The Silicon Tracking System of the CBM at FAIR: detector development and system integration.

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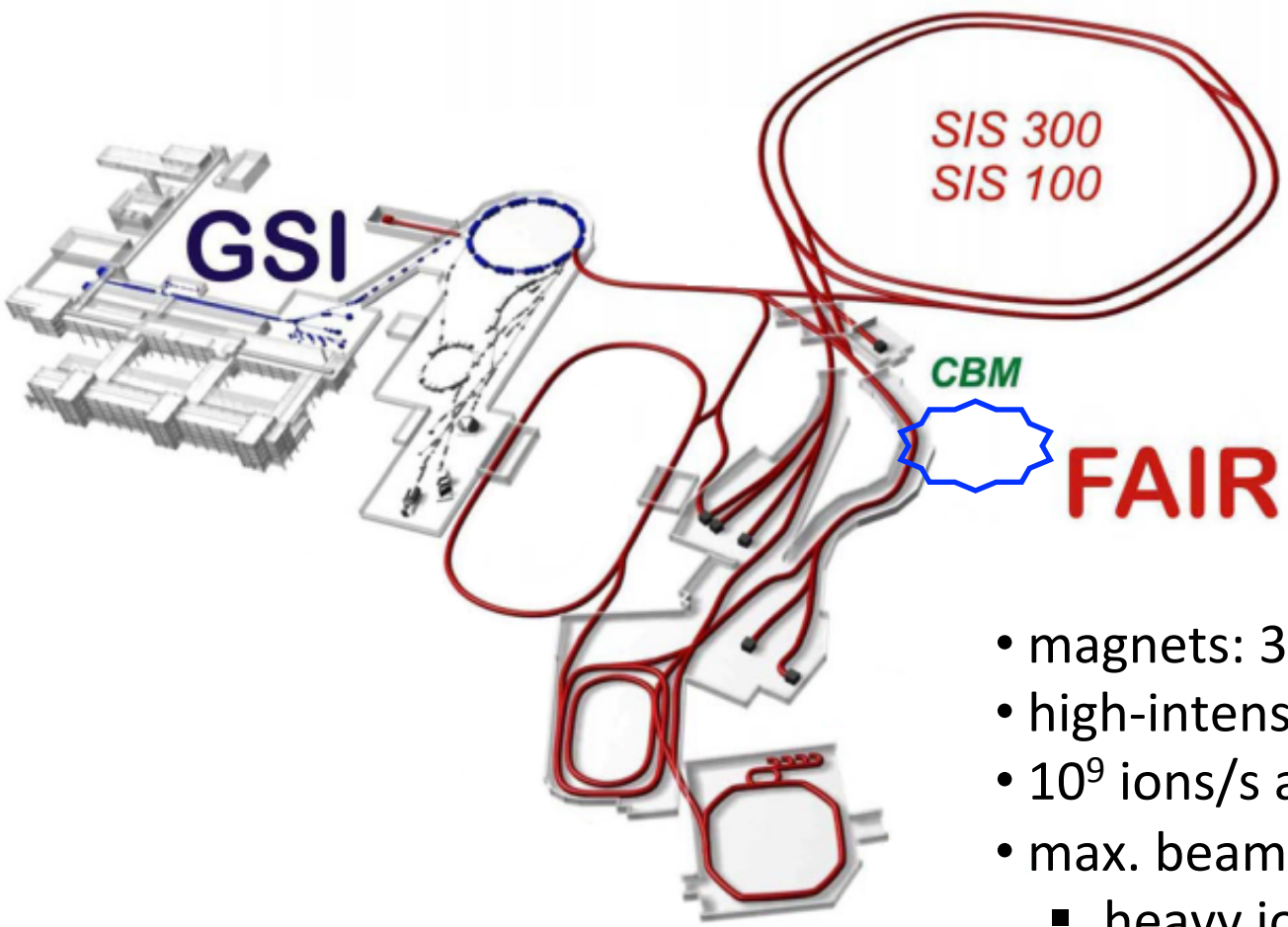
TIPP '14, Amsterdam

KINR

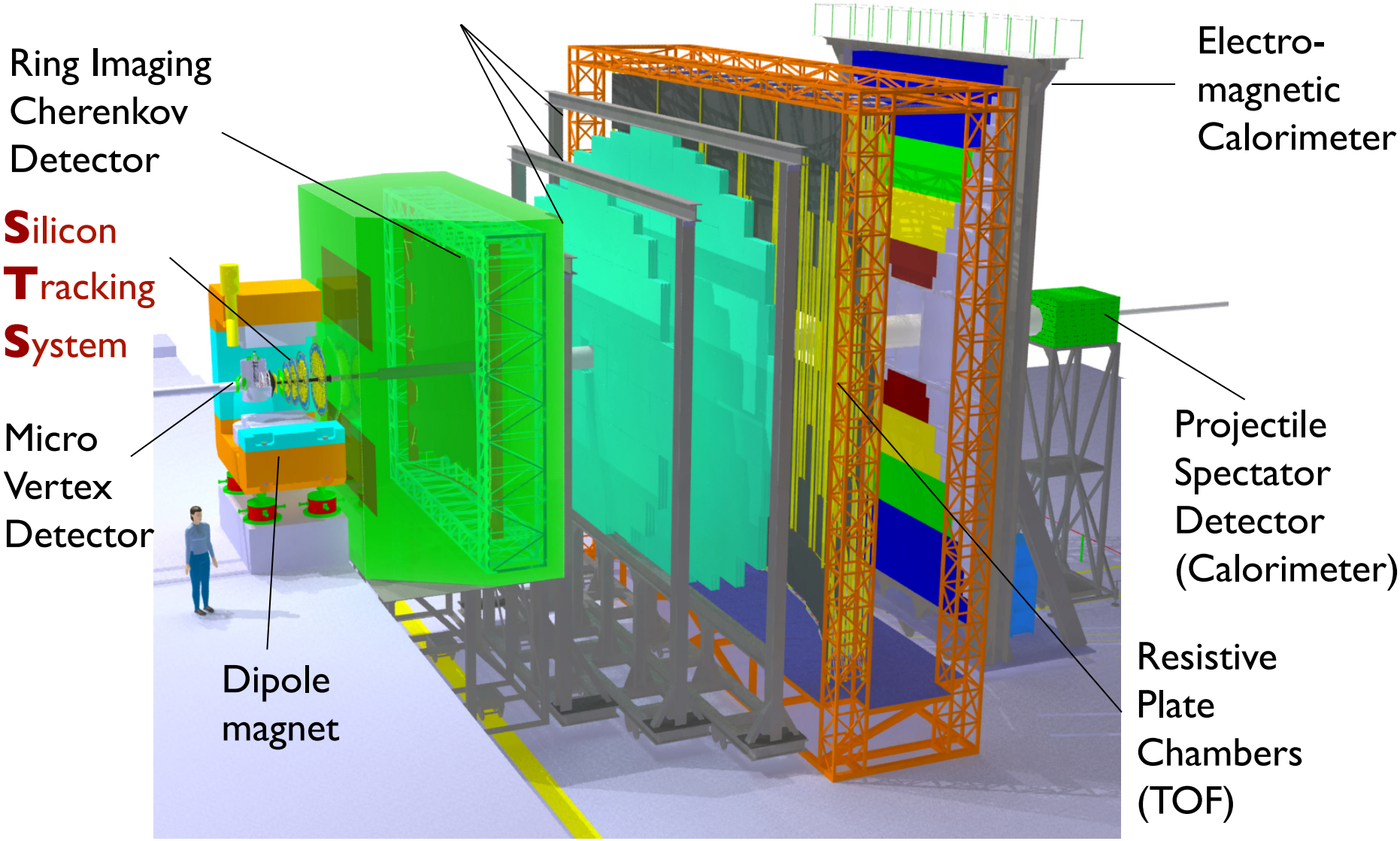
Facility for Antiproton and Ion Research



