DIAMOND-II RF SYSTEM
Upgrade Plan and Status

Arash Kaftoosian

ESLS-RF and HarmonLIP Workshop
October 22nd-24th 2025

Diamond Site

Harwell Science and Innovation Campus
South Oxfordshire

Diamond-II RF System Overview

Linac

- The linac will continue to operate at 100 MeV, with minimal changes.
- Current linac structures will be preserved.
  - Frequency tuning to Diamond-II will be achieved through temperature adjustments.
  - Internal load inspections will be conducted to confirm their reliability.
- The linac RF system will remain the same, utilizing two Thales TH2100 Klystrons powered by thyratron-triggered PFN modulators.
- RF redundancy and availability will be enhanced by using the SLED cavity.

Booster

- Booster will continue using two existing five-cell Petra-type cavities.
- Each cavity will have an 80 or 120 kW amplifier.
- Digital LLRF will be implemented.

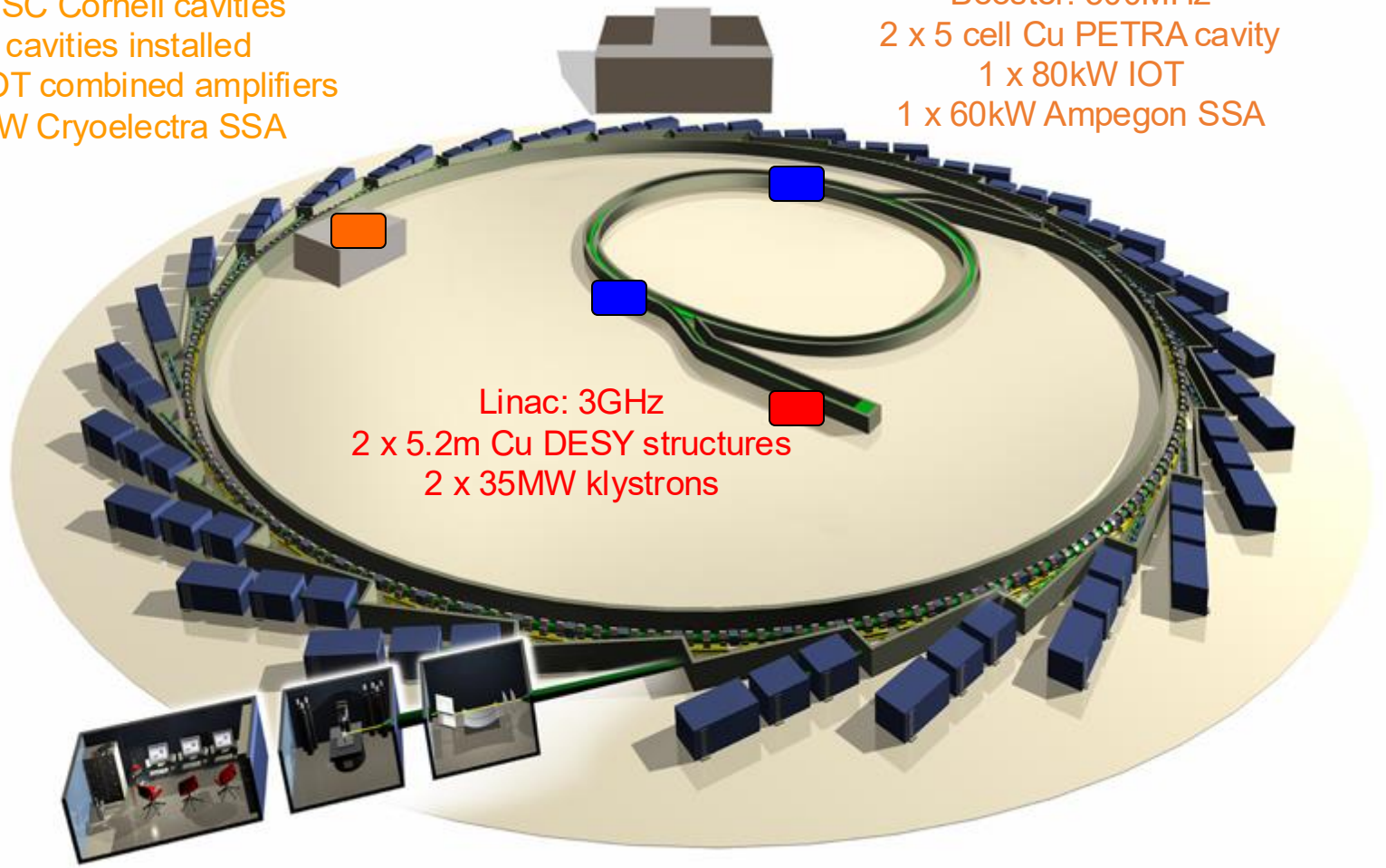
Storage Ring

- Eight HOM-damped cavities will be used from day one.
- Each cavity will be driven by a 120 kW solid-state amplifier, supported by digital LLRF.
- The cavities will be positioned in the mid-straight sections at K05, K09, K10, and K15.
- A superconducting third harmonic passive cavity will be installed in cell 17. (see Pengda's presentation on Friday)

Diamond RF System Overview

Storage ring: 500MHz
2 x 1 cell SC Cornell cavities
3 x NC cavities installed
3 x 300kW IOT combined amplifiers
1 x 120 kW Cryoelectra SSA

Booster: 500MHz
2 x 5 cell Cu PETRA cavity
1 x 80kW IOT
1 x 60kW Ampegon SSA



Diamond RF is concentrated in one area

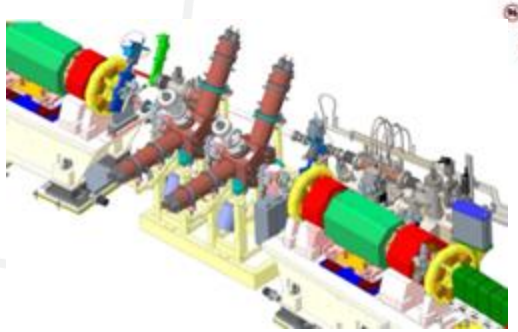
- Amplifiers in RF hall
- Cavities in single RF straight

