Belle-II PXD support: Thermo-mechanical activities at Valencia

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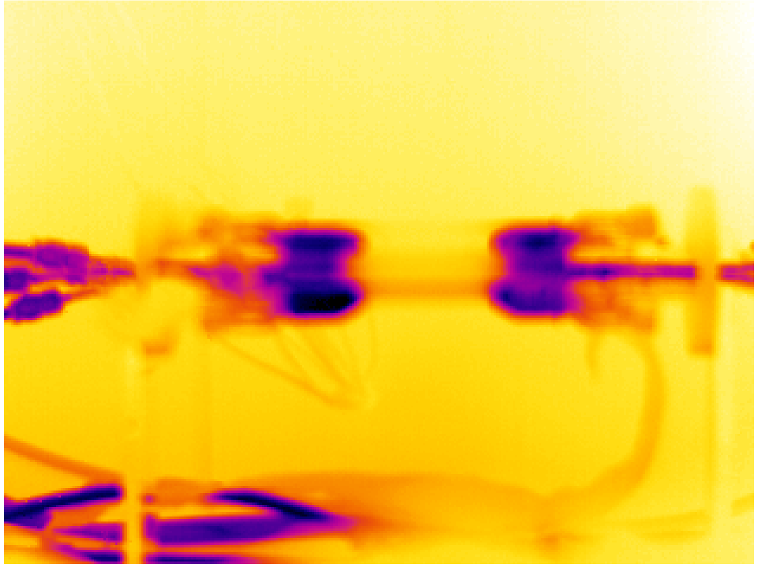
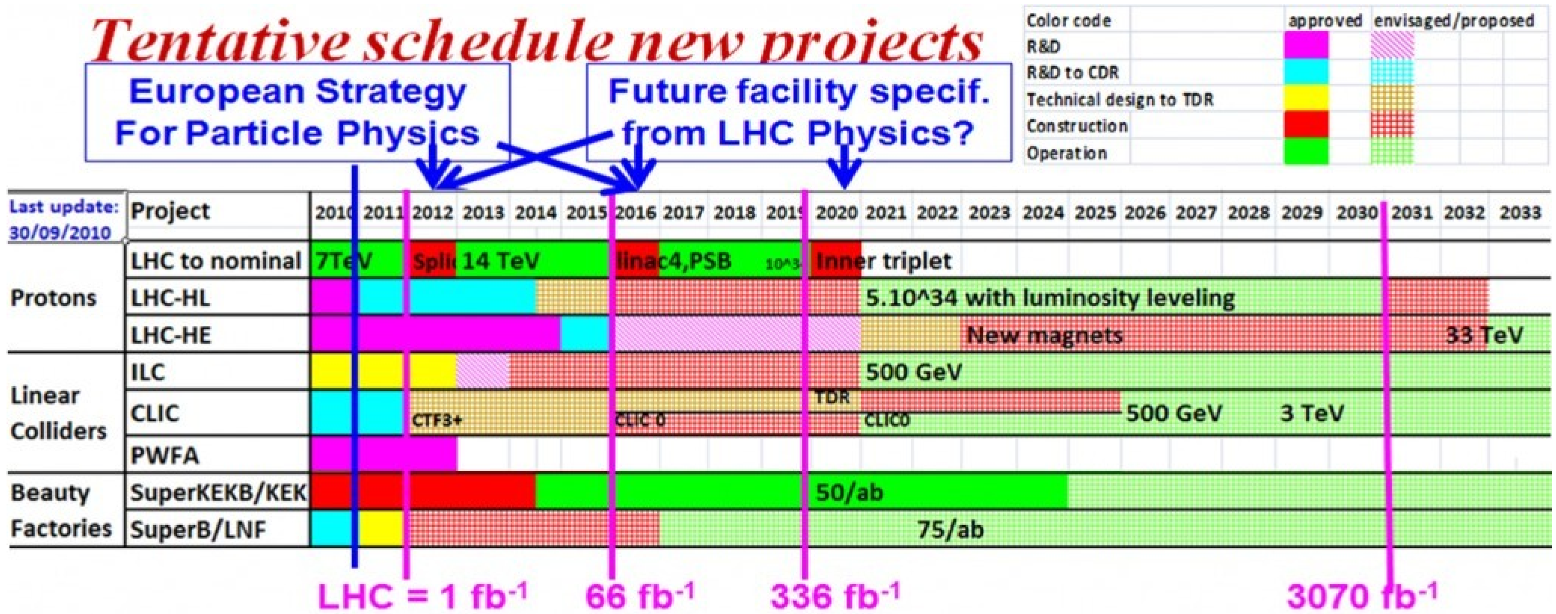
(IFIC - Valencia)



Outline

- Motivation
- The Belle-II Pixel detector (PXD)
- Thermal mock-up at Valencia
- First studies of cooling
- Conclusions

Motivation

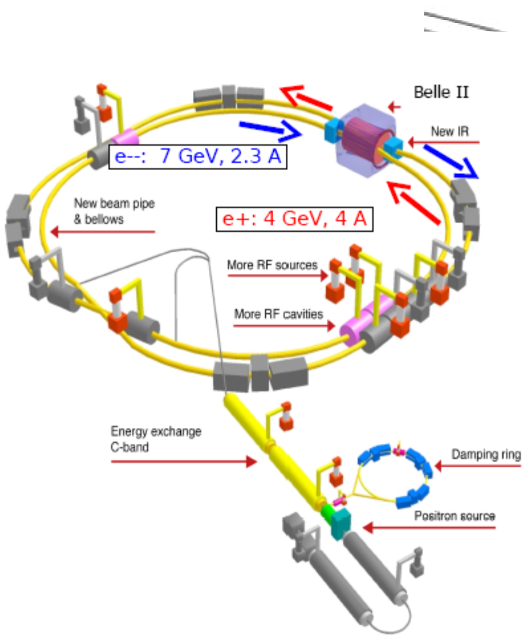


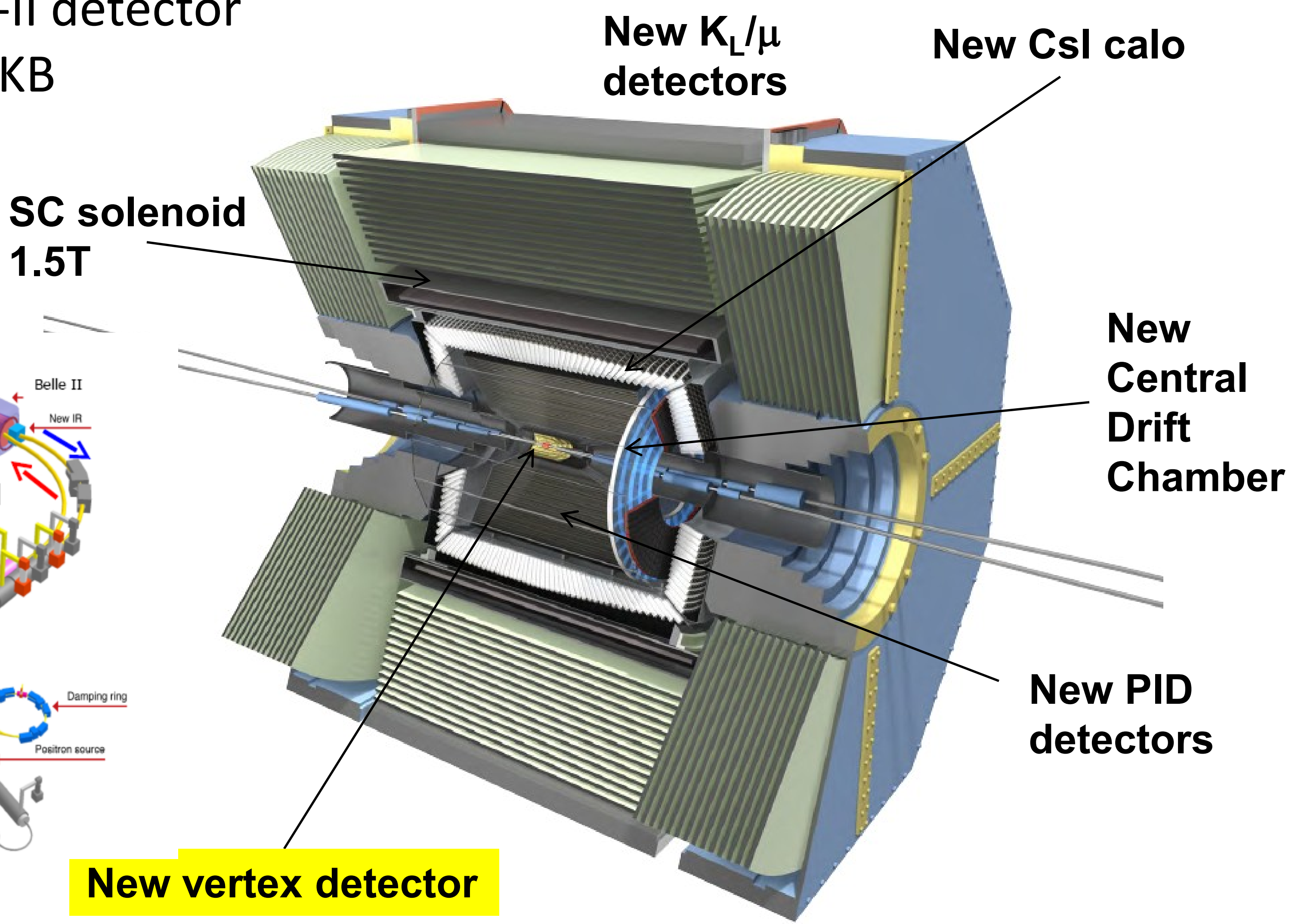
http://newsline.linearcollider.org/2011/03/31/i-have-a-dream/

- **LHC**: results decisive to define future strategies (2012)
  → Present explotation of data is fundamental
- **ILC/CLIC**: construction envisaged for 2014/16, operation in 2021
  → Present R&D is fundamental
- **Super Flavour Factories**: unique competitive and complementary data with LHC in this era
  → Present contribution to construction (and data explotation) is fundamental

The Belle-II PXD

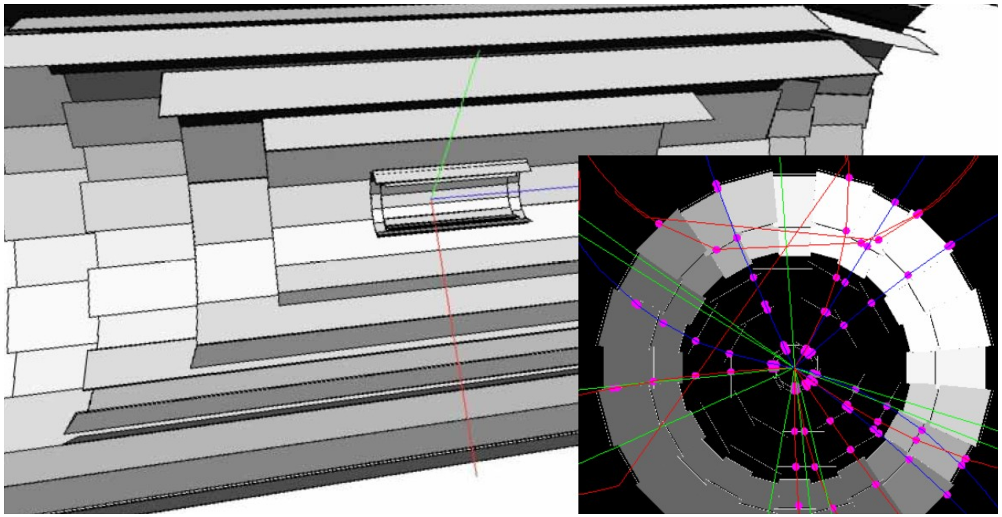
- The Belle-II detector
@ SuperKEKB

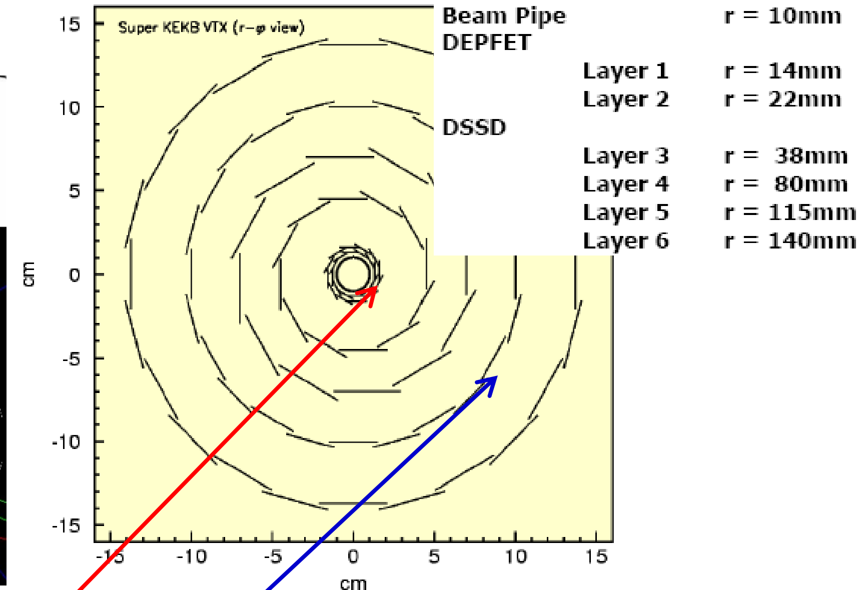




The Belle-II PXD

- The Belle-II vertex detector

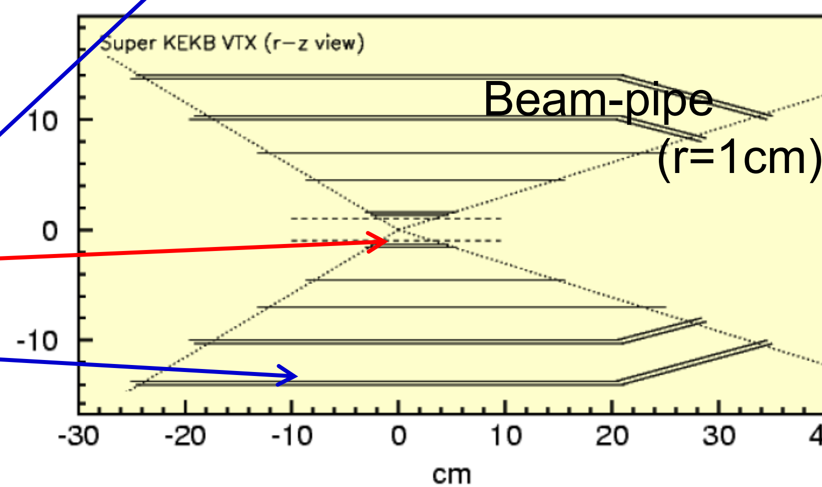




- 6 layers at radii from 1.4 cm to 14 cm,
(4 times more readout channels compared to SVD2 (BELLE))

