



PXD Thermal Mock-up Study

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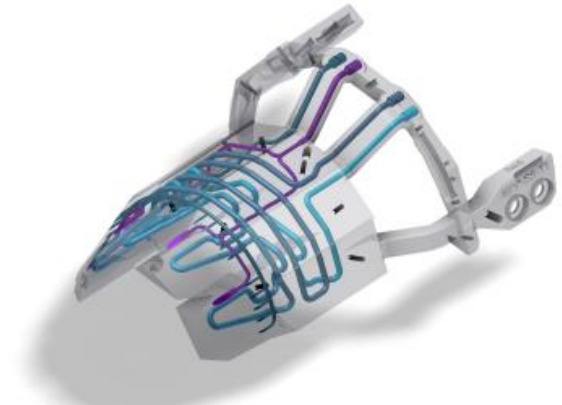
DESY

(hua.ye@desy.de)

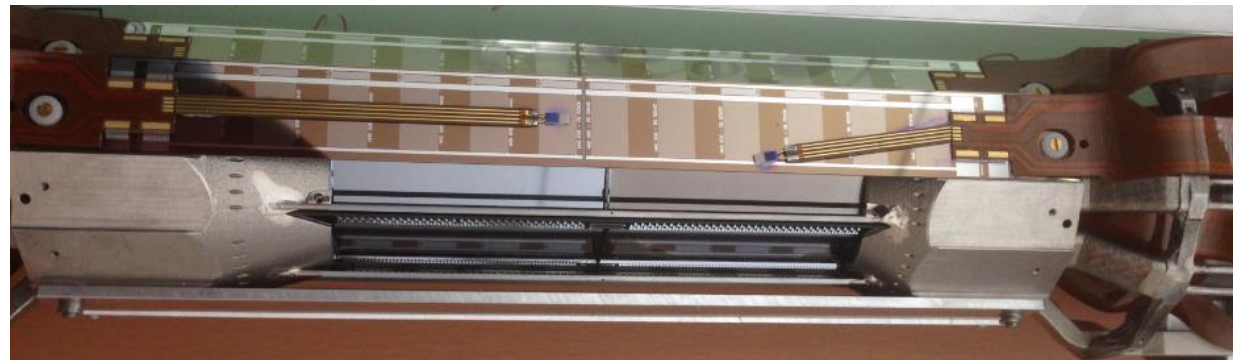
Cooling System Requirements

- ❑ Sensor < 25°C (minimize shot noise due to leakage current)
- ❑ ASICs < 50°C (avoid risk of electro-migration)

CO ₂ Circuit	Detector	Half	Layer	Type	Side	Power [W]
1	PXD	up	1&2	ending	bwd	90
2			1&2	ending	fwd	90
3		down	1&2	ending	bwd	90
4			1&2	ending	fwd	90
sum PXD						360



SCB (Support Cooling Block), manufactured by 3D printing technology, with CO₂ and N₂ channels inside.

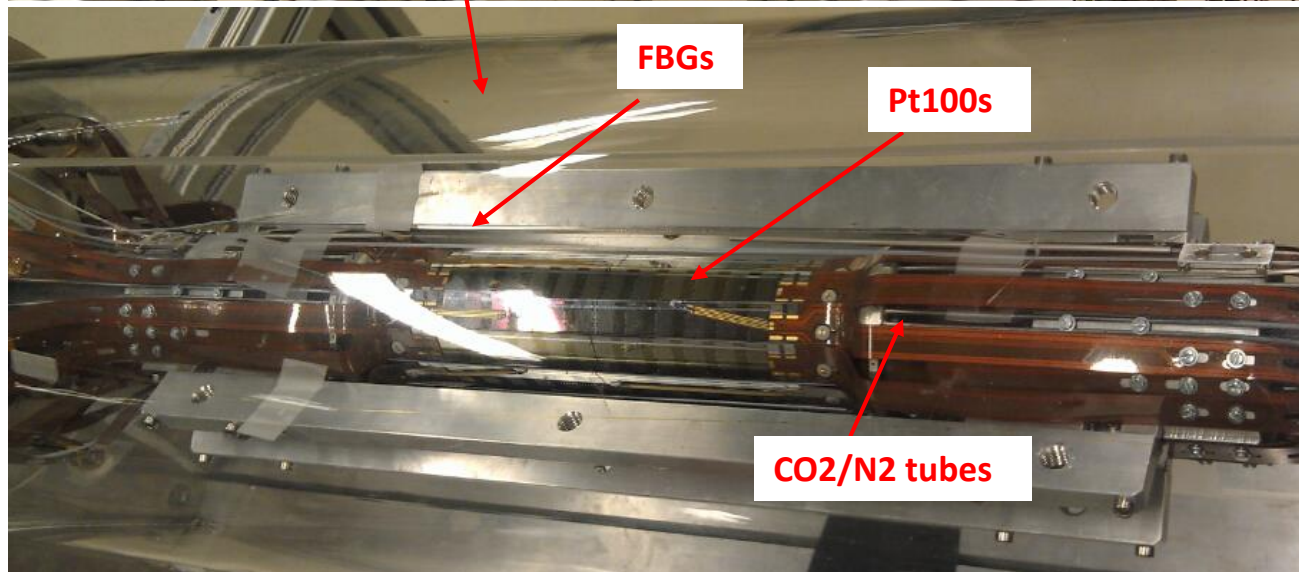
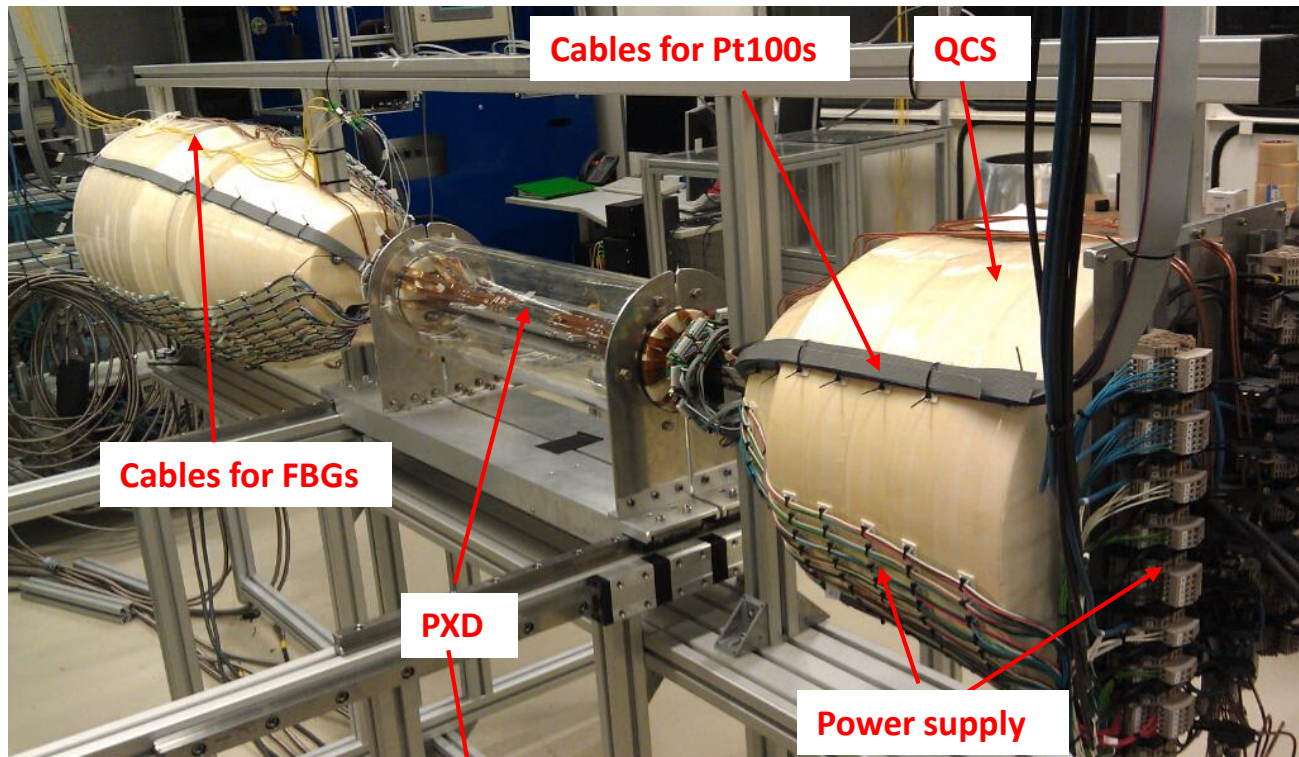


2-phase CO₂ Cooling

Efficient cooling concept for low-mass detector.

