A Mini Time Projection Chamber for the PEN Experiment

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Outline

PEN Experiment: Motivation and Context

Mini Time Projection Chamber (mTPC)

Global Context $\pi \longrightarrow e\nu$

THEORY: $BR = \dfrac{\Gamma(\pi \longrightarrow e\nu(\gamma))}{\Gamma(\pi \longrightarrow \mu\nu(\gamma))} =$

$$\begin{cases} (1.2352 \pm 0.0005) \times 10^{-4} & \text{Marciano and Sirlin, [PRL } \mathbf{71} \text{ (1993) 3629]} \\ (1.2354 \pm 0.0002) \times 10^{-4} & \text{Finkemeier, [Phys. Lett. B } \mathbf{387} \text{ (1996) 391]} \\ (1.2352 \pm 0.0001) \times 10^{-4} & \text{Cirigliano and Rosell, [PRL } \mathbf{99}\text{, 231801 (2007)]} \end{cases}$$

EXPERIMENT [PDG]: $BR = (1.230 \pm 0.004) \times 10^{-4}$; $\dfrac{\delta BR}{BR} \approx 3.3 \times 10^{-3}$

PEN GOAL: $\dfrac{\delta BR}{BR} < 5 \times 10^{-4}$

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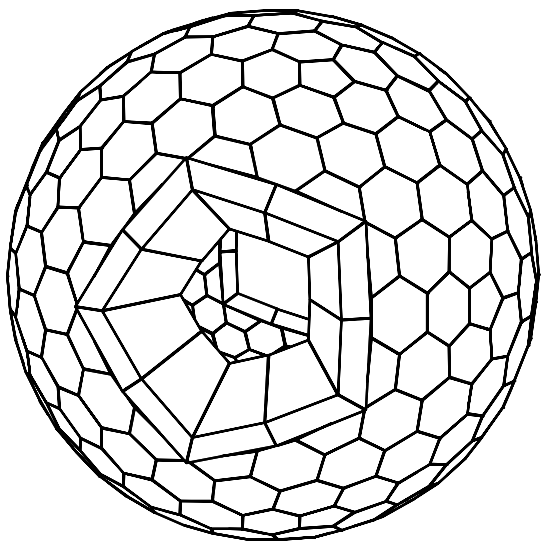
PEN Experimental Program

Precision measurement of hadronic charged current decay

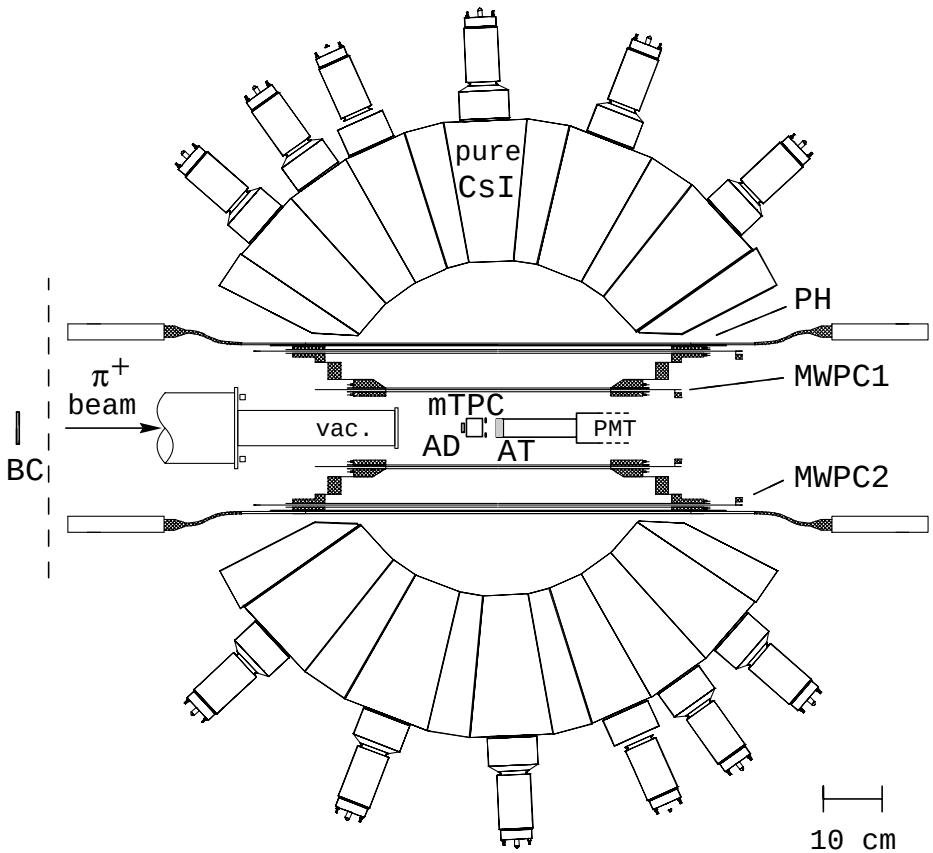
- $\pi^+ \longrightarrow e^+ \nu_e$
  - $e - \mu$ universality
  - **V-A** coupling deviations (pseudoscalar)
  - m_{h^+},PS/V leptoquarks, etc.
- $\pi^+ \longrightarrow e^+ \nu_e \gamma$
  - **V-A** coupling deviations (tensor)
  - $\mathbf{F_A/F_V}$, χPT test
- $\mu^+ \longrightarrow e^+ \nu_e \bar{\nu}_\mu \gamma$
  - $\mathcal{L}_{weak}$ departures from V-A



