Astrofisica con Specchi
a Tecnologia Replicante Italiana

INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS

MIUR

Universidade de São Paulo

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

UVscope

an instrument for calibration support

Giovanni La Rosa
for the CTA ASTRI Project
INAF/IASF-Palermo, Italy

This work was conducted in the context of the CTA ASTRI Project

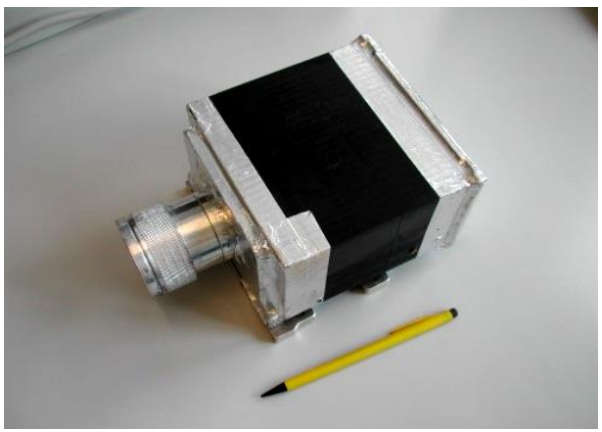
***UVscope:** an instrument for calibration support*

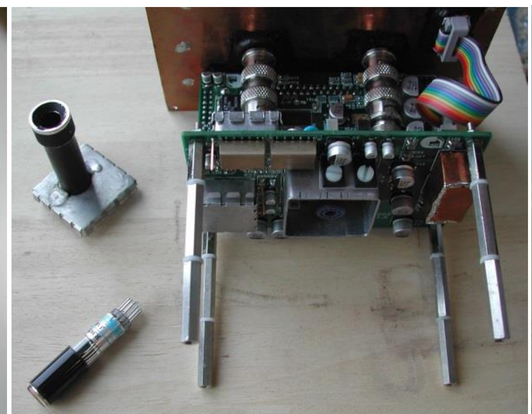
- *short history of the instrument*
- *general description of UVscope*
- *how to command the data acquisition*
- *how it was calibrated*
- *status of UVscope*
- *can UVscope be used inside CTA observatory?*

UVscope: a short history

UVscope entirely designed and realized at INAF-IASF Palermo

- ***it is very a simple photon counting instrument: just a PMT and a pinhole (No optic system)***
- ***it is absolute calibrated (only 2007+)***
- ***it is devoted to Night Sky Background measurement but it is also capable to measure the photon flux of a light source (on ground or in the sky).***

