

# FCC Software Status and Plans

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for the FCC Experiment Software Team

FCC-hh Detector Meeting

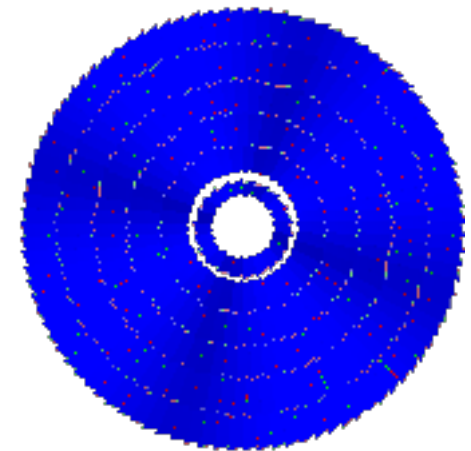
27 July 2015



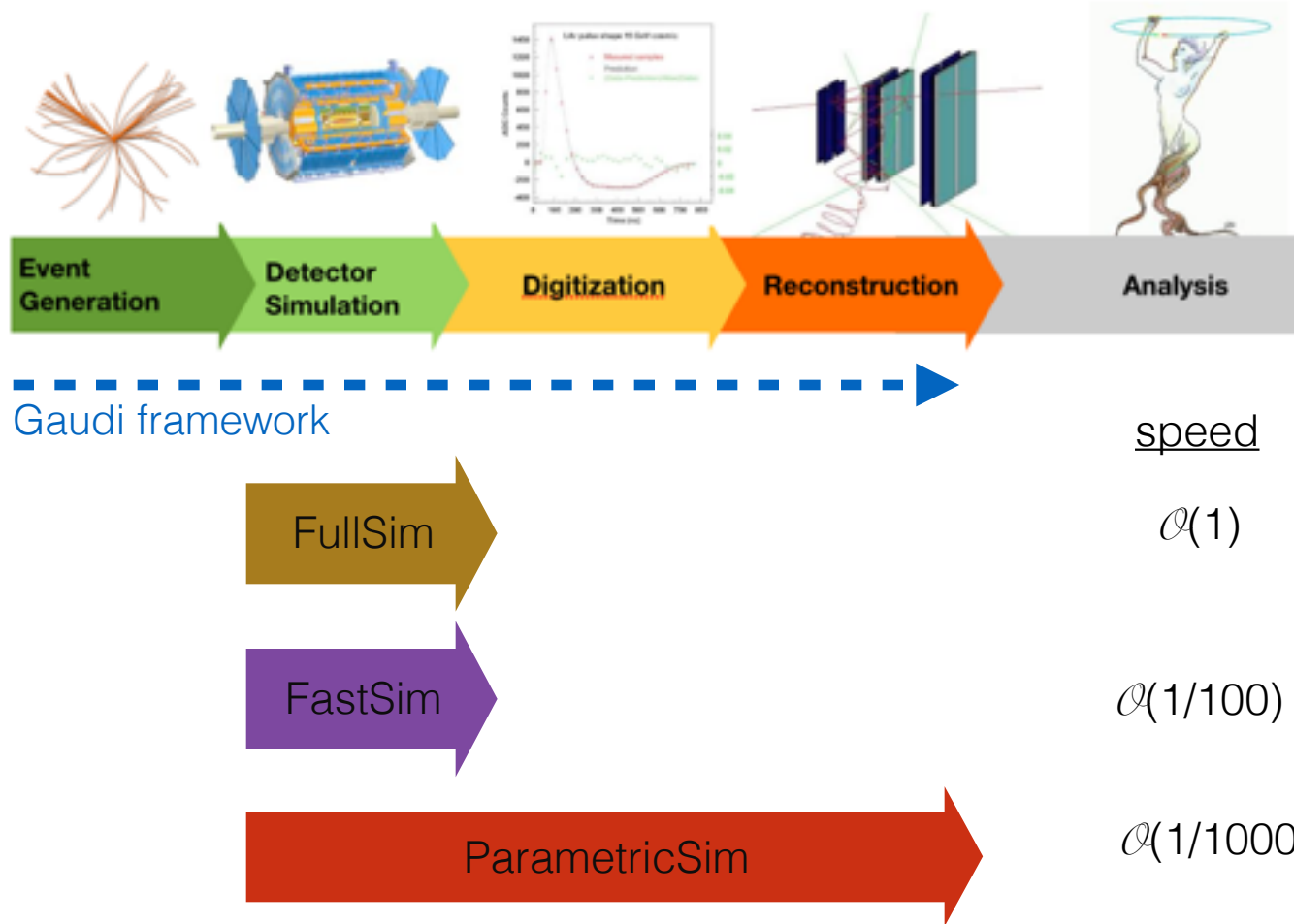
- FCC Software needs to support the studies of multiple detectors
- At different stages different level of detail required
  - Smearing vs. fast sim vs. full sim
- FCC choices are
  - Delphes (\*)
  - Fast simulation
  - Full simulation with Geant4
- Should all be accessible from within the same framework

