Istituto Nazionale di Fisica Nucleare

FCCIS – The Future Circular Collider Innovation Study. This INFRADEV Research and Innovation Action project receives funding from the European Union’s H2020 Framework Programme under grant agreement no. 951754.

A MDI KEY TOPIC:
IR MOCKUP GOALS AND TESTING OF CRITICAL CONCEPTS

Manuela Boscolo (INFN-LNF)

MDI & IR Mockup Workshop
16-17 November 2023,
Frascati, Italy

FUTURE CIRCULAR COLLIDER
Innovation Study

FCCIS WP2 Task3 Workshop
16-17 November 2023 Frascati

https://agenda.infn.it/event/37720/

Workshop Goals

- Sign-off meeting for the IR mockup
- Discuss critical concepts for the MDI design & IR mockup in particular
  - Accelerator and detector constraints in the IR
  - IR quads & cryostats
  - Synchrotron radiation
  - IR Beam losses
  - Heat loads
  - IR Radiation damage
  - IR optics
  - Alignment
  - Vacuum

FUTURE CIRCULAR COLLIDER

FCC-ee MDI & IR mockup Workshop

16–17 Nov 2023
Laboratori Nazionali di Frascati
Europe/Rome timezone

Enter your search term

Overview
Timetable
Registration
Participant List
Committees
Hotel suggestions
Privacy Policies
Zoom Conference Room
Wifi Internet Access

Contacts
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fcc.logistics@lists.lnf.infn.it

Welcome to the FCCIS MDI and IR mockup workshop in Frascati!

The MDI and IR mockup workshop of FCC Innovation Study of WP2 and Task 3 will be held in Frascati, National Laboratories of INFN, from 16 to 17 November 2023.

This workshop will focus on Machine-Detector-Interface studies and on the IR mockup, covering topics such as:

- IR mockup critical concepts,
- Beam losses in the IR,
- Synchrotron radiation,
- IR HOM calculations,
- Vertex detector integration & cooling,
- Accelerator and detector constraints in the IR.

We are looking forward to seeing you in Frascati !

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Starts 16 Nov 2023, 08:00
Ends 17 Nov 2023, 17:15
Europe/Rome

Laboratori Nazionali di Frascati
Aula Salvini
Via Enrico Fermi, 60, 00044 Frascati RM, Italie
Go to map

FRANK ZIMMERMANN
Manuela Boscolo

There are no materials yet.

Workshop Sessions

Discussions welcomed in all sessions

Satellite meetings possible

Thursday, 16 November 2023	
09:00	
09:25	MDI overview & IR mockup
11:00	Coffee break
11:20	Vertex detector mockup & cooling
13:05	Lunch
14:30	Vacuum & heat load
15:40	Coffee break
16:00	Lab Tour of DAFNE & SPARC
17:00	IR optics
18:30	Self-standing dinner at LNF

Friday, 17 November 2023	
08:30	Machine & detector integration
10:20	Coffee break
10:40	IR quads & cryostat
12:10	Discussion
12:20	SR, beam losses, bkg
13:00	Lunch
14:30	SR, beam losses, bkg
15:10	Summaries & next steps
16:40	**Closing** - FRANK ZIMMERMANN (CERN)
16:55	Adjourn

Progress & plans on key aspects of the MDI design

❑ IR Mechanical model, including vertex and lumical integration, and assembly concept

- Services (i.e. air & water cooling for vertex and vacuum chambers) and cables
- Anchoring to the detector
- Accessibility & Maintenance
- Vacuum connection
- IR BPMs
- Integrate in the design an alignment system

❑ IR magnet system & Cryostats

- FF Quads & Correctors
- Solenoid comp. scheme & anti-solenoid design

❑ Beam induced backgrounds

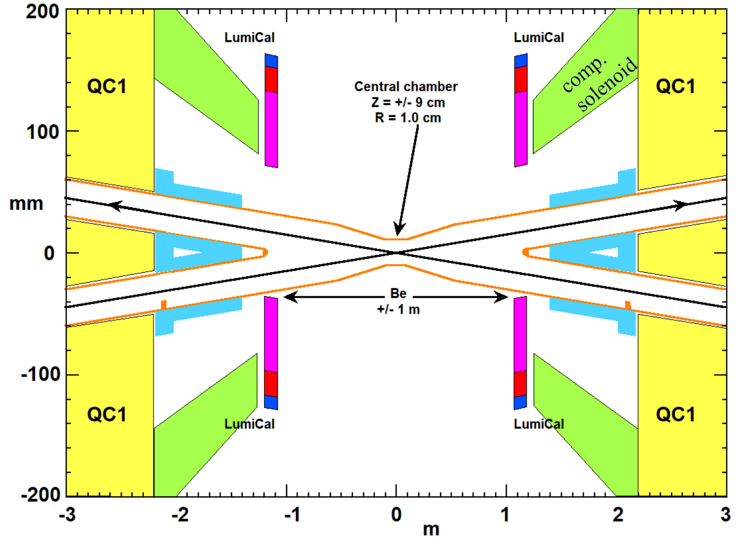
- The MDI region is now improved as more realistic, and software model developed. Need to update and complete those studies .
- Backgrounds, halo beam collimators, IR beam losses, SR, IR radiation level & fluences
- Beamstrahlung dumps with radiation levels

