Possible approaches to silicons-only tracking in HLT

FSP Workshop: Slow pion tracking

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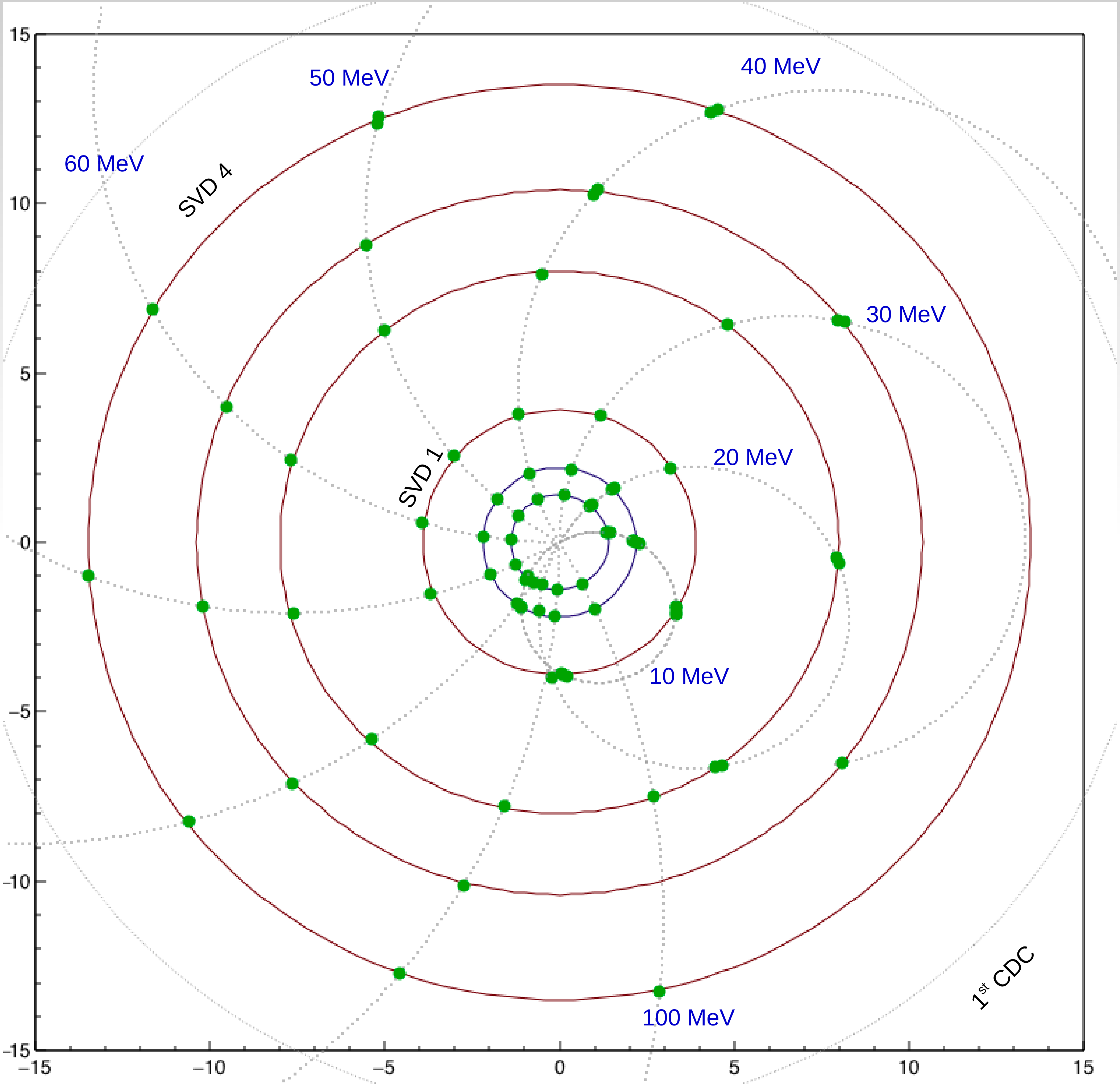
Introduction

The high instantaneous luminosity requires highly performing track-finding software, capable to cope with high rates and significant background, while maintaining high efficiency and resolution for particles with momenta as low as 50 MeV/c.

Essential role in reconstruction of decay chains of short-living beauty and charm particles play tracking detectors around interaction point.