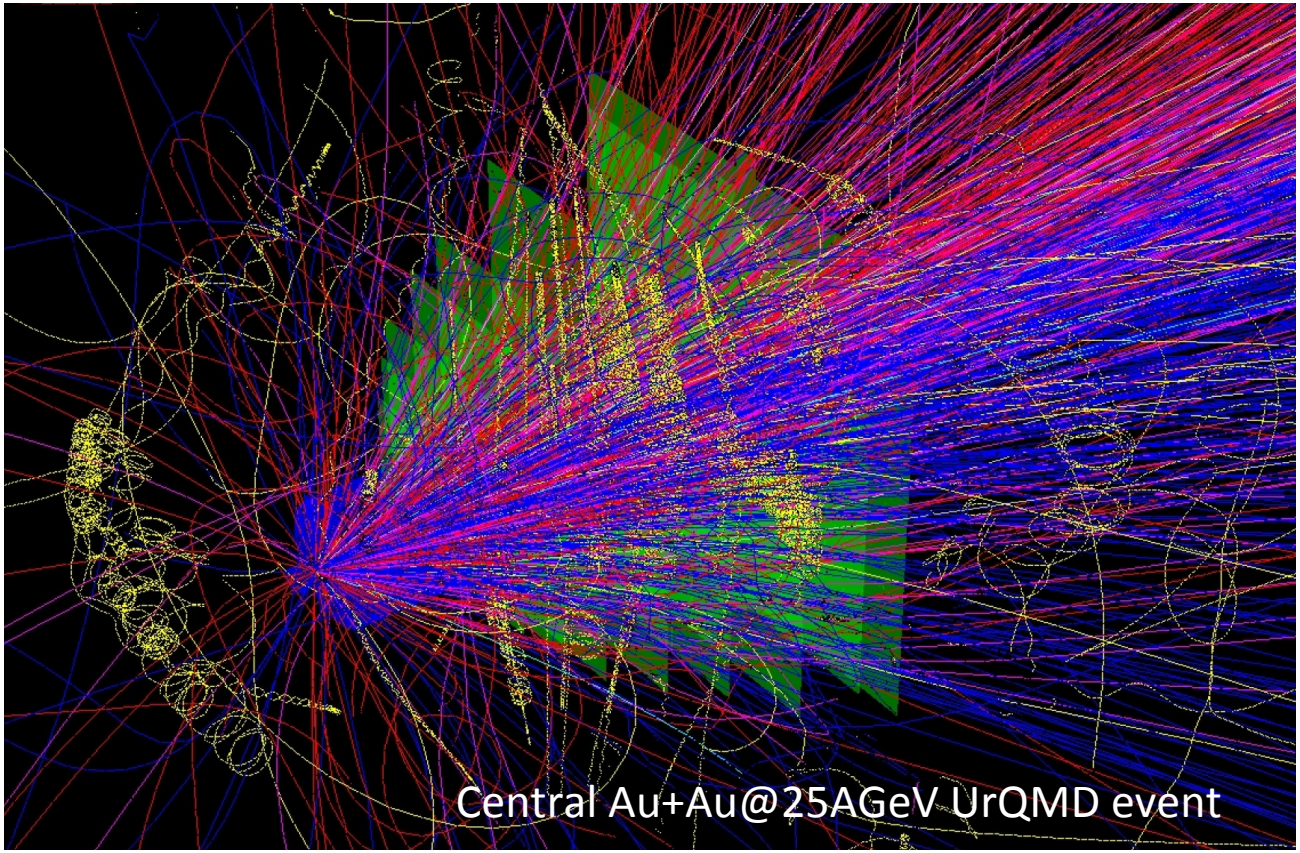
- magnets: 300 Tm bending power
- high-intensity DC beam:
- 10^9 ions/s at CBM
- max. beam energies:
  - heavy ions: 45 GeV/u
  - protons: 90 GeV

2012: World intensity record for low Charge State Heavy Ions (e.g., U^{28+})

