

DIAMOND-II RF SYSTEM Upgrade Plan and Status

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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 thyatron-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

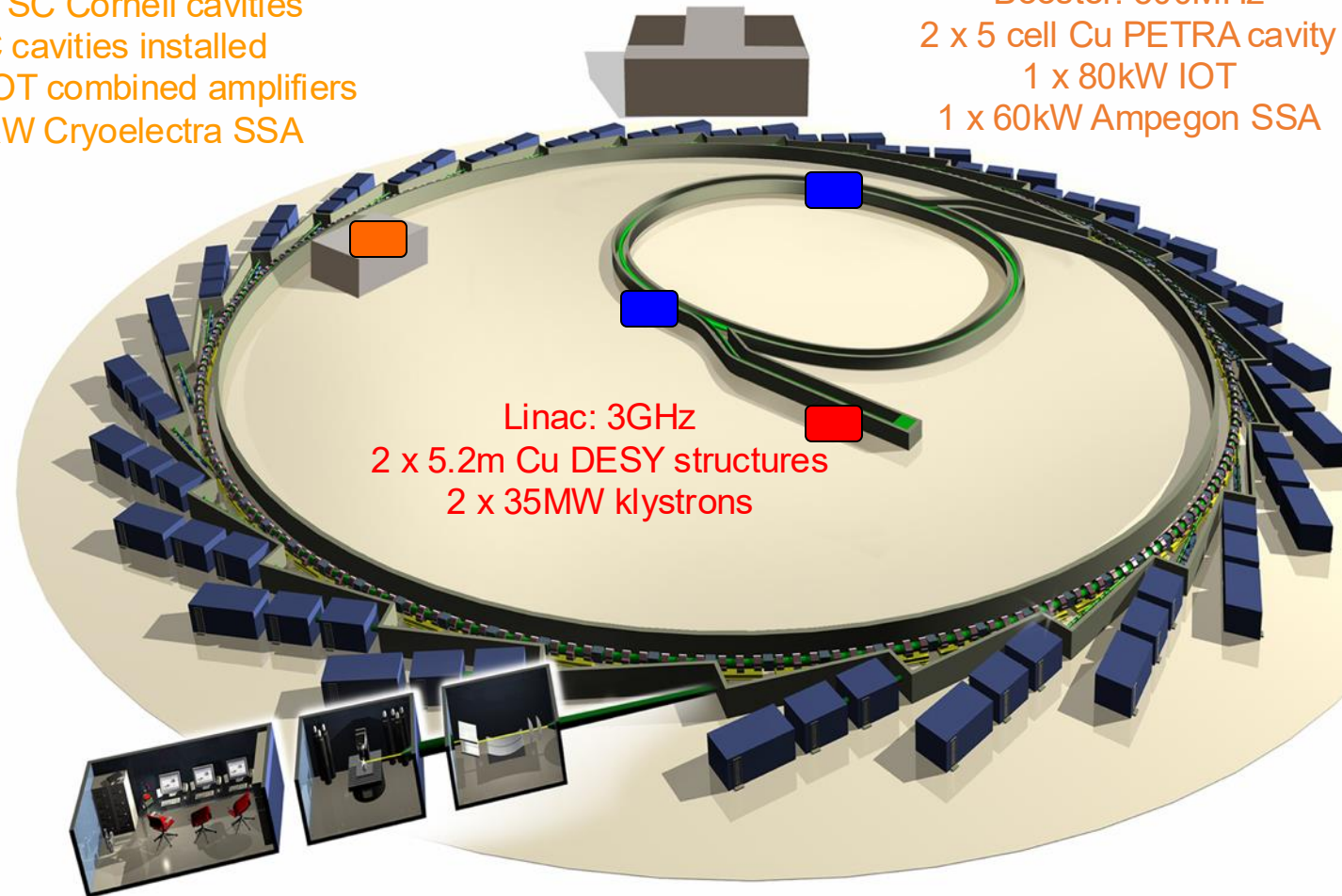
2 x 5 cell Cu PETRA cavity

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



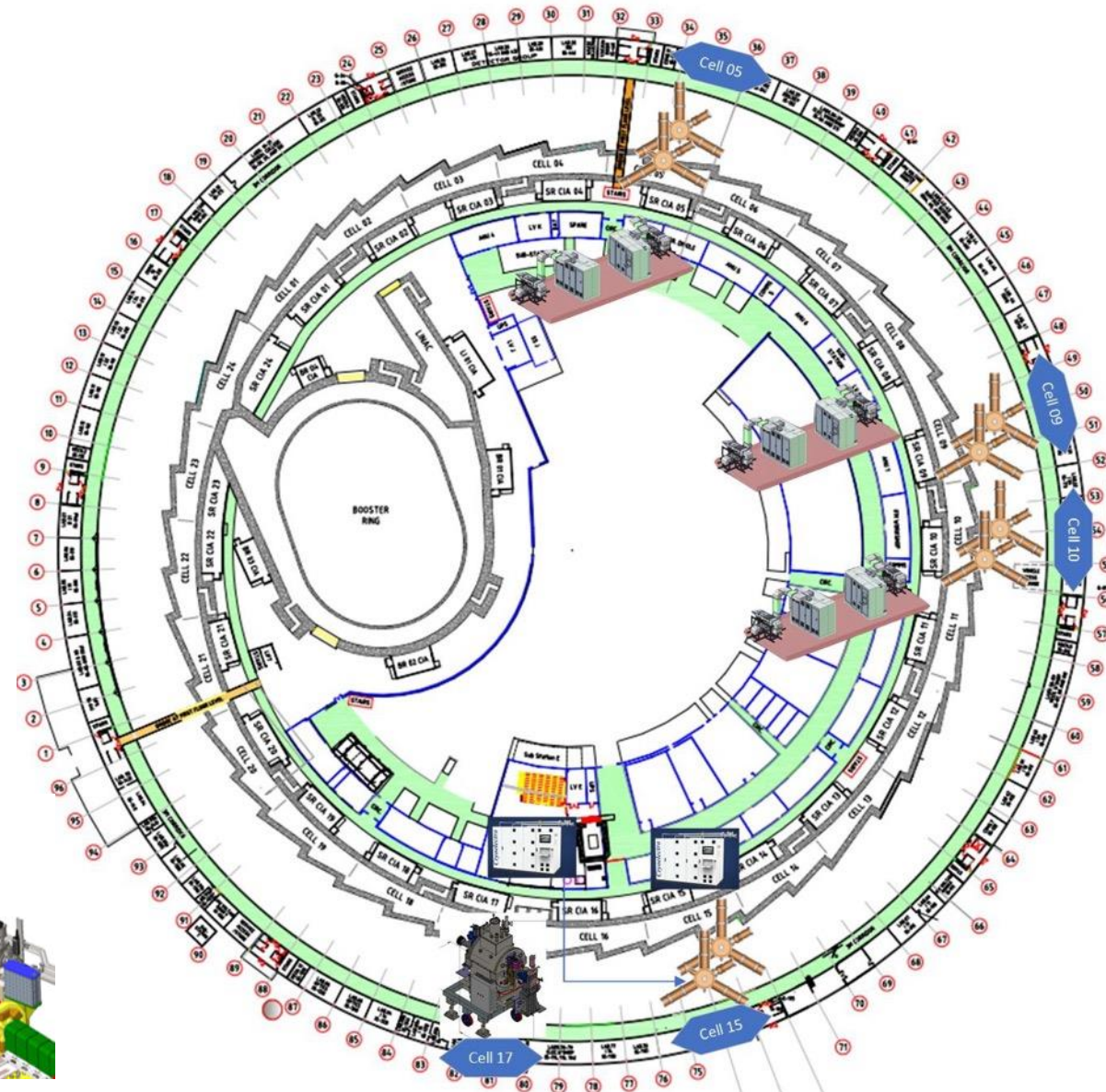
