This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

Vertical cavity testing at DESY

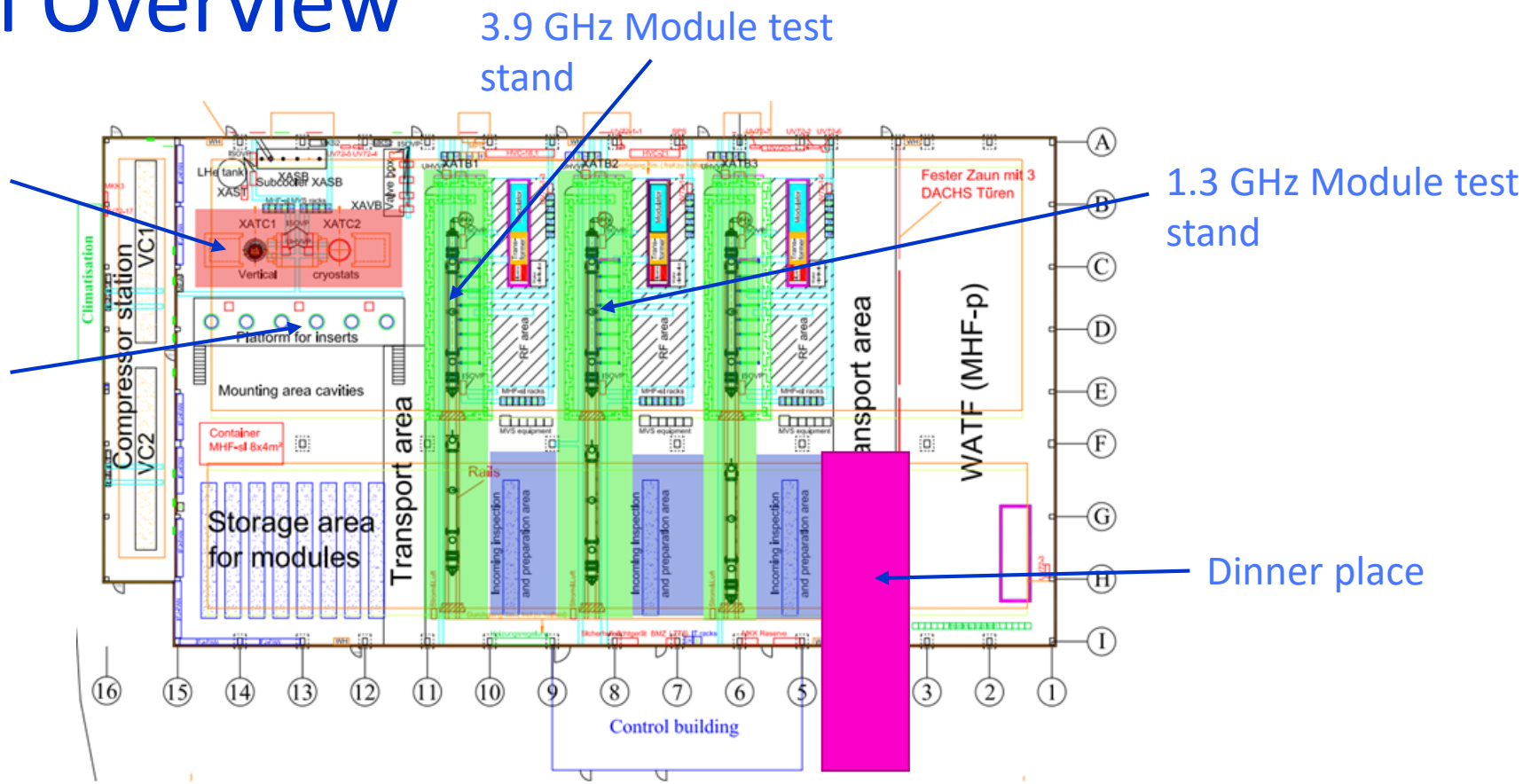
AMICI ETIAM Workshop on Vertical SRF Cavity testing
14-15.09.2022 DESY Hamburg

Mateusz Wiencek (DESY MSL)

Outline

- AMTF Hall overview
- Cavities preparation area overview
- Test stands overview
- VT procedure
- Current projects
- Future plans and possibilities
- Cavities testing in serial mode
- Summary

AMTF Hall Overview

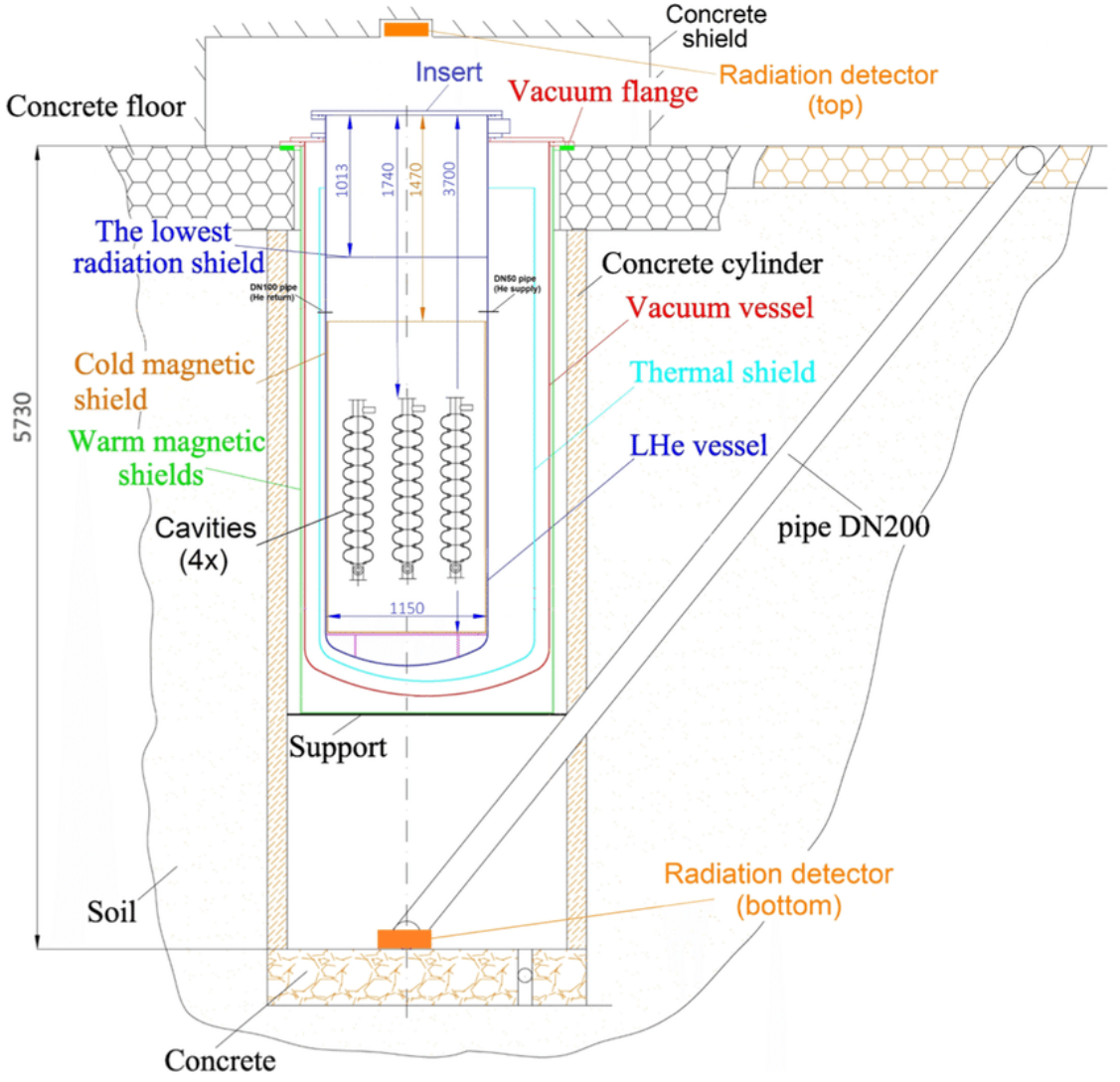


Cavities preparation area overview

- 6 inserts
  - 1 x Up to 4 x 1.3GHz 9-cells cavities
  - 1 x Up to 3 x 1.3GHz and 1 x QPR housing
  - 2 x Up to 2 x 704MHz 6 cells cavities
  - 2 x R & D 1.3GHz with additional instrumentation