In the final configuration Vertex detector will contain silicon pixel detectors (PXD) arranged in 2 cylindrical layers with radii 14 and 22 mm and double sided silicon strip detectors (SVD) arranged in 4 cylindrical layers with radii 39, 80, 104 and 135 mm. PXD has in total ~7.7 million pixels and SVD – 223 thousands strips.

VXD



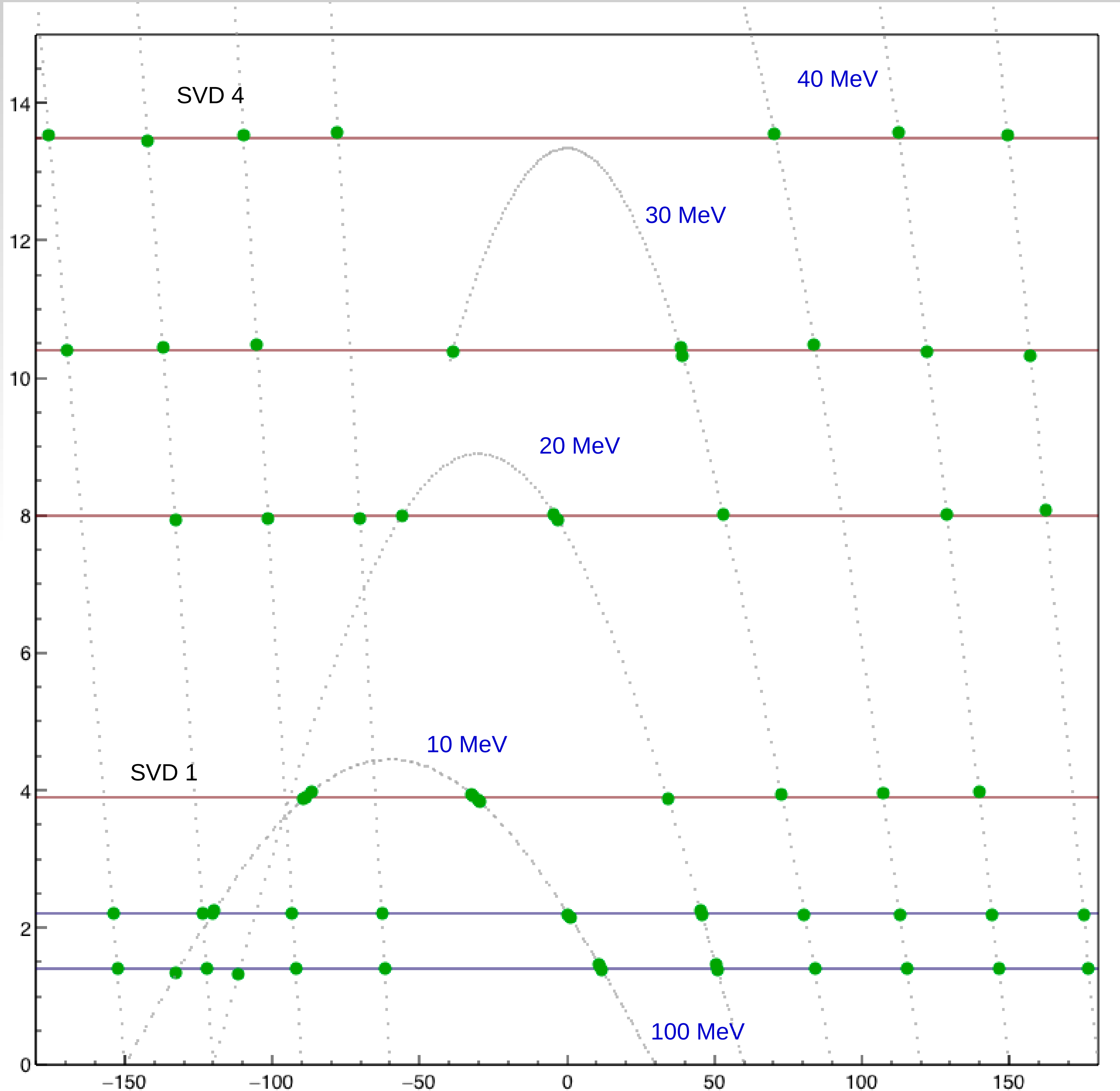
B = 1.5 T

$\theta = 90^o$

$\phi = 30^o, 60^o, 90^o...$

VXD

$\rho-\phi$



B = 1.5 T

$\theta=90^{o}$

$\phi=30^{o},60^{o},90^{o}$...