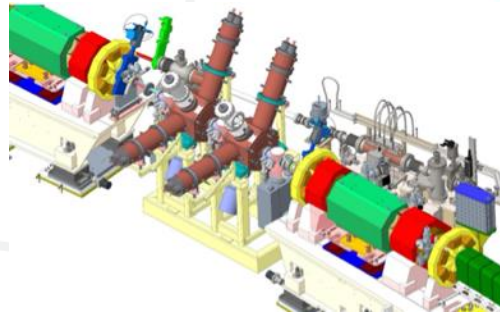
Linac: 3GHz
2 x 5.2m Cu DESY structures
2 x 35MW klystrons

- 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

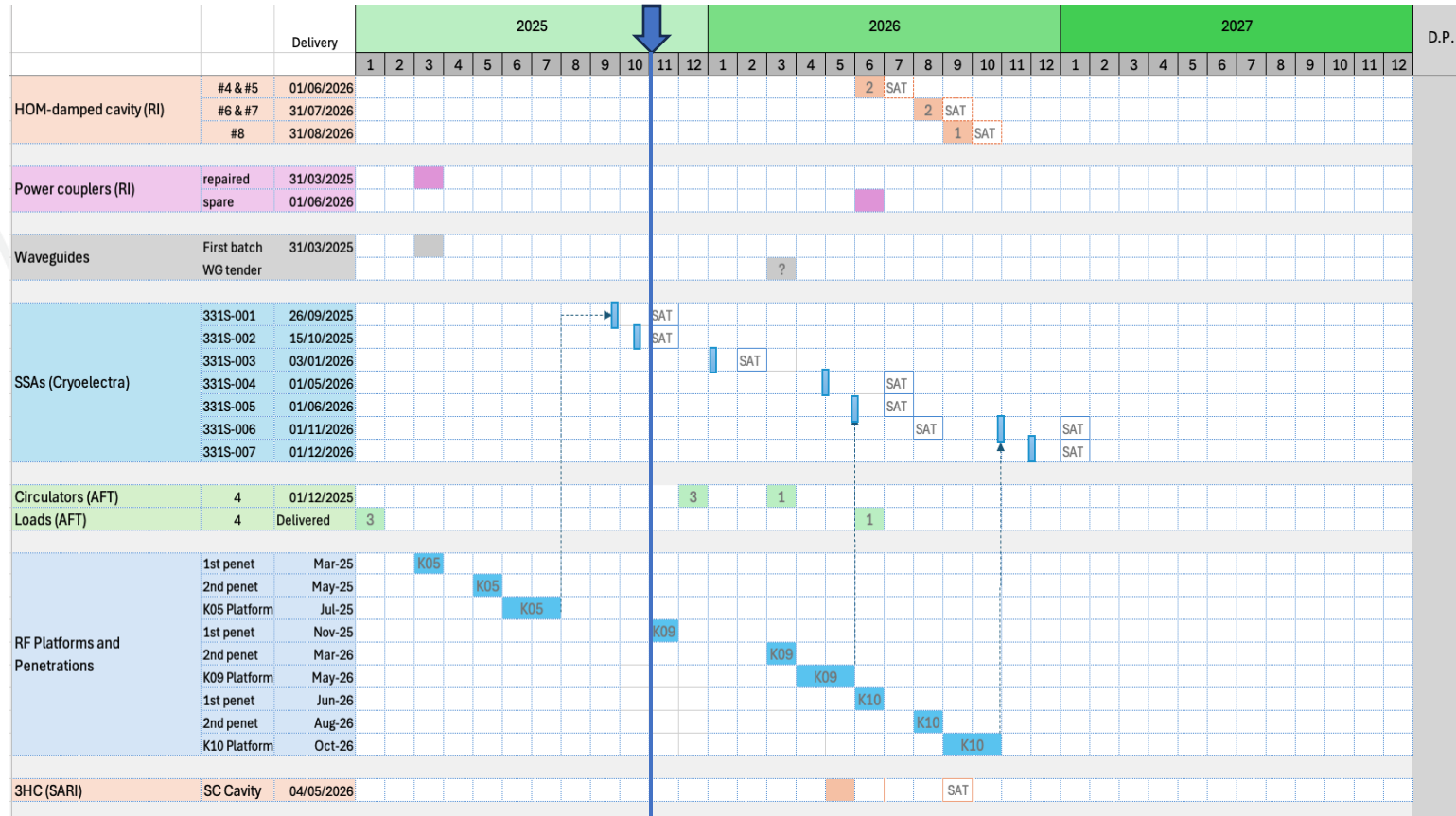
Cavity Location	SSA/Circulator/Load Location	SSA/Cavity qty.	Platform Required
K05	Between CIAs 4 & 5	2	Double
K09	Between CIAs 8 & 9	2	Double
K10	Between CIAs 10 & 11	2	Double
K15	RF Hall & Single platform	2	None