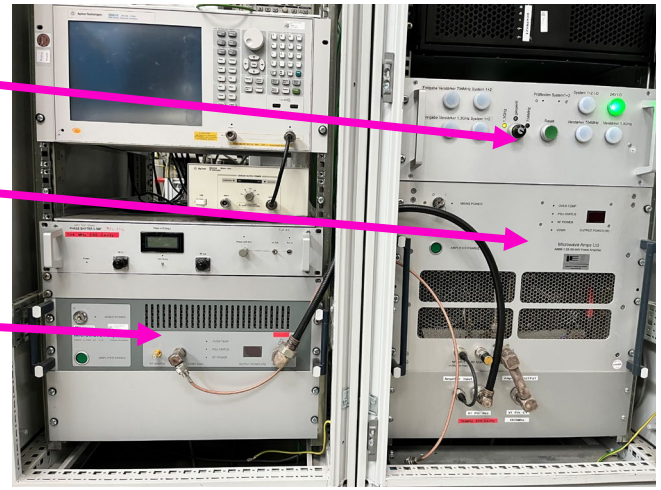
Vertical cryostats

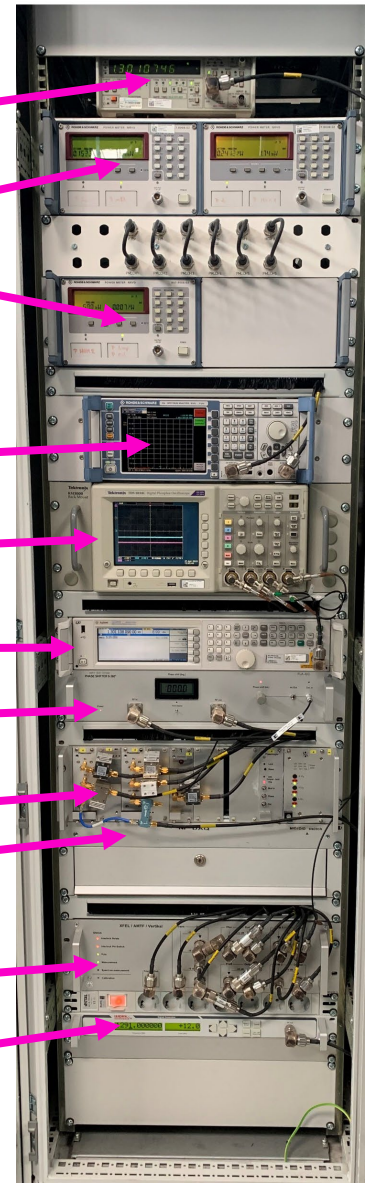
2 x



Vertical test stands hardware

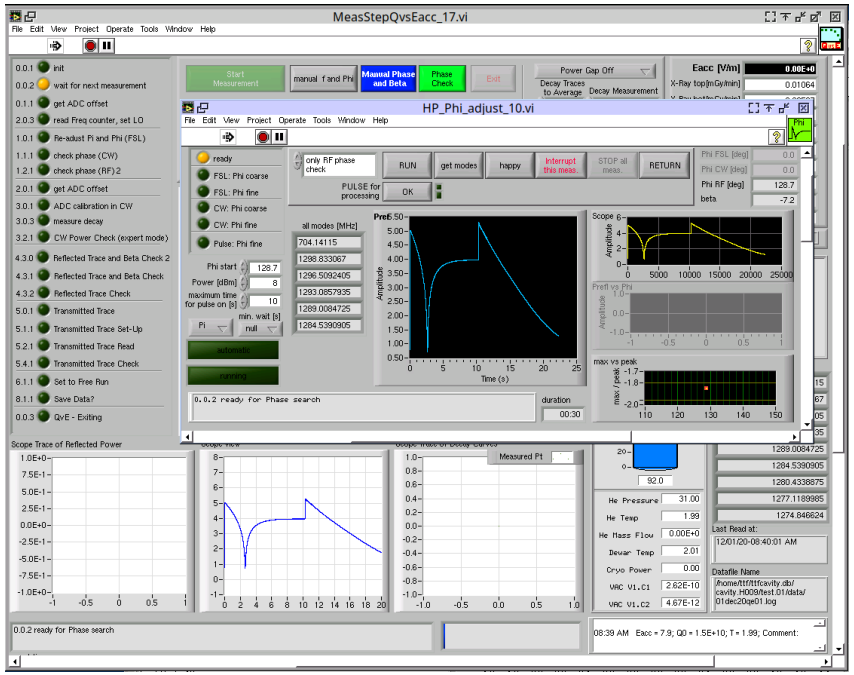
- XATC1
  - 2 amplifiers (1.3 GHz & 704 MHz) and auxiliaries
- XATC2
  - Currently only 1.3 GHz

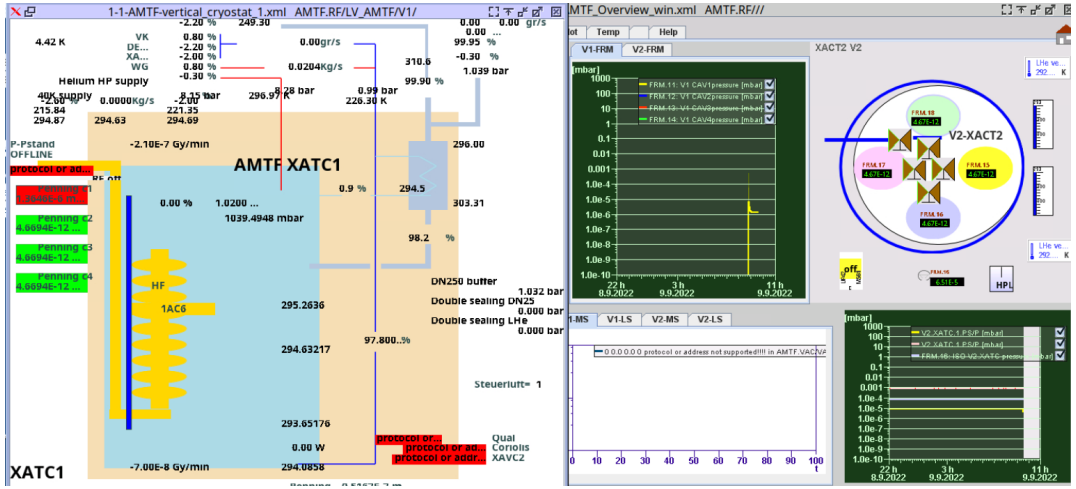




Vertical test stands software

- Most signals available in DOOCS and EPICS
- Measurements performed with semi – automatic Labview software
- Some additional scripts and software for VNA





