Optimizing Secondary Vertex Reconstruction: Latest SpdRoot source code Updates and Performance Tests for the Silicon Vertex Detector

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Introduction

- **Vertex detector** is responsible for precise determination of the primary interaction point and measurement of the secondary vertices from the decays of short-lived particles;
- On 2d stage SVD (DSSD or MAPS) is planned to be installed;
- D^0 decay length 123 μm => secondary vertex resolution ~50-80μm is required;
- Previous studies show that both MAPS & DSSD configuration satisfies that condition;

- Initial assumption:
  - SV coord. resolution depends on L_{max}:
    $L_{max} = \max(l_1, l_2, \dots l_N)$,
    where l_i — distance for the closest hit for i track;
  - For $D^0 \to \pi^+ K^-$ SV: value — angle between $\pi^+ K^-$ tracks;

SpdRoot source code updates

Currently, the code has been updated with the capability to retrieve the number of ITS hits in the barrel and endcaps separately.
https://git.jinr.ru/spd/spd-sw/spdroot/-/merge_requests/117

Instructions:

```
SpdTrackMC *track;
track = (SpdTrackMC*)fTracks→At(i);

track->GetNHitsItsB();
track->GetNHitsItsEC();
track->GetNHitsIts(); // still available
```

Test description

- Pythia 8 + SpdRoot (SpdD0Generator)
- Open-charm process, $D^0 \rightarrow \pi^+ K^-$ forced;
- Event vertex Z: Gaussian profile with σ_Z = 50 cm;
- Event vertex X, Y: Gaussian profile with $\sigma_{X,Y}$ = 0.1 cm;
- KFParticle to reconstruct secondary vertex (D^0);
- SpdMCTrackFinder settings:
  - Minimum number of ITS hits = 2 (SVD);
  - Minimum number of TS hits = 6;
- Resolution obtained from the distribution of (Reco — MC True) secondary vertex positions
- Each normalized distribution is fitted with 3 gaussians;
- σ is weighted average of σ_1 and σ_2;

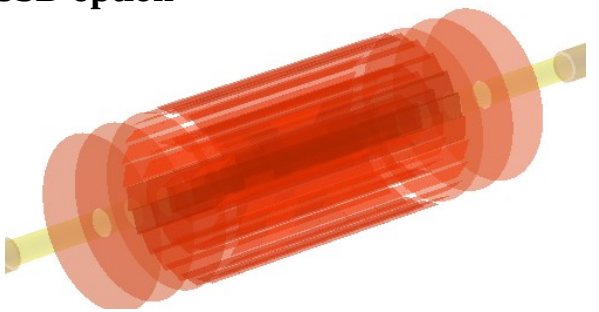
SpdD0Generator was developed by Amaresh Datta:

- D^0 partical gun with proper P_T distribution for pp collisions $\sqrt{s}$ = 27 GeV;
- The PDF is presented as a two-dimensional histogram (p — θ);
- Hit-and-miss method is used;

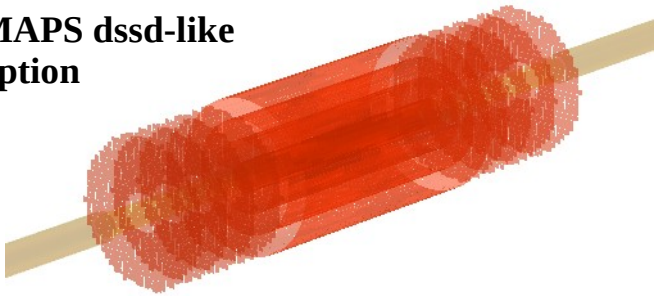
Detector setup:

- Aluminium pipe — for stage1 VD;
- Berrylium pipe — for stage2 VD;
- Magnetic field;
- Vertex detector + Straw tracker;

