

Measurement and simulation of Two-phase CO₂ cooling in Micromegas for LP-TPC

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Requirement for cooling

The electronics runs at 5 Volt and consumes power nearly 26 Watts

6 FECs	ASICs = 12 Watts	19 Watts
	Power Regulators = 7 Watts	
FEM		3.5 Watts
FPGA		3.5 Watts
Total		26 Watts

Requirement for cooling

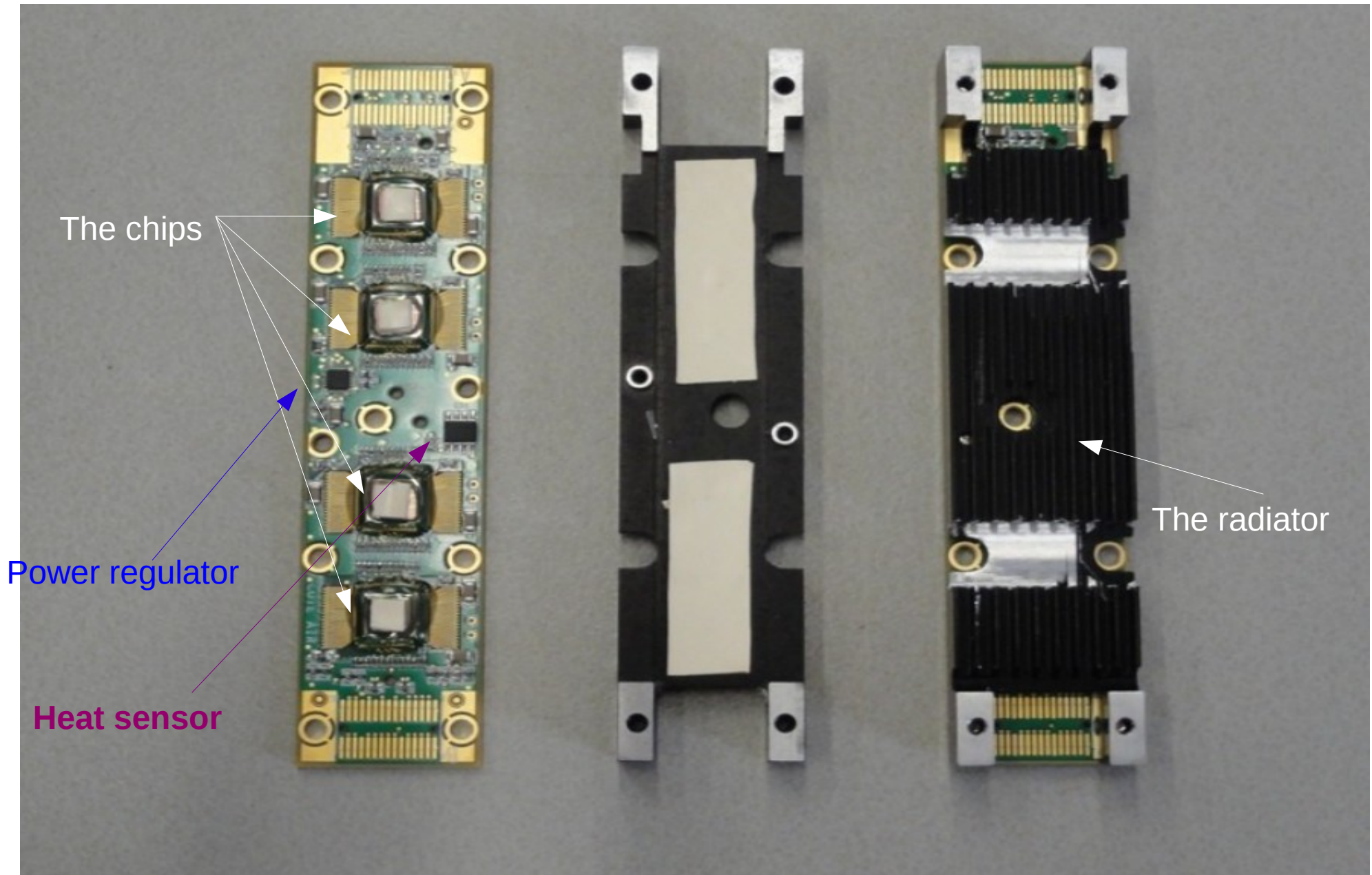
This power consumption rises up temperature of the Module up to 60 degrees

