Joint Institute for Nuclear Research (Dubna)

Test beam measurements of the straw charge and spatial resolution

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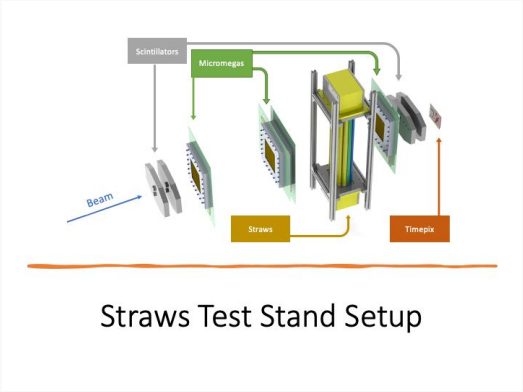
on behalf of ST beam test team

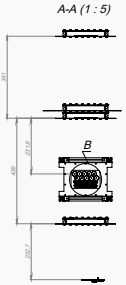
SPD Collaboration meeting, Almaty

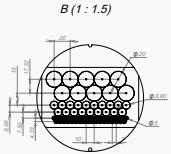
24^{th} of May, 2024

Beam setup

Test beam: August 2023, CERN. ~100 GeV μ-beam
Straw tubes: 20 mm, 10 mm, 5 mm
Straw readout: VMM3 based (mu2e)







Two data samples

In test beam setup VMM3 electronics was used in two modes:

1. 25 ns peaking time, gain 3.0 mV/fC. Optimal for time measurements
2. 200 ns peaking time, gain 0.5 mV/fC. Optimal for charge measurements

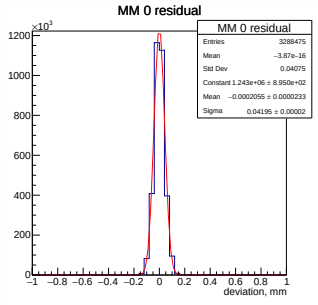
With the first option we are measuring hit time (used for measurement of spatial resolution)

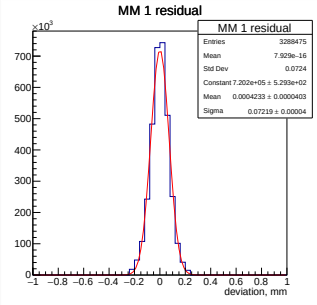
With the second option we are measuring hit charge (used for measurement of energy resolution).

