Cryogenic System for Turkish Accelerator and Radiation Laboratory in Ankara

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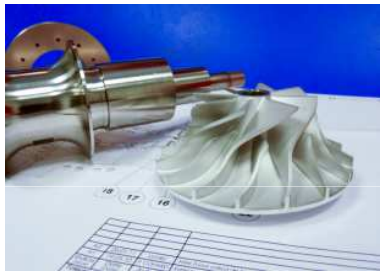
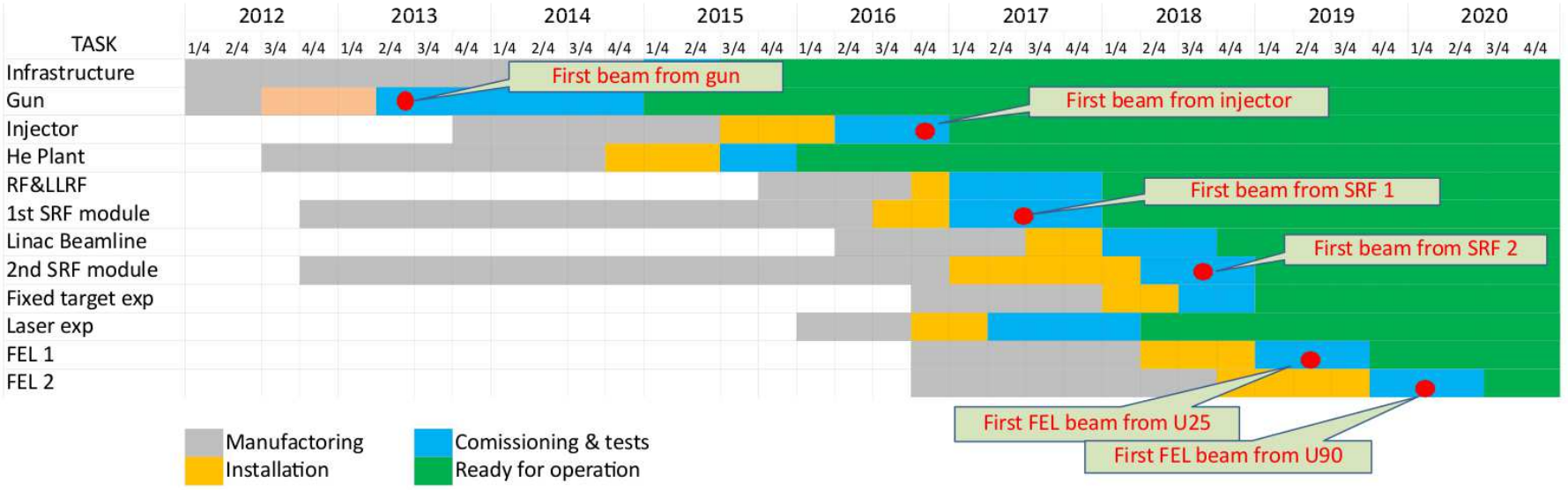


