CO_2 Cooling Plants for the LHCb upgrade

LHCb infrastructure workshop February 19+20

Burkhard Schmidt
With input from Bart Verlaat,
Paolo Petagna and Lukasz Zwalinski

The Plan

- The coordination effort for the $C0_2$ cooling needs of the LHCb upgrade started in May 2014, having as goal the:

  "Development and construction of a CO_2 plant for the VELO and UT detectors for the LHCb upgrade, in collaboration between PH-DT and the LHCb detector groups."

- The idea is to built two identical CO_2 cooling plants based on the 2 Phase Accumulator Control Loop (2PACL) with a total cooling power of ~7kW, one for VELO and one for UT.

- The total cooling power should be sufficient to cool both detectors with one plant in case of maintenance or an emergency.

Plan and Status

- From the beginning we underlined the strong interplay between
  - the detector design,
  - the requirements for the thermal management
  - the detector control and safety systems and
  - the design of the cooling plant

  and hence the need for close collaboration between cooling experts and detector development groups is mandatory.

- The goal for 2014 has been the documentation of the cooling specifications of the VELO and UT sub-detectors.
  - ➢ They are in advanced state

Cooling system development road map

- Development from evaporator to cooling plant.

1. Detector evaporator design :
   - Output to transfer line development:
     - Flow condition, mass flow, temperature, pressure head, stability, cool down rate

2. Transfer line development:
   - Output to CO2 cooling plant specification:
     - Flow condition, pressure drop, temperature range, volume

3. CO_2 Cooling plant development
   - Output to chiller specification
     - Sub cooling (chiller temperature)
     - Total heat load (detector + ambient heating + control heat)

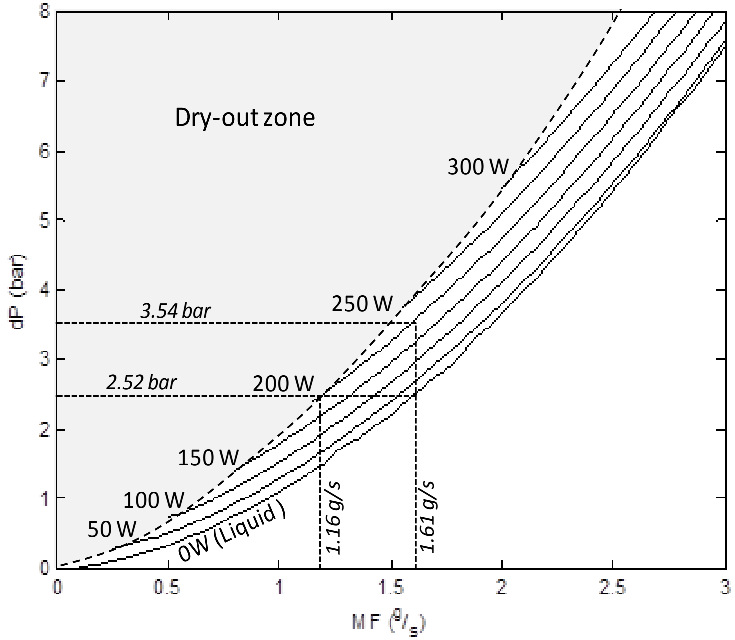
4. Chiller development

Evaporator development

- The evaporator development is detector specific and requires several iterations between detector group and cooling experts.
- A single evaporator developed in the lab must work together with all the other evaporators
  - Flow distribution
  - Pressure drop characteristics

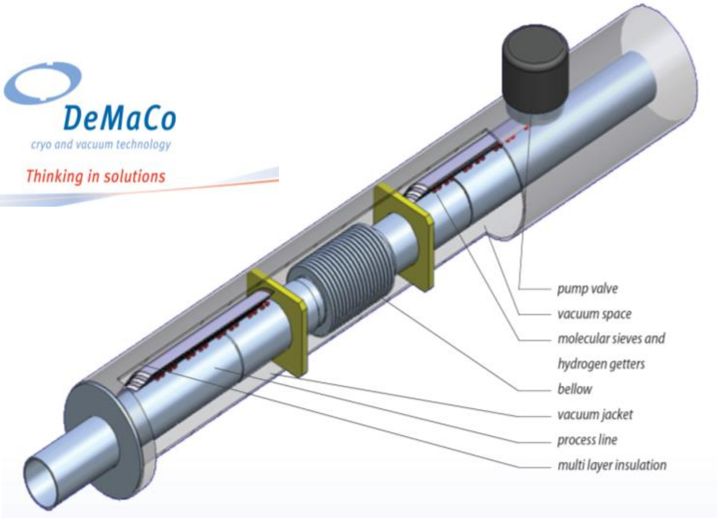
➢ The above means understanding the behavior in graphs as shown

