Low-momentum track finding in Belle II

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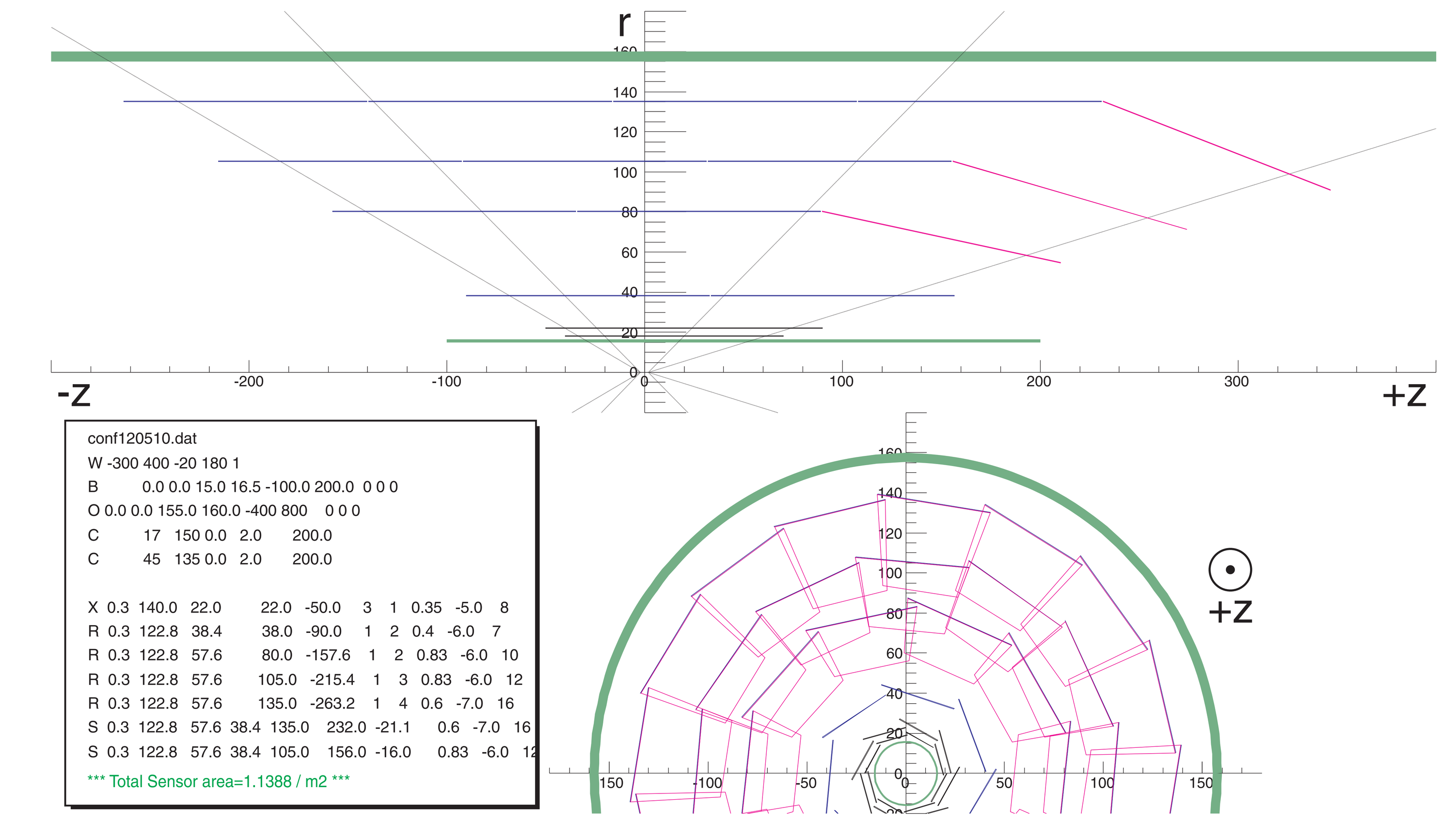
1. The Belle II Silicon Vertex Detector

