Tracking and Fitting with SODTracker & KFFitter

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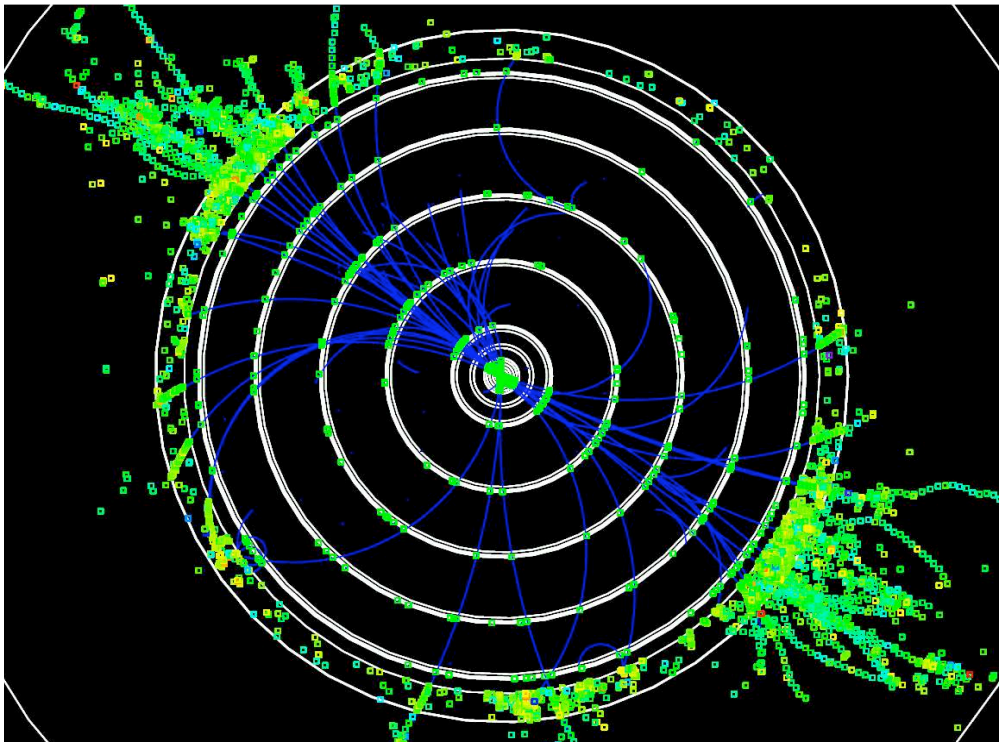
Tracking: SODTracker

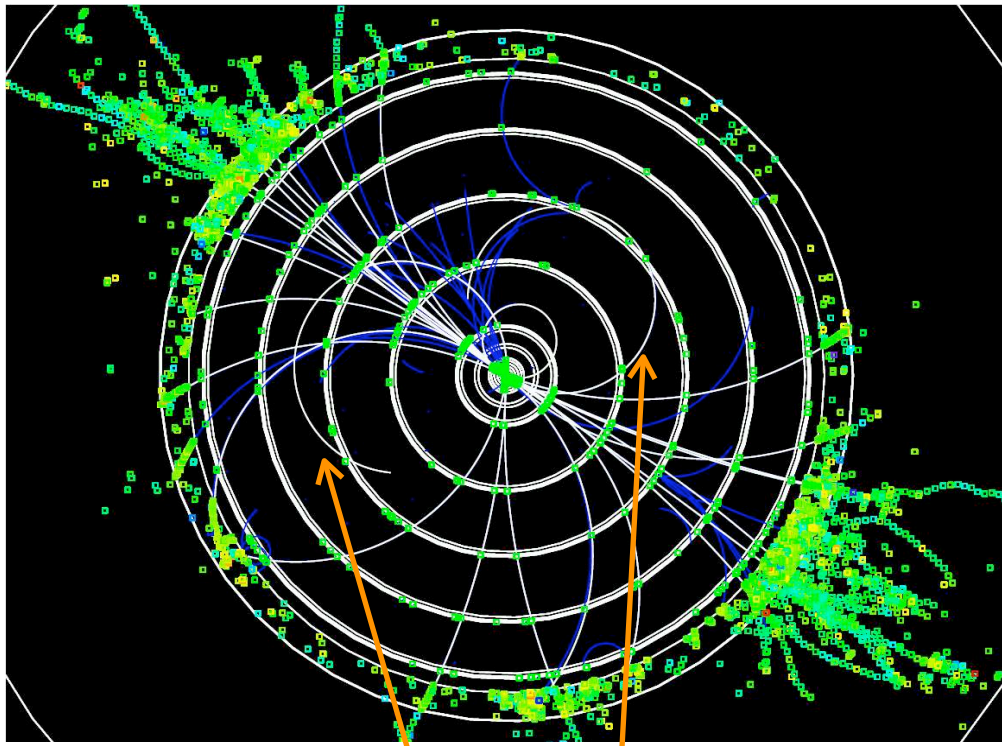
- Track finding in the Silicon Outer Detector (SOD)
- Tracking method:
  1. **Obtain seed track in the Vertex Detector** (VD)
     - seed tracks from hit combinations in VD or from MCParticle true information (cheat track).
     - can use Tracks from any track finder when available.
  2. **Add hits from the Barrel strip tracker** (Endcaps coming soon)
  3. **Fit track**
     - **Helix fit** (or Kalman Filter with KFFitter)
  4. **Insert SODTrack in event**

