RD_FCC

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The activity is organized in Working Packages and the LNF group was involved on WP2 MDI (M. Boscolo, convener), and WP7 Micro-RWELL R&D. We will describe the activities for each WP, where WP2 is also part of the FCC-IS (Innovation Study) EU-H2020-INFRADEV project, started on October 2020. This report includes also the activity for FCC-IS.

An outreach activity connected to future colliders and FCC was carried on and financed by CCN3M, named "What next".

The FCC design study is at the feasibility study (FS) level, which followed the CDR published in 2019. The LNF has good representation in the FCC governance, with the vice-chair of the ICB (M. Boscolo) and WP leader of the FCC FS for the MDI (M. Boscolo).

1 WP2: Machine Detector Interface and FCC-IS EU-H2020 Project

M. Boscolo (resp.), F. Fransesini (AdR), S. Lauciani (Tec), L. Pellegrino, M. Zobov

The activity of WP2 is focused on the design of the interaction region extended to the Machine Detector Interface area for FCC-ee. This activity is also part of the FCC-IS EU-H2020 project, as Task 2.3, and the members of this group work in synergy with FCC-IS. The TD contracts for F. Fransesini, M. Behtouei are indeed covered by external funds from FCC-IS.

The interaction region (IR) is one of the key issues of a collider, it determines its success. It has to provide high luminosity that can be used for physics studies in the detectors with tolerable backgrounds and radiation. For this reason it requires a careful design, balancing the requirements from the accelerator and detector sides.

The mechanical design of the FCC-ee interaction region is a crucial task for the MDI study. In order to ensure an optimal and feasible engineered design, it is necessary to take into account novel technologies and evaluate every aspect, including the manufacturing process and the assembly strategy for all the MDI components (Figure 1).

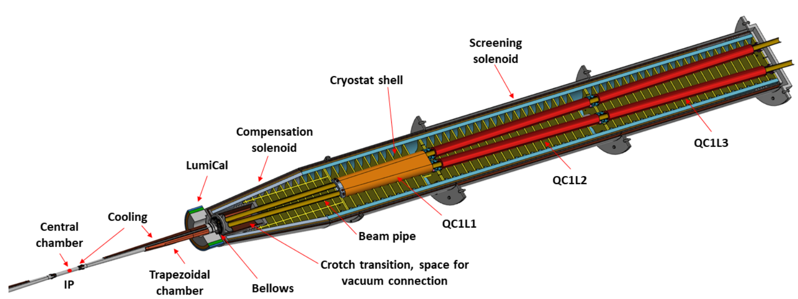


Figure 1: *FCC IR layout*

Figure 2: Central chamber

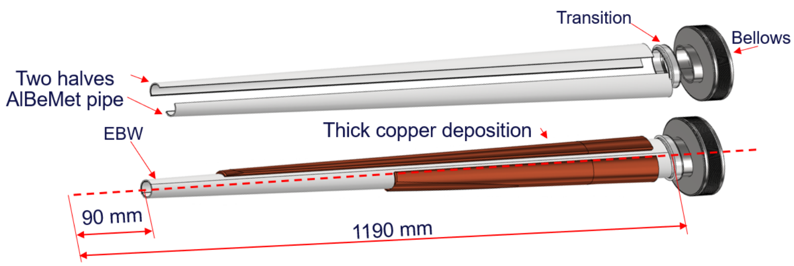


Figure 3: Trapezoidal chamber

During this year, the design changed from a conceptual to an engineered one; with this purpose accurate drawings have been created, including some manufacturing details. The IR vacuum chamber is essential in our design; it is composed of three main parts: the central chamber, starting from 0 to 90 mm from IP; the trapezoidal chamber, starting from 90 mm to 1200 mm; the bellows, with two different concepts. The first part studied is the central chamber (Figure 2), made in AlBeMet162 (62% Be, 38%Al), composed of two concentric cylinders, 0.35 mm thick, divided by a gap of 1 mm for the paraffin flow, to ensure the cooling of the pipe. The cooling inlet and outlet are made of copper, shaped to fit with the vertex detector.

