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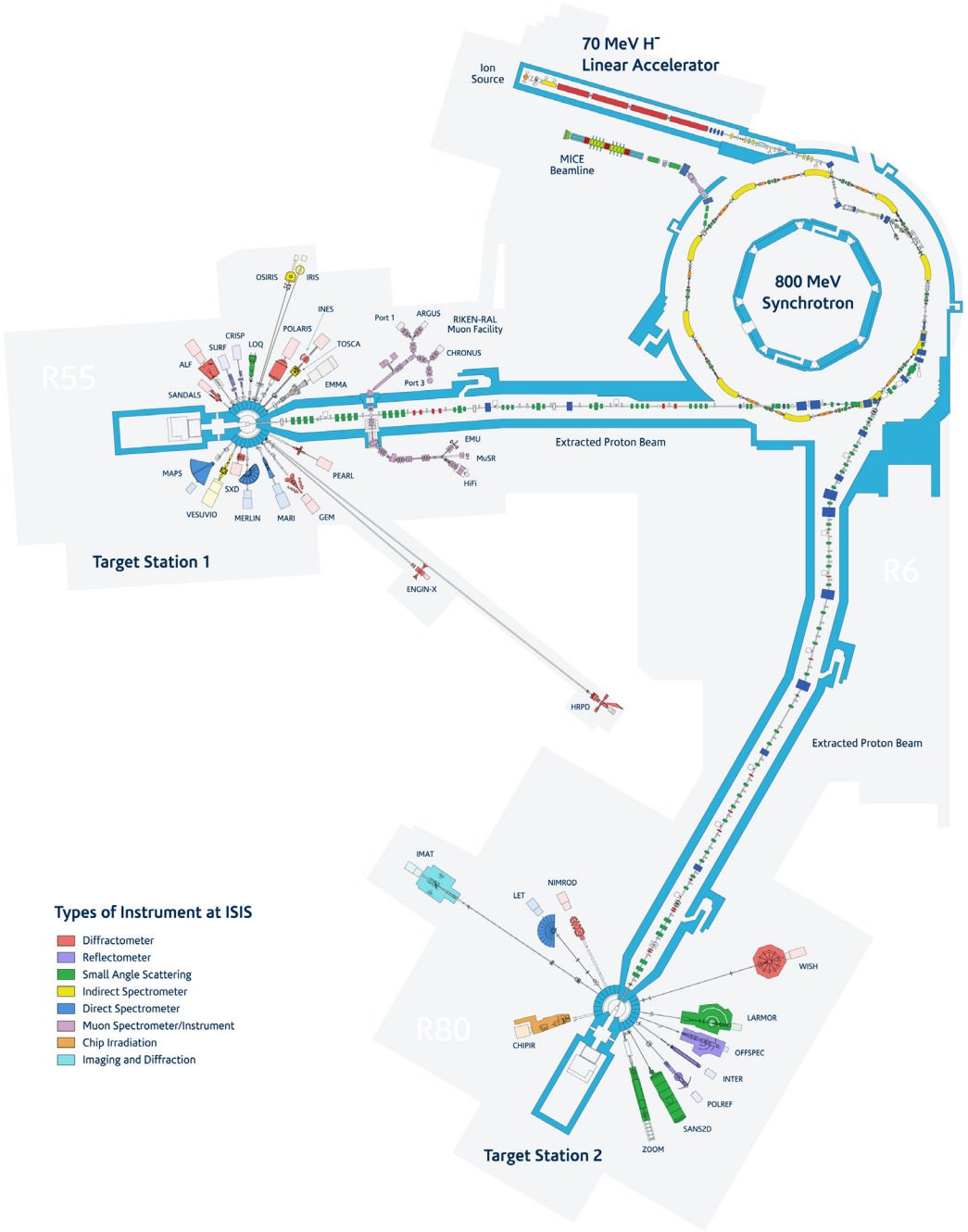
Upgrades and Developments at the ISIS Linac

Alan Letchford
Head of Linac R&D

ISIS Pulsed Spallation Neutron & Muon Facility
Rutherford Appleton Laboratory

ISIS



- Pulsed spallation neutron and muon facility at the Rutherford Appleton Laboratory near Oxford
- Short pulse
- 800 MeV RCS at 50 Hz
- 2 target stations
- 70 MeV H^- injector linac

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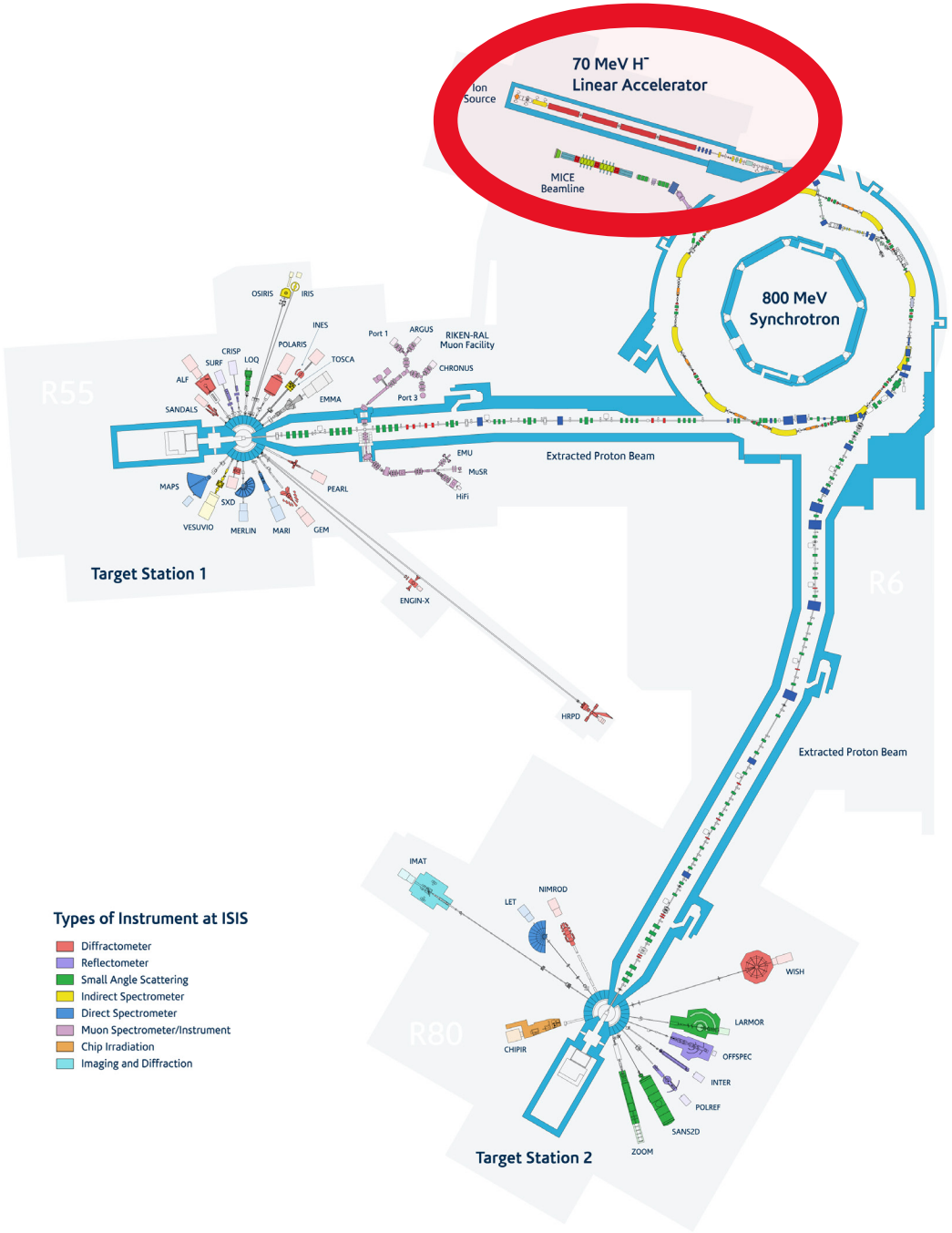

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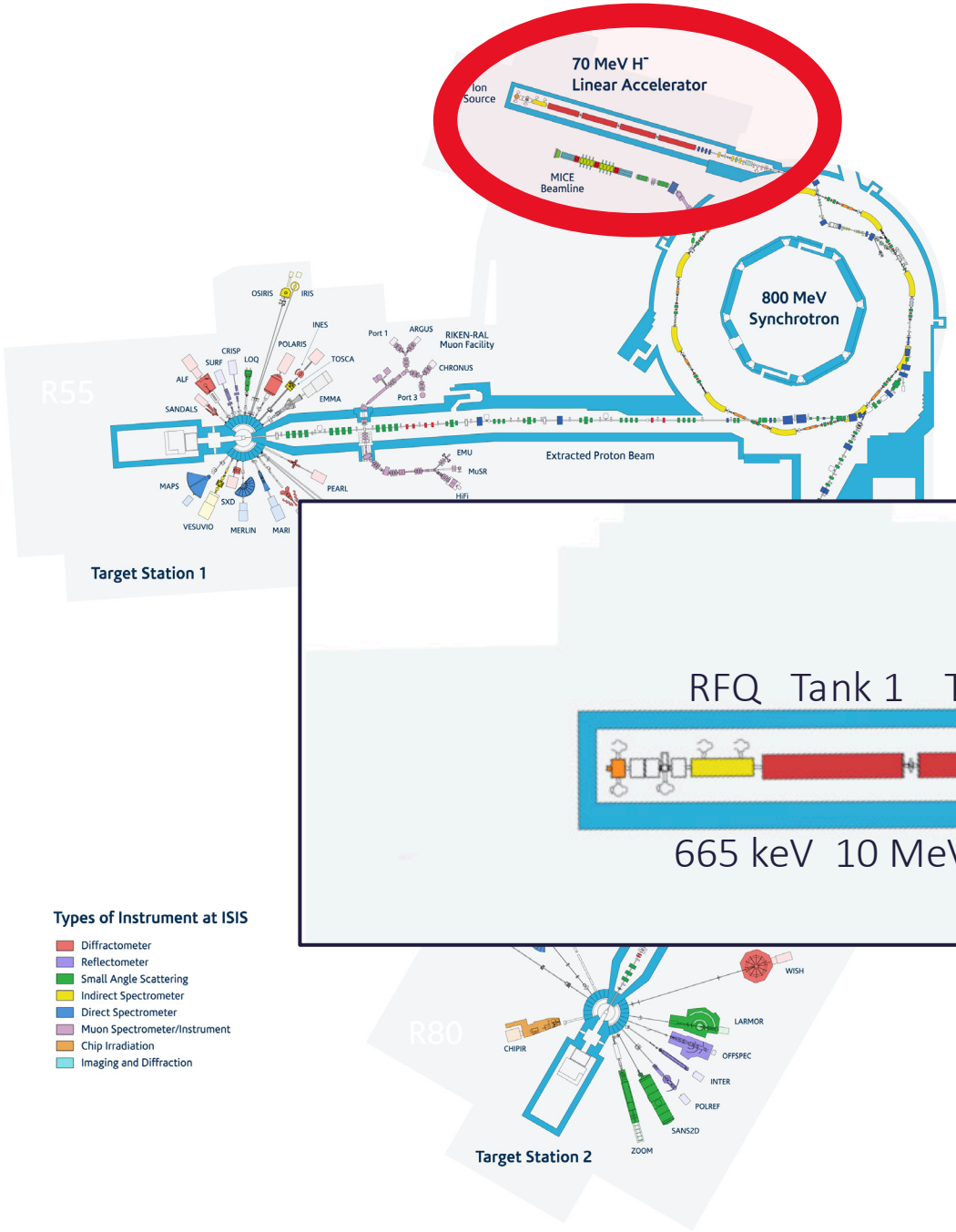

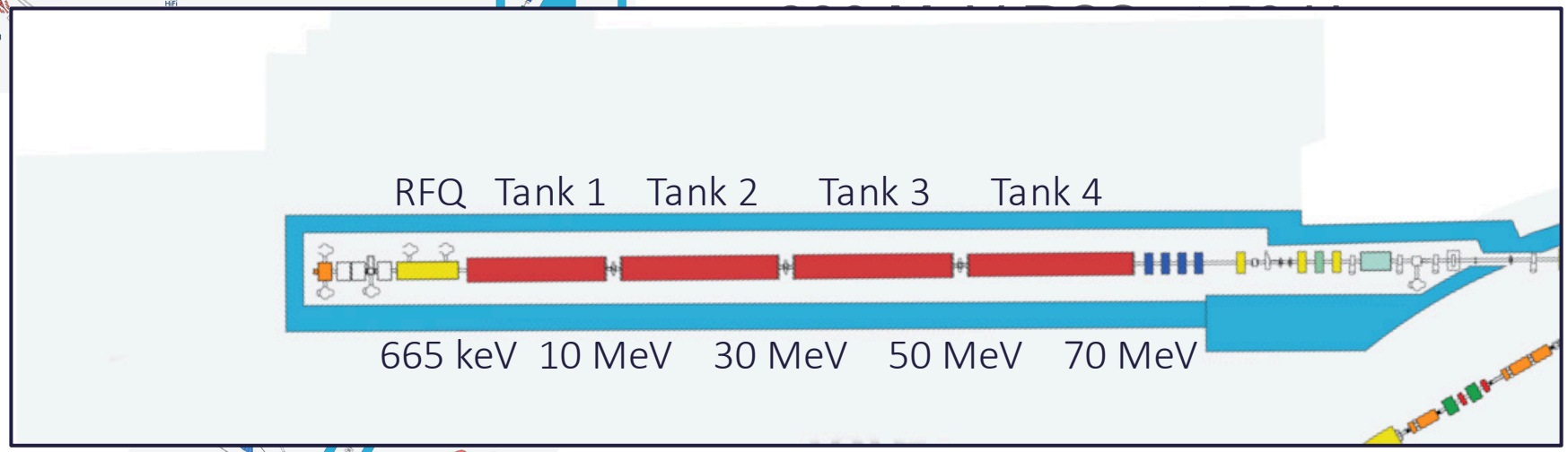

Today’s talk

- The replacement of DTL Tank 4
- A MEBT for the pre-injector
- The Front End Test Stand

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  - To increase the performance of the Linac
- The Front End Test Stand
  - Not for this Linac but the Linac that is to come after it

Replacement of Tank 4

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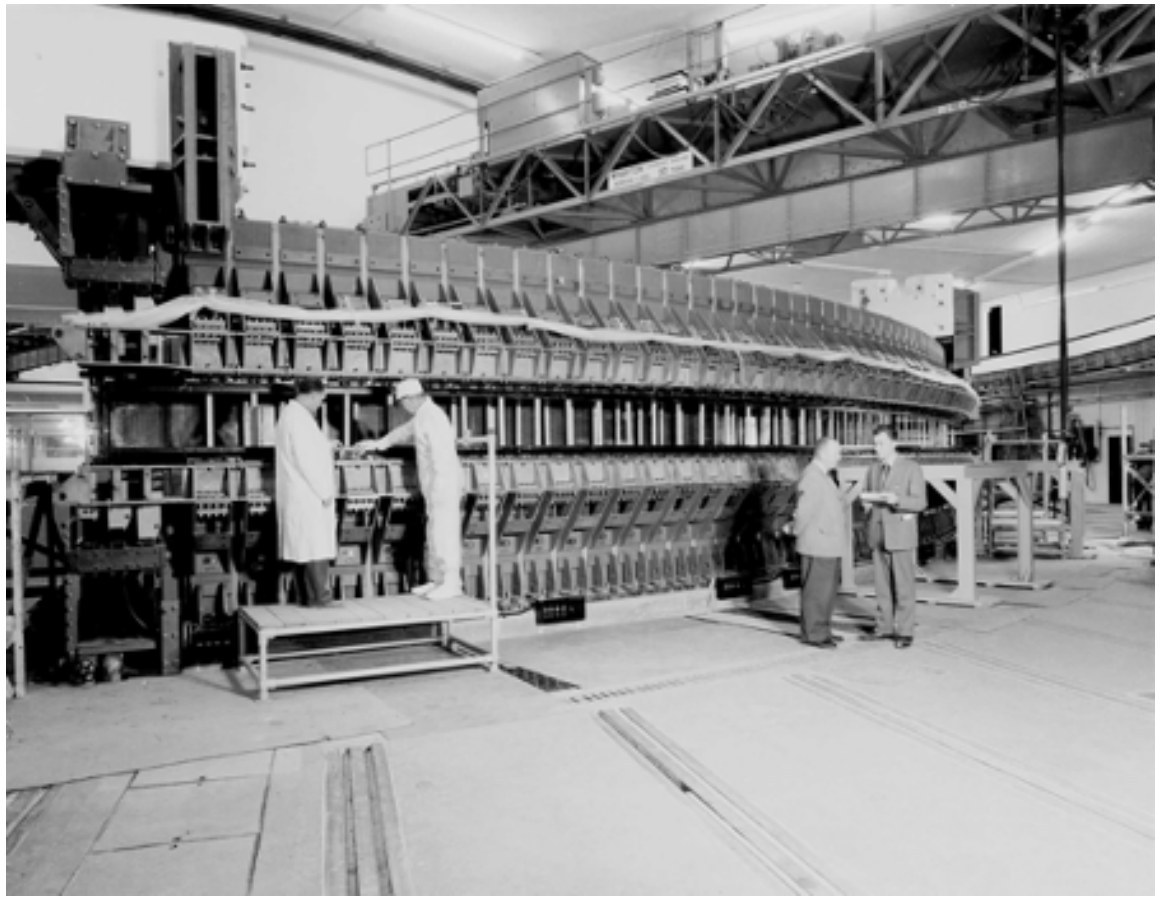

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The 70 MeV linac was originally intended as an upgrade for the 15 MeV injector on NIMROD.

It would recycle two DTL tanks from the 50 MeV Proton Linear Accelerator (PLA) which operated at RAL from 1959 to 1969.

Before the new injector could be finished NIMROD was shut down.

The 70 MeV linac became the injector for ISIS using parts recycled from NIMROD which used parts recycled from the PLA.

PLA and NIMROD operated at 1 Hz. ISIS operates at 50 Hz.

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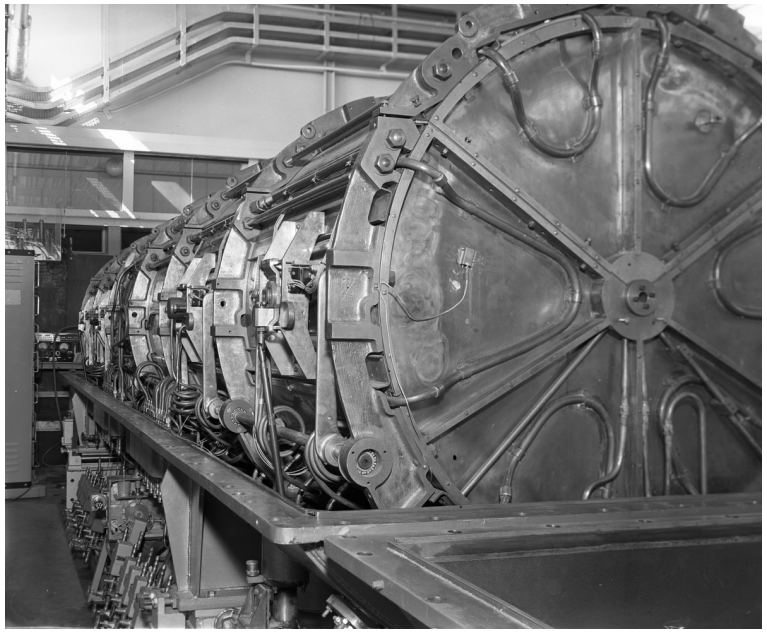

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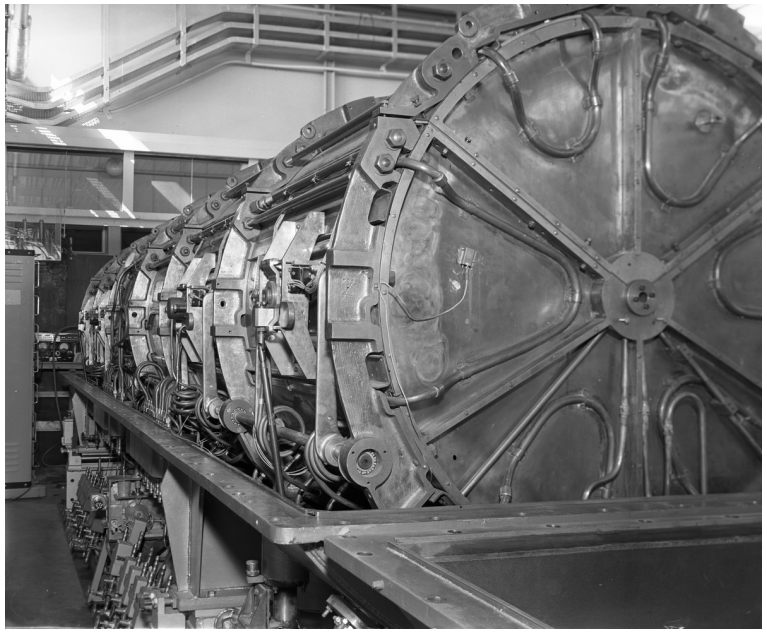

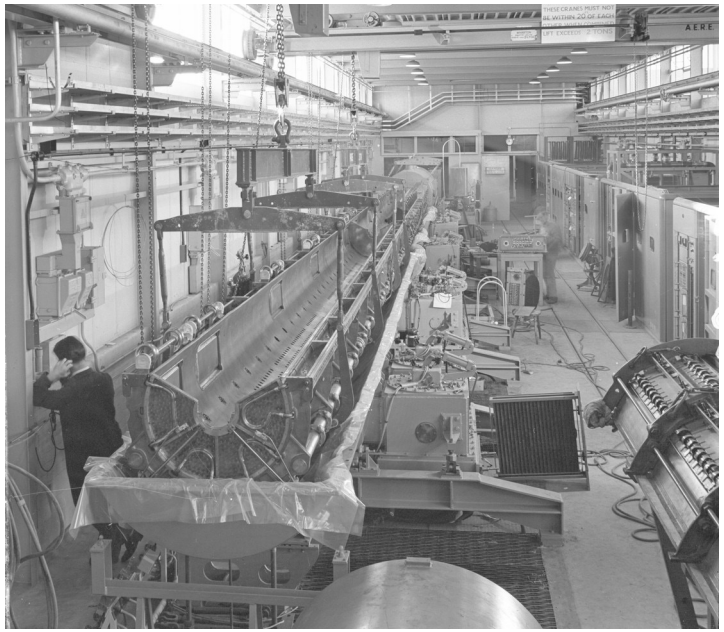

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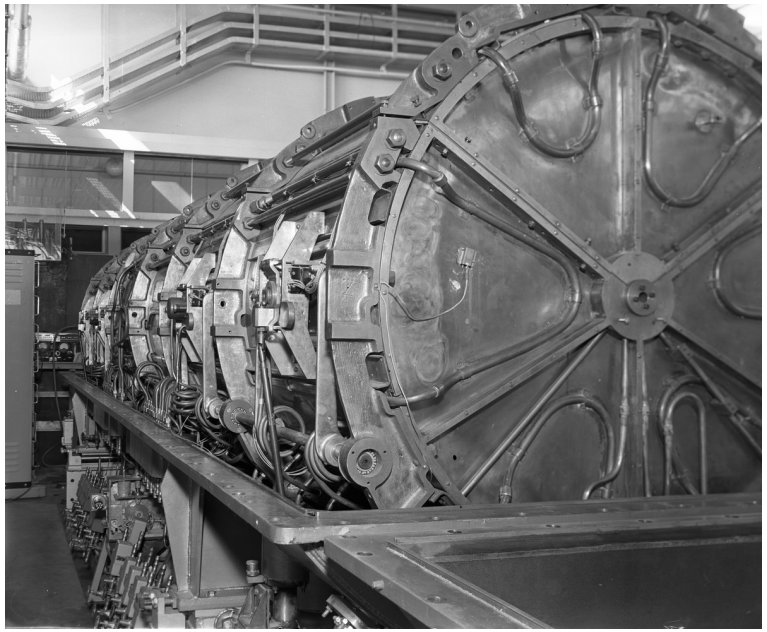

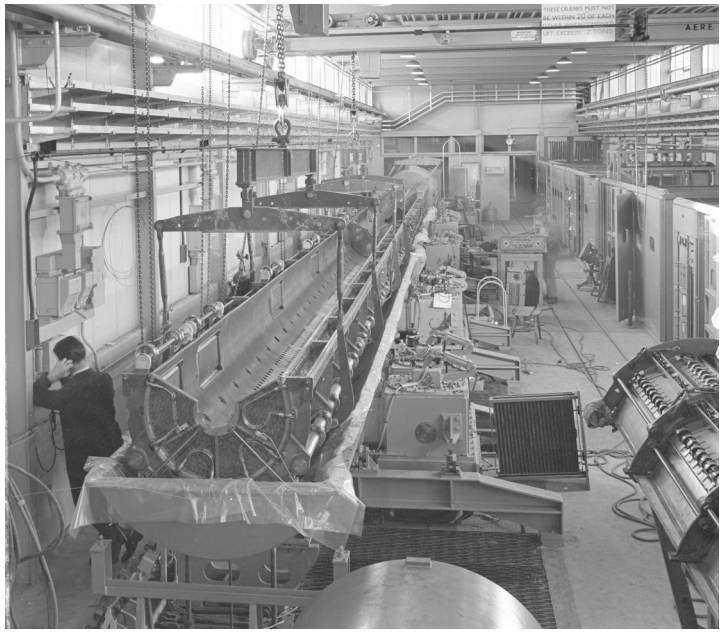

Because of the way these old tanks are made every part of them is accessible and therefore repairable.