PEN Experimental Setup

- πE1 beamline at PSI
- Stopped π^+ beam
- 240-module CsI calorimeter
- Active target
- Central tracking

- Some Systematics
  - Decay in flight events
  - CsI gainmatching
  - Detector Alignment



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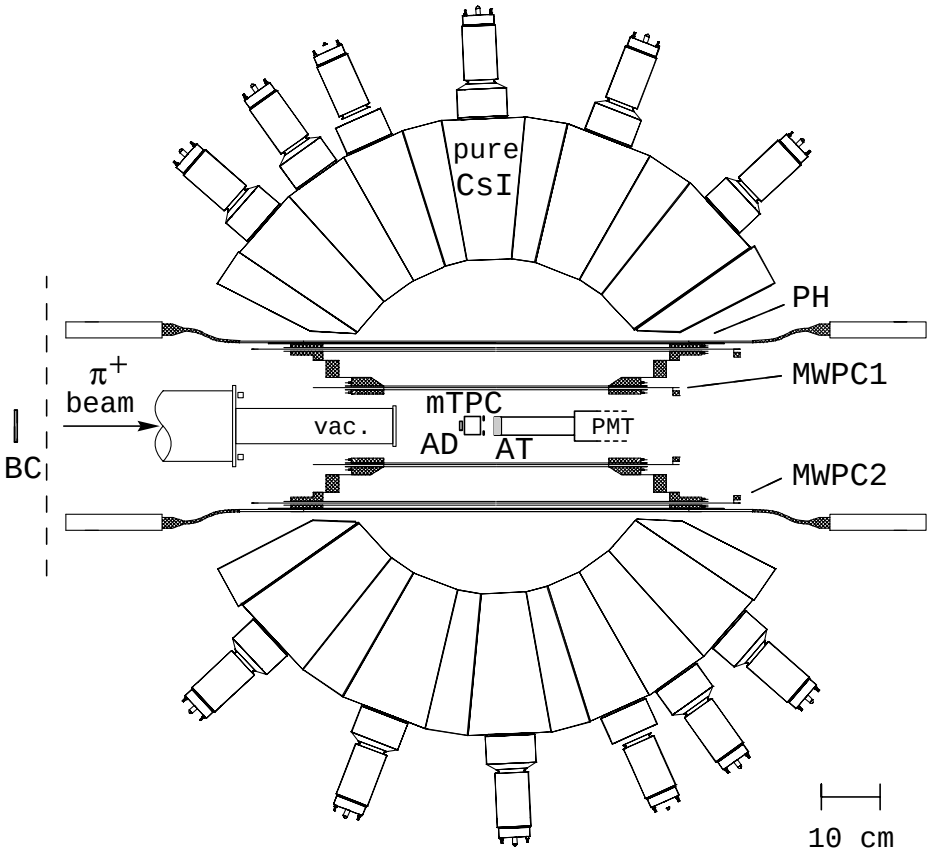
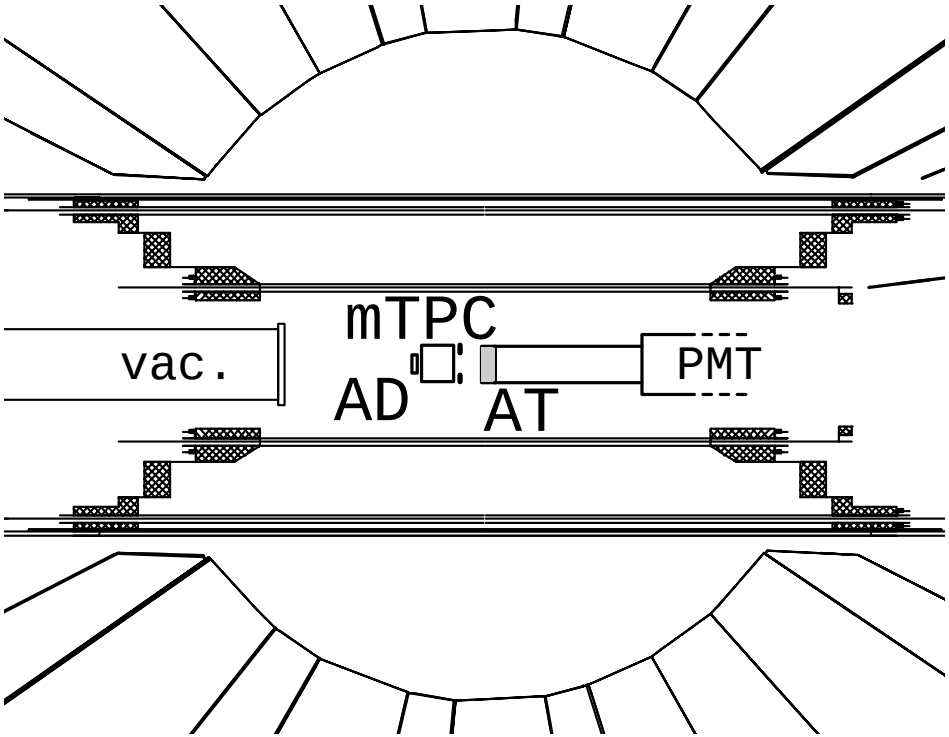
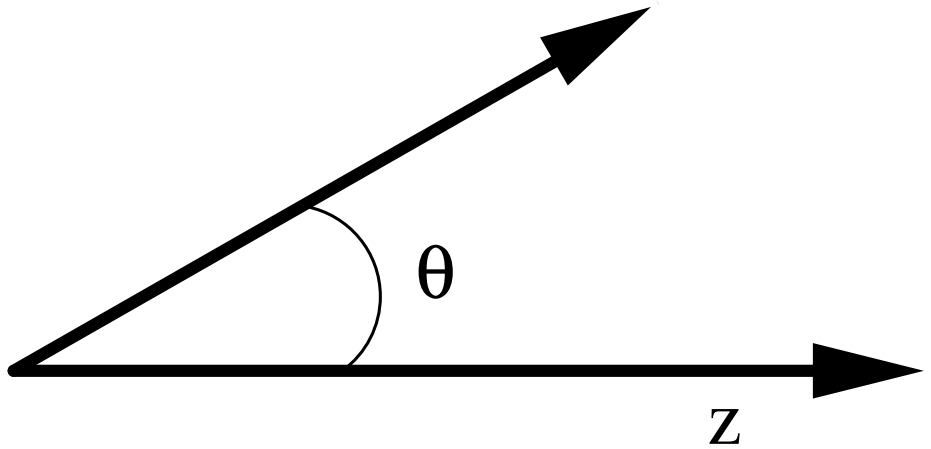
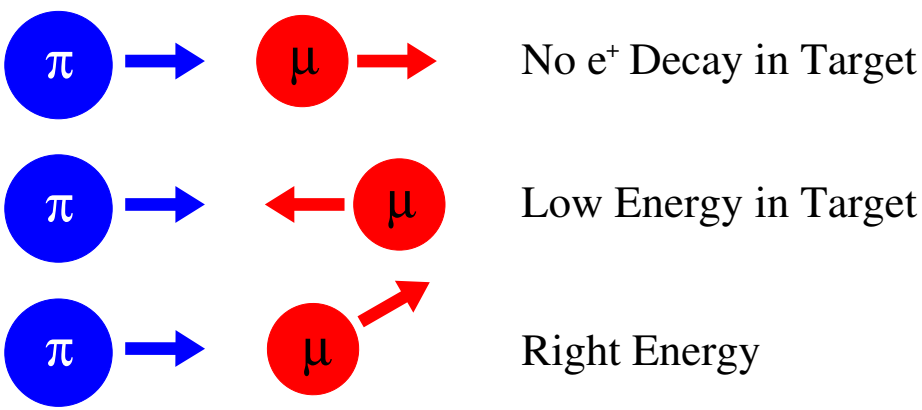
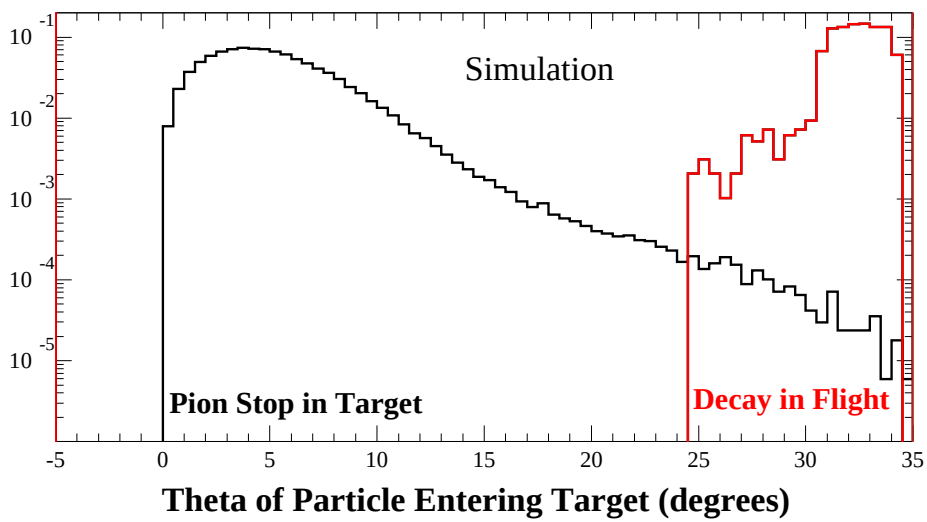


