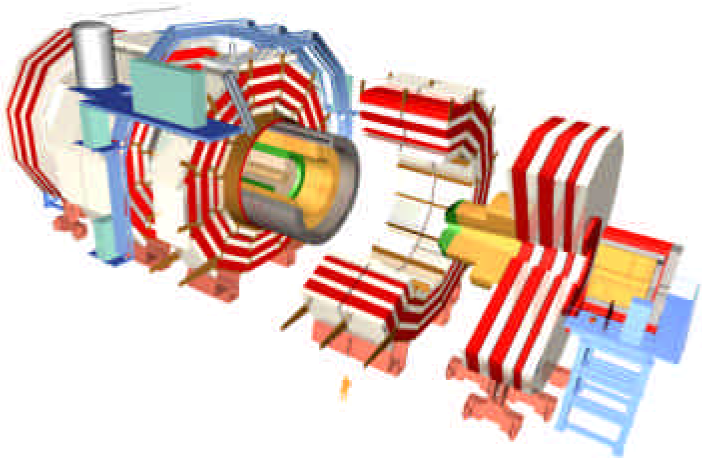


Development of

ECAL COOLING PLANT

Application to a Super Module

Contents

Introduction

First step Module 0

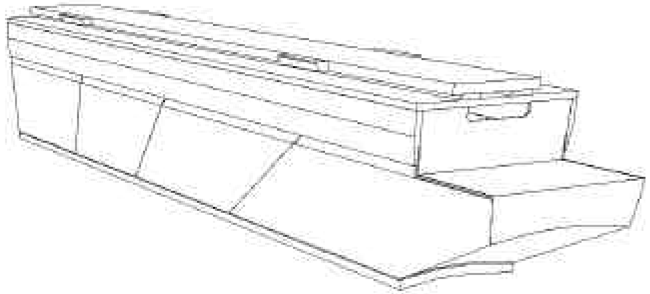
New design

Application to a Super Module

Introduction

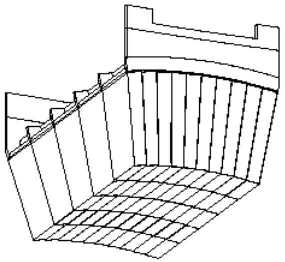
Technical requirements

-Remove the heat produced by the electronic readout boxes

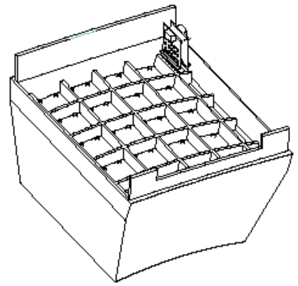


ECAL Supermodule

-Maintain the crystals temperature within ±0.05K



Crystals



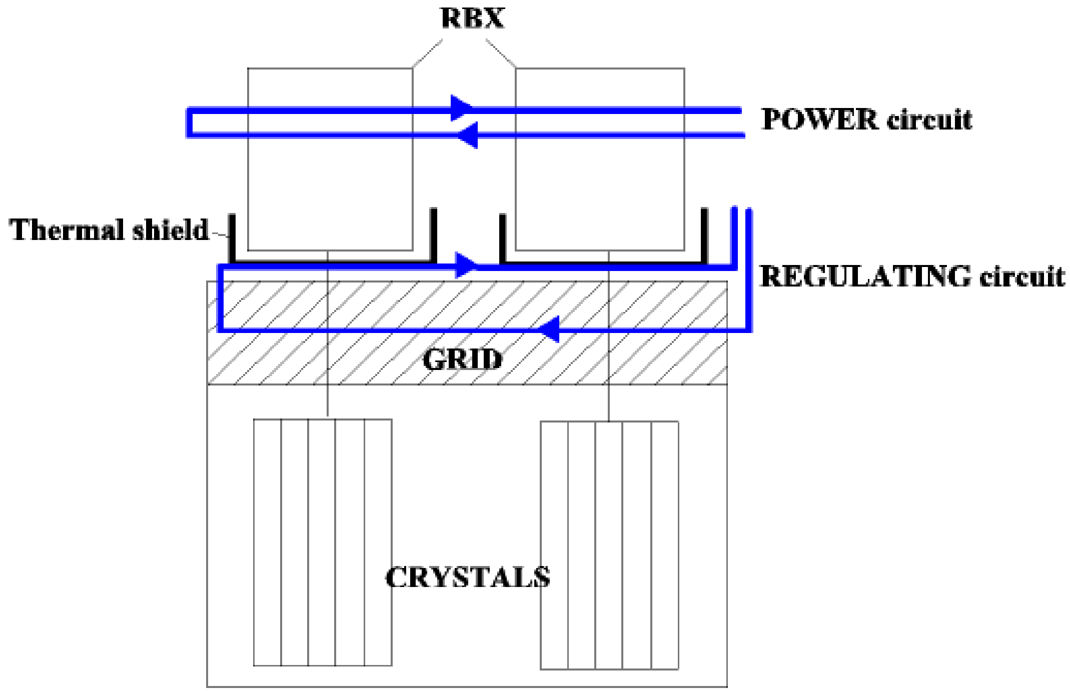
Electronic boxes

Drawings F.Mossiere

Cooling strategy inside ECAL

2 independent circuits:

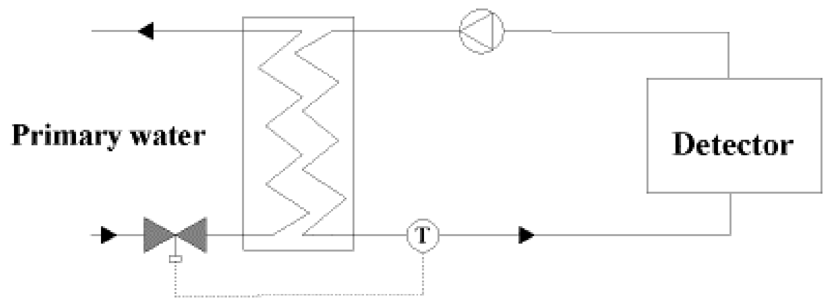
- Power circuit to remove the main part of the heat
- Regulating circuit to stabilize the crystals temperature



First step: Module0

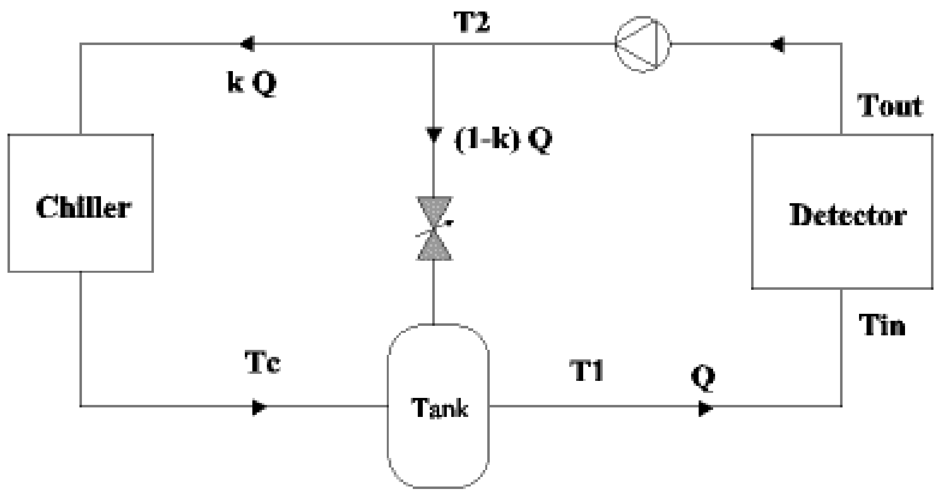
Principle

Power circuit



Regulating circuit

Flow splitting to increase accuracy



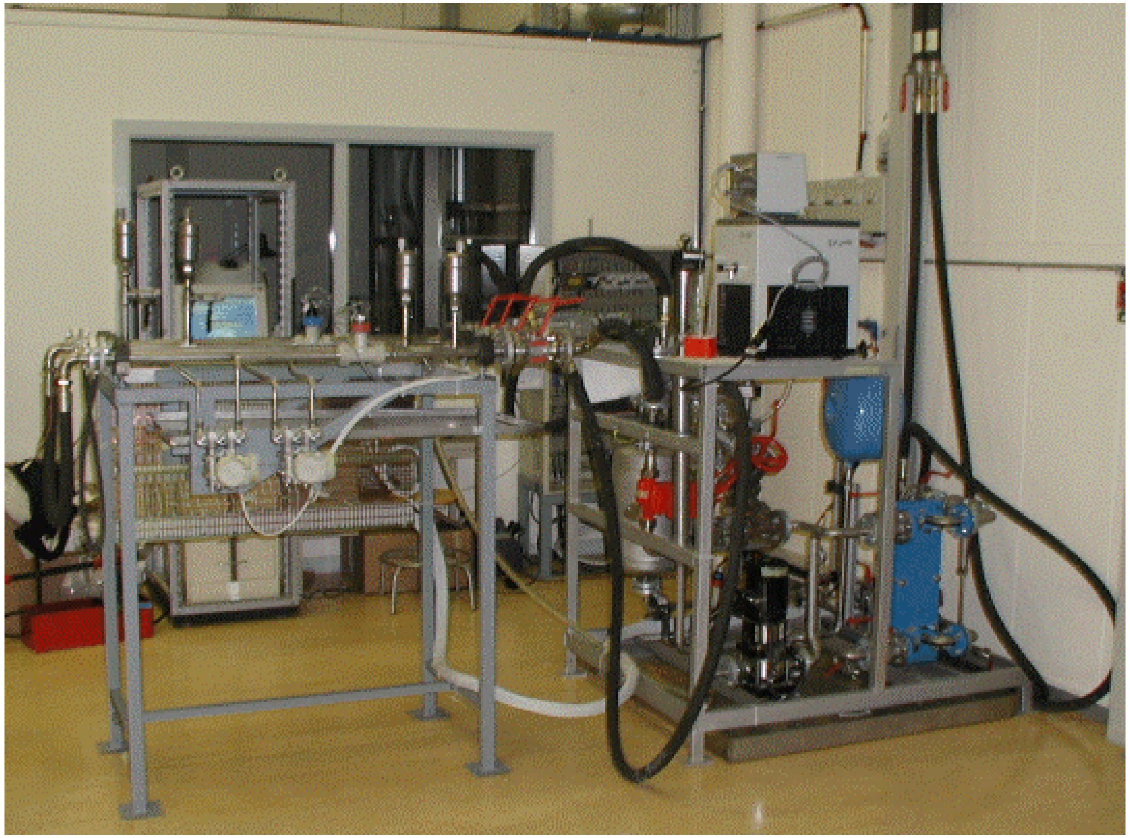
First step: Module0

Main purpose and results

Allow thermal tests on the Module 0, according to the requirements

Better knowledge of thermal exchange process

Improvements of the inner cooling circuit:Copper braid, cavalier…



First step: Module0

Limitations

- Temperature oscillations in the power circuit due to a low quality regulation loop (self operated valve).

