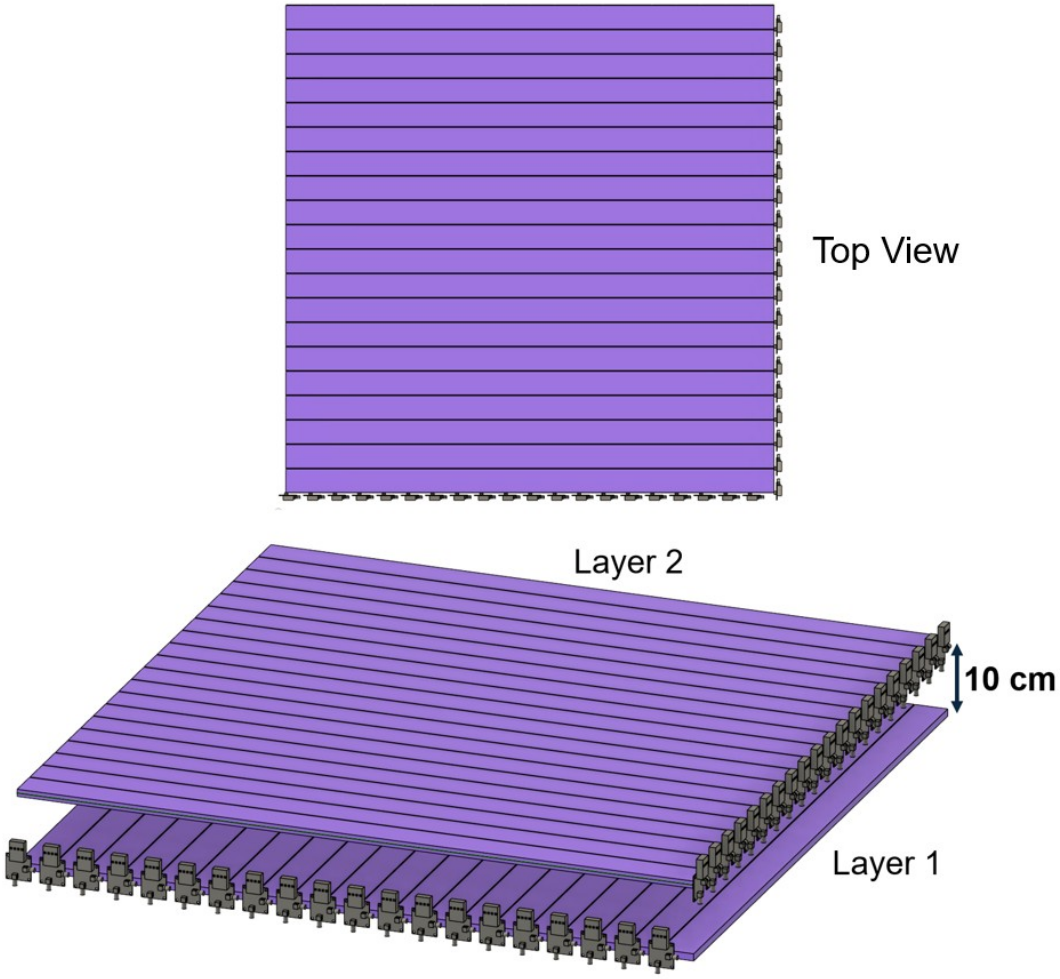
- Finalizing tests for the 40 ACORDE plastic scintillator bars
- Procurement of SiPMs (Hamamatsu S14160-3050HS) for the full chamber is still in progress.
- Finalizing simulations and determining detector acceptance for comparison with the Test Beam 2025 data.

Radiation Campaign (IRRAD)

- Participating in irradiation studies at CERN IRRAD in May
- Testing ACORDE scintillator samples (10×10×5 mm^3) with three different fluences per sample
- Testing custom-made scintillator samples developed by the BUAP group.

Mechanical Structure Development

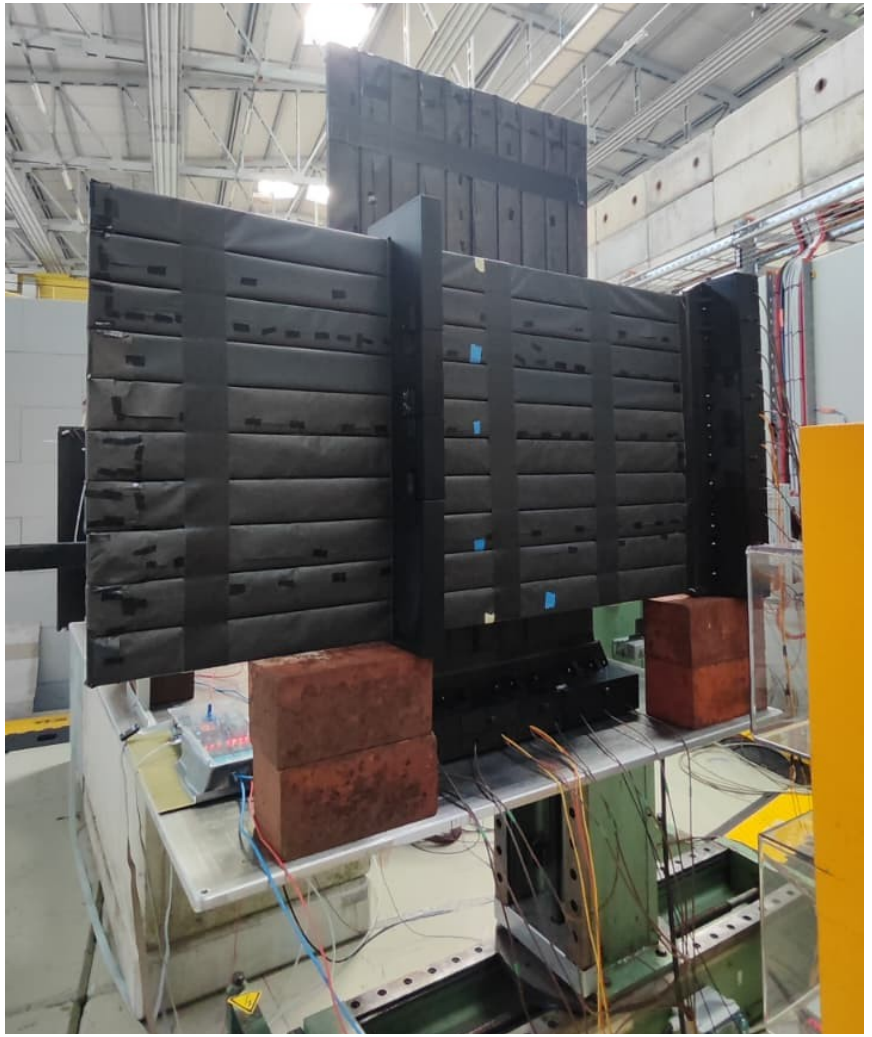
- Working on the mechanical structure of the full MID chamber
- Based on the design report provided by UNAM (thanks to the UNAM group)



Conclusions

The MID detector prototype based on ACORDE plastic scintillator achieves efficiencies above 95% for cosmic rays and for a 6 GeV pion beam, producing on average 30 photons. The bars have been tested along their full length. Under these conditions, time resolutions between 1.2 and 3.5 ns are achieved using SensL C-Series SiPMs (model 60035). This performance is approximately 3% lower than that of the UNAM module in cosmic-ray tests using Fermi plastic scintillator and Hamamatsu SiPMs.

Finalizing simulations and determining the detector acceptance are necessary to accurately calculate the efficiency of the full module tested during the 2025 test beam. Simulation studies must be completed to include the acceptance factor in the efficiency evaluation.

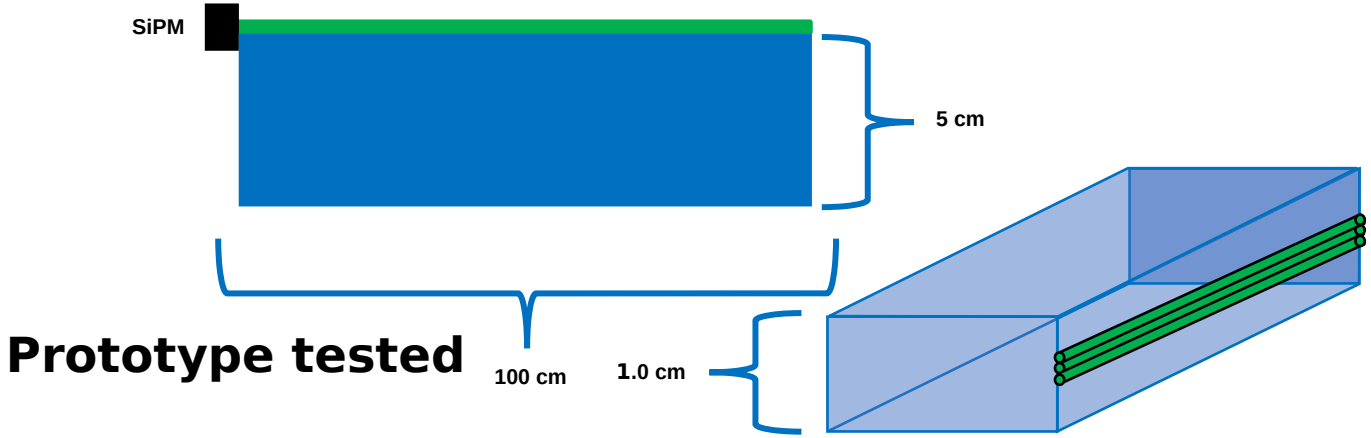


Thank you!