RF Systems Delivery and SAT Plan

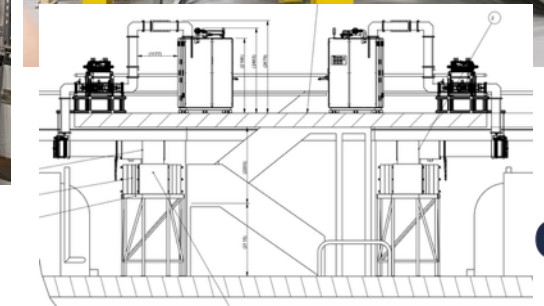
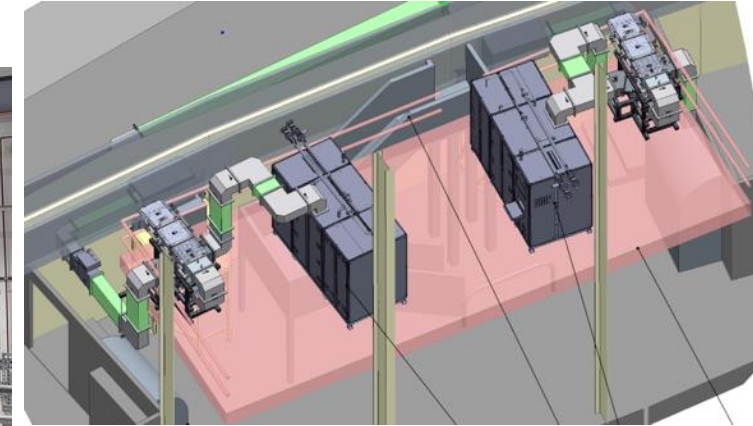
Ongoing RF contracts:

- 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.



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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
- 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 Cryoelectra GmbH

