Monitoring Laser Performance at Caltech and H4

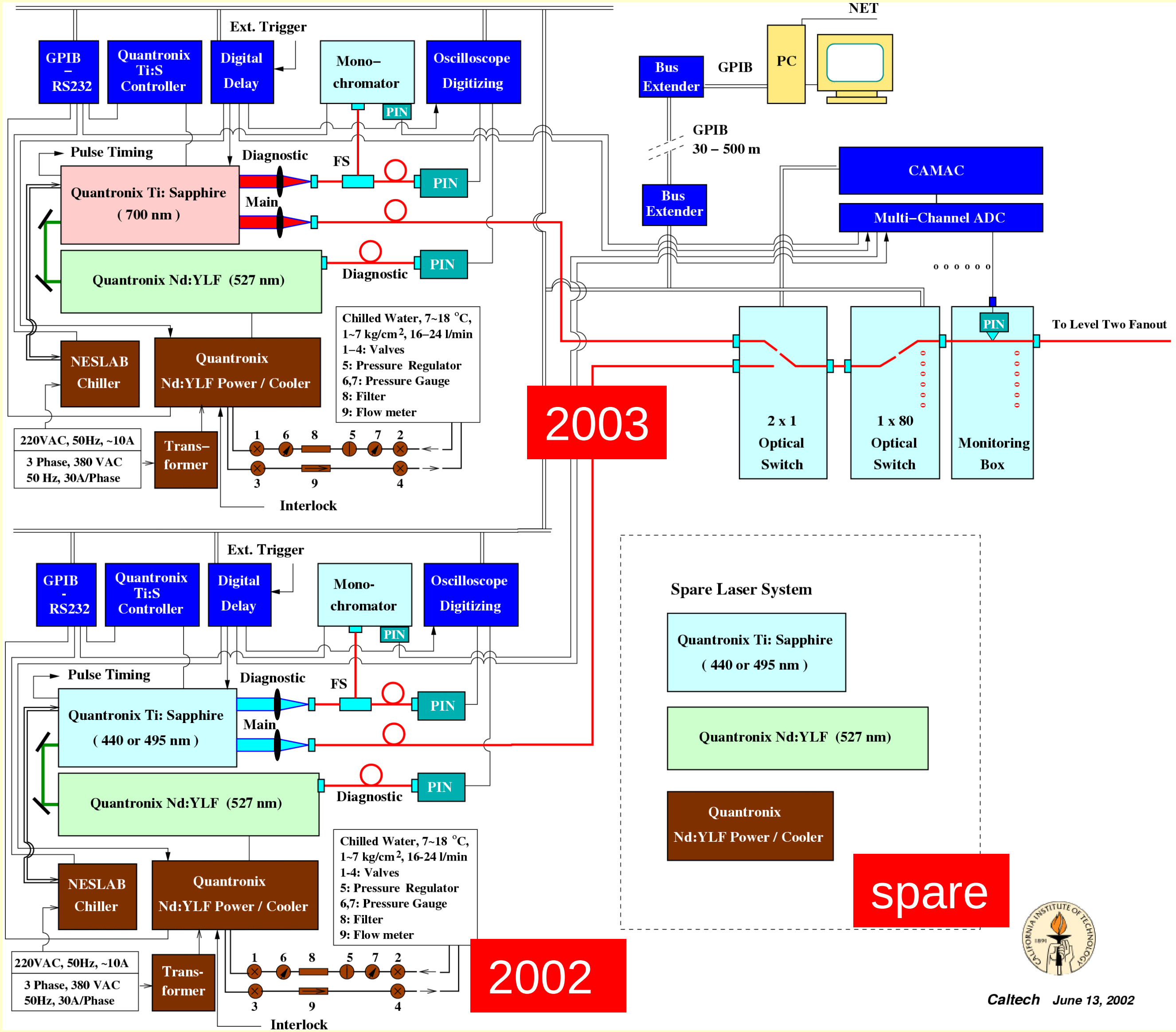
Ren-yuan Zhu

California Institute of Technology

Outline

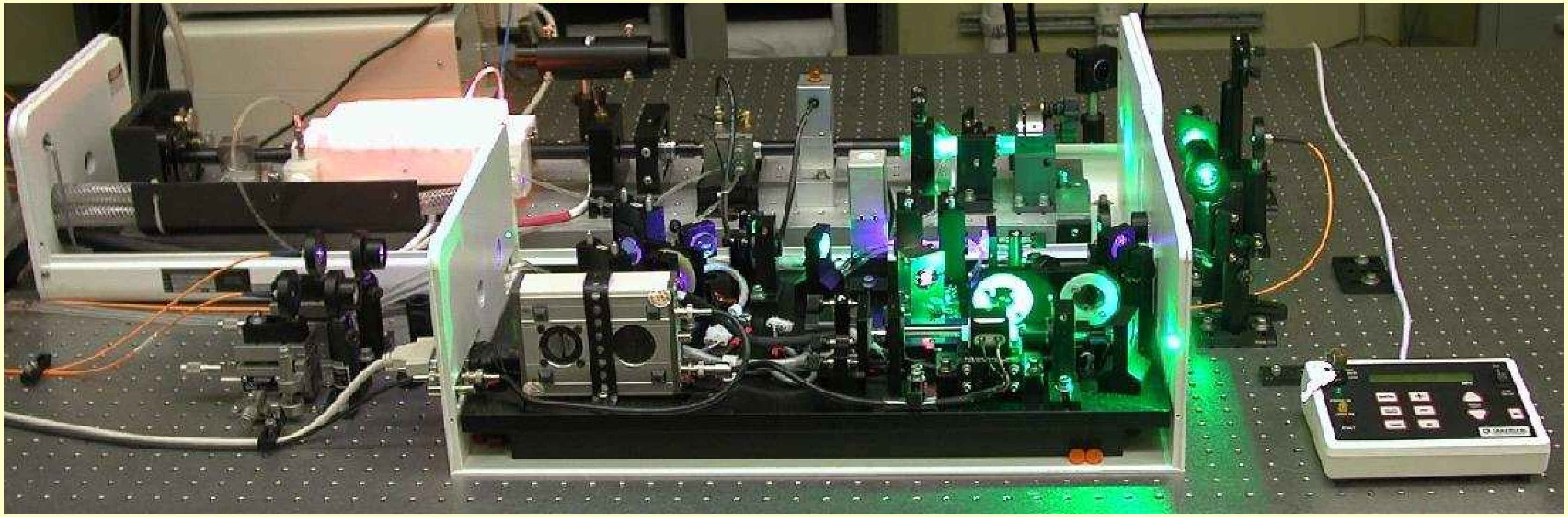
- Lasers at H4: 2002 and 2003.
- Short term performance with different pumping current.
- Long term performance.
- Performance during beam test.
- Laser Maintenance & Operation.
- Improvements?

