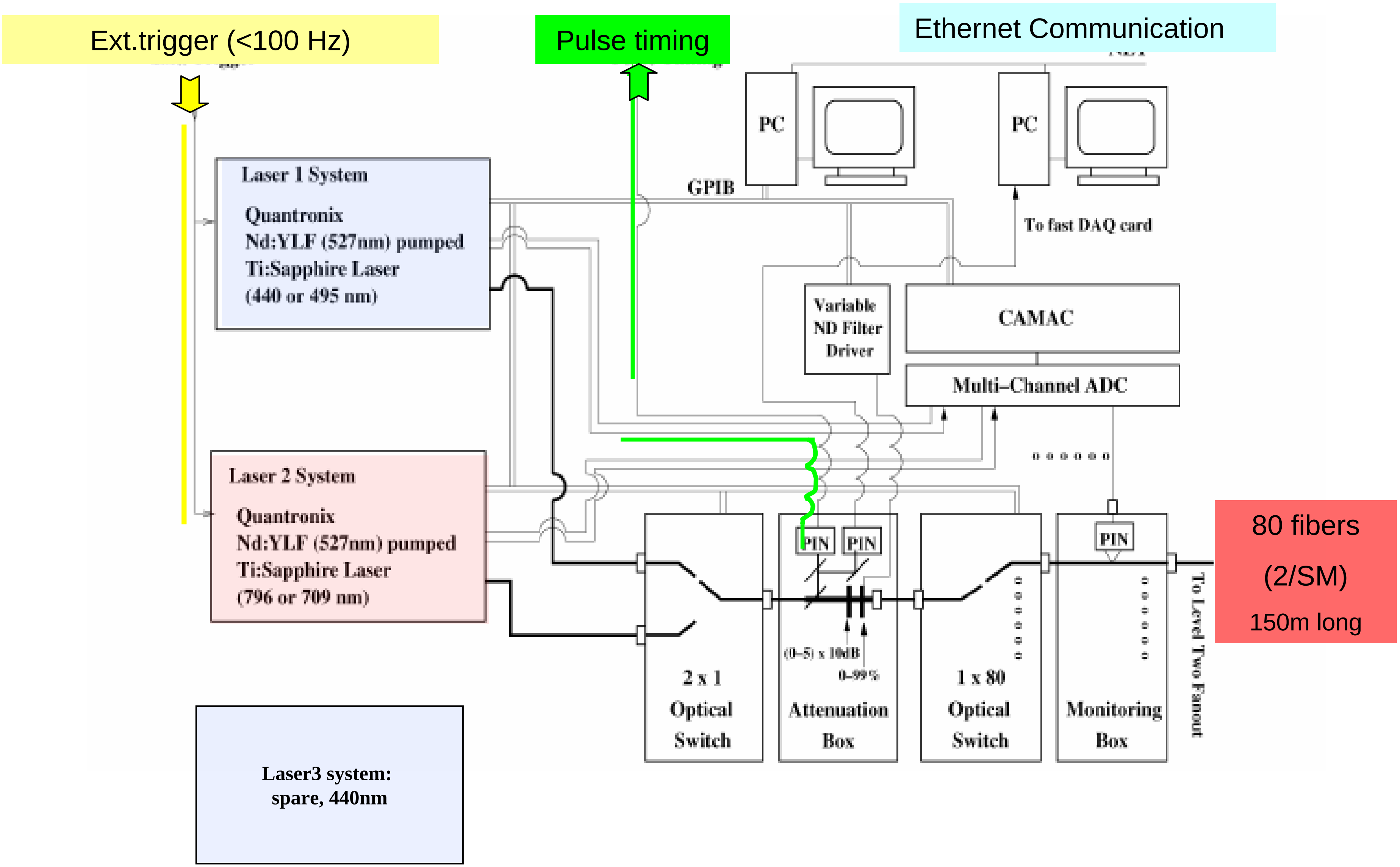
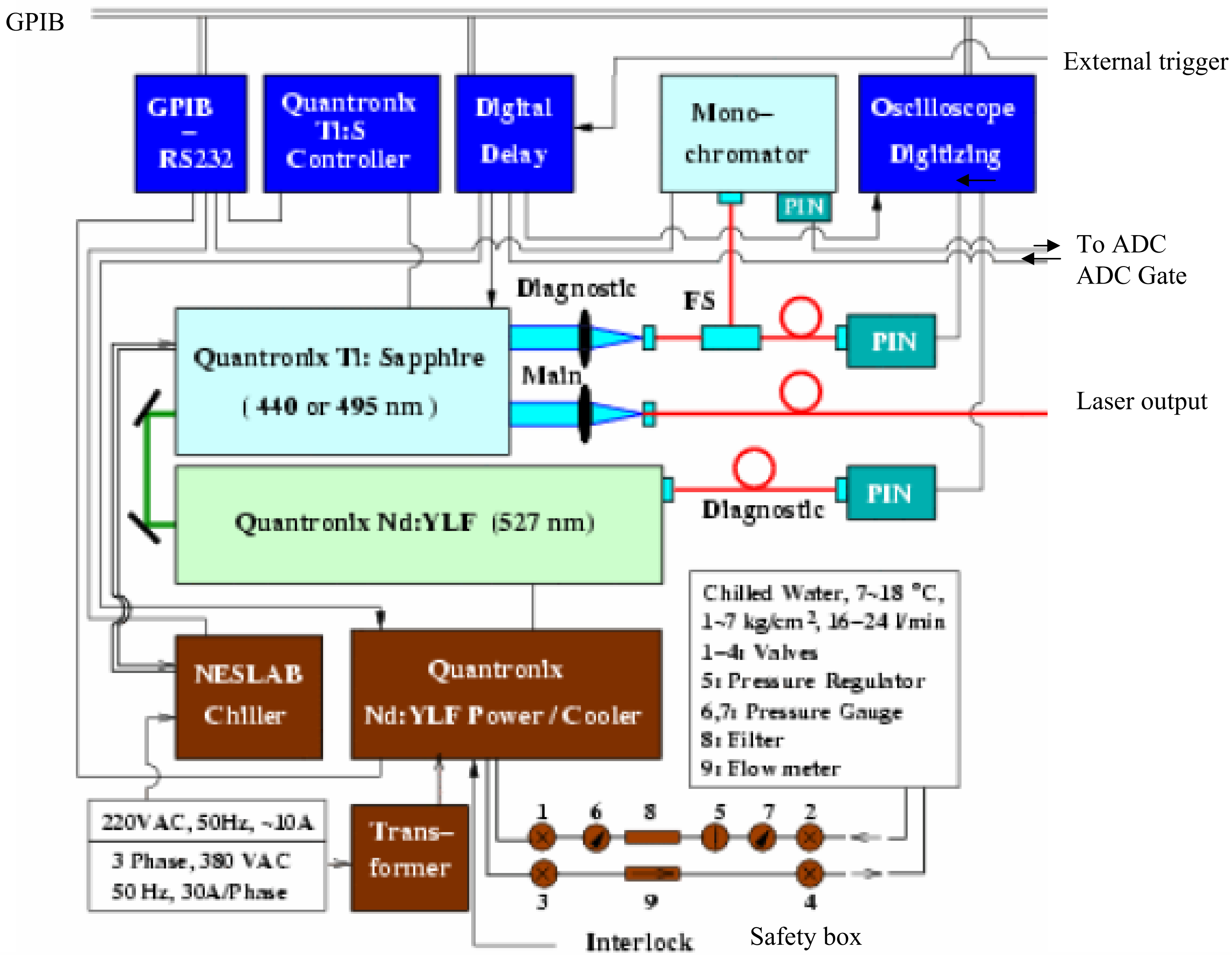
Laser Monitoring: Hardware

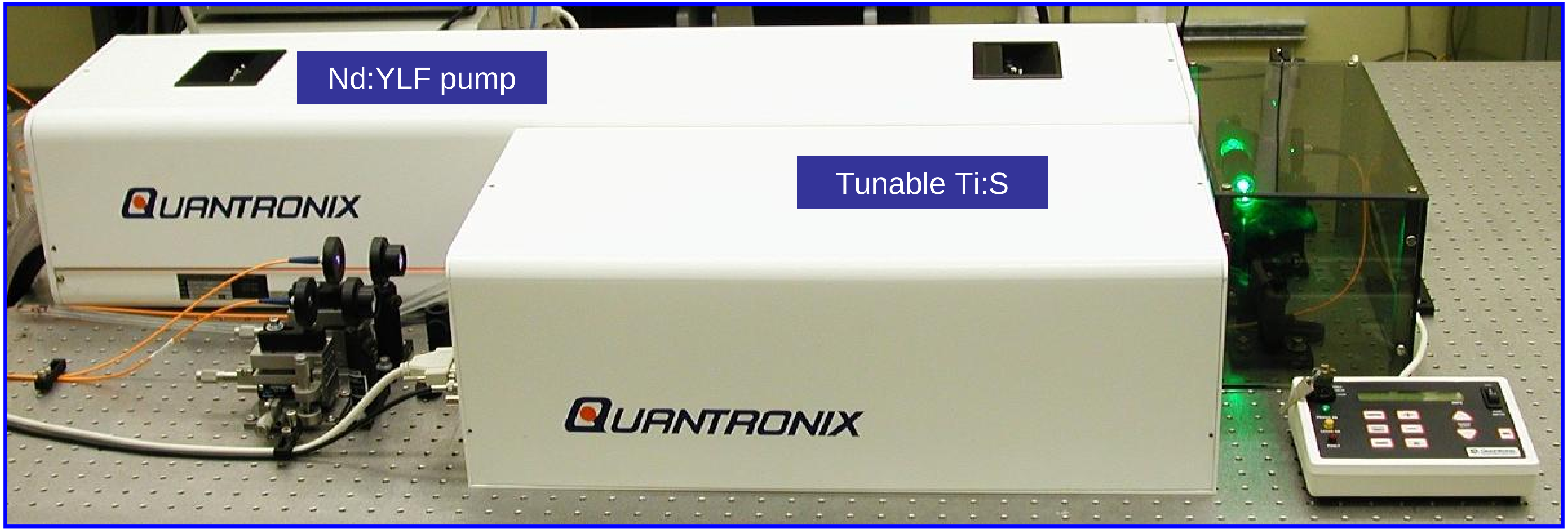
The system is design to continuously monitor the ECAL *in situ* at CMS

