Karlsruhe Institute of Technology

SuperKEKB

CO_2 Cooling of PXD Endflange: Results of CERN Cooling Test

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Institut für Experimentelle Kernphysik

Belle II

DEPFET

Active Pixel Detector

Overview

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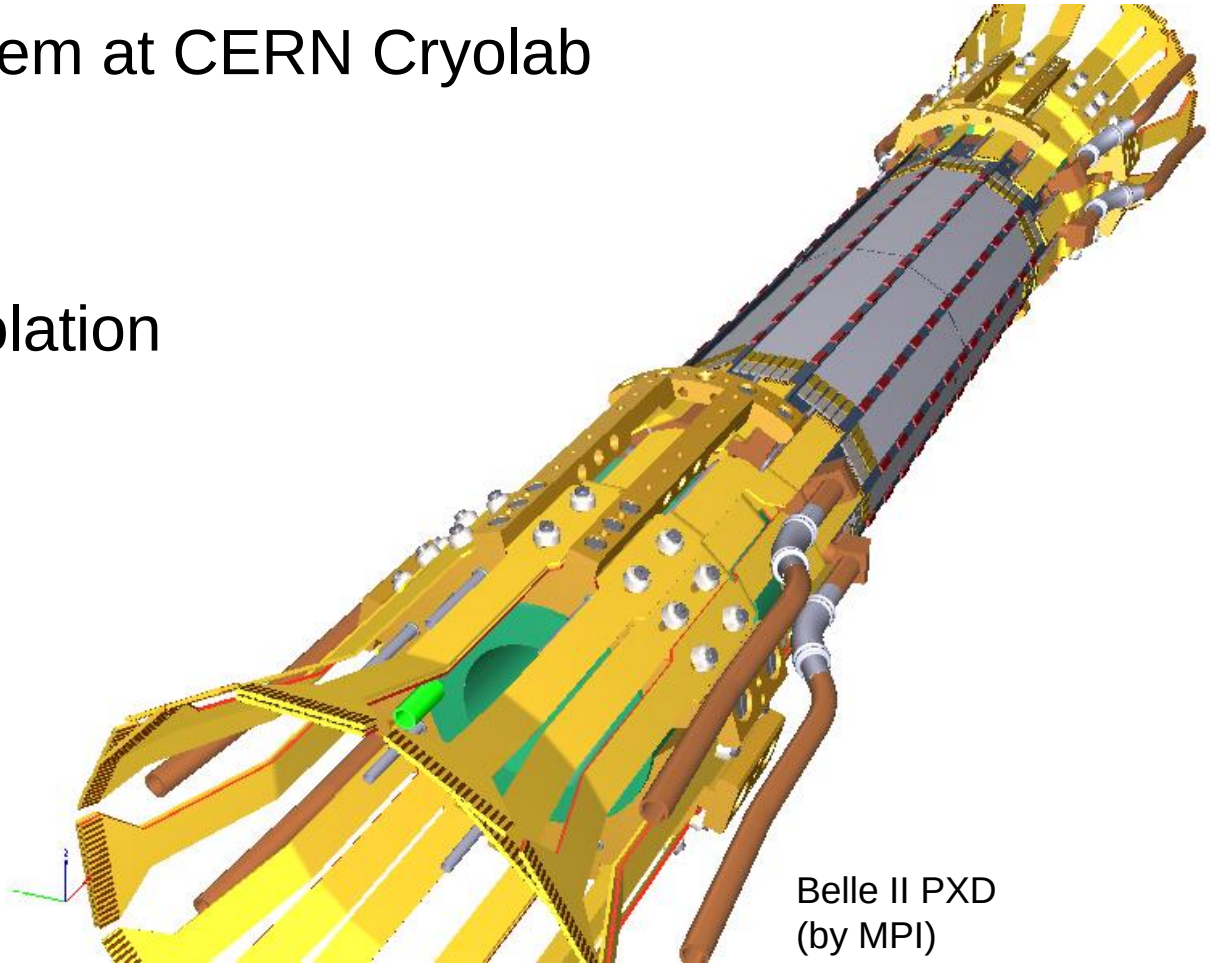
6. Summary

