Experience with cryogenic operation of Accelerator Module Test Facility during testing of one third of XFEL cryomodules

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- Complete cold performance tests of all XFEL cryomodules before tunnel installation (RF measurements, vacuum check, cryo-losses)
  103 cryomodules, rate: 1 cryomodule/week

- Cold RF tests of all XFEL superconducting cavities before cryomodule assembly
  824 cavities, rate: 6 cavities/week

- Cold tests of all superconducting magnet packages before cryomodule assembly
  103 magnets, rate: 1 magnet/week
AMTF Hall – Cavities and Cryomodules

- Vertical Cryostat
- Radiation protection shielding
- Cavity preparation area
- Unloading of the cryomodule after transport
- Cryomodule preparation area
- XATB – module inside radiation protection shielding
Red = Wroclaw University of Technology+Kriosystem, Poland (in-kind)

Blue = DESY MKS acting for XFEL company (no in-kind!)
-> DeMaCo, Netherlands

Green= Budker Institute of Nuclear Physics, Russia (in-kind)
Manufacturer: Oerlikon Leybold

2 sets of compressors for 2K operation at AMTF (2 x 20 g/s helium at 20 mbar)

1 set = 12 x parallel pump stations
(WS 2001 RUVAC roots vacuum pump + SOGEVAC SV750B rotary vane vacuum pump)

– simple, modular, redundant

In average: about 8000 h operation (status June 2015)
AMTF Vertical Cryostats

SPEC DESY
April 2009
Design & Construction
WUT&Kriosystem
Delivery & installation:
July 2012 – April 2013

Cavity Frame
Design:
DESY FLA
6 inserts for AMTF

 Courtesy of J.Schaffran
First test stand delivered & installed May 2013 (cold commissioning July 2013)
Cold commissioning of 3rd test stand December 2013

2 cryostat adapters for the test of single dressed cavities at AMTF
DESY is acting for XFEL company

Manufacturer: DeMaCO

Sub-Cooler Box XASB
Valve Box XAVB
L Helium Dewar XAST

Wessington Cryogenics Ltd, UK
Supplied by HERA helium refrigerator.

- 33 g/s of LHe and cooling capacities of about 3 kW at 40/80K, 0.5 kW at 4.5K.
- Modular structure - independent operation of test stands from each other.
- Buffering of extra liquefaction in 10000 ltr liquid helium storage dewar (XAST).
- Missing of air condensation on cryogenic valves during exchange of modules or cavities.
- Capacity limits – return gas peak, screw compressor capacity during cool down/warm-up, 2 dynamic procedures in parallel.

Cool down and Warm up

**XATC1, XATC2**
- Manual pump and purge
- Cool-down to 4K, liquid helium transfer and warm-up in automatic mode
- Manual pump-down to 2K

**XATB1, XATB2, XATB3**
- Manual pump and purge
- Mainly automatically warm-up,
- Cool-down partially in automatic mode
Serial tests with installation work and commissioning at the same time

Mixing of warm & cold gas for controlled cool-down/warm up

LHe level measurements affected by electrical heaters

2K supply JT-valve in module test stand 3 (XATB3) out of shape

Misalignment of process tube flanges (feed-caps) -> install adapters

“Digital ” operation of valve positioners -> change type of positioners

Some cold and warm valves have leakages over the seats as well as jerk movement of valve stems

Bad thermal contacts of some electrical heaters -> use of other heater type

Liquid level measurements -> increase current

Mix-up of thermometers (calibration) -> try to sort, some re-calibration
All superconducting magnets are tested!

In total, 720 Cavity Tests were performed on vertical cryostats.

Specified test rate of accelerator module is reached!

Total heat load (static+dynamic) in line with budget.

Near all results above XFEL specification:

- accelerating gradient 23.6 MV/m
- cavity quality factor $Q_0 = 10^{10}$ at 23.6 MV/m
Some preliminary conclusions

- Deliveries & installation of XATCs, XASB, XAVB, XATL were “just-in-time“ for start-up of cavity production
- Deliveries & installation of XATBs were “just-in-time“ for start-up of cryomodule production
- No dedicated debugging of cryo-supply and other systems
- XATCs design capacities demonstrated
- Complexity of XATBs commissioning underestimated
- General effort for installation & commissioning underestimated
- 1 cryomodule test/week is reached (further ramping-up rate is under investigation)
- So far: in budget and almost “in time“ (not “on schedule“)
Thank you for your attention!