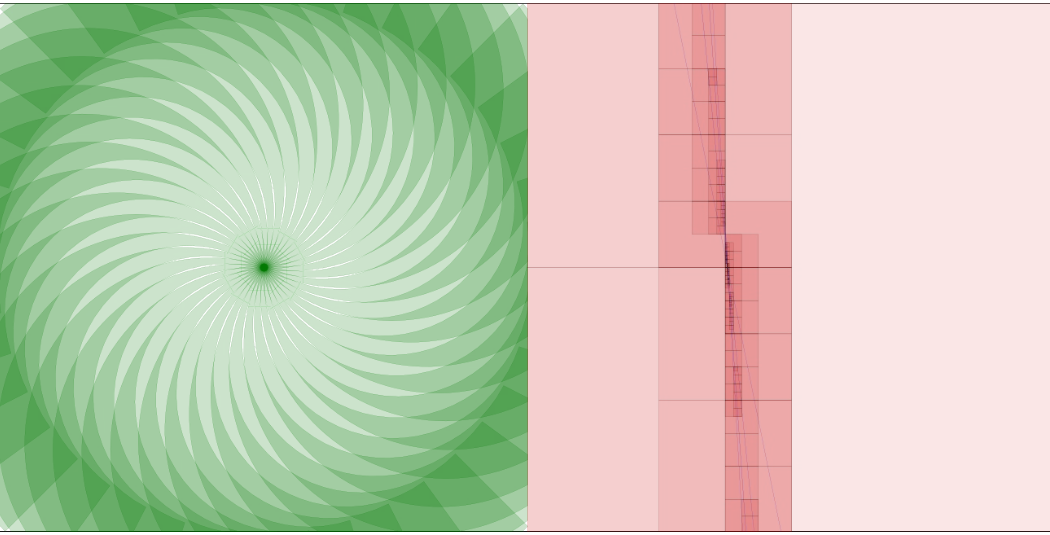
Status of PXD data reduction



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Belle II PXD/DEPFET Meeting
26/01/2010

Excellence Cluster Universe

Belle II

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Outline

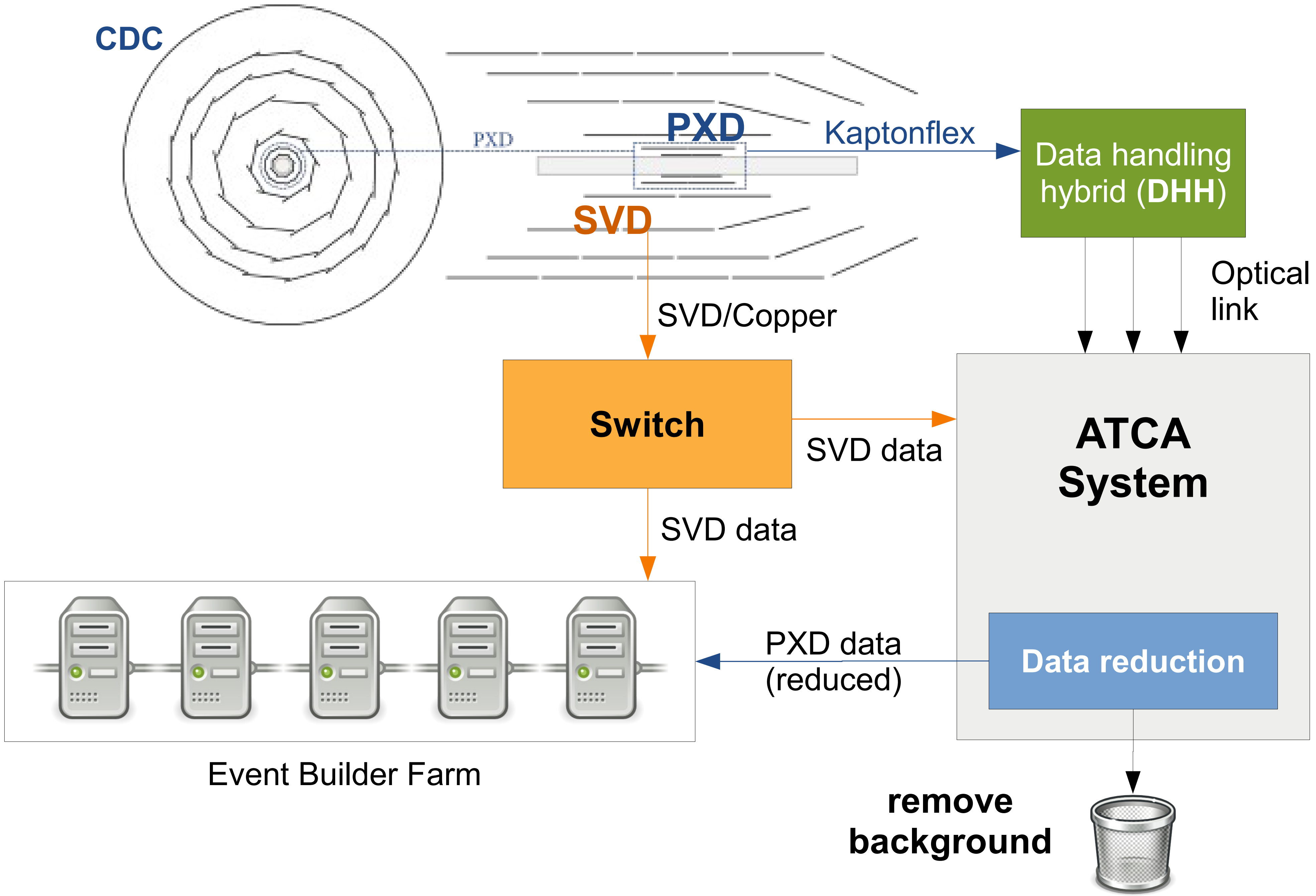
Since New Barcelona

- DAQ Scheme proposal
- Track finding in 2D (r – z projection)
- Fast Hough transform
- Dividing the space into sectors
- First results of different sector schemes (with background)

Short Reminder: **Why data reduction ?**

- Total event size: ~1 Mbyte
- 200 Gb/s (already zero-suppressed)

DAQ Scheme (Proposal)

