



WP1: FE-FRT

Steering Committee Meeting
27.01.2026

Activities Update – Points of attention

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WP1: FE-FRT (Official overview)

HZB, CERN, CNRS, Uni.Lancaster

Convener: Axel Neumann (HZB), deputy Alick Macpherson (CERN)

Main contacts with other partners: Alick Macpherson (CERN), Walid Kaabi (CNRS), Graeme Burt (Uni.Lanc.), industry: Alexei Kanareykin (Euclid Techlabs)



Task 1.1: Coordination of R&D on FE-FRT – M1-M48 (HZB)

- General coordination by HZB.

Task 1.2: FE-FRT for *Transient Beam Loading* – M1-M40 (CERN)

- Design a full FE-FRT-based 400 MHz tuner, applicable to *LHC transient detuning* scenarios.
- Perform full RF, mechanical and cryogenic evaluation of the FE-FRT-equipped . LHC cryo-module.
- Use design lessons learned to design a tuner for transient detuning of FCC 800 MHz multi-cell cavities.

Task 1.3: FE-FRT for *Microphonics* – M1-M48 (HZB)

- Establish characteristics and performance of FE-FRT ferroelectric material at frequencies ≥ 1300 MHz.
- Design, fabricate and validate an FE-FRT for *microphonics suppression* on a single-cell 1.3 GHz cavity.
- Design, fabricate and validate an FE-FRT for *multi-cell cavity at 1300 MHz*, in a cryomodule-like setup.

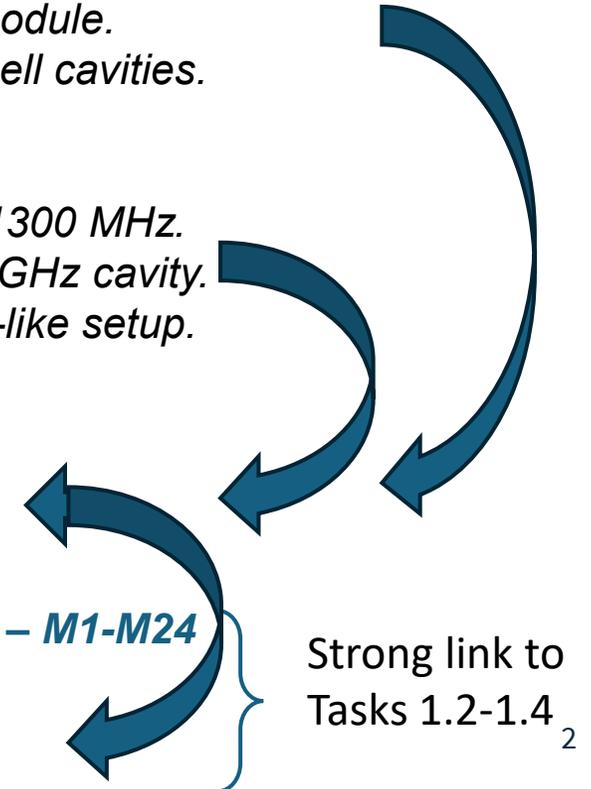
Task 1.4: FE-FRT in Energy-Recovery LINAC (ERL) mode – M1-M48 (CNRS)

- End-group design study for integration into ERL-type cavity, study *HOM+BBU* properties.
- FE-FRT design study for *RF and mechanical integration into upgraded ERL* cavity.

Task 6.2: Retrofitting Fast Reactive Tuners into existing cryomodules HL-LHC oriented – M1-M24

- Study of frequency domain multiplexor-based HOM coupler
- Study the effect of *HOMs on FE-FRT* operation to define max leakage
- Study the heating due to high fundamental power in the coupler

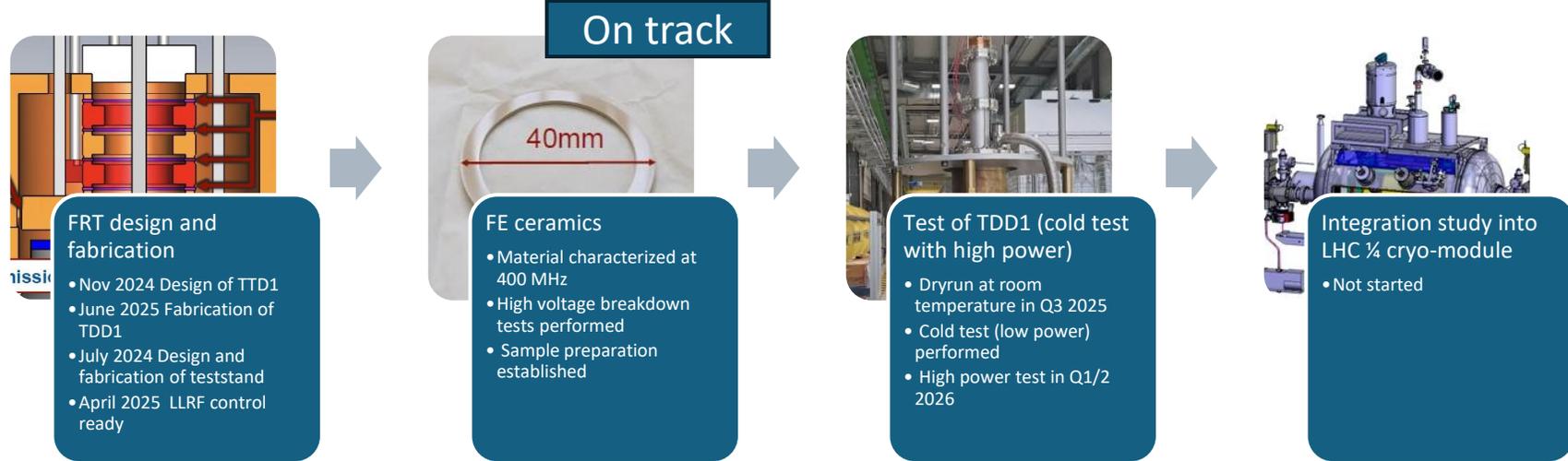
- Task 2.4 *Integrated LLRF control using FE-FRT*
- Task 3.3 *RF tunability*, FE-FRT for Nb3SN coated cavities?



