Measurement of Photonics Industries DP2-447 laser at Caltech

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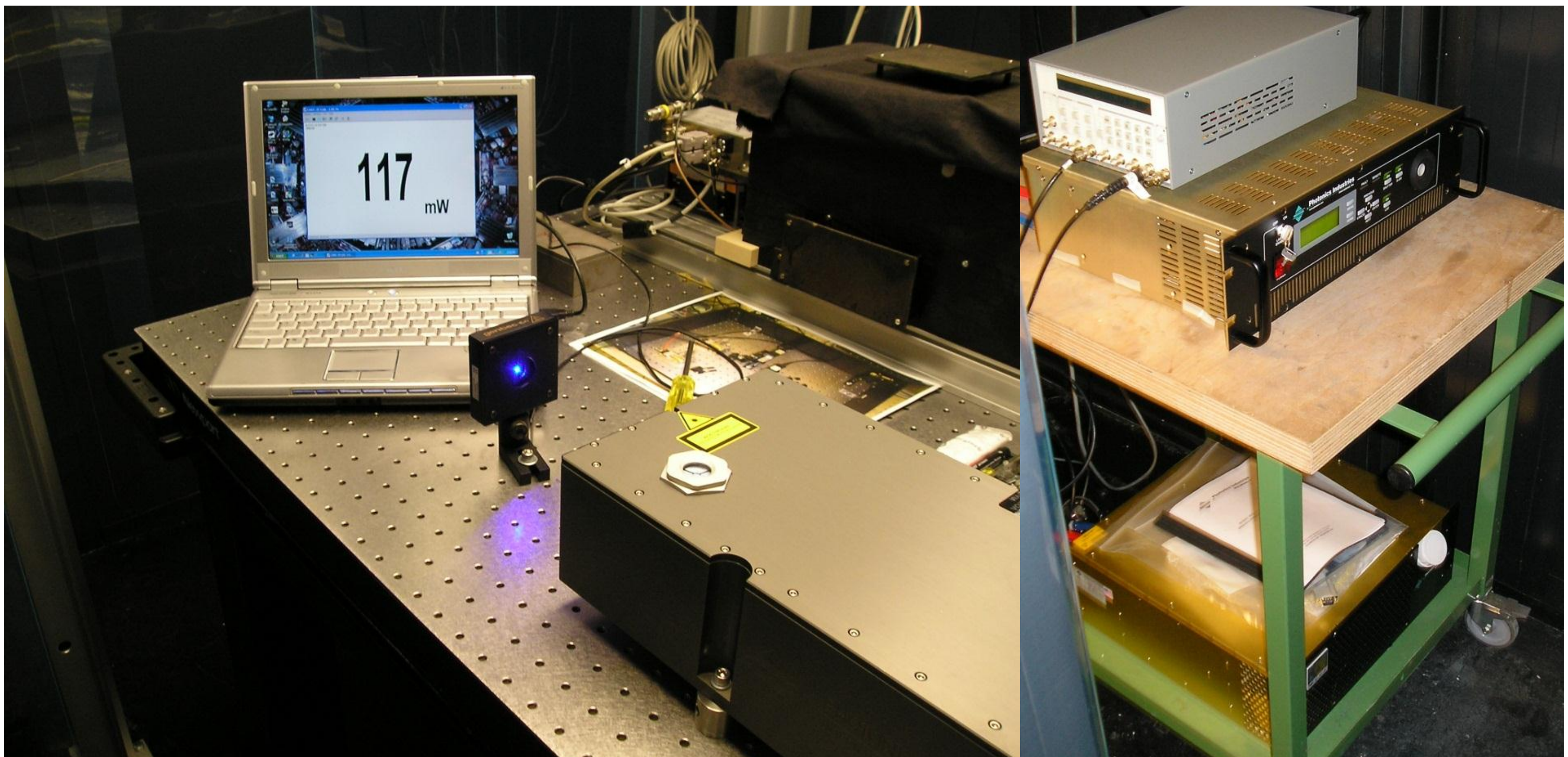
DP2-447 at P5 Yesterday

DP2-447 arrived Geneva in noon, 3/20, with initial Installation done in afternoon, 3/21. Its output power consists with what measured at Caltech, indicating no B field effect.



