Simulation update

LCUK Silicon meeting
14 April 2015

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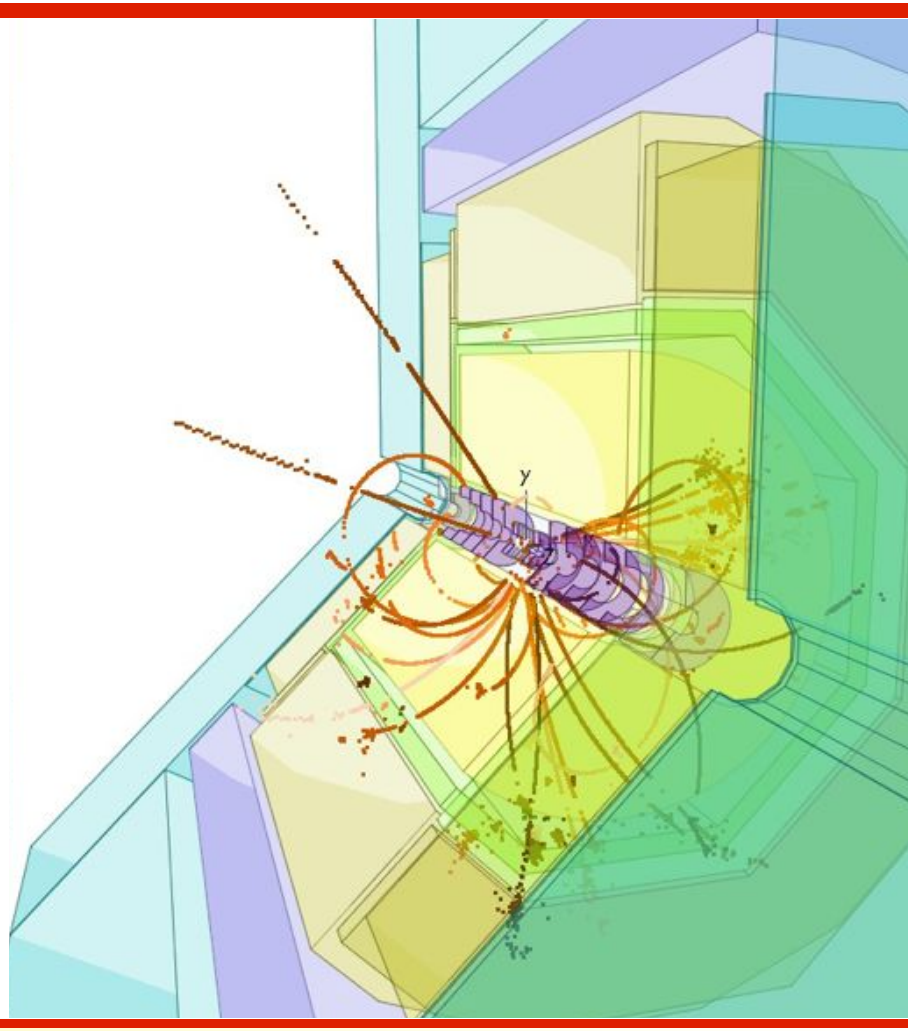
University of Glasgow | Experimental Particle Physics



