Collaboration Meeting January 2020

Development of a two-phase CO_2 cooling plate in additive fabrication

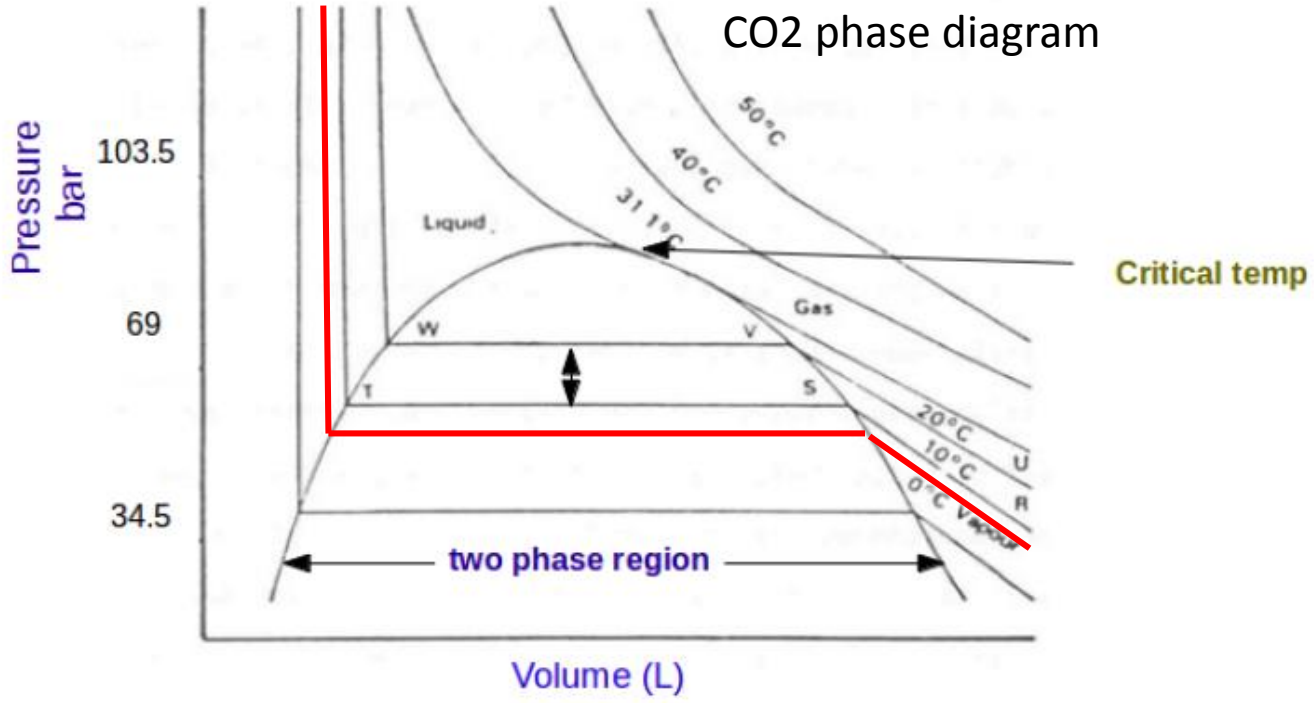
P. Colas

Advantages of CO_2
- large latent heat in vaporisation
- large specific heat
- low viscosity

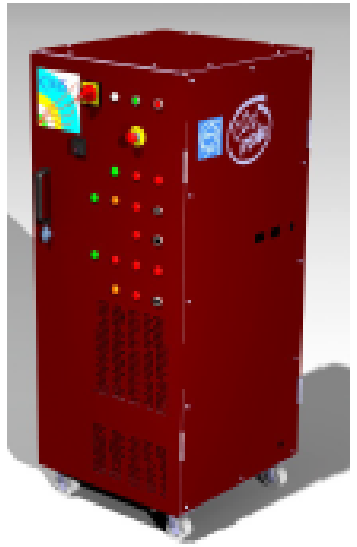
At 50-65 bar the two-phase fluid is at almost 10-20 °C
- avoids condensation.
- takes out heat at room temperature, avoiding temperature inhomogeneity