Introduction

The challenging task of the "silicon-only" tracking project is the reconstruction slow pions from decays with little energy release in the presence of a high background from e^+e^- tracks using the information from the silicon vertex detectors only.

There are two main tasks:

(1) distinguish the response of the silicon detectors of background e^+e^- and wanted slow pions.

(2) apply a track finding algorithm as part of HLT to:

a) enhance fraction of events with slow particles

b) remove hits not associated with track candidates (to reduce data flow)

Possible approaches

For task (2) following approaches are planned to be tested:

1) Kalman filter tree search
2) Pattern matching.
3) “Image” recognition.

Kalman filter technique

- Kalman filter is iterative procedure:
- On every step track parameters vector **X** with it's **covariance matrix** ...

  (1) … is extrapolated to the surface of tracking detector. Extrapolation procedure uses magnetic field map and materials map (to take into account multiple scattering and energy losses)

  (2) … is updated by measurement **M**, where **M** is cluster coordinates with **covariance matrix** (could be ommited).

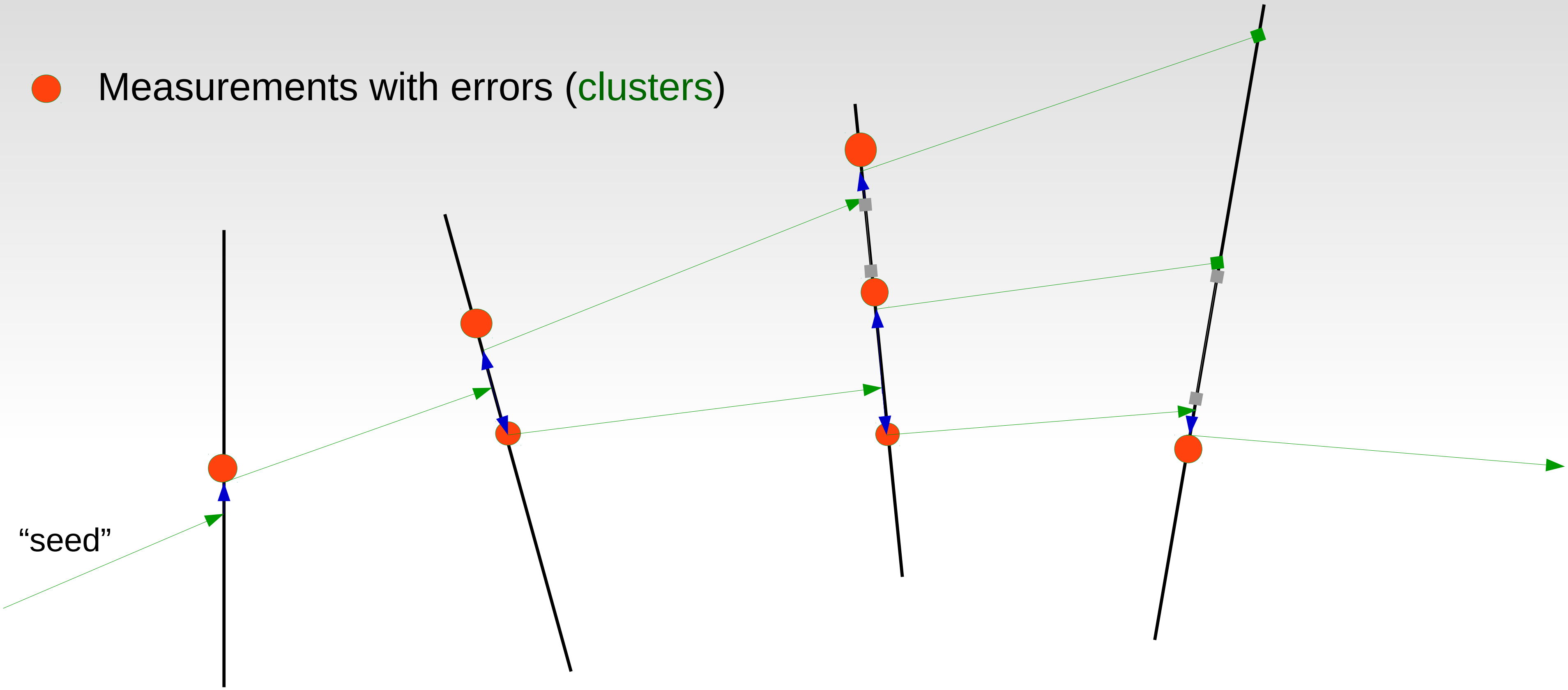
- At the end of iterations we have the best track parameters estimator with it's covariance matrix

Kalman filter technique

- Advantages of Kalman filter technique:
  - Manipulation with matrices of maximal size NxN where N is length of track parameters vector (usually 5) independent of number of used measurements.
  - Before "update" step, contribution of measurement **M** to final tracks' Chi2 could be calculated → we can decide to include this measurements to the track or not (i.e. to do filtering).

