



Options for Laser Replacement

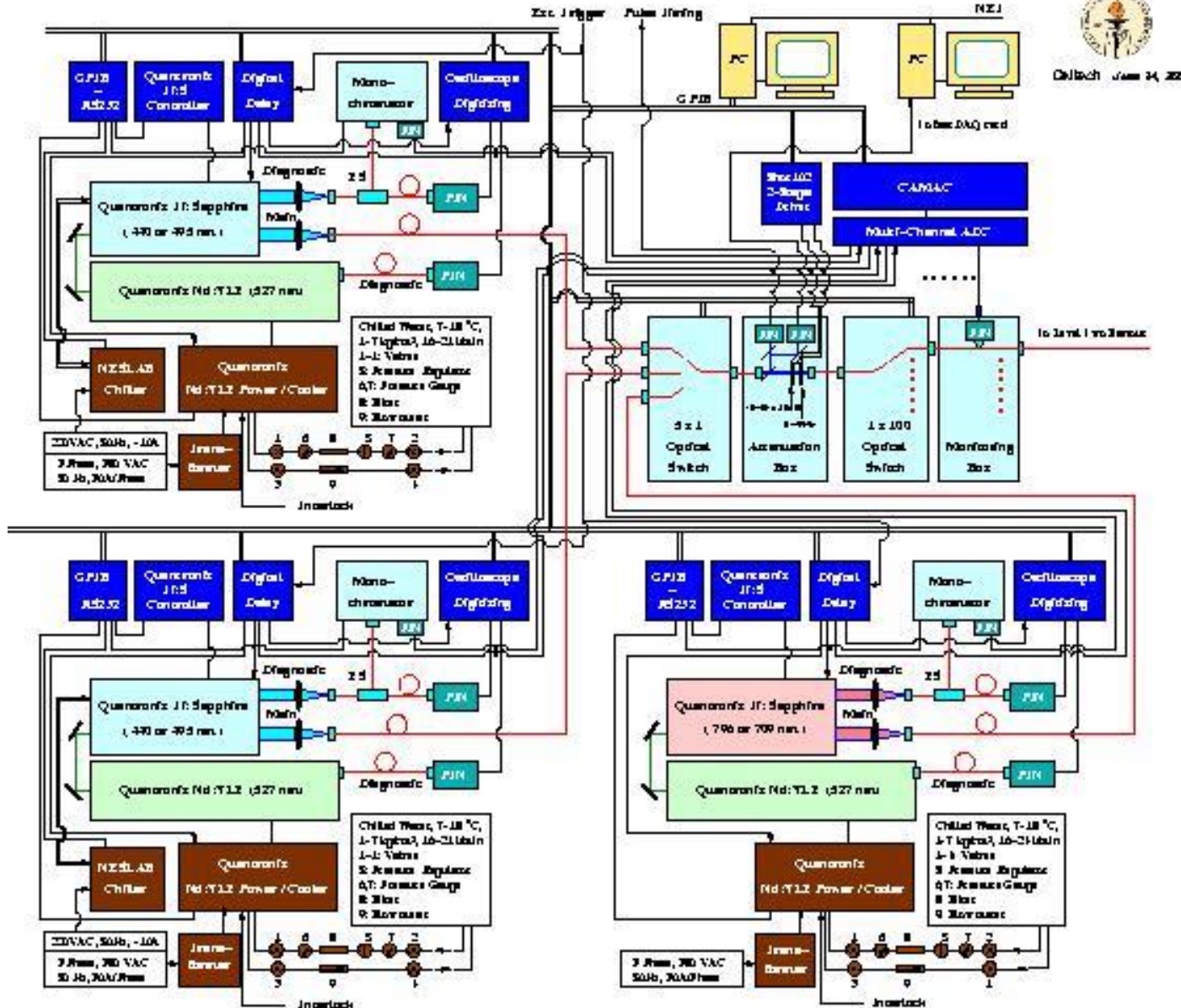
Ren-yuan Zhu

Caltech

December 7, 2010



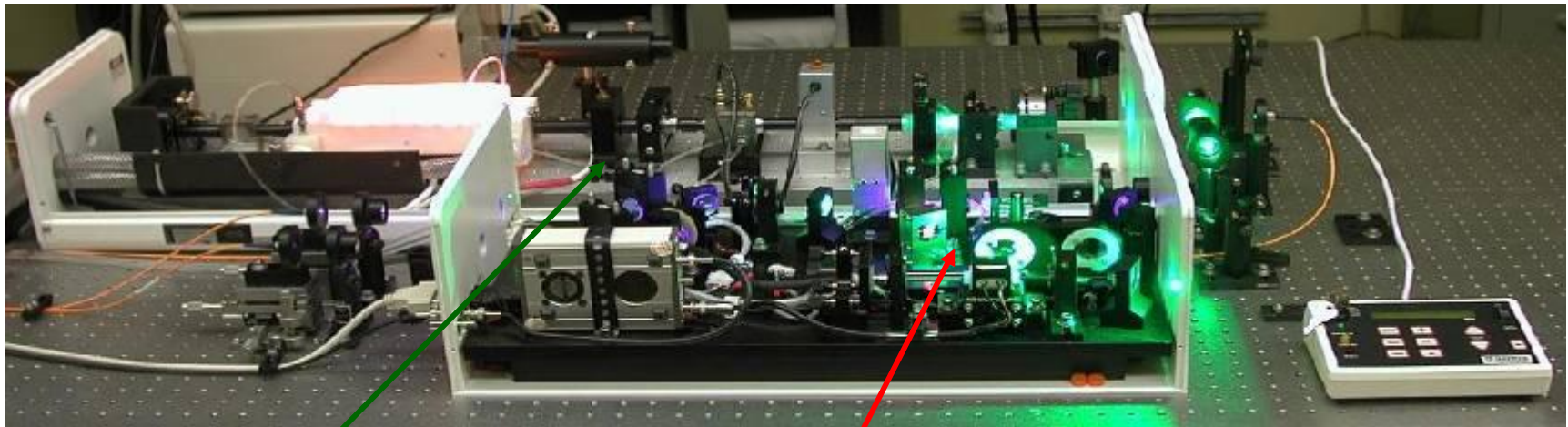
ECAL Laser System



It includes three lasers with diagnostics, two optical switches and intensity attenuators.

1st laser at H4: 08/2001
 2nd & 3rd lasers: 8/2003
