Status report on the activities in progress in Pisa for the TileCal detector

S. Leone, F. Scuri

Atlas Pisa weekly meeting - July 16, 2013

Outlook:

1) The laser II project (optics)

2) Activities in the Atlas-Pisa lab

3) Analysis of the TileCal calibration data

1 - The laser II project - Summary

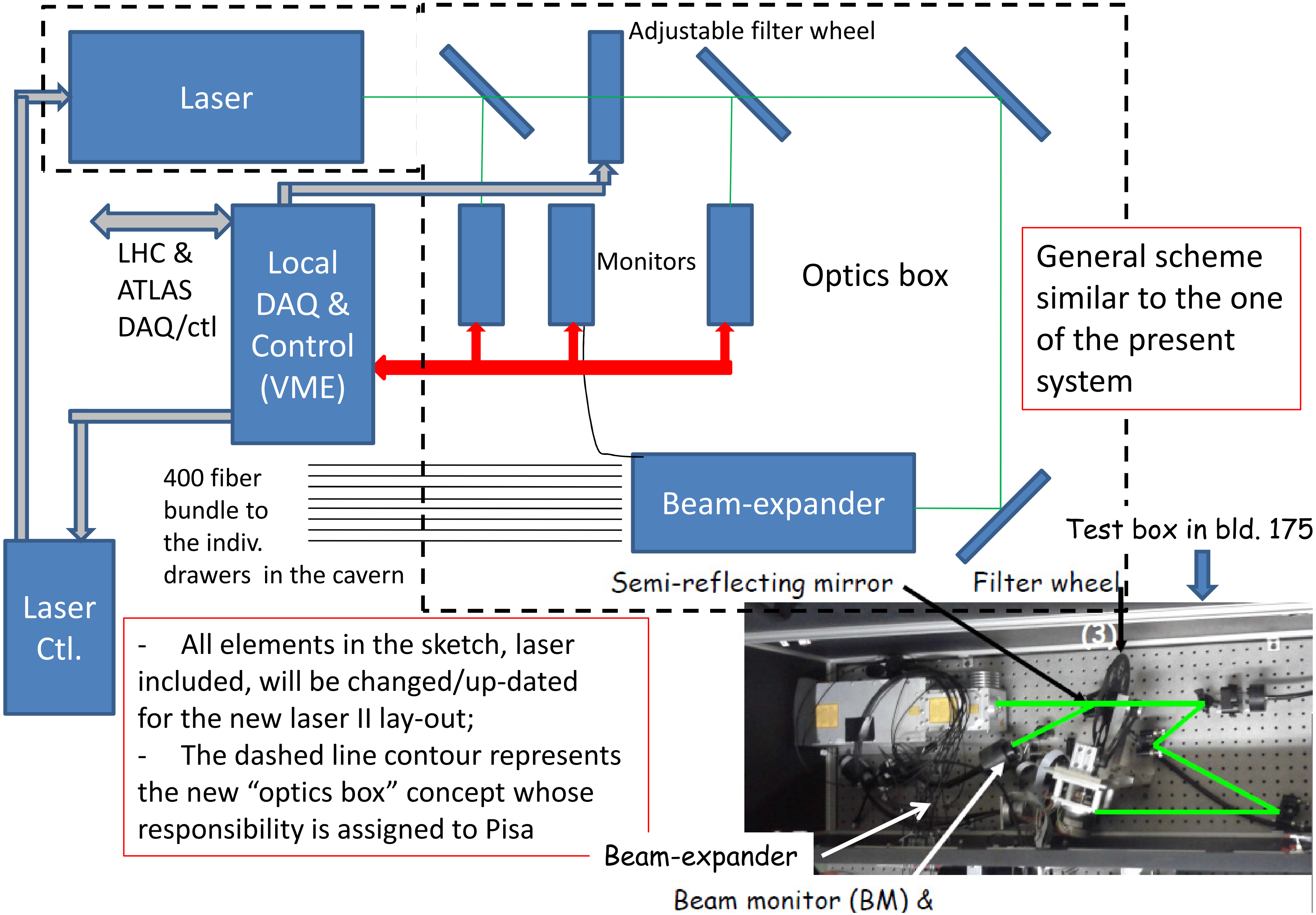
- Tests of the new optical system ended (paused) on May 20, 2013, due to the moving of the test system from CERN (bld. 175) to Clermont-Ferrand for up-grading the electronics

- Very encouraging results obtained with the September 2012 – May 2013 test campaign (short summary below)

- Extensive tests of the beam-expander (transmission uniformity and stability) done, but not fully completed; a lot of data taken in bld. 175 still to be analyzed, a program to set-up a suitable arrangement in the Atlas-Pisa lab for test completion is running …. (see section 2)

- Meanwhile, Pisa took the responsibility of the design of the new optics box; A. Moggi was assigned to Atlas for the executive drawings, production will be made in Coimbra.

1 - The laser II project – The system building blocks



General scheme similar to the one of the present system

- All elements in the sketch, laser included, will be changed/up-dated for the new laser II lay-out;
- The dashed line contour represents the new “optics box” concept whose responsibility is assigned to Pisa

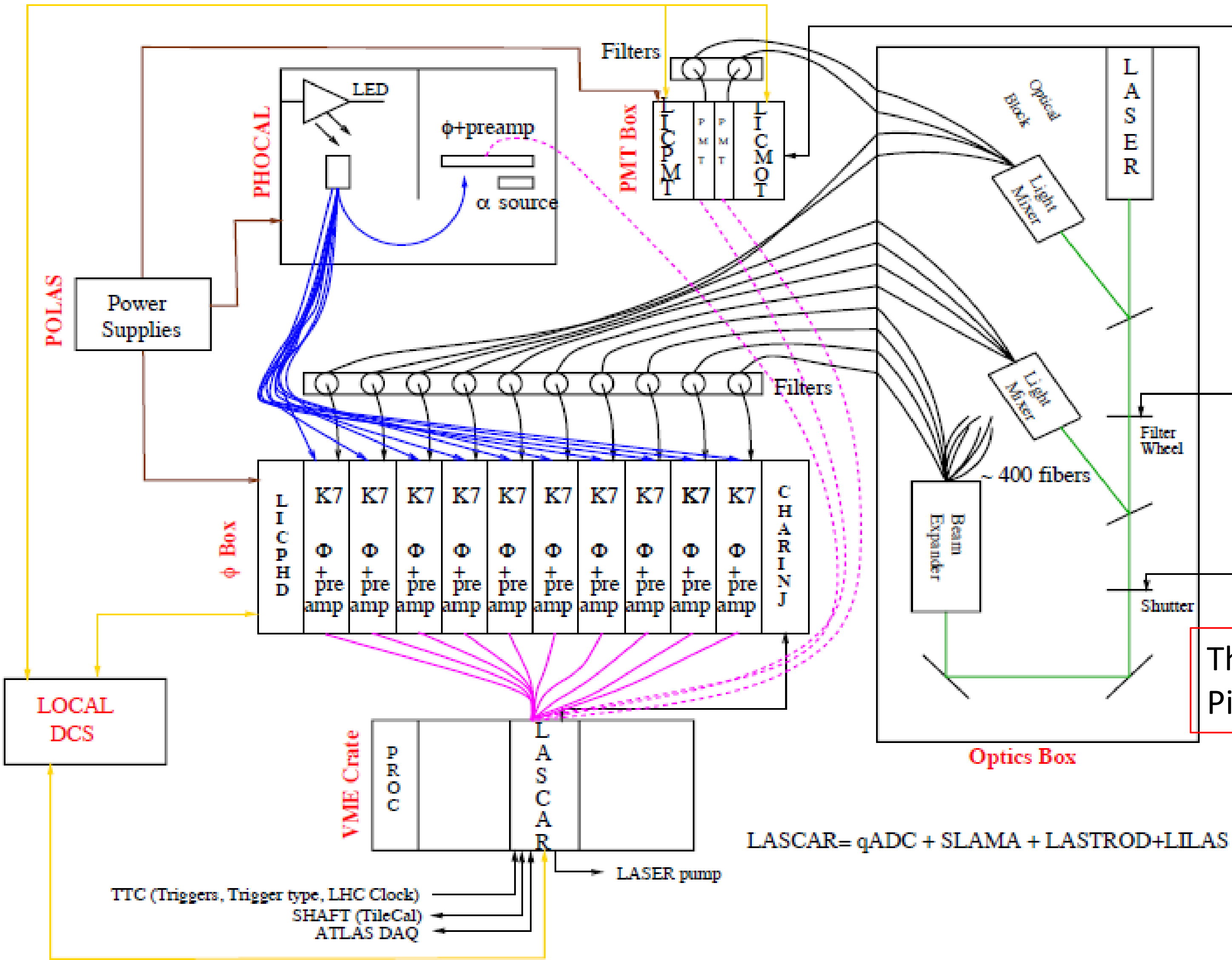
1 - The laser II project – Result summary of the test in bld.175

