



CLIC Physics and Detectors Meeting

Cooling of the CLIC_ILD inner detectors

F. Duarte Ramos, M.A. Villarejo Bermudez

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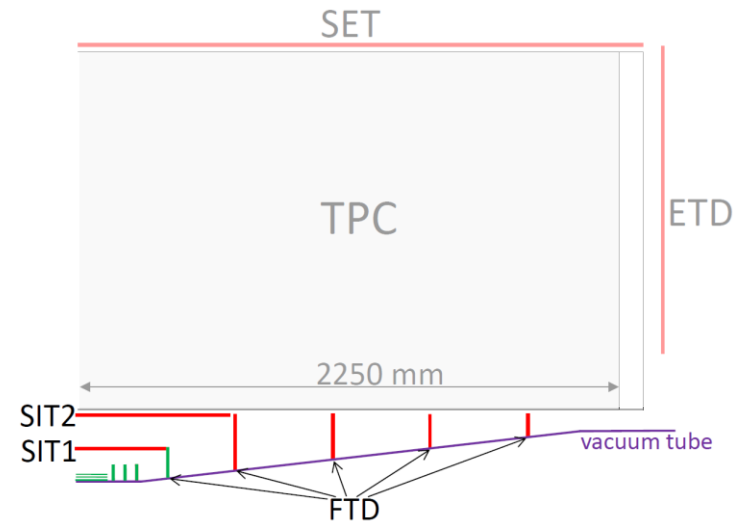
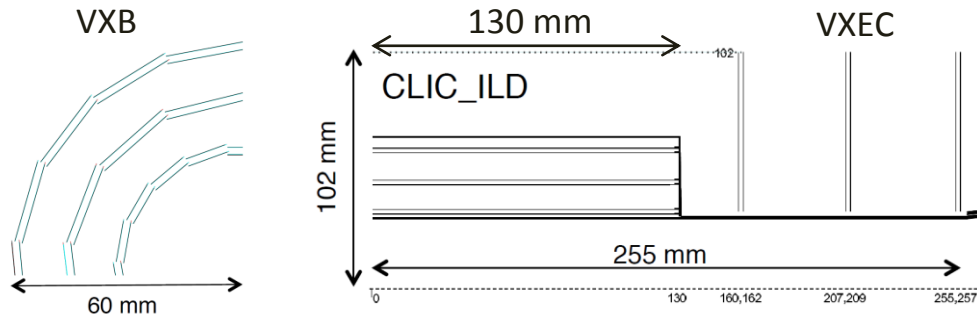
Cooling studies

- Phase I
 - Conceptual design of cooling strategy
 - First order thermal-fluid simulations
- Phase II
 - Development of thermo-mechanical test bench
 - Measurement of cooling performance/vibration
 - Thermal-fluid models validation

Phase I studies

Conceptual design

Layout and constraints

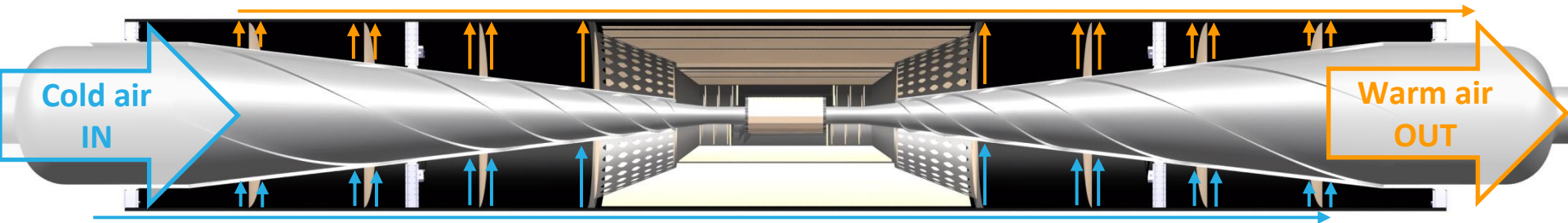


- ≈ 470 W heat load (pwr. pulsing)
- Room temperature operation
- Low material budget

Dry gas cooling (Air/N₂)

