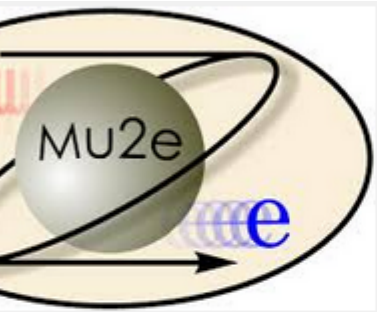

The Mu2e experiment

Cooling system of the electronics of the electromagnetic Calorimeter

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University of Pisa

Final review 09/23/2015

Outline

- Mu2e experiment overview
- Experimental setup
- The electromagnetic Calorimeter
- Cooling of Digitizers
- Crates Design
- Crates mounting
- Fluid distributing system
- Experimental testing setup

Mu2e in one page

- Searching for a CLFV process: coherent muon conversion in a nucleus field

$$\mu^- N \rightarrow e^- N$$

- Experimental signature: monoenergetic electron

$$E_e = m_\mu c^2 - B_\mu(Z) - C(A) = 104{,}973 MeV$$

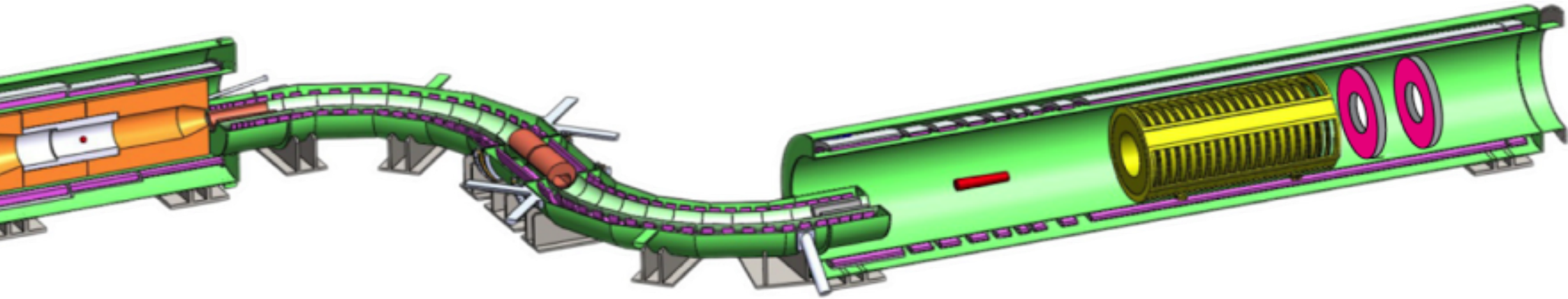
- Mu2e expectation:

$$BR_{\mu e} = \frac{\Gamma(\mu^- + N(A,Z) \rightarrow e^- + N(A,Z))}{\Gamma(\mu^- + N(A,Z) \rightarrow all\ muon\ captured)} \leq 6 \times 10^{-17}$$

Experimental setup

eV proton beam hits the
duction target in the PS,
roducing almost pions.

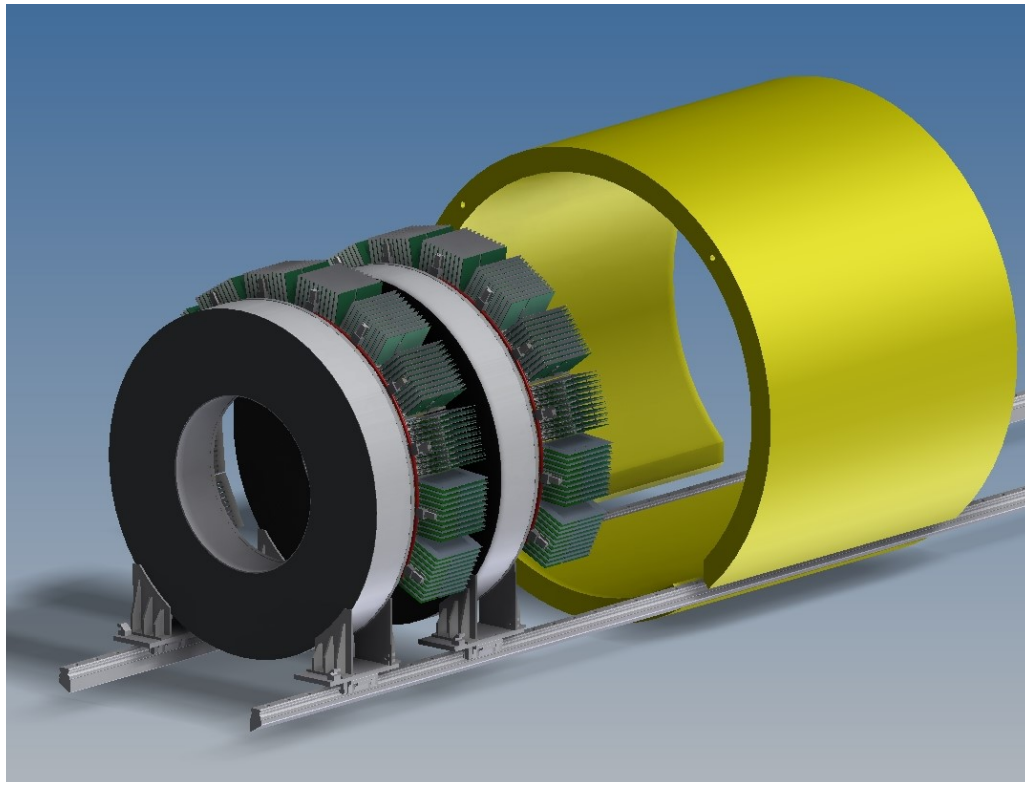
Negative muons hit the thin Al target, where they are stopped producing Electrons.
The DS houses the tracker and calorimeter too.



Muons produced by pions decays are transported from the PS to the DS by the TS.
Only low energy negatively charged muons arrive to the DS.