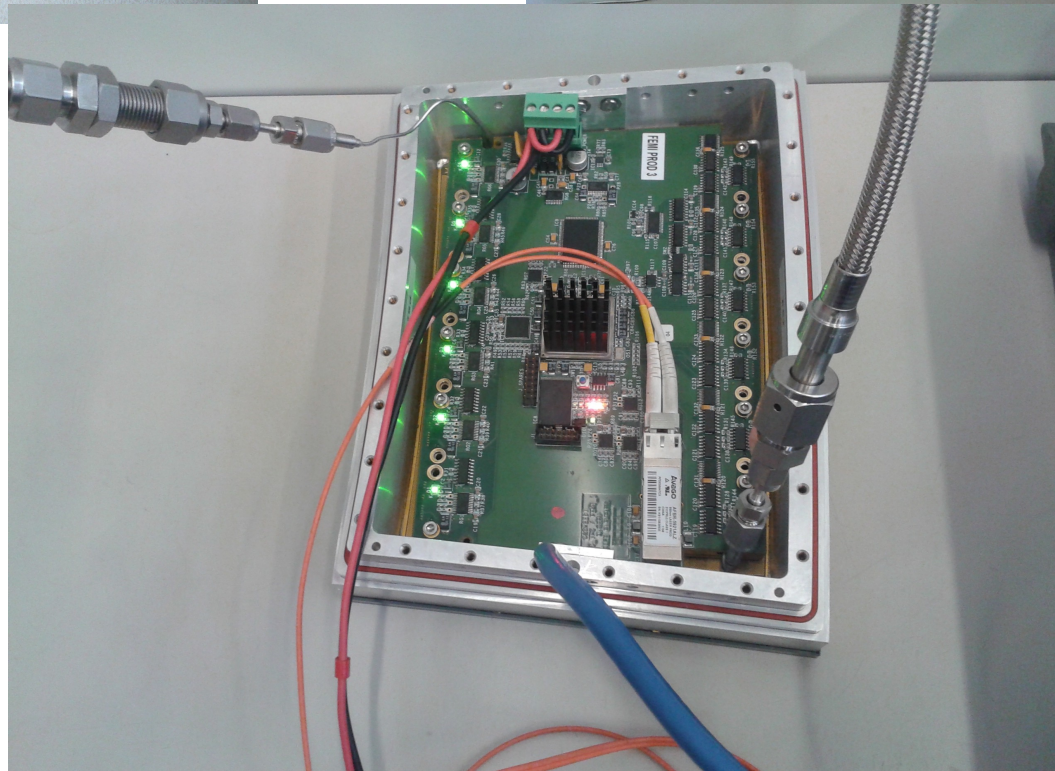
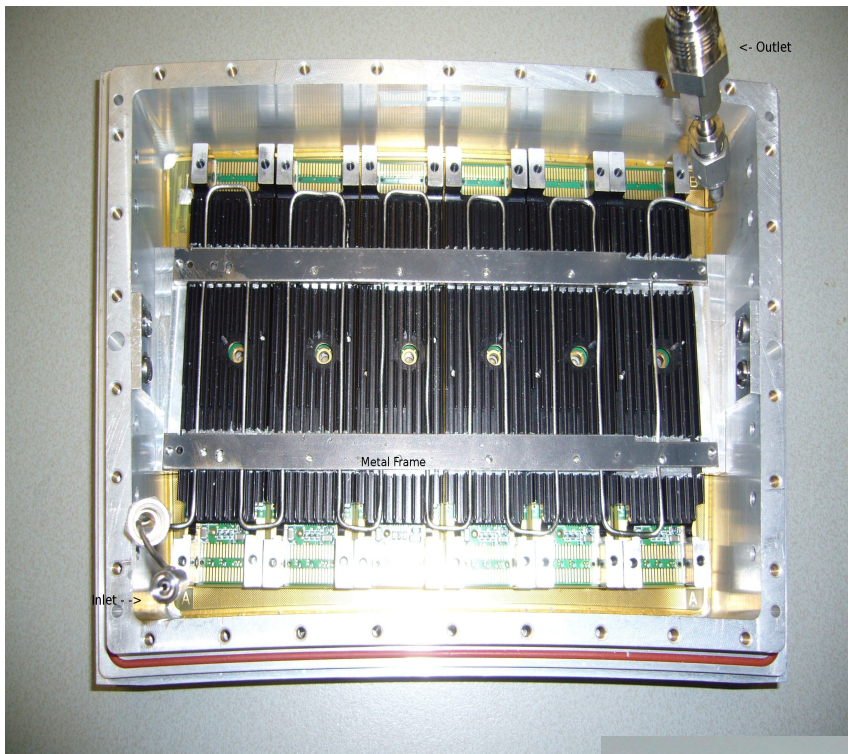
Growth of temperature results in:

- possibility of damage in electronics if left running for hours without cooling
- heating up of pad plane
and hence convection in TPC gas

Conclusion: 'proper cooling is necessary'

The FEC and the Radiator. Each FEC contains one heat Sensor.