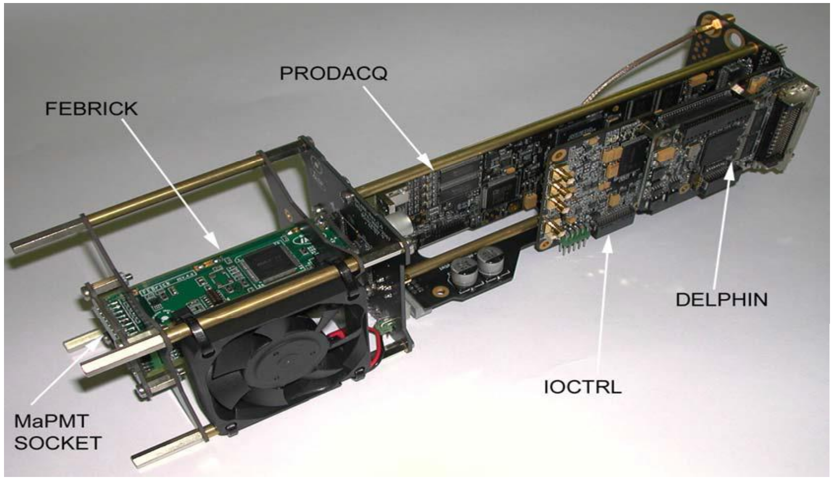




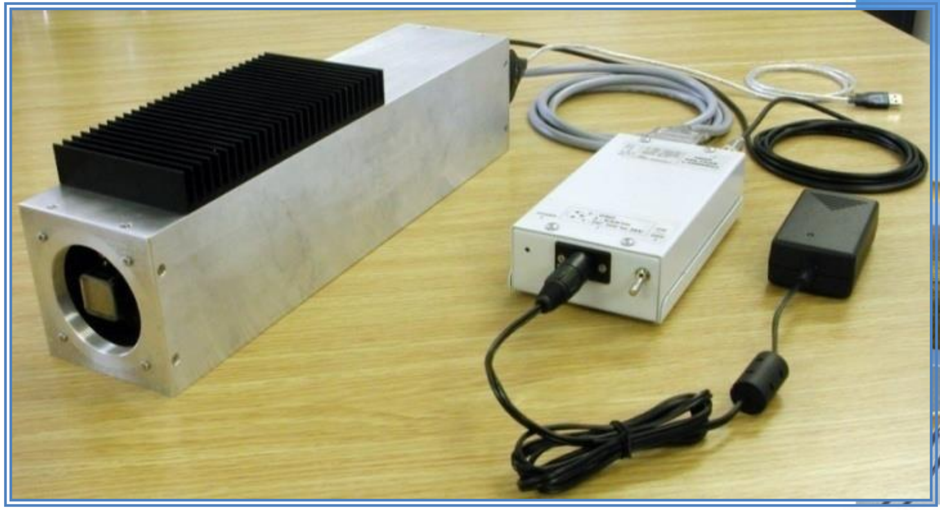
The pioneer version of UVscope was built in 2004.
It was equiped with a 1cm Ø PMT with double chain FEE for simultaneous photon counting & charge integration capability.

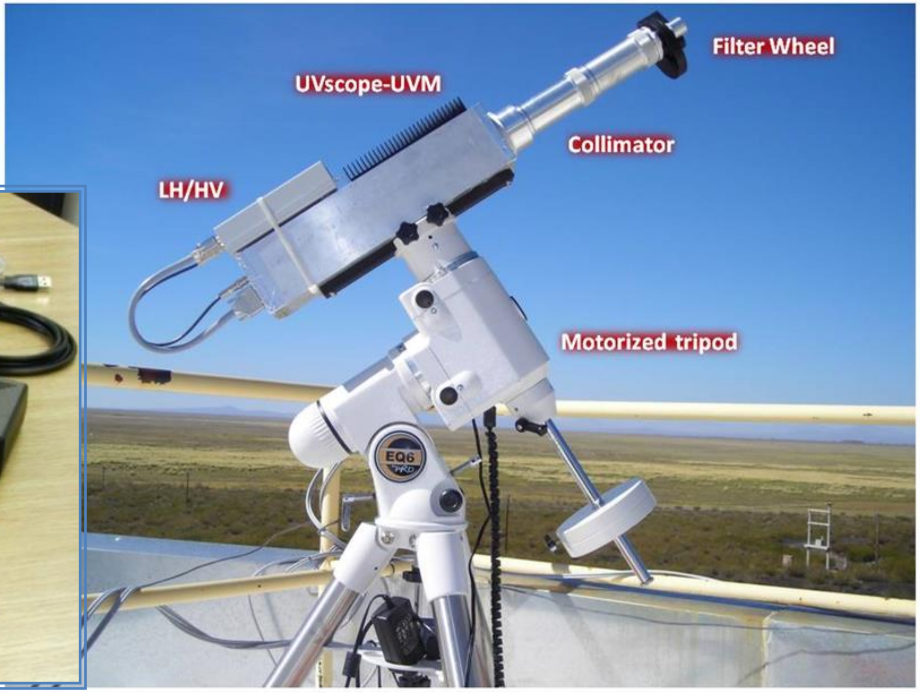
The second version, completely redisegned, of UVscope was issued in 2007

it is based on the FEE, already designed and realized, of a Flourescence Telescope (GAW project)



- *It is equiped with a multianode PMT (8x8 pixels)*
- *FEE with 64 channels (pre-amp + discriminator)*
- *DAcq Board*
- *DELPHIN I/F board (SCSI disk)*