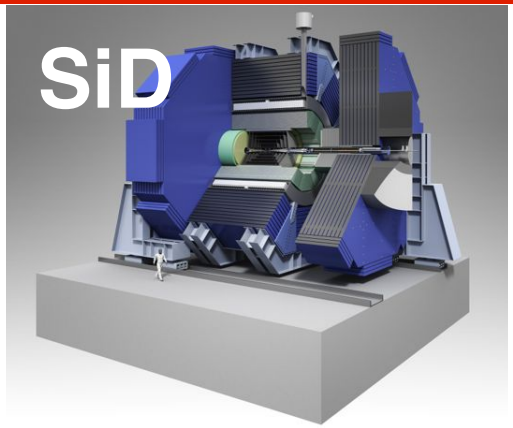
Outline

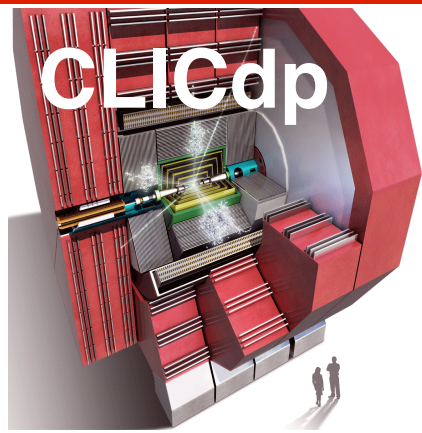
- Experiment s/w strategies (current & future)
- SiD software installation and running
- First successful modifications of silicon geometry
- Plans and questions to all

(Everything comes with caveat that it's only my current understanding!)

Software strategies

CURRENT



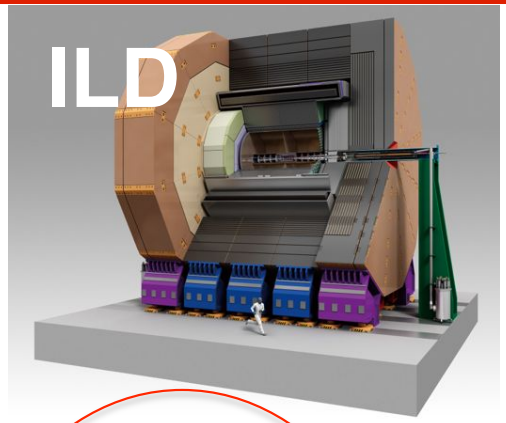


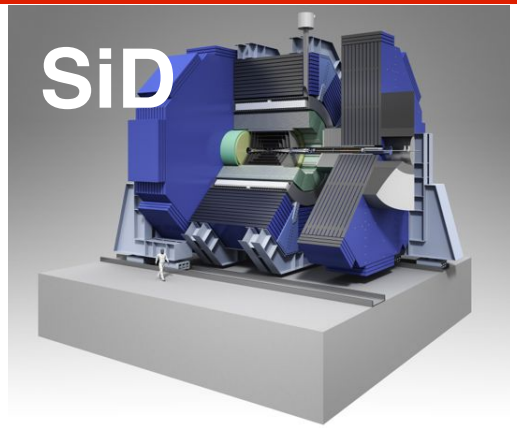
Detector geometry	accessed from db (can modify at run-time, GEAR file generated to handle geometry)	lcdd generated from xml	both (ILD & SiD)
Detector simulation	mokka (GEANT4)	slic (GEANT4)	both (ILD & SiD)
Reconstruction	Marlin (Modular analysis & reco for linear colliders)	lcsim and slicPandora	both (ILD & SiD)
Event data model	LCIO	LCIO	LCIO

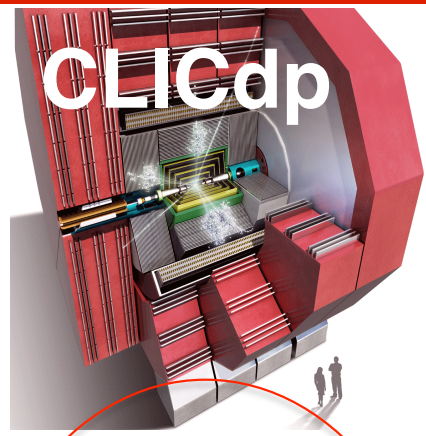
Software strategies

FUTURE

'DD4HEP'







	ILD	SiD	CLICdp
Detector geometry	lcgeo takes xml, generates standard detector description	lcdd generated from xml	lcgeo
Detector simulation	DDG4 (/ddsim)	slic (GEANT4)	DDG4 (/ddsim)
Reconstruction	DDRec	lcsim and slicPandora	DDRec
Event data model	LCIO	LCIO	LCIO

software future

CLICdp new detector model is being written in DD4HEP

ILD has decided to use DD4HEP for its next round of optimization studies
- has a little manpower