SODTracker package

- Code ported from *hep.lcd* to *org.lcsim*
- Results stored in **SODTrack** object
  - SODTrack: implementation of *org.lcsim.event.Track*
- SODTracker package in CVS (*org.lcsim.contrib.SODTracker*)
- Tested on single track and physics samples
  - runs without crashing
  - allows visualization of SODTracks on event display and event browser (see next page)
- Package contains test driver in *test/TestSOD.java*

Event display for $e^+e^- \rightarrow Zh$ MC





- **MCparticles in blue**
- **SODTracks in white**
- Show barrel only
- Most barrel tracks are reconstructed (including curlers)

Performance studies

A. Track finding **efficiency**

B. Helix fit **resolution** and **bias**

- Assumed resolution:
  - $5\mu m$ ($r\phi$ and z) in the Vertex Detector
  - $7\mu m$ in the Tracker

- Input data (*sidaug05*):
  - single-track Monte-Carlo:
    2GeV, 10GeV, 20GeV (θ=90°) pions
    100GeV muons (θ=90°, 120°, 130°, 140°)
  - *ZZ* and *Zh* physics Monte-Carlo

Track finding efficiency

- Run on (barrel-only) single-track MC
- Reject tracks strongly interacting with detector material
- Count tracks with 9 or 10 hits

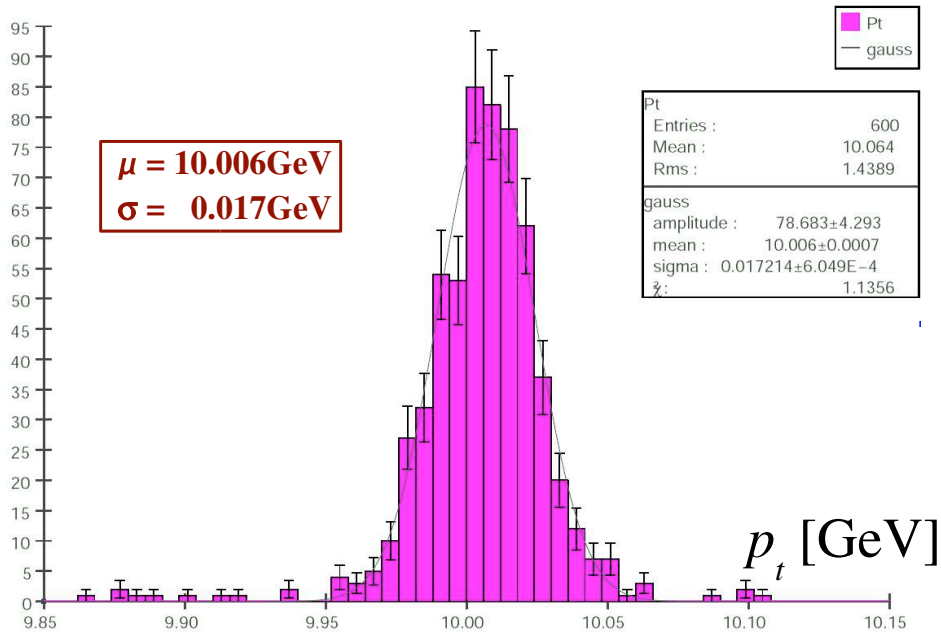
p_t	Efficiency
2GeV	99.3%
5GeV	99.9%
10GeV	99.9%
20GeV	100%
100GeV	100%

