



# GSI2021 Analysis Performance Updates

**Giacomo Ubaldi**

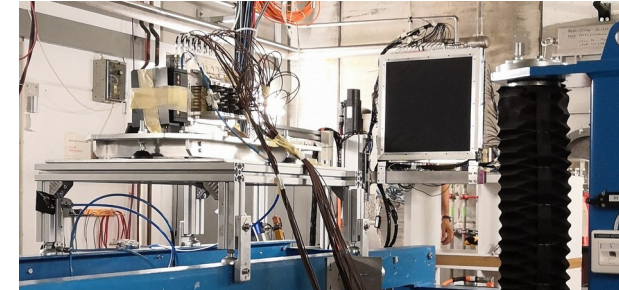
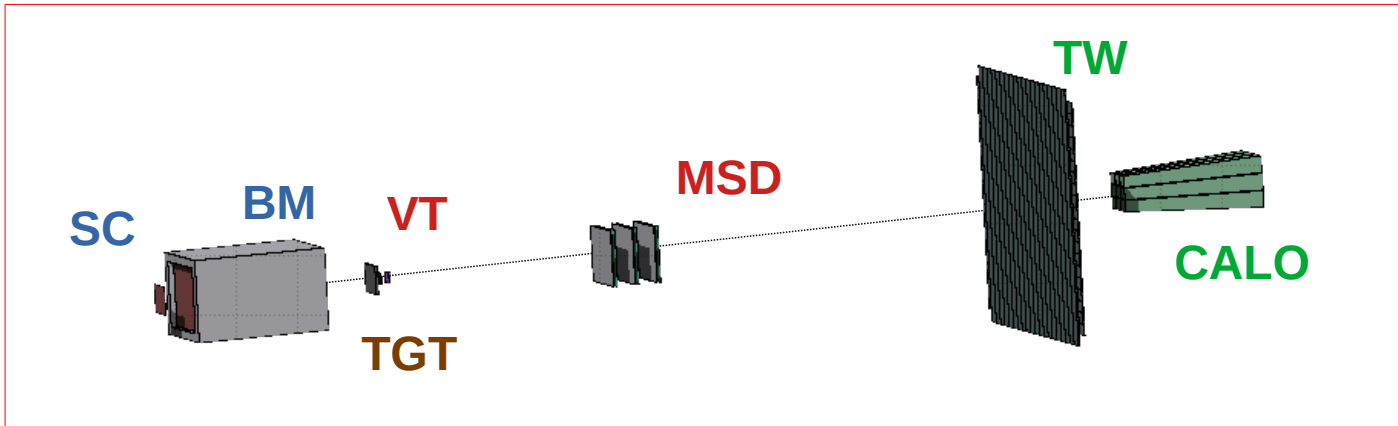
***XIV FOOT Collaboration Meeting***

*Bergamo*

06/06/2023

# GSI 2021 Analysis

- Data-taking at GSI (Darmstadt, Germany) in 2021
- $^{16}\text{O}$  400 MeV/u on 5 mm C target
- Partial setup: no magnet, only one module of calorimeter



- Global tracking with **VT** and **TW** used

# Pull

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

- $x_{fit}$  is the fit result
  - $x_{meas}$  is the measurement
  - $\sigma_{fit}$  is the error associated to the fit
  - $\sigma_{meas}$  is the resolution of the measurement
- 
- $p$  should be a Gaussian distribution with  $\mu=0$  and  $\sigma_{pull} = 1$

For more details:

[https://lucdemortier.github.io/assets/papers/cdf5776\\_pulls.pdf](https://lucdemortier.github.io/assets/papers/cdf5776_pulls.pdf)



# Glb Tracking Pull

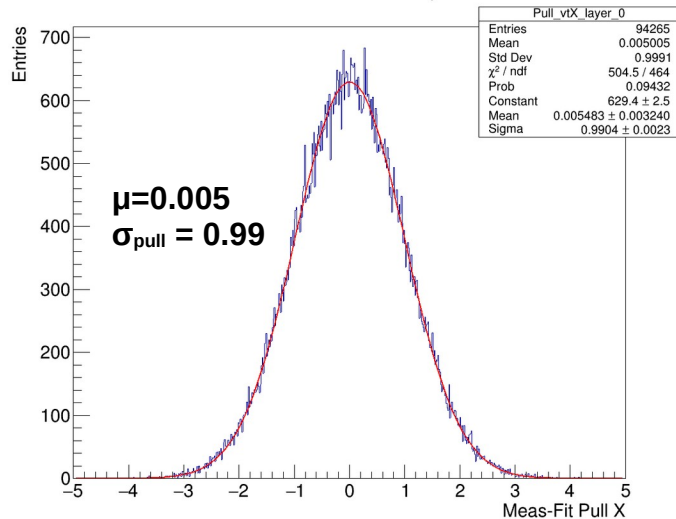
# Pull – X coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

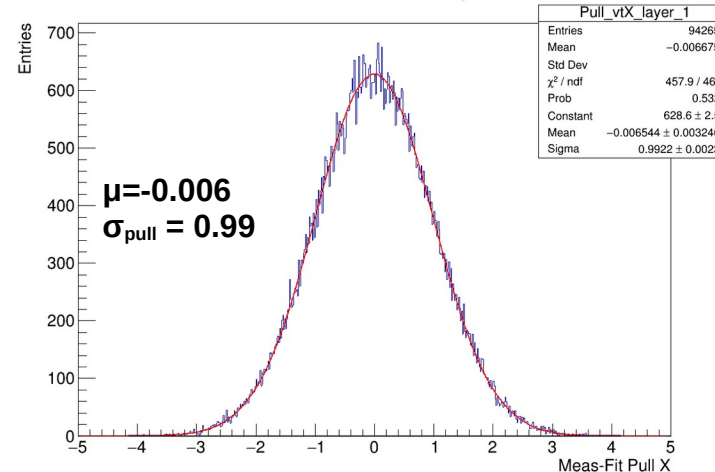
MC data

- pulls for every VT plane
- good as expected

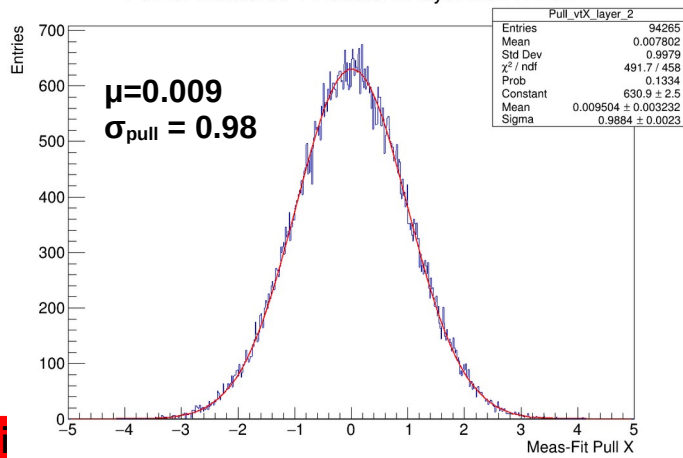
Pull for measured VT cluster in layer 0 on X view



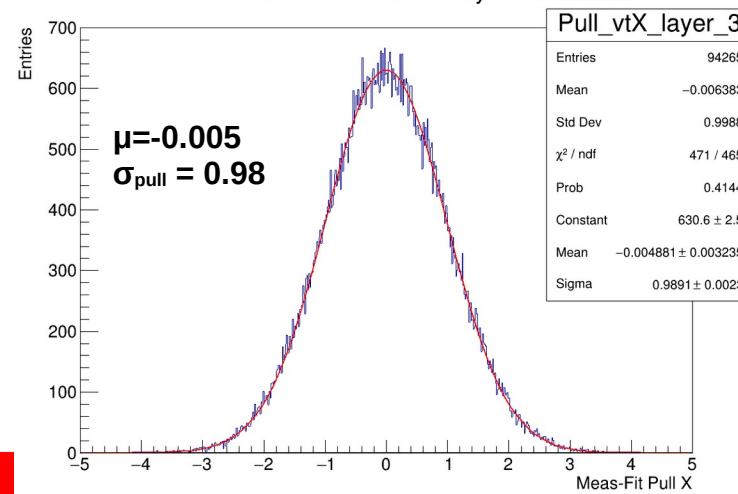
Pull for measured VT cluster in layer 1 on X view



