Misalignment Effects on Track Reconstruction for CBM-STS

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Introduction

The Silicon Tracking System (STS) facilitates the track reconstruction and momentum determination of charged particles for the Compressed Baryonic Matter (CBM) experiment. For this work, STS geometry version 15b has been taken, which consists of 8 Stations, 106 ladders, 212 halfladder, 900 modules, 1220 sensors in five step hierarchial structure. 8 tracking layers of silicon detectors are located downstream of the target at distances 30cm and 100cm inside the magnetic dipole field. The concept of the STS tracking is based on silicon microstrip sensor mounted onto lightweight mechanical support ladders. The microstrip sensors have been designed to be double-sided with a stereo angle of 7.5°, a strip of 58μm and a thickness of 300μm of silicon.

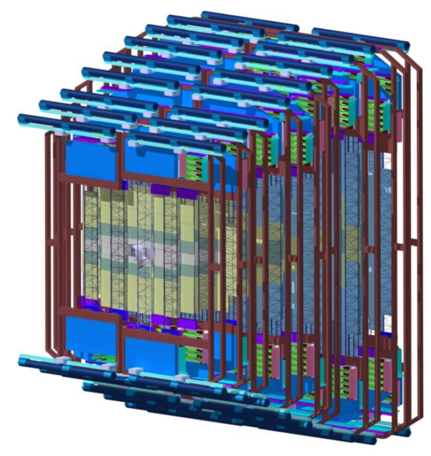

Fig. 1: Structure of STS Geometry

Motivation

- Limited mechanical mounting precision ($\sim$100μm)
- Possible deformations due to temperature effect.
- Influence of magnetic field leads to mis-alignment of the ideal detector.
- Only mechanical mounting fails to provide unprecedented spatial resolution of the STS.
- Therefore, the track them-selves are more reliable to use to determine the exact STS element positions($\sim$10μm)after alignment.

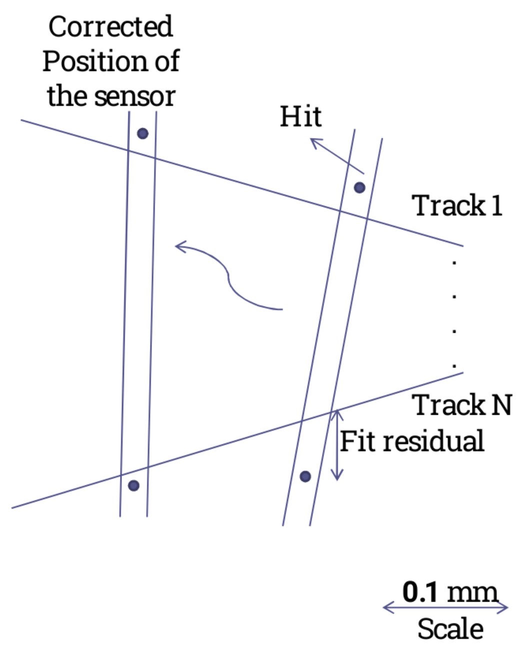

Fig. 2: Track Based Alignment

Theorem for Residual

$\varepsilon_{ij}(a,\tau_j) = m_i - f_i(a,\tau_j)$
ε_{ij} = residual of i^{th} hit of j^{th} track
m_i = measured hit positions w.r.t. detector module
$f_i(a,\tau_j)$ = values obtained from track model
a = alignment parameters
τ_j = track parameters
σ_i = measurement uncertainty
$\chi^2(a,\tau) = \sum_{j\in tracks}\sum_{i\in hits}\frac{\varepsilon_{ij}^2(a,\tau_j)}{\sigma_i^2}$

*the residual distribution to be minimized
MILLEPEDE package will come into play

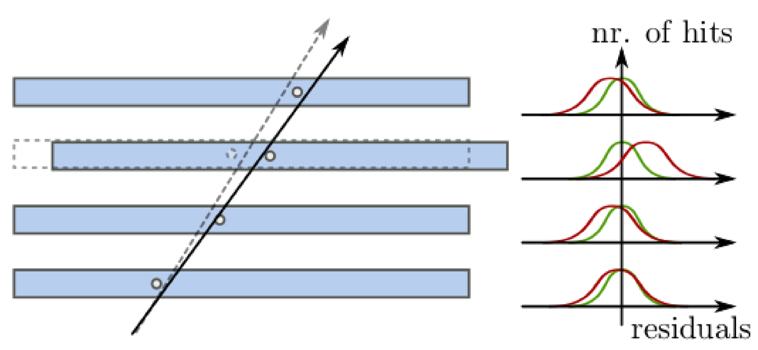

Fig. 3: Residual Distribution

Misalignment strategies

For this work three misalignment scenarios have been introduced in the STS geometry on hierarchial basis(i.e., to the sensors, ladders, stations). A Virtual technique has been used for misalignment, i.e., according to the misalignment scenarios, the transformations have been applied on the STS hits at the time of track reconstruction without modifying the ideal geometry (**Scenario_0**).