This allows to build pattern recognition algorithm based on Kalman filter (Kalman filter tree).

Kalman filter tree
(illustration of principle)



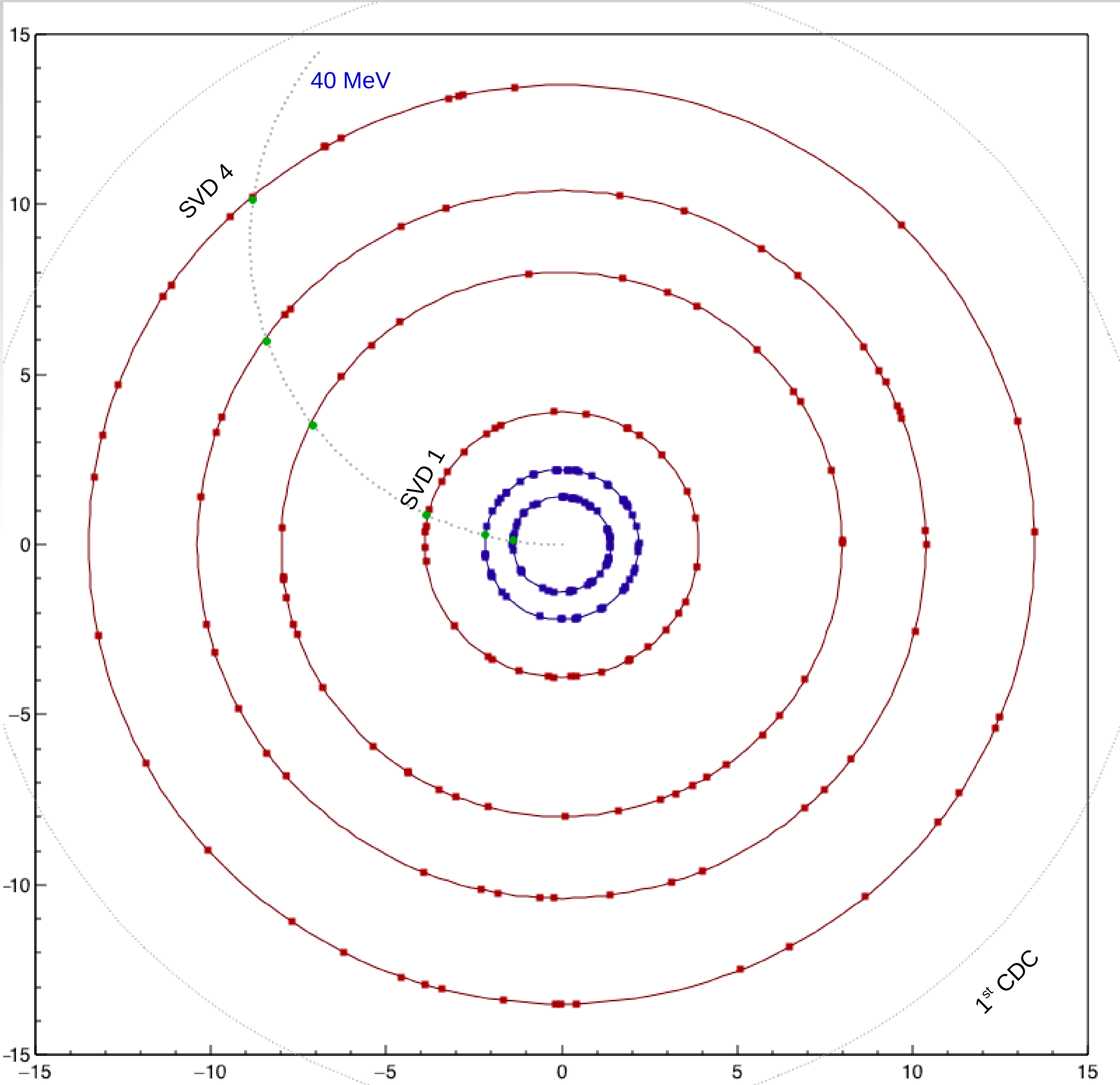
- Extrapolate **X** and it's **covariance matrix** to detector's surface
- Update **X** by measurement **M**
- Check Chi2 increment. No "update" if it's too big.
- Stop track following ("dead branch of the tree")

