SciFi further optimization: alignment per Mat

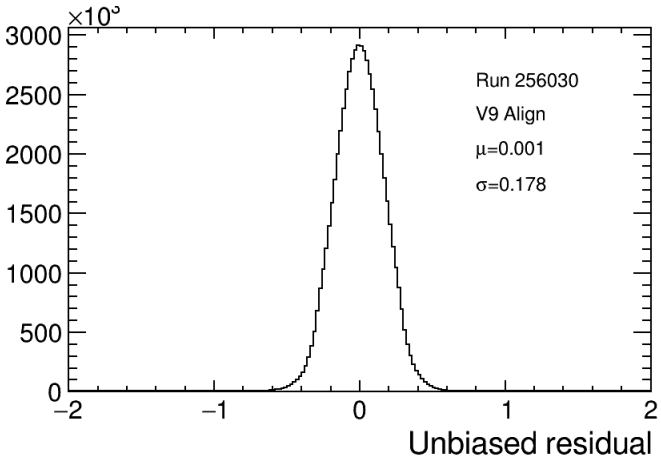
Zehua & Sophie with SciFi software group

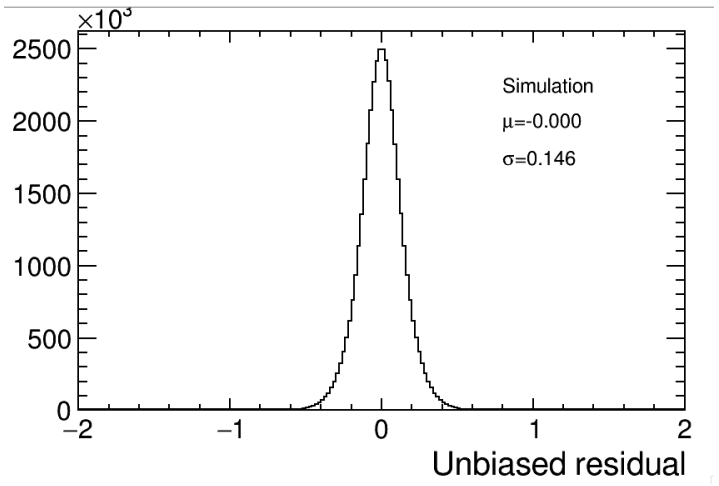
RTA WP4

April 13, 2023

Motivation

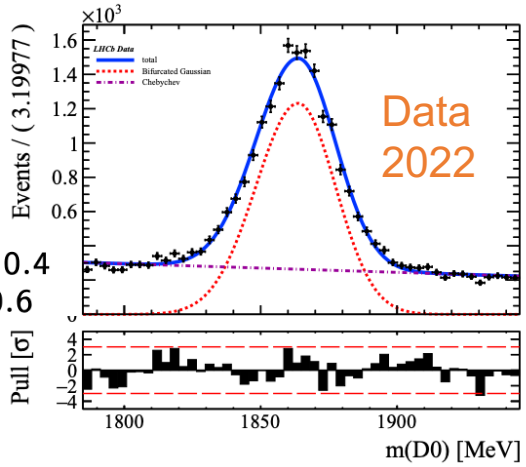
- RMS of hits residuals (SciFi) larger than expected value