Programma di test 09/2012 – 06/2013 guidato e svolto principalmente da Pisa

	Sistema usato fino allo shut-down	prototipo LASER II
Stabilità elettronica di Front-End per lettura di fotodiodi e PMT di monitor	0.3 %	0.1%
Stabilità monitor prima del beam-exp. breve termine (8 ore)	0.5%	0.2 %
Stabilità monitor prima del beam-exp. lungo termine (4 mesi)	2 %	1 %
Stabilità monitor in uscita al beam-exp. breve termine (8 ore)	1 %	0.3 %
Stabilità monitor in uscita al beam-exp. lungo termine (4 mesi)	1 %	N/A
Uniformità mixing del beam expander*)	5 %	1%

*) Miglioria fondamentale per correggere il drift in stabilità dei monitor dovuto al variare, in funzione della temperatura della testa del laser e della sua intensità, della caratteristica di beam-pointing stability

1 - The laser II project – Overall scheme for the installation

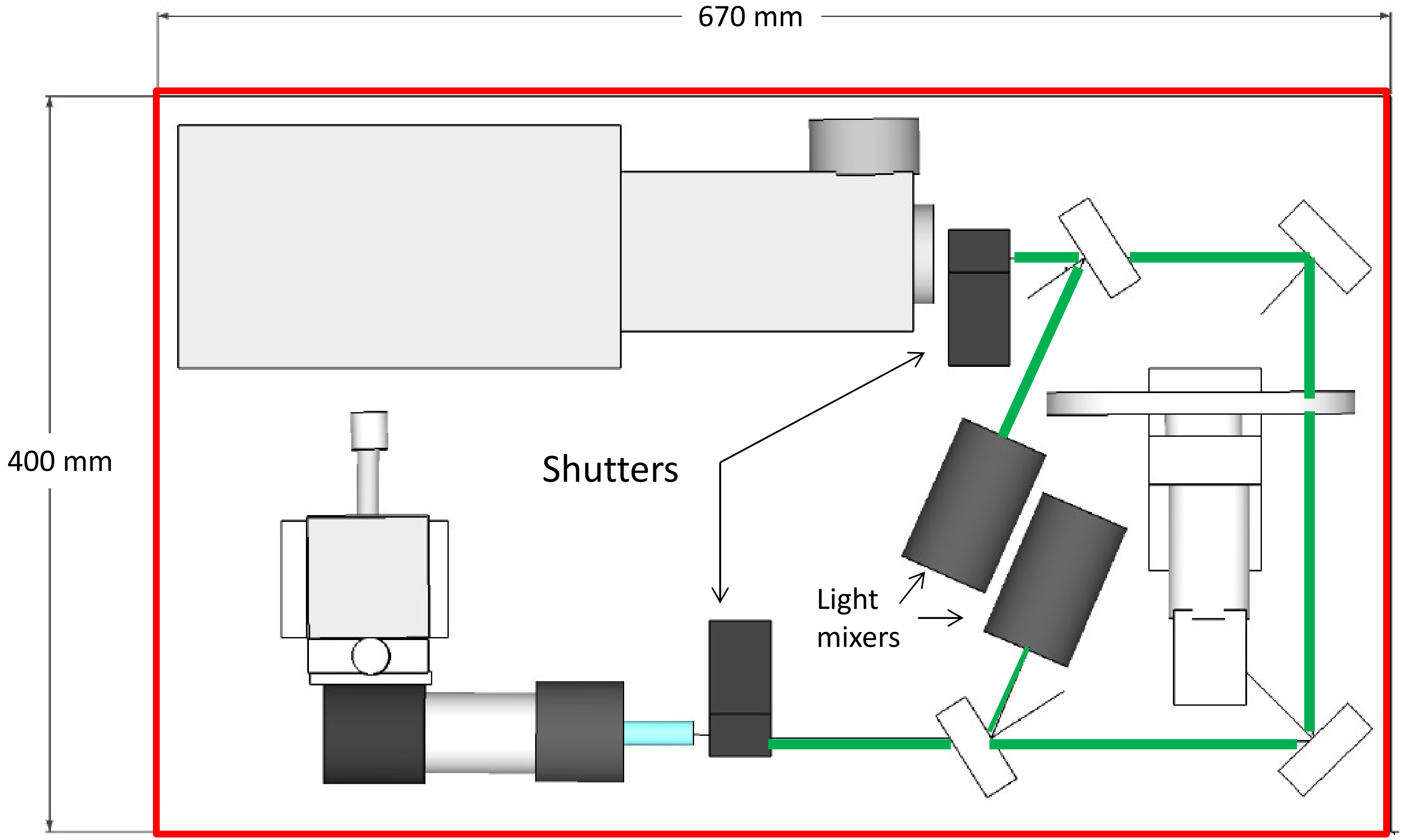


This is the Pisa busness

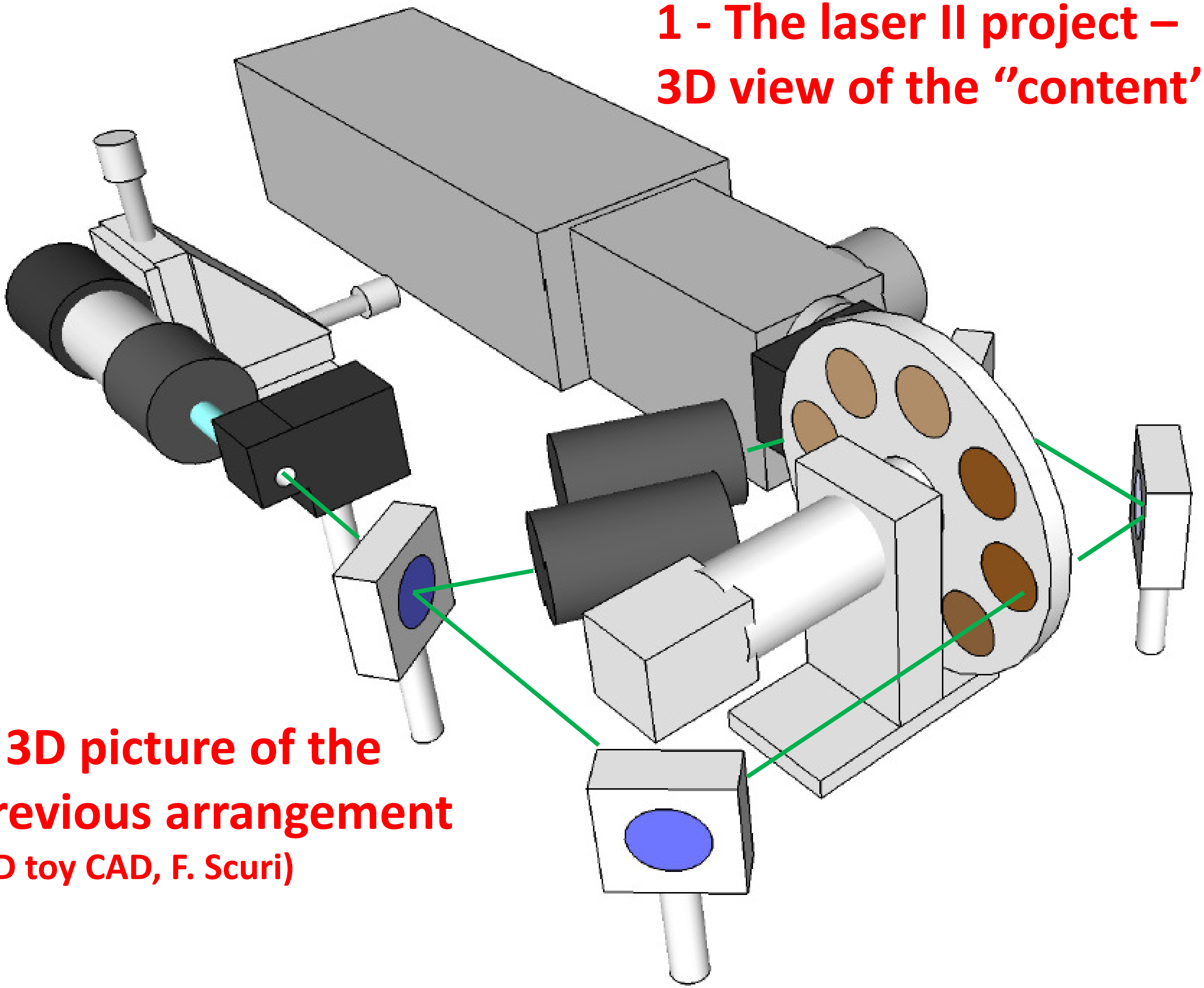
1 - The laser II project – The new optics box geometry

All pieces have real dimensions to scale

Lay-out (red square) dimensions " squeezed " to well fit inside the rack volume



1 - The laser II project – 3D view of the ''content''

