# UPDATE ON STT TESTBEAM DATA ANALYSIS

10.03.2010 I GABRIELA PEREZ ANDRADE

PANDA COLLABORATION MEETING

# OUTLINE

- TESTBEAMS AT COSY
- STT Self-calibration method
- Global calibration
- Efficiency studies (method)
- Summary

# TESTBEAMS AT COSY

- Setups with approximately 6 straw layers
- ~ 24 straws per layer:
  - Particle tracks with > 24 hits simmilar to PANDA STT case
- Proton and Deuteron beams
- Momentum range: 0.5 - 3.0 GeV/c
- Ar/CO2 gas mixture

- Raw data:
  - Time information ($t_{LE}$, $t_{TE}$)
  - Signal pulse width ($t_{TE}$-$t_{LE}$)
  - Channel ID ($i_{chann}$, $i_{straw}$, $i_{layer}$)


Figure. One of the two straw test systems.

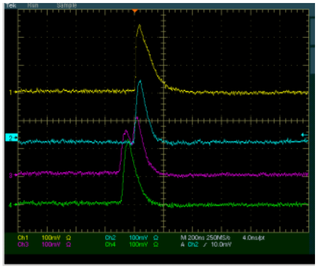


Figure. Straw signals (in-beam)

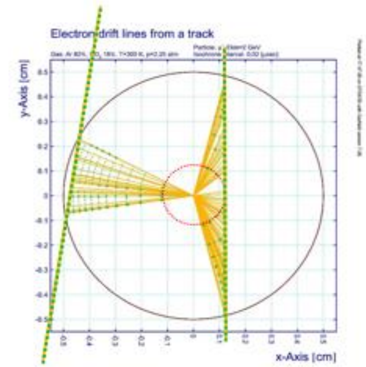



Figure. Electrons drift from particles path through the straw

# SELF-CALIBRATION

i. Isochrone curve $\mathrm{r(t_i)}$ parametrization, relating the electron drift time $\mathrm{t_i}$ and its traveled distance to the wire:

$$\frac{N_{Total}}{R} = \frac{\sum_{t_{min}}^{t_i} N_i}{r(t_i)} \rightarrow \mathrm{r(t_i)} = \sum_{\mathrm{i=0}}^{4} \mathrm{P_i} \times \mathrm{t_i}$$

ii. Determination of straws center position.

iii. Tracking and systematic error correction.

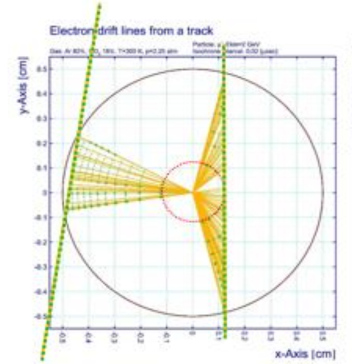
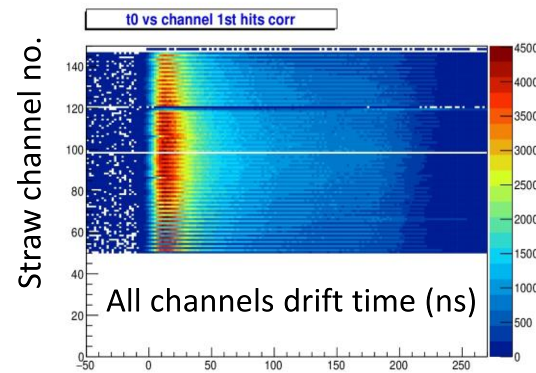
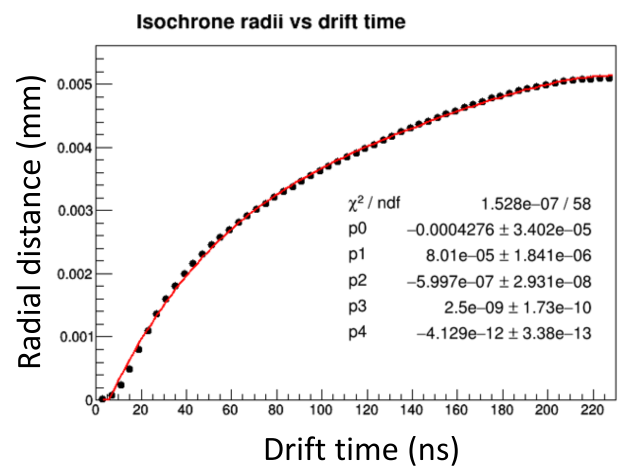
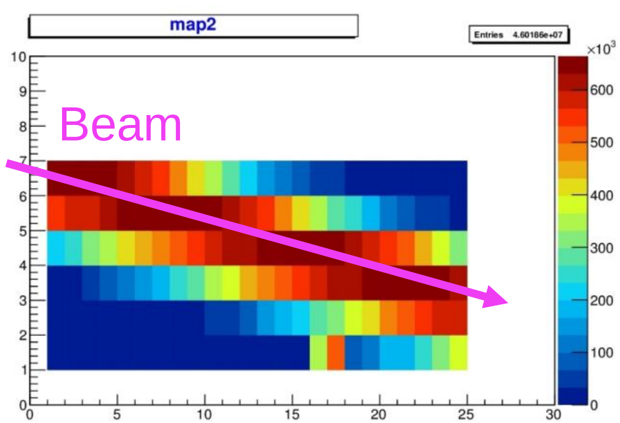