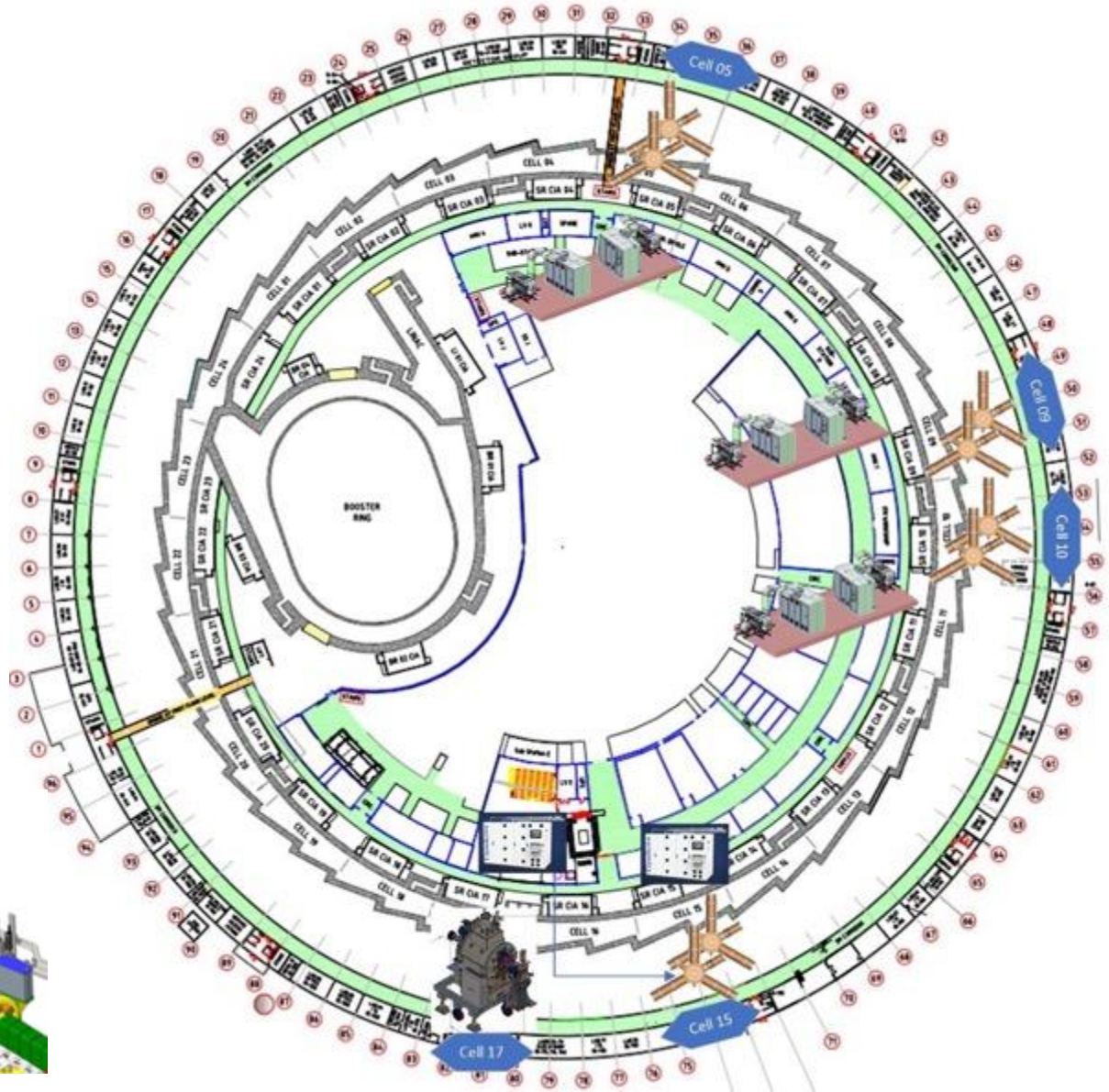
- 3 GeV 300 mA 3rd generation light source
- NC Linac and full energy Booster, SC storage ring RF
- Operating for users since 2007

Diamond-II RF System Overview

- RF cavities' locations:
  - Fundamental RF cavities in pairs: K05, K09, K10, K15
  - Super-conducting 3rd Harmonic cavity in K17
- Amplifiers' locations:
  - Three double platforms for K05, K09 and K10 to accommodate 6 amplifiers.
  - A single platform already in use for K15.
  - One amplifier inside the RF Hall to be used for K15 cavity or the RF Test Facility

Cavity Location	SSA/Circulator/Load Location	SSA/Cavity qty.	Platform Required
K05	Between CIAs 4 & 5	2	Double
K09	Between CIAs 8 & 9	2	Double
K10	Between CIAs 10 & 11	2	Double
K15	RF Hall & Single platform	2	None

