INFN LNF
Istituto Nazionale di Fisica Nucleare

# IR MOCK-UP PROJECT FOR THE FCC-EE INTERACTION REGION

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3rd FCC@LNF
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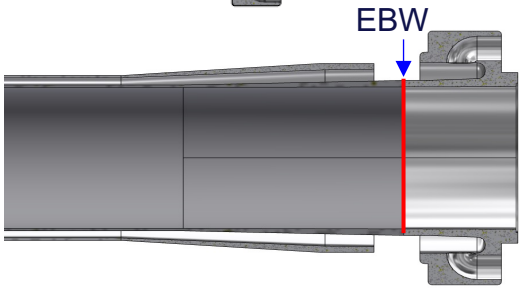
FUTURE CIRCULAR COLLIDER
Innovation Study

# Tentative Milestones (timing relative to T0)

**3 months**: Executive drawings vacuum chamber, bellows.
**6 months:** Executive drawings mock-up vertex.
**12 months:** Executive drawings carbon-fibre cylinder.
**9 months**: Prototypes of vacuum chambers delivered and mockup vertex.
**9-18 months**: Preliminary stand-alone vertex cooling studies at Pisa.
**18 months**: Mockup carbon fibre cylinder delivered, mechanical supports, mockup lumical, mechanical structures, mounting all components together on their supports, and assembly tests.
**18-27 months**: Test of the assembly & Experimental test on vertex detector air cooling
**Additional 2 months of** contingency, to be finished by December 2025.

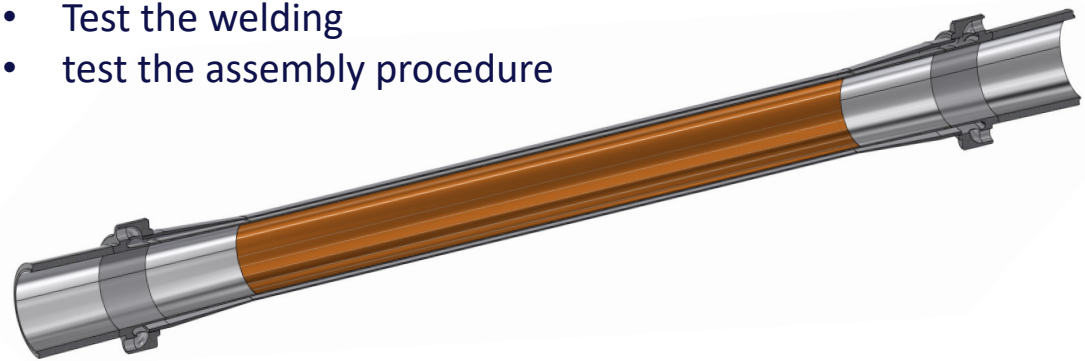
# Technological relevant deliverables – I

## 1. Prototype of the Albemet162 central IP chamber including cooling system and flanges




The distributor of paraffin is welded to the internal part using the EBW (Electron beam welding).

- Test the welding
- test the assembly procedure

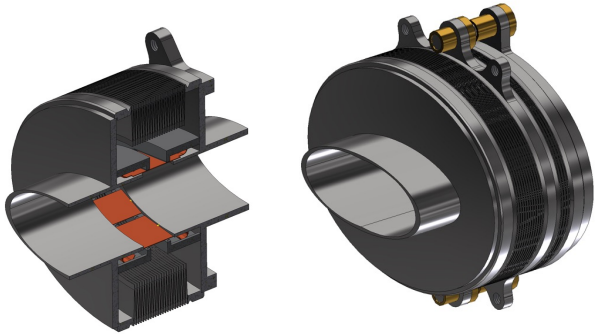


(T0+10 months).

