Overview of the Feasibility Study Report MDI chapter (Vol. 1)

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A big effort by a lot of people!

(see contributors on the final slide)

- Based on the detailed MDI note being written and to be finalised by March
- Chapter 4 of the Feasibility Study Report in Volume 1:
  - 9 ¼ pages
  - 10 Figures
  - 1 Table

Introduction

Table 12: Key parameters of FCC-ee IR for scenarios with 4 IPs.

	Z	W	H	ttbar
Beam energy (GeV)	45.6	80	120	182.5
Luminosity/IP (10^{34}cm^{-2}s^{-1})	145	20	7.5	1.41
beam current (mA)	1294	135	26.8	5.1
bunch number /beam (#)	11200	1852	300	64
bunch spacing (ns)	27	163	1008	4725
σ_x^* (μm)	9.5	21.8	12.6	36.9
σ_y^* (nm)	40.1	44.7	31.6	43.6
bunch length by SR /BS (mm) σ_z	4.7/14.6	3.46/5.28	3.26/5.59	1.91/2.33
energy spread by SR /BS (%) σ_δ	0.039 / 0.121	0.069 / 0.105	0.102 / 0.176	0.151 / 0.184

Sets the stage and gives the main parameters

- Beam crossing angle of 30 mrad in x-z
  - Allows to reach high luminosity
  - Determines the luminous region size in x and z
- Beam power limited to 50 MW (due to synchrotron radiation) by design
  - determines maximum beam current per each c.o.m. energy and therefore limits the available instantaneous luminosity
  - In turn determines the no. of bunches → interaction frequency
  - Also determines the size of the beam in z together with the beamstrahlung
- Final focus superconducting quadrupoles inside the detector (L*=2.2 m)
  - Determines the luminosity and the beam size in y
- Maximum detector B-field at 2 T not to decrease luminosity

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Interaction region layout

- **Beam pipes in AlBeMet (68% Al, 32% Be)**
- **Central beam pipe 1 cm internal radius**
  - Internally 5µm gold coated to reduce impedence and shield of sync. rad. photons.
- **Actively cooled**
  - Liquid paraffin for the central one (60 W) and water for the lateral ones (130 W).
- **Minimised material budget**
  - Central beam pipe double wall AlBeMet, paraffin and Au (0.68% X_0)
  - Lateral beam pipes minimised within LumiCal acc.: (mostly 7% X_0, few regions up to 50% of X_0). Shaped to minimise showers off manifolds

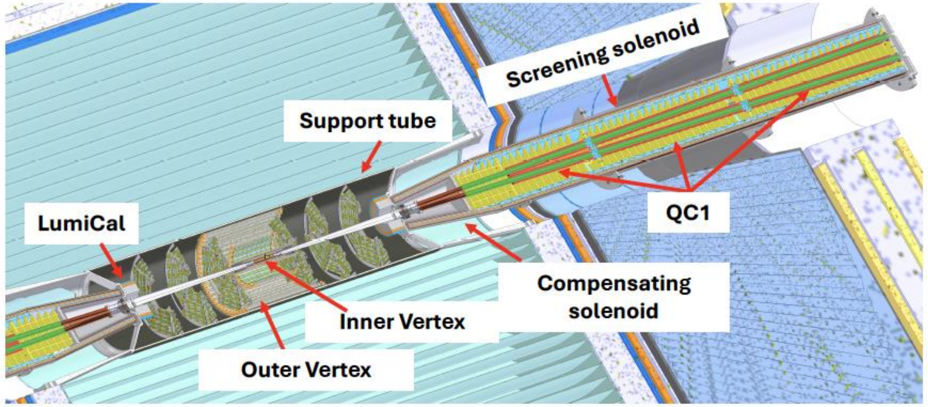

Fig. 47: Interaction Region overall layout. The support tube allows to integrate the luminosity calorimeter (LumiCal) and the vertex detector. Also shown the three segments of the final focus quadrupoles (QC1) together with the screening and compensating solenoids.