(\*) <http://delphes.hepforge.org>

- Goal is to have a **combined fast and full simulation**
  - Decide at the config level where to do what
- (Semi-) automatic extraction of fast simulation parameters from full simulation
  - To be able to do fast-sim for any detector design
- Though not re-inventing the wheel, we are heavily re-designing it



# Full and Fast Simulation



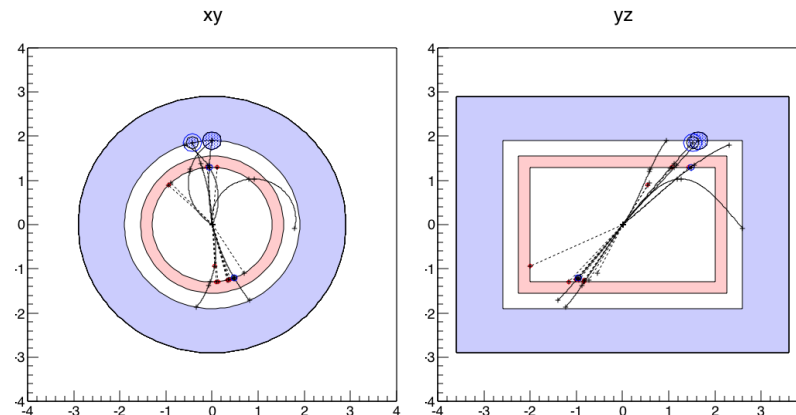
many thanks to J. Hrdinka and A. Zaborowska for this and the following figures!

- Delphes has been (mostly) integrated into the FCC SW
  - Mapping of Delphes data types to FCC data types done
  - Expect a new Delphes version beginning of July for integration

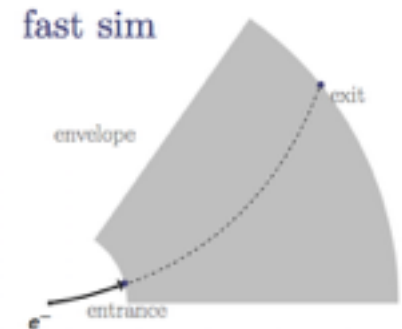
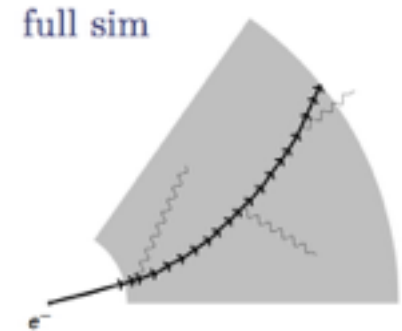
<https://indico.cern.ch/event/399484/contribution/0/material/slides/0.pdf>

- How far does it bring you for FCC-hh studies?
- What's the strategy for obtaining/defining resolutions?

