On muon identification in SPD RS

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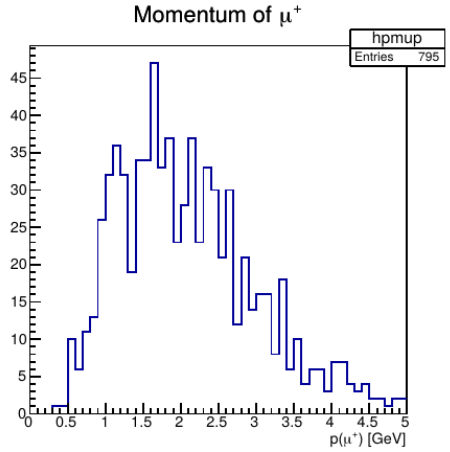
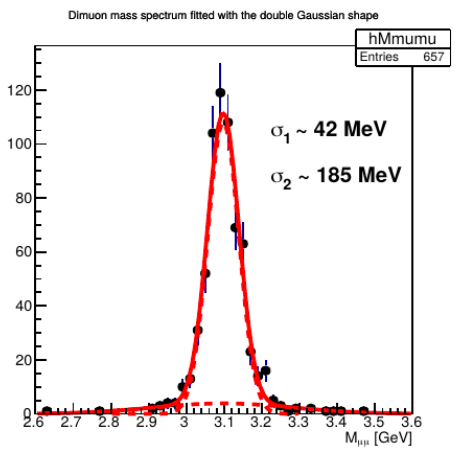
Motivation of this talk

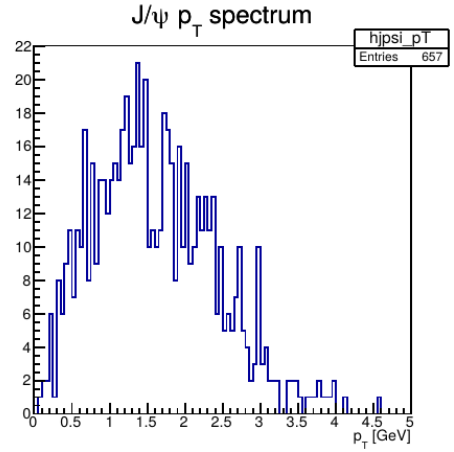
- Artur has updated SpdRoot: “MC-clusters” are included (see the “artur-dev” branch).
- How different are muon and pion signals?
- What can be achieved using GenFit as a tool to identify muon tracks.
- What are the optimal algorithms for muon identification?

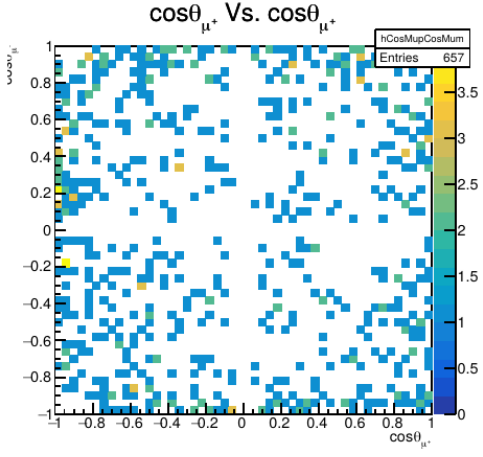
$J/\psi \rightarrow \mu^+\mu^-$

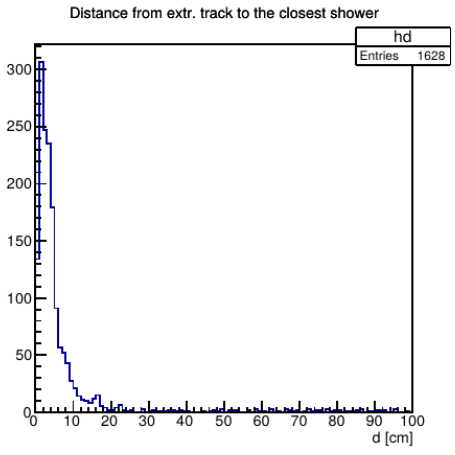
- Example: jpsi-mumu
- Magnetic field: 1T
- 1K event generated

