The Laser workshop

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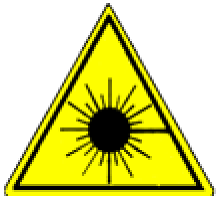
VI Summary



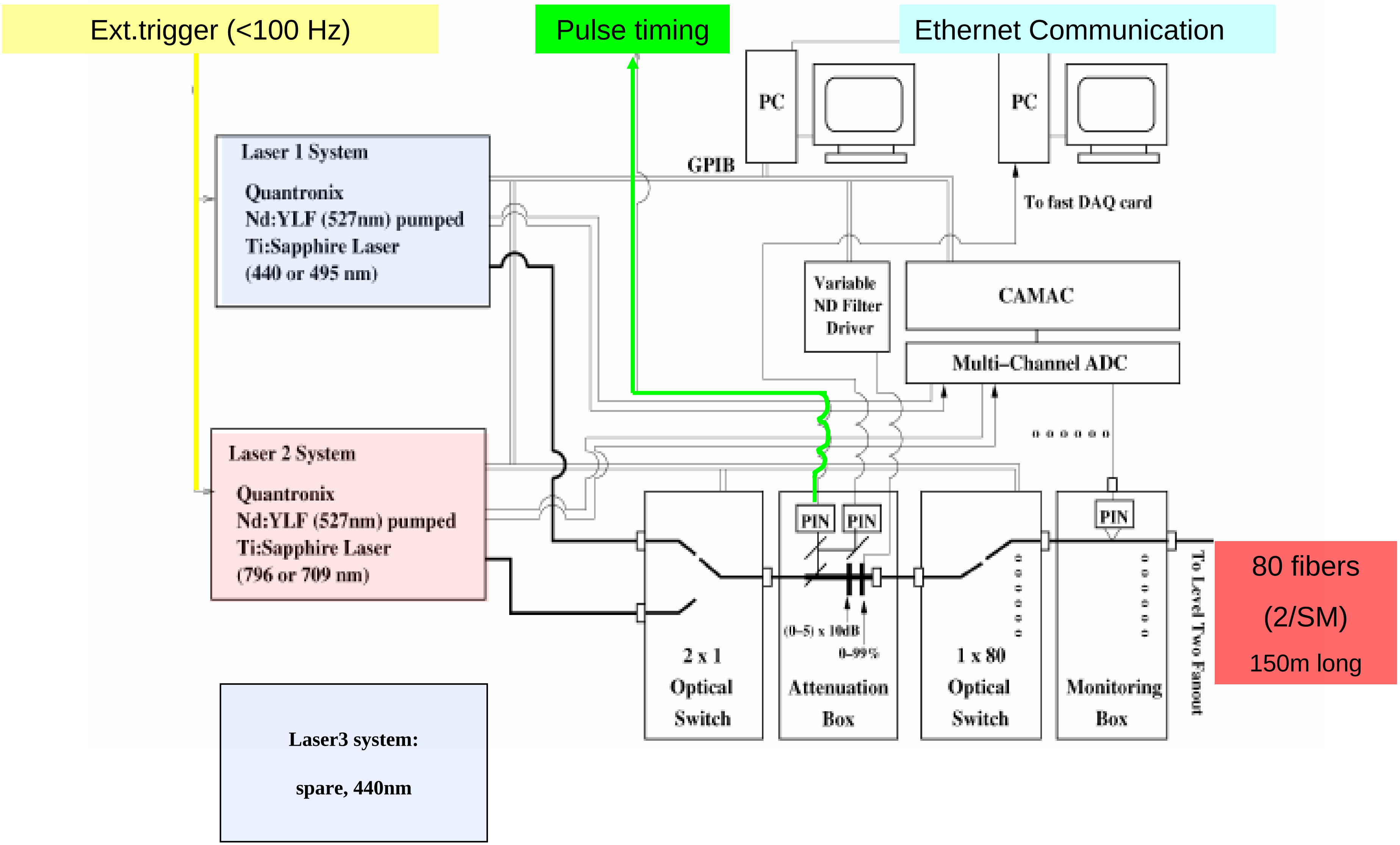
David BAILLEUX
University of Minnesota

CERN, September 16 2005

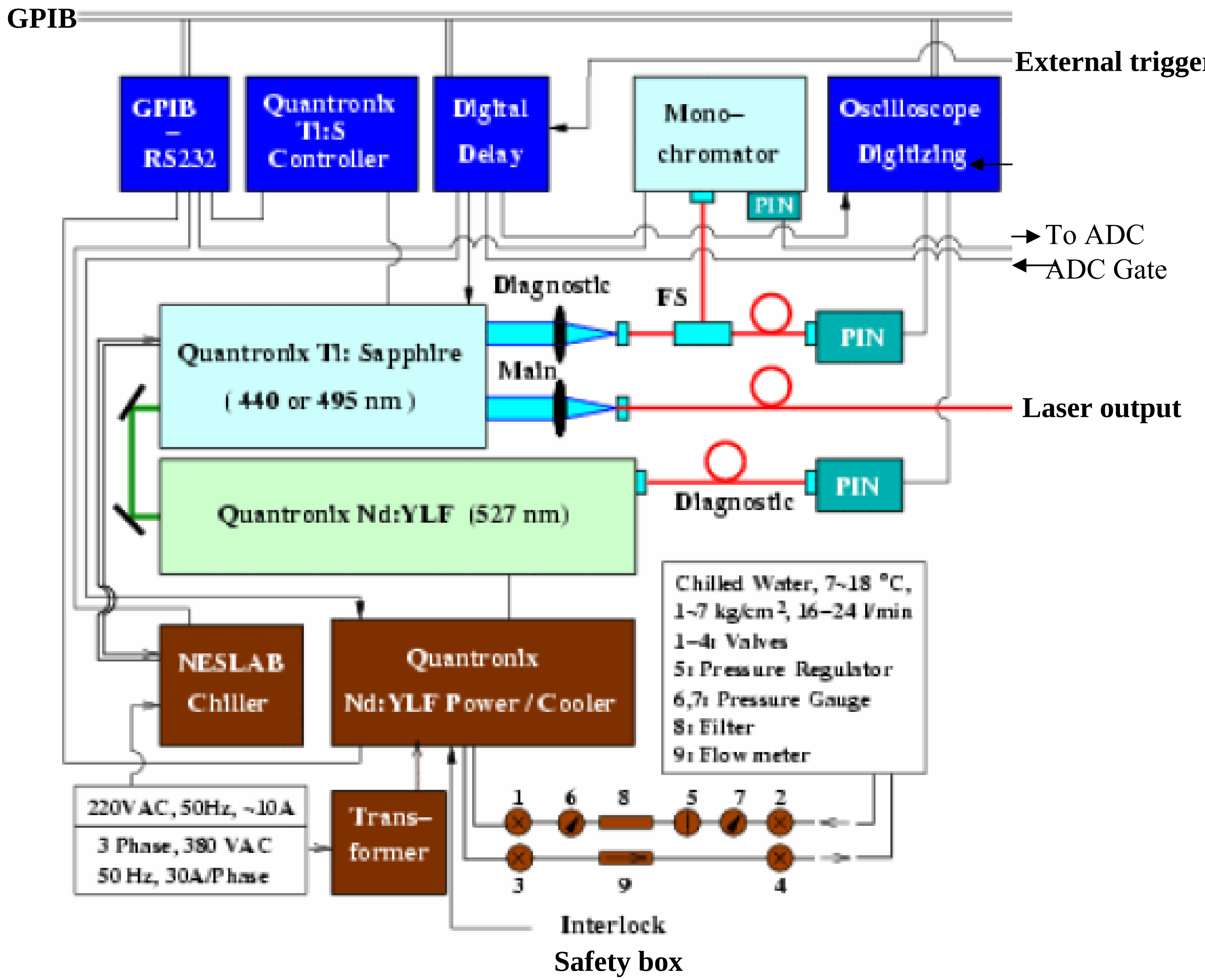
I Laser monitoring: hardware

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

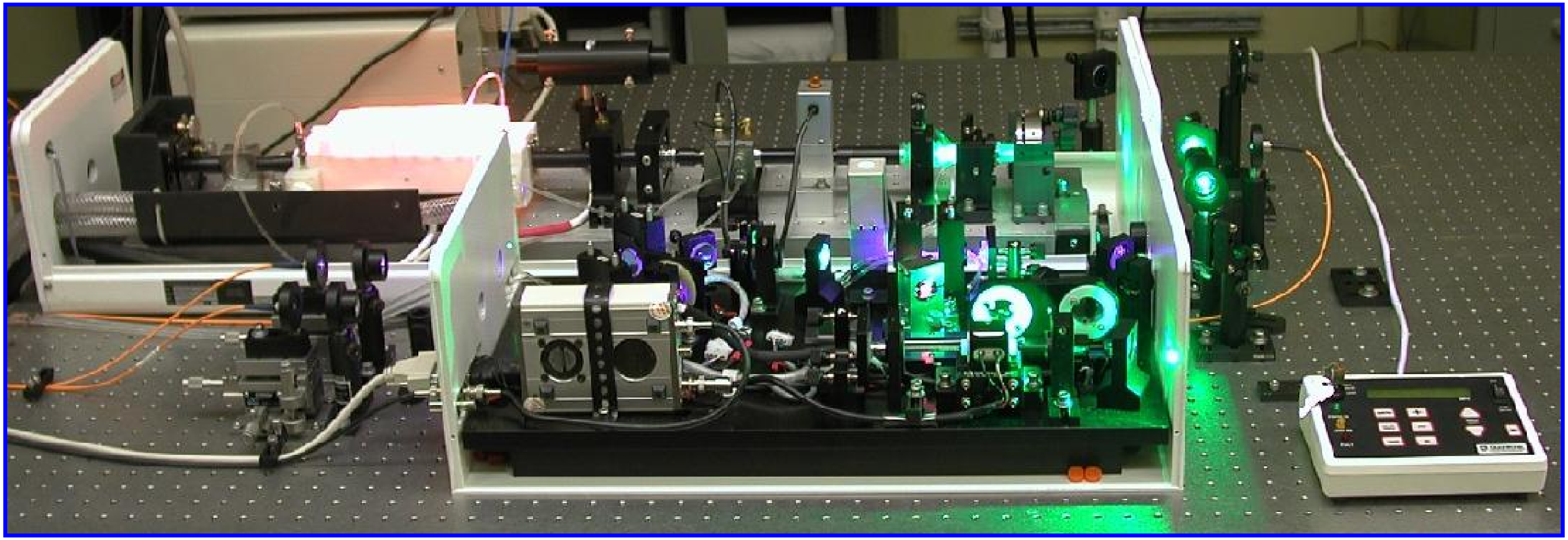
I Light source and high level distribution



I Details of One Laser System

