# WBS 4.4 $PbWO_4$ Monitoring

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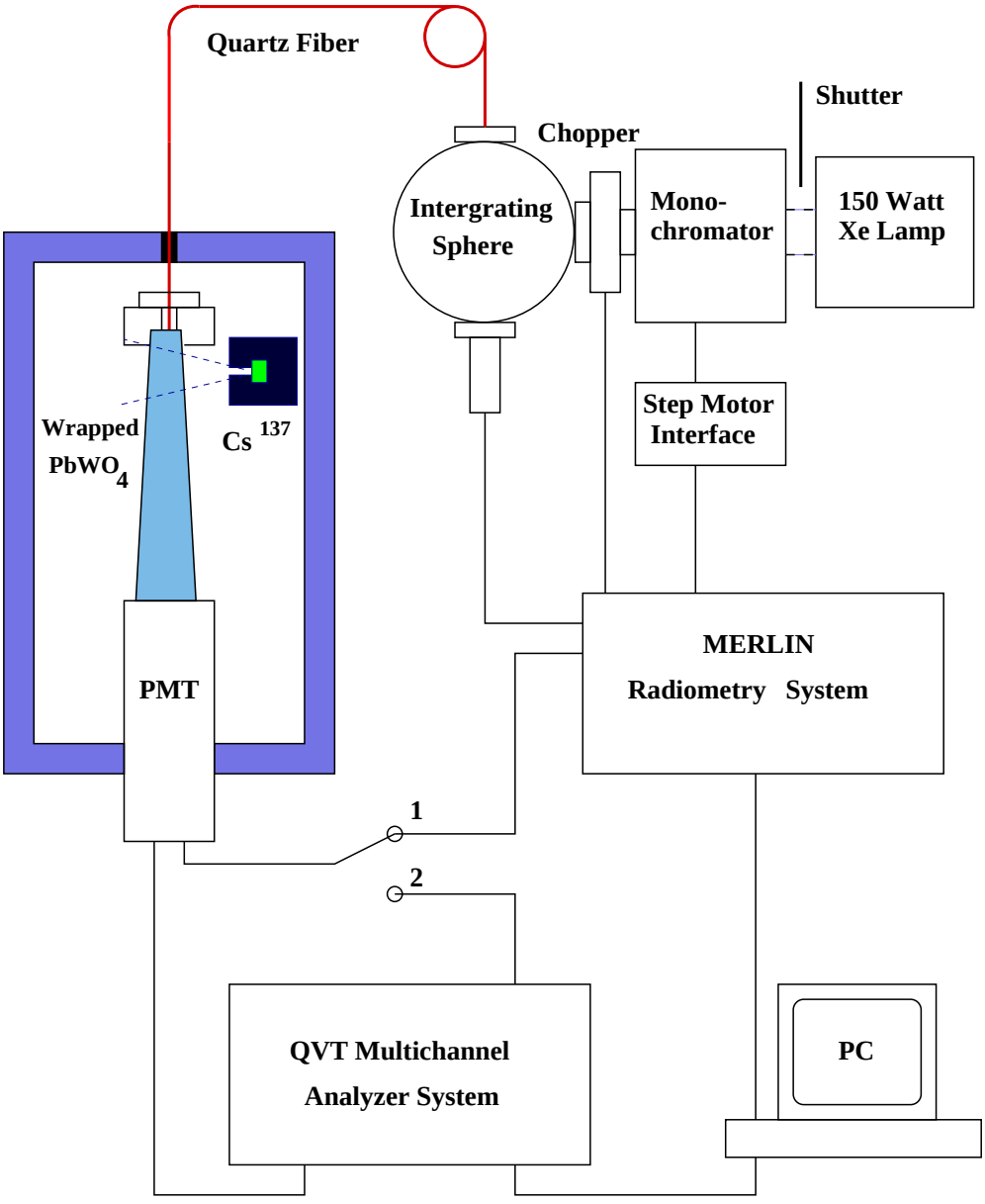
DoE Lehman Review
FNAL, Batavia
May 9, 2001

- Completed monitoring test bench, determined monitoring wavelengths at 440 nm.
- Monitoring construction is on schedule and cost.
  - The first laser system was repaired by Quantronix.
  - Control software are under development.
  - Completed a 240 h long term stability test.
  - The first laser system will be installed at CERN in August.

# Light Monitoring Test Bench

Based on ORIEL Optics

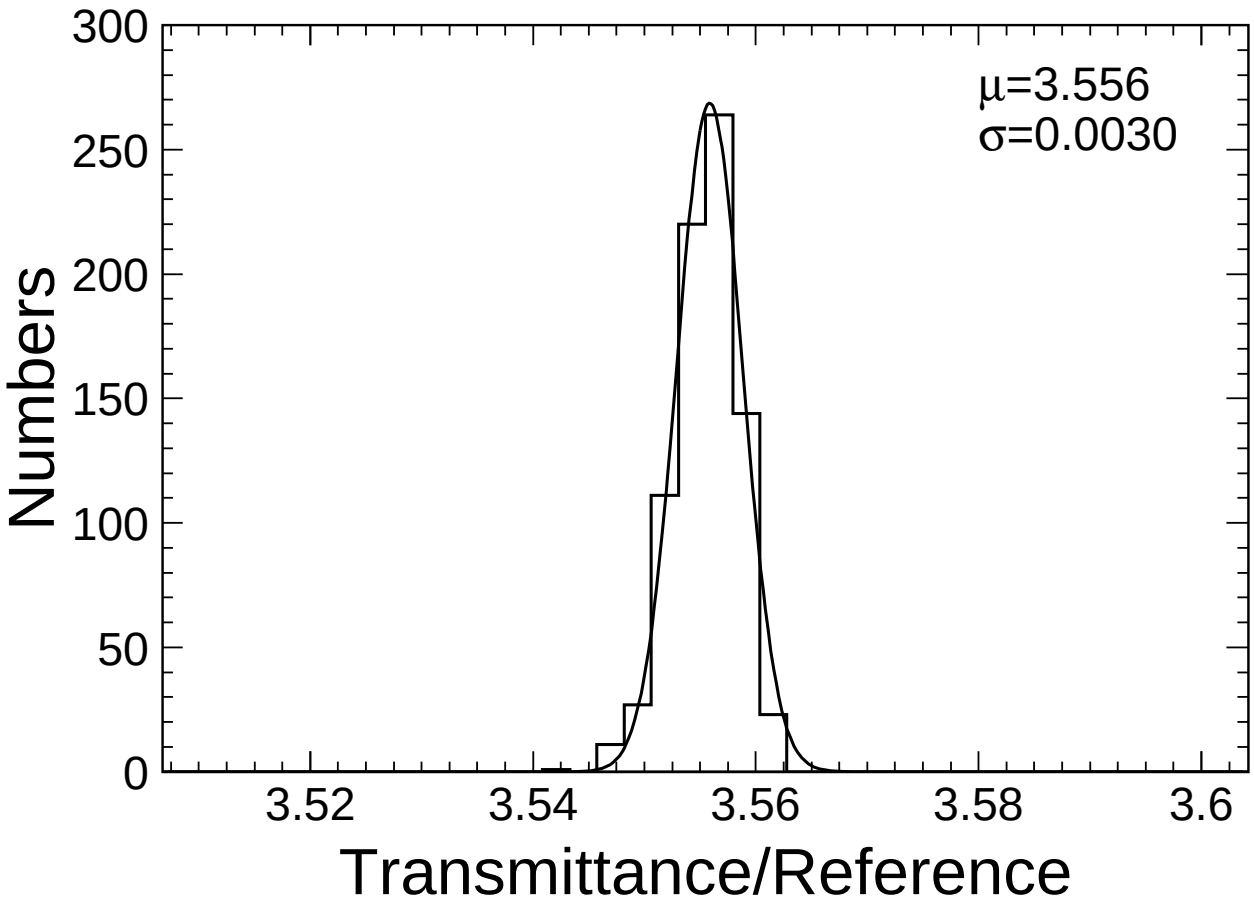
Position 1: Monitoring, Position 2: Light Output Measurement



