Cooling Operation and VXD Thermal Mock-up Studies

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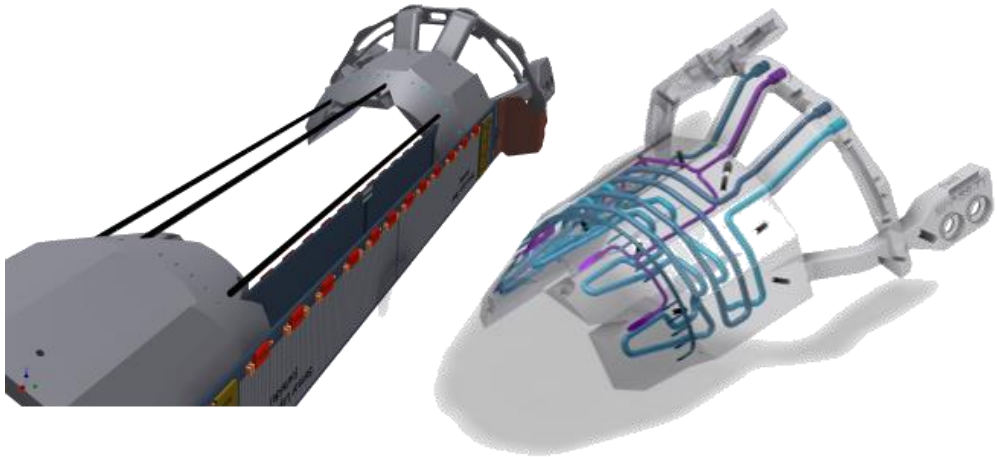
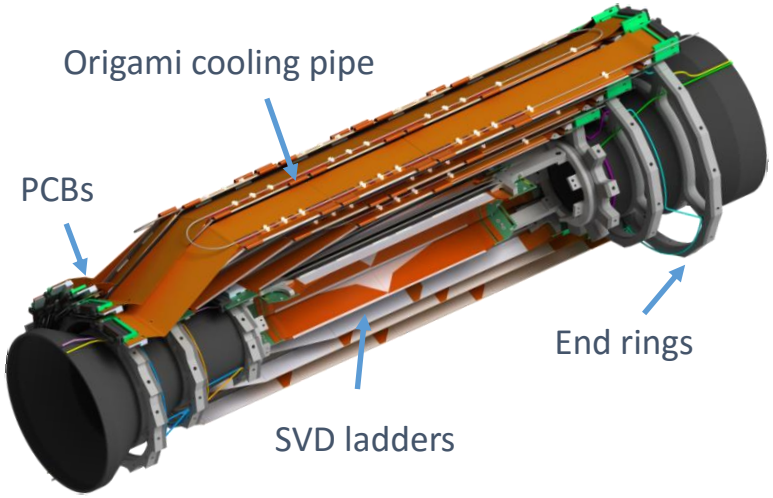
VXD Cooling System

Cooling of the PXD



Combined Support Cooling Block (SCB), manufactured using 3D printing technology, with CO_2 and *N2* channels inside.

