Secondary Track Finder: a (*non*) new approach

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LI PANDA Collaboration Meeting – Jülich, 9 – 12 December 2014
Pattern Recognition Section

Recap: why do we need it?

- To reconstruct neutral particles decaying far from the IP it is necessary to write a pattern recognition without any constraint on the position of the vertex

The code I will present is available in **pandaroot/tracking**

- *structure classes* are available to have a more readable, modular and OO code*

https://subversion.gsi.de/fairroot/pandaroot/trunk/tracking/TrkAlgo
https://subversion.gsi.de/fairroot/pandaroot/trunk/tracking/TrkData
https://subversion.gsi.de/fairroot/pandaroot/trunk/tracking/TrkSecondary
https://subversion.gsi.de/fairroot/pandaroot/trunk/tracking/TrkStructure

**with respect to the very first version used in TPC/STT decision & STT TDR studies*

Recap: previously…

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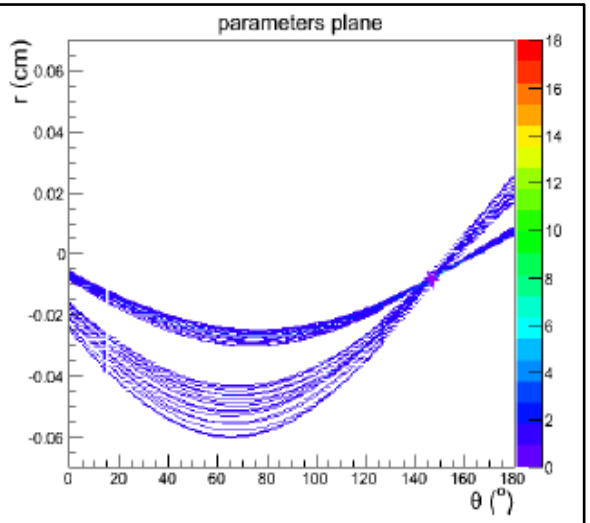
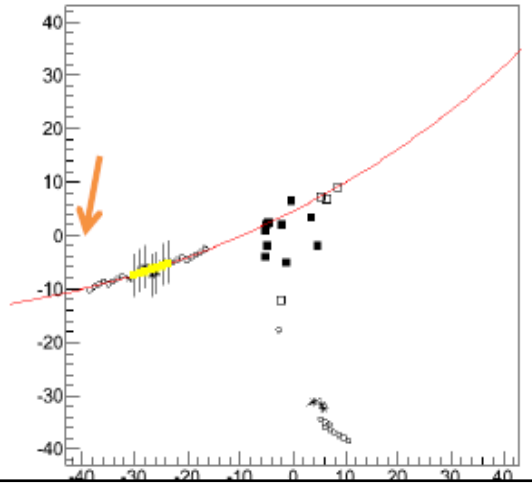
procedure

- the problem is divided in *xy projection* and *zϕ projection*
- *xy projection:*
  - Conformal & Legendre transformation
  - the CT transforms circular tracks into straight lines
  - the LT finds the straight line tangent to the hits belonging to the track
  - the hits are associated with distance criterion
  - the found track is refitted with a Least Square fit
- *zϕ projection:*
  - the projections of the skewed wires are drawn in the *xy* plane
  - if they intercept the track they are associated to it
  - a straight line fit is performed in the *zϕ* plane

- *the CT needs a translation to a point on the track: for primaries it is the IP; for secondaries it is the minimum isochrone tube center*





Recap: tracks not stemming from IP

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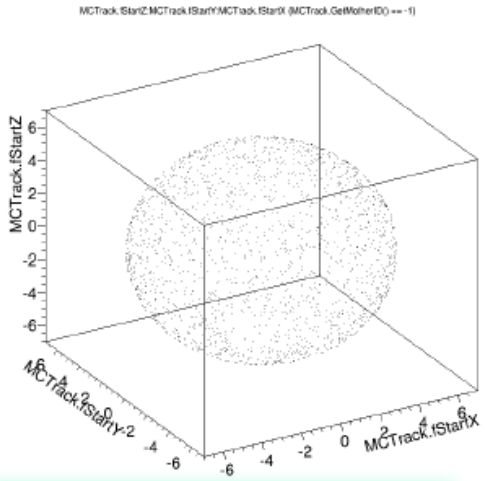
Secondary tracks

1000 μ^- events generated over a sphere centered in the IP with radius = 6 cm
multiplicity = 2, momentum = 1 GeV/c

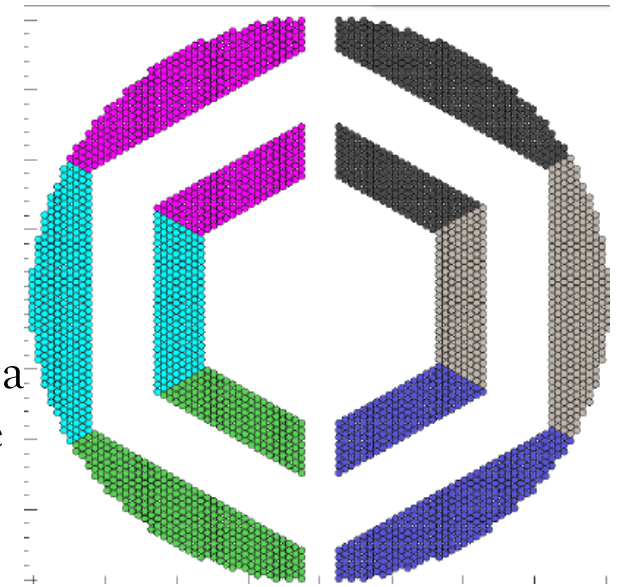


# Tracks	p (GeV/c)	Good	Wrong	Missed	Ghost	Ignored
4	1	0.46	0.43	0.12	0.41	0.31

The results are **not good**:
Too many wrong trks
Too many missed
Too many ghosts

Proposed solutions:

- Fine tuning on the required hit-to-track distance
- Sectorization
- Avoid using the pixel due to a problematic treatment of the noise ← NOW FIXED



Recap: $p\bar{p} \rightarrow \Lambda\bar{\Lambda}$

```
Decay pbarpSystem
      1.0 anti-Lambda0 Lambda0 LambdaLambdaBar 1.643;
Enddecay
```

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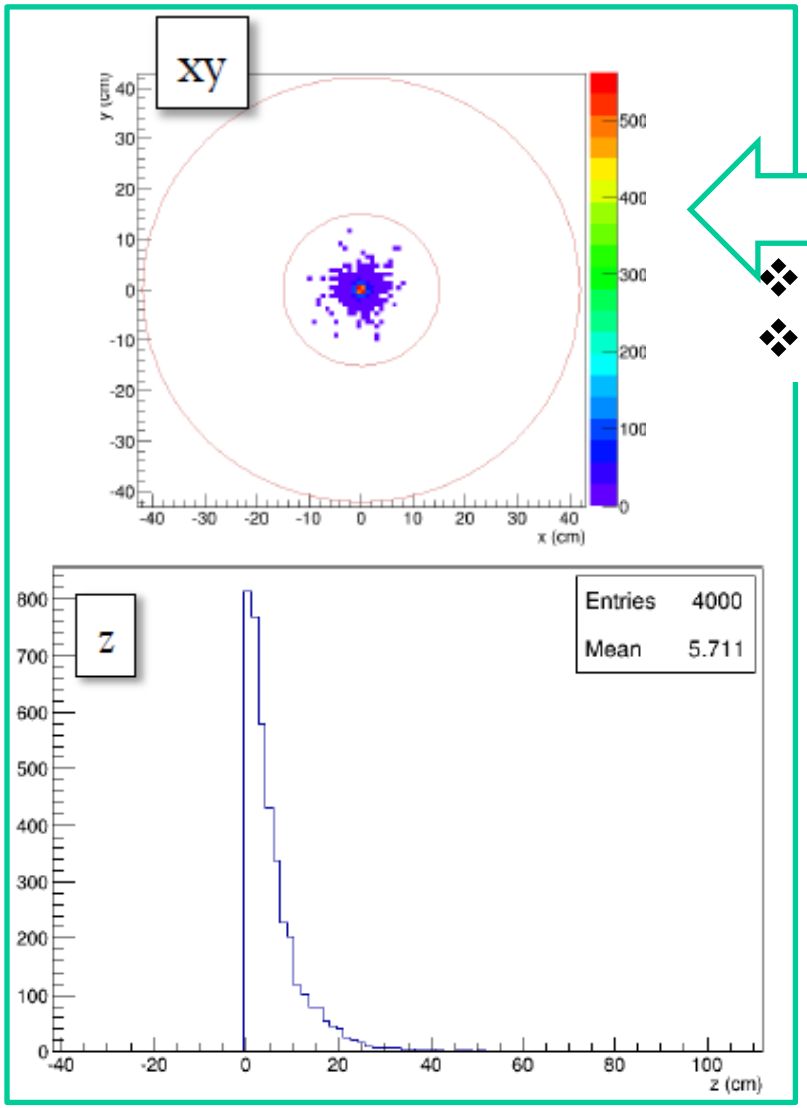

Specific issues:

displaced vertices
- ❖ inside the STT inner radius
- ❖ fwd boost

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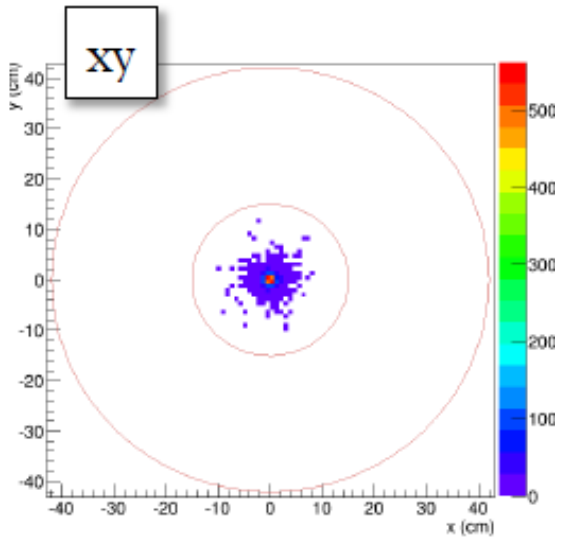
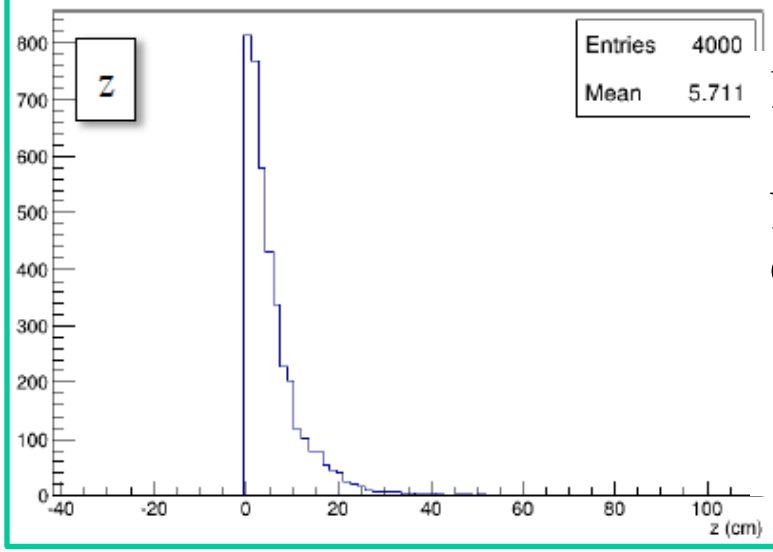