## Monitoring Stability: Transmittance/Reference

Data taken in 23 hours

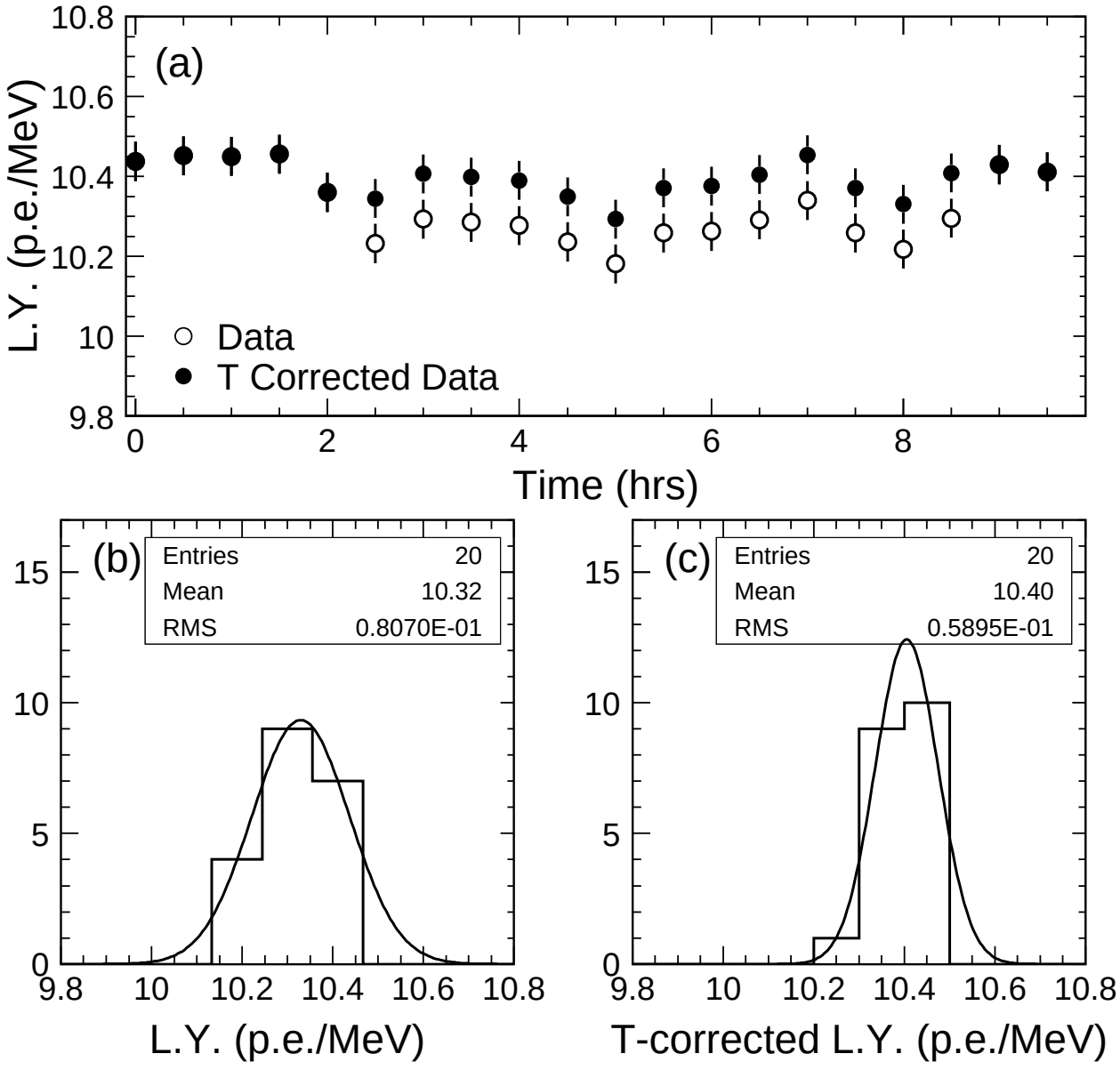
**0.1% is achieved**



# Monitoring Stability: Light Output

Data taken in 10 hours

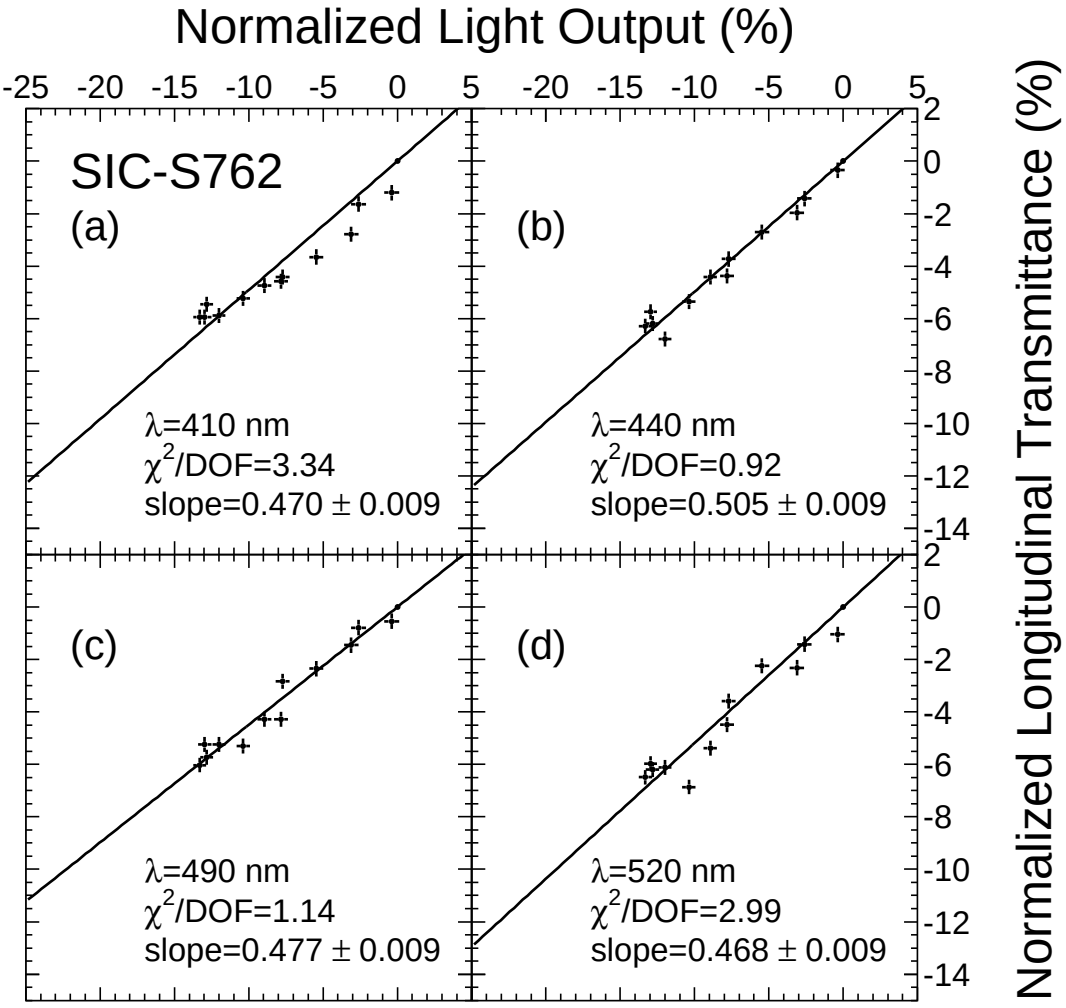
**Without/with T Correction: 0.8/0.6%**



# Correlations between Variations of T and L.O.

Linear Fit: $\frac{\Delta T}{T} = slope \times \frac{\Delta LY}{LY}$

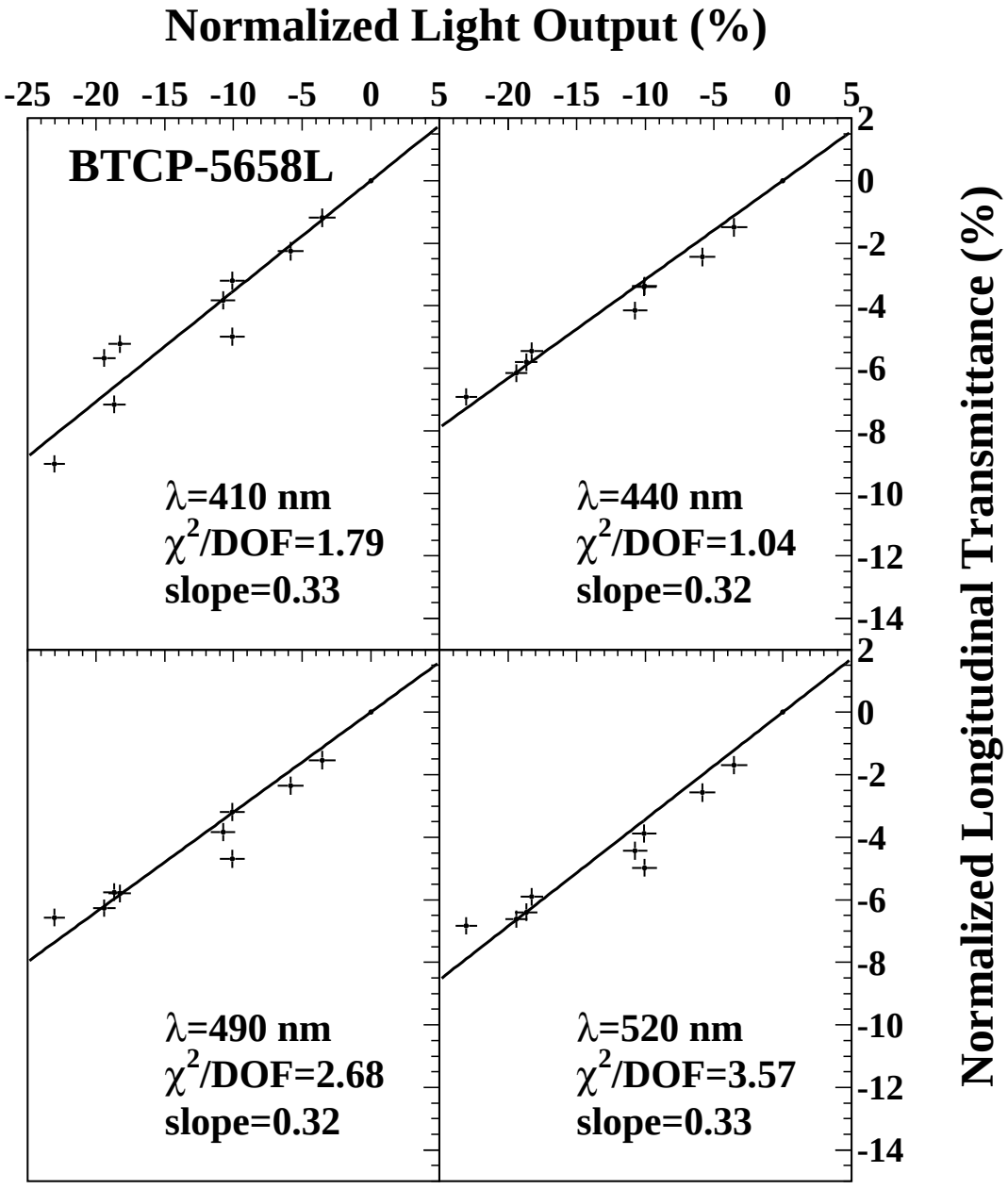
**Y** Doped $PbWO_4$ Sample SIC-S762



# Correlations between Variations of T and L.O.

Linear Fit: $\frac{\Delta T}{T} = slope \times \frac{\Delta LY}{LY}$

**Y/Nb** Doped $PbWO_4$ Sample BTCP-2133

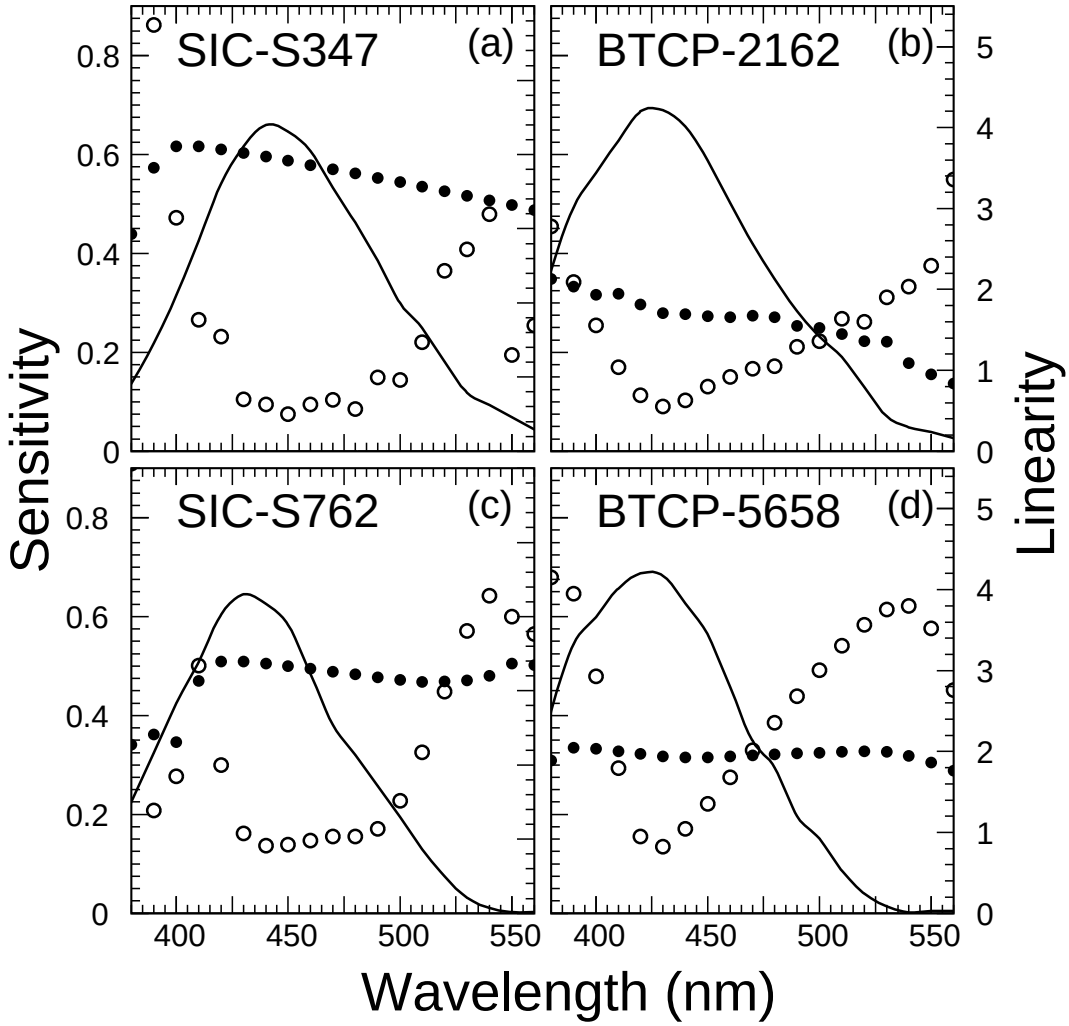


# Monitoring Sensitivity and Linearity

**Y** and **Y/Nb** Doped $PbWO_4$ Samples

Wavelength of Choice: 440 nm

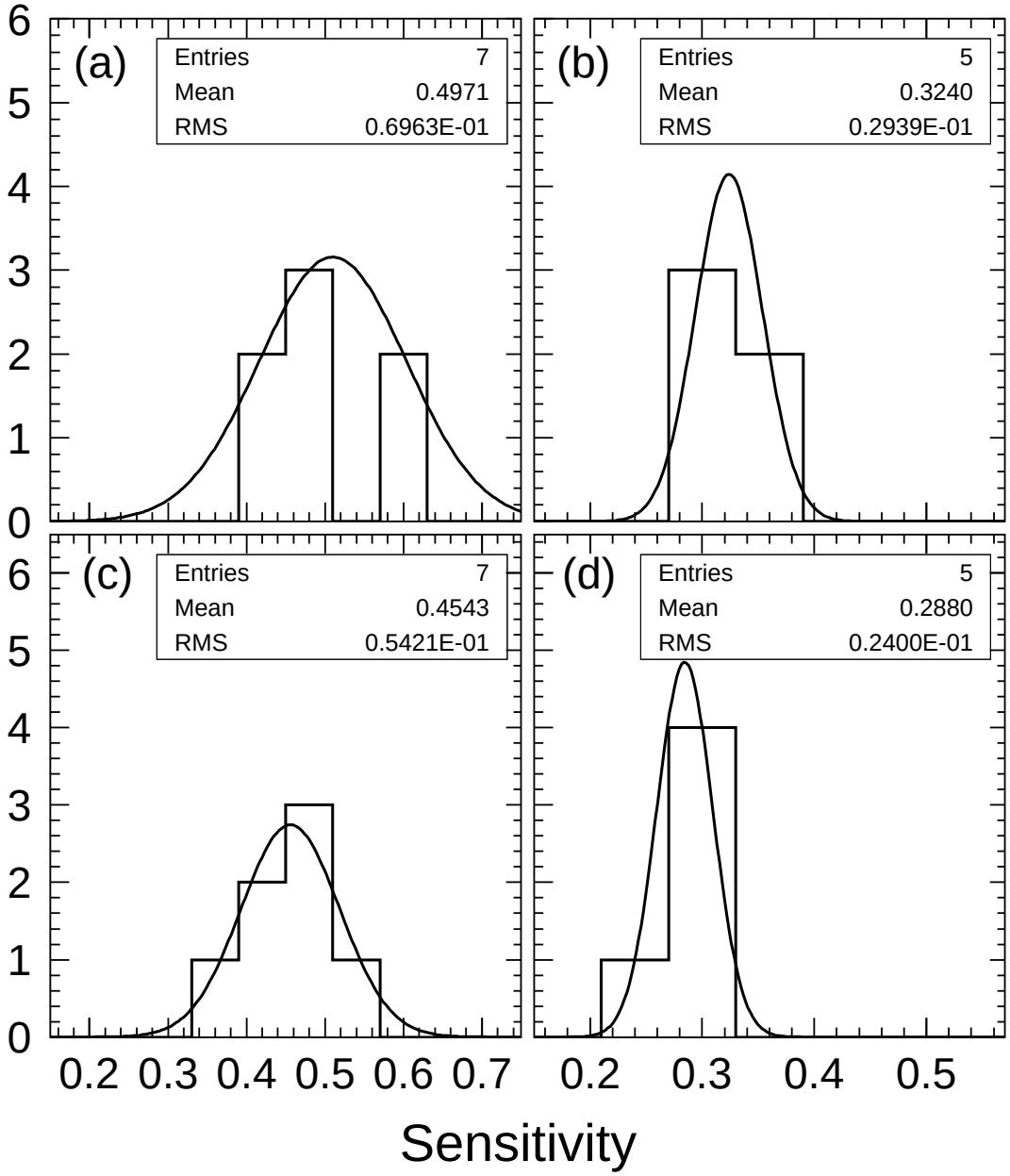
*IEEE Trans. Nucl. Sci.* **NS-47** (2000) 1741.



# Consistency of Sensitivity at Wavelength of 440/490 nm

for 7 Bridgman (a/c) and 5 Czochralski (b/d) $PbWO_4$ Samples

**14/12% and 9.1/8.3%**



## Status of Monitoring Construction

1. The lasers was sent back to Quantronix in July 2000, for repair.

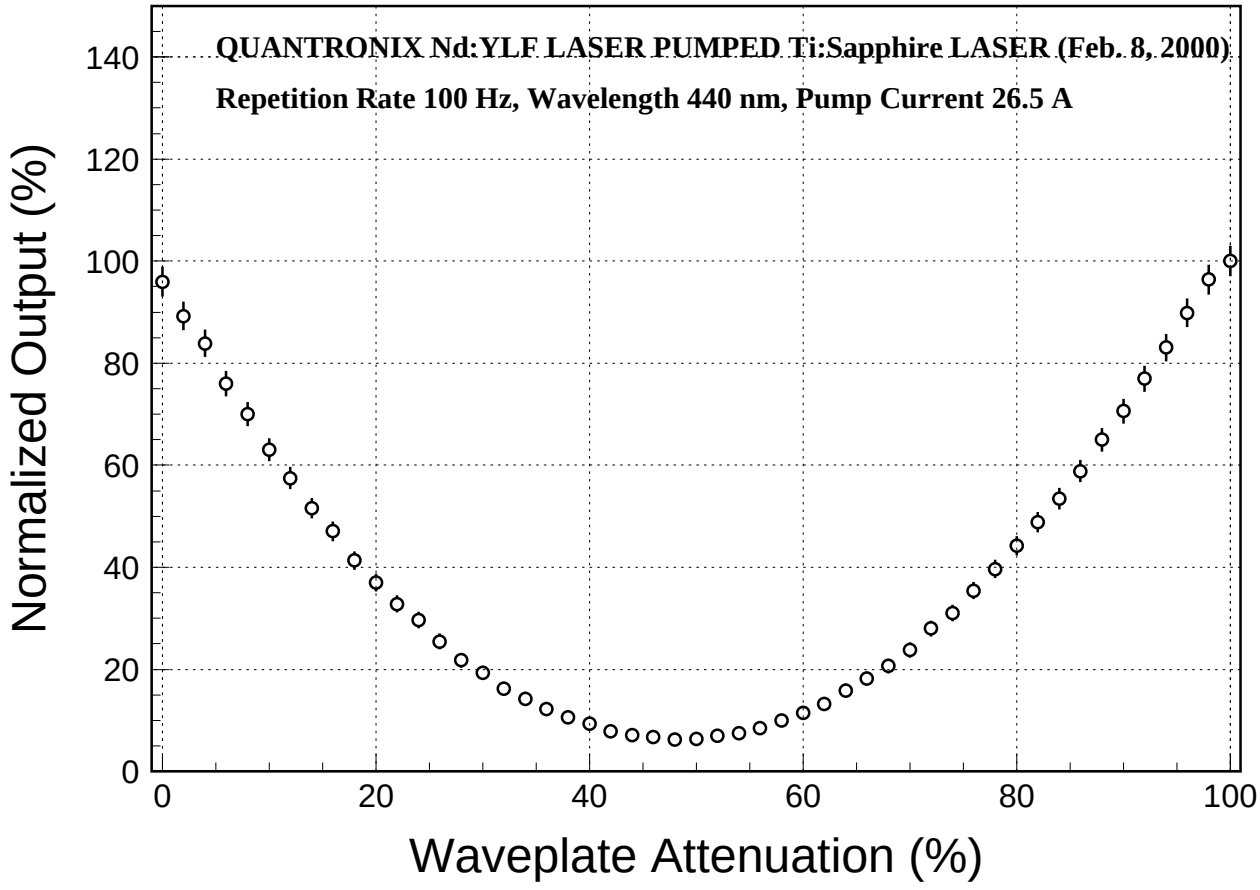
2. The software control and readout are under construction.