Kalman filter tree
(track “seeds”)

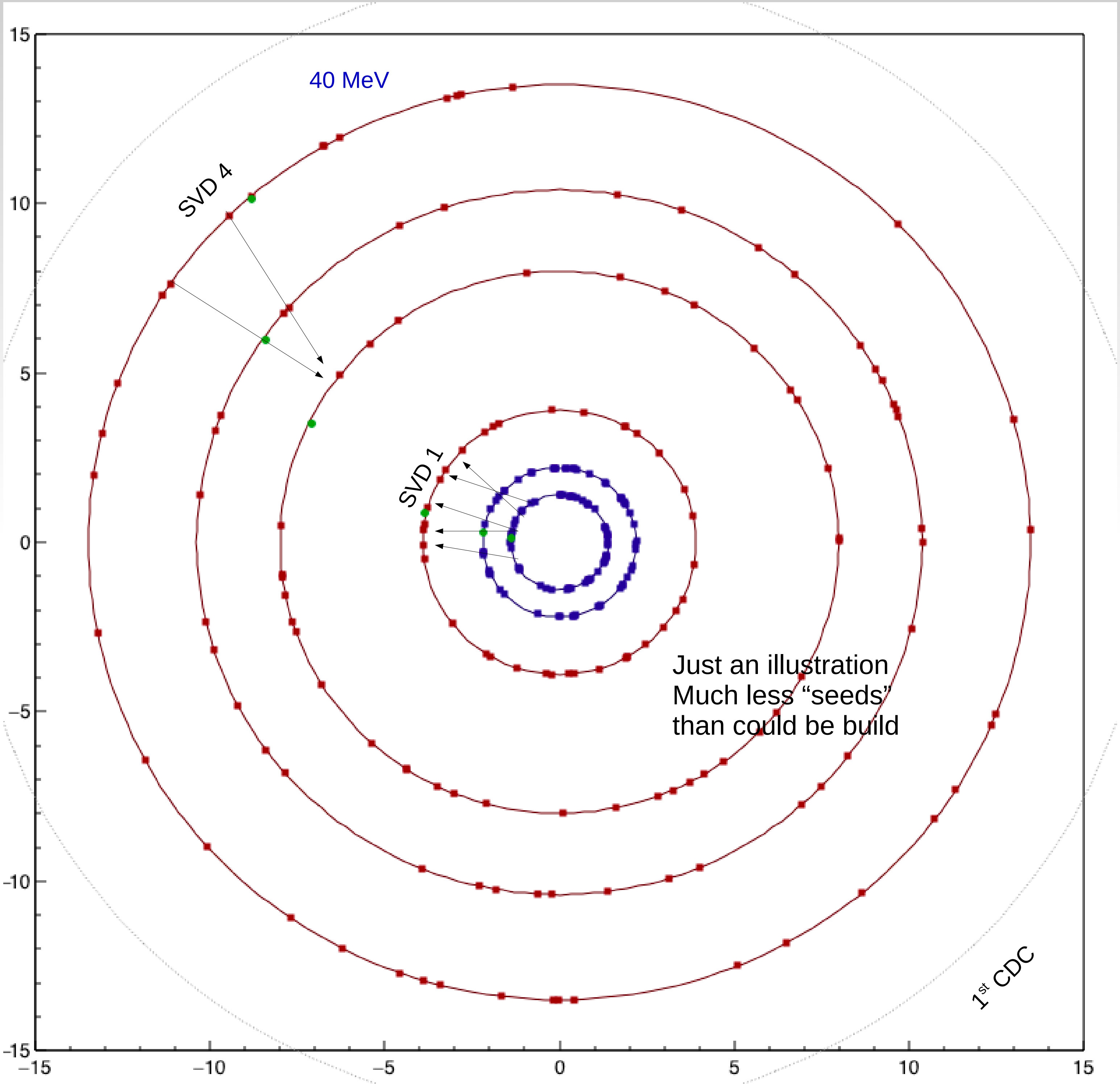
Crustal point is a creation of track “seeds”

