Development of 1.3 GHz Cavity Test Facilities

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ASTeC/CI
On behalf of a TF SRF team at DL

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Introduction

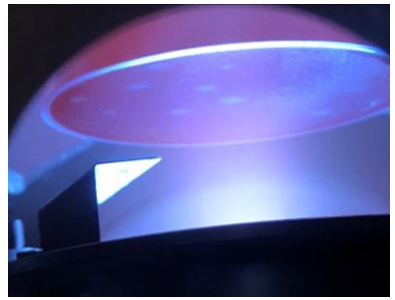
Present state

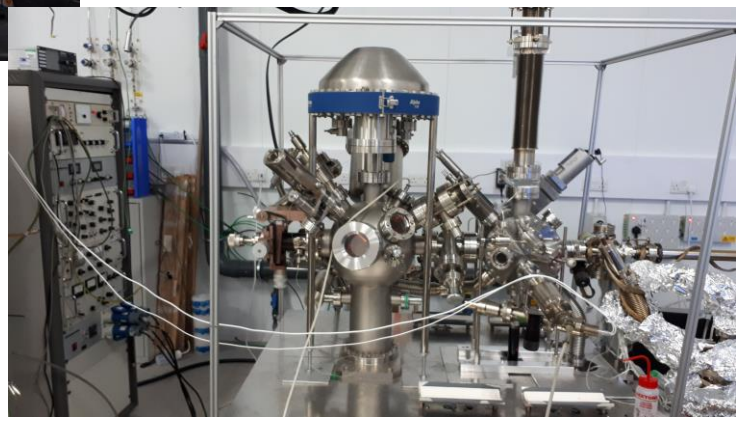
UK team (UKRI/STFC/ASTEC/CI/LU/UL) is doing most of work related to TF SRF:

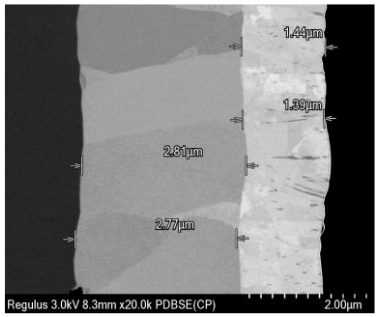
- Surface preparation
- TF deposition
- Plasma characterisation
- TF characterisation

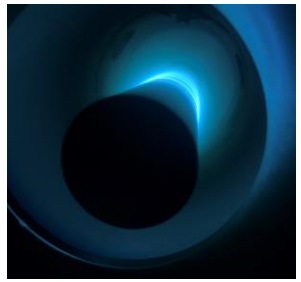
Reza Valizadeh on Tuesday
Stephane Simon on Monday

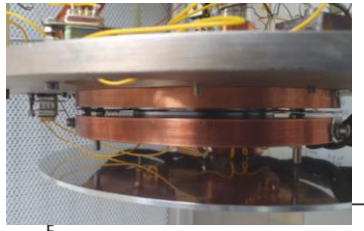
- DC TF superconductivity evaluation (*Liam Smith – next talk)*
- Low power RF testing of planar samples at 7.8 GHz (*Daniel Seal, this session)*
- Low power RF testing of 6 GHz cavities (*Nathan Leicester, this session*)

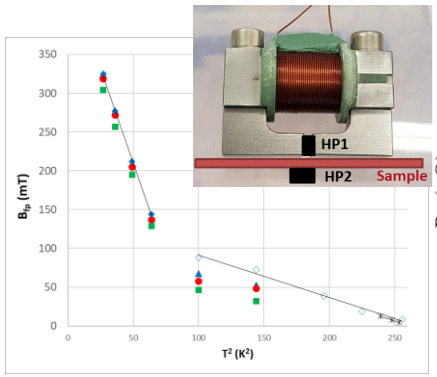


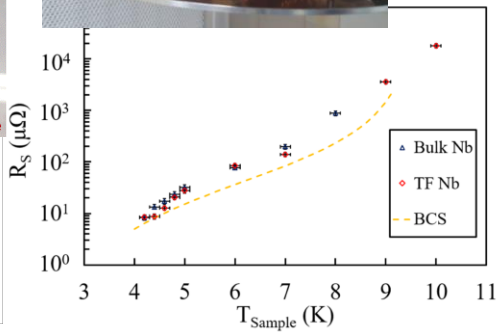












What is needed most for TF SRF programme in UK

- Copper cavity production
  - outside of scope of this talk
- Copper cavity surface polishing
  - outside of scope of this talk
- 1.3 GHz cavity coating optimisation for various SC materials
  - ongoing (talks of Reza Valizadeh on Tuesday and Stephane Simon on Monday)
- RF cavity testing facility for a 1.3 GHz cavity
  - in this talk