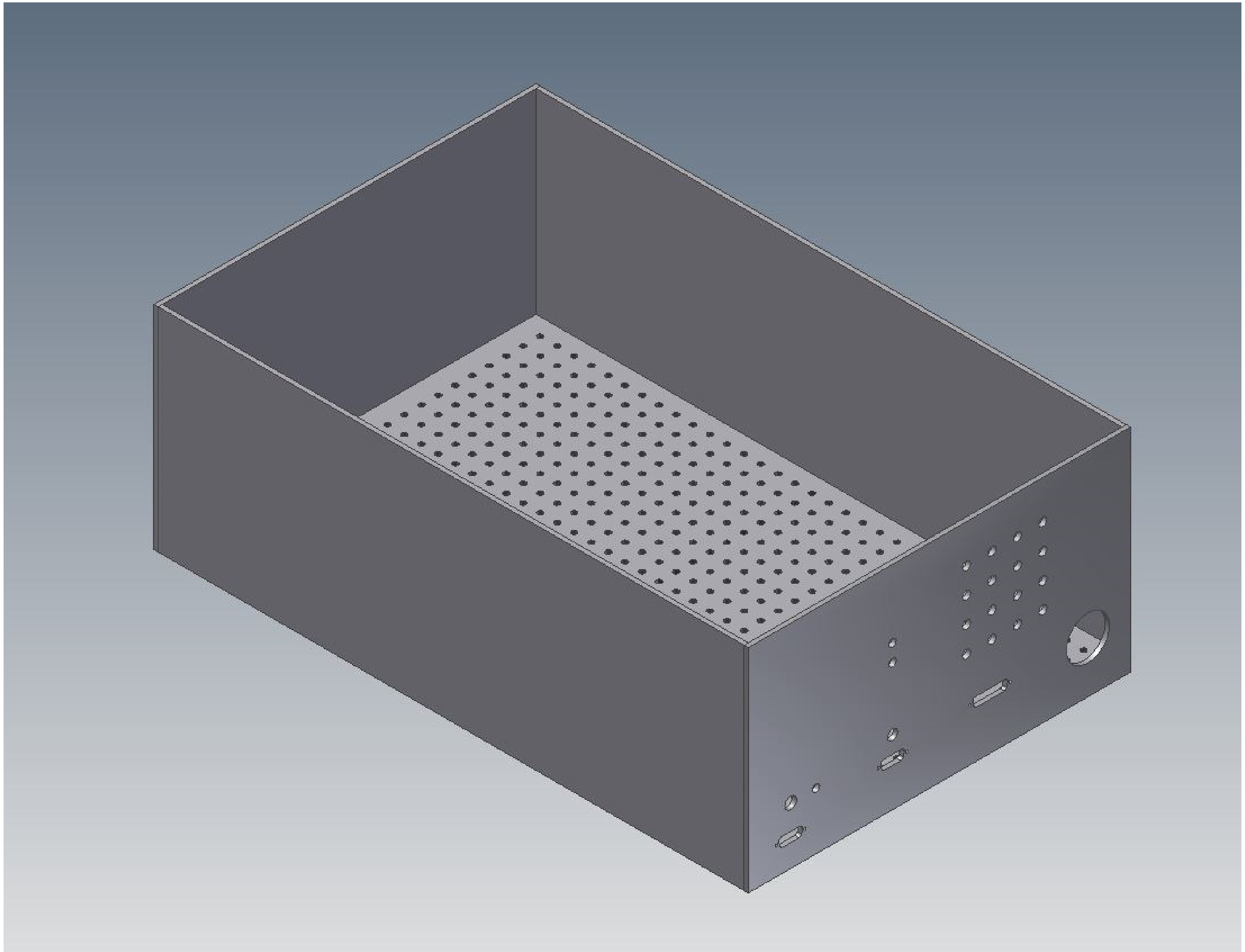


A 3D picture of the previous arrangement

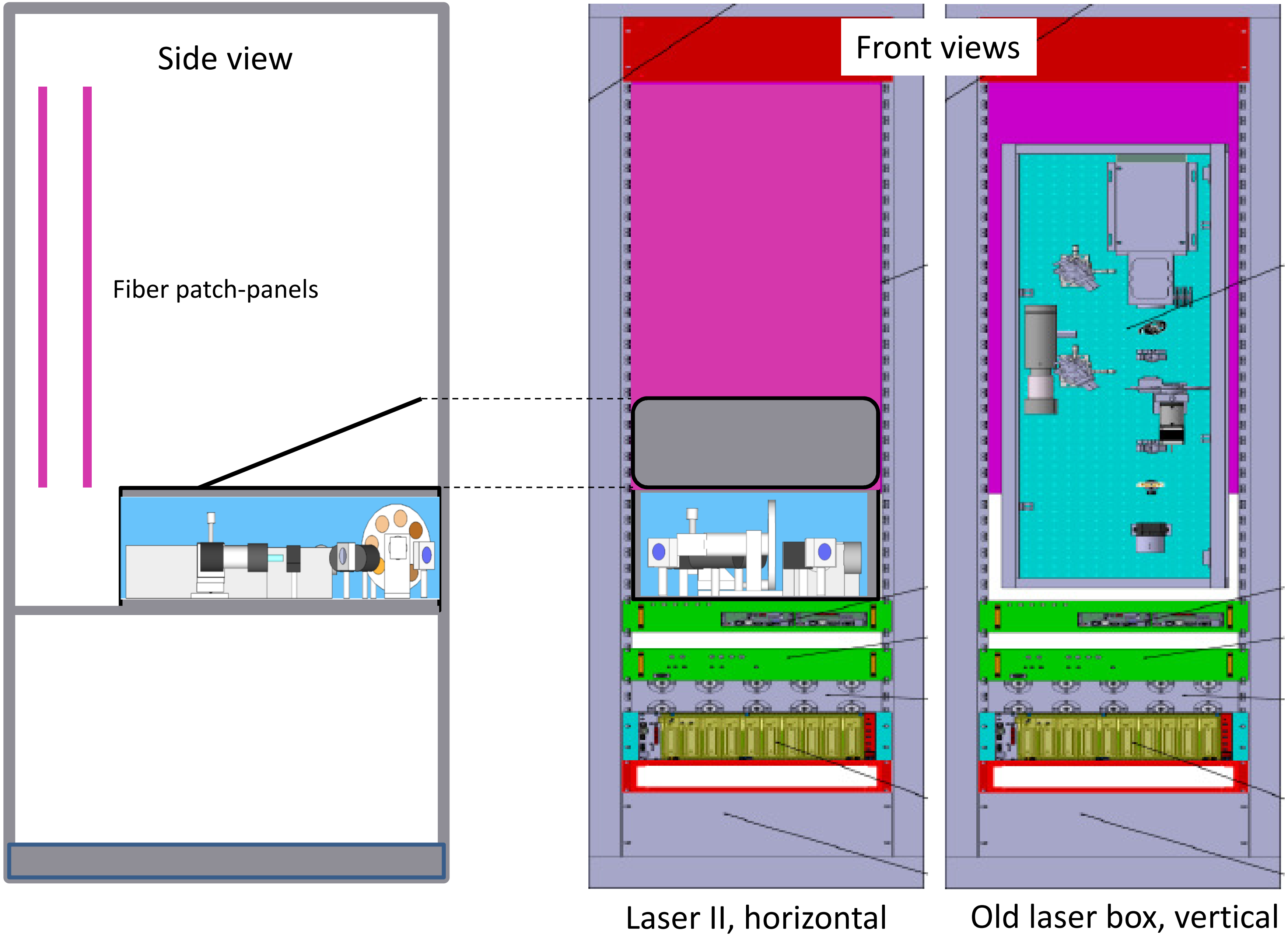
(3D toy CAD, F. Scuri)

1 - The laser II project – 3D view of the "container"

Optics box start files with Autocad Inventor (A. Moggi)



1 - The laser II project – Arrangement in the USA-15 pit



1 - The laser II project – Time schedule

Part	Phase	Date of completion	
Photodiode Box	Commissioning	-	Clermont-F.
PHOCAL	Commissioning	-	Clermont-F.
POLAS	Commissioning	-	Clermont-F.
PMT Box	Production	31 july 2013	Clermont-F.
LASCAR	Test	31 july 2013	Clermont-F.
Optics box	Design	September 2013	**Pisa**
	Production	October 2013	Coimbra
	Tests (in bld. 175)	December 2013	**Pisa** + Coimbra + CERN
Fibers+filters	Production	26 july 2013	Clermont-F.
DCS	Design	october 2013	Clermont-F.
DAQ	Design	october 2013	Clermont-F.

Each part is added gradually
Qualification of all pieces except the optics box will be performed with the « old » optics box at Clt-Fd – Integration of the full system at CERN (175 and then USA15)

2 - The Atlas-Pisa lab – Activity overview

- Clean-up and re-ordering the whole lab:
  - desks and work tables now ''usable'';
  - a lot of ancient and/or broken material still to be decommisioned;
  - optical bench space divided in two sectors: old PMT test box and new laser test station;
  - all Newport mechanics and optics, ordered on June 15, delivered on July 9.