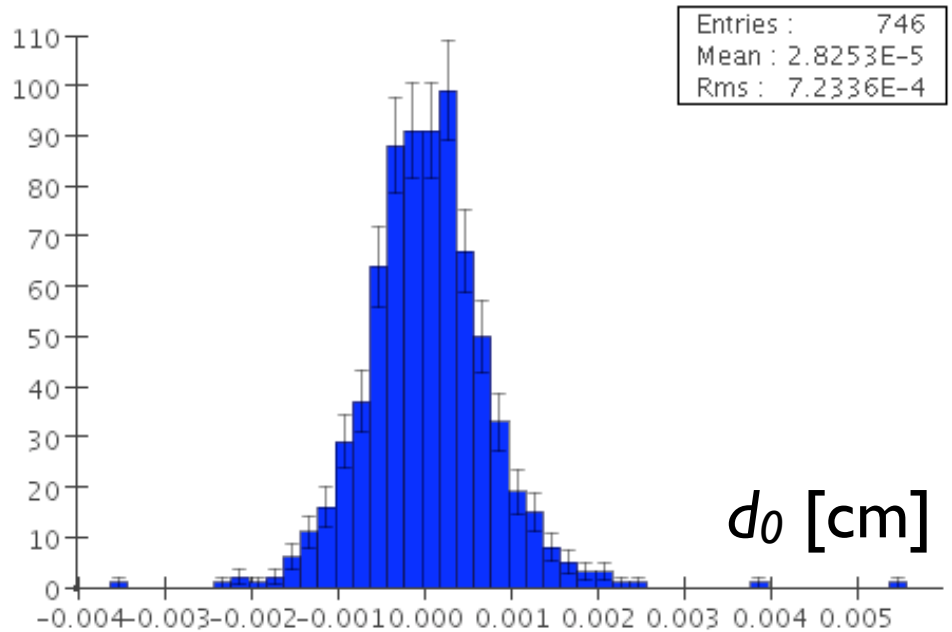
- Previous studies showed:
  - 99.5% efficiency for $Z^0 \rightarrow \mu^+\mu^-$ tracks embedded randomly in 2-jet events [reported at Snowmass 2005]
  - 97% for tracks embedded very close to the core of the jet, >99% everywhere else. Reduction in efficiency thought to be an artifact of the embedding technique [reported at Paris LCWS'04 and in SLAC-PUB-10991]

Helix fit: p_t resolution

- Run on single-track MC
- Fit gaussian to p_t distribution:
  - **$\Delta p_t/p_t$=0.17%** for 2-20GeV
    $\Delta p_t/p_t$=0.29% at 100GeV
  - small bias relative to generated momentum
    - **$p_t^{meas}-p_t^{gen} < 0.1\%$** (~0.07% at 20GeV)
    - further improvement expected with Kalman filter

Helix fit: p_t and d_0

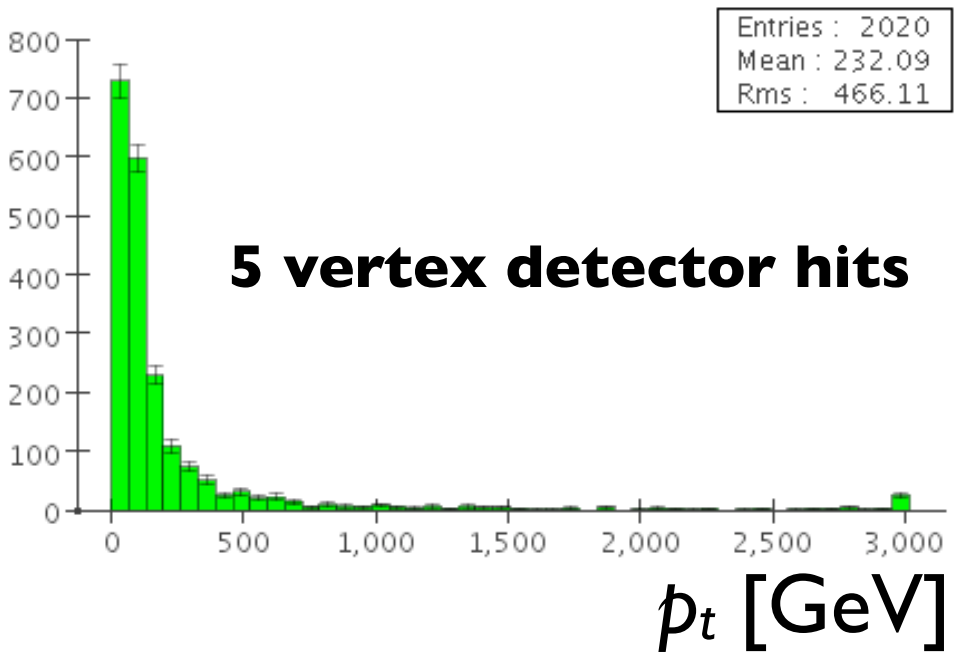




	p_t =10GeV	DOCA (distance of closest approach)
Resolution	$\Delta p_t/p_t$=0.17%	RMS = 7μm
Average bias	<0.1%	<0.3μm