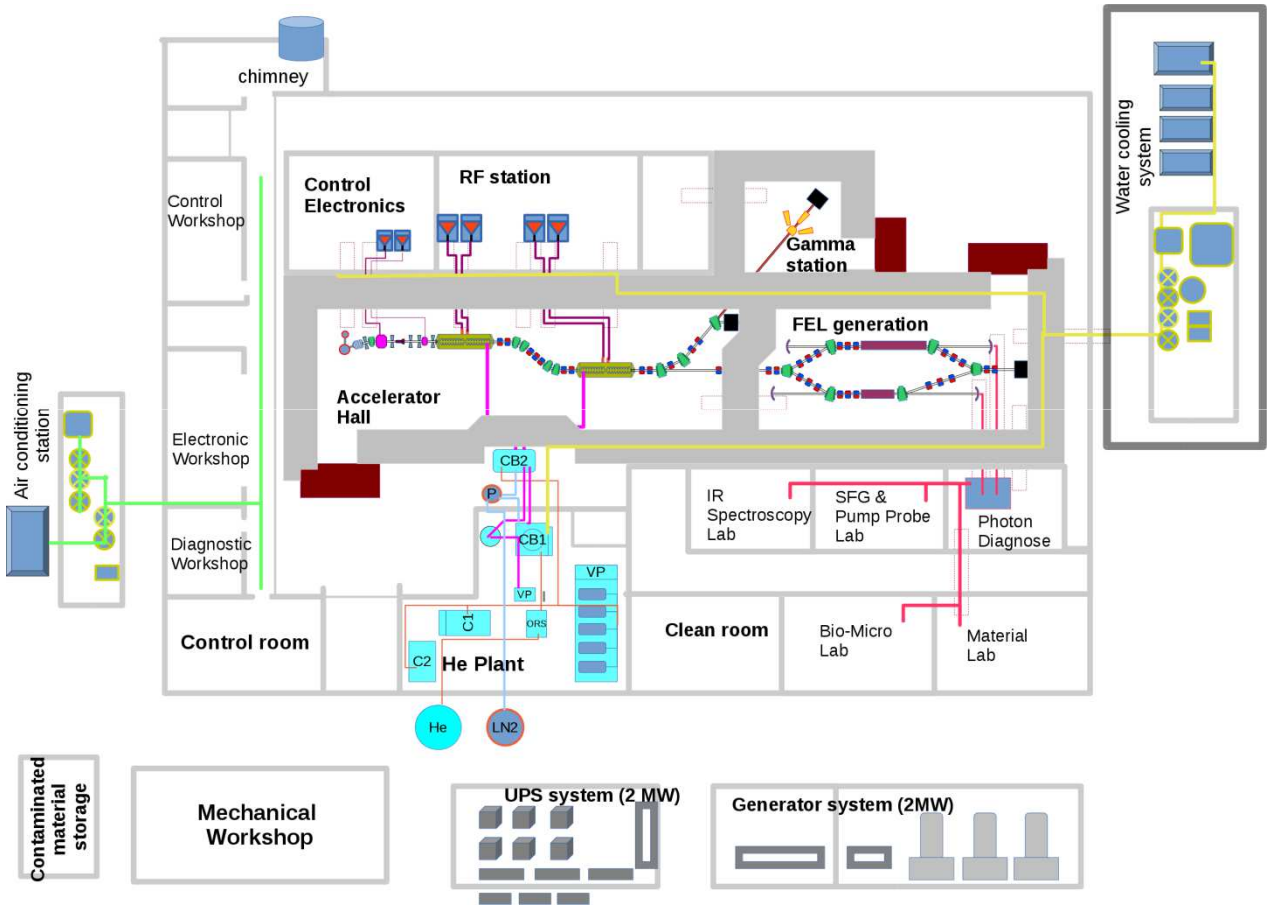
Framework of the project

- TARLA Facility : 1st of the Institute of Accelerator Technologies of Ankara University in Golbasi Campus (15 km south of Ankara)
- Purpose : Drive two FEL covering the range of InfraRed region (3-250 µm)
- FEL : Research in material science, nonlinear optics, semiconductors, biotechnology, medicine and photochemical processes.
- Also Electron beam will be used to generate Bremsstrahlung radiation



