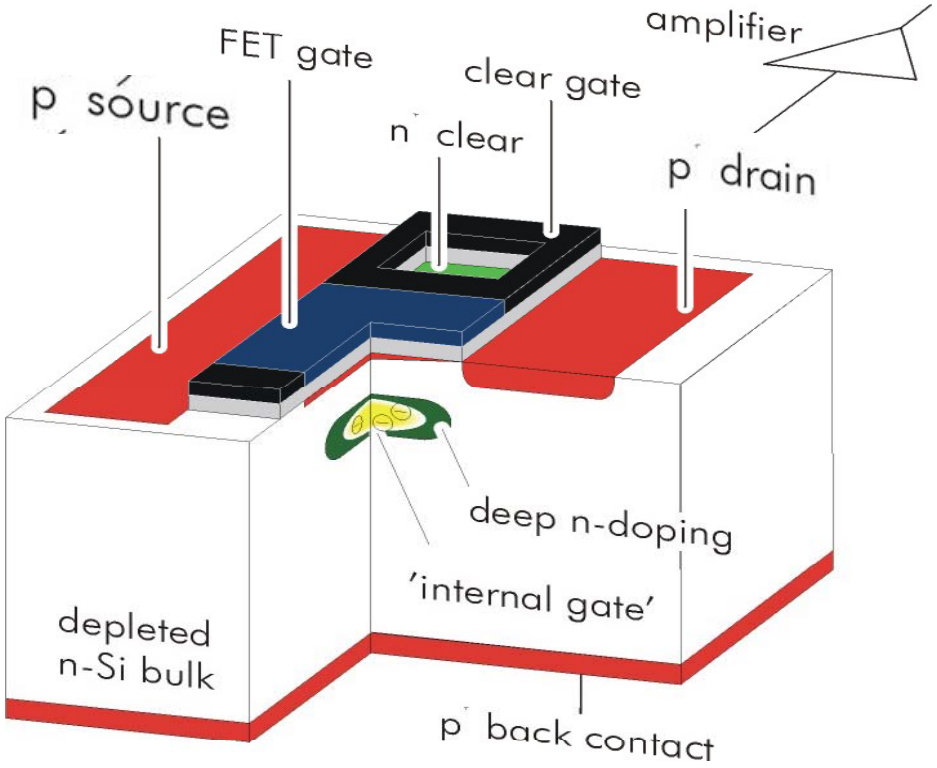
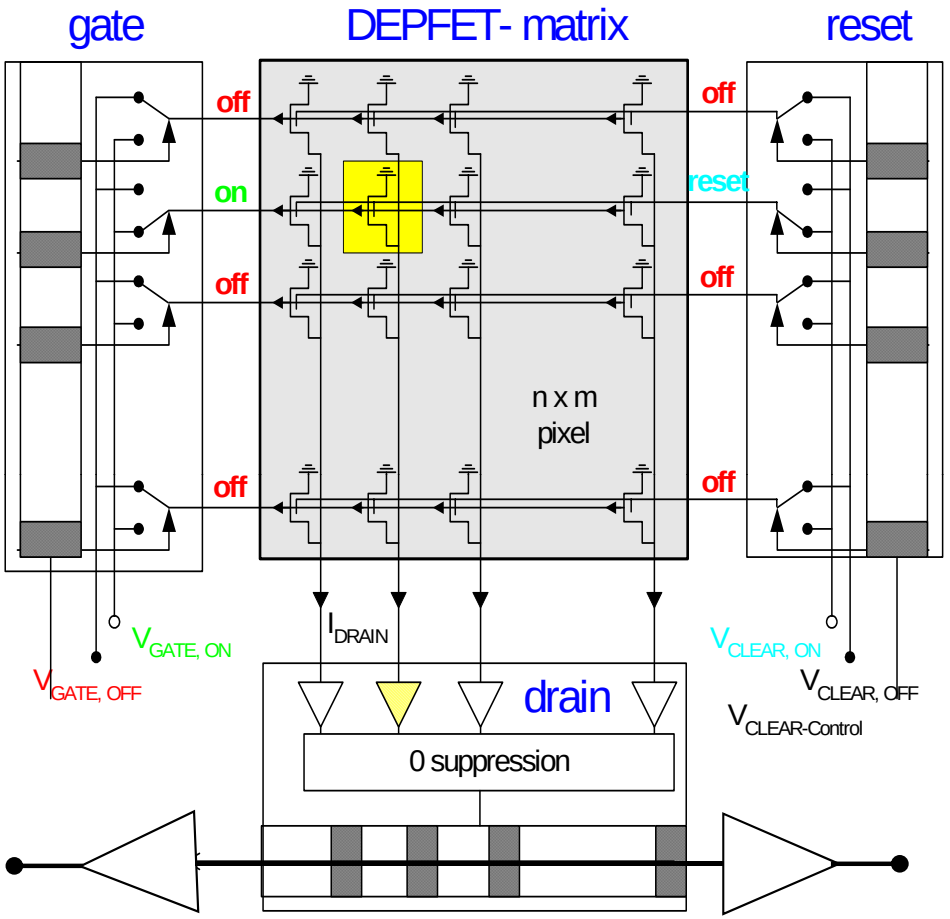
Algorithms for the PXD Data Reduction

DEPFETs for Belle-II

Depleted p-channel FET





- large signal, fast signal collection
- low noise
- low power

- Switcher
- DCD (drain current digitizer)