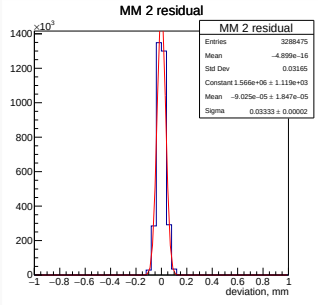
Performance of reference tracking

3 MicroMegas with strip width of 250 um

$\sigma = 0.042\ mm$ $\sigma = 0.072\ mm$ $\sigma = 0.033\ mm$

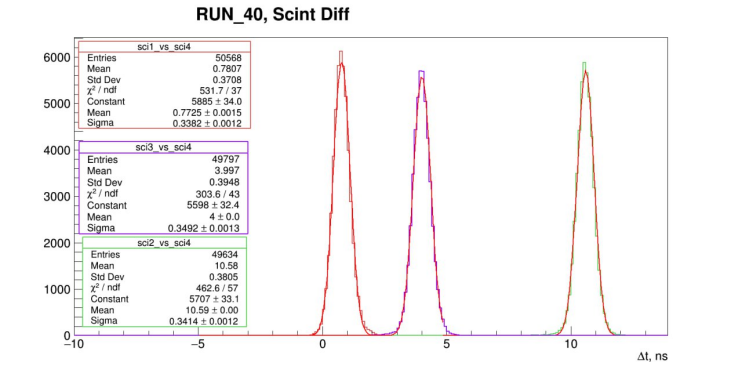




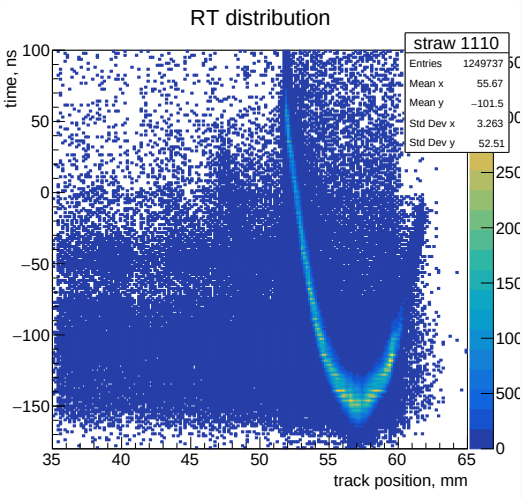


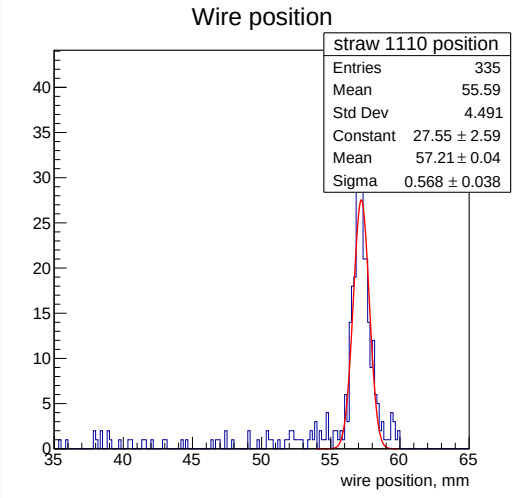
Performance of reference timing

4 scintillators with SiPM readout, T0 resolution better than 350 ps

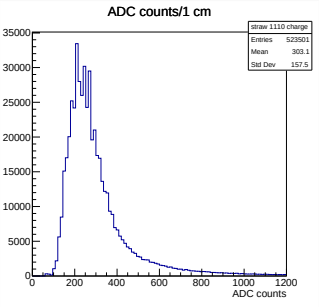


RT distribution, local coordinate definition





Truncated mean method - dE/dx resolution



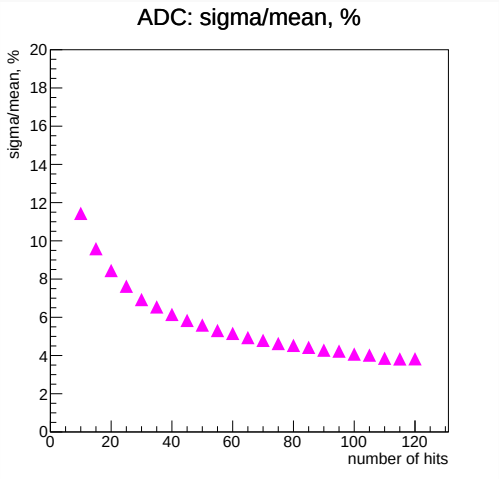
Method:

1. particle is crossing N tubes
2. released charge (dQ) is normalizing on travel length in each tube (dx)
3. the charge of highest 30% is truncated and mean value of dQ/dx of remain path is calculated
4. all values of trancated mean are fitted by gaussian and sigma/mean value is calculated

This value give us energy resolution of tubes.

