On muon/pion separation in RS

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Motivation of this talk

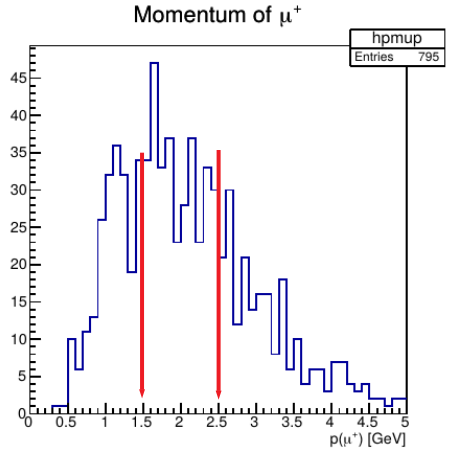
The muon identification plays the **key** role in reconstruction of **J/ψ** (and higher states decaying to J/ψ), it can be also used for open charm studies (not discussed here).

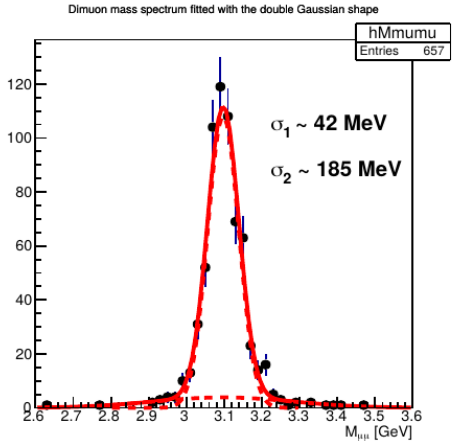
Questions:

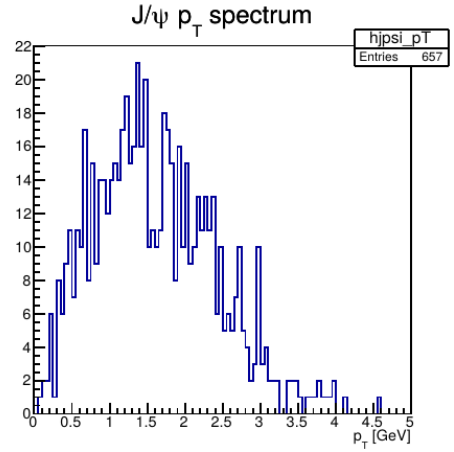
- What performance can we expect from our RS for pion/muon separation?
- What performance would be sufficient for our measurement goals?

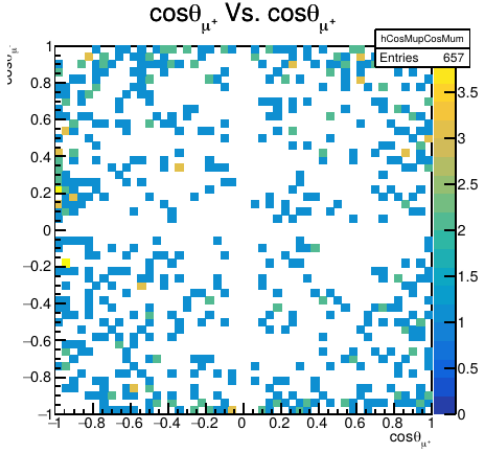
$J/\psi \rightarrow \mu^+\mu^-$

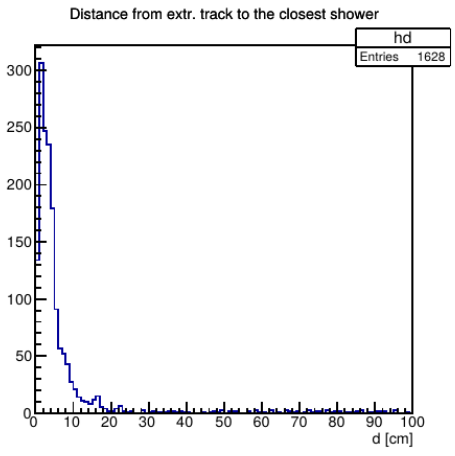
- Example: jpsi-mumu
- Magnetic field: 1T
- Collision energy: 27 GeV
- 1K event generated

