PH-DT
Detector Technologies

CO_2 evaporative cooling: the future for tracking detector thermal management

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Why evaporative cooling?

- ✓ Low flow and higher Heat Transfer Coefficient (HTC) : smaller pipes!
- ✓ Limited temperature excursion on the detector: isothermal evaporation
- ✓ Temperature control through pressure control

Why CO_2?

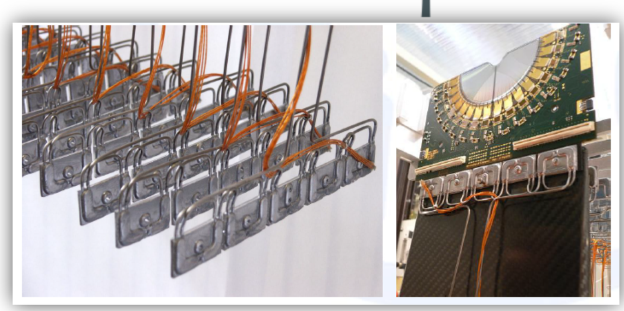
Significant saving on material budget

- ✓ large latent heat of evaporation
- ✓ low liquid viscosity
- ✓ higher Heat Transfer Coefficient than, e.g. C_3F_8
- ✓ high thermal stability due to the high pressure

Very practical fluid to work with

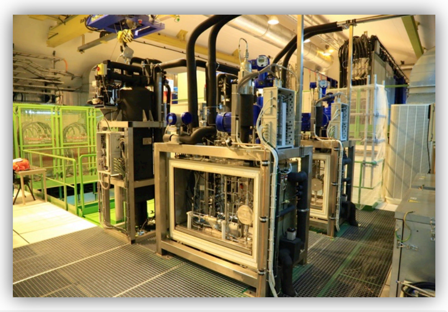
- ✓ Environmental friendly with respect to presently used fluorocarbons
- ✓ Radiation resistant
- ✓ Cheap