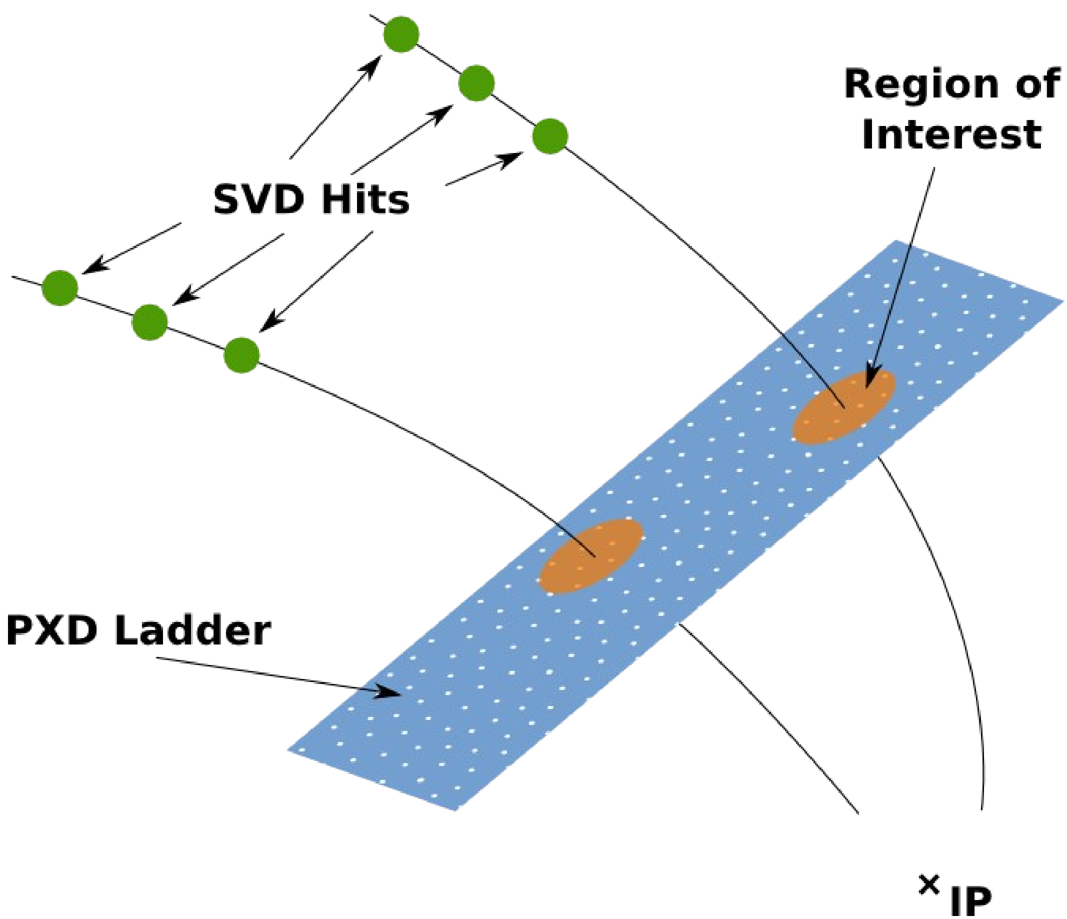


Use **SVD data** because

- low occupancy (< 1%)
- fast readout (20 ns) ⇦ **1000 times** faster than PXD readout

Basic idea:

1. Find and **propagate** tracks from SVD back to PXD
2. Build **regions of interest** on PXD and keep only data of those regions



Make sure all physics relevant information is kept

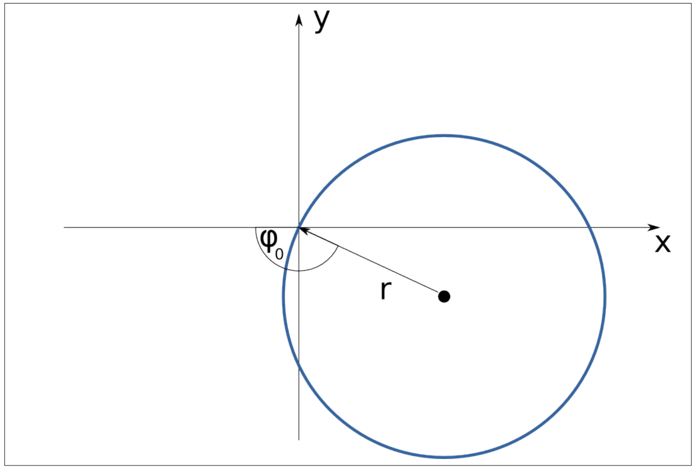
To achieve a sufficient **speed** for the online data reduction:

- do track finding in 2D (**r – z projection**)
- do track finding and region building on a highly parallel system

Tracks in 3D (x,y,z)

$$x = R\left(\cos(\omega t + \phi_0) - \cos(\phi_0)\right)$$
$$y = R\left(\sin(\omega t + \phi_0) - \sin(\phi_0)\right)$$
$$z = v \cdot t$$

pitch



$$a = \frac{q\,B}{2\,p_L}$$

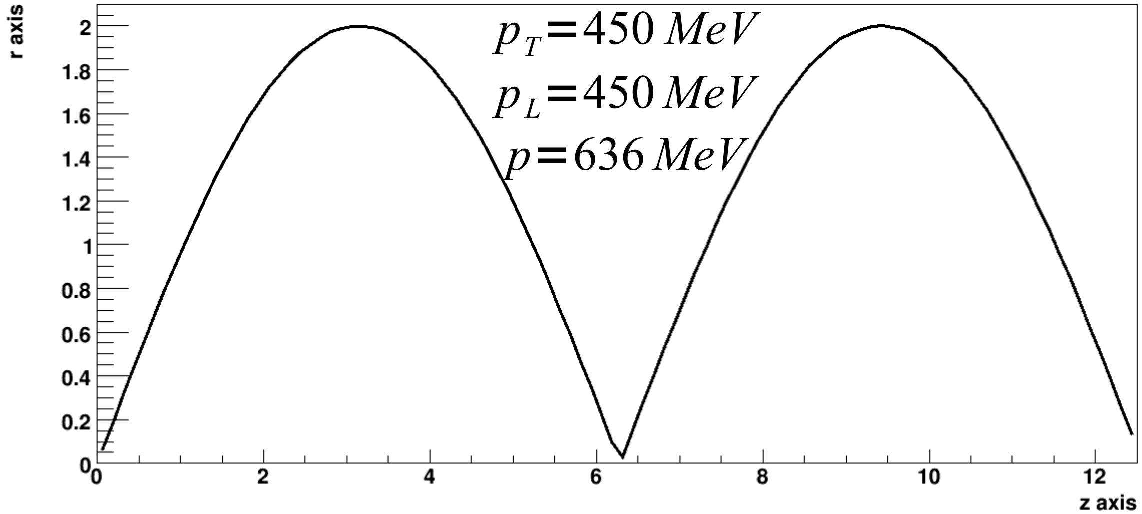
$$b = \frac{2\,p_T}{q\,B}$$

Tracks in 2D (r,z)

$$r = \frac{1}{b} \cdot \sin(a \cdot z)$$

$$b = \frac{1}{2R}$$

limits b to [0 , $1/R_{SVD}$]



How to find tracks in 2D (r,z) ?

2D r – z space → 2D parameter space → Find local maxima → feed parameters back in track hypothesis

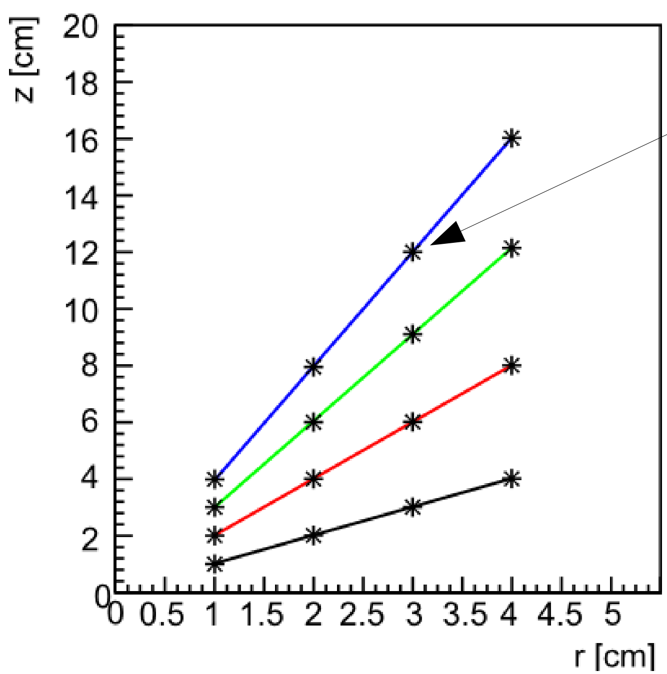
hough transform

(m,t)

