Progress towards the commissioning and installation of the 2PACL CO_2 cooling control systems for Phase II upgrade of the ATLAS and CMS experiments

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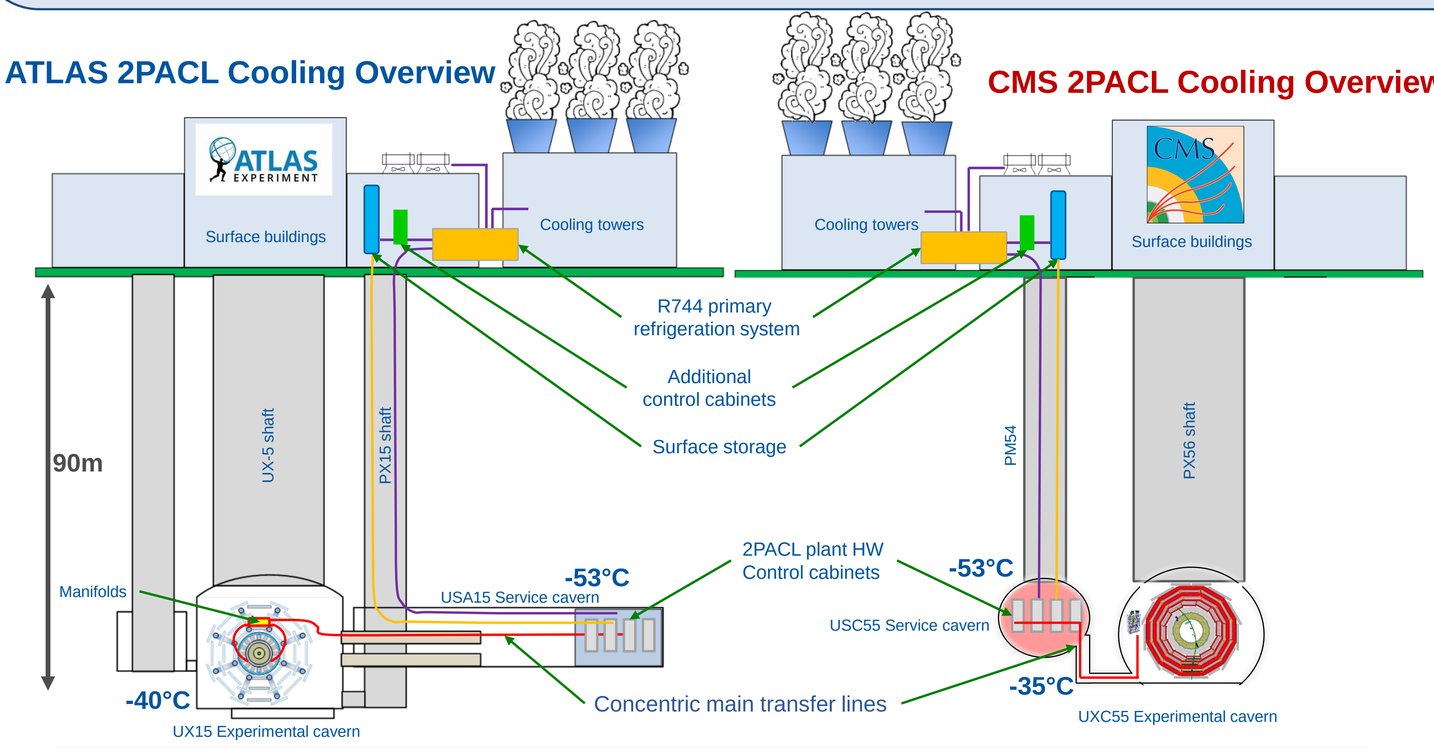
EP-DT
Detector Technologies