Pull for measured VT cluster in layer 2 on X view



Pull for measured VT cluster in layer 3 on X view

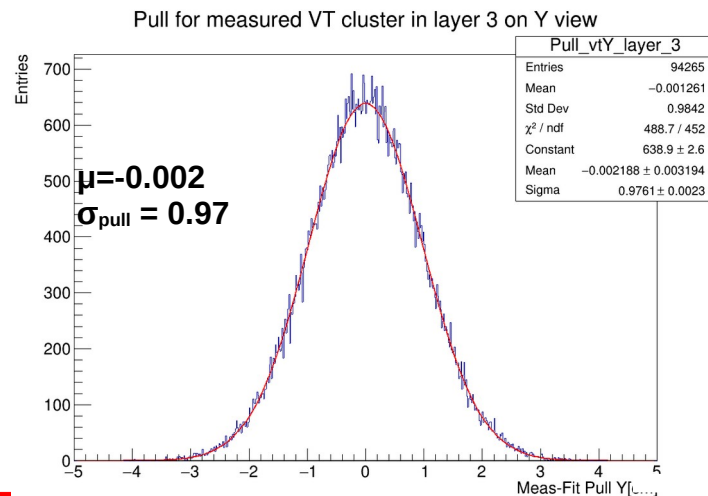
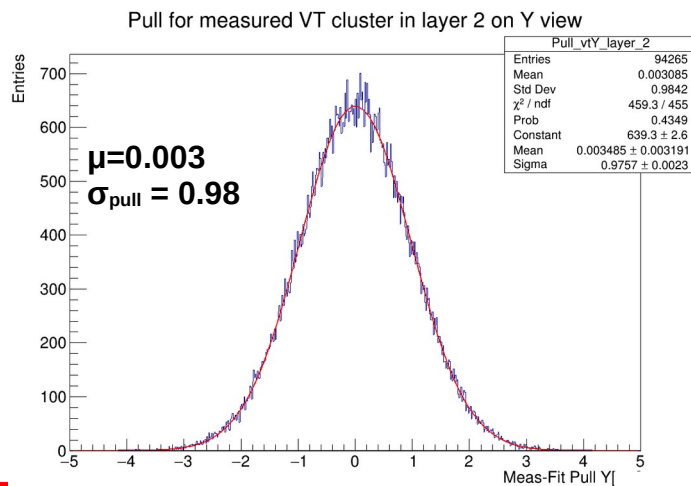
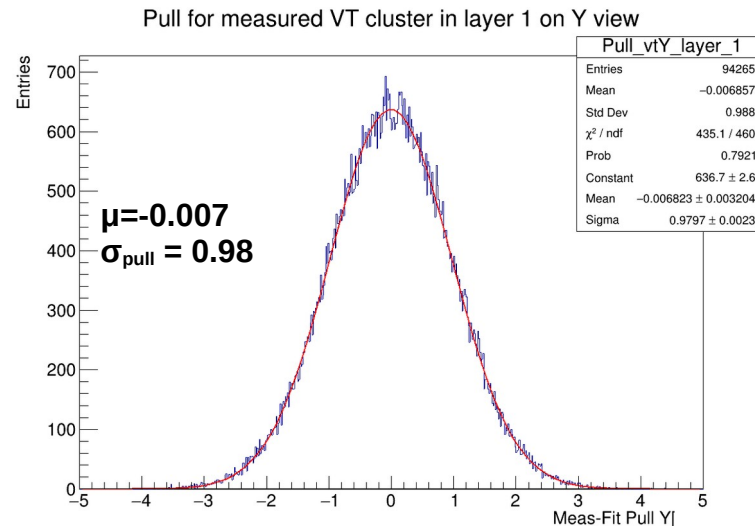
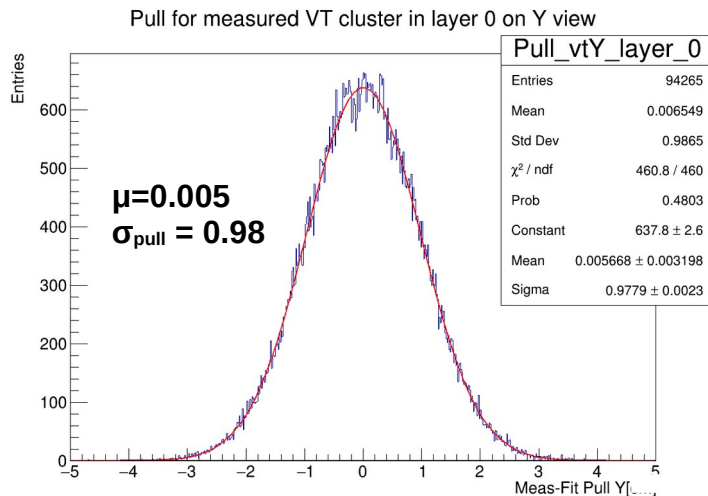


# Pull – Y coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

MC data

- pulls for every VT plane
- good as expected

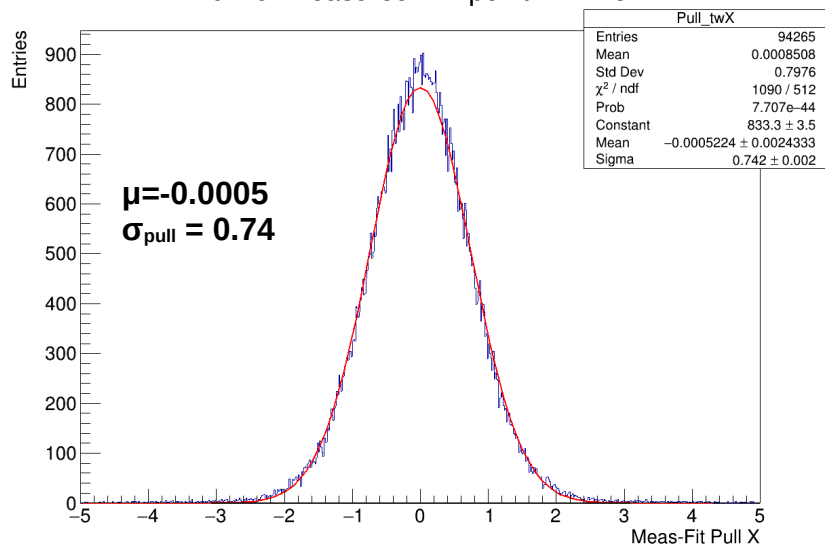


# Pull TW point

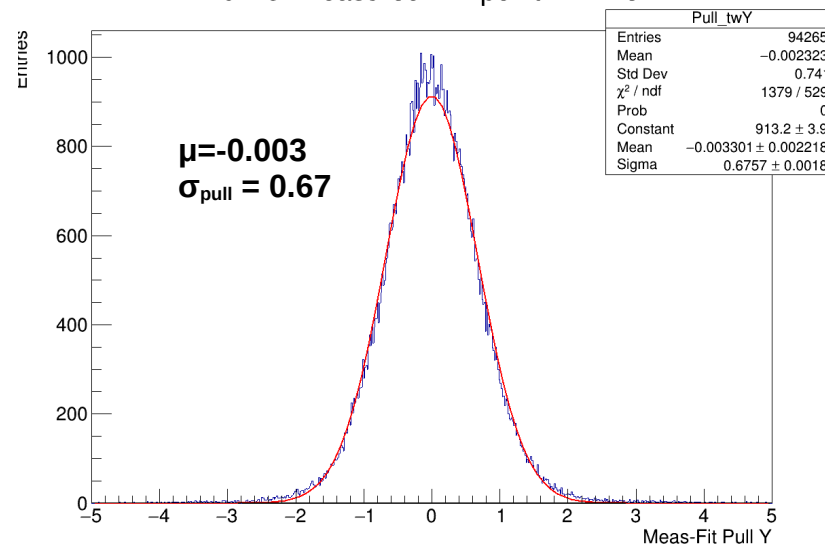
$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

MC data

Pull for measured TW point in X view



Pull for measured TW point in Y view



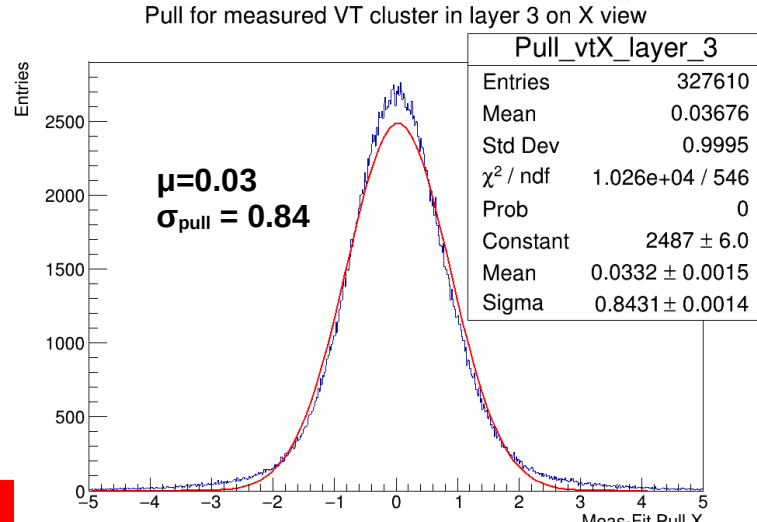
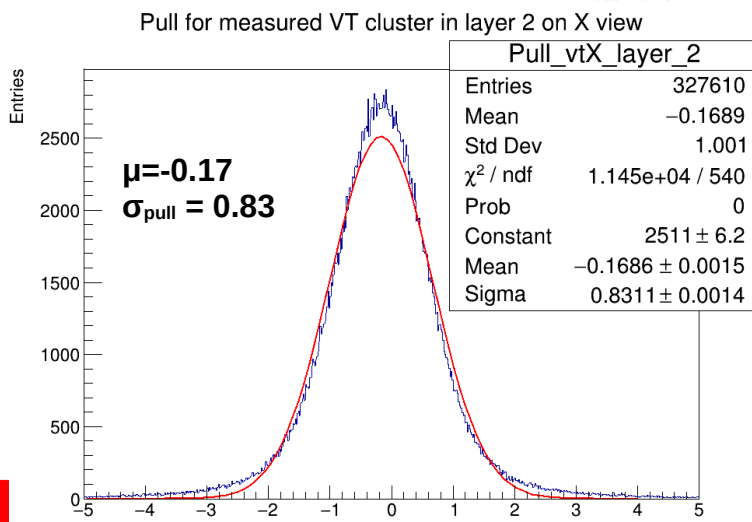
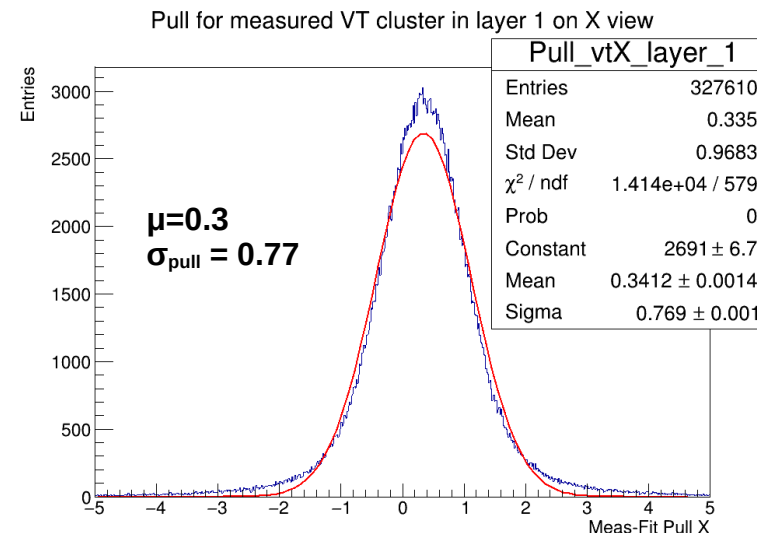
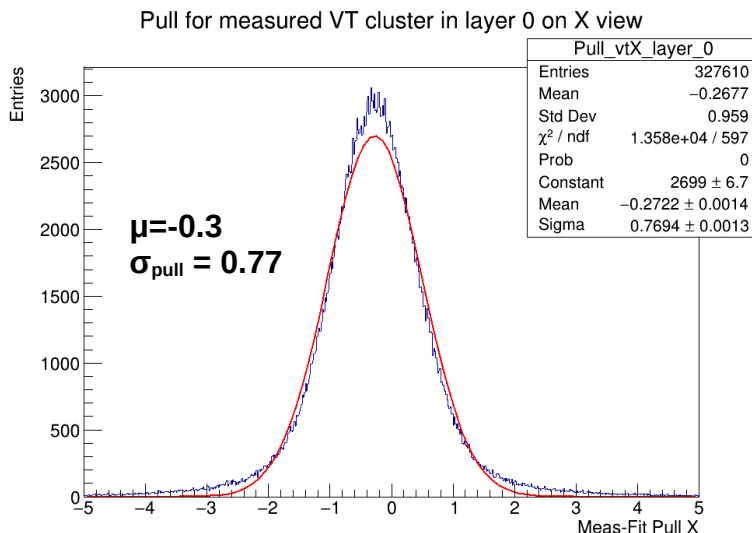
- pulls for measurements in TW
- lower  $\sigma_{pull}$  than expected: overestimation of the error of the TWPoint?