F. Fransesini, MDI meeting 11/9/23, https://indico.cern.ch/event/1316343/

# Technological relevant deliverables – II

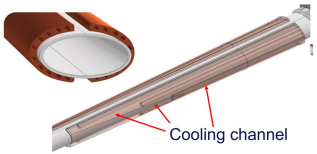
2. **Prototype of the bellows** aimed to study:
   - the fabrication, assembly procedure and electron beam welding over an elliptical geometry,
   - the thermal/electrical contact effectiveness,
   - the AlBeMet 162/stainless steel transition.

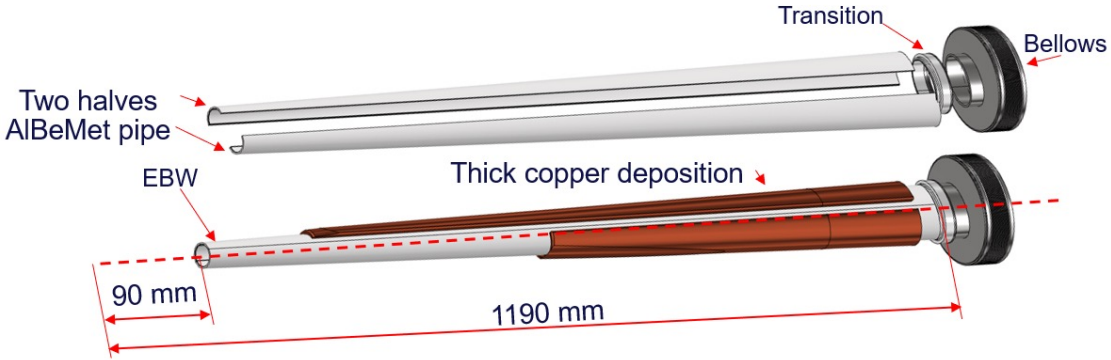


(T0+10 months).

# Technological relevant deliverables – III

3. **Prototype of the trapezoidal 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.

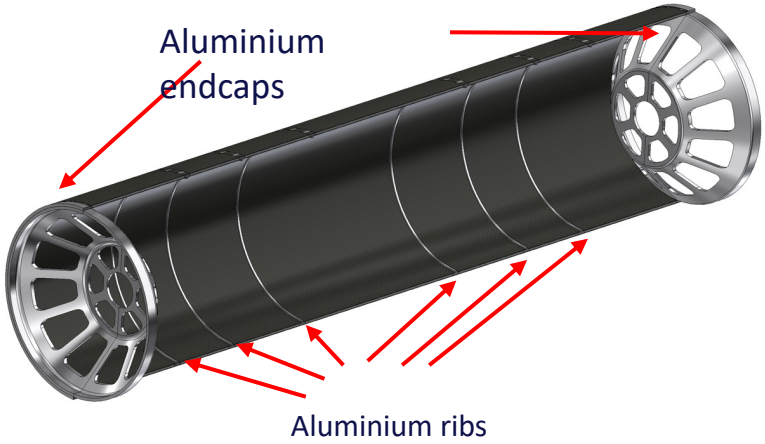


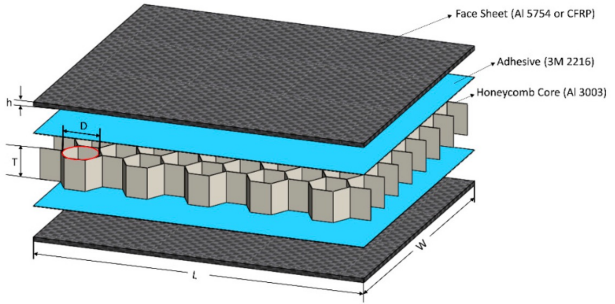




(T0+10 months).

