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# BENEMÉRITA UNIVERSIDAD AUTÓNOMA DE PUEBLA

# PERFORMANCE OF ACORDE SCINTILLATOR BARS

By

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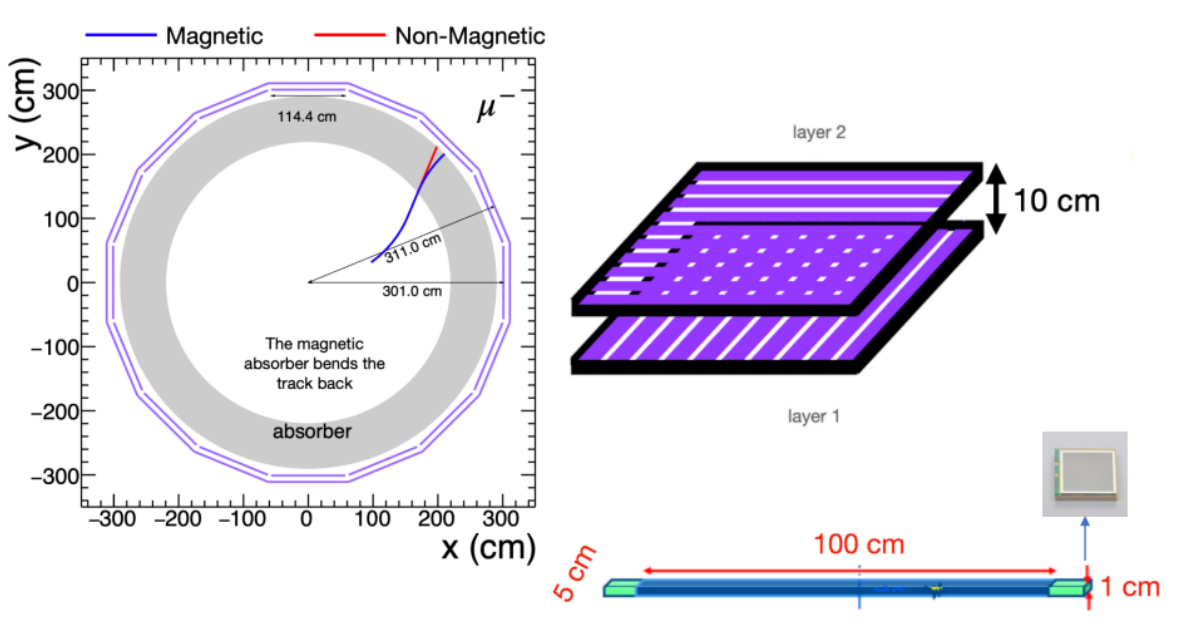
# Content Outline

- MuonID Detector
- ACORDE Scintillator Bars
- Cosmic Rays Test
- Test Beam 2023
- Test Beam 2024
- Conclusions
- Bibliography

# MuonID Detector



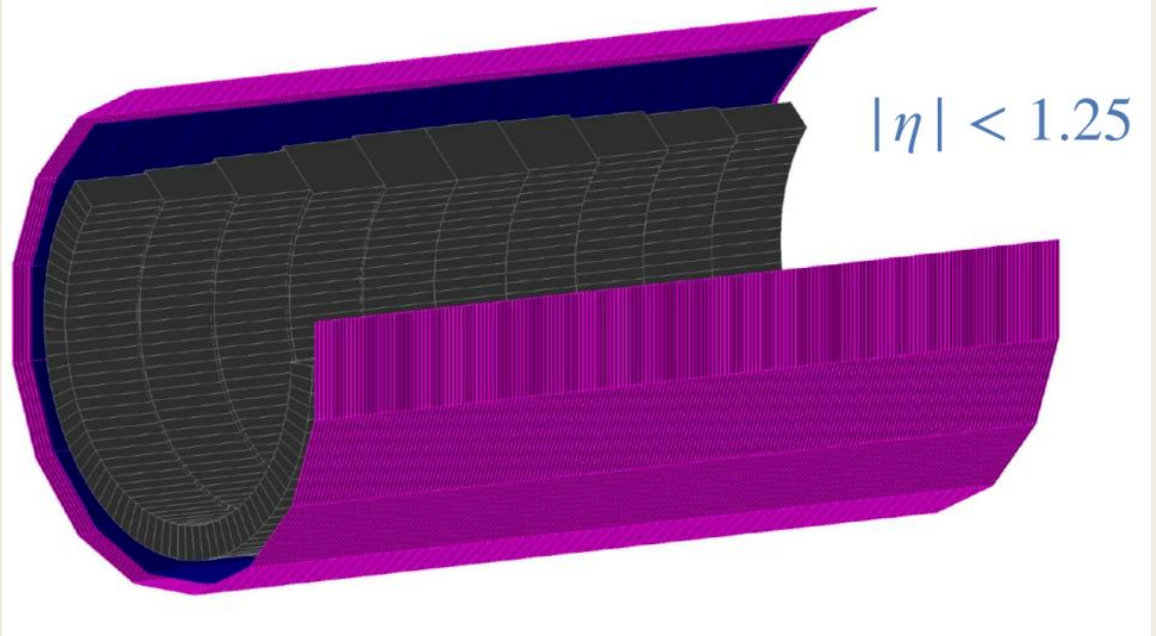




Figure 1. MuonID Detector.

## Plastic Scintillator Option

The ALICE-3 Letter of Intent (LoI) [1] considers the use of scintillator bars equipped with wavelength-shifting (WLS) fibers and silicon photomultiplier (SiPM) readout as the baseline option. This design includes two layers of crossed scintillator paddles, each 100 cm long, 5 cm wide, and 1 cm thick, with a 10 cm gap between the layers [2].

**Assumptions:**

- 10 rings
- 16 segments per ring
- 1 chamber per segment
- 40 channels per chamber
- 6400 channels in total

# ACORDE Scintillator Bars

The ACORDE plastic scintillator material is being cut into bars measuring 100 × 5 × 1 cm³ using the workshops at CINVESTAV and ALICE.

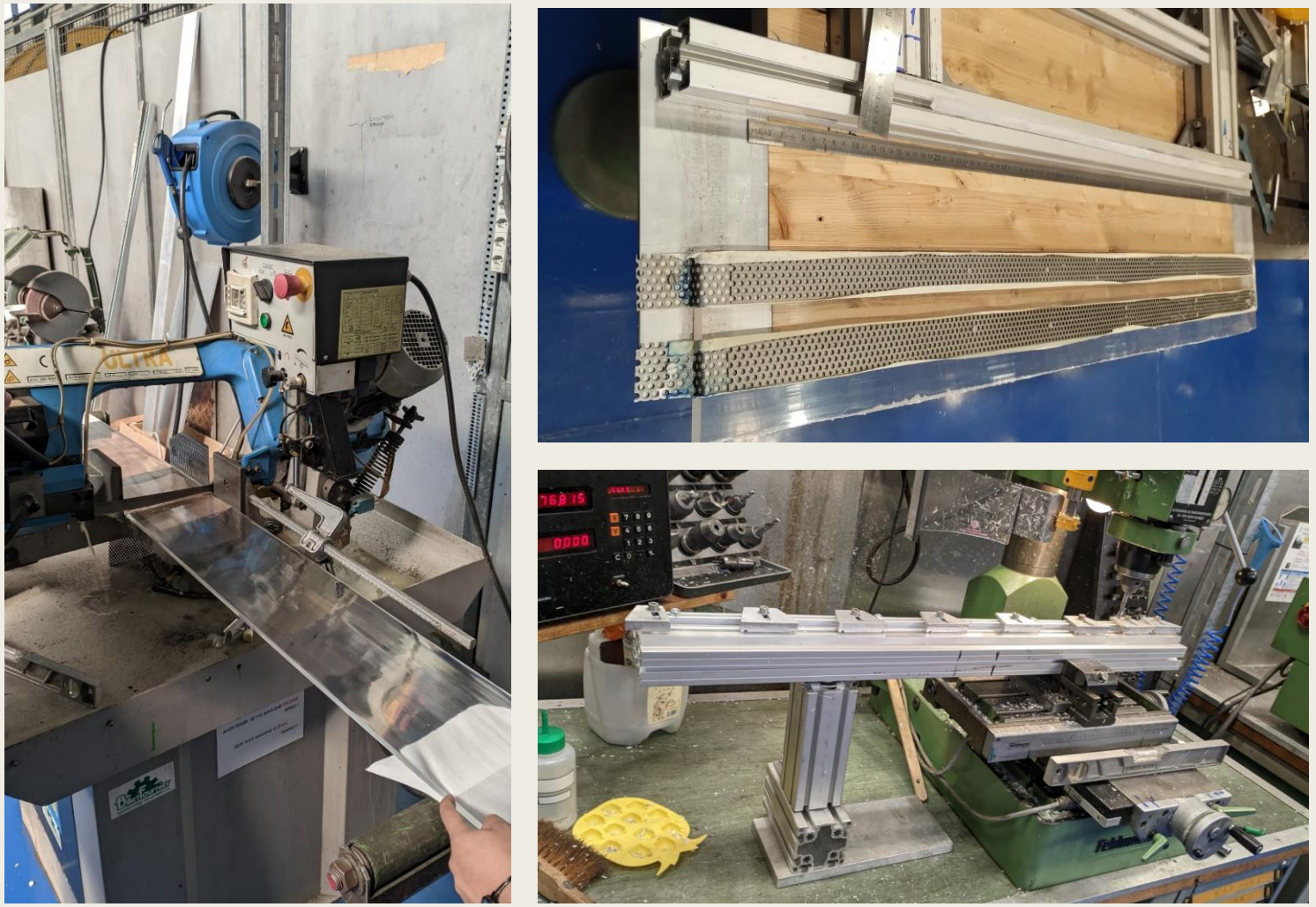
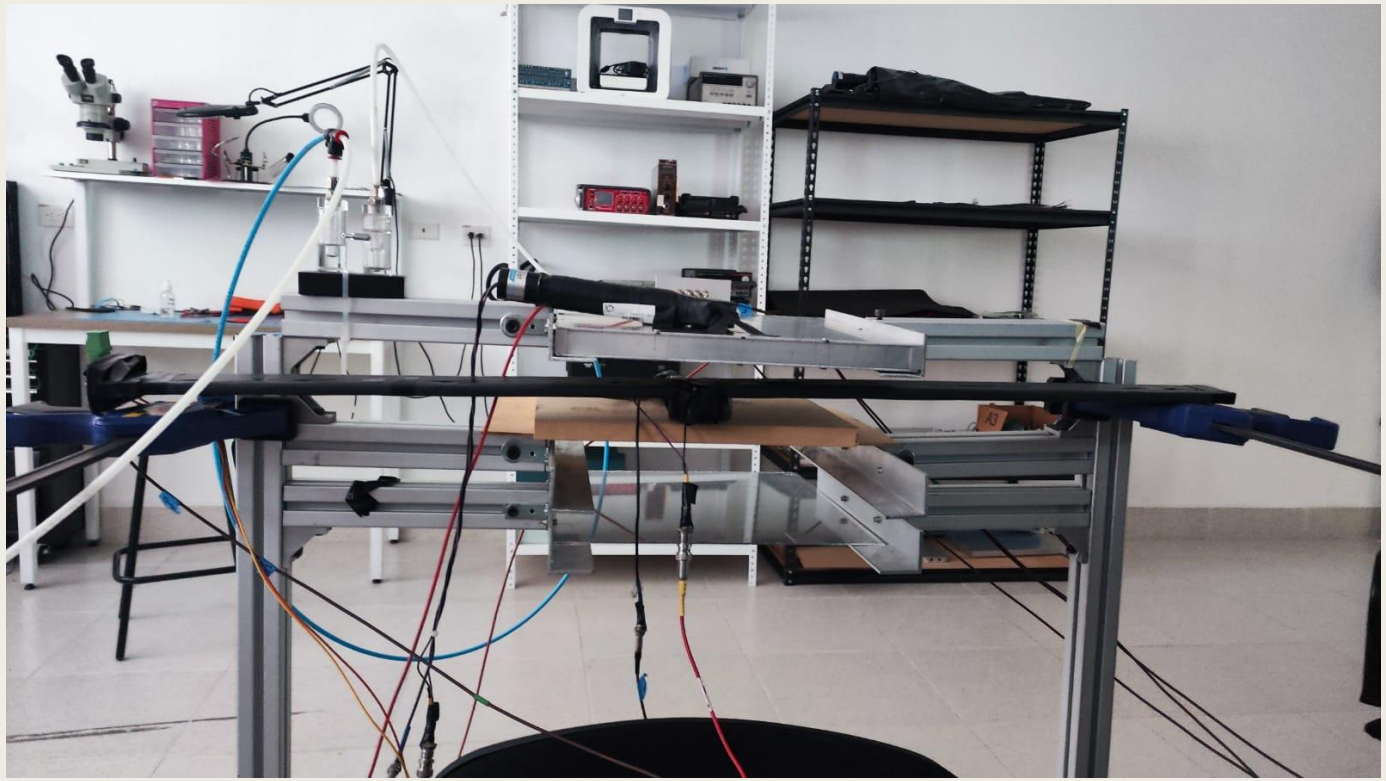


Figure 2. ACORDE Scintillator Bars – Workshop.

# Cosmic Rays Test – Setup @BUAP



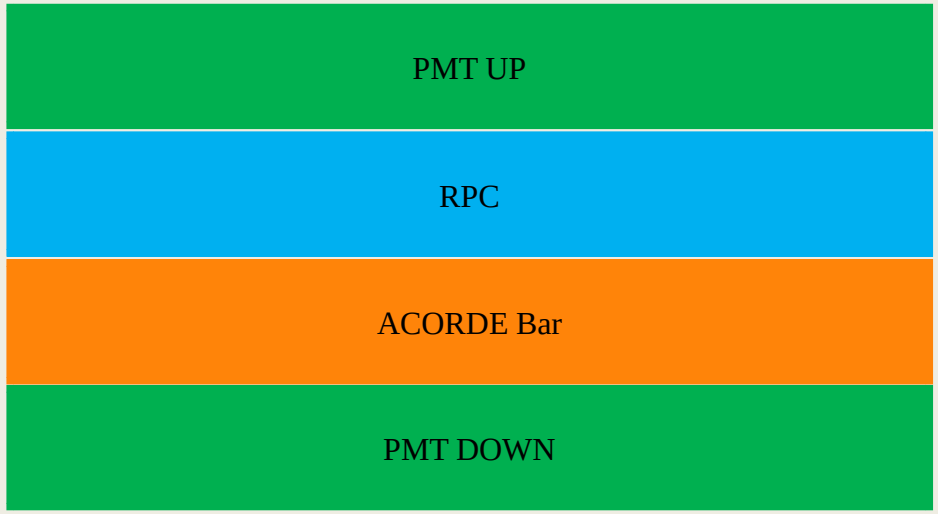
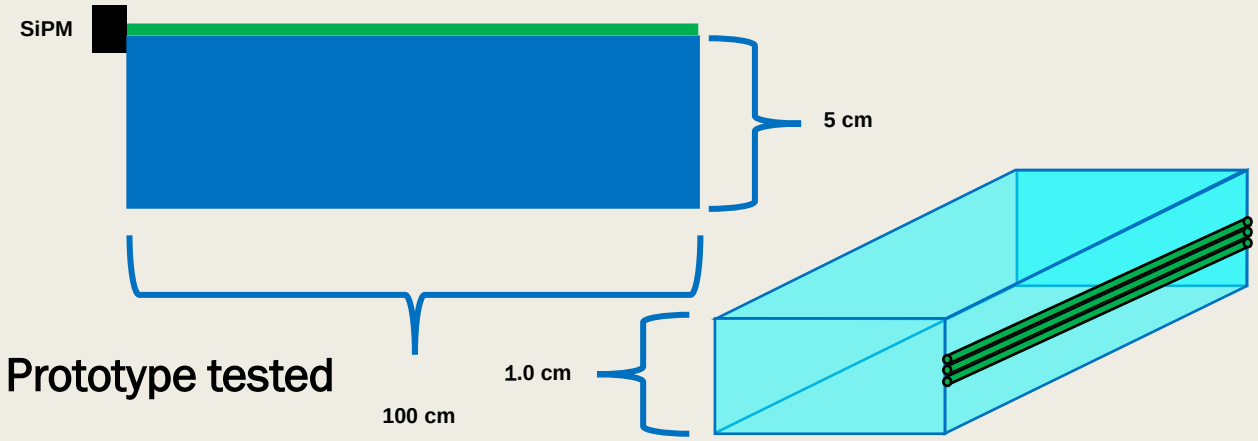
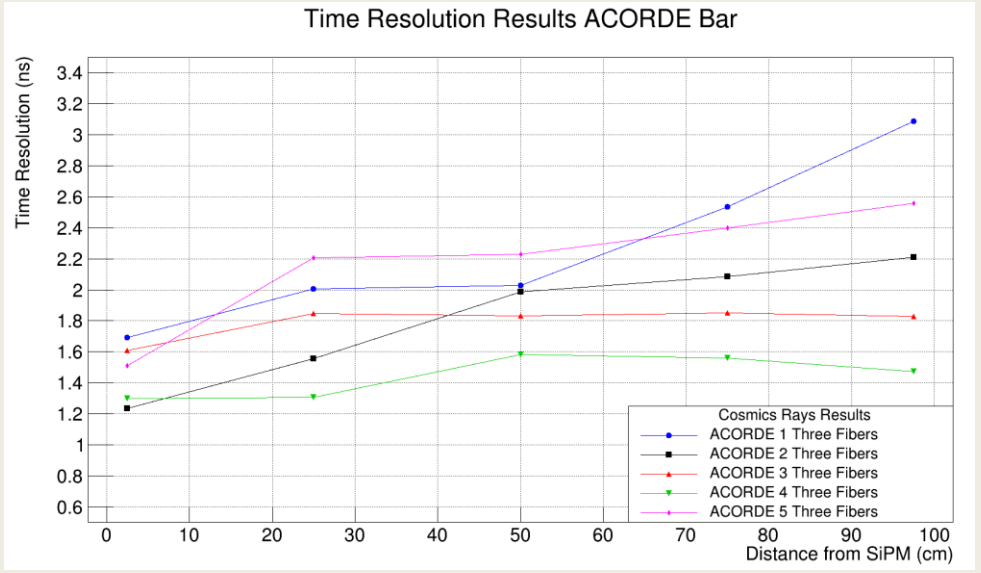
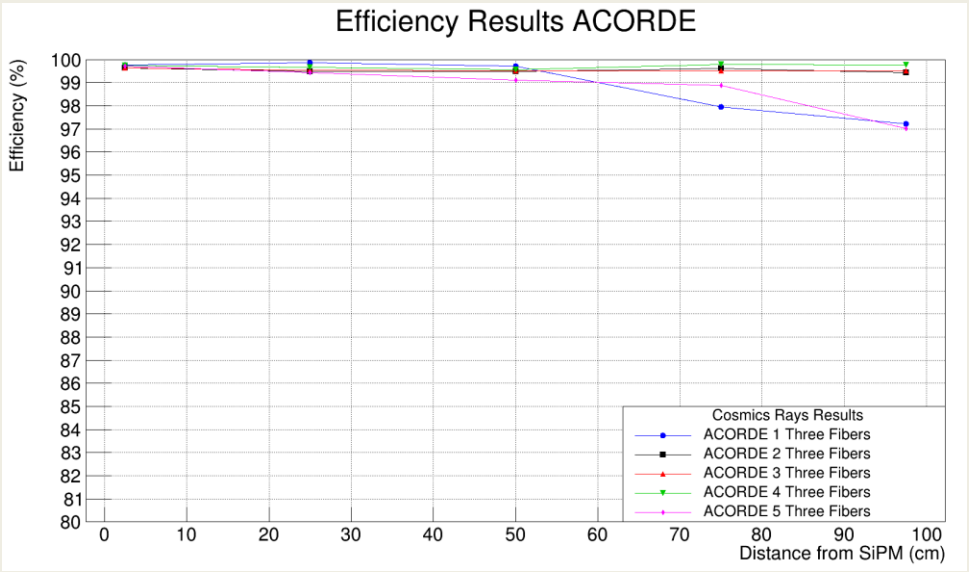



Figure 3. Cosmic Rays Test: ACORDE bar and RPC setup @BUAP.

# Cosmic Rays Test



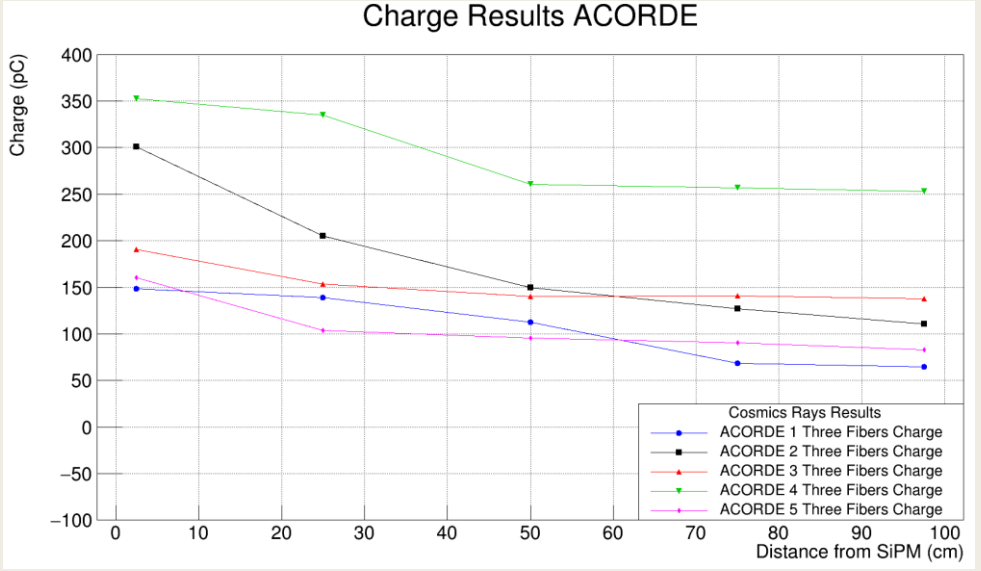




Figure 4. Cosmic Rays Test: Efficiency, Time Resolution, and Charge Results.

