Reminder: calculation method

Method Description

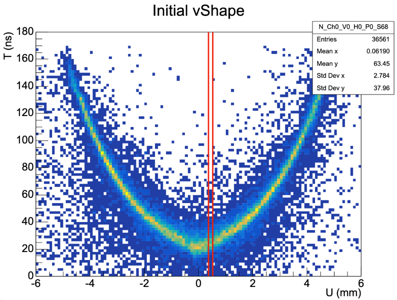
6.2 Resolution from drift time distributions

In the procedure described in this section, the spatial resolution $\sigma(Y)$ was obtained from drift time resolution applying statistical methods to the measured V-shape. The time resolution $\sigma_t(Y)$, in turn, was evaluated from a Gaussian fit of the drift time distributions obtained individually for narrow slices of the Y_{tr} coordinates. The total Y range of a V-shape was divided into slices of 100 µm. Explicitly, a distribution of measured drift time t was obtained for each slice and fitted with the following Gaussian distribution, with mean T, standard deviation σ_t and a normalisation factor C:

$$N(t, T, \sigma_t) = \frac{C}{\sigma_t\sqrt{2\pi}} \cdot exp\left(-\frac{(t-T)^2}{2\sigma_t^2}\right). \quad (13)$$

The fit was performed in the region of the most probable value for the bins with statistics exceeding 10% of the most populated bin content. Figure 35 shows examples of the time distributions for four different Y_{tr} slices along with the Gaussian fit results. At the straw edges, Figure 35 (a), there are less track signals and the results are more prone to noise hits. The two parameters T_i and $\sigma_{t,i}$ are thus obtained as fit results for every Y_i value. Statistical uncertainties on the mean drift time δT and the drift time resolution $\delta\sigma_{ti}$ were estimated within the fit procedure. Examples of the resulting $T(Y_{tr})$ and $\sigma_t(Y_{tr})$ dependencies are shown in Figure 36 for the short straw tube with wire eccentricities of 0.02 mm, 1.10 mm and 1.97 mm. Note the Y coordinate is shifted by about 1 mm with respect to the straw center.

For a small variation of Y, the dependence $T = F(Y)$ can be considered as quasi-linear. Therefore, within a narrow slice Y_i, the reconstructed coordinates $Y = F^{-1}(t)$ can also be



from 27.03.2024 slides

Reminder: calculation method

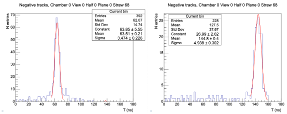


Figure 35: Drift time distributions for a straw tube with wire eccentricity of 0.19 mm obtained for different Y slices. The slices of 100 µm width are centred at $Y = -8.95$ mm (a) and $Y = 4.65$ mm (b). The fitted Gaussian distributions are shown with red curves.

described with a normal distribution. The width of this distribution can be estimated as

$$\sigma = \frac{\sigma_t}{\left|\frac{dF(Y)}{dY}\right|} = \frac{\sigma_t}{|F'|} \qquad (14)$$

where the uncertainty $\delta\sigma$ is defined by the time resolution error $\delta\sigma_t$:

$$(\delta\sigma)^2 = \left[\frac{\partial\sigma}{\partial\sigma_t}\right]^2 \cdot (\delta\sigma_t)^2 + \left[\frac{\partial\sigma}{\partial F'}\right]^2 \cdot (\delta F')^2 = \left(\frac{1}{F'}\right)^2 \cdot (\delta\sigma_t)^2 + \left(-\frac{\sigma_t}{F'^2}\right)^2 \cdot (\delta F')^2. \qquad (15)$$

The derivative F' was estimated numerically for every slice Y_i using the obtained $T = F(Y)$ dependence. In order to minimize fluctuations, while keeping the variation of Y small, four neighboring slices were used for the derivative calculation:

$$F'_i = \frac{T_{i+2} - T_{i-2}}{4Y_w}, \qquad (16)$$

where Y_w is the width of Y_{tr} slices. The corresponding uncertainty was evaluated as

