

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

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presented by Anatoly Zhirnov, DESY, MKS

With a huge appreciation to colleagues from INP-PAS (Poland), WUT (Poland), BINP (Russia) and other DESY groups for joint fruitful work during AMTF test activity



**HELMHOLTZ
ASSOCIATION**

AMTF: purpose & objectives (TDR)

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



■ Vertical Cryostat



■ Radiation protection shielding



■ Cavity preparation area



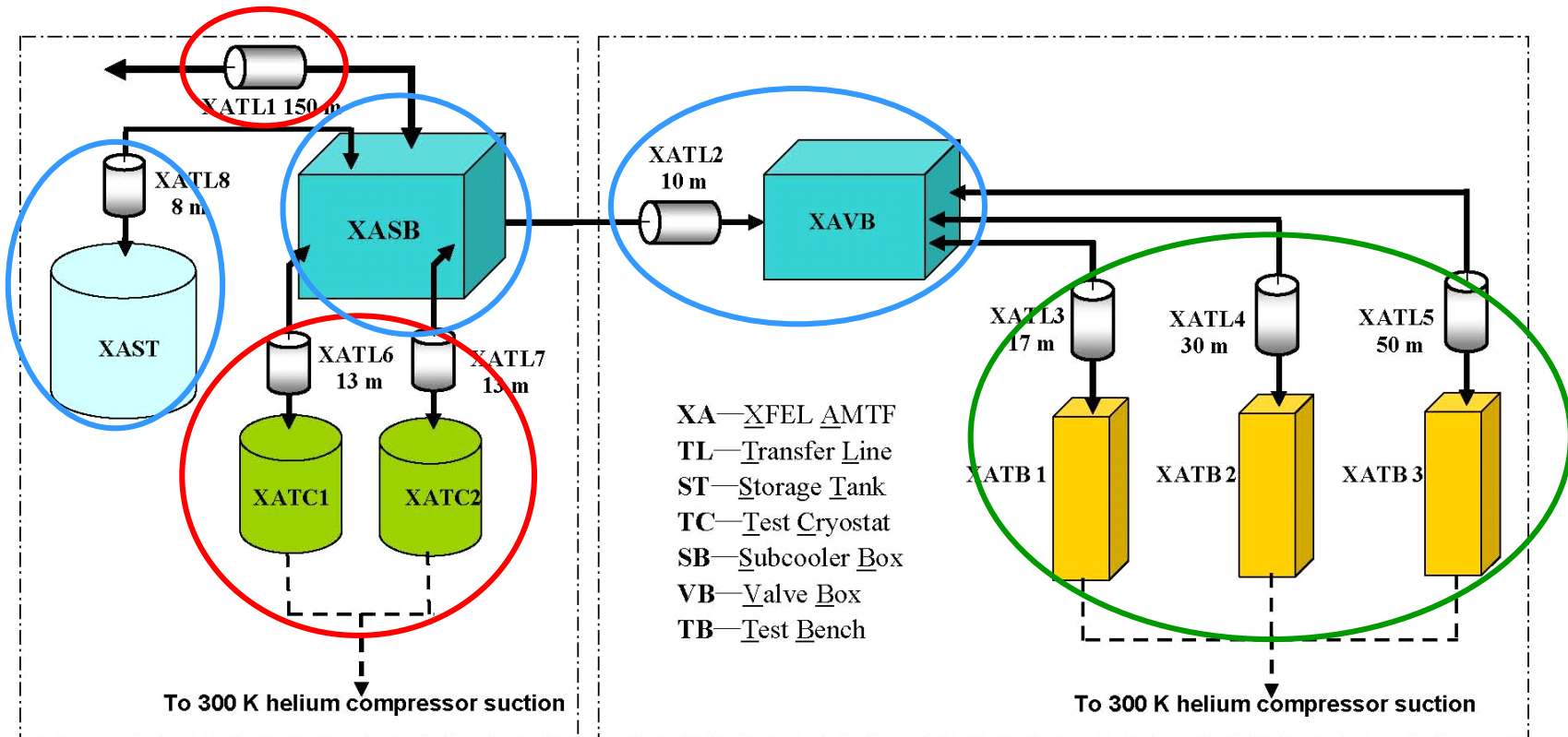
■ Unloading of the cryomodule after transport