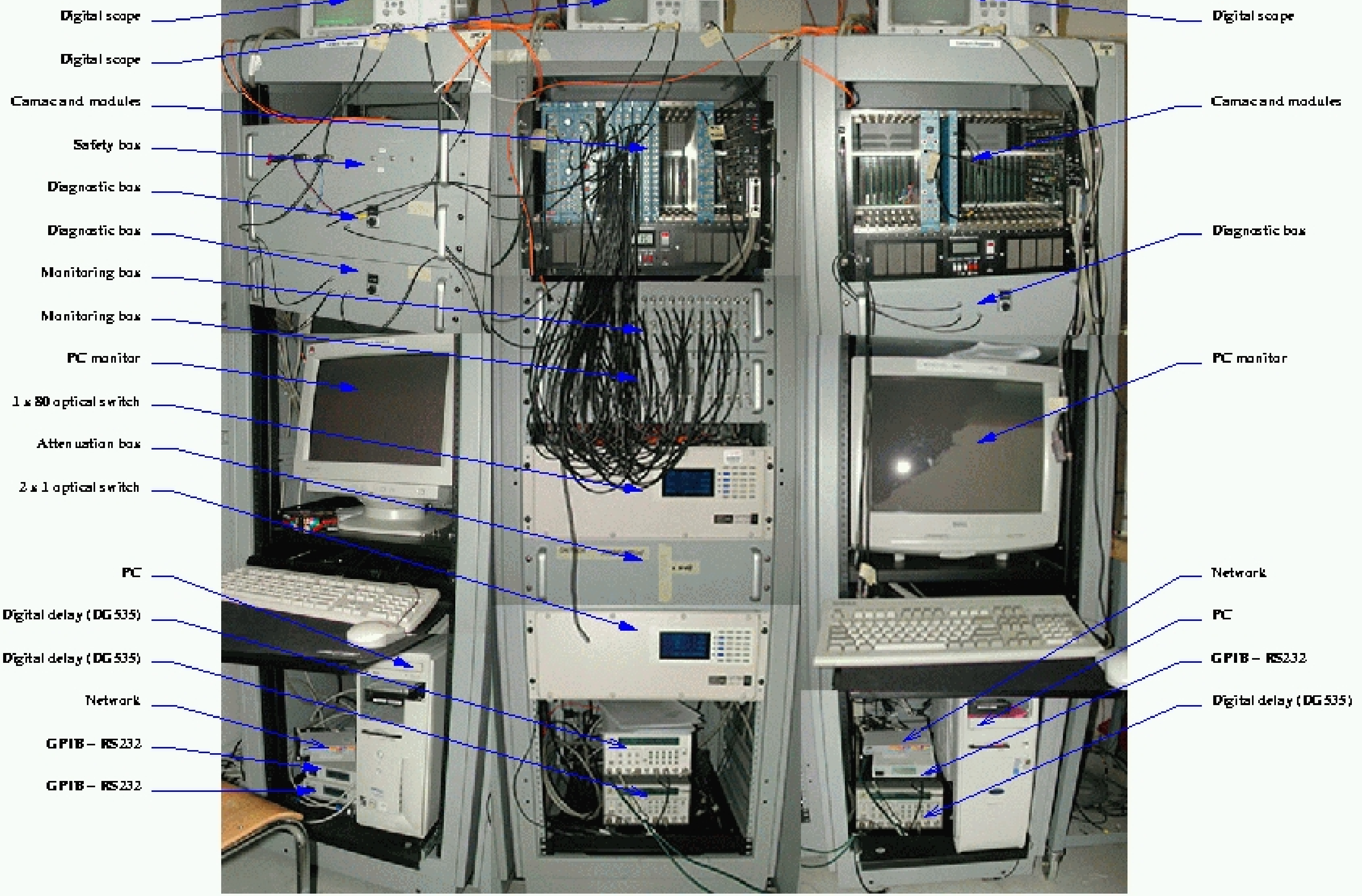


I Quantronix Laser



On–Line System

Off–Line System



I Laser Specifications & Environment

ECAL 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%

Quantronix laser:

	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*

temperature stabilized to ± 0.5 °C: *to be done in CMS (ALEPH Air-Conditioning Unit)*

Humidity <60%: *to be done in CMS*

I Electronic cable connections

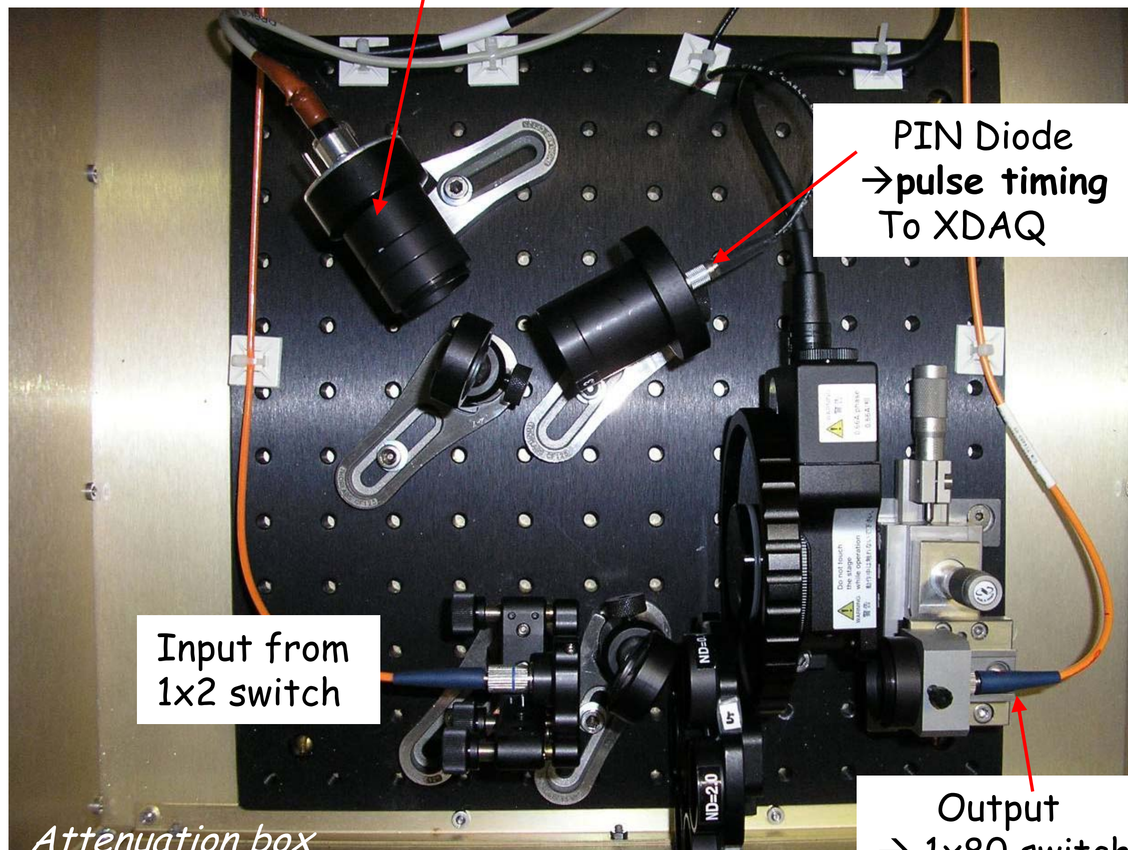
Input/Output laser barrack:

