



Towards modern electron reconstruction for future Higgs factories

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CERN & University of Bonn

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What will I talk about



Electron reconstruction

- ▶ Here mainly tracking
- ▶ In the future also bremsstrahlung photon recovery
- ▶ Idea: “just use a gaussian sum filter, e.g. from ACTS”
- ▶ Reality: this talk

Focus is on the CLD detector but algorithms will be mostly detector agnostic

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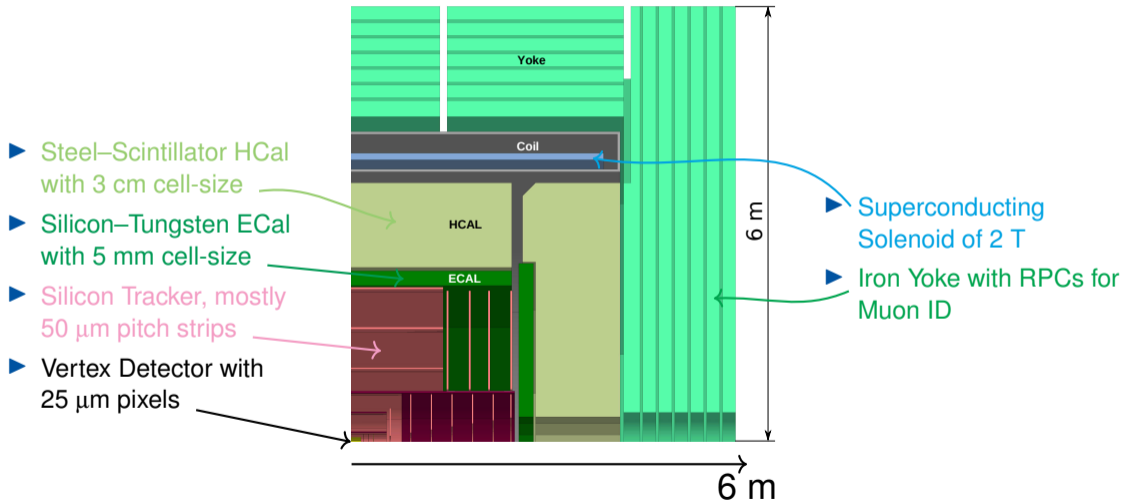
Agenda:

- ▶ Do we need special treatment for electrons?
- ▶ Tracking in Key4hep
- ▶ State of k4ActsTracking
- ▶ Future plans

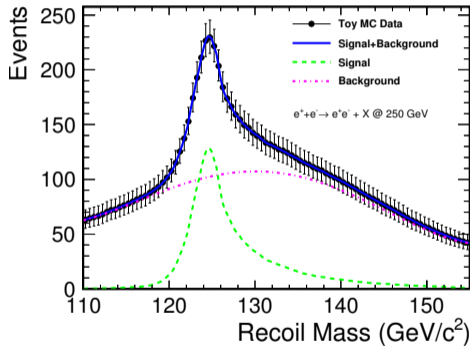
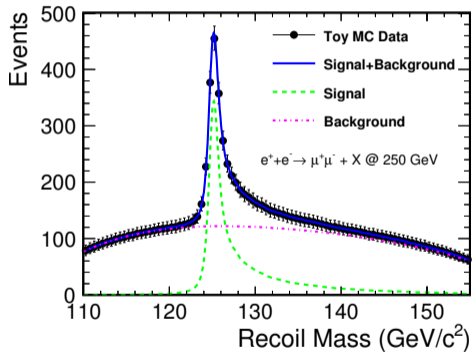
CLD



General purpose detector for Particle Flow reconstruction [1]



Muons vs. electrons

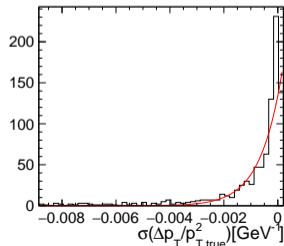
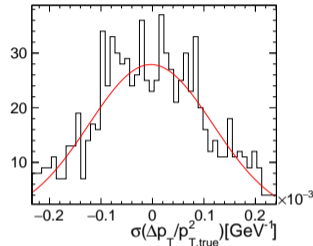