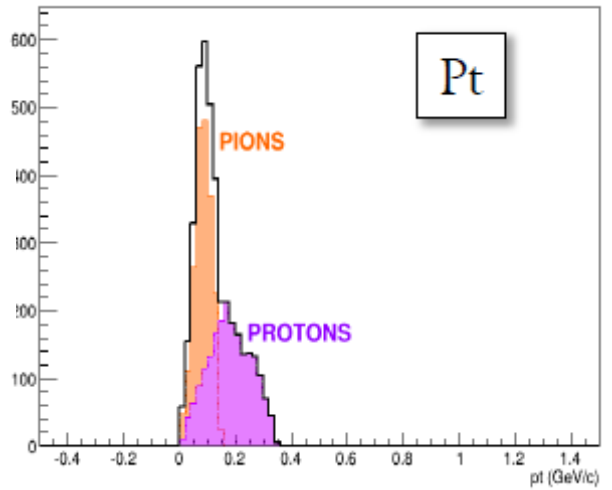
Specific issues:

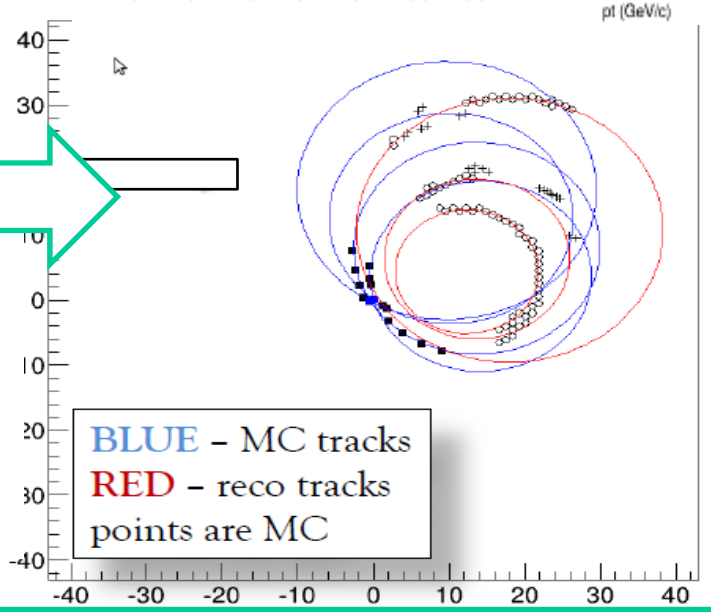
displaced vertices
- ❖ inside the STT inner radius
- ❖ fwd boost

low P_T
- ❖ looping particles

BUT

@ 1.643 GeV/c half magnetic field→ radius of curvature is twice this one





November 2014: a new start

... keeping in mind the past experience, particularly:

Hough T

in real plane with drift

- ❖ Apollonius problem: does not give good results

Conformal T

- ❖ is (almost) necessary to fit the tracks easilly (analitically)
- ❖ the origin needs to be translated near the track

Legendre T

in conf. plane with drift

- ❖ the origin needs to be translated near the track
- ❖ needs a good peak finder to be used as track finder
- ❖ good as track fitter

Clusterization

- ❖ cleans the sample
- ❖ can find crossing tracks as a unique track → cleaning needed

Sectorization

- ❖ lowers the noise
- ❖ may cut tracks crossing two sectors

hit-to-track distance

- ❖ gets more hits (→ better efficiency)
- ❖ gets also wrong hits (→ worse purity)

The *new* strategy

Divide the problems

- find the *long* tracks first, without information on the vertex
- find the *looping* tracks afterwards

Take inspiration from the past experience of all groups

- **Triplet Finder** → the idea to have pivotal layers, BUT not considering the IP as one of the triplet hits!
- **Cell Finder** → consider as indivisibles the unambiguous tubes
- **Conformal map** → to transform circles into straight lines
- **Legendre transform** → to fit the track

The primary – secondary track finder interaction

Up to now it was given as a fact that the primary track finder should leave unassigned *all and only* the secondary track hits together with the background and/or time overlap hits

BUT

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BUT

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Simulation of $p\bar{p} \rightarrow \Lambda\bar{\Lambda}$ at 1.64 GeV/c

Case	Particle	Eff (%)
Ideal	Λ	56
	Λbar	44
	Λ, vertex fit	45
	Λbar, v. fit	38
	ΛΛbar	13
Nonideal	Λ	20
	Λbar	16
	Λ, vertex fit	15
	Λbar, v. fit	13
	ΛΛbar, v. fit	1.9

The results for the ideal case agree with the Physics Book results.

The results obtained with ideal and real P.R. disagree.

BUT: improvement by a factor of 2 since April!

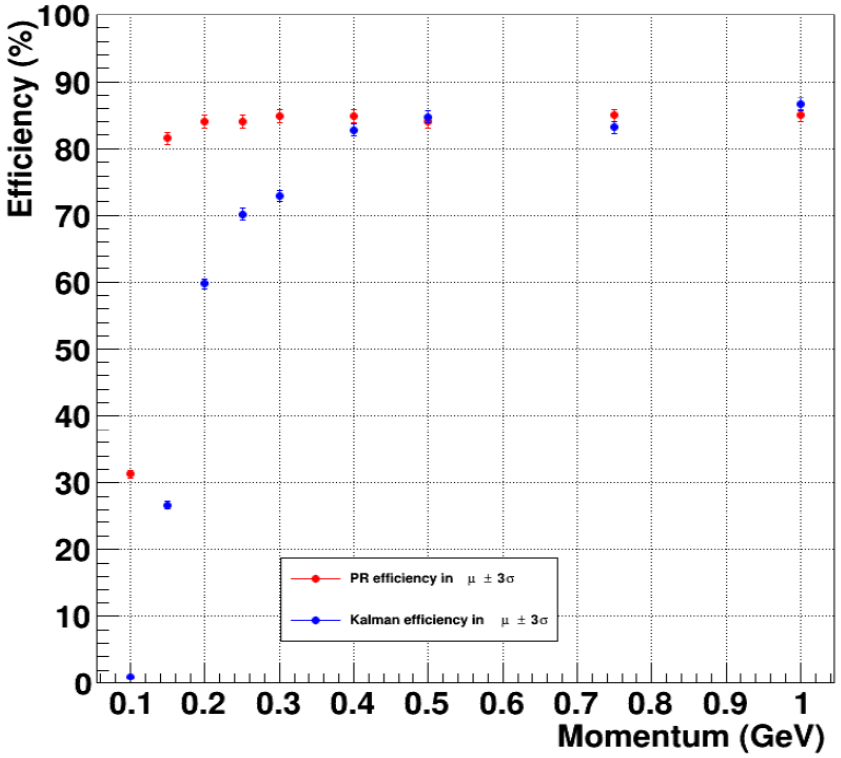
Actually the primary track finder can reconstruct tracks which originate:

- ❖ up to some mm from the beam line in radial direction
- ❖ up to some cm in z direction

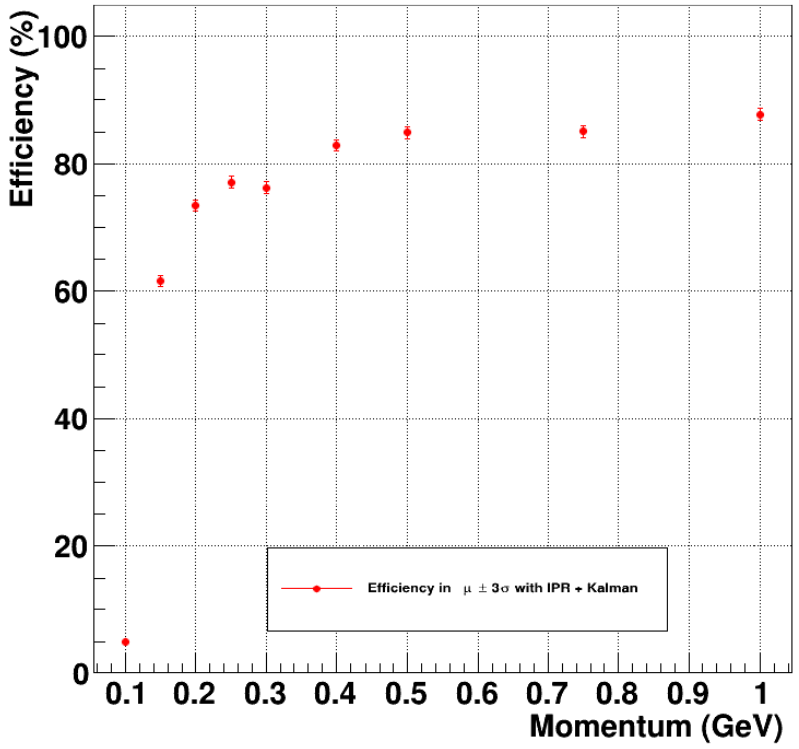
The Kalman filter issue

The Kalman filter has a drop for low momentum particles
The efficiency is much lower than the realistic primary track finder