PXD Layout, Control & DAQ

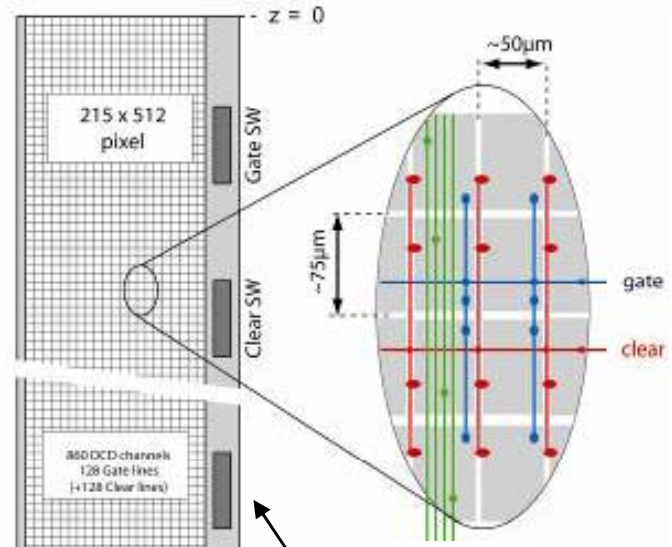
2 layers: @1.4(2.2) cm

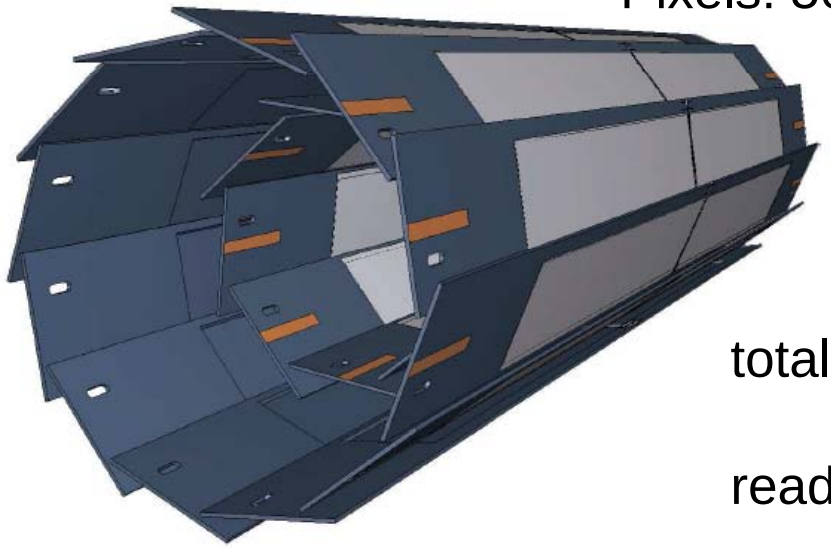
Pixels: 50 x 50(75) µm

half ladder: 800 rows

250 cols

15 x 70 (85) mm

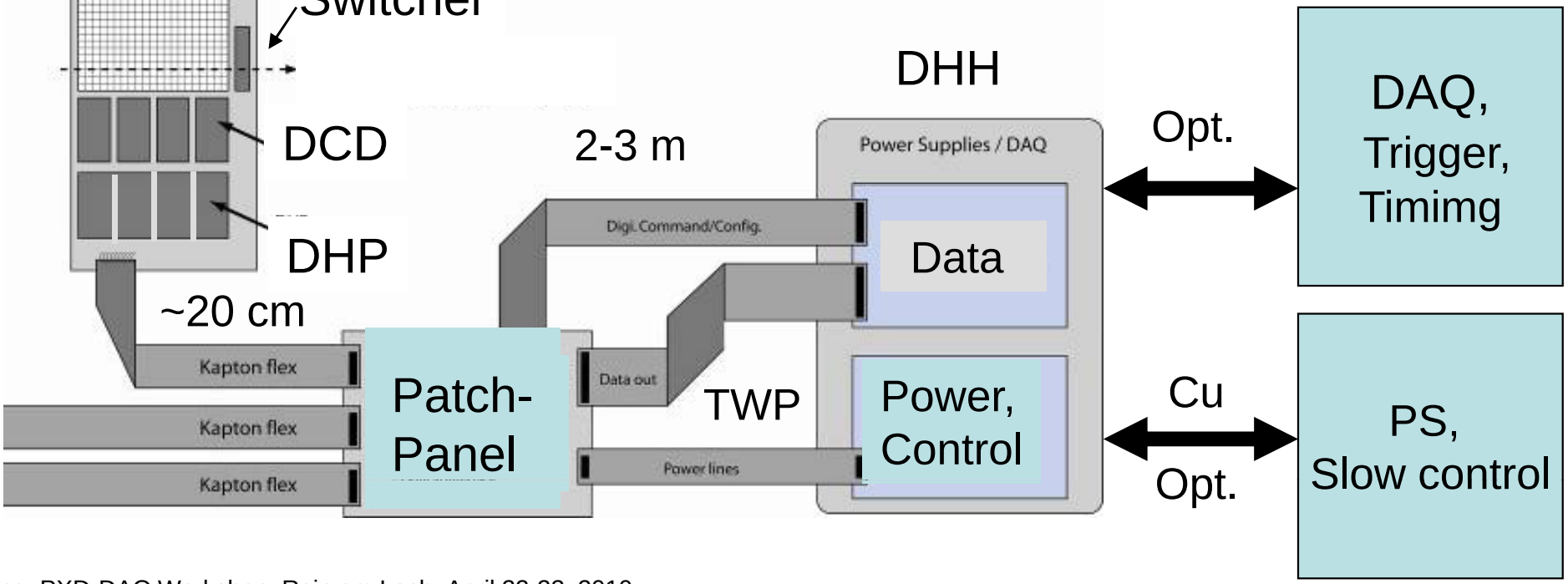




Thickness: 50 or 75 µm

total of 8 Mpx

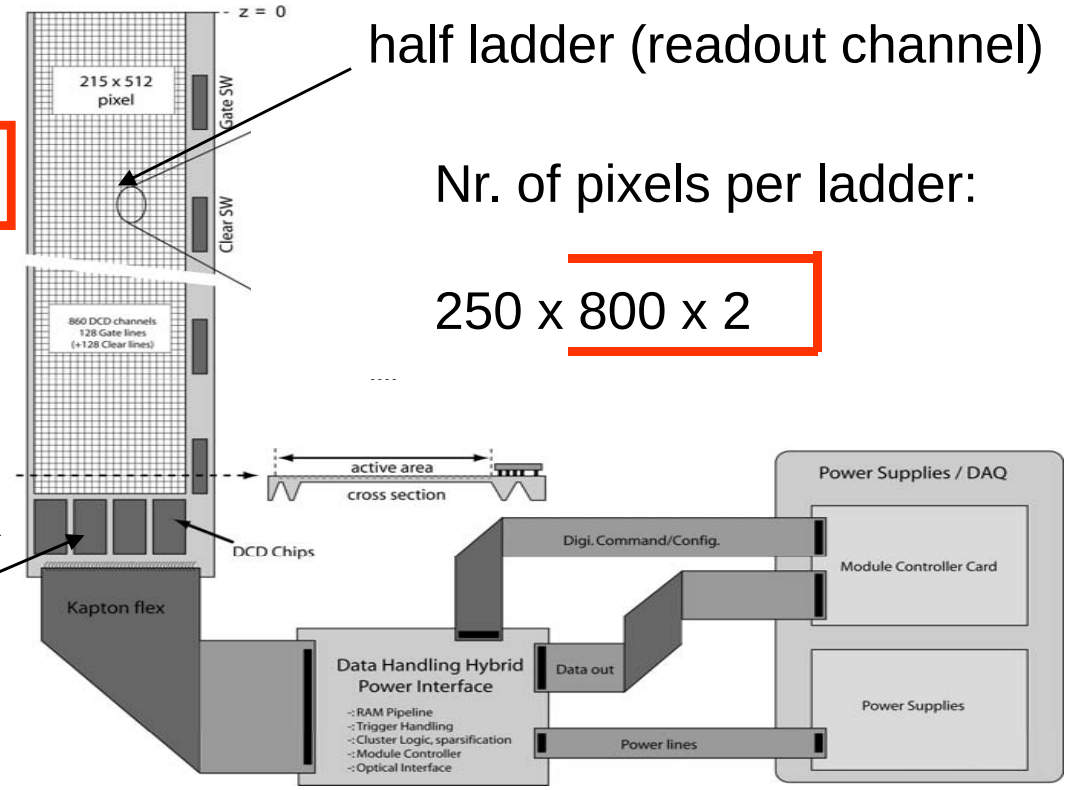
readout: 20 µs



Rate Estimates for the PXD

250

800



half ladder (readout channel)

Nr. of pixels per ladder:

250 x 800 x 2

- 40 half ladders:
  8 Million pixels (px)
- 1% occupancy:
- 80 kpx on at any time
- ~ 3×10^5 px in each event

  (safety factor 3)
- Trigger rate: 10-30 KHz

  Total rate: 9×10^9 px/s
- 4 bytes per px (pos + ADC)

DHP:
zero-suppression
readout buffers (10 MB ?)
slow control …

DHH: module controller
data link

Digitzation (DCD)

Total rate: 300 GBits/s

6.0 GBits/s
per R/O channel

General Remarks

- Signal / Noise ~ 1/1000 („real“ hits / background hits)
- Data Reduction must be achieved with the tracking system:

  PXD; SVD; CDC

  (other subdetectors cannot help)

- PXD in its present form (2 layers) cannot do the job by itself

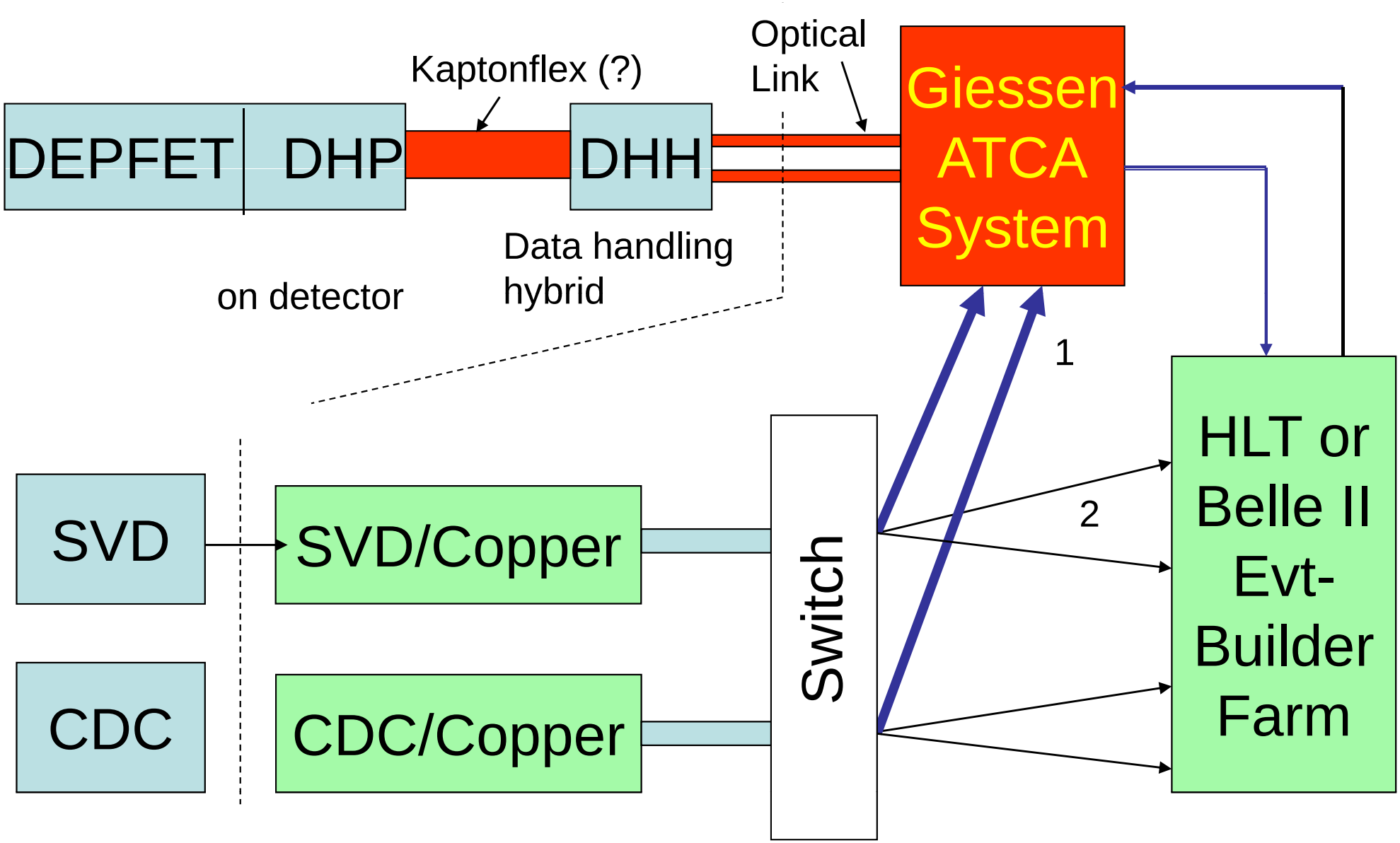
  .