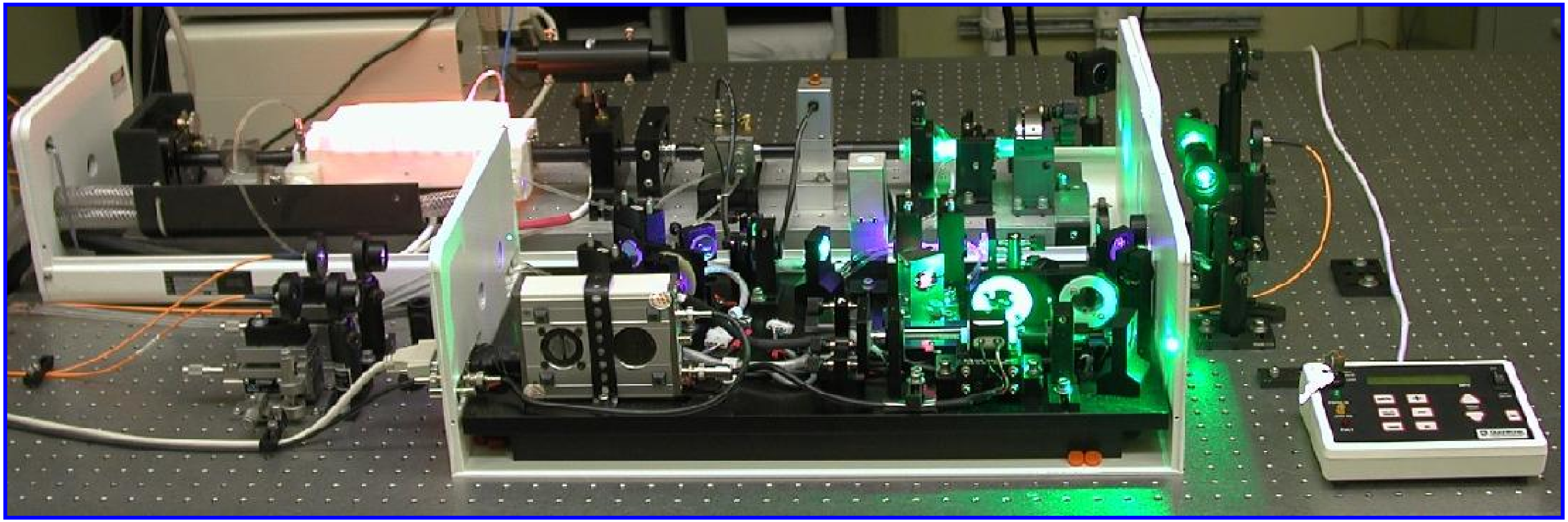
Monitoring Light Source and High Level Distribution



Details of One Laser System




Nd:YLF pump
Tunable Ti:S
QUANTRONIX
QUANTRONIX



Laser Specifications & Environment

Laser specifications :

- 2 wavelengths:
  - one close to the emission peak → best monitoring linearity (440 nm)
  - one to monitor readout electronics chain from the APD to the ADC (796 nm)
- Pulse Jitters: < 4ns/2ns for long (24 h)/short (0.5 h) term
  Pulse width: < 40ns
  Pulse energy: 1 mJ/pulse (>1TeV equivalent energy deposition in each crystal).
  Pulse rate: <100 Hz
  Intensity instability: < 10%

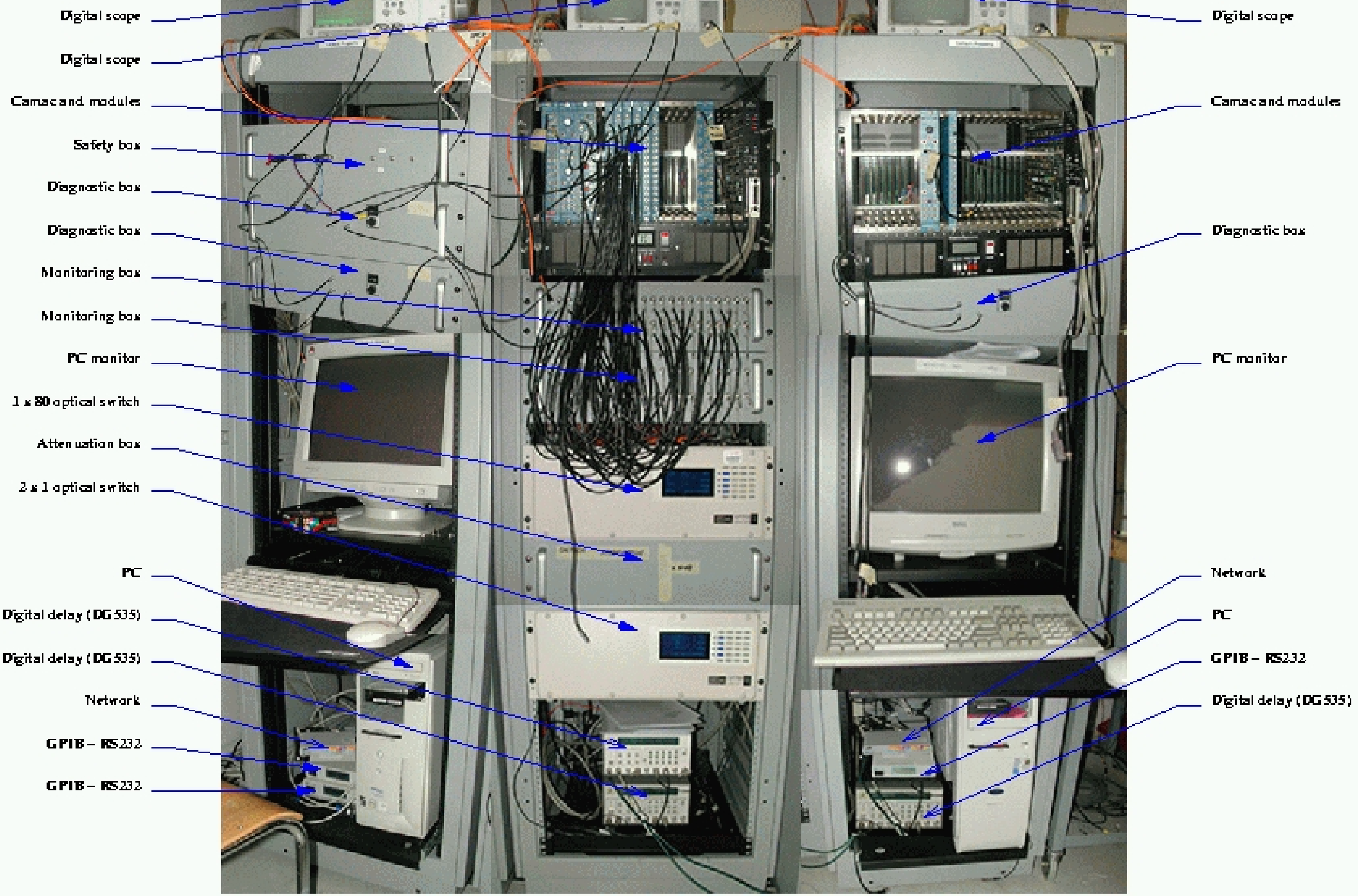
	YLF*	Ti:S 1		Ti:S 2	
λ (nm)	527	440	495	796	709
Pulse energy (mJ)	20	1	0.5	1.5	0.42
Pulse width (ns)	100-170	25-30	40-50	25-30	30

*YLF = *Yttrium Lithium Fluoride*

- Environment:
  - cleanroom class <10,000 : *done since May 2005 with softwall clean room facility*
  - temperature stabilized to ± 0.5 °C: *to be done in CMS by ALEPH Air-Conditioning Unit*
  - Humidity <60%: *to be done in CMS by ALEPH Air-Conditioning Unit*

