Algorithm of recognizing tracks with the PANDA detector at FAIR

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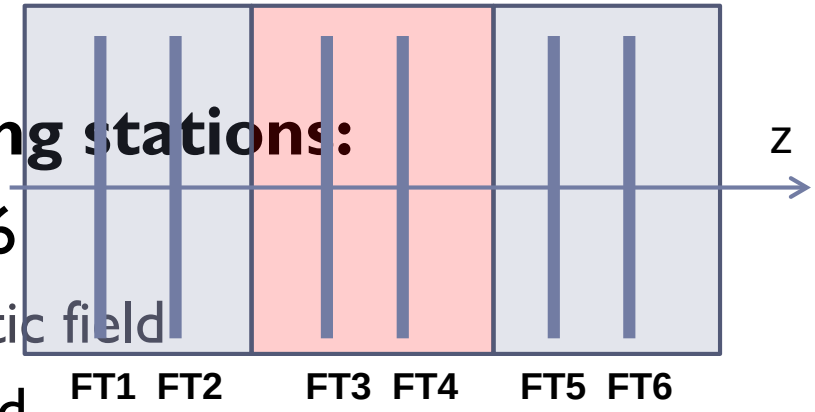
The PANDA Forward Straw Tube Tracker

Properties of straws:

- Straw diameter: 10.1 mm, tube wall 0.03 mm Mylar
- Sense wire diameter 0.02 mm, wire material: Tungsten
- Gas filling: 90% Ar + 10% CO2 at 2 bar

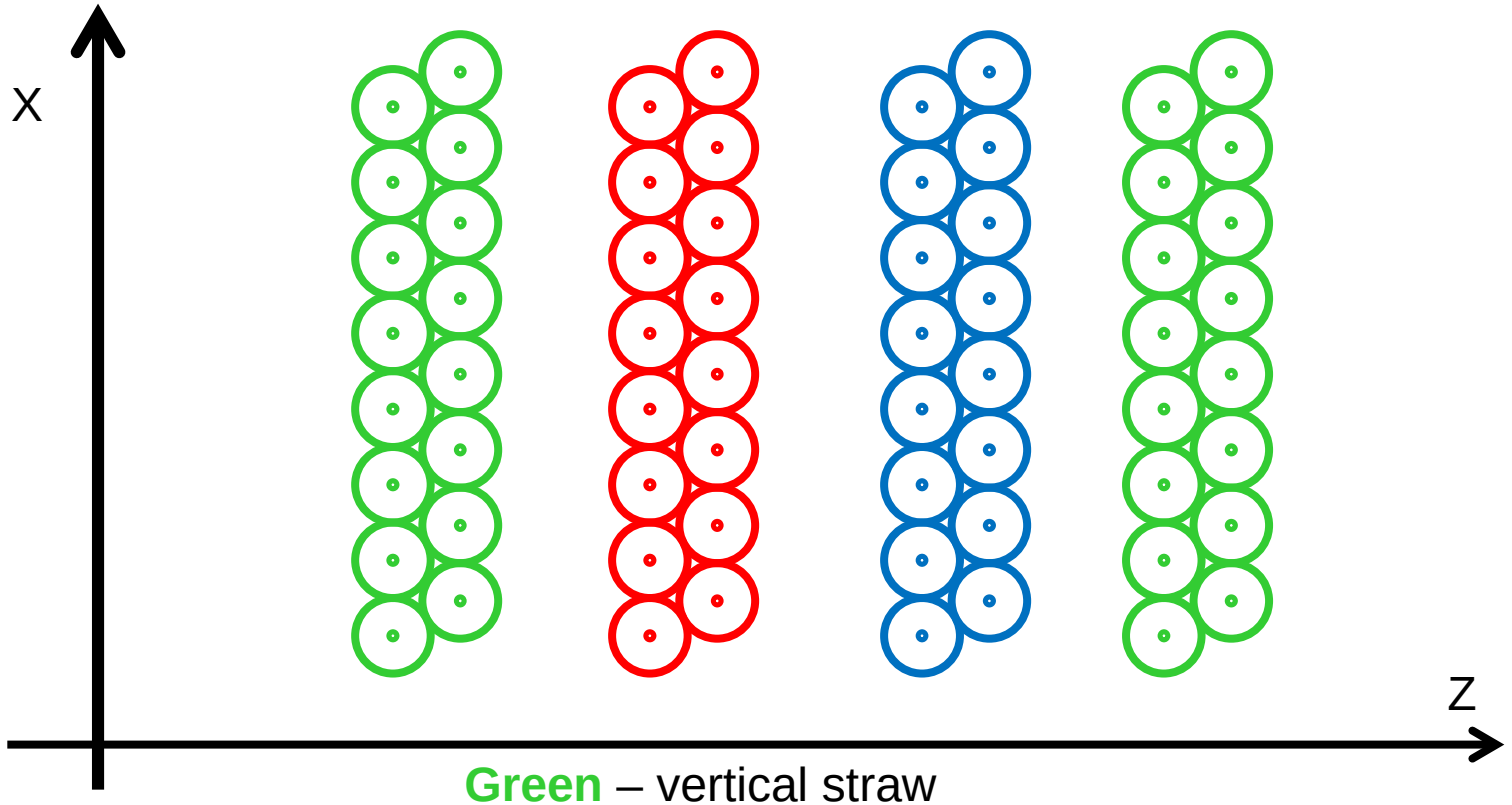
Basic features of the tracking stations:

- Six tracking stations: FT1..FT6
  - **FT1, FT2** outside the magnetic field
  - **FT3, FT4** in the magnetic field
  - **FT5, FT6** outside the magnetic field



One Forward Tracking Station

- four double layers of straw tubes oriented respectively at 0°, +5°, -5° and 0°



Green – vertical straw
Red, **Blue** – skewed straw

Data structure for storing the geometry of the detector

map<int, gstraw>

associative container stores elements by a combination of a *key value* and a *mapped value*

key value - the global id number of a straw,

mapped value - coordinates of straw

```
struct gstraw{
        int l ;
        float x ;
        float y ;
        float z ;
};
```

l - the number of the layer,

x, y, z coordinates of the straw.

Input data

A set of triplets:

- number of event,
- number of lighted straw,
- drift radius.

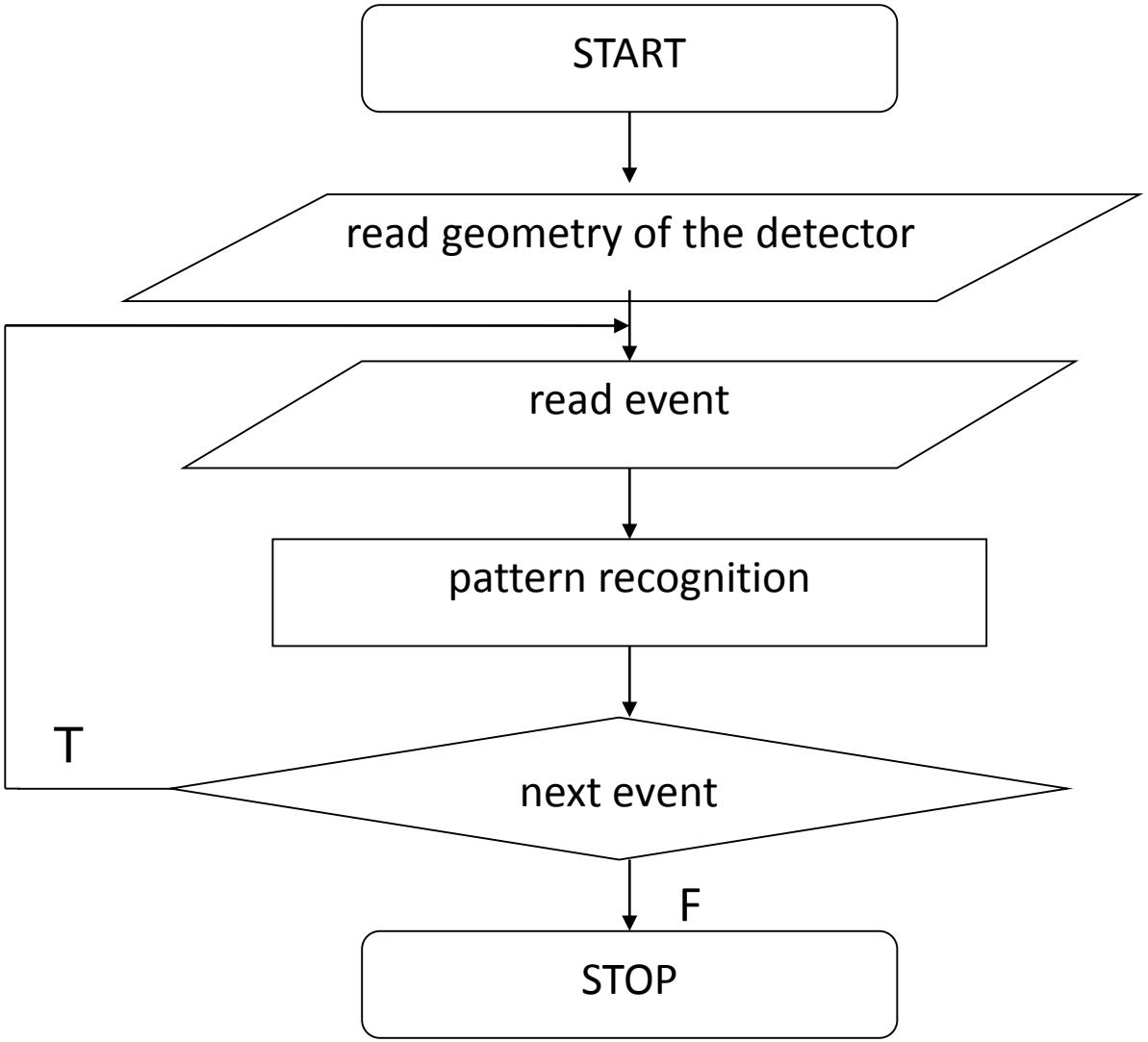
Input data is loaded into two arrays for each of three groups of forward trackers: FT1-FT2, FT3-FT4, FT5-FT6.