Ethernet : IN/OUT
Communication with XDAQ & DIM DNS server

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

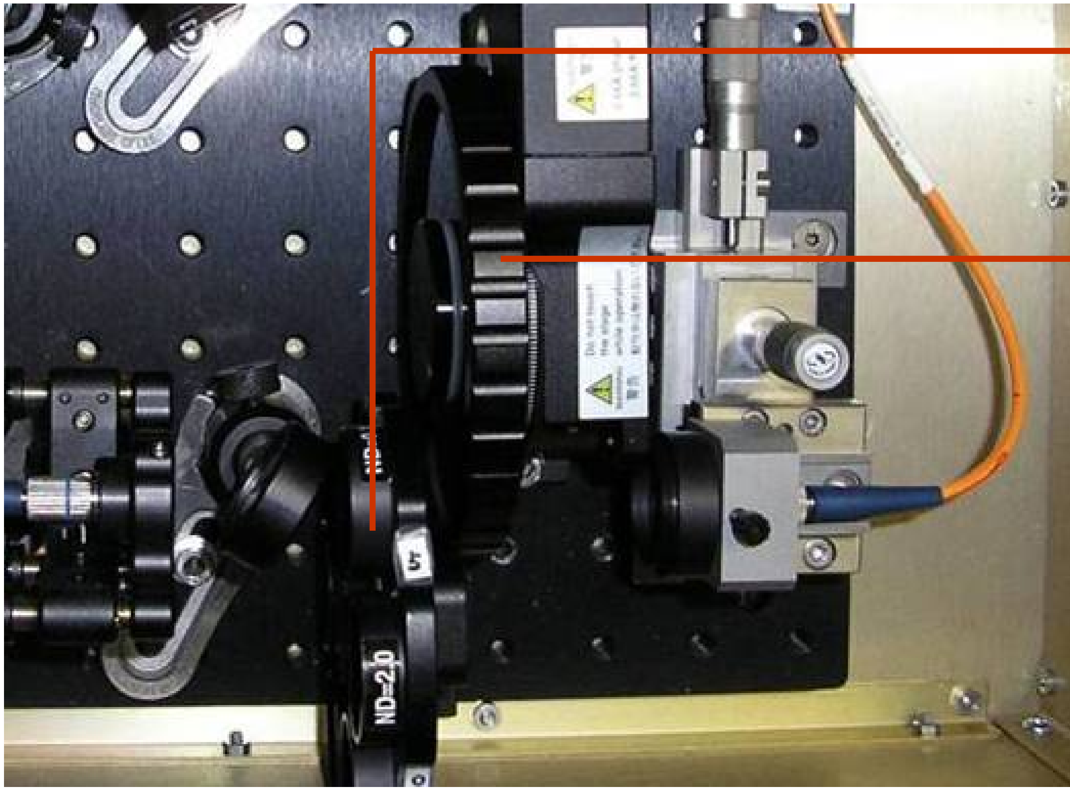
Level 2 TTL for safety: INPUT
from MEM to safety crate, 5V

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



I Laser pulse intensity adjustment

Attenuation box:



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

+

Variable Reflective Neutral Density Filters

Optical Density from 0.04 - 2.7

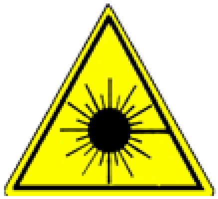
⇩

Remote control (XDAQ): 1% by 1%

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

I 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

II 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 to 1000 hrs (20 to 40 days).**

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

~ 3 hrs

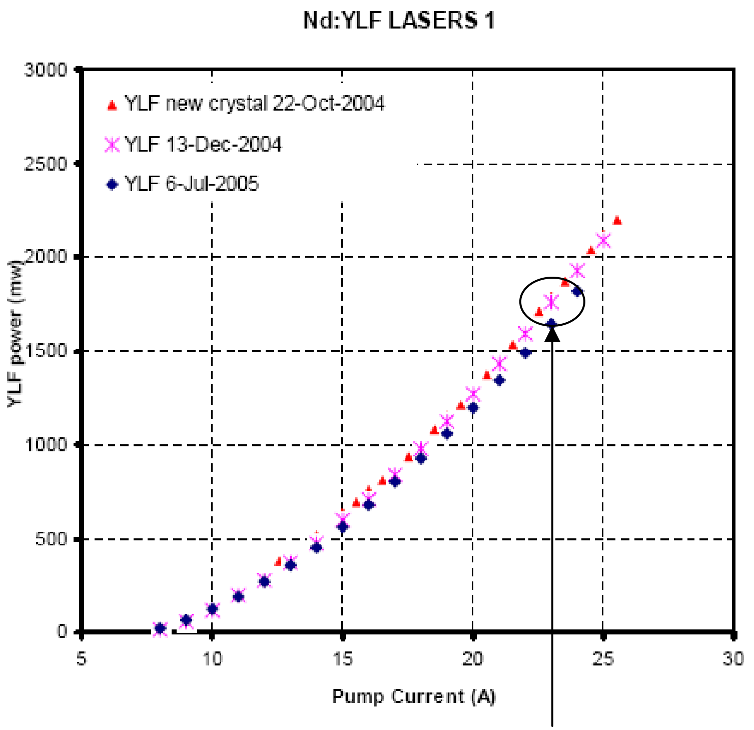
Reach performance Spec. ?