This is why they are still operating at 50 times the original rep. rate over 60 years later.

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Tank 4 is one of the ‘new’ tanks made in the late 1970s.

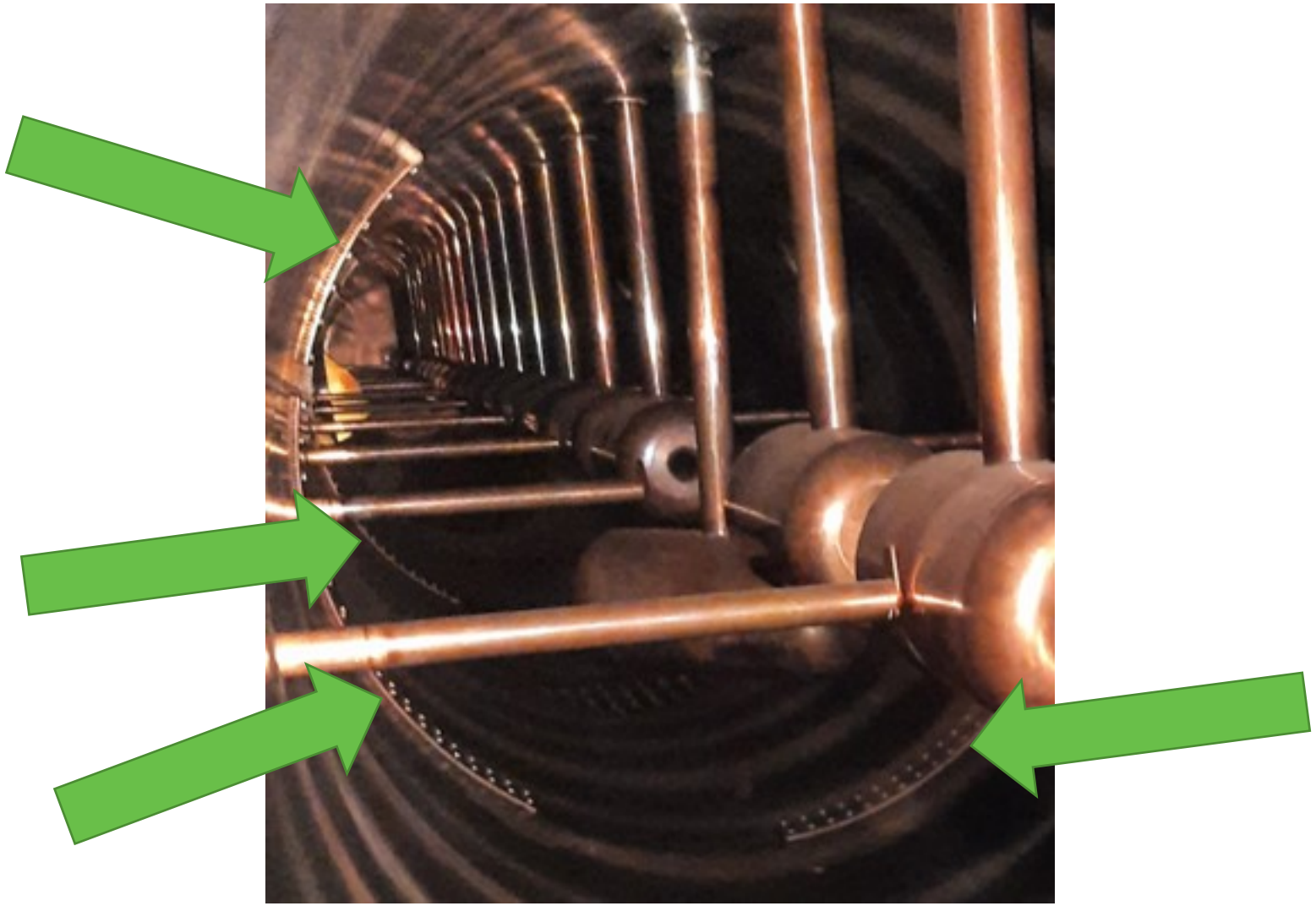
It is made in a much more recognisably modern way.

- Steel tank with explosion bonded copper lining.
- Drift tubes hang by a single stem from above.
- 6 sections bolted together and internally welded.

Essentially a copy of the Fermilab DTL.

The internal welds cracked and leaked from the beginning.

The solution was to fit vacuum patches over all the leaking cracks.



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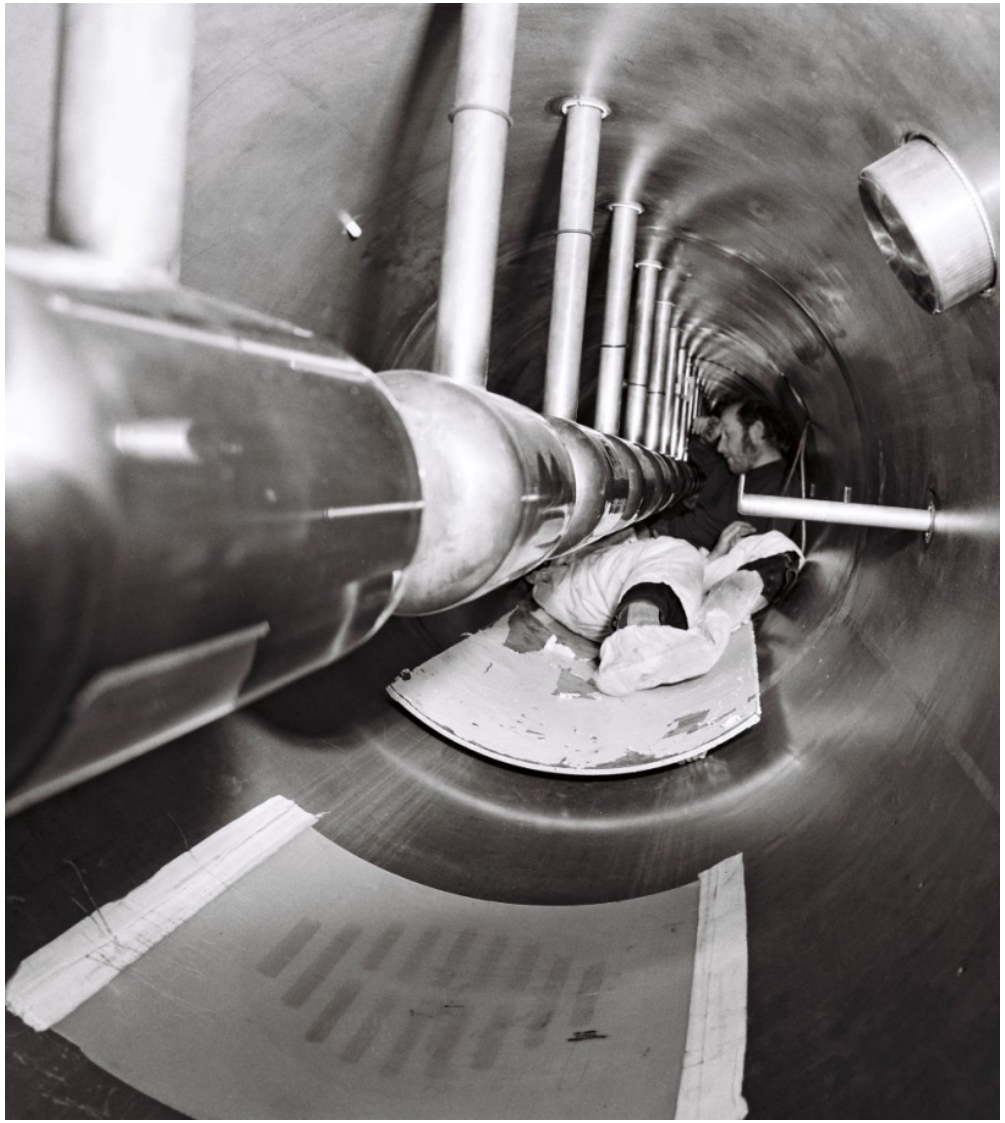
Mainly because we could no longer do this.



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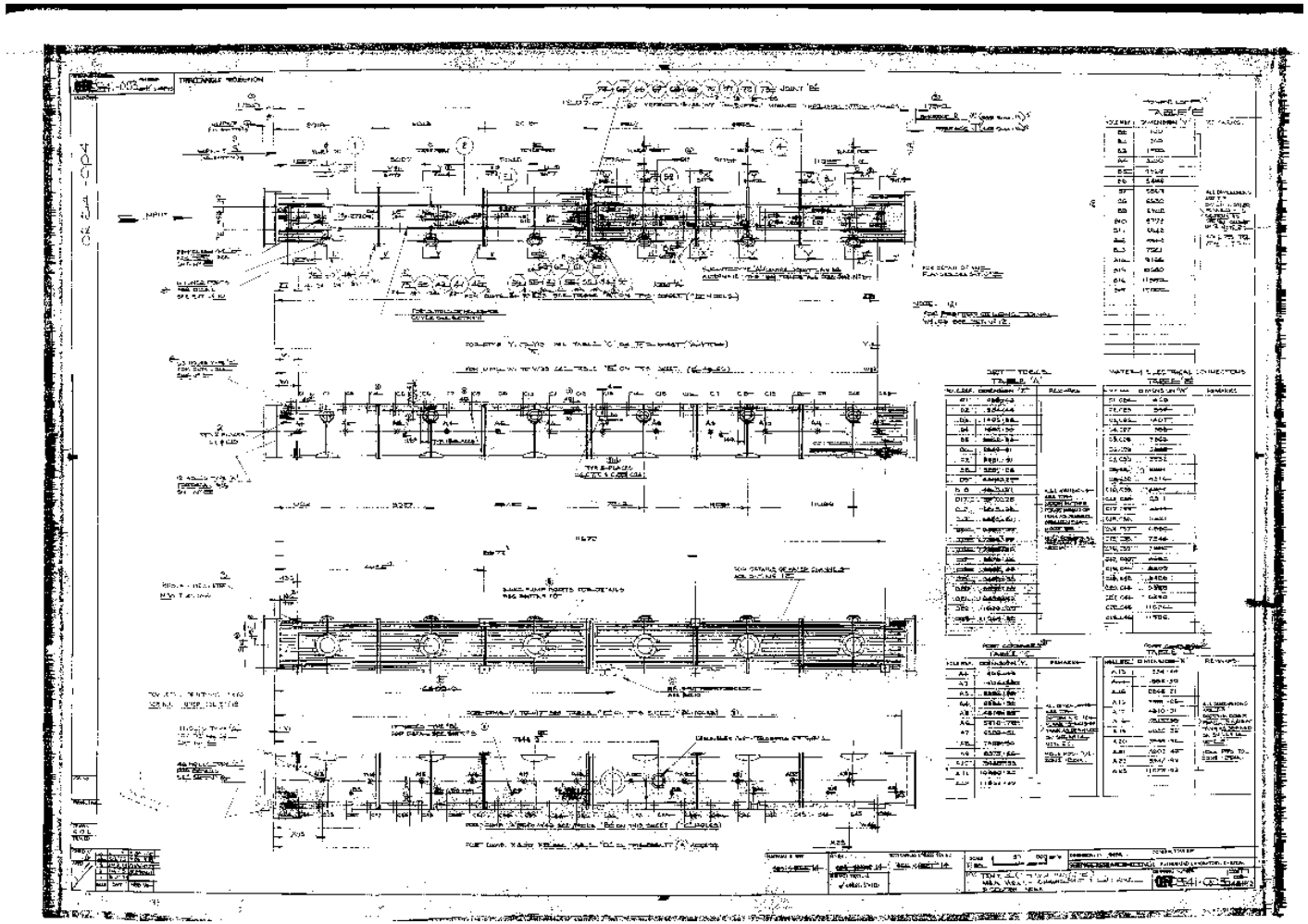

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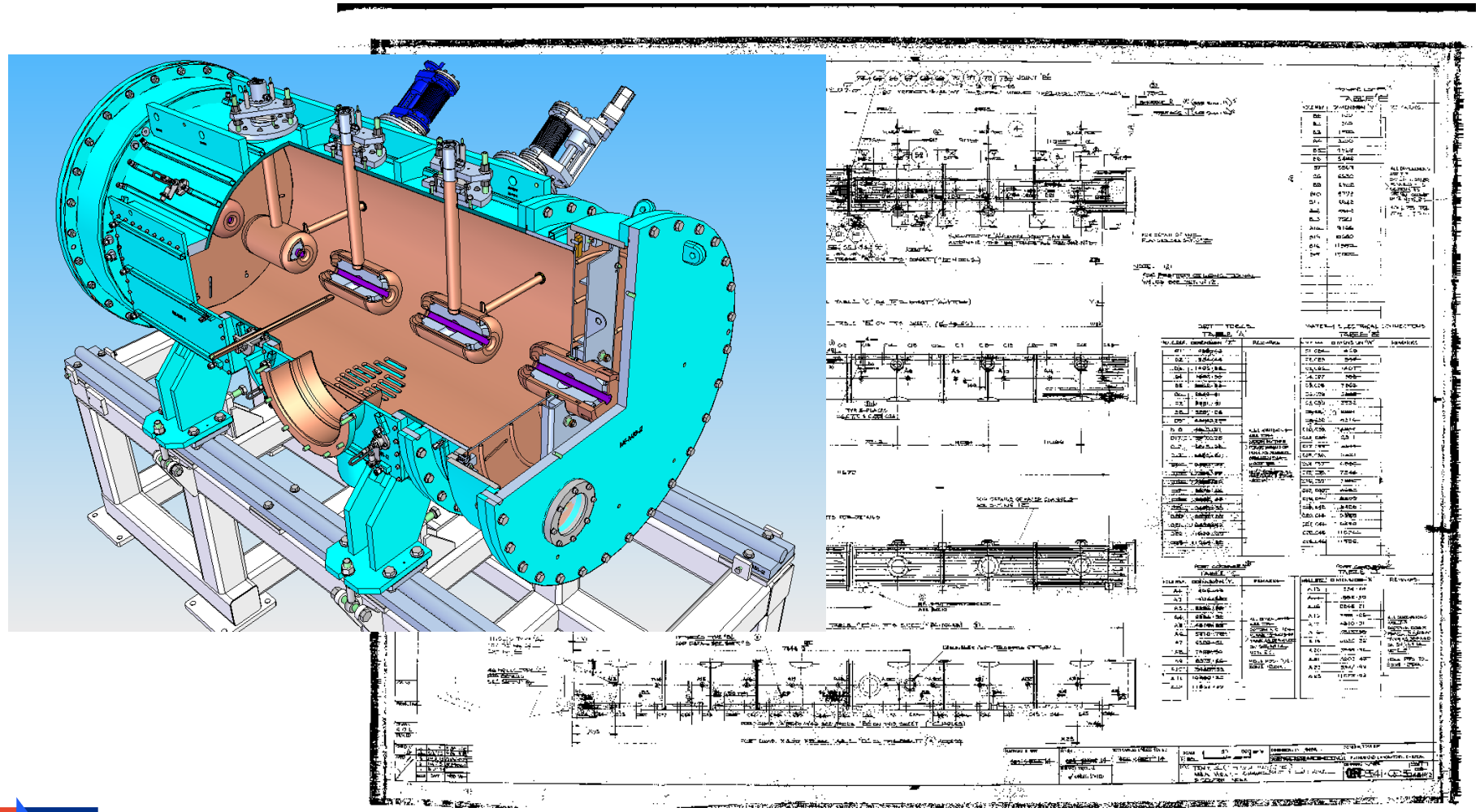

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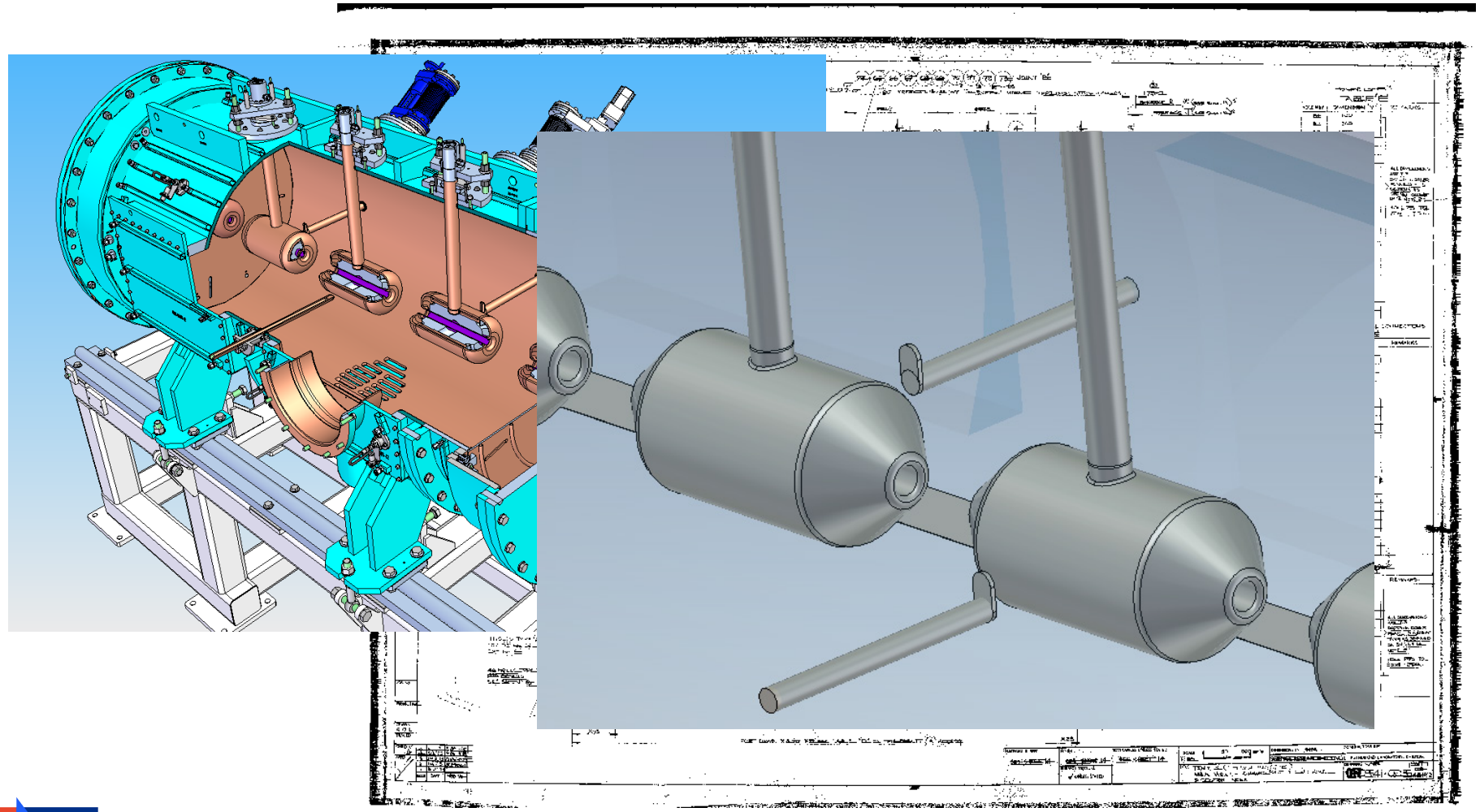

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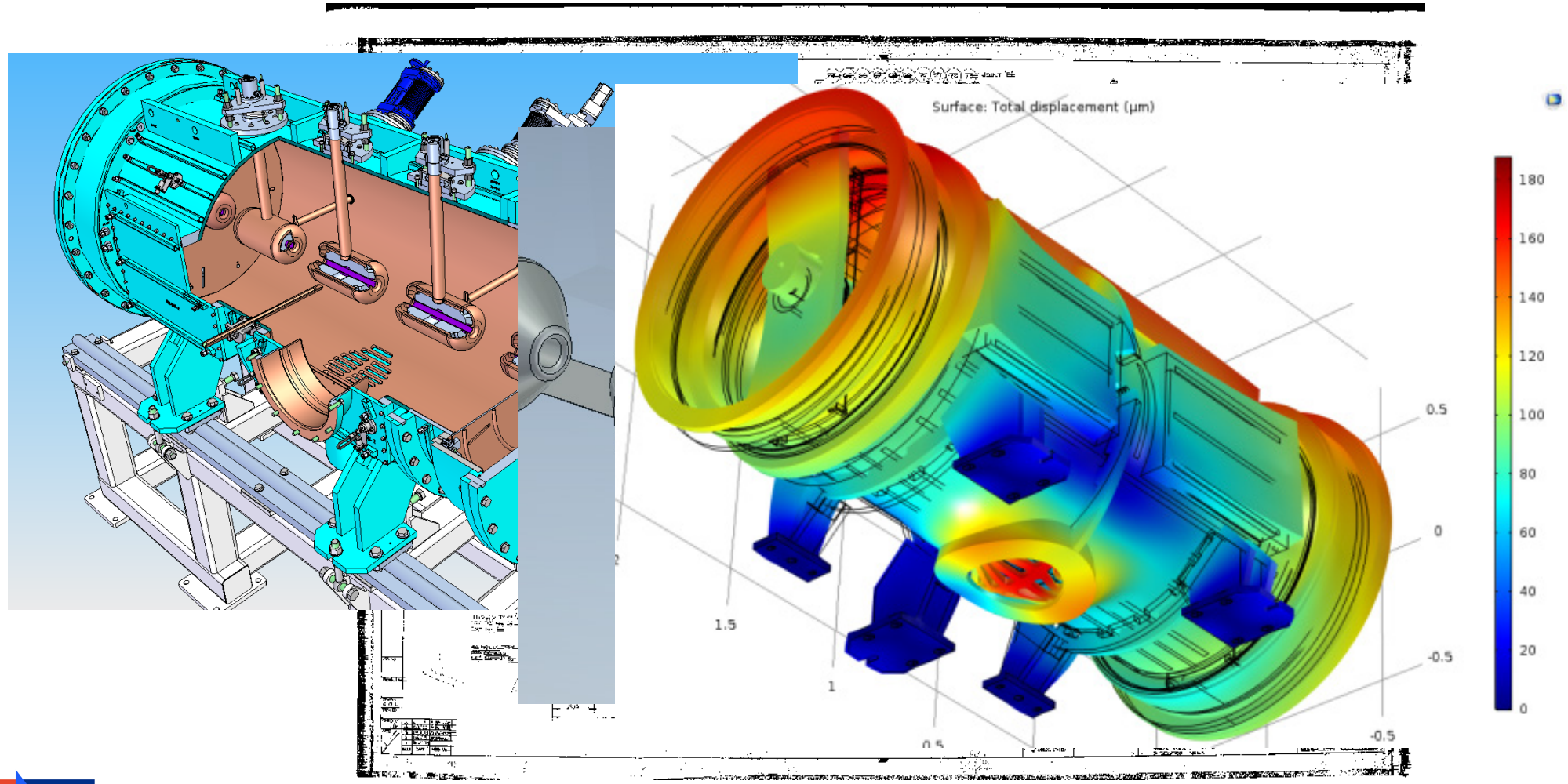

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One design goal was to have a new tank which wouldn’t leave a future generation of operators with the same predicament we faced.

Sections of tank are bolted together with HELICOFLEX™ seals for vacuum and RF.

Could be dismantled in future if necessary.