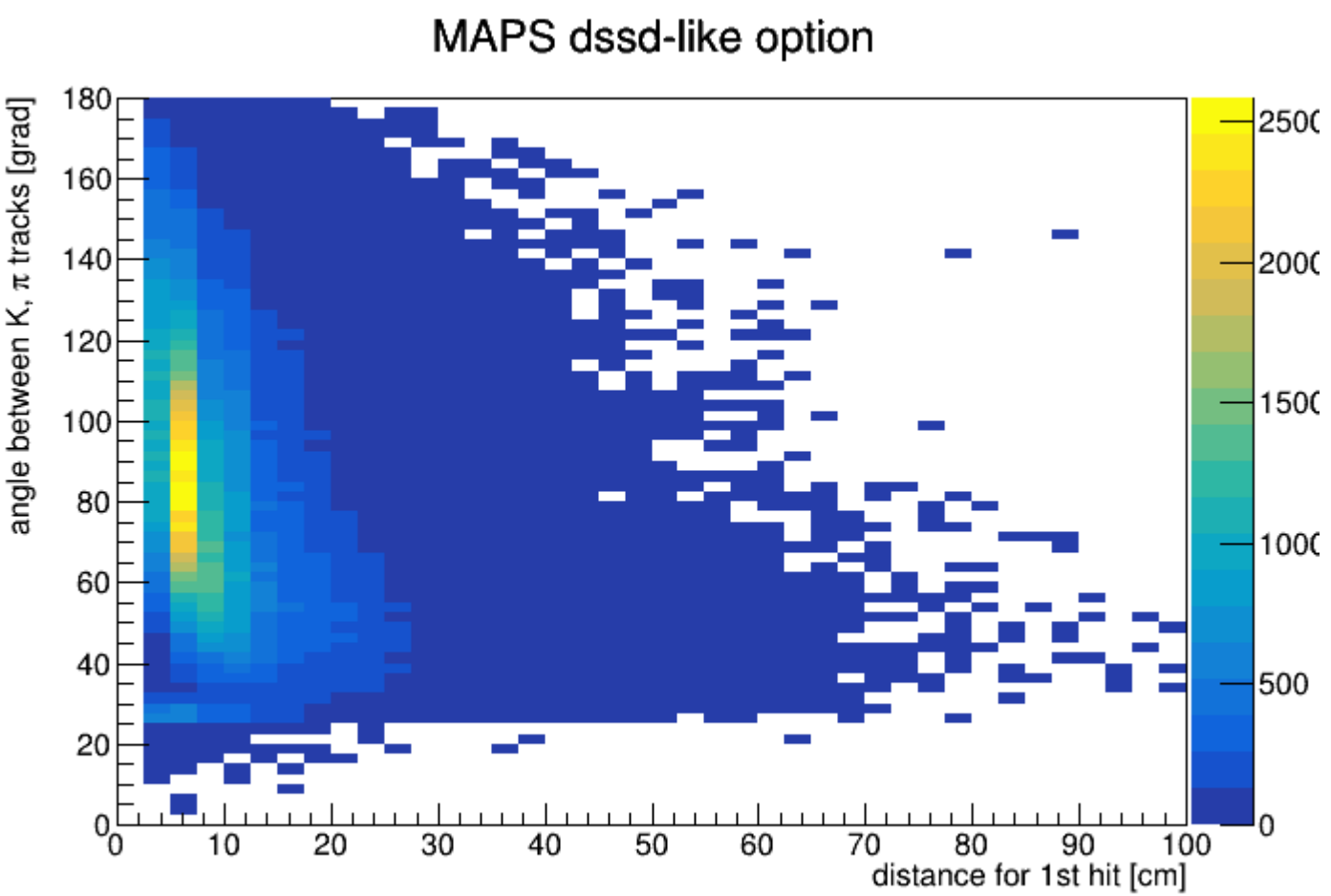
DSSD option

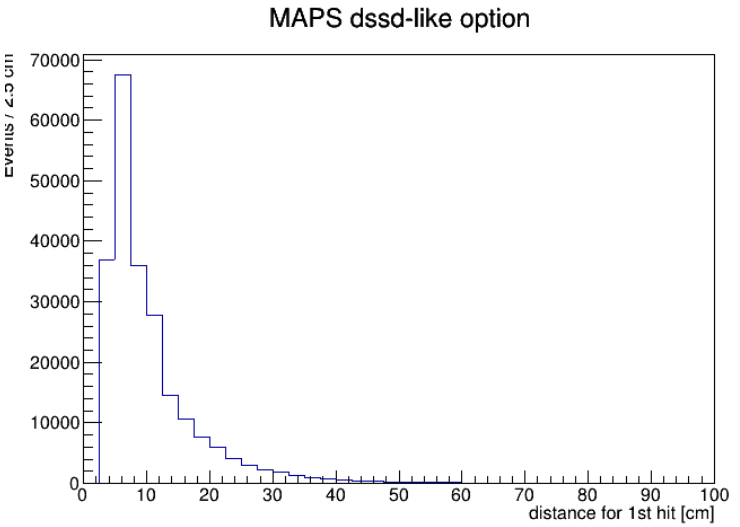


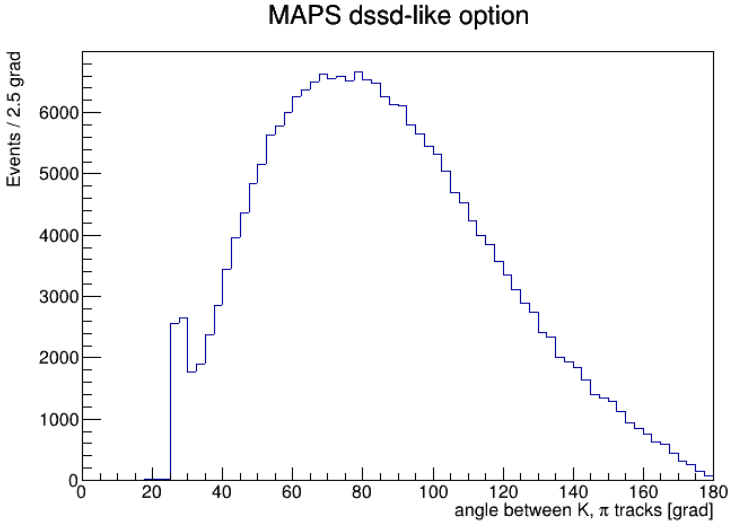
MAPS dssd-like option



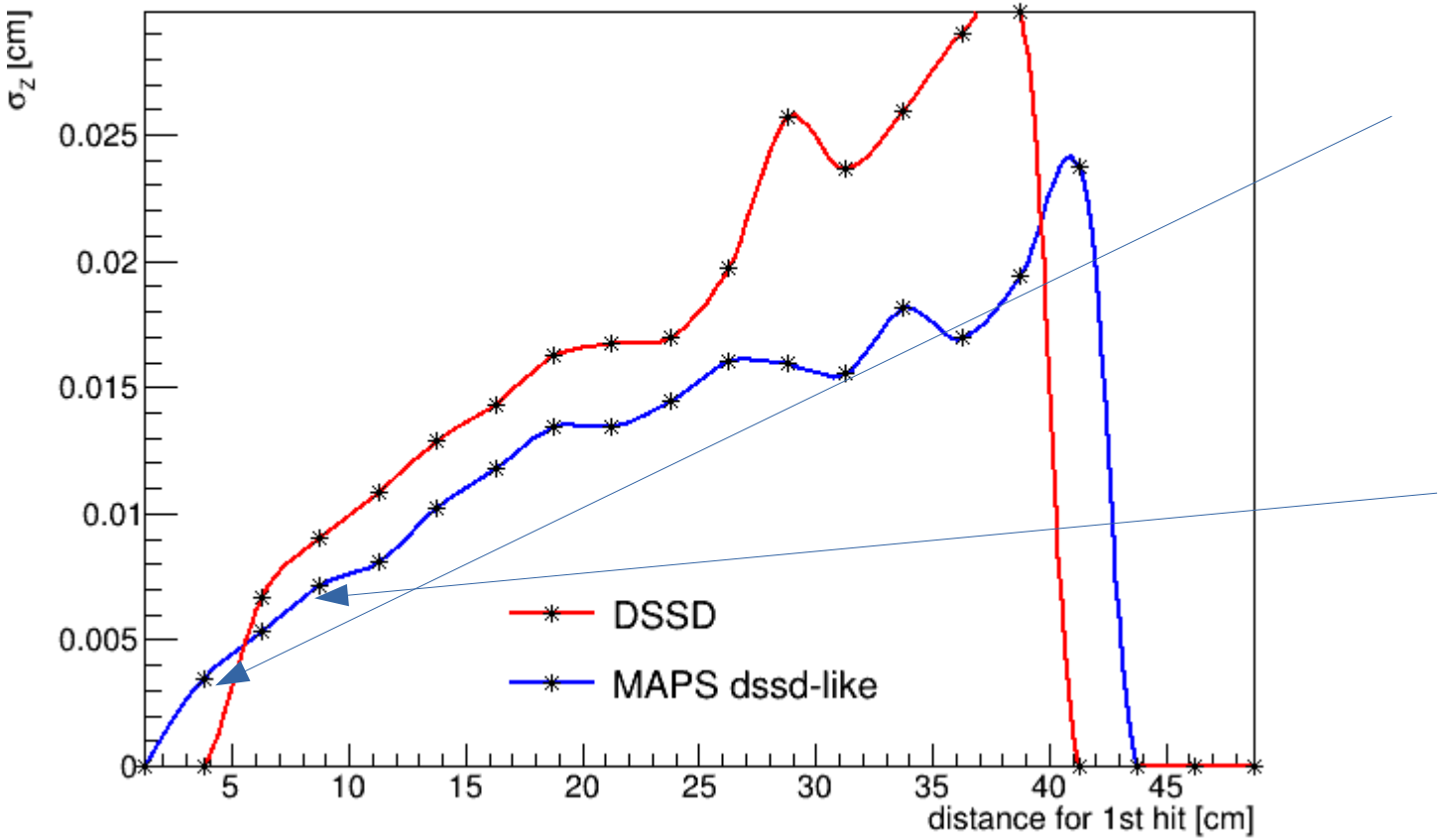
Distribution of observables for selection

