Status of the Cellular Automaton track finder

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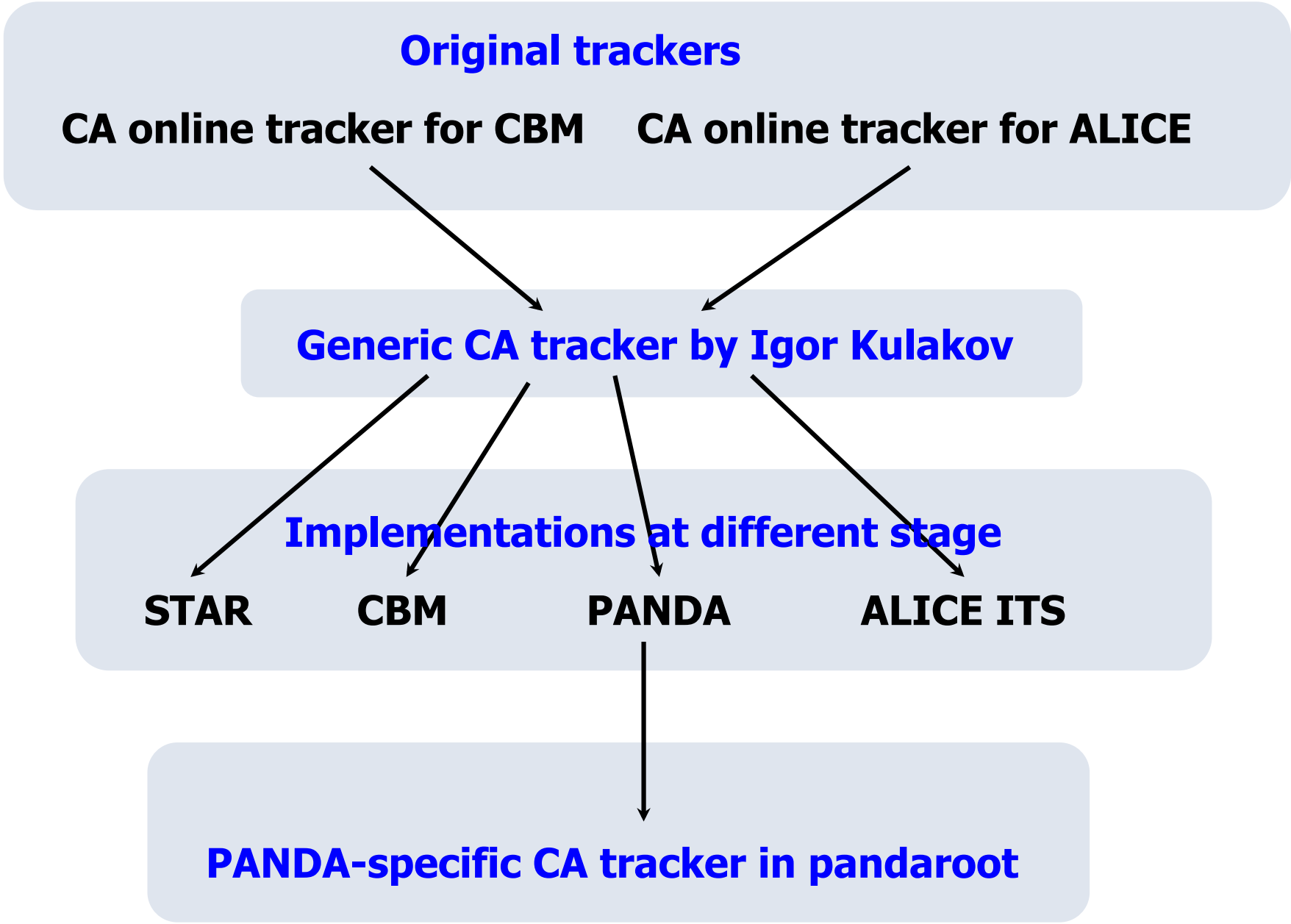
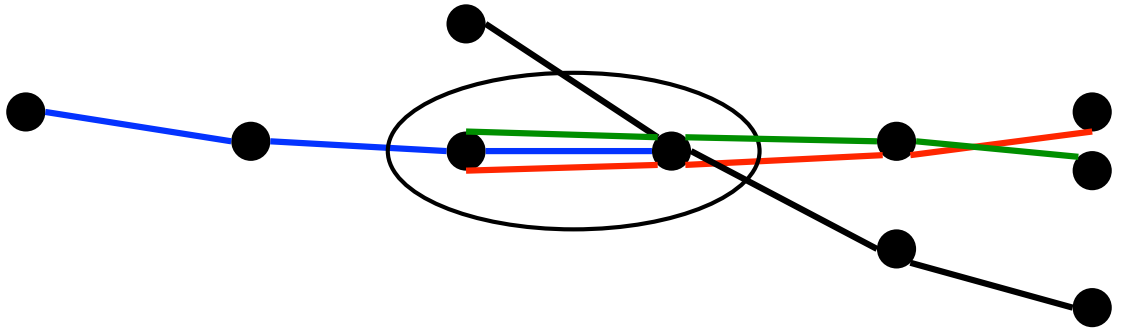
CA tracker development history