# Cosmic Rays Test – ACORDE bars

Table 1. Cosmic Rays Test: 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 | 1.693 ± 0.013 | 99.64 | 1.233± 0.007 | 99.64 | 1.608 ± 0.013 | 99.75 | 1.300 ± 0.009 | 99.72 | 1.511 ± 0.017 |
| 25 | 99.87 | 2.005 ± 0.013 | 99.50 | 1.556± 0.010 | 99.55 | 1.847 ± 0.013 | 99.67 | 1.307 ± 0.008 | 99.43 | 2.205 ± 0.021 |
| 50 | 99.71 | 2.027 ± 0.014 | 99.49 | 1.988± 0.013 | 99.51 | 1.831 ± 0.013 | 99.56 | 1.584 ± 0.011 | 99.12 | 2.227 ± 0.018 |
| 75 | 97.94 | 2.535 ± 0.034 | 99.62 | 2.085± 0.013 | 99.52 | 1.852 ± 0.013 | 99.80 | 1.559 ± 0.010 | 98.88 | 2.397 ± 0.015 |
| 97.5 | 97.22 | 3.085 ± 0.033 | 99.43 | 2.208 ± 0.018 | 99.51 | 1.827 ± 0.013 | 99.77 | 1.473 ± 0.009 | 97.02 | 2.557 ± 0.025 |

**Efficiency: ≈ 100%**

**Time resolution: 1.2 – 3.0 ns**

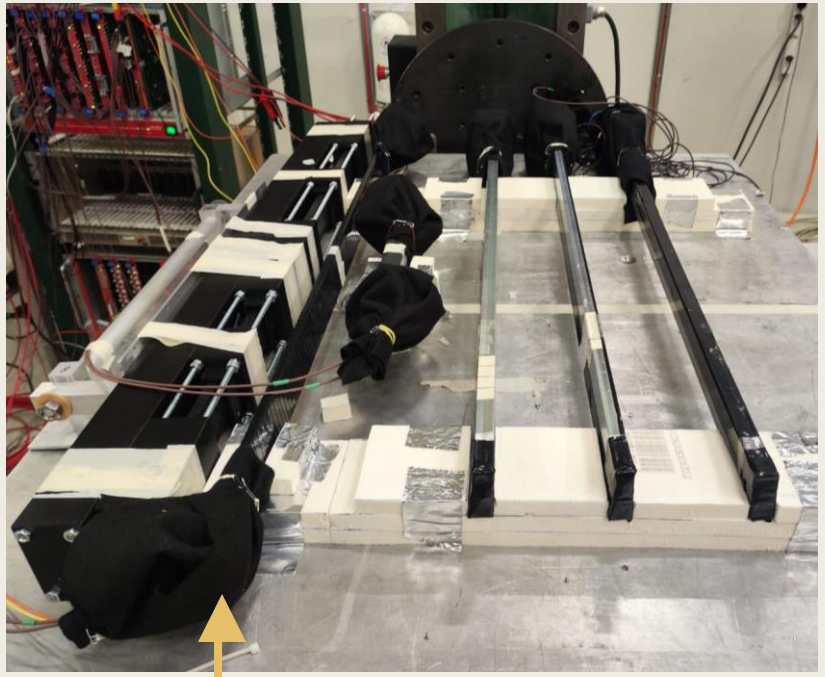
# Cosmic Rays Test – ACORDE bars

Table 2. Cosmic Rays Test: 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**

# Test Beam 2023 – Setup



ACORDE

Figure 5. Test Beam 2023: Setup.

# Test Beam 2023 – Setup

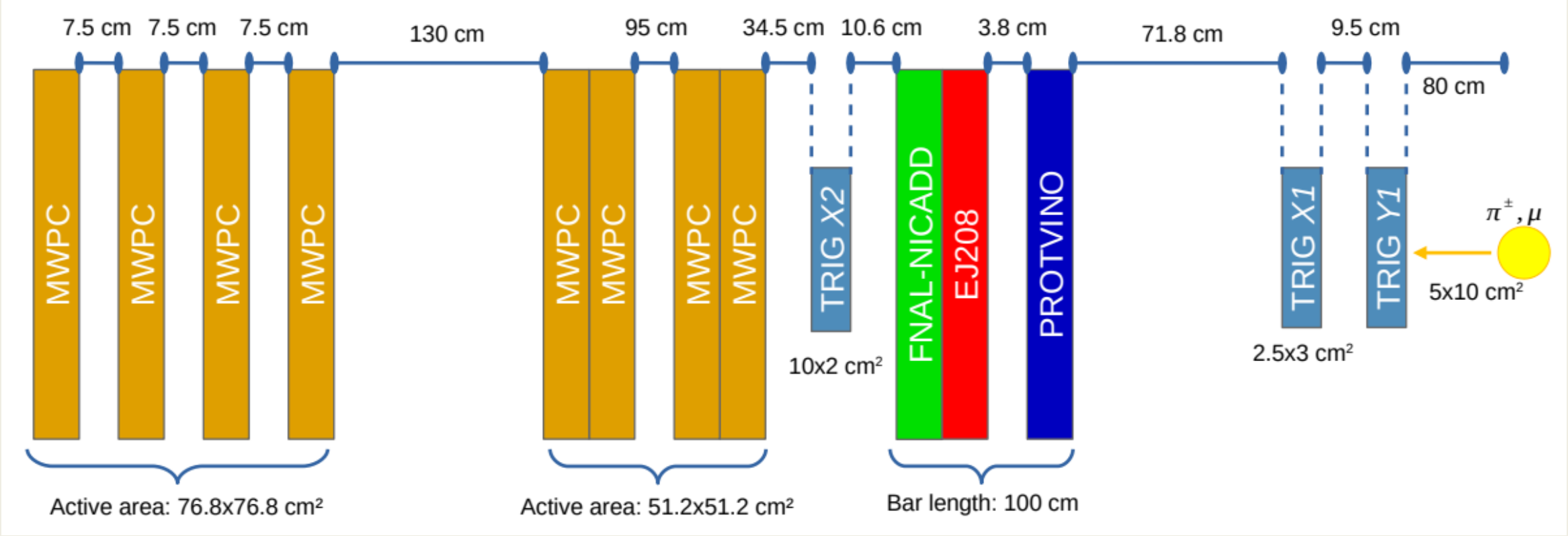
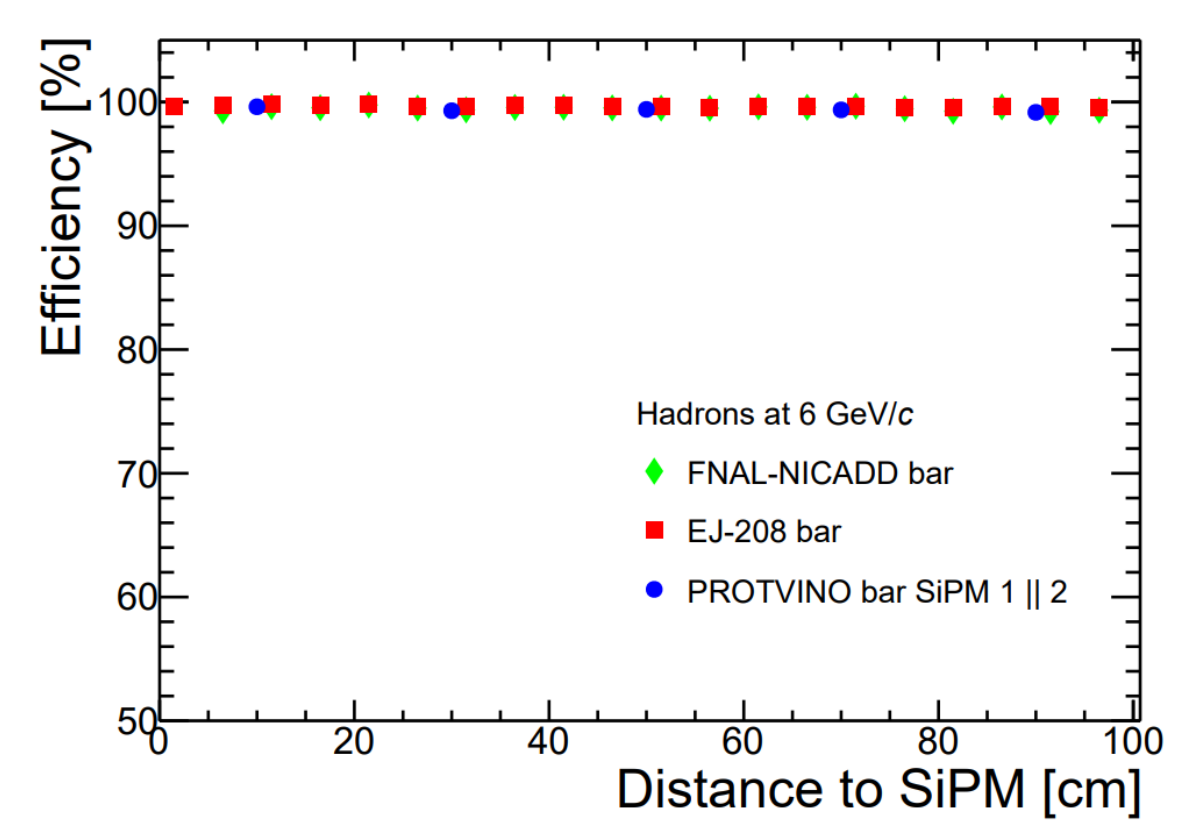



Figure 6. Test Beam 2023: Prototypes Setup.

# Test Beam 2023 – Paper Results



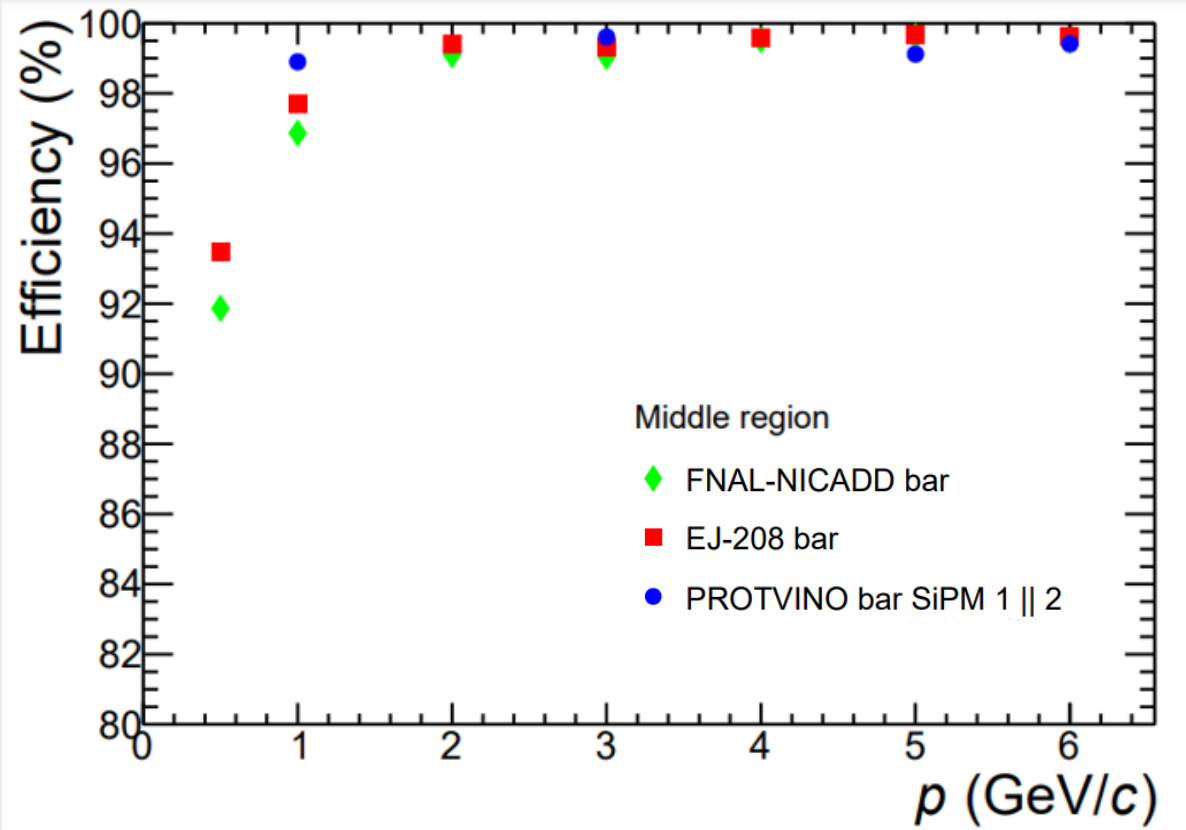




Figure 7. Test Beam 2023: Paper Results. [3]

Ruben Alfaro et al 2024 JINST 19 T04006

# Test Beam 2023 – Results

Table 3. ACORDE Horizontal Scan Results

| Distance from SiPM (cm) | Efficiency (%) |
|---|---|
| | SiPM1 \|\| SIPM 2 |
| 10 | 99.62 |
| 30 | 99.30 |
| 50 | 99.41 |
| 70 | 99.37 |
| 90 | 99.17 |

Table 4. ACORDE Energy Scan Results

| Momentum (GeV/c) | Efficiency (%) |
|---|---|
| | SiPM1 \|\| SIPM 2 |
| 1 | 98.90 |
| 3 | 99.61 |
| 5 | 99.12 |
| 6 | 99.41 |
| 10 | 99.03 |

# Test Beam 2024 – ACORDE Chamber Prototype

- Five Plastic Scintillator Bars
- SiPM SensL C-Serie 6x6 mm
- Three WLS fibers – Kuraray
- Simulations in progress

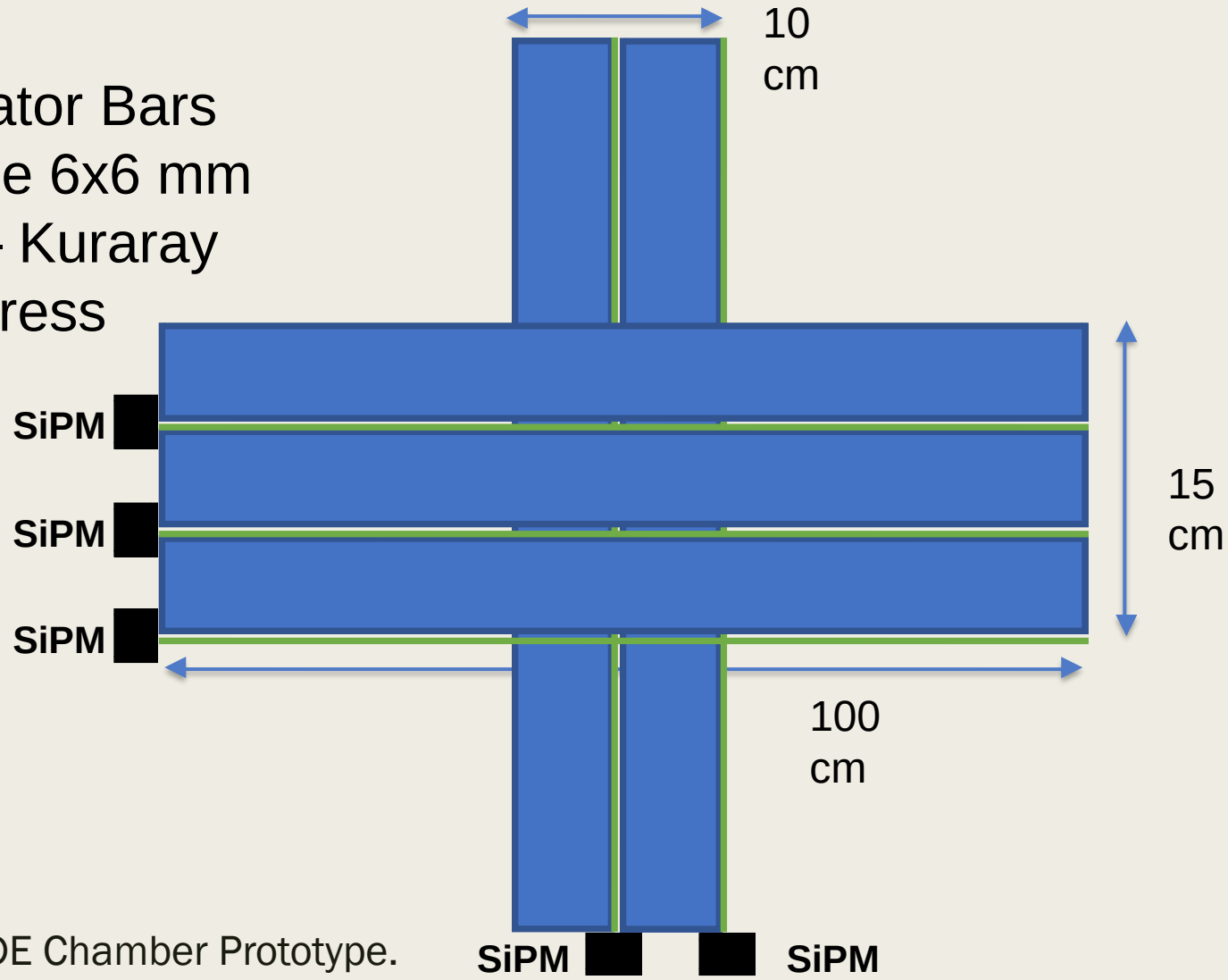



Figure 8. ACORDE Chamber Prototype.

# Test Beam 2024 – Setup

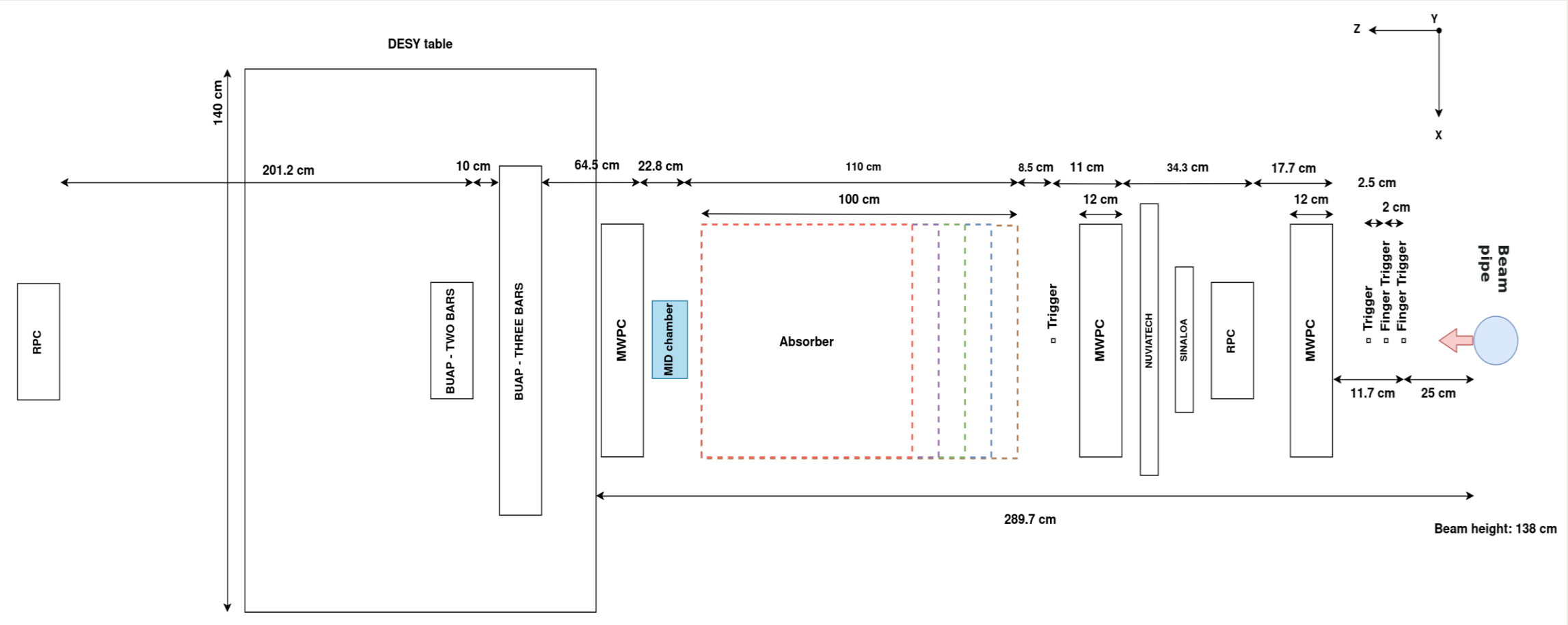



Figure 9. Test Beam 2024: Setup.

# Test Beam 2024 – Setup


Figure 10. Test Beam 2024: Setup.