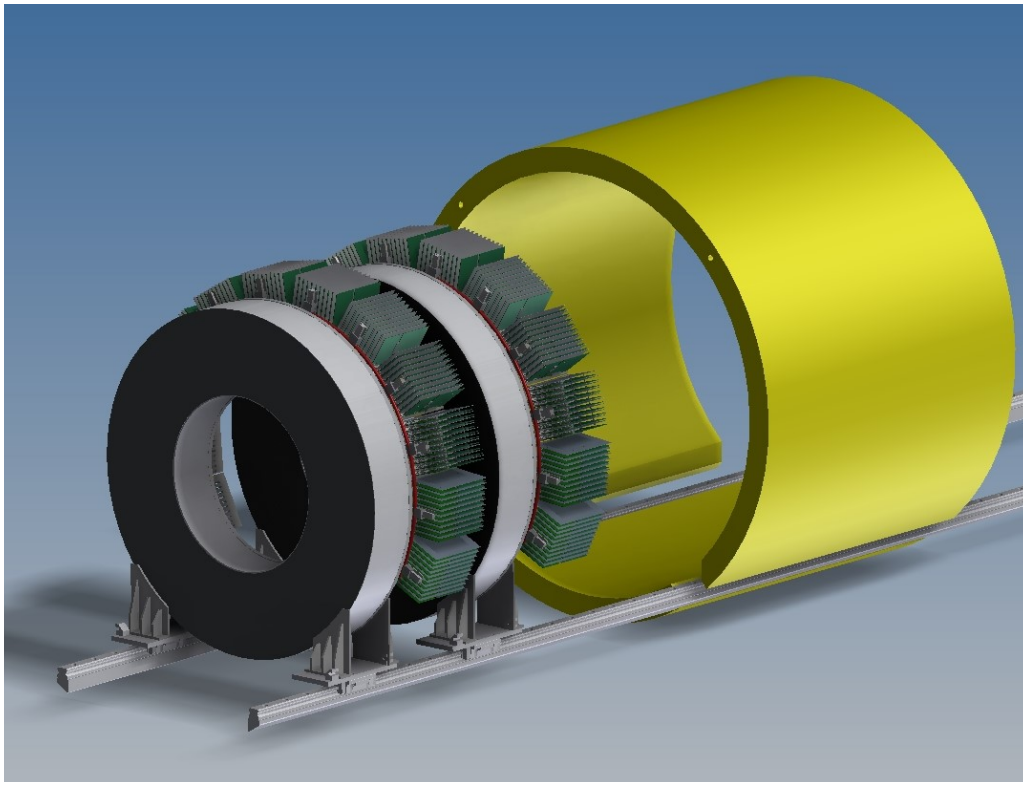
The Calorimeter (1)

- Inserted in a uniform 1 T magnetic field
- Acceptance optimized to detect Conversion Electrons (105 MeV/c)
- Two discs of 910 BaF2 square crystals each
- Readout: 2 large area APDs per crystal



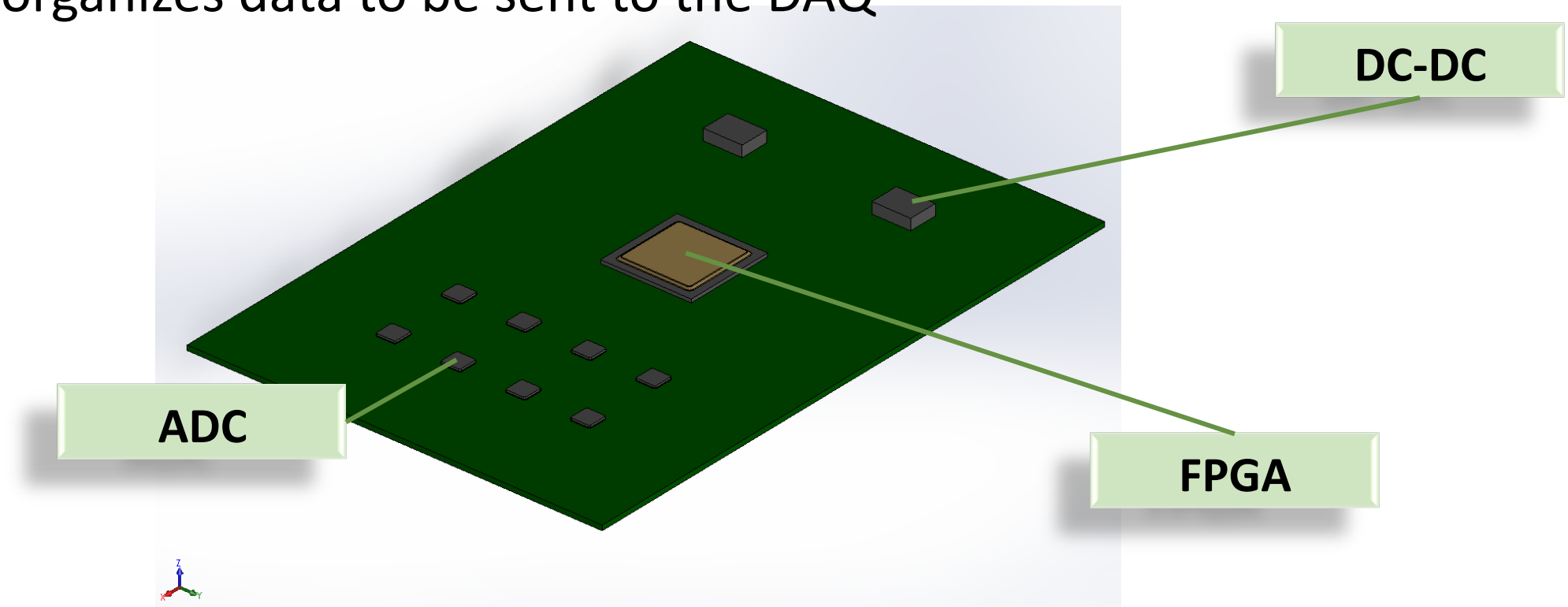
The Calorimeter (2)

- Digitizer: 120 boards per disc (12 crates
- Cryostat Vacuum pressure: 10^{-4}Torr
- Cryostat Temperature: 25°C



Waveform Digitizer Board (1)

- The Waveform converts the analogic signals into digital ones and it organizes data to be sent to the DAQ

