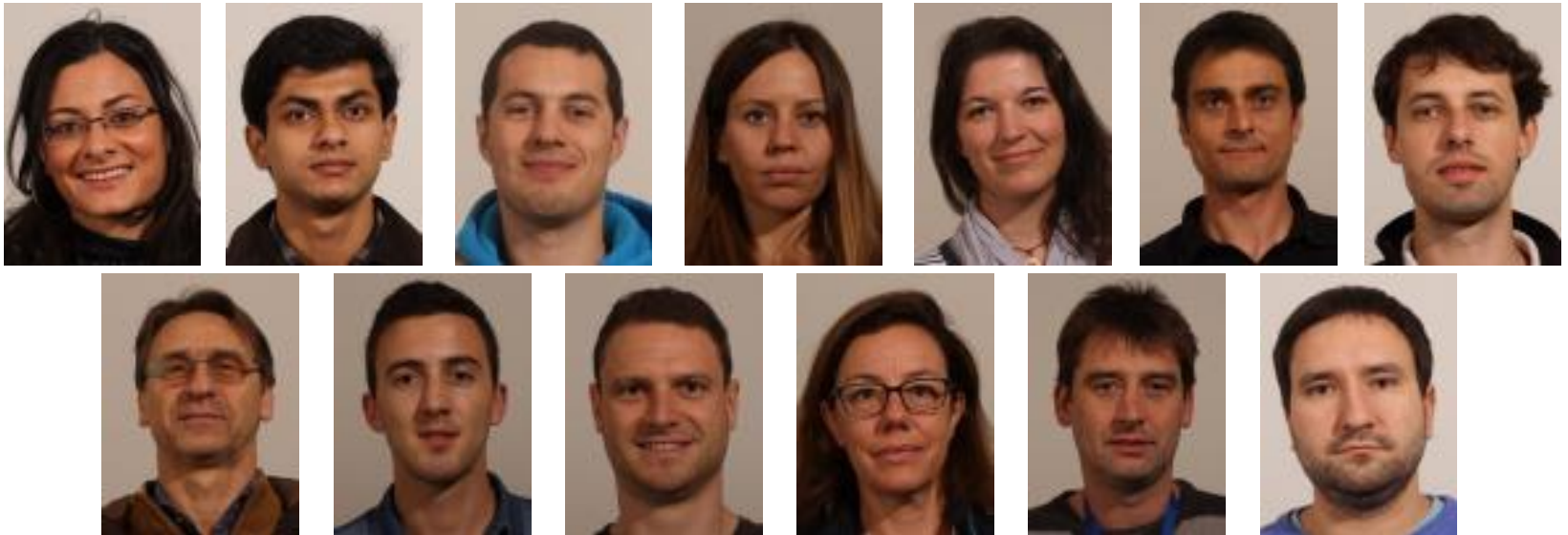


Cooling Service and R&D activities

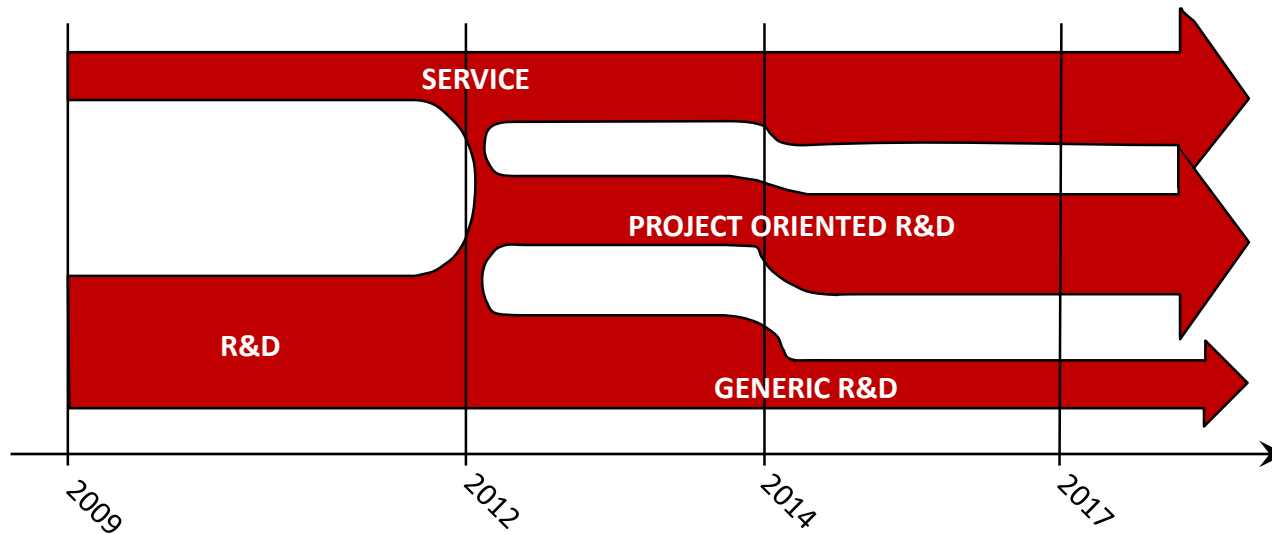
June 22, 2017



EP-DT Cooling Project - tasks

Mandate: {

- Design and build new CO₂ cooling plants for tracking detectors
- Develop innovative techniques for on-detector thermal management.



Past presentations to track a bit of history and the main achievements:

[42nd DT Coordination Meeting, 31 March 2011](https://indico.cern.ch/event/132892/)

[55th DT Coordination Meeting, 08 March 2012](https://indico.cern.ch/event/181075/)

[PH-DT Cooling Meeting, 23 Jan 2015](https://indico.cern.ch/event/369541/)

[1st DT-FS Section Meeting, 19 Nov 2015](https://indico.cern.ch/event/459747/)

[6th DT-FS Section Meeting, 30 Nov 2016](https://indico.cern.ch/event/581322/)

EP-DT Cooling Project - people

EP-DT Cooling FTE in 2017 (typical)

	STAF	FELL	DOCT	TECH	TRNE	COAS	
EP	6	1	1		2		10
Experiments		2	1	1	1.5	1	6.5
External			1				1
	6	3	3		3.5	1	17.5

STAFF	Daguin, J.	(LD)
	Noel, J.	(IC)
	Petagna, P.	(IC)
	Tropea, P.	(IC)
	Verlaat, Z.	(LD)
	Zwalinski, L.	(IC)
FELL	Berruti, G.M.	EXP
	Giakoumi, C.	EXP
	Ostrega, M.	
DOCT	Hellenschmidt, A.D.	EXT
	Pimentel Das Neves, T.	
	Schmid, D.	EXP
COAS	Bhanot, V.	EXP (non-eligible PhD Student)