Figure. Electrons drift from particles path through the straw



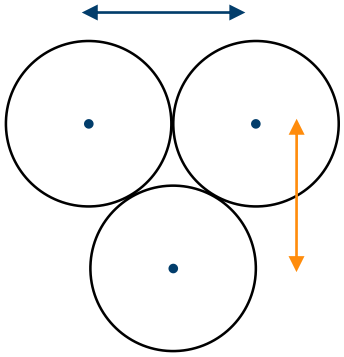
# SELF-CALIBRATION

i. Isochrone curve $\mathrm{r}(\mathrm{t_i})$ parametrization, relating the electron drift time $\mathrm{t_i}$ and its traveled distance to the wire:

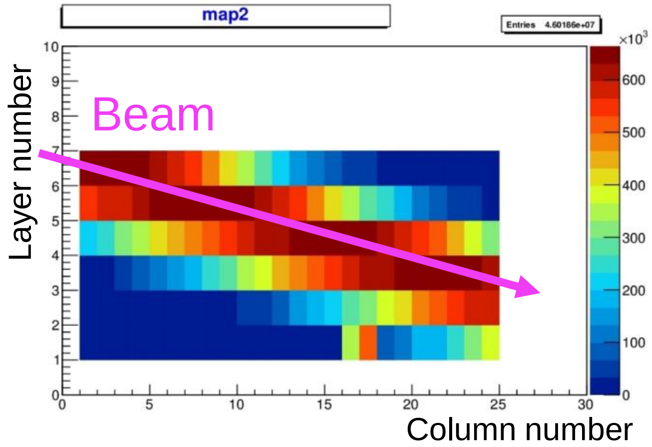
$$\frac{N_{Total}}{R} = \frac{\sum_{t_{min}}^{t_i} N_i}{r(t_i)} \rightarrow \mathrm{r}(\mathrm{t_i}) = \sum_{\mathrm{i}=0}^{4} \mathrm{P_i} \times \mathrm{t_i}$$

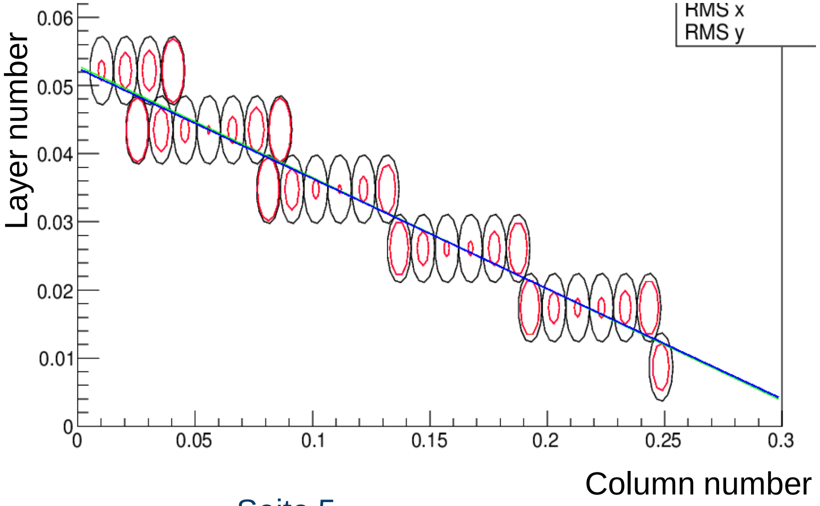
ii. Determination of straws center position:

   i. With channel ID information $(i_{straw}, i_{layer})$ the straw centers can be determined.




iii. Tracking and systematic error correction

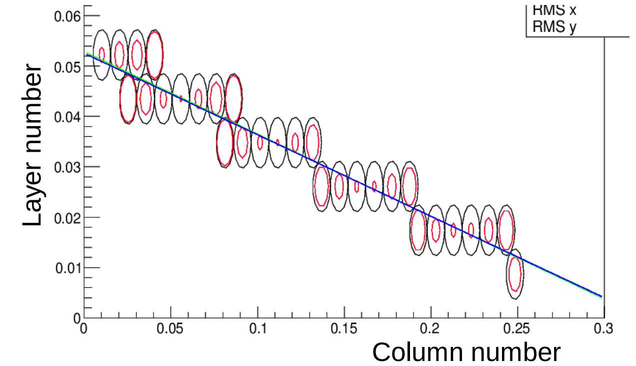


# SELF-CALIBRATION

i. Isochrone curve $\mathrm{r}(\mathrm{t_i})$ parametrization, relating the electron drift time $\mathrm{t_i}$ and its traveled distance to the wire:

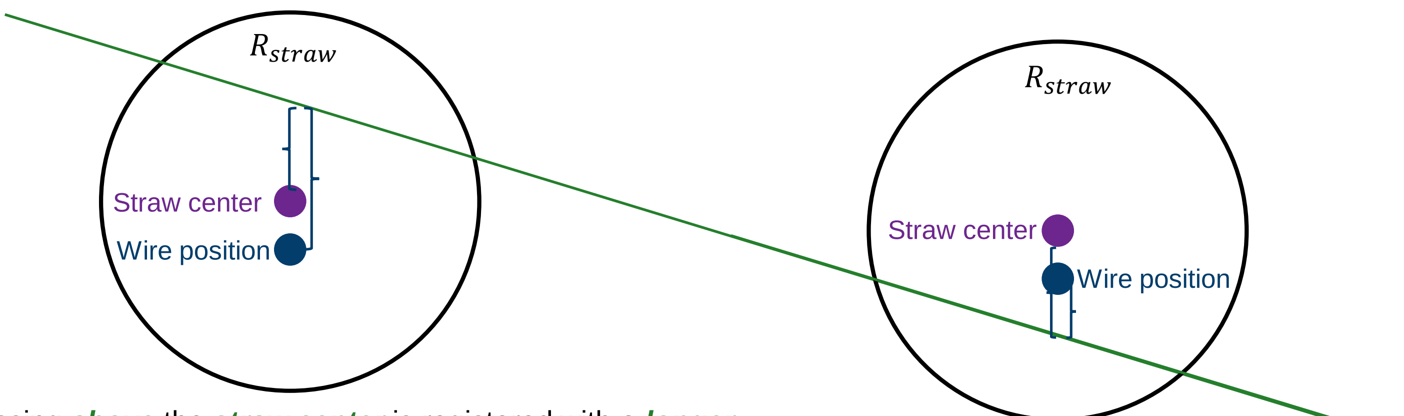
$$\frac{N_{Total}}{R} = \frac{\sum_{t_{min}}^{t_i} N_i}{r(t_i)} \rightarrow \mathrm{r}(\mathrm{t_i}) = \sum_{\mathrm{i}=0}^{4} \mathrm{P_i} \times \mathrm{t_i}$$




ii. Determination of straws center position:

  i. With channel ID information $(i_{straw}, i_{layer})$ the straw centers can be determined.

iii. Tracking and systematic error correction (due to *e.g.* gravitational sag).




A track crossing ***above*** the ***straw center*** is registered with a ***longer drift time*** and therefore $\mathrm{r}(\mathrm{t_i})$ yields a ***larger isochrone radius***

A track crossing ***below*** the ***straw center*** is registered with a ***shorter drift time*** and therefore $\mathrm{r}(\mathrm{t_i})$ yields a ***smaller isochrone radius***

# SELF-CALIBRATION

iii. Tracking and systematic error correction :

i. Pre-fit line using positions of fired straws.

ii. $r(t_i)$ calculation for each hit.

iii. Track residuals definition: $r_{res} = |r_{track}| - r_{iso}$

iv. Best line fit through residuals minimization:

$$\frac{\chi^2}{ndf} = \left(\frac{1}{n_{hits} - 2}\right) \sum_{n=1}^{n_{hits}} \frac{r_{res}^2}{\sigma_{iso}^2(r)}$$

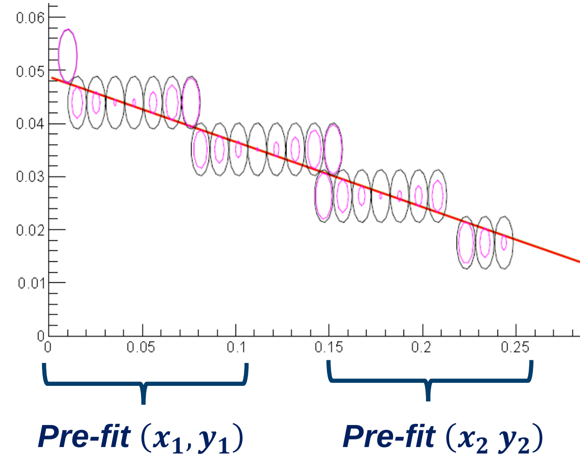
i. Single outliers rejection:

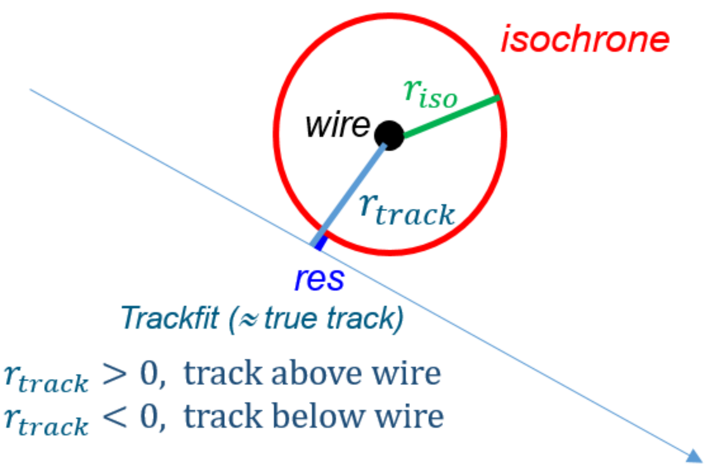
i. If $|r_{track}| > 900$ µm

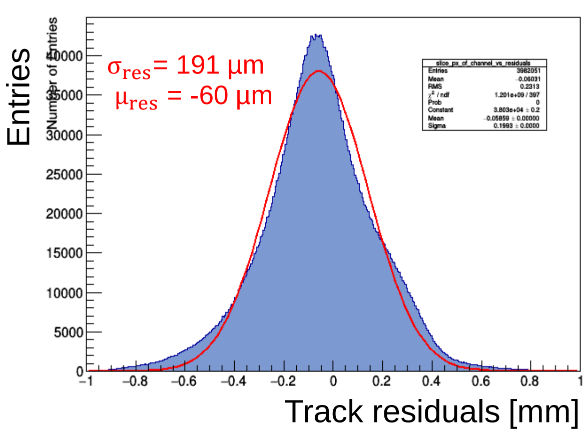
ii. If distance $|r_{track}|$ > 2.5 × $\sigma_{iso}(r)$

iii. Maximum number of outliers < 8

ii. Spatial resolution defined as the width of residuals distribution $\boldsymbol{\sigma_{res}}$.



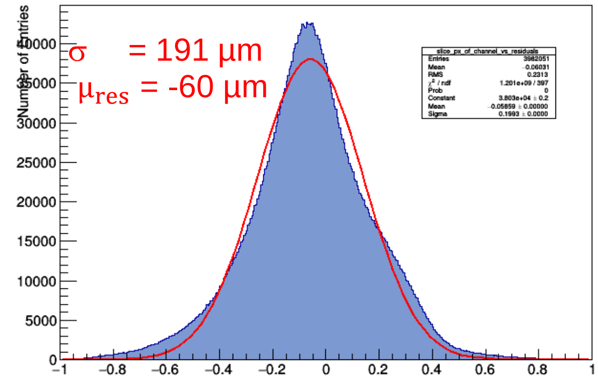






JÜLICH Forschungszentrum

# SELF-CALIBRATION



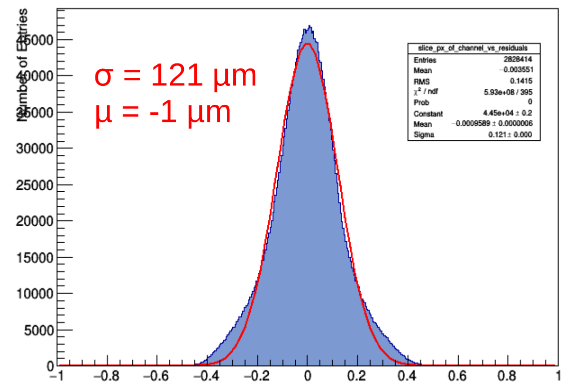

vii. Systematic error determined by residuals distribution mean $\mu_{res}$

viii. Correction by shifting the isochrones parametrization:

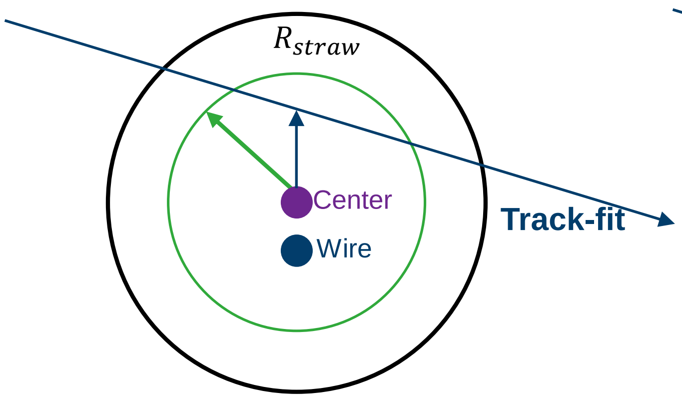
$$r_{new} = r(t_i) + \mu_{res}$$

i. Re-fit using new isochrones $r_{new}$

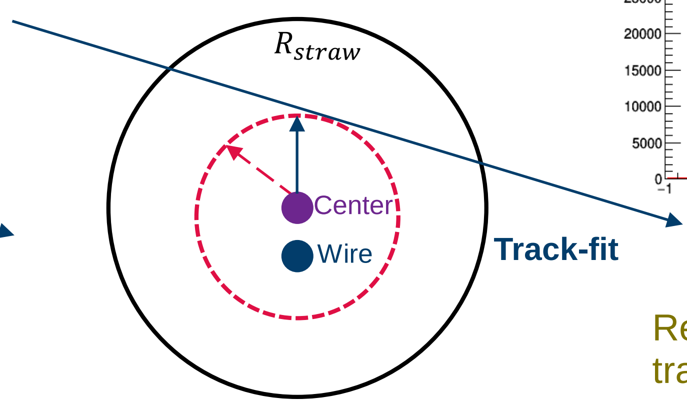
ii. Iterative process until residual distribution shift is negligible, *i.e.* $\mu_{res} \sim 0$




$$r_{res} = |r_{track}| - r_{iso} < 0 \rightarrow r_{new} < r(t_i)$$




Before correction




After correction

Residuals separately calculated for tracks above and below the wire !

# SELF-CALIBRATION

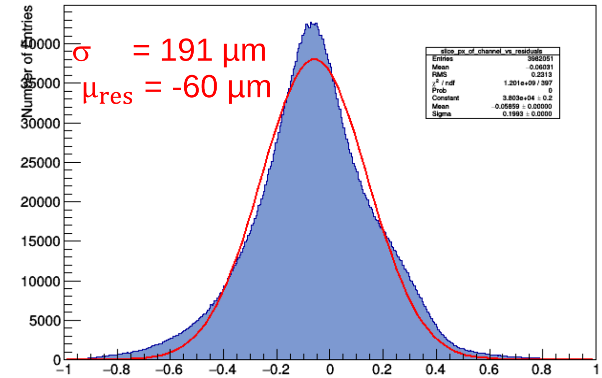
vii. Systematic error determined by residuals distribution mean $\mu_{res}$

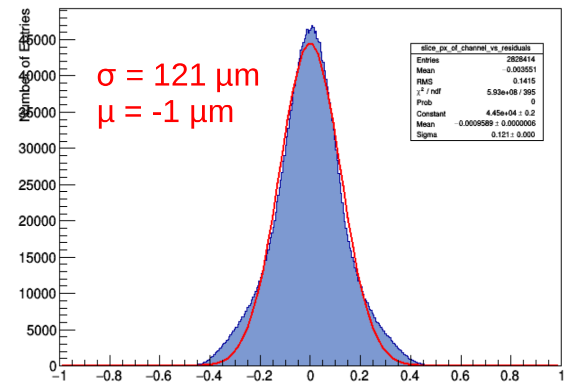
viii. Correction by shifting the isochrones parametrization:

$$r_{new} = r(t_i) + \mu_{res}$$

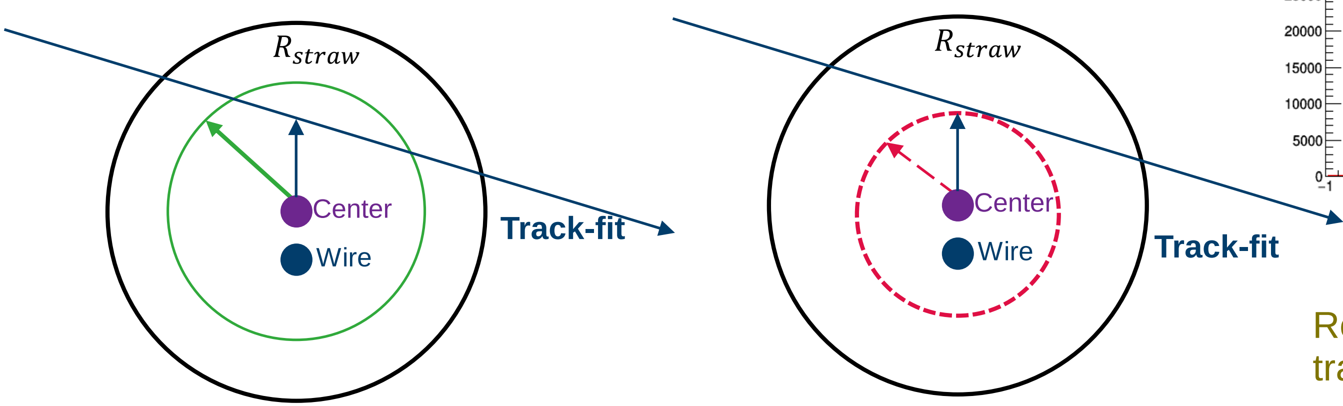
i. Re-fit using new isochrones $r_{new}$

ii. Iterative process until residual distribution shift is negligible, *i.e.* $\mu_{res} \sim 0$




$$r_{res} = |r_{track}| - r_{iso} < 0 \rightarrow r_{new} < r(t_i)$$




Before correction

After correction

Residuals separately calculated for tracks above and below the wire !

