Laser Monitoring Pulse Width Nonlinearity

! Everything Preliminary and in Progress !

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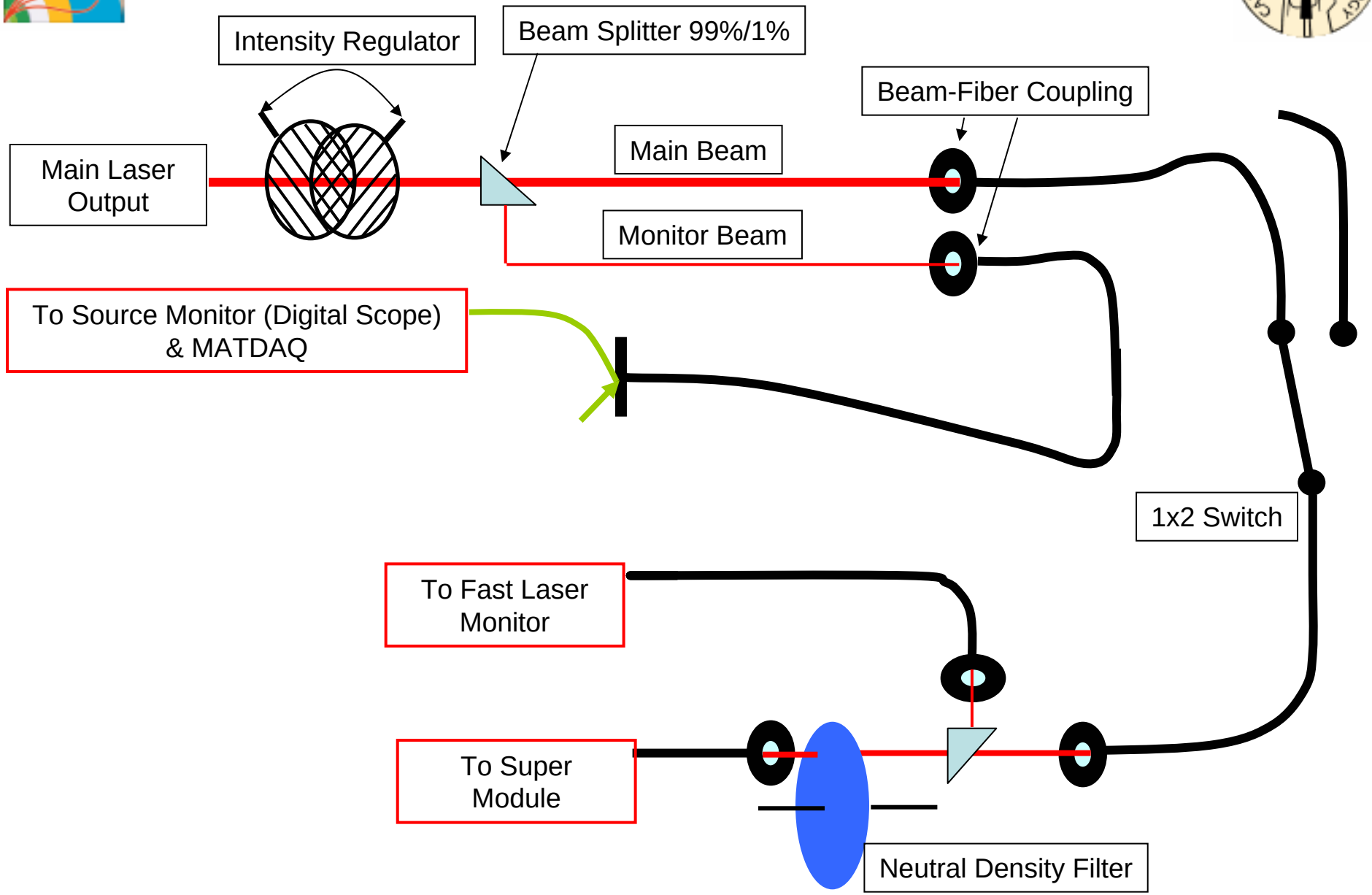
Test Beam Meeting
6. Oktober 2004 - CERN

Details of the Source Monitors (2004)



Overview Laser Monitoring

- **Slow Laser Source Monitor**

  Digital scope, pulse energy, width and timing for YLF and TiS Laser, one for each of the three systems, 1 Hz max rate.

- **MATDAQ (new since spring 2004)**

  Event by event measurement of pulse energy and width, H4 trigger, 1 (?) GHz sampling, uses one of the 'Slow Laser Source Monitor' diodes.

- **Fast Laser Source Monitor (new since fall 2004)**

  Event by event measurement of pulse energy and width, self-triggered, always on 'active' laser beam, 2 GHz sampling