PR vs PR+Kalman



Ideal PR + Kalman



SUSANNA COSTANZA @ SOFTWARE SEEVOGH MEETING - 23 JULY 2014

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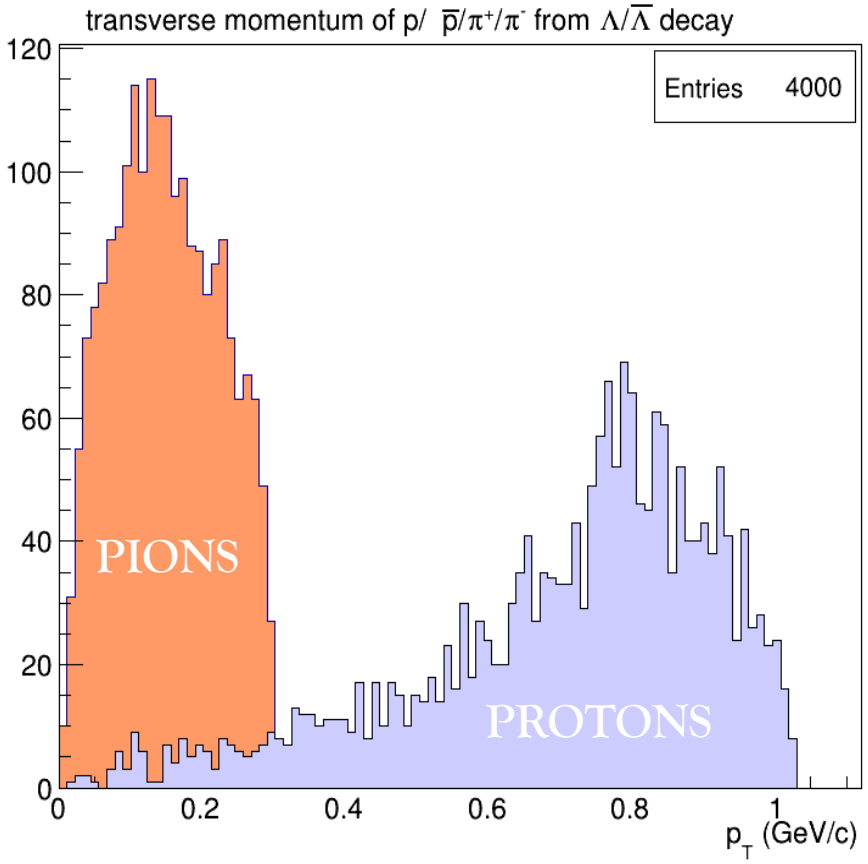
Divide the problems

- find the long tracks first
- the looping tracks afterwards

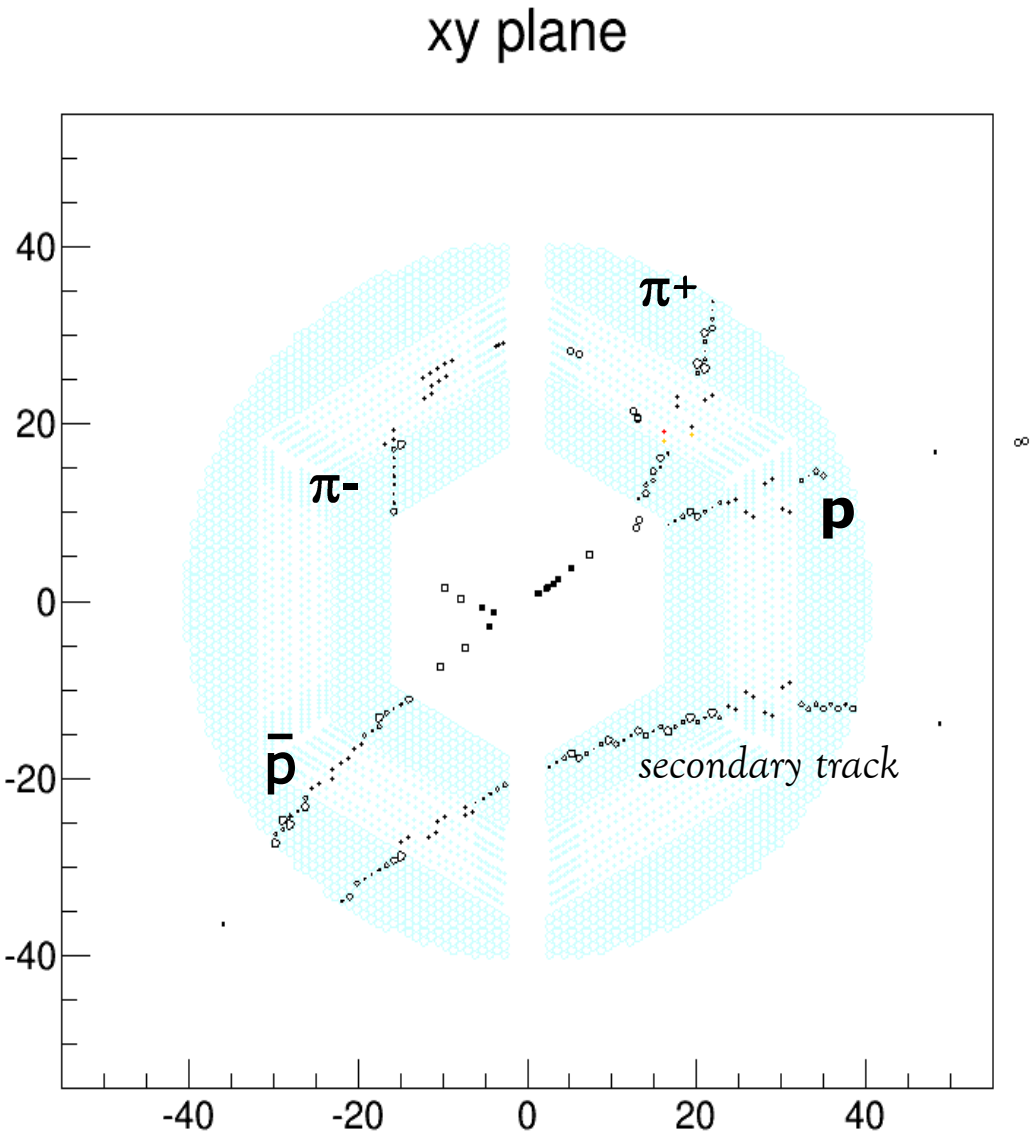
MC generation

@ 4 GeV/c

```
noPhotos

Decay pbarpSystem
   1.0   anti-Lambda0   Lambda0      PHSP
Enddecay

Decay Lambda0
   1.0   p+ pi-         PHSP;
Enddecay

Decay anti-Lambda0
   1.0   anti-p- pi+         PHSP;
Enddecay

End
```