The second part analyzed is the trapezoidal chamber (Figure 3), made in two halves of AlBeMet162, with copper cooling channels.

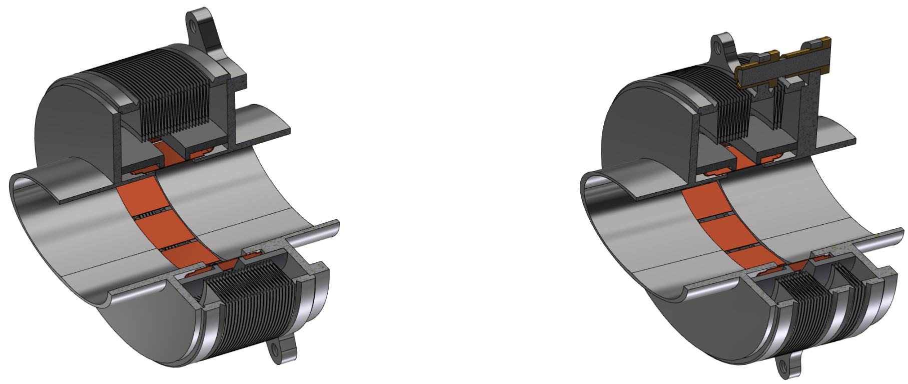
In order to assemble the chamber with the cryo-magnets system, the bellows has been designed. We proposed two different concept according to the different elongations needed and the anchoring point of the chamber (Figure 4).

To support the vacuum chamber, the LumiCal, the vertex detector, inner tracker, outer tracker and medium tracker has been proposed a supporting structure made by a support cylinder with reinforcement ribs and endcaps (Figure 5). The cylinder presents a multiple layers structure composed of carbon fiber and honeycomb, adequately arranged.

Another essential part of the activities consists of the structural analysis for the support cylinder and the thermo-structural analysis for the vacuum chamber; both are needed to calculate the stress, strain and displacement due to the loads applied over the structures.

In order to integrate all components of the interaction region, a first assembly strategy has been conceived; the procedure is in continuous update and refinement. Currently the procedure starts with mounting the medium tracker, outer tracker, and disks over one half of the support tube; the subsequent step consists of mounting the LumiCal on the endcaps. At this point, it is possible to slide the chamber and the inner tracker, attached to the chamber, inside the assembled structure; after the alignment of the LumiCal, it is possible to close the support tube mounting the other half and then slide all components inside the main detector.

The LNF group of WP2 studies also the impedance budget for the machine, collective effects, beam-beam with longitudinal impedance, beam backgrounds, and synchrotron radiation. Some of these crucial topics will be studied in more details in 2023, with a new post-doc that will be hired with the FCCIS EU-H2020 INFRADEV external fund.



(a) Single bellows (b) Double bellows

Figure 4: Bellows concepts of FCC IR

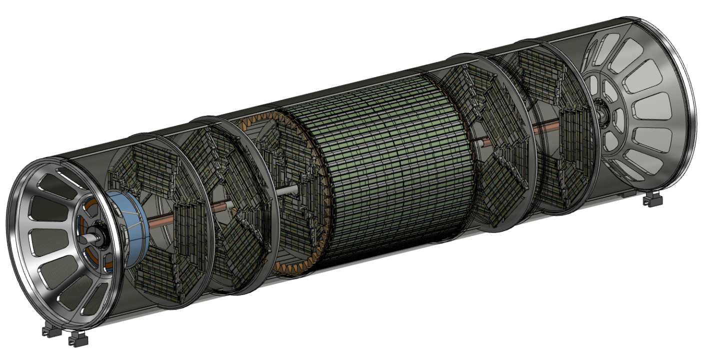


Figure 5: Support tube

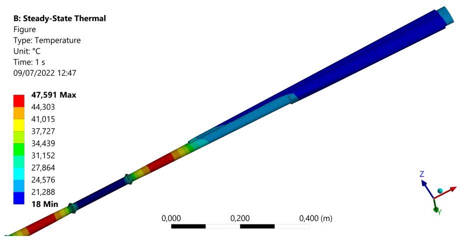
Regarding the impedance model and collective effects, we calculated the longitudinal and transverse impedances of FCC collimators. To accomplish this, we utilized the ECHO3D code to run simulations. We cross-checked our results using CST particle studio for long bunches, and found them to be in good agreement. For short bunches, we used the convolution method to compare the results. We have also calculated the impedance of Bellows using CST (original shape proposed by CERN Vacuum group).

