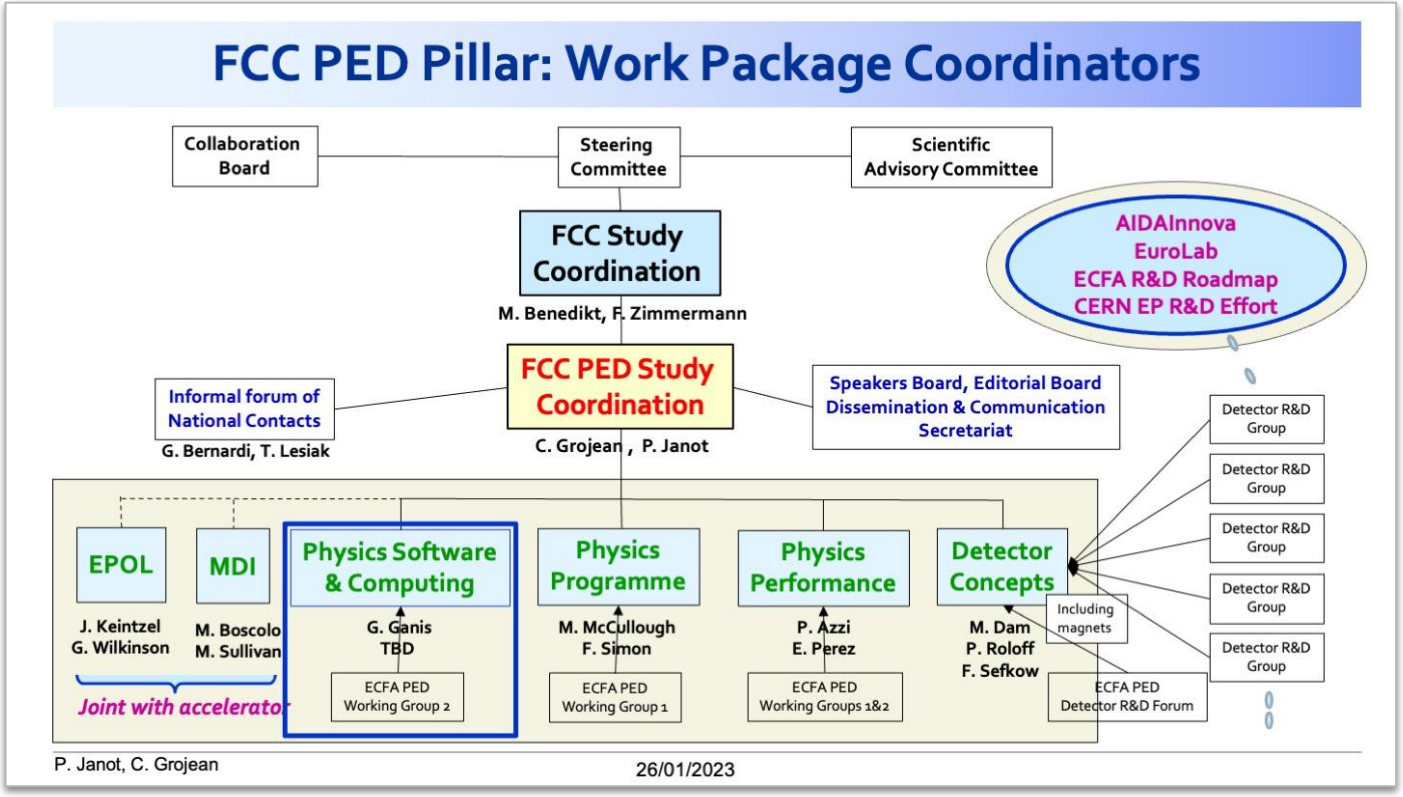
Software for PED studies

Future Plans Software & Computing