- This could be done two ways:
  - a) Upward: using combinations of space points in 2 layers of PXD constrained by position of interaction point
  - b) Downward: using combination of 2-3 space points built in SVD

1 track
+ noise



1 track
+ noise



Two SP seeds

Kalman filter tree
(creation of track “seeds”)

Difficulties:

a) Upward: due to high occupancy number of combinations could be unmanageable

b) Downward: building of space points out of 1-d measurements in double sided SVD may produce a lot of “ghosts”. One needs procedure(s) to suppress them. E.g. strips charge correlation (if there are ADC readout)

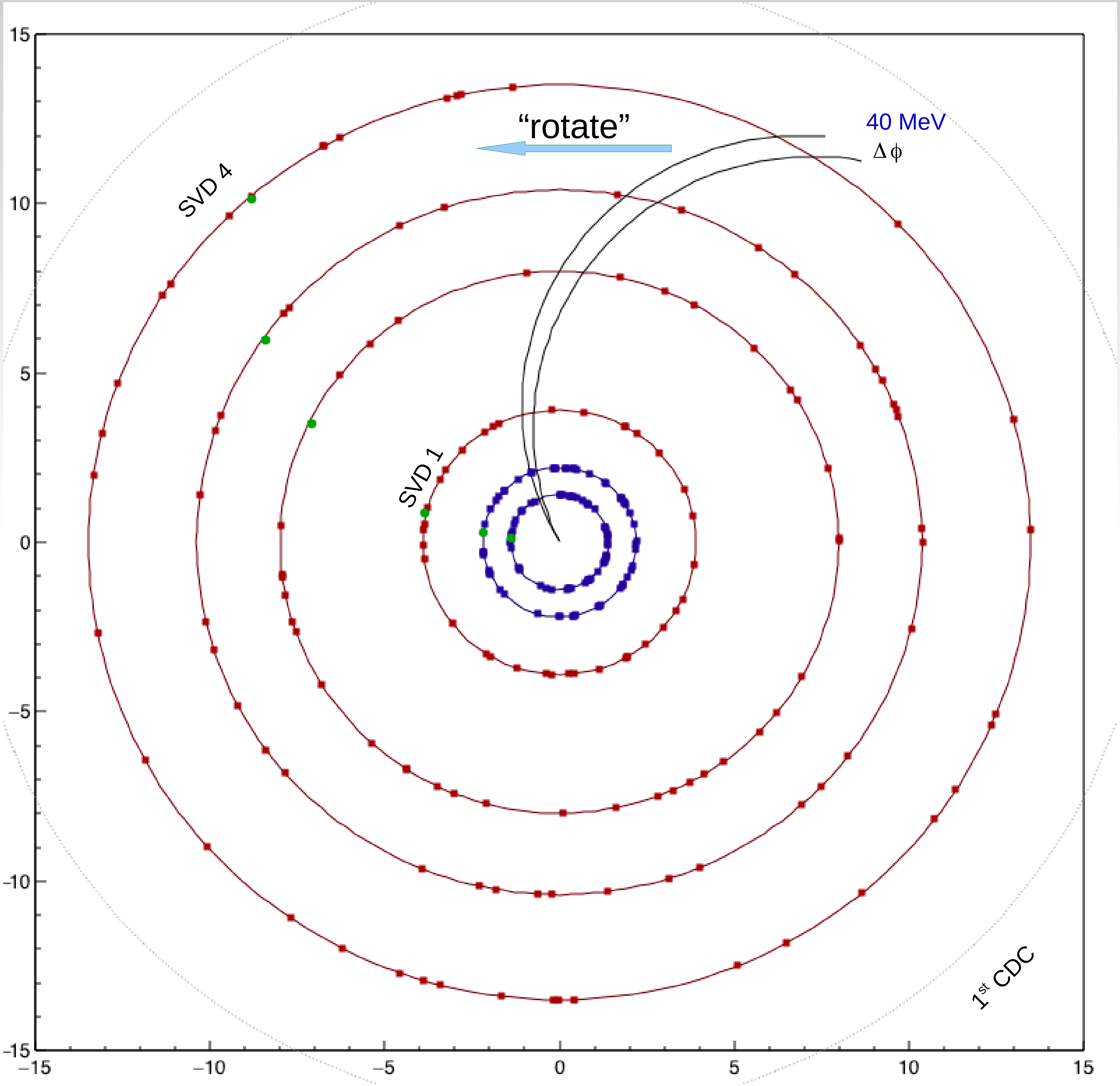
Kalman filter tree

- Advantages:
  - Simultaneous pattern recognition and track fit.
  - Possible reuse of existing code.
- Disadvantages for use in HLT:
  - Complex calculations → could be slow.