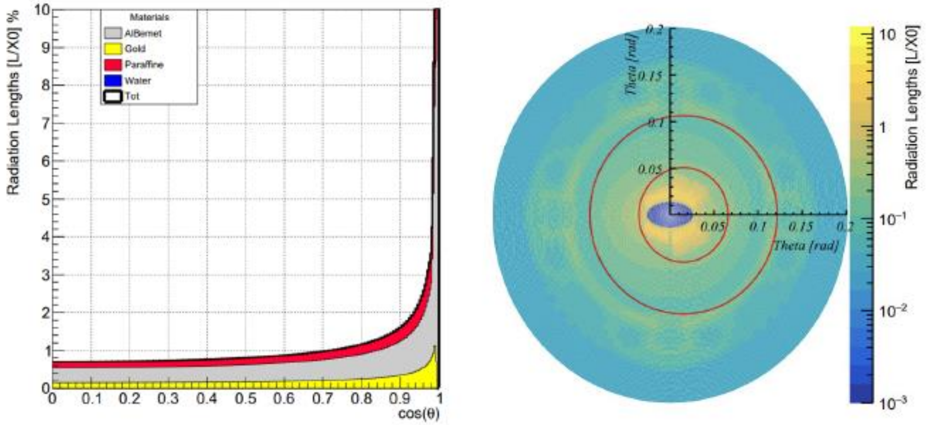

Fig. 50: Material budget of the beam pipe as a function of the polar angle (left) and in front of the LumiCal (right) in the region $\theta \in [0, 0.2]$ rad. The red lines represent the LumiCal acceptance, i.e. the 50 mrad and 105 mrad cones.

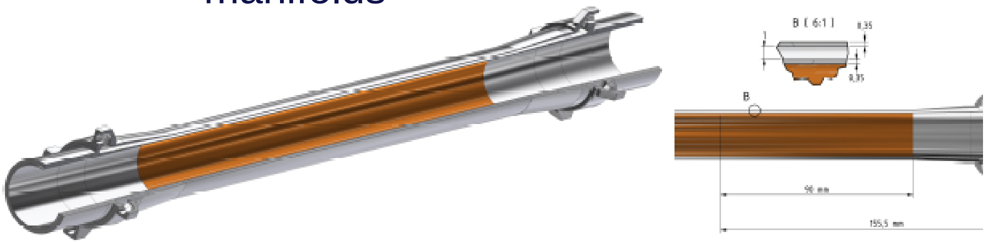

Fig. 48: Central chamber in AlBeMet162 including cooling inlets and outlets (left); cross-s and zoom of the structure of the cooling channel for the paraffin flow.

Fig. 49: Ellipto-conical vacuum chamber.

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Vertex and LumiCal integration