❑ Heat Loads from wakefields in IR region

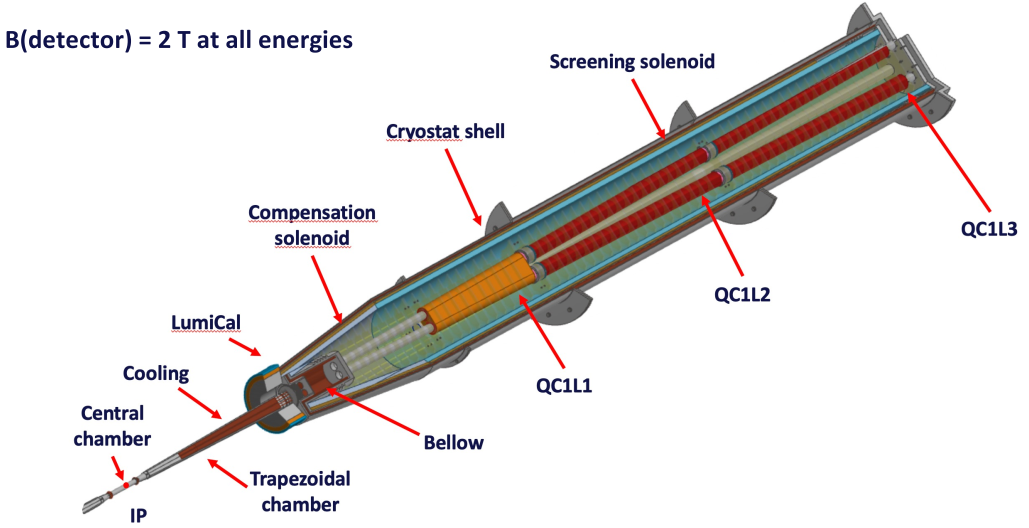
- In progress

MDI Status & Plans, FCCIS Workshop 15/11/23 link

FCC-ee Interaction Region Baseline layout



B(detector) = 2 T at all energies



3D view of the FCC-ee IR until the end of the first final focus quadrupole

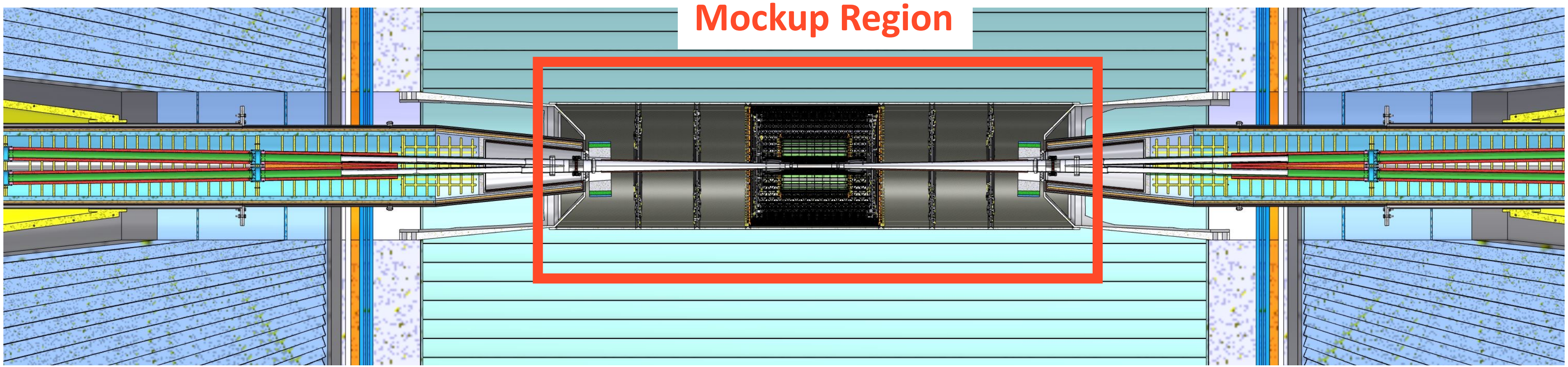
- L* is **2.2** m (L* is the face of the first final focus quadrupole QC1, and the free length from the IP).
- Central vacuum chamber has 10 mm radius, 180 mm long.
- Crotch at about 1.2 m, with two symmetric beam pipes with radius of 15 mm.

QC1 almost entirely inside the detector, being the half-length of the detector about 5.2 m and the end of QC1L3 at 5.56 m.

The IR layout depends on the IR optics and on the solenoid compensation scheme

FCC-ee Interaction Region +/- 1.2 m

3D view of FCC-ee IR: zoom at the very central region about 2.4 m



View including the rigid support tube, vertex detector and outer trackers

Ref: M. Boscolo, F. Palla, et al., *Mechanical model for the FCC-ee MDI,* EPJ+ Techn. and Instr., https://doi.org/10.1140/epjti/s40485-023-00103-7

Complementarity between mockup and CAD model

CAD MODEL

- Extent and coverage
- Rapid modeling with high level of detail
- Parametric design
- Numerical simulations
- Ease of sharing

MOCKUP

- Feasibility studies
- Full-scale measurements of mechanical and thermal behavior
- Evaluation of tolerances, alignment and survey issues
- Assessment of maintenance and operation
- Personnel training
- Cost and manpower estimation for final implementation

Mock-up of the interaction region

Goals

- Validation of the MDI CAD drawings
- Enables better understanding of services, such as cables and pipes
- Allows a broader view of the installation sequence and potential issues
- Can help predict potential access problems to the IR
- Not a usual mockup! Real prototypes of some critical parts both for accelerator and vertex foreseen
- Outreach

Main goals of the IR mock-up

The main goals of the IR mock-up are related to addressing and studying the main issues related to the design, operation, and assembly.

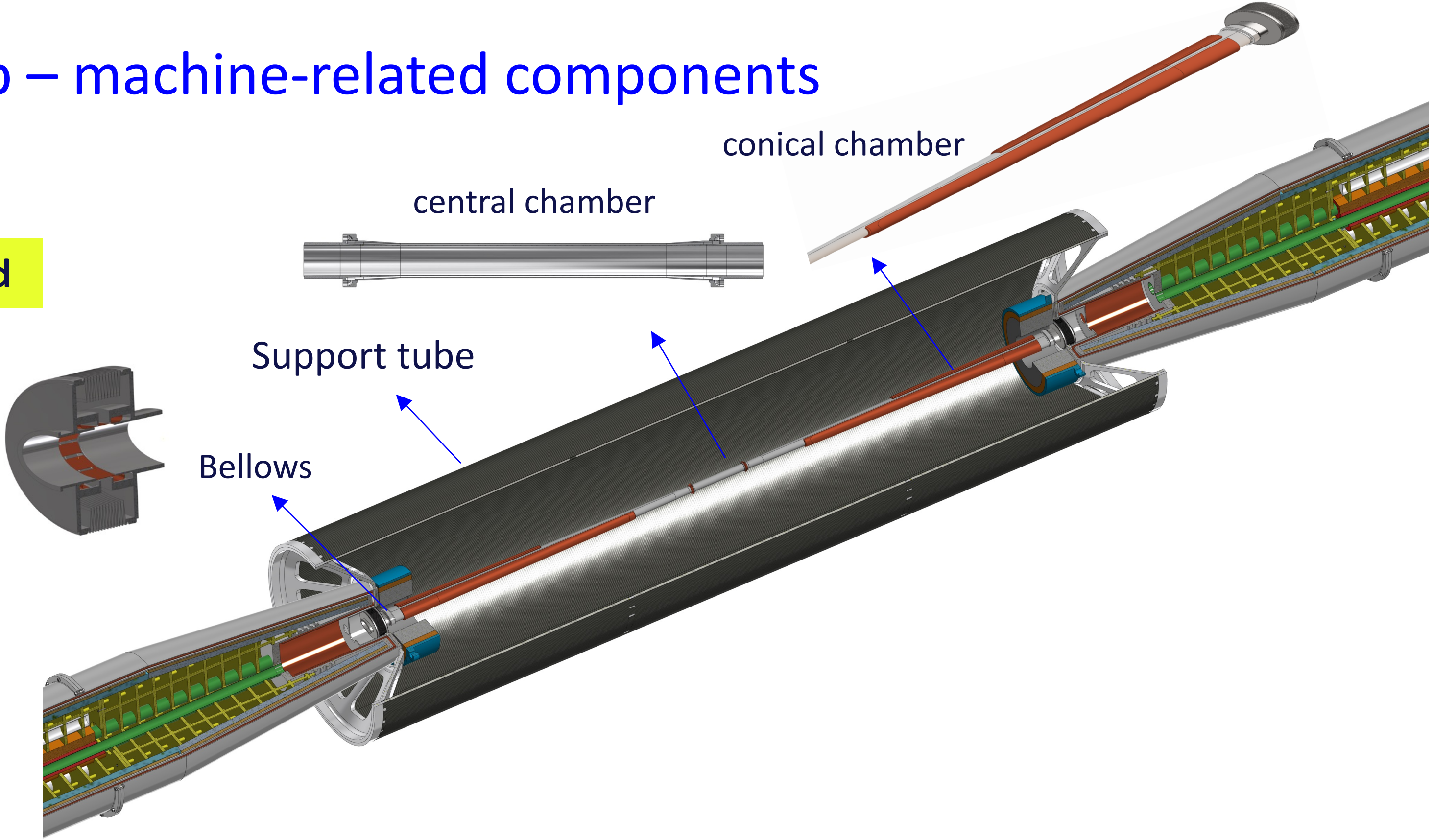
The main identified goals and deliverables are:

- verify the technological feasibility of some key components
- establish the optimal construction sequence of the IR
- finalize the dimensioning of all the components, as close as possible to the final requirement of design, as a result of the complexity of the assembly sequence, including dedicated tools to be developed and survey
- anticipate any possible assembling issue
- tests *in situ* vertex detector air cooling

- Test bench for alignment strategy

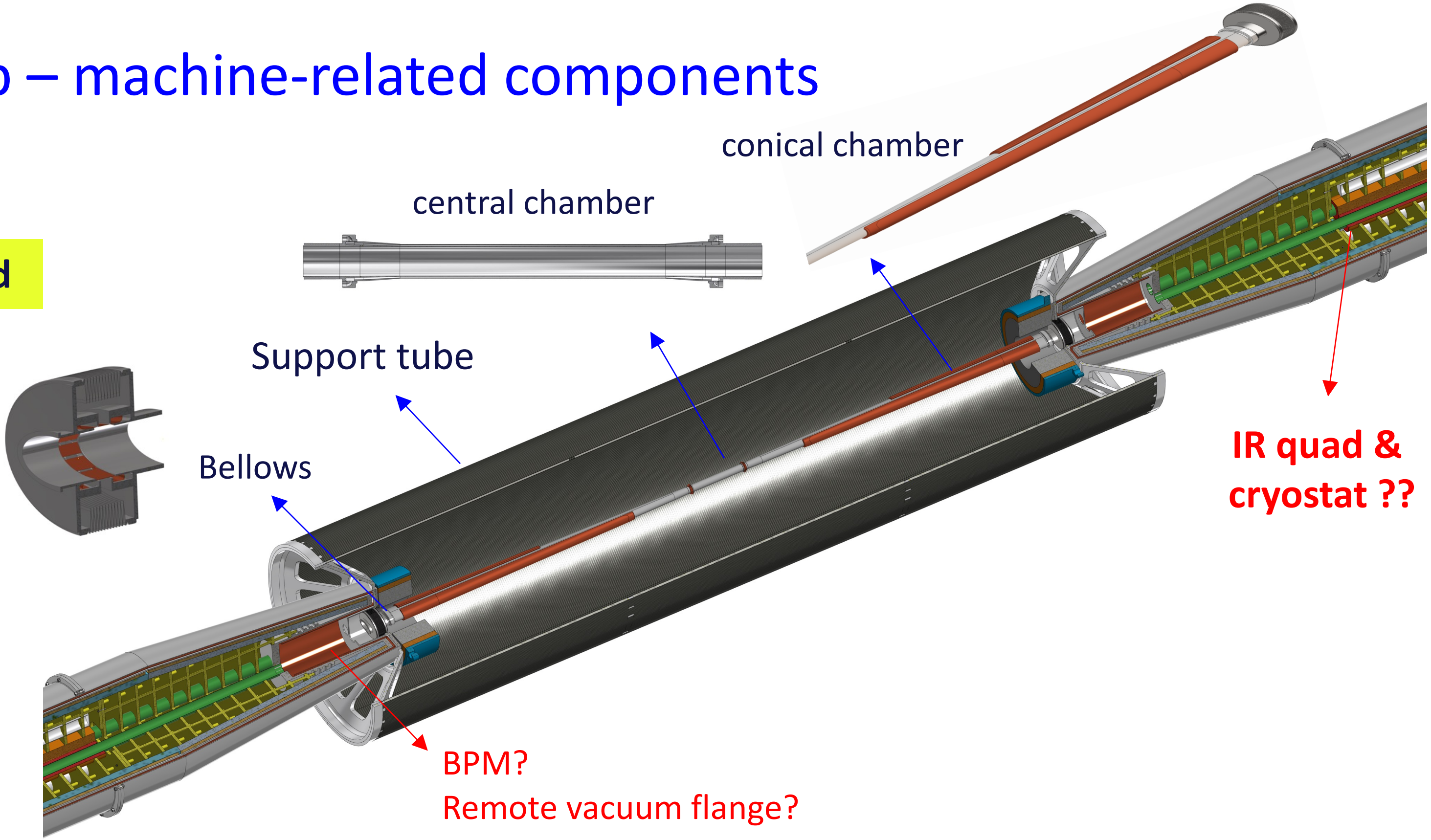
IR Mockup – machine-related components

To be fabricated



IR Mockup – machine-related components

To be fabricated



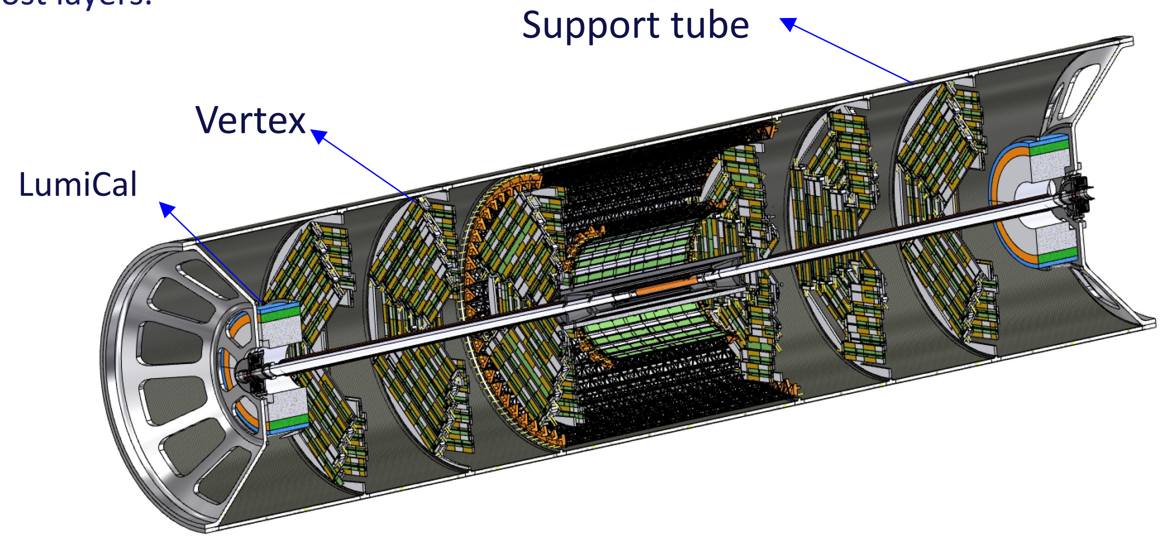
To be addressed during the workshop

