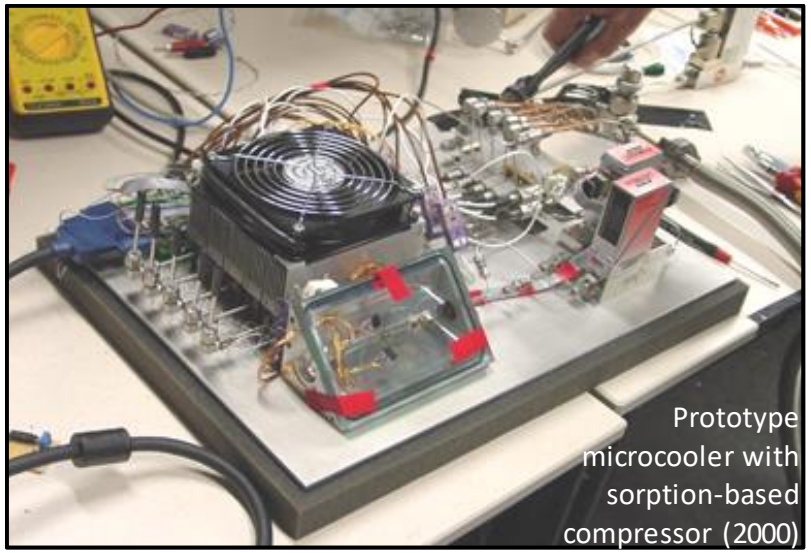
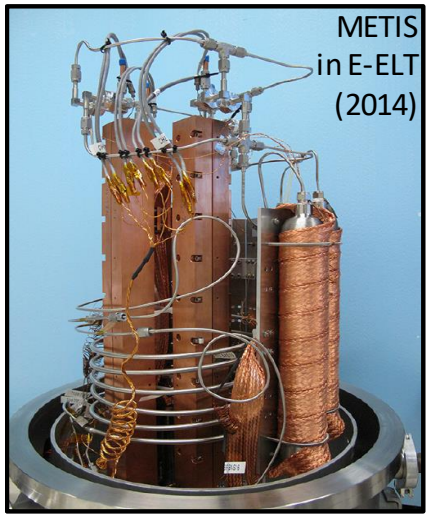
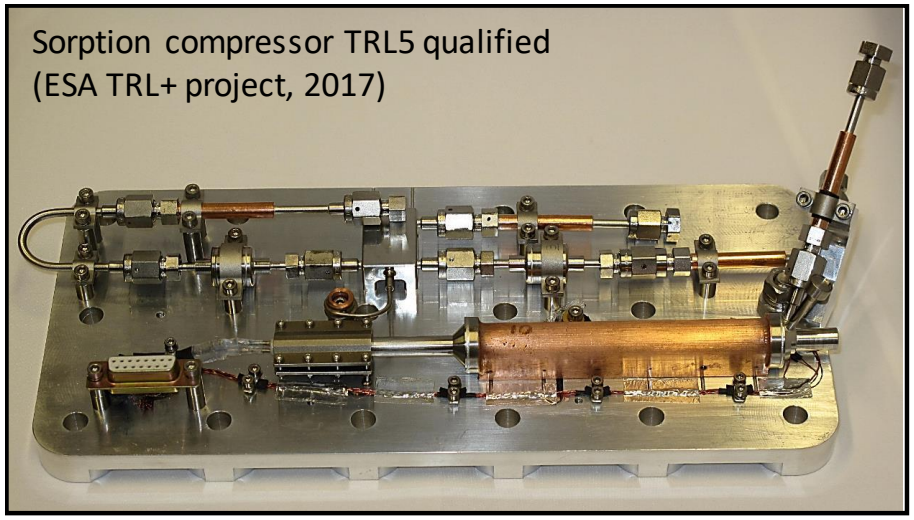
Vibration-free sorption-based JT cooling