3. Quantronix sent back the lasers in January, 2001. A long term stability test of 240 hours was carried out.

4. The 1st laser system is scheduled to be installed at CERN in August 2001.

# Pulse Intensity Attenuation with Wave Plate Angle

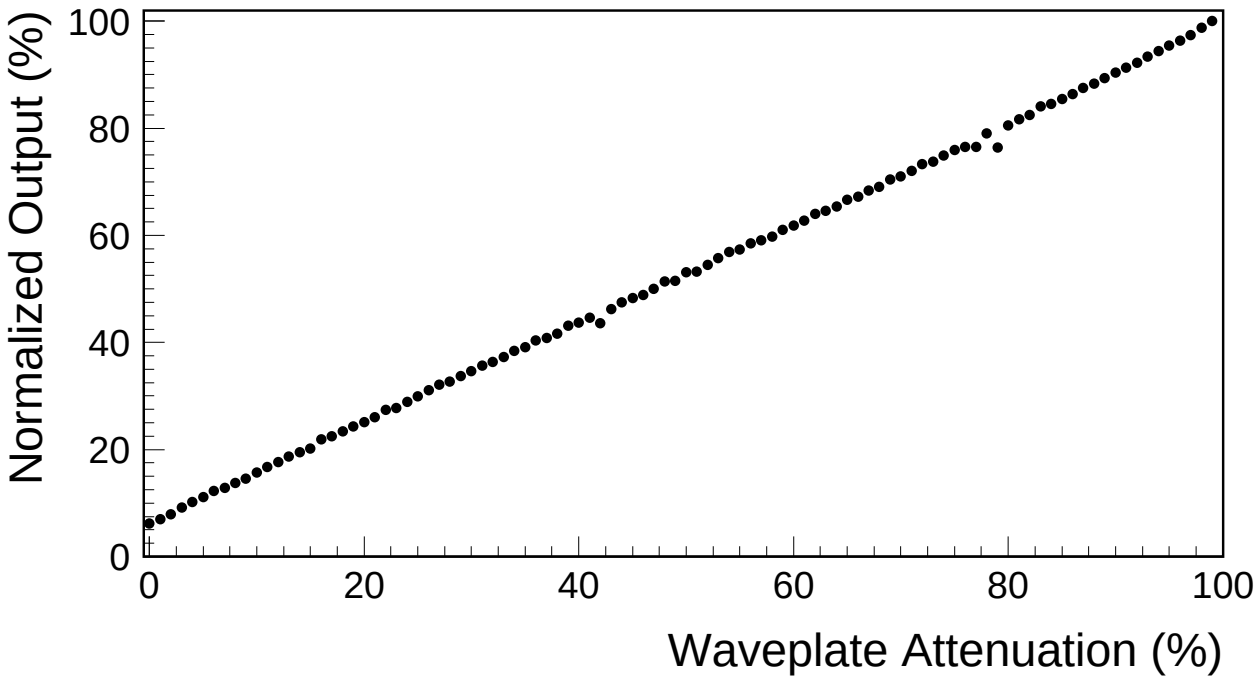
Before Laser System Repair



# Pulse Intensity Attenuation with Wave Plate Angle

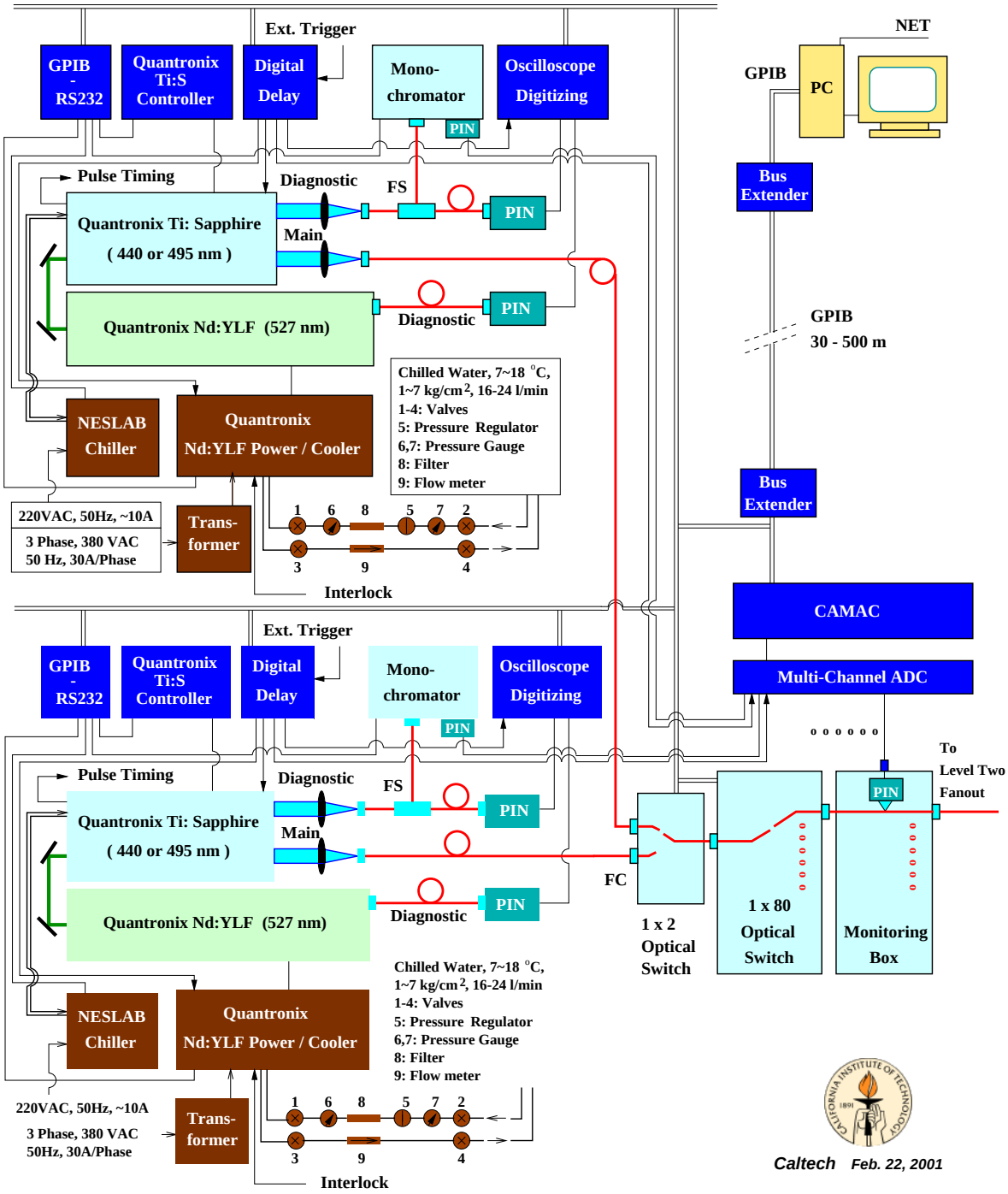
After Laser System Repaired

**1% Step**



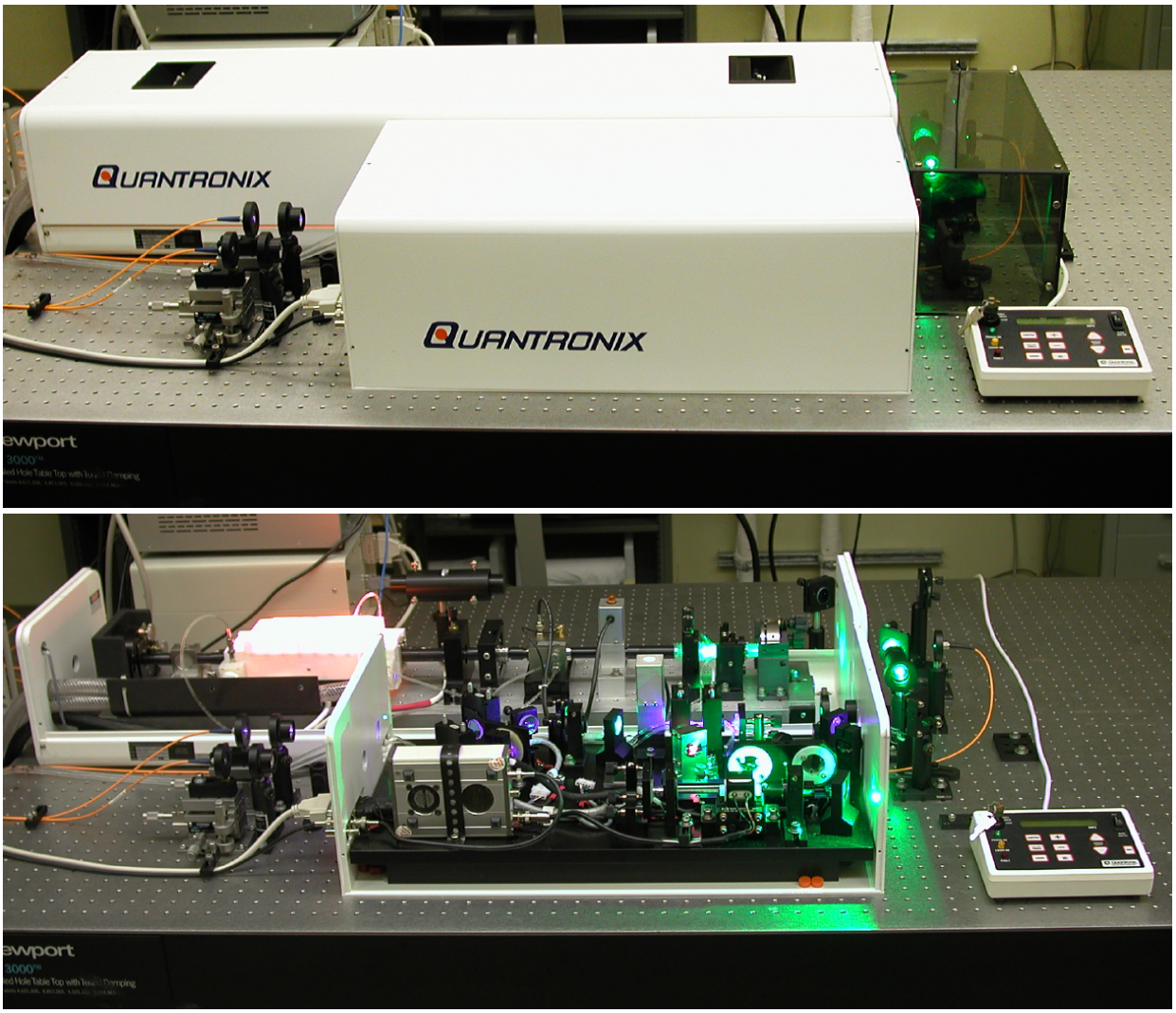
# Monitoring Light Source & High Level Distribution