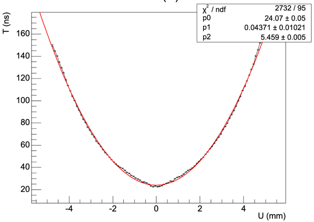
$$\delta F'_i = \frac{\sqrt{(\delta T_{i+2})^2 + (\delta T_{i-2})^2}}{4Y_w}. \qquad (17)$$

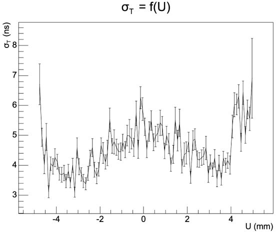
The resulting spatial resolutions as a function of the Y_{tr} coordinate are shown in Figure 37 for the short straw tube with the wire eccentricities of 0.02 mm, 1.10 mm and 1.97 mm. As was the case for the other methods, the spatial resolution exhibits plateaus of about 100 µm at each side of the straw and raises around the anode wire.

The analysis was performed for all data sets measured with the short straw tube for different applied tube offsets. The results are shown and discussed in 6.3.

$$\Delta F(U) = \sigma_T^2 = \left(\frac{dF(U)}{dU}\right)^2 \cdot \sigma_U^2$$

3



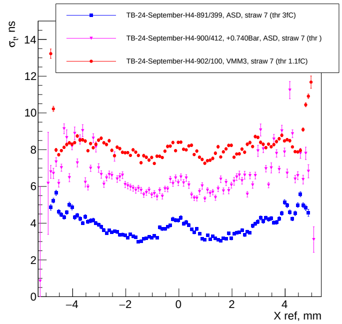


from 27.03.2024 slides

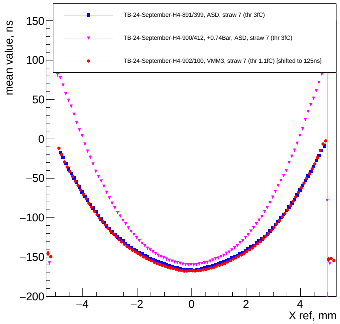
Recheck of ASD resolution

Recheck of ASD resolution
Ar:CO_2 70:30, straw 7, 100μm bin

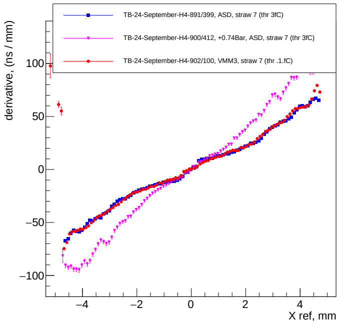
Time resolution



Mean value



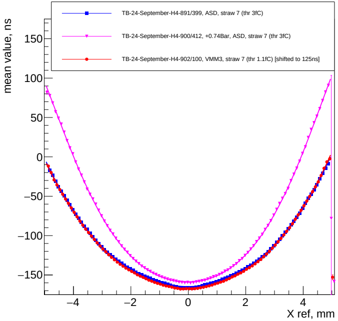
Derivative



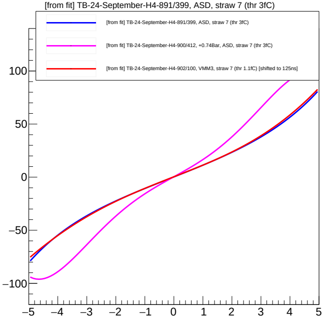
- Blue – sMDT ASD, no overpressure
- Magenta – sMDT ASD, 0.740 Bar overpressure
- Red – VMM3, no overpressure