# Pull – X coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

run 4306

- discrepancies between  $\mu$  and lower  $\sigma_{pull}$  than expected
- not best modelling for fitting





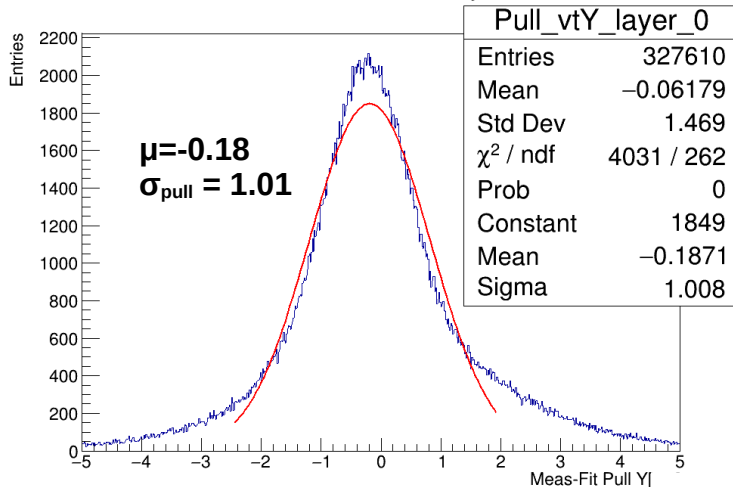
# Pull – Y coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

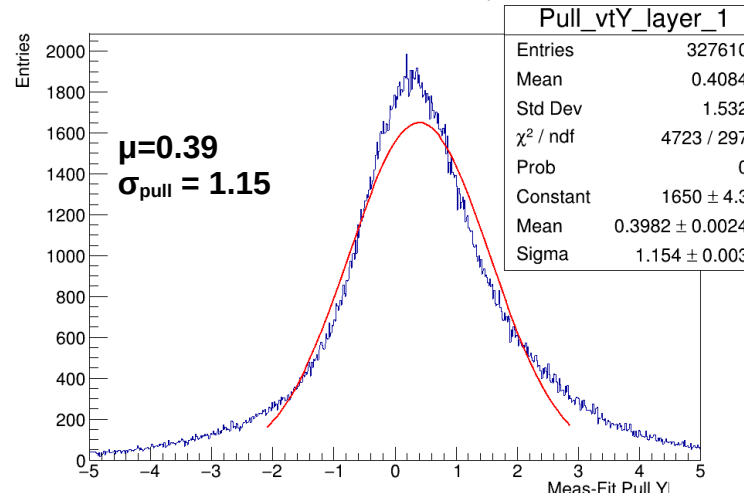
run 4306

- discrepancies between  $\mu$  and lower  $\sigma_{pull}$  than expected
- not best modelling for fitting

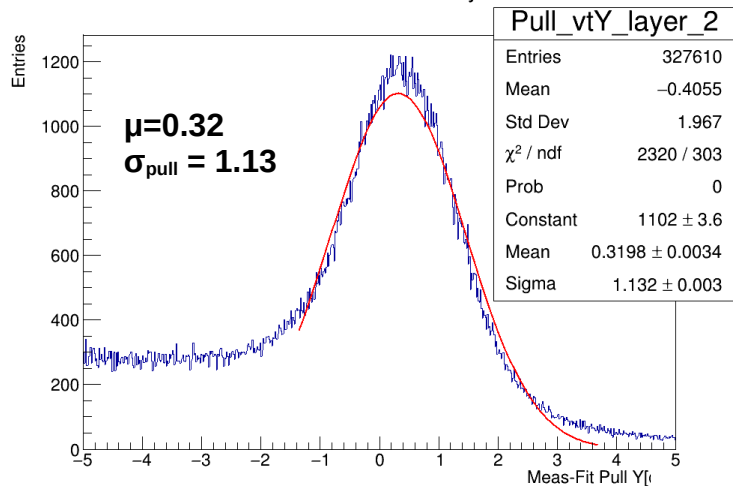
Pull for measured VT cluster in layer 0 on Y view



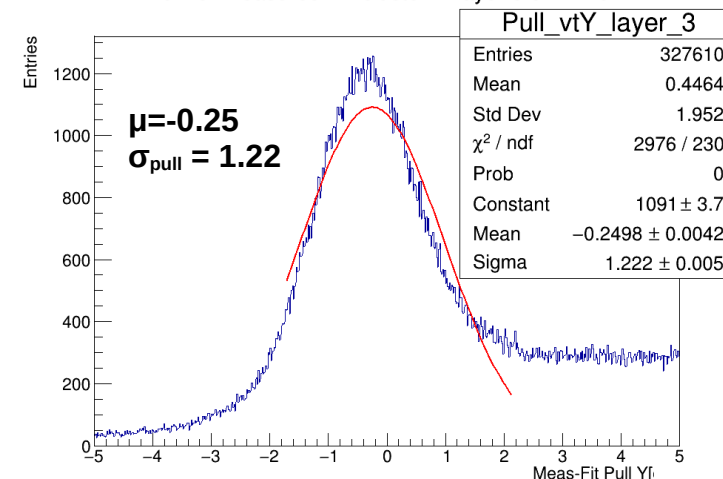
Pull for measured VT cluster in layer 1 on Y view



Pull for measured VT cluster in layer 2 on Y view



Pull for measured VT cluster in layer 3 on Y view

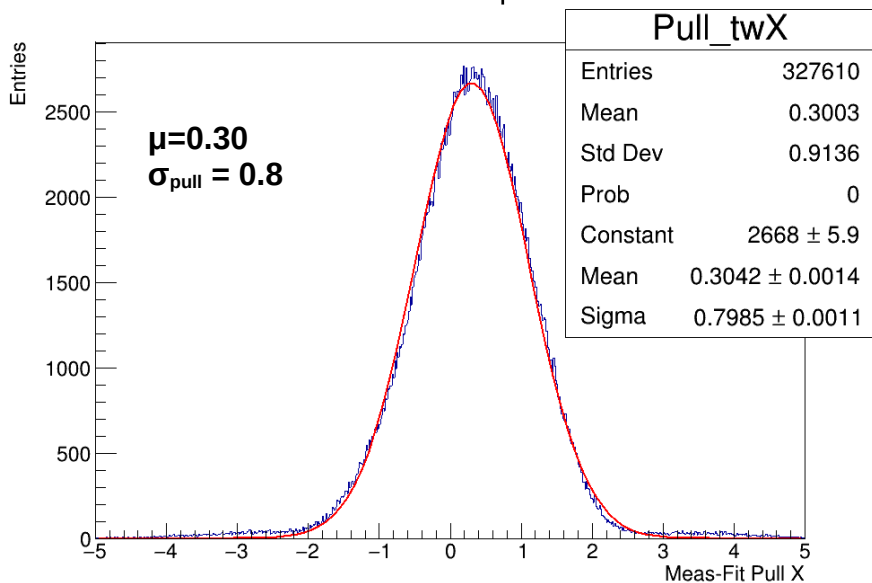


# Pull TW point

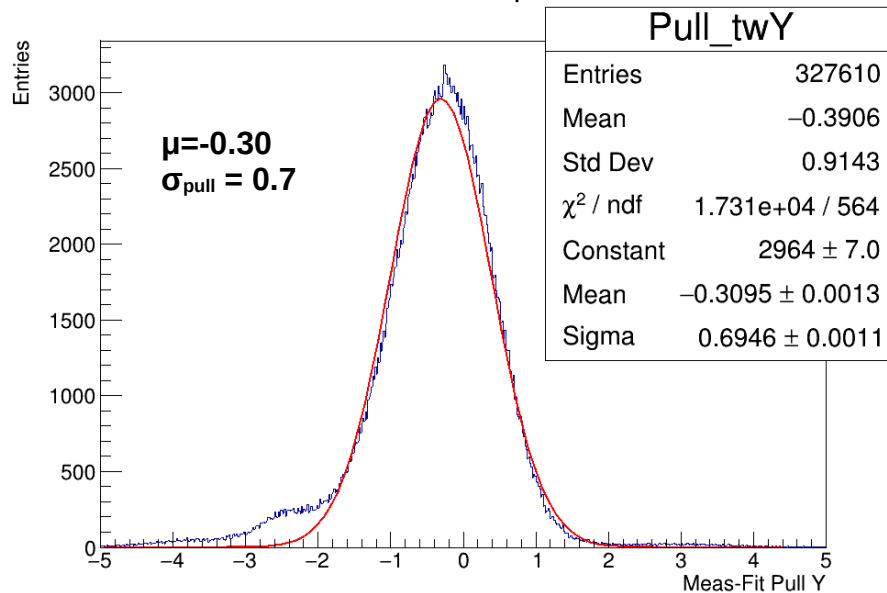
$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

run 4306

Pull for measured TW point in X view



Pull for measured TW point in Y view



- discrepancies between  $\mu$  and lower  $\sigma_{pull}$  than expected
- not best modelling for fitting

# Observations

- The resolution of the pul in real data measurements is still overestimated ( $\sigma_{\text{pull}} < 1$ )
- Misalignment to be investigated in contiguous runs
- Tails in Y position present in VT points and even in TW points
  - could be associated to a inter-misalignment between planes
  - Chi<sup>2</sup> cuts and polar angle studies under investigation

# Conclusion

Analysis focused on run **4306** of GSI2021 data

- synchronization issues fixed
- alignment issues fixed

Single detector performance studies as a main step for the analysis chain

- ✓ BM
- ✓ VTX
- ✓ TW

Performance studies about global tracking to discover issues to be fixed

→ Global Tracking Analysis chain to be applied

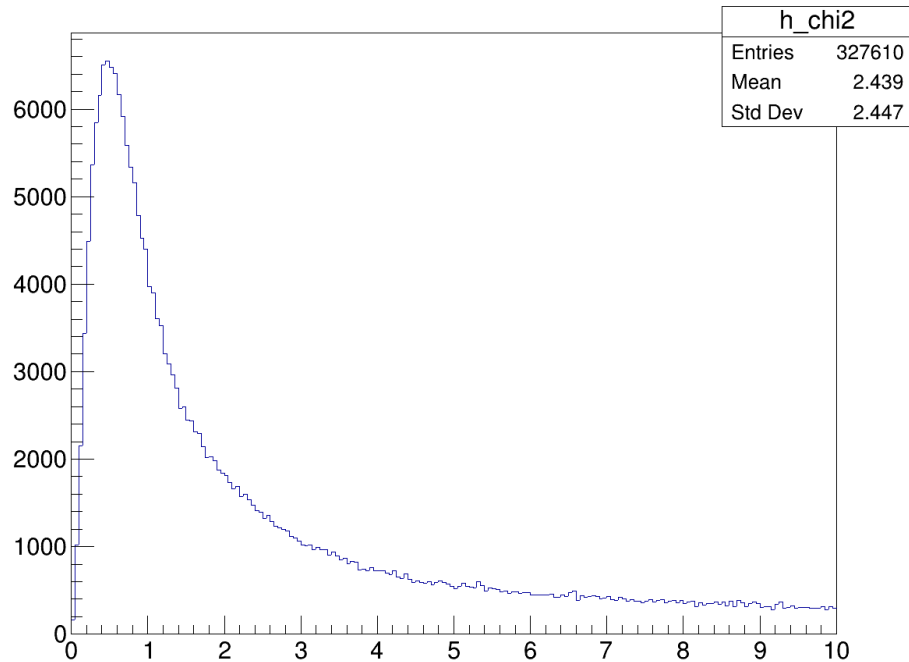
Thanks to Mauro, Matteo, Marco for the assistance and help!



