Status of Event Reconstruction with Cellular Automaton and KF Particle

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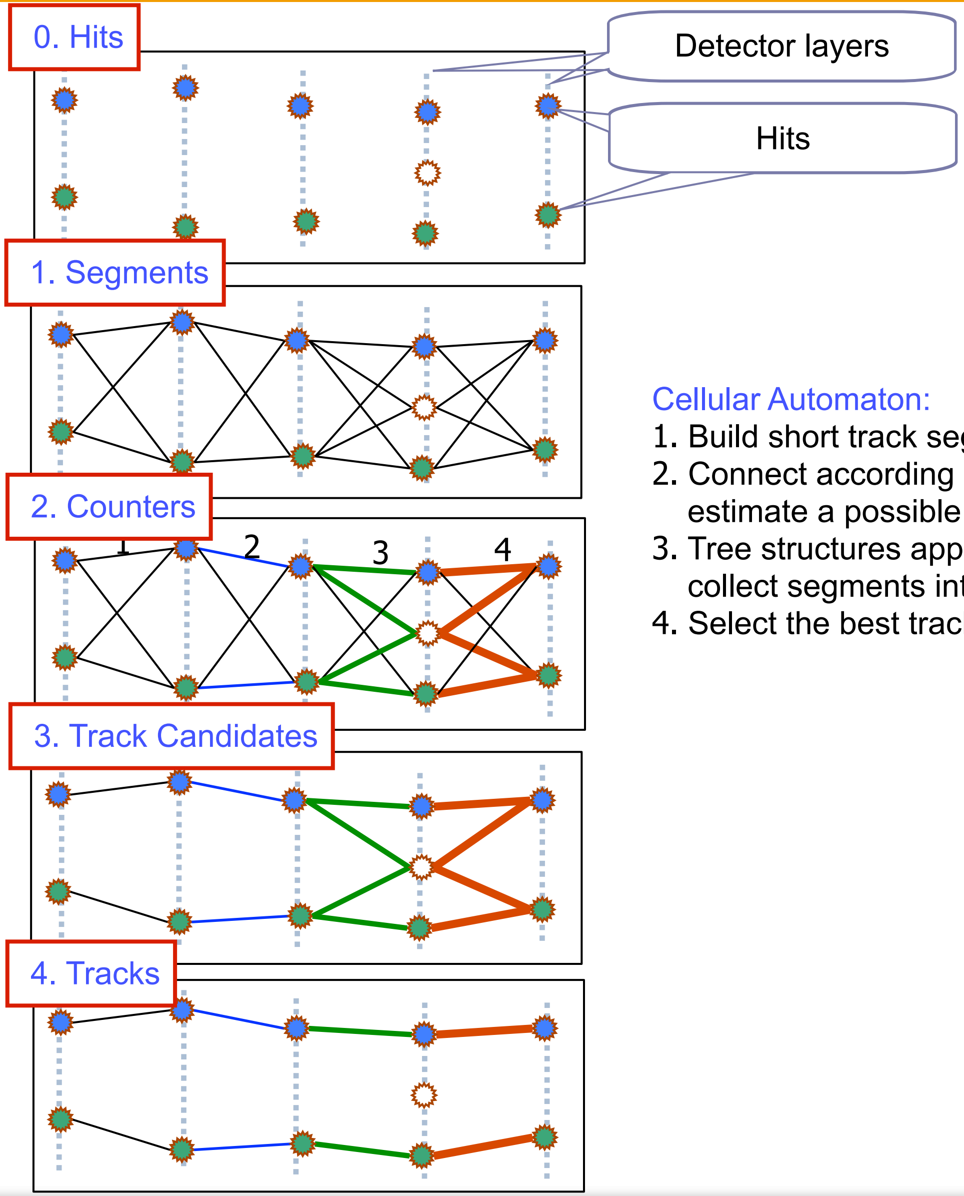
Cellular Automaton (CA) as Track Finder



Cellular Automaton:
1. Build short track segments.
2. Connect according to the track model, estimate a possible position on a track.
3. Tree structures appear, collect segments into track candidates.
4. Select the best track candidates.