Taken from 1604.07524 [2]

Electron reconstruction



- ▶ Tracking usually done assuming pion mass as they are the most common
- ▶ Electrons are much lighter and have a much higher probability for material interactions
- ▶ They experience greater and less regular energy losses than expected by the track fit
- ▶ Improving their resolution can improve many physics studies

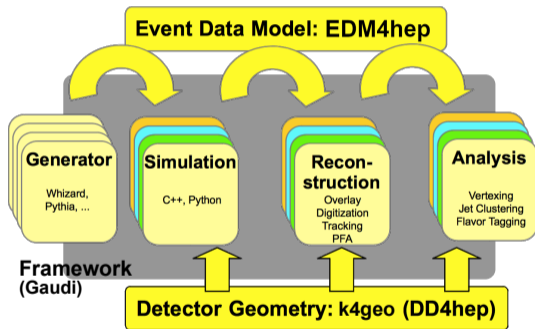


Reconstruction in Key4hep



- ▶ Reconstruction is performed by a chain of Gaudi algorithms
- ▶ Algorithms can be easily put together if they take in and put out data in a common format: EDM4hep
- ▶ Geometry dependent algorithms can be re-used for different detector models if there is a standardized description of the geometry: DD4hep
- ▶ Usually: one algorithm per task, e.g. digitization, track finding/fitting, vertexing

For more details (re-)check [Juan's talk](#)



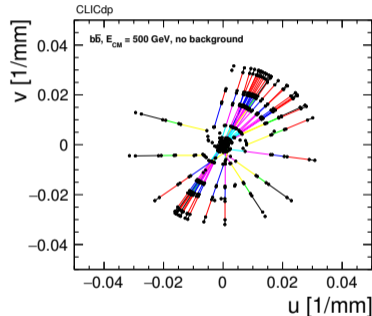
Tracking in Key4hep



Used by CLD/CLICdet:

- ▶ MarlinTrkProcessors
 - ▶ A collection of processor for digitization, track finding and fitting.
 - ▶ DDPlanarDigiProcessor, RefitFinal, ClonesAndSplitTracksFinder
- ▶ MarlinTrk
 - ▶ Provides track factory and interface to different fitters (DDKalTest, aidaTT)
- ▶ ConformalTracking
 - ▶ Finds and fits tracks using a conformal mapping[3]

More details: [FCC SW meeting](#) and [1st ECFA Reco WS](#)

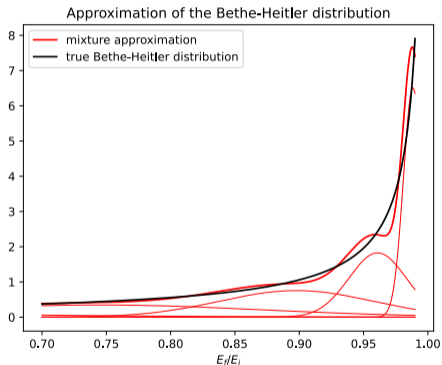


Tracks in conformal space

Gaussian sum filters (GSF)



- ▶ Approximate more complicated energy loss by a mixture of gaussians
- ▶ Successively remove or down-weight components incompatible with measurements
- ▶ Available in recent ACTS releases and actively improved on a regular basis

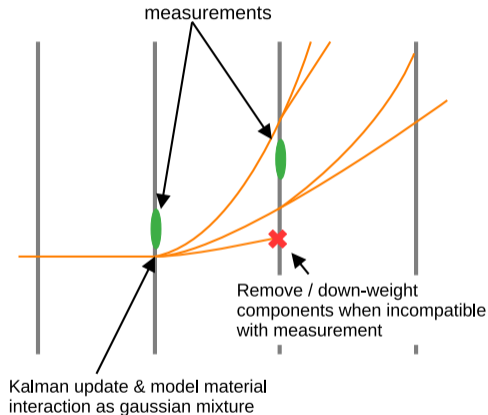


[\[ACTS documentation\]](#)

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[\[ACTS documentation\]](#)

Improving the performance



Idea:

- ▶ A gaussian sum filter could improve the electron track reconstruction, especially for a detector with silicon tracking like CLD
- ▶ Do not re-implement this ourselves but use a modern tracking framework that already supports GSFs: ACTS
- ▶ Bonus: maybe gain a speedup from the more sophisticated ACTS geometry navigation also for the regular Kalman filter track fit

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Necessary ingredients:

- ▶ Detector geometry ✓
(ACTS DD4hepPlugin)
- ▶ Tracker hits, tracks ✓
(ACTS EDM4hepPlugin)
- ▶ Also reliable back-and-forth conversion of LCIO-EDM4hep ✓

Sounds very straightforward, maybe someone has already done it?

