PAD*MME* Test Beam

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Introduction

Proposed Configuration

- Test of MicroMegas prototype chamber for PADME
  - 5 cm drift gap
  - Gas mixture: $Ar:CF_4:Iso$ (88:10:2)
  - Strip readout
- Several runs taken in different conditions
  - High stat @ Nominal HV
  - Drift HV scan
  - High Multiplicity @ low HV
  - Different tilt of the chambers
- Data Analysis using TBReco
  - Charge Centroid for perpendicular tracks
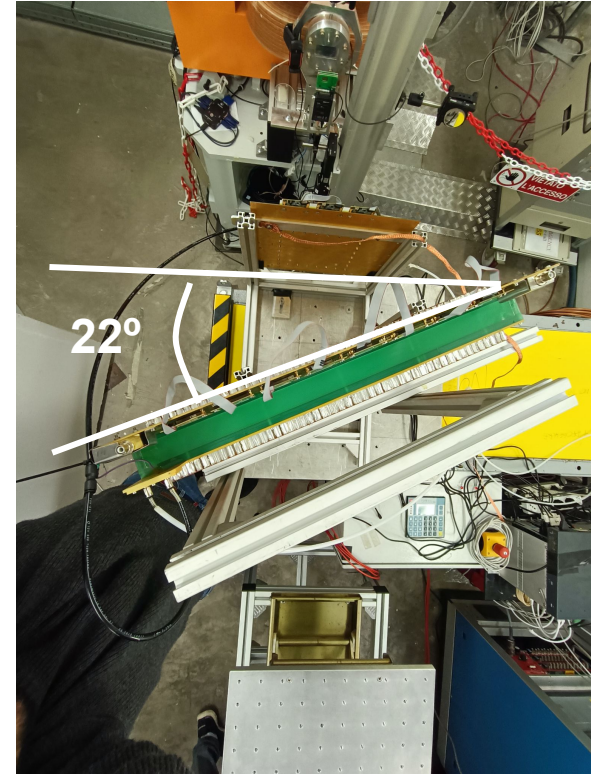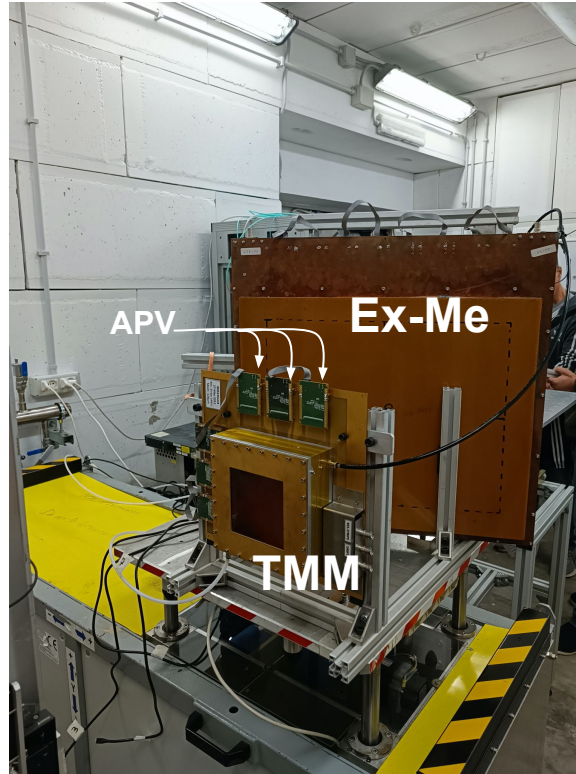 - Micro-TPC for inclined tracks
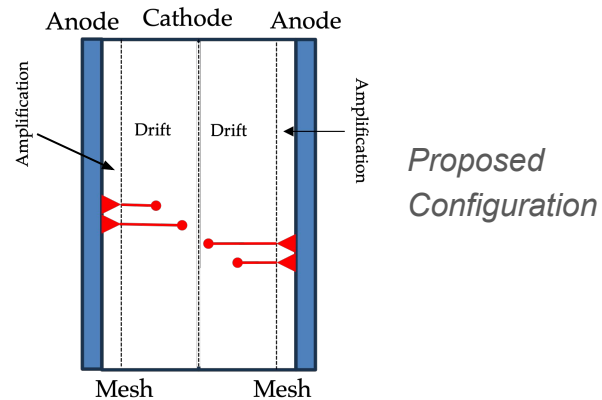
*Test Beam prototype*
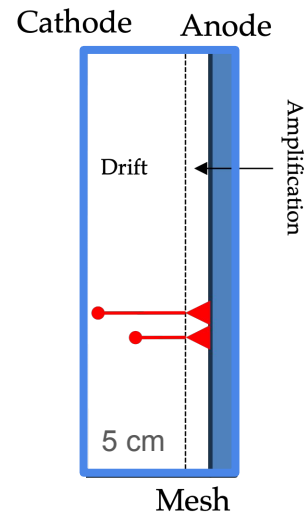
Setup @ BTF