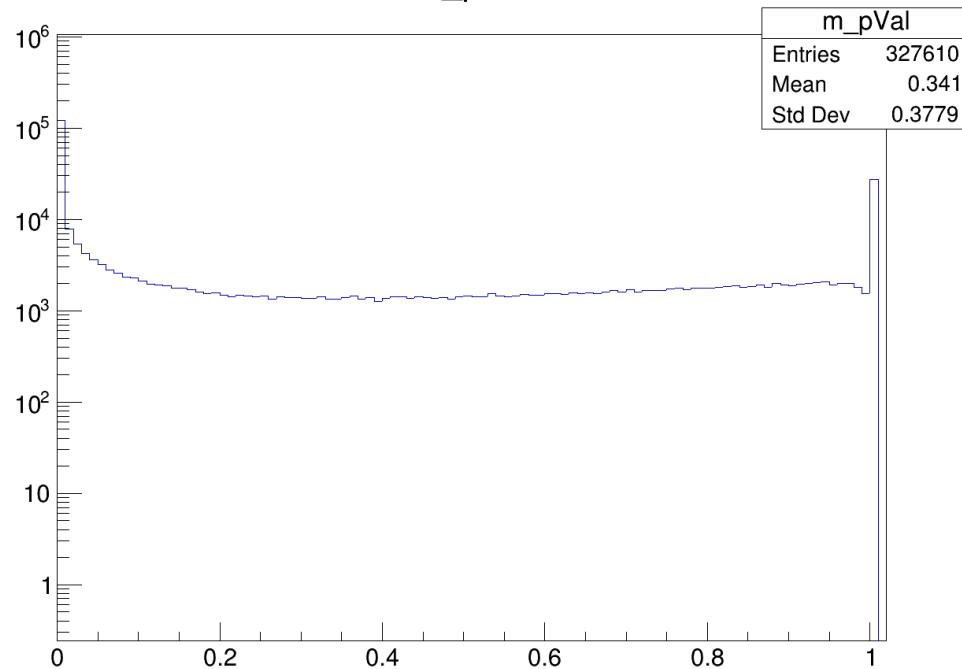
$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

run 4306

h\_chi2



m\_pVal



- absent values at low Chi<sup>2</sup> distribution



**VTX pull**

# vtx Clusterization

## measurements:

- cluster position from center of gravity of the pixels
- cluster position resolution as follows:

$$x = \frac{\sum f_n x_n}{\sum f_n} \quad y = \frac{\sum f_n y_n}{\sum f_n}$$

$$\sigma_{\mu'} = \frac{\sigma_x}{\sqrt{2n}}$$

where  $\sigma_x = \sqrt{\frac{\sum f_n (x_n - x)^2}{\sum f_n}}$

## fit:

- linear fit extrapolation at z of each plane
- resolution given by error propagation

$$x = mz + q$$

$$\sigma_x = \sqrt{\left(\frac{dx}{dm} \sigma_m\right)^2 + \left(\frac{dx}{dq} \sigma_q\right)^2 + 2 \frac{dx}{dm} \frac{dx}{dq} \text{cov}(\sigma_m, \sigma_q)}$$

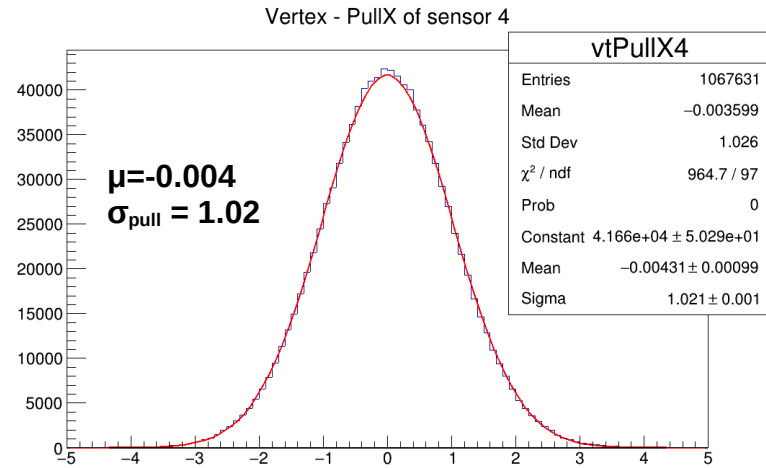
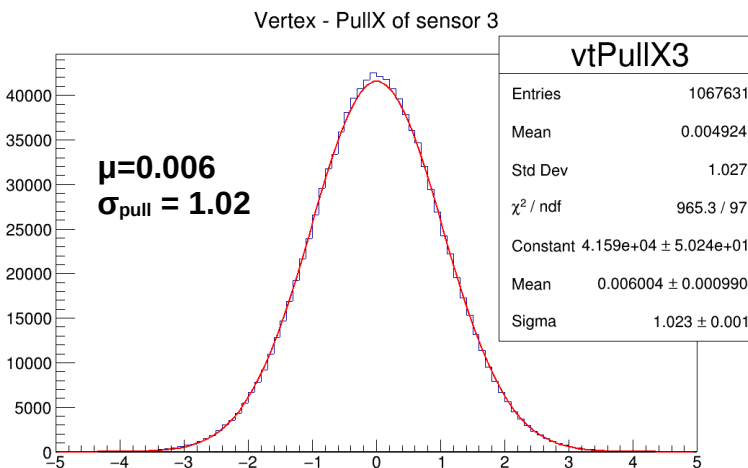
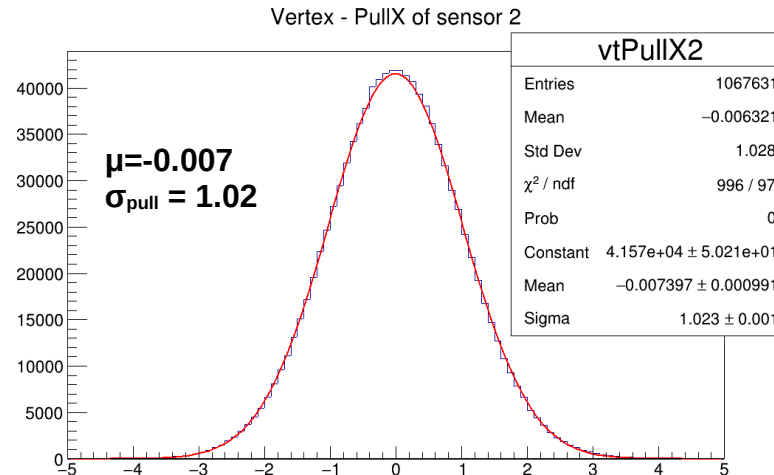
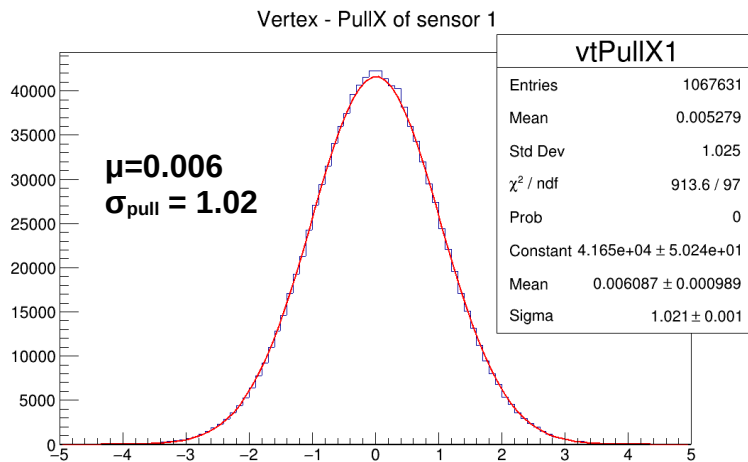