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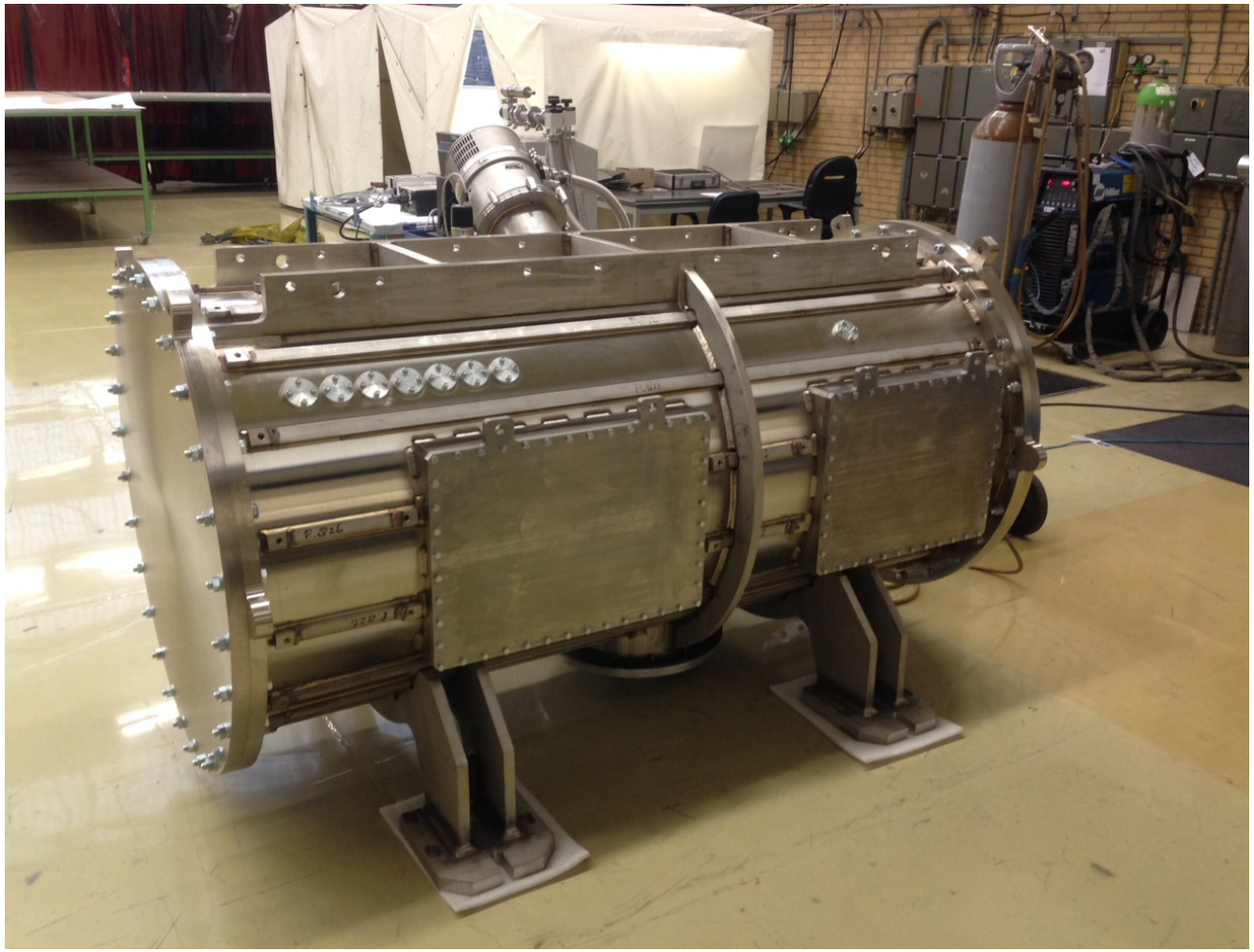

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Linac Test Area built to assemble and test the new tank.

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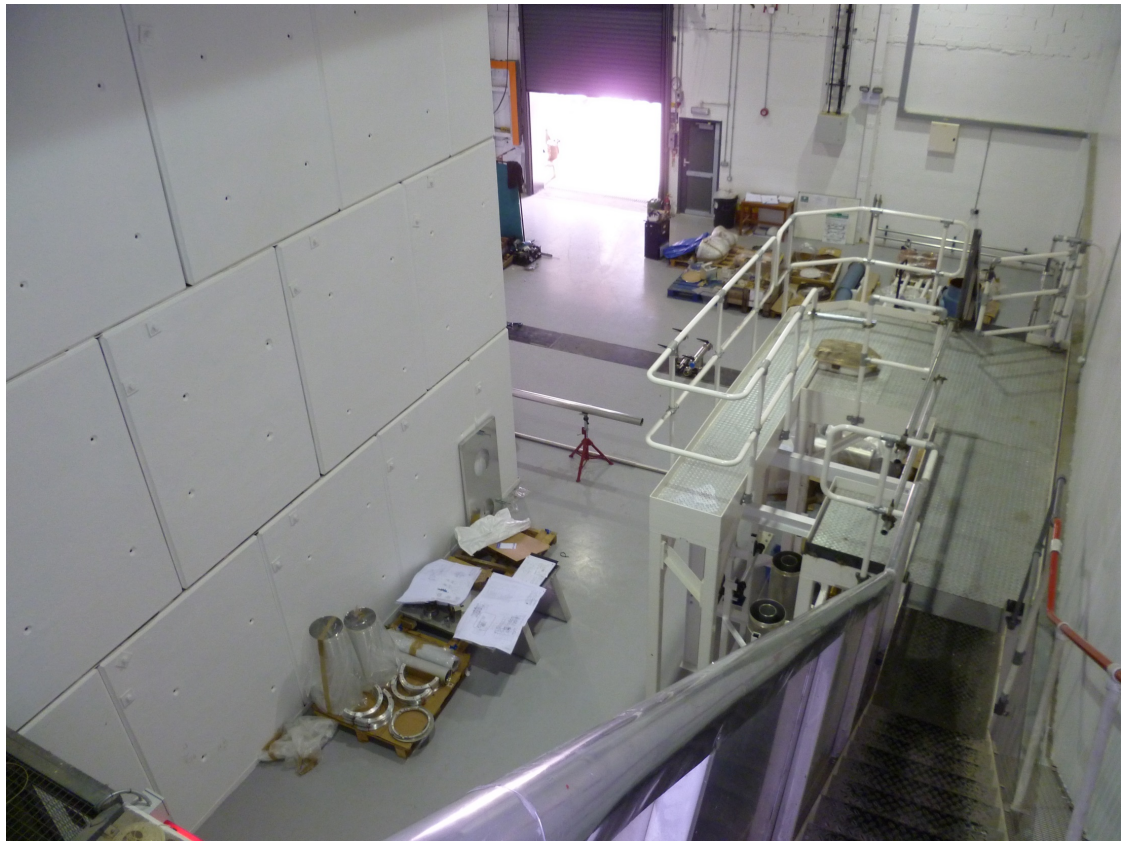

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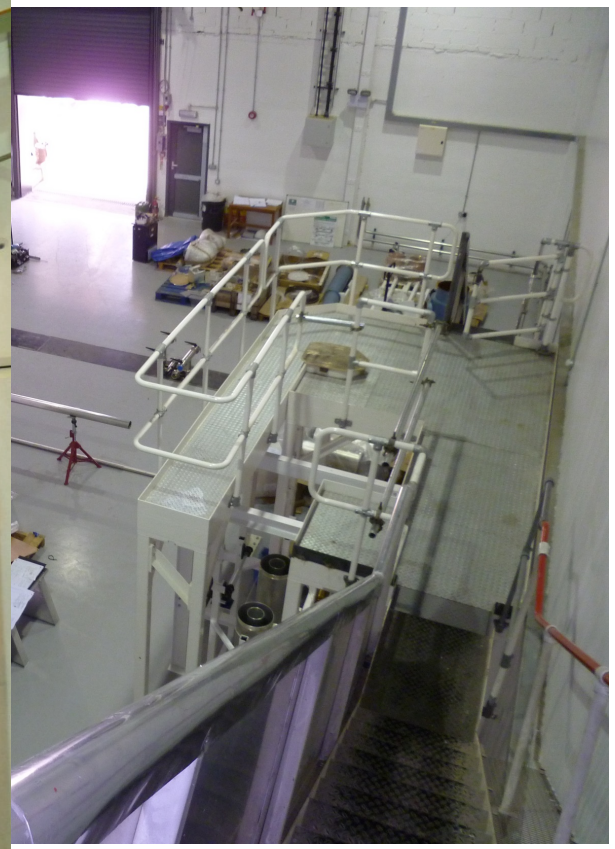

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A single section Test Tank to check modelling and manufacturing techniques.

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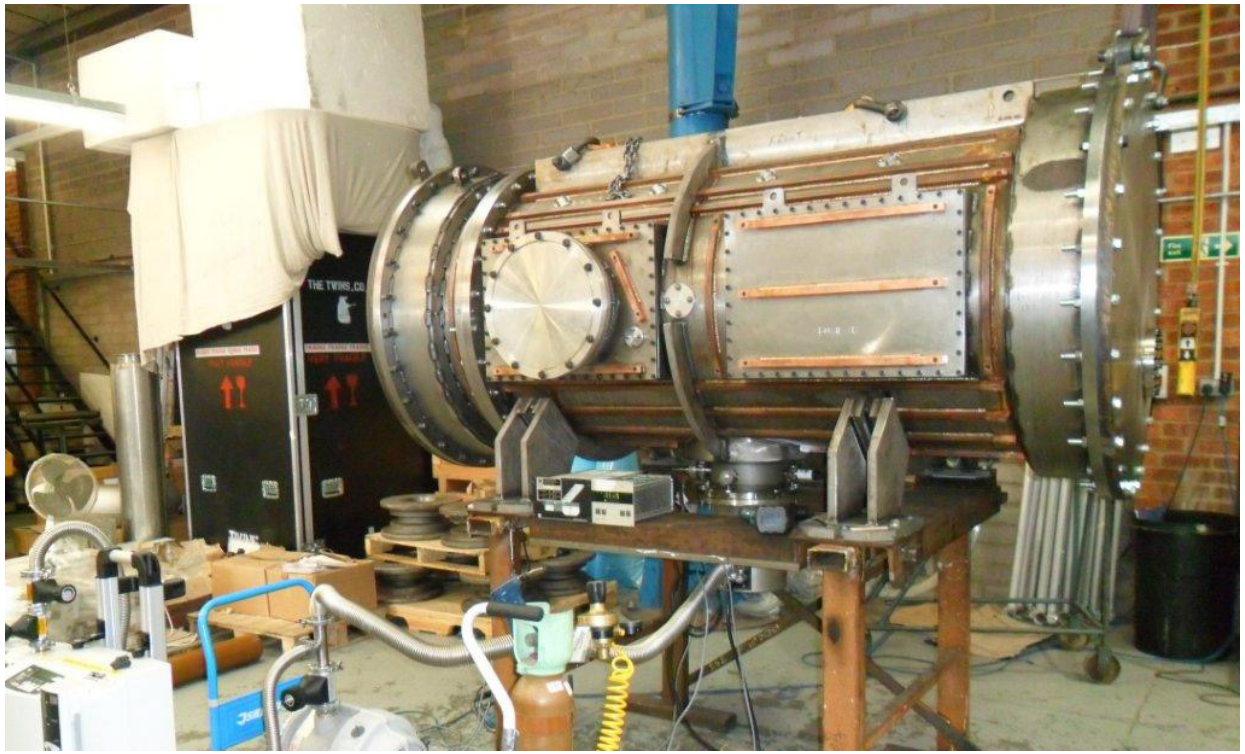

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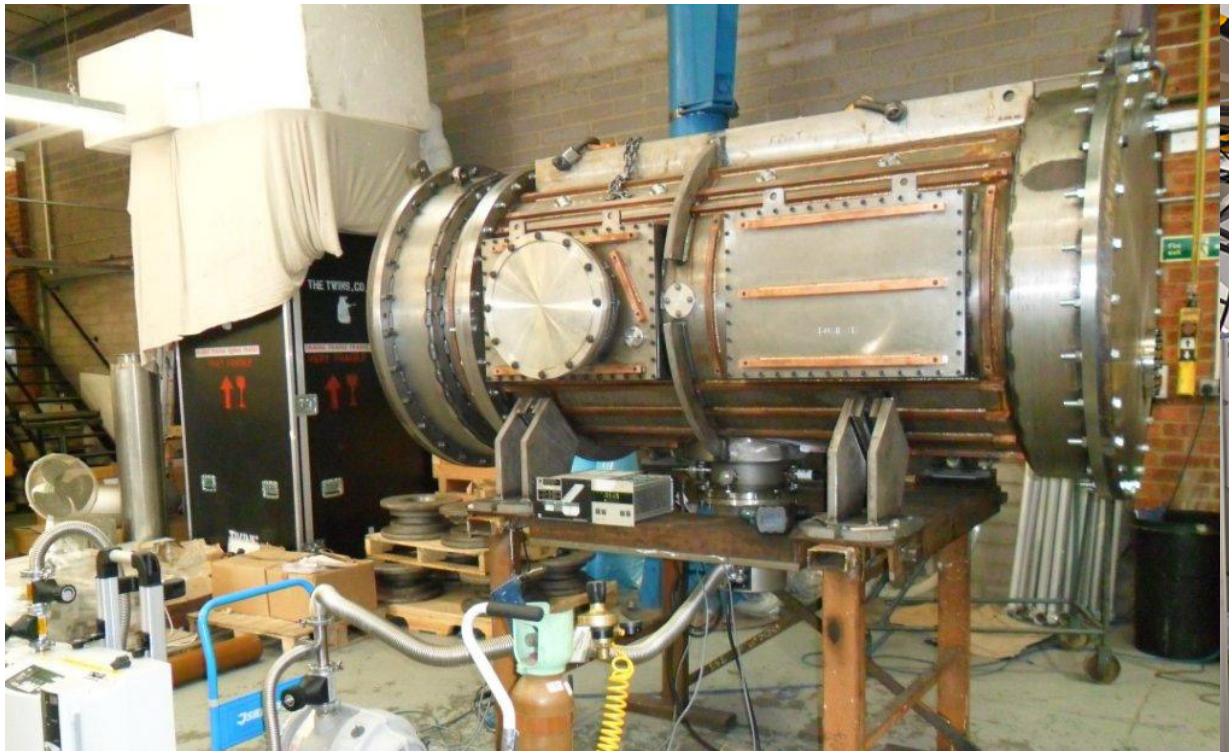

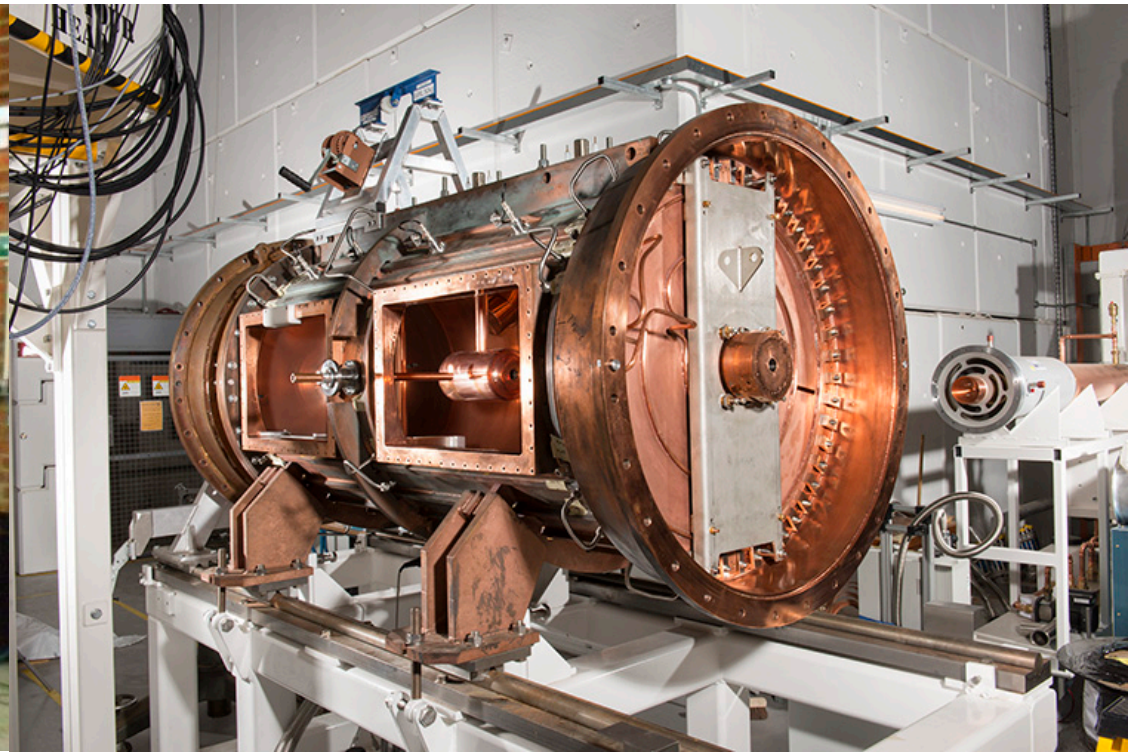

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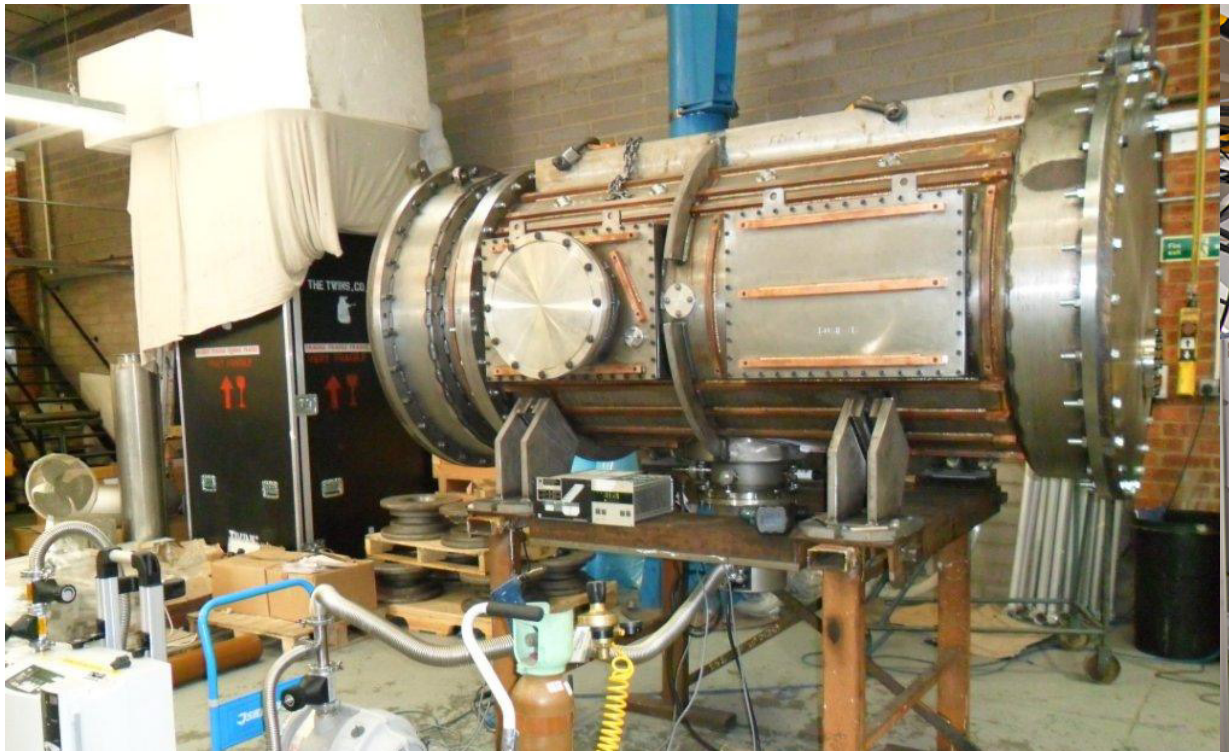

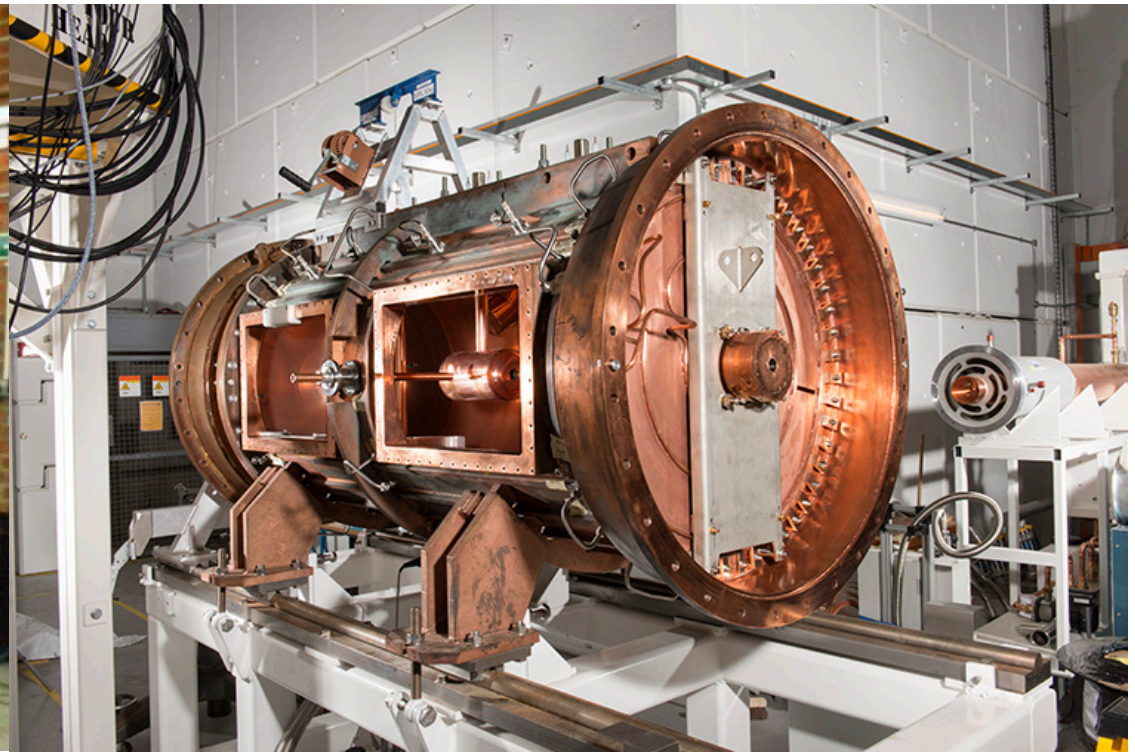

Test Tank RF conditioned and operated at full power for an extended period.