- Two pixel layers
- Four double-sided silicon layers



2. Motivation

- Important physics channel with low-momentum pion:

$$D^{*+} \rightarrow D^0 \pi^+$$

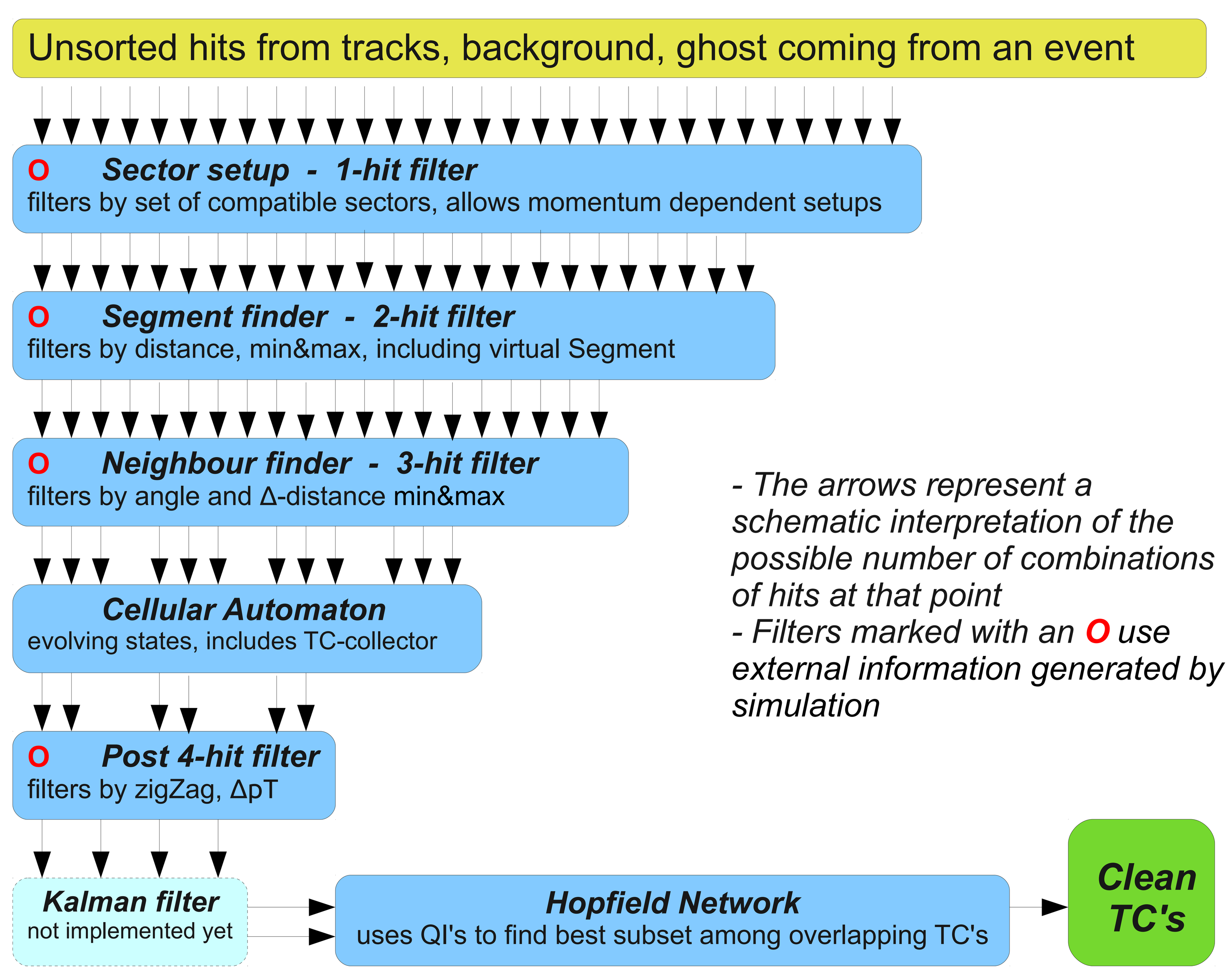
- Define region of interest for pixel readout, data reduction

3. Track finding strategy

Global structure

- Stepwise reduction of combinatorics
- Cellular automaton (CA) for finding track candidates
- Kalman filter for computing quality indicators
- Hopfield network for eliminating overlapping candidates

