# ECCE All Si Tracker Design Optimisation

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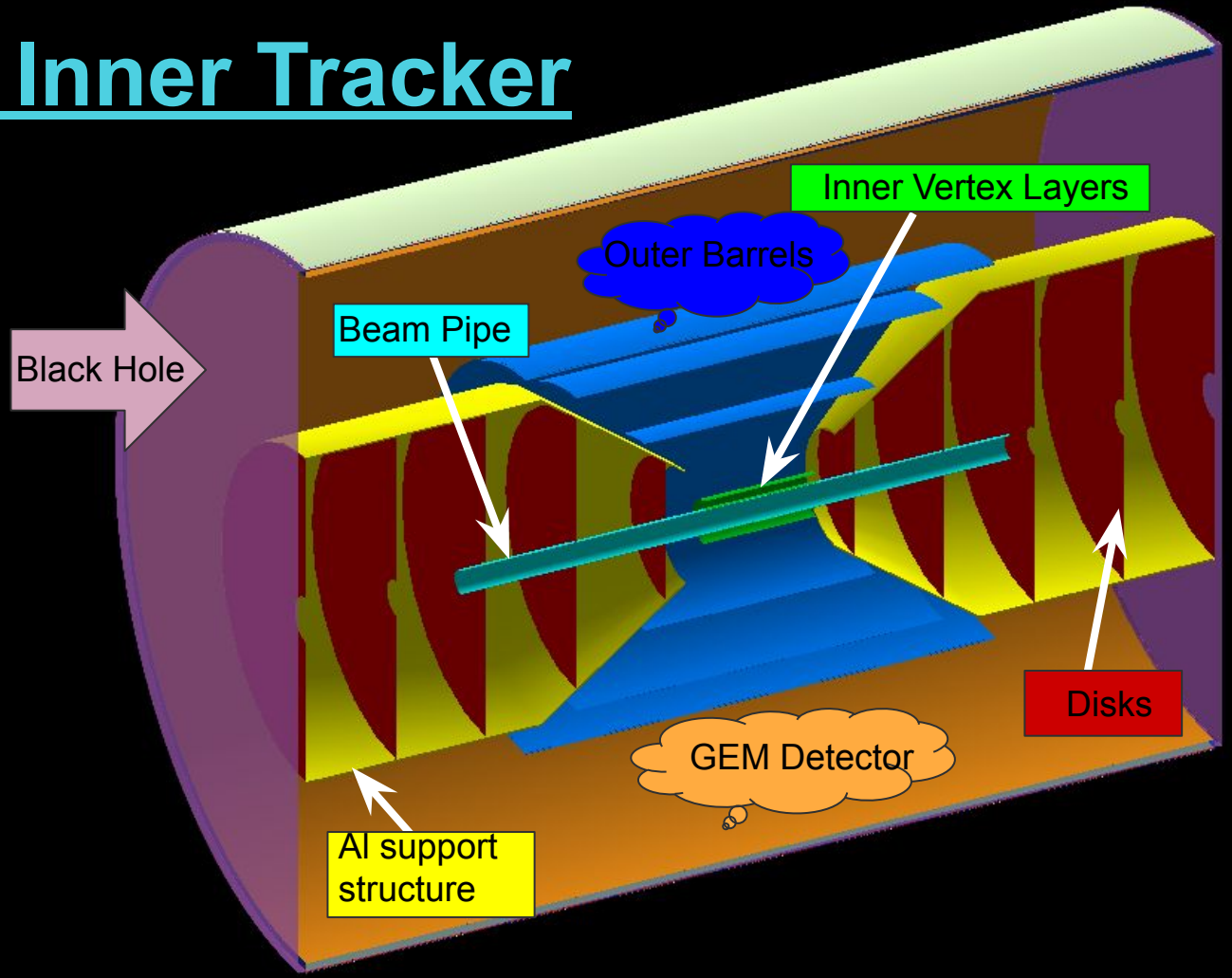
July 6 2021