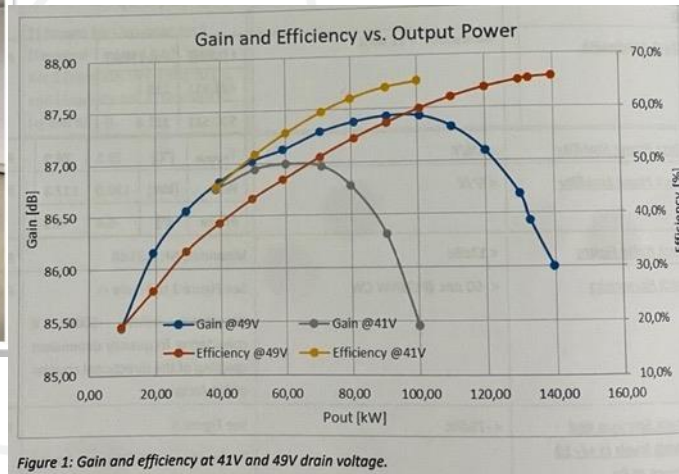
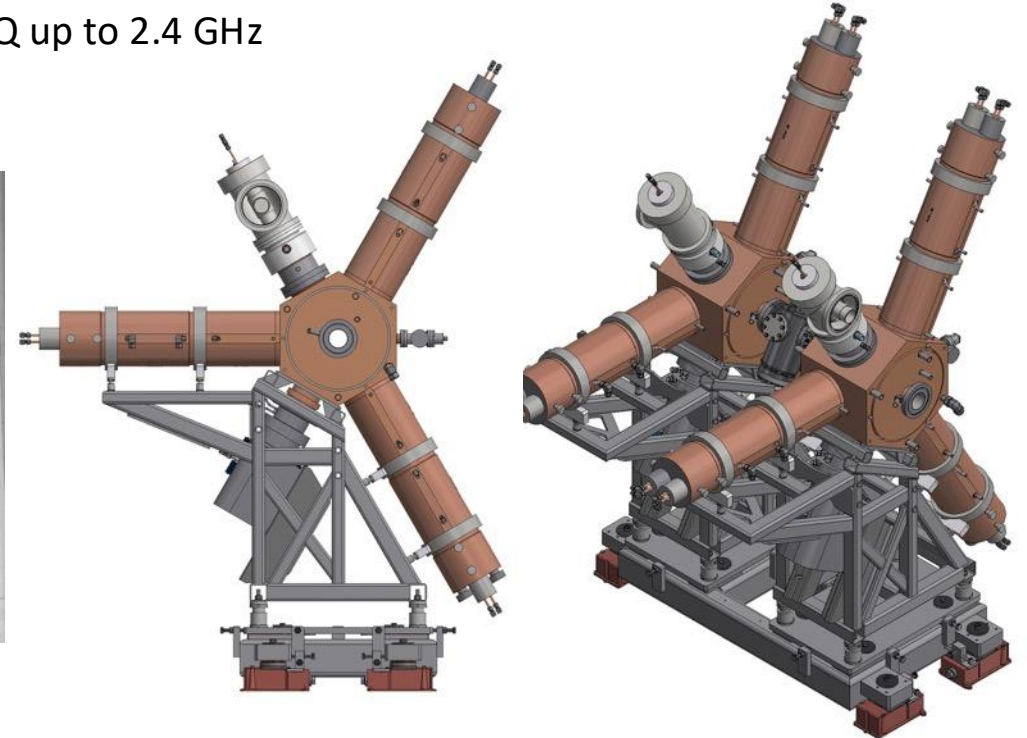


Figure 1: Gain and efficiency at 41V and 49V drain voltage.

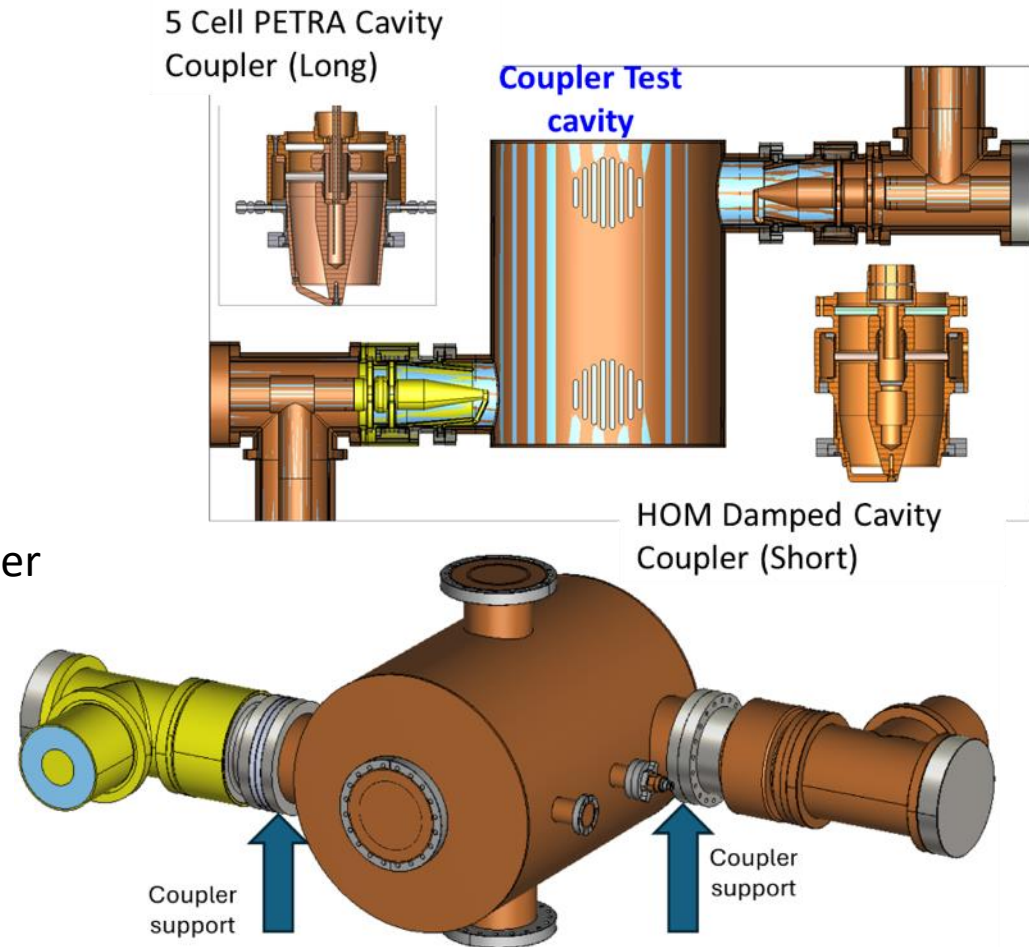


Courtesy of Research Instrument (RI) GmbH

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 $>\pm 750$ kHz
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- RF design and simulations have been finalized.
 - Outsourced for thermal and mechanical design and manufacturing.
 - The expected delivery timeframe is 9 months.