SiD says it's happy with current slic/lcsim (but may have to switch if SLAC support stops)
- has very limited manpower

ILD/Frank Gaede estimated total: 17 person-months aim to be done by end of summer

Towards a timeline for software I

Frank Gaede, ILD Optimization Meeting, April 8, 2015

- ingredients and missing items needed for defining a timeline for ILD software development:
  - need first functional version of ILD_o1_v05 in DD4hep/DDSim ~done
  - need functional interface to existing reconstruction (GEAR/DDRec) ~done
  - need testing and validation
  - define the ILD optimization models - how many (2-3) ?
    - reference detector + smaller detectors …
  - implement these models
  - need testing and validation
  - define the physics benchmarks/data samples that need to be processed
    - 250 GeV, 350 GeV, 500 GeV full SM ?
  - finalize the Grid production infrastructure w/ ILCDirac ~done
  - adapt reconstruction to new models
  - need testing and validation
  - estimate the CPU (and storage) needs
  - the actual Monte Carlo mass production

https://agenda.linearcollider.org/event/6730/

software direction?

In Glasgow we are devoting some effort to DD4HEP /
– responsible for ECAL implementation for ILD and CLICdp

– keen for everything to move in the same direction...

… but SiD is more natural starting model for silicon developments…

SiD simulation installation

Step-by-step guide from Marcel Stanitsky via Joel:
https://wikis.bris.ac.uk/display/sid/From+Zero+to+SiD

Also have older Glasgow ilcsoft installation guide
https://twiki.ppe.gla.ac.uk/bin/view/LinearCollider/ILCSoft

Marcel/Joel instructions needed some extra massaging
[I wanted single release to work for SiD and CLICdp development]
– I was asked to revamp 'official' SiD confluence page and add instructions, and will do so shortly
https://confluence.slac.stanford.edu/display/SiD/

SiD simulation running

Runs in several separate steps

starting from stdhep events:

1. slic [geant4 simulation]
2. lcsim [tracker hit digitization and track reco]
3. slicPandora [calor clustering and particle flow]
4. lcfi, through Marlin [vertexing/flavour tagging]
5. lcsim again [truth linking, final DST generation]

A bit painful to run all these steps separately but it works
I will also move this documentation to main confluence site:
https://confluence.slac.stanford.edu/display/~stanitz/From+Zero+to+SiD+-+Running+Sim+Reco

Afterwards: analysis via own module in Marlin
[similar for all, CLICdp, ILD, SiD]
or jas for event display
or …