2 WP7: Micro-RWELL detectors

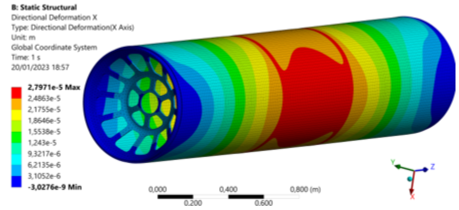
The RD on the u-RWELL detectors for the RD_FCC project is described in the paragraph DDG_LAB of the laboratori tecnologici section.

3 List of Invited Talks on FCC

1. M. Boscolo, Overview of accelerators deliverables for the FCC Feasibility Study, FCCFrance & Italy Workshop, Lyon, Nov. 2022.



(a) FEA chamber



(b) FEA support tube

Figure 6: FEA

2. M. Boscolo, FCC, Giornata Acceleratori, Milano 8 Aprile 22.
3. M. Boscolo, FCC accelerator activities: Italian involvement, First FCC-Italy workshop, 21 March 2022.
4. M. Boscolo, FCC, INFN-Accelerator seminar, 11 March 2022.

4 Invited Talks on WP2 MDI at conferences and workshops

5. M. Boscolo, MDI workshop summary, FCC-IS 2022 Workshop, CERN, December 2022
6. F. Fransesini, MDI mechanical model and mockup plans, FCC-IS 2022 Workshop, CERN, December 2022
7. M. Boscolo, FCC-ee MDI, FCC France & Italy Workshop, Lyon, Nov. 2022
8. F. Fransesini, Mechanical design of FCC IR, FCC France & Italy Workshop, Lyon, Nov. 2022
9. M. Behtouei, FCC-ee Collimator Impedance Model, CC-EIC Joint & MDI workshop, CERN, Oct. 2022.
10. M. Boscolo, FCC-ee MDI, FCC-EIC Joint & MDI workshop, CERN, Oct. 2022
11. M. Boscolo, FCC-ee IR mock-up, FCC-EIC Joint & MDI workshop, CERN, Oct. 2022
12. F. Fransesini, IR Engineering:Thermal and Structural Issues, FCC-EIC Joint & MDI workshop, CERN, Oct. 2022
13. F. Fransesini, S. Lauciani, Mechanical model of IR and IR vacuum chamber, MDI #42 & Detector Concepts, CERN, Sep. 2022
14. M. Boscolo, FCC-ee MDI, 65th ICFA Adv. BD Workshop, eeFACT22, Frascati, 13 September 2022
15. M. Boscolo, Interaction Region of the FCC-ee, 108 Congresso Nazionale SIF, Milano 12 settembre 2022
16. F. Fransesini, S. Lauciani, Mechanical model of IR and of vacuum chamber, MDI meeting, CERN, Jul 2022