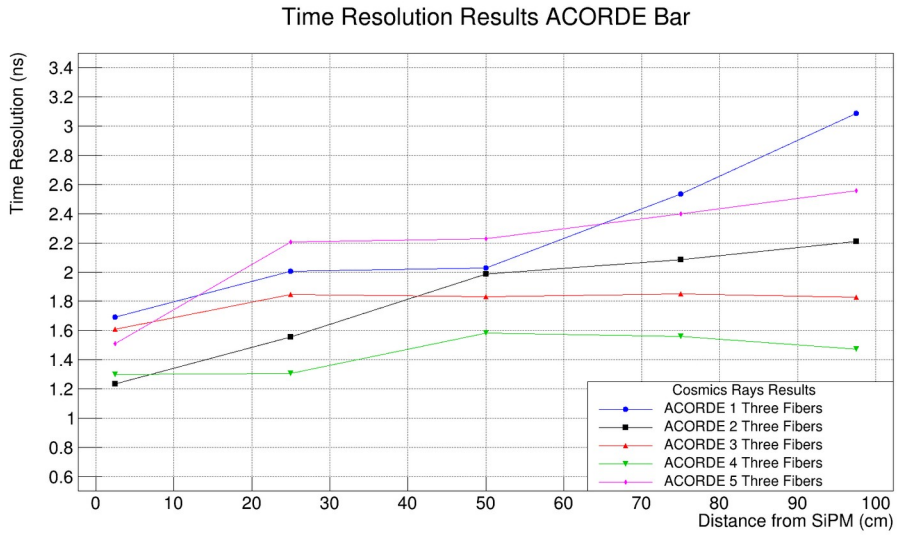
Questions or comments?