Cooling of the SVD

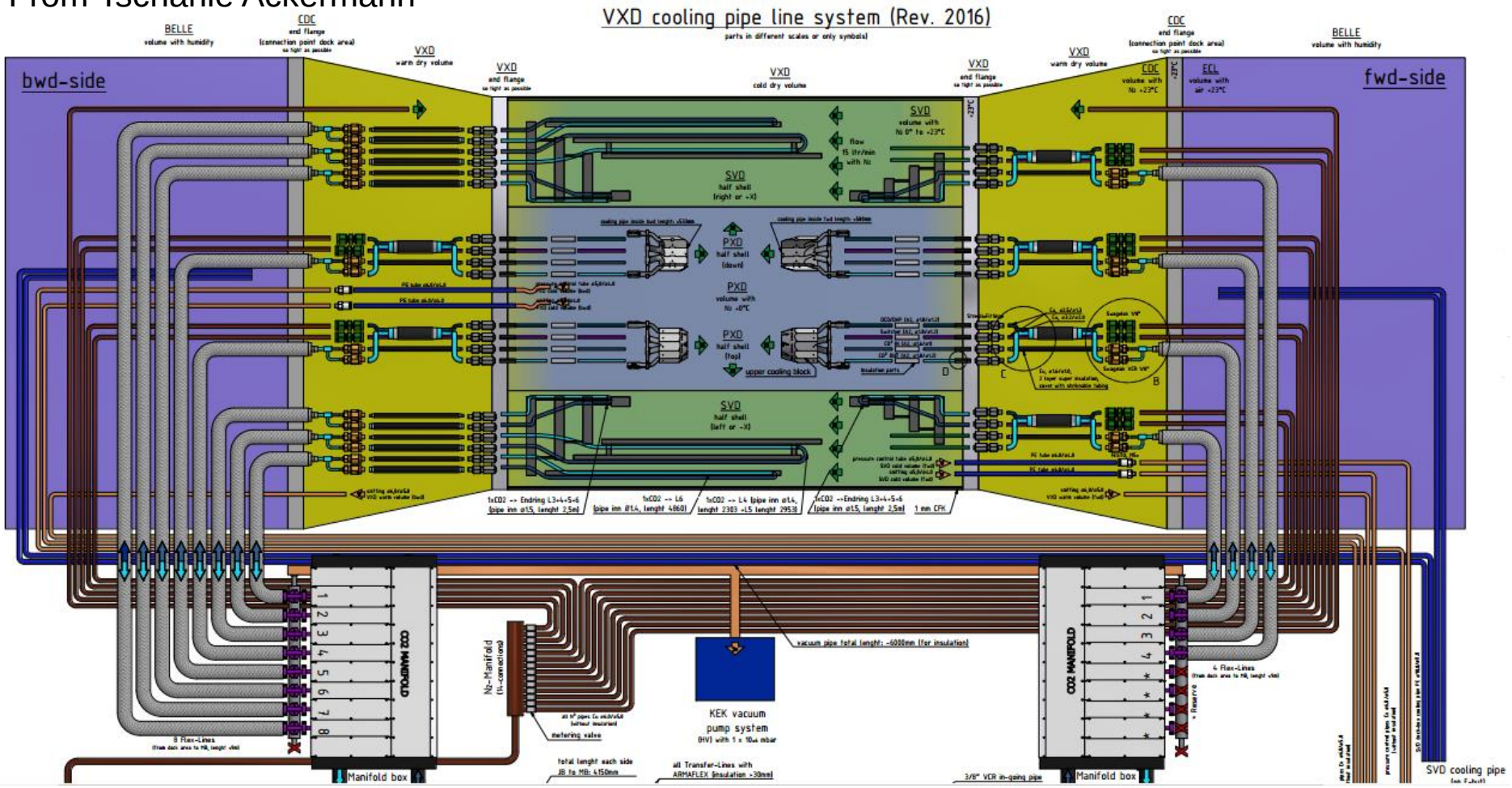


Requirements

- ❑ PXD: Sensor < 25°C to minimize shot noise due to leakage current; ASICs < 50°C to avoid risk of electro-migration;
- ❑ SVD: APV25 readout chips surface@~0°C for SNR improvement;
- ❑ Power consumption: PXD 360W; SVD 700W, required cooling capacity of 2-3kW.

VXD Cooling Pipe Line System

From Tscharlie Ackermann

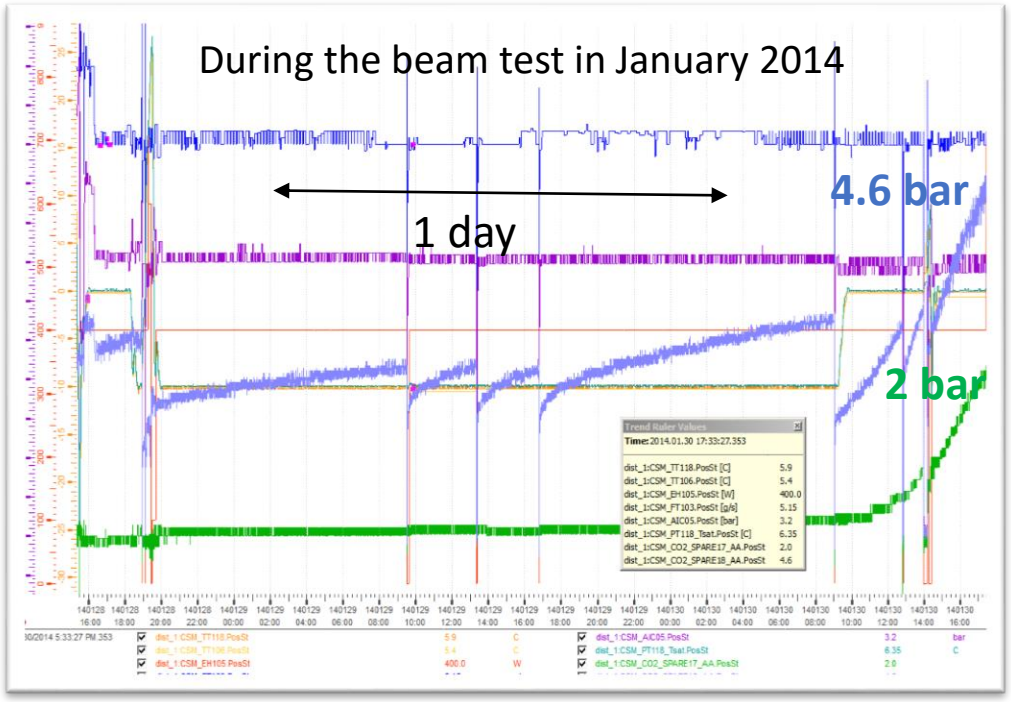


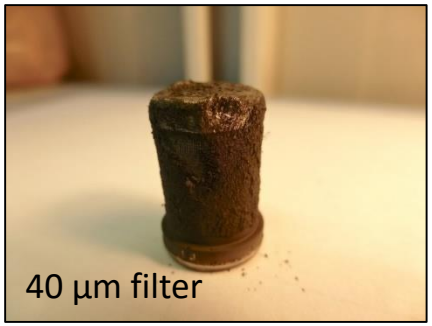
It is difficult to protect the N2 from assuming ambient temperature, even after rerouting.
The SCB provides sufficient cooling to N_2.

Cooling Operation in Test Beam

Things that worked for long term operation

- In TB14, abrasive wear of gears caused clogging of micro filters. The new pump (upgraded in Jan.2016) worked fine and solved this problem.