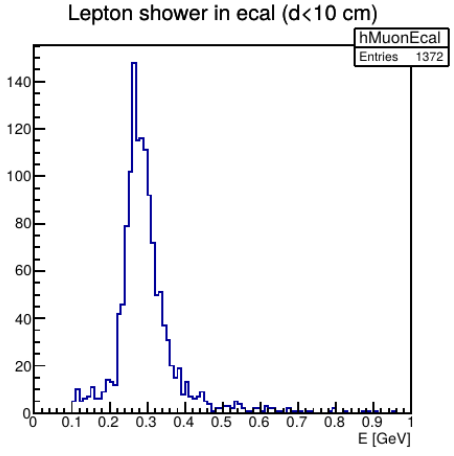




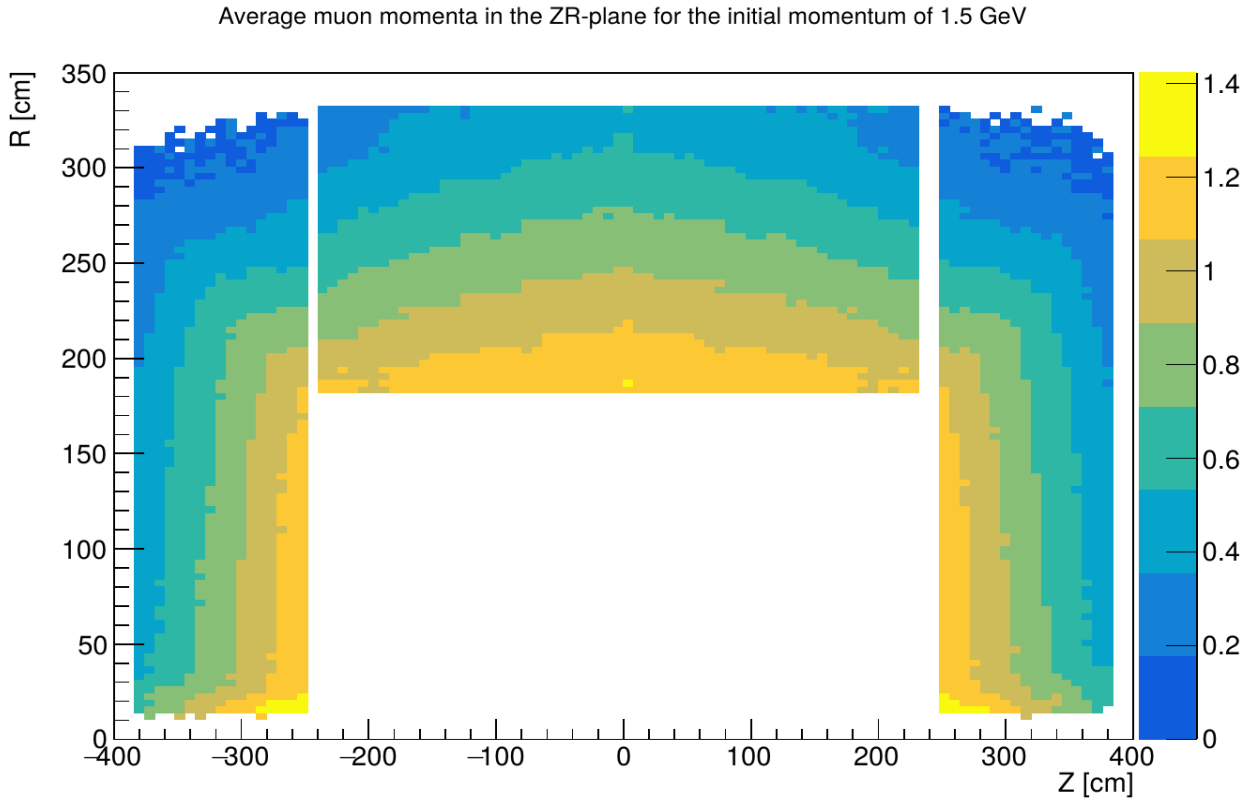






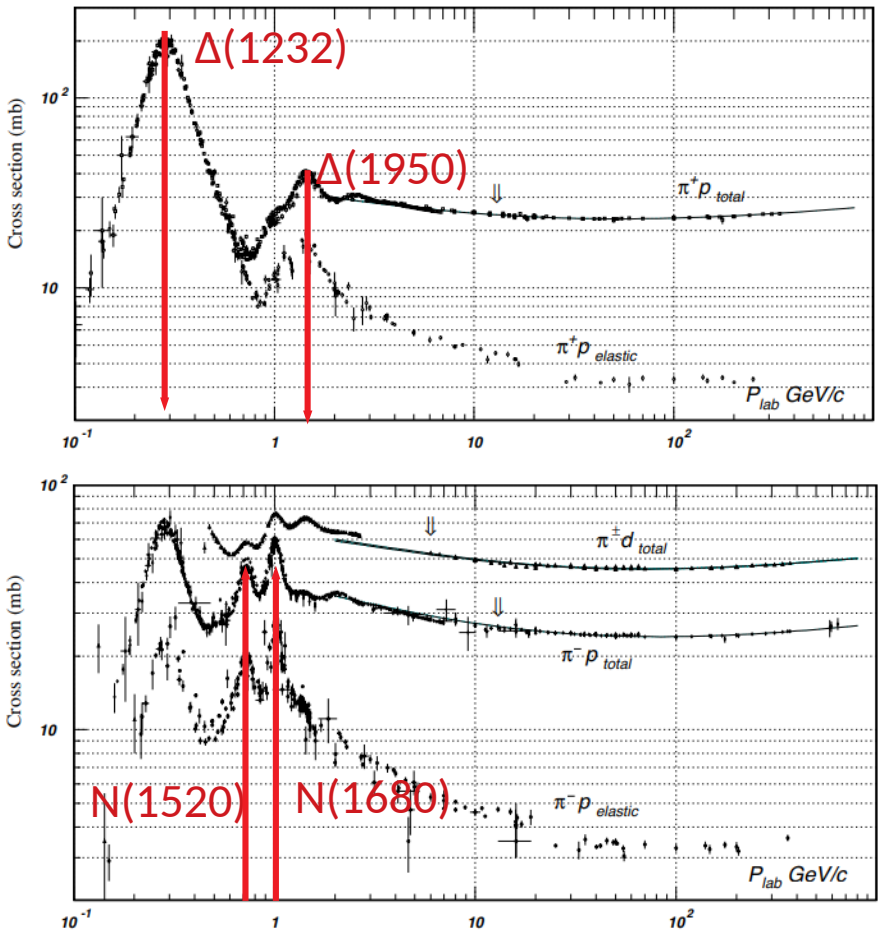


Muons in RS

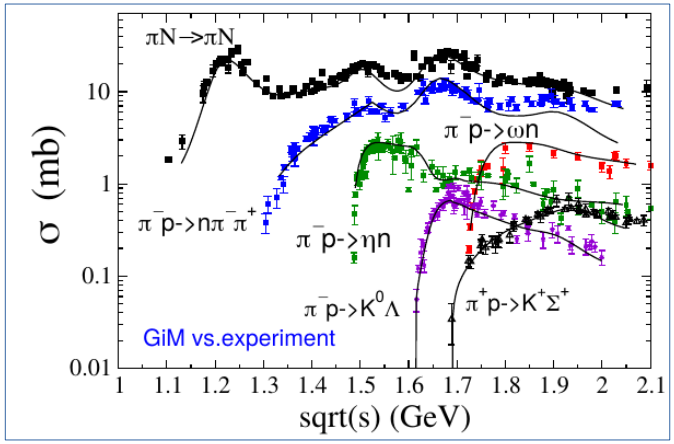


Most of pions from J/ψ decays should cross RS.