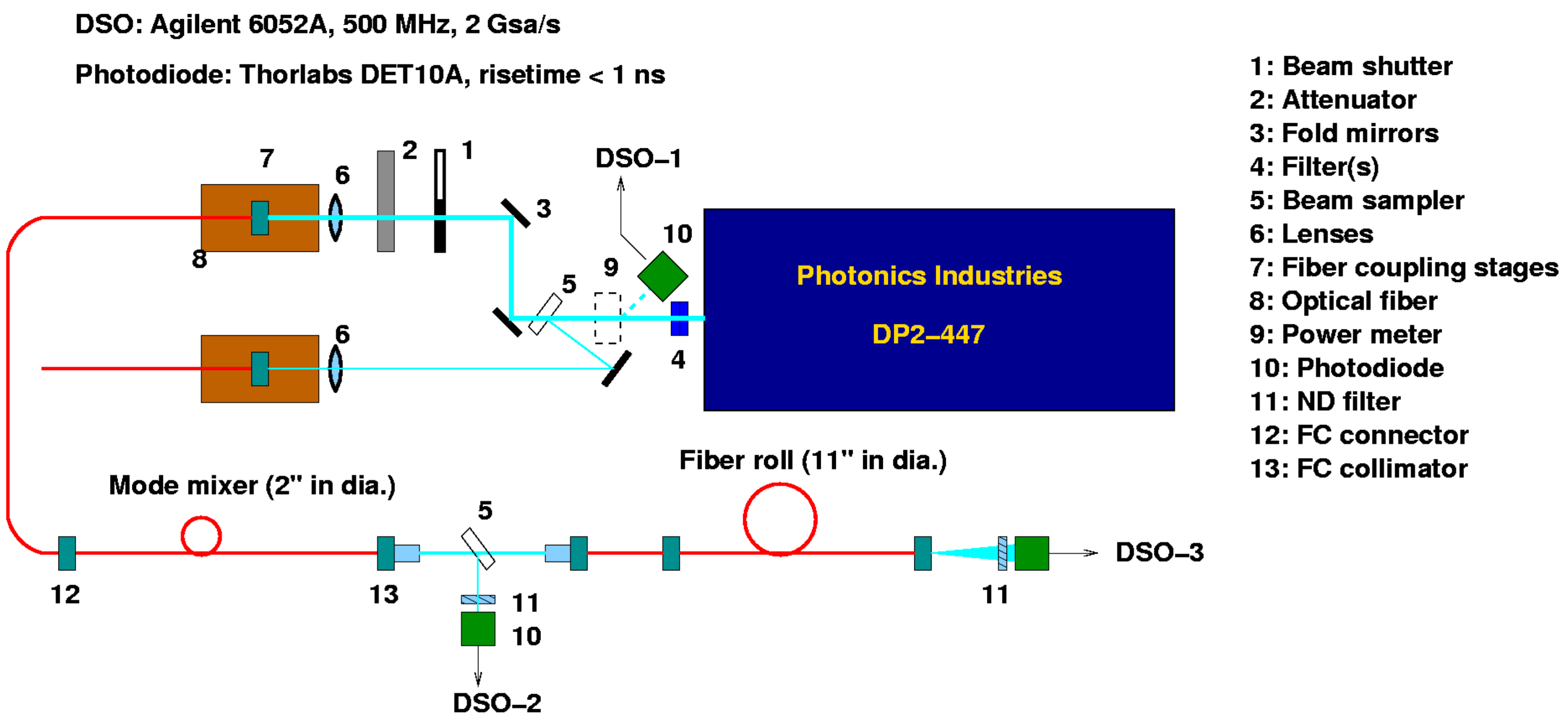
Revised Specifications for RFQ

- **Pulse energy:** 1 mJ/pulse at 440 nm, equivalent to 1.3 TeV in dynamic range.
- **Pulse intensity instability:** < 3%.
- **Pulse FWHM:** < 30 ns to match ECAL readout.
- **Pulse jitter:** < 3 ns for synchronization with LHC.
- **Pulse repetition rate:** 0-100 Hz, scan of full ECAL in 20min.
- **Pulse delay from external trigger:** < 90 μs, for monitoring trigger to stay in one LHC beam cycle.

The laser will be integrated into the existing monitoring system, so a compact system is highly desired. The laser will be run in the 24/7 mode, MTBR (mean time between repairs) is required to be longer than 3 months.

