**Universidad Autónoma de Sinaloa**

Facultad de Ciencias Físico-Matemáticas


# “Performance of AD detector in Beam-Test”


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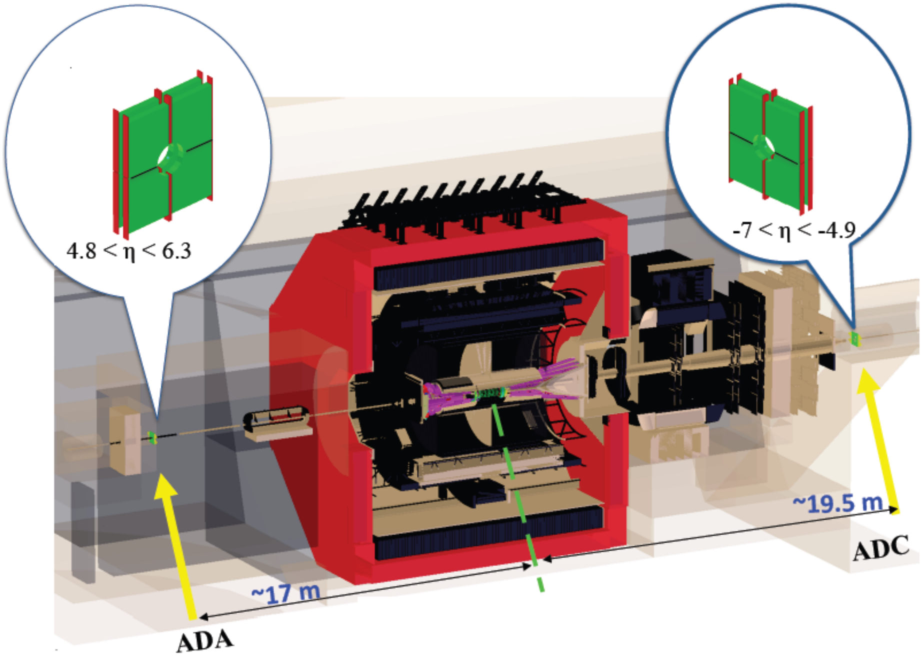
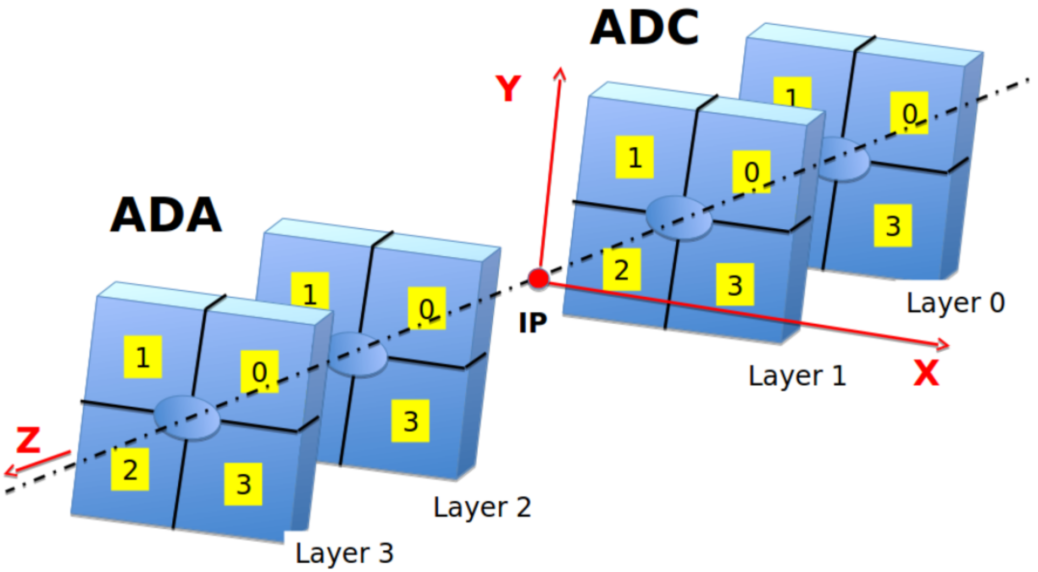
4/11/2017

# AD detector

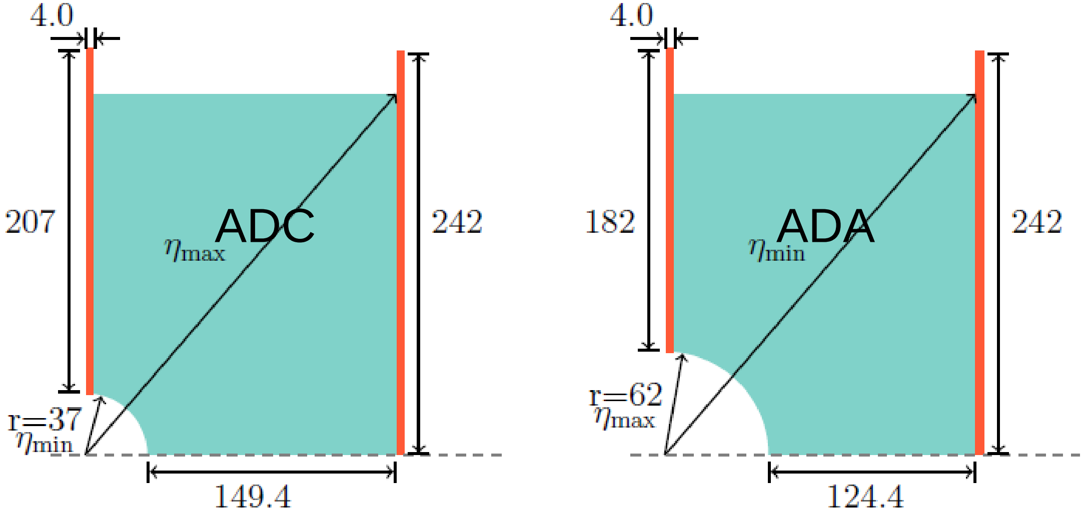
- Study of diffractive physics is of a great interest topic for LHC CERN.
- ALICE have an excellent tracking and particle identification, providing a good capabilities to investigate diffractive production as can be seen in [2] [3] ,proving that is possible to measure single and double diffractive processes.
- ALICE Diffractive was designed to improve the sensitivity of ALICE increasing the pseudorapidity coverage of the experiment.

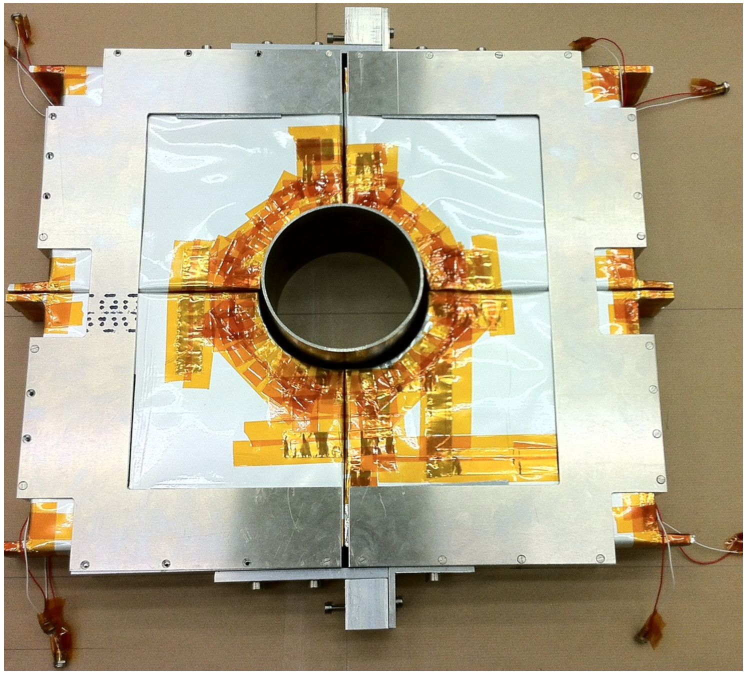


# Mechanical design and geometry

- **Plastic scintillator: *BC-404***
- **WLS bars: *ELJEN (EJ-280)***
- **Optical fibers: *Kuraray (PSM-Clear)***
- **PMTs: *Hamamats- R5946 (16 dinodes)***



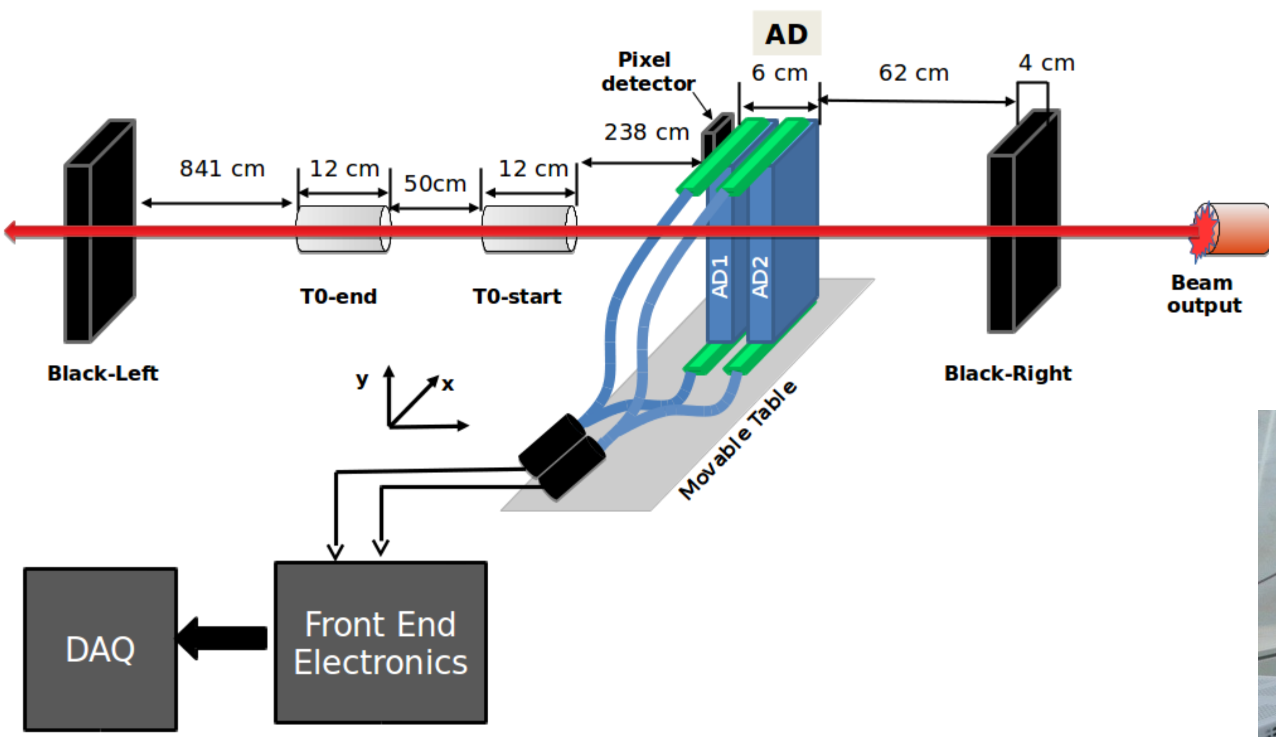
# Beam-test Setup

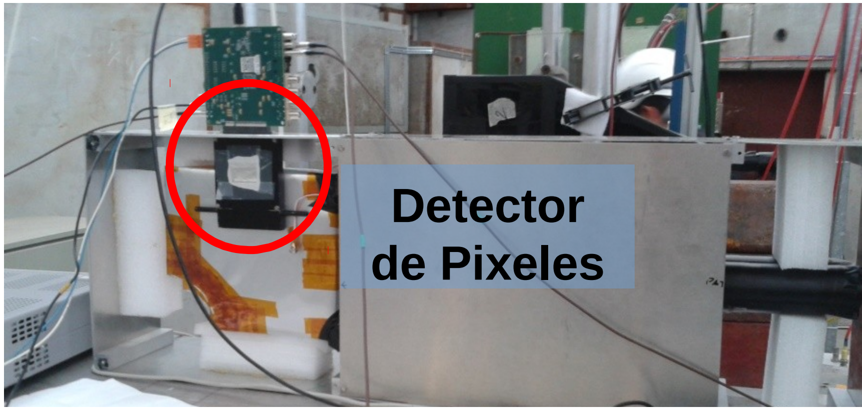
- Were used two kind of detectors for trigger:
  1) Scintillator hodoscopes → **Black-Left** and **Black-Right**
  2) Cherenkov radiators → **T0-end** and **T0-start**

- In a special run were measured the properties of the WLS bar using a pixel detector.

- The momentum of the beam is 1 GeV/c for all the runs except for the pixel run, was set at 1.5 GeV/c.

- Were used an ADA and ADC modules, labeled as AD1 and AD2 respectively.