# Technological relevant deliverables – IV

4. **Mock-up of the carbon-fibre cylinder structure with endcaps and its mechanical support**, 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

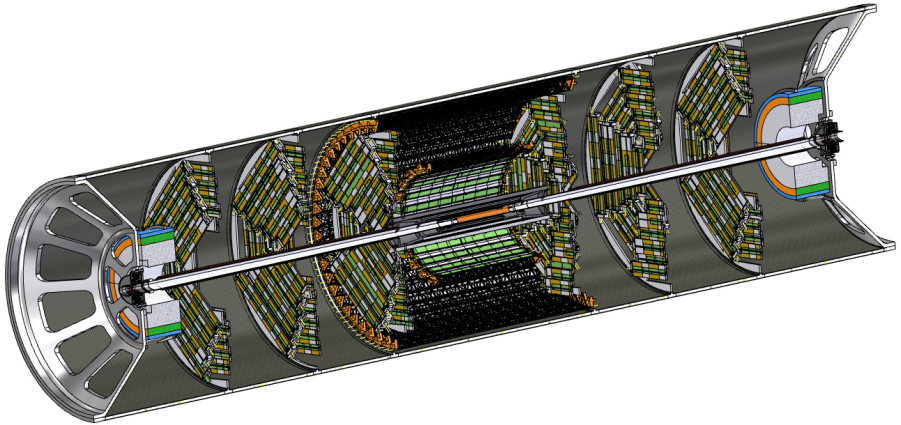



(T0+22 months).

# Technological relevant deliverables – V

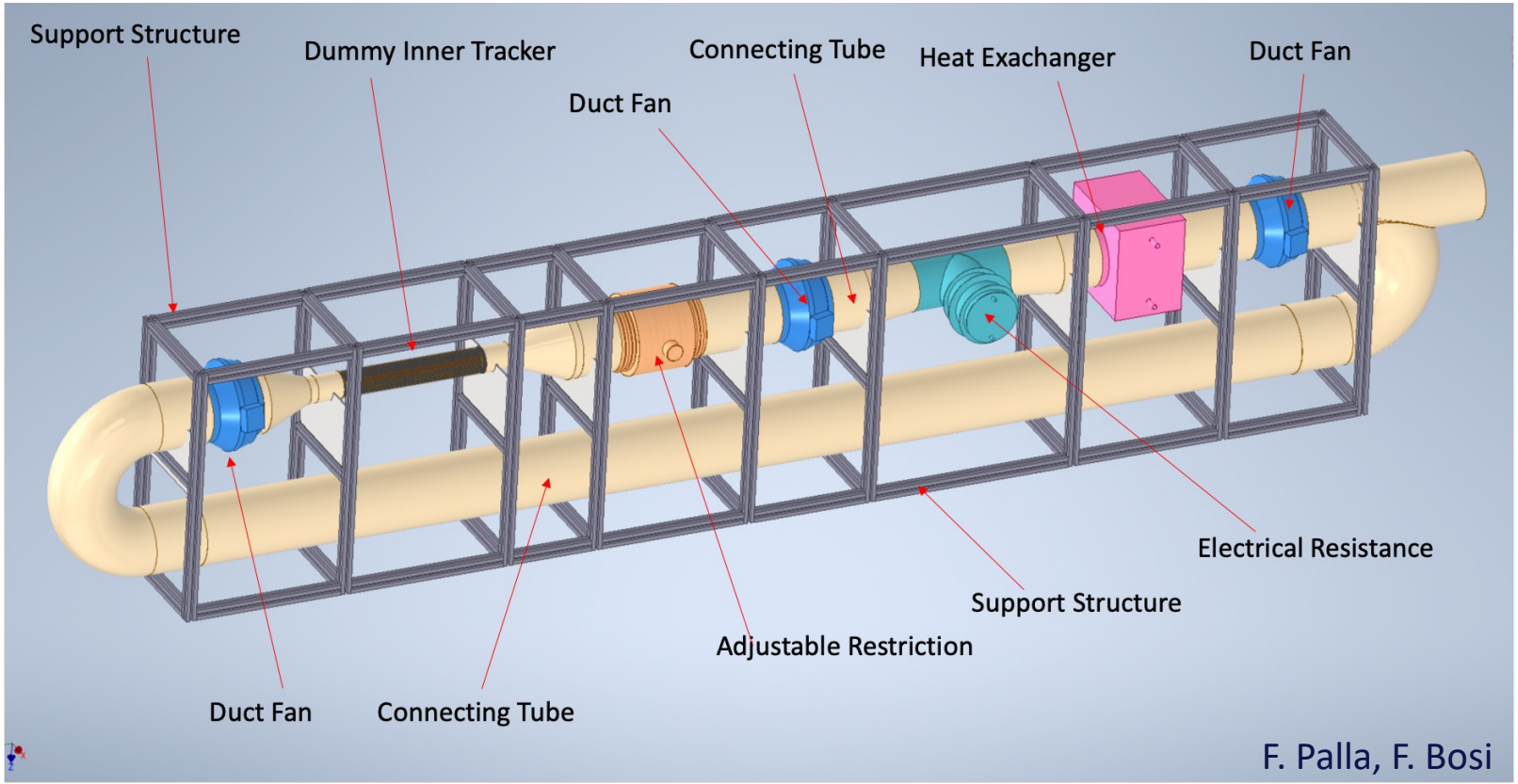
4. **Mechanical temporary support structure** (Bosch or similar)
5. **Mock-ups of the vertex mechanical structures**
   - Aluminium for the Outer Vertex part and the discs
   - Carbon fibre for the inner vertex detector
   - Study of services (cables and cooling pipes) routing
   - Validation of inner vertex air cooling
     - Needs a “cooling tunnel” to be implemented