# VTX Pull – X coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

MC data

- pulls for every VT plane
- good as expected

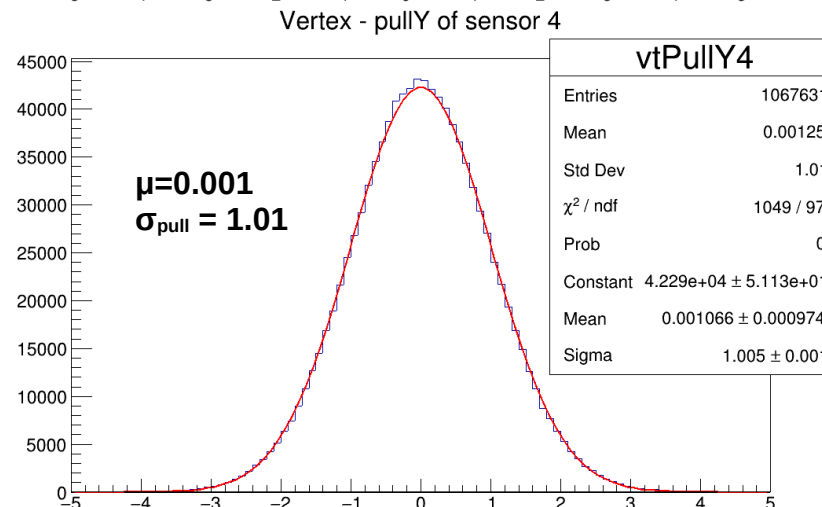
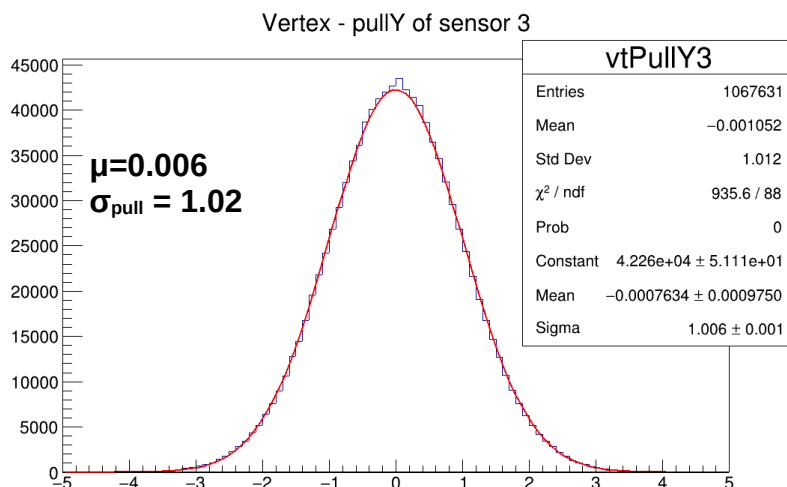
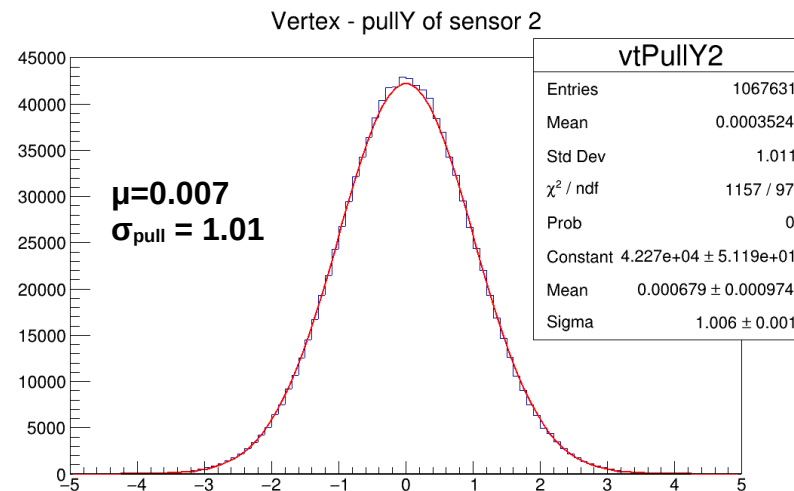
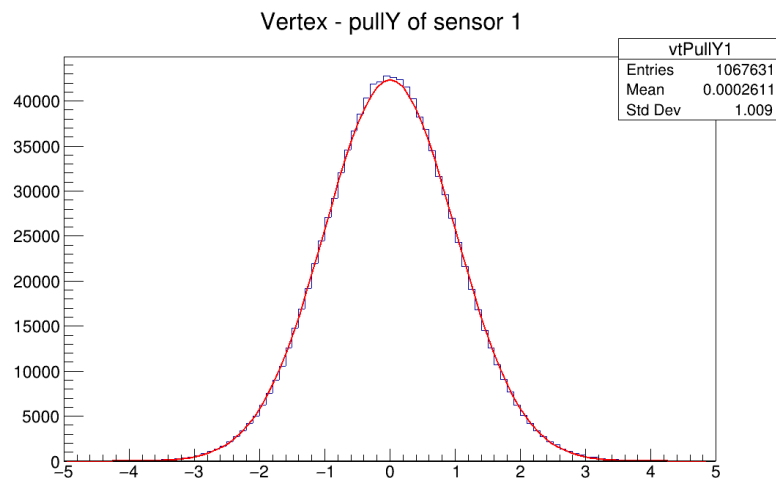


# VTX Pull – Y coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

MC data

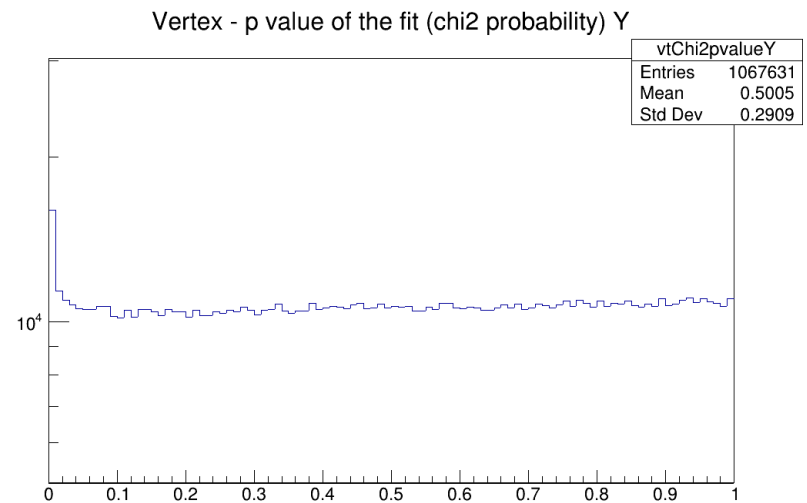
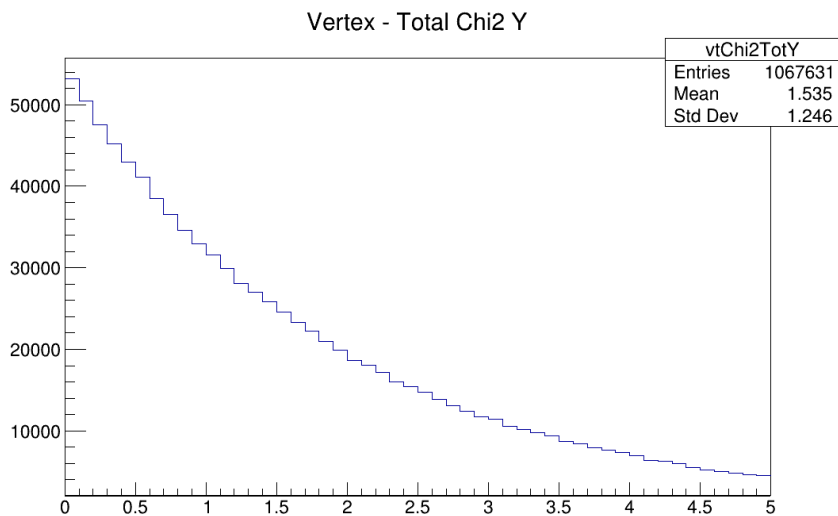
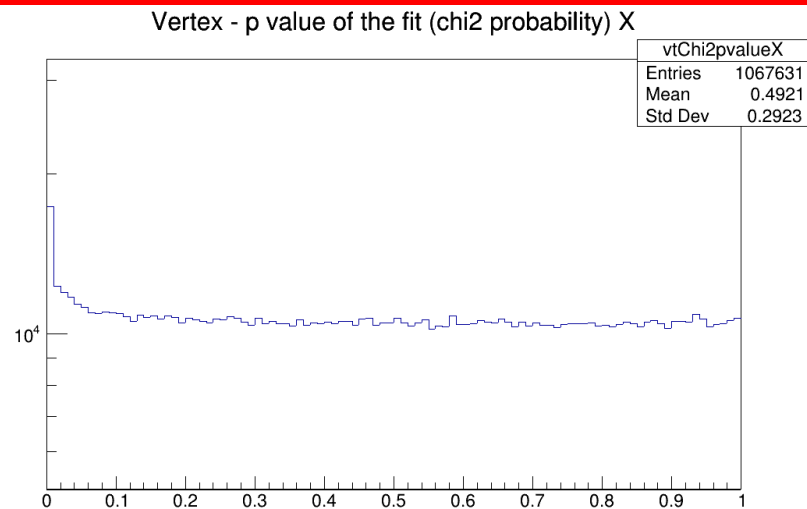
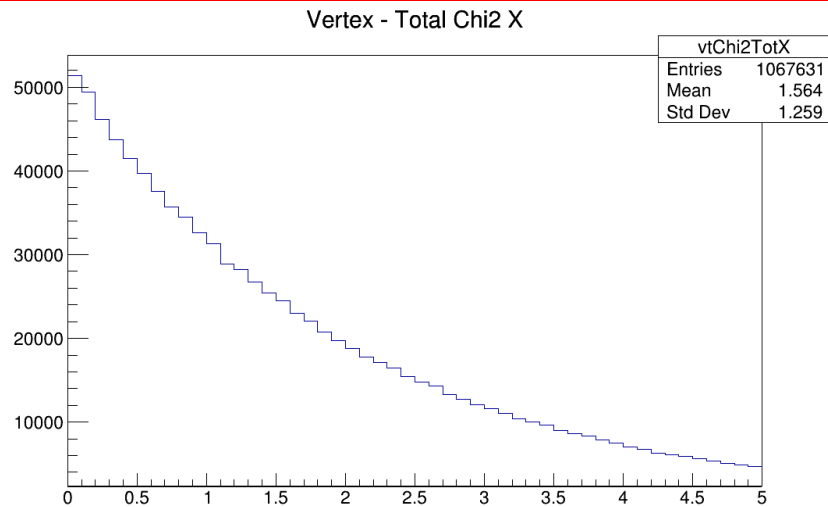
- pulls for every VT plane
- good as expected



# Chi2

MC data

- p-value with uniform distribution



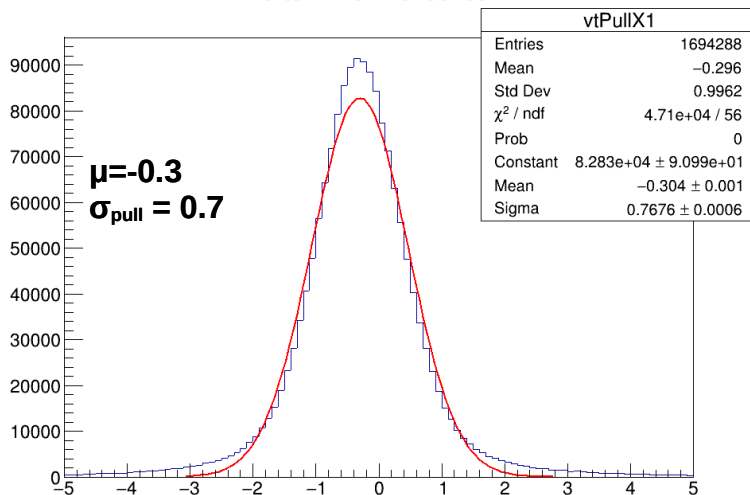
# VTX Pull – X coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