# Test Beam 2024 – Preliminary Results

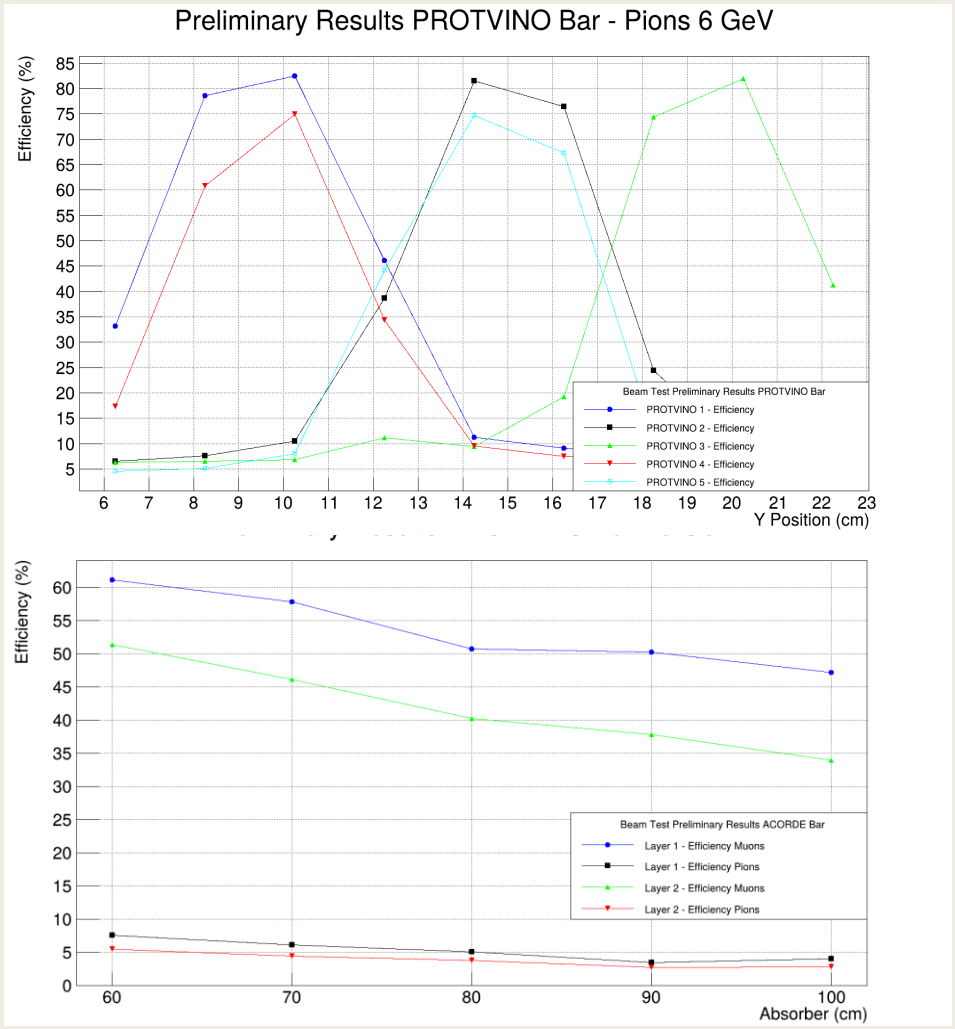



Figure 11. Test Beam 2024: Preliminary Results.

Data analysis is still ongoing. For pions, efficiency is notably low and decreases further as the absorber length increases, reducing the number of particles that pass through.

On the other hand, muons exhibit higher efficiency, though it also diminishes with increasing absorber thickness.

Defining the acceptance factor for our module is still pending and we are working on the simulations.

These results will be further analyzed and validated to deepen our understanding of their behavior.

# Conclusions

- The ACORDE scintillator bars, coupled with three WLS fibers and one SiPM, demonstrate ≈ 100% efficiency.
- The best time resolution achieved is approximately 1.2 ns.
- On average, we can collect ≈ 40 photons.
- These results are competitive compared to other materials tested, including FNAL-NICADD and EJ-208.

# Bibliography

[1]. ALICE Collaboration. Letter of intent for ALICE 3: A next generation heavy-ion experiment at the LHC. Technical report, CERN, Geneva, Mar 2022.

[2]. A. Ortíz Velázquez. MID WP: Summary. 3rd ALICE Upgrade Week. Technical report, CERN, Geneva. May, 2023.

[3]. R. Alfaro et al. Characterisation of plastic scintillator paddles and lightweight MWPCs for the MID subsystem of ALICE 3. JINST 19(04):T04006, 2024.

# Backup

# Time resolution equation

The variance of correlated random variables is given by equation 1.1:

$$\sigma_{12}^2 = \sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2 \qquad \ldots (1.1)$$

Where ρ is the correlation. In this case, the correlation between the variables of each detector is zero, because there is no relationship between them. Therefore, equations 1.2 are obtained:

$$\sigma_{12}^2 = \sigma_1^2 + \sigma_2^2 \;\; ; \;\; \sigma_{13}^2 = \sigma_1^2 + \sigma_3^2 \;\; ; \;\; \sigma_{23}^2 = \sigma_2^2 + \sigma_3^2 \qquad \ldots (1.2)$$

# Time resolution equation

From the data, $\sigma_{12}$, $\sigma_{13}$ and $\sigma_{23}$ are already known, but it is necessary to know the SiPM detector time resolution $\sigma_3$. Solving for $\sigma_3$ from equations 1.2 and adding them, expression 1.3 is the result.

$$2\sigma_3^2 = \sigma_{13}^2 + \sigma_{23}^2 - \sigma_1^2 - \sigma_2^2 \quad \ldots (1.3)$$

Finally, the SiPM time resolution can be obtained from the equation 1.4:

$$\sigma_3 = \sqrt{\frac{\sigma_{13}^2 + \sigma_{23}^2 - \sigma_{12}^2}{2}} \quad \ldots (1.4)$$

# Cosmic Rays Test – Connection Diagram

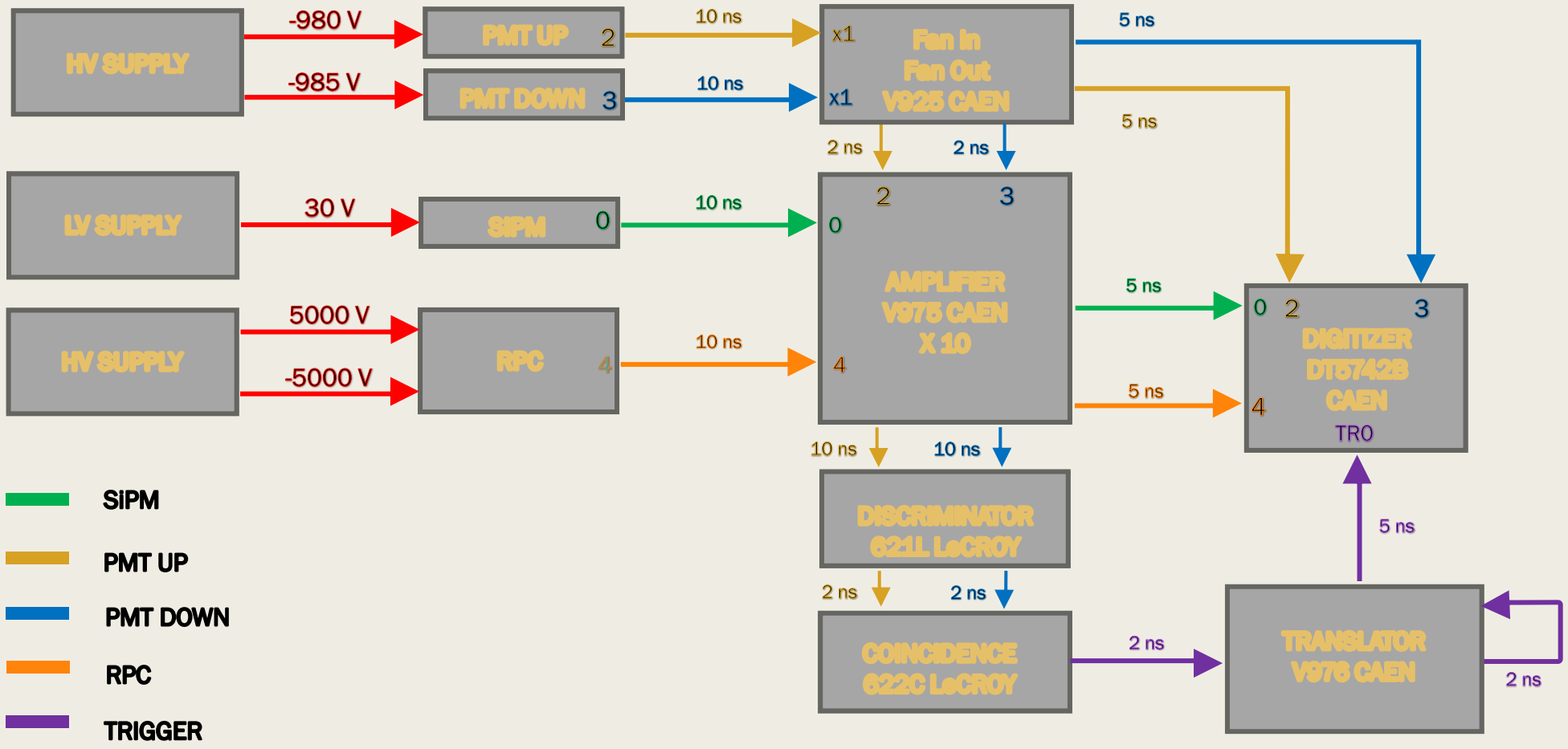



Figure 12. Cosmic Rays Test: Connection Diagram with ACORDE and RPC in parallel.

# Cosmic Rays Test – Digitizer Screen

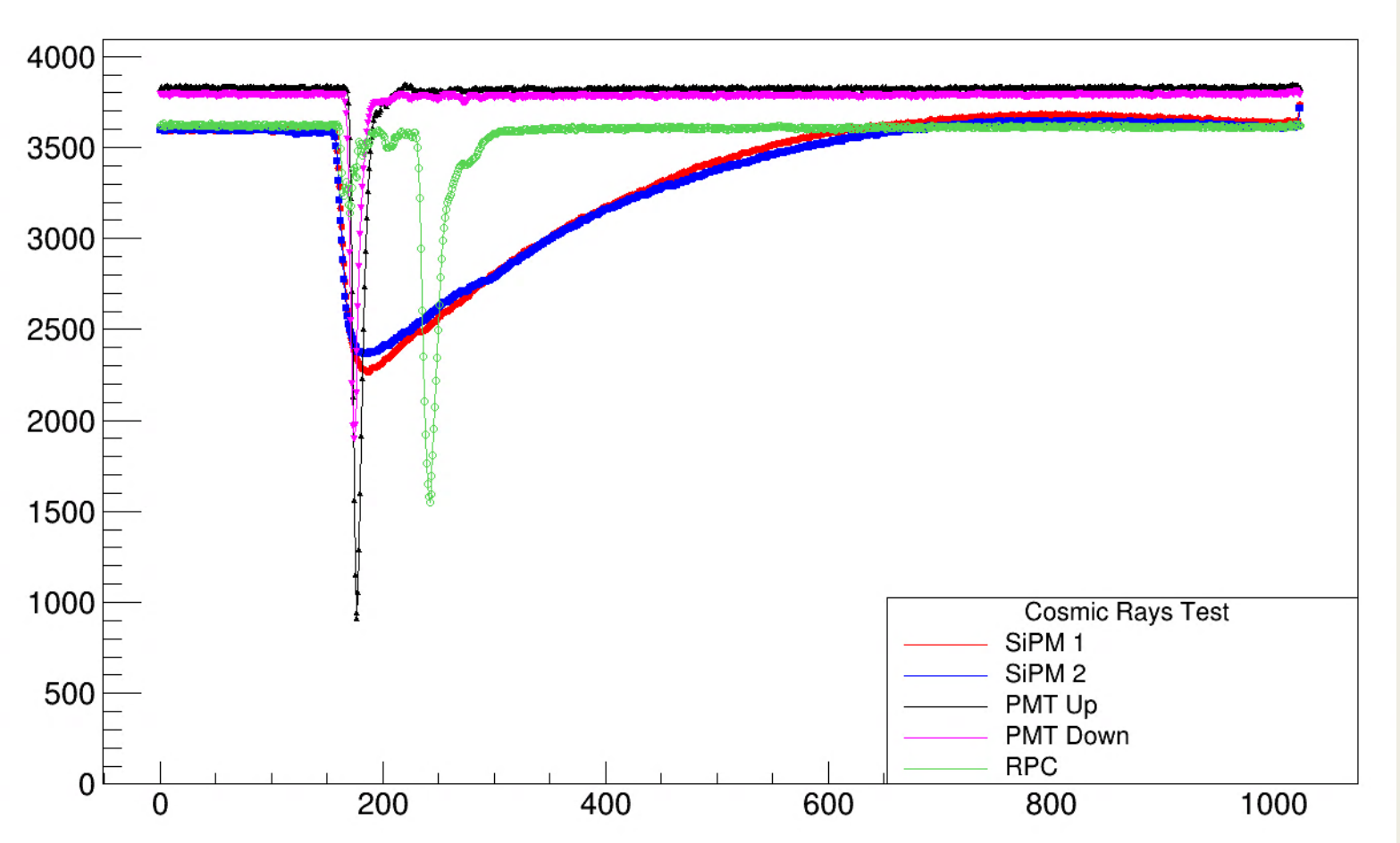



Figure 13. Cosmic Rays Test: Digitizer Screen.

# ACORDE bars

Figure 14. ACORDE bars and mechanical support.

# Cosmic Rays Test – Prototype

Figure 15. Cosmic Rays Test: ACORDE Bar Prototype with two 1.0 mm WLS fibers.

# Cosmic Rays Test – ACORDE bars

Table 5. Cosmic Rays Test: ACORDE 1 efficiency and time resolution results varying number of fibers

| Distance from SiPM (cm) | ACORDE 1 with one WLS fiber | | ACORDE 1 with two WLS fibers | | ACORDE 1 with three WLS fibers | |
|---|---|---|---|---|---|---|
| | Efficiency (%) | Time Resolution (ns) | Efficiency (%) | Time Resolution (ns) | Efficiency (%) | Time Resolution (ns) |
| 2.5 | 99.30 | 1.796 ± 0.024 | 99.86 | 1.267± 0.011 | 99.76 | 1.693 ± 0.013 |
| 25 | 85.76 | 3.631 ± 0.102 | 99.23 | 1.846± 0.035 | 99.87 | 2.005 ± 0.013 |
| 50 | 78.98 | 6.821 ± 0.717 | 99.66 | 2.053± 0.022 | 99.71 | 2.027 ± 0.014 |
| 75 | 70.17 | 14.304 ± 3.132 | 97.87 | 2.707± 0.024 | 97.94 | 2.535 ± 0.034 |
| 97.5 | 38.81 | 14.960 ± 4.175 | 94.56 | 2.776 ± 0.036 | 97.22 | 3.085 ± 0.033 |

# Cosmic Rays Test – ACORDE bars

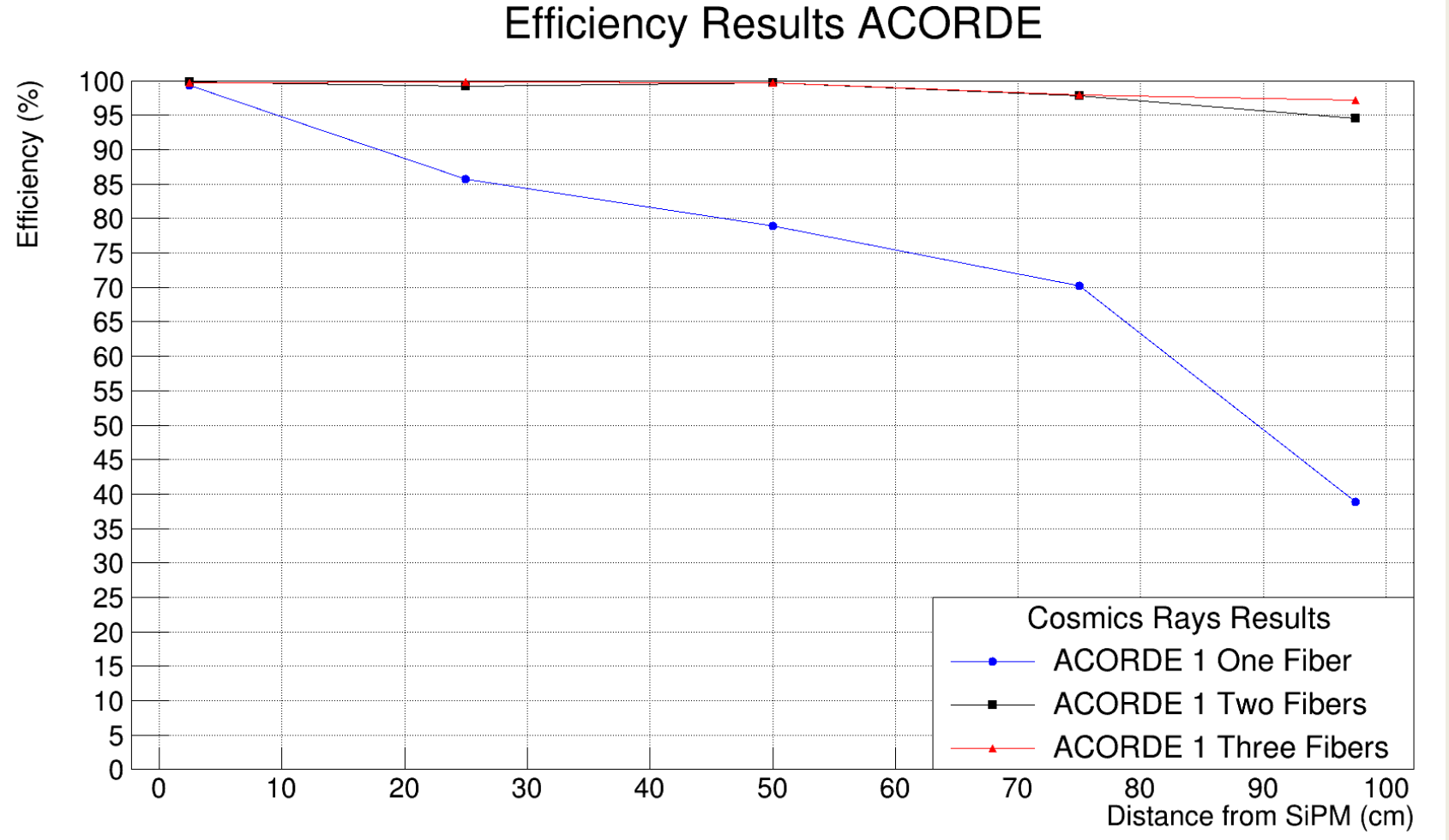



Figure 16. Cosmic Rays Test: ACORDE 1 – Efficiency Results

# Cosmic Rays Test – ACORDE bars

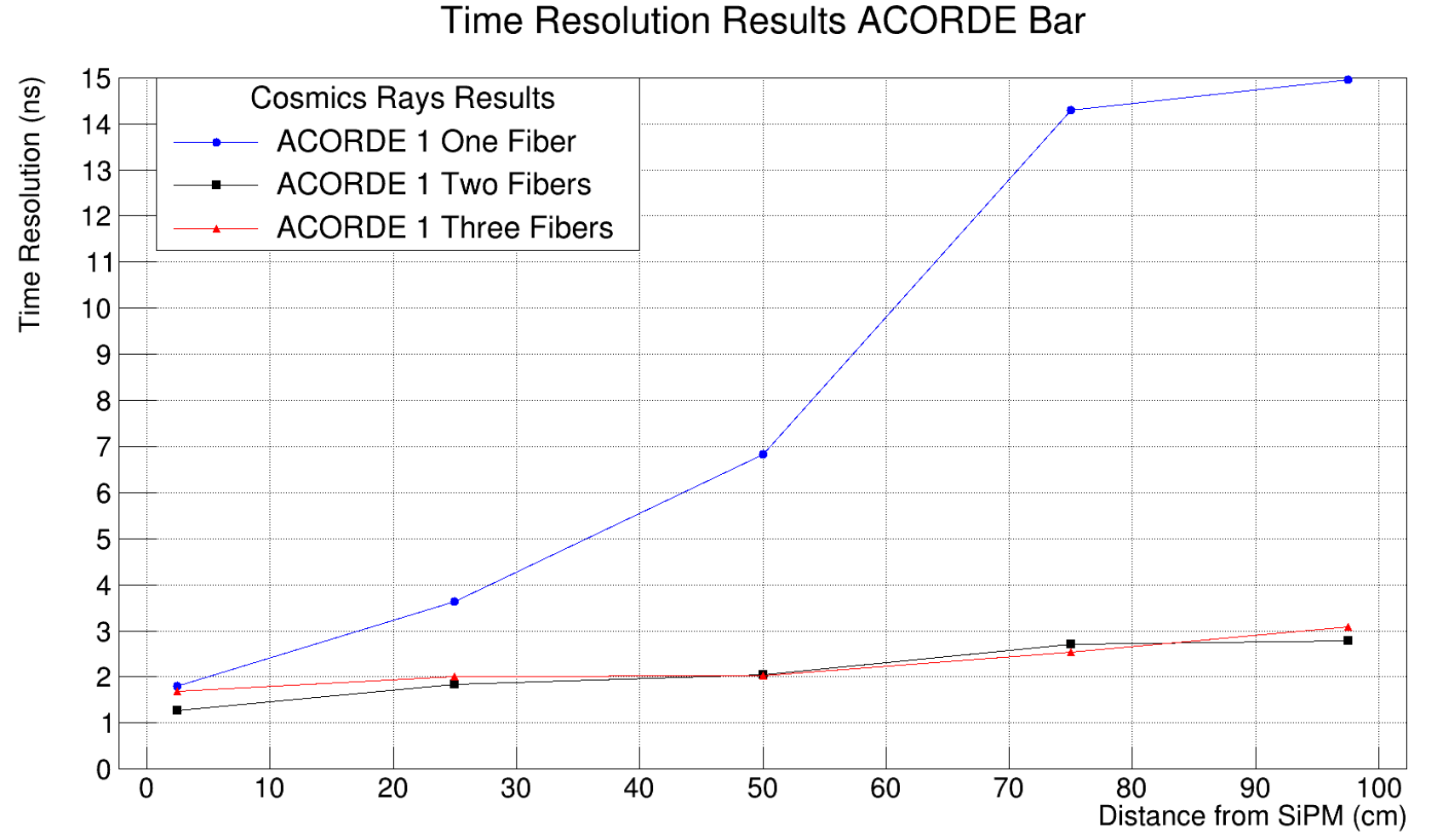



Figure 17. Cosmic Rays Test: ACORDE 1– Time Resolution Results

# Cosmic Rays Test – ACORDE bars

Table 6. Cosmic Rays Test: ACORDE 1 amplitude and charge results varying number of fibers