- At ~ 6 iterations, the resolution value stabilizes
- Final resolution in general is $\sigma_{r\varphi}$< 130 µm (PANDA design goal of $\sigma_{r\varphi}$= 150 µm)

# METHOD REMARKS

- The self-calibration processing time depends on the iterations that each dataset requires to reach the optimal resolution.
- At PANDA, the particle momenta will be available only after the tracking *i.e*. the method should be dE/dx independent.
- The isochrone parametrization and systematic error correction should be performed only once.
- The ongoing work focuses on testing if the use of a common global calibration is possible for all datasets taken with the same experimental set up.
- The global calibration method has been tested in a group of proton and deuteron datasets (3 each) at different beam momenta.

# GLOBAL CALIBRATION

The *global* dataset is chosen based on uniform illumination.

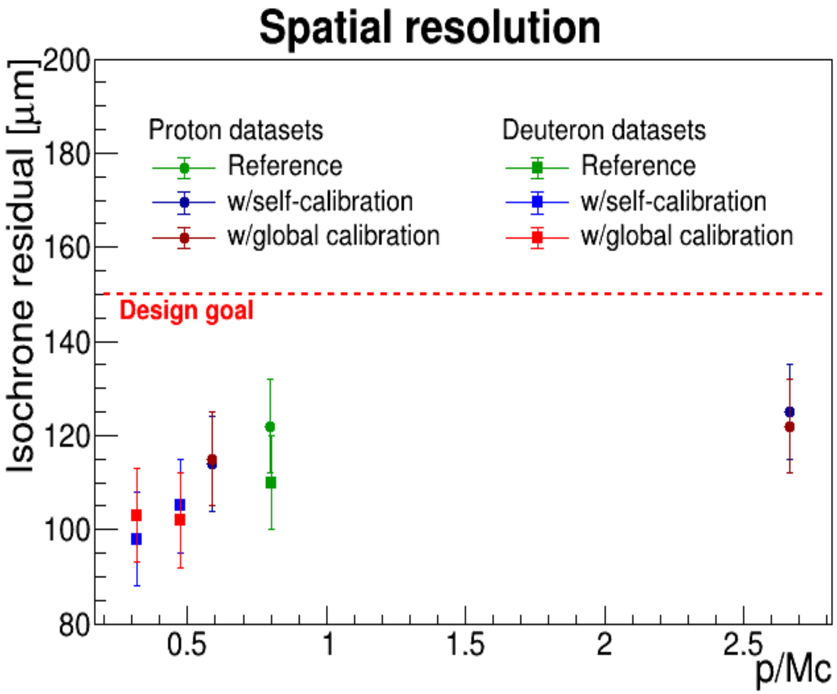
i. Global dataset self-calibration is performed with necessary iterations to reach the optimal value, obtaining as output:
   - Isochrone parametrization
   - $r_{\text{mean up/down}}$ correction

ii. Output parameters from self-calibration are used as input for other datasets of same particle specie, without further iterations.

iii. TASK: To compare hit resolution and residual shift correction.