- CO₂ is in the two-phase regime.
- Heat removal by evaporating liquid CO₂ at the constant temperature and pressure.

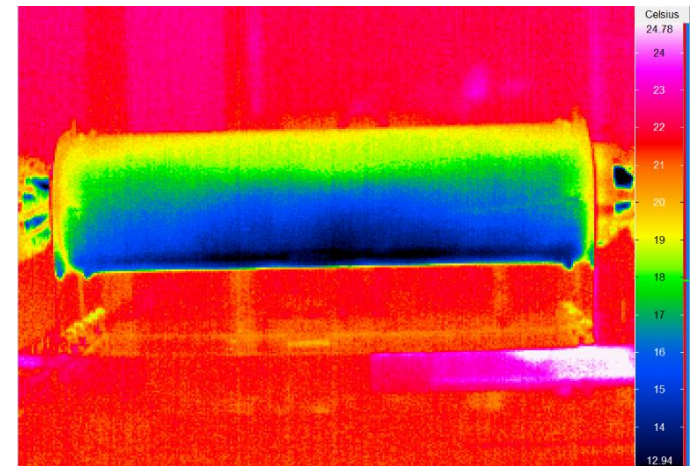
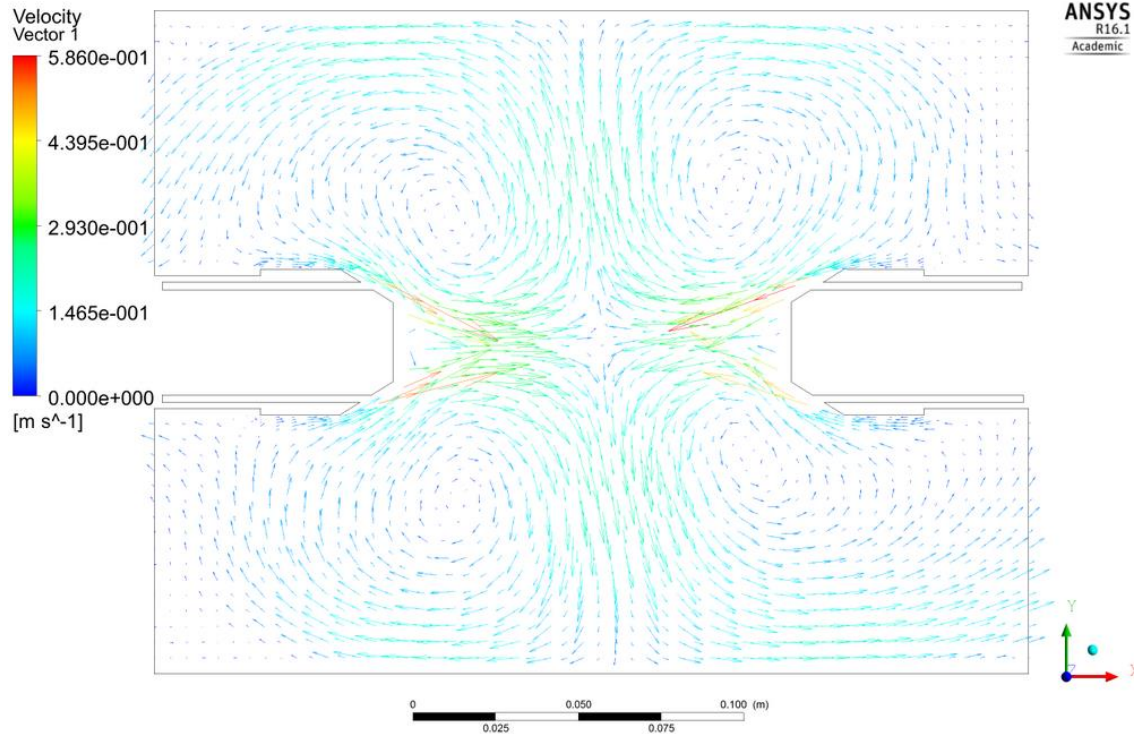
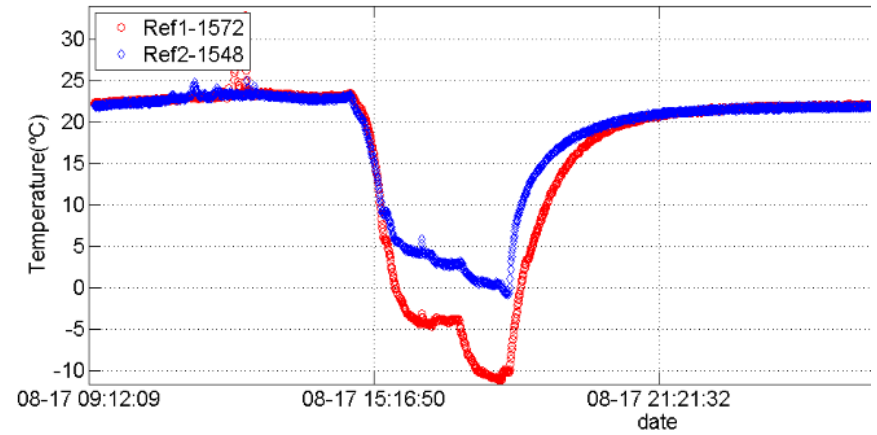
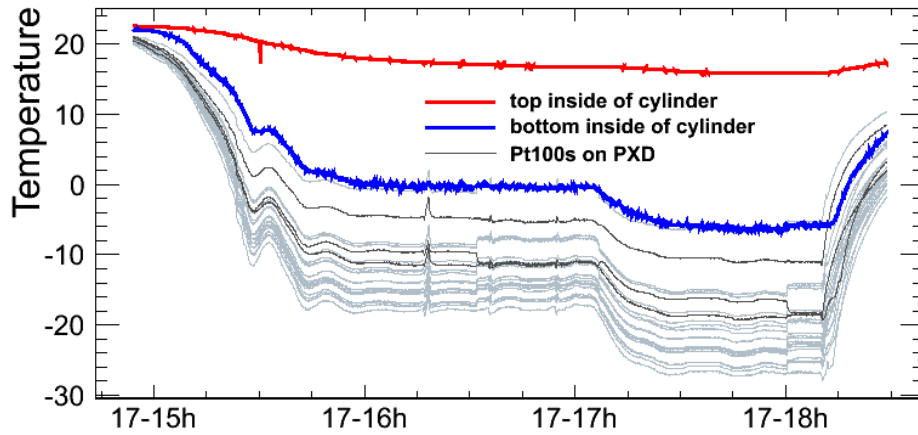
The thermal mock-up at DESY



The thermal mock-up is built to study and optimize the cooling system for the BelleII vertex detector.

- ❑ Closed CO_2 channel to cool the end of sensors;
- ❑ Nitrogen channels to provide air flow;
- ❑ Pt100s to monitor temperature on sensors;
- ❑ Fiber Sensors(FBGs) to monitor temperature and humidity around PXN.