■ Cryomodule preparation area



■ XATB – module inside radiation protection shielding



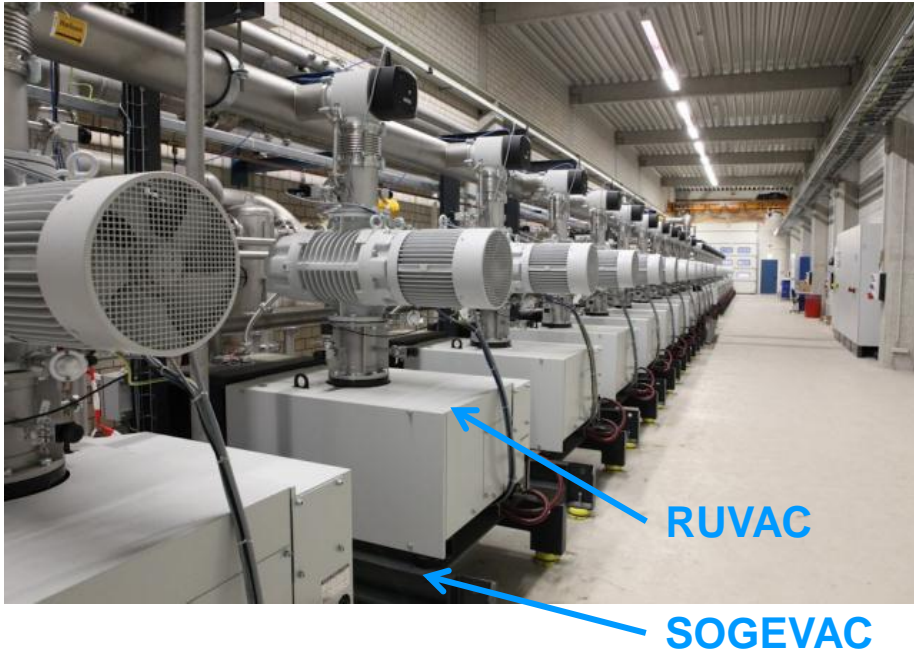
Red = Wroclaw University of Technology+Kriosystem, Poland (in-kind)

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

Green= Budker Institute of Nuclear Physics, Russia (in-kind)

Helium compressors (DESY 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:

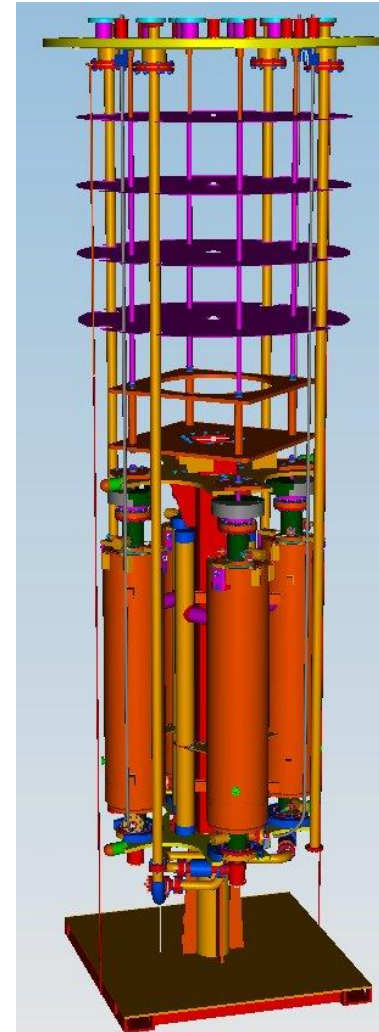
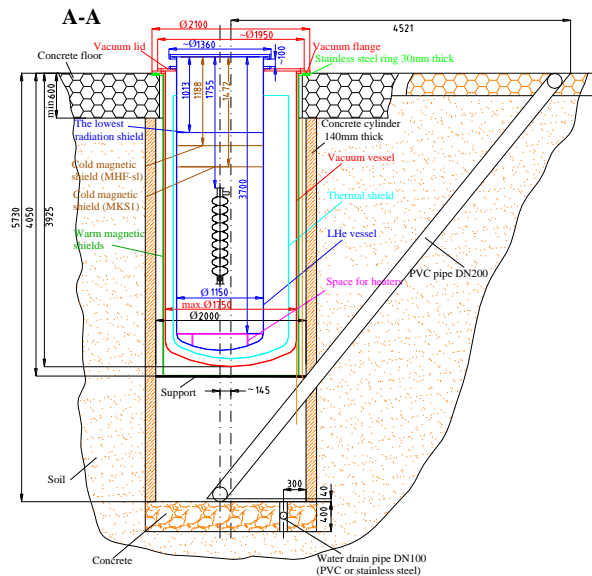
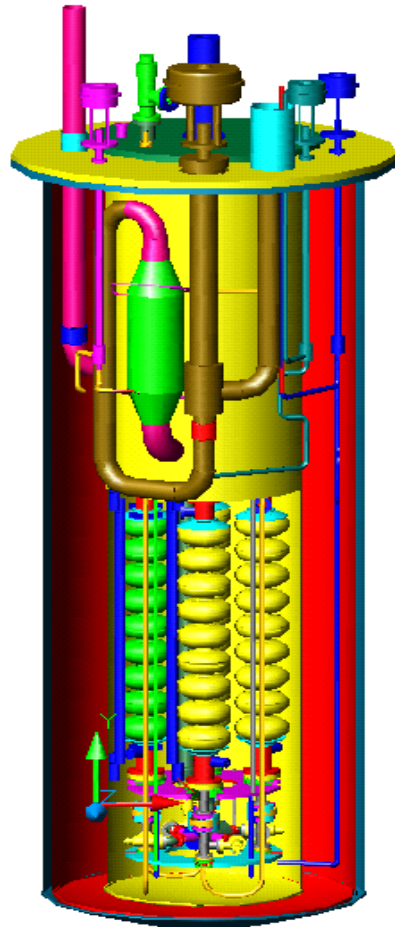
July 2012 – April 2013