Decay In Flight Kinematics

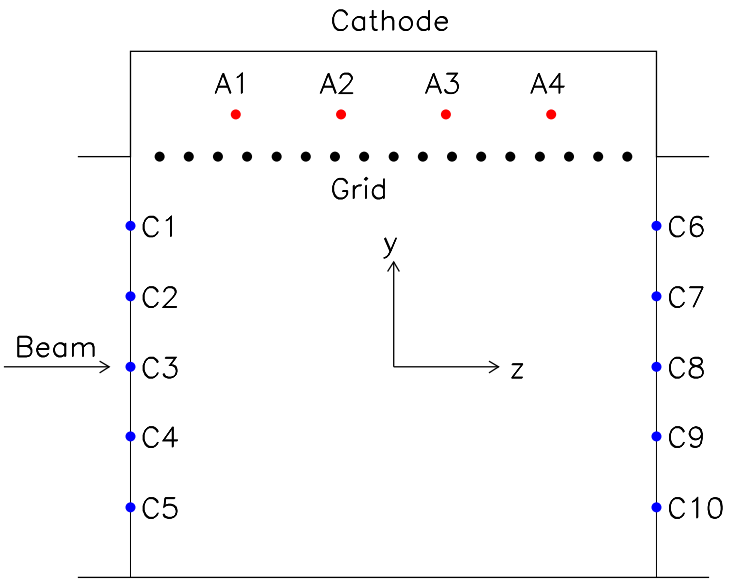






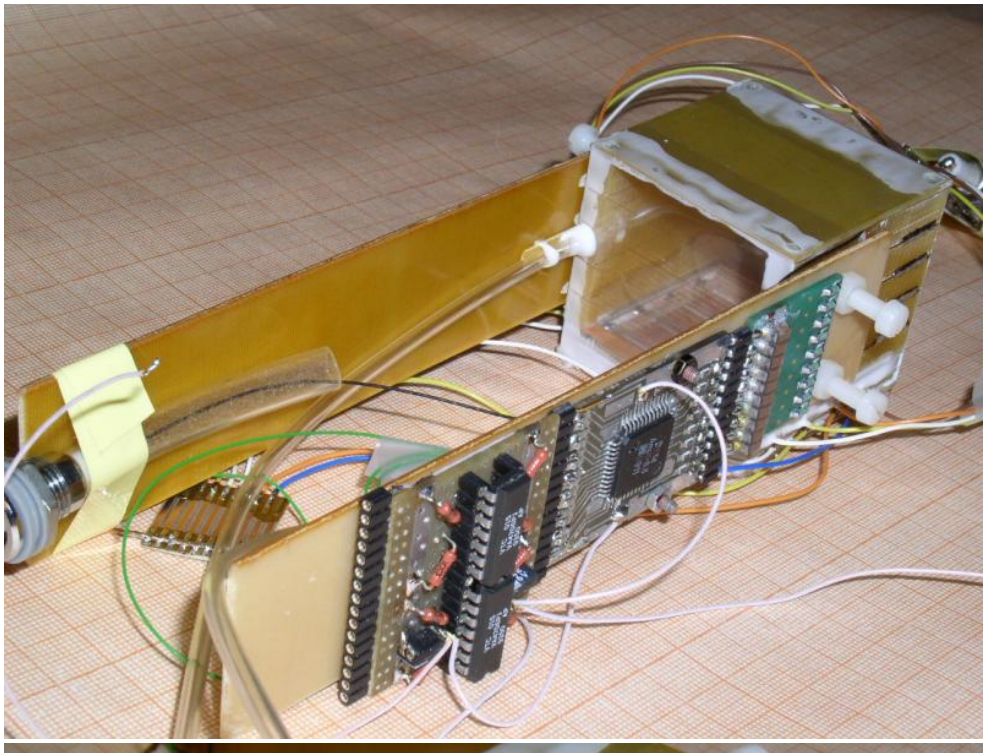


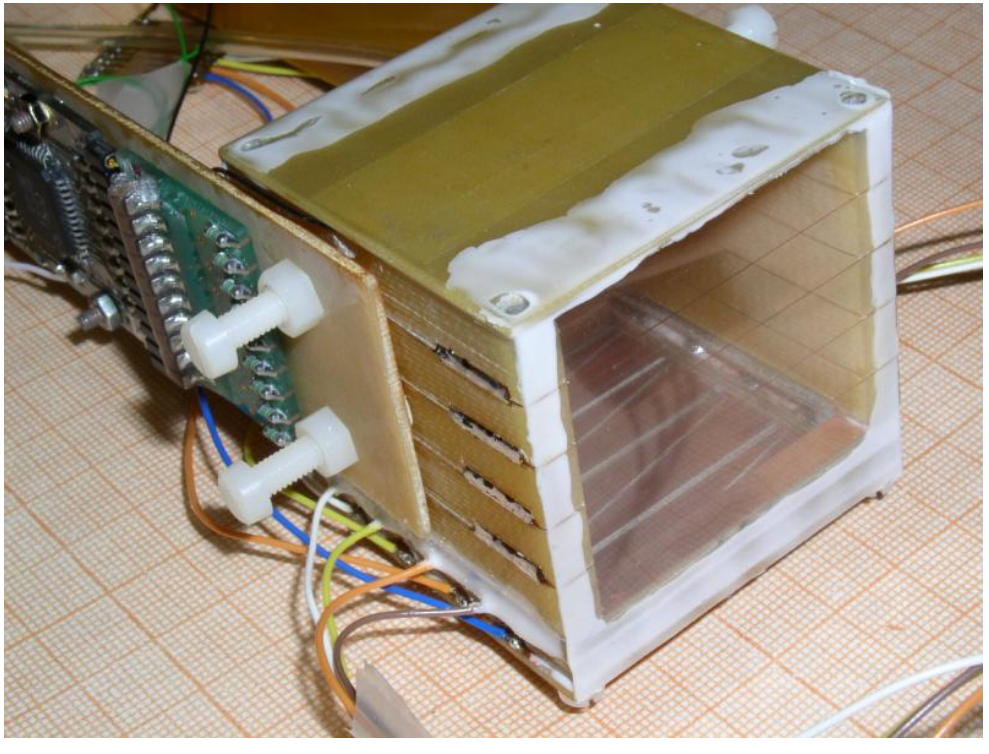
mTPC Technical Specifications

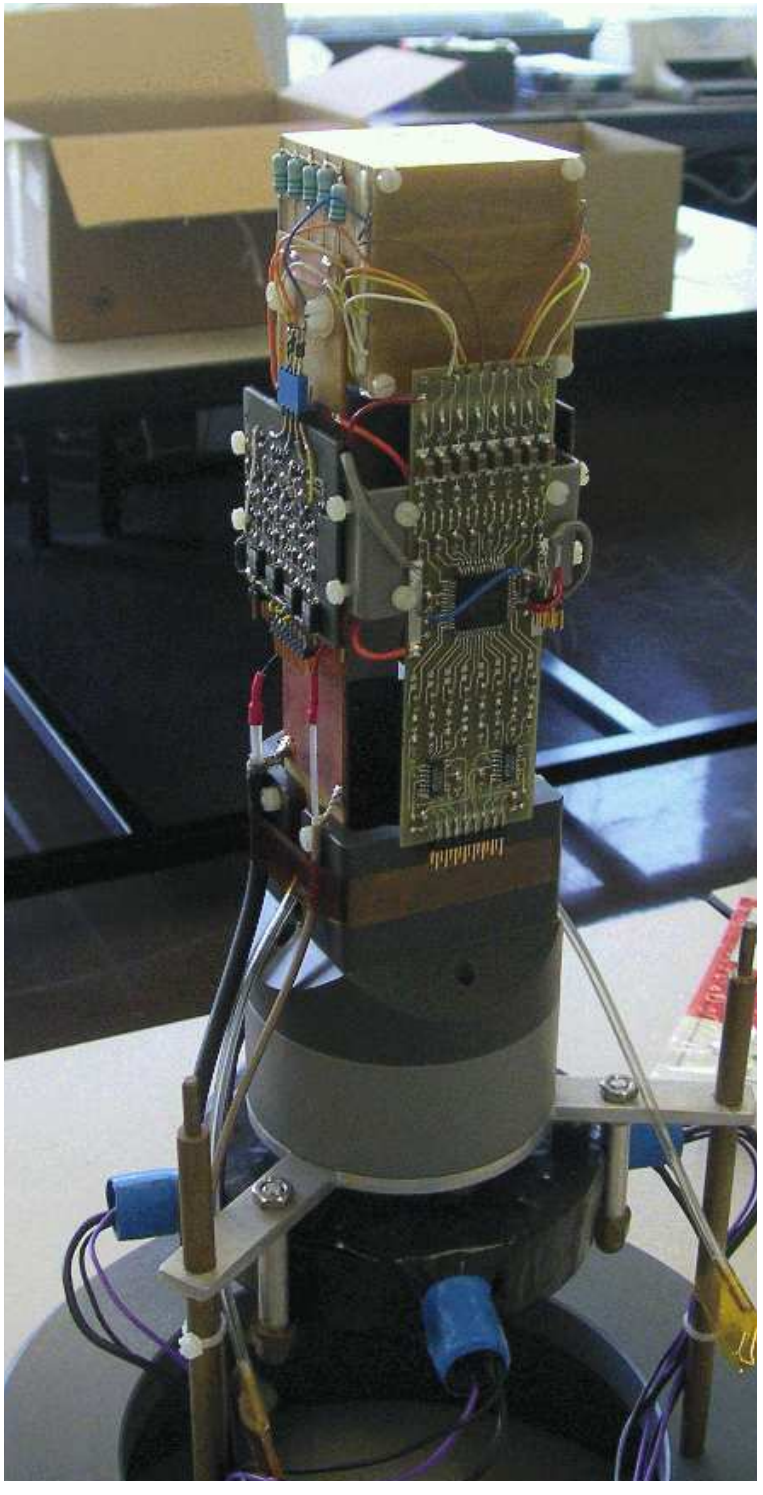


- Proportional Region: 40x6x40 mm
- Drift Region: 40x40x50 mm