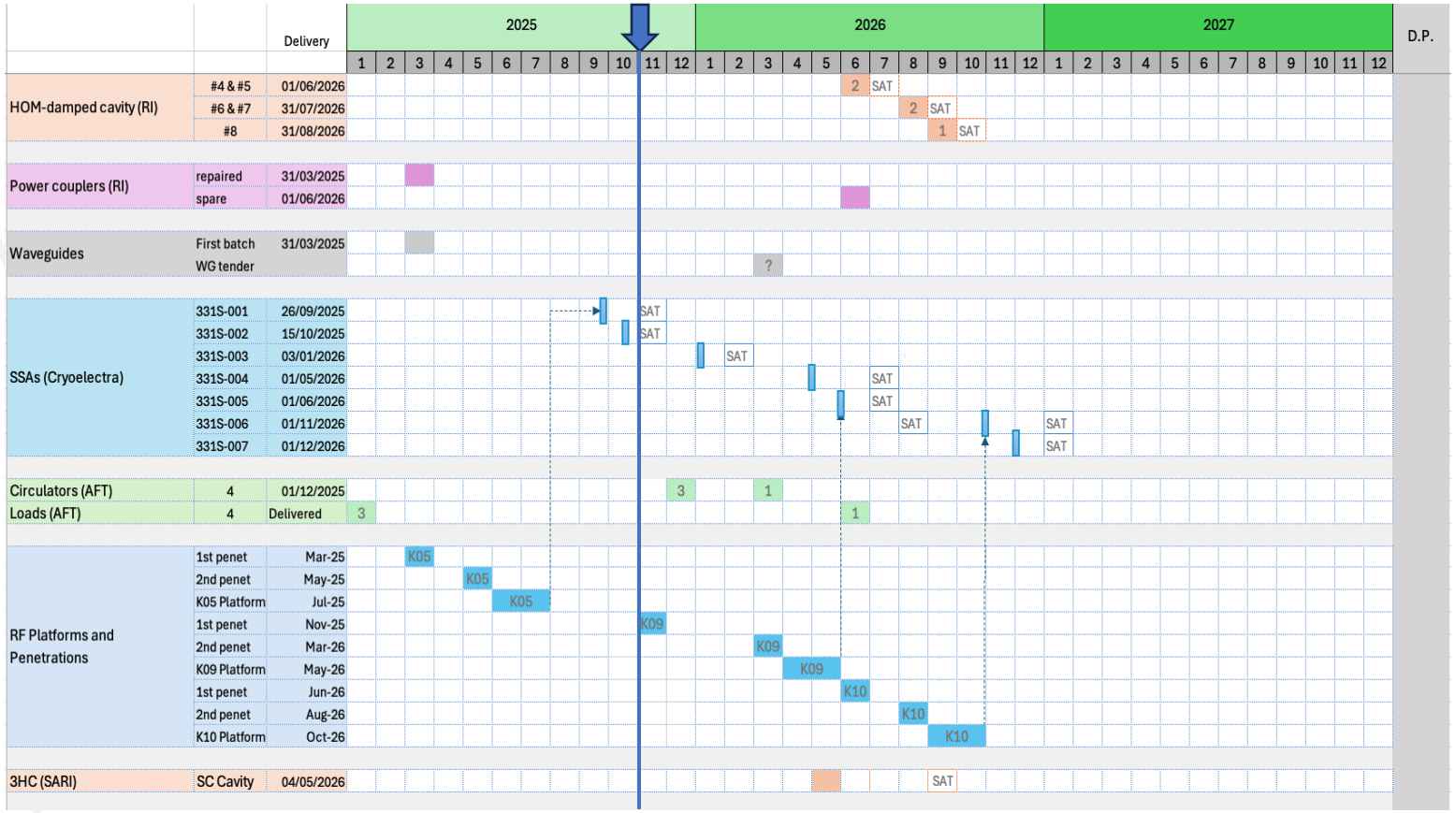




RF Systems Delivery and SAT Plan

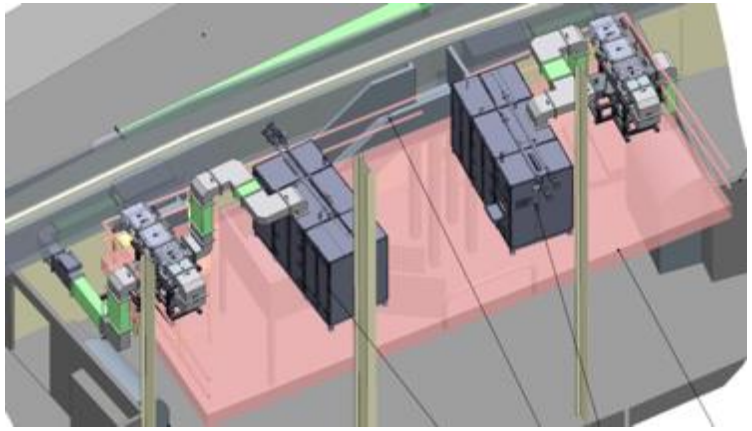
Ongoing RF contracts:

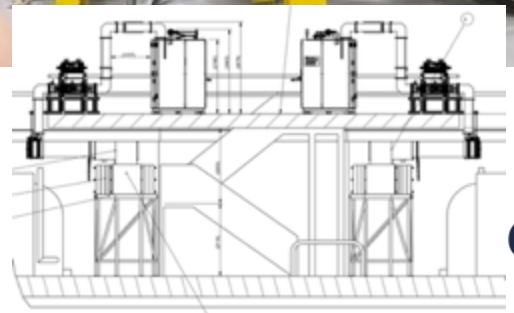
- Five HOM-Damped cavities plus couplers, tuners, supports and water distribution (RI), delivery scheduled for mid 2026
- Waveguides: Preparing tender documents
- Solid-State Amplifiers (Cryoelectra), two delivered, 5 more to be delivered before end of 2026 (one year ahead of the original schedule)
- Circulators and loads (AFT) , January to June 2026
- RF platforms, penetrations and shielding, local companies, to be completed before end of 2026
- Superconducting 3rd Harmonic Cavity, SARI (SSRF), mid 2026



RF Platforms and Amplifiers

- Amplifiers:
  - Two 120 kW amplifiers have been delivered after successful FAT at supplier (Cryoelectra)
  - Installation is ongoing on the K05 platform
  - Site Acceptance Tests for the first two SSAs is scheduled for 17th November 2025.
- K05 platform:
  - Both penetrations implemented and their shielding with support structures installed.
  - Platform is ready
  - Electrical and mechanical services installation ongoing.
- K09 platform:
  - The first penetration is being drilled.
  - The shielding will be installed during this shutdown
  - The second penetration and the platform will be ready in March and May/June 2026, respectively.
- K10 platform:
  - Design stage to be started shortly.





RF Amplifiers and NC Cavities

- The contract with Cryoelectra for seven 120kW Solid-State Amplifiers is in progress.
- Cryoelectra proposed to complete delivery of all 7 amplifiers by the end of 2026 (the initial delivery plan was by end of 2027).
- %65 AC to RF efficiency: @ 130kW /49V or @100kW /41V

Courtesy of Cryoelectra GmbH

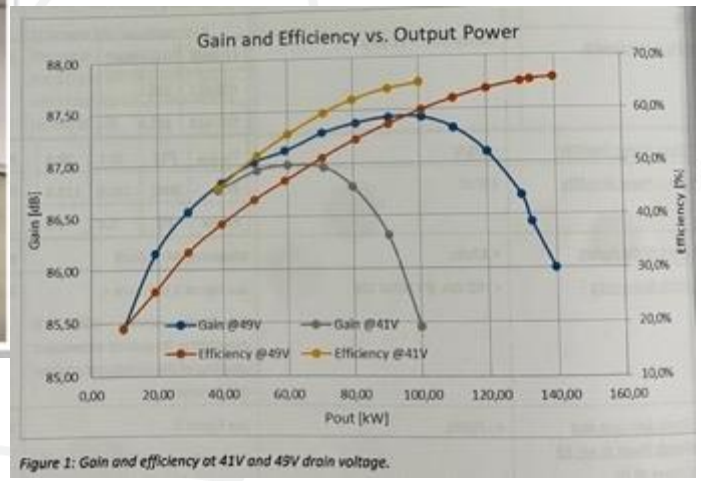
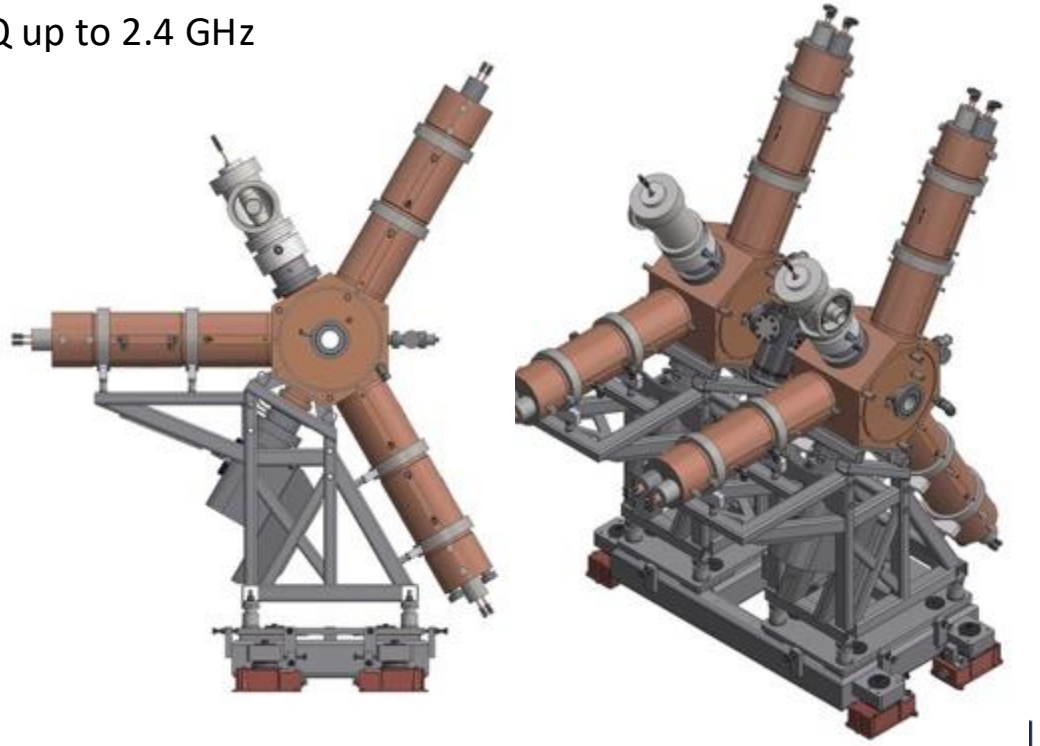


Figure 1: Gain and efficiency at 41V and 49V drain voltage.