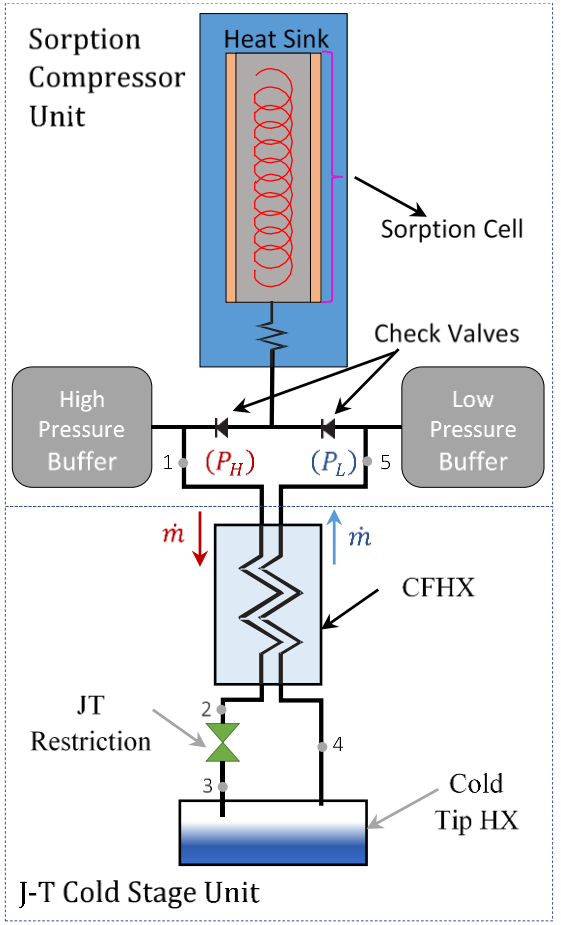
Marcel ter Brake
University of Twente

UT heritage on Vibration-Free Sorption-based JT Cooling



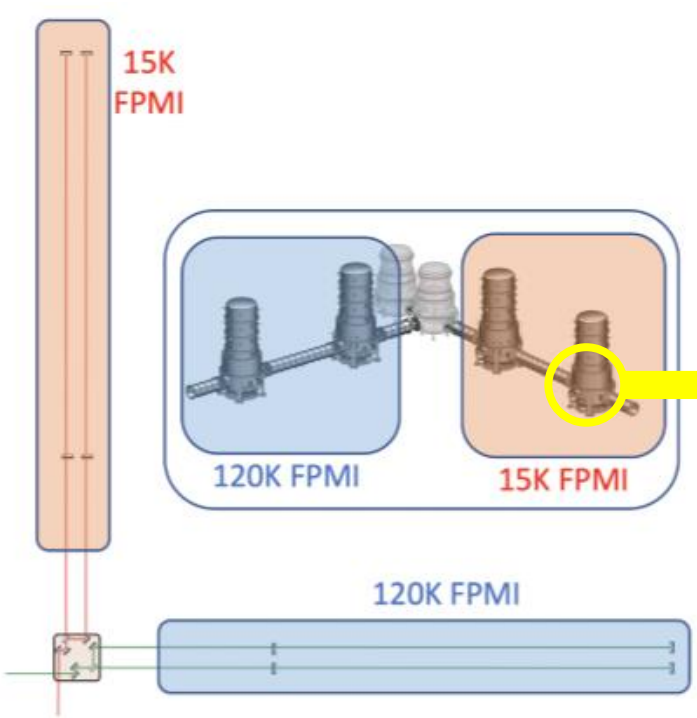


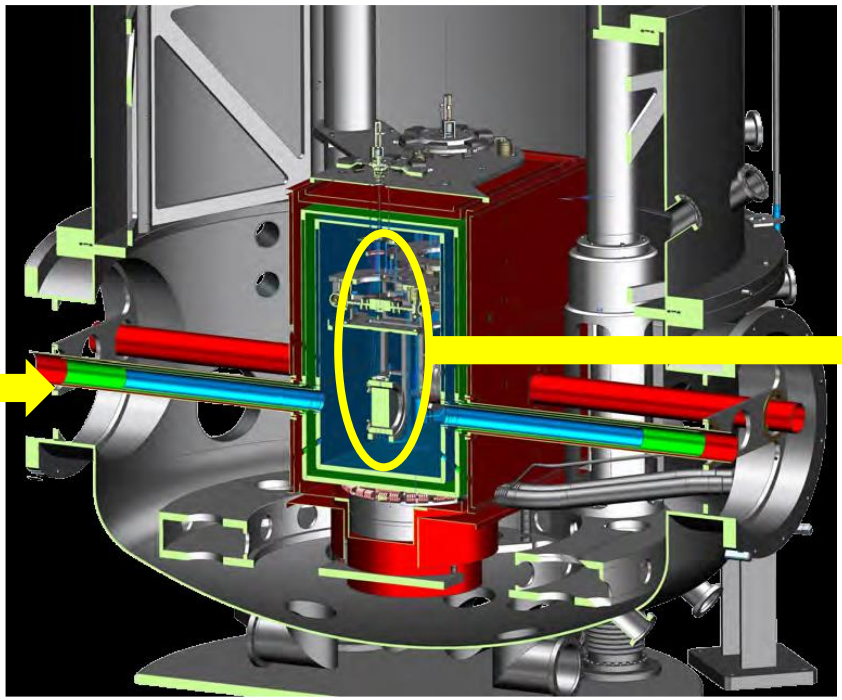


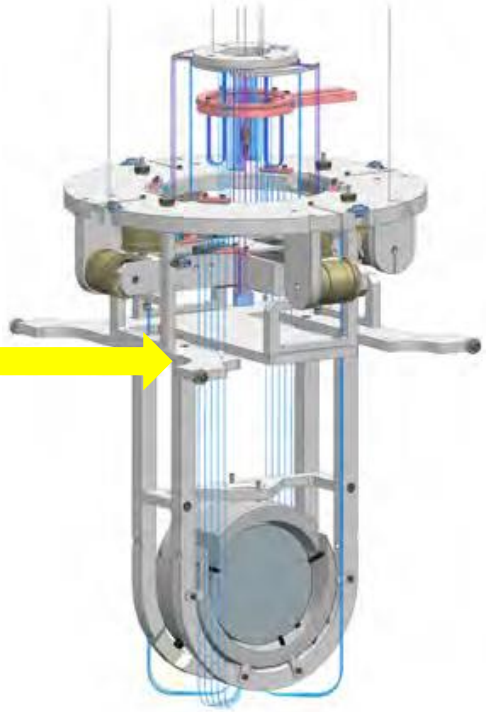