Cooling distribution

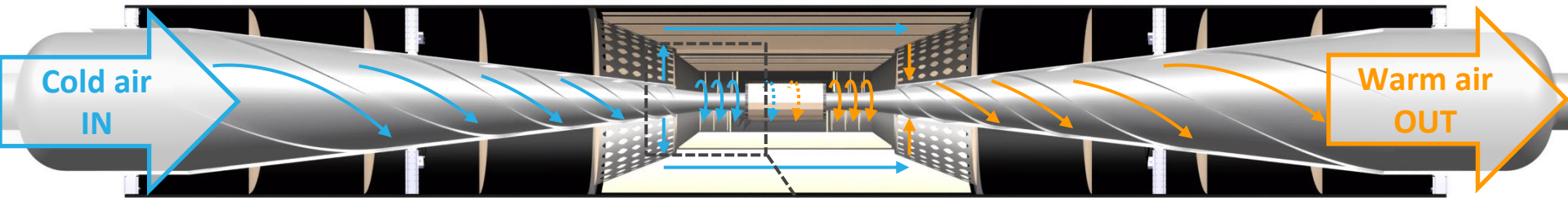
Outer stream



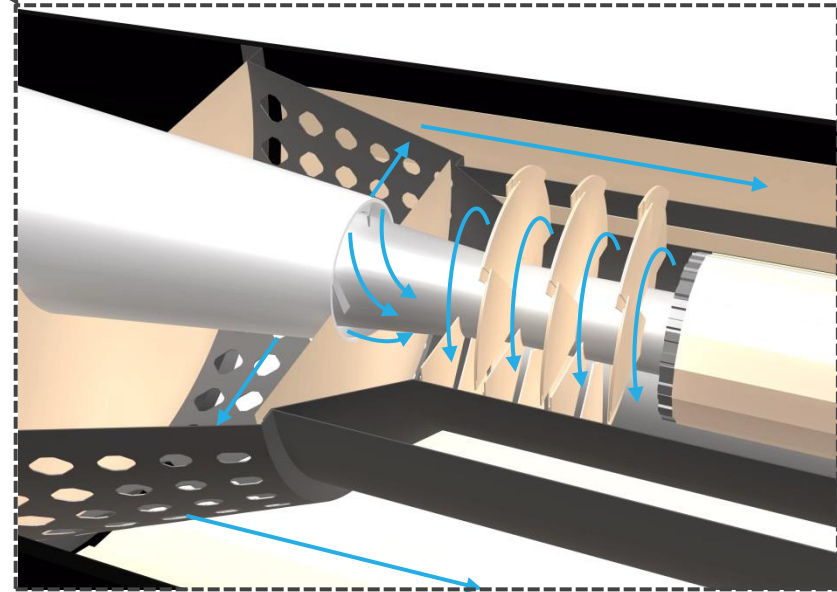
- Cooling of FTDs 1-5
- Low heat load (silicon micro-strips)
- Natural convection/low velocity forced convection
- Air/N₂ delivered/extracted through openings in the CFRP support tube

