ESS Target Moderator Cryogenic Plant.

Process Design.

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EUROPEAN SPALLATION SOURCE

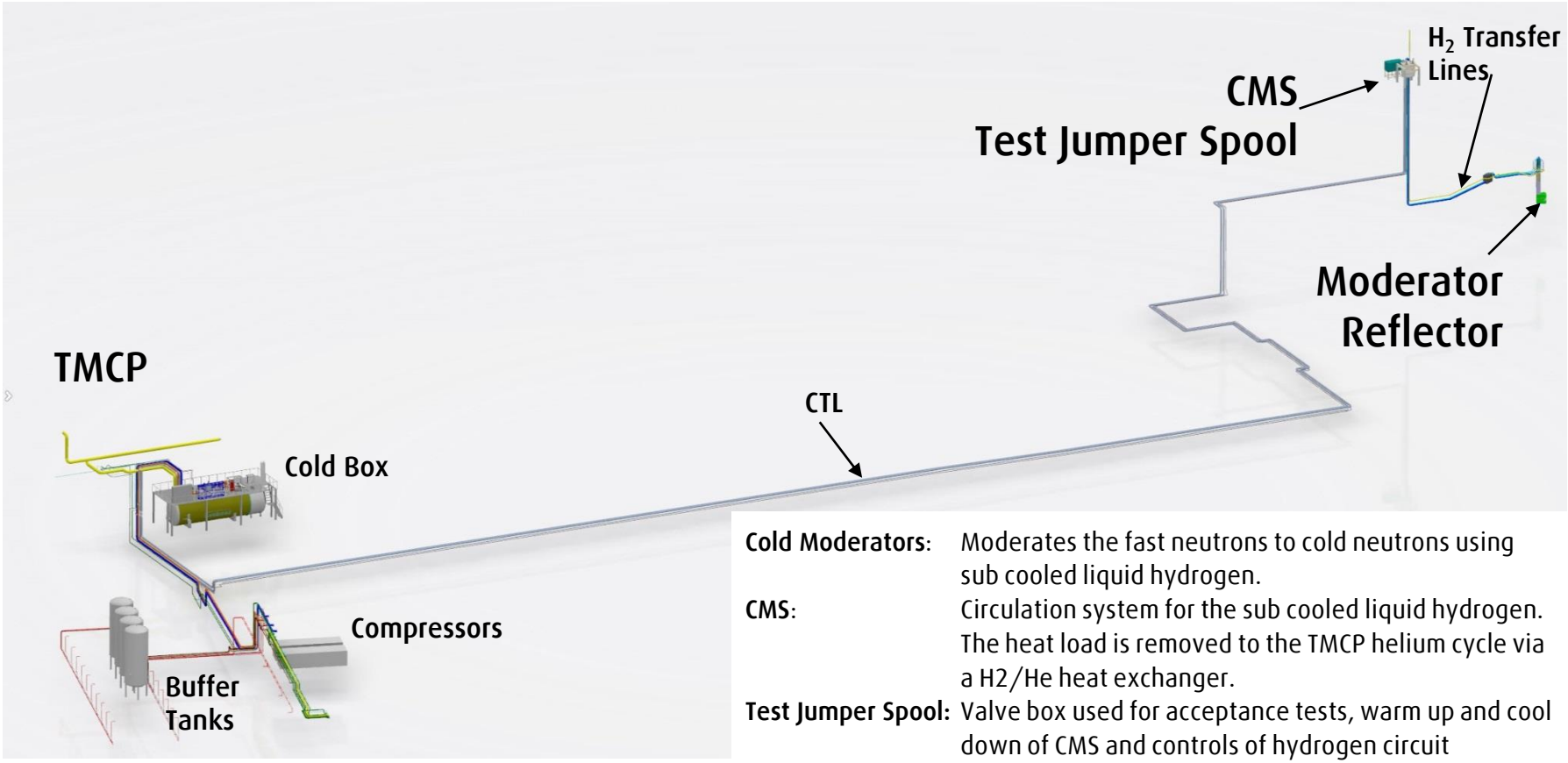
THE LINDE GROUP

Contents.

ESS Overview.

Photo courtesy of ESS

ESS Overview.



Cold Moderators: Moderates the fast neutrons to cold neutrons using sub cooled liquid hydrogen.

CMS: Circulation system for the sub cooled liquid hydrogen. The heat load is removed to the TMCP helium cycle via a H2/He heat exchanger.

Test Jumper Spool: Valve box used for acceptance tests, warm up and cool down of CMS and controls of hydrogen circuit

CTL: Cryogenic Transfer Line: Connection from TMCP to Test Jumper Spool

TMCP: Target Moderator Cryoplant: Helium cycle that cools hydrogen circuit

ESS Overview.