Sorption-based thermal compressor operating without mechanical vibrations

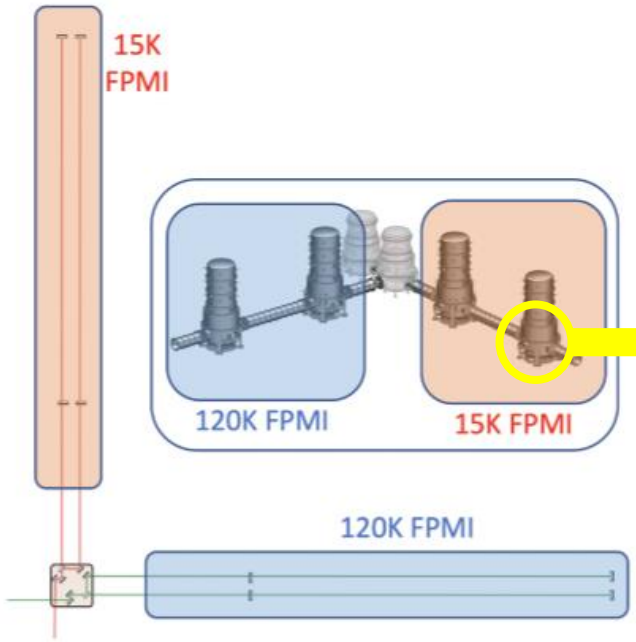
Einstein Telescope PathFinder

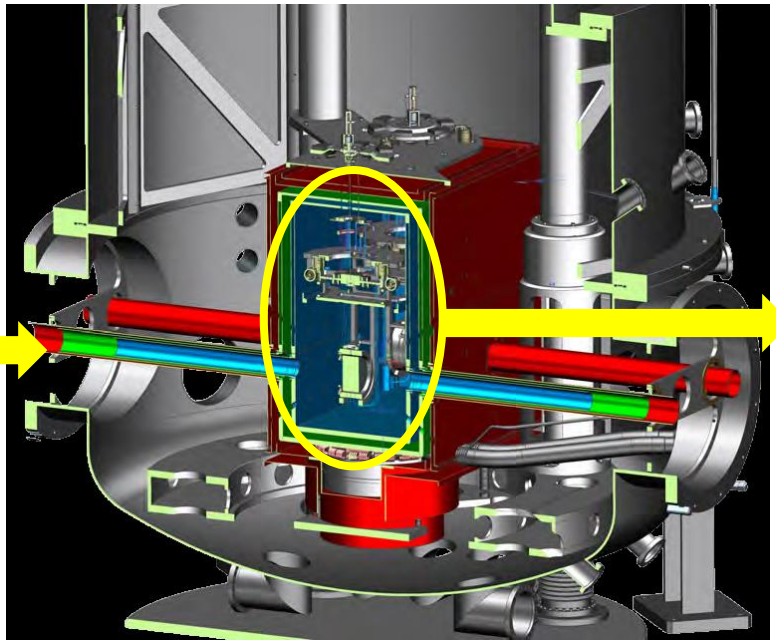


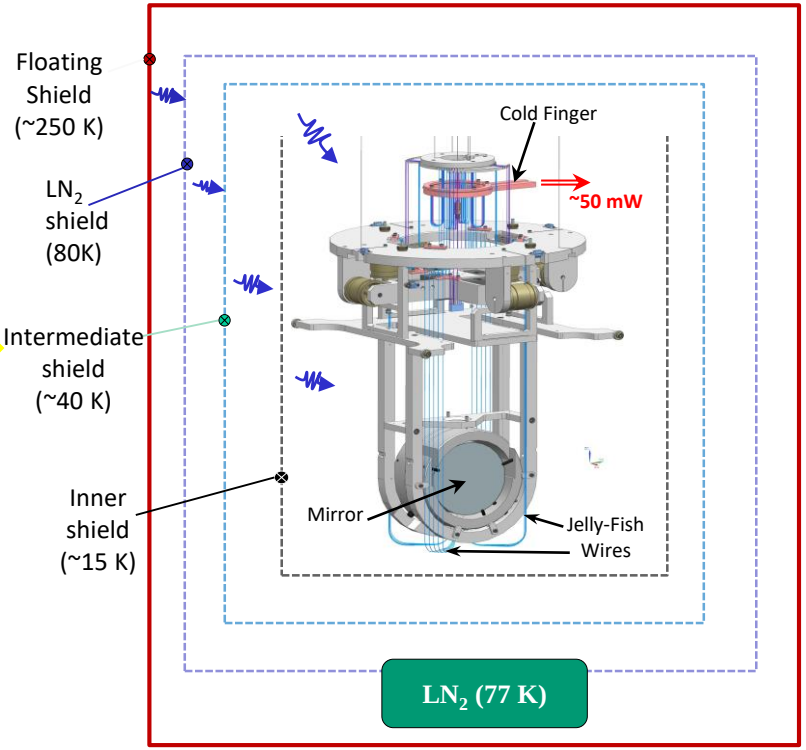




Einstein Telescope PathFinder



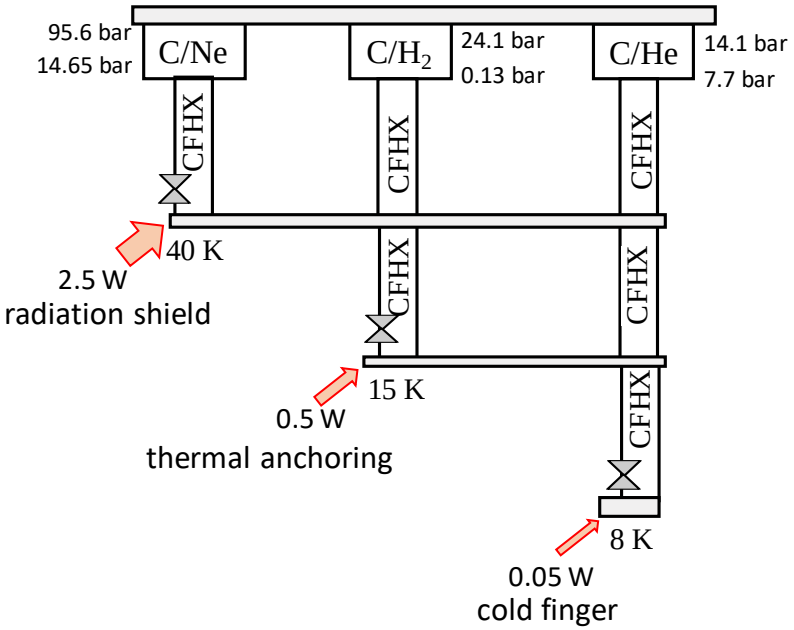


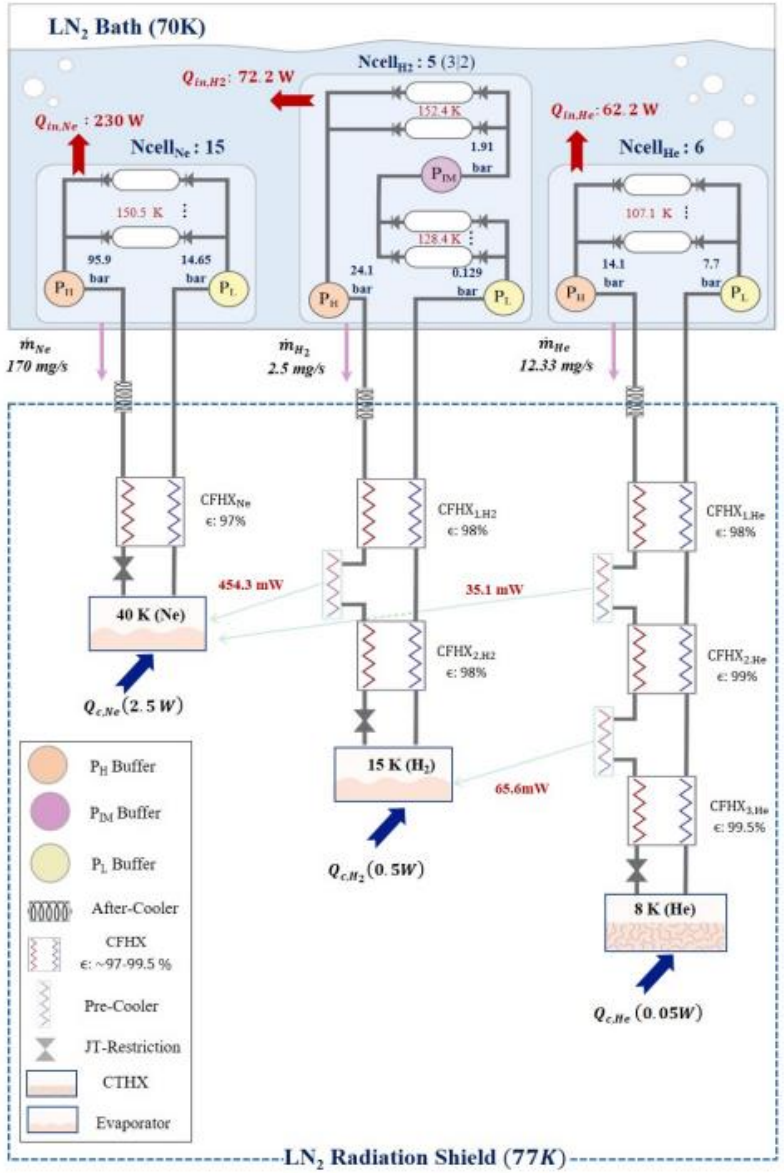