## Two Laser Systems, Switch, Monitor and Control

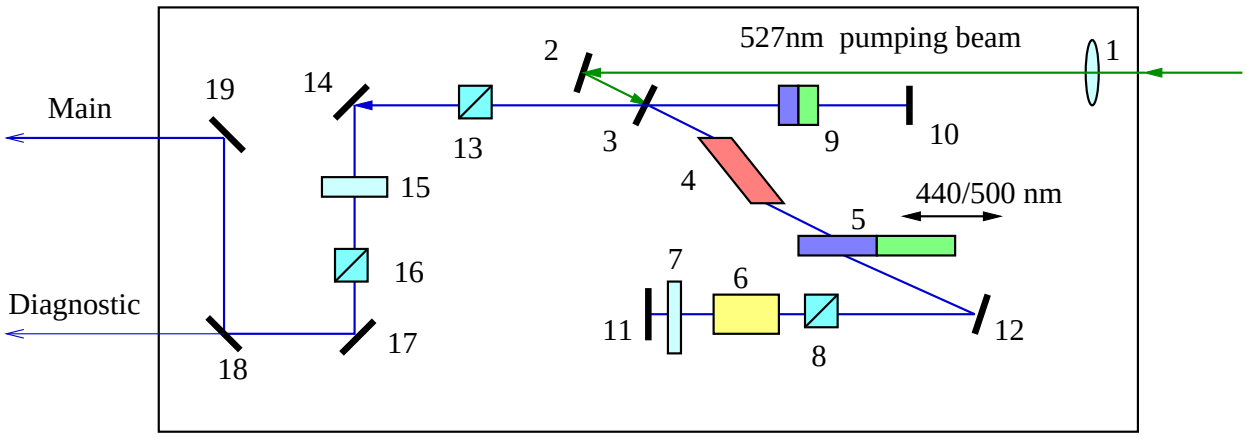



*Caltech* *Feb. 22, 2001*

# Nd:YLF and Ti:S Monitoring Lasers



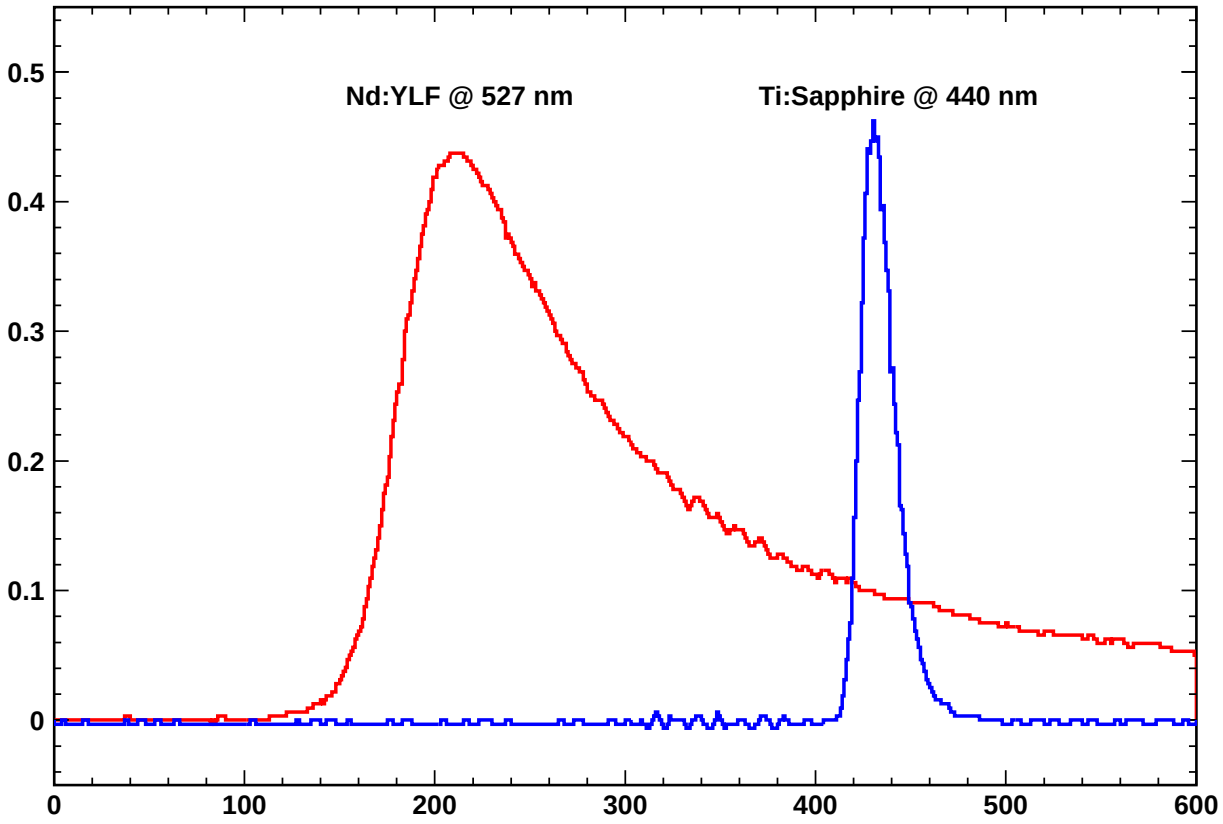
# Nd:YLF and Ti:S Monitoring Lasers




1: Pumping lens
2: Fold mirror
3: Pumping coupling and laser output mirror
4: Ti:Sapphire crystal
5: Birefringent filters (440/500 nm)
6: Pockel Cell
7: 1/4 waveplate
8: Polarizer
9: SHG crystals (LBO)
10, 11: Cavity mirrors
12: Cavity fold mirrors
13: Polarizer
14: Background depressing mirror
15: Waveplate
16: Polarizer
17: Background depressing mirror
18: 0.1/99.9 splitter
19: HR mirror

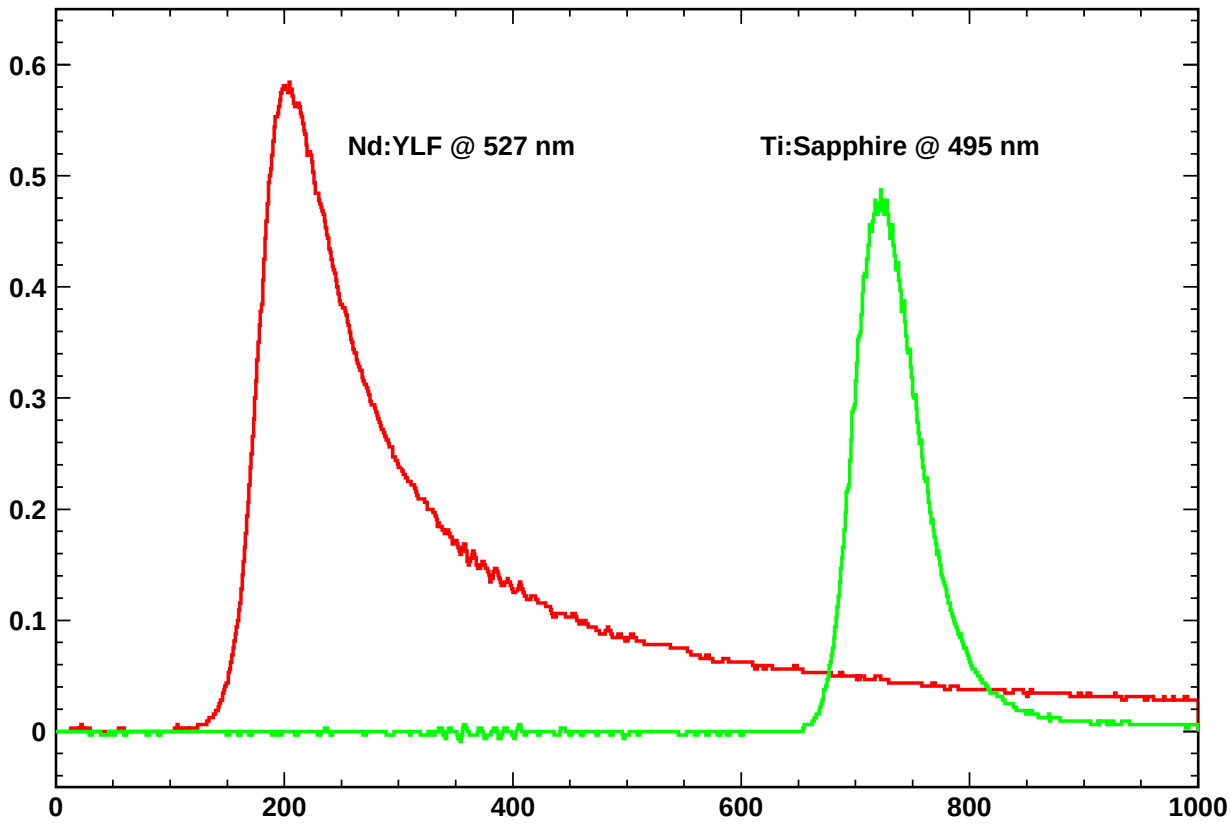
# Monitoring Laser Pulse Shape @ 440 nm

Recorded by HP54111D Digital Scope



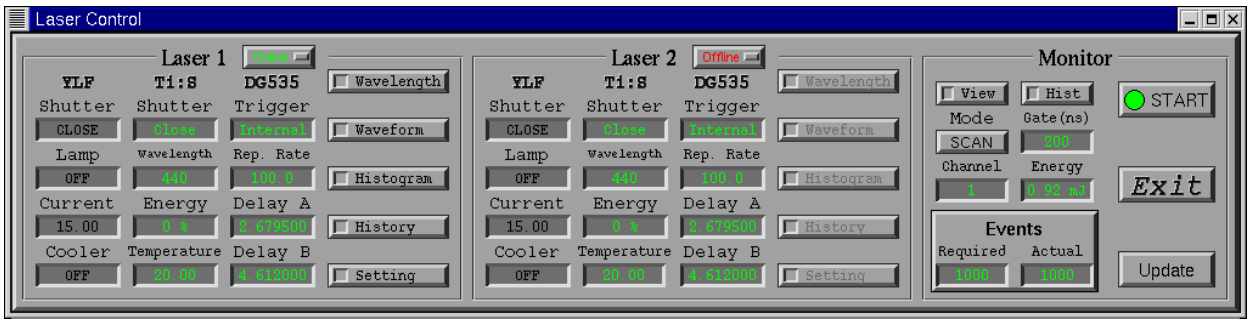
# Monitoring Laser Pulse Shape @ 495 nm

Recorded by HP54111D Digital Scope



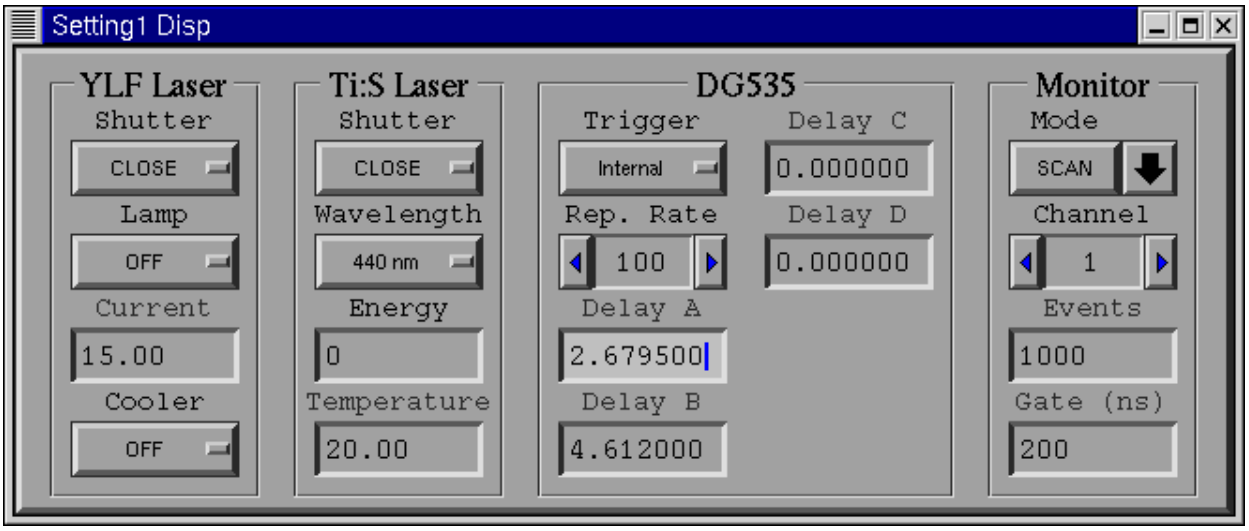
# Main Control for Monitoring Light Source