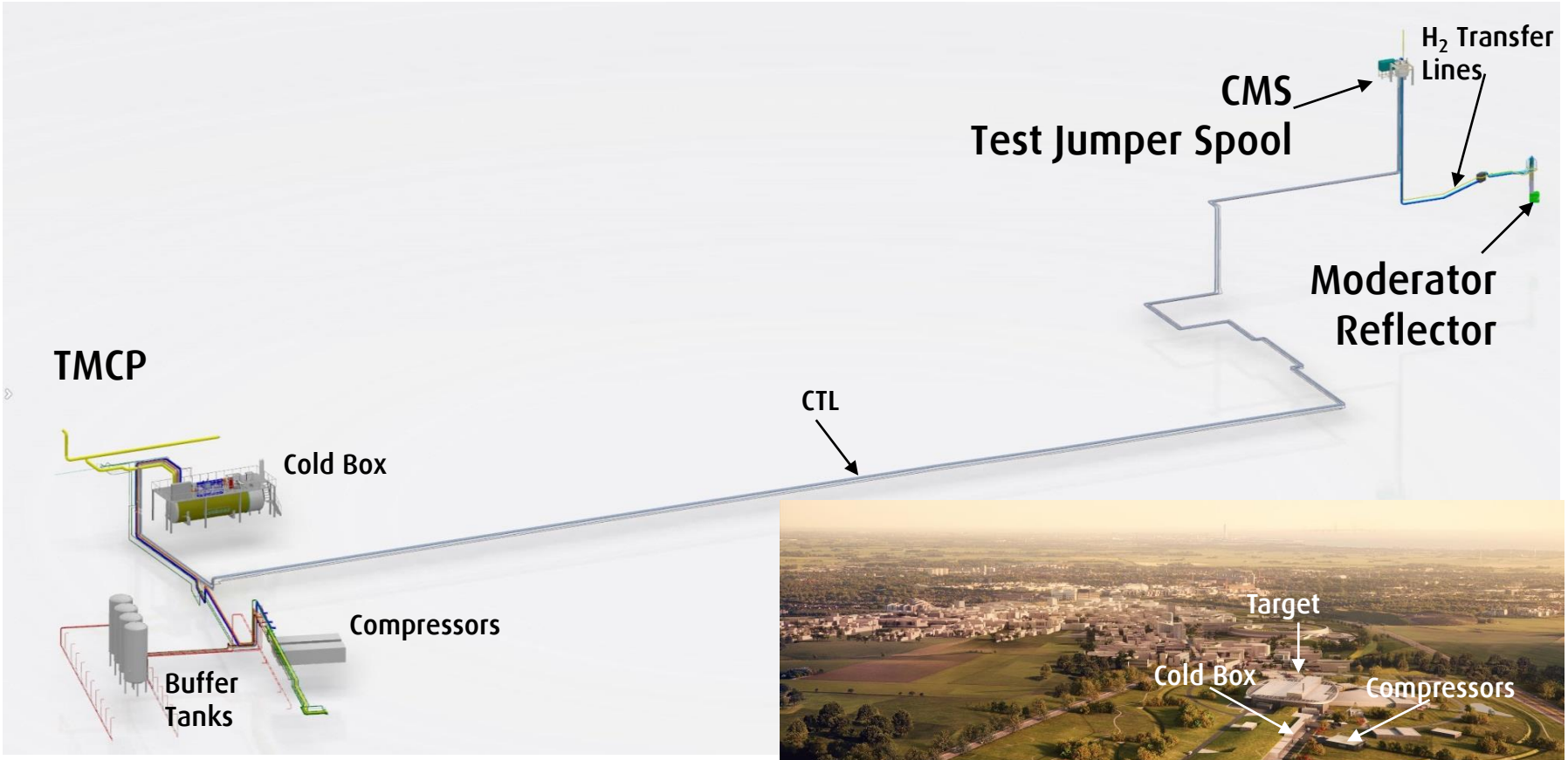


Photo courtesy of ESS

TMCP Requirements.

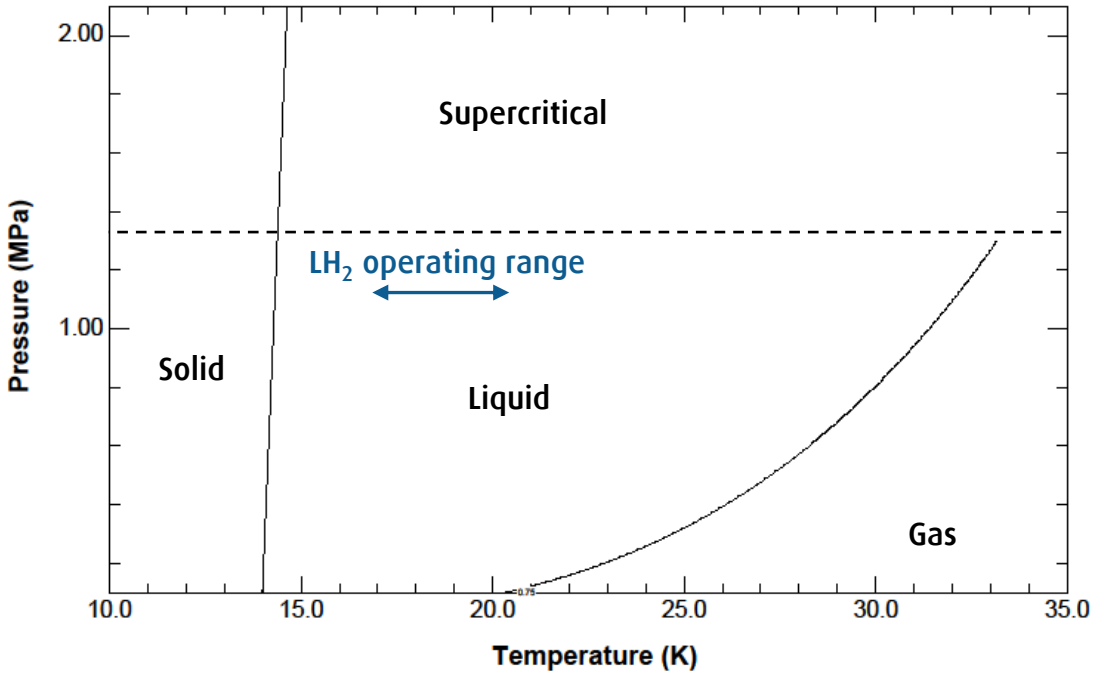
Operation mode	Heat load [W]	Supply temp. [K]	Return temp. [K]
Nominal design maximum	30300	≥15	≤20
Nominal design minimum	14900	≥15	≤20
Nominal low power maximum	8300	≥15	≤20
Nominal low power minimum	5400	≥15	≤20
Nominal turndown	4900	≥15	≤20
Minimal turndown	2300	≥15	≤20

- World's largest refrigerator of its kind!
- Exceptional high turndown ratio > 13 (max. capacity / min. capacity)
- Large heat load and narrow temperature range of hydrogen circuit lead to a high helium mass flow (>1000 g/s at maximum load)

TMCP Requirements.