TARLA Facility

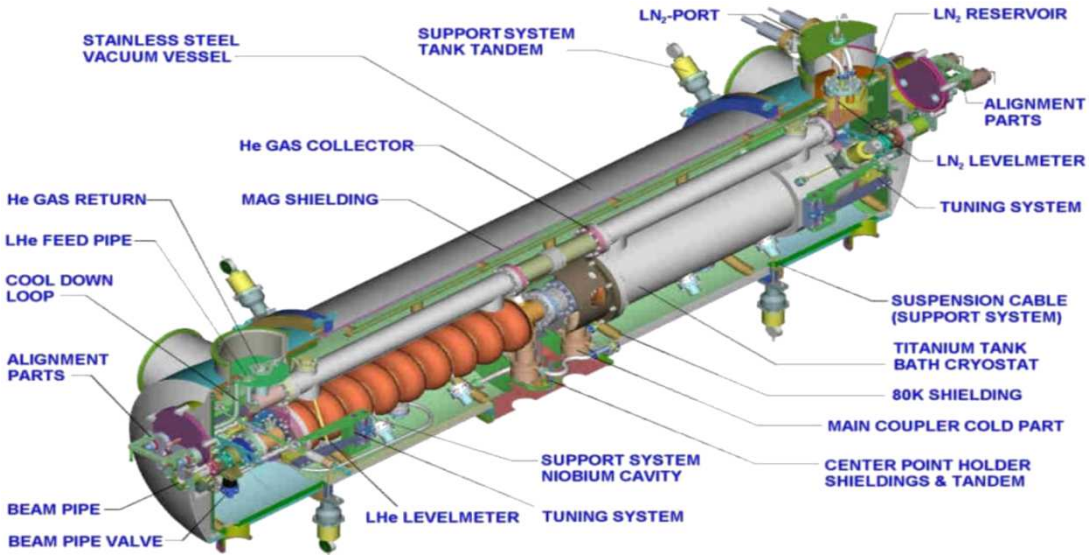
- Electron beamline subdivided in 3 parts :
  - Injector => High current continuous wave 250 kev
  - Main accelerating section => 2 SC accelerating modules (Linac 1&2) to 15-40 Mev
  - Transport lines to 2 independent undulators to generate FEL Radiation
- Cryogenic Area close to main facility but not affected by radiation environment



Cryogenic requirement from TARLA

- 1 CM (supplied by RI) => 2 x 9-cell TESLA Nb cavities (10 MV/m)
- Cryostat and mechanical tuning developed for ELBE project (collab. with Stanford Univ (Forschungszentrum Dresden/Rossendorf))
- Long-term experience and partnership between TAC and Dresden

Parameter	Unit	Cryom. I & II
Dynamic Heat Load (including cont.)	W	80
Static Heat Load (including cont.)	W	15
Operating Temperature (max/min)	K	2.1/1.8
Pressure Stability	mbar	± 0.2
Liquid Level Stability	l LHe	± 2
Inventory	l	60



- **Global solution** => 220W@1.8K
- Controlled cool-down & warm-up
- Stand-by mode 40W@1.8K
- Liquefaction capacity with LN_2

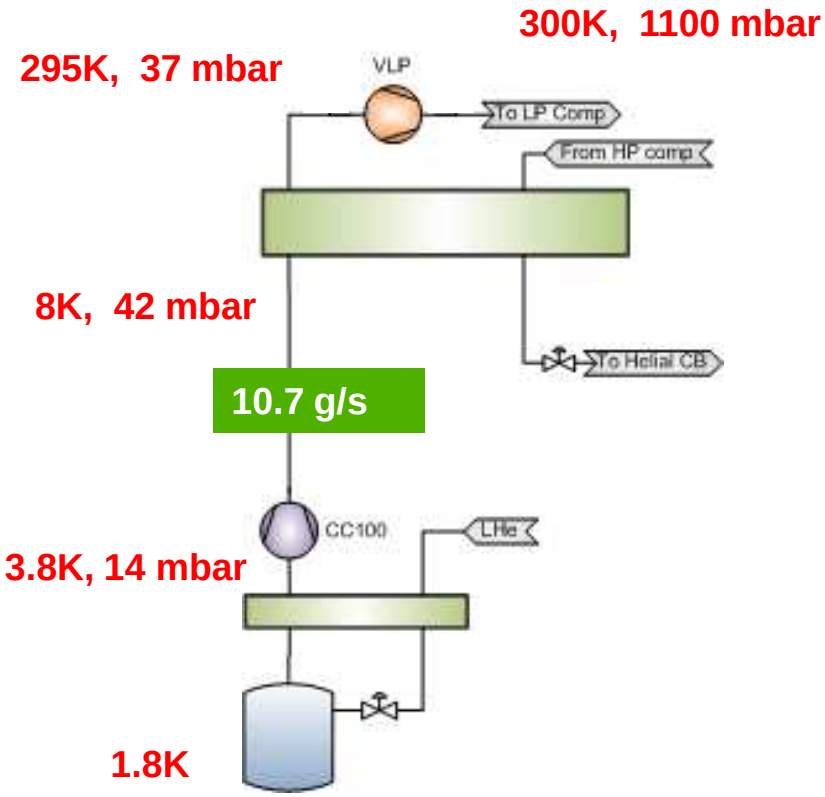
The cryogenic system designed by ALAT

- A standard Helium Refrigerator : HELIAL MF
  - Delivering Helium@4.5K in a standard Dewar
  - Equipped with 2 Turbo-Expanders in series
  - Cool-down circuit for SC module
  - 2 screw compressors (80g/s) in parallel with standard ORS