Cooling distribution

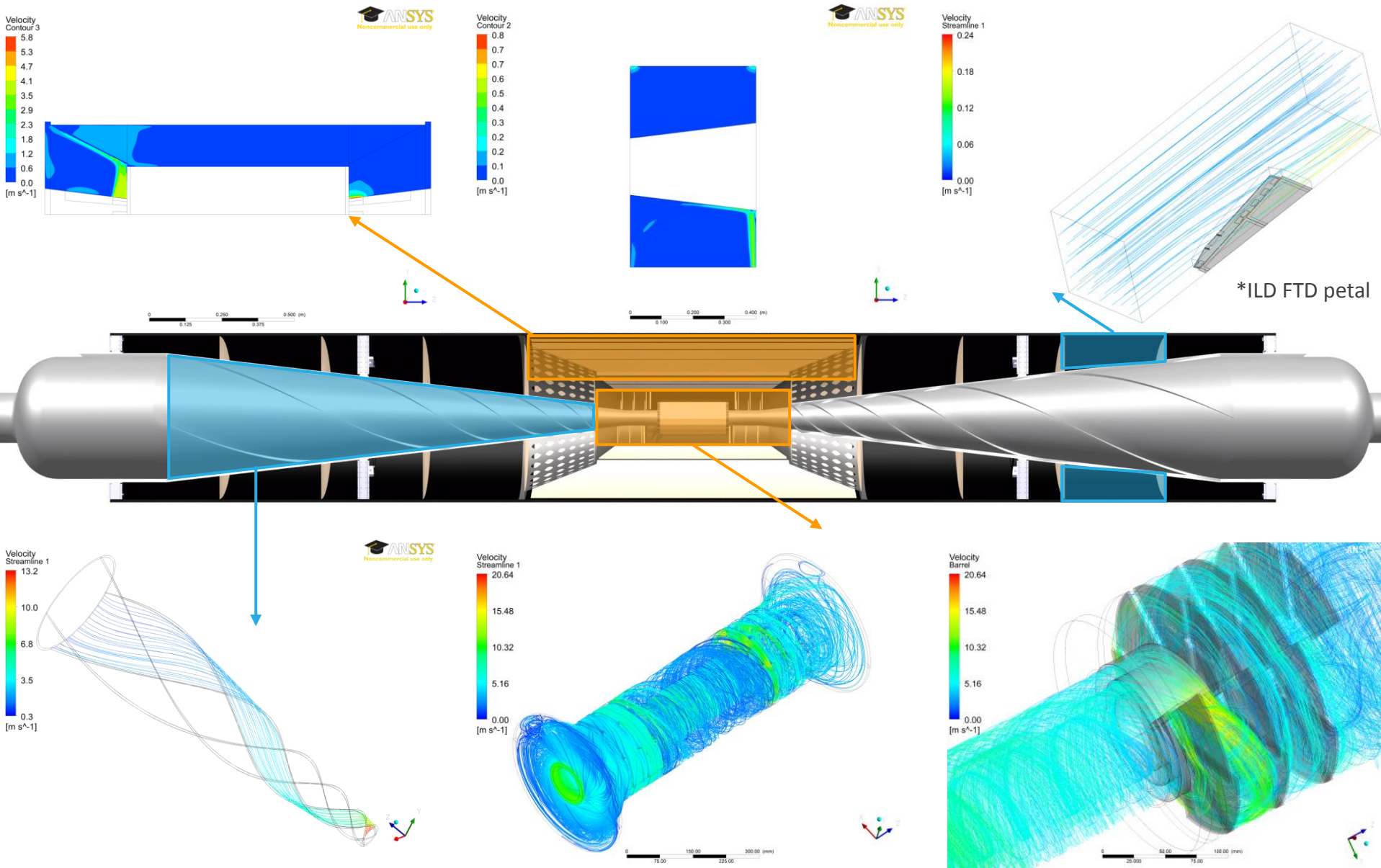
Inner stream



- Cooling of VTX and SIT
- High heat load (silicon pixel + micro-strips)
- Moderate velocity forced convection
- Air/N₂ delivered/extracted through channel between beampipe and conical shield