Temperature in volume

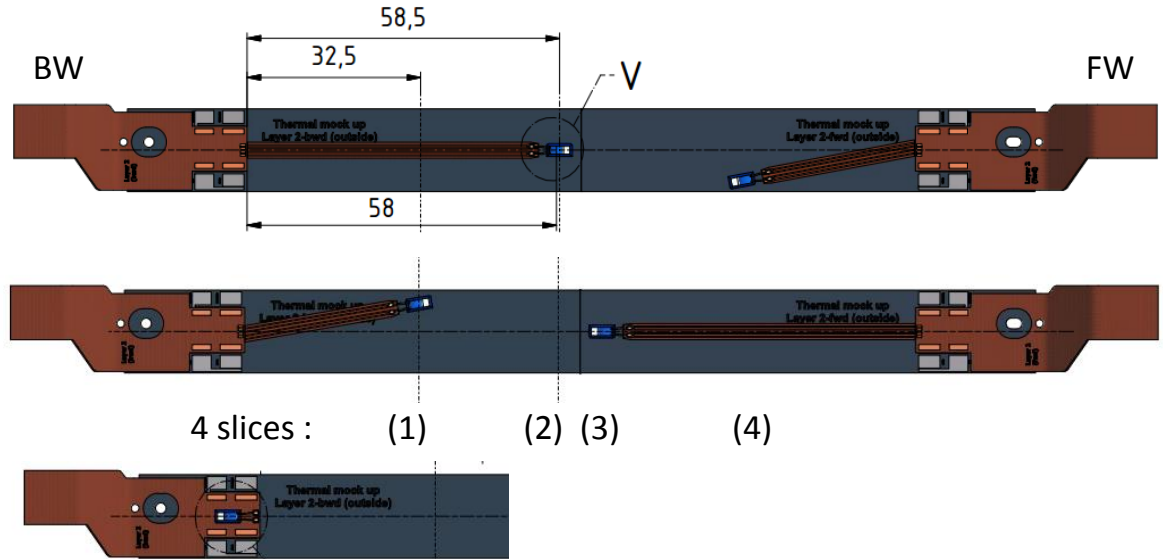
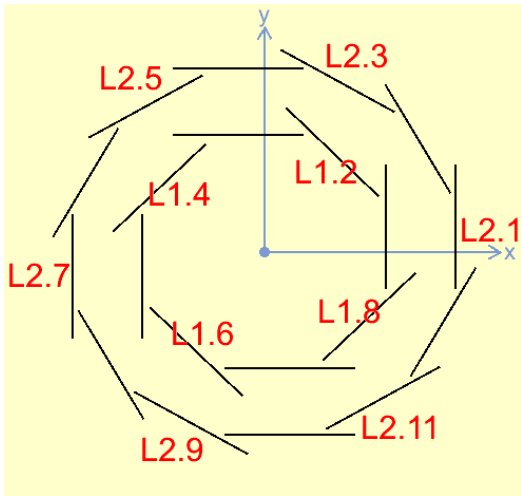


Cold gas goes to the bottom.

Pt100s on PXD

The Pt100s on sensitive area can be classified into 4 slices, and another one glued near DHP/DCD.
 FBGs locate above L2.5 and L2.11.

Detector Layout



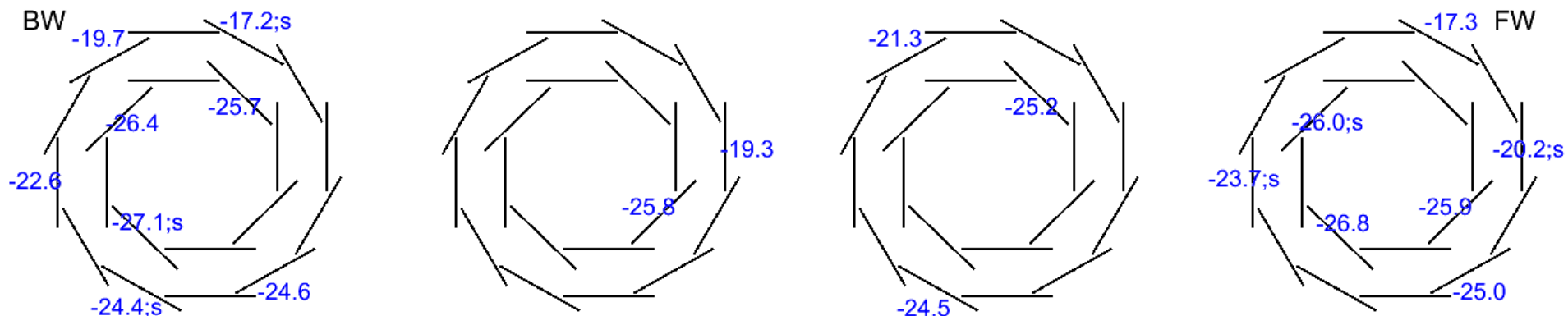
Power on PXD Mock-up

- DCD/DHP ~230W
- Switcher ~20W
- Sensor ~20W
- Kapton cable ~100W
- Total ~370W

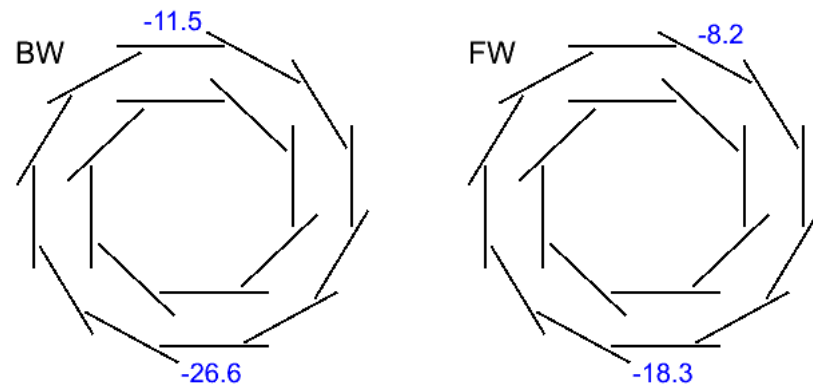
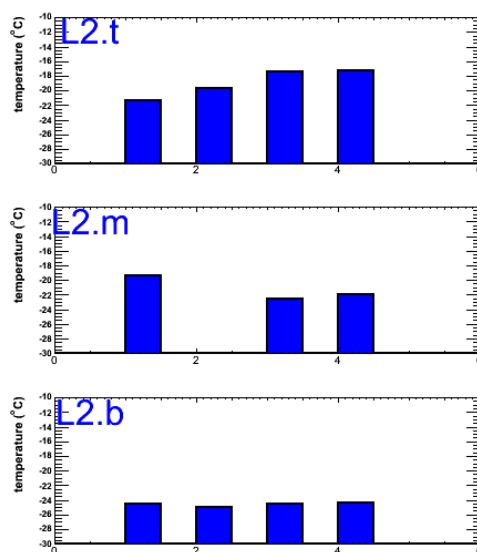
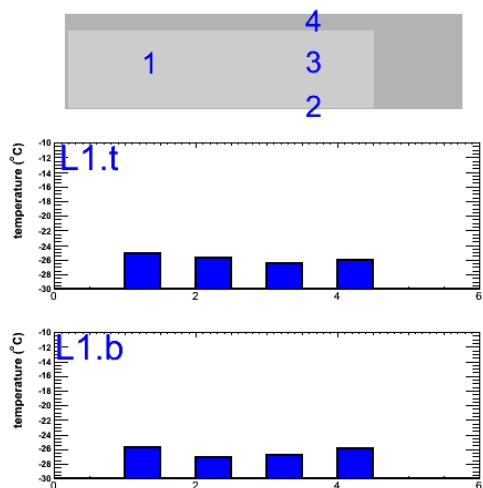
Spare Pt100s.

- 3 locate near DCD/DHP,
- ...