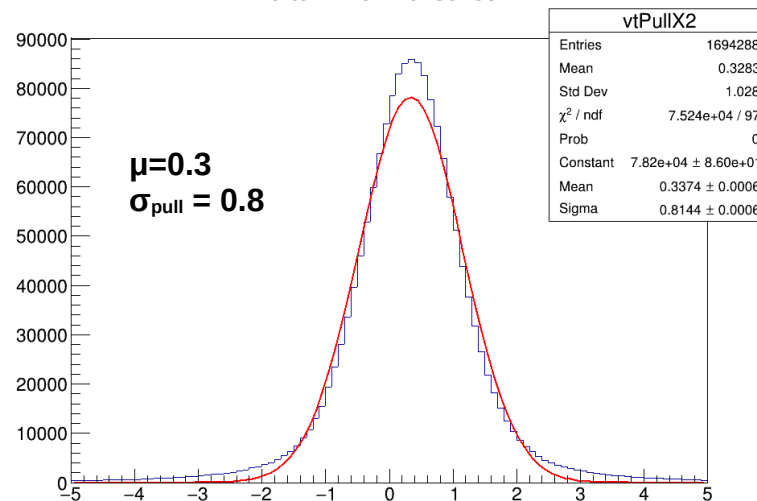
run 4306

- discrepancies between  $\mu$  and lower  $\sigma_{pull}$  than expected

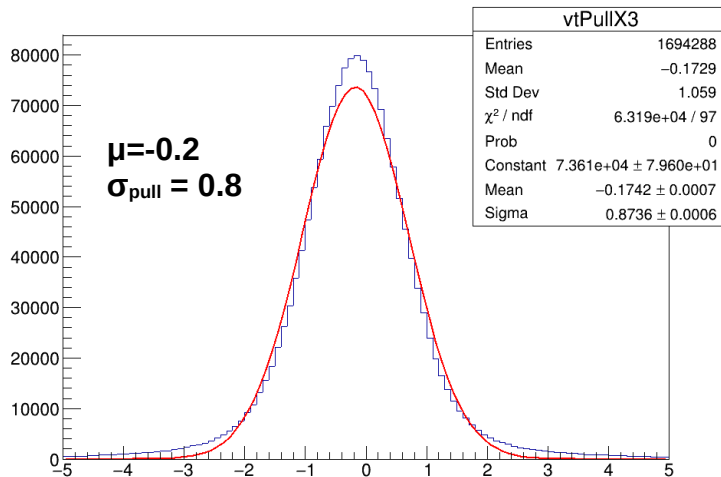
Vertex - PullX of sensor 1



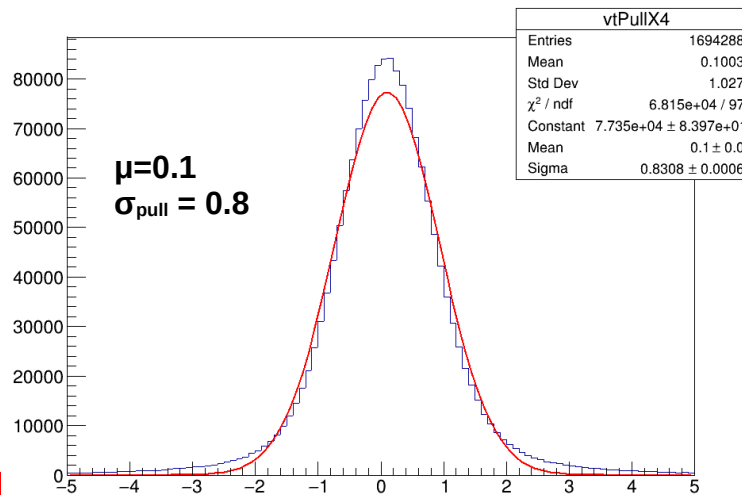
Vertex - PullX of sensor 2



Vertex - PullX of sensor 3



Vertex - PullX of sensor 4



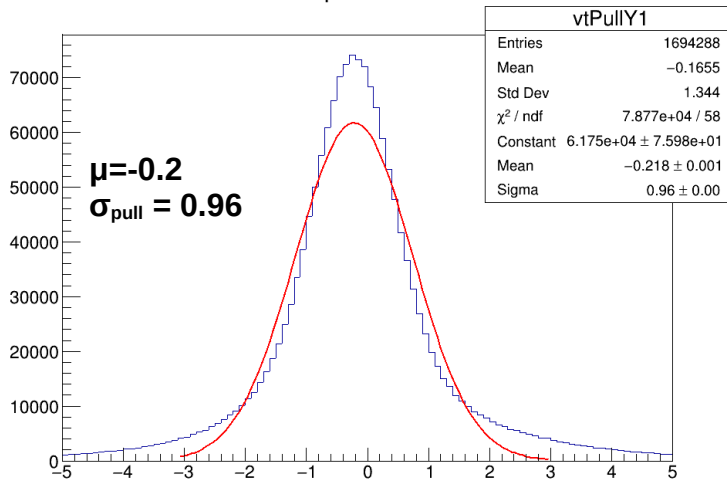
# VTX Pull – Y coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