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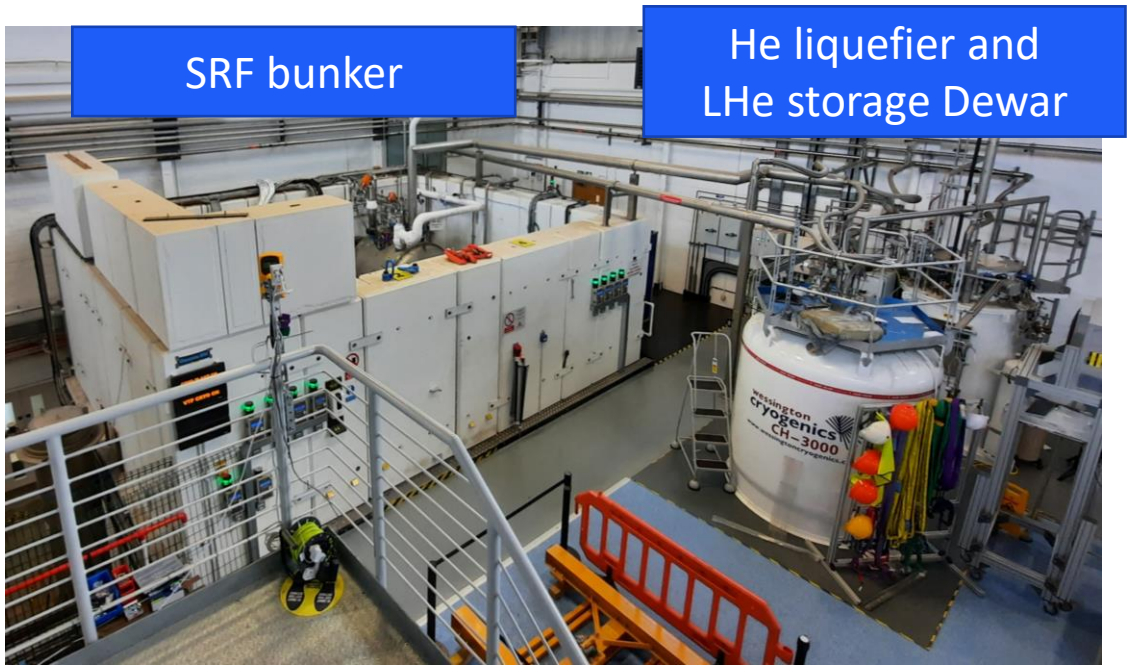
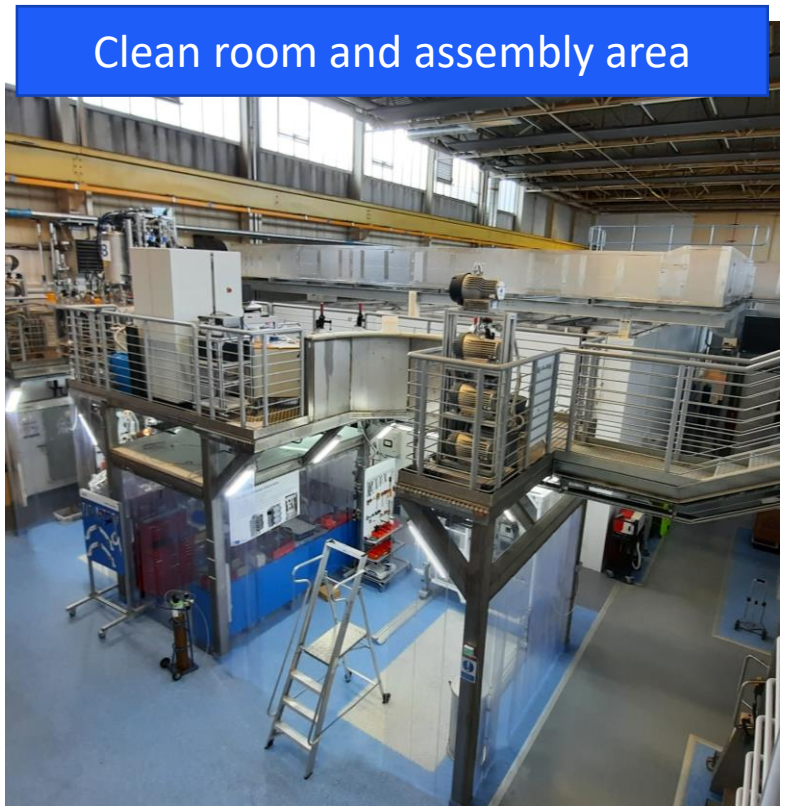
Full power RF testing

We want to fully characterise our coated cavities

Superconducting Cavity Evaluation in SuRF lab

- Very good infrastructure exist in SuRF lab at STFC Daresbury Laboratory
  - Used for bulk Nb cavity testing for ESS and PIP-II
  - Full Q_0 vs E_{acc} test with LHe
    - RF single system for 650 MHz, 700 MHz and 1.3 GHz
    - $P \leq 200$ W, $T = 2$ K and 4.2 K

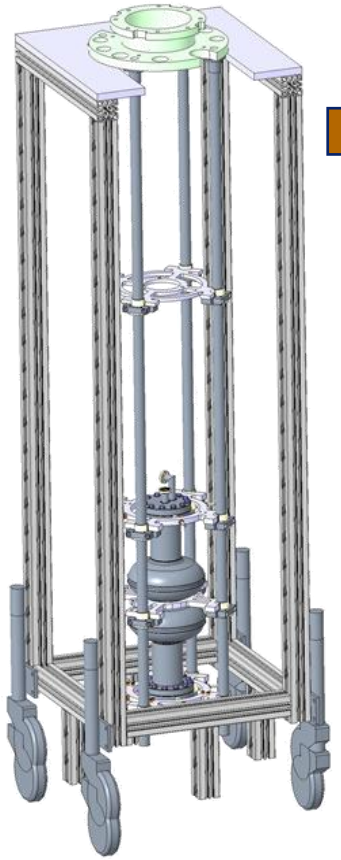




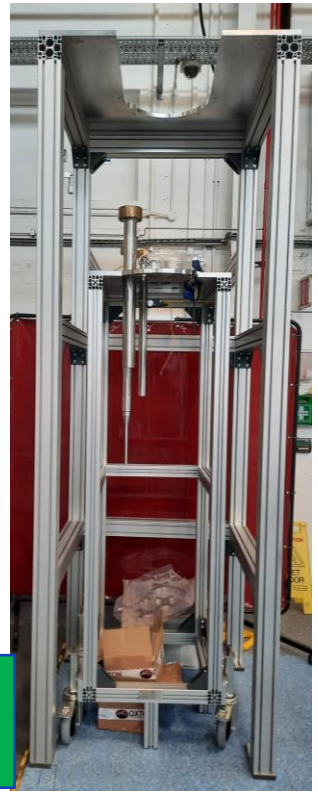
- But it has a very limited access for research cavity tests