Pion interactions in RS



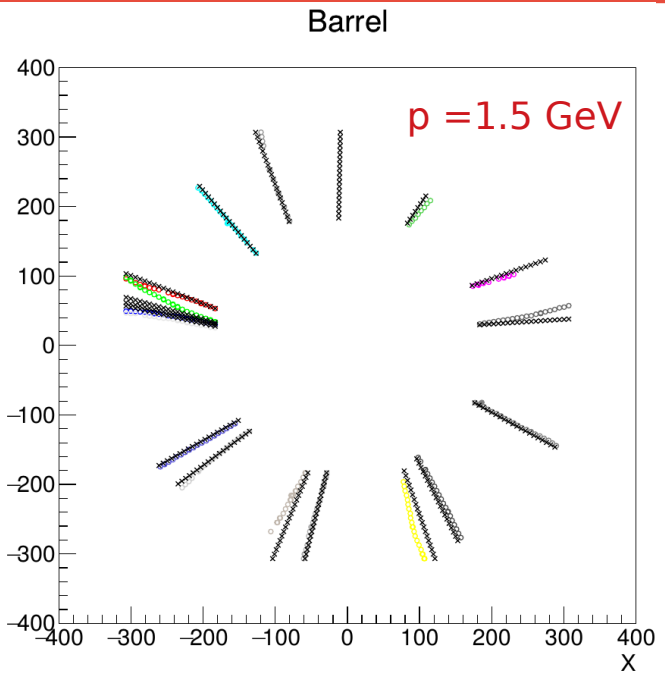
PRC93, 045206

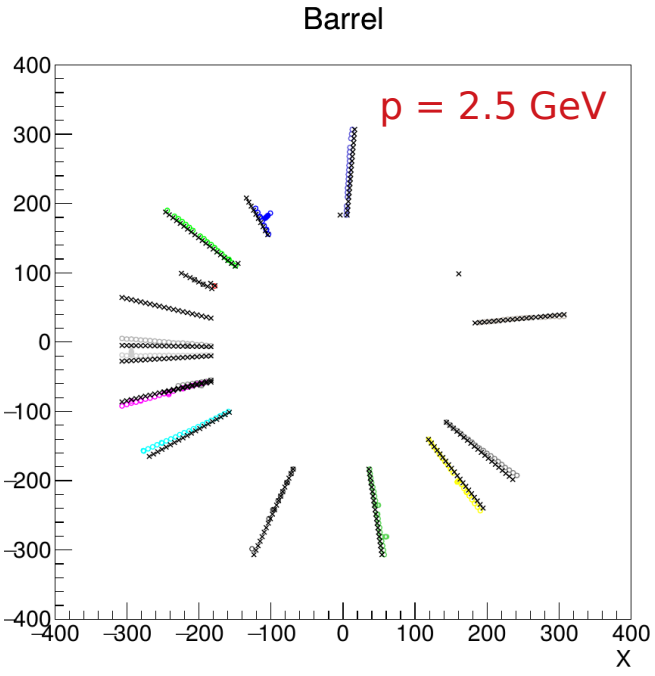


Δ(1232) I=3/2	
$\pi^+p \rightarrow$	π^+p
$\pi^+n \rightarrow$	$1/3\ \pi^+n + 2/3\ \pi^0p$
$\pi^-p \rightarrow$	$1/3\ \pi^-p + 2/3\ \pi^0n$
$\pi^-n \rightarrow$	π^-n

- Large fraction of elastic πN scattering below 1GeV
- Difference for π^+ and π^- interactions

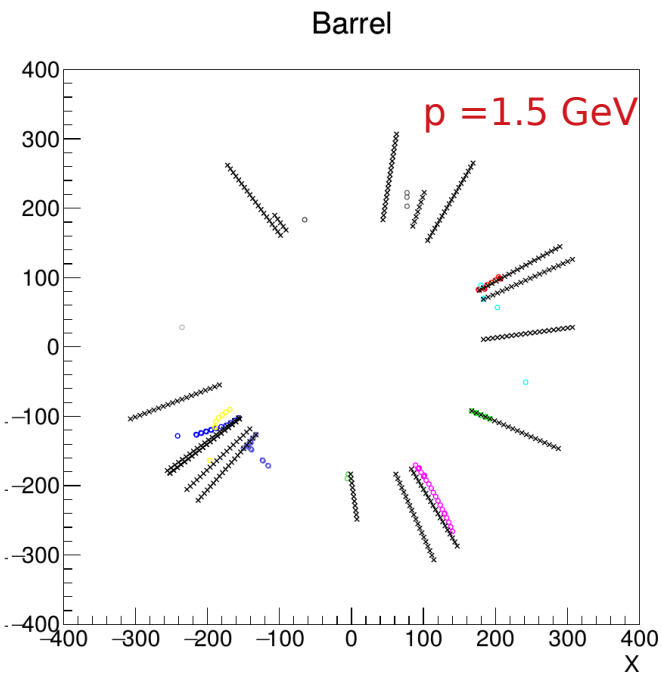
Muon tracks

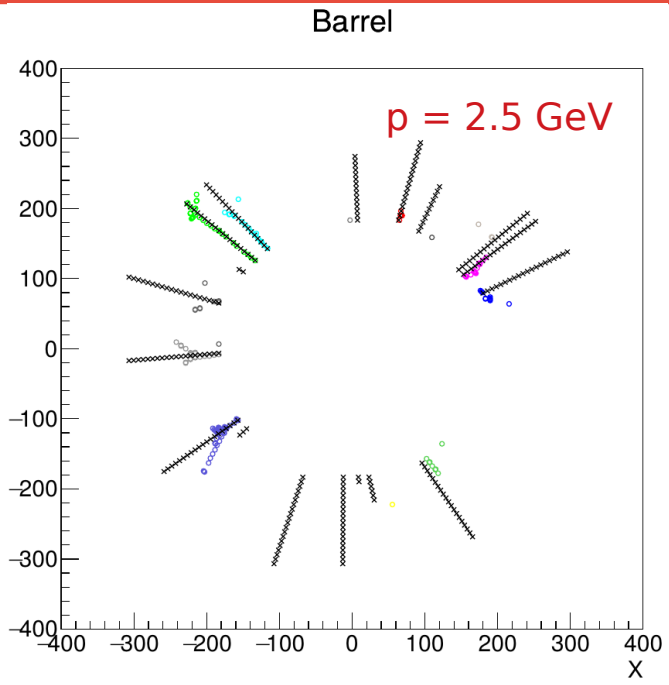




- Muons in the barrel part of RS
- Hits are shown by circles, color indicates cluster. Crosses are result of the GF track extrapolation to RS with material effects.
- No magnetic field in RS!