- Cooling power of the regulating circuit limited by the chiller (Lauda).

- The flow splitting and mixing introduce dead time in the regulation loop of the chiller. Moreover, the set point on Tc has to follow variations of T2.

⇨ This solution, even improved, cannot be applied to the entire circuit of ECAL

A new design must be developed

New Design

Origin

Discussion with companies:

- Samson, valve manufacturer
- Eurotherm Automation, specialized in thermal regulation
- Eurodifroid, manufacturer of chiller units

The attempt to use a chiller unit failed, the precision required was not reached.

Key ideas

Use CERN facilities: Chilled water in underground area

Provide a design with a technology independent from the size (Super Module, final circuit)

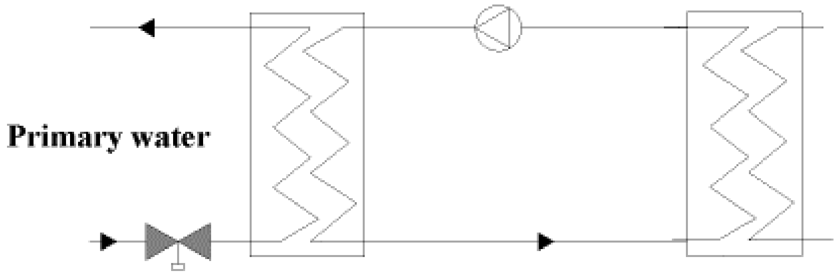
New Design

Principles

Chiller made with plate heat exchanger

Double stage heat exchanger

↳Already used in industry for its stability



No flow splitting as a first approach

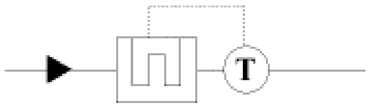
Regulation on a constant value

↳Easier regulation

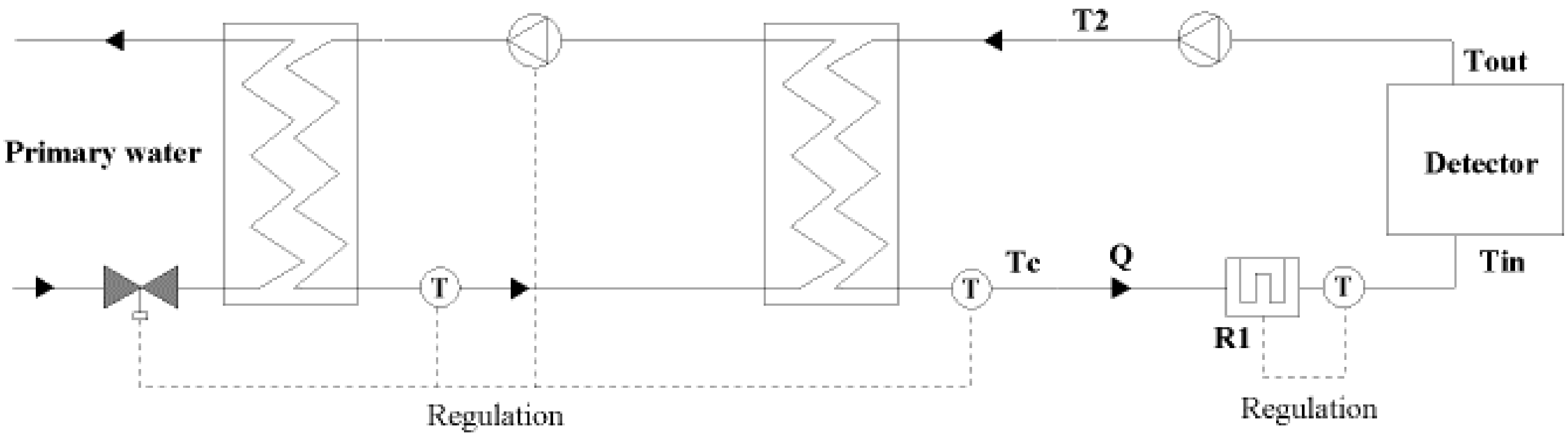
Regulate the temperature value lower than requirement (18ºC) and adjust with a heater