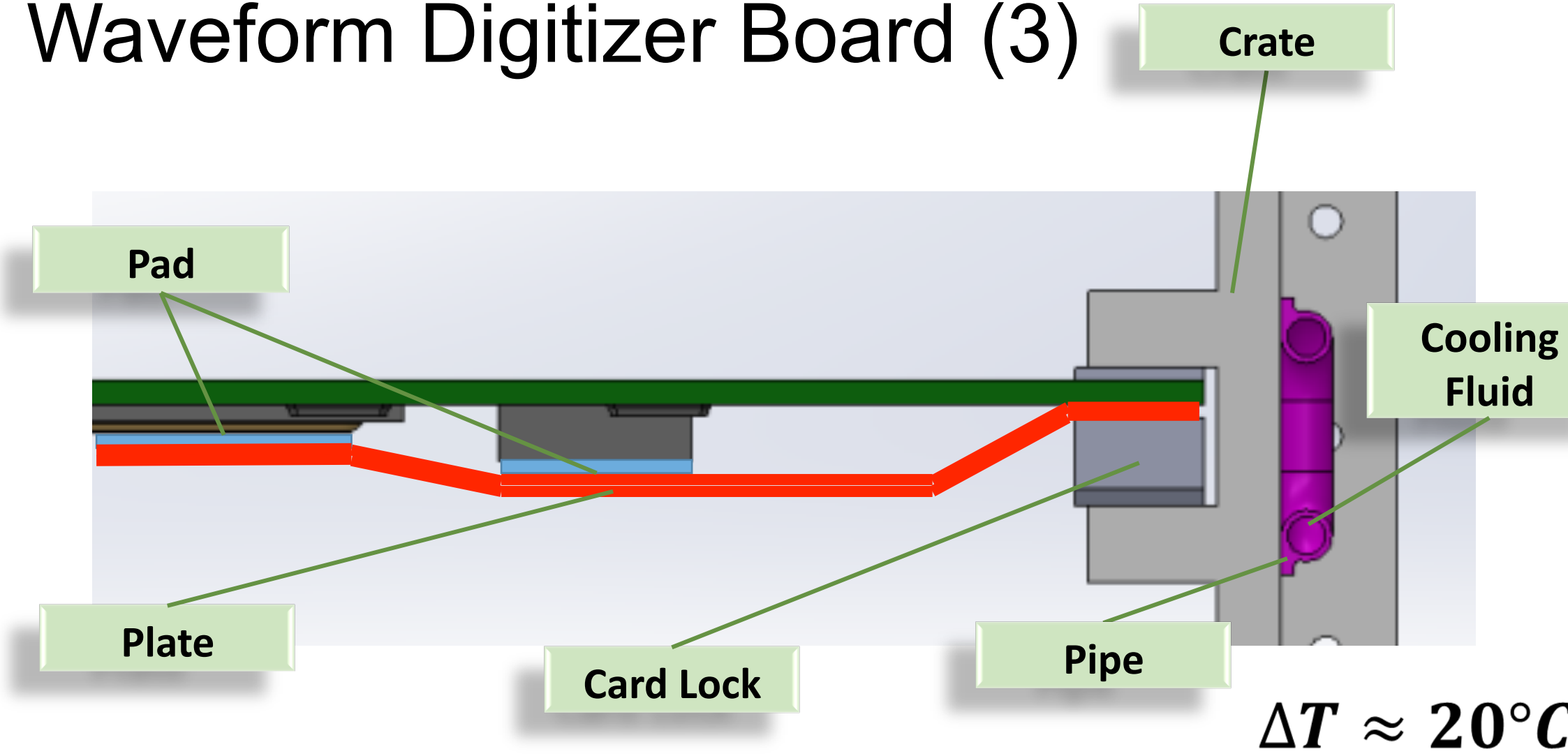


Waveform Digitizer Board (2)

- 1 FPGA 7 W
- 2 DCDC 2x3 W
- 8 ADC 8x0,47 W

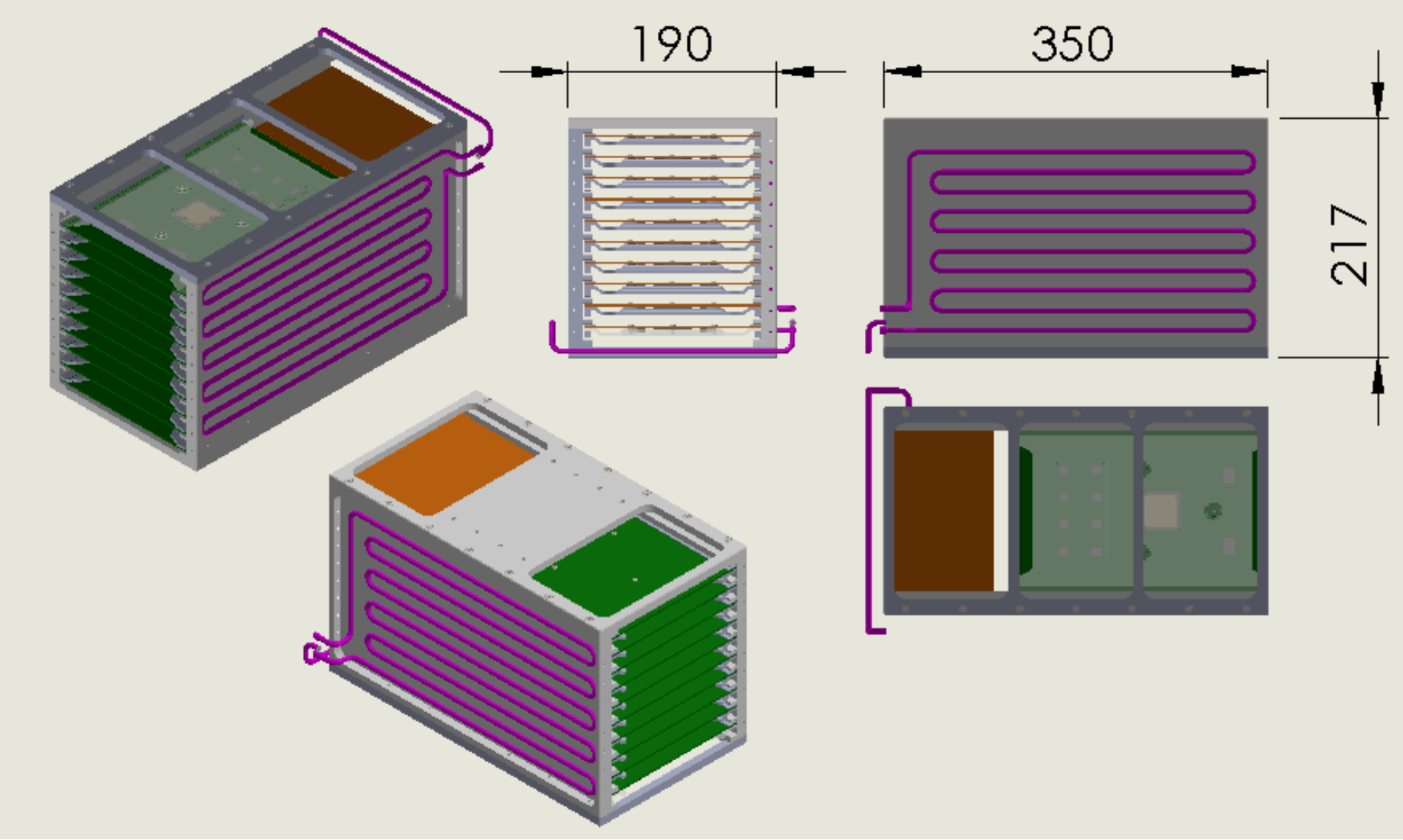
- We cannot use ground layer in the board for electronic reasons to cool down the components
- We decided to use an aluminum plate in contact to each board and in thermal contact with the heating components