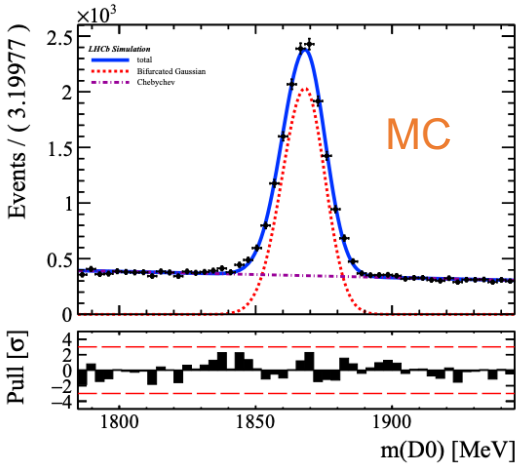




- Mass resolution worse than expected number

$\mu = 1863.7 \pm 0.4$
$\bar{\sigma} = 14.6 \pm 0.6$





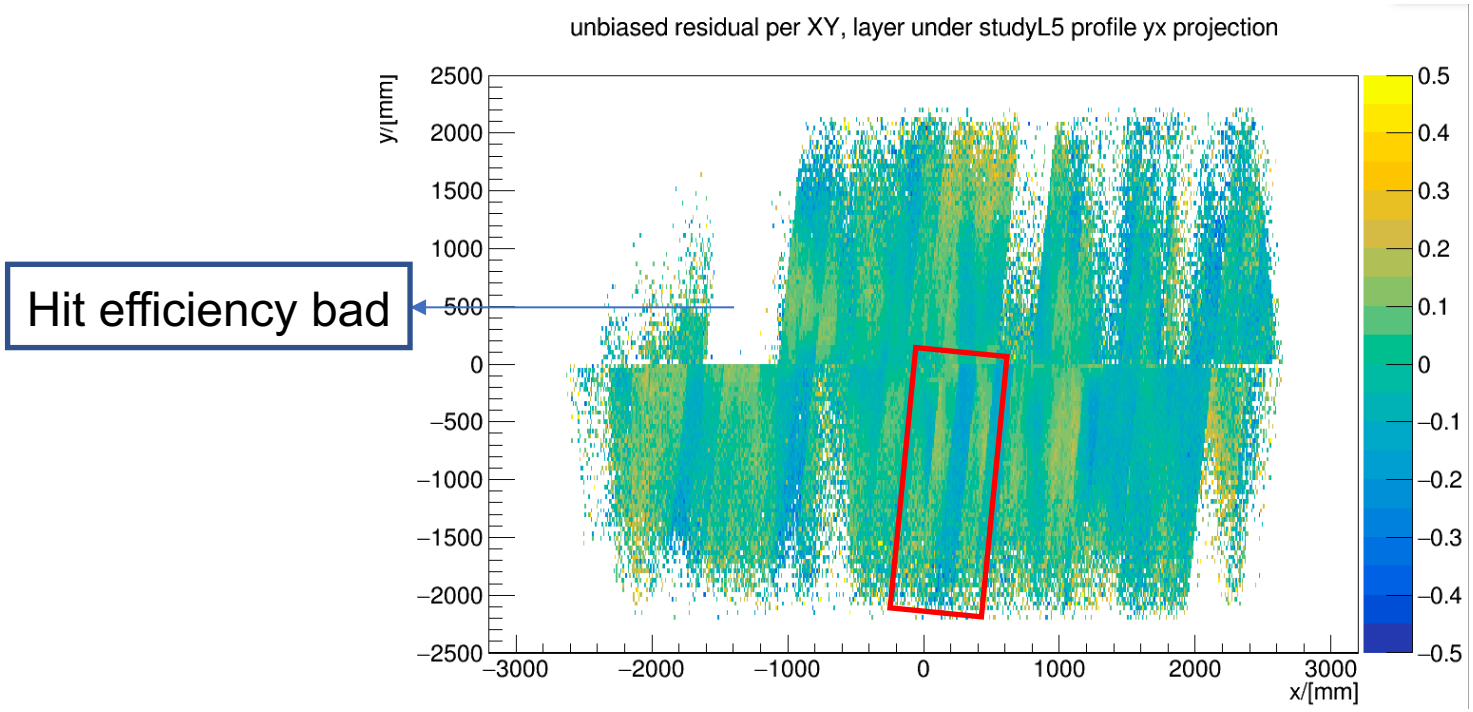
$\mu = 1868.1 \pm 0.2$
$\bar{\sigma} = 7.9 \pm 0.3$

Taken from Aodhan's talk

What leads to large hit resolution?

- Possible reasons:
  - SciFi scintillator mat quality not good enough?
  - Further improvement from software alignment?