- Drift Gas: 90% He and 10% C_2H_6
- 4000 V across drift region
- Grid: 50 μm wires with 1 mm spacing
- Nichrome Anode Wires
  - 40 mm length
  - 20 μm diameter
  - 10 mm spacing
  - 235 Ω resistance
- CAEN VME digitizer V1720

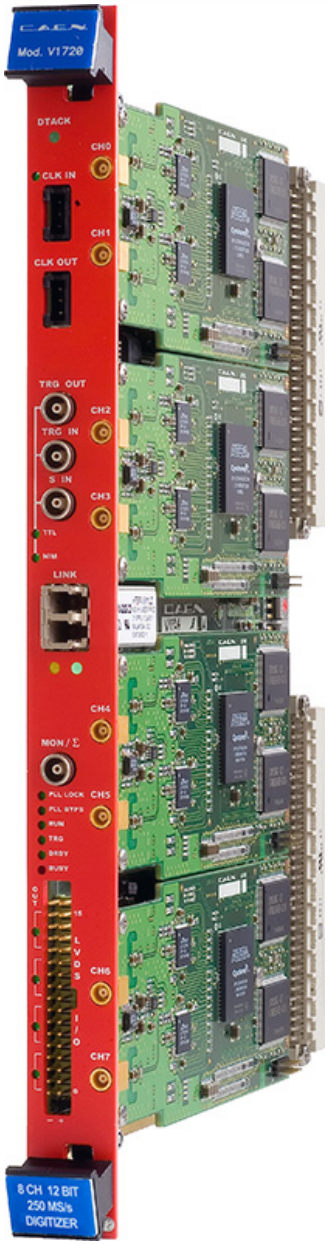
Fabricated by our collaborators from Dubna, Russia