 Software Feedback: 05/2006
 Lasers at P5: since 03/2007

DC Kr Pumped & Ti:Sapphire Lasers



Internal attenuator at 1% step for intensity adjustment

Two λ using interference filters in path

Blue/green: 440/495 nm

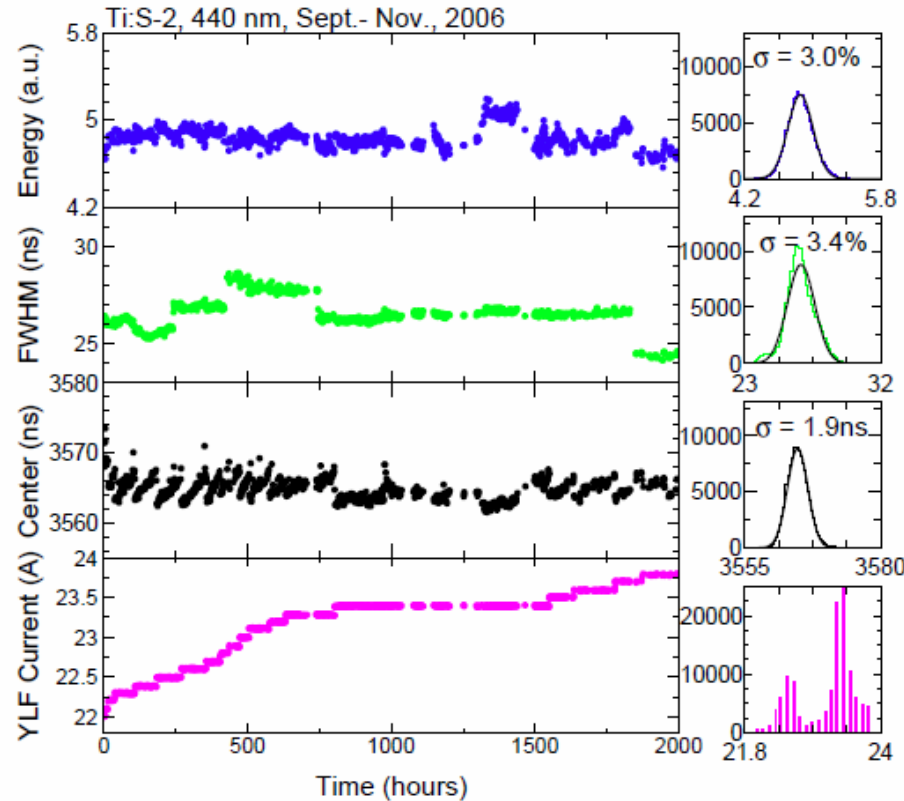
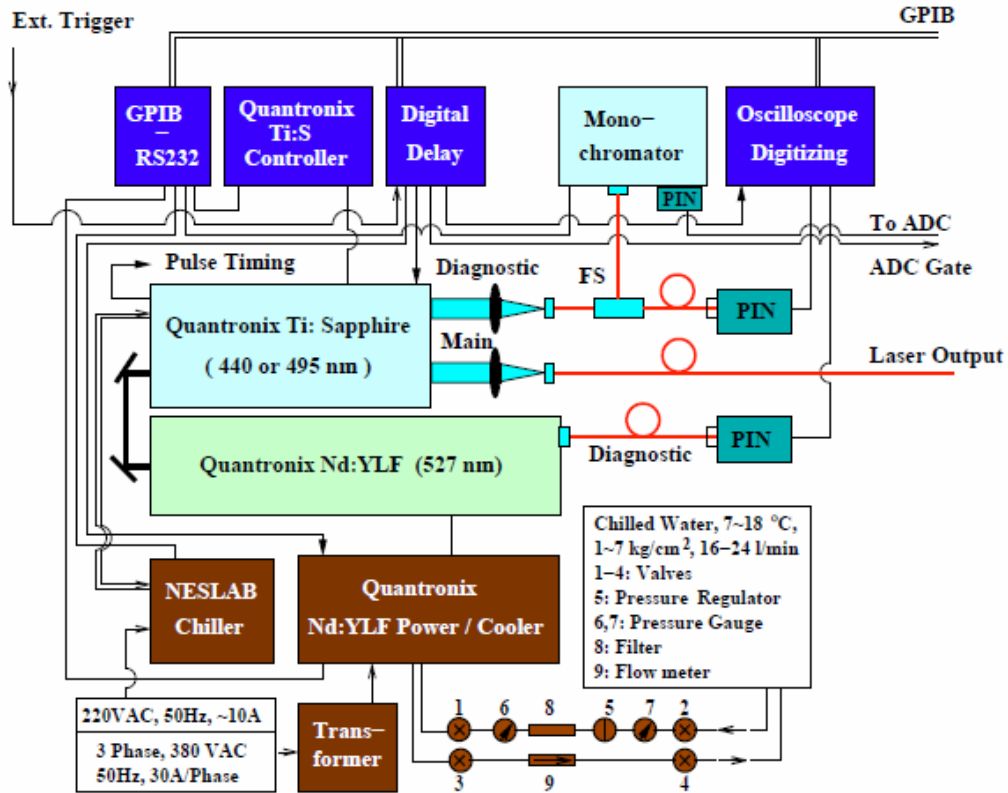
IR/Red: 796/709 nm



