CA tracker for TPC online reconstruction

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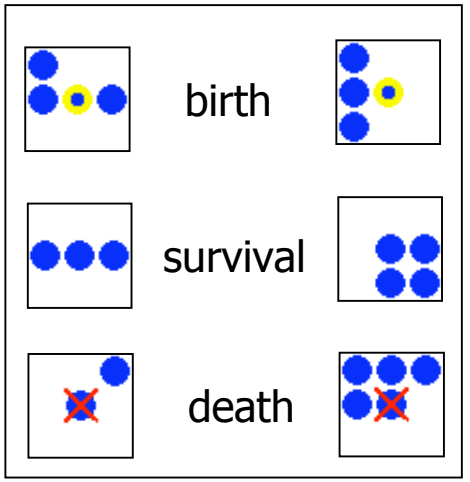
Tracking with the Cellular Automaton method: principles

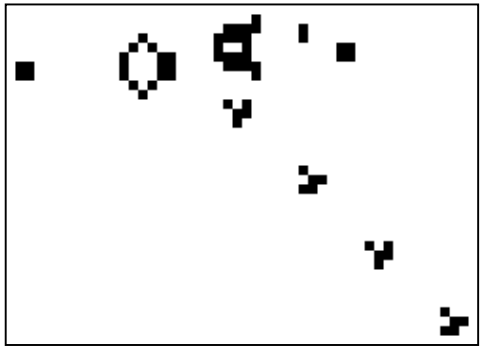
"Game of life" - origin of the Cellular Automatons:

- A dead cell with exactly three live neighbors becomes a live cell (birth)
- A live cell with two or three live neighbors stays alive (survival)
- In all other cases, a cell dies or remains dead (overcrowding or loneliness)
- Evolution of all the cells proceeds in parallel, generation by generation

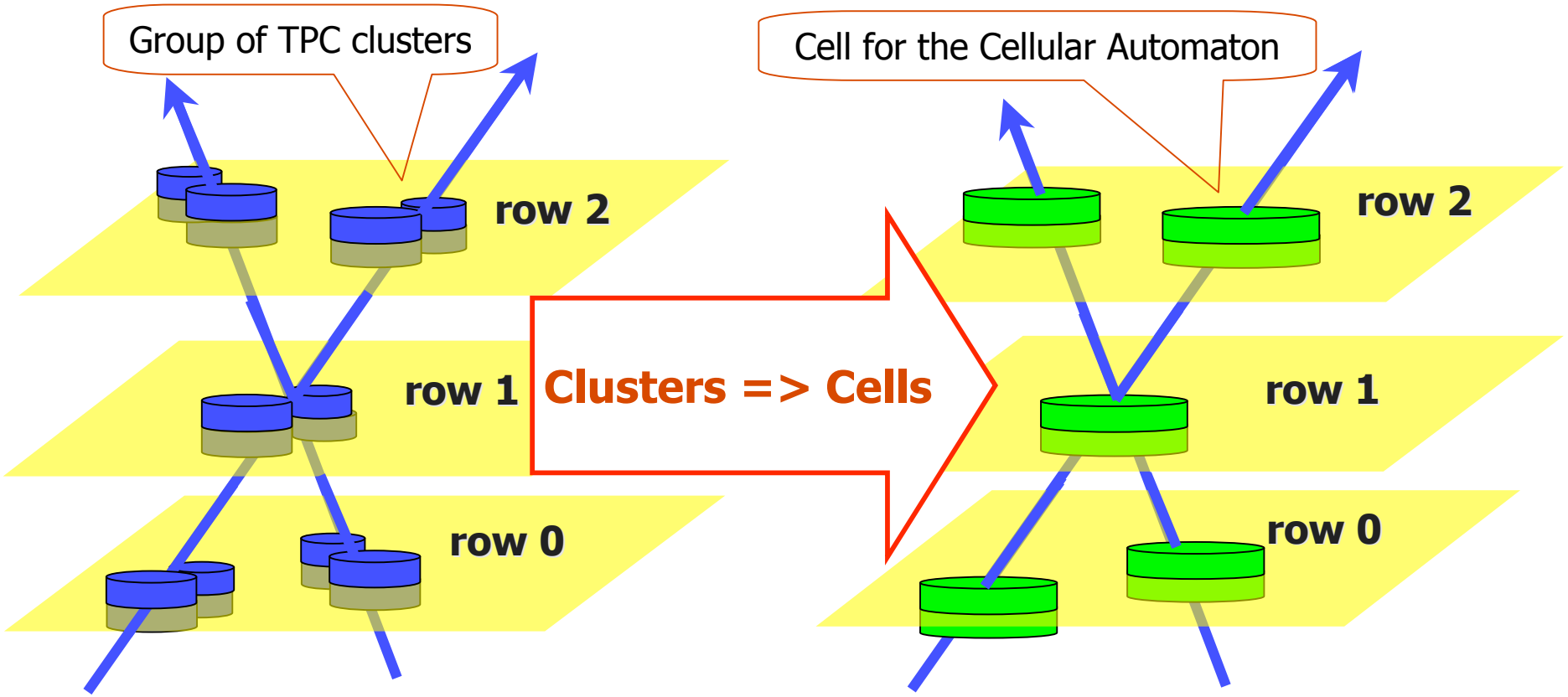


The Cellular Automaton method for tracking, principles:

- Construction of global thing (track) using only local operations (hit-to-hit linking)
- Try to keep combinatorics at the local level
- Try to perform calculations in parallel
- Gradual complication of the calculations with complication of processed data



Cellular Automaton - step 1: Creation of "cells"



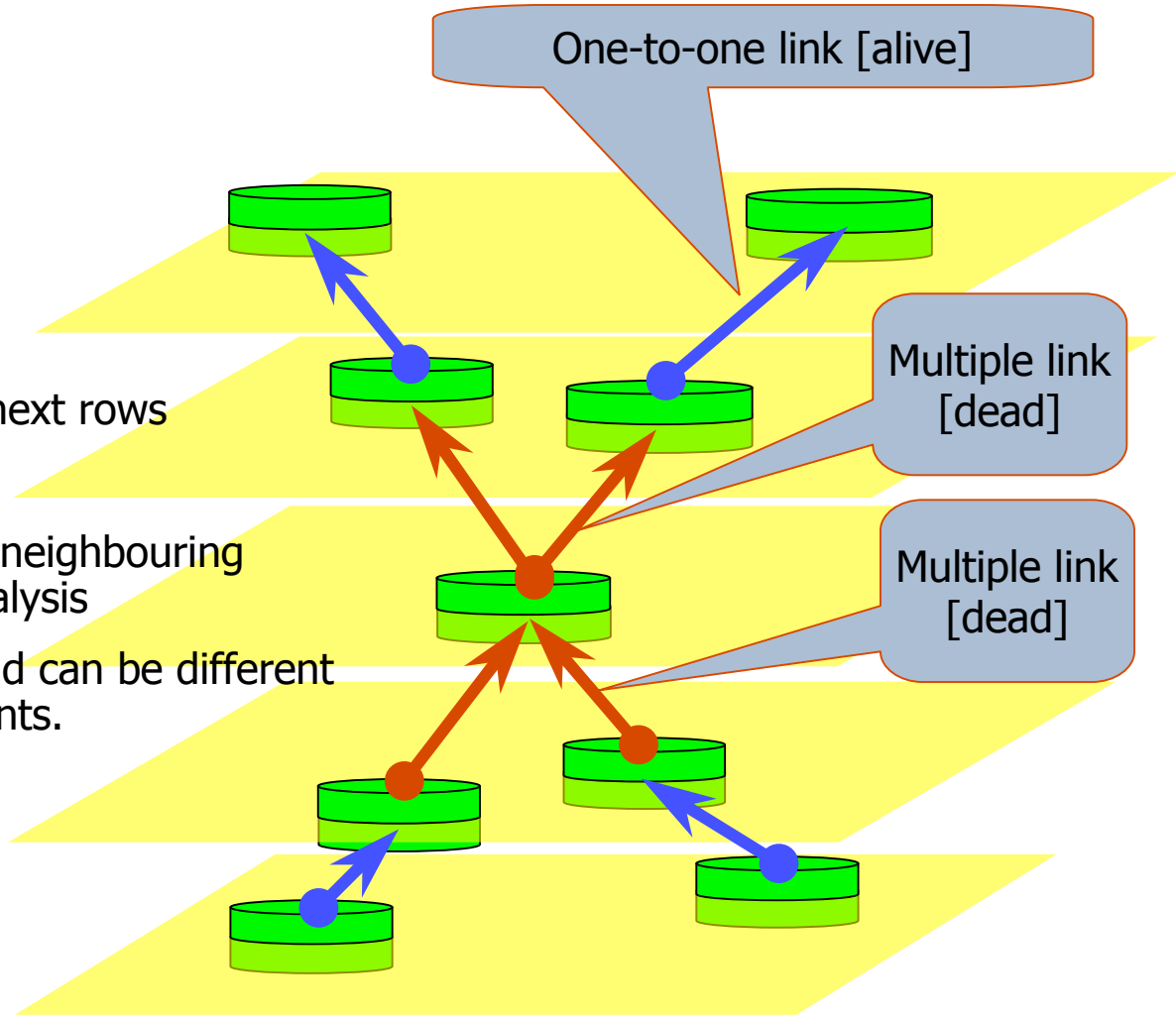
Creation of cells - "horizontal tracking":

- local search for neighbors for each TPC cluster
- cluster-wise parallelism
- less combinatorics left for the further processing
- less data