- Challenges
  - Micro channel behavior
  - Vertical channels
  - Special junction box for the VELO with safety volume



Transfer line design

- The right transfer line design together with the evaporator behavior form an important for the P&ID
  - Inputs to the plant design are:
    - Pressure drop of return line (Dynamic and static)
    - Heat exchange capacitance = operational temperature range
    - Ambient heating = chiller capacity
    - Volume = accumulator volume



➢ We intend to use concentric vacuum transfer lines
  - 1 line per plant: input inner part, output outer part

Control and Power Cables

Power and Control cables for cooling plant :

Function	Cable type	Diameter (mm)
Heater for plant commissioning	Tri-phase power cable for 3kW	18.5
Heater surface temperature signal	Thermo coupled type K	8
Spare TC type K;	Thermo coupled type K	8
Pressures	NG8	11.1
Temperatures	NG18	16.5
Thermal switches	NG4	8.7
Manual Valves status	NG18	16.5
Spare	NG8	11.1
Communication with DSS	NE10	11

The table is based on the ATLAS IBL design

Cooling plant schedule

- **2014**
  - Q34: Requirement document by VELO and UT
- **2015**
  - Q12: Development and definition of evaporator systems
  - Q23: Concept P&ID
    - Preliminary sizing
    - Control philosophy
    - Redundancy approach
  - Q3: P&ID document & functional analyses
  - Oct 2015: Cooling EDR
  - Q4 start of design
- **2016**
  - Q123 Detailed 3D design of hardware
    - Evaporator, junction box, transfer line, cooling plants
  - Oct 2016: Cooling PRR
  - Q4 Production of transfer line and junction box
- **2017**
  - Q1 Transfer line and junction box installation (EYETS, 19 weeks)
  - Q1234 Production of the cooling hardware
- **2018**
  - Q12 cooling system installation in UXA (preferred place: A-side alcove)
  - Q234 Cooling system over junction box commissioning
  - Q3 start of LS2
  - Q4 Removal of current VELO and TT
- **2019**
  - Q2 Upgrade VELO and UT installation
  - Q34 Detector commissioning with cooling
  - Q4 end of LS2

Comments:

- The schedule is driven by
  - the LHC schedule,
  - the LHCb upgrade plan and
  - the availability of resources in PH-DT:
    - Design effort in 2015/2016
    - Construction 2017
    - Installation and start of commissioning in 2018

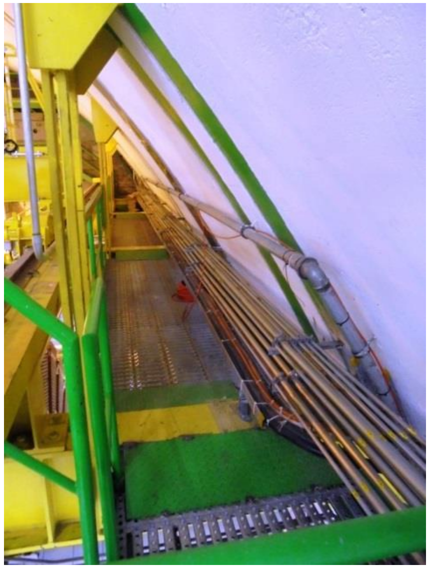
Cooling plant location

Prefered Location:

Alcove PZ85 (VELO side)

- About 25-30m^2 are available and easy to access.
- Area needs to be equipped with power (EXD, EBD, ESD), network, primary cooling
- poor ventilation

→Despite some drawbacks, this seems to be the best option.



- **Additional advantage:**
  - The transfer line towards the detector would be straight.
  - Passing the shielding wall looks not too complicated.

Status and Plans

- In parallel to the design/development effort on the evaporator and the transfer lines, we are working on the *organizational issues in relation to design and construction of the cooling plant.*

- In the past months much effort went into the organizational aspects:
  - The part PH-DT is ready to take up has been summarized by Paolo Petagna *(slides are uploaded to the agenda)*
  - An action plan in relation to the responsibility of the LHCb groups has been prepared, aiming at an EDR for the cooling plant in October 2015
  - To follow the action plan is critical for the continuation of the project. Human resources are very tight.