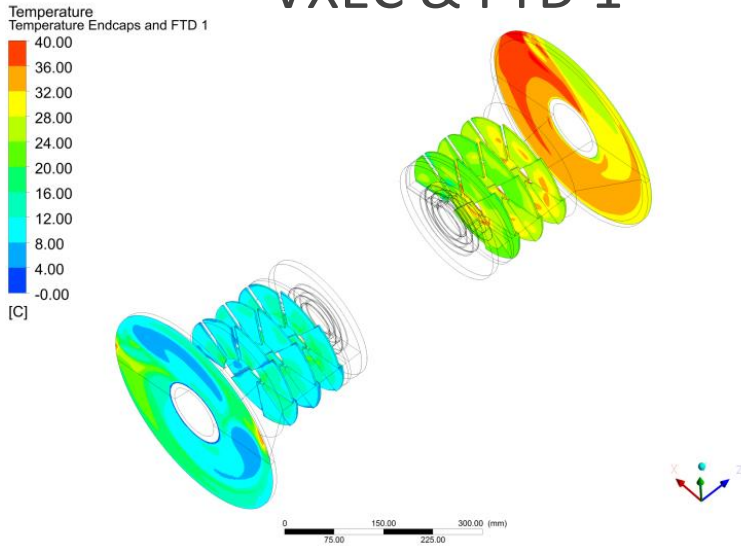


Thermal-fluid simulations

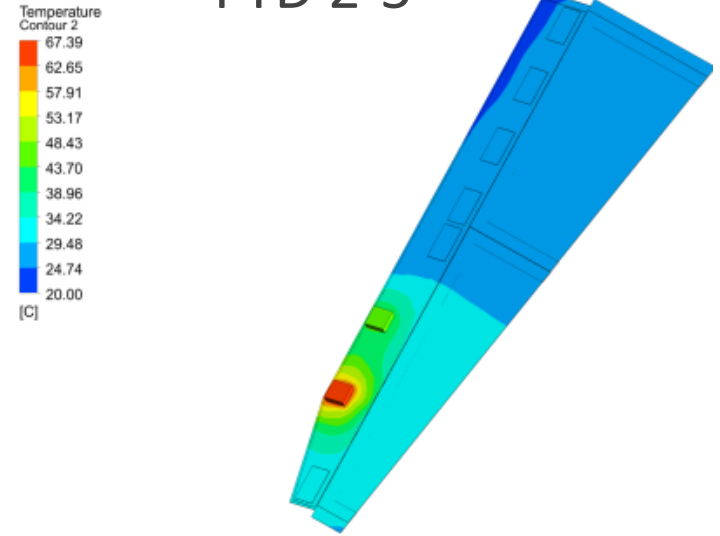


Thermal-fluid simulations

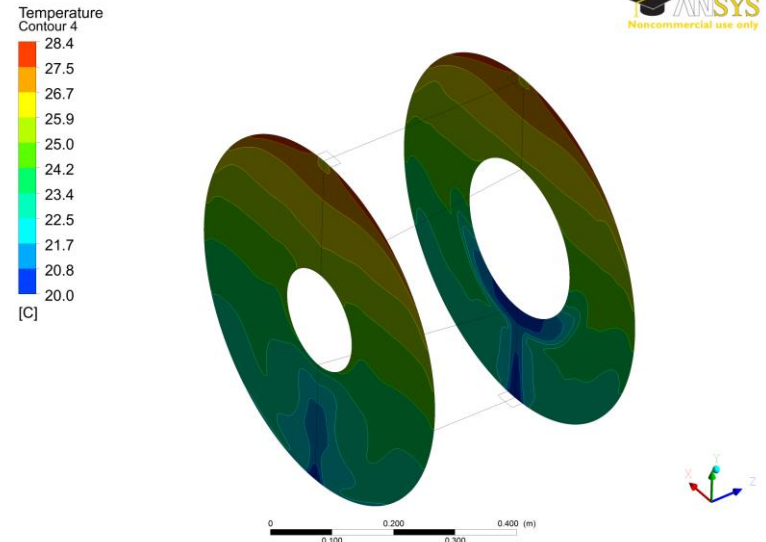
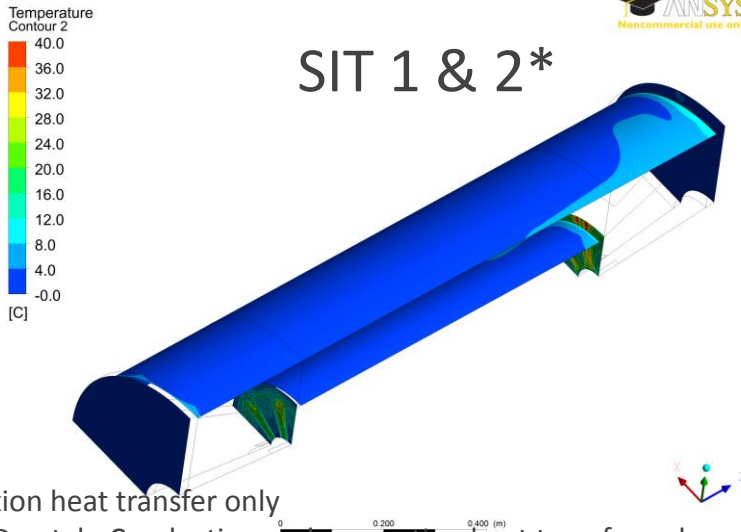
VXEC & FTD 1*