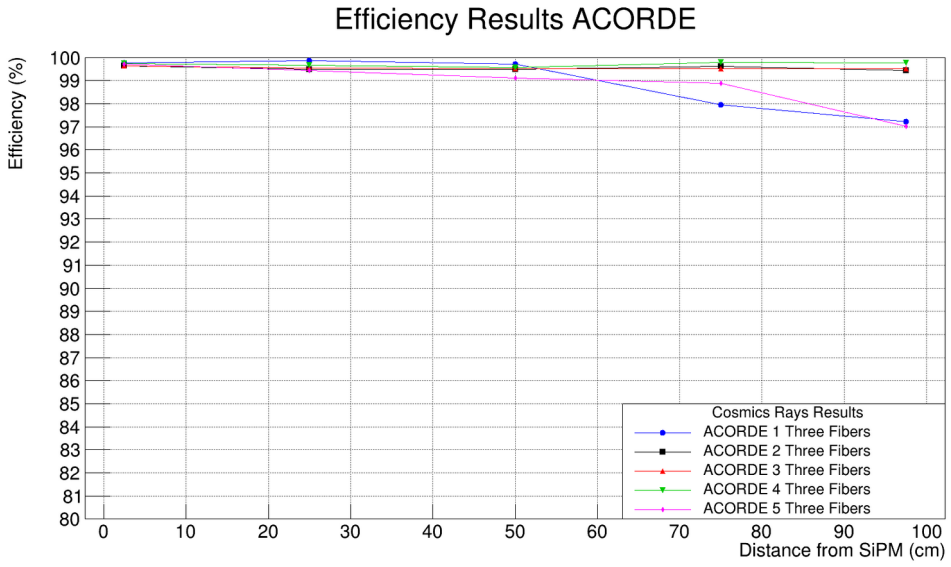
Backup

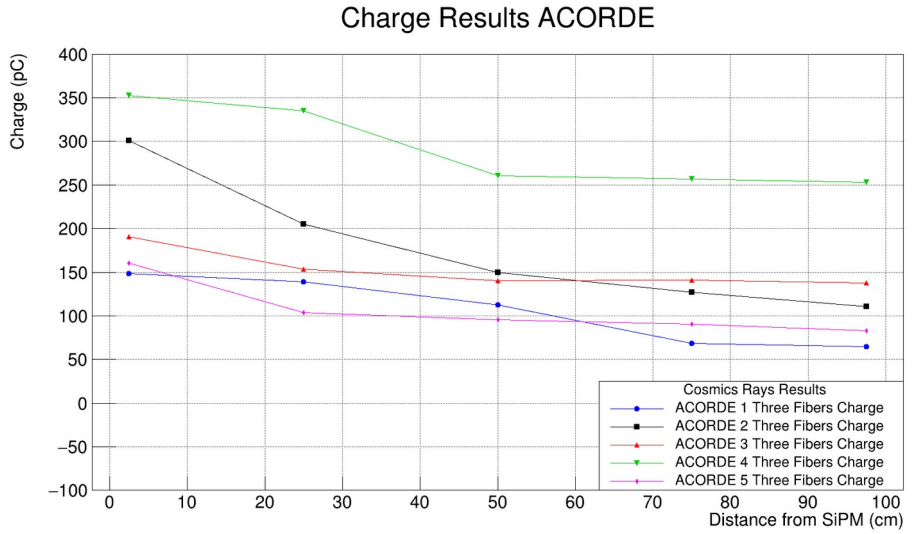
Cosmic Rays Tests



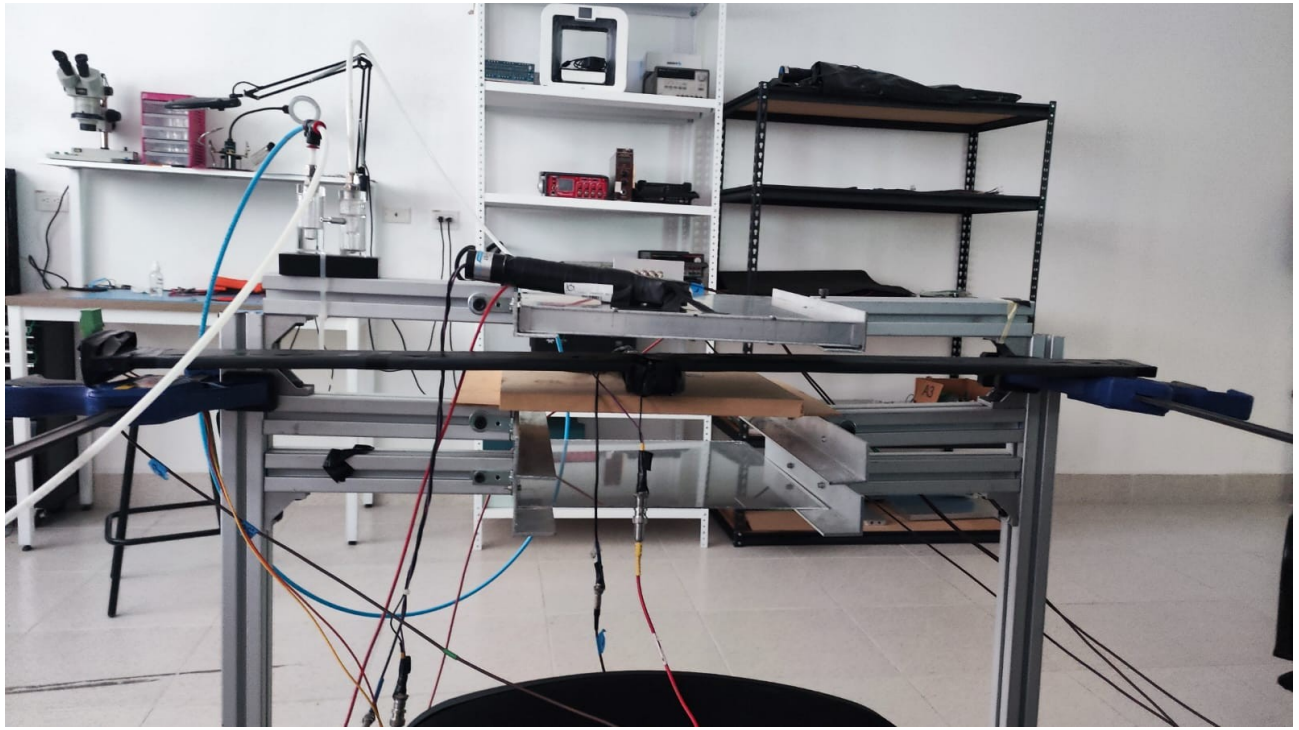
Prototype tested

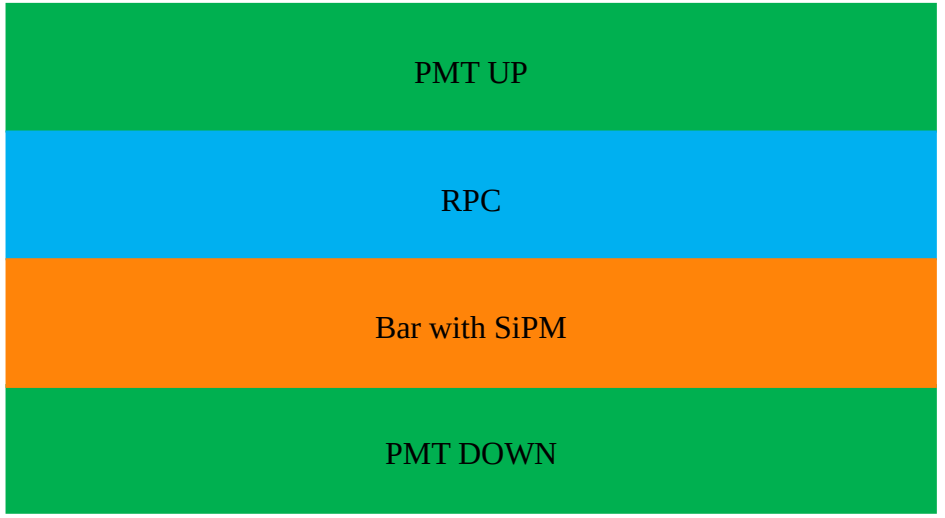






Cosmic Rays Tests – Setup





Cosmic Rays Tests – Results

ACORDE bars efficiency and time resolution results with three WLS fibers

Distance from SiPM (cm)	ACORDE 1		ACORDE 2		ACORDE 3		ACORDE 4		ACORDE 5	
	Efficiency (%)	Time Resolution (ns)	Efficiency (%)	Time Resolution (ns)	Efficiency (%)	Time Resolution (ns)	Efficiency (%)	Time Resolution (ns)	Efficiency (%)	Time Resolution (ns)
2.5	99.76	1.7 ± 0.1	99.64	1.2± 0.1	99.64	1.6 ± 0.1	99.75	1.3 ± 0.1	99.72	1.5 ± 0.1
25	99.87	2.0 ± 0.1	99.50	1.5± 0.1	99.55	1.8 ± 0.1	99.67	1.3 ± 0.1	99.43	2.2 ± 0.1
50	99.71	2.0 ± 0.1	99.49	2.0± 0.1	99.51	1.8 ± 0.1	99.56	1.6 ± 0.1	99.12	2.2 ± 0.1
75	97.94	2.5 ± 0.1	99.62	2.1± 0.1	99.52	1.8 ± 0.1	99.80	1.6 ± 0.1	98.88	2.4 ± 0.1
97.5	97.22	3.1 ± 0.1	99.43	2.2 ± 0.1	99.51	1.8 ± 0.1	99.77	1.5 ± 0.1	97.02	2.6 ± 0.1

Efficiency: ≈ 99%

Time resolution: 1.2 – 3.0 ns

Cosmic Rays Tests – Results

ACORDE bars amplitude and charge results with three WLS fibers

Distance from SiPM (cm)	ACORDE 1		ACORDE 2		ACORDE 3		ACORDE 4		ACORDE 5	
	Amplitude (mV)	Charge (pC)	Amplitude (mV)	Charge (pC)	Amplitude (mV)	Charge (pC)	Amplitude (mV)	Charge (pC)	Amplitude (mV)	Charge (pC)
2.5	34.39 ± 0.13	148.6 ± 1.9	60.30 ± 0.20	300.6 ± 1.8	44.27 ± 0.16	190.4 ± 2.5	72.26 ± 0.26	352.3 ± 3.9	34.08 ± 0.16	160.2 ± 2.1
25	34.14 ± 0.12	138.7 ± 1.6	43.89 ± 0.15	205.2 ± 1.6	35.43 ± 0.12	153.5 ± 1.8	70.17 ± 0.23	335.0 ± 2.0	22.30 ± 0.10	103.56 ± 1.3
50	29.43 ± 0.12	112.5 ± 1.8	32.04 ± 0.11	149.7 ± 1.7	34.22 ± 0.13	140.0 ± 1.6	56.57 ± 0.24	260.8 ± 2.1	20.84 ± 0.07	95.79 ± 1.2
75	16.63 ± 0.05	68.68 ± 1.08	30.51 ± 0.10	127.2 ± 1.8	34.20 ± 0.10	140.9 ± 1.6	55.41 ± 0.21	256.5 ± 2.1	19.71 ± 0.06	90.37 ± 1.2
97.5	16.03 ± 0.07	64.72 ± 1.06	26.92 ± 0.11	110.9 ± 1.7	31.82 ± 0.12	137.4 ± 1.6	52.33 ± 0.19	252.9 ± 2.3	18.23 ± 0.08	82.63 ± 1.2

Cosmic Rays Tests – Results

ACORDE bars charge and number of photons results with three WLS fibers

Distance from SiPM (cm)	ACORDE 1		ACORDE 2		ACORDE 3		ACORDE 4		ACORDE 5	
	Charge (pC)	Photons (γ)	Charge (pC)	Photons (γ)	Charge (pC)	Photons (γ)	Charge (pC)	Photons (γ)	Charge (pC)	Photons (γ)
2.5	148.6 ± 1.9	≈ 32.96	300.6 ± 1.8	≈ 68.09	190.4 ± 2.5	≈ 45.51	352.3 ± 3.9	≈ 83.58	160.2 ± 2.1	≈ 35.54
25	138.7 ± 1.6	≈ 30.76	205.2 ± 1.6	≈ 46.48	153.5 ± 1.8	≈ 36.69	335.0 ± 2.0	≈ 79.48	103.56 ± 1.3	≈ 22.97
50	112.5 ± 1.8	≈ 24.96	149.7 ± 1.7	≈ 33.91	140.0 ± 1.6	≈ 33.46	260.8 ± 2.1	≈ 61.87	95.79 ± 1.2	≈ 21.25
75	68.68 ± 1.08	≈ 15.24	127.2 ± 1.8	≈ 28.81	140.9 ± 1.6	≈ 33.67	256.5 ± 2.1	≈ 60.85	90.37 ± 1.2	≈ 20.05
97.5	64.72 ± 1.06	≈ 14.36	110.9 ± 1.7	≈ 25.11	137.4 ± 1.6	≈ 32.84	252.9 ± 2.3	≈ 60.01	82.63 ± 1.2	≈ 18.33

Average number of photons (γ): ≈ 40

Cosmic Rays Tests – Results

ACORDE bar efficiency and time resolution results varying number of fibers

Distance from SiPM (cm)	ACORDE bar with one WLS fiber		ACORDE bar with two WLS fiber		ACORDE bar with three WLS fiber	
	Efficiency (%)	Time Resolution (ns)	Efficiency (%)	Time Resolution (ns)	Efficiency (%)	Time Resolution (ns)
2.5	99.30	1.796 ± 0.024	99.74	1.447 ± 0.016	99.64	1.608 ± 0.013
25	85.76	3.631 ± 0.102	99.59	1.802 ± 0.023	99.55	1.847 ± 0.013
50	78.98	6.821 ± 0.717	99.46	1.984 ± 0.021	99.51	1.831 ± 0.013
75	70.17	14.304 ± 3.132	97.26	2.537 ± 0.031	99.52	1.852 ± 0.013
97.5	38.81	14.960 ± 4.175	90.79	2.763 ± 0.039	99.51	1.827 ± 0.013

Test Beam 2023

Period: June 7 to June 21, 2023

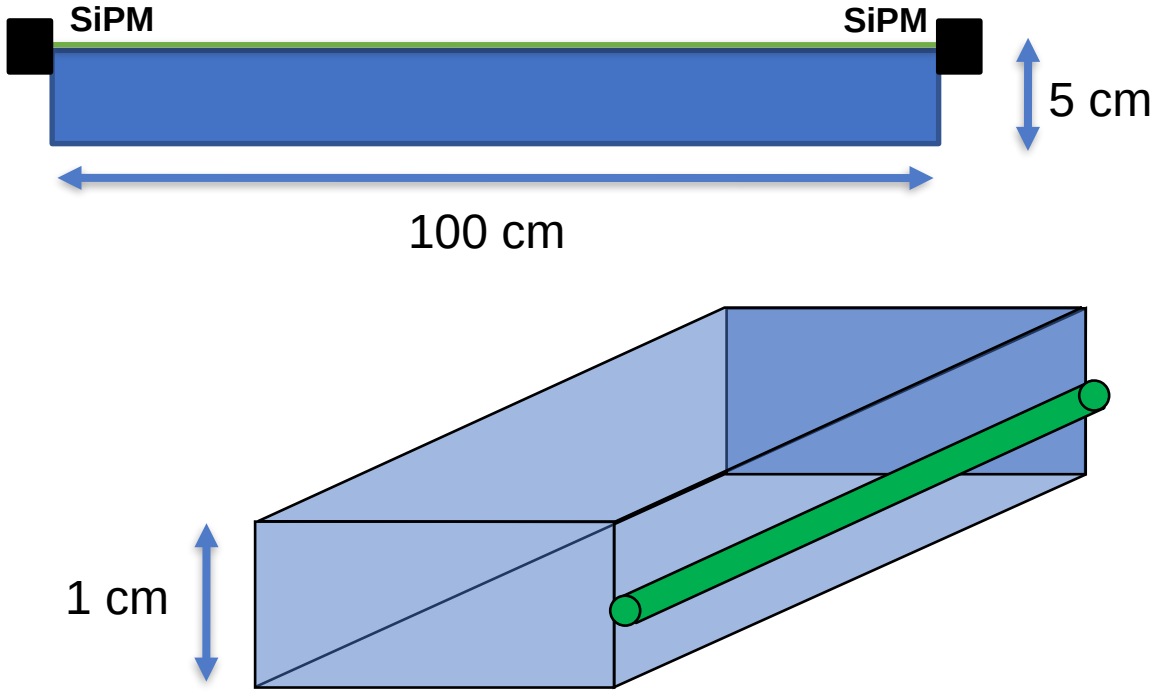
Location: T10 beamline at the CERN PS facility

Prototype:

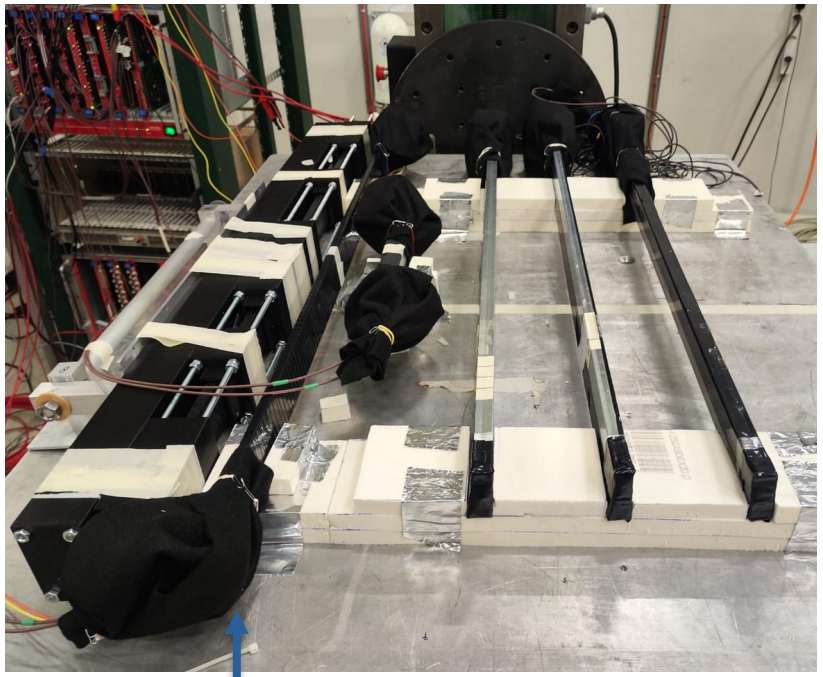
- One plastic scintillator bar of ACORDE material.
- Bar dimensions: 100 × 5 × 1 cm³
- SiPMs: SensL C-series 6×6 mm².
- Two SiPMs attached to the edges of the bar.
- One Kuraray Y-11(200) WLS fiber of 1.5 mm diameter.

Goals:

- Evaluate detector performance all along the bar.
- Evaluate detector performance with different beam energies.



Test Beam 2023 – Setup



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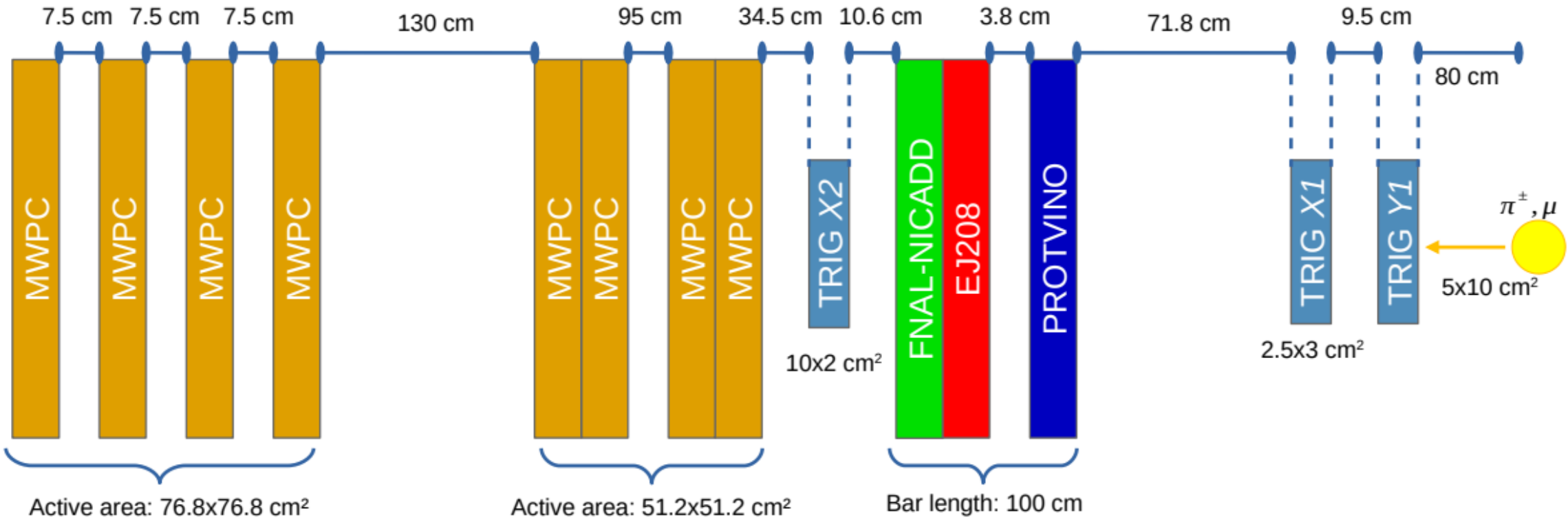
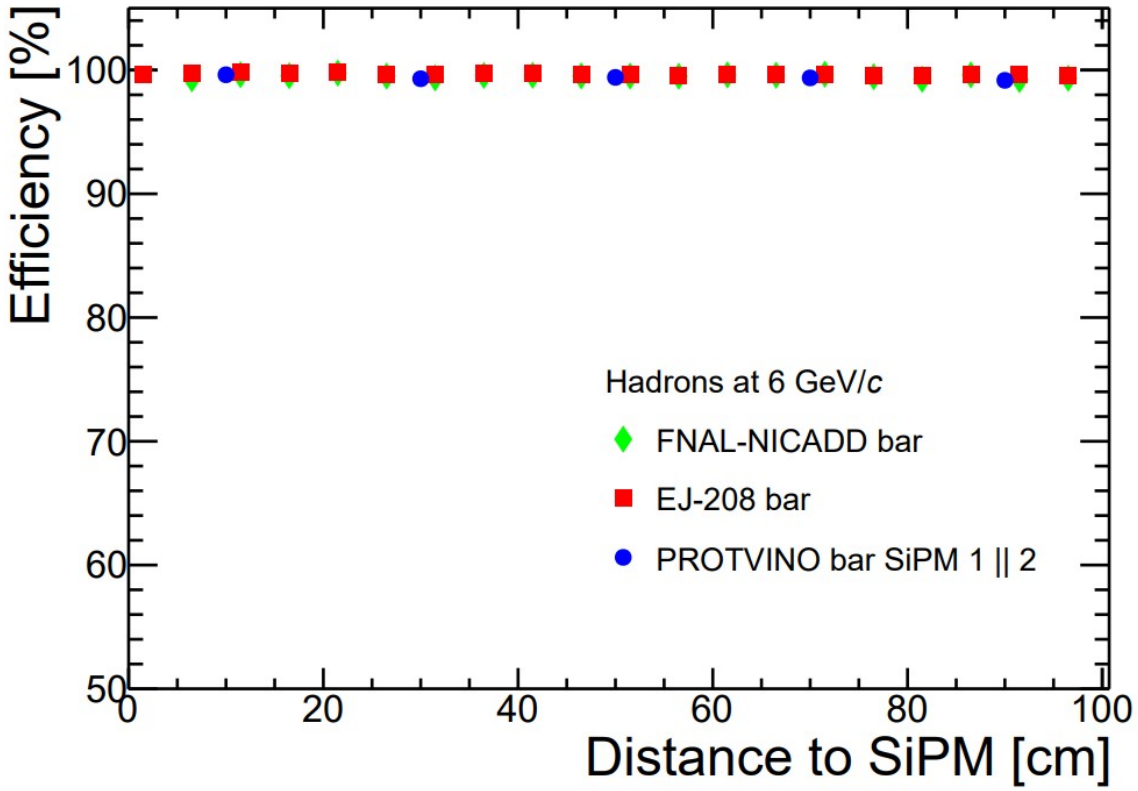
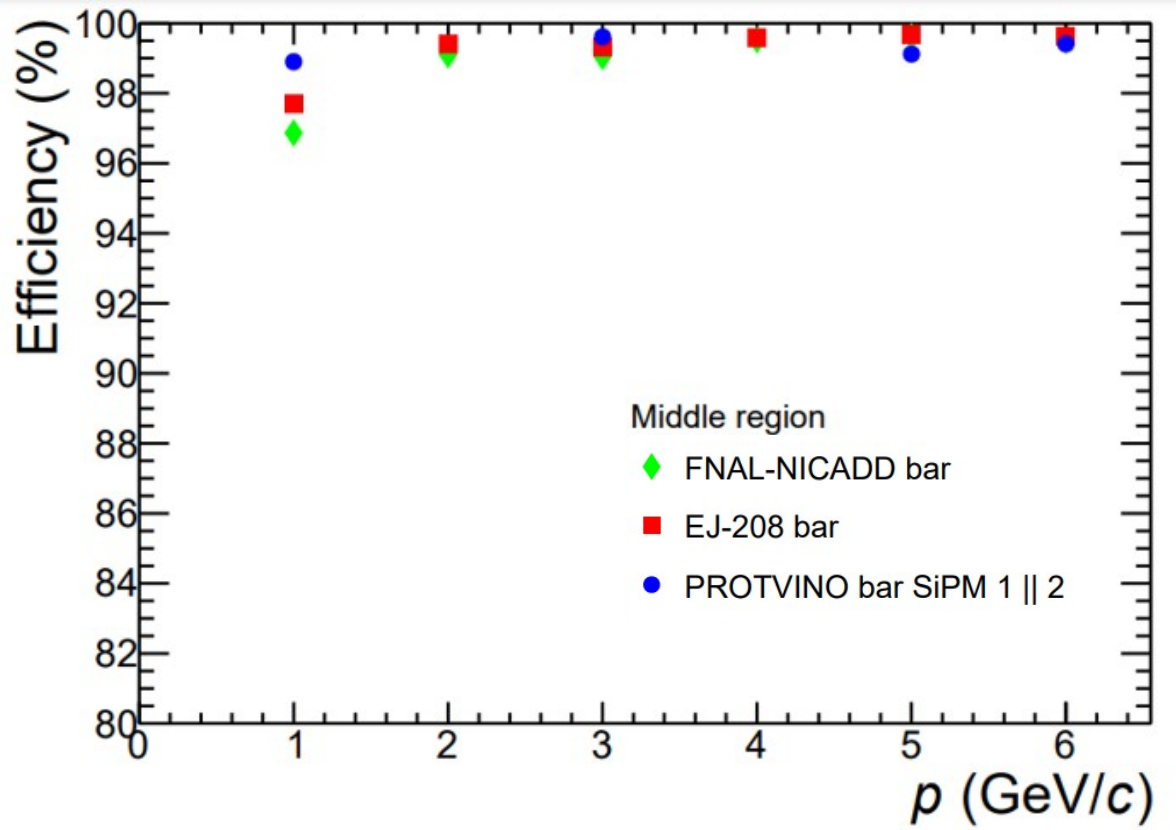
Test Beam 2023 – Setup