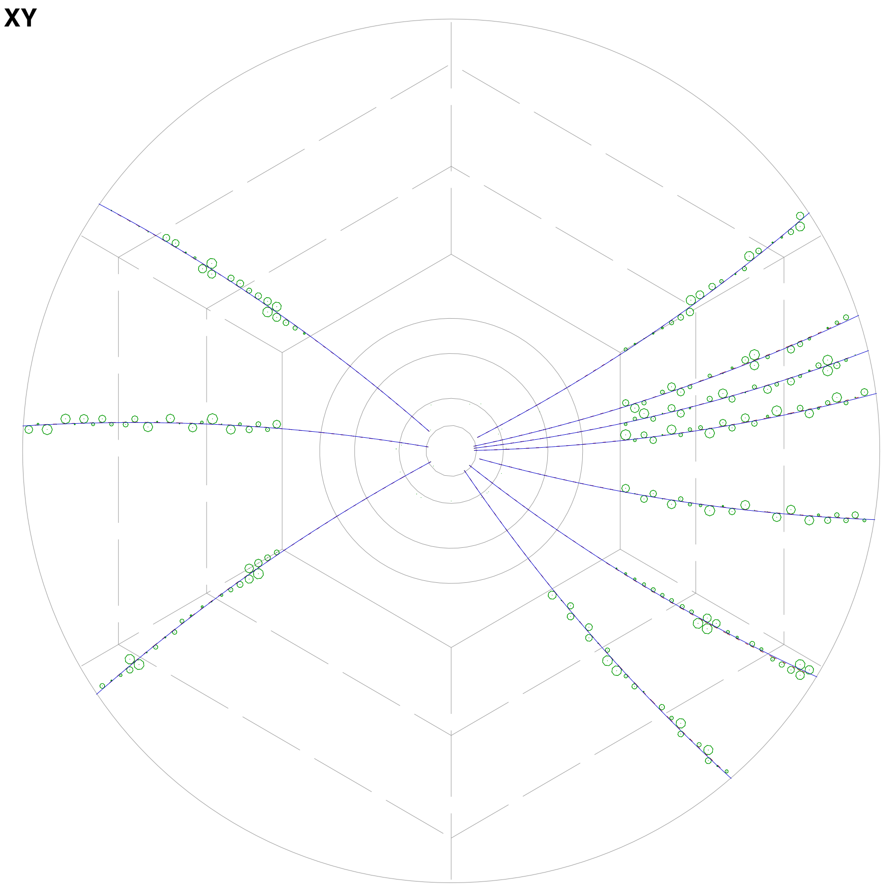
Cellular Automaton:
- local w.r.t. data
- intrinsically parallel
- extremely simple
- very fast

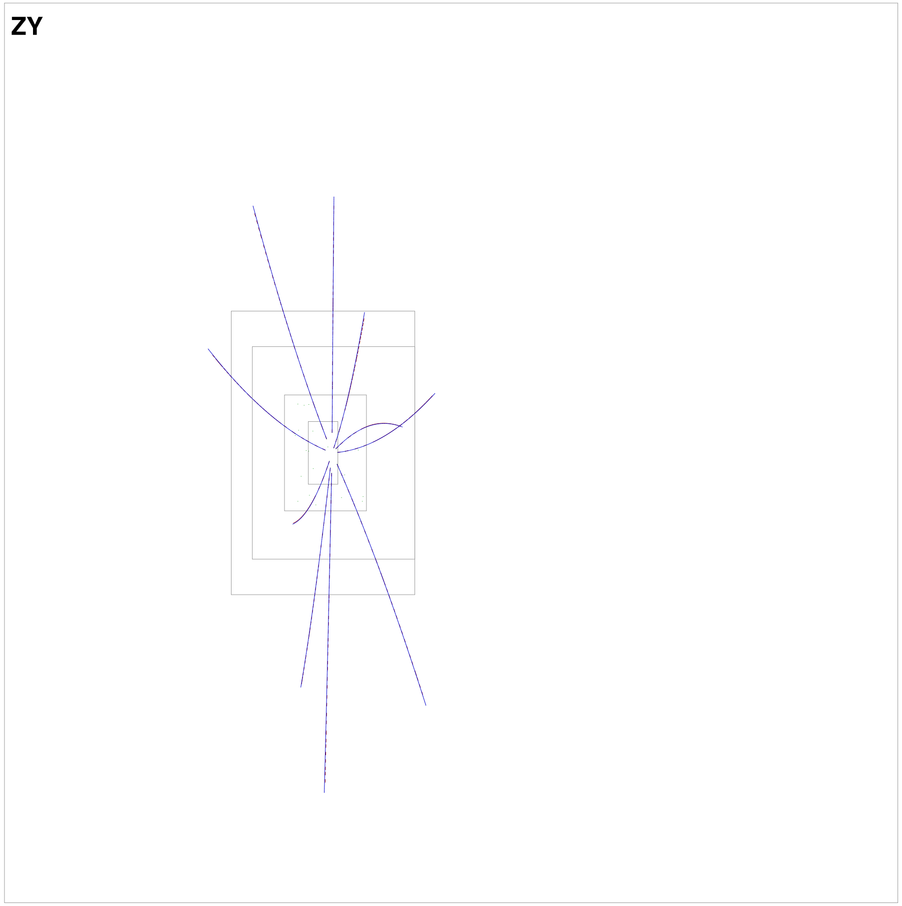
Perfect for many-core CPU/GPU !