Use of an immersion heater

↳Fast response time



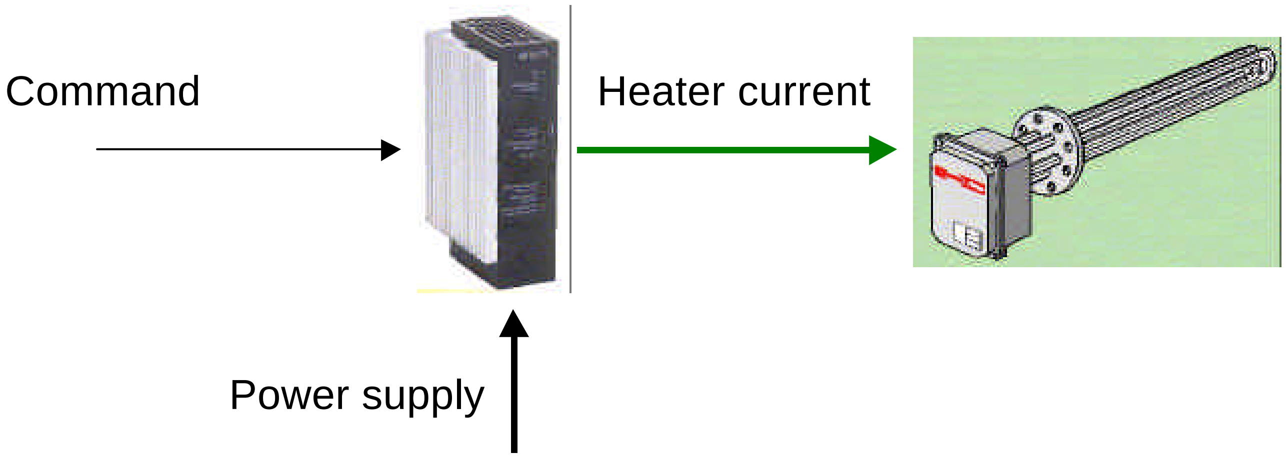
Proposal

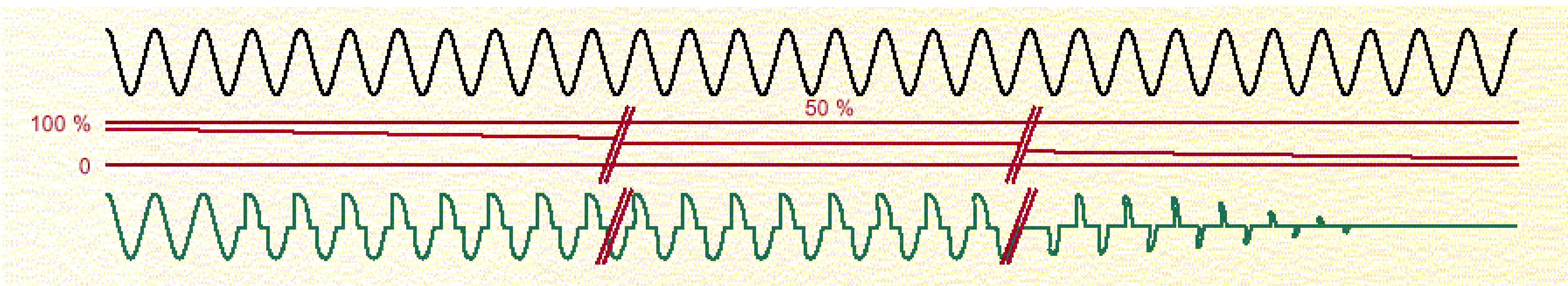


Possible multi-variable regulation (temperature, flow)

New Design

Immersion heater Regulation





Phase angle regulation – 20 ms period

Application to a Super Module

Planning

Super Module1 calibration in H4: from *1 March 2003*

O.Teller, SPES 11/2001

Evolution of requirements

The power dissipated by channel changed:

From *1.2 W/Ch* to *2.5 W/Ch*

The flow rate is limited by the diameter of the pipes to be installed inside CMS where space is restricted

Flow rate for ECAL Barrel:	
Power: 10 l/s	Regulating: 50 l/s

Application to a Super Module

Instrumentation

This cooling station will provide the cooling for the calibration of the Super Modules, but it is also a hydraulic test bench to understand the process.

For this reason, a lot of instrumentation will be installed on it, mainly temperature probes (TT), but also pressure (PT) and flow (FT) measurement.

Flexibility

Every pump will be equipped with a variable speed drive to give a wide range of operating condition.

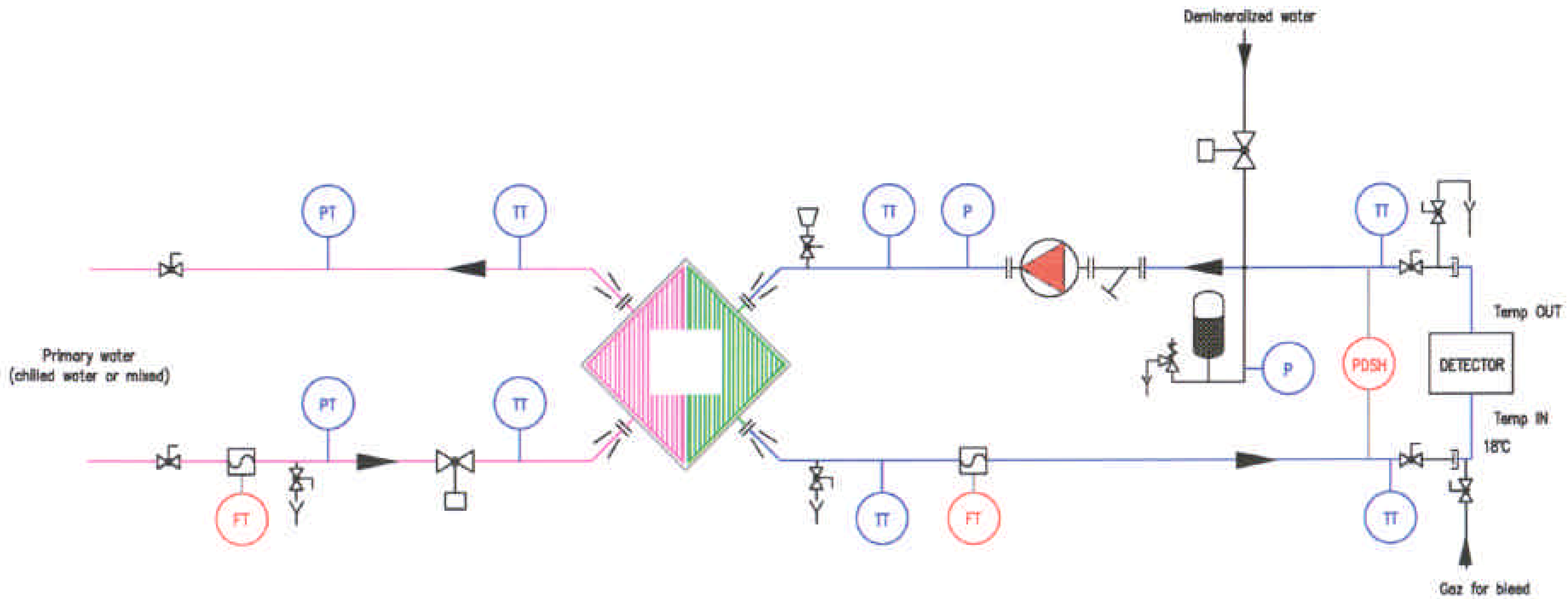
The cost (~ +10% of the pump's price) is negligible compare to the project price.