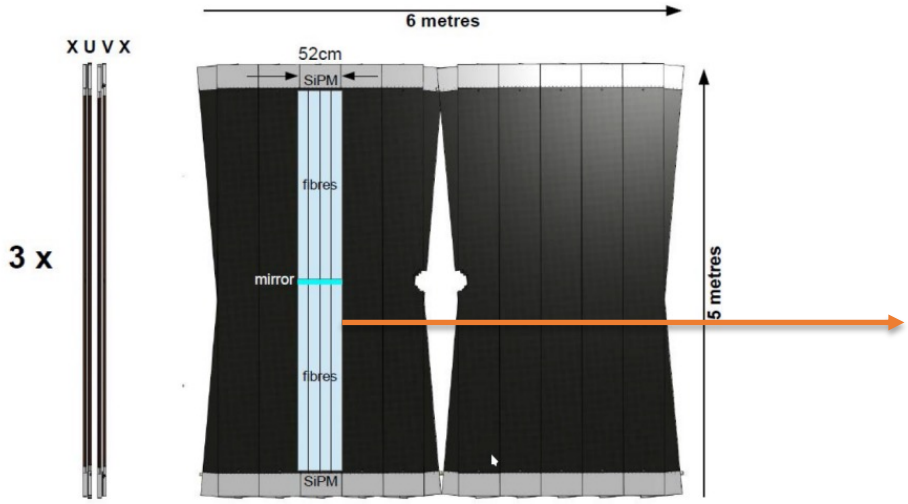
- New function to monitor SciFi residuals per layer in XY (MR 3371)



- Mat residuals not consistent within one module
  - ➔ finer alignment per Mat

Proposal of mat alignment

- One long module contents 8 mats



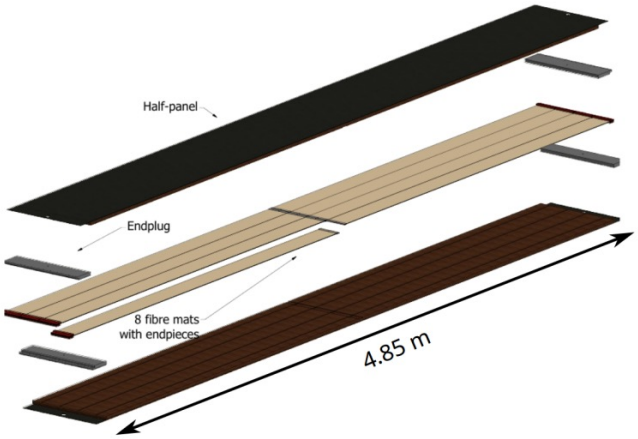
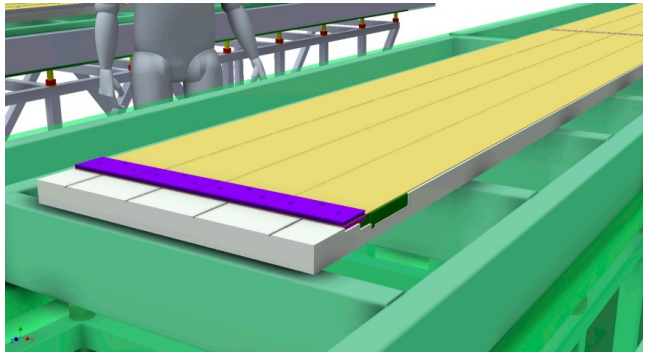


Figure 6: A schematic of a SciFi module.

- 8 fiber mats are glued and aligned together with during the module assembly
- The misalignment among mats comes from scintillator elements assembly rather than mat itself; does not mean poor performance of SciFi

