Laser Monitoring system - status and plans

ECAL General Meeting

September 24, 2013

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Introduction

- **Evolution of the laser monitoring system since report at the ECAL General Meeting in December 2012 :** https://indico.cern.ch/conferenceDisplay.py?confId=220826
- **Photonics lasers**
- **P5 infrastructure**
- **Future plans**

With inputs from Emanuele, Liyuan, Renyuan, David B. and many others.

2012 : First Photonics Laser (DP2)

- Decision from task force to persue new blue laser option
- Order placed verbally on 11.11.2011
- At Caltech February 2012
- At CERN March 2012, in operation in April 2012

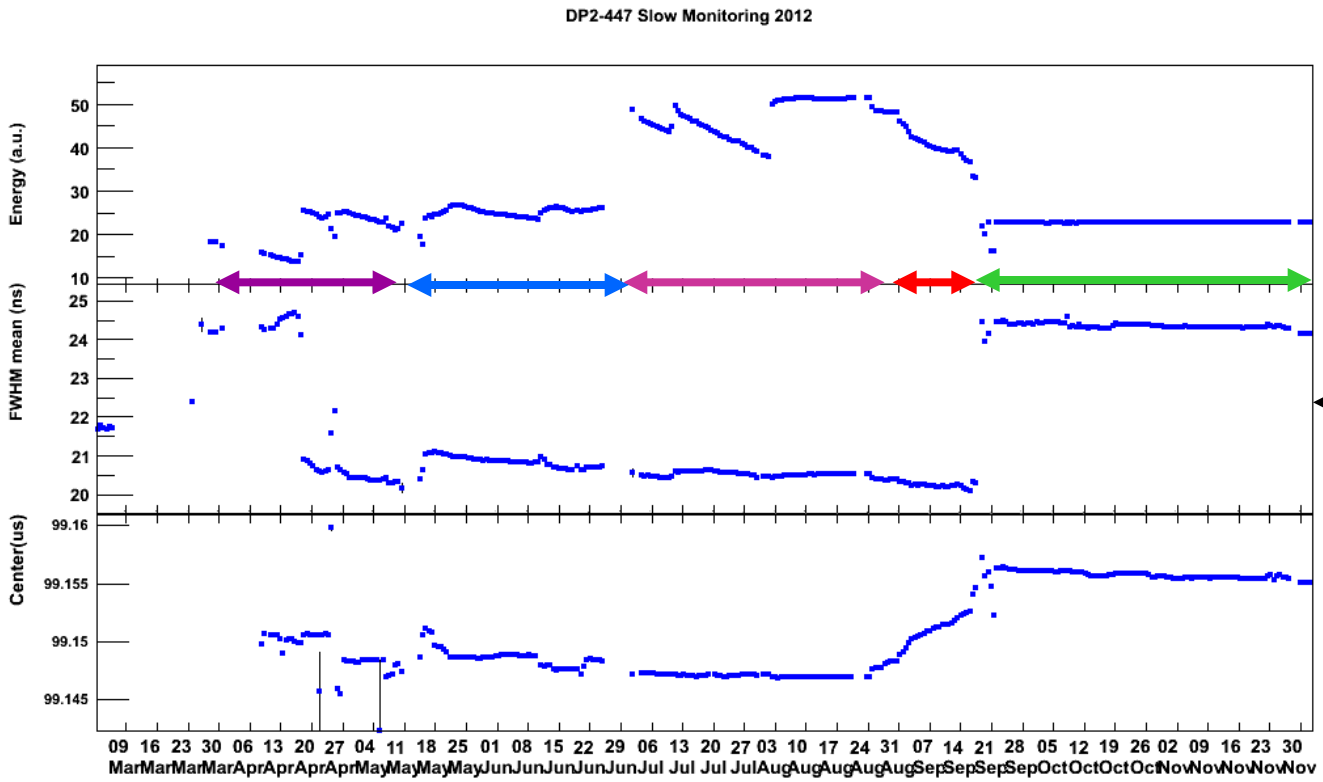
⇒ 6 months from order to operation.

Photonics Performance 2012

- After some initial operational optimization at P5, very stable operation.
- In Summer, some degradation traced to auxilliary optics.
- End of summer some degradation suspected to be caused by issues internal to the laser. ⇒ See discussion later.

⇒ Reduce power from 55 A to 45 A pump current to minimize further degradation.

⇒ Very stable operation after this.



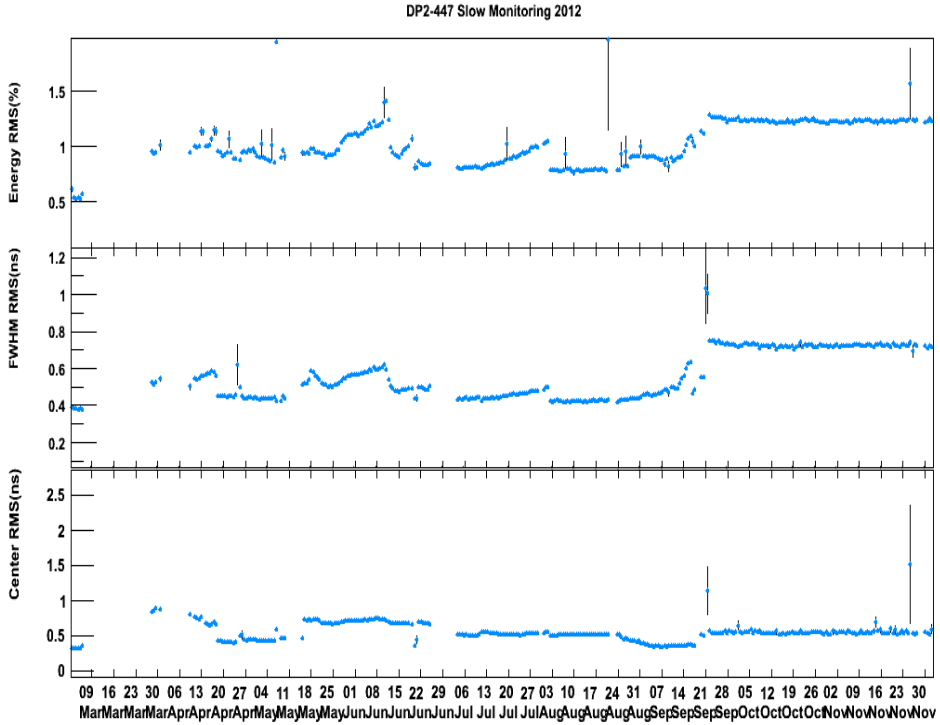
Two periods with better than 1 ns pulse width stability