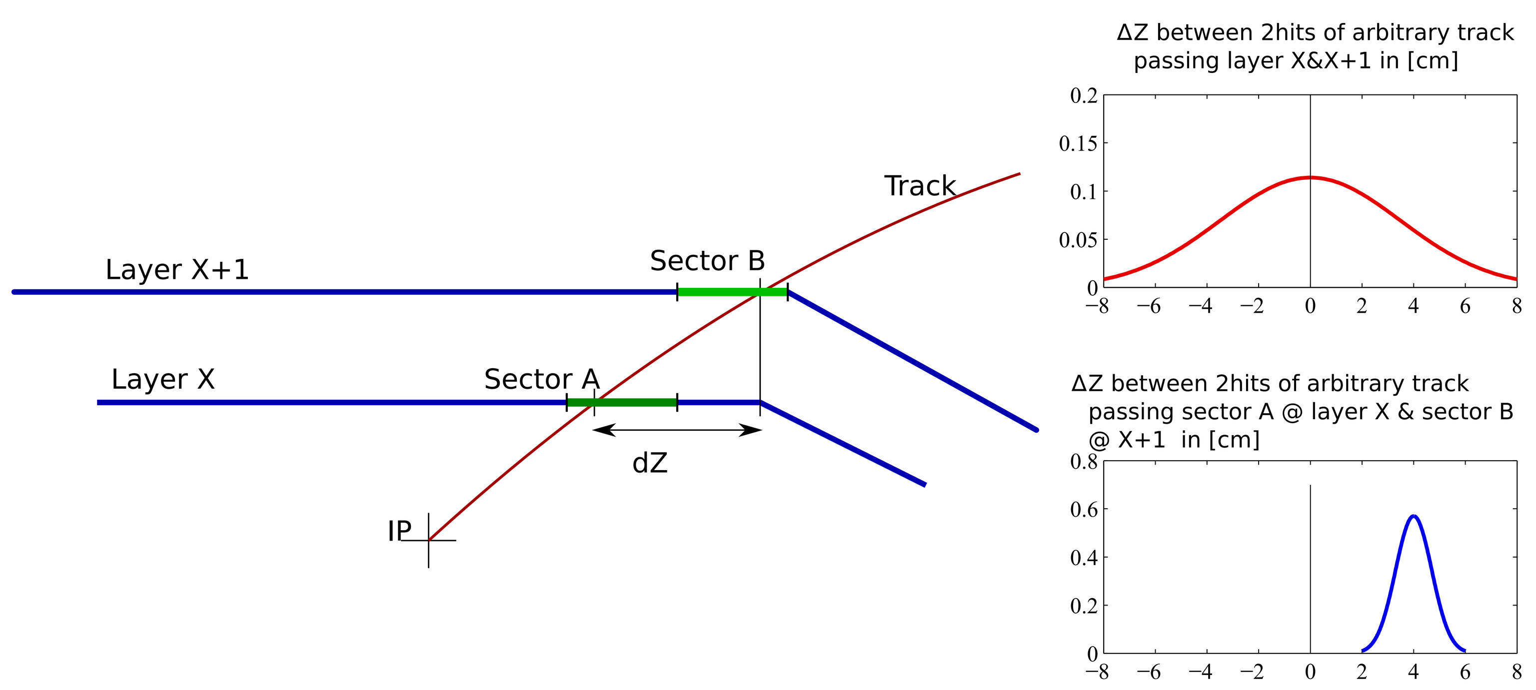
Schematic view of the low momentum track finder in Belle II



- The arrows represent a schematic interpretation of the possible number of combinations of hits at that point
- Filters marked with an **O** *use external information generated by simulation*

Sectors

- Cells of CA are track segments connecting two hits
- Sensors are divided into **sectors**
- This allows for tighter cuts in the segment filters and reduces the number of allowed hit combinations



Segment finder

- An allowed hit combination forms a **segment**
- Segments are filtered my minimal and maximal length
- **Virtual segments** connect the innermost hits with the interaction point

Neighbour finder

- Two segments connected by a common hit are called **neighbours**
- Neighbours are filtered by minimal/maximal angle and difference in length

Cellular automaton

- The cellular automaton assigns **states** to each segment in a discrete time evolution process
- A string of neigbouring segments with decreasing states is a **track candidate**

Track candidate filter

- Candidates that form zig-zag patterns are discarded
- Candidates with large changes in p_T are discarded