Measurement Setup Layout

DSO-1 was used to evaluate DP2-447 Performance



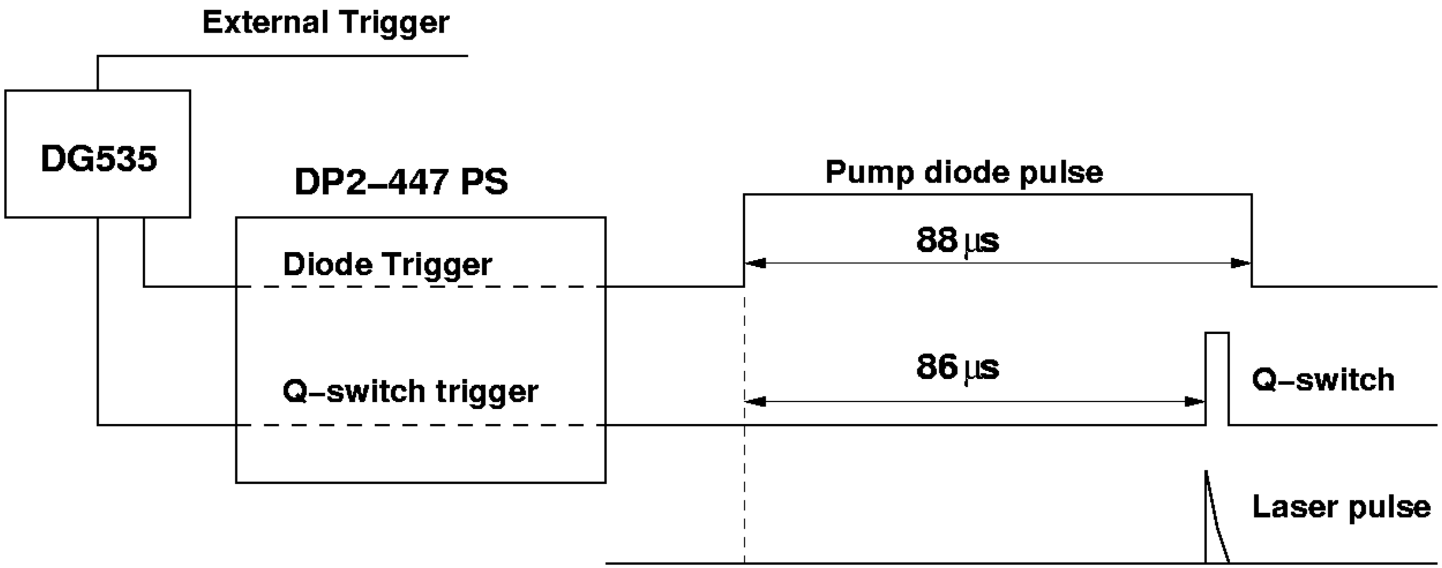
DSO-2 and 3 were used to measure fiber dispersion

DP2-447 Trigger Scheme

Dual trigger inputs: Two triggers were optimized by Photonics Industries for DP2-447 to meet the specifications. Fine tune for optimization is possible.

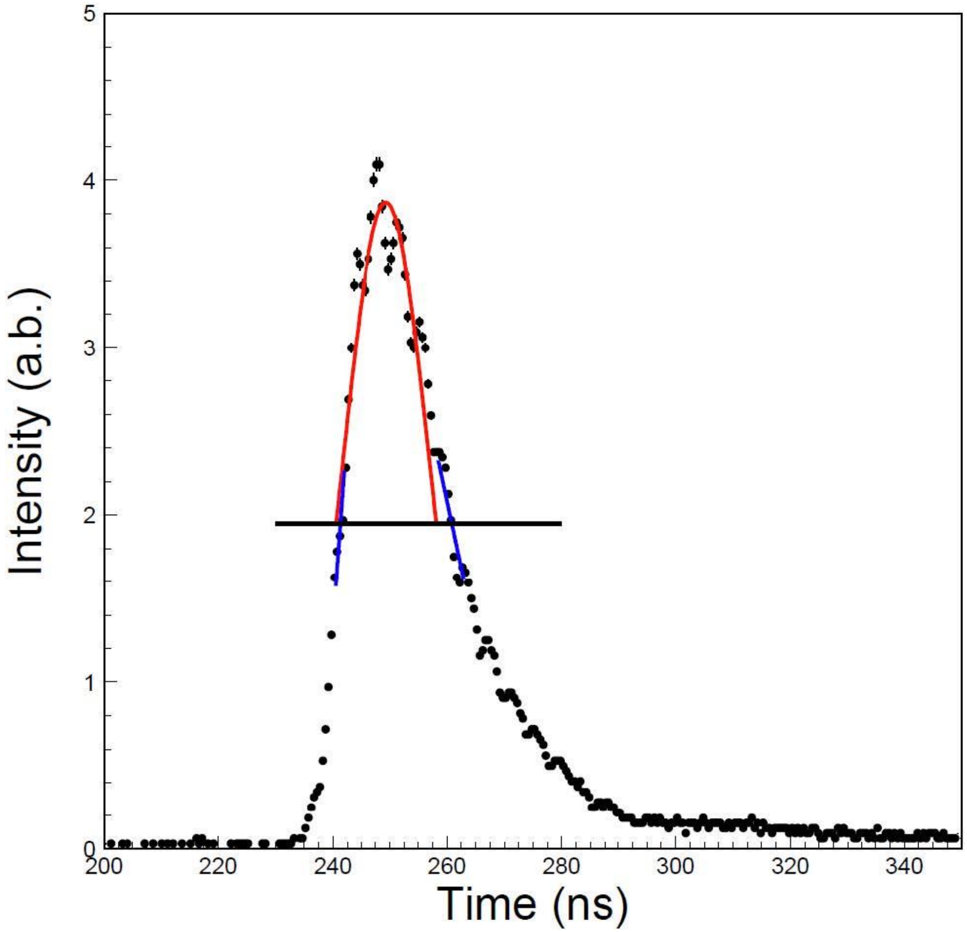
Diode Trigger: the rise/fall edge turns ON/OFF the pumping diode.