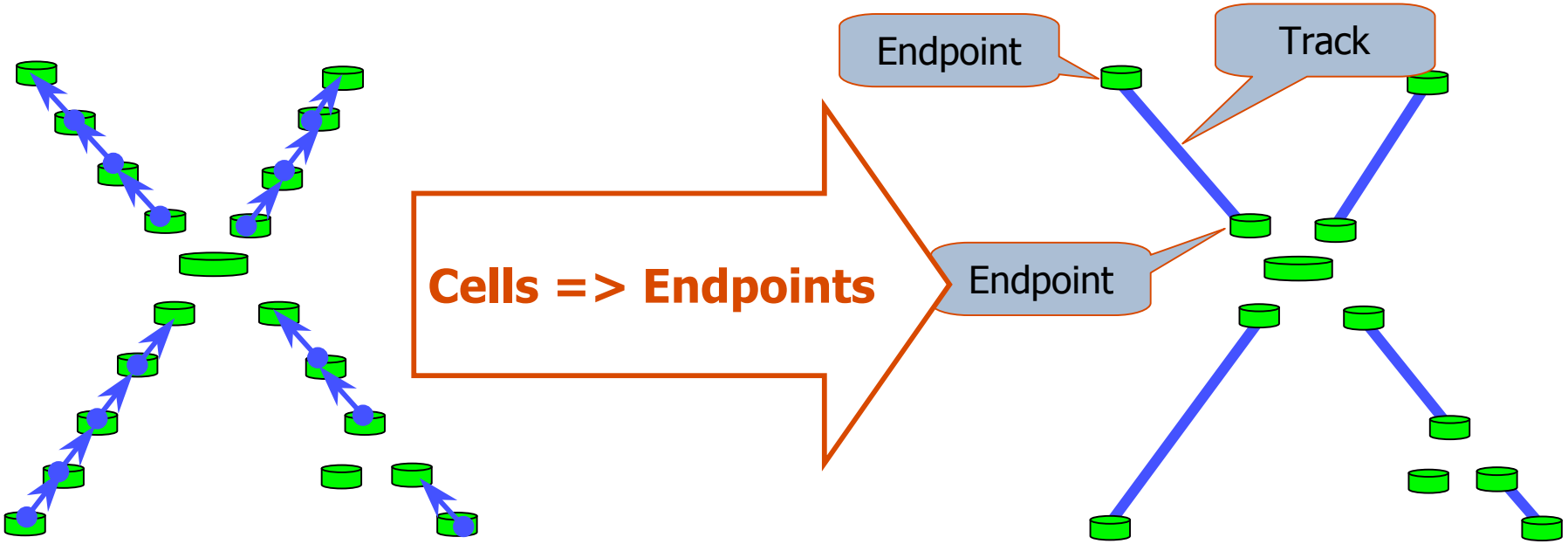
Cellular Automaton - step 2: Merging cells

Merging cells - evolution step:

- local search for neighbors in the next rows
- cell-wise parallelism
- cells are linked one-to-one, multi-neighbouring situations are left for the further analysis
- neighbouring criteria is flexible and can be different for physics, cosmics, calibration events.