First array stores information on vertical straws, the other on skewed straws.

Output data

- Collection of hit straws belonging to one track

Scheme of the algorithm

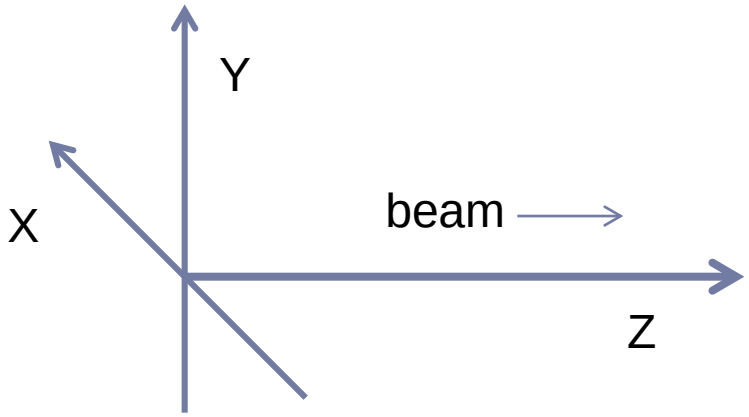


Particle track in 3D

- 2D track on horizontal plane *ZOX* using vertical straws
- 2D track on vertical plane *ZOY* using skewed straws

Z -axis is parallel to the beam and

Y - axis is vertical.



Wires of straws located above the opening for the beam are aligned to the corresponding straws located below the opening. Therefore, they are described by the same equations.

Pattern recognition

- Pattern recognition in FT1-FT2 and FT5-FT6 uses the same procedure:
  - Line on *ZOX* plane – vertical straws
  - Line on *ZOY* plane –skewed straws

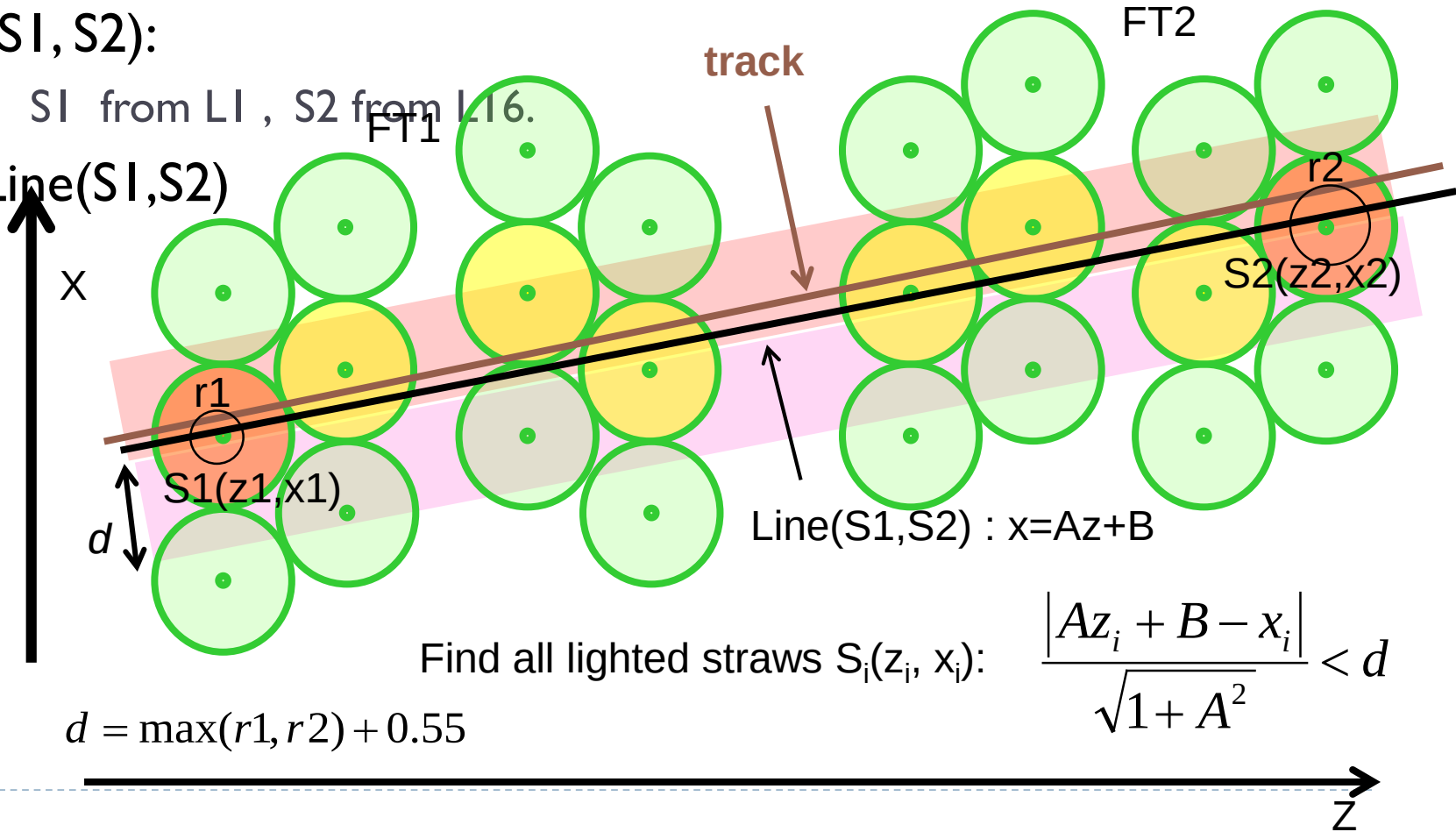
- Pattern recognition in FT3-FT4
  - Fit line on *ZOY* plane from FT1-FT2 with line from FT5-FT6
  - determination of the radius of the circle on *ZOX* plane
    - Fit vertical straws
  - Fit skewed straws

Pattern recognition in FT1-FT2

ZOX plane – **only vertical straws**

Candidates to track

- for all pairs of lighted straws (S1, S2):
  - S1 from L1 , S2 from L16.
- Line(S1,S2)



Pattern recognition in FT1-FT2

ZOX plane

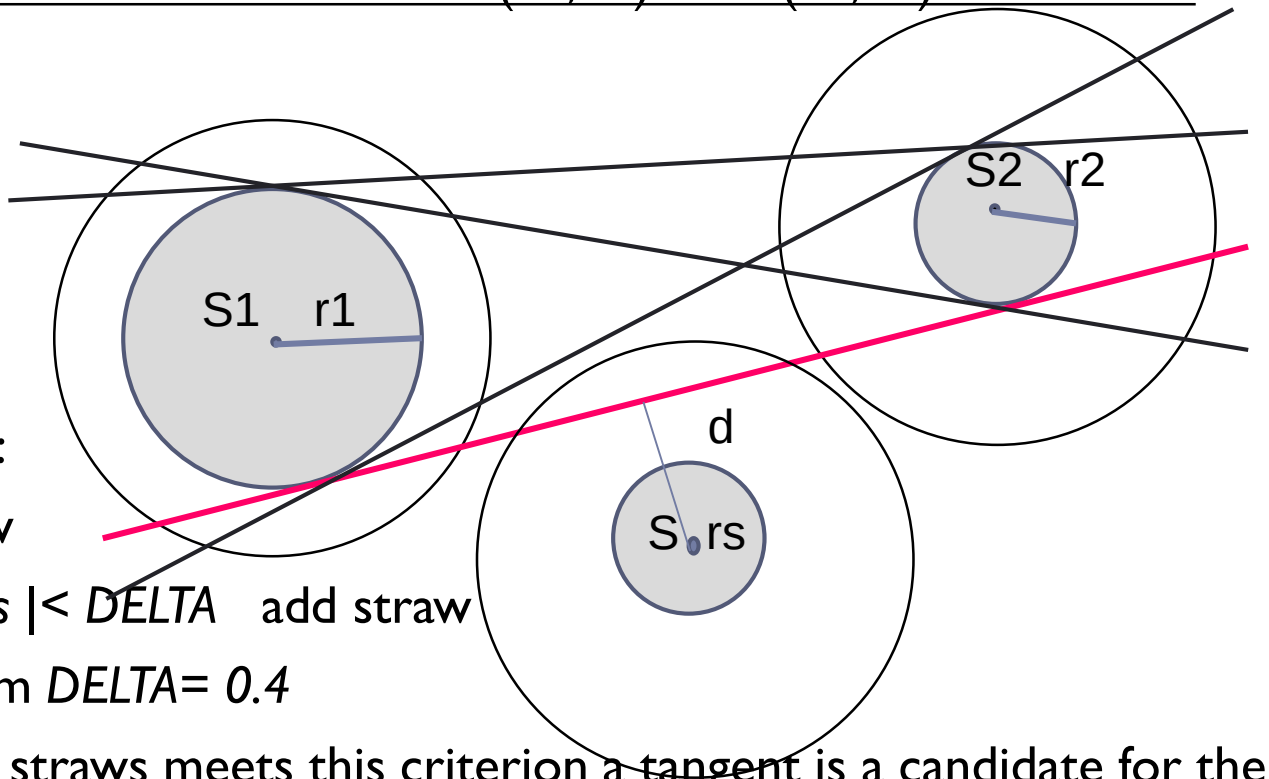
- Candidates for tracks are tested on the number of selected straws (with S1 and S2)
  - if less than 6, we not further consider this candidates