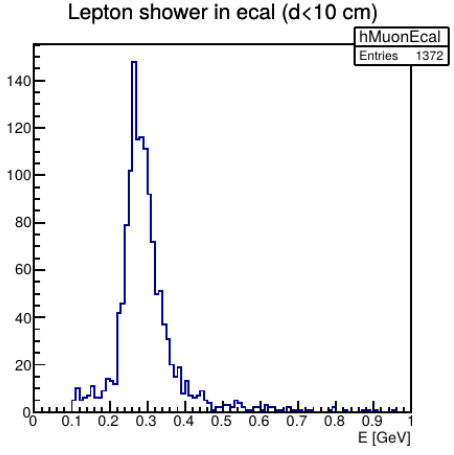




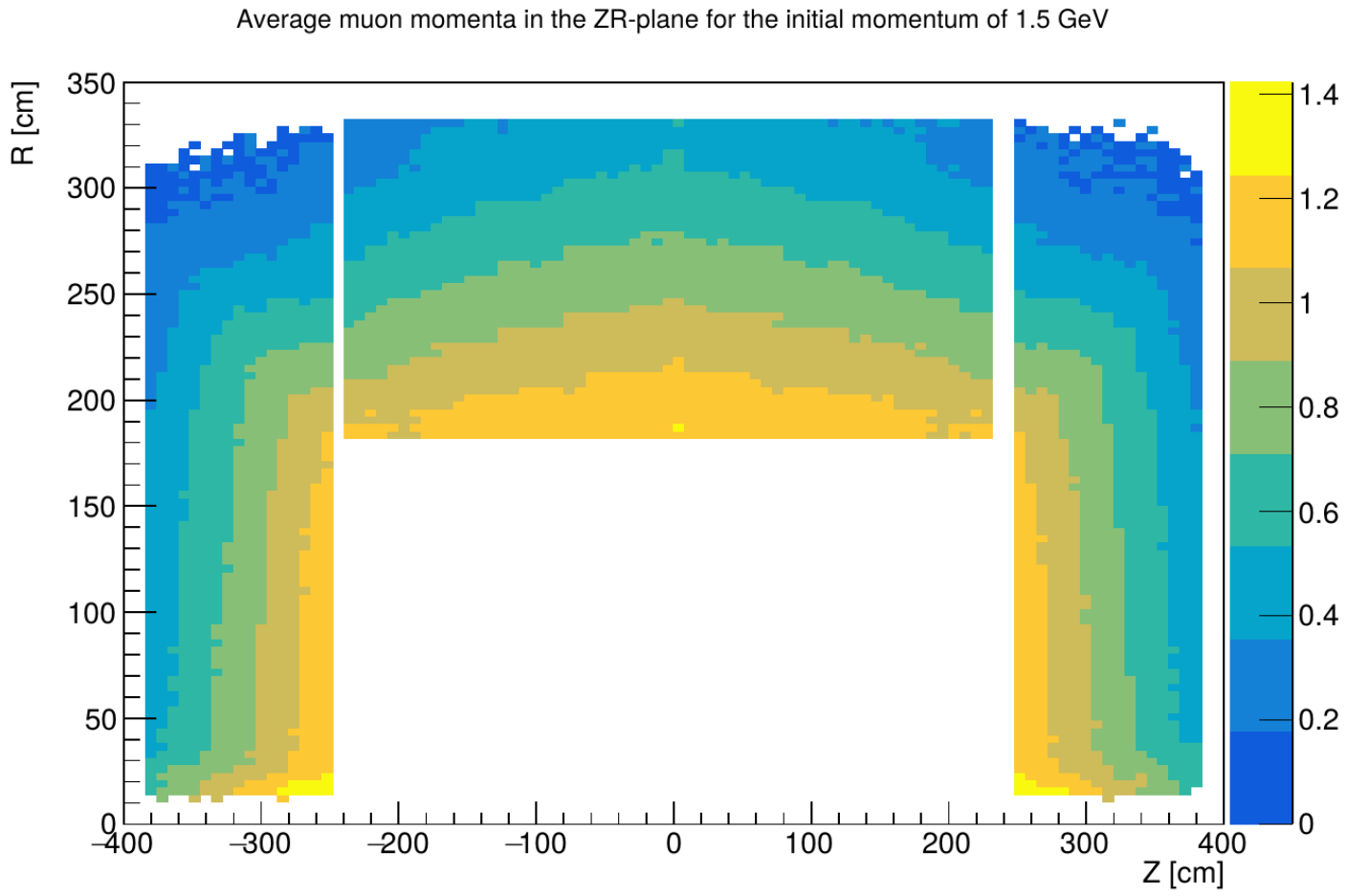








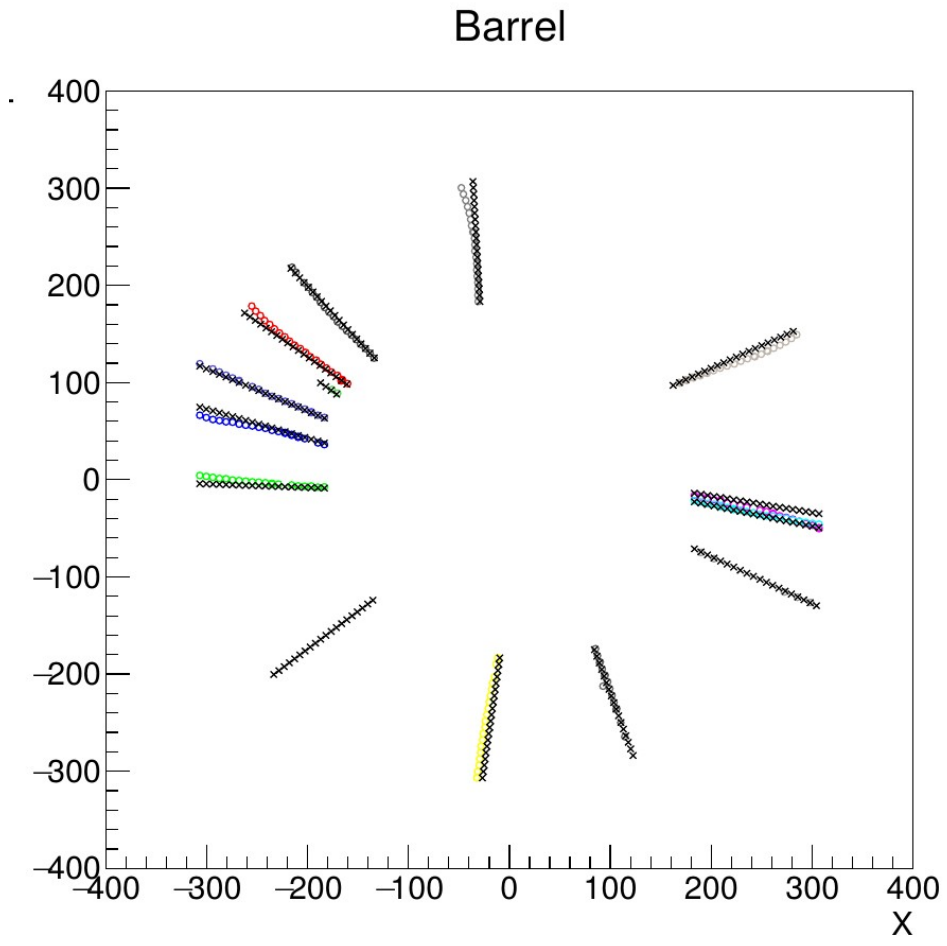
Muon energy loss in RS



μ^+/π^+ @ 1.5 GeV

μ^+ @ 1.5 GeV

- 20 particles per track, only the barrel part of RS is shown.
- Hits are shown by circles, color indicated cluster.
- Crosses are result of the GF track extrapolation to RS **without** material effects.



μ^+ @ 1.5 GeV

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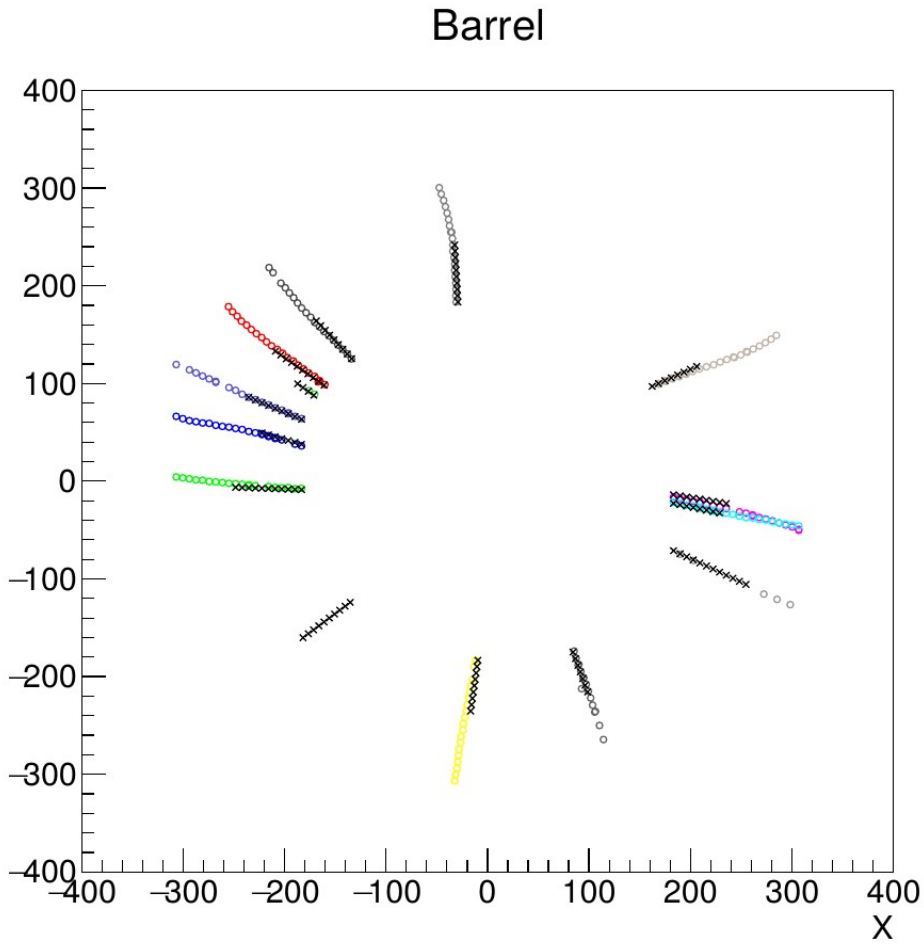
- GF was stopping tracks to early!