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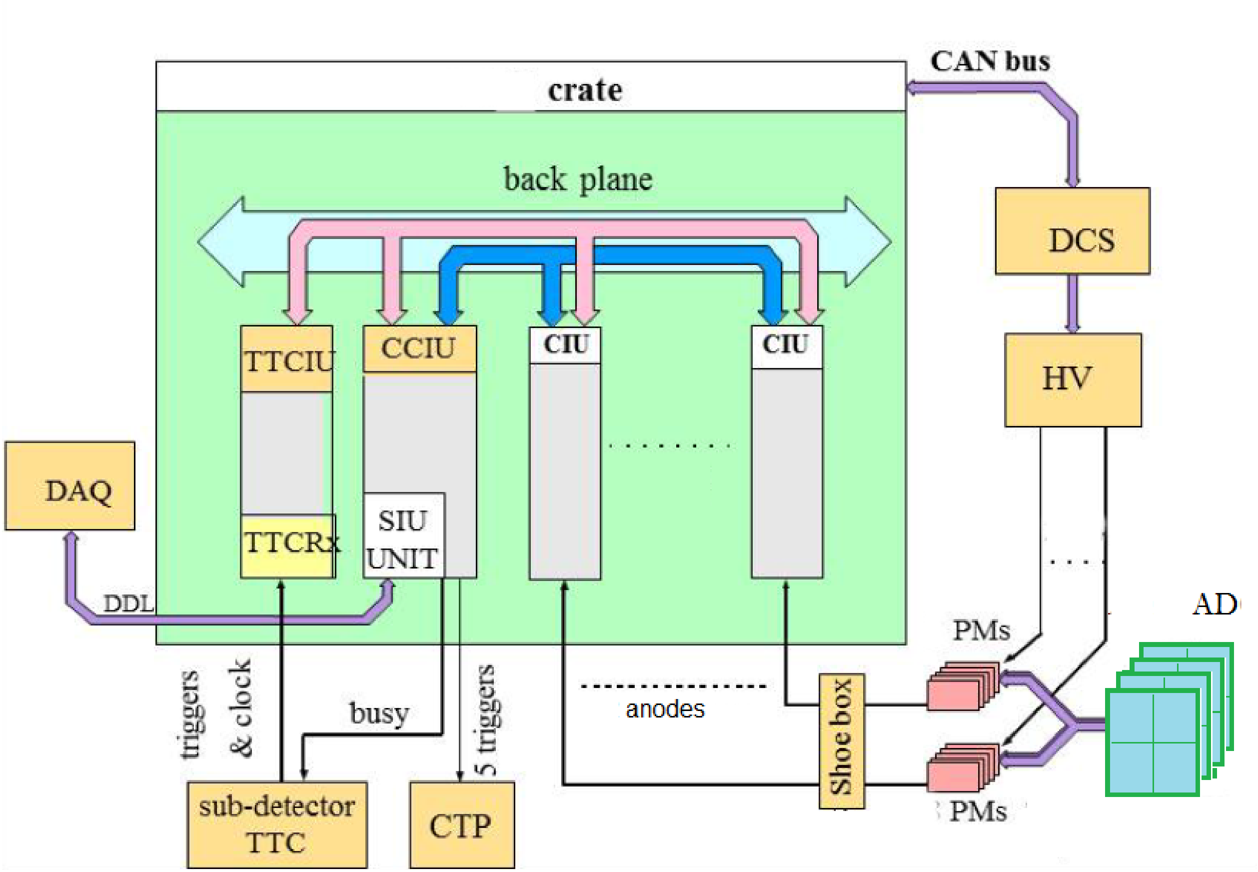
# Front End Electronics



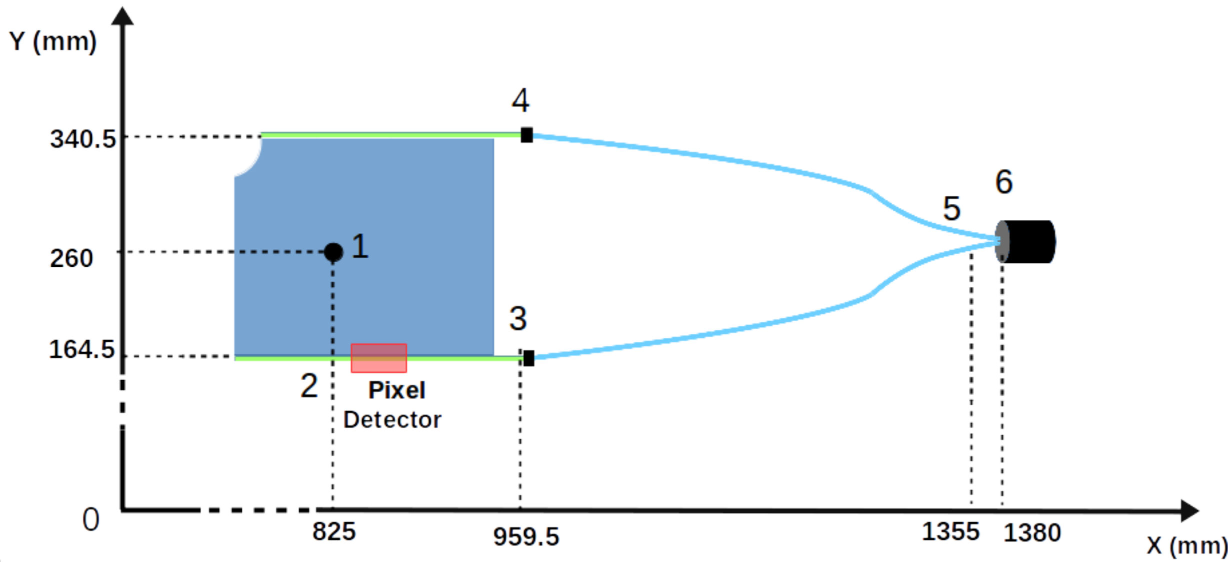

The electronics used to measure the signals during the beam-test is the same that is installed in the ALICE experiment, which is currently been used by ALICE-Diffractive and V0 detectors.

# Beam-test Setup (table positions)

- In the table below can be seen:
  - ✓ The table positions.
  - ✓ T0 detector overlap area.
  - ✓ Collimator aperture.
  - ✓ Beam momentum

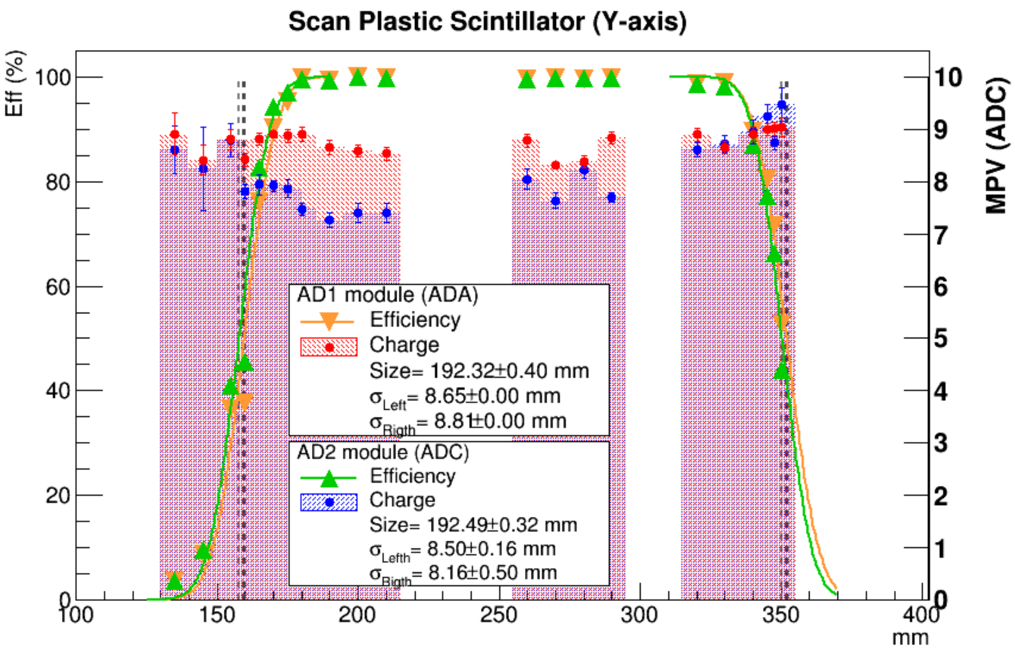
-The fiber length used for the test was 47 cm.

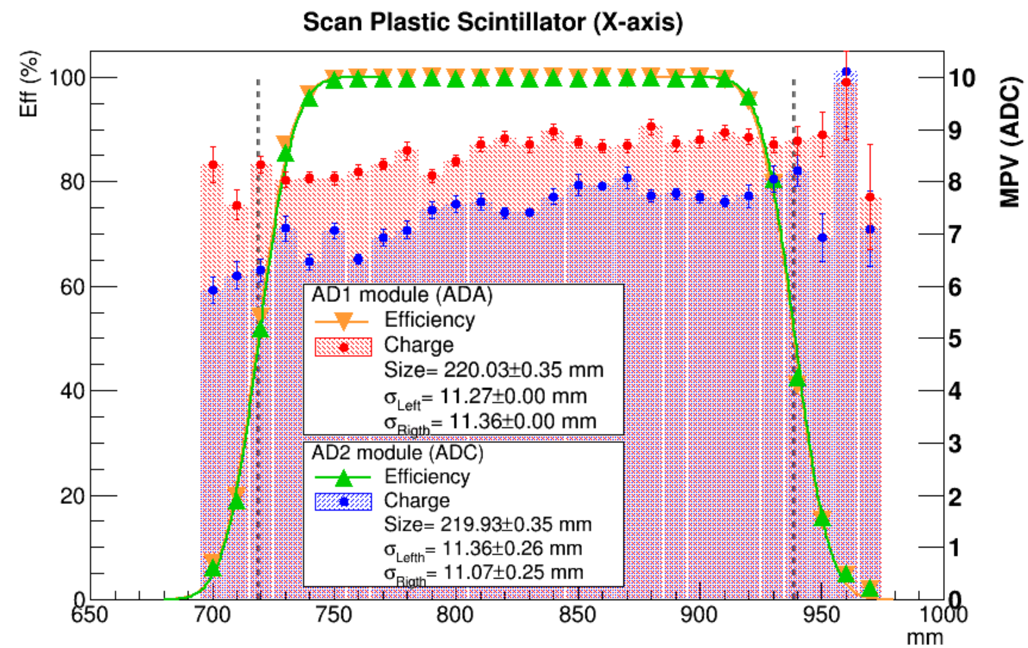
-Were done scans along the Y and X axis respect to the points shown in the the draw shown at the right.




| No. | Section | X position (mm) | Y position (mm) | T0 overlap (mm) | Collimator (mm) | Momentum (GeV/c) |
|---|---|---|---|---|---|---|
| 1 | Center | 825 | 260 | 2 | 24 | 1 |
| 2 | Border | 827.5 | 348 | 1 | 40 | 1 |
| 3 | Conn. 1 | 959.5 | 159.5 | 1 | 24 | 1 |
| 4 | Conn. 2 | 959.5 | 340.5 | 1 | 24 | 1 |
| 5 | Fibers | 1355 | 245 | 1 | 24 | 1 |
| 6 | PMT | 1380 | 260 | 1 | 24 | 1 |
| | Pix. Detector | 827.5 | 152 | 1 | 5 | 1.5 |

# Efficiency and charge plots
# **Scan a long the center**



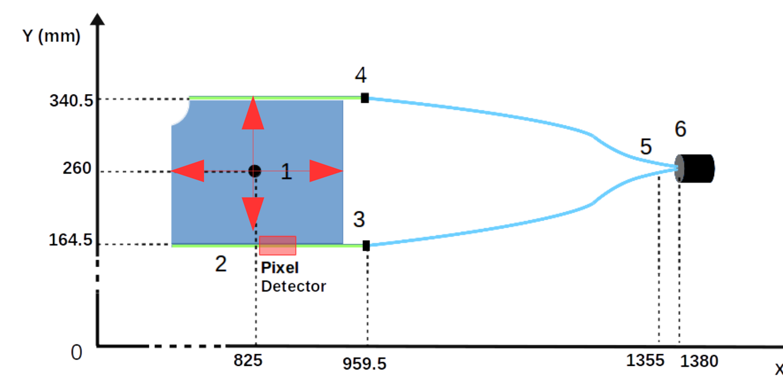




Efficiency calculation :

$$\text{Efficiency} = \frac{\mathrm{N}_{\text{T0-start}} \wedge \mathrm{N}_{\text{T0-end}} \wedge \mathrm{N}_{\text{AD}}}{\mathrm{N}_{\text{T0-start}} \wedge \mathrm{N}_{\text{T0-end}}}$$

Was fitted a Cumulative gaussian distribution to the borders :

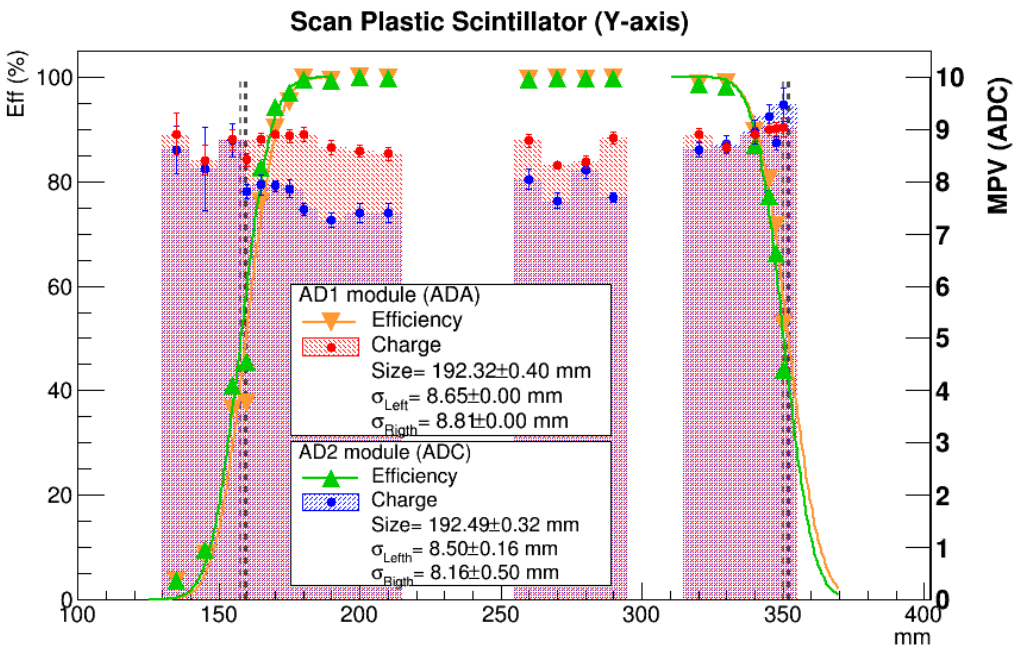
$$p = F(x|\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} e^{\frac{-(t-\mu)^2}{2\sigma^2}} dt$$

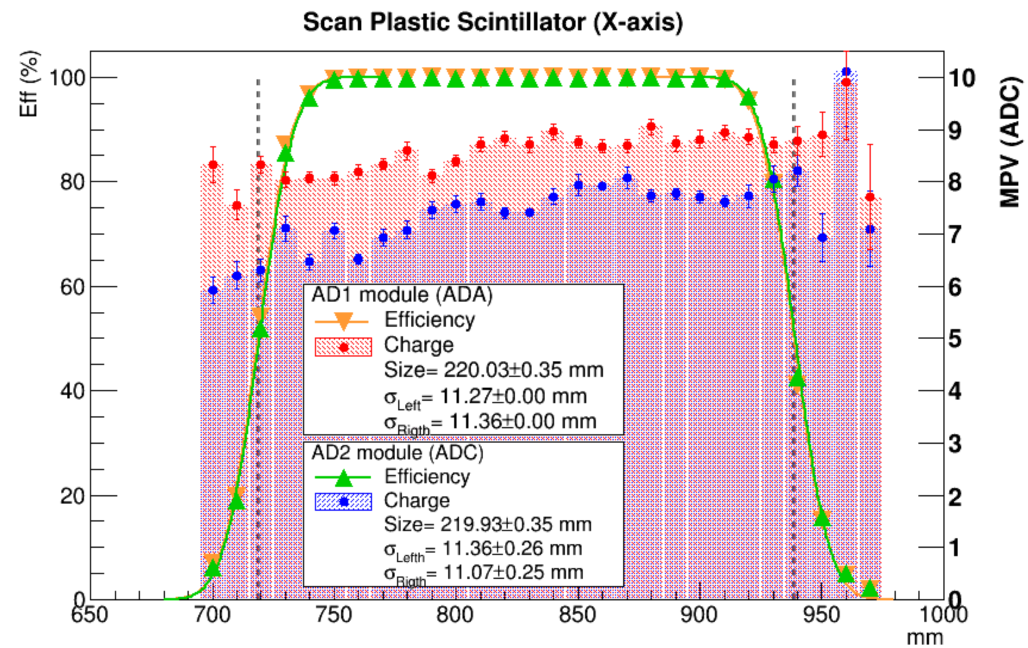



Charge calculation :