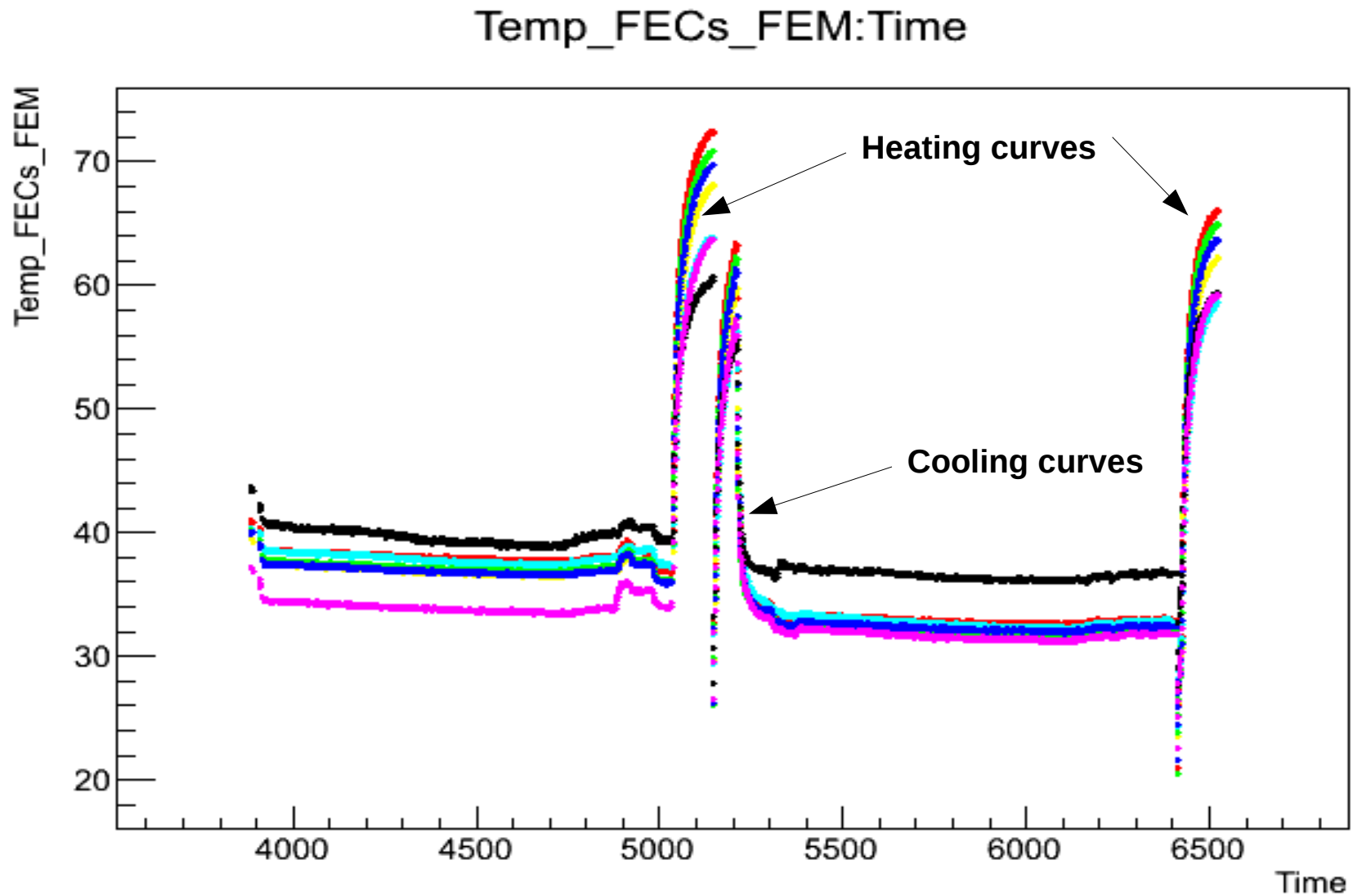


Temperature difference with and without cooling*

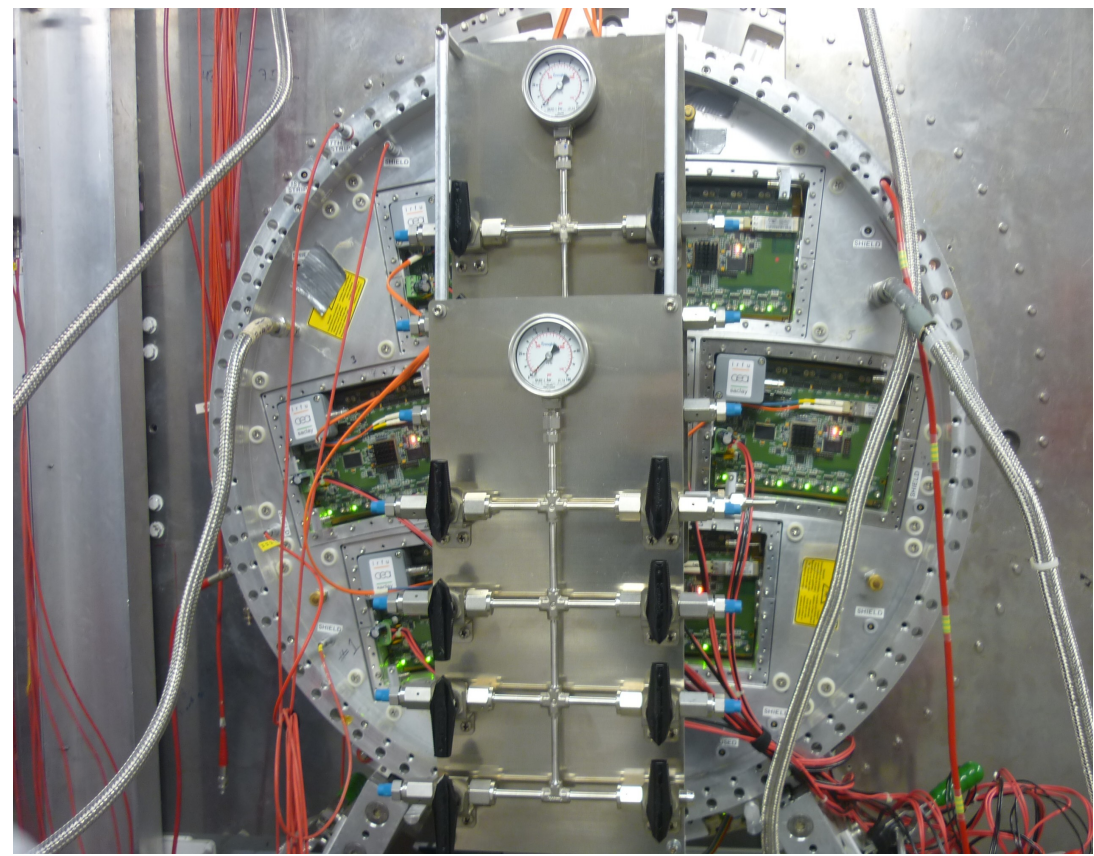
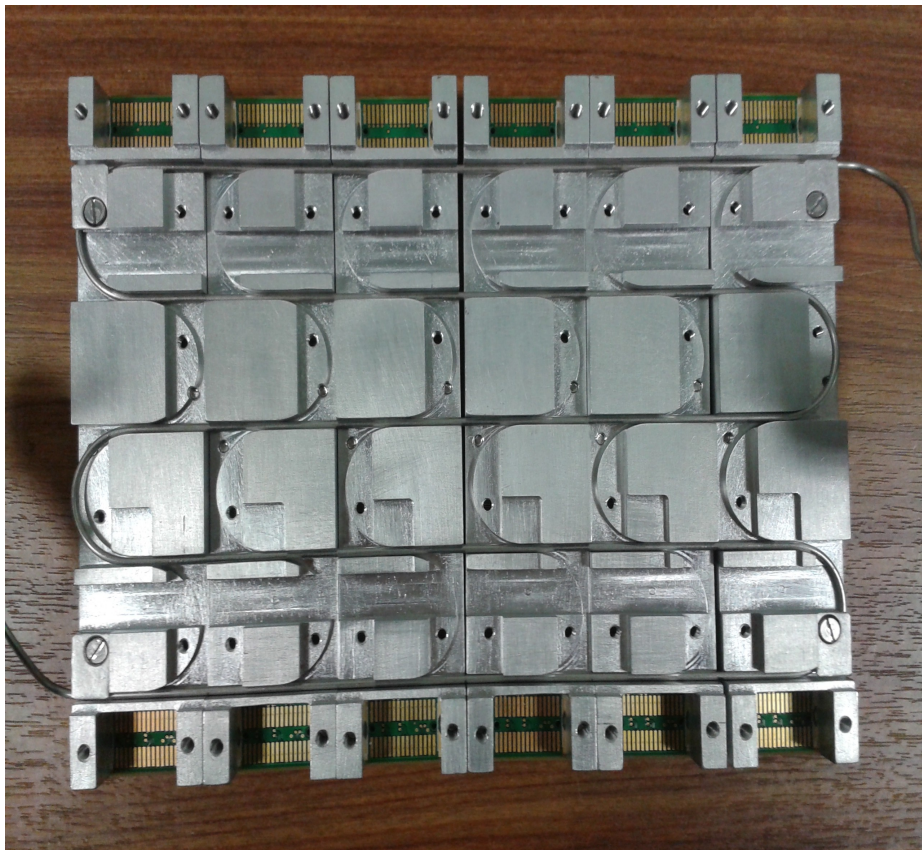
FECs and FEMI	Temp (°C) With Out Cooling	Temp (°C) With Cooling (in 45 bar)
FEC 0	55	35
FEC 1	58	34
FEC 2	61	33.5
FEC 3	62	34.5
FEC 4	60	34
FEC 5	55.5	33.5
FEMI	54.5	37

*At Out-Pressure=45 bar, In-Pressure=55.2 bar, Temp 10.0 °C, Flow rate=2.0 gm/sec