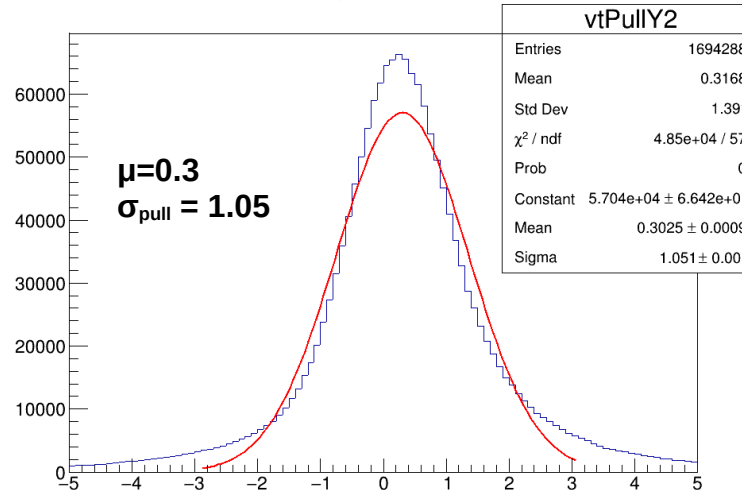
run 4306

- discrepancies between  $\mu$  and lower  $\sigma_{pull}$  than expected

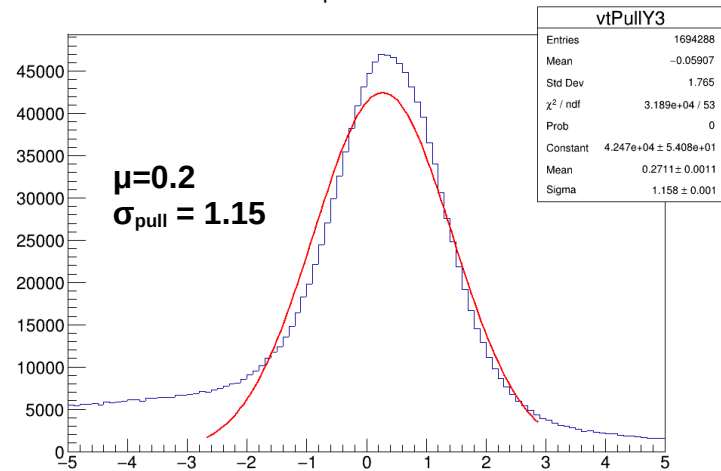
Vertex - pullY of sensor 1



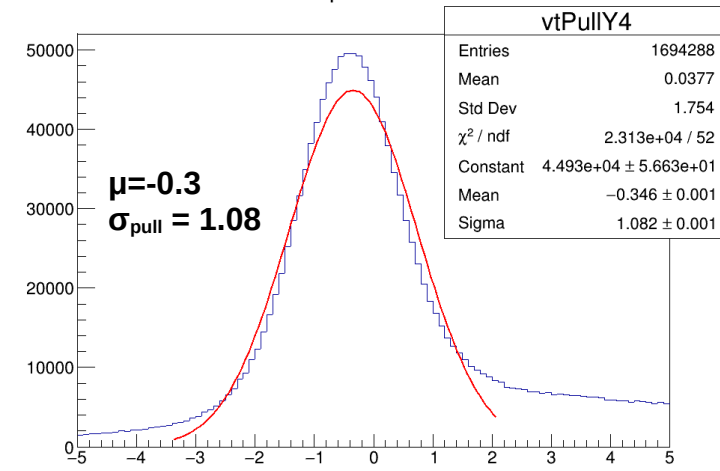
Vertex - pullY of sensor 2



Vertex - pullY of sensor 3



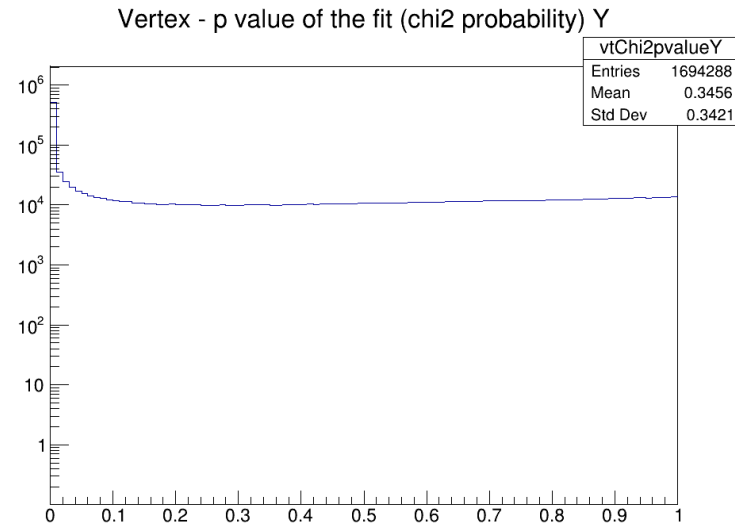
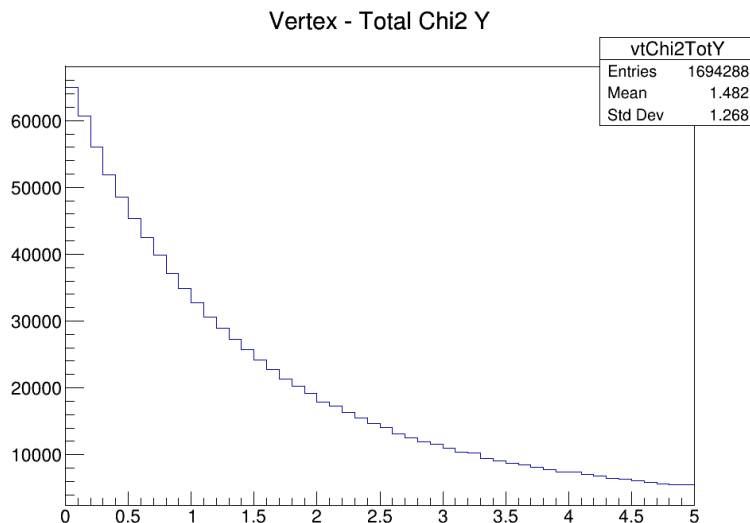
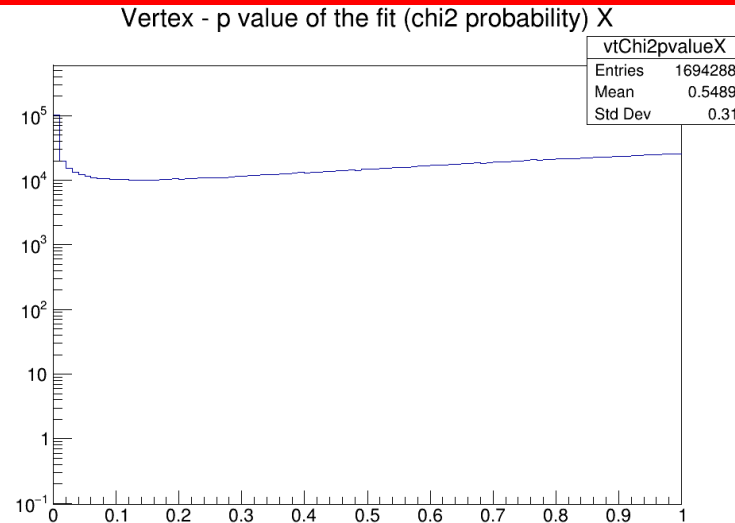
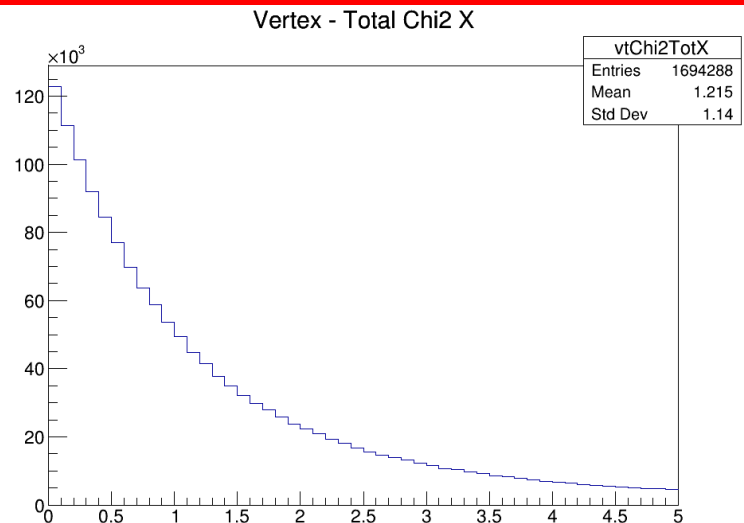
Vertex - pullY of sensor 4



# Chi2

run 4306

- p-value with slightly increment
- Chi2 distribution after  $x=5$  to be studied



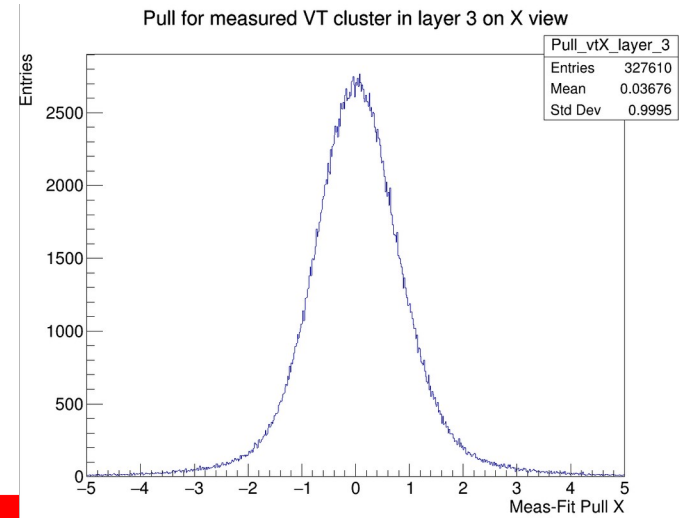
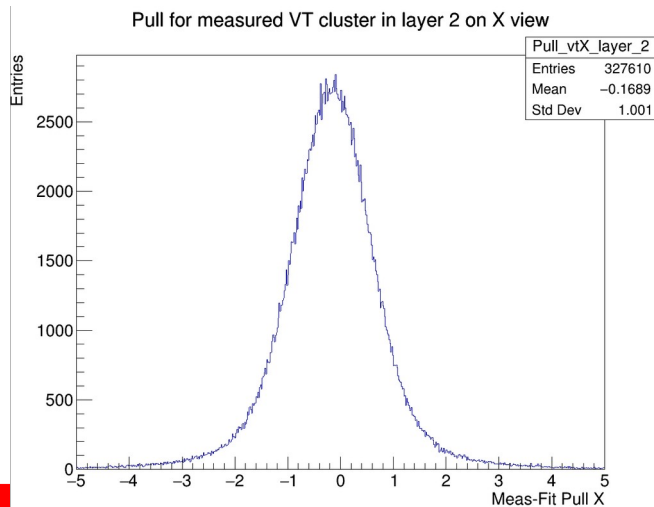
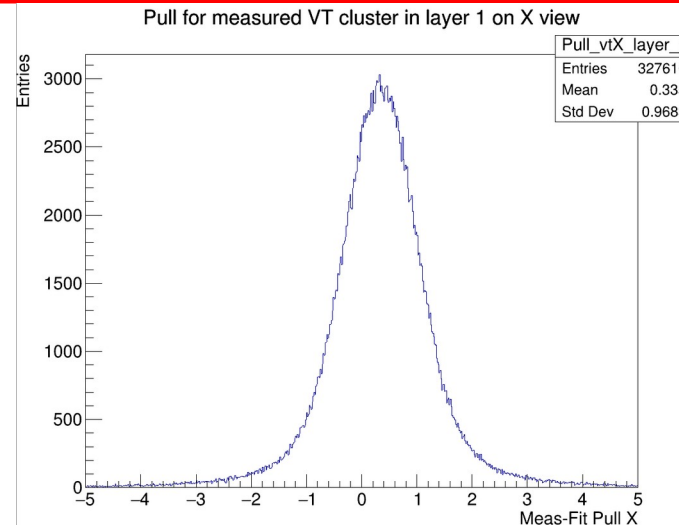
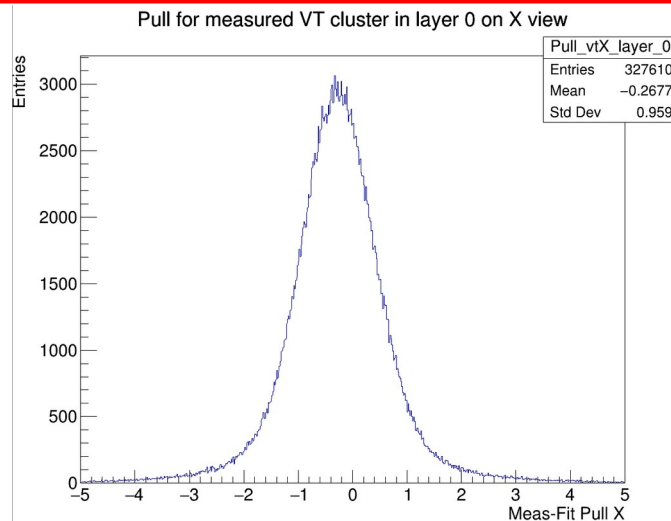
# Observations

- The resolution of the pull in real data measurements is still overestimated ( $\sigma_{\text{pull}} < 1$ )
- Tails in Y position could be associated to a intra-misalignment between planes
  - relation between **tails** vs **polar angle** and **chi2** under investigation

# Pull – X coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

run 4306

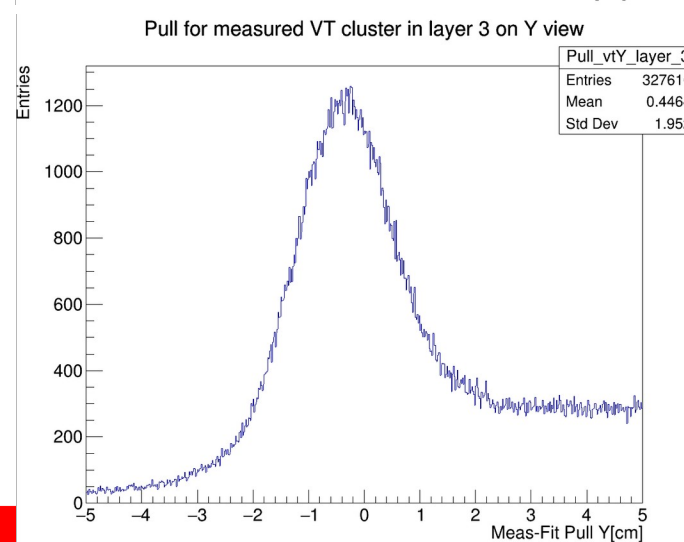
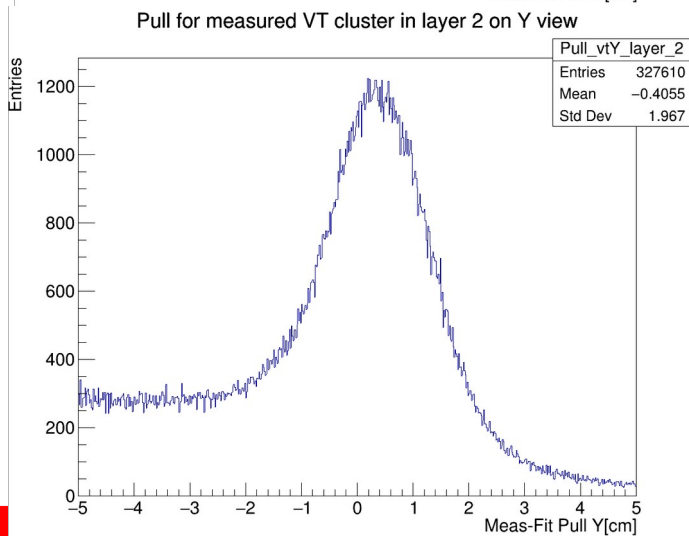
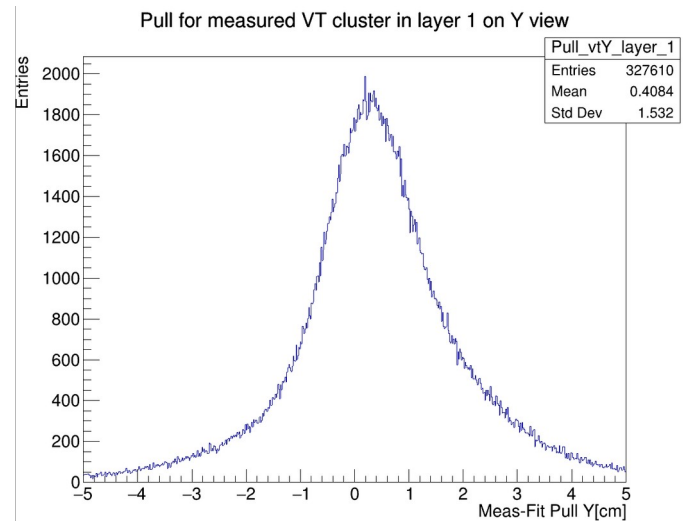
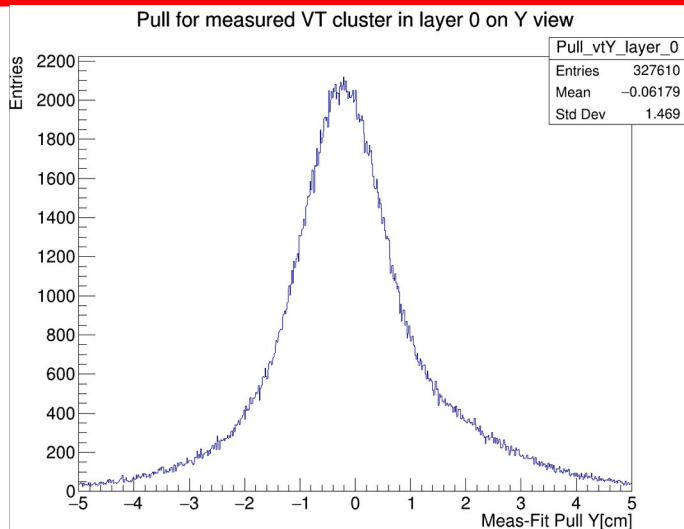