Lasers in 2002 and 2003

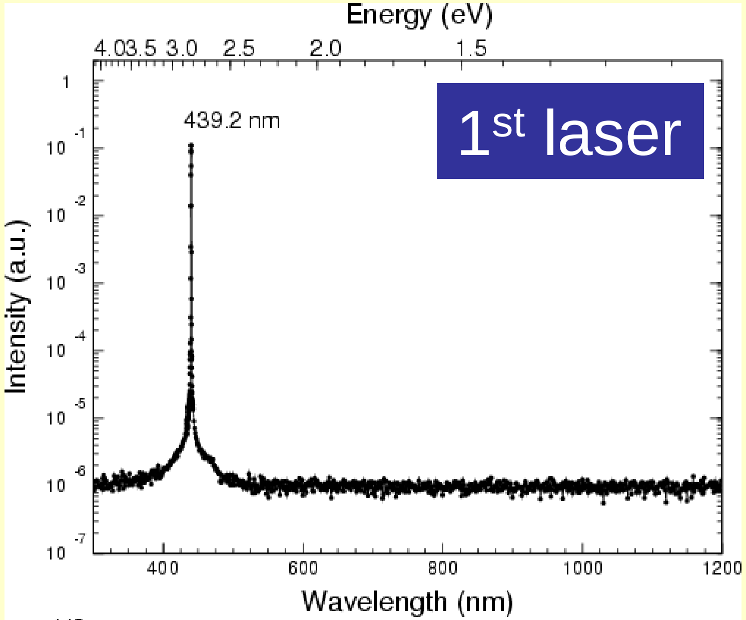


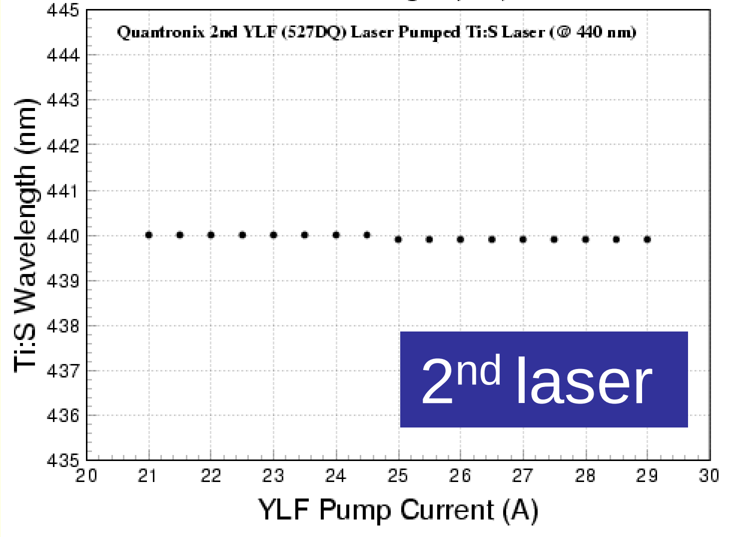
- Two laser systems: at 440/495 nm and 700/800 nm with own diagnostics on wavelength, pulse shape and intensity.
- An optical switch directs monitoring laser pulses to 80 super-modules.
- A PC based DAQ controlling lasers and recording the history of laser performance.