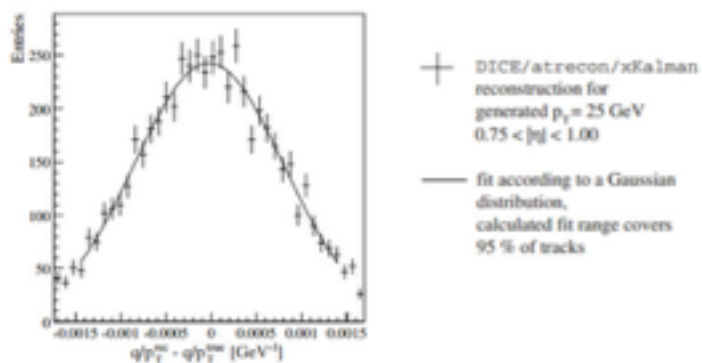
- **PAPAS** is a **PA**rametrized **PA**rticle **S**imulation package
  - based on particle flow experience mainly from CMS
  - prototyping environment for new algorithms in Python
  - ‘integrated’ into FCC software by using the same EDM
  - developed by Colin Bernet
- First test example yielded very promising results
  - under development to transform prototype into a more widely-applicable tool
- Focusses on FCC-ee though



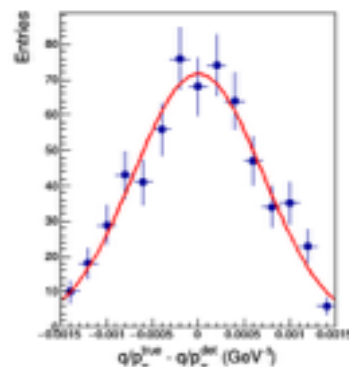
- fastest kind of simulation
- needs parametrisation taken from detector simulation
- different fast simulation models
  - attached to regions in detector/regions of interest
- transversing particle from entry to exit point
- smearing momentum/energy/track resolutions
- Currently three approaches available:
  - Delphes
  - PAPER
  - flexible parametric simulation integrated in Geant4 framework



Residuals of  $\Delta q/p_T$  tested against ATLAS TDR resolution file

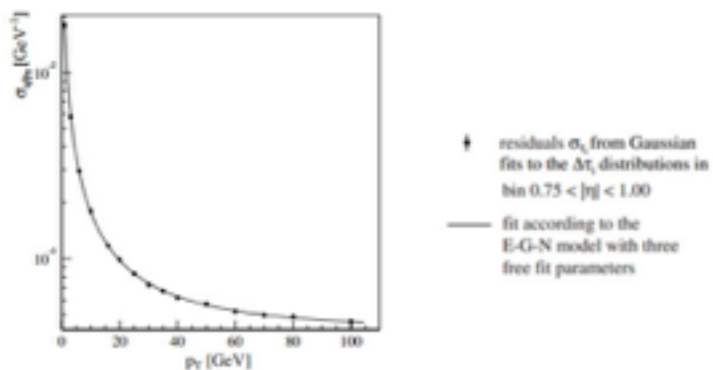


CERN-THESIS-2004-051 Fig. 6.3.