CBM experiment



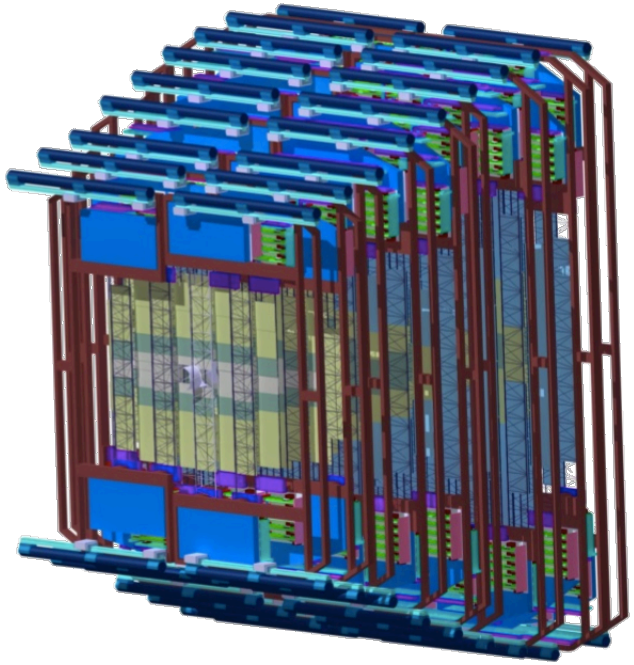
Tracking challenge



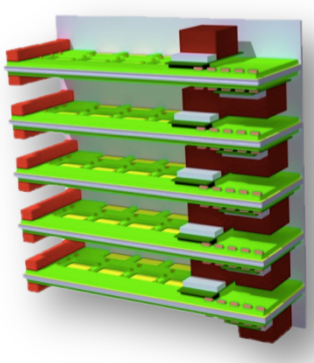
- Au+Au at 10 MHz interaction rate
- Up to 700 charged particles/evt
- Track densities up to 30 cm^{-2}/evt

Need fast and radiation hard detectors as well as fast data acquisition system for online event selection

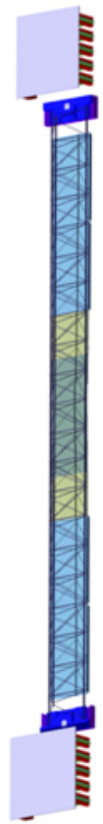
Silicon Tracking System



8 stations



212 FEE blocks



106 ladders

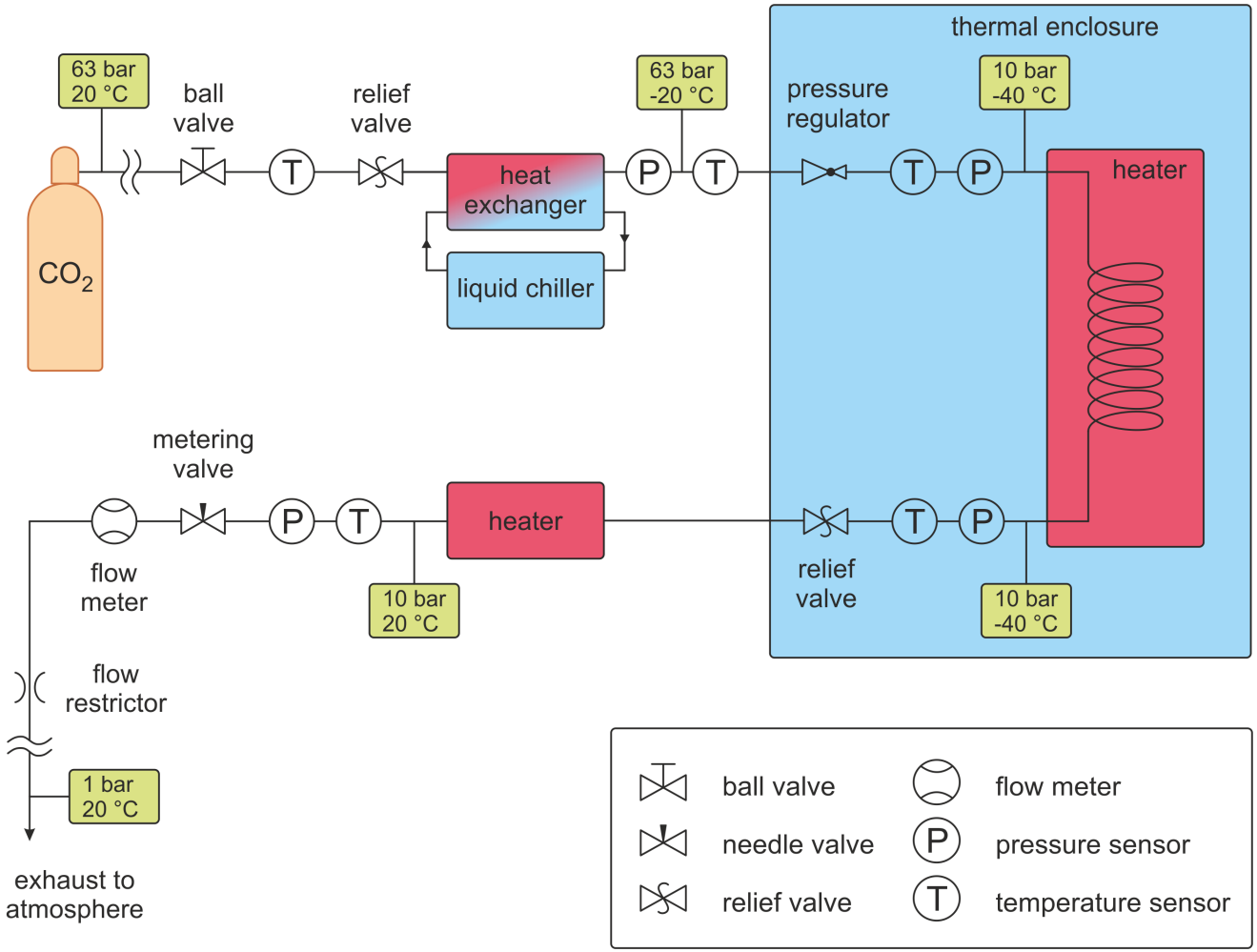
- 2133k r/o channels
- 212 FEE blocks at 140 W (10 FEBs with 14 W each) + 60 W (HUB chip)
- FEE heat dissipation of 42.4 kW

- Total power dissipated by sensors after irradiation ~ 1 W → Convective cooling

<u>Cooling R&D</u>:

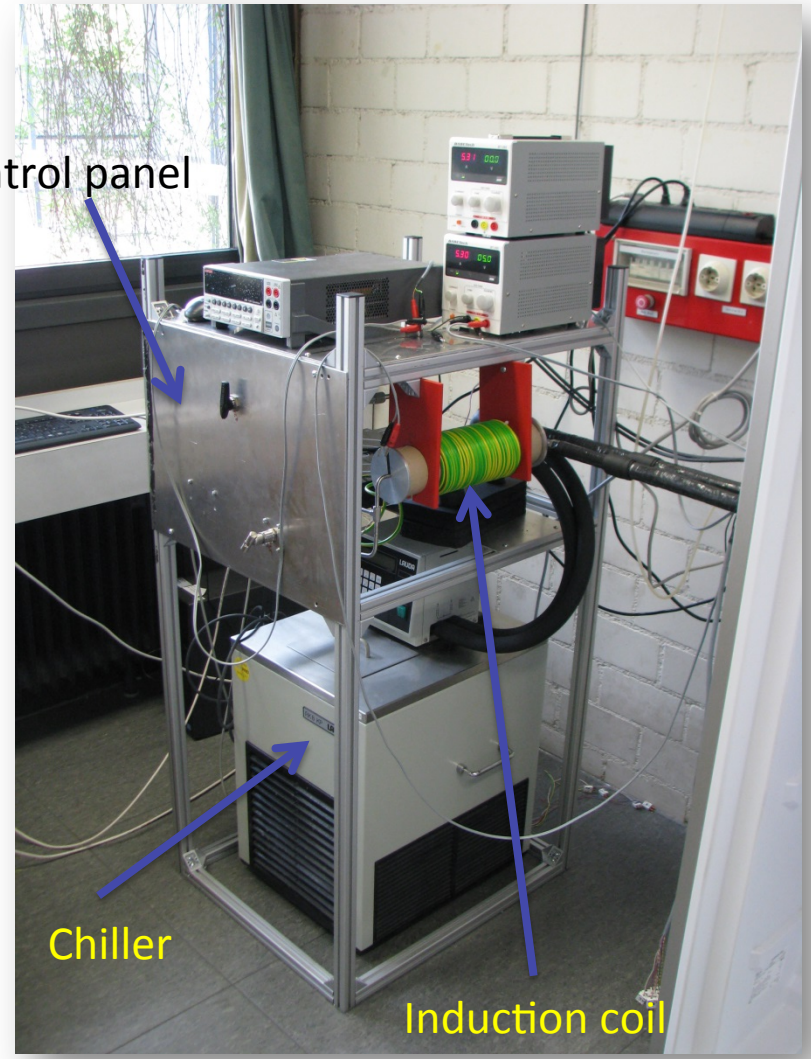
- Open blown CO_2 system
- 1 kW CO_2 system TRACI-XL
- Plans for 50 kW system

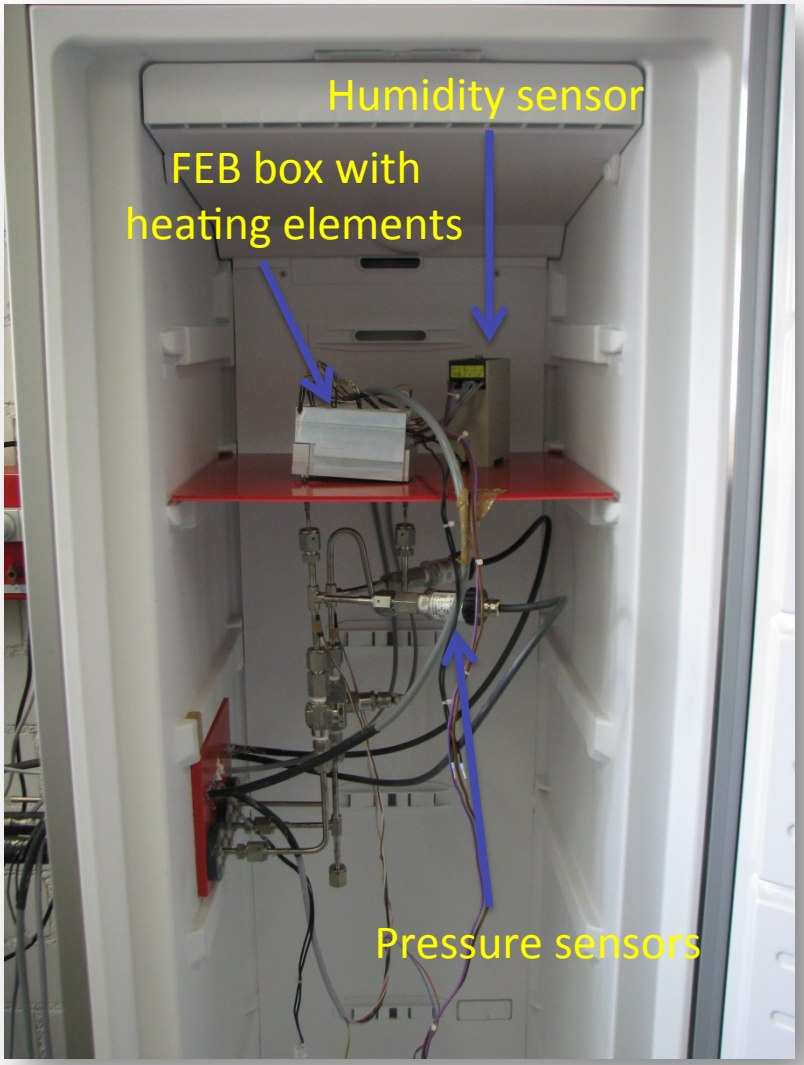
Open CO_2 system



Built to validate heat exchanger design. Currently commissioned and running.