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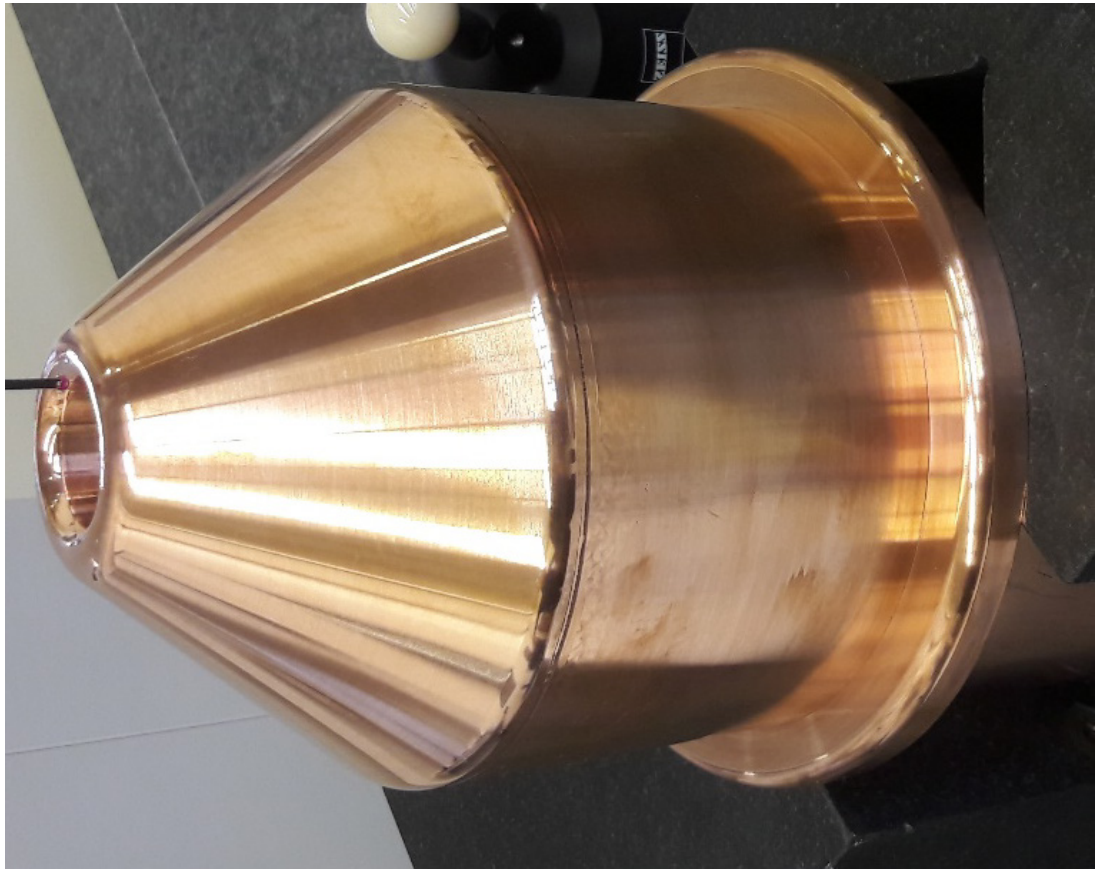

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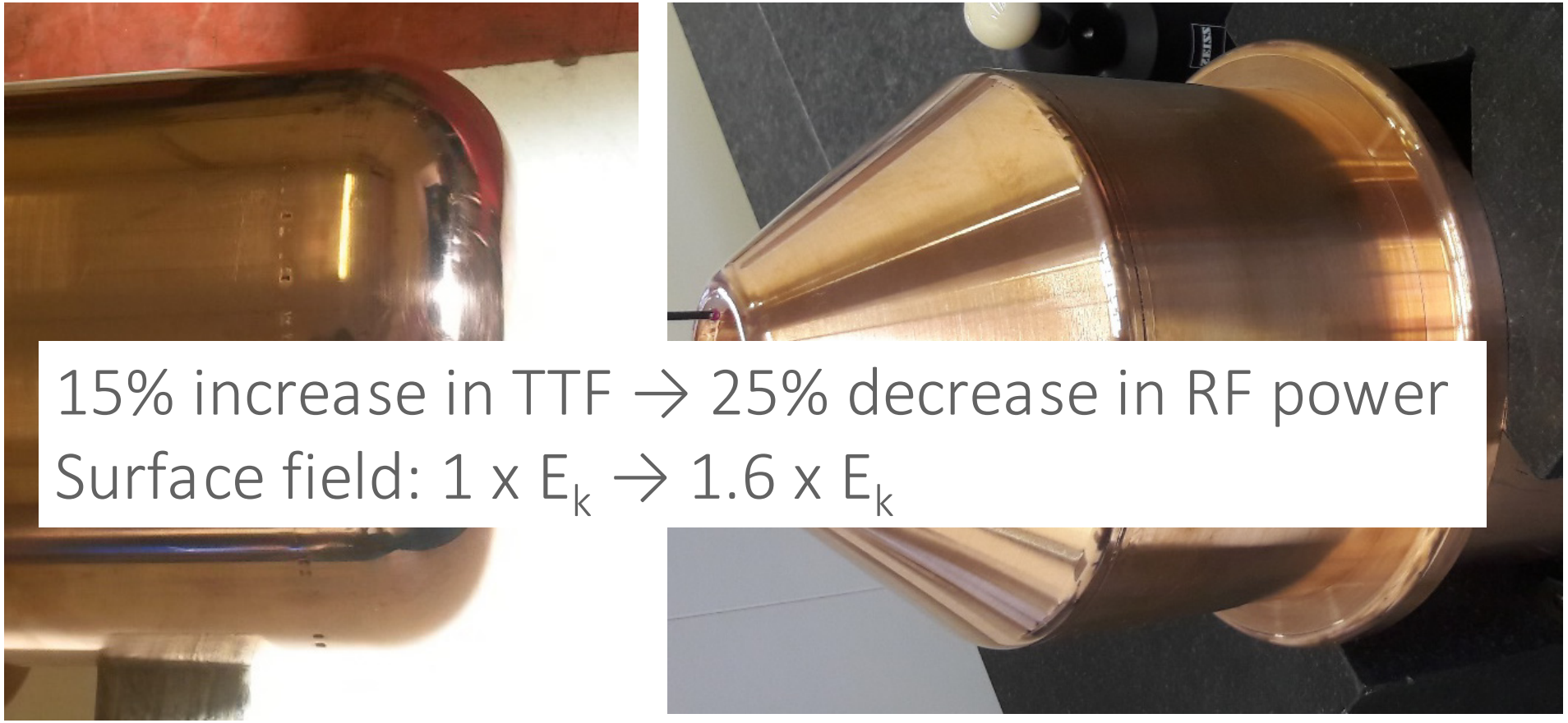

15% increase in TTF → 25% decrease in RF power

Surface field: 1 x E_k → 1.6 x E_k

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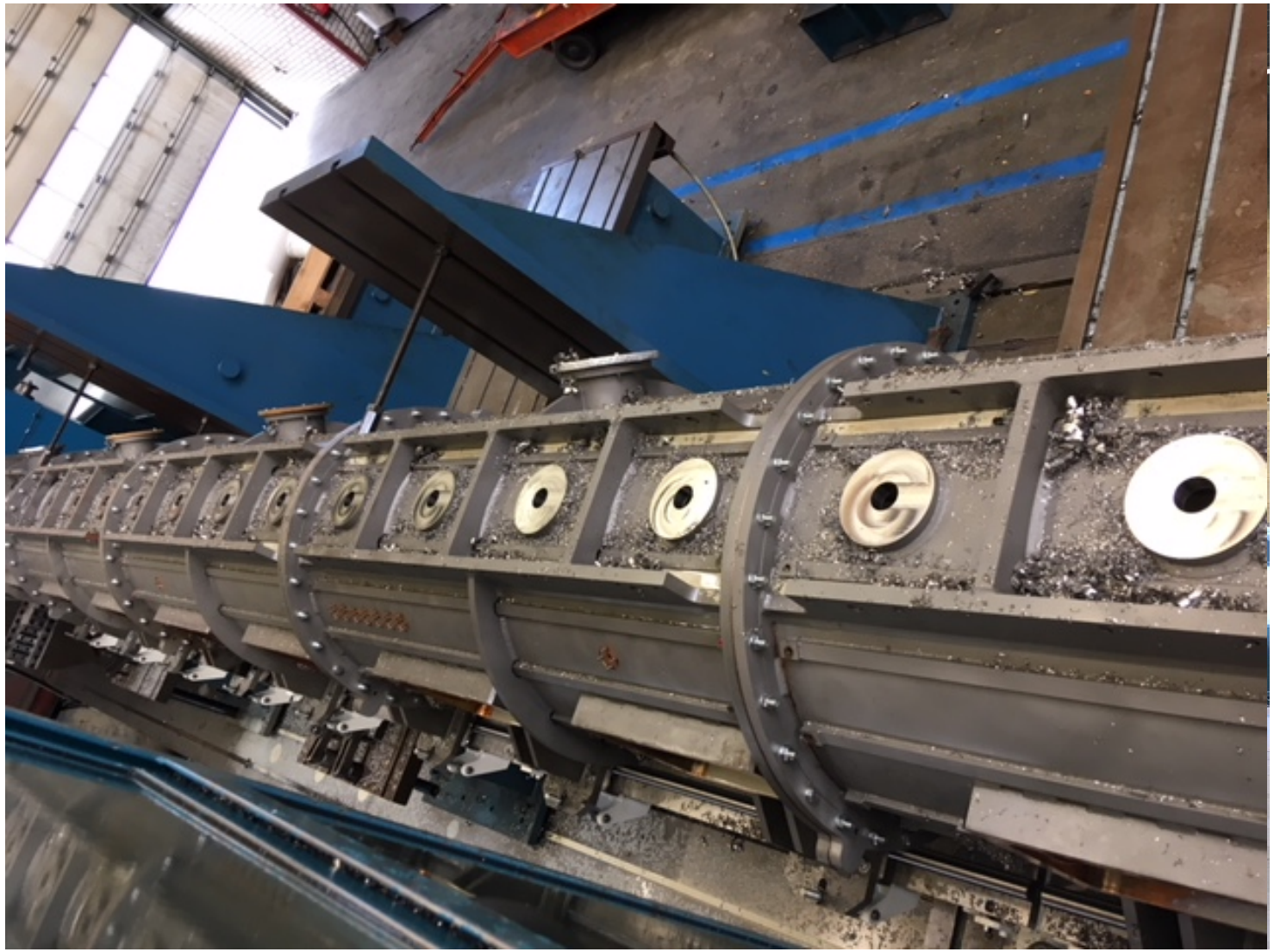

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Tank assembled in the LTA.

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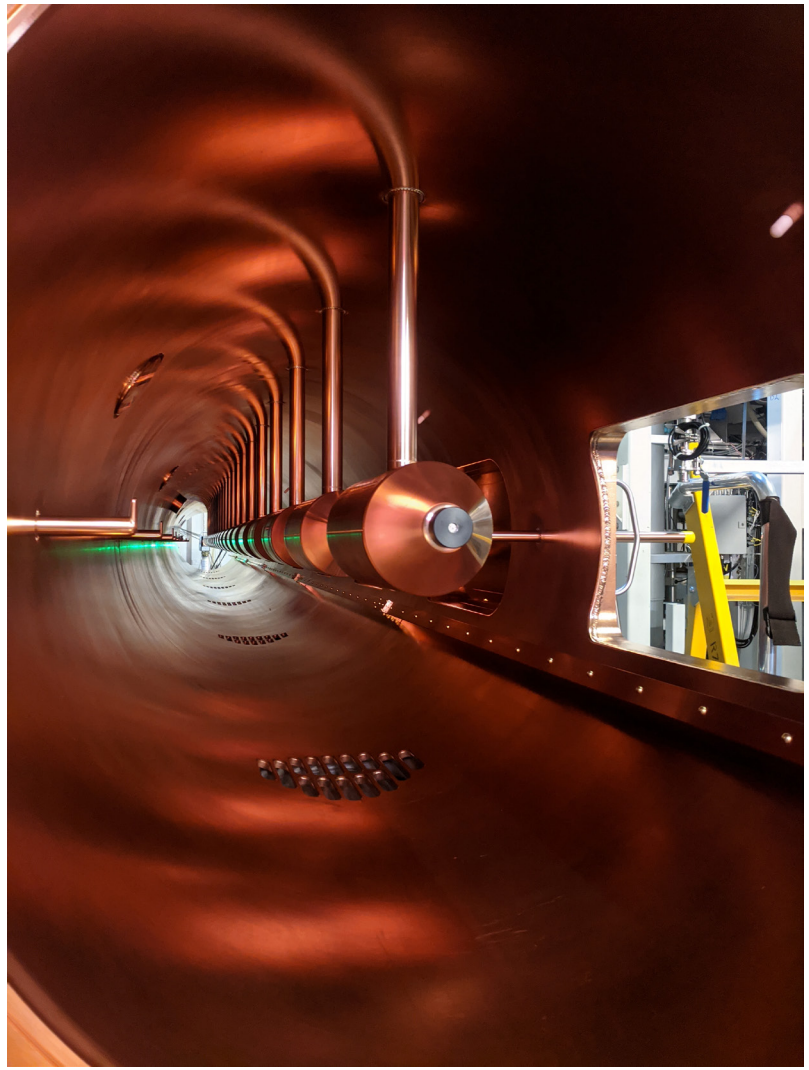

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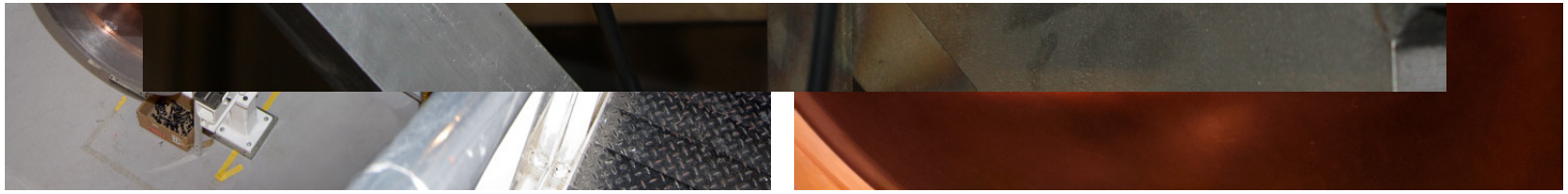
Tank assembled in the LTA.

After alignment, vacuum testing, tuning and field stabilisation

- RF conditioned to 110% field level
- Soak tested in simulated user run conditions
  - Operated continuously for 6 weeks
  - Shutdown for inspection & maintenance
  - Operated continuously for another 6 weeks

All testing completed in time to commit to installation in a long shutdown 2021/22.



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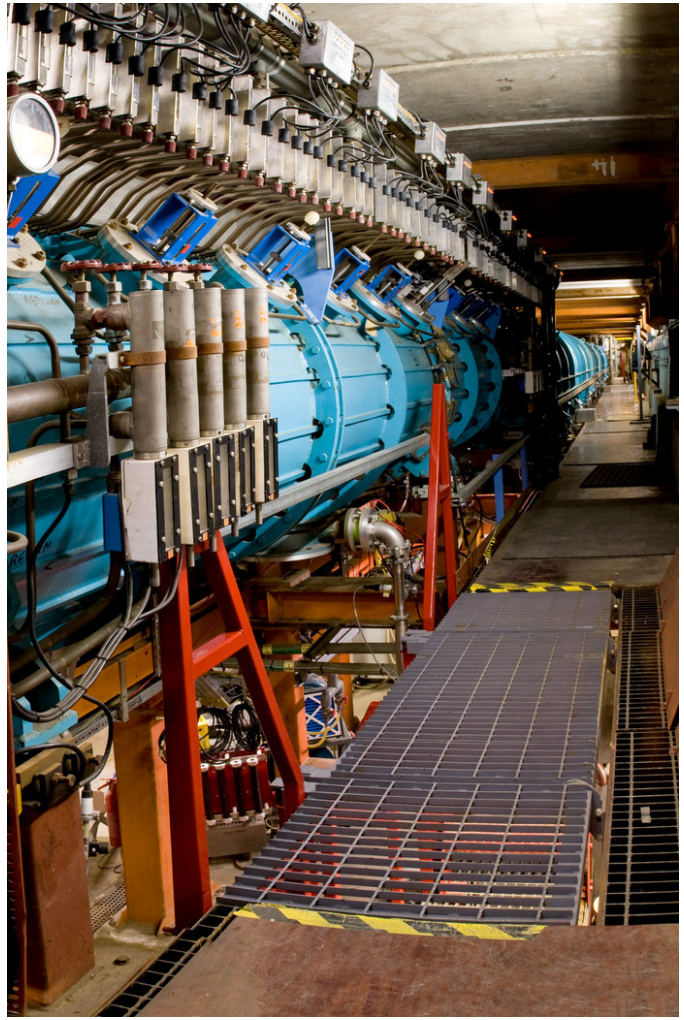

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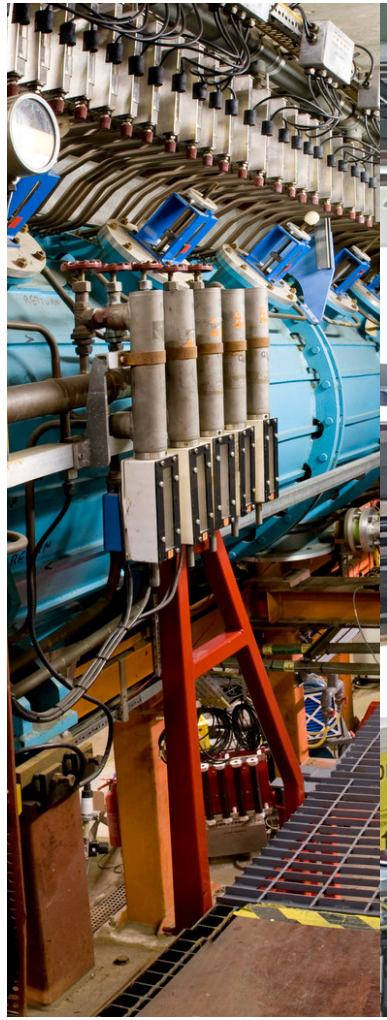

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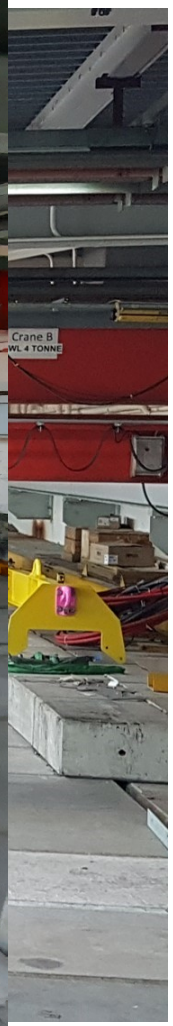

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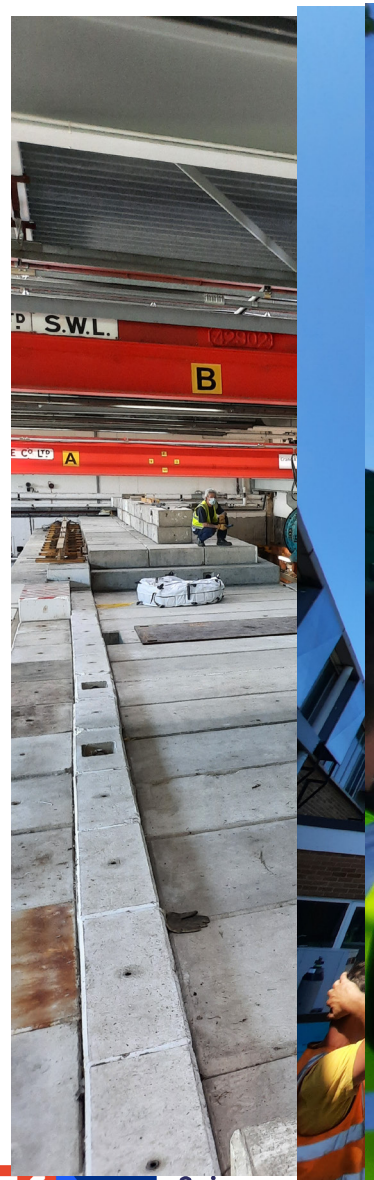

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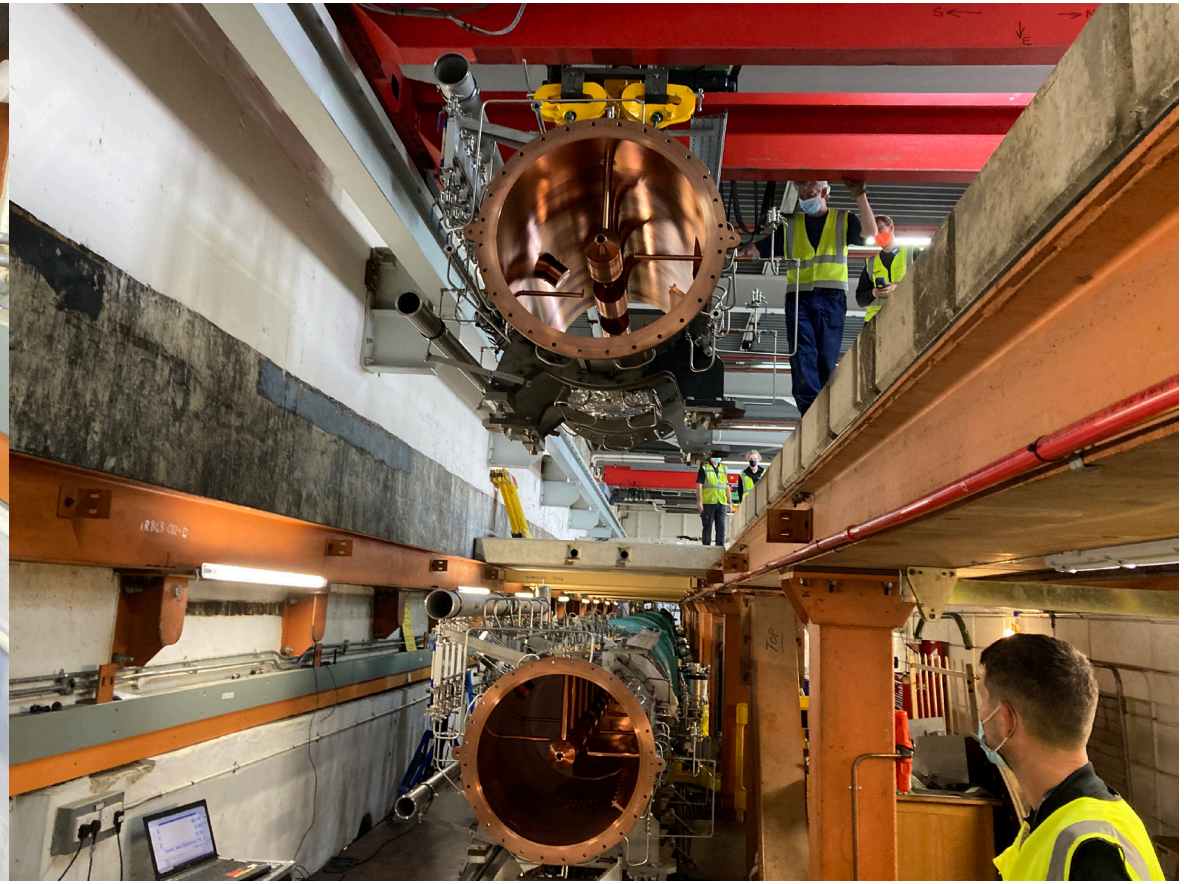

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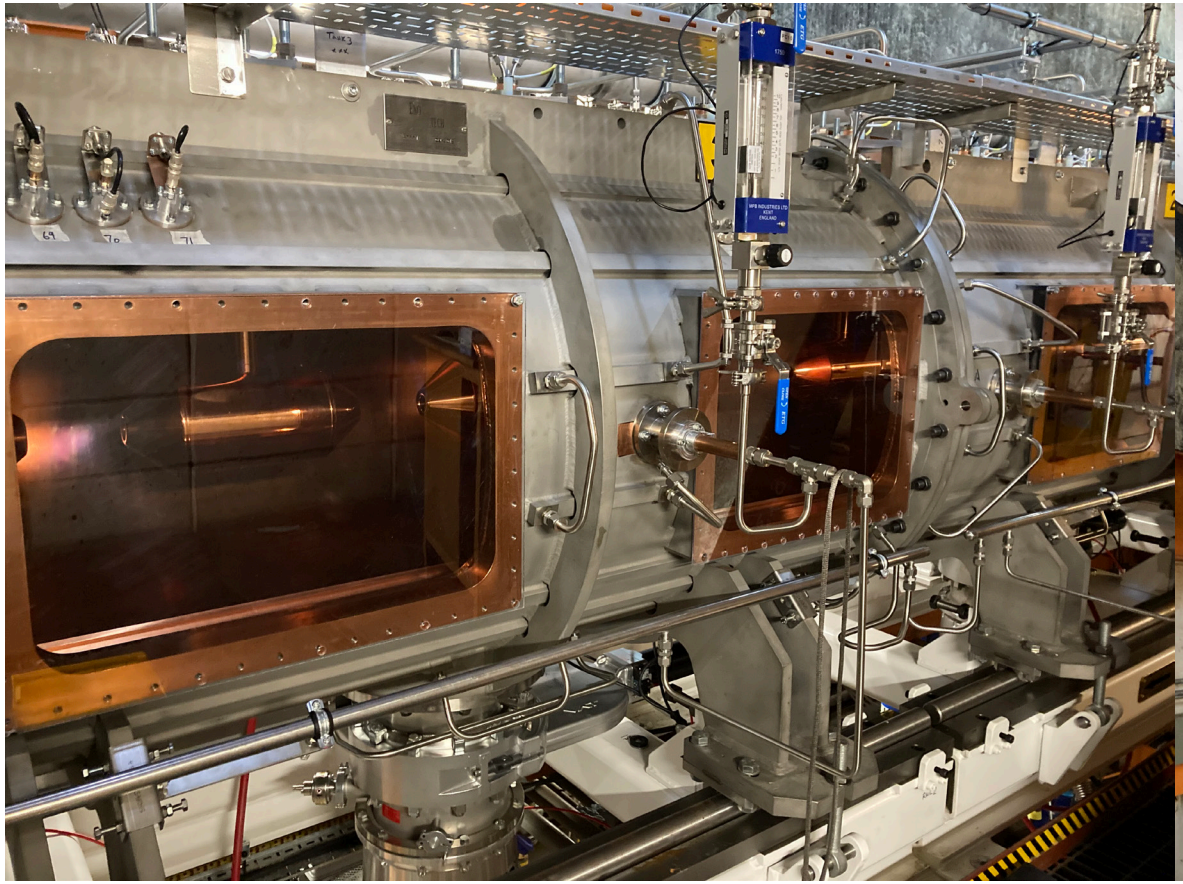