Marco at -30C no heat N2: 6L/min; average : -21.4C



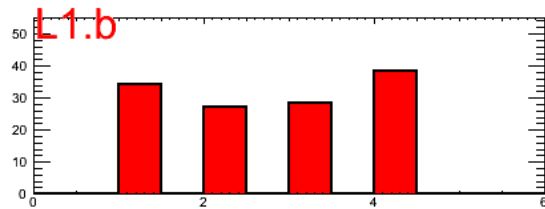
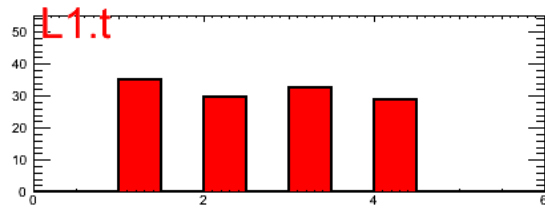
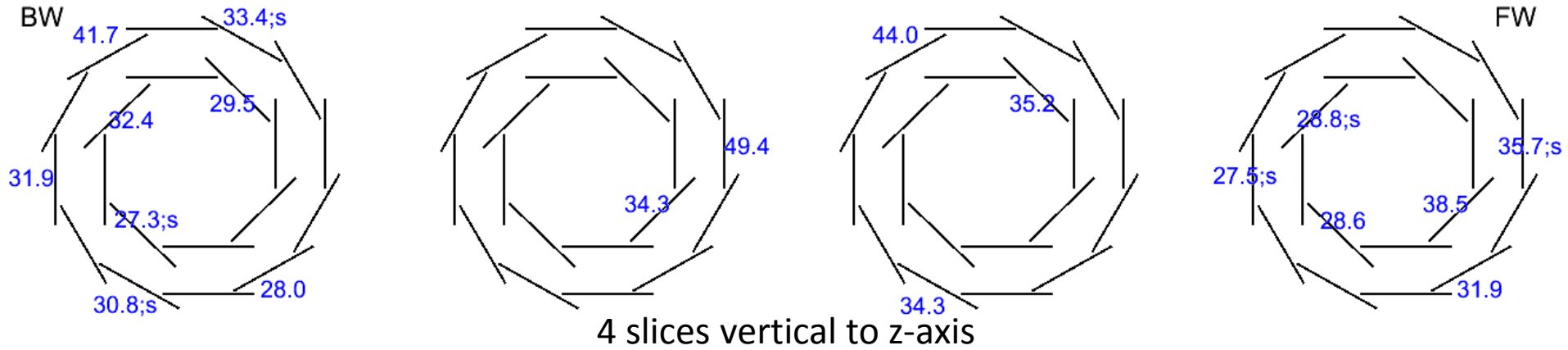
4 slices vertical to z-axis



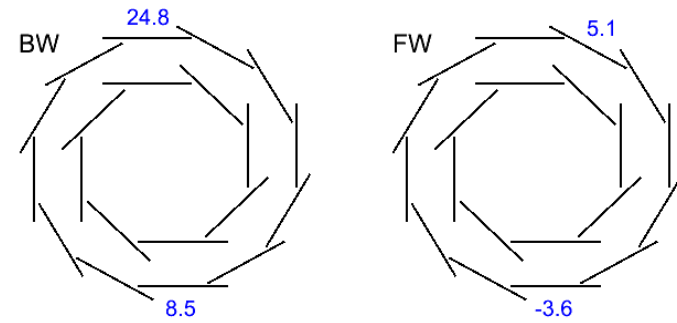
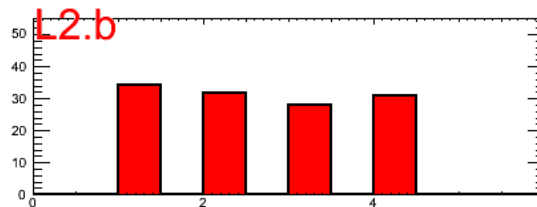
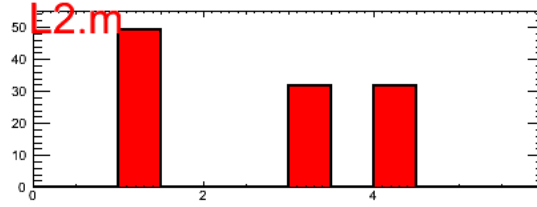
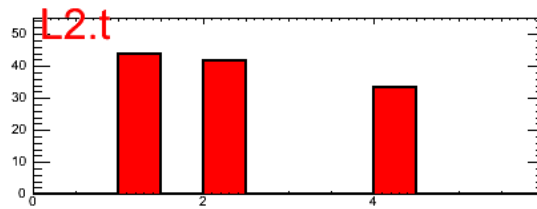
Near DCD/DHP

5 slices horizontal to z-axis

Marco at -30C; N2: 6L/min; DCD/DHP on; Switcher + Sensor on



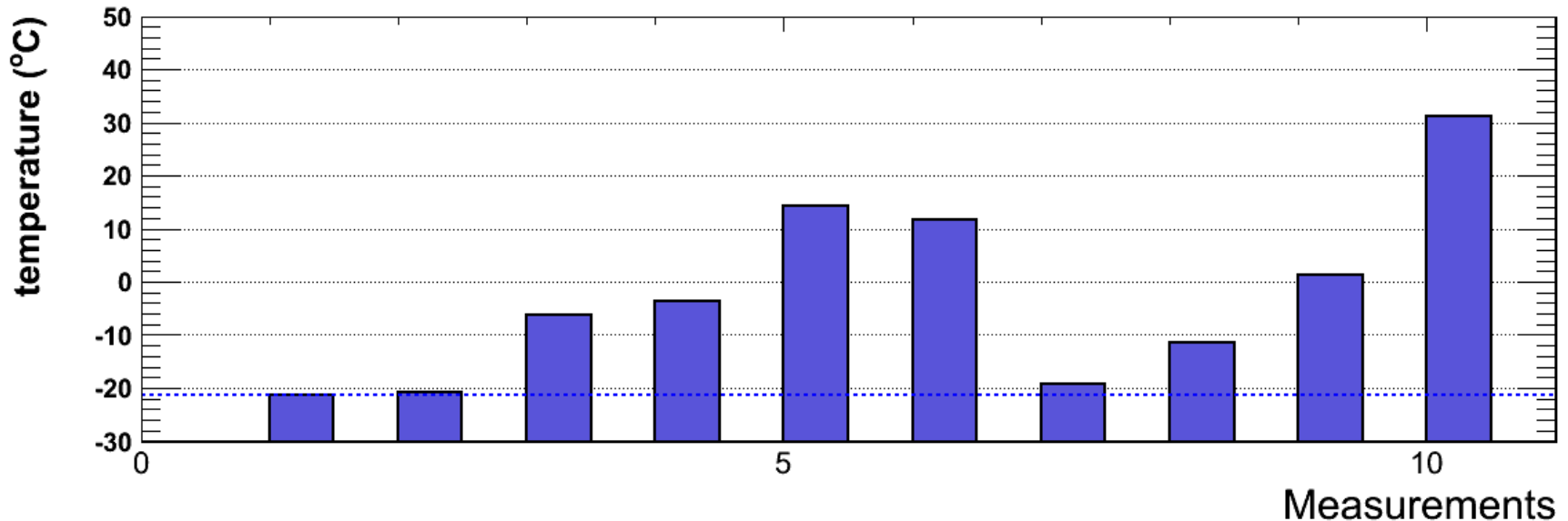
5 slices horizontal to z-axis



Summary of the temperature

Marco at -30C

1. N2: 6L/min; no heat; average : -21.4C
2. N2: 4L/min; no heat; average: -20.9C
3. N2: 4L/min; Sensor on; average : -6.2C
4. N2: 4L/min; Switcher on; average : -3.7C
5. N2: 4L/min; Sensor+Switcher; average : 14.4C
6. N2: 6L/min; Sensor+Switcher; average : 11.7C
7. N2: 6L/min; 1/3 DCD/DHP on; average : -19.2C
8. N2: 6L/min; 2/3 DCD/DHP on; average : -11.5C
9. N2: 6L/min; 3/3 DCD/DHP on; average : 1.2C
10. N2: 6L/min; 3/3 DCD/DHP+Sensor+Switcher; average : 31.2C