# All Si Inner Tracker



# Baseline Design Parameters

| Si Vertex Detector | Radii [cms] | Length [cms] |
|---|---|---|
| Layer 1 | 3.3 | 30.0 |
| Layer 2 | 5.7 | 30.0 |

| Outer Si Barrels | Radii [cms] | Length [cms] |
|---|---|---|
| Layer 1 | 21.0 | 54.0 |
| Layer 2 | 22.68 | 60.0 |
| Layer 3 | 39.3 | 105.0 |
| Layer 4 | 43.3 | 114.0 |

| Forward Si Disks | Z position [cms] | RMin [cms] | RMax [cms] |
|---|---|---|---|
| Disk 1 | 25.0 | 3.18 | 18.48 |
| Disk 2 | 49.0 | 3.18 | 36.28 |
| Disk 3 | 73.0 | 3.50 | 43.2 |
| Disk 4 | 97.0 | 4.70 | 43.2 |
| Disk 5 | 112.0 | 5.90 | 43.2 |

# Common Parameters

| Si Vertex Detector | Pixel um | Resolution [cms] |
|---|---|---|
| Z | 10 | 0.001/sqrt(12) |
| phi | 10 | 0.001/sqrt(12) |

| | |
|---|---|
| P range | 1 - 30 GeV/c |
| $\eta$ range | 0 - 3.5 GeV/c |
| Magnetic Field | 1.4 T BaBar |
| Black hole | Final Layer + 2 cms |

| Outer Si Barrels | Pixel [um] | Resolution [cms] |
|---|---|---|
| Z | 10 | 0.001/sqrt(12) |
| phi | 10 | 0.001/sqrt(12) |

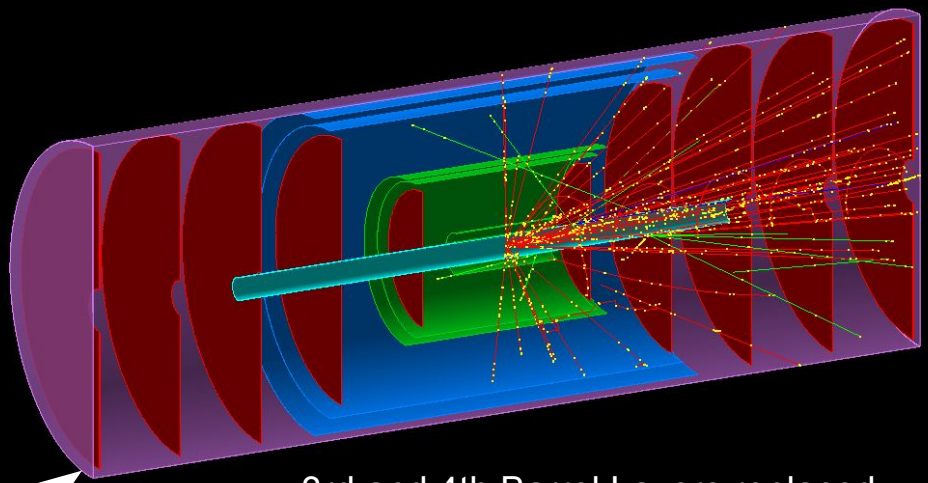
| Forward Si Disks | Pixel [um] | Resolution [cms] |
|---|---|---|
| Radial (r) | 10 | 0.001/sqrt(12) |
| Phi | 10 | 0.001/sqrt(12) |

| | |
|---|---|
| Vertex Budget Barrel [1 - 2] (X/X0) | 0.05 % |
| Barrel Budget Barrel [3 - 6] (X/X0) | 0.55% |
| Disk Budget (X/X0) | 0.24 % |

# So Far

- Used the All Si Tracker design shown before as Baseline and optimised the detector design without having the outer GEM detector (at 92cms).
- Cris had shown the results of the optimisation in various places [June 12 2021 AI WG Meeting]
- Rey showed results with replacing the 3rd and 4th Barrel layers with Vertex layer technology (X/X0 = 0.05%).
- The plots shown from now on is for the design here