Q-switch trigger: the rise edge turns on the Q-switch.



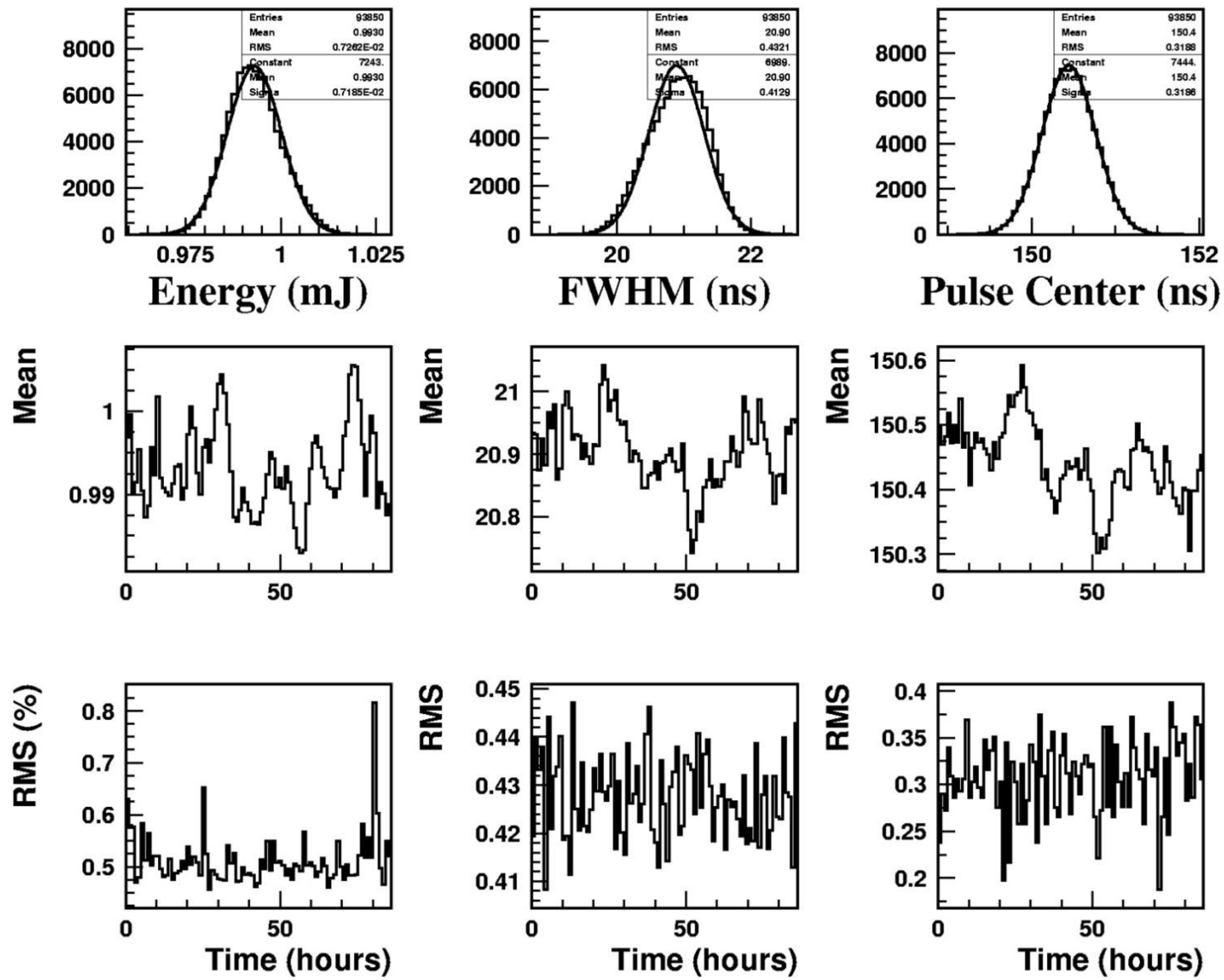
Pulse Shape Reconstruction

500 MHz, 2 GS/s DSO

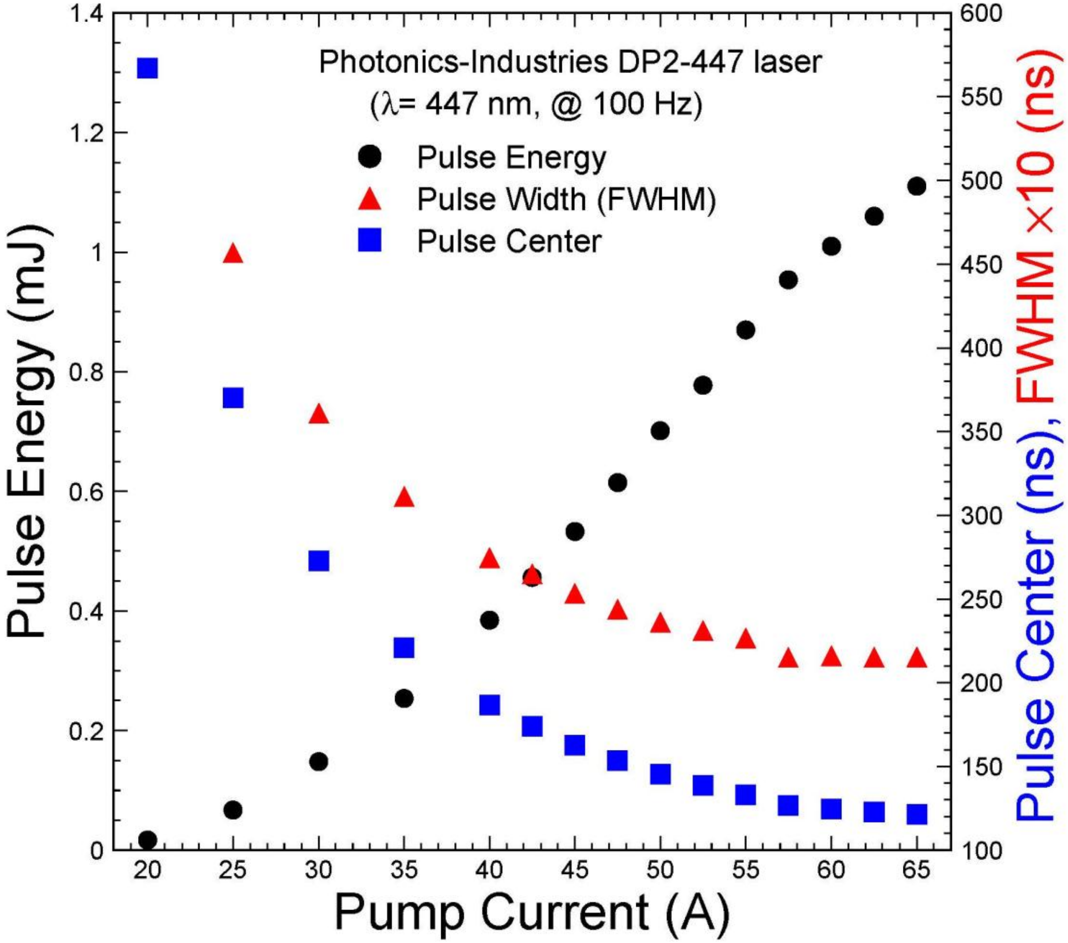


- Find maximum pulse V_m
- Find time at $V_m/2$: t_1 and t_2
- Gaussian fit in (t_1, t_2)
- Pulse energy: Σy_i in $(-4\sigma, 8\sigma)$
- Pulse center: $\Sigma t_i y_i / \Sigma y_i$ in $(-4\sigma, 8\sigma)$
- Pulse width: 5 points (2 before and 2 after) linear fits to find t_{1f} and t_{2f} at $V_m/2$. FWHM = $t_{2f} - t_{1f}$

Instability Observed in a Test of 87 hours: 0.7%/2%/0.3 ns for Intensity/Width/Jitter