These truncated means can be used for particle identification in tubes

dE/dx resolution - preliminary

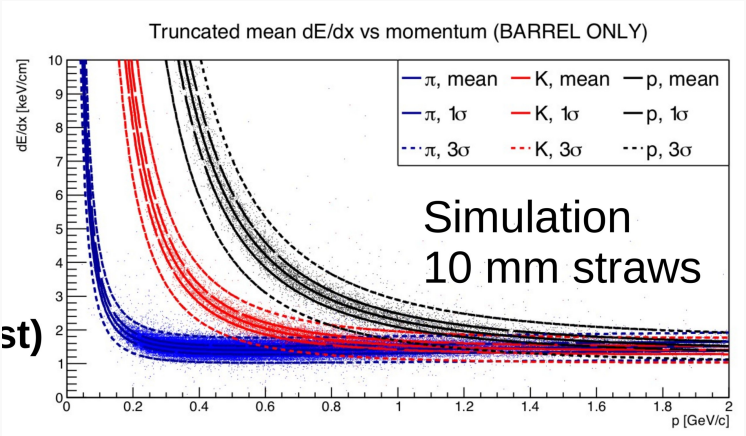


$$\sigma^2_{dE/dx}(n) = \sigma^2_{syst} + \frac{\sigma^2_{stat}}{n}$$

$$\sigma_{syst} = 2\%,\ \sigma_{stat} = 36\%$$

5% resolution correspond to 64 tubes number

Energy loss - Geant4 simulations



by Ruslan Akhunzyanov

Spatial resolution

Three methods:

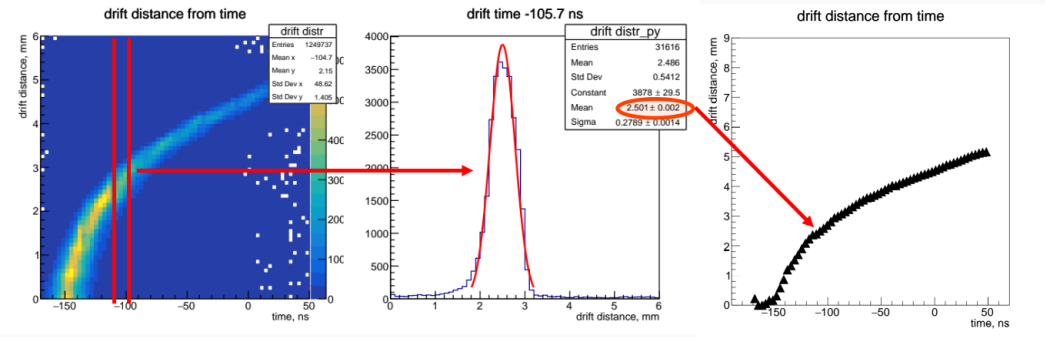
1) calculation through the function derivative – $r = f(t)$

$$\sigma_r^2 = \left(\frac{\partial f}{\partial t}\right)^2 \sigma_t^2$$

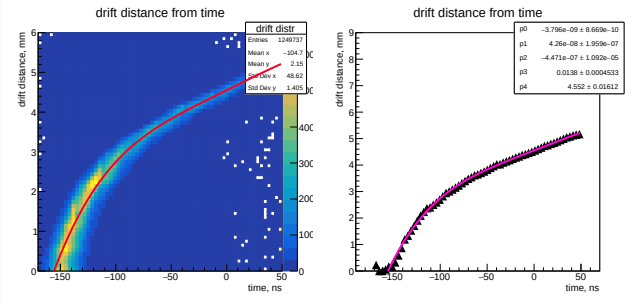
2) calculation through the difference between predicted $f(t)$ and measured values