- A 2K secondary Cold Box equipped with :
  - Cold Compressor
  - Coiled VLP Heat exchanger 8K-300K
  - Plate-Fin Heat Exchanger 2-4K
  - LN_2 shield
  - Helium guard

- A vacuum pump group (Oerlikon-Leybold 5*[WS2001FU/SV750BF])

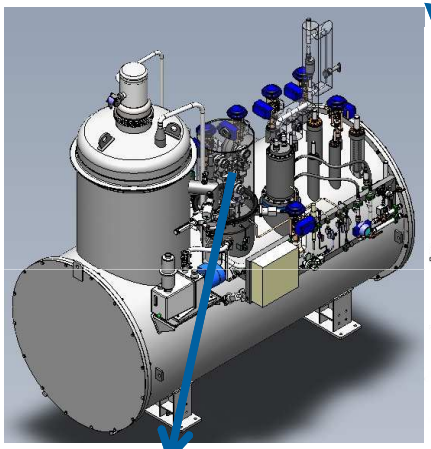
- Multi-channel transfer lines (ALAT manufacturing) from 2K VB to CMs (LN_2 shield)



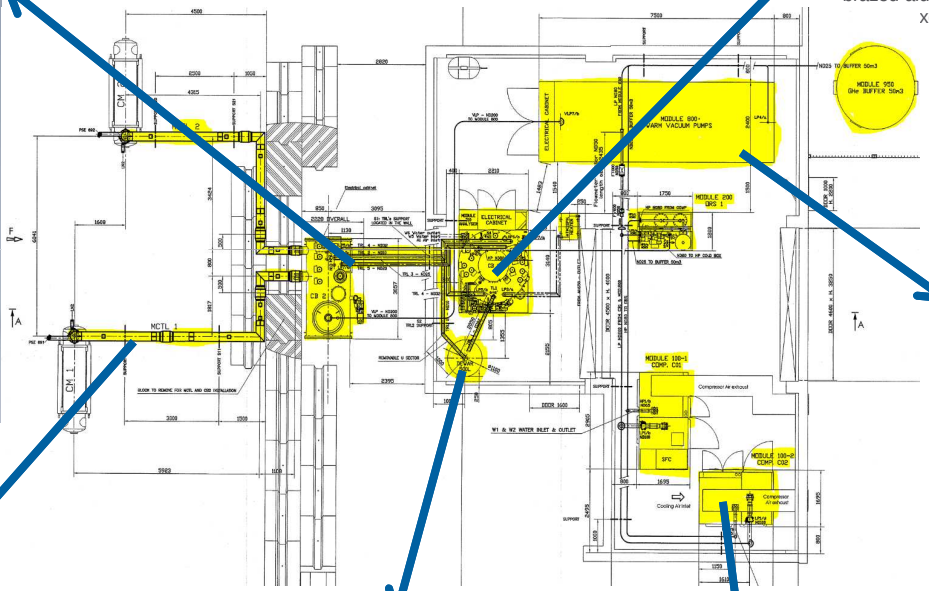
TARLA - The He Refrigerator for the Turkish Accelerator and Radiation Laboratory

3 Cold Box 2

Purpose: Subcool Helium from 4,5K@1,01 bar to 1,8K@16 mbar to feed customer SRF modules.
Features & design:
- ALAT in-house Cold compressor
- Coil heat exchanger with only 3mbar of pressure drop
- Stainless steel tube heat exchanger 4,5 to 1,8K
- Thermally shielded with liquid nitrogen at 80K