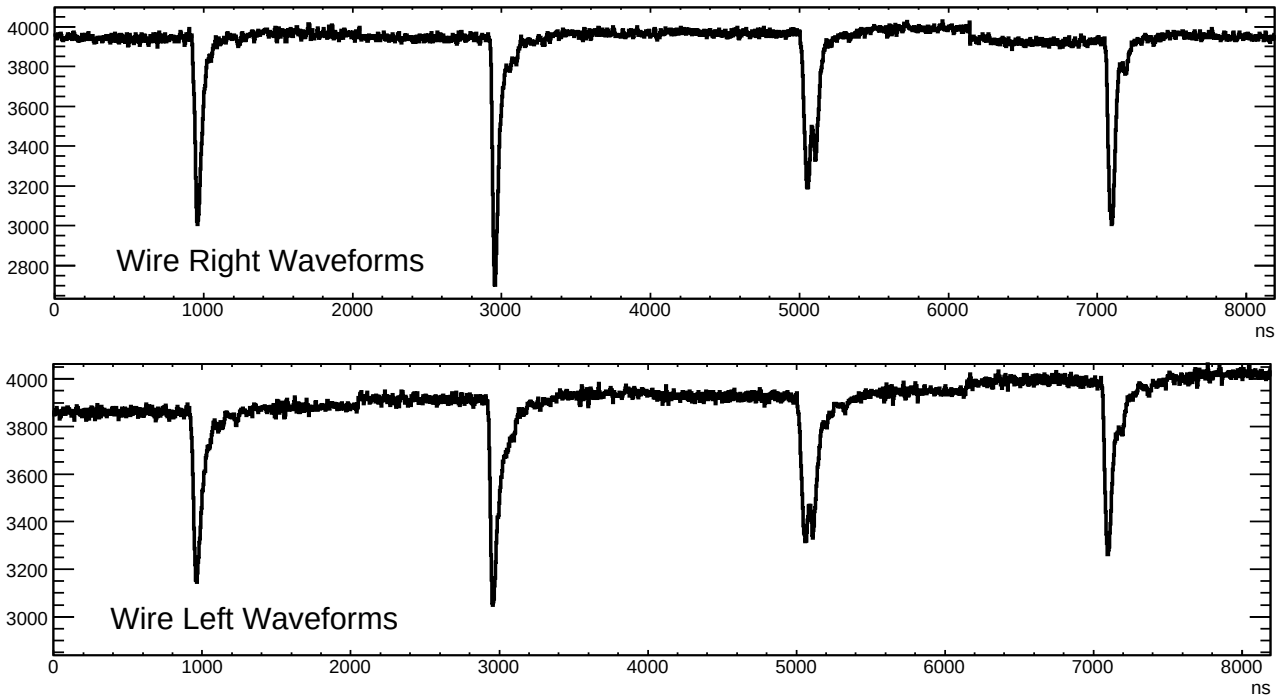






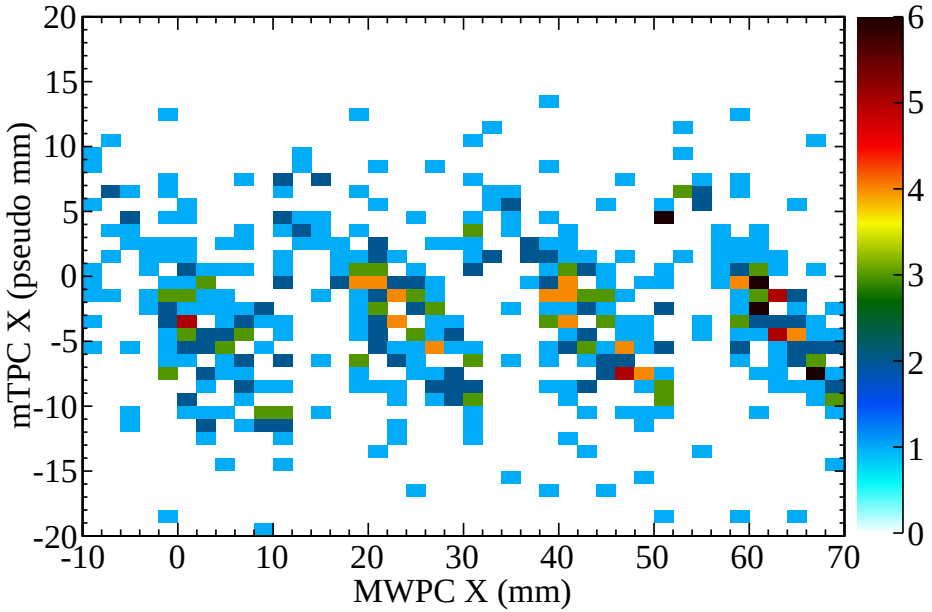
Waveform Digitization

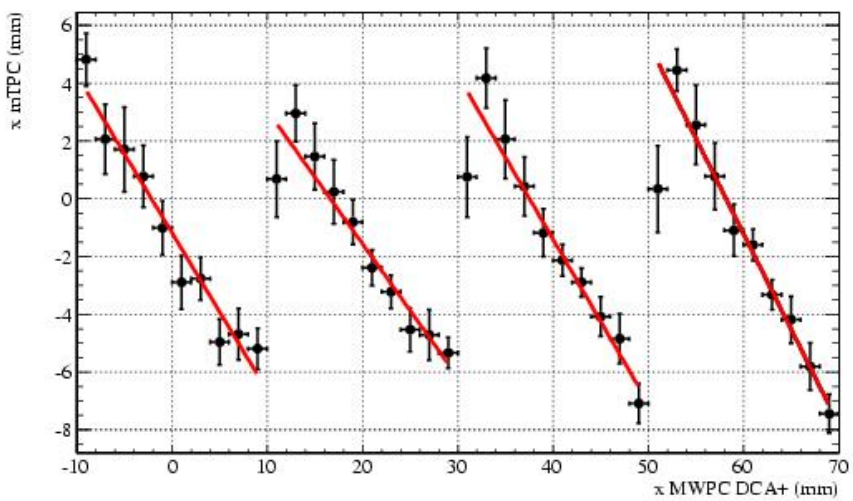




- x: charge division
- y: drift time
- z: wire location

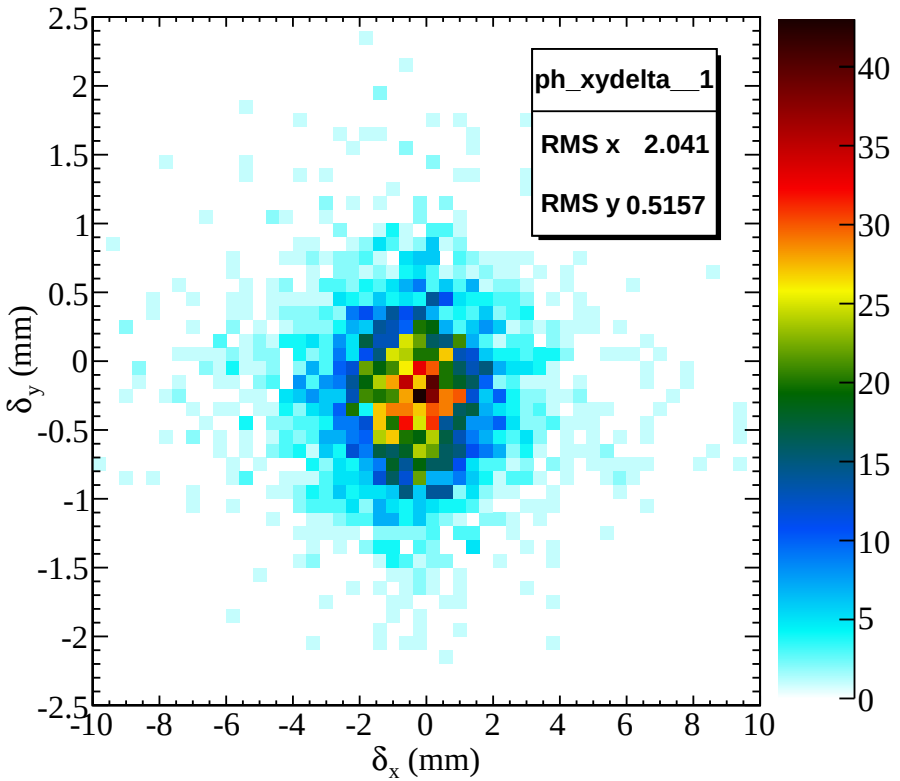
mTPC Coordinate Calibration





- MWPC coordinates well known
- Calibrate mTPC with MWPC

mTPC coordinate Resolution



$$\delta_i = i_2 - i_1 + \frac{(i_0 - i_3)}{3}$$

$$\sigma_i = \frac{RMS_{\delta_i}}{\sqrt{1^2 + 1^2 + (1/3)^2 + (1/3)^2}}$$

$\Rightarrow \sigma_x < 1.3\,\text{mm}$ (charge division)

$\Rightarrow \sigma_y < 0.35\,\text{mm}$ (drift time)