Einstein Telescope PathFinder (sorption-based cooler chain)

T heat sink at 70 K, entrance CFHX at 77 K

Ne	H_2	He	Total
15 cells	5 cells	6 cells	26 cells 39 liter
243 W	87 W	65 W	395 W

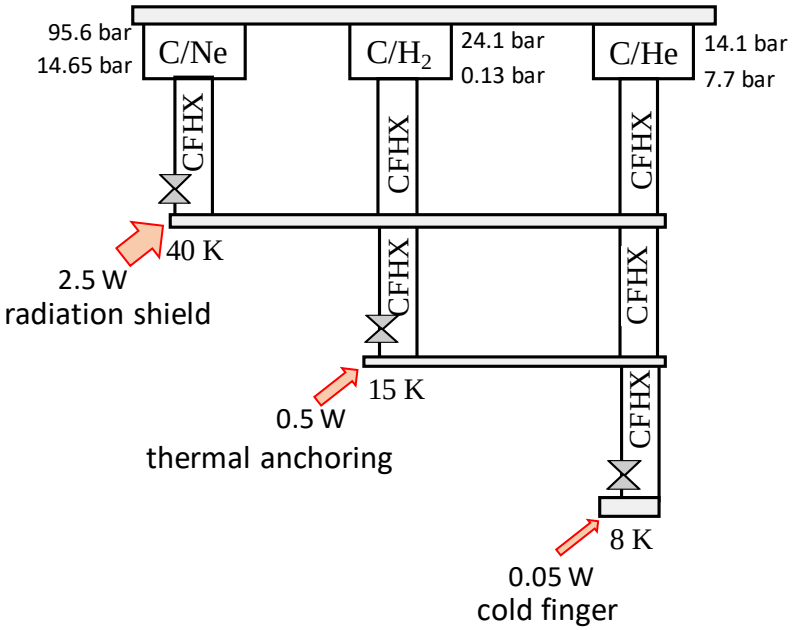




Einstein Telescope PathFinder (sorption-based cooler chain)