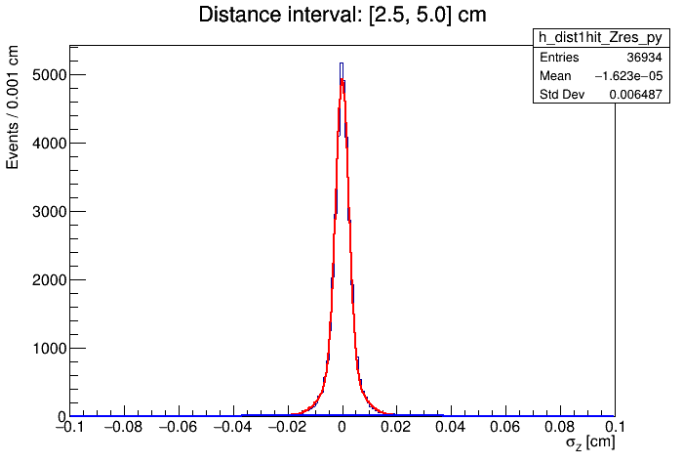


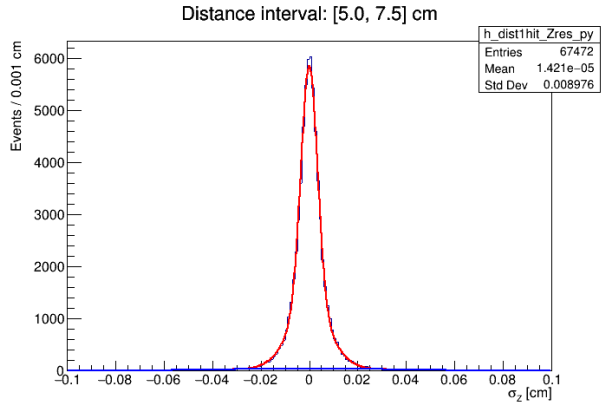




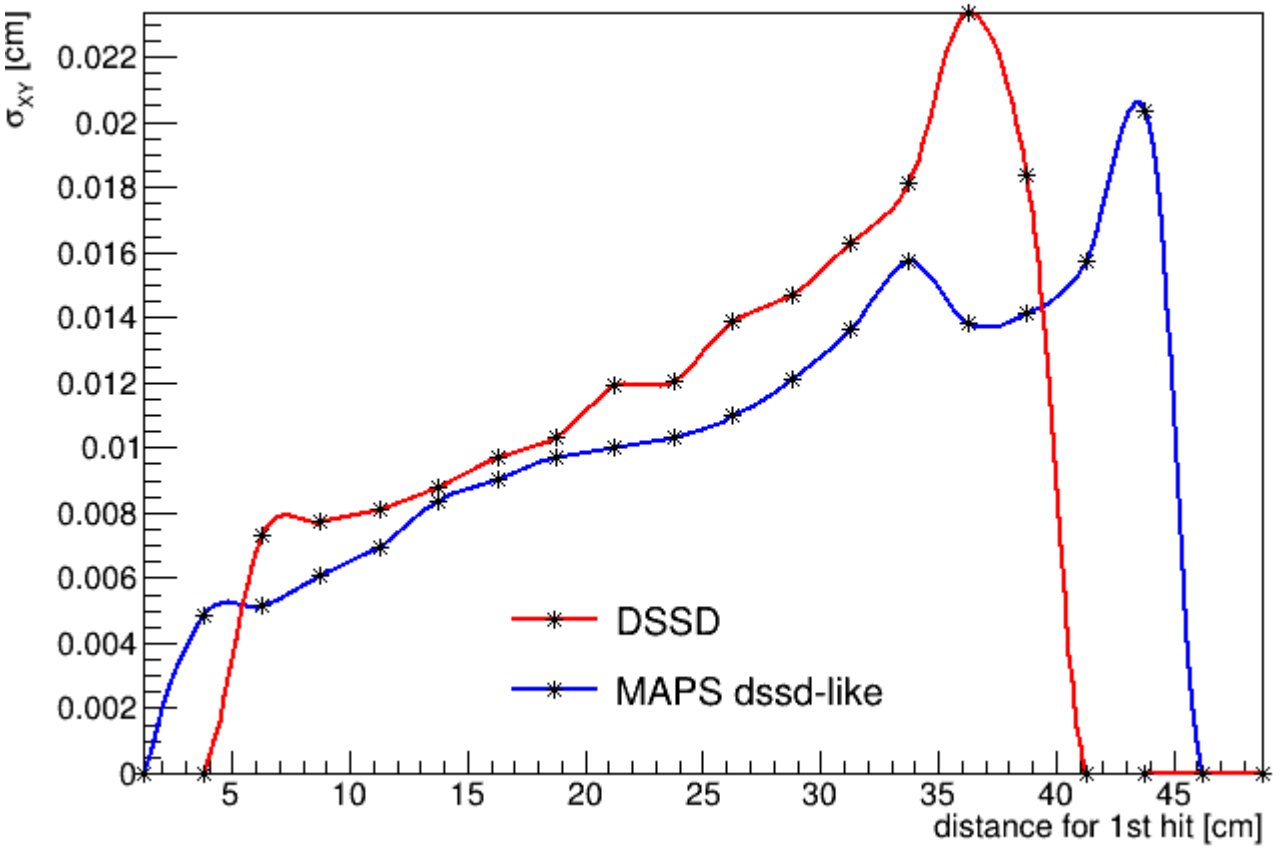
SV Z-coord. res. (dist. to the 1st hit)