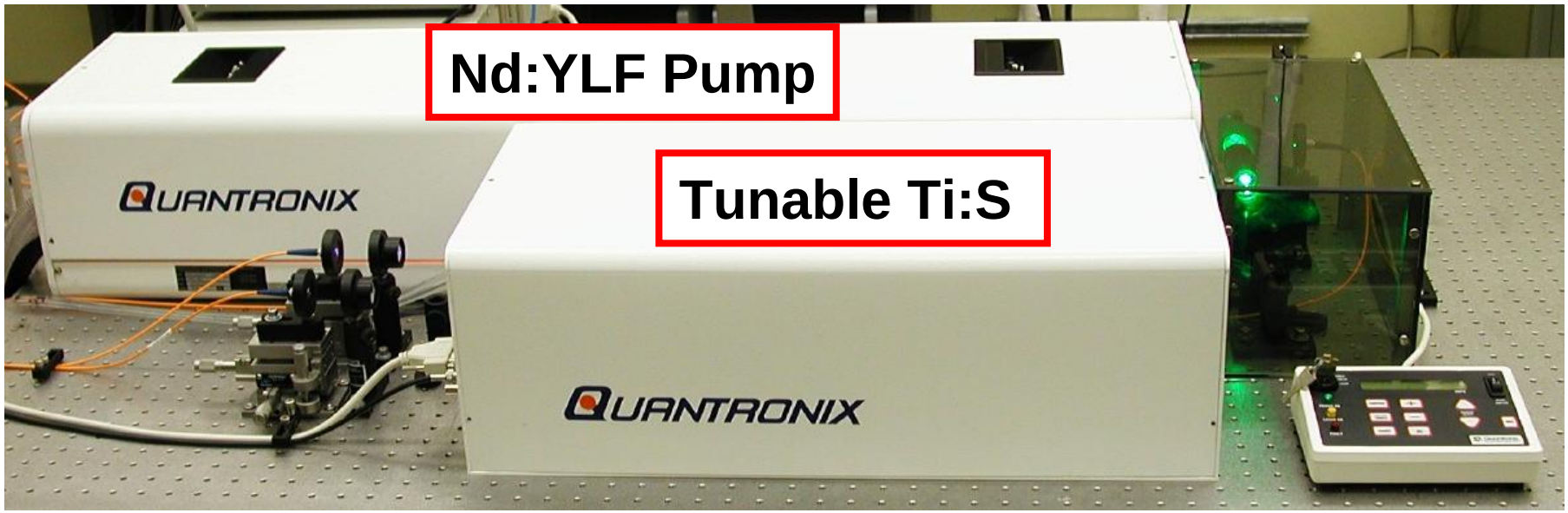
- **APD**

  Pulse energy measurement, no or poor pulse width measurement, shaping time 40 ns.

- **PN Diode**

  Pulse energy measurement, no or poor pulse width measurement, shaping time >> 40 ns

Reminder : Pulse Energy & Pulse Width



If the laser system is flawless :

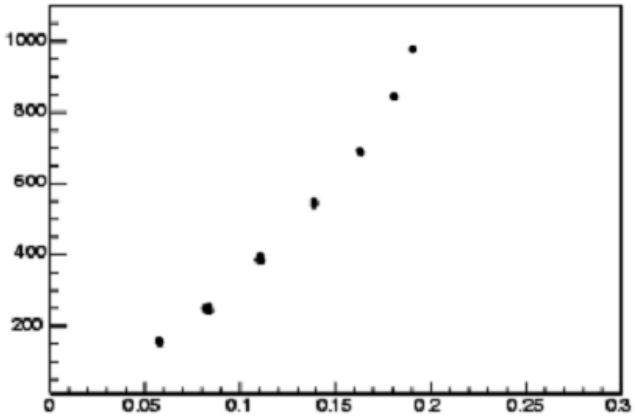
TiS pulse energy is correlated with the YLF pulse energy.
TiS pulse energy is ANTICORRELATED with the TiS pulse width.
(compare 'long term fluctuations' in 2003 laser data)
BUT : Short term fluctuations on the ~2 - ~3 % level in energy and width are not correlated (?? .. Beyond measurement precision)

If the laser system is flawless :

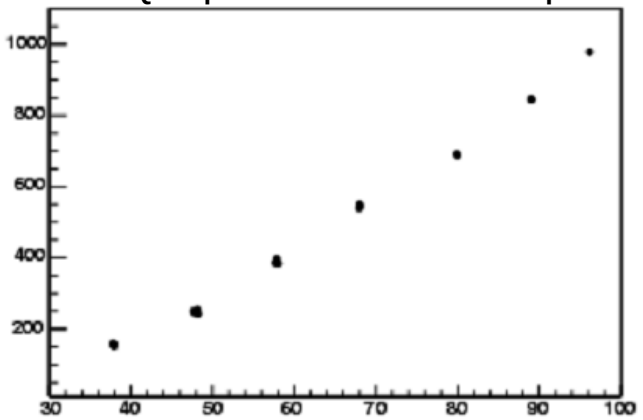
Everything can happen, in particular the TiS pulse energy and the TiS pulse width can change inan uncorrelated way

Comparison Fast/Slow/MATDAQ Monitors

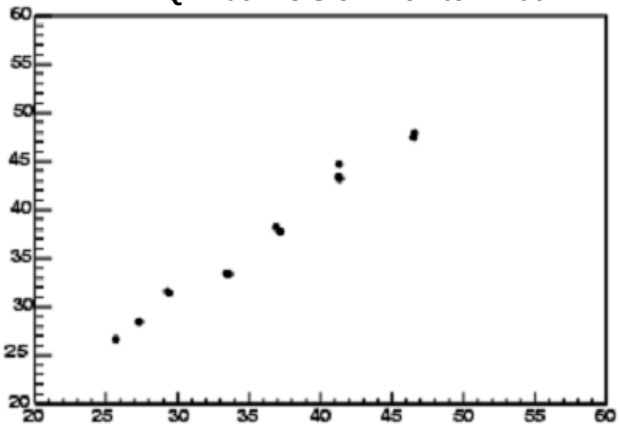
MATDAQ Amplitude vs Slow Monitor Amplitude



