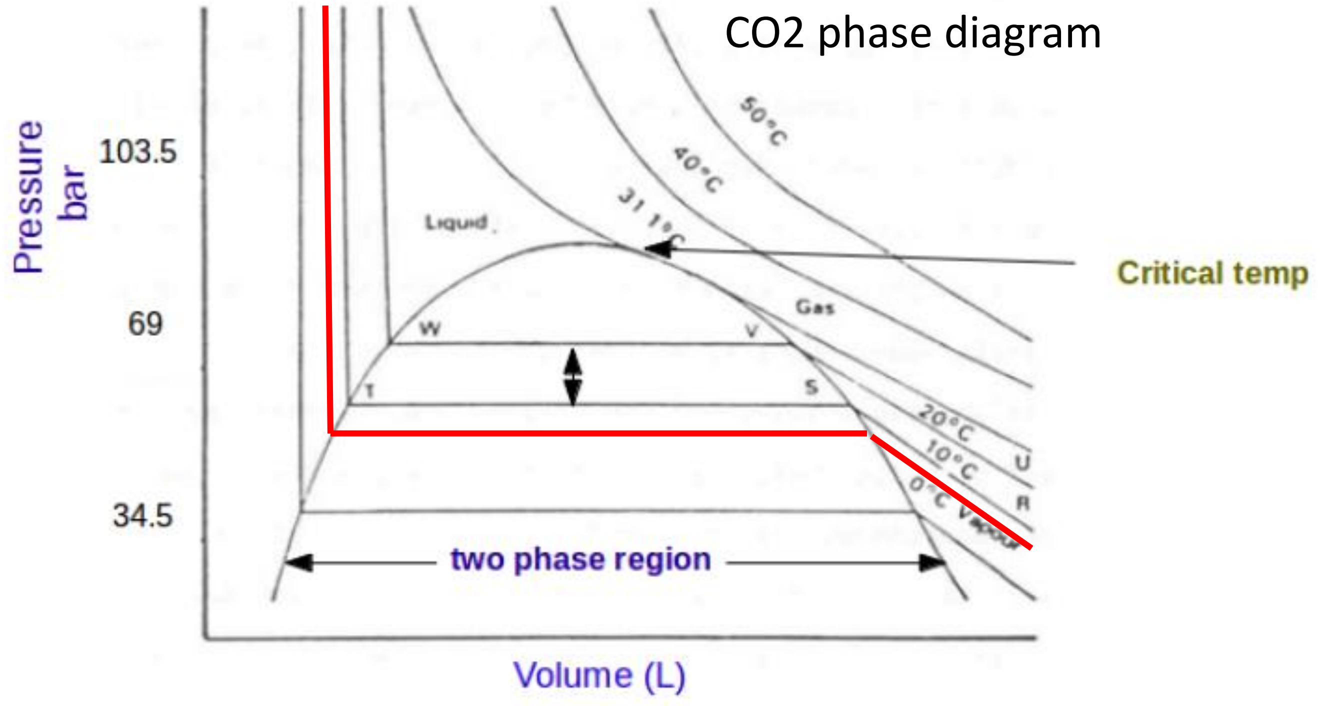
Two-phase CO_2 cooling

P. Colas

CO2 has a large latent heat in vaporisation, a large specific heat, and a low viscosity

