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Status of track reconstruction for SPD experiment

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Introduction

- Track reconstruction is traditionally divided into separate sub-tasks:
  - track finding
  - track fitting (is already introduced in SPD on the base of Kalman filter)

- Track finding (or pattern recognition):
  - division of set of measurements in a tracking detectors into subsets
  - each subset contains measurements believed to originate from the same particle

- Track fitting:
  - starts with the measurements inside one subset as provided by the track finder

Pattern recognition (scheme)

1. all change are done inside SPDroot software

2. 1-step – event generation

3. 2-st step (simulation) => produce sim-hits using SPDroot with vertex and tracker

4. 3-d step => produce digi-hits (this options is now in SPDroot, contains x-y coordinates with smearing for vertex and straw detectors)

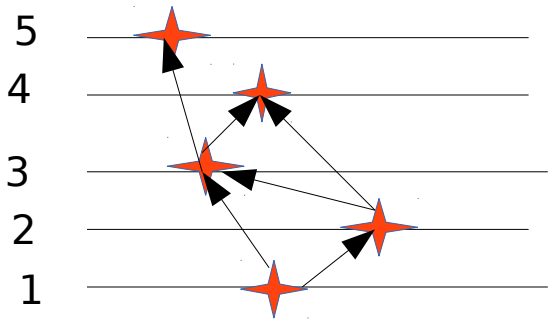
5. 4-th -step (pattern recognition) => produce track candidates with the set of vertex and straw hits

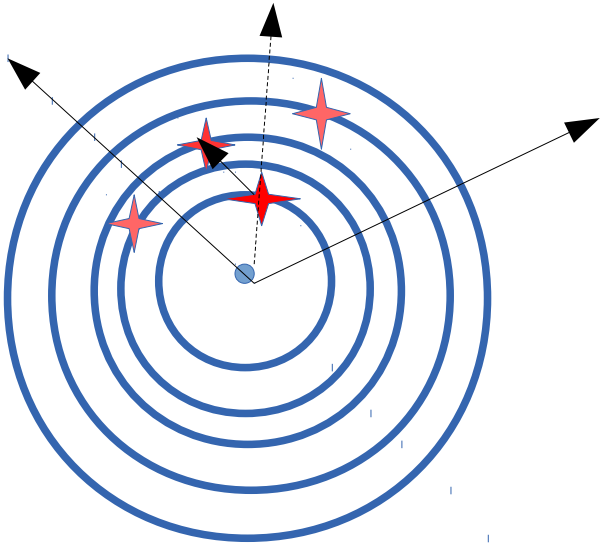
6. final Kalman fit of track candidates

Pattern recognition means:
- construct track seed using hits in vertex detector;
- add consistently straw detector hits to vertex track candidate;
- and finally create track candidate which contains as vertex and straw tracker hits.

Track seed in vertex detector (1)

1. Silicon vertex detector – 5 cylinders in barrel and 5 disks in endcap parts





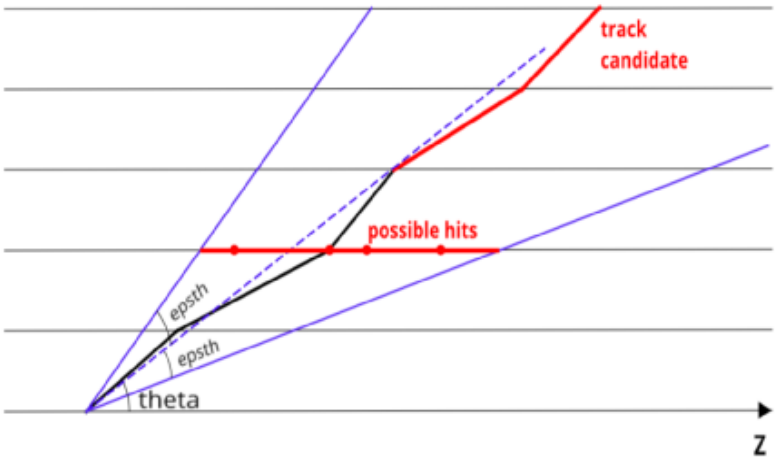
2. produce 2-points seed => next 2 – points combinations between hits are considered (ordered in layers):