Pion signatures





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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

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

Hit:

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

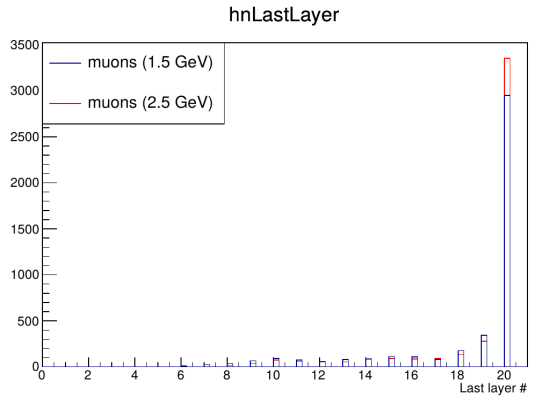
A simple GF-based algorithm to search for muon tracks

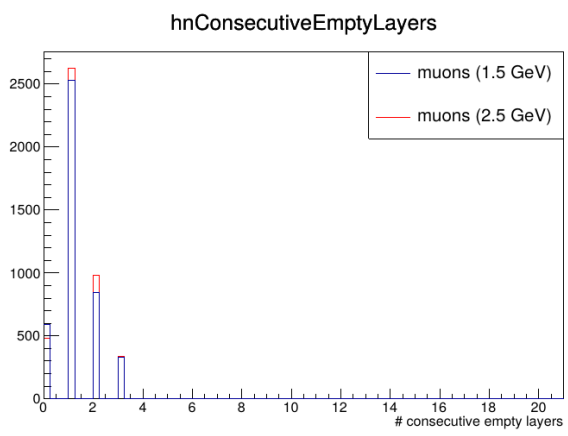
Used parameters

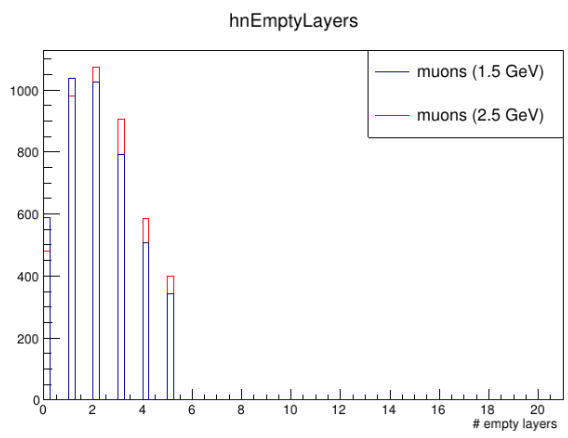
- points with $\chi^2<4$ are accepted, if $\chi^2<1.5$ extrapolation point is not added
- no more than **3 lost hits in a row**
- no more than **5 missing hits in total**
- among the track-candidates
  - the ones which cross the maximum amount of layers are selected,
  - the one with the largest probability is selected (layers detection efficiency **p=0.97** is used).

Tracks:

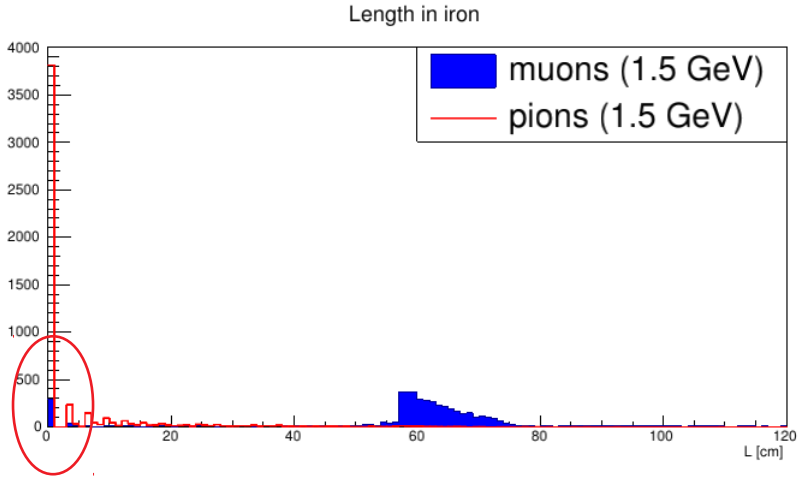
- Uniformly distributed muons and pions with **p = 1.5 GeV** and **p = 2.5 GeV**, one track per event, samples of 5000 events generated.
- Only well-converged tracks considered.

