Laser monitoring system for the CMS lead tungstate crystal calorimeter

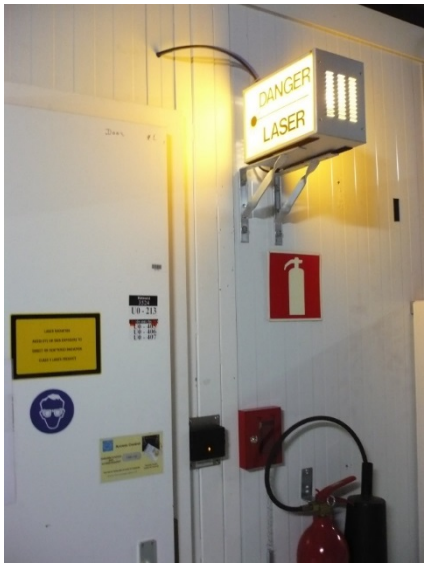
Abstract

Monitoring the changes in channel response is crucial to maintain the energy resolution of the CMS electromagnetic calorimeter.

Lasers have been installed in USC in 2007, for the operation in 2008.

A new diode-pumped solid state blue laser was commissioned and installed at CERN for 2012 operation.

This presentation is to give an overview of the monitoring system in USC55 in order to go around all problems in case of moving area or reducing the space for LS3.



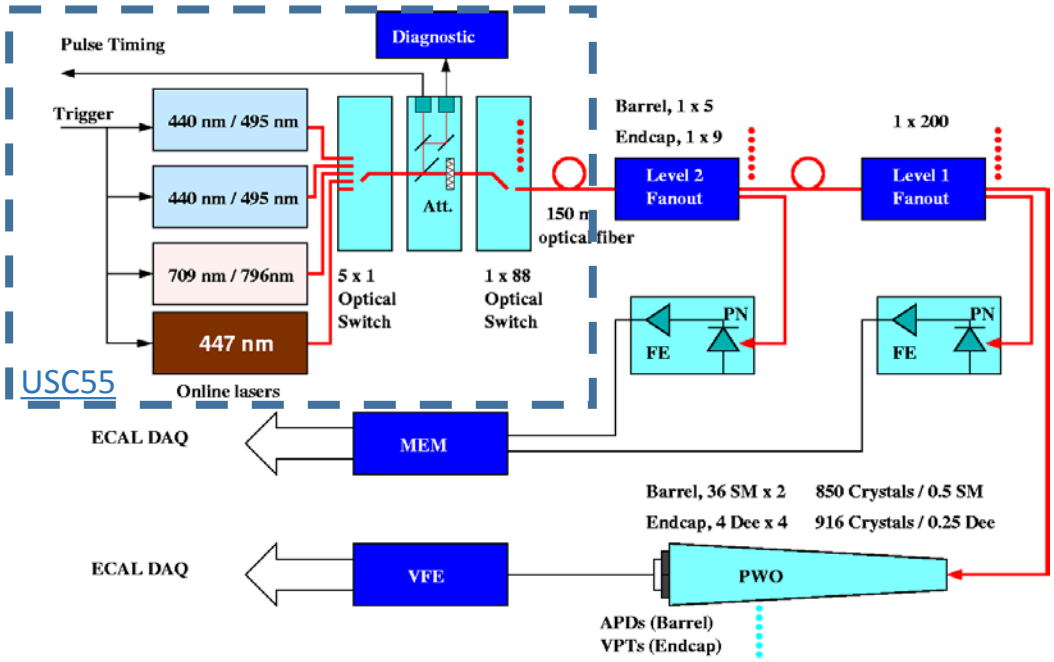
David Bailleux *as ECAL TC , laser expert and CMS LSO*

General schematic

The monitoring laser pulses of different color selected by a 5 × 1 fiber optical switch are distributed via a 1× 88 switch to one of 88 calorimeter elements. A two stage distribution system mounted on each calorimeter element delivers monitoring laser pulses to each individual crystal.