Waveform Digitizer Board (3)

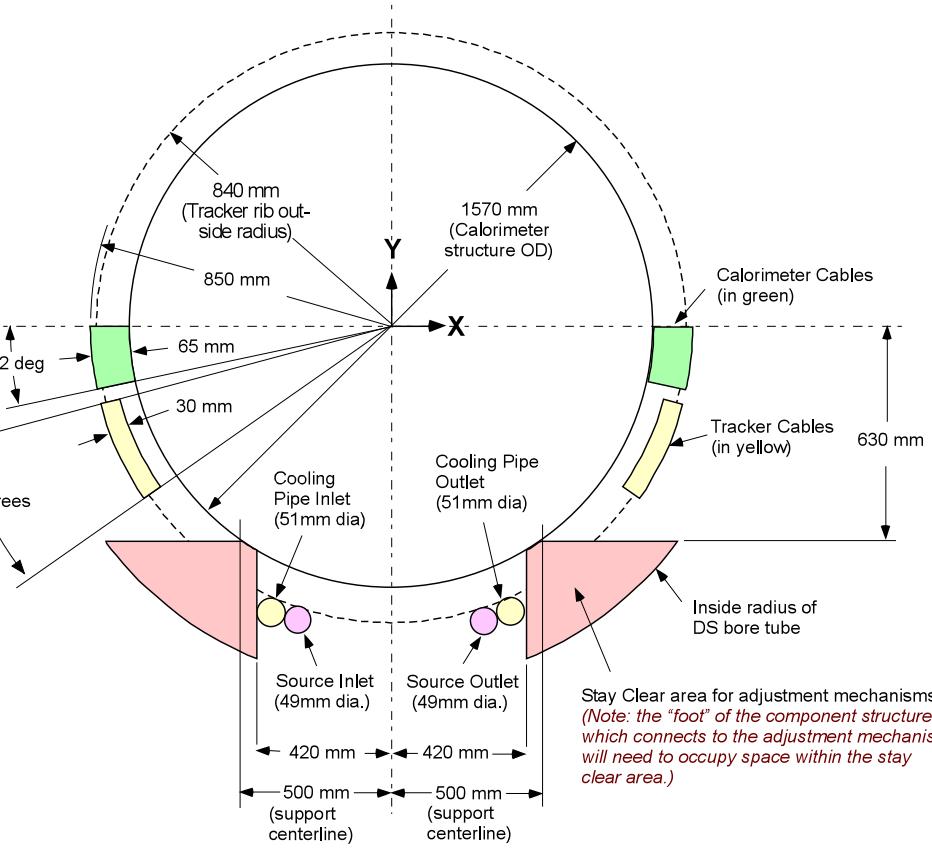


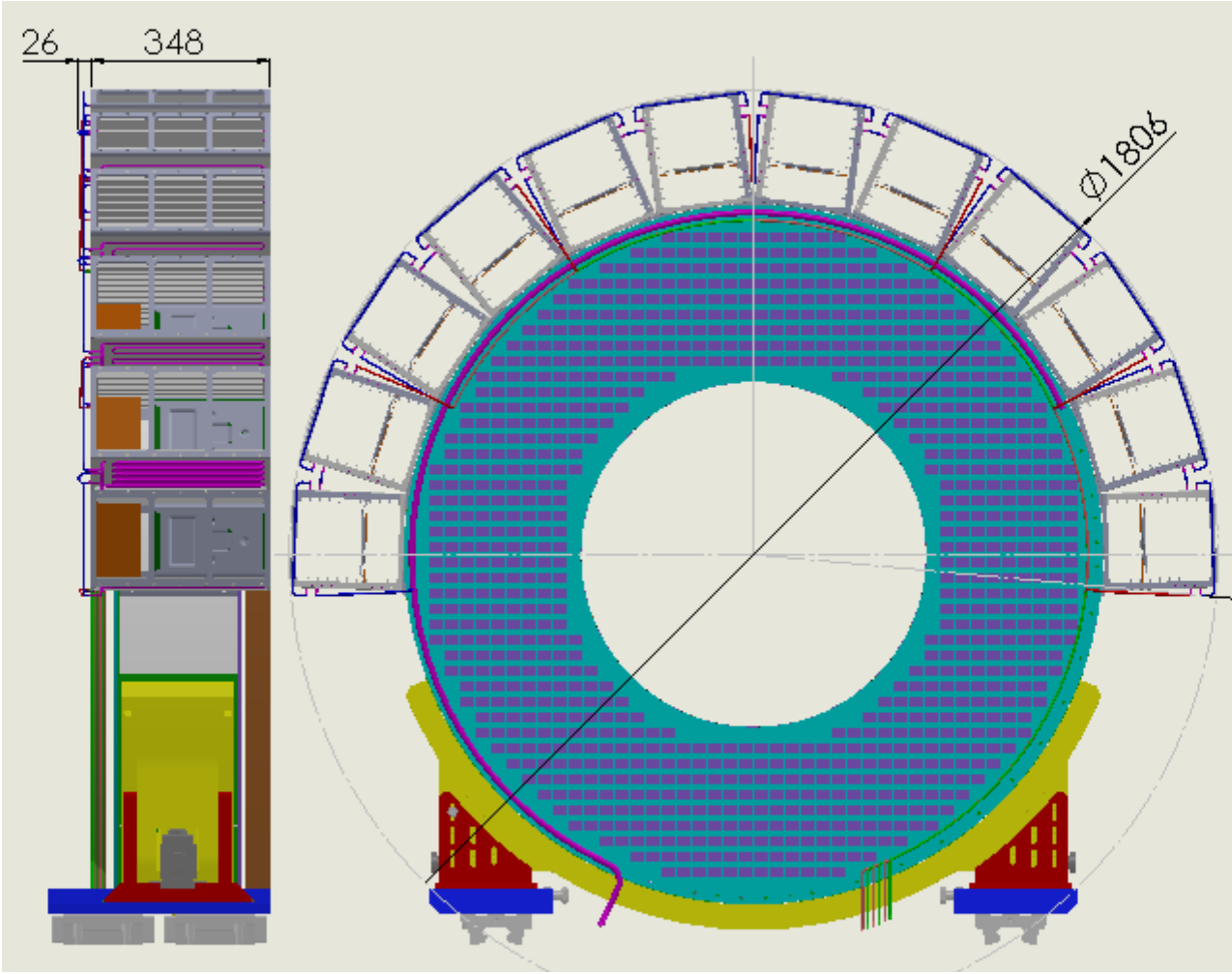
$$\Delta T \approx 20°C$$

Crate



Crate positioning

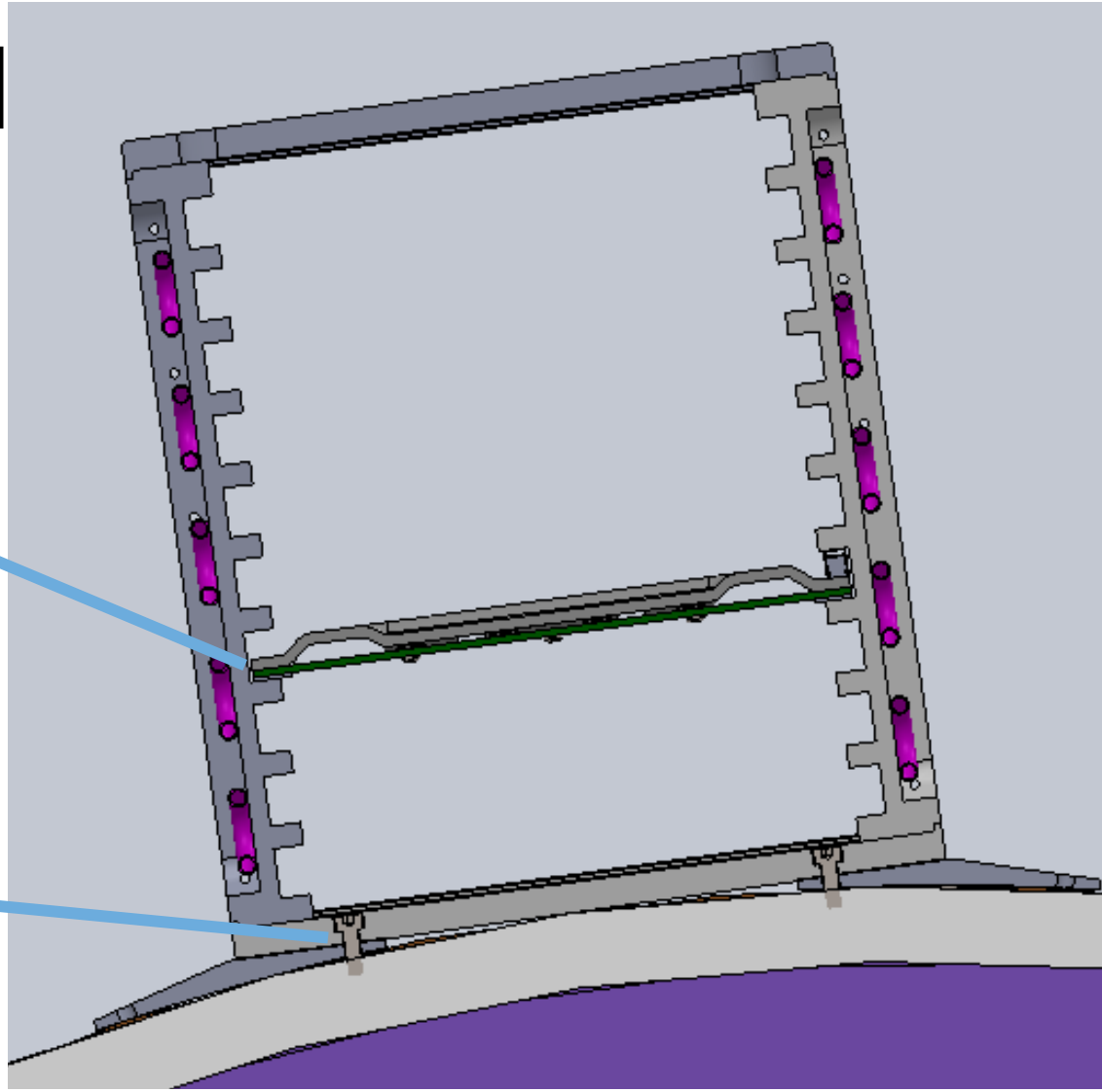




