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First look into track reconstruction at the full-silicon ILD

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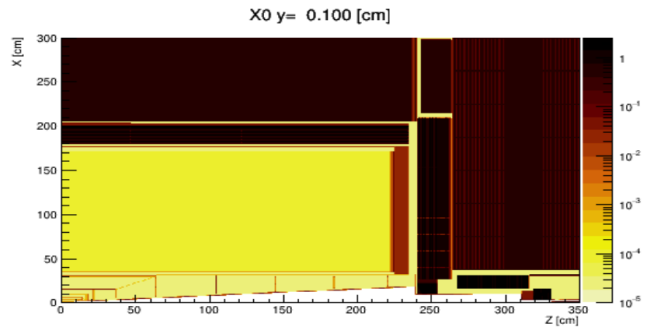
Full-silicon ILD

Proposed and implemented in DD4hep by Daniel Jeans (geometry already available in lcgeo)

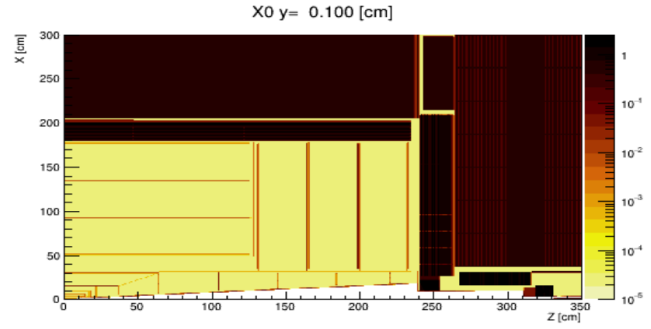
The idea:

- Replace TPC and SET with CLIC outer tracker
- 1 additional barrel layer w.r.t. CLIC
- Endcap layers slightly more separated w.r.t. CLIC

ILD_l5_v02



ILD_l5_v09



Goals:

- Compare the performance with the ”standard” ILD

  → interesting also for the ongoing LLP search analysis

Tracking - digitisation

```
<processor name="OuterPlanarDigiProcessor" type="DDPlanarDigiProcessor">
  <!--PlanarDigiProcessor creates TrackerHits from SimTrackerHits, smearing them according to the input parameters.-->
  <parameter name="SubDetectorName" type="string"> OuterTrackers </parameter>
  <!--whether hits are 1D strip hits-->
  <parameter name="IsStrip" type="bool"> false </parameter>
  <!--resolution in direction of u-->
  <parameter name="ResolutionU" type="float"> 0.007</parameter>
  <!--resolution in direction of v-->
  <parameter name="ResolutionV" type="float"> 0.09 </parameter>
  <!--Name of the Input SimTrackerHit collection-->
  <parameter name="SimTrackHitCollectionName" type="string" lcioInType="SimTrackerHit">OuterTrackerBarrelCollection </parameter>
  <!--Name of TrackerHit SimTrackHit relation collection-->
  <parameter name="SimTrkHitRelCollection" type="string" lcioOutType="LCRelation">OuterTrackerBarrelHitsRelations </parameter>
  <!--Name of the TrackerHit output collection-->
  <parameter name="TrackerHitCollectionName" type="string" lcioOutType="TrackerHitPlane">OTrackerHits </parameter>
  <!--verbosity level of this processor ("DEBUG0-4,MESSAGE0-4,WARNING0-4,ERROR0-4,SILENT")-->
  <parameter name="Verbosity" type="string">DEBUG </parameter>
</processor>

<processor name="OuterEndcapPlanarDigiProcessor" type="DDPlanarDigiProcessor">
  <!--PlanarDigiProcessor creates TrackerHits from SimTrackerHits, smearing them according to the input parameters.-->
  <parameter name="SubDetectorName" type="string"> OuterTrackers </parameter>
  <!--whether hits are 1D strip hits-->
  <parameter name="IsStrip" type="bool"> false </parameter>
  <!--resolution in direction of u-->
  <parameter name="ResolutionU" type="float"> 0.007 </parameter>
  <!--resolution in direction of v-->
  <parameter name="ResolutionV" type="float"> 0.09 </parameter>
  <!--Name of the Input SimTrackerHit collection-->
  <parameter name="SimTrackHitCollectionName" type="string" lcioInType="SimTrackerHit">OuterTrackerEndcapCollection </parameter>
  <!--Name of TrackerHit SimTrackHit relation collection-->
  <parameter name="SimTrkHitRelCollection" type="string" lcioOutType="LCRelation">OuterTrackerEndcapHitsRelations </parameter>
  <!--Name of the TrackerHit output collection-->
  <parameter name="TrackerHitCollectionName" type="string" lcioOutType="TrackerHitPlane">OTrackerEndcapHits </parameter>
  <!--verbosity level of this processor ("DEBUG0-4,MESSAGE0-4,WARNING0-4,ERROR0-4,SILENT")-->
  <parameter name="Verbosity" type="string">DEBUG </parameter>
</processor>
```