Reliability

Calibration of 36 Super Modules over a long period

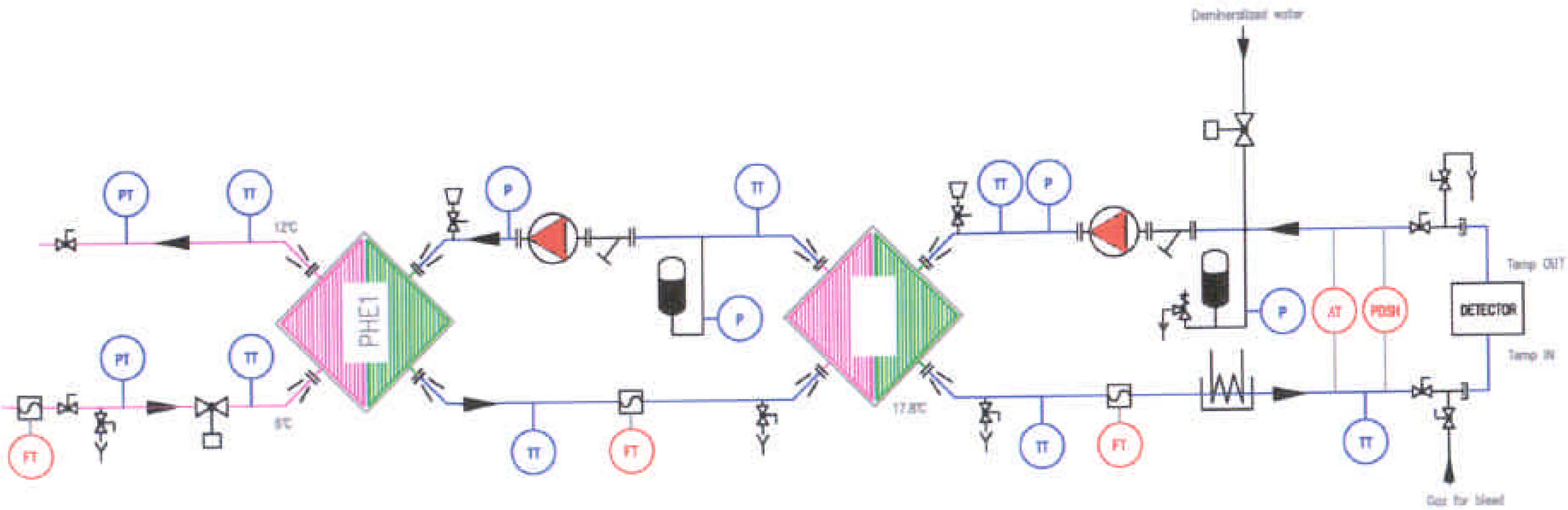
Application to a Super Module

Hydraulic plans: Power circuit



Drawing B.Bourgoin

Hydraulic plans: Regulating circuit



Drawing B.Bourgoin

Application to a Super Module

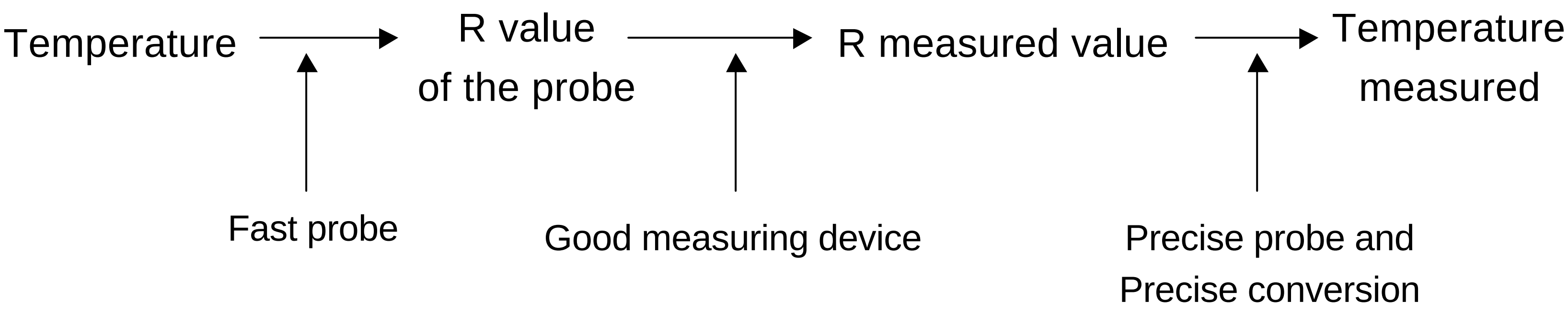
Thermo-hydraulic parameters

3 W/ch (design value), 1700 ch/Super Module => 5.1 kW/Super Module

	Power circuit	Regulating circuit
Heat dissipation in ECAL	**4.59 kW**	**0.51 kW**
Flow	**0.28 l/s**	**1.39 l/s**
ΔT	3.95 K	0.09 K
Pump Flow rates	0,2...0,6 l/s	1,2...2,8 l/s
Pump Pressure Drops	5...10 bars	1,5...4 bars
Pipe diameter	DN20	DN40
Pump power	0.8 kW	1.6 kW
Resistance		1.8 kW
Heat to remove (no margin)	5.4 kW	3.3 kW
HE used values	**7 kW**	**4.5 kW (5 kW)**