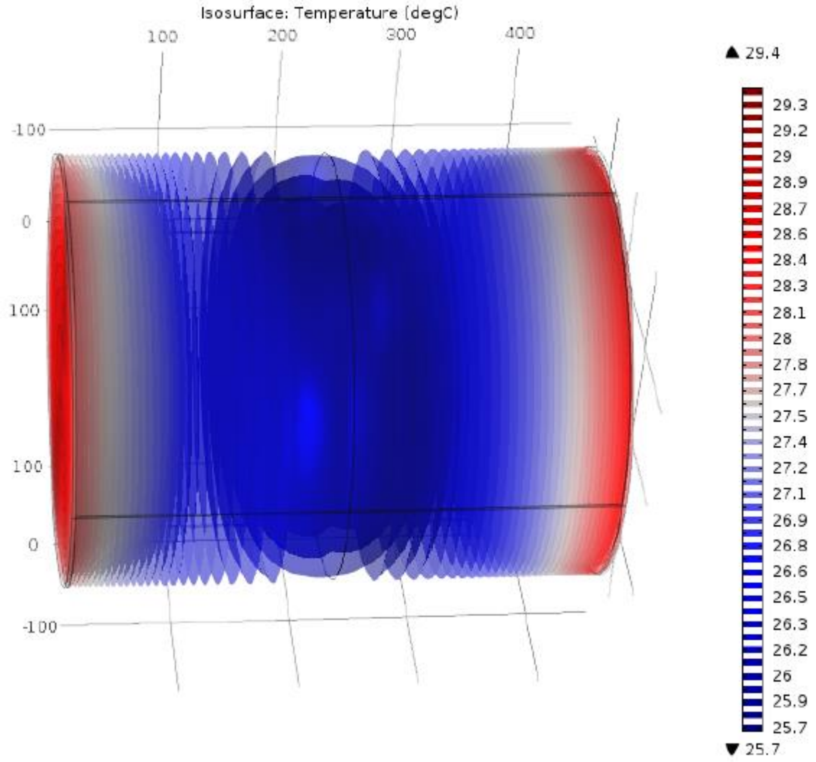
At 50 bar the two-phase fluid is at almost 10°C, avoiding condensation. At 65 bar it can take out heat at room temperature.

CO2 phase diagram



Thermal simulation of the TPC

Without power pulsing: 32 to 68 degree
With power pulsing: 26 to 29 degree after 7h



Measurement and simulation of two-phase CO_2 cooling in Micromegas modules for Large Prototype Time Projection Chamber

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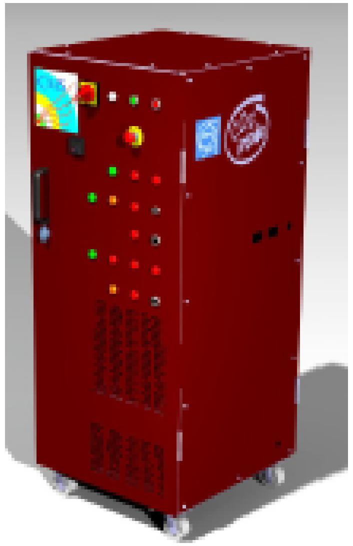
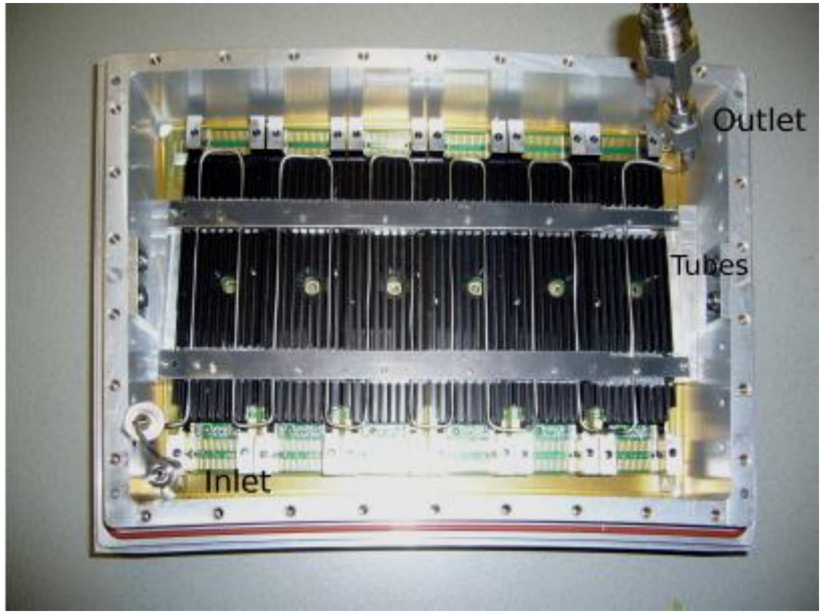
ABSTRACT: The readout electronics of a Micromegas (MM) module consume nearly 26 watts of electric power. This power consumption causes the temperature of electronic board to increase up to 70°C. As a result, chances of damage of the detector increase. Development of temperature gra-