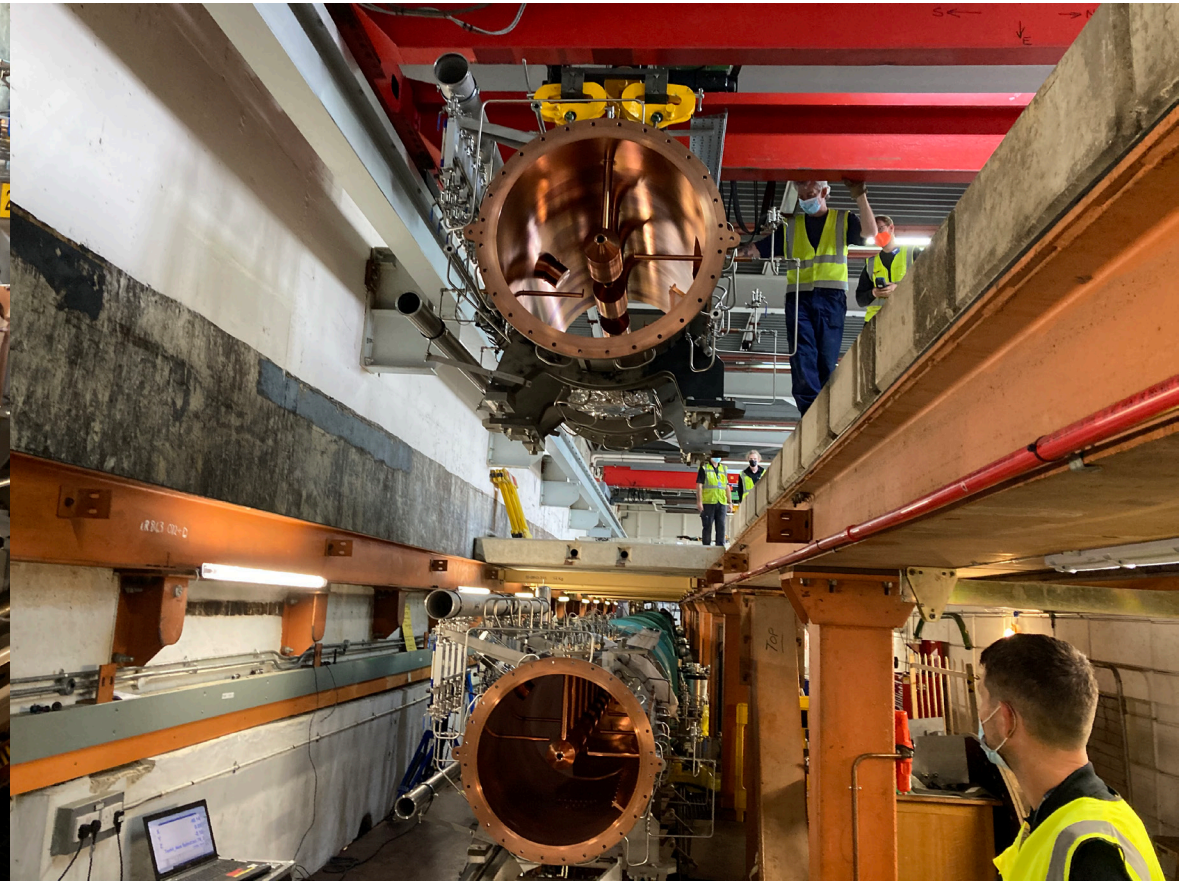

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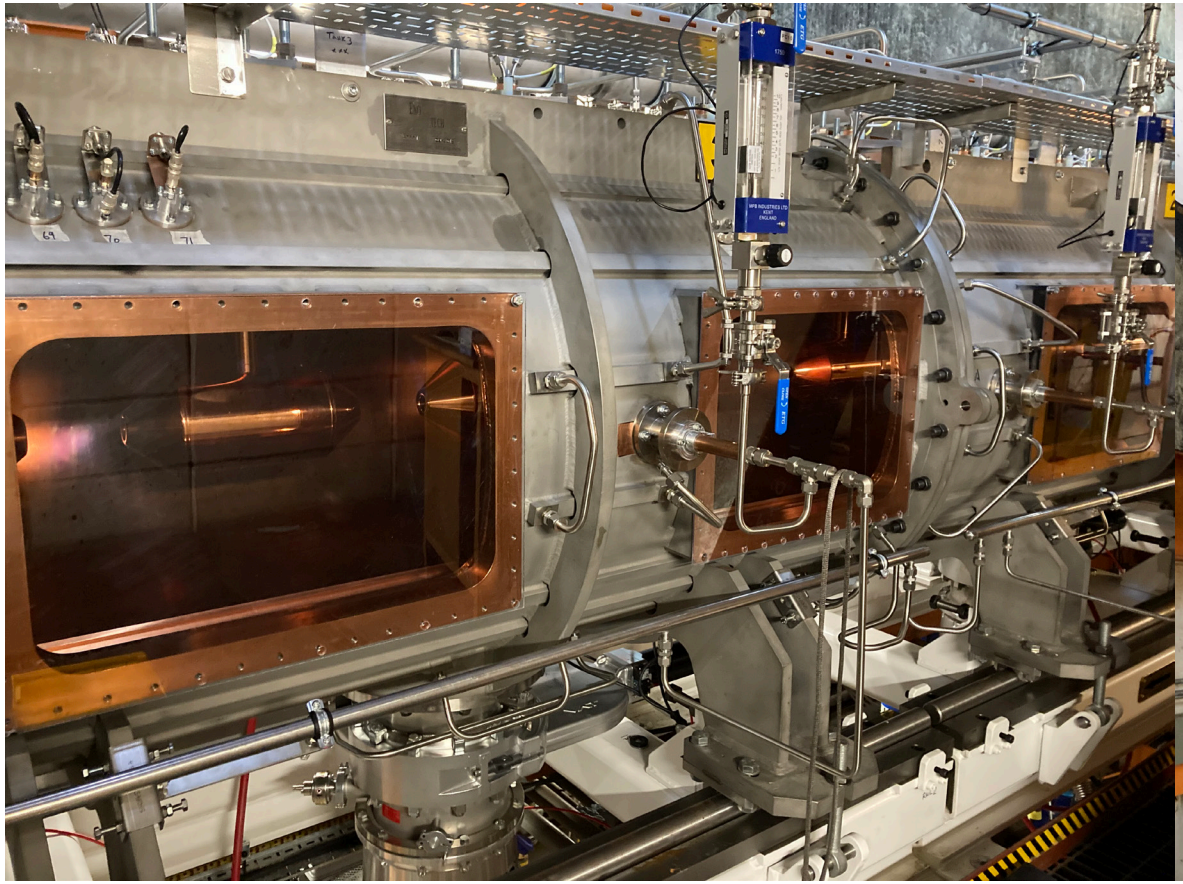

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- After installation the bead pull was repeated to confirm the alignment.
- With all services connected and the shielding reinstated the tank was reconditioned.
- Beam commissioning by the Δ-t method took one day in April 2022.
- An initial miscalibration resulted in too high field level and some window failures.
- The problem was identified and resolved and the Δ-t measurements repeated.

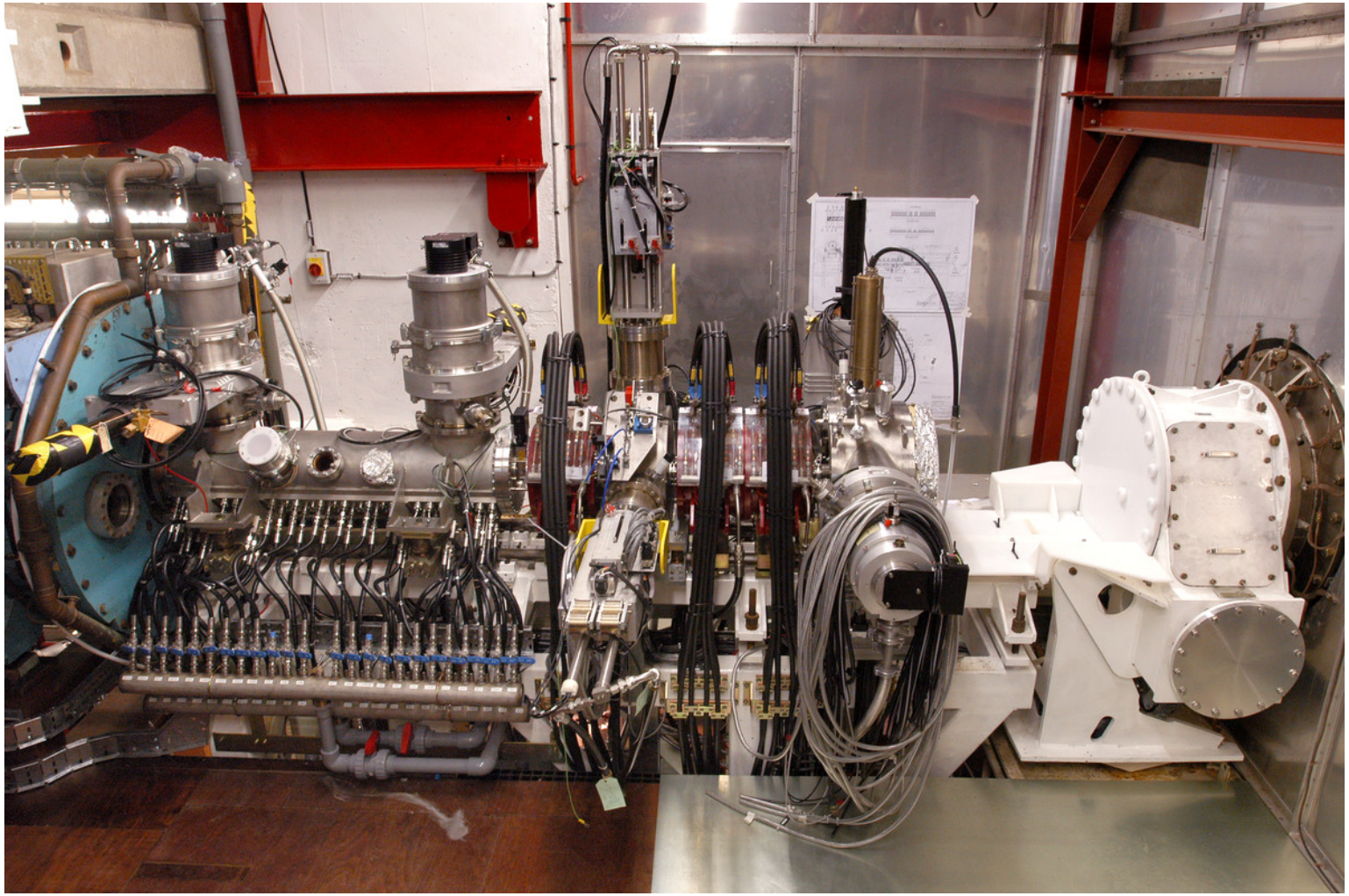
New Tank 4 has been operational on ISIS since April and so far has performed well.

The project was very successful and a great deal was learnt.

The goals were met and in time for the scheduled long shutdown.

Pre-injector MEBT Upgrade

When the RFQ was installed on ISIS in 2004 the available space was highly constrained.



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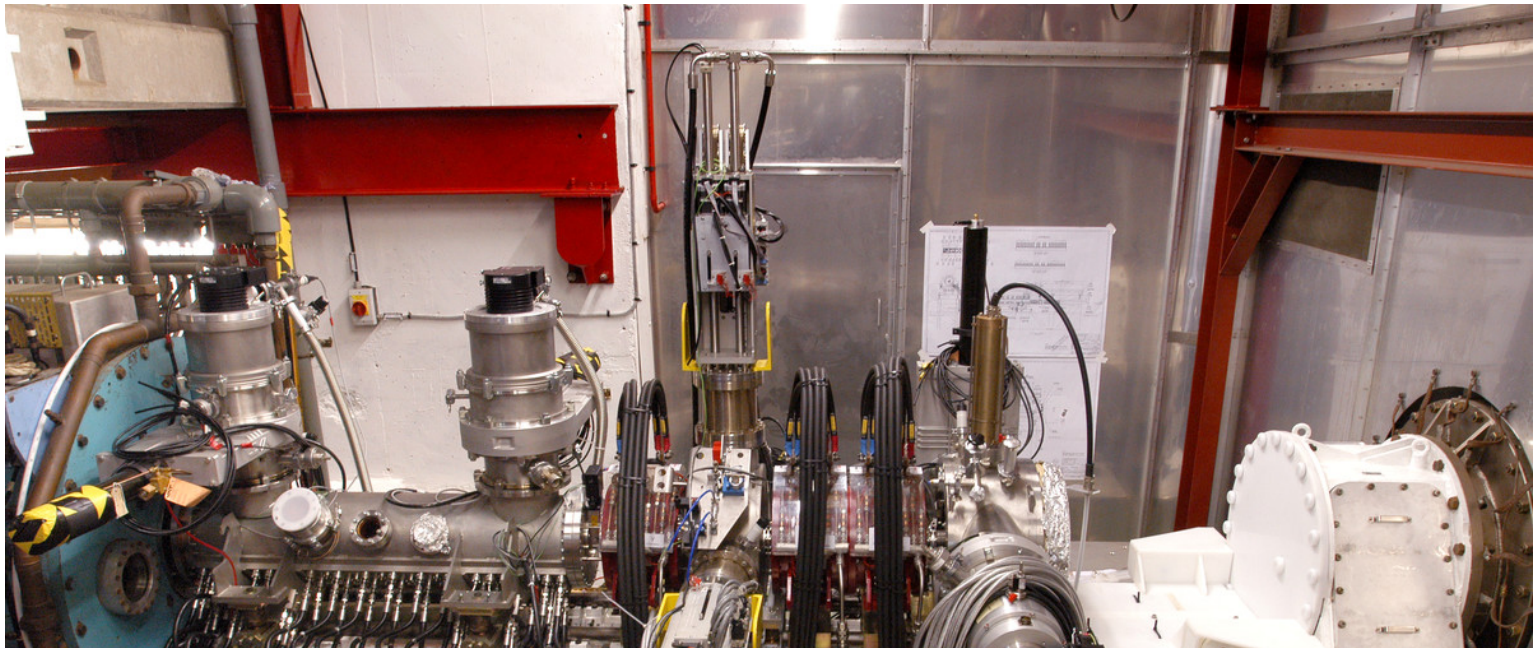
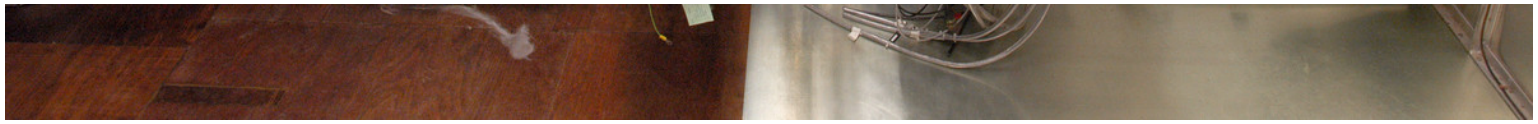


It was always anticipated that we would eventually install a MEBT.

After a decade of almost faultless operation we decided it was perhaps time to take that risk.



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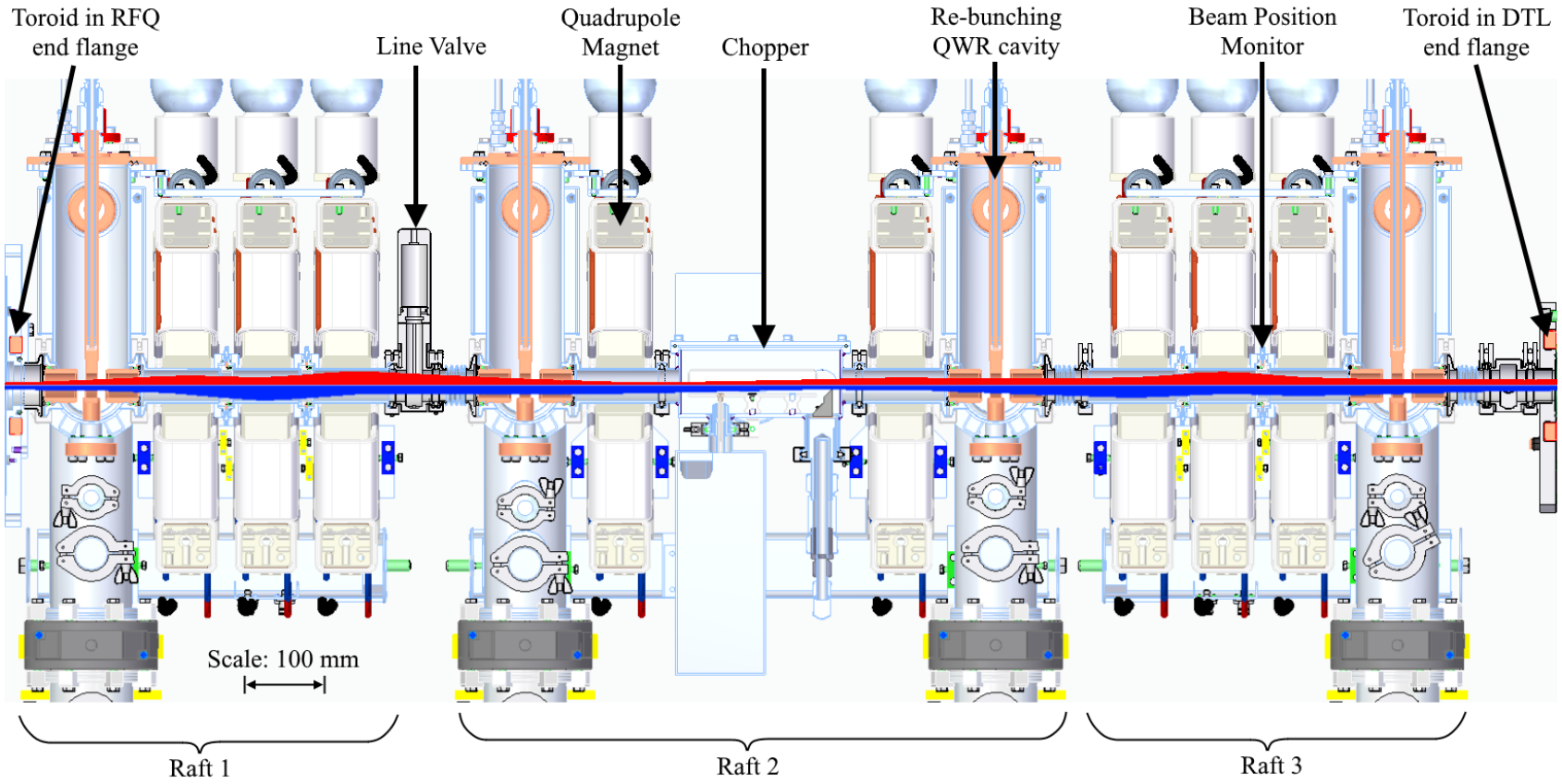

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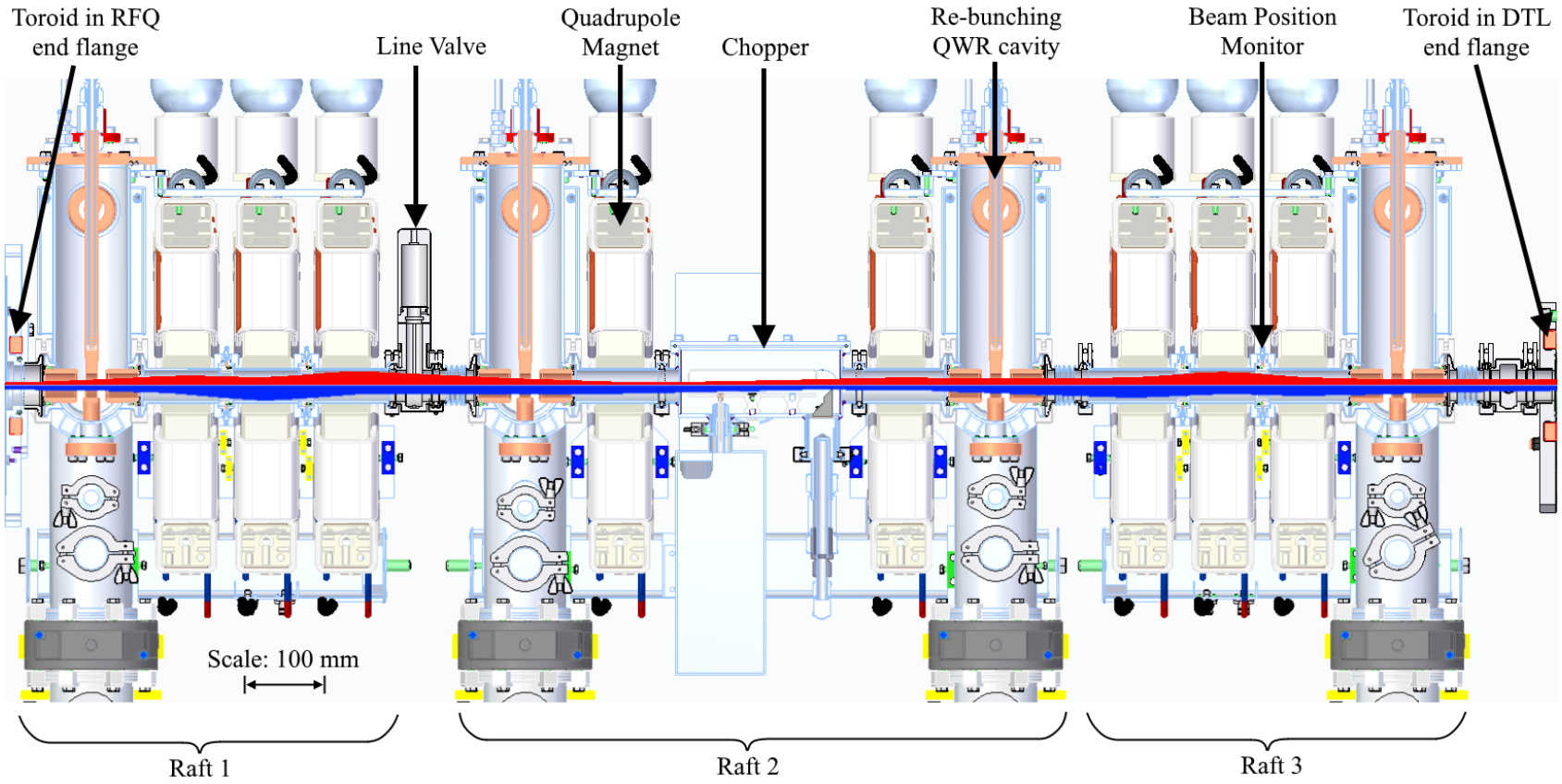