Misalignment Data Table

Element	Sensor	Ladder	Station
X	10μm	50μm	200μm
Y	10μm	50μm	200μm
α	50μrad	250μrad	1000μrad
β	50μrad	250μrad	1000μrad
γ	50μrad	250μrad	1000μrad

Fig. 4: Transformation Data

All the data (as standard deviation) have been diced using Gaussian distribution to make the transformations random.

- On the first scenario (**Scenario_1**), transformed data have been applied at the local sensor level of ideal geometry(**Scenario_0**).
- On the second scenario (**Scenario_2**), in addition to the sensor level modifications, transformed data have been applied to the local ladder level.
- On the third scenario (**Scenario_3**), in addition to the last two scenarios, transformed data have been applied to the local station level.
- **Important assumption**: **Z-value** has been kept constant throughout, as the projection has always been taken to the X-Y plane.

Results

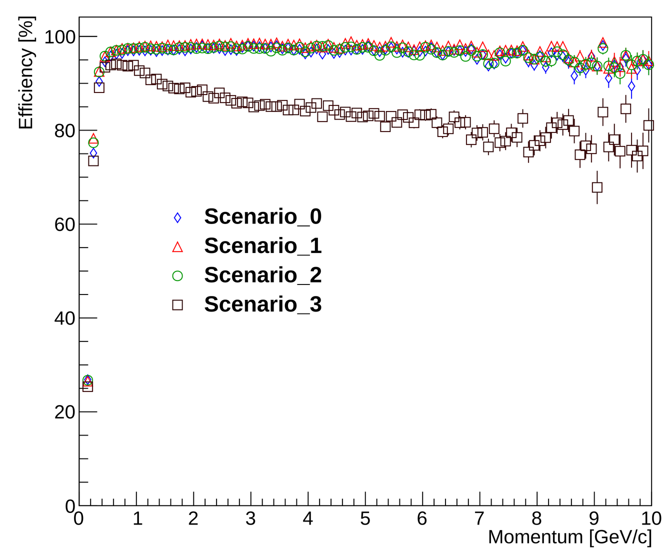

Fig. 5: Primary Track Efficiency vs. Momentum

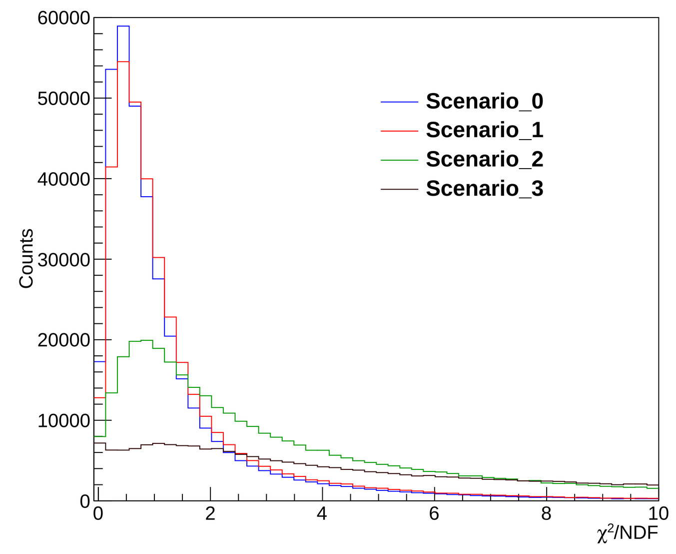

Fig. 7: Track Quality Evaluation in Terms of χ^2/NDF

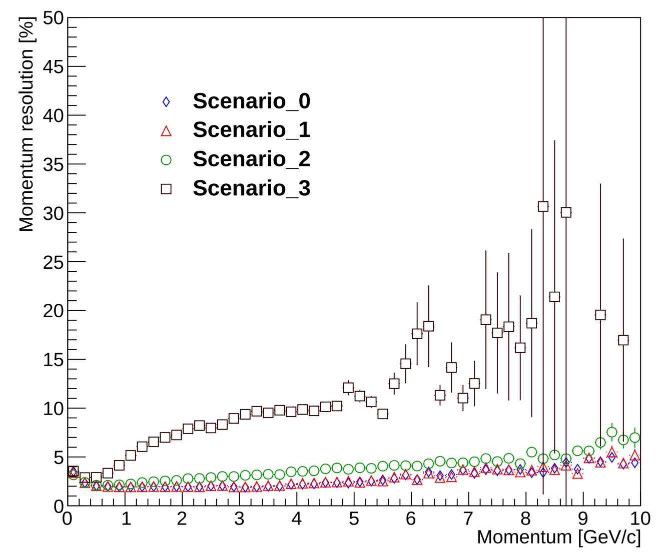

Fig. 6: Momentum Resolution vs. Momentum