2-phase CO_2 cooling

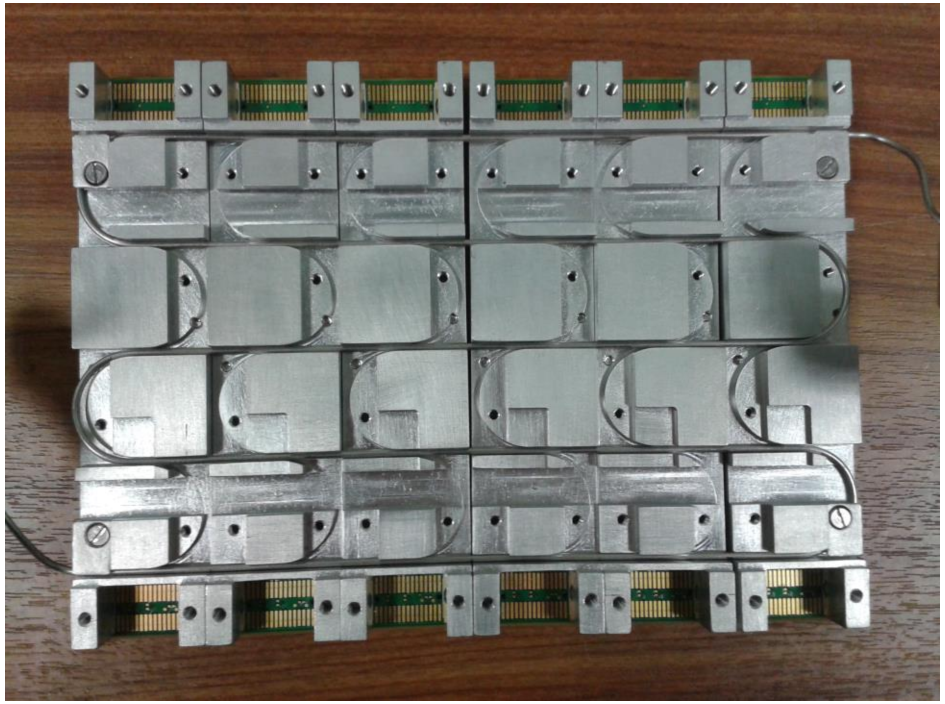


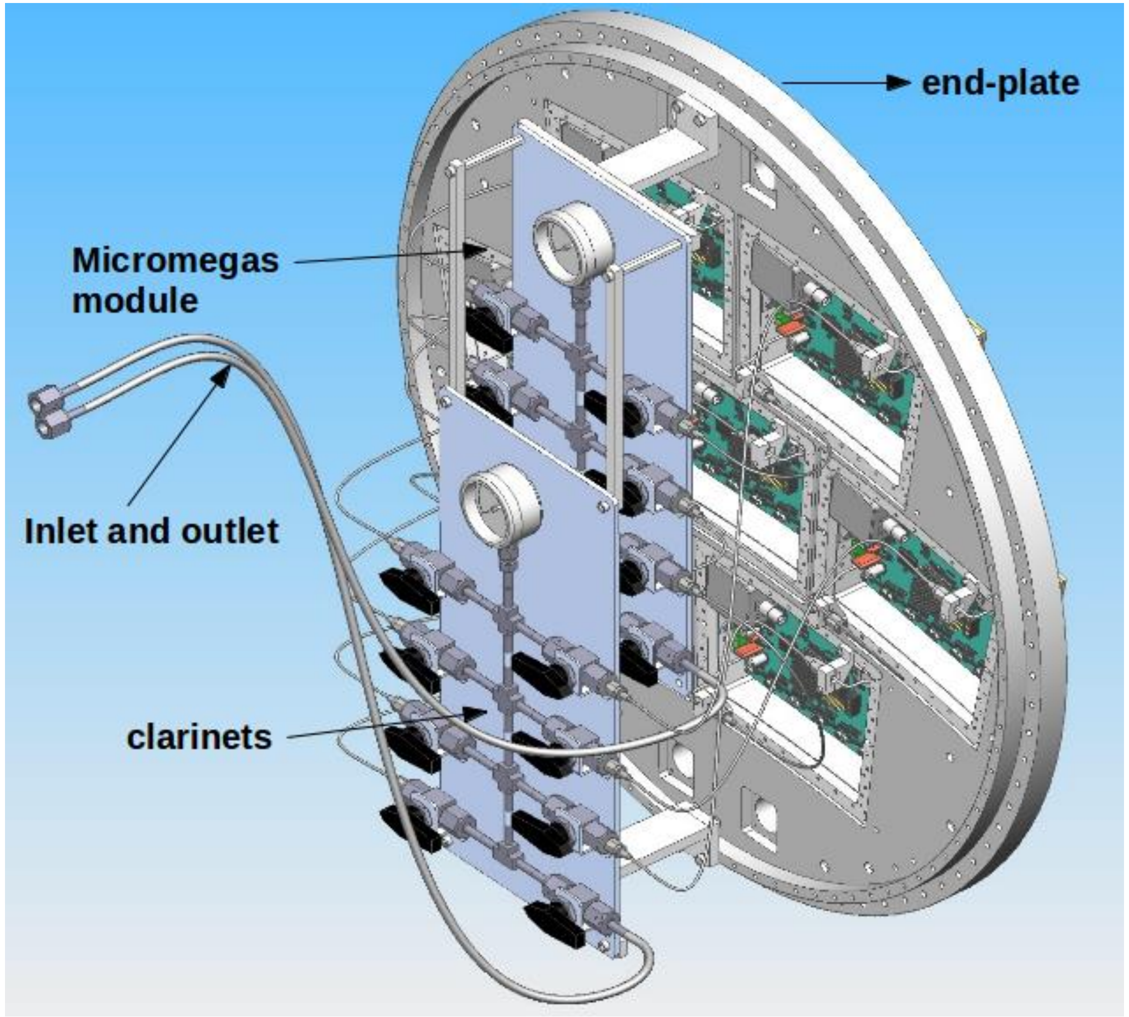
- Pioneered at Nikhef and CERN, studied at KEK.
- KEK bought a compressor (« TRACI ») for ILC and Belle II, installed at DESY Test Beam T24.
- Tested in 2014 and 2015 with 7 independent modules with a distribution by a manifold (« clarinette »). 0.8 mm inner diameter pipe
- This time (2018) tested with 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.