altering SiD detector model

I started from the SID LOI model sidloi3 and tested modifying the geometry

made ‘new’ detector:
lcsim/LCDetectors/detectors/sidloi3ar

declared it in ~/.lcsim/alias.properties
so that the reco could find it

modified the compact.xml detector description

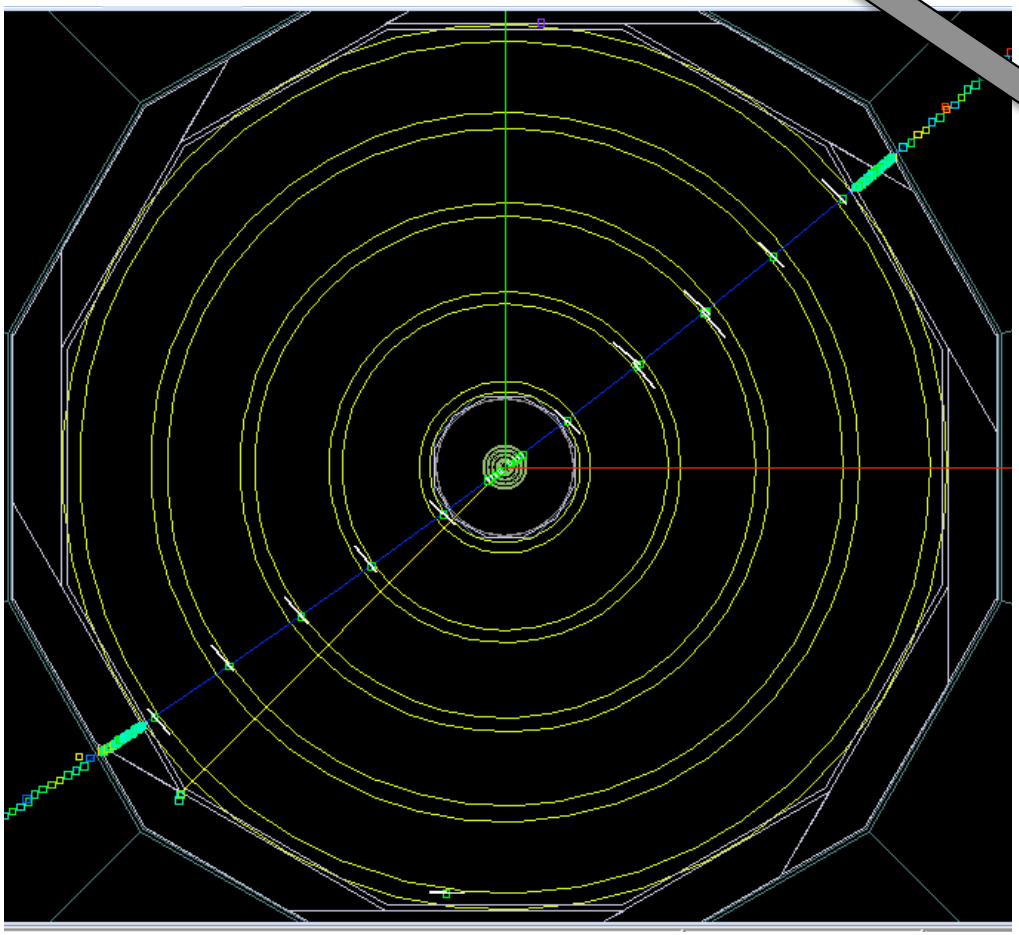
converted it to lcdd using GeomConverter

reran slic (simulation) and lcsim (reco)