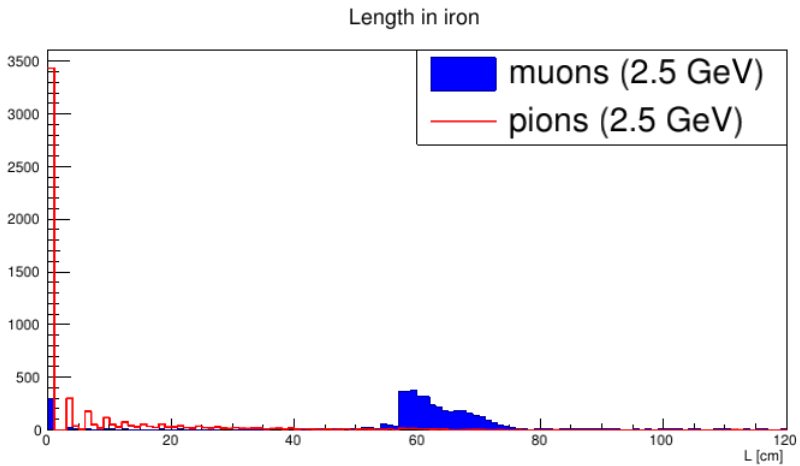




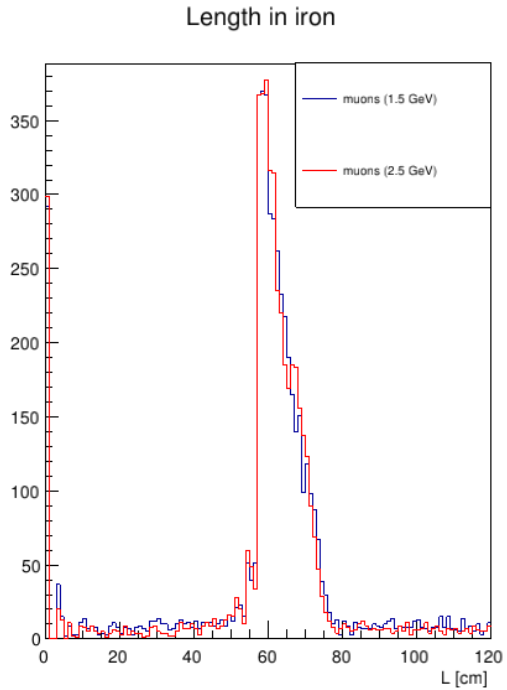


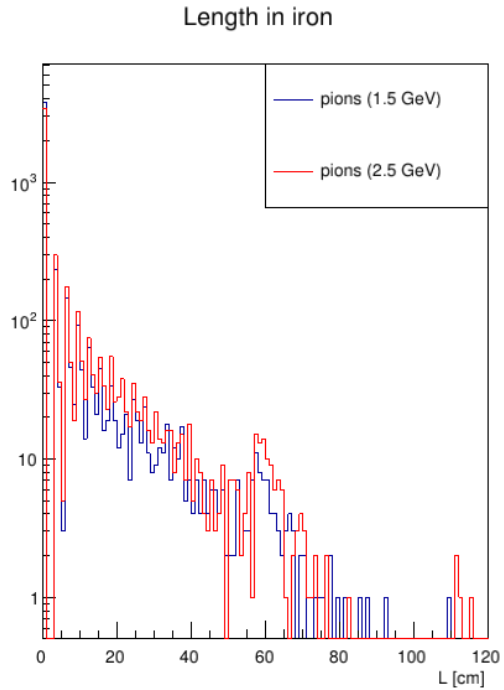
Track extrapolation length in iron



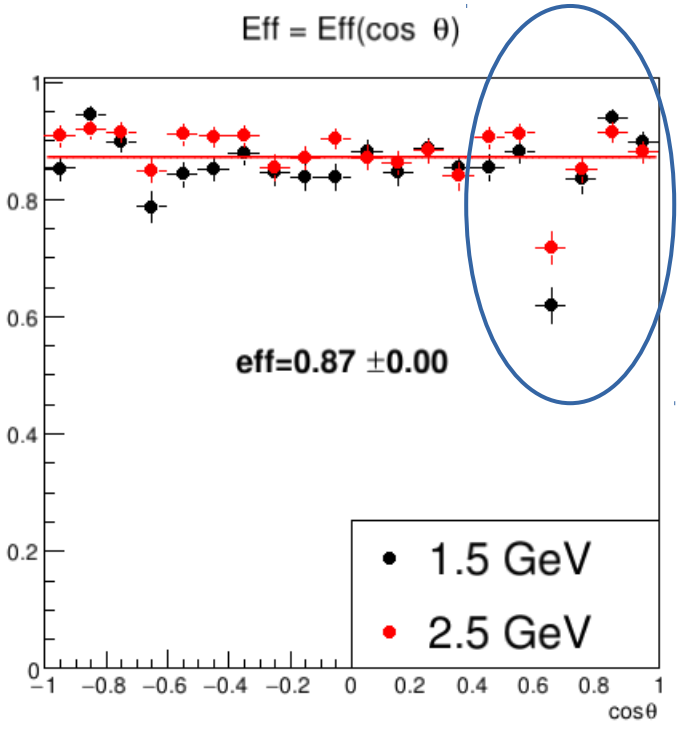


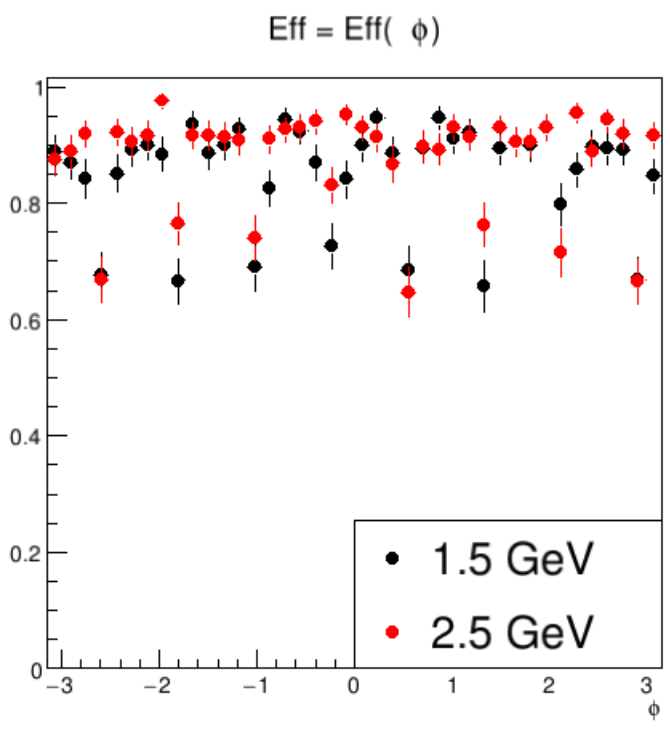
- Only well-fitted tracks are considered
- length in iron **excluding first 6 cm** layer is shown
- using L Vs. p correlation is not possible