Two MM chambers:

- One 10x10 cm^2 TMM chamber as reference (orthogonal to the beam)

- One Ex-Me 40x50 cm^2 chamber (tilted of 22º wrt the beam)

- Electronics: APV
  - 6 APV on the TMM
  - 8 APV on the Ex-Me

- HV settings (nominal):
  - TMM Amp: 460 V, Drift: 3 kV
  - Ex-Me Amp: 490 V, Drift: 3 kV

Setup @ BTF

- TMM chamber can reconstruct two coordinates:
  - x is the precision one
  - y is reconstructed thanks to the signal induced on the second strip readout layer
- Ex-Me can reconstruct only one coordinate, the precision one (which goes along with the y of the TMM in this setup)

Beam

y

x

Local coordinates!

strips pitch 250 µm

table

x

strips pitch 400 µm

table

Beam

22°
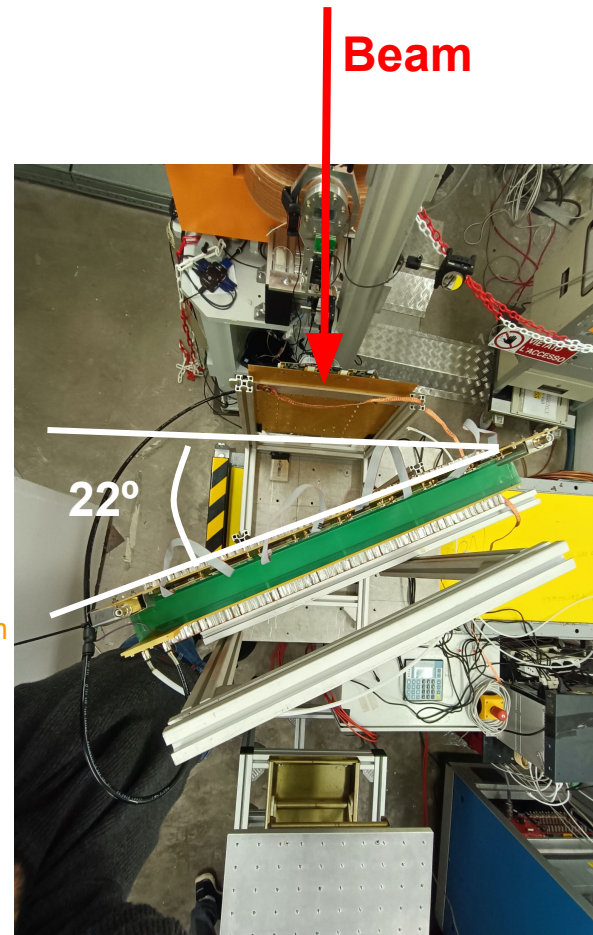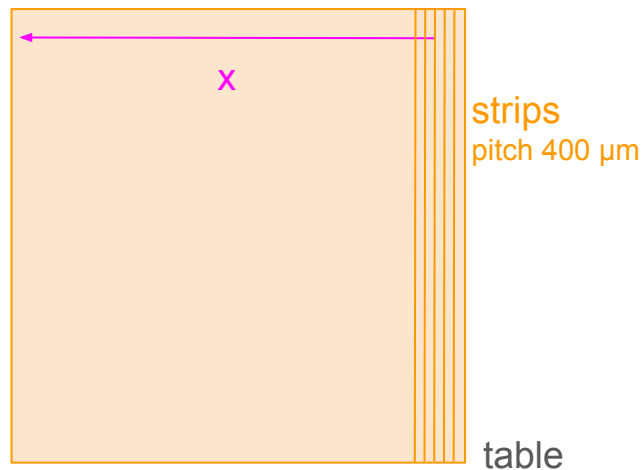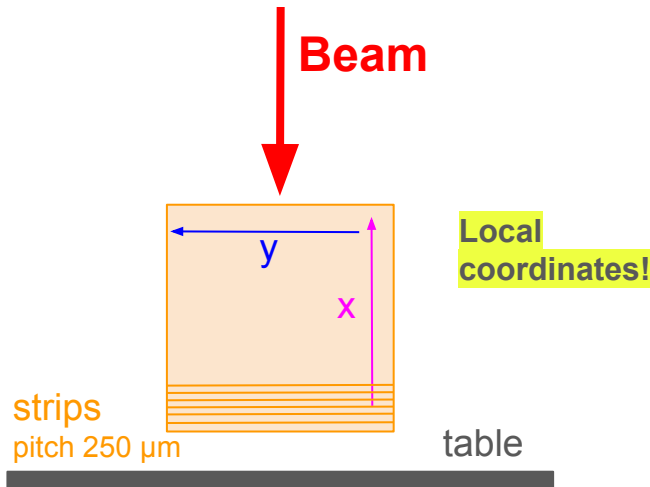
Runs