- 8 quadrupoles
- 4 bunching cavities
- Beam chopper
- 4 BPMs

All in less than 2 m

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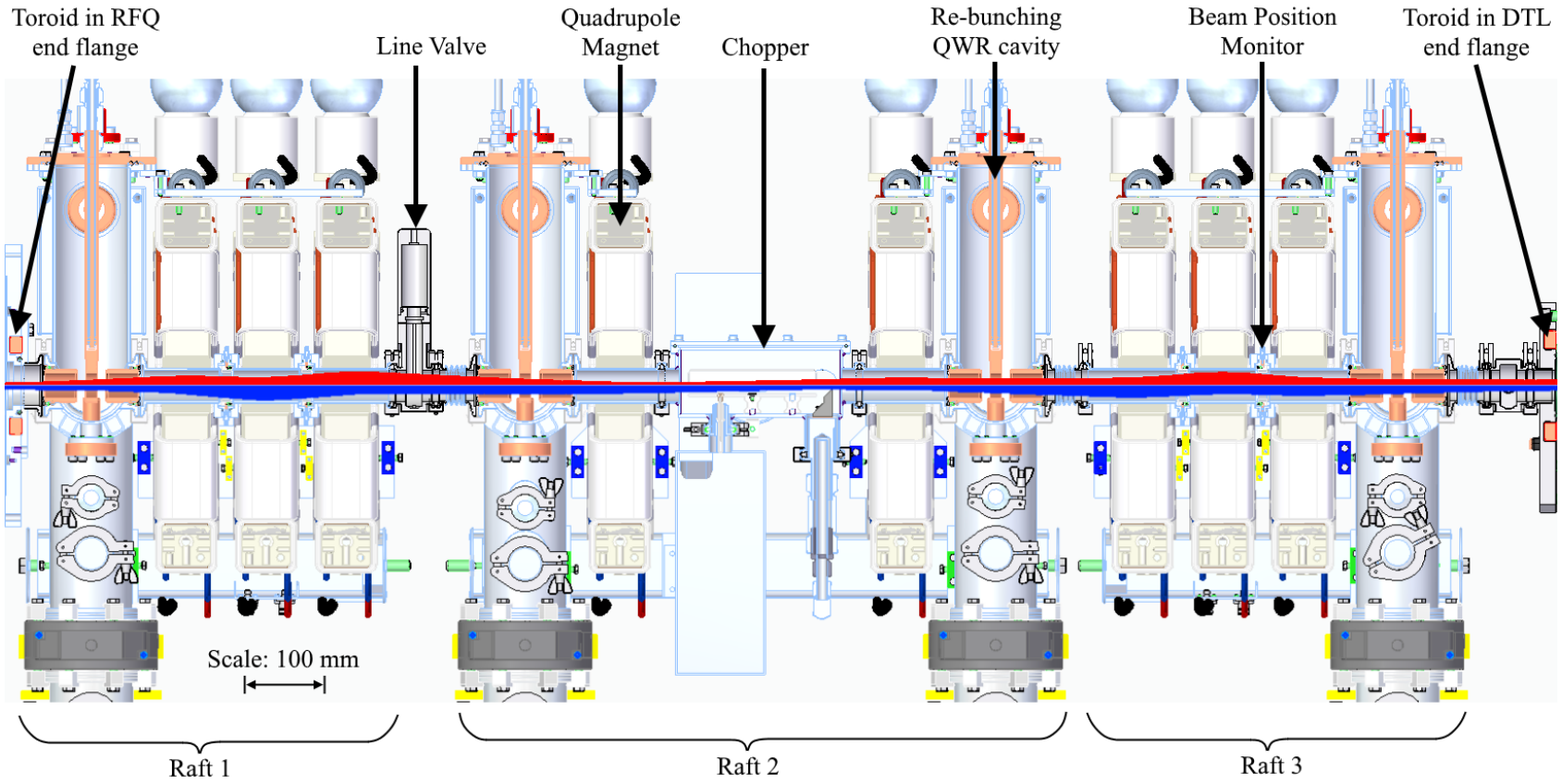

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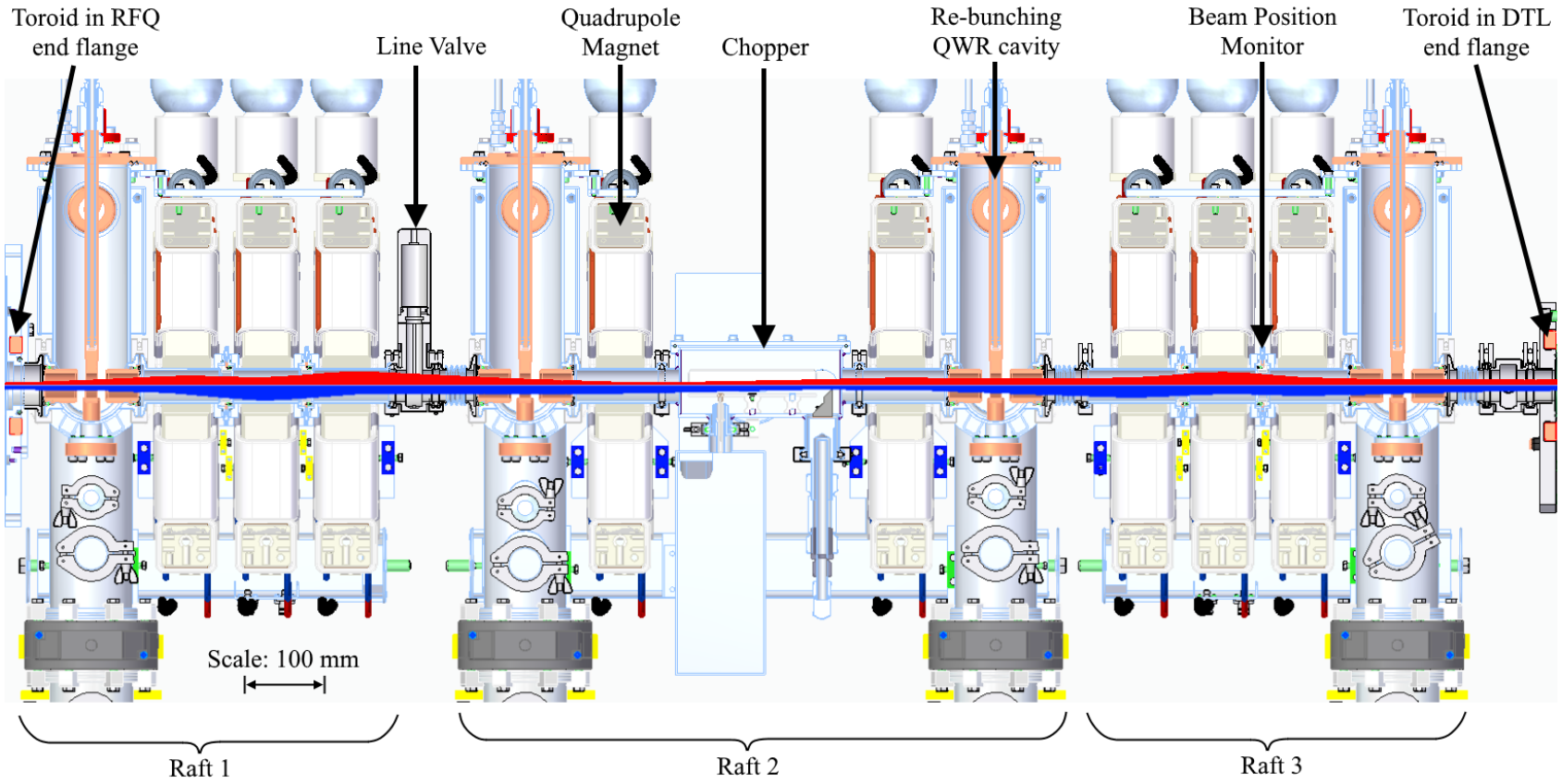
Even with extra space available to design of the MEBT is very constrained.



- 8 quadrupoles
- 4 bunching cavities
- Beam chopper
- 4 BPMs

All in less than 2 m

Quite challenging

The MEBT should achieve close to 100% transmission in Tank 1.

Science and Technology Facilities Council

The improved performance of the pre-injector with the MEBT installed will reduce the demands on the ion source.

A new un-caesiated RF volume source is being developed in parallel with the MEBT.

Most of the components are complete or in the final stages of manufacture.

Science and Technology Facilities Council

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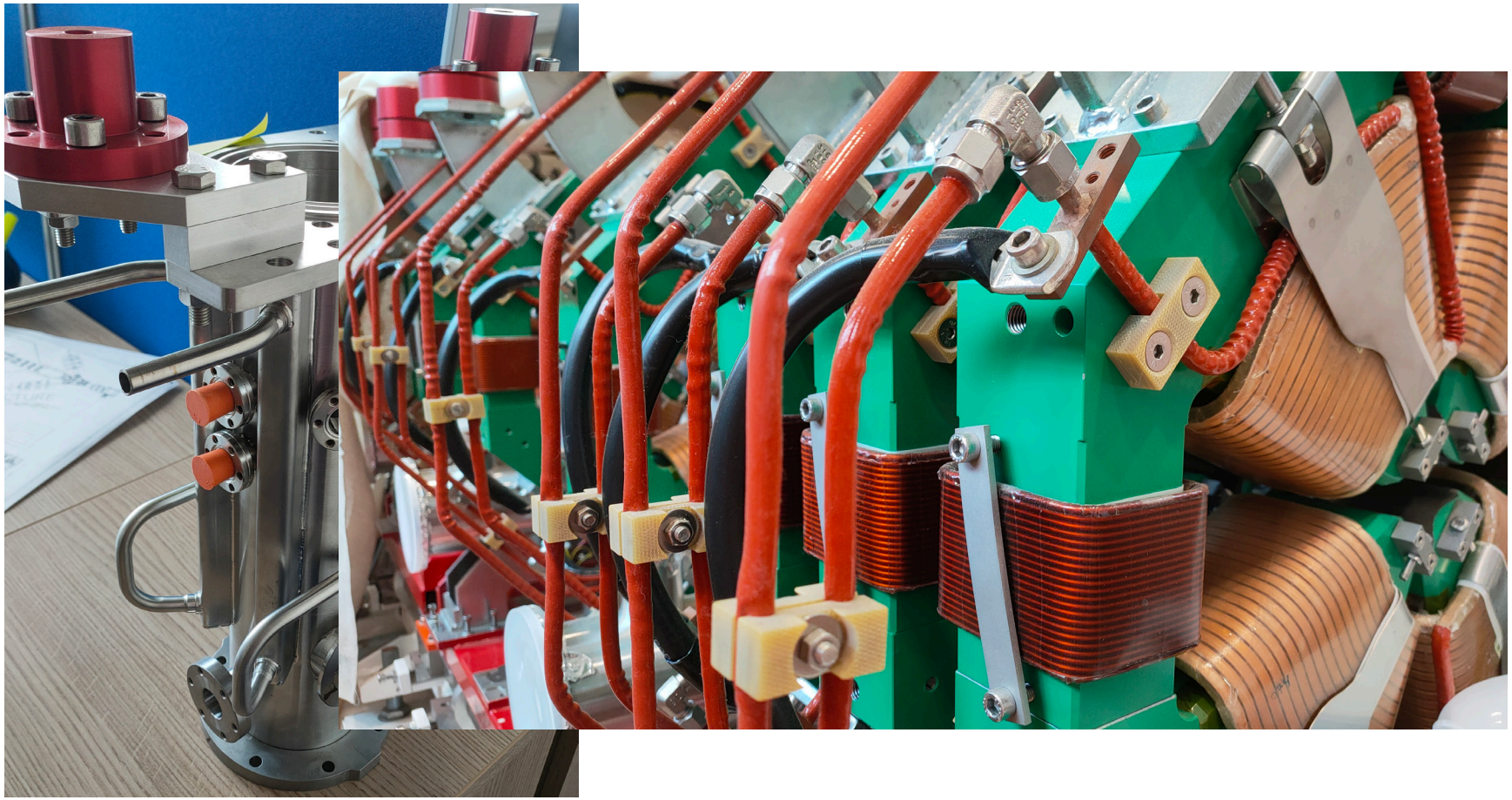

Science and Technology Facilities Council

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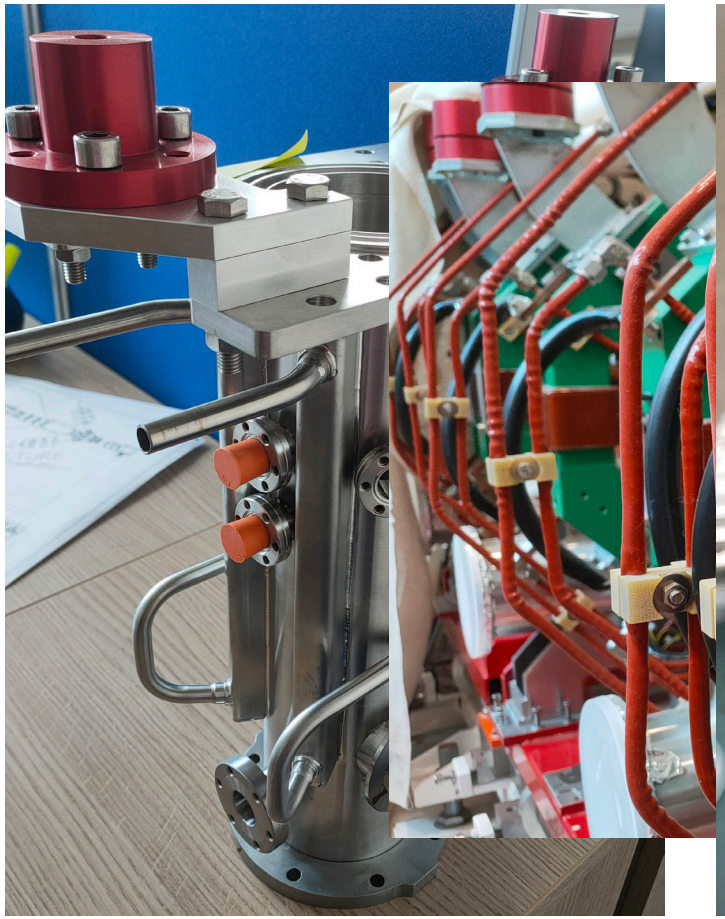

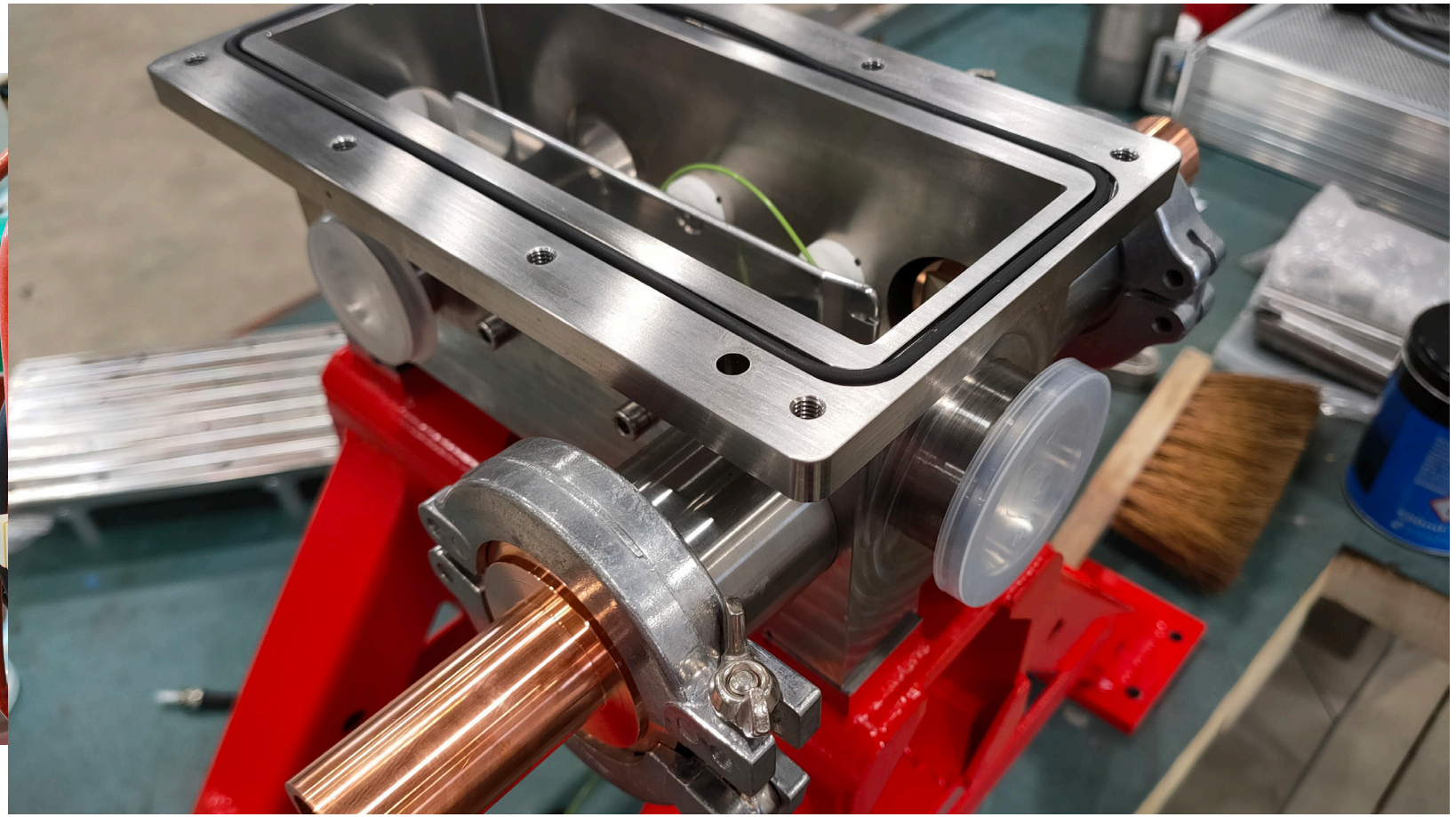

Science and Technology Facilities Council

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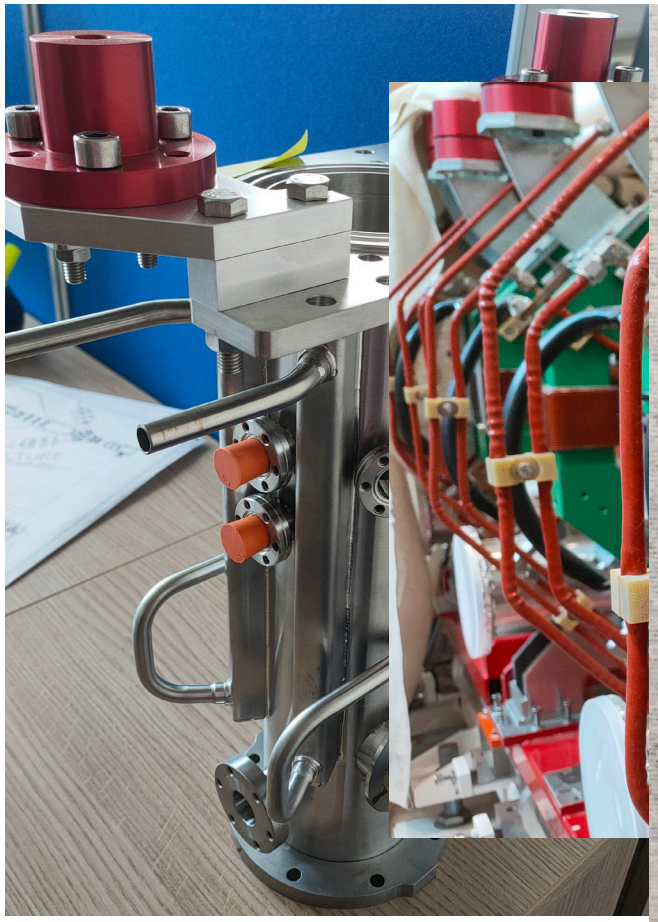
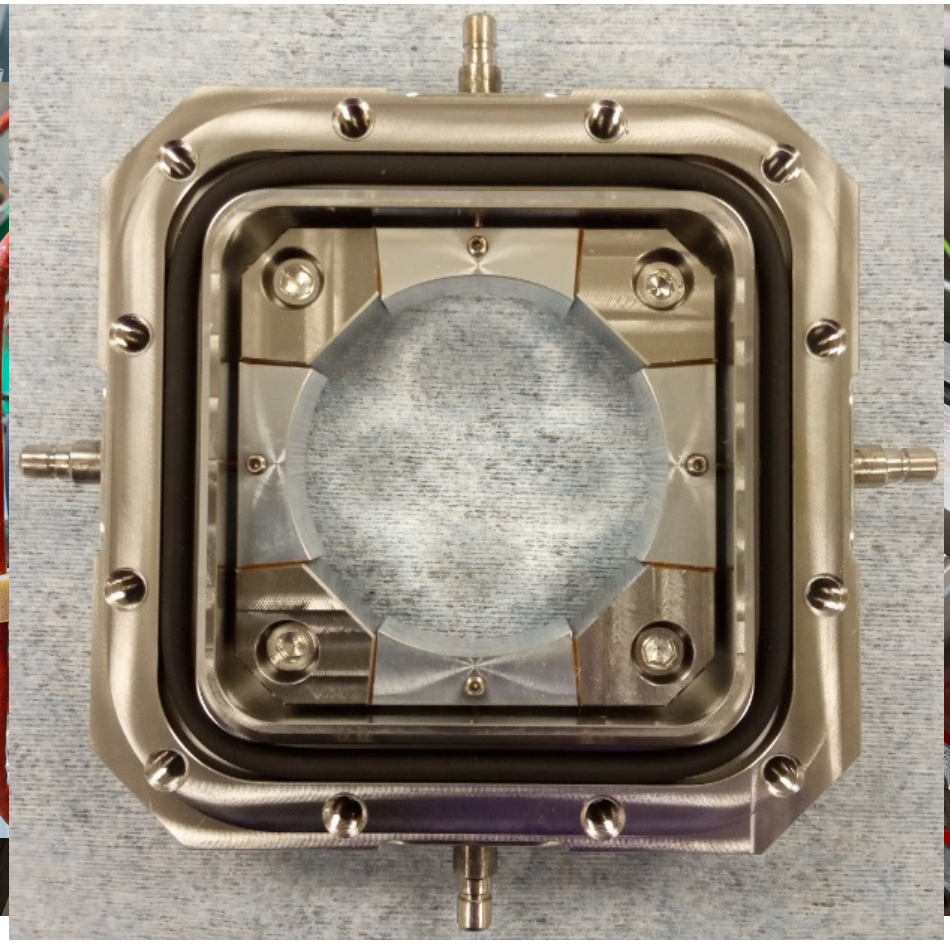
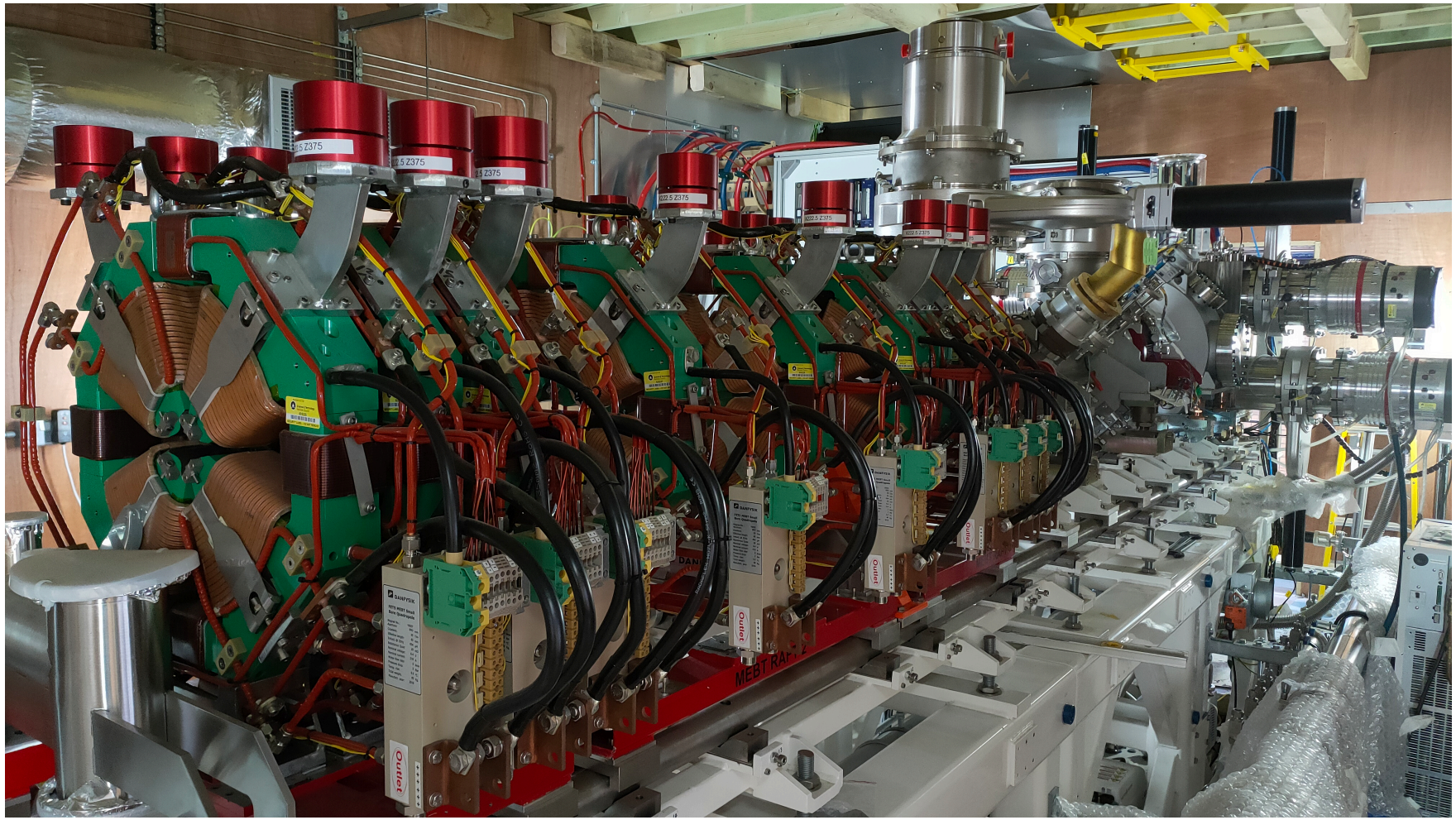




Science and Technology Facilities Council

A test stand based around the spare RFQ is being built to allow commissioning and long term testing of the complete pre-injector.