| Distance from SiPM (cm) | ACORDE 1 with one WLS fiber | | | ACORDE 1 with two WLS fibers | | | ACORDE 1 with three WLS fibers | | |
|---|---|---|---|---|---|---|---|---|---|
| | Amplitude (mV) | Charge (pC) | Photons (γ) | Amplitude (mV) | Charge (pC) | Photons (γ) | Amplitude (mV) | Charge (pC) | Photons (γ) |
| 2.5 | 32.62 ± 0.16 | 131.6 ± 2.0 | ≈ 29.19 | 35.46 ± 0.22 | 140.2 ± 2.7 | ≈ 31.17 | 34.39 ± 0.13 | 148.6 ± 1.9 | ≈ 32.96 |
| 25 | 23.38 ± 0.08 | 67.32 ± 1.8 | ≈ 14.93 | 33.17 ± 0.16 | 132.3 ± 1.8 | ≈ 29.35 | 34.14 ± 0.12 | 138.7 ± 1.6 | ≈ 30.76 |
| 50 | 15.67 ± 0.27 | 41.29 ± 2.0 | ≈ 9.16 | 27.05 ± 0.14 | 113.1 ± 2.1 | ≈ 25.09 | 29.43 ± 0.12 | 112.5 ± 1.8 | ≈ 24.96 |
| 75 | 12.12 ± 0.17 | 24.41 ± 3.8 | ≈ 5.41 | 17.41 ± 0.09 | 73.6 ± 3.1 | ≈ 16.33 | 16.63 ± 0.05 | 68.68 ± 1.08 | ≈ 15.24 |
| 97.5 | 10.22 ± 0.05 | 20.45 ± 7.4 | ≈ 4.54 | 15.28 ± 0.09 | 64.3 ± 3.1 | ≈ 14.26 | 16.03 ± 0.07 | 64.72 ± 1.06 | ≈ 14.36 |

# Cosmic Rays Test – ACORDE bars

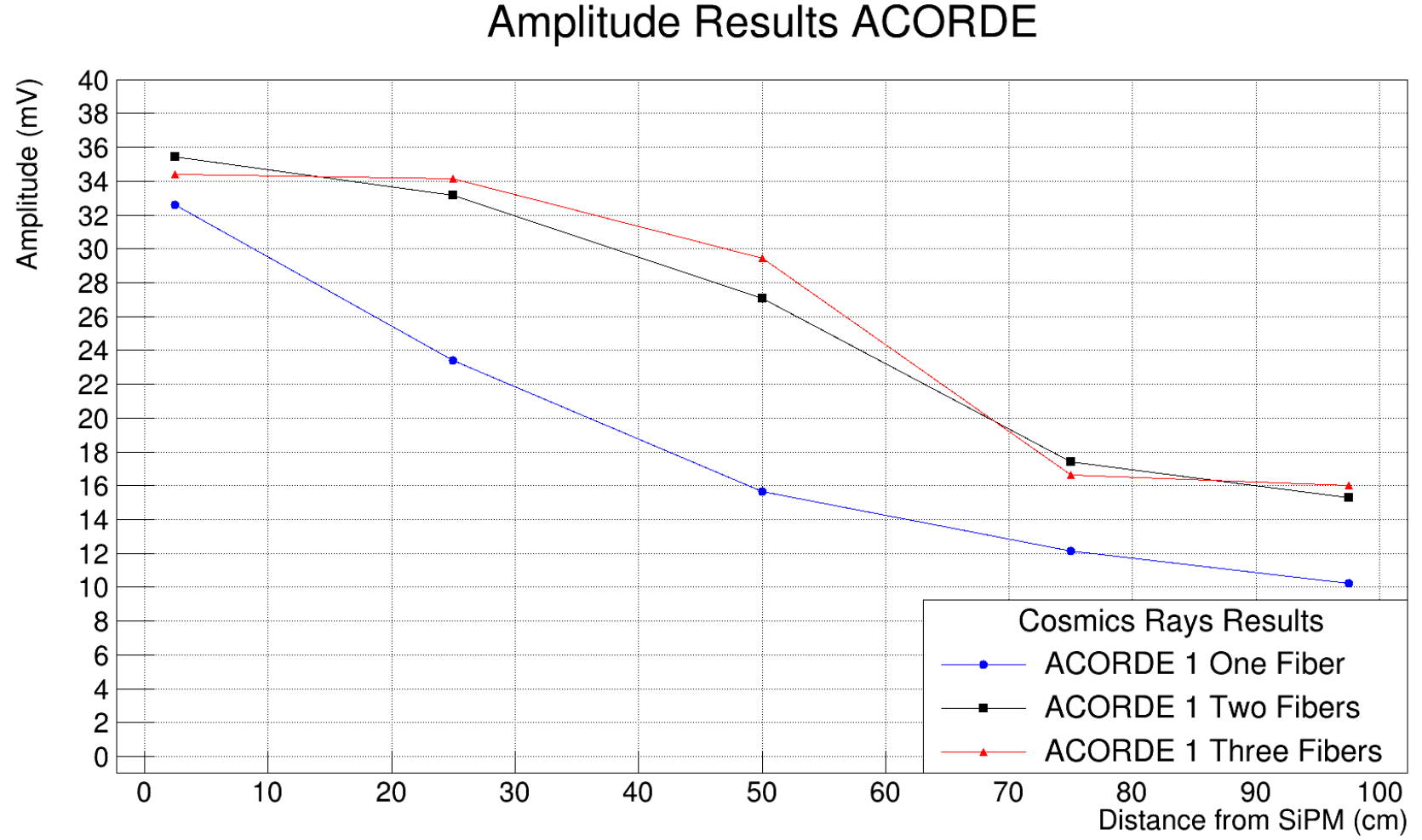



Figure 18. Cosmic Rays Test: ACORDE 1 – Amplitude Results

# Cosmic Rays Test – ACORDE bars

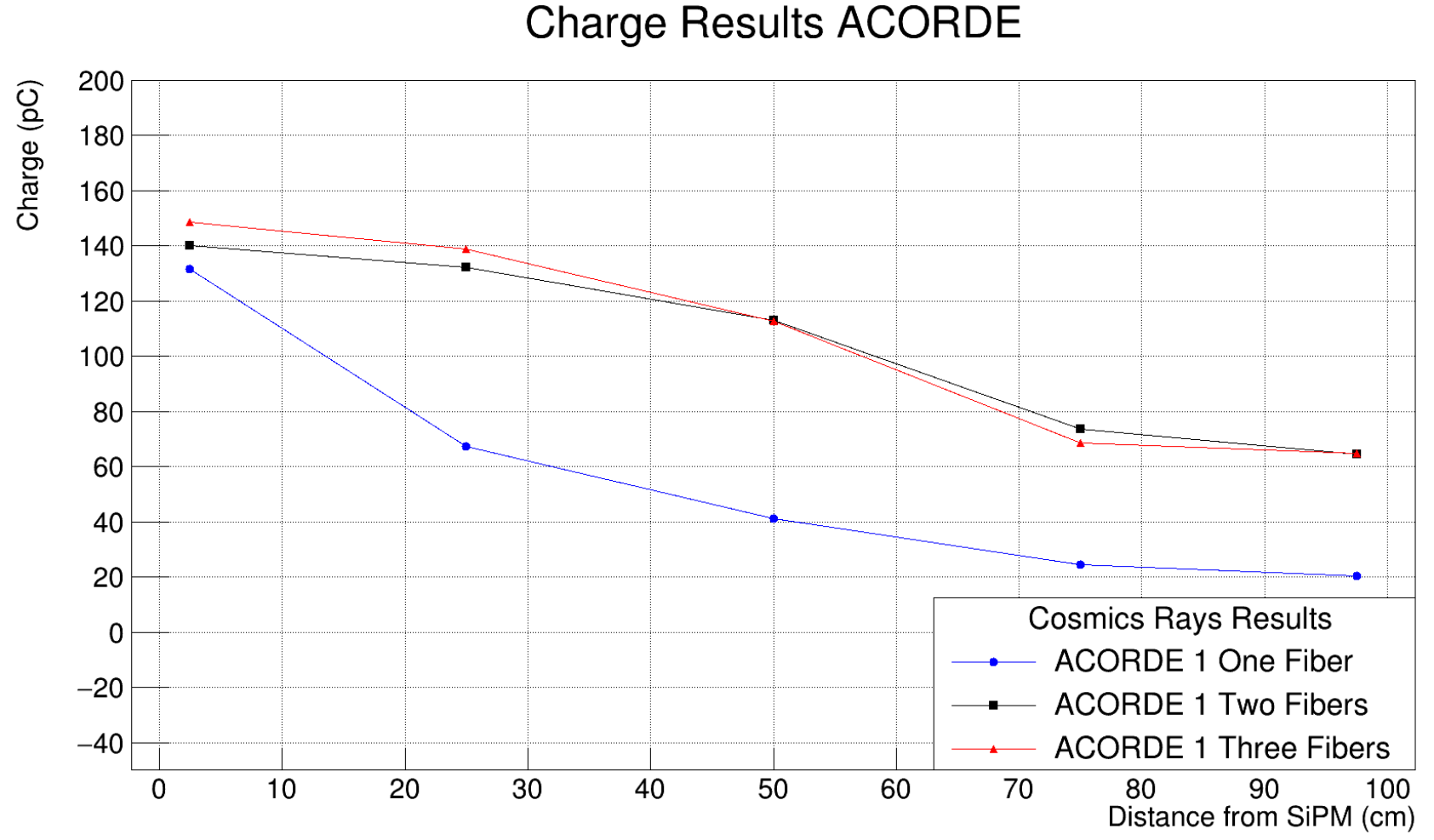



Figure 19. Cosmic Rays Test: ACORDE 1 – Charge Results

# Cosmic Rays Test – ACORDE bars

Table 7. Cosmic Rays Test: ACORDE 3 efficiency and time resolution results varying number of fibers

| Distance from SiPM (cm) | ACORDE 3 with two WLS fibers | | ACORDE 3 with three WLS fibers | |
|---|---|---|---|---|
| | Efficiency (%) | Time Resolution (ns) | Efficiency (%) | Time Resolution (ns) |
| 2.5 | 99.74 | 1.447 ± 0.016 | 99.64 | 1.608 ± 0.013 |
| 25 | 99.59 | 1.802 ± 0.023 | 99.55 | 1.847 ± 0.013 |
| 50 | 99.46 | 1.984 ± 0.021 | 99.51 | 1.831 ± 0.013 |
| 75 | 97.26 | 2.537 ± 0.031 | 99.52 | 1.852 ± 0.013 |
| 97.5 | 90.79 | 2.763 ± 0.039 | 99.51 | 1.827 ± 0.013 |

# Cosmic Rays Test – ACORDE bars

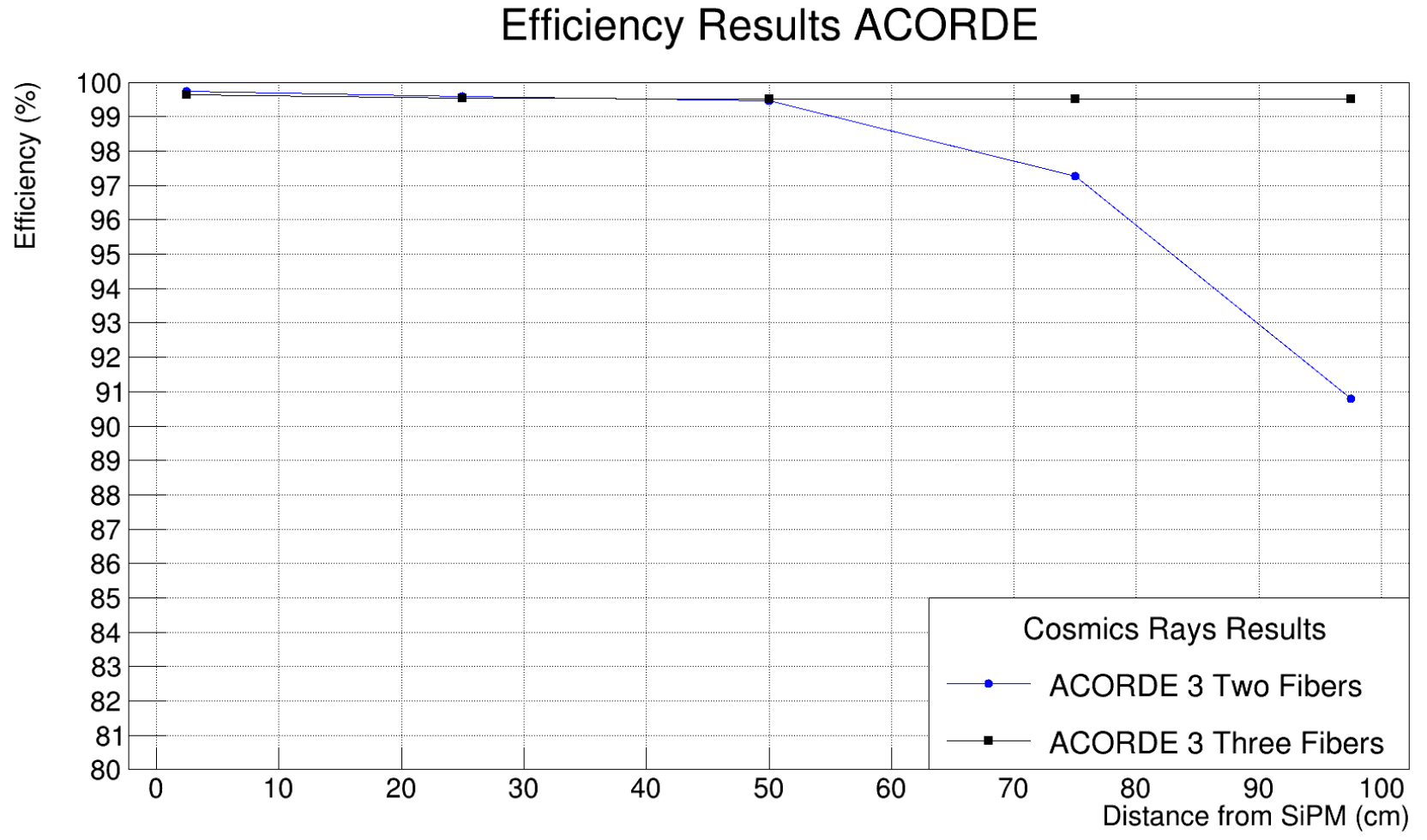



Figure 20. Cosmic Rays Test: ACORDE 3 – Efficiency Results

# Cosmic Rays Test – ACORDE bars

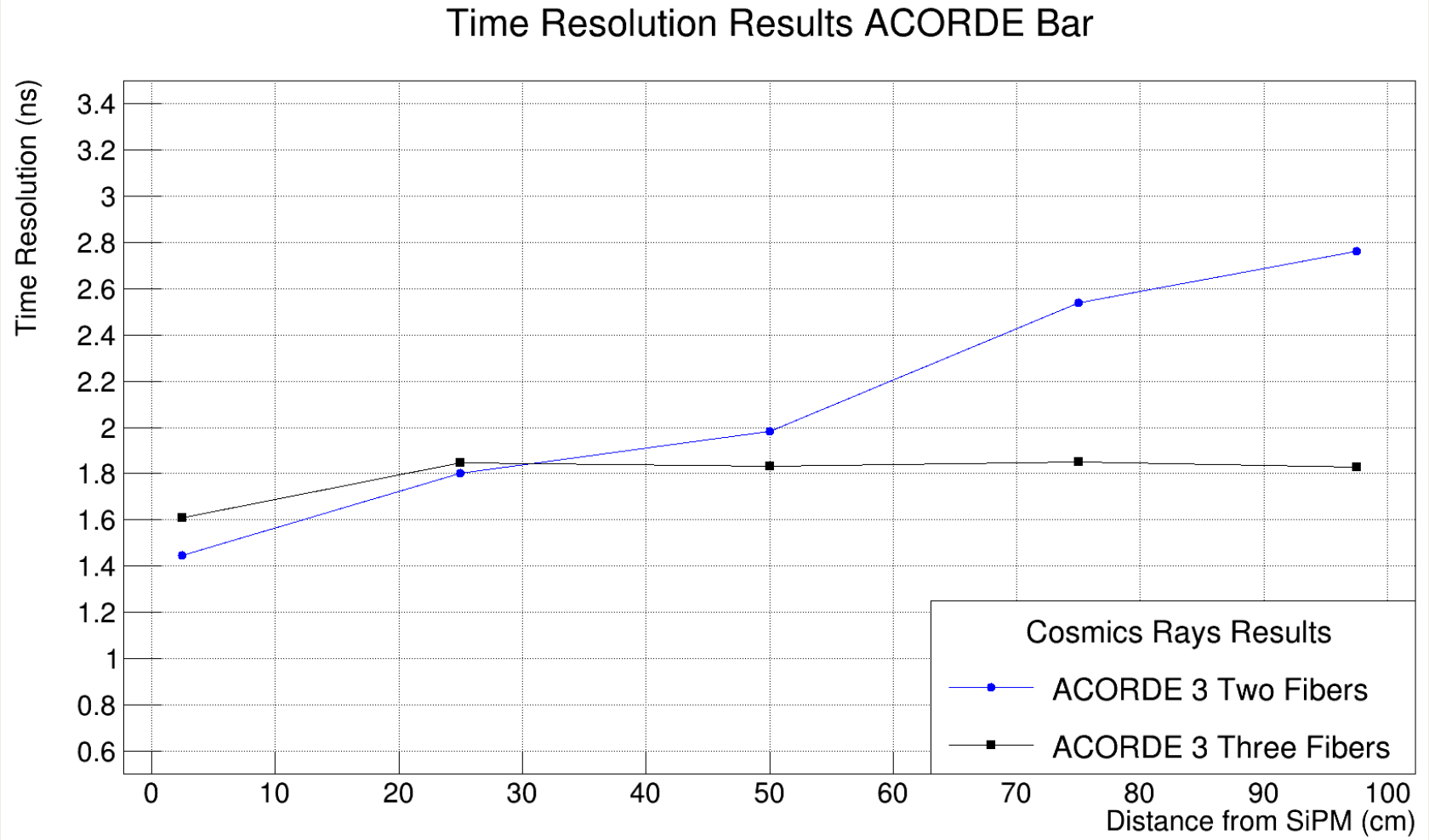



Figure 21. Cosmic Rays Test: ACORDE 3 – Time Resolution Results

# Cosmic Rays Test – ACORDE bars

Table 8. Cosmic Rays Test: ACORDE 3 amplitude and charge results varying number of fibers

| Distance from SiPM (cm) | ACORDE 3 with two WLS fibers | | | ACORDE 3 with three WLS fibers | | |
|---|---|---|---|---|---|---|
| | Amplitude (mV) | Charge (pC) | Photons (γ) | Amplitude (mV) | Charge (pC) | Photons (γ) |
| 2.5 | 55.02 ± 0.35 | 259.9 ± 2.4≈ | ≈ 62.12 | 44.27 ± 0.16 | 190.4 ± 2.5 | ≈ 45.51 |
| 25 | 41.03 ± 0.24 | 185.4 ± 2.1 | ≈ 44.31 | 35.43 ± 0.12 | 153.5 ± 1.8 | ≈ 36.69 |
| 50 | 35.32 ± 0.17 | 153.8 ± 1.6 | ≈ 36.76 | 34.22 ± 0.13 | 140.0 ± 1.6 | ≈ 33.46 |
| 75 | 22.09 ± 0.11 | 93.21 ± 1.8 | ≈ 22.28 | 34.20 ± 0.10 | 140.9 ± 1.6 | ≈ 33.67 |
| 97.5 | 16.89 ± 0.11 | 76.27 ± 1.1 | ≈ 18.23 | 31.82 ± 0.12 | 137.4 ± 1.6 | ≈ 32.84 |