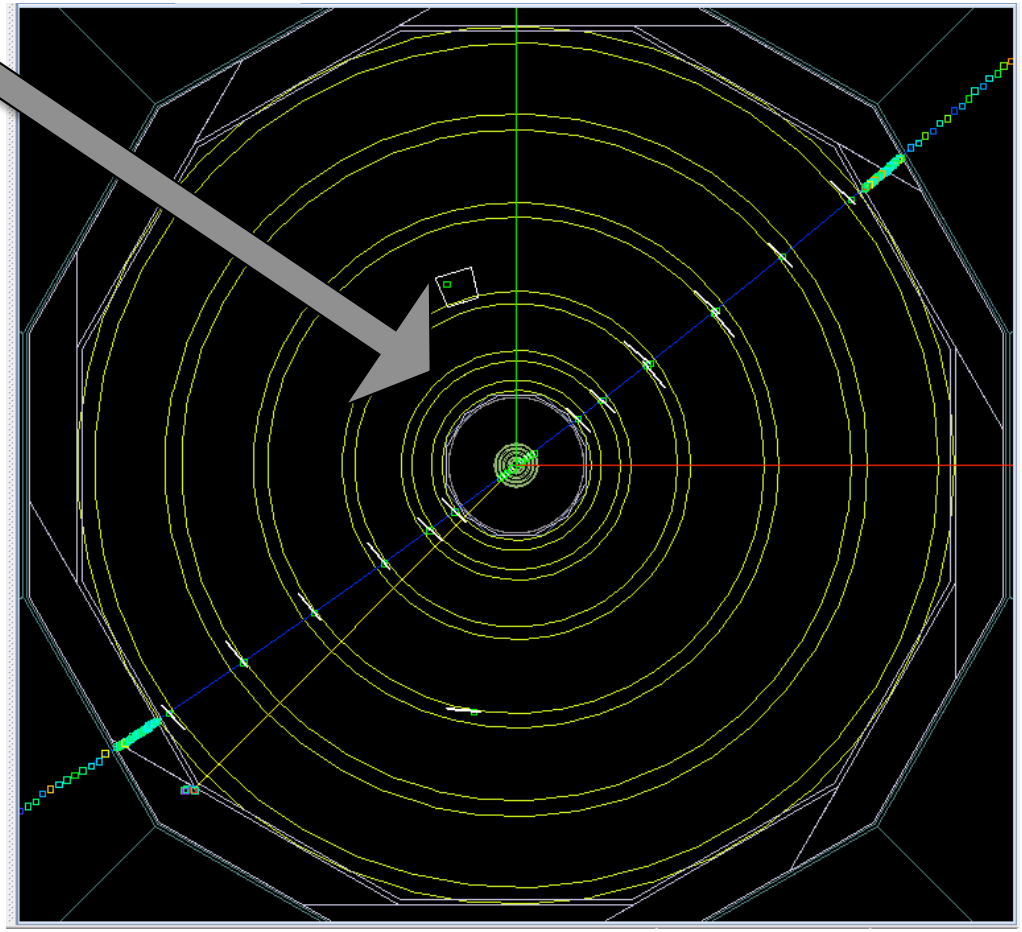
Proof-of-principle was to insert an extra silicon tracker barrel layer

modified detector

Inserted 6th barrel tracker layer (between layers 1 and 2) as proof of principle



original sidloi3



modified

level of simulation detail

```
<module_component width="97.79" length="97.79" thickness="0.016*cm" material="CarbonFiber_50D" sensitive="false">
    <position z="-0.122*cm" />
</module_component>
<module_component width="97.79" length="97.79" thickness="0.18*cm" material="Rohacell31_50D" sensitive="false">
    <position z="-0.024*cm" />
</module_component>
<module_component width="97.79" length="97.79" thickness="0.0175*cm" material="Epoxy" sensitive="false">
    <position z="0.07475*cm" />
</module_component>
<module_component width="97.79" length="97.79" thickness="0.016*cm" material="CarbonFiber_50D" sensitive="false">
    <position z="0.0915*cm" />
</module_component>
<module_component width="92.031" length="92.031" thickness="0.03*cm" material="Silicon" sensitive="true">
    <position z="0.1145*cm"/>
</module_component>
<module_component width="97.79" length="97.79" thickness="0.00048*cm" material="Silicon" sensitive="false">
    <position z="0.12974*cm"/>
</module_component>
<module_component width="97.79" length="97.79" thickness="0.0038*cm" material="Kapton" sensitive="false">
    <position z="0.1375*cm"/>
</module_component>
<module_component width="97.79" length="97.79" thickness="0.00038*cm" material="Copper" sensitive="false">
```

```
<layer module="SiTrackerModule_Layer2" id="2">
    <barrel_envelope inner_r="300." outer_r="330.0" z_length="578 * 2"/>
    <rphi_layout phi_tilt="0.17506" nphi="26" phi0="0.15" rc="301.5 + 5.0" dr="0.0"/>
    <z_layout dr="4.0" z0="512.128" nz="13"/>
```

Dan has already been using overlap-finding tools etc, needed when developing more complex models

digitization

The layer geometry of the tracking layers has to be fixed before the slic simulation phase (of course)