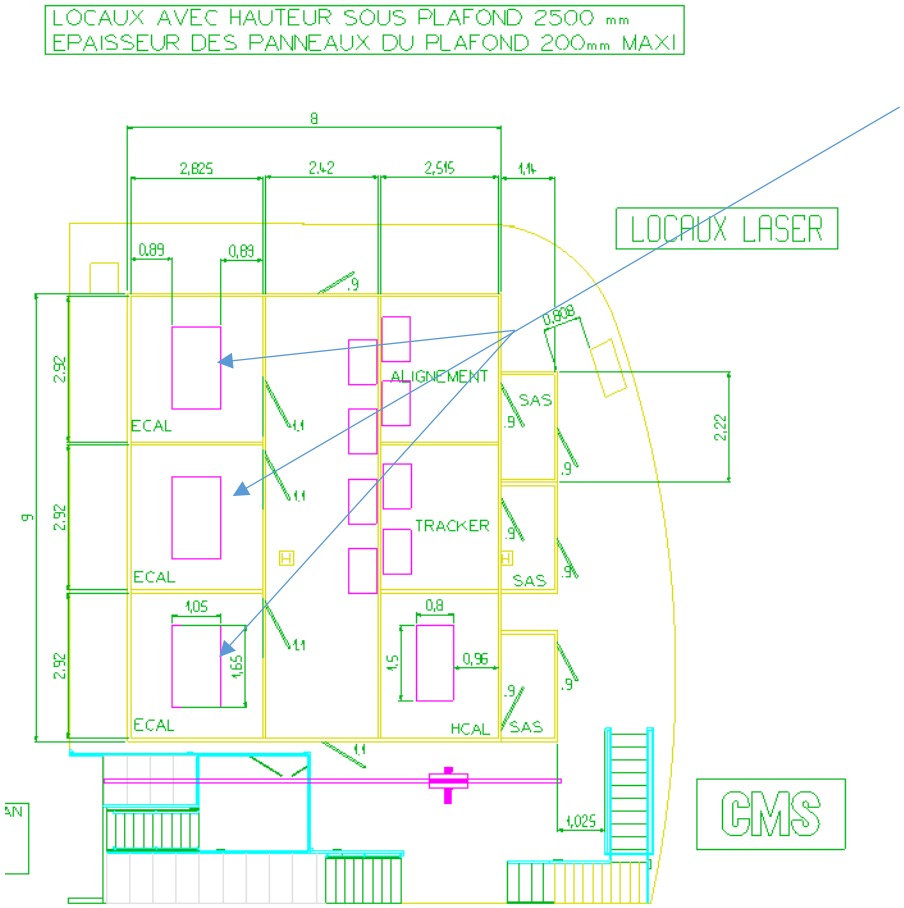
In the Barrel ECAL (|η| < 1.48) the light is detected by Avalanche Photodiodes (APDs), in the Endcaps by the VPTs. The APD/PN, or VPT/PN, ratio is the monitoring signal and must be measured to a precision of 0.2% to achieve a 0.5% inter-calibration precision.

The CMS ECAL monitoring light source uses 2 diode pump lasers (447nm) and one green laser.

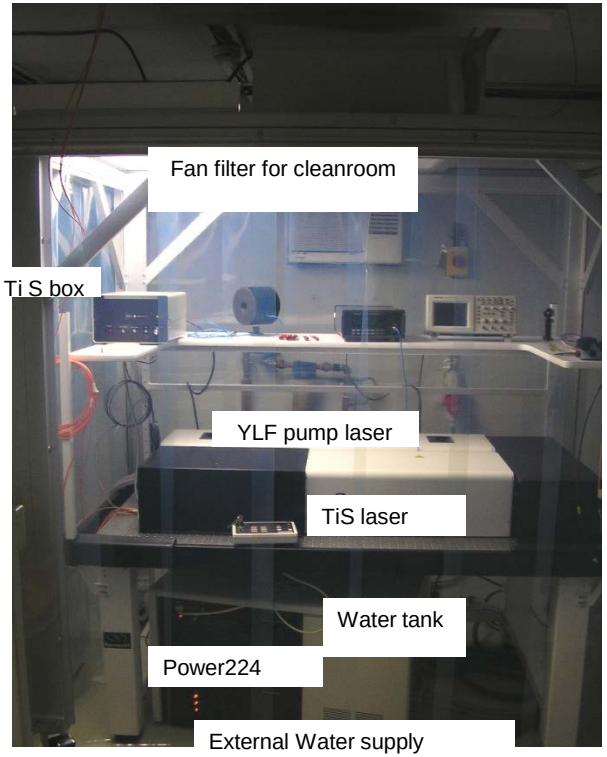


Distribution System Application	Multi-mode step-index fiber type	Core/cladding/ sheath(s) Ø (µm)	NA	SpecTran Identification
Primary distribution	silica-silica-polymer-Tefzel®	365/400/ 430/700	0.22	HCG-M0 365T High OH⁻
Secondary 1:7 fan-out (L2)	silica-silica-polymer-Tefzel®	365/400/ 430/700	0.22	HCG-M0 365T High OH⁻
Tertiary 1:240 Fan-out (L1) ECAL barrel	silica-polymer-Tefzel®	200/230/ 500	0.37	HCP-M0 200T Low OH⁻
Tertiary 1:240 Fan-out (L1) ECAL end-cap	silica-silica-polymer-Tefzel®	200/240/ 260/375	0.22	HCG-M0 200T High OH⁻