3D printing methods suitable to make a cooling plate

CO2 phase diagram

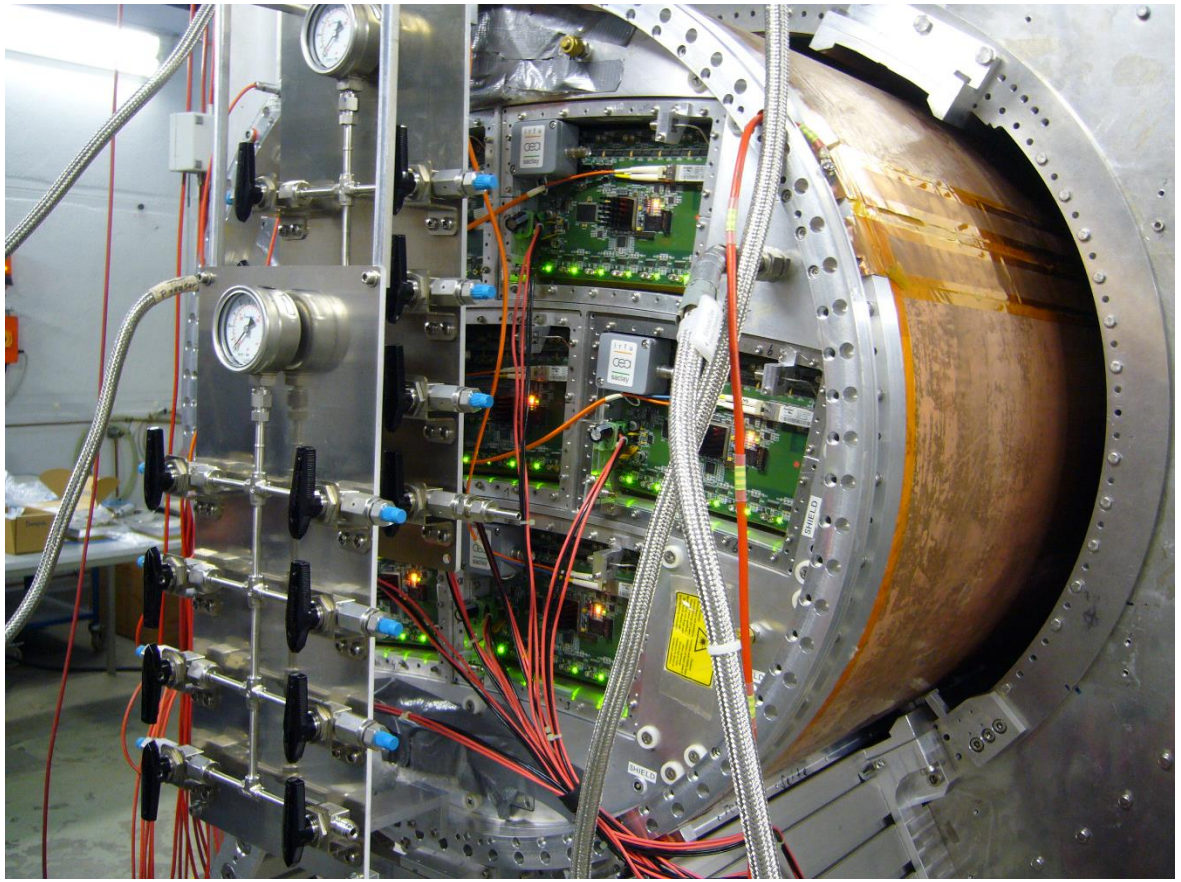


2-phase CO2 cooling

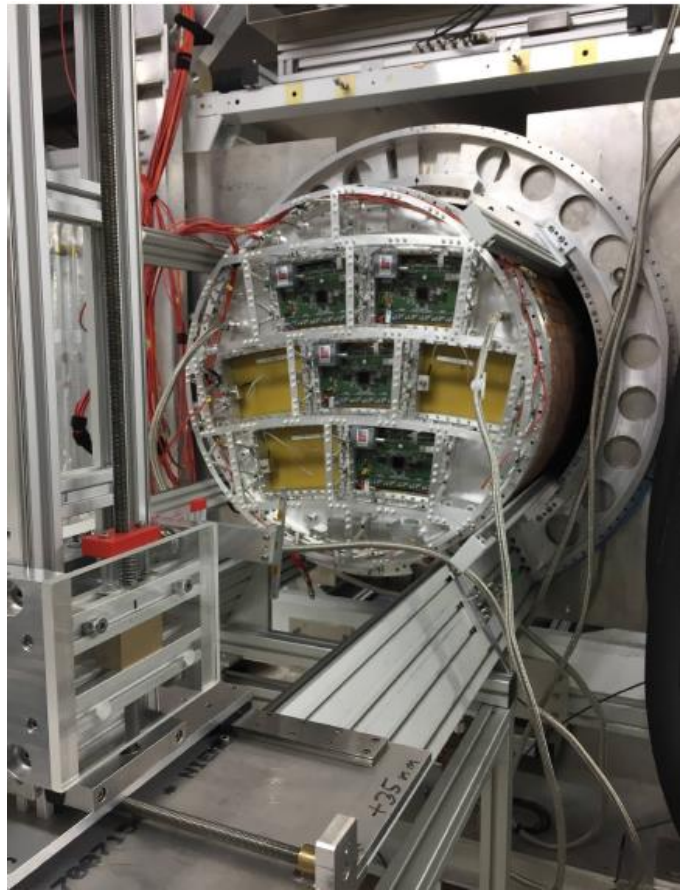


- Pioneered at Nikhef and CERN, studied at KEK.
- KEK bought a compressor (« TRACI ») for ILC and Belle II, installed at DESY Test Beam T24.
- Tested in 2014 and 2015 with 7 independent modules with a distribution by a manifold (« clarinette »). 0.8 mm inner diameter pipe
- Tested in November 2018 with 4 modules in one loop. Very stable operation at 50 bar. 28-31°C on the FECS: continuous operation during 11 days without any incident.