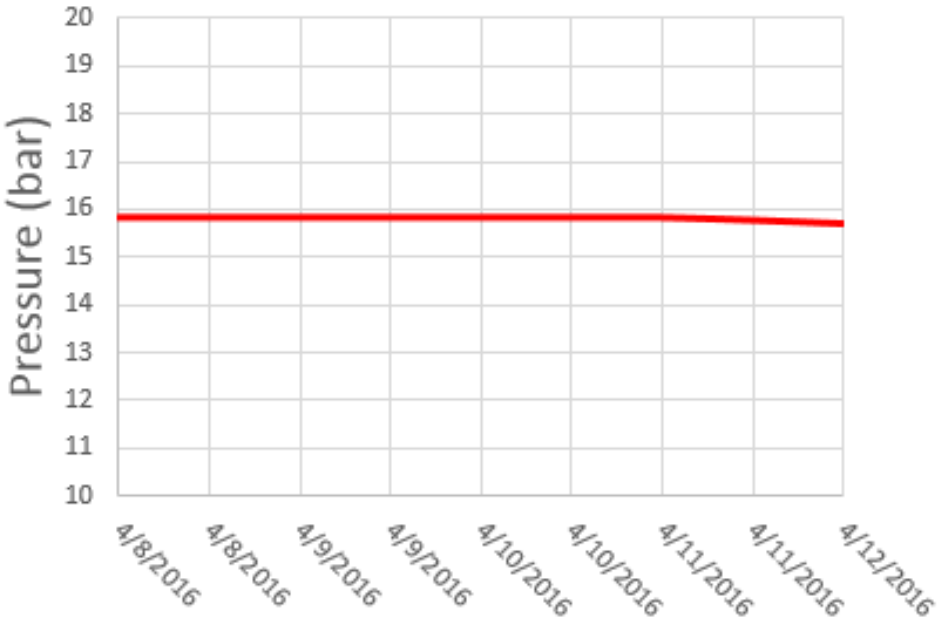
- For long term running, we need to fill CO_2 while it's running, with the speed of 100g/min, no temperature changes in detector.

Cooling Operation in Test Beam

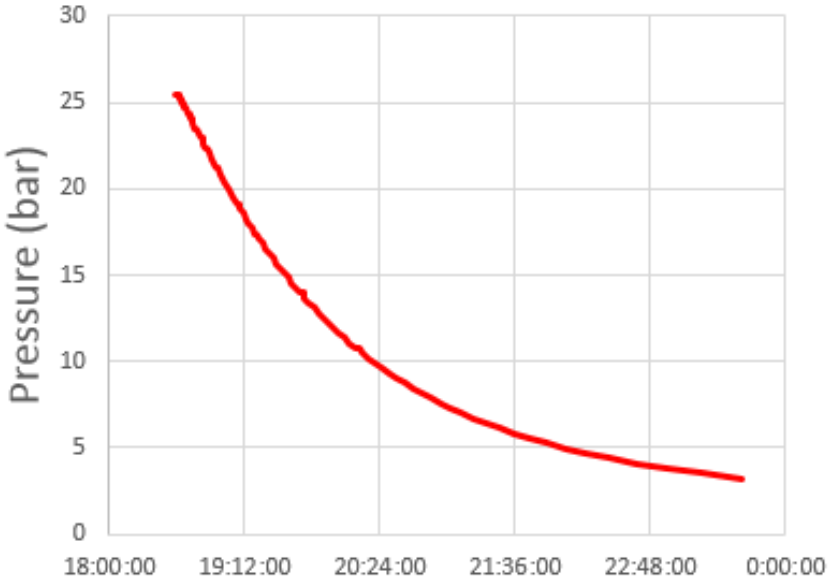
Things did not work during TB16

- Leakage of CO_2!

Pressure test



Before commissioning



After the test beam

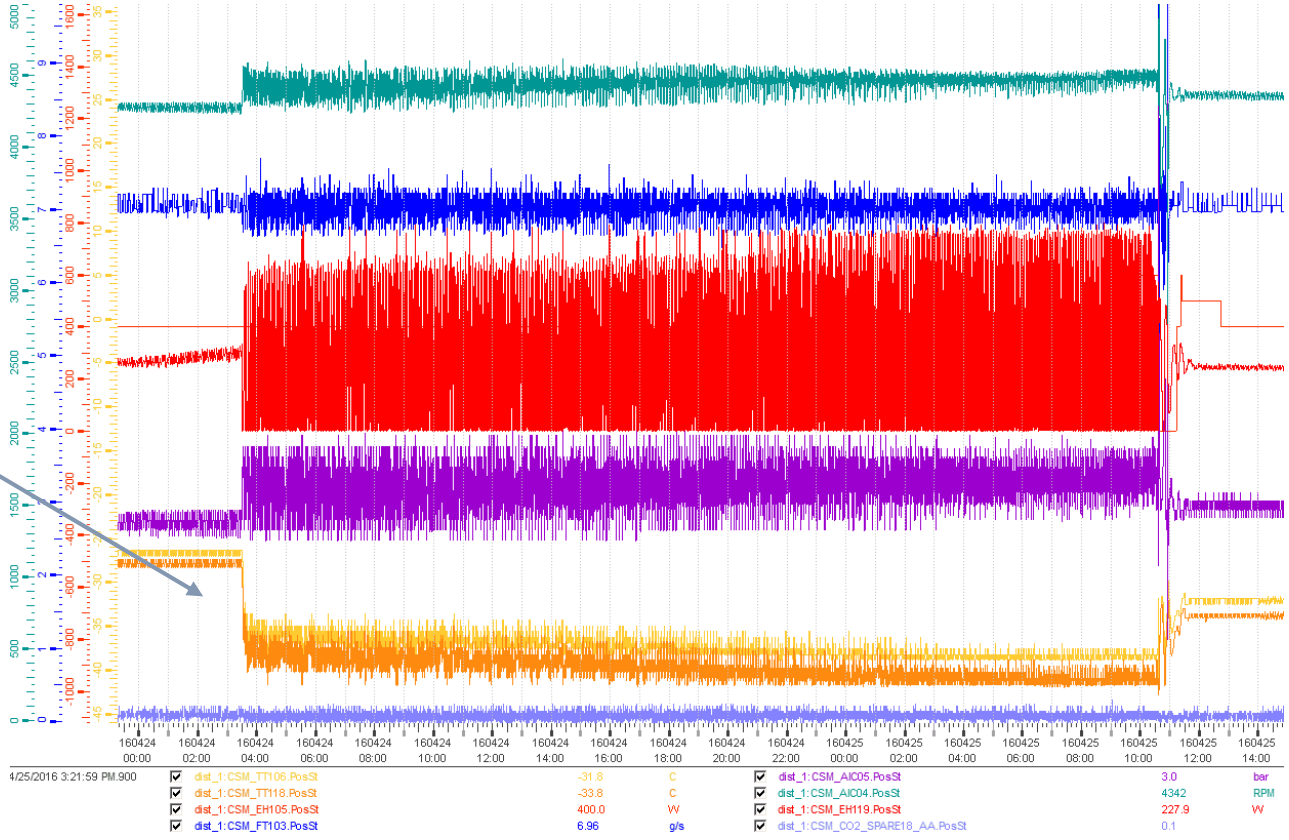
Cooling Operation in Test Beam

→ Leakage result in low temperature below dew point (~-34°C)