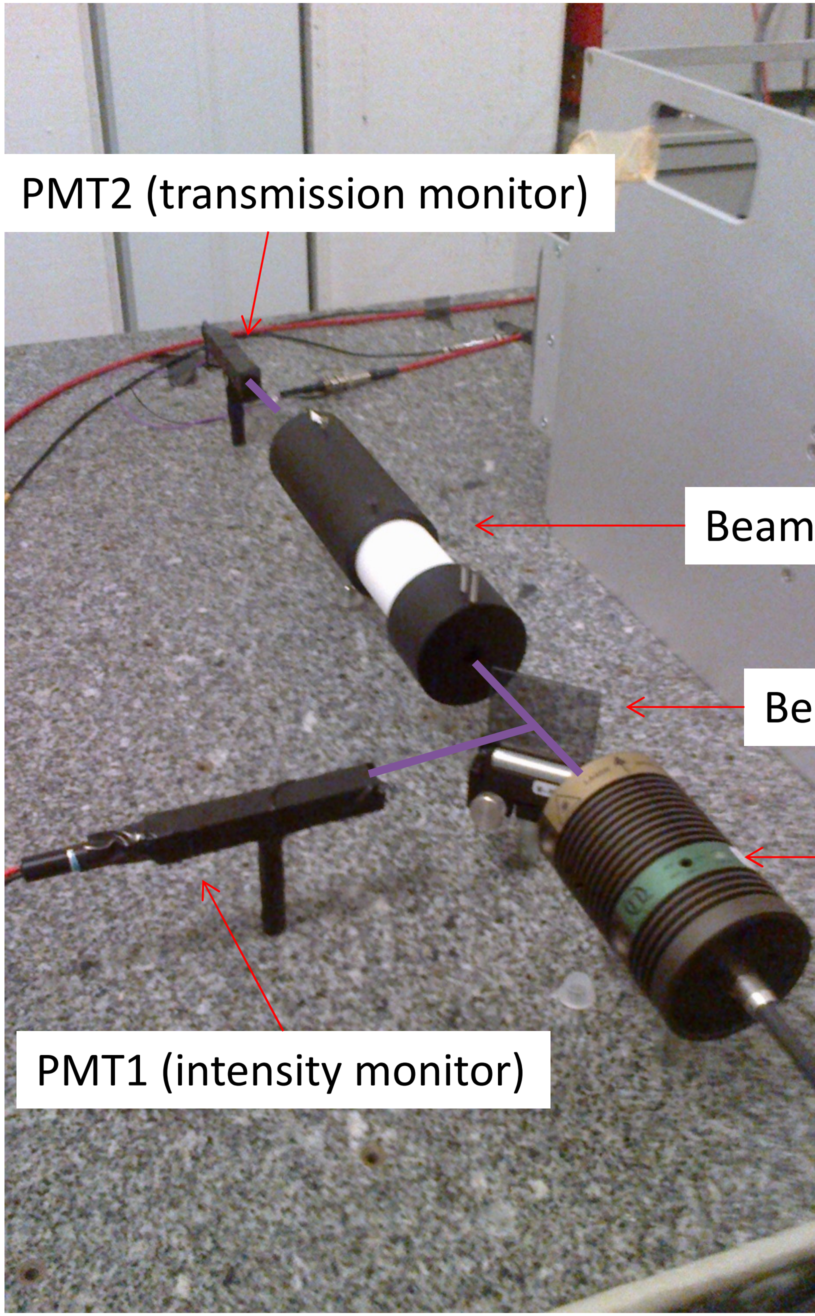
- PCATLAS26 desktop (the one with the CAEN PCI-VME interface):
  - new root password set;
  - created the AtlasDAQ account for data-taking SW

- Resuming the DAQ operations (no data taking since spring 2011)
  - a happy accident (see below)

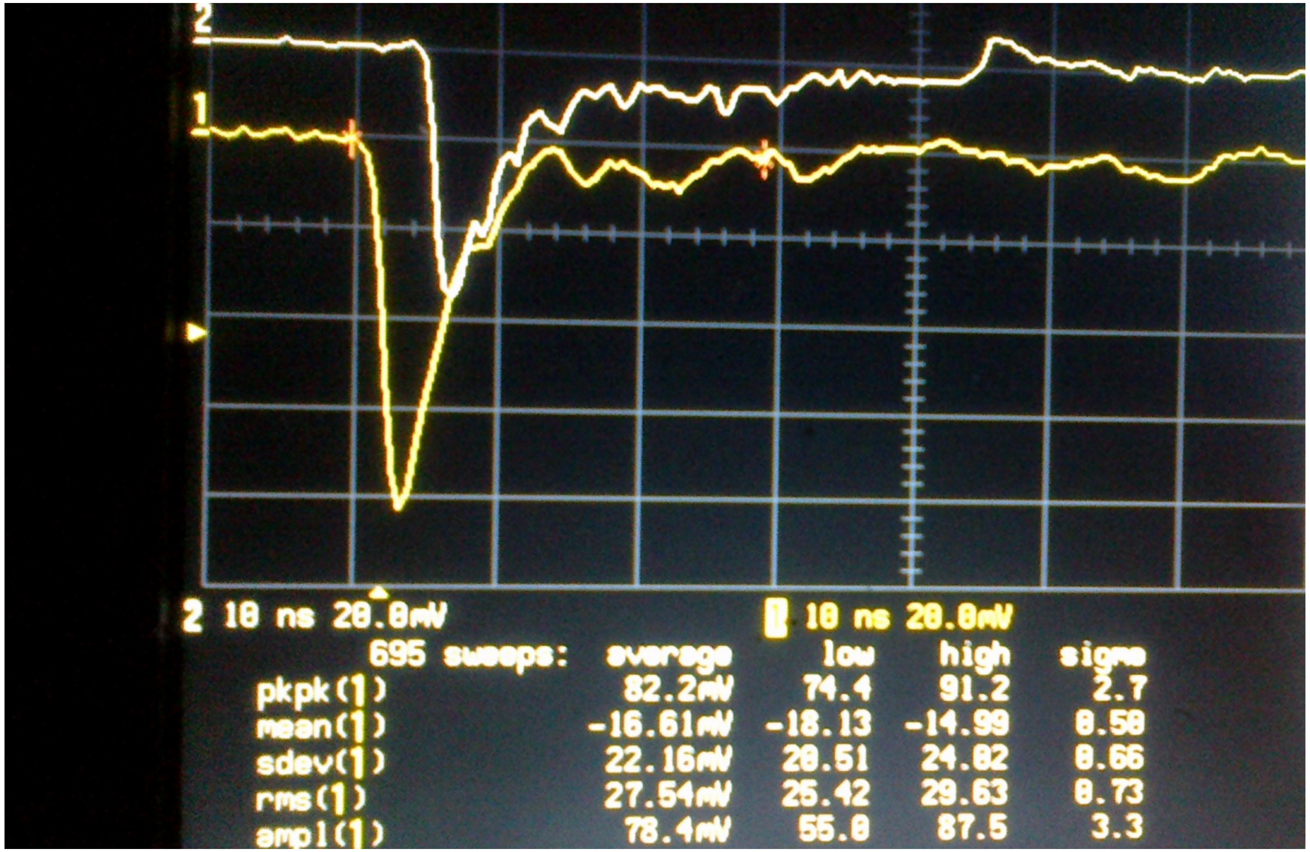
2 - The Atlas-Pisa lab – Reproducing the test system of bld 175

A. Sardelli is preparing:

- a light tight black box which will cover the optical bench area hosting the optics;
- All the mechanical mounts to fit the optical elements in the beam-expander (PMMA guides and mixer, diffuser, lens)



2 - The Atlas-Pisa lab – PMTs signals at large intensity laser pulses



The Hamamatsu R1635 PMTs are operated here at 650 V (PMT2 transmitted light) and at 900 V (PMT2, reflected light) at laser driver half-maximum power. (1250 V is the nominal PMT oprating voltage …)

Pulse width (<10 ns FWHM) doesn't depend from the repetition rate (20 KHz to 8 MHz with the PDL 200 driver)

Pulse amplitude, at fixed driver output power, slightly depends (up to a factor 2) on the repetition rate

The ripples on the pulse trailing edge are typical of PMTs with HV values well below the nominal one and many photoelecrons at the cathode (high laser intensity)

2 - The Atlas-Pisa lab – DAQ

Thanks to Nino's tutorial on the existing SW for the DAQ systems used for PMT characterization till spring 2011, we were able to:

- set-up a VME only based DAQ system without compiling any new library and without removing/re-using any electronics element of the old DAQs which are left as they were.