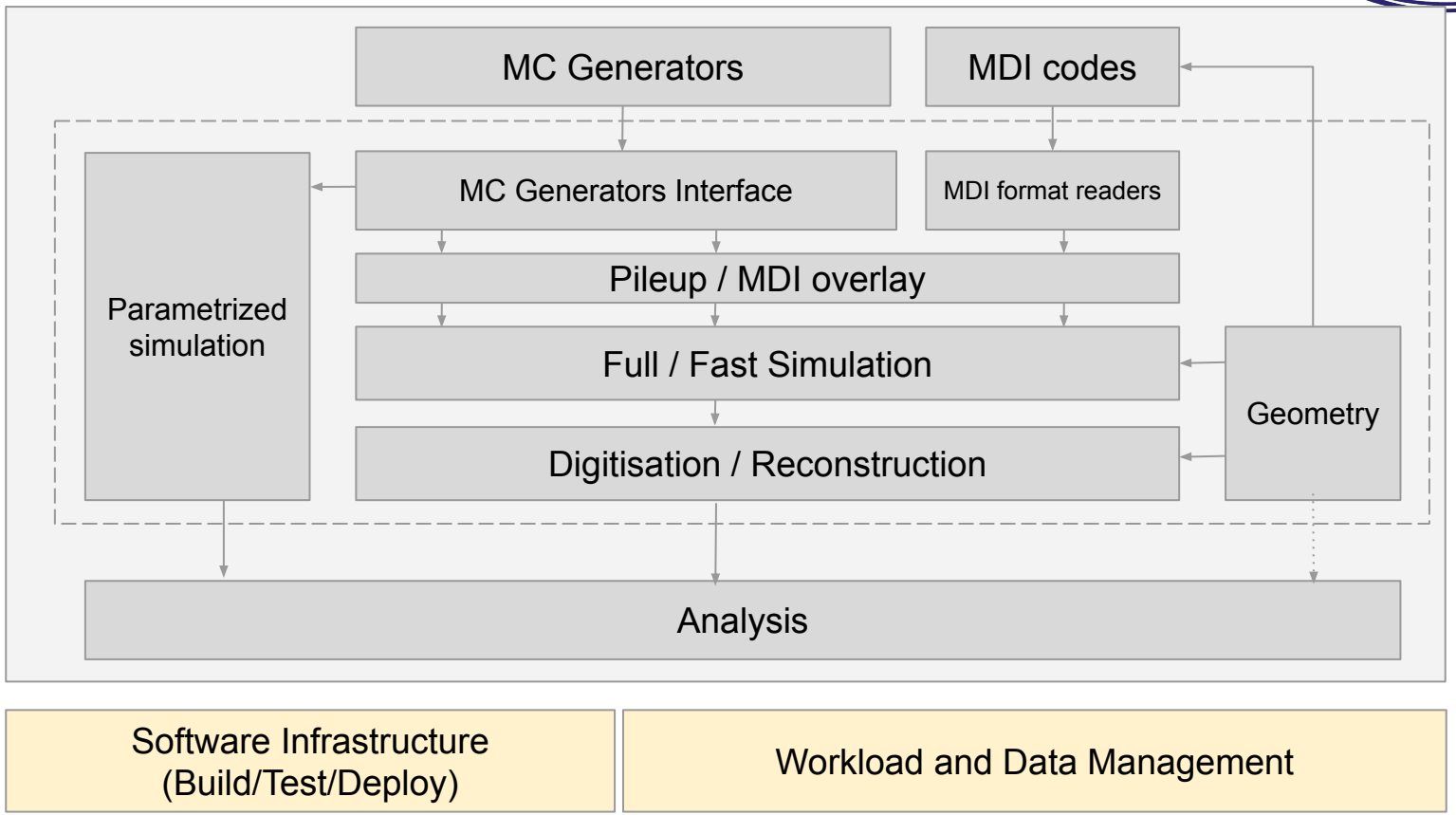
FCC Physics Workshop 2023
Krakow, Poland