Test Beam 2023 – Results





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Test Beam 2024

Period: October 9 to October 16, 2024

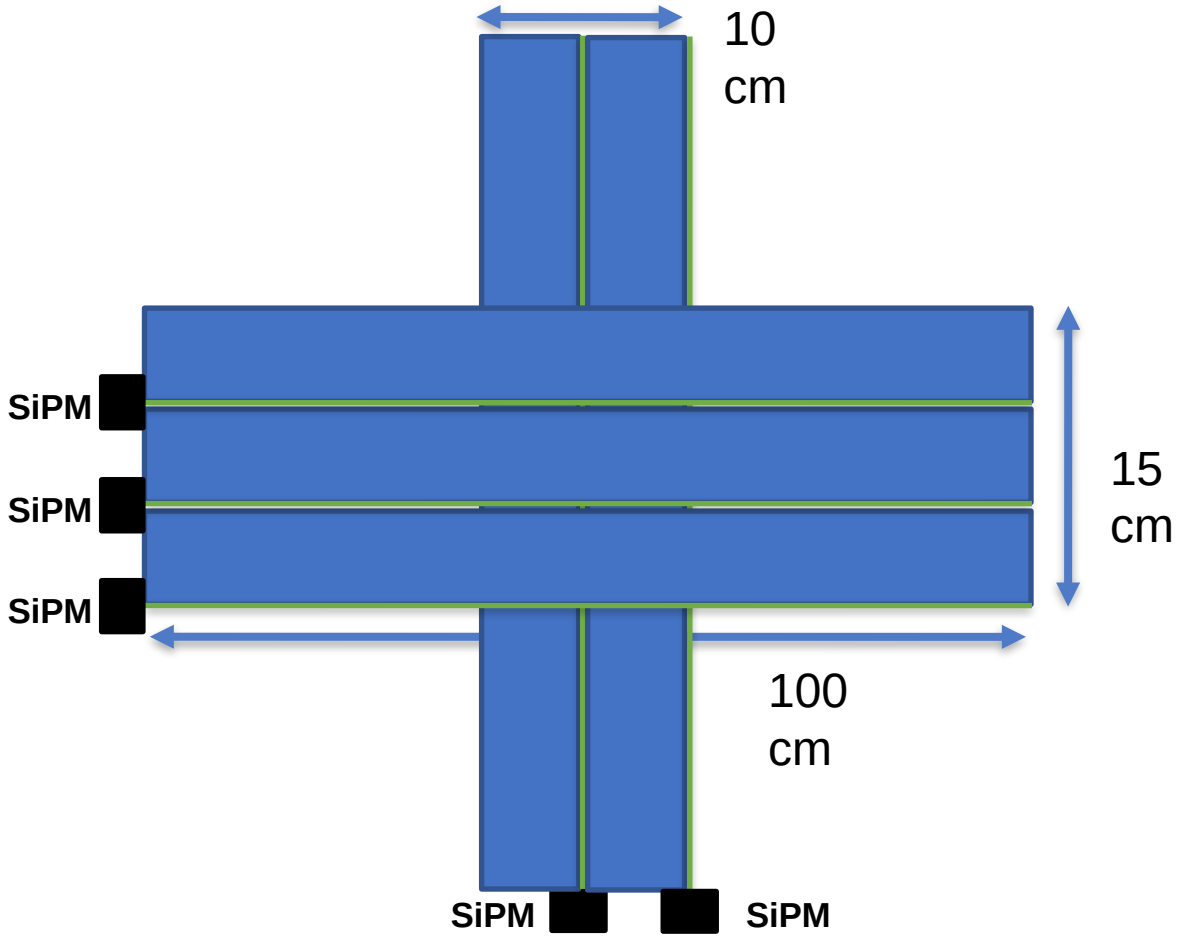
Location: T10 beamline at the CERN PS facility

Prototype:

- Five plastic scintillator bars. First layer with three bars and second layer with two bars.
- Bar dimensions: 100 × 5 × 1 cm³
- SiPMs: SensL C-series 6×6 mm².
- One SiPM per bar
- Three Kuraray Y-11(200) WLS fibers per bar

Goals:

- Evaluate detector performance with the absorber scan and energy scan
- Optimize light collection and electronics integration
- Validate the prototype design for the MuonID system



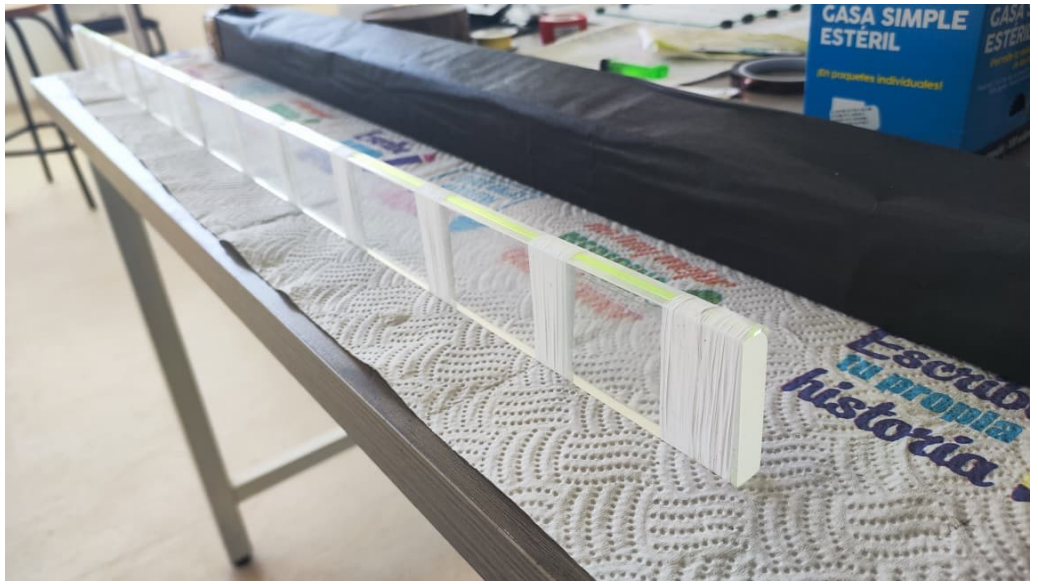
Assembling

Assembly components:

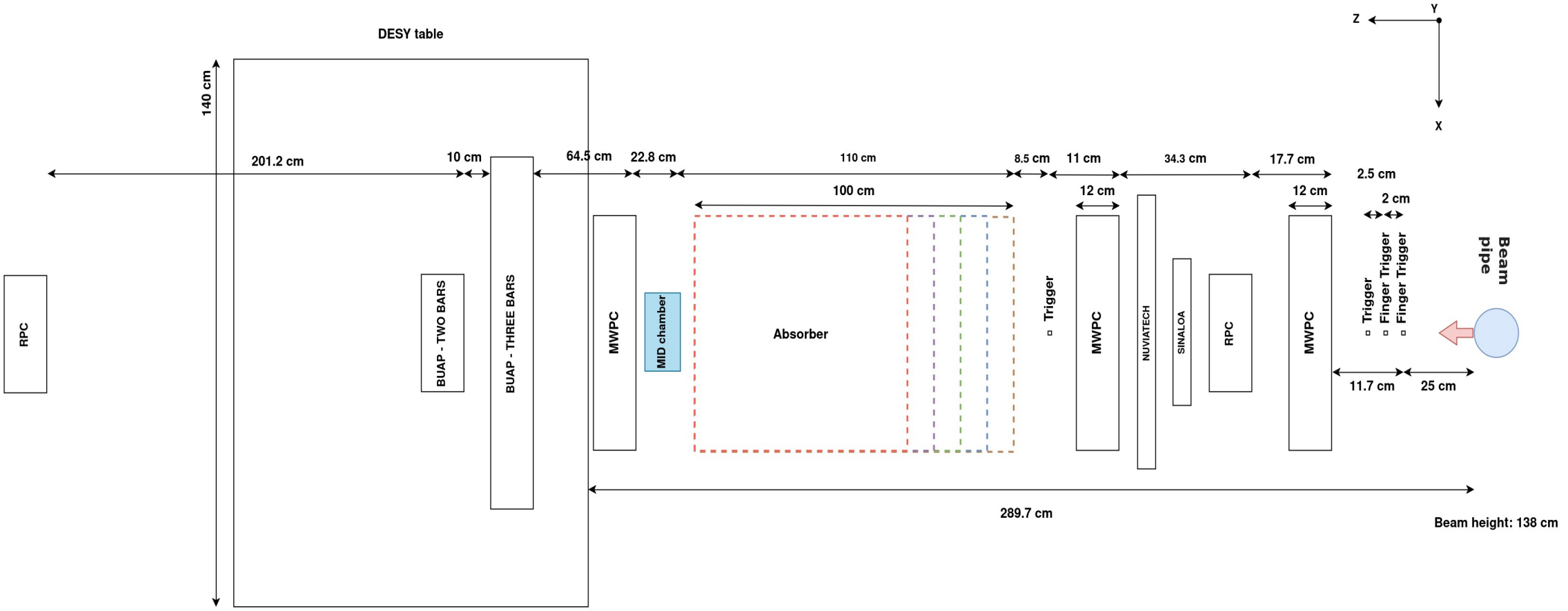
- Three WLS fibers attached to one of the edges of each bar.
- One layer of Mylar reflective film.
- Two layers of Tyvek black paper.