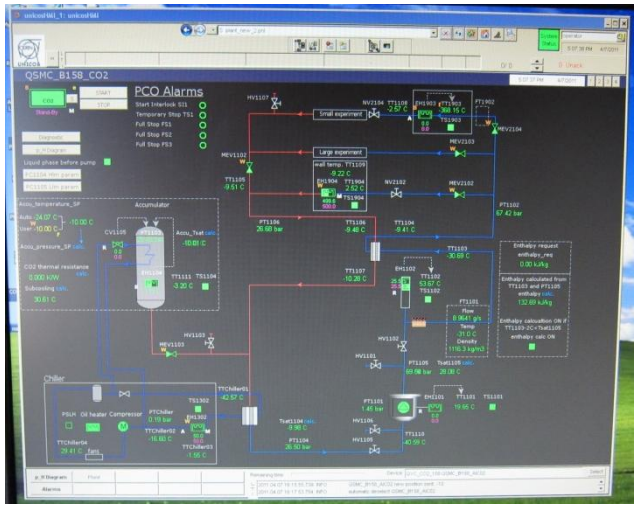


Belle II PXD
(by MPI)

1. CERN Cooling Test

- **Purpose:** demonstrate PXD cooling solution working with closed CO_2 system

- Stayed at CERN from 04.04. to 08.04.: three full days of data taking
- About 2 million data points taken
- No major problems during test



PVSS Control Software

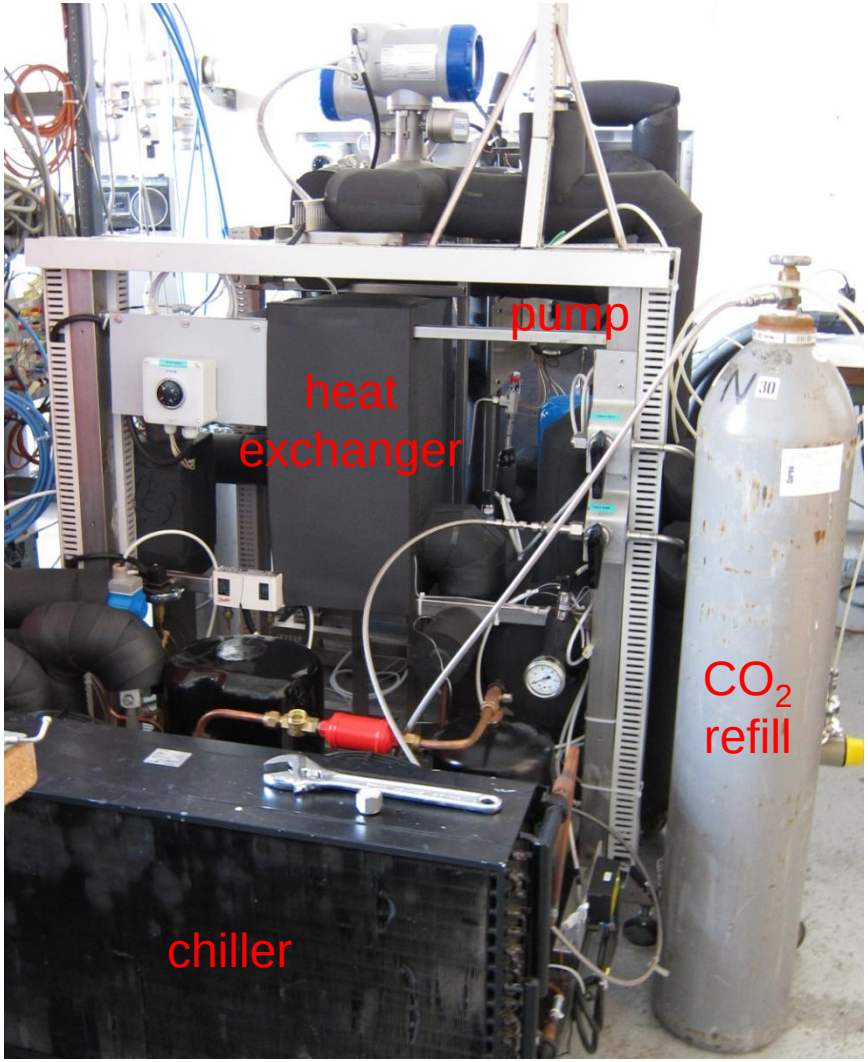
- Friday: “Detector Seminar” on CO_2 cooling by B. Verlaat (download at http://indico.cern.ch/conferenceDisplay.py?confId=132770)