p_t resolution with 5 & 10 hits

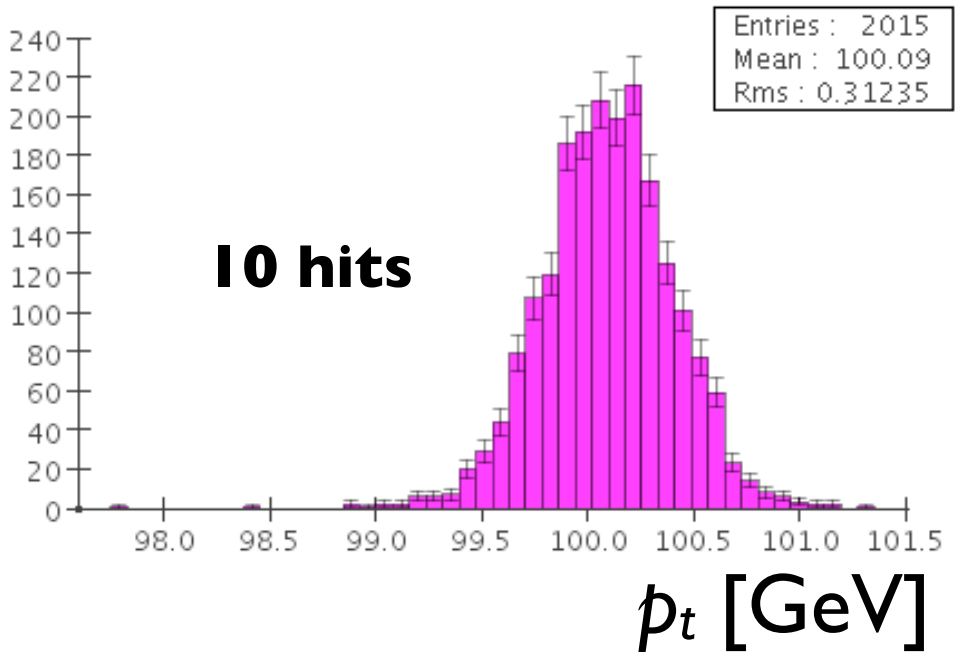
- Compare p_t resolution from
  - Vertex Detector only (5 hits, 4.6cm transverse path length)
  - Vertex Detector + Tracker (10 hits, 128.1cm transverse path length)
- Run on 100GeV single muon MC



5 vertex detector hits

p_t [GeV]