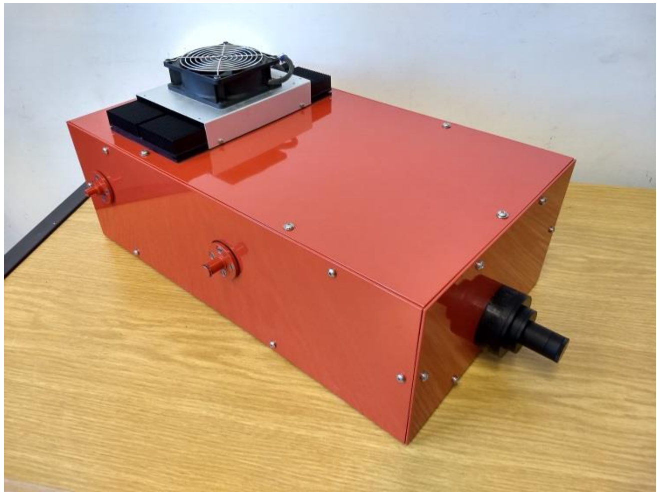




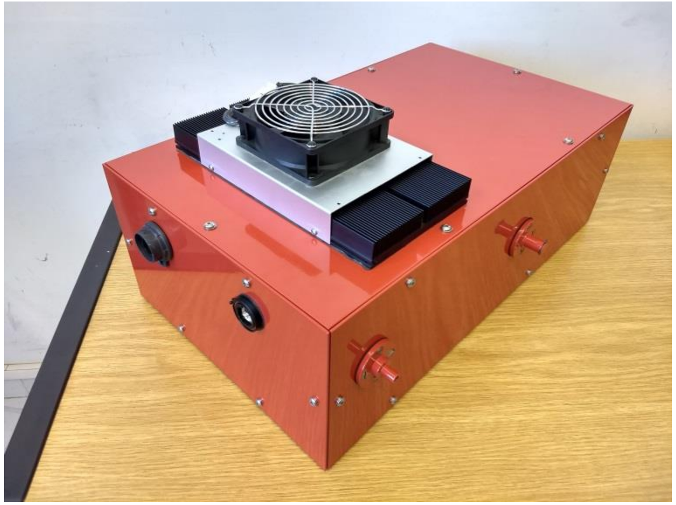
UVscope: a short history

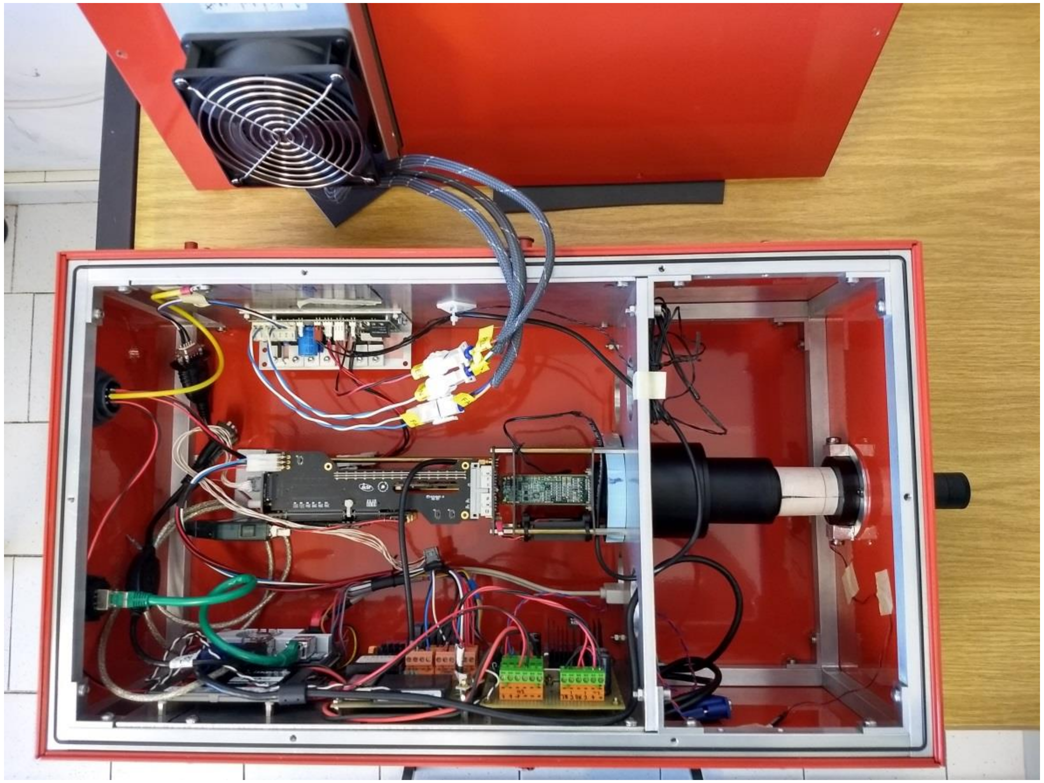
The last version of UVscope is a recent story.. aboard the ASTRI telescope !!!