Useful for complicated event topologies with large combinatorics and for parallel hardware

Event Display (STT+MVD Barrel)

10 primary tracks with pt = 1 GeV/c





CA Track Finding Efficiency

10 primary tracks with pt = 1 GeV/c

only tracks with all (4 barrel) MVD hits are selected

	STT	STT+MVD
Efficiency	97.2	99.3
Clone	1.8	9.2
Ghost	2.5	2.5
Tracks/event	10	10
Time, ms/event	5	7

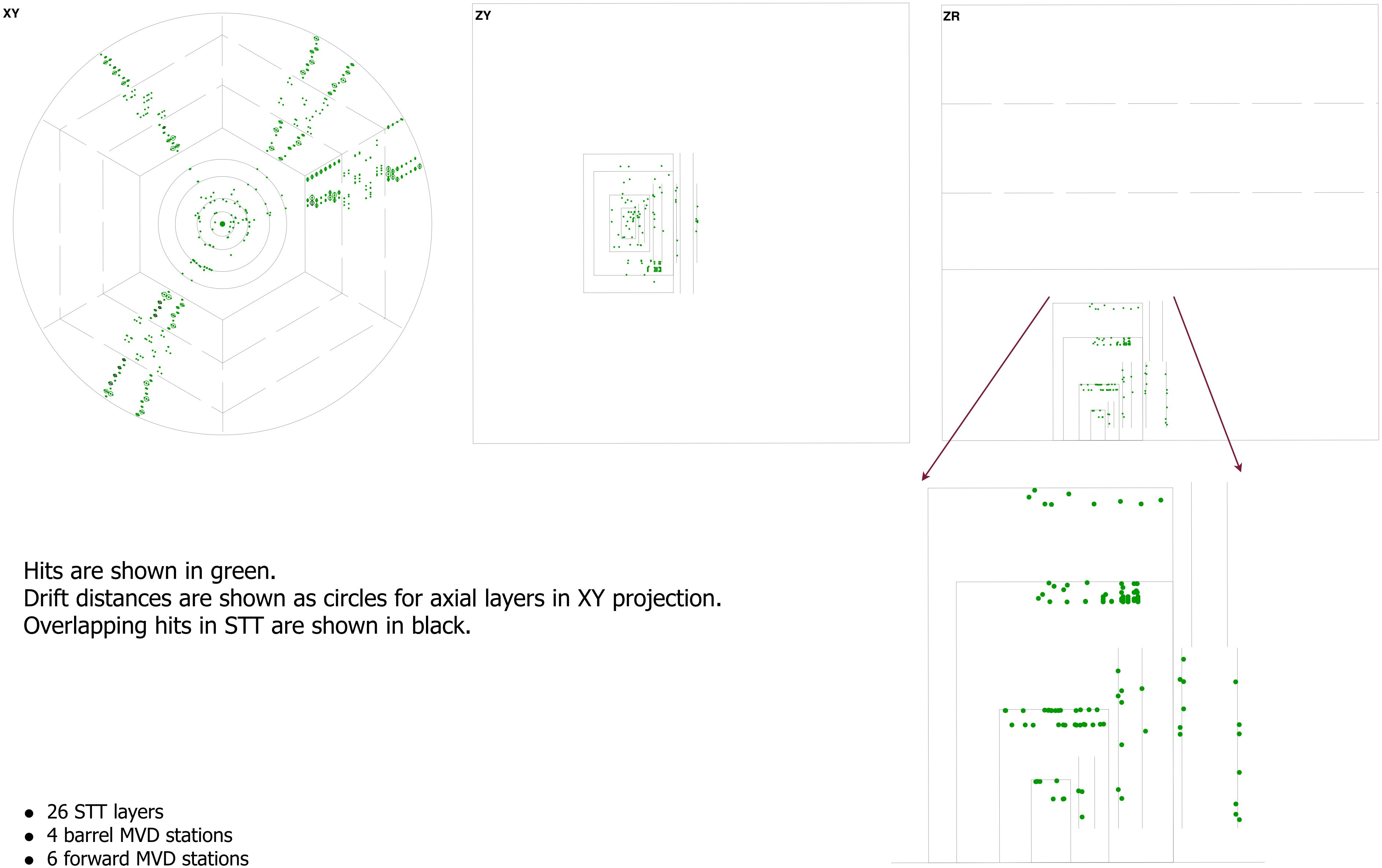
Reconstructable track: ≥ 6 consecutive MC points
Ghost: purity < 75%