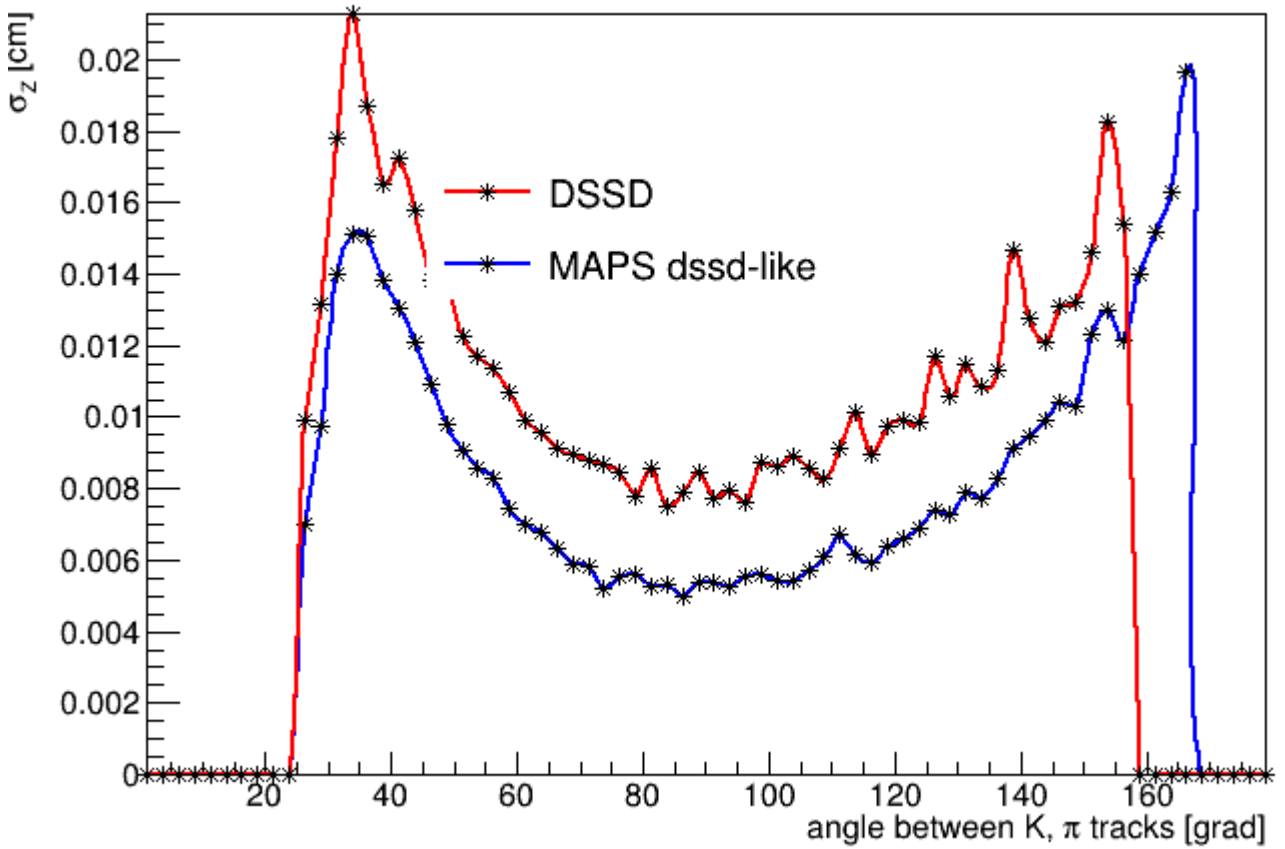




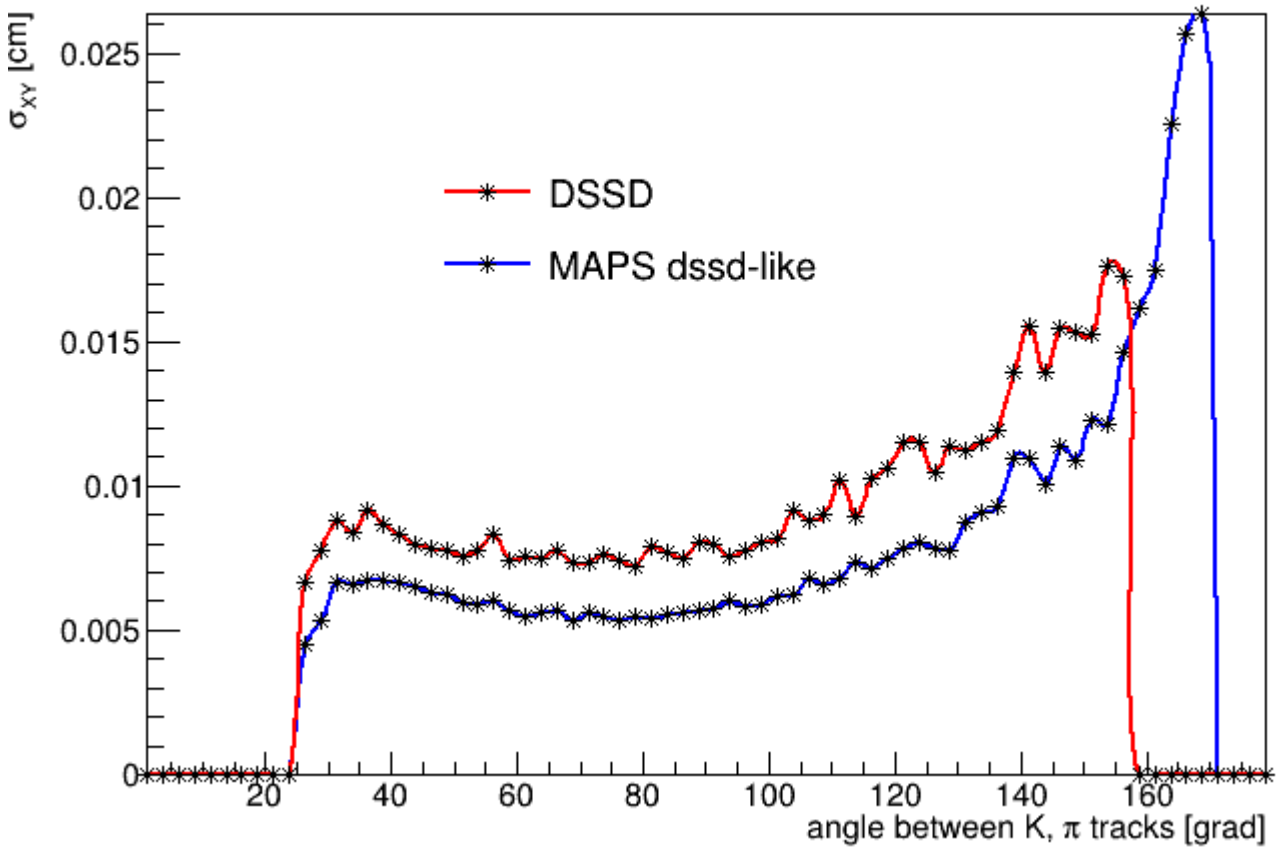
Test results: SV XY-coord. res. (dist. to the 1st hit)



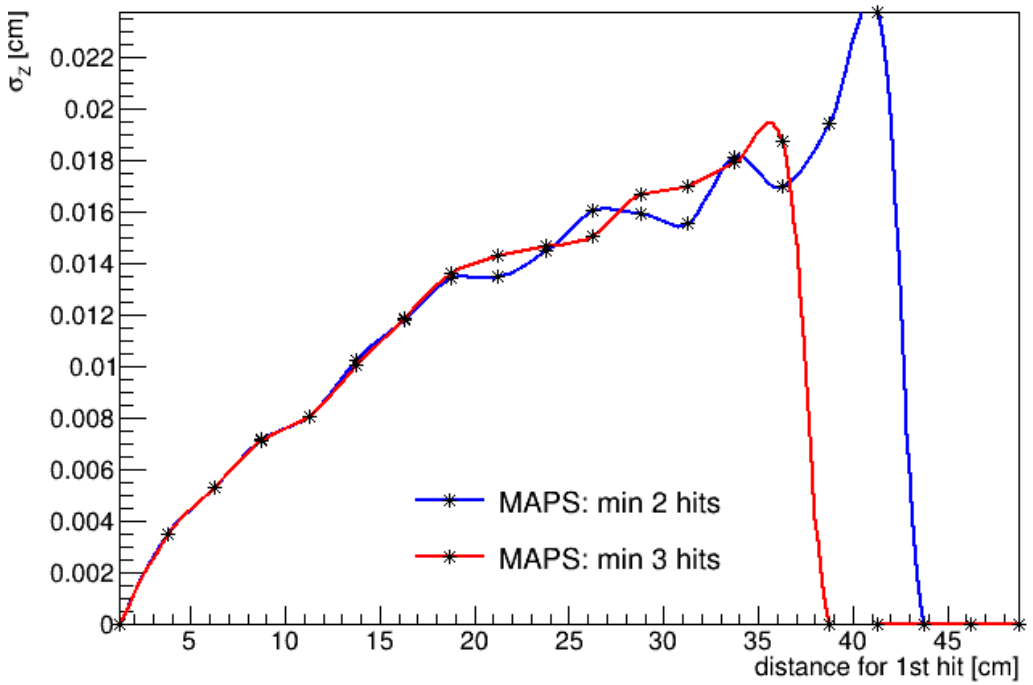
Test results: SV Z-coord. res. (angle between K, π tracks)