- Problem: lack of lit straw from layer L1 or L16
  - Solution: take S1 from L1 or L2, S2 from L15 or L16
  - Caveats: creation of duplicated candidates – need procedure to find duplicates and remove them

Pattern recognition in FT1-FT2

ZOX plane – one track

for each candidate with two circles c(S1, r1) and c(S2, r2) we set four tangents



For each tangent:

- for each straw

  if $|d - rs| < DELTA$ add straw
- in the algorithm $DELTA = 0.4$
- if more than 5 straws meets this criterion a tangent is a candidate for the track
- take tangent with min $\sum|d(S,tangent) - rs|$;

Reconstruction of tracks on the plane ZOX

for each straw S1 from a layer 1 or 2

for each straw S2 from a layer 15 or 16

line(S1,S2);

find all straw S which |d(S,line)-rs| < 0.4;

if(number of straws < 6) take next pair;

else

appoint four tangents for c(S1,r1) and c(S2,r2) and

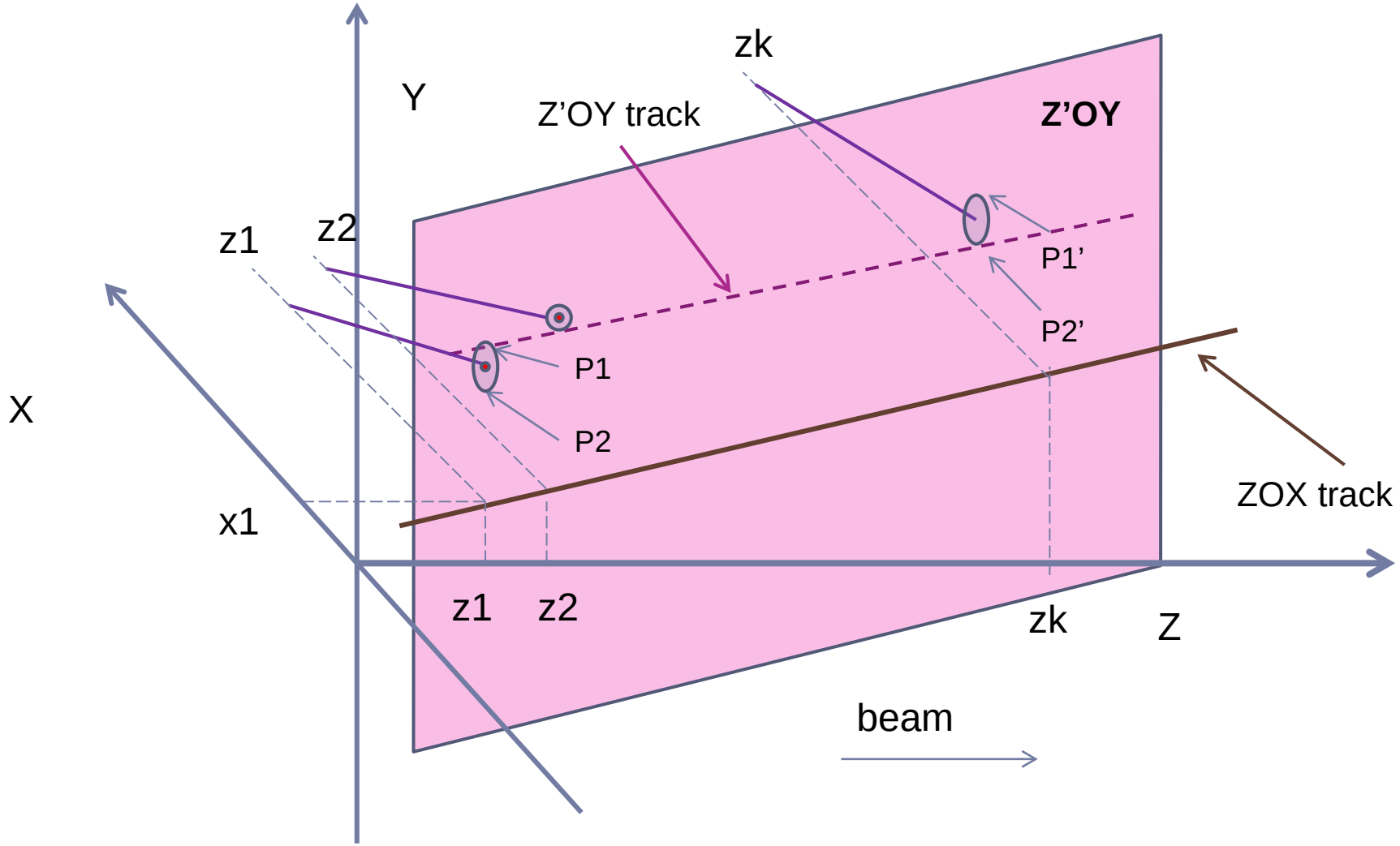
compute dd= ∑|d(S,tangent)- rs|;

take this tangent which has min ∑|d(S,tangent)- rs|;

compare found tracks to delete duplicates;