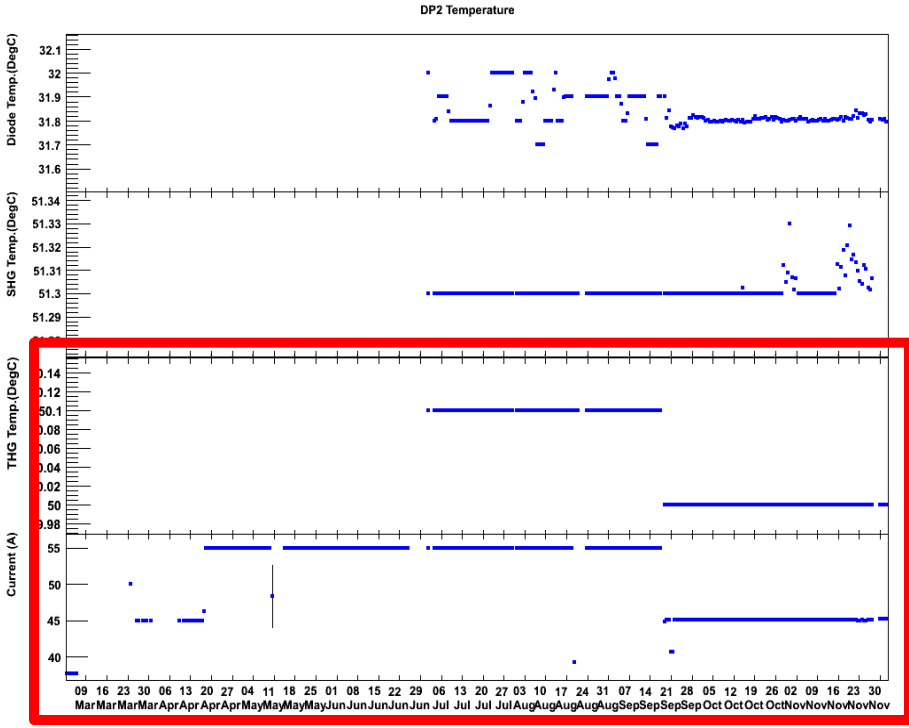
Photonics Tuning & Operation 2012

Emanuele DiMarco & laser team

- **Comissioning phase (April 2011) : Cooling, power setting, laser DAQ**
- **Summer 2012 power degradation :**
  - **External optics degraded, fixed.**
  - **Issue internal to the laser suspected, can only be verified by opening cavity (⇒ warranty). Power reduced, since stable.**
- **On-call interventions in 2012 :**
  - **24 in total : https://twiki.cern.ch/twiki/bin/viewauth/CMS/EcalLaserMonitoringOnCallShiftIncidents**
  - **11 related to Photonics, 6 in the first weeks (commissioning).**
  - **Most interventions related to DAQ/communication.**
  - **On-call service mostly performed by 2 people, more experienced shifter.**

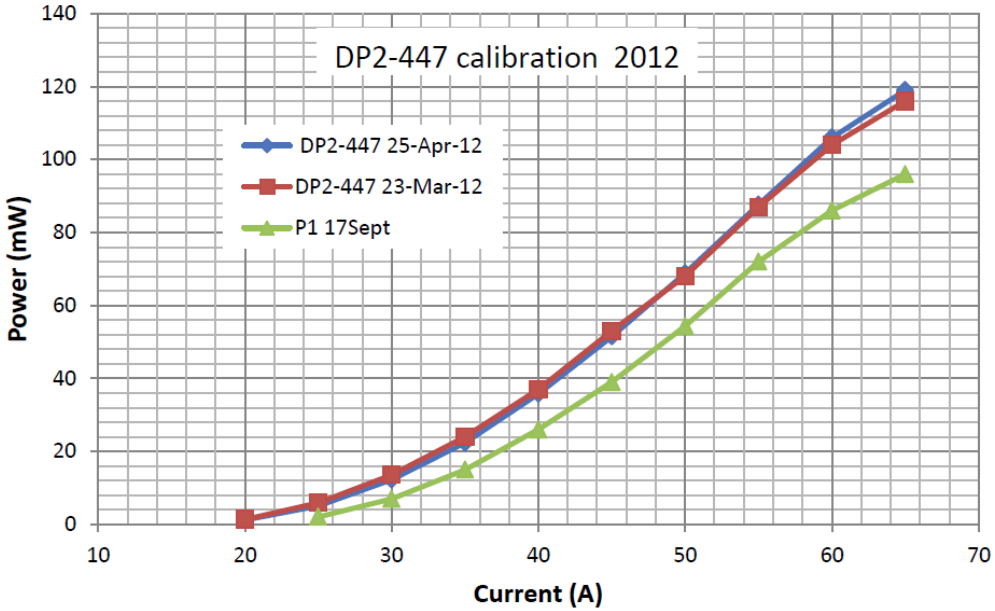
More Details on 2012 Photonics Operation





- **Main feature of the DP2 long term trends in 2012 related to the pumping current.**
- **Choosen at the time after an initial drop in output power, at least partly traced to auxilliary optics later.**