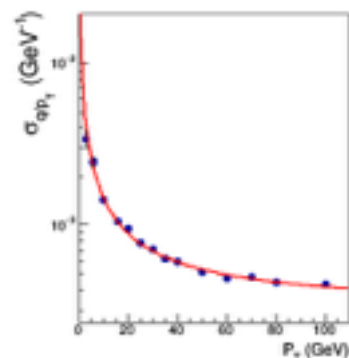


Example of smearing in a standalone G4 fast-sim  
20k muons,  $|\eta| < 5.5$

Muons  
20k  $\mu^\pm$   
 $p_T = 25$  GeV



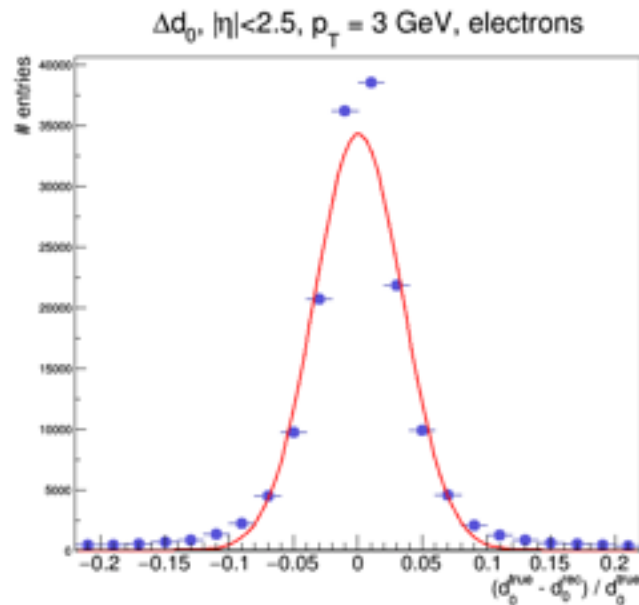
CERN-THESIS-2004-051 Fig. 6.5.



Example of smearing in a standalone G4 fast-sim  
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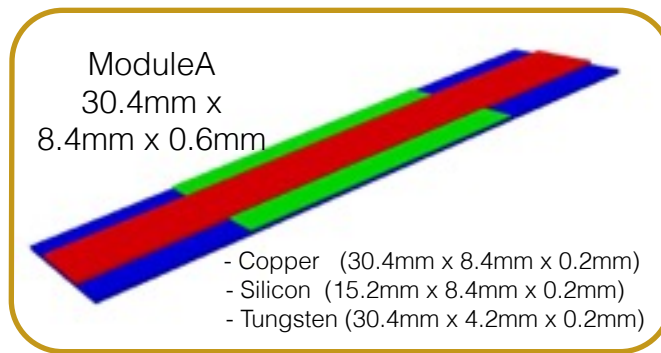


- parametrisation is detector dependent
  - general approach: resolution is obtained from full simulation
  - possibility to obtain smear parameters from simplified G4 detector and track fit



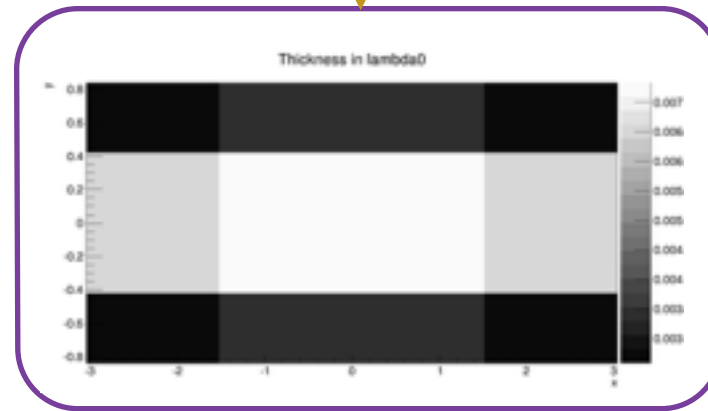
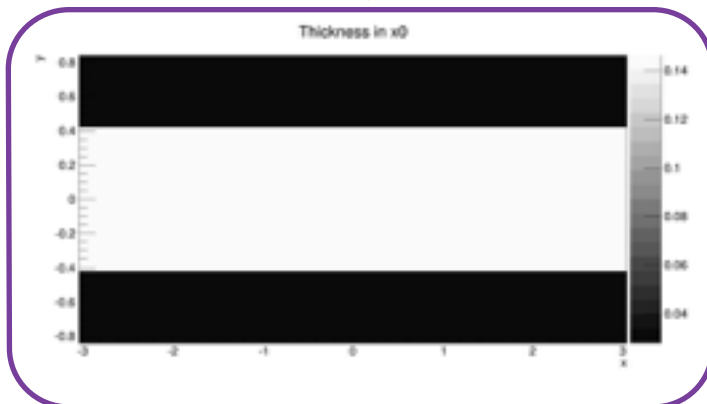
track parameter  
resolution obtained with  
simplified test detector  
and kalman fit