  (small factor (of order 2) achievable by clustering)

- Basic Idea: Build „roads“ from non-PXD trackers and reject pixels outside these roads

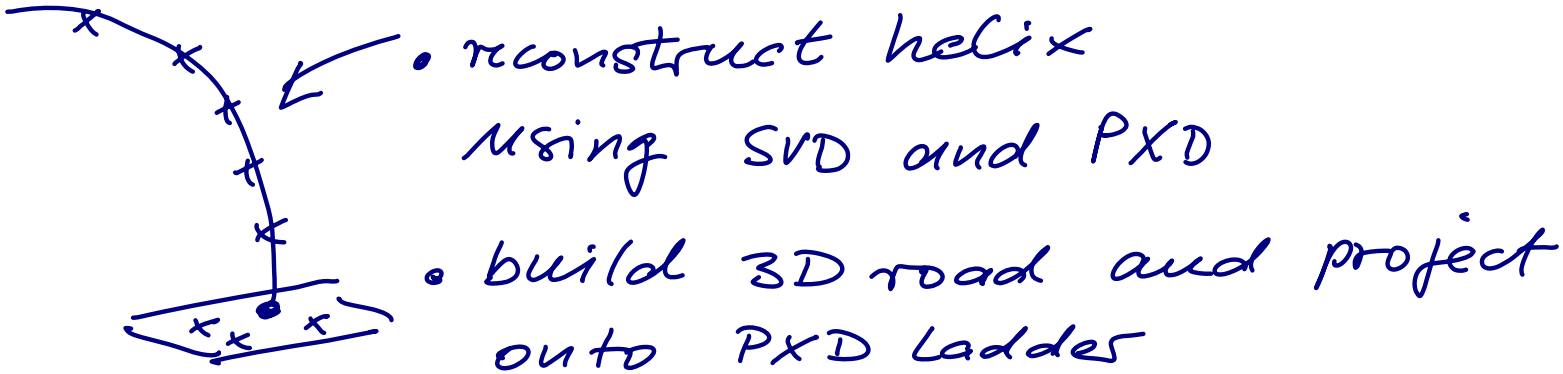
$$p[GeV] = r[m]0.3B[T]$$

Options for the PXD DAQ

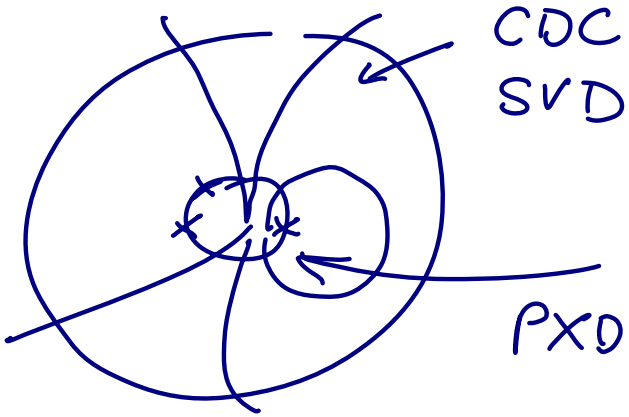


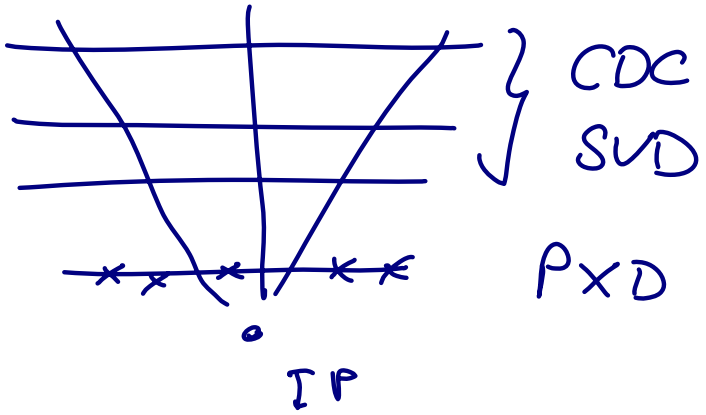
How to Build the Roads?

3D Method (full reconstruction)



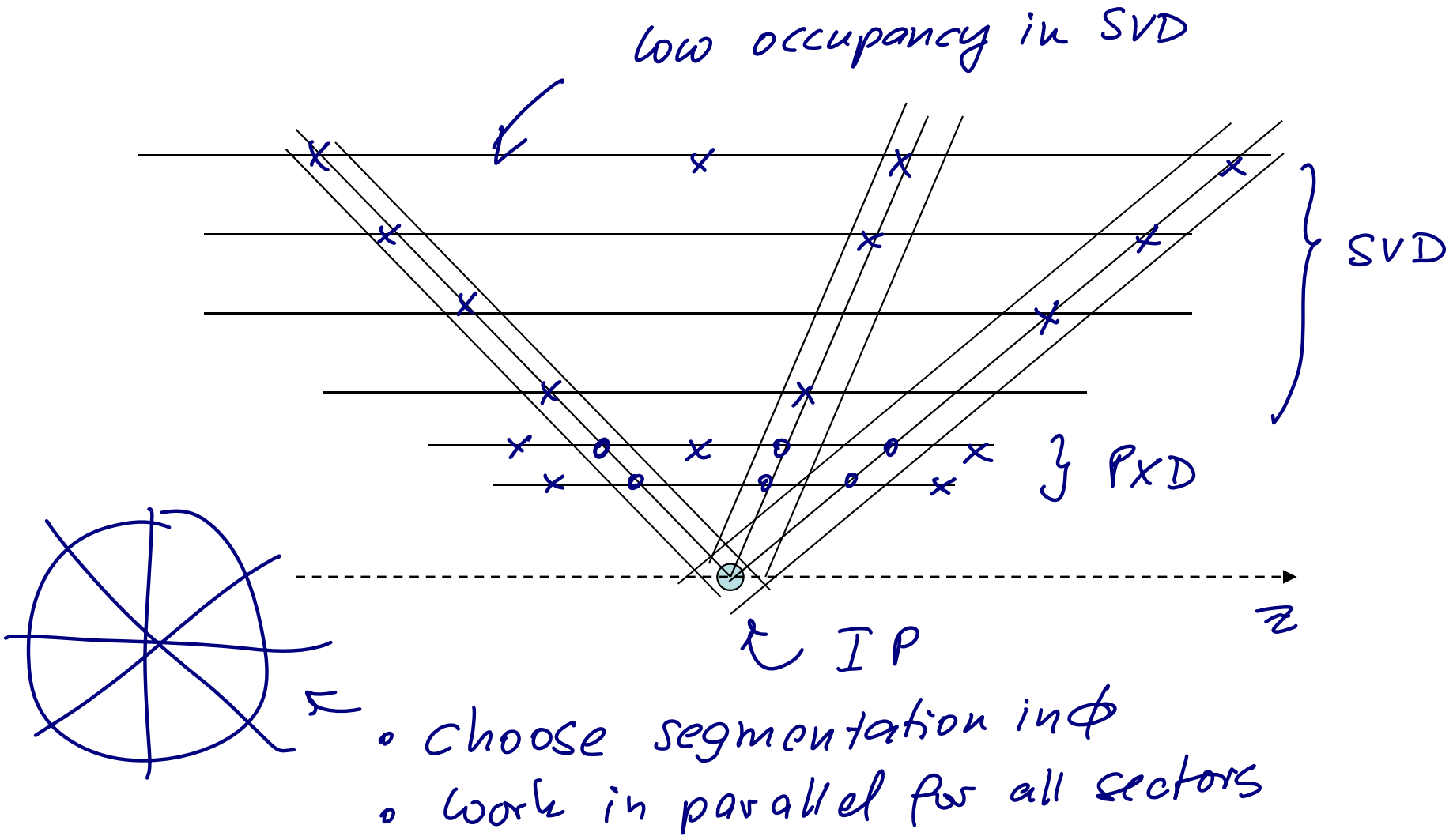
2D Method (work in Rφ or Rz Projections)