T heat sink at 70 K, entrance CFHX at 77 K

Ne	H_2	He	Total
15 cells	5 cells	6 cells	26 cells
243 W	87 W	65 W	39 liter 395 W



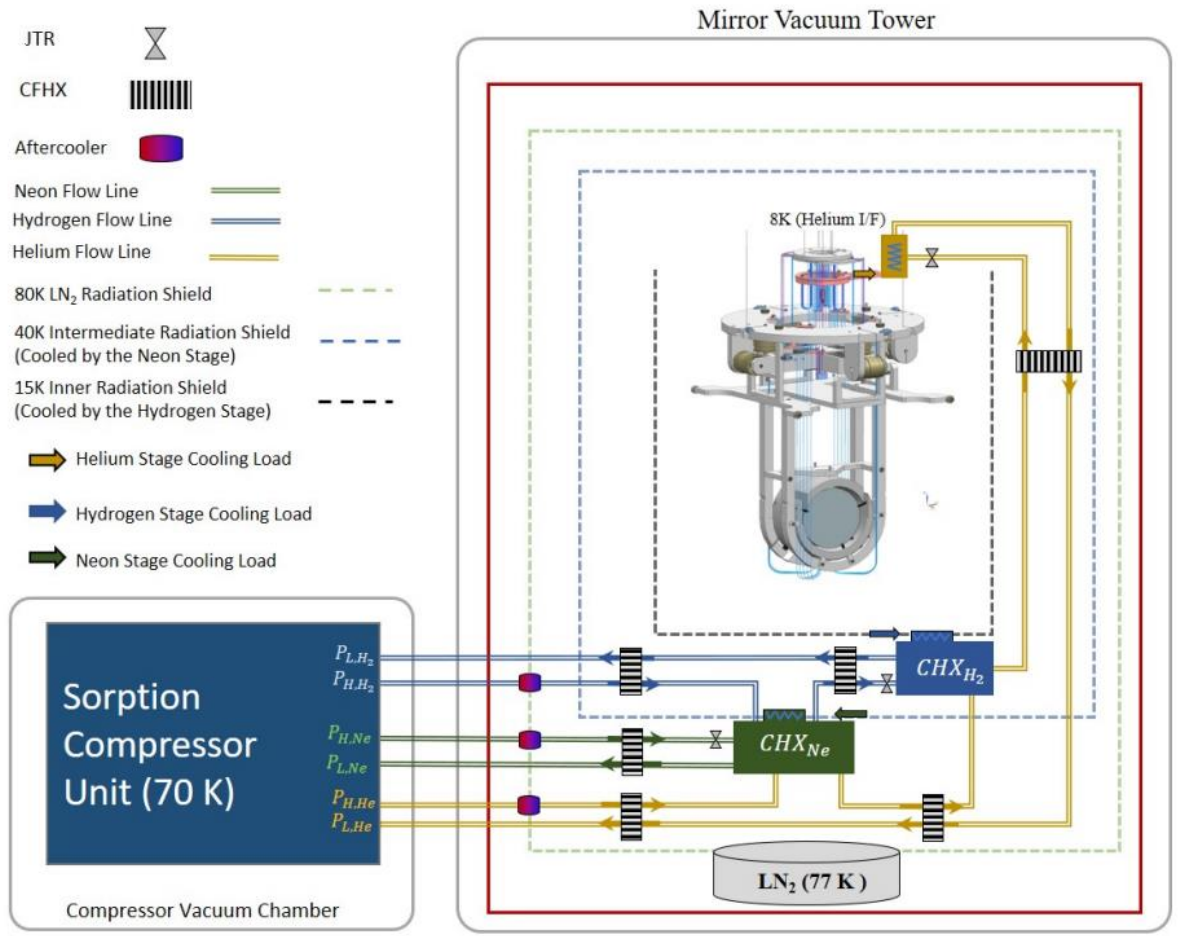
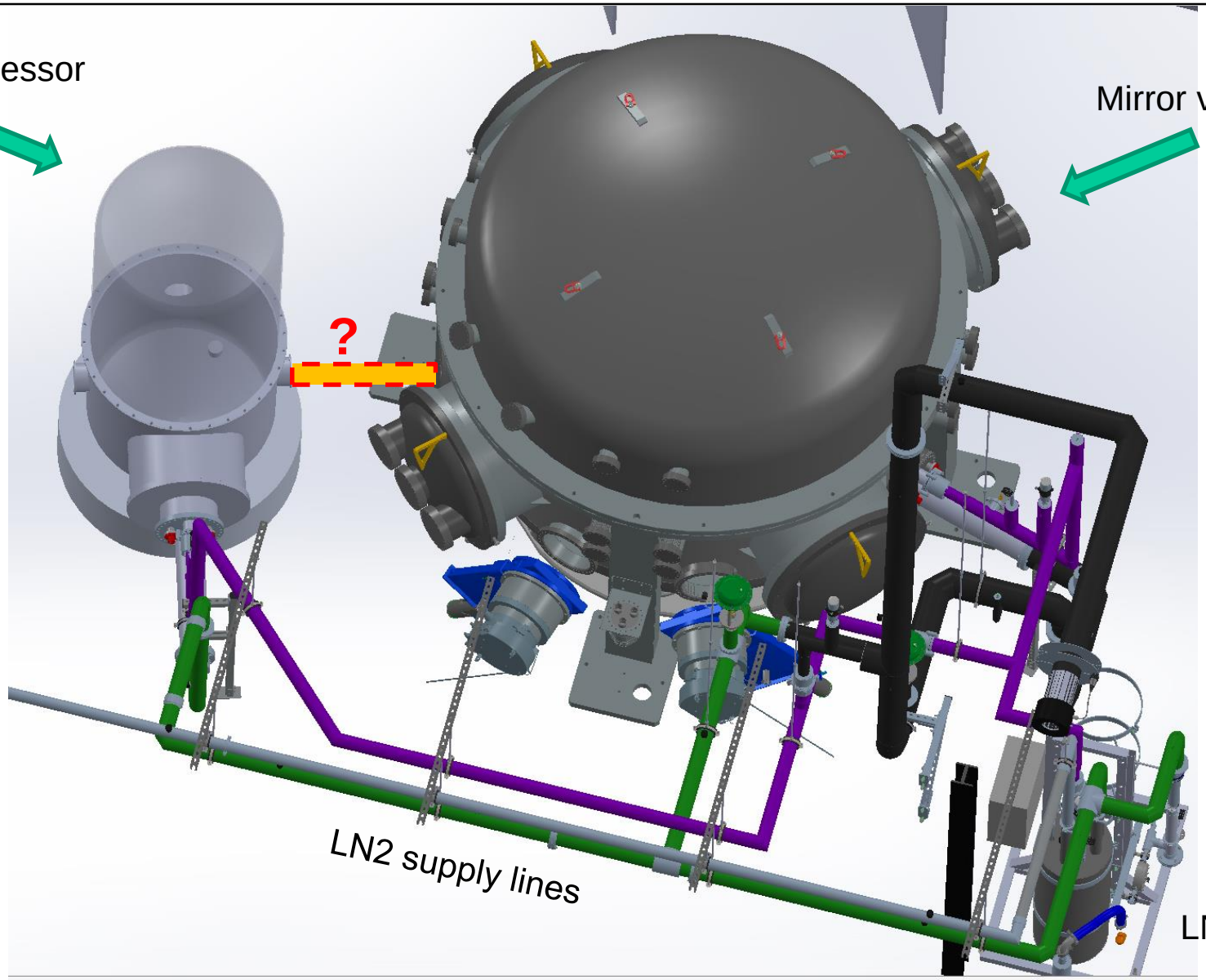
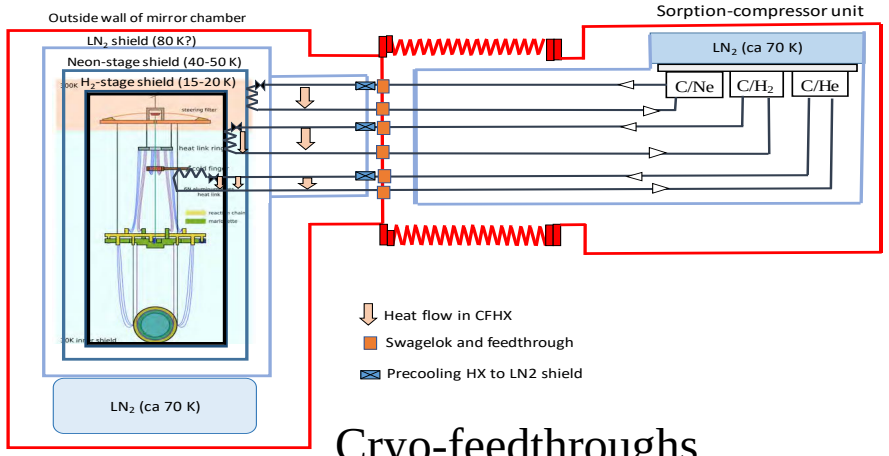