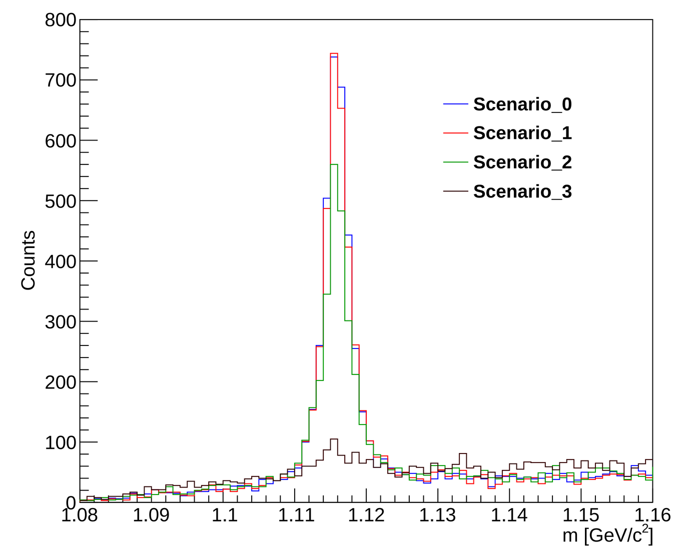

Fig. 8: Reconstructed mass of Λ as an Example

Conclusion

- So, this was the first successful attempt to apply the misalignment on the STS geometry. And there is a clear indication of deterioration of reconstructed track quality.
- Hit Residual calculation is still in progress and on the next step **MILLEPEDE** software package will be used to recover the misalignment. One Schematic work flow diagram is given below.

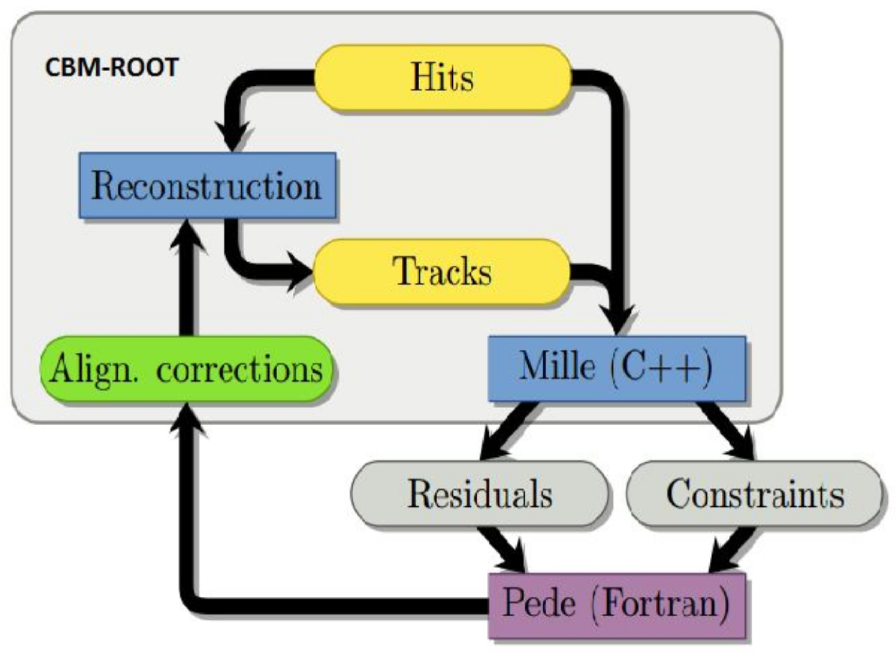

Fig. 9: Workflow Schematic Diagram

References

References

[1] S. Das and H. R. Schmidt et al., CBM Progress Report, 2016
[2] V. Blobel and C. Kleinwort, A New Method for the High-Precision Alignment of Track Detectors, 2002. arXiv:hep-ex/0208021.
[3] V. Blobel. Millepede II. Institut für Experimentalpyhsik, Universität Hamburg. 2007. url: http://www.desy.de/ blobel/mptalks.html.
[4] R. Frühwirth, Nucl. Instr. and Meth. A 262 (1987) 444
[5] Impact of CMS silicon tracker misalignment on track and vertex reconstruction, Nucl. Instr. and Meth. A 566 (2006) 45-49
[6] http://aliceinfo.cern.ch/Offline/Activities/Alignment.html