YLF & TI:Sapphire Lasers

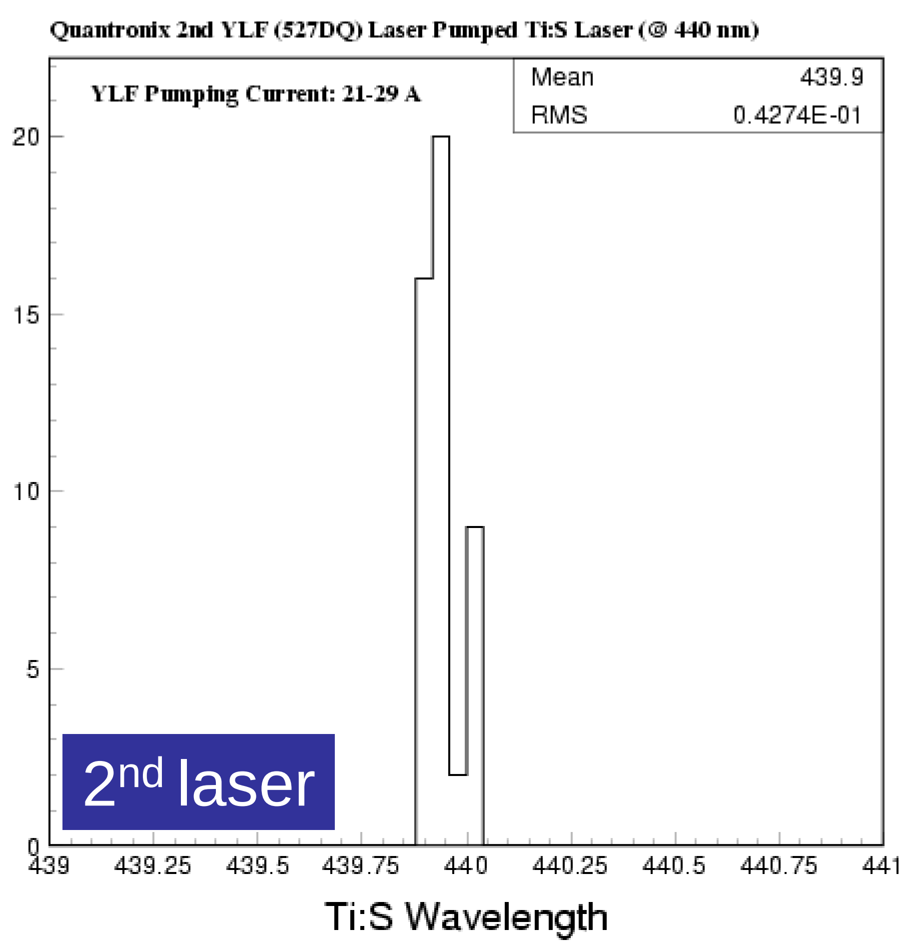


Ti:S Wavelength

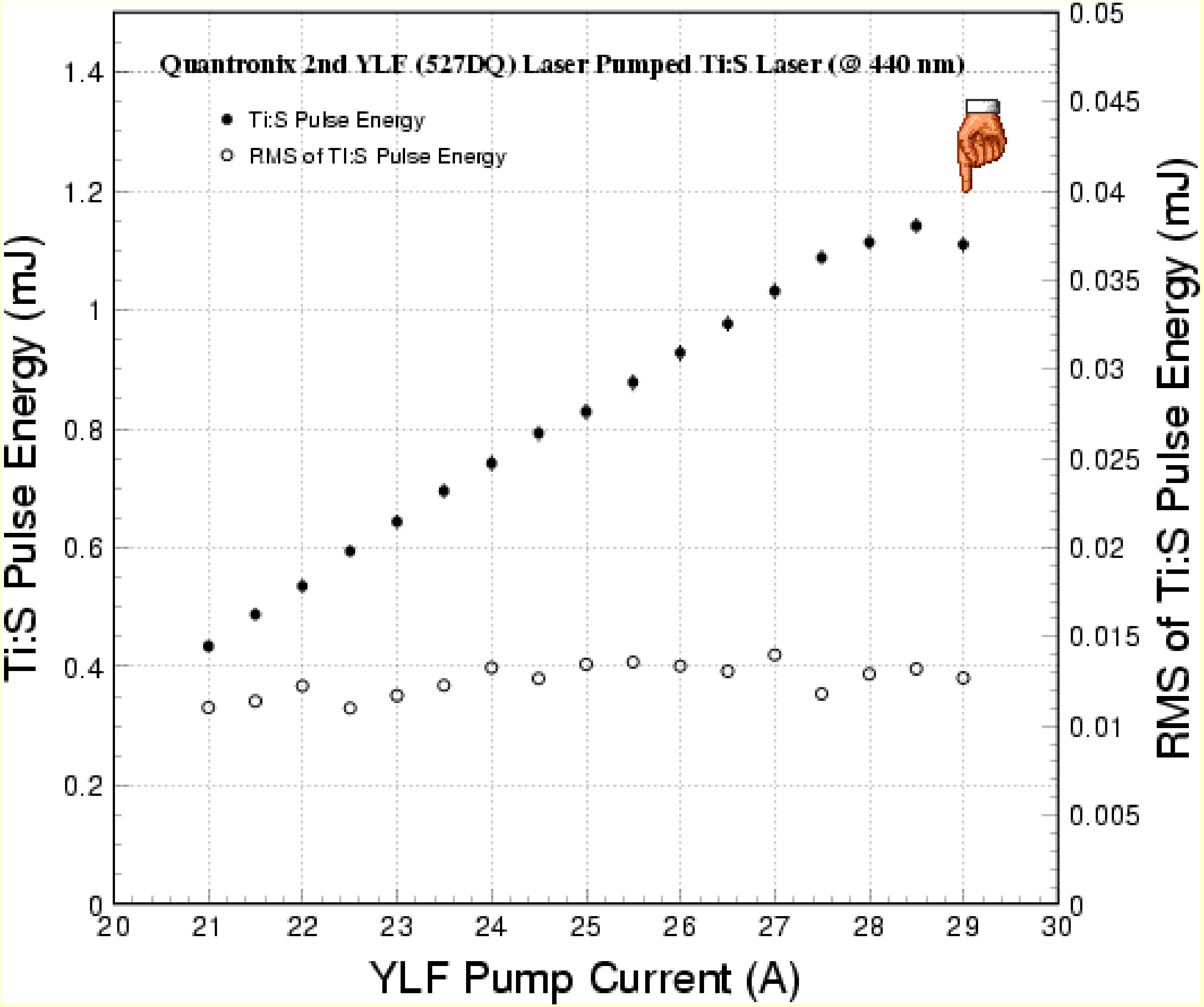




Ti:S wavelength is not a function of pumping current or YLF pulse energy

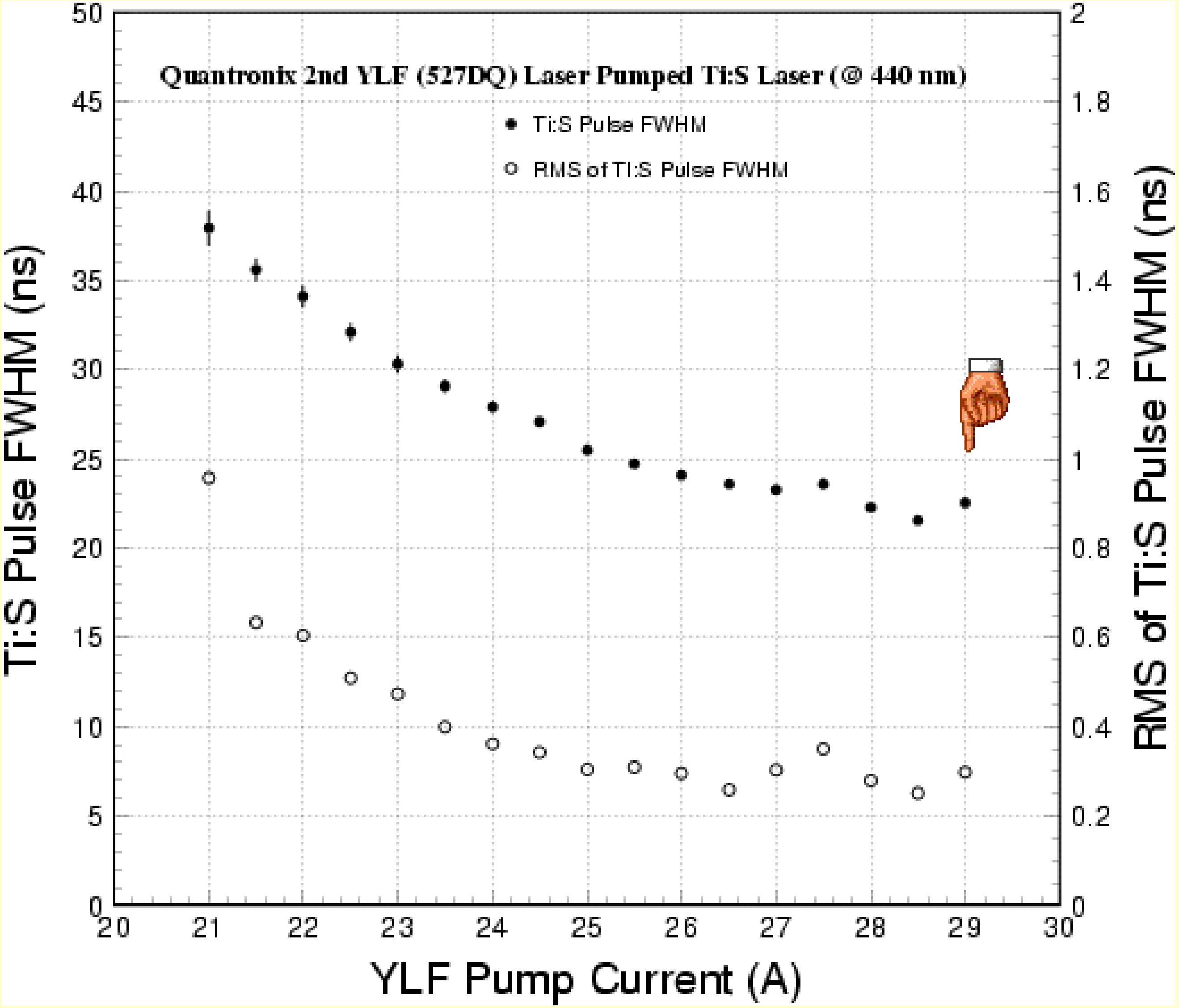


2nd Ti:S Pulse Energy & r.m.s.



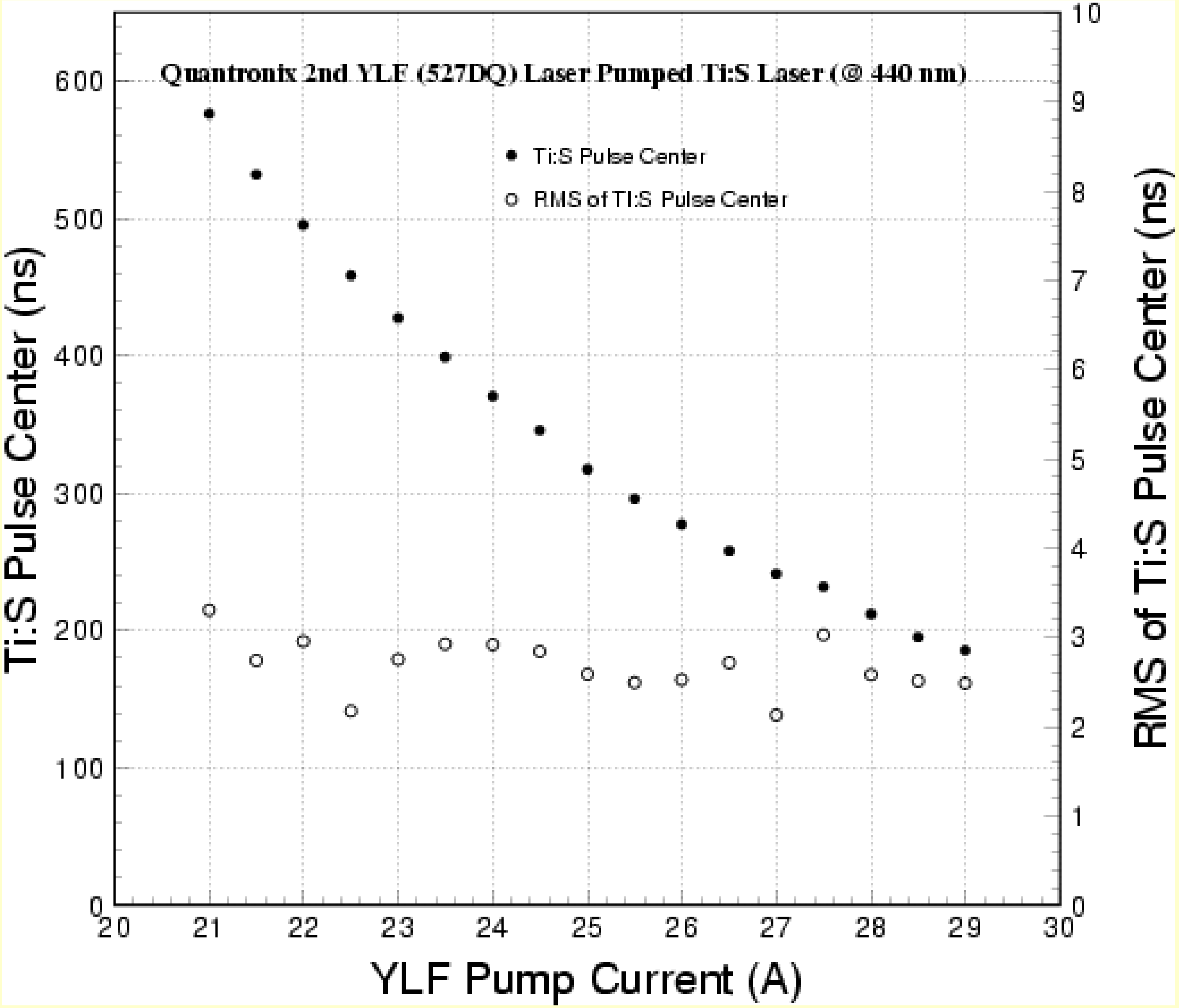
- Peak pulse energy: ~1 mJ.
- After peak degradation caused by the 2nd harmonics.
- Good stability 15 uJ, or 1.5%, at peak power.

2^{nd} Ti:S Pulse FWHM & r.m.s.