Status of Monitoring Lasers



It operates 24/7 as designed, providing 100% availability of the blue (440 nm), and the IR (800 nm) as the 2nd wavelength for the barrel. With a software feedback and an inserted delay the laser pulses show the same intensity and width with about 3% instability and 3 ns jitter.





Four Existing Issues



1. Need spare Dicon optical switches: 5 x 1 and 1 x 100. The system will not function when they break.
2. Quantronix discontinued DC Kr lamp pumped Nd:YLF laser in 2005. All parts, e.g. RF driver, power distribution unit etc., are discontinued since 2009. Consumable, e.g. pumping housings etc., are no longer available.
3. There has been a discussion since 2008 about adding a 2nd wavelength at 600 nm for the endcaps, where both PWO transparency and VPT gain change *in situ*.
4. Spare lasers for the second wavelengths are needed if 100% availability is required.



Quotation: GP700 Optical Switch



DiCon
FIBEROPTICS, INC
 1689 REGATTA BLVD.
 RICHMOND, CA 94804
 TEL (510) 620-5200
 FAX (510) 620-4102
 sales@diconfiber.com
 www.diconfiber.com

TO:
 LIYUAN ZHANG
 ZHANG_L@LIGO.CALTECH.EDU
 CALIFORNIA INSTITUTE OF TECHNOLOGY
 MS 256-48, CALTECH
 391 S. HOLLISTON
 PASADENA, CA 91125
 UNITED STATES
 TEL: 626-395-6618
 FAX: 626-795-3951

Sales Quotation		Quote ID No. & Rev.	7077B
FOB	ORIGIN	Quote Issue Date	10/5/2010
Payment Terms		NET30 FROM SHIPMENT DATE	
DiCon Contact		DICON SALES (510) 620-5200, SALES@DICONFIBER.COM	

Item	DiCon's Part No. / Buyer's Part No. / Description	Quantity / Unit Price	Shipment Dates
1	DiCon's P/N: GP700-2-1/1X5-8-365-FC-B-Z Description: GP700 PROGRAMMABLE PLATFORM SPECIAL Buyer's P/N: Note: Special pricing for educational purposes. Special Requirements: 365um Silica-Silica HCG-M0365T fiber to be supplied by the customer. FC/PC stainless steel connectors to be ordered by DiCon. Alignment & testing will be done at 850nm.	\$8,745.00 each Pricing valid if both lines, 1 and 2, are purchased together.	4 - 6 weeks OAD
2	DiCon's P/N: GP700-4-1/1X100-8-365-FC-B-Z Description: GP700 PROGRAMMABLE PLATFORM SPECIAL Buyer's P/N: Note: Special pricing for educational purposes. Special Requirements: 365um Silica-Silica HCG-M0365T fiber to be supplied by the customer. FC/PC stainless steel connectors to be ordered by DiCon. Alignment & testing will be done at 850nm.	\$62,150.00 each Pricing valid if both lines, 1 and 2, are purchased together.	6 - 8 weeks OAD



Replacing DC Kr Lamp Pumped Nd:YLF with Laser-Diode Pumped Nd:YLF

Quantronix replaced DC Kr pumped Nd:YLF laser with laser-diode pumped Nd:YLF laser in their product line starting 2005. The later has the following advantages.

1. Better pulse intensity stability;
2. Better life time over 10,000 h;
3. Less maintenance requirement;
4. Less power consumption.