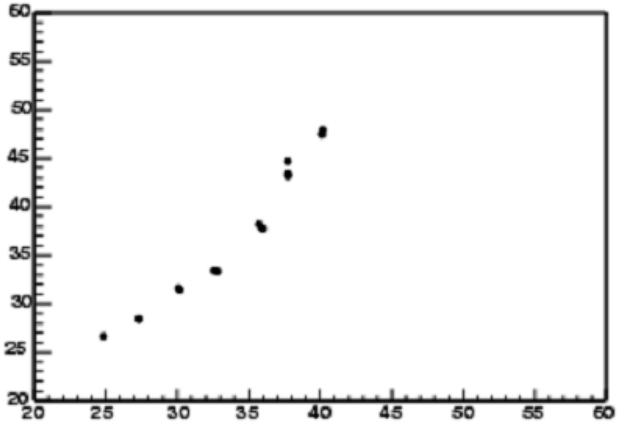
MATDAQ Amplitude vs Fast Monitor Amplitude



MATDAQ Width vs Slow Monitor Width



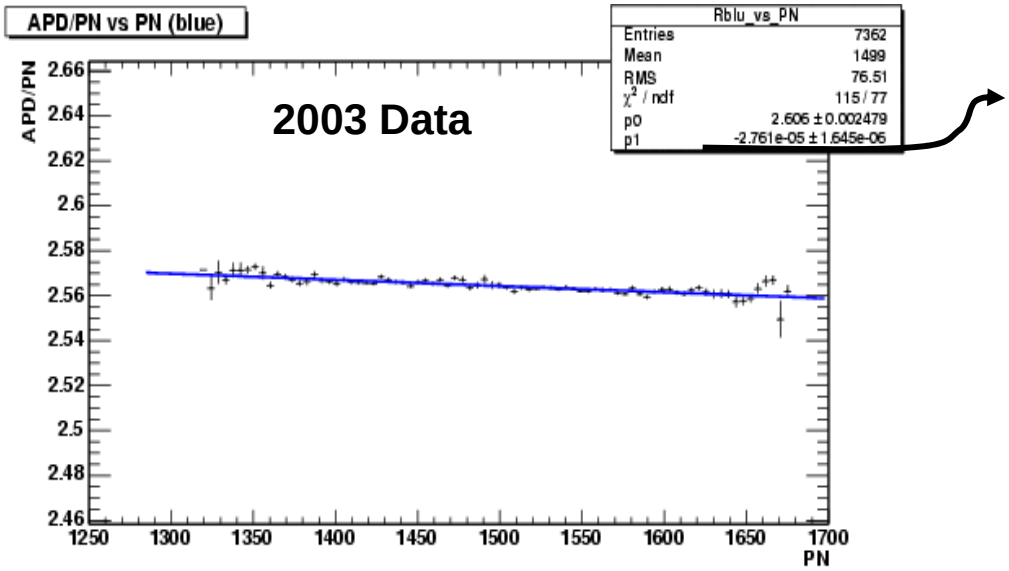
MATDAQ Width vs Fast Monitor Width



Generally the three monitors are ~correlated - BUT systematic effects.
We have since worked on fine tuning the fast monitor. More studies needed.

Pulse Height Nonlinearity

The 'Italian Way' (eg. Malberti et. al. , March 2004, 2003 Data):
Plot Apd/PN vs PN and fit linear function to the nonlinearity.

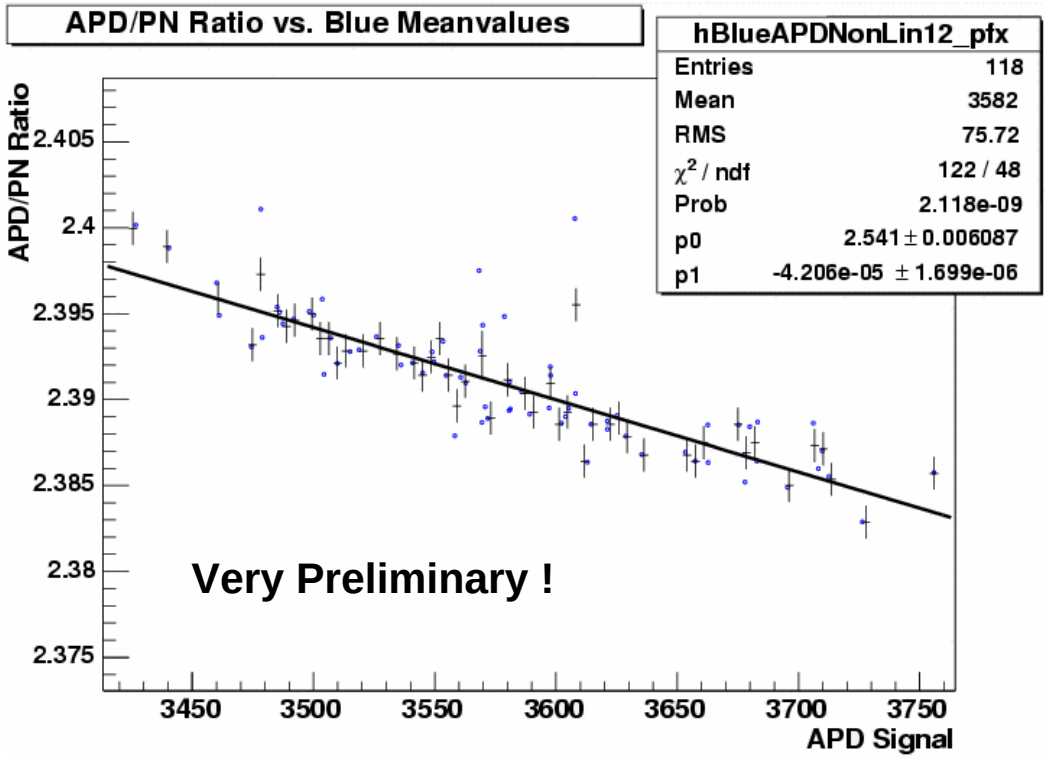


R slope : $-2.76*10^{-5}$
R Nonlinearity : 1.6 %
That is :
If PN changes by x%
R changes by 0.016x%
Note :
If eg. Laser pulse energy changes by 10%, R changes by 0.16%.
This 'adds' 0.16% to the constant term.