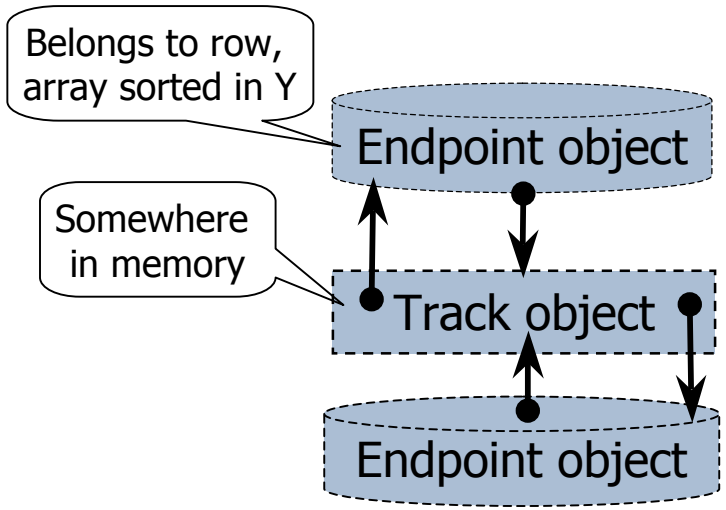


Cellular Automaton - step 3: Creation of track segments

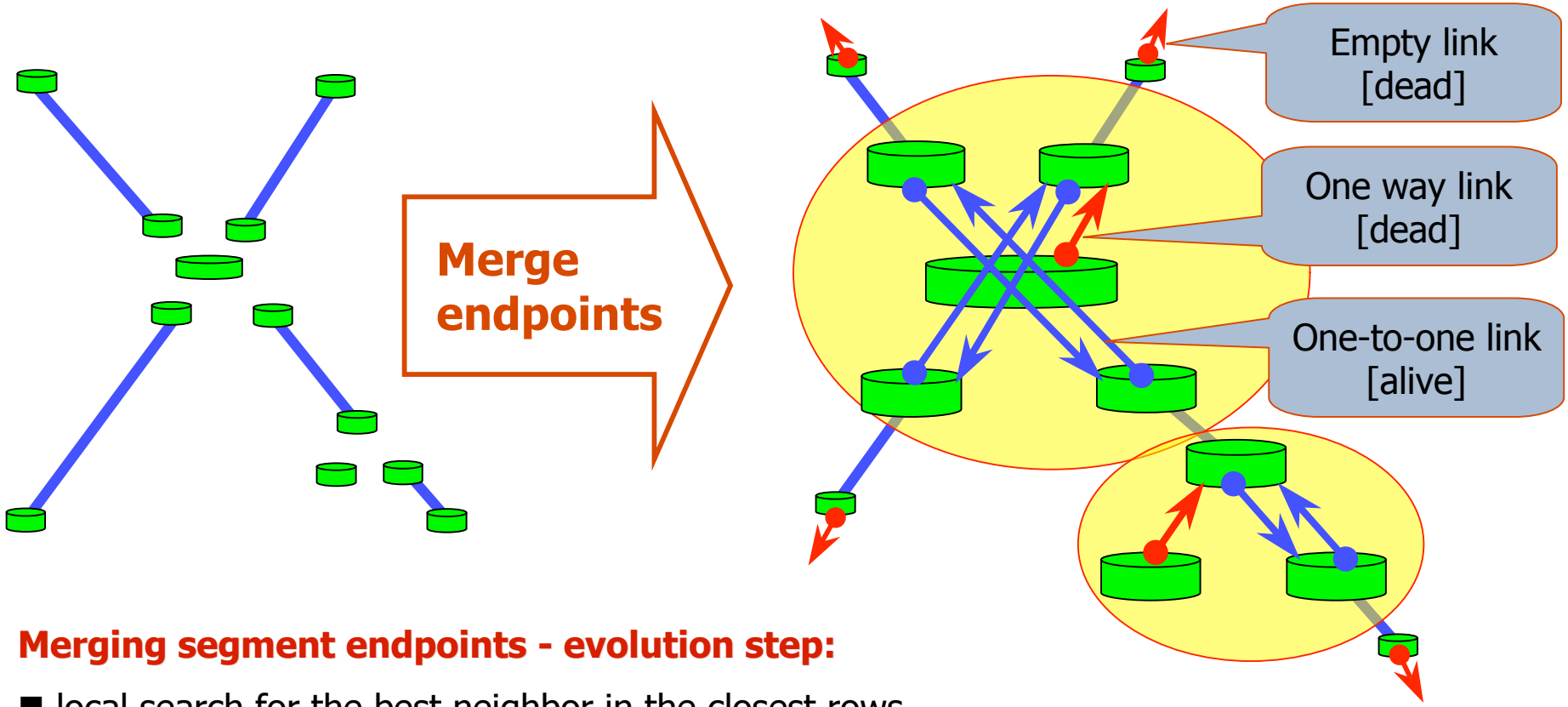


Creation of the track segments:

- each sequence of the neighboring cells is composed to the track segment.
- track segment-wise parallelism
- no search, no combinatorics
- fitting mathematics
- only endpoints are left for the further reconstruction



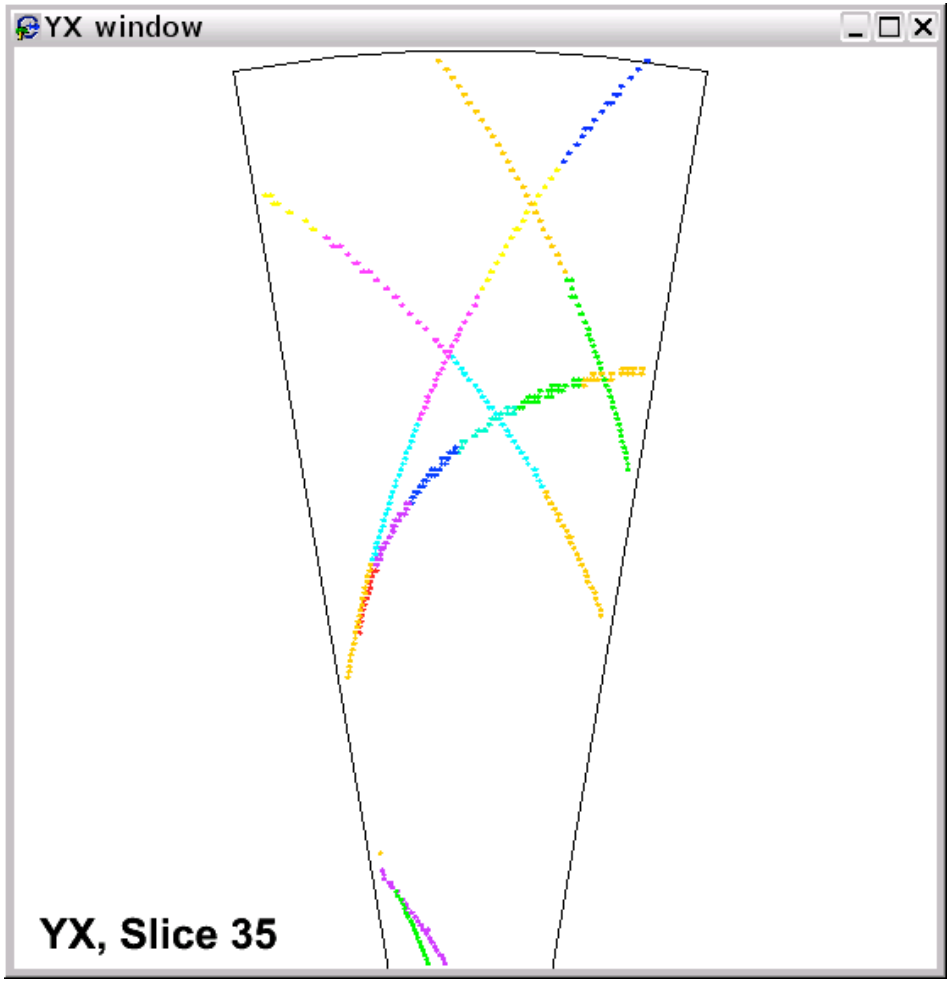
Cellular Automaton - step 4: Merging of segments