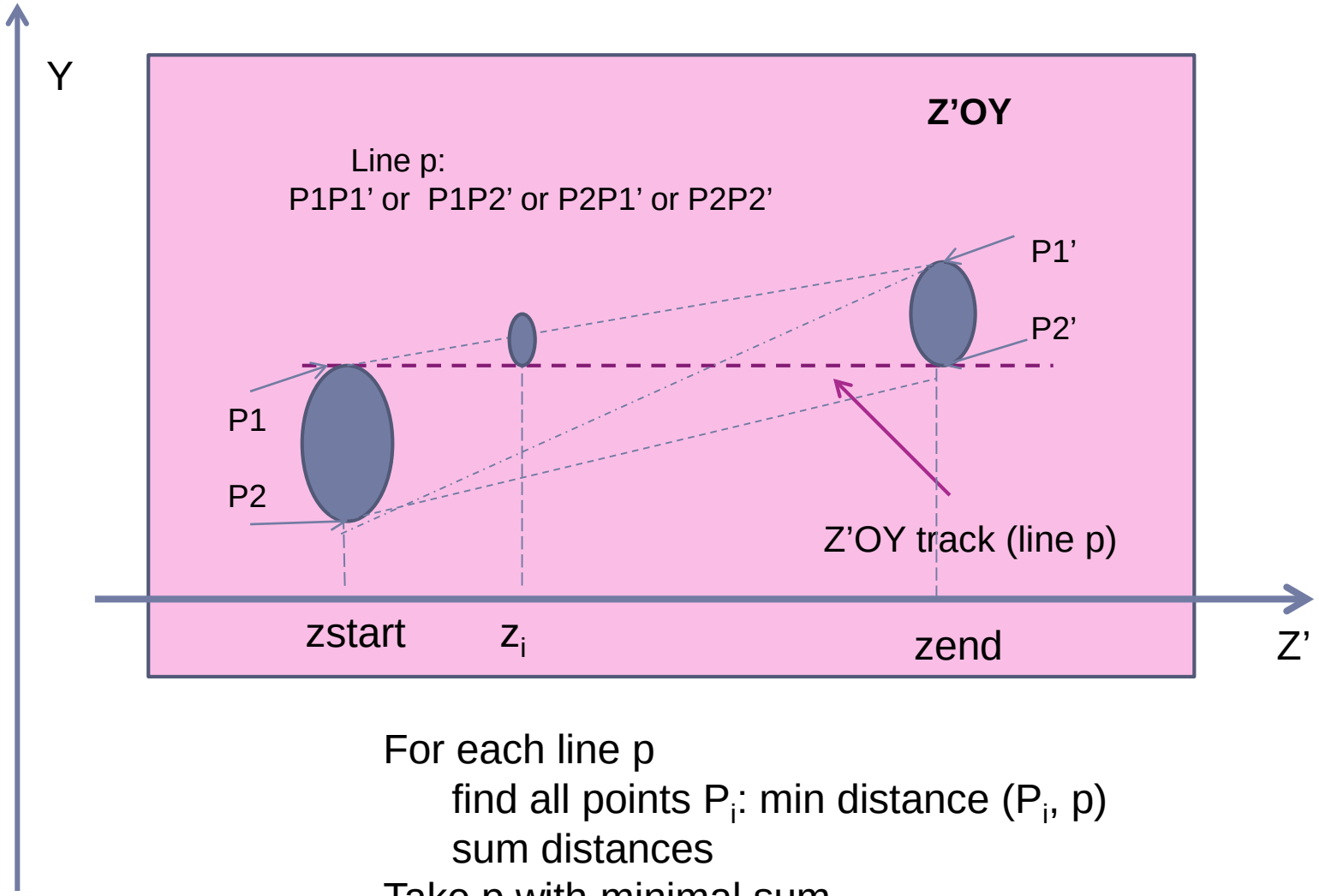
Pattern recognition in FT1-FT2

Z'OY plane – **only skewed straws**



Pattern recognition in FT1-FT2

Z'OY plane – **only skewed straws**



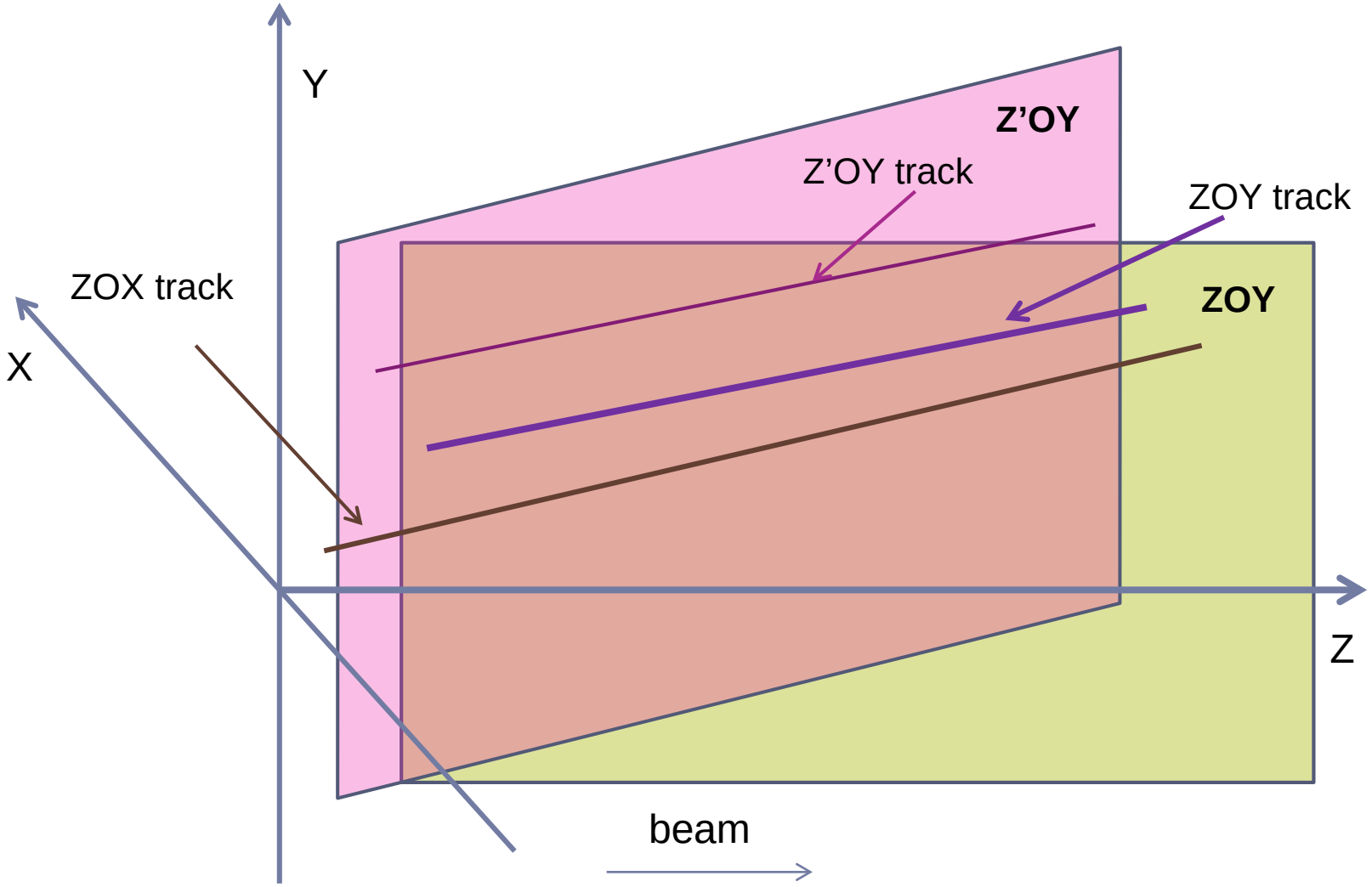
For each line p

find all points P_i: min distance (P_i, p)

sum distances

Take p with minimal sum

Pattern recognition in FT1-FT2
ZOY plane – transformation Z'OY on ZOY



Reconstruction of tracks on the plane ZOY

for each track on XOZ plane

for each straw S

compute points P1(S_z,y1) and P2(S_z,y2)

(where y1=y+cc; y2=y-cc; cc=r*sqrt(1+a^2); y=a*(x-S_x)+S_y)

for each point K from layer 3 or 4 (first skewed layers)

for each point M from layer 13 or 14 (last layers)

line(K, M);

dd= min $\sum_{layer}$ min d(P,line);

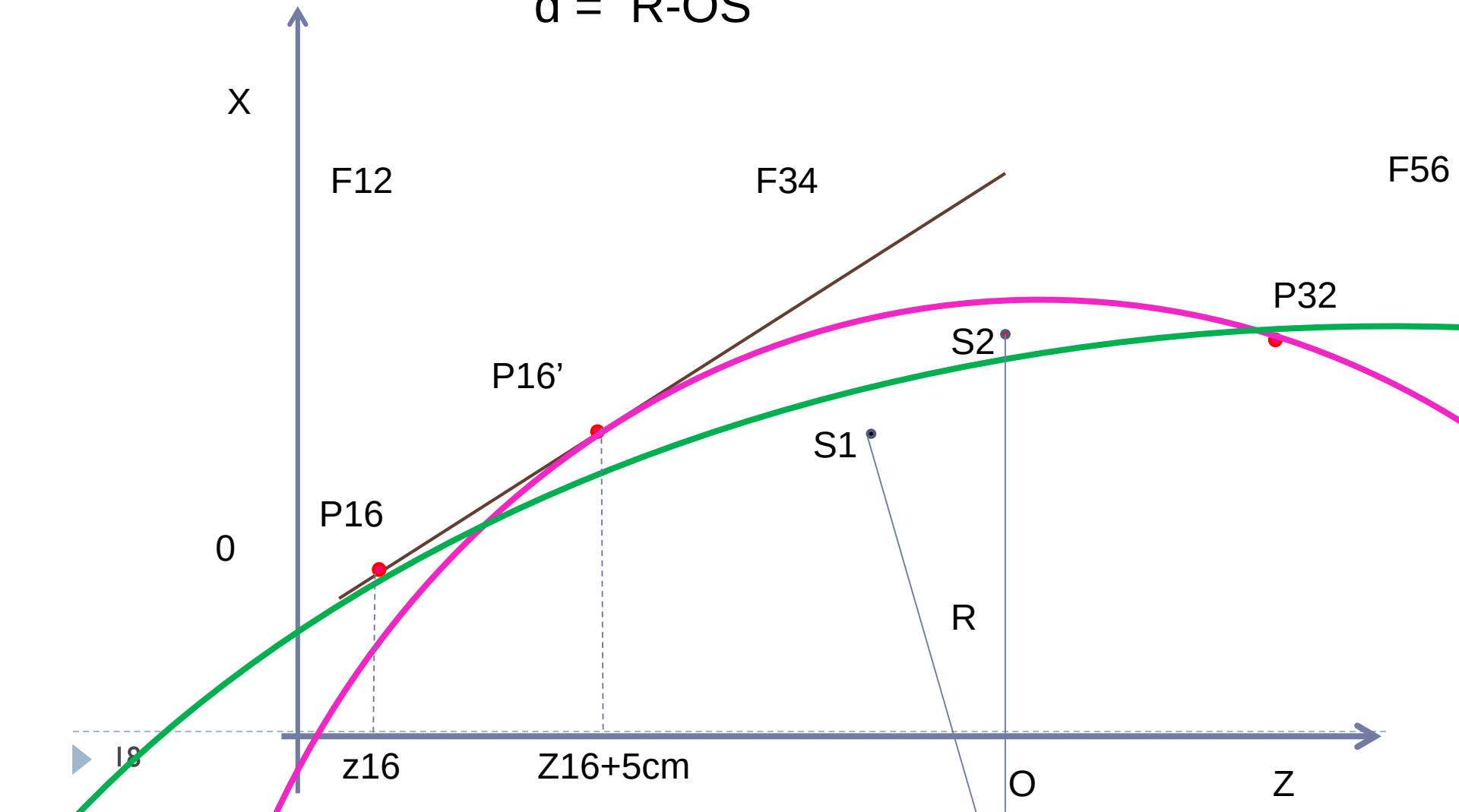
compare found tracks to delete duplicates;