January 27, 2023
G Ganis, CERN-EP

S&C relation with other groups



Reminder of the workflows to support



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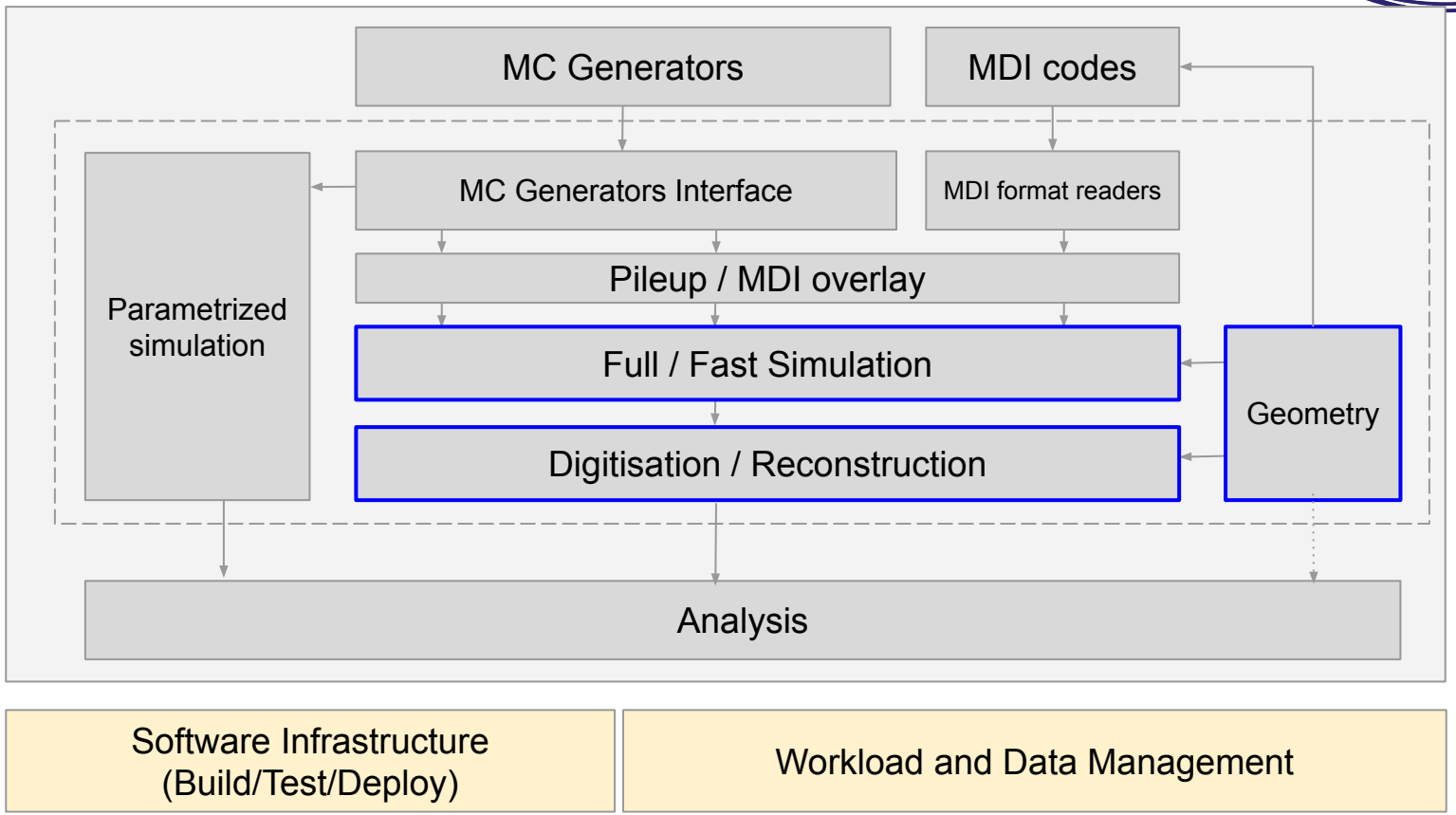