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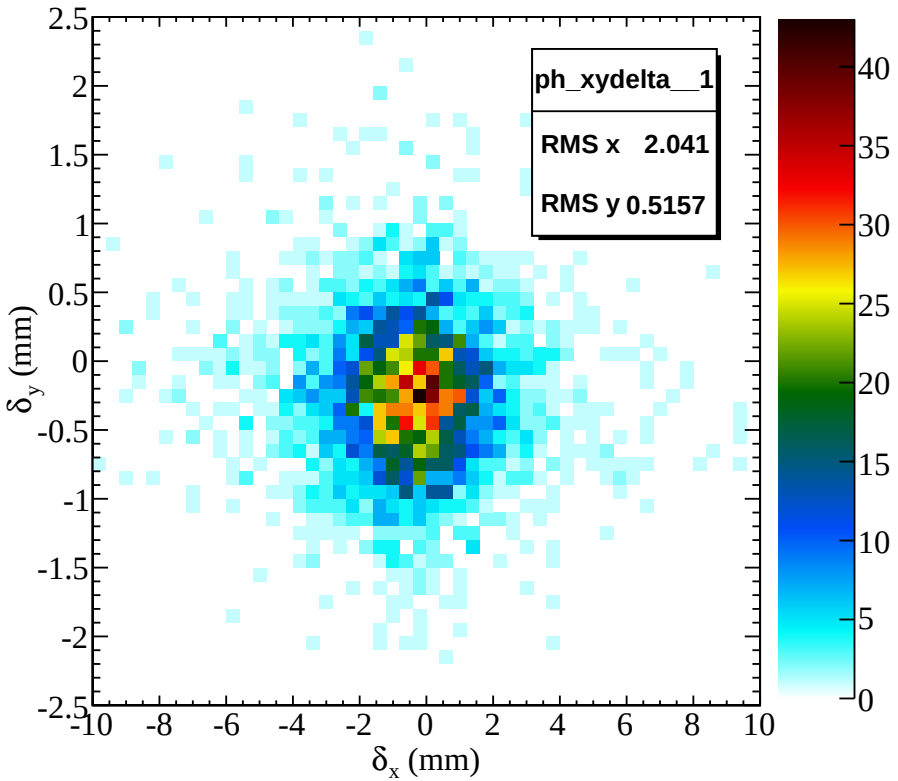

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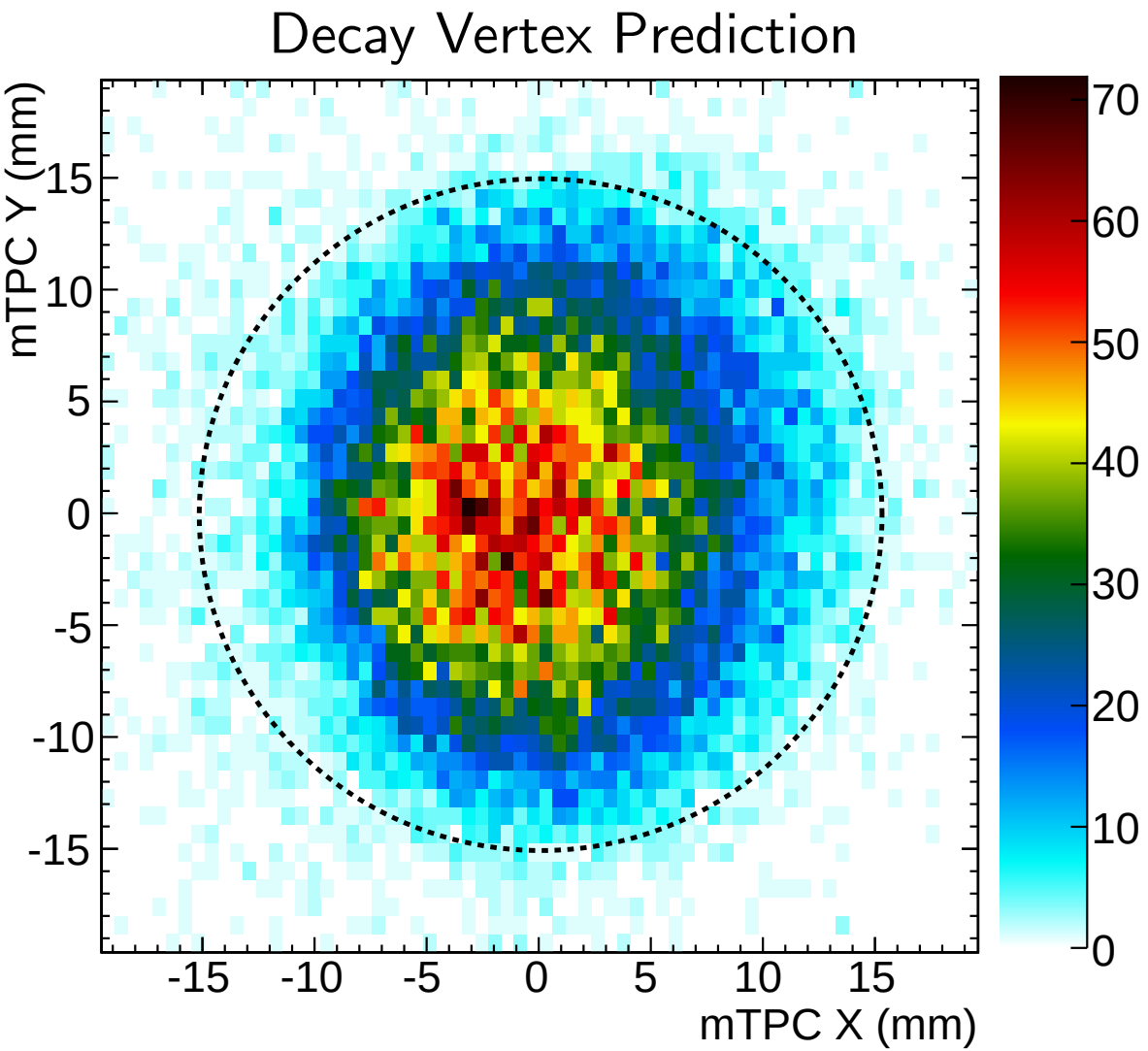
Results from 2009 Data Run



- X Position
  - charge division
  - $\sigma_x < 1.3\,\text{mm}$
- Y position
  - drift time
  - $\sigma_y < 0.35\,\text{mm}$

Experiment R-05-01 (PEN) collaboration members:

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