2. Closed CO_2 system at CERN Cryolab

- Closed system built by the "CO_2 Cooling Collaboration" (B. Verlaat, H. Postema et al.)
- Based on experience with AMS and LHCb systems

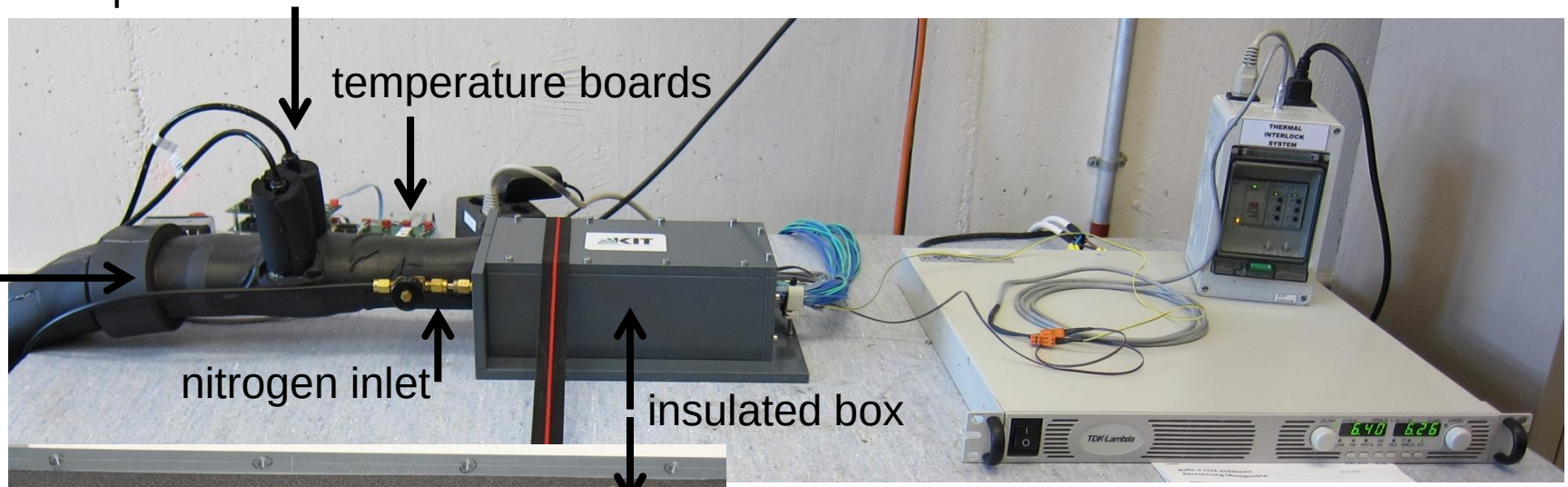
- Max. cooling power: >2000 W
- Max. CO_2 mass flow: 10 g/s

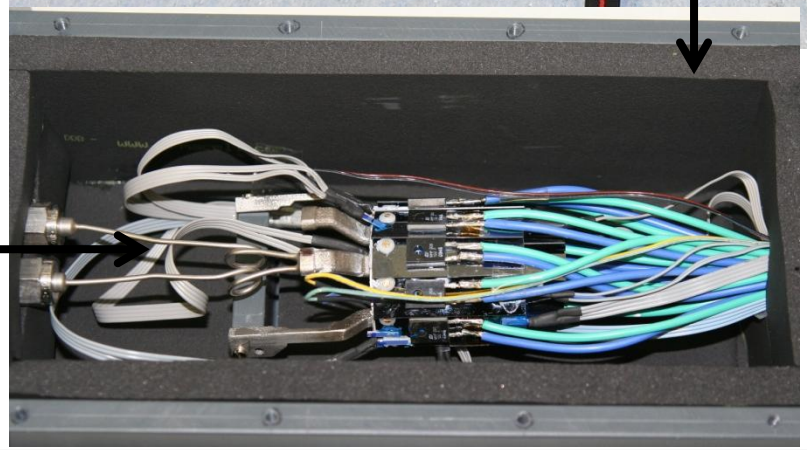
- Seen as a test system only (too complicated)