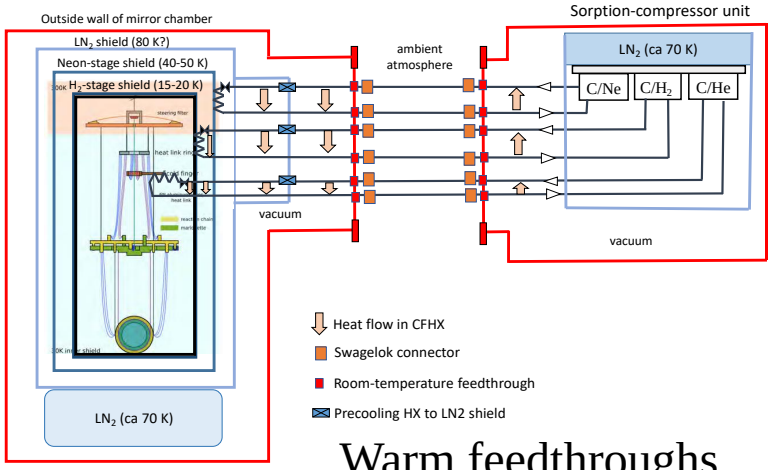
Figure 3: Schematic of the proposed sorption-based cryochain architecture depicting the envisioned thermal interfaces with the shields as well as the interlinked pre-cooling paths


Sorption compressor chamber
Mirror vacuum tower
?
LN2 supply lines
LN2 subcooler

Two options for connecting sorption compressor unit to cold stages in mirror tower

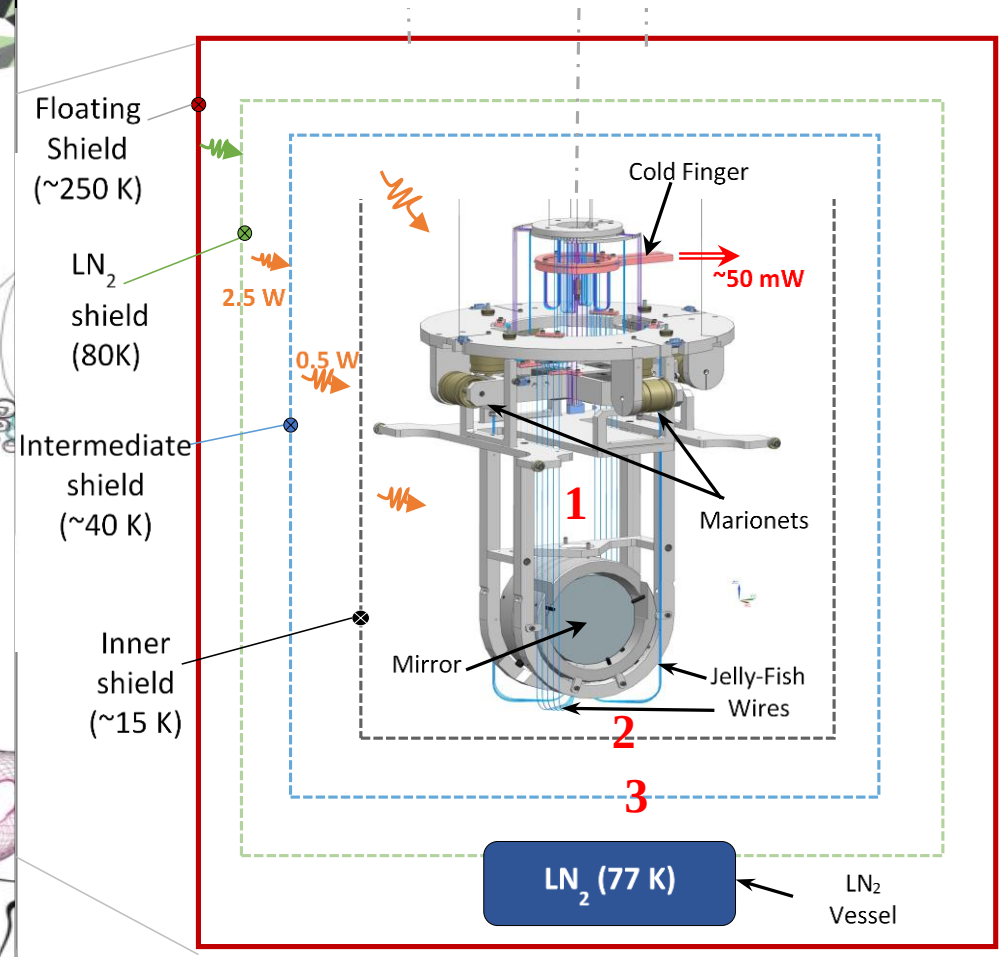


Cryo-feedthroughs



Warm feedthroughs

Complexity in manufacturing	Cryogenic feedthroughs	Additional heat exchangers (CFHXs)
Complexity in operation		Connecting sorption-compressor unit to mirror tower is simpler
LN2 consumption	ca. 1-2 % less LN2	
Vibrations	Adequate damping of line vibrations has to be realized	Lines rigidly connected to wall of mirror chamber (perfect damping)



