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CO_2 Cooling for the CMS Tracker at SLHC

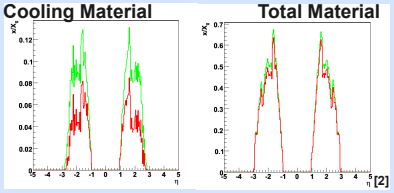
Evaporative CO_2 Cooling for SLHC

- High power consumption of new tracker
- Performance benefits from low material budget
- Effective and low mass cooling needed

→ CO_2 cooling system [1]
- Low operating temperature
- Reduction of material budget

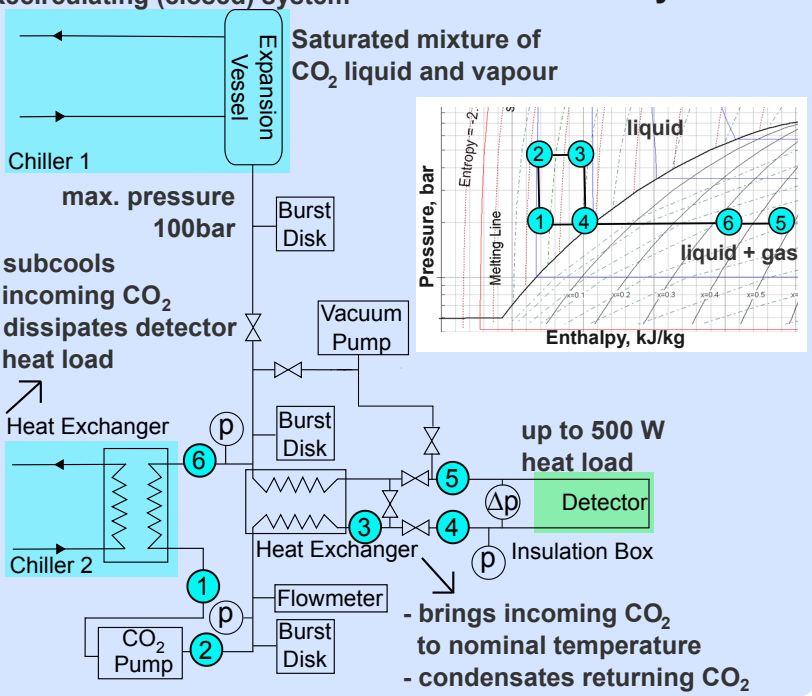
Current cooling system
monophase, C_6F_{14}
CO_2 cooling system
for current power consumption

CMS Tracker Endcap

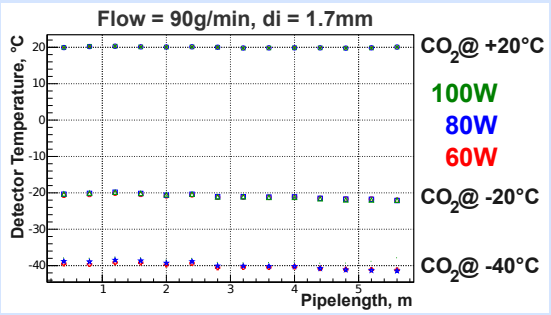


Aachen's Test System

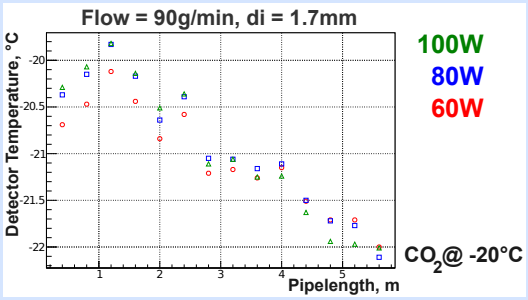
Recirculating (closed) system



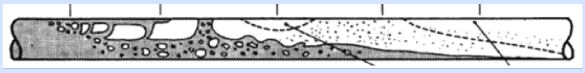
Temperature Distribution over Det. Pipe



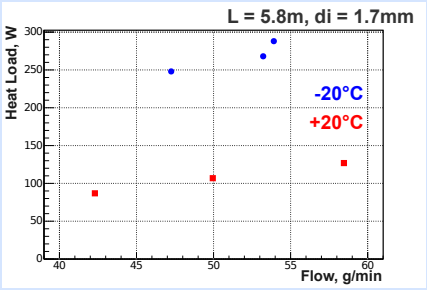
- Detector temperature constant, even with heat load
- -40°C can be reached



Dryout Measurement

liquid  gas

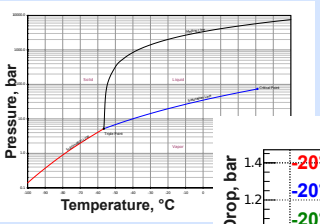
- Dryout: pipe walls not in touch with liquid anymore
- No heat dissipation by evaporating CO_2
  → Rapid rise in detector temperature
- Determine minimal required flow for applied heat load
- In real system: apply safety factor

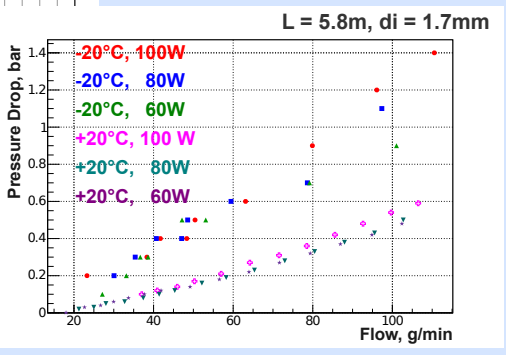


Measurements corrected for heat input from environment: needs crosscheck in vaccum box

Pressure Drop

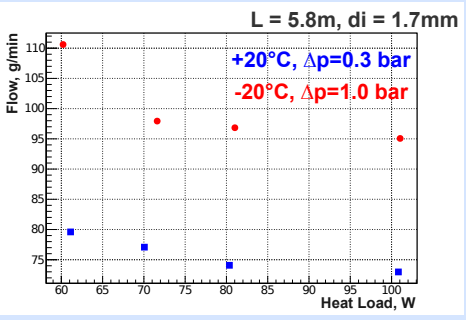
- 2-phase flow: pressure drop = temperature drop
- Measure pressure gradient → precise control of det. temp.
- Determine Δp between inlet and outlet of detector pipe





Parallel Cooling Branches

- Keep pressure drop constant
- Apply heat load and determine flow
- High heat load → low mass flow
- Influence on parallel piping
  → insert restrictions in each branch



Summary

- CO_2 cooling system with thin pipes
- Detector temperature: -40°C to +20°C

Outlook

- Investigate different pipe routings
- Measure thermal contacts
- Operation of parallel piping

References
[1] B. Verlaat et al., CERN-2008-008, *CO_2 cooling for HEP experiments*
[2] J. Merz, Diploma Thesis, *Studien zur Verringerung des Material-Budgets für einen neuen CMS-Spurdetektor am SLHC*