- Contract for design, manufacturing and delivery of 5 HOM-Damped cavities is progressing with Research Instruments GmbH (RI)
- Delivery schedule: from 31st May 2026 to 31st August 2026
- Cavities will be assembled in pairs at DLS and will be tested (including their couplers) inside RF Test Facility using 120kW amplifier.
- HOM measurements will be done based on CST simulation results of R/Q up to 2.4 GHz

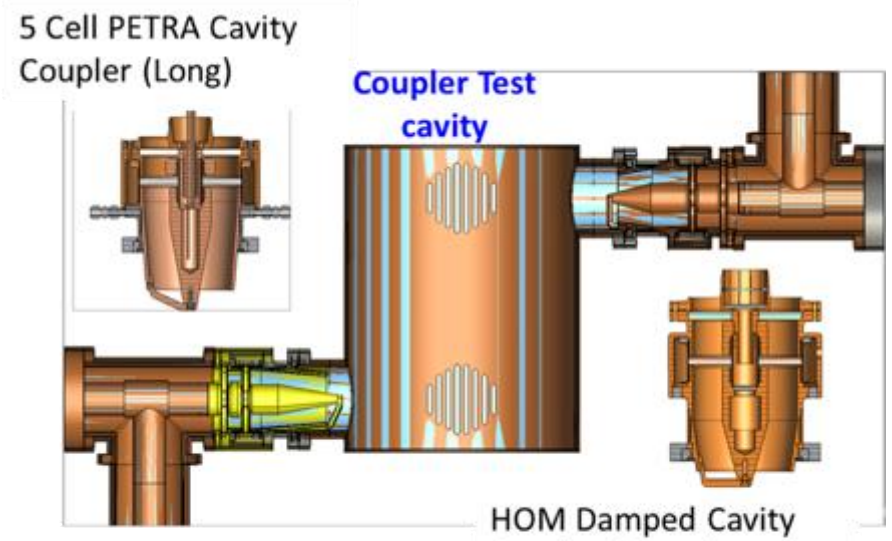


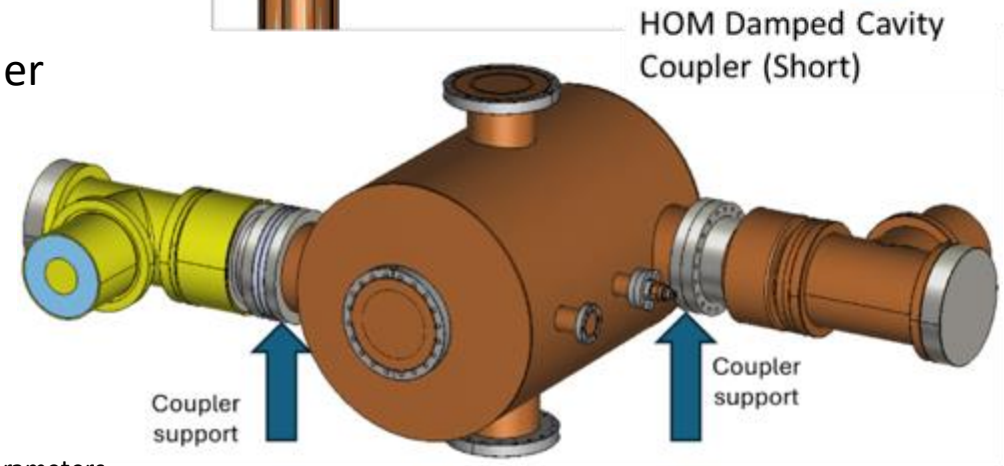
Courtesy of Research Instrument (RI) GmbH

Power Coupler Test Cavity Project

Major Considerations

- Rated Coupler power/voltage test capability
- Uniformity of field / power dissipation on the surface
- Ease of cooling
- Ease of pumping
- Tunability
- Ease and cost of manufacturing
- Pill Box (cylindrical) geometry – TM010 mode
- Two Port structure – Excitation at one port and load at the other
- Single coupler test, full power dissipation in the structure
- Variable coupling by the coupler rotation
- With PETRA Cavity tuner, tunability >±750 kHz





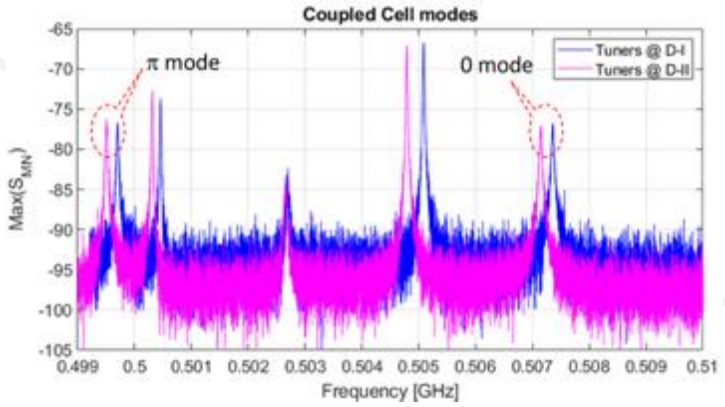
- RF design and simulations have been finalized.
- Outsourced for thermal and mechanical design and manufacturing.
- The expected delivery timeframe is 9 months.