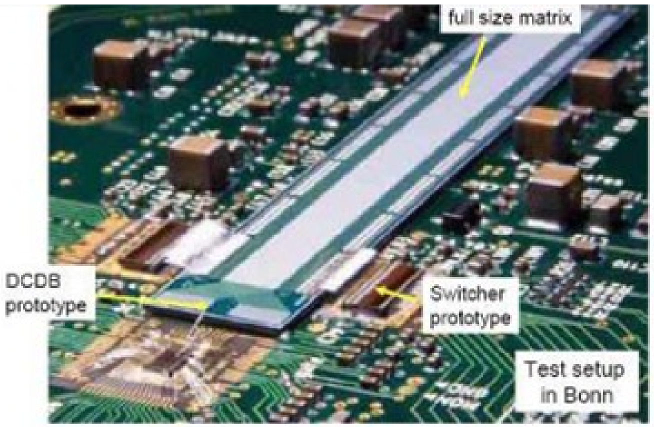
2 layers of pixel detectors (DEPFET)

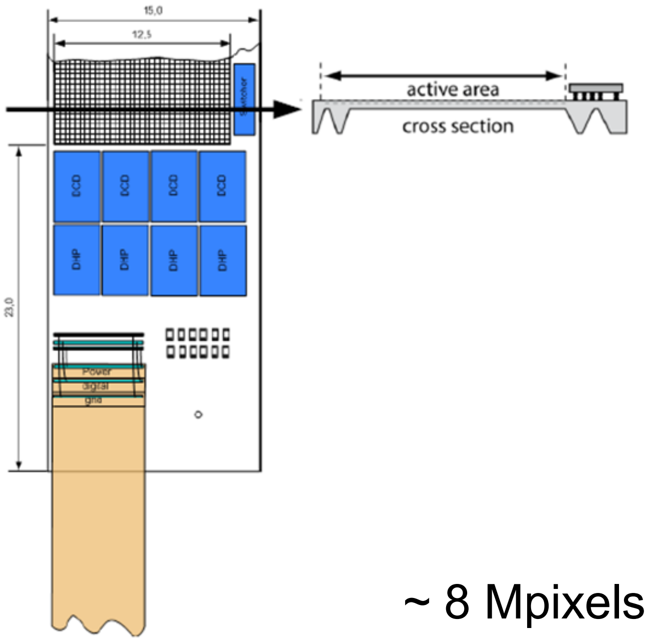
4 layers of strips (DSSD)



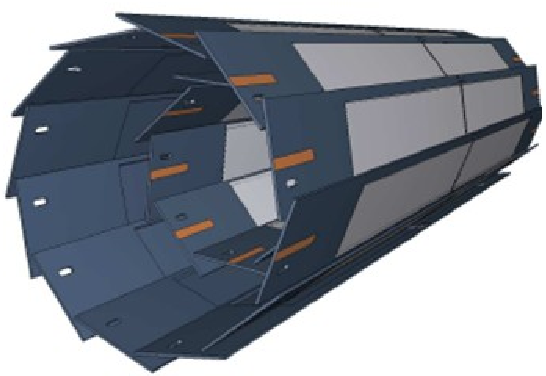
The Belle-II PXD

Prototype DEPFET pixel sensor and readout





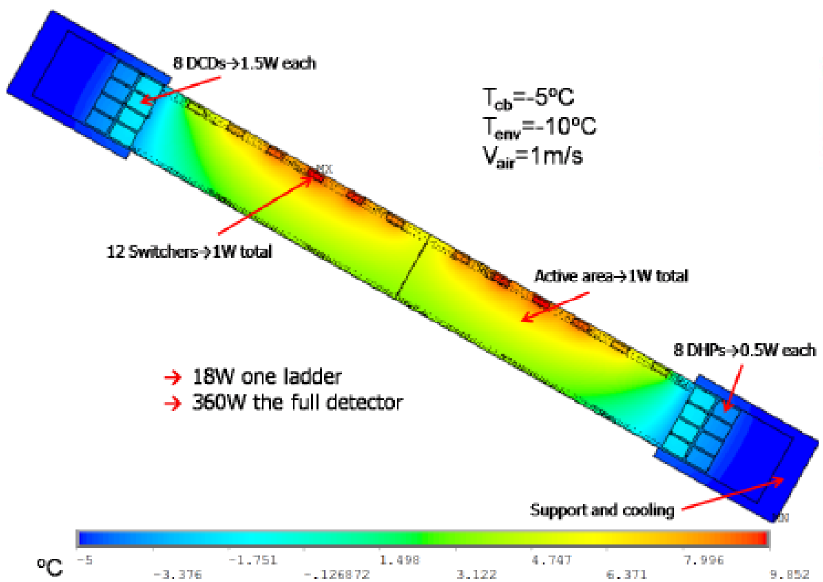
~ 8 Mpixels



	Inner layer	Outer layer
# ladders	8	12
Radius	1.4 cm	2.2 cm
Pixel size	50x50 μm2	50x75 μm2
# pixels	1600(z)x250(R-ϕ)	1600(z)x250(R-ϕ)
Thickness	75 μm	75 μm

Thermal Mock-up

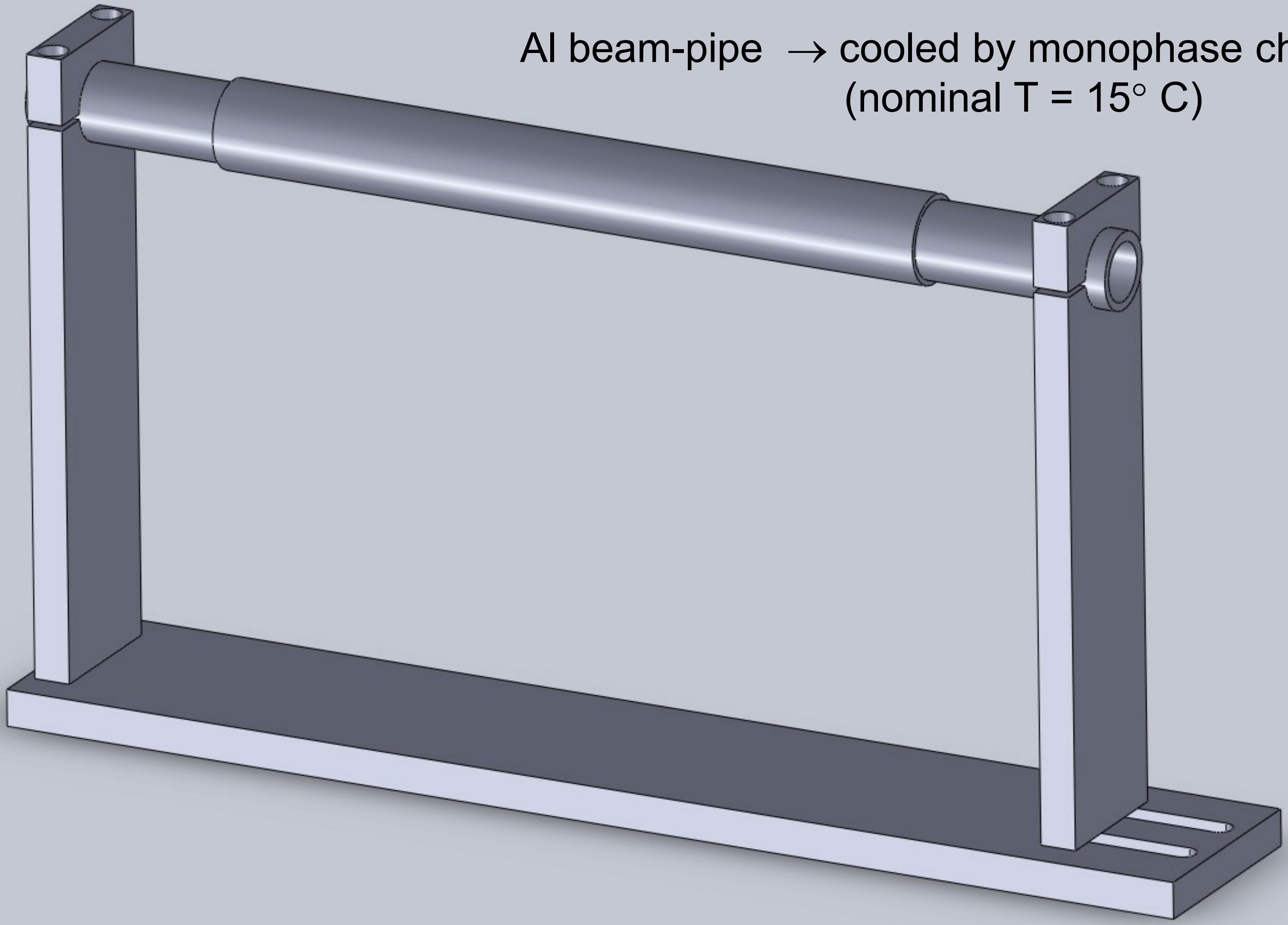
- Thermo-mechanical activities at Valencia:
  - Determine the optimal conditions for the sensors:
    - Cooling of support structures (cooling blocks)
    - Heat dissipation along the sensors (air flow studies)
    - Heat dissipation in the PXD volume
  - Cross-check simulation studies (Carlos Mariñas)



Mechanical mockup of pixel detector

Thermal Mock-up

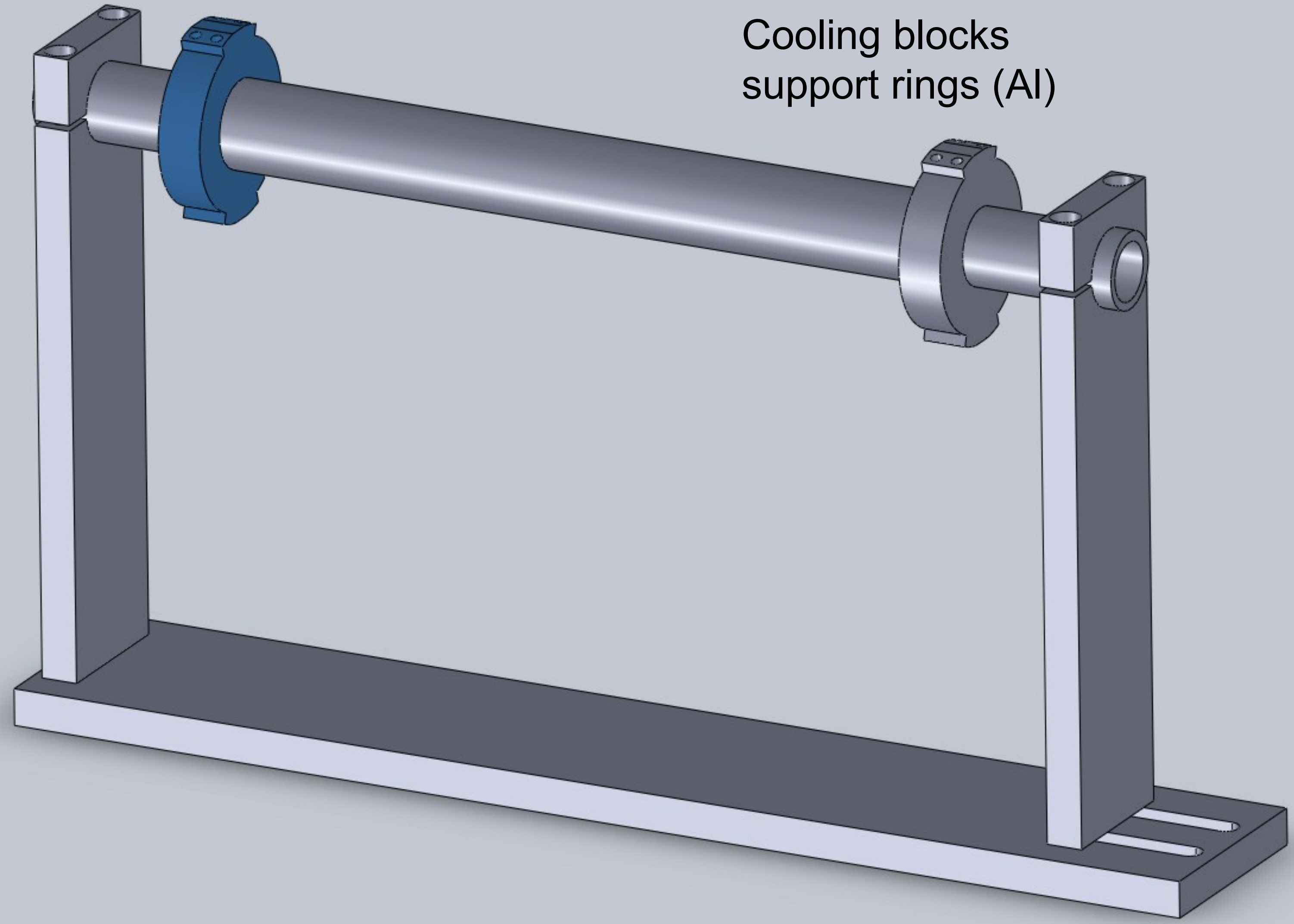
- Thermal mock-up at Valencia:



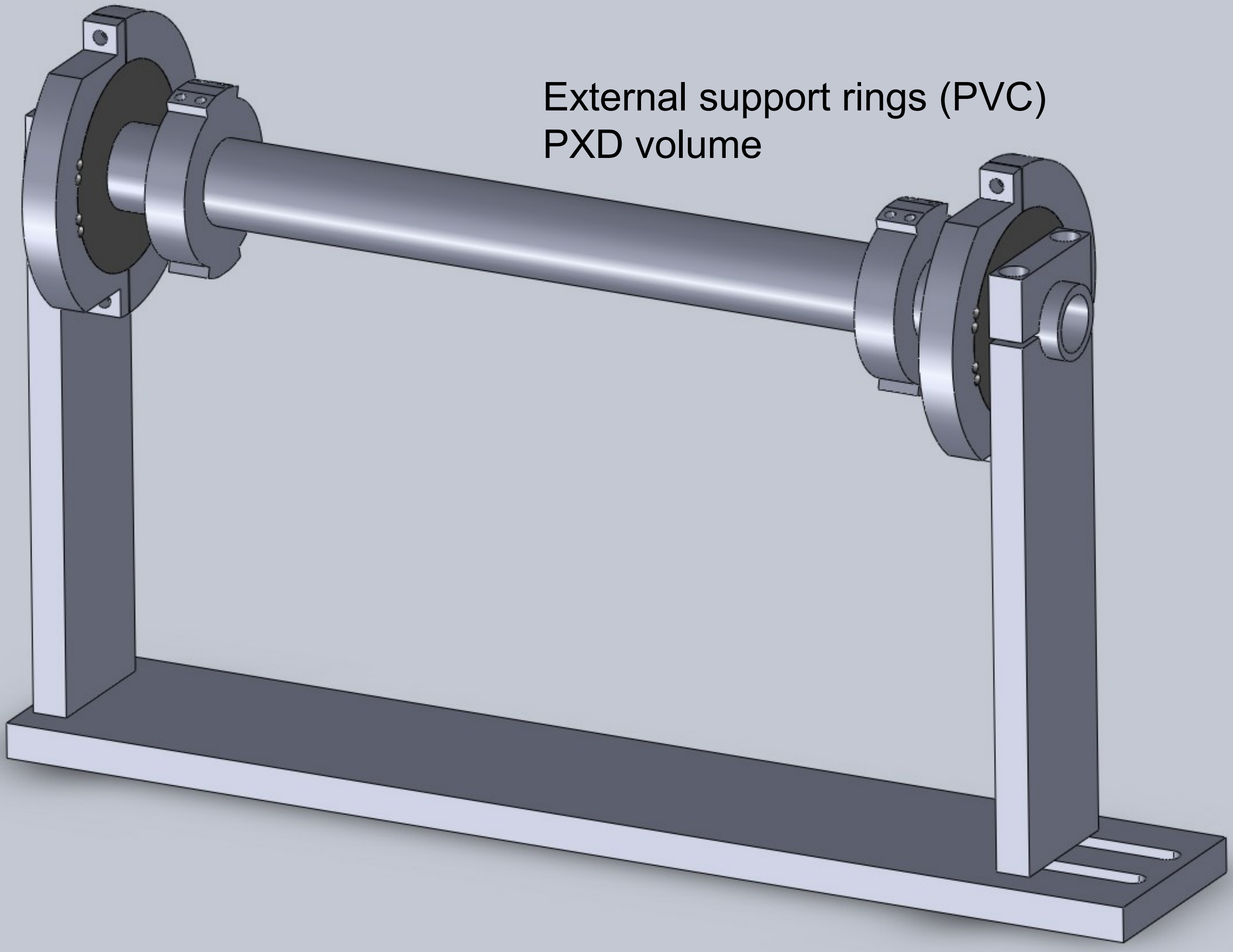
Al beam-pipe → cooled by monophase chiller (nominal T = 15° C)

Thermal Mock-up

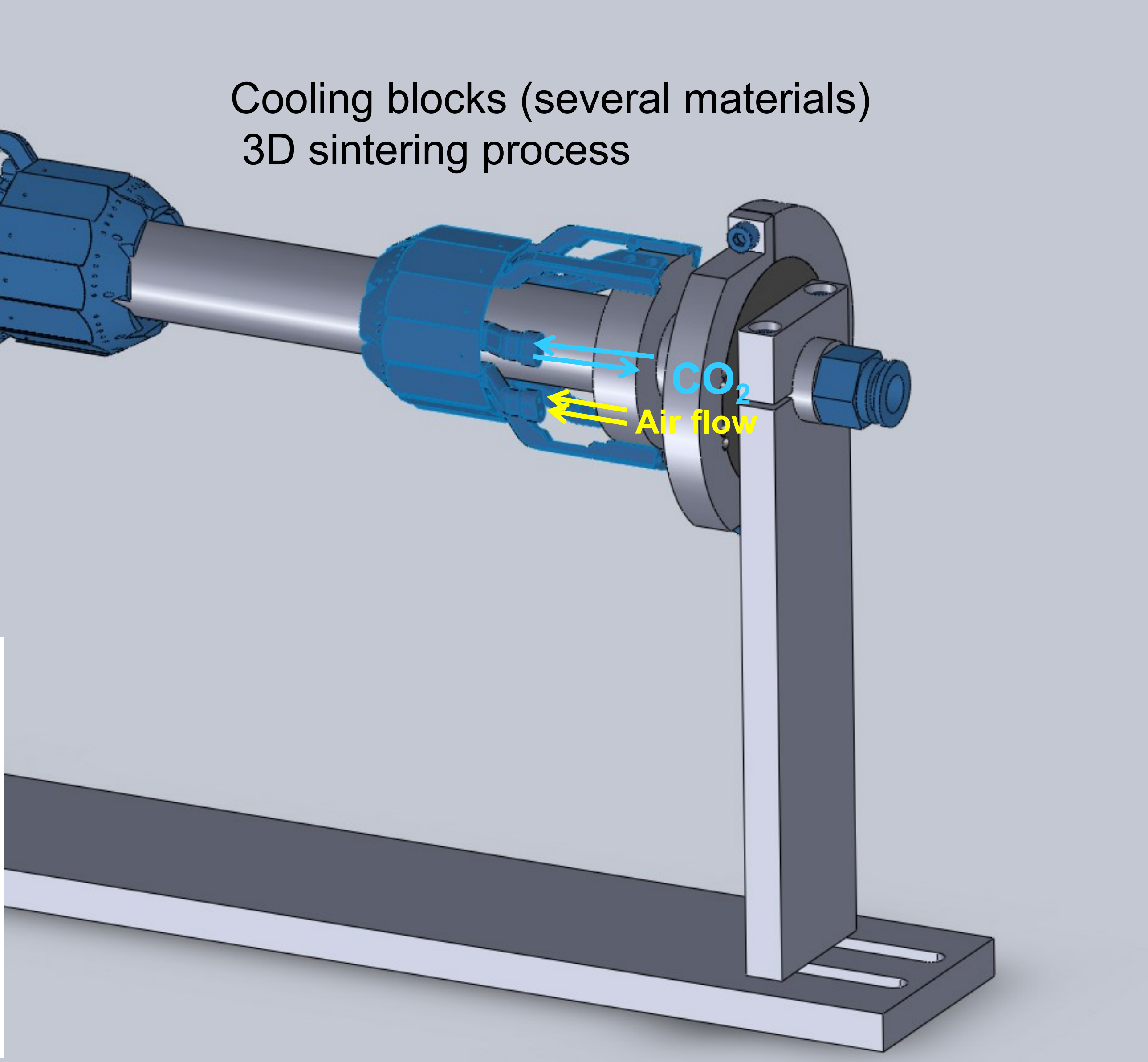
- Thermal mock-up at Valencia:

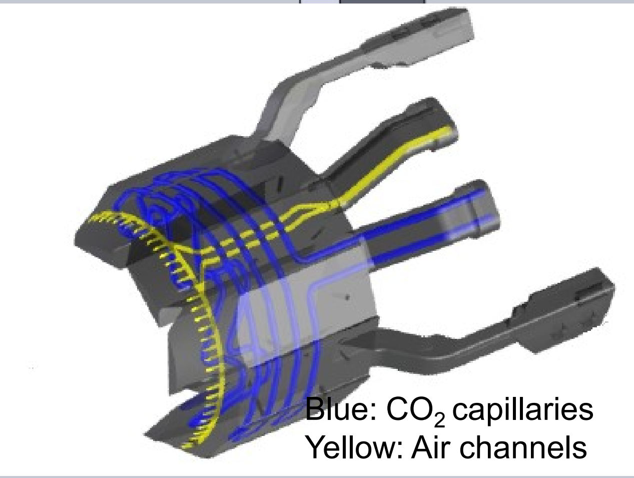


Thermal Mock-up



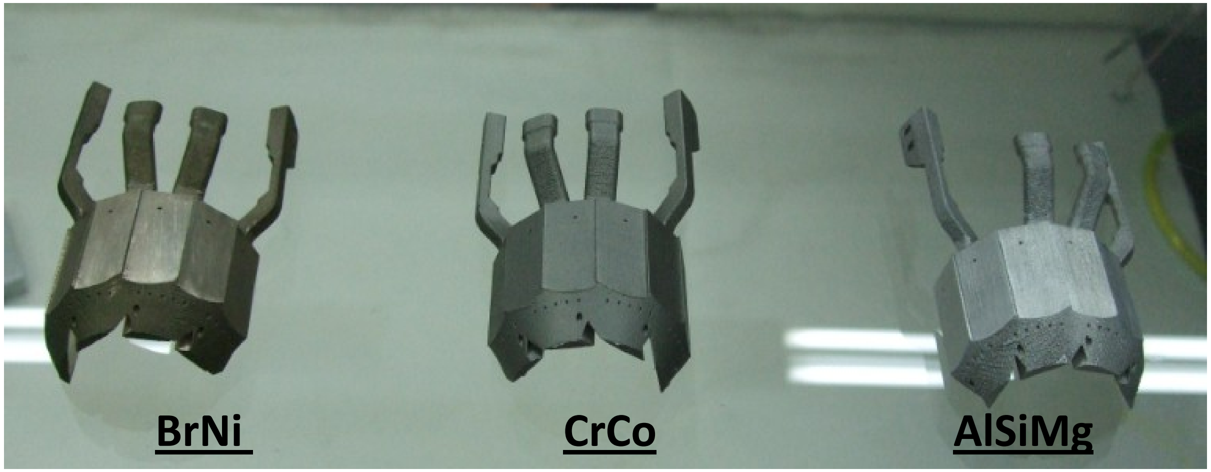
Thermal Mock-up





Thermal Mock-up

- Cooling block materials:



→ Going to MPI for pressure tests

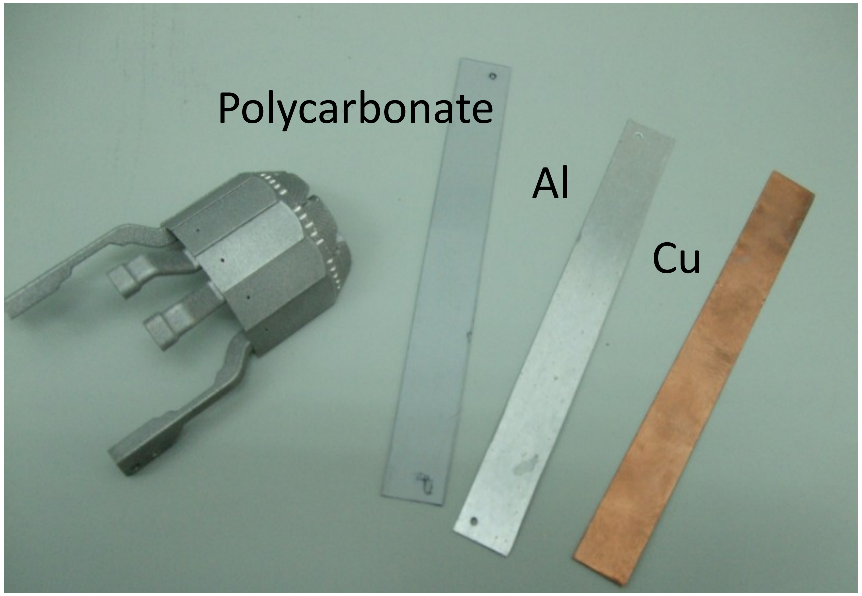
Stainless steel

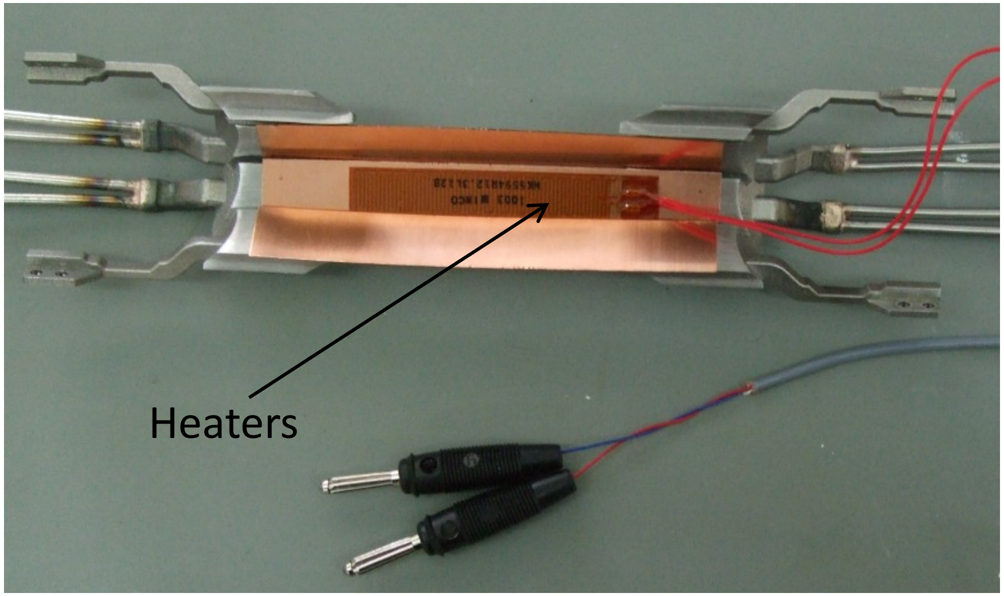
Properties:

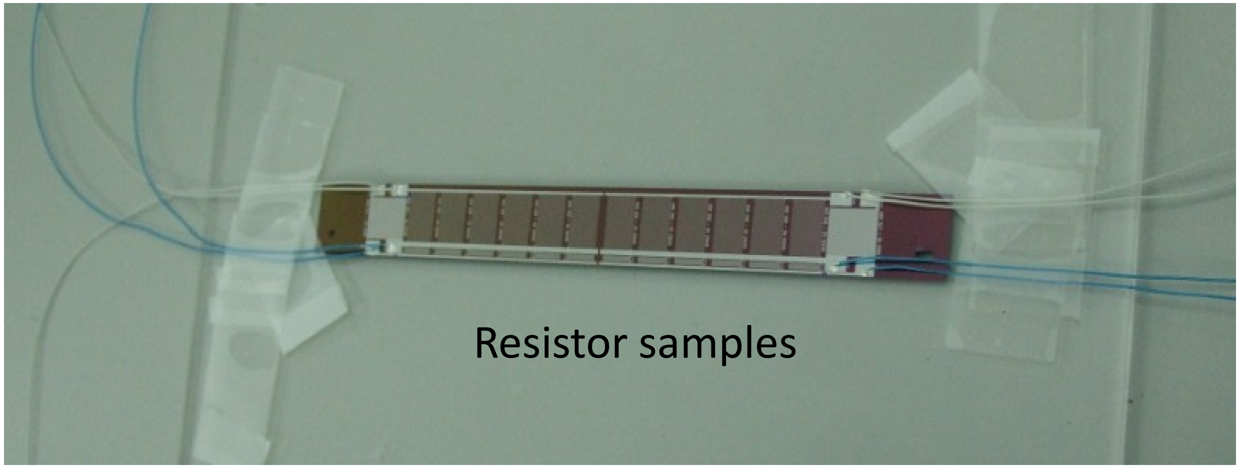
	BrNi	CrCo	AlSiMg	Stainless steel
Therm. conduct. (W/mK):	**30**	**13**	**140**	**15**
CTE (um/m°C):	**18**	**14**	**21**	**17**
Resistence (N/mm²):	**400**	**1200**	**310 (?)**	**650**
Comments :	**Residual magnetism Porous (!)**	**- Difficult to machine (polish, drill, etc.) - Non magnetic**	**-"malleable" (to drill, polish...) -Non magnetic**	**Pores and leaks in our samples (leaks by manipulation)**

Thermal Mock-up

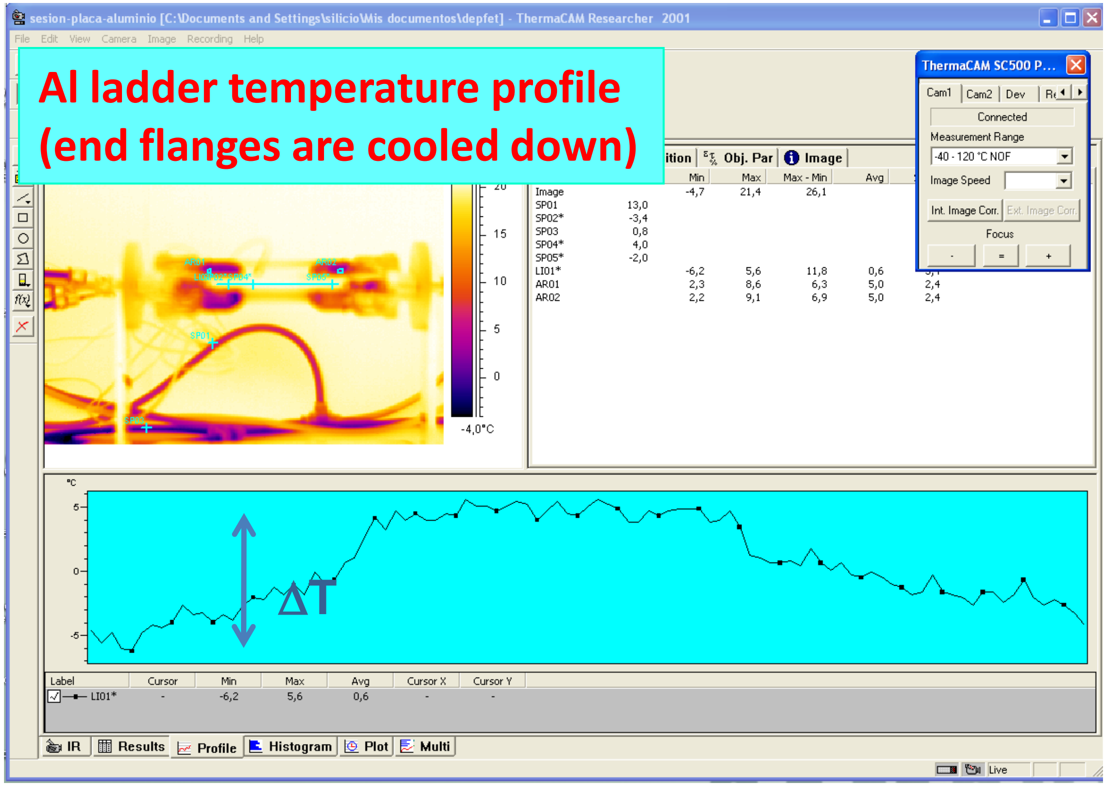
- Dummy ladders:

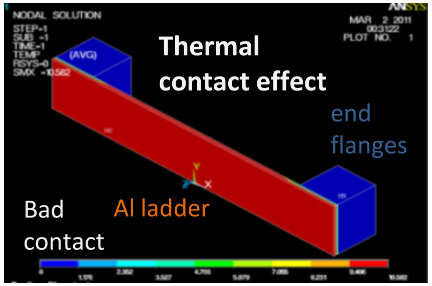


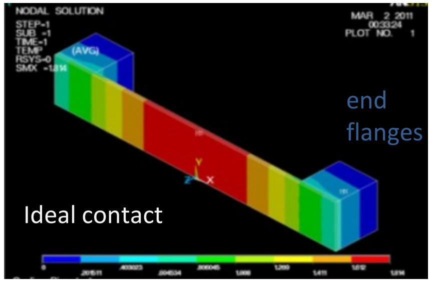




- Thermal contact between cooling block and ladder





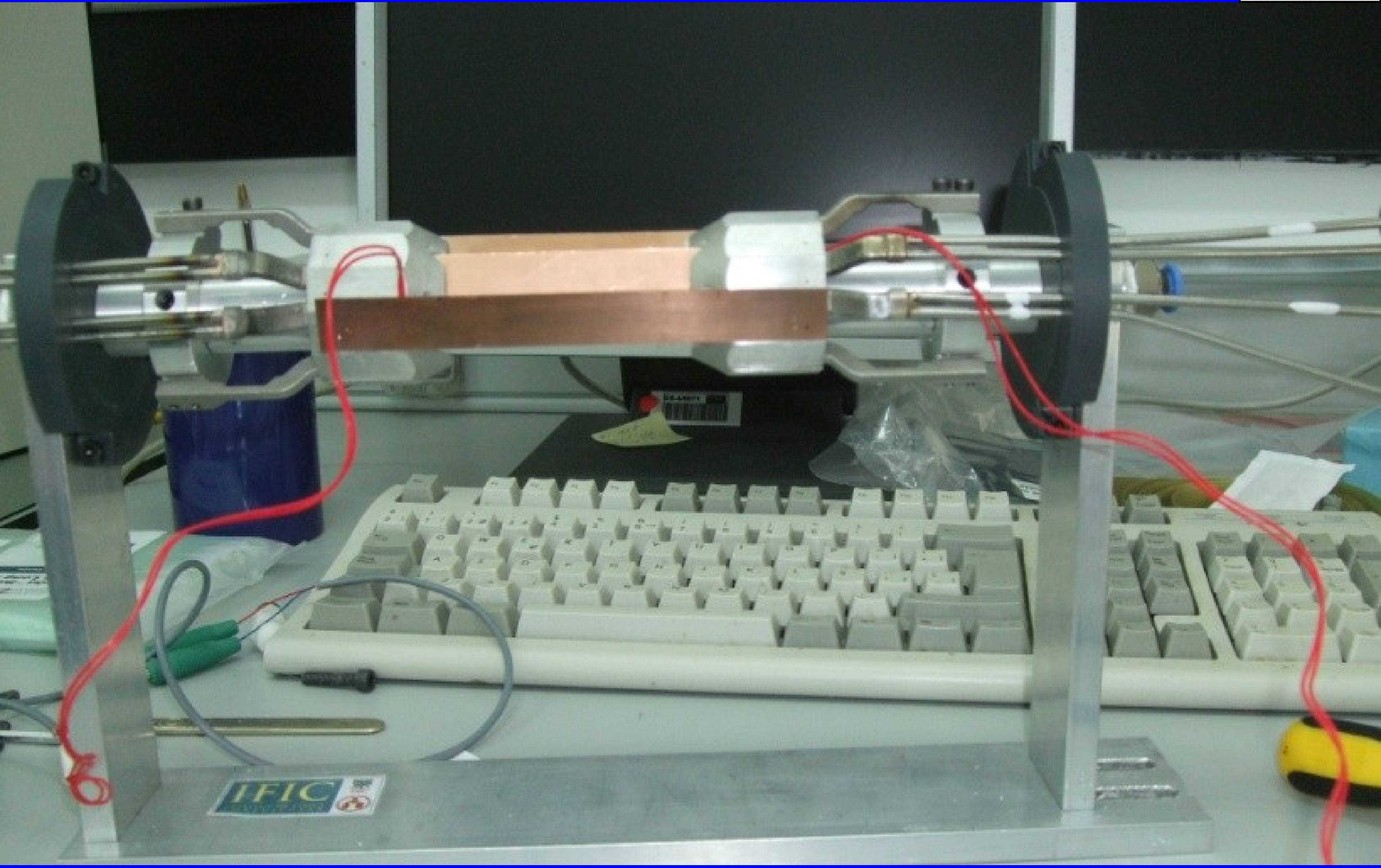


→ΔT strongly depends on the thermal contact

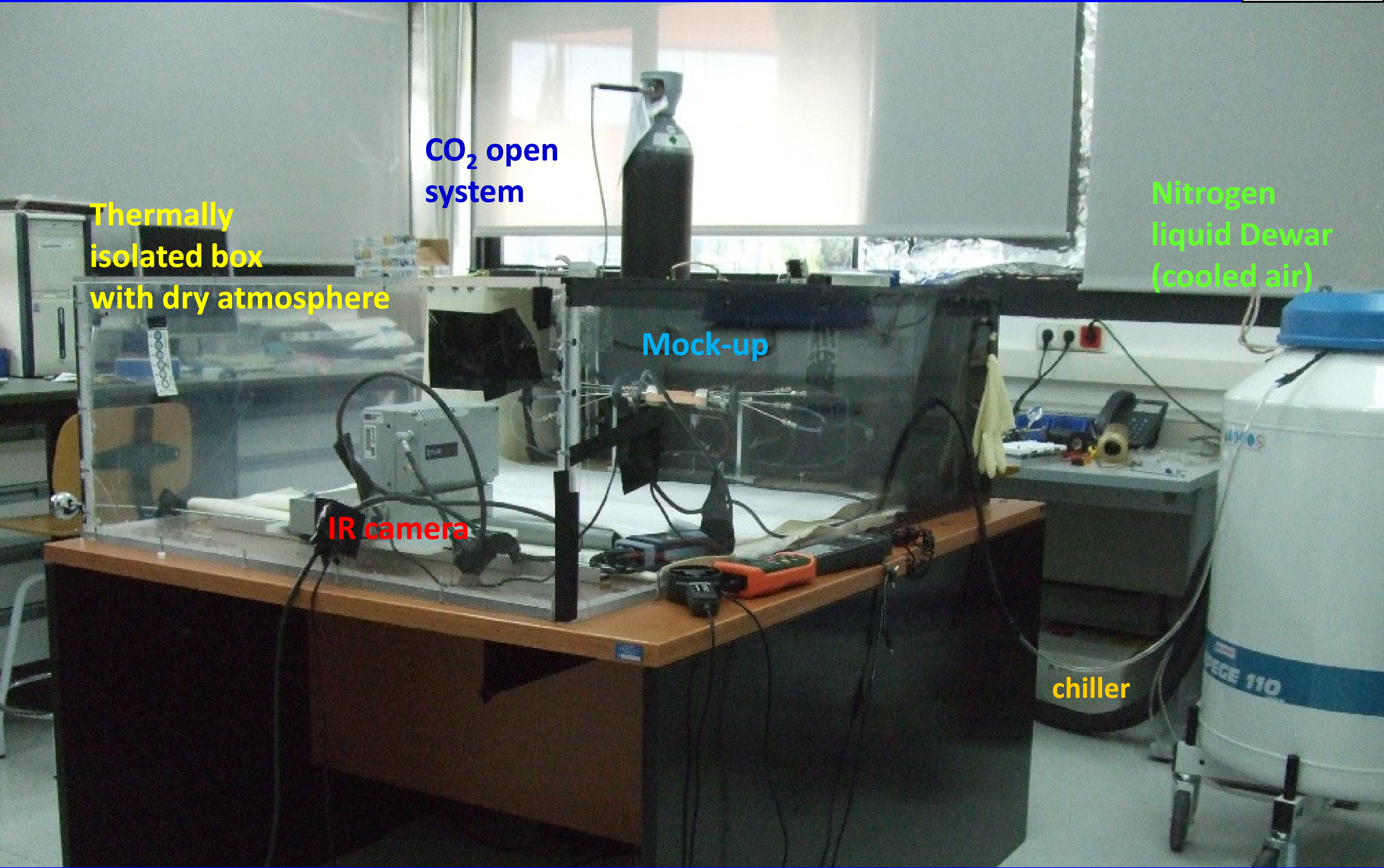
→ Thermal paste + screws

→Quite difficult to thread on CrCo, at present using double sided thermal tape (thermal conductivity = 0.8 W/mK)

Thermal Mock-up



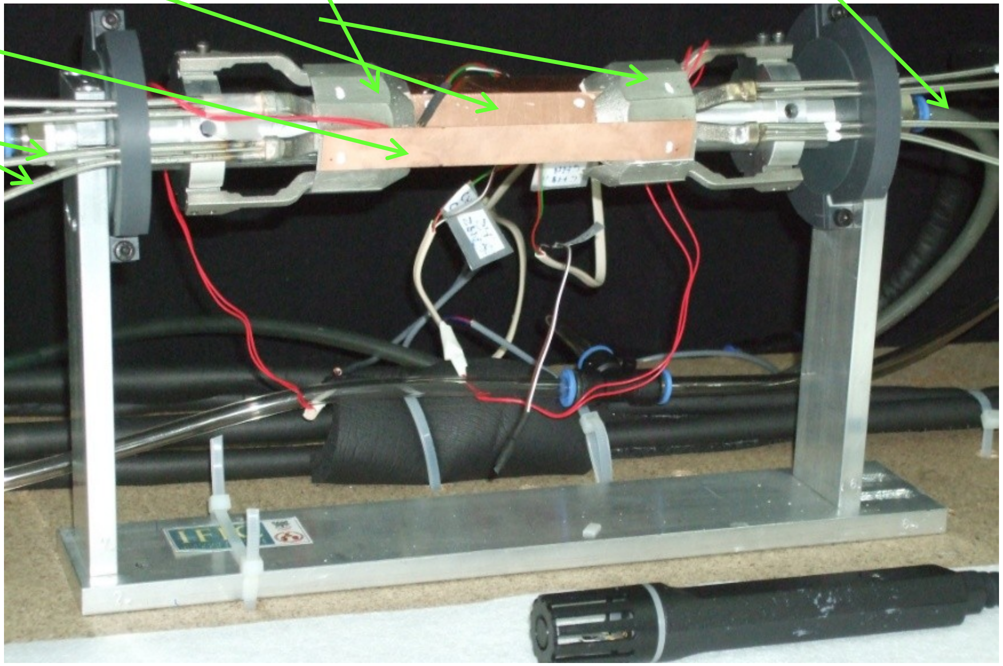
Thermal Mock-up



Cooling studies

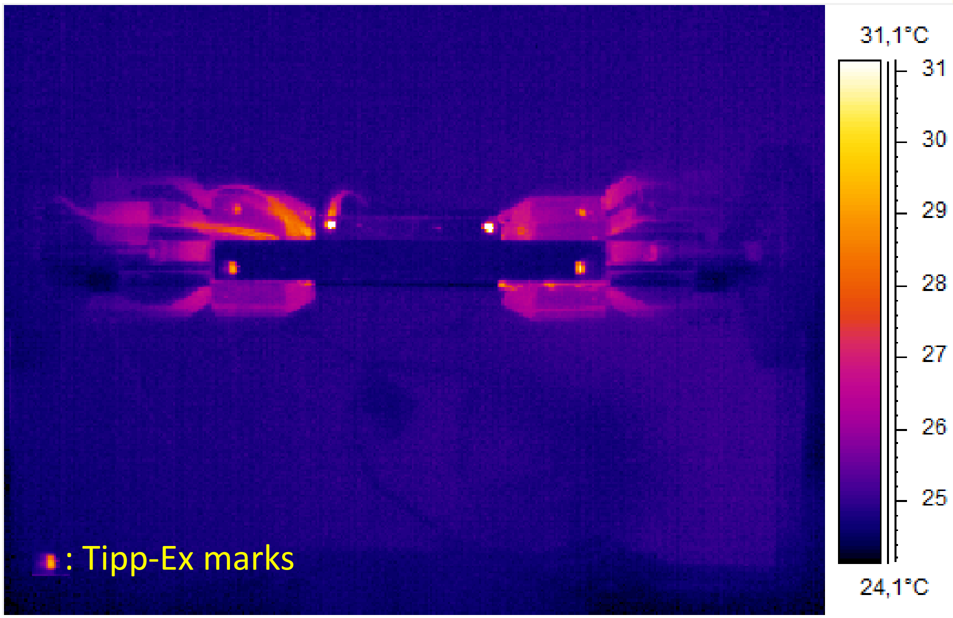
- <u>Effect of air flow cooling</u>

- Beam pipe at room temperature (can be cooled with chiller → 15 °C)
- CrCo end flanges (2), cooled down with CO_2 (~12bar)
- Cu ladders with heaters:
  - Power dissipated along ladder: 1W → T ~ 30°C;
  - 4 inner ladders, only one with heater
  - 1 outer ladder with heater
- Air flow: dry air at ~ room temperature (20°C) or cooled down with liquid N_2
- Measure temperature on inner and outer ladders with IR camera, calibrated with PT100s and Tipp-ex marks (ε=0.95)
- Room: T=24° C, Humidity=8%

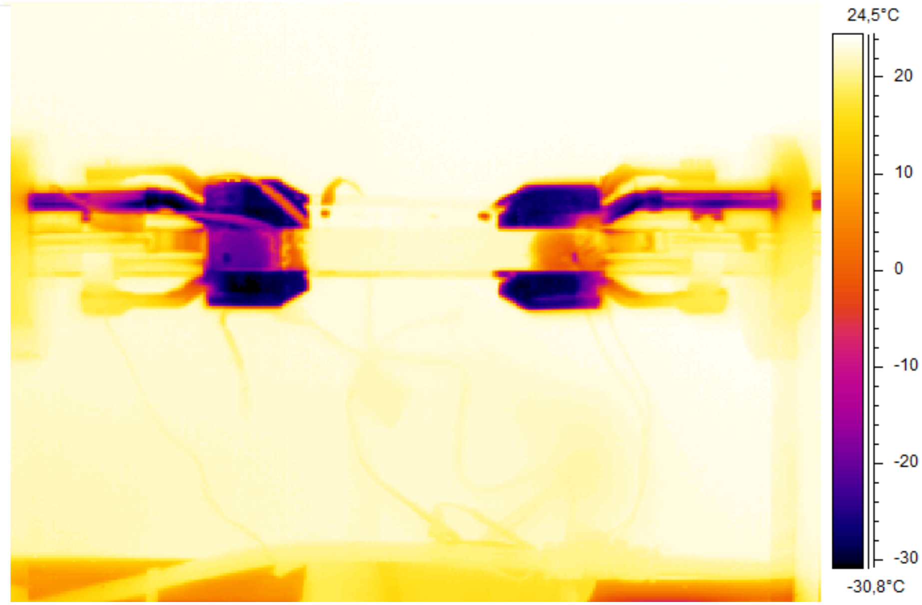


Thermal images:

Switching the heaters on



Cooling down the end flanges with CO_2



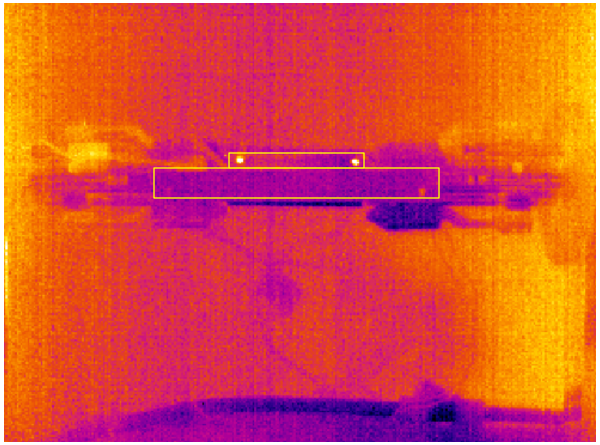
→ Real temperature given by Tipp-ex marks (ε=0.95) (global image emissivity)

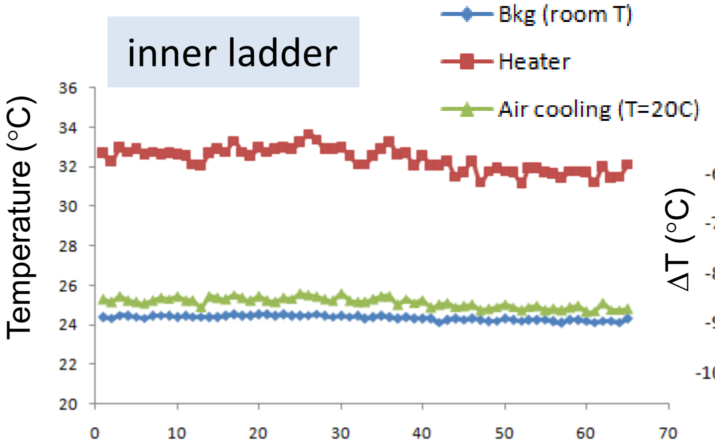
→ Emissivity of other materials have to be corrected