Temperature profile for all the FECs and the FEMI



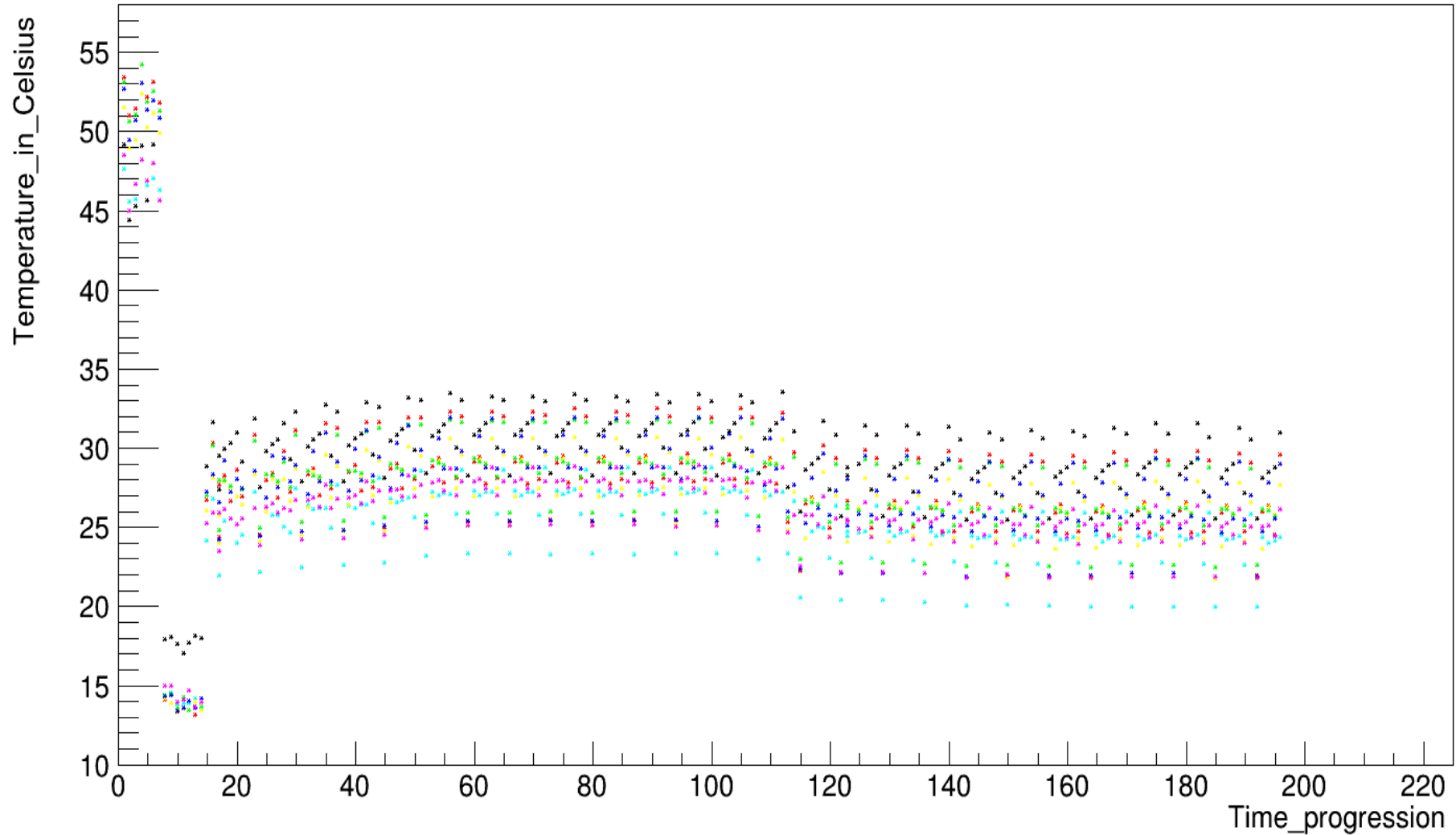
Newly build radiator