This is due to the logic setting in Marco

When liquid level in accumulator is low, temperature inside raised fast with the heater and triggered the condenser. Iteratively the experiment circuit got cooled.

T(CO_2) in/outlet decreased to -40°C.



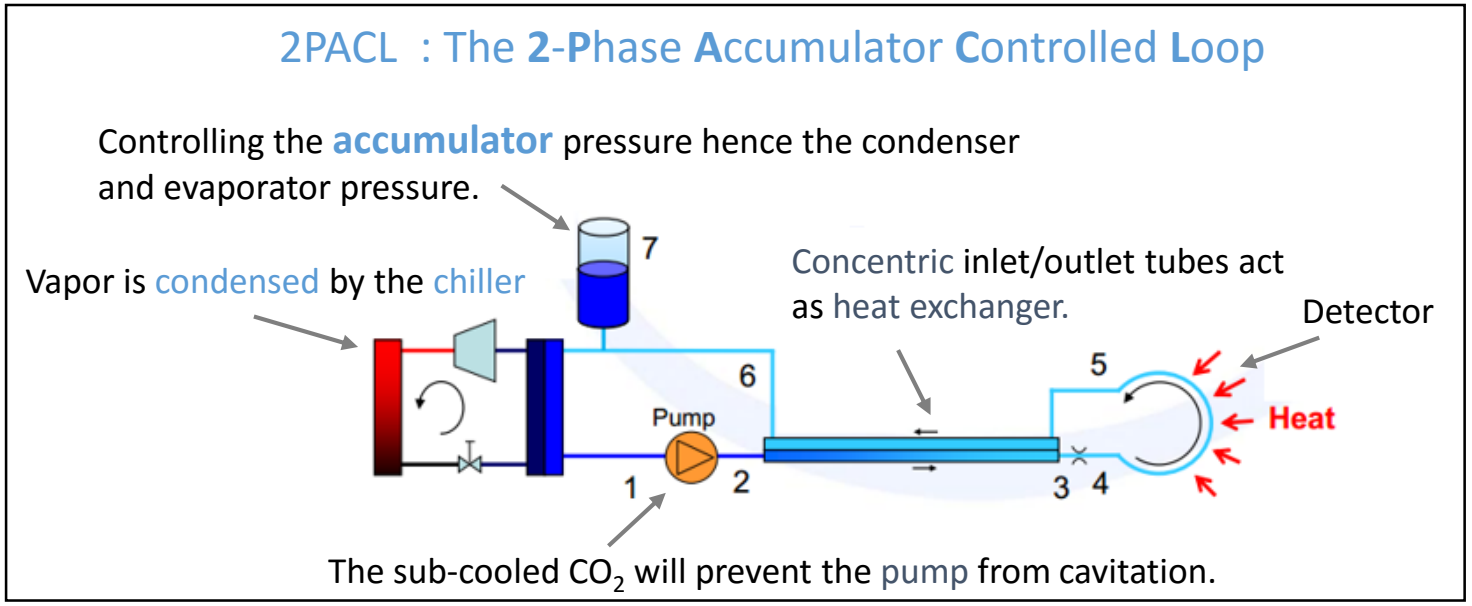
Cooling Operation in Test Beam

Thermal test with our VXD mockup

CO_2@-40°C, dew point ~ -35°C, endrings temperature ~-30°C

After 2 hours running, no condensation observed.

→ Leakage may cause cavitation at the CO_2 pump, which can be easily damaged in this case.



Pressure of 2-phase CO_2@-30°C is about 14bar.

Thermal Mock-up Studies@DESY: Temperature on PXD

A plastic cylinder (ID 18cm, length 70cm) act as dry volume.