Example of an event



Example of an event

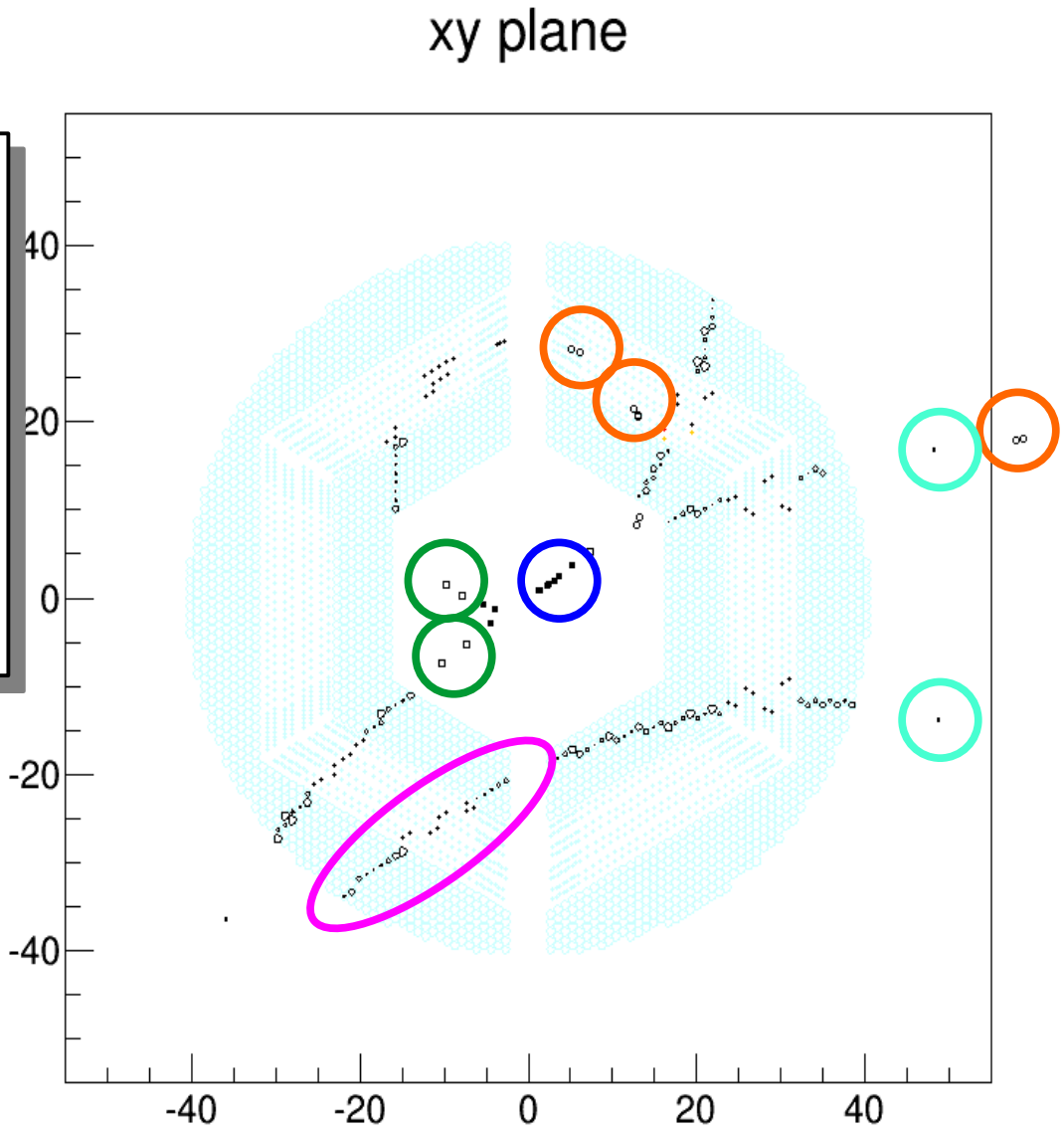
MVD PIXEL

MVD STRIP

STT

GEM

SCITIL



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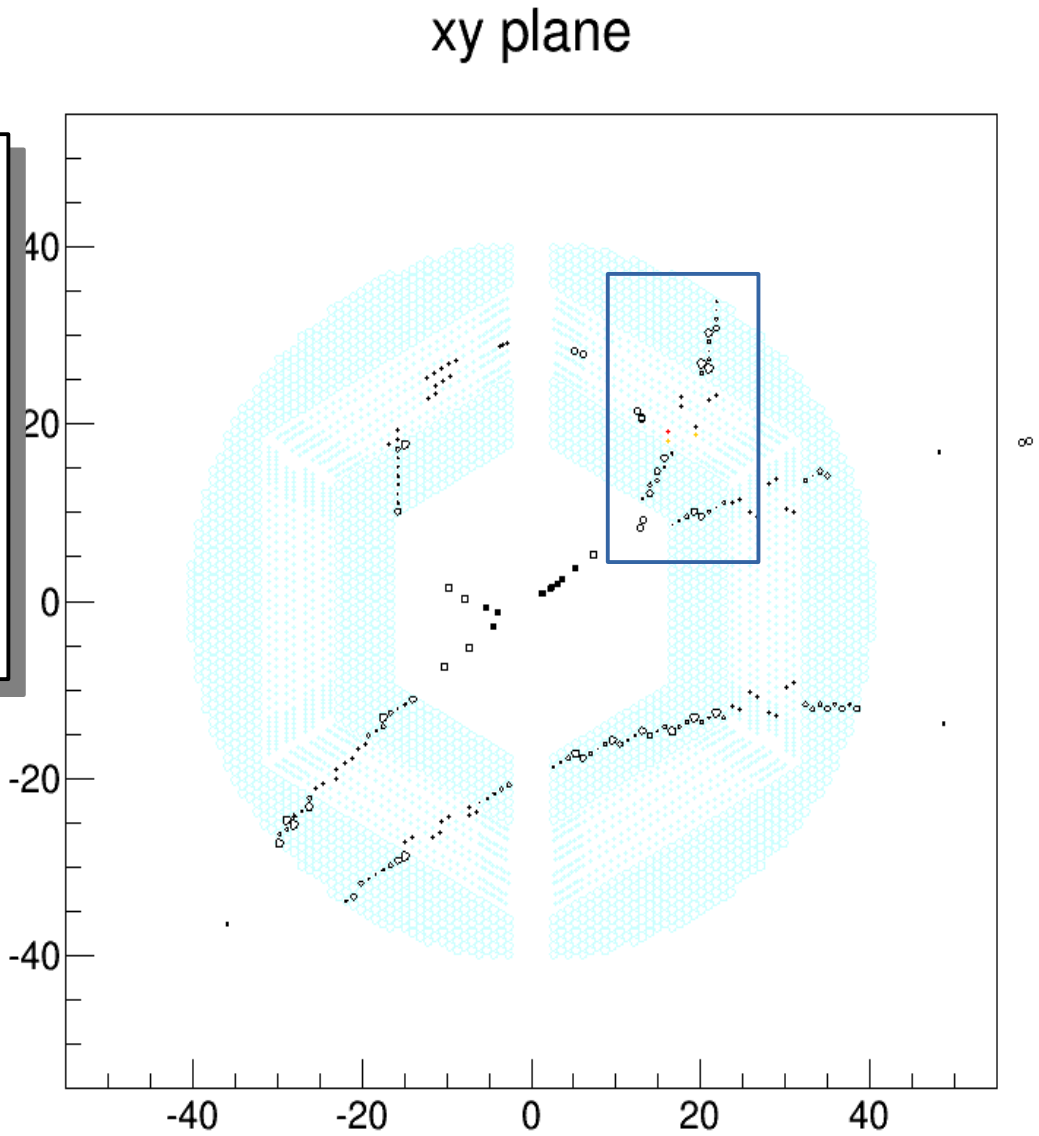

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Divide the problems

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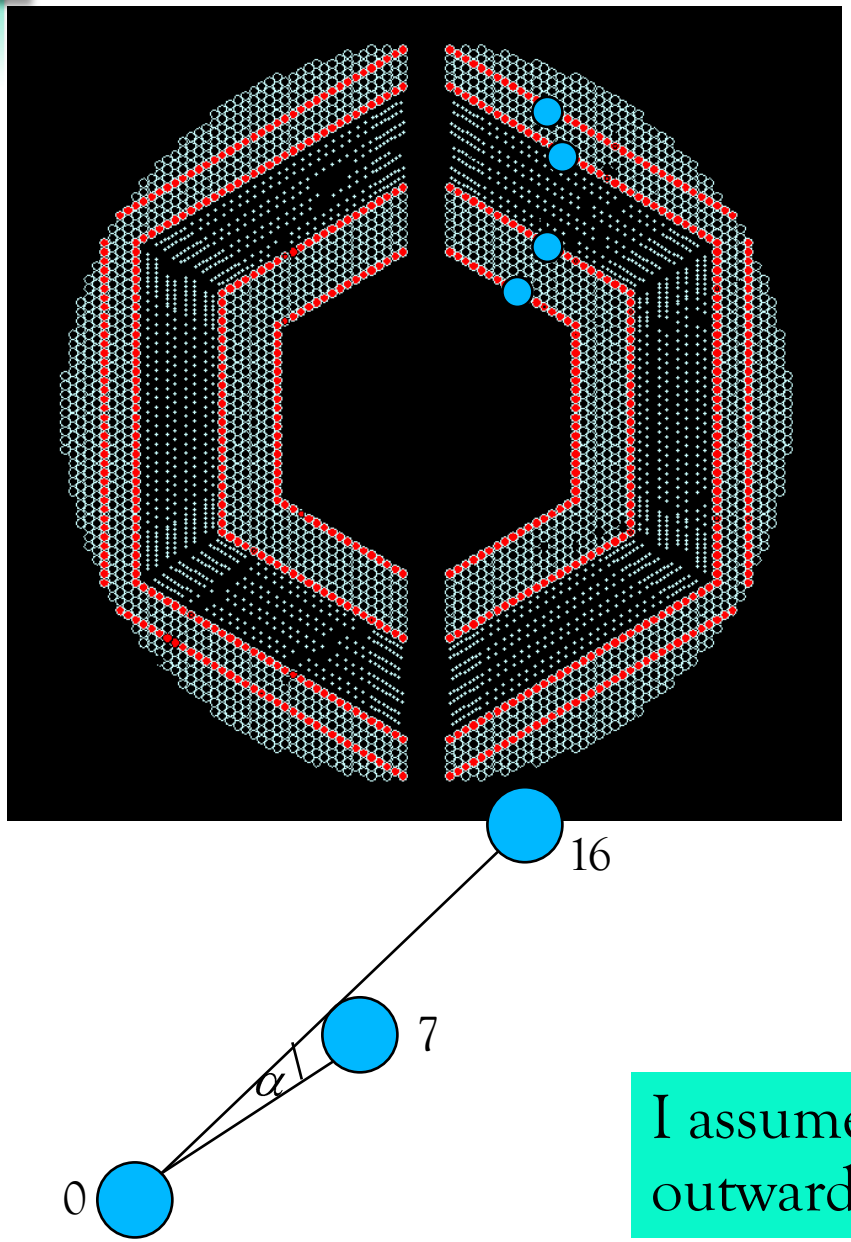
Create quadriplet of hits on parallel tube layers n. 0, 7, 16, 20 and *fit* a circle among them

Find a quadriplet



I search for hits on layers 0, 7, 16 and 20

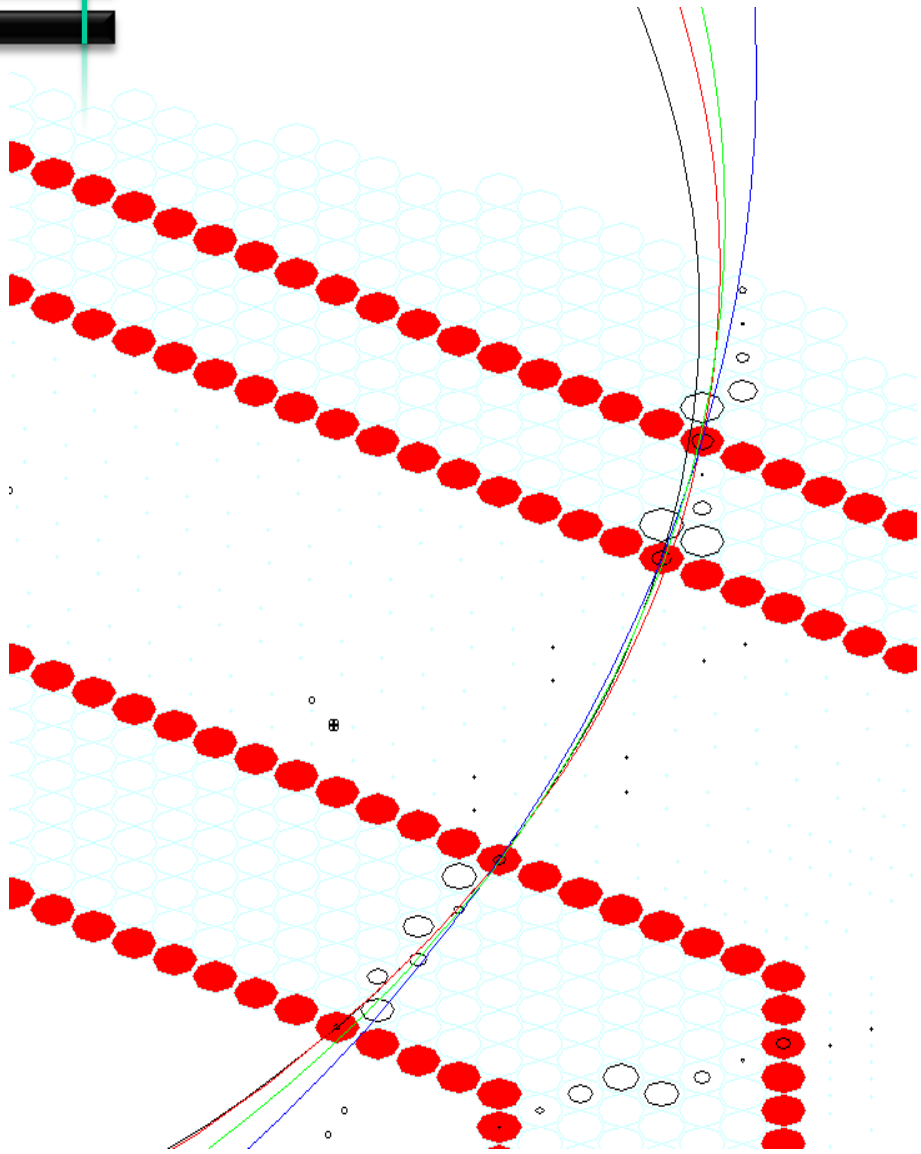
Combine the hits on layers 0 & 7
CUTTING on:
- xy distance < 10 cm
- $\cos\alpha > 0.94$

Combining duplets to hit on layer 16
- same CUTS

Combining triplets to hit on layer 20
- same CUTS

I assume the tracks come from the IP area and go outwards, but not (!) that they stem from the IP

Find a circle



Once we have quadriplets:

- Compute the circles through three points out of the four we have, using all the combinations:
  Black 0 1 2
  Red 0 1 3
  Blue 3 1 2