IR Mockup –Vertex & lumical detectors

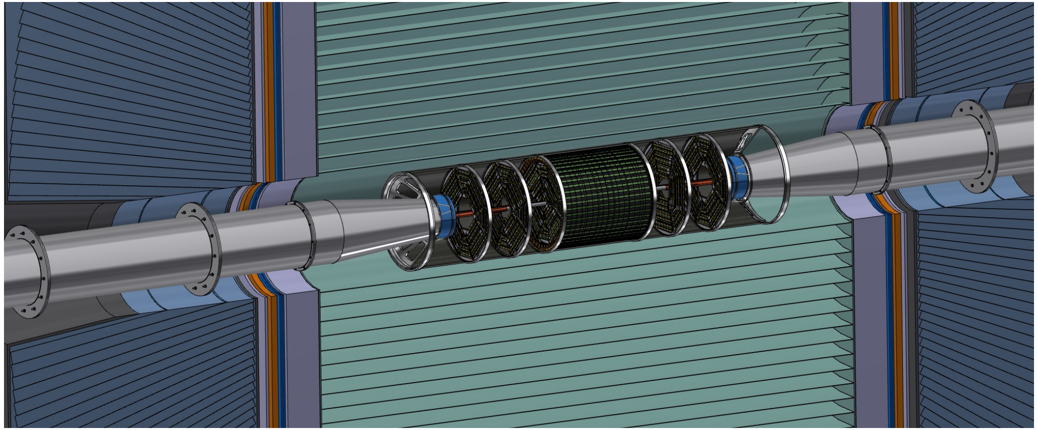
Vertex inside the same volume of the support tube that holds also the LumiCal

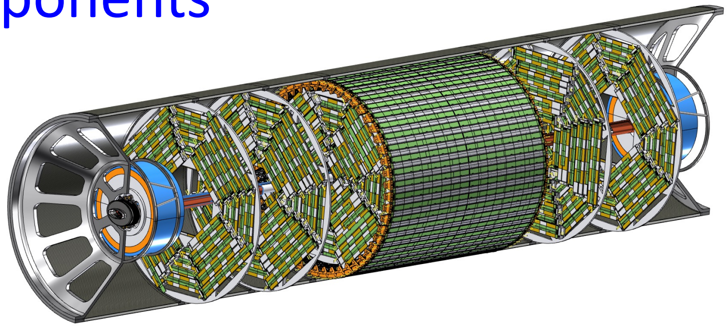
- This study is performed for the IDEA and ALLEGRO concept detector.
- Air cooling test for the innermost layers.
- Services envelope tests.

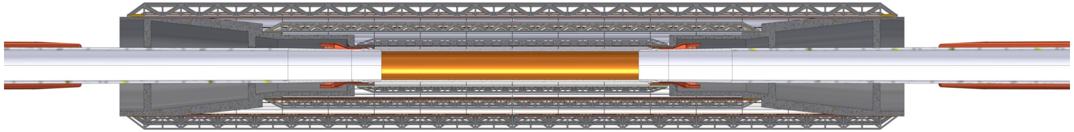
To be fabricated



Vertex integration with accelerator components



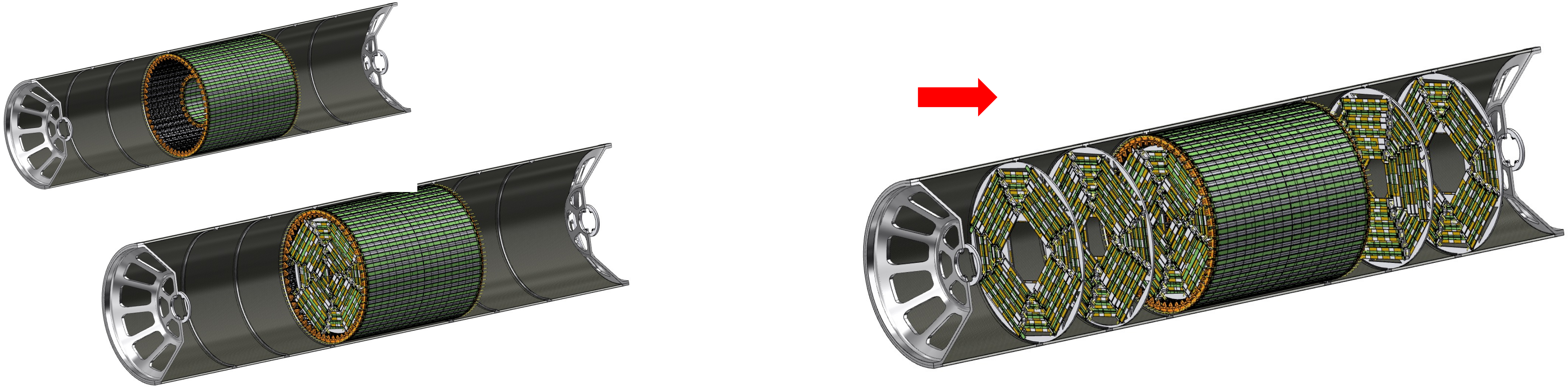




Vertex (MAPS) with 3 inner layers supported by the conical chamber and mounted with the beam pipe and LumiCal to the support tube

Vertex outer layers and 6 disks (MAPS) mounted directly on the support tube.