Recheck of ASD resolution
Ar:CO_2 70:30, straw 7, 100μm bin

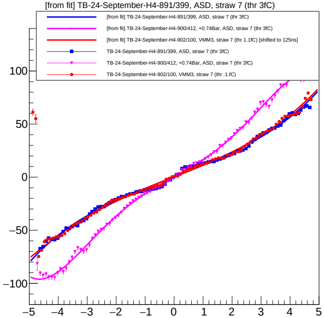
Mean value + pol6 fit



Derivative from fit



Calculated & measured derivative

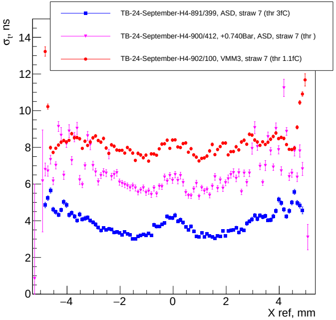


- Blue – sMDT ASD, no overpressure
- Magenta – sMDT ASD, 0.740 Bar overpressure
- Red – VMM3, no overpressure

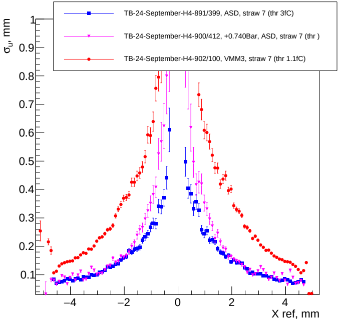
Recheck of ASD resolution

Recheck of ASD resolution
Ar:CO_2 70:30, straw 7, 100μm bin

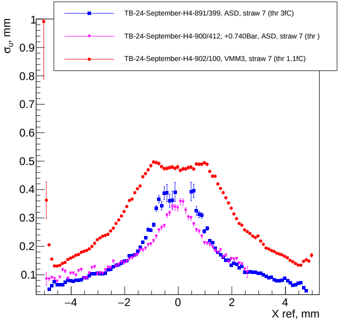
Time resolution



Spatial resolution, derivative method



Spatial resolution, ShipWay method



- Blue – sMDT ASD, no overpressure
- Magenta – sMDT ASD, 0.740 Bar overpressure
- Red – VMM3, no overpressure

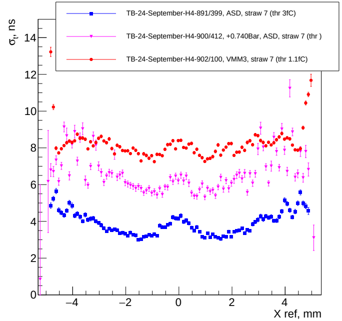
Backup slides

Recheck of ASD resolution

Recheck of ASD resolution

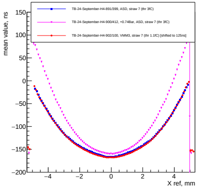
$Ar:CO_2$ 70:30, straw 7, 100μm bin

Time resolution

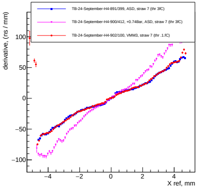


- Blue – sMDT ASD, no overpressure
- Magenta – sMDT ASD, 0.740 Bar overpressure
- Red – VMM3, no overpressure

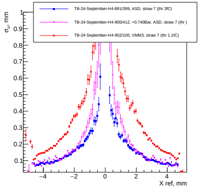
Mean value



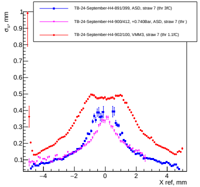
Derivative



Spatial resolution, derivative method



Spatial resolution, ShipWay method



Straw number for the ASD sMDT channels

μST (μSPD) prototype

ASD Channel	Straw Tube#
0	43
1	58
2	38
3	55
4	41
5	56
6	11
7	6
8	26
9	9
10	23
11	8
12	24
13	7
14	25
15	10
16	22
17	27
18	40
19	39
20	57
21	42
22	54
23	59

Combined (old) prototype

Mu2E #	Type	Straw #	ASD #
46	10mm	**5**	7
42	10mm	14	8
40	10mm	13	9
36	10mm	12	10
38	20mm	5	11
47	5mm	25	12
37	5mm	20	13
39	5mm	21	14
33	5mm	18	15
35	5mm	19	16
29	5mm	16	17
31	5mm	17	18
21	5mm	12	19
17	5mm	10	20
23	5mm	13	21
34	10mm	11	22
30	10mm	10	23
32	20mm	4	24