FTD 2-5**



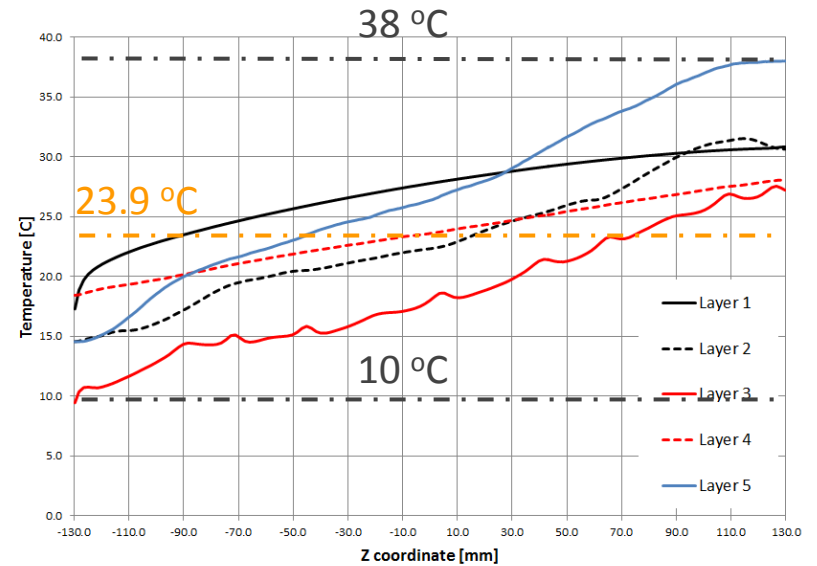
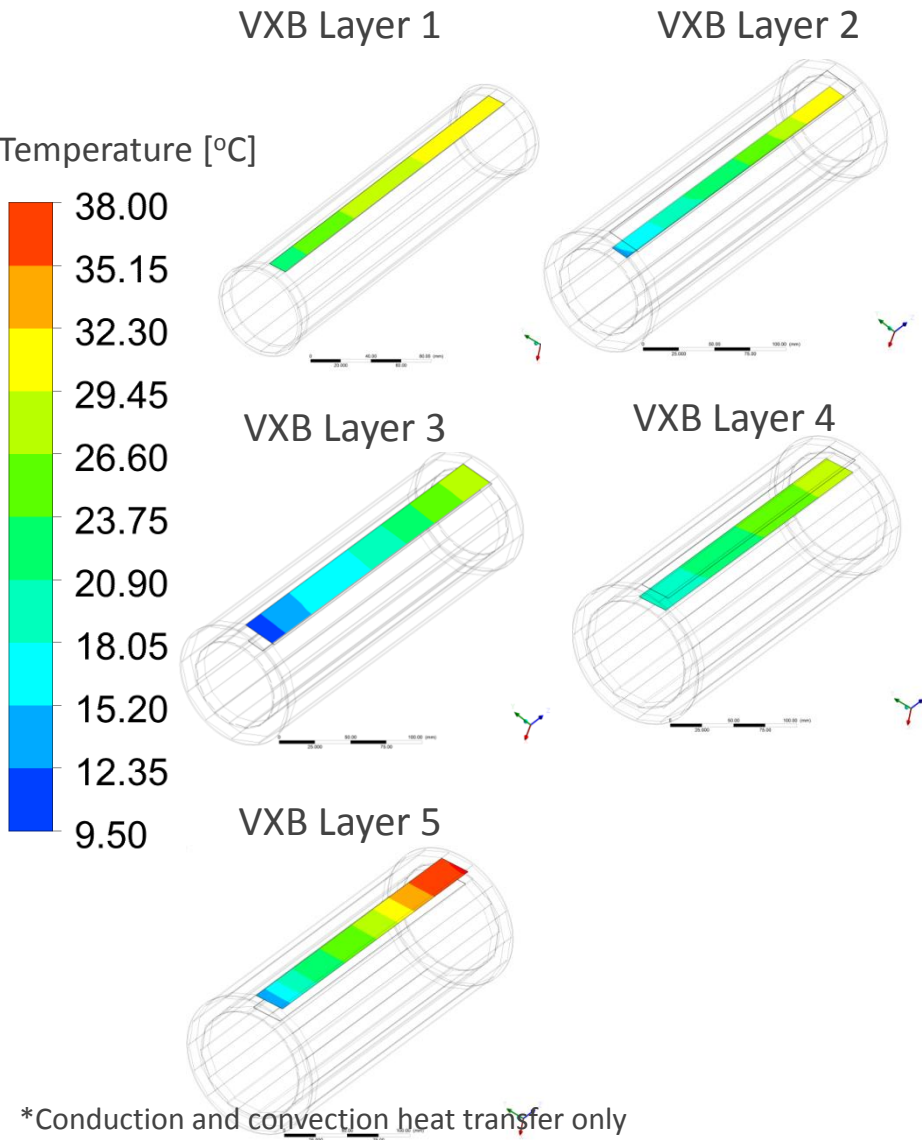
SIT 1 & 2*