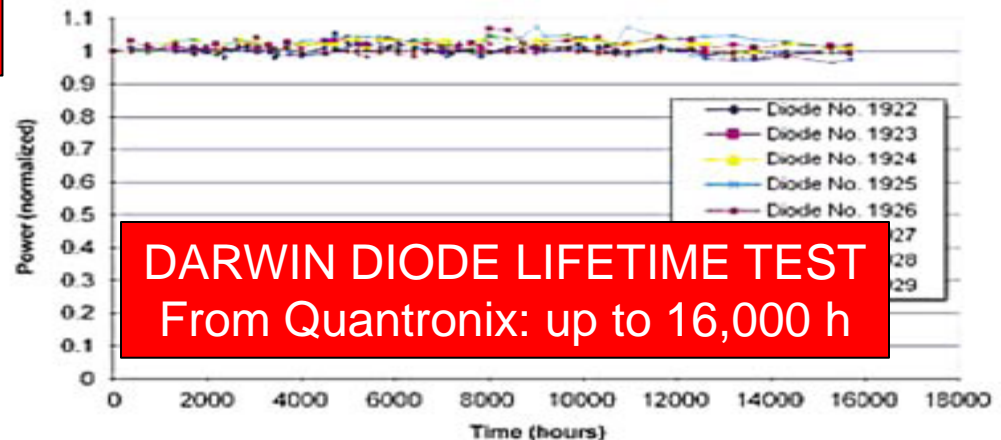
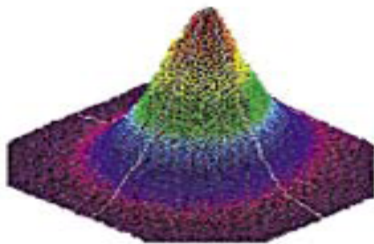


Pump Laser Comparison



Parameters at 1KHz	DC Kr Lamp pumped 527DQ-S	Diode pumped Darwin 527-40-M
Average Output power (W)	20	25
Power instability (% RMS)	2	0.5
Pulse energy (mJ)	20	25
Pulse width, typical (ns)	150	150
Beam pointing stability (μ rad)	30	25
Beam diameter (mm)	3	2.5
Divergence (mrad)	5	8

DARWIN 3D BEAM PROFILE





Darwin Laser User Reference



Prof. Michael Fayer of Stanford university replaced three Quantronix 527DQ Nd:YLF lasers with diode pumped Darwin lasers five years ago and provided the following comments.

- Low maintenance: water filters replaced once per three months; fine tuning optics some times.
- The diode module needs to be run continuously for extended lifetime, which is the case of our application.
- Good reliability: none of the three lasers was sent back for a reparation. One of the three pumping diode modules was replaced (~\$10K) after 40,000 hrs, other two are still working with accumulated run times of 20,000 and 30,000 hrs without significant degradation in the laser output.
- Two additional failures happened in the last five years: one was in an RF driver and other in a water chiller.



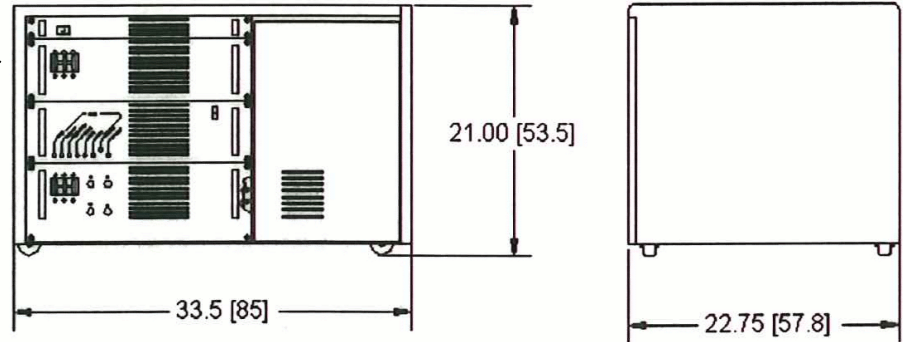
Issues to be Addressed

Replacing the DC Kr lamp pumped Nd:YLF laser with diode pumped model is not straight forward. Three issues need to be addressed.

- Quantronix claims that the Darwin 527-40-M works in the residual B-field in the laser barrack at P5, but not guaranteed. An return option is offered in their quotation with 30% restocking fee within one month.
- Because of the change of the beam divergence the coupling optics between YLF and Ti:S needs to be redesigned with new parts. Quantronix will **NOT** provide this service. We'll have to do it by ourselves.
- The laser power supply for the diode pumped laser is a new model. The laser DAQ software needs to be updated for this replacement.