Road Finders in Rz

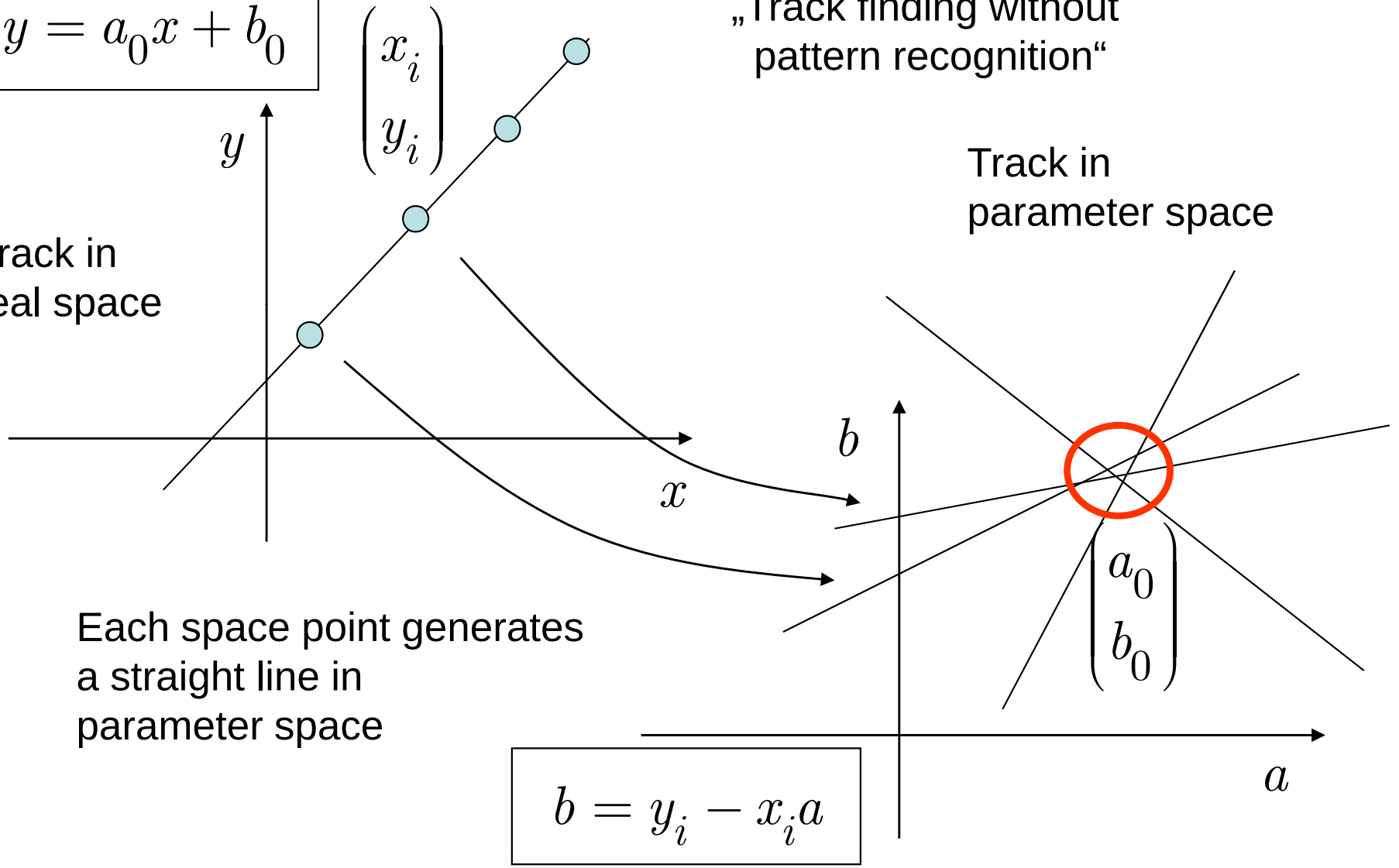
Advantage (over R-phi): tracks almost straight (easy pattern recognition)



Hough Transforms

$$y = a_0 x + b_0$$

„Track finding without pattern recognition“

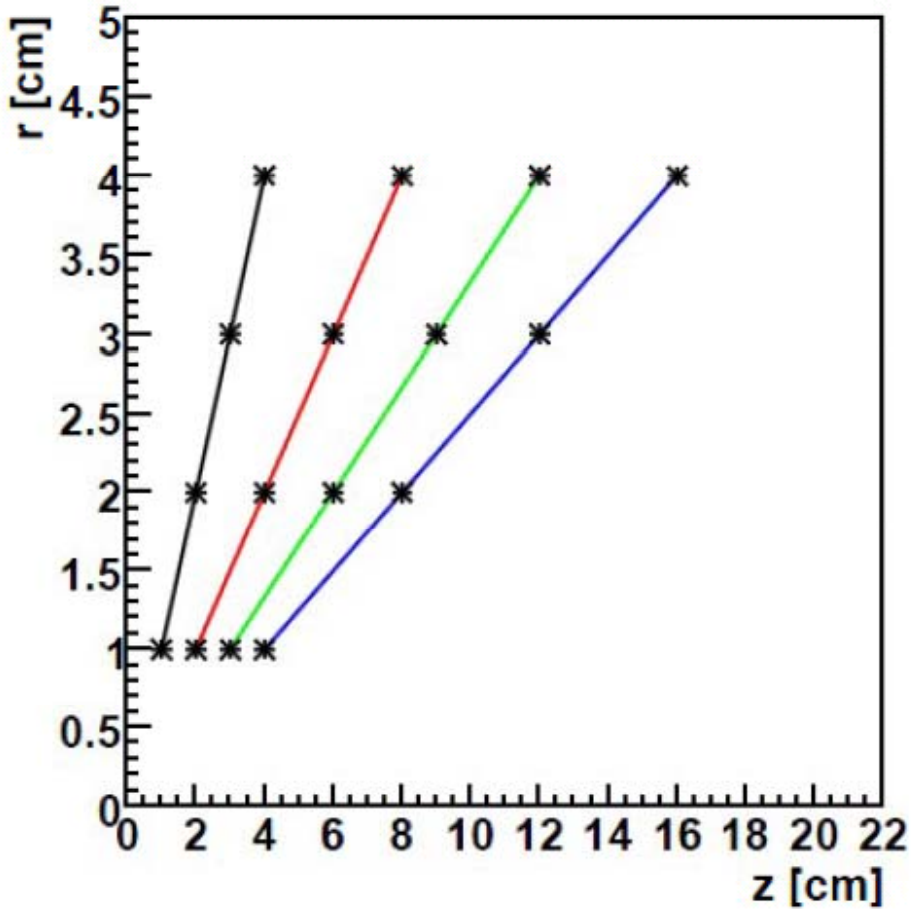


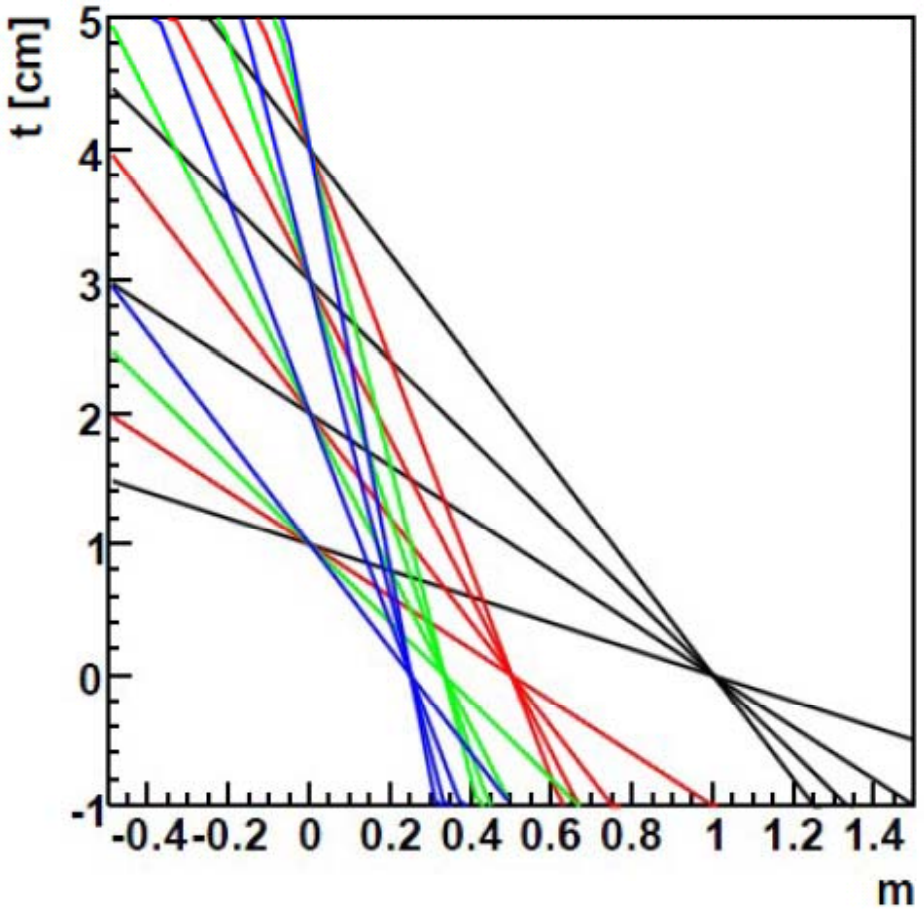
Each space point generates a straight line in parameter space

$$b = y_i - x_i a$$

Track parameters cluster!