- Where selected Time≠0 events.
- Was fitted a Landau+Gaussian distribution and MPV value was taken

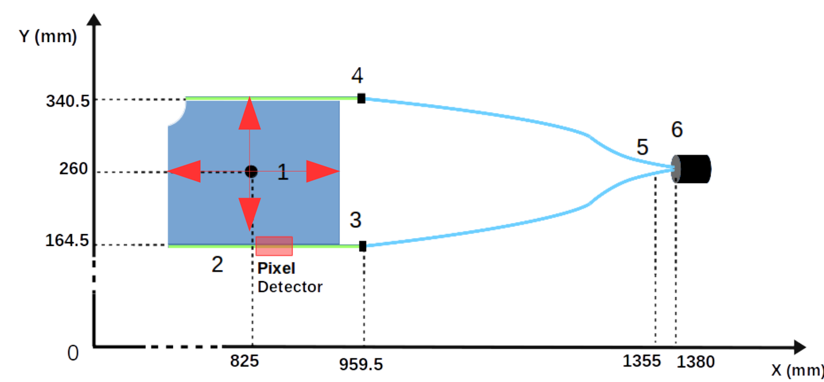
# Efficiency and charge plots
# **Scan a long the center**




The mean of the borders of both modules allow us to estimate the size of the modules.

| | X-axis length (*mm*) | Y-axis length (*mm*) |
|---|---|---|
| **Real** | 216 | 181 |
| **AD1** | 220 ± 0.35 | 192.32 ± 0.4 |
| **AD2** | 219.9 ± 0.35 | 192.49 ± 0.32 |



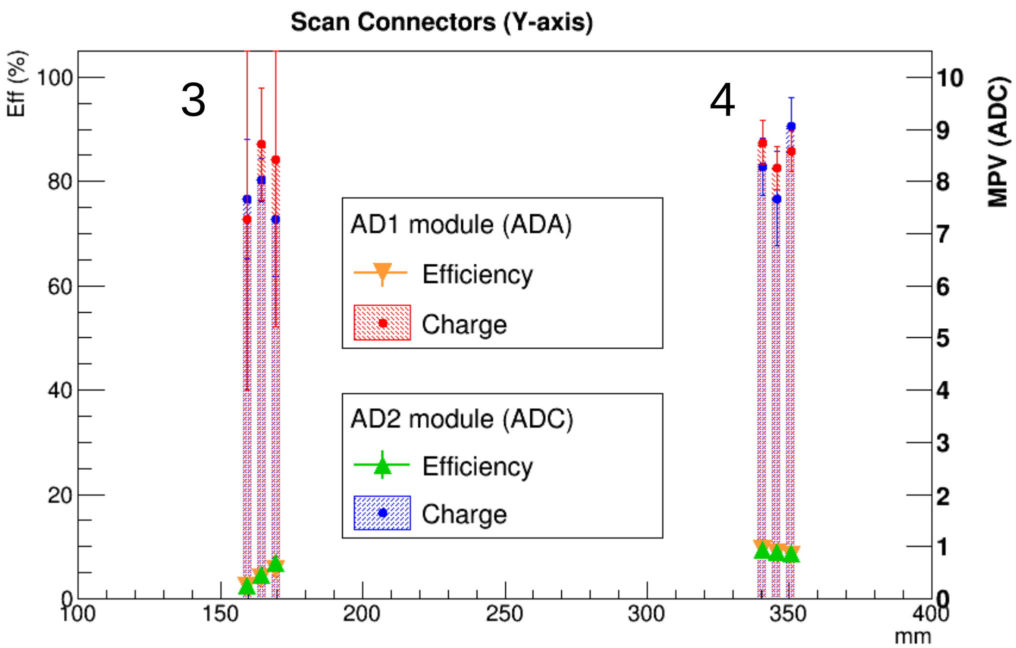

An estimation* of the beam size was calculated using the sigma information of the gaussian cumulative distribution function:

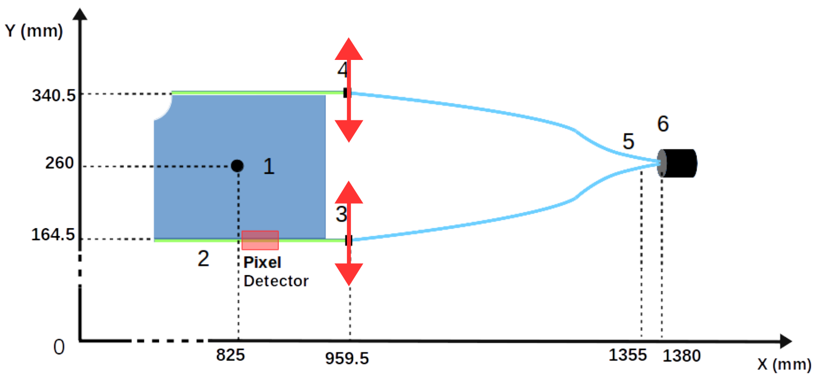
$\sigma_x$=11.29 ± 0.31 mm

$\sigma_y$=8.53 ± 0.16 mm

**Average of four sigma, two sides and modules per axis.*

# Efficiency and charge plots
# **Scan a long Connectors**




Efficiency calculation :

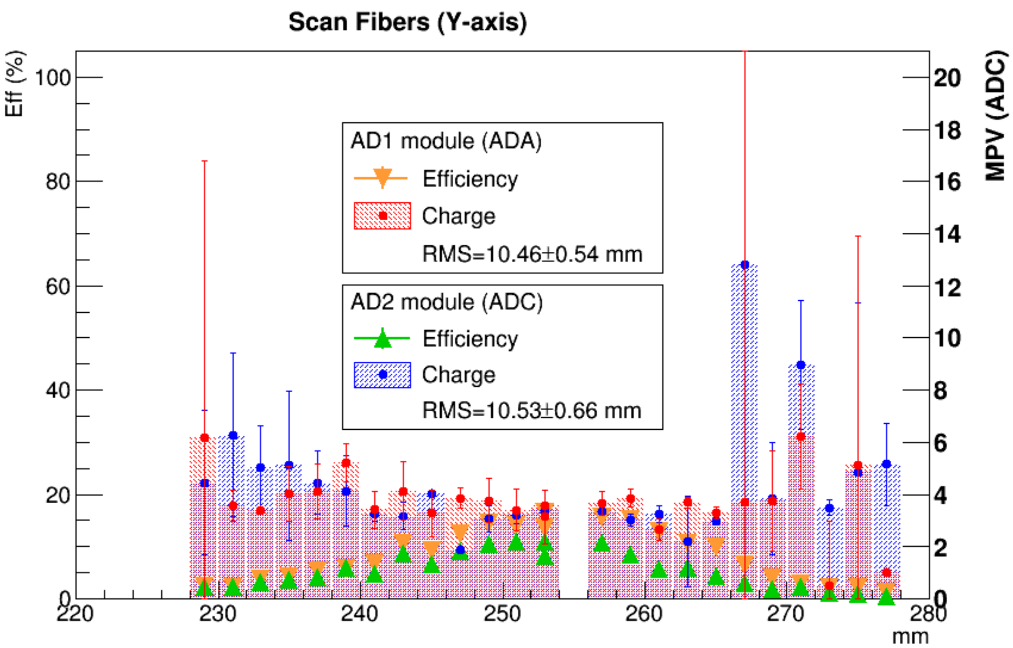
$$\text{Efficiency} = \frac{\mathrm{N_{T0\text{-}start}} \wedge \mathrm{N_{T0\text{-}end}} \wedge \mathrm{N_{AD}}}{\mathrm{N_{T0\text{-}start}} \wedge \mathrm{N_{T0\text{-}end}}}$$

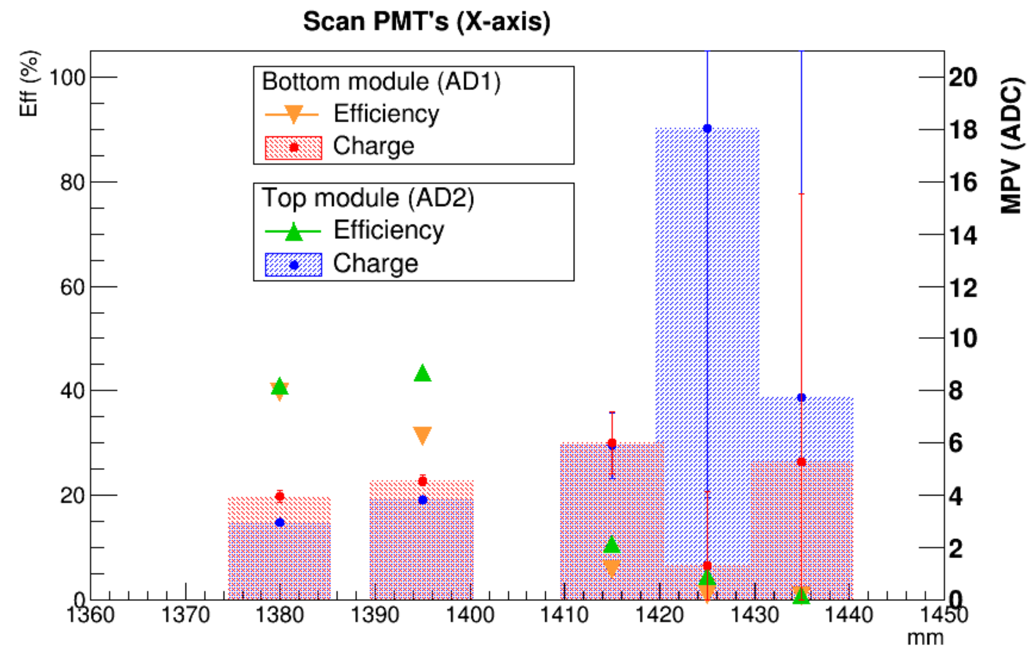
Charge calculation :

- Where selected Time≠0 events.
- Was fitted a Landau+Gaussian distribution and MPV value was used.

# Efficiency and charge plots

## Scan a long the Fibers and PMT



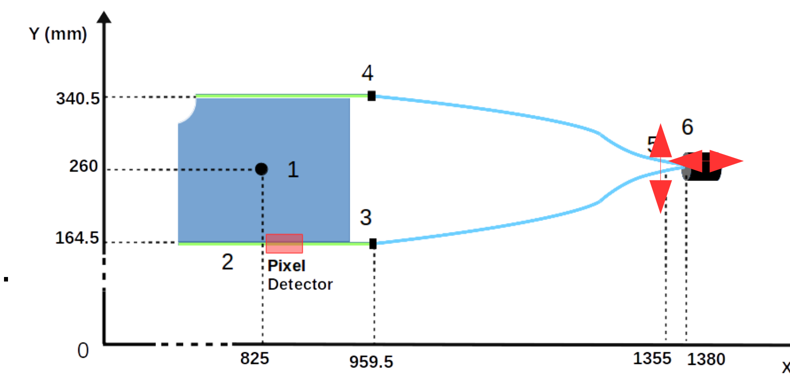




Efficiency calculation :

$$\text{Efficiency} = \frac{N_{\text{T0-start}} \wedge N_{\text{T0-end}} \wedge N_{\text{AD}}}{N_{\text{T0-start}} \wedge N_{\text{T0-end}}}$$

Charge calculation :

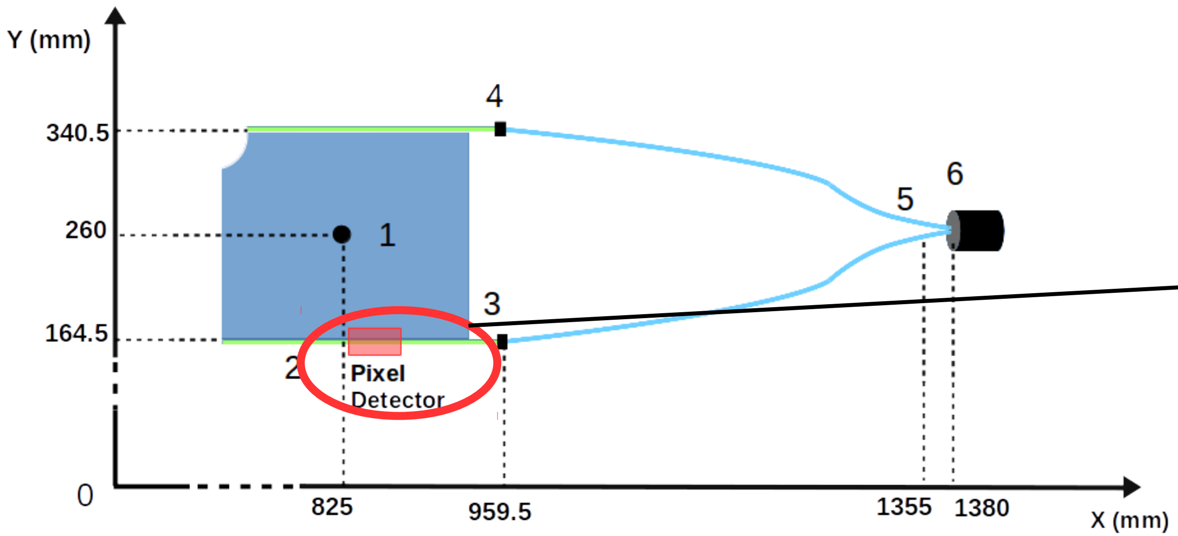
- Where selected Time≠0 events.
- Was fitted a Landau+Gaussian distribution and MPV value was used.