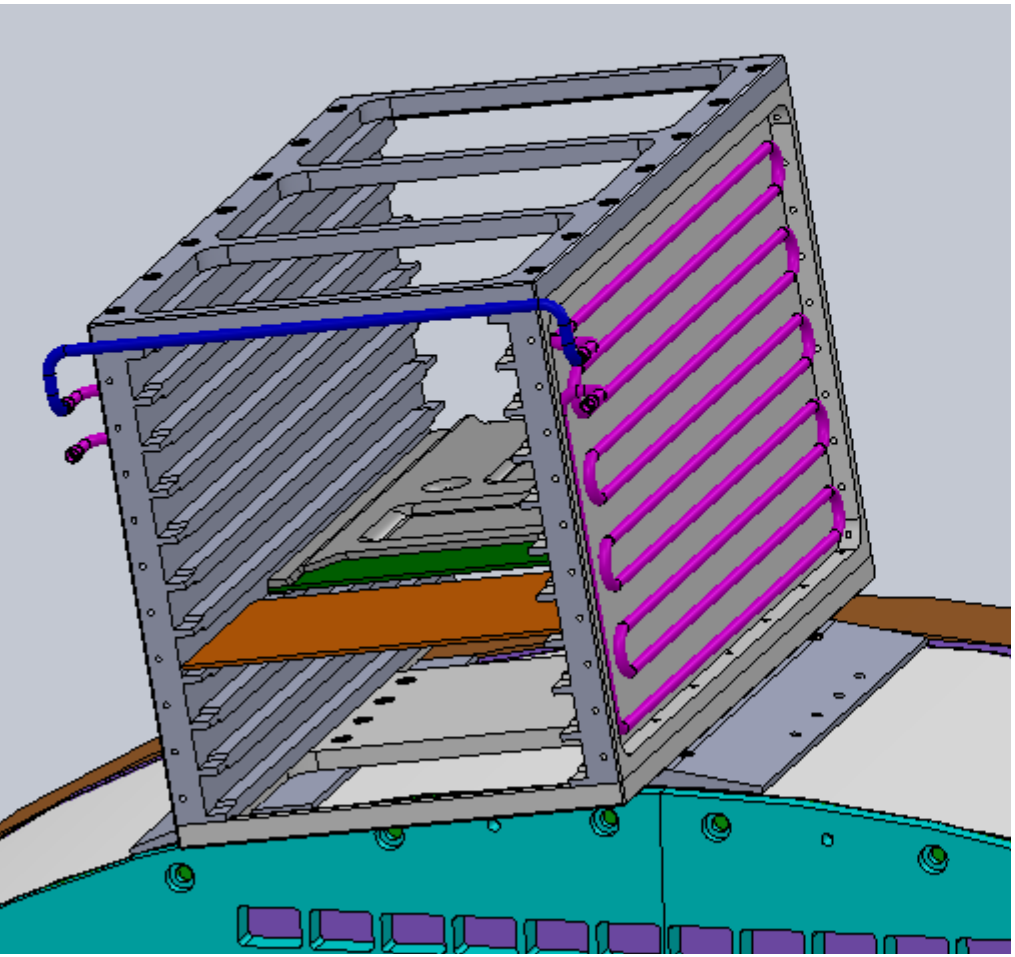
low to mount crates (1

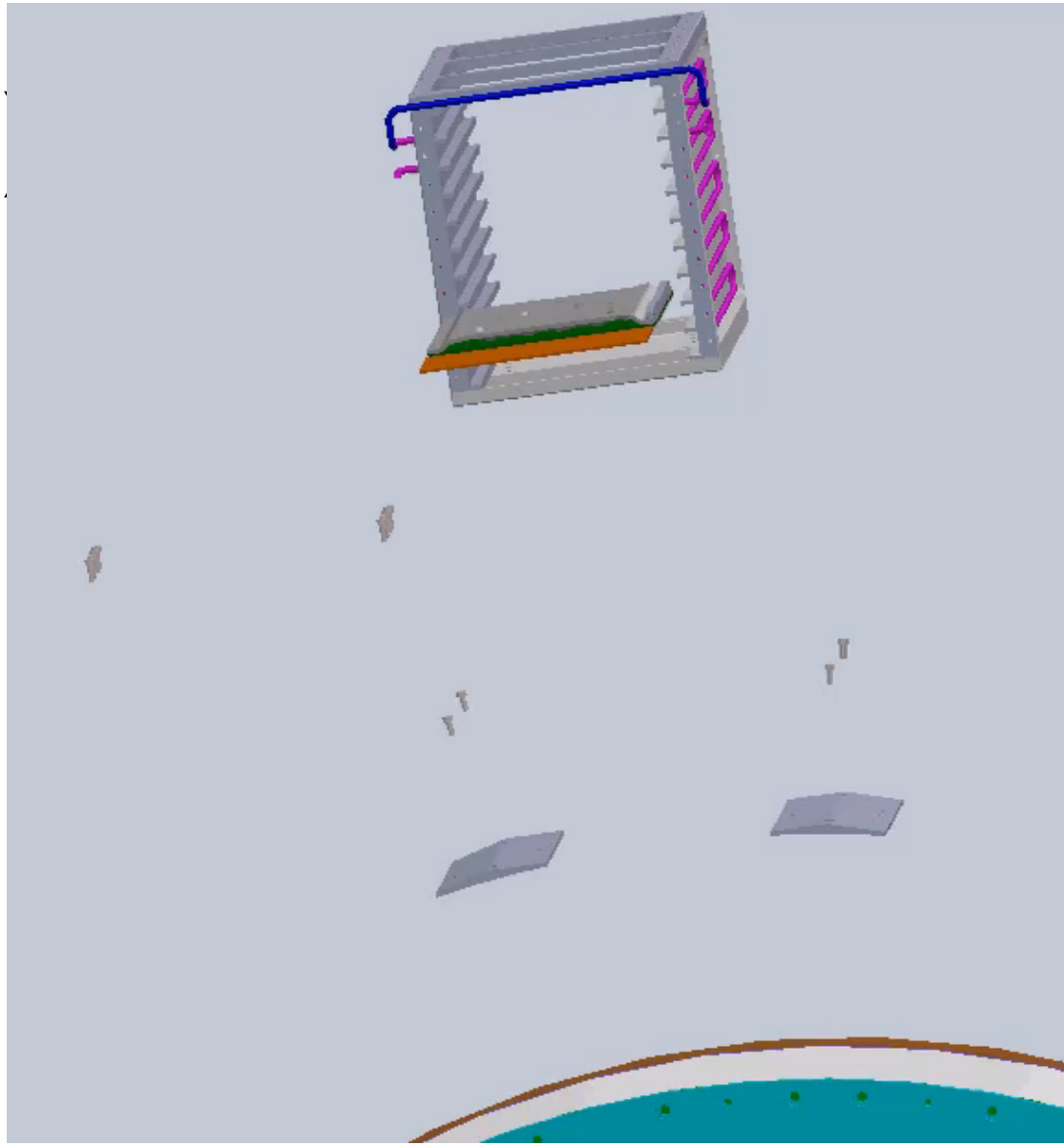
Crate are screwed with no boards mounted and with pipes disconnected