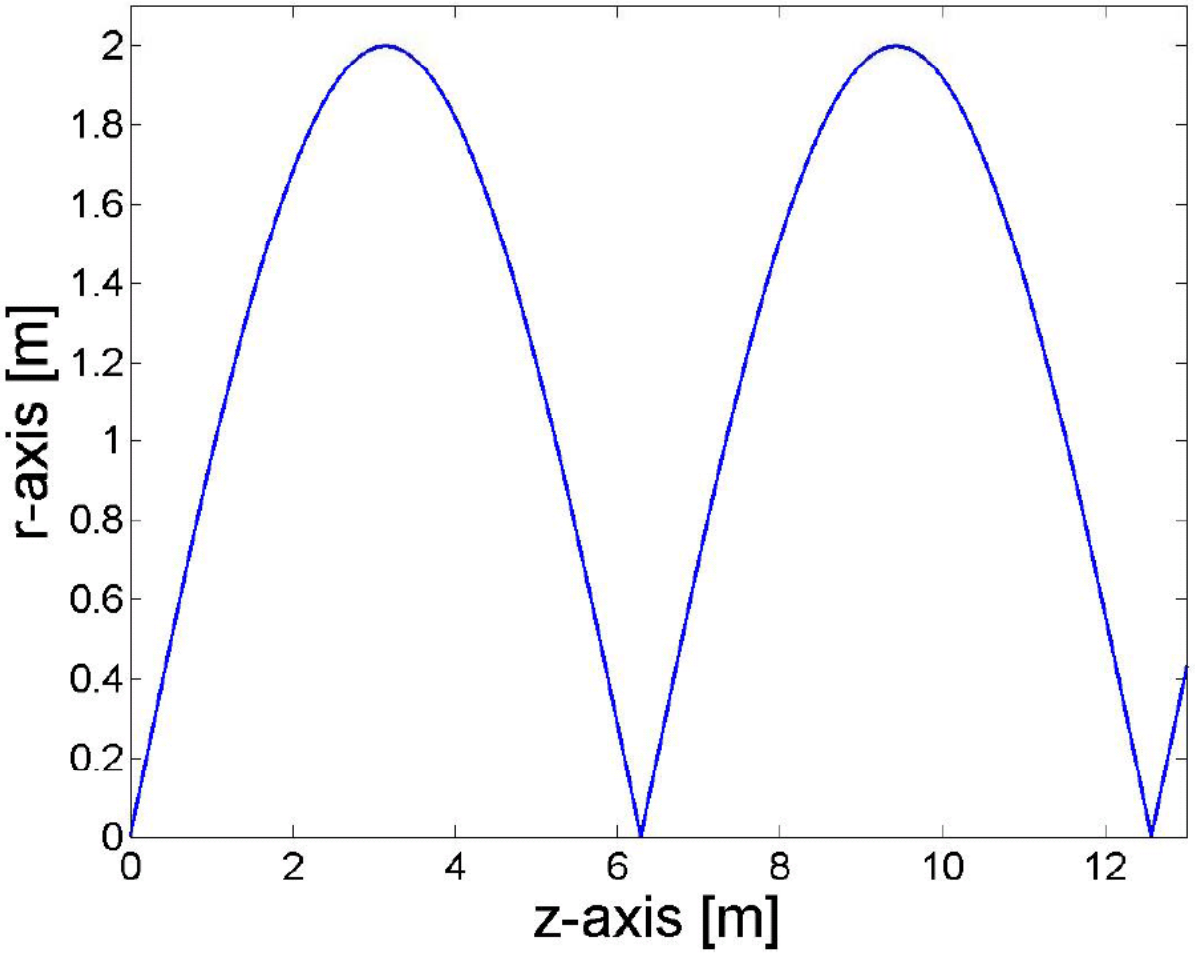
Hough Transforms



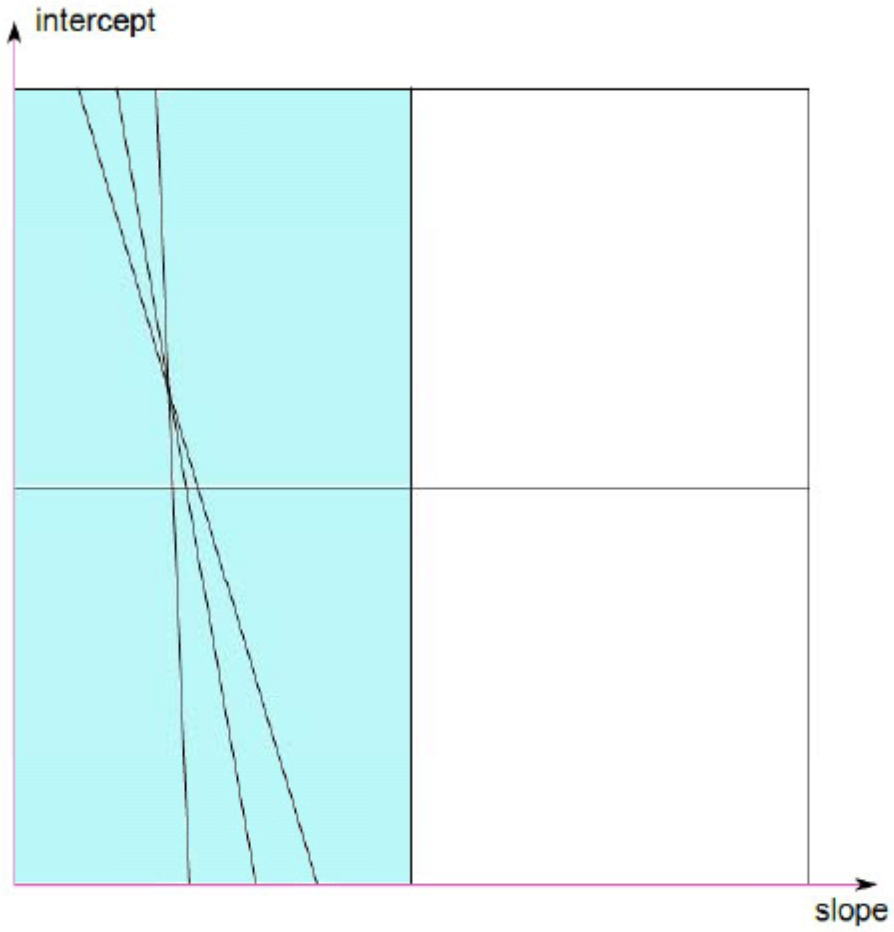


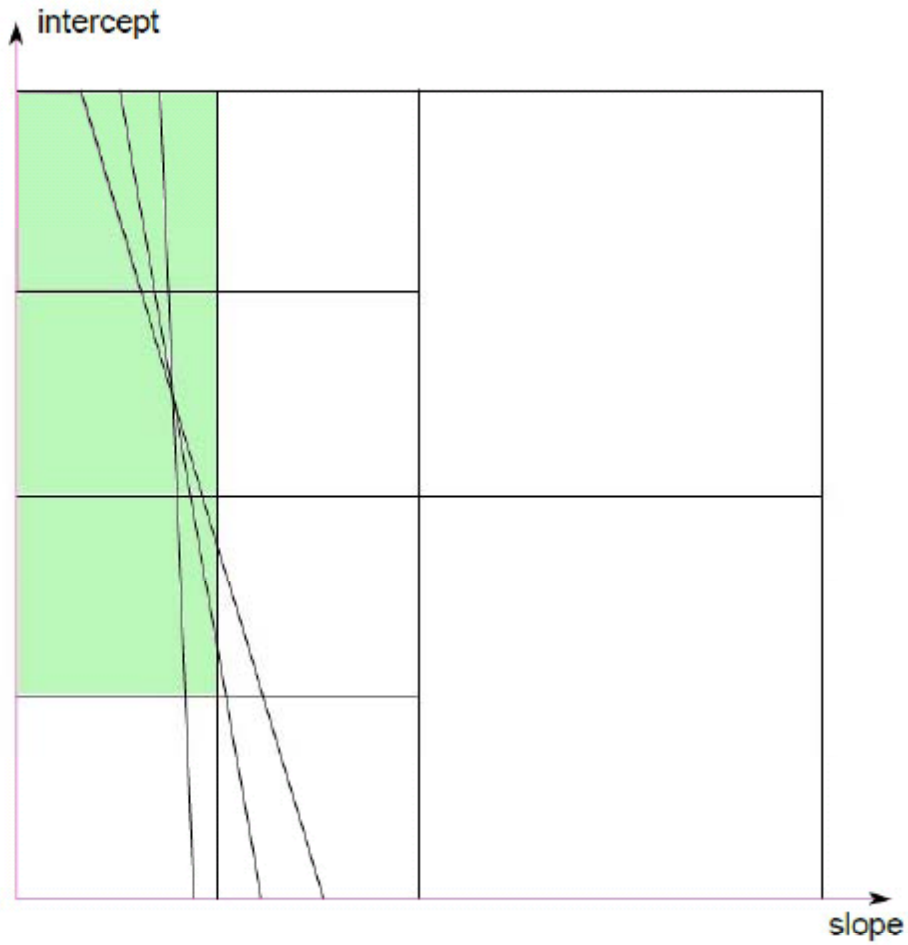
Finite Momenta

straight line -> sine function



Finding the Points of Intersection





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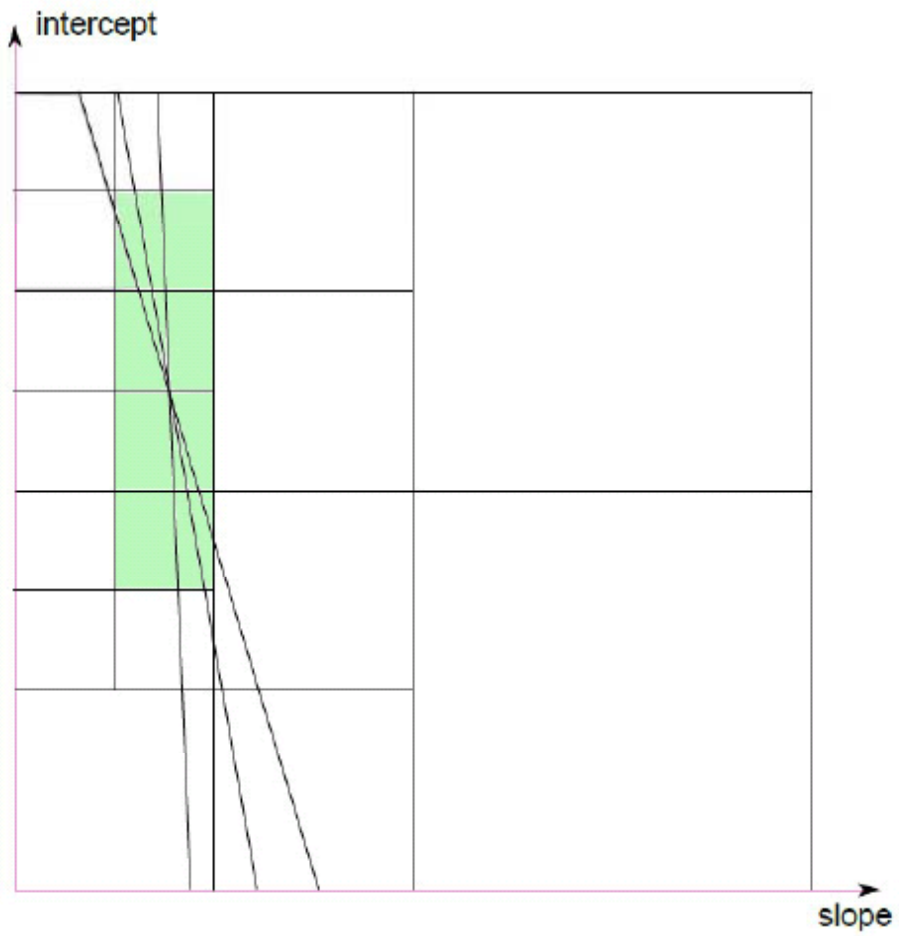