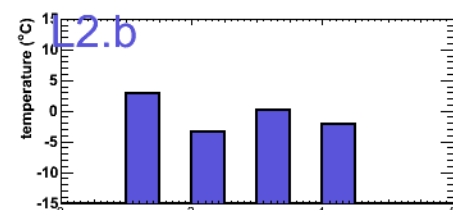
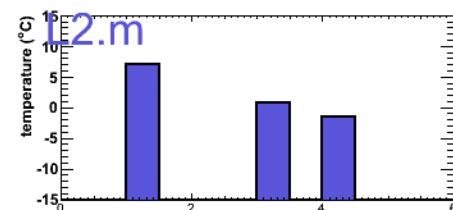
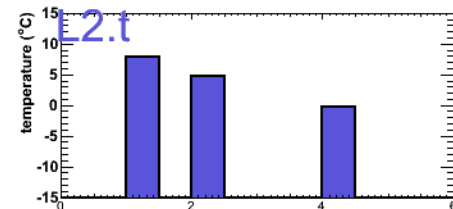
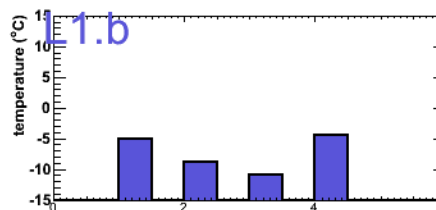
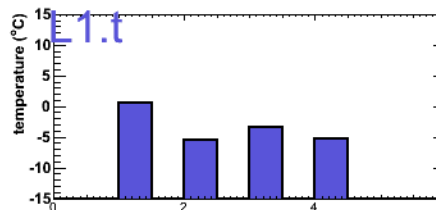


Compare different N2 cooling method

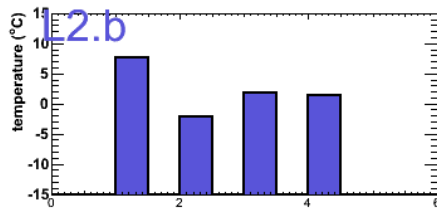
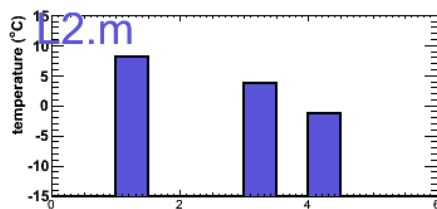
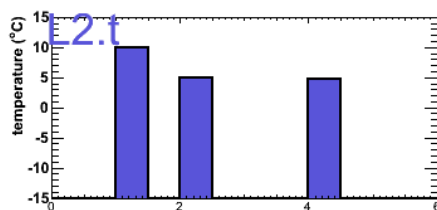
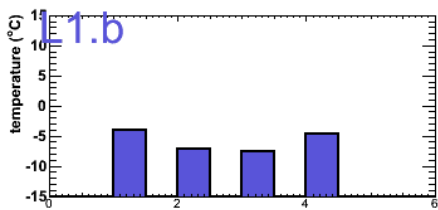
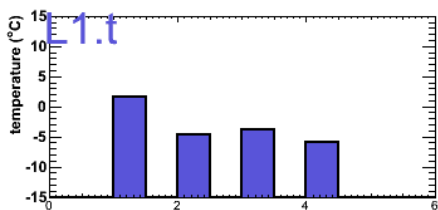
Marco at -30C;
1/3 DCD/DHP + sensor on;



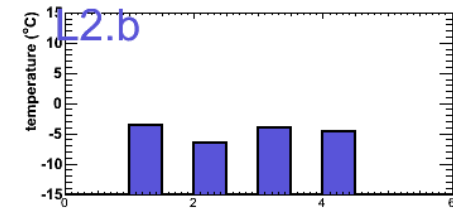
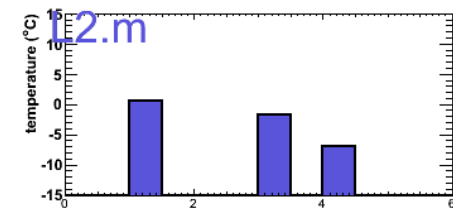
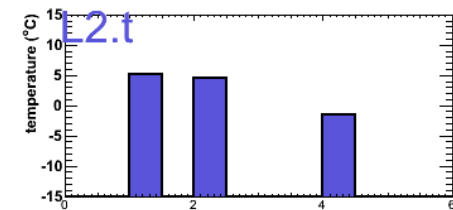
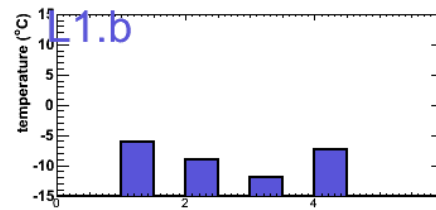
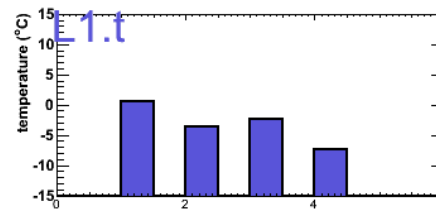
N2: 6L/min;
Average : -1.6C



N2 only flushing, 6L/min;
Average : -0.1C



N2 only tube, 6L/min;
Average : -3.7C

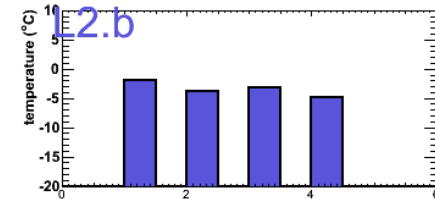
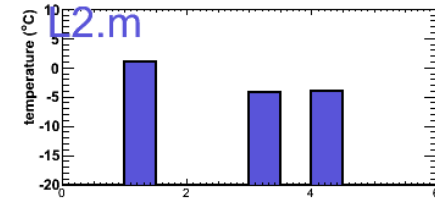
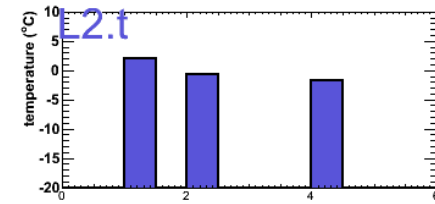
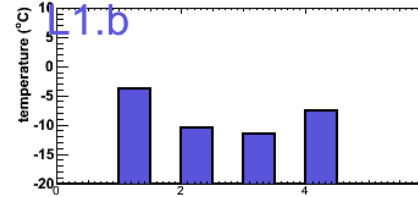
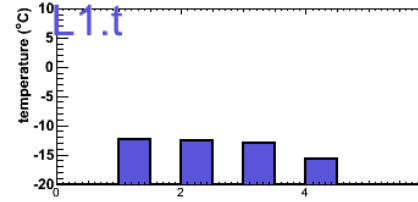


Marco at -30C;
Switcher on;