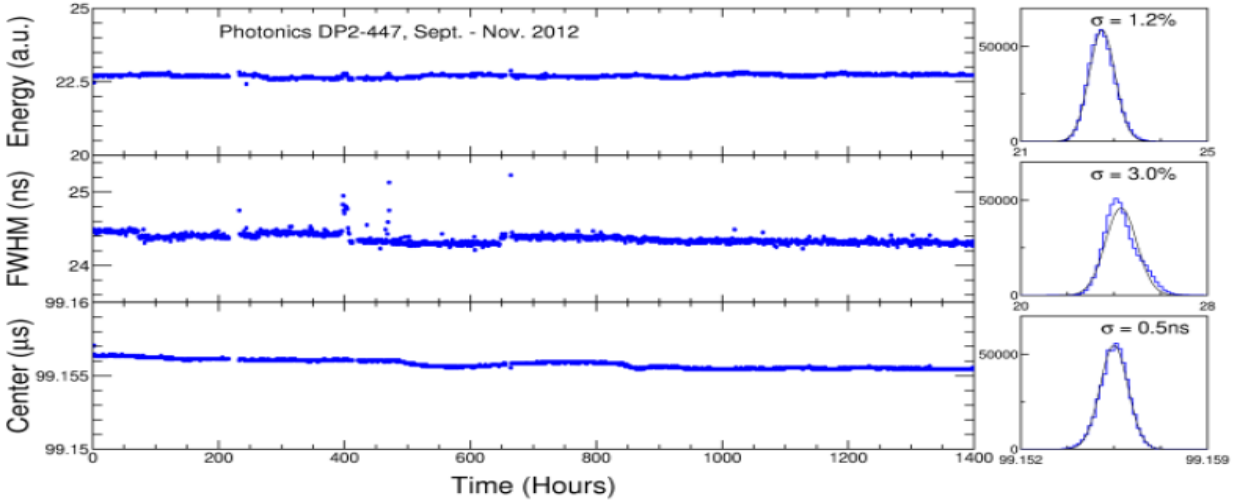
DP2 laser 2012 - pp running



- After 6 months of operation, the laser power was found ~20% lower than April.
- Given 24/7 operation, not a very surprising fact !

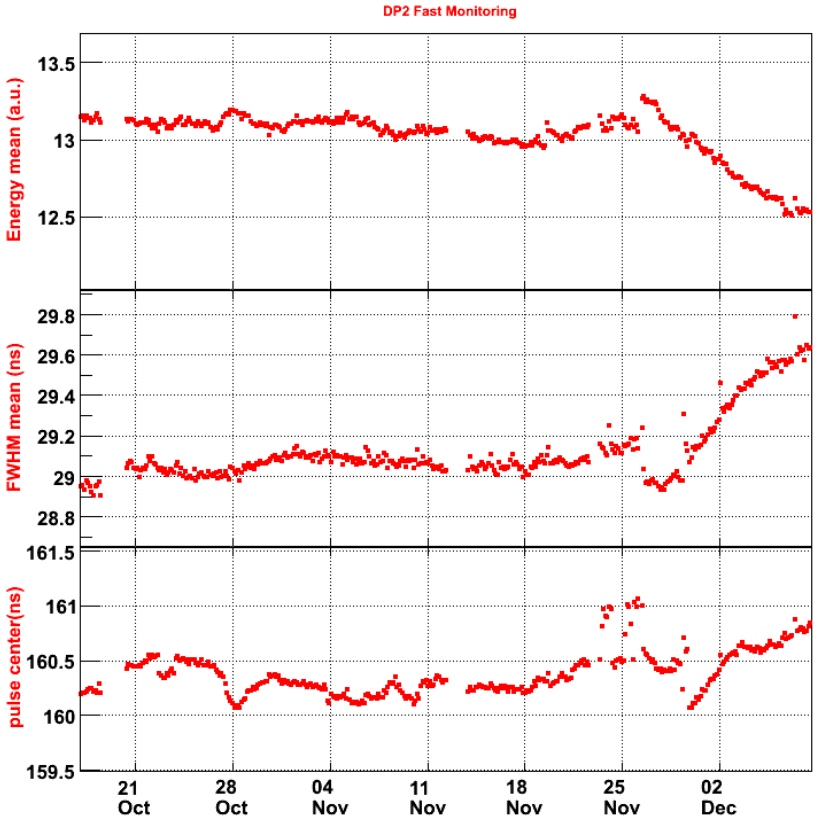
- Decided to ask for a service intervention on 1st DP2 laser head.

Performance well within specs, eg. Amplitude stability 1.2%



DP2 laser 2012 - HI running

- Decided to continue using the DP2 during HI operation.
- Observed increased instability in December and again in January.



Decision on second DP2 purchase

- The purchase of a second DP2 was already foreseen early in 2012.
- At the time decided to wait until last moment to gain as much experience with first to confirm design choice.
- December 2012 : Photonics agreed on extension of the warranty for first DP2 to June 2013, conditionally on the purchase of a second DP2.
- This option was chosen.
- We also factored in : Good performance of the first DP2, market survey when choosing Photonics laser.
- February 2013 : First DP2 shipped from CERN to Photonics

DP2 lasers at Photonics

March 2013 :

- **1st DP2 at Photonics for reparation.**
- **2nd DP2 under test at Photonics.**
- **Training session (David&Liyuan) with the 2 lasers at Photonics.**

Photonics report in March :

- **The reduced power output was caused by a damaged third harmonic crystal. Damage was also found on the 2 others crystals: 3 new crystals mounted.**
- **Difference in the efficiency observed between the new laser and the first DP2.**
- **Traced to the new diodes having a better spectrum, now used.**
- **2nd DP2 : new commercial chiller unit (stabilized). Result of our experience of a small residual temperature depence.**

DP2 lasers at Caltech

May-June:

Two DP2 lasers were shipped from Photonics to Caltech.

- **Much reduced power observed in 1st DP2 laser.**
- **Shipped back to Photonics, traced to an internal desiccator that was touching an optical component.**
- **The performance of the 2nd DP2 at Caltech was found meeting our specifications.**
- **At Photonics, upon fixing first DP1, Photonics observed 10% loss of efficiency, correlated with the relative humidity (RH) in the laser head. Optimal value 30%±5%.**
- **Similar test carried out at Caltech on DP2.**
- **New half-wave plate based attenuator works fine. It will be implemented at P5 for the 1st DP2 laser system.**
- **The pump diodes of both the 1st and 2nd DP2 lasers were measured for power versus the pumping current, which will be useful references for laser operation at CERN**

September Update on DP2 Lasers

- Photonics received the CERN PO for RH sensor installation in two DP2 lasers on Aug. 23, and issued an RMA for the 2nd DP2 (SN:12-658), following which the 2nd DP2 was shipped back from Caltech to Photonics.

- The RH sensor installation is finished for both lasers on Sept 23, 2013. While the QC process in on the way and the full test reports are not provided, Photonics released laser output power measurements as shown in the following slides.