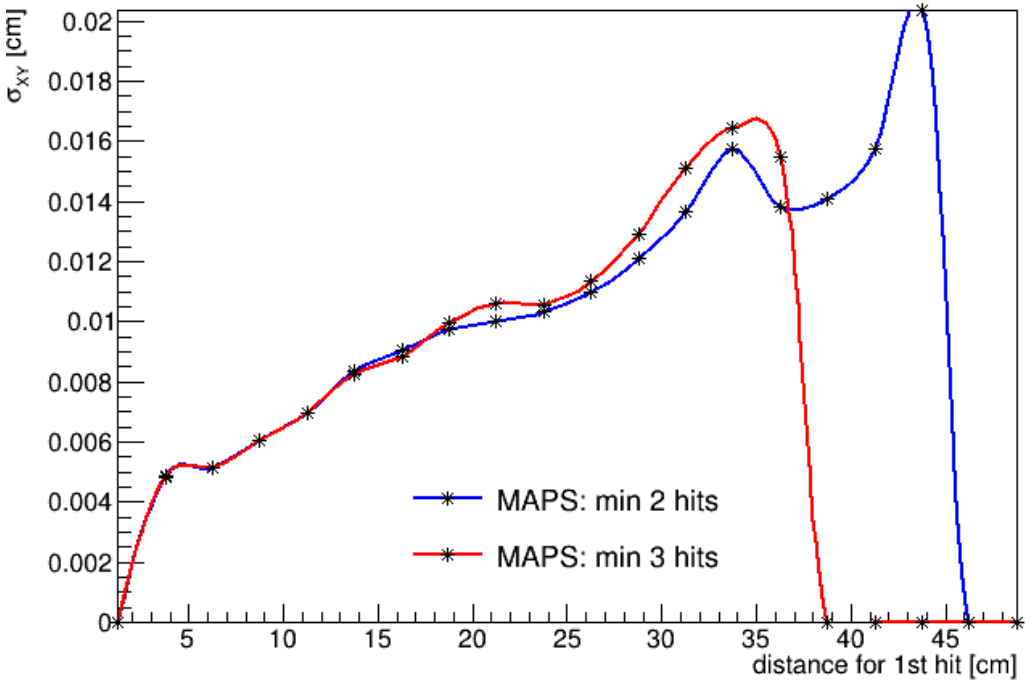


Test results: SV XY-coord. res. (angle between K, π tracks)

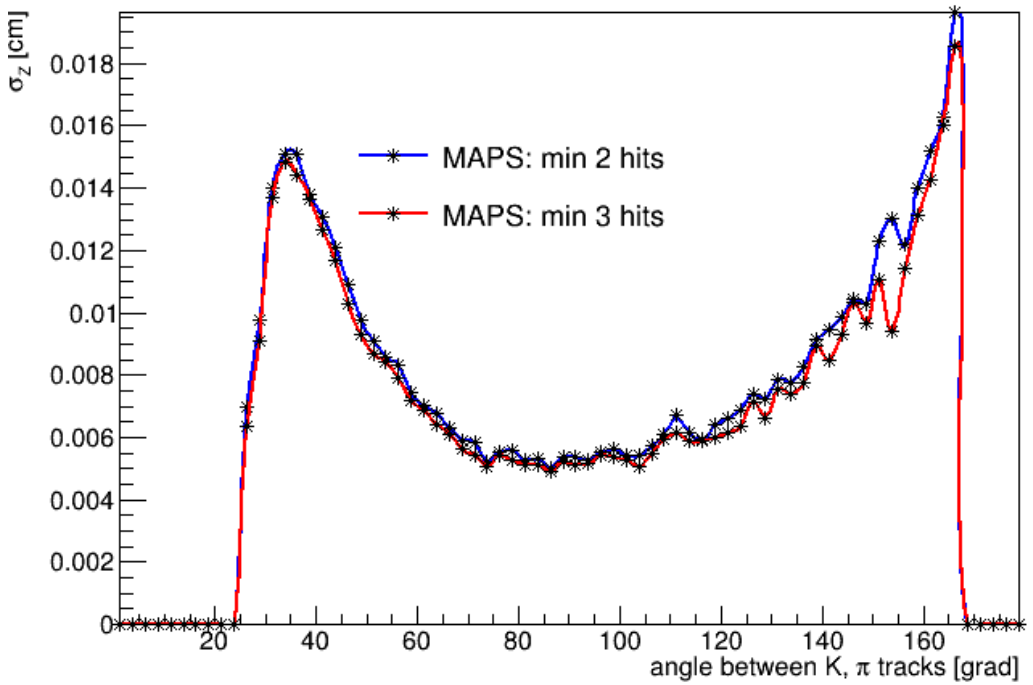


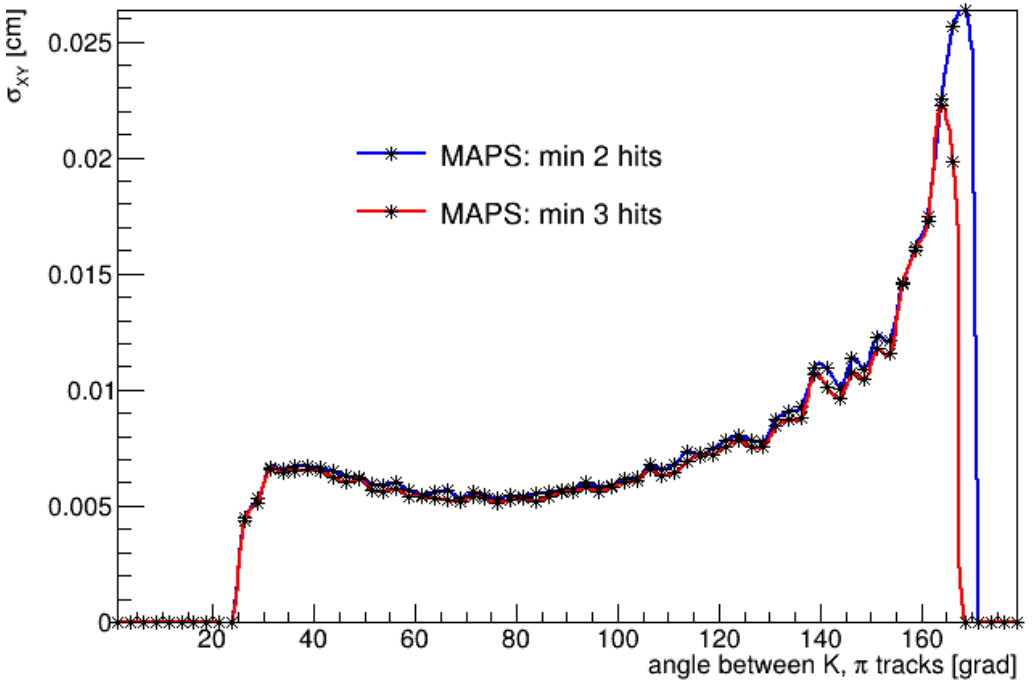
Test results: minimum 3 ITS hits | dist. to the 1st hit | MAPS