In Nov.2015

CO_2@-30°C; N_2 23L/min

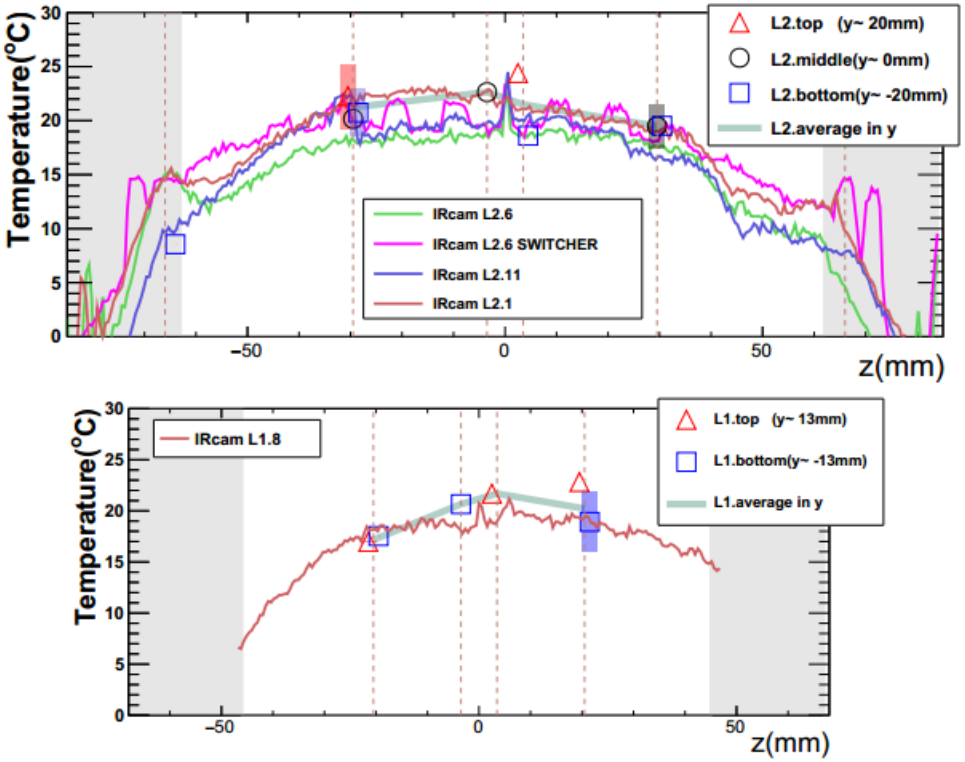


Figure 5: The temperature distribution of PXD ladders along the z-direction. BW(FW) is on the left(right) side. The gray areas indicate the regions of DCD/DHP, while the 75μm thick sensitive area is shown in the center. The thick solid line indicates the averaged temperature along z-direction measured from the Pt100s. Different markers show the average temperature in y-direction at certain position along z-axis, the error bar on the marker represents the temperature range in x-direction. Thin solid lines show the temperature distribution measured by the IR camera on selected ladders.

Thermal Mock-up Studies@DESY: Temperature on PXD

A plastic cylinder (ID 18cm, length 70cm) act as dry volume.

A paper will be submitted to Nucl.Instrum.Meth.A

Thermal mock-up studies of the DEPFET pixel vertex detector for Belle II

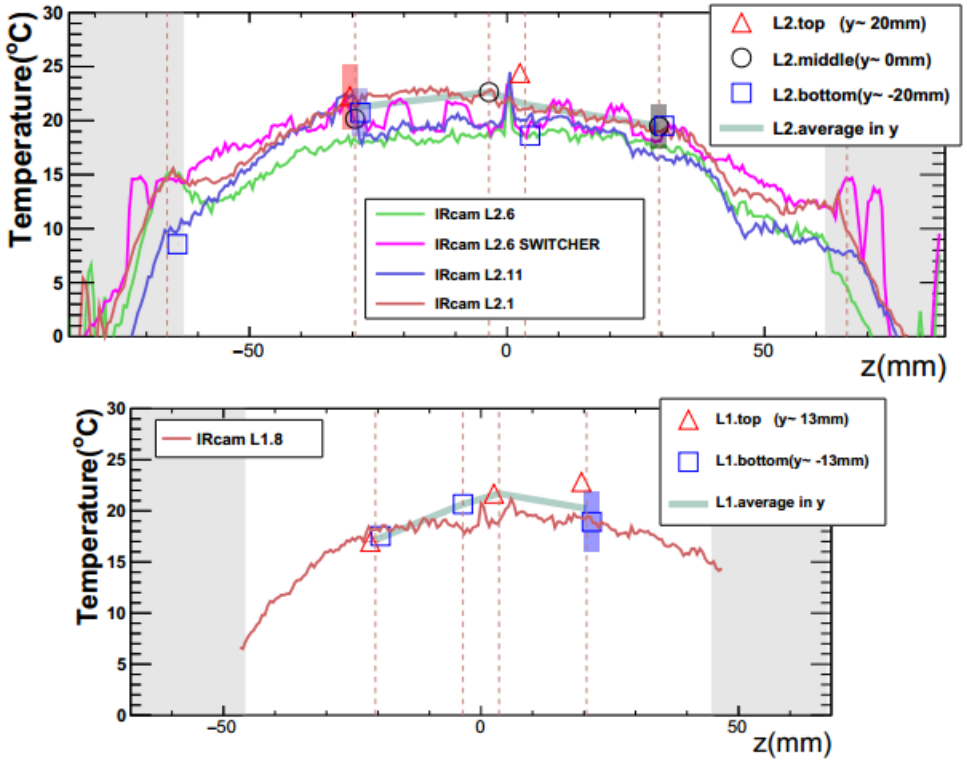
Author List

Abstract

The Belle II experiment currently under construction at the e^+e^--collider SuperKEKB in Japan is designed to explore new physics beyond the standard model with an approximately 50 times larger data sample compared to its predecessor. The vertex detector (VXD), comprising a two layer DEPFET pixel detector (PXD) surrounded by four layers of double sided silicon strip detector (SVD), is indispensable for the accurate determination of the decay point of B or D mesons as well as track reconstruction of low momentum particles. In order to guarantee acceptable operation conditions for the VXD and the surrounding Belle II drift-chamber (CDC) the cooling system must be capable of removing a total heat load from the very confined VXD volume of about 1 kW plus some heat intake arising from the SuperKEKB beam pipe. Evaporative two-phase CO_2 cooling in combination with forced air flow has been chosen as technology for the VXD cooling system. To verify and optimize the vertex detector cooling concept, a full-size VXD mock-up is being constructed at DESY. First studies of the thermal and mechanical performance of the PXD mock-up are presented in this paper.

