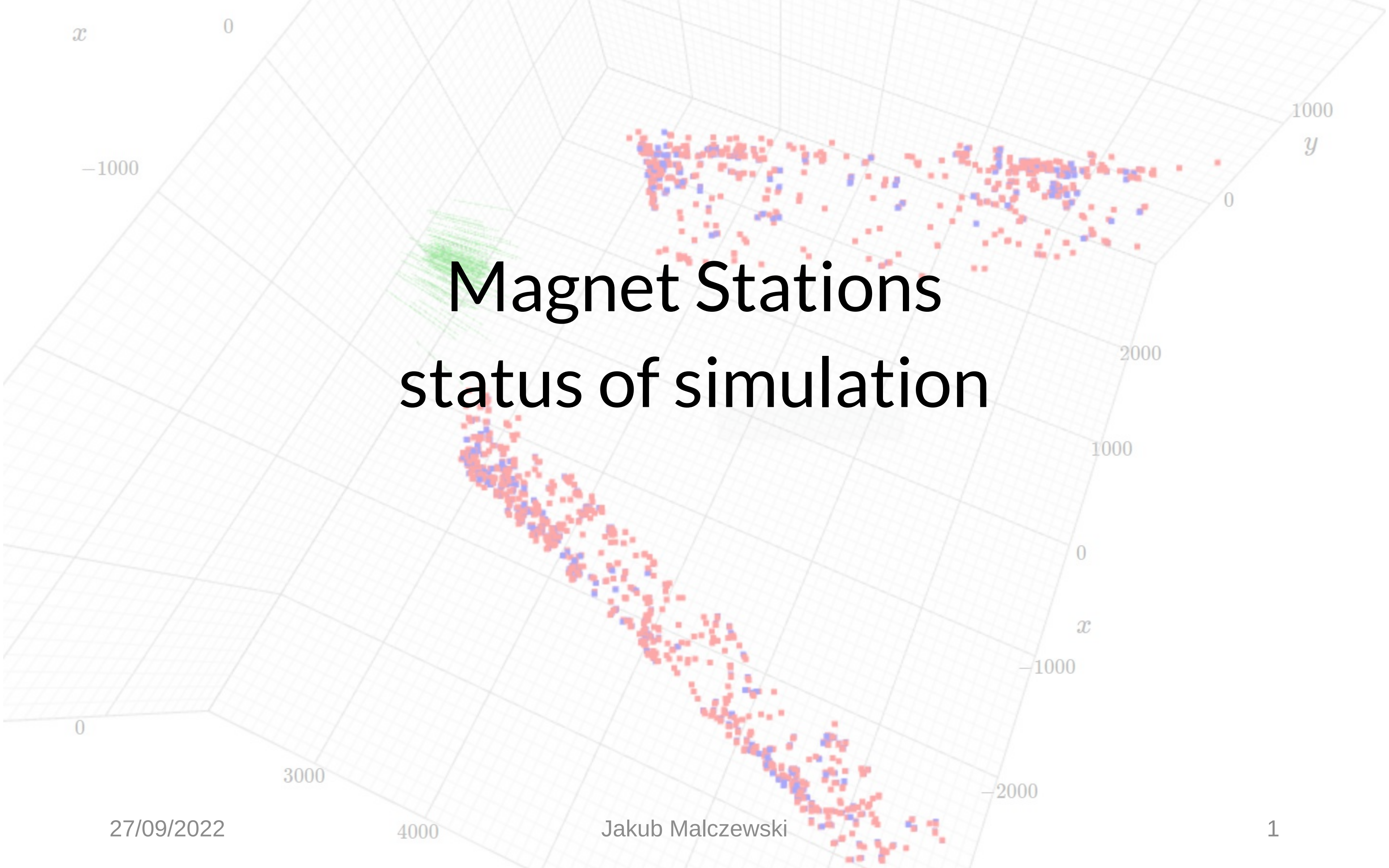
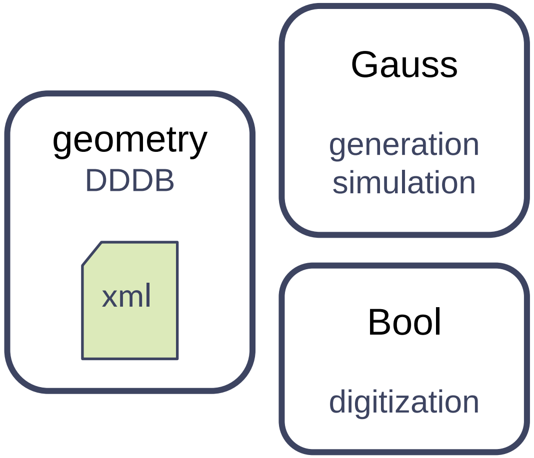
Magnet Stations status of simulation