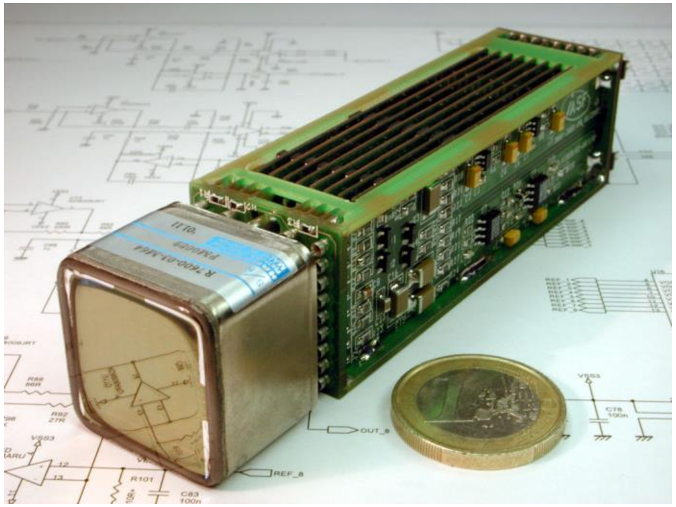
now it is a real stand-alone instrument, the only connection we need are: a 24V power and a LAN



- *It is equiped with SBC (no need of a dedicated PC)*
- *a Peltier system maintains the right temperature inside*
- *a shutter was added*
- *the weight raised to 20Kg.*

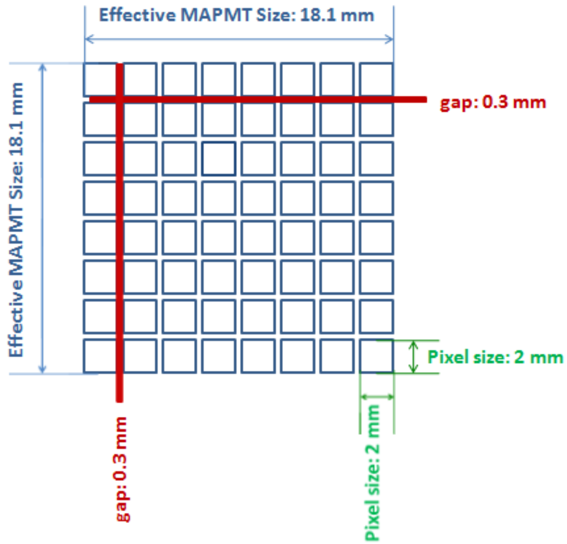


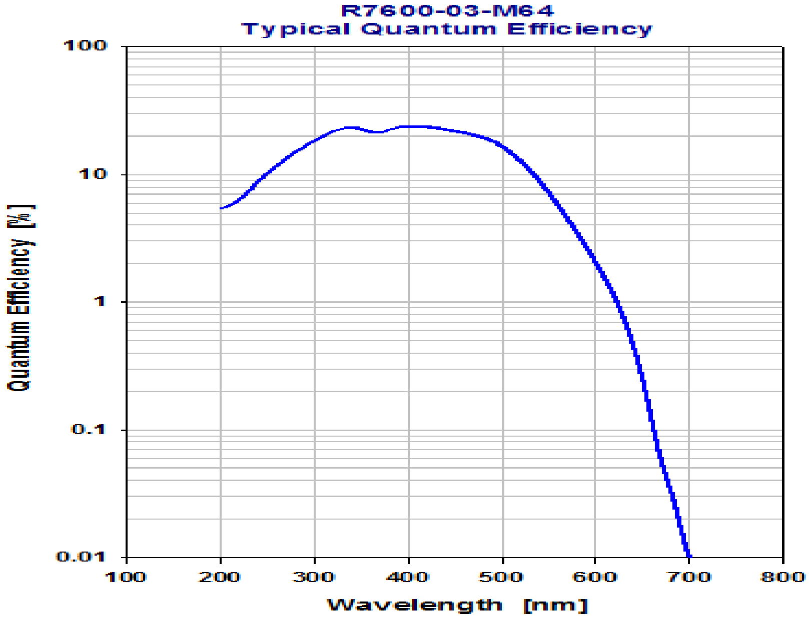




PMT features:

- *MA-PMT Hamamatsu R7600-03-M64 with 64 anode output arranged in a matrix of 8x8 pixels*
- *The PMT has a bialkali photocathode deposited on a UV-glass*
- *the typ QE is 20% @ 420 nm*
- *12 stages metal channel dynode structure*
- *Gain ~ 3×10E5 @800 V - pulse rise time ~1ns*
- *Cross talk between adjacent pixels: below 1%.*