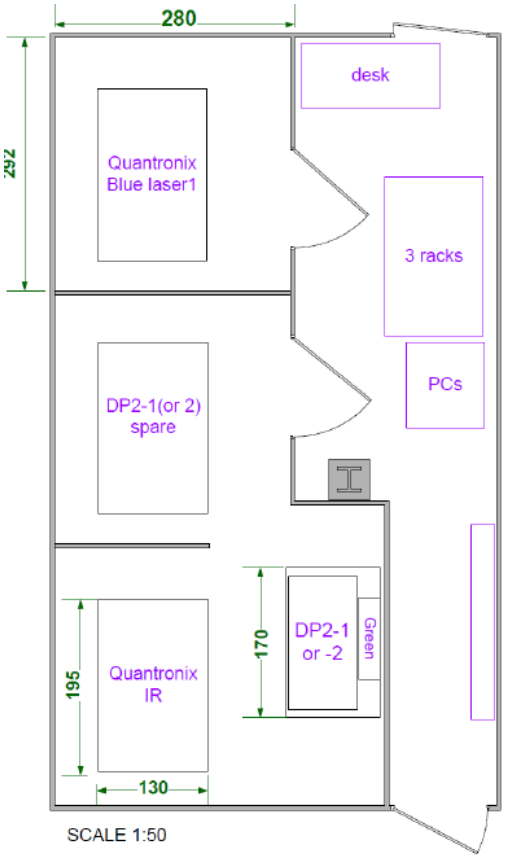
Laser barrack 2006-2012



From 2007 to 2012, the lasers in used was a lamp-pumped system : TiS laser pumped by a YLF
1 Main blue
1 blue as spare
1 Main infrared