# Cosmic Rays Test – ACORDE bars

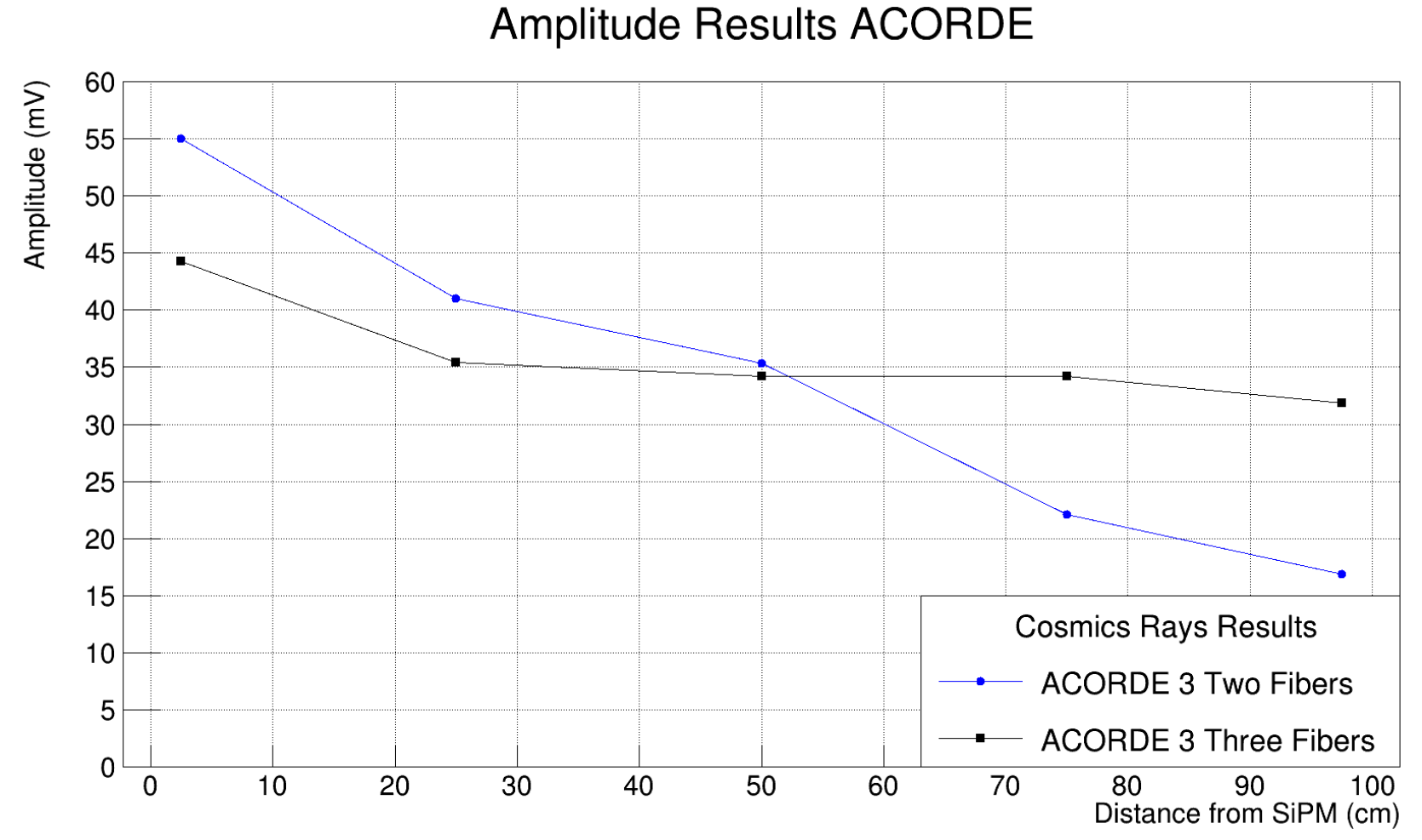



Figure 22. Cosmic Rays Test: ACORDE 3 – Amplitude Results

# Cosmic Rays Test – ACORDE bars

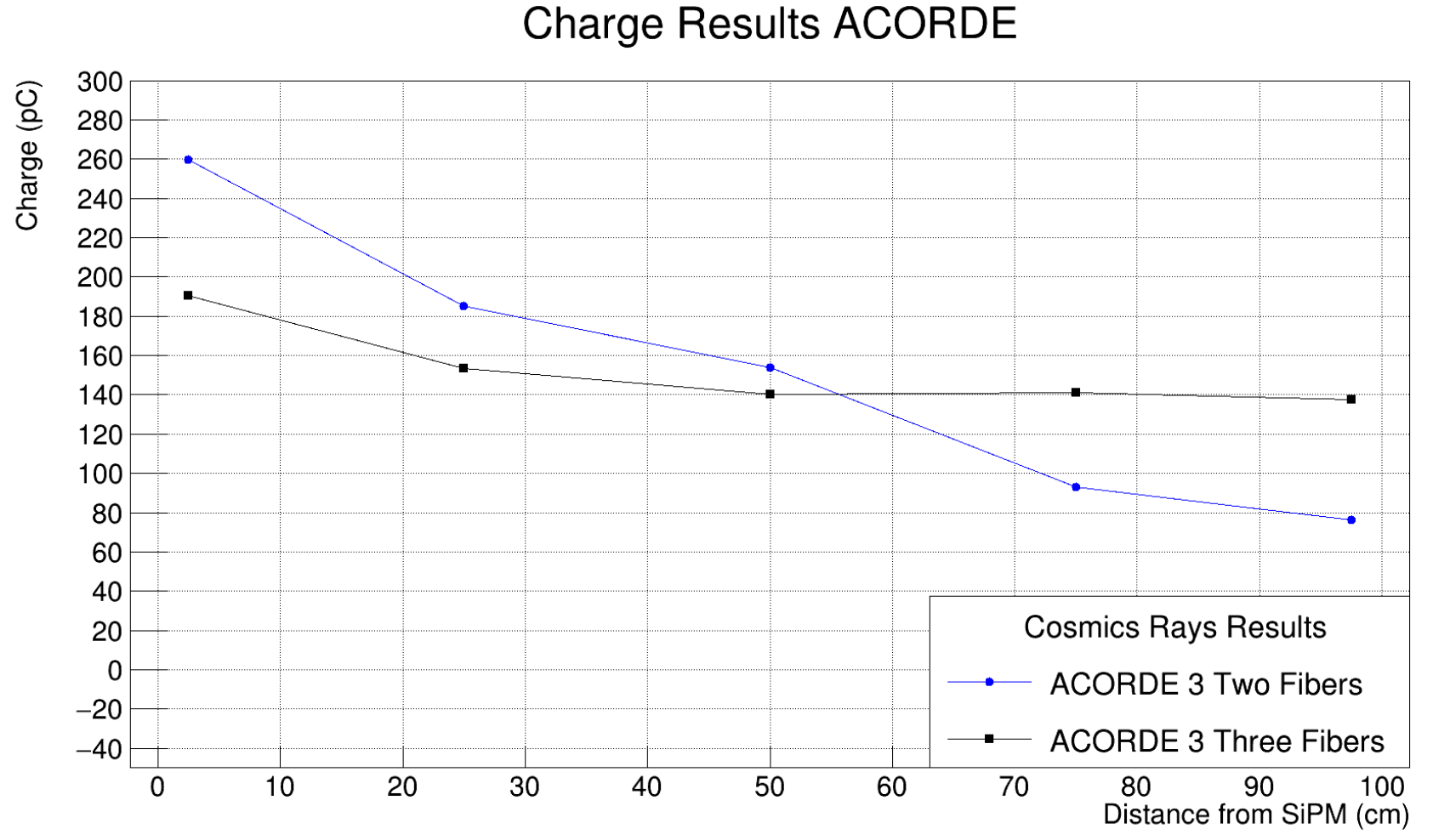



Figure 23. Cosmic Rays Test: ACORDE 3 – Charge Results

# Test Beam 2023 – Prototype

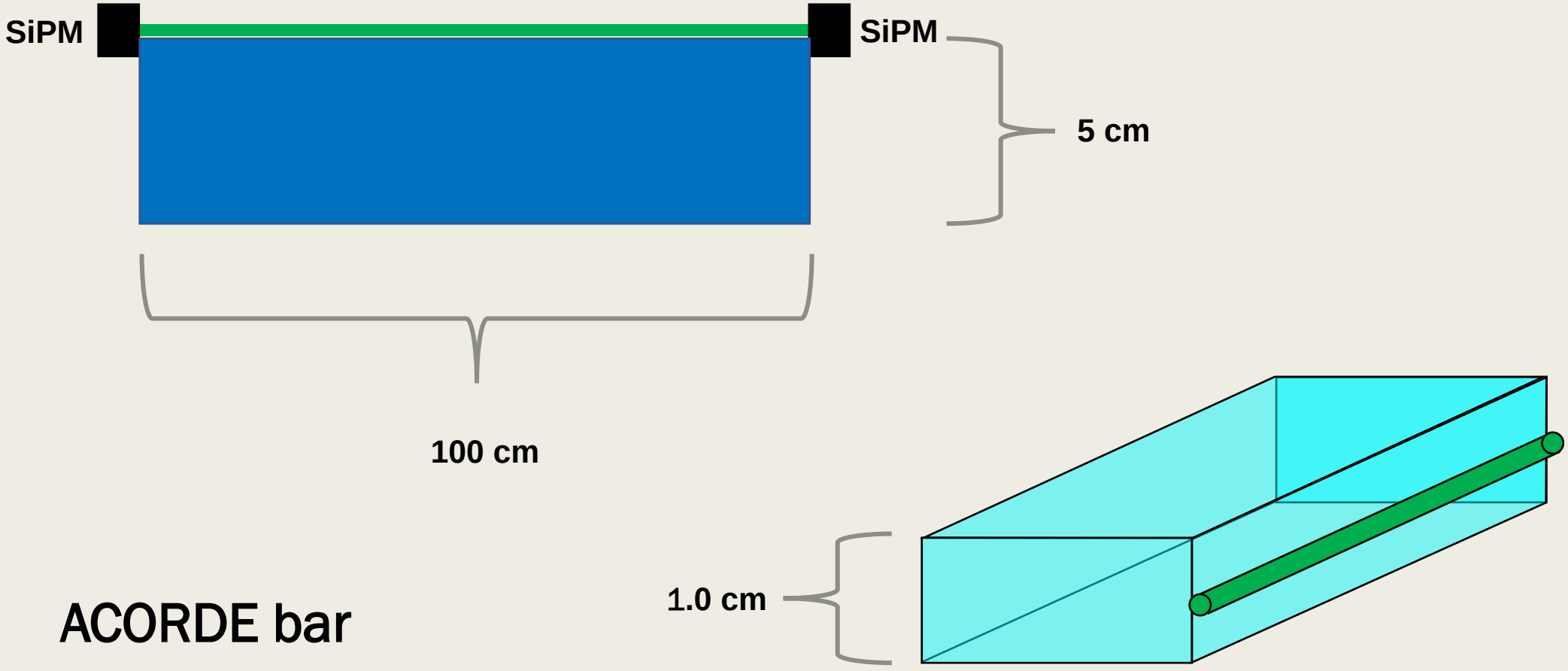



Figure 24. Test Beam 2023: ACORDE Bar Prototype.

# Test Beam 2023 – Trigger Connection Diagram

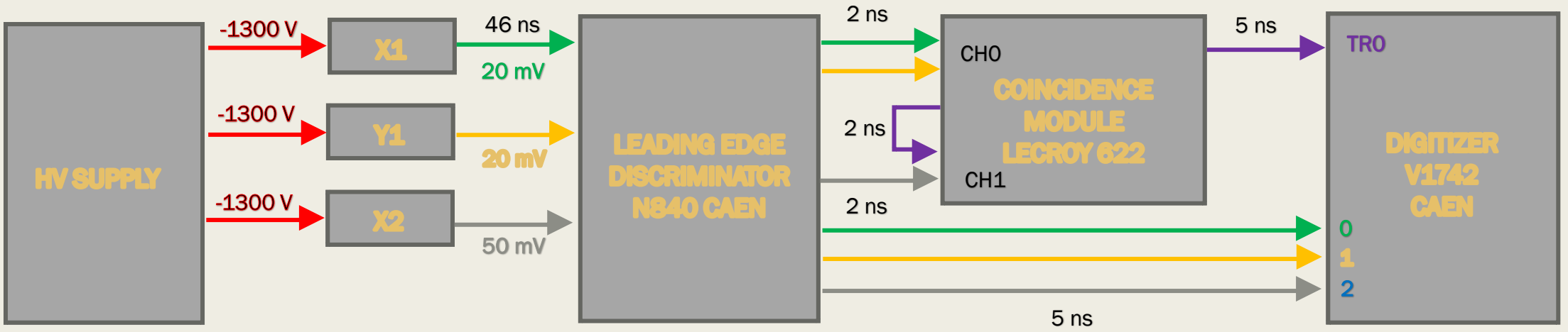



Figure 25. Test Beam 2023: Trigger connection diagram.

# Test Beam 2023 – Prototypes Connection Diagram

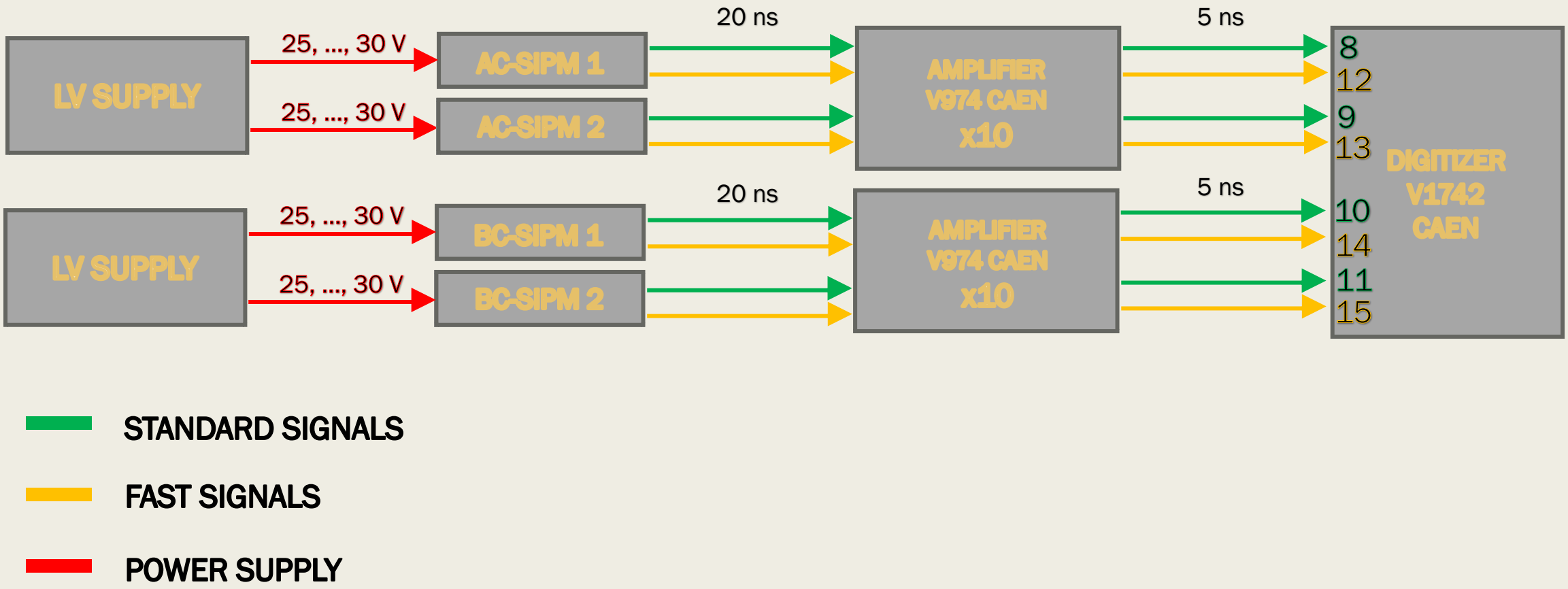
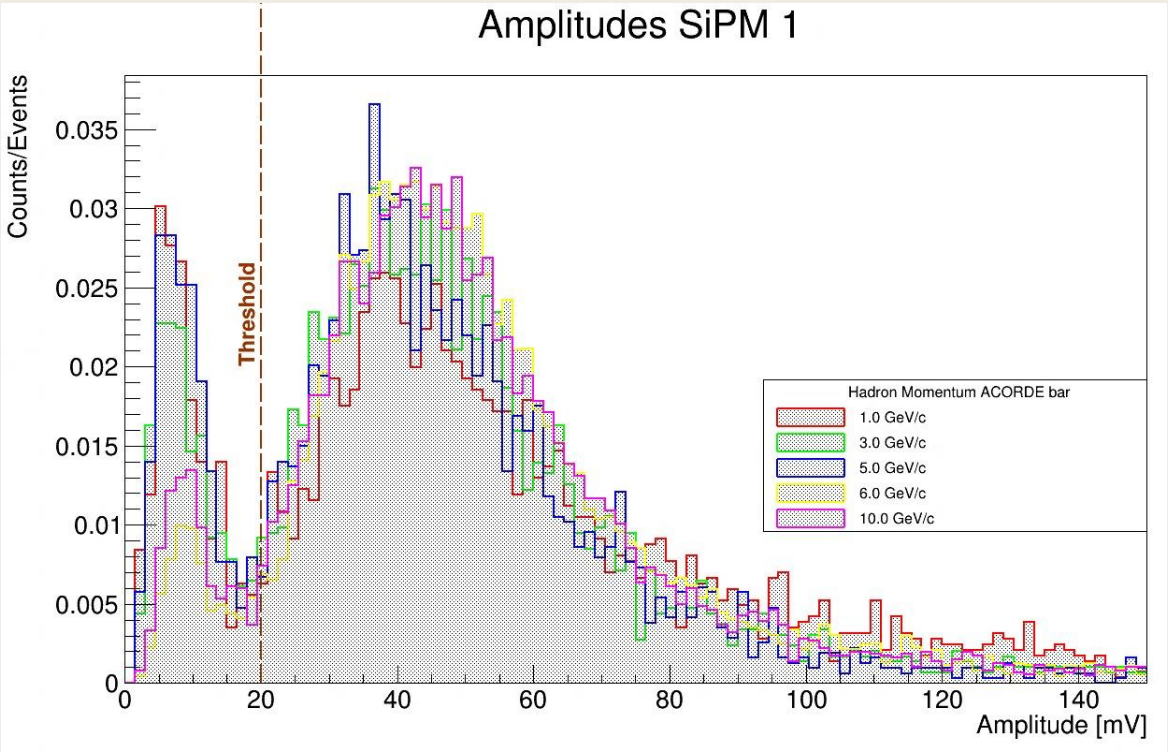



Figure 26. Test Beam 2023: Prototypes connection diagram.

# Test Beam 2023 – Pedestal



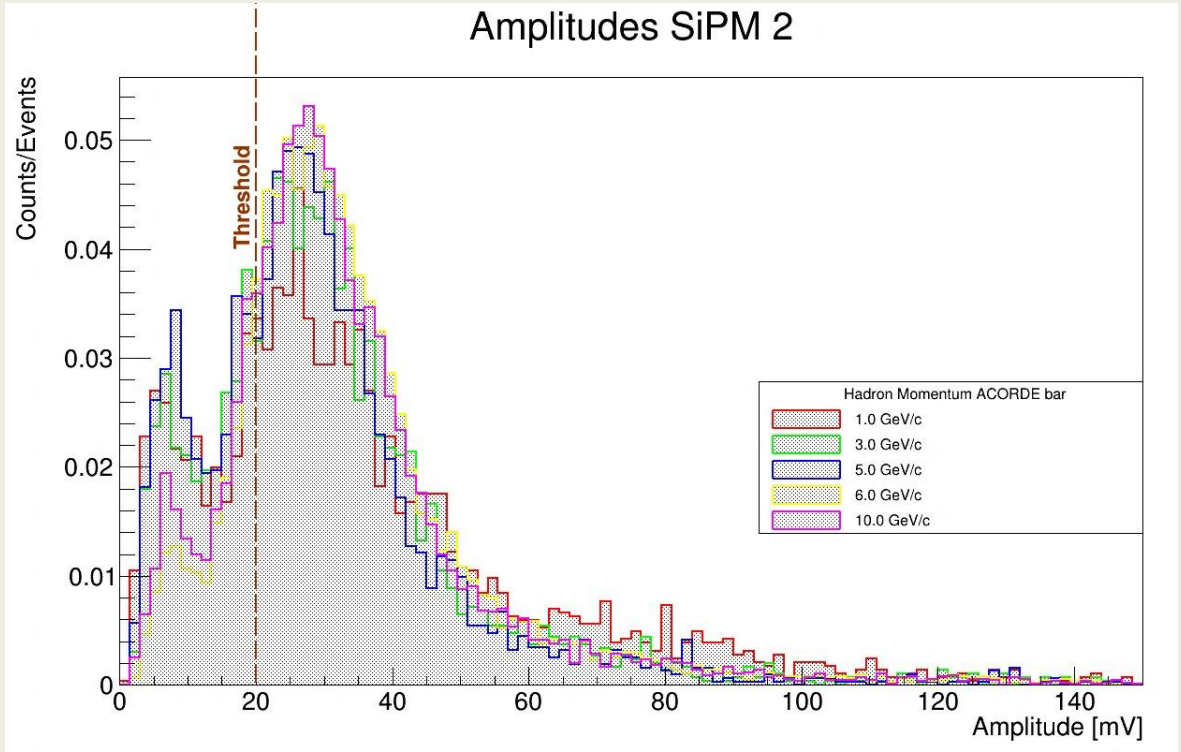




Figure 27. Test Beam 2023: Pedestal and Threshold Level.