# Pull – Y coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

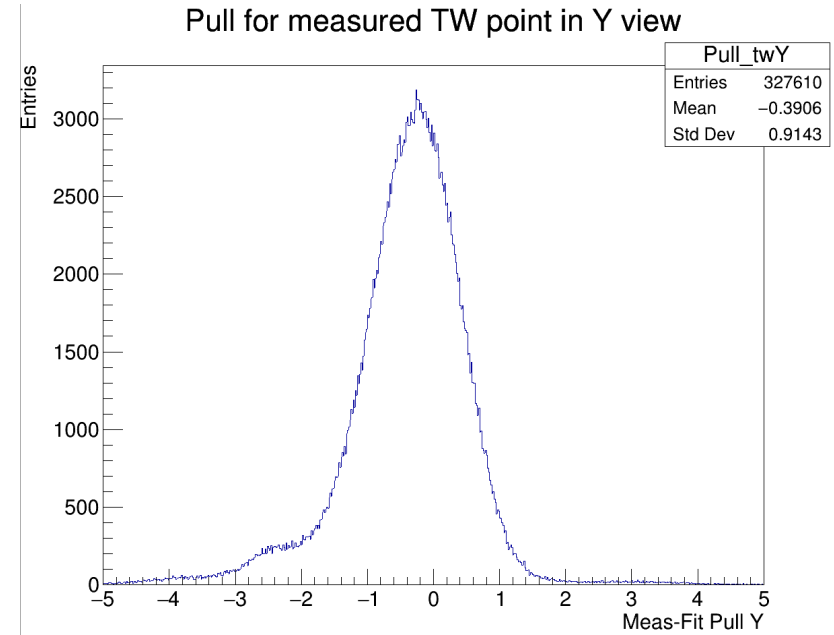
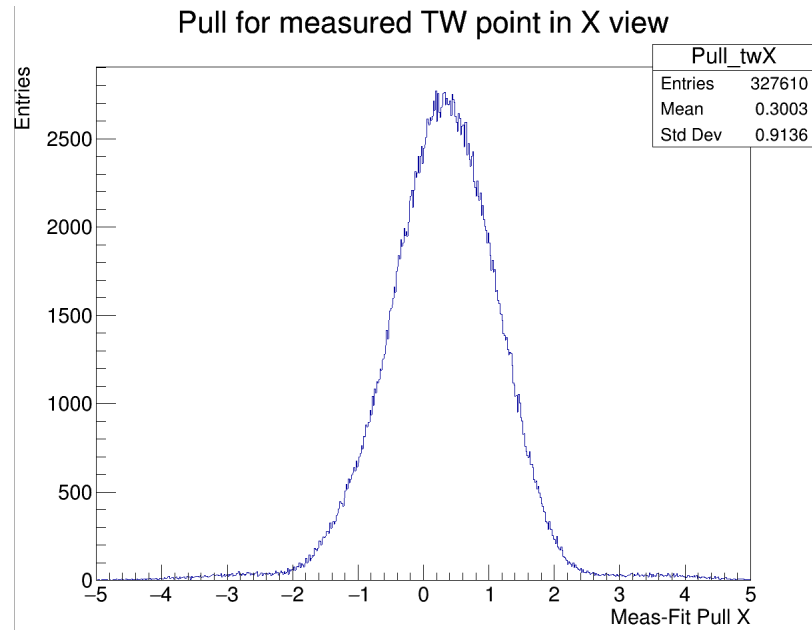
run 4306



# Pull TW point

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

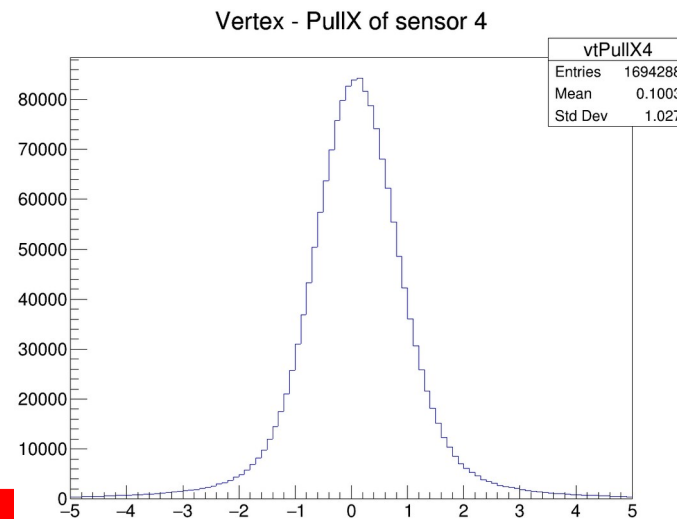
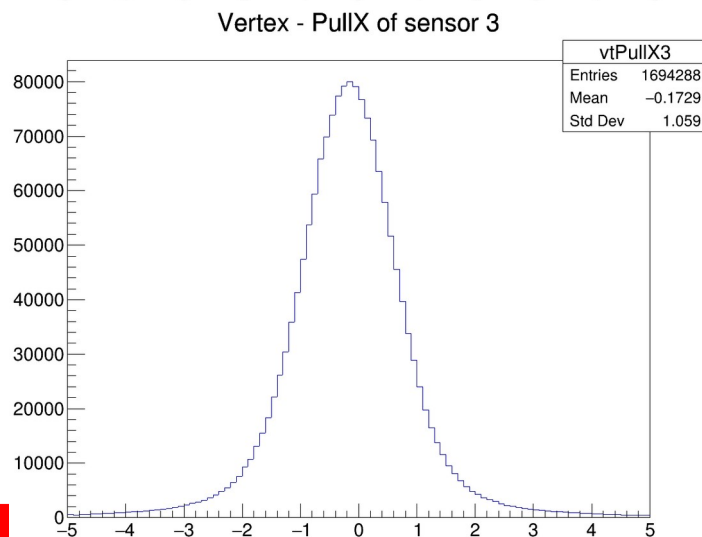
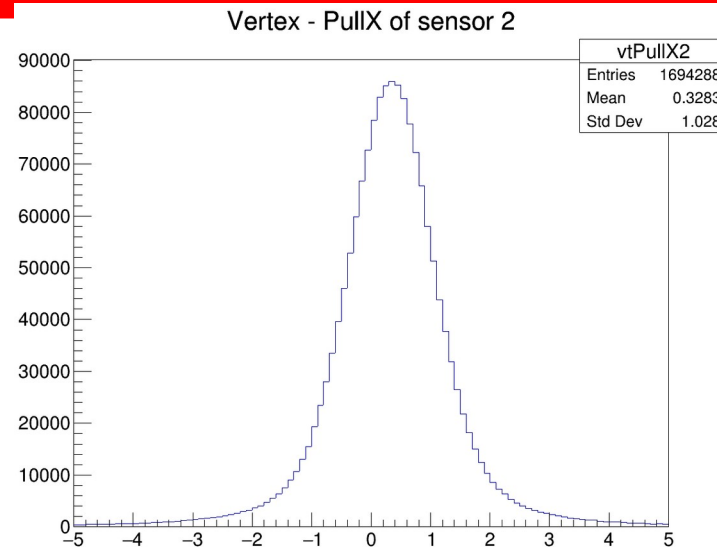
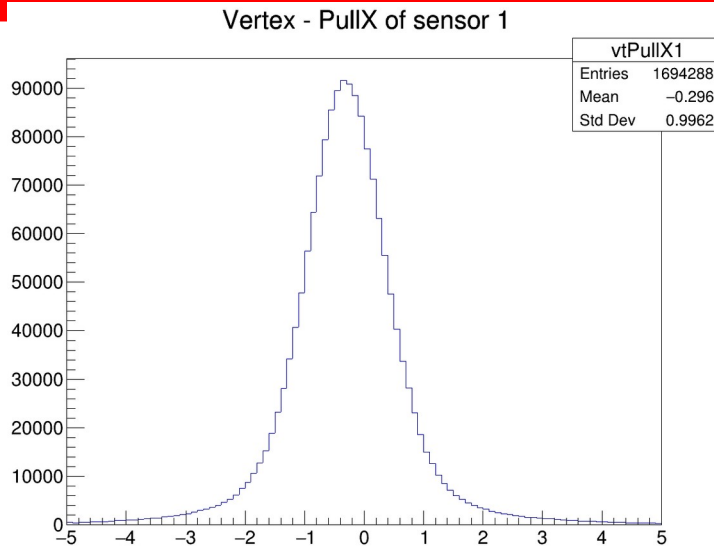
run 4306



# VTX Pull - X coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

run 4306



# VTX Pull – Y coordinate

$$p = \frac{x_{fit} - x_{meas}}{\sqrt{\sigma_{meas}^2 - \sigma_{fit}^2}}$$

run 4306