*Convection heat transfer only

**ILD FTD petal - Conduction and convection heat transfer only

Thermal-fluid simulations



*Conduction and convection heat transfer only

Summary of phase I studies

- A cooling strategy for the inner region has been developed
- Integrated approach for air delivery and extraction
- First simulations indicate that air cooling seems feasible ($T_{\text{sensor}} < 40 \text{ }^{\circ}\text{C}$)
- Temperature gradients are important (typical of external gas cooling approaches) but not yet optimized
- Thermal deformations not yet addressed
- Moderate velocities may cause unwanted vibrations (to be tested)

Phase II studies (ongoing)

Thermo-mechanical test bench

In collaboration with PH/DT:

François-Xavier Nuiry

Wolfgang Klempt

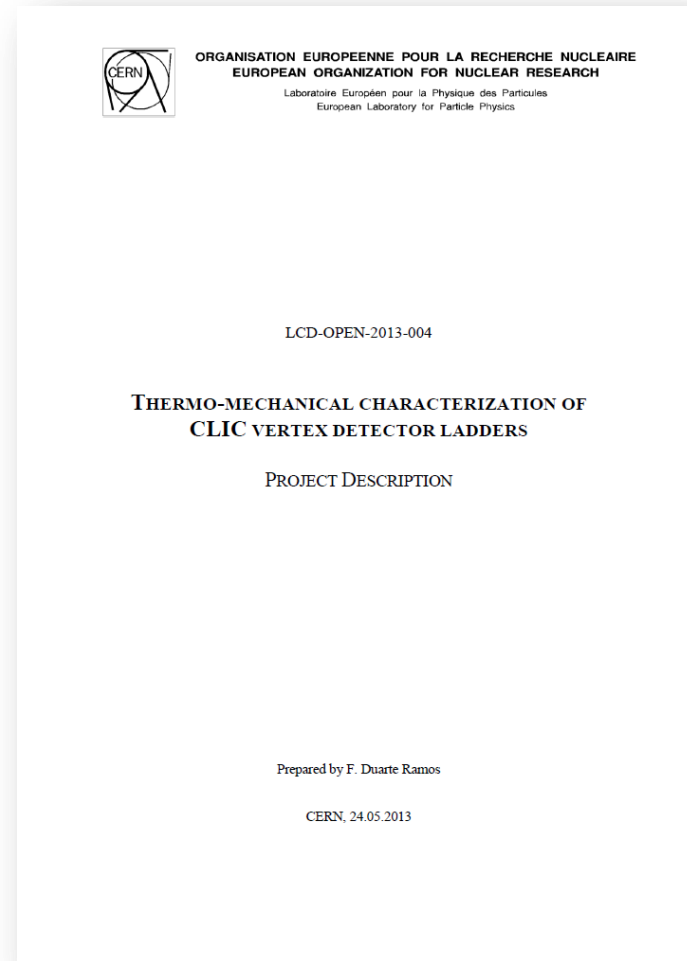
Christophe Bault

Maxence Curdy

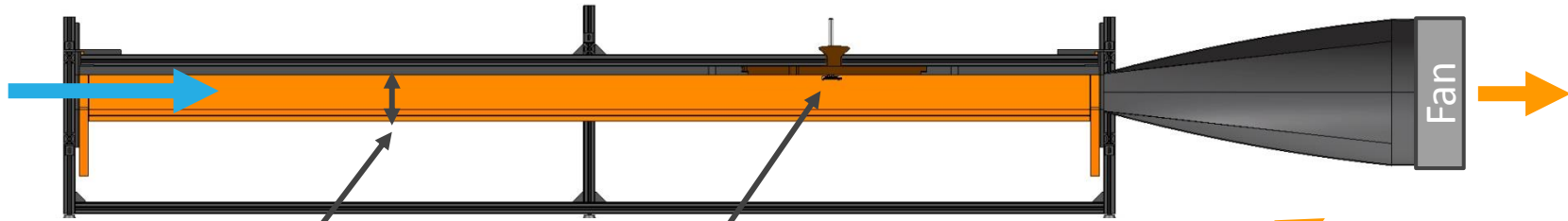
Robin Volet

Thermo-mechanical test bench

- Evaluate forced convection air cooling of a single dummy VTXB ladder heated with the nominal load (50 mW/cm²)
- Measure air flow induced vibrations
- Measure temperature induced deformations
- Validate dedicated finite element models