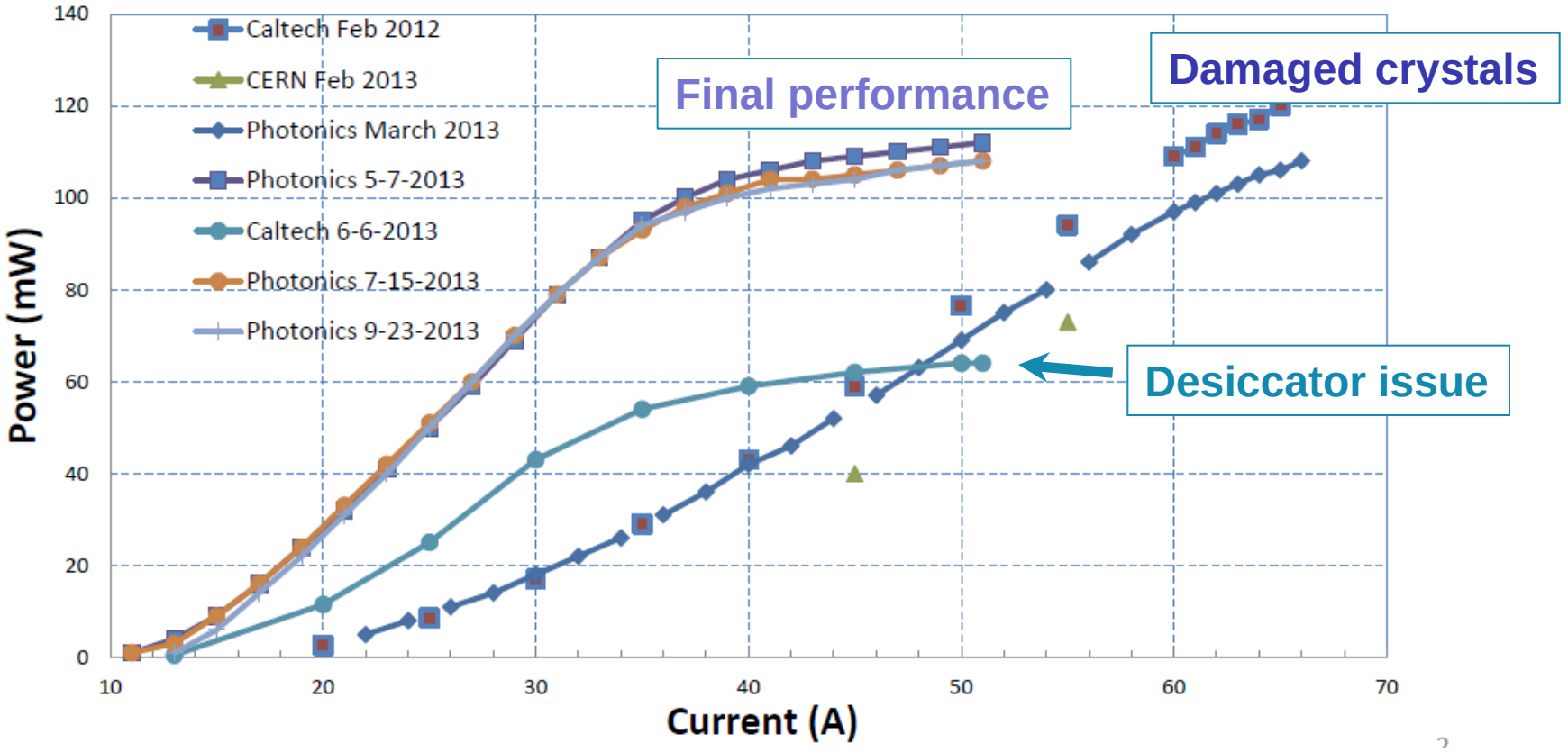
- The plan is to have the 1st DP2 shipped to CERN by the end of Sept and be commissioned at P5 in Oct for global runs in Nov.

- The 2nd DP2 will be shipped back to Caltech in Oct and be integrated with ancillary optics and a monitoring box. It will be tested with new laser DAQ software at Caltech. Aiming at commissioning the 2nd DP2 at P5 in Dec, the final decision will be made in late Oct.