3. Test setup

- Overview:

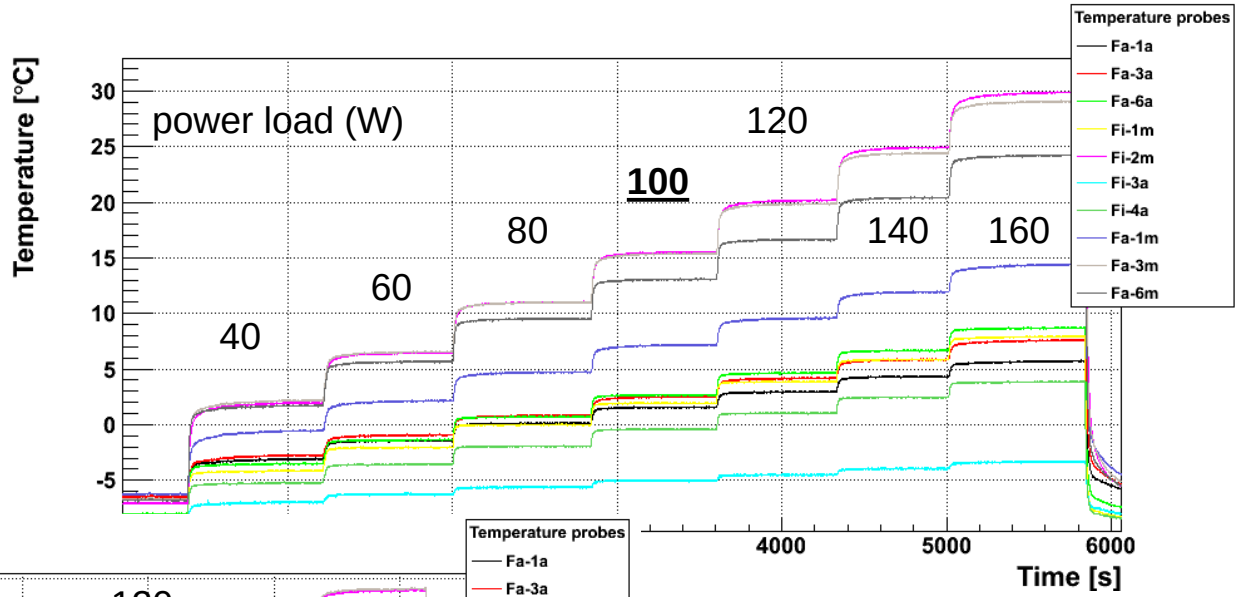


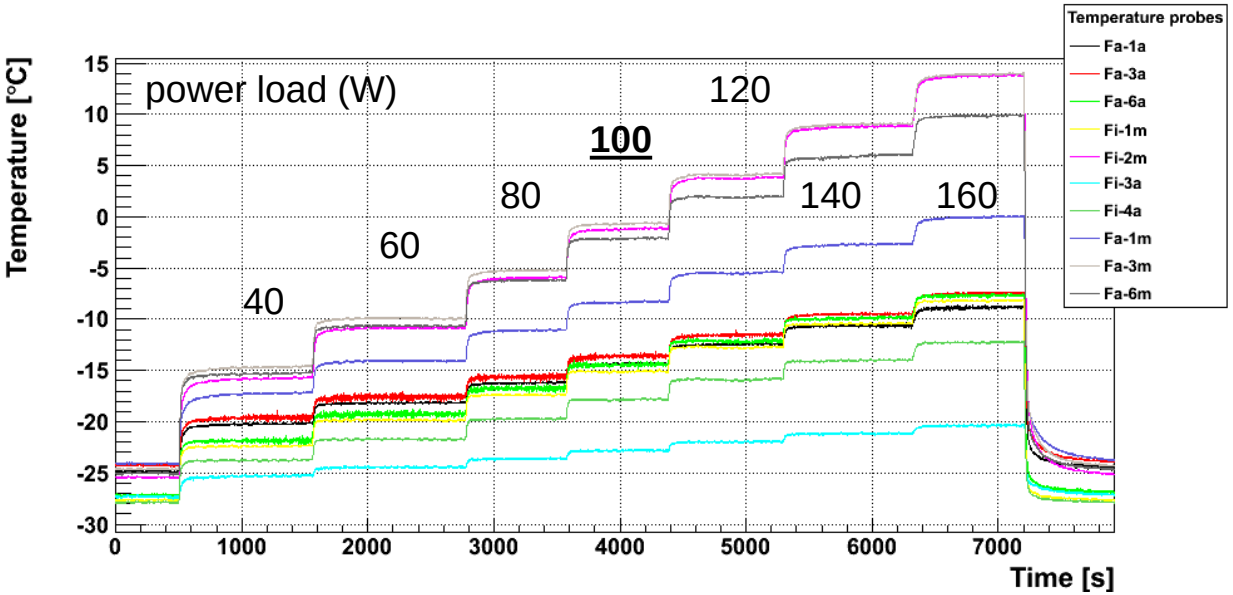


- Endflange prototype in N_2-flushed box
- Equipped with silicon pieces and resistors (20 W each)
- 11 Pt1000 for temperature readout