Pulse Intensity, Width, Timing vs. Current

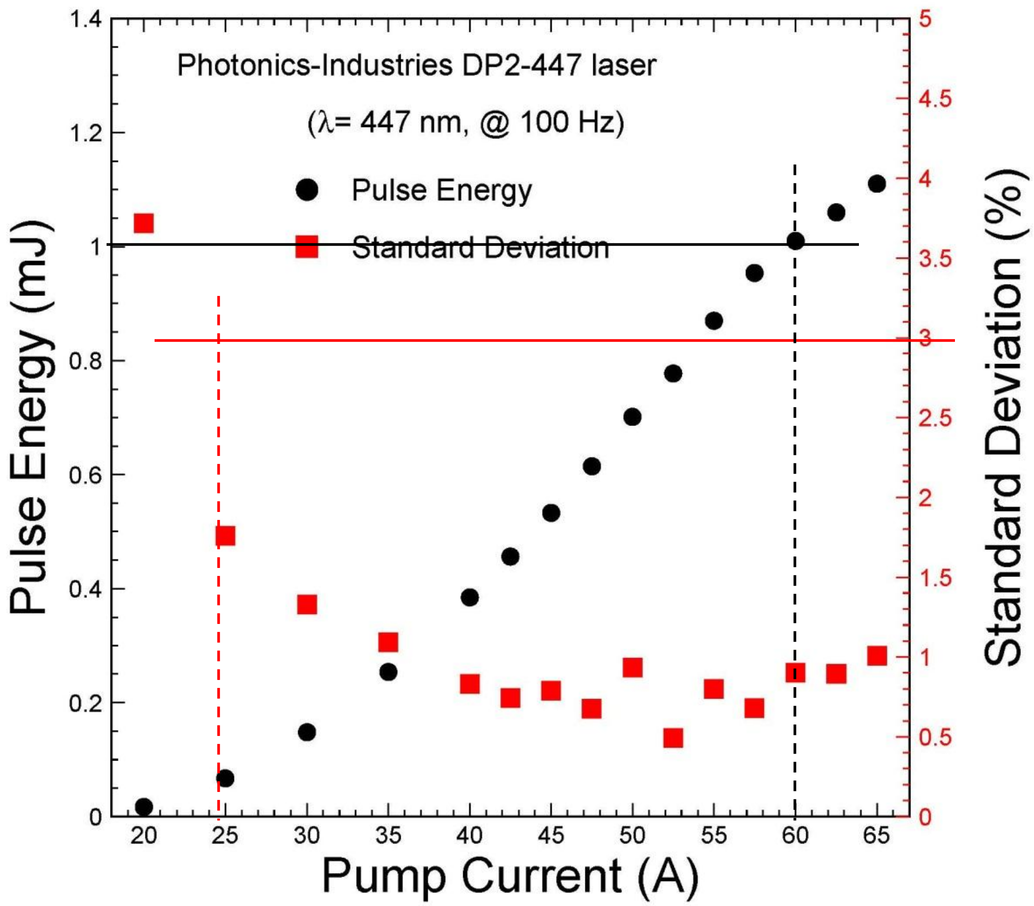


All measurements were done with the default trigger setting.

Diode Trigger width: 88 µs.

Q-switch trigger: 86 µs.