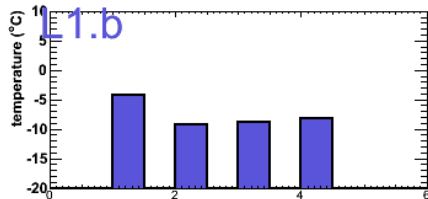
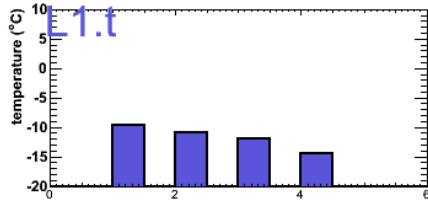
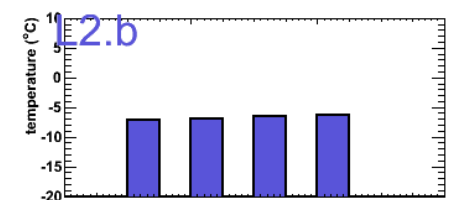
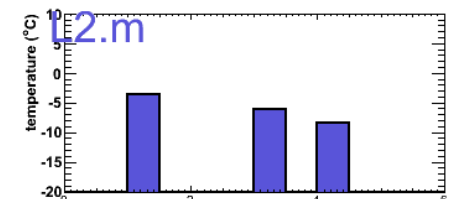
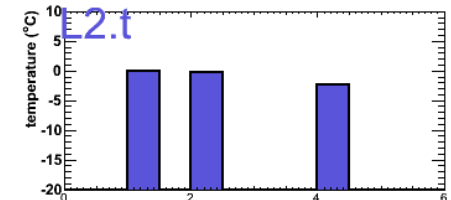
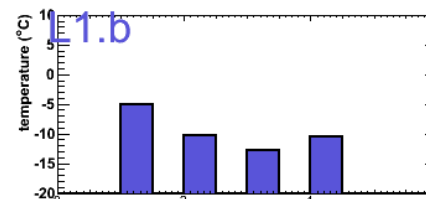
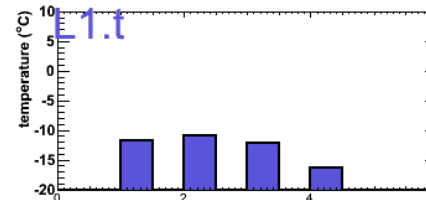
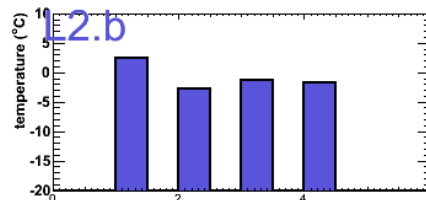
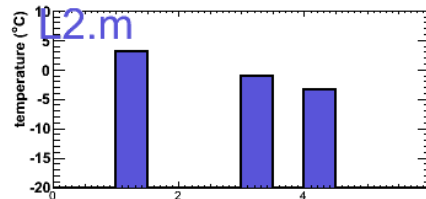
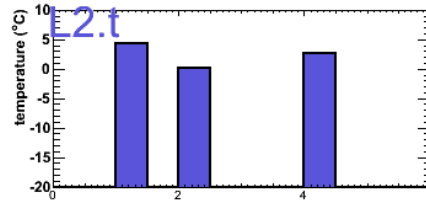
N2 tubes give better cooling
performance at 6L/min.

N2 only flushing, 6L/min;
Average : -4.0C

N2: 6L/min;
Average : -5.7C



N2 only tube, 6L/min;
Average : -7.3C



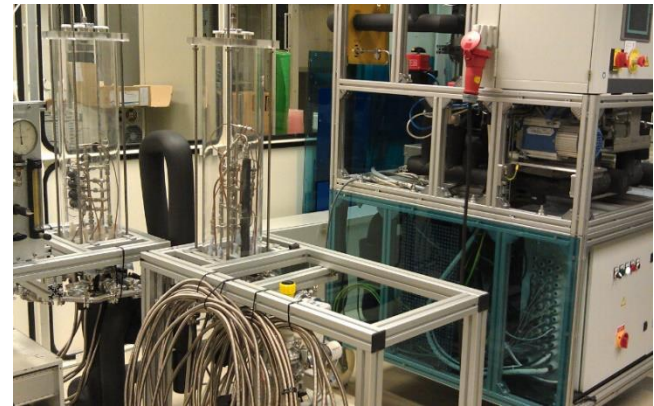
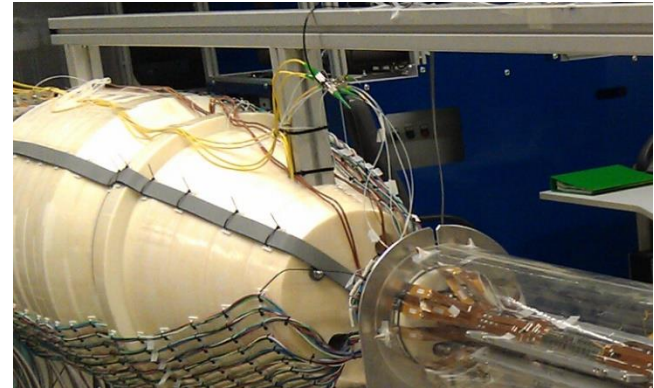
Pt100s indicate the N2 temperature is $< 0^{\circ}\text{C}$ (Marco@ -30°C).

We want better cooled N2.

2 spare CO_2 line to cool N2: 12m long flex line.

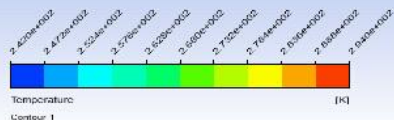
Indicated from thermal simulation, N2 easily gets heat from environment.

To do heat isolation.

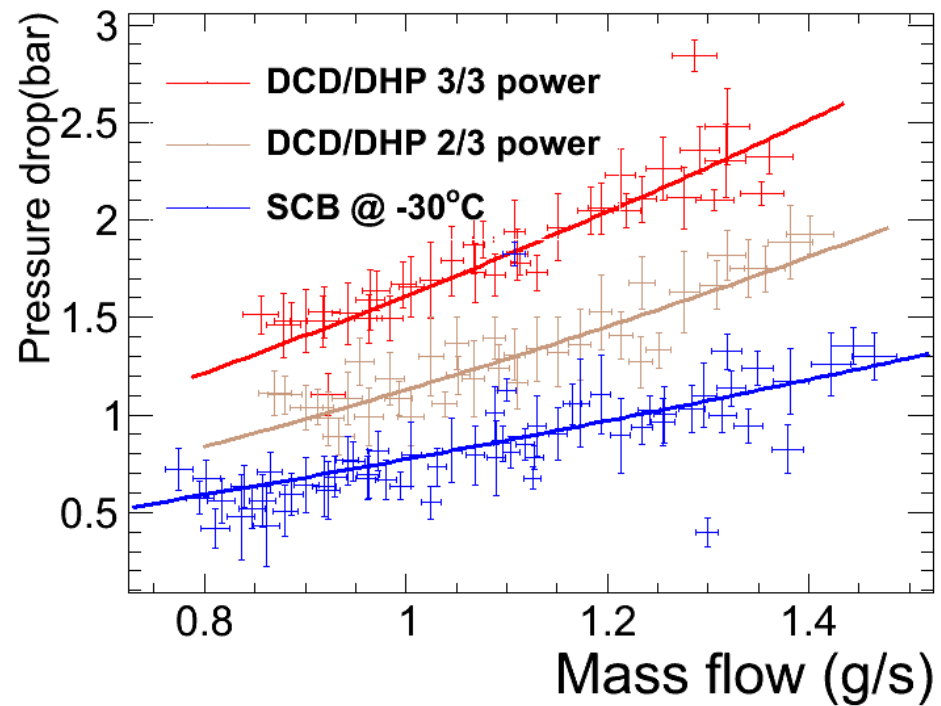
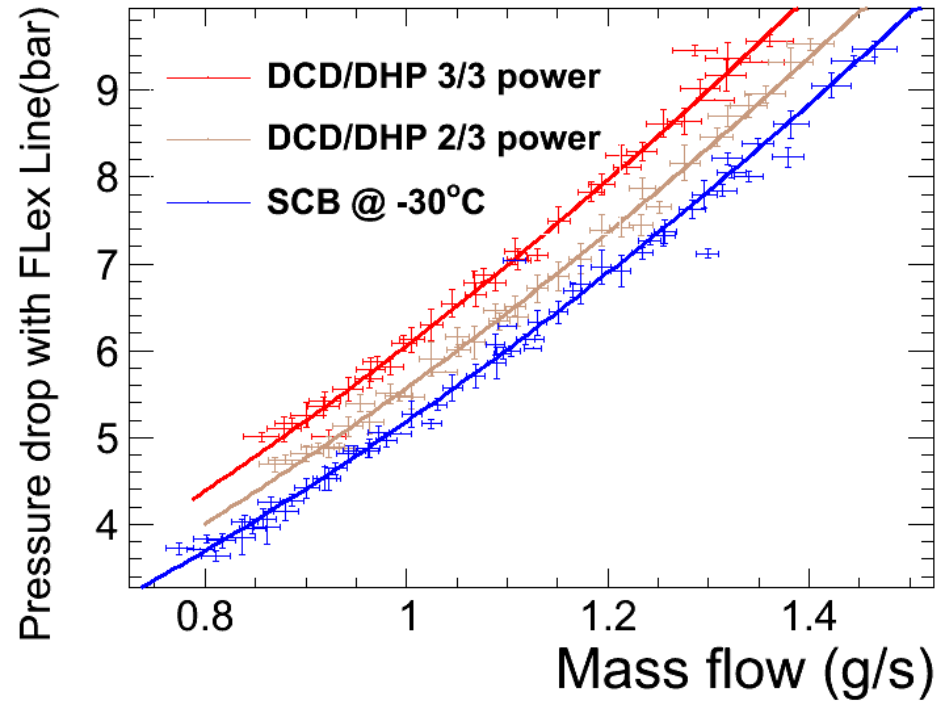