Power Supply Unit Comparison

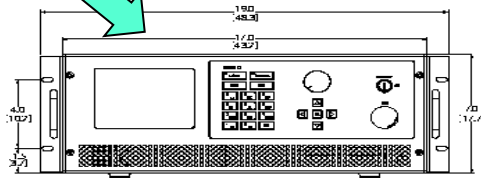
Kr lamp pumped 527DQ:
 33.5"(L)×22.8"(D) ×21.0"(H)



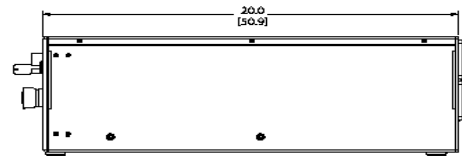
Diode pumped 527-40-M, two units:
 19.0"(L)×20.0"(D) ×7.0"(H)
 19.0"(L)×27.5"(D) ×16.2"(H)



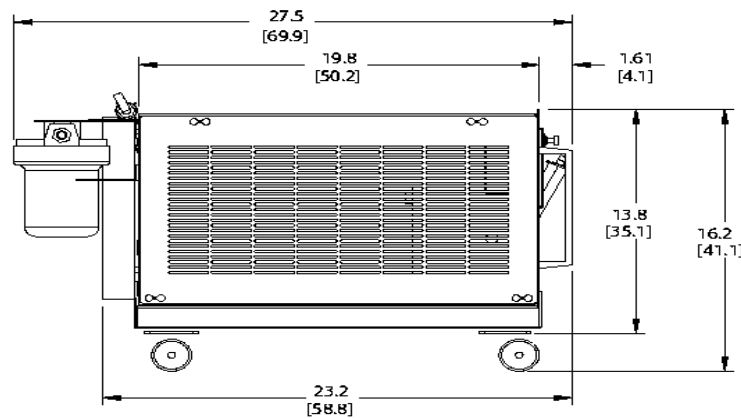
FRONT VIEW
(POWER SUPPLY)



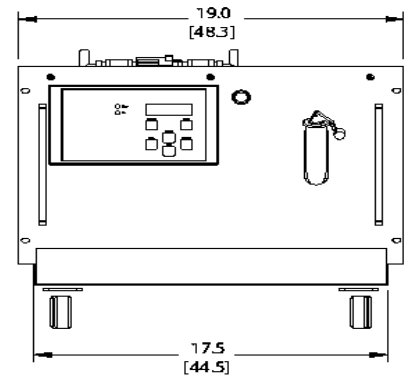
SIDE VIEW



SIDE VIEW
(CHILLER)



FRONT VIEW





Quotation: Darwin-Pro-527-40-M



41 Research Way
East Setauket, NY 11733
Phone (631)784-6100 FAX (631)784-6101

Quotation No

2191 - 001-10

CUST REF #:

DATE: November 15, 2010

VALID FOR: 30 Days

PAGE NO. 1 of 3

Attn: Dr. Liyuan Zhang
California Institute of Technology
244 Lauritsen Laboratory
Pasadena CA 91125
Tel: (626) 395-6618 Fax:
E-mail: liyuan@hep.caltech.edu

Send Purchase Order to:
Quantronix Corp
41 Research Way
East Setauket, NY 11733
Email: hseferyan@quantronixlasers.com
Phone: 1-631-784-6100
Fax: 1-631-784-6101

WE ARE PLEASED TO QUOTE THE FOLLOWING:

ITEM	QTY	DESCRIPTION	UNIT PRICE	TOTAL	
1	1	Darwin-Pro-527-40-M (DPSS Nd:YLF Laser) * Wavelength: 527nm * Power: 40W at 3kHz * Please refer to the attached spec sheet for more information * Price includes standard diode module warranty	65,000.00	65,000.00	
2	0	Upgrade to Water/Water Heat Exchanger	500.00	0.00	
3	0	Longer Umbilical Cable (20 ft) * Please note that the return of Item #1 is possible within 30 days of the purchase; a 30% restocking fee will be applied based on the current list price.	1,000.00	0.00	
			Subtotal	65,000.00	
F.O.B.		Payment Terms	Delivery	Sales Tax %	0.00
East Setauket, NY		Net 30 days	60 - 90 days ARO	Transportation	
			Total USD	\$65,000.00	

All Items In This Quote Is Subject To The Quantronix Scientific Standard Terms And Conditions. Please Reference Quote Number When Ordering. Customs, Taxes Are Extra, If Applicable. All Prices In Quote Are In Us Dollars.

for additional information contact:
Hrant Seferyan, Regional Sales Manager
hseferyan@quantronixlasers.com



2nd Wavelength for Endcaps



2nd wavelength is needed to disentangle variations of PWO and VPT. Because of the VPT response it should not be longer than 610 nm. This light source can be provided by two approaches: (1) multiple sources distributed to all L1 fan-outs on detector or (2) a centralized laser source in the laser barracks at USC55 satisfying the following original specification.

- Pulse Width: Full width at half maximum (FWHM) < 40 ns to match the ECAL readout.
- Pulse Jitters: < 3 ns for trigger synchronization to the LHC beam.
- Pulse Rate: ~ 80 Hz, which is the rate at which the “spy mode” ECAL DAQ used for monitoring events can operate.
- Pulse Energy: 1 mJ/pulse at monitoring wavelength, corresponding to 1.3 TeV in full dynamic range, and a linear attenuator at 1% step down to 13 GeV.
- Pulse Intensity Instability: < 10% to guarantee moni-



Power Requirement of the Monitoring Light Source



To keep 1.3 TeV dynamic range, the required pulse energy with a pulse width of < 40 ns would be

In laser barracks to switches:

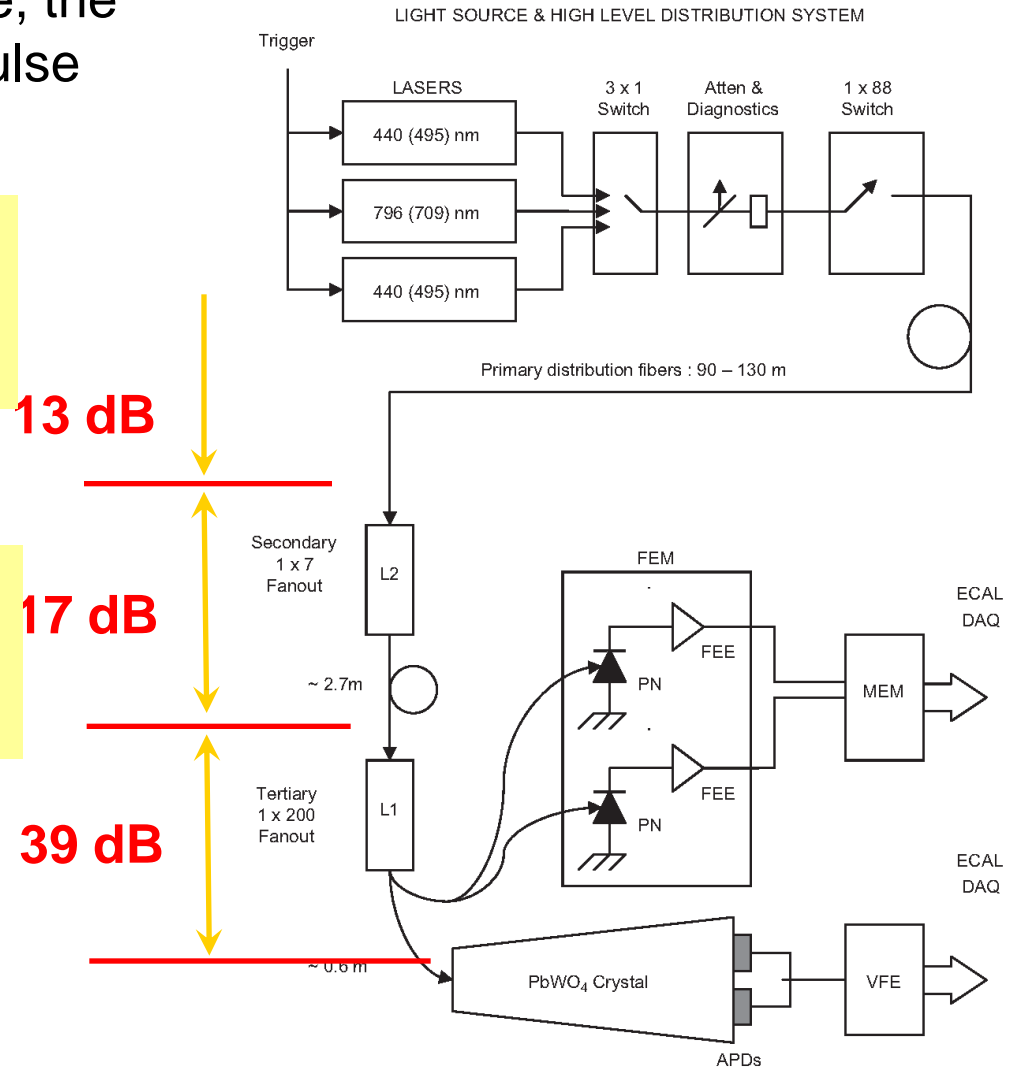
1 mJ (or peak power **25 kW**)

On detector to L1 Fanouts:

1 μ J (or peak power **25 W**)

Commercial LED/laser diode does not provide such power.