Narrow operating range for hydrogen: 17 K – 20.5 K

Lowest allowed hydrogen temperature given by solidification line

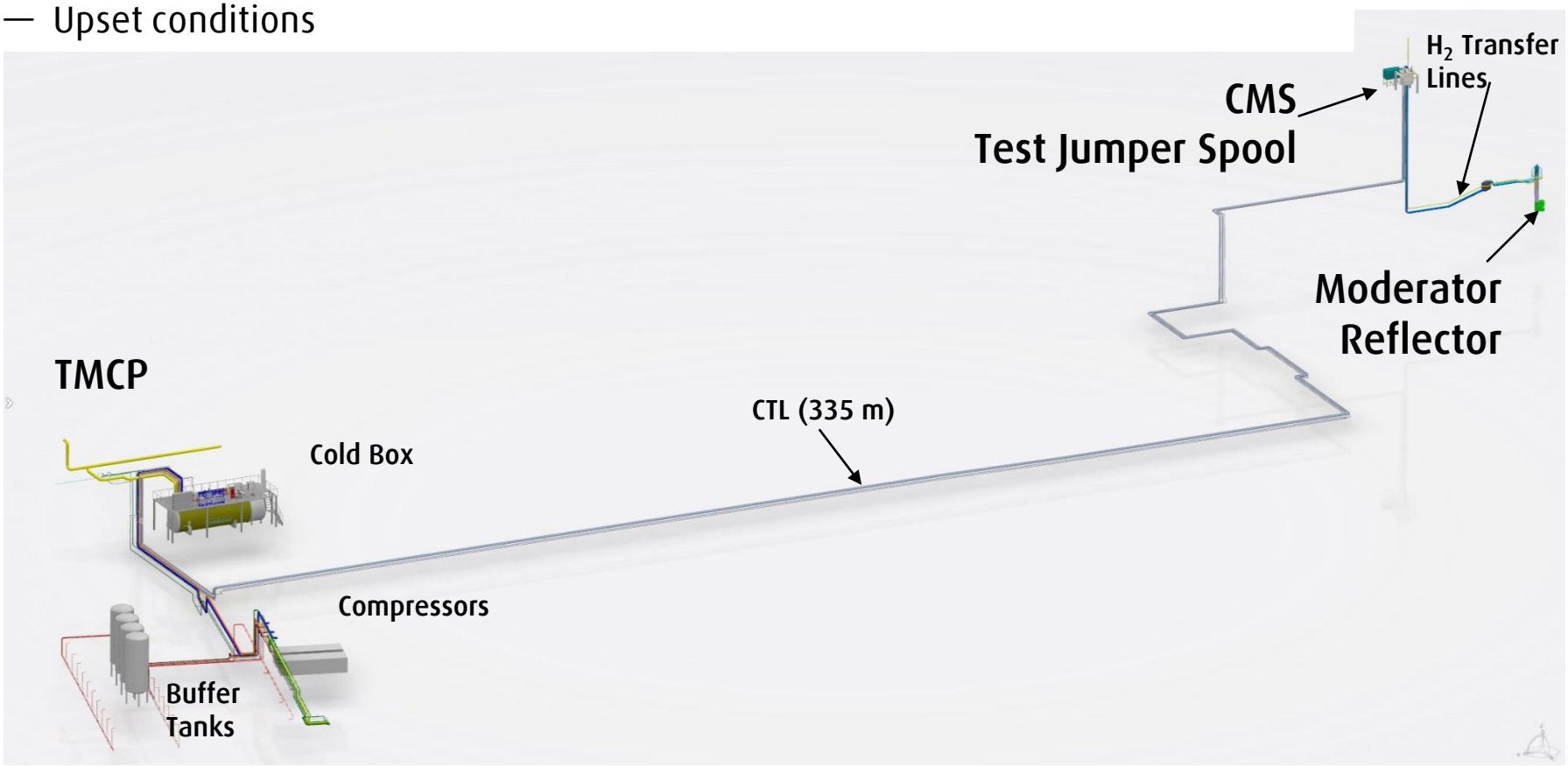


TMCP Requirements.

Large helium inventory (221 kg) in CTL has to be handled carefully in

— Loading and unloading processes

— Upset conditions



TMCP Requirements.

Unsteady operation modes

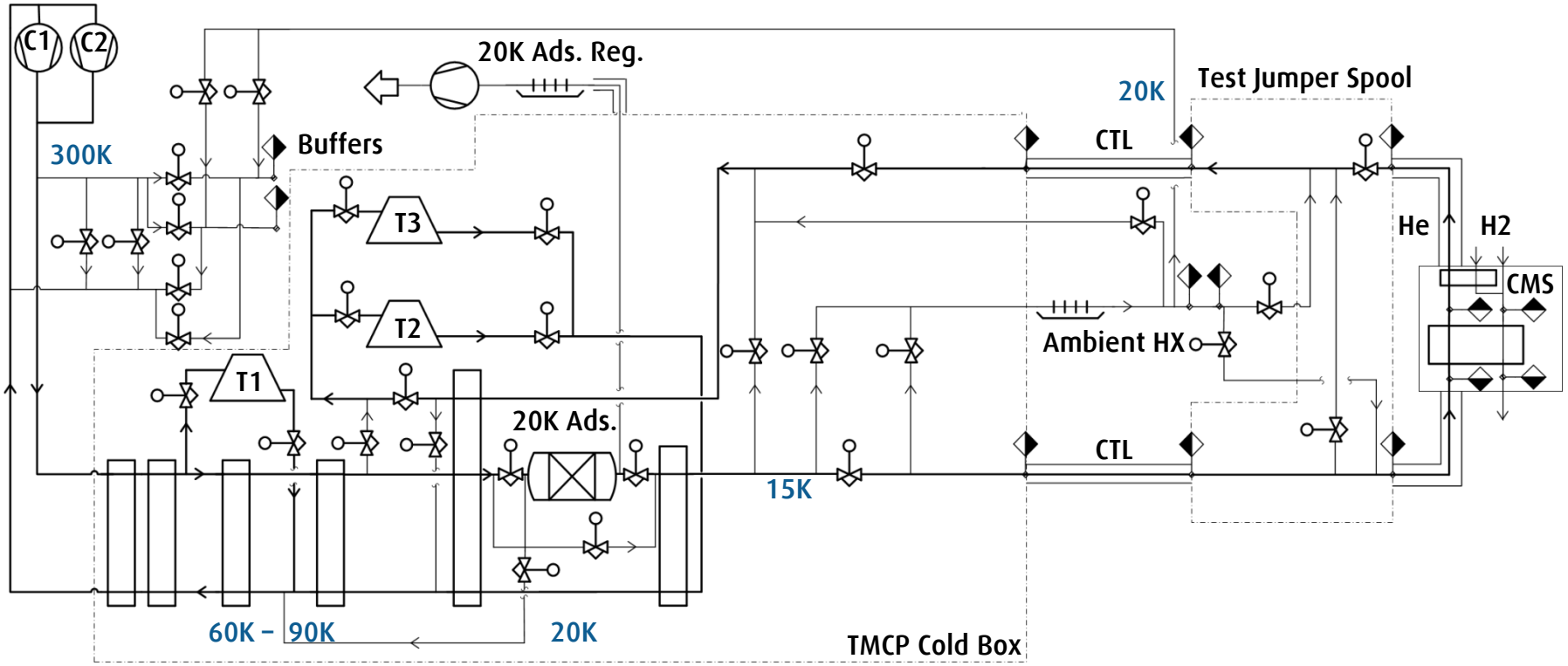
- Slow switching modes (refrigeration capacity is ramped up/ down)
  - Long term switch

- Fast switching modes (constant refrigeration capacity)
  - Short term switch
  - Beam trip

- Transient operation modes
  - Warm up
  - Cool down

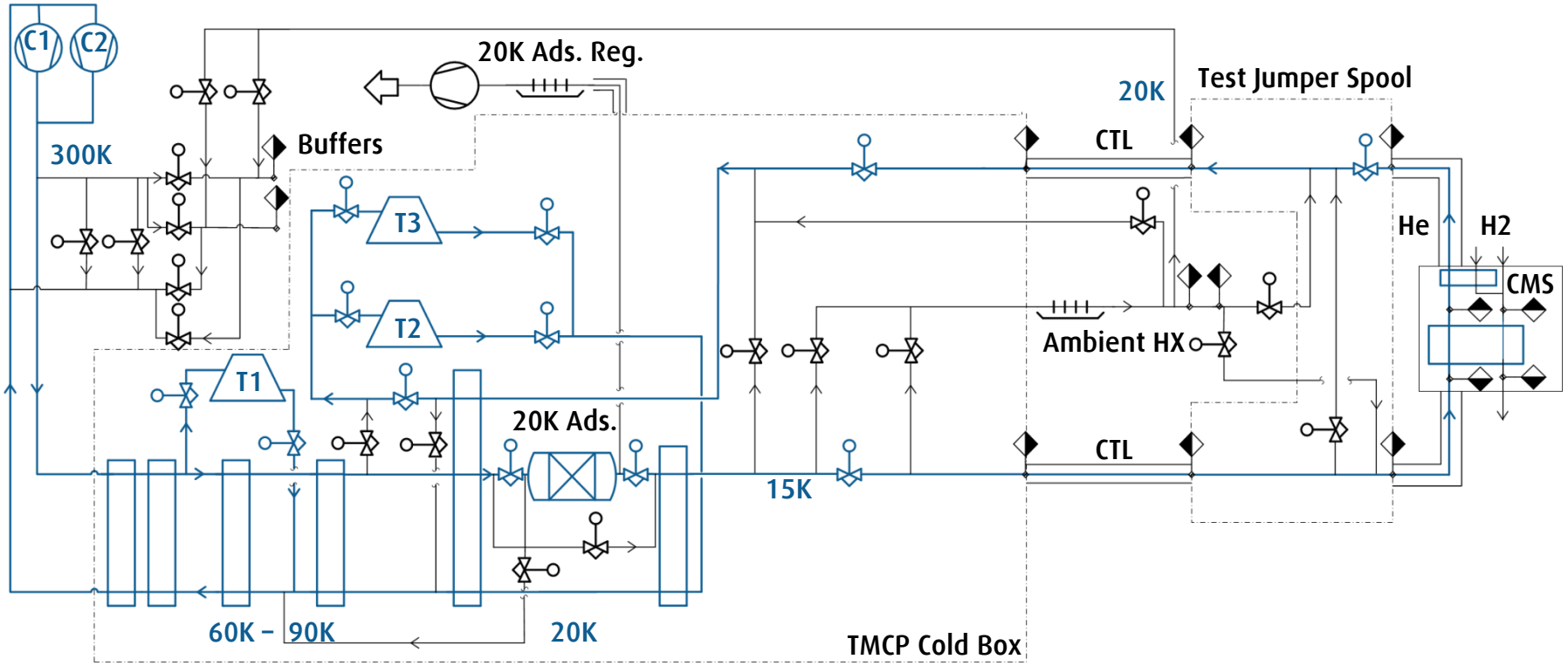
Process Design.