(T0+22 months).

# Wind tunnel for VTX air cooling

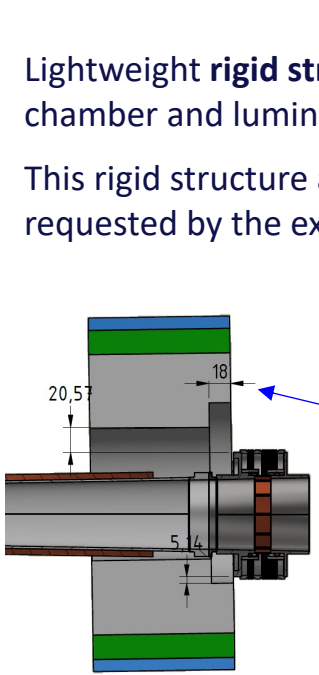
to be tested at Pisa next year, before the test at LNF



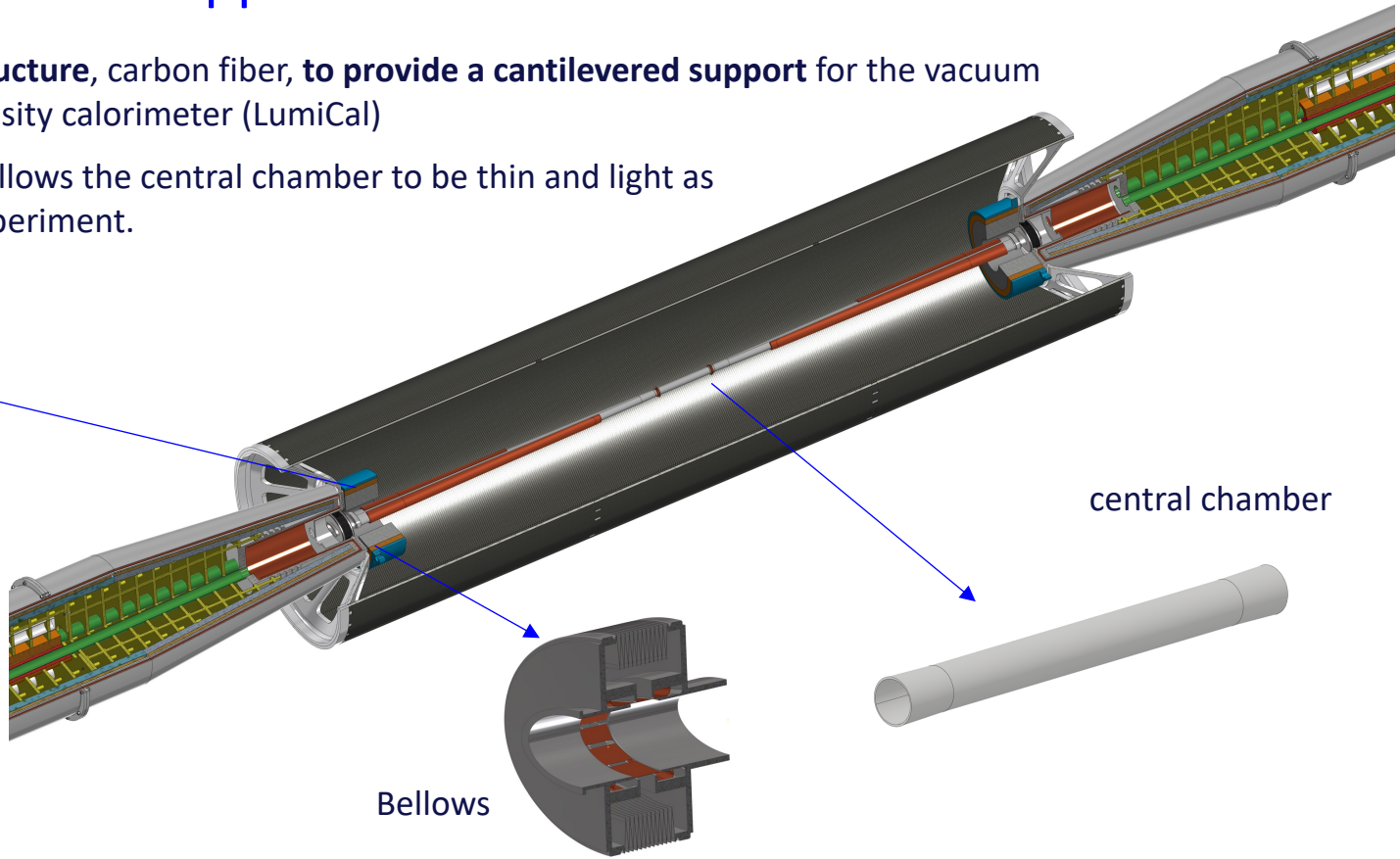
# FCC-ee IR and its support tube

Lightweight **rigid structure**, carbon fiber, **to provide a cantilevered support** for the vacuum chamber and luminosity calorimeter (LumiCal)

This rigid structure allows the central chamber to be thin and light as requested by the experiment.