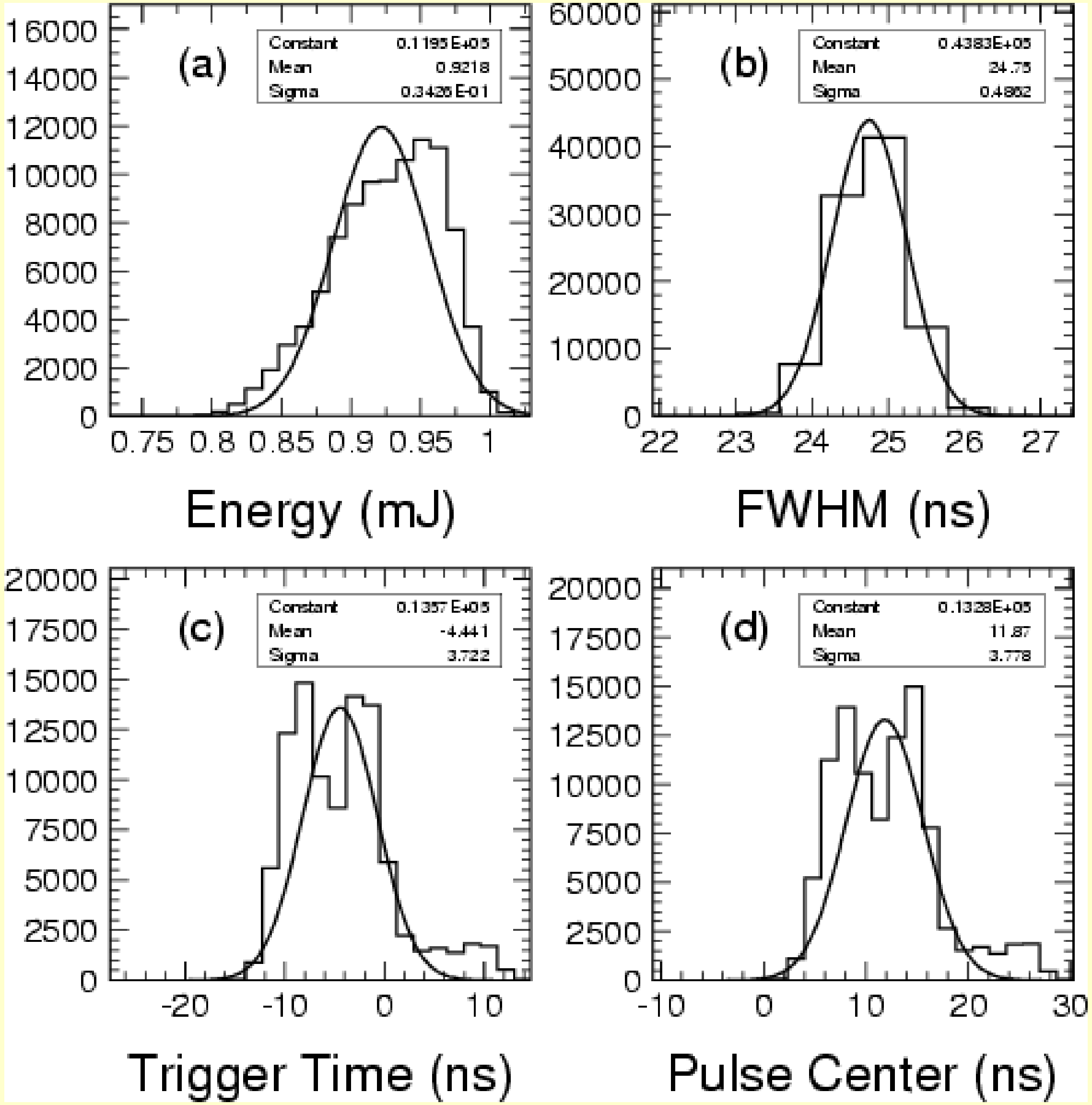
- FWHM less than 25 ns with current > 25 A.
- r.m.s. less than 0.4 ns with current > 24 A, or <1.6% with current > 22 A.
- Good stability when running at peak power.

2nd Ti:S Pulse Timing & Jitter



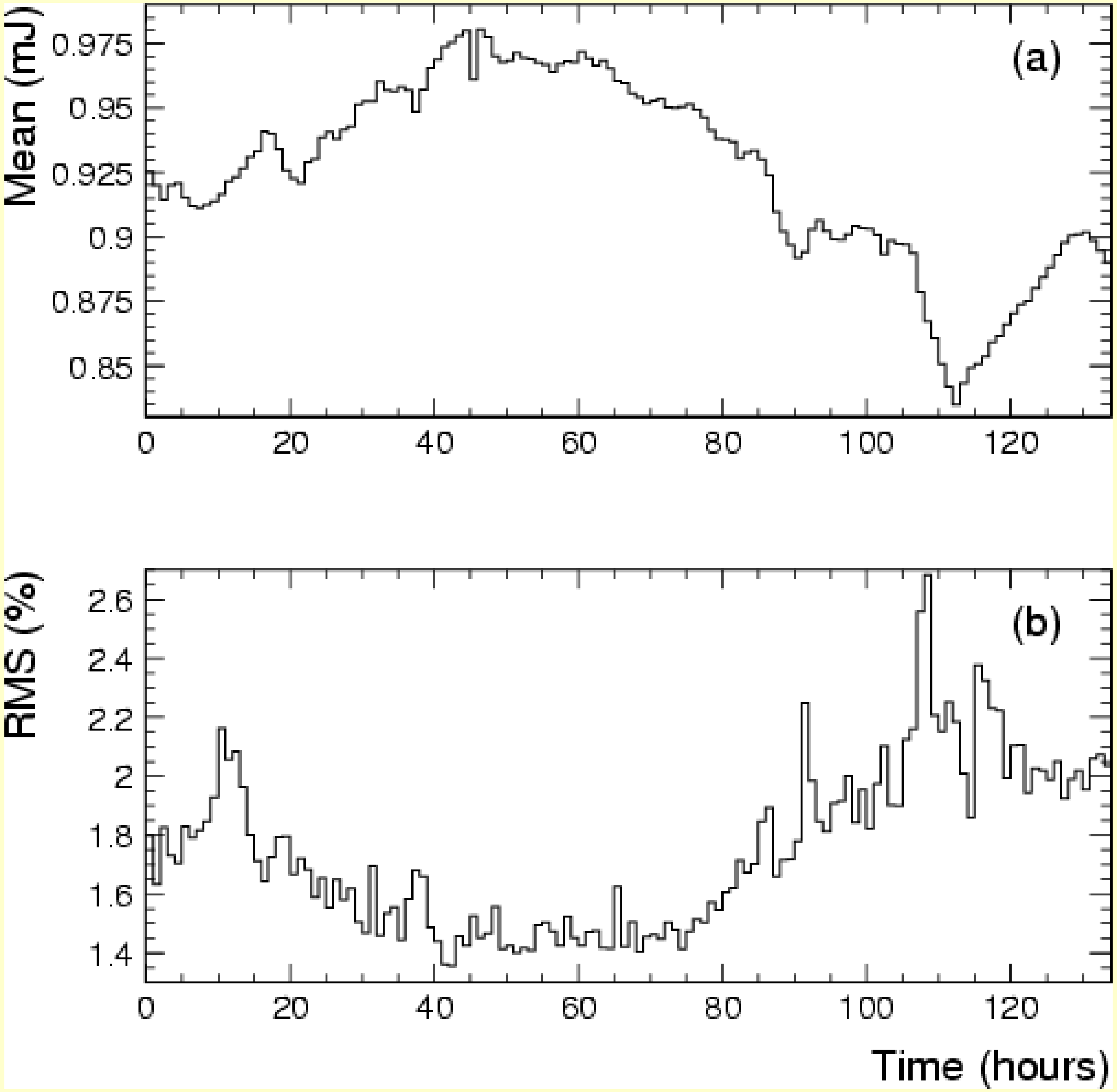
- Pulse timing is a function of pumping current or YLF pulse energy.
- Pulse jitter is 3 ns.
- Stable timing requires stable YLF pulse energy.