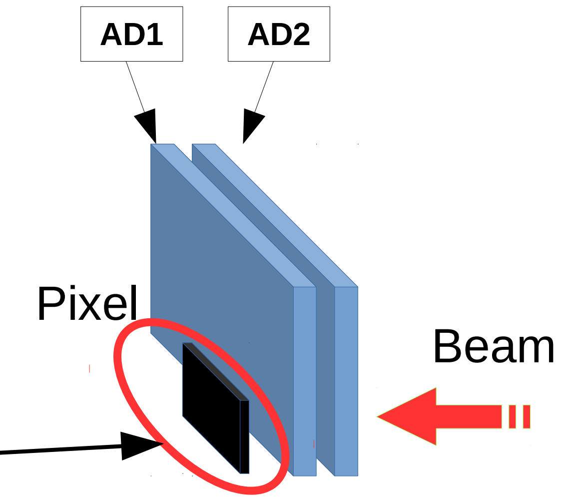


# Border Analysis (Pixel detector)

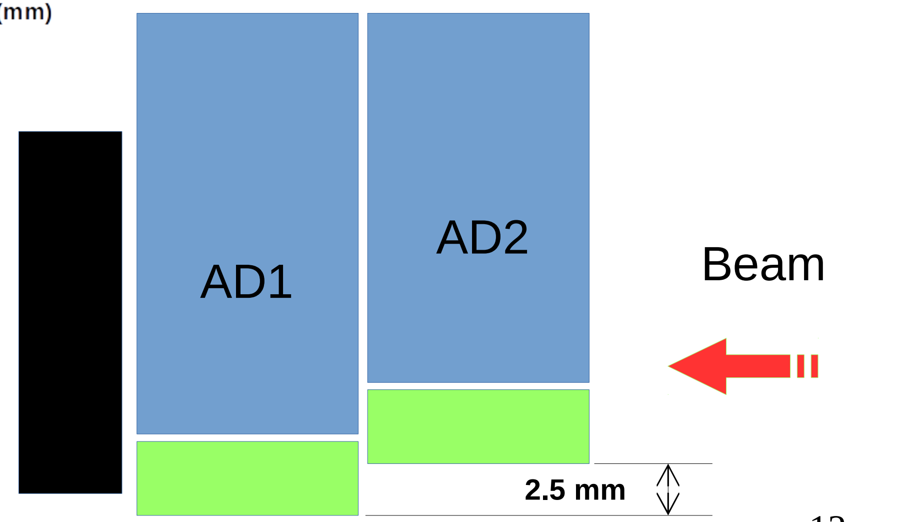
# Border analysis

The pixel detector* was placed behind the AD modules to get a precise information of the characteristics in the WLS bar.




Pixel Area
1024 * 512 pixels
3 * 1.5 cm$^2$

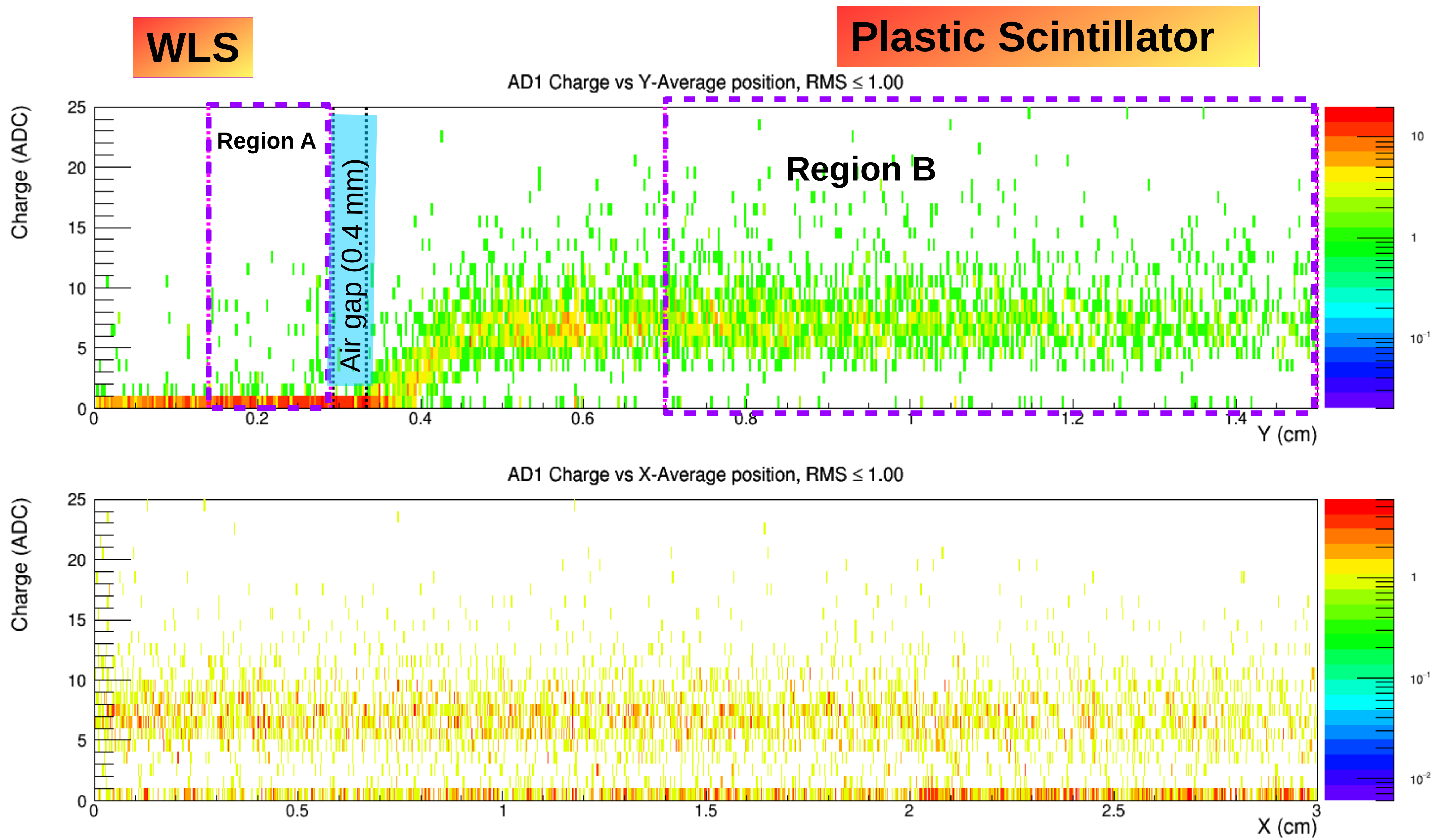





* Povided by ITS group (arxiv:1607.01171)

# AD1 → Charge vs Y (pixel position)

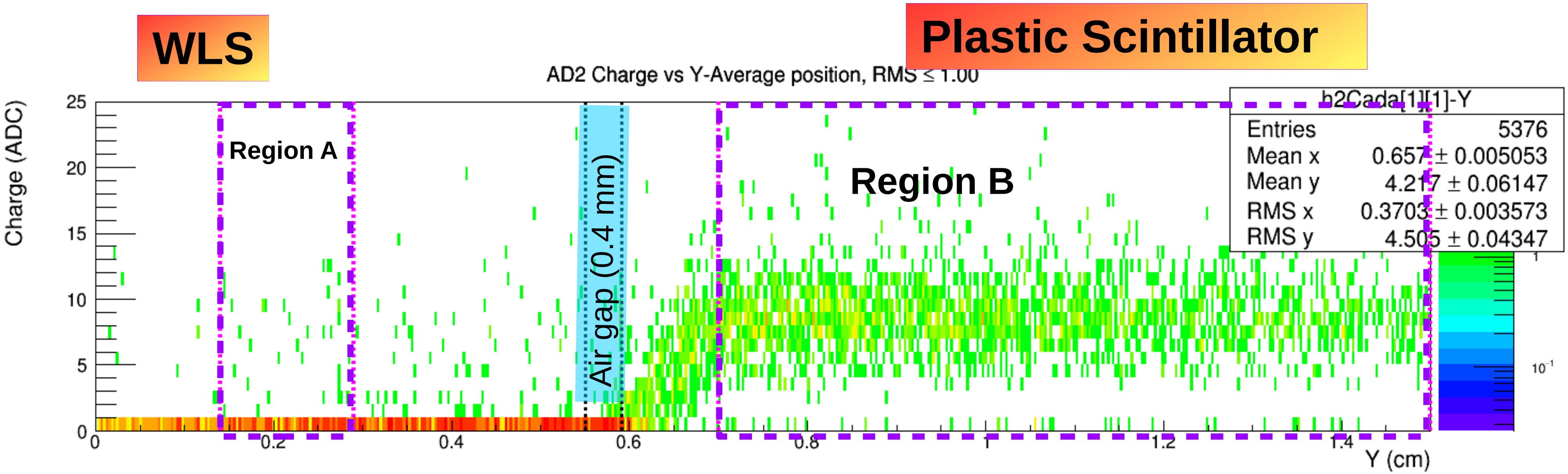
**Selection of event in WLS Bar and plastic scintillator**

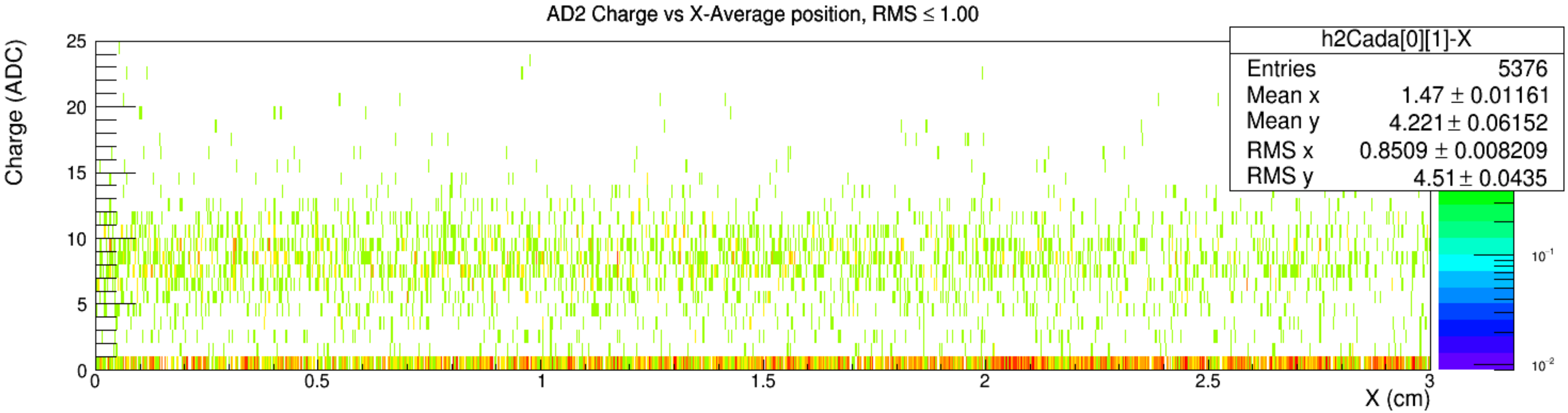



**Top plot:** Region **A** and **B** defined on **AD1** module along the **Y axis**.
**Bottom plot:** The **charge** along the **X axis** looks homogeneous.

# AD2 → Charge vs Y (pixel position)

**Selection of event in WLS Bar and plastic scintillator**

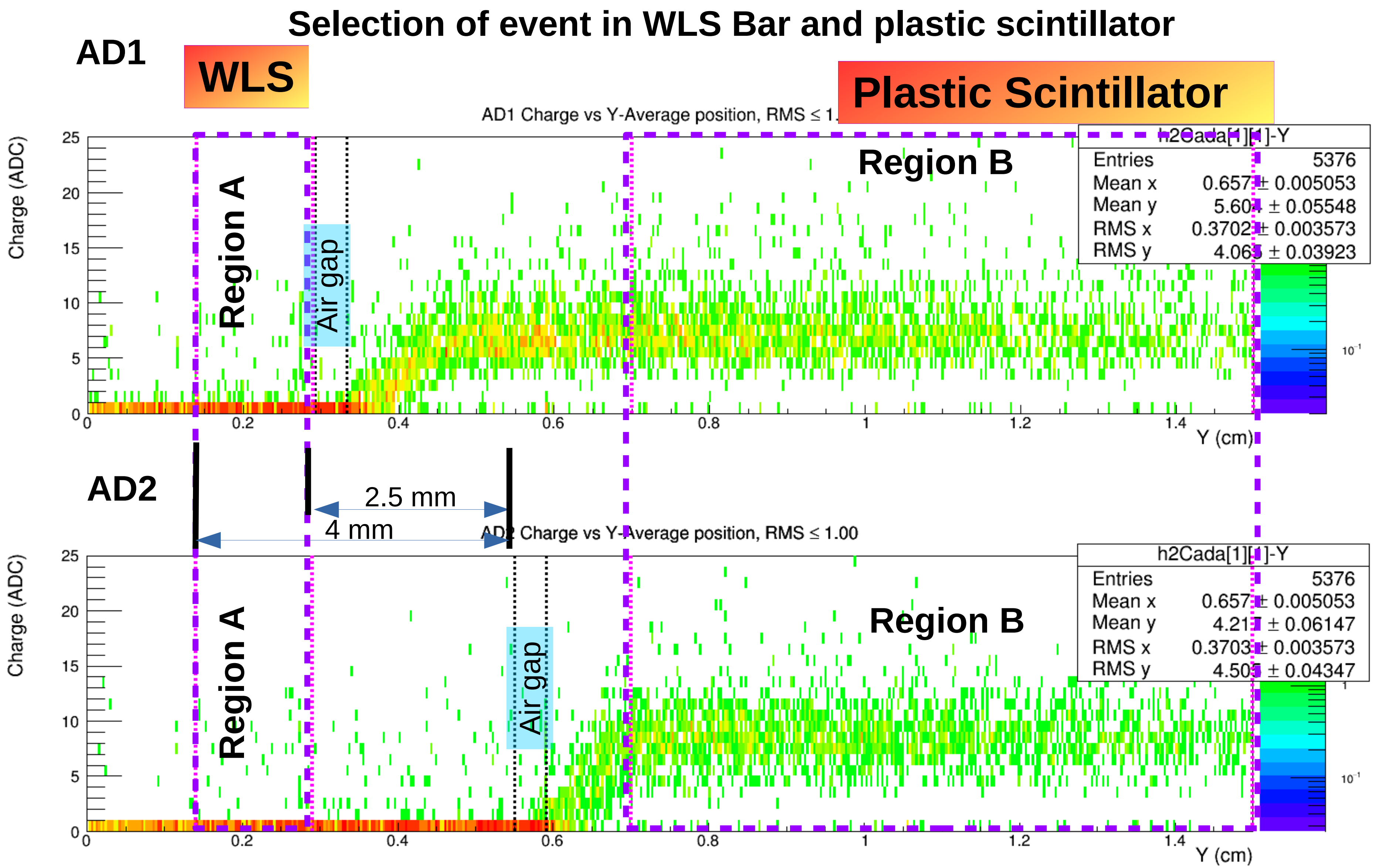



**Top plot:** Region **A** and **B** defined on **AD2** module along the **Y axis**.
**Bottom plot:** The **charge** along the **X axis** looks homogeneous.