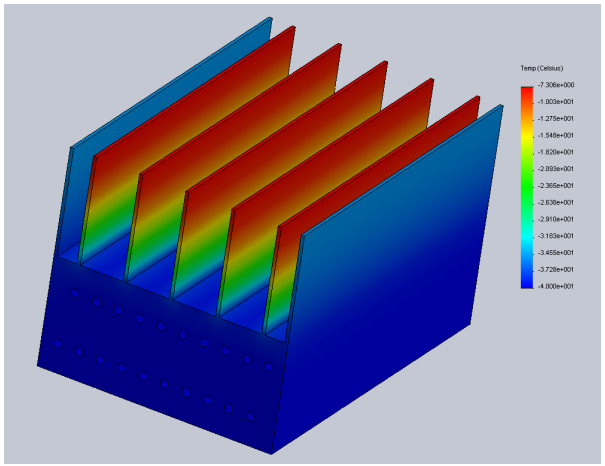
Experimental setup





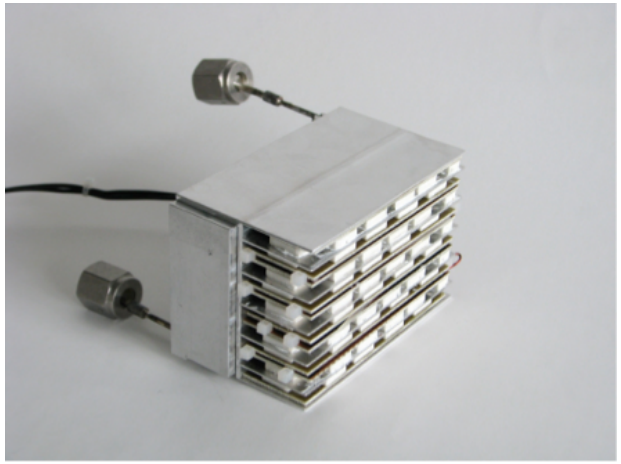
Heat exchanger studies

Simulation studies



- FEM calculation (Solid Works)
- 200 W input power
- 1 mm thick fins

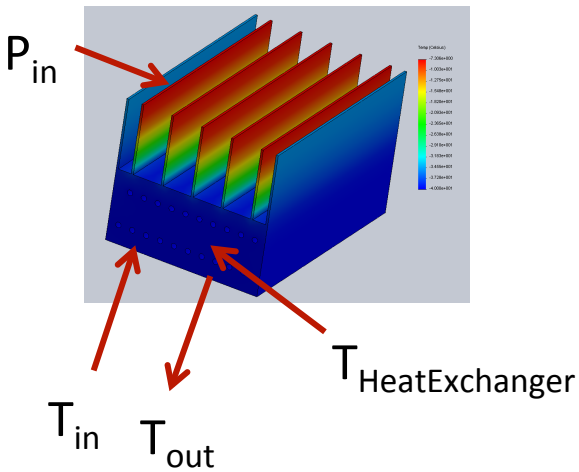
Prototype



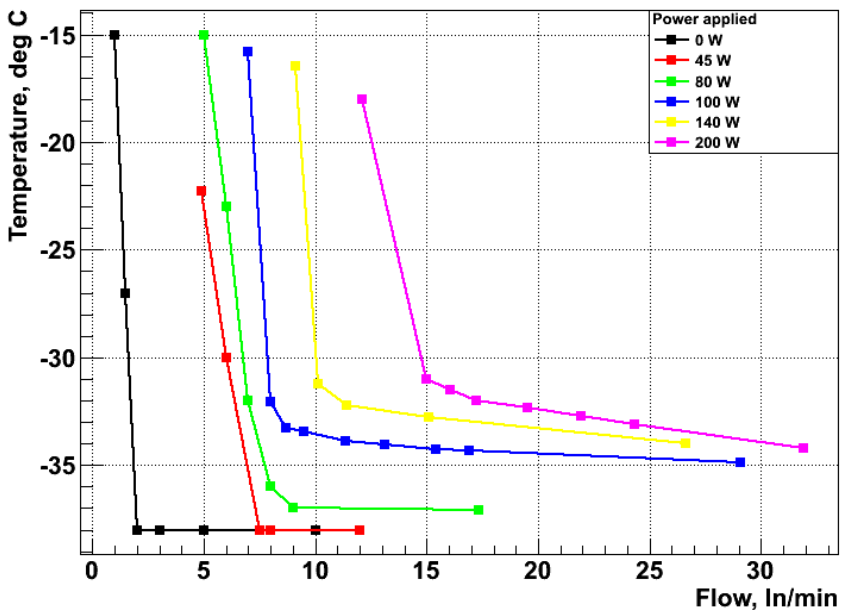
- 200 W heat load by resistors
- 1.8 m long tube with ø1.8 mm (optimal parameters)
- Obtain temperature distributions
- Check thermal contact

Goal: optimize heat exchanger/cooling fins geometry. Guarantee thermal neutrality (-5 ˚C).

Very first results



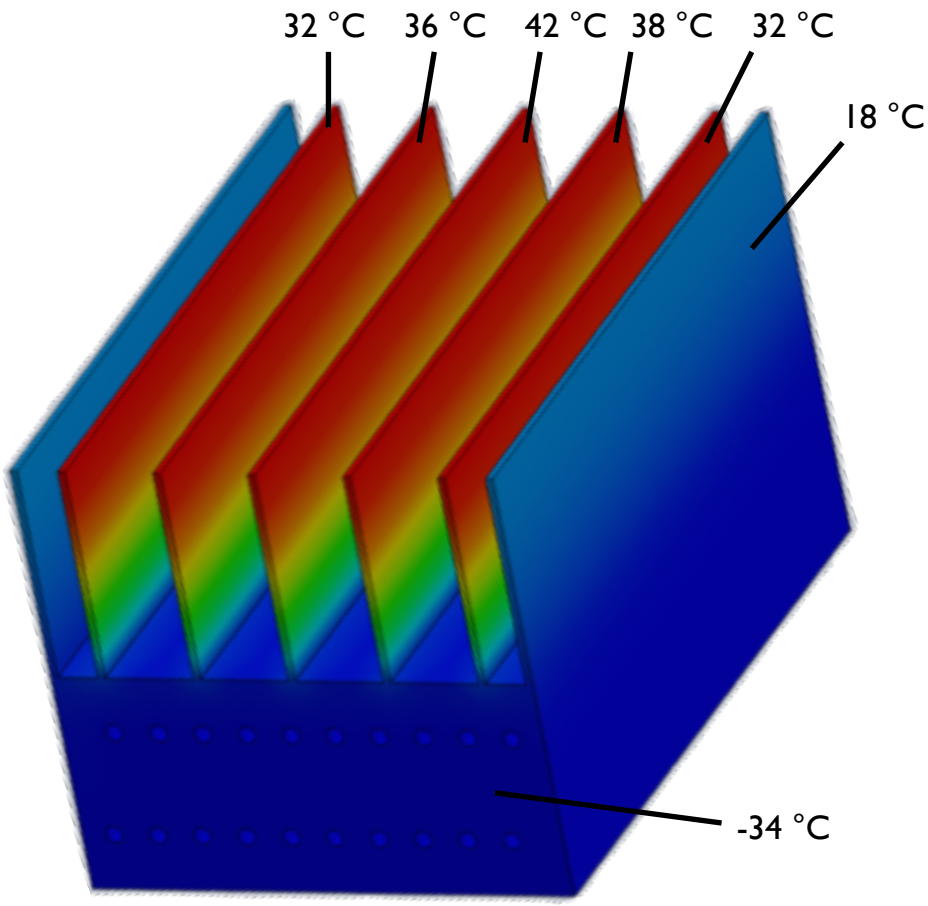
- input power P_{in}: 0, 45, 80, 100, 140, 200 W
- liquid CO_2 input temperature T_{in}: -40 °C