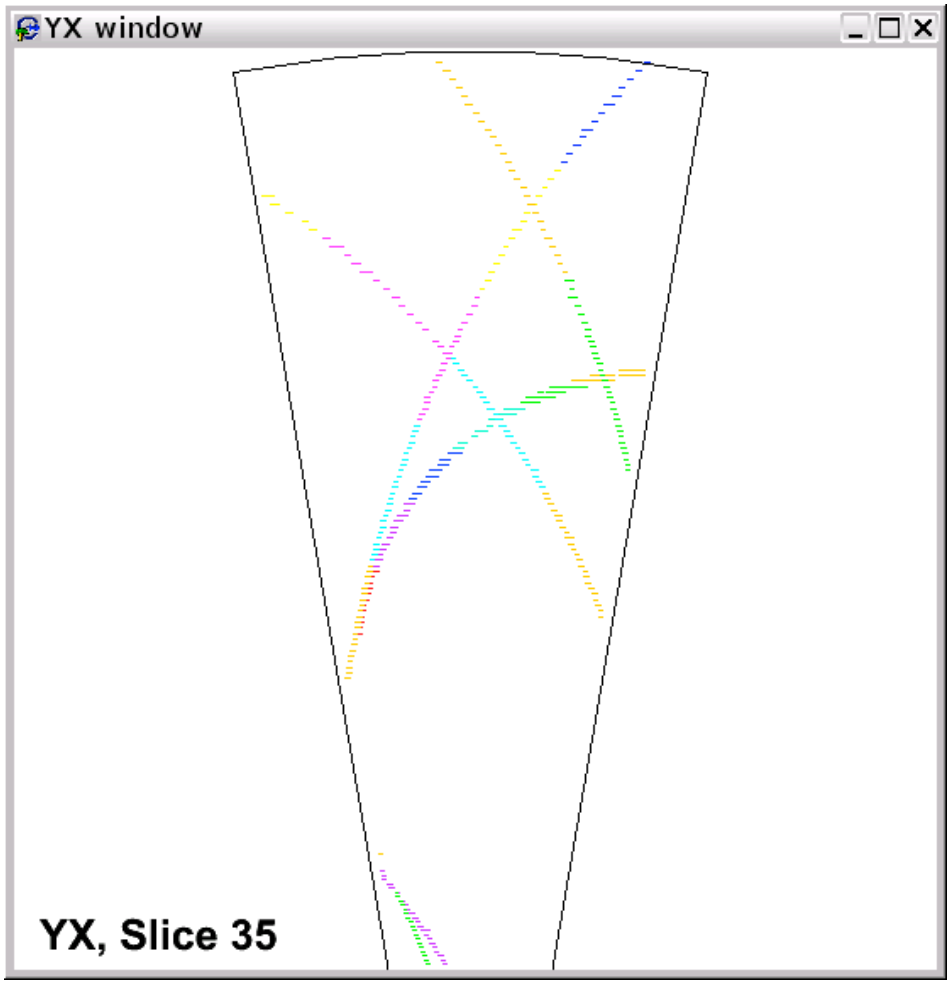


Merging segment endpoints - evolution step:

- local search for the best neighbor in the closest rows
- endpoint-wise parallelism
- competition between links (track length, closeness of the neighbour)
- endpoints are linked one-to-one
- fitting mathematics (χ^2 check)