FCCSW: status of things

- Monte Carlo generators ..... ✓≈
  - General purpose + old LEP available
  - Treatment of BES, x-angle, ... still in progress
- MDI interfaces ..... ≈
  - GuineaPig prototype available, start investigation of SR
- Fast simulation (Delphes) .... ✓
- Full simulation and reconstruction ..... ≈
  - Single components available (machine elements, simplified vertex+DC, LAr calo, ...)
  - CLD (reconstruction through iLCSoft wrappers)
  - IDEA standalone, integration scheduled
- Distributed computing ..... ✓≈
  - iLCDirac instance set up (CERN, CNAF storage)
- Analysis ..... ✓≈
  - FCCAnalysis (EMD4hep, ROOT::RDF)
- Documentation ..... ✓≈

S&C at 6th FCC PED Workshop

09:00 → 10:35 **Software and Computing**

Tue, 24 January 2023

- 09:00 **Introduction and statuts of things**
  Speaker: Gerardo Ganis (CERN)
- 09:20 **Key4hep and FCC software**
  Speaker: Gerardo Ganis (CERN)
- 09:45 **Analysis and visiualisation** ¶
  Speaker: Juraj Smiesko (CERN)
- 10:10 **Tools for Monte Carlo productions**
  Speaker: Andre Sailer (CERN)

Wed, 25 January 2023

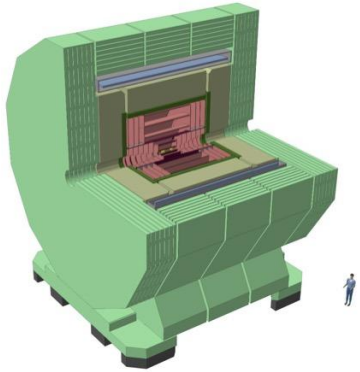
11:00 → 13:05 **Joint Detector/Software**

- 11:00 **Strategy and plans for detector software**
  Speaker: Brieuc Francois (CERN)
- 11:25 **ARC: progress update and plans towards full simulation**
  Speaker: Martin Tat (University of Oxford)
- 11:50 **Modelling signal digitisation for test calorimeters: the CALICE experience (remote)**
  Speaker: Vincent Boudry (LLR, CNRS, École polytechnique, Institut Polytechnique de Paris)
- 12:15 **Modelling signal digitisation for trackers ~~(remote)~~**
  Speaker: Riccardo Farinelli (Universita e INFN, Ferrara (IT))
- 12:40 **Performance of an ALICE ITS3-like vertex detector for FCC-ee (remote) and progress on the IDEA vertex detector implementation in full simulation**
  Speakers: Armin Ilg (University of Zurich) , Leila Freitag (University of Zürich)

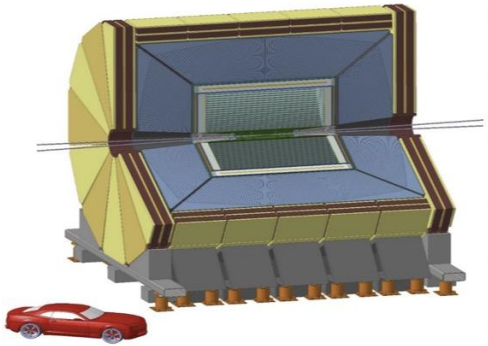
Current Detector Concepts for FCCee

- Two concepts proposed for the FCC-ee CDR: **CLD, IDEA**
- More detectors needed if we have more than 2 IPs
  - New concept based on **High Granularity Noble Liquid calorimeter** under development
- Many different sub-detector technologies on the table!
- Ultimate goal pursued: **full inter-operability of sub-detectors** (eased by DD4Hep plug-and-play approach) and **reconstruction algorithms** (dataformat, more challenging)