10 tracks with pt = 1 GeV/c; 100 events
1 core of Intel Core i7, 3.4 GHz, 8 MB L3 cache, 32 GB RAM

Efficiency 99.3% at 7 ms per event

Event Display (STT+MVD Barrel&Forward)

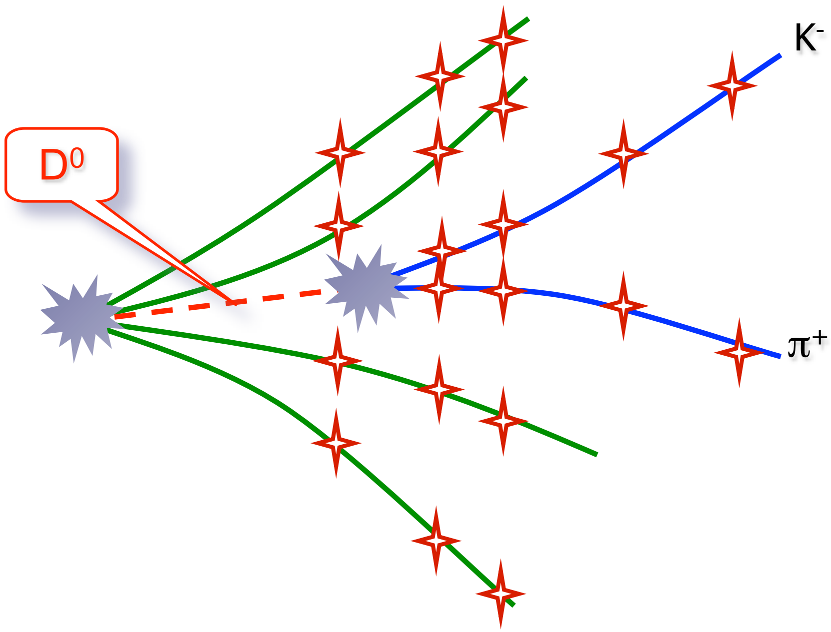
10 primary tracks with pt = 1GeV/c



Hits are shown in green.
Drift distances are shown as circles for axial layers in XY projection.
Overlapping hits in STT are shown in black.

- 26 STT layers
- 4 barrel MVD stations
- 6 forward MVD stations

KF Particle: Reconstruction of Vertices and Decayed Particles



State vector

Position, direction, momentum and energy

$$r = \{ x, y, z, p_x, p_y, p_z, E \}$$

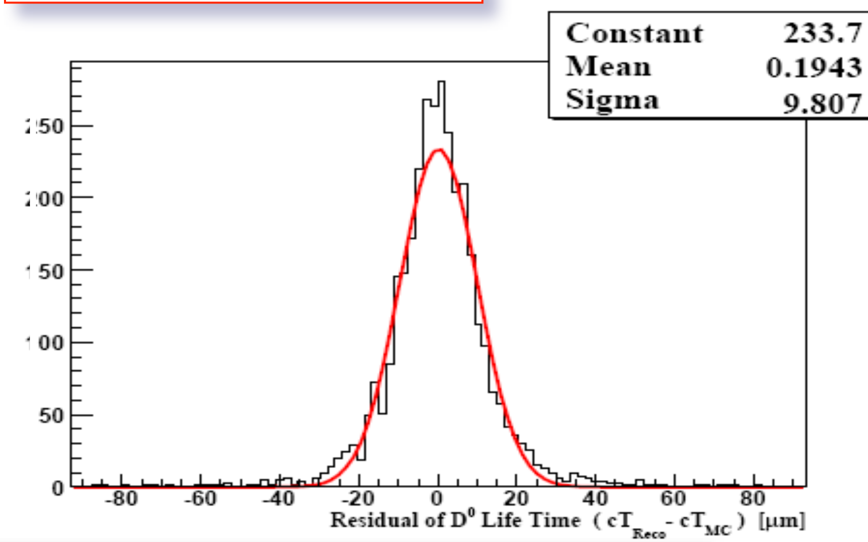
- Mother and daughter particles have the same state vector and are treated in the same way
- Geometry independent
- Kalman filter based