Tested in 2014 and 2015
with 7 Micromegas modules



Tested in 2018 in one loop
with 4 Micromegas modules

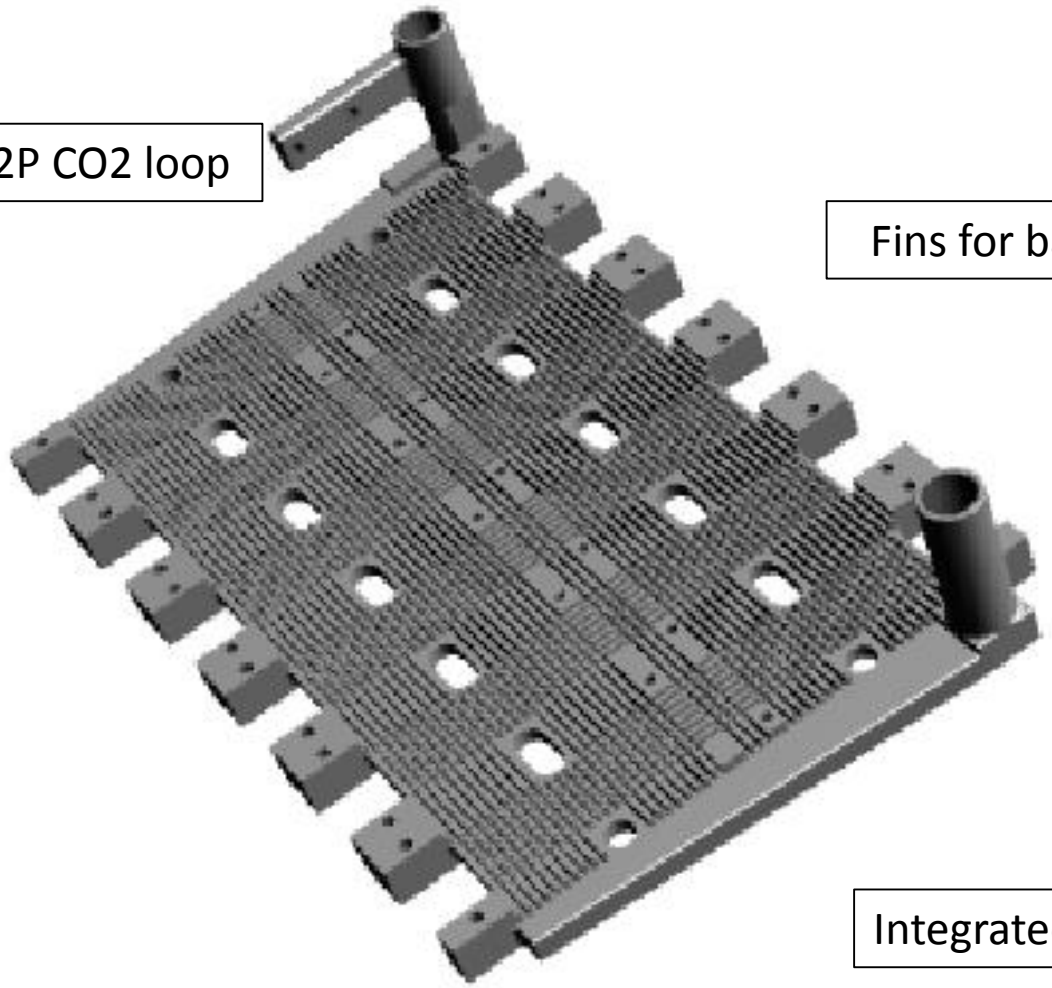


3-D printing (=additive manufacturing)

- Very easy way to manufacture complicated structures, including shapes like an integrated serpentine where no drilling tool can be used
- However every layer must be almost totally supported