Pattern recognition in FT3-FT4

ZOX plane – **only vertical straws**

for each real point (for vertical straws)

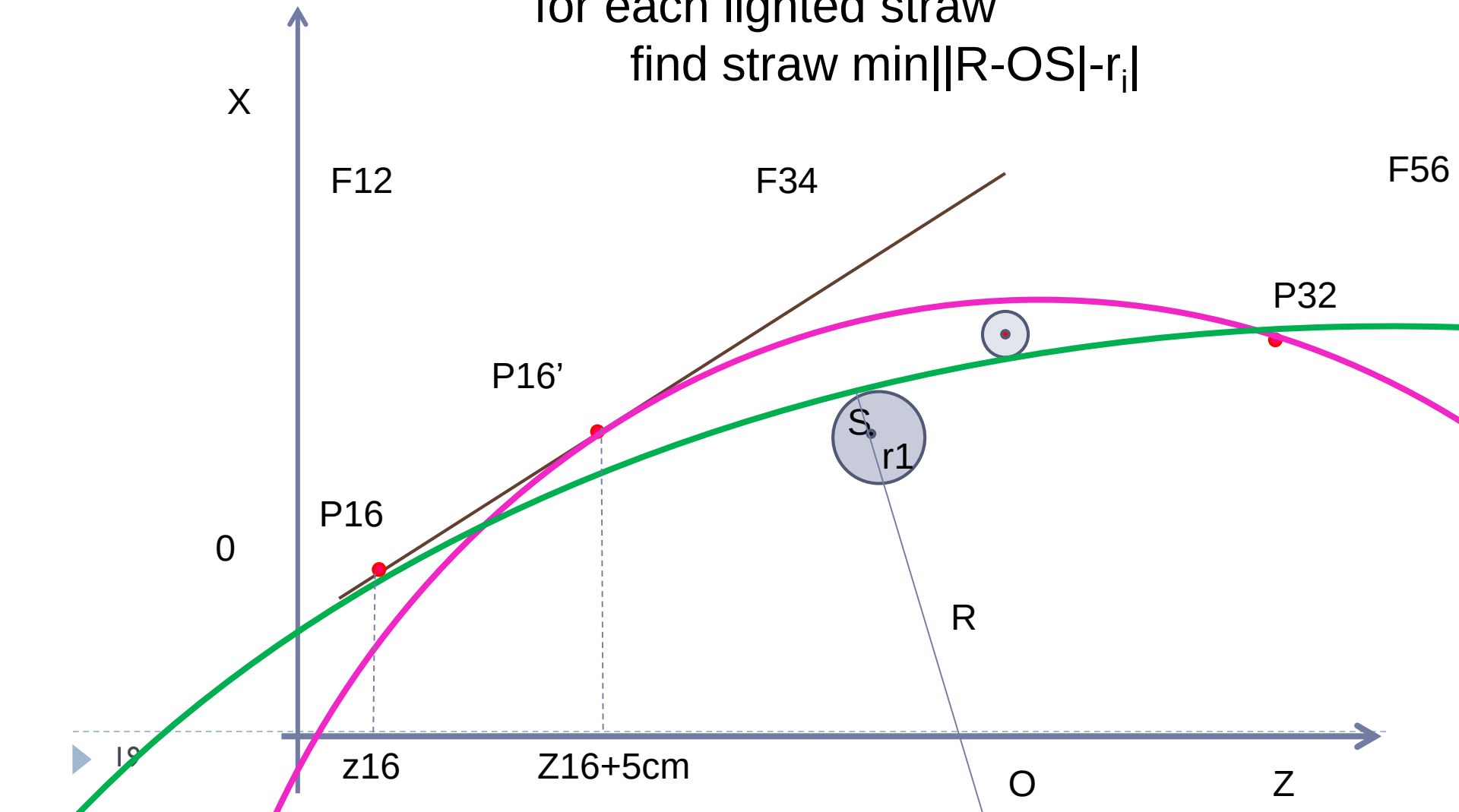
d = R-OS



Pattern recognition in FT3-FT4

ZOX plane – **only vertical straws**

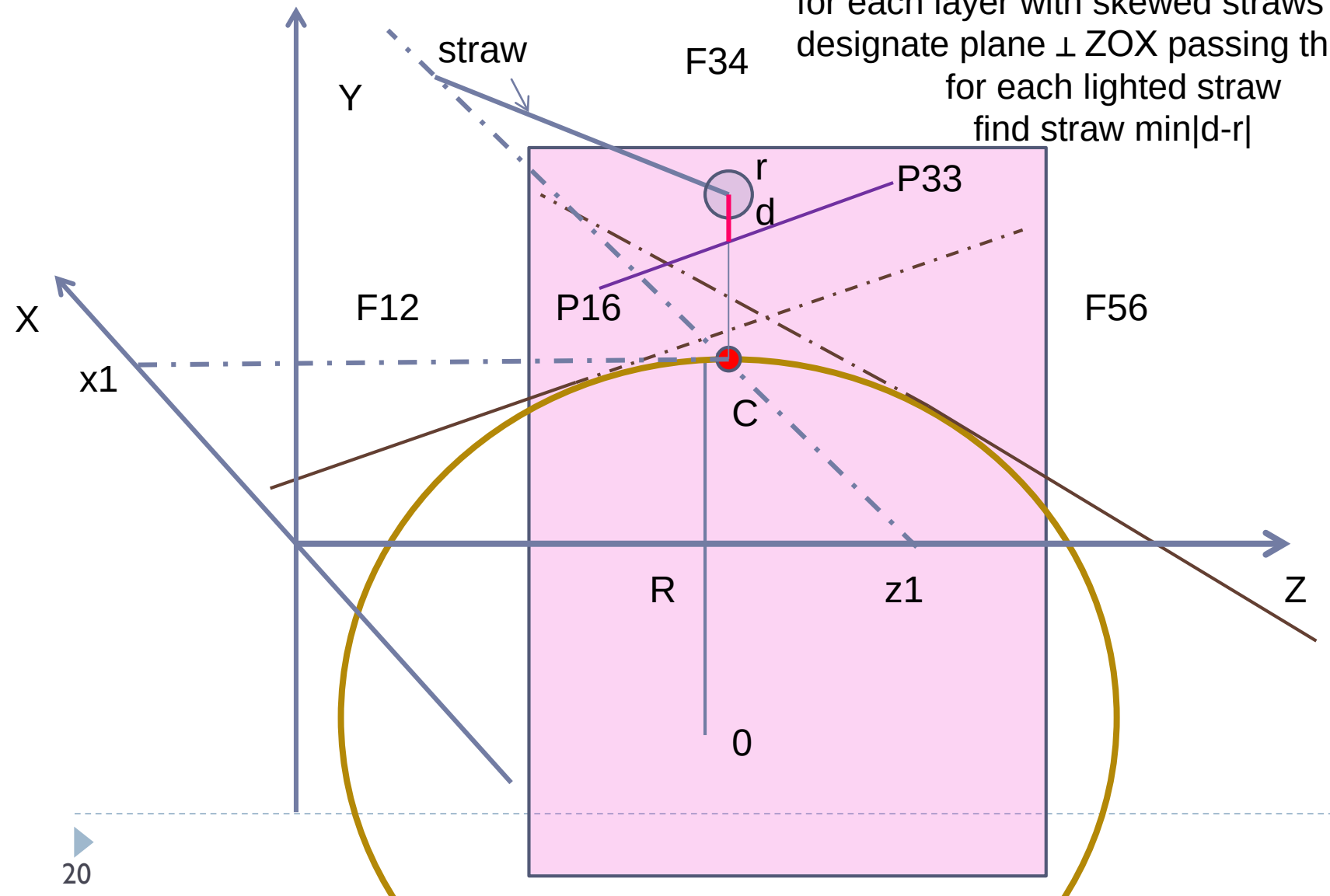
for each layer with vertical straws
for each lighted straw
find straw min||R-OS|-r_i|