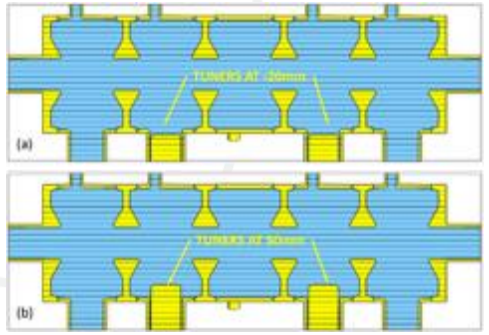
Design parameters

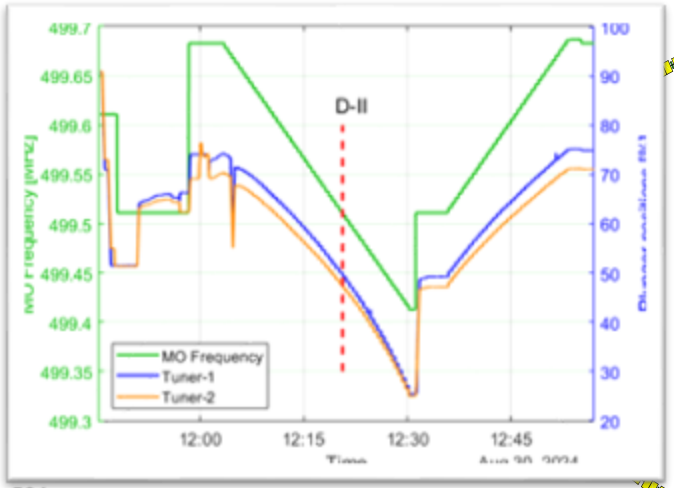
Resonant frequency (at pressure $1x10^{-9}$ mbar)	499.36 MHz
Quality factor	>51000
Typical operating pressure	< 1.0x10-9 mbar
Maximum power dissipation in the cavity walls	120 kW
Material for the cavity and port tubes:	Oxygen Free High Conductivity (OFHC) Copper

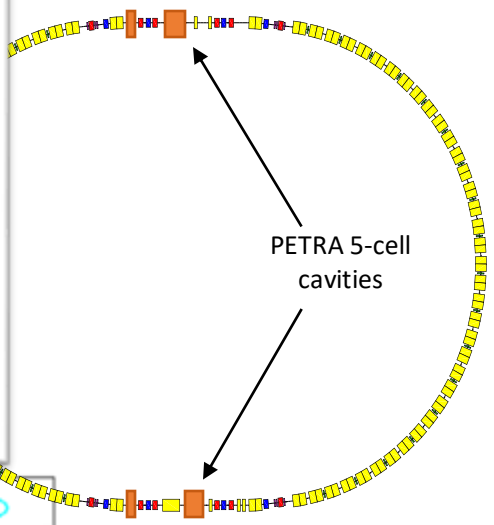
Diamond-II Booster Synchrotron

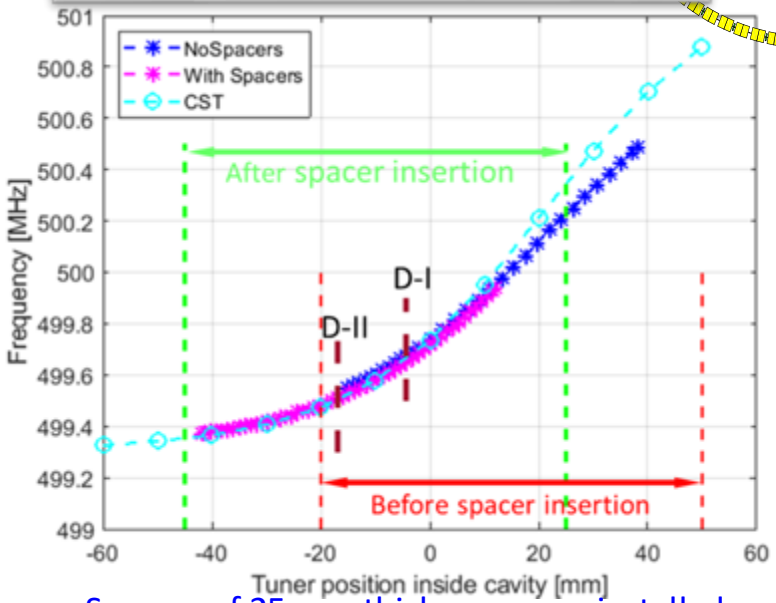
- Diamond II Booster synchrotron will use two Petra type 5-cell cavities.
- D-II frequency is achieved by adding spacers to the tuners
- One 80kW IOT (old) and one 80kW solid state amplifier will feed cavities.
- Each cavity voltage can reach to 1.3MV using 80kW amplifier. D-II booster loss per turn will be ~1MeV
- Tests are planned to measure the minimum required voltage in Diamond Booster (with ~600KeV loss per turn) and extrapolate it to estimate the D-II Booster voltage requirement.
- Based on the results, decision will be made if one or both amplifiers must be replaced with 120kW amplifiers to ensure redundancy in D-II Booster RF system.

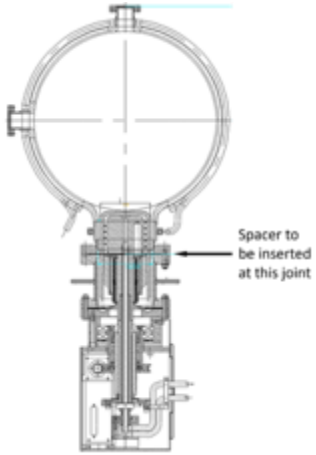












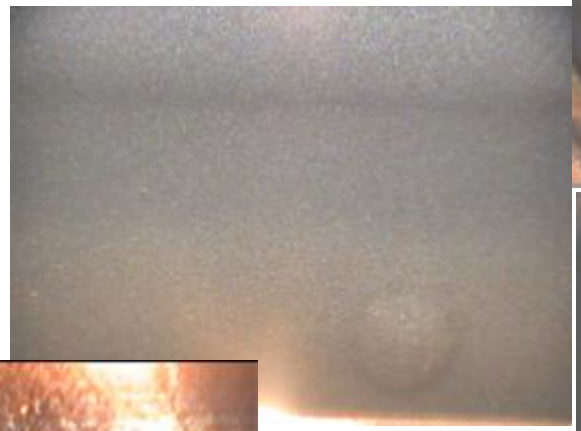
- Spacers of 25 mm thickness were installed on both the tuner ports
- The measured frequency versus tuner position matches well with the simulations