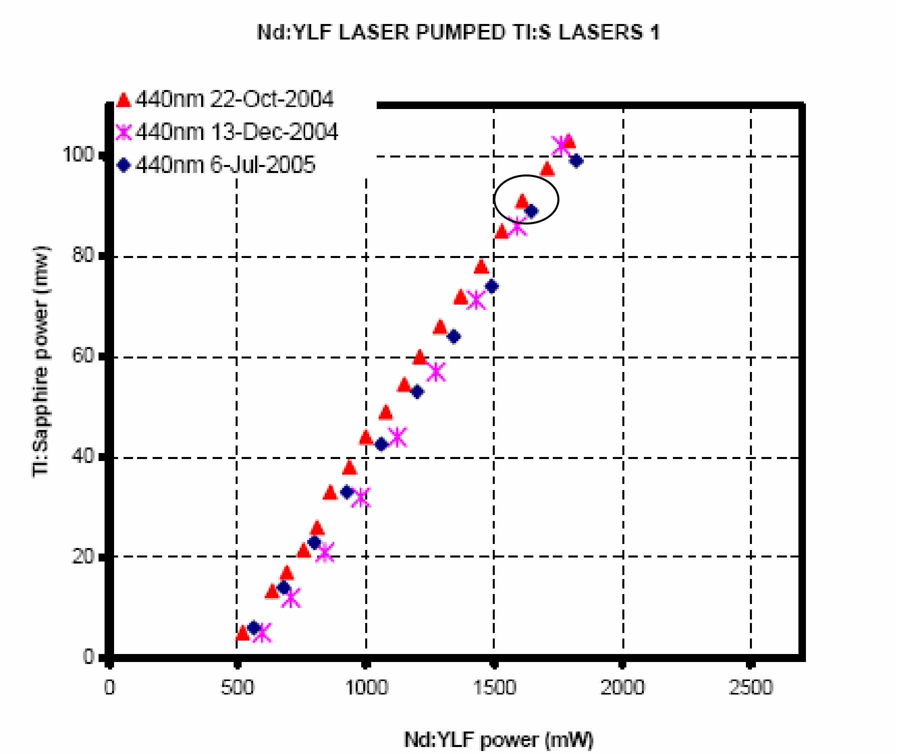
NO

YES

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

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

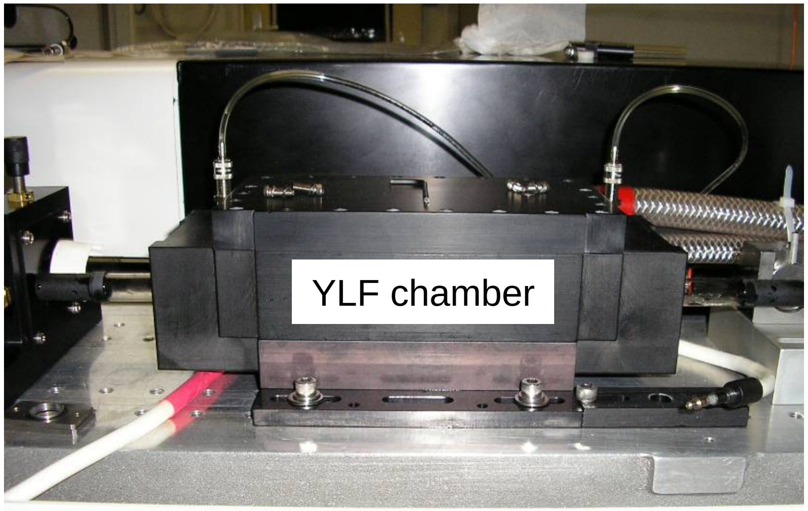




Working point: 23A

II Experience with hardware failures

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



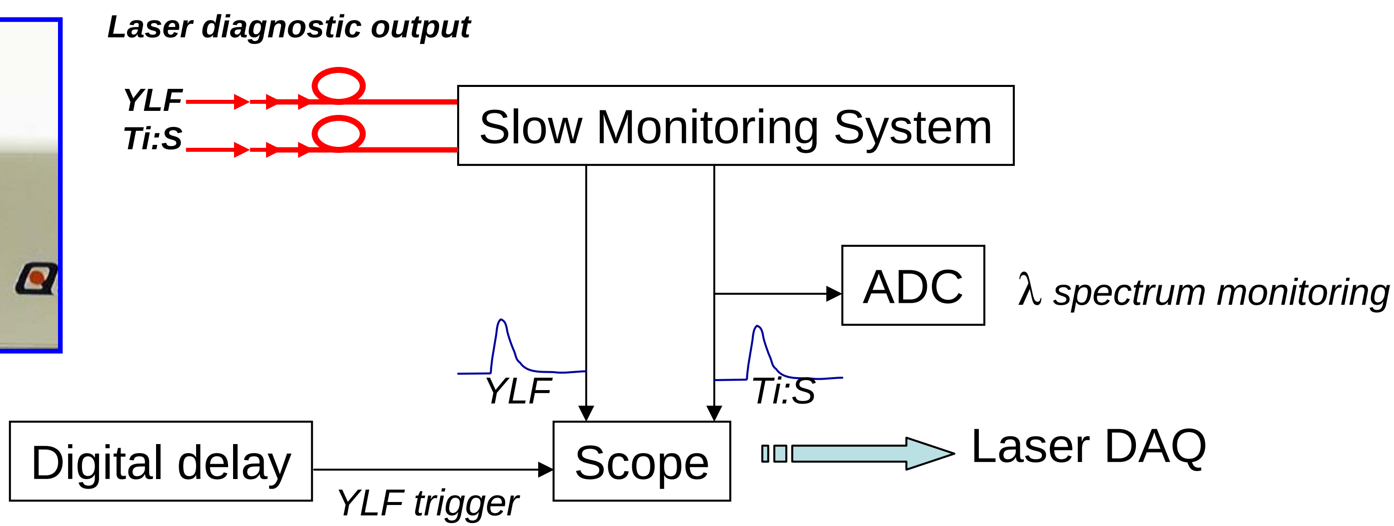
Life time:
- lamp: ~ 1000 hrs → Lamp aging: **0.5% daily**
- flow tube: 1 year
- gold reflector: to be checked every year

III Laser pulse monitoring

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

Slow monitoring:

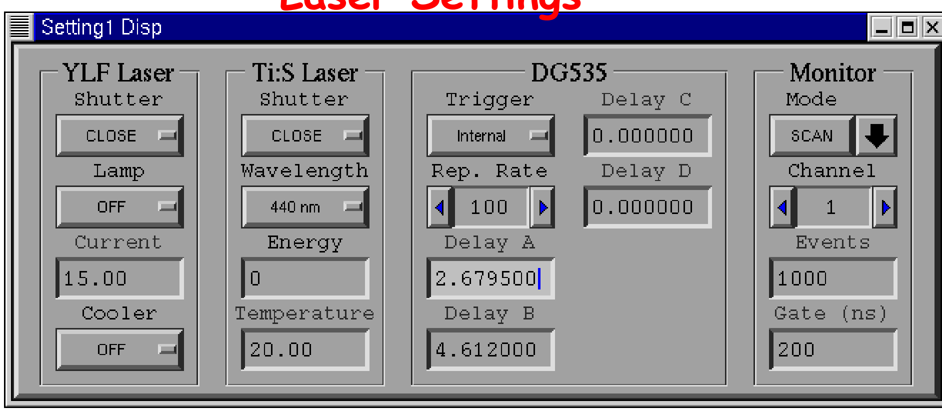
→Control lasers setup,
→Check YLF and Ti:S performance at ***1Hz,***
→Keep laser history for diagnostics.