# Regions definition for analysis

## Charge vs Y pixel position*



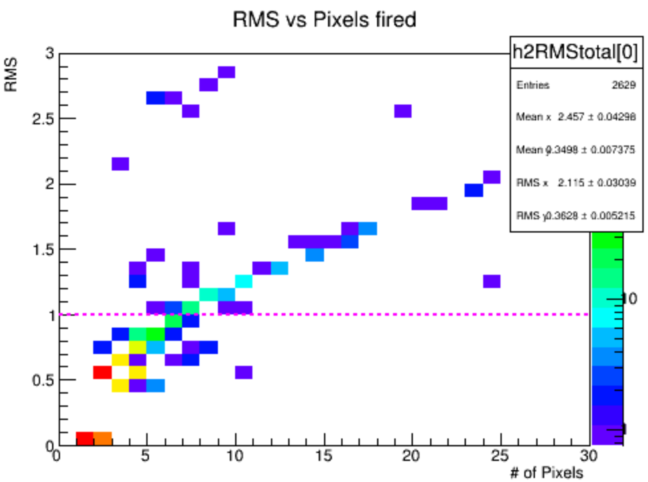


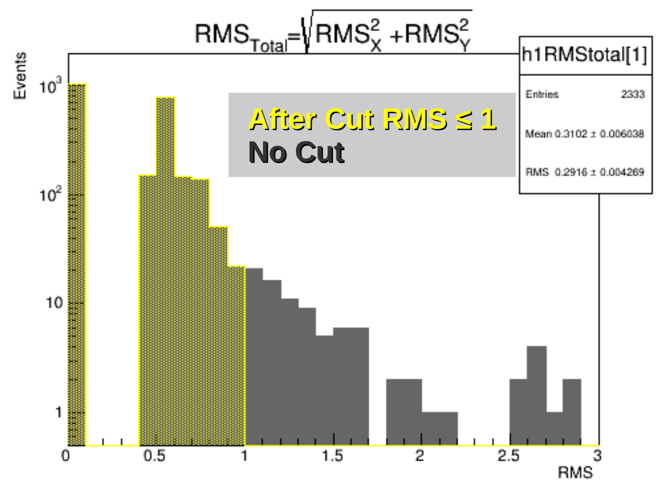

*Due that in a single event triggered can be fired several pixels, was used an average pixel position per event.

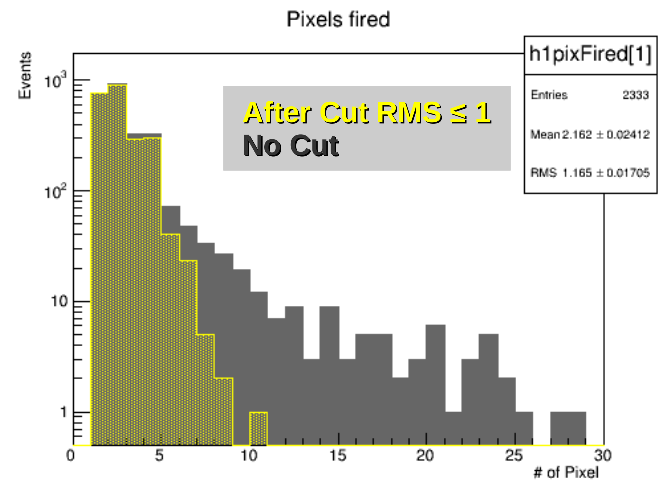
# Number of pixel fired VS RMS (of pixels positions)

The RMS value of the pixels position fired on every event was calculated in order to clean the data.

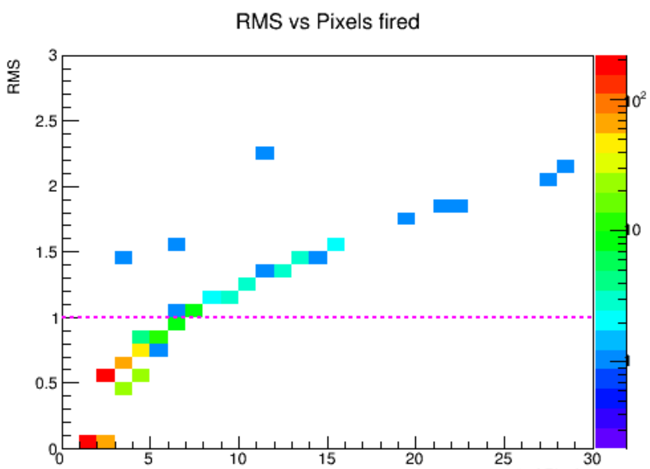
## Scintillator (Region B)

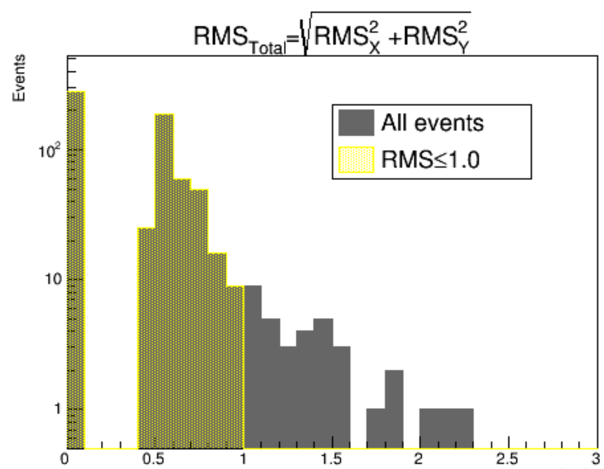


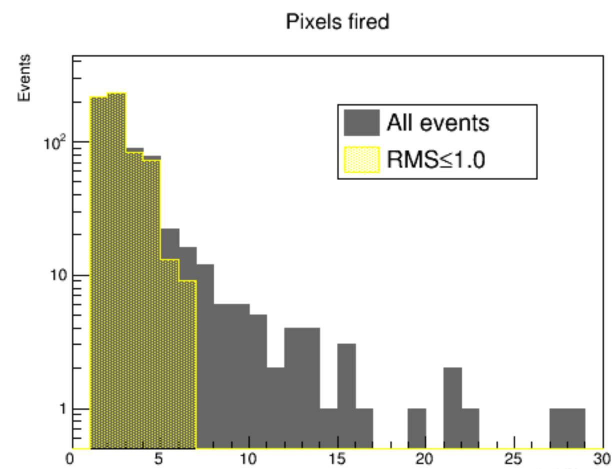




## WLS (Region A)





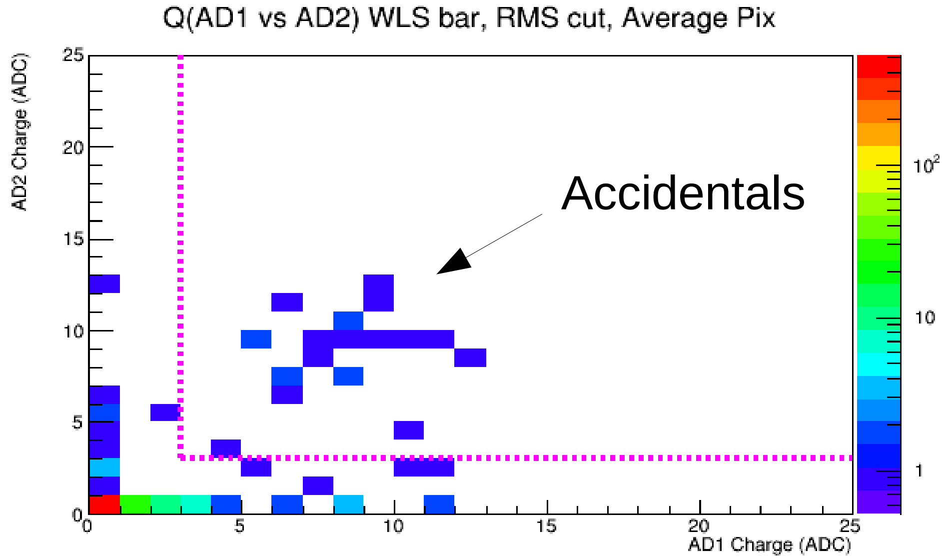



Same for AD1 and AD2 → Were used AD coincidences.