Note : This 'integrates' all nonlinearities AND possible other effects which change R (eg. Irradiation).

Nonlinearity in 2003 Data (American a la Italian Way)

Study from J. Homnick, CIT Summer Student :

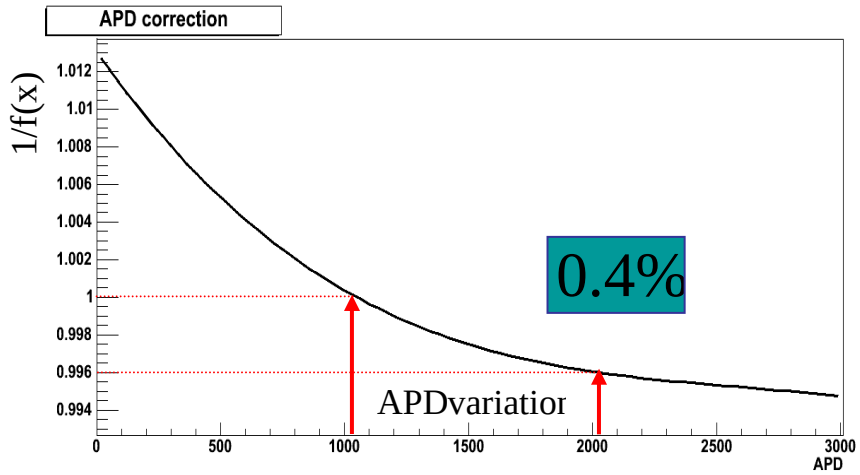


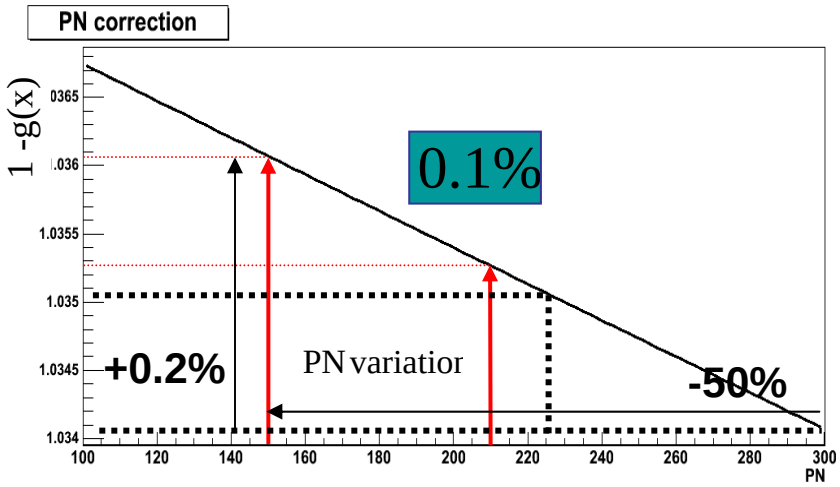
crystal	slope	errors
2	-1.8E-05	1.75E-06
4	-2.8E-05	1.96E-06
7	-2E-05	7.44E-07
9	-3E-05	1.58E-06
11	-3.1E-05	2.04E-06
12	-4.3E-05	2.12E-06
13	-3.1E-05	1.77E-06
14	-1.5E-05	1.32E-06
17	-2.5E-05	1.93E-06
18	-3.8E-05	2.62E-06
19	-1.7E-05	9.9E-07
21	-2.1E-05	9.65E-07
23	-2.8E-05	1.79E-06

Fit R vs APD (both averaged over one laser run).
Lot of systematic effects in 2003 data (cooling and electronics problems, irradiation during most of the 'stable running' period.
Overall trend similar to Malberti et. al. , channel to channel variations 'small'.

Nonlinearity from Laser Ramps

The 'French Way' (Verrecchia & Dejardin 2004, 2004 Endcap Data) :
Use laser ramps and electronic pulse ramps to measure nonlinearity





Plots from Roberto (red lines correspond to equivalent runs ?? If so, why -50% in APD, -33% in PN ?)