Used stand alone simulation



3rd and 4th Barrel Layers replaced with vertex technology

The Detector geometry is the same as the Baseline Design except

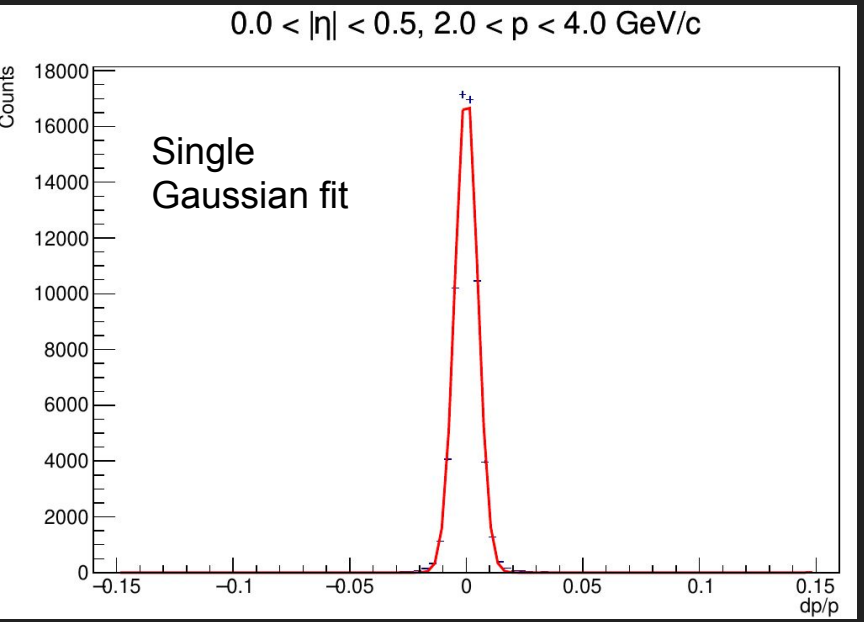
1. No GEM
2. Barrel layers 3 and 4 are replaced with Vertex Technology

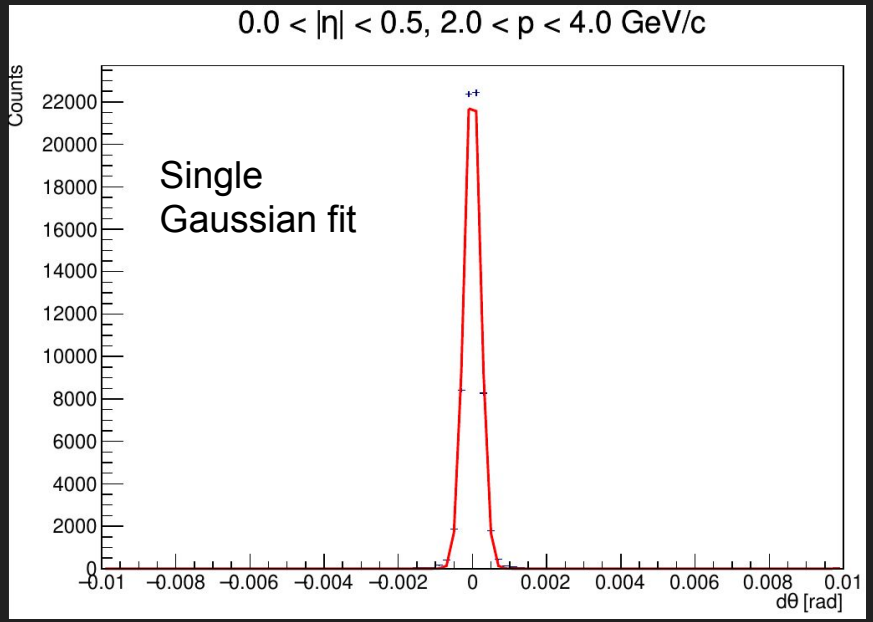
| | |
|---|---|
| Vertex Budget Barrel [1 - 4] (X/X0) | 0.05 % |
| Barrel Budget Barrel [5 - 6] (X/X0) | 0.55% |
| Disk Budget (X/X0) | 0.24 % |