On–Line System

Off–Line System



Electronic Cable Connections

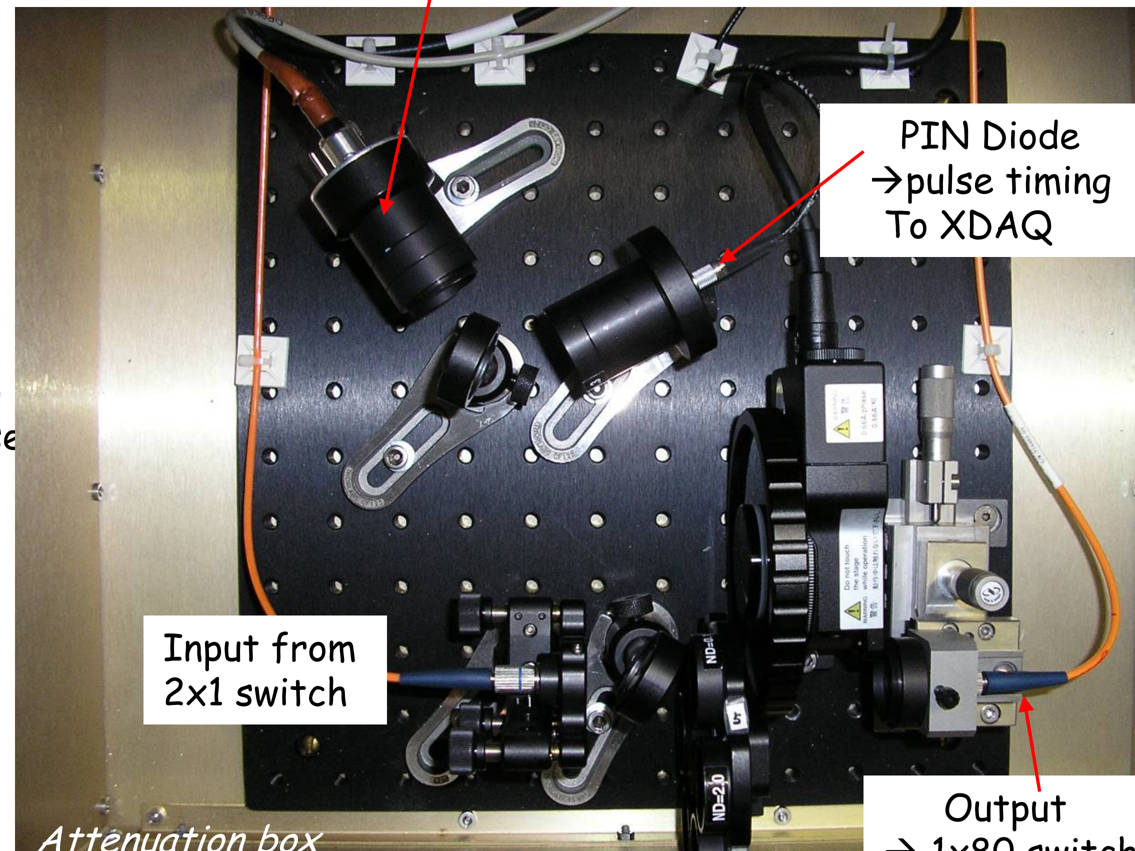
Input/Output laser barrack:

Ethernet communication: IN/OUT
With XDAQ & DIM DNS server

External trigger: INPUT (XDAQ)
Use to generate YLF laser pulse
< 100 Hz, TTL

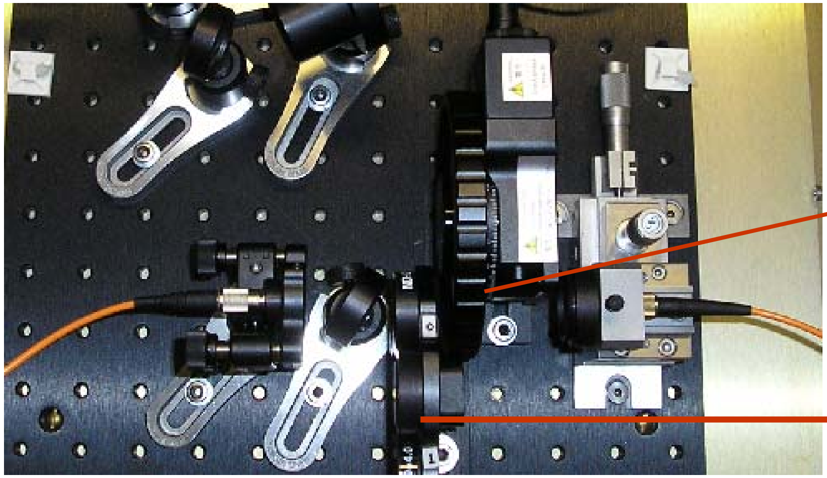
Pulse timing: OUTPUT (XDAQ)
Laser pulse digitalized: inform when pulse has been sent to SM.
Before 1x80 switch
(Before 150m long fibers)

Level 2 TTL for safety: INPUT
from MEM to safety crate, 5V



Laser Pulse Intensity Adjustment

Attenuation box:



Variable Reflective Neutral Density Filters
Optical Density from 0.04 - 2.7

+

neutral density filters: 0-10-20-30-40-50 dB

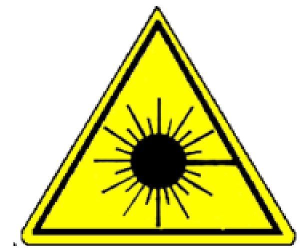
Software modification for attenuation mode:
0-100% with Ti:S regulator → variable density filter

⇩

0% = max. attenuation (27 dB loss)
100% = min. attenuation (0.4 dB)

Laser Safety

Laser safety: → Limited access to the barrack



CLASS 4

All the safety is controlled by the safety box:

- **Outer door** : - interlock + flash lamp + 3 LED
- **Inner doors** : - 3 interlocks
  - 3 boxes: Flash LED+ yellow LED
- **Level 2 TTL** from MEM box:
  - → low level if the laser pulse does not reach level 2 fanouts (e.g., accidentally broken fiber)
  - → high level if the level 2 fanouts receive laser pulse.

2 modes of operation:

1) **Normal operation** : inner doors should be closed and you can enter in the barrack without closed the shutter
2) **Maintenance operation**: inner doors can stay opened to work on the laser, then the outer door controls the shutters

Laser Hardware Maintenance

- Check the chilled water, change filter if it is too dirty
- Check the internal cooling water level (distilled water)
- Change the deionizing cartridge and the particle filter in the internal cooling unit (90 days)
- Check Neslab water level for Ti:S LBO

- Change **YLF lamp every 500 up to 1000 hrs (20 to 40 days).**

Normal degradation with lamp life time

↓

Check YLF & Ti:S pulses
→ tuning, calibration, short run in internal trigger mode

↓

Reach performance Spec. ?

NO → (back to check)

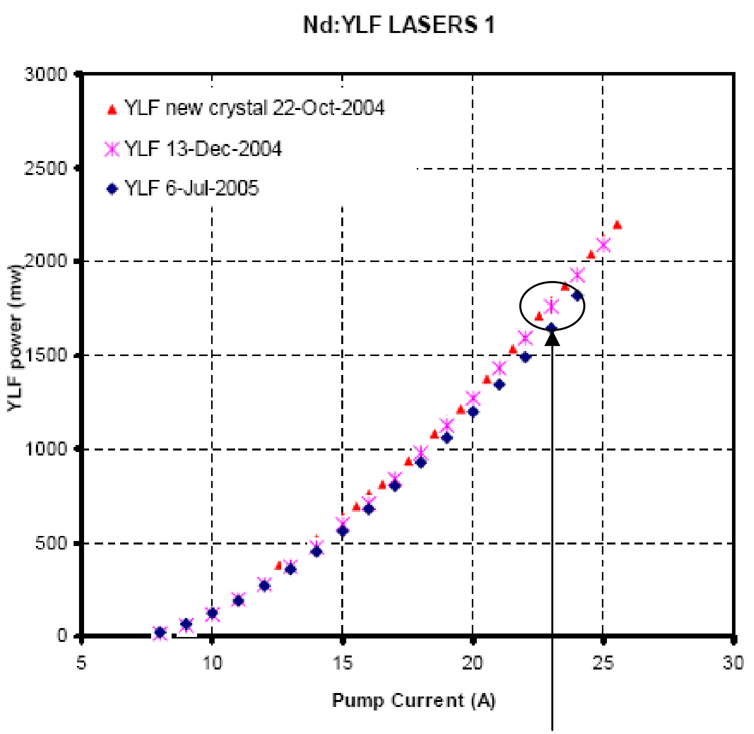
YES ↓

Would need to readjust the attenuation,
Controlled by the Laser Supervisor

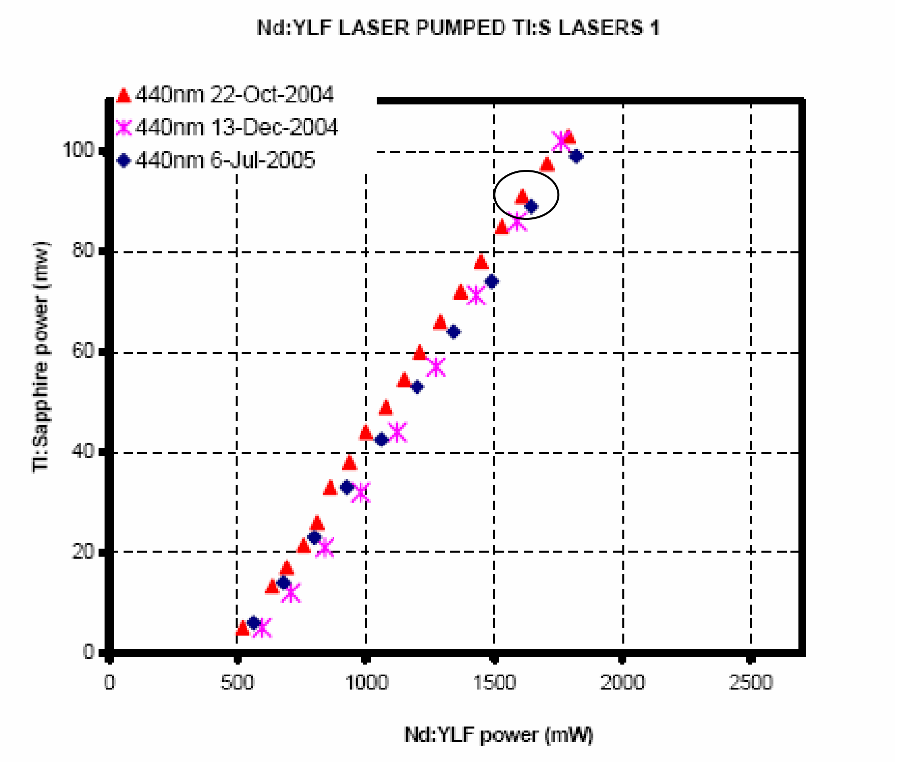
} ~ 3 hrs

Laser Calibration

Laser main controls: **YLF:** pump current
Ti:S: pulse delay/YLF pulse: ~5ns max. (+optics tuning, HV Q-switch)