4. Results

- CO_2 flow: 1,5 g/s
- right:
  setpoint **-10°C**
- below:
  setpoint **-30°C**

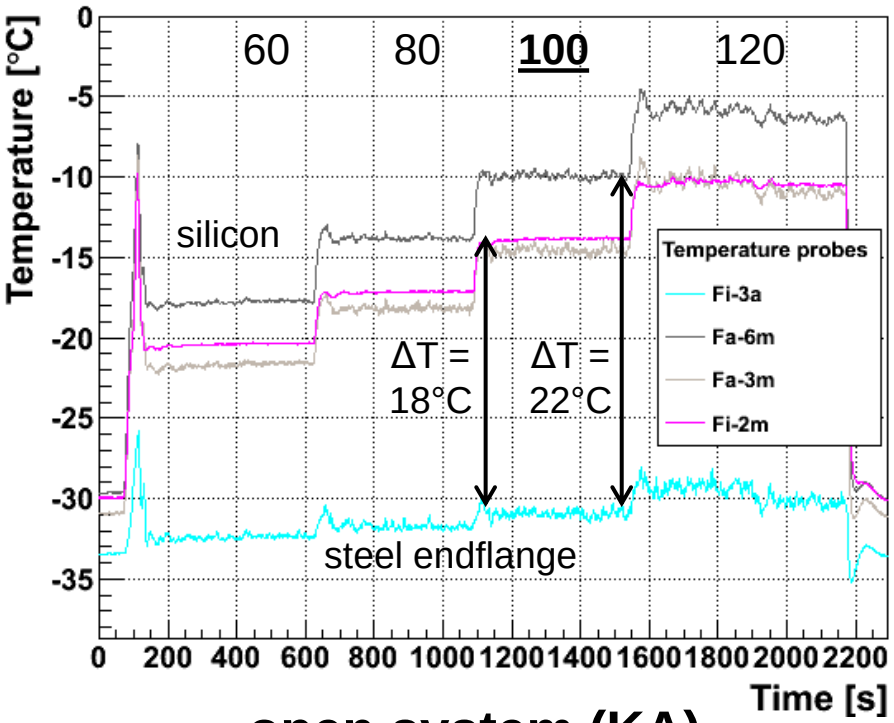




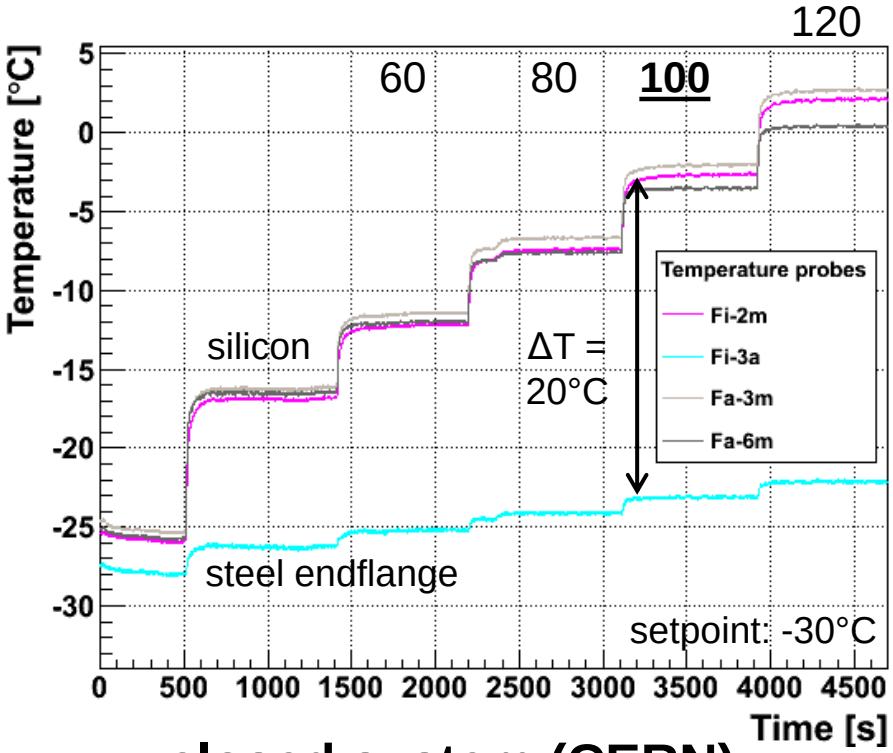
- -10°C:
  all points below 15°C (@100 W)
- -30°C:
  all points below 0°C (@100 W)

4. Results

- Comparison between open and closed system:



open system (KA)



closed system (CERN)

- temperature difference comparable between systems
  (remark: some silicon pieces replaced)

5. CO_2 flow extrapolation

- Test done with ¼ of real PXD detector (power load: 100 W)

- **Question:** CO_2 flow needed for full detector (400 W)?
- Simple calculation: ~~4x 1 g/s = 4 g/s~~ **Not correct!**