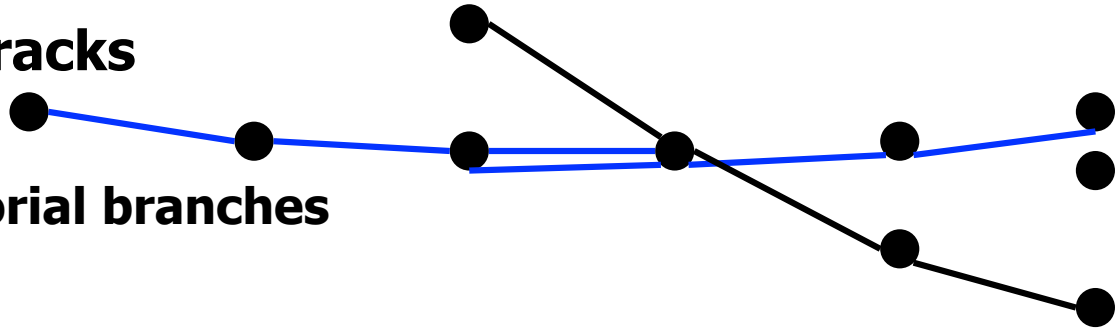
The Cellular Automaton method

1. **Create tracklets**
   - everywhere
   - simple math



2. **Find neighbours**
   - look for common hits
   - look for same geo params

3. **Merge tracklets + fit tracks**
   - Kalman filter
   - select best combinatorial branches
   - suppress fakes