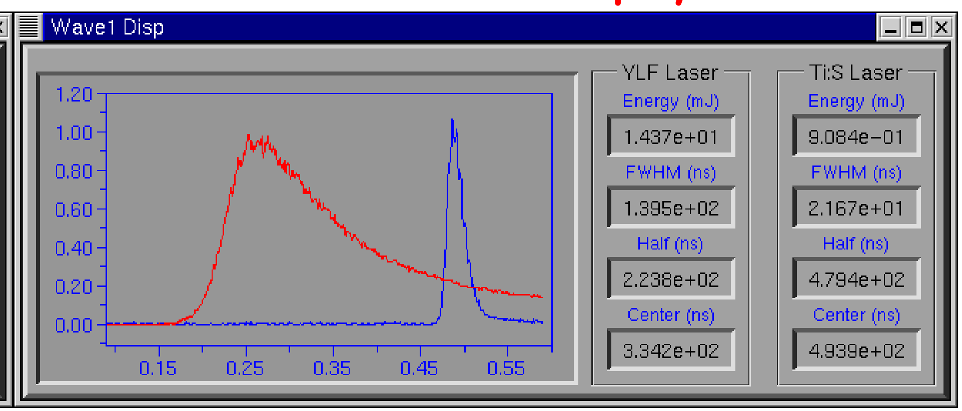
III Laser DAQ control display

Laser System Control

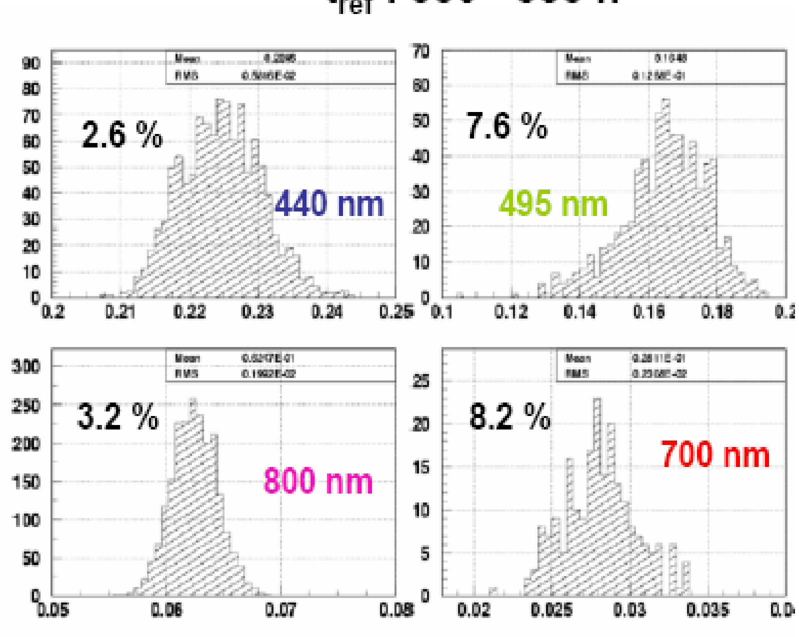
Laser Settings



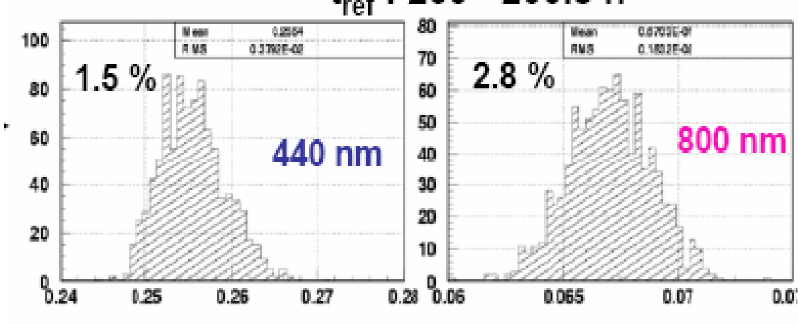
Waveform Display



t_{ref} : 330 - 355 h

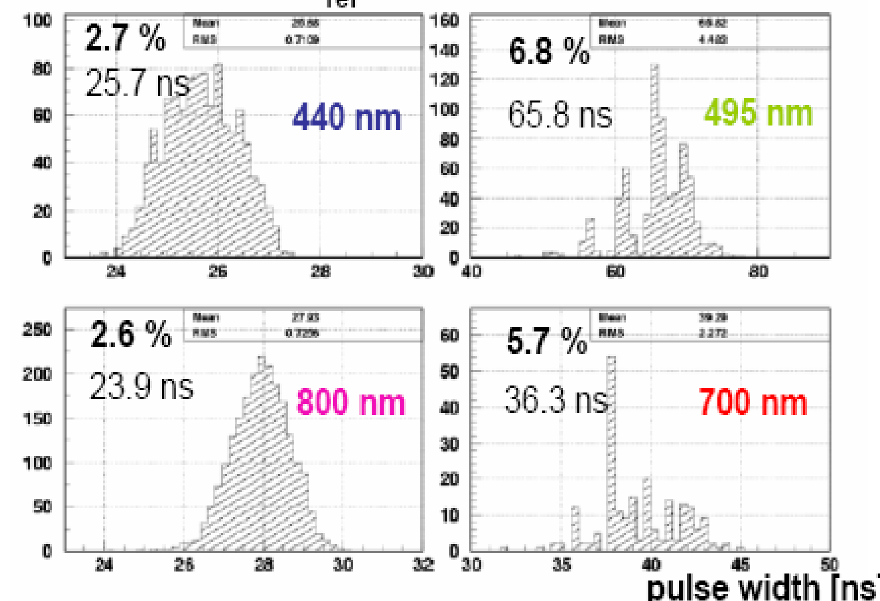


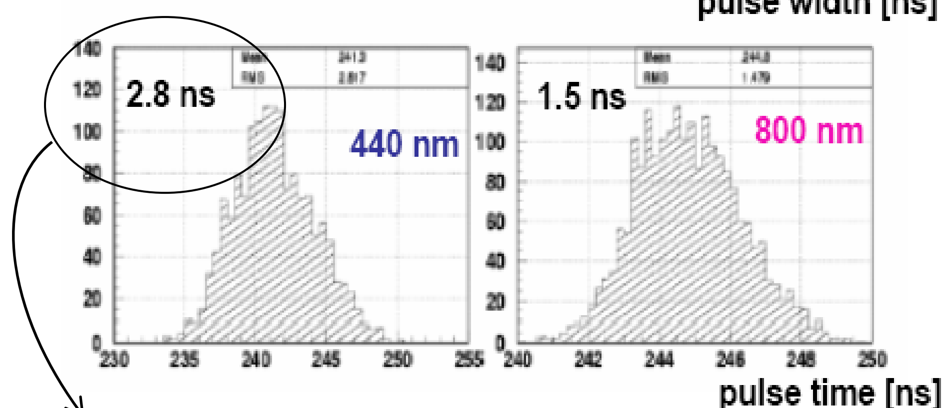
t_{ref} : 200 - 200.5 h



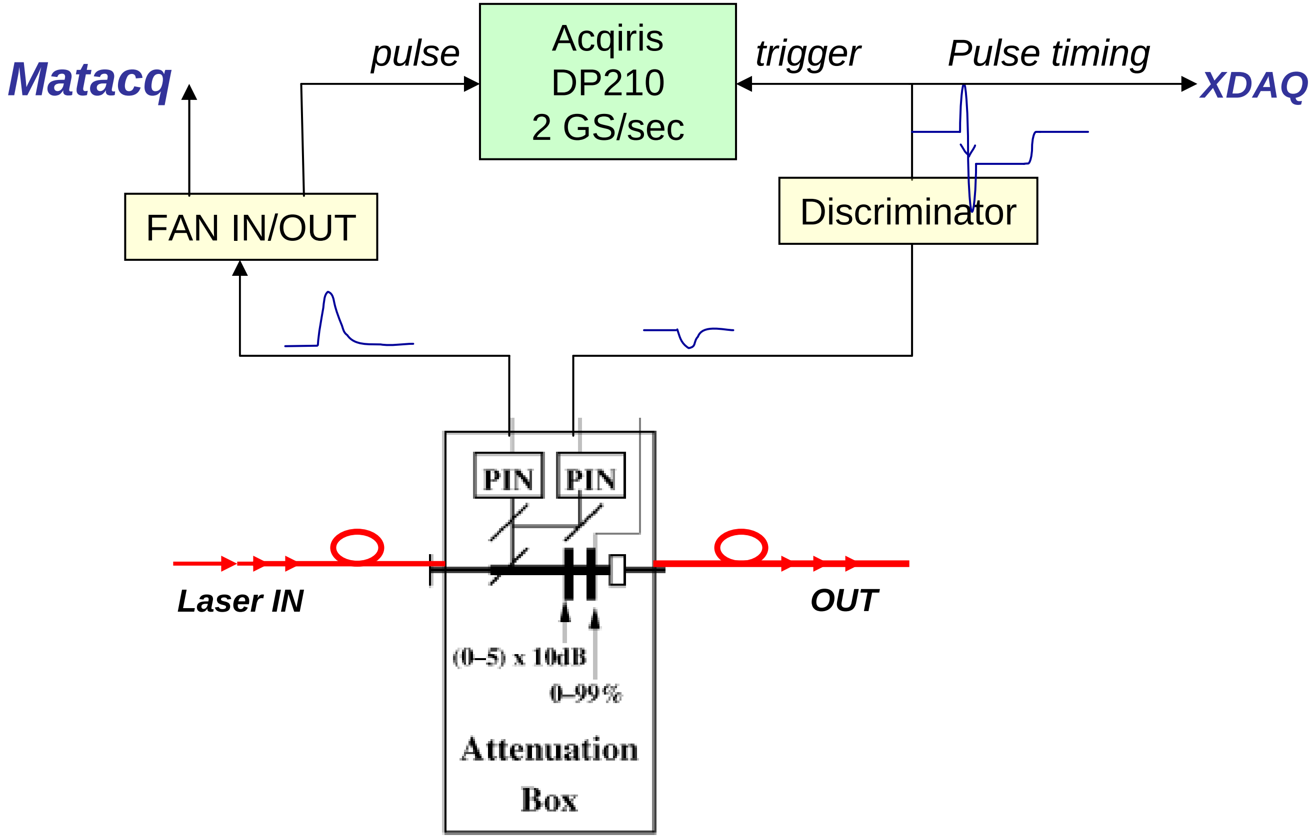
Pulse energy

t_{ref} : 330 - 355 h





Pulse jitter of monitoring light



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

III Acqiris DP210 Card (2GS/s, 2004)

To follow Ti:S performance pulse by pulse

↓

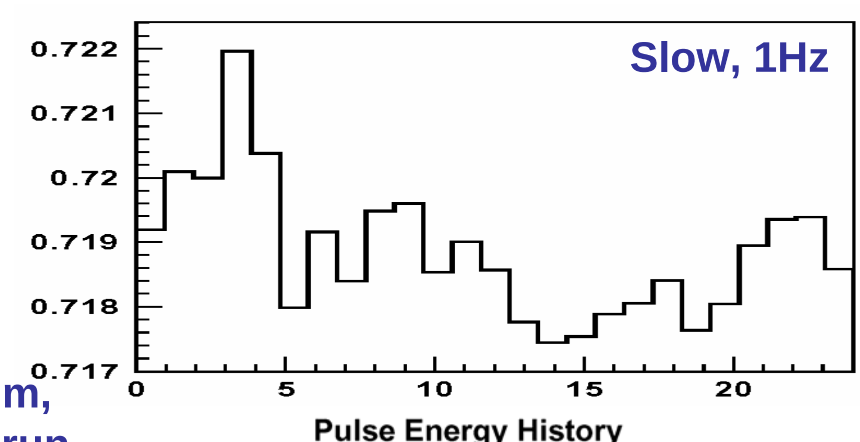
Fast sampling ADC (2 GS/s) on one PC

→ Acqiris DP210, PCI card with oscilloscope characteristics, 500MHz BW, 8bit

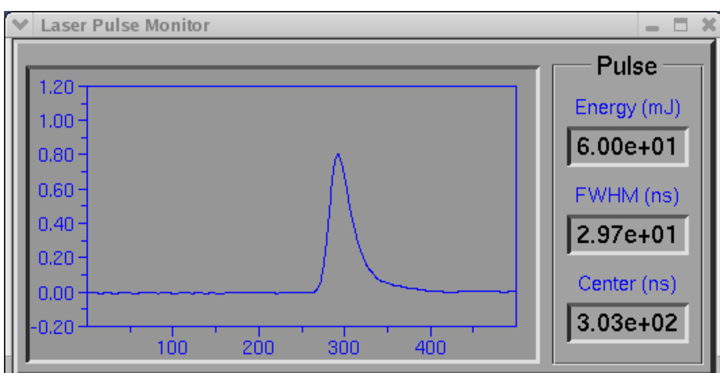
↓

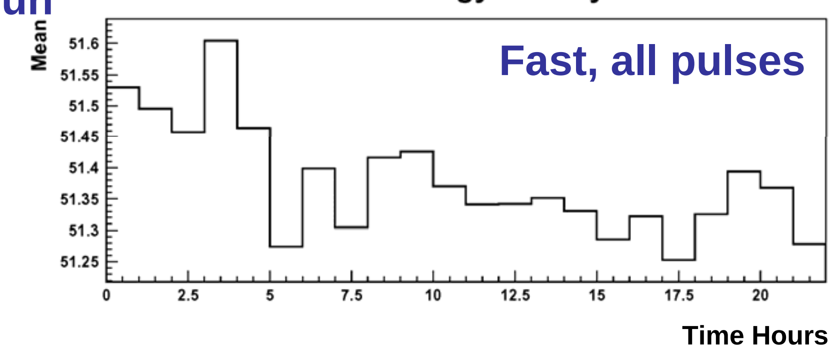
Record all Ti:S pulses: Intensity & FWHM

No laser timing information: self-triggered



440 nm, Same run





Option: filter 60MHz available

IV Communication with ECAL: Laser Supervisor

Communication with the XDAQ: 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.