Set up the digitisation first:

- Replace TPC and SET segments with *DDPlanarDigiProcessor* for **CLIC outer barrel** and **endcap**
- Conformal Tracking requires 2D TrackerHitPlane as an input, so:

  → set *IsStrip=false* for FTD Strip hits digitisation

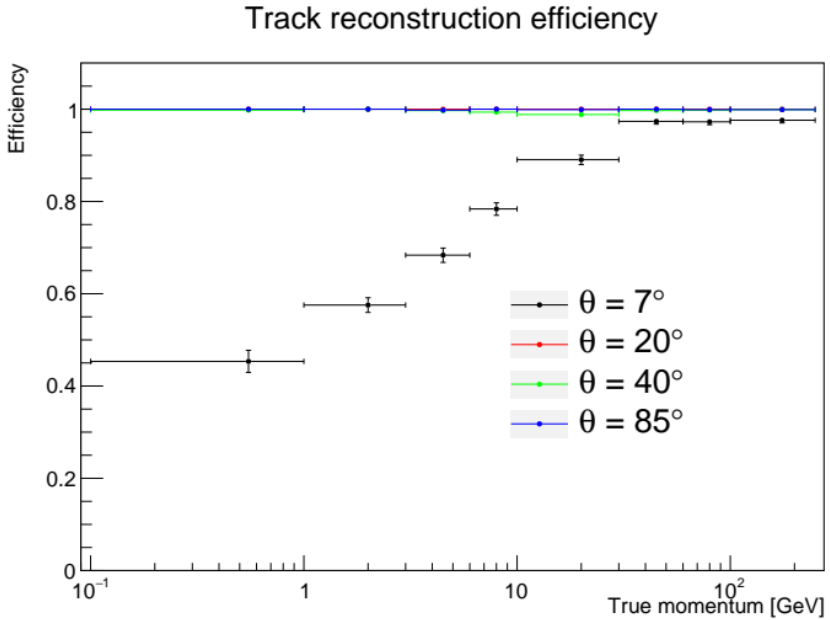
  → remove *FTDDDSpacePointBuilder*
- Make sure the number of layers in resolution setting is correct (or not specified)