Cellular Automaton: example of event reconstruction

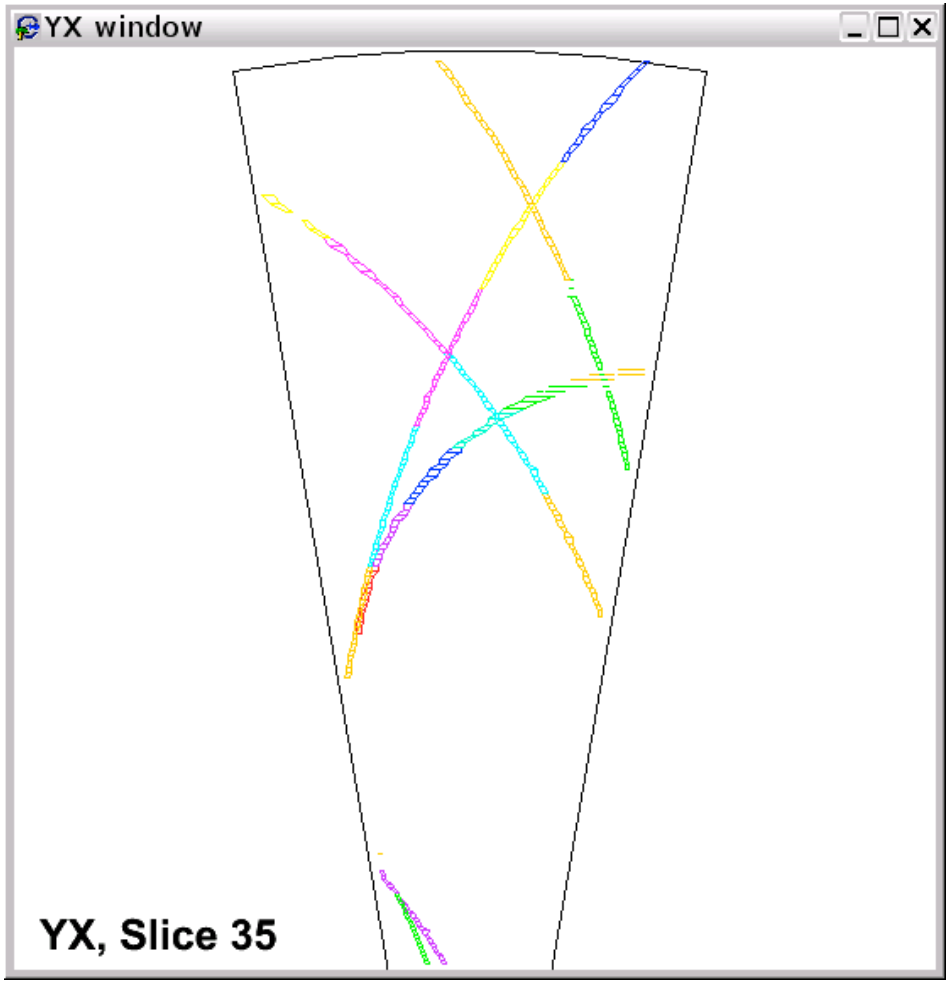




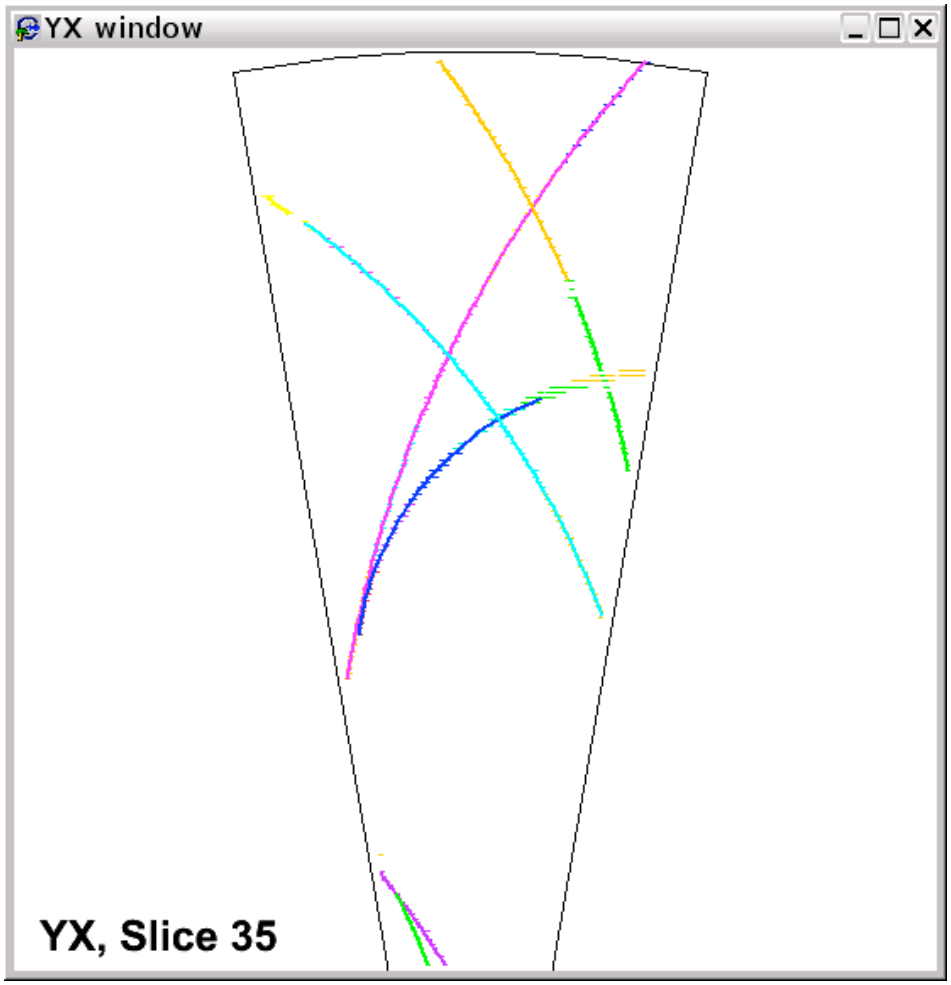
Step 0: TPC clusters

Step 1: Cells

Cellular Automaton: example of event reconstruction

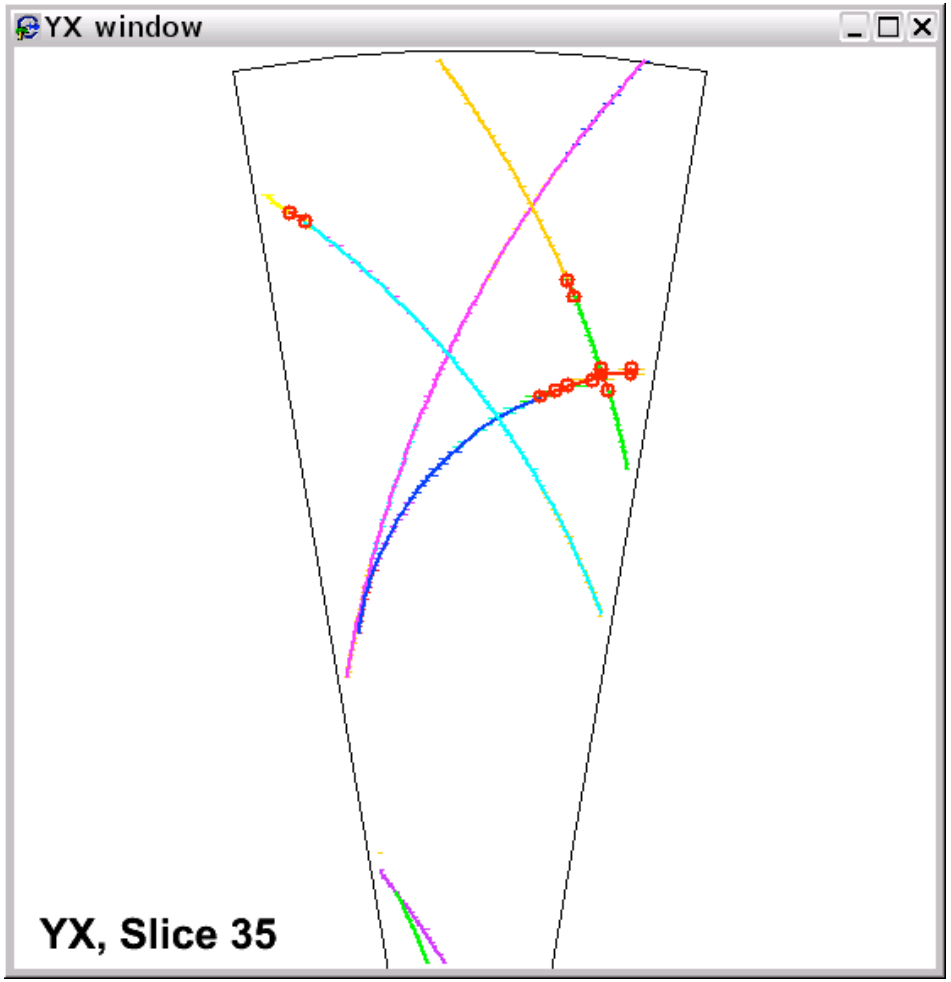


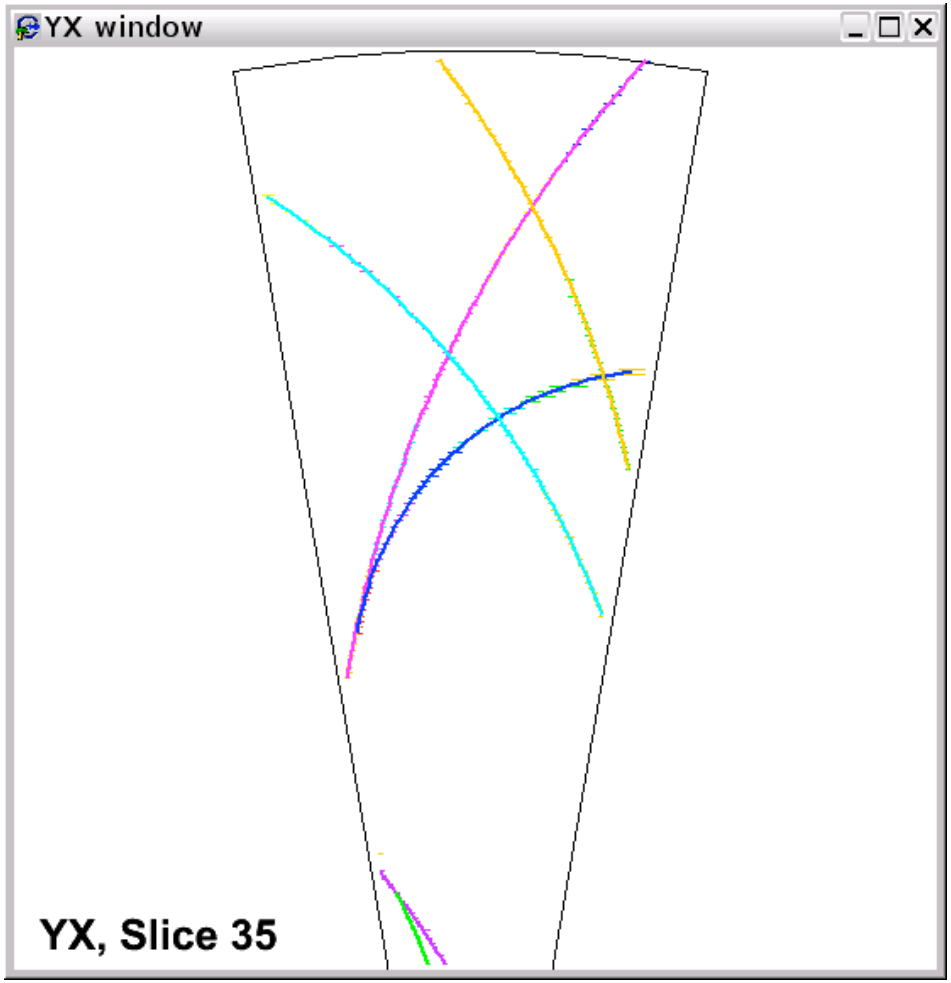
Step 2: Merging cells



Step 3: Creation of track segments

Cellular Automaton: example of event reconstruction





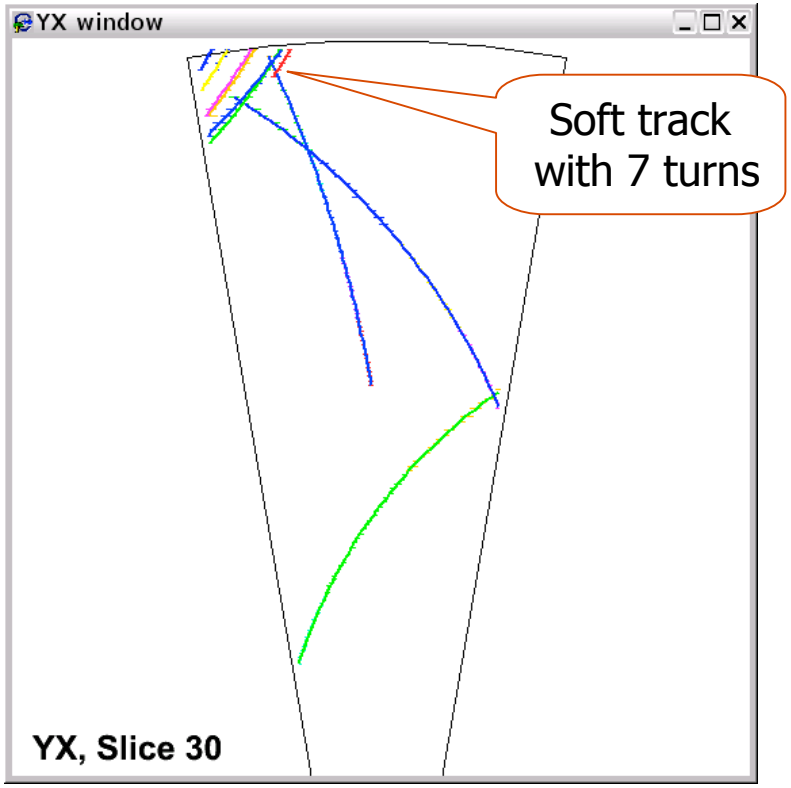
Step 4: Merging of segments

Result: Reconstructed tracks

Cellular Automaton: performance

Reconstruction time for the whole TPC (36 slices) :

Construction of cells … 0.5 ms
Merging of cells …….. 0.3 ms