Design for High Power Research Cavity Test

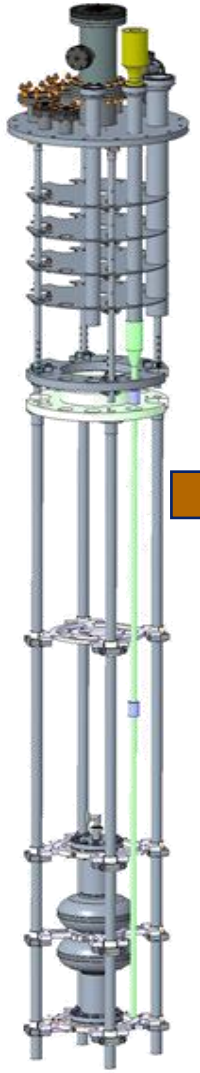
Cavity stand:
Up to 9-cell cavity



Cavity and cavity insert stands

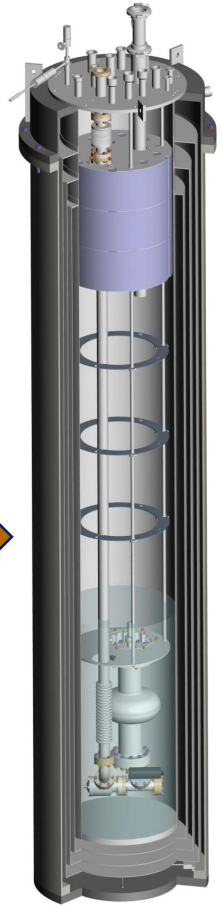


Cavity insert

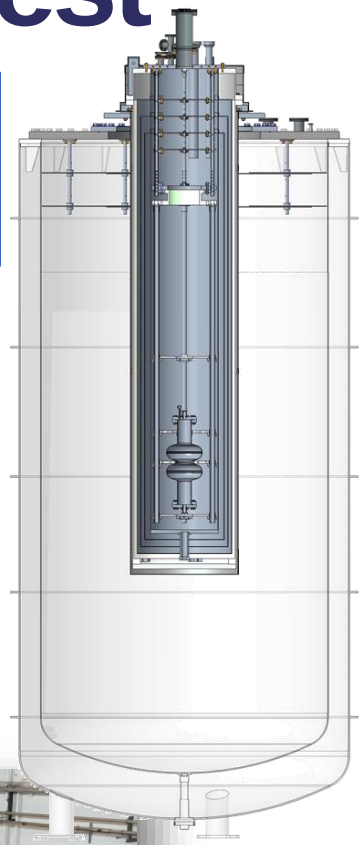


Cryostat

Cavity insert inside a cryostat



Cryostat with RF cavity in SRF bunker

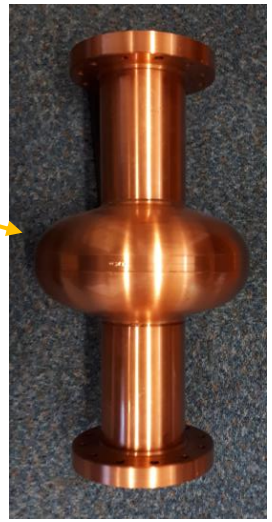


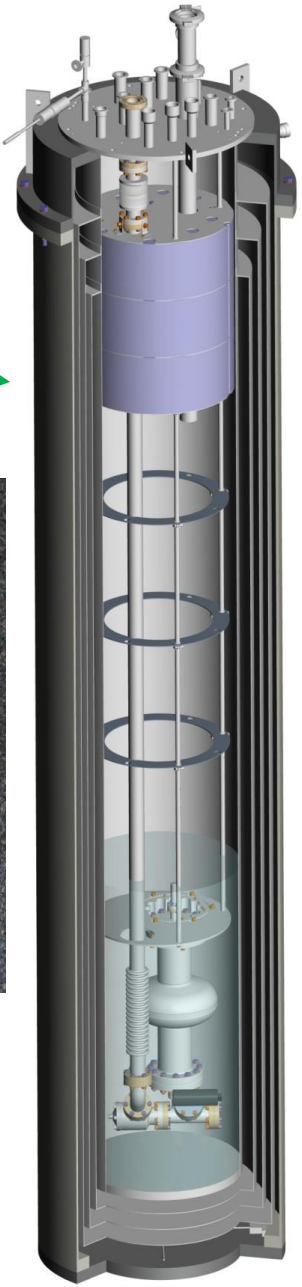
Design: Courtesy of T. Sian & C. Hill

SRF bunker

1.3 GHz cavity test readiness

- Cryostat and insert:
  - Cryostat is available
  - Cavity and cavity insert stands are ready
  - New insert is designed, parts are produced and delivered
    - to be assembled in October 2024
  - 1.3 GHz cavities:
    - Copper cavity will be provided by I.FAST partners: LNL/INFN
    - Then coated with Nb_3Sn (or other materials) in ASTeC
    - Optional bulk Nb cavity test
    - After deposition, the cavities will be delivered with closed valves and under vacuum (no venting and no pumping)
  - Could be assembled and inserted into the cryostat without troubling an ongoing work in the SuRF lab and wait for a free timeslot for the RF test. A crane will move it into and out of the bunker
- Bunker and cryogenics: SuRF fully available
  - 1.3-GHz RF amplifier is ready
  - Very limited number and durations for free timeslots, i.e. only good cavities to be characterised





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Low power RF testing

We want a quick RF test to ensure
that coated cavities are reasonably good
for a full power test