First check for alignment with mat

- Alignment with DD4hep



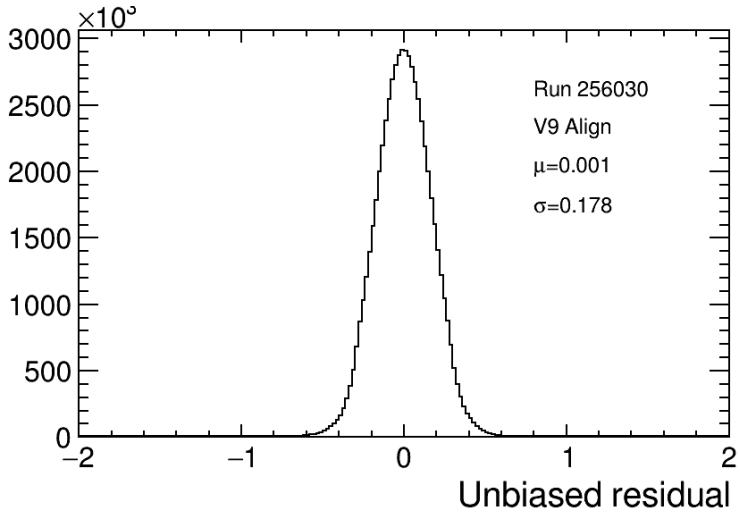
- SciFi local alignment process:
  - Sample: Run 256030
  - Start from tagged V9 alignment
  - Use Good Long tracks (50k events)
  - SciFi mat alignment ($T_x T_z$)
  - 20 Iterations
  - Converged since 11 iteration

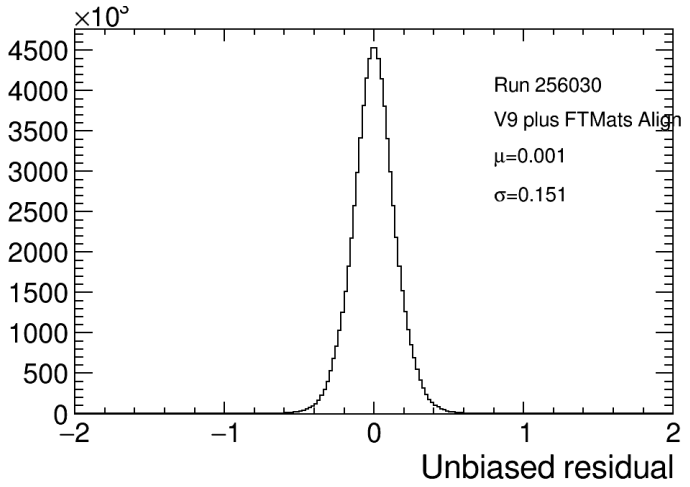
Good Long tracks :

```
from Configurables import TrackSelector
a.Selector = TrackSelector()
a.Selector.MinPCut = 5000
a.Selector.MaxPCut = 200000
a.Selector.MinPtCut = 200
a.Selector.MaxNTHoles = 1
a.Selector.TrackTypes = ["Long"]
if self._fitted:
    a.Selector.MaxChi2Cut = 5
    a.Selector.MaxChi2PerDoFMatch = 5
    a.Selector.MaxChi2PerDoFVelo = 5
    a.Selector.MaxChi2PerDoFDownstream = 5
```

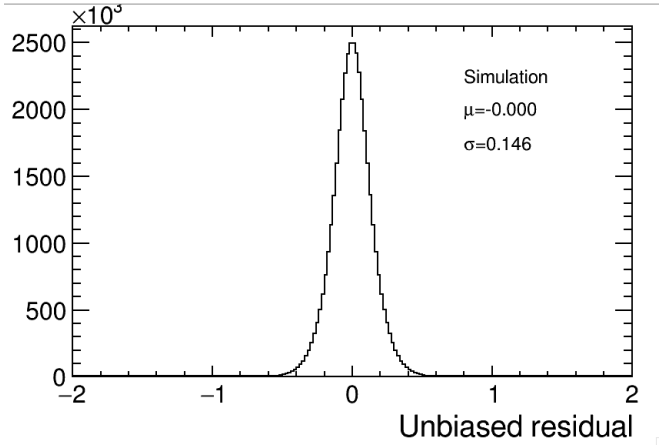
- Alignment result:
  AlignmentV9_2023_03_16_VPSciFiRich_plus_FTMats