# Procedure

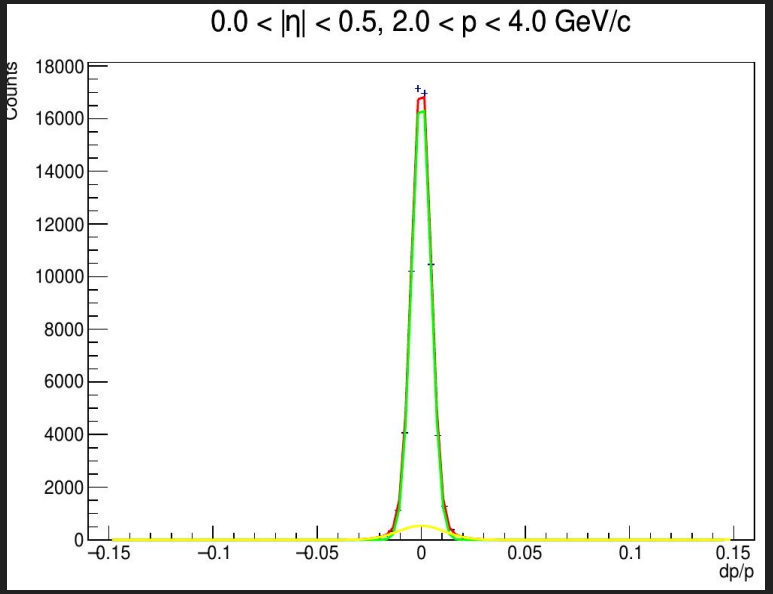
1 M events between 0 to 0.5 in eta with p range between 1 - 30 GeV/c

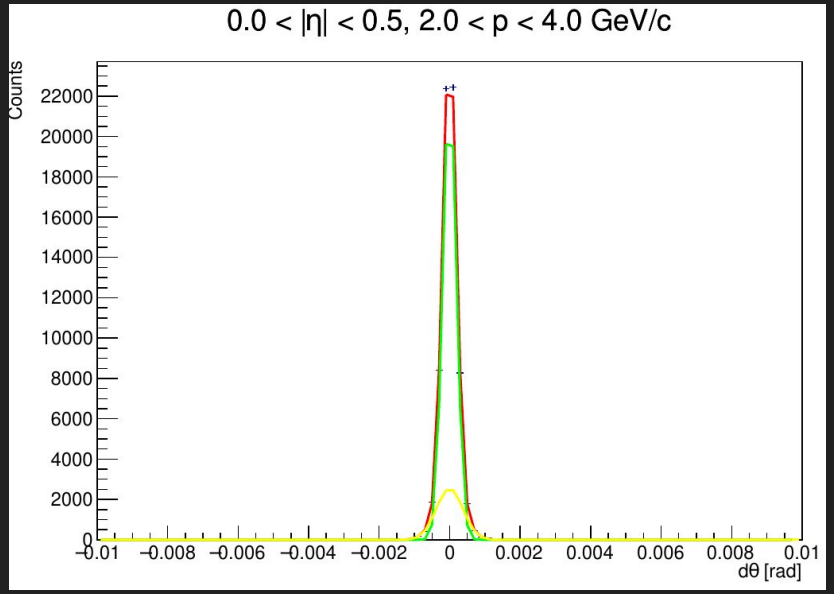
- Resolutions in p, theta, dca2d along with Kalman Filtering Inefficiency is used as objective to optimise the detector design parameters
- Each of the resolutions are extracted in bins of generated momenta (p) and generated pseudo rapidity ($\eta$).
- The distributions are fit with a single gaussian so far.
- A double gaussian fit with same mean seems to fit better the distributions



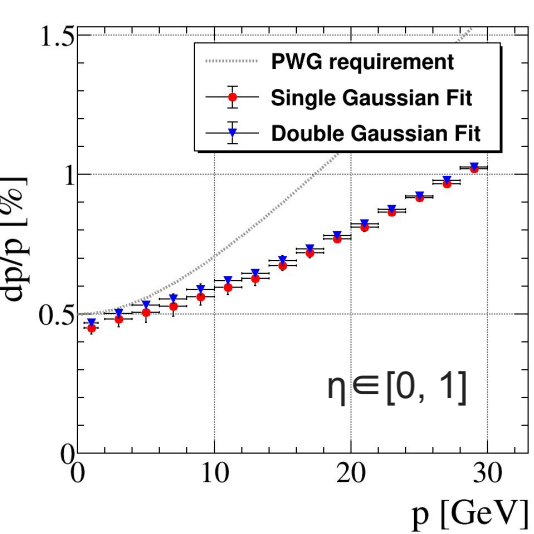
$$D_1 e^{(x-\mu)^2/\sigma_1^2)} + D_2 e^{(x-\mu)^2/\sigma_2{}^2)}$$