from a crate to another one

Aluminium foot screwed to aluminium external cylinder



low to mount crates (2





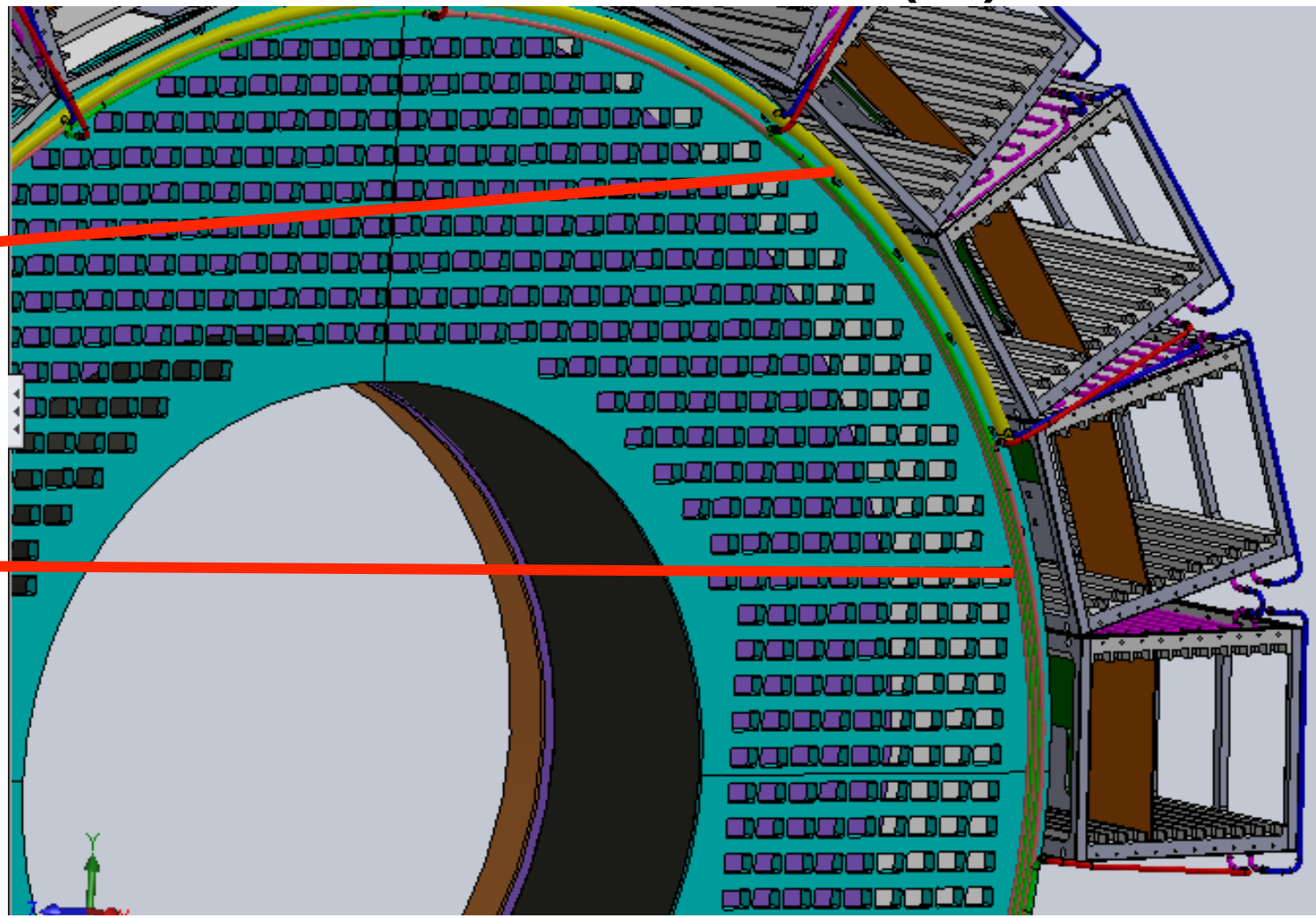
Pipe connection between crates (1)

