Detector Concepts

Introduction

CERN, January 13, 2025

Mogens Dam (NB), Marc-André Pleier (BNL), Felix Sefkow (DESY)

Opening Remarks

In this Talk

Detector Concepts in the Feasibility Study Report

Detector Concepts at this Workshop

Outlook and Plans

Detector EoI Process

Detector Concepts in the Feasibility Study Report

Structure

Detector Requirements: 48 pages

- by Physics Performance Group

Detector Concepts and Systems: 30 pages

- Detector Concepts Group
  - Concepts: 4 pages
  - Systems: 26 pages
- Reflecting plug & play approach

Detector Concepts in the Feasibility Study Report

Acknowledgments

Text and figure input provided

- M. Aleksa
- F. Bedeschi
- P. Colas
- R. Ferrari
- R. Forty
- C. Gargiulo
- P. Giacomelli
- F. Grancagnolo
- R. Hirosky
- M. Lucchini
- G. Marchiori
- M. Mentink
- N. Morange
- M. Poli Lene
- G. Sadowski
- M.-H. Schune
- M. Selvaggi
- O. Solovyanov
- F. Palla
- J. Zhu

A giant Thank you!

Without your help it would have been impossible

- Few parts written by ourselves (MD, MAP, FS)
- All parts have been edited

All mistakes are ours!

- Many thanks to our “referees"
  - F. Bedeschi
  - C. Haber
  - P. Janot
  - S. Rajagopalan

Detector Concepts in the FSR

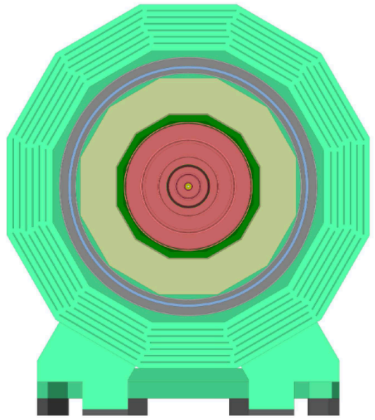
Content

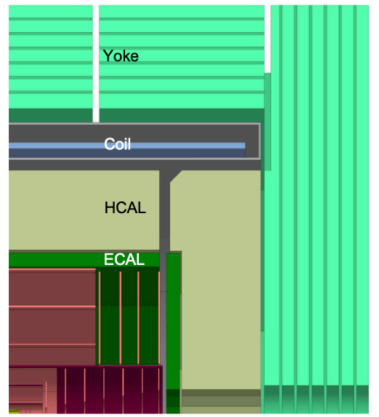
Introduction

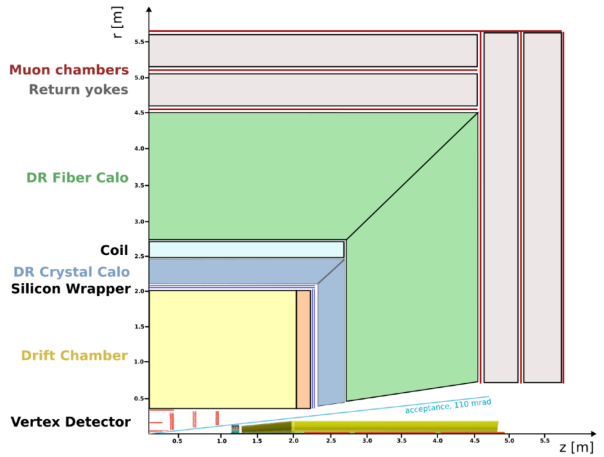
- Challenge, also vs. linear collider detectors
- Relation with DRDs and role of concepts
- Emphasis on full simulations, Key4HEP and plug & play

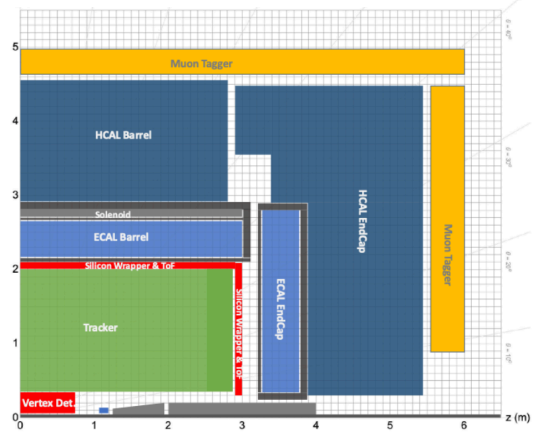
Detector Concepts

- Intro: calorimeters driving concepts
- CLD/ILD, IDEA, ALLEGRO:
  - rationale, architecture
  - technology options for sub-systems
  - status of simulations