- Material availability still reduced, but evolving

Monolithic cooling plate in 3D printing

Connectors to 2P CO2 loop



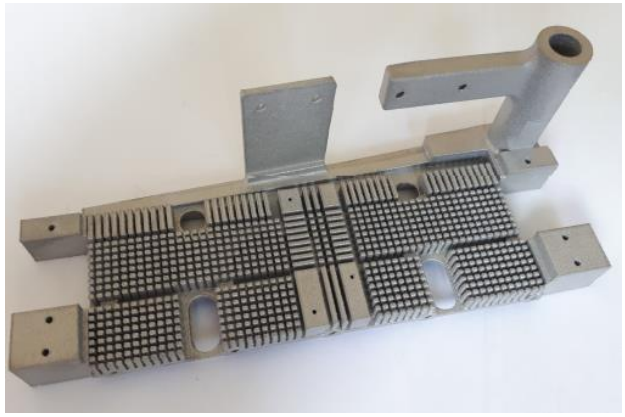
Fins for backup air-cooling

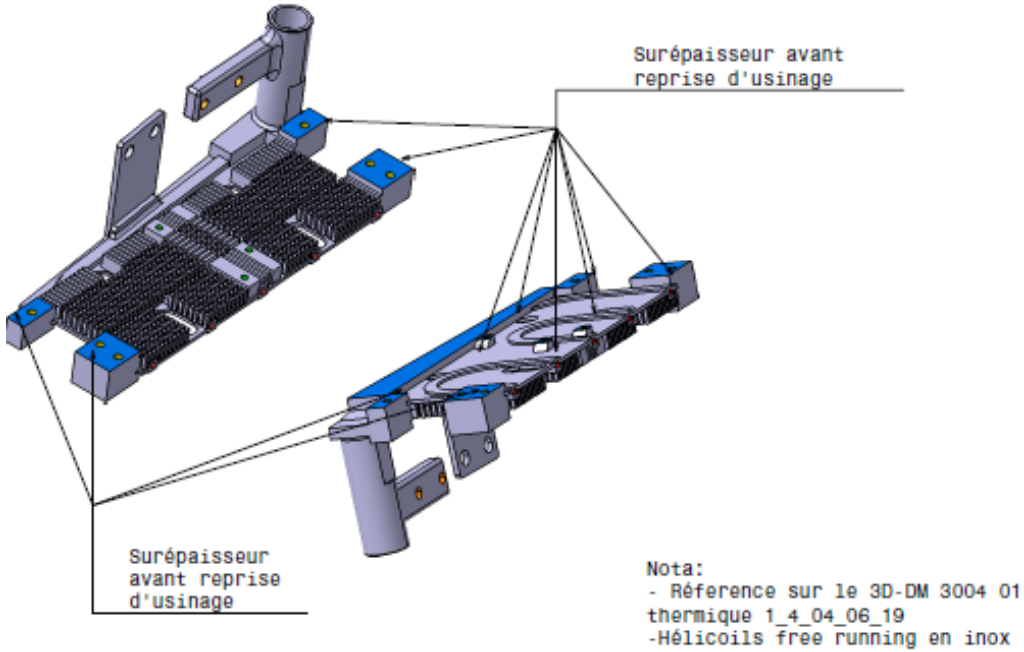
Integrated serpentine

Being realized at Saclay within a R&D project on metallic additive manufacturing (COSTARD)
Could be tested in a future beam test

