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 CO₂ and N₂ channels inside.

Cooling of the SVD

Origami cooling pipe
PCBs
End rings
SVD ladders

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.
It is difficult to protect the N2 from assuming ambient temperature, even after rerouting. The SCB provides sufficient cooling to N$_2$. 

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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.

40 µm filter

New pump
Cooling Operation in Test Beam

Things did not work during TB16

- Leakage of CO₂!

Pressure test

Before commissioning

After the 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(CO₂) 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.

2PACL : The 2-Phase Accumulator Controlled Loop

Controlling the accumulator pressure hence the condenser and evaporator pressure.

Vapor is condensed by the chiller

Concentric inlet/outlet tubes act as heat exchanger.

The sub-cooled CO$_2$ will prevent the pump from cavitation.

Pressure of 2-phase CO$_2$@-30ºC is about 14bar.
A plastic cylinder (ID 18cm, length 70cm) act as dry volume.

In Nov.2015

\( \text{CO}_2@-30^\circ\text{C}; \text{N}_2 \text{ 23L/min} \)

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

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

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VXD Thermal Mockup @DESY

In Mar.2016
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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CO\textsubscript{2}@-30\degree C; N\textsubscript{2} 20L/min

In VXD volume, PXD temperature is \(~3\degree C\) lower than previous result, due to different N\textsubscript{2} flow pattern and better heat dissipation in larger volume.

Increased power to switchers (0.5W -> 0.9W) will raise the temperature for \(~5\degree C\)
**Vibration** injected by 20L/min N2 flow: frequency of 175Hz, amplitude of about 0.02μm.

**Deformation** caused by temperature gradient along the sensor:
When CO₂ 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.
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 CO₂ pump, which can easily damage the pump in this case.

- How to address.
  Make sure the whole circuit is leak tight (Pressure test)
  No level meter in Marco (not IBBelle), we need interlock on CO₂ temperature.

- Things to be tested:
  Do we really need so cold CO₂ of -30°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.