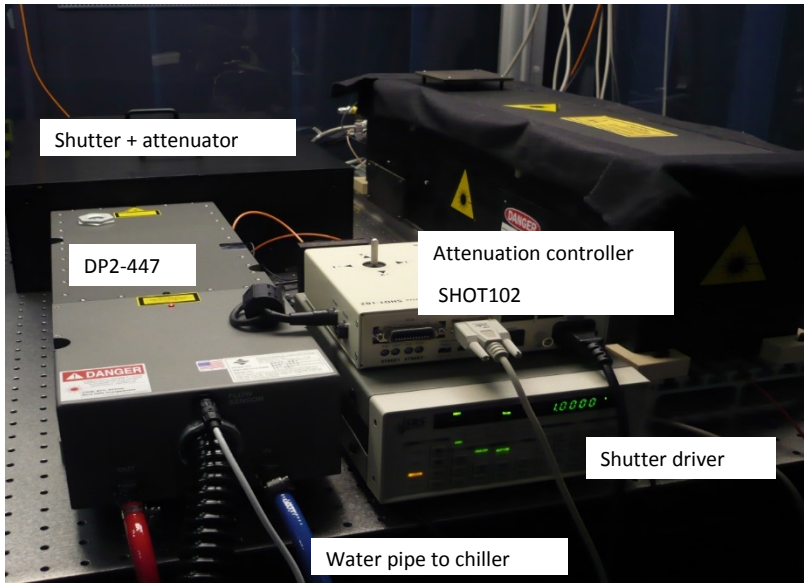


Laser barrack from 2012

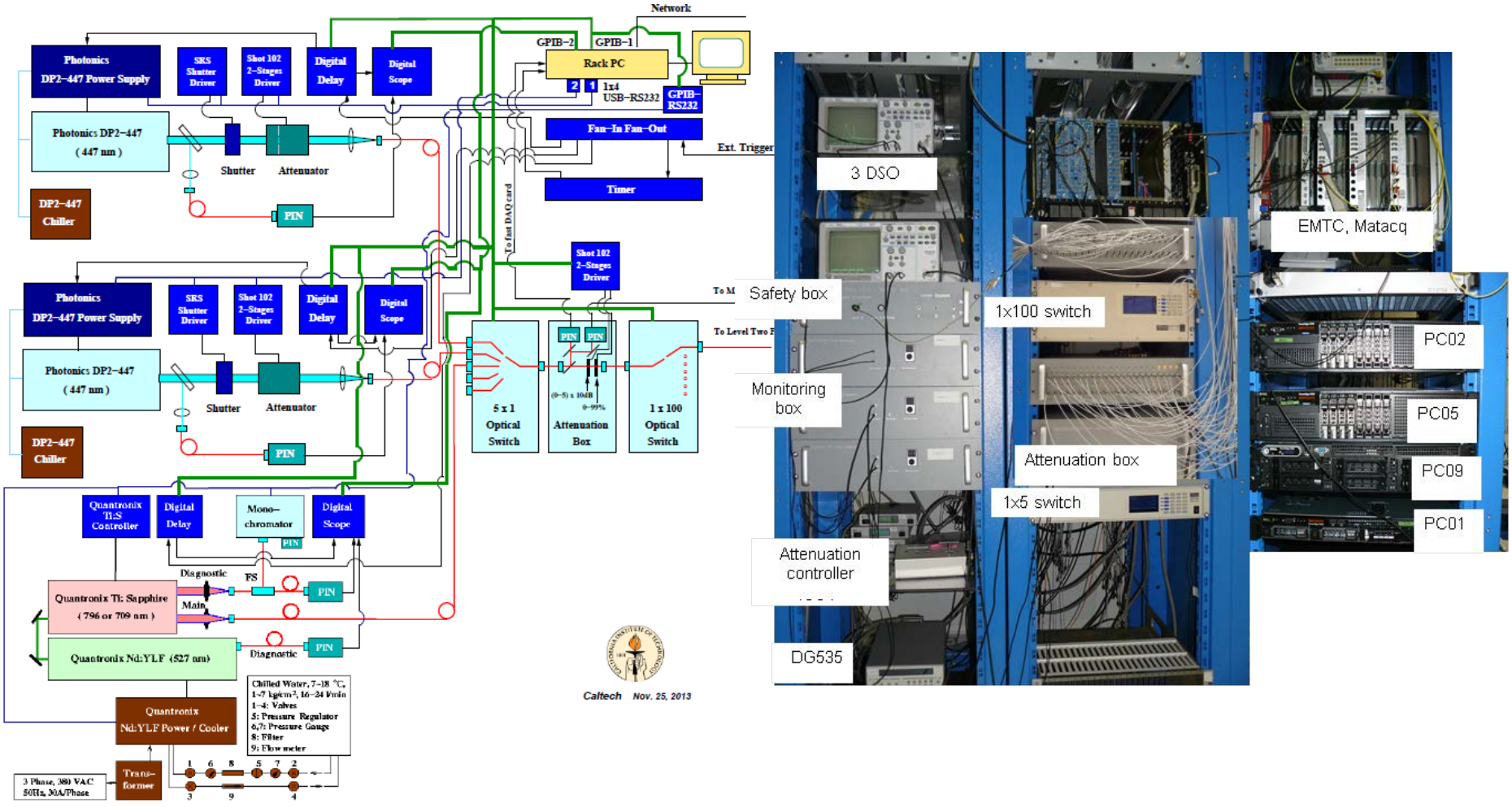


In 2011 : agreement to replace the old lamp-pumped lasers.
Photonics DP2-447 DPSS blue laser (447 nm) was selected in November 2011, and was delivered to Caltech in February 2012.
In 2012: After a short period of integration at Caltech it was successfully commissioned at CERN in March 2012.
The barrack have been refurbished to add one more optical table : keep old lasers as spare for the transition period.
In 2013: second Photonics DP2-447 as spare → remove one old laser definitively.

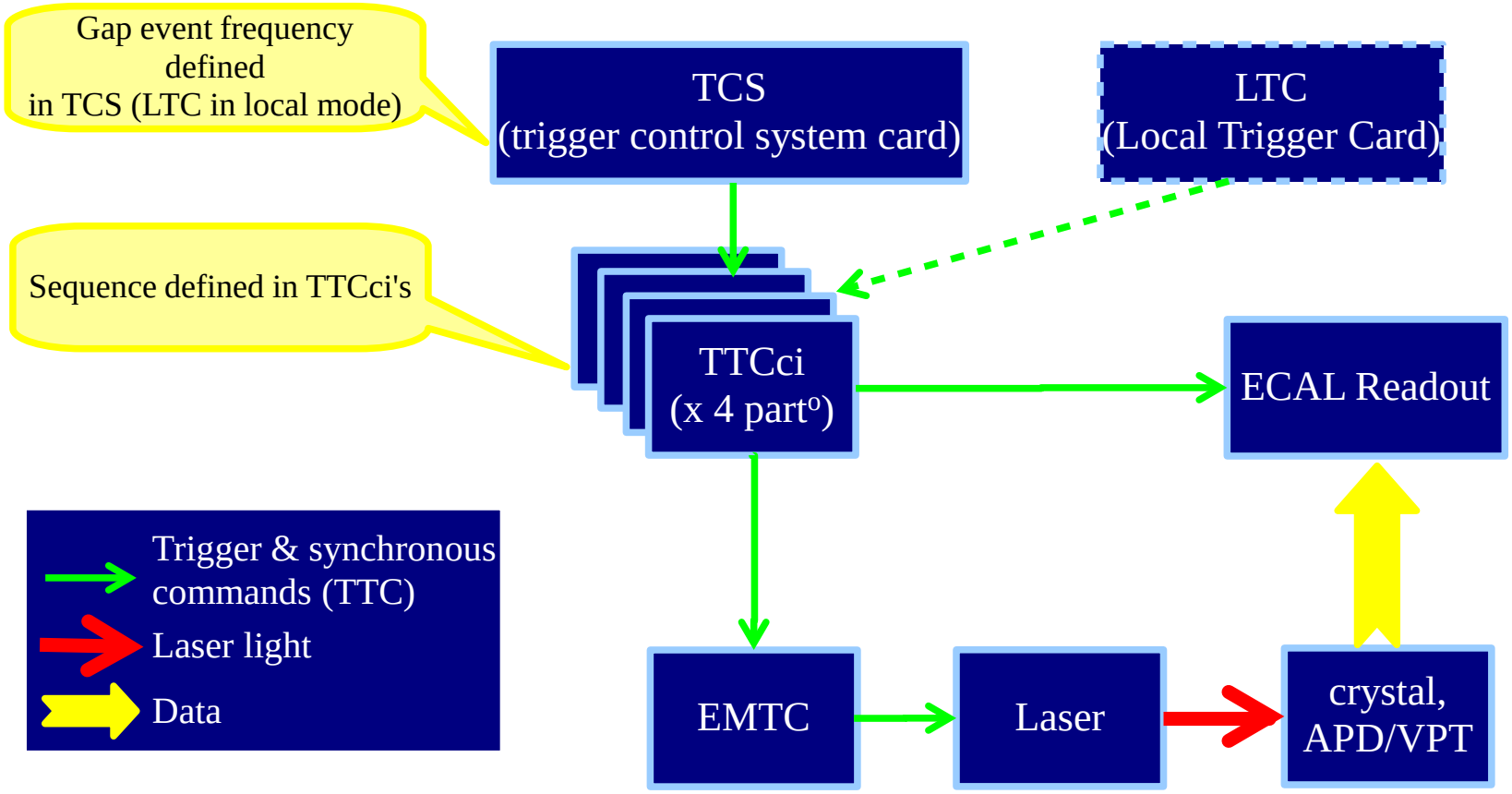
2 diode lasers + 1 old blue + 1 old RED + 1 green + 2nd green ordered