$x, y, z, p_x, p_y, p_z, E, m, L, c\tau$

```
AliKFVertex PrimVtx( ESDPrimVtx );  // Set primary vertex
                                    // Set daughters
AliKFParticle K( ESDp1, -321 ), pi( ESDp2, 211 );

AliKFParticle  D0( K, pi );          // Construct mother
PrimVtx += D0;                       // Improve the primary vertex

D0.SetProductionVertex( PrimVtx ); // D0 is fully fitted
K.SetProductionVertex( D0 );       // K is fully fitted
pi.SetProductionVertex( D0 );      // pi is fully fitted
```



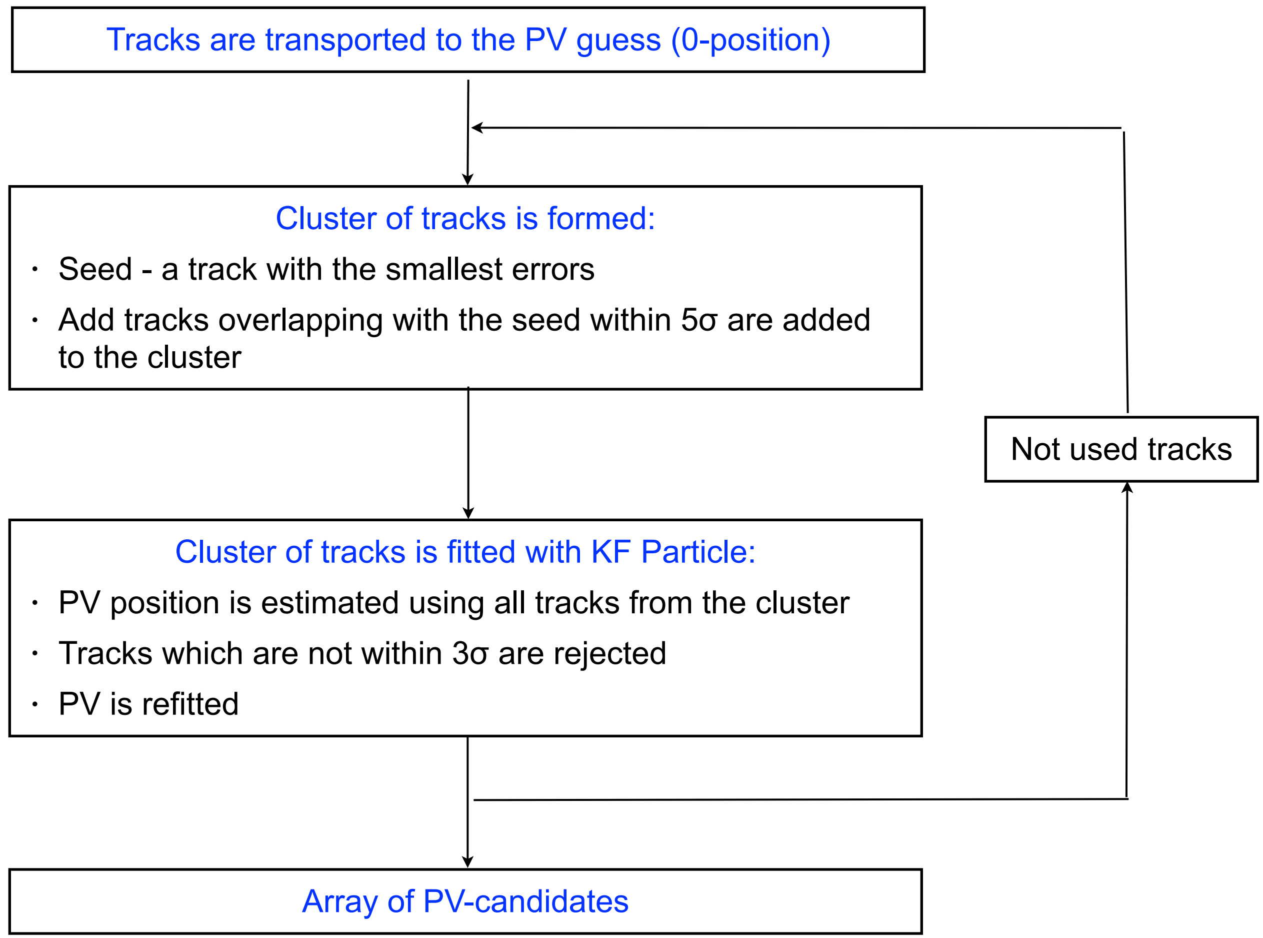
KF Particle provides uncomplicated approach to physics analysis (used in CBM, ALICE and STAR)