Peaks at zero due to ~1/3 of tracks have wrong curvature sign



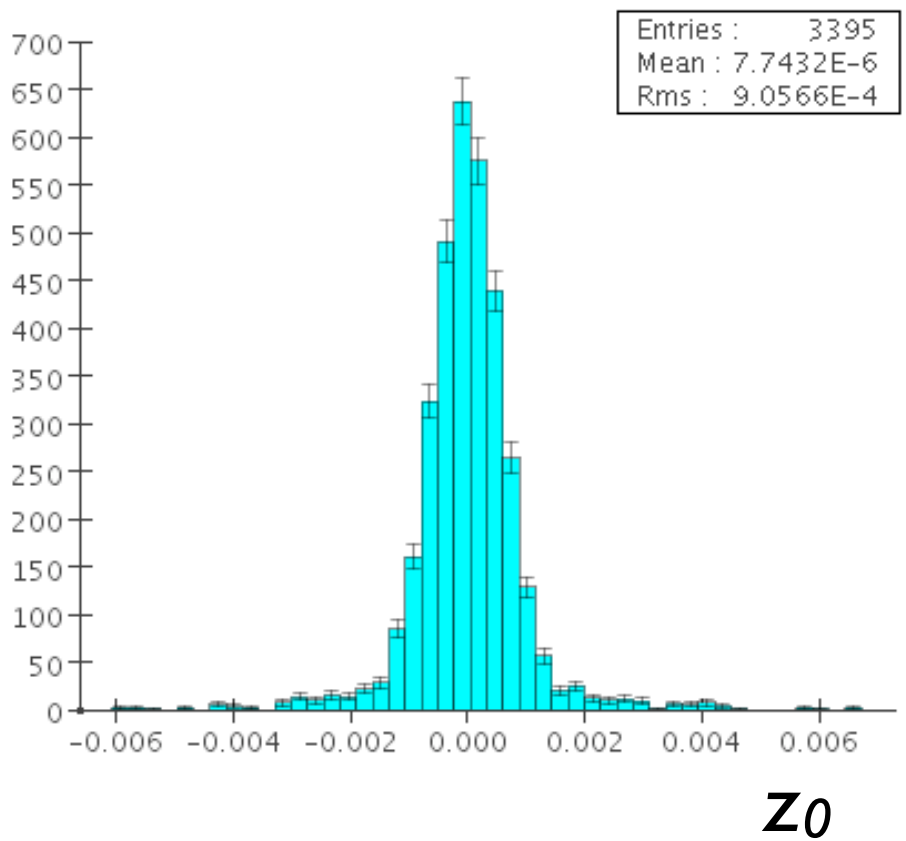
10 hits

p_t [GeV]

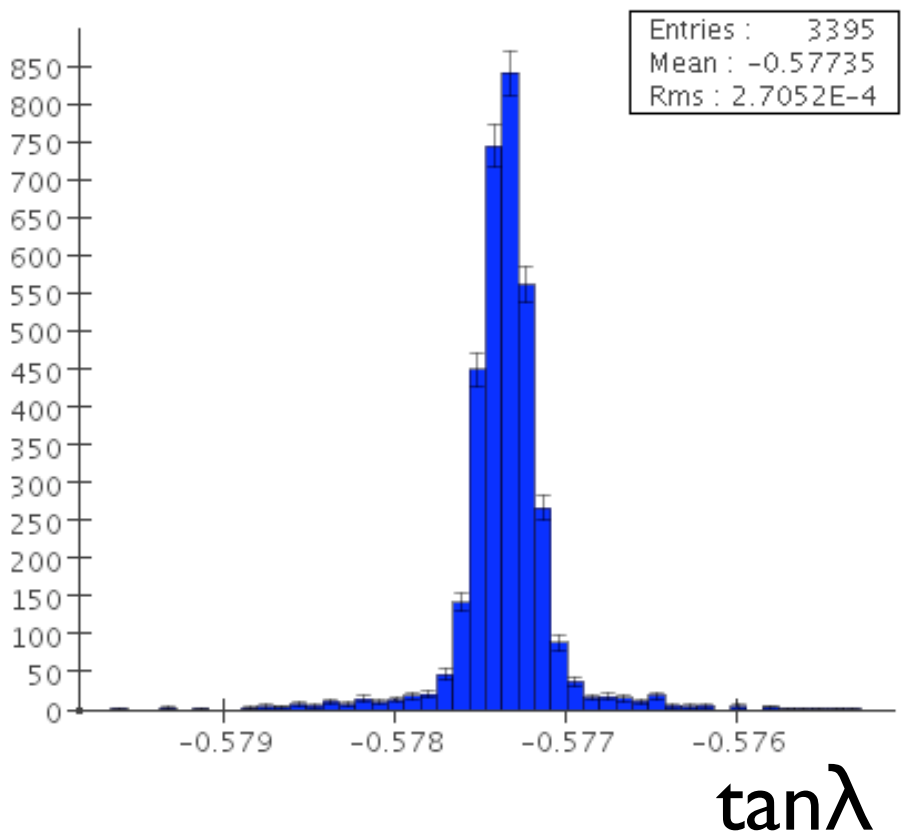
Very good resolution with 10hits/128.1cm => shows necessity for Tracker!