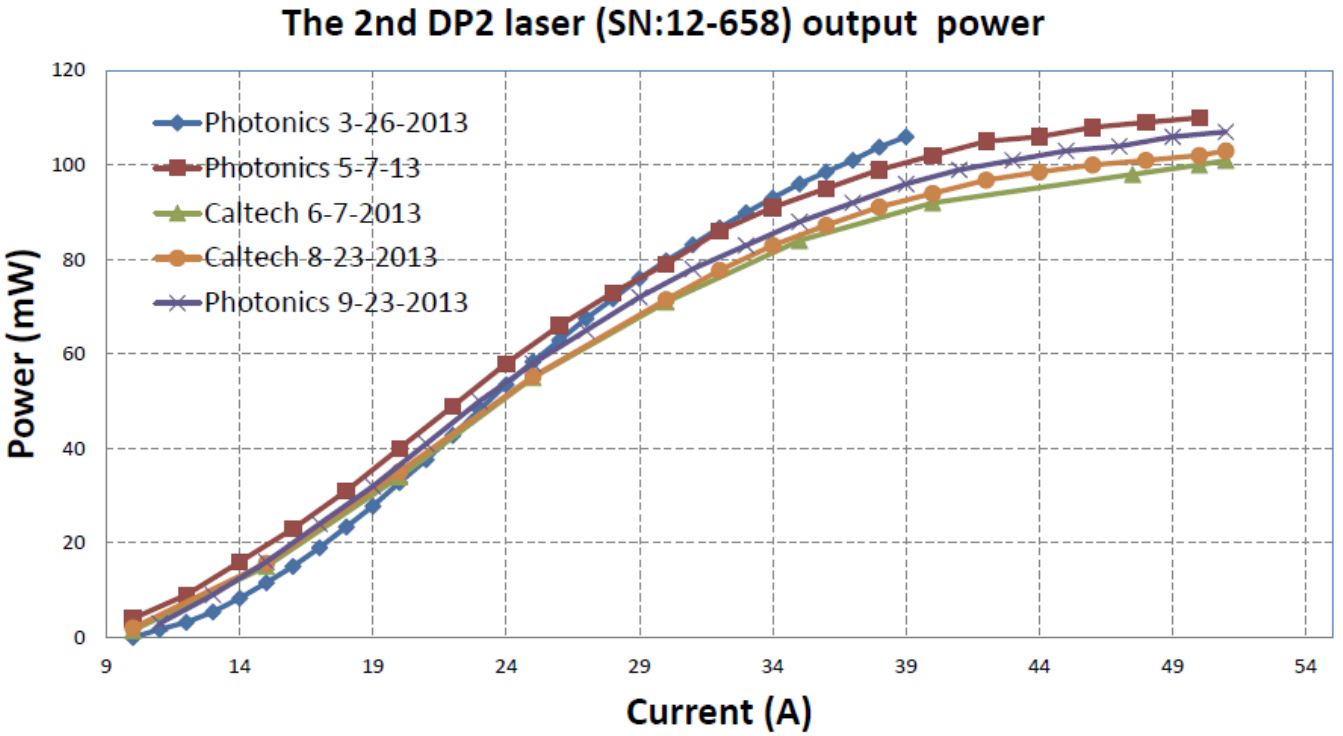
Summary of first DP2 output power

After the RH installation and a routine optimization, the output power of the 1st DP2 is consistent with July 15, but is a few percent lower than May 7.

The 1st DP2 laser (SN:11-381) output power



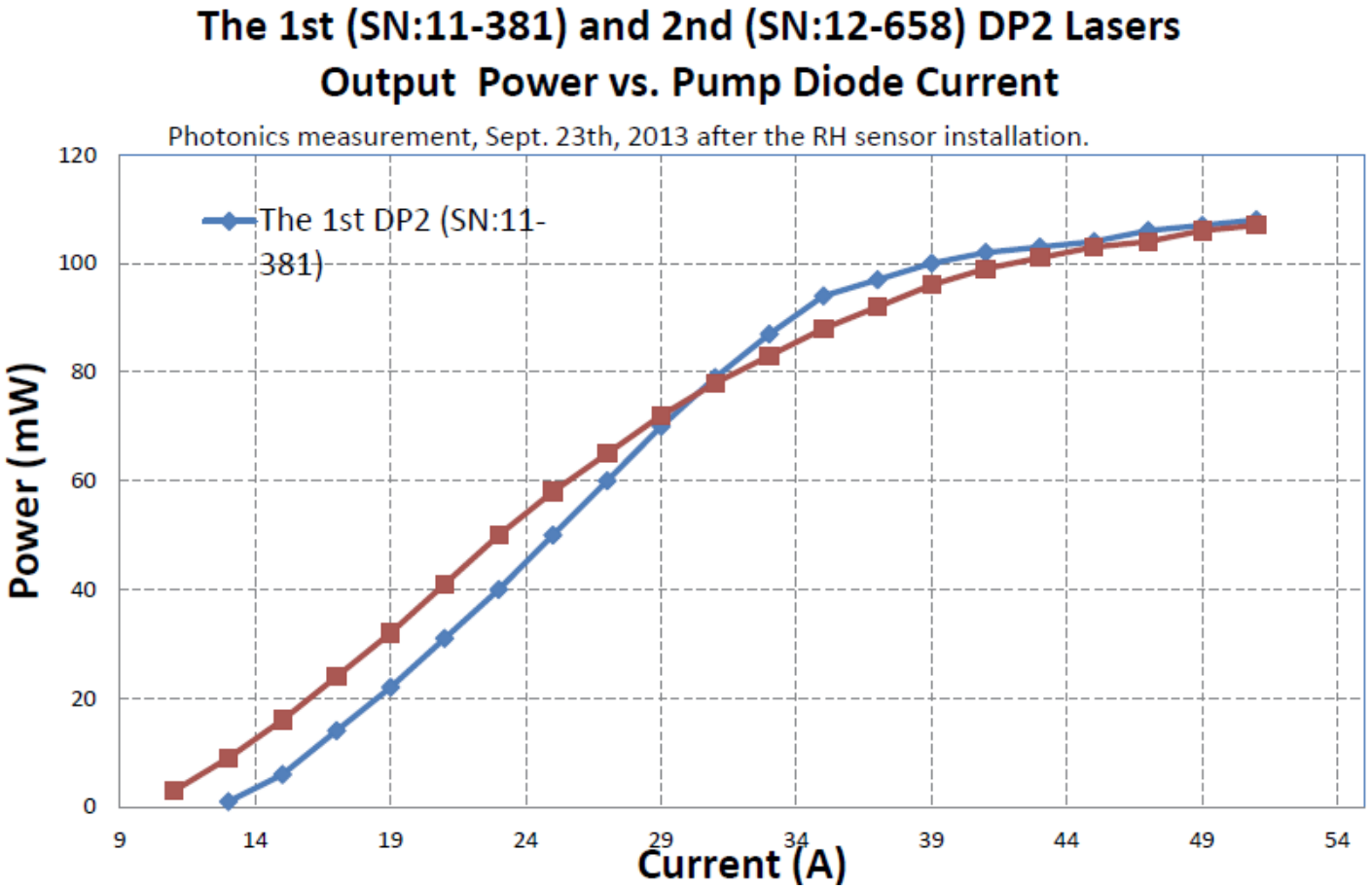
Summary of second DP2 output power



- **Good agreement among various measurements within ±5%.**
- **Several iterations between Caltech and Photonics to understand difference between measurements, no problem detected.**