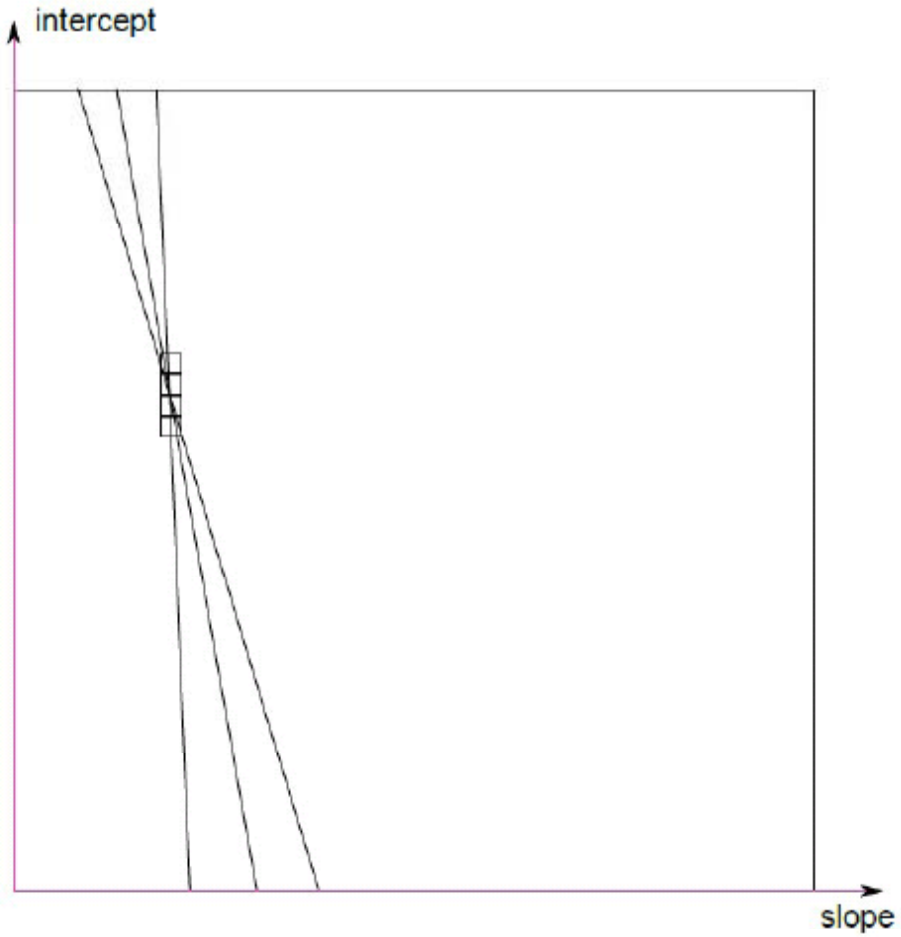
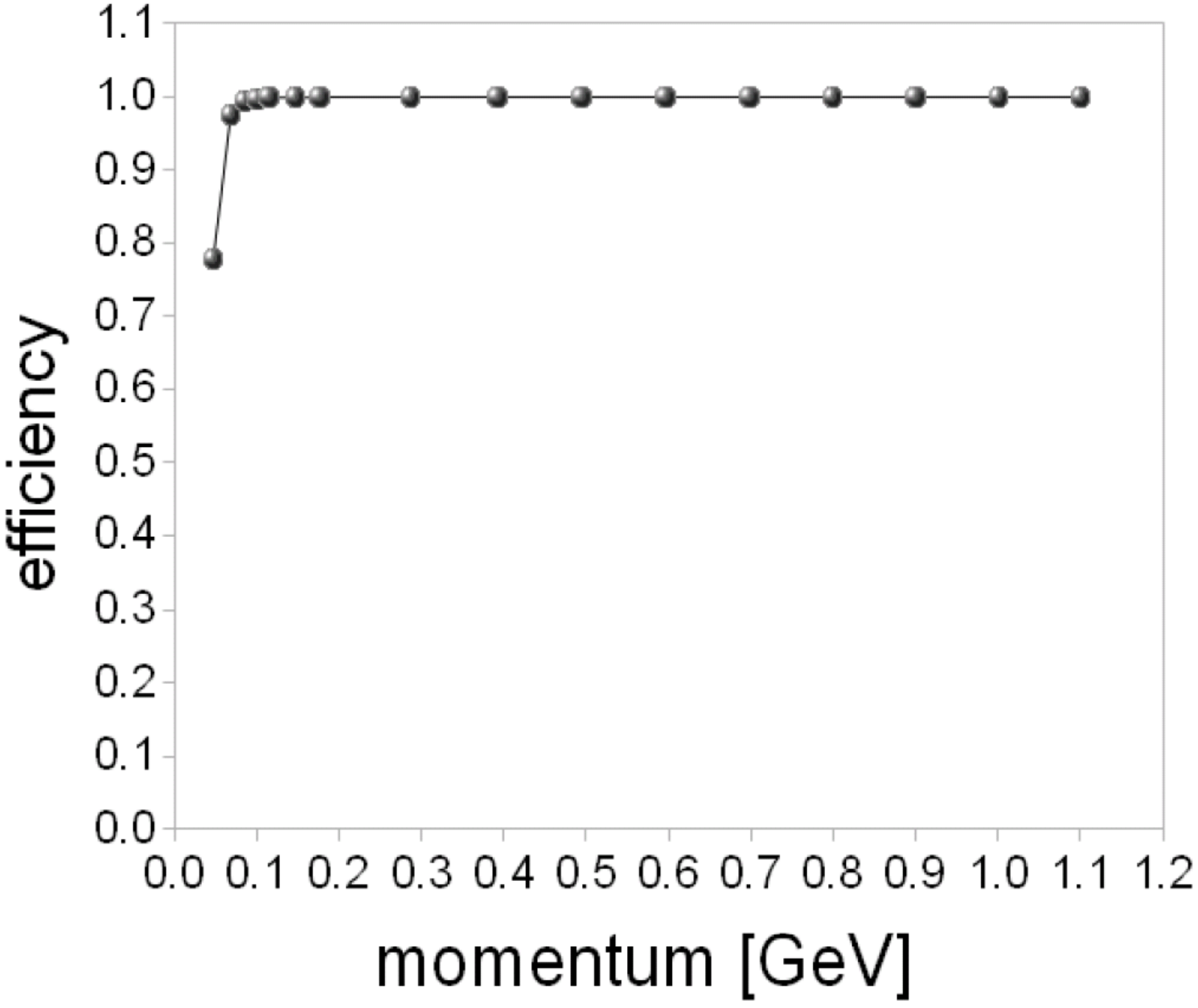




Track Finding Efficiency



Rz-Road Finders in phi-Sectors

- Occupancy of PXD: ~ 1%

  ↳ 20 pixels on per column

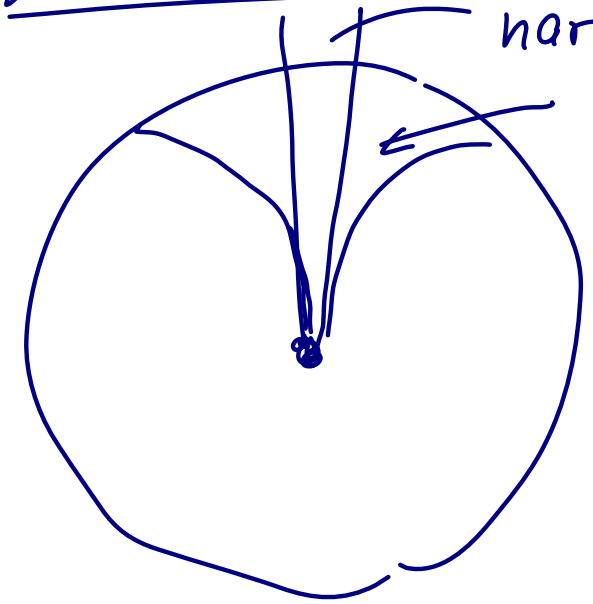
  5000 " on per Ladder!! (250 rows!)

  each cell of projection hit several times!