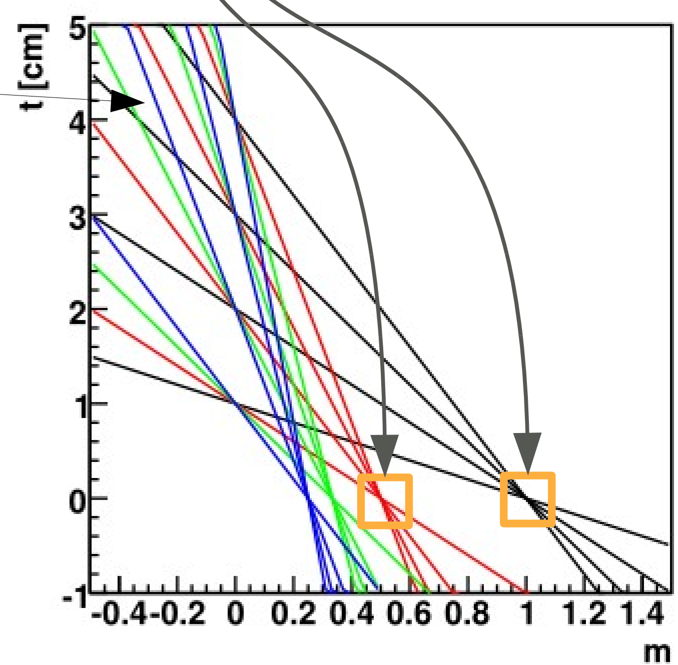
$$z = m \cdot r + t$$

Example: find parameters for a straight track

$$z = m \cdot r + t \quad \Rightarrow \quad t = z - m \cdot r$$

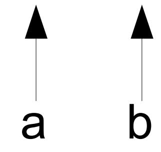


SVD Hit



In general: Find values for two parameters **a** and **b**

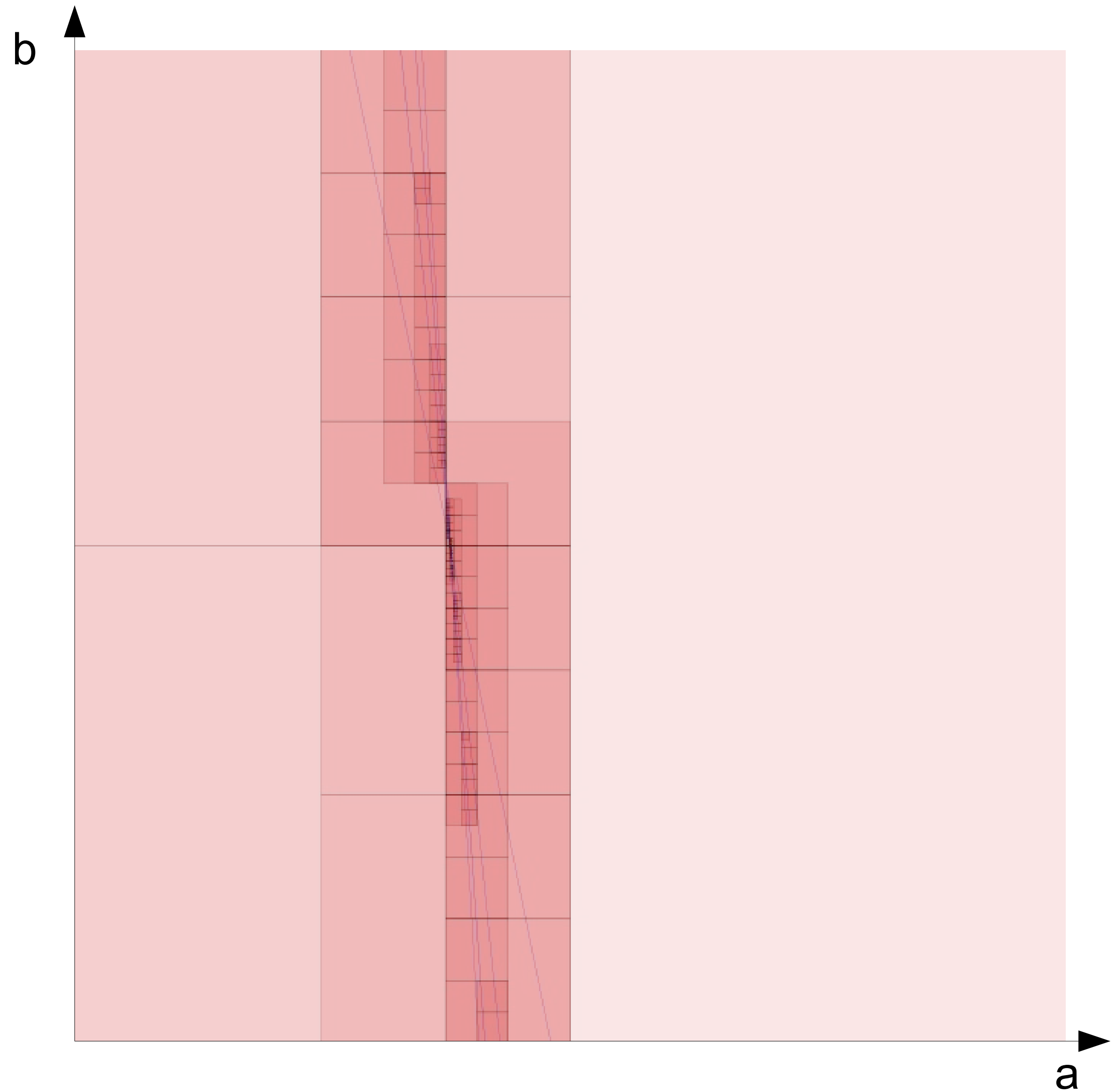
Example: $z = m \cdot r + t$



Use **space subdivision** scheme to be fast
and to find values for **a** and **b** in a stable way