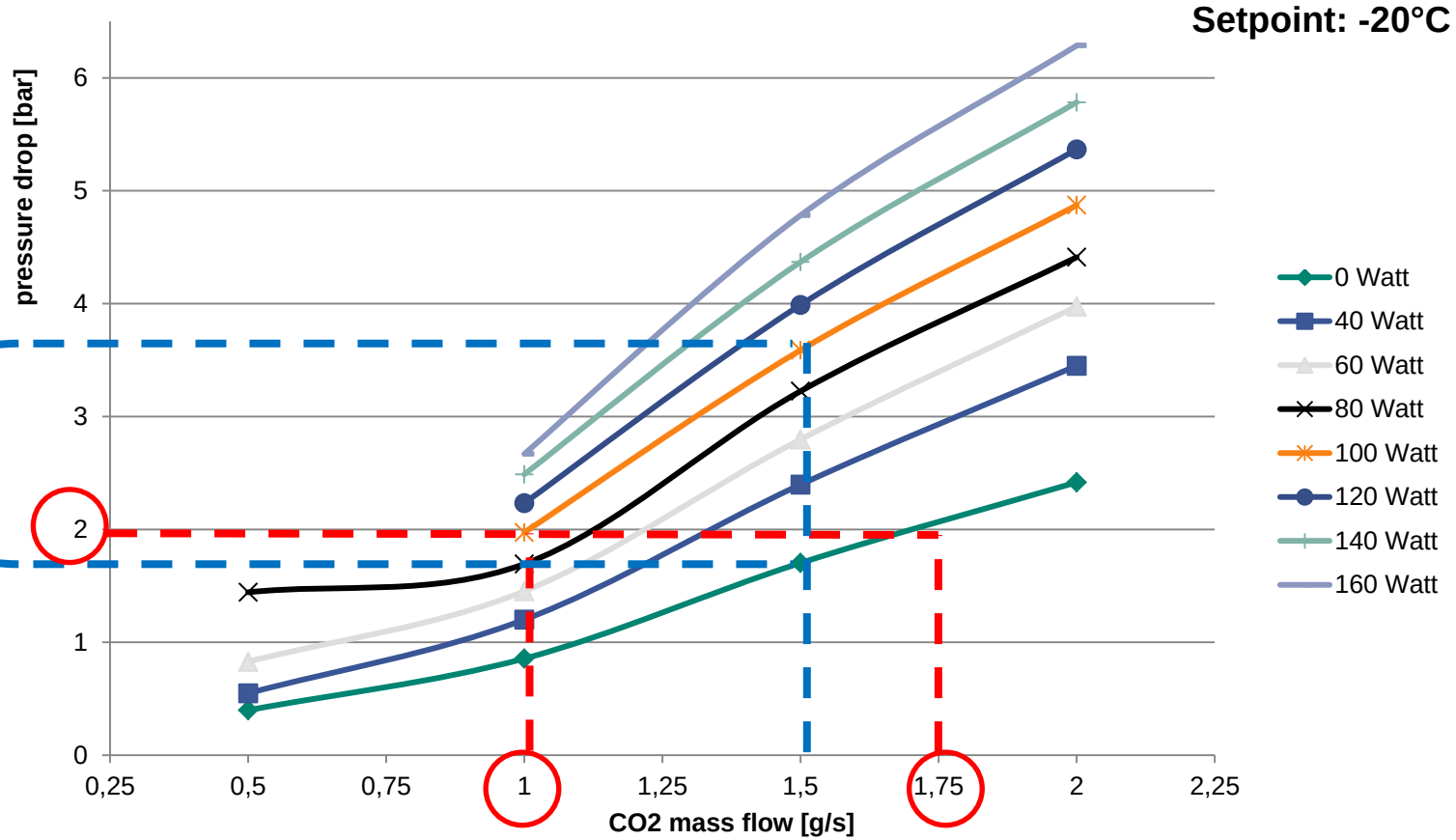
- Different power loads result in different flows
- Problem: highest power load receives smallest flow
- For safety: max. evaporation 50%!

- **Solution:** run system with overflow
  - Worst case scenario: one flange @ 100 W, three @ 0 W

5. CO_2 flow extrapolation

- Extrapolate total flow from pressure drop plots:

3. all blocks equally heated: 6.25 / 4 = 1.56 g/s → pressure drop: <u>1.7 to 3.7 bar</u>