First test in 2014 at Nikhef with a Micromegas module

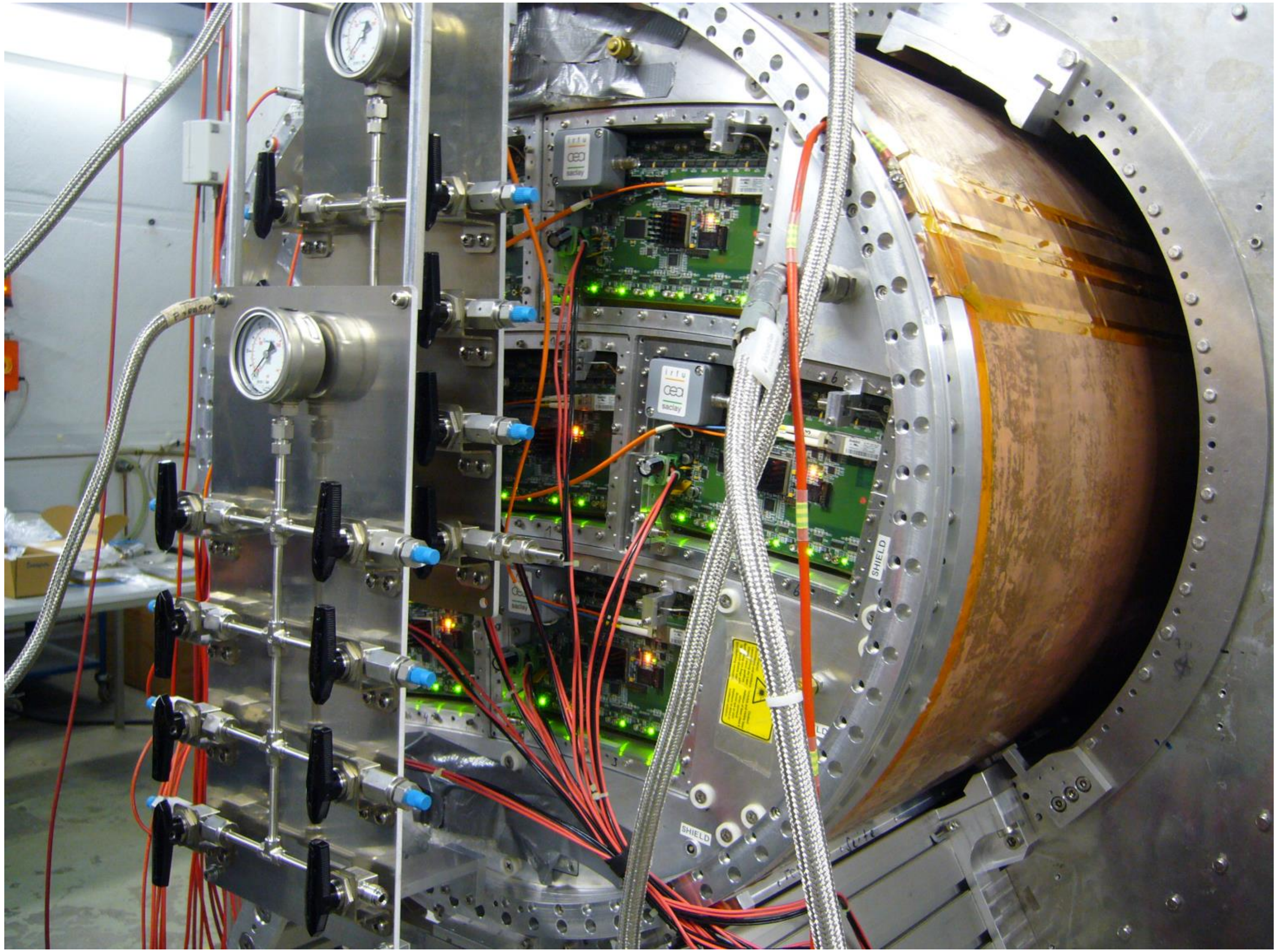


Tests in 2014 and 2015 at DESY Test beam with 7 Micromegas modules

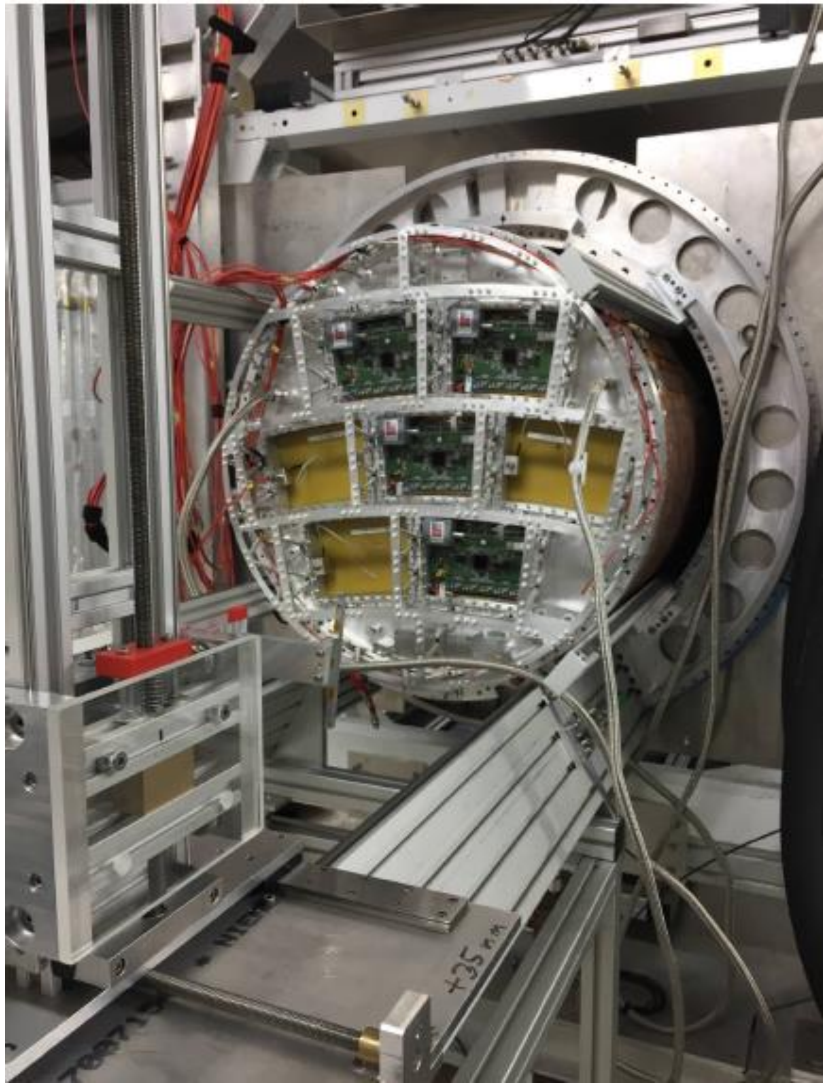




Tests in 2014 and 2015 at DESY Test beam with 7 Micromegas modules