μ^+ @ 1.5 GeV

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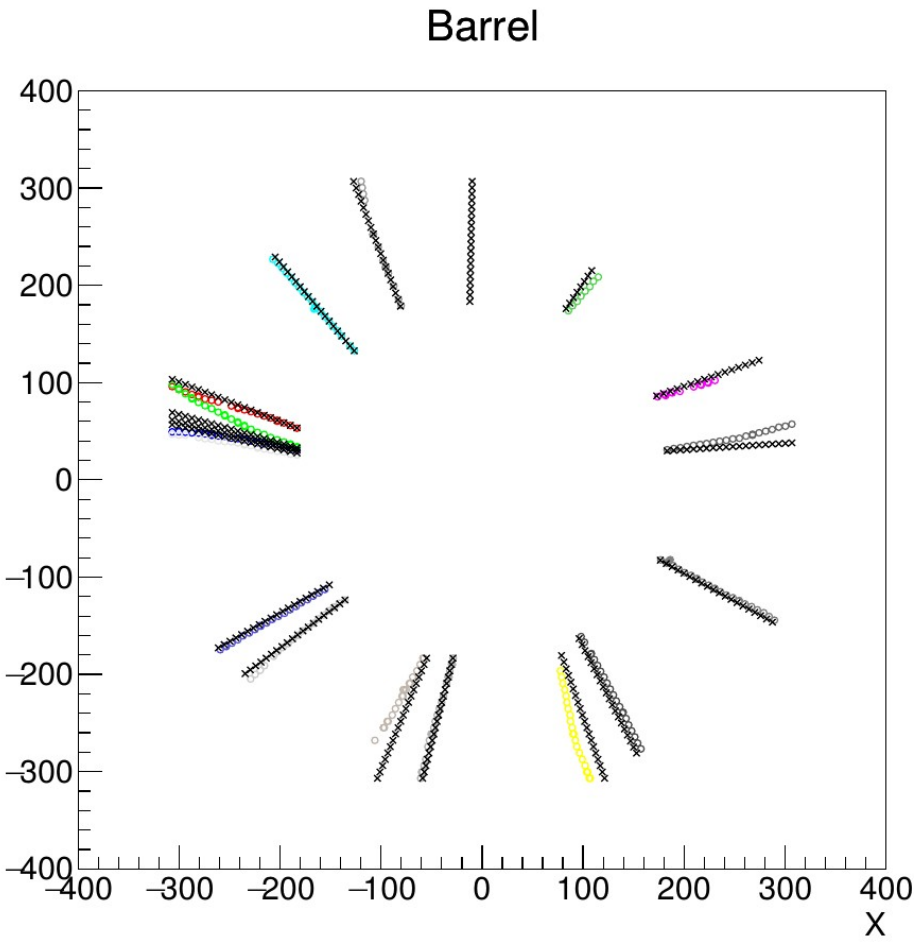
- Crosses are result of the GF track extrapolation to RS **with** material effects.
- GF was stopping tracks to early – fixed by Artur!



π^+ @ 1.5 GeV (event 1)

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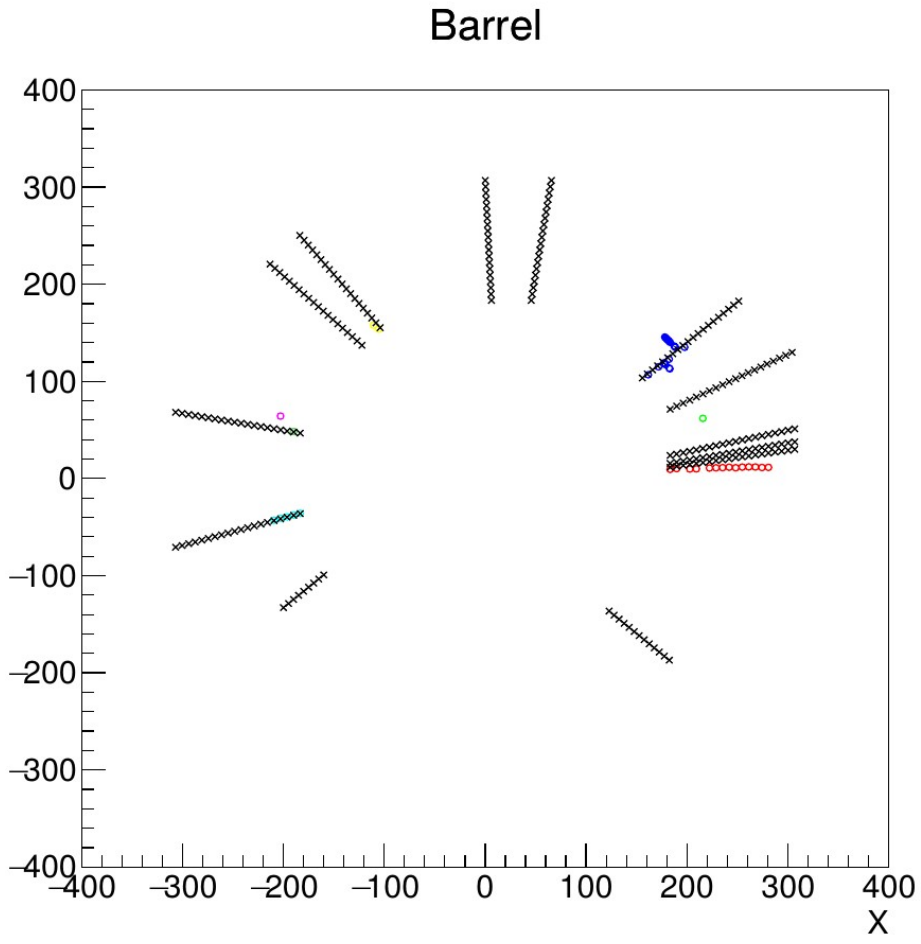