PFD Process Flow Diagram



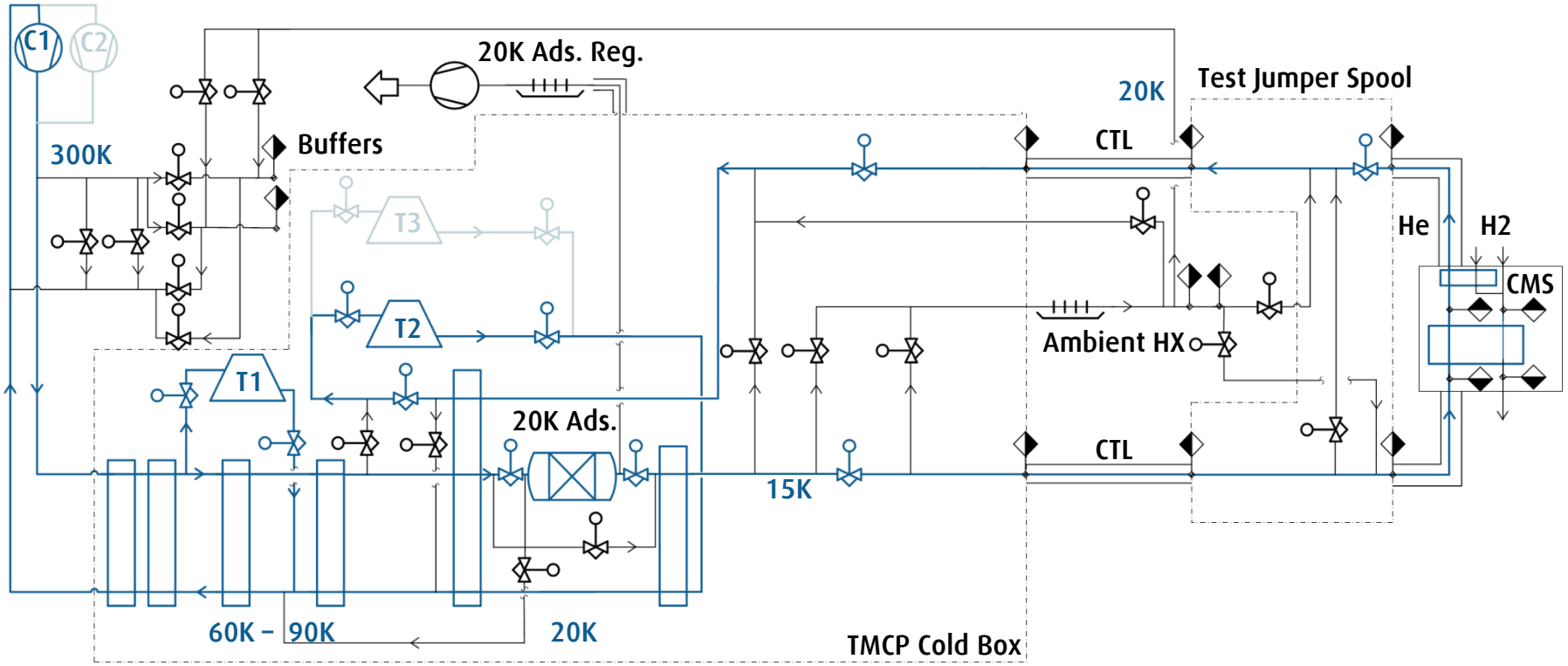
Process Design.

Operating modes: nominal design maximum (30300W)



Process Design.

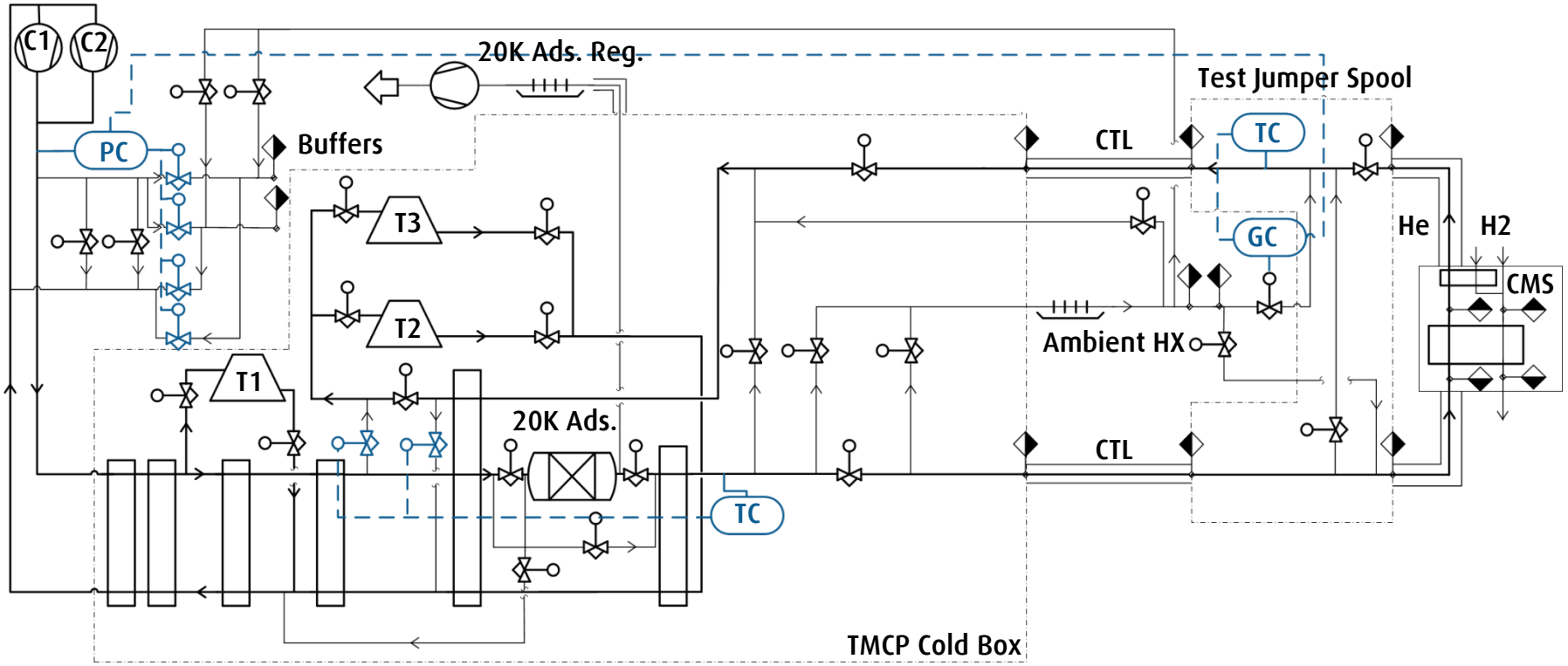
Operating modes: nominal turndown (4900W)