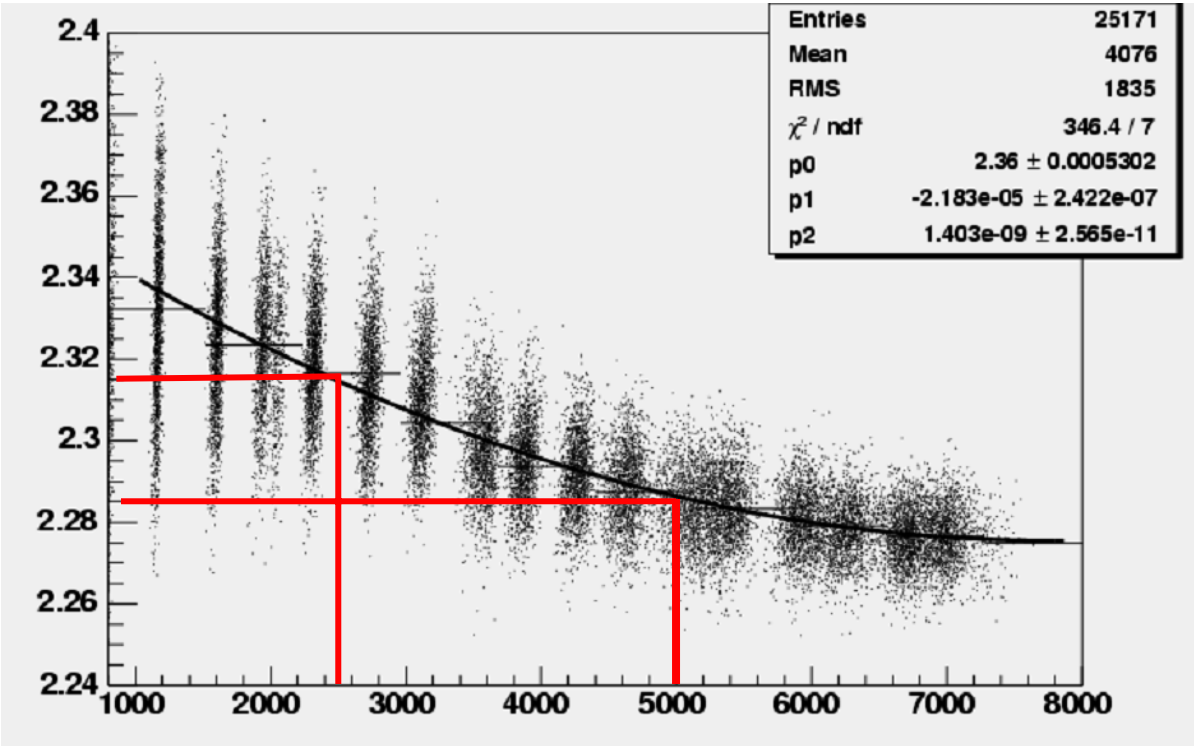
APD Nonlinearity : -0.8%
(-50% APD signal ⇒ +0.4% APD correction)

PN Nonlinearity : -0.4%
(-50% PN signal ⇒ +0.2% APD correction)

Since R = APD/PN : R Nonlinearity ~0.2% (?)

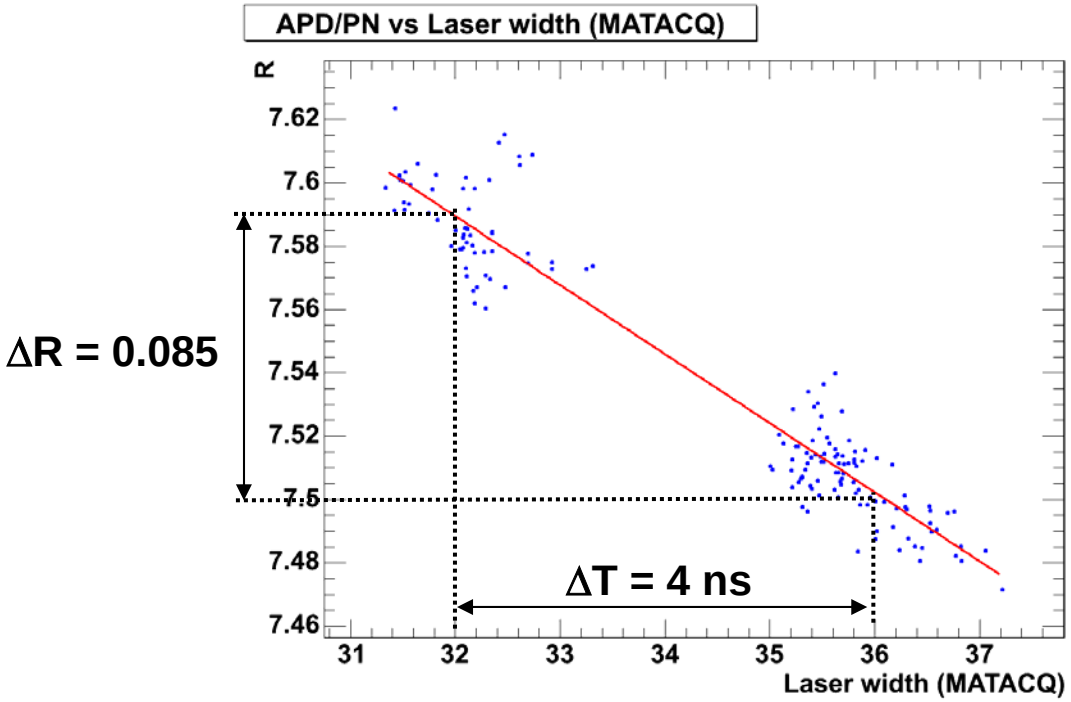
Unfortunately 2004 laser ramps not publicly available (?)

2003 Laser Ramp



-50% APD ⇒ + 1.3 % in R ⇒ - 2.6% Nonlinearity
More consistent with 'Italian Way' ??

Pulse Width Nonlinearity (2004 SC)