Current conceptual assembly procedure

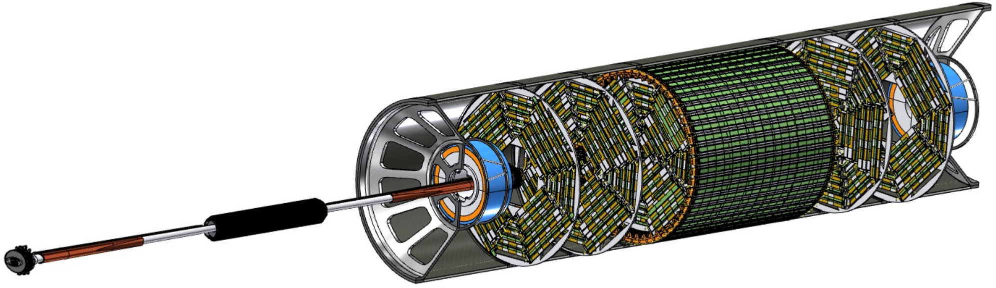


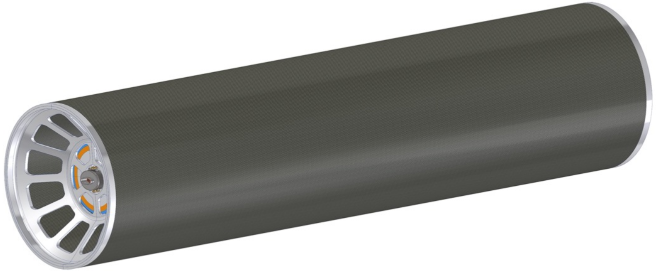
1) Outer vertex tracker, middle vertex tracker and disks 1 installed as a rigid structure inside the support tube

2) Disks 2 and 3 installed inside the support tube

to be revisited addressing the integration of the services

Current conceptual assembly procedure

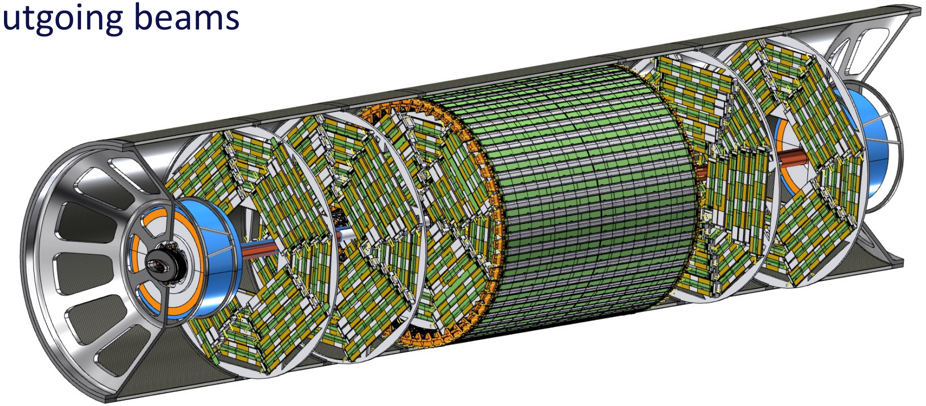




3) LumiCal is installed in centered position, then beam pipe with inner vertex detector inserted with a dedicated tool inside disks and outer vertex tracker, then fixed to both endcaps

→ 4) LumiCal aligned in the correct position on the outgoing beams

→ 5) Support tube closed



to be revisited addressing the integration of the services

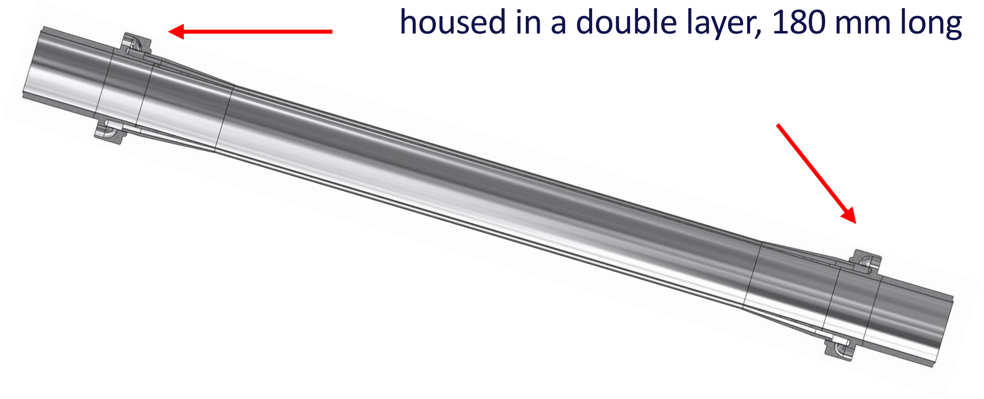
Technological relevant deliverables

see talk by F. Fransesini

Prototype of the Albemet162 central chamber with cooling system to study:

- its thermal interface effectiveness and the tightness of cooling circuits
- the paraffin cooling system pressure drop and thermal exchange coefficient
- the chamber strength in operating conditions (vacuum inside and coolant pressure outside)

Inlets/outlets for the paraffin cooling circuit housed in a double layer, 180 mm long



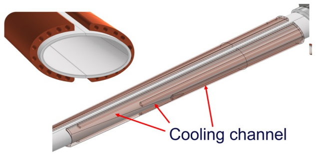
Central chamber in AlBeMet162 with a double layer for the liquid coolant.

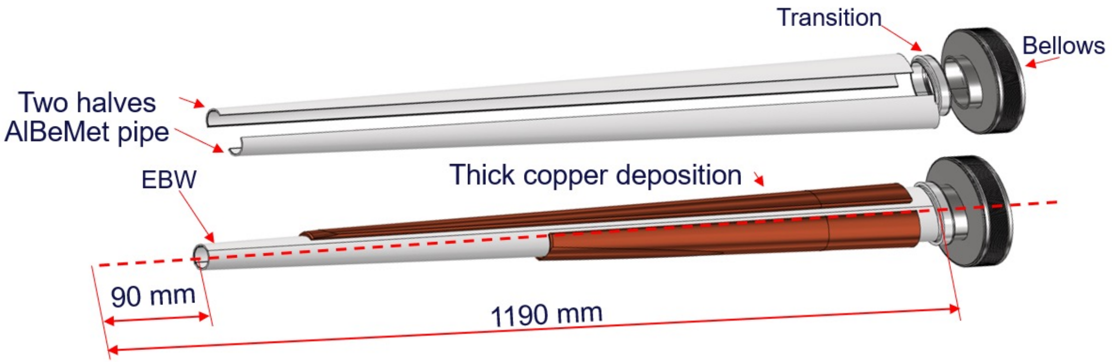
Technological relevant deliverables

see talk by F. Fransesini

Prototype of the conical chamber with cooling system until the crotch, aimed to study the:

- accuracy of the elliptical varying section shape
- thick copper deposition over an elliptical shape with embedded channels
- tightness of the channels and thermal contact between deposited copper and AlBeMet.