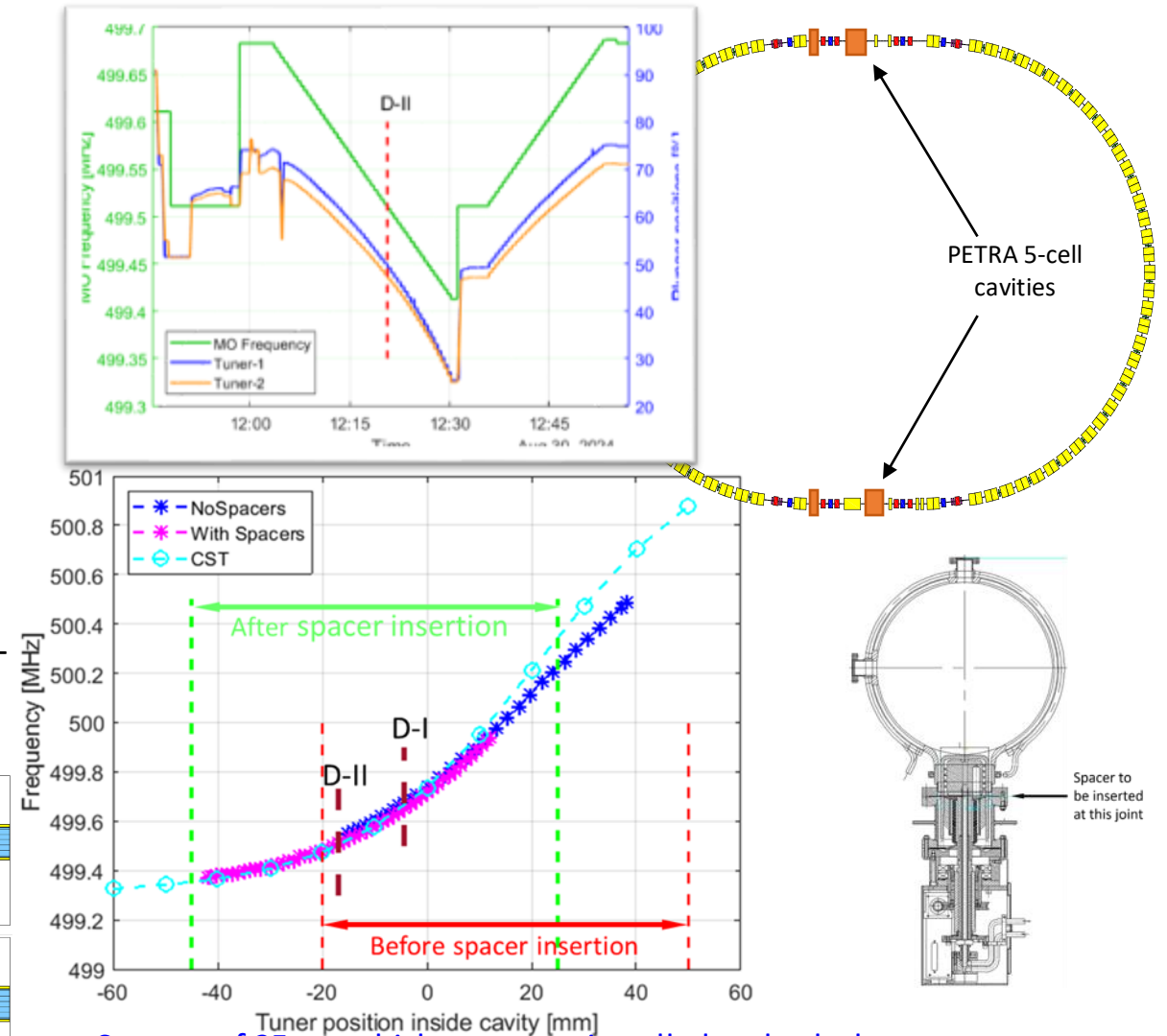
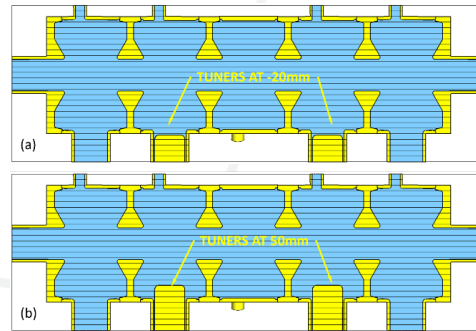
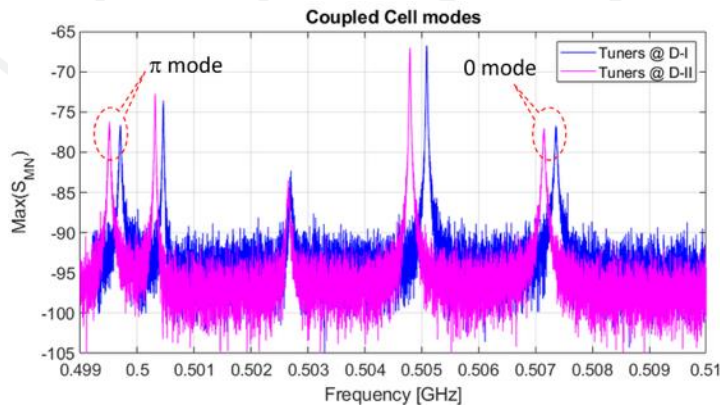


Design parameters

Resonant frequency (at pressure 1×10^{-9} mbar)	499.36 MHz
Quality factor	> 51000
Typical operating pressure	$< 1.0 \times 10^{-9}$ 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