Design for Low Power Research Cavity Test

A cryocooler based facility

2.7-W cryocooler

1.3 GHz cavity

6 GHz cavity

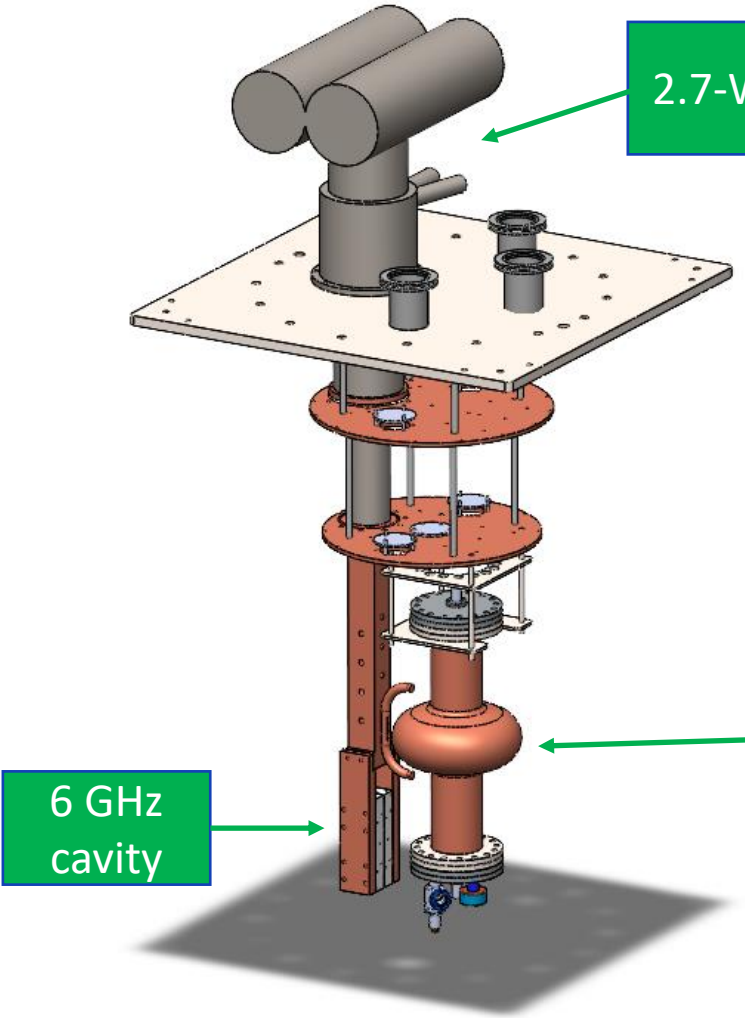
Cryostat assembly

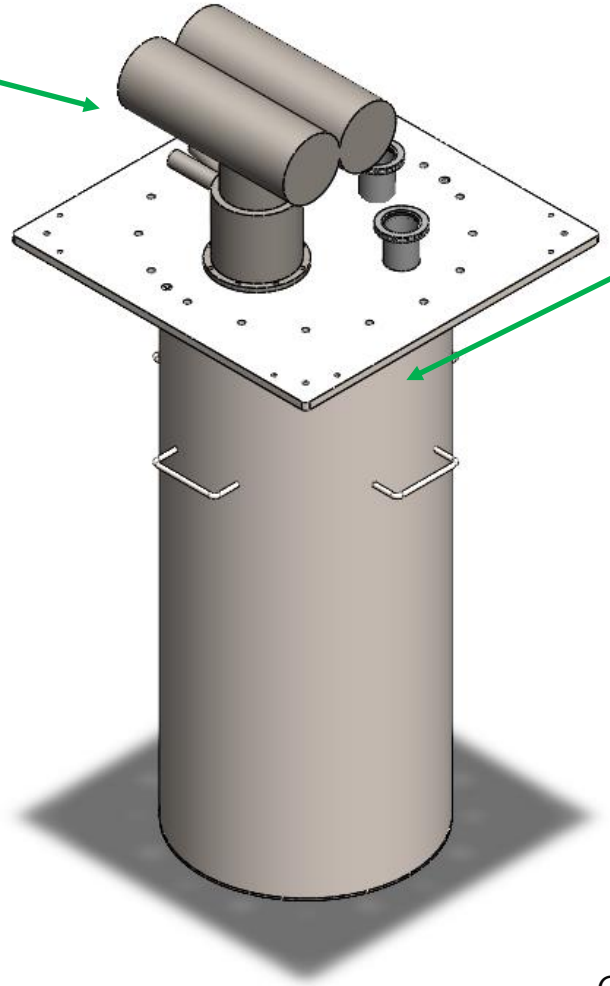
Cavities inside a cryostat

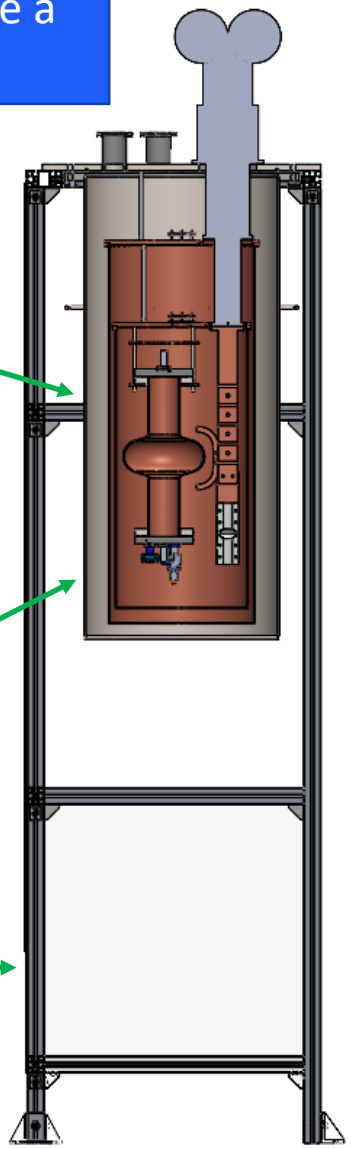
Vacuum chamber

Thermal radiation screens

Stand







Courtesy of O. Poynton & J. Rigby

Design: Courtesy of T. Sian & C. Hill

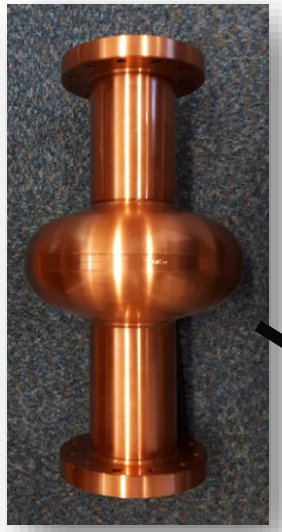
Low Power Cavity Testing

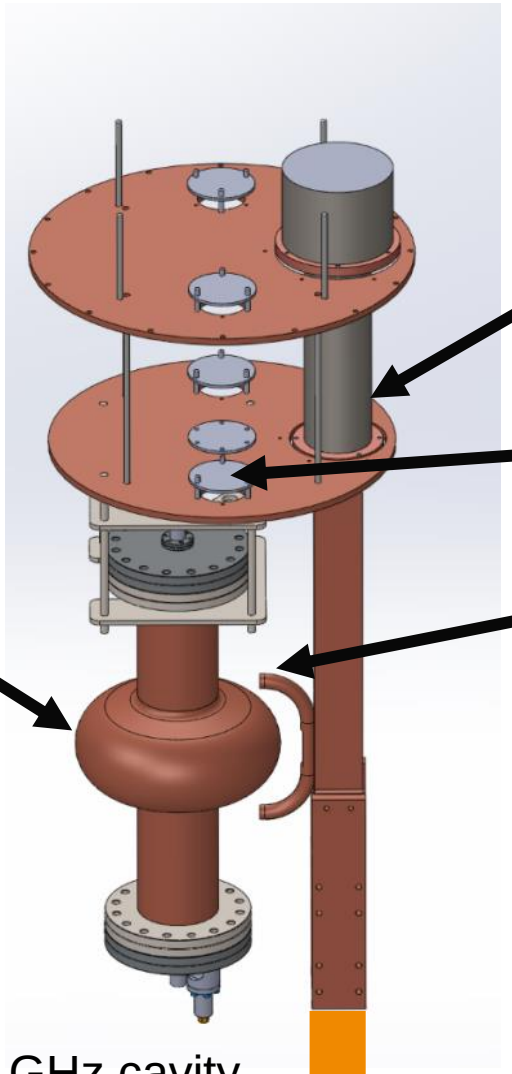
Cryocooler based facility

- $P < 2.7$ W, $T > 4$ K (est.)