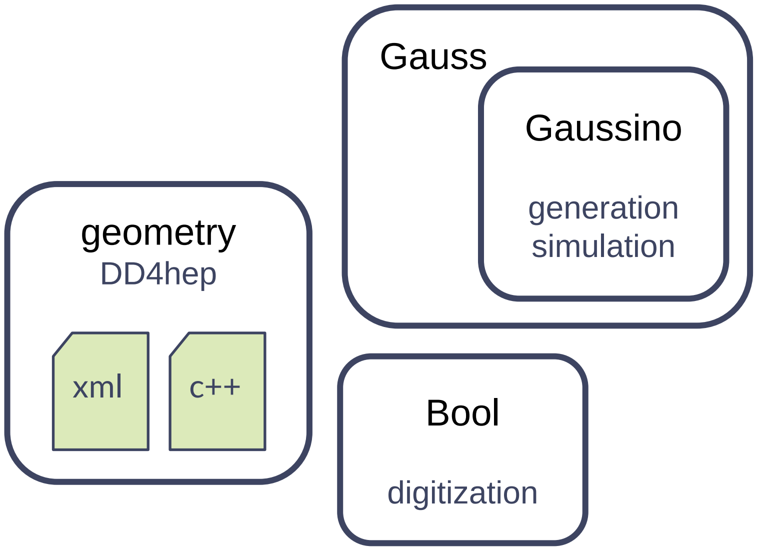


Simulation evolution

old version



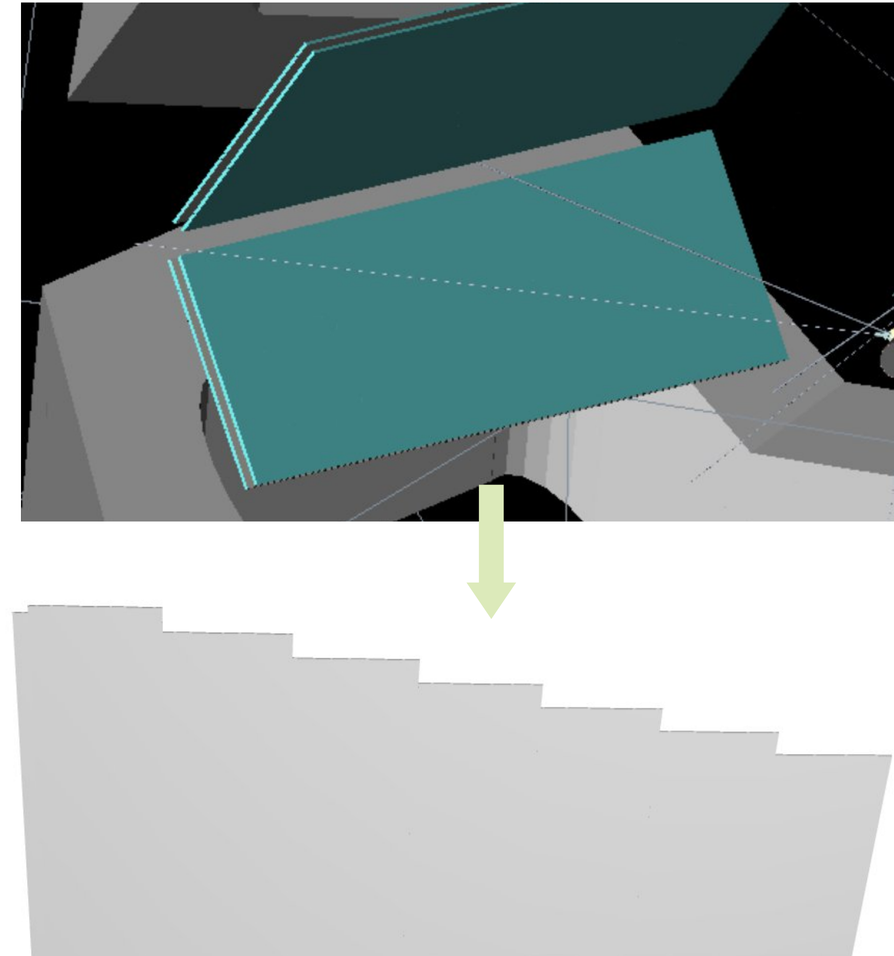
new version

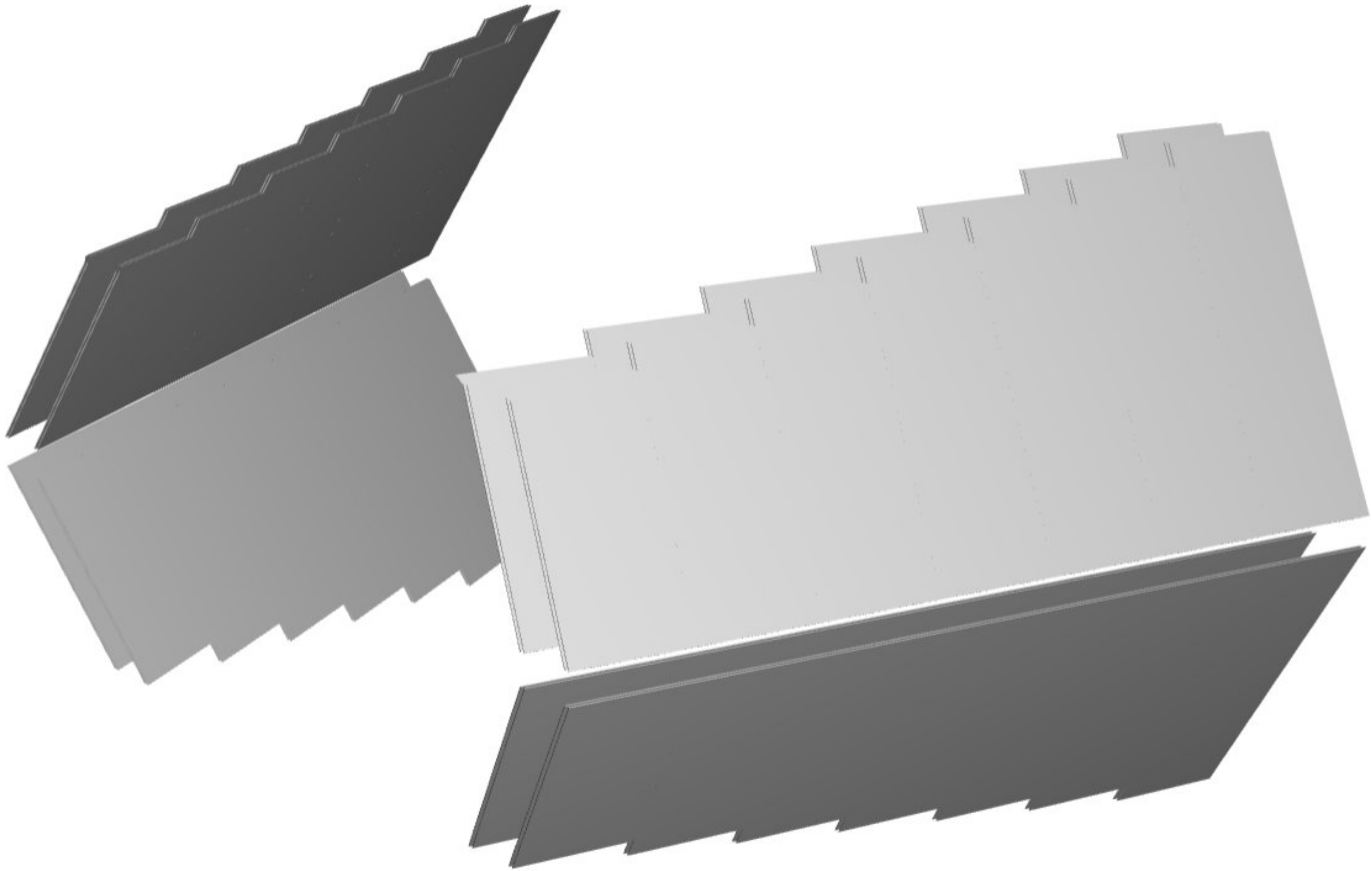


Detector geometry

Magnet Stations geometry design evolved over time. The main change included moving from a simple rectangle to a polygon, to better accommodate the space inside the LHCb magnet.

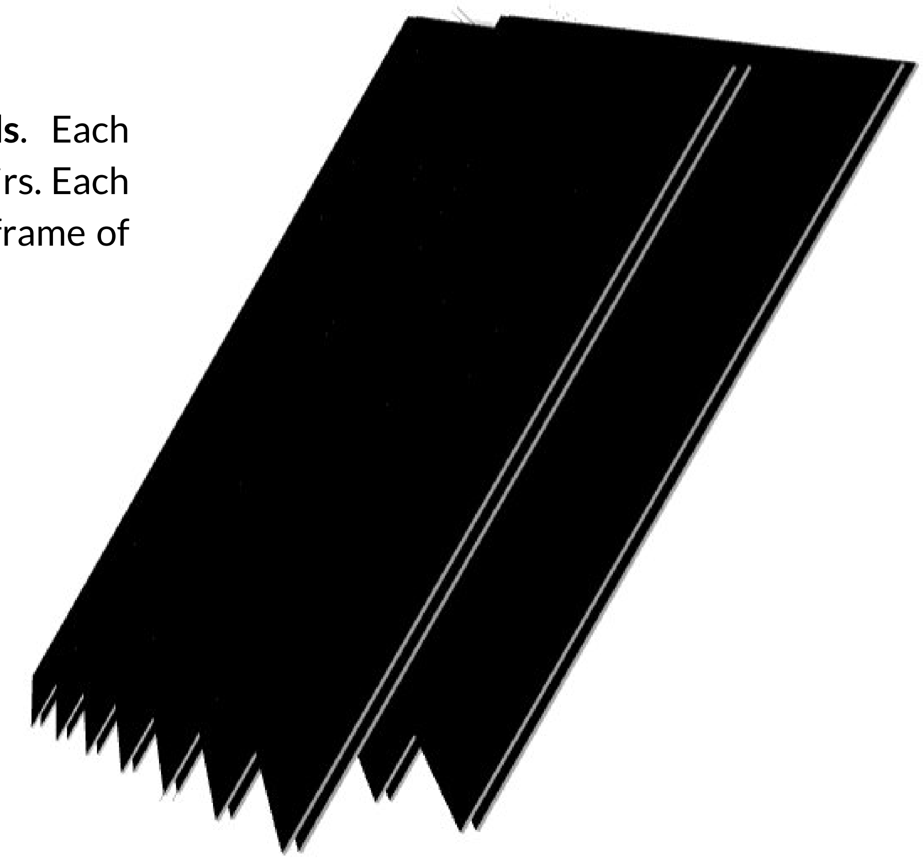
Most of the plots in this presentations were made before this modification.





Geometry structure

Magnet Stations consist from **4 panels**. Each panel (station) has **4 layers** grouped in pairs. Each layer is shifted along x-axis of the LHCb frame of reference.

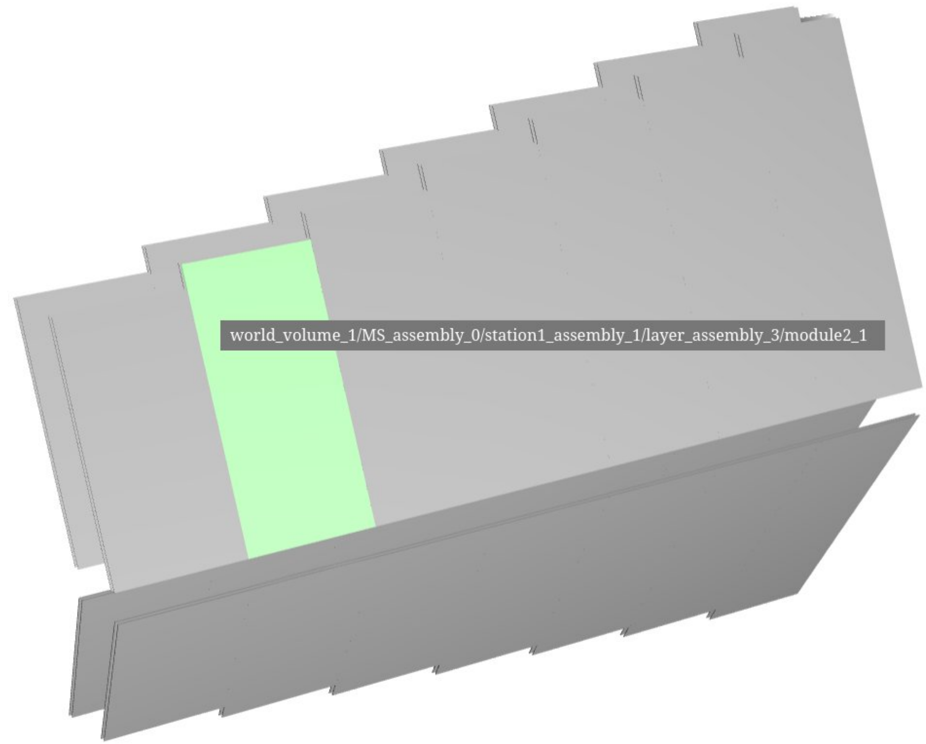


Geometry structure

Inside a simulation object are grouped in a hierarchical order.