# SELF- CALIBRATION AND GLOBAL CALIBRATION COMPARISON

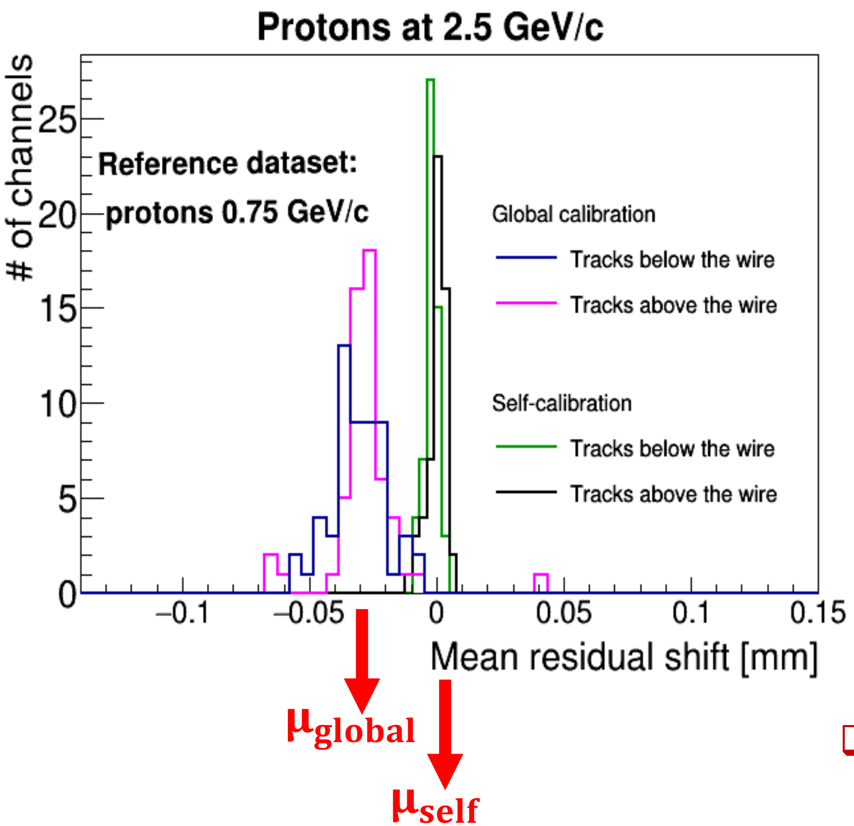
## Spatial resolution




Difference between the results obtained from both methods is **< 5µm**, showing that a good resolution is achieved using a ***common global calibration***.

# SELF- CALIBRATION AND GLOBAL CALIBRATION COMPARISON

## Systematic error correction



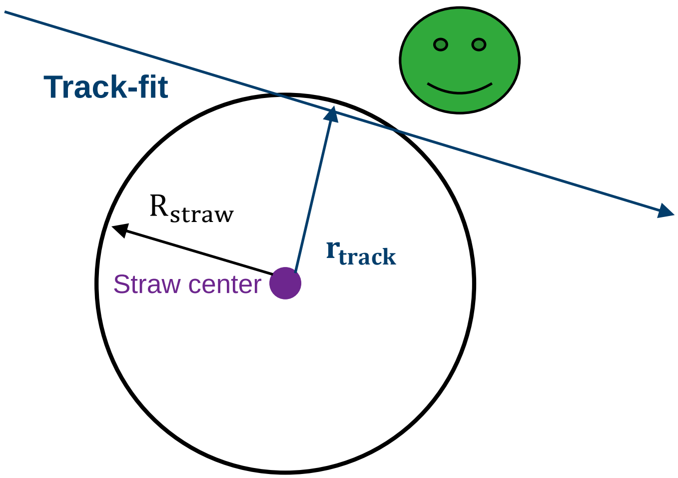

- A proton dataset calibrated using both methods.
- Approx. 9 straws per layer with uniform illumination are chosen.
- The mean residual obtained after the global and self-calibration (last iteration)

$\mu_{self-below} = -2\ \mu m$ $\mu_{global-below} = -31 \mu m$

$\mu_{self-above} = 1 \mu m$ $\mu_{global-above} = -28 \mu m$

- ❑ Difference between mean values < 30 $\mu m$
  - ❑ Contribution to overall error is of ~ 4 $\mu m$ (negligible)
- ❑ The results from tracks crossing above and below the center are in agreement.

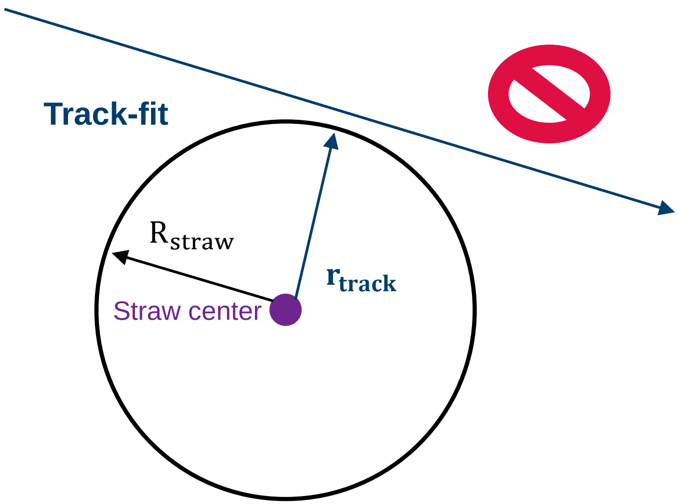
# STRAW HIT EFFICIENCY




- All fitted tracks should cross within a certain distance from the straw center (~ $R_{straw}$).