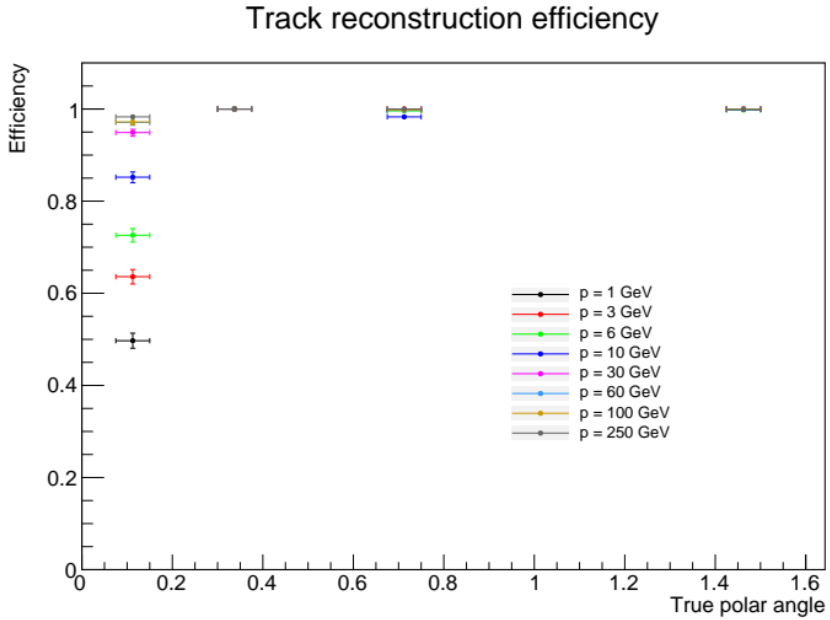
Conformal tracking setup

- For now completely straightforward from CLIC setup:
  VXDEndcapTrackerHits → FTDPixelTrackerHits, ITrackerHits → SITTrackerHits,
  ITrackerEndcapHits → FTDStripTrackerHits
- Parameters probably require tuning (e.g. *SlopeZRange* due to higher disks separation)

```
<!--steps for the pattern recognition-->
<parameter name="Steps" type="StringVec">
  [VXDBarrel]
  @Collections : VXDTrackerHits
  @Parameters : MaxCellAngle : 0.005; MaxCellAngleRZ : 0.005; Chi2Cut : 100; MinClustersOnTrack : 4; MaxDistance : 0.02; SlopeZRange: 10.0; HighPTCut: 10.0;
  @Flags : HighPTFit, VertexToTracker
  @Functions : CombineCollections, BuildNewTracks
  [VXDEncap]
  @Collections : FTDPixelTrackerHits
  @Parameters : MaxCellAngle : 0.005; MaxCellAngleRZ : 0.005; Chi2Cut : 100; MinClustersOnTrack : 4; MaxDistance : 0.02; SlopeZRange: 10.0; HighPTCut: 0.0;
  @Flags : HighPTFit, VertexToTracker
  @Functions : CombineCollections, ExtendTracks
  [LowerCellAngle1]
  @Collections : VXDTrackerHits, FTDPixelTrackerHits
  @Parameters : MaxCellAngle : 0.025; MaxCellAngleRZ : 0.025; Chi2Cut : 100; MinClustersOnTrack : 4; MaxDistance : 0.02; SlopeZRange: 10.0; HighPTCut: 10.0;
  @Flags : HighPTFit, VertexToTracker, RadialSearch
  @Functions : CombineCollections, BuildNewTracks
  [LowerCellAngle2]
  @Collections :
  @Parameters : MaxCellAngle : 0.05; MaxCellAngleRZ : 0.05; Chi2Cut : 2000; MinClustersOnTrack : 4; MaxDistance : 0.02; SlopeZRange: 10.0; HighPTCut: 10.0;
  @Flags : HighPTFit, VertexToTracker, RadialSearch
  @Functions : BuildNewTracks, SortTracks
  [Tracker]
  @Collections : SITTrackerHits, FTDStripTrackerHits, OTrackerHits, OTrackerEndcapHits
  @Parameters : MaxCellAngle : 0.05; MaxCellAngleRZ : 0.1; Chi2Cut : 2000; MinClustersOnTrack : 4; MaxDistance : 0.02; SlopeZRange: 10.0; HighPTCut: 0.0;
  @Flags : HighPTFit, VertexToTracker, RadialSearch
  @Functions : CombineCollections, BuildNewTracks
  [Displaced]
  @Collections : VXDTrackerHits, FTDPixelTrackerHits, SITTrackerHits, FTDStripTrackerHits, OTrackerHits, OTrackerEndcapHits
  @Parameters : MaxCellAngle : 0.05; MaxCellAngleRZ : 0.05; Chi2Cut : 1000; MinClustersOnTrack : 5; MaxDistance : 0.015; SlopeZRange: 10.0; HighPTCut: 10.0;
  @Flags : OnlyZSchi2cut, RadialSearch
  @Functions : CombineCollections, BuildNewTracks
</parameter>
```