Mechanical structure:

- 3D-printed housing
- Protects the SiPMs from external light.
- Allows alignment of the SiPMs with the ends of the WLS fibers.
- Gap between the bars of ≈ 2 mm



Test Beam 2024 – Setup



Test Beam 2024 – Setup

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Test Beam 2024 – Preliminary Results

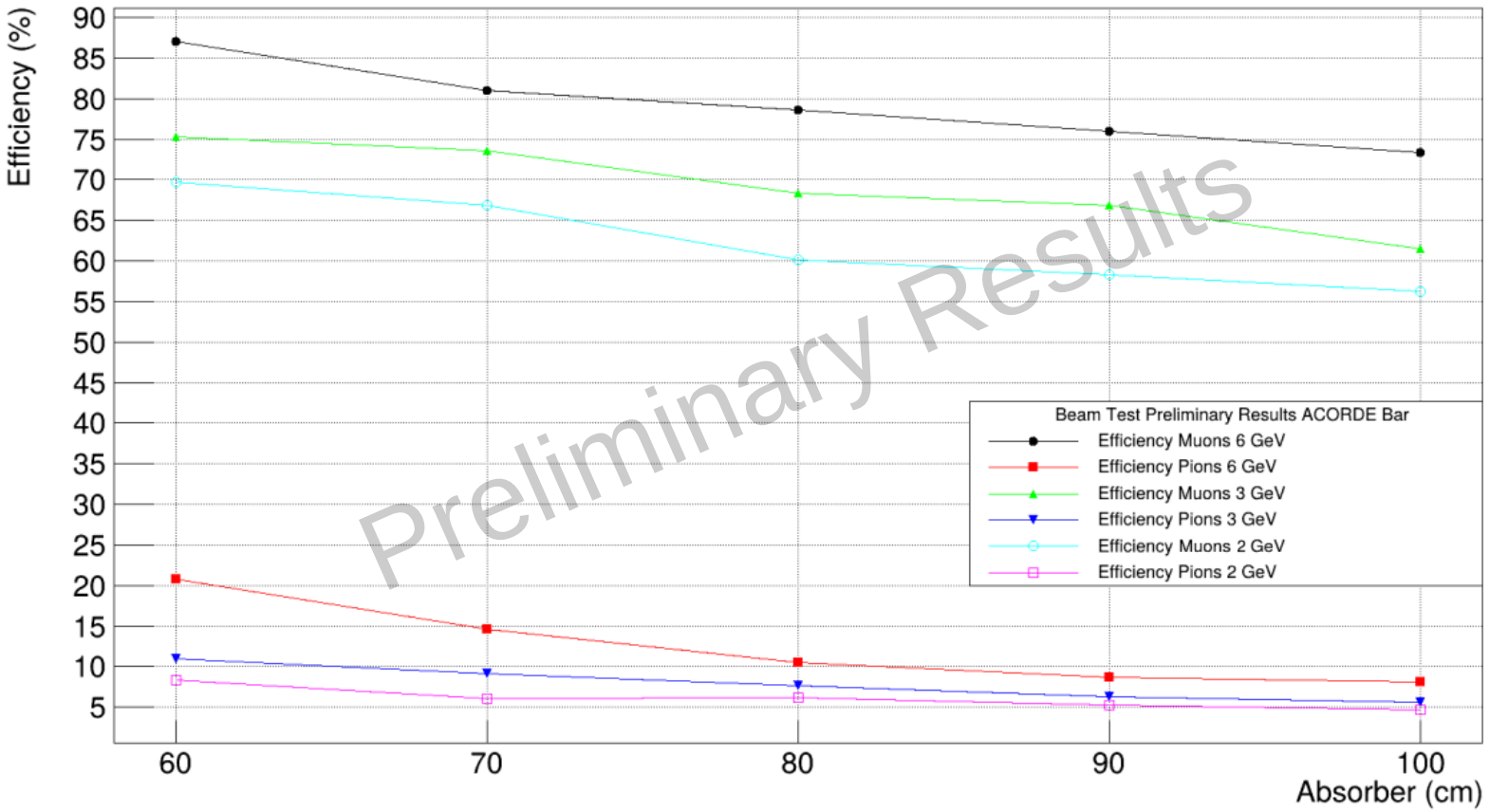
Absorber (cm)	6 GeV		3 GeV		2 GeV	
	Muon Efficiency (%)	Pion Efficiency (%)	Muon Efficiency (%)	Pion Efficiency (%)	Muon Efficiency (%)	Pion Efficiency (%)
60	87.01 ± 0.19	20.75 ± 0.27	75.31 ± 0.31	10.91 ± 0.12	69.69 ± 0.17	8.33 ± 0.10
70	81.03 ± 0.11	14.58 ± 0.16	73.54 ± 0.20	9.11 ± 0.09	68.88 ± 0.30	6.03 ± 0.07
80	78.59 ± 0.23	10.51 ± 0.09	68.30 ± 0.22	7.68 ± 0.08	60.10 ± 0.36	6.17 ± 0.08
90	75.93 ± 0.27	6.33 ± 0.08	66.81 ± 0.18	6.33 ± 0.07	58.35 ± 0.32	5.23 ± 0.07
100	73.39 ± 0.22	5.55 ± 0.07	61.45 ± 0.17	5.55 ± 0.06	56.24 ± 0.29	4.71 ± 0.05

Test Beam 2024 – Preliminary Results

For pions, the efficiency is notably low and decreases further with increasing absorber length, which reduces the number of particles passing through.

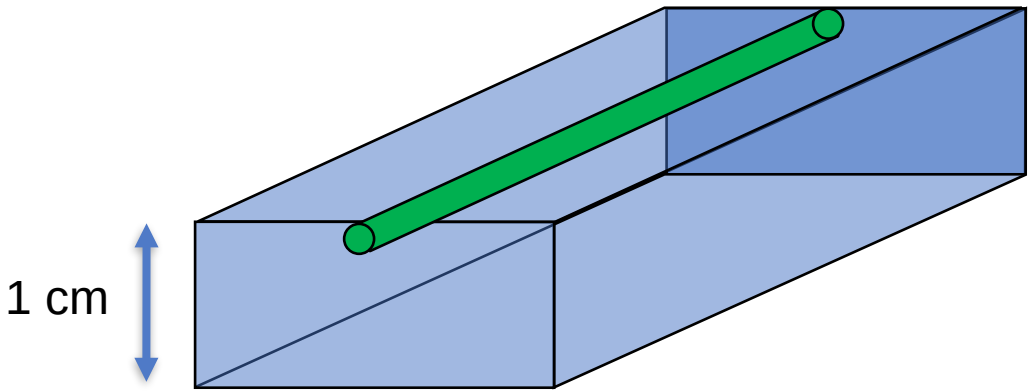
In contrast, muons show higher efficiency; however, as the energy increases, the beam composition exhibits greater pion contamination.

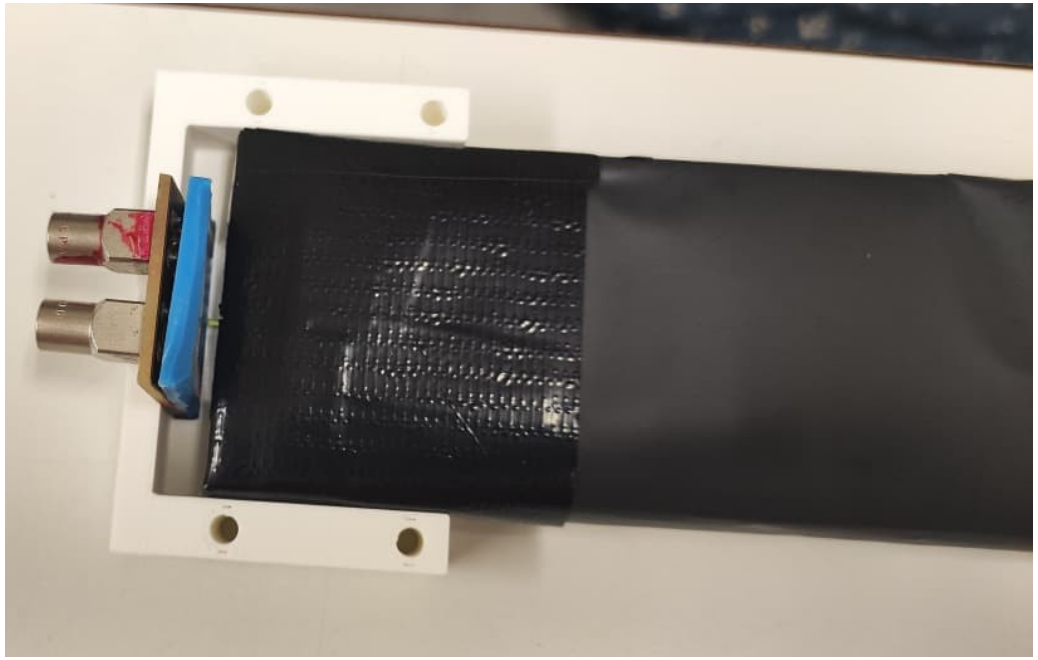
Determining the acceptance factor for our module remains an open task, and we are actively working on corresponding simulations.