Flow in primary	0,28...0,56 l/s DN20	0,18...0,36 l/s DN15

Temperatures encountered in the circuit for nominal flow and load		
Tin	18.0°C	18.0°C
Tout	22.0°C	18.1°C
T after pump	22.4°C	18.2°C
T after HE	18.0°C	17.8°C

Temperature measurement Pt100



It is difficult to find measurement chains that ensure 0.05K of precision, with a probe and its associated transmitter

Firms: ABB Automation, Rosemount

Good quality (fast and precise) Pt100 probes can be found but an important repeatability error comes from the conversion of the Resistance to a Temperature.

Repeatability in measurement is a very important factor for regulation stability

Application to a Super Module

Temperature measurement Pt100

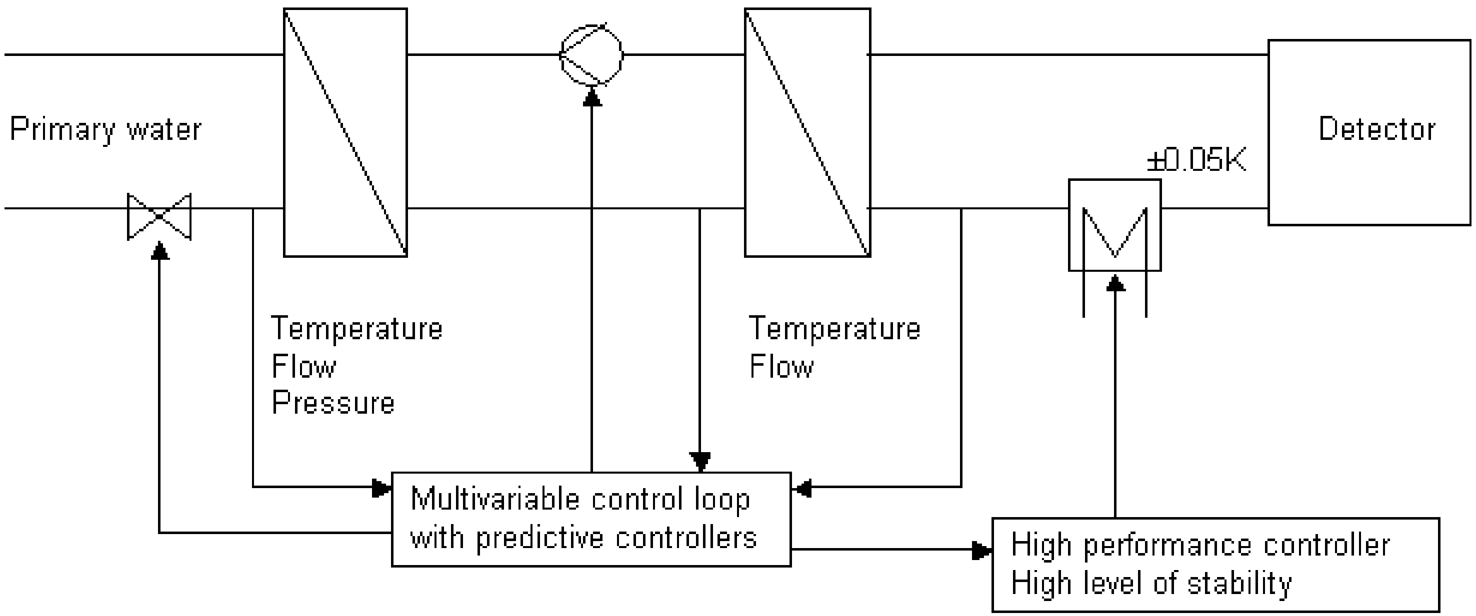
Alternative solution with acquisition unit: Agilent 34970A
Laboratory device.