Performance check - residuals

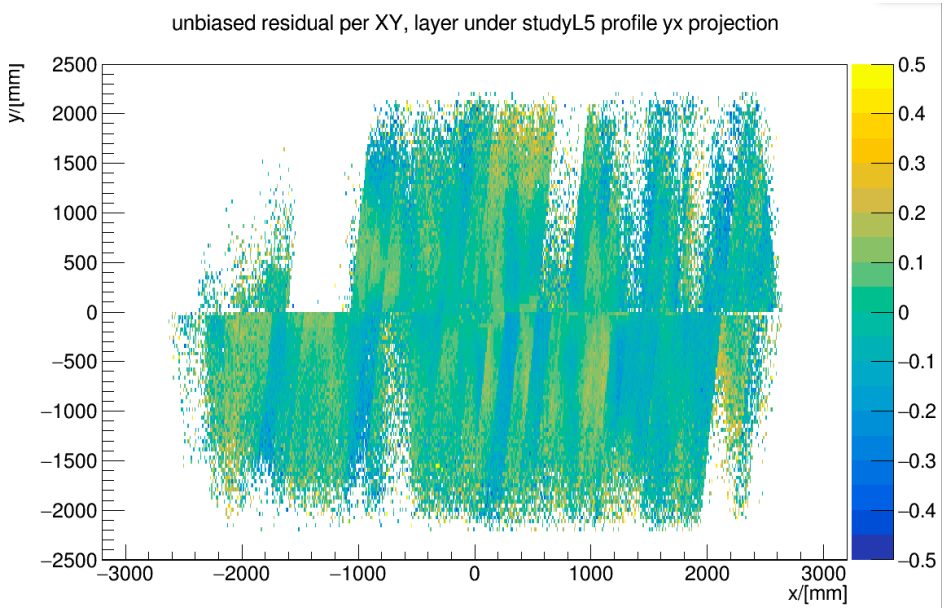




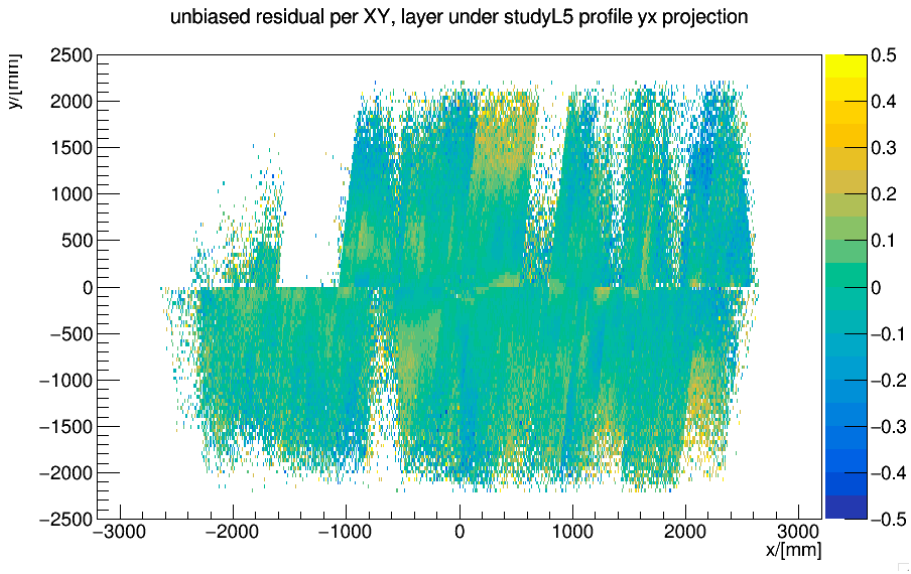
- SciFi position resolution (RMS of unbiased-residuals) improved a lot:
  0.178 ➔ 0.151
  Very close to the value from simulation (0.146)