- **Support tube provides integration of beam pipes, vertex and LumiCal**

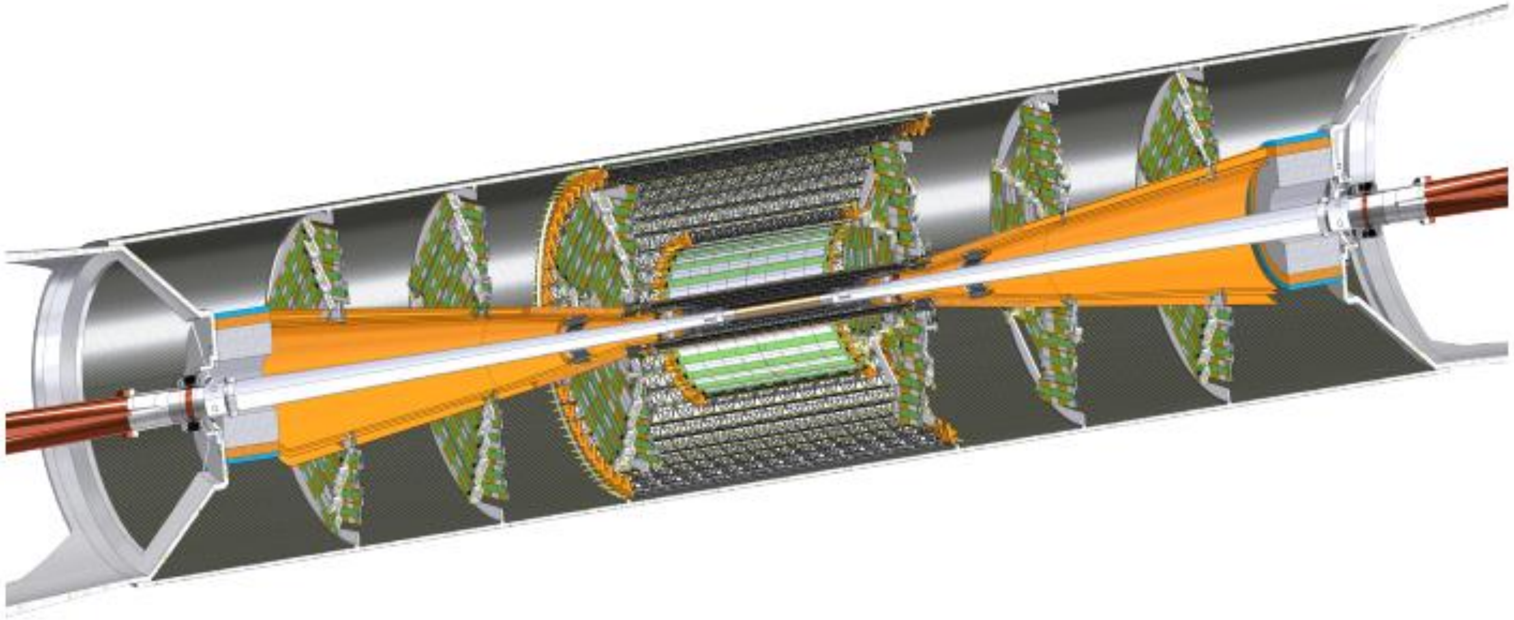

Fig. 53: Support tube showing the supported beam pipes and bellows, the vertex detector with air-cooling cones, luminosity detector, and at the edges, in brown, the vacuum chambers internal to the cryostat (not shown).

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Vertex and LumiCal integration

- **Inner vertex detector anchored to the lateral beam pipe and air(or He)-cooled:**
  - maximum $\Delta T < 15ºC$ and maximum vibration 1.5 µm radial (reported in the detector chapter).
- **Integration with central beam pipe services and cooling cones has been engineered**

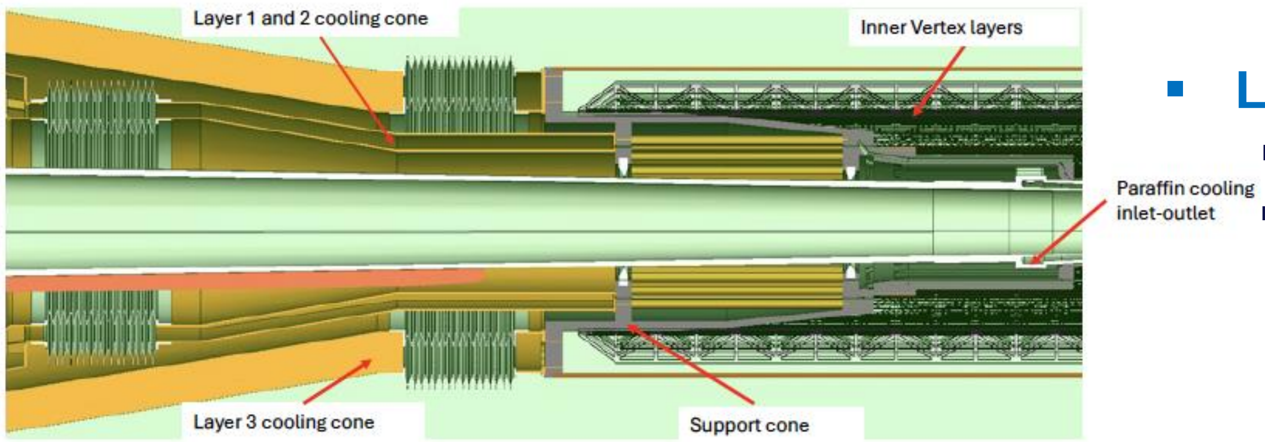

Fig. 52: Longitudinal section of the beam pipe and the inner vertex. The dark gray object is the conical support of the vertex detector, which is supported by the conical beam pipe. At the edge of the support cone, the inlet/outlet paraffine of the central chamber cooling manifolds are visible. The orange structures show the cooling cones.