Keywords: DEPFET, Belle II, vertex detector, CO_2 cooling, thermal mock-up

CO_2@-30°C; N_2 23L/min



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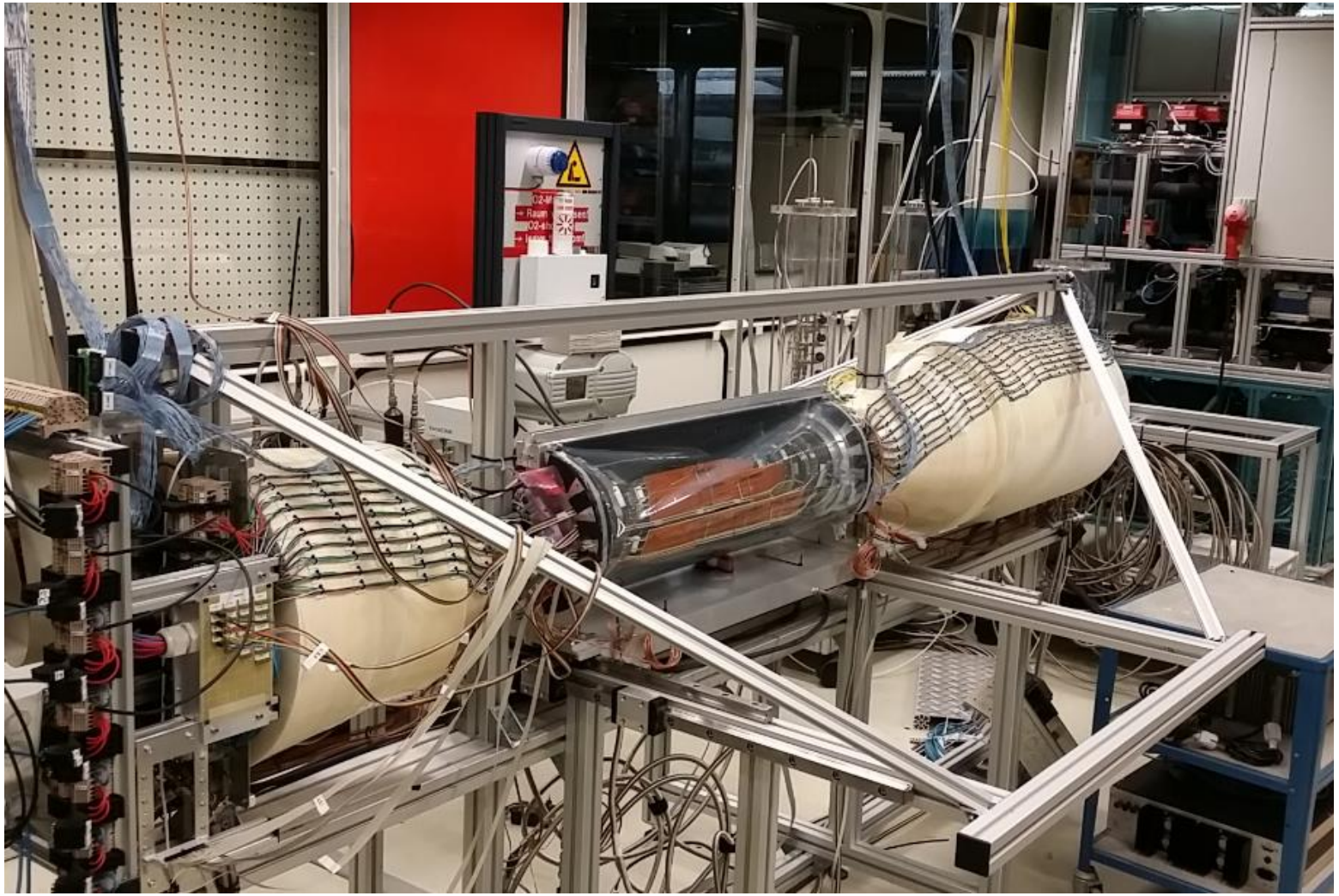
VXD Thermal Mockup @DESY



In Mar.2016

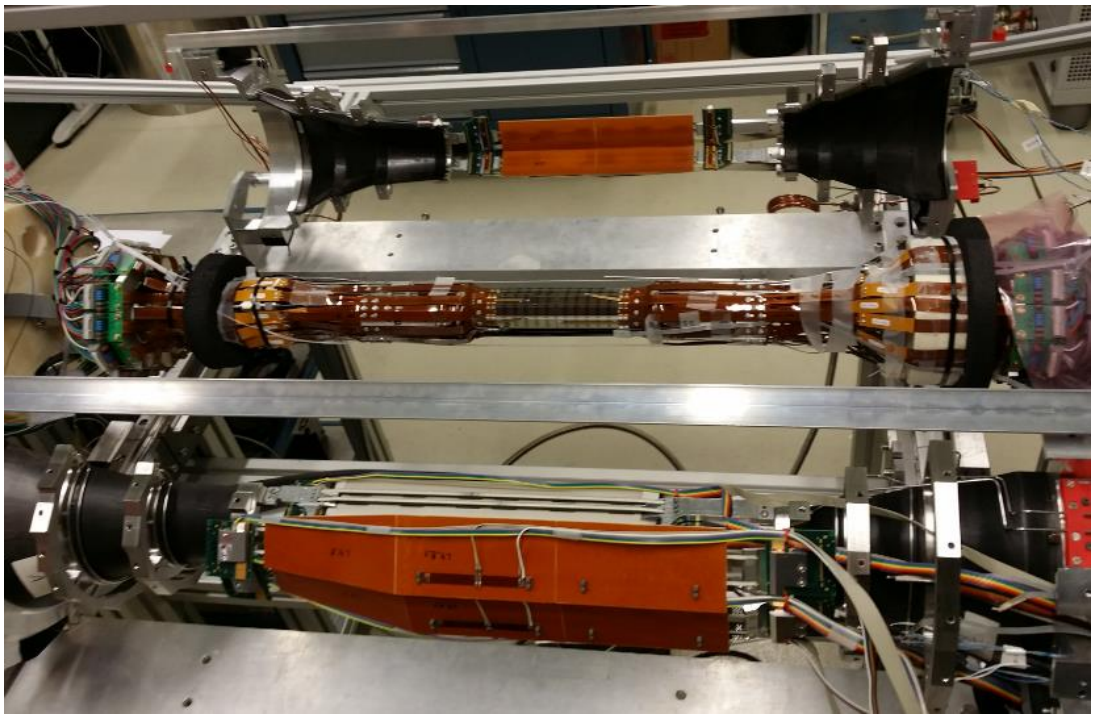
VXD Thermal Mockup @DESY

Preparation of SVD parts:

- ✓ SVD Ladders
- ✓ Endring
- ✓ L.6 Cooling pipe
- ✓ NTCs on endring and CO2 in/outlet from Trieste group

What are missing?

- L4/5 cooling pipes
- Two L.6 ladders with tunnels for FBGs.



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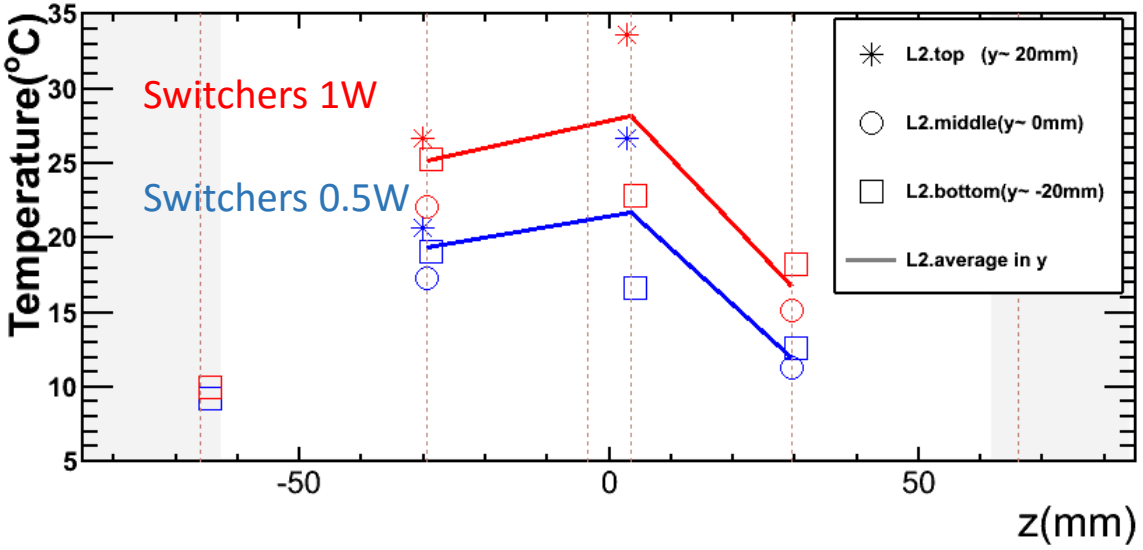
Temperature distribution on PXD in VXD volume

CO_2@-30°C; N_2 20L/min

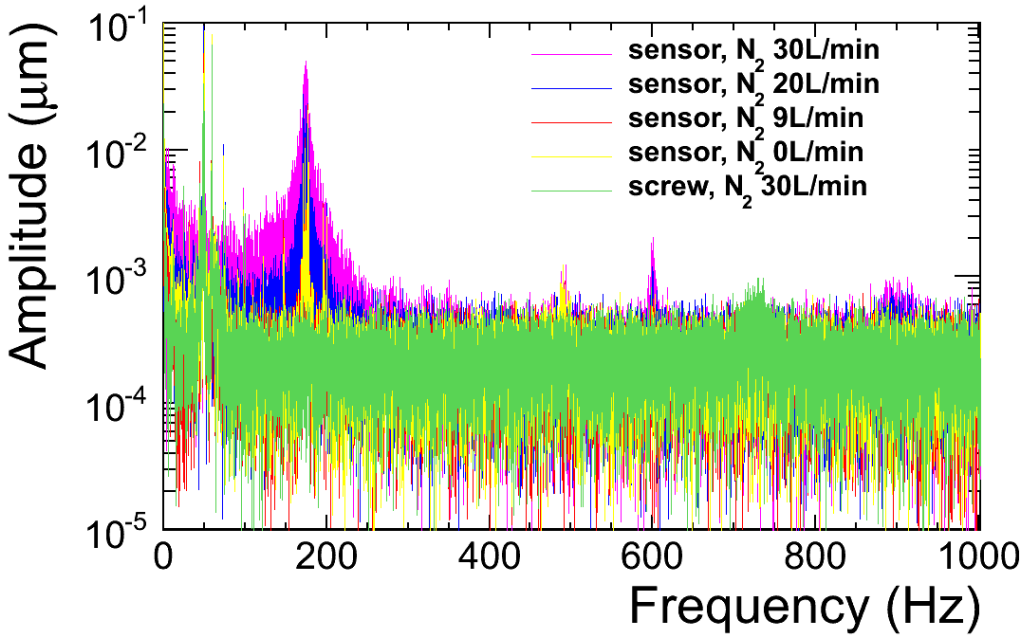
In VXD volume, PXD temperature is ~3°C lower than previous result, due to different N_2 flow pattern and better heat dissipation in larger volume.

Increased power to switchers (0.5W -> 0.9W) will raise the temperature for ~5°C



Mechanical Studies

Vibration injected by 20L/min N2 flow: frequency of 175Hz, amplitude of about 0.02µm.



Deformation caused by temperature gradient along the sensor:
When CO_2 reach -30°C, PXD sensors deforms ~200µm in +r direction.
With the full load given, the sensors comes back to room temperature, the deformation is ~40µm.