– Switch-off of some machines and decreased pressure

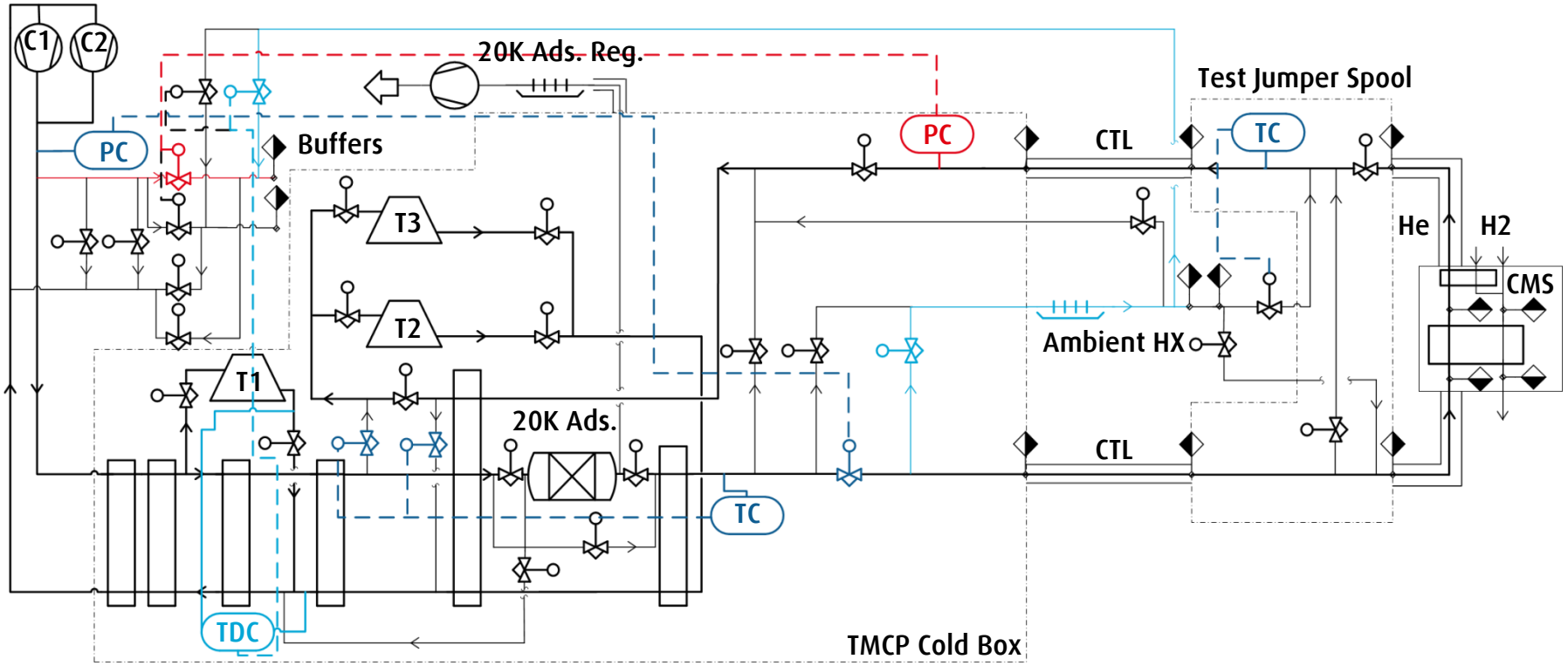
Process Design.

Temperature and pressure control



Process Design.

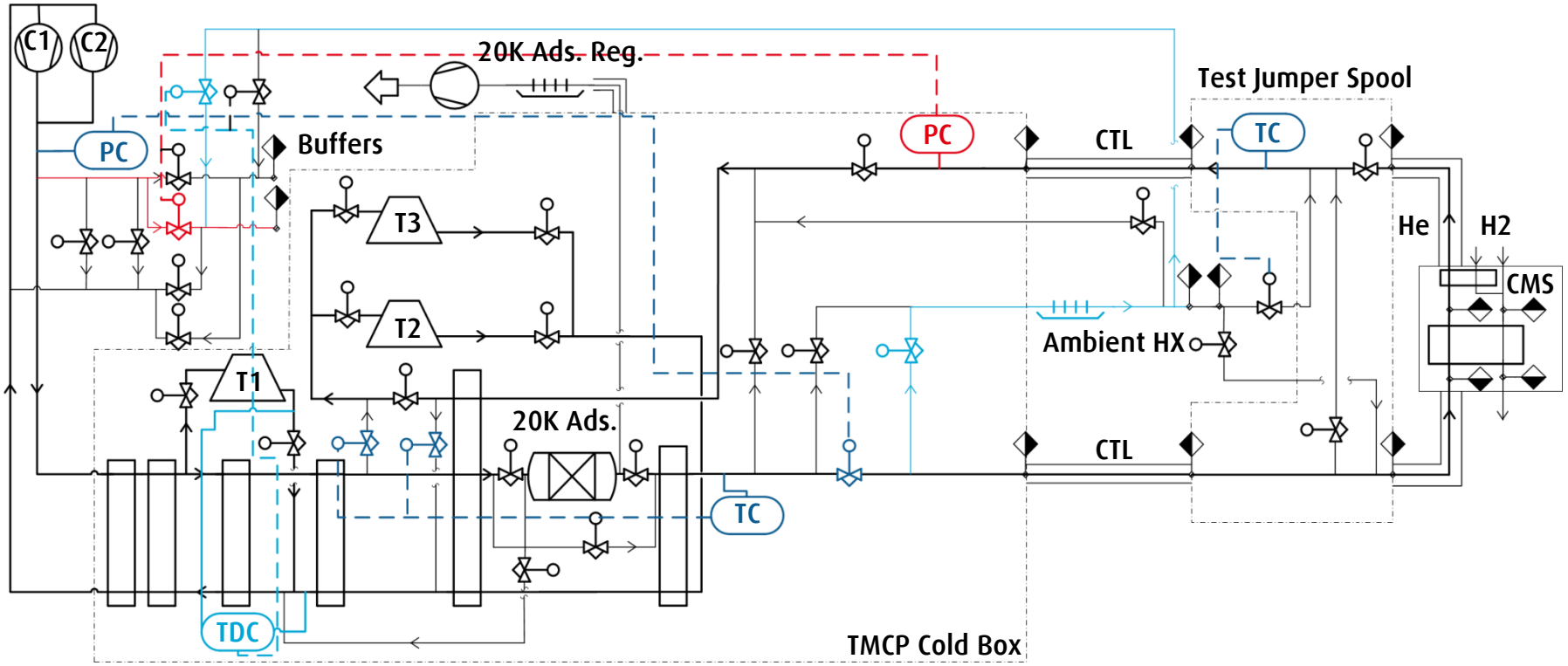
CTL unloading



– CTL unloading first to HP buffer

Process Design.