M. Anfreville et al. / Nuclear Instruments and Methods in Physics Research A 594 (2008) 292-320

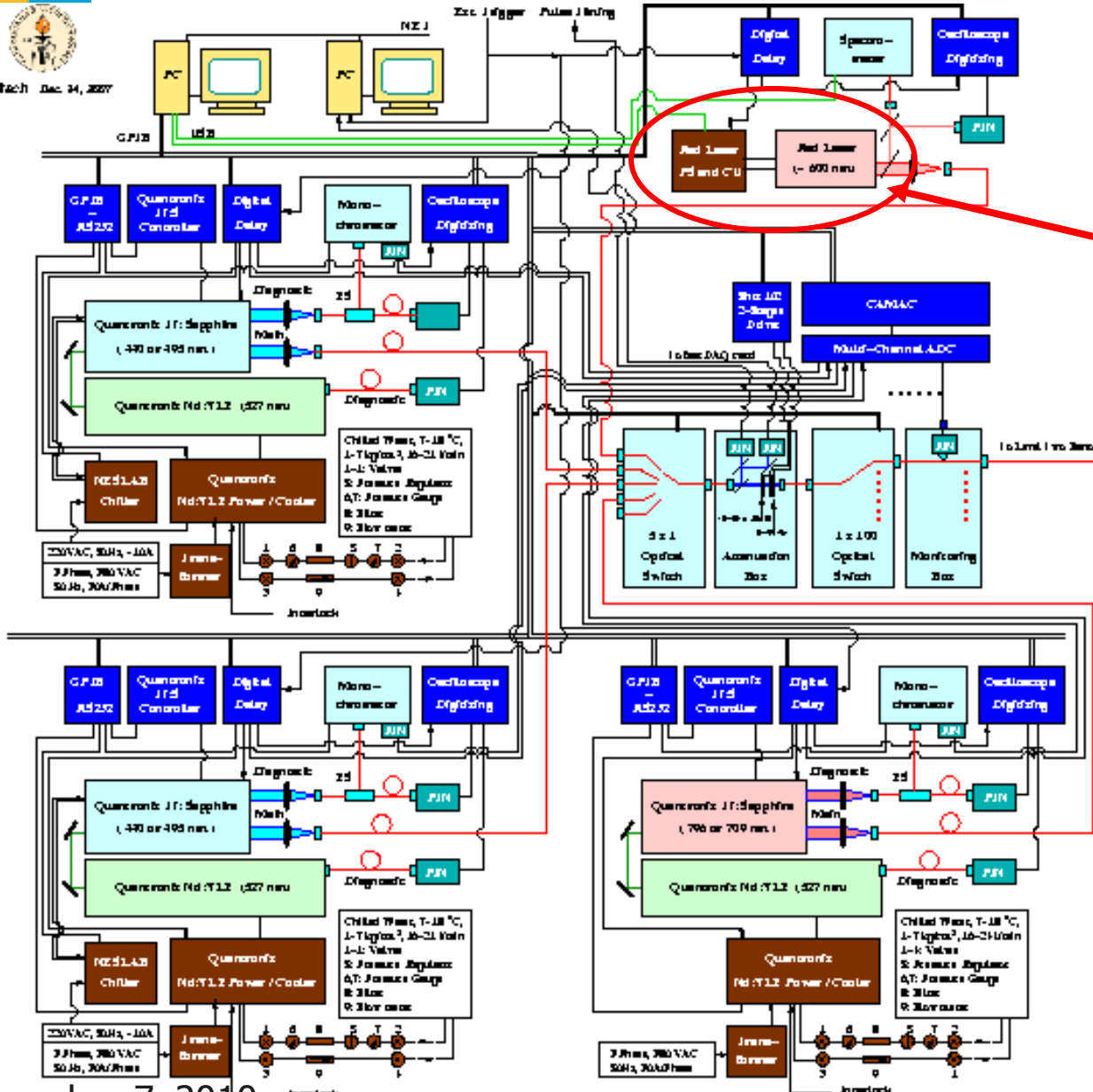




Adding an Orange Laser



Caltech Dec 14, 2007



With the 5 x 1 switch an orange/red laser at 600 nm may be added into the existing system.



Request for Quotation, Fall, 2010



- Pulse energy: 1 mJ at the vicinity of 600 nm
- **Pulse repetition rate: 0 – 100 Hz**
- Pulse width: < 40 ns
- Pulse jitter: < 3 ns
- **Pulse delay from external trigger: < 90 μ s**

The RFQ with above specifications was sent to more 20 laser vendors. Three positive responses were received:

- 1) Opotek: flash lamp pumped Nd:YAG + OPO
- 2) Photonics Industries: DC or pulsed diode pumped Nd:YLF + intra-cavity OPO + THG
- 3) Spectra-Physics: DC diode pumped Nd:YLF + dye laser.

A diode pumped Nd:YLF + intra-cavity OPO + THG from Photonics Industries seems meeting all requirements.



Response to October RFQ



Parameters	Opotek OPO Opolette-HR355LD	Photo.-Ind. OPO+THG DP-OPO-600-1	Photo.-Ind. OPO+THG DS-OPO-600-1	Spec.-Phys. Dye laser
Wavelength (nm, PE > 1 mJ)	Tunable 450 – 600	Fixed at 610 ±10	Fixed at 610 ±10	Tunable 600 – 620
Pulse energy: (mJ)	>1	>1	>1	>1
Pulse repetition rate (Hz):	Fixed at 100	0 - 100	0 - 100	0 -100
Pulse width (ns)	5	< 20	< 20	< 30
Pulse jitter (ns, rms)	1	3	3	2
Delay (µs) (Ext. trigger->Output)	~200	~500	< 5	~100
Pulse to Pulse Instability (%rms)	10	3	3	10
Quoted Cost	\$83K	\$150K	\$200K	\$150K



Quoted Dimensions



OPO Series

High Repetition Rate OPO Optical Parametric Oscillator



Laser Head
22"(L) x 7.5"(W) x 3.75"(H)

Control Unit
13.5"(L) x 19"(W) x 5.25"(H)

OPO Series

Photronics Industries OPO series of diode-pumped, intra-cavity frequency conversion, Q-switched Optical Parametric Oscillator (OPO) produces stable, high repetition rate pulses in a compact, industry rugged design. An air cooled version is also available.