<u>Laser parameters controlled by XDAQ :</u>

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

IV Communication protocol

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

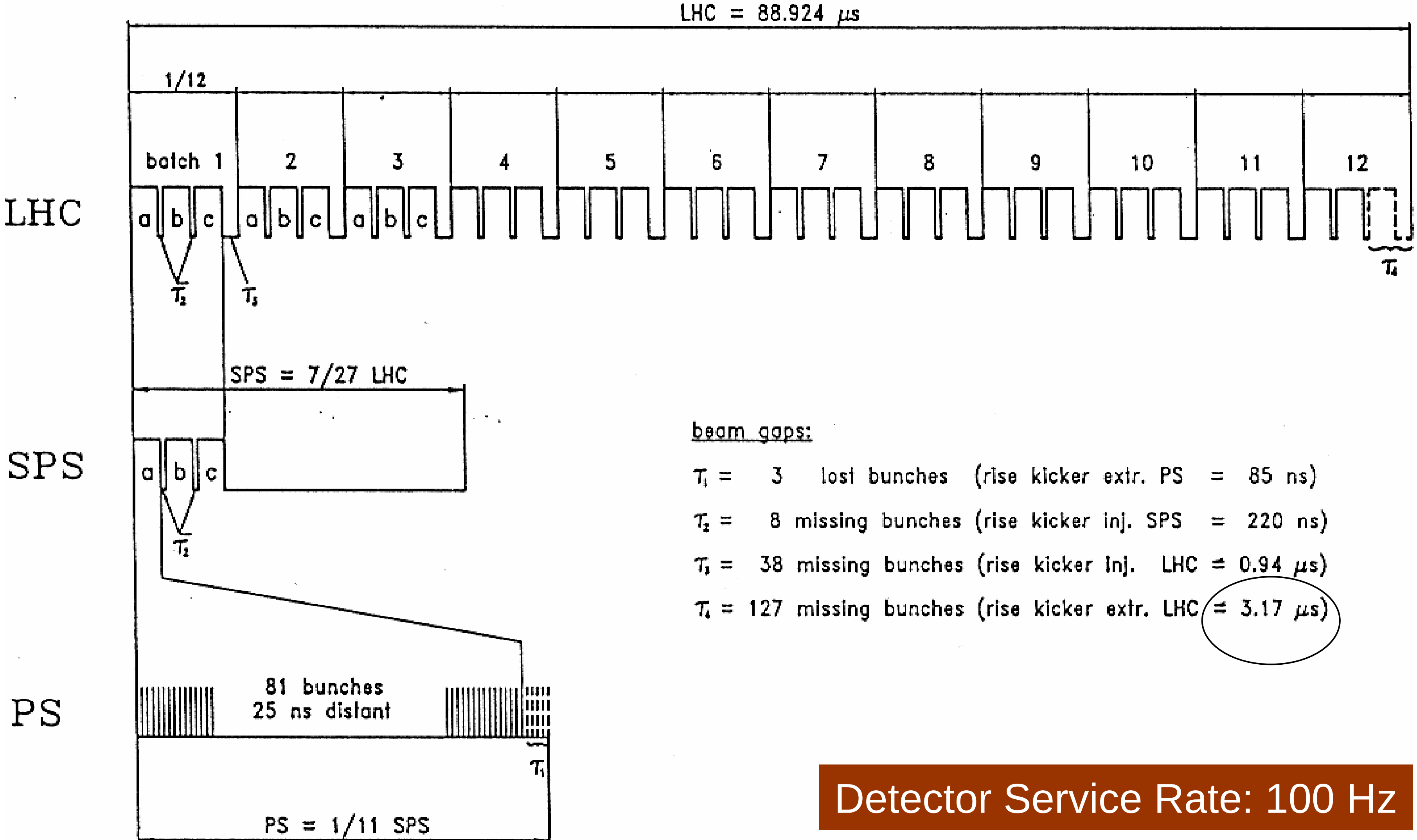
COMMAND TYPE (int)	0: request laser parameters
	1: set laser parameters
	2: get laser parameters and pulse information
WAVELENGTH (int)	0: 440 nm
	1: 495 nm
	2: 709 nm
	3: 800 nm
ATTENUATOR (int)	1 – 99 % of laser power, in 1% step
SWITCH CHANNEL (int)	1 – 80
CHECK-SUM (int)	Bitwise inversion of the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

IV Continuous monitoring at CMS

Using 1% beam gaps in the LHC beam structure



Detector Service Rate: 100 Hz

IV Time needed to scan the ECAL

Time to scan entire ECAL: **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
With XDAQ control:	*unknown*

→ Total time: depends on # of events/channel & XDAQ overhead

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

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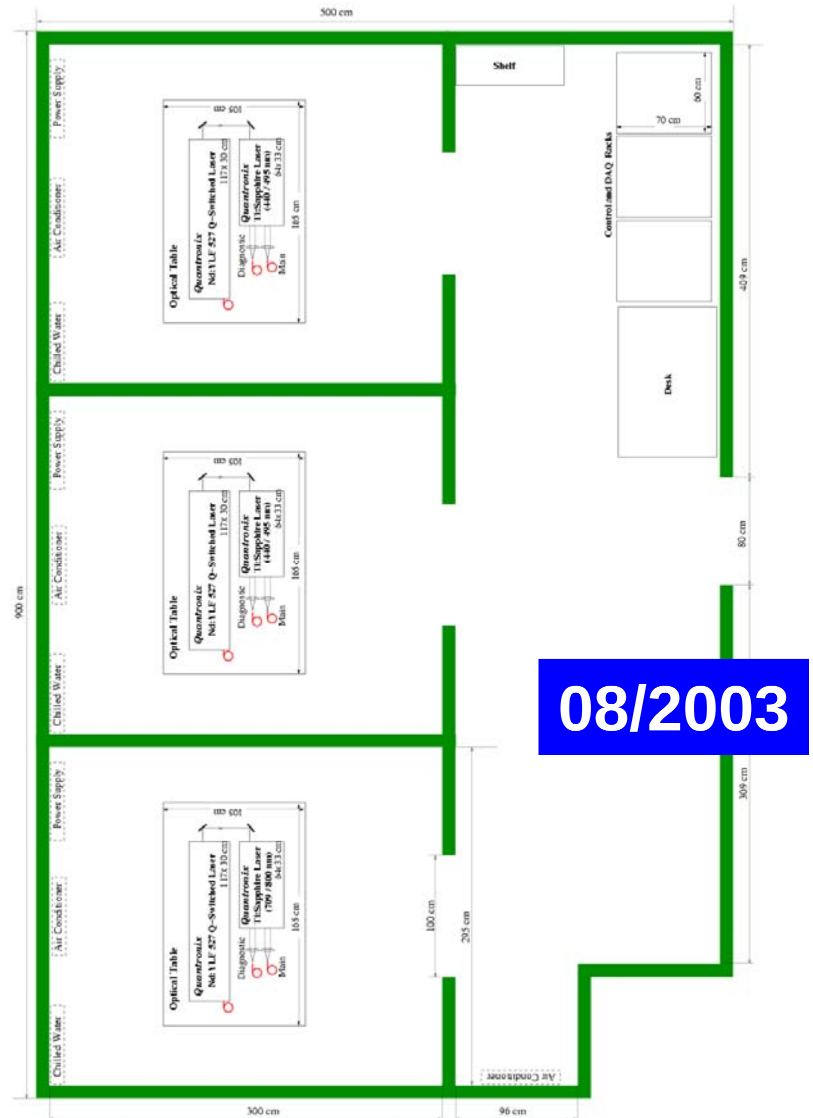
If so, can the XDAQ handle the laser scan data ?