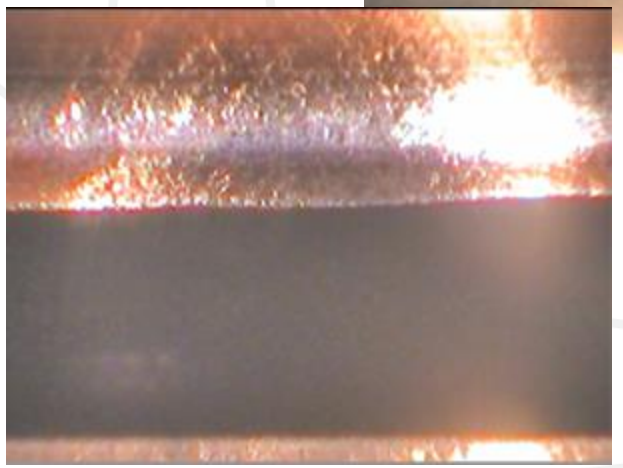
Linac Inspection

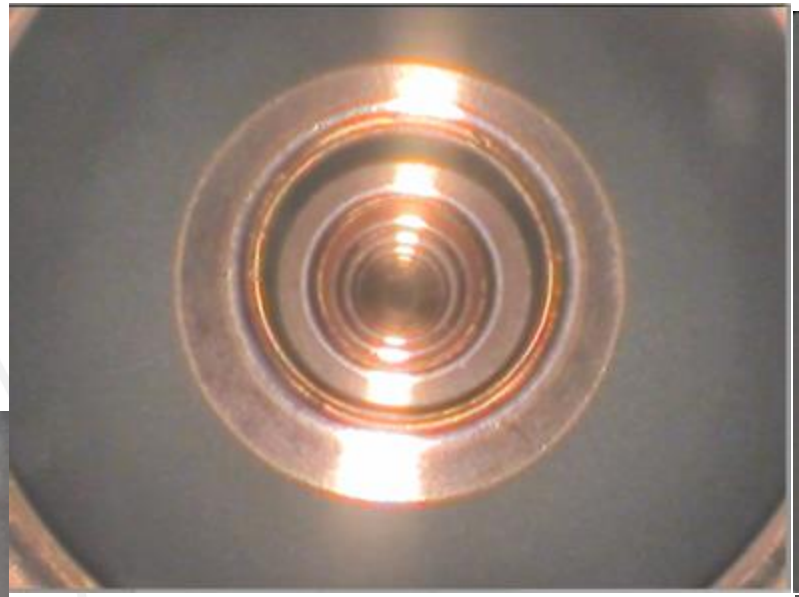
- The final objective is to ensure the internal loads (last 7 cells of each structure) are in good shape and reliable for D-II injector operation.
- Vacuum intervention and inspection by sending an endoscope inside the structure has been carried out on Accelerator structure #2
- Opening from end as the last 7 cells have SiC coating (internal RF load)
- Special adapters were developed to support endoscope movement inside the structure

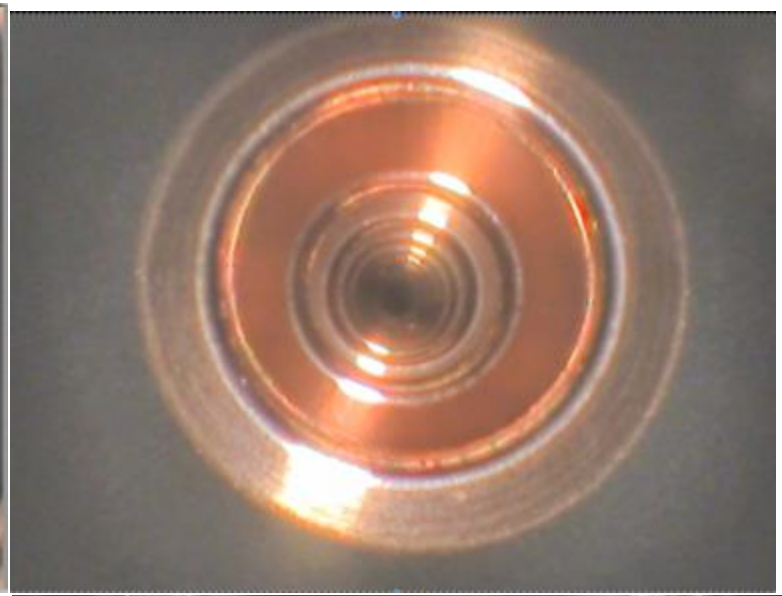
Linac Inspection

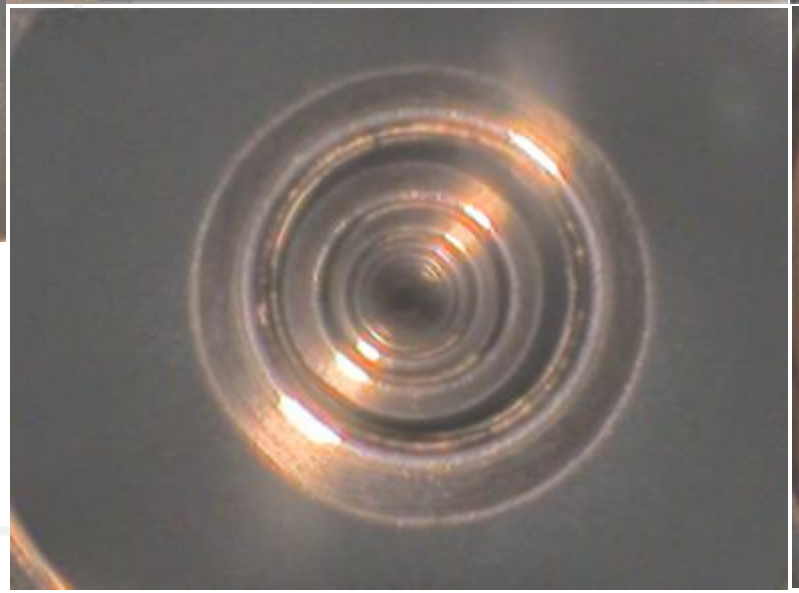
- Vacuum level recovered after closing the structure. No bake-out required.
- The final 7 cells of AS#2 showed no signs of damage.
- The experiment will be repeated for AS#1