Laser system from 2012



Operating system

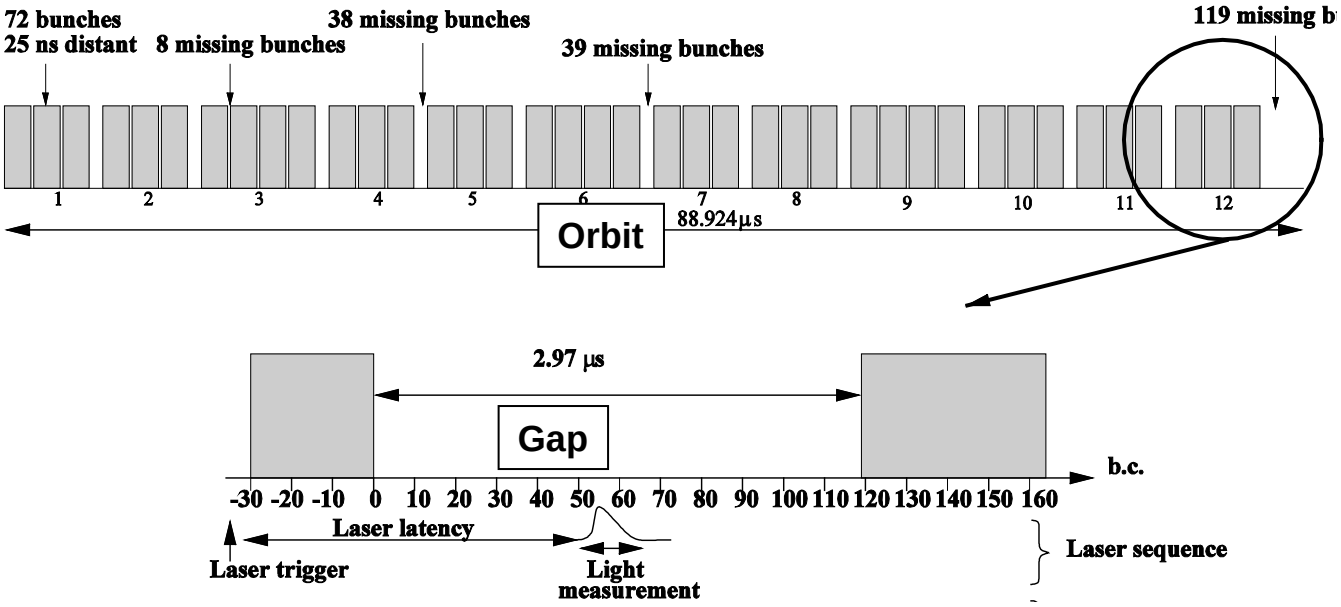


Operating system

Abort gaps occur at ~10 kHz, 3564 bunch crossings, 756 empty bunch crossing, 118 empty bunch crossings at the end of the orbit

Laser pulses at ~100 Hz

⇒ Use ~1% of gaps for the transparency measurement



WarningTestEnable TestEnable L1A GT issues these triggers.