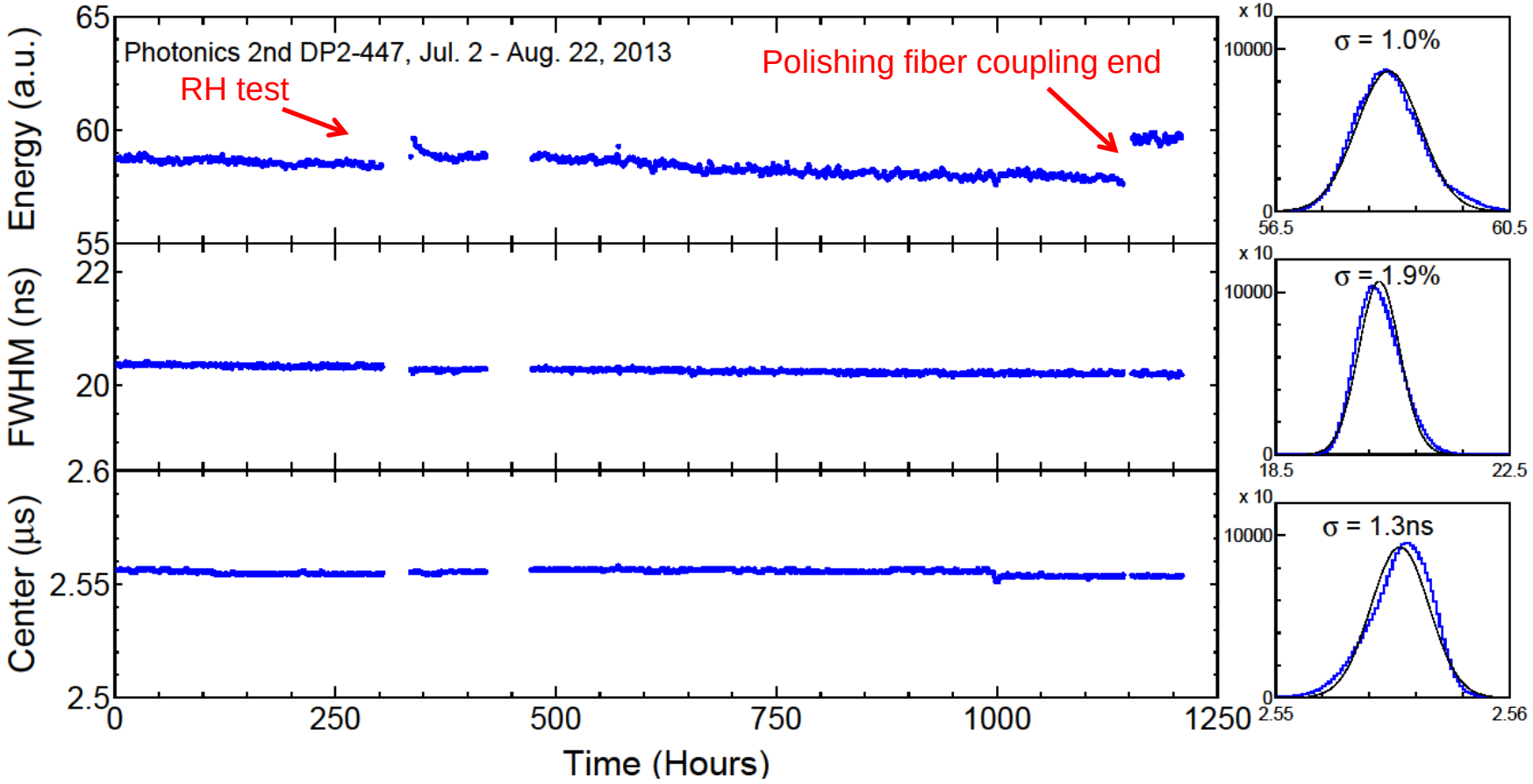
Comparison of two DP2 lasers

Both DP2 lasers meet the 1 mJ specification at about 40A, which shows a significant improvement as compared to 60A for the 1st DP2 in 2012. Their power versus pumping current behavior, however, is slightly different, which may be caused by different diodes and optical parts in the laser cavity etc.

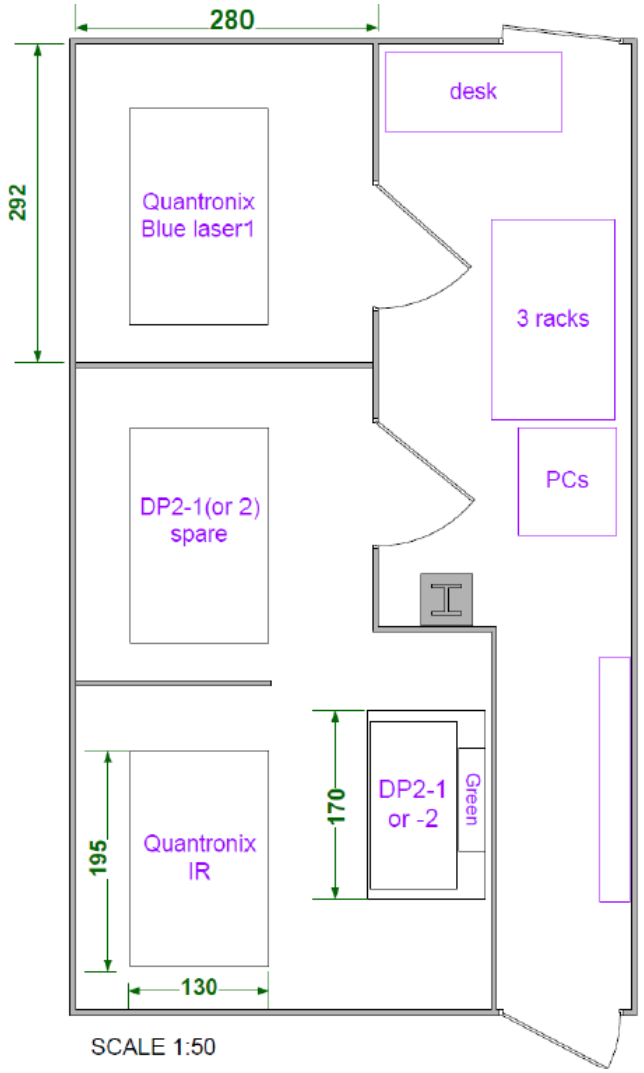


Long term test of the 2nd DP2

- 2nd DP2 tested at Caltech for ~1200 hrs.
- Stability of the pulse energy, FWHM and center are all well within the specifications, a very slow decrease (~1.5%/1000 hrs) of pulse energy was observed.
- Polishing the fiber fixed this problem.