Helix fit: tan(λ) and z_0

- Measure z_0 and tanλ from helix fit
- 100GeV single muon MC, generated at 120° (tanλ=-0.57735), and z_0=0
- Fitted value are unbiased



z_0



tanλ

Kalman Filter Fit: KFFitter

- Apply **Kalman filter technique** to SODTracks
- KFFitter (loosly) inspired by BABAR Kalman Fitter
  [D.Brown CHEP'97 http://www.ifh.de/CHEP97/abstract/a341.htm]
- Fitting method:

  1. define track as collection of *Sites*:

  a. hits

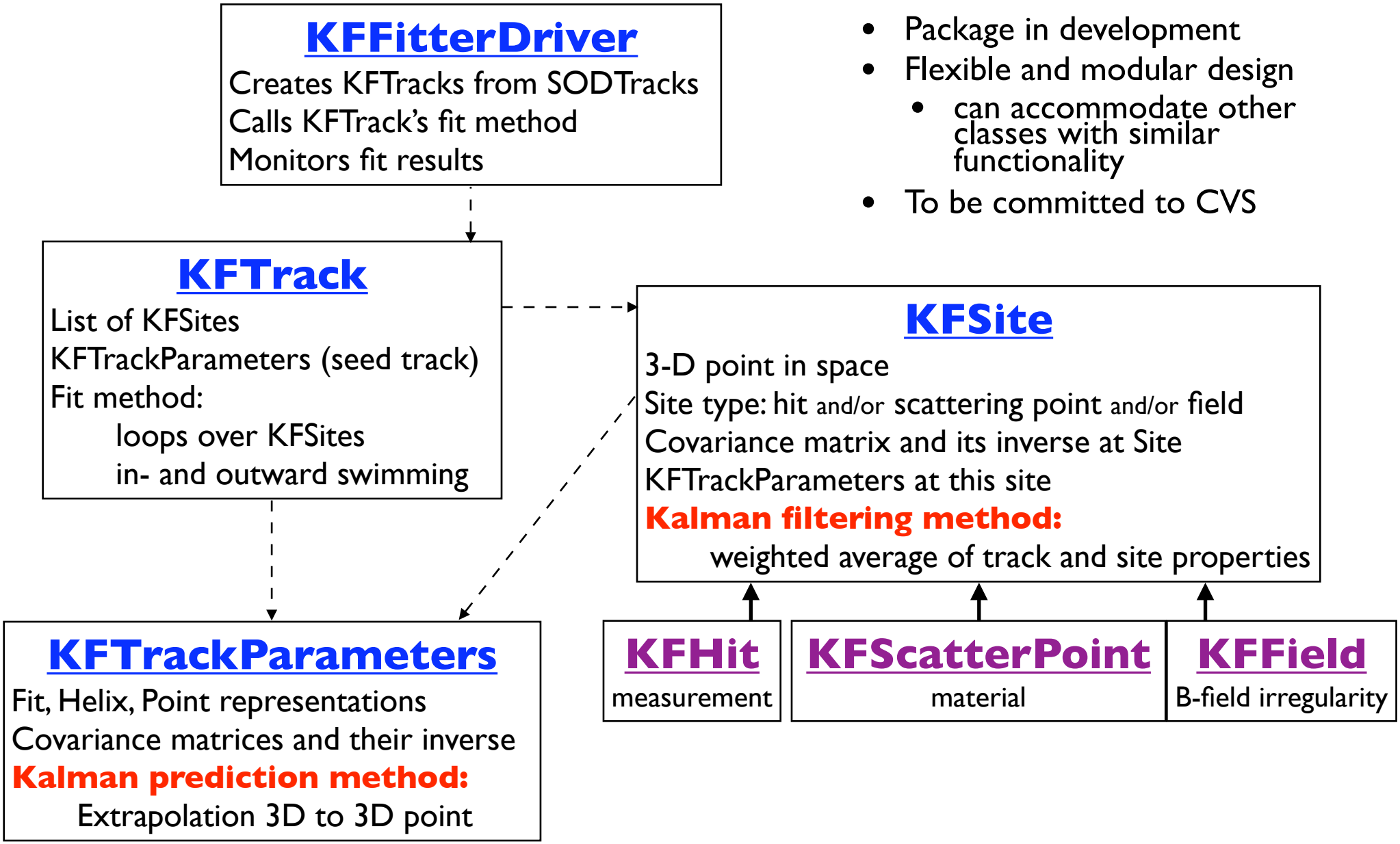
  b. scattering points

  c. B-field irregularities

  2. swim through *Sites* and apply Kalman filter

- Modular, flexible implementation

KFFitter: package structure



- Package in development
- Flexible and modular design
  - can accommodate other classes with similar functionality
- To be committed to CVS

Conclusion

- **SODTracker:**
  - efficient hit adder for the outer detector
  - recently added Helix fit (to be committed as V01-01-00)
  - available in *org.lcsim.contrib.SODTracker*
- **KFFitter**:
  - Kalman filter fitting package
  - modular design
  - in development

- Packages to be combined for **Kalman-based hit adding**