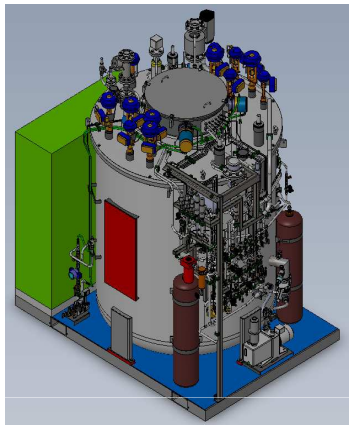


20m



2 Refrigerator Cold Box (CB1)

Purpose: Supply liquid Helium at 4,5K and 1,01 bar
Features &design:
- HELIAL MF with 2 ALAT 's C3 gas bearing turbines and a brazed aluminum Plate xchanger

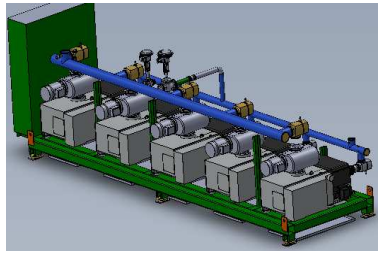


5 Cold Compressor

Purpose: Compress cold gas return from 16mbar to 37mbar.
Features & design:
~40 000 tr/min ; 10g/s
Magnetic bearings

6 Warm vacuum group

Purpose: Compress gas return from cold compressor outlet to atmospheric pressure to feed cycle compressors.



Features &design:
-5 oil lubricated pumping groups in parallel (rotary vane + roots) to cope with 10,7g/s

4 Multi Cryogenic Transfer Lines (MCTL)

-Purpose: Transfer liquid Helium at 1,8K@16mbar for SRF modules feed and gas return from the modules to the CB2.
Features & design:
- 2x 9 m long each thermally shielded multi-lines
- Limited heat leaks and pressure drop