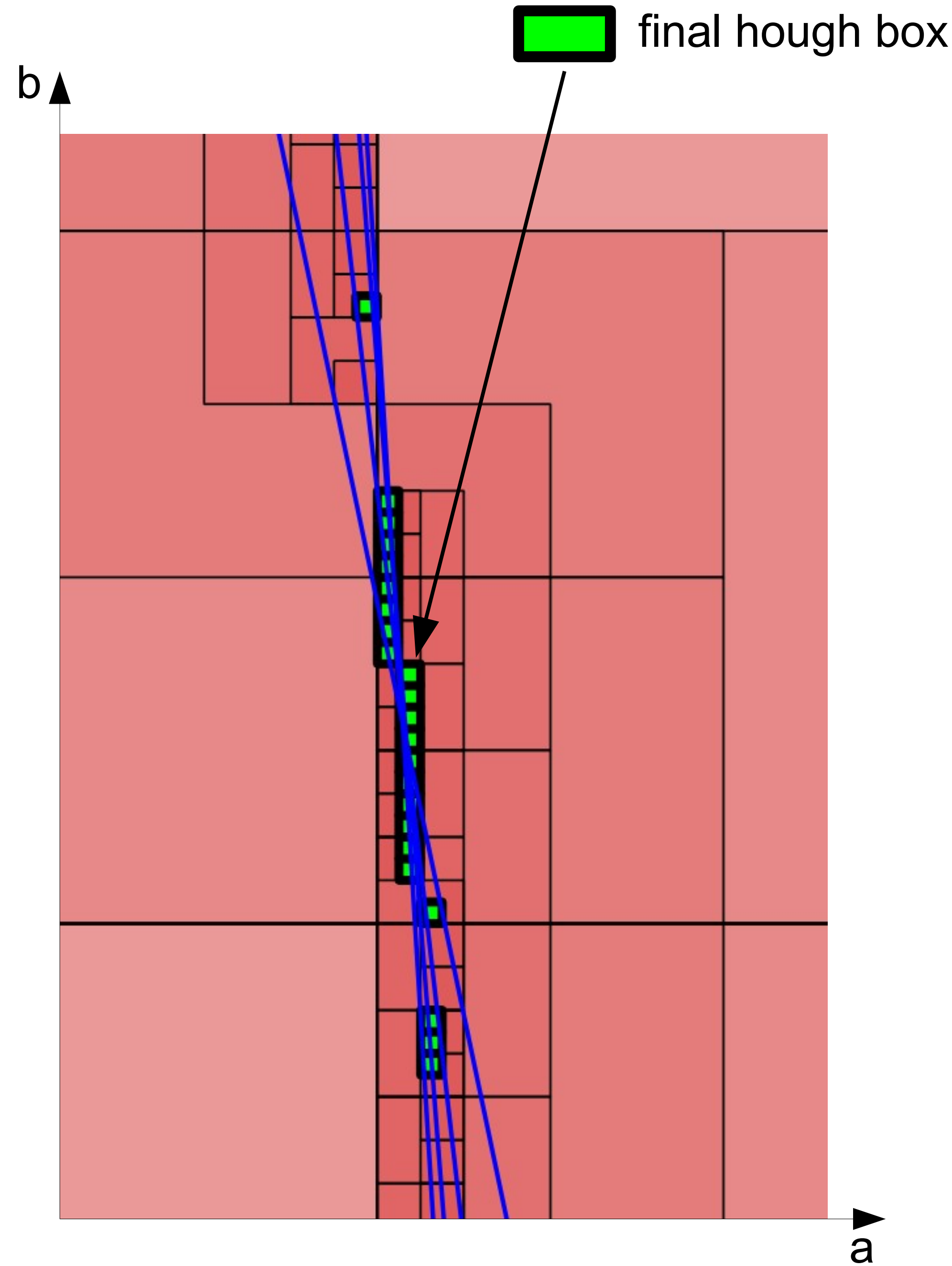
Method:

- start with initial **hough box**
- **divide** each edge of a hough box by **2** if the edge exceeds a given limit
- calculate the **number** of lines in each box
- keep only hough boxes containing **at least 3** lines
- **repeat** steps with remaining hough boxes



- **Stop** space subdivision if both hough box edges are lower than a given limit.
- Take **center of box** for the values of **a** and **b**.
- Take **box size** as error for **a** and **b**.

Feed parameters back in track hypothesis formula



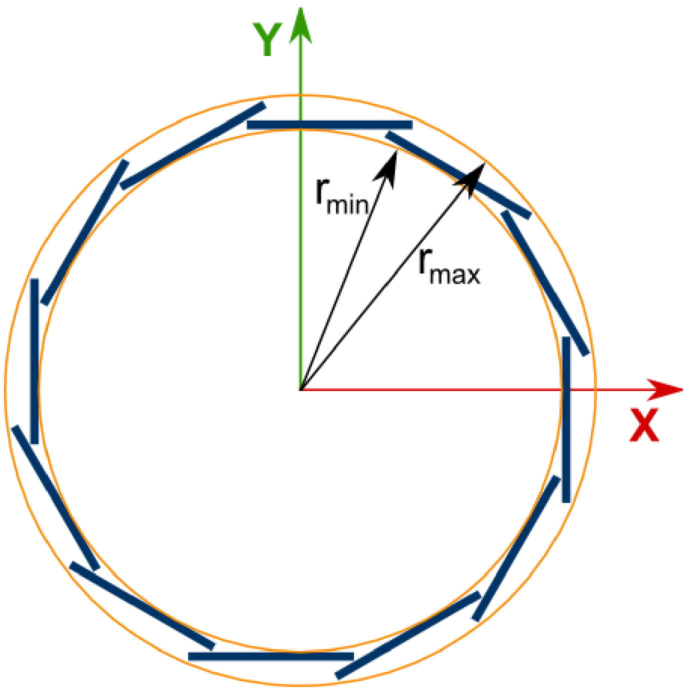
a b

$$z = m \cdot r + t$$

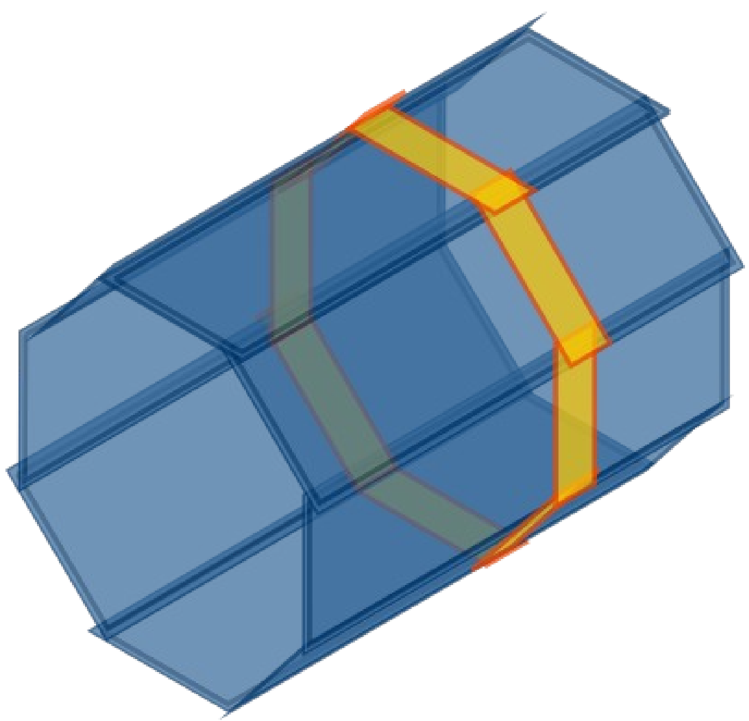
Using **a** and **b**, find **region (r,z)** in PXD ladder

Range of possible **radii** for PXD hits: [r_{min}, r_{max}]