π^+ @ 1.5 GeV (event 2)

- 20 particles per track, only the barrel part of RS is shown.
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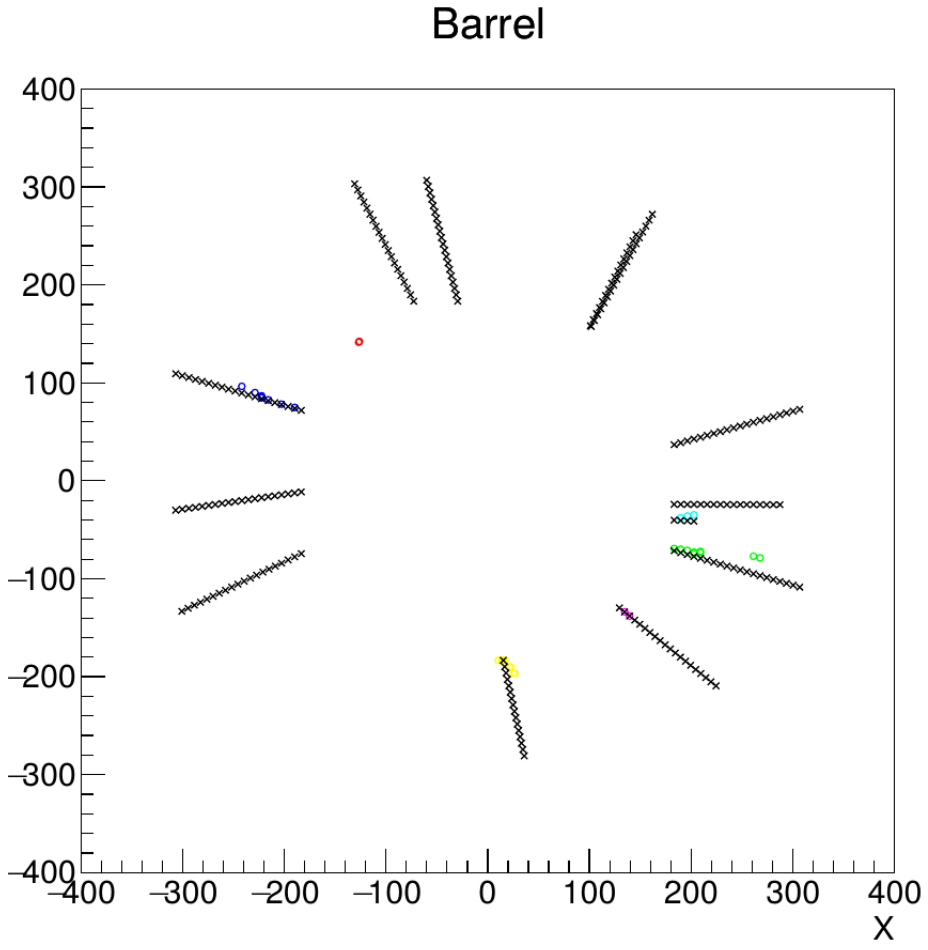
- Crosses are result of track extrapolation to RS without effects.



π^+ @ 1.5 GeV (event 3)

- 20 particles per track, only the barrel part of RS is shown.
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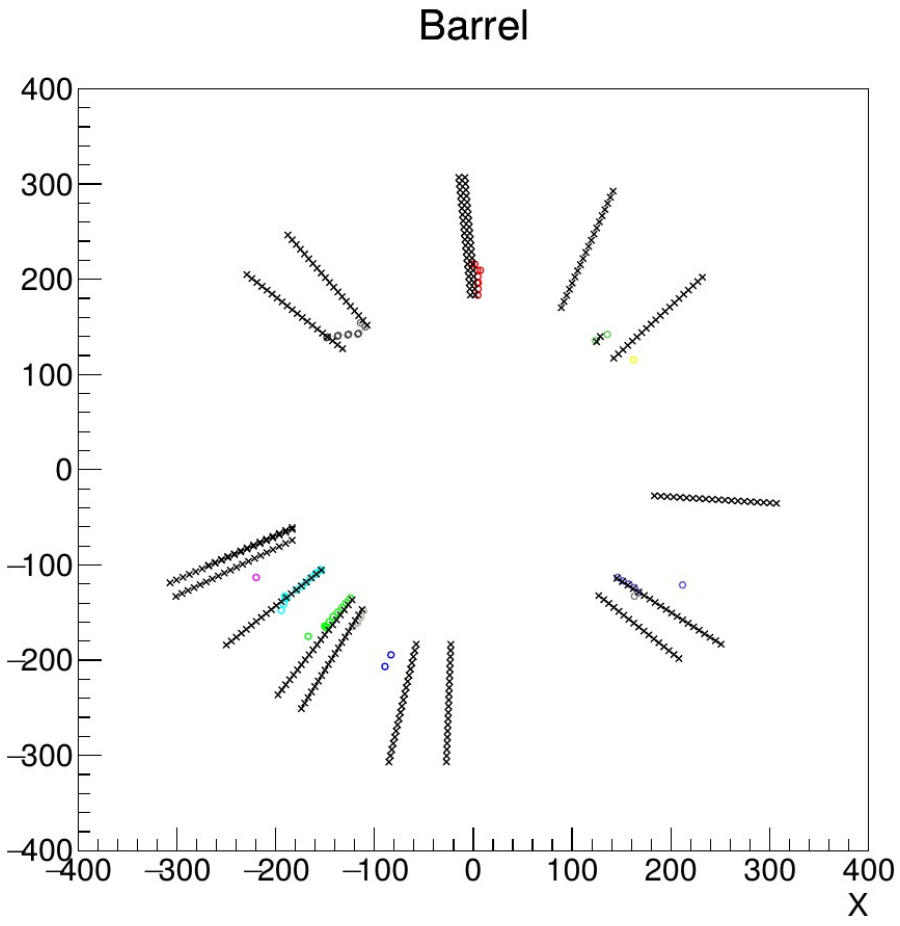
- Crosses are result of track extrapolation to RS without effects.