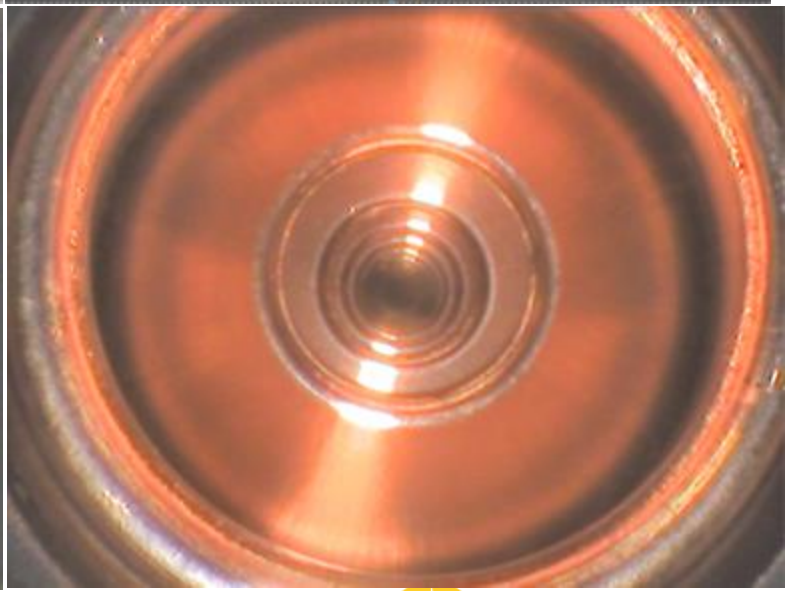










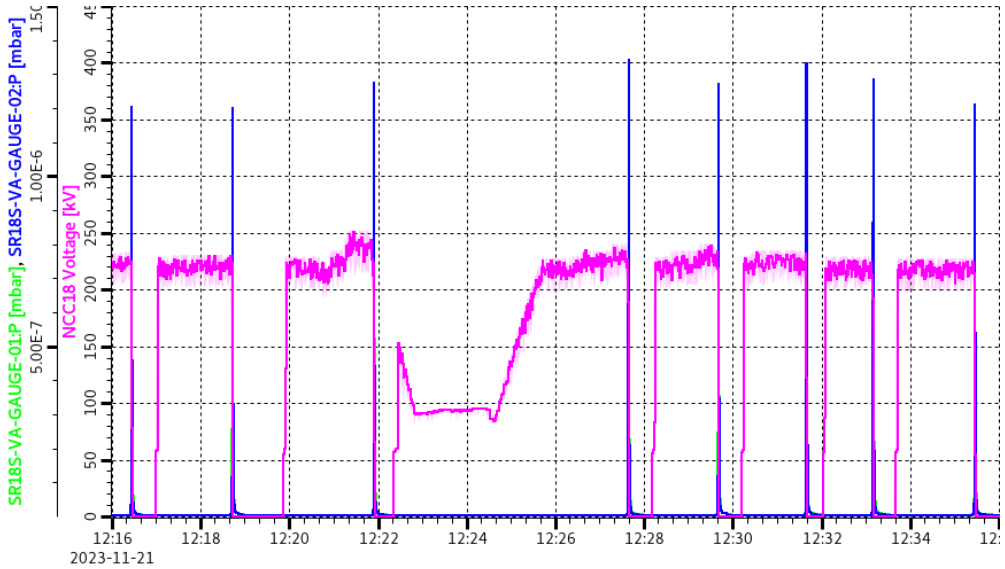


Pictures taken inside the last cells

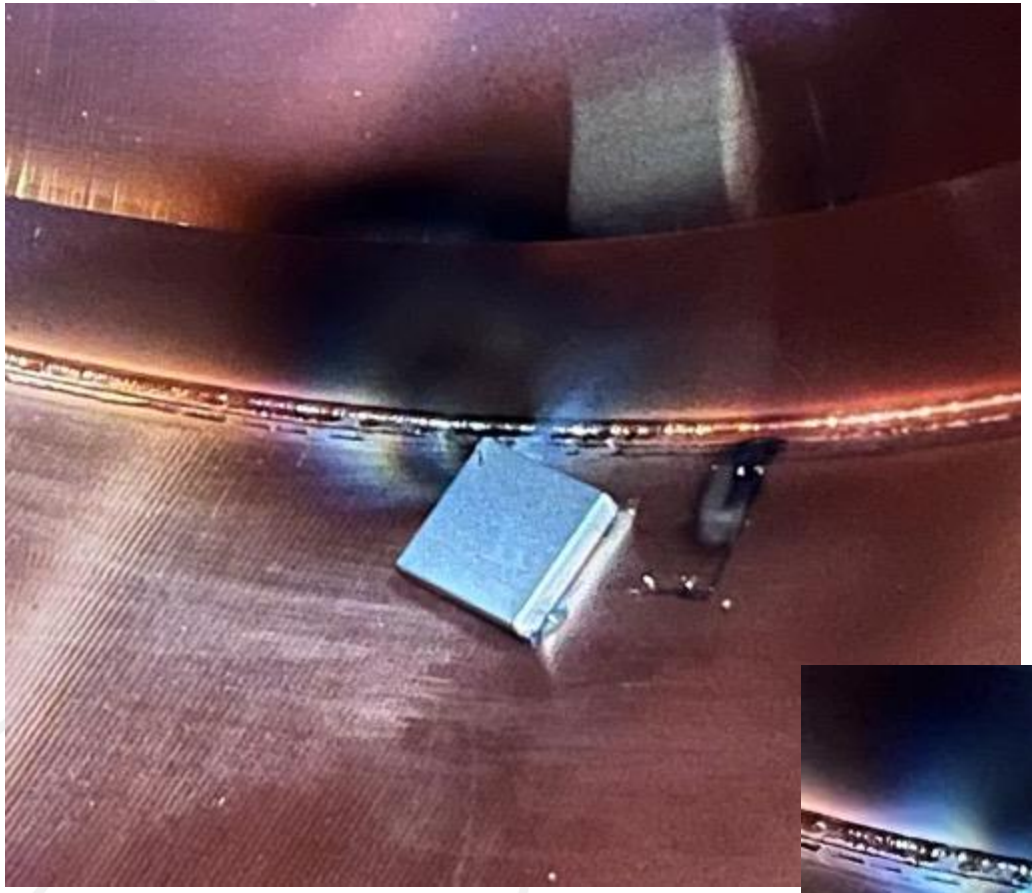
Normal conducting HOM-damped cavity and SSA experience in Diamond SR

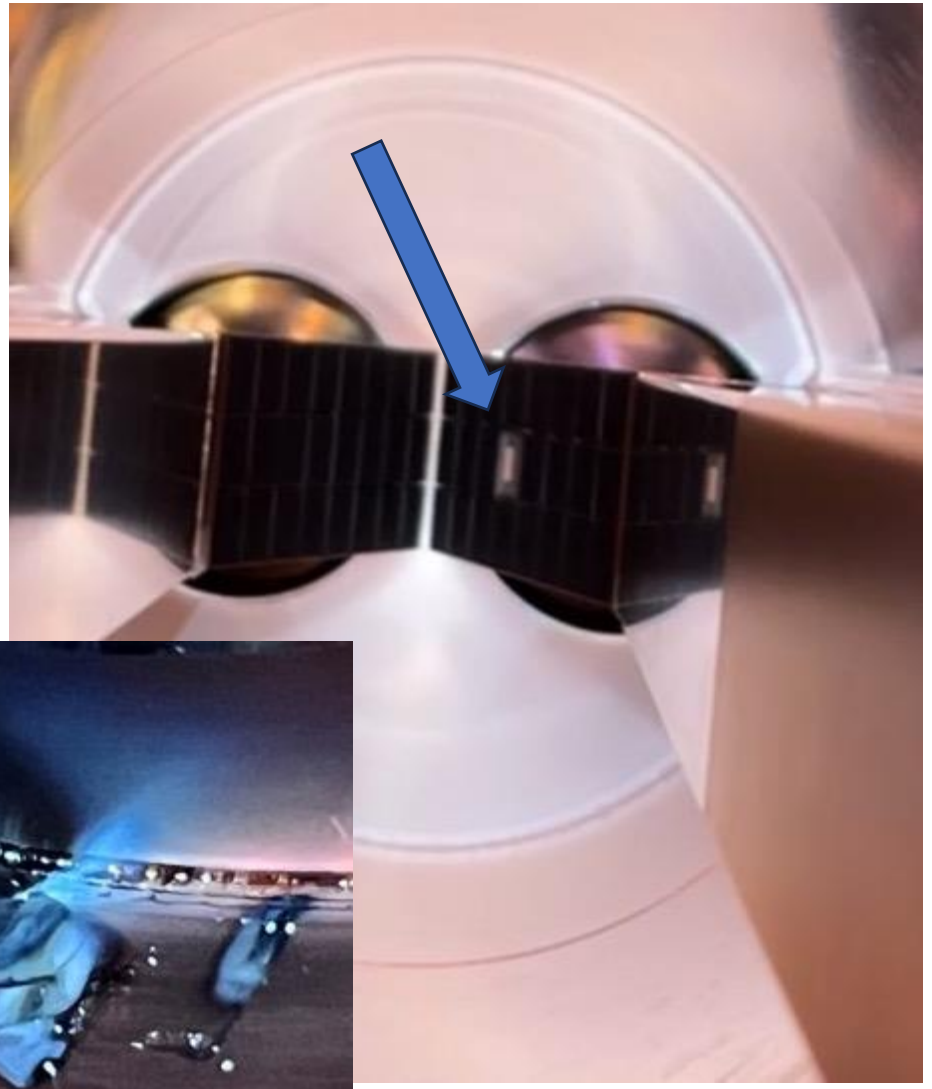
- A complete system including 120kW Cryoelectra SSA, HOM-damped cavity and digital LLRF has been in user mode operation since September 2023, with 250 – 300 MV accelerating voltage in cell 15
  - Only one amplifier trip due to false drip tray sensor activation, which appeared to be an RF/EM interference. They will be replaced with more robust (mechanical) ones.
  - A few load/circulator arcs. The single-channel arc detectors will be relaced with dual channels to avoid any false alarm.