ABSTRACT

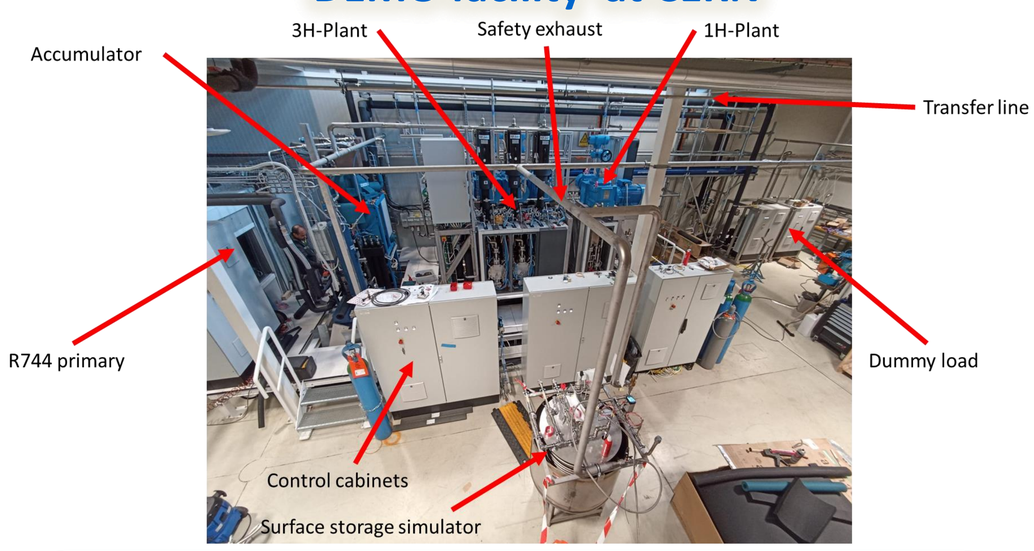
In the scope of the High Luminosity program of the Large Hadron Collider at CERN, the ATLAS and CMS experiments are advancing the preparation for the production, commissioning and installation of their new environment-friendly low-temperature detector cooling systems for their new trackers, calorimeters and timing layers. The selected secondary "on-detector" CO_2 pumped loop concept is the evolution of the successful 2PACL technique allowing for oil-free, stable, low-temperature control. The new systems are of unprecedented scale and largely more complex for both mechanics and controls than installations of today. This paper will present a general system overview and the technical progress achieved by the EP-DT group at CERN over the last few years in the development and construction of the future CO_2 cooling systems for silicon detectors at ATLAS and CMS. We will describe in detail a homogenised infrastructure and control system architecture which spreads between surface and underground and has been applied to both experiments. Systems will be equipped with multi-level redundancy (electrical, mechanical and control) described in detail herein. We will discuss numerous controls-related challenges faced during the prototyping program and solutions deployed that spread from electrical design organization to instrumentation selection and PLC programming. We will finally present how we plan to organise commissioning and system performance check out.

ATLAS 2PACL Cooling Overview



CMS 2PACL Cooling Overview

DEMO facility at CERN



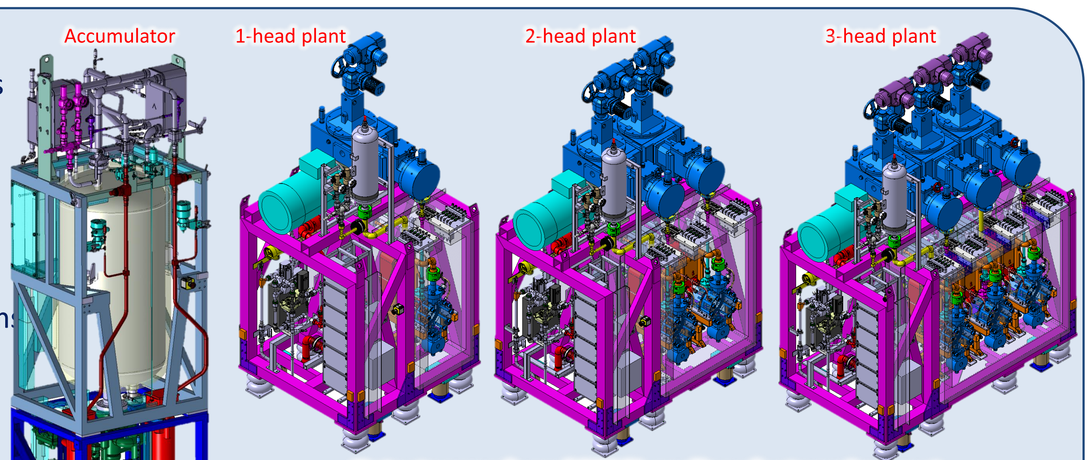
The DEMO facility is made up of one large-capacity 3-head cooling plant (the Lewa LDG3 pump), one smaller-capacity one-head plant (the Lewa LDG1 pump), an accumulator unit, a surface storage simulator, and a R744 primary system nicknamed "System A". DEMO is a 1:1 size pre-production and test system for both mechanics and controls. This CERN based facility is shown in Fig. 4. All the individual components and instruments are tested under real operational conditions, and at cooling loads up to 100kW. The load on the cooling plant mimics the detector and is achieved by two Dummy Load skids. Each skid is equipped with two 25kW heaters, controlled valves and instrumentation piloted by two independent M340 Schneider PLCs based on CERN's UNICOS framework. The System A R744 chiller is a prototype for the final primary chiller, and is the first ever R744 unit built at CERN. It served as a prototype and proof-of-concept for future multi-stage R744 primary systems of ATLAS and CMS.