nominal flow to neutralize 200 W:
1 g/s = 27 l_n/min

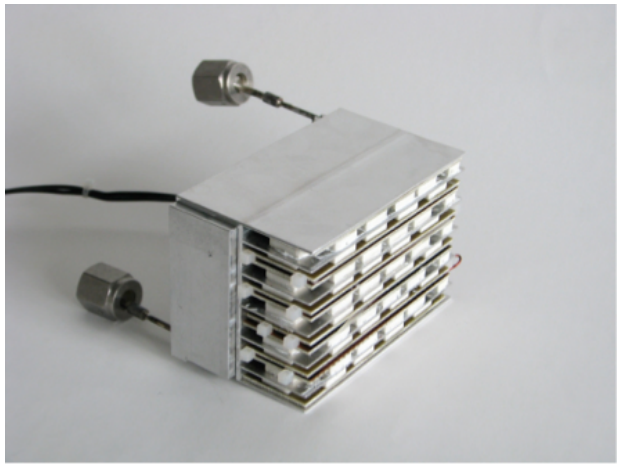
saturation temperature T_{HX} is reached at flows > 15 l_n/min

Very first results II



Much higher than -5 °C
(not thermally neutral)

<u>probable cause:</u> insufficient thermal contact between heat exchanger and FEB box

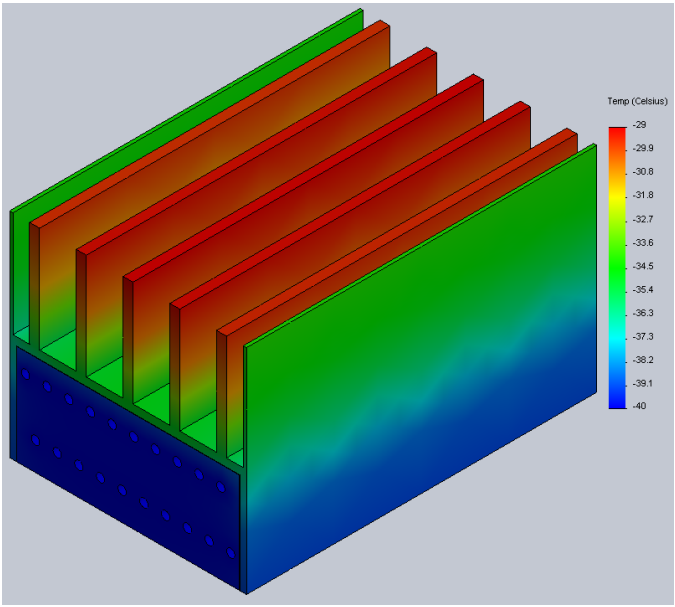


Flow: 30 l_n/s, input power: 200 W

Simulations studies

Temperature maximum

Fin width	all aluminum	air gap (100 µm)	thermal grease gap	grease with Cu-FEB Box	grease with all Cu
1 mm	-7.05	35.1	-3.97	-18.2	-18.5
2 mm	-21.4	24.7	-18.3	-26.2	-26.6
3 mm	-26.9	20.9	-23.4	-29	-29.4

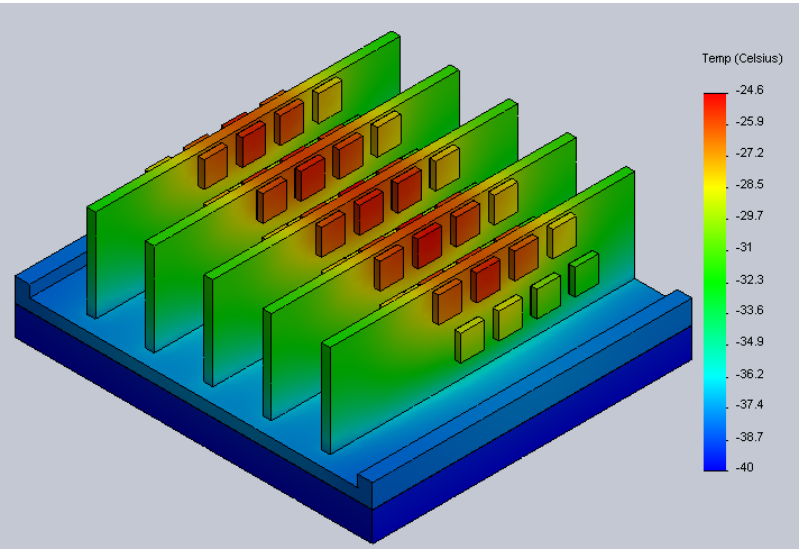


- simulations confirm experimental observations
- good thermal coupling and wider fins (2 mm) should allow complete thermal neutralization
- experimental verification underway