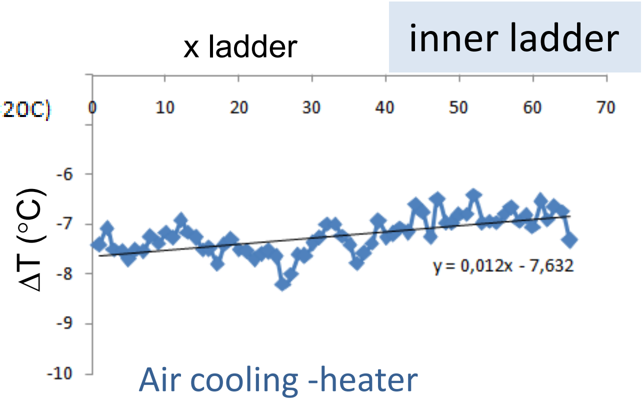
[→ Ice emmisivity ~ 0.97 → frost (slightly, H=8%) give approximate temperature]

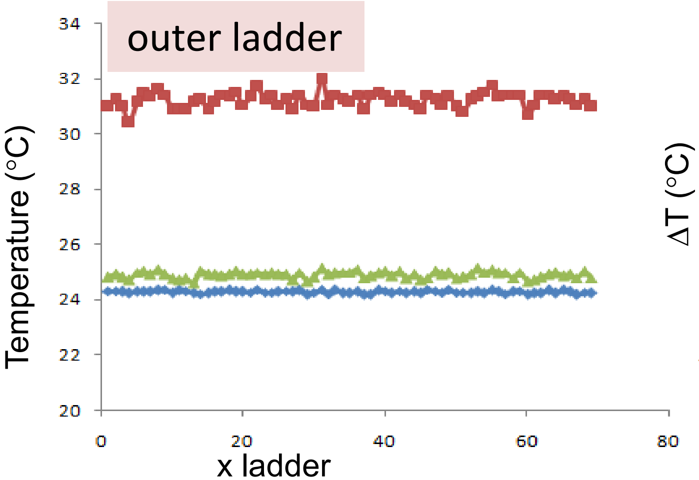
Cooling studies

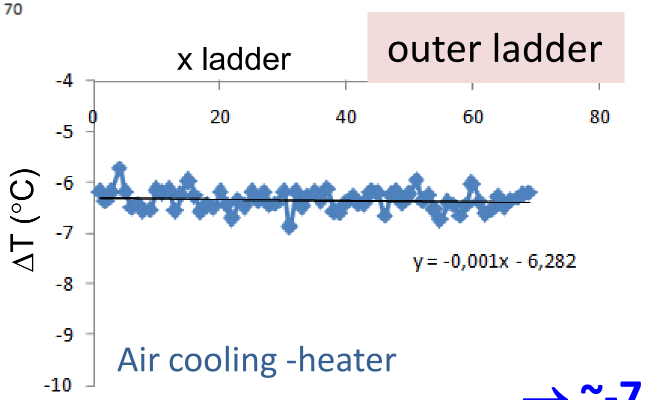
- Heaters on
- Air flow at 20 °C (~2m/s)
- Cooling blocks at room T







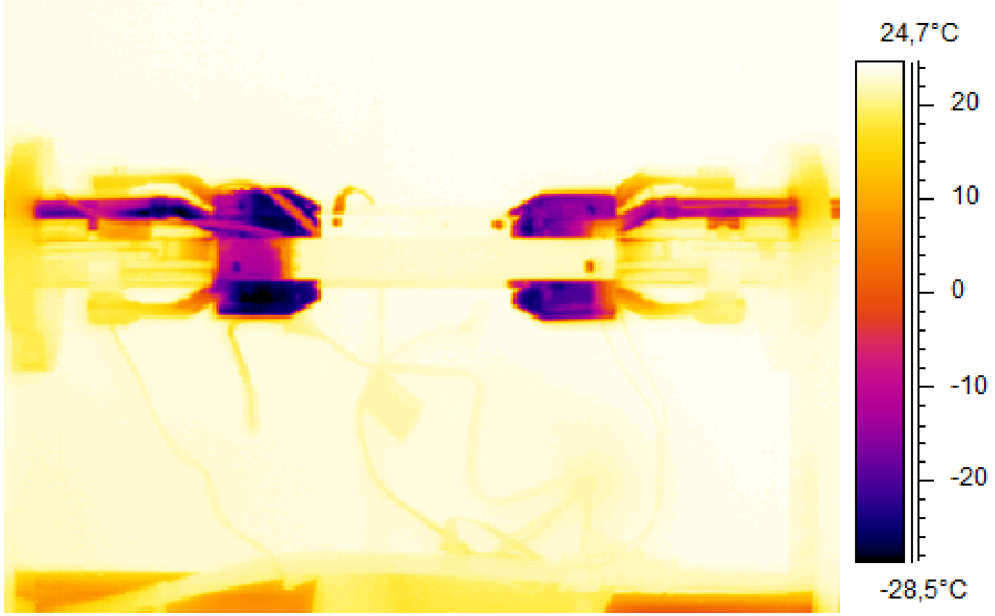




→ **~-7 °C in both ladders**

Cooling studies

- Heaters on
- Air flow at 20 °C
- Cooling blocks with CO_2 (12bar)



→ **Not good thermal contact (thermal tape)**

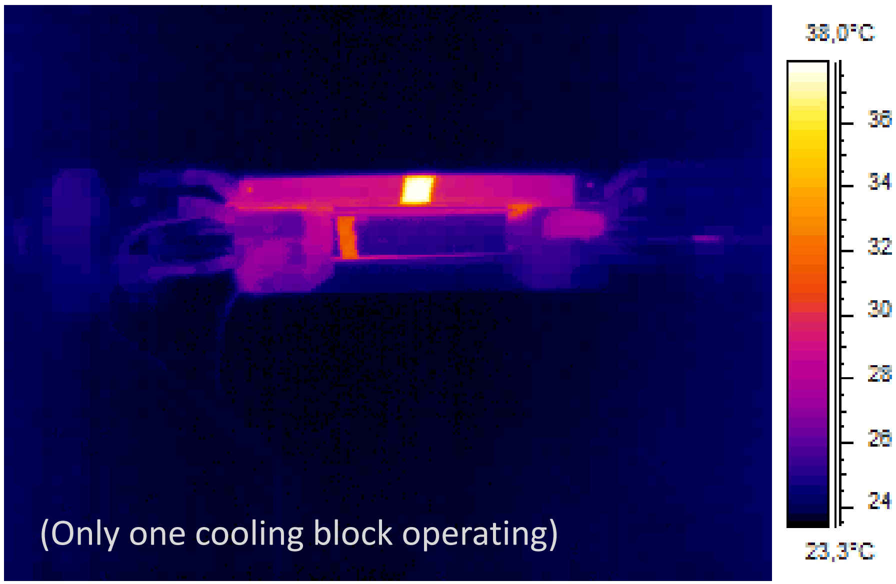
→ **Cooling blocks at -31 °C**

→ **Images still to be analized, PT100s and Tipp-ex marks show a few degrees for inner ladder (IL) (worst thermal contact) and -6 °C for outer ladder (OL).**

→ **Switching off the air flow → - 4 °C (IL) -10 °C (OL)**

Cooling studies

→ **Tests by cooling the air with liquid N_2 → difficult to control the temperature, inner and outer ladders at – few degrees.**



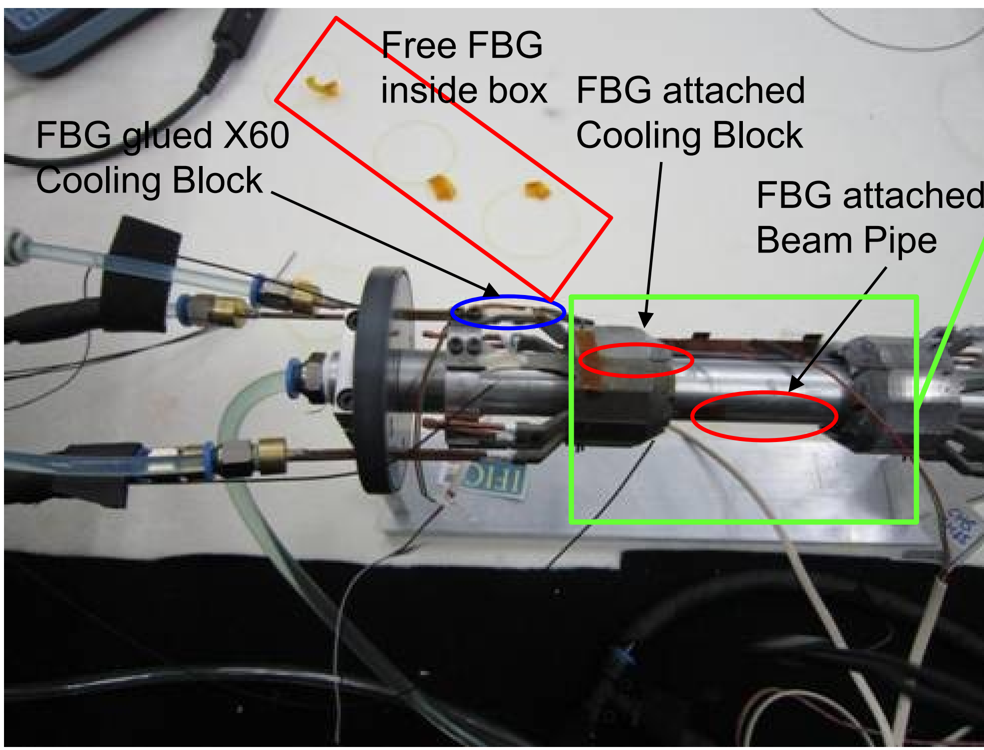
(Only one cooling block operating)

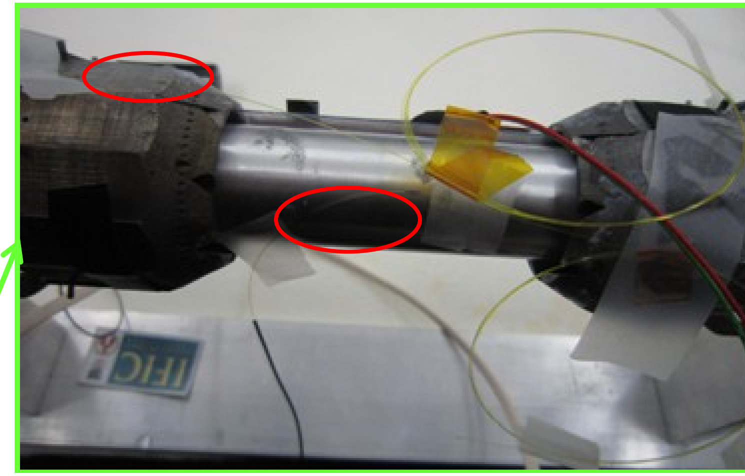
(Only cold air flow (N_2)
Cooling blocks at room T)

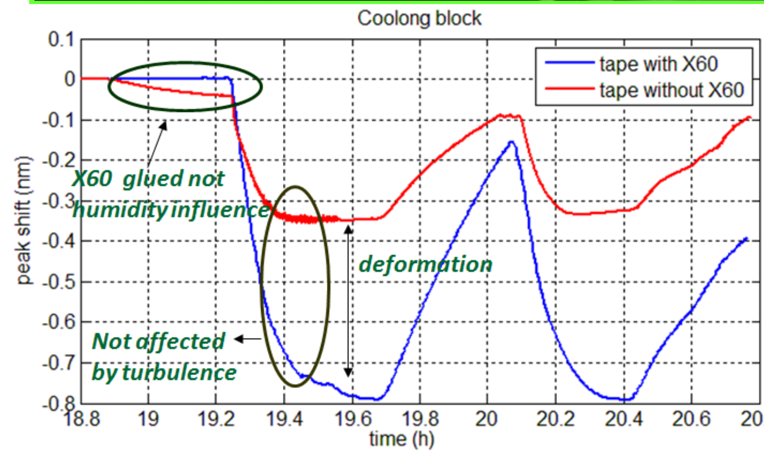
??