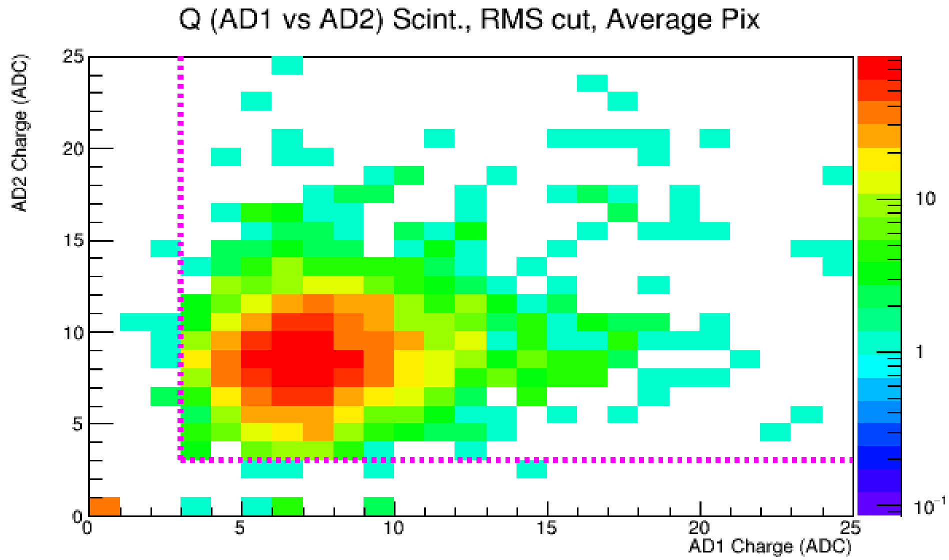
# Charge correlation→  AD1 vs AD2

RMS ≤ 1

Region A




Region B

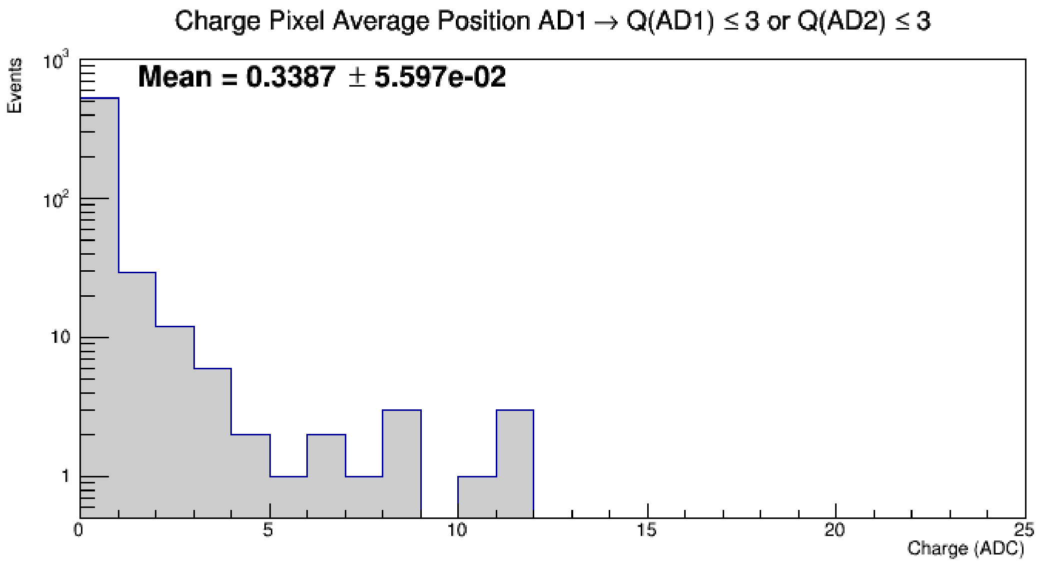


# Charges selection events

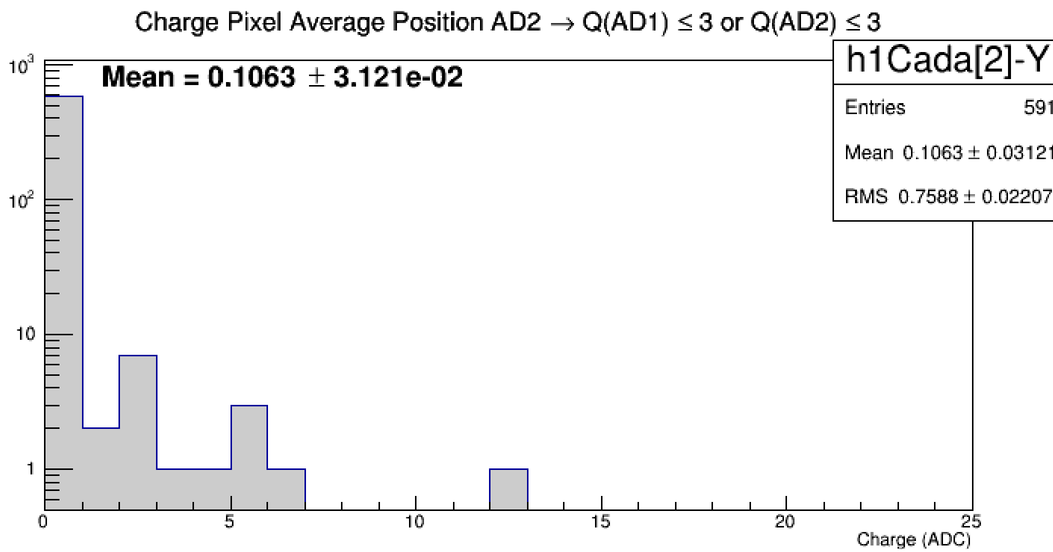
**Pixel position Average**

Selection:
**Q(AD1) $\leq$ 3** or **Q(AD2) $\leq$ 3**

AD1



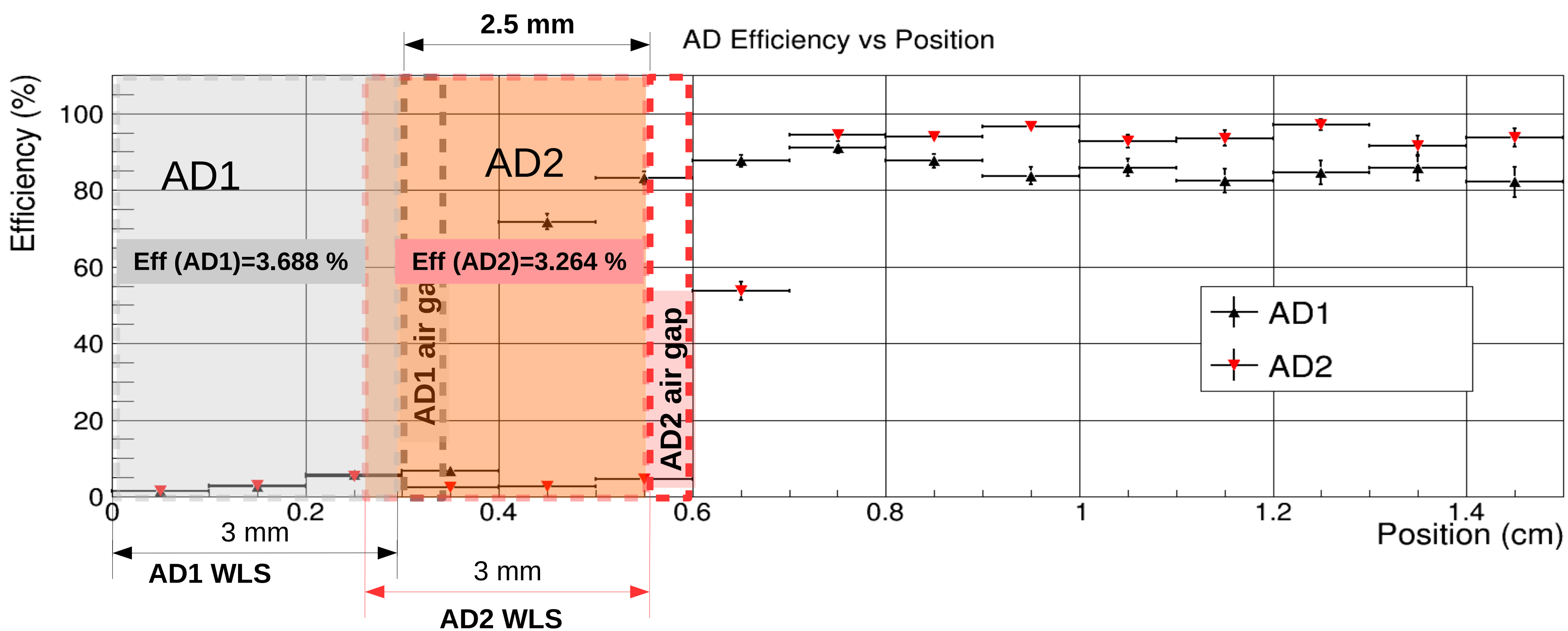

AD2



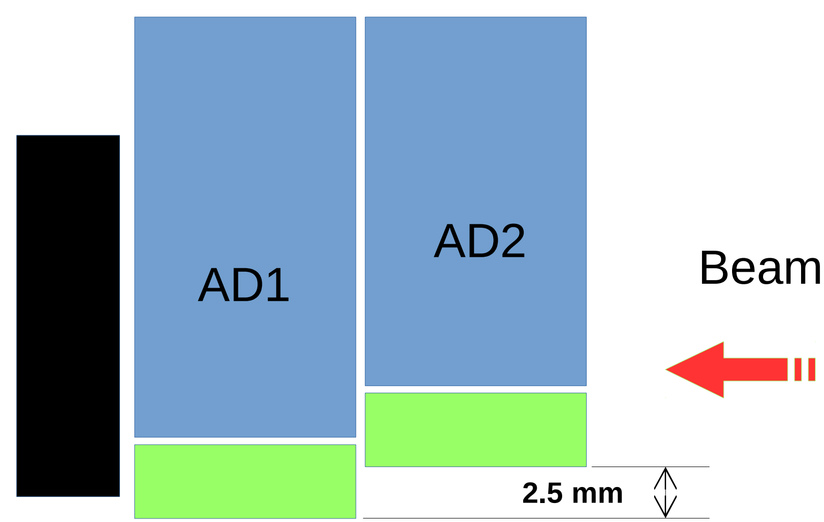
# WLS-bar efficiency analysis

**Efficiency =** (Black_Left ∧ Back_Right ∧ Pix ∧ **AD**) / (Black_Left ∧ Back_Right ∧ Pix)

- Time flags used to calculate the efficiency.
- RMS cut was applied.




| | WLS bar (%) (3 mm zone) |
|---|---|
| **AD1** | **3.688 ± 0.668** |
| **AD2** | **3.264 ± 0.317** |



# Results using pixel detector

## Charges (ADC counts)

| | **WLS (mean)** |
|---|---|
| **AD1** | 0.34 ± 0.06 |
| **AD2** | 0.10 ± 0.03 |
| **AD** | **0.22 ± 0.08** |

## Efficiency (%)

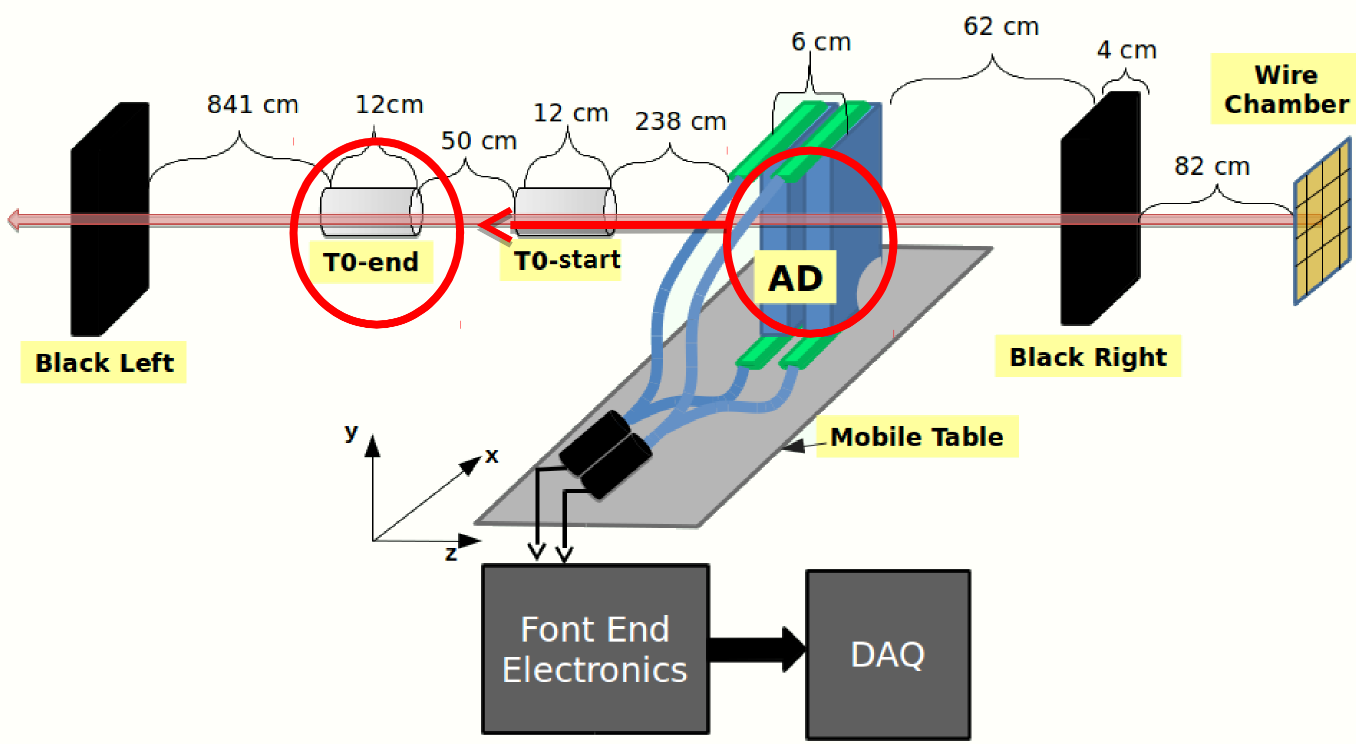
| | **WLS** |
|---|---|
| **AD1** | 3.69 ± 0.67 |
| **AD2** | 3.26 ± 0.32 |
| **AD** | **3.47 ± 0.74** |

# Particle identification

- The composition of the beam in T10 beam facilities is mainly composed by pion and protons.
- Trough Time of flight technique is possible to identify particles

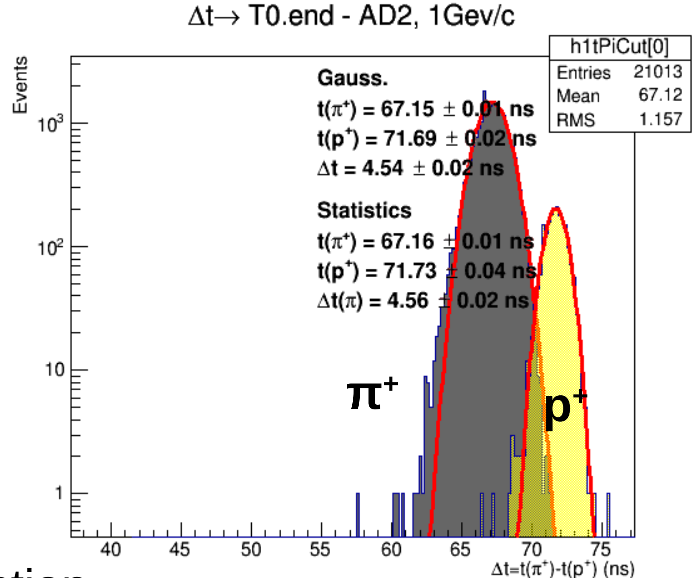
Theory → $$\Delta t = \frac{L}{pc^2}\left(\sqrt{p^2c^2 + m_1^2c^4} - \sqrt{p^2c^2 + m_2^2c^4}\right)$$

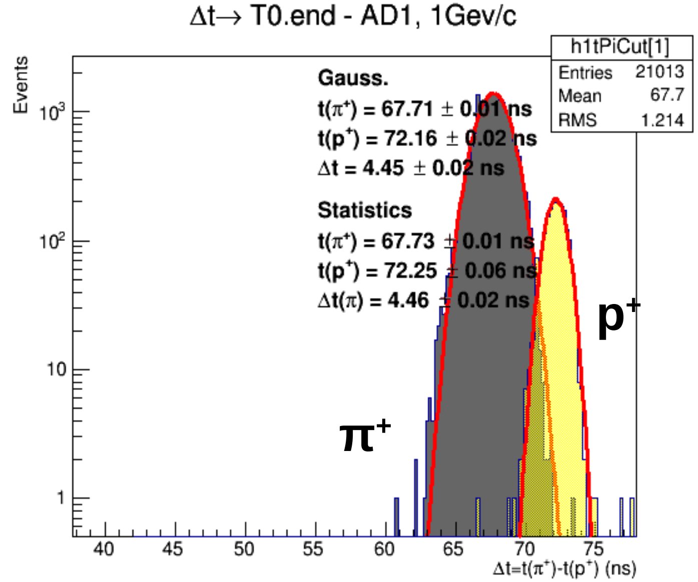
Experiment → $$\Delta t = t_{AD} - t_{\mathrm{T0-end}}$$