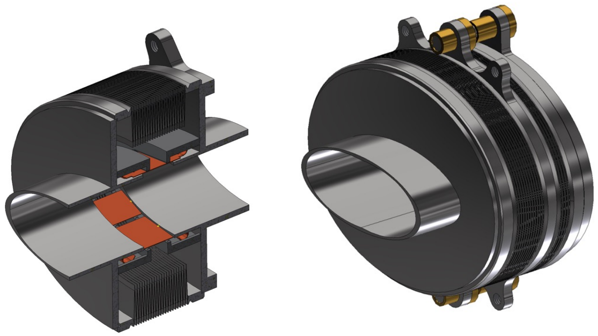


Technological relevant deliverables

see talks by S. Lauciani

Prototype of the bellows aimed to study:

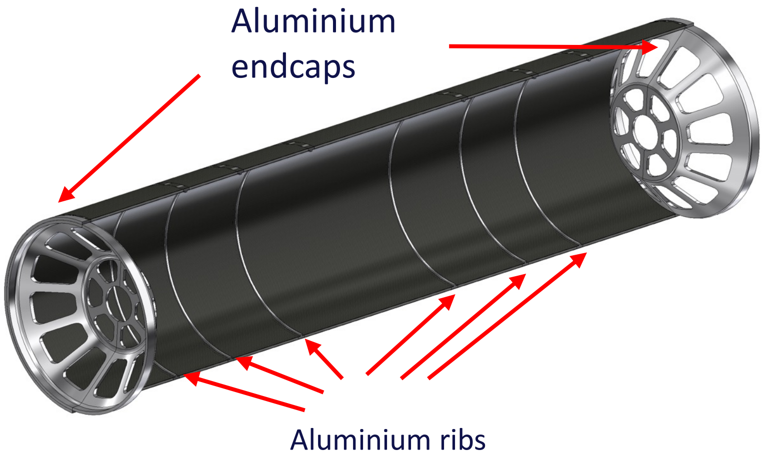
- the fabrication, assembly procedure and electron beam welding over an elliptical geometry
- the thermal/electrical contact effectiveness
- the AlBeMet 162/stainless steel transition.

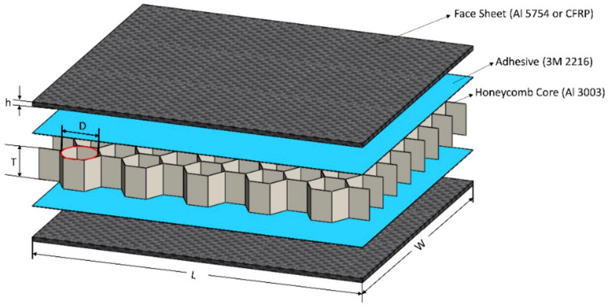


Technological relevant deliverables

Mock-up of the carbon-fibre cylinder support tube with endcaps to verify

- the fiber carbon composite fabrication technology including the reinforcements for anchoring LumiCal and outer tracker
- the shape accuracy and rigidity of the structure





Lightweight carbon fiber & honeycomb tube walls

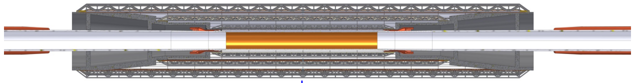
1mm CF + 4mm Al HC + 1mm CF

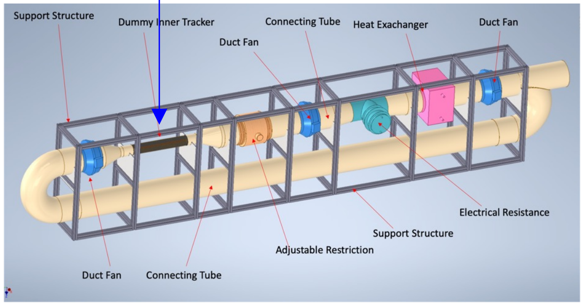
Technological relevant deliverables

see talks by F. Palla, F. Bosi

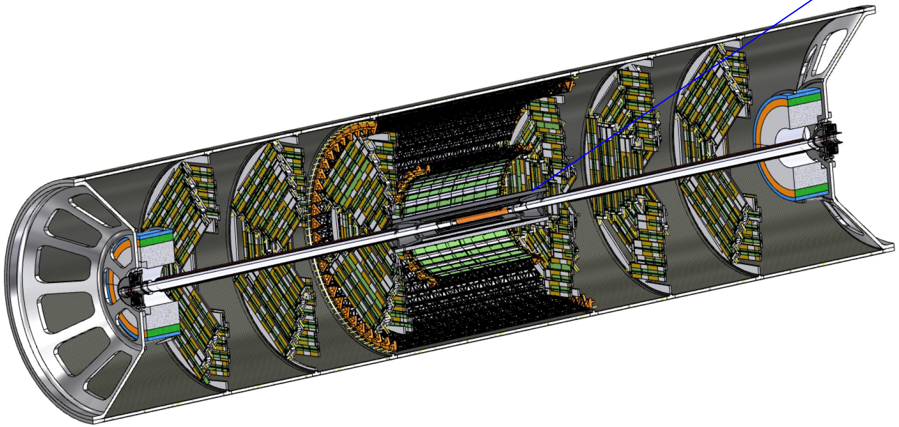
Mock-ups of the vertex detector mechanical structures

- Aluminium for the Outer Vertex part and the discs
- Carbon fibre for the inner vertex detector
- Study of services (cables and cooling pipes) routing
- Validation of inner vertex air cooling
  - Needs a “cooling tunnel” to be implemented





Wind tunnel for VTX air cooling



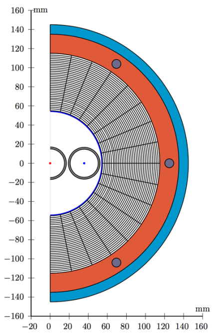
Mechanical temporary support structure (Bosch or similar)