- **LumiCal integrity has been preserved**
  - Important for energy resolution
  - Mounted sliding it through the beam pipe and bellows

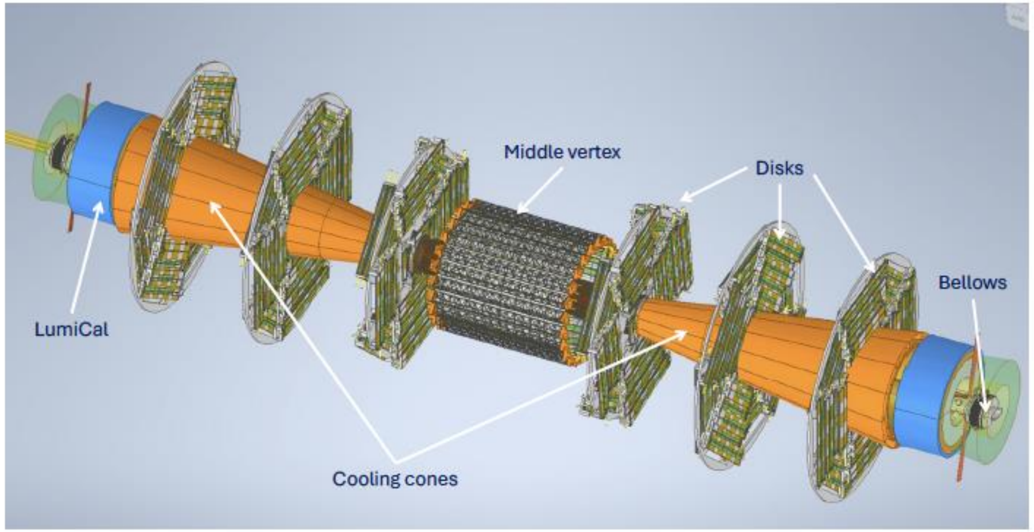

Fig. 51: Layout of the vertex detector cooling cones assembly, together with the main elements to be integrated around.

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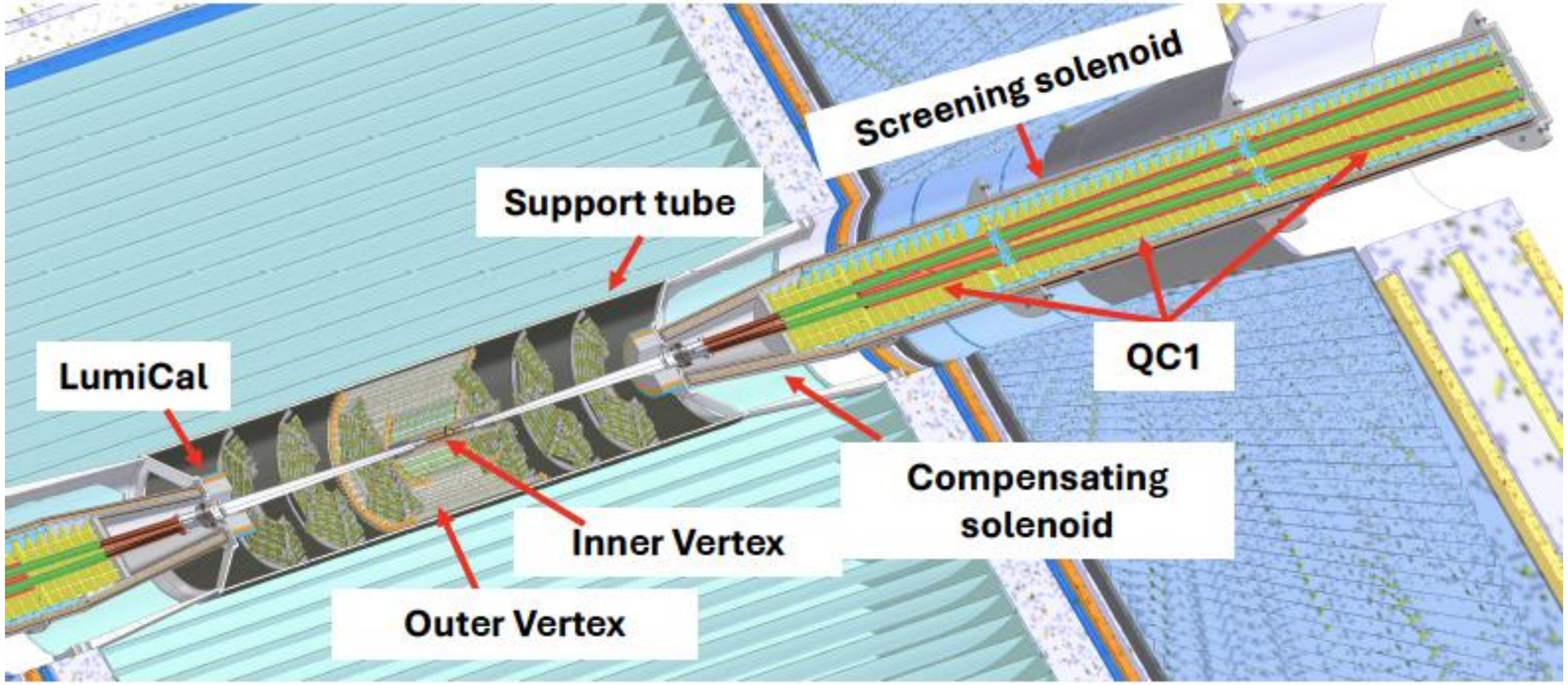
IR magnet system integration