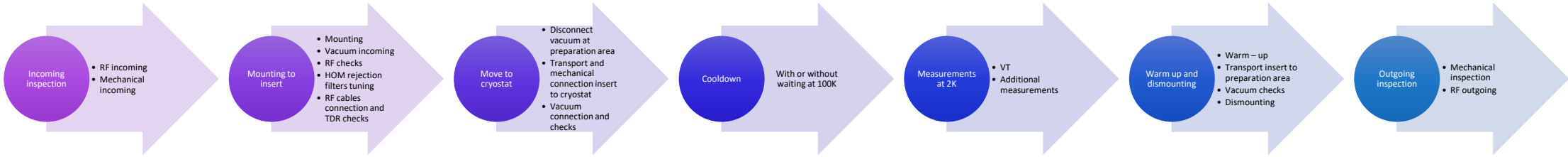
DESY Test stand XATC1 summary

XATC1				
No	Property name	Value	Unit	Comment
1	LHe volume	2000	L	
2	Operating temperature	4.2 – 1.4	K	
3	Diameter / size	1.150	m	
4	Number of inserts	6		For 2 cryostats
5	RF Frequency	1300, 704	MHz	
6	Maximum Incident power	200	W	
7	Additional instrumentation	Second Sound, Additional T-sensors, Magnetometers		R&D inserts
8	Typical testing rate (VTs / year)	127 (2021)		For 2 cryostats
9	Possibility to test naked cavities	YES	YES / NO	
10	Infrastructure for small intervention	YES	YES / NO	

DESY Test stand XATC2 summary

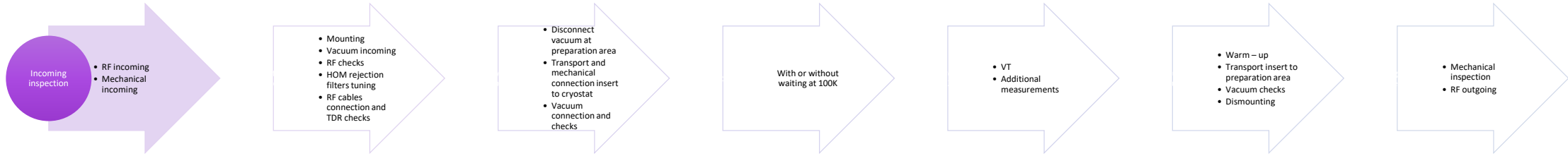
XATC2				
No	Property name	Value	Unit	Comment
1	LHe volume	2000	L	
2	Operating temperature	4.2 – 1.4	K	
3	Diameter / size	1.150	m	
4	Number of inserts	6		For 2 cryostats
5	RF Frequency	1300	MHz	
6	Maximum Incident power	200	W	
7	Additional instrumentation	Second Sound, Additional T-sensors, Magnetometers		R&D inserts
8	Typical testing rate (VTs / year)	127 (2021)		For 2 cryostats
9	Possibility to test naked cavities	YES	YES / NO	
10	Infrastructure for small intervention	YES	YES / NO	

VT procedure

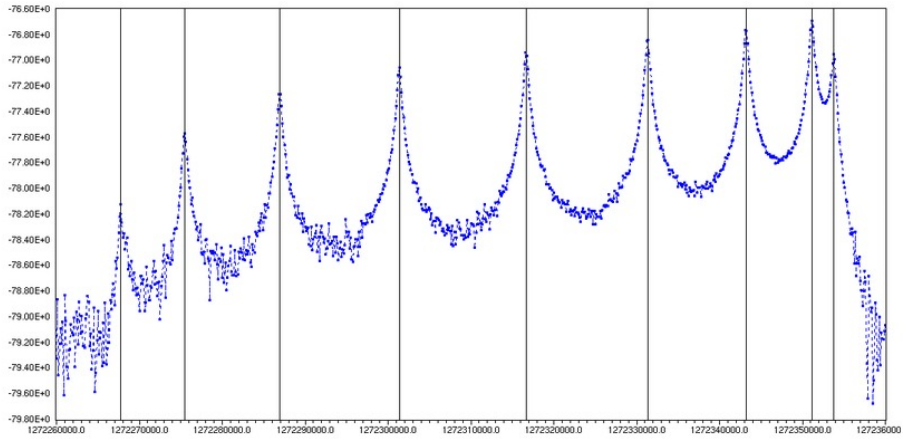


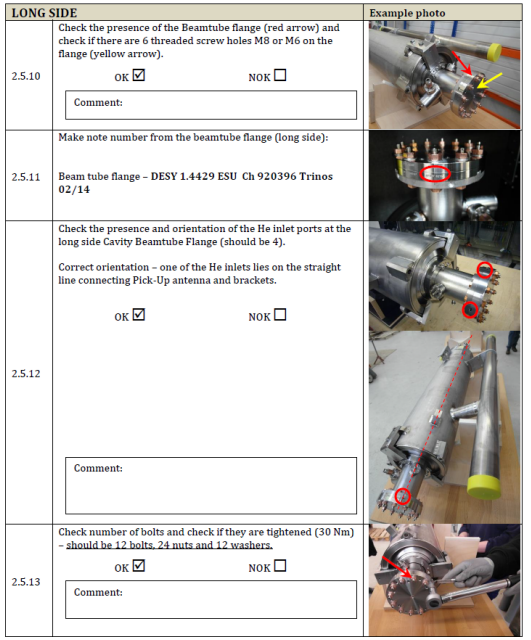
- Whole procedure usually takes around 2 weeks
- Cryogenic operations and 2K measurements around 3 - 5 working days
- Requires good cooperation within several experts from different fields
  - Vacuum
  - Mechanics
  - Cryogenics
  - RF

VT procedure – Incoming inspection



- RF Incoming
  - FM Spectra
  - Antennas shortcuts check
- Mechanical incoming
  - Shock loggers disassembly
  - Torques on screws
  - Positions of auxiliaries
  - AV closed properly?
  - etc…





LONG SIDE		Example photo
2.5.10	Check the presence of the Beamtube flange (red arrow) and check if there are 6 threaded screw holes M8 or M6 on the flange (yellow arrow). OK ☑ NOK ☐ Comment:	
2.5.11	Make note number from the beamtube flange (long side): Beam tube flange – **DESY 1.4429 ESU Ch 920396 Trinos 02/14**	
2.5.12	Check the presence and orientation of the He inlet ports at the long side Cavity Beamtube Flange (should be 4). Correct orientation – one of the He inlets lies on the straight line connecting Pick-Up antenna and brackets. OK ☑ NOK ☐ Comment:	
2.5.13	Check number of bolts and check if they are tightened (30 Nm) – should be 12 bolts, 24 nuts and 12 washers. OK ☑ NOK ☐ Comment:	

VT procedure – insert assembly and checks

- RF incoming
- Mechanical incoming

Mounting to insert

- Mounting
- Vacuum incoming
- RF checks
- HOM rejection filters tuning
- RF cables connection and TDR checks