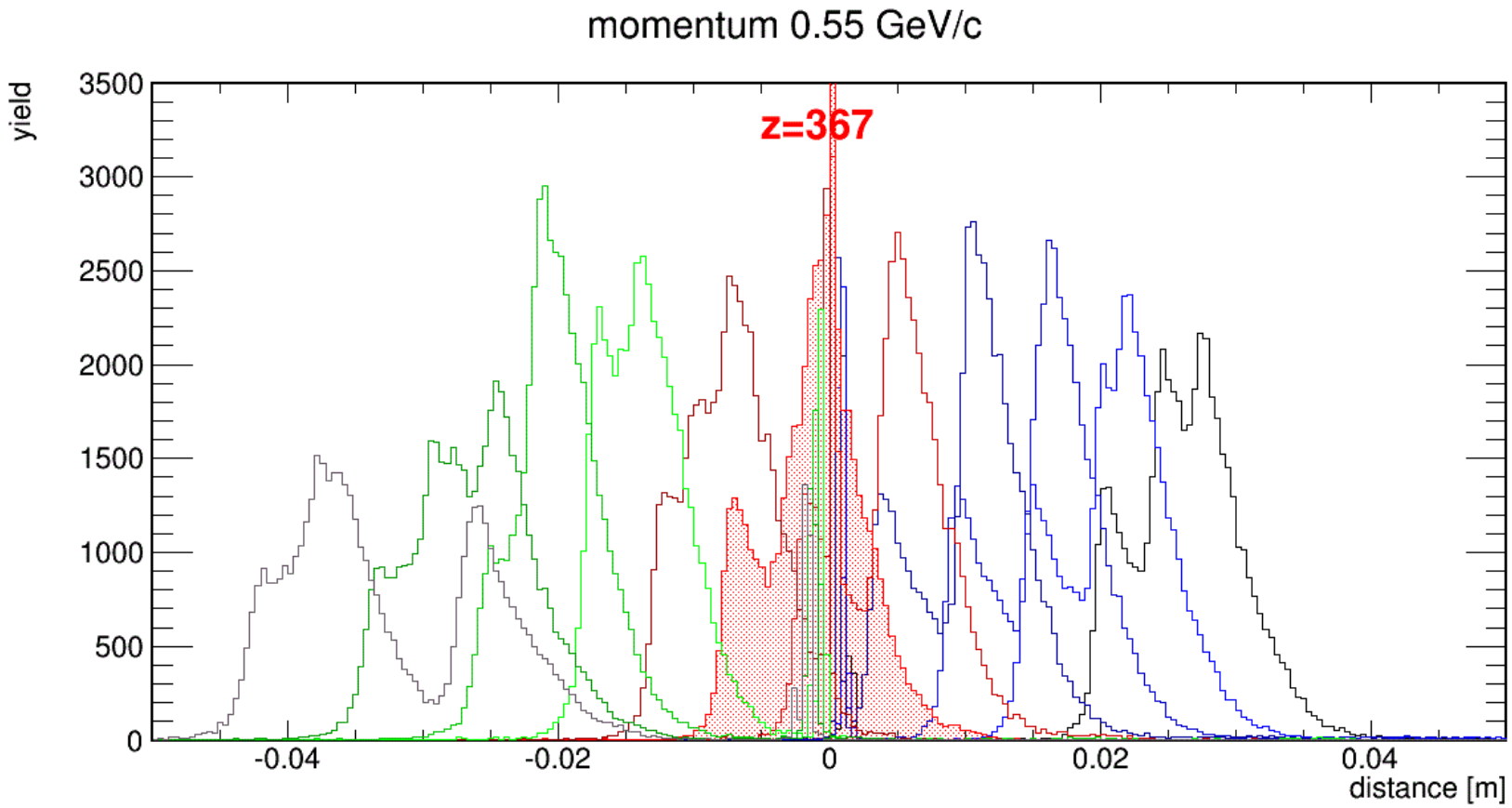
Pattern recognition in FT3-FT4

ZOY plane – **only skewed straws**

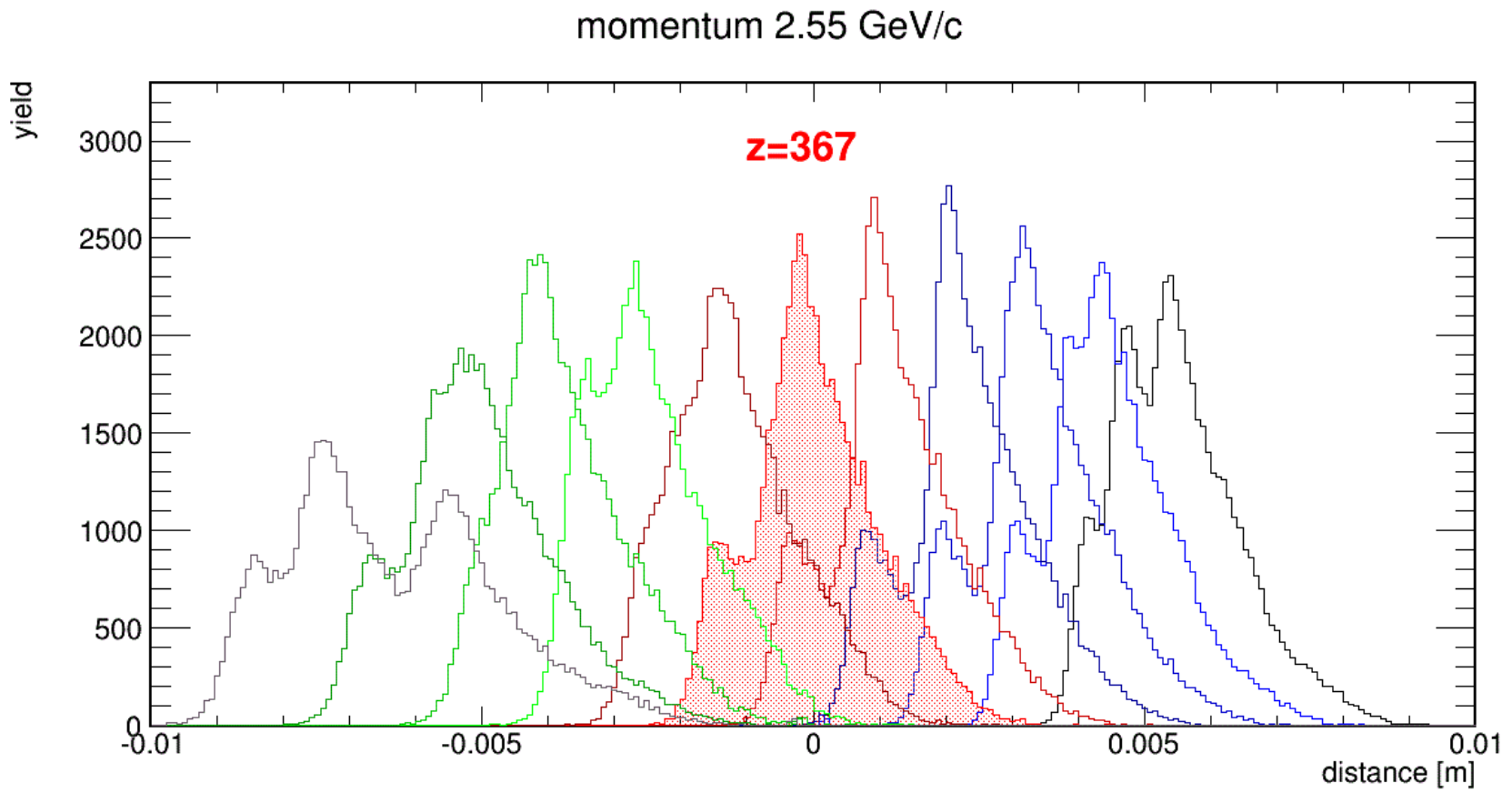
for each layer with skewed straws
designate plane ⊥ ZOX passing through C
for each lighted straw
find straw min|d-r|