Very precise measurement, multiplexing
Price ~3500 CHF for 20 Pt100

The communication with a PLC needs a small development
RS232 ASCII communication

=> Very interesting Solution, far better than former solutions

Control strategy: Process control diagram

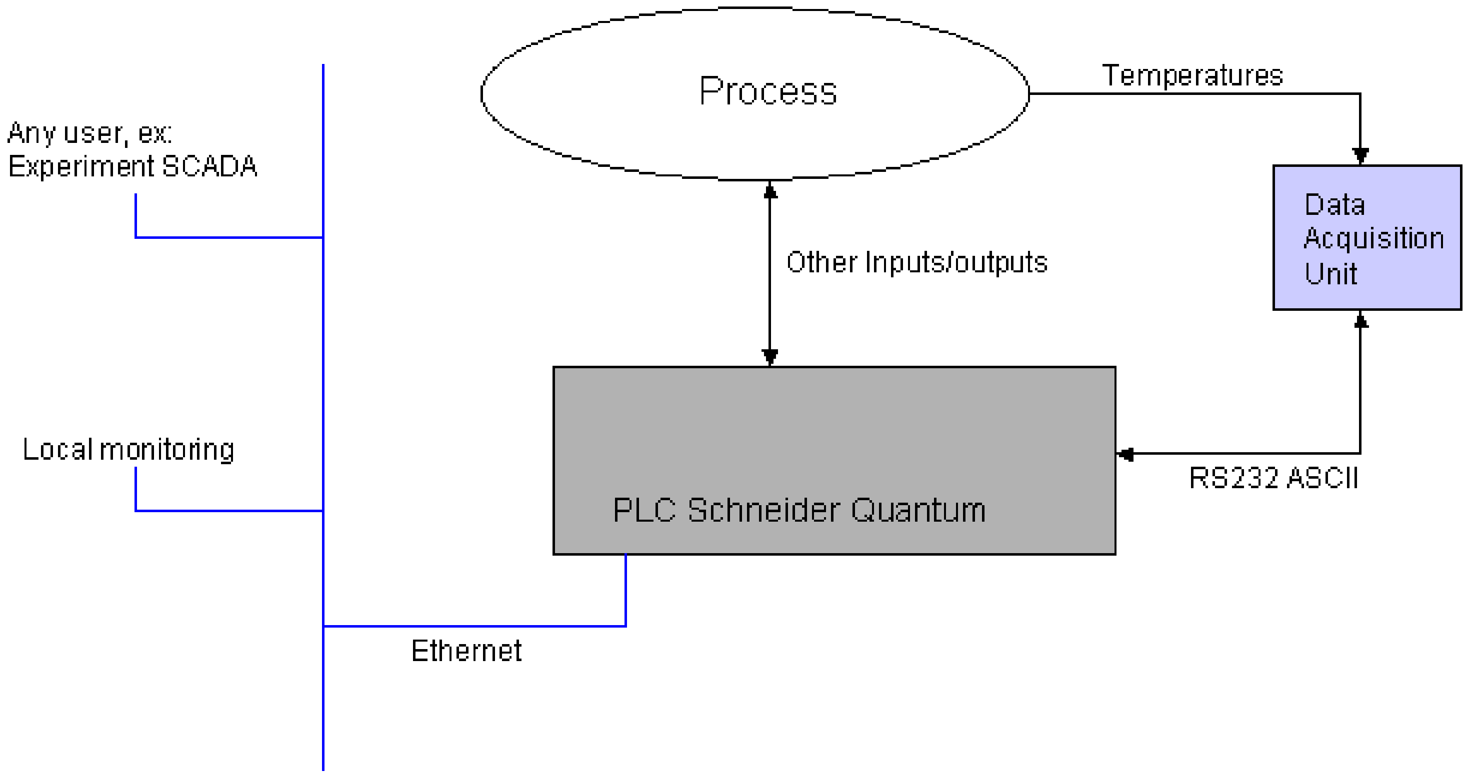


This type of process control requires a specific device: PLC Schneider Quantum

And a specific development

Application to a Super Module

Control strategy: Control architecture



Application to a Super Module

Control strategy: Control architecture

The Quantum PLC with advanced regulation is already used at CERN for some ST/CV cooling towers