Additional contributions of ~10 FTE from ATLAS and CMS (STAFF, COAS, TECH, FSU...) to work under DT supervision on specific detector-related cooling service.

Collaborations with several research institutes: CUT (Cracow), MPI (Munich), MACE and S.P.&A. (Manchester), EPFL (Lausanne), INSA (Lyon), CSEM (Neuchatel), IFIC (Valencia), LPNHE (Paris), UNISANNIO (Benevento), ATOMKI (Debrecen)...

EP-DT Cooling Project – activities (2017 & on)

- CO₂ cooling systems:** M&O service (CMS – in discussion for ATLAS IBL)
Design & Construction service (ATLAS + CMS + LHCb)
Technology Transfer to industry
Project Oriented R&D for HL-LHC (ATLAS + CMS)
Generic R&D (AIDA-2020)
- Micro-channel cooling:** Engineering Support service (NA62)
Technology Transfer and collaboration (LHCb)
Generic R&D (AIDA-2020)
- Optical fibre sensors:** M&O service of installed network (CMS)
Project Oriented R&D for LS2 (ATLAS + CMS)
Generic R&D

In addition, from its very beginning, the EP-DT Cooling Project provides the COOLING COORDINATOR to both ATLAS and CMS, with the following mandate:

“Ensures the coordination between experiment’s T.C. and the sub-detectors with EP-DT and EN-CV for the design, maintenance and operation of detector and infrastructure cooling systems. Is responsible for all equipment from the cooling plant up to the heat source. Manages a small support team provided by the experiment, dedicated to cooling M&O.”