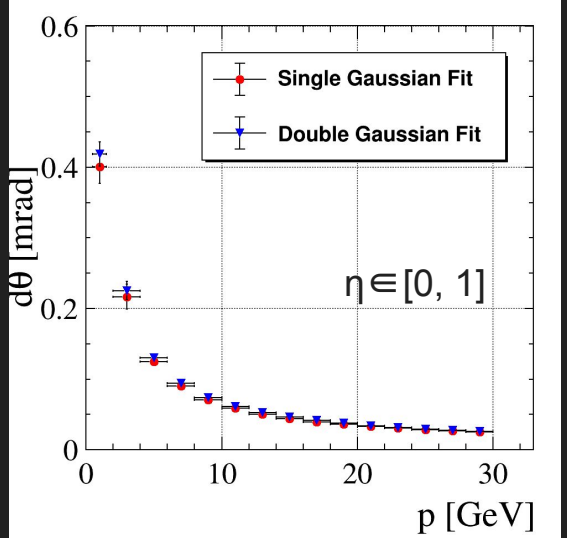


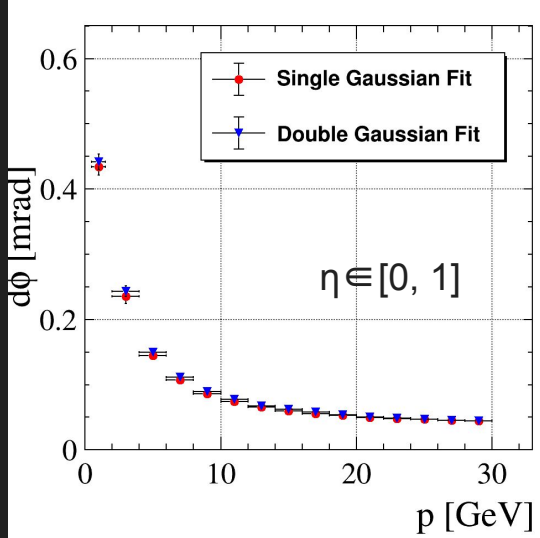



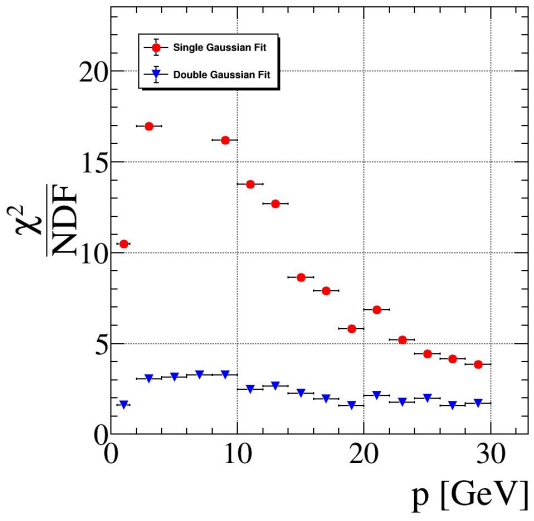

The resolution is weighted average of the 2 sigmas, A's are the area of the curve

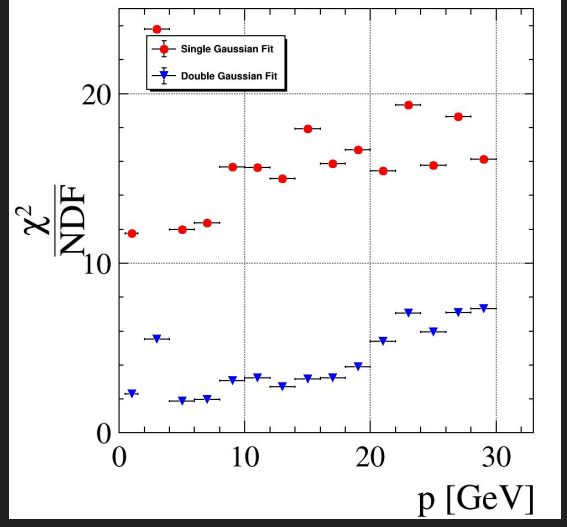
$$\sigma = \frac{\sigma_1 A_1 + \sigma_2 A_2}{A_1 + A_2}$$