- we just use the CAEN libraries for the PCI-VME USB communication, installed on Pcatlas26, and the CAEN libraries to make standard VME access through generic board handlers prepared by the previous users;

- we just modified in a new data-taking macro the event loop and the board access sequencies according to the specs of the specific units we plan to use;

- we plan to use only two very old VME boards found abandonned in the closets:
a CAEN V262 I/O register for setting the run conditions logic (physics/pedestal/test) and
a LeCroy 1182 charge integrating ADC (12 bit, 0.5 pC/bit, 8 single-ended chs, multiplexed conversion within 16 μs/channel, 16 event memory buffer);

- With a skeleton DAQ program we were able to check that both units are fully operating;

- It's a kind of miracle that things gone so fast and easy ….

2 - The Atlas-Pisa lab – workplan and time schedule

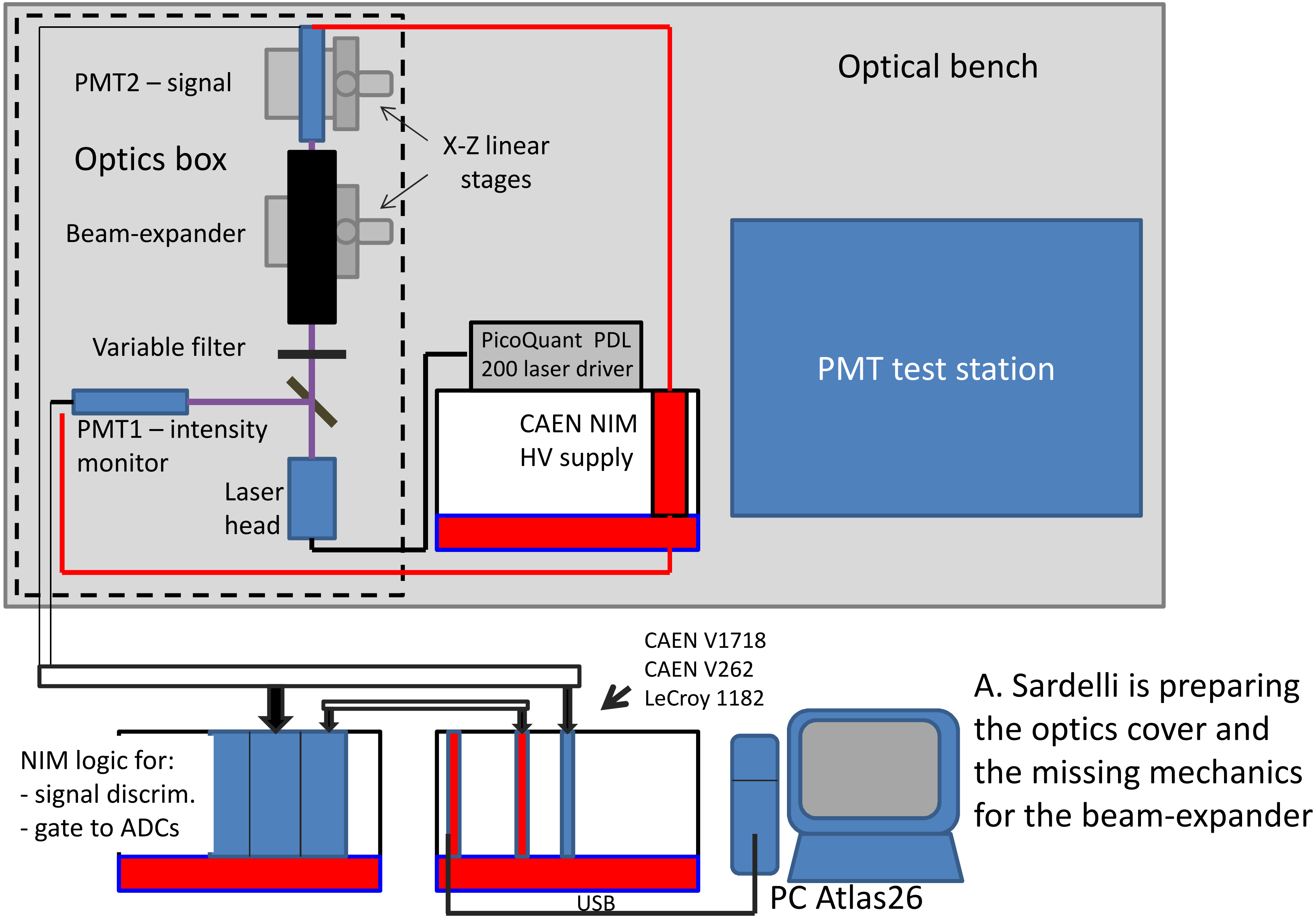
- Main goal of the arrangement in the Pisa lab is to complete the test program developed with the installation in bld. 175 at CERN, i.e:

- to complete mapping of the beam-expander output uniformity;
- to measure again the transmission factor s of the optical elements in the beam-expander ;
- to complete the studies the expander response as a function of the laser intensity;

- Estimated time schedule:

- construction of the optics cover and of the small mechanical pieces for the beam-expander elements } A. Sardelli, July 20
- Completion and test of the DAQ SW ——— F.Scuri, S.Leone ? - July 31
- Test program described above ——— S.Leone, F. Scuri - September 30
- Eventual long term stability test (in parallel with the new system in bld. 175 at CERN). } F.Scuri, S.Leone - December 24

2 - The Atlas-Pisa lab – Final set-up for expander mapping



A. Sardelli is preparing the optics cover and the missing mechanics for the beam-expander

3 – Calibration data analysis – Activity overview

Thanks to many tutorial sessions with Federico B. and to its patience we were able learn how to install and to run the SW required to access standard TileCal calibration n-tuples.

We already did some trials with personal root macros.

We would like to start with studies on the PMT constants ''k'' used in the so called ''Pisa method'' to correct for laser intensity fluctuations in the method for counting the photo-electrons number of each individual channel in an absolute way.

This would allow us to:

- compare our results with already presented ones in the TileCal calibration working group;
- check, if good data are available, the stability of the ''k'' constant versus the laser intensity when:
  a) the pulse intensity is changed by filters at fixed laser pumping power;
  b) the pulse intensity is changed by varying the laser pumping power at fixed transmission.