Two Laser Systems and Monitor Run Control



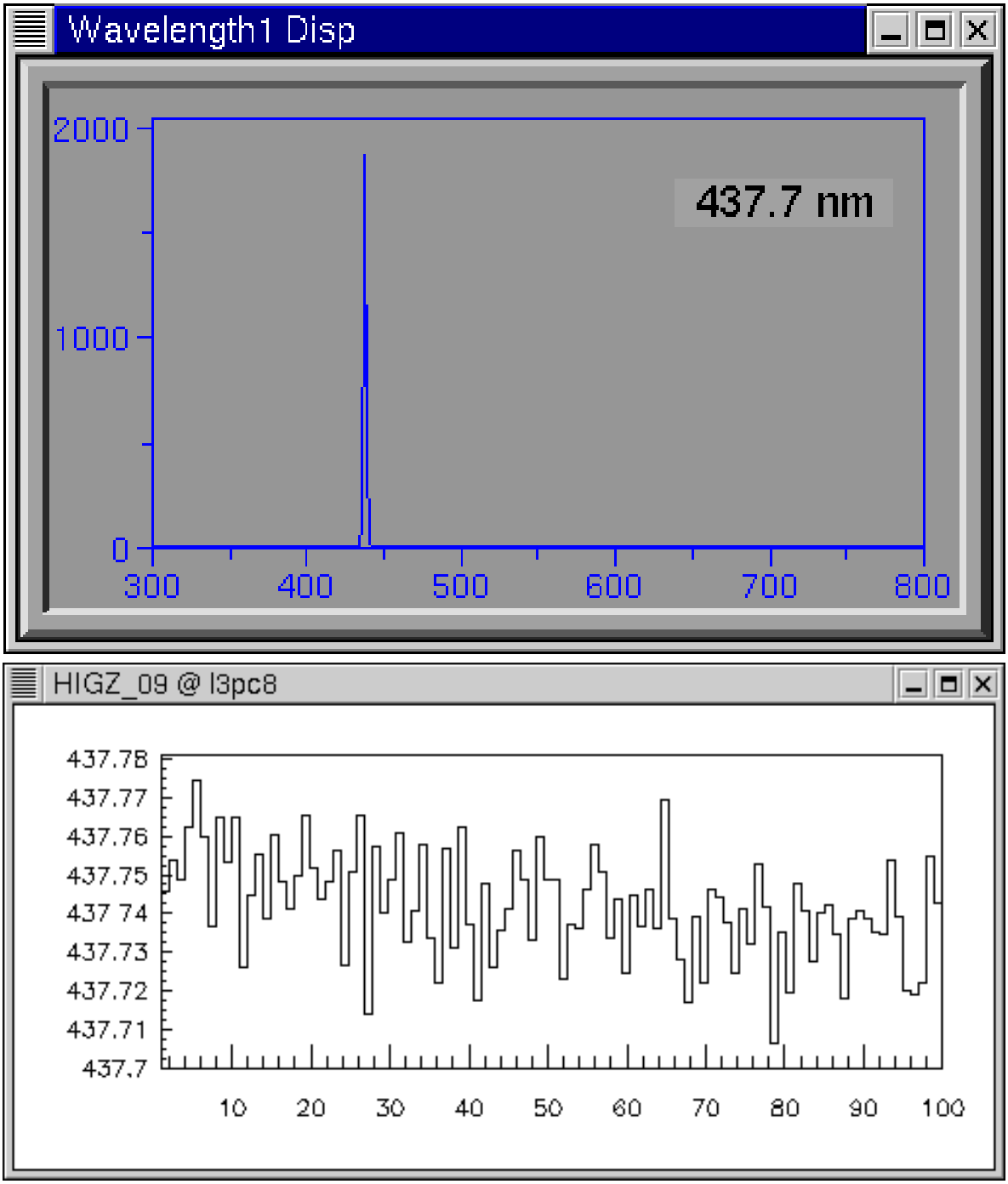

# Pop up Window for Laser Setting

Shutters, Lamp, Current, Coolings, Wavelength, E, Delays, Mode

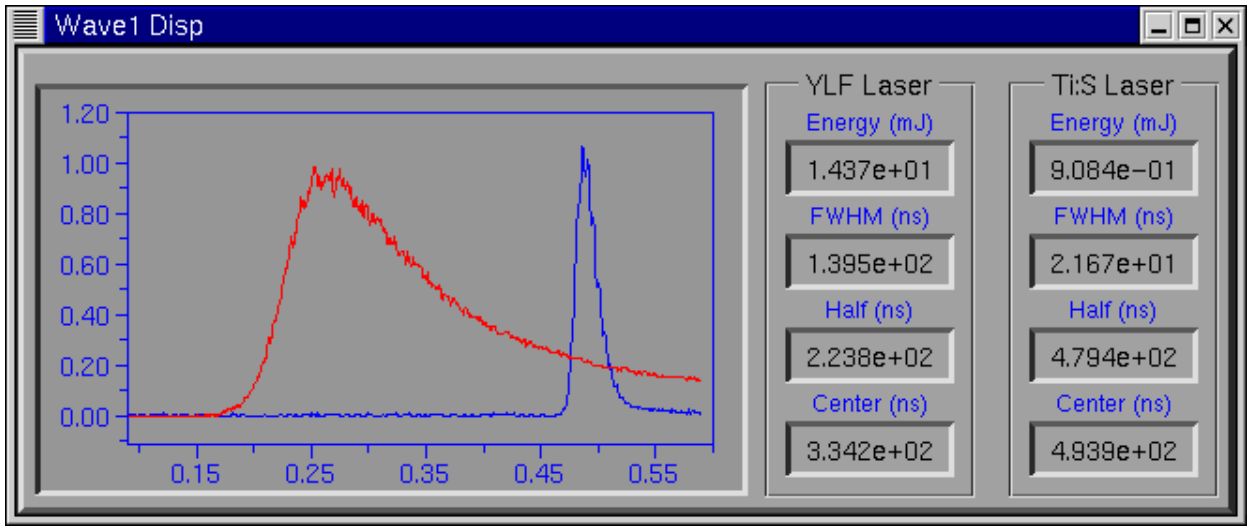


# Pop up Window for Wavelength Display

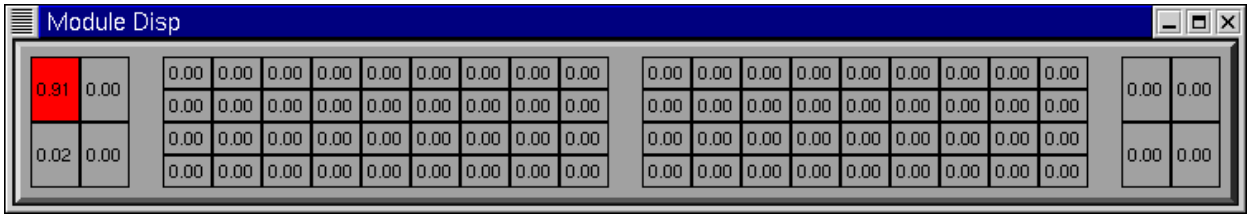
Spectrum and Histogram



# Pop up Window for Waveform Display

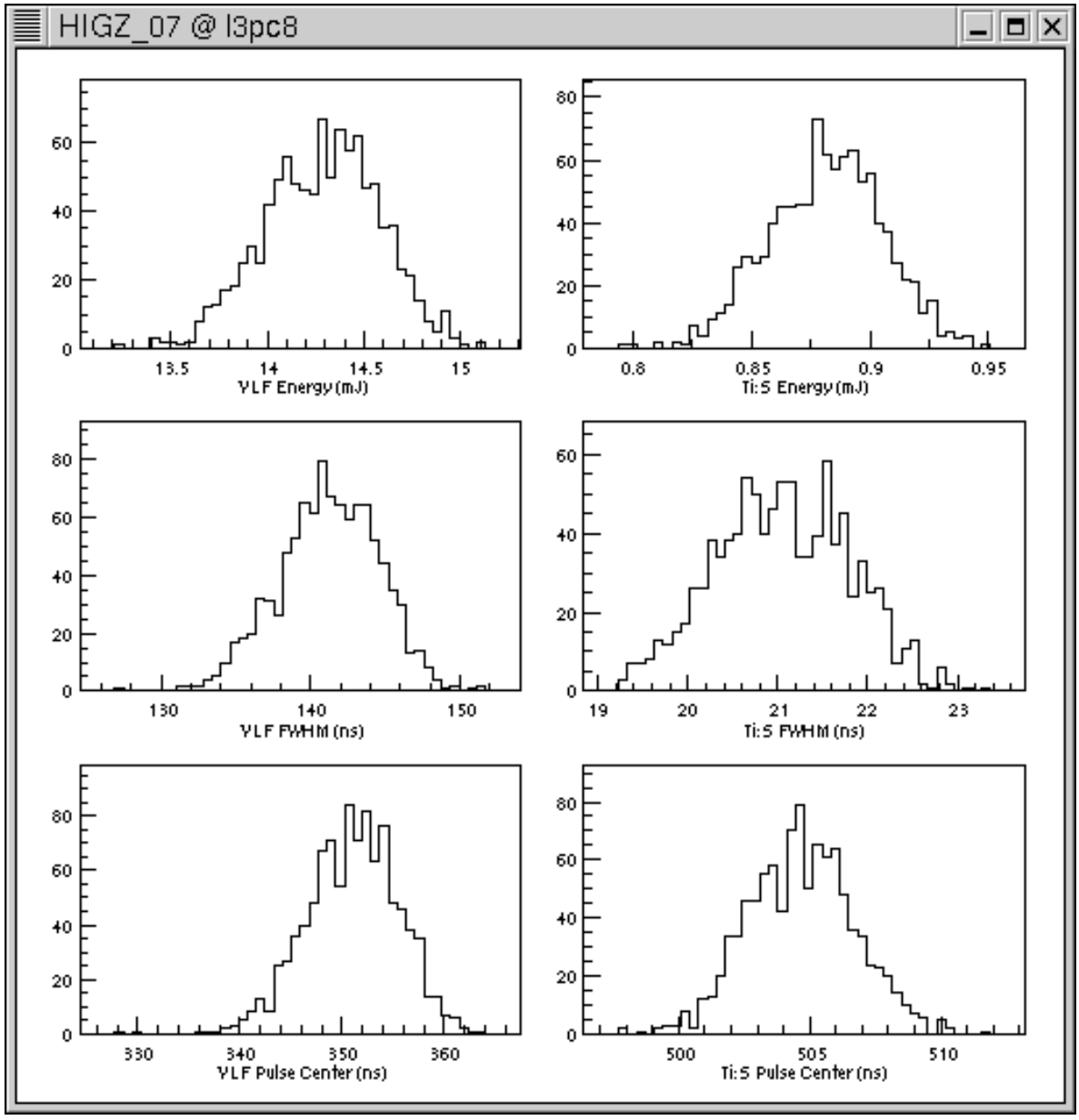



# Pop up Window for Switch Display



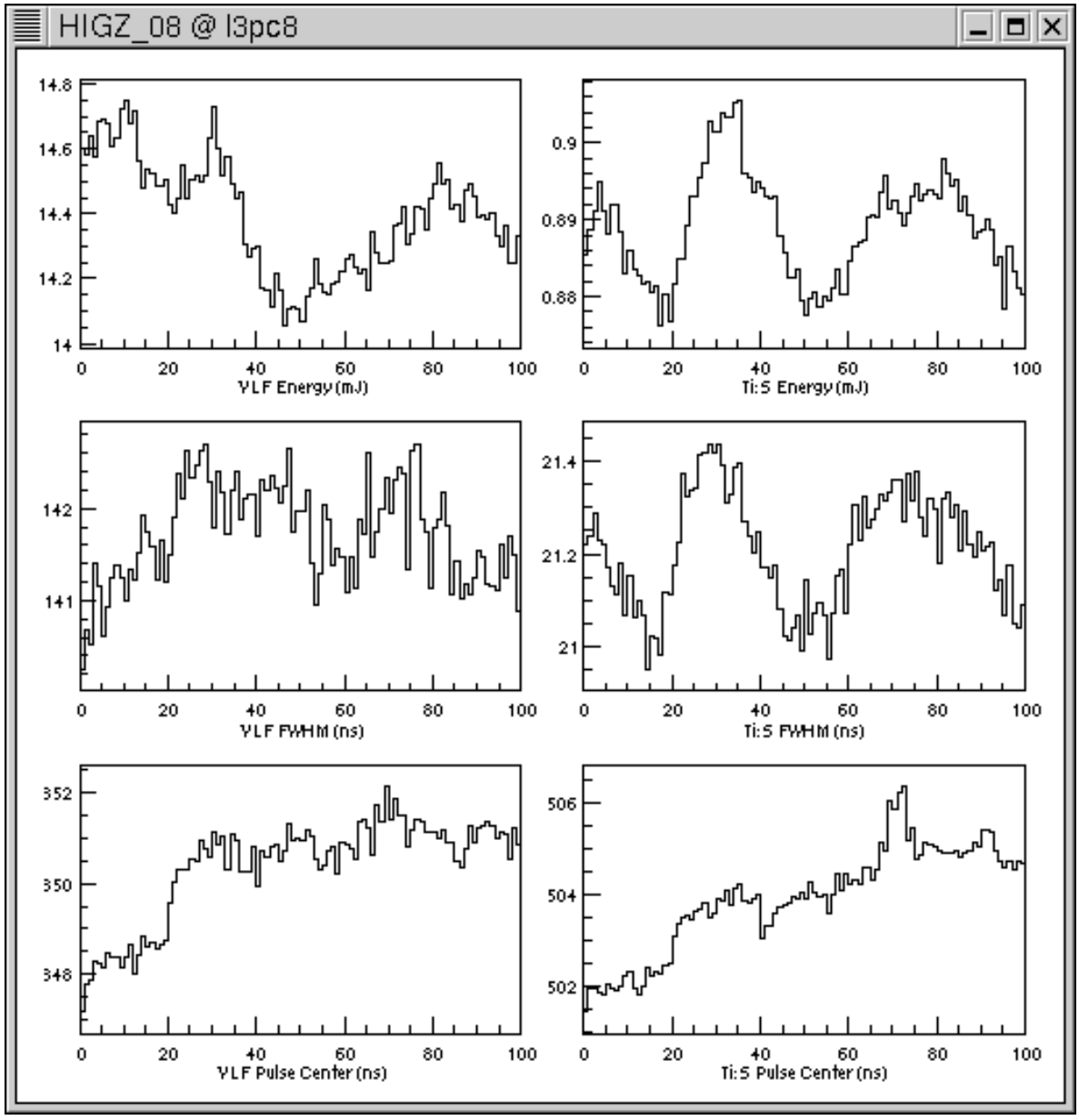
# Pop up Histogram for Laser Performance