Test results: minimum 3 ITS hits | angle between K, π tracks





Conclusion

Summary:

- SpdRoot source code: the new code allows detailed analysis of ITS hits (barrel/endcaps separately);

- The dependence of the SV coord. resolution on:
  - maximal distance for the closest hit for SV tracks;
  - angle between π+K- tracks

  was tested;

- A requirement of 3 hits in the SVD detector changes the resolution only slightly;

- This observations can be used to optimize SVD geometry;

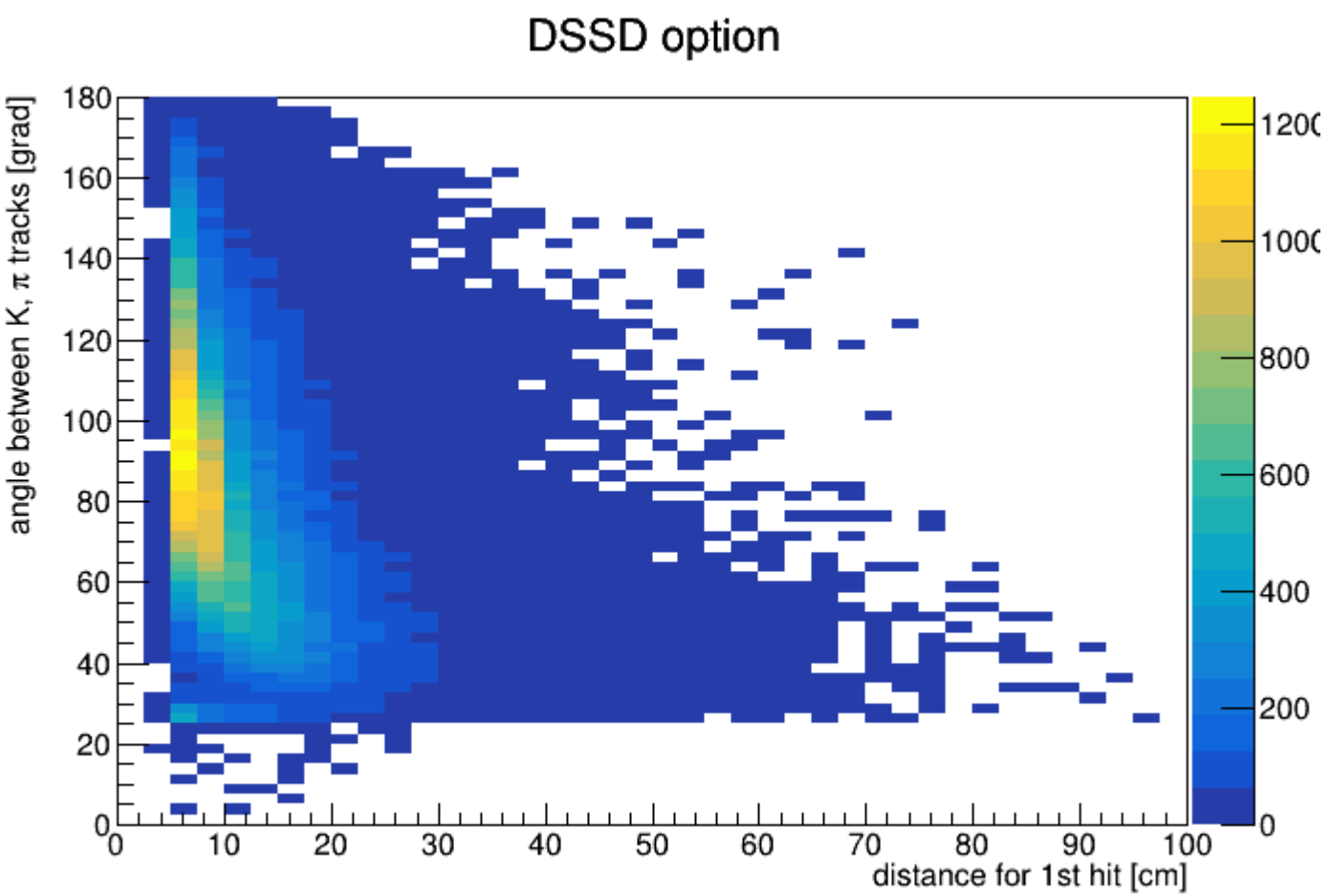
Plans:

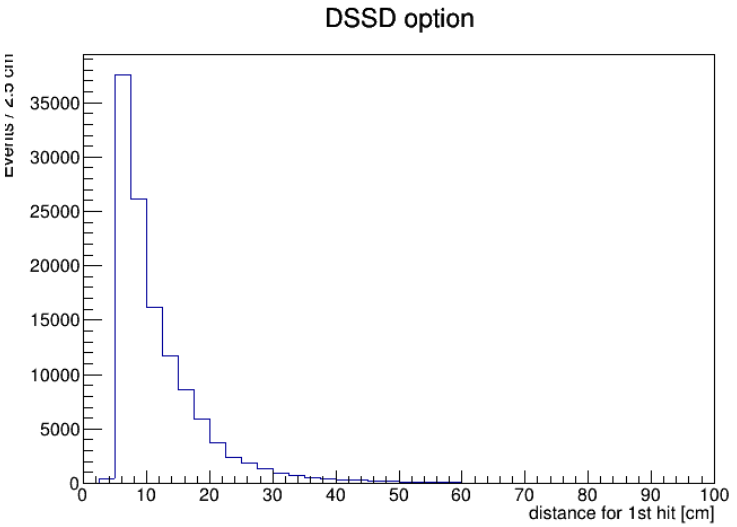
- Perform the same analysis across different X_F bins;

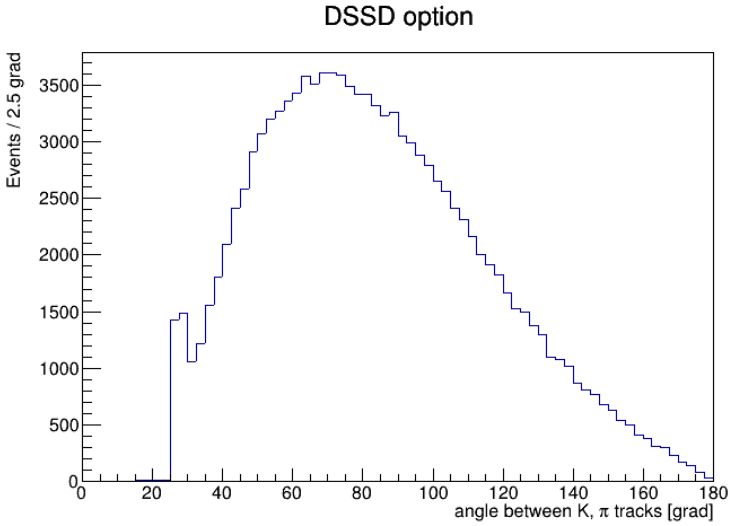
- Formalize geometry optimization proposals based on these results;

Thank you for your attention!