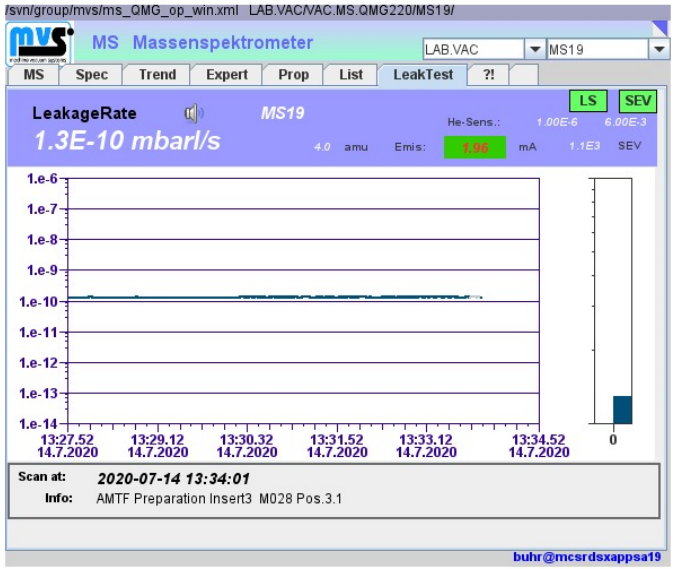
- Disconnect vacuum at preparation area
- Transport and mechanical connection insert to cryostat
- Vacuum connection and checks

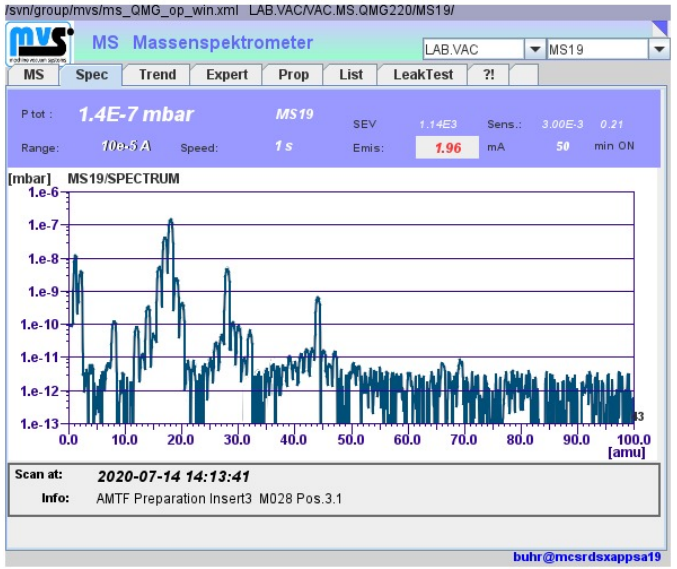
With or without waiting at 100K

- VT
- Additional measurements

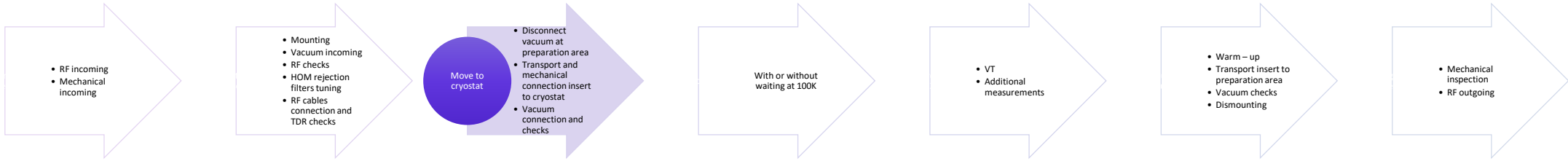
- Warm – up
- Transport insert to preparation area
- Vacuum checks
- Dismounting