π^+ @ 1.5 GeV (event 4)

- 20 particles per track, only the barrel part of RS is shown.
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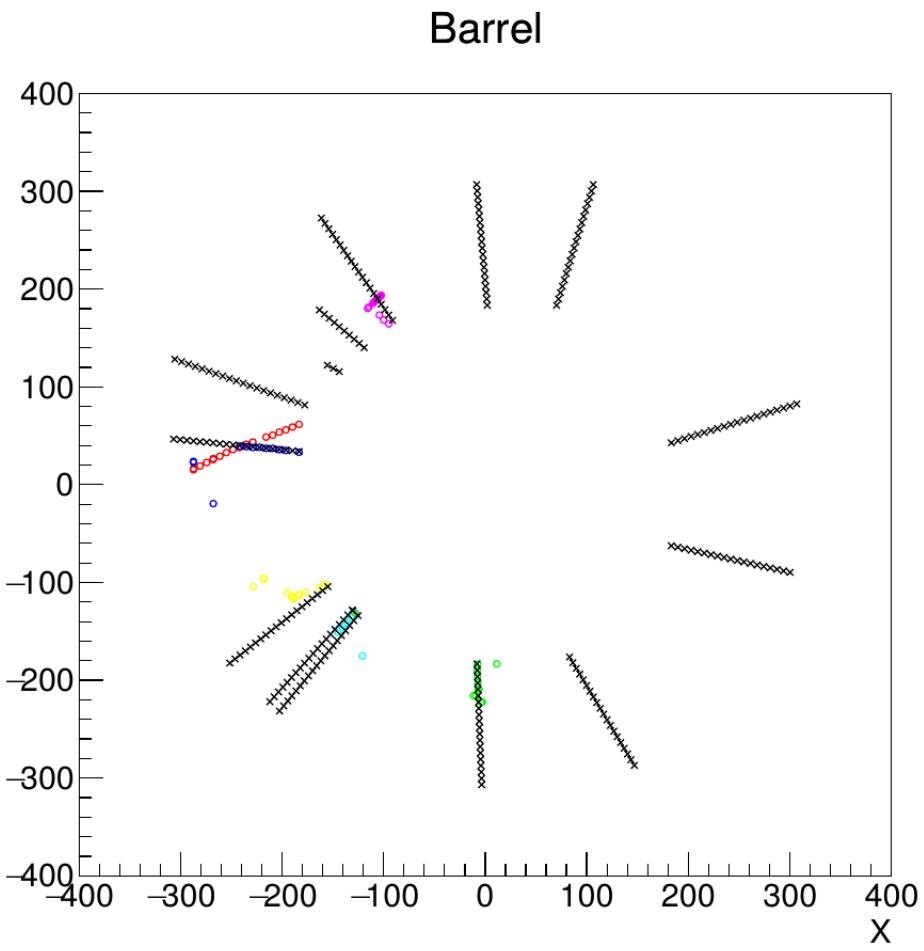
- Crosses are result of track extrapolation to RS without effects.



π^+ @ 1.5 GeV (event 5)

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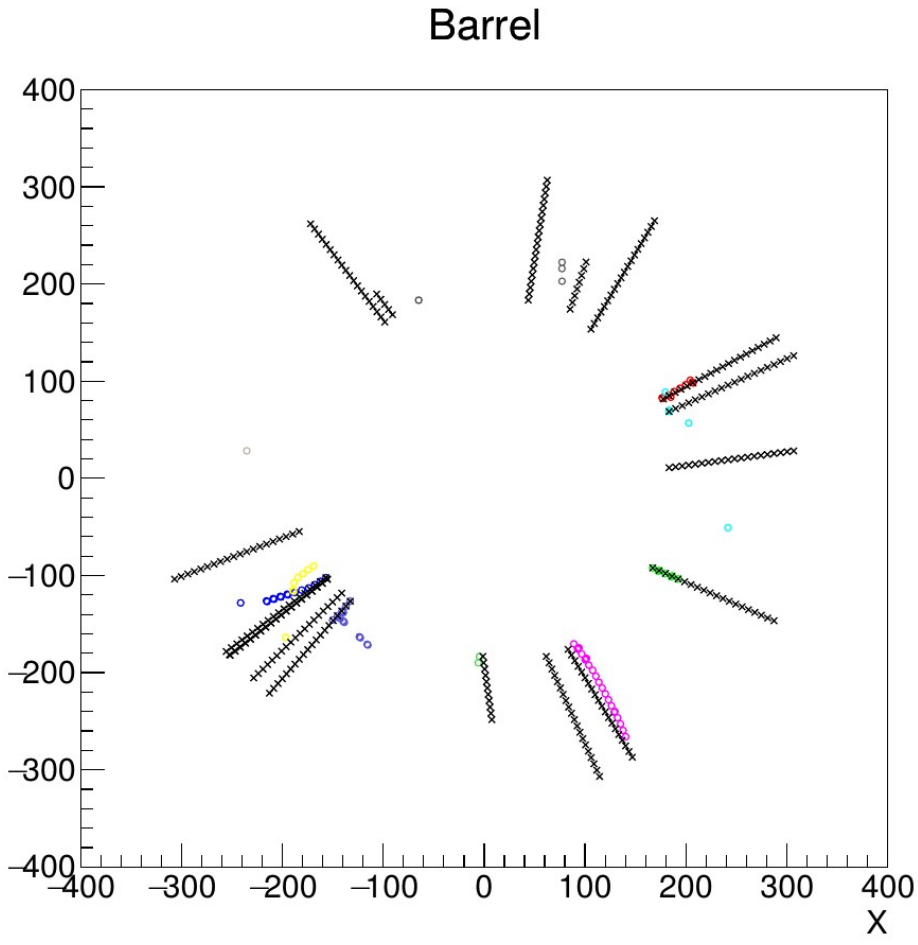

μ^+/π^+ @ 2.5 GeV

μ^+ @ 2.5 GeV

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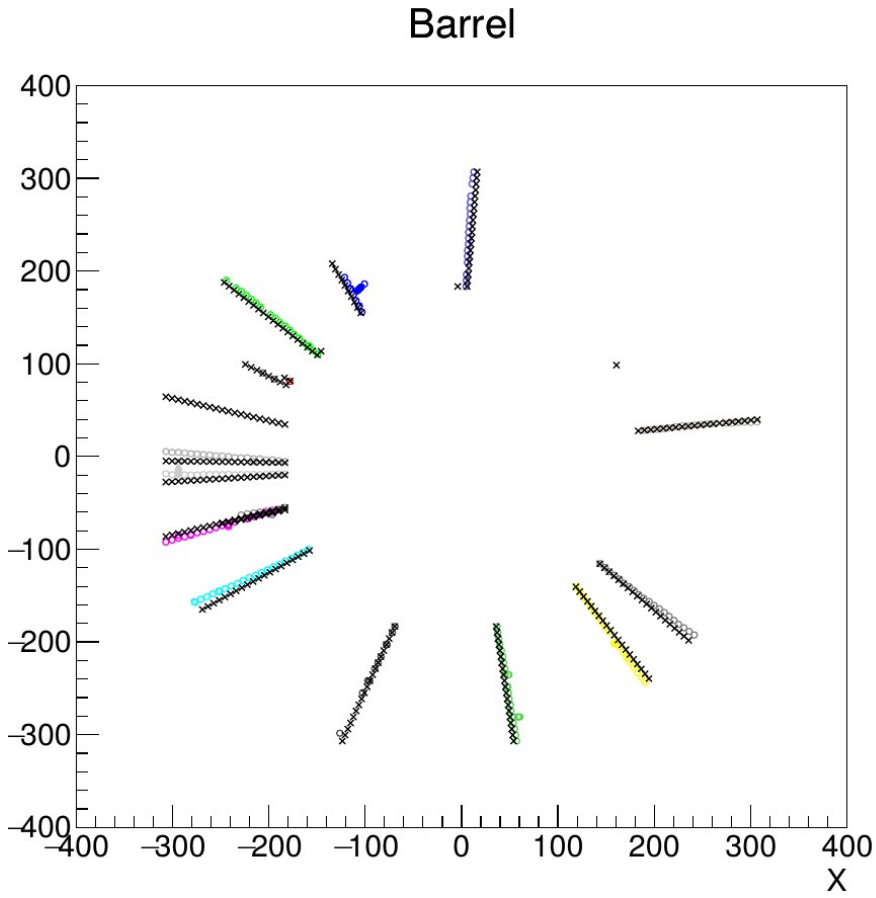