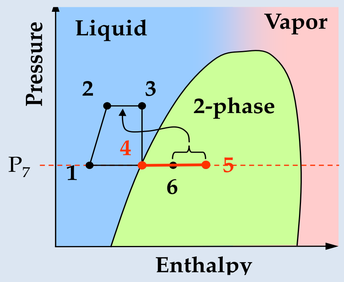
Final 2PACL cooling plants

- **ATLAS = 6 + 1 backup**
- **CMS = 8 + 1 backup**

Final R744 primary systems

- **ATLAS = 6+1**
- **CMS = 12+1**





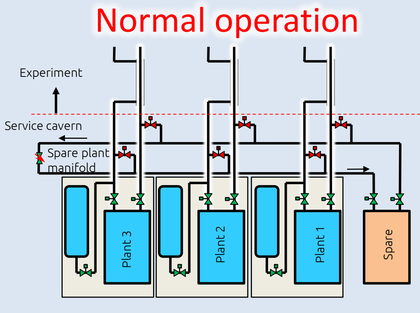
- No interruption of CO_2 flow to detector acceptable in case of power cut.
- CO_2 systems are designed as N+1 redundant, supplied via UPS backed-up by diesel, both for 2PACL and part of R744 to allow for continuous running and ambient heat pickup removal even when detector power is off.
- Fully CERN UNIOCS based control system with redundant PLCs architecture using distributed I/Os spread over long distance between surface and underground.
- Very advanced detailed integration studies both in ATLAS and CMS.

Detector needs and 2PACL cooling plants assignment

ATLAS	Temp. at detector exit	Heat per cooling unit	Cooling units	Plant type (Pump heads)	Max power/unit	Detector distribution lines
	ºC	kW	#	#	kW	#
Pixel End Cap (PEC)	-40	57	2	2	69	6
Pixel Barrel (POB)	-40					16
Pixel inner system (PXI)	-40	29	1	1	34	6
Strip End Cap (SEC)	-38	55	2	2	69	8
Strip barrel (SBR)	-38					16
HGTD	-40	54	1	2	69	8
Spare plant			1	3		
		Total cooling power requested		***kW***	**309**	

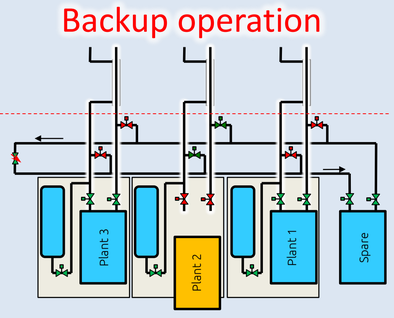
CMS	Temp. at detector exit	Heat per cooling unit	Cooling units	Plant type (Pump heads)	Max power/unit	Detector distribution
	ºC	kW	#	#	kW	#
Outer Tracker (OT)	-35	86	2	3	103	46
Inner Tracker (IT)	-35					24
Barrel Timing Layer (BTL)	-35	46	1	2	69	12
Calorimeter Endcap (CE) +z NEAR	-35	62	1	2	87	12
Calorimeter Endcap (CE) +z FAR	-35	62	1	2	87	12
Calorimeter Endcap (CE) -z NEAR	-35	62	1	2	87	24
Calorimeter Endcap (CE) +z FAR	-35	62	1	2	87	24
Endcap Timing Layer (ETL) +/-z	-35	85	1	3	103	4
Spare plant			1	3		
		Total cooling power available (30% VQ)		***kW***	**552**	

Normal operation

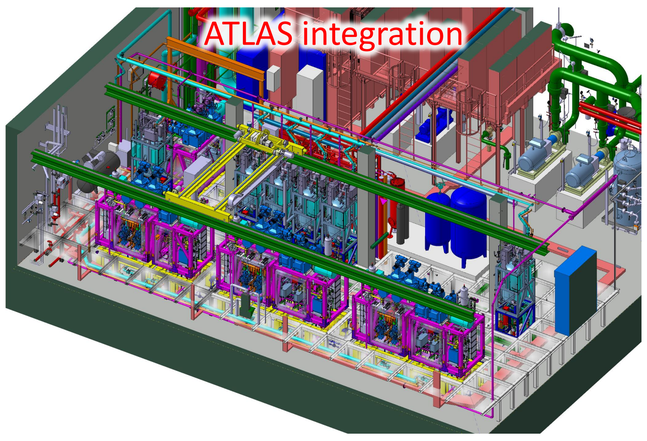


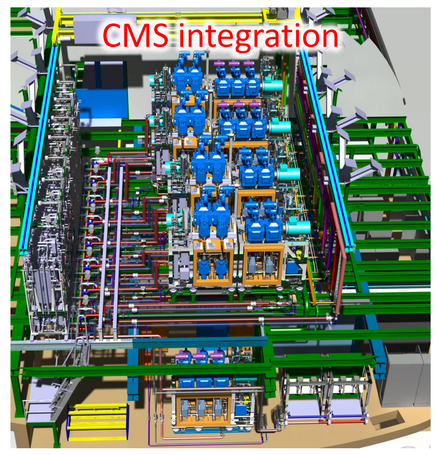
Spare plant runs cold over the spare manifold for direct kick-in (IBL method)