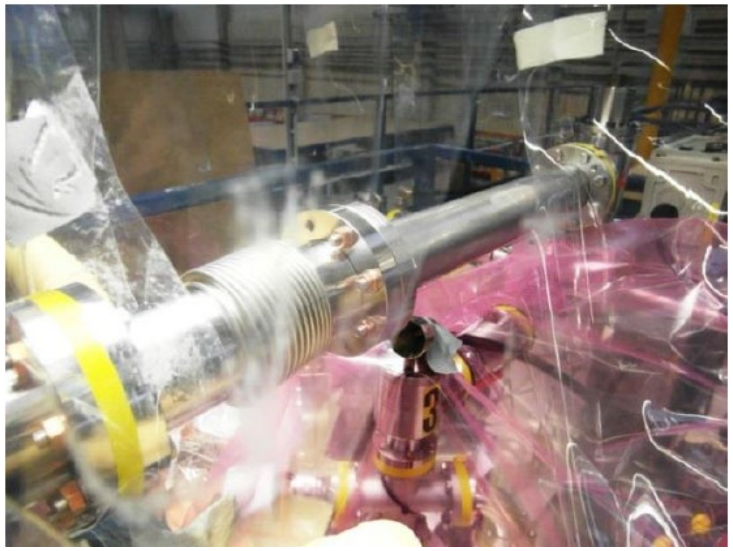
- Mechanical inspection
- RF outgoing

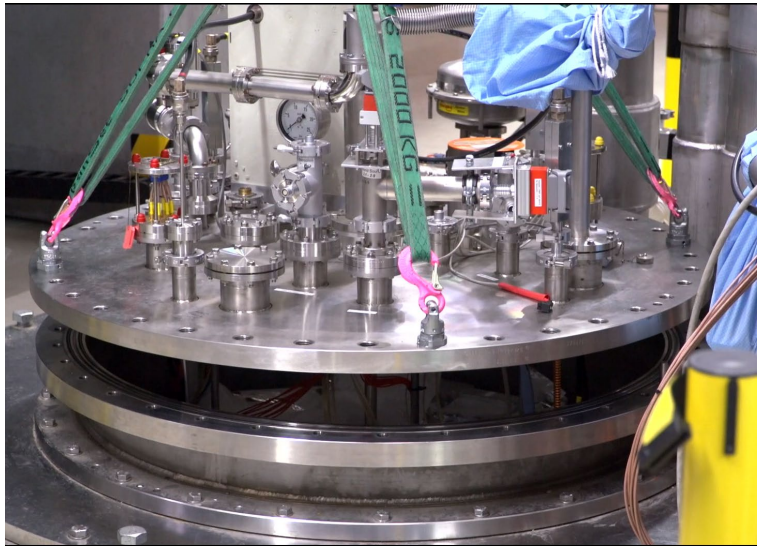




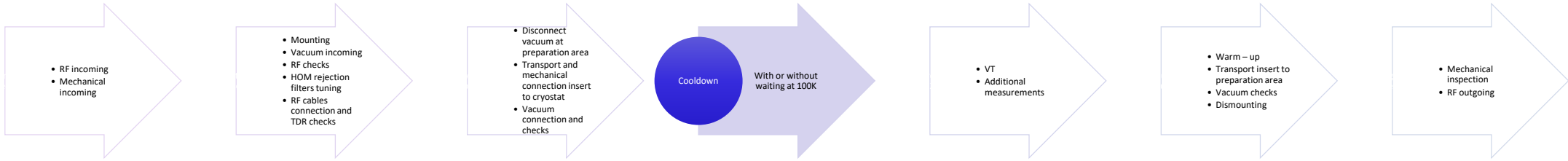
VT procedure – move insert to cryostat



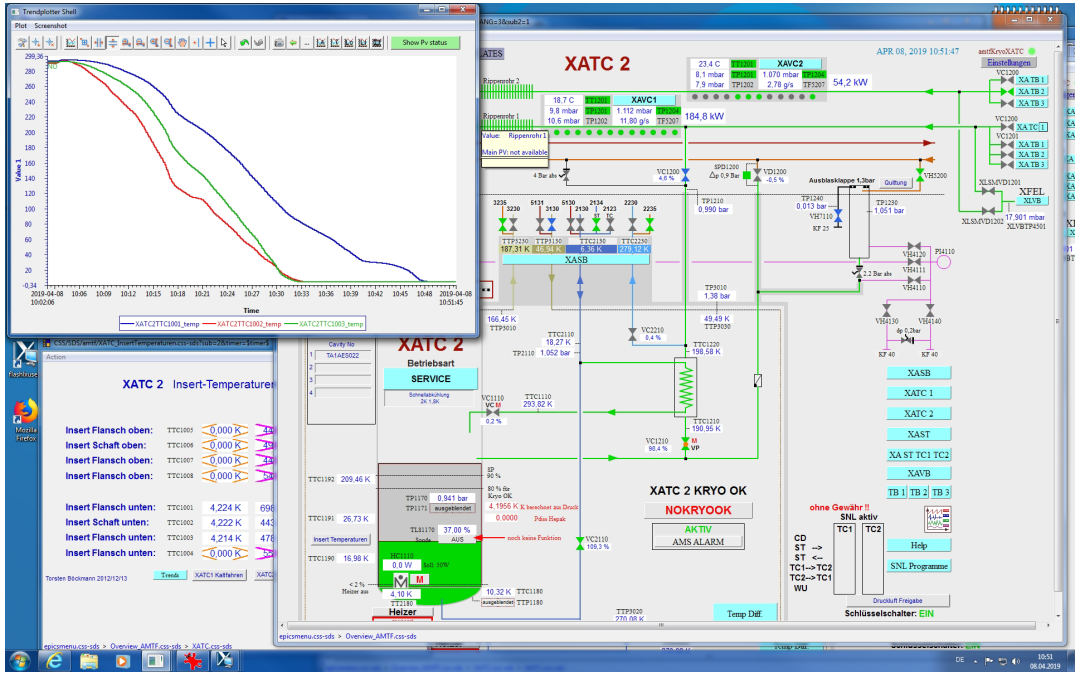




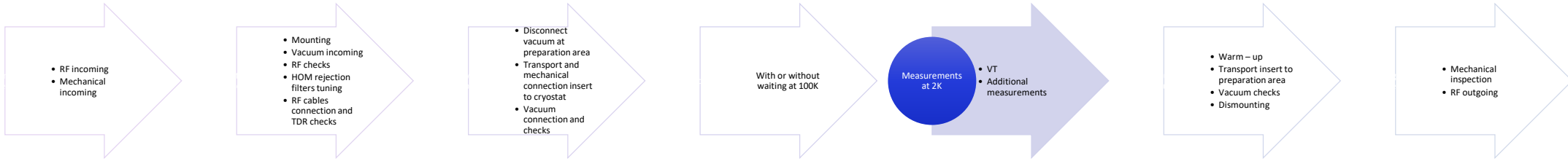
VT procedure - cool down



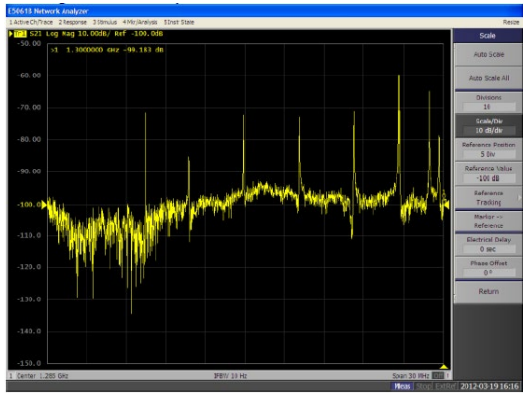
- Standard cool down performed with FSM by cryo shift
- Different cool down speeds possible

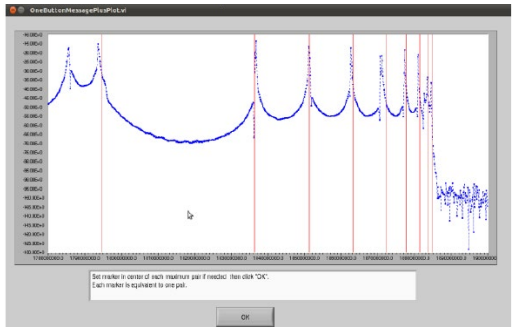


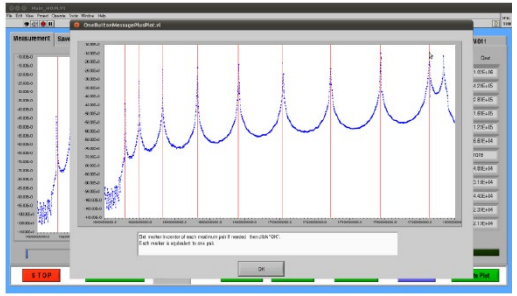
VT procedure - measurements at 2K – FM Spectra, HOM Spectra



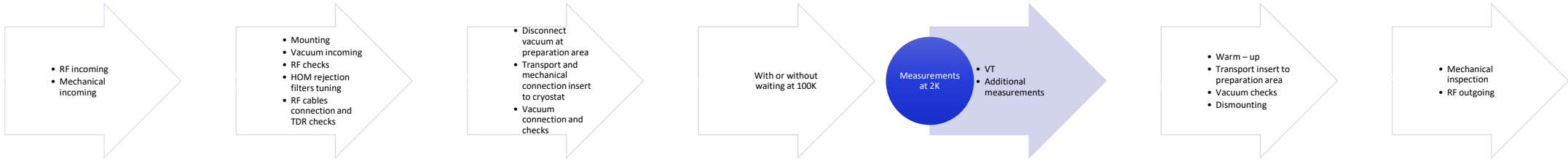
- Fundamental mode spectra
- HOM Spectra



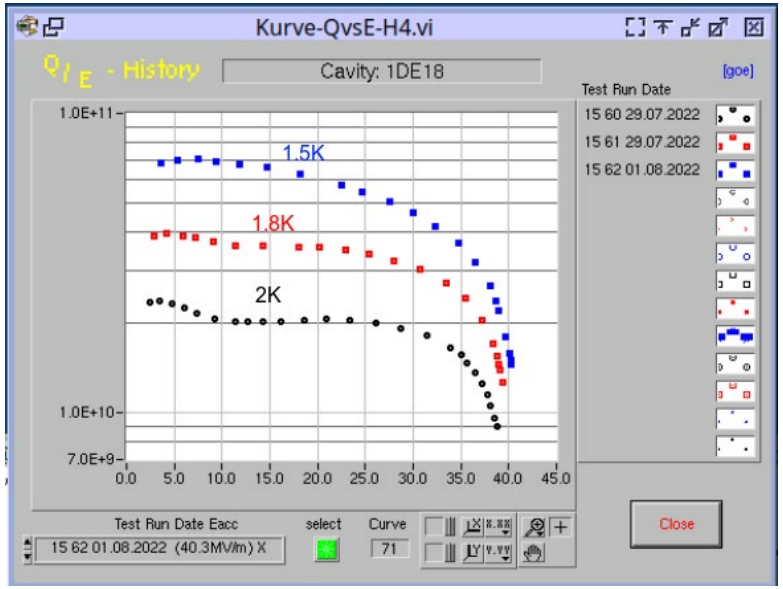




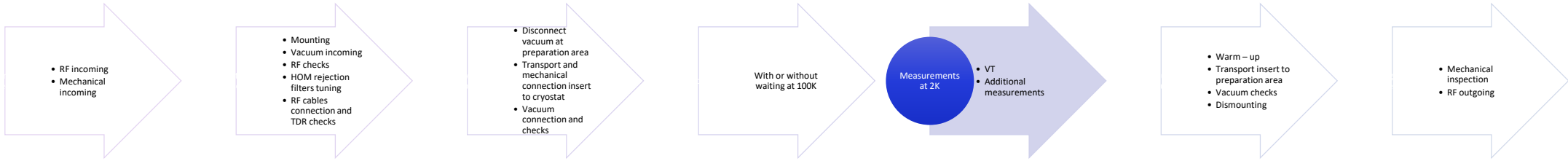
VT procedure - measurements below Tc - QvsE



