Development of 3-cell traveling wave SRF cavity

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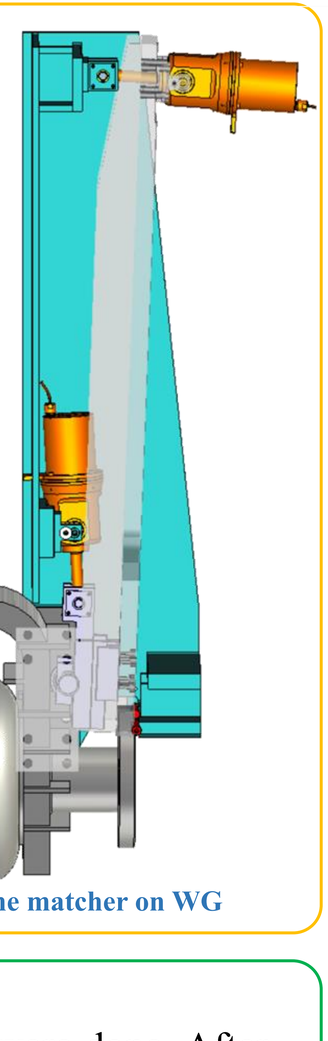
Introduction

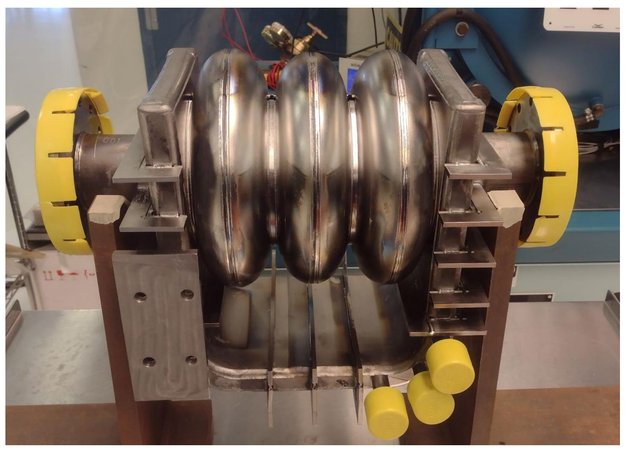
Presently all superconducting RF (SRF) cavities operate in a standing wave (SW) resonance field. Changing to a travelling wave (TW) mode operation can improve the efficiency of acceleration per cell defined as the transit time factor T ($T=E_{acc}/E_{ave}$., E_{acc}; accelerating gradient, *Eave*; average accelerating gradient over the cell gap) . T of the TW mode could be much higher than that of SW mode.
An early study suggested that >20% higher T can be achieved. Thereby, TW mode operation allows higher accelerating fields with niobium SRF cavities beyond the maximum gradient of 50 - 60 MV/m in a SW mode for the same peak surface magnetic field condition.

Early achievements by Euclid Techlabs and Fermilab

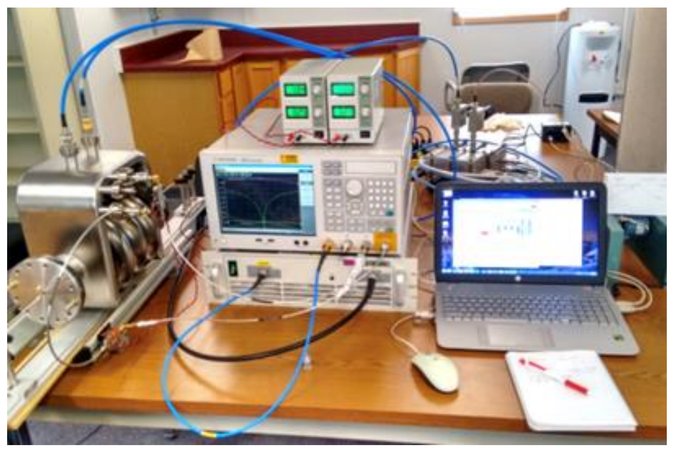
- Previously, conceptual designs have been proposed to adopt TW regimes to SRF cavities. A 3-cell proof-of-principle TW cavity was fabricated as part of an SBIR project and demonstrated the TW resonance excitation at room temperature in collaboration with Euclid Techlabs.
- Special tuner (the matcher) to control TW resonance in the 3-cell was also fabricated. The preliminary test at room and liquid nitrogen temperatures indicated the feasibility of achieving TW resonance in 2K



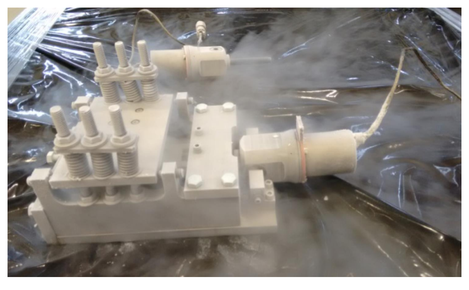
3D model of the cavity with the matcher on WG



TW 3-cell prototype



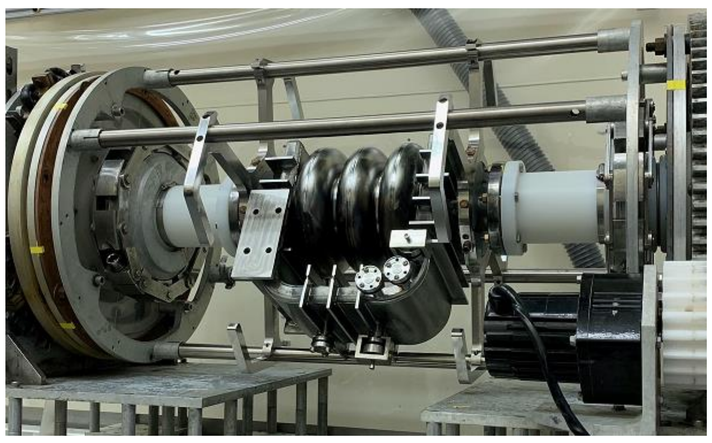
RF set up for TW resonance excitation by Euclid