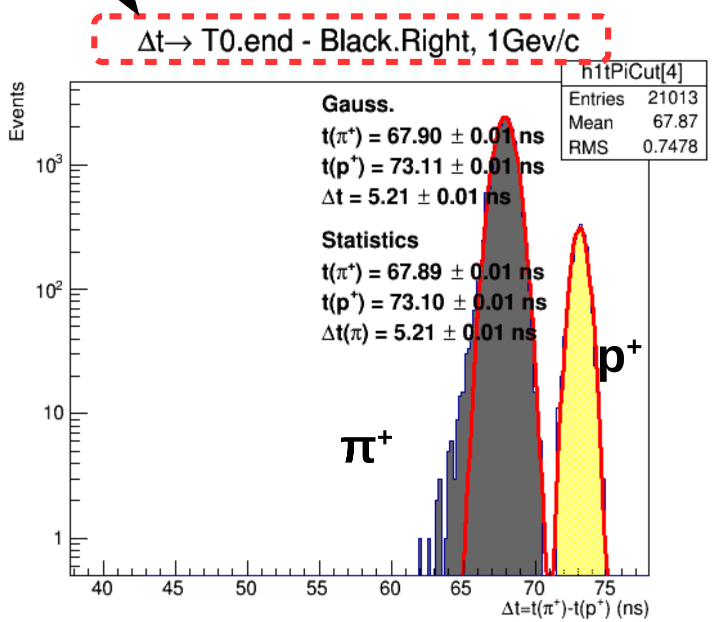
# Particle selection at 1 GeV/c

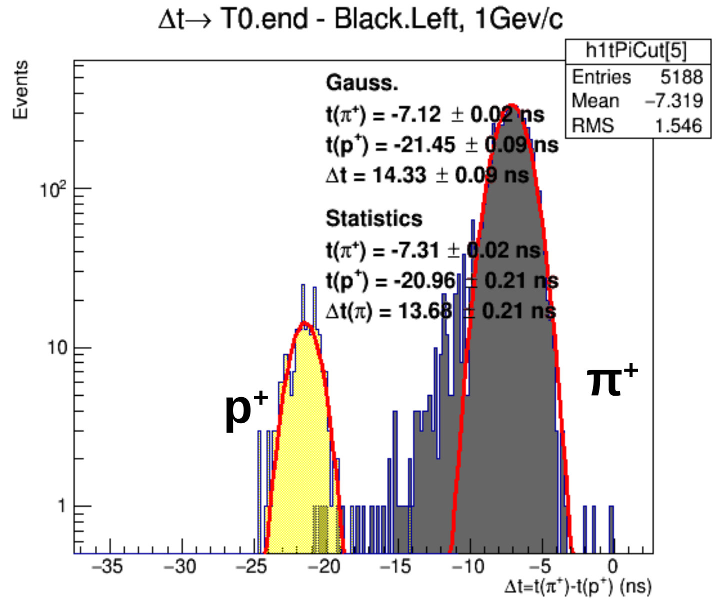
## Respect to **T0.end**



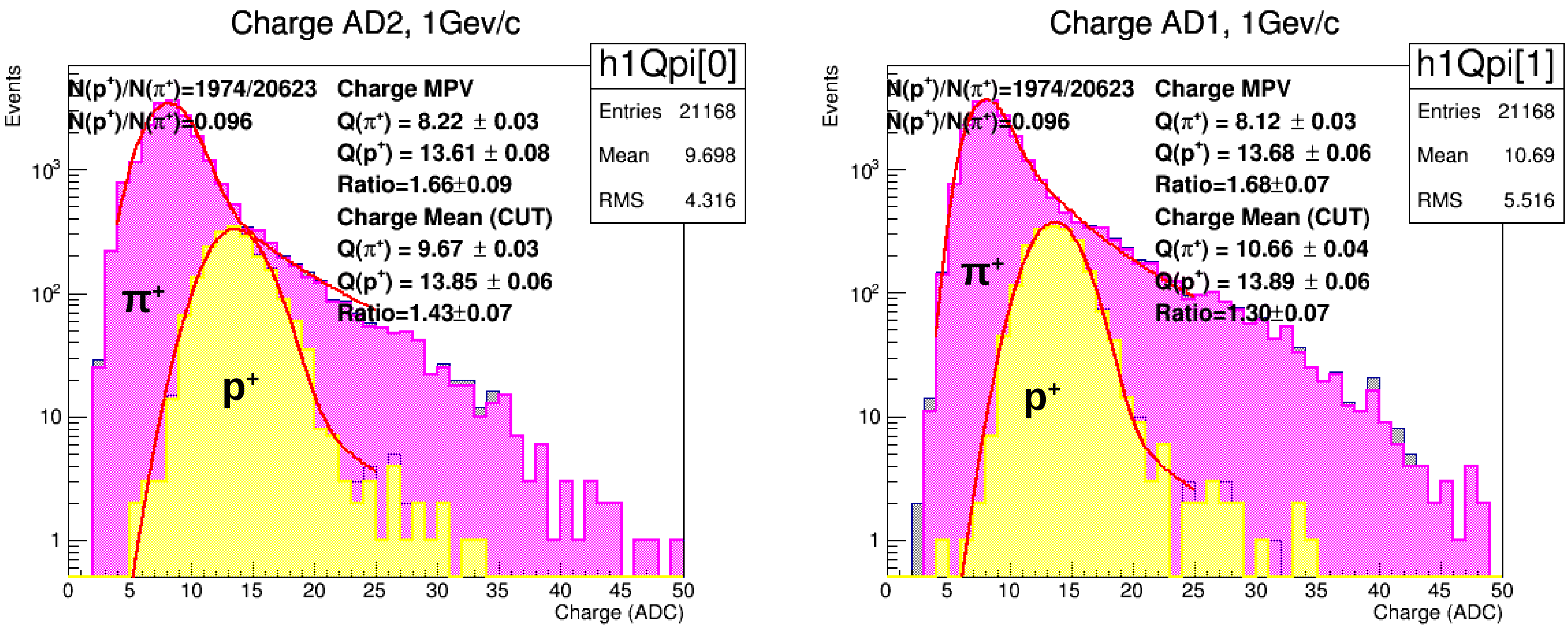




Particle selection



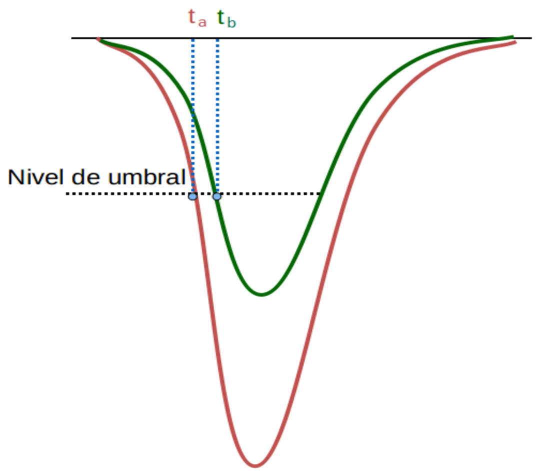



# Charges of Pion and Protons (1 GeV/c)



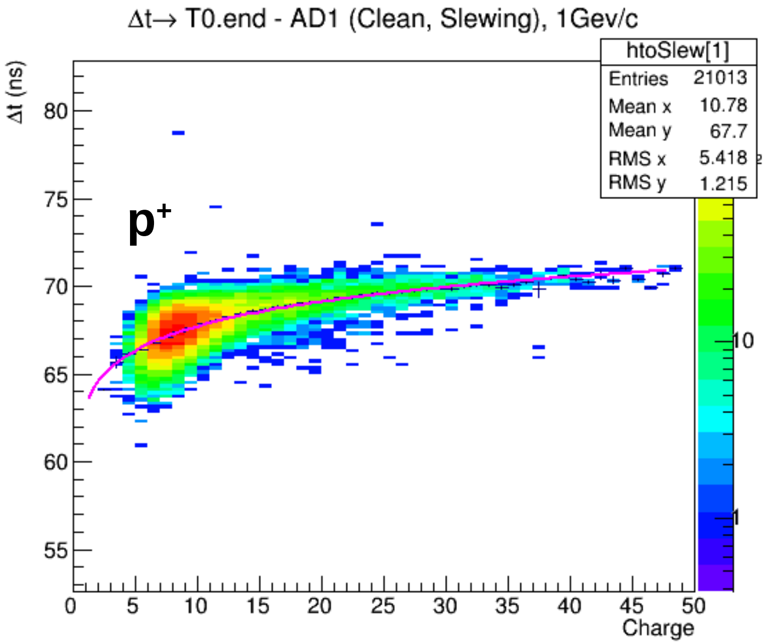
# Time-slewing correction

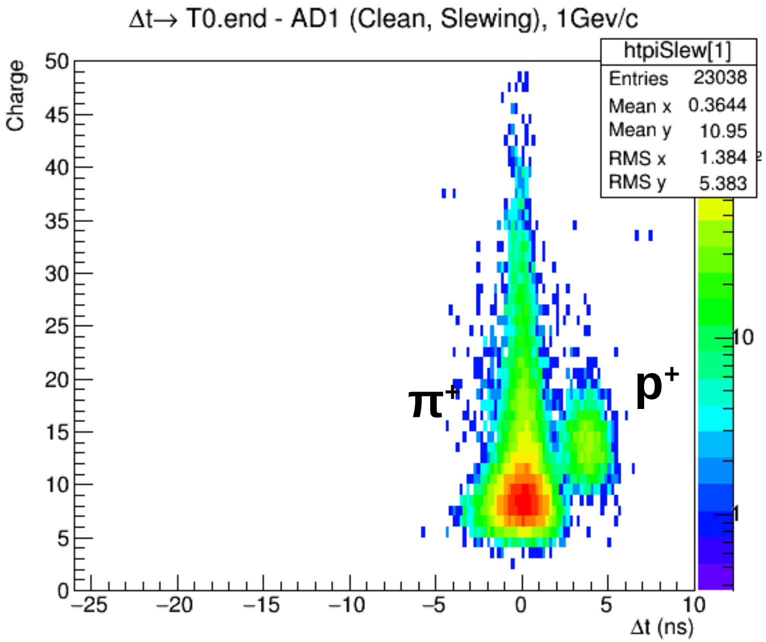
- We used a time difference correction using an exponential function adjusted to the charge and time correlation.
- The slewing effect is due the technique used to measure the time in the FEE.
- The leading time crossing the threshold depends on the charge.



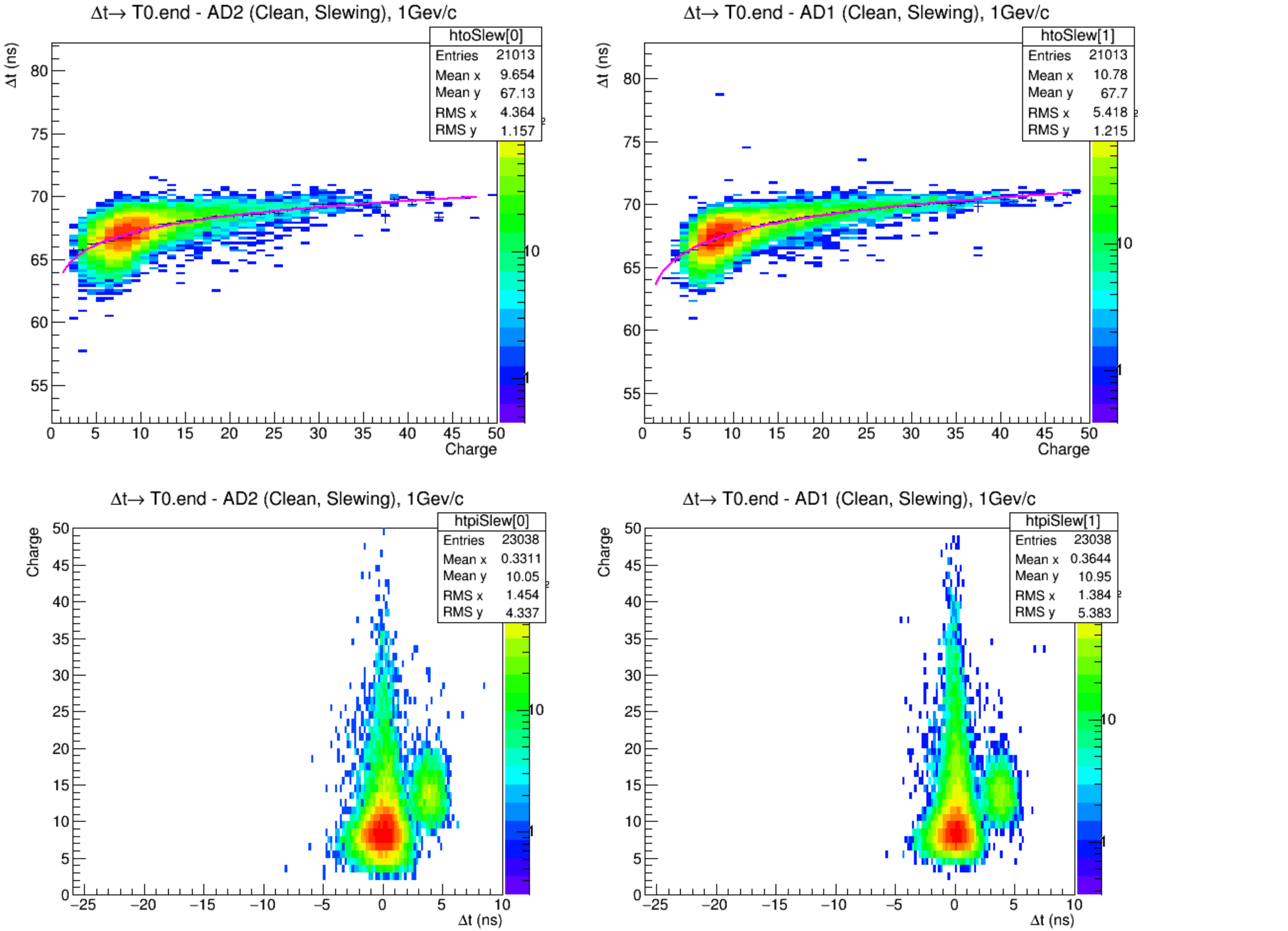

$$t(\mathbf{Q})=A+B\mathbf{Q}^{c}$$

$$t_{corrected}=t_{measured}-t(\mathbf{Q})$$

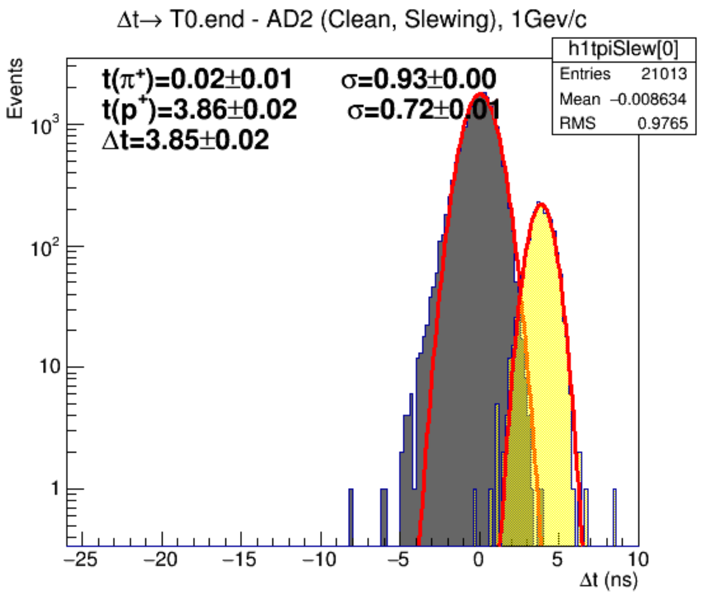


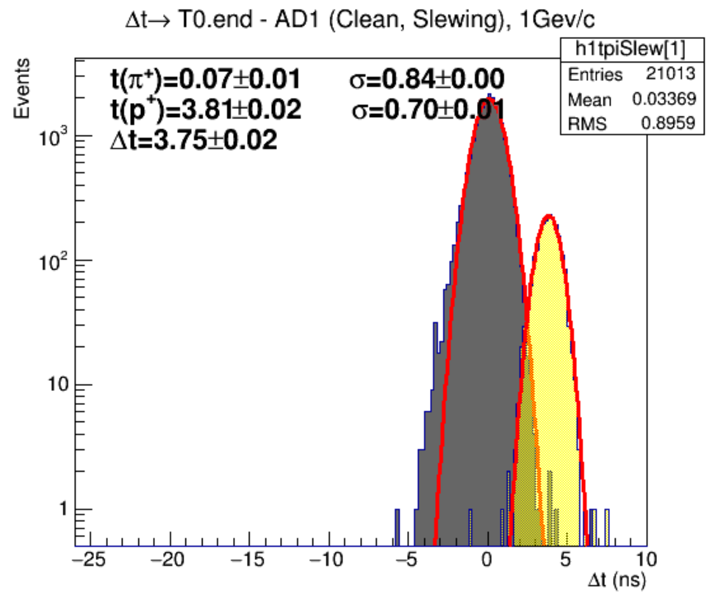



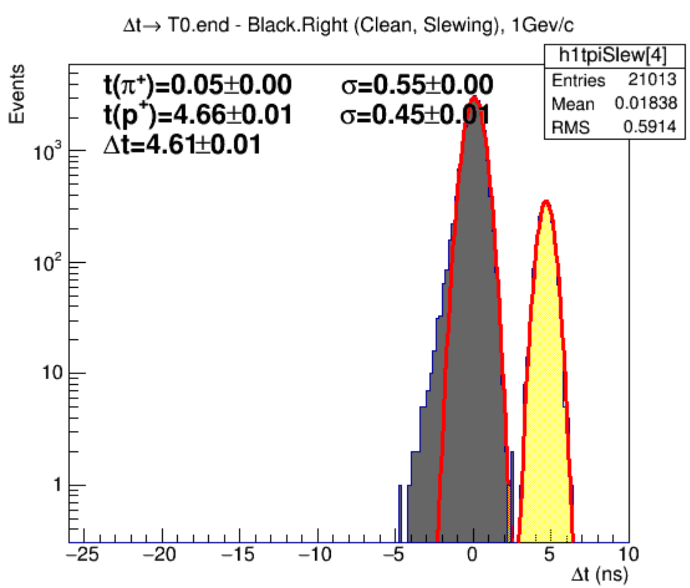
# Slewing correction (1 GeV/c)
# Respect to **T0.end**