Applications

- Chemical Detection
- Eye-Safe Illumination
- NIR Spectroscopy
- MID-IR Spectroscopy
- LIDAR
- IR-MALDI
- Rangefinder, Designator
- Material Processing Research & Production

Features

- Diode Pumped Technology
- Wavelength: 1.5µm to 2.0µm (signal)
2.2µm to 3.4µm (idler)
 - Fixed Wavelength or Tunable Versions Available
- Pulse Rates from Single Shot to 50kHz
- TEM₀₀ Beam with M² ~ 1.3
- mJ Pulse Energy at kHz Repetition Rates
- Field Replaceable Diode
- Compact, Rugged Design
- Patented OPO Generation Technology
- External TTL Triggering and Gating Input
- Air Cool Version Available



Photronics Industries

International, Inc.

The Pioneer of Intra-Cavity Solid-State Harmonic Lasers

A system more compact than the Quantronix lasers.



User References



Photonics Industries claims that most of its OPO lasers are used in military and private industry.

University of Washington (Prof. Thomas SPIRO group)

Dr. Balakrishnan and a Postdoc commented on their Nd:YLF pumped OPO system of Photonics Industries purchased about 5 yrs ago. They are basically satisfied with the laser. The laser is run at 1 KHz, but NOT in 24/7 mode. The original diode module is still in good shape with accumulated time of over 3500 hrs. There were some small issues like power dropping, chiller not working properly etc. The service is not as good as expected. While hoping Photonics will improve its service, they recommended the Photonics Industries.

Oakridge National Lab

Dr. Yuan LIU commented on the Nd:YLF pumped Ti:Sapphire laser system of Photonics Industries procured about one year ago. The laser system is run at 10 KHz in 24/7 mode for several weeks each run. While the Ti:Sapphire laser has no problem, the Nd:YLF had a problem caused by condensed water and it was fixed by Photonics Industries. She recommended Photonics Industries.



DS-OPO-600-1 Quotation



Photonic Industries

390 Central Ave., Bohemia, NY 11716, USA International, Inc.
Tel: 631-218-2240 Fax: 631-218-2275
www.photonix.com info@photonix.com

Quotation Number: Q10-1118AI **QUOTATION**
Date: 11/10/10
Valid Until: 12/10/10
Payment: 50% with order / 50% upon shipment
Freight: F.O.B. Bohemia, NY
Delivery: 14-16 Weeks ARO (exact date provided at time of order acceptance)

To: California Institute of Technology
1200 E California Blvd,
Pasadena CA 91125

From: Photonic Industries
390 Central Avenue
Bohemia, NY 11716

Tel:
Fax:
Attn: Liyuan Zhang

Tel: 631-218-2240
Fax: 631-218-2275
Attn: Andrew Iadevaia

Description	Price		
DS-OPO-600-1 Laser – Specifications (CW pumped) Wavelength 600nm +/-10nm (Fixed wavelength must be chosen when order is placed.) Pulse Energy @ 100Hz 1mJ Pulse Width @ 100Hz <20 ns Beam Mode TEM ₀₀ Pulse Jitter <3ns rms Divergence <2mRad Pulse to Pulse Instability 3%rms Pulse delay from external trigger < 5 μs Pulse Repetition Rate 0 to 100Hz Dimensions (L x W x H) 22" x 7.5" x 3.75"	\$200,000.00		
OPO Laser Control Unit Provides control functions for the operation of the OPO laser, including diode settings, Q-switch, PRF and Gate. All functions can be controlled from the front panel or remotely from a PC. BNC connectors enable control of Gate, PRF and pulse energy. Dimensions (L x W x H) 13.5" x 19" x 5.25"	Included		
Optional DM Water to Water Chiller Dimensions: <table border="1" data-bbox="216 1149 1541 1182"> <tr> <td>Dimensions (W/H/D)</td> <td>19"/12HU/32"</td> </tr> </table>	Dimensions (W/H/D)	19"/12HU/32"	\$1,500.00
Dimensions (W/H/D)	19"/12HU/32"		
System Software OPO Control software provides basic system operating controls in a convenient graphical user interface configuration.	Included		
Warranty Standard Photonic Industries one (1) year parts and labor warranty. Warranty repairs are provided at Photonic Industries authorized factory service center or at customer's site. Travel and living expenses are to be paid by the customer for service at his site. The diode is warranted for one (1) year or 5000 hours of operation.	Included		



Summary



Our monitoring laser performs as designed. The following actions are recommended to improve the existing system.

1. Procure two Dicon switches: 5 x 1 and 1 x 100.
2. Procure a Quantronix Darwin-Pro-527-40-M diode pumped Nd:YLF laser to replace one existing DC Kr Lamp pumped 527DQ-S Nd:YLF laser at P5. The proposed system will have a better stability and less maintenance requirement. Replace all three after successful test.
3. Investigate further Photonics Industries DS-OPO-600-1 laser as the 2nd wavelength for the endcaps.

Orange Laser Hardware Needed

- 1) Laser & Power Supply and Cooler Unit;
- 2) Optics for fiber coupling;
- 3) Diagnostics: DSO and Spectrometer;
- 4) Trigger Electronics: Digital Delay.