World ▸ LHCb ▸ MagnetRegion ▸ ▸ MS ▸ panel ▸ layer ▸ module

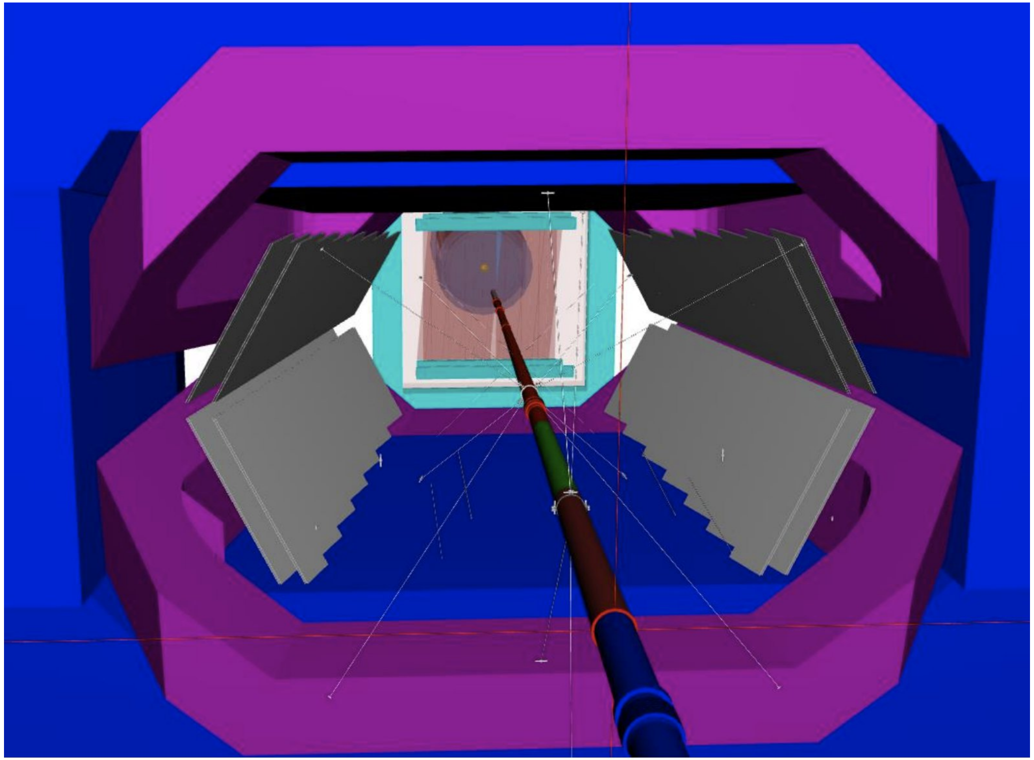
Modules are not divided into individual scintillators due to a performance hit associated with a large number of volumes.



Other volumes

To properly analyze backgrounds we need a good implementation of the support structures around MS and beam pipe.

MS is situated outside of the acceptance of the downstream detectors.



DD4hep features

Xml files contain: parameters, material's properties, logical order and shape description.

C++ constructor is importing objects from xml files and putting them together. It is possible to import a shape once and put it in a final geometry multiple times.

Pros: easy parametrization

Cons: constructor has to support all the (production ready) xml versions

Code development

Main repository	url:	gitlab.cern.ch/lhcb-magnet-stations/magnet-stations.git
	branch:	dd4hep
LHCb submodule	url:	gitlab.cern.ch/lhcb/LHCb
	branch:	MS
Detector submodule	url:	gitlab.cern.ch/lhcb/Detector
	branch:	MS
Gauss submodule	url:	gitlab.cern.ch/lhcb/Gauss
	branch:	MS

```
#TODO
– write automatic tests
– code review
```

General simulation upgrade

STATUS TABLE

		BCM	RMS	PLUME	VELO	RICH	UT	FT	CALO	MUON
Steps in G-on-G	XML description	Not yet	Not yet	Private tests	Done	Done	Done	Done	Private tests	Done
	Python configuration	Not yet	Not yet	Private tests	Done	Done	Done	Done	Private tests	Done
	Extra changes	Not yet	Not yet	Private tests	Done	Done	Done	Done	In progress	In progress
	Hits OK	Not yet	Not yet	Private tests	Done	Done	Done	Done	In progress	In progress
	Histograms	Not yet	Not yet	In progress	Done	Done	Done	Done	To be checked	To be checked
	Physics			needed?		In progress				needed?
Integration Gauss!872	MR Created	Not yet	Not yet	Not yet	Done	Gauss!820	Gauss!827	Gauss!856	Not yet	!850
	MR Reviewed	Not yet	Not yet	Not yet	Done	Changes needed	Changes needed	Changes needed	Not yet	Changes needed
	MR Integrated	Not yet	Not yet	Not yet	Done	Not yet	To be validated	To be validated	Not yet	Not yet
Testing	Validation issue	Not yet	Not yet	Not yet	Gauss#64	Not yet	Gauss#65	Gauss#66	Not yet	Not yet
	Nightlies*	Gauss ready	Gauss ready	Gauss ready	Test ran	Test inactive	Test ran	Test ran	Gauss ready	Test inactive
	LHCbPR**	Gauss ready	Gauss ready	Gauss ready	t.b.v. w/DetDesc	Test inactive	t.b.v. w/DetDesc	t.b.v. w/DetDesc	Gauss ready	Test inactive

KNOWN ISSUES

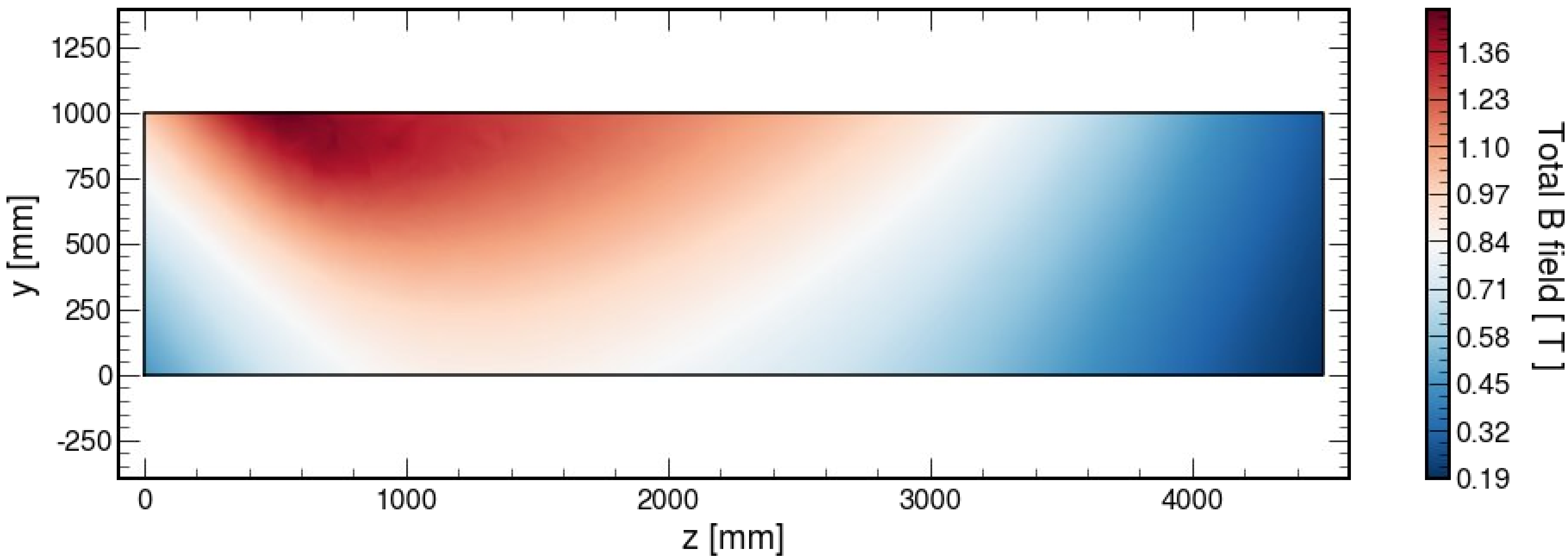
Magnet	need to implement DeMagnet for now magnetic field is turned off
ParticlePropertySvc	not available, using Gaussino's table for now for more info see: Gauss!848

← no magnetic field

https://docs.google.com/spreadsheets/d/1-0kgbYxsgo2HrLx2uBtzJhwX_tlNHkD1Lm6krA5MI70

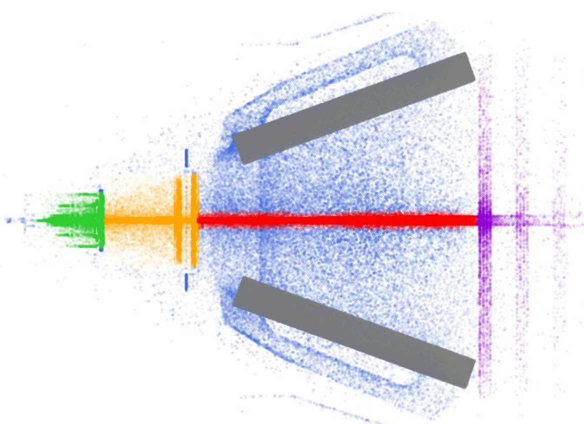
Physics conditions

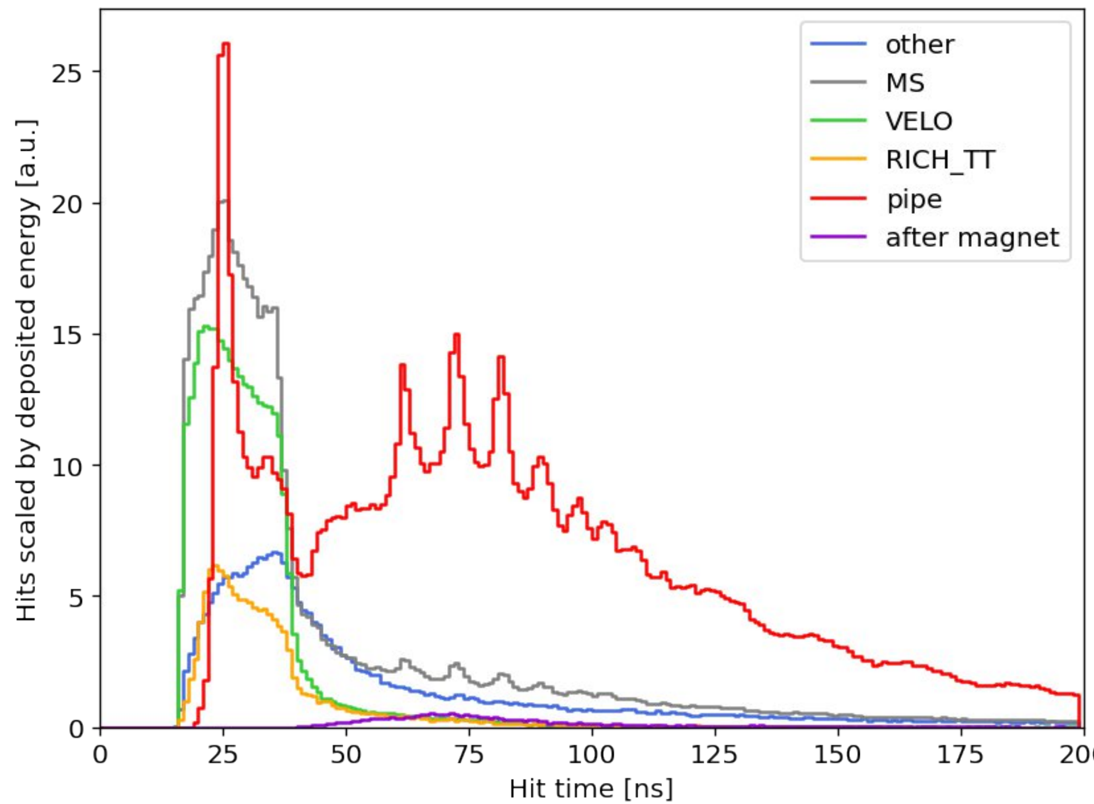
Magnetic field inside the MS makes it unique and breaks most of the classical track reconstruction algorithms.