| Who	When	Run Number	Pedestal/Physics	N. events	N. events offline	Beam conditions	HV ExMe	Drift ExMe	HV Tmm	Drift Tmm
Chiara, Valerio, Fabio	23/11/2023 17:49	2004	Pedestal	1901		random trigger - no beam	490	3000	460	3000
Chiara, Valerio, Fabio	23/11/2023 17:58	2005	Physics	131000	49066	both e+ and e-	490	3000	460	3000
SCAN DRIFT										
tanta gente	24/11/2023 10:25	2006	Physics	71000	30079	both e+ and e-	490	2500	460	3000
Chiara, Valerio	24/11/2023 11:36	2007	Physics	74000	27608	both e+ and e-	490	2250	460	3000
Chiara, Valerio, Levan	24/11/2023 13:00	2008	Physics	76574	18927	both e+ and e-	490	1750	460	3000
Chiara, Valerio, Levan, Beka	24/11/2023 14:14	2009	Physics	80526	27927	both e+ and e-	490	2750	460	3000
Chiara, Valerio, Levan, Beka	24/11/2023 15:29	2010	Physics	860	553	both e+ and e-	490	4000	460	3000
Chiara, Valerio, Levan, Beka	24/11/2023 15:47	2011	Physics	38534	38135	both e+ and e-	490	4000	460	3000
Chiara, Valerio, Levan, Beka	24/11/2023 15:47	2012	Physics	50203	50127	both e+ and e-	490	3250	460	3000
SCAN HV AMP 1500 particles										
Chiara, Valerio, Levan, Beka	24/11/2023 18:05	2013	Physics	5000		e-	280	3000	280	3000
Chiara, Valerio	24/11/2023 18:15	2014	Physics	4600		e-	300	3000	300	3000
Chiara, Valerio	24/11/2023 18:20	2015	Physics	5000		e-	320	3000	320	3000
TILTED TMM CHAMBER ALMOST AT THE SAME ANGLE OF EX-ME										
Chiara, Valerio, Levan	24/11/2023 19:10	2016	Pedestal	2000		random trigger - no beam	490	3000	460	3000
Chiara, Valerio, Levan	24/11/2023 19:20	2017	Physics	108884		both e+ and e-	490	3000	460	3000
TMM back to perpendicular position										
Chiara, Mario, Beka	25/11/2023 11:05	2018	Pedestal	2000		random trigger - no beam	490	3000	460	3000
Chiara, Mario, Beka	25/11/2023 11:15	2019	Physics	126808		both e+ and e-	490	3000	460	3000
Chiara, Mario, Beka	25/11/2023 13:13	2020	Physics	119846		both e+ and e-	490	3000	460	3000
Chiara, Levan, Beka, Mario	25/11/2023 15:07	2021	Physics	87231		both e+ and e-	490	3000	460	3000
Levan, Beka, Mario	25/11/2023 16:42	2022	Physics	74113		both e+ and e-	490	3000	460	3000
Levan, Beka	25/11/2023 18:04	2023	Physics	8350		both e+ and e-	490	3000	460	3000
Levan, Beka	25/11/2023 18:35	2024	Physics	91795		both e+ and e-	490	3000	460	3000