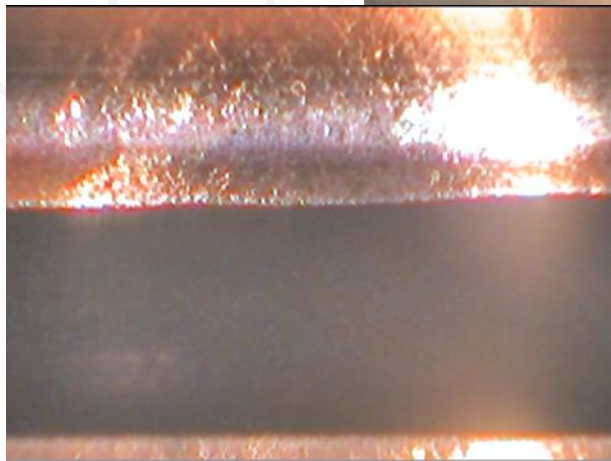
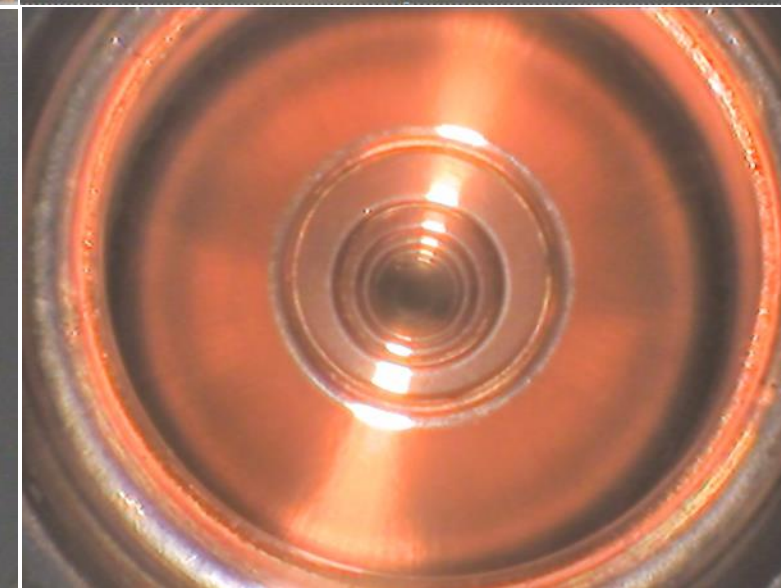
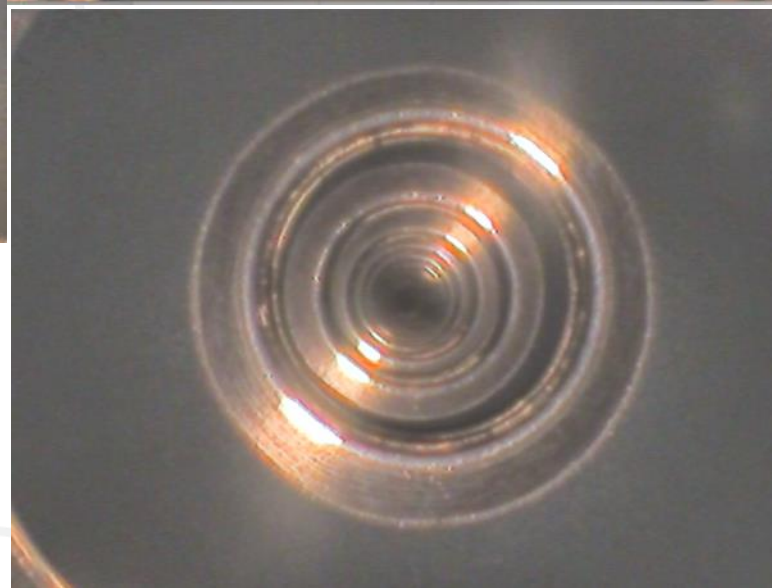
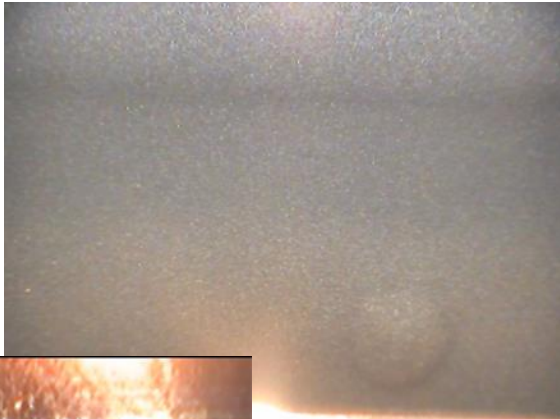
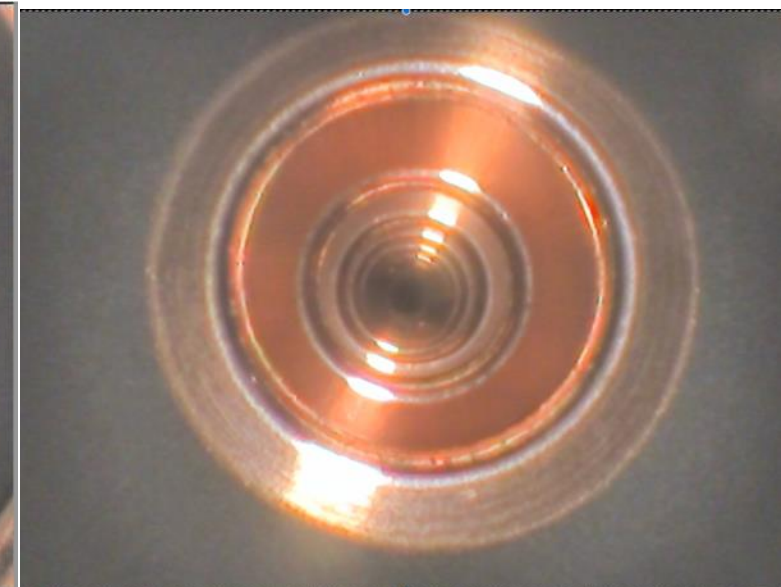
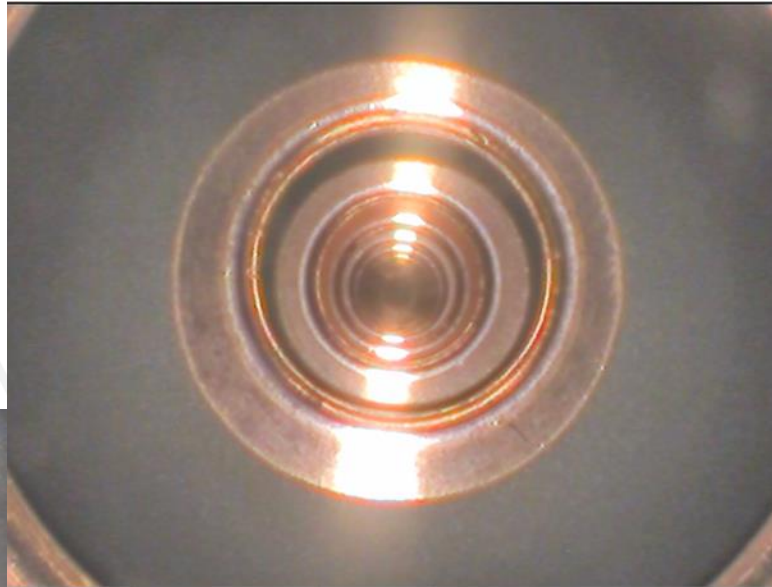
Linac Inspection