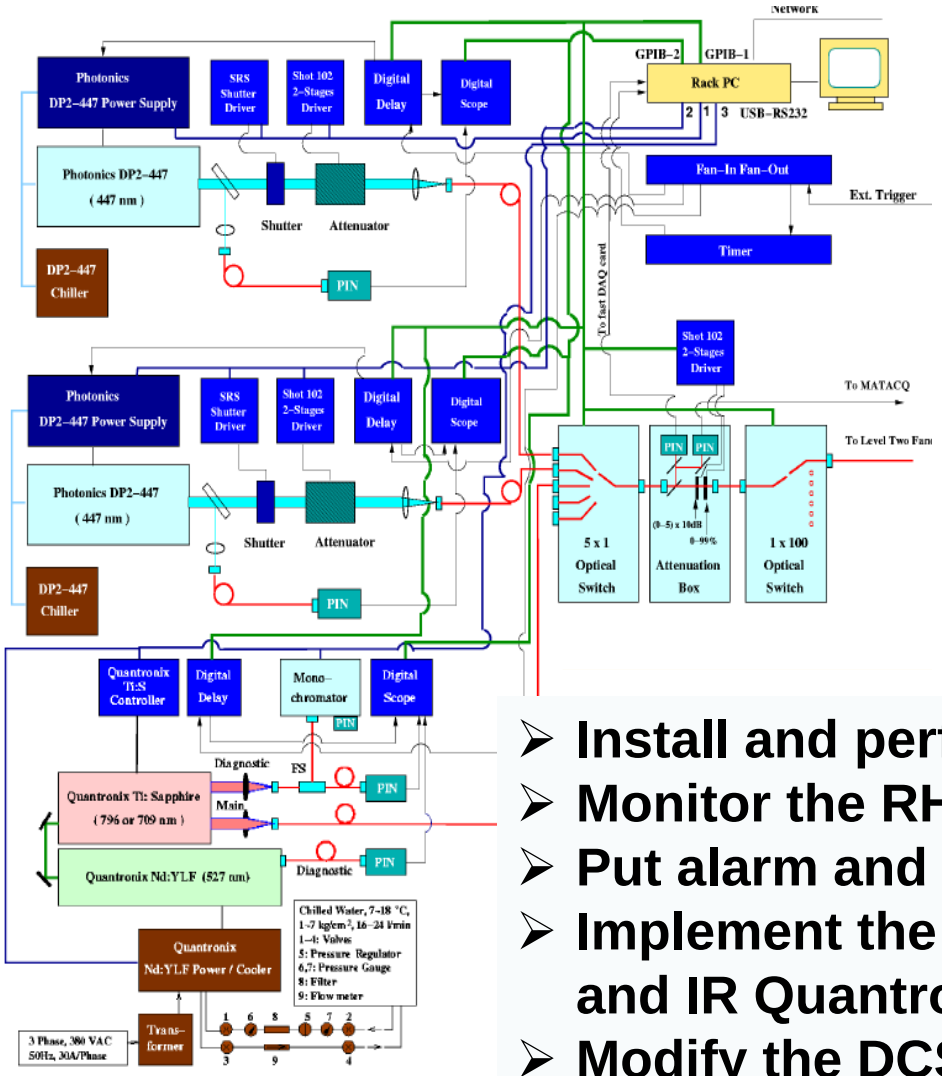


Laser barrack at Pt5



- 1st Quantronix blue laser online for the ECAL tests August and Sept.
- 2nd Quantronix blue laser: decommissioning and in a safe storage area.
- 3rd Quantronix RED laser: keep in safe condition for future data taking.

Ongoing work during LS1



I/O Interface Needed

- 1 PCI slot for Agilent U1071A-002 Digitizer card (fast monitoring).
- 2 PCIe slots for 2 PCI-GPIB cards.
- 3 USB ports for USB-RS232 for 3 lasers,

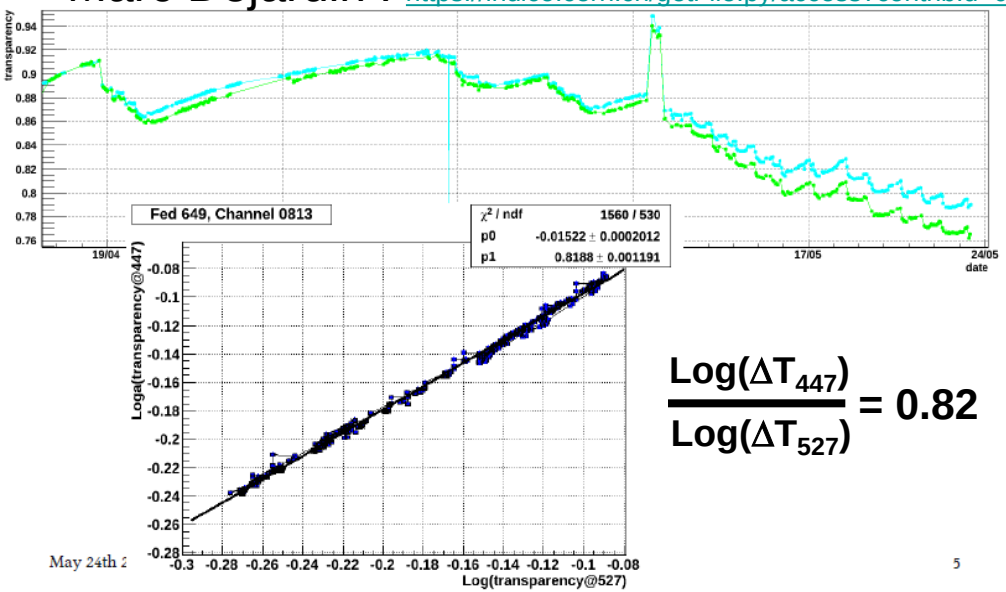
Two DP2 blues & one Quantronix IR

3 PCs used now for the slow and fast monitoring and the 1st DP2 will be replaced by one racked mounted standard PC supported by CMS.