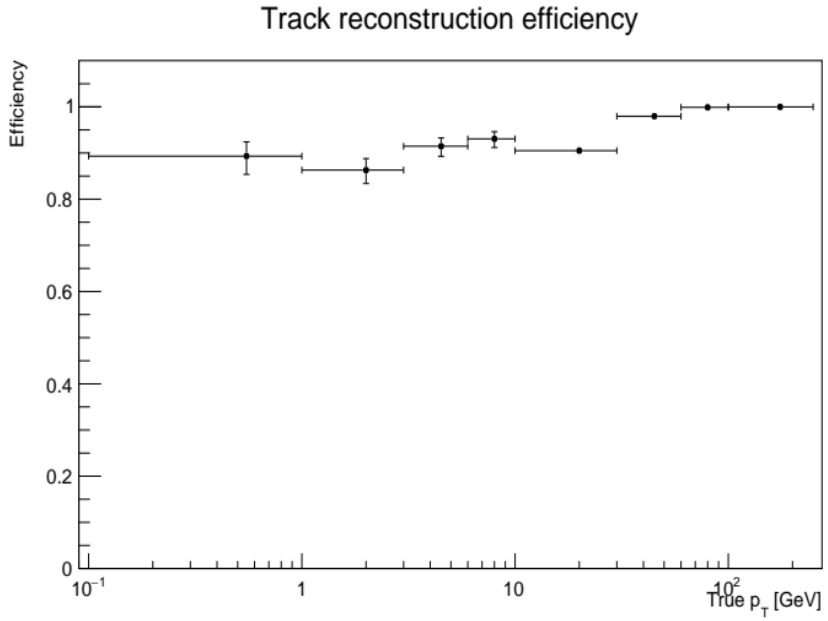
Performance (single muons)

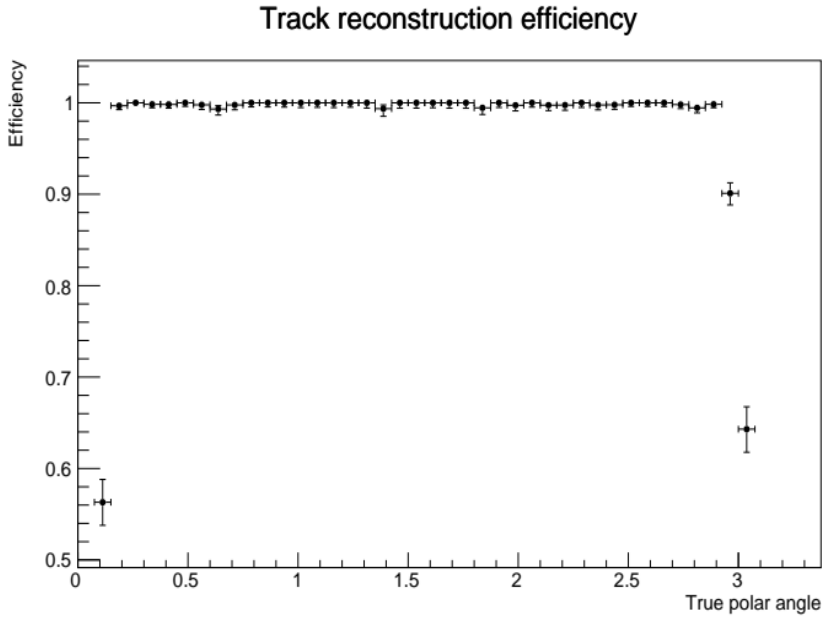




- Single muons with fixed 8 momenta and 4 polar angles
- Simple matching of tracks to MC truth within angular cone
- Good performance apart from lower momenta in forward direction.
- Two tracks instead of one reconstructed in some of the events

Performance (μμ sample)





- $e^+e^- \rightarrow \mu^+\mu^-$ sample generated in Whizard
- Simple matching of tracks with MC truth within angular cone
- Efficiency significantly drops only at the edge of acceptance

Summary

- First look into track reco. in the ILD with full-silicon, CLIC-like tracker
- Slight changes in the digitisation required
- Implementation inspired by the CLIC setup rather straightforward
- Steering files available on Github, pull request created (work in progress)
- Next steps:

  → simulation and tests on the ttbar events

  → tests on events with displaced vertices