However, the readout segmentation is controlled separately during digitization in the lcsim reco phase, so testing e.g. pixel size should be do-able without redoing all the simulation every time

```
        <!-- Define tracker barrel sensor segmentation -->
        <driver name="TrackerBarrelSetup"
                type="org.lcsim.recon.tracking.digitization.sisim.config.SiTrackerBarrelSensorSetup">
            <subdetectorName>SiTrackerBarrel</subdetectorName>
            <readoutElectrodesPitch>0.050</readoutElectrodesPitch>
            <senseElectrodesPitch>0.025</senseElectrodesPitch>
            <transferEfficiencies>0.986 0.419</transferEfficiencies>
        </driver>
sid_dbd_prePandora_noOverlay.xml   22% L53    (XML)----------------------------------------------------------
        <!-- Define vertex barrel sensor segmentation -->
        <driver name="VertexBarrelSetup"
                type="org.lcsim.recon.tracking.digitization.sisim.config.SiVertexBarrelSensorSetup">
            <subdetectorName>SiVertexBarrel</subdetectorName>
            <readoutPitchX>0.02</readoutPitchX>
            <readoutPitchY>0.02</readoutPitchY>
            <sensePitchX>0.02</sensePitchX>
            <sensePitchY>0.02</sensePitchY>
            <transferEfficiency>1.0</transferEfficiency>
```

Tracking

The tracking algorithm in place is ‘SeedTracker’ – helix fitter using 3 seed spacepoints, 1 ‘confirm’ point, and more ‘extend’ points

```
<?xml version="1.0" encoding="UTF-8"?>^M
<StrategyList xmlns:xs="http://www.w3.org/2001/XMLSchema-instance" xs:noNamespaceSchemaLocation="htt
strategies.xsd">^M
  <!--Strategy list Autogenerated by Strategy Builder on Wed Aug 29 11:32:27 CEST 2012.-->^M
  <TargetDetector>sidloi3ar</TargetDetector>^M
  <!--1-->^M
  <Strategy name="BARRELONLY_LOWPT">^M
    <!--Num findable tracks (total, not additional): 25758-->^M
    <!--Cutoffs-->^M
    <MinPT>0.2</MinPT>^M
    <MinHits>6</MinHits>^M
    <MinConfirm>1</MinConfirm>^M
    <MaxDCA>5.0</MaxDCA>^M
    <MaxZ0>10.0</MaxZ0>^M
    <MaxChisq>10.0</MaxChisq>^M
    <BadHitChisq>5.0</BadHitChisq>^M
    <!--Layers-->^M
    <Layers>^M
      <Layer type="Seed" layer_number="3" detector_name="SiVertexBarrel" be_flag="BARREL" />^M
      <Layer type="Seed" layer_number="4" detector_name="SiVertexBarrel" be_flag="BARREL" />^M
      <Layer type="Seed" layer_number="5" detector_name="SiVertexBarrel" be_flag="BARREL" />^M
      <Layer type="Confirm" layer_number="1" detector_name="SiTrackerBarrel" be_flag="BARREL" />^M
      <Layer type="Extend" layer_number="2" detector_name="SiVertexBarrel" be_flag="BARREL" />^M
      <Layer type="Extend" layer_number="1" detector_name="SiVertexBarrel" be_flag="BARREL" />^M
      <Layer type="Extend" layer_number="2" detector_name="SiTrackerBarrel" be_flag="BARREL" />^M
      <Layer type="Extend" layer_number="3" detector_name="SiTrackerBarrel" be_flag="BARREL" />^M
      <Layer type="Extend" layer_number="4" detector_name="SiTrackerBarrel" be_flag="BARREL" />^M
      <Layer type="Extend" layer_number="5" detector_name="SiTrackerBarrel" be_flag="BARREL" />^M
    </Layers>^M
  </Strategy>^M
```