Creation of segments . 0.3 ms
Fit of segments …… 0.1 ms
Merging of segments . 1.8 ms



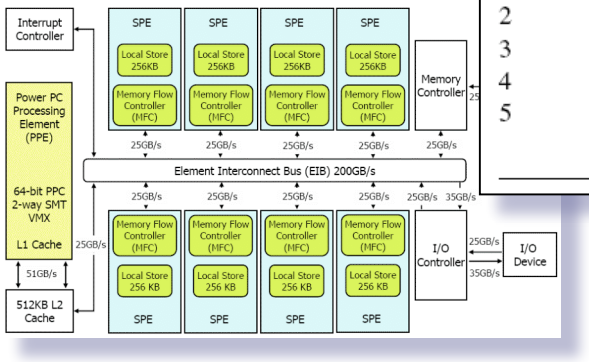
Reconstruction performance:

All Set (Hits >10, P > .05)		Reference Set (All Set + P>1.)		Extra Set (All Set + P<1.)			
Eff	Clone	Eff	Clone	Eff	Clone	Ghost	Time [ms]
94.7	**29.6**	**97.9**	**5.9**	**94.5**	**30.6**	**2.9**	**3.3**

Cellular Automaton: use of parallel hardware

Hardware possibility for the parallel calculations:

- SIMD CPU instructions
- multi-threading
- multi-core CPU
- special hardware (Cell processor, Graphics cards)



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Summarized stages of the porting procedure

Stage	Description	Time/track	Speedup
	Initial scalar version	12 ms	–
1	Approximation of the magnetic field	240 µs	50
2	Optimization of the algorithm	7.2 µs	35
3	Vectorization	1.6 µs	4.5
4	Porting to SPE	1.1 µs	1.5
5	Parallelization on 16 SPEs (2 Cells)	0.1 µs	10
	Final SIMDized version	0.1 µs	120,000

Summary and plans

Summary:

- The Cellular Automaton tracker for ALICE HLT has been developed
- The tracker shows good performance and speed
- It reconstructs all kinds of data: Physics, Cosmics, Calibration events; with and w/o magnetic field.
- Running on-line in HLT

Current work:

- Speed up and tuning for Pb-Pb collisions
- Investigation of parallel hardware