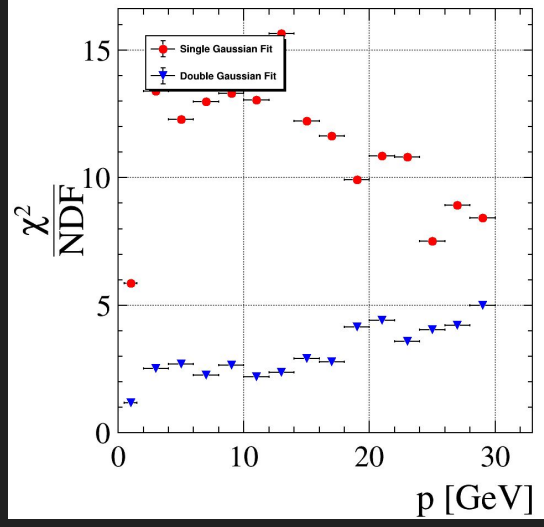

PWG requirement
Single Gaussian Fit
Double Gaussian Fit
dp/p [%]
η∈[0, 1]
p [GeV]


Single Gaussian Fit
Double Gaussian Fit
dθ [mrad]
η∈[0, 1]
p [GeV]

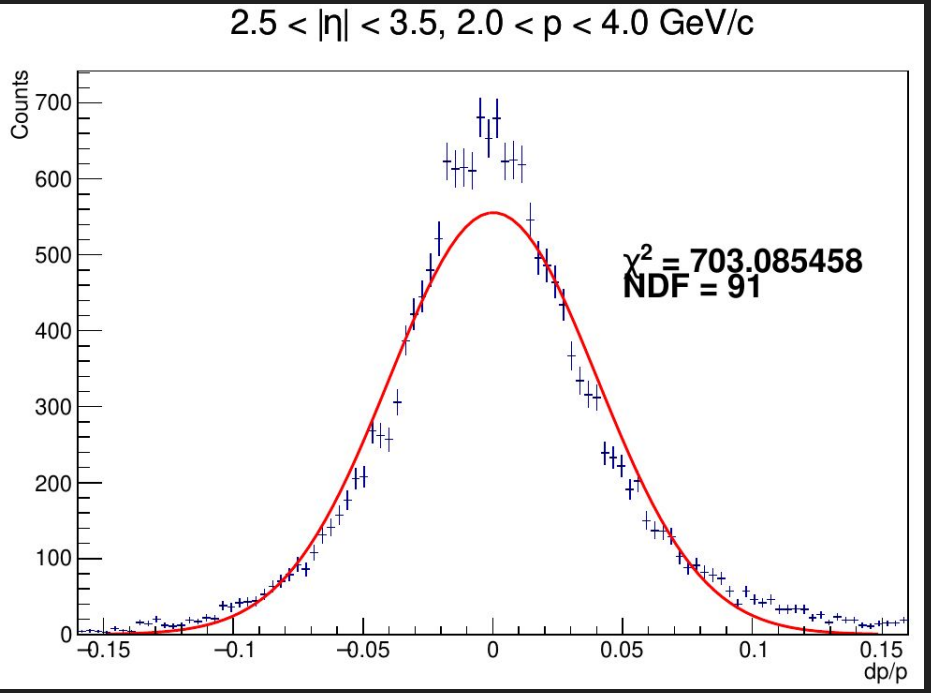

Single Gaussian Fit
Double Gaussian Fit
dφ [mrad]
η∈[0, 1]
p [GeV]