17. M. Boscolo, Overview of the FCC-ee MDI region, FCC week 2022, Sorbonne Université, Paris Jun 2022
18. F. Fransesini, Mechanical design of MDI, FCC week 2022, Sorbonne Université, Paris Jun 2022
19. M. Boscolo, MDI Status and Upcoming plans, 5th FCC Physics Workshop, Liverpool 11 February 2022
20. M. Behtouei, et al., Collimator model and FCC-ee impedance model, Workshop on impedance modeling and impedance effects at SuperKEKB and future colliders, Tokyo, Japan, December 2022
21. M. Behtouei, et al., Collimator model & FCC-ee impedance model, Joint FCC-France & Italy Workshop in Lyon, France, Novembre 2022 (Invited Talk).
22. M. Behtouei, et al., FCC-ee Collimator Impedance Model, SBAI, Sapienza university of Rome, Novembre 2022.
23. E. Carideo, M. Migliorati, F. Zimmermann, M. Zobov, D.Quartullo, Y.Zhang, M.Behtouei, B. Spataro FCC-ee Collective Effects 65th ICFA Advanced Beam Dynamics Workshop on High Luminosity Circular e+e- Colliders (eeFACT2022), September, INFN-LNF, Italy
24. E. Carideo, M. Migliorati, F. Zimmermann, M. Zobov, D.Quartullo, Y.Zhang, M.Behtouei, B. Spataro FCC-ee Collective Effects and their mitigation, 41th International Conference on High Energy Physics (ICHEP 2022), July, Bologna, 2022.
25. M. Migliorati, C. Antuono, M. Behtouei, E. Carideo, B. Spataro, M. Zobov, Studies and mitigation of collective effects in FCC-ee, Proceedings of the IPAC 2022, Bangkok, Thailand
26. M. Migliorati, C. Antuono, M. Behtouei, E. Carideo, B. Spataro, M. Zobov, Single-beam collective effects, FCC Week 2022 - Campus des Cordeliers - Sorbonne Universite'.
27. M. Migliorati, C. Antuono, M. Behtouei, E. Carideo, B. Spataro, M. Zobov, Impedance budget and single bunch instability for 4IP parameters, 150th FCC-ee Optics Design Meeting & 21st FCCIS WP2.2 Meeting

5 Publications for the year 2022 on WP2 MDI and FCC Accelerator

1. Fatih Yaman, Mikhail Zobov et al., "Mitigation of electron cloud effects in the FCC-ee collider",EPJ Tech.Instrum., Aug. 2022
2. M. Migliorati, C. Antuono, M. Zobov et al., "Impedance modelling and collective effects in the Future Circular e+ e- Collider with 4 IPs", EPJ Tech.Instrum., Aug. 2022
3. M. Migliorati, C. Antuono, M. Behtouei, M. Zobov et al., "Studies and Mitigation of Collective Effects in FCC-ee", JACoW IPAC2022, Jul. 2022
4. E. Carideo, F. Zimmermann, M. Zobov, M. Migliorati, "FCC-ee Collective Effects and their mitigation", PoS ICHEP2022, Nov. 2022
5. F. Zimmermann, M. Boscolo, et al., "Power Budgets and Luminosity Risks of Future Higgs Factories", Jacow, eeFACT22, Sept. 22.

6. F. Bedeschi, M. Boscolo, and M. Cobal, "Future Circular Collider workshop debuts in Italy", CERN Courier 2022 July-August.

7. M. Boscolo, H. Burkhardt, K. Oide and M. K. Sullivan, "IR challenges and the machine detector interface at FCC-ee," Eur. Phys. J. Plus **136** (2021) no.10, 1068 doi:10.1140/epjp/s13360-021-02031-5

8. M. Boscolo, H. Burkhardt, G. Ganis and C. Helsens, "Review and outlook of accelerator-related codes and their interplay with the experiments software," Eur. Phys. J. Plus **137** (2022) no.1, 38 doi:10.1140/epjp/s13360-021-02212-2 [arXiv:2111.09870 [hep-ex]].

9. I. Agapov, M. Benedikt, A. Blondel, M. Boscolo, O. Brunner, M. C. Llatas, T. Charles, D. Denisov, W. Fischer and E. Gianfelice-Wendt, *et al.* "Future Circular Lepton Collider FCC-ee: Overview and Status," [arXiv:2203.08310 [physics.acc-ph]].

10. X. Lou, M. Boscolo and F. Zimmermann, "Status of the ee Collider Projects in Asia and Europe: CEPC and FCC-ee," JACoW **IPAC2022** (2022), 815-820 doi:10.18429/JACoW-IPAC2022-TUIZSP1