Muon selection efficiency

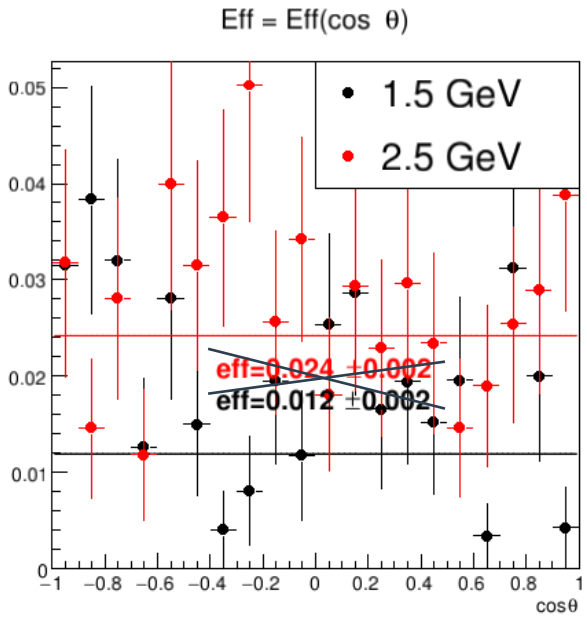


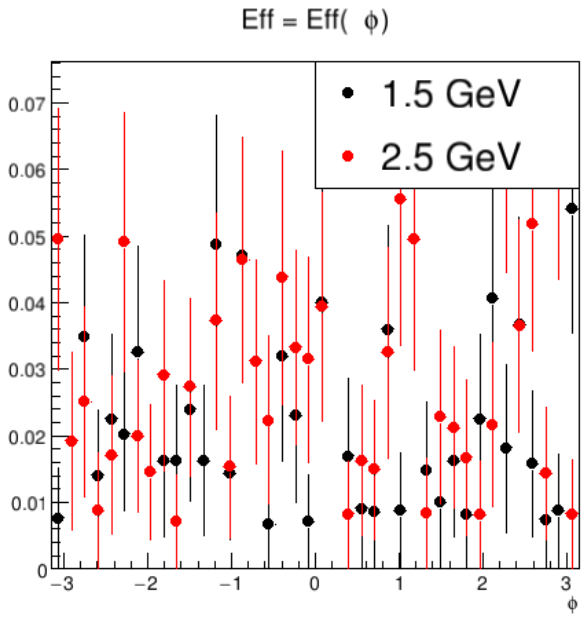


- L > 50 cm
- 5000 events generated

Pion survival fraction

- L > 50 cm
- 5000 events generated





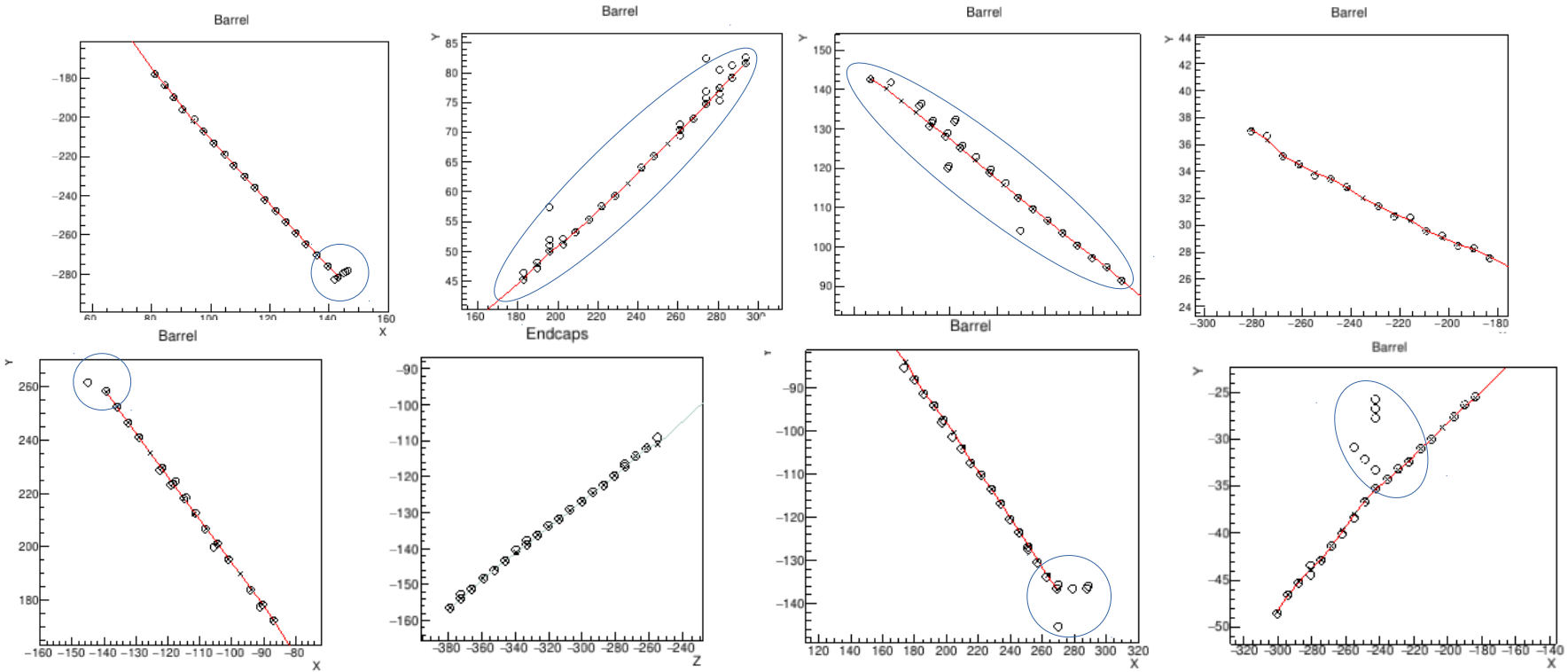
Background study

p = 1.5 GeV
- misid.: **2.6%** (128 events)
- decays before RS: 47
- decays in RS (p_μ>0.1): 18