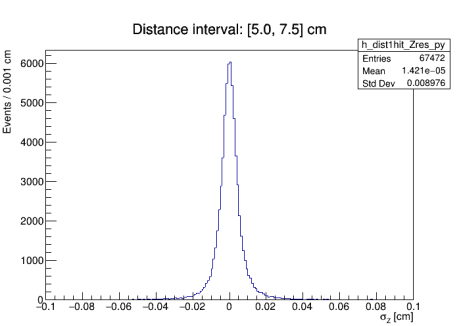
Ap. 1 | Distribution of observables for selection | DSSD

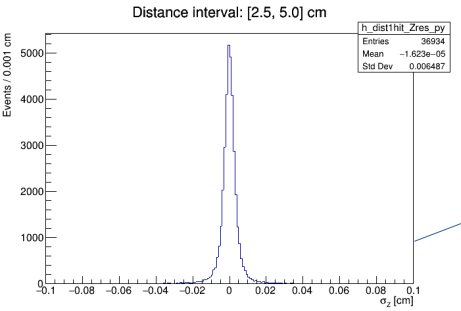


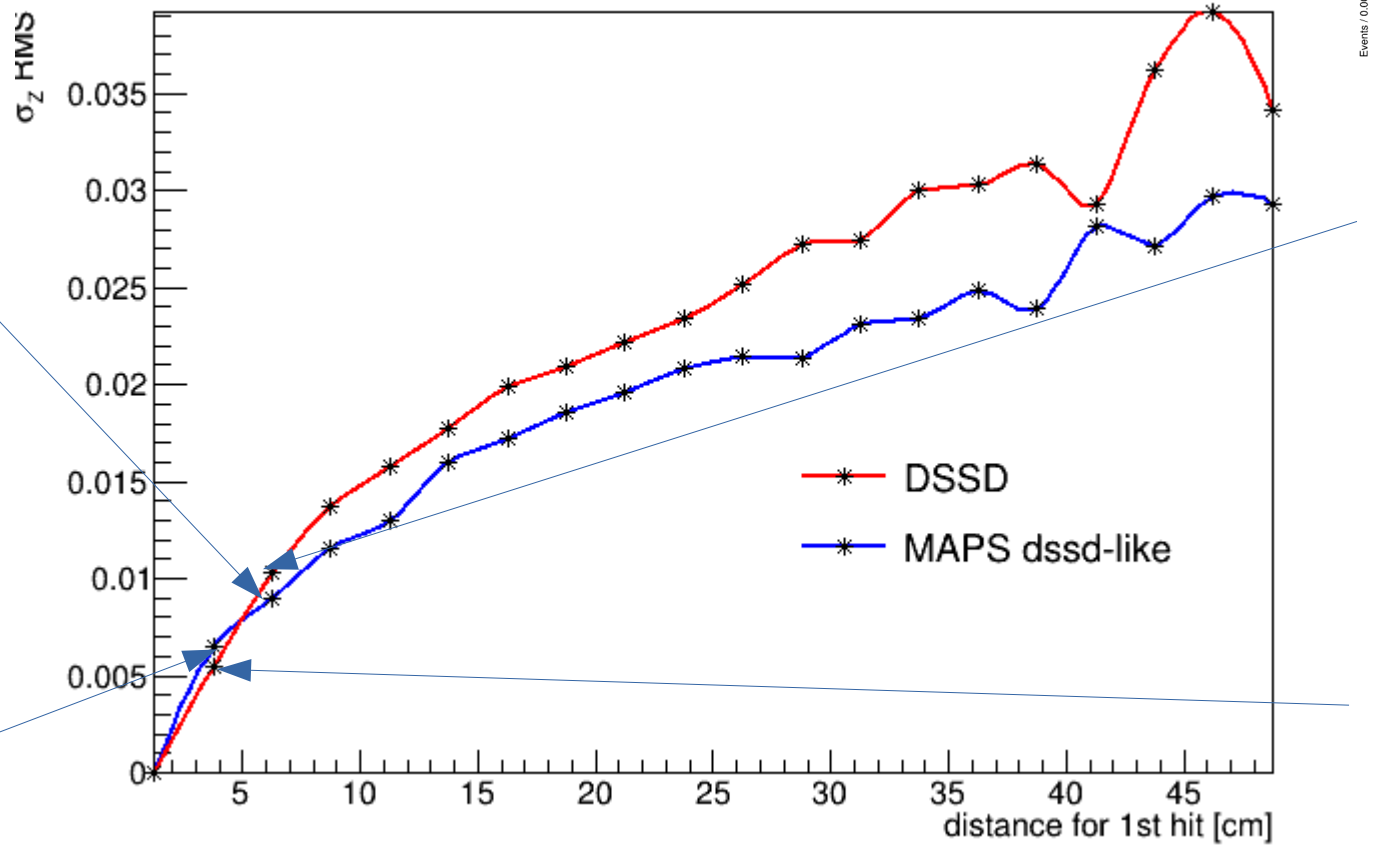


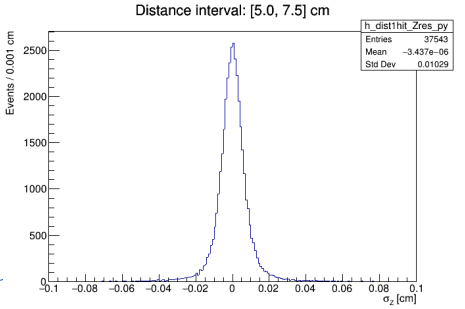


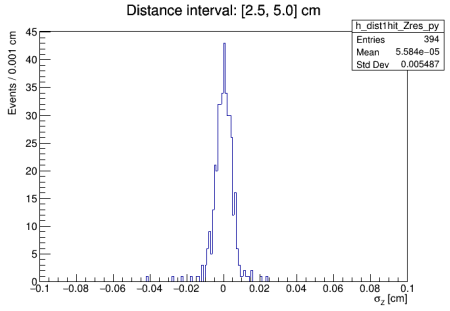
Ap. 2 | Test results: SV Z-coord. res. (dist. to the 1st hit) | RMS