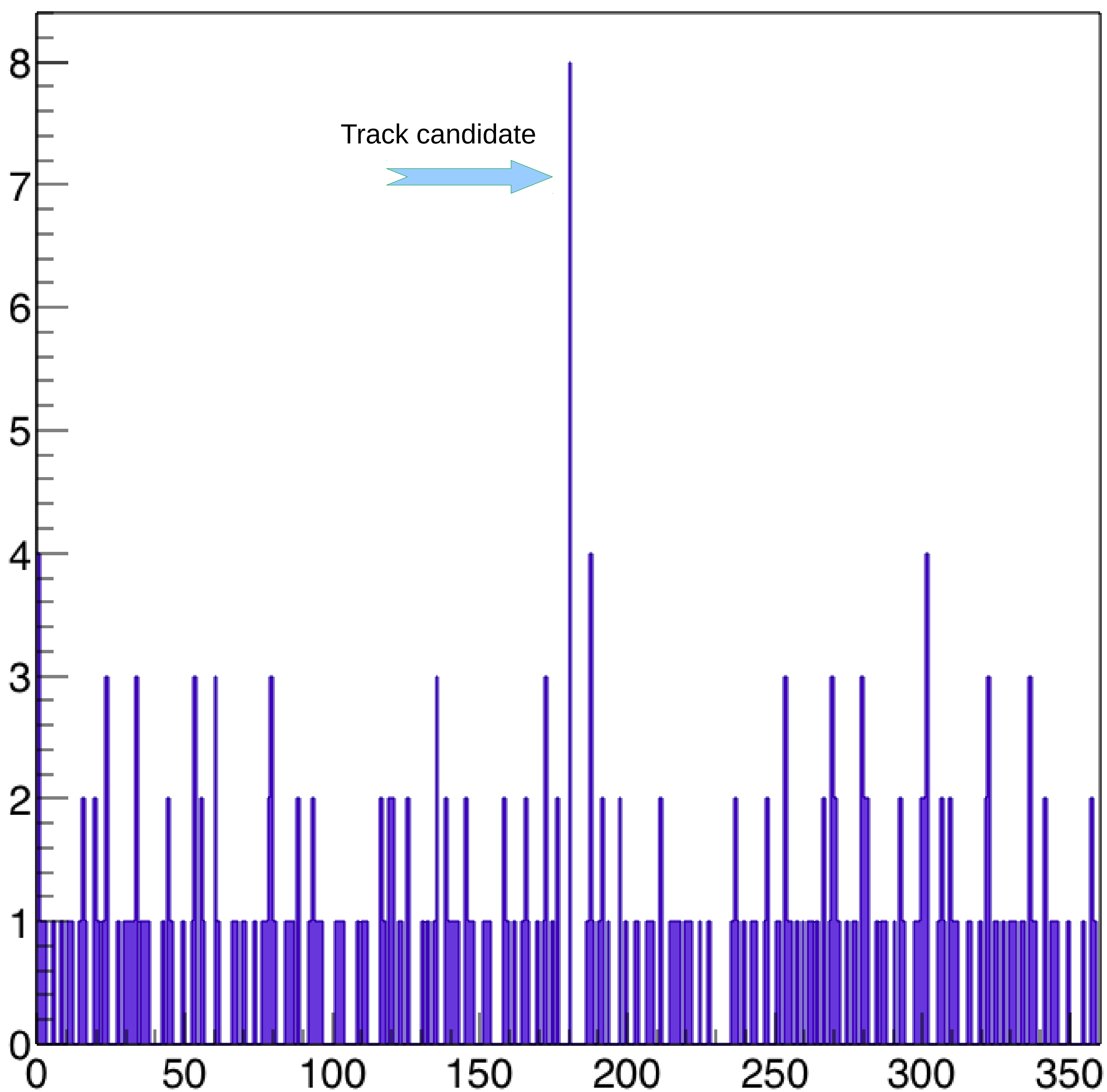
Pattern matching

- Check number of coincidences of event hit patters (in one or two projections) with predefined patterns in bins of phase space of slow pions (MC based):