- 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

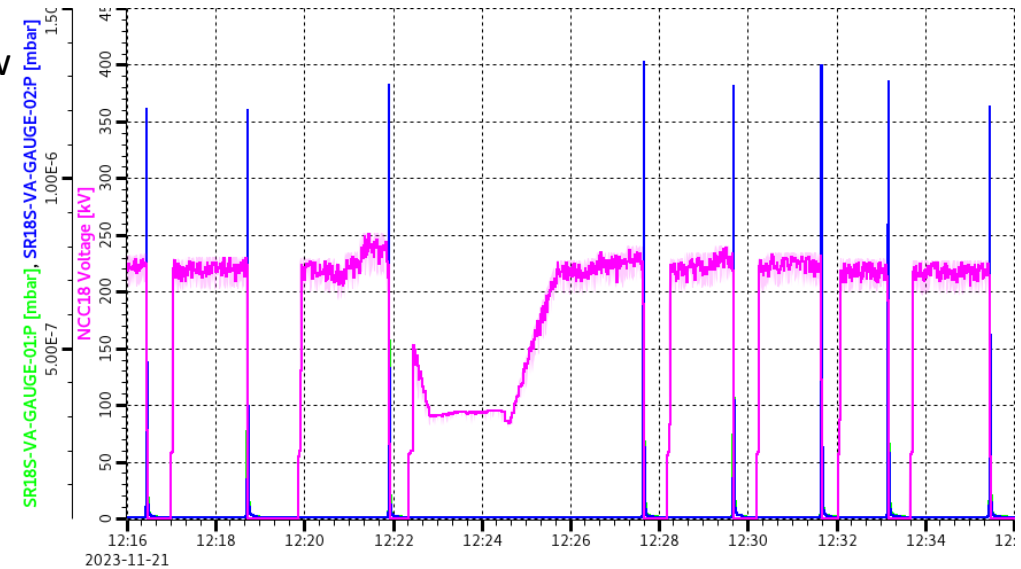
- Vacuum level recovered after closing the structure. No bake-out required.
- The final 7 cells of AS#2 showed no signs of damage.
- The experiment will be repeated for AS#1