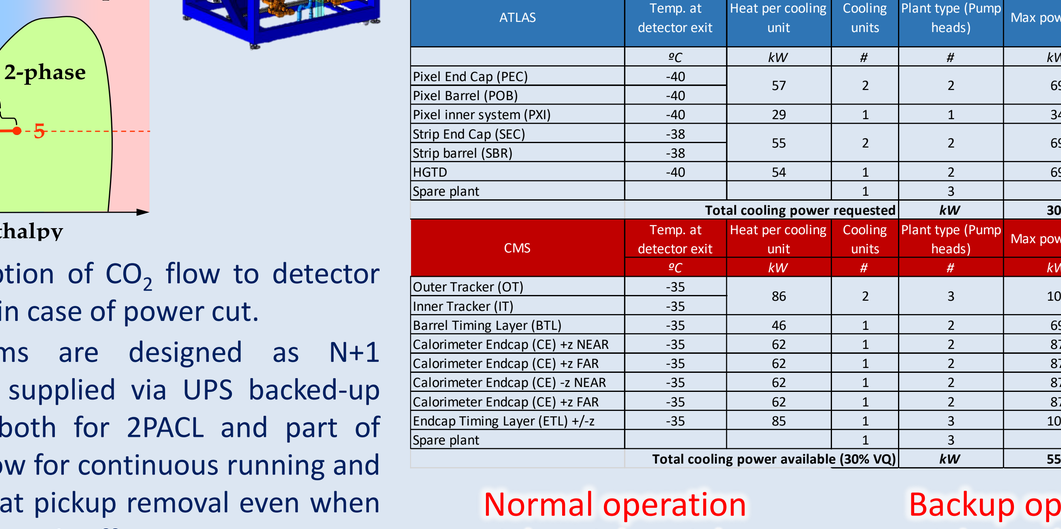
Backup operation



Spare plant replaces any of the other units, which can be dismounted for maintenance or repair



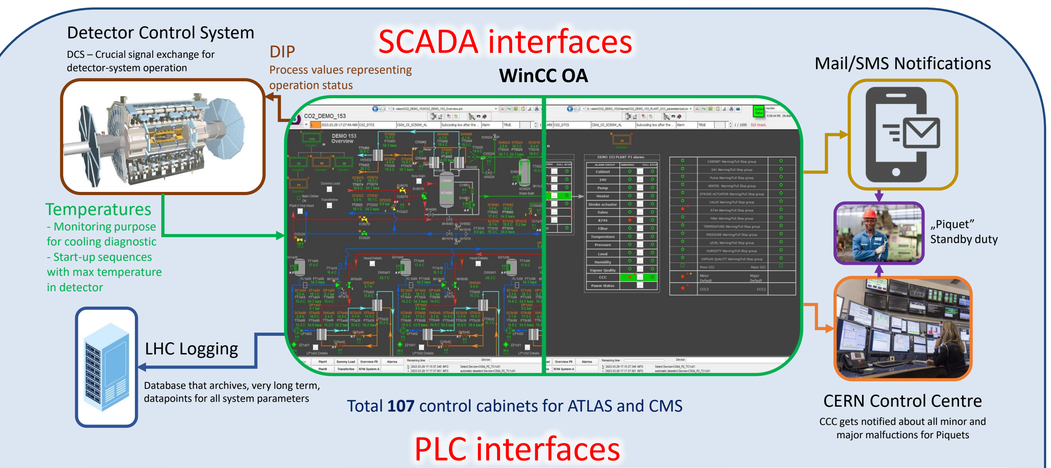




CONCLUSIONS

During the last two years the CERN EP-DT CO_2 cooling team consolidated numerous results from a large-scale DEMO prototype commissioning phase. The outcome of the DEMO exercise has been implemented in final designs for all controls, the first 60 control cabinets are currently under production. The cooling plants and accumulators are designed and are currently in the tendering phase. This has brought us very close to the production of upcoming cooling plants and their installation and commissioning at ATLAS and CMS experiments.

SCADA interfaces



PLC interfaces