Put r_{min} and r_{max} in formula to get z_{min} and z_{max}



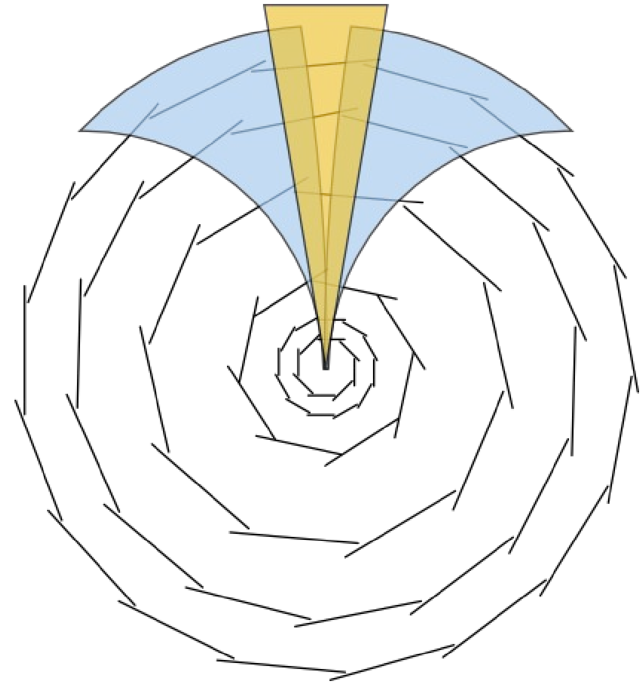
the **regions** found look like a "ring" in 2 pi with thickness z_{max} - z_{min}



Regions are to big:
Finer granularity needed

Divide space into sectors

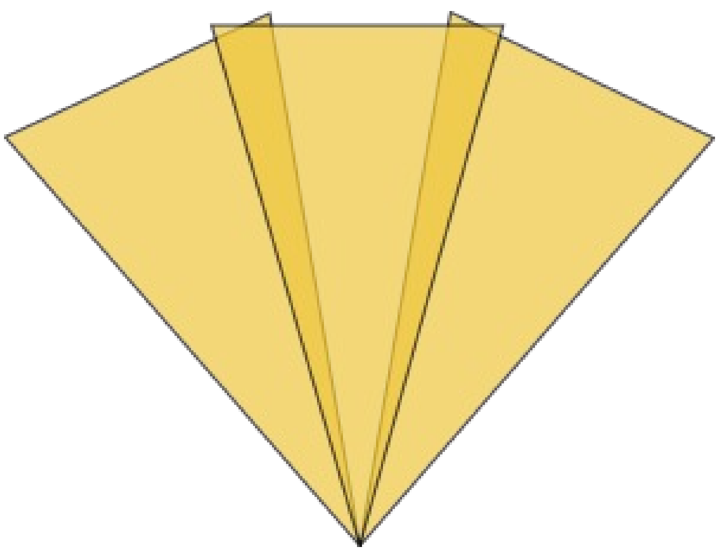
- Divide space into sectors



- ✓ **Smaller** regions in phi
- ✓ **Parallel computation**:
  do hough transform in each sector separately

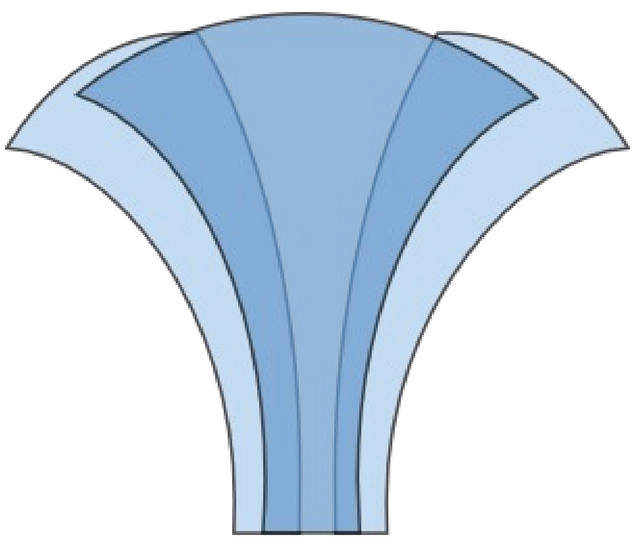
Two types of sectors:

straight



for high momentum tracks
(search for straight lines)

arc



for mid / low momentum tracks
search for sine curves

First test – 4 sectors

- **4** types
- **60** sectors per type

straight

arc 1
pt = [33.75, 47.25] MeV

arc 2
pt = [45, 72] MeV

arc 3
pt = [67.5, 186.75] MeV

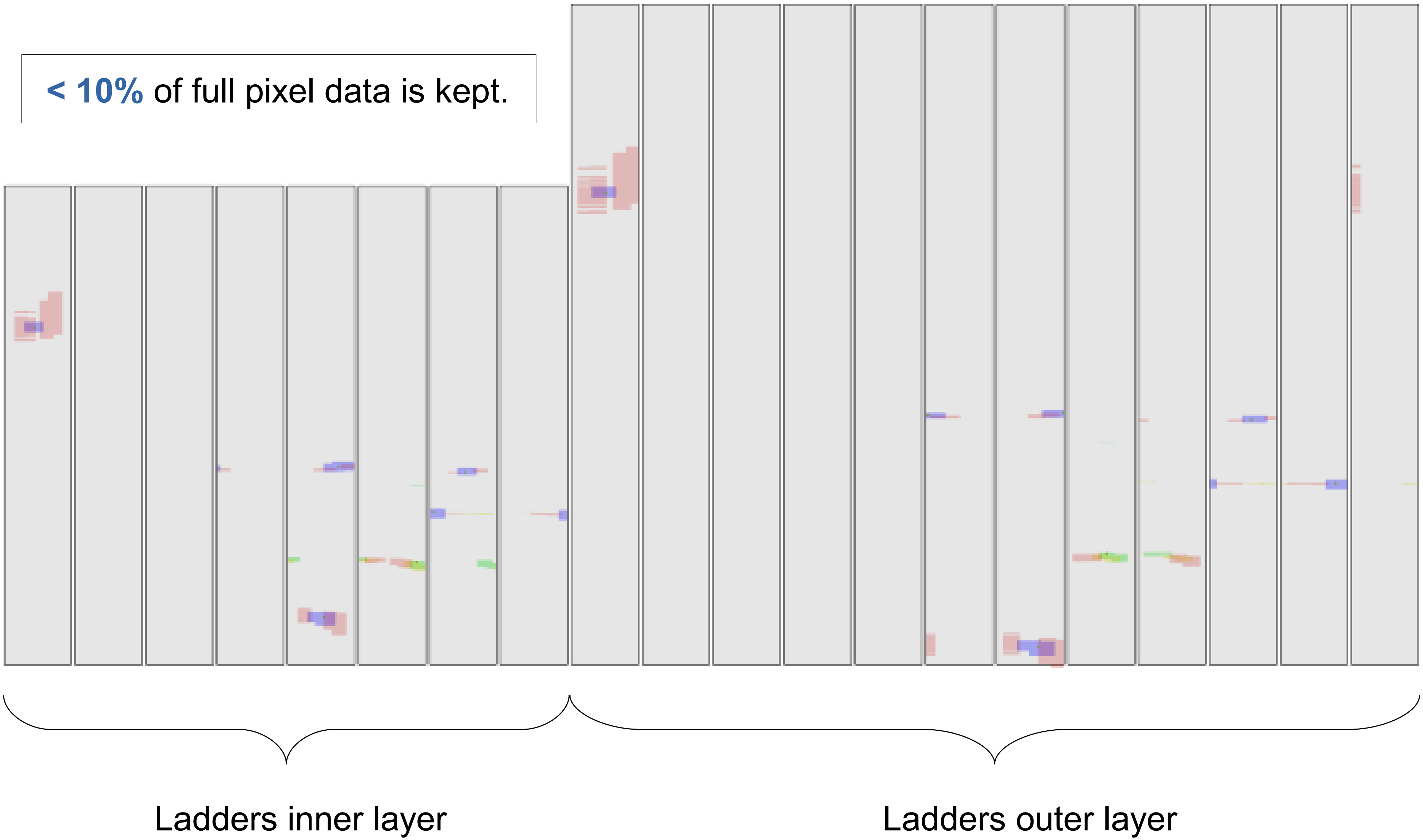
PXD detector model

# pixel inner layer:	1600
# pixel outer layer:	1600
radius inner layer:	14 mm
radius outer layer:	22 mm
sensor thickness:	50 mμ