- CMS & ATLAS use a similar approach for the fast simulation based on a Simplified geometry
  - e.g. ATLAS:  $O(10^6)$  nodes  $\rightarrow$   $O(10^2)$  nodes + active modules consisting of active material + simplified material setup (approximation of material necessary)



e.g. Transformation of a complex module into a single surface

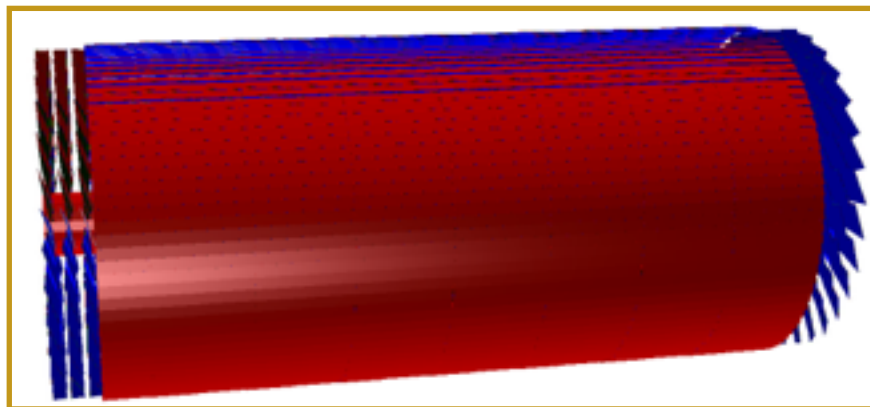
Converter



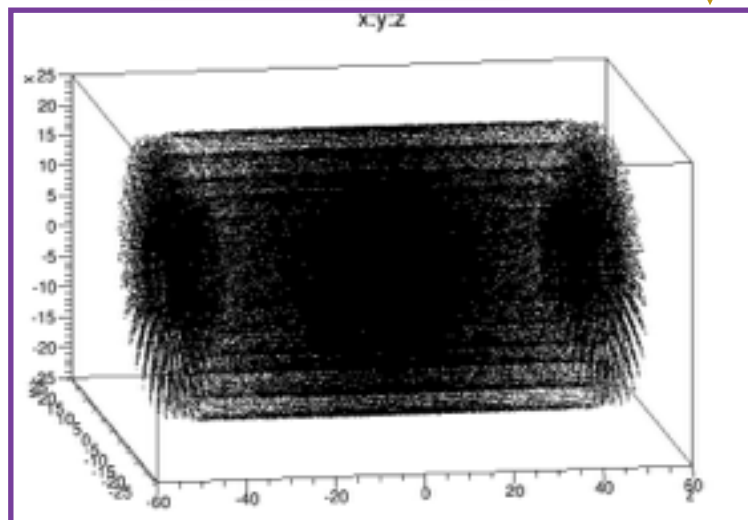
# Geometry Hit Simulation

$\sqrt{s} = 500 \text{ GeV} \cdot c^{-1}$   
 $H, A \rightarrow \tau\tau \rightarrow \text{two } \tau \text{ jets} + X, 60 \text{ fb}^{-1}$