- Quick first cavity test
- Good cavities will go for a high power test in LHe

5 types of cavity

- 1.3 GHz closed
- 1.3 GHz split (in development)
- 6 GHz closed
- 6 GHz split
- 3 GHz closed (future option)



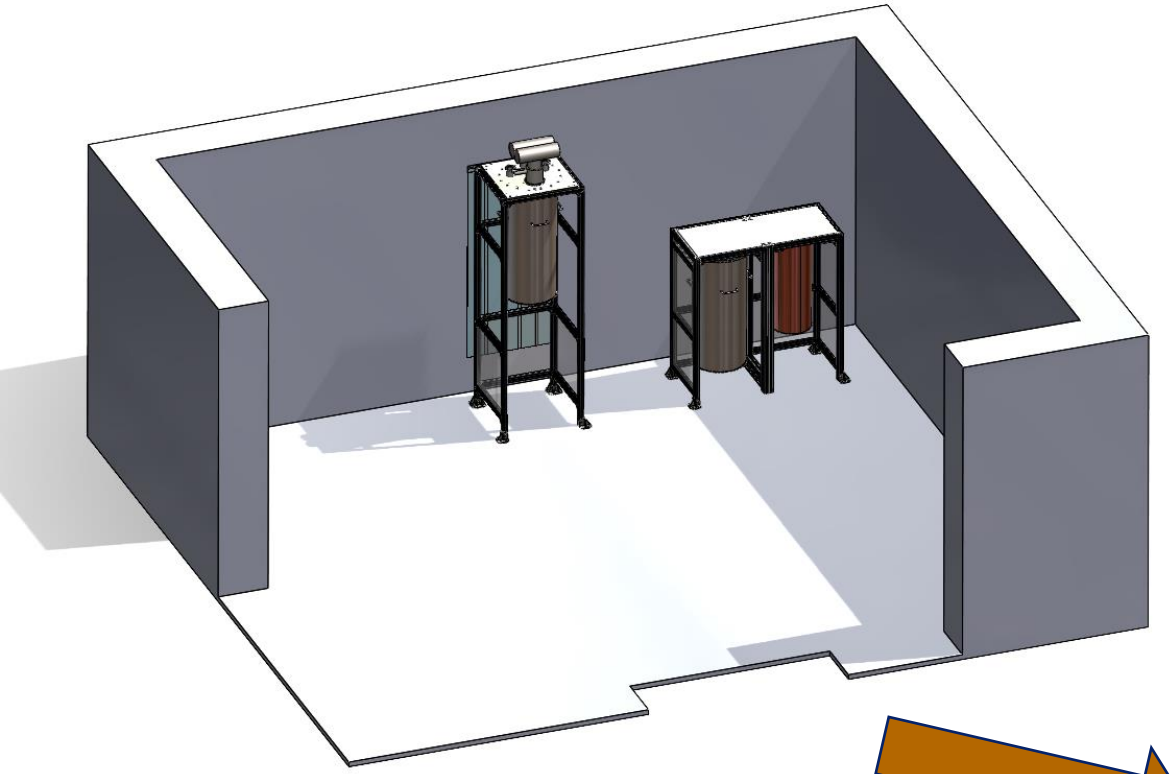


1.3 GHz cavity (close or split)

6 GHz cavity (split or close)

Courtesy of O. Poynton & J. Rigby

A new CI bunker



Design: Courtesy of T. Sian & C. Hill

Facility Readiness

New CI SRF bunker

Facility stand with an installed cryocooler

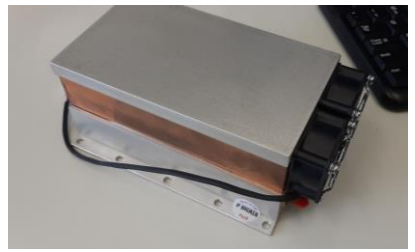
Magnetic shields, Vacuum chamber and thermal radiation screen