Simulations with detailed layout

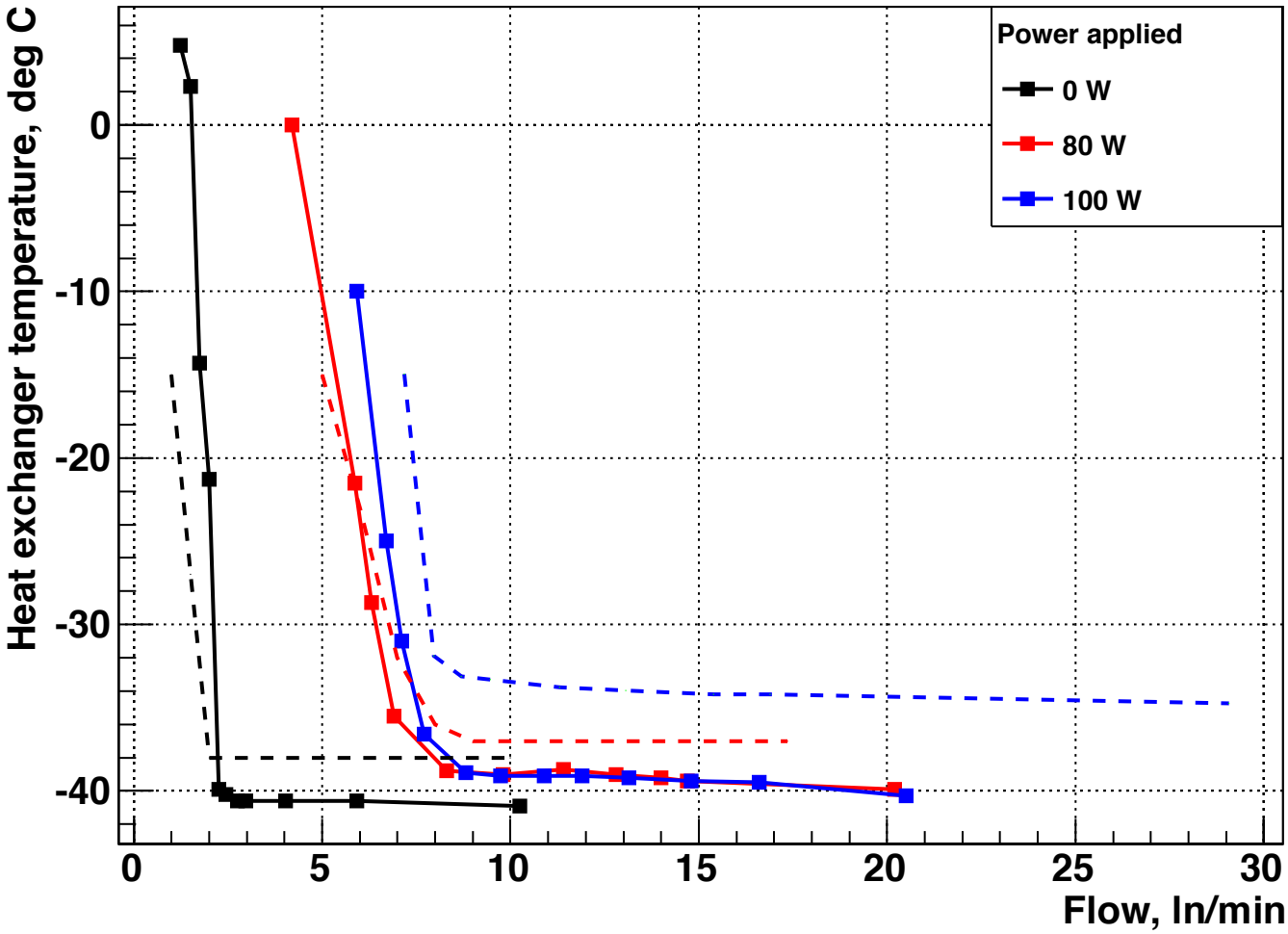
Temperature maximum °C

fin width	all aluminum	air gap	thermal grease gap	grease with Cu FEB box	grease with all Cu
1 mm	-5.09	34.2	7.18	-9.54	-10
2 mm	-11.4	23	-8.92	-20	-20.5
3 mm	-18.4	18.7	-15.7	-24.1	-24.6
4 mm	-22.8	15.8	-20	-26.8	-27.3