ACTS usage in (or related to) Key4hep



As far as I know:

- ▶ EIC: in [Juggler/JugTrack](#). Usage of ACTS in Gaudi, but algorithms do not interface via EDM4hep. Loads geometry using ACTS' DD4hep plugin.
- ▶ Muon collider:
[MuonColliderSoft/ACTSTracking](#)
Marlin/LCIO based.
- ▶ LUXE: Fork of
MuonColliderSoft/ACTSTracking
- ▶ Key4hep "proper": k4ActsTracking

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[key4hep/k4ActsTracking](#)

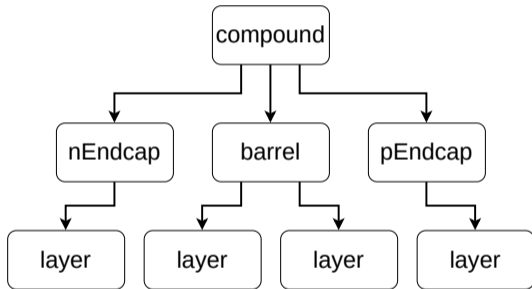
- ▶ Goal: provide general purpose Gaudi algorithms for ACTS usage with plain EDM4hep interface for easy plug-and-play
- ▶ So far only geometry loading à la Juggler, sadly not yet working for arbitrary DD4hep detectors
- ▶ Soon: track (re-)fits with free choice of fitter e.g. GSF

From DD4hep to ACTS surfaces



ACTS DD4hep plugin

- ▶ Parses the DD4hep geometry to build the ACTS tracking surfaces
- ▶ To not complicate the parser it expects a certain hierarchy of the geometry (see right)
- ▶ Most detector model implementations in `k4Geo` do not fulfil the criteria
- ▶ It is a problem to only have one endcap that is mirrored like in the DD4hep examples

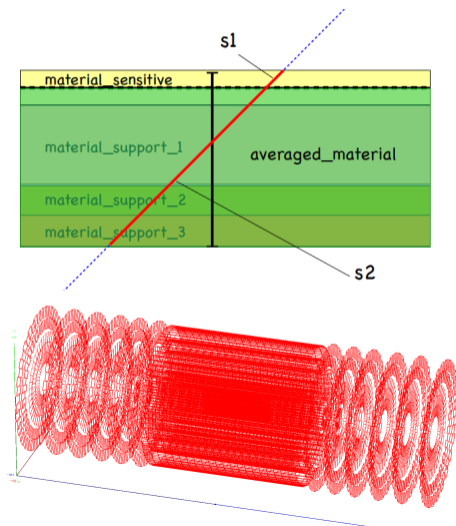


DD4hep geometry definition layout expected by ACTS

Tracking surfaces



- ▶ Both ACTS and the tracking algorithms already available in Key4hep use a simplified geometry
- ▶ Sensors approximated by surfaces with averaged material
- ▶ All our k4Geo/DD4hep geometries already have this DDRec surface information
- ▶ Ongoing cooperation with the ACTS authors to initialize ACTS geometry from our DDRec surfaces



Future plans



- ▶ Get DDRec surface support into ACTS
- ▶ Implement ACTS track fit (functional) Gaudi algorithm for Key4hep in `k4ActsTracking`
- ▶ Validate `k4ActsTracking` by comparing it to the Marlin-based track reconstruction
- ▶ Create a dedicated electron reconstruction in Key4hep and test it on $ee + X$ -recoil and WW/evW benchmark analyses

Summary



- ▶ Electron reconstruction requires special attention and solutions
- ▶ ACTS integration into Key4hep is on a good way
- ▶ A dedicated electron reconstruction algorithm for Key4hep will follow
- ▶ Let me know if you are also interested in this!

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