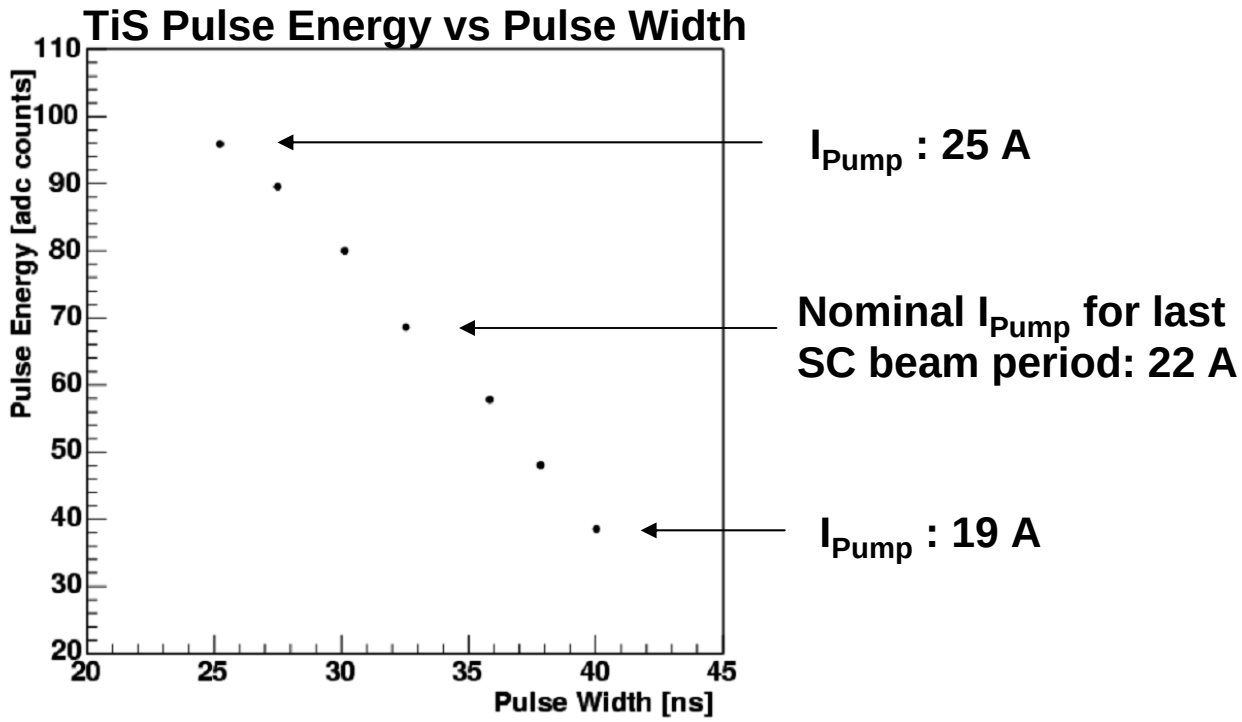


Pulse Width Nonlinearity, based on MATDAQ measurement : ~10 % !!
eg. If Width changes by 10% R changes by 1%.

Plots and MATDAQ : Salerno et. al. & Verrecchia et. al.

Pulse Width Scan

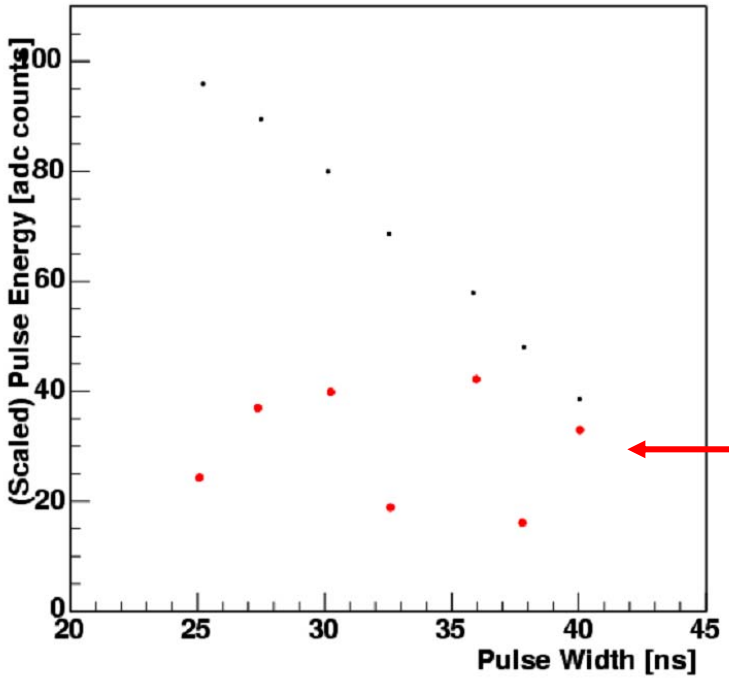
Take advantage of the facts stated on slide 4 :
Reduce YLF pump current ⇒ Reduce TiS energy ⇒ Reduce TiS pulse width
Done September 6 2004, Runs 72720 - 72744



Note : First serious usage of fast monitor, not optimized and tuned.
⇒ Potentially systematic effects, but overall linear dependency as expected.

Pulse Width Scan (continued)

Try to keep effective pulse energy sent to the ECAL ~constant by adjusting the intensity setting of the neutral density filter :

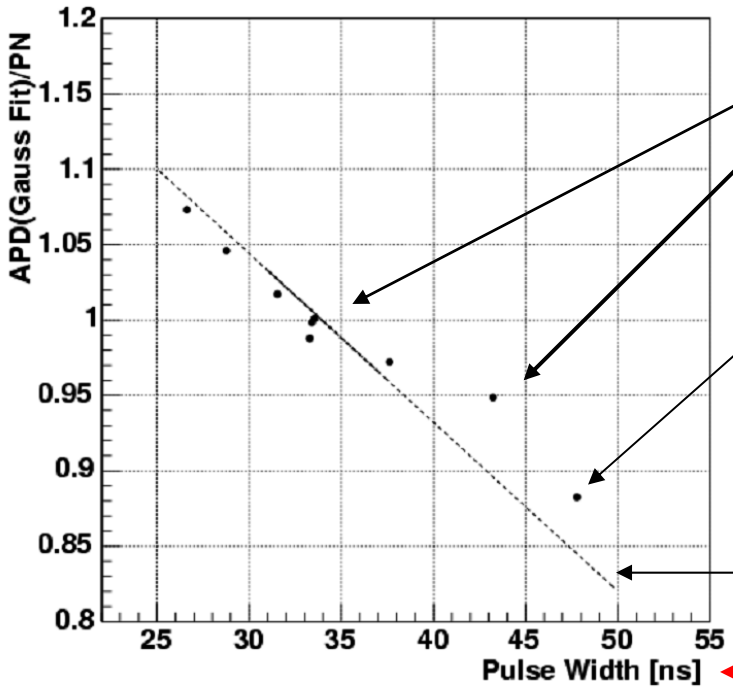


Pulse energy scaled by the intensity setting.
Due to usage of the slow monitor (limited statistics) very inaccurate setting
⇒ Can be done much better next time by using fast monitor.