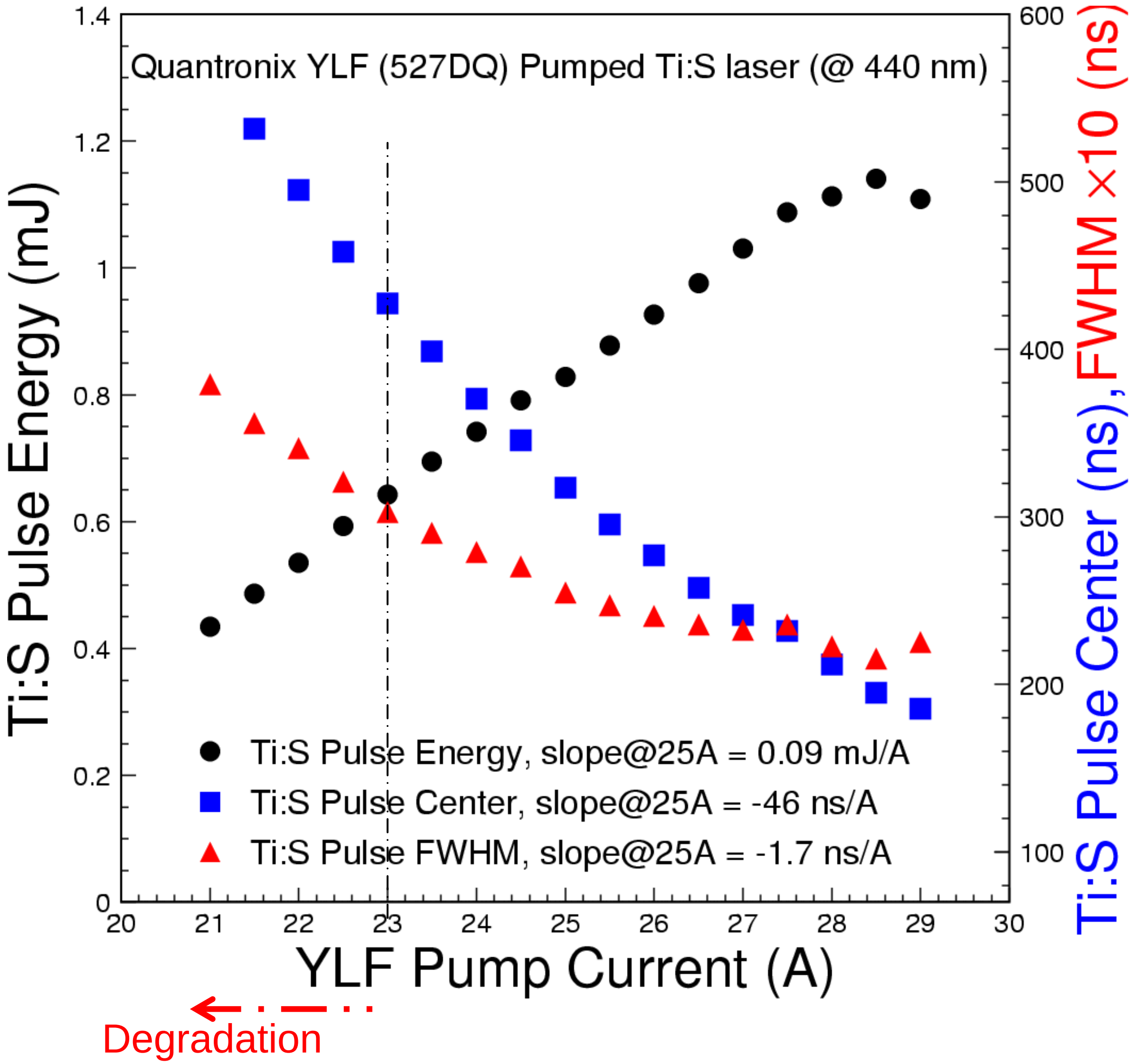
V Laser barracks at H4



V 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.

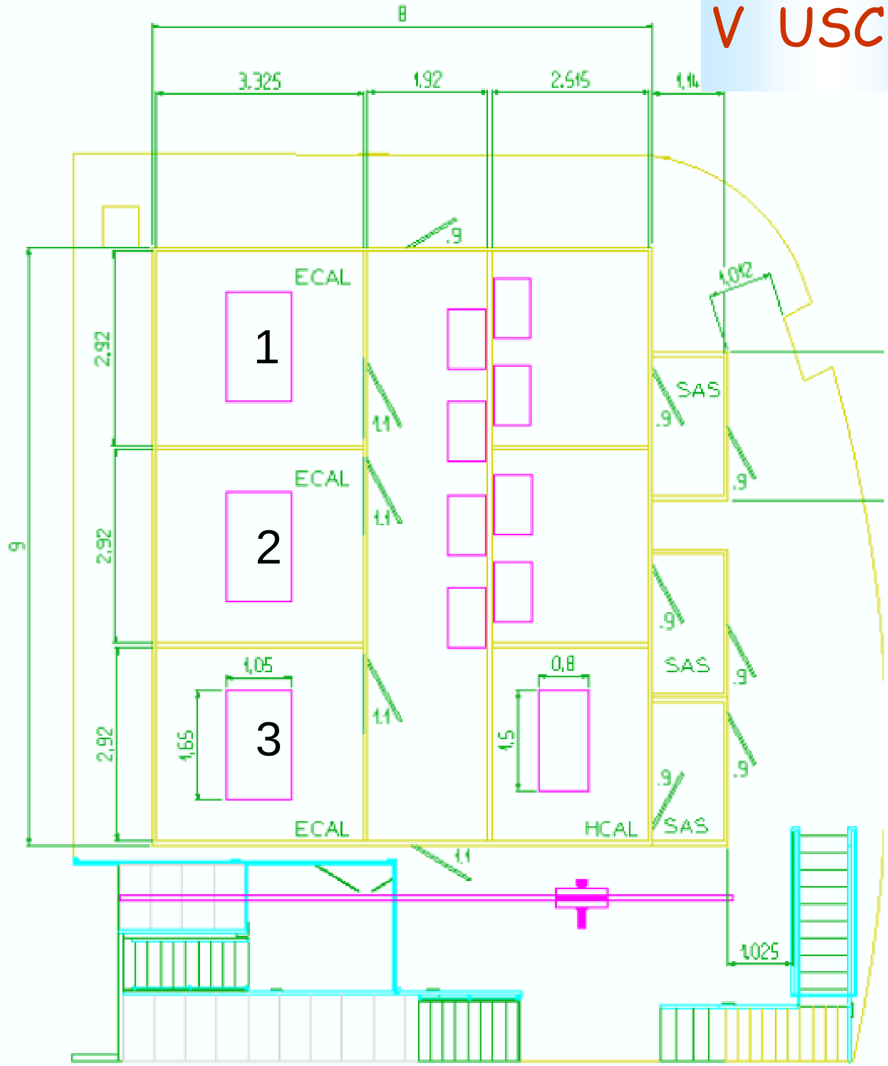


Laser pulse intensity, width and timing are correlated with the pumping current.

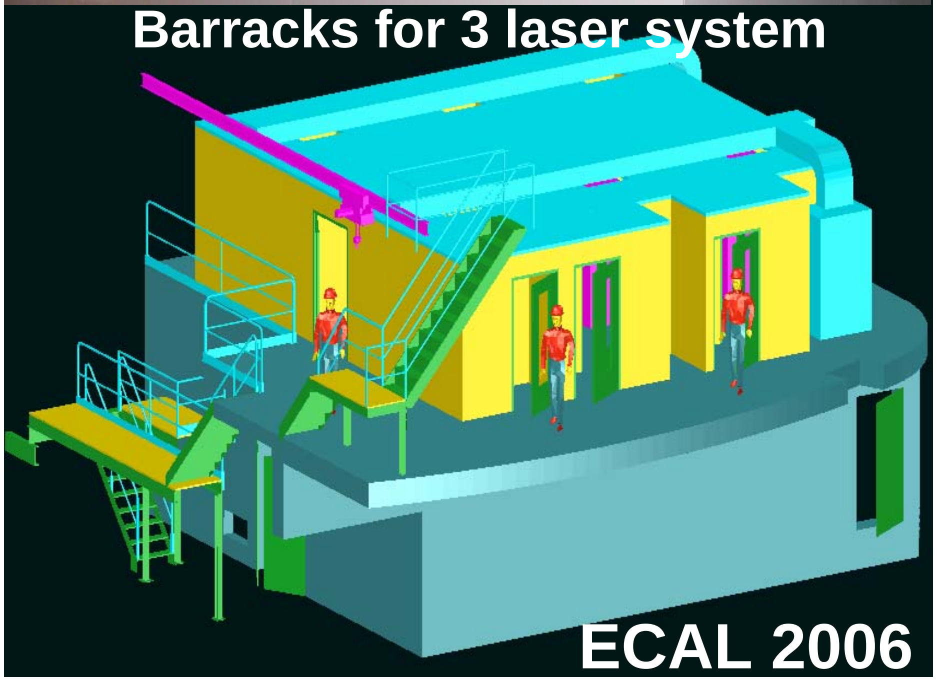
Better pulse stability could be achieved by trimming the YLF pumping current.