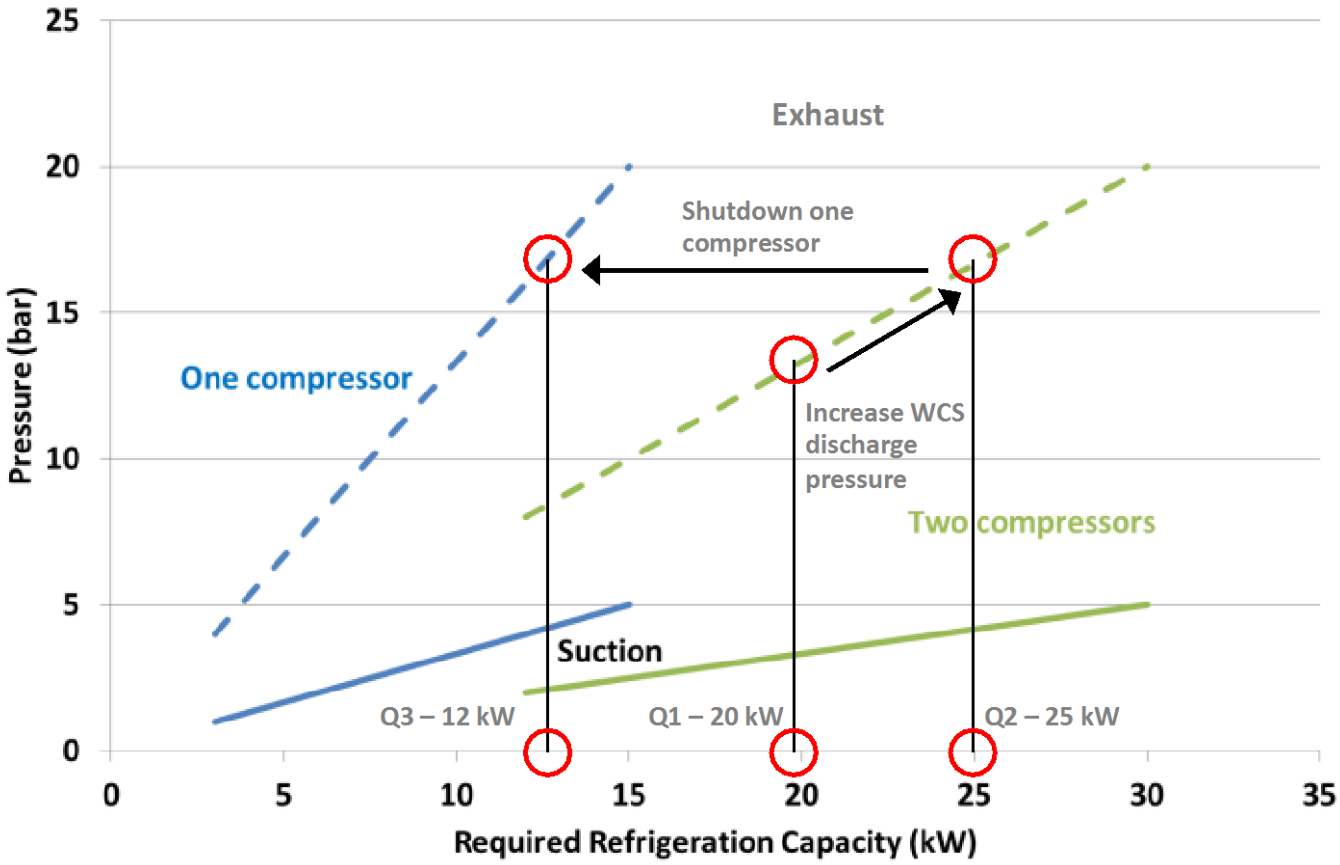
CTL unloading



– CTL unloading then to LP buffer

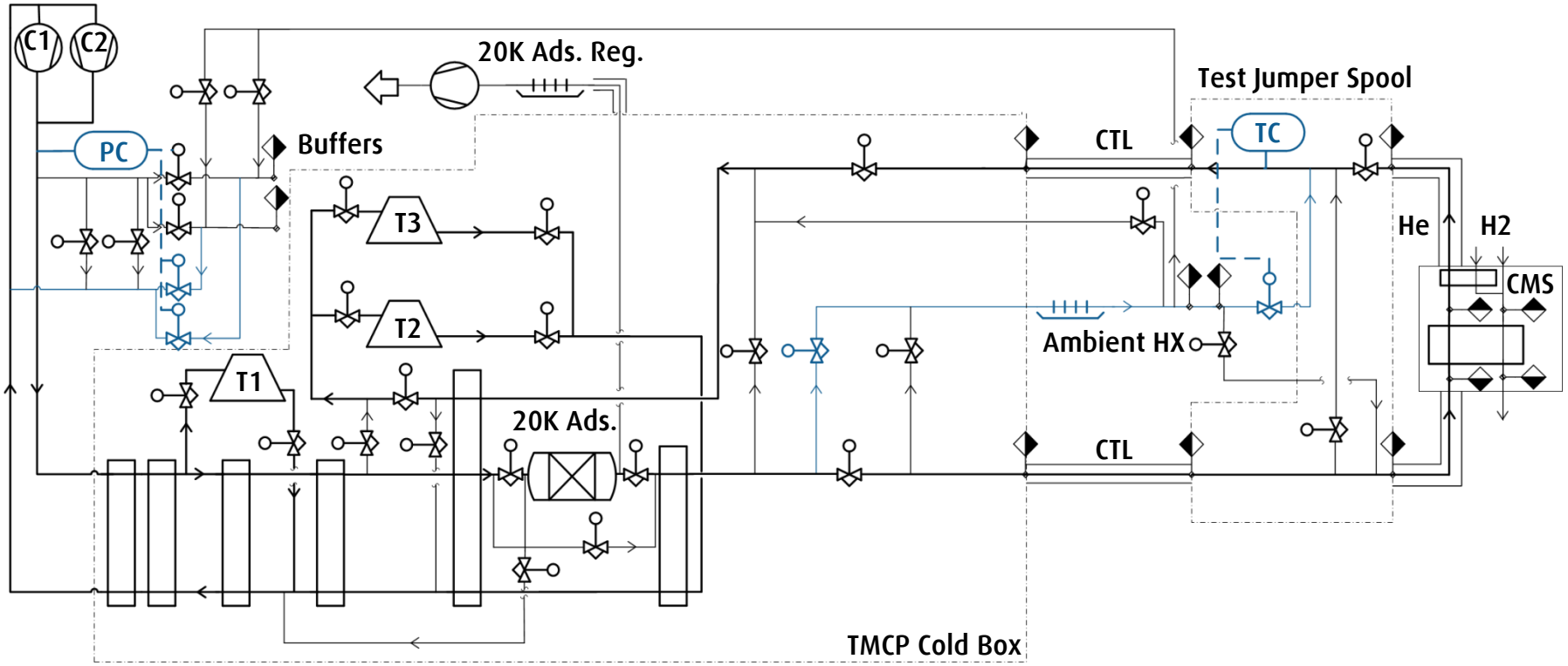
Process Design.