# Test Beam 2023 – Results

Table 9. Test Beam 2023: ACORDE Horizontal Scan – Results

| Distance from SiPM (cm) | Efficiency (%) | | | Amplitude (mV) | | Charge (pC) | | Time resolution (ns) | |
|---|---|---|---|---|---|---|---|---|---|
| | SiPM1 | SiPM2 | SiPM1 \|\| SIPM 2 | SiPM1 | SiPM2 | SiPM1 | SiPM2 | SiPM1 | SiPM2 |
| 10 | 98.76 | 93.85 | 99.62 | 56.06 ± 0.27 | 36.21 ± 0.23 | 246.9 ± 1.4 | 174.9 ± 1.4 | 1.451 ± 0.019 | 1.802 ± 0.028 |
| 30 | 97.12 | 86.59 | 99.30 | 42.62 ± 0.21 | 29.92 ± 0.19 | 178.5 ± 1.1 | 142.6 ± 1.1 | 1.759 ± 0.025 | 1.972 ± 0.030 |
| 50 | 95.49 | 82.65 | 99.41 | 39.40 ± 0.20 | 26.90 ± 0.11 | 164.1 ± 1.0 | 125.3 ± 0.7 | 1.913 ± 0.025 | 2.083 ± 0.029 |
| 70 | 93.21 | 75.88 | 99.37 | 37.37 ± 0.25 | 25.40 ± 0.10 | 156.5 ± 1.3 | 116.2 ± 0.8 | 2.049 ± 0.031 | 2.138 ± 0.034 |
| 90 | 89.78 | 70.84 | 99.17 | 36.62 ± 0.26 | 24.64 ± 0.15 | 153.5 ± 1.4 | 114.6 ± 0.8 | 1.973 ± 0.032 | 2.106 ± 0.039 |

# Test Beam 2023 – Results

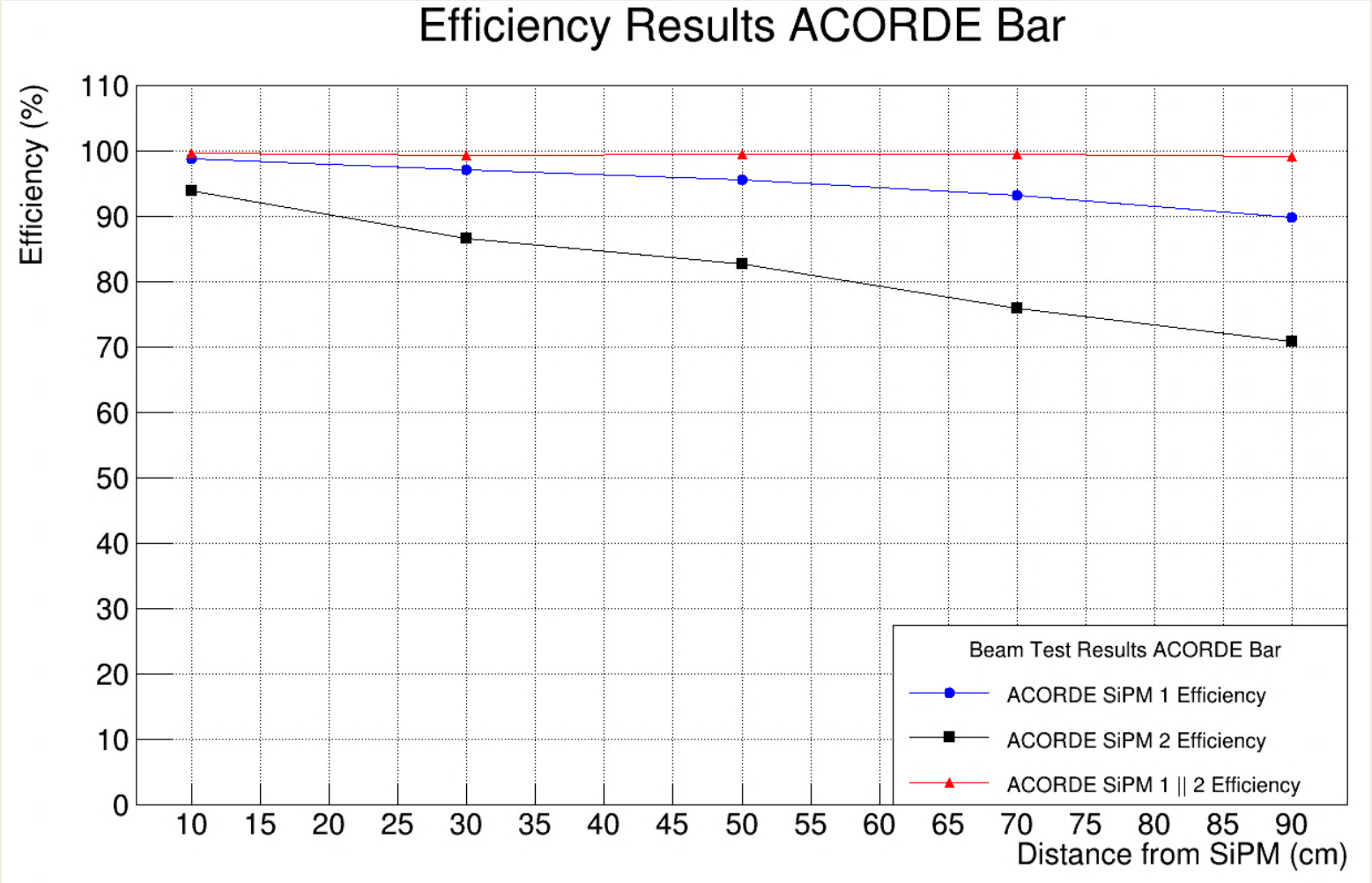



Figure 28. Test Beam 2023: ACORDE Bar Horizontal Scan – Efficiency Results.

# Test Beam 2023 – Results

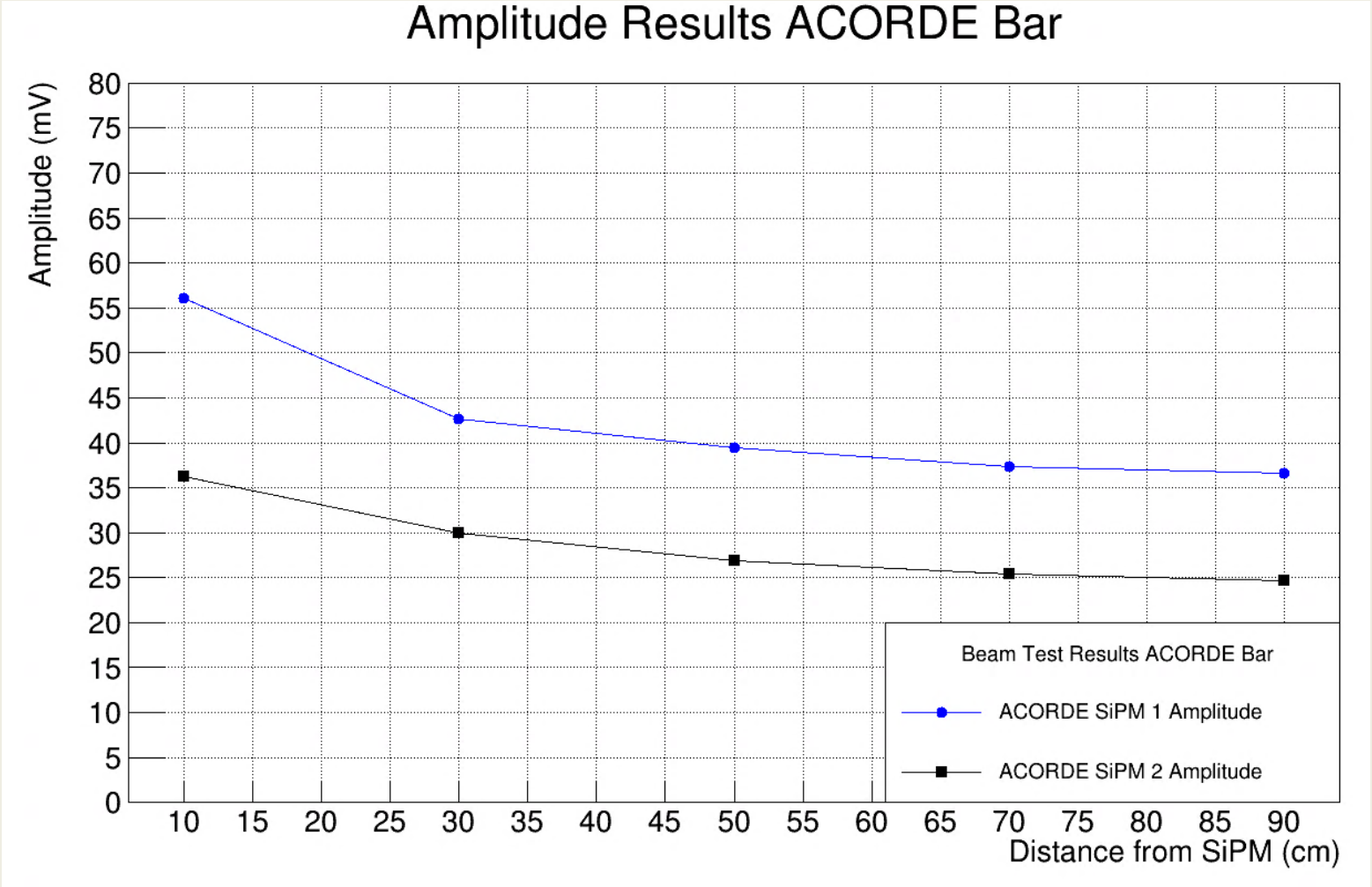



Figure 29. Test Beam 2023: ACORDE Bar Horizontal Scan – Amplitude Results.

# Test Beam 2023 – Results

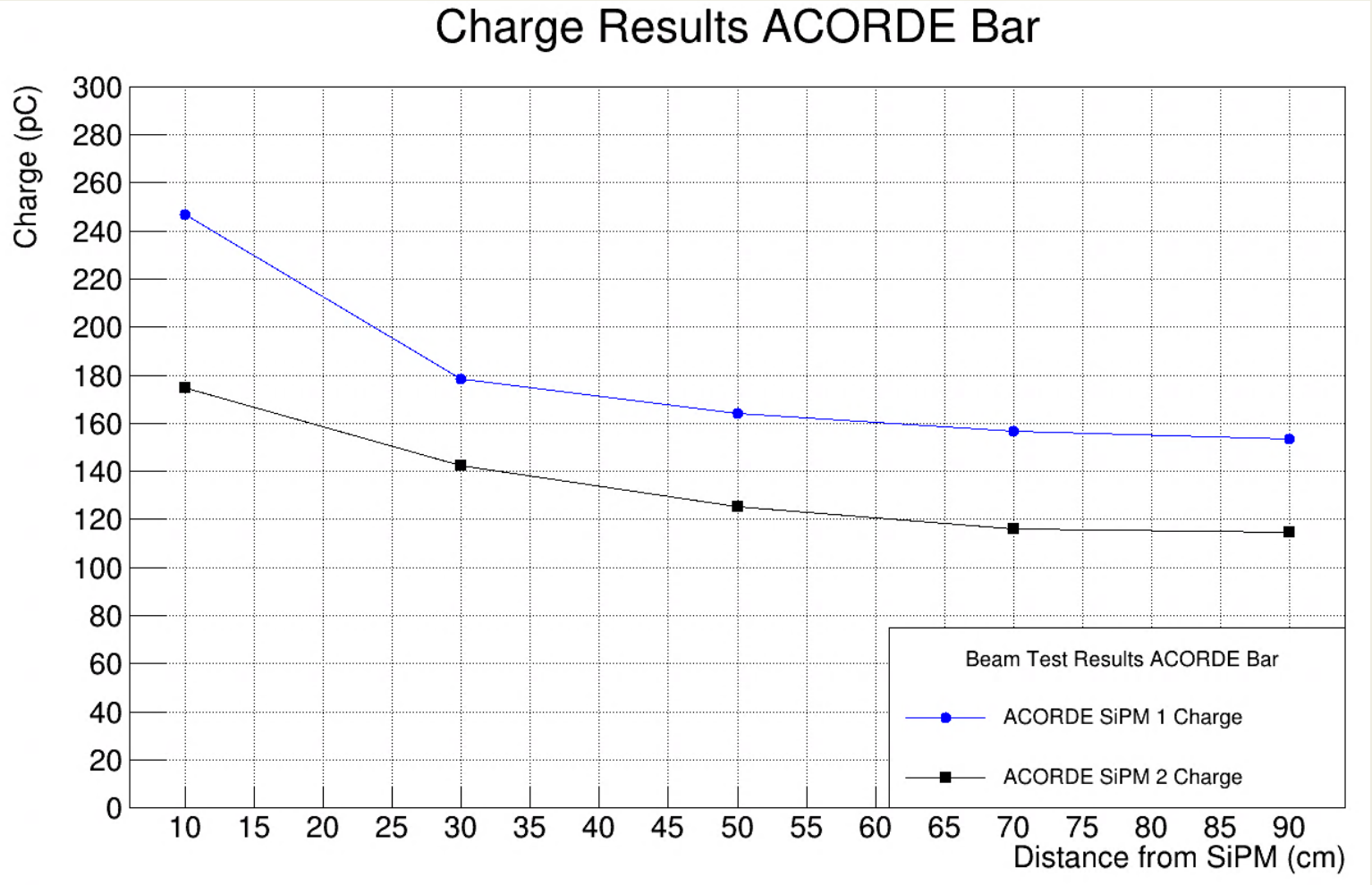
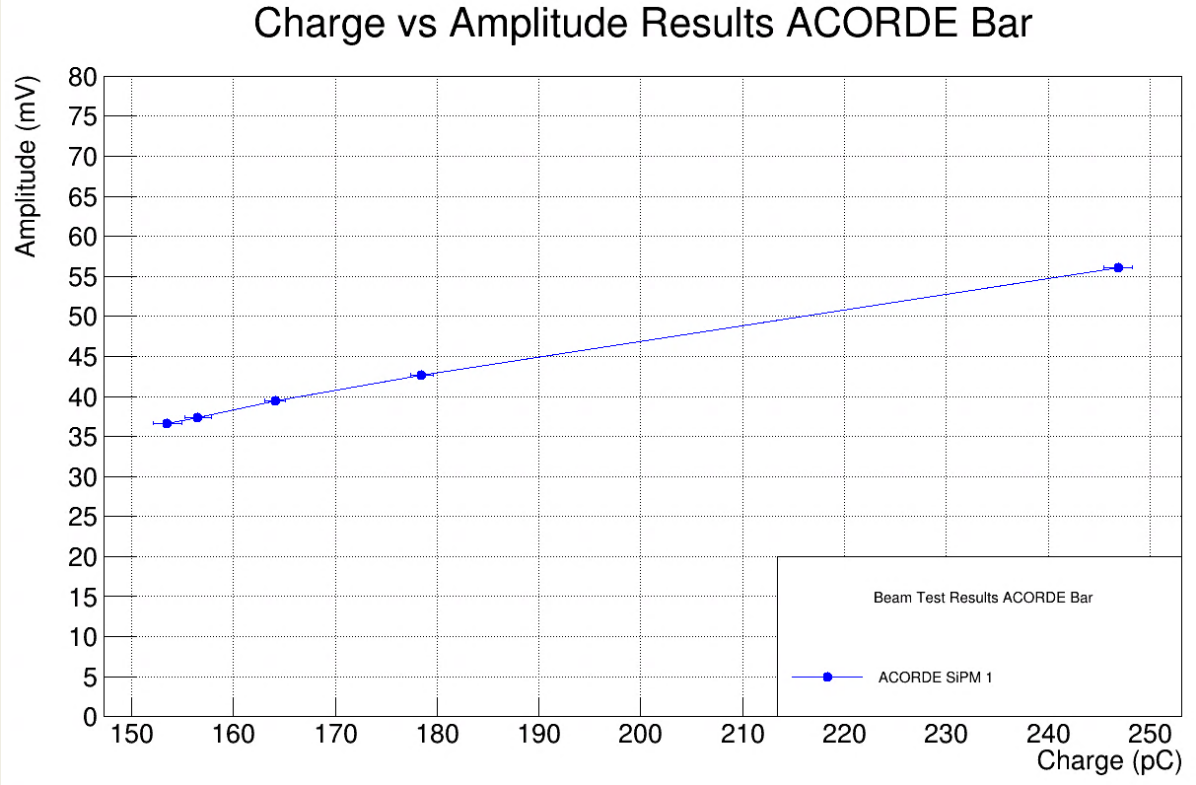



Figure 30. Test Beam 2023: ACORDE Bar Horizontal Scan – Charge Results.

# Test Beam 2023 – Results



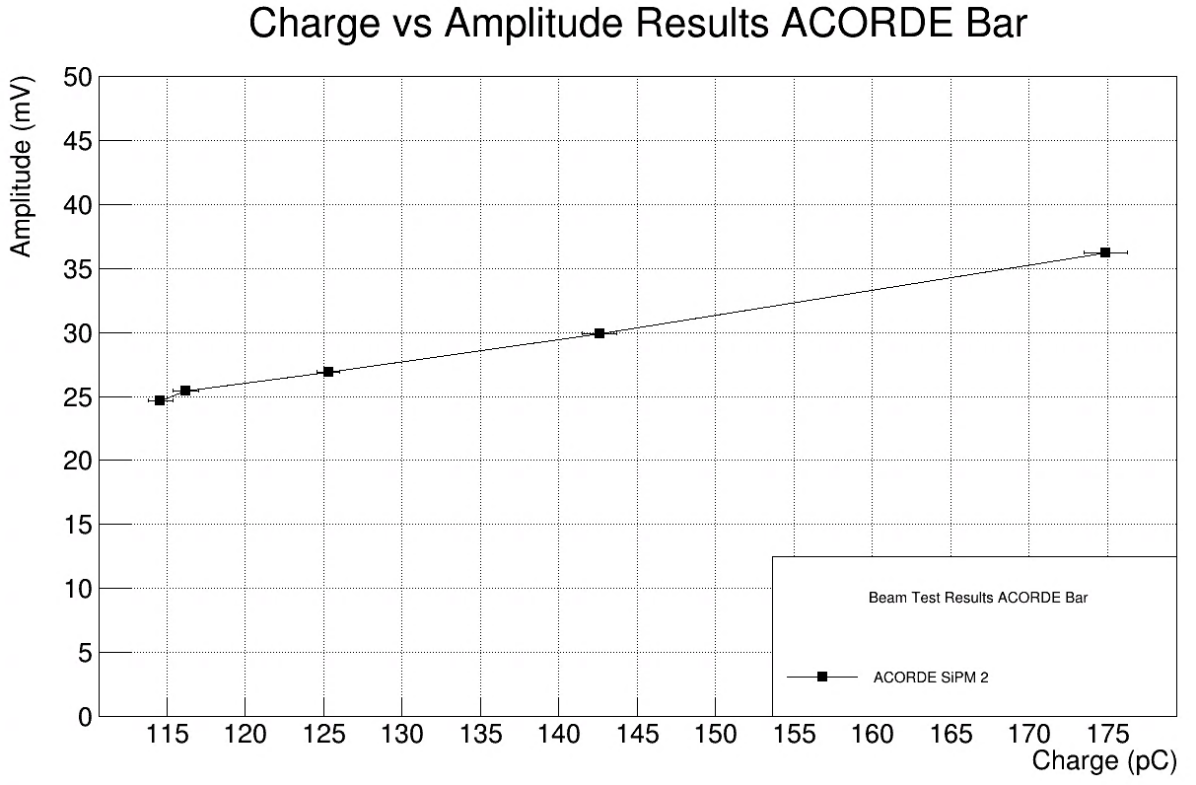




Figure 31. Test Beam 2023: ACORDE Bar Horizontal Scan – Amplitude vs Charge Results.