- Refrigerant is bi-phase state SUVA R410A @25°C
- During cooling, pressure drop laminates fluid and decrease its pressure and temperature
- In order to have a limited pressure drop I decided to connect in series only two crates in row at time
- Each pair is supplied by an unique inlet inner pipe (yellow) and connected to it’s own outlet pipe (pink and green)

Pipe connection between crates (2)

Inlet distributor pipe

Outlet distributor pipes



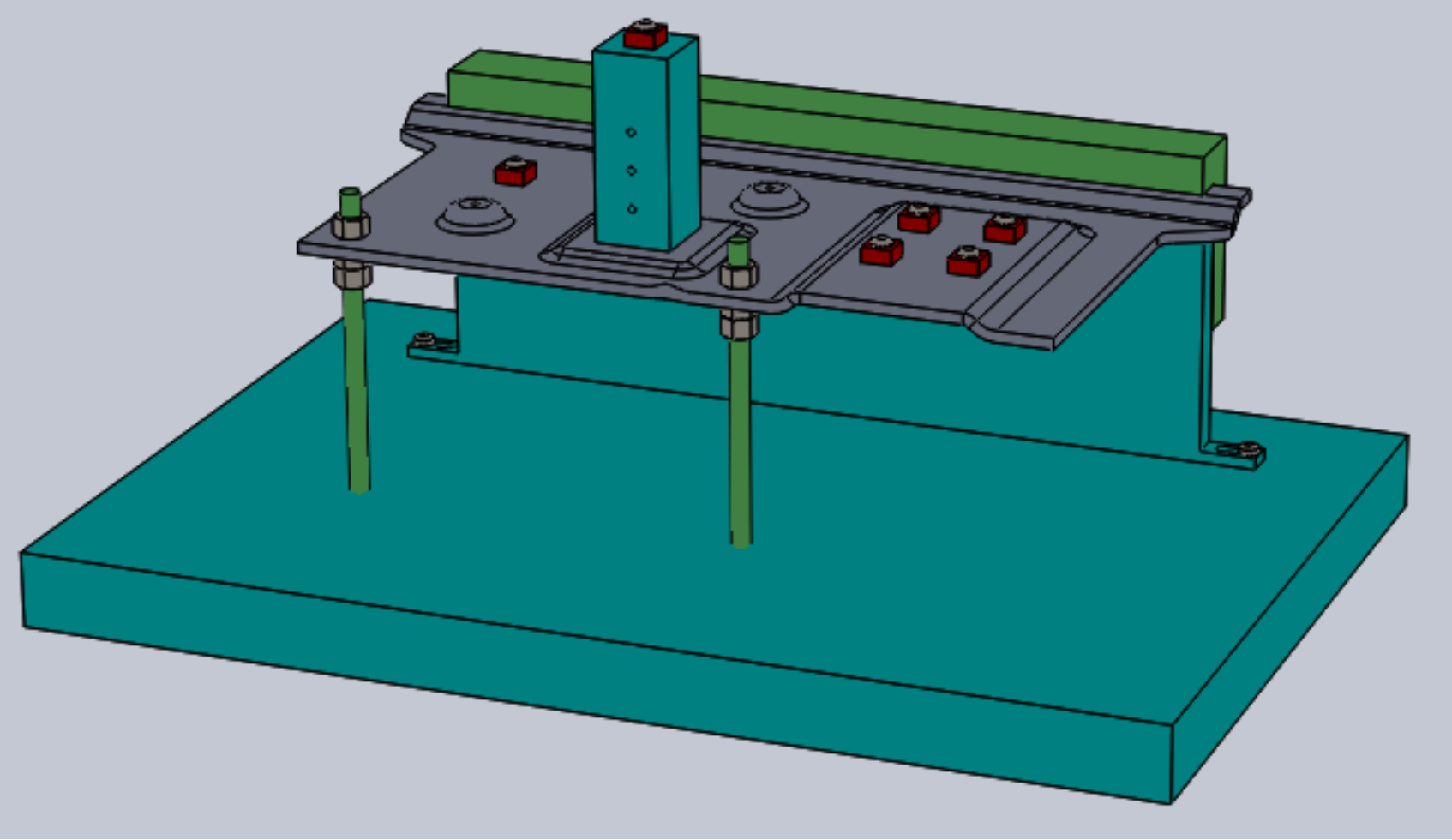
Pipe connection between crates (3)

- The separate outlet pipes are for the possibility to regulate pressure drops in the different pipe paths and so to have the same flow in each branch
- Valves will be settled outside the cryostat (the external pipe routing still have to be done) and they will be automatic controlled in order to change flows to prevent accidentally overheating on the boards