CO₂ systems – M&O services

- EP-DT-FS is committed to **M&O of the CO₂ systems** designed for the experiments
- This is regulated by **specific WP's** agreed with the experiments
- With the start in service of the new **CMS PIX** (phase I) this includes **STAND BY DUTY**
- Cooling team presently in “**training**” phase, also learning from gas team experience
- **Synergies** between the two EP-DT-FS teams (cooling and gas) foreseen in the future

Existing M&O agreement with **CMS**:

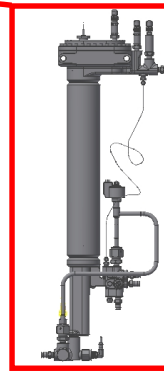
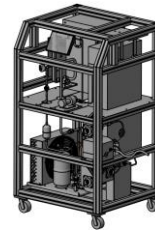
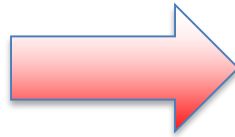
<https://edms.cern.ch/document/1720879/2>

A similar WP will be prepared for **LHCb** in the context of the delivery of the new CO₂ systems in LS2

Discussions presently on-going with **ATLAS** to recuperate the M&O of the IBL CO₂ systems (included in stand by duty).

CO₂ systems – design service

“MARTA”: a much awaited user-friendly CO₂ laboratory unit resulting from a technology transfer from EP-DT to an industrial partner.



successful technology transfer to industry

From “TRACI”⁽¹⁾ 9 protos in 3 versions built by EP-DT between 2011 and 2015

To “MARTA”⁽²⁾ Licensed industrial product available as from July 2017

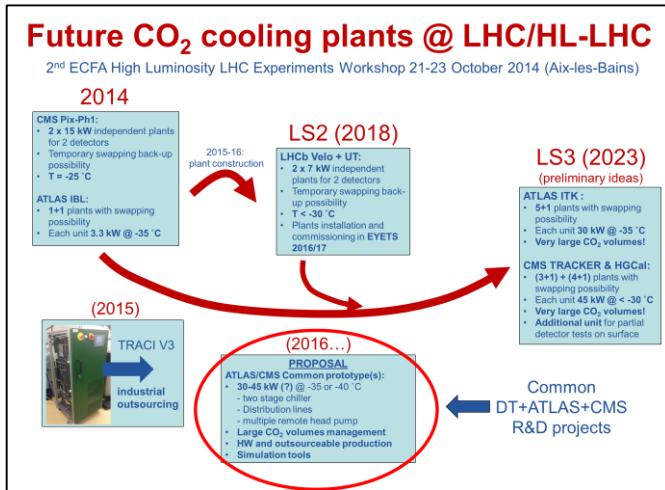
“LUCASZ”: a new detector testing/commissioning unit developed in 1 year at the request of the CMS and LHCb experiments.



The first prototype of “LUCASZ”⁽³⁾ class delivered to CMS at the end of 2016.
Three more units are being built by EP-DT-FS in 2017 (1 for CMS and 2 for LHCb).
Possible new technology transfer.

preparing for new technology transfer

CO₂ systems – design service



Roadmap for LS2 and LS3 CO₂ systems presented and agreed in the frame of the 2nd ECFA Workshop on High Luminosity LHC Experiments in October 2014.

LHCb VELO + UT: agreement for DESIGN and CONSTRUCTION of 2 x 7 kW redundant CO₂ systems. The next challenge.