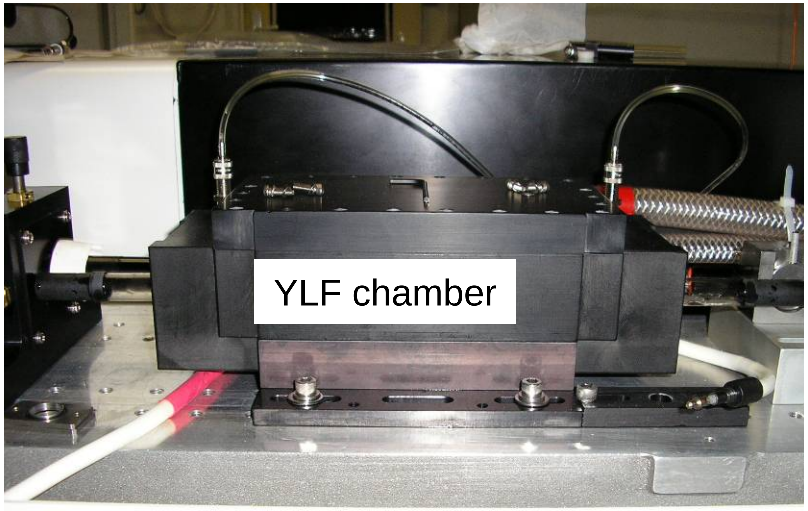


Working point: 23A



Experience with Hardware Failures

2004: Optics damage caused by dirty environment and broken flow tubes
2005: Broken flow tubes and electronics: mother board of 1x80 switch



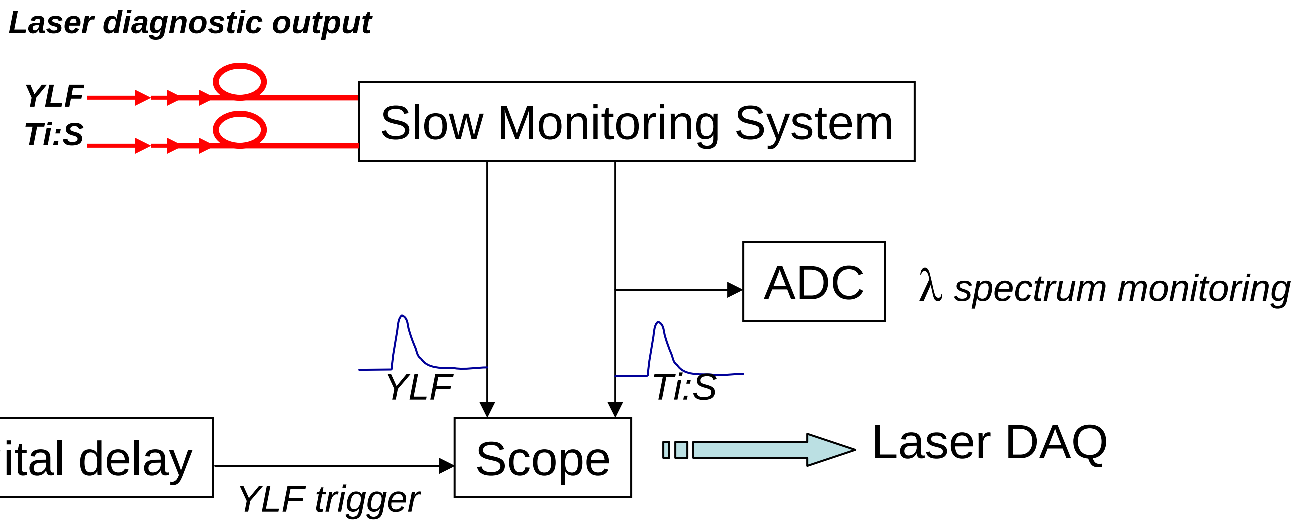
Life time:
- lamp: ~500 – 1000 hrs.
  → Lamp aging: 0.5% daily
- flow tube: 1 year
- gold reflector: to be checked every year


Laser Pulse Monitoring

3 monitoring systems: SLOW (DSO for each laser system) &
2 FAST (Acqiris DP210 & MATACQ)

Slow monitoring

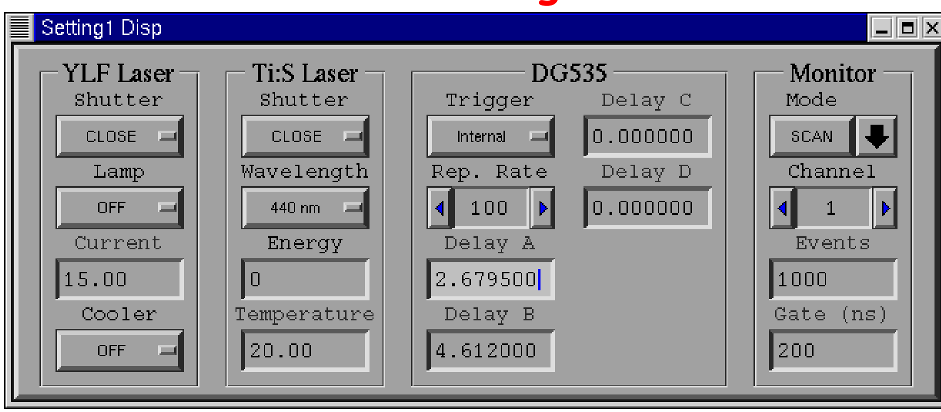
→Control lasers setup,
→Check YLF and Ti:S performance at *1 Hz*
→*Keep laser history for diagnostics*