1^{st} TI:S 135 hour Test



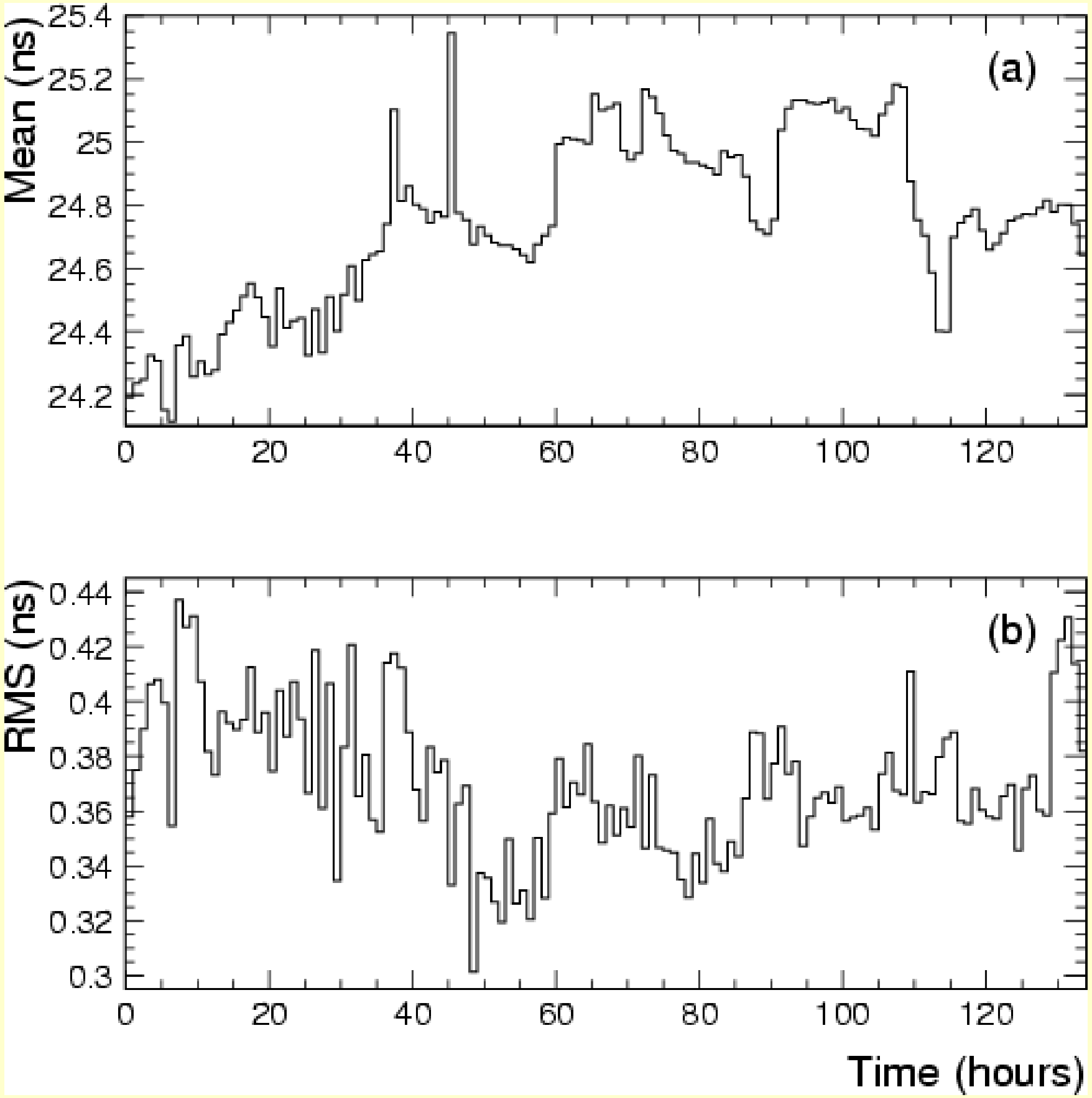
- Pulse energy of 1.0/0.6 mJ and FWHM of 25/35 ns at 440/495 nm.
- Long/short term stabilities for pulse energy and FWHM are 3.7/1.8% and 2.0/1.6% respectively.
- Long/short term Jitter: 3.7/1.6 ns.
- Laser rate: 100 Hz.
- Laser DAQ rate: 1 Hz.

History: 1^{st} Ti:S Pulse Energy & r.m.s.



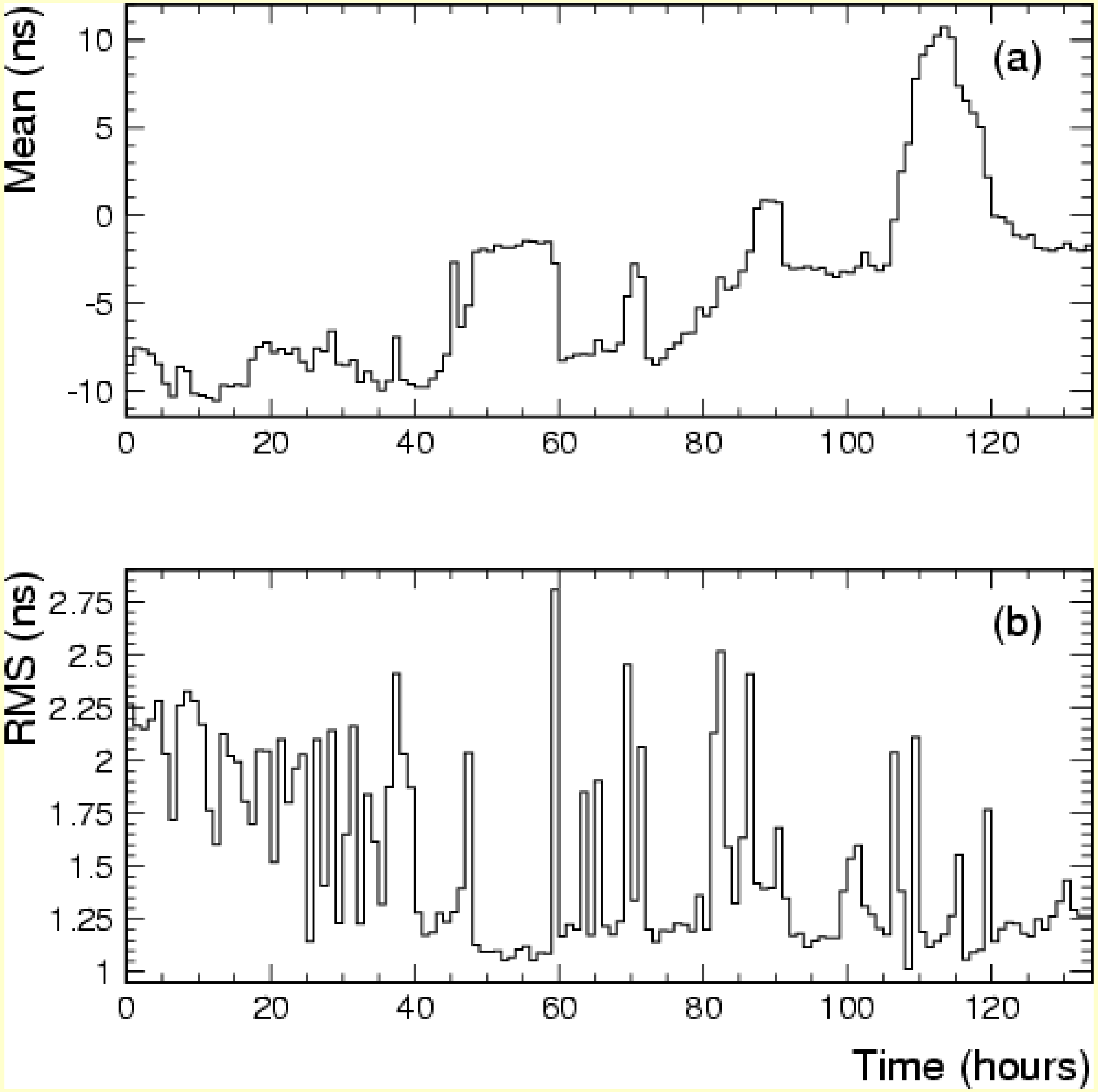
- Short term r.m.s 1.7%, or 15 uJ, consistent with the 2^{nd} laser.
- Peak to peak variation 15%, corresponding to overall r.m.s. 3.7%.
- Specification: r.m.s. <10%.
- Drifting: power, temperature…