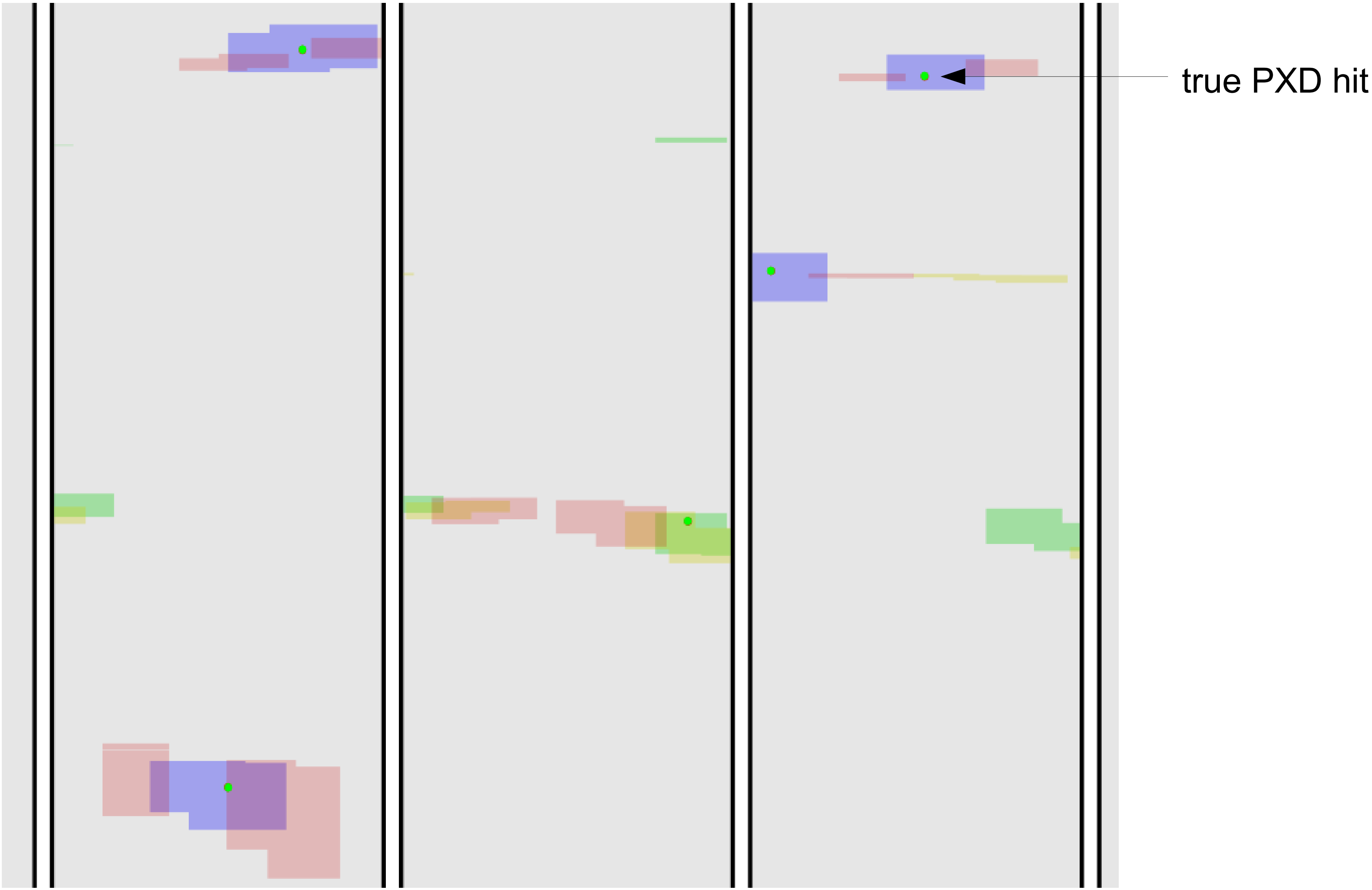
Result of first test – overview PXD ladders

Event: J/Psi, Ks

< 10% of full pixel data is kept.



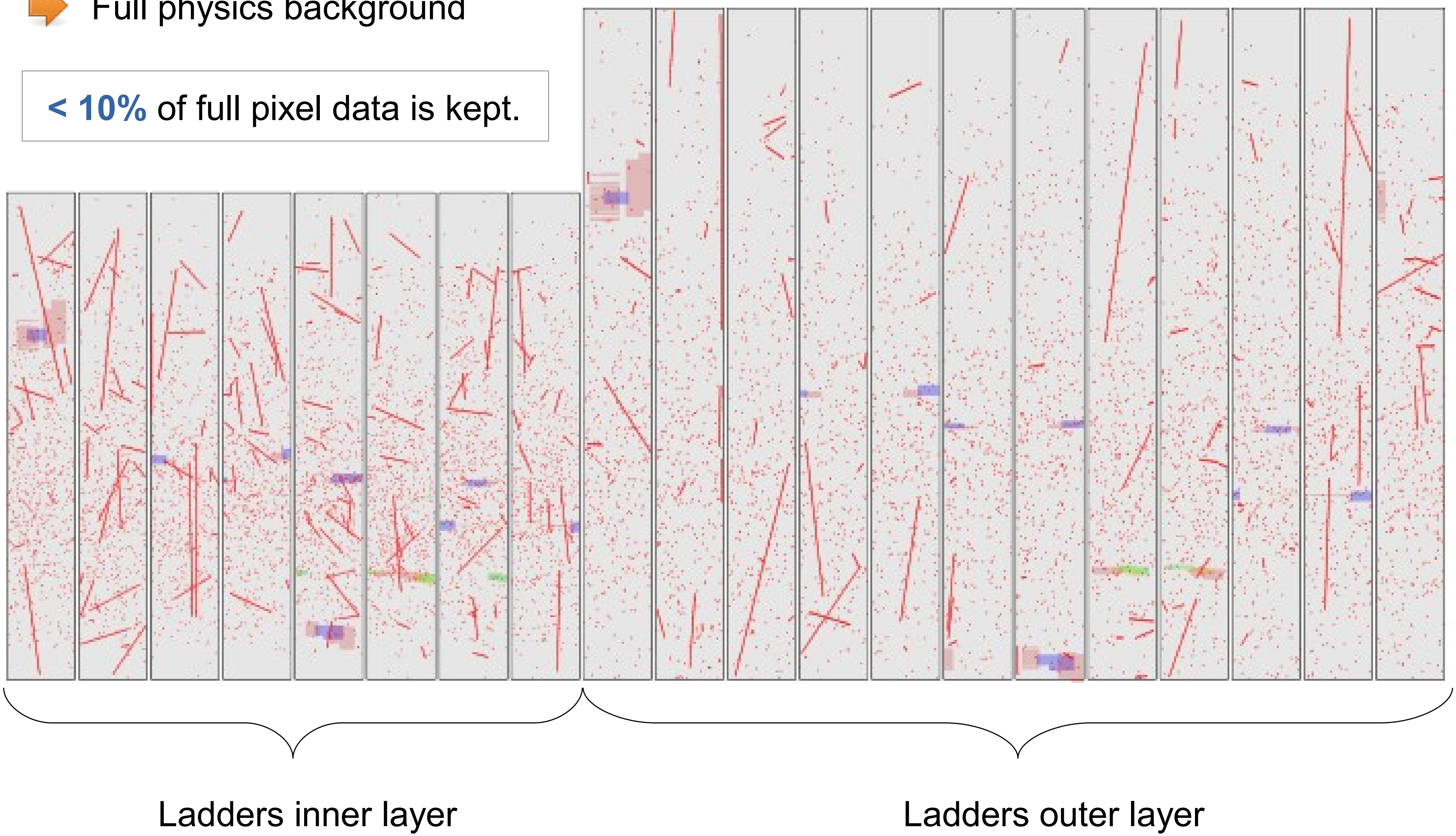
Result of first test – zoom view of PXD ladders