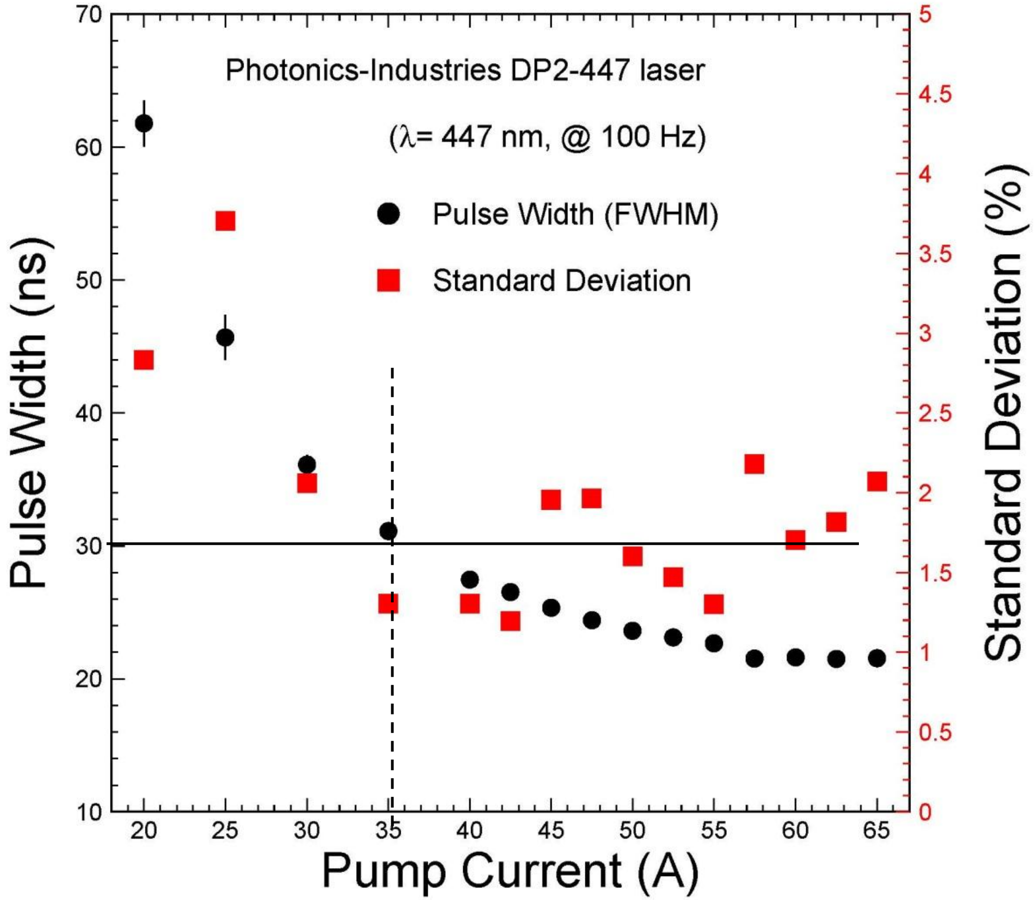
Pulse Energy and Its Instability



To reach 1 mJ pulse energy the pumping current should be >= 60A.

Optimized stability (<1%): 40 to 65 A.

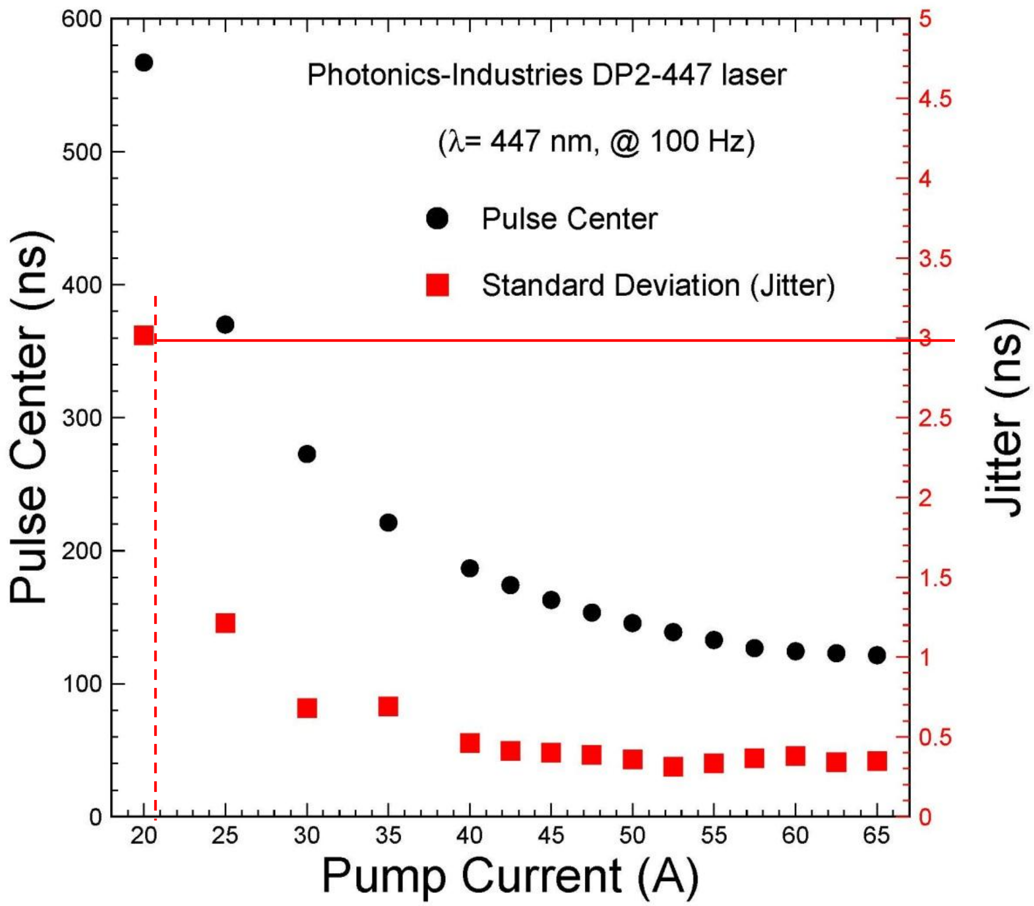
Pulse Width and Its Instability



Above 35 A, the pulse width meets the spec: <30 ns with its instability about 2%.