- IR magnet system inside the detector and is all cryogenic
  - Compensating solenoid
  - Final focus quadrupole QC1
  - Screening solenoid



Space budget is critical, especially for the first segment of QC1, due to the close proximity of the exterior of the two beam pipes because of their size and crossing angle.

Widening the 100 mrad cone size of the cryostat could alleviate the problem, but the impact on the detector calorimeter acceptance needs to be evaluated.

Alignment

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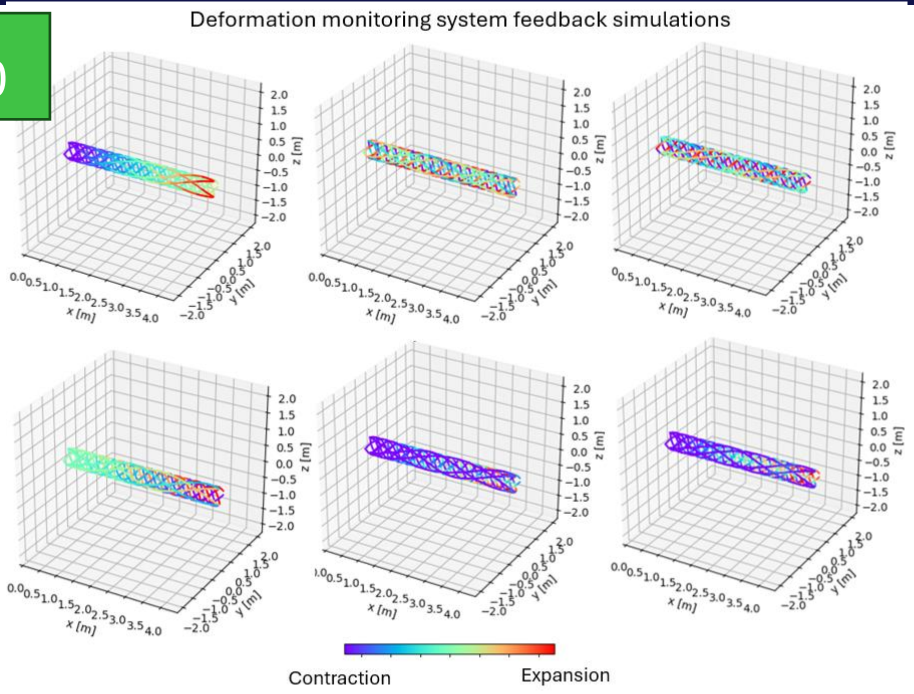
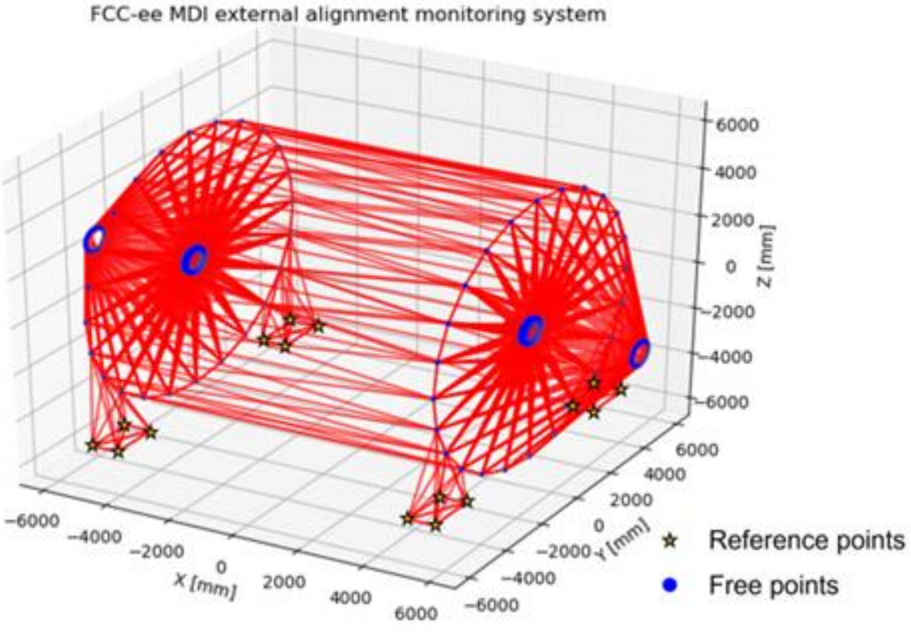
- **Aligment system based on three levels**
  - A deformation monitoring system of the shape of the screening solenoid with laser and fibres interferometric system (IMD-FSI)
  - A short-distance monitoring system, targeting QC1, LumiCal, etc, similar to FSI and HL-LHC MDI
  - A long-range FSI system joining the two sided of the detector