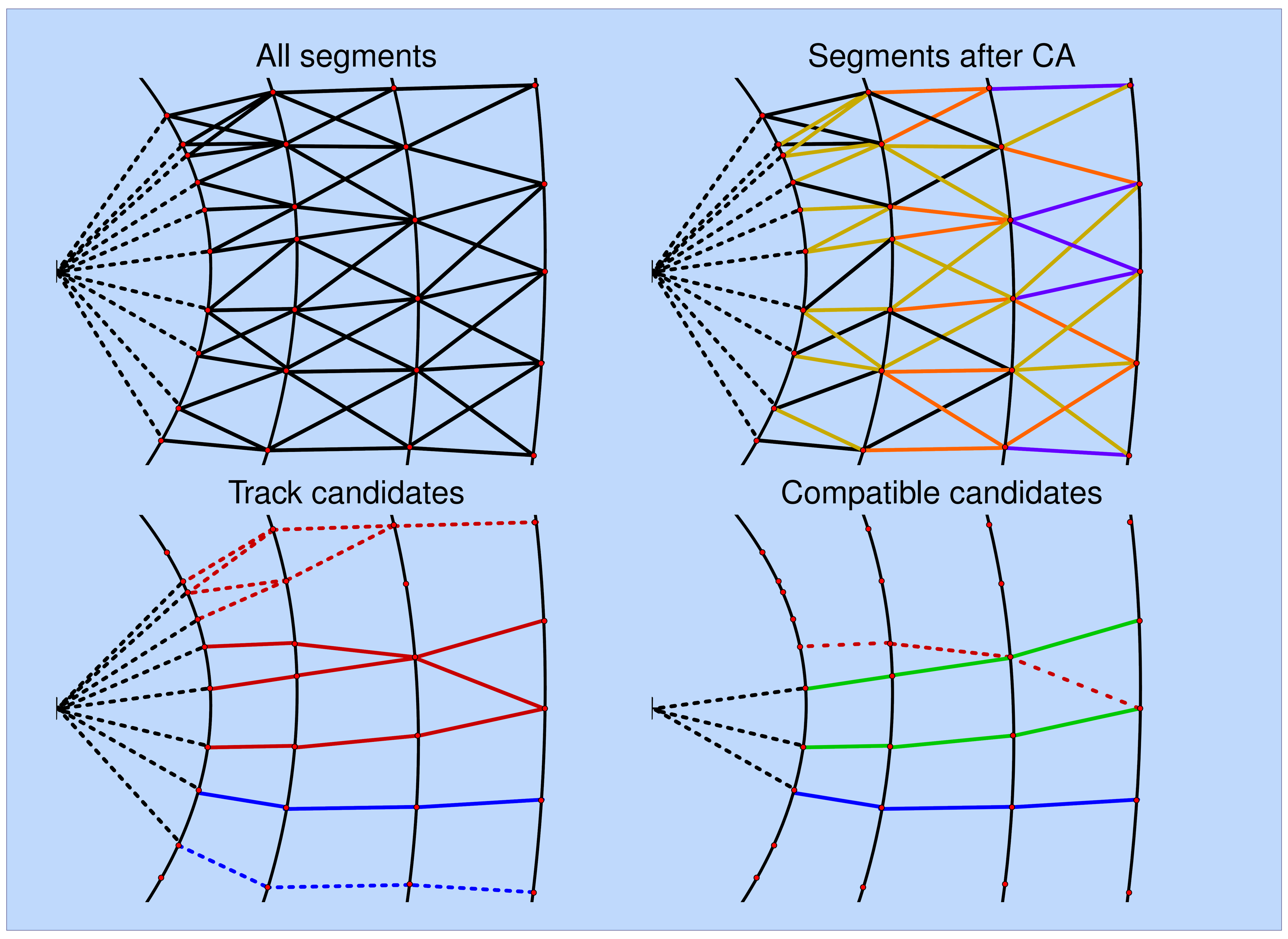
Track quality

- A **quality indicator** (QI) is computed for each track candidate
- Currently this is the number of hits in the track
- Later the QI will be computed by a preliminary track fit

Hopfield network

- Hopfield network finds **best subset** of **compatible** track
- Tracks with large quality indicators are preferred

4. An example



5. Results

- Efficiency for two transverse momentum ranges, with and without PXD
  - Low: 60MeV/c – 70 MeV/c, 3 layers (w/o PXD)
    filters activated: distZ,distNorm3D, distDeltaZ, anglesRZ, deltaPt, zigZag
  - Low: 60MeV/c – 70 MeV/c, 5 layers (with PXD)
    filters activated: dist3D, distXY, distZ, distNorm3D, distDeltaZ, angles3D, anglesXY, anglesRZ, deltaPt, zigZag
  - High: 70MeV/c – 100 MeV/c, 4 layers (w/o PXD)
    filters activated: distXY, distZ, distNorm3D, distDeltaZ, angles3D, anglesXY, anglesRZ, deltaPt, zigZag
  - High: 70MeV/c – 100 MeV/c, 6 layers (with PXD)
    filters activated: dist3D, distXY, distZ, distNorm3D, distDeltaZ, angles3D, anglesXY, anglesRZ, deltaPt, zigZag
  - 1000 events with 10 and 20 tracks each, no noise
  - No Kalman filter, no Hopfield network

Momentum range	# of layers	# of tracks	results post TCC			
			clean	cont.	lost	rec_{tot}
Low	3	10 000	88.9%	0.48%	10.7%	**89.3%**
		20 000	88.2%	1.1%	10.8%	**89.2%**
Low	5	10 000	99.6%	0.1%	0.3%	**99.7%**
		20 000	99.1%	0.3%	0.6%	**99.4%**
High	4	10 000	99.6%	0.1%	0.4%	**99.6%**
		20 000	99.5%	0.1%	0.4%	**99.6%**
High	6	10 000	99.6%	0.1%	0.3%	**99.7%**
		20 000	99.4%	0.2%	0.4%	**99.6%**