Event Display

Hit Charge Strip

Hit Time Strip
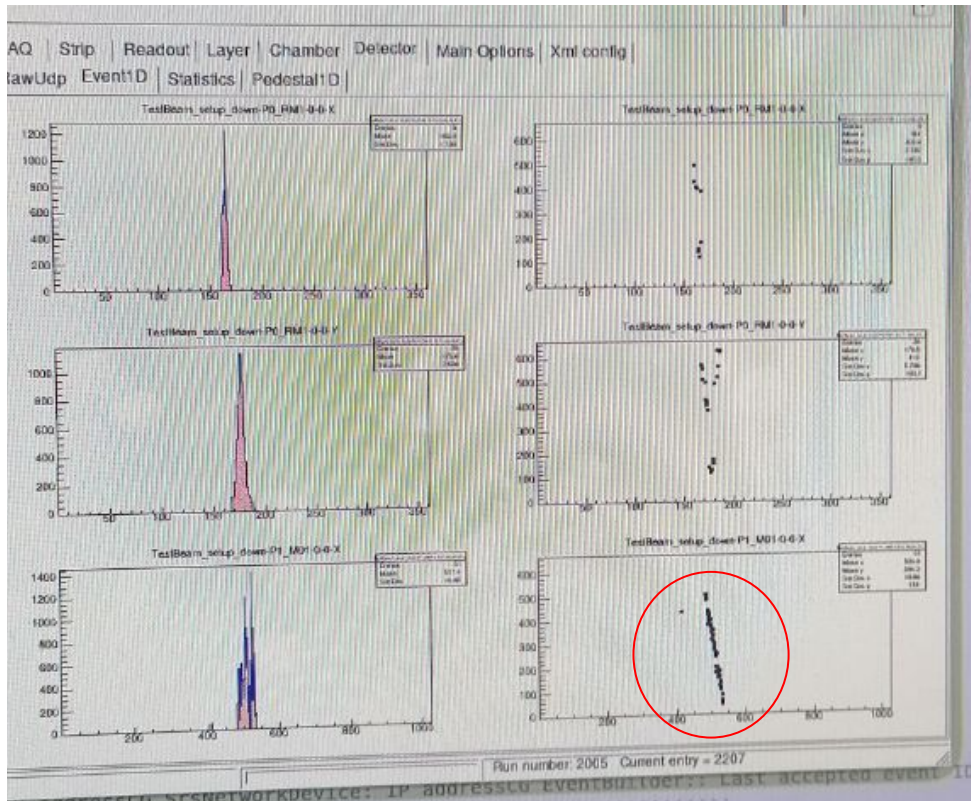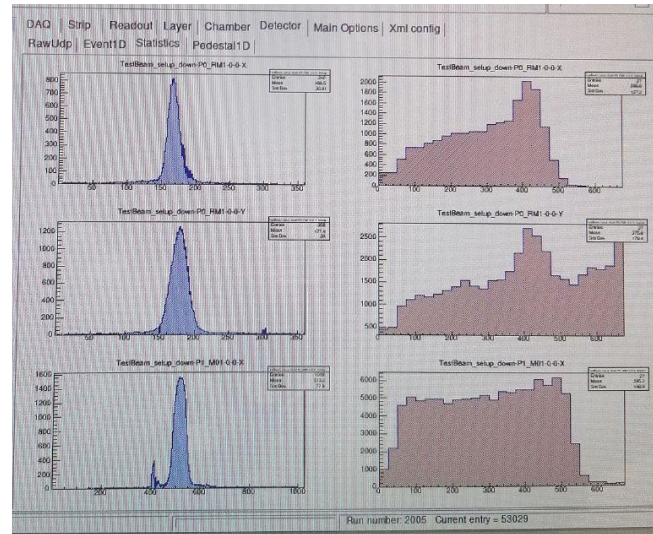
**TMM
x - coordinate**

**TMM
y - coordinate**

**Ex-Me
x - coordinate**

Statistics collected

We can see the angle in the time of the hits!