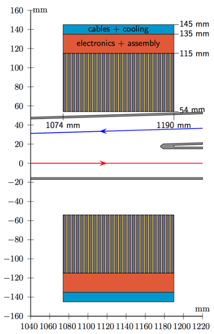
Technological relevant deliverables

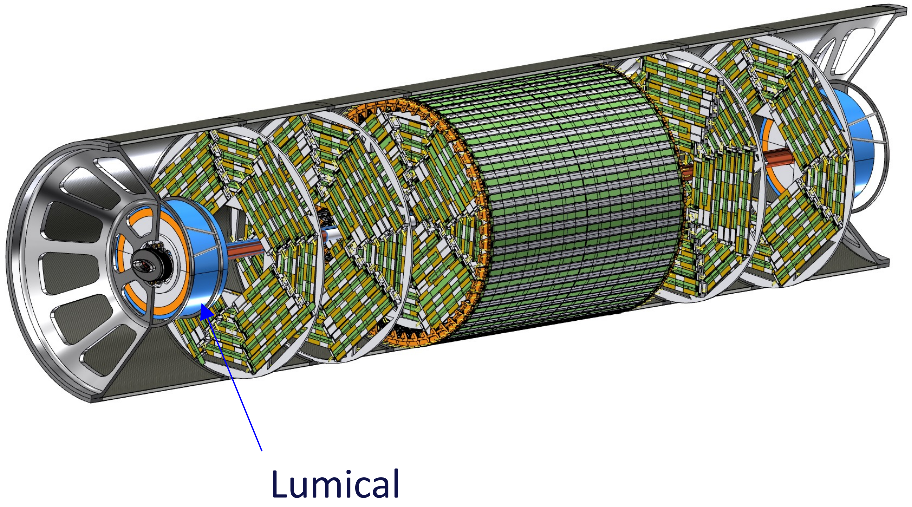
see talk by M. Dam

Mock-up of the Luminosity monitor (Lumical) in *lead (Pb) ?* to validate

- Structural weight analysis on the Support tube
- Installation sequence





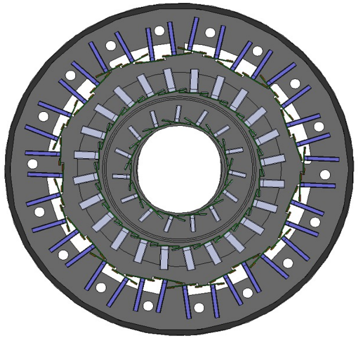


Thermal simulation started

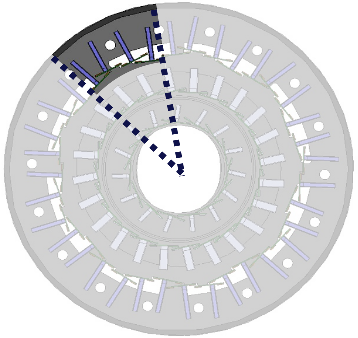
see talk by G. Baldinelli

Start from a radial sector of layer 3 (relying on periodic symmetry) and import in ANSYS FEA. Then move to all other layers.

FIRST STEPS

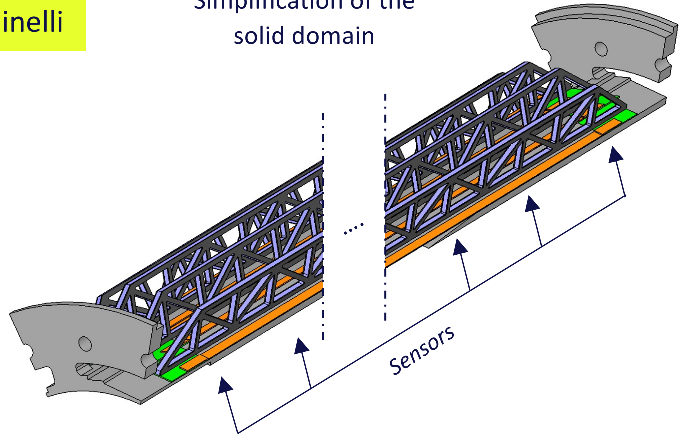


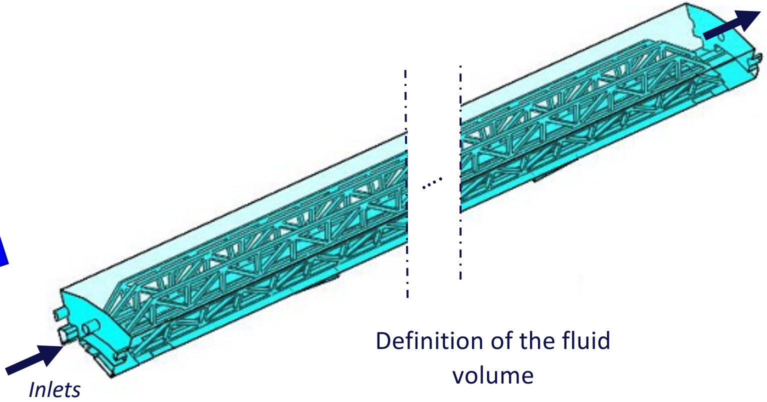
Full model



Extraction of a radial sector for layer 3

Simplification of the solid domain





Definition of the fluid volume

see talk by E. Di Pasquale

Assembling and test lab at the LNF

- Identified one laboratory with a sufficient granite table.
- Some structural and equipment upgrades needed.

Visit to the lab this afternoon

Prototyping FF quad & cryostat

Proposal of IR magnet design and final focus demonstrator (prototype) including correction coils to be pursued between CERN and BNL under discussion.