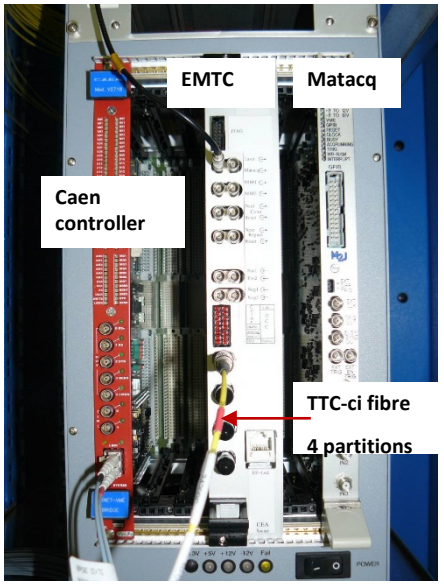
Operating system

EMTC Ecal Monitoring Trigger Card

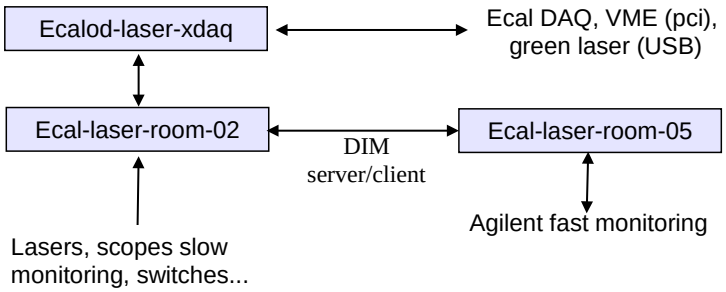
The EMTC receives the trigger and clock signal issues from the TTCci's, one per ECAL partition, through optical link.

- it merges the 4 signals;
- it decodes the signal and extract:
  - the warning test enable: used to trigger the laser
  - the trigger type and laser setting (switch, λ)
- it sends 2 NIM signal : trigger laser and Matacq
- it provides the decoded trigger information.

→ **Laser setting is known 4s in advance when changing switch and more when changing wavelength.**



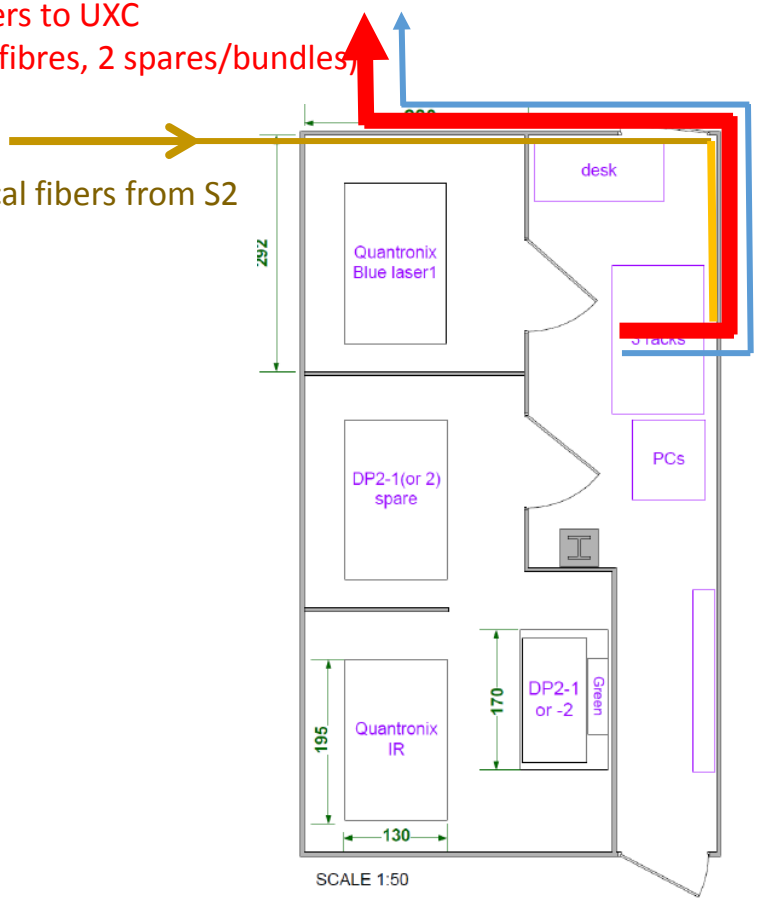
Laser control schematic:



Laser system from 2012

88 optical fibers to UXC
(bundles of 6 fibres, 2 spares/bundles)

4 TTCci optical fibers from S2



Voltage injection V_{inj} test pulse:
500mV through 12 cables

From barrack to ECAL :

- For EB : 95 meters
- FOR EE : 105+25

- The 88 fibers are connected to the optical switch 1x100, controled by GPIB.
The optical devices and their controls can not be decoupled: GPIB chain for all blue lasers, same software.