Event Display
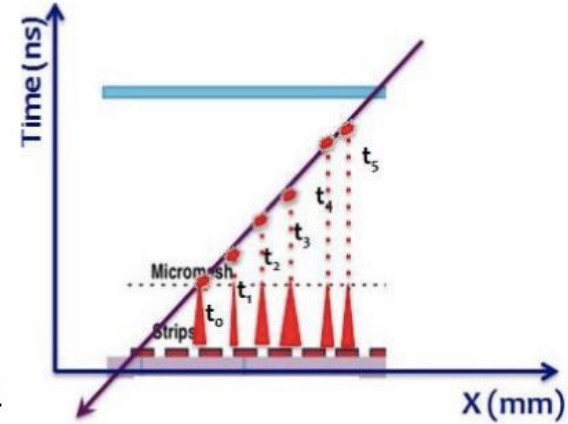
Inclined TMM
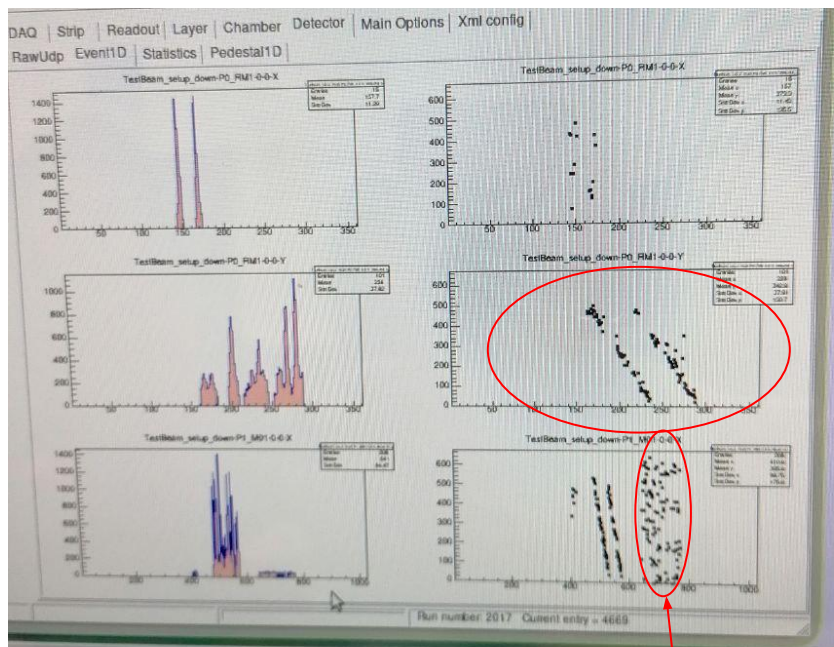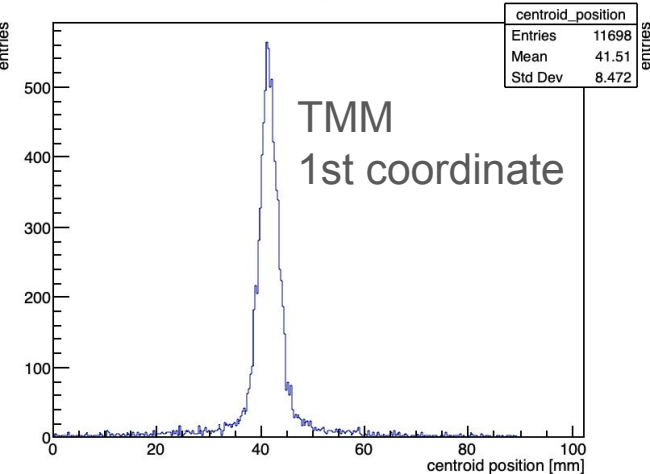
High-Multiplicity
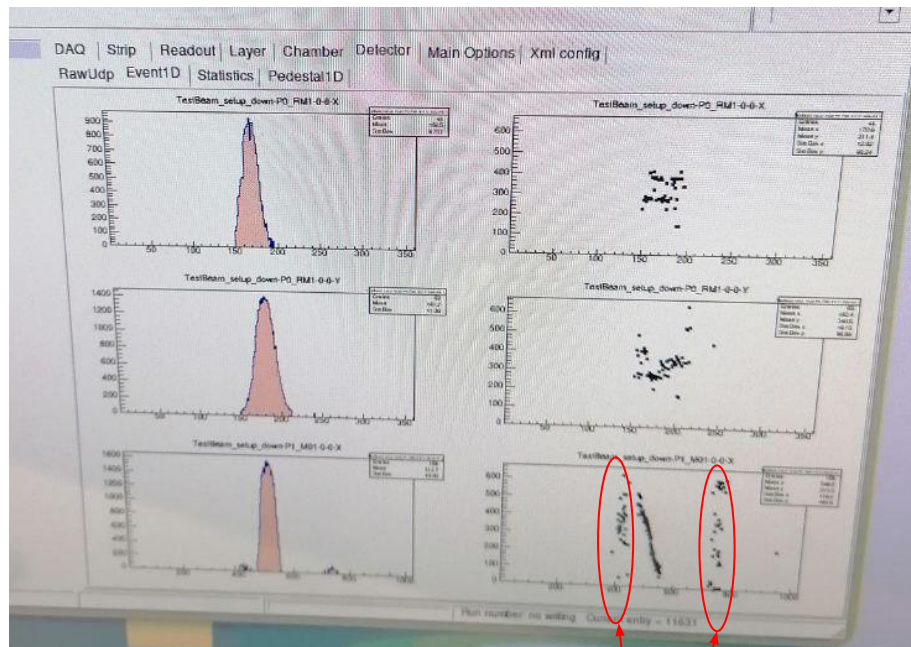
noisy channels