π^+ @ 2.5 GeV (event 1)

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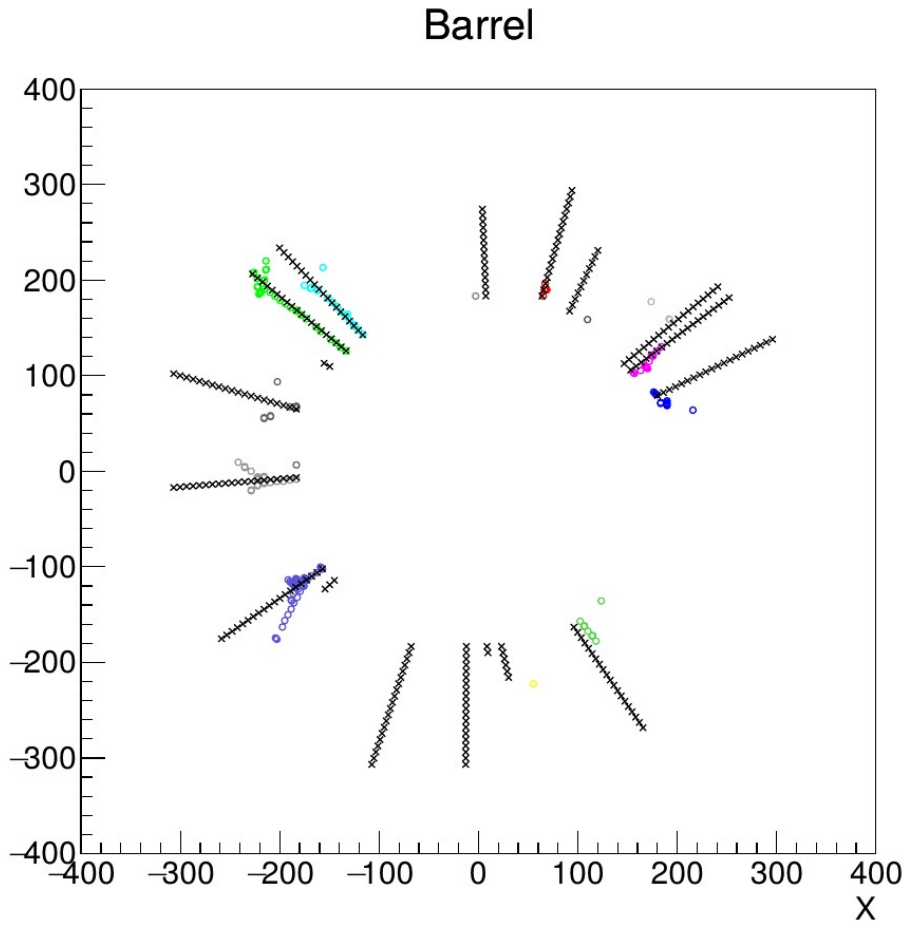
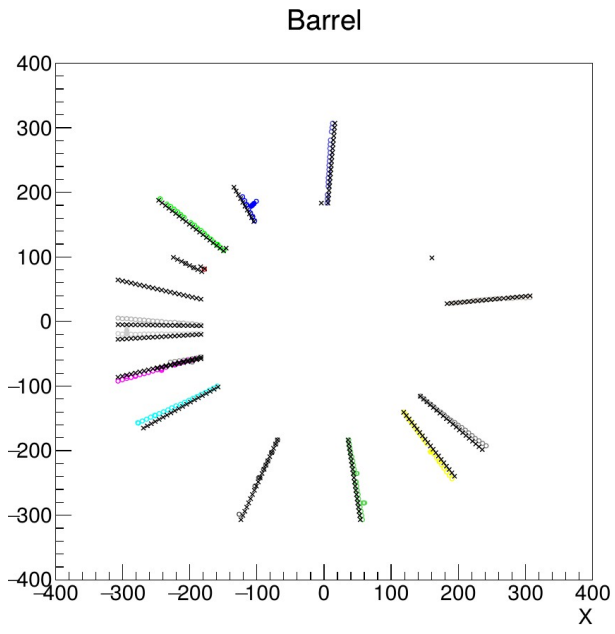
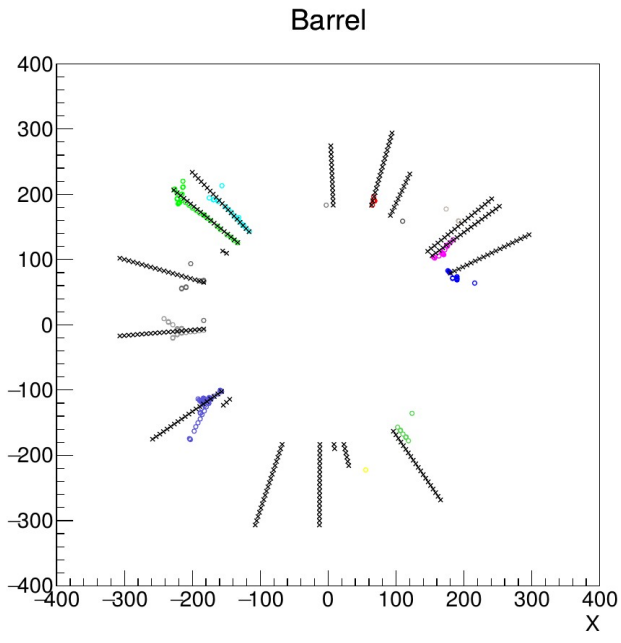


Muon identification

Tools to identify muons:

- decision trees (ongoing work by Georgy),
- classical algorithms,
- CNN?





Demonstrator of a simple GF-based algorithm to search for muon tracks

GenFit2:

- track fitting and extrapolation
- accounts for material effects (dE/dx, multiple scattering, and Bremsstrahlung for e^+ and e^-)

Idea: starting from the last track state in the tracker, prolong track adding points one by one based on χ^2 value.

Advantages: reconstructs track in 3D, allows extrapolation from barrel to endcaps, accounts for physics.