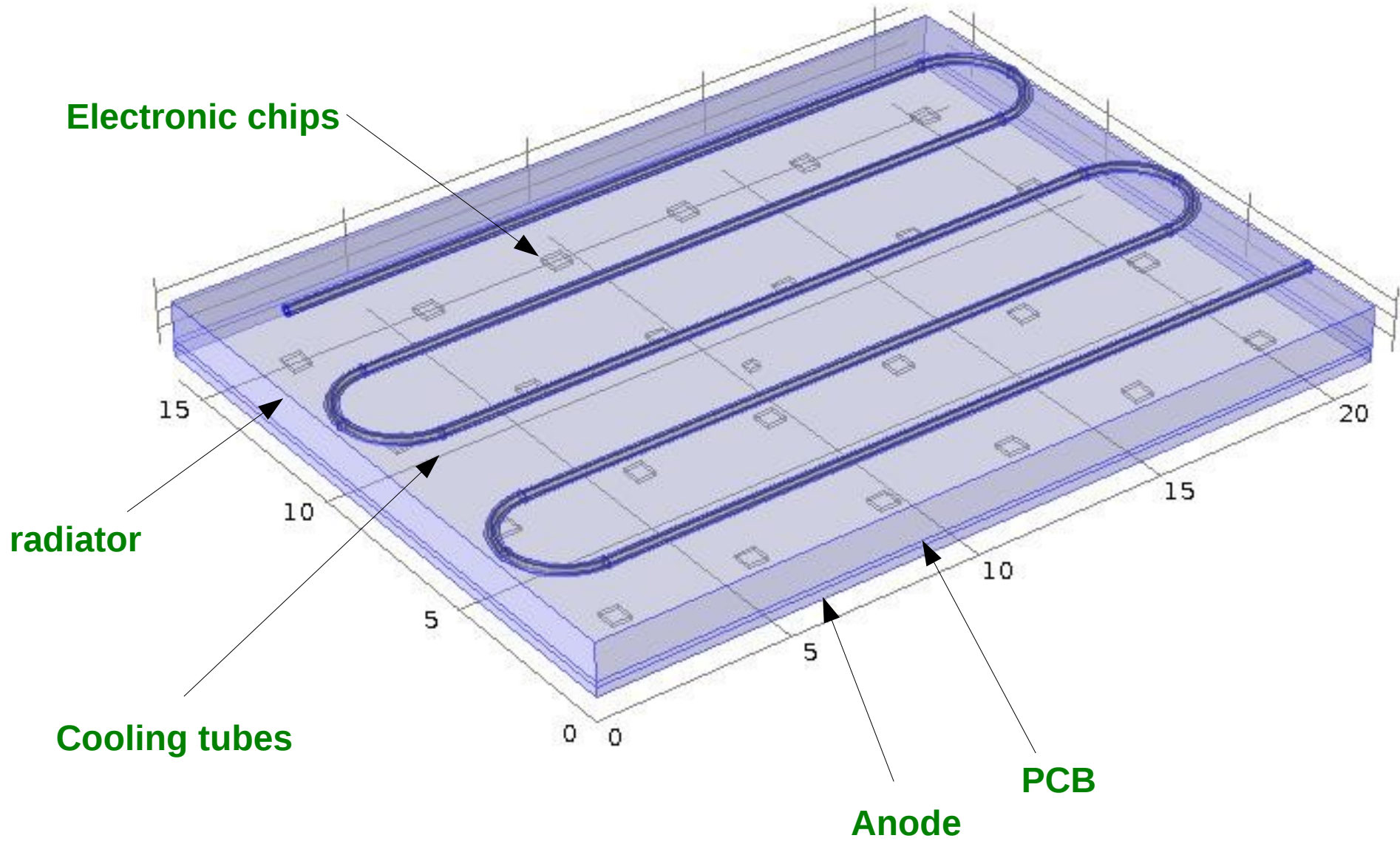
**Cooling is applied to the MM modules
Commissioned at the end plate of LP-TPC**