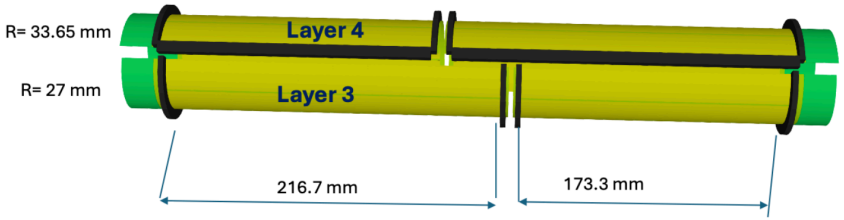


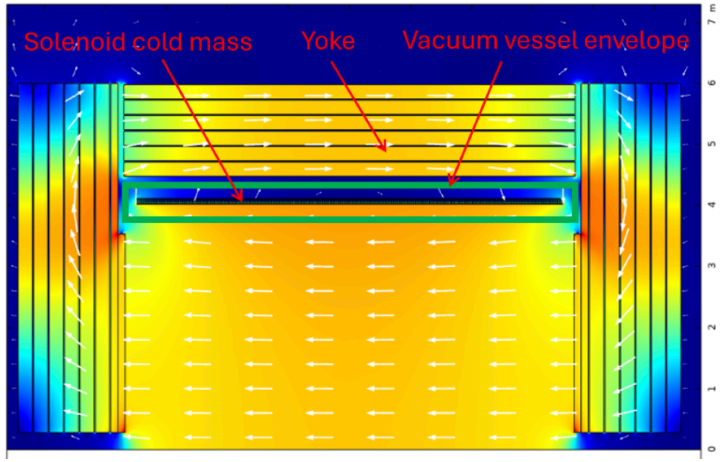
Detector Concepts in the FSR

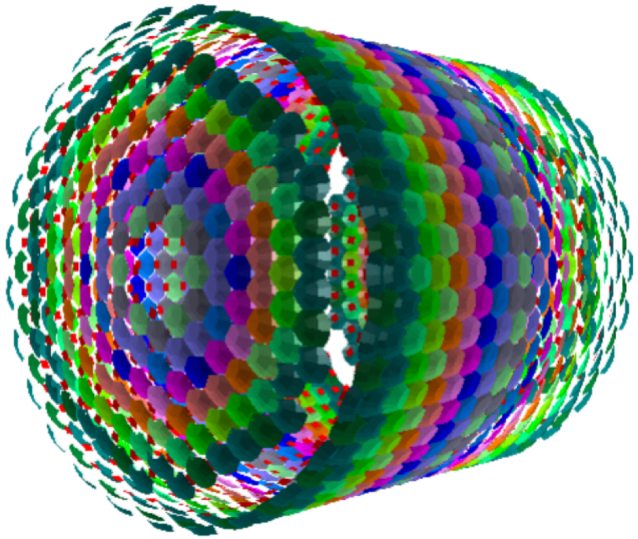
Content

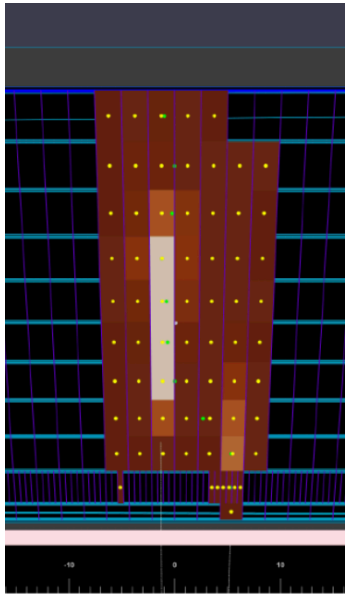
Detector Systems

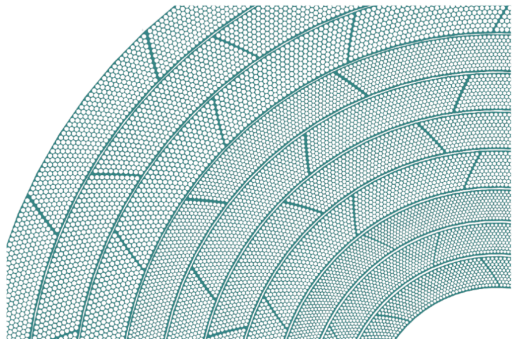
- Technology, rationale
- Sub-system lay-out
- R&D status and challenges