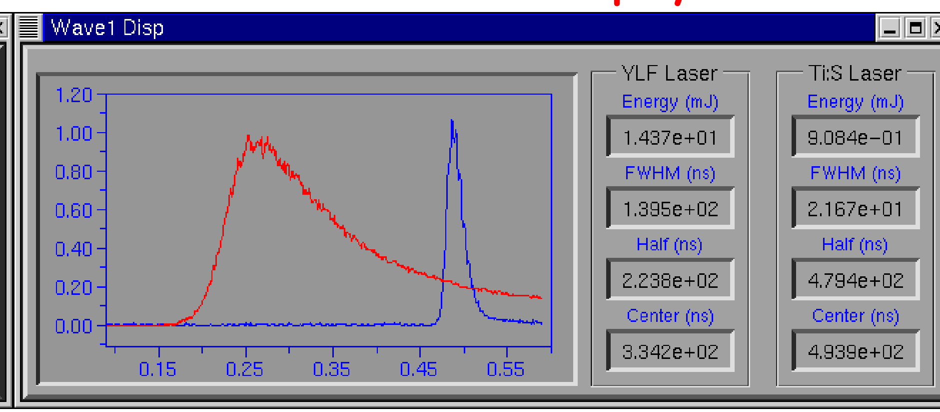
Laser DAQ Control Display

Laser System Control

Laser Settings

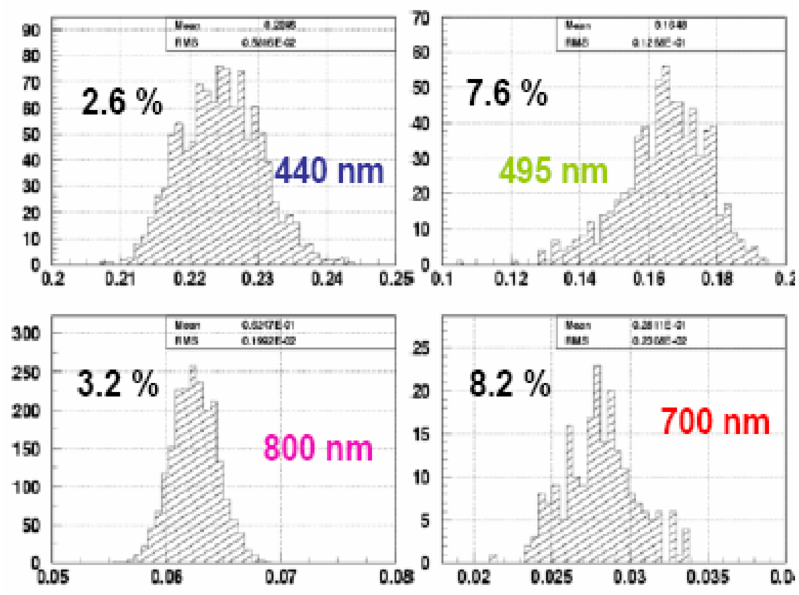


Waveform Display

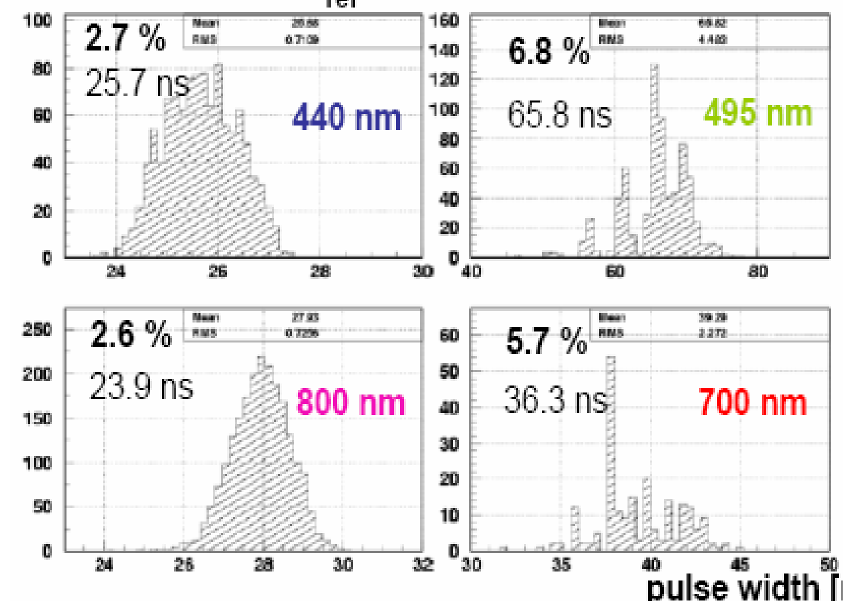


Result of the Slow Monitor: Intensity, FWHM, Timing

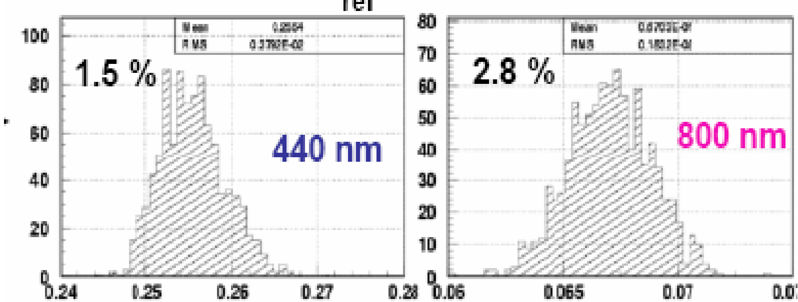
t_{ref} : 330 - 355 h



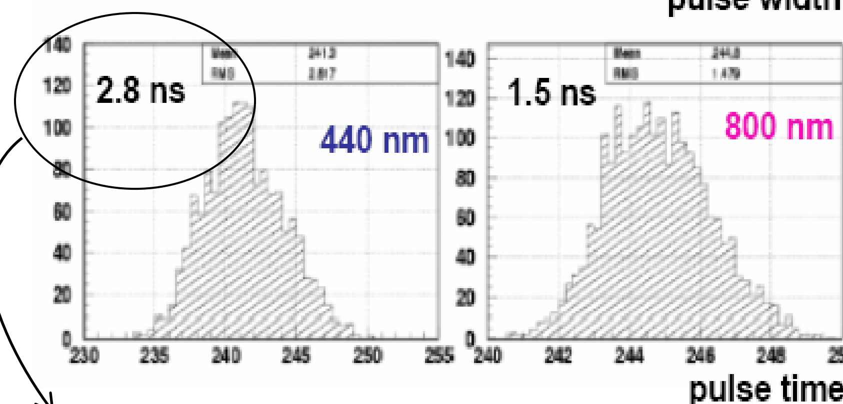
t_{ref} : 330 - 355 h



t_{ref} : 200 - 200.5 h

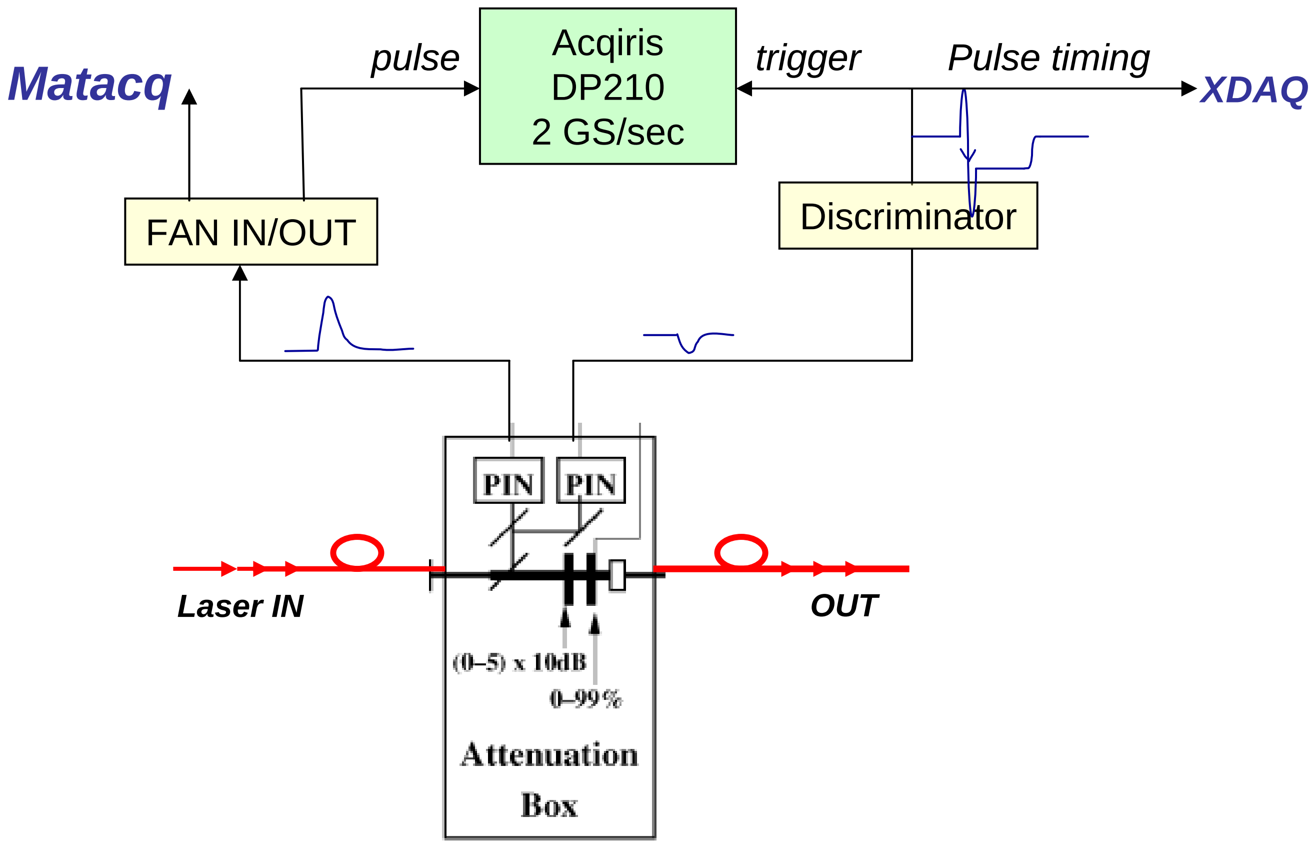


Pulse energy



Pulse jitter of monitoring light

Fast Monitors: Acqiris DP210 and Matacq



MATACQ: *Fast acquisition card developed by **CEA/Saclay**, IN2P3/LAL*
Sample frequency: 1GHz, 2GHz in boosted mode.

Acqiris DP210 Card (2GS/s, 2004)

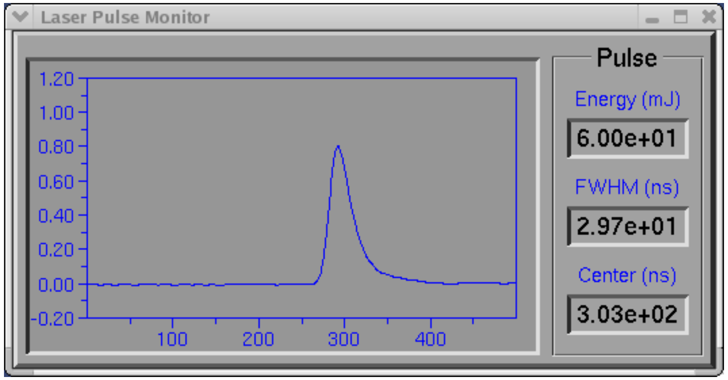
To follow Ti:S performance pulse by pulse

⇩

Fast sampling ADC (2 GS/s) on one PC
→ Acqiris DP210, PCI card with oscilloscope characteristics, 500MHz BW, 8bit

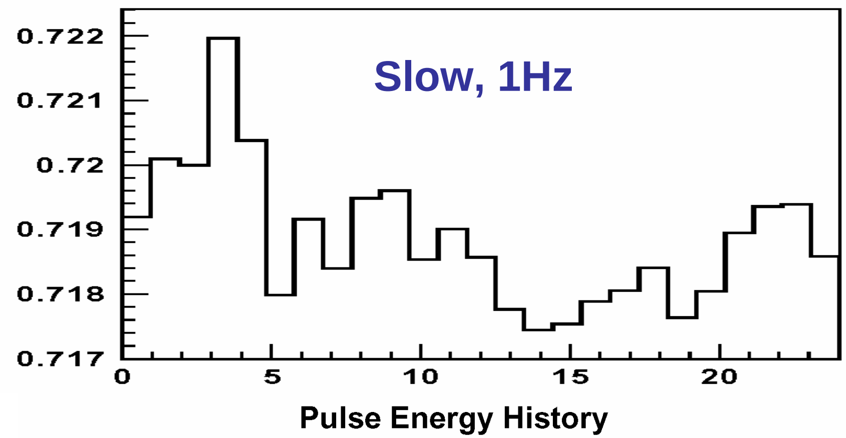
⇩

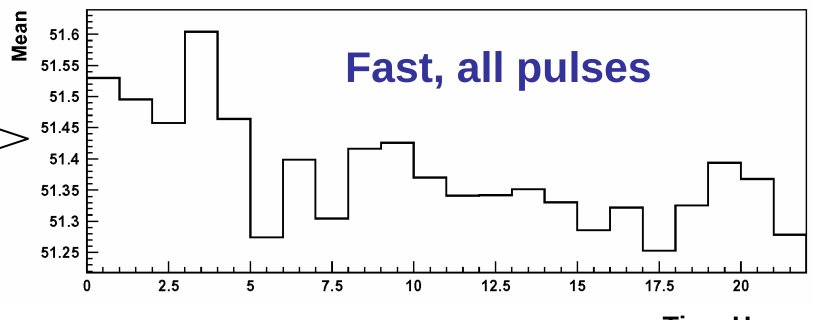
Record all Ti:S pulses: Intensity & FWHM
No laser timing information: self-triggered



Option: filter 60MHz available

440 nm, Same run





Communication with ECAL: Laser Supervisor

Communication with the XDAQ is through Ethernet.

At the beginning of each run, the DAQ sets and checks laser parameters by sending a command file, and the laser responds to the DAQ by sending an acknowledge file.