Maintenance and accessability of the detectors

Three options for opening the detector in the caverns

1. longitudinal shift
   - FFQ and other machine elements beyond detector endcaps shall be removed (with their supports). BP vacuum broken also in cold pipes Realignment of the machine needed.
2. longitudinal + transverse shift
   - Split endcaps significantly deteriorate detector precis measurements. BP vacuum stay (or Ne flushing), no realignment needed.
3. Transversal shift of the full detector and the FFQ assembly (parking position), then extraction of the FFQ and full longitudinal opening of the detector endcaps
   - Optimal detector acceptance. FFQ assembly stays inside the detector, temporarily supported by the detector's endcaps. Machine elements beyond detector endcaps also stay in place. BP vacuum broken for detector beampipe. Realignment needed
   - Can only be done for large caverns

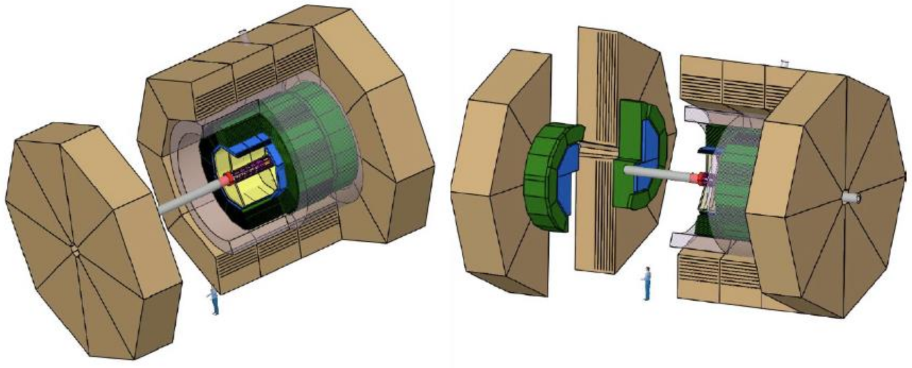
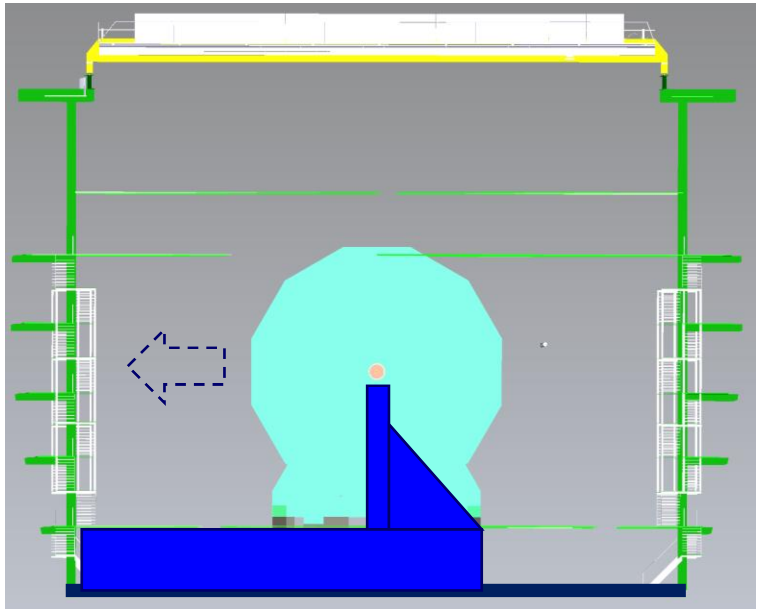


Fig. 54: Longitudinal (left) and short longitudinal plus transversal endcap (right) detector opening