From the test done in bld. 175 we have many hints that the ''Pisa method'' can not be easily applied in case b) (see below)

3 – Calibration data analysis – The "Pisa method" revisited

The principle of the "Pisa method" (simplified)

- The R.M.S. of the integrated charged distribution Q of PMT pulses can be expressed by:

$$(\sigma_Q)^2 = (\sigma_Q)^2_{\text{photo-statistics}} + (\sigma_Q)^2_{\text{laser intensity}} + \text{correlation term}$$

- For sake of simplicity, the following assumptions are made:

- the correlation term is neglected (but it is considered in the algorithm used for the n-tuples);
- the gain G fluctuations are also neglected;
- the Poisson statistics is assumed for the photo-electron emission/amplification, so that:

$$<Q> = <n_{p.e.}> \times e \times \mathrm{G}; \qquad (\sigma_Q)_{\text{photo-statistics}} = \sqrt{<n_{p.e.}>} \times e \times \mathrm{G};$$

- the laser intensity fluctuation is a fraction to the average intensity at fixed pumping frequency: $(\sigma_Q)_{\text{laser intensity}} = a \times <Q>;$

- With these assumptions, the PMT gain G is related to the parameters of the integrated charge distribution by:

$$\frac{(\sigma_Q)^2}{<Q>} = e \times \mathrm{G} + a^2 \times <Q> = e \times \mathrm{G} + \boxed{\mathrm{k}} \times <Q>;$$

3 – Calibration data analysis – The ''Pisa method'' revisited (II)

If the calibration pulse intensity on the PMTs is varied by changing the transmission of fixed laser intensity with the filter wheel, previous equation holds for any light intensity detected by the PMTs; the gain G and the factor k can be extracted from a linear fit of ''i'' measures of quantities corresponding to different filter transmission factors :

$$\left.\frac{(\sigma_Q)^2}{<Q>}\right|_i = \mathrm{A} + \mathrm{B}\times\left.<Q>\right|_i \qquad \text{with } \mathrm{A} = e\times\mathrm{G} \quad \text{and} \quad \mathrm{B} = \mathrm{k} = a^2$$

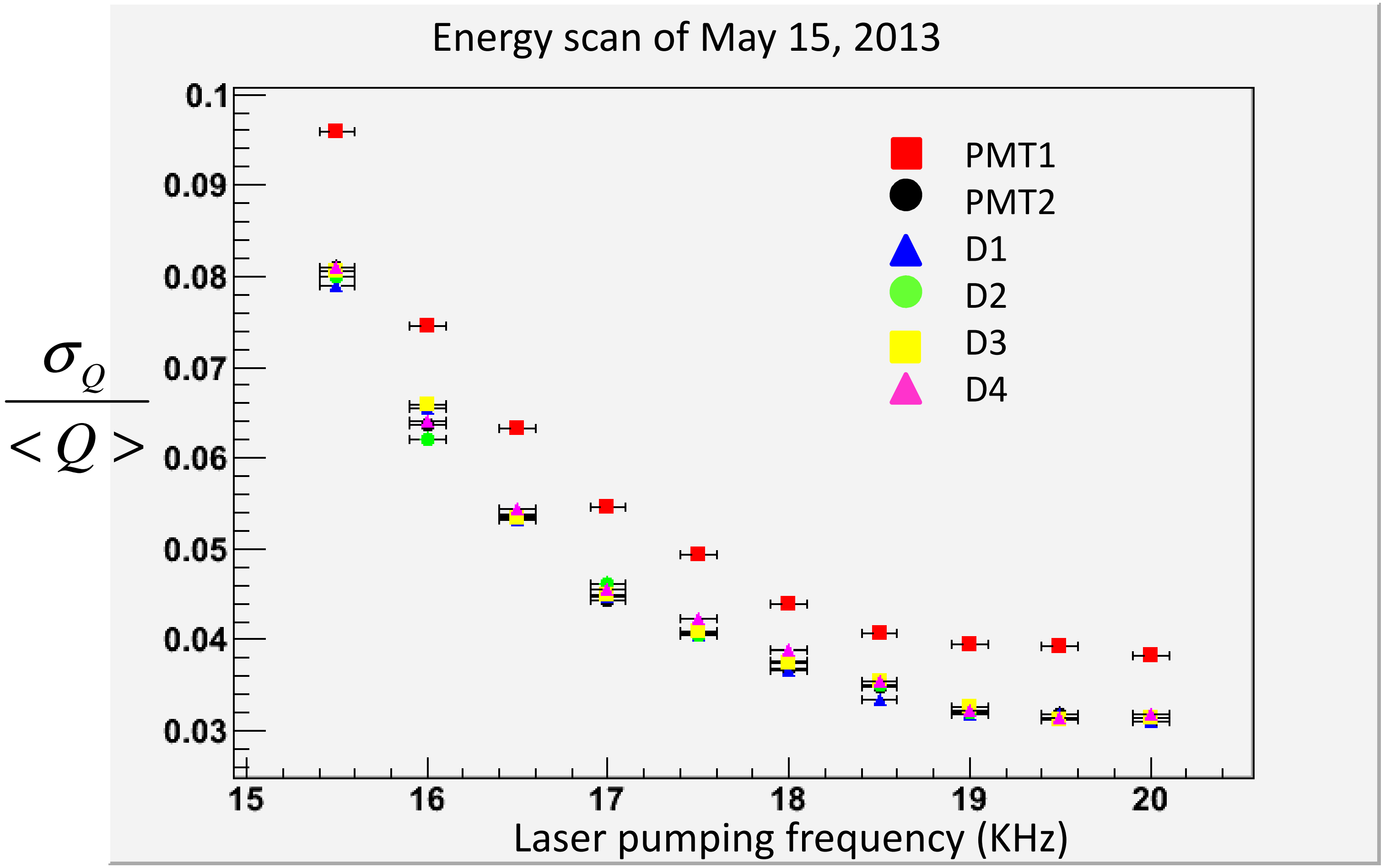
In principle, two calibration points with different filters on the wheel are enough to simultaneously determine each PMT gain factor G and the global laser ''stability'' ***constant* k**

Question : is k *constant* ? Or :
is the laser intensity fluctuation indpendent from the pumping frequency ?

Answer : 1) probably not with the laser in USA-15; we want to check it with the 2011, 2012 calibration data;
2) surely not with the (expected better) laser in bld.175 (see below)

Consequence: the '' Pisa method '' cannot be used, at least in the present version, to correlate calibration points at different laser pumping frequencies.