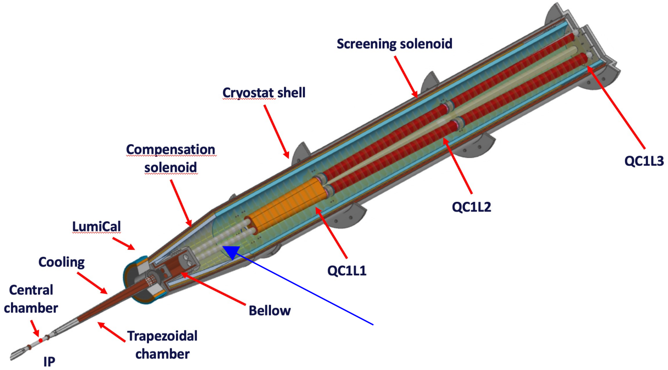
- This prototyping should be in full synergy with the IR mockup
- Coordination required
- possibility of integration to have an extended and consistent mockup comprehensive of the IR quad & cryostat
  - This could also allow for vibration studies

P. Raimondi

New IR quadrupoles asymmetric layout option

MOTIVATION

- Enhance luminosity by squeezing the beam at IP → horizontal and vertical beam sizes decrease by ~ 30%
- Left Final Focus chromaticity and sextupoles are reduced up to 40%
- Sextupoles strength and tolerances scale accordingly (weaker by ~30%-40%) → smaller FF emittance contribution, better dyn. ap.
- FF Left Right sides asymmetries better match the requirements in terms of synchrotron radiation in the IR, because smaller BSC and masking on left side



- E_c ~ 130 keV from last dipoles upstream the IP
- **Chromatic correction sextupoles can be normal conducting** (890 T/m^2, L=0.60 m)

HOW IT CAN BE DONE

- QC1L1 located closer to the IP, as close as possible i.e. up to the crotch, (shorter L* for the incoming beam to the IP), and stronger (~ 130 T/m) → shorter incoming beam sizes and larger stay clear.
- QC1L&R will be interleaved – challenge to compensate the quads magnetic field leakage on the other beam.
- QC1R/L effectively independent.

Conclusion

The mockup project has received a great deal of interest within the FCC community

- primarily for technology validation of the MDI design for the Feasibility Study
- contacted by several groups for additional measurements (e.g., alignment, vibration, diagnostics, ...)

Resources from CERN are being approved.
Despite delays we are working on technical implementation.

And thanks to many people for inputs!

Additional material for the discussion

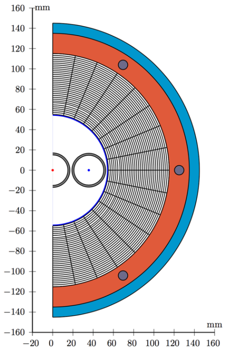
Activity planned for the mock-up for 2024-5

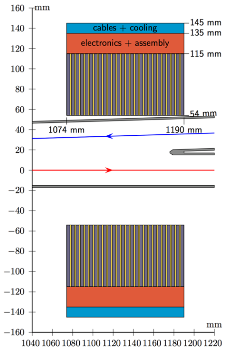
- 1:1 scale mechanical models of the central vacuum chamber and conical chamber including cooling circuits
- Validation test of thick copper deposition on the AlBeMet
- Mechanical model of the bellows
- Executive drawing of carbon-fiber support structure together with Pisa
- Mechanical supports drawing
- Assembly

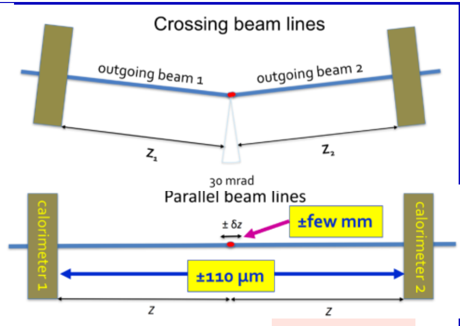
LumiCal Integration

Goal: absolute luminosity measurement 10^{-4} at the Z
Standard process Bhabha scattering

- Bhabha cross section 12 nb at Z-pole with acceptance **62-88 mrad** wrt the outgoing pipe
- The LumiCals are centered on the outgoing beamlines with their faces perpendicular to the beamlines
- Requirements for alignment few hundred μm in radial direction
  few mm in longitudinal direction



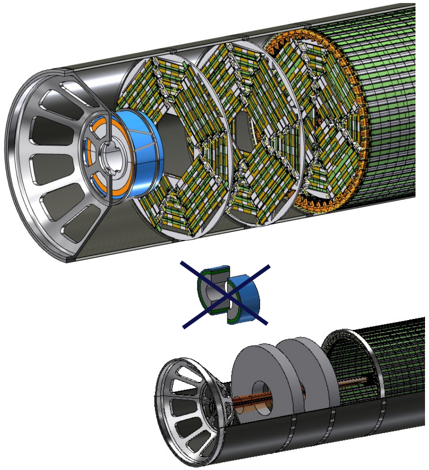




M. Dam

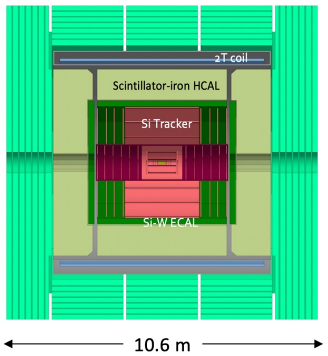
Study on the integration of the lumical performed:

- **Asymmetrical cooling system** in conical pipe to provide angular acceptance to lumical
- **Support tube includes the lumical** (structural analysis with realistic weights performed)
- We avoid the splitting of the lumical in two halves for the assembly
- Engineering of the lumical required



FCC-ee Detector Concepts

CLD

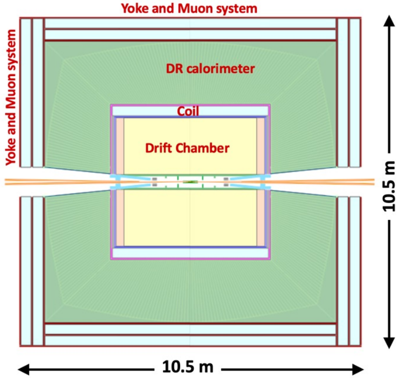


CDR

- Full Silicon vertex detector + tracker;
- Very high granularity, CALICE-like calorimetry;
- Muon system
- Large coil outside calorimeter system;

- Possible optimization for
  - Improved momentum and energy resolutions
  - PID capabilities

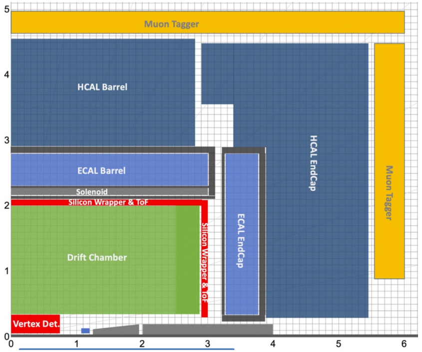
IDEA



- Si vertex detector;
- Ultra light drift chamber w. powerfull PID;
- Monolitic dual readout calorimeter;
- Muon system;
- Compact, light coil inside calorimeter;

- Possibly augmented by crystal ECAL in front of coil;

Noble Liquid ECAL based



new

- High granularity Noble Liquid ECAL as core;
  - PB+LAr (or denser W+LCr)
- Drift chamber (or Si) tracking;
- CALICE-like HCAL;
- Muon system;
- Coil inside same cryostat as LAr, possibly outside ECAL.