Decide which layers are seed layers
all combinations of hits in seed layers are initial track candidates

long sequence of layer role permutations

Tracking (2)

```
Strategy name="AUTOGEN9_193865204ENDCAP_NORTH">^M
 <!--AUTOGEN STATISTICS:
                    Score: 19453.144715324044
                    Unweighted Score (num new tracks): 6394
                    Adjacency: 0.9682010902483343

                    NOTE: These layers are combined for both endcaps of this symmetrized strategy
             -->^M
 <!--Cutoffs-->^M
 <MinPT>0.2</MinPT>^M
 <MinHits>7</MinHits>^M
 <MinConfirm>1</MinConfirm>^M
 <MaxDCA>5.0</MaxDCA>^M
 <MaxZ0>10.0</MaxZ0>^M
 <MaxChisq>10.0</MaxChisq>^M
 <BadHitChisq>5.0</BadHitChisq>^M
 <!--Layers-->^M
 <Layers>^M
   <Layer type="Seed" layer_number="1" detector_name="SiTrackerBarrel" be_flag="BARREL" />^M
   <Layer type="Seed" layer_number="1" detector_name="SiTrackerEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Seed" layer_number="2" detector_name="SiTrackerEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Confirm" layer_number="3" detector_name="SiTrackerEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Extend" layer_number="3" detector_name="SiVertexBarrel" be_flag="BARREL" />^M
   <Layer type="Extend" layer_number="2" detector_name="SiTrackerBarrel" be_flag="BARREL" />^M
   <Layer type="Extend" layer_number="4" detector_name="SiVertexEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Extend" layer_number="3" detector_name="SiVertexEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Extend" layer_number="4" detector_name="SiTrackerEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Extend" layer_number="2" detector_name="SiVertexEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Extend" layer_number="1" detector_name="SiVertexEndcap" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Extend" layer_number="1" detector_name="SiTrackerForward" be_flag="ENDCAP_NORTH" />^M
   <Layer type="Extend" layer_number="1" detector_name="SiVertexBarrel" be_flag="BARREL" />^M
 sidloi3ar_trackingStrategies_default.xml    4% L30    (XML)----------------------------------------
```

– example with barrel & endcap hits

tracking directions?

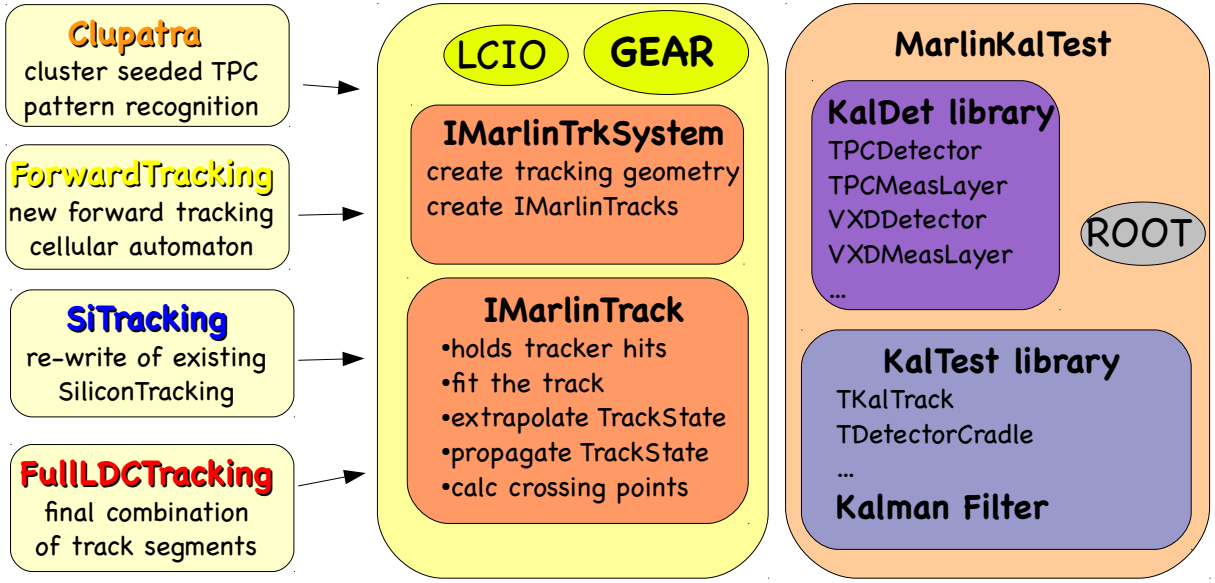
ILD implemented abstract interface *MarlinTrk*
using pattern-recognition code *KalTest/KalDet*
standalone track-finding in the VTX and SIT (*SiliconTracking*)
followed by merging of TPC, VTX/SIT. and FTD tracks (*FullLDCTracking*)