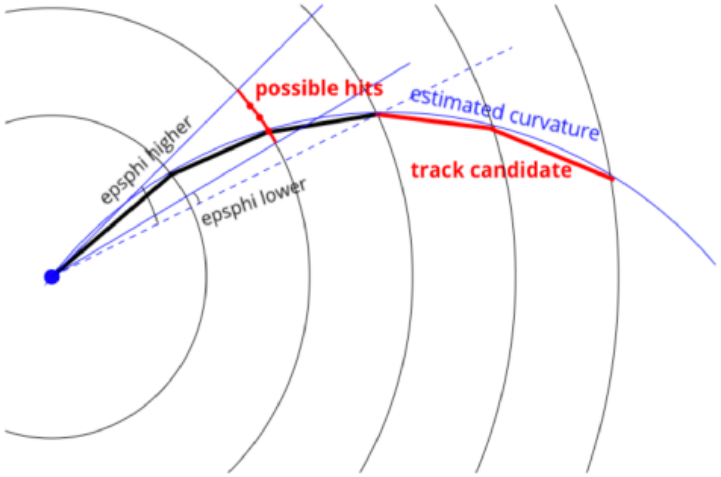
a) 1 layer <=> 2 layer b) 1 layer <=> 3 layer c) 1 layer <=> 4 layer
d) 1 layer <=> 5 layer
e) 2 layer <=> 3 layer f) 2 layer <=> 4 layer g) 2 layer <=> 5 layer
h) 3 layer <=> 4 layer I) 3 layer <=> 5 layer
j) 4 layer <=> 5 layer

3. point in the next layer is accepted if this point is inside some phi-range => produce 2-points seed

Track seed in vertex detector (2)

4. produce 3-points seed => add 3-d point to primary 2-points seed:
   (1,2) <= 3 layer; (1,2) <= 4-th layer; (1,2) <= 5-th layer on the base next conditions:





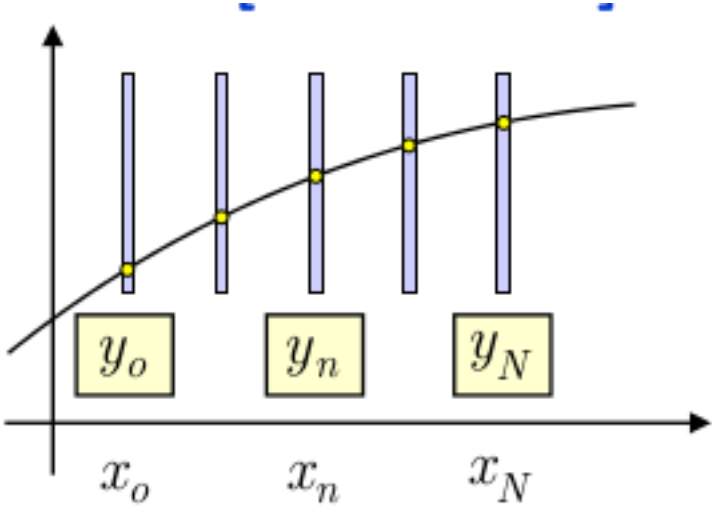
a) use 2 points in (1,2) layers for primary estimation of theta direction and then
   3-d point (in 3-d, 4-th or 5-th layers) should be inside some delta theta range
   => first check

b) as primary vertex on xy-plane has small sigma (~0.2 cm) then zero point (0,0)
   is used as 1-st point for curvature estimation

c) next 3-d point (in 3-d, 4-th or 5-th layers) should be also inside some delta phi range
   => second check