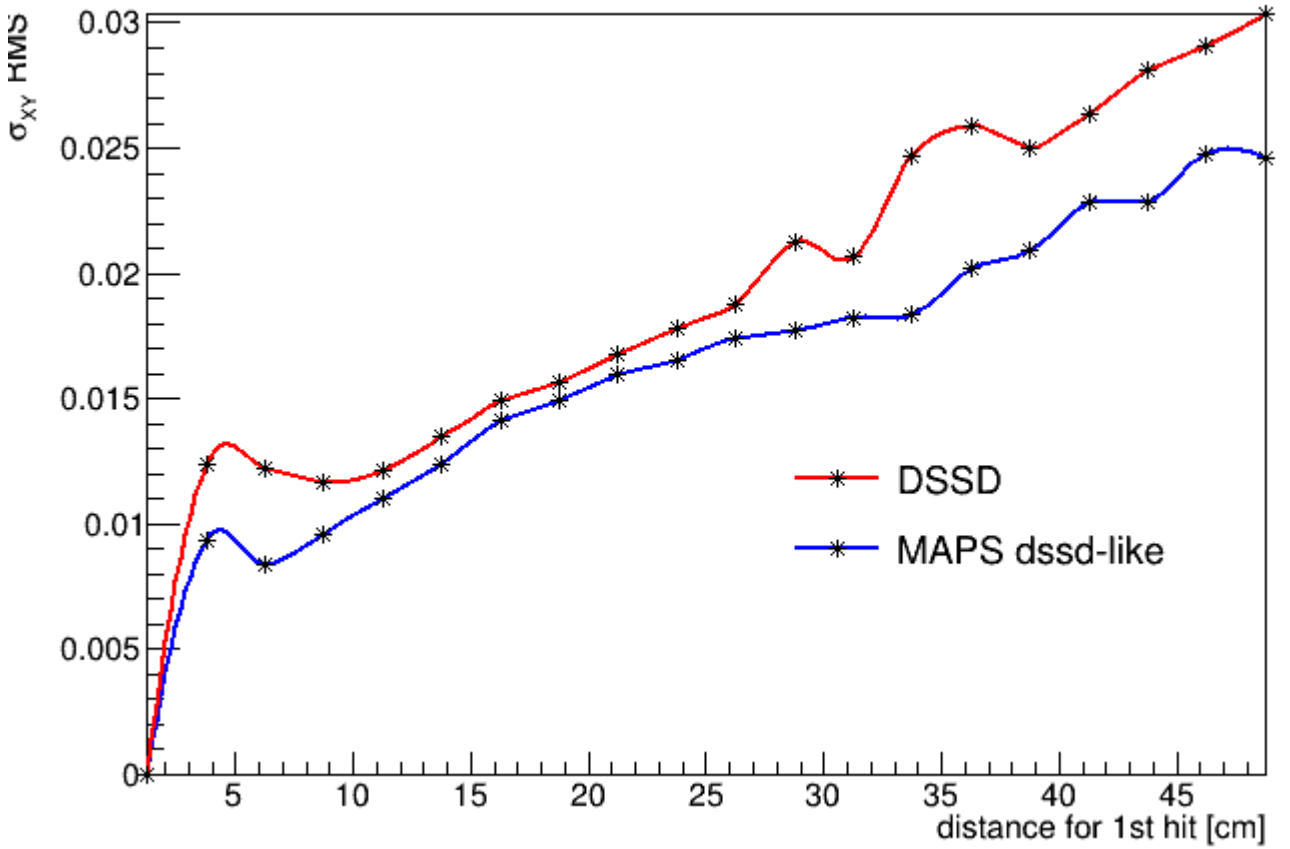




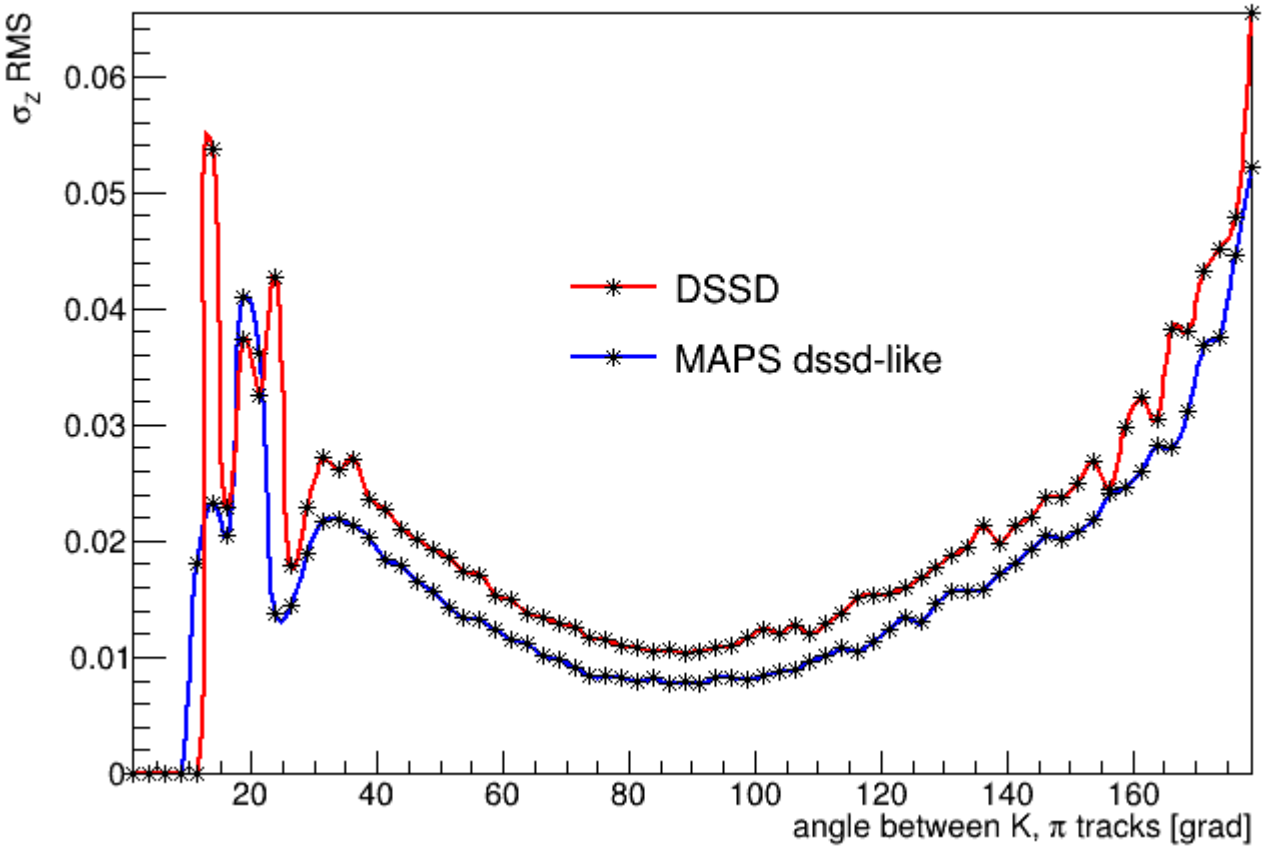




Ap. 2 | Test results: SV XY-coord. res. (dist. to the 1st hit) | RMS



Ap. 2 | Test results: SV Z-coord. res. (angle K, π) | RMS



Ap. 2 | Test results: SV XY-coord. res. (angle K, π) |RMS