⇒ Repeat more carefully with SM10

Pulse Width Nonlinearity

Pulse Energy (Gauss fit to peak of all samples) vs pulse width from MATDAQ



These points were scaled down Too much - thus would get corrected upwards from pulse height nonlinearity (but by less than 1% ?)

This point may suffer from an unstable laser ?

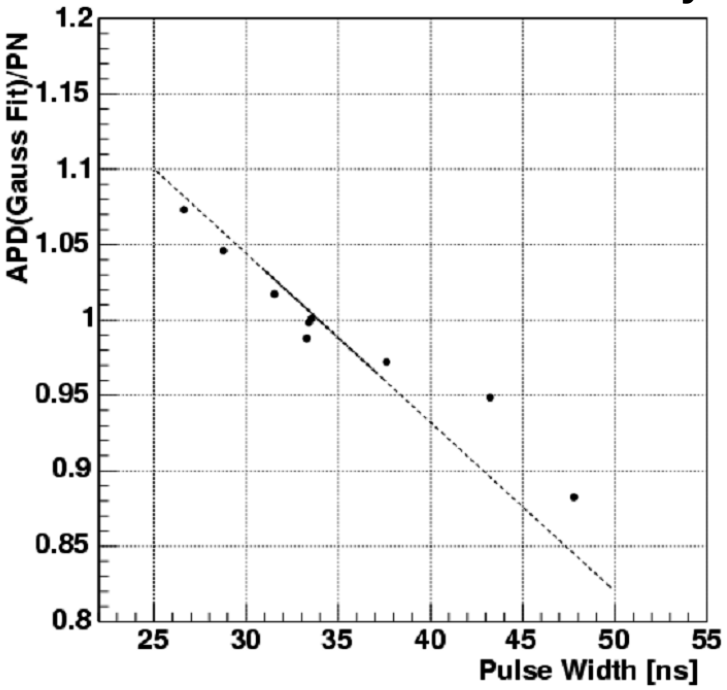
Slope : -0.011 [1/ns] from Roberto's Plot, Y-offset arbitrary

Note : This is now MATDAQ width !

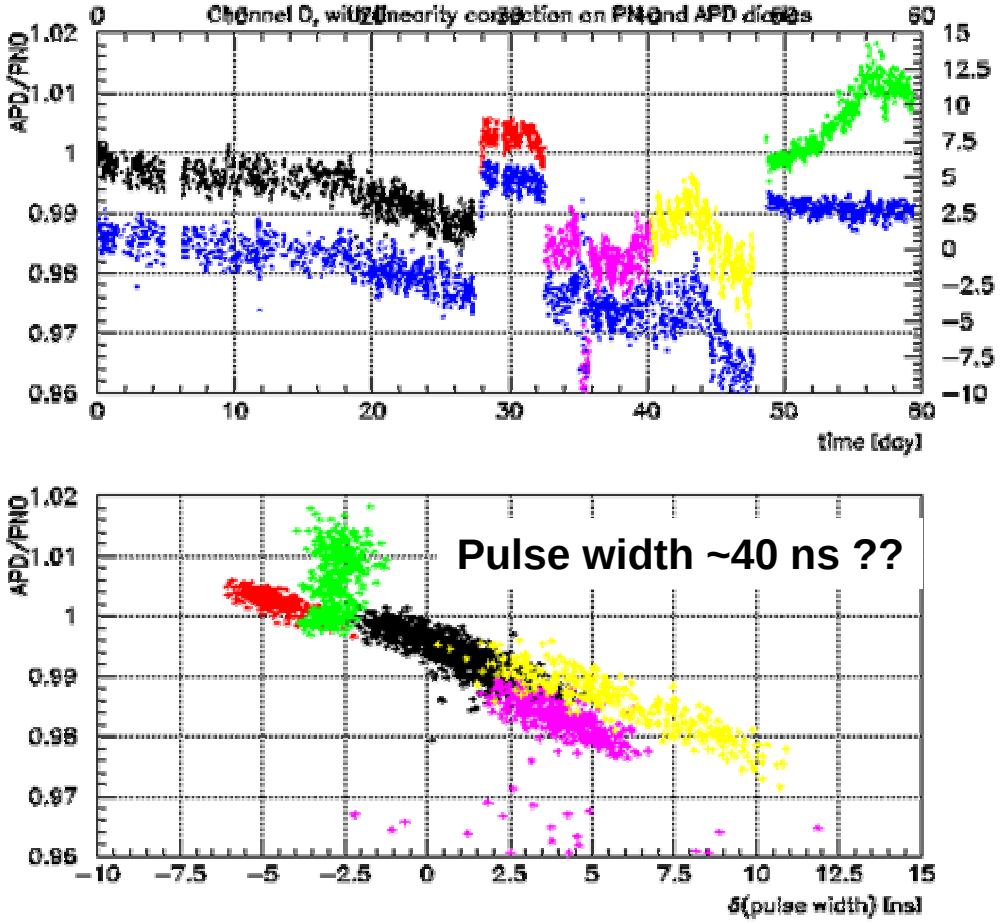
⇒ **Confirms large pulse width dependency qualitatively and ~quantitatively**