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

V USC55



Barracks for 3 laser system



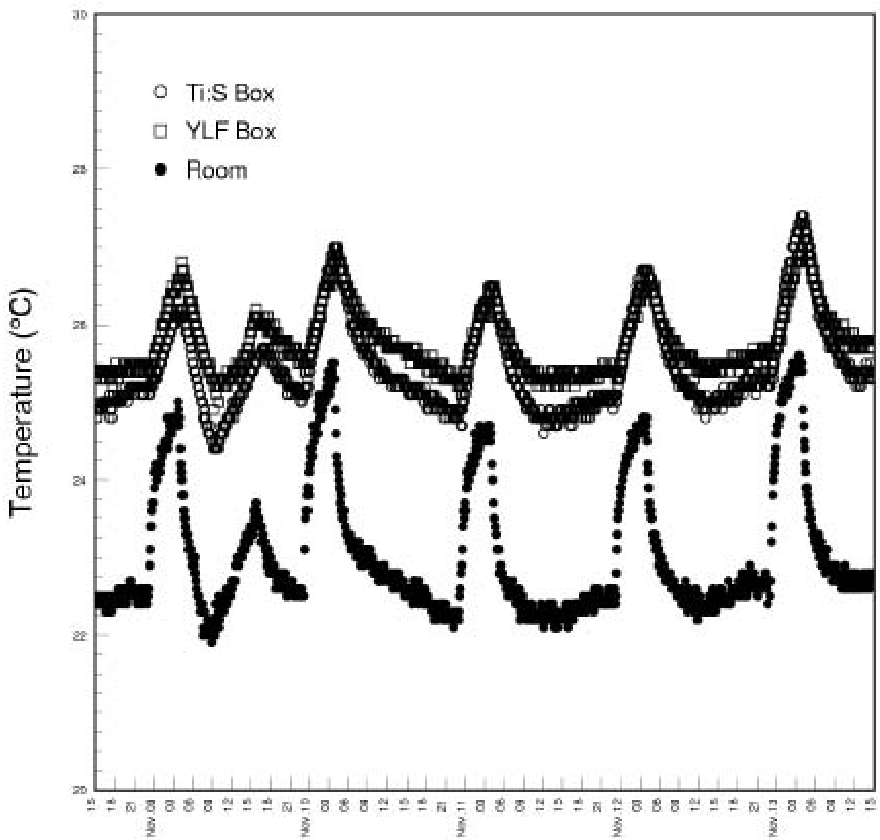
Barrack ready for April 2006

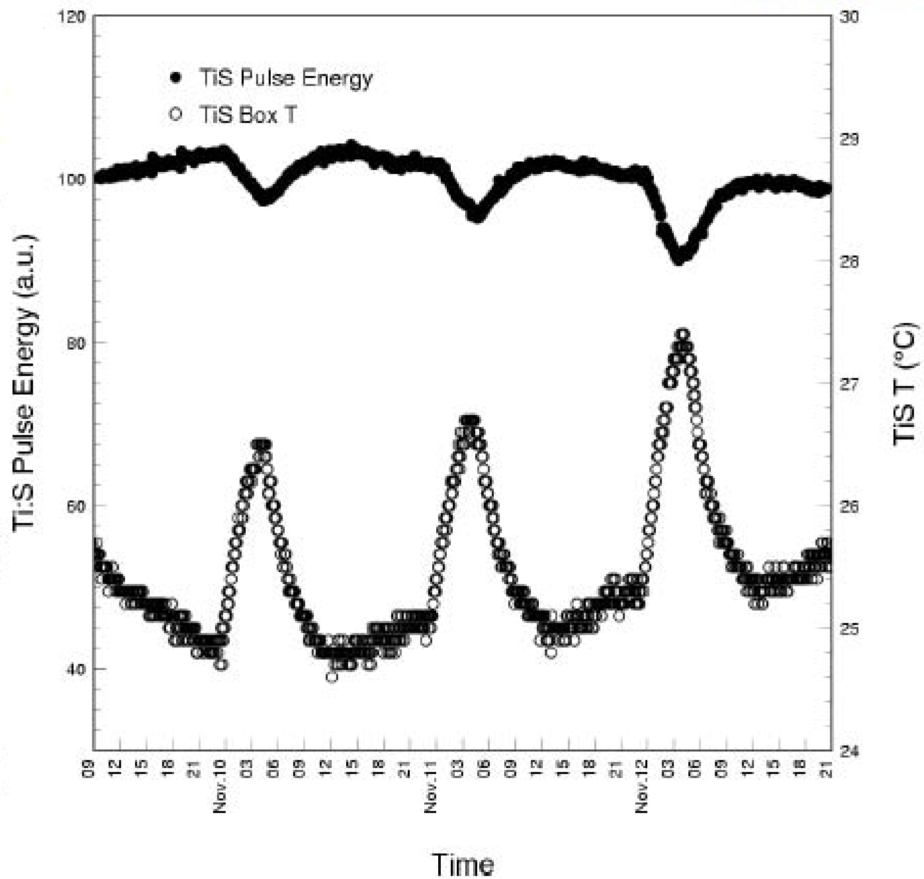
New: temperature stability ± 0.5 °C

One laser will be moved to USC55 in 2006?

A Study on Temperature Effect

Room T Variations in 5 Days

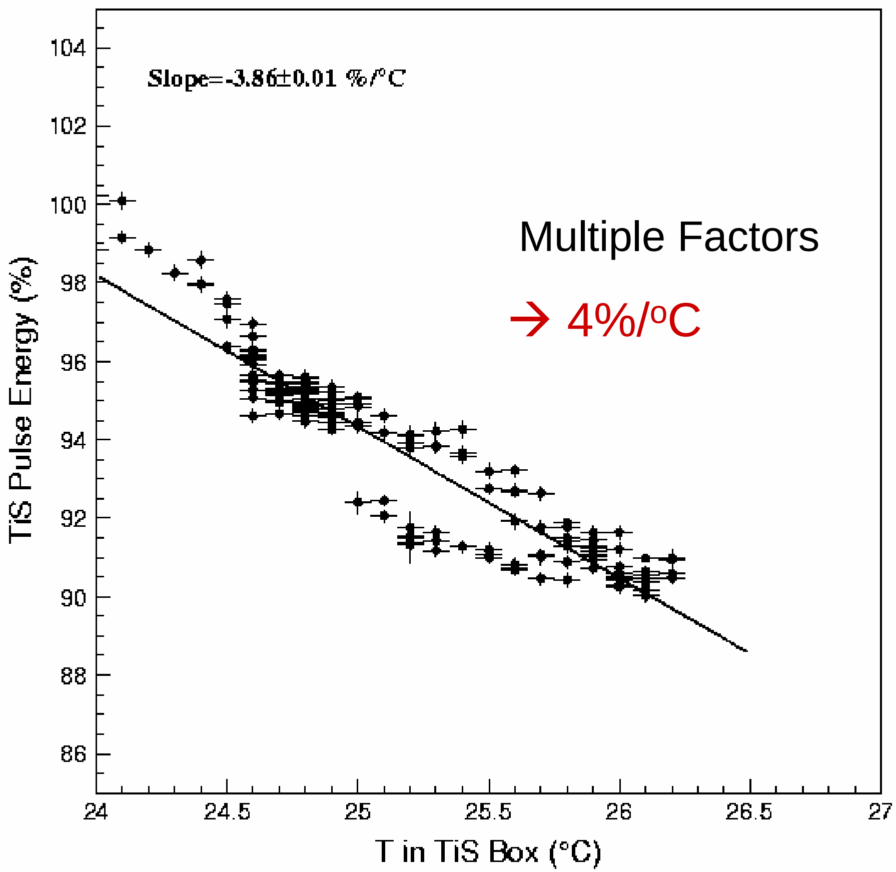




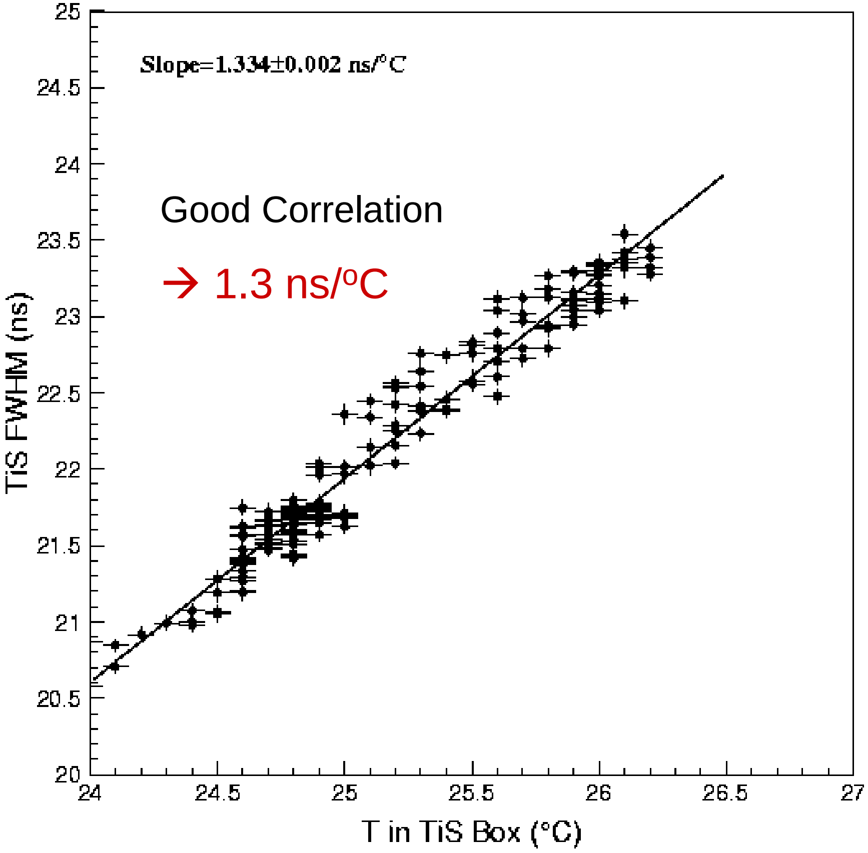
Ti:S Pulse Energy and T

V Temperature dependence

Ti:S Pulse Energy versus T



Ti:S Pulse FWHM versus T



Summary

- Laser performances 440nm:
  - Pulse width: <30ns
  - Pulse jitter: 2 to 4ns
  - Short term (0.5 h) instabilities: <2%
  - Long term (24 h) instability: 3%

  Stability getting better with improvement of the environment

- All 3 monitoring systems are consistent

- Laser maintenance: every **40 days minimum**
  - 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),*

For our planning:

Decisions on:
- when the laser system is needed at USC55 and
- if we want to keep 2 working laser systems at both H4 and USC55 ? for how long ?

Caltech laser group: Renyuan Zhu *(main responsible)* – Liyuan Zhang *(laser)* – Kejun Zhu *(software)* – Adolf Bornheim (safety+ analysis)

http://laser-caltech.web.cern.ch/laser-caltech/