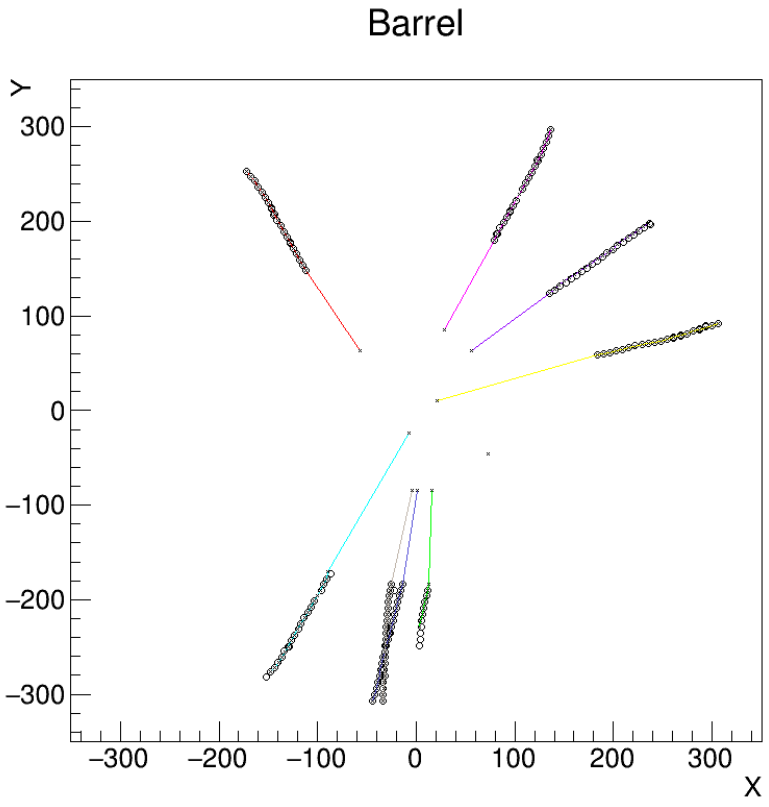
p = 2.5 GeV
- misid.: **3.1%** (153 events)
- decays before RS: 46
- decays in RS (p_μ>0.1): 5

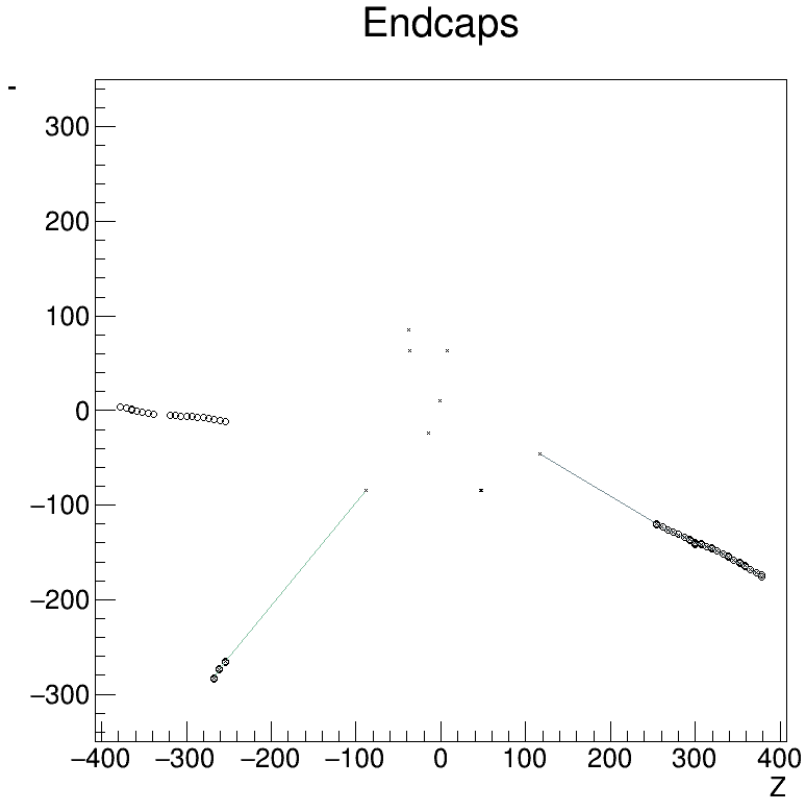
Pion survival ratio can be decreased

- 8 consecutive pion events (p = 2.5 GeV) passing L>50 cm cut
- Further improvement is possible! E.g. number of all tracks in the “cone” divided by number of tracks in the track or branches in a track.