# Test Beam 2023 – Results

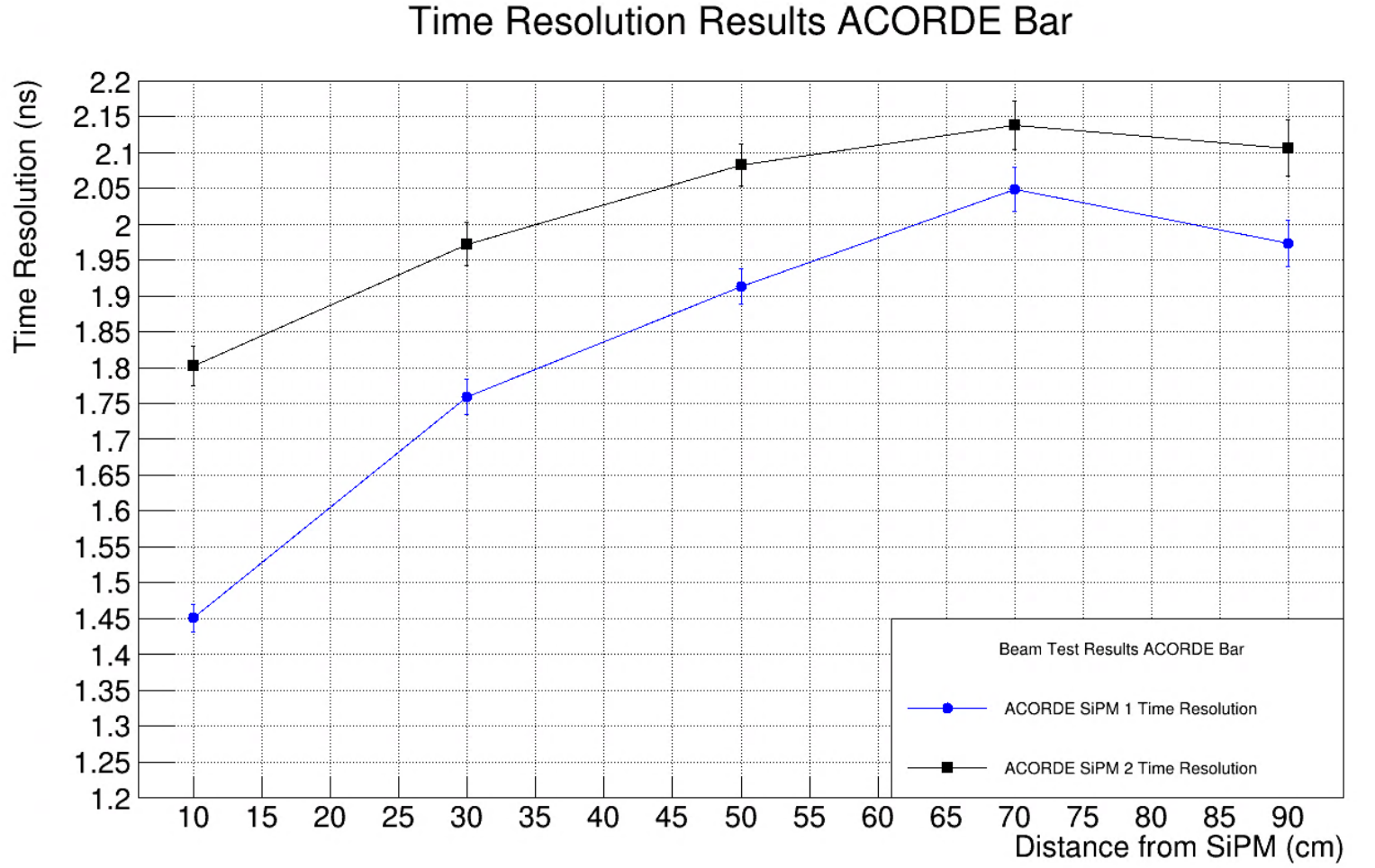



Figure 32. Test Beam 2023: ACORDE Bar Horizontal Scan – Time Resolution Results.

# Test Beam 2023 – Results

Table 10. Test Beam 2023: ACORDE Energy Scan – Efficiency Results

| Momentum (GeV/c) | Efficiency (%) |
|---|---|
| | SiPM1 \|\| SIPM 2 |
| 1 | 98.90 |
| 3 | 99.61 |
| 5 | 99.12 |
| 6 | 99.41 |
| 10 | 99.03 |

# Test Beam 2023 – Results


Figure 33. Test Beam 2023: ACORDE Bar – Energy Scan – Efficiency Results.

# Selection Criteria

- Criterion 1:

The SiPM sensor pulses start times must be less than the PMT Up and Down pulse start times.

- Where:
  - $t_1$-> PMT Up pulse time.
  - $t_2$-> PMT Down pulse time.
  - $t_3$-> SiPM pulse time.

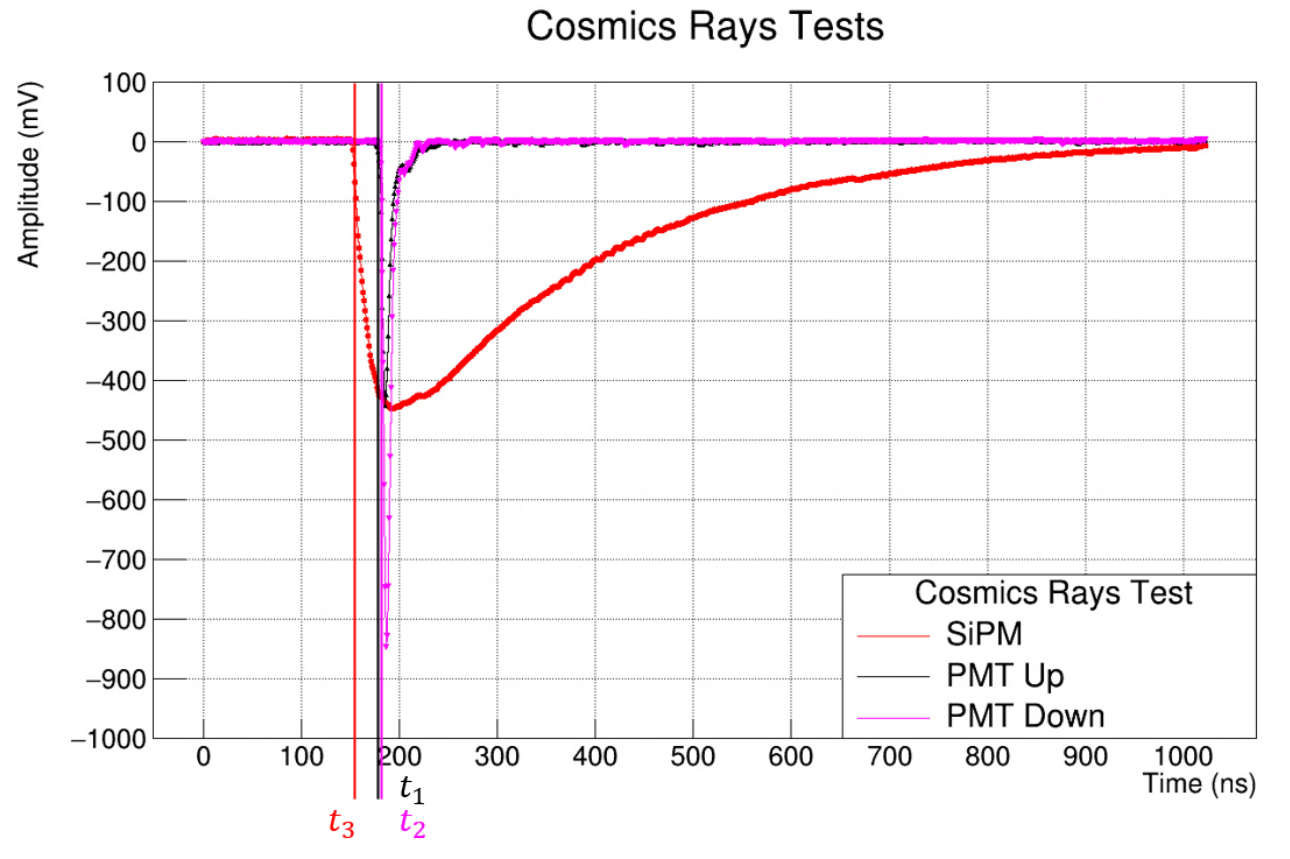



Figure 34. Selection criterion 1 for the digitizer.

# Selection Criteria

- Criterion 2:

The pulse width for the SiPM standard signal must be greater than 100 ns and less than 800 ns.

- Where:
  - t3-> SiPM first time.
  - t4-> SiPM second time.

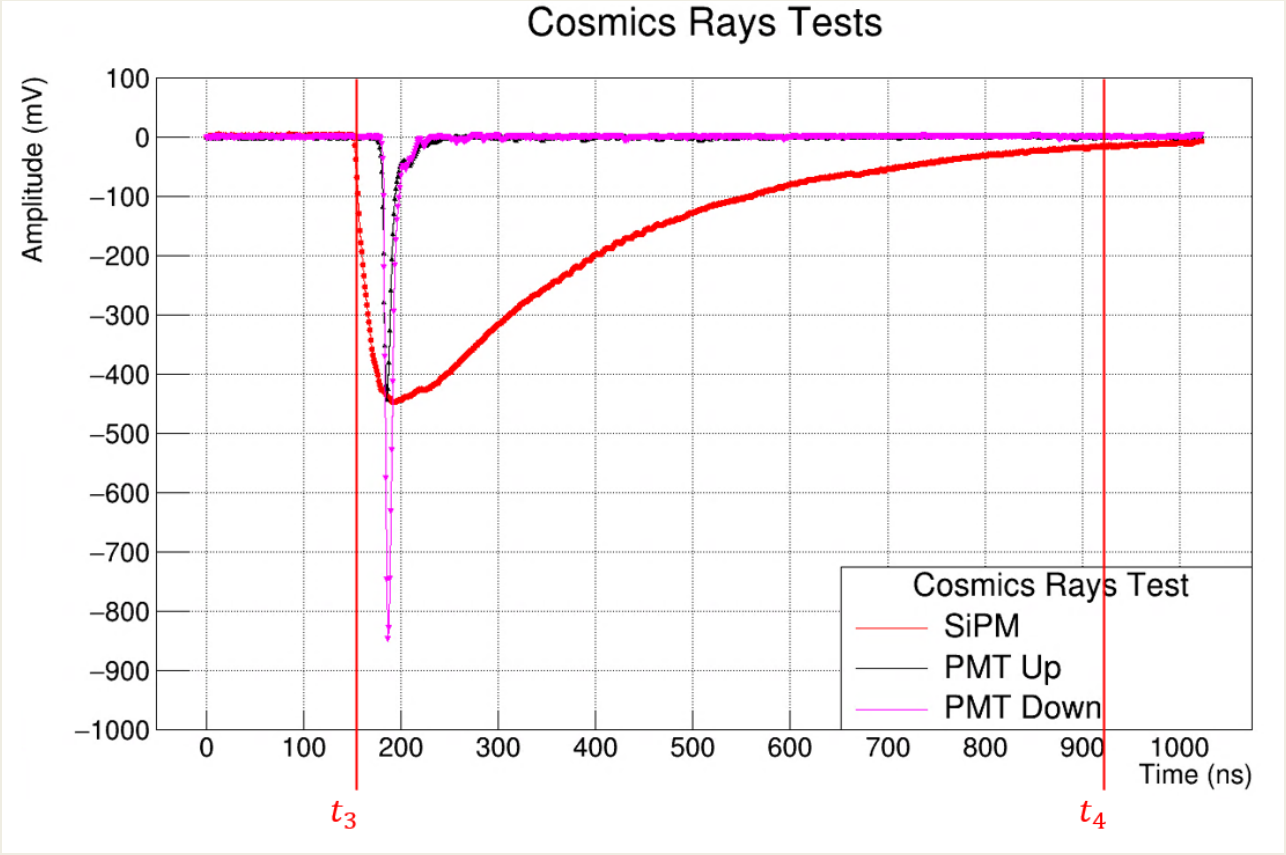



Figure 35. Selection criterion 2 for the digitizer.

# Selection Criteria

- Criterion 3:

The pulse area of the standard signal from the SiPM ought to be positive; any negative values are attributed to electronic noise or baseline fluctuations, which were subsequently excluded.

- Where:
  - area -> SiPM charge.

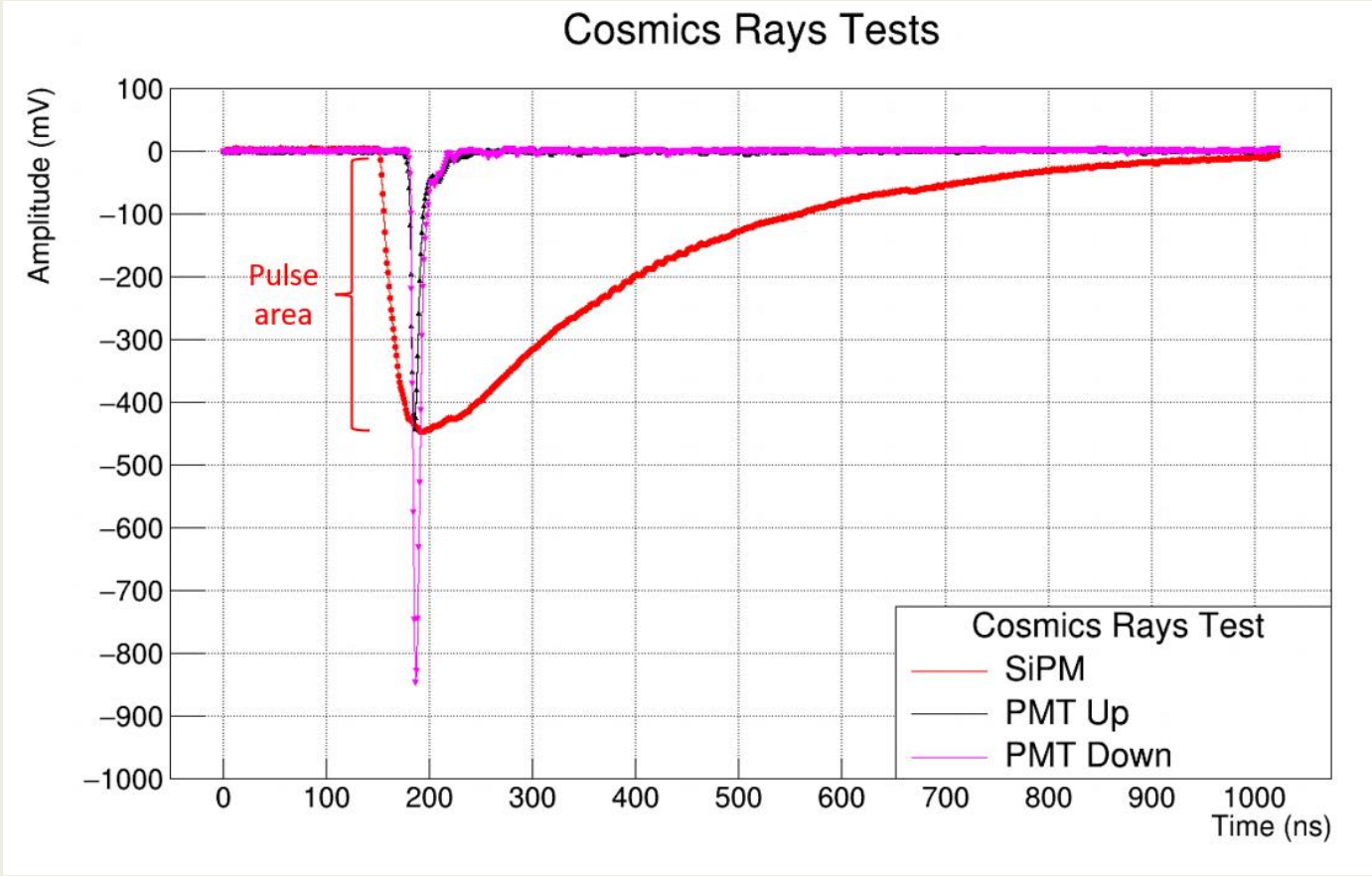



Figure 36. Selection criterion 3 for the digitizer.

# Selection Criteria

- Criterion 4:

The events of greatest interest are within the average of the PMT charges, giving a radius around the average of 10 pC.

Within the red circle, the events of interest will be considered for the analysis of the time resolution and the efficiency of the SiPM detectors.

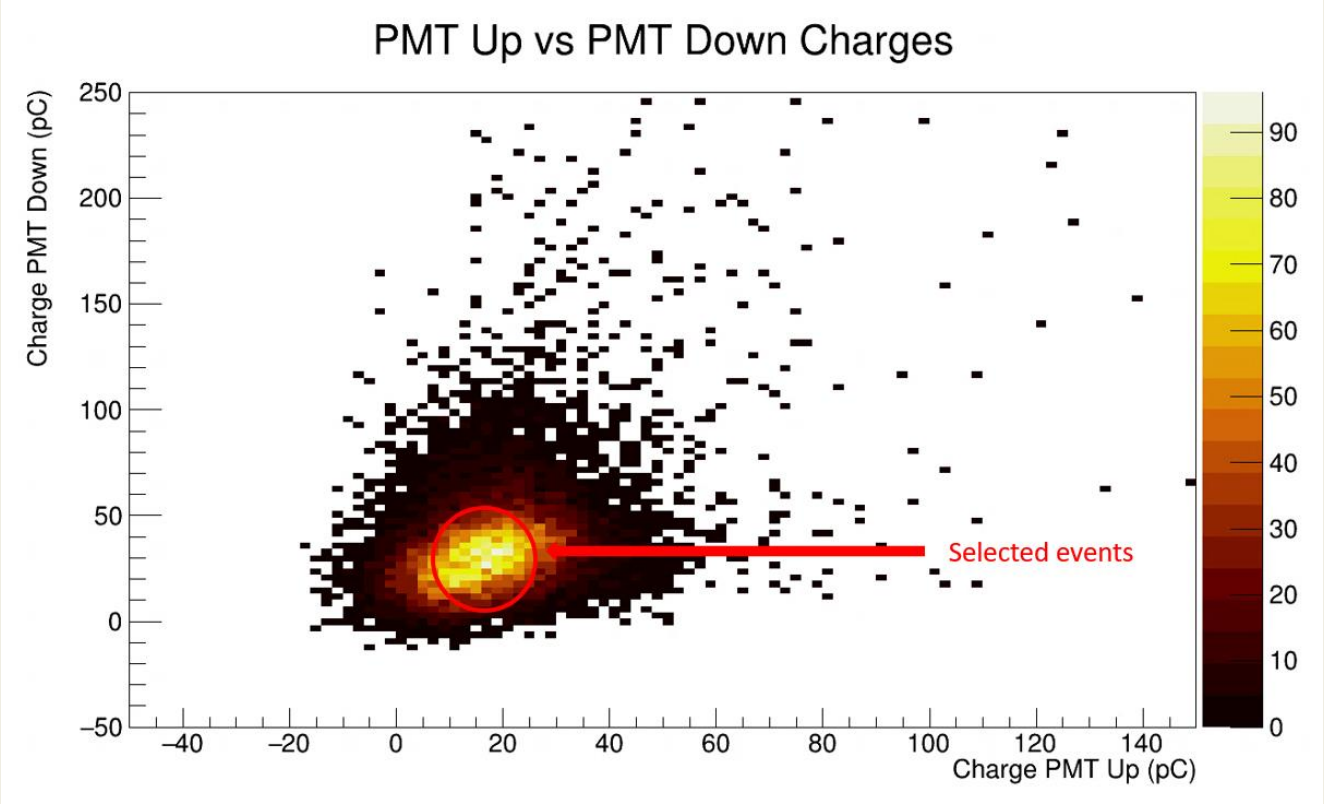



Figure 37. Selection criterion 4 for the digitizer..

# Selection Criteria

- Criterion 5:

The SiPM sensor pulses must exhibit a pulse amplitude above the pedestal to be considered as valid. Any pulse within the pedestal range of amplitudes will be excluded.

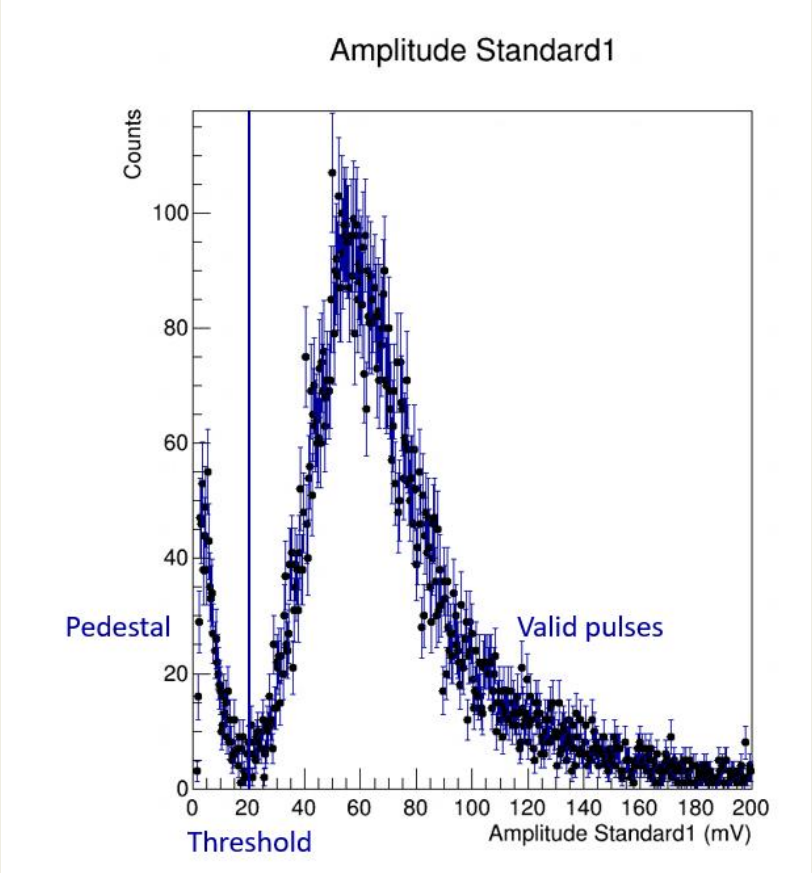



Figure 38. Selection criterion 5 for the digitizer..