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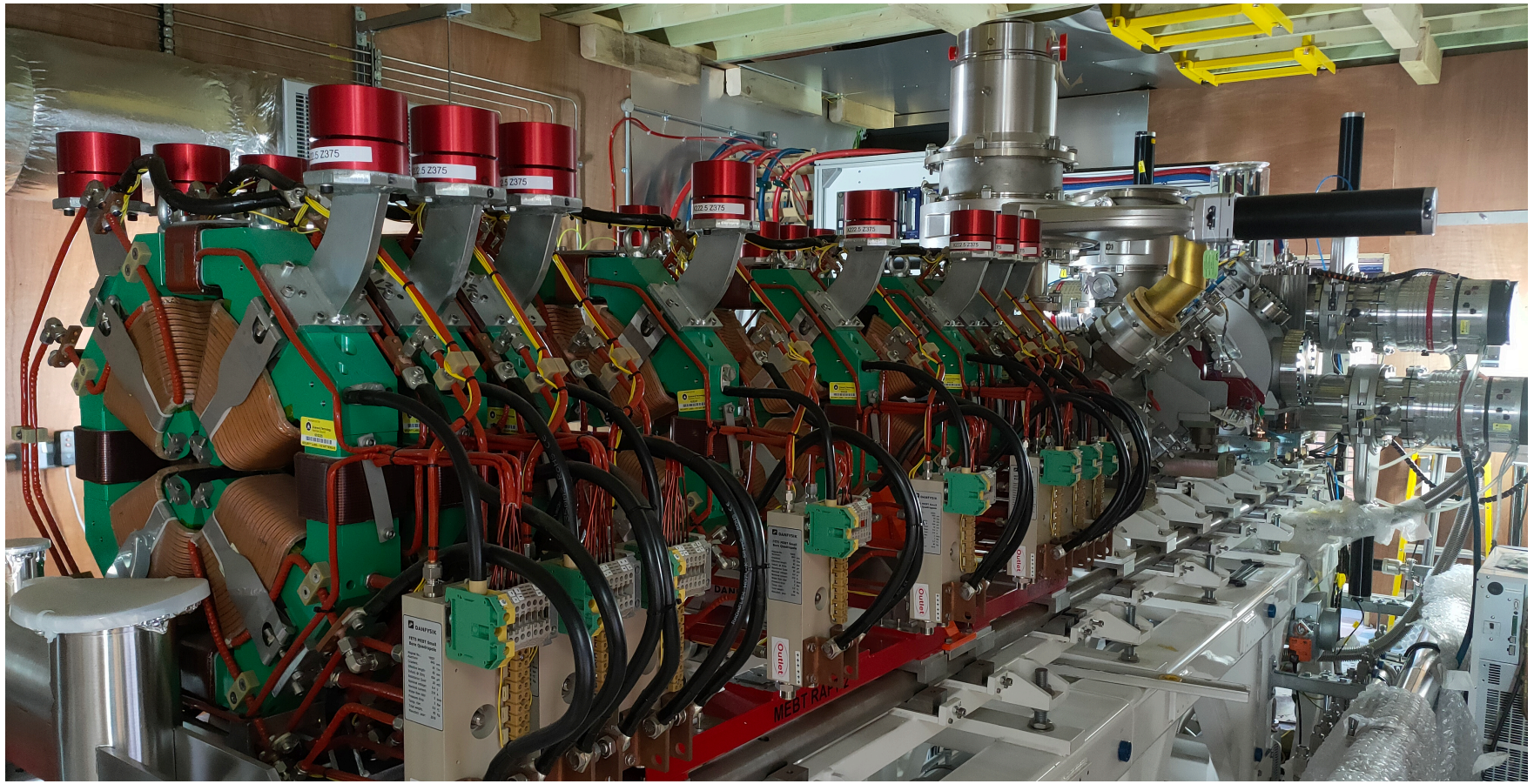


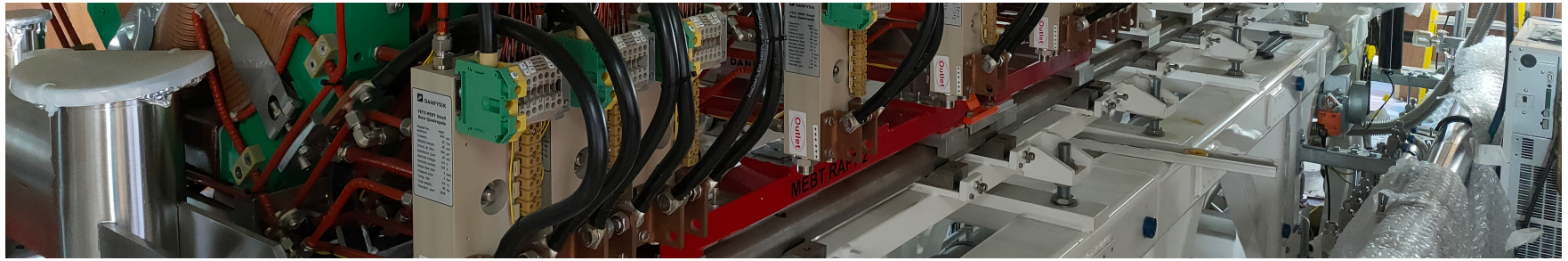
First beam in anticipated in 2023 with installation possibly in 2024

Science and Technology Facilities Council

A test stand based around the spare RFQ is being built to allow commissioning and long term testing of the complete pre-injector.

First ion source beam as achieved this month.

For more details see Scott Lawrie’s poster TUPOJO21.



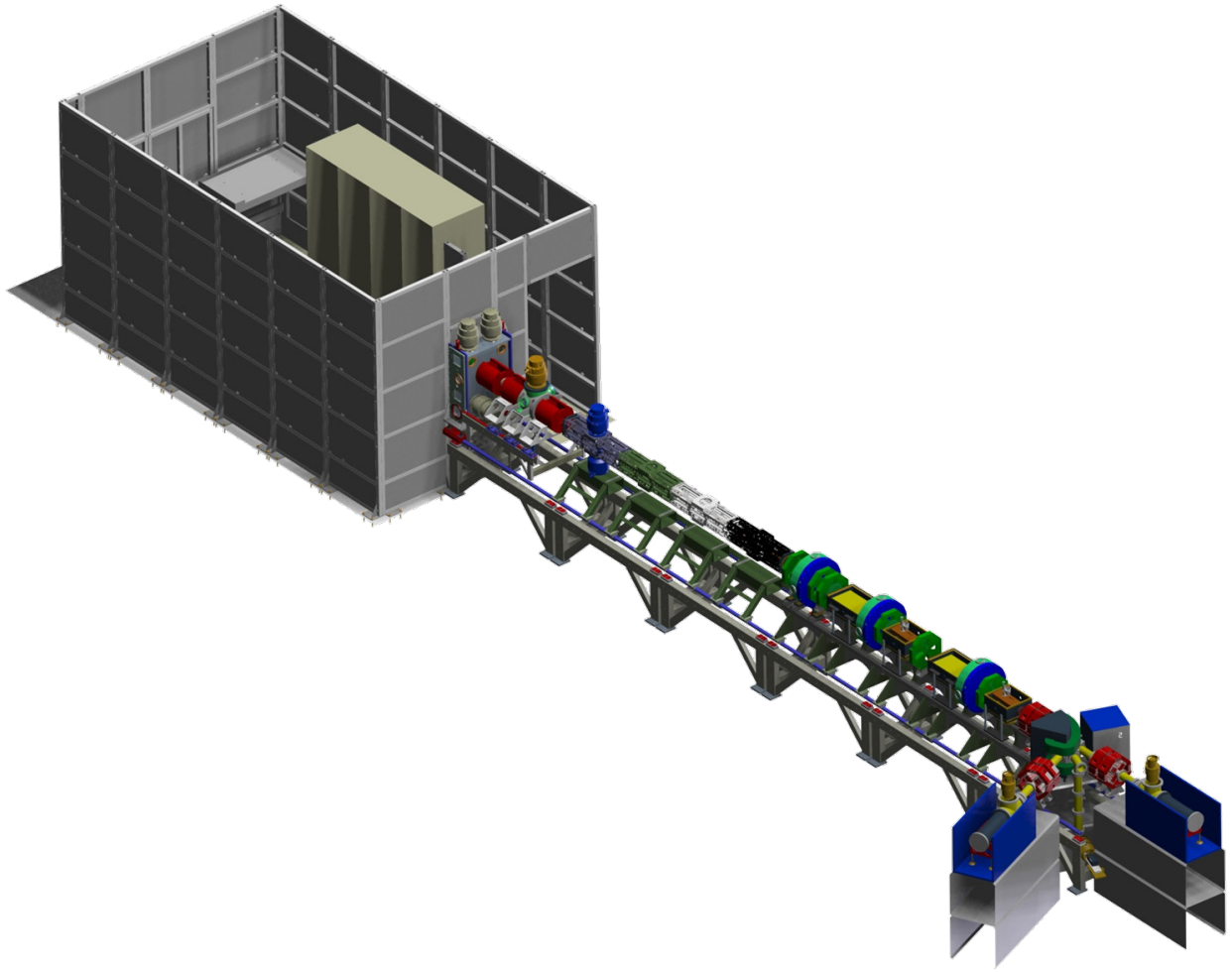
First beam in anticipated in 2023 with installation possibly in 2024

Science and Technology Facilities Council

Front End Test Stand (FETS)

The history of FETS is long, involved and at times ugly.

The project is now being completed in the context of ISIS II, the next UK neutron source.



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All components of FETS have been manufactured and tested except the beam chopper which awaits testing.

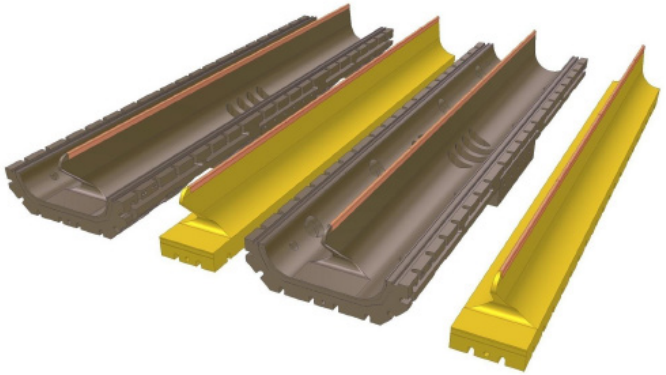
Phase 1 operation will be of the RFQ directly into the beam dump.

Primarily for radiation checks and to understand operation of the RFQ.

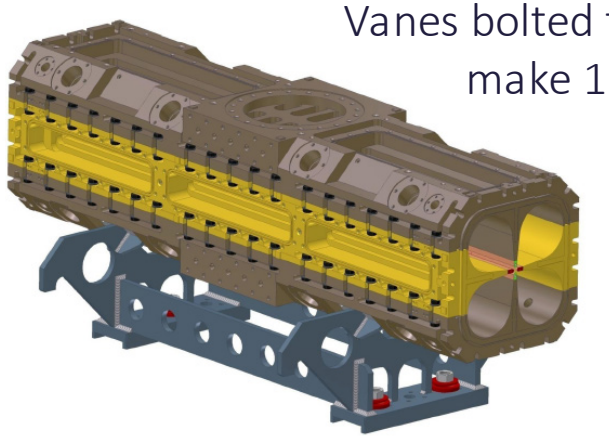
Phase 2 will include the whole of the MEBT.

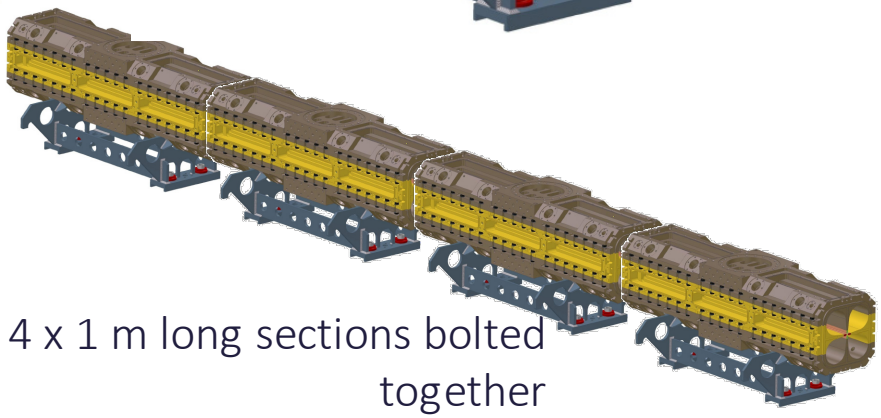
The RFQ is of all bolted design with only two small vacuum brazing operations.

Sections made of 2 major and 2 minor vanes



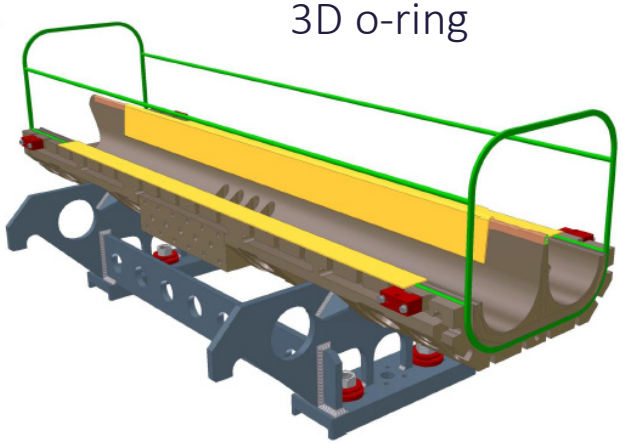
Vanes bolted together to make 1 m sections





4 x 1 m long sections bolted together

3D o-ring



Science and Technology Facilities Council

Each section was inspected, assembled and aligned on a CMM.

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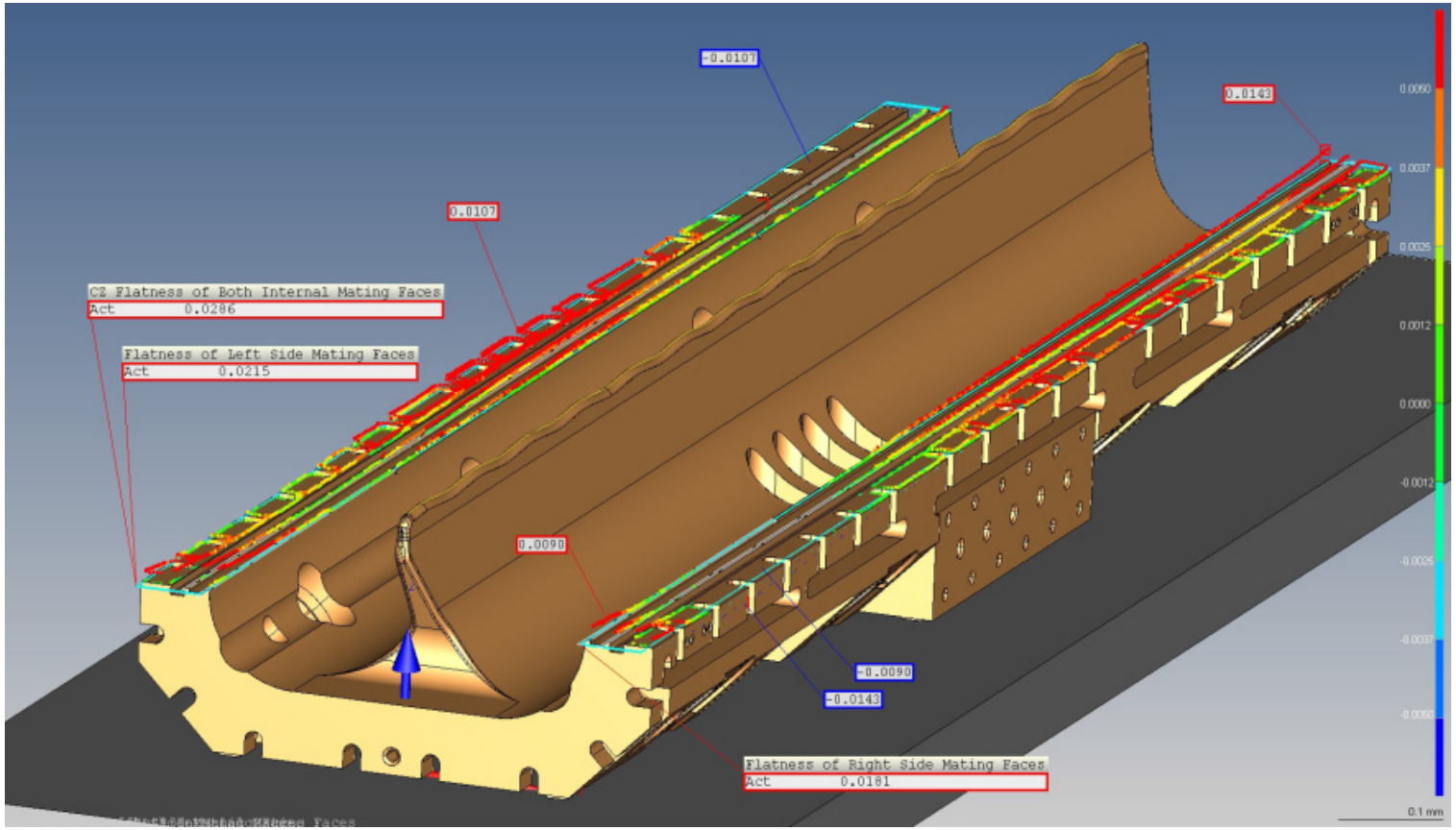

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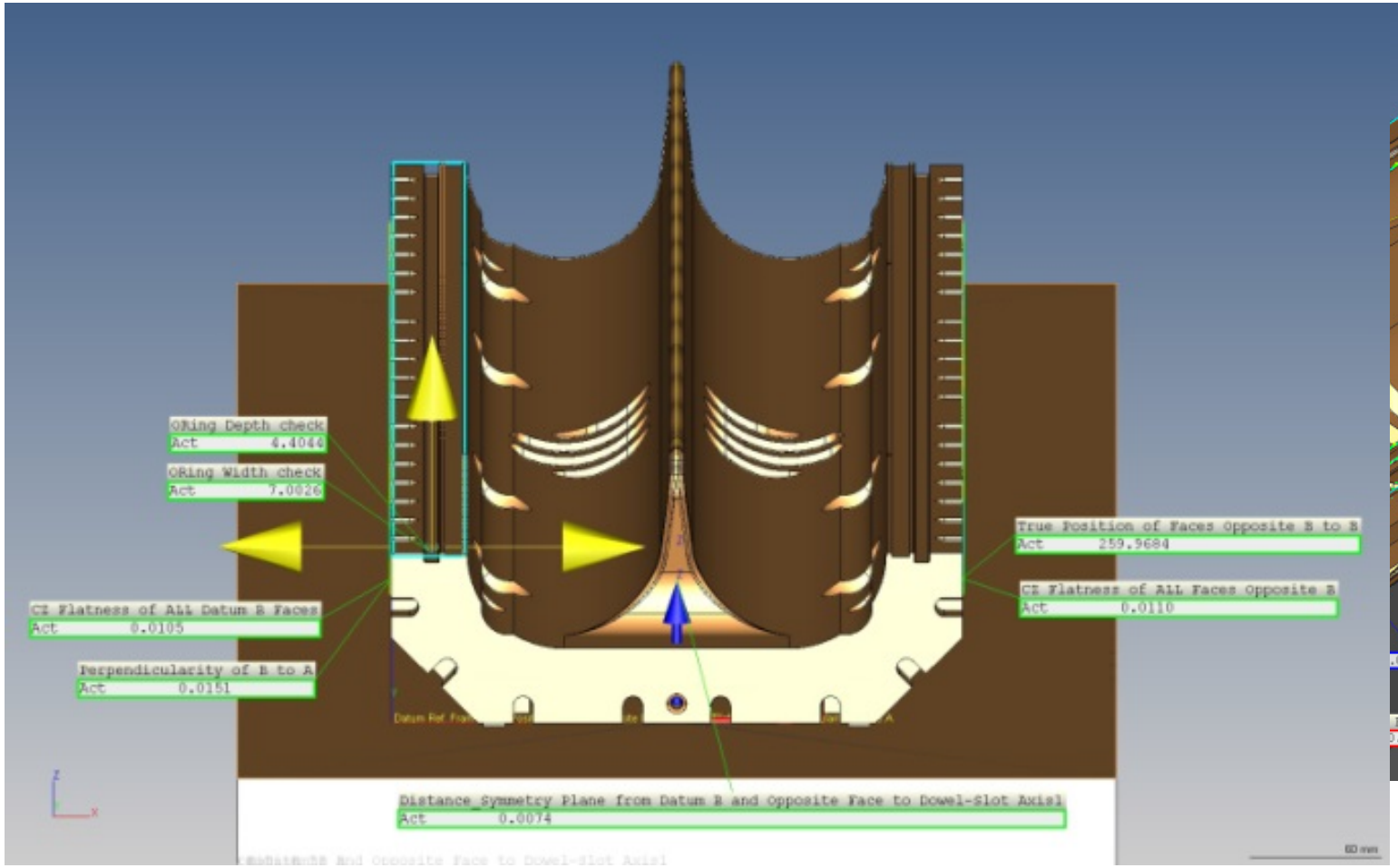