→ very narrow ϕ sectors needed! → 10 pixels wide

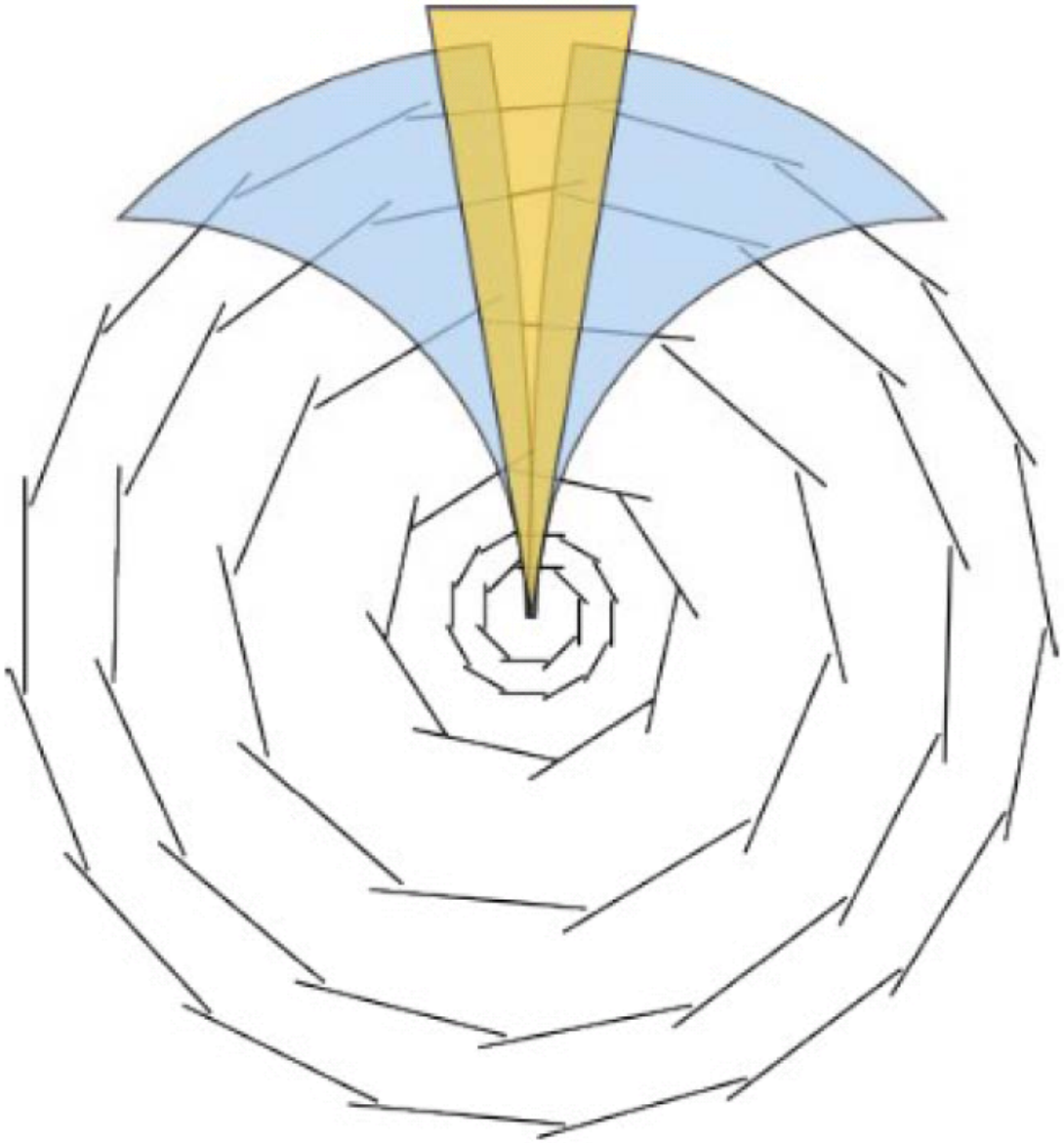
→ about 25 sectors per Ladder!