Track seed in vertex detector (3)

5. in general, track trajectory can be approximated by parabola on XY-plane and parameters and chi2 can be estimated using the next expression:



$$\begin{cases} a\sum_{i=1}^{n} x_i^2 + b\sum_{i=1}^{n} x_i + nc = \sum_{i=1}^{n} y_i, \\ a\sum_{i=1}^{n} x_i^3 + b\sum_{i=1}^{n} x_i^2 + c\sum_{i=1}^{n} x_i = \sum_{i=1}^{n} x_i y_i, \\ a\sum_{i=1}^{n} x_i^4 + b\sum_{i=1}^{n} x_i^3 + c\sum_{i=1}^{n} x_i^2 = \sum_{i=1}^{n} x_i^2 y_i; \end{cases}$$

$$\chi^2 = \sum_{n=0}^{N} \frac{\left(y_n - a - bx_n - cx_n^2\right)^2}{\sigma_n^2}$$

a) new point is added on the base of chi2 value estimation => third check (this check is optional)

6. this procedure starts from 2-points seed => produce 3-points seed => use 3-points seed => produces 4-points seed =>use 4-points seed => produce 5-points seed

Track seed in vertex detector (4)

7. z-coordinate of primary vertex is very important parameter for track extrapolation
   => some procedure is applied for z-coordinate estimation

8. then merging procedure is applied:

   a) if 3-points seed contains all points of 2-points seed => 2-points seed is removed
   b) if 4-points seed contains all points of 3-points seed => 3-points seed is removed
   c) if 5-points seed contains all points of 4-points seed => 4-points seed is removed

9. finally there are => 2-points, 3-points, 4-points and 5-points seeds

10. run separate Spd task for this seed finding procedure which produces the new
    SpdTrackSeed and SpdTrackSeedpar classes as output with the next information:

    a) estimated charge
    b) estimated radius (=> or Pt)
    c) estimated theta
    d) estimated phi (phi in 1-st seed point)
    e) estimated z-coordinate of primary vertex

    and some additional information

Pattern recognition
(add straw detector hits)

1. new Spd task SpdRCTrackFinder is created which uses seeds as input data

2. do Kalman fit of seed (using seed parameters and vertex hits) and find track candidate parameters

3. extrapolate track candidate to virtual cylinder with radius 48.0 cm (minimum radius of tracker barrel module) and find module in barrel or endcap in which track candidate hits

4. extrapolate track to 1-st straw layer in this tracker module and find hit points on the plane

5. check distance between hit point and fired straw wire on this plane

6. add “good” straw hit to track candidate points, update track parameters (do new Kalman fit) and then extrapolate to the next straw layer

7. if 2 or more straw hits on one layer are consisted with the track candidate => the new track candidate is created, all hits are copied to the new track candidate and then extrapolation and fitting procedure are applied for all new candidates => so called Kalman tree method

8. if in more than 4 consecutive layers no good hits were find the extrapolation for this track candidate is stopped

Pattern recognition (2)
(add straw detector hits)

9. finally, as the result "big" number of track candidates are produced which contains as vertex and straw detector hits

10. merge track candidate which were produced from the same seed:
    a) check common number of straw hits
    b) if this number is more than some value (80%) then remove track candidate with less number of straw hits (?)
    c) or combine straw hits from these two track candidates (?)

11. merge track candidate which are produced from the different seeds:
    a) check common number of vertex hits
    b) check common number of straw hits
    c) if common number of straw hits is more than some value (80%) then check the common number of vertex hits and track parameters
    d) remove track candidate or combine vertex and straw hits from these track candidates (?)

12. do final Kalman fit for remaining track candidates

Summary

1. this version of track finding is ready and works

2. debugging and tuning procedure is underway

The next two points are important:

1. check finding procedure for 2-points seed

2. optimization of all selection parameters and tune procedure for track candidate merging