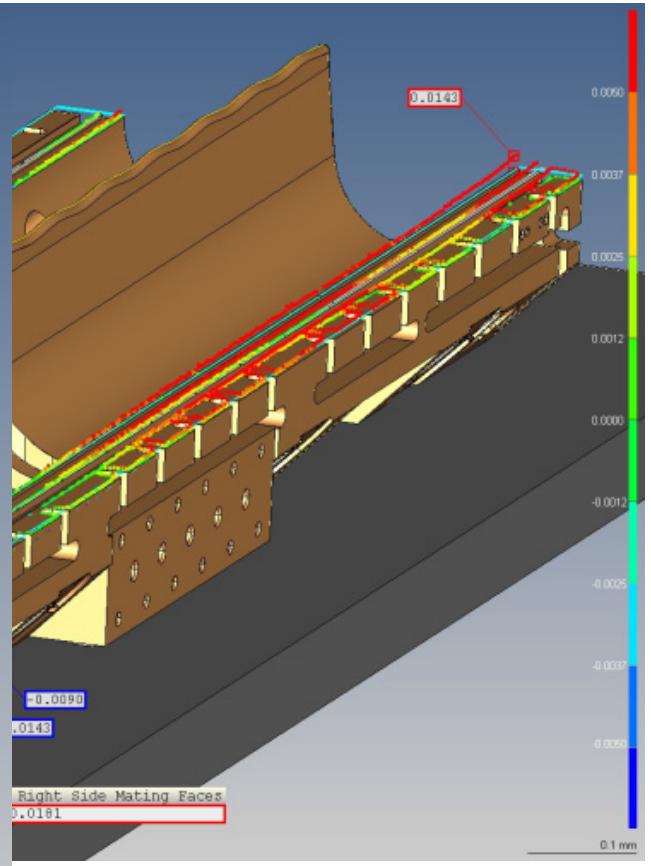

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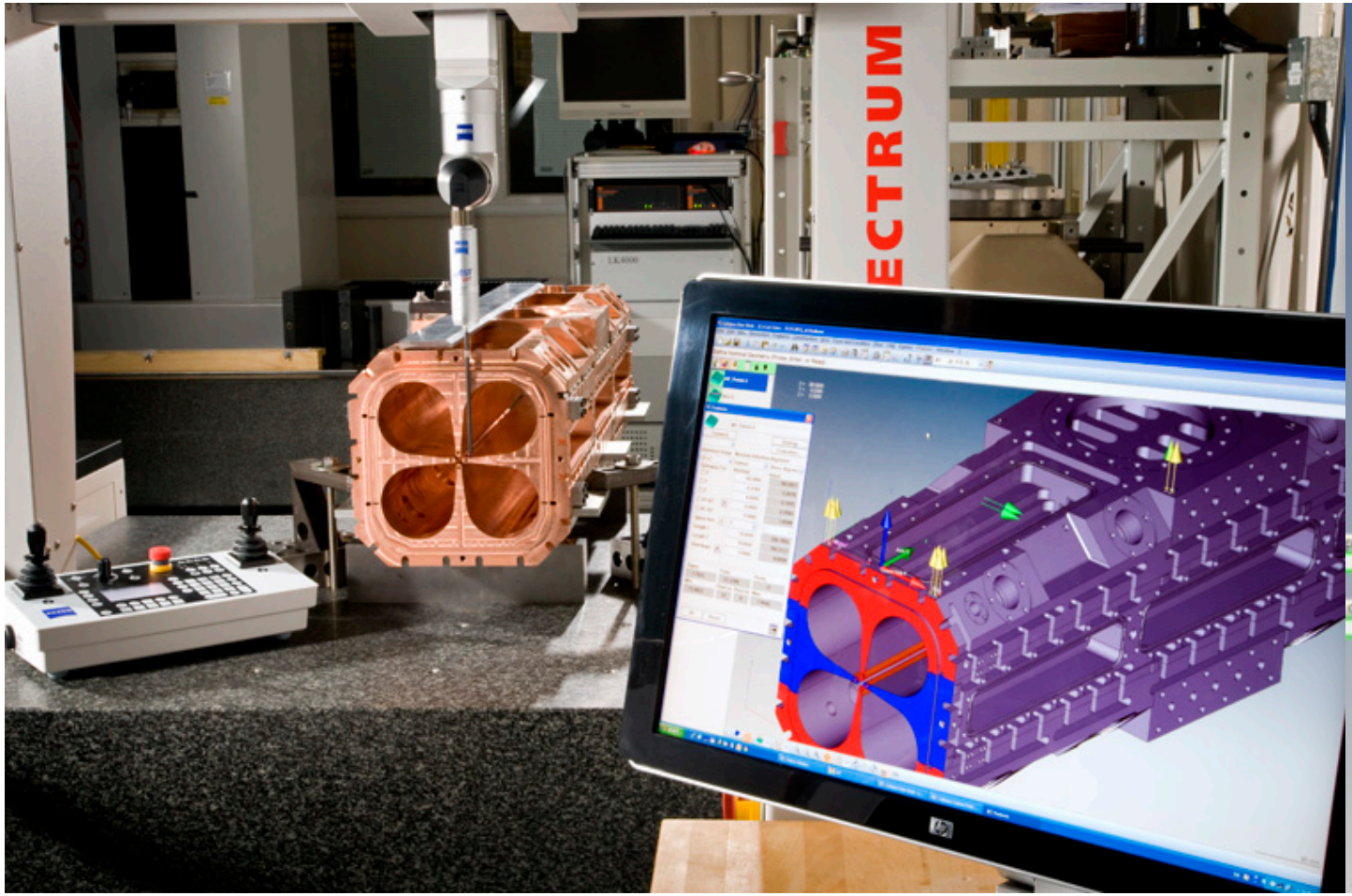

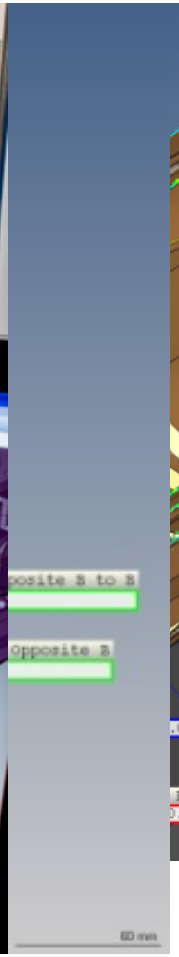

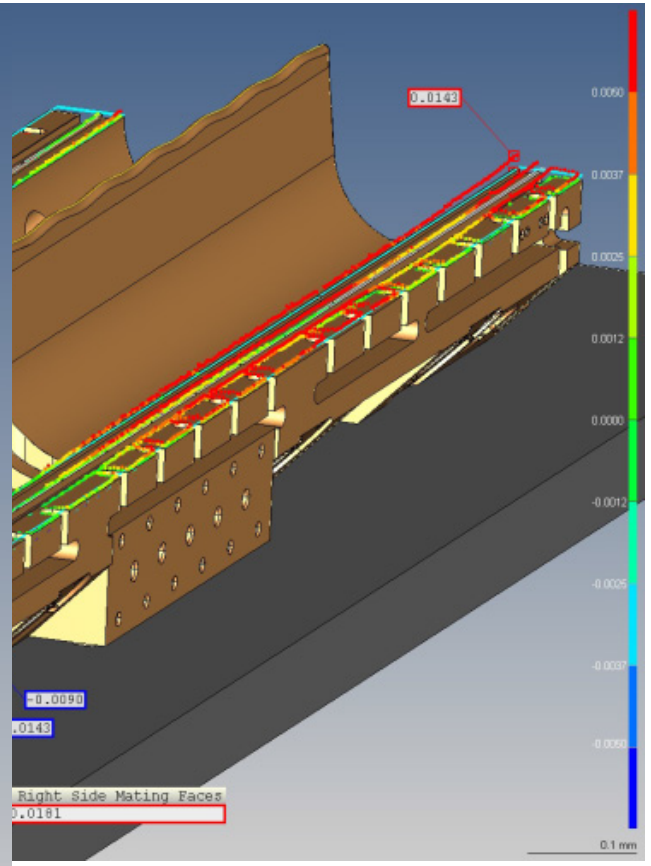

Science and Technology Facilities Council

RF and vacuum tests completed on each section.

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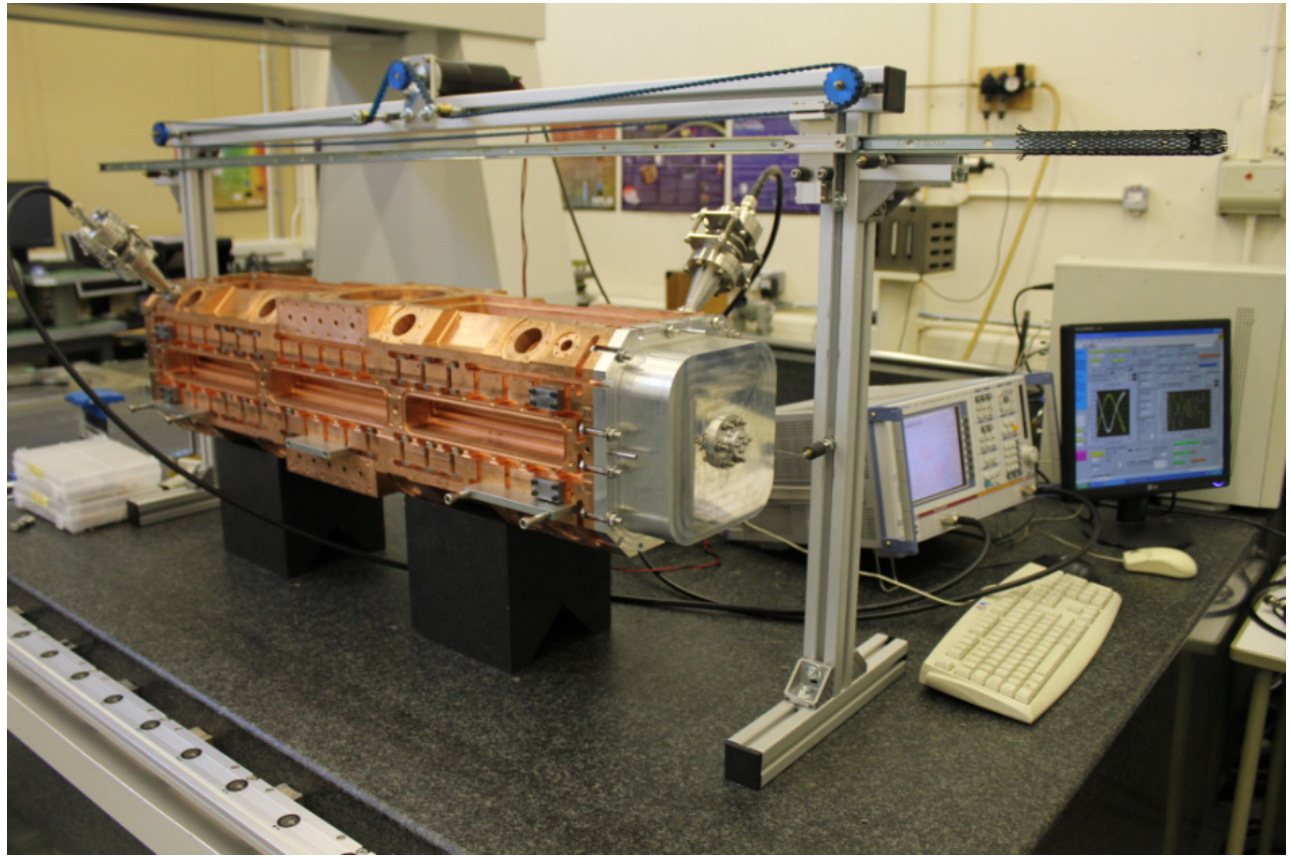

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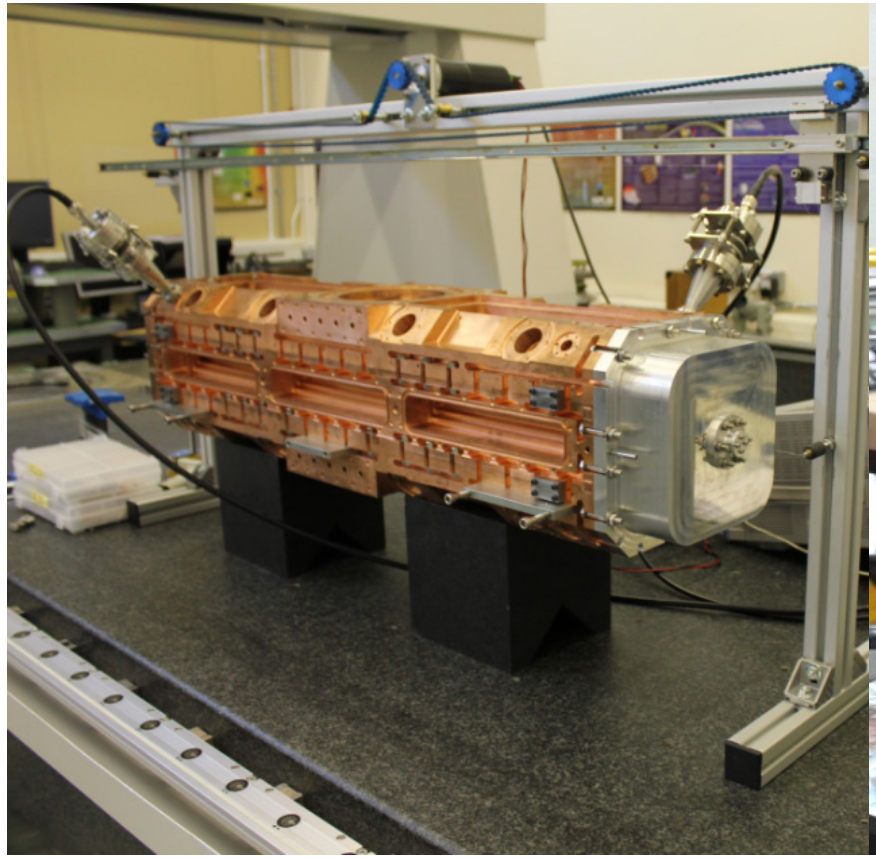

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Beadpull performed to set 62 adjustable tuners.

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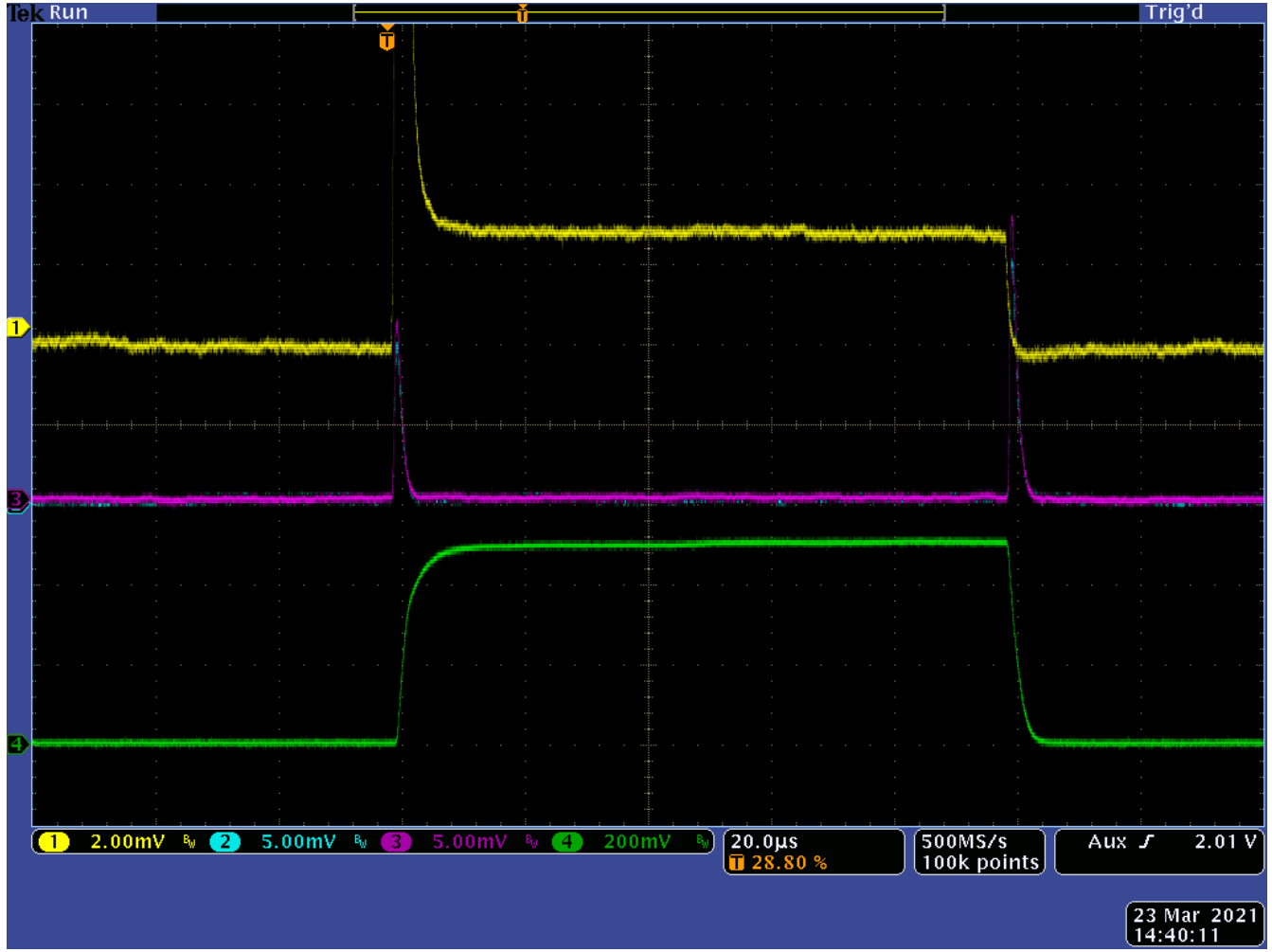
RF conditioned at 50 pps and 5% duty factor.



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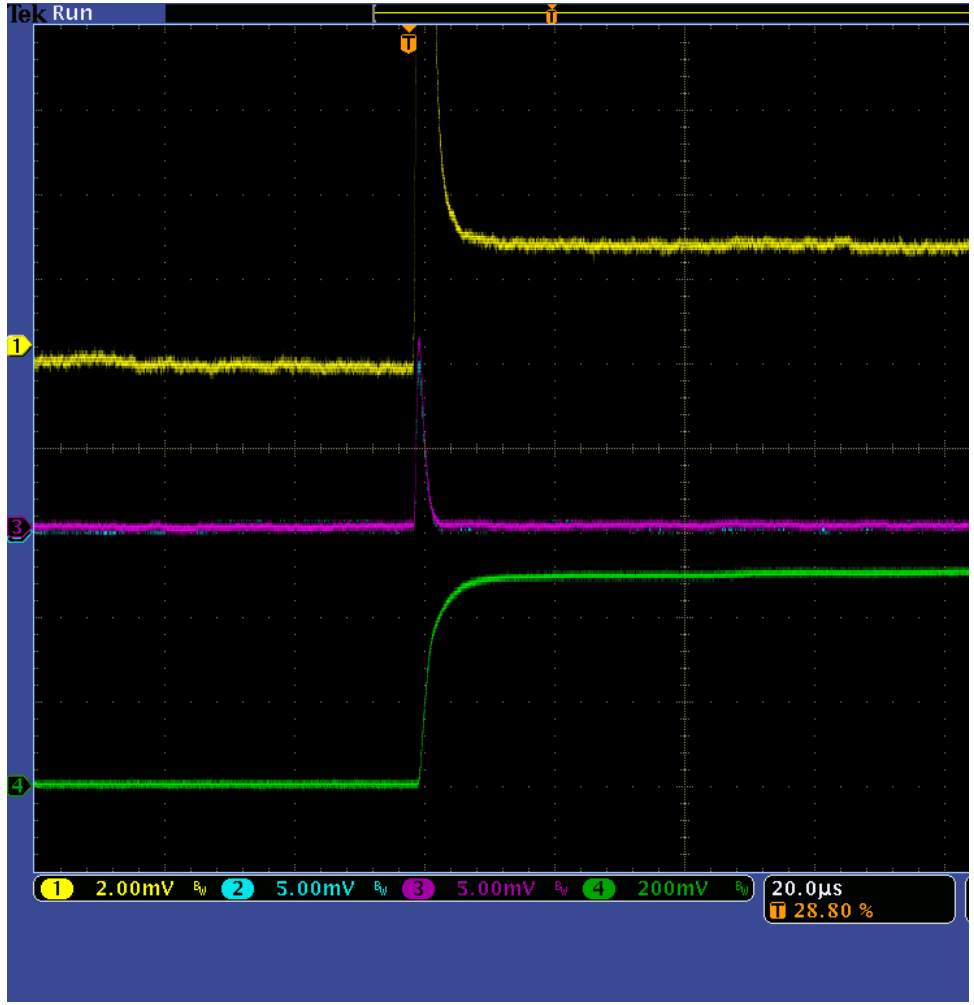

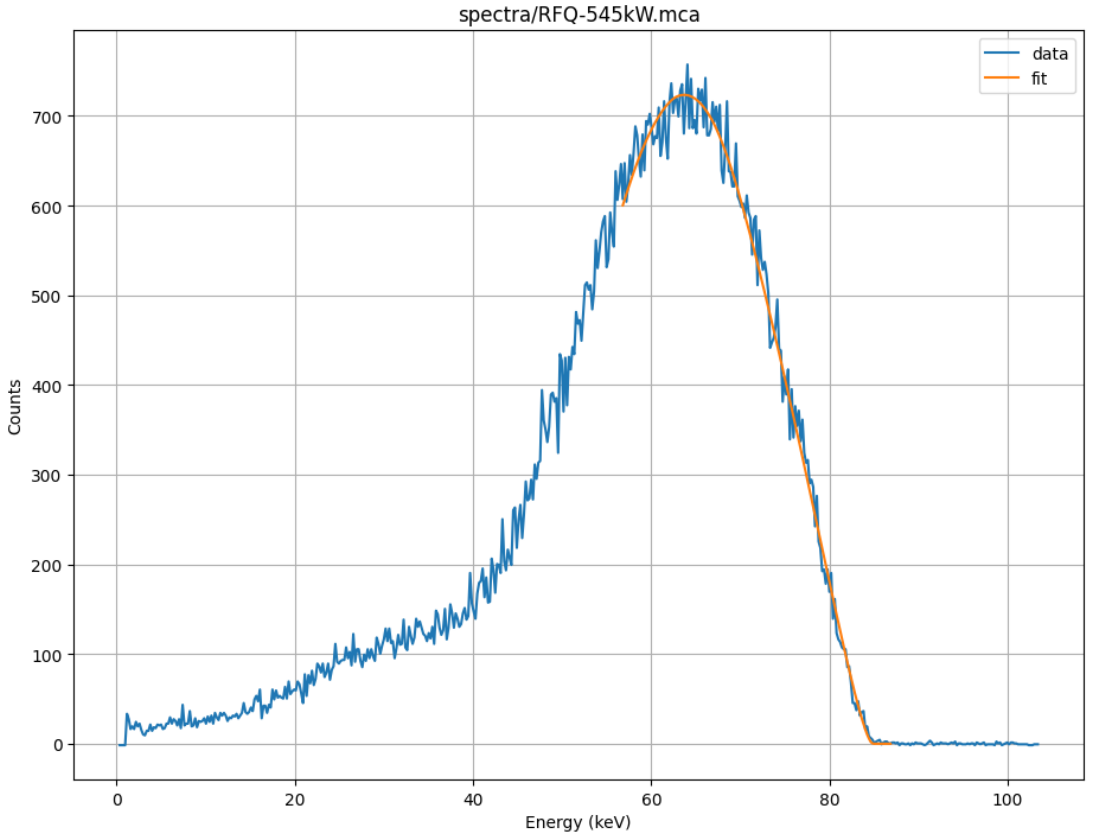

545 kW for full field level confirmed by X-ray measurements.

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First beam accelerated in RFQ this year.

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- Ion source emittance too high

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- One LEBT solenoid not functioning

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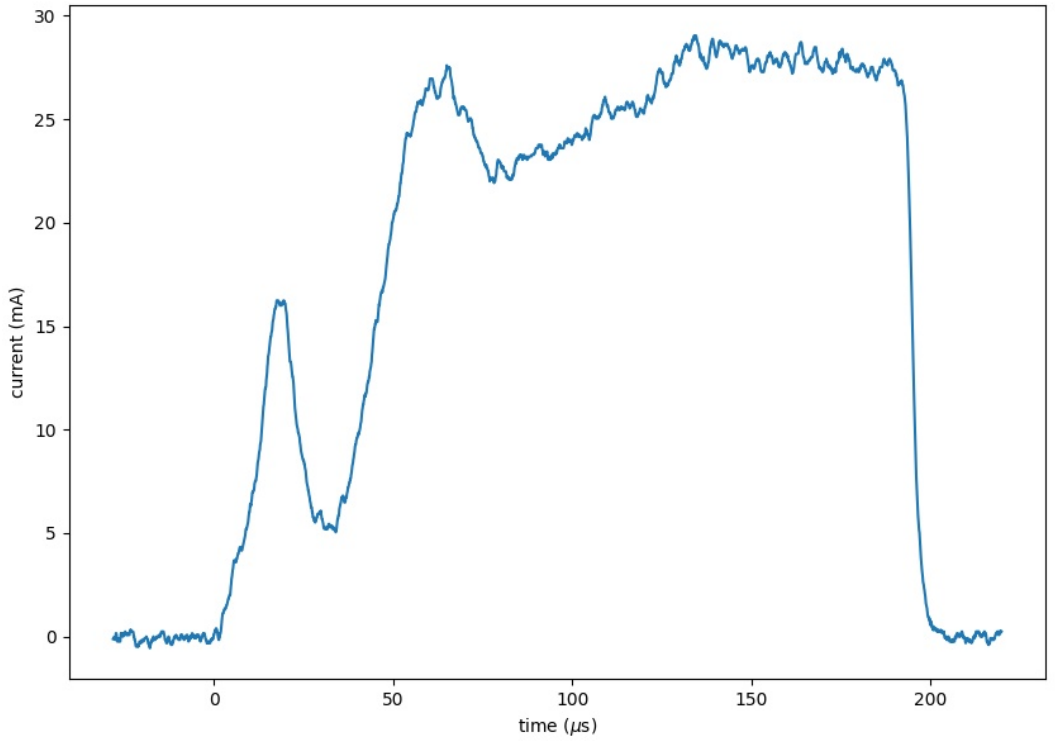
28 mA achieved at RFQ exit



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Summary

There is an active programme of linac R&D taking place at ISIS.

These projects will enable continued reliable operation of the facility with increased performance over the coming years and prepare the way for development of the next generation of neutron source in the UK.

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Thank you