Laser parameters controlled by XDAQ :

-laser wavelength *(change : ~1 min.),*
-linear attenuator,
-output channel number of the 1x80 optical switch.

Communication Protocal

1. The command file from the **H4 DAQ** to the laser:

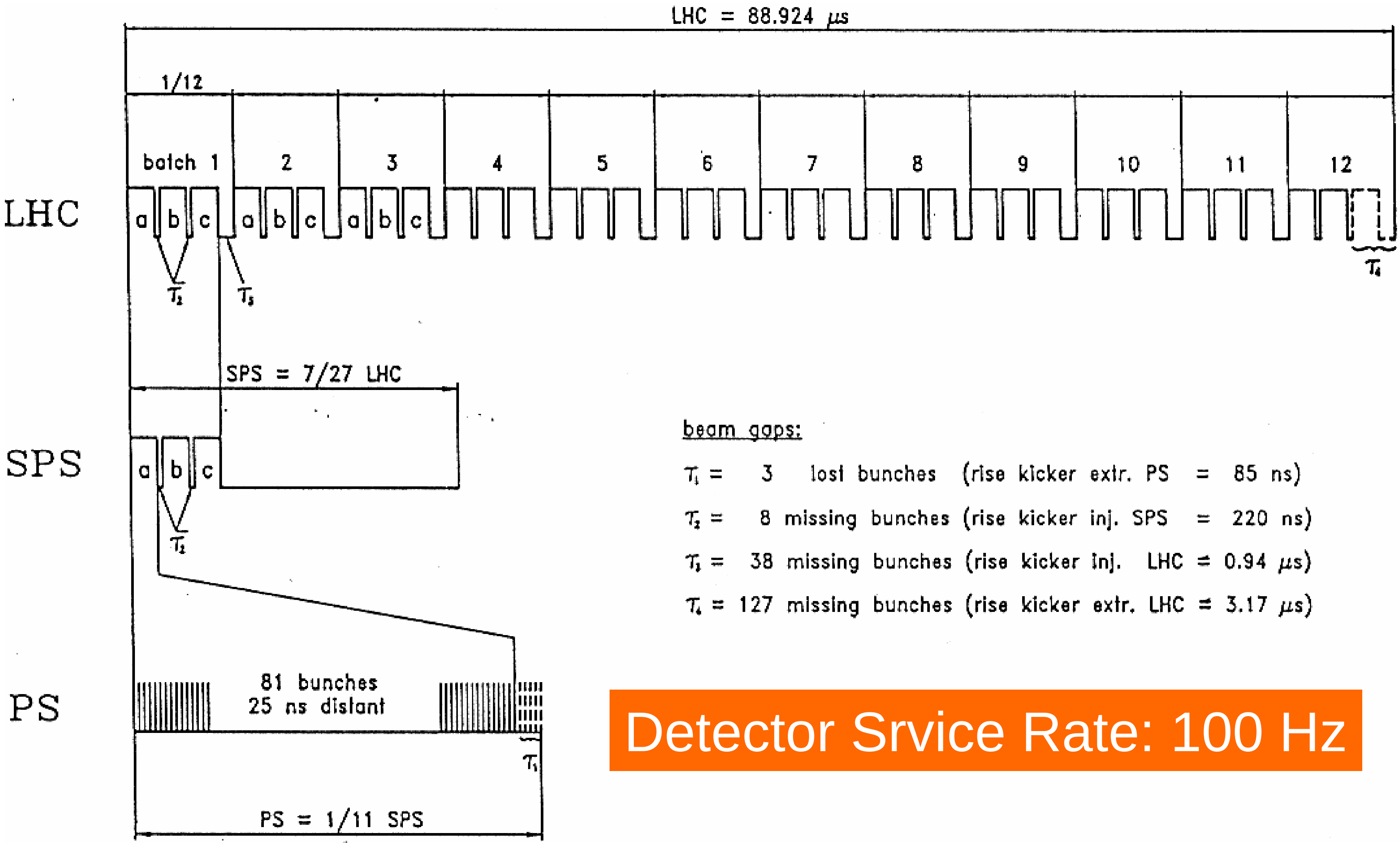
COMMAND TYPE (int)	**0:** request laser parameters
	1: set laser parameters
	2: get laser parameters and pulse information
WAVELENGTH (int)	**0: 440** nm
	1: **495** nm
	2: **709** nm
	3: **800** nm
ATTENUATOR (int)	1 – **99** % of laser power, in 1% step
SWITCH CHANNEL (int)	1 – **80**
CHECK-SUM (int)	**B**itwise inversion of the sum of preceding 4 data

2. The acknowledge file from the laser to the **DAQ:**

COMMAND TYPE (int)	**0:** setting in progress
	1: setting finished, the laser parameters are ready
WAVELENGTH (int)	**0: 440** nm
	1: **495** nm
	2: **709** nm
	3: **800** nm
ATTENUATOR (int)	1 – **99** % of laser power, in 1% step
SWITCH CHANNEL (int)	1 – **80**
CHECK-SUM (int)	**B**itwise inversion of the sum of preceding 4 data

Continuous Monitoring at CMS

Using 1% beam gaps in the LHC beam structure



Detector Srvice Rate: 100 Hz

Time Needed to Scan the ECAL

Time to scan entire ECA: **30 min (23 sec/channel)**

Time needed for channel switching:

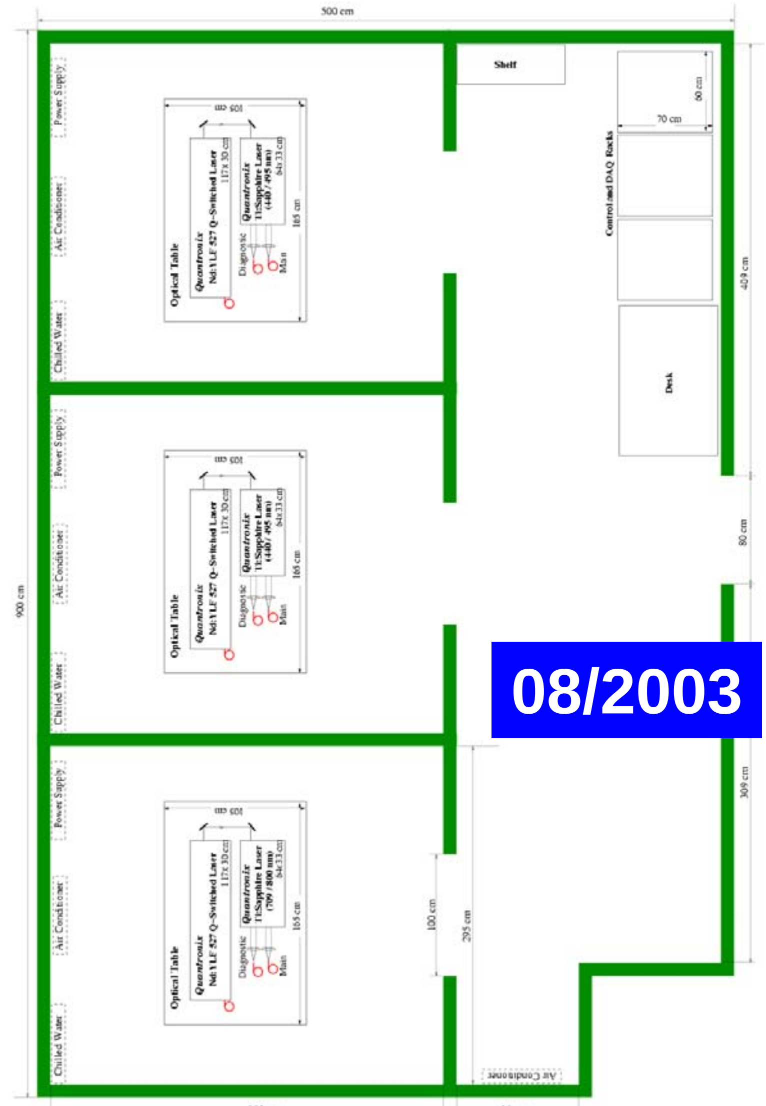
With laser DAQ control:	1 sec/Channel
With client communication:	2 sec/Channel
With slow monitor data taking:	4 sec/Channel

→ The total time depends on # of events/channel & XDAQ overhead

→ Laser scan may also be controlled by the laser DAQ, not the XDAQ

→ If so, can the XDAQ handle the laser scan data?