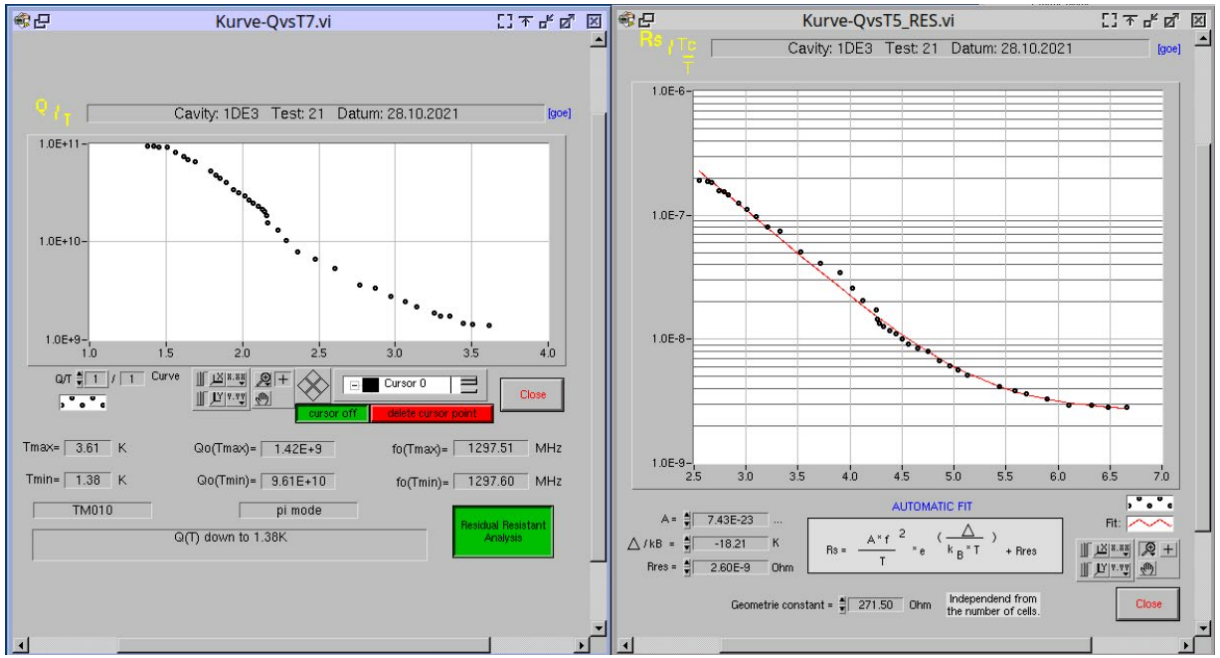
- QvsE
  - 2K → Cavity performance
  - 1.8K → Second sound
  - 1.5K → Obtain R_{BCS} at 2K



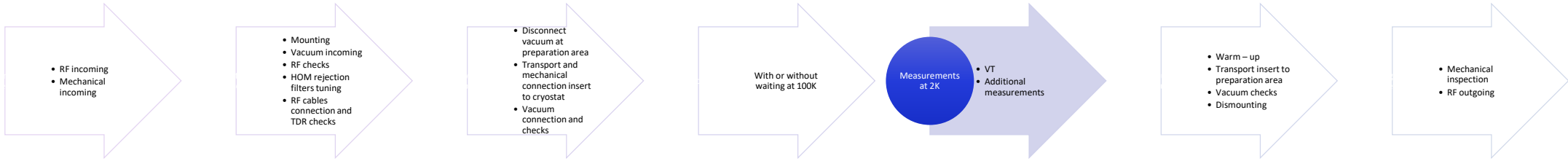
VT procedure - measurements below Tc - QvsT

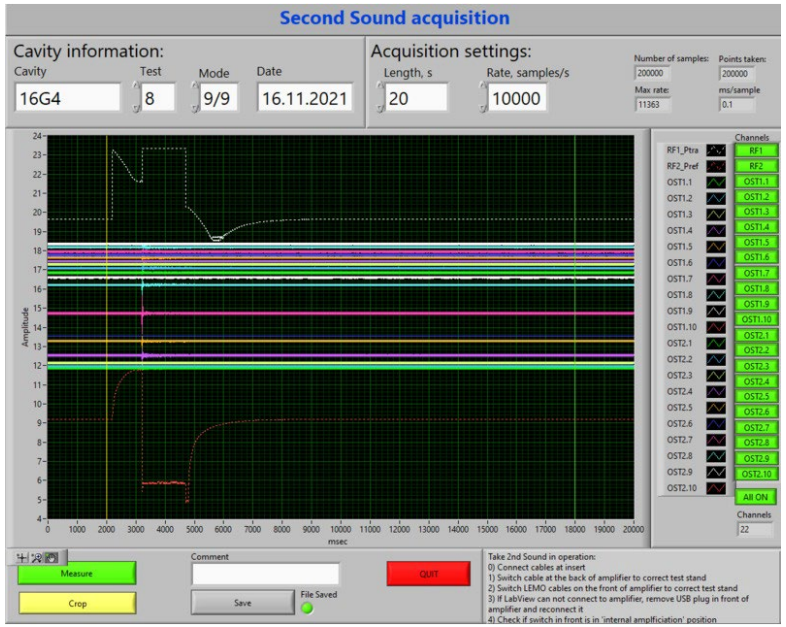


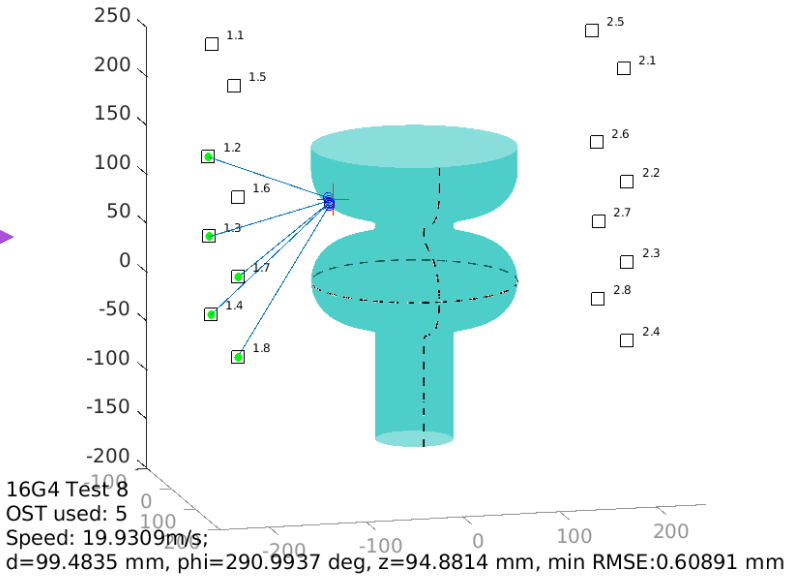
- QvsT
  - Obtain R_{res}
  - Eacc between 3 and 5 MV/m
  - 3.5 K → 1.4 K
  - Movable antenna