4L/min N2 in 2mm tube

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R16.1
Academic



Mass flow v.s. Pressure drop

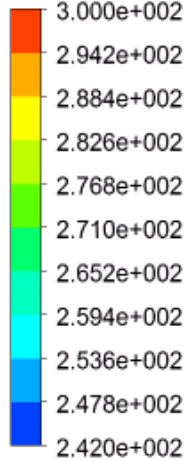


Summary

- ❑ First measurement is done, preliminary results are got.
- ❑ CO₂ gives good performance, DCD/DHPs are under 50°C.
- ❑ Heat causes about 1 bar's pressure drop.
- ❑ The PXD sensitive area is hot, N₂ plays a big rule in cooling, we want cold N₂.

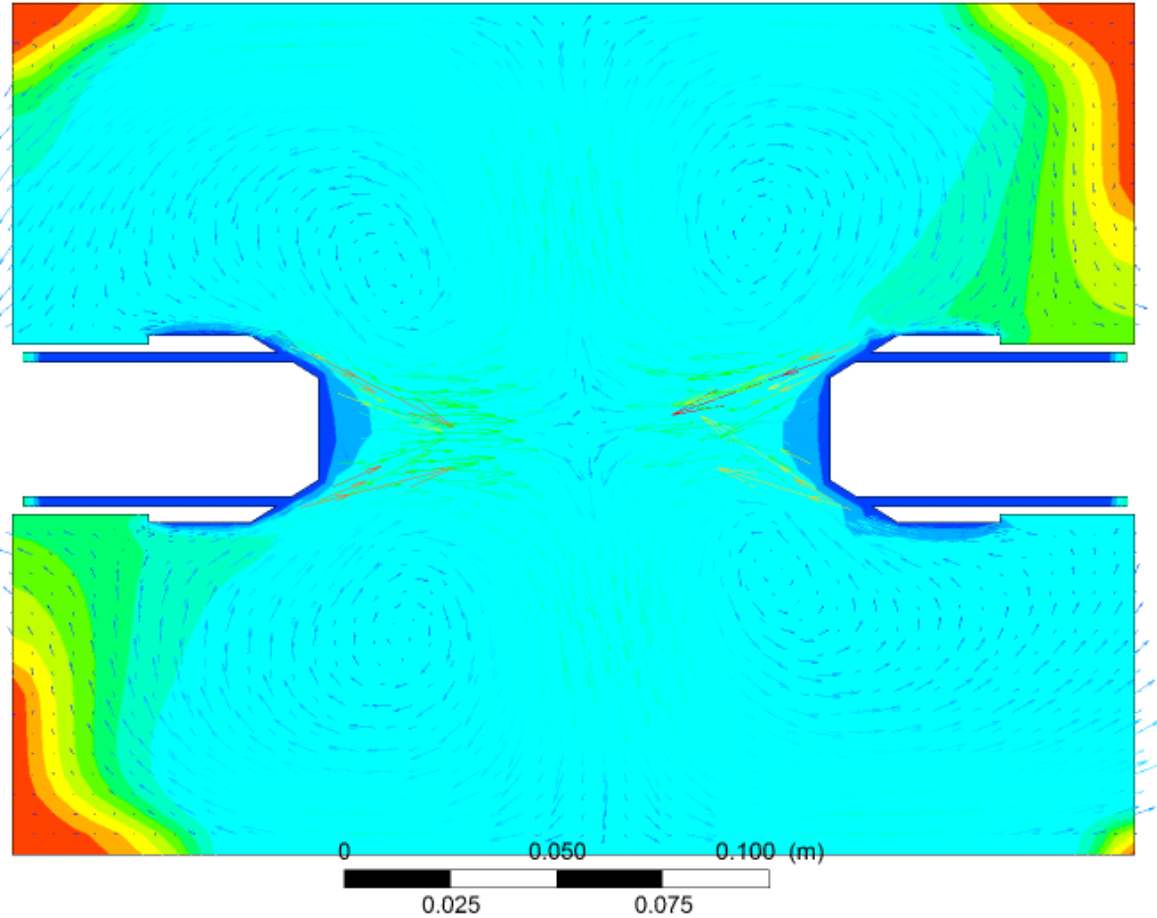
Backup

Temperature
Contour 1

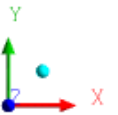


3.000e+002
2.942e+002
2.884e+002
2.826e+002
2.768e+002
2.710e+002
2.652e+002
2.594e+002
2.536e+002
2.478e+002
2.420e+002

[K]



ANSYS
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Academic

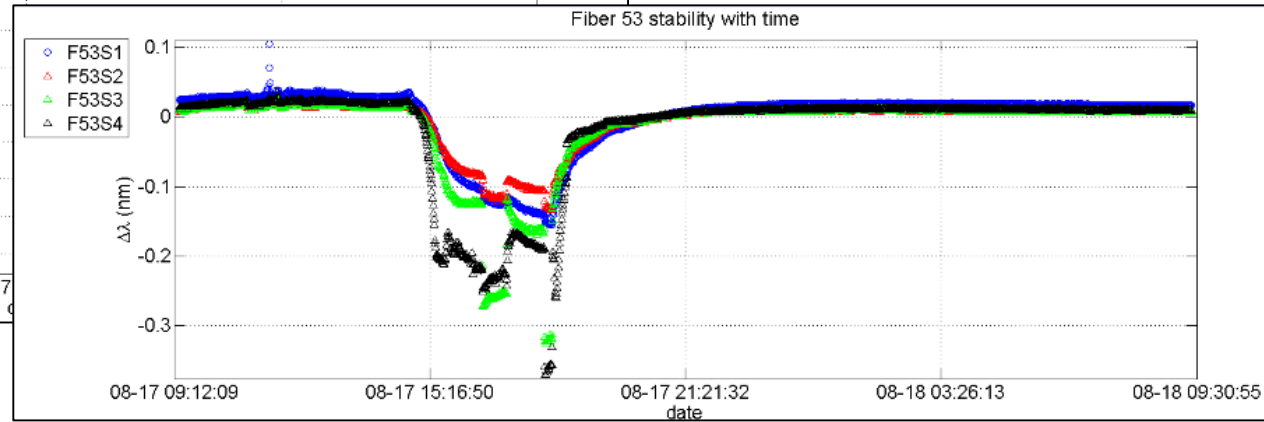
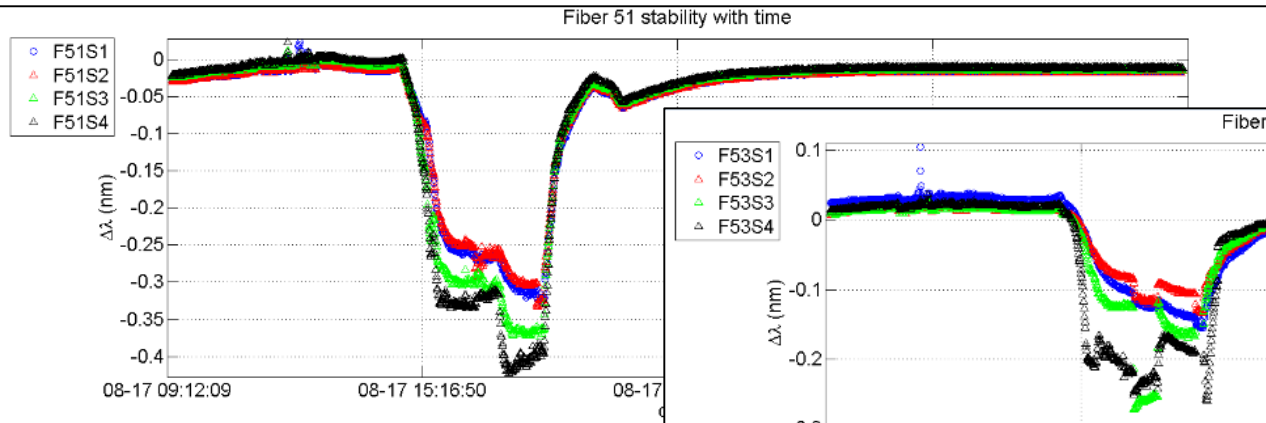