4. **Final tuning - pick up missed hits, merge gaps, etc**

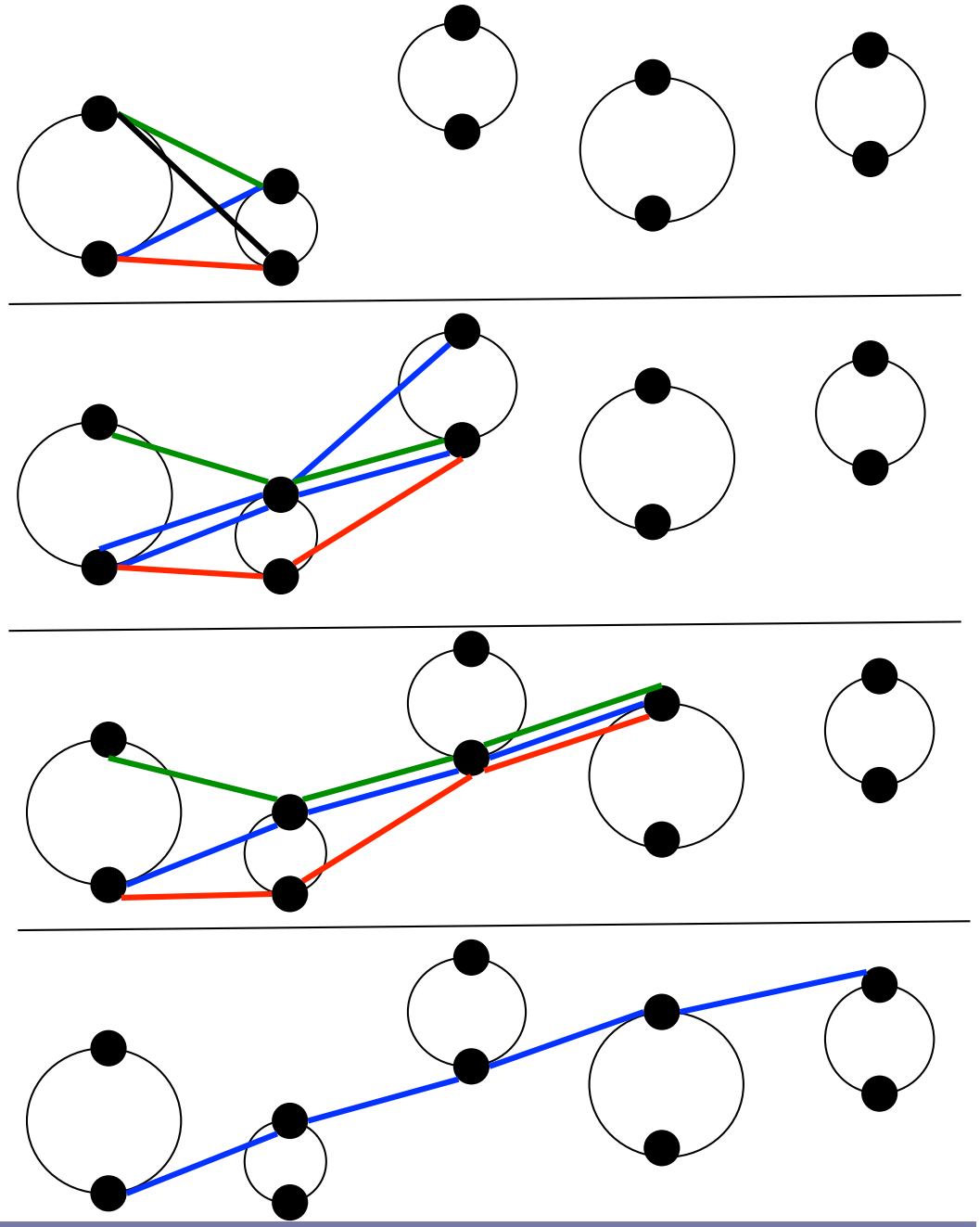
CA tracking in PANDA

Tracking in PANDA:

- **tracks are well separated**
- **tens of detector layers**
- **constant field**
- **~no scattering**

CA features (generic algorithm):

- **5-station-tracklets**
- **separate left & right hits**
- **full combinatorics: all hit combinations -> tracklets**
- **Kalman filter at early stage, already for tracklet creation**



Optimization – Kalman filter

Use of "light" Kalman filter for track finding

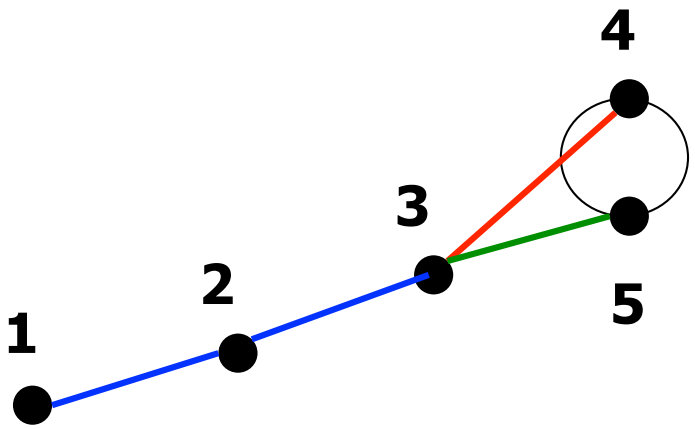
Example: linearisation at q/p=0 :

```
const float_v ex = t0.CosPhi();
const float_v ey = t0.SinPhi();
const float_v k  = t0.QPt() * Bz;
const float_v dx = x - X();

 float_v ey1 = k * dx + ey;
 float_v ex1 = CAMath::Sqrt( 1.f - ey1 * ey1 );
 ex1( ex < Vc::Zero ) = -ex1;
 const float_v dx2 = dx * dx;
 const float_v ss = ey + ey1;
 const float_v cc = ex + ex1;
 const float_v cci = 1.f / cc;
 const float_v exi = 1.f / ex;
 const float_v ex1i = 1.f / ex1;
 float_m mask = _mask && CAMath::Abs( ey1 ) <= maxSinPhi && CAMath::Abs( cc ) >= 1.e-4f && CAMath::Abs( ex ) >= 1.e-4f && CAMath::Abs( ex1 ) >= 1.e-4f;
 const float_v tg = ss * cci; // tan((phi1+phi)/2)
 const float_v dy = dx * tg;
 float_v dl = dx * CAMath::Sqrt( 1.f + tg * tg );
 dl( cc < Vc::Zero ) = -dl;
 const float_v dSin = CAMath::Max( float_v( -1.f ), CAMath::Min( float_v( Vc::One ), dl * k * 0.5f ) );
 const float_v dS = ( CAMath::Abs( k ) > 1.e-4f )  ? ( 2 * CAMath::ASin( dSin ) / k ) : dl;
 const float_v dz = dS * t0.DzDs();
```