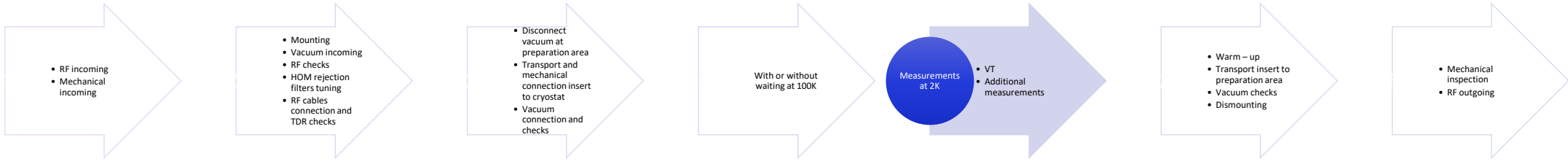
VT procedure - measurements below Tc – Second Sound



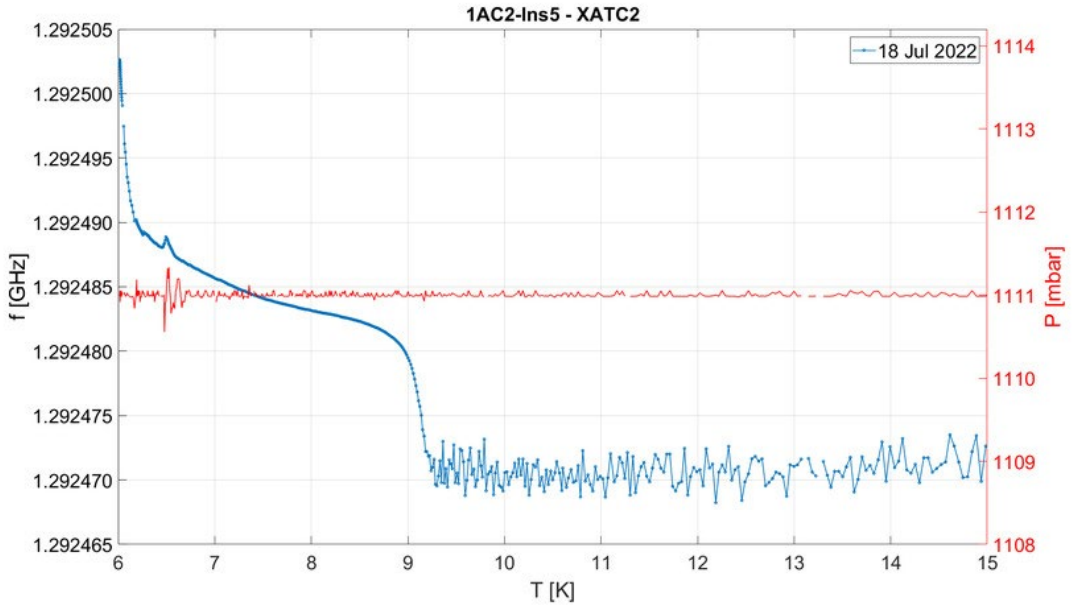




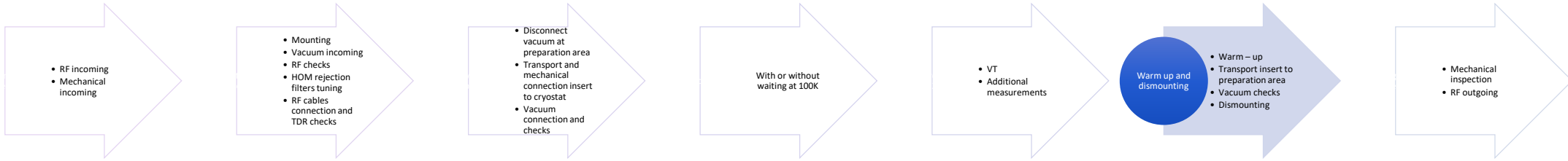
VT procedure - measurements around Tc - FvsT



- FvsT
  - Constant pressure inside cryostat
  - Frequency change around T_c

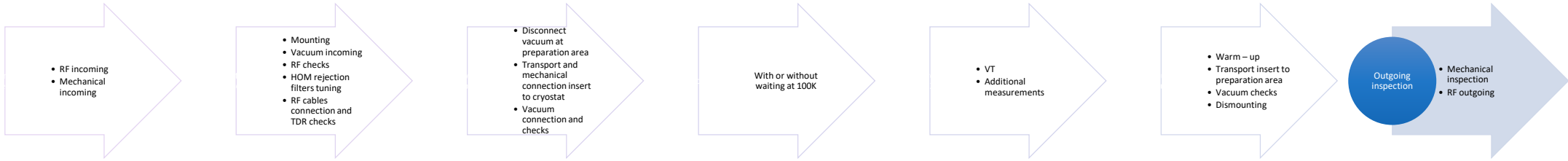


VT procedure – after cold test



- Shielding opening, radiation measurement
- Warm – up to room temperature
- Vacuum disconnection at cryostat
- Transport of the insert to preparation area
- Vacuum connection, LC & RGA after cold test
- Vacuum disconnection
- Cavity dismounting

VT procedure – outgoing inspection



- Mechanical outgoing
  - Torques on screws
  - Positions of auxiliaries
  - AV closed properly?
  - Shock loggers assembly
  - etc…
- Additional procedures (if requested)
- RF Outgoing
  - FM Spectra
  - Antennas shortcuts checks