noisy channels
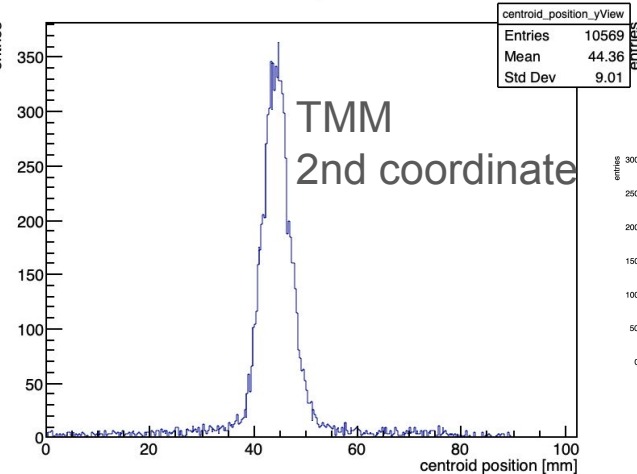
Data Analysis

Possible to reconstruct position with 2 methods:

- Charge centroid (~0°) $x_{centroid} = \frac{\sum_{i=1}^{N} q_i x_i}{\sum_{i=1}^{N} q_i}$
- Micro–TPC (>10°) $z_i = v_{drift} \cdot t_i$, $x_{half} = \frac{z_{half} - q}{m} = \frac{2.5mm - q}{m}$

centroid position

TMM
1st coordinate

centroid_position	
Entries	11698
Mean	41.51
Std Dev	8.472

centroid position

TMM
2nd coordinate

centroid_position_yView	
Entries	10569
Mean	44.36
Std Dev	9.01

centroid position

ExMe

Centroid
position is
shifted by
3 mm here!

centroid_position	
Entries	7703
Mean	203.4
Std Dev	18.45

| centroid_position	
Entries	7703
Mean	204.3
Std Dev	5.56
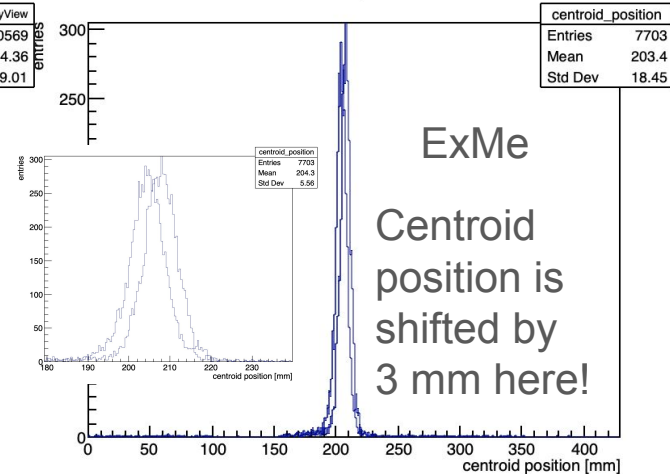
Data Analysis

- Micro-TPC reconstruction for ExMe clusters
- Large cluster size → many points for track fit
- Good track angle reconstruction: 21.5°
- Sometimes track angle is not well reconstructed and can be connected to double tracks merged in 1 single cluster