Thermo-mechanical test bench



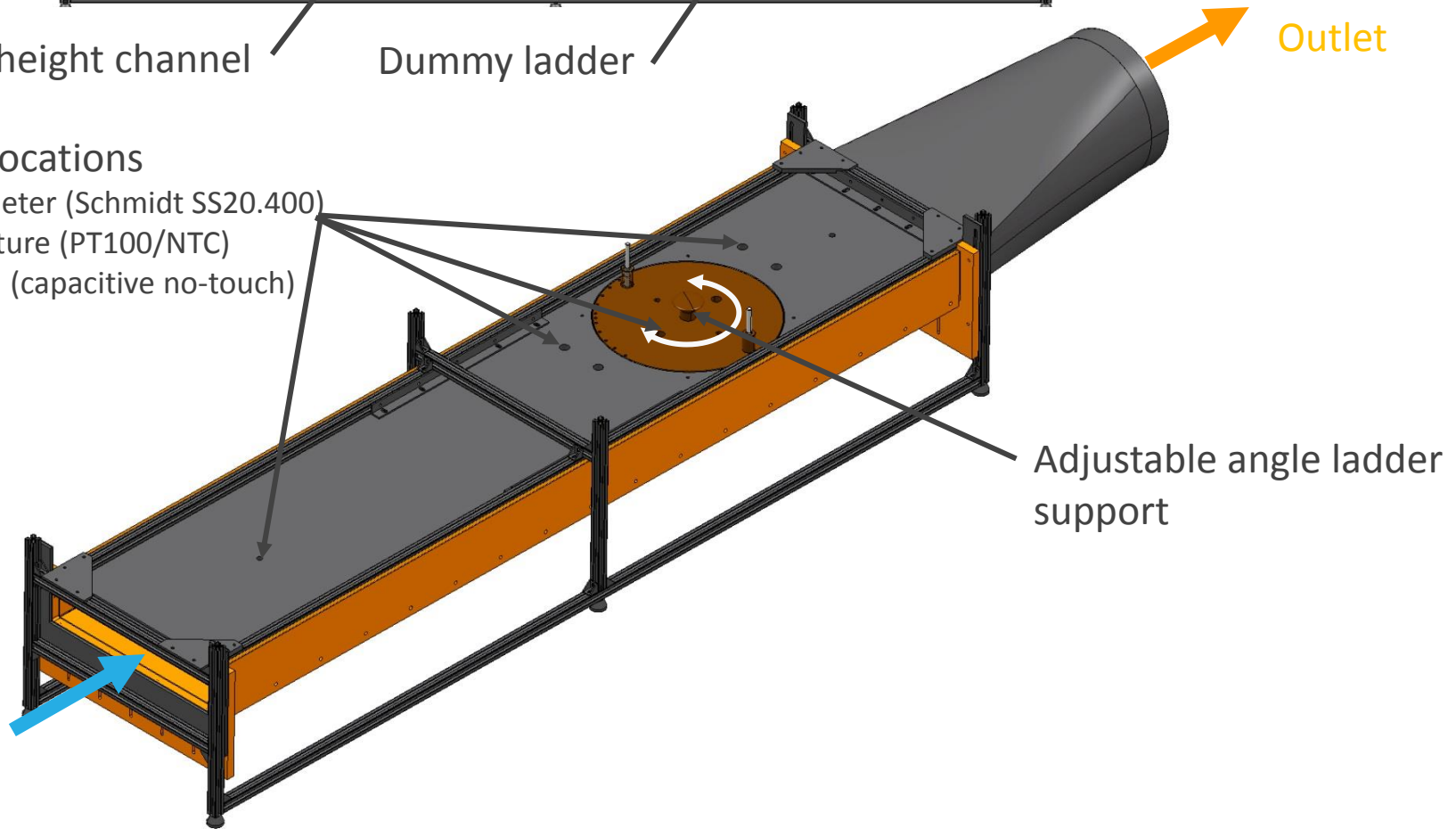
Adjustable height channel

Dummy ladder

Outlet

Sensor locations

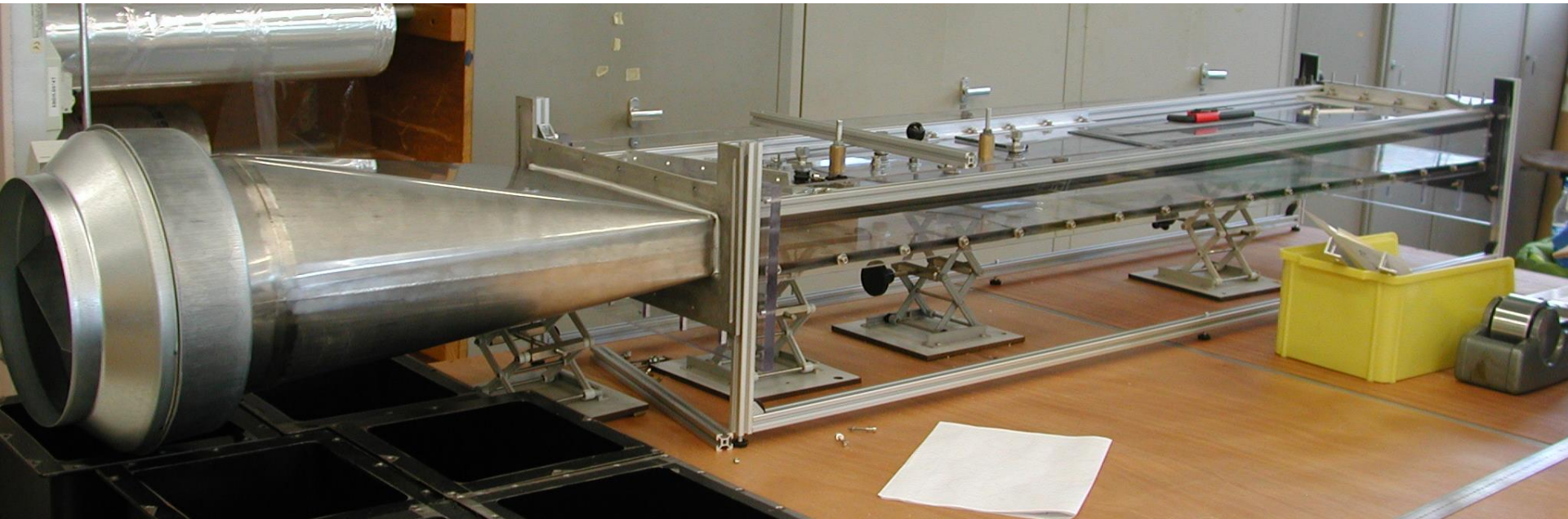
- Anemometer (Schmidt SS20.400)
- Temperature (PT100/NTC)
- Vibration (capacitive no-touch)