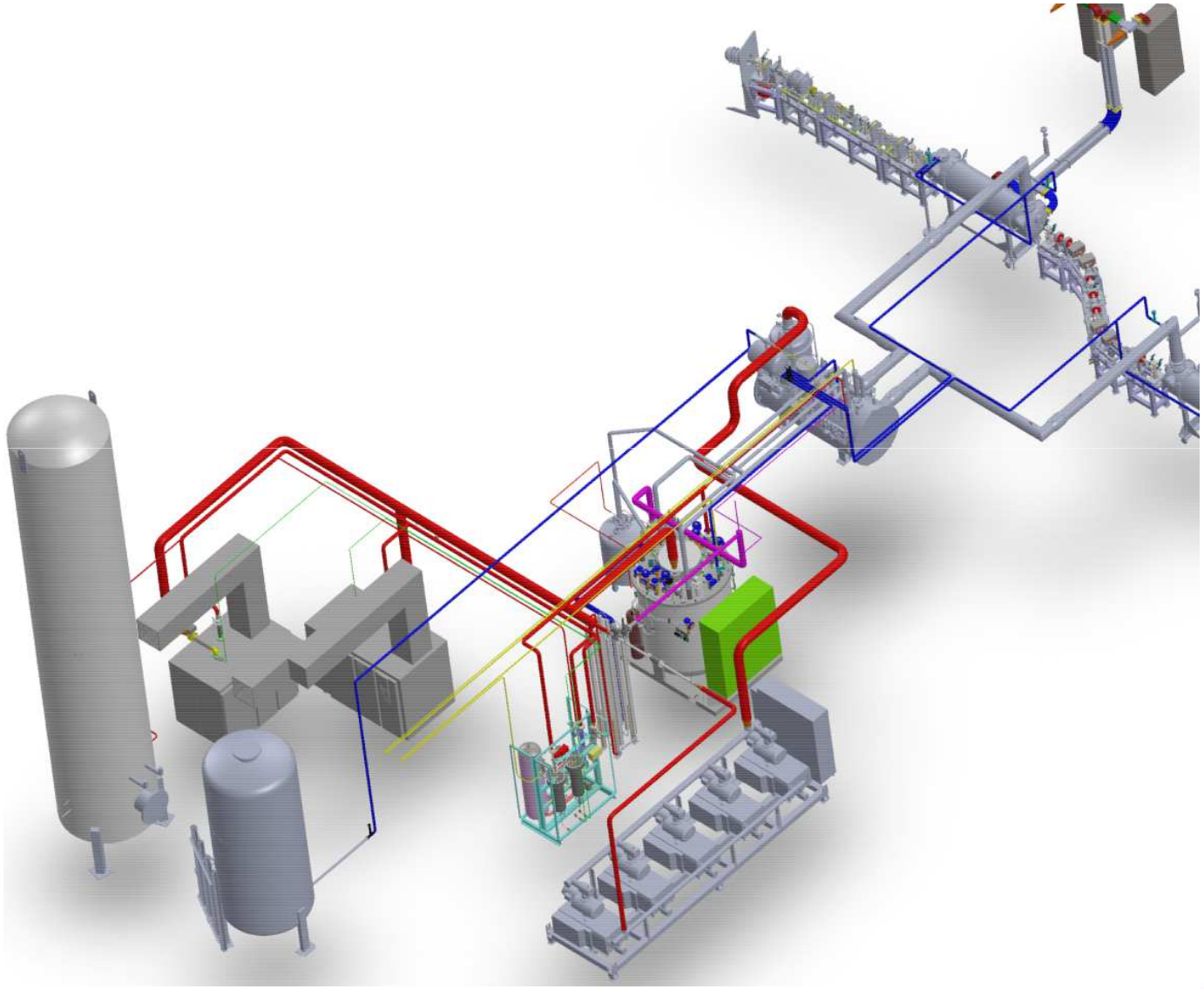
Liquid and gaseous Helium Storages

Purpose: Delivered compressed oil free Helium to the refrigerator Cold box.
Features&design:
- 500l Liquid Helium Dewar 1,01bar@4,5K
- 50m^3 gaseous Helium buffer 20bar @ ambient T

1 Cycle compressors

Purpose: Deliver compressed oil-free Helium to the refrigerator Cold box.
Features&design:
- 2x 50% oil lubricated screw compressors (DSD238) delivering 40g/s@14,5bar
- Standard Oil removal system (ORS2000)

Lay-out of the cryogenic system



Some pictures

Cold compressor solution

- Long experience and internal know-how at AL.aT in Cryogenic machines
  - Turbo-expanders for He (Low T applications) and other industrial applications
  - Cold compressors (more than 40 references), for example :
    - JLAB
    - CEA
    - CERN

Standard, long lifetime, reliable, easy-to-maintain cryogenic rotating machines with large frame of operation and common design philosophy (Cold Compressor & Circulator)