Performance check - residuals



V9 alignment

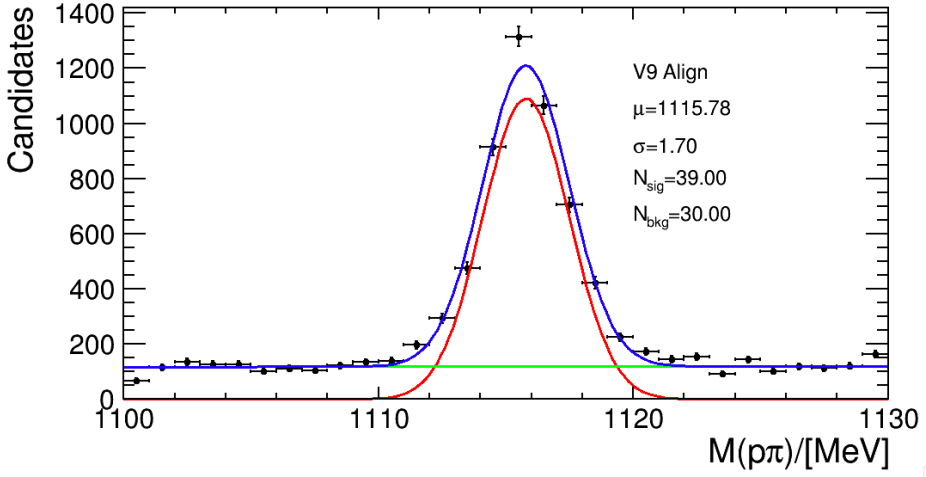


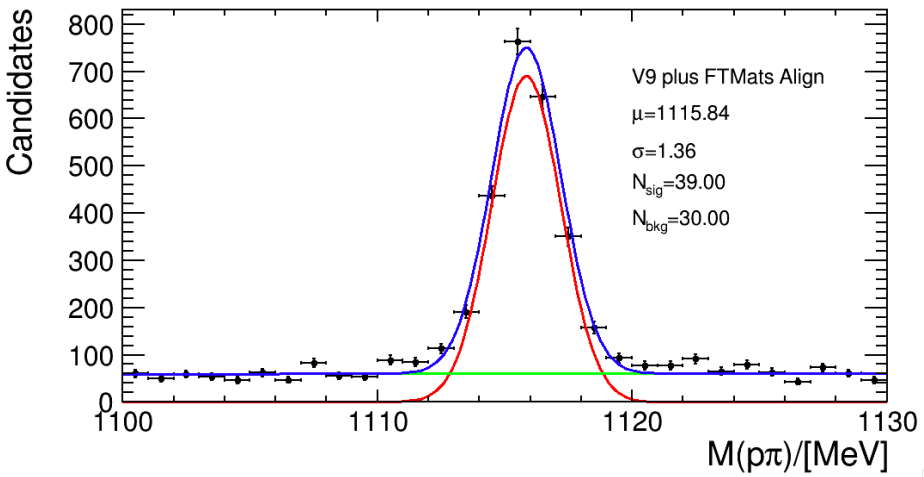
V9 + FTMat alignment

- No clear sign of Mat structure from the mean residual plot after FTMat alignment

Performance check

- Output of lambda_ll_line()