- Low momentum tracks

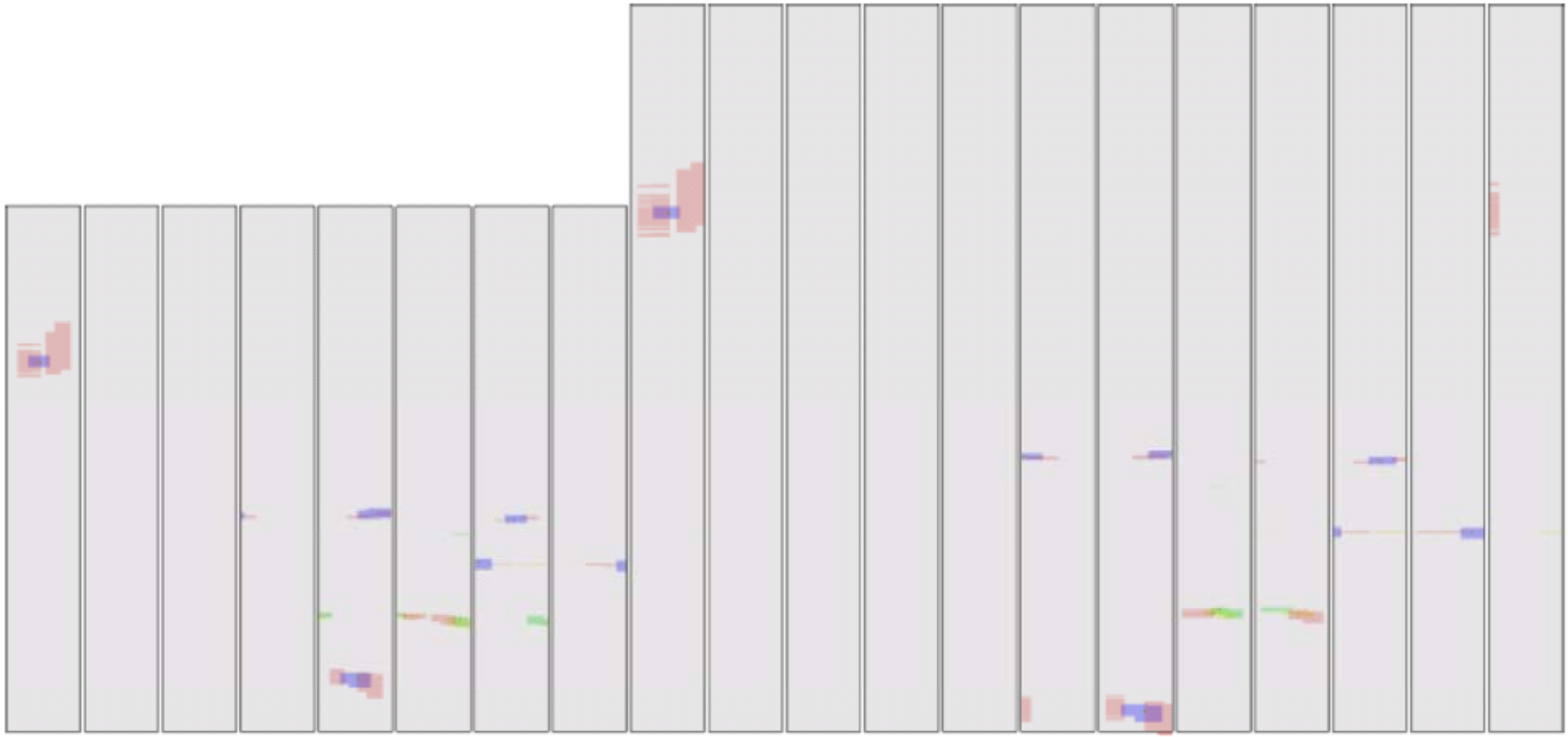


→ 22 × 25 ≈ 500 sectors

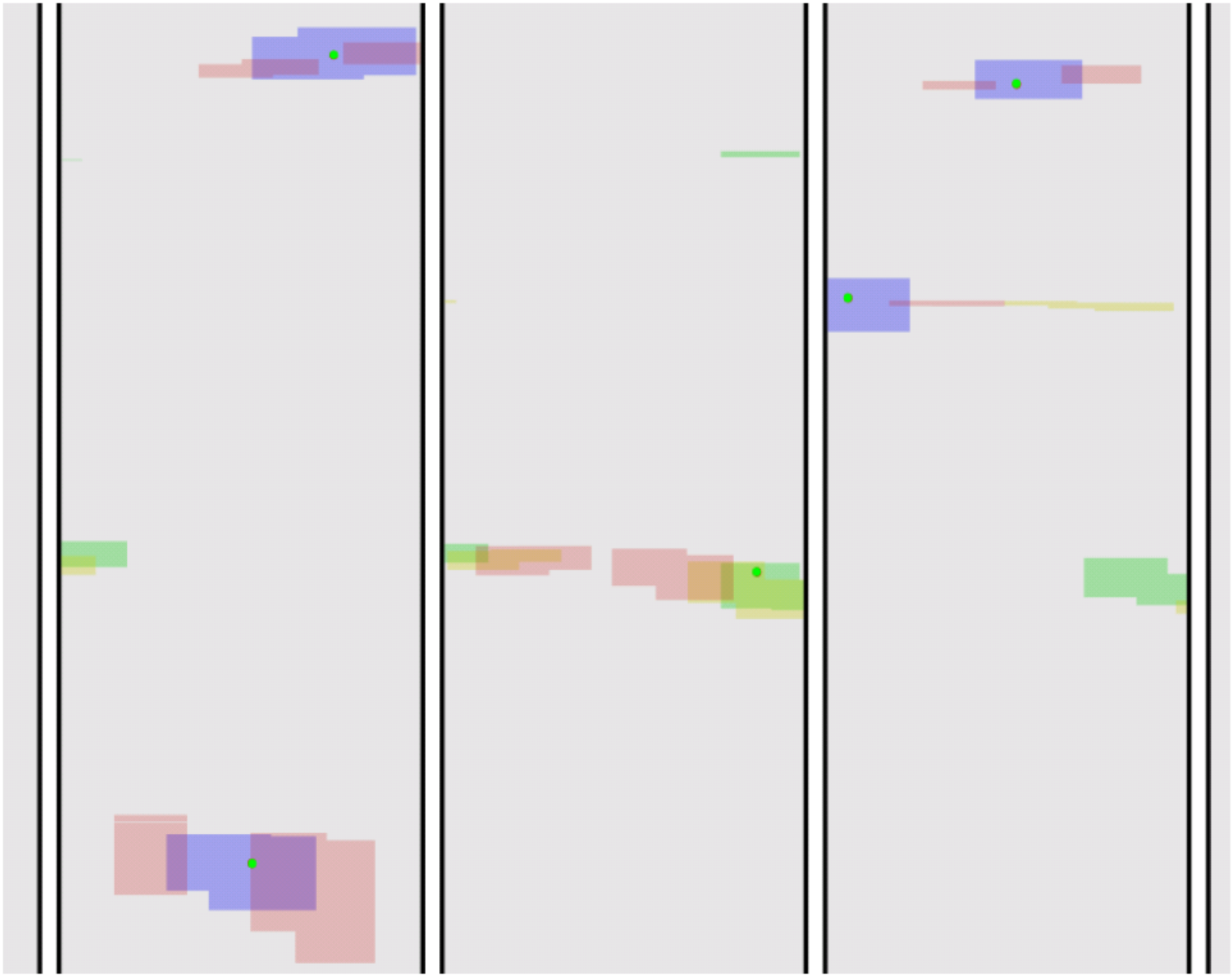
→ massively parallel computing



Regions of Interest from Hough Transform

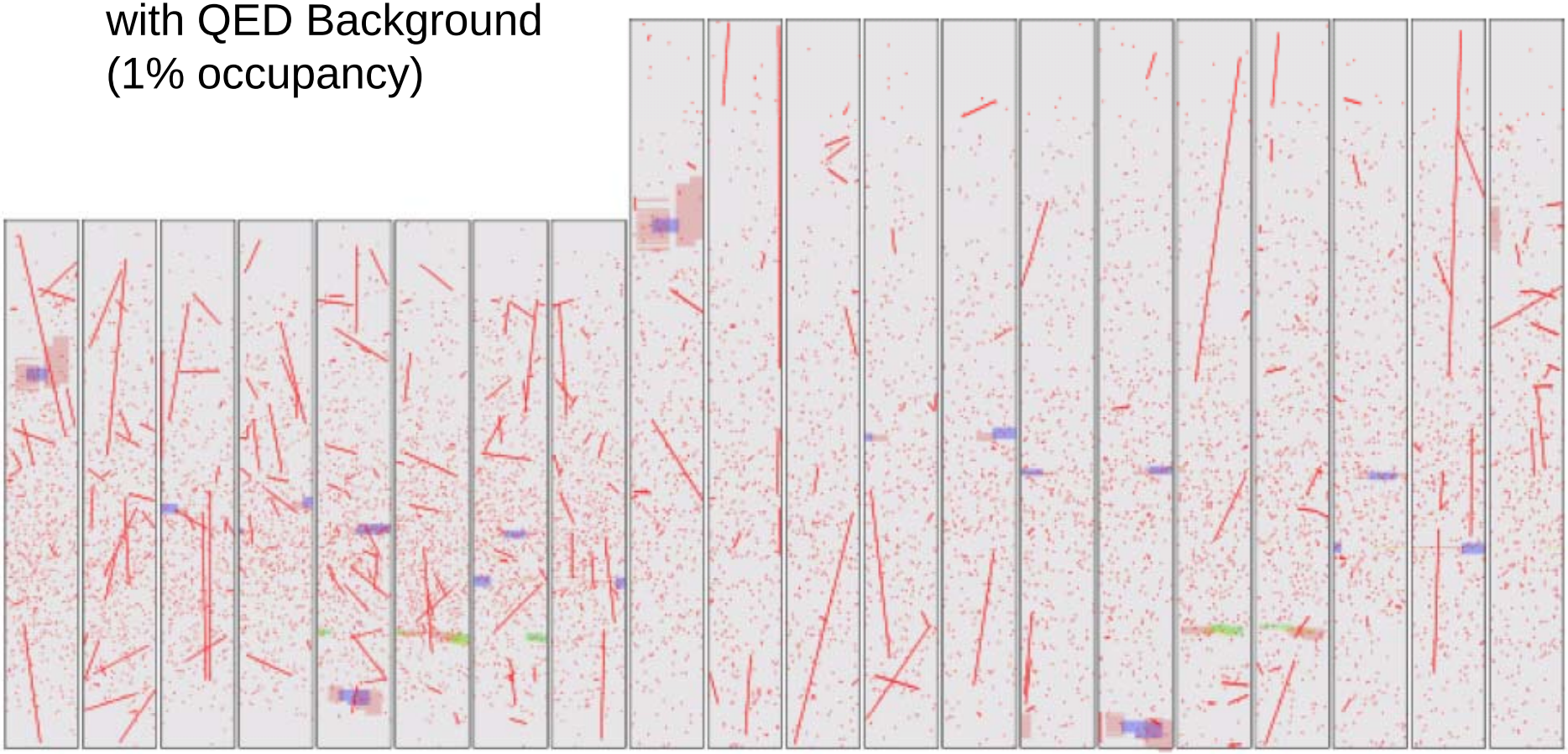


ROIs from Hough Transform (Zoom)

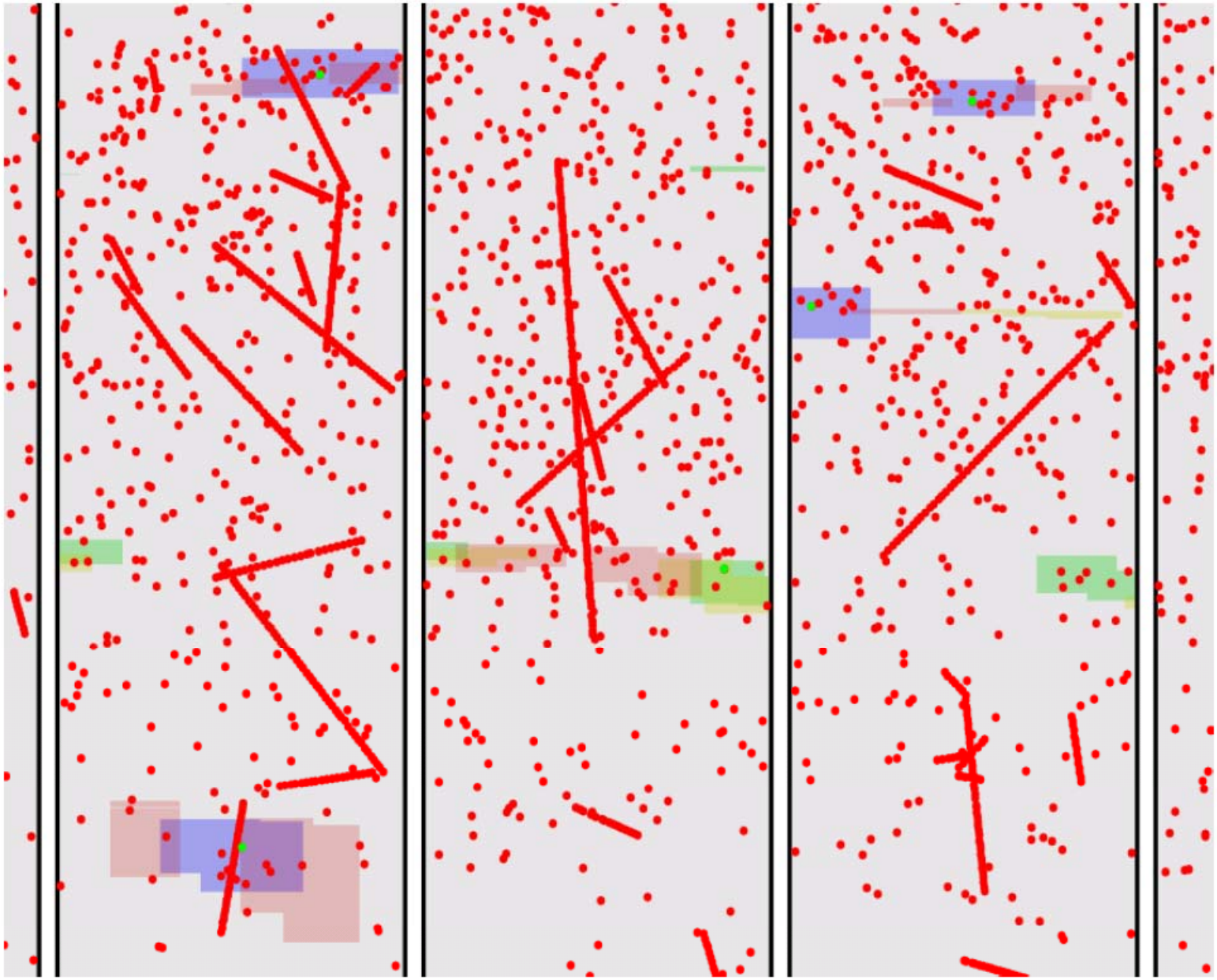


Regions of Interest from Hough Transform

with QED Background
(1% occupancy)



ROI from Hough Transform (Zoom)



Track Finding Efficiency (with sectors)