Backgrounds and timing

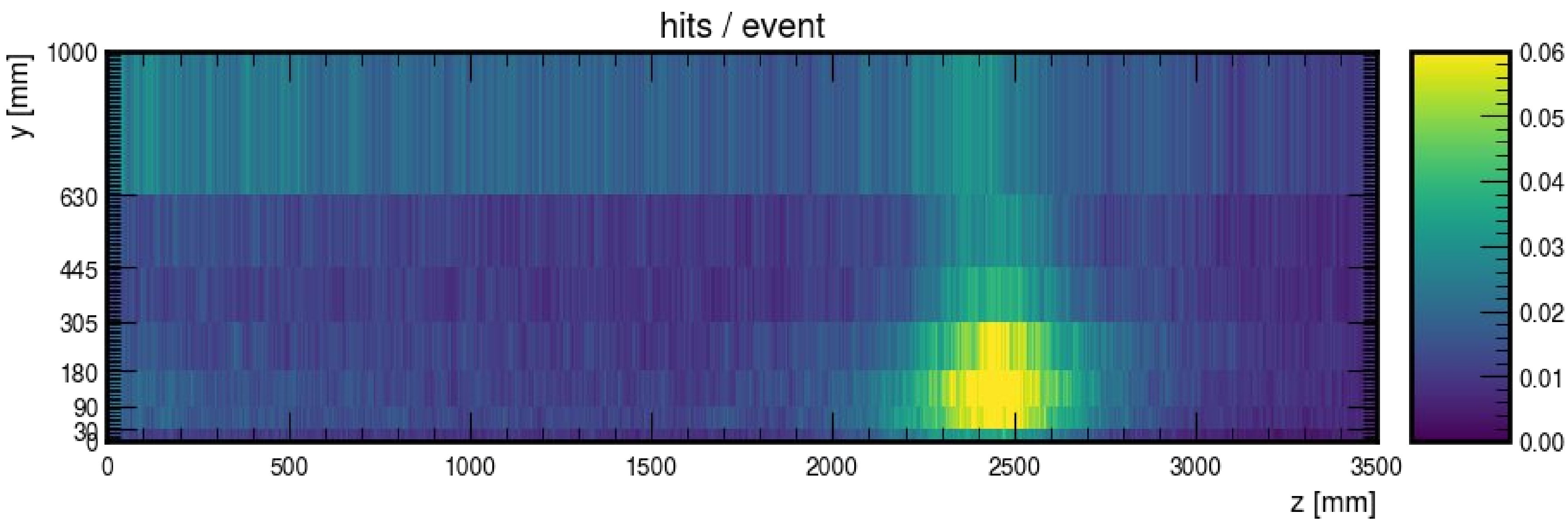
Most of the particles created in a primary collision hit MS in around 25 ns window.





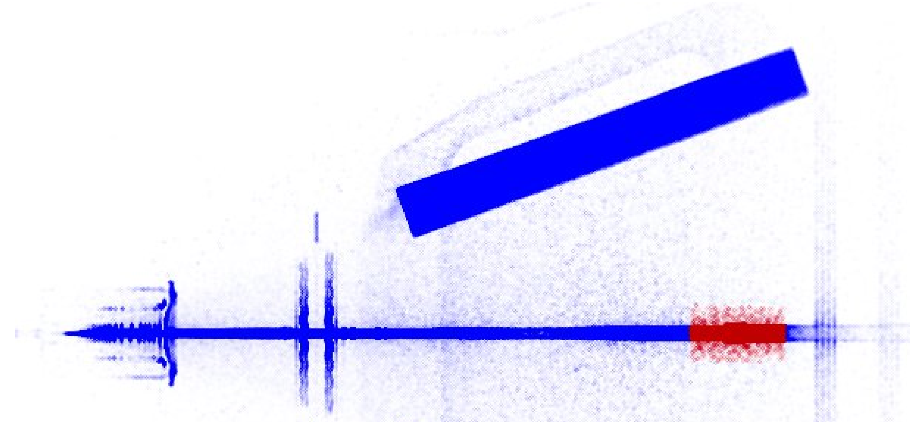
Backgrounds

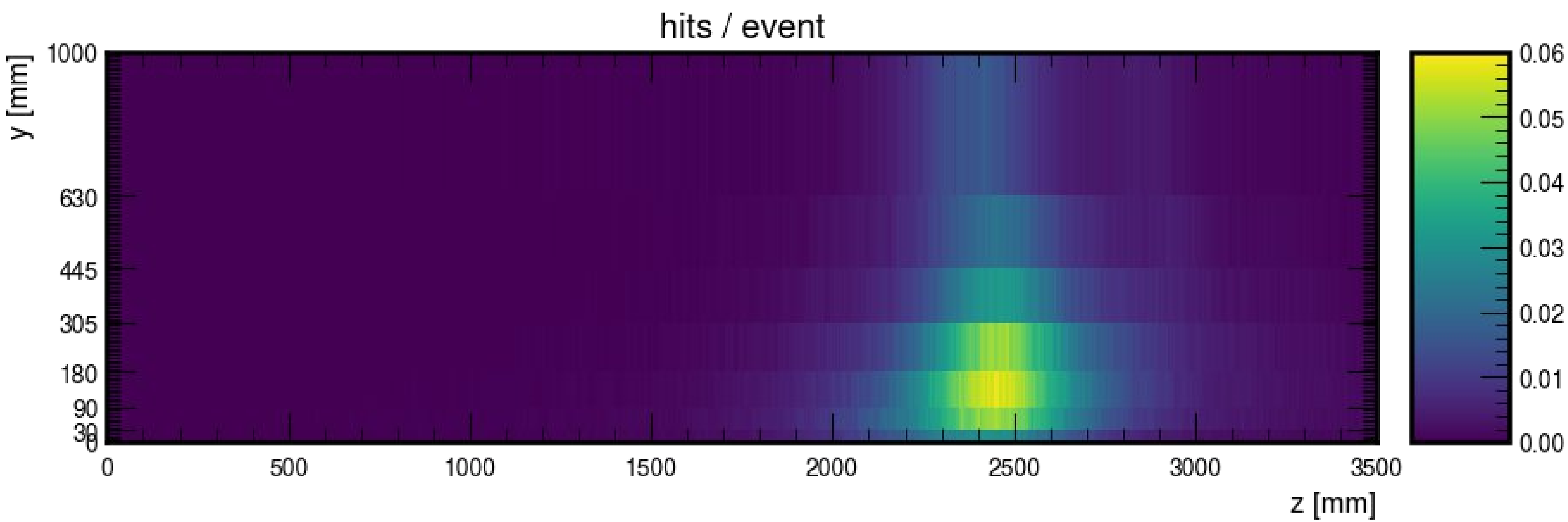
Most of the background comes from the beam pipe and structure around it. The detector granulation makes it mostly uniform with a one hot spot around z = 2500 mm.



Hot spot

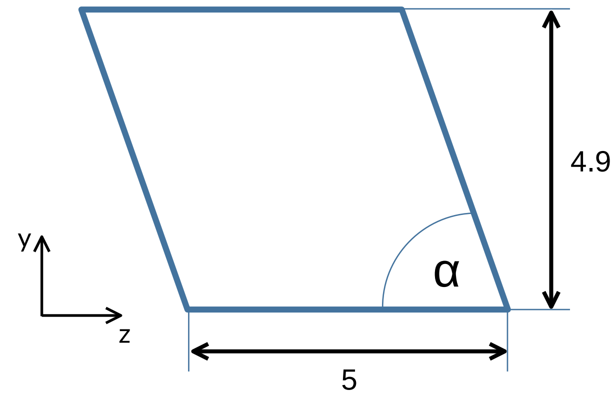
One of the main background will come from the beam support structure.

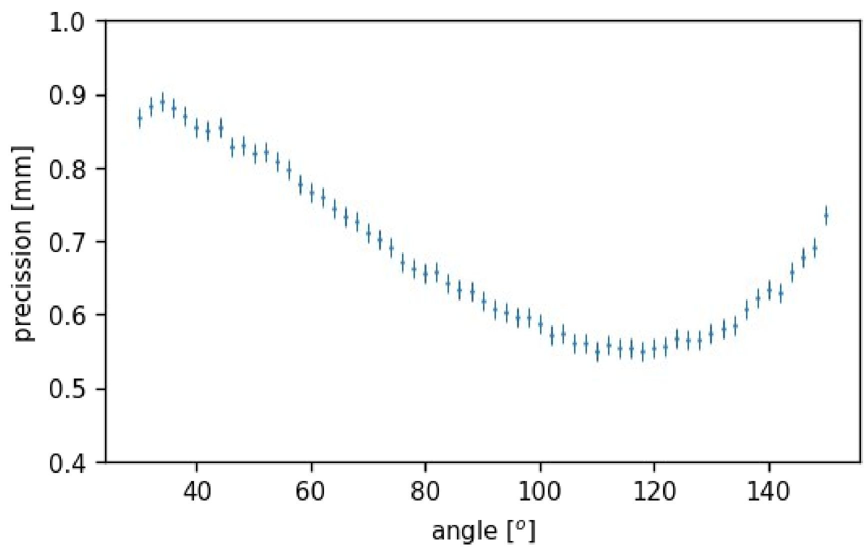




Cell shape

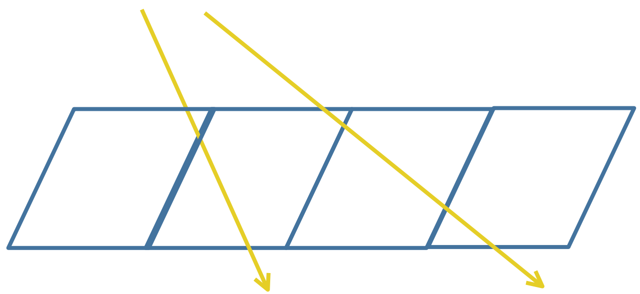
We simulated different shapes of cells. For a 4-level readout the best shape is tilted in the direction of the z-axis. With this setup, usually a final hit position is calculated as an average based on three bars.

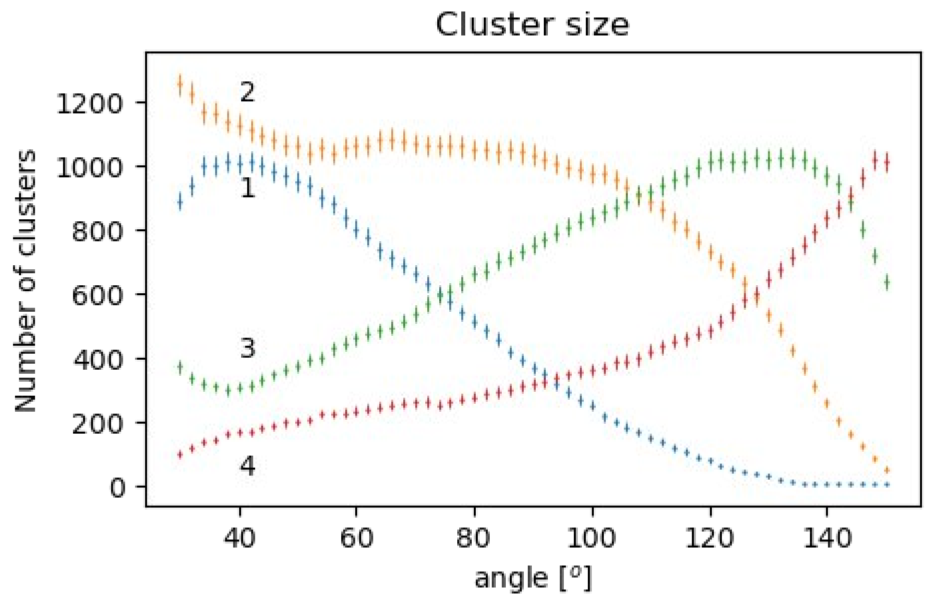




Cell shape

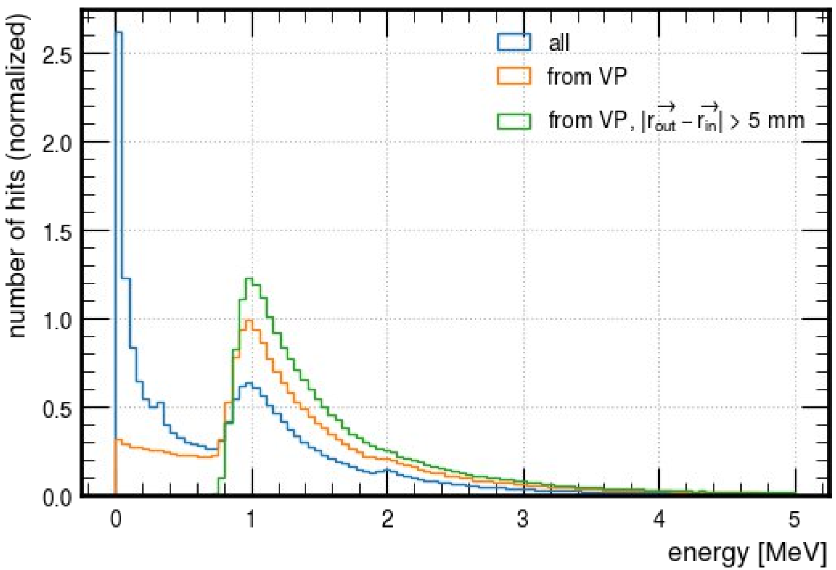
Most of particles from VP hit MS at angle of 30-50º. By changing the cell geometry we can modify the average cluster size.

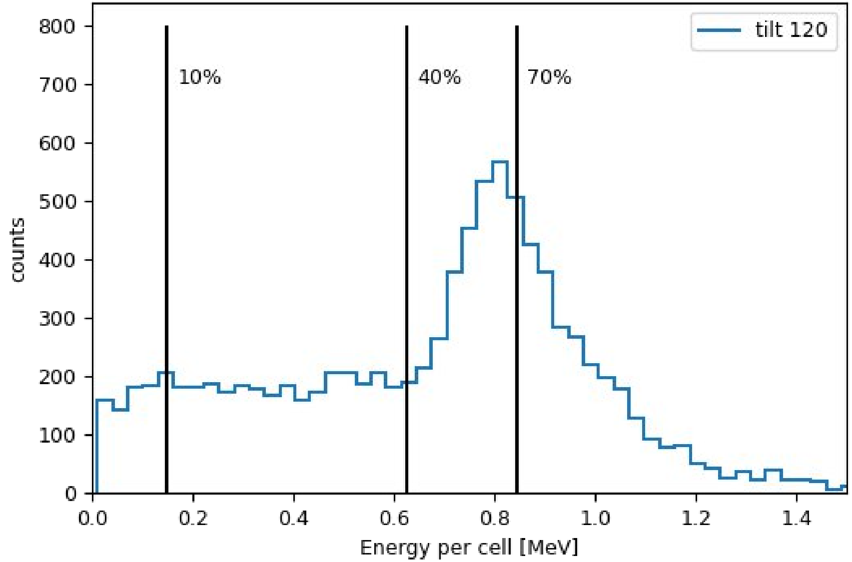




Energy threshold

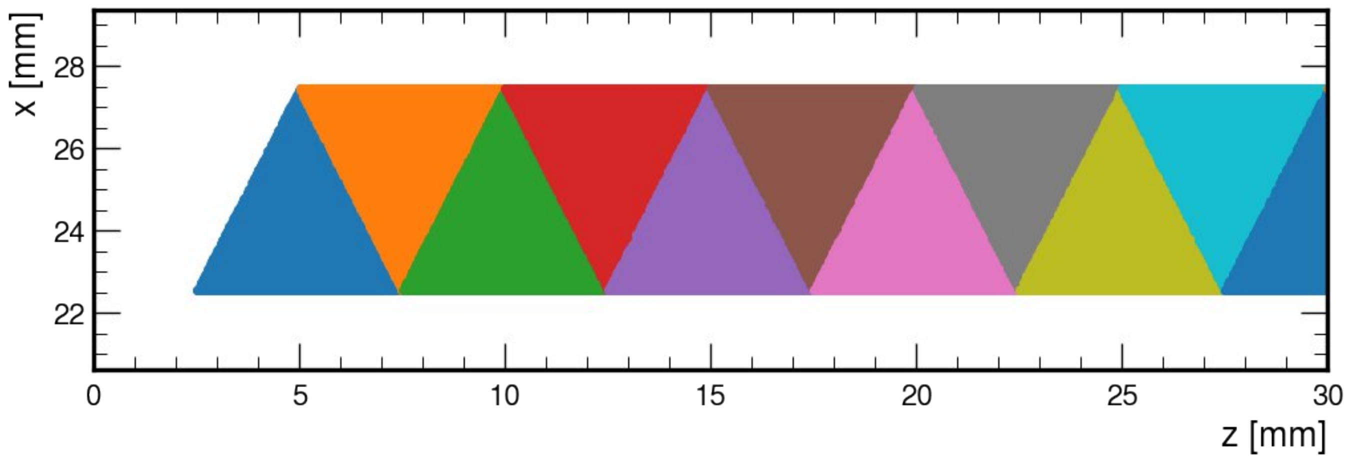
Most of the particles that are crossing the scintillators in and out deposit at least 0.8 MeV per layer.





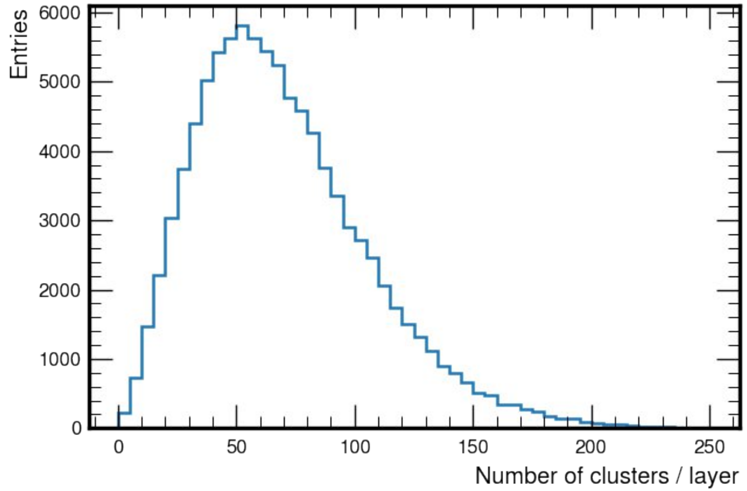
Number of clusters

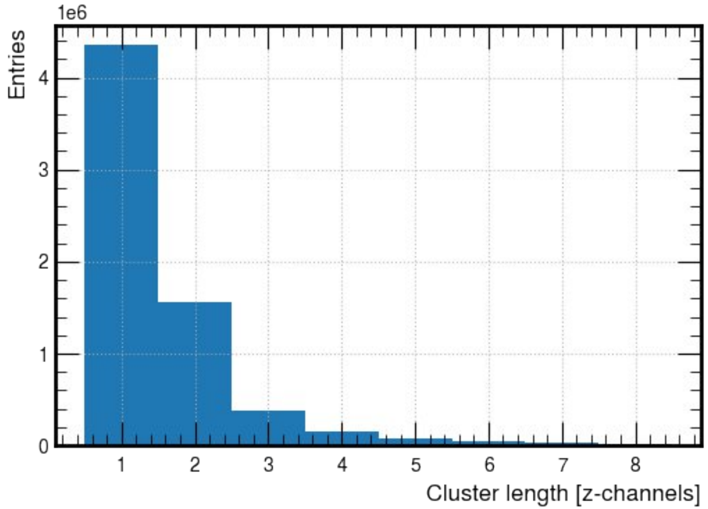
Precise study of clusters requires a simulation with the new detector shape, energy threshold, readout levels, timing and spillover, new cell shape and structural backgrounds.

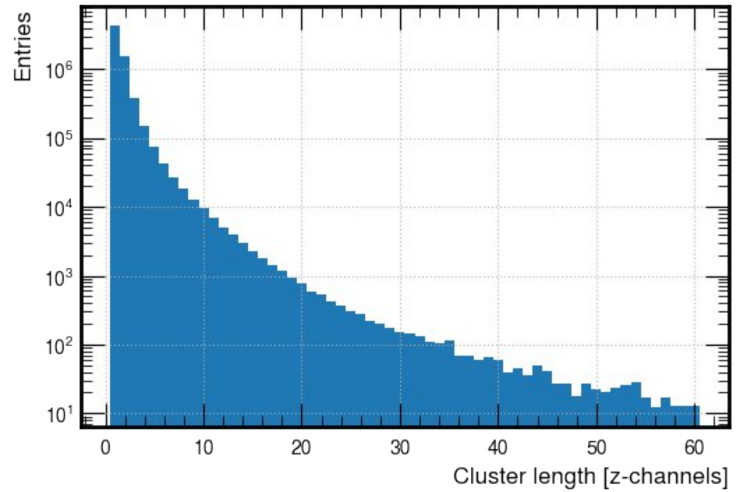


Number of clusters

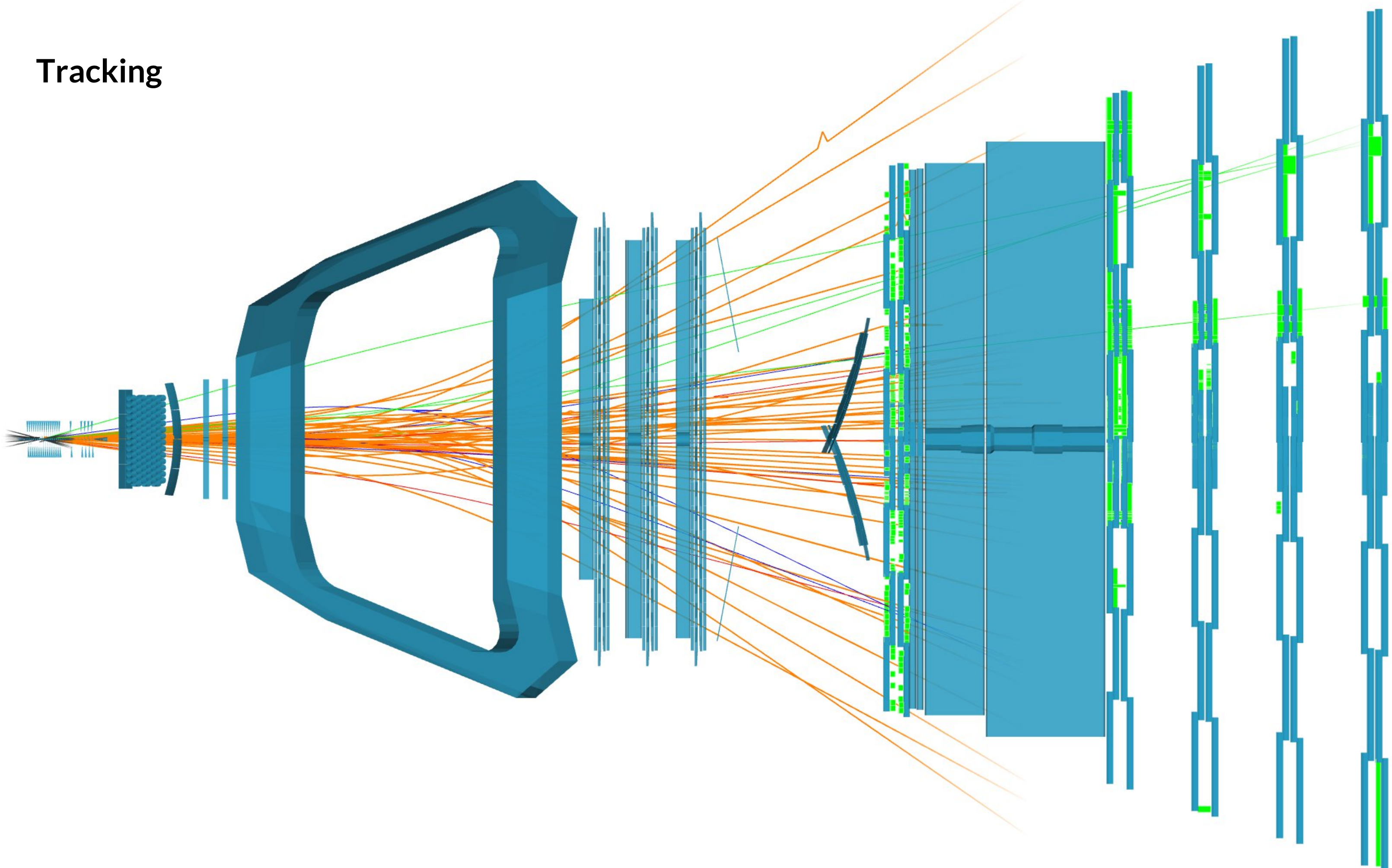
Estimation for the triangular bars with, with an optimistic threshold.



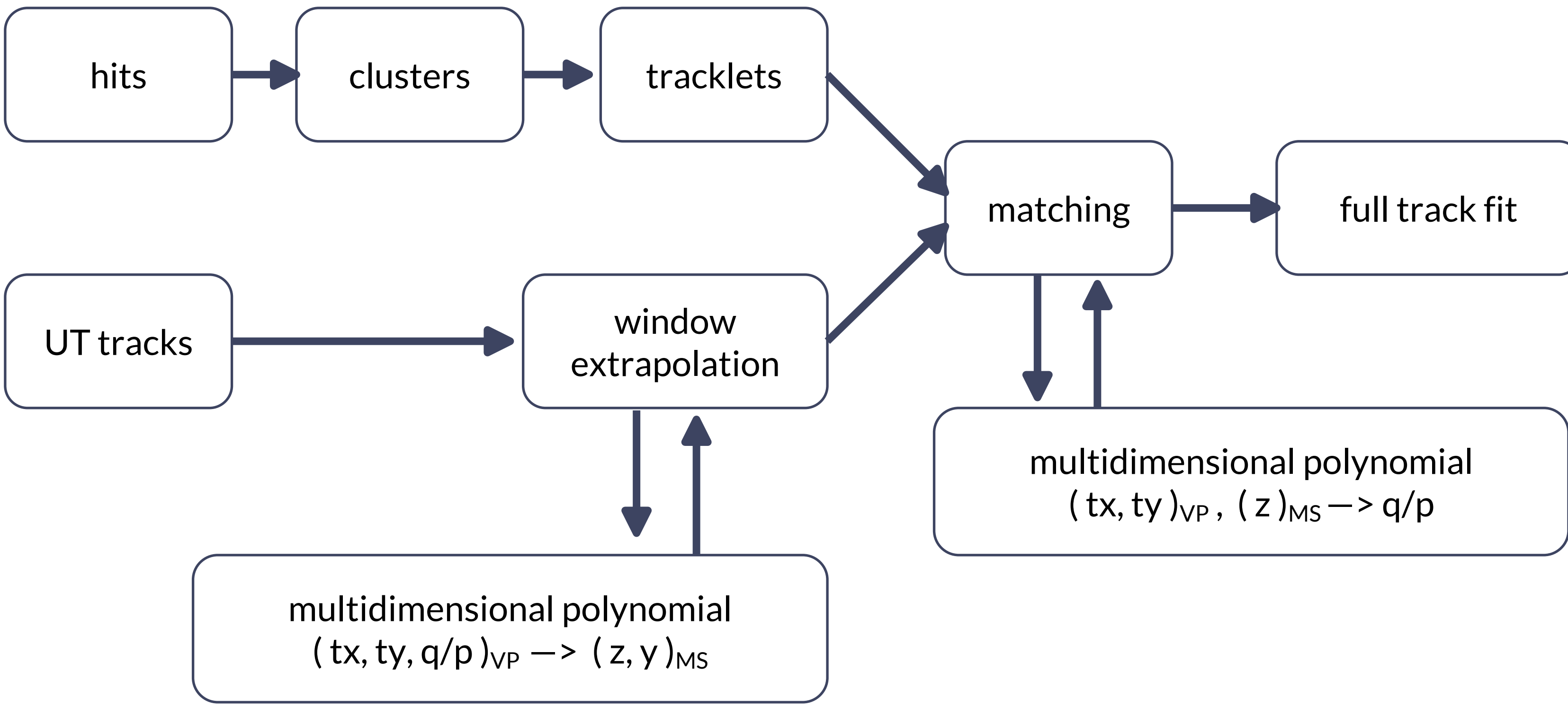




Tracking



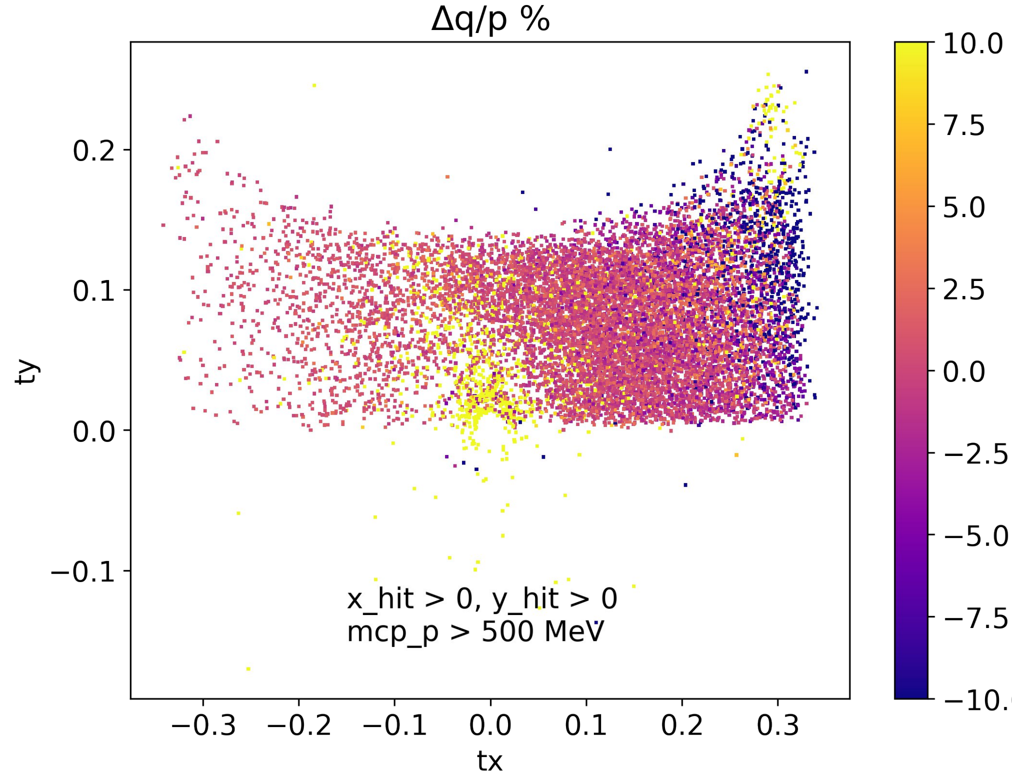
Tracking: option I



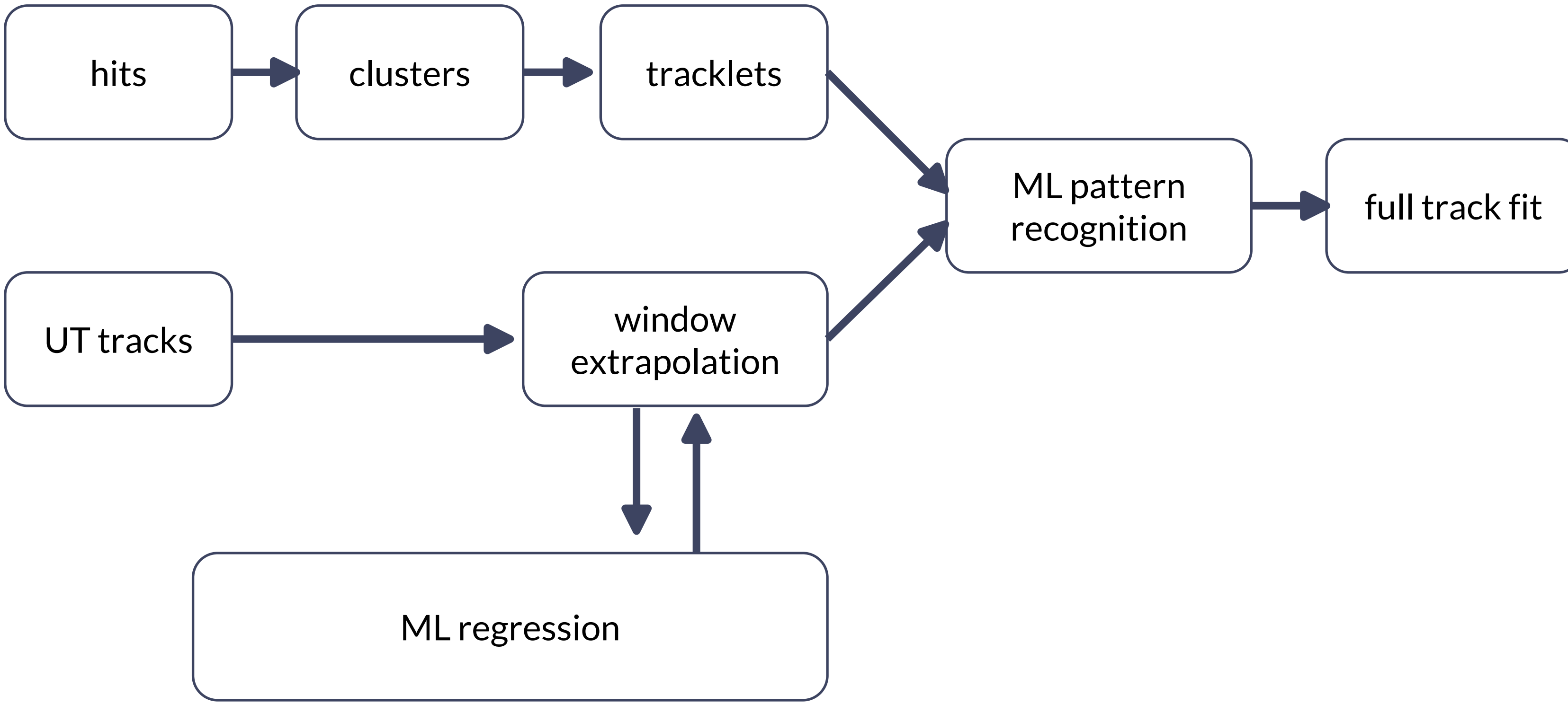
Tracking: option I

Pros: easy to fit with only MS geometry and a field map, easy to maintain, can be done parallel between UT tracks

Cons: less flexible



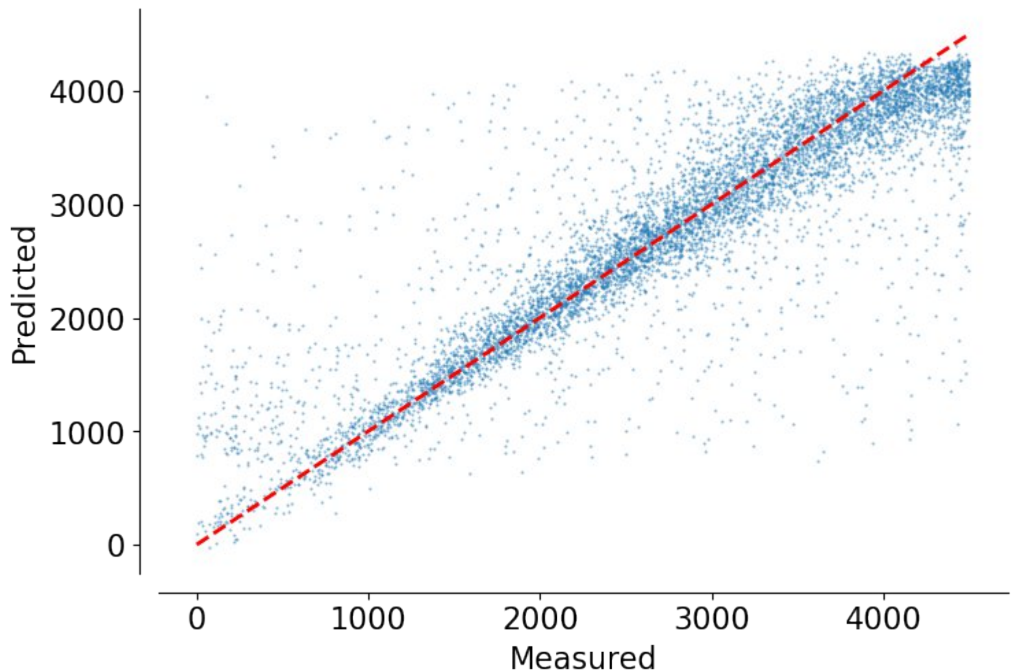
Tracking: option II



Tracking: option II

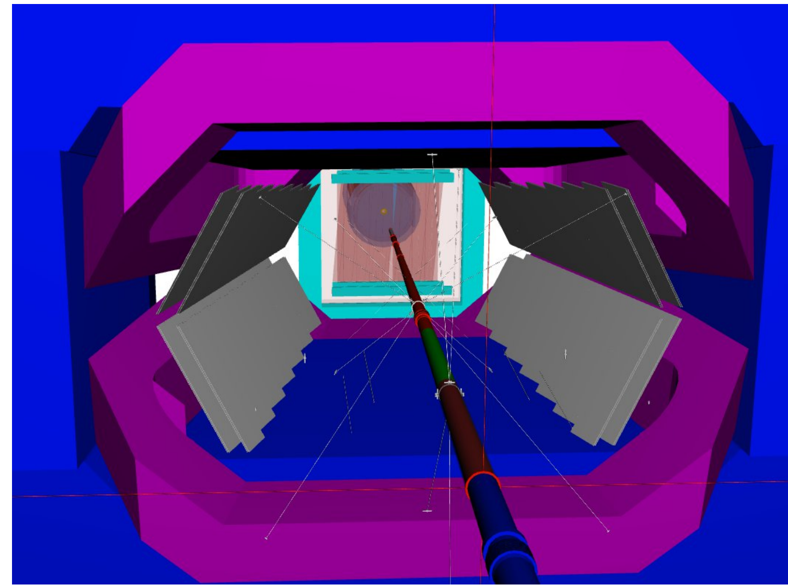
Pros: future proof, more precise fit, universal across panels

Cons: require proper simulated samples to fit, more complicated to implement, requires monitoring

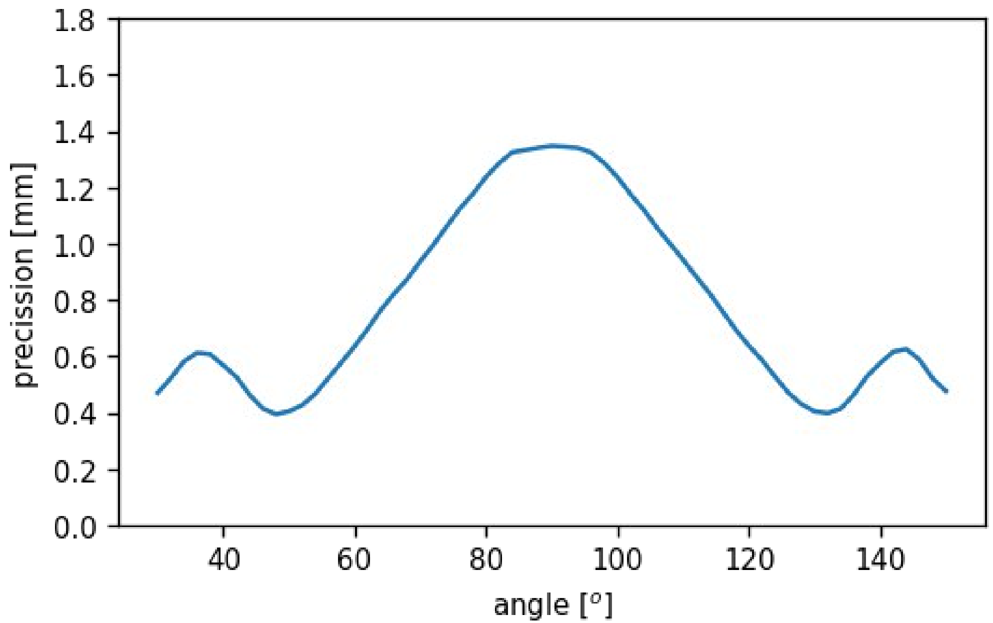


Things to do with the MS simulation

1. Parameters for the readout design
2. Digitization and clustering algorithm
3. Look-up-table
4. Tracking algorithm – simple version
    1. UT extrapolation to MS
    2. UT tracks vs Traklets matching
    3. Ghost killing
    4. Track fit
5. Tracking algorithm – ML powered
6. Physics gain studies
7. Code maintenance
8. Integration with Bool
9. Support others in simulating MS



Backup



1.8
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1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
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100
120
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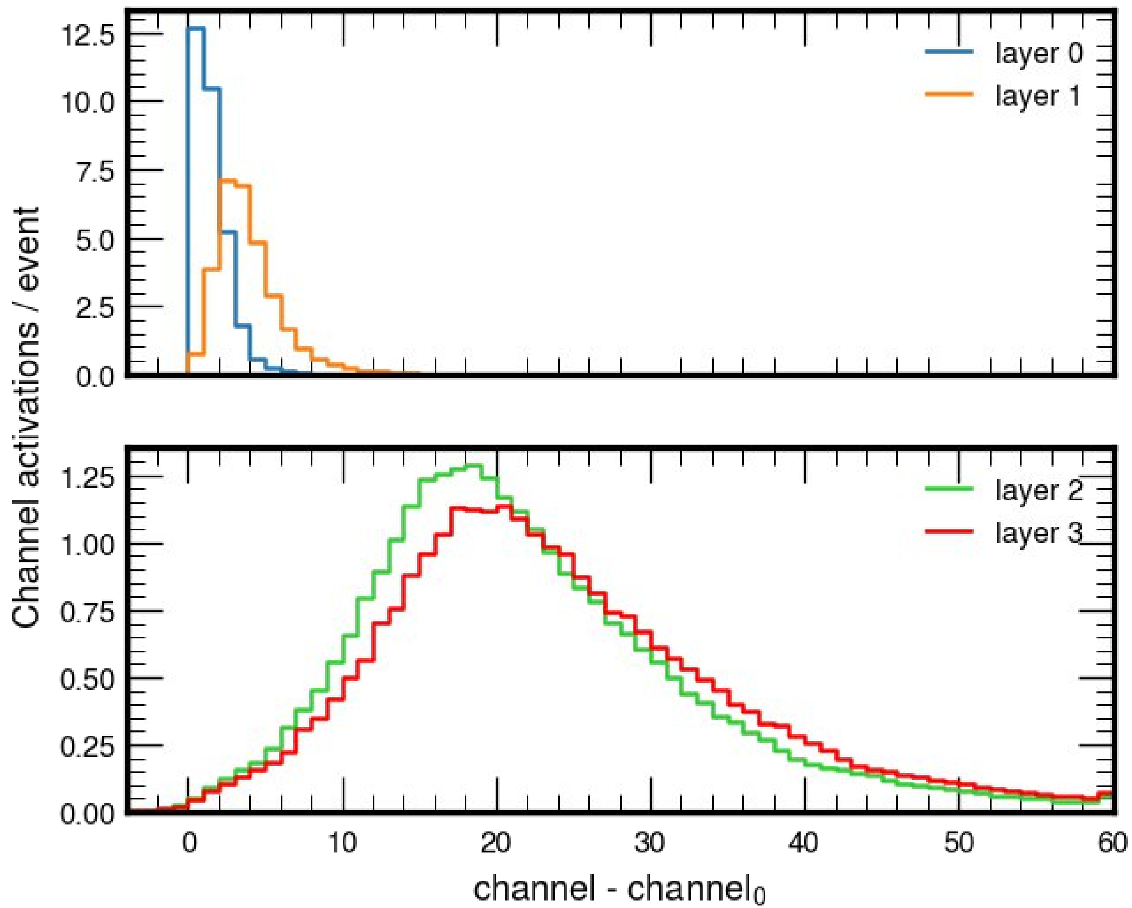
angle [^{o}]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layer 1
layer 2
layer 3
Channel activations / event
channel - channel$_0$
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10.0
7.5
5.0
2.5
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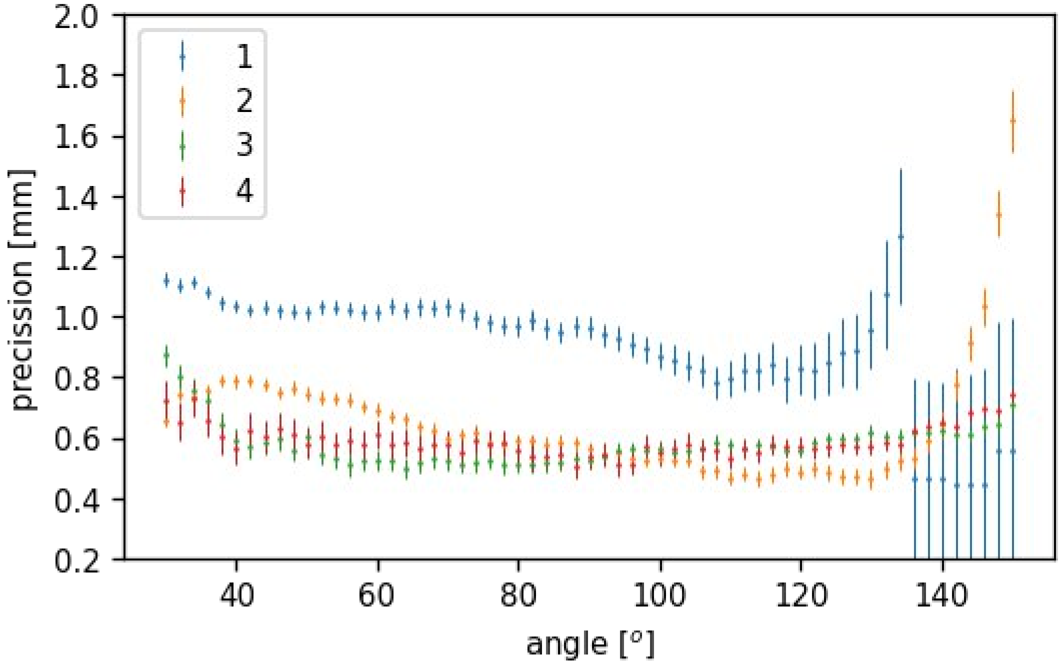
2.0
1.8
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0.8
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0.2
precission [mm]
1
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angle [^{o}]