iSAS timeline and milestones

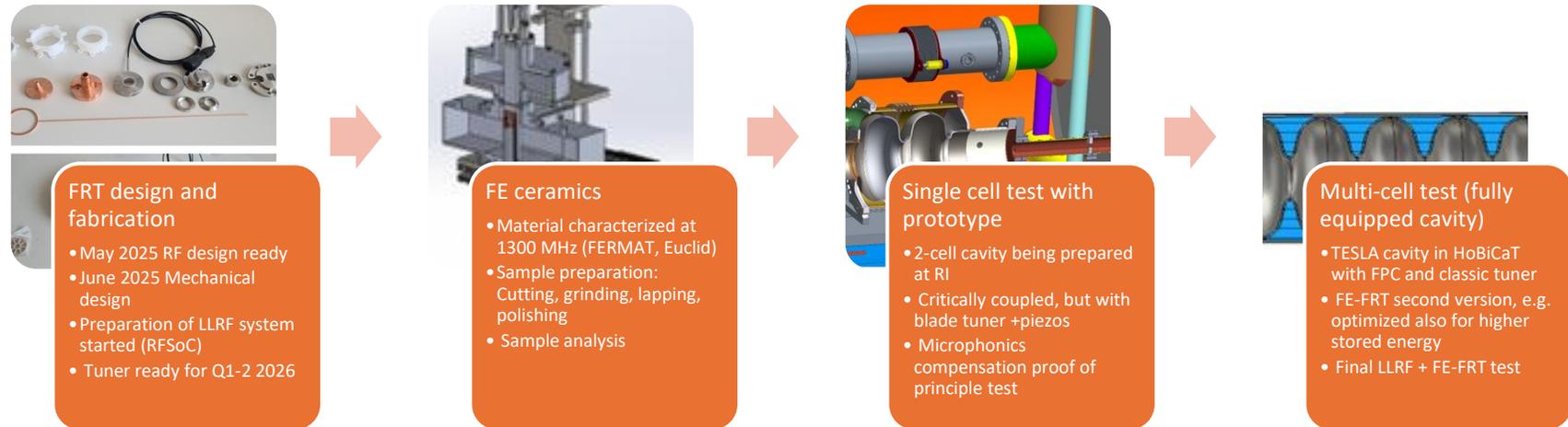
Task 1.2: FE-FRT for Transient Beam Loading – M1-M40 (CERN)

iSAS funds:
0.44 M€



Task 1.3: FE-FRT for Microphonics – M1-M48 (HZB)

iSAS funds:
0.57 M€



MS41/ Feb 26
Risk analysis

On track

On track

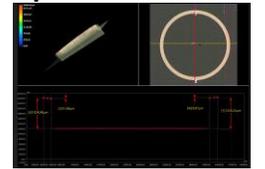
MS1/ Feb 26

MS4/ Feb 27

MS5/ Oct 27

Observed issues (selection, MS1 related)

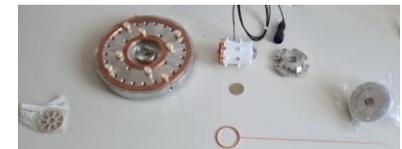
- The ferroelectric ceramics are the key component: They need to reach about $8\text{V}/\mu\text{m}$ without discharge
 - HZB reached $3.6\text{V}/\mu\text{m}$ in FERMAT: Reason mostly problems with surface finish and parallelism of surface
→ FERMAT design probes quality of sample by RF mode distribution, here also under N_2 atmosphere
 - CERN reached $7.2\text{V}/\mu\text{m}$ in HV teststand under vacuum



- The ceramics need to properly attach to the surrounding Cu matrix, capacitor structure
 - Sample surface finish and parallelism/flatness of both ceramics surfaces need to be controlled to a high level → Currently studies ongoing at CERN (successful), HZB and Euclid to improve on this



- FE-FRTs are very compact devices and house fragile ceramics: The design needs to avoid discharges, a safe assembly, at best particulate free assembly and lower sensitivity to mechanical tolerances



Especially at HZB this caused more work and new research, which was not accounted for from the start





WP1– FE-FRT: points of attention

- Points of attention
 - CERN reached ceramics quality sufficient for their teststands and design, data for the MS about characterization at 400 MHz are taken, MS will be completed in time (Feb/26)
 - Hiring of iSAS fellow at CERN awaits final approval by upper management, this person will be working for 800 MHz multi-cell FRT. An FRT based phase shifter developed at CERN for that purpose was demonstrated to work → this will impact the PERLE design as well.
 - The first cold test of TDD1 showed problems with controlling the temperature of the ceramics, this is being re-worked. A new cold test is planned for Q1 or Q2 2026.
 - HZB still invests more work into preparing FE-FRT ceramics for tuner usage:
 - Preparing surface finish and parallelism: Lapping at UK branch of Lappmaster Wolter
 - Coating of ceramics with e.g. gold: Working with Euclid and Vacuum alliance Dresden
 - Hired a student (intern from EBU Bilbao) and a phd from external HZB project to take more data with teststand FERMAT
 - Annual iSAS meeting: Website ready for posting, registration to be opened after some issues with HZB funding of the workshop