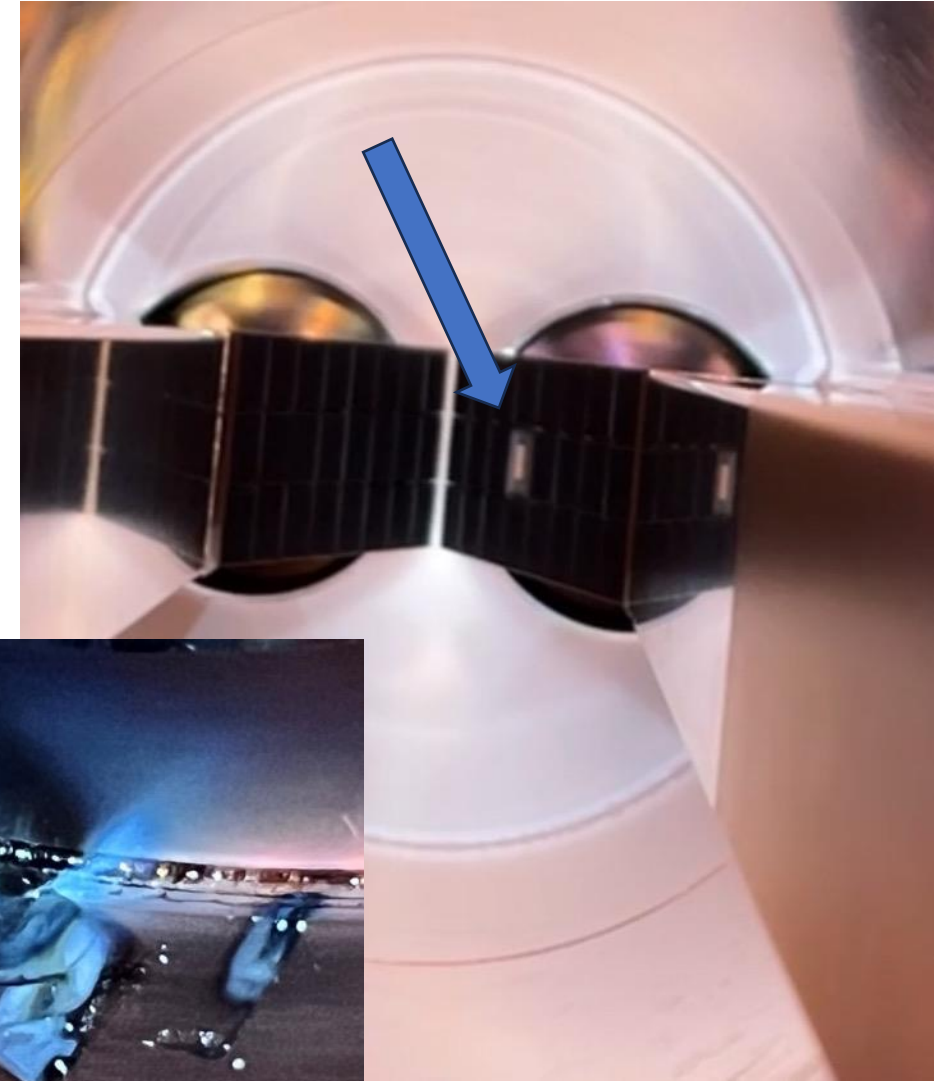
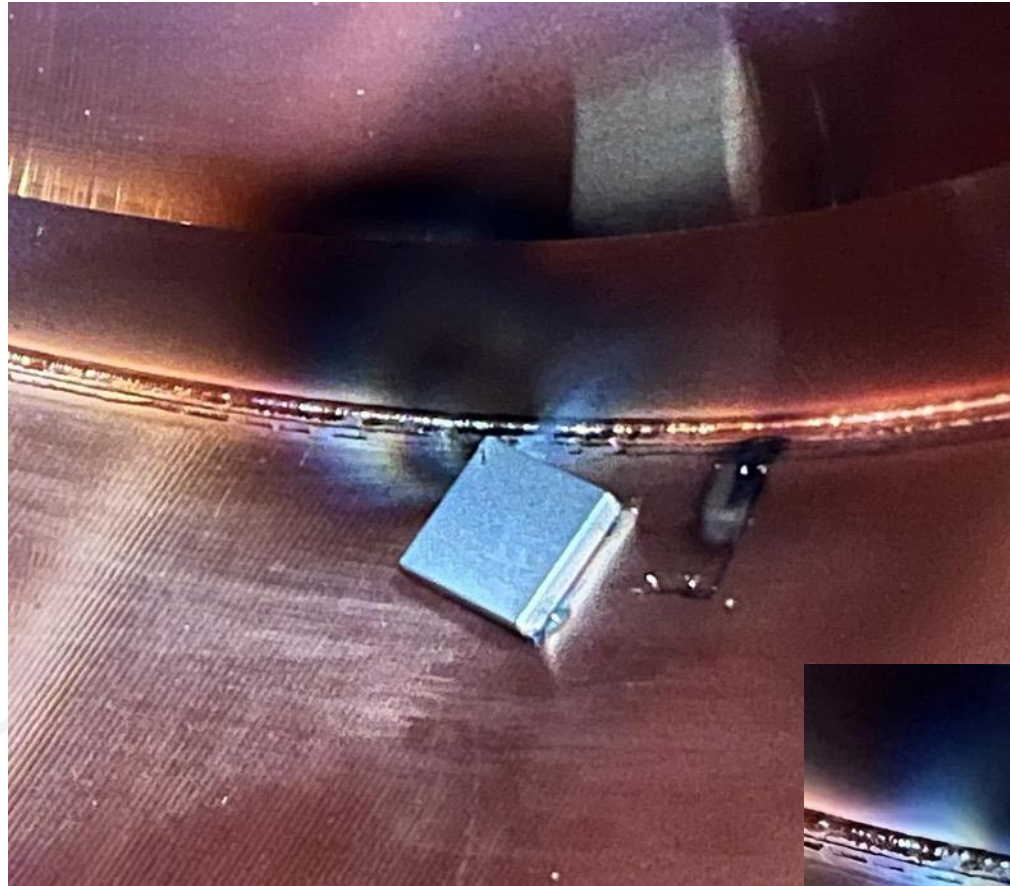
Pictures taken inside the last cells

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 replaced 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



Thanks for your attention

On Behalf of the RF Team:

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Anton Tropp

Marco Marziani

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