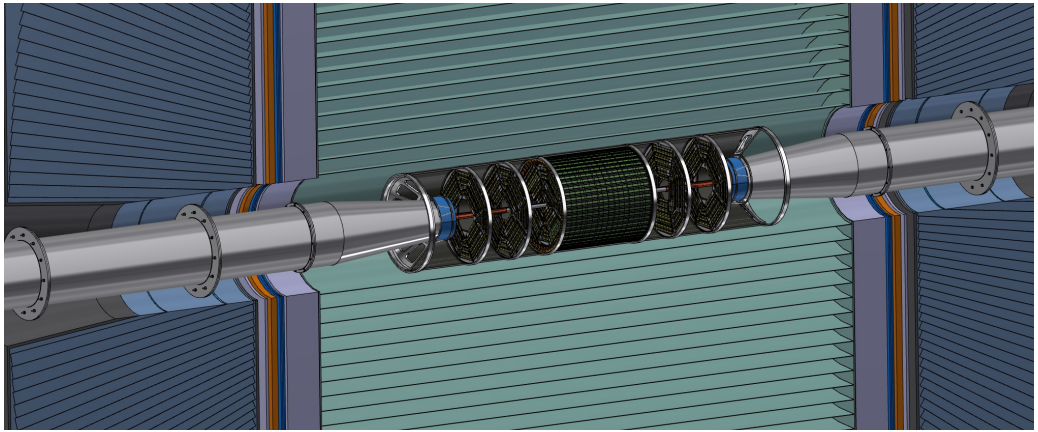

LumiCal

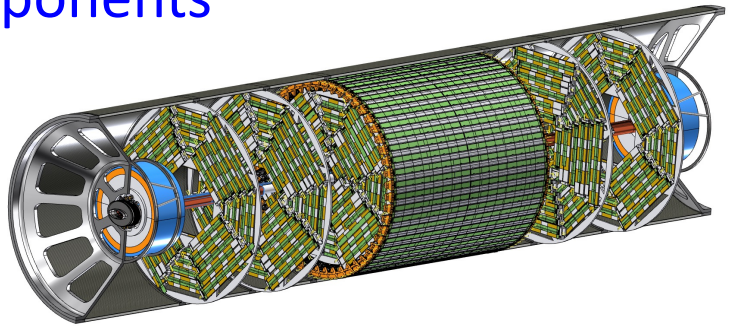


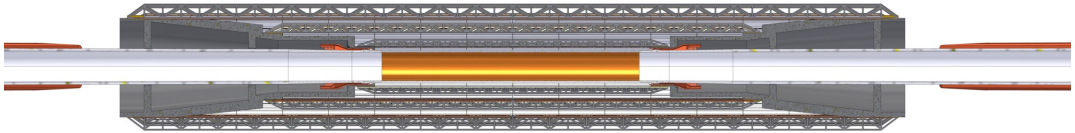
central chamber

Bellows

# 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.

# 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;
- in situ vertex detector air cooling system verification, that takes into account surrounding
- structures. [Similar tests were performed by other experiments like CLIC and CMS]

# Complementarietà tra mockup e modello CAD

- Estensione e copertura
- Modellazione rapida con elevato livello di dettaglio
- Progettazione parametrica
- Simulazioni numeriche
- Facilità di condivisione
- Studi di fattibilità
- Misure in scala reale del comportamento meccanico e termico
- Valutazione delle tolleranze, problemi di allineamento e rilievo
- Valutazione della manutenzione e del funzionamento
- Formazione del personale
- Stima dei costi e della manodopera per la realizzazione finale

# Technological relevant deliverables – V

4. **Mock-up of the Luminosity monitor** (Lumical) in lead (Pb) [funds ?] to validate
   - Structural weight analysis on the Support tube
   - Installation sequence

(T0+22 months).

# Personale

- 1.4 FTE x 2 anni  2 Tecnologi meccanici (LNF)
- 0.3 FTE x 2 anni  1 Progettista meccanico (LNF)
- 0.2 FTE x 2 anni  1 Primo tecnologo (LNF)
- 0.1 FTE x 2 anni  1 Dirigente ricerca (Pisa)
- 0.1 FTE x 2 anni  1 Tecnologo meccanico (Pisa)
- + 1 associato senior tecnologo (Pisa) best effort

- + personale tecnico sia ai LNF che a Pisa

**Team Preliminare:**
LNF: M. Boscolo (PI), F. Fransesini, E. Di Pasquale, S. Lauciani
Pisa: F. Palla, F. Bosi, + ing. mecc. [tbd]
CERN: A. Gaddi, R. Kersevan

# Conclusioni

Il progetto del mockup ha ricevuto un grande interesse all'interno della comunità FCC

- in primis per la validazione tecnologica del progetto MDI per il Feasibility Study
- contattati da diversi gruppi per misure addizionali (e.g. allineamento, vibrazioni, diagnostica, ...)