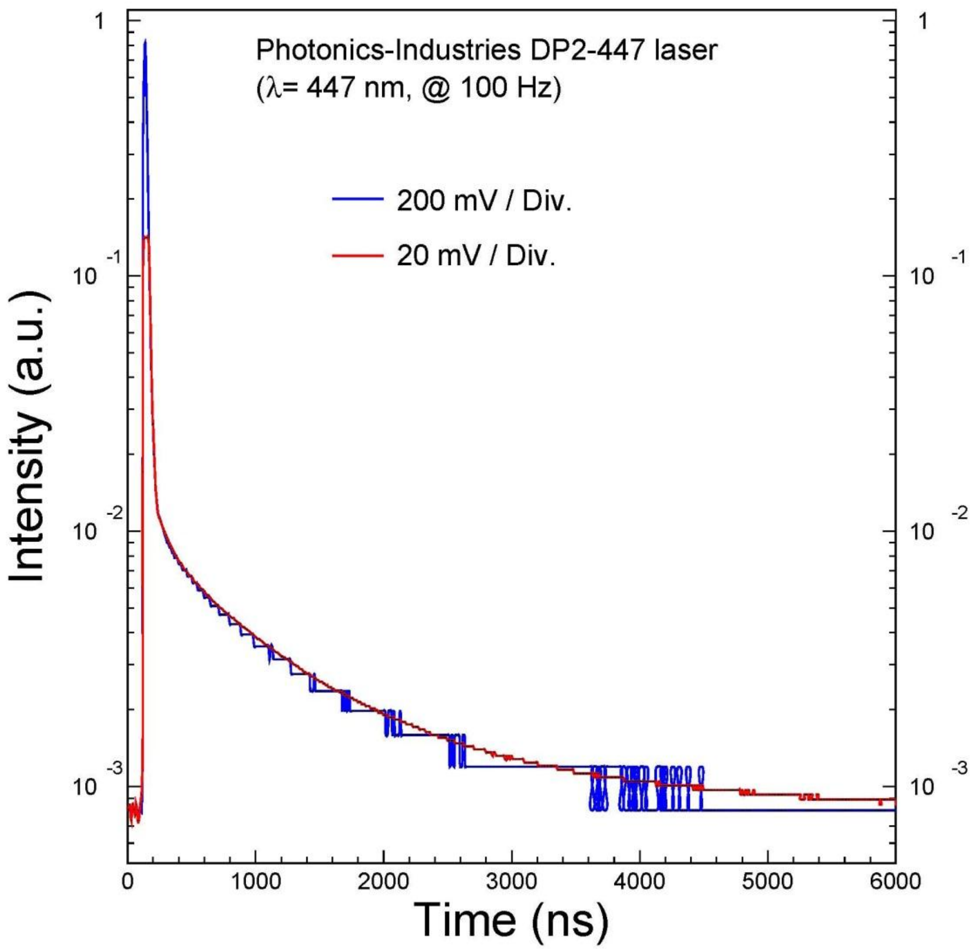
Pulse width down to 22 ns may be achieved pumping current of > 55 A.

Pulse Center Timing and Its Jitter



This laser featured with very small jitter of < 0.5 ns for pumping current of > 40 A.

DP2-447 Laser Pulse Tail



At 60A pumping current, the laser pulse was measured at two scales by using an average function of the DSO (256).

A pulse tail of up to 6 μs with an amplitude down to 10^{-3} was observed.

Safety Issues

The DP2-447 equips with two interlocks for the intra-cavity shutter.

1.) TTL logic Interlock in shutter driver (Software).

2.) Shutter Power supply interlock (Hardware).

We may consider to add Software interlock into the door and safety cover loop, and Hardware interlock into Emergency loop.

Summary

Measurements at Caltech show that the DP2-447 laser meets original specifications. Good stability was observed in a run of 87 hours: 0.7%/2%/0.3 ns for the laser pulse intensity/width/jitter.

Pumping current of 60 A is required to reach 1 mJ with diode pumping time width of 88 µs and Q-switch delay of 86 µs.

Pumping current for DP2-447 may be reduced to 40 A to extend laser life time. The corresponding performances are (1) the laser pulse energy/width of 0.4 mJ/27 ns, and (2) the laser pulse instability in intensity/width/jitter of 1%/2%/0.5 ns.

Laser pulse tail up to 6 µs was observed with amplitude down to 0.1%. Further study on this issue may be carried out at CERN.

Further optimization on laser triggers may also be carried out.