Pulse Energy, Width and Timing



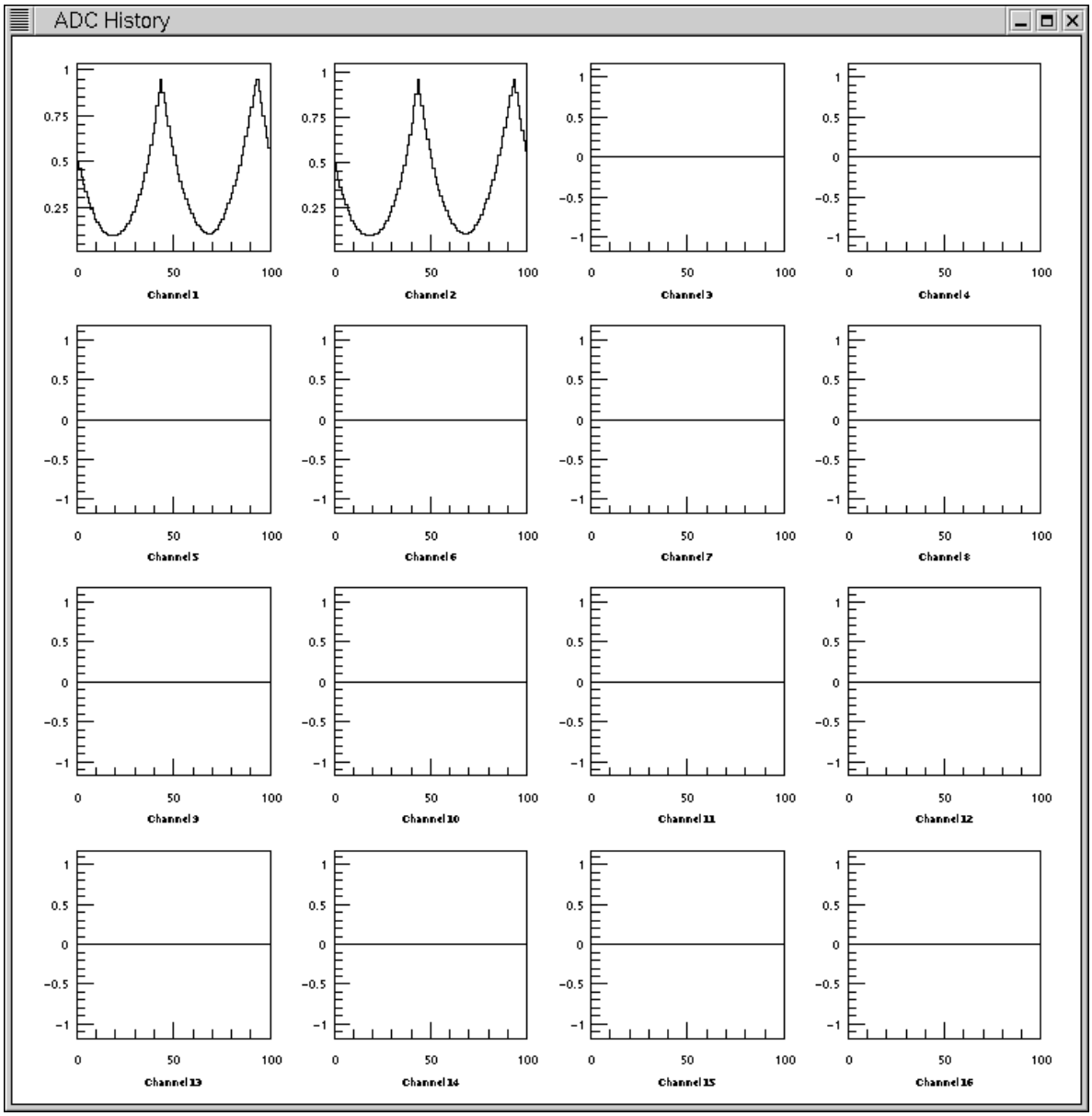
# Pop up History for Laser Performance

Pulse Energy, Width and Timing



# Pop up History for all 80 Channels

Pulse Energy, Width and Timing

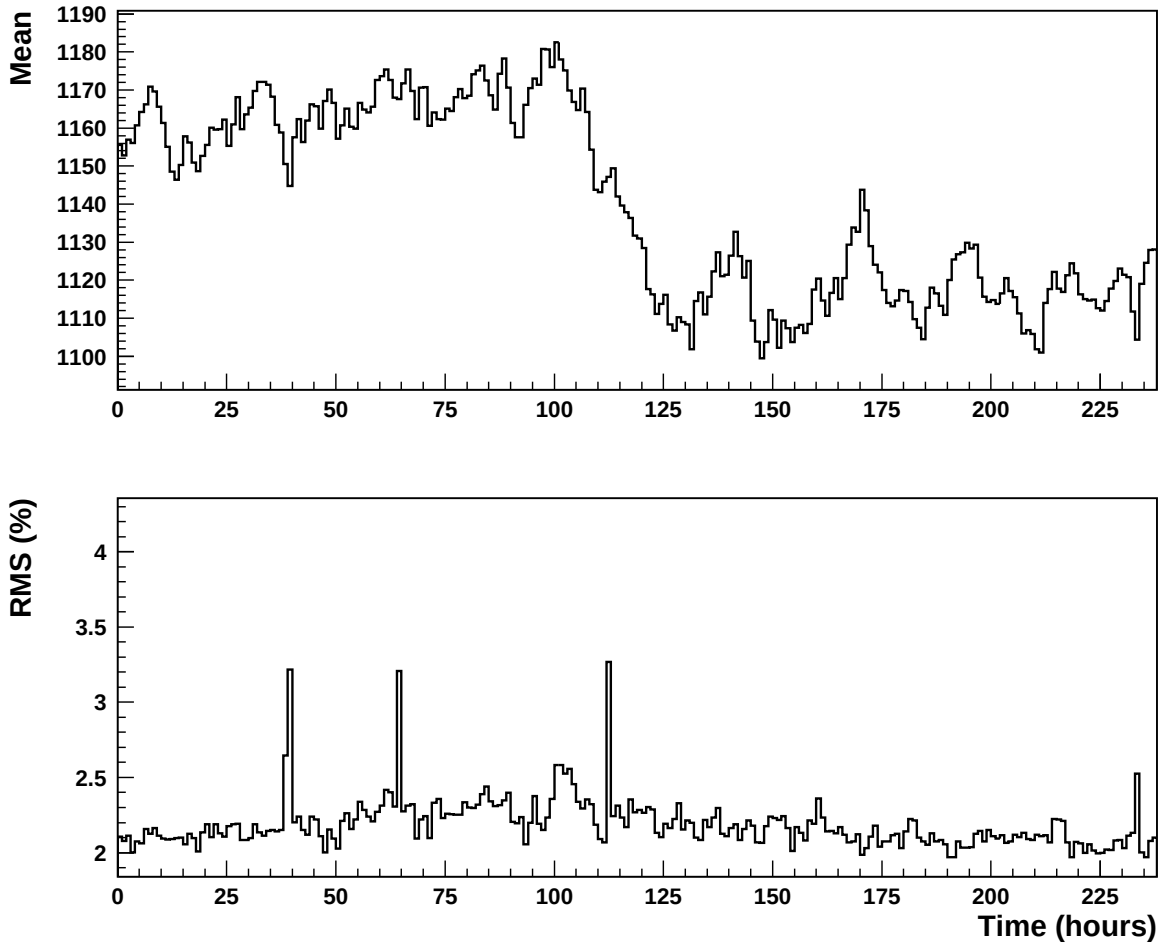


# Pulse Energy, Ti:Sapphire, 440 nm

240 Hour Stability Test

**2%/3.2% Short/Long Term Instability**

## ADC Channel 1 History

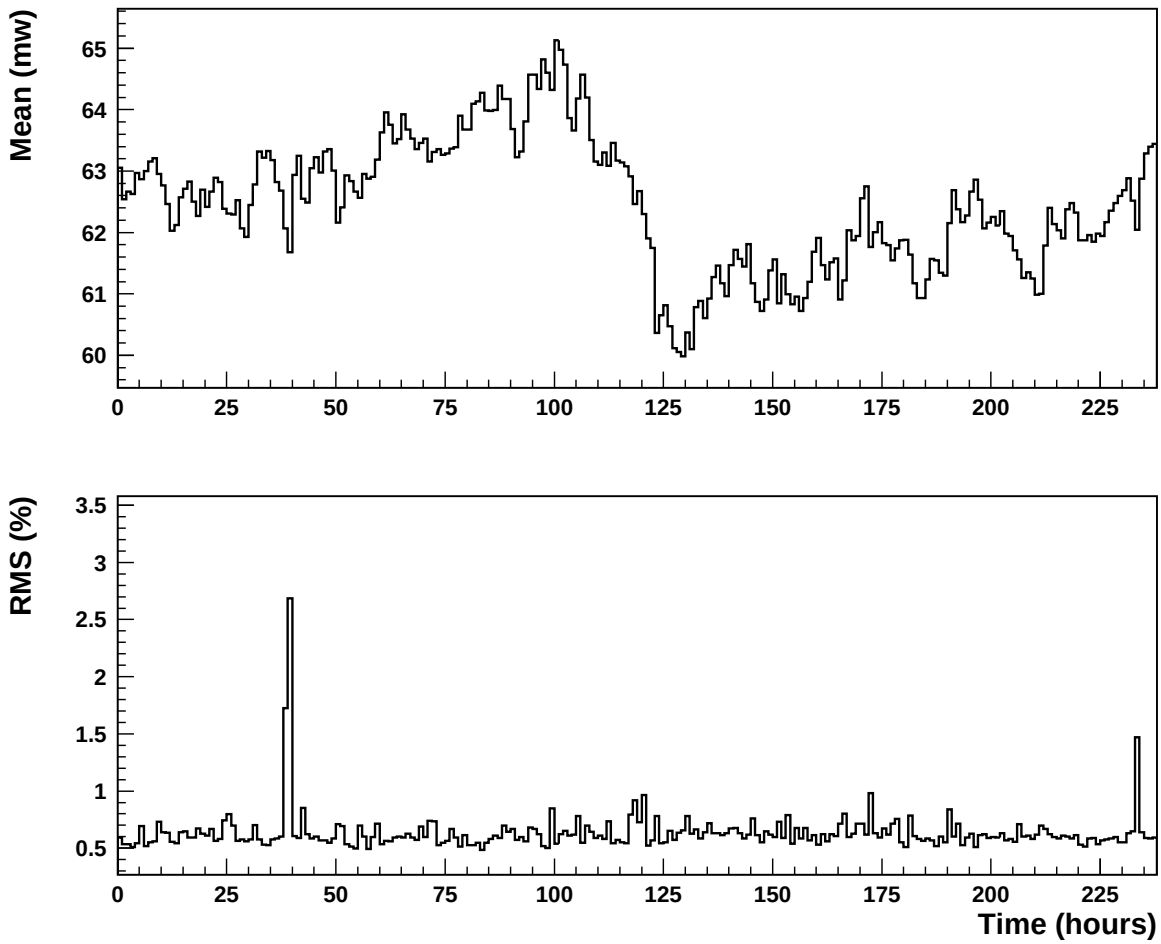


# Ti:Sapphire Power, 440 nm

240 Hour Stability Test, Ti:S Laser

**0.6%/1.0% Short/Long Term Instability**

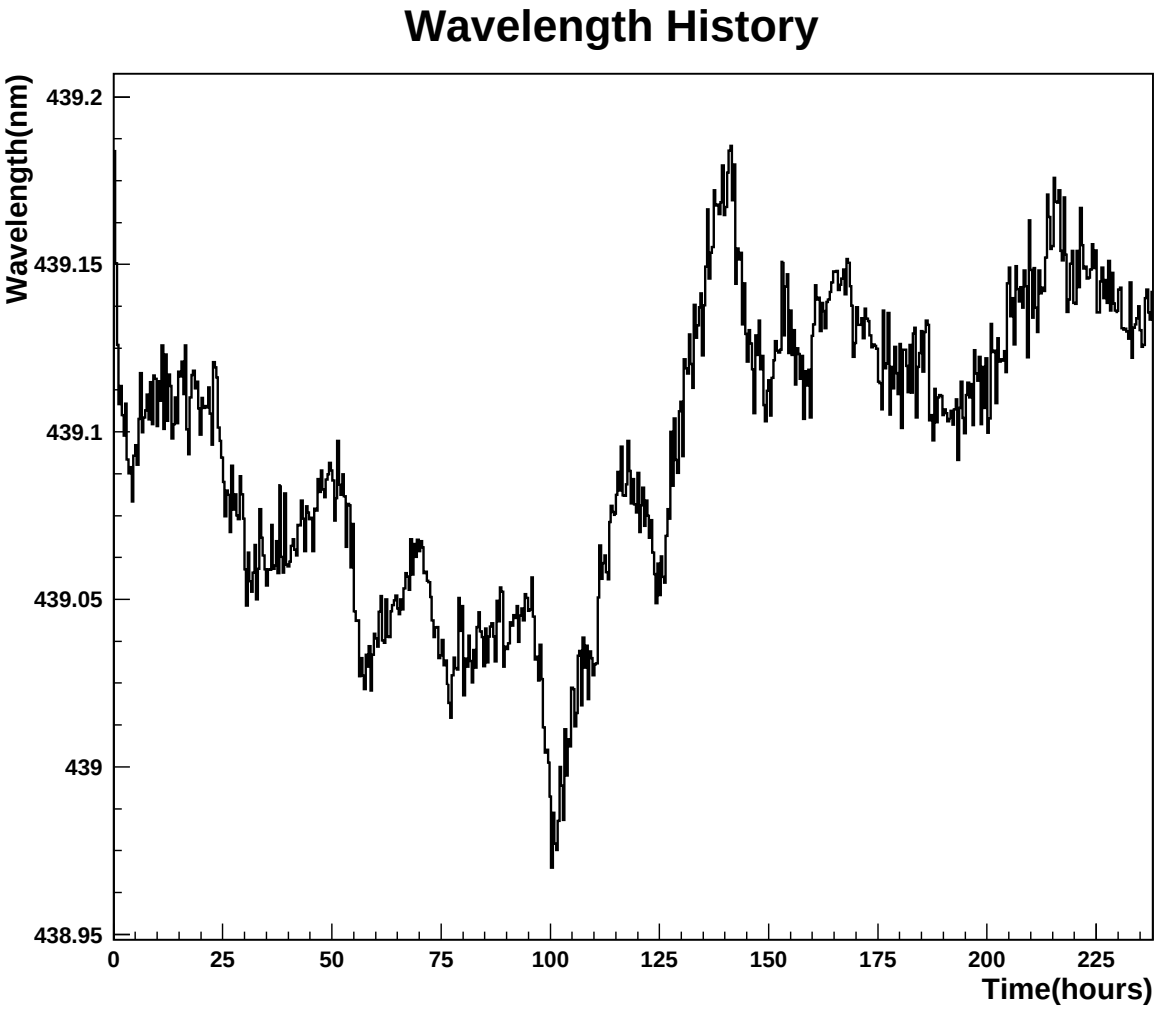
## Power Meter History



# Ti:Sapphire Wavelength, 440 nm

240 Hour Stability Test, Ti:S Laser

**Instability** $2 \times 10^4$

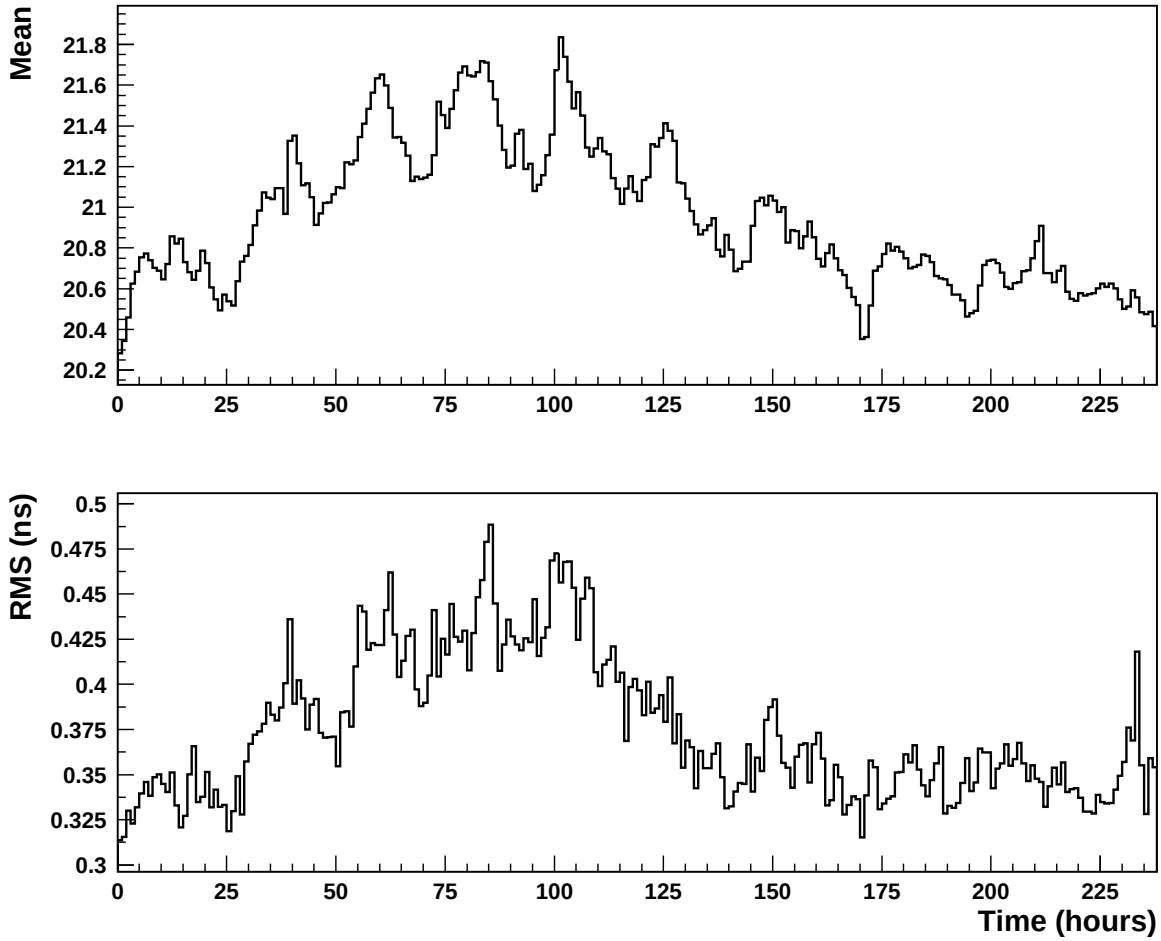


# Pulse Width, Ti:Sapphire, 440 nm

240 Hour Stability Test, Ti:S Laser

**20 ns FWHM, 2%/2.5% Short/Long Term Instability**

## Ti:S Laser FWHM History

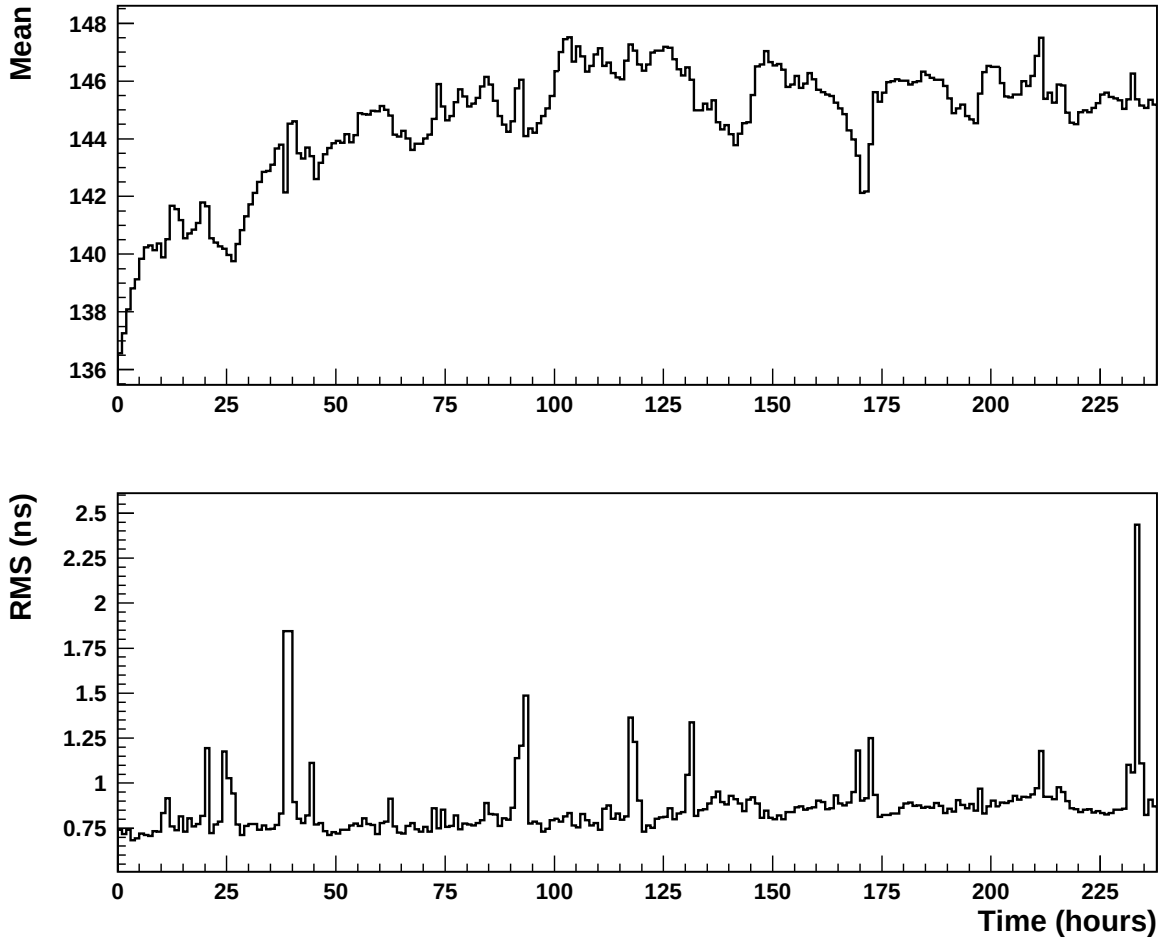