1 track
+ noise



1 track
+ noise



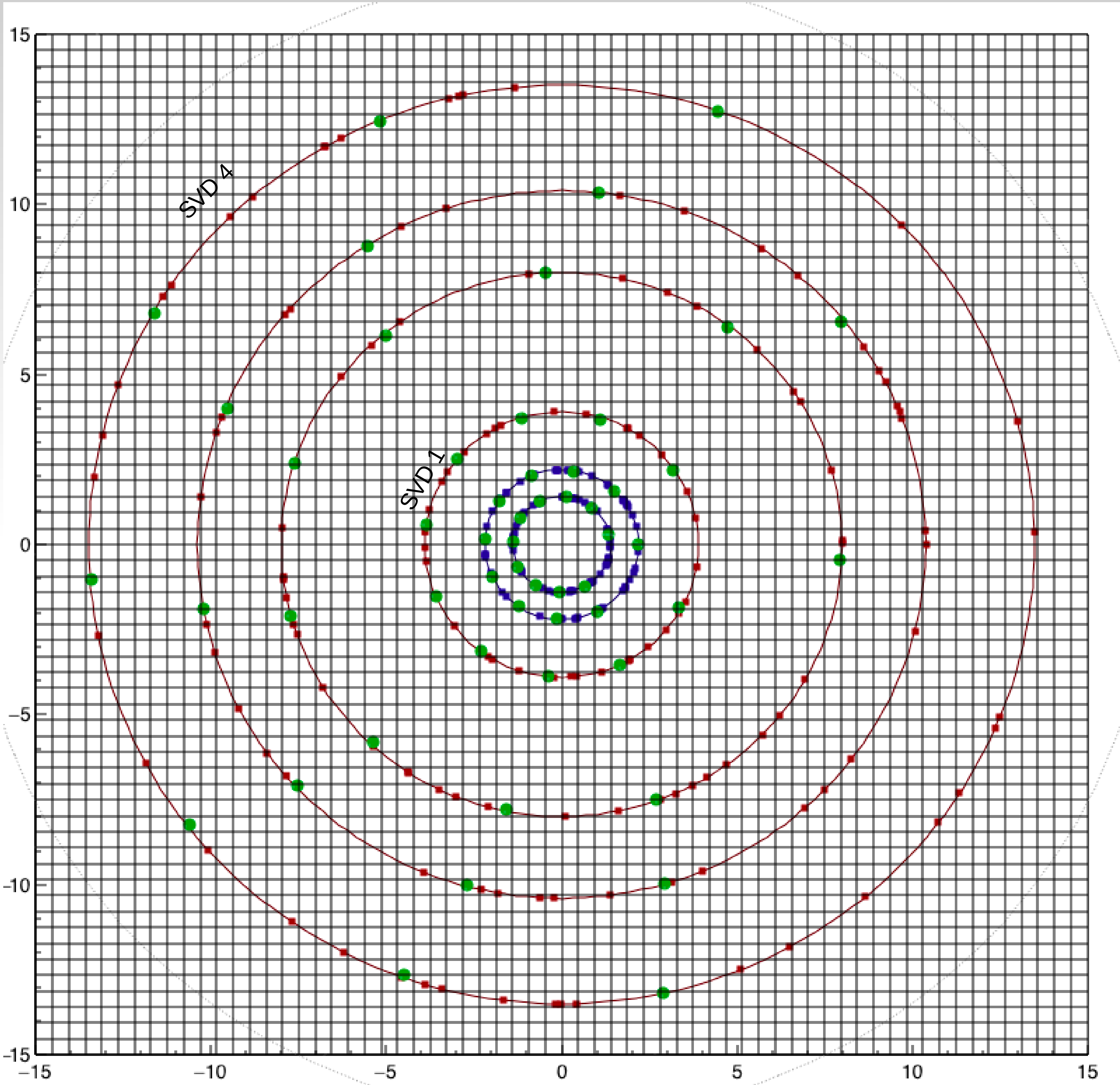
Pattern matching

- Advantages: simple and potentially fast
- Disadvantages: very crude track finding without track fit.

“Image” recognition using machine learning algorithms

- One could try to use popular and well developed machine learning software for an “event image” recognition to detect looping tracks in one or two projections
- Training samples could be MC generated or offline reconstructed.

1 track
+ noise



64 x 64
pixels

Conclusions

- Known algorithms could be tried to use in HLT.
- Performance and efficiency are key issue for HLT → probably one has to sacrificed track finding purity.