Tuesday MDI session 14 Jan @9.00 and 16.30

Tuesday MDI session 14 Jan @11.00

Beam induced backgrounds

Two classes of backgrounds: single beam and colliding beams induced

- **Single beam induced:**
  - Beam halo losses, due to beam instabilities, interaction with residual gas, intra-beam scattering, magnet misalignments, and magnetic field errors are ‘cleaned’ by the collimator system
  - Beam-gas causes negligible losses in the detector and FFQ
  - Synchrotron radiation caused by imperfections and beam tails are being studied
- **Colliding beams induced:**
  - Incoherent Pair Creation (IPC)
    - 200 MHz/cm^2 in the innermost layer of VDET, 7% occupancy in Drift chamber, 0.2% in ECAL
  - Radiative Bhabha $e^+e^- \to e^+e^-\gamma$, where one particle hits the FFQ or detector elements have a large cross-section and simulated with BBBREM and GuineaPig
    - Large energy deposits in QC1 needs 2.5 to 5 mm tungsten shielding

Total Ionisation Dose and Fluence

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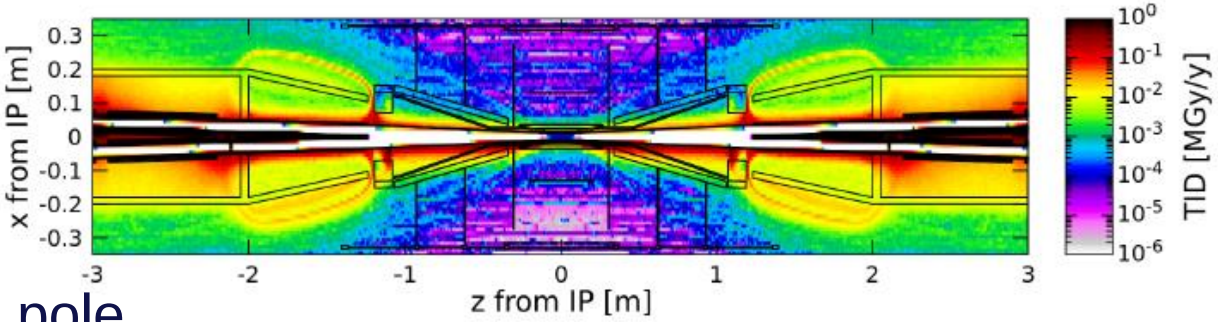
Studied with FLUKA.

At the moment only two major sources: IPC and radiative Bhabha. Beam gas at least one order of magnitude smaller



- Largest dose and fluence occurs at the Z pole
  - Inner layers (barrel and disks) of the vertex detector
    - Few tens of kGy/year
    - 10^{13} /cm^2 1 MeV n_{eq}.

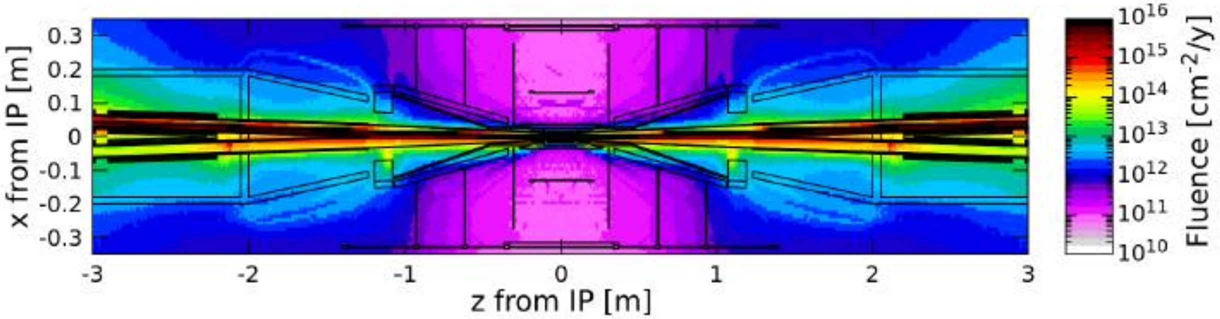
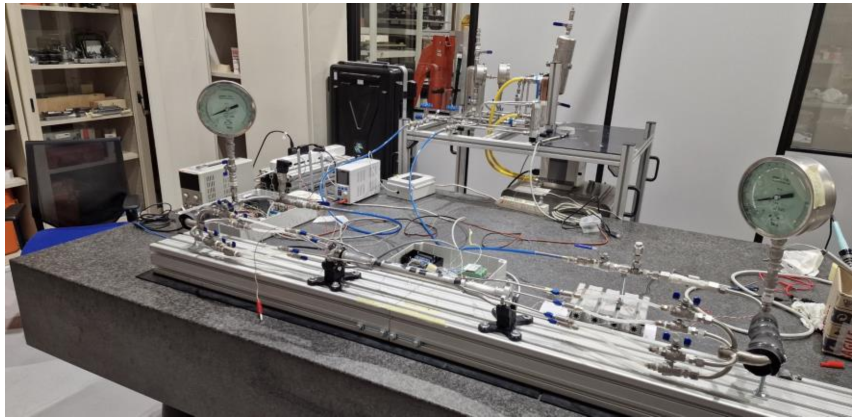