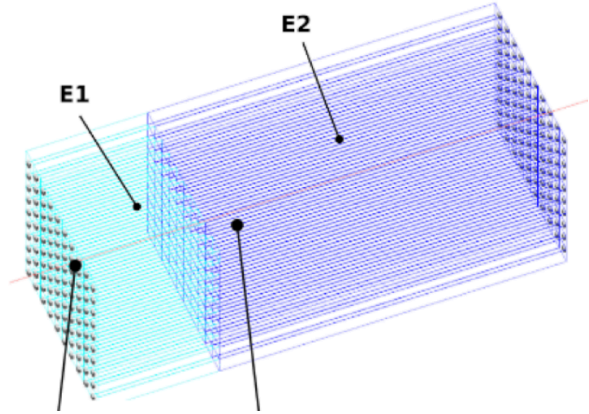


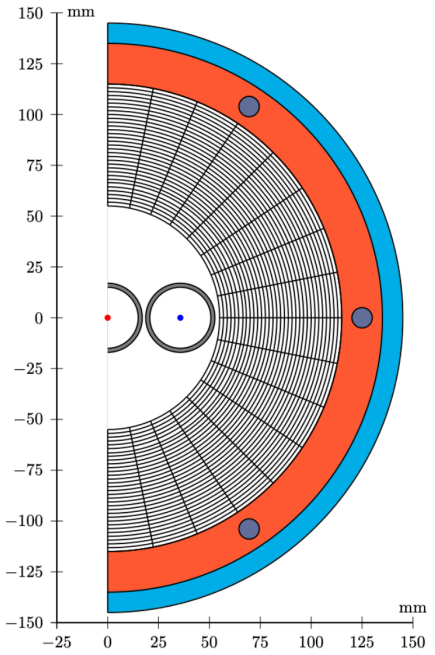












Detector Concepts in the FSR

Outlook and Plans

To be written after this workshop

- parallel sessions and satellite meeting

Exploit the full simulations

- optimisation using high-level full-event reconstruction, e.g. particle flow, flavour tag
- consolidate background simulation and IR optimisation
- strawman TDAQ concept and resulting on-detector electronics requirements

Detector R&D ramping up

- demonstrators & prototypes: feed-back results, validate simulations
- new technologies - new concepts

Validate expected performance vs. requirements

Detector Concepts at this Workshop

Overview on Sessions - including Joint Sessions

Tuesday

Vertex detector & integration

09:00 → 10:30 **Joint MDI and detectors: Beam pipe, vertex detectors, LumiCal**

Convener: Fabrizio Palla

- 09:00 **Vertex Detector Cooling simulations** ¶
  Speaker: Dr Giorgio Baldinelli (University of Perugia)
- 09:20 **Lumical - residual B field effects and bkgs**
  Speaker: Mogens Dam (University of Copenhagen (DK))
- 09:40 **Curved VDX layout, performance and constraints**
  Speaker: Armin Ilg (University of Zurich)
- 10:00 **Detector integration and maintenance**
  Speaker: Andrea Gaddi (CERN)

Background & irradiation

11:00 → 12:30 **Joint MDI and Software and Detectors: Beam backgrounds**

Convener: Helmut Burkhardt (University of Freiburg (DE))

- 11:00 **Backgrounds on detectors**
  Speaker: Andrea Ciarma (INFN e Laboratori Nazionali di Frascati (IT))
- 11:15 **Simulation interface of accelerator backgrounds in the detectors**
  Speaker: Brieuc Francois (CERN)
- 11:30 **Synchrotron Radiation bkgs**
  Speaker: Kevin Daniel Joel Andre (CERN)
- 11:50 **Beam losses in the IR**
  Speaker: Giacomo Broggi (CERN, Sapienza Università di Roma e INFN Laboratori Nazionа
- 12:10 **FLUKA results on fluences, doses and backgrounds on the detector**
  Speaker: Alessandro Frasca (University of Liverpool (GB))