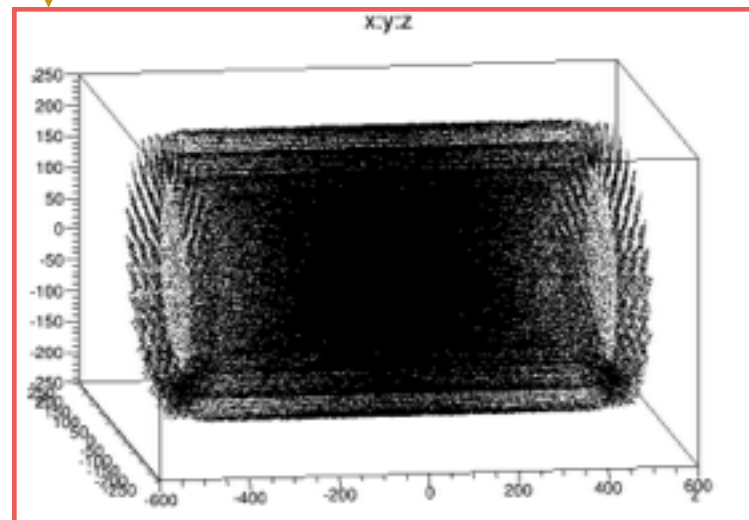
DD4hep



Fast Simulation

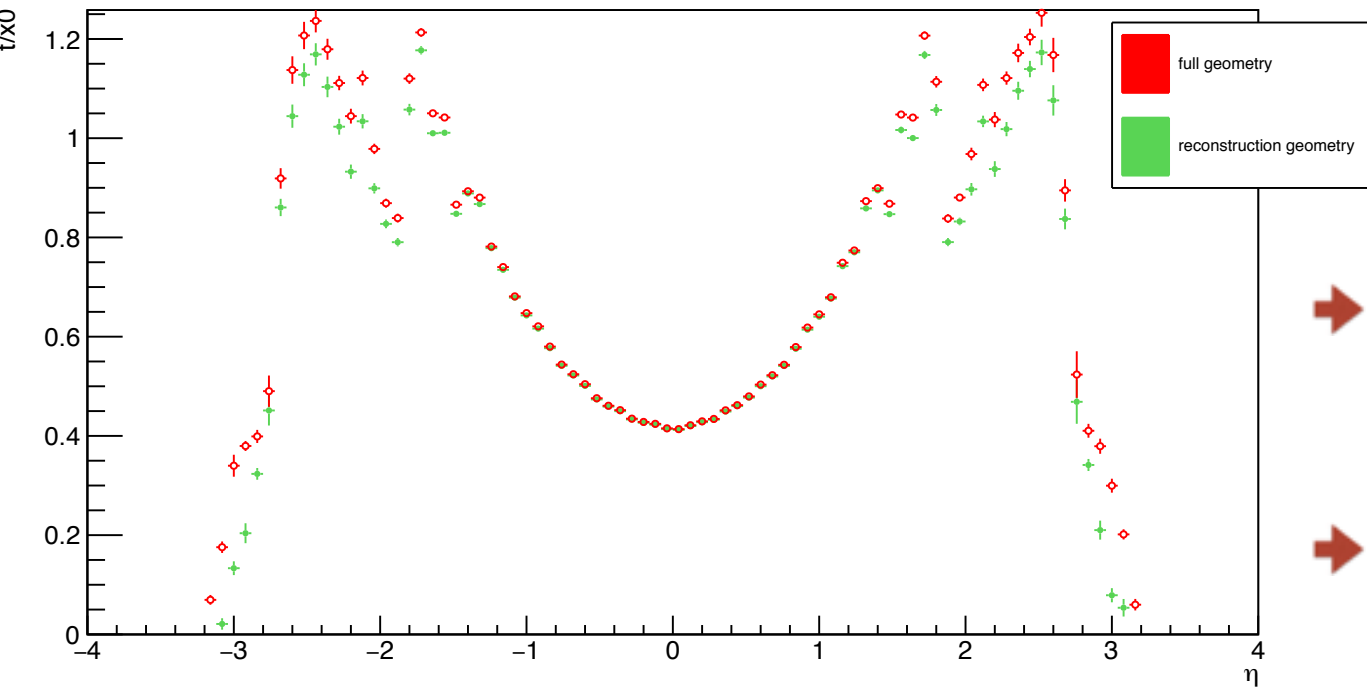


Geant4 Simulation



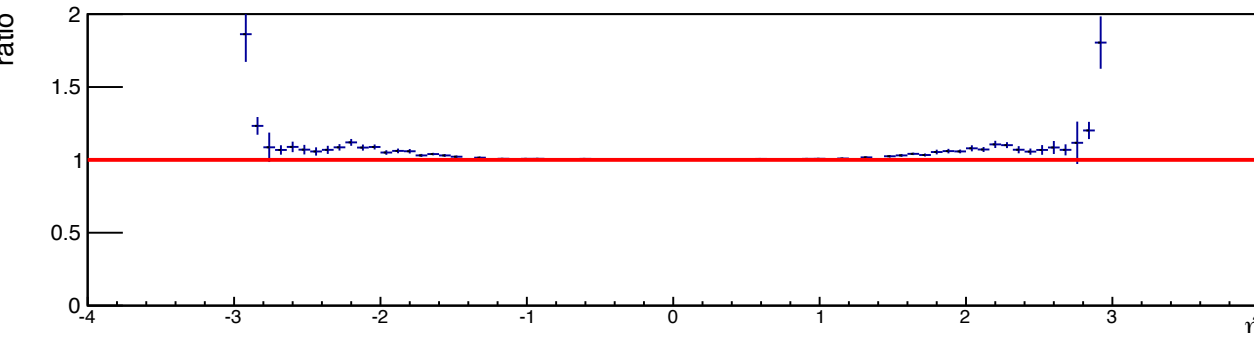
# Comparison of Material Budget

Thickness in  $x_0$  over Eta



➔ description of material essential

➔ good agreement of reconstruction geometry with full geometry (despite edge effects)



The chosen approach works!

- Feature limited version of the library provided early this year
  - In use by multiple FCC software projects
- Second iteration of the library in progress
  - Prototype stage finished, but behind hoped schedule for putting it in production
- Discussions with LCIO developers whether this can be the next iteration LCIO implementation
  - Would mean share of manpower
  - Very encouraging so far
- The EU funded AIDA2020 program contains a data model deliverable
  - the FCC EDM library is now prime candidate for that effort
  - Distant future though

# Data Model - the Data Types

A library is one thing - the definition of physics another!

Zillions of ~equivalent data definitions around.

- Contain almost the same physics content
- Are quite different in their organization

Spent some time to come up with a **tracking data model**

- Folding in experience from ATLAS, CMS and ILC
- Organizing data for easier access and usage given existing LHC code
- Track parameterization w/o assumption of a certain field
- **First iteration of tracking data model finished**

<https://indico.cern.ch/event/400956/contribution/0/material/slides/0.pdf>