1. Cold payload
(8 K, 40 kg Al,
40 kg Cu, 8 kg Si)

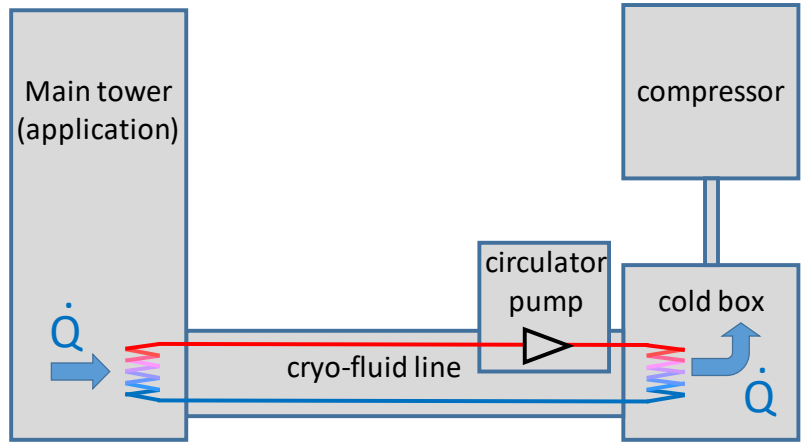
2. H_2-stage shield
(15 K, 40 kg Al)

3. Neon-stage shield
(40 K, 130 kg Al)

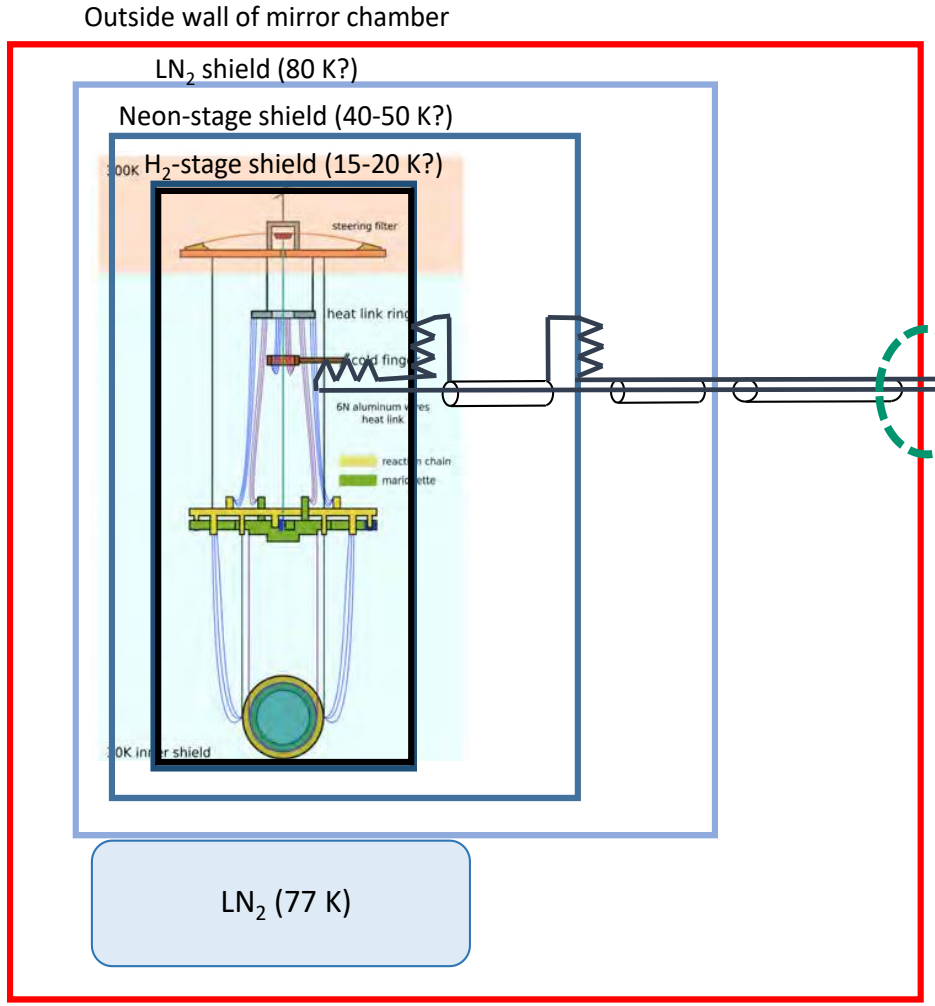
Cool-down will be limited by 8K stage (only 50 mW)