Timeline & performances



LHCb Velo
1 kW, -30 °C

ATLAS IBL
2 x 3 kW, -35 °C



CMS Pixel Phase I
2 x 15 kW, -25 °C

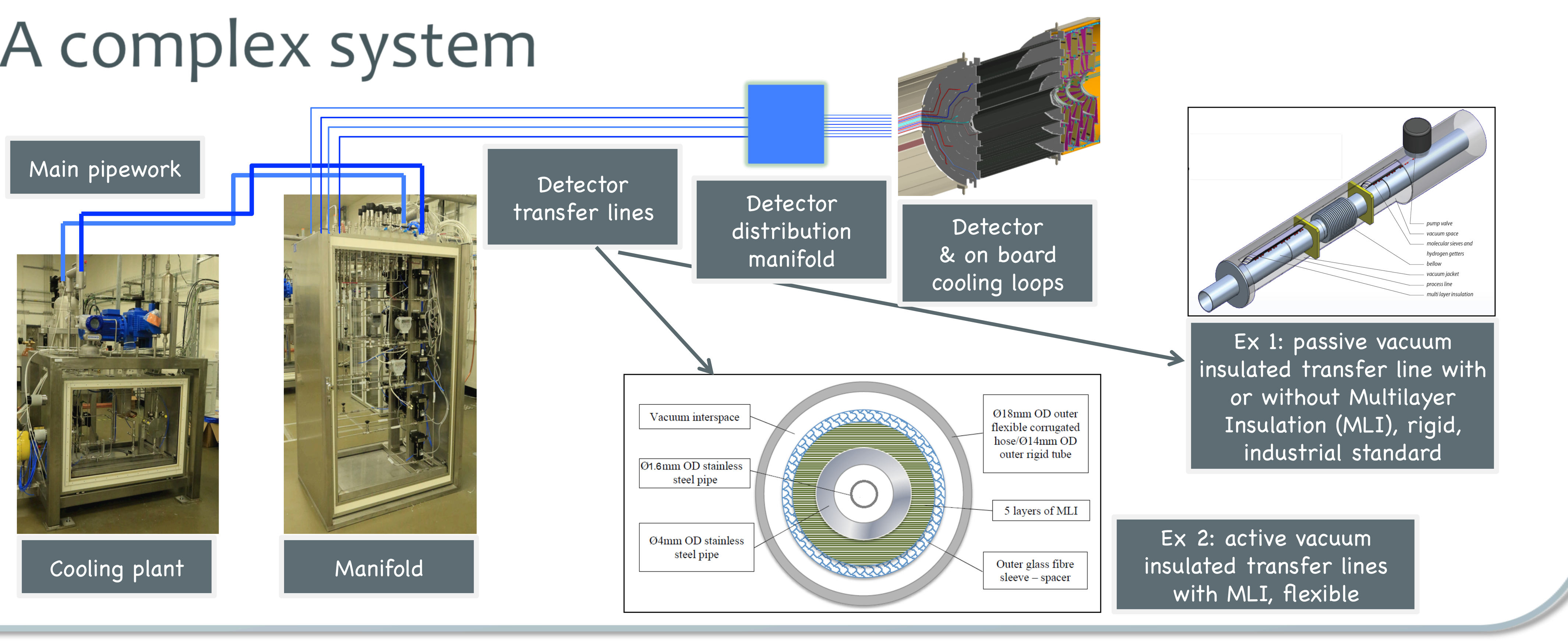
LHCb Velo II & UT
2 x 7 kW, -30 °C

CMS Tk Upgrade
100 kW, – 30°C

ATLAS ITk Upgrade
140 kW, – 35°C

2003 — 2014 — 2015-17 — 2018-19 — 2023-24

A complex system

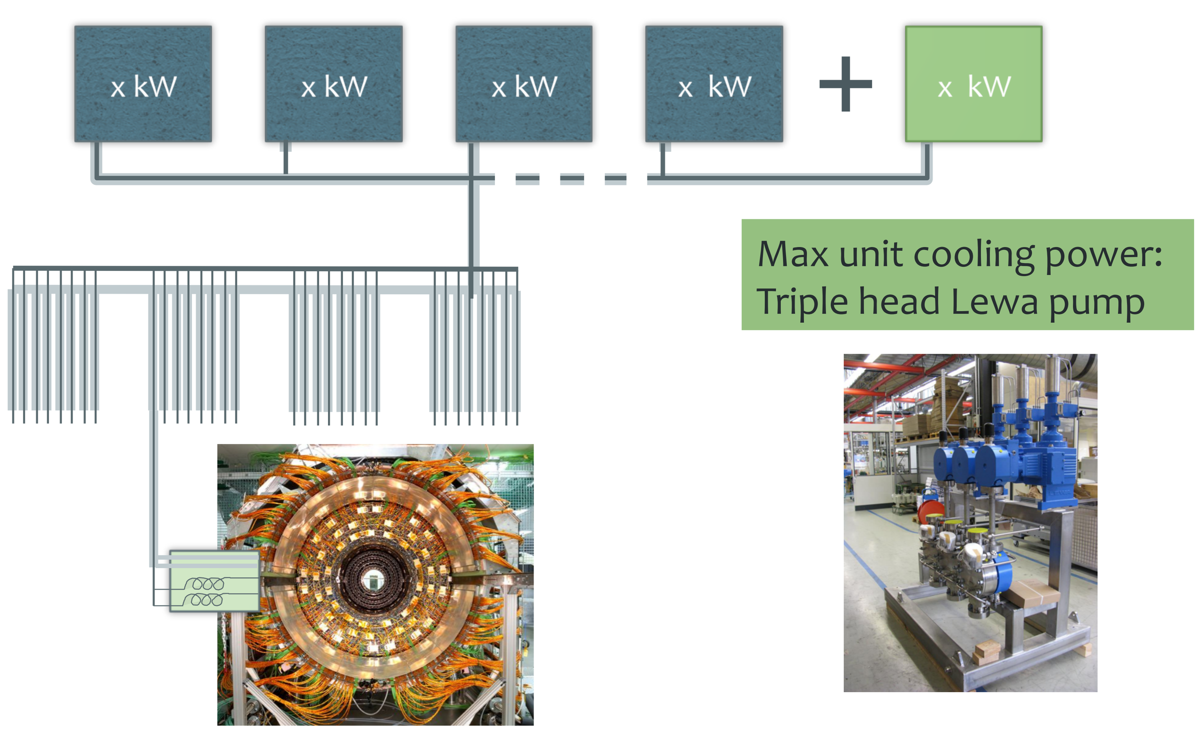


Technological challenges

- Low temperature (practical operation limit @ -40°C)
- Redundancy policy
- CO2 storage: surface or underground
- Primary system: industrial approach
- Space allocation in underground (replacement of old systems or new areas?)
- Transfer lines: insulation, total number, sizing

Tracker II Demo cooling system (2019) to prove:

The modular concept



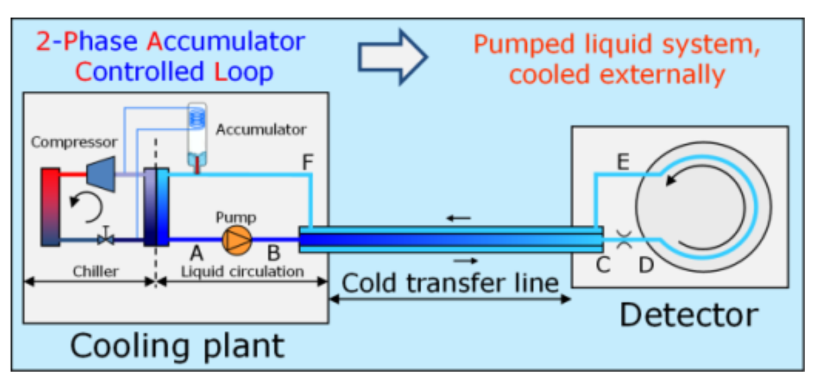
Max unit cooling power: Triple head Lewa pump

N+1 plants: swap in operation, distribution, optimization of transfer lines. R&D needed for parallel operation!

The regulation concept

2PACL system: local accumulator and pressure control through heating and cooling of the vessel

- requires local underground fluid storage
- can be designed with one active accumulator + local warm storage volume (bottles? -> concerns for underground)



Alternative design to allow surface storage: local pump and pressure control through pressure regulation valves – TO BE TESTED!

The primary system

The challenges:

- Space constraints