History: 1st TI:S Pulse FWHM & r.m.s



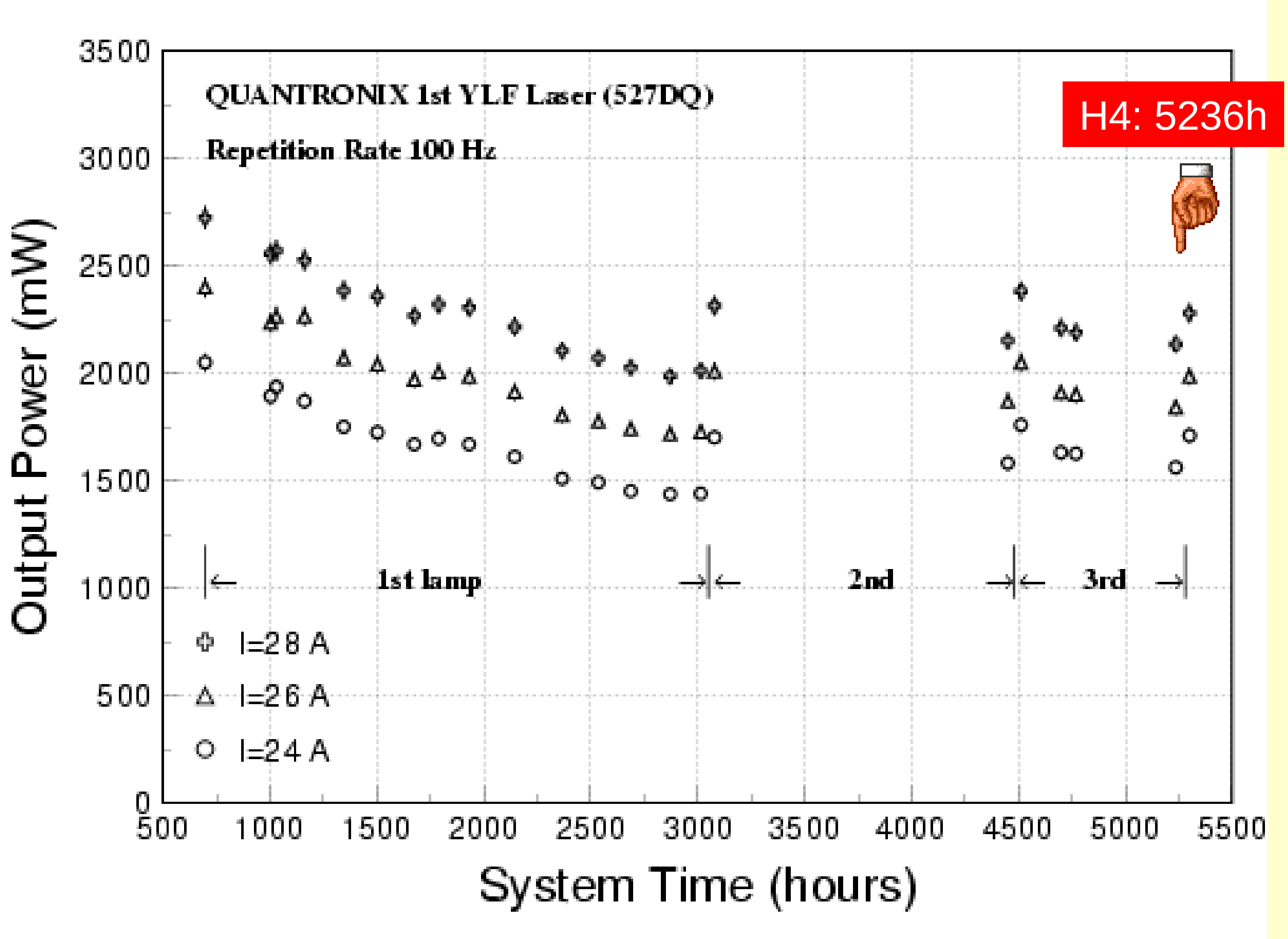
- Short term r.m.s 0.38 ns, or 1.6%, consistent with the 2nd laser.
- Overall r.m.s. 0.5 ns, or 2%.
- Specification: FWHM < 40 ns.
- Drifting: roughly anti-correlated to the pulse energy.

History: 1st Ti:S Pulse Timing & Jitter



- Short term jitter 1.5 ns, better than the 2nd laser.
- Overall jitter 3.8 ns caused by the timing drifting.
- Drifting: strongly anti-correlated to the pulse energy.

1st YLF DC Kr Lamp Degradation



- ~20% loss in the 1st 1,000 h.
- Lamp needs to be replaced after 1,000 h.

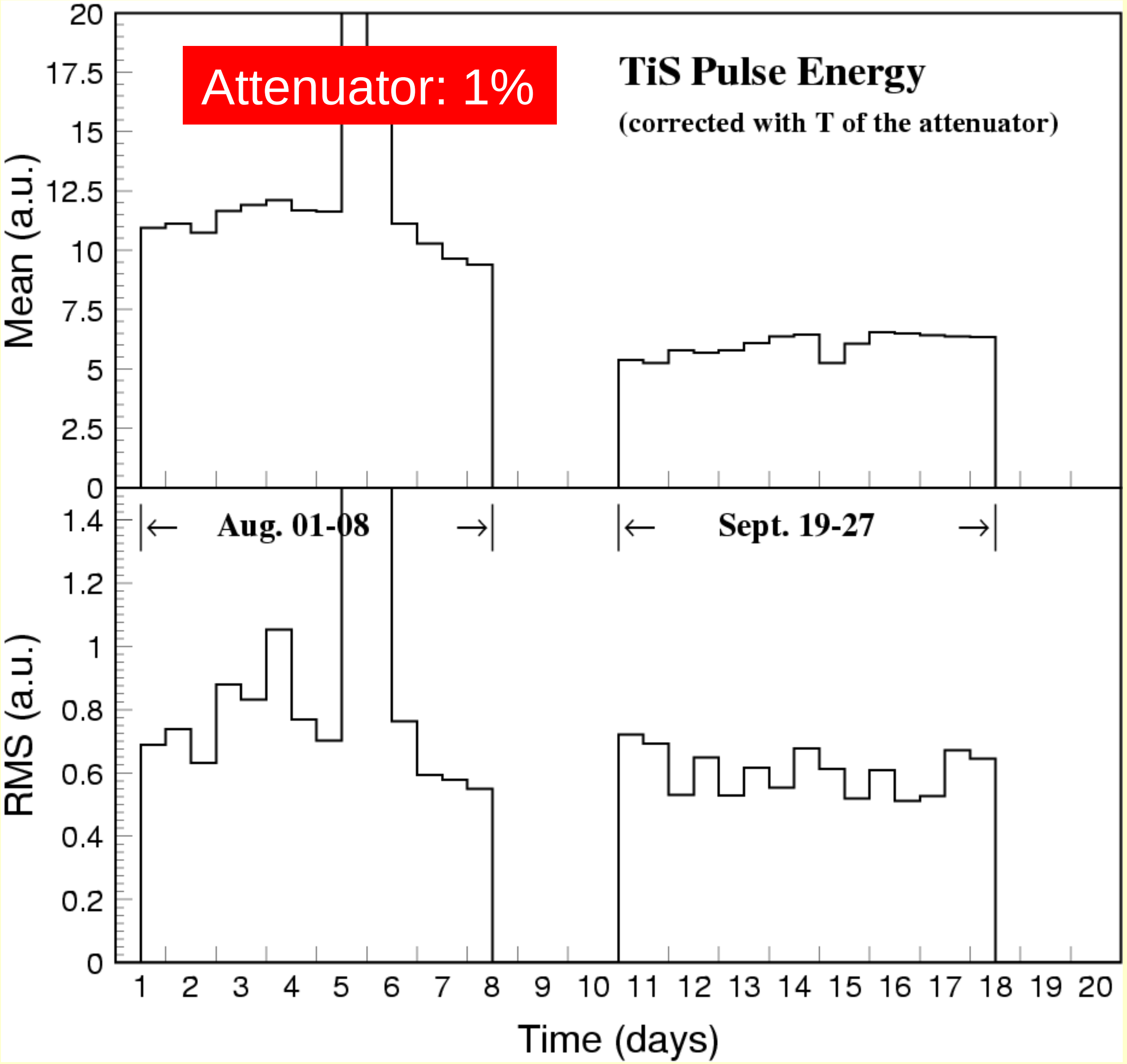
Laser Performance Summary

- Ti:S laser provides laser pulse of 25 ns FWHM at the peak power of 1 mJ. Its Intrinsic stability is better than 2% in both pulse intensity and FWHM (0.4 ns) at the peak power, but degrades off the peak.
- Ti:S pulse timing is a function of YLF pulse energy or pumping current. Stable timing requires stable YLF pulse energy.
- Contributions to the long term drifting are power fluctuation, temperature fluctuation and lamp degradation.