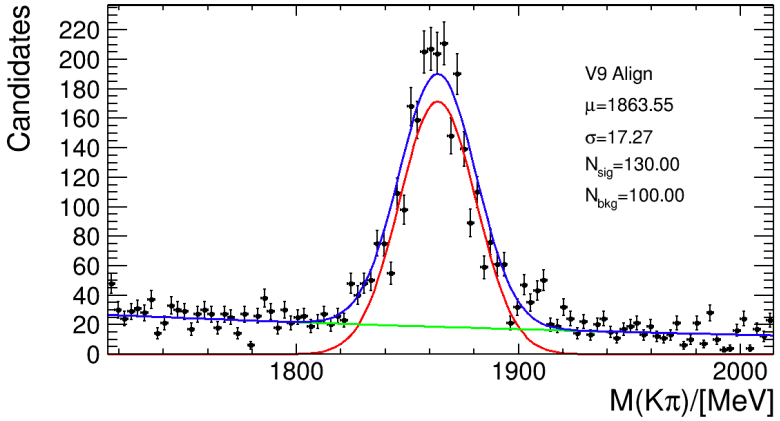


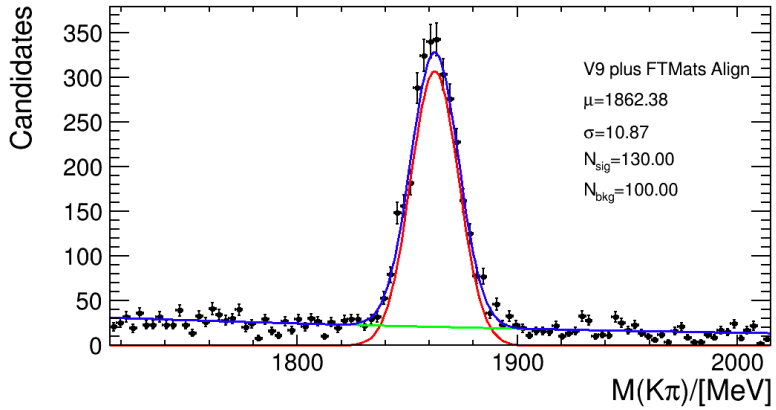


- Mass resolution of Λ^0 improved by around 20%

Performance check - D^0

Output of dzero2kpi_line()





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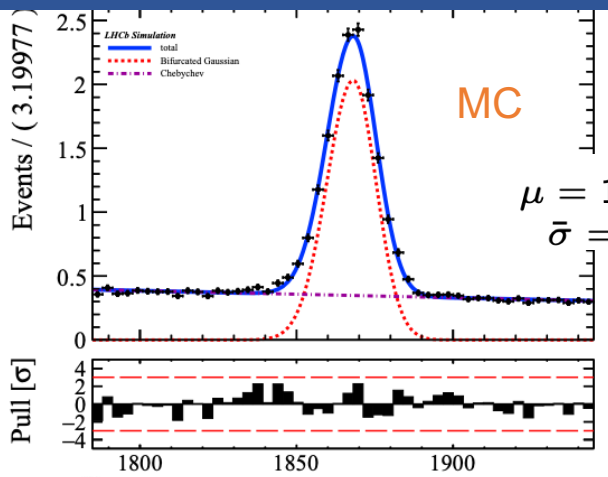

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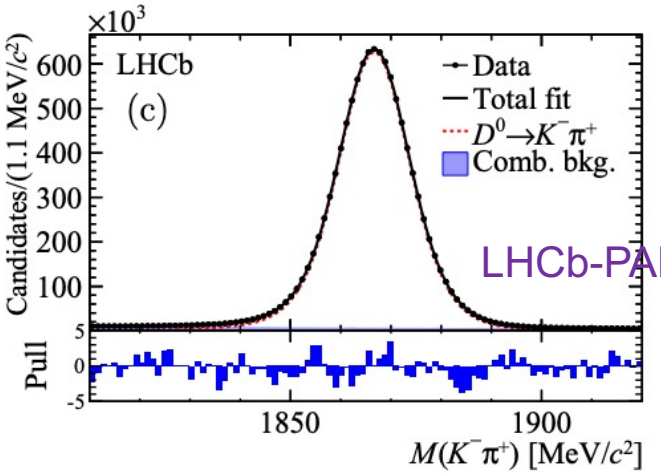

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- Mass resolution of D^0 improved around ~40%, 18 MeV➔11MeV
- There are still space to implement finer alignment, 8 MeV in MC
- D^0 mass resolution close to Run 1&2 analysis performance

Summary and plans

Summary:

- SciFi mat alignment can significantly improve hit position resolution, close to design goal
- Mass resolution of Λ^0, D^0 improved a lot with mat alignment, close to Run1&2 performance
- Offline mat alignment consume a lot of computing time

Plans:

- Maybe further improvement is possible with other degrees of freedom (more tests needed)
- Mat alignment an important piece of the 2022 data quality puzzle. We want to avoid to give an impression that SciFi resolution is not good.
- Existing Goal: re-run HLT2 with improved SciFi alignment for 2022 samples to correct curvature/low efficiency issues. New goal: also run a mat alignment after curvature/efficiency fixes finished.
- 2023 physics goal: halflayer alignment online, module alignment possibly online, mat alignment performed offline.
- Residuals XY plane monitor online or offline

Backup