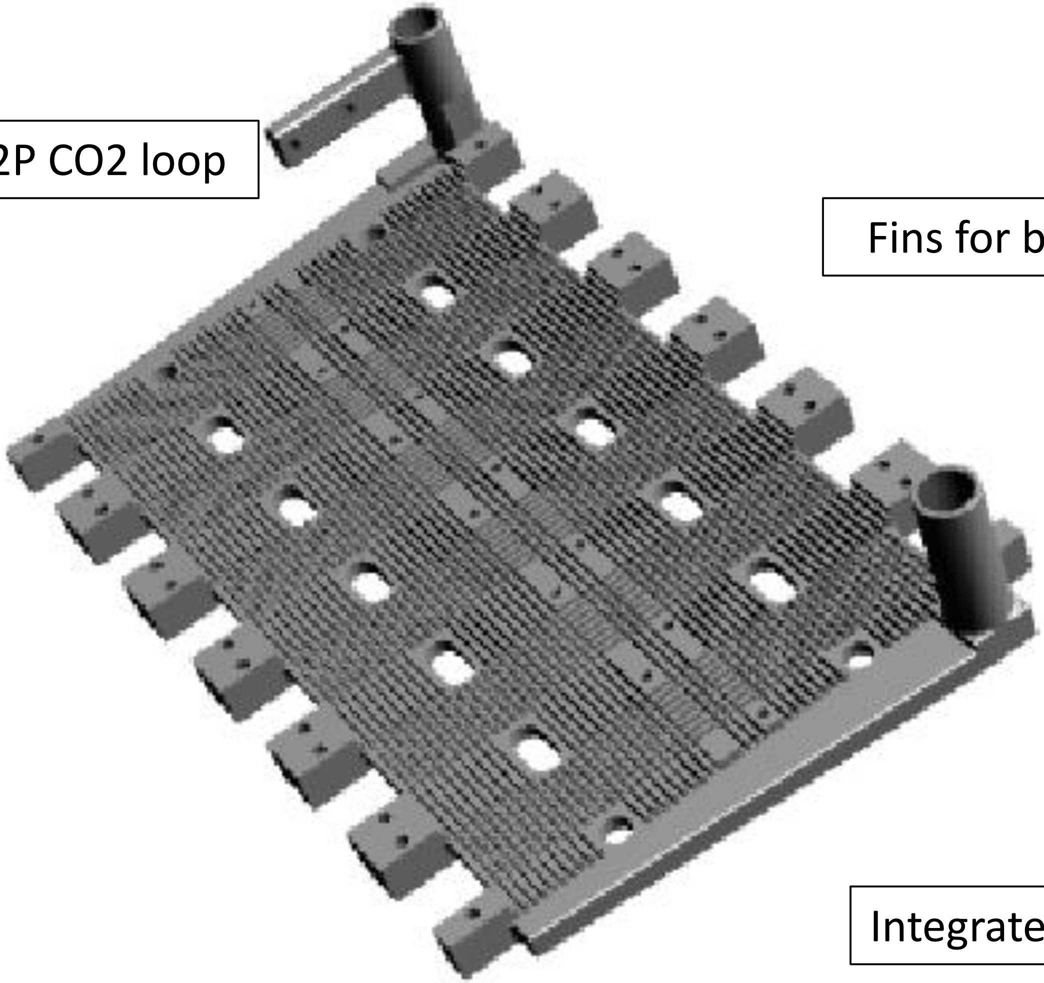
Tests in 2018 at DESY Test beam with 4 Micromegas modules in one loop



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



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

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).