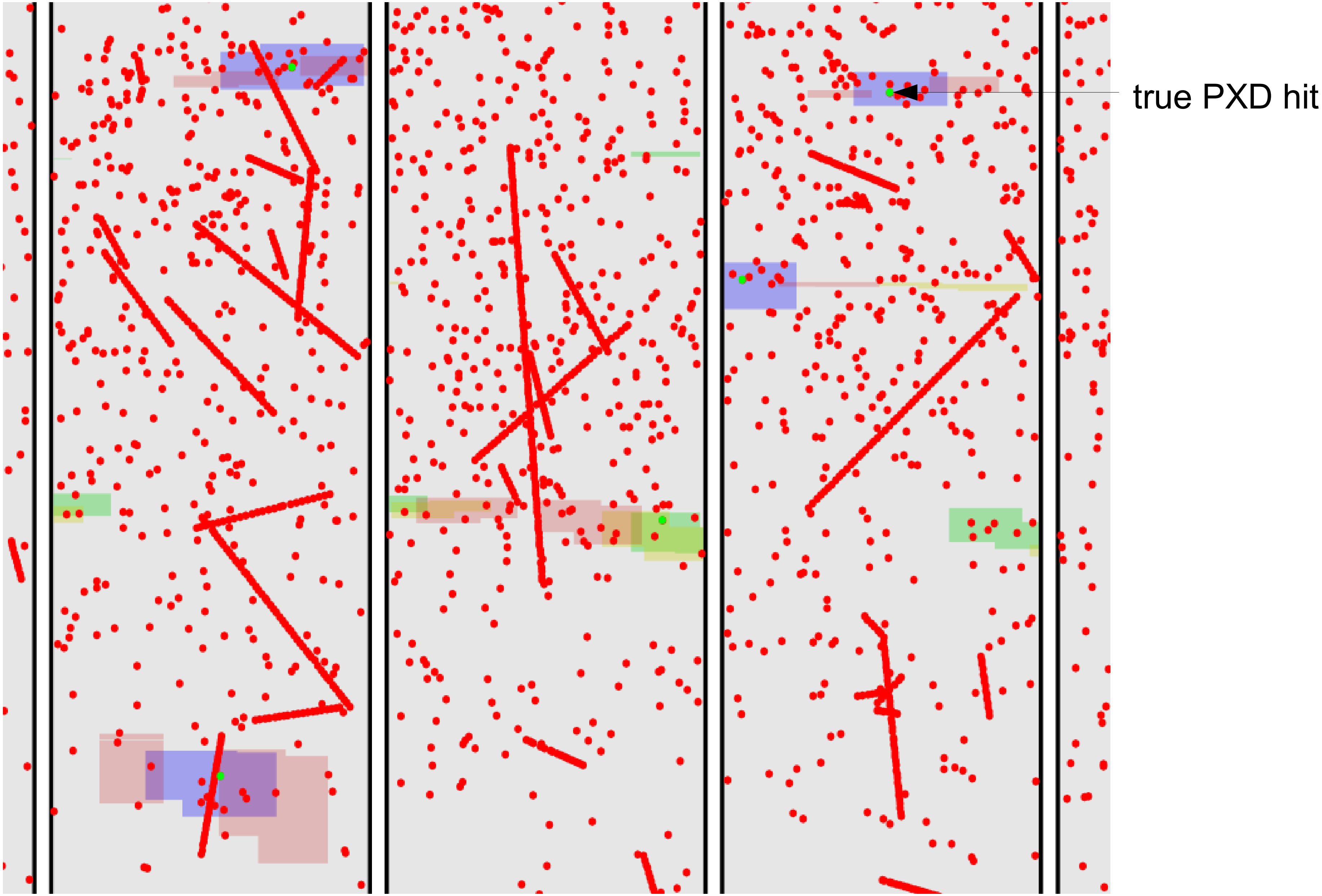
Turn **on background** simulation (background: see talks tomorrow)

- Full physics background

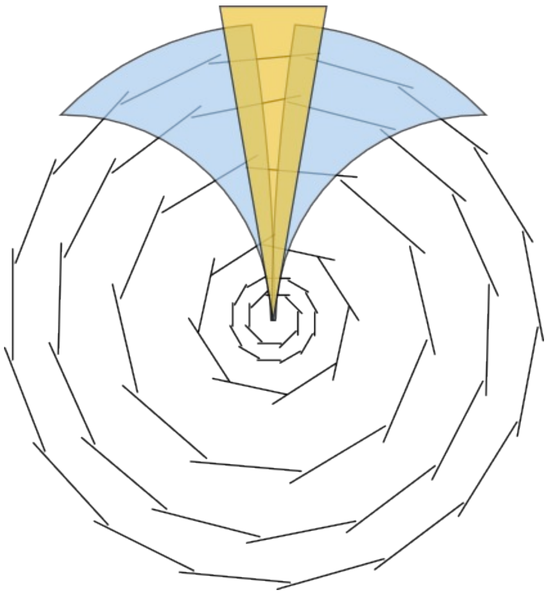
< 10% of full pixel data is kept.