- Vinj: only power supply can be move to keep the distribution box underground

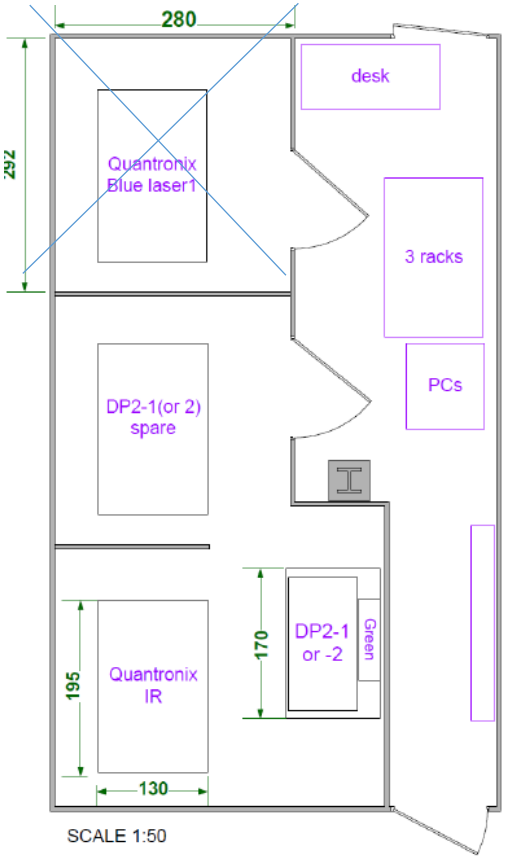
Laser system from 2012

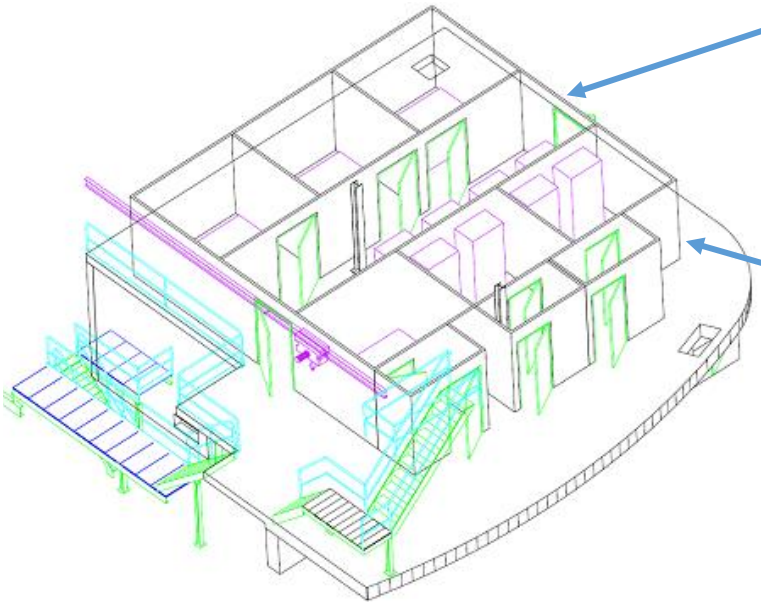
Old RED and BLUE laser are no more used

→ one room free (storage for spare parts: dehumidifying cabinet, ect)

→ No need cooling anymore, no need 3 phases transformer

→ New IR laser in discussion





Miscellaneous and first comments

In addition to the operating parts (3 laser tables, 3 racks) , we have :

1 working desk for daily operation (desk for small mechanics, cleaning optics, etc. Already too small.)
2 cupboards inside the room, 2 cupboards outside
1 dehumidifying cabinet for optics
Storage in B.27 for larger spare parts because of no place in USC (optical switch 76k$/unit, etc..)



Miscellaneous and first comments

Reducing or moving the barrack : need to be done during a shutdown → outside physics
to be optimized to reduce the time with no ECAL calibration

<u>Moving the barrak upstairs</u>: First comments:

Advantages

- Easy access for operation and for safety,
- New room so refurbishment of safety system,
- Larger area for spare parts and working area ?

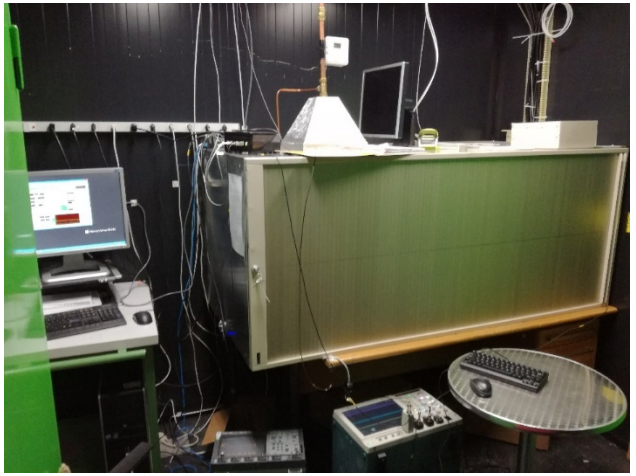
Constraints/questions

- Extension of 88 optical fibers (new fibres anyway)
- Extension of TTCcis fibers + LV cable for Vinj
- Cost, Schedule? Issue schedule and manpower in LS3?
- Green laser to be replaced for power budget
- Dispersion between fiber due to the length ?
→ far from detector so need clear understanding of dispersion for channel to channel calibration