Stable temperature during data acquisition

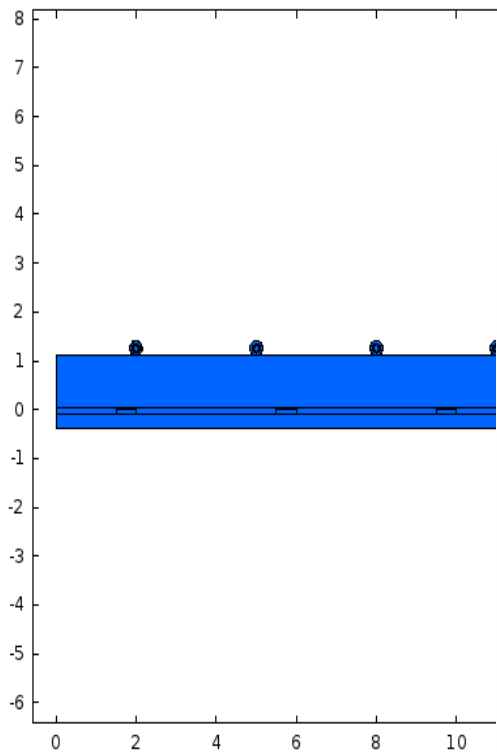
Temperature_in_Celsius:Time_progression



Geometry of the radiator and the cooling tubes

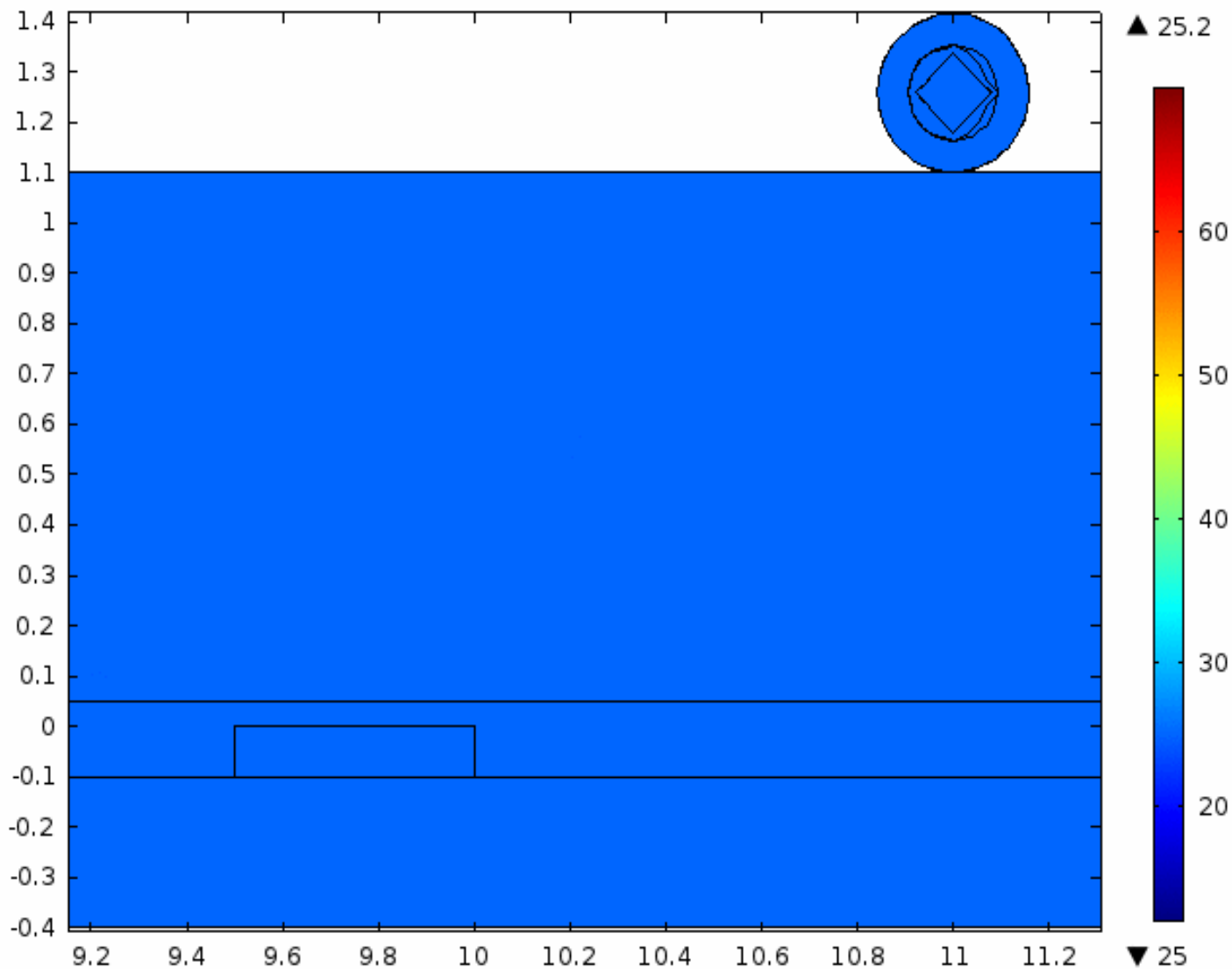


Time=0 min Surface: Temperature (degC)