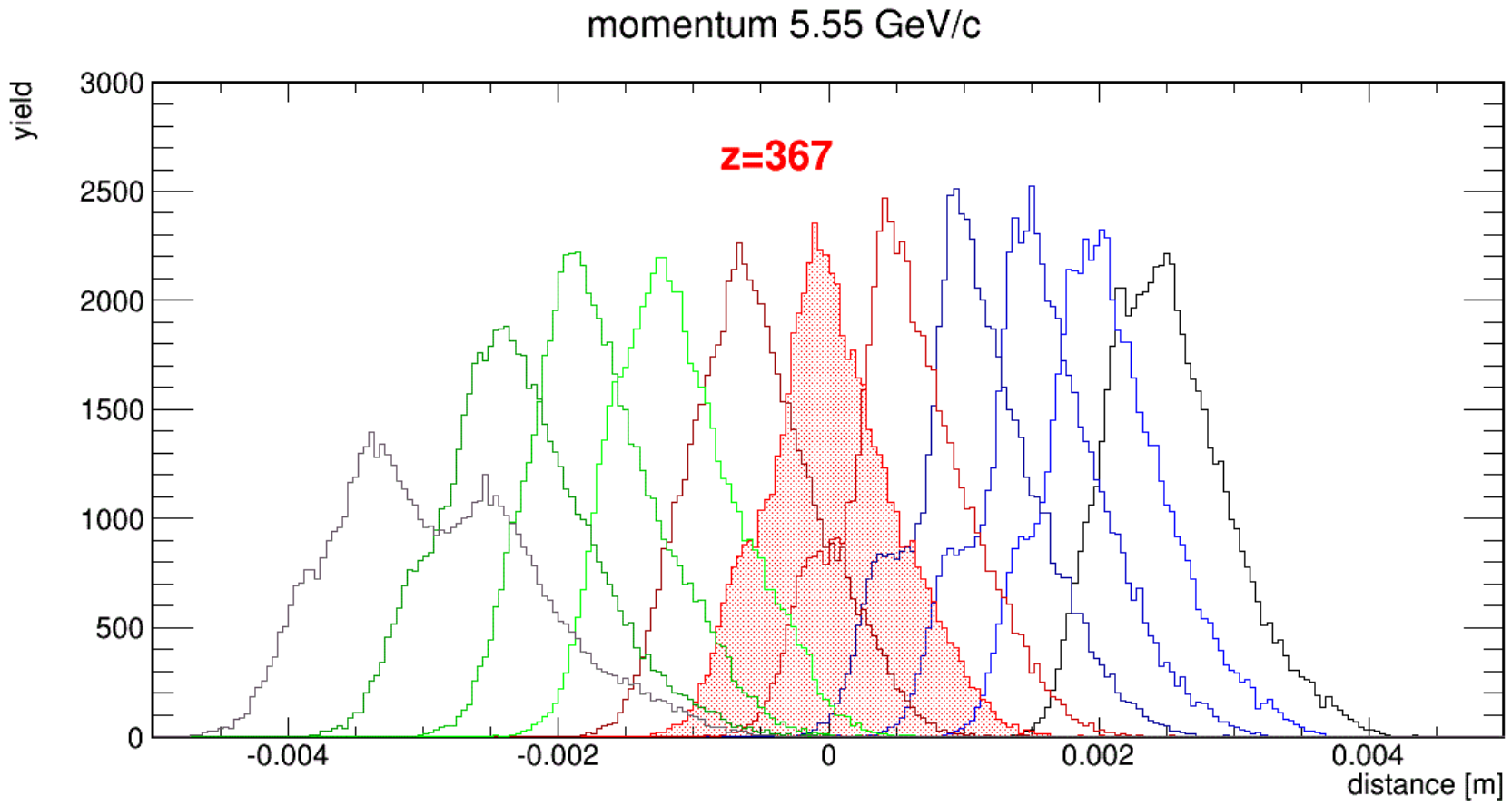
Results


momentum 0.55 GeV/c
yield
z=367
3500
3000
2500
2000
1500
1000
500
0
-0.04
-0.02
0
0.02
0.04
distance [m]

Results


momentum 2.55 GeV/c
yield
z=367
3000
2500
2000
1500
1000
500
0
-0.01
-0.005
0
0.005
0.01
distance [m]

Results


momentum 5.55 GeV/c
yield
3000
2500
2000
1500
1000
500
0
z=367
-0.004
-0.002
0
0.002
0.004
distance [m]

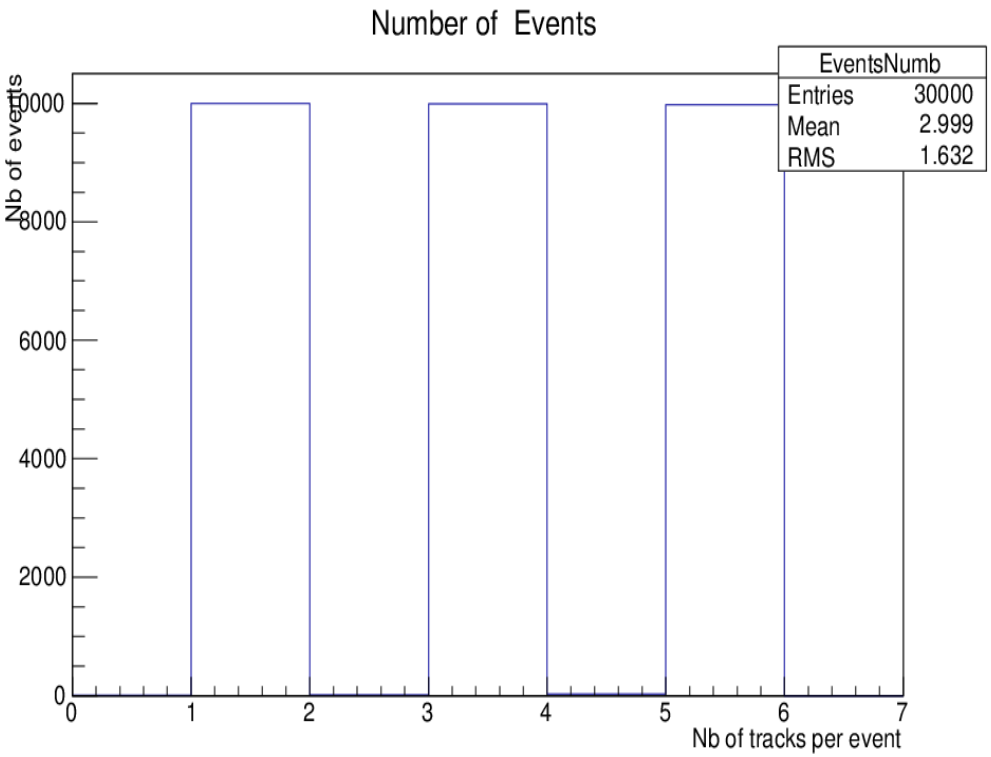
Results

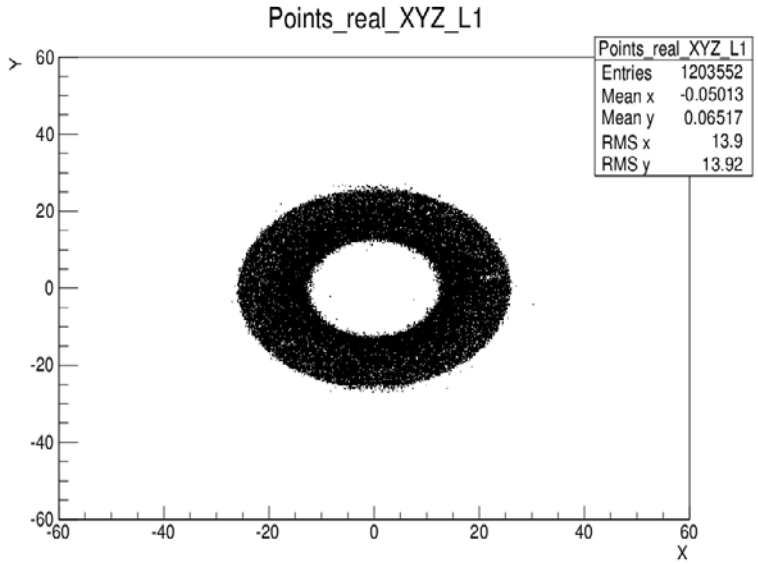
Data from symulator:

- muon
- energy:
  - 5.55Gev
- polar: 2.5 – 5 deg

Results F12 muon, 5.55 Gev

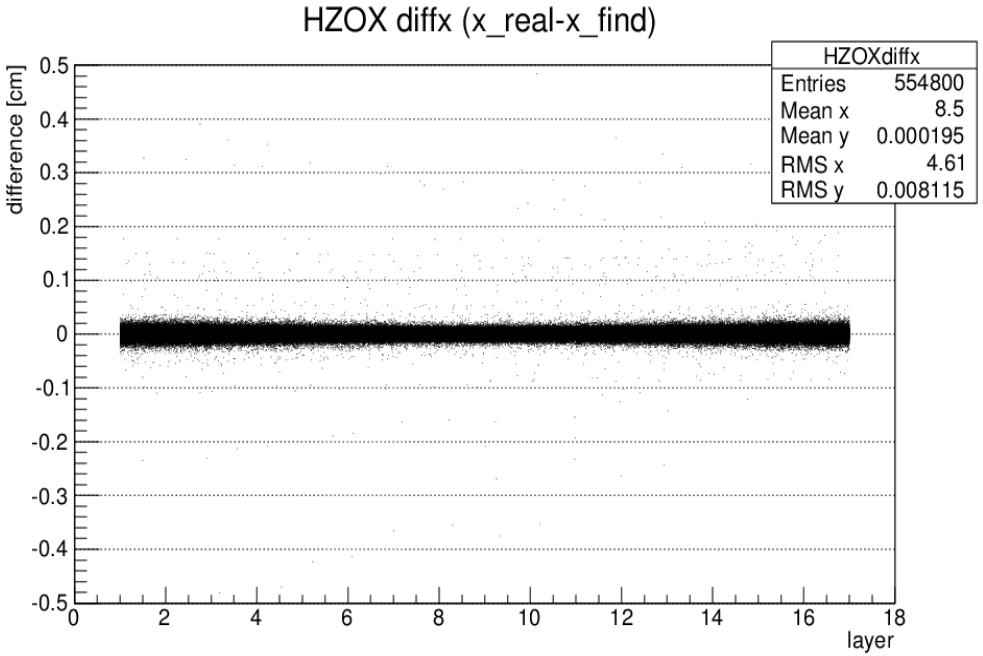
The pandaroot was used to generate 30k input events:
10k with 1 muon, 10k with 3 and 10k with 5. Files with events were concatenated. Tracks were required to have a hit in each double layer.