3) independent measurements by A. Zelenov

R(t) distribution

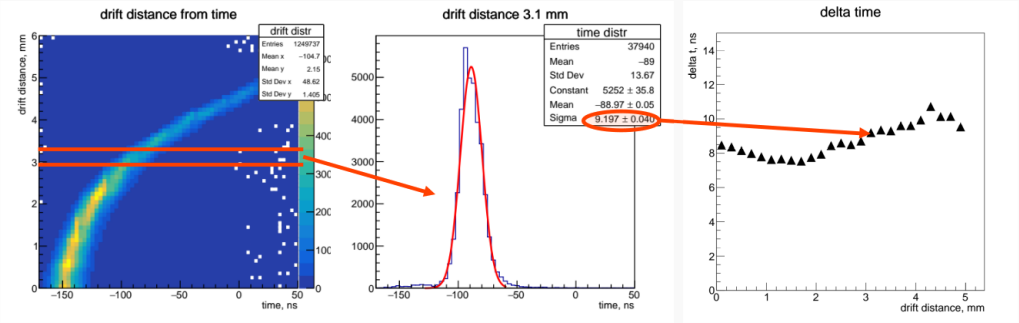


R(t) distribution

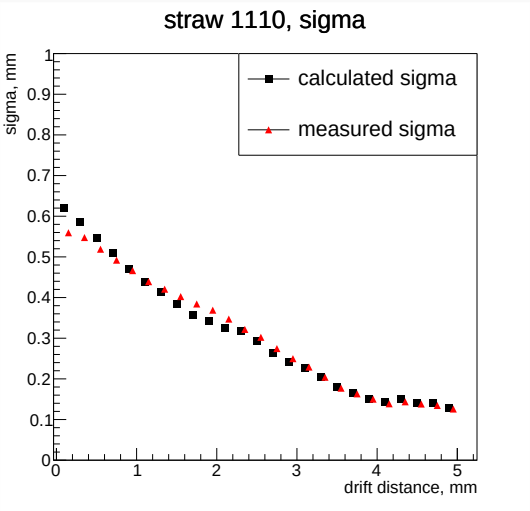


Fitting by polynomial of 4^{th} order - get R(t)

Δt measurements



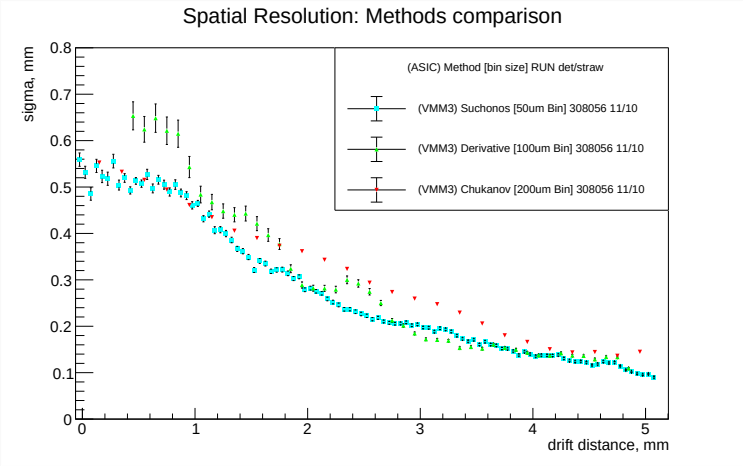
Spatial resolution measurements - preliminary



calculated sigma - spatial resolution calculated through the function derivative

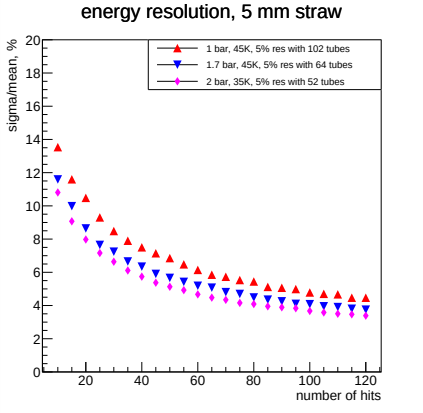
measured sigma - spatial resolution calculated through the difference between predicted and measured values

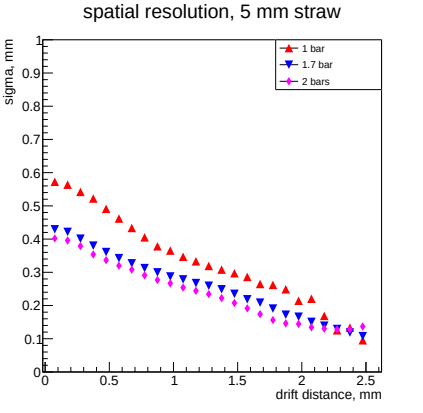
Spatial resolution measurements - methods comparison



Results with different pressures - 5 mm straw

During the test beam we had collected data for 5 mm straw tubes with different pressures





Proposal

With higher pressure we have an improvement in energy and spatial resolutions

Can we increase pressure in straw tubes for resolution improvement?

Conclusion

- analysis of test beam data is in progress (in this year we have 3 runs in SPS and 2 runs in PS accelerators)
- energy and spatial resolutions for 10 mm straws have been measured
- energy and spatial resolutions for 5 mm straws have been measured with different pressures
- with higher pressure we have better resolutions
- plans: subtract tracking resolution from spatial resolution graph, present all resolutions with error bars