Cooling studies

- Mock-up used as test-bench to measure temperature, deformation and vibrations with FBGs (IFCA activities at Valencia)







D. Moya (VII DEPFET Workshop)

Conclusions

- Mockup ready at Valencia to give support to Belle-II PXD :

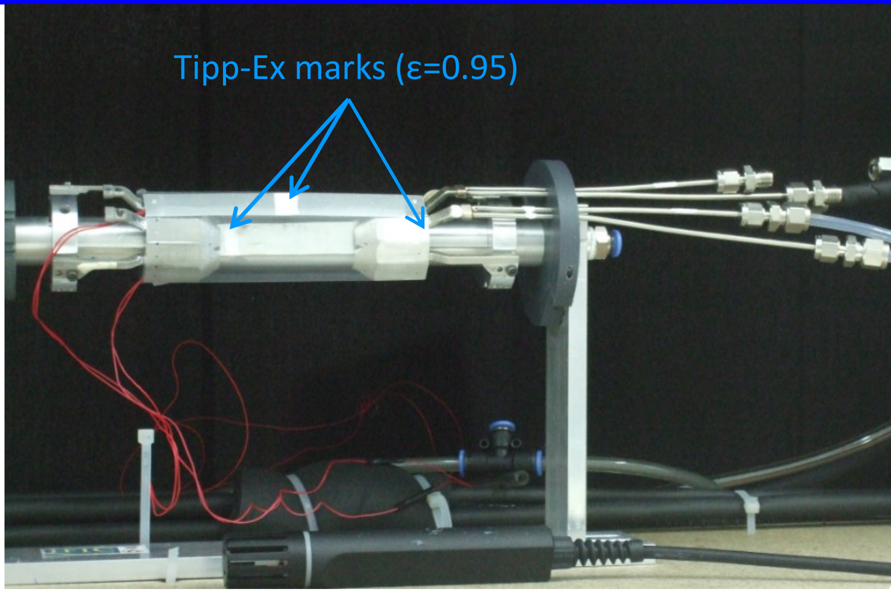
  - Cooling studies to determine the optimal conditions for the sensors

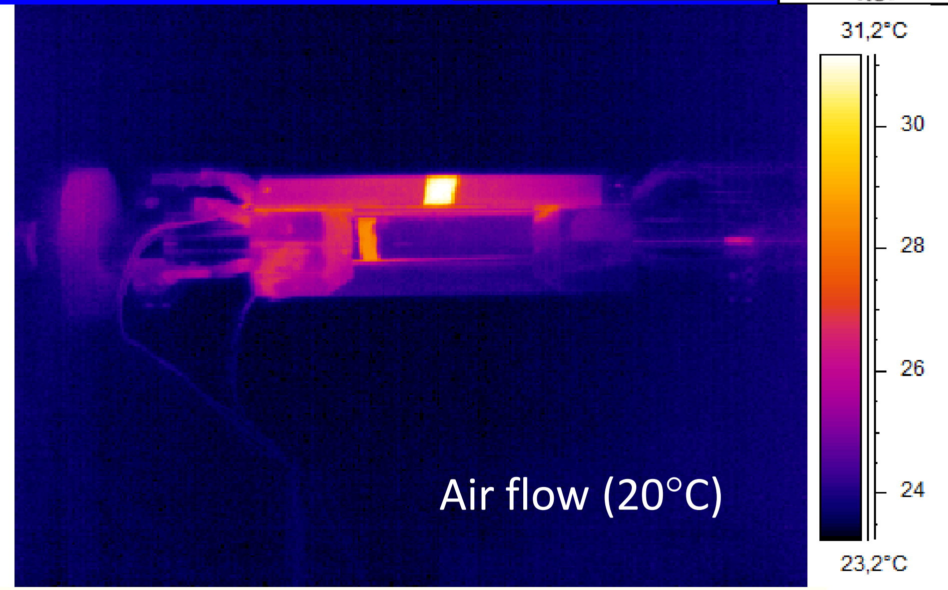
    * Caveats: in AlSiMg samples stainless steel pipes cannot be directly welded $\rightarrow$ trying with aluminium pipes (resistent to CO_2 pressure??)
    + problems in the welding process: blocked pipes, have to be removed and re-welded

- Several test expectd in the coming weeks with the two types of cooling blocks.

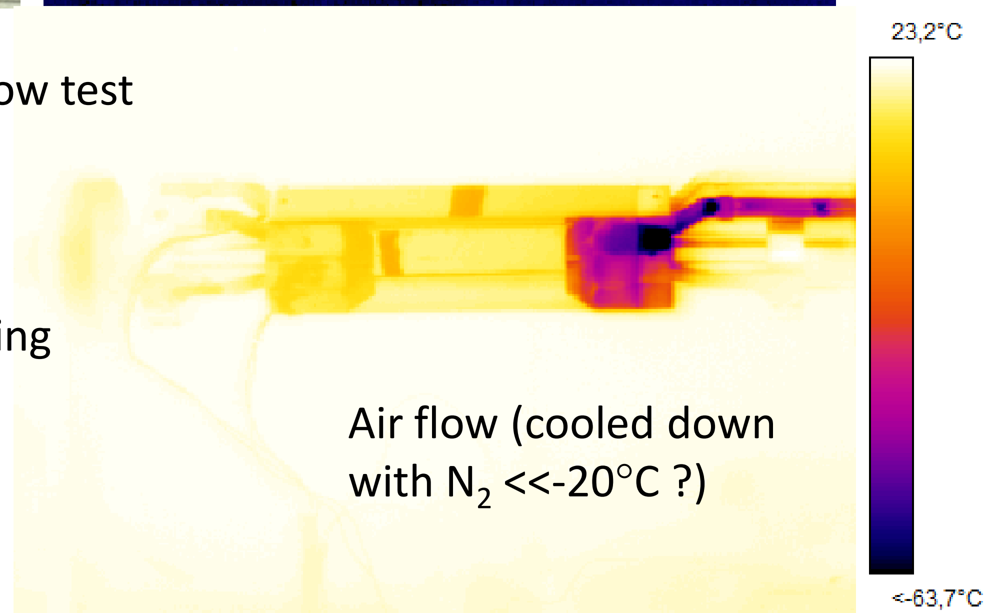
- This mockup may also be useful for other groups/tasks:
  - FBG's tests from IFCA
  - AIDA activities (?)
  - ITA (?)

Backup





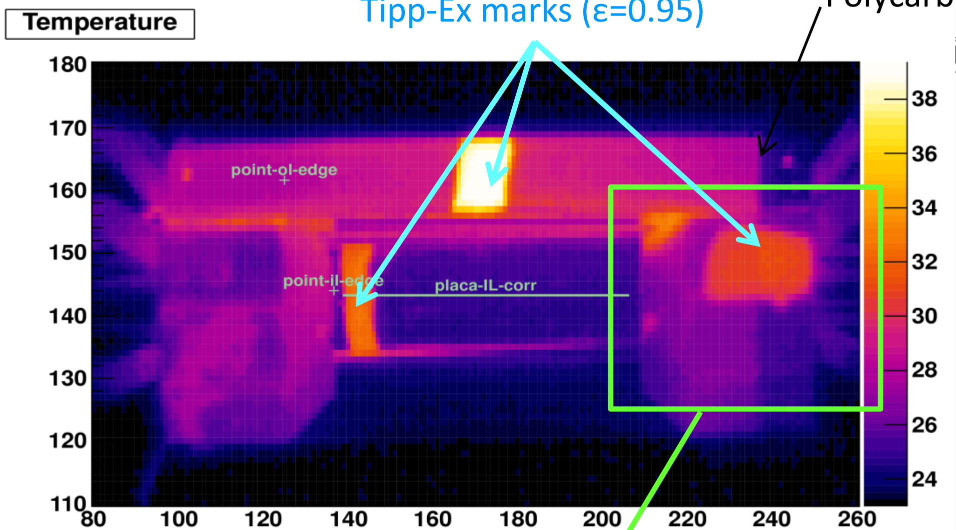
- Only 1 CrCo operating end flange → air flow test
  - Aluminium ladders with heaters (1W);
    - 1 inner ladder with heater
    - 1 outer ladder with heater
- IR transparent polycarbonate sheet covering
  - Dry air at ~ room temperature (20°C) or cooled down with liquid N_2
- IR pictures, Tipp-ex marks calibration

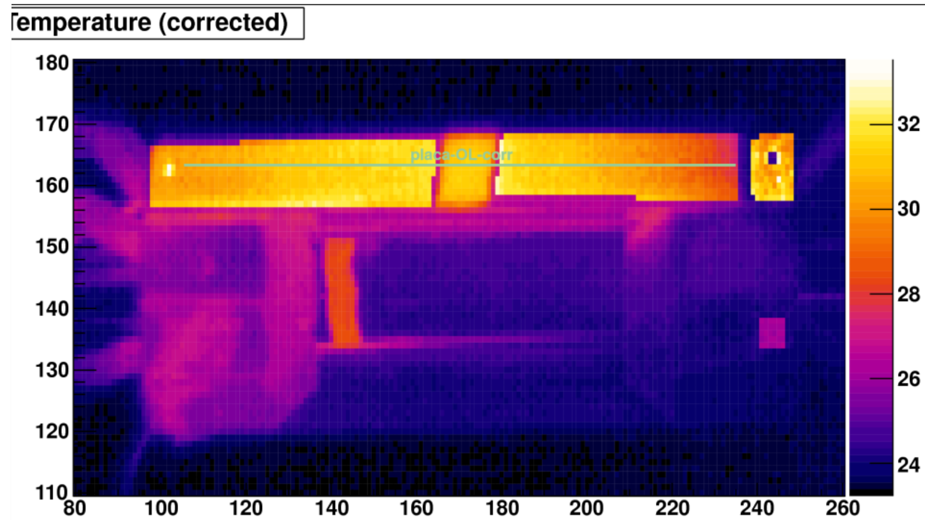


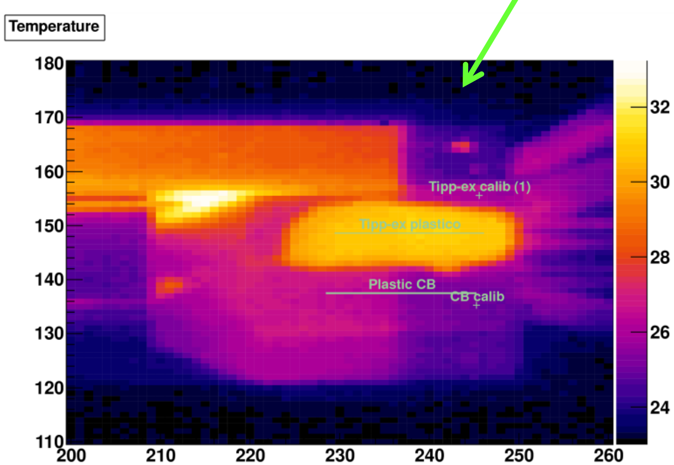
Backup

Tipp-Ex marks (ε=0.95)

Polycarbonate cover (relatively IR transparent)



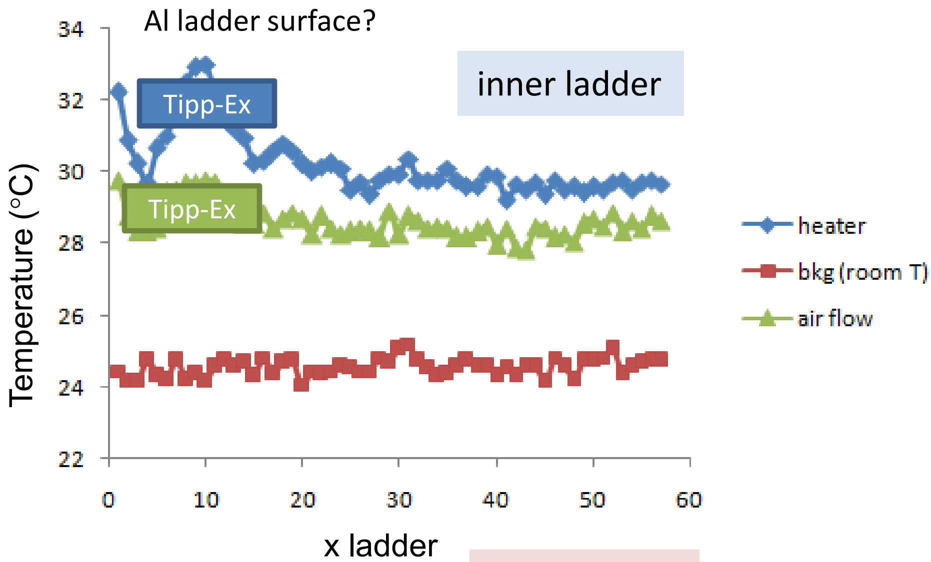




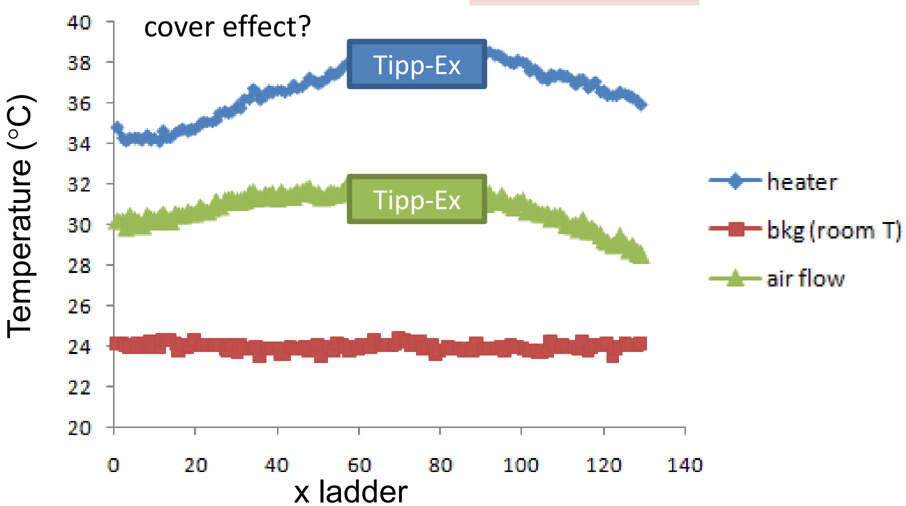
Outer ladder: properly corrected (ε_{eff})

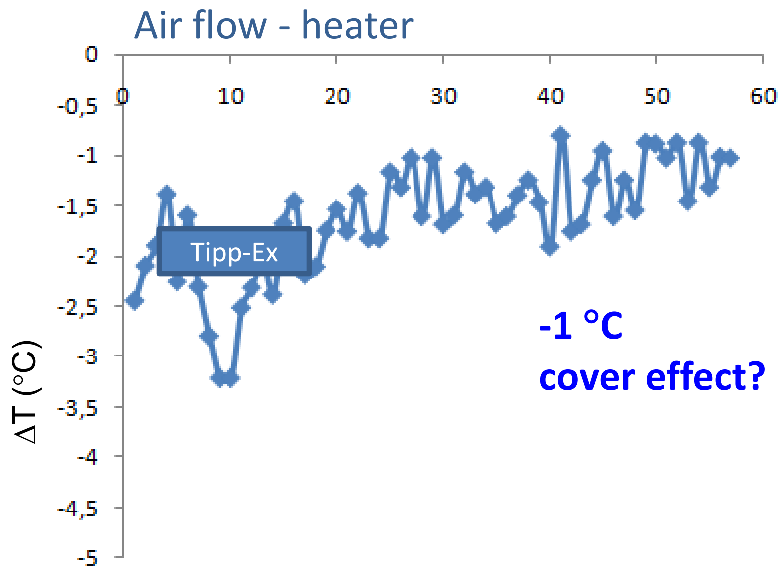
Inner ladder: effect of cover + air?