Result with background – zoom view

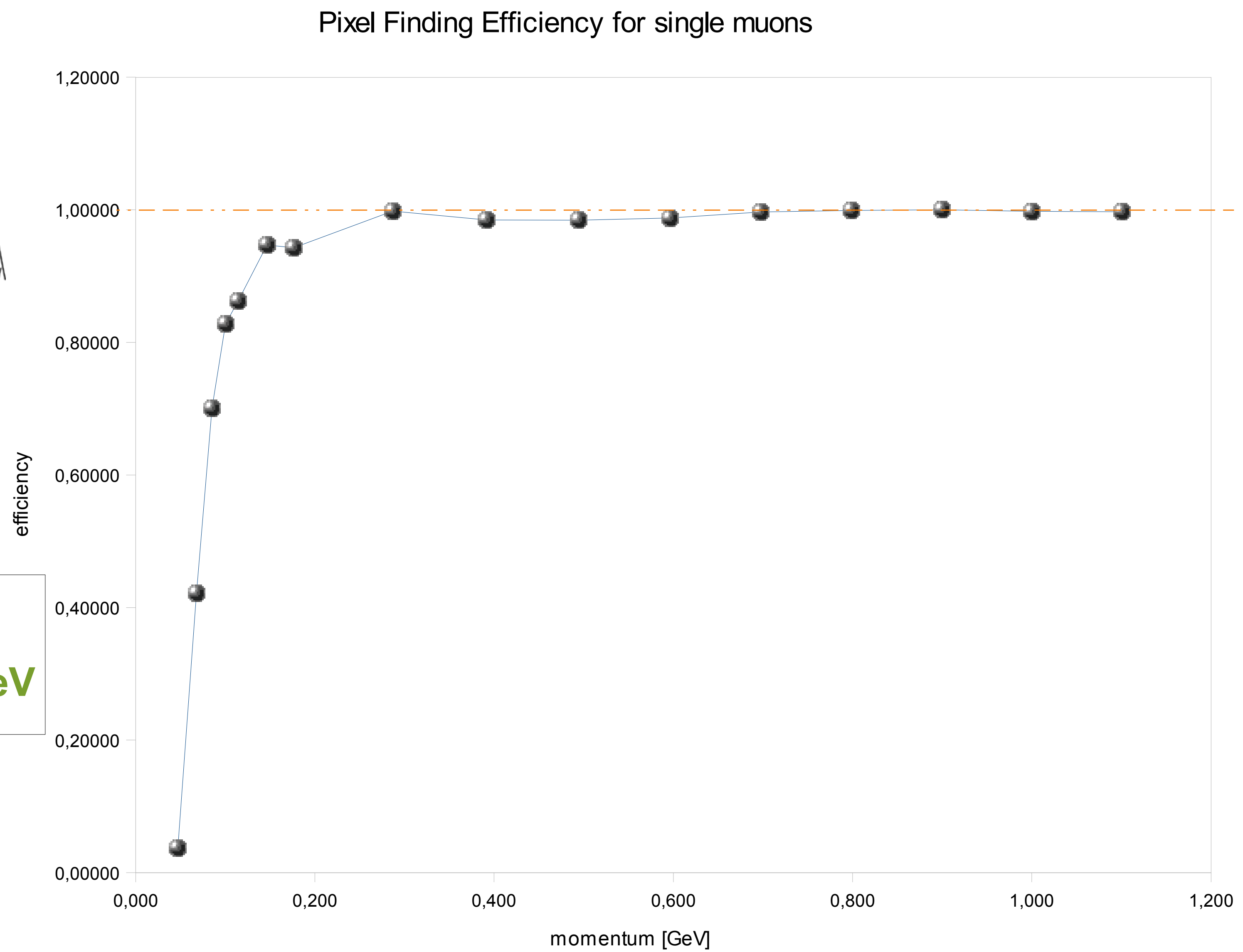


Full efficiency scan (1 straight, 2x1 arc sectors):



40 sectors per type

arc sector pt: **[50, 360] MeV**

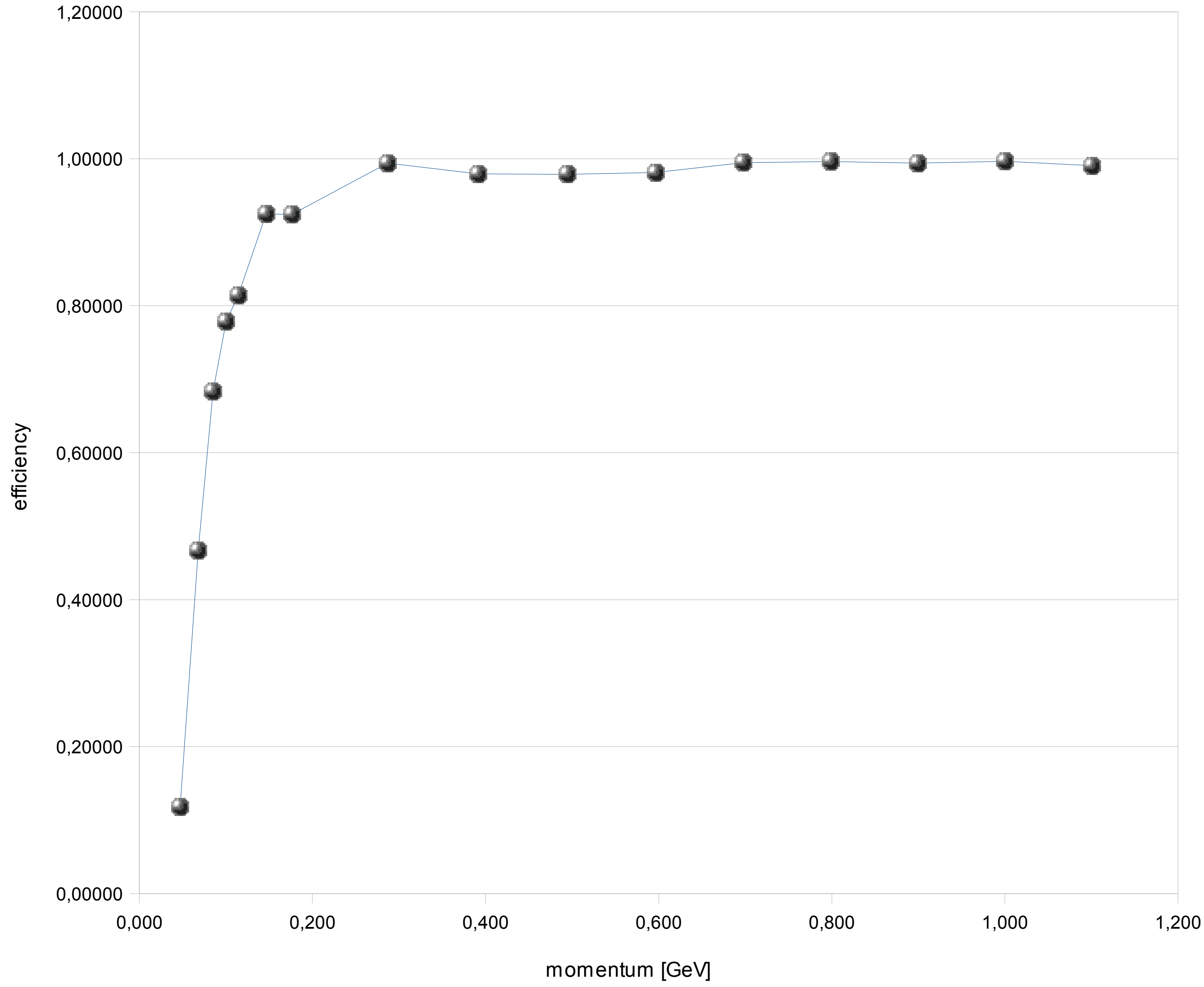


Full efficiency scan (1 straight, 2x3 arc sectors):

60 sectors per type

pt ranges

[33.75, 69.75] MeV
[67.50, 137.25] MeV
[135, 360] MeV



- Data reduction software **rewritten** (now part of optimization framework)
- Introduced **sectors** (smaller regions and parallel computation)
- First tests with **physics background** look very promising
- Efficiency of **99 %** down to 300 MeV
- Average data reduction factor of **10** achieved

Next steps:

- Try different sector configurations
- Perform reduction on the PXD ladder pixel level