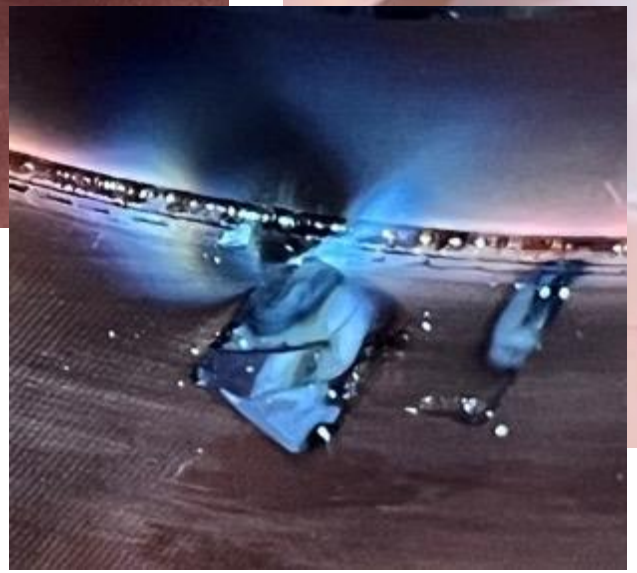
- NCC18 (HOM-damped cavity installed in cell 18) was in operation for user run 2 in 2023 but from November 2023, NCC18 started demonstrating strange vacuum behaviour for accelerating voltage > ~250kV showing pressure spikes after a few minutes.
  - Investigation and visual inspection done by removing the coupler to check inside the cavity.
  - One ferrite tile was found inside the cavity fallen from vertical HOM absorber.
  - Arcing and burn marks were observed on internal surface caused by the object burned by RF power
  - The object was removed, and cavity internal surface cleaned properly.
  - After installing the coupler, vacuum leak detected from the window area.
  - Coupler was replaced and the cavity was conditioned successfully.



HOM-damped cavity (NCC18) Issue





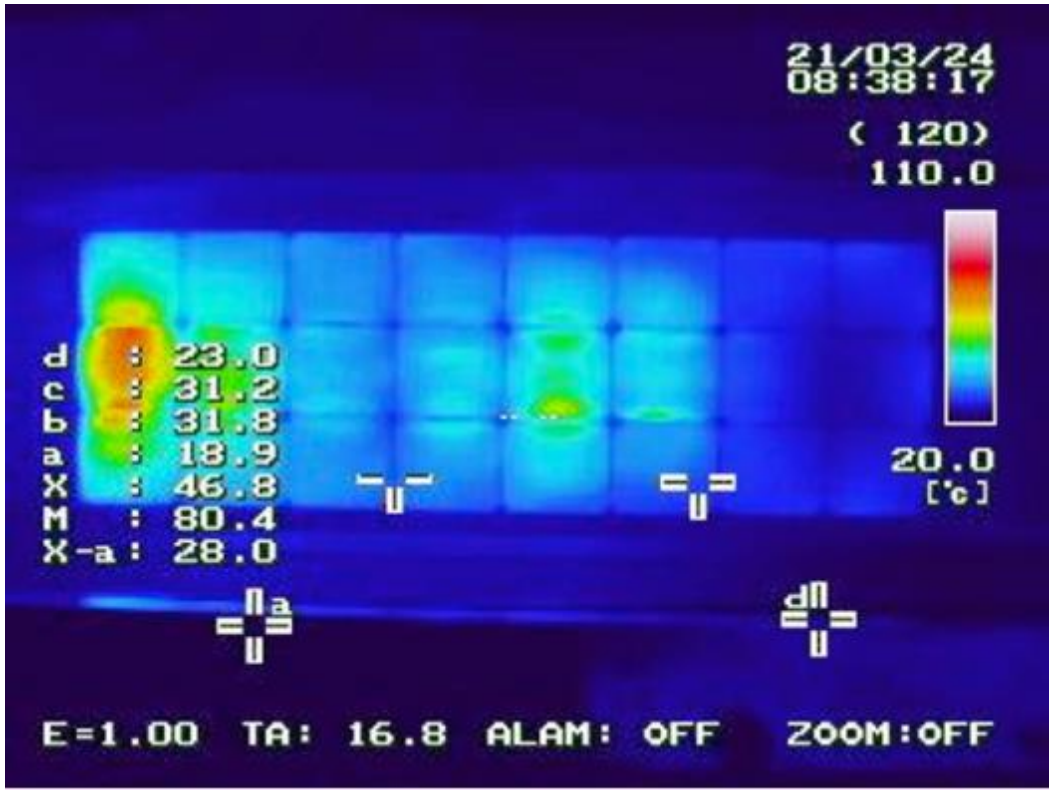


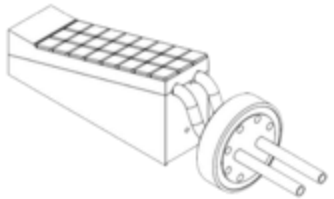
Ferrite tile found inside NCC18 with burn marks.
The tile was detached from vertical HOM absorber

Ferrite Tiles Issue

HOM absorber test at factory: A 600w CW magnetron at 2.45GHz will be used with a sliding short to form a standing wave voltage that will be moved along the ferrite tiles. Any temperature above 100°C will not be acceptable

Using SiC absorbers might be considered in the future to replace the ferrite type





Thanks for your attention

On Behalf of the RF Team:

Pengda Gu
Adam Rankin
Shivaji Pande
Amir Mogheyseh
Anton Tropp
Marco Marziani
David Child

diamond