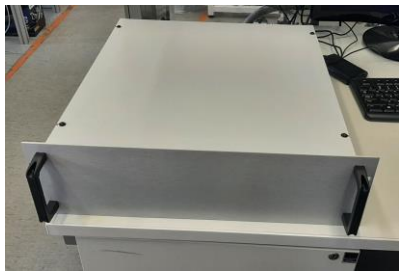
Vacuum and thermometry is partially installed.
All other parts designed, manufactured, received.
To be mounted, assembled and tested in Oct. 2024

Compressors for cryocooolers and water chiller

Low Level RF design

- Modular design
  - Tasks separated in different rackmount cases
- Suitable for current applications and future development and upgrades
- LLRF case with PLL for High Q cavity measurements
  - Possibility to operate in pulsed mode to reduce an average power dissipation
- Present stage:
  - Design completed
  - Purchasing
- Next stage:
  - Mounting all parts, then assembling and testing the system





Courtesy of Amir Hamzeh Mogheyseh

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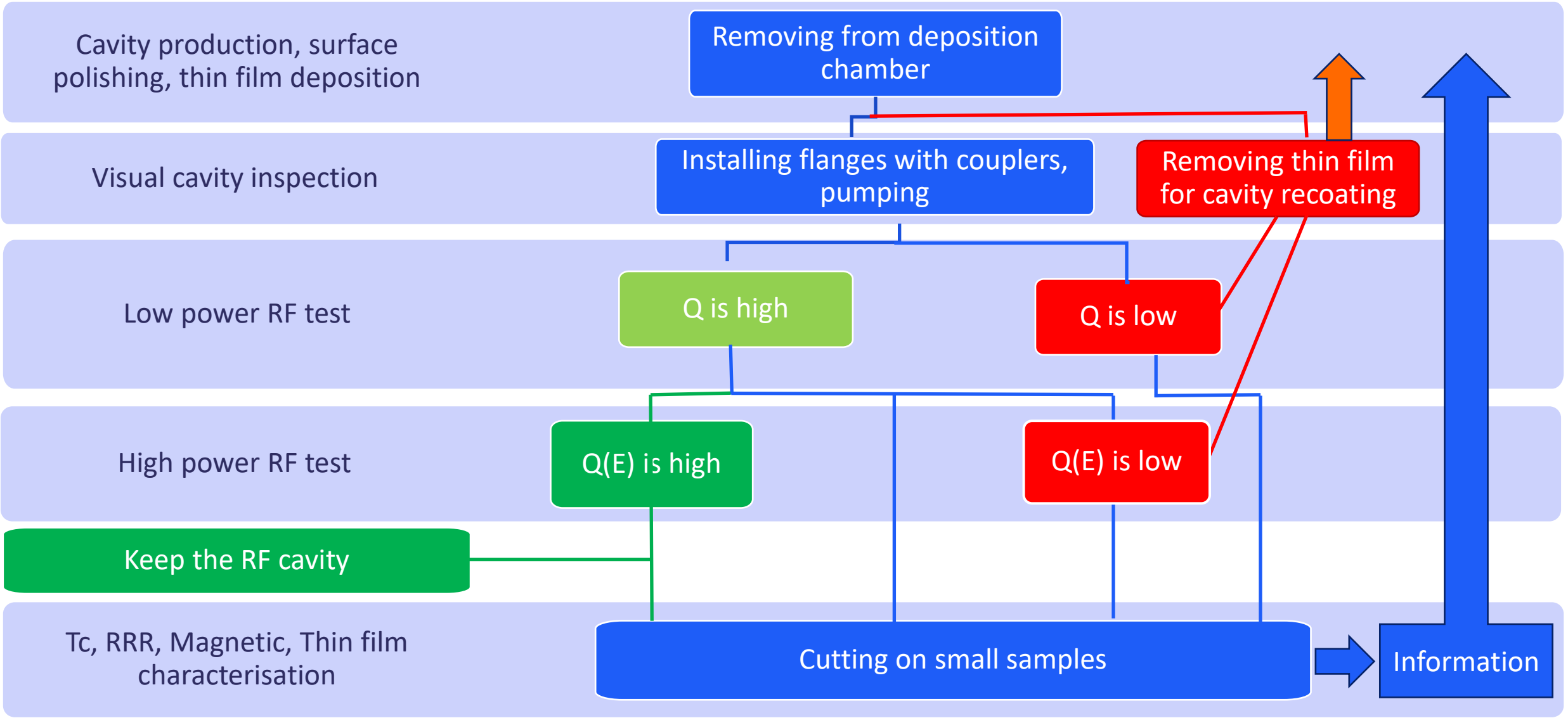
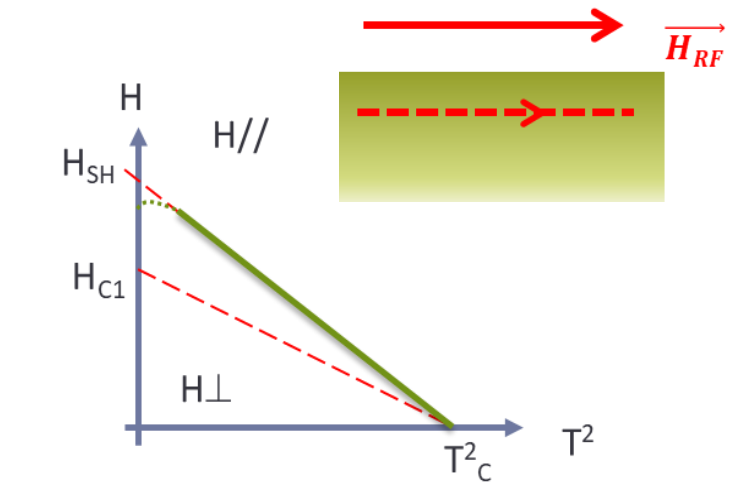
A path towards the goal