KF Particle: Functionality

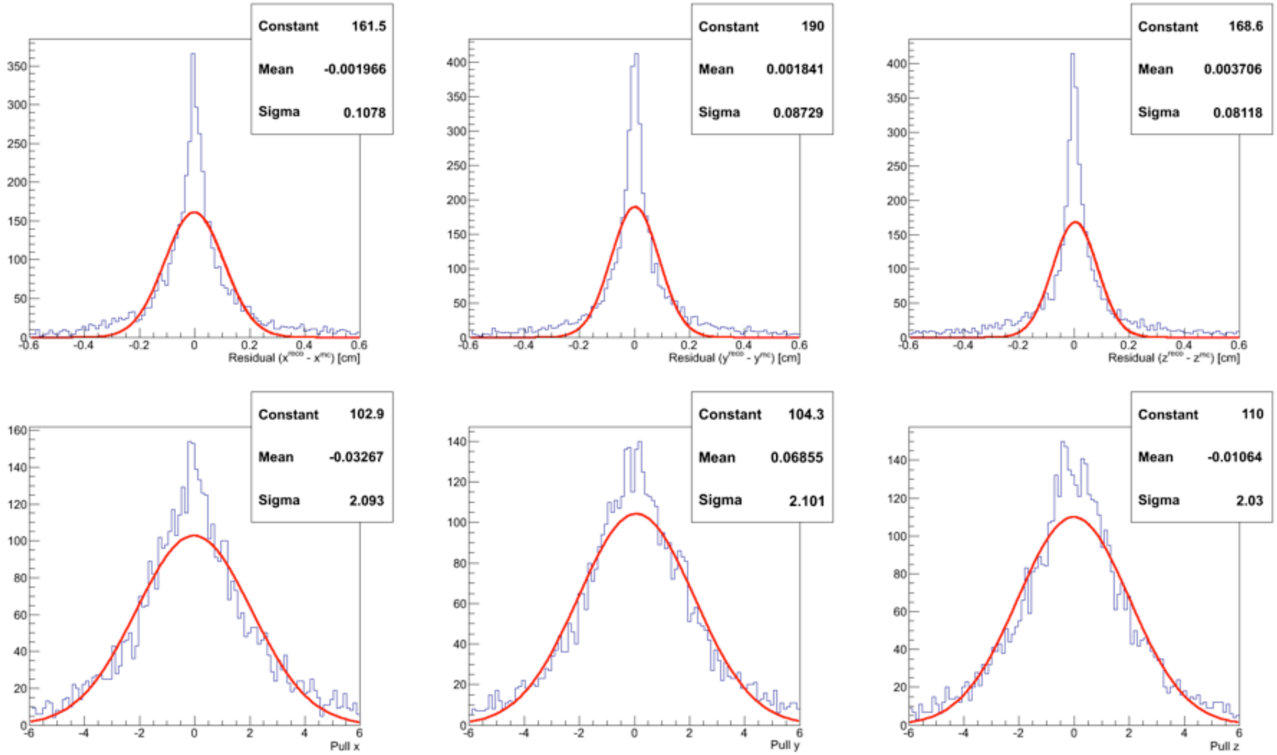
Functions	CBM	ALICE, STAR, PANDA
Construction of mother particles	+	+
Addition and subtraction of the daughter particle to (from) the mother particle	+	+
+= and -= operators	+	+
Accessors to the physical parameters (mass, momentum, decay length, lifetime, rapidity, etc)	+	+
Transport: to an arbitrary point, to the decay and production points, to another particle, to a vertex, on the certain distance	+	+
Calculation of a distance: to a point, to a particle, to a vertex	+	+
Calculation of a deviation: from a point, from a particle, from a vertex	+	+
Calculation of the angle between particles	+	+
Constraints: on mass, on a production point, on a decay length	+	+
KF Particle Finder	+	+