# Pulse Jitter, Ti:Sapphire, 440 nm

240 Hour Stability Test, Ti:S Laser

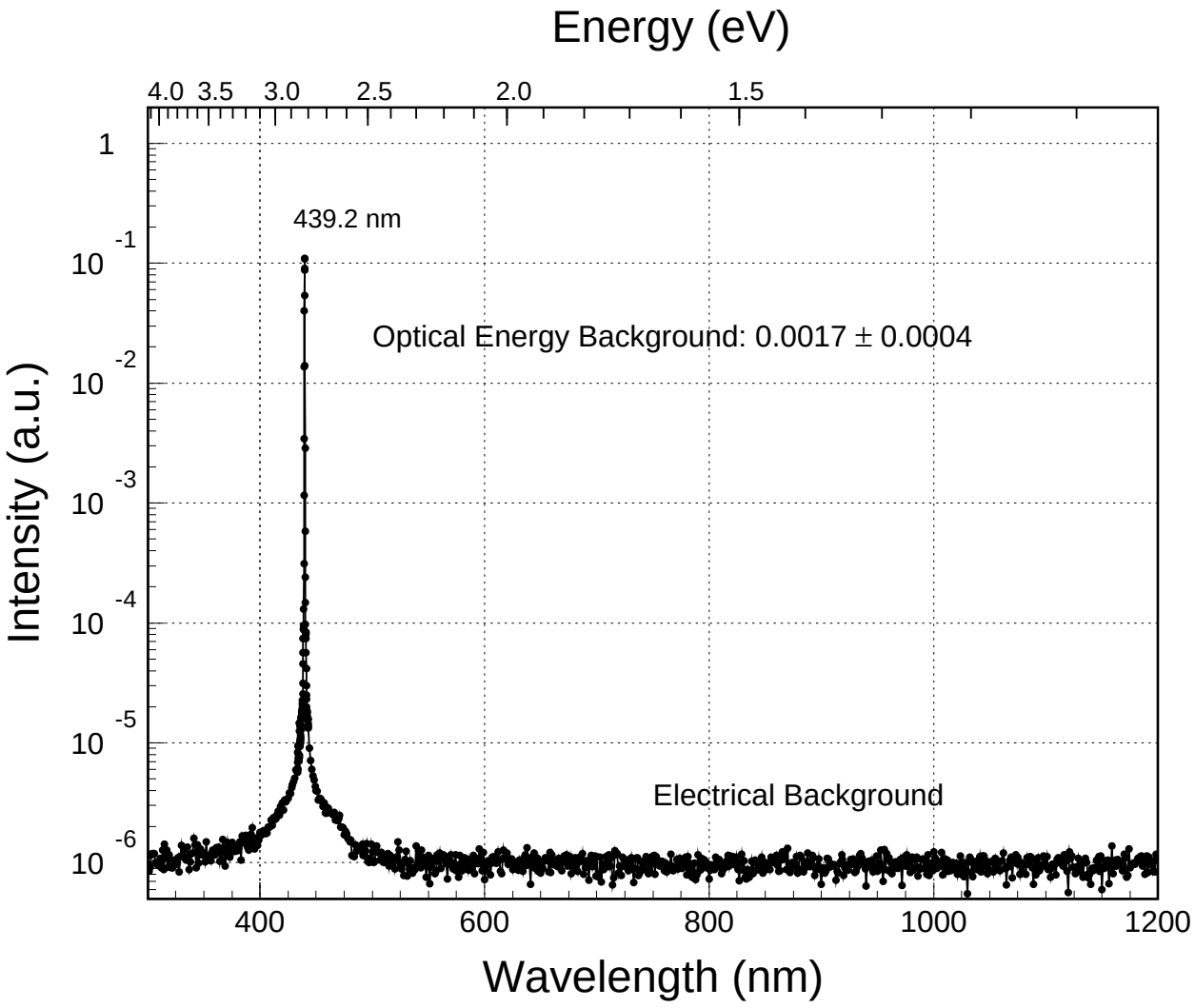
**1 ns/2.2 ns Short/Long Term Jitter**

## Ti:S Laser Pulse Center History



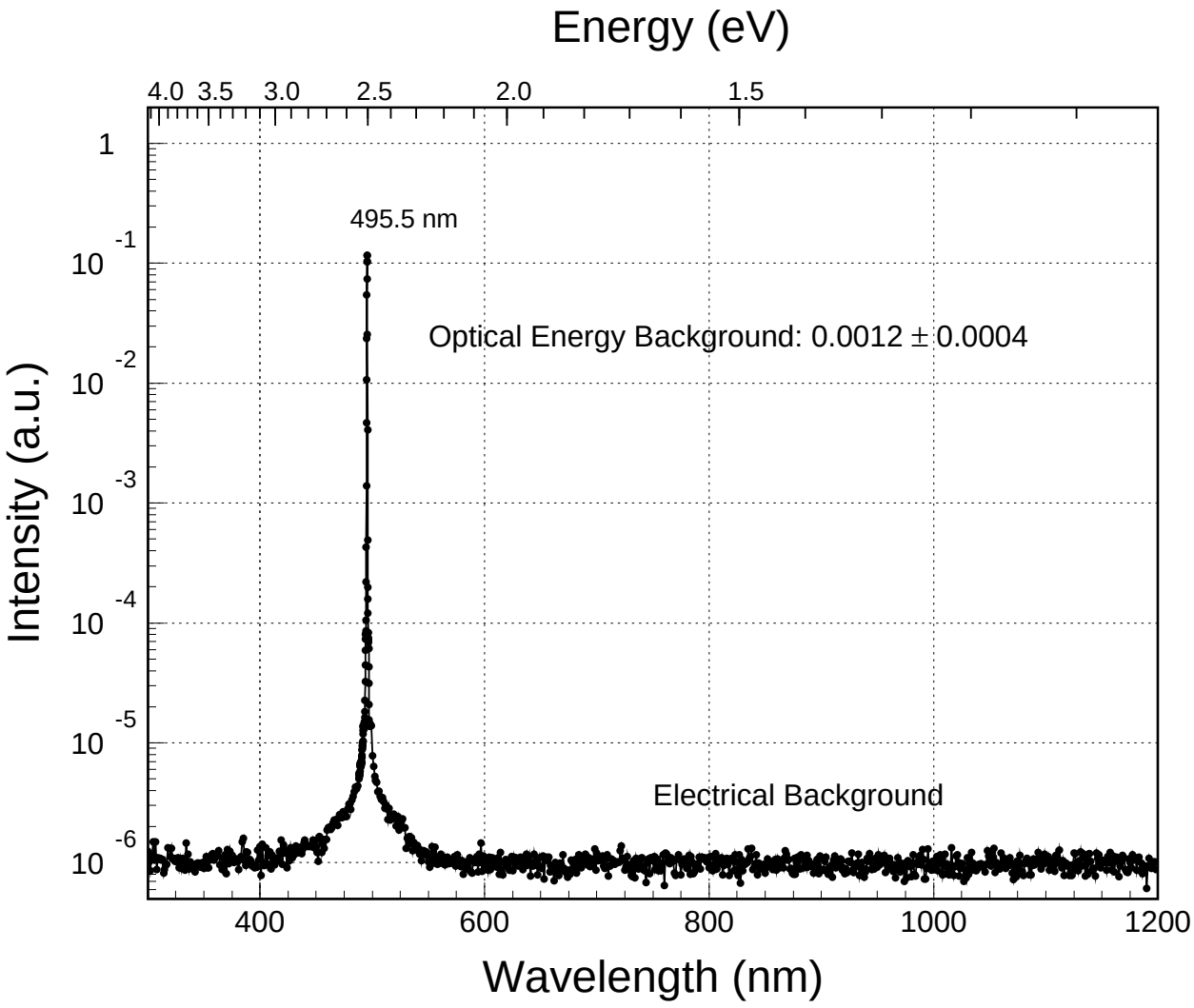
# Spectra of Ti:Sapphire Pulse @ 440 nm

Contamination (0.17 ± 0.04)%



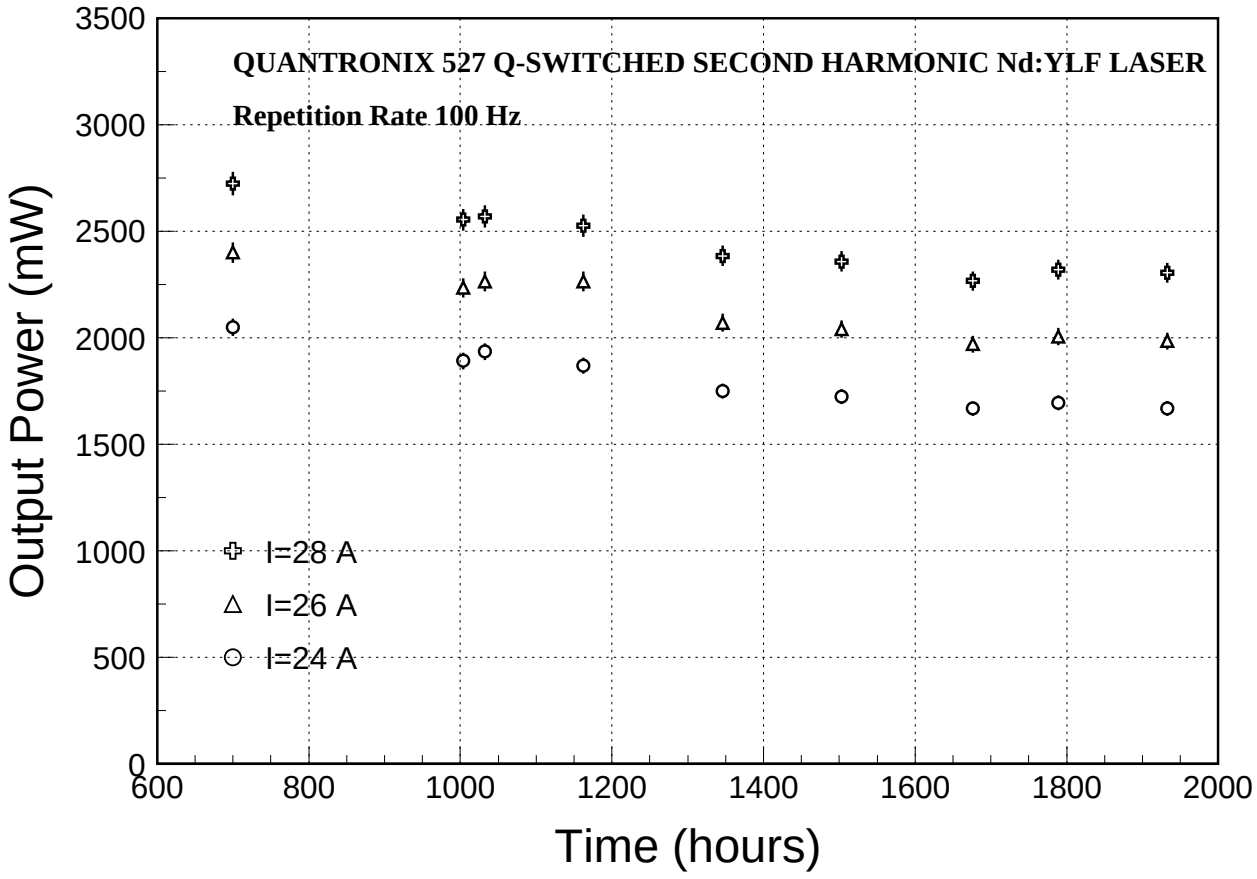
# Spectra of Ti:Sapphire Pulse @ 495 nm

No Contamination (0.12 ± 0.04)%



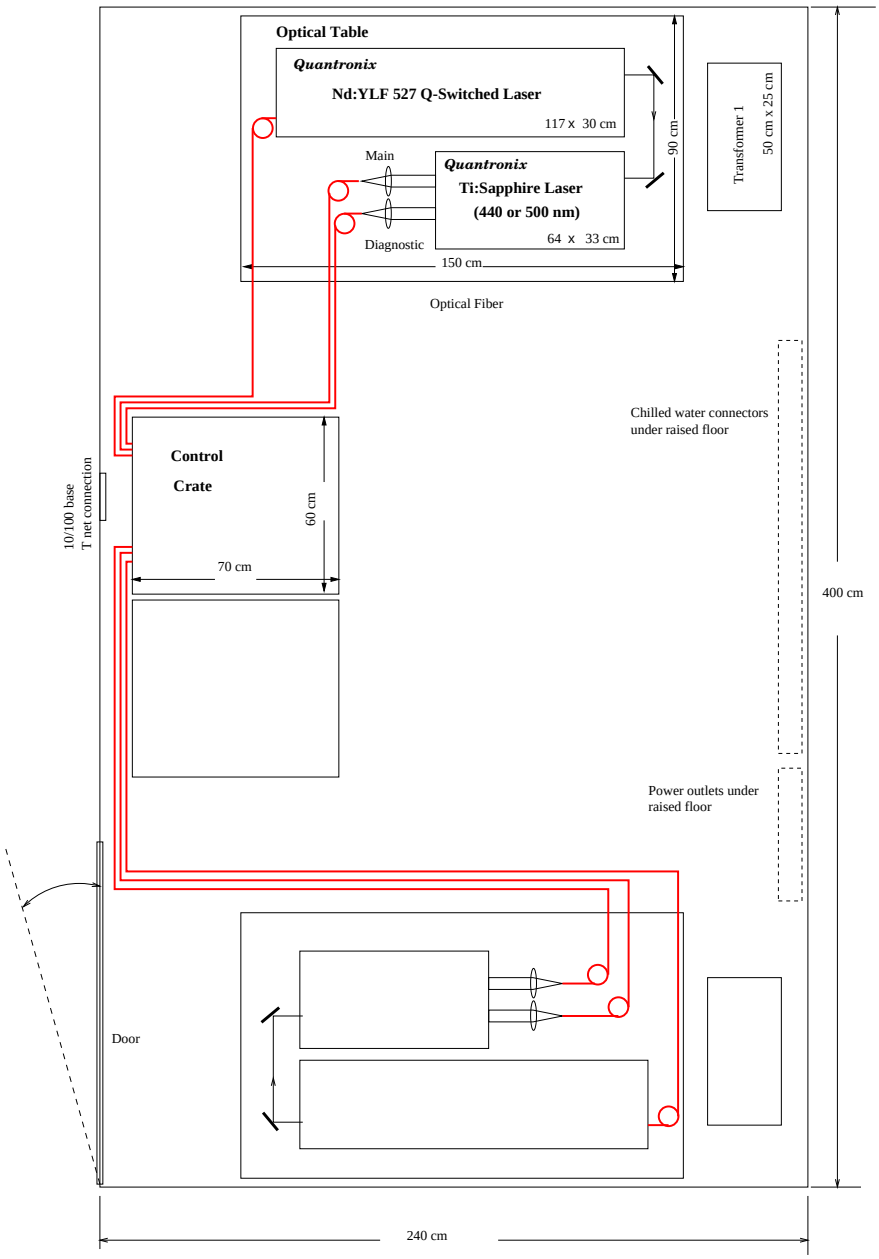
# Life Time of DC Krypton Lamp

10/20% degradation after 1,000/2,000 h



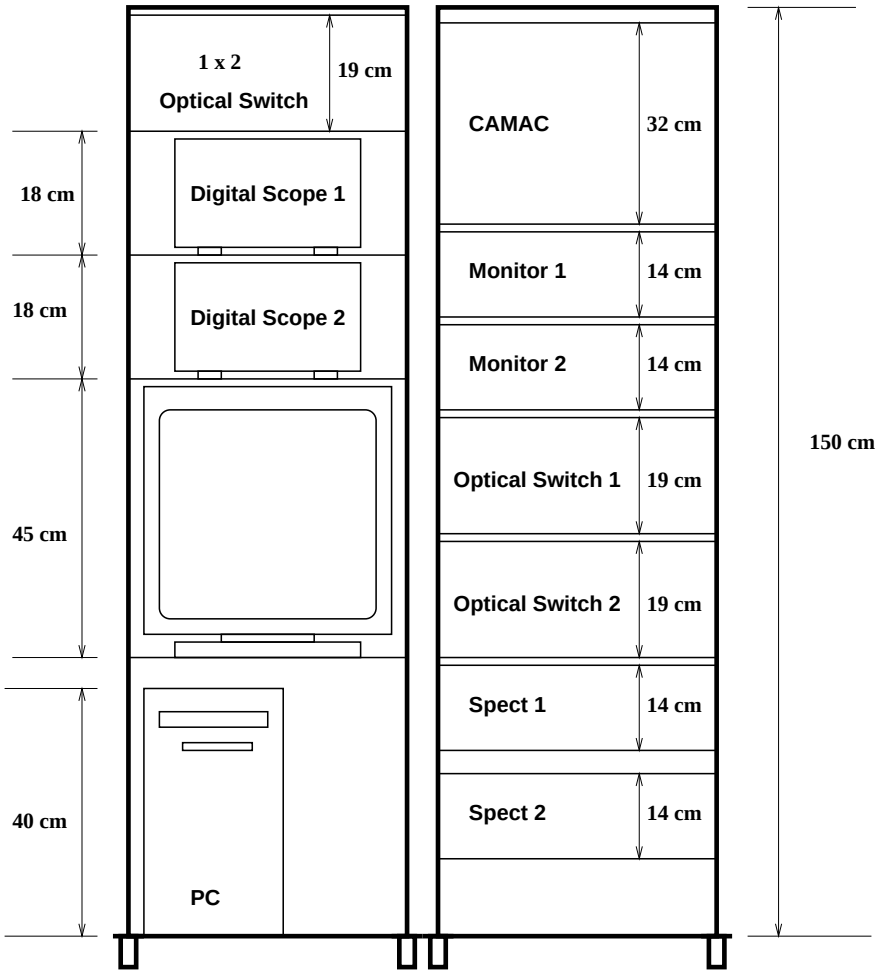
# System Installation at H4, CERN

## Floor Arrangement



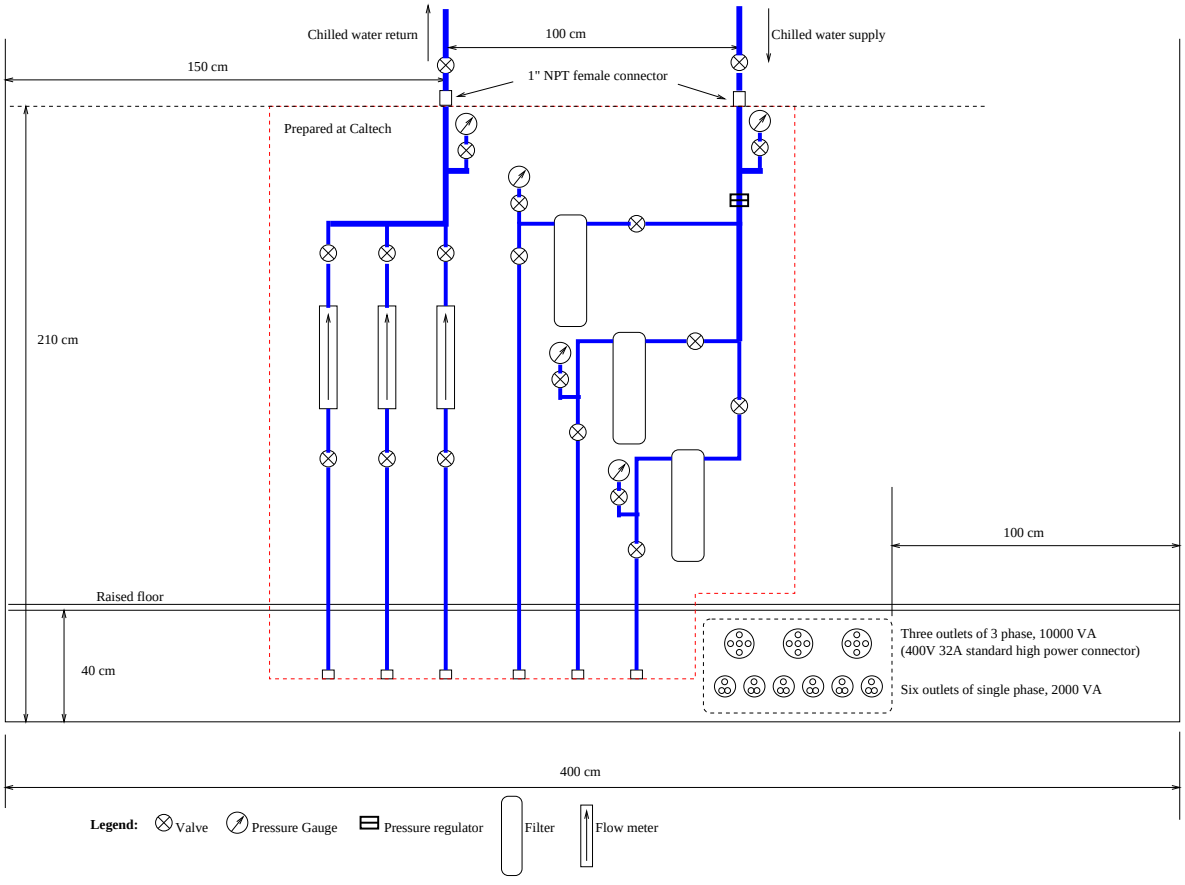
# System Installation at H4, CERN

Rack Arrangement



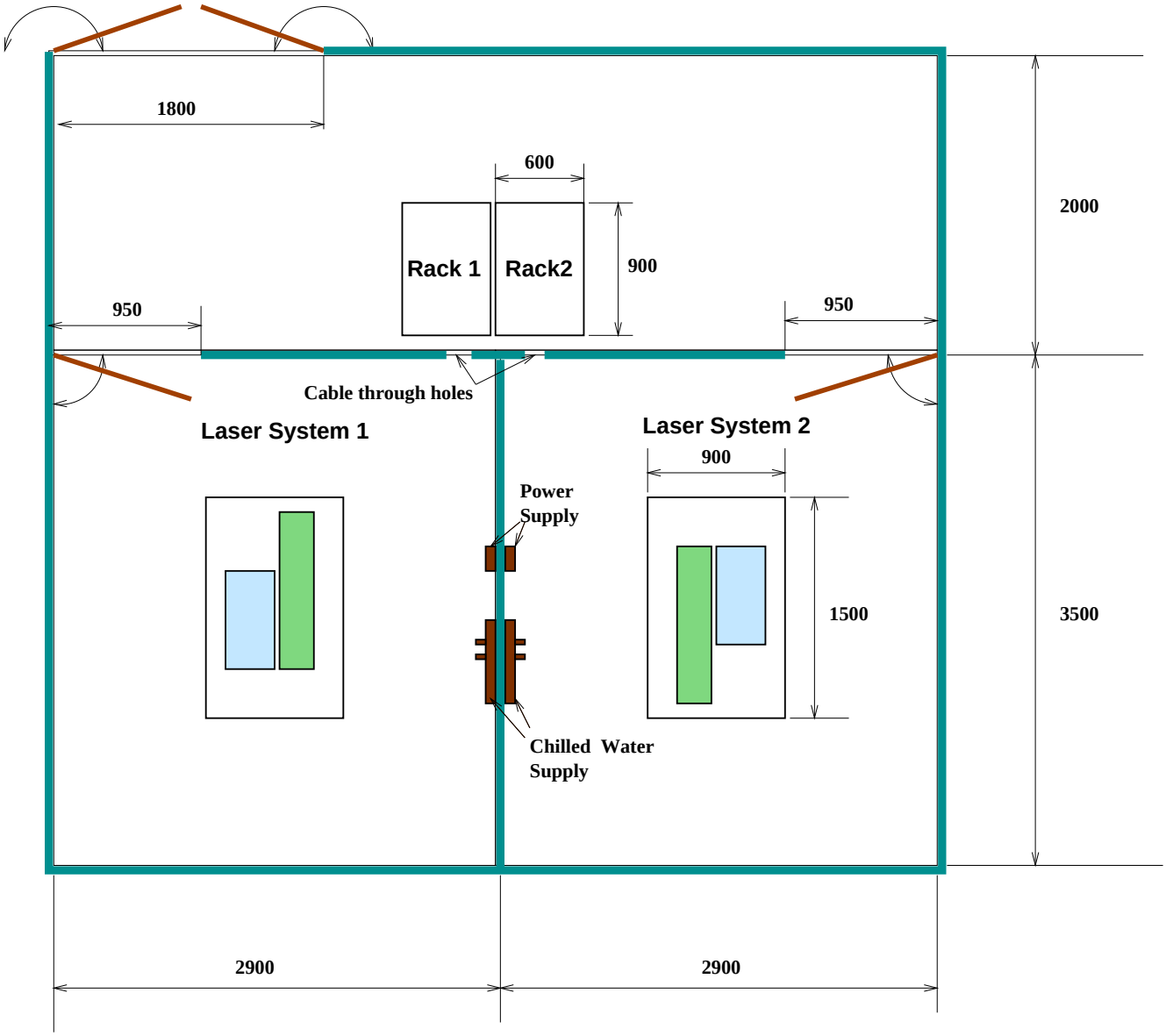
# System Installation at H4, CERN

## Utility Arrangement



# System Installation at USC55, CERN

## Monitoring Light Source & High Level Distribution




**Room Requirement for LSDS Installation in USC55.**

# Summary: WBS4.3 Monitoring Light Source

1. Completed test bench for preproduction $PbWO_4$ crystals. Determined monitoring wavelengths of 440 nm for good linearity.

2. Quantronix corrected some early design errors, e.g. neutral density attenuator.

3. The laser system provides pulse energy (1.0/0.6 mJ) and width (20/35 ns) at 440/500 nm with long/short term jitter of 2.2/1 ns.

4. The system also provides clean laser pulse with wavelength stability of $2 \times 10^{-4}$ and contamination of less than $10^{-3}$.

5. Construction of the system is on schedule and cost. The first laser will be installed at H4 in August, 2001. A technician hired by US_CMS ECAL will operate this laser starting September.

6. A red laser is under consideration to be added to the system.