HCAL laser,
German Martinez

The setup can not be moved to the surface easily. There are eighteen fibers from different subdetectors and purposes coming to the laser room, moving the laser upstairs would mean to put a 100 m extension for each and we would loose also a lot of light: ~10 dB (100 dB/km@ 337nm)
→ compromise severely megatile radiation damage studies.

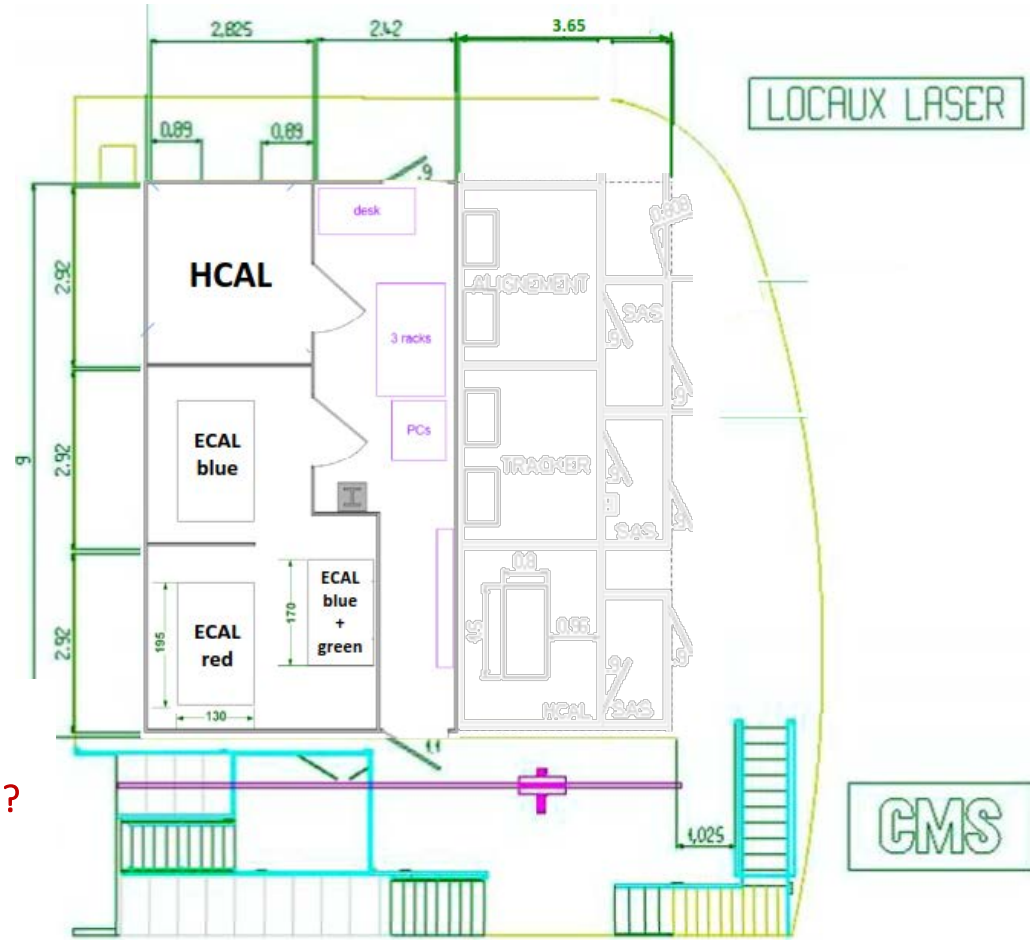
On the other hand, our setup is small and as it is not open but enclosed in an interlocked metallic box (~1mx1mx1.5m), it can share space easily in a room with other setups.



Proposal from ECAL :
Free some space «as much as possible» with minimum of ressources

- Remove the old pump and heat exchanger from the corner
- Move HCAL laser to ECAL room :
  . Fibre length OK.
  . Need to review the gaz system for HCAL laser.
  . Share the same access (more attention for HCAL)
- Move the Tracker and Muon racks:
  . still need a dedicated room or just enclosed rack ?
  . Or put it together on the same room (keep one room)

Max benefit :	33.8 m2
Minimum benefit:	23.15 m2



→ If agree very desirable to be done during LS2 !
→ If the space is still not enougth after modifications ?
→ New lasers in future ?