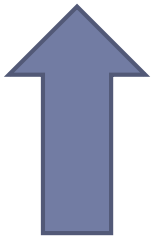


Distribution of angles for simulated tracks at the first layer

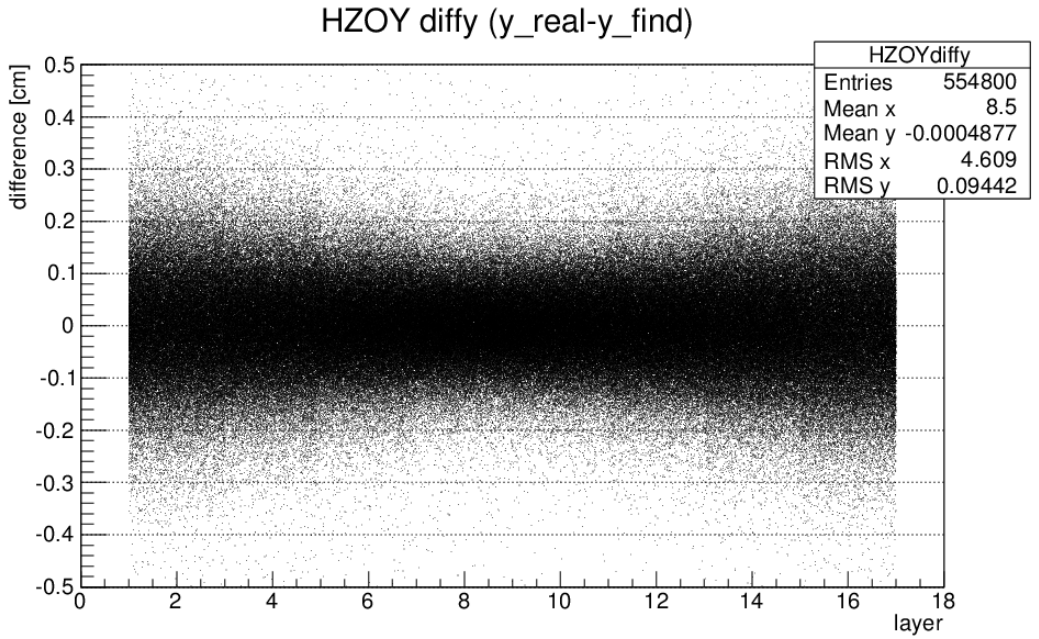
Results F12 muon, 5.55 Gev



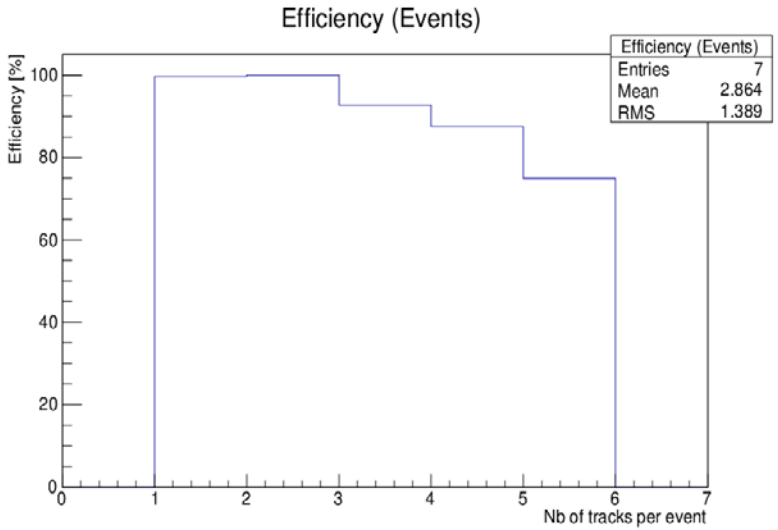
Difference in Y coordinate at each layer of FT12 for simulated and reconstructed tracks



Difference in X coordinate at each layer of FT12 for simulated and reconstructed tracks

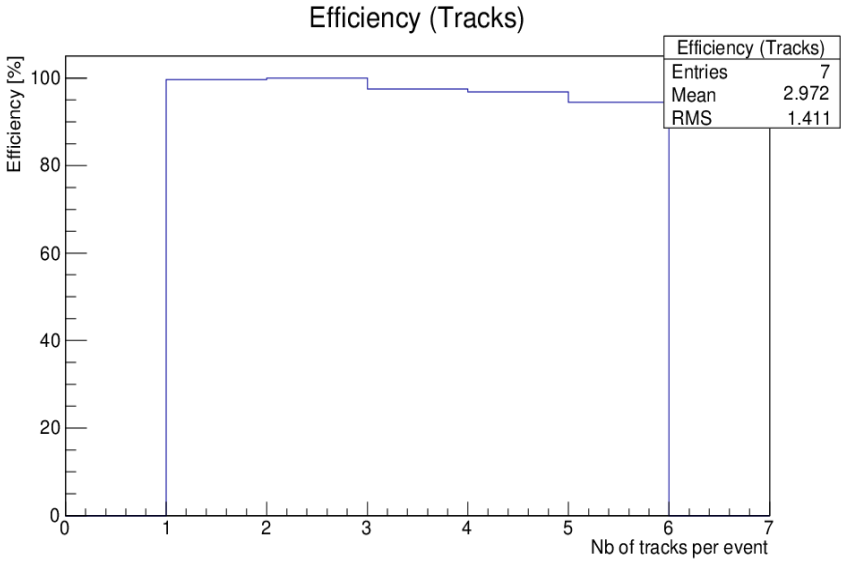


Results F12 muon, 5.55 Gev

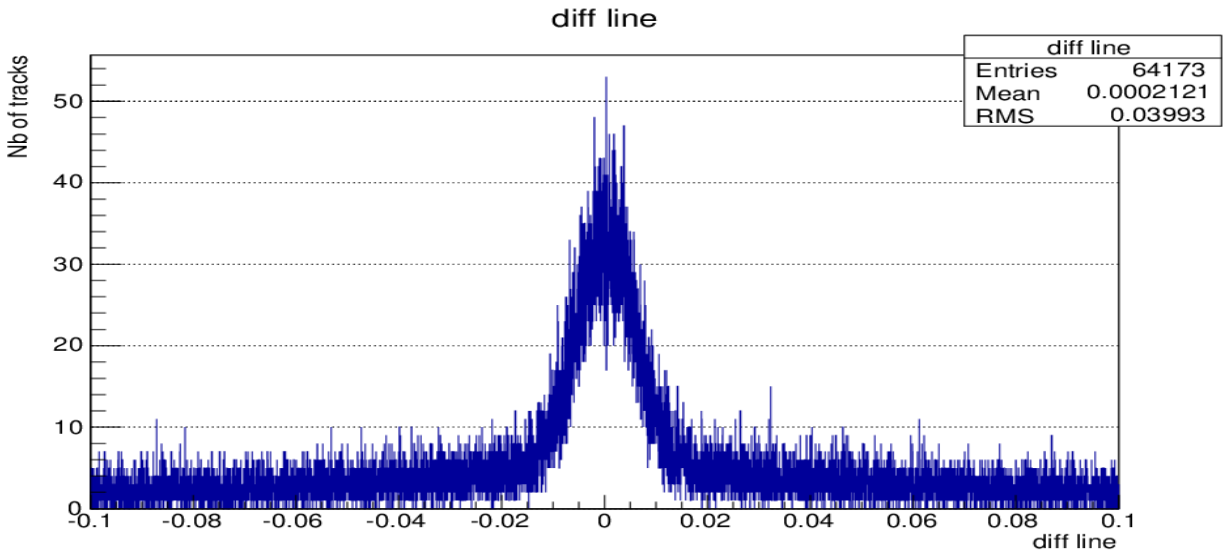


Fraction of events with tracks with at least 13 hits in 16 layers

Algorithm efficiency as function of number of good tracks in events (good=min 13 layers with hit)



Results F12 & F56
muon, 5.55 Gev



in ZOY: |tan(αF12) – tan(βF56)|

Summary

- Pattern recognition for F12 and F56 is working
  - for vertical and skewed straws

- Track model in magnetic field in progress:
  - Promising approximation with circle
  - Located front position of magnetic field
  - End position to be investigated