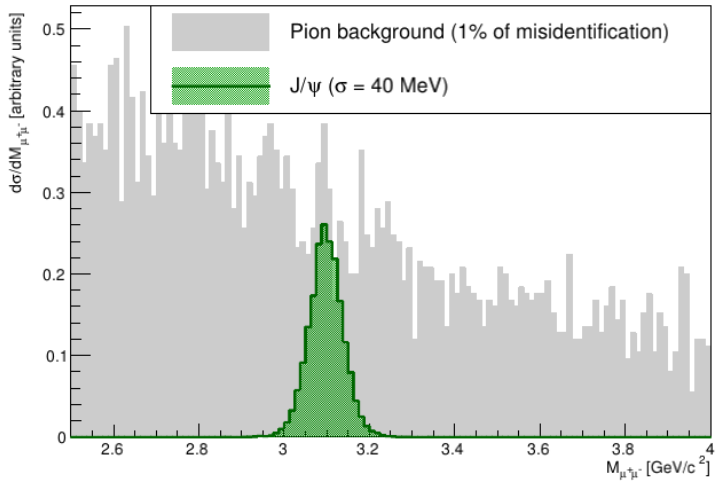
Multiple track reconstruction

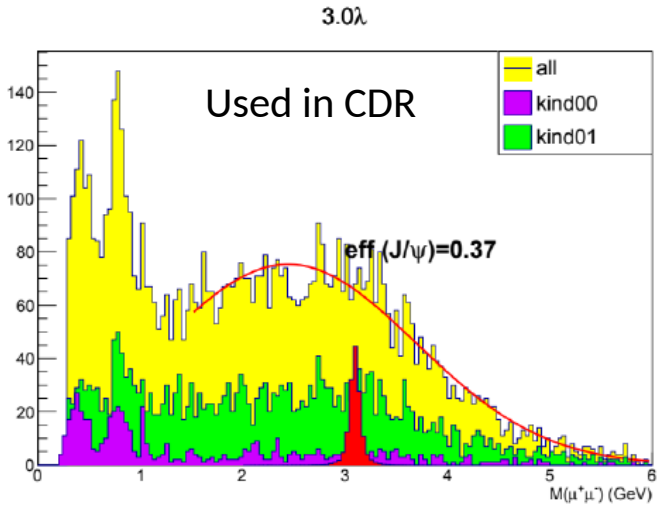




- Parameters chosen above may be far from optimal
- Computational performance is very low
- There some issues

Target values for pion suppression





case 1

$|\cos\theta_\mu|<0.9$

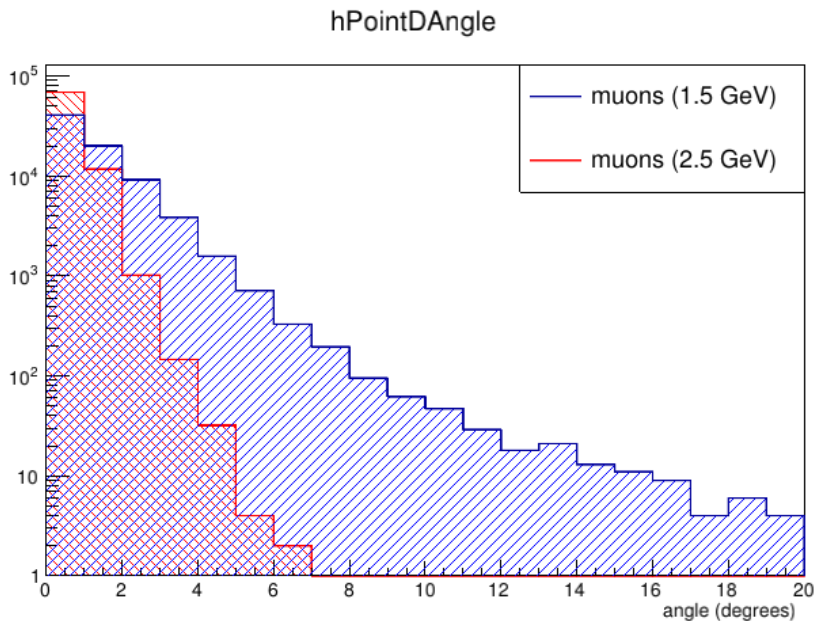
Gen-level events:

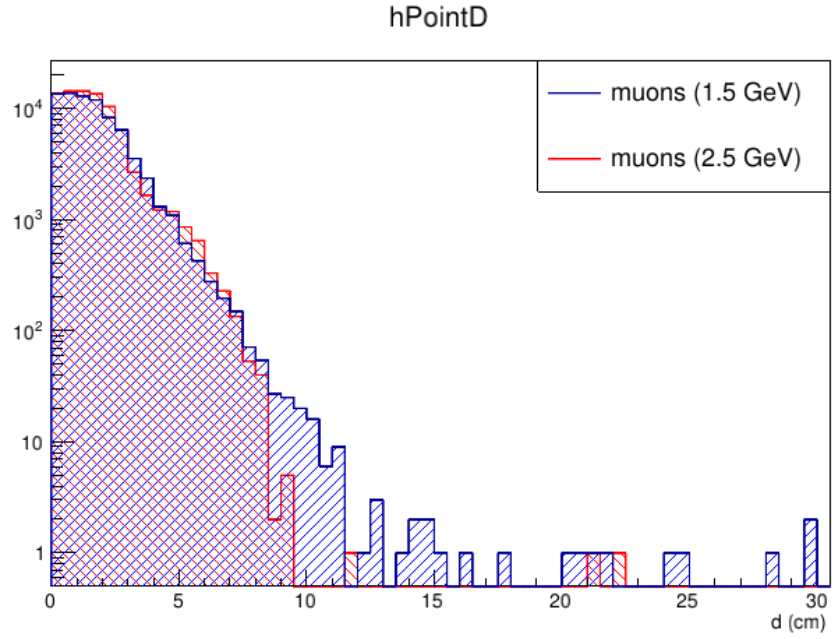
- only **pions** considered
- for pions misidentification of 1% is assumed
- only pions with $|\cos\theta|<0.9$ are selected

The target value for pion survival ratio should be ≤ 1%.

Based on study of two samples with p=1.5 GeV and p=2.5 GeV pion decays contribute 30-50% to the misidentification of pions as muons.

On simplified reconstruction





In the absence if magnetic field simple track selection algorithms should work well.

Comments, summary and plans

- After the detector geometry update and new field map a publicly available code will offered.
- For the moment a particle type from MC-truth is used, to be changed to muons.
- Assuming that simulation is correct, pion suppression rate ~ 97% can be expected for the muon selection efficiency of 90% (projected to well-fitted tracks). Pion misidentification can be further suppressed.
- The target value for pion suppression should be ~99%.
- Our Geant4 physics list validation to be validated.
- Currently, the track reconstruction in RS takes very significant time. To be improved with other reconstruction methods like DT (ongoing work by Georgiy), CNN, etc…