Monitoring Laser Barracks at H4

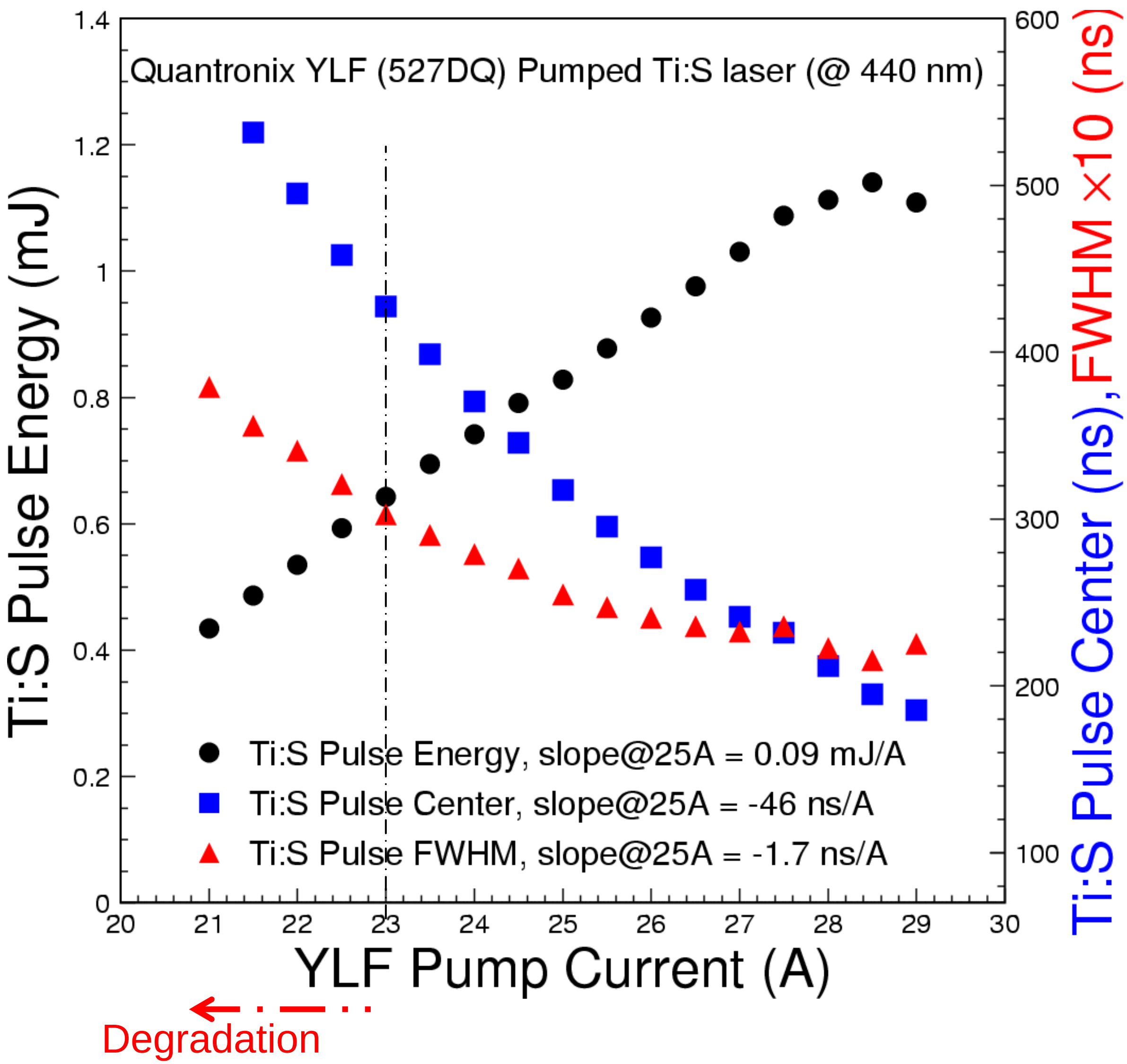


Softwall Clean Room Facilities

Portable softwall clean room facilities installed in the H4 laser barracks at CERN in Spring, 2005. They provide an environment of better than class 1,000 for laser optics protection (measured at 100)

Laser short/long term stabilities: < 2% and 3%; lamp aging: 0.5% daily. A stable laser pulse would improve monitoring stability.

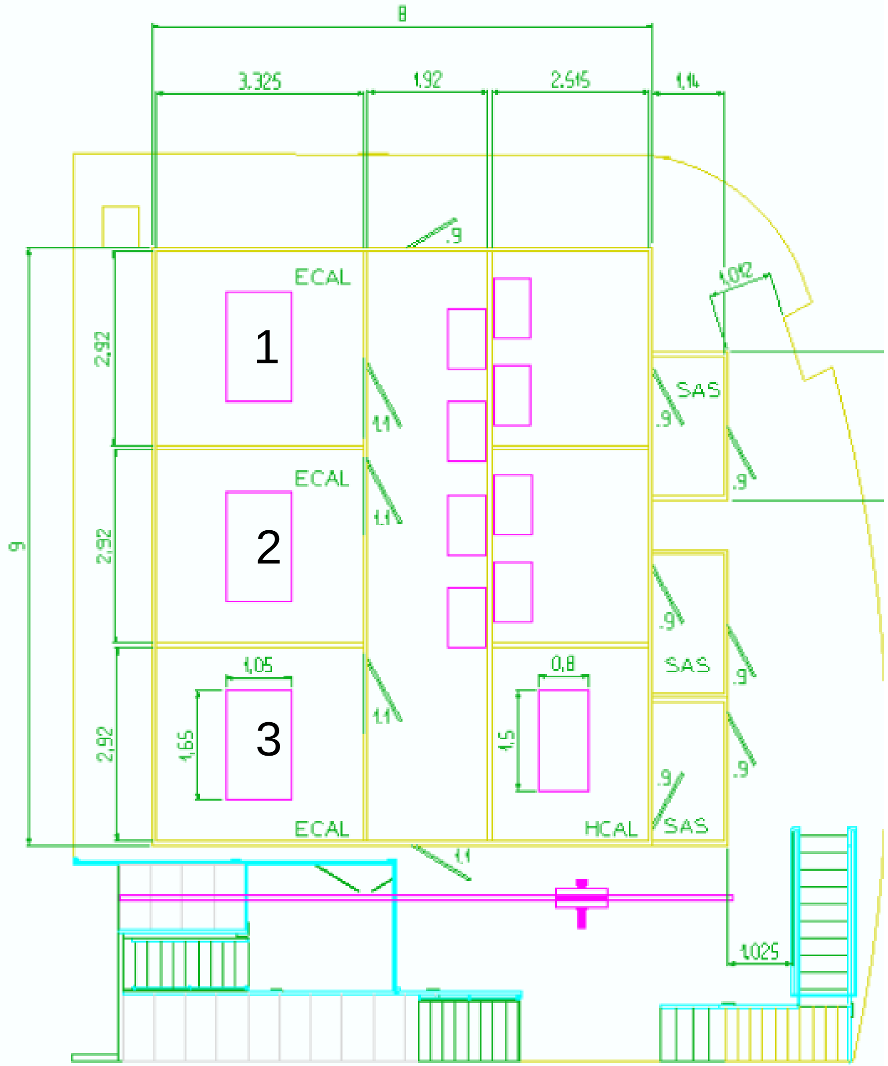
Software Feedback

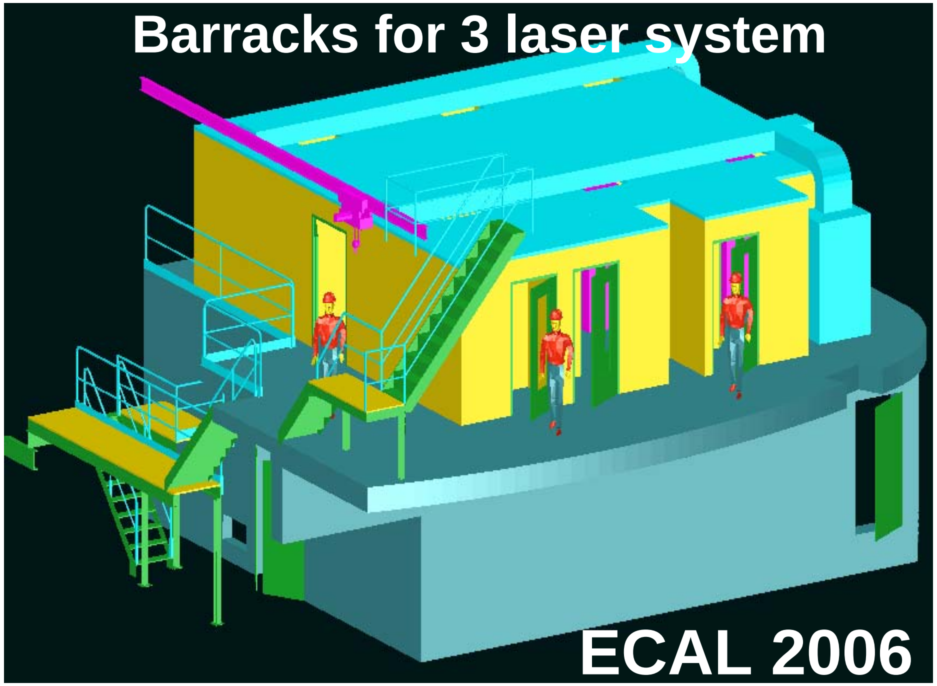


Laser pulse intensity, width and timing are correlated with the pumping current.

Better pulse stability could be achieved by trimming the YLF pumping current.

Dr. Kejun Zhu wrote a code, which will be tested by Dr. Liyuan Zhang during his visit at CERN on September 24-28, 2005