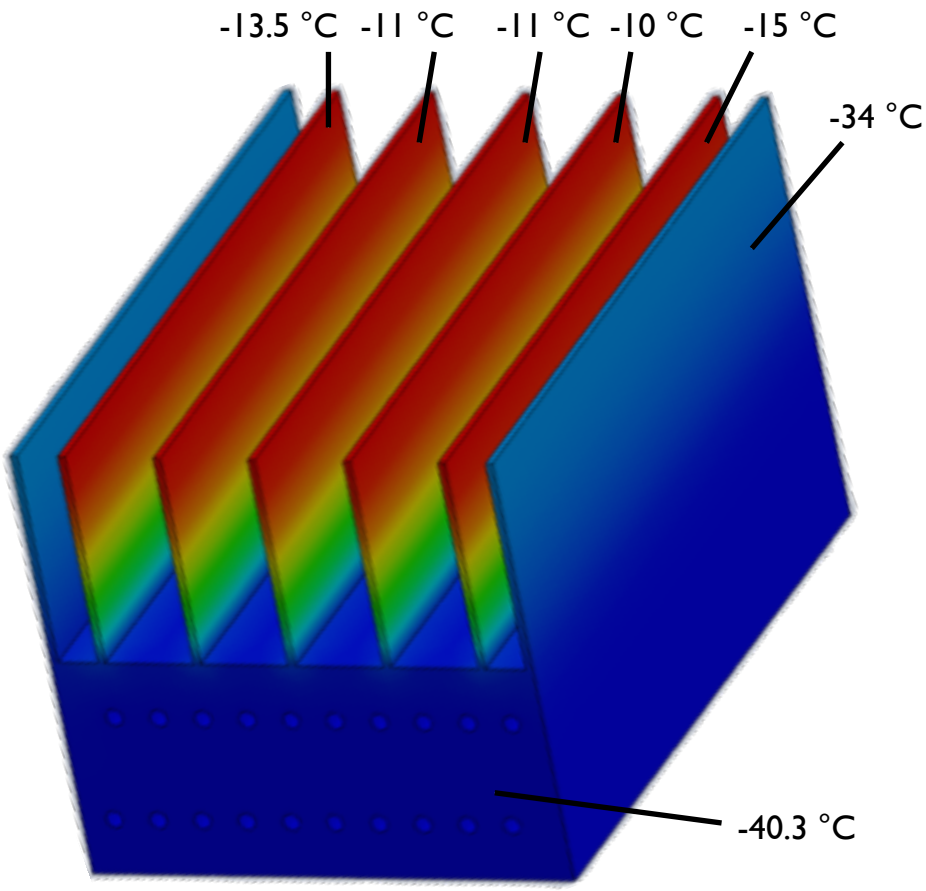


realistic placement of heat sources suggests 2-3 mm fins

New measurements: improved thermal contact



New measurements: T @ 100 W



SolidWorks simulations predict -19.4 °C highest temperature in this regime

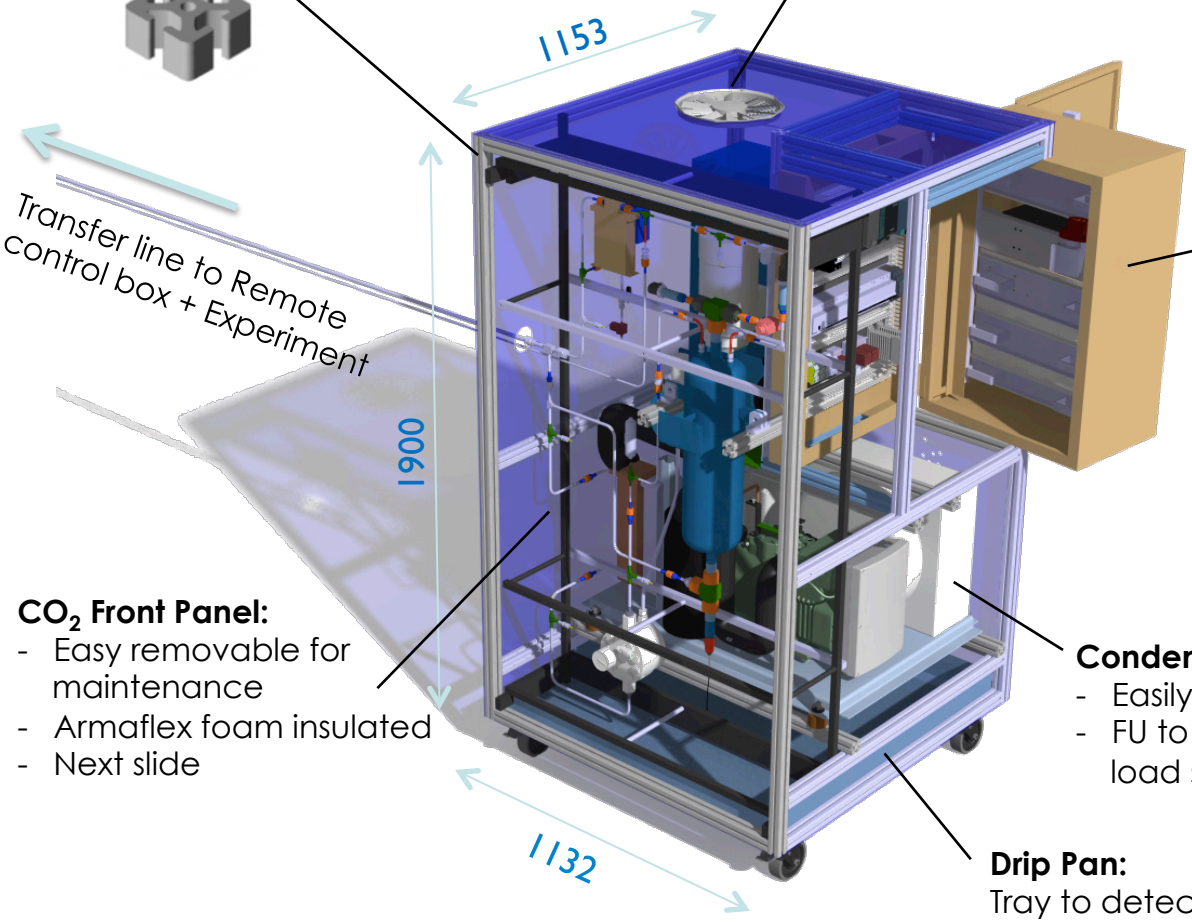
Flow: 20.5 ln/s,
applied heat power: 100 W

Solidworks reproduces measurement trends correctly.
Thermal neutrality is achieved with thicker fins.

TRACI-XL Main components

Aluminum profiles frame:
Item profiles 8 40x40 mm

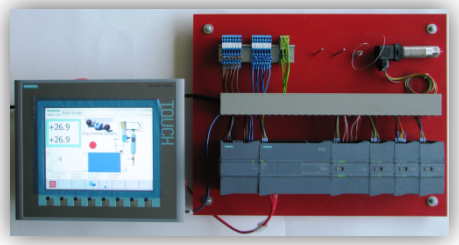
Top Exhaust:
Extract pump + electronics heat



Technical specifications

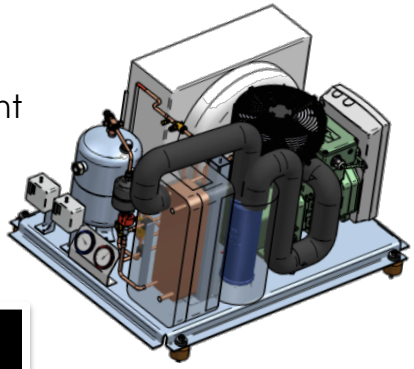
- Power: 1kW @ -40 ºC
- Power supply: three-phase
- Weight almost 600 kg
- Dimensions: 1132x1153x1900
- PLC controlled

Control cabinet:
- 2 Layer (HV + LV)
- HMI for friendly User experience
- GSI+Tübingen



CO_2 Front Panel:
- Easy removable for maintenance
- Armaflex foam insulated
- Next slide

Condensing unit:
- Easily detachable
- FU to adapt to different load situations



Drip Pan:
Tray to detect CO_2 leakages

With TRACI-XL you will be able to test **7 FEE blocks** of 140 W
For example ¼ Stations 4, 5 or 6 →
Thermal box is foreseen to have this size or maybe half station size with dummy loads instead the rest of blocks

Commercial CO_2 power plant

- No oil-free setup needed
- No particular temperature stability requirement
- 50 kW externally cooled liquid CO_2 system with 1 kW standby power

- Company: Hafner-Muschler (http://www.hafner-muschler.de/)
- System similar to CERN 2PACL principle with liquid CO_2 (not transcritical)

Conclusions

- CO_2 based cooling system is required to cool 42 kW of power.
- Heat exchanger design has been optimized using simulation approach
- Verified by the measurements
- 1 kW TRACI-XL system is in production. Commissioning to start in July
- Industry partners identified for a final STS cooling system.