Adjustable angle ladder support

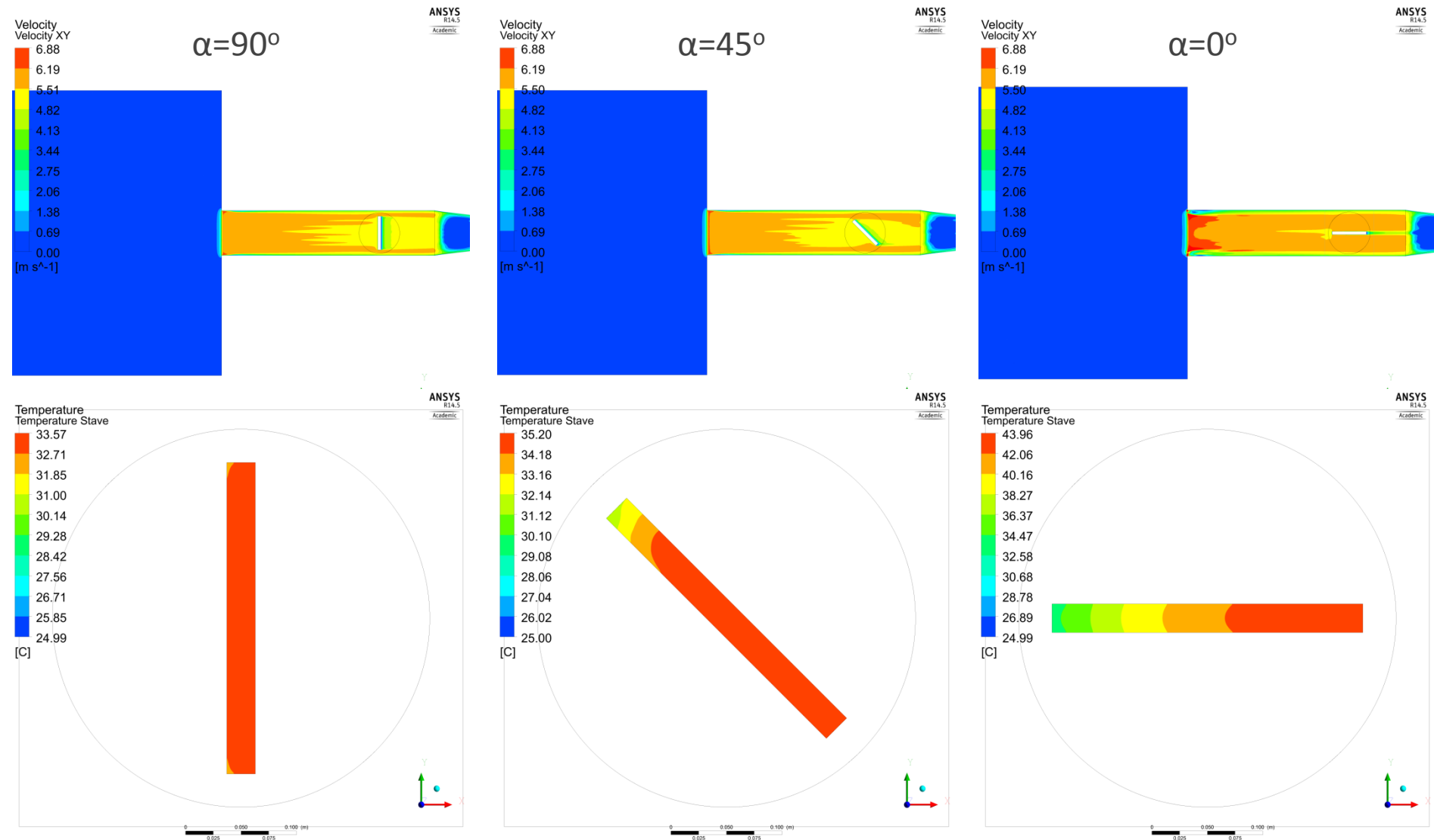
Inlet

Thermo-mechanical test bench



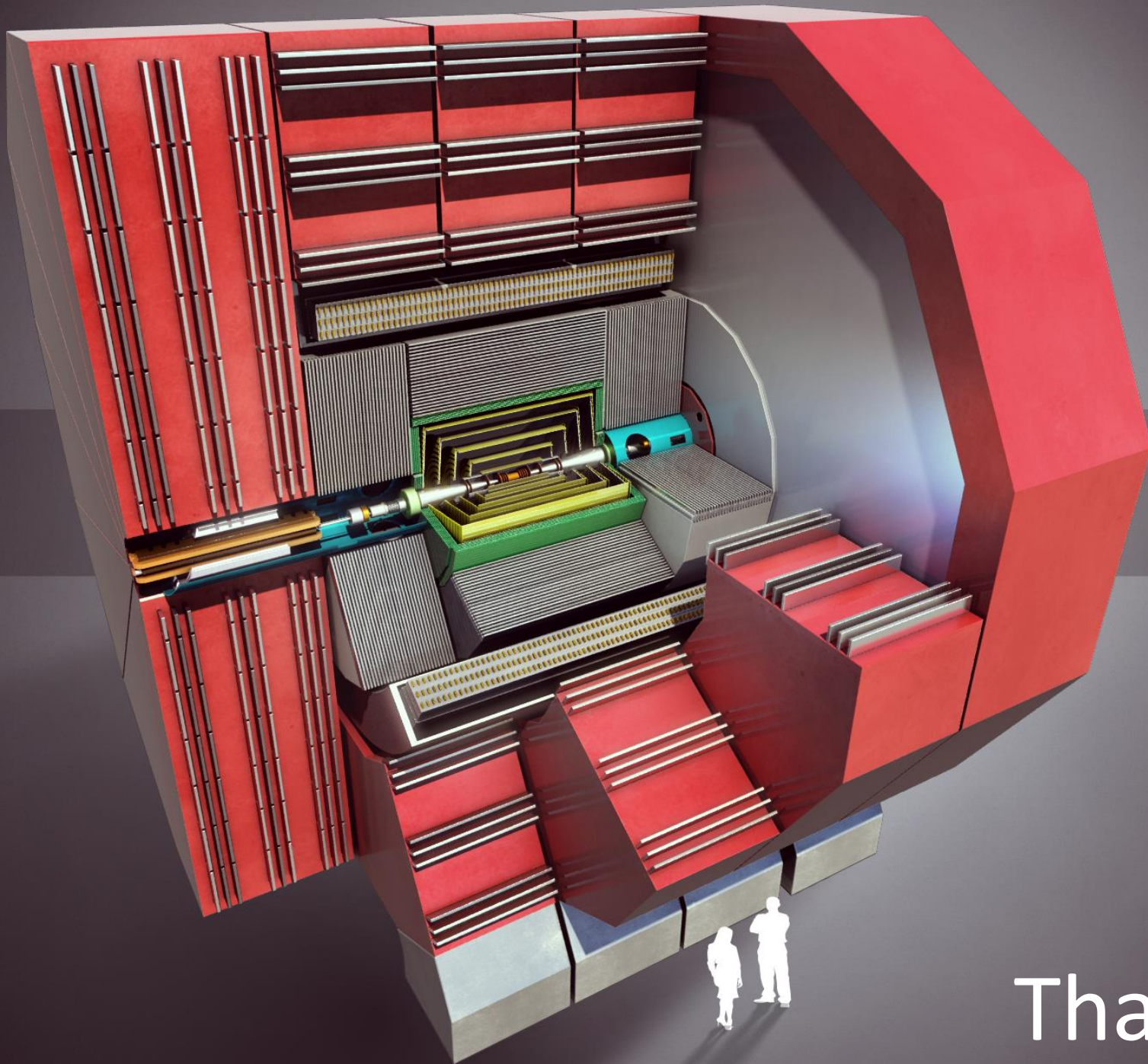
Dedicated CFD models

$V_{avg} = 5 \text{ m/s}; H = 20 \text{ mm}$



Summary of phase II studies

- Development of small-scale technological prototypes has started (support structures and cooling)
- Thermo-mechanical test bench under development
 - Temperature vs Velocity measurements
 - Vibration/thermal deformation measurements
- Dedicated models under development for preliminary validation of Phase I simulations



Detector



Thank you