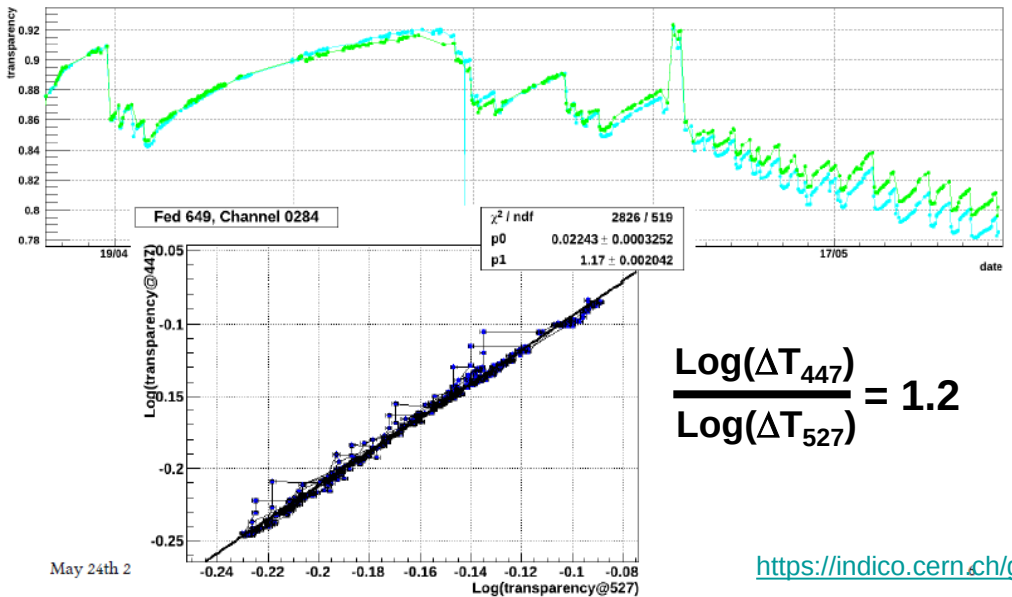
- **Install and perform long test of the two DP2s;**
- **Monitor the RH of the laser room.**
- **Put alarm and define procedure;**
- **Implement the new laser software for the 2 DP2 and IR Quantronix on rack mount PC;**
- **Modify the DCS for PVSS monitoring value.**

Other light sources

Marc Dejardin : https://indico.cern.ch/getFile.py/access?contribId=0&resId=0&materialId=slides&confId=191786



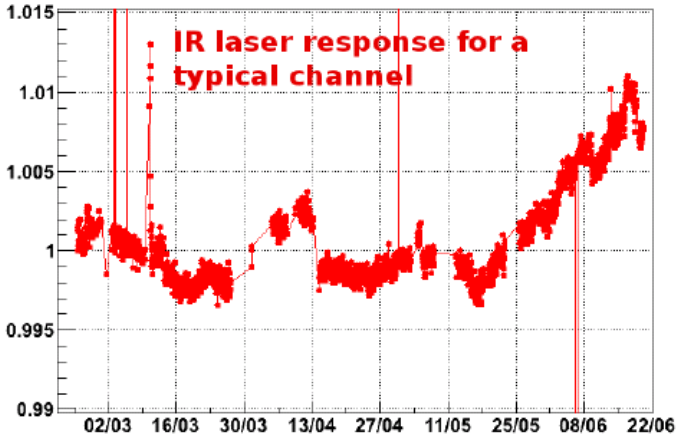
$$\frac{\text{Log}(\Delta T_{447})}{\text{Log}(\Delta T_{527})} = 0.82$$



$$\frac{\text{Log}(\Delta T_{447})}{\text{Log}(\Delta T_{527})} = 1.2$$

- **Saclay green laser : very short pulses, used for SRP and linearity.**
- **Wavelength dependency to be studied, full tag in preparation.**
- **Quantronix red laser : potentially very useful for alpha studies.**

⇒ **Variation of alpha is a significant effect in EE now. Attempts to measure alpha in situ precisely had limited success.**



Federico Ferri : https://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=144440

An illustration

From Shervin, Aug. 29., DPG :

ECAL Region of the two electrons	additional smearing: $\Delta\sigma$ (%) smearing method		
	Moriond std Madgraph V3 pho regr. WP90PU sel.	22Jan std Madgraph V3 pho regr. WP90PU sel.	22Jan run dep powheg V5 pho regr. loose sel.
EB $\|\eta\| < 1$ $R9 < 0.94$	1.07 ± 0.06	0.88 ± 0.02	0.83 ± 0.02
EB $\|\eta\| < 1$ $R9 > 0.94$	1.11 ± 0.07	0.97 ± 0.02	0.72 ± 0.03
EB $\|\eta\| > 1$ $R9 < 0.94$	1.94 ± 0.11	1.87 ± 0.03	1.87 ± 0.02
EB $\|\eta\| > 1$ $R9 > 0.94$	1.55 ± 0.40	1.31 ± 0.14	1.07 ± 0.09
EE $\|\eta\| < 2$ $R9 < 0.94$	2.76 ± 0.13	2.32 ± 0.03	1.98 ± 0.04
EE $\|\eta\| < 2$ $R9 > 0.94$	2.95 ± 0.25	2.25 ± 0.07	1.56 ± 0.08
EE $\|\eta\| > 2$ $R9 < 0.94$	3.71 ± 0.16	2.69 ± 0.04	1.94 ± 0.05
EE $\|\eta\| > 2$ $R9 > 0.94$	3.70 ± 0.11	2.54 ± 0.03	1.87 ± 0.04

- **Run dependent MC (partly increased noise due to transparency change scaling) significantly improved DATA/MC agreement.**
- **One previous occasion of such a large gain in understanding was tuning of alpha.**
- **But, alpha is globally tuned.**
- **Should be better to do it crystal by crystal ?**

Decommissioning of Quantronix

- **Sad :**

- **Red Quantronix remains in P5, usable.**
- **With existing material, should have many months of operation of red Quantronix.**
- **Blue Quantronix serve as a spare part repository.**

Future usage of Quantronix

- We discussed possible use of the old Quantronix laser for possible upgrade activity :
  - No test beam in CERN until at end of 2014 (earliest).
  - Even if we use crystal scintillators again, fast response changes may be avoidable with some crystals.
  - Sub-percent level precision not (yet) the issue for ongoing Phase II R&D.
  - No urgent needs for now
- Usage of red laser for detailed studies of the crystal performance may turn out to highly beneficial for ECAL performance beyond 2015 and for the upgrade.
- May consider shipping Quantronix parts to Caltech.

Summary

- **Upgrade of the laser monitoring system on-going to run with two Photonics DP2 starting soon.**
  - **In the process of servicing the first DP2 and commissioning the second DP2 we learned many details about these specific lasers.**
  - **Adding humidity monitoring (and control) to temperature, electricity, magnetic field, pulse shape and human interference monitoring of the lasers.**
- **In retrospective, our strategy and decisions on laser system evolution turned out to be correct and successful.**
- **With the Photonics lasers typically stable at the level of 1% over the time span of many months, we are very well equipped for the future.**
- **Need to look beyond ultimate precision of continuous monitoring towards more fundamental studies of crystal evolution.**

Backup