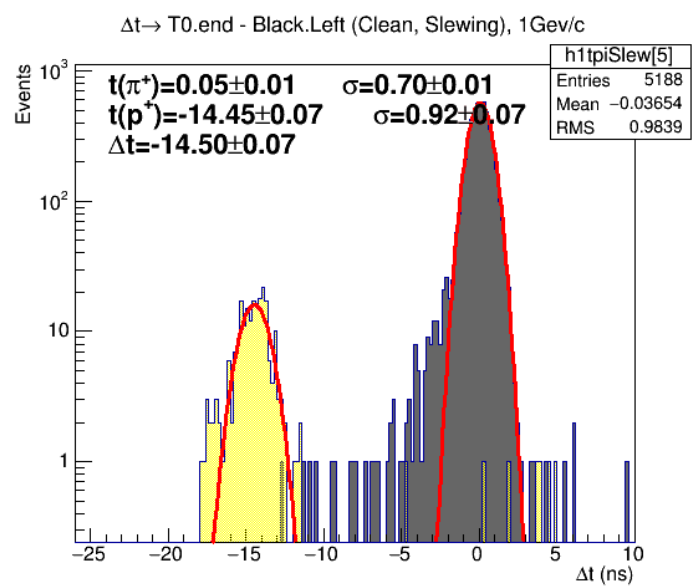


# After Slewing correction (1 GeV/c)
# Respect to **T0.end**



# Results

| Momentum 1 GeV/c, Δt(π+,p+)=1.21 ns/m | | | | | | |
|---|---|---|---|---|---|---|
| | | | No Slewing | | Slewing Correction | |
| **Detector** | **distance (cm)** | **Δt(pi,proton) (ns) Theoretical** | **Δt(pi,proton) (ns)** | **Error** | **Δt(pi,proton) (ns)** | **Error** |
| AD2 | 305.5 | 3.684 | 4.54 | 0.02 | 3.85 | 0.02 |
| AD1 | 302.5 | 3.648 | 4.45 | 0.02 | 3.72 | 0.02 |
| T0.start | 62 | 0.748 | 1.12 | 0.01 | - | - |
| Black.Rigth | 371 | 4.474 | 5.21 | 0.01 | 4.61 | 0.01 |
| Black.Left | 845 | 10.190 | 14.33 | 0.09 | 14.5 | 0.07 |

| Time resolution → Momentum 1 GeV/c | | | | |
|---|---|---|---|---|
| | Pion | | Proton | |
| **Detector** | **σ (ns)** | **Error** | **σ (ns)** | **Error** |
| AD2 | 1.1 | 0.01 | 0.89 | 0.06 |
| AD1 | 1.18 | 0.01 | 0.84 | 0.01 |

| After Slewing Time resolution → Momentum 1 GeV/c | | | | |
|---|---|---|---|---|
| | Pion | | Proton | |
| **Detector** | **σ (ns)** | **Error** | **σ (ns)** | **Error** |
| AD2 | 0.93 | 0.01 | 0.72 | 0.01 |
| AD1 | 0.84 | 0.01 | 0.7 | 0.01 |

Thanks !

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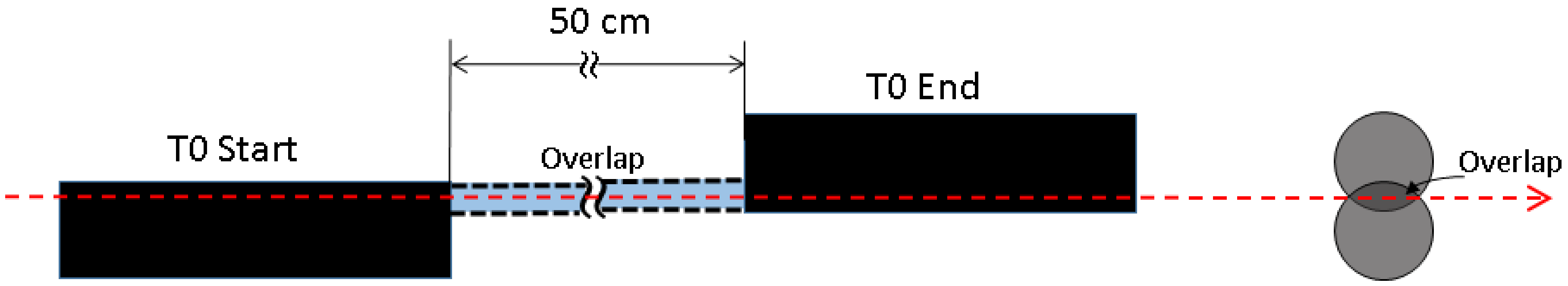
11) S. Evdokimov, Difraction physics with ALICE at the LHCarXiv:1412.127.7300.
12) Front end electronics and first results of the ALICE V0 detector, Y. Zoccarato et. al., 6 October 2010, Nuclear Instruments and Methods in Physics Research A.

# Appendix

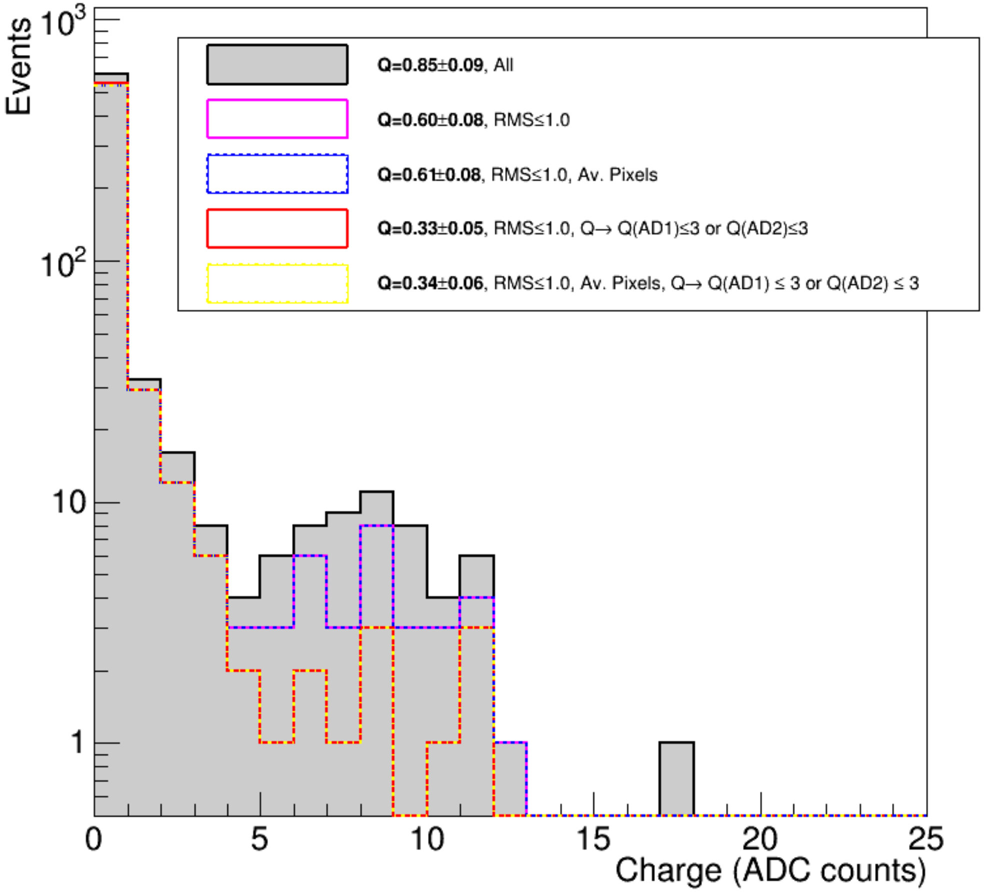
# T0 overlap



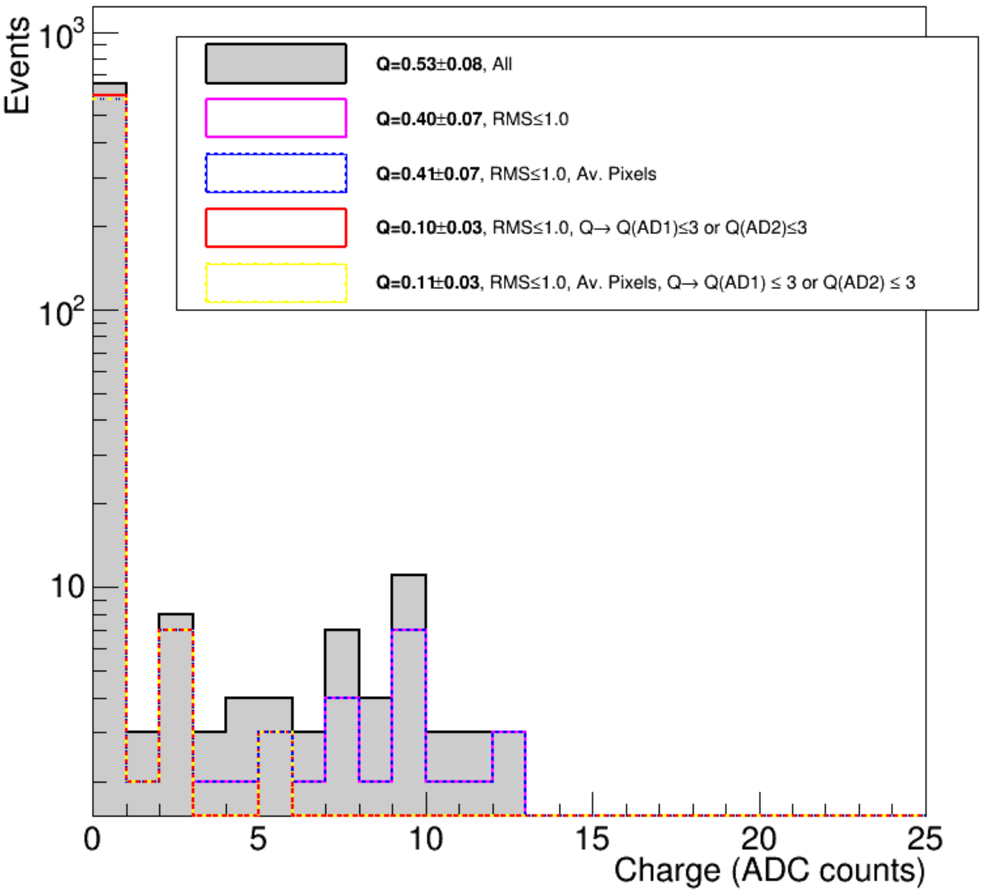
# Comparison on methods to clean up charge analysis with pixel detector

- There are not significant difference on the charge analysis by use the average position of the pixels fired every event.

AD1 Charges



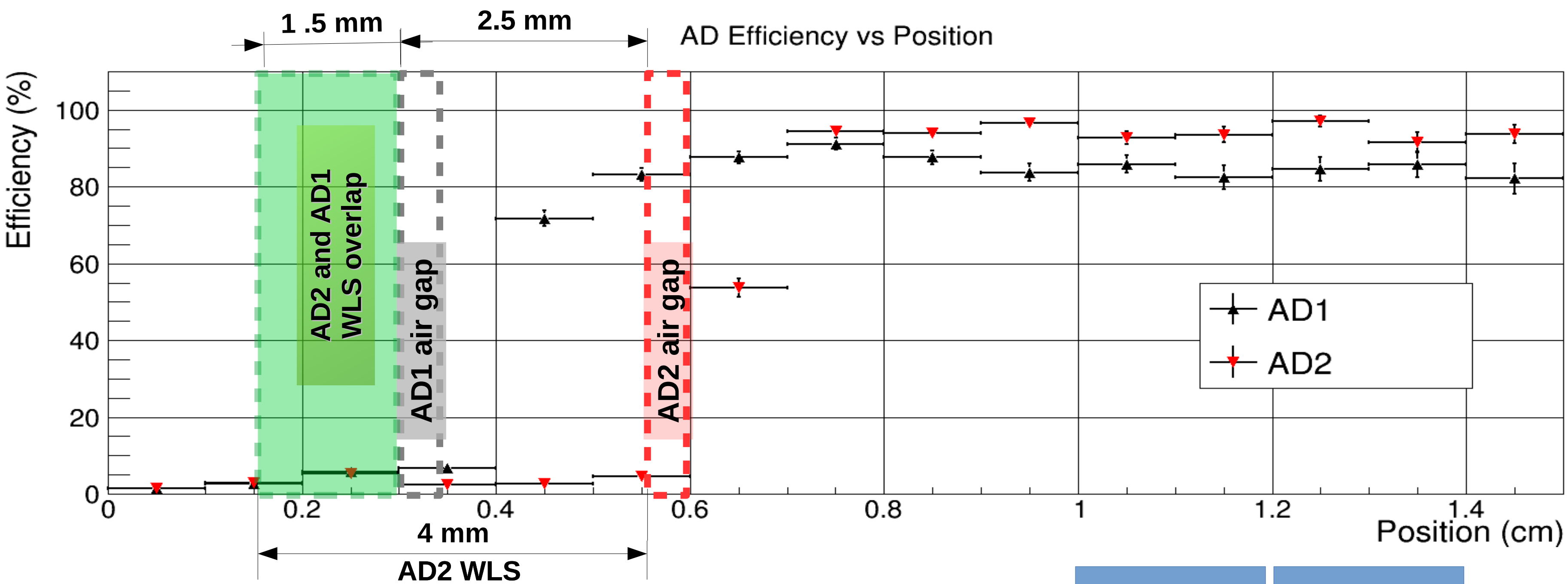

AD2 Charges



# WLS-bar → Efficiency

**Efficiency =** (Black_Left ∧ Back_Right ∧ Pix ∧ **AD**) / (Black_Left ∧ Back_Right ∧ Pix)

- Time flags were used to calculate the efficiency.
- RMS cut was applied.




| | WLS bar (%) (common region) | Scintillator (%) |
|---|---|---|
| **AD1** | 5.263 ± 0.263 | 88.169 ± 0.668 |
| **AD2** | 4.146 ± 0.796 | 94.942 ± 0.453 |