Optimization of data structures

Example: storing hits, associated to track during branching



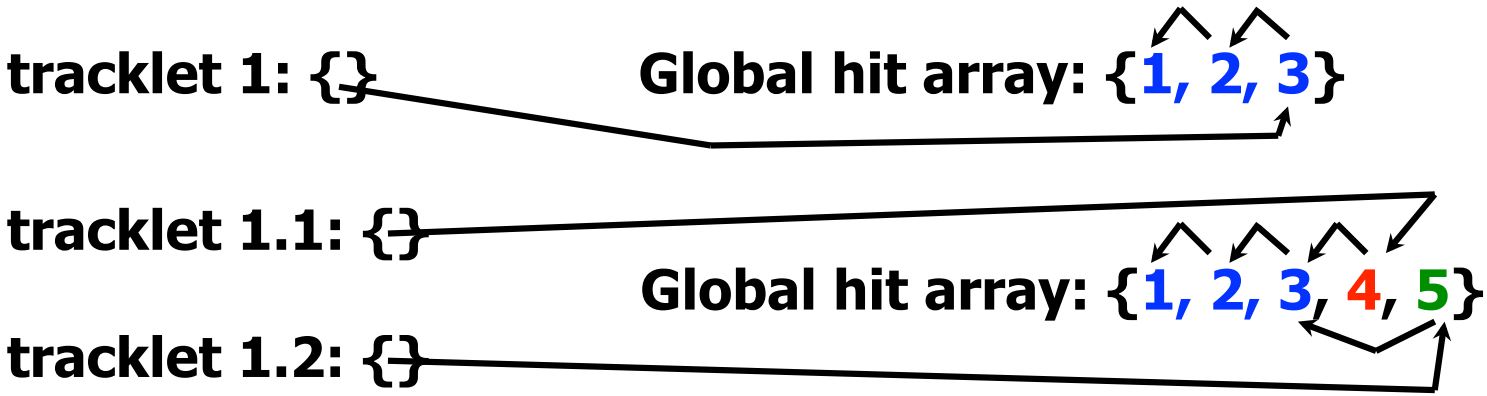
tracklet 1.1: {1,2,3,4}

tracklet 1: {1,2,3}

Array copy!

tracklet 1.2: {1,2,3,5}

New structure: 1 link to the last hit per track. No copy, no arrays.



Other optimizations

- **Using of SIMD vectors for calculations (VC package)**
  (SIMD was already implemented, but with almost no gain)
- **Optimizing calculations**

Current status

Efficiency: ~100.0 % (of MC tracks are reconstructed)
Fake rate: 1.5 % (of reco tracks are fake)
Clone rate: 4.8 % (of reco tracks are duplicated)
Speed : 1.0 ms (/event on single core AMD 2.9GHz)
+Final Fit: +0.7 ms (/event " - ")

- the code is in PandaRoot/catracking/*
- compiles (also on Mac) and runs
- sim/digi/reco macros are provided: macro/catracking/*
- tested (thanks to Stefano!) and ready to use

To do:

- further clean up the code
- tune the algorithm for the standard QA