KF Particle provides uncomplicated approach to physics analysis (used in CBM, ALICE and STAR)

KF Particle: Primary Vertex Finder



KF Particle: Primary Vertex Finder



	Resolution
X, cm	0,11
Y, cm	0,09
Z, cm	0,08
	Pull
X	2,1
Y	2,1
Z	2,0

	PV
Efficiency, %	71,1
Clone, %	1,7
Ghost	16,6

- Efficiency is normalized to the MC primary vertices with at least two reconstructed daughter particles
- Pulls are wide due to a large fraction of short tracks with not enough information about Z and p_t

10000 DPM events at 7.24 GeV, Ideal track finder

KF Particle Finder for Physics Analysis and Selection

Tracks: $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, $K^{\pm}$, $p^{\pm}$
secondary and primary

Open-charm:
$D^0 \rightarrow \pi^+ K^-$
$D^0 \rightarrow \pi^+ \pi^+ \pi^- K^-$
$\bar{D}^0 \rightarrow \pi^- K^+$
$\bar{D}^0 \rightarrow \pi^- \pi^- \pi^+ K^+$
$D^+ \rightarrow \pi^+ \pi^+ K^-$
$D^- \rightarrow \pi^- \pi^- K^+$
$D_s^+ \rightarrow \pi^+ K^+ K^-$
$D_s^- \rightarrow \pi^- K^+ K^-$
$\Lambda_c \rightarrow \pi^+ K^- p$

Strange particles:
$K^0_s \rightarrow \pi^+ \pi^-$
$\Lambda \rightarrow p\, \pi^-$
$\bar{\Lambda} \rightarrow \pi^+ p^-$

Gamma:
$\gamma \rightarrow e^- e^+$
Strange resonances:
$\bar{K}^{*0} \rightarrow K^+ \pi^-$
$K^{*0} \rightarrow \pi^+ K^-$
$\bar{\Lambda}^* \rightarrow p\, K^-$
$\Lambda^* \rightarrow p^- K^+$
Light vector mesons:
$\rho \rightarrow e^- e^+$
$\rho \rightarrow \mu^- \mu^+$
$\omega \rightarrow e^- e^+$
$\omega \rightarrow \mu^- \mu^+$
$\varphi \rightarrow e^- e^+$
$\varphi \rightarrow \mu^- \mu^+$
$\varphi \rightarrow K^- K^+$
Charmonium:
$J/\Psi \rightarrow e^- e^+$
$J/\Psi \rightarrow \mu^- \mu^+$

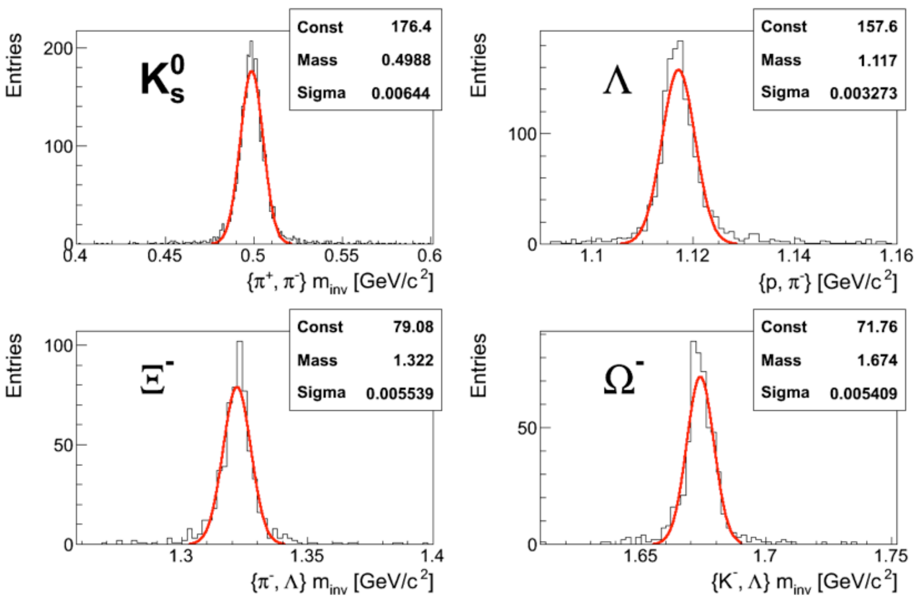
Multi-strange hyperons:
$\Xi^- \rightarrow \Lambda\, \pi^-$
$\Xi^+ \rightarrow \bar{\Lambda}\, \pi^+$
$\Omega^- \rightarrow \Lambda\, K^-$
$\Omega^+ \rightarrow \bar{\Lambda}\, K^+$