Disadvantage: speed,…

Algorithm

Recursively

- find a layer where the track can be extrapolated to;
- check hits in the layer: for “good” points update the track state and repeat the procedure;
- if there are no good points, add extrapolated point and repeat

Stop when track can not be extrapolated, there to many missing hits or the last layer is reached.

Currently, I fit two “measurements”: point representing the last track state and a new measurement.

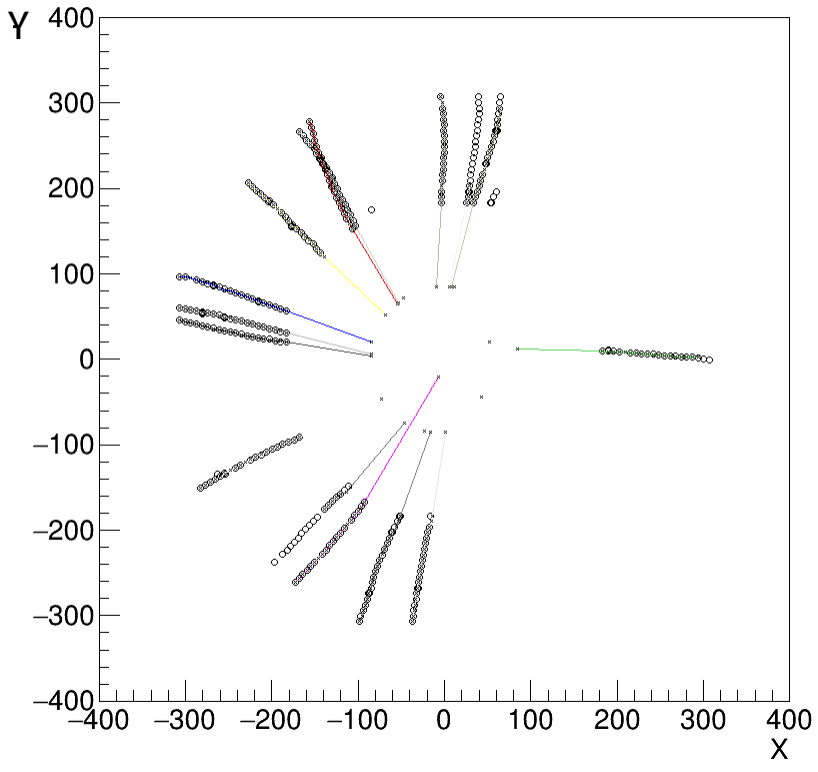
Hit:

- defined by the ends of MDT wire and distance
- for the moment distance is set to zero with the error of pitch/sqrt(12)

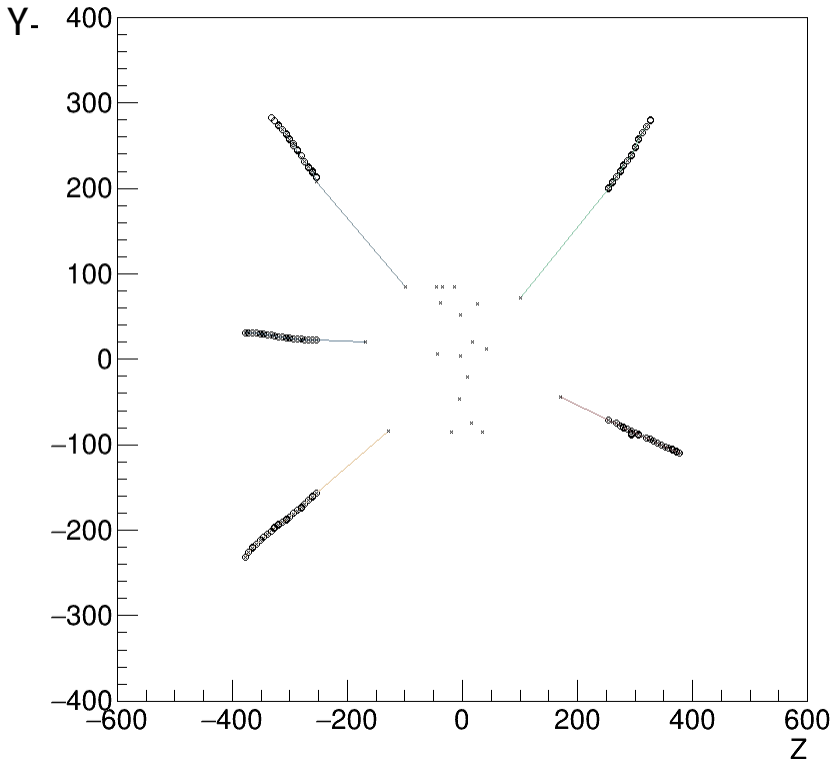
A simple GF-based algorithm to search for muon tracks