Cavity Frame

Design:

DESY FLA

6 inserts for
AMTF

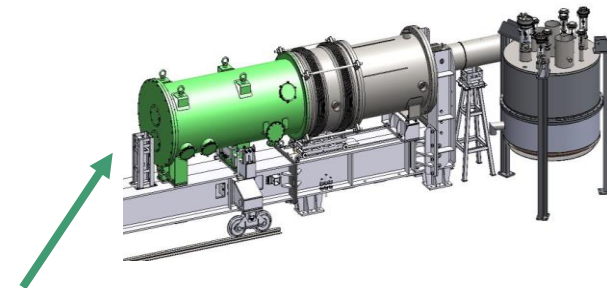
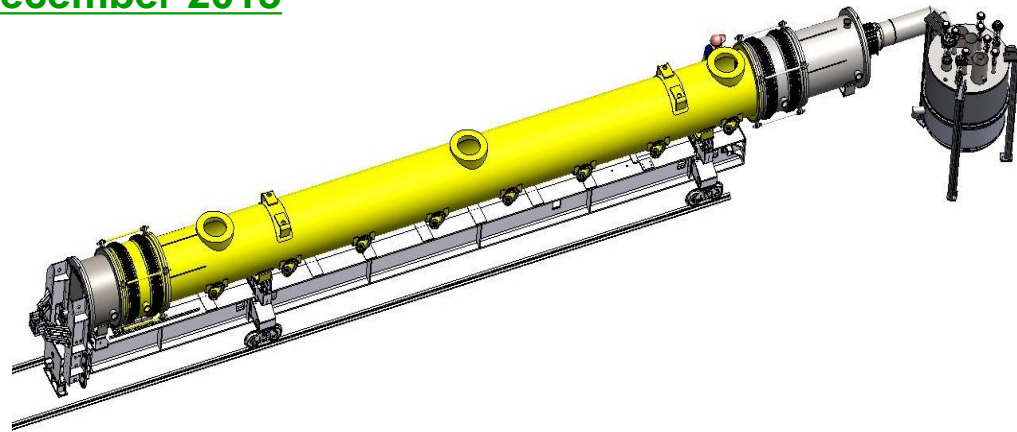


Courtesy of J.Schaffran

Spec DESY (February 2010) Design, Construction, Installation: BINP

First test stand delivered & installed May 2013 (cold commissioning July 2013)

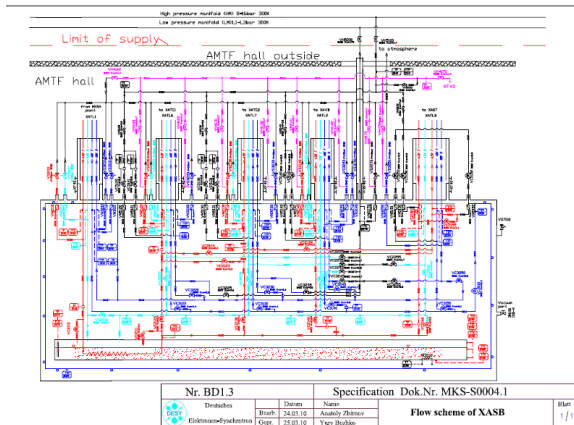
Cold commissioning of 3rd test stand December 2013



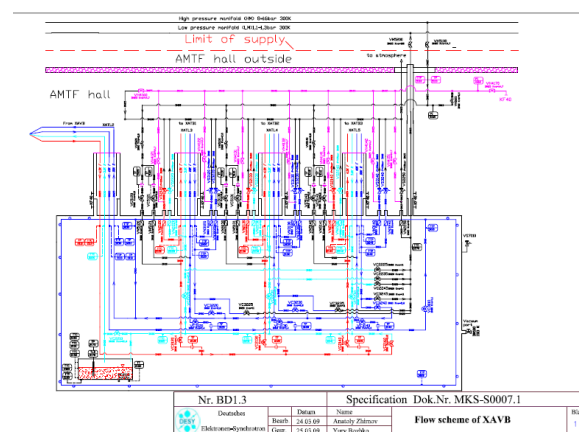
2 cryostat adapters for the test of single dressed cavities at AMTF