Tracking & vertexing Silicon & Gas

14:00 → 16:00 **Detectors: Tracking and vertexing**

Conveners: Felix Sefkow (Deutsches Elektronen-Synchrotron (DE)), Marc-Andre Pleie
Copenhagen (DK))

- 14:00 **FCC-Seed : a snail shape detector concept for FCCee**
  Speakers: Dr Auguste Guillaume Besson (Centre National de la Reche
  Scientifique (FR))
- 14:24 **Status of the ALICE ITS3 development**
  Speaker: Marius Wilm Menzel (Heidelberg University (DE))
- 14:48 **Large area silicon detectors for FCC**
  Speaker: Ulrich Parzefall (University of Freiburg (DE))
- 15:12 **TPC (remote)**
  Speaker: Paul Colas (Université Paris-Saclay (FR))
- 15:36 **Straw tube tracker for FCC-ee**
  Speaker: Chihao Li (University of Michigan (US))

Detector Concepts at this Workshop

Overview on Sessions - including Joint Sessions

Wednesday

Magnet, cryostat, yoke TDAQ and operability

11:00 → 12:30 **Detectors: Detector concepts, large-scale structures and cryostats**

Conveners: Felix Sefkow (Deutsches Elektronen-Synchrotron (DE)), Marc-Andre Pleier (Brookhaven National L
Copenhagen (DK))

- 11:00 **Solenoid detector magnets for FCC-ee**
  Speaker: Matthias Mentink (CERN)
- 11:18 **Light composite material cryostats**
  Speaker: Corrado Gargiulo (CERN)
- 11:36 **A High-Precision, Fast, Robust, and Cost-Effective Muon Detector Concept**
  Speaker: Jianming Qian (University of Michigan (US))
- 11:54 **Ideas on getting started with FCCee TDAQ activities**
  Speaker: Steven Schramm (Universite de Geneve (CH))
- 12:12 **TPC and background**
  Speaker: Victor Schwan

Full simulation & detector s/w integration

14:00 → 16:00 **Joint sessions Detectors and Software**

Conveners: Brieuc Francois (CERN), Felix Sefkow (Deutsches Elektronen-Synchrotron (DE)), Gerard
Laboratory (US)), Mogens Dam (University of Copenhagen (DK))

- 14:00 **CLD / ILD rationale and full-sim based studies**
  Speaker: Frank-Dieter Gaede (Deutsches Elektronen-Synchrotron (DE))
- 14:25 **IDEA: rationale, full simrec focus**
  Speaker: Lorenzo Pezzotti (Universita e INFN, Bologna (IT))
- 14:50 **ALLEGRO: rationale, full simrec focus**
  Speaker: Giovanni Marchiori (APC, CNRS/IN2P3 and Université Paris Cité)
- 15:15 **Bigger picture on detector integration into concepts in software**
  Speaker: Alvaro Tolosa-Delgado (CERN)

Calorimetry & PID

16:30 → 18:30 **Detectors: PID, Calorimetry**

Conveners: Felix Sefkow (Deutsches Elektronen-Synchrotron (DE)), Marc-Andre Pleier (Brookhaven National Laboratory (US)
Copenhagen (DK))

- 16:30 **Simulation and performance study of the ARC concept for a compact RICH detector**
  Speaker: Alvaro Tolosa-Delgado (CERN)
- 16:54 **Noble liquid calorimetry**
  Speaker: Nicolas Morange (Université Paris-Saclay (FR))
- 17:18 **Si and SiPM-on-Tile: scalability**
  Speaker: Matthias Komm (Deutsches Elektronen-Synchrotron (DE))
- 17:42 **Crystals - CalVision**
  Speaker: Grace Cummings (Fermi National Accelerator Lab. (US))
- 18:06 **TileCal (remote)**
  Speaker: Archil Durglishvili (Ivane Javakhishvili Tbilisi State University (GE))