The matcher test assy after LN_2 test

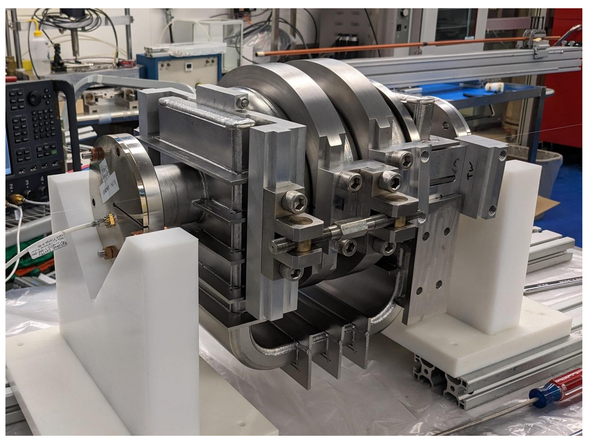
Recent progresses

The TW 3-cell prototype is being processed and prepared for the first cryogenic testing. Bulk BCP, degas, and final light BCP were done. After final BCP, the cavity was successfully tuned in SW mode to the simulated field distributions from CST for 3 cell TW mode. Cell tuning hardware for the 3-cell prototype is designed and fabricated by Euclid Techlabs. The TW operation frequency should be close to the second eigenmode (gray in the field profile).

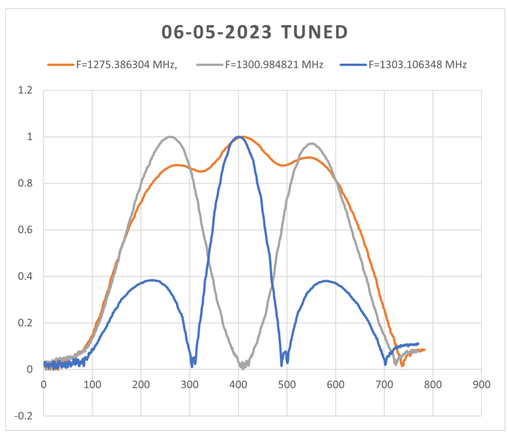


BCP at ANL

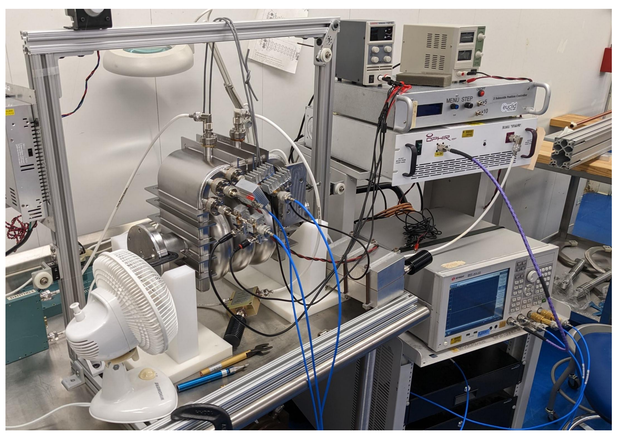
HPR at FNAL

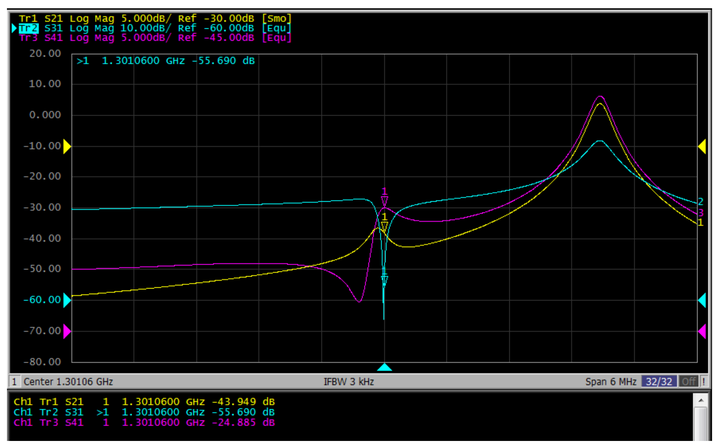


Tuning hardware on the 3-cell and the field profiles post tuning.



TW resonance excitation in the TW 3-cell prototype at room temperature was demonstrated again post the cell tuning. An example of TW at 1301.06MHz was shown in the chart with two processed signals; blue shows a suppressed backward wave and magenta shows a maximum forward wave. Yellow is an unprocessed signal from the calibration pick up.





TW resonance excitation at room temperature post the cell tuning

Summary

Surface processing and cell tuning on the TW 3-cell prototype had been completed. TW resonance excitation at room temp was also confirmed. The cavity and the WG tuner are ready for cryogenic test assembling. Final machining and modification on the test hardware is in progress.
The first cryogenic testing of the TW 3-cell prototype will be carried out soon.

The goals of TW 3-cell prototype cryogenic testing

- Demonstrate TW resonance in 3-cell at 2K
- Study TW resonance control in cryogenic temperature
- Study high gradient in TW regime

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