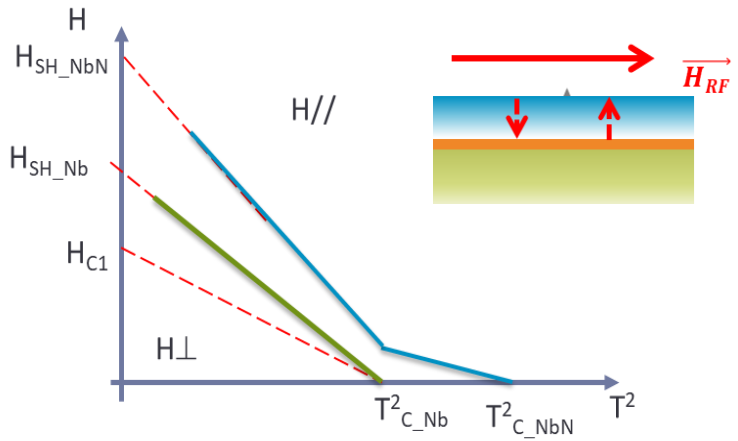
A planned routine for cavity coating and testing

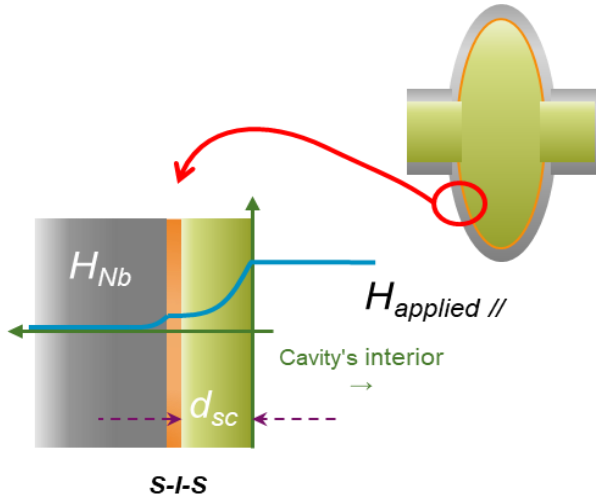
Research RF cavity cycles

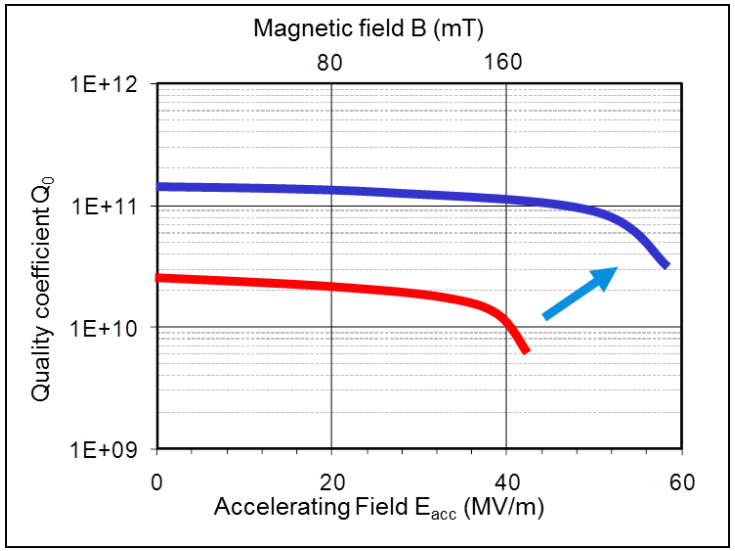


We would like to relate DC magnetometry and RF cavity results







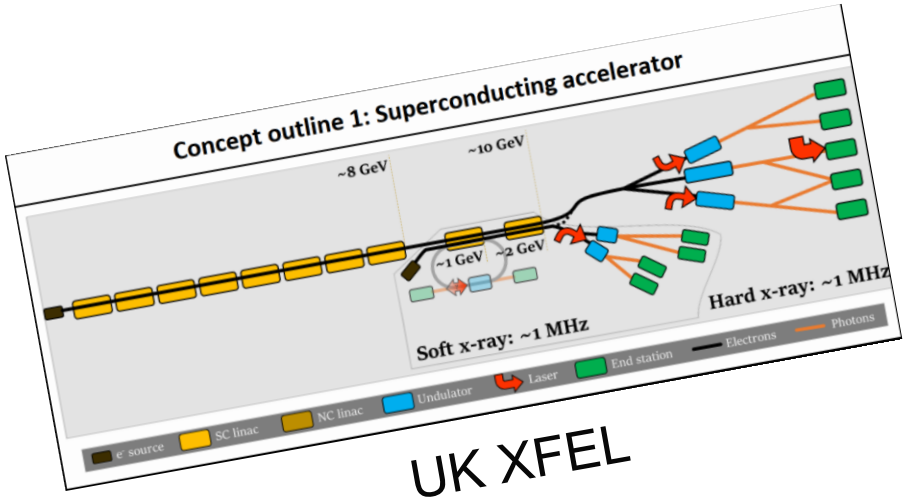


Courtesy of C. Antoine (CEA, France)