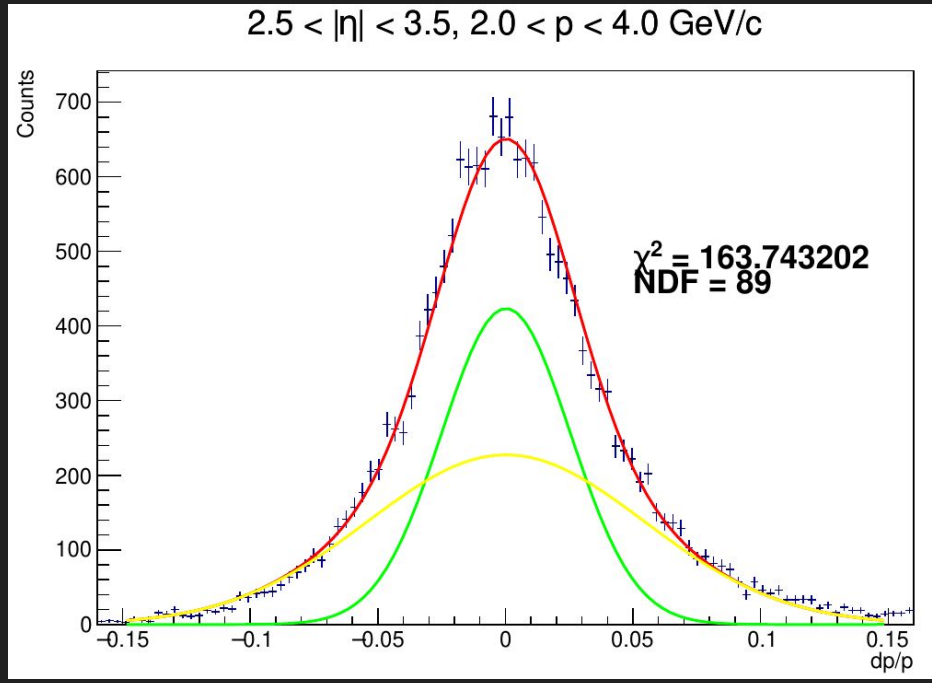

Single Gaussian Fit
Double Gaussian Fit
χ²/NDF
p [GeV]

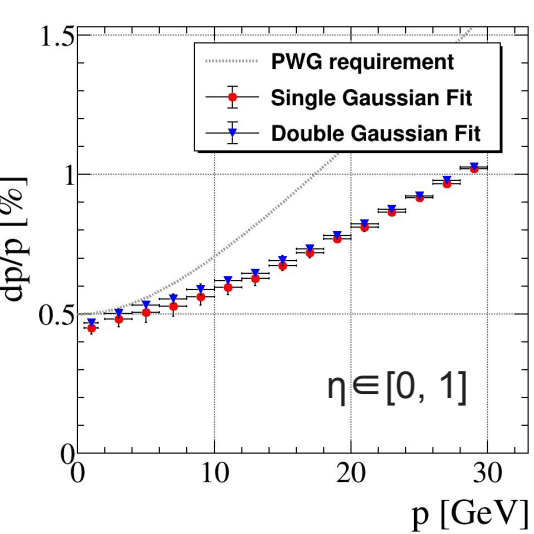

Single Gaussian Fit
Double Gaussian Fit
χ²/NDF
p [GeV]

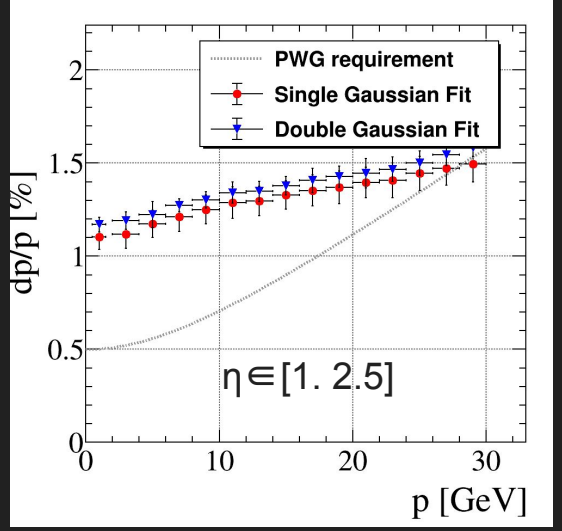

Single Gaussian Fit
Double Gaussian Fit
χ²/NDF
p [GeV]

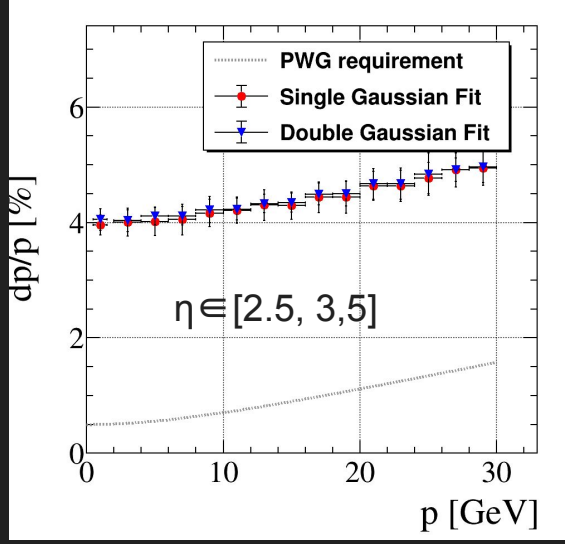
# Higher η range fits are better with double gaussian fits