2002 Beam Test

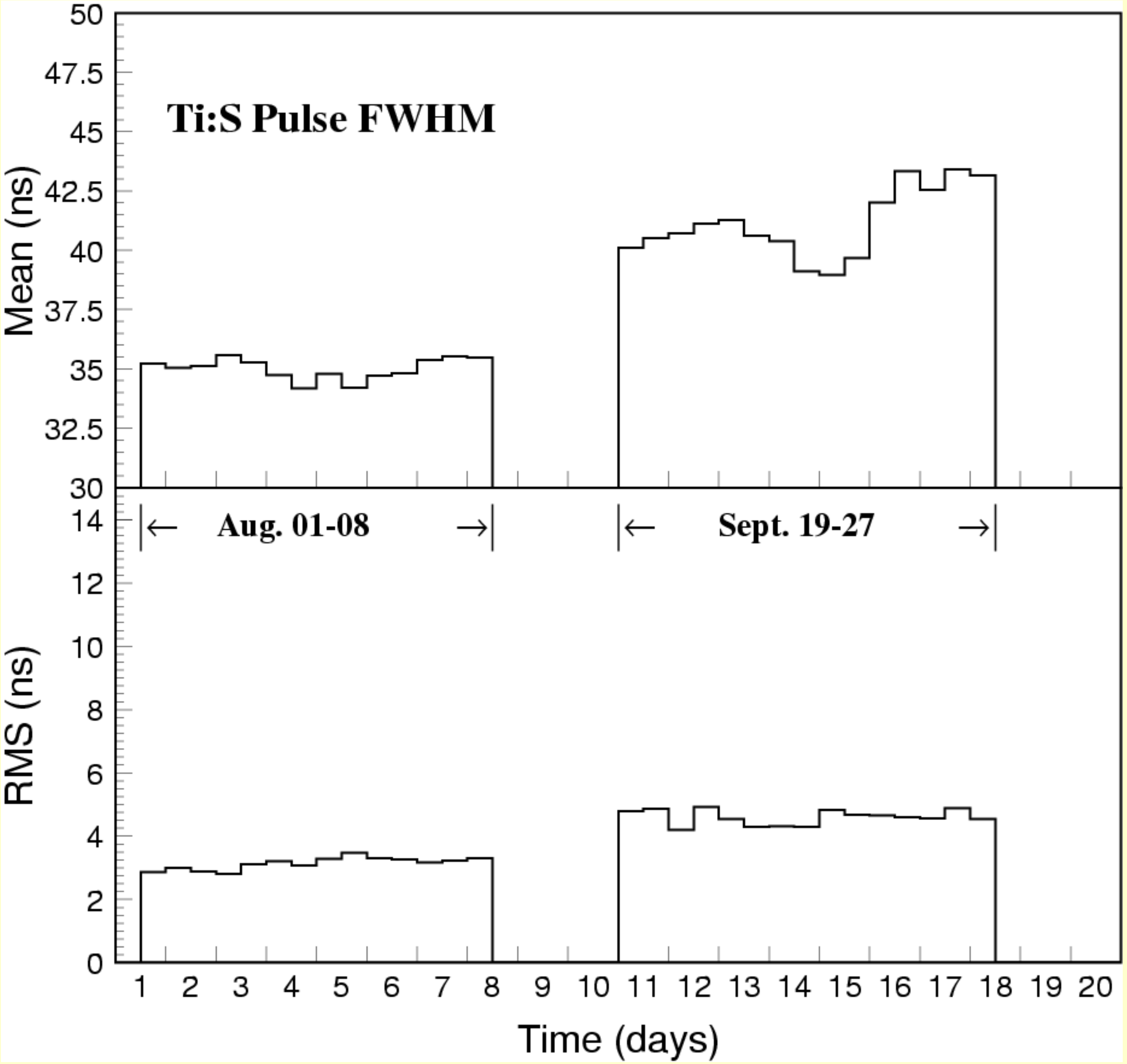
- 1^{st} laser system I&C completed 08/01.
- 440 nm available all time during BT.
- Laser controlled by H4 DAQ, ran 20 seconds every 40 minutes at 100 Hz. Ti:S pulse attenuator set by H4 DAQ.
- Laser DAQ ran two weeks: Aug. 1-8 and Sept. 19-27, with ~360 events every 12 hours.
- Significant degradation during BT. DC Kr lamp changed on Sept. 27 with 2,374h. Can not produce 495 nm.

BT: 1st TI:S Pulse Energy & r.m.s.



- Pulse energy, corrected by the attenuator setting, degraded because of lamp aging.
- r.m.s. degraded from 6 to 8%.

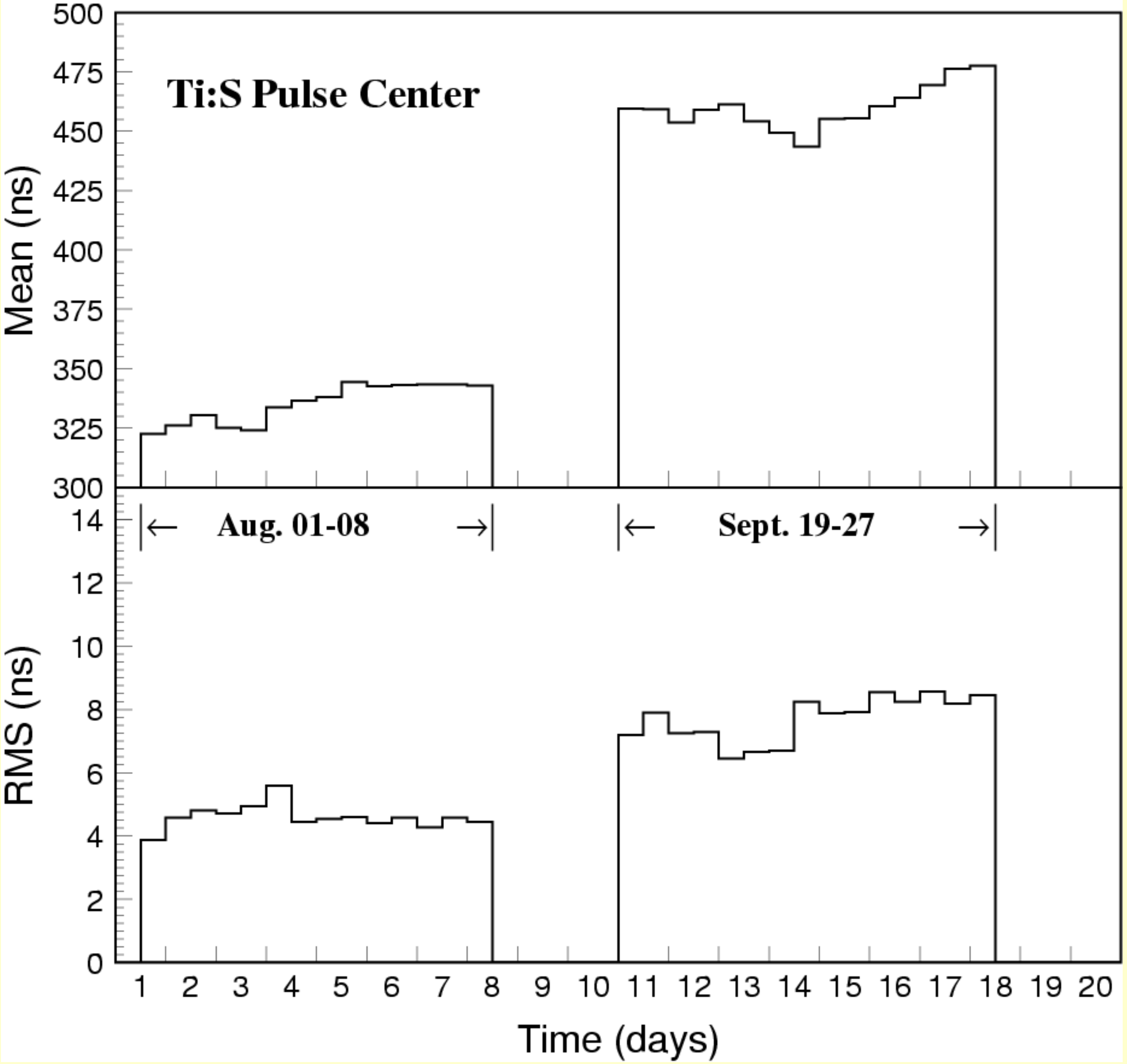
BT: 1st Ti:S Pulse FWHM & r.m.s.