- Environmental policy
- Low T limits & stability (evaporation T on primary = -45°C)
- Solid industrial components: reliability & maintainability

The appealing solution TO BE TESTED: industrial CO2 chillers:

- up to several hundred kWs
- small footprint
- requires sub-zero cold source (glycol?)
- Environmental friendly
- Good T range

Conclusions

- R&D and conceptual development exploiting full synergies for Phase II detectors
- LHCb Upgrade profiting of the experience of both ATLAS and CMS on CO_2 cooling
- Common Demo system necessary on medium term to verify conceptual design
- CO_2 cooling is a complex system where on-detector and off-detector design shall be developed together: synergies and collaboration needed between detector experts and cooling team

References

1) Verlaat B. et al. 2008, *CO_2 Cooling for the LHCb-VELO Experiment at CERN*, 8th IIF/IIR Gustav Lorentzen Conference on Natural Working Fluids, CDP 16-T3-08
2) Zwalinski, L. et al. 2014, *CO_2 Cooling System for Insertable B Layer Detector into the ATLAS Experiment*, 3rd Conference on Technology and Instrumentation in Particle Physics, PoS(TIPP 2014)224
3) Tropea, P. et al. 2014, *Design, construction and commissioning of a 15 kW CO_2 evaporative cooling system for particle physics detectors*, 3rd Conference on Technology and Instrumentation in Particle Physics, PoS(TIPP 2014)223

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