Unsteady operation modes: slow switching modes



Process Design.

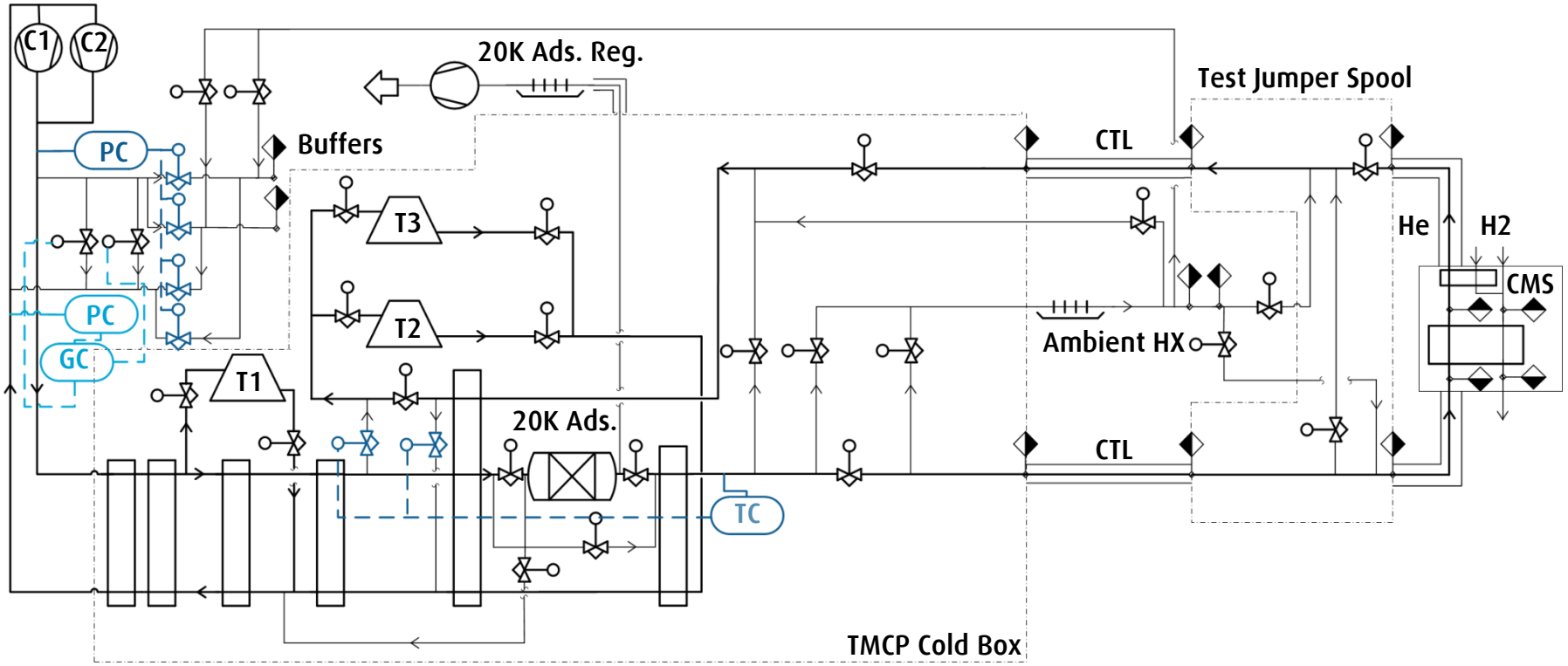
Unsteady operation modes: slow switching modes



– HP pressure increase

Process Design.

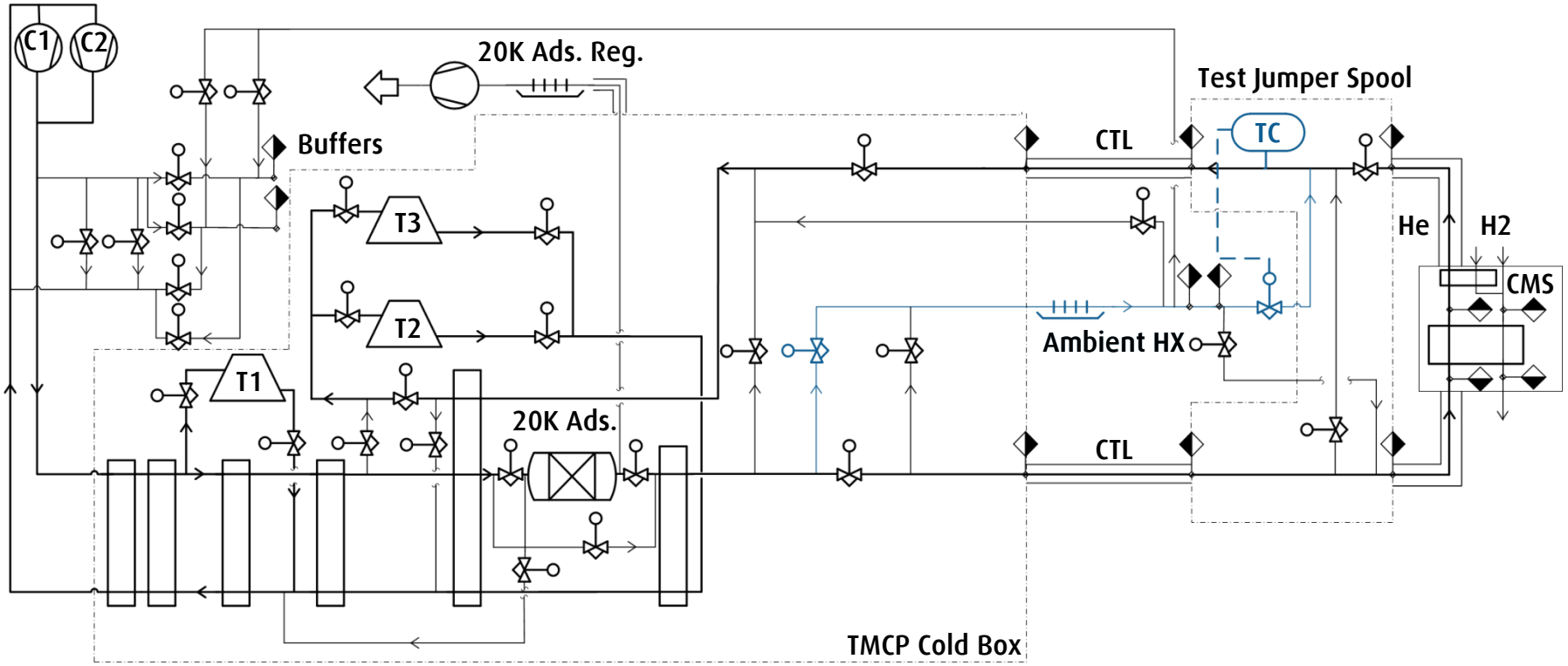
Unsteady operation modes: slow switching modes



– Starting and shutdown of machines

Process Design.