- FWHM degraded from 35 to 40 ns, caused by lamp aging.

- r.m.s. degraded from 3 to 4.5 ns.

BT: 1st Ti:S Pulse Timing & Jitter



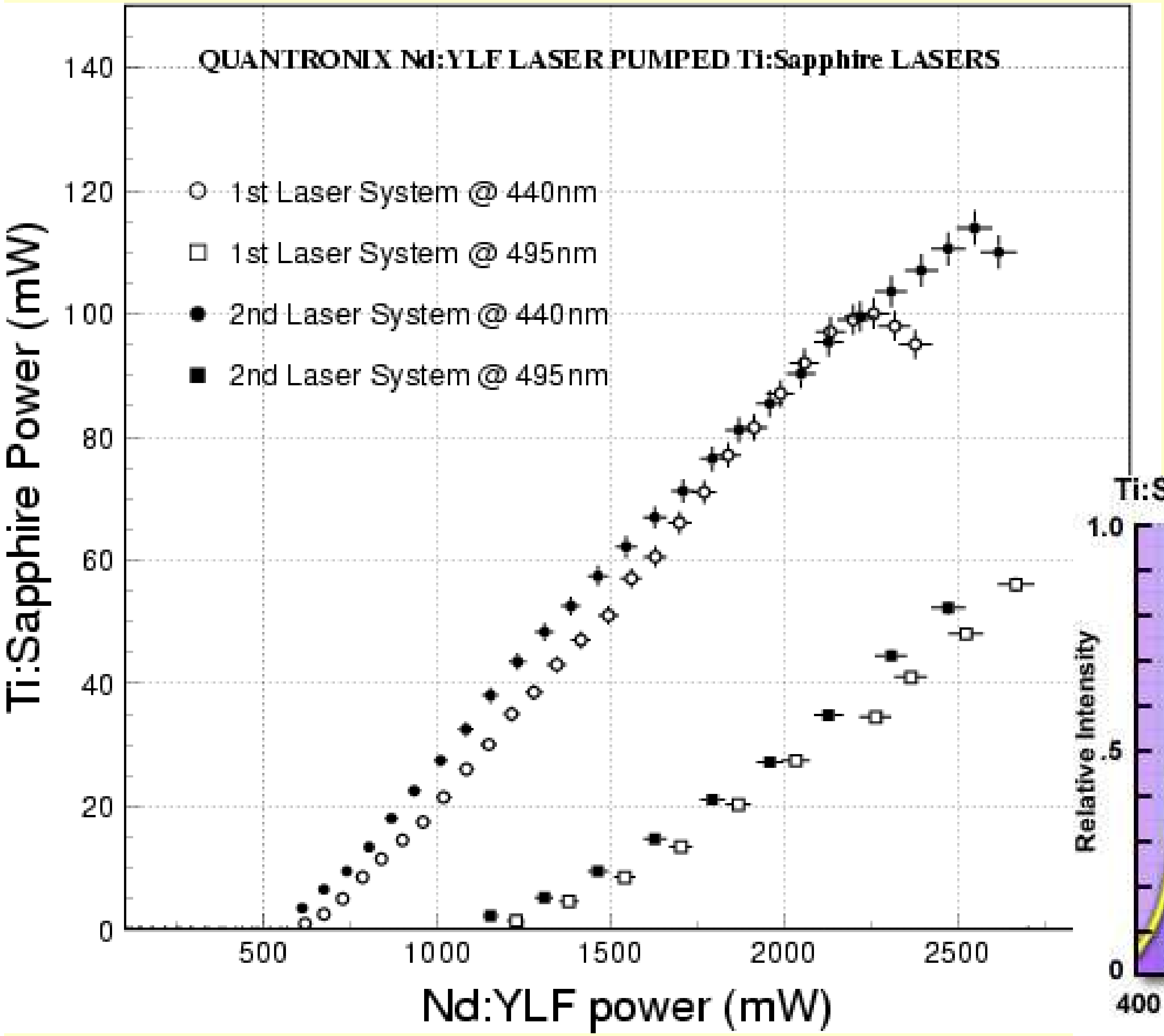
- Pulse Timing shifted by about 150 ns because of lamp aging.

- Pulse jitter degraded from 4 to 8 ns.

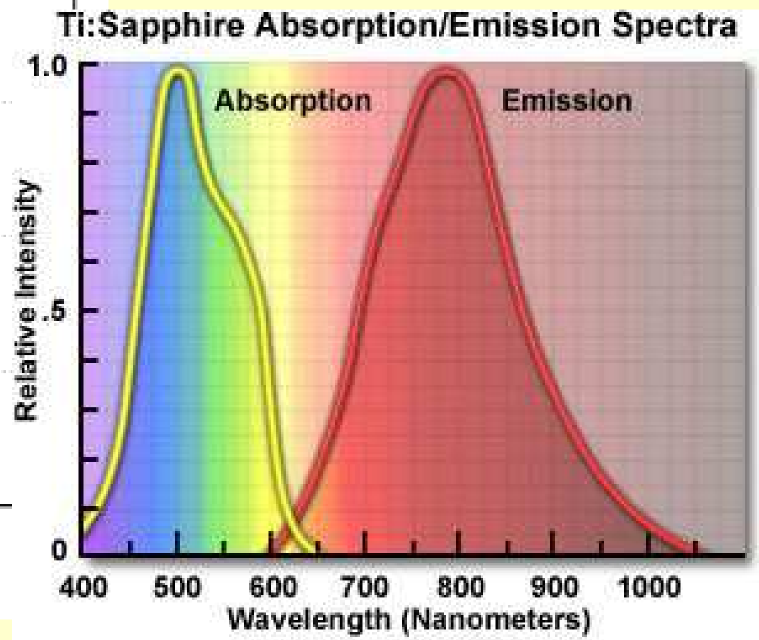
BT Performance Summary

- Laser performance worse than what achieved at Caltech since the YLF laser could not produce enough power, which was confirmed by no 495 nm light after the lamp change on Sept. 27.
- Performance was further degraded because of poor temperature regulation and lamp aging.
- Service call to Quantronix-Europe was issued on Oct. 4, and laser will be fine tuned today on Oct. 15.

Ti:Sapphire Lasing Threshold



- 495 nm needs higher YLF pulse energy.
- 2nd laser has a little lower lasing threshold.



Laser Maintenance & Operation

- Performance: keep laser DAQ running and checking pulse intensity, FWHM and timing daily. Plan to be integrated to the H4 DAQ.
- Hardware: weekly checking electricity, chilled water and filter, measure laser power and lasing threshold.
- Fine adjust the laser if necessary and replace lamp every 1,000 hours.
- Contact Caltech if there is serious problem. Call Quantronix-Europe for service if we can not resolve the problem.

Improvements?

- Extend laser barracks to accommodate two lasers and improve temperature stability.
- Laser pulse intensity may be stabilized by using a photo diode based feedback circuit which trims the power supply, such as ORIEL 68850. We are discussing with Quantronix on the feasibility of implementing “laser stabilizer” for the existing two power supplies.
- We may also run the laser at power over peak if pulse timing drifting is not a crucial issue, but higher current will shorten lamp lifetime.