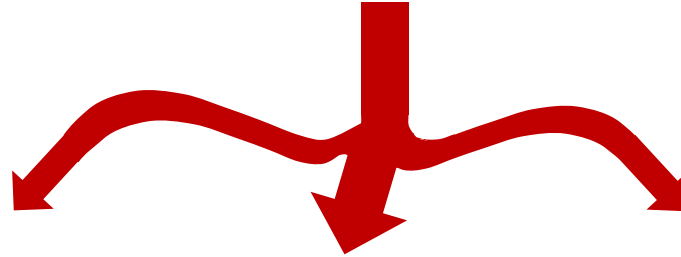
Presently under design, target is installation in the experiment during LS2.

Agreement on a common DESIGN based on redundant modular units for the TRACKERS of ATLAS and CMS for HL-LHC (LS3). Number of units to be produced to be defined.

Production will be OUTSOURCED

CO₂ systems – project oriented R&D

Common lines of R&D directly defined
from 2014 ECFA Workshop roadmap:



“BABY DEMO” (2017-2018...)

Fast-track for **minimum saturation temperature** guaranteed in the detector. ATLAS project with scientific supervision from EP-DT



“DEMO” (2017-2020...)

Full-size prototype of the common modular approach for **CO₂ cooling units of HL-LHC detectors**:

- Maximum refrigeration power
- Redundancy approach
- Control principle
- CO₂ storage
- Optimized design
- ...

“DYNASIM” (2016-2019...)

A new tool for dynamic simulation of full 2-PACL CO₂ cooling systems

A new life for the very first CO₂ prototype plant built at CERN!



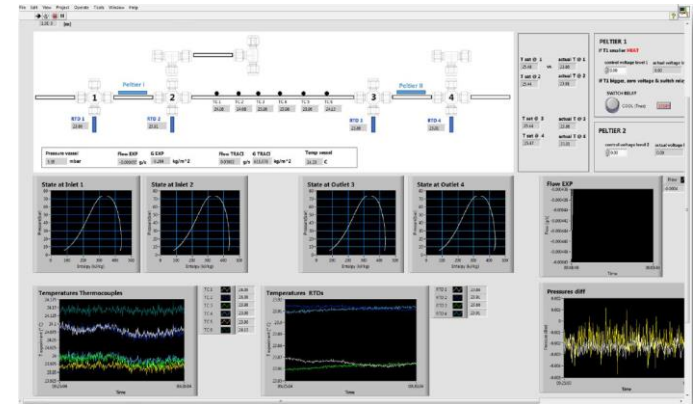
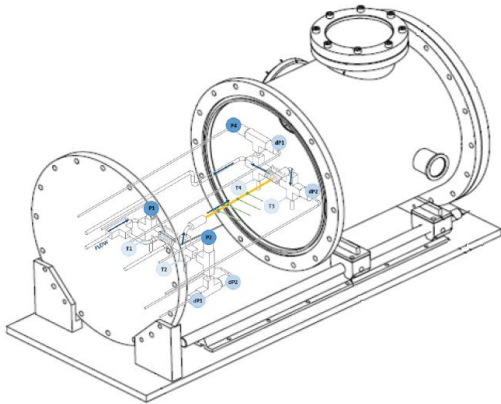
CO₂ mini-/micro-channels – R&D

A brand new dedicated test set-up for **high precision** systematic measurement of heat transfer and fluid dynamic properties of CO₂ evaporative flows in pipes and in micro-structured cold plates with D_H from 2 mm to 100 μm .

Extensive and reliable **database for model improvement**.

In the context of AIDA-2020 (2016-2109).

Main deliverable of CERN for AIDA-2020 WP9.



From conception...