- **More details on tracking later in this session**

Rest of the data model rather simple compared to it

- Preliminary definitions exist and are in use, but deserve a second iteration

- Manpower still very critical
  - In particular lack of **expert knowledge** to take full advantage of the other volunteer work
  - E.g. no dedicated release manager to combine all the ongoing efforts into one single piece of software in a timely manner
  - Speed not limited by ideas, but by people contributing
- Manpower only slowly arriving:
  - one doctoral student for simulation (CERN FCC budget)
  - soon two more doctoral students
  - Senior fellow dedicated to SW only starting late fall

# Next steps and related projects

- There is a huge list of items to tackle
  - Complete common EDM development and definition
  - Merge all simulation development streams back into Gaudi-driven framework
  - Reconstruction development just starting
  - Creating a proper test suite
- Many software efforts going on in parallel
  - DD4hep under heavy development
  - Data model library part of AIDA2020 program
  - Gaudi-modernization effort between FCC/LHCb/ATLAS



- Ideas are getting turned into real code
  - Fast/full sim design validated and being turned into real code
  - Data model library in 2nd iteration
  - ...

- Details being discussed (almost) every week Thursday noon:

<https://indico.cern.ch/category/5666/>

- ... and on our mailing list

- **Please sign up and join!**

[fcc-experiments-sw-dev@cern.ch](mailto:fcc-experiments-sw-dev@cern.ch)