Detector Concepts at this Workshop

Overview on Sessions - including Joint Sessions

Thursday

Digitisation & reconstruction

09:00 → 10:30 **Joint Software, Physics Performance & Detectors: reconstruction**

- 09:00 **Detailed vertex detector digitization**
  Speaker: Gaelle Boudoul (Centre National de la Recherche Scientifique (FR))
- 09:18 **Drift chamber digitization**
  Speaker: Nicola De Filippis (Politecnico/INFN Bari (IT))
- 09:36 **Standalone muon reconstruction in IDEA**
  Speaker: Mahmoud Ali (University and INFN Bologna)
- 09:54 **Particle Identification with the ARC in Key4hep**
  Speaker: Serena Pezzulo (INFN e Universita Genova (IT))
- 10:12 **Jet clustering algorithms for ZH fully hadronic**
  Speaker: Anna Elizabeth Connelly (Brookhaven National Laboratory (US))

High-level reco & performance

11:00 → 12:30 **Joint Software, Physics Performance & Detectors: reconstruction**

- 11:00 **ML based flavor tagging in Fast/Full sim**
  Speaker: Sara Aumiller (Technische Universitat Munchen (DE))
- 11:22 **ML based tau identification**
  Speaker: Laurits Tani (National Institute of Chemical Physics and Biophysi
- 11:44 **Particle Flow at FCC**
  Speaker: Anna Zaborowska (CERN)
- 12:06 **Tracking and ML based Particle Flow**
  Speaker: Andrea De Vita (University of Padova)

Summary

- 14:40 **Detectors**
  Speaker: Marc-Andre Pleier

Calls for Expressions of Interest

FCC Detector Community

Encourage federation of world-wide efforts focussing on one or few technologies for FCC sub-detectors

- well connected to technological R&D in DRD collaborations, large overlap
- complementary: focus on systems aspects at sub-detector level and integration into one or several detector concepts
- support and guide the R&D with simulation and optimisation, together with detector concepts

Invite short documents (2-4 pages)

- scope for next 3-5 years
- connections with DRDs and concepts
- partners, contacts, references to more detailed documentation

Similar but separate call for detector concept activities

- simulation and reconstruction software and engineering at full detector level
- short documents, focus next 3-5 years

Process and Timeline

The Calls

Sent out **Calls for Expressions of Interest** on October 11

- one on detector concepts, on on sub-detectors - EoIs should refer to each other

Simultaneously: opened a **web page** for interested parties to sign up, declaring intent to prepare an EOI

- to foster cooperation between groups and facilitate common EoIs
- soft **deadline mid November,** closed recently

More than 90 EoIs received, most of them for small groups of institutes, some large consortia, too

- plus about 15 on theory and physics studies - not included here
- proposed some grouping see next slide

Satellite **meeting** to this FCC Physics Workshop (Friday **Jan 17**)

- short presentations on upcoming EoIs

Deadline Jan 31 for submission of EOIs to **PED**

- for editorial feedback and inclusion in combined FCC submission summary

Deadline Mar 31 for submission to **ESU**

- submission of executive summary and attached EoIs (optional)

Editorial team:
Srini Rajagopalan,
Guy Wilkinson,
with MD, MAP, FS

Grouped EoIs

https://docs.google.com/spreadsheets/d/1iHTDN1TJpfk_sDrYm7HrY8zuQxfDZj4MtFooziXq5rQ/edit?usp=sharing