Test Beam 2025 – Preliminary Results

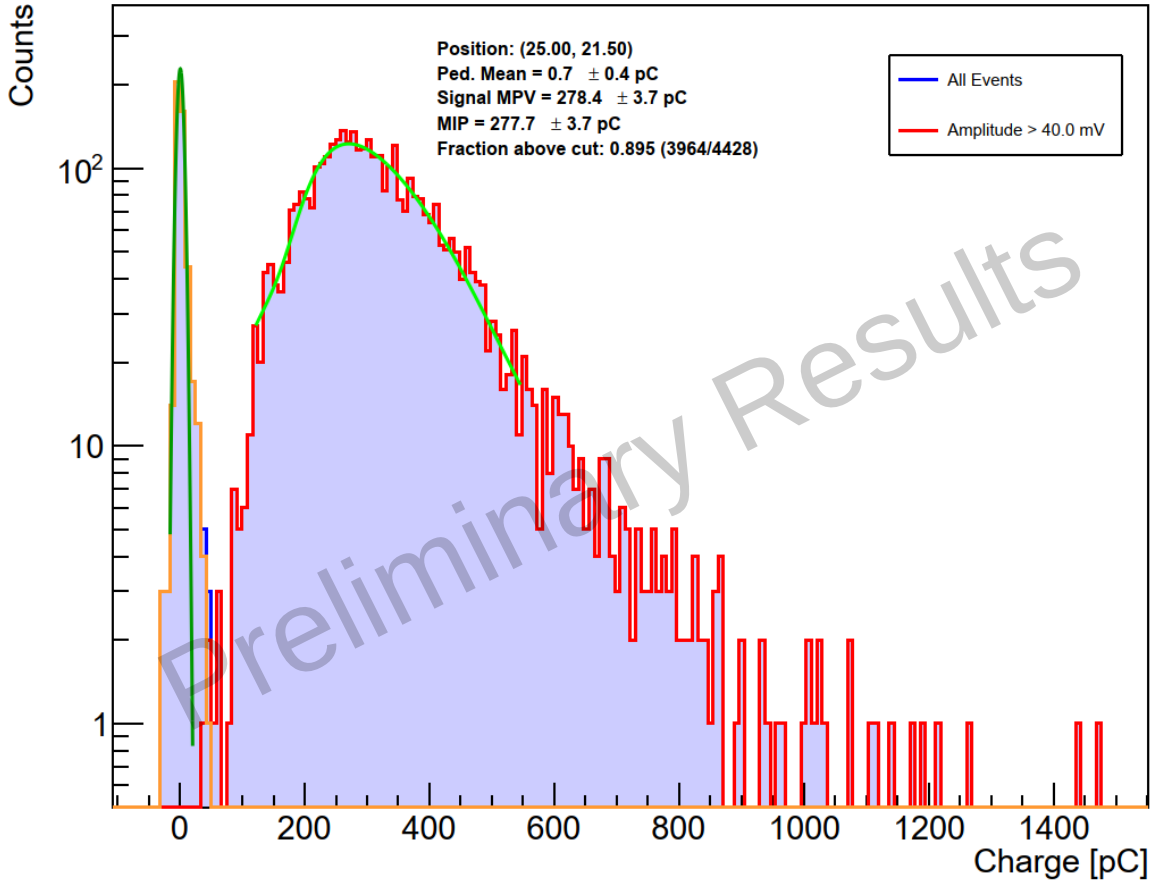
Machined groove for placing a 1 mm diameter WLS fiber. With an air gap, without optical glue.

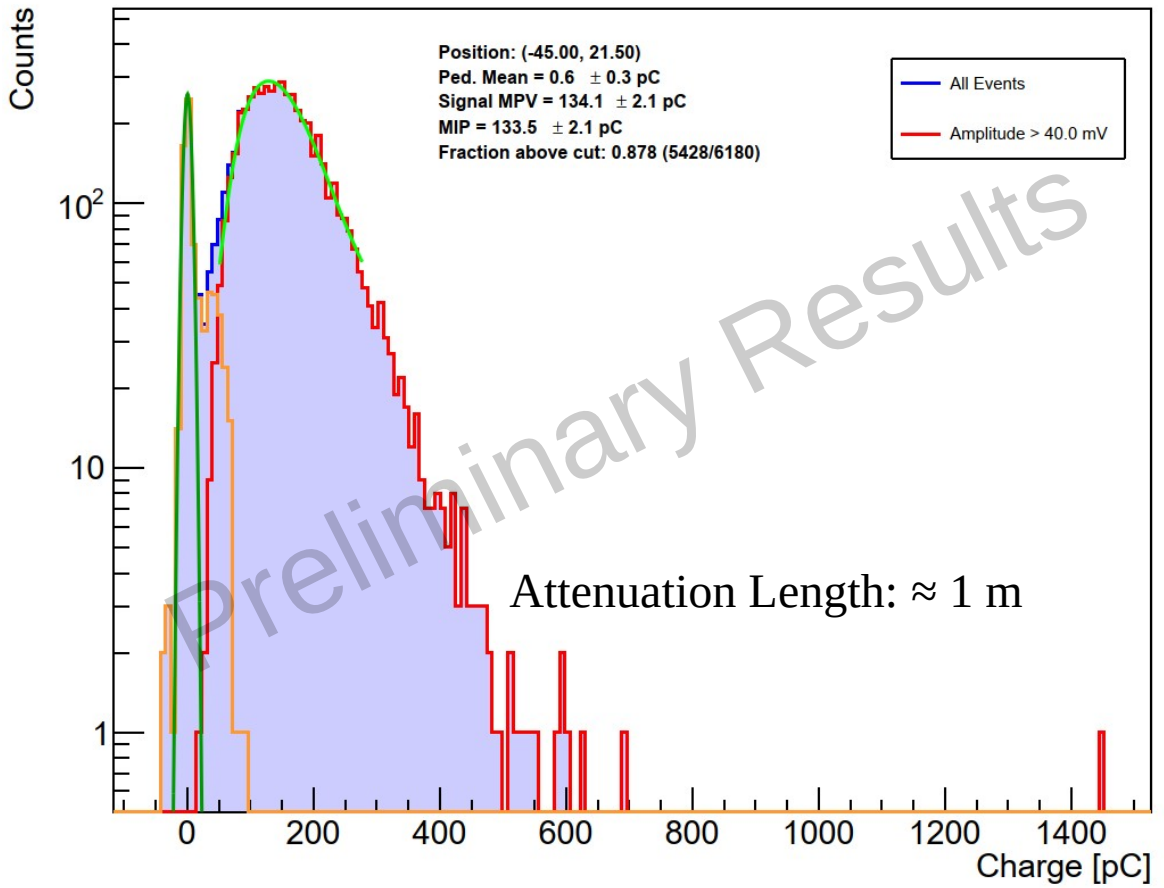




Tested with Hamamatsu SiPM.