Current R&D projects

Single cells R&D

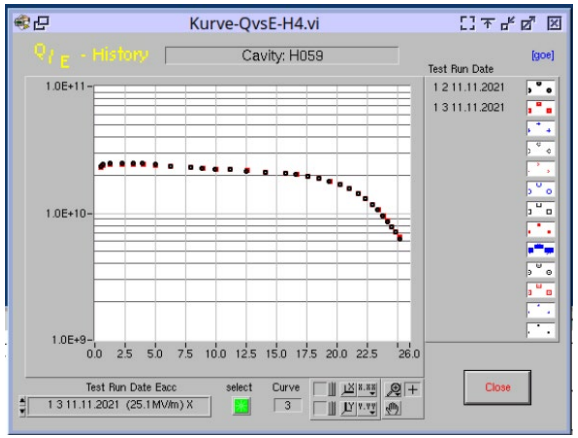
- Mid-T backing
- Low-T backing

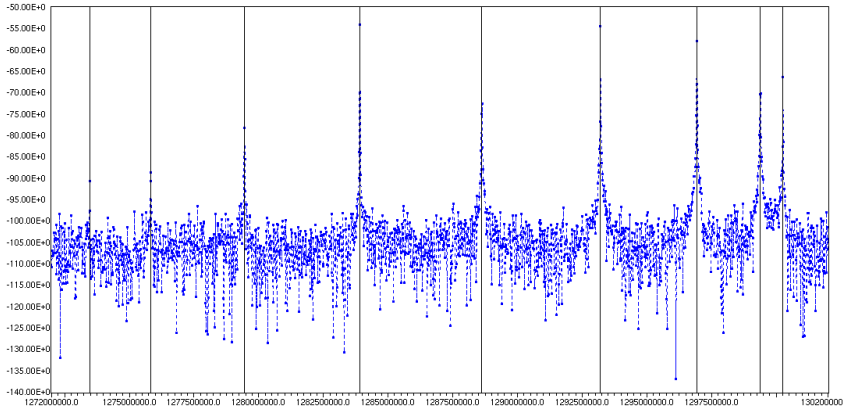
SRF GUNs

QPR

Current and recently finished external projects

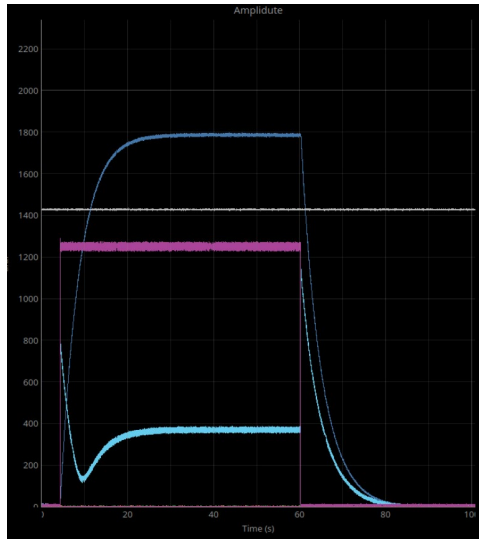
- ESS MB
- ESS HB
- POLFeL
- Another 1.3GHz cavities on request from industry





Future plans

- Test stands
  - Switch test stand hardware to digital system (MTCA4)
  - B-mapping
  - Additional Xrays detectors (Gamma Spectrometer)
- Projects
  - PIP II
  - XFEL upgrade

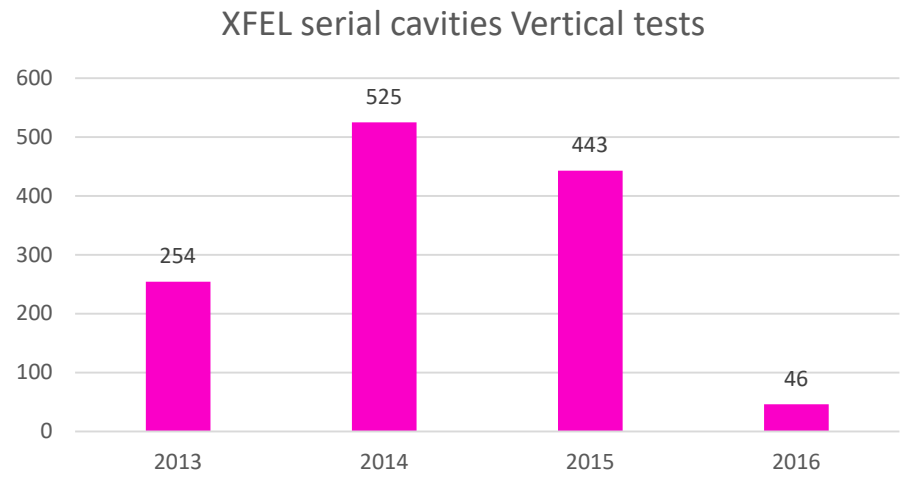


Additional possibilities

- Change to other frequencies
  - Mechanical adaptation of the insert
  - Switch measurement hardware
    - Amplifier
    - Frequency shifter
    - Some passive elements (directional couplers, additional cabling etc…)
    - Personal interlock adaptation
- Cryogenic test of components in cryostat

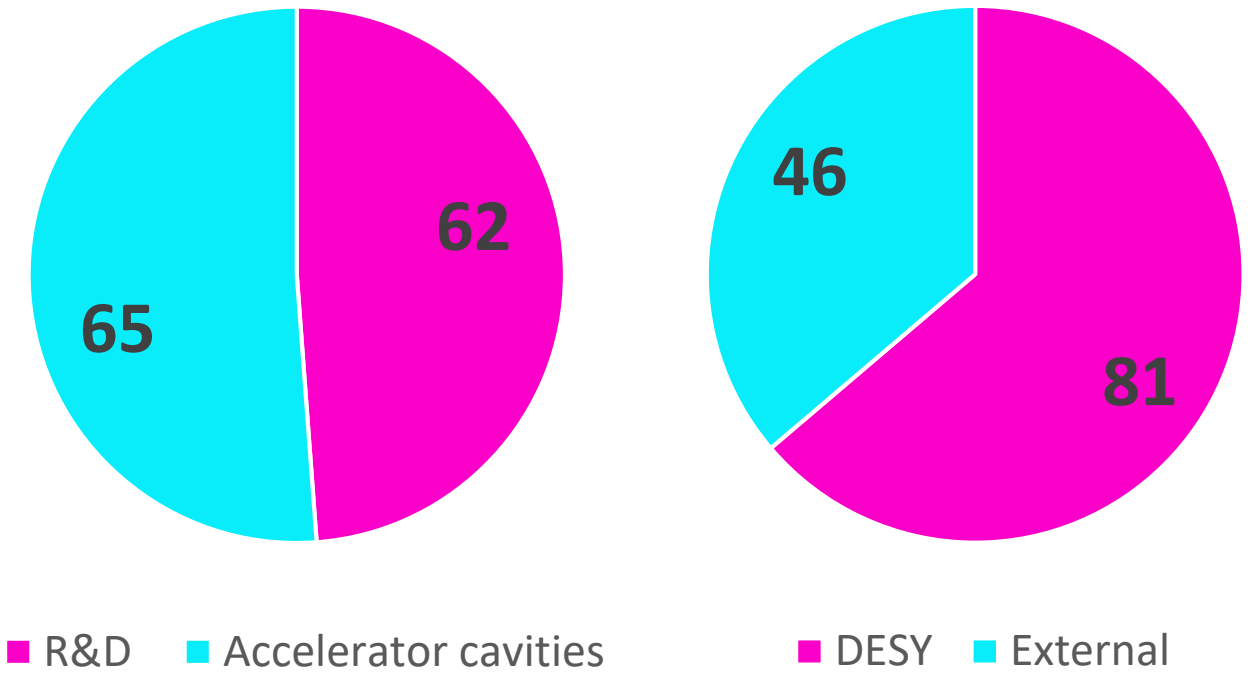
Cavities testing in serial mode - XFEL

- 1276 VTs for serial XFEL cavities performed over 3,5 years
- In 2014 (testing peak) – 525 Vertical tests performed
  - 10 VTs / week (including holidays, maintenance etc…)
- Special testing team working on 2 shifts



Last year (2021) VT summary

- 127 VT
  - R&D single cells – 50
  - DESY 1.3GHz 9 cells – 19
  - SRF GUN – 12
  - ESS MB – 12
  - ESS HB – 21
  - Other 9-cells 1.3GHz – 4
  - POLFel - 9



Summary

- In AMTF hall at DESY performing of cavity vertical test is a daily routine
  - Long time experience
  - Trained personnel
- Big cryostats give a lot of possibilities
- Test stands serve for both: R&D and accelerator cavities
- Currently 2 cavities types (1300 MHz, 704 MHz) can be measured
  - There is a possibility to switch to other frequency

THANK YOU VERY MUCH!!

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.