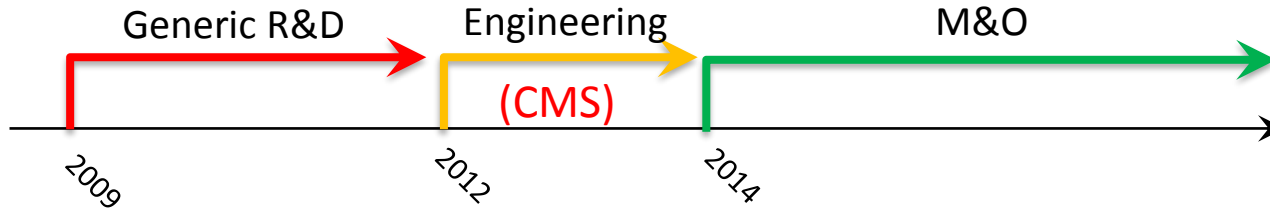
...To realization...

...To measurements and data analysis

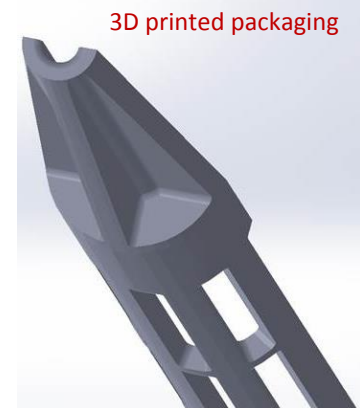
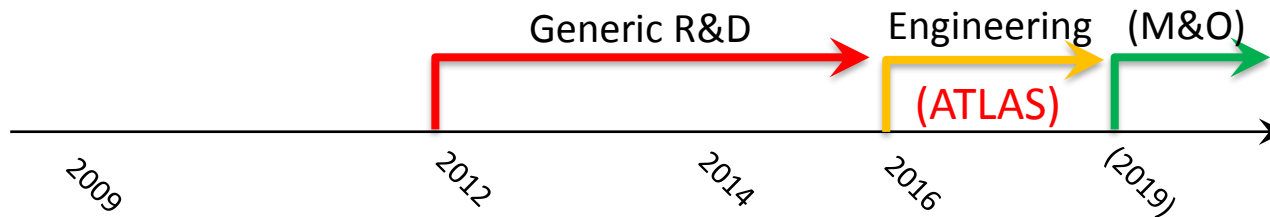
In addition to the collaboration with the EP-DT-DD microfab team (see previous talk by A. Mapelli), still in the context of the AIDA-2020 WP9 Network activity.

Fiber Optic Sensors – a complete example

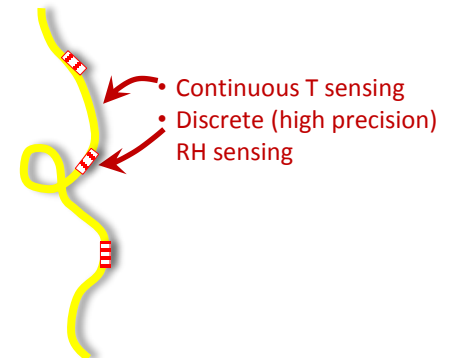
1st GENERATION (FBG T sensors / FBG + Polyimide RH sensors)



2nd GENERATION (FBG T sensors / LPG + TiO₂ RH sensors)



3rd GENERATION (Continuous T sensing / LPG + TiO₂ RH sensors)



Summary and conclusions

- The relatively recent addition of the Cooling Project (2009) extended the wide range of expertise of DT with specific competences on the thermal management of silicon trackers, from system aspects to detector aspects
- The activity extends to all the building blocks of complex cooling systems, including the creation of the HW and SW tools required by the HEP community to develop a correct local thermal management of future trackers
- After ~8 years of activity, the team is now the main reference in HEP community in particular for CO₂ cooling technology of present and future detectors
- While providing a direct service to the experiment, in terms of both system design and M&O, we develop the technologies required by the experiments for their upgrade programmes
- At the same time, we try to anticipate important future needs of detectors via selected lines of generic R&D
- A well defined roadmap is laid down until LS3. In order to match the very ambitious goals set it is fundamental to ensure the consolidation of the available human resources