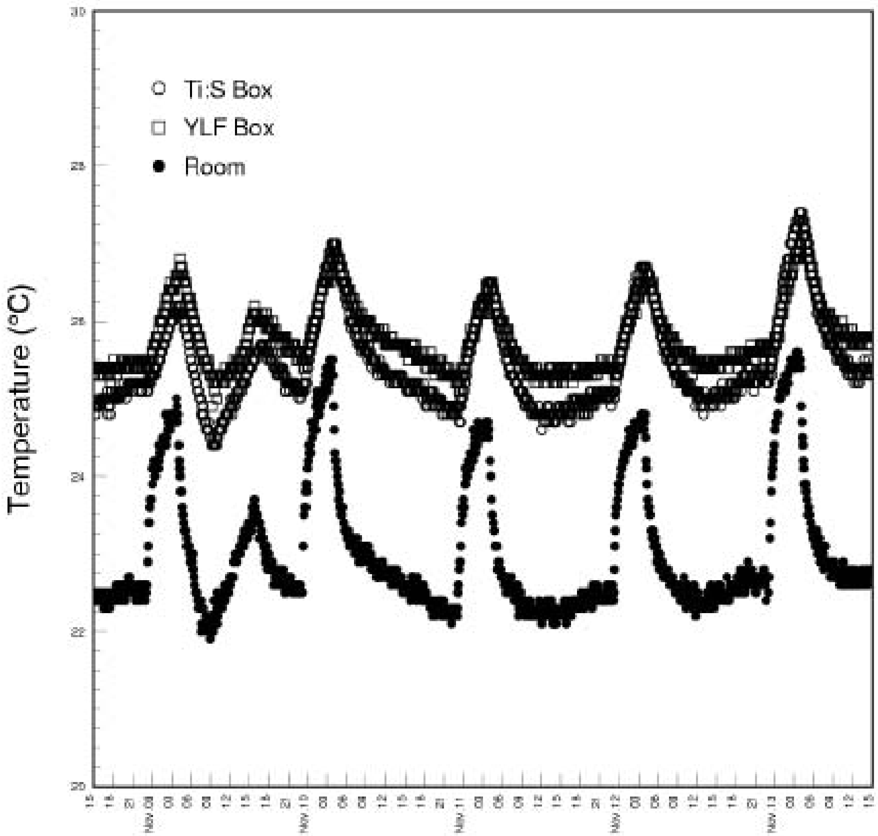
Barrack ready for April 2006

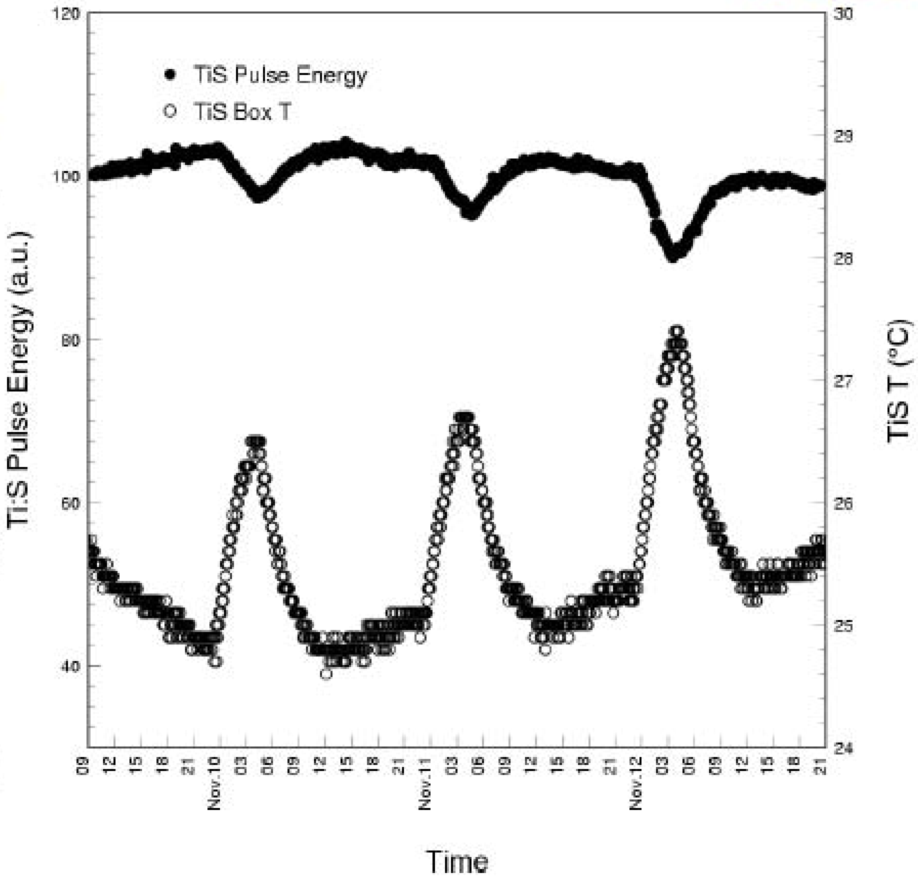
New: temperature stability ± 0.5 °C

One laser will be moved to USC55 in 2006?

A Study on Temperature Effect

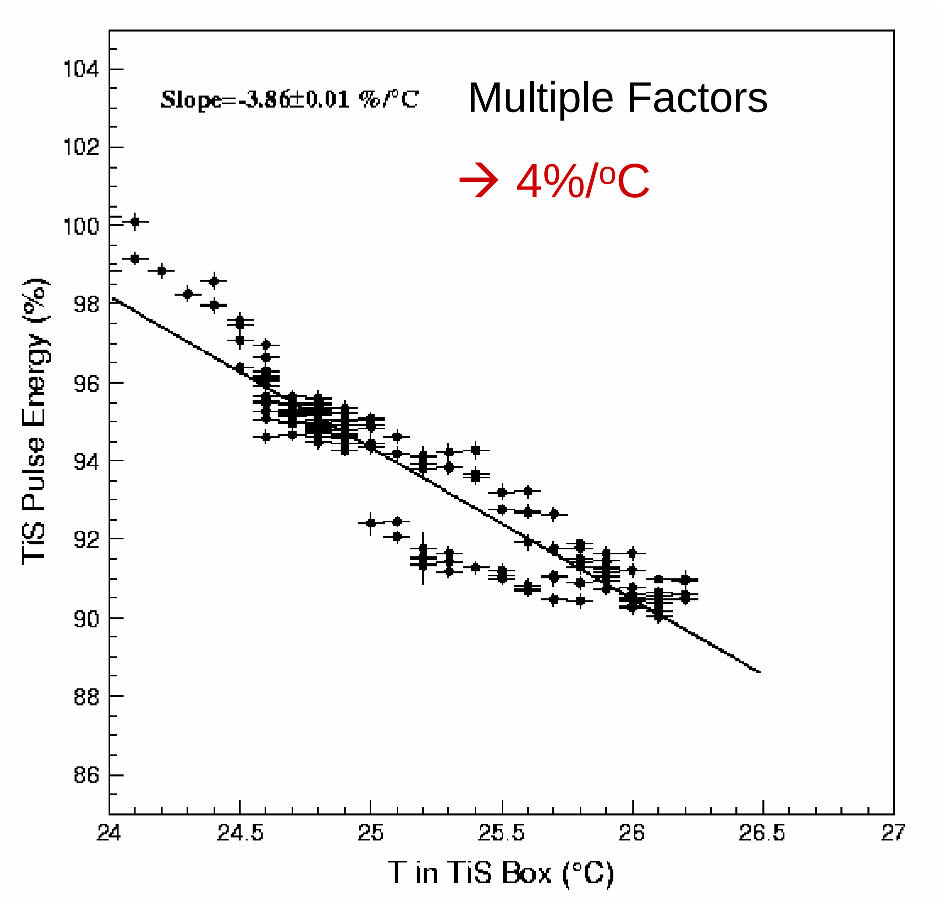
Room T Variations in 5 Days





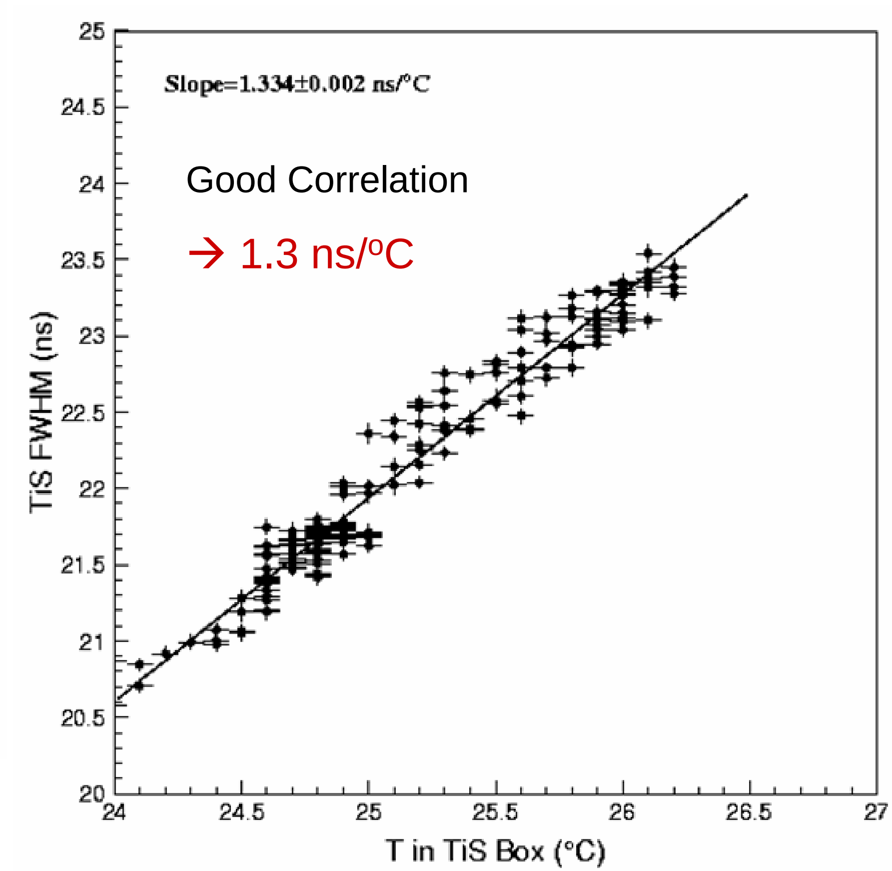
Ti:S Pulse Energy and T

Temperature Dependence



Ti:S Pulse Energy versus T

Ti:S Pulse FWHM versus T



Conclusion

Laser performance :
- Pulse width: OK
- Pulse jitter: 3 ns (24 h)
- Short term (0.5 h) instabilities: <2%
- Long term (24 h) instability: 3%

} *Stability getting better with improved environment*

→ All 3 monitoring systems are consistent

⇨ Laser maintenance: every **40 days minimum**
In H4: put spare laser online each time? else stop data taking?
CMS: need a 1x3 optical switch to reduce the transition time

⇨ To do list:
- Software feedback will be tested on September 24-28, 2005
- Develop scan software if ECAL scan is controlled by the laser DAQ
- Procure a 1x3 switch and a 1x80 switch as spare *(broken in July, 05)*
- Laser at USC55: installation schedule to be defined

Decisions on (1) when the laser system is needed at USC55 and (2) if we want to keep two working laser systems at both H4 and USC55 and for how long are important for our planning.