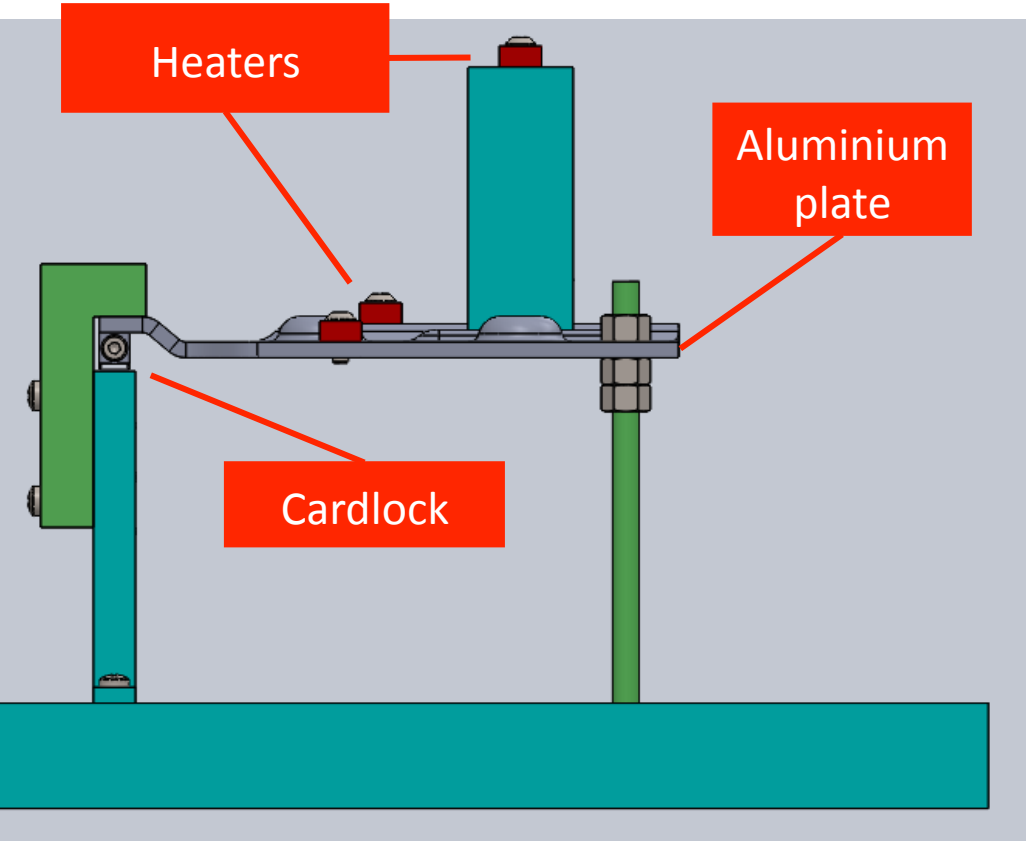
Experimental setup (1)

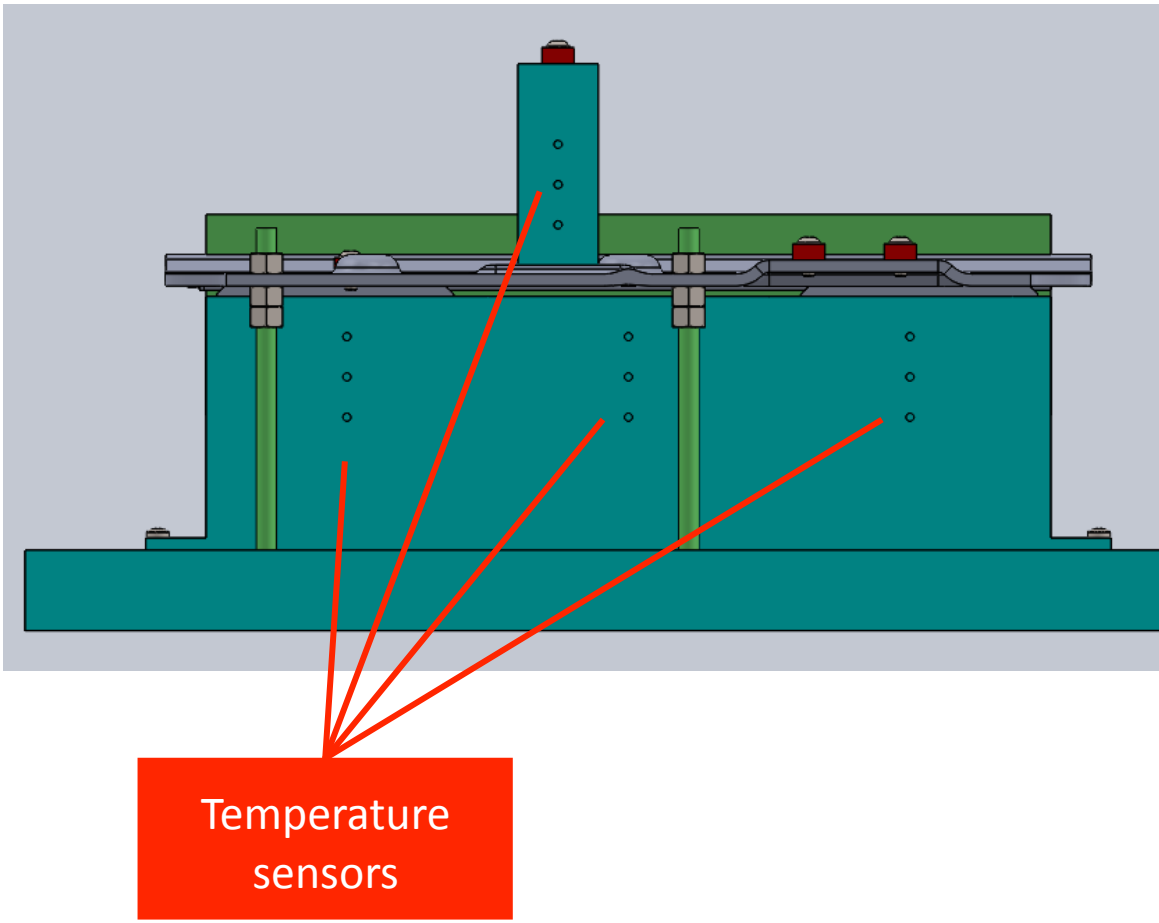
- To check computer analysis and to be sure about properties of purchased components, we decide to organize some experimental tests:
- Thermal resistance of cardlocks used to connect the Waveform Digitizer and the Interface Board
- Outgassing rate of the crate and components to better understand outgassing total time
- Refrigerating crate test with SUVA coolant and real drop pressures into the (for a single crate)

Cardlock sketch setup (1)



Cardlock sketch setup (2)





Thank you for your attention