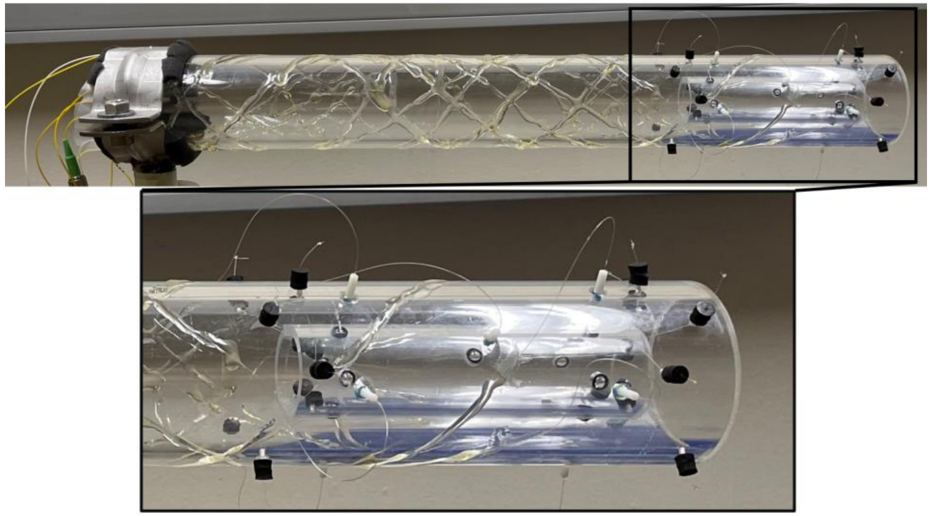
Fig. 56: Total Ionisation Dose (top) and 1MeVn_{eq} fluence (bottom) in the interaction region of the IDEA detector concept.

Experimental activities



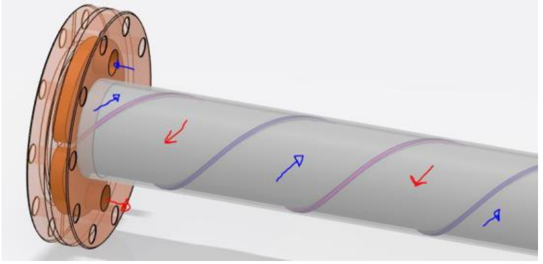
Ongoing activities

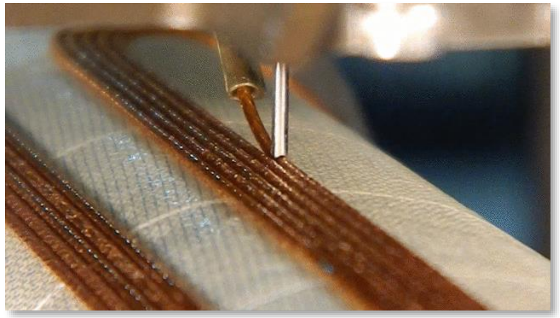
- INFN + CERN: IR full scale mockup in Frascati –
  - Linked to the DRD8 WP1.1
- CERN: Alignment system of the FFQ 1:2 mock-up



- **Proposed activities**

- BNL: QC1 prototypes using direct winding technique
- LAPP: HTS magnet for QC1, and its integration with the water-cooled beam-pipe.





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That's not all … though

MDI is also documented in Vol. 2 (accelerator) where more machine related aspects are addressed

Prospects and next steps will be addressed by Manuela in her talk on Thursday.

List of contributors to the MDI chapter in Vol. 1

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Thank you
for your attention.