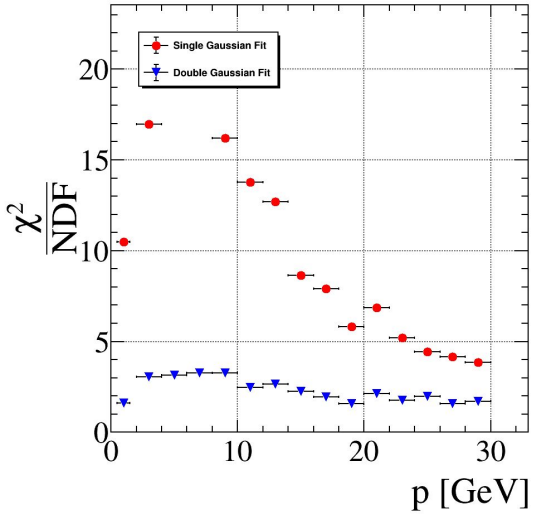


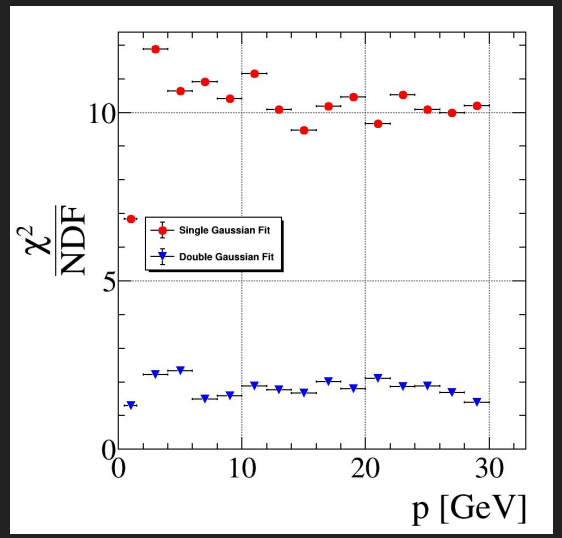



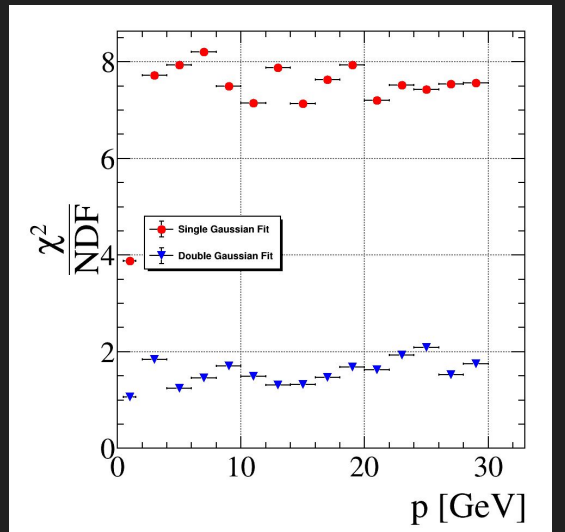

PWG requirement
Single Gaussian Fit
Double Gaussian Fit
dp/p [%]
η∈[0, 1]
p [GeV]


PWG requirement
Single Gaussian Fit
Double Gaussian Fit
dp/p [%]
η∈[1. 2.5]
p [GeV]


PWG requirement
Single Gaussian Fit
Double Gaussian Fit
dp/p [%]
η∈[2.5, 3,5]
p [GeV]


Single Gaussian Fit
Double Gaussian Fit
χ²/NDF
p [GeV]


Single Gaussian Fit
Double Gaussian Fit
χ²/NDF
p [GeV]


Single Gaussian Fit
Double Gaussian Fit
χ²/NDF
p [GeV]

# Summary

- This study on the fit functions was made as an effort to optimise the All Silicon Inner tracker design using AI
- Fitting the resolution distributions with a double gaussian, do not have a huge impact on the resolutions themselves but on the quality of the fits ($\chi^2$/NDF)
- Fit results with double gaussian are more stable at higher $\boldsymbol{\eta}$ (pseudo rapidity).
- Fit results with double gaussian are more stable especially with lower statistics