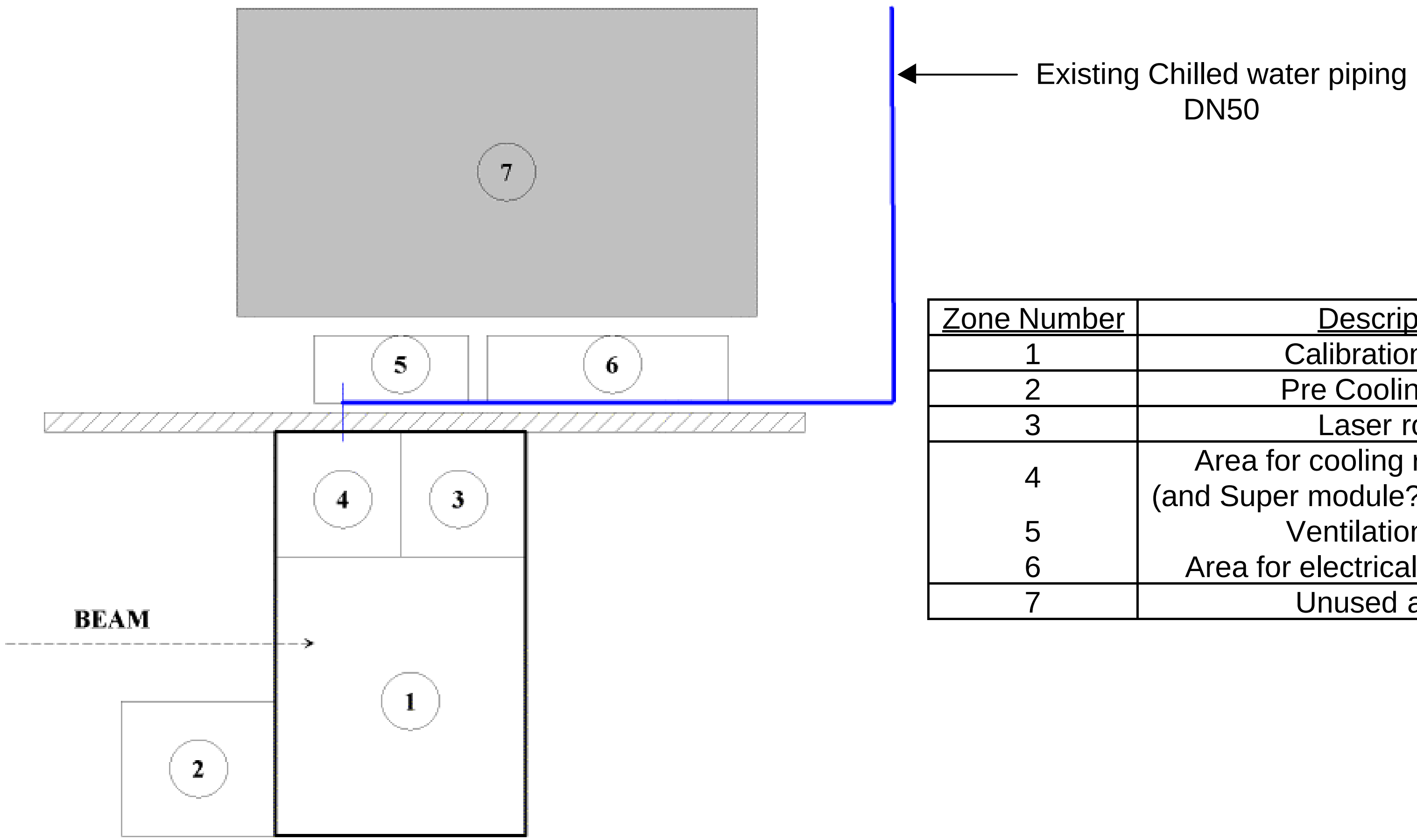
This architecture is fully compatible with CERN environment concerning experiments and Accelerator control and supervision

It can be applied to the final ECAL cooling plant

Information and data accessible from anywhere

Application to a Super Module

Specificity H4 zone



B.887 ZONE H4 ECAL Calibration

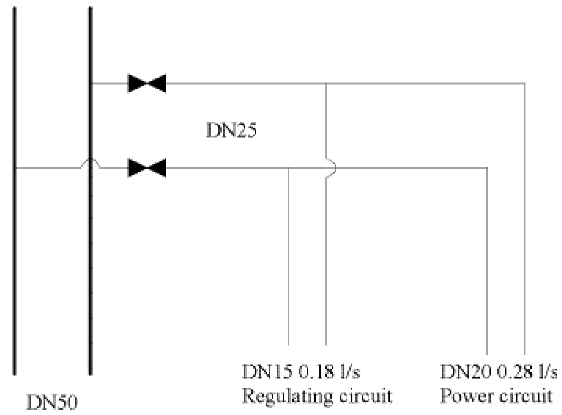
Zone Number	Description
1	Calibration room
2	Pre Cooling area
3	Laser room
4	Area for cooling rack Module0 (and Super module? ~ 2.8m * 1.5 m)
5	Ventilation Rack
6	Area for electrical power supply
7	Unused area...

Application to a Super Module

Specificity H4 zone

Need to define the space used by the cooling plant and in which zone it can be installed

Some minor piping from the existing DN50 to the heat exchangers has to be done



Check that the chilled water circuit gives enough flow rate, *which is not the case now*. This circuit is a part of a circuit feeding several buildings, and it is the end of the line. Only a little pressure drop is available.

Operating conditions in H4

Some points need to be defined more precisely, especially the procedures linked with Super Modules replacement in calibration chain.

Purging and refilling of one part of the circuit

The cooling plant can be stopped or loop in a by-pass or in a fake load during Super Module replacement

…

Application to a Super Module

Budget KCHF

Power circuit material	20
Power circuit assembly	10
Regulating Circuit material	35
Regulating circuit assembly	30
Electrical material + assembly	15
H4 installation	10
Control (PLC, PC, Software)	20
Development, programming (PC, PLC)	?? 50 ??

Total: ~ 200 KCHF

Conclusion

Concerning the cooling plant for Super Modules calibration, work has been done on:

-System design

-Hydraulic plans

-Specific material (temperature measurement)

-Control architecture

-H4 local constraints

-Budget

-Industrial contacts

<u>Next step is to prepare a SPEC and start a CERN project</u>

Only 1 circuit

Change in strategy

Modification of hydraulic components size

Advantages

Costs: ~ -50% for final circuit

~ -15 % for Super Module prototype

Disadvantages

Regulation…