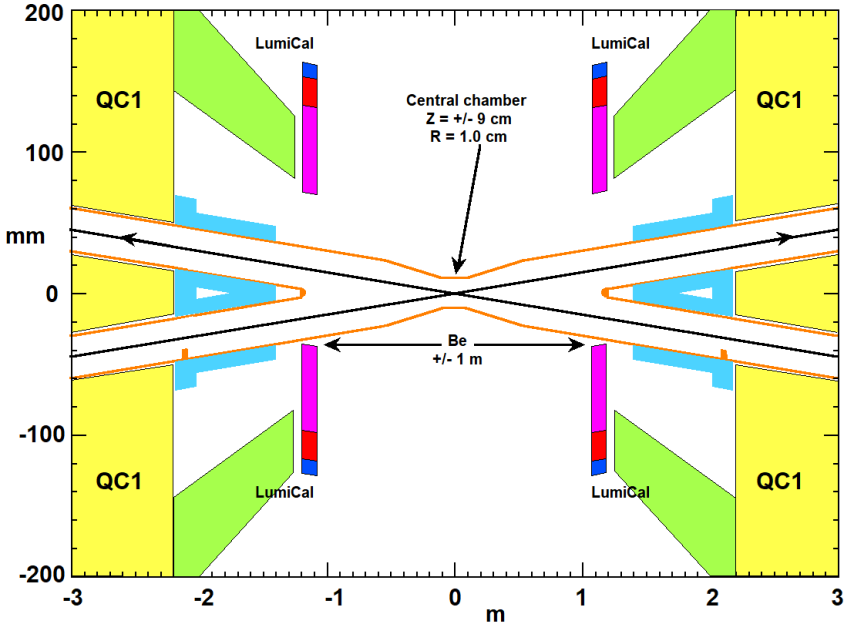
Le risorse da parte del CERN sono in via di approvazione.
Nonostante i ritardi accumulati stiamo lavorando all'implementazione tecnica.

FCC IR mock-up project has additional benefits

- It will give visibility to the LNF and to INFN not only within the FCC collaboration, but for the R&D Accelerator programs for the next EU Strategy.
- It will allow reinforcing the small but excellent & engaged INFN-FCC accelerator core team which has been slowing forming and growing these years around FCC-ee.

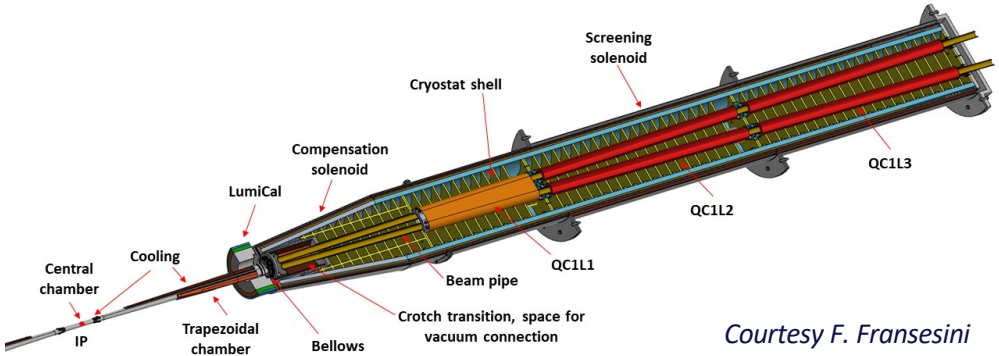
# Additional material

# FCC-ee Interaction Region




FCC-ee IR layout. The face of the first final focus quadrupole QC1, and the free length from the IP, L*, is 2.2 m. The 10 mm central radius is foreseen for ± 9 cm from the IP, and the two symmetric beam pipes with radius of 15 mm are merged at 1.2 m from the IP.

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




*Courtesy F. Fransesini*

This will be inside the detector, being the half-length of the detector ~5.2 m and the end QC1 at about 8.4 m.

# Central Support tube and Vertex integration

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