- Compute the *mean value* of x0, y0, R
  Green is the *mean value*

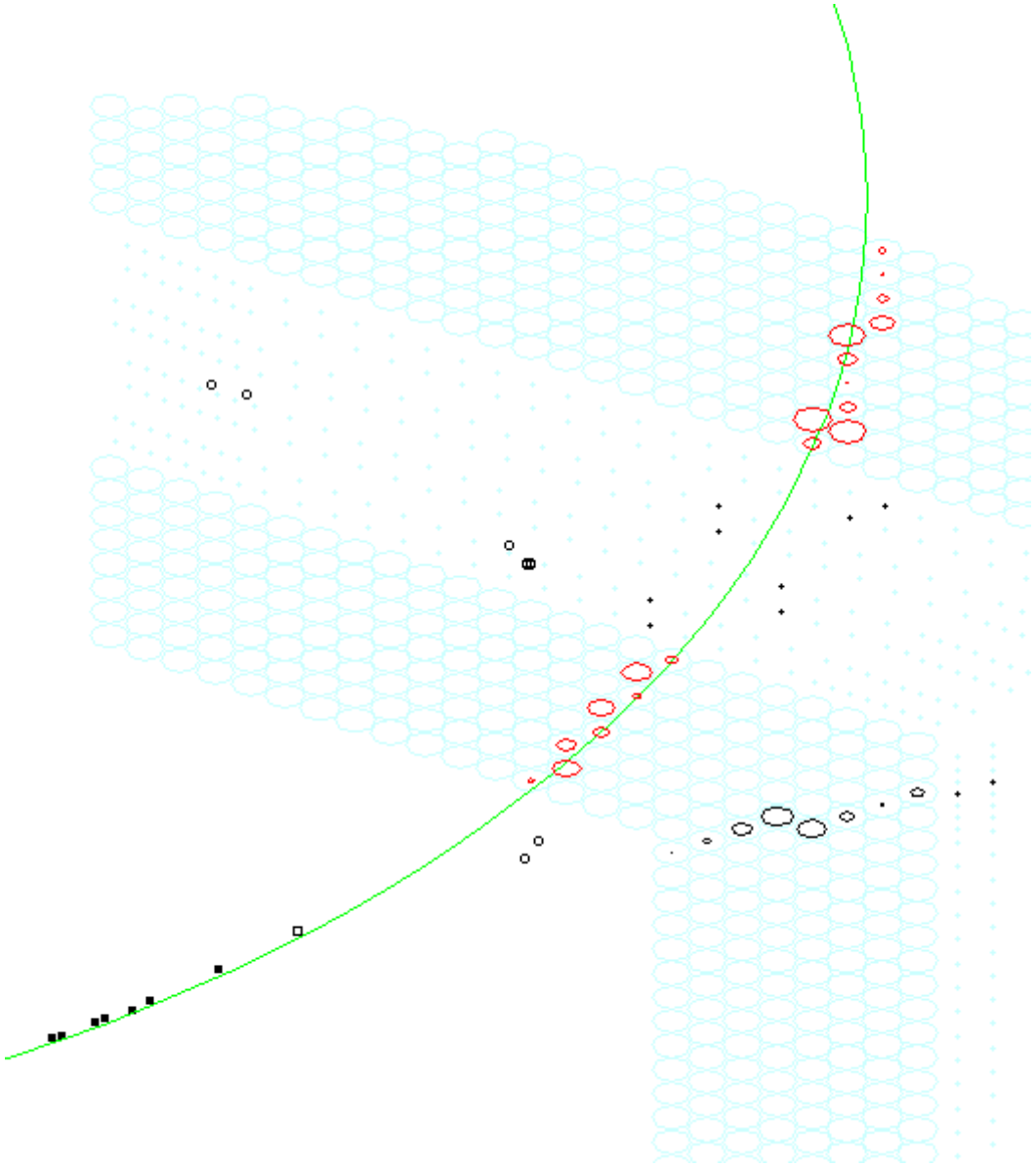
- The found line is taken as *prefit* around which the cluster hypothesis is built

- Suppress identical clones
- Request 10 < R < 2500
  - 10 because it touches layers 0 and 20 → minimum diameter = 20 * 1 cm = 20 cm → R > 10
  - 2500 [cm] = 15 [GeV/c] / 0.006

First cluster hypothesis

❖ A cluster is created in the same sector or nearby if at the limit of two sectors

❖ The STT hits are assigned if the hit-to-track distance < 1. cm



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Divide the problems

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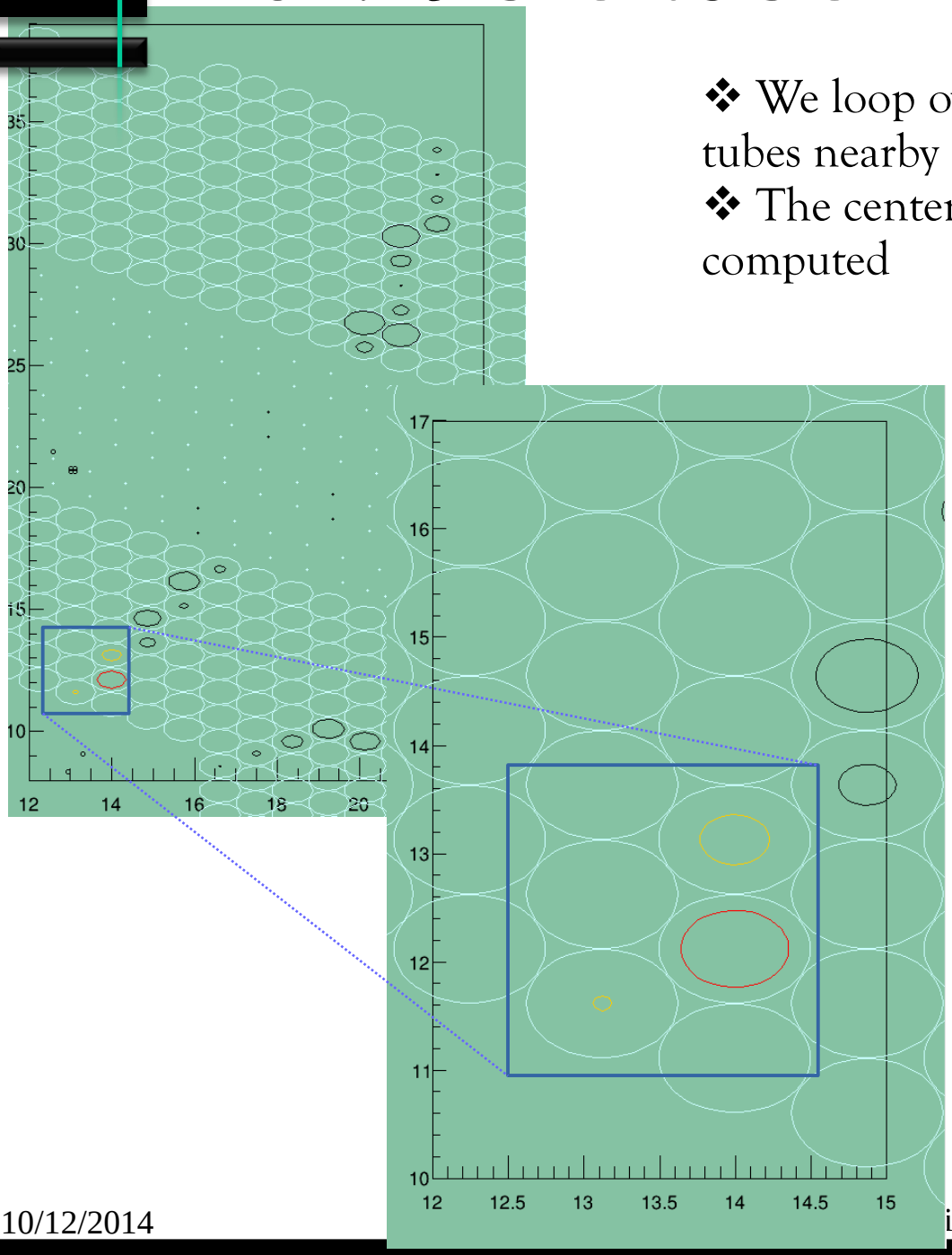
- the looping tracks afterwards

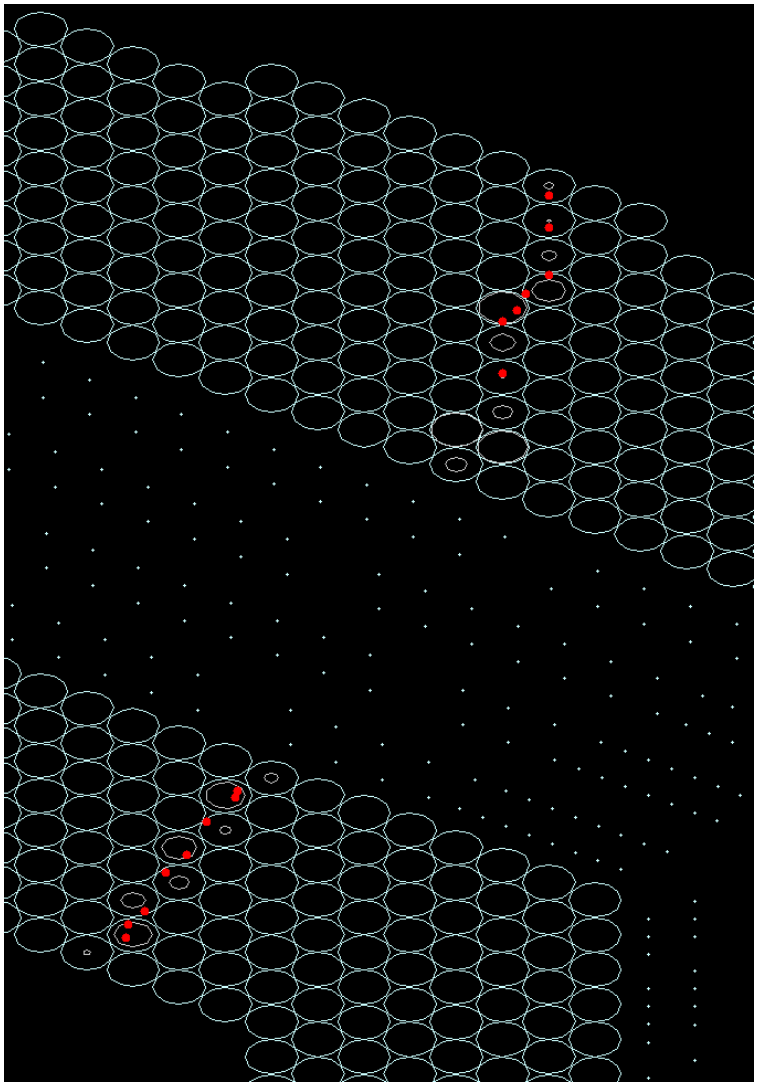
I need a point close to the track to go to the conformal plane
→ search for indivisible hits