M. Riallot, Y. Jan

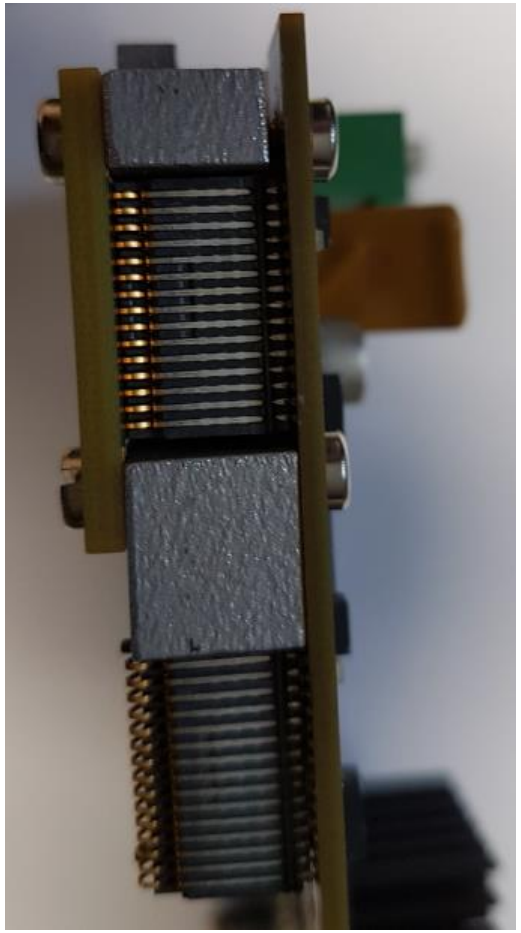
1/10 prototype (2019)

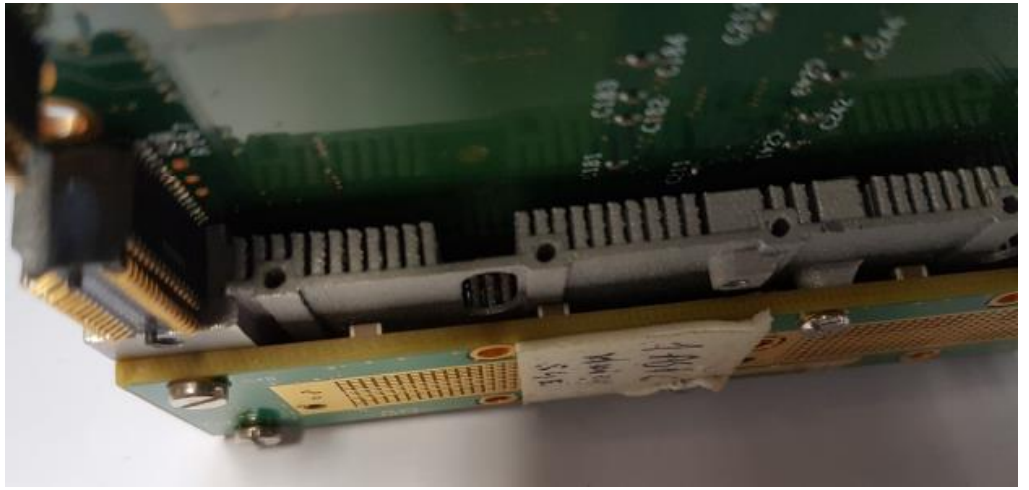




-Easy to remove the remaining powder
-threads
-Next : test at 120 bar and test gas-tightness
- Need a full-size prototype

Insertion on a FEC





Conclusion

2-phase CO2 cooling is a mature technology suited for ILD TPC modules. It has been demonstrated to be very stable and efficient in Micromegas beam tests.

3-D printing might help to optimize the performance and simplify the manufacturing of a cooling plate.

On the longer term, other options are under study (channels in the bulk of the PCB, microchannels, new materials : TPG, etc…).