# Selection Criteria

Without selection criteria

With selection criteria

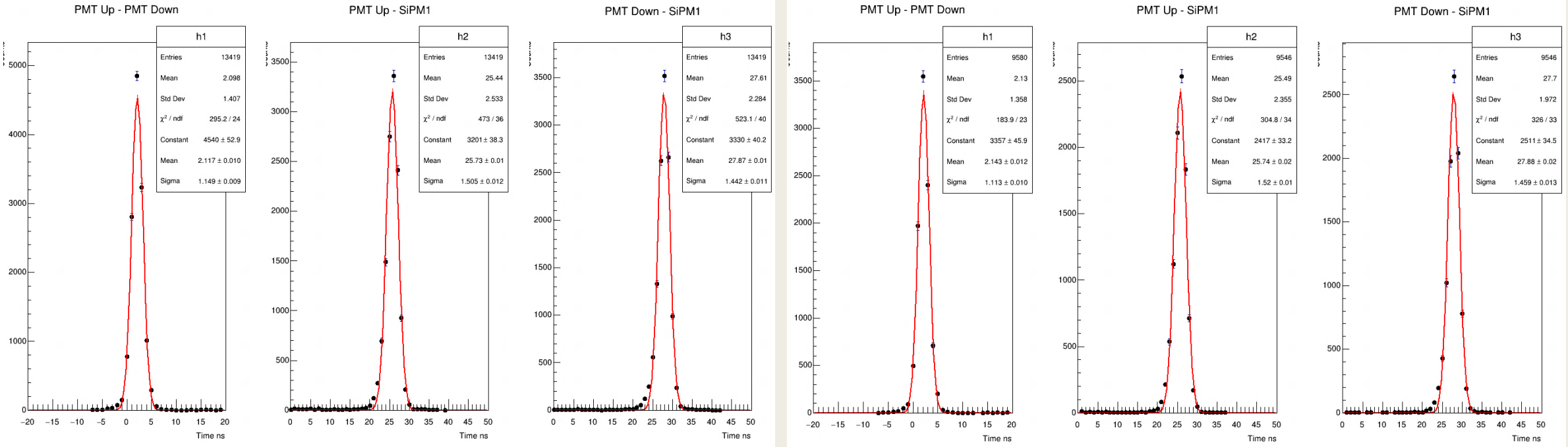
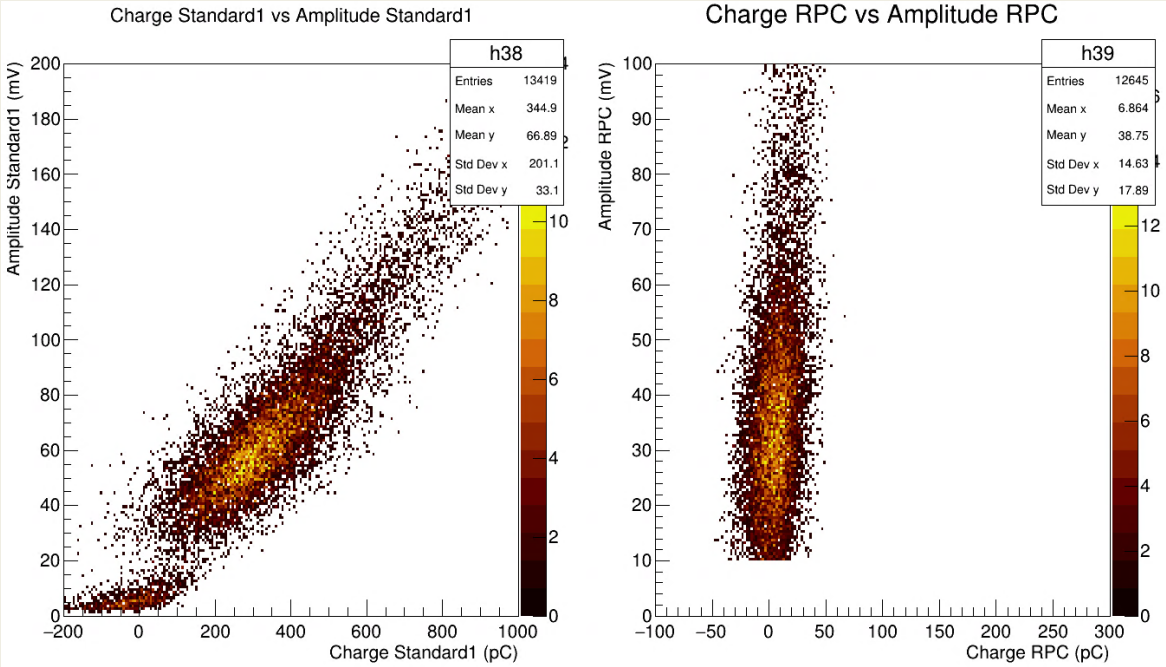



Figure 39. Time resolution comparison without selection criteria and with selection criteria.

# Selection Criteria

## Without selection criteria




## With selection criteria

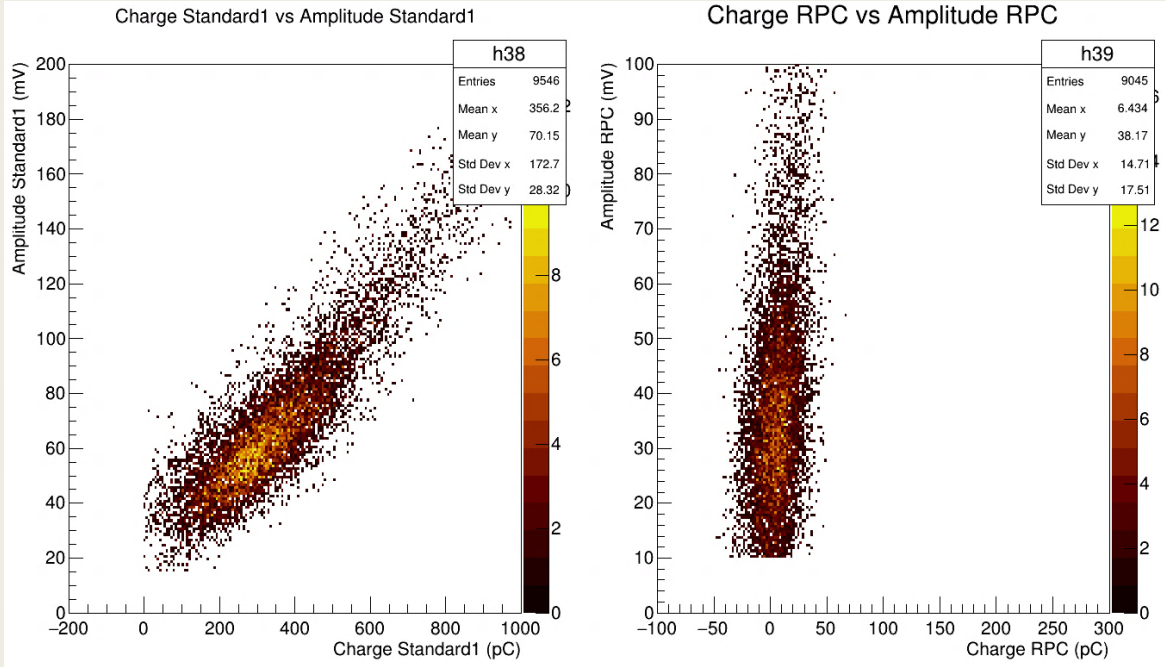



Figure 40. Charges comparison without selection criteria and with selection criteria.

# ACORDE Results – Pions 6 GeV

Table 11. Test Beam 2024: ACORDE Bars – Vertical Scan – Efficiency Preliminary Results.

| Y Position (cm) | ACORDE 1 | ACORDE 2 | ACORDE 3 | ACORDE 4 | ACORDE 5 |
|---|---|---|---|---|---|
| | Efficiency (%) | Efficiency (%) | Efficiency (%) | Efficiency (%) | Efficiency (%) |
| 6.25 | 33.15 | 6.51 | 6.36 | 17.35 | 4.61 |
| 8.25 | 78.66 | 7.55 | 6.57 | 60.80 | 5.12 |
| 10.25 | 82.47 | 10.56 | 6.90 | 74.94 | 7.99 |
| 12.25 | 46.16 | 38.70 | 11.17 | 34.34 | 44.14 |
| 14.25 | 11.26 | 81.51 | 9.40 | 9.59 | 74.71 |
| 16.25 | 9.06 | 76.50 | 19.22 | 7.48 | 67.33 |
| 18.25 | 7.62 | 24.46 | 74.39 | 6.97 | 12.03 |
| 20.25 | 7.01 | 8.14 | 82.01 | 6.92 | 5.21 |
| 22.25 | 7.05 | 6.79 | 41.23 | 6.63 | 4.87 |

# ACORDE Results – Pions 6 GeV

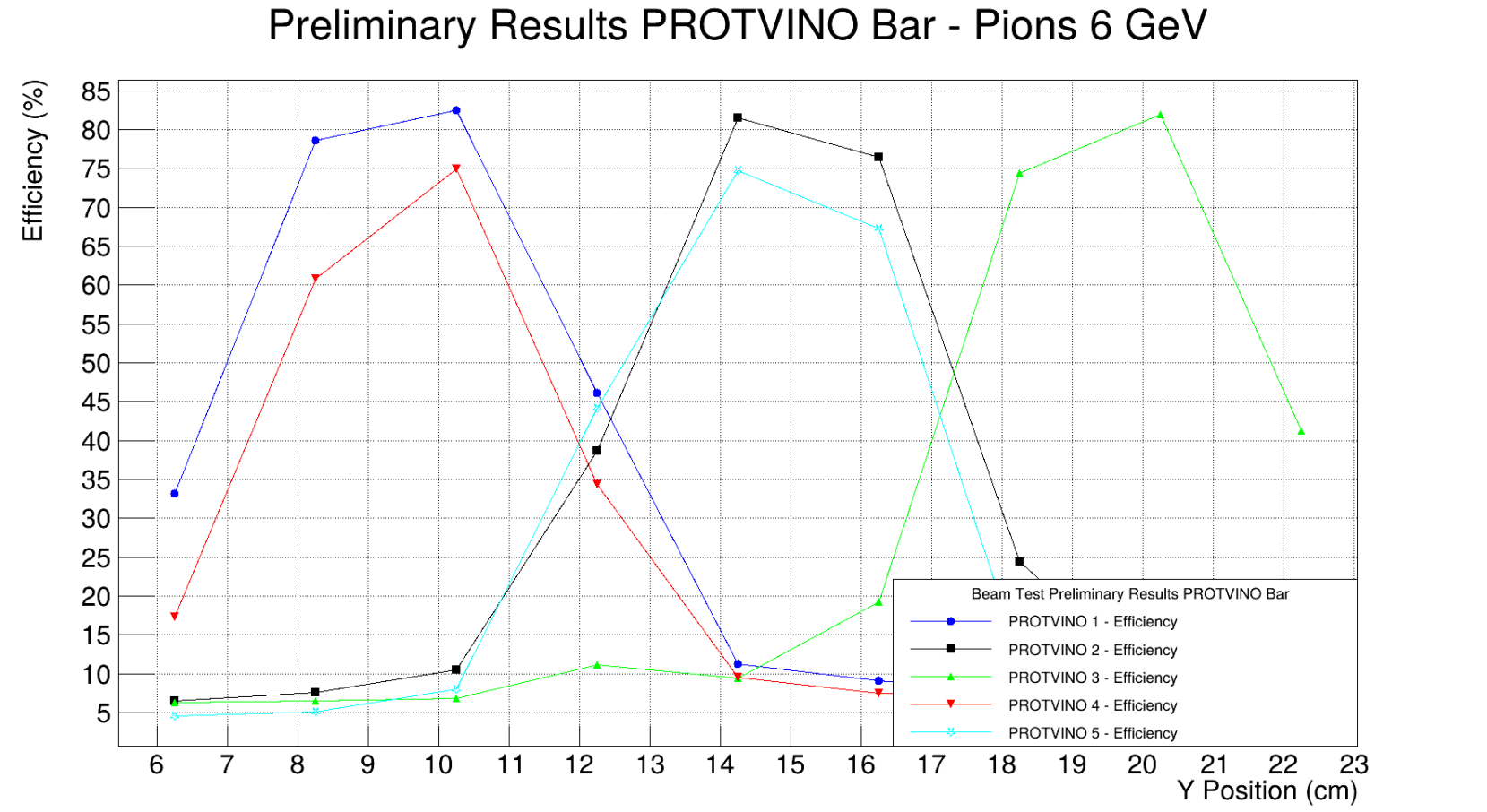



Figure 41. Test Beam 2024: ACORDE Bars – Vertical Scan – Efficiency Preliminary Results.

# ACORDE Results – Pions 6 GeV

Table 12. Test Beam 2024: ACORDE Bars – Horizontal Scan – Efficiency Preliminary Results.

| X Position (cm) | ACORDE 1 | ACORDE 2 | ACORDE 3 | ACORDE 4 | ACORDE 5 |
|---|---|---|---|---|---|
| | Efficiency (%) | Efficiency (%) | Efficiency (%) | Efficiency (%) | Efficiency (%) |
| 0.075 | 9.01 | 76.04 | 12.19 | 8.35 | 75.03 |
| 10.075 | 11.00 | 75.74 | 12.01 | 8.77 | 73.54 |
| 20.075 | 10.87 | 75.84 | 12.01 | 9.65 | 73.96 |
| 22.075 | 10.14 | 76.31 | 11.49 | 8.90 | 74.33 |
| 24.075 | 10.29 | 76.62 | 12.62 | 9.09 | 74.13 |
| 34.075 | 12.04 | 76.19 | 12.89 | 9.68 | 73.32 |
| 44.075 | 9.07 | 76.23 | 12.33 | 9.49 | 74.50 |

# ACORDE Results – Pions 6 GeV

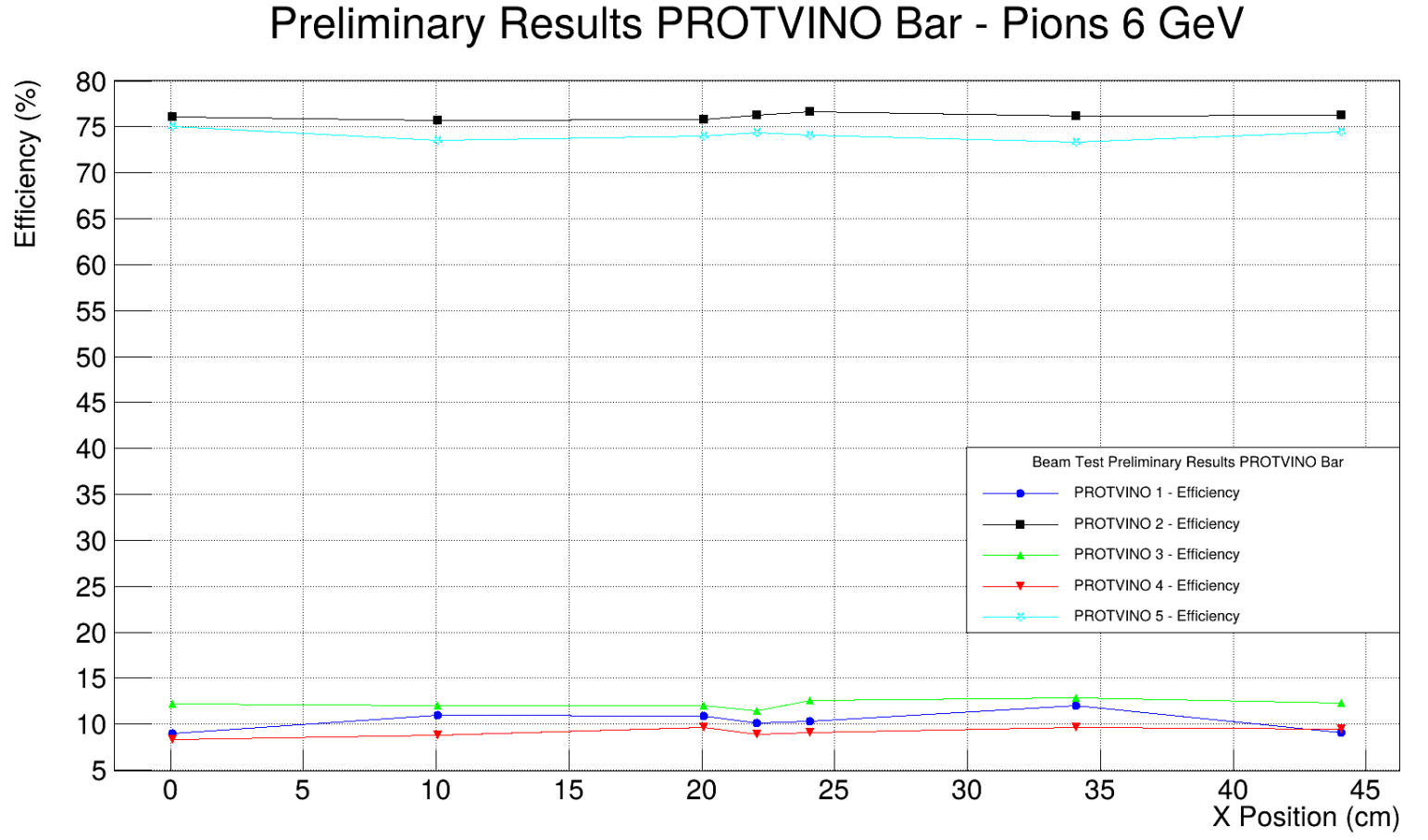



Figure 42. Test Beam 2024: ACORDE Bars – Horizontal Scan – Efficiency Preliminary Results.

# ACORDE Results – Pions 6 GeV

Table 13. Test Beam 2024: ACORDE Bars – Voltage Scan – Efficiency Preliminary Results.

| Voltage (V) | ACORDE 5 | |
|---|---|---|
| | Efficiency (%) | Time Resolution (ns) |
| 26 | 11.20 | 4.033 ± 0.073 |
| 27 | 68.33 | 3.379 ± 0.028 |
| 28 | 93.19 | 3.065 ± 0.020 |
| 29 | 99.29 | 2.763 ± 0.017 |
| 30 | 99.65 | 2.612 ± 0.017 |

# ACORDE Results – Pions 6 GeV

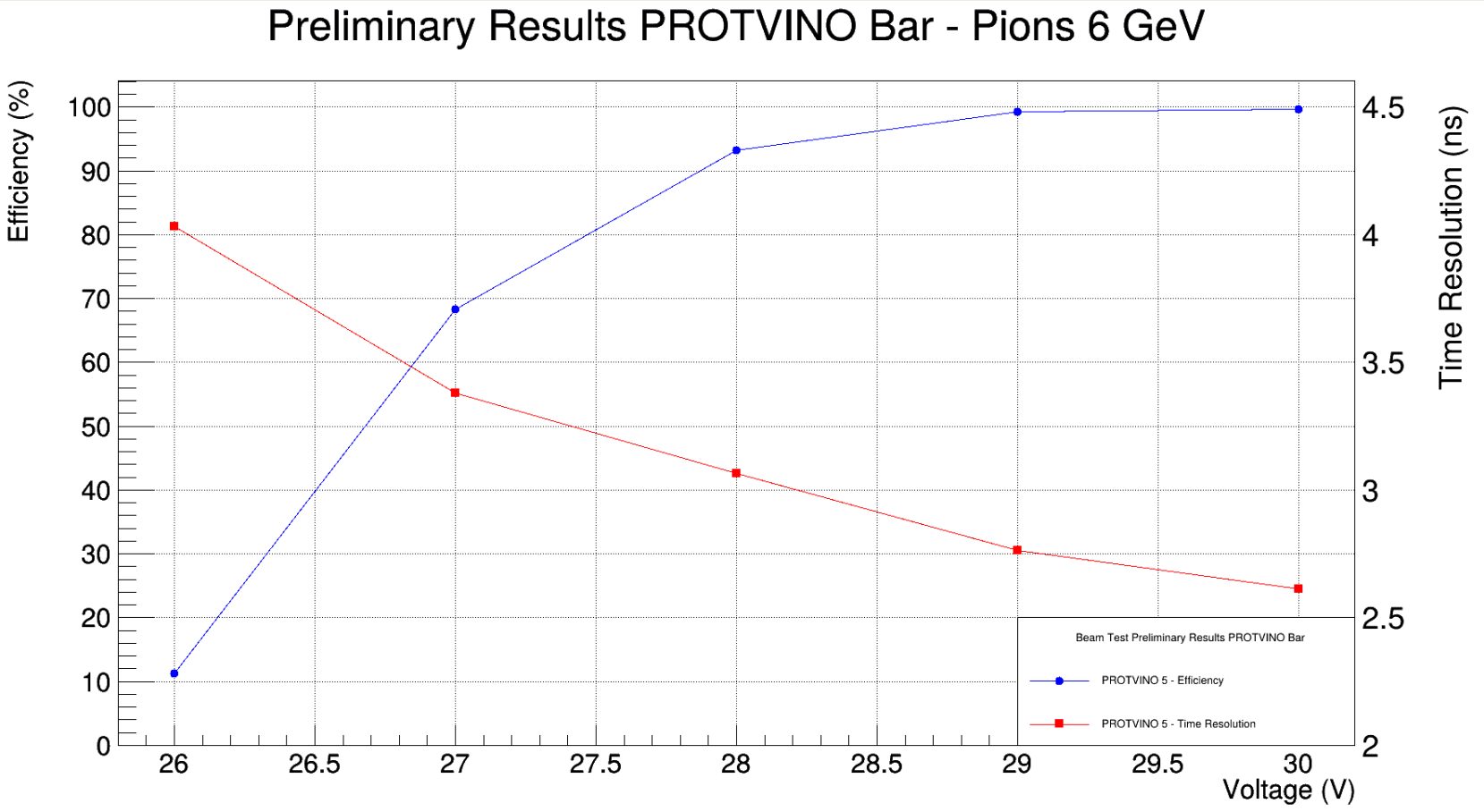



Figure 43. Test Beam 2024: ACORDE Bar – Voltage Scan – Efficiency Preliminary Results.