20 muons with the momentum of 1.5 GeV

Barrel

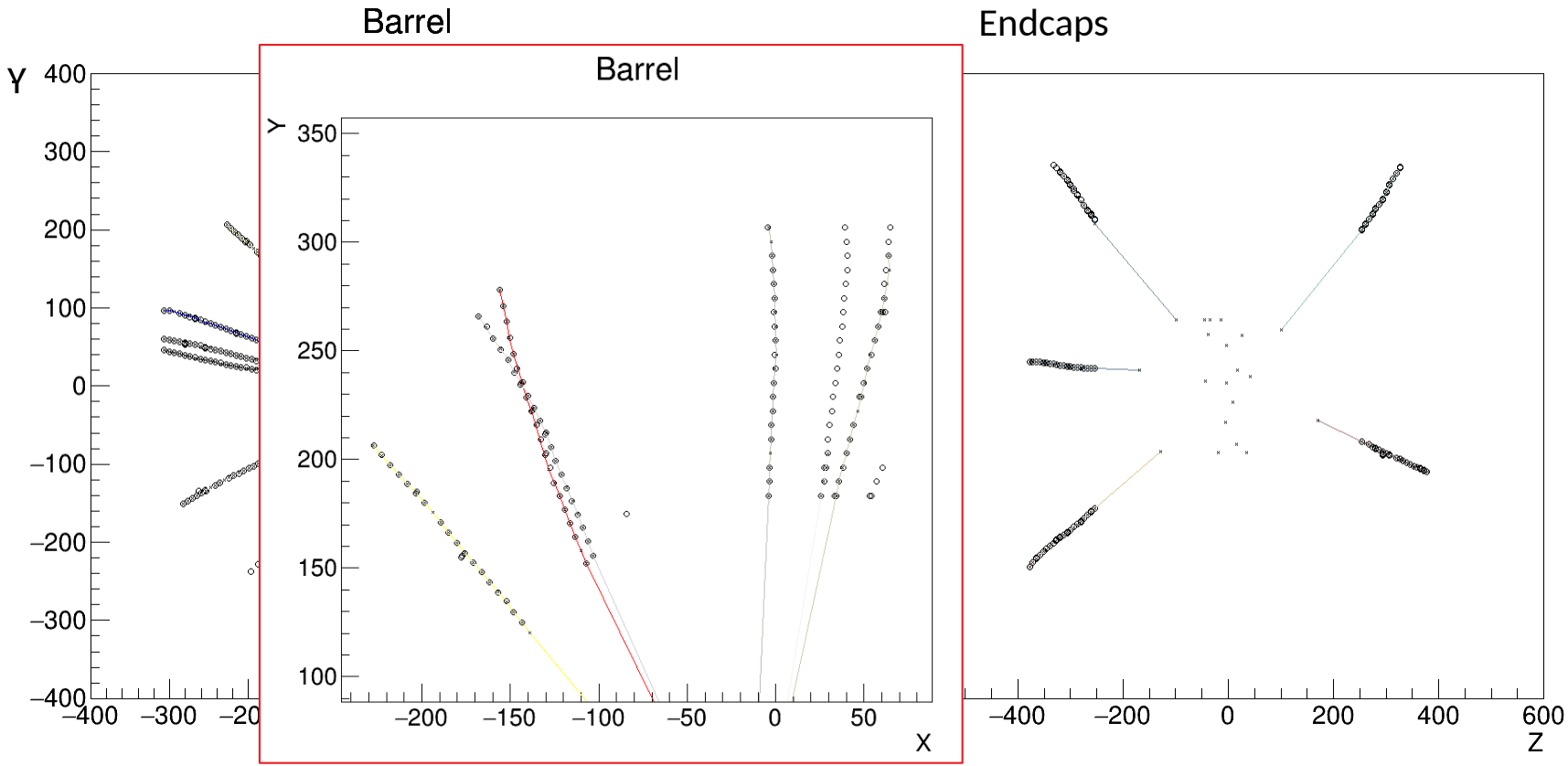


Endcaps



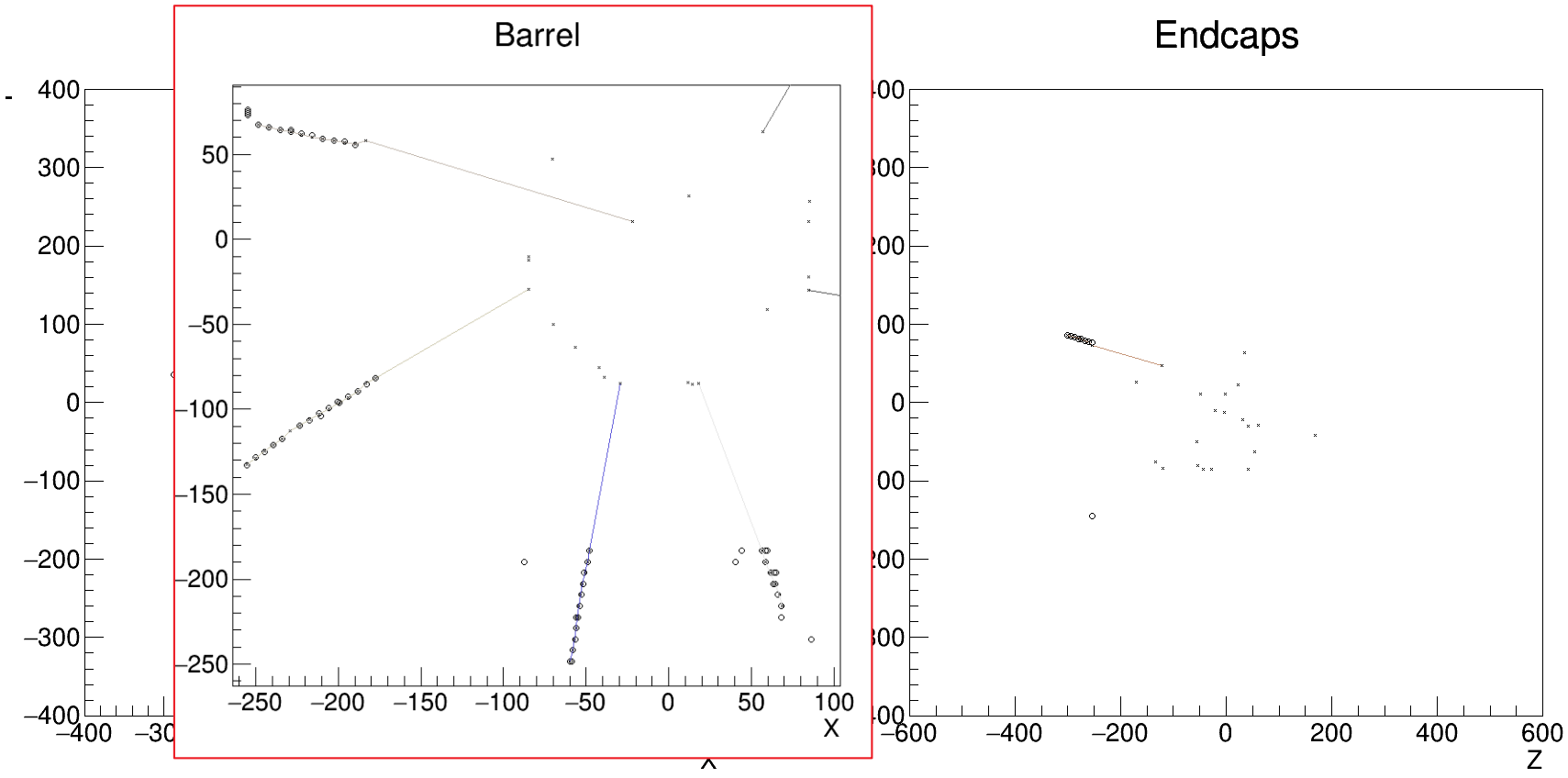
A simple GF-based algorithm to search for muon tracks

20 muons with the momentum of 1.5 GeV



A simple GF-based algorithm to search for muon tracks

20 pions with the momentum of 1.5 GeV



Missing in SpdRoot

In SpdRoot a part, that can provide information on position and dimension of MDT layers, the direction and endpoints of MDT wires, etc., is missing.

Artur helped me to get parts of this information from ROOT geometry, but it is quite inconvenient and by far incomplete.

Summary and plans

- RS length is close to optimal for our energies.
- “MC showers” in RS are in SpdRoot artur-dev branch (thx to Artur!). ML is possible. Integration of XGBoost is considered to use BDT.
- A very simple iterative algorithm to identify muons tracks shows reasonable preliminary results. Validation of the presented algorithm results and its optimization to follow.
- CNN may be another powerful tool.
- Our Geant4 physics list validation is important for muons with low momenta in RS. Separate treatment of π+ and π- may be necessary.
- Mentioned extension of SpdRoot may simplify and help to optimize mentioned tasks.
- Why don’t we have stereo layers in RS (at least in endcaps)?