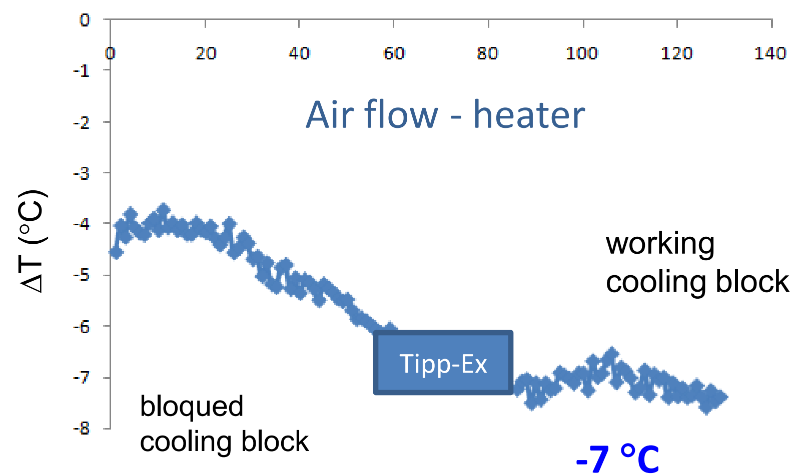
Backup



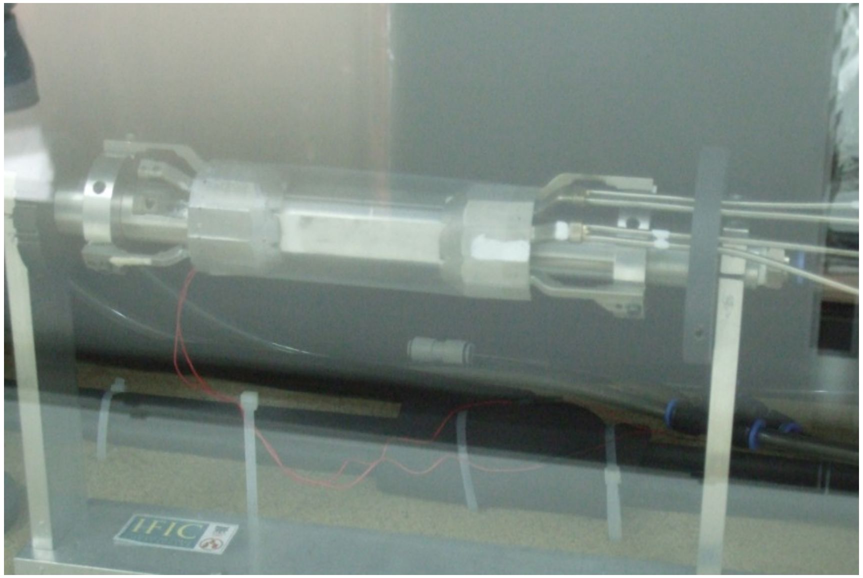
outer ladder

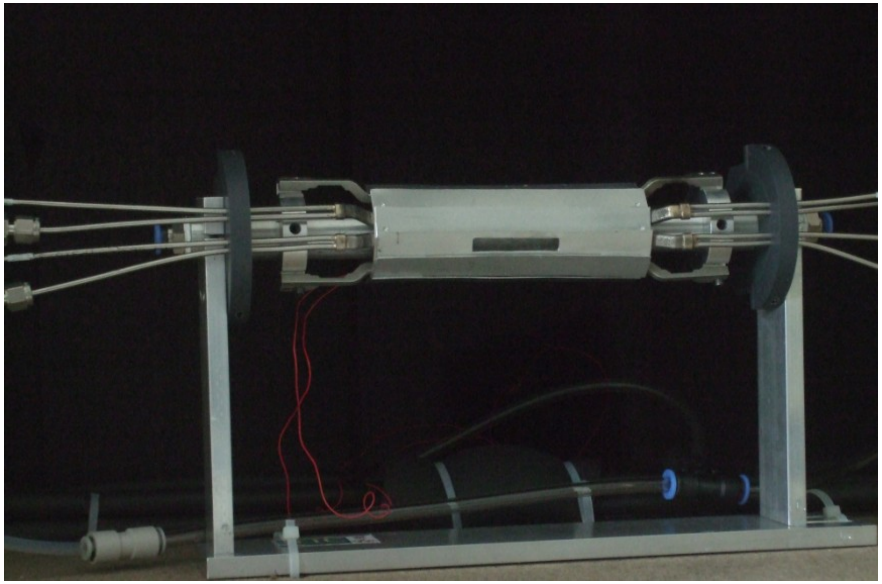


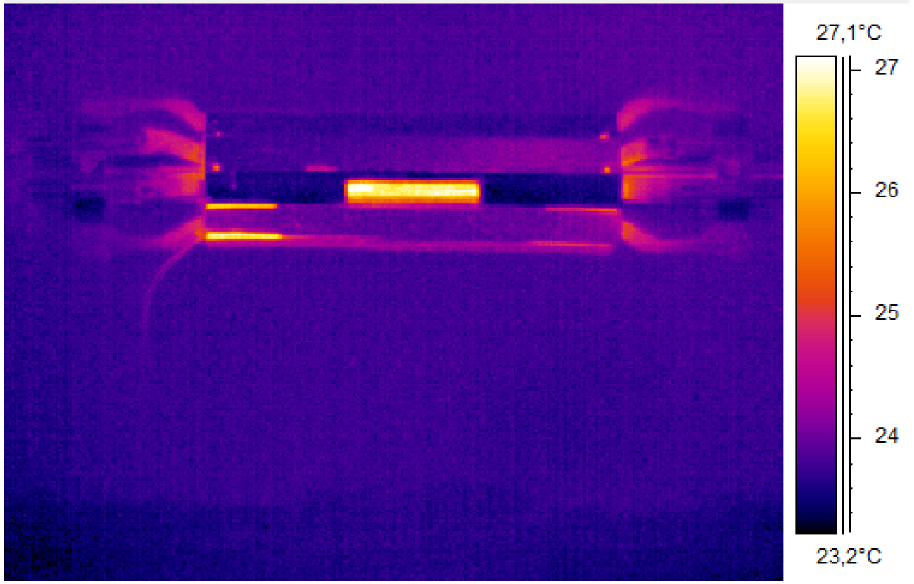




Backup



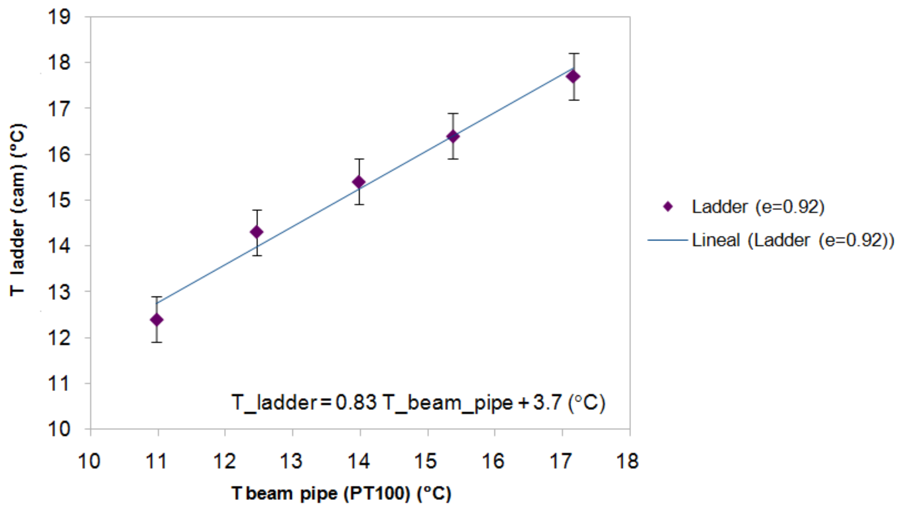


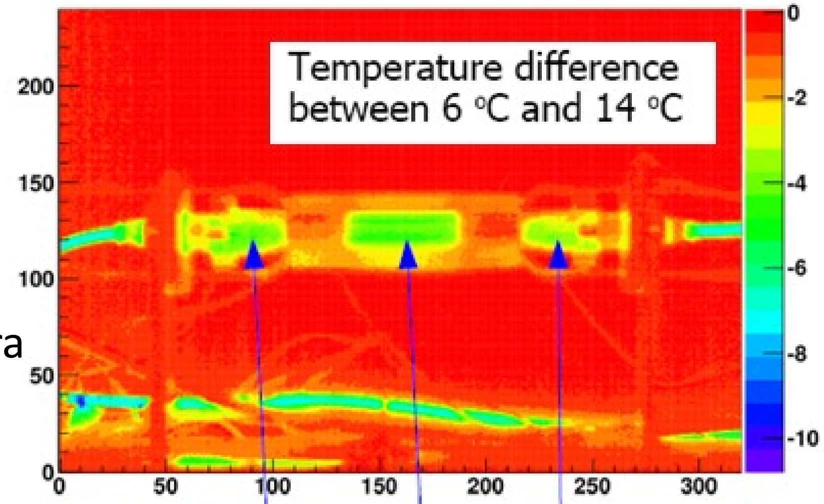


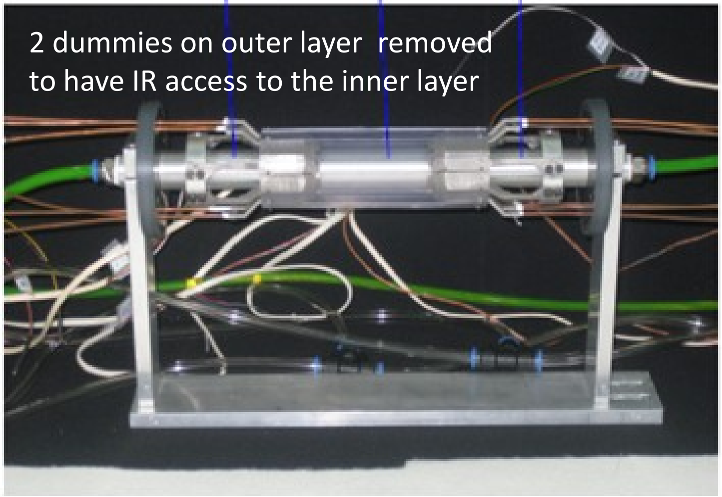
Cooling studies

- <u>Effect of beam-pipe temperature on the inner layer</u>

  - Cooling beam pipe with chiller
  - End flanges at room temperature (stainless steel)
  - Transparent polycarbonate dummies
  - Measure temperature on first layer with IR camera (calibrated with PT100s)







→ Impact of several degrees on first layer (under these conditions)

Backup

- Belle-II is an "intermediate point" in our way to the ILC…
  → … but it is more challenging in some points

	ILC	Belle-II
Occupancy	0.13 hits/mm^2/s	0.4 hits/mm^2/s
Radiation	< 100 krad/year	> 1Mrad/year
Duty cycle	1/200	1
Frame time	25-100 µs	10 µs
Momentum range	All momenta	Low momentum (< 1 GeV)
Acceptance	6º-174º	17º-150º

- ILC
  - Excellent single point resolution (3-5 µm) → Small pixel size 25µm^2
  - Low material budget (0.12%X_0/layer)

- Belle II
  - Modest spatial resolution (10µm) → Moderate pixel size (50 x 75 µm^2)
  - Few 100 MeV momenta → Lowest possible material budget (0.15% X_0/layer)