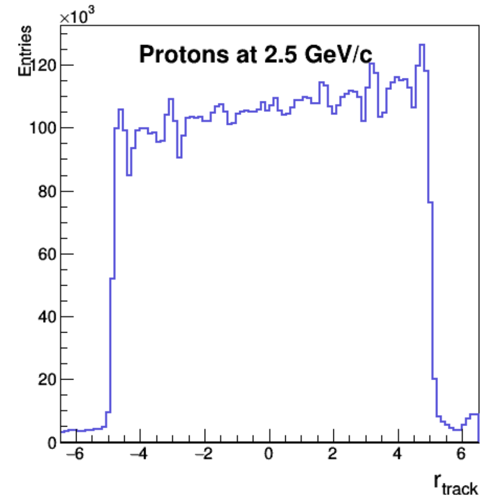
- The straw hit efficiency of the $i_{th}$ straw is defined as:

$$\epsilon_{hit_i} = \frac{\text{Crossing track with } r_{track} < \text{distance cut}}{\text{Total number of crossing tracks}}$$




  - All the tracks which fulfill the distance requirement are counted :
    - Different distance cuts to be tested
  - The normalization is given by the total number of tracks registered in such straw i.e. a recorded drift time

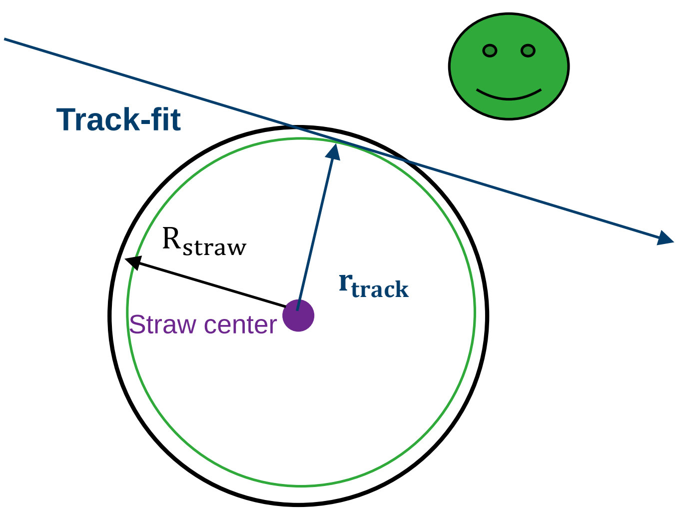
# STRAW RADIAL EFFICIENCY

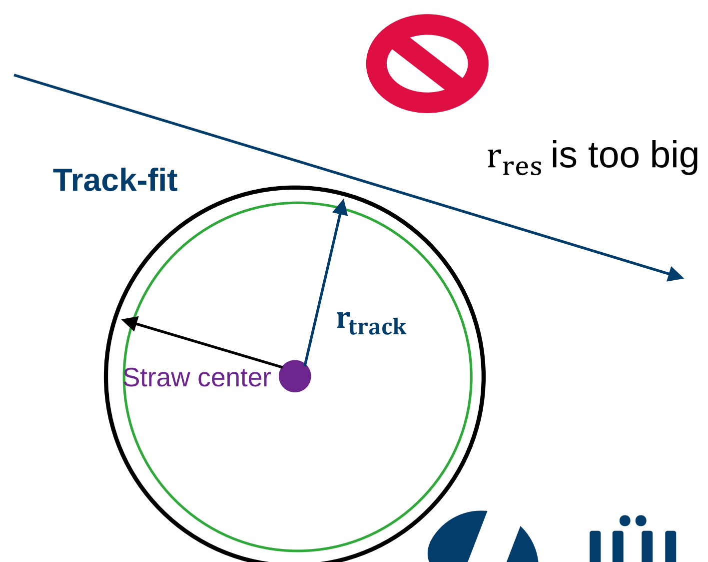



- The straw radial efficiency is given by:

$$\epsilon_{radial} = \frac{\text{Crossing track with } \mathrm{r_{res}} < \text{residual cut}}{\text{Total number of crossing tracks}}$$

- Look at the residual values of the tracks reconstructed along the radius.



# SUMMARY

- With the self-calibration method, resolution values of $\sigma_{r\varphi}$ < 130 µm is achieved (PANDA design goal is $\sigma_{r\varphi}$ < 150 µm) .

- The self-calibration processing time depends on the iterations that each dataset requires to reach the optimal resolution.

- To optimize the method, a global calibration method has been tested in a group of proton and deuteron datasets at different beam momenta.

- The difference between the achieved spatial resolutions with the self and global calibration methods is < 5 µm.

- The mean residuals ($\mu_{\mathrm{res}}$) deviation is successfully corrected with global calibration and the $\mu_{\mathrm{res}}$ values only differ by < 30 $\mu\mathrm{m}$ between methods.

- The straw efficiency is currently under investigation.

# THANK YOU!

# GLOBAL CALIBRATION

- A *global* dataset is chosen based on uniform illumination.
- Parameters from calibration and giving optimal hit resolution are obtained, *i.e.*
  - Isochrone parametrization
  - $r_{mean\ up/down}$ correction
- Output parameters from calibration and tracking are used as input for other datasets of same particle specie.
- Compare hit resolution and residual shift correction.