μTPC track reconstruction, θ=22.1   MM chamber P1_M01

uTPC angle

utpc_angle	
Entries	7695
Mean	21.52
Std Dev	5.513
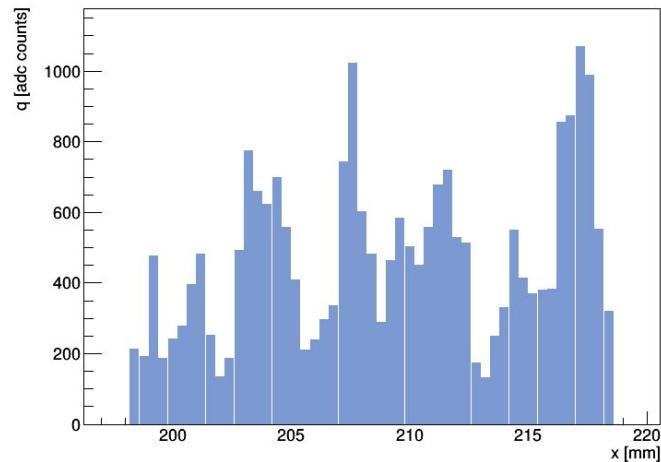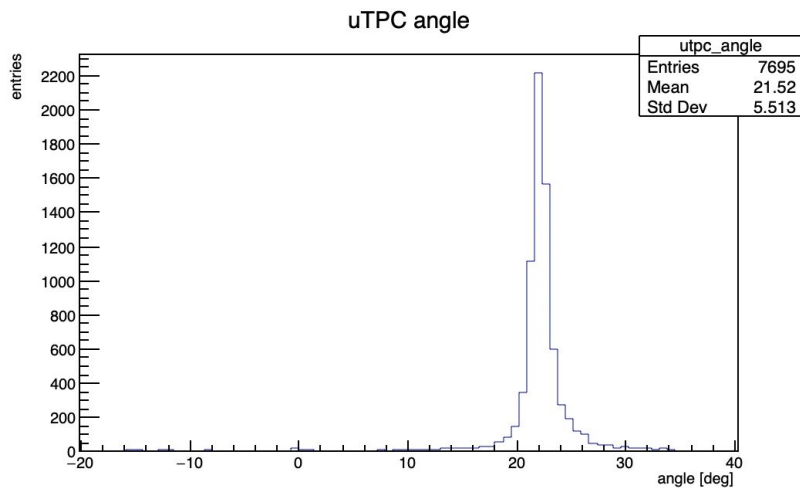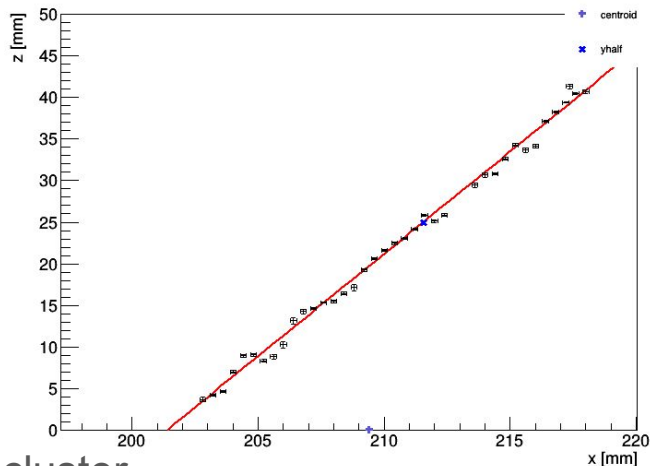
TBReco

- Test beam reconstruction software
- Reads raw data and produces histograms and ntuples
- 2 main classes that can be modified:
  - **TBReco/TBReco.h** → settings: events to run, selection cuts, etc
    (already tuned for this test beam, probably not needed also to be modified)
  - **Root/ResolAnaPadme.cxx** → dedicated class for this test beam,
    with ad-hoc plots and analyses
- All the rest is the core of the code, no need to modify it
- Other easier option is to use the output ntuple of TBReco
  and do the analysis using custom root or python macros
- All cluster informations are available in the tree
  (hit informations can be added if you want to test another
  clusterization algorithm)

TBtree;1
- run_number
- event_number
- clusters_centroid_x
- clusters_centroid_ex
- clusters_centroid_y
- clusters_centroid_ey
- clusters_centroid_z
- clusters_centroid_ez
- clusters_utpc_x
- clusters_utpc_ex
- clusters_utpc_y
- clusters_utpc_ey
- clusters_utpc_z
- clusters_utpc_ez
- clusters_utpc_angle
- clusters_utpc_pchi2
- clusters_utpc_m
- clusters_utpc_q
- clusters_nstrips
- clusters_nholes
- clusters_totcharge
- clusters_issecondcoord
- clusters_chamber
- clusters_hasutpcfit
- clusters_strips_indices