DESY is acting for XFEL company
Manufacturer: DeMaCO

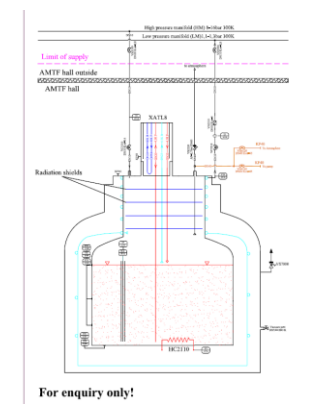
**Wessington
Cryogenics Ltd, UK**



Sub-Cooler Box XASB



Valve Box XAVB



L Helium Dewar XAST

- 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

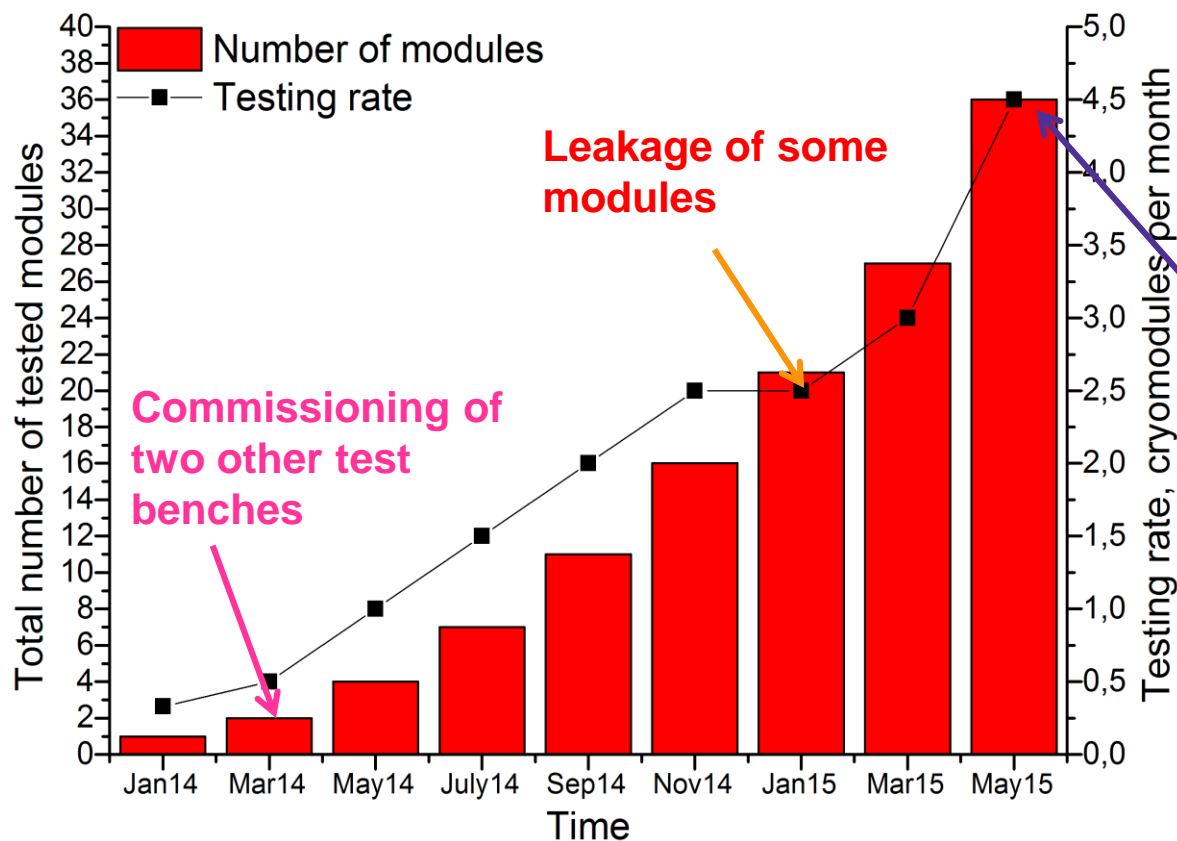
XATB1, XATB2, XATB3

- Manual pump and purge
- Mainly automatically warm-up,
- Cool-down partially in automatic mode

Main Cryo Operation Problems in AMTF

- 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**

Summary of preliminary results (status May 2015)



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 !