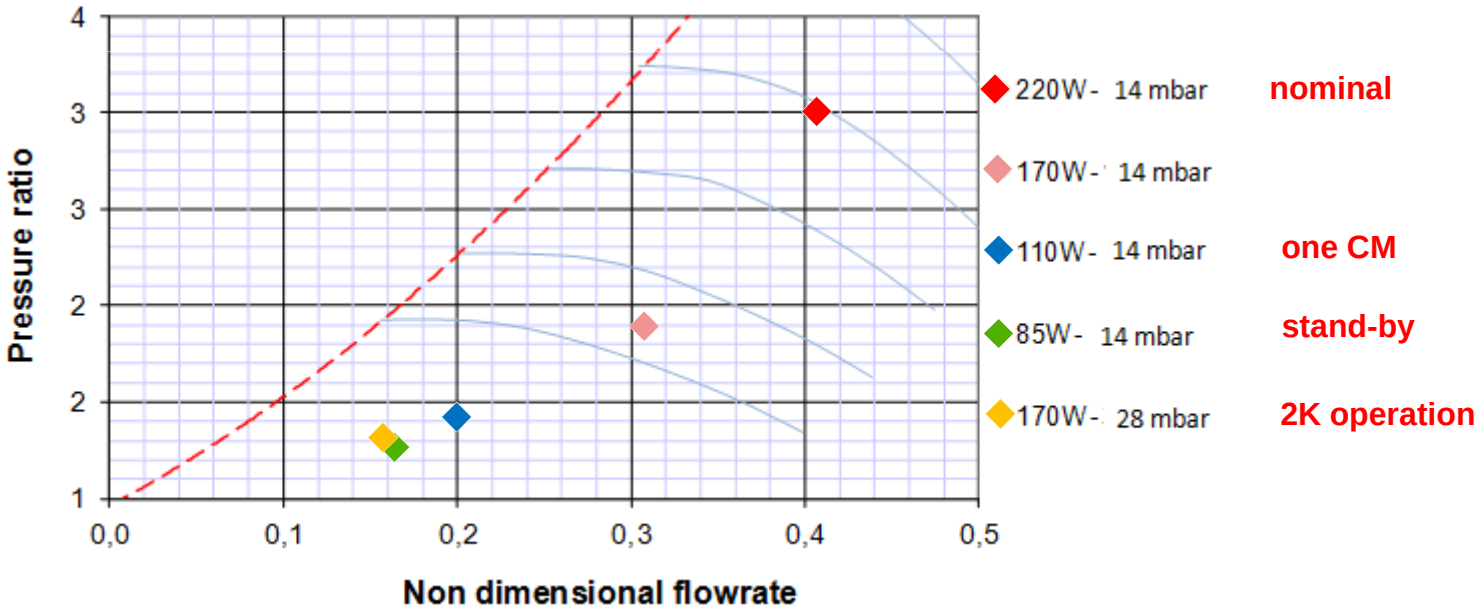
- Cold compressor main features
  - **Standard** 13kW motor cartridge
    - 13kW@55000 rpm high speed synchronous motor
    - Five axis active magnetic bearings
    - 40 bar housing
  - **Standard** electrical cabinet
  - **Customised** parts : impeller and cryogenic shaft extension, scroll, diffuser and casing
  - For details please refer to poster C3PoE-01 (tomorrow 9-11 A.M.): ***Air Liquide latest developments of turbomachines : from design to commissioning (Cécile GONDRAND)***

Operation of cold compressor for TARLA

- Control strategy :
  - Vacuum pump group at full capacity
  - Cold compressor adapting rotation speed to control upstream pressure
  - System will be fully adapted to real heat loads and can be slowed-down to stand-by mode

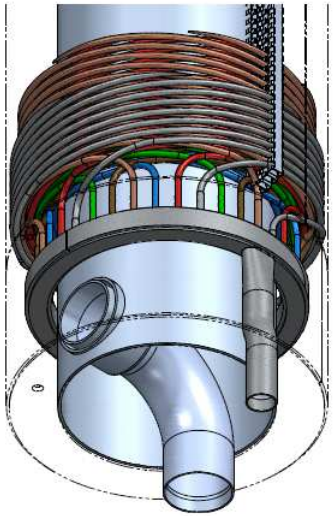
Nominal = 14 mbar, 3.7K, 10.5 g/s

- Operating points reachable with the designed machine: Flexibility



Lessons learnt during project

- Use of standard systems => Cost and Risk management
- Feedback from users
  - Rosendorf meeting with TAC-ELBE-R.I.-ALAT => Information on real operation at ELBE accelerator : cool-down phase, impurity management, control loops
  - Visit at CEA-Grenoble of 400W@1.8K test station
- 2K Process design
  - Flexibility of operation with combination of cold compressor and vacuum group
  - Sensitivity study to evaluate impact of component discrepancy : Vacuum pump can mitigate
- Manufacturing : VLP Coil heat exchanger : recover a strong experience for next projects
- Careful follow-up of vacuum pump manufacturer from specification to final tests : tightness, oil temperature, performance & good feedback from current projects (Neurospin & DESY)



Conclusion

- TARLA : 1st major Particle accelerator project in Turkey
- Air Liquide has developed a global solution based on standard modules :
  - Refrigeration system : HELIAL MF
  - Vacuum pump groups
  - Cold compression standard machine
- Standard solution for cold compression and circulation, first of a series : JT60, RAL, …
- All equipment delivered as expected during spring 2015
- Start-up programmed this autumn in Ankara

Thank you for your attention

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