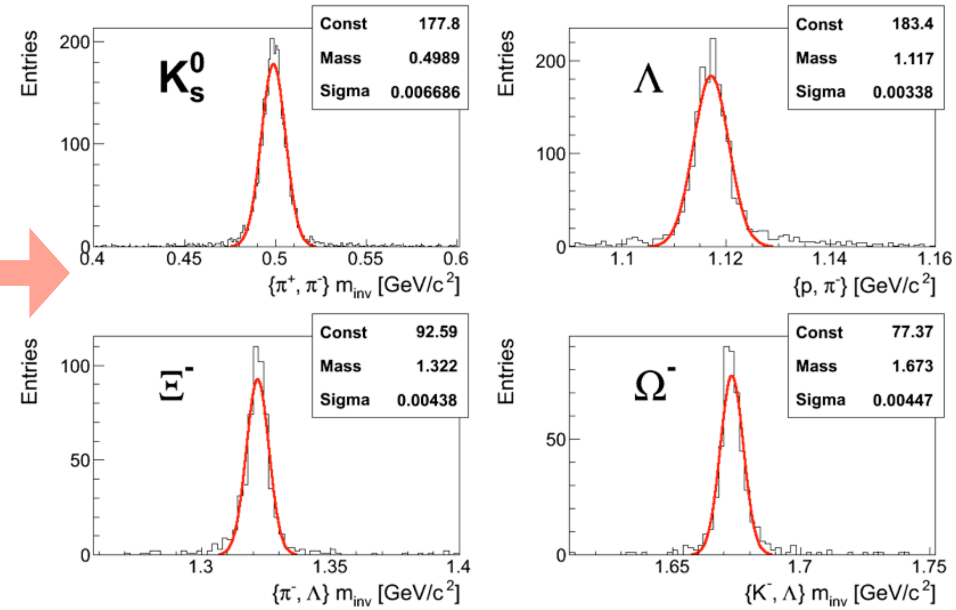
Strange and multi-strange resonances:
$\Sigma^{*+} \rightarrow \Lambda\, \pi^+$
$\bar{\Sigma}^{*+} \rightarrow \bar{\Lambda}\, \pi^-$
$\Sigma^{*-} \rightarrow \Lambda\, \pi^-$
$\bar{\Sigma}^{*-} \rightarrow \bar{\Lambda}\, \pi^+$
$K^{*-} \rightarrow K^0_s\, \pi^-$
$K^{*+} \rightarrow K^0_s\, \pi^+$
$\Xi^{*-} \rightarrow \Lambda\, K^-$
$\Xi^{*+} \rightarrow \bar{\Lambda}\, K^+$

Open-charm resonances:
$D^{*0} \rightarrow D^+ \pi^-$
$\bar{D}^{*0} \rightarrow D^- \pi^+$
$D^{*+} \rightarrow D^0 \pi^+$
$D^{*-} \rightarrow \bar{D}^0 \pi^-$

Multi-strange resonances:
$\Xi^{*0} \rightarrow \Xi^- \pi^+$
$\bar{\Xi}^{*0} \rightarrow \Xi^+ \pi^-$
$\Omega^{*-} \rightarrow \Xi^- \pi^+ K^-$
$\Omega^{*+} \rightarrow \Xi^+ \pi^- K^+$

Reconstruction of Strange Particles





Particle	p_t of generated signal, GeV/c	Efficiency
$K^0{}_s$	1	56,2%
Λ	1	32,0%
Ξ^-	2	14,1%
Ω^-	2	17,1%

Particle	p_t of generated signal, GeV/c	Efficiency
$K^0{}_s$	1	64,2%
Λ	1	45,3%
Ξ^-	2	15,0%
Ω^-	2	16,9%

- Efficiency is normalized to the MC particles with all daughter tracks reconstructed
- Efficiencies of Ξ^- and Ω^- are lower due to the efficiency of Λ reconstruction

10000 signal events with fixed p_t, Ideal track finder, MC primary vertex

Summary

The event reconstruction algorithms:

- Cellular Automaton (CA) Track Finder
- Kalman Filter (KF) Track Fitter
- KF Primary Vertex Finder
- KF Particle Finder

for the STT and MVD B&F detectors are under development