CLD



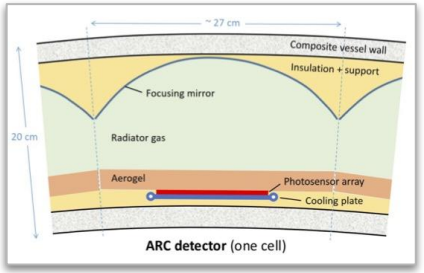
IDEA



Noble Liquid Based

+

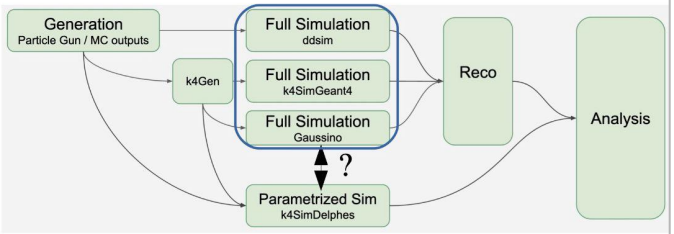
ARC



From full sim to parametrized sim to phys perf

Dreaming bigger

- Common reconstruction tools between detector concepts?
  - Quite challenging
    - The optimal solution always depends on the specific features of the detector
  - Stating the obvious: write reconstruction algorithm as generic as possible
    - For simple cases: optimal solution for a given detector by tuning few parameters
    - For complex cases (e.g. Particle Flow): orchestration of modular tools that each detector implementation can arrange, tune or completely overwrite
- Ease (automatize?) the translation between detector performance evaluation from full sim and parametrized simulation
  - Allows us to sweep detector free parameters, probe their comprehensive impact on physics performance
- …



Detector Software Strategy and Plans Brieuc Francois 13

FCCSW: status of things

- Monte Carlo generator and interfaces ..... ✓≈
  - Generator palette ✓
  - General treatment of interaction region (BES, x-angle, packet length, ...)
- MDI interfaces ..... ✓≈
  - GuineaPig ✓
  - {SR, beam losses, beamstrahlung} through authors' particle lists ✓≈
- Geometry description and full simulation ..... ✓≈
  - New machine region elements, CLD, LAr calo, IDEA DR calo ✓
  - ARC, IDEA DC, vertex, cristal ECAL, muon on-going
  - Streamlining procedure to interchange detectors (Plug&Play)
- Digitisation ..... ✓≈
  - CLD, LAr calo, IDEA DR calo ✓≈
  - ARC, IDEA DC, vertex, cristal ECAL, muon

FCCSW: status of things

- Reconstruction ..... ✓≈
  - CLD via wrapper(iLCSoft tools), LAr calo, IDEA DR calo ✓
  - ARC, IDEA DC, vertex, cristal ECAL, muon
  - ACTS, Pandora PFA
- Distributed computing ..... ✓≈
  - iLCDirac to be commissioned
- Analysis ..... ✓≈
  - FCCAnalysis consolidation
- Documentation ..... ✓≈
  - Tutorials ✓≈
  - Reference documentation ≈

Plans ahead, horizon FSR

Objective

Have results based on full simulation of our current detector concepts presented at the 7th FCC PED Workshop, Q1/2024

How do we get there?

- Check point FCC Week, June 2023

Plans ahead (⇒FSR): FCC Week (6/23)

- Fully move to new k4geo repository
  - Includes adoption of versioning scheme for bookkeeping of detector solutions
- Finalize geometry and first version of digitisation of IDEA missing components
  - Vertex + DC ok, muon remains to be seen
  - Need to *activate* DR calo DD4hep version in key4hep
- Consolidate CLD reconstruction w/ wrapper(ILCSoft tools)
  - Studies of CLD performances with particle guns and selected event samples
- Pandora PFA
  - CLD particle flow with Pandora in Key4hep

Plan to have on this time scale a note describing the status of things in S&C to be used as input to the MTR23