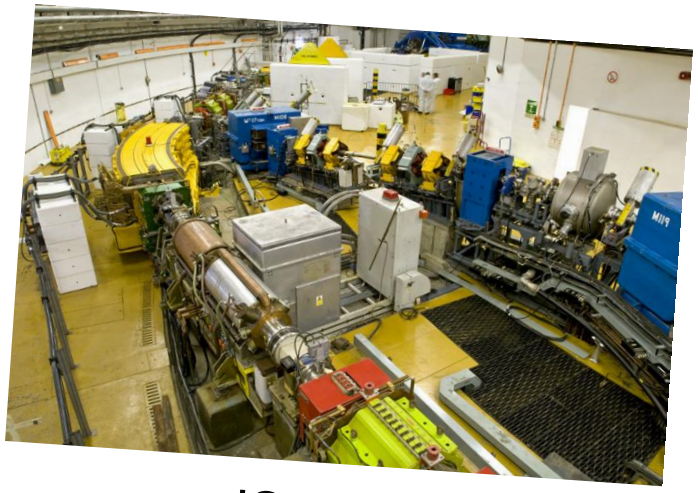
The Future of Thin Film SRF in the UK

Continuing R&D

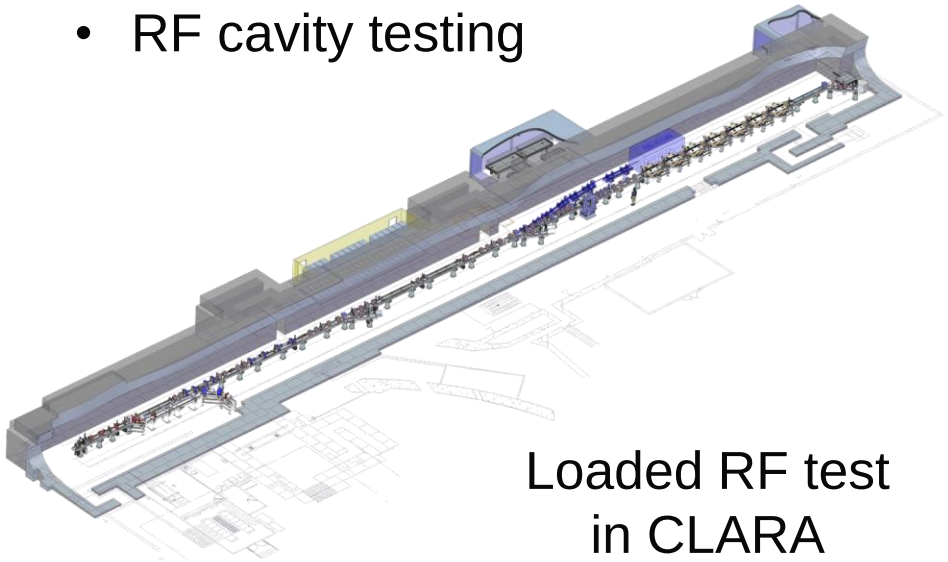
- Thin film coatings
- Post-processing
  - FLA, laser, …
- Quick small sample characterisation and SC testing
- Split cavities
- Multi cell cavities
- RF cavity testing



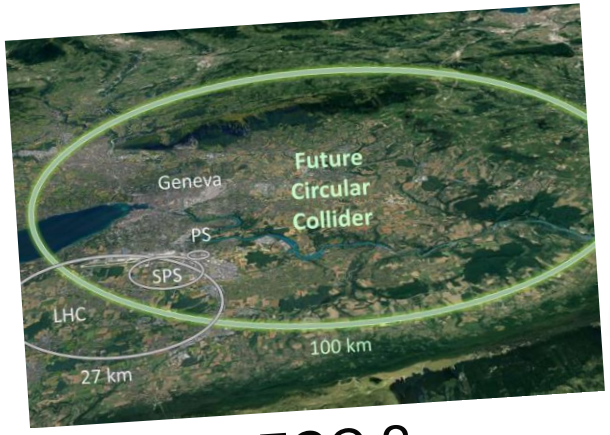
UK XFEL



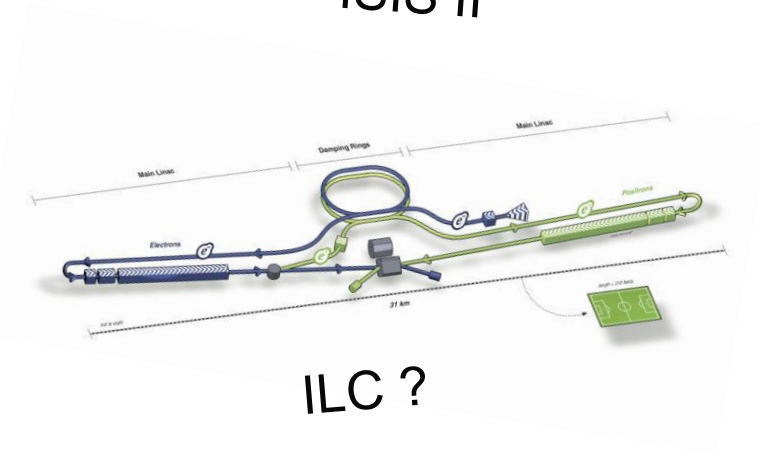
ISIS II



Loaded RF test in CLARA



FCC ?



ILC ?

Conclusions

- Two Facilities for testing various **Research RF cavities** are under construction at STFC Daresbury Laboratory in UK
  - Low power test for quick turnout and initial evaluation
    - LHe-free system
    - 4 K ≤ T ≤ 20 K
    - For 1.3, 3 and 6 GHz cavities
    - Suitable for close and split cavities
    - For thin films of Nb, Nb_3Sn, NbTiN, Mg_2B, and SIS structures
  - Full power cavity facility for full testing
    - LHe based
    - T = 4.2 K, also suitable for T = 2 K
    - For 1.3 GHz close cavities
    - Suitable for multicell cavities
  - Enables studying corelations between Q(E) vs thin film characterisation results
    - SEM, XPS, XRD, EDX, etc.
  - and Q(E) vs DC superconducting properties
    - T_c, *RRR*, B_c, B_{c1}, B_{c2}, $B_{FP,}$ B_{SH}, etc.

Acknowledgements

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