FBGs Results

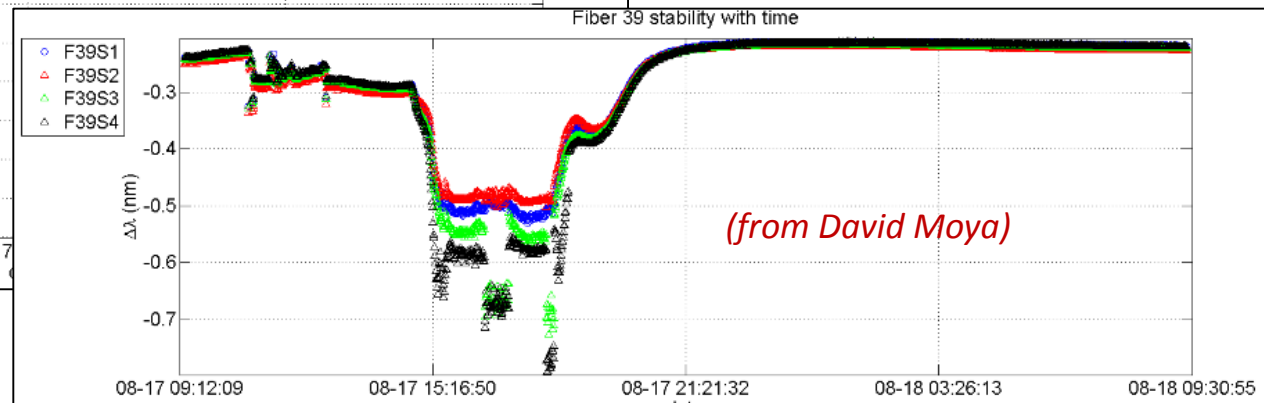
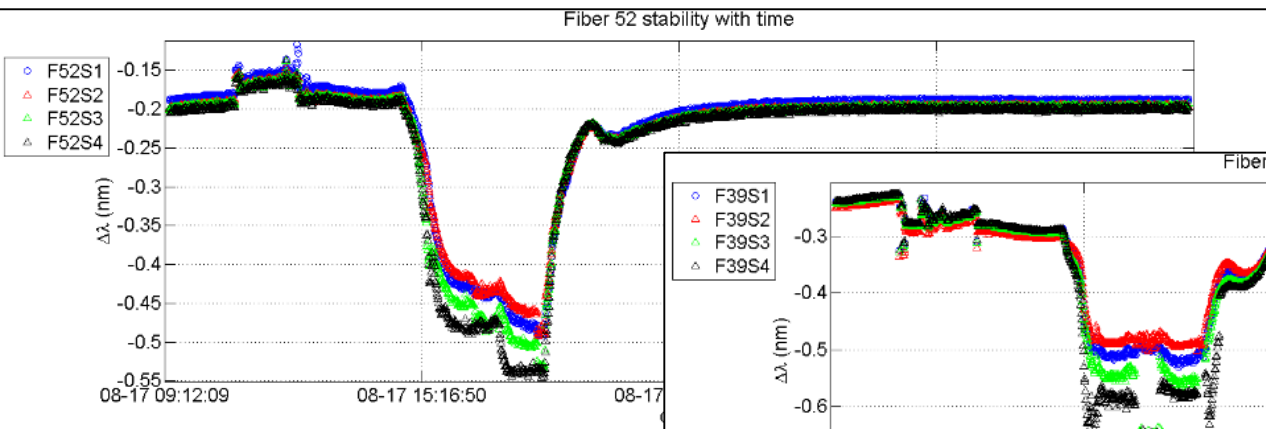
Layout: Fiber 51,52,53 sensitive to temperature; Fiber39 sensitive to temperature+humidity.

Fiber51,52 on top of PXD; Fiber 53,39 on bottom.

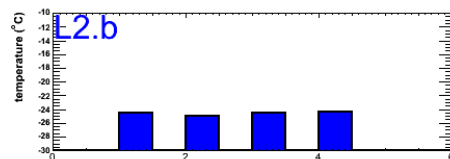
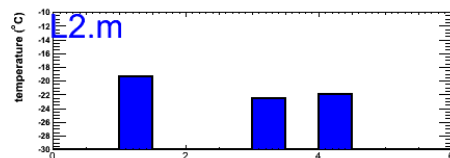
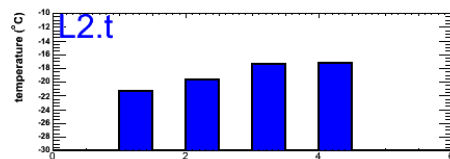
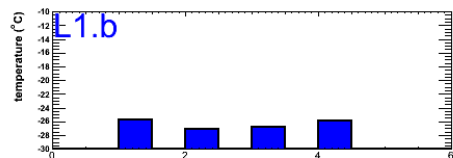
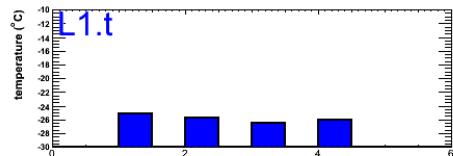
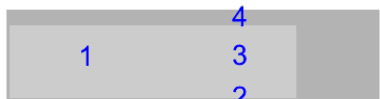
The sensor 4 is in the Backward, while the sensor 1 is in forward side.



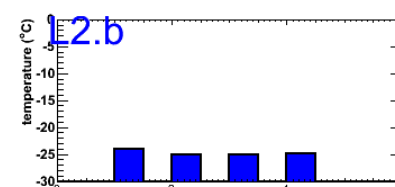
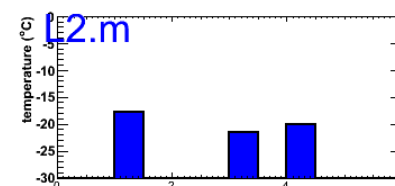
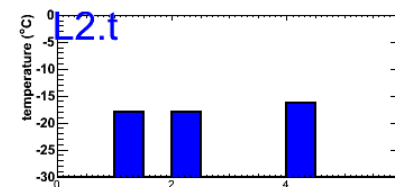
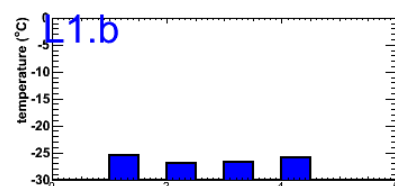
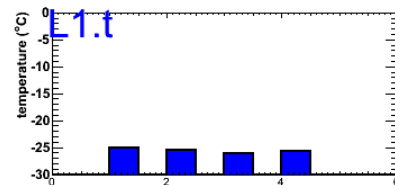
Lower temperature in the bottom.



Marco at -30C no heat N2: 6L/min;
average : -21.4C



Marco at -30C no heat N2: 4L/min;
average : -20.8C



Marco at -30C; N2: 6L/min; DCD/DHP on; Switcher + Sensor on