3 – Calibration data analysis – The energy scan with the system in 175



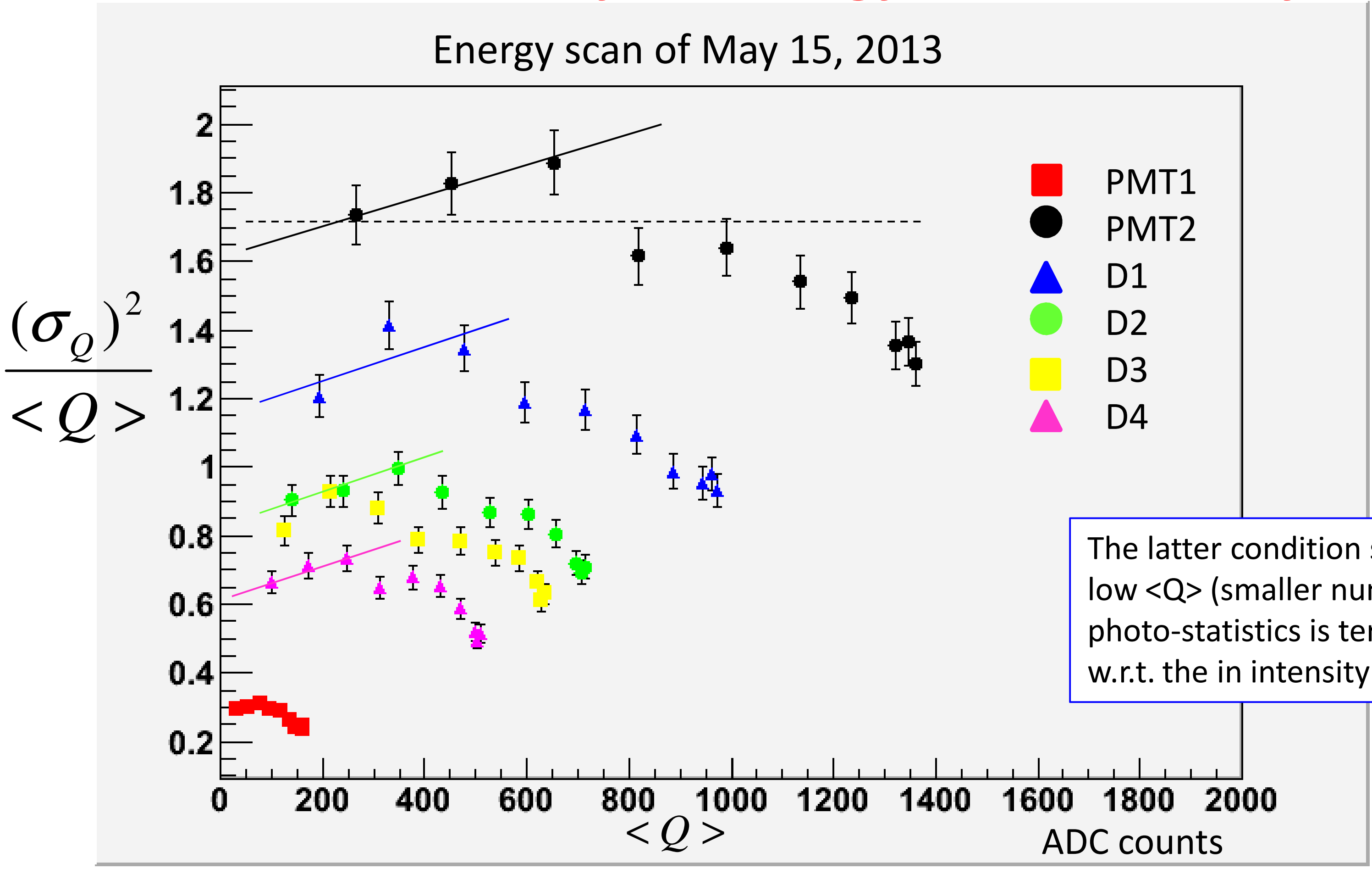
PMT1, PMT2 and D1 readout light at the laser output (intensity monitors);

D2, D3 and D4 readout the light at the beam-expander exit (transmission Monitors)

- The laser intensity fluctuations dominate over the photo-statistics, but in the case of PMT1;
- All detectors, with different gains and intensities on the photo-sensor, show exactly the same dependence ($<Q>_{PMT1}$ is about 10% of all the other detector signal, lower gain and/or lower $N_{p.e.}$?)

==> The laser intensity fluction is not constant with pumping power.

3 – Calibration data analysis – Energy scan with the system in 175 (II)



The latter condition seems to hold at low <Q> (smaller number of Np.e., i.e. photo-statistics is term non negligible w.r.t. the in intensity fluctuation one

$\frac{(\sigma_Q)^2}{<Q>}$ as a function of <Q> would be:

- a constant (dashed line) if $\frac{(\sigma_Q)^2}{<Q>} = \frac{(\sigma_Q)^2_{photo-statistics}}{<Q>} = e \times G$
- a straightline with positive slope (solid lines) if: $\frac{(\sigma_Q)^2}{<Q>} = \frac{(\sigma_Q)^2_{photo-statistics}}{<Q>} + \frac{(\sigma_Q)^2_{intensity}}{<Q>} = e \times G + k \times <Q>$

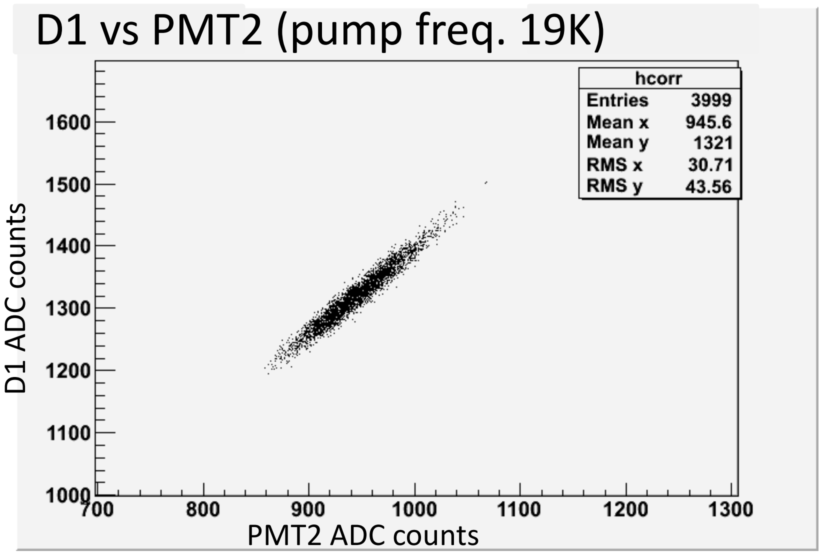
3 – Calibration data analysis – Workplan

- Check the laser intensity fluctuation characteristics with other energy scans we made during the test program in bld. 175

- Try alternative methods to subtract the laser fluctuation term from the $\frac{(\sigma_Q)^2}{<Q>}$ distributions:

  a) parametrization of $\frac{(\sigma_Q)_{\text{intensity}}}{<Q>}$ as a function of the laser pumping frequency;

  b) use of the almost full correlation between the response of any pair of detectors:



- Apply the new methods to the 2011-2012 calibration data, if we can prove they work on the data taken during the tests in 175 (or in the Atlas-Pisa lab …).

Conclusions

- A lot of work done and in progress both on the HW and SW point of view;
- All activities matched and still are matching the time schedules;
- Collaboration with the Clermont-Ferrand, Coimbra, and CERN colleagues is, at least up to now, good and fruitful.
- We hope to go on keeping the ''rythm'' ….

Personal (F. Scuri) final comment:

the global context of the present Pisa activities for the TileCal detector (calibration and Laser II project) cover experimental activities on DAQ and optics HW, both at CERN and locally; at the same time, there is the opportunity to develop SW for calibration tools connected to the calorimeter resolution performances and, therefore, to the physics potential.
It's a typical environment where young people could get a complete high level formation.
Is anybody else tempted ?