Indivisible tube map



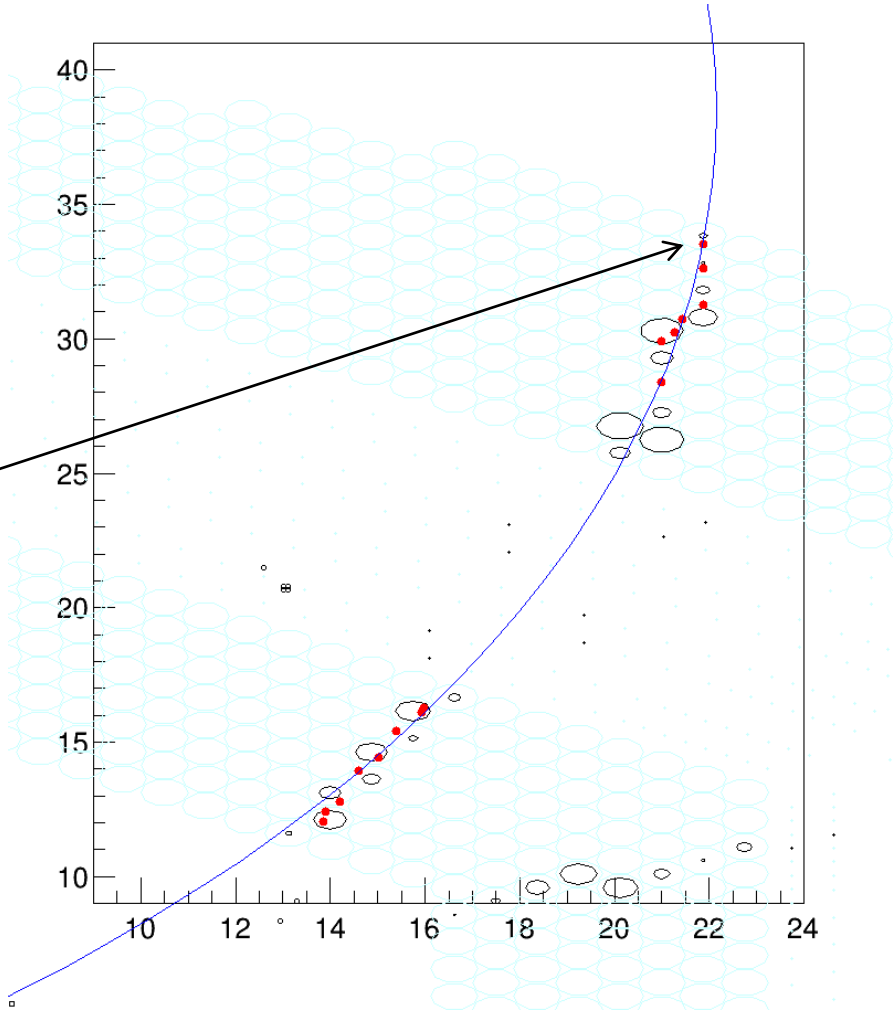
❖ We loop over the hits and if a hit has only two firing tubes nearby → the three hits are considered indivisibles

❖ The center of mass of the 3 indivisible drift circles is computed



First cluster hypothesis

- A cluster is created in the same sector or nearby if at the limit of two sectors
- The STT hits are assigned if the hit-to-track distance < 1. cm
- Add also the indivisible hits
- Translate on the LAST indivisible hit the origin of the axes



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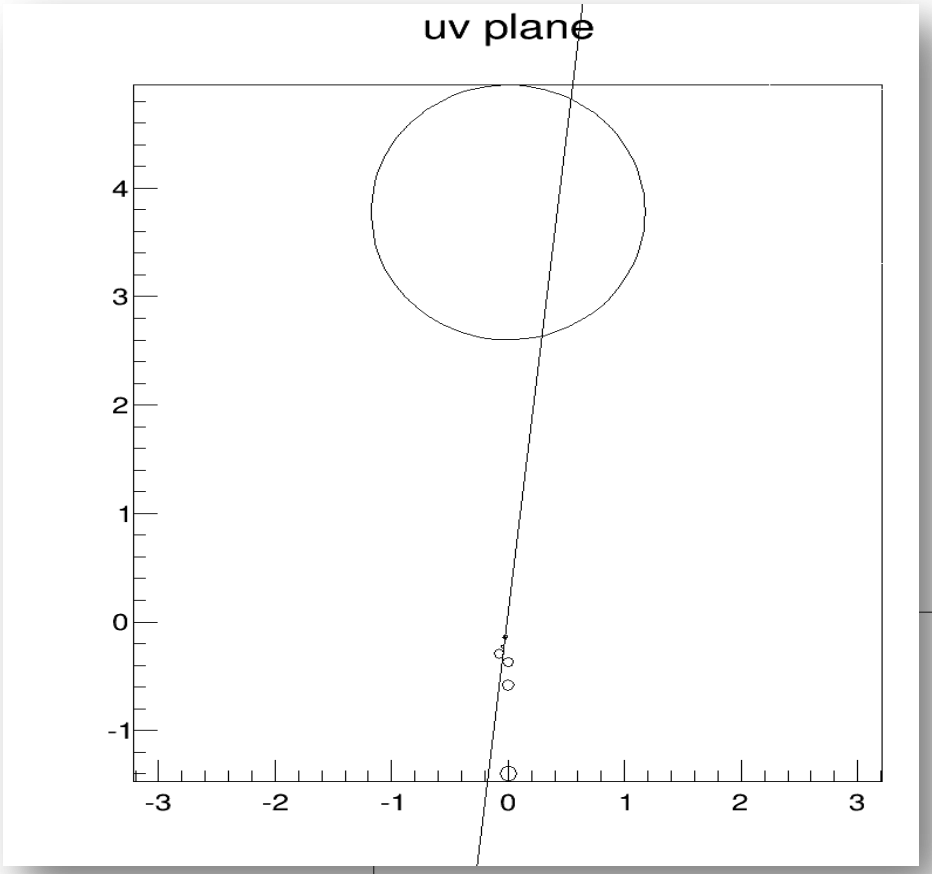
Divide the problems

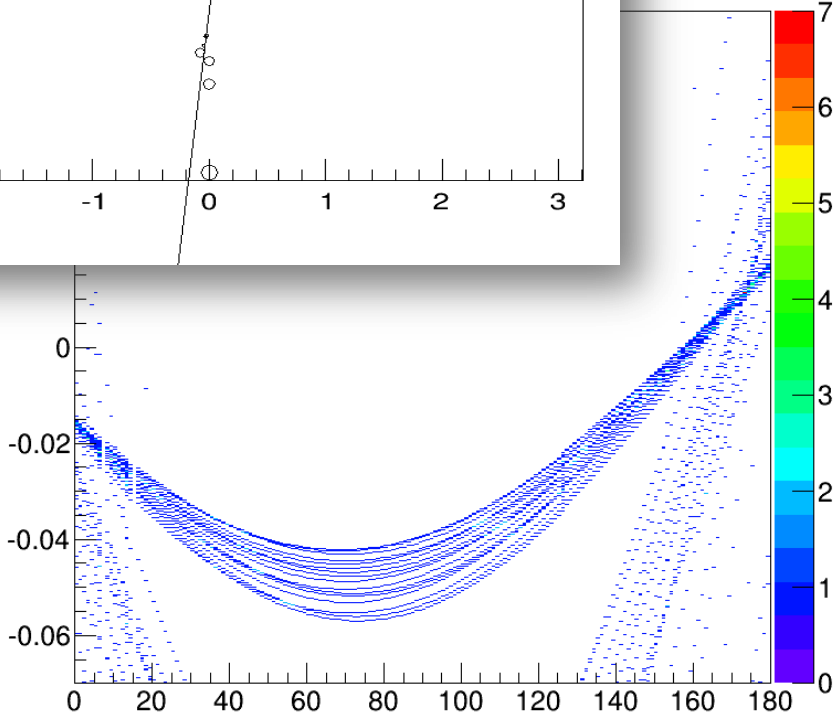
- find the long tracks first
- the looping tracks afterwards

Find the peak in the Legendre plane to fit the track

First cluster hypothesis

- A cluster is created in the same sector or nearby if at the limit of two sectors
- The STT hits are assigned if the hit-to-track distance < 1. cm
- Add also the indivisible hits
- Translate on the LAST indivisible hit the origin of the axes
- Go to the conformal plane
- Fit the straight line porting the circles in the Legendre plane