Pulse Width Dependency 2004/2002

2004 Scan : ~10% Nonlinearity



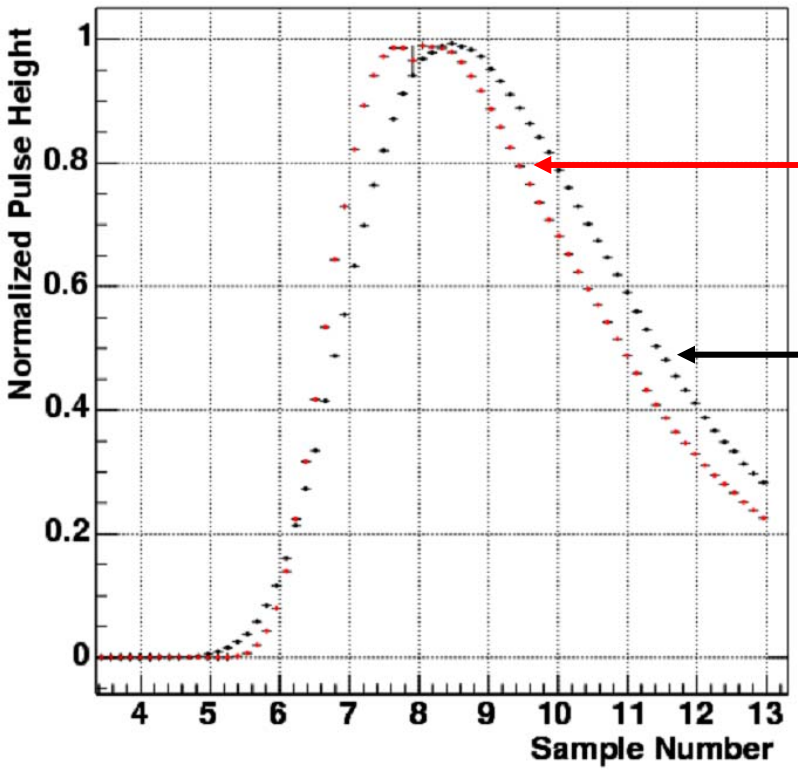
Marc, WACH2002, Paris, 2002 Data



-25% pulse width ⇒ +2.5 % R ⇒ ~10% non

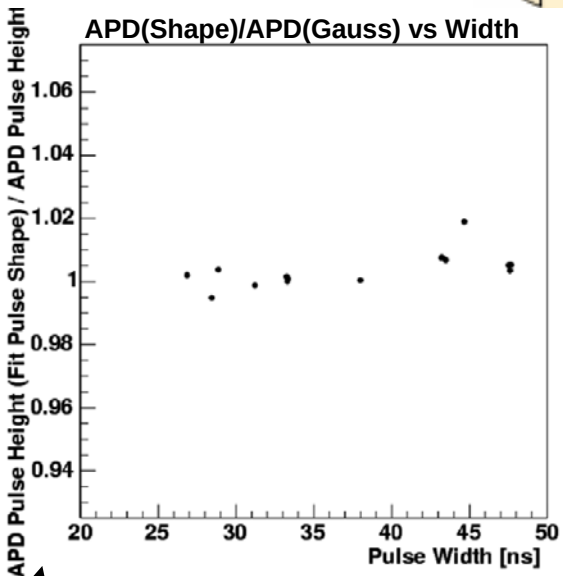
⇒ Pulse width dependency consistent ! Even compared to 2002 with different electronics ...

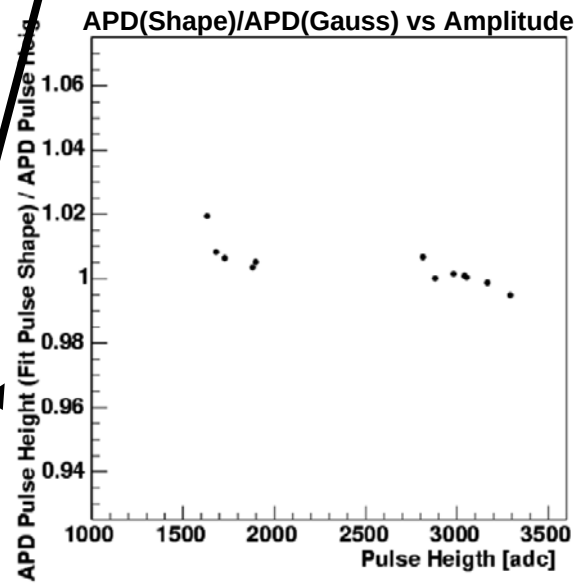
Pulse Shape Effects



I_{Pump} : 25 A

I_{Pump} : 19 A





Most prominent effect : Faster Pulse Rise Time.
Width and Rise Time fits underway …

Looks more like a effect as function on pulse energy than width ?

Summary

The APD and PD response to laser pulses (and thus R=APD/PN) shows a clear pulse energy and laser pulse width dependence (nonlinearity).

The pulse width dependency seems to be stronger and more important to monitor. We also seem to see more consistent values for it from different studies.

Even for a flawless laser the intrinsic pulse width fluctuations are significant.

Outlook

Carry out a careful pulse width scan with SM10. Needs at least 1 shift /8 h (?). Needs no beam, so hopefully no problem.

Do a careful study of everything I showed to get reliable numbers.
Test corrections on SC data (and possibly SM10 data).