Plans ahead (⇒FSR): fall 2023

- Streamline procedure to interchange sub-detectors
  - At least provide a few meaningful versioned combinations so that comparison studies can start
- Finalize ARC geometry, first version of digitisation and reconstruction
  - Integration in detector concepts (CLD, …) and demo of combined operation
- ACTS track reconstruction in Key4hep
  - CLD, Drift Chamber
- General treatment of the interaction region
  - Consistent set of modules in k4Gen for study the effects of BES, x-angle, packet length, …
- MC productions w/ iLCDirac
  - Commission relevant workflows, setup/structure of storage elements
- Consolidation of FCCAnalysis
  - Including interface with ILCDirac storage elements
- Adequate reference documentation

Summary

- Focus on getting full simulation of the detector concepts usable
- Objective: have full sim based results by the next PED workshop
  - Check-point: FCC Week, also fixing input for Mid-Term Review
- Schedule is tight, priorities set
  - Support by the FCC community is required
    - In ensuring committed contributions
    - Engage in new activities following concrete opportunities presented at IFNC (also in backup slides)

Synergy with ‘stakeholder’ WG (Physics Performance, Detector Concepts, …) is essential for evaluations of the FCC physics potential as realistic as possible

Backup

Technical tasks

1. [R] Validate iLCSoft reconstruction algorithms for FCCee

   Validate relevant algorithms using k4MarlinWrapper (MarlinTrk, LCFIplus, …) to understand possible performance bottlenecks requiring native porting.
   Start form CLD and extend to other detector concepts as they become available

2. [D] Port/implement IDEA Drift Chamber digitisation in Key4hep

   Identify related standalone code and make it running in the common framework to feed reconstruction

3. [R] Migrate existing IDEA reconstruction algorithms in Key4hep

   Algorithms should be, when possible, generalized to be applicable to other detector configuration

4. [R] Pandora integration in Key4hep

   Make the k4Pandora algorithm use a DD4hep geometry service and validate it with CLD in preparation for usage with the other detector concepts (IDEA, LAr, …)

5. [R] ACTS integration: CLD and IDEA track reconstruction with ACTS in Key4HEP

   Implement ACTS interface in k4ActsTracking and test/validate it with CLD first, and extend to IDEA Drift Chamber

[R] Reconstruction, [G] Generators interfaces, [S] Simulation, [D] Digitisation

Technical tasks

6. [S] Investigate use of Geant4 fast simulation for FCCee detector concepts

   There are several improvements in fast simulation, using classic (parametrization) and modern (ML) techniques which might become interesting for FCCee detector concepts

7. [S] Optimise speed-up of full simulation through ddsim and k4SimGeant4

   Make sure that all options are used (e.g. multi-thread execution) for an optimal use of the available resources.

8. [S] Running simulation of CLD in k4SimGeant4

   Understand current limitations and lift them. It should be possible to run ddsim and k4SimGeant4 (k4Gaussino) interchangeably to optimise workflows

9. [G] Consolidation and maintenance of k4Gen

   Make sure that tools for crossing angle, energy spread are validated and can be used for generators not implementing the functionality. Make sure that all required readers are available and functional.
   Make sure that tools for mixing and overlapping events are available and functional.

[R] Reconstruction, [G] Generators interfaces, [S] Simulation, [D] Digitisation

Coordination opportunities

1. ## Monte Carlo Production coordinator and DIRAC liaison

   Coordinate all facets of Monte Carlo production including sample prioritization. Works with generator experts, resource managers, and others to ensure that needed samples are produced in a timely way [...]. Assists users with MC sample availability issues and their interactions with DIRAC

2. ## Resource coordinator

   Responsible for identifying and coordinating compute and storage resources for `FCC`. Works with resource providers, including CERN, WLCG grid sites involved in `FCC` research, and `HPC` centers to enable `FCC` Monte Carlo production and analysis needs. [...]

3. ## Analysis Tools coordinator

   Establish and maintain infrastructure and best practices for user analysis. Assist user community with on-boarding and encourage integration of user-developed features into the infrastructure.

4. ## Generators Liaison

   Works with physics group and generator authors to integrate and update generator software needed for FCC studies. Fosters use of the agreed exchange formats for passing results between generators and from generators to detector simulation applications. [...]