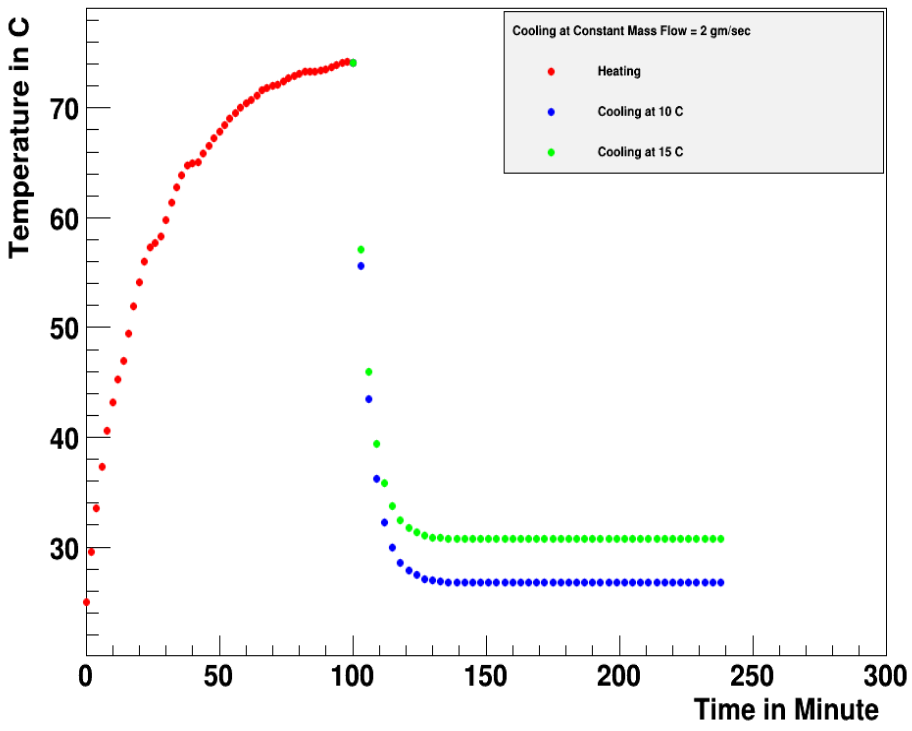


Cross section of the module

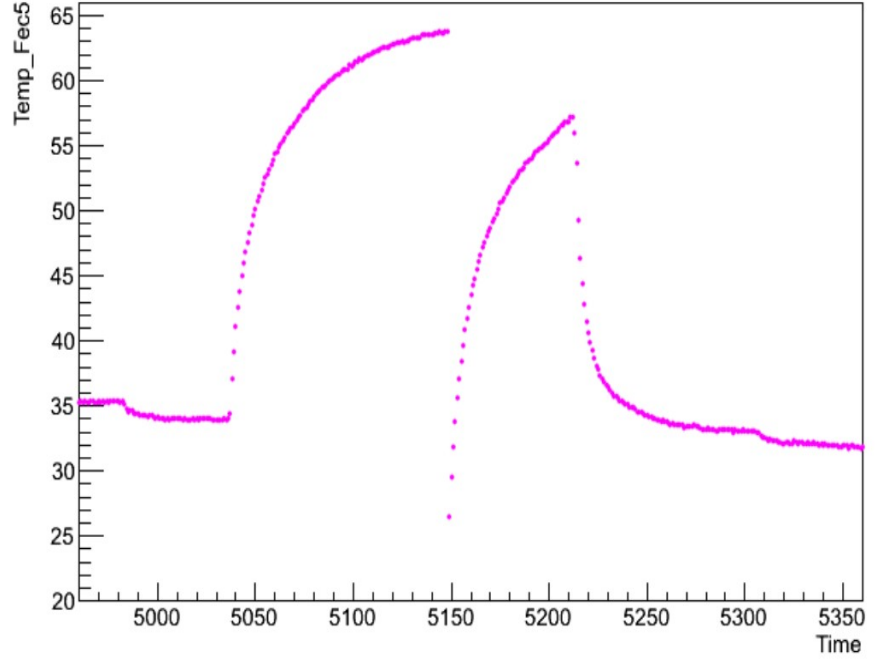
Time=0 min Surface: Temperature (degC)



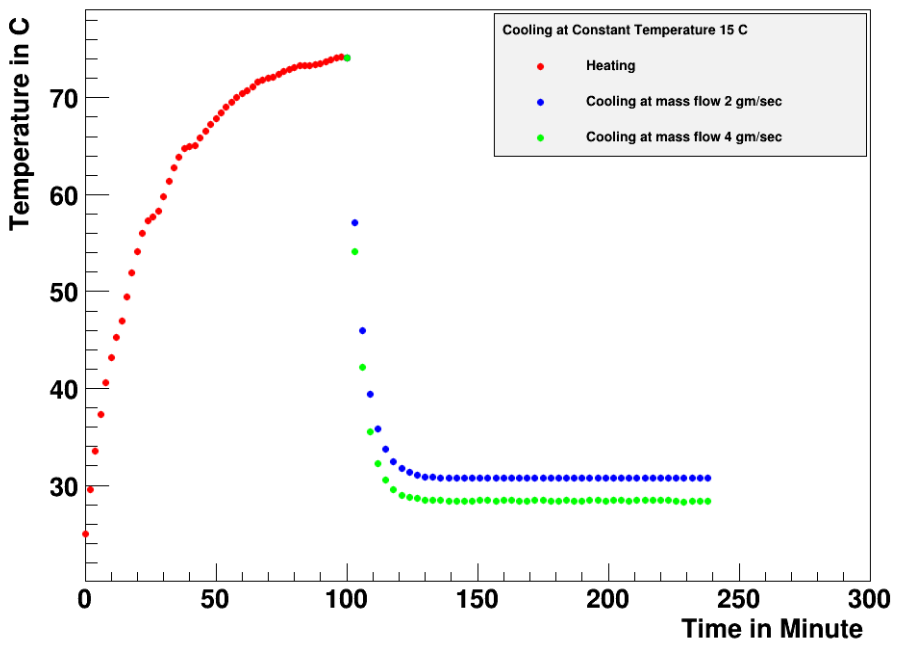
Heating and Cooling at different boiling points of CO2



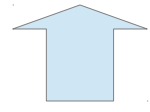
graph-2 Temperature Profile for FEC 5
Temp_Fec5:Time



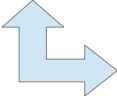
Heating and Cooling at different CO2 mass flow



temperature fall



From experiment



From simulation

Thank you for your attention