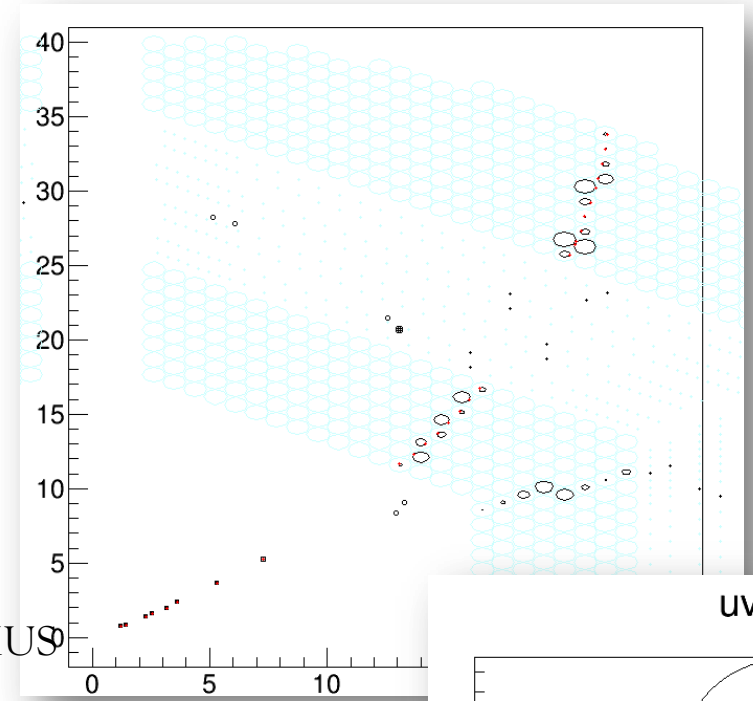


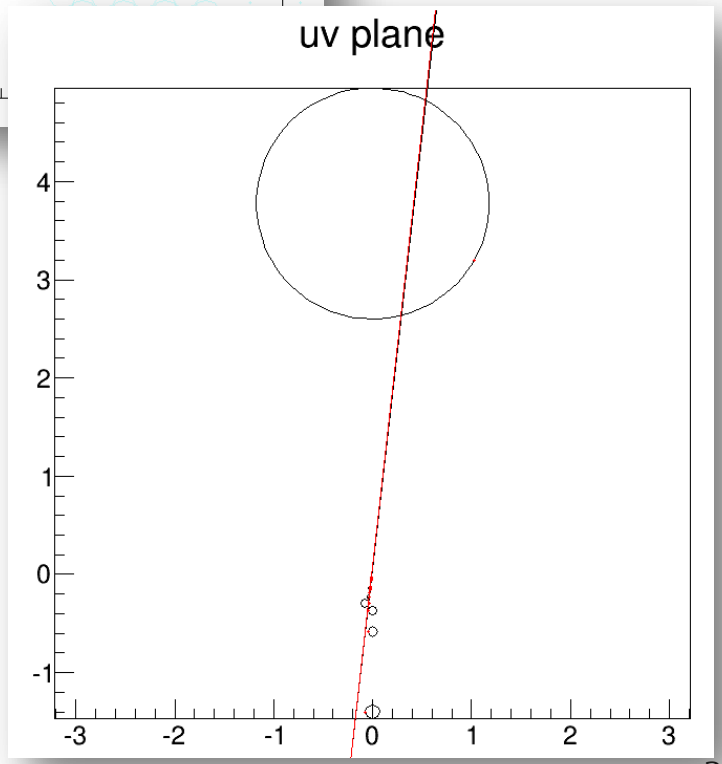
Add other points to the cluster

- MVD pixel
  - hit-to-track distance < 1 cm
  - sector
- MVD strip
  - hit-to-track distance < 1 cm
  - sector
- GEM
  - hit-to-track distance < 1 cm
  - sector
  - radial distance > CTOUTERRADIUS
- SCITIL
  - hit-to-track distance < 10 cm
  - choose the closest one
  - distance from hit@layer20 < 30 cm

Go to conformal plane again and refit analytically

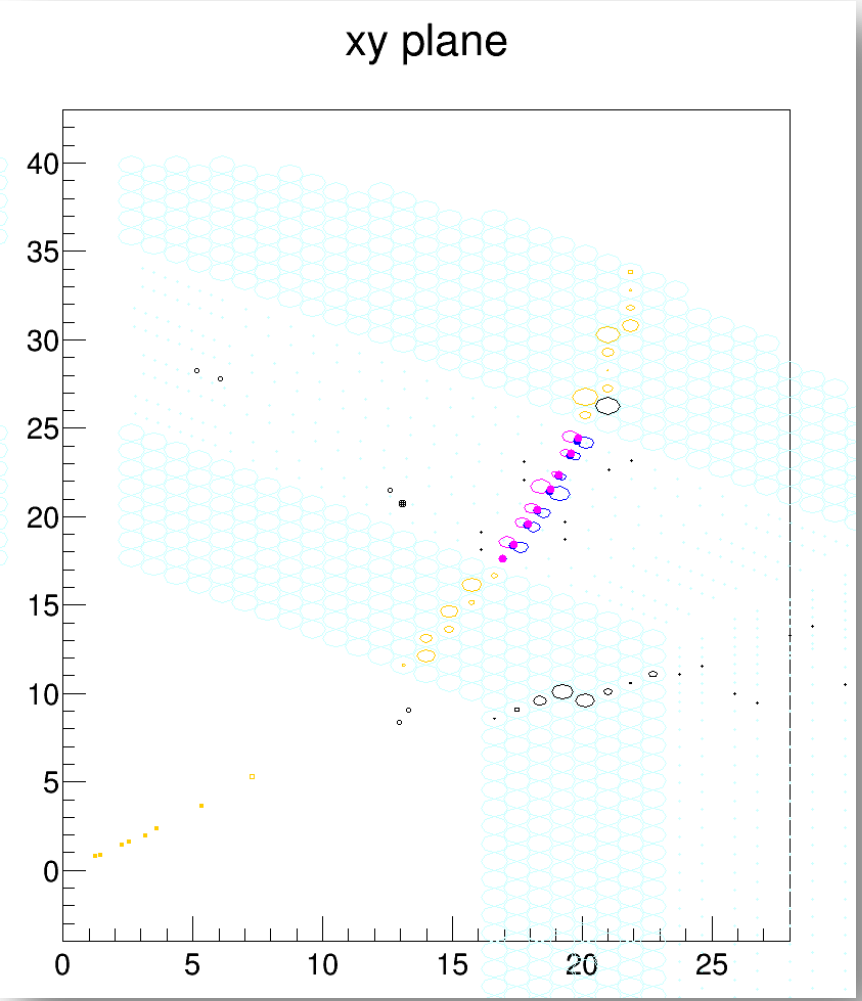
Final *xy* cluster: add MVD, STT, GEM, SCITIL if **hit-to-track distance < 0.5 cm**





z finding and last two parameters

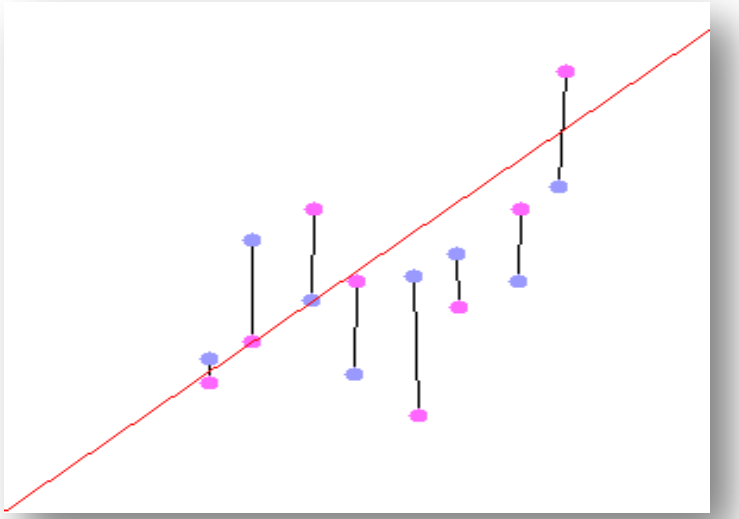
❖ The skewed tubes which intersect the track in *xy* plane are associated to the tracks

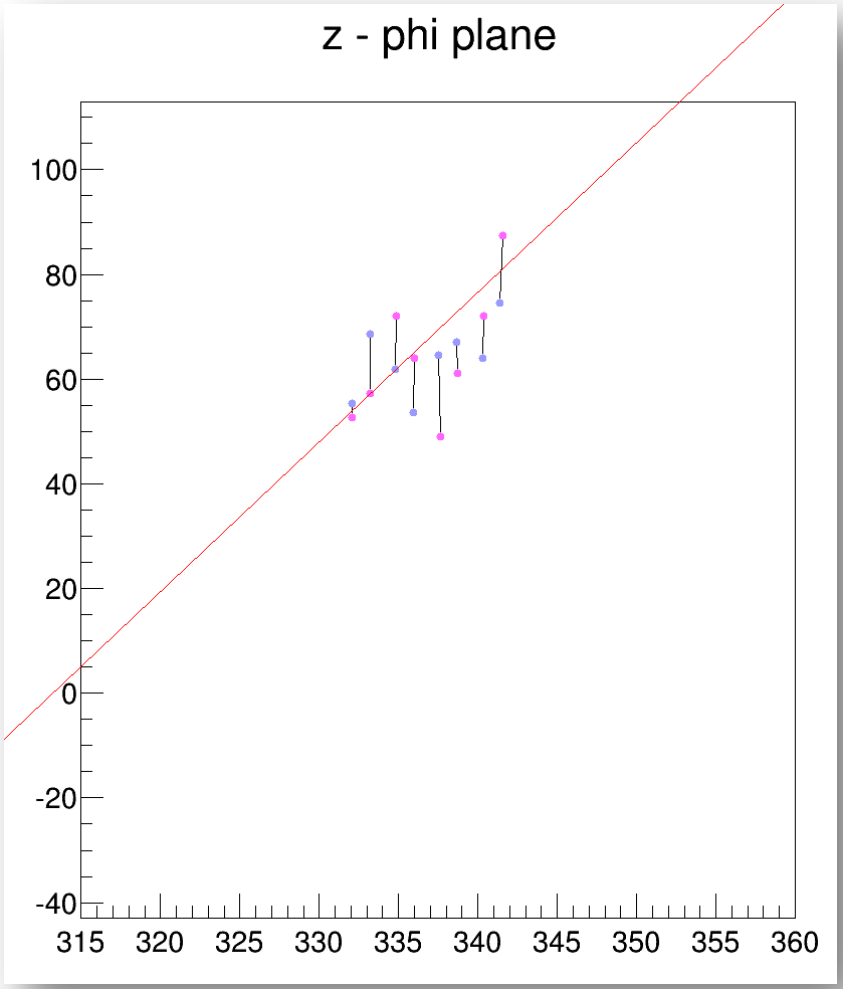


z finding and last two parameters

❖ The skewed tubes which intersect the track in *xy* plane are associated to the tracks

❖ Each skewed tube provides two solutions, i.e. two *x*, *y*, *z* positions and two $z - \phi$ couples