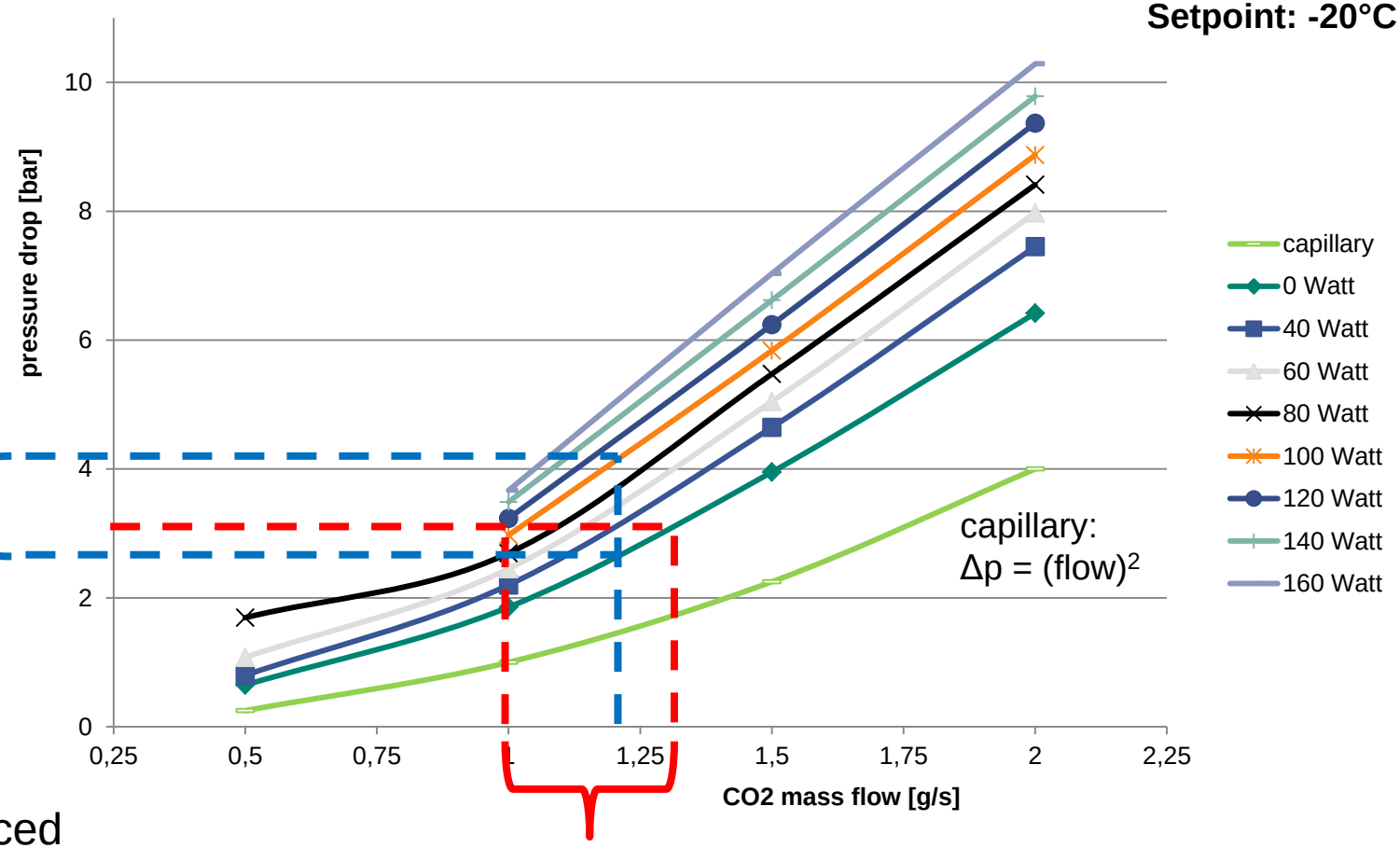
1. one block at 100 W: min. 1 g/s → defines pressure drop

2. block at 0 W, same drop: 1.75 g/s → total flow: 1+3*1.75 = <u>6.25 g/s</u>

5. CO_2 flow extrapolation

- Optimization of results: adding an inlet resistance

Setpoint: -20°C



3. all blocks equally heated: 4.9 / 4 = 1.23 g/s → pressure drop: <u>2.7 to 4.2 bar</u>

Max. flow and variation reduced due to inlet capillary.

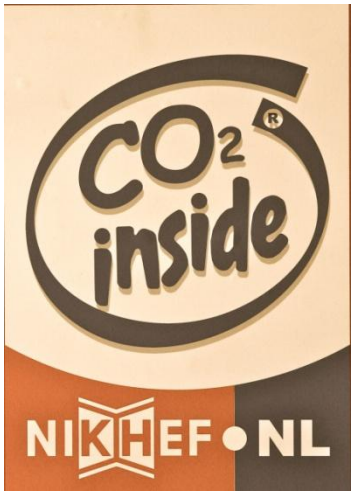
2. new total flow: 1+3*1.3 = <u>4.9 g/s</u> (~78%)

6. Summary

- Results from open CO_2 system confirmed:
  PXD cooling concept working!
- Next iteration of endflanges will give even better results

- First extrapolation to requirements of full detector: minimum flow about **5 g/s** (plus any heat leaks!)
- Inlet resistance (e.g. capillary) required

- Thanks to Bart Verlaat, Hans Postema and the "CERN CO_2 Cooling Collaboration" for providing the closed system and support



Thank you…

Backup

3a. Positions of temperature probes