Test Beam 2025 – Preliminary Results

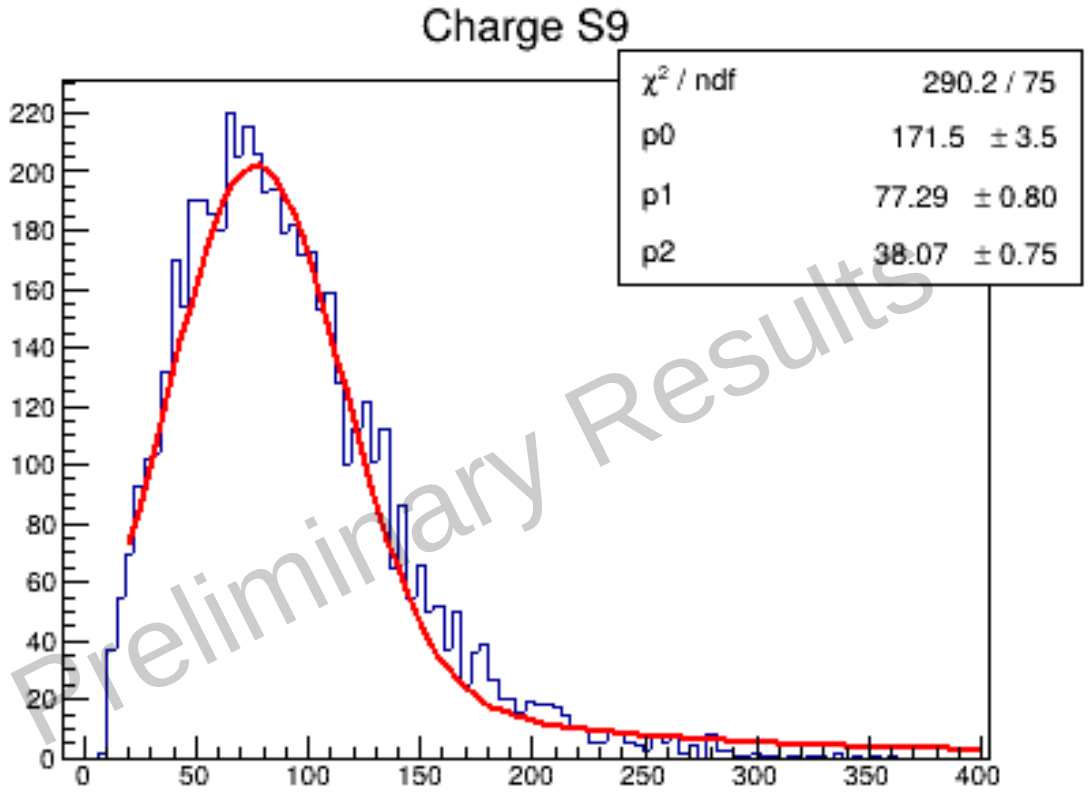


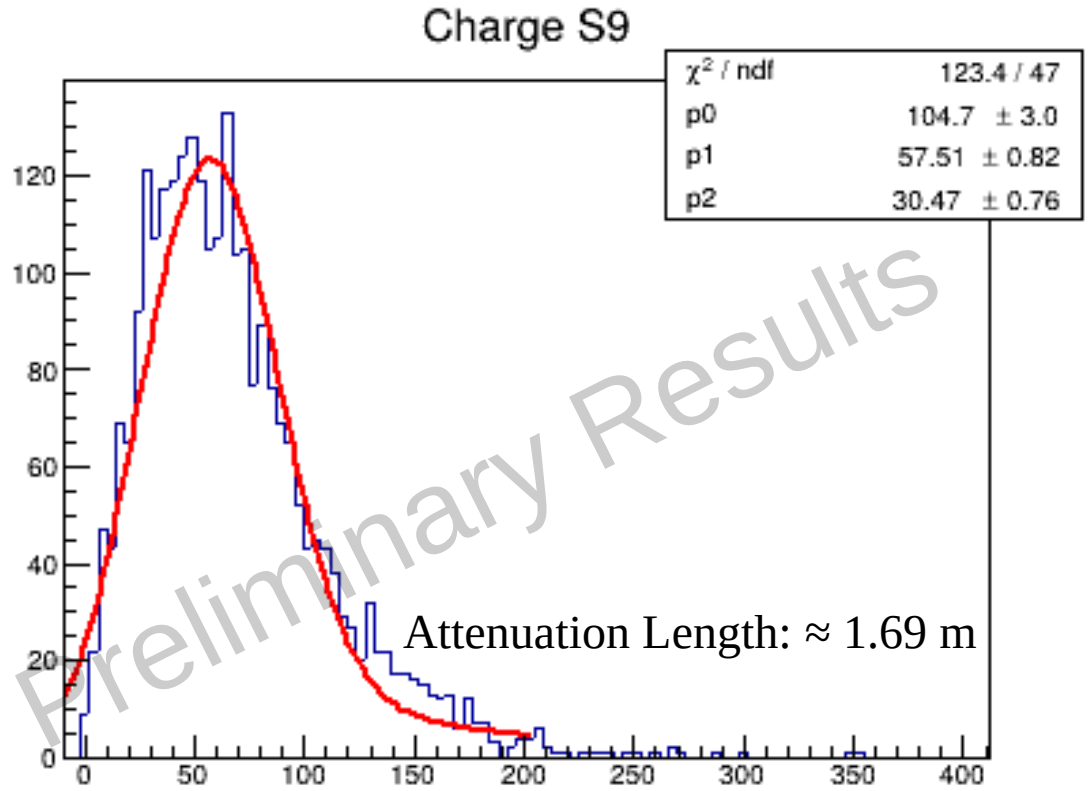


Charge is well separated from the pedestal. 70 cm difference between these two graphs.

Attenuation goes from 278.4 pC to 134.1 pC. Approximately, from 41 phe to 20 phe.

Test Beam 2025 – Preliminary Results

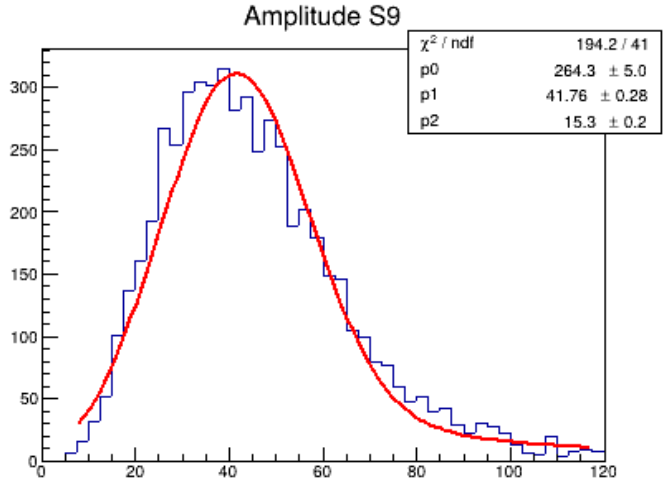


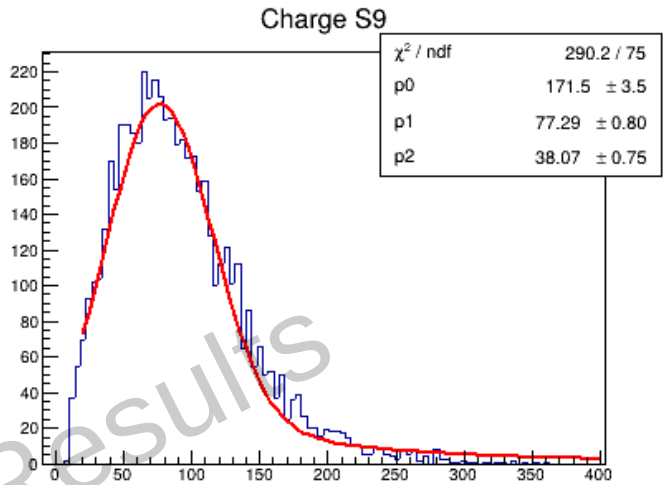


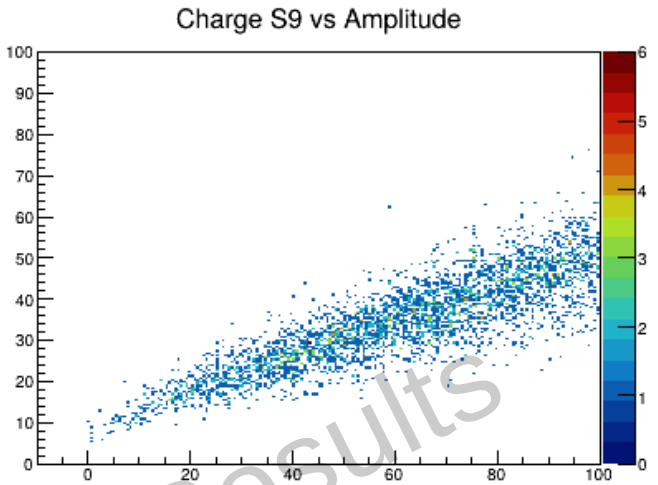
50 cm difference between these two graphs.

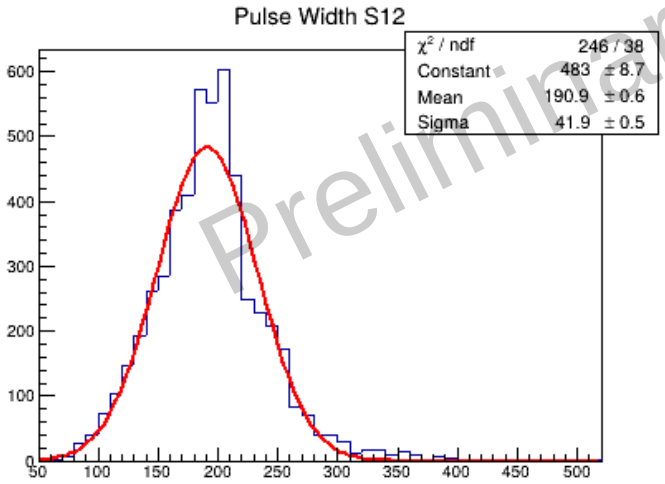
Attenuation goes from 77.29 pC to 57.51 pC.

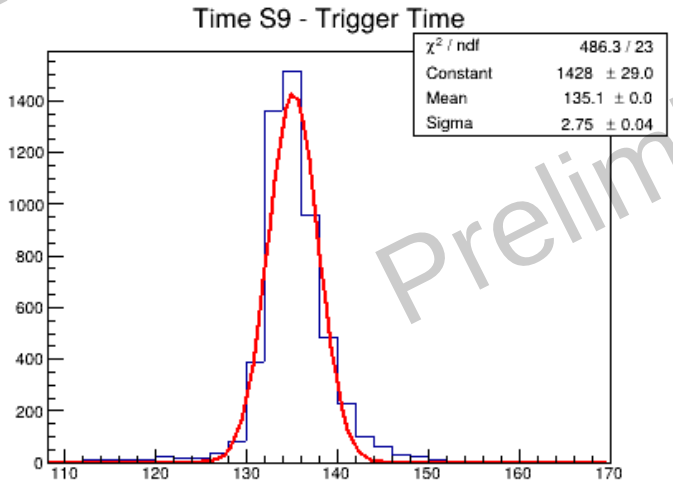
Test Beam 2025 – Preliminary Results

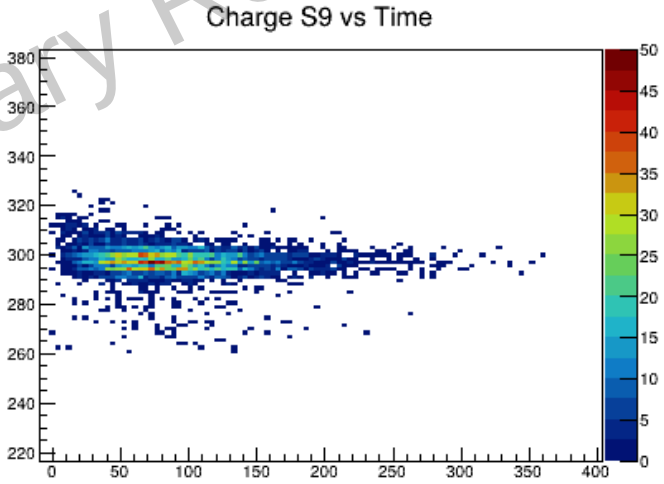












Test Beam 2025 – Preliminary Results