Even when precooled by LN2 to 100K, cool-down will take 8 to 9 months

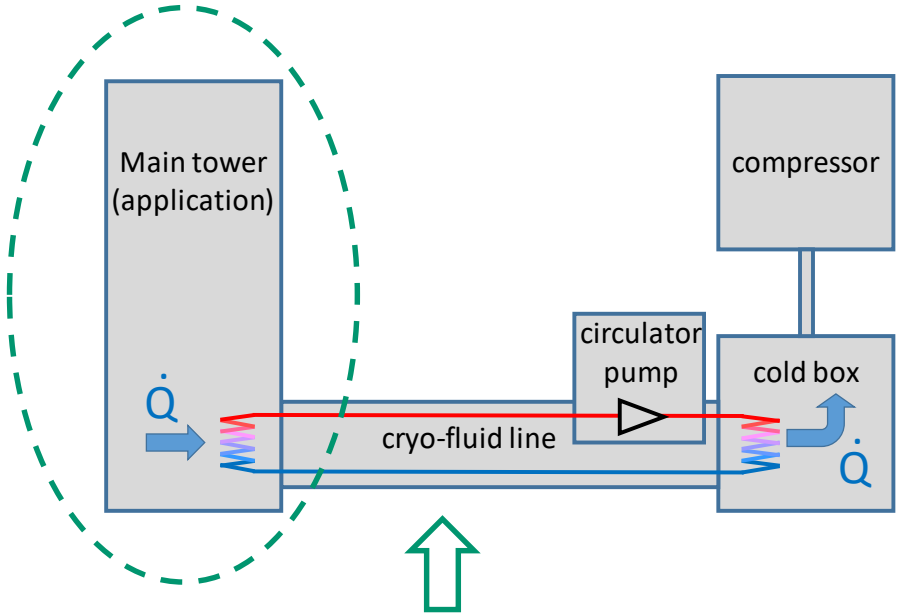
Speed up cool-down by cold helium-gas flow



Cool-down assisted by cold helium flow ('kick-starter')



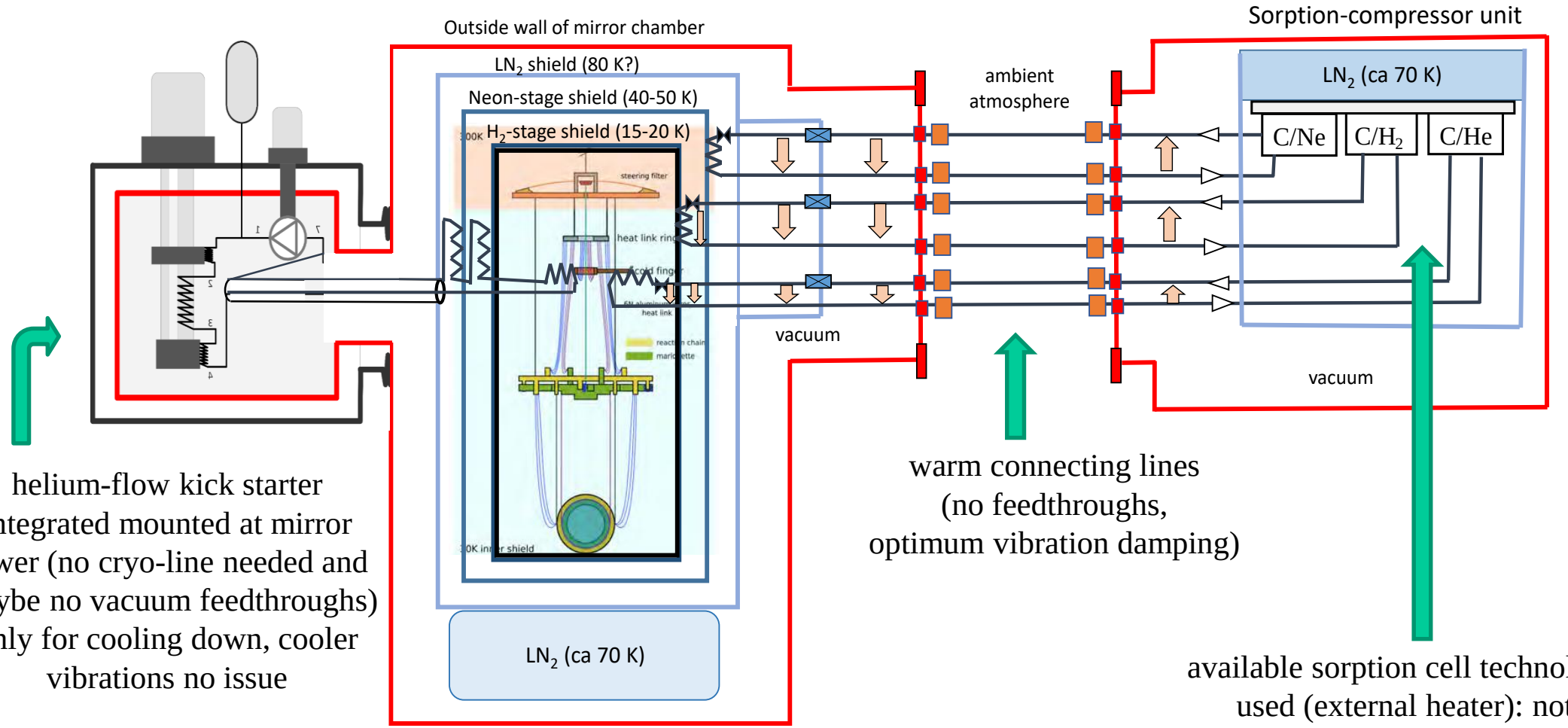
He-gas flow
(0,2 g/s ca 1W/K)



cryo-fluid line not simple

complex feedthrough required with vacuum barrier
(cryogenic supply and cryogenic return, ca. 6K and 50 K)

ETPF Sorption-cooler configuration for quick realization validating sorption-cooler feasibility (2026)



helium-flow kick starter integrated mounted at mirror tower (no cryo-line needed and maybe no vacuum feedthroughs) only for cooling down, cooler vibrations no issue

warm connecting lines (no feedthroughs, optimum vibration damping)

available sorption cell technology used (external heater): not optimum bu much simpler

LN2 systems installed, flanges waiting for sorption compressor units

ETPF @ Maastricht

ETPF Cryogenic Test Facility @ Twente

Thank you !

Current partners in this development

Maastricht University

JPE
Driven by innovation

DEMCON | kryoz

Nikhef

DEMACO

cryoworld
advanced cryogenics

COOLL