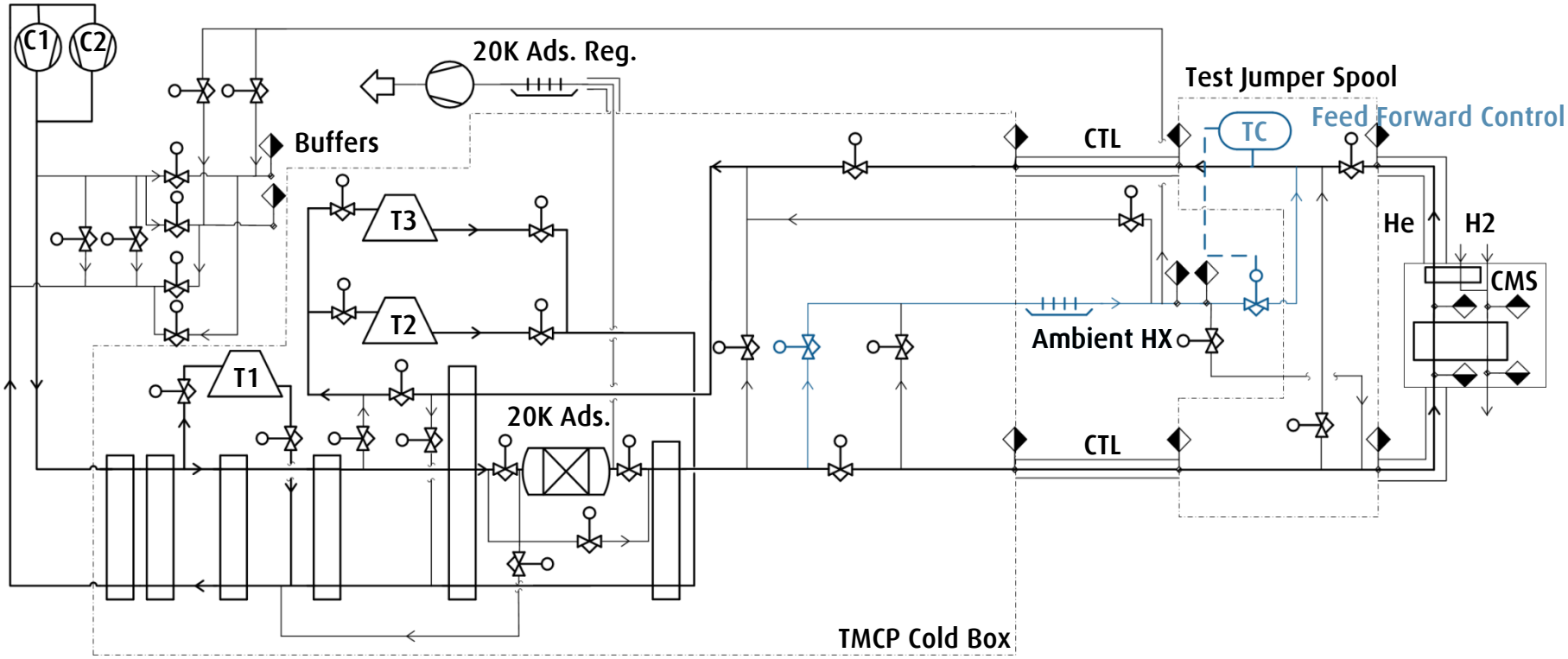
Unsteady operation modes: fast switching modes



– Missing heat load is provided by ambient heater

Process Design.

Unsteady operation modes: fast switching modes



– Beam trip

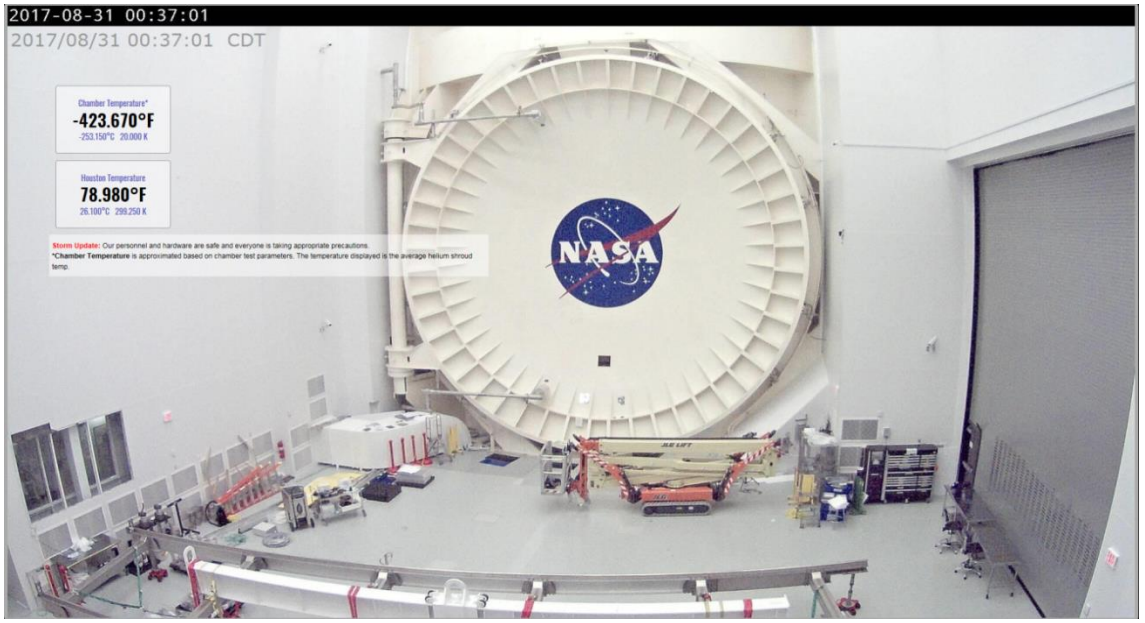
Turbines.

Turbine 1: TED45WK

— Increased pressure (p_{in} > 20 bara)

— Increased speed

— Increased axial thrust capacity



Source: https://jwst.nasa.gov/webcam.html

Cold Box Design.

Technical data	
Length	9800 mm
Diameter	3500 mm
Height valve plate	4100 mm
Total height	5600 mm
Weight	38000 kg

Summary.

Linde Kryotechnik (LKT) was contracted by ESS to provide cryogenic cooling for the cryogenic hydrogen moderators and the linear accelerator (2K cryo plant).

Challenging requirements demand special solutions.

The TMCP project is on schedule:

- Main equipment (heat exchangers, compressors) manufactured
- Process controls defined and specified
- Cold box design finished

Future milestones:

- TMCP cold box shipment: Q2 2018
- TMCP commissioning complete: Q1 2019

Thank you for your attention.

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TU Dresden
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