e.g. LCFI sits on top of FullLDCTracking + Pandora

SiliconTracking is brute force seed-triplet search in fixed solid angle sectors; followed by road search; refitted with Kalman filter in *MarlinTrk* afterwards

IMarlinTrk interface for (ILD) tracking

- common API for developing tracking code (in Marlin)
- provides loose coupling between pattrec and fitting
- defined abstract interface IMarlinTrk and implement using KalTest/KalDet
- originally developed for new ILD tracking used in the DBD
- will be adapted to DDRec to be also usable for new CLIC simulation

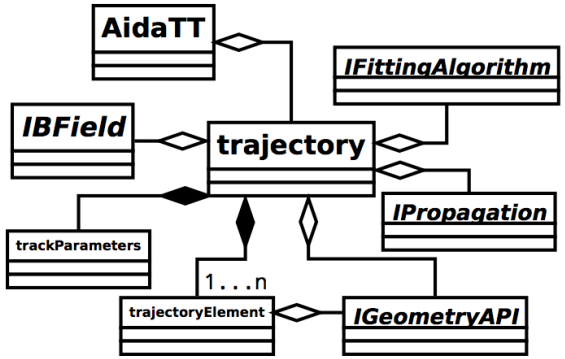


Frank Gaede, CLIC WS 2015, Jan 26-30, 2015

CLIC tracking direction

aidaTT

- Tracking Toolkit
  - track fitting (and finding)
    - GBL, Kalman, ...
  - track propagation, extrapolation
  - intersection calculation
- developed in AIDA WP2



- geometry implementation from dd4hep::DDSurfaces
  - coordinates, measurement directions, normal, material, insideBour
  - tracking provides intersection with surfaces
- track parameters: L3/LCIO perigee parameters:
  - omega, D0, Phi0, Z0, tanL
- will eventually implement the IMarlinTrk interface

First CLIC tracks reconstructed SiTracking from ILD for CLIC vertex tracks extrapolated to barrel tracker and pick up hits using IMarlinTrk interface and DDKalTest (F. Gaede/ R. Simoniello / N. Nikiforou)

Frank Gaede, CLIC WS 2015, Jan 26-30, 2015

aidaTT and DDkalTest status

- DDKalTest
  - replaced GEAR geometry description with DDRec::Surfaces
  - implemented planar measurements for 1-d and 2-d hits
  - implemented energy loss and multiple scattering using DDRec::Material
  - to do:
    - cylindrical and disk measurement layers
    - then can run complete MarlinTrk tracking code with DD4hep based simulation
- aidaTT
  - implemented complete core functionality for track fitting with GBL
  - planar and disk measurement layers (using DDRec)
  - simple example for fitting tracks from Si-Trackers DD4hep models
  - to do:
    - add cylindrical layers
    - energy loss and multiple scattering
    - implement IMarlinTrk interface

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Summary

- Software landscape is messy
- We have full SiD (and also CLIC) software chain running (and ILD code all there too, just haven't tried)
- We can successful modify SiD silicon geometry and run reco
- I will provide detailed instructions and update 'official' SiD pages
- I will meet SiD people at ALCW next week

Questions for all

- What are others' experiences with this?
- What do you think is the right direction and highest priorities?