EOI Grouping

File Edit View Insert Format Data Tools Extensions Help

A1 EOI Abstract ID

	A	B	C	D	E	F	G
17			SiPM-on-Tile HCAL				
18	**D0032**	Calorimeter	**Development of the SiPM-on-Tile Analog Hadron Calorimeter (AHCAL) technology: detector geometry, readout and trigger concept and electronics, mechanical and thermal integration, photon sensors, scintillators, simulation and reconstruction.**	Frank Simon	KIT	frank.simon@kit.edu	DESY, U Hamburg, U Heidelberg, KIT, U Mainz, UT Arlington, NIU, FZU Prague
19			SiW ECAL				
20	**D0039**	Calorimeter	**SiW-ECAL : a silicon-tungsten highly granular electromagnetic calorimeter suitable for particle flow-based detector concepts at a Higgs/ElectroWeak/Top factory.**	Vincent Boudry	LLR – LLR, CNRS, École polytechnique, Insti	Vincent.Boudry@in2p3.fr	IJCLab (Orsay), LLR (Palaiseau), LPNHE (Paris), Omega (Palaiseau), DMLab, IFIC (Valencia), CERN, U. Tokyo, KEK, iThemba labs (Cape Town)
21	**D0074**	Calorimeter	**Building on the experience / contribution to CMS and CMS Upgrades - and in particular HGCAL and design studies, high throughput digital electronics and algorithms. Most of the potential effort is currently focused on completing the latter.**	Anne-Marie Magnan	Imperial College London	a.magnan@imperial.ac.uk	TBD
22			MAPS ECAL				
23	**D0059**	Calorimeter	**Development of MAPs for Si-tungsten calorimeter.**	Alexander Paramonov	Argonne National Laboratory	aparamonov@anl.gov	ANL
24			Tile fibre HCAL				
25	**D0086**	Calorimeter	**The ALLEGRO HCAL is a concept of a scintillating tile hadronic calorimeter for the central region, designed to provide a high-performance, high granularity and cost-effective solution for FCC-ee.**	Henric Wilkens	CERN	Henric.Wilkens@cern.ch	LIP, CERN, ITIM Cluj, IFIC Valencia, Univ. of Be
26			LumiCal				
27		Lumical	**Development of Lumical**	Mogens Dam			
28			Carbon fibre wire chamber				
29	**D0013**	Main Tracker and Envelopes	**Interested and working towards detector concept based on a novel wire chamber concept employing carbon fiber wires for the Outer tracking device of FCC-ee. Open for additional collaborators.**	Andy Jung	Purdue University	andreas.werner.jung@cern.ch	Purdue University
30			Straw-tube tracker				
31	**D0015**	Main Tracker and Envelopes	**Straw-tube tracker design and tracker design optimization**	Oliver Kortner	Max-Planck Institute for Phyics	Oliver.Kortner@cern.ch	University of Michigan, Ann Arbor
32							
33	**D0062**	Main Tracker and Envelopes	**R&D for straw tracker electronics/readout**	Anyes Taffard	UC Irvine	ataffard@uci.edu	UM, MSU, UMass, Harvard, Duke, UT Austin, MPI
34	**D0038**	Main Tracker and Envelopes	**Development of a thin-wall straw tracker for FCC-ee inner tracking system. Combined with the pixel detector and silicon wrapper, it will provide excellent momentum resolution and PID capability over a wide momentum range**	Junjie Zhu	University of Michigan	junjie@umich.edu	MPI, UMass, Harvard, Tufts, MSU, UC Irvine, Duke, UT Austin

Satellite Meeting, Following FCC workshop at CERN

Friday January 17, 0900-1300, Filtration Plant

Ask each EoI group to present

- sounds challenging - but worked well at US FCC, MIT

Encourage groups to merge

- ideally merge EoI documents
  - merged EoIs got more time

Prepared template

- distributed in December
- now being filled, gaining momentum
  - presentation, via zoom, by proxy or zoom proxy, or by convenor possible
- don't miss out!

<ID No> <Your Technology Title>

Contact Persons:

- Name 1, email
- Name 2, email
- Name 3, email

Collaborating Institutes & expertise/facilities:

- Institute 1
  - Expertise 1, facility 1
- Institute 2
  - Expertise 2, facility 2
- Institute 3
  - Expertise 3, facility 3

Connections with DRDs:

- DRDa, WPx: …
- DRDb, WPy: …

Connections with Concept Groups:

- Engineering/Simulation studies with concept NN

References: [1]: A detailed write up of technology A, NIM-A, vvv, pppp, 2024; [2]: A detailed write up of technology B, JINST, vv, ii, 2021; [3]: Our EoI draft in overleaf <link>

<ID No> <Your Technology Title>

Planned activities for the next 3-5 years

- 2025: Task 1
- 2026: Task 2
- 2027: Task 3

Eye candy, prototype results, …

<For each merged EoI you may add one extra slide. >

References: [1]: A detailed write up of technology A, NIM-A, vvv, pppp, 2024; [2]: A detailed write up of technology B, JINST, vv, ii, 2021; [3]: Our EoI draft in overleaf <link>

Back-up