Short Summary

Cooling Operation

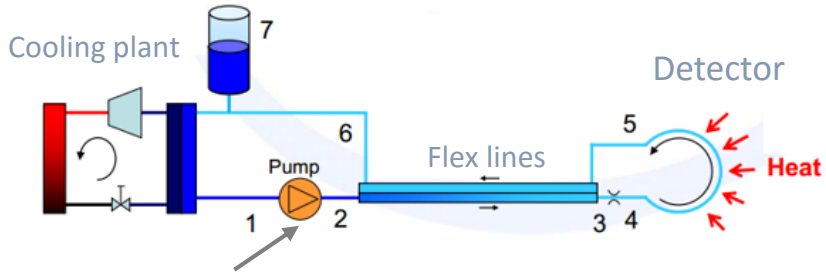
- The new pump works fine.
- We need to make sure there is no CO_2 leakage.
- Interlock on lower limit of CO_2 temperature is necessary.

VXD Thermal Mock-up

- A paper about thermal tests of PXD is prepared will be submitted to Nucl.Instrum.Meth.A.
- Combined thermal tests with PXD and SVD will come soon.

backup

→ May result in cavitation in the CO_2 pump, which can easily damage the pump in this case.



The sub-cooled CO_2 will prevent the pump from cavitation.

How to address.

Make sure the whole circuit is leak tight (Pressure test)

No level meter in Marco (not IBBelle), we need interlock on CO_2 temperature.

Things to be tested:

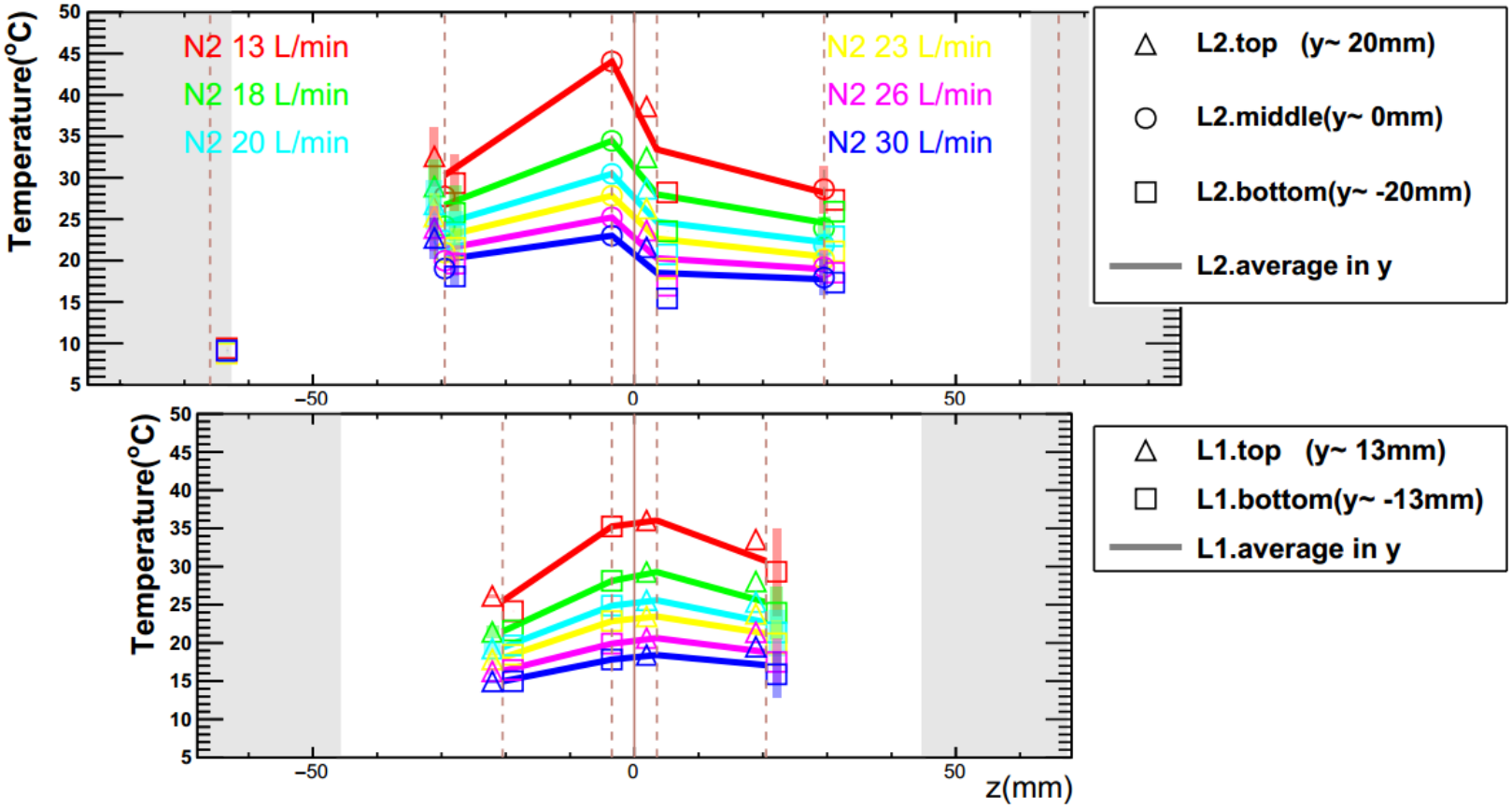
Do we really need so cold CO_2 of -30^{o}C? The full VXD thermal mock-up will tell us.

Lessons learnt.

Be careful in transportation.

Comparison between different N_2 flow

CO_2@-30C, power on.



Comparison between different CO_2 temperature

N_2 flow 23L/min; power on.