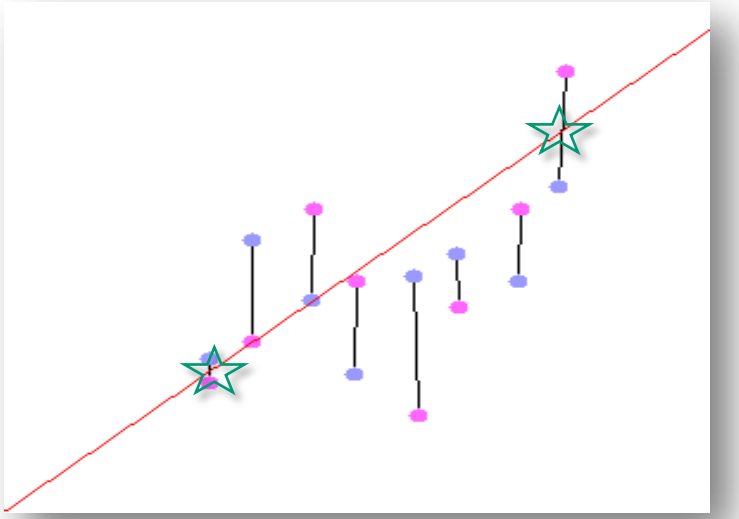


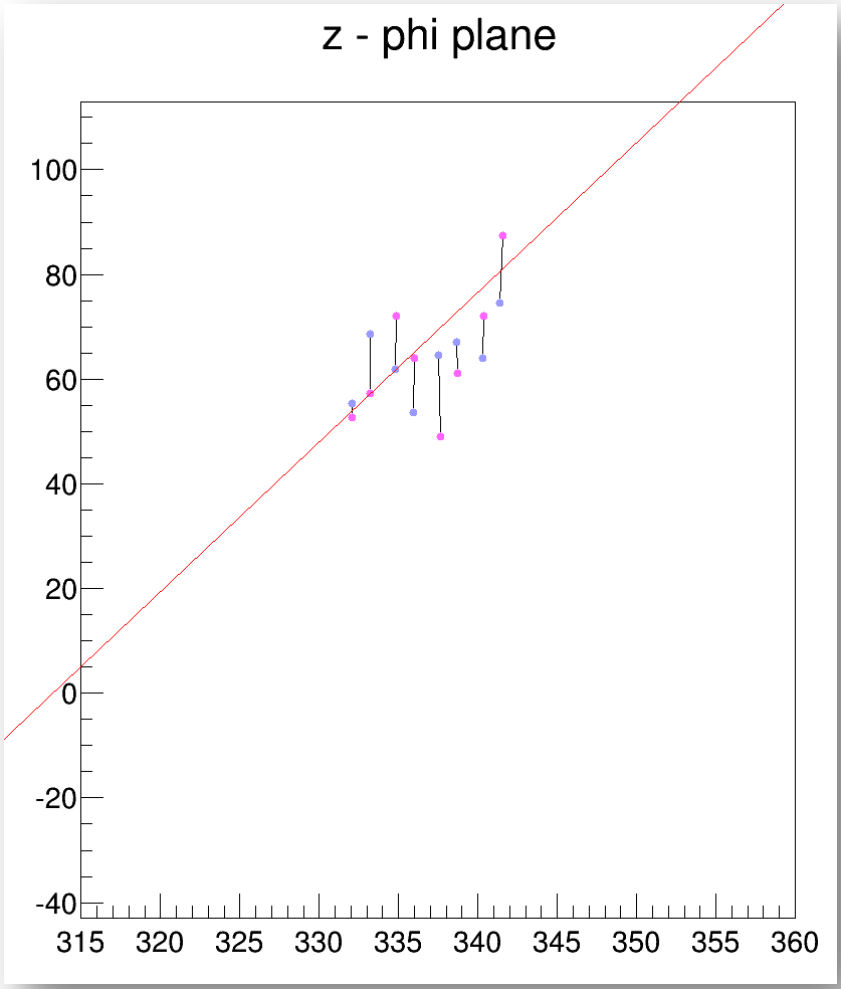
z finding and last two parameters

❖ The skewed tubes which intersect the track in *xy* plane are associated to the tracks

❖ Each skewed tube provides two solutions, i.e. two *x*, *y*, *z* positions and two $z - \phi$ couples

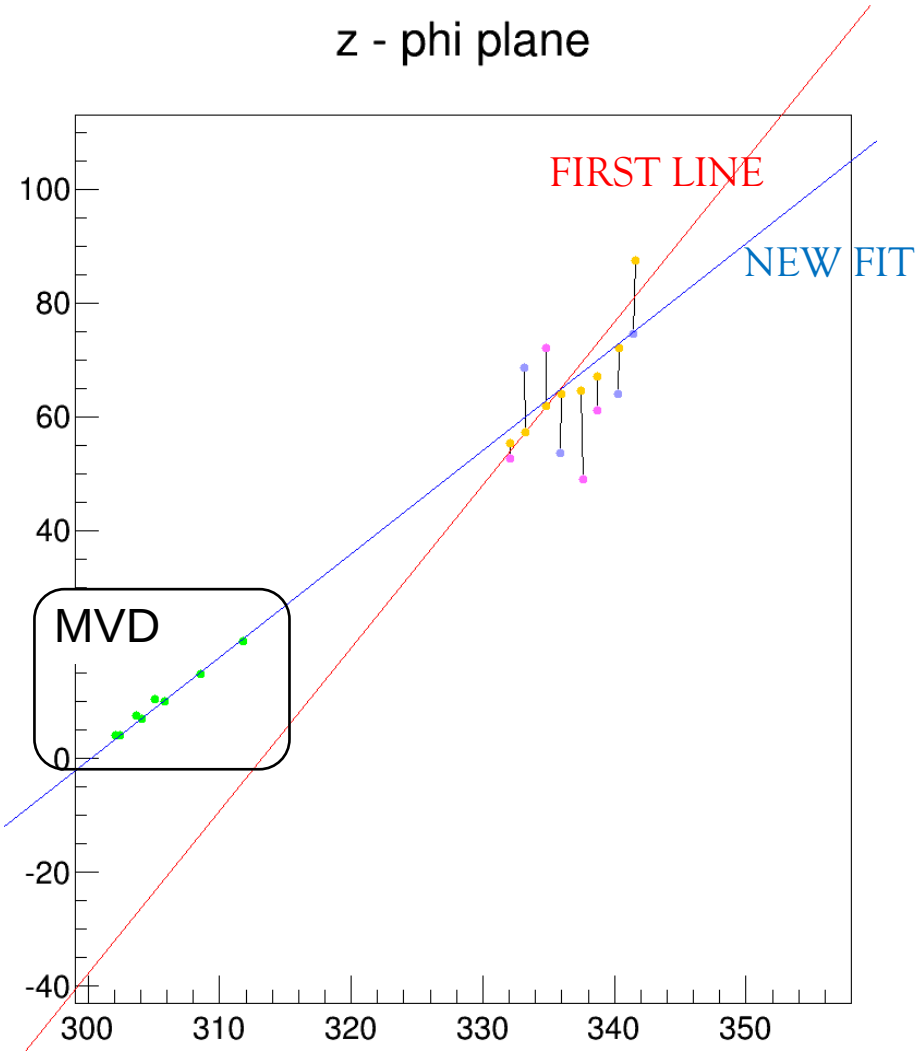
❖ Check neighborings @ layer 8 & 15 and connect the middle points of 8 to 15: choose the two with smallest *z* difference



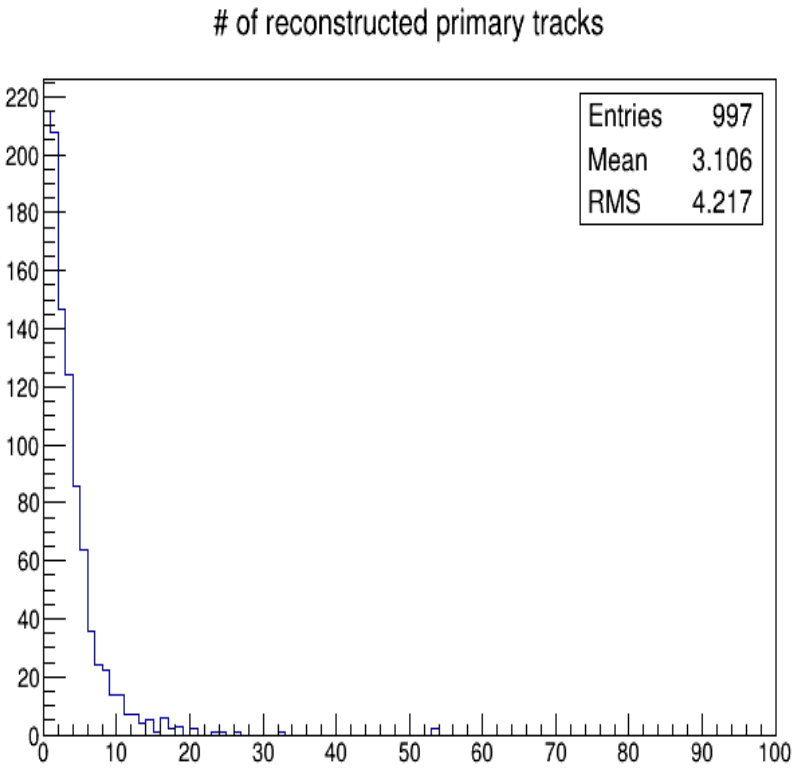


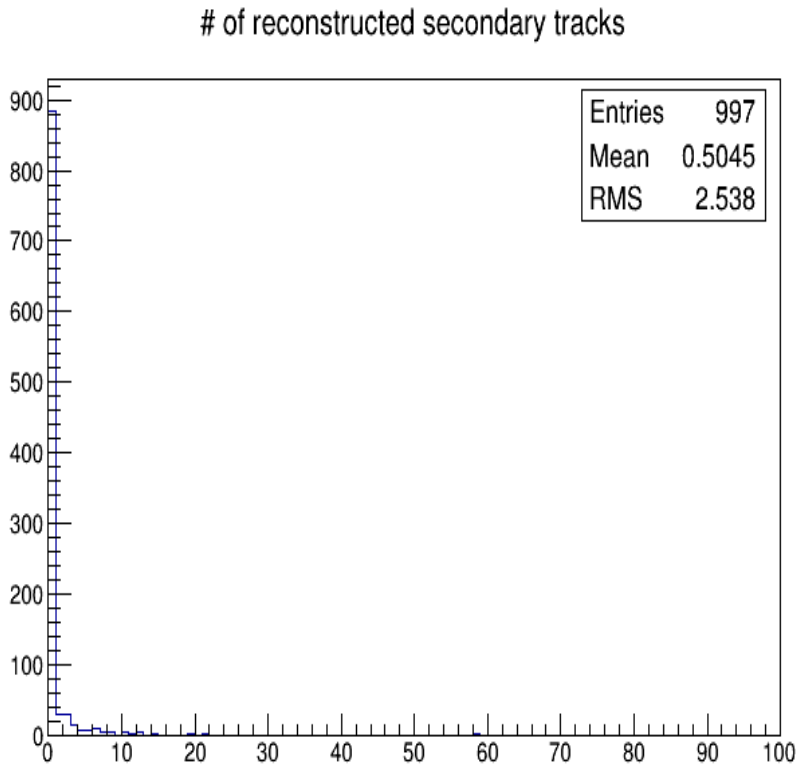
z finding and last two parameters

- The solution with hit-to-line distance < 3 cm and the smallest one are associated to the track
- Refit with a line to get tanλ and z0
- Compute the charge
- Convert:
  - PndTrkTrack → PndTrack
  - PndTrkCluster → PndTrackCand
- ... and register to output



#Reconstructed tracks/event





Conclusions

- This new strategy seems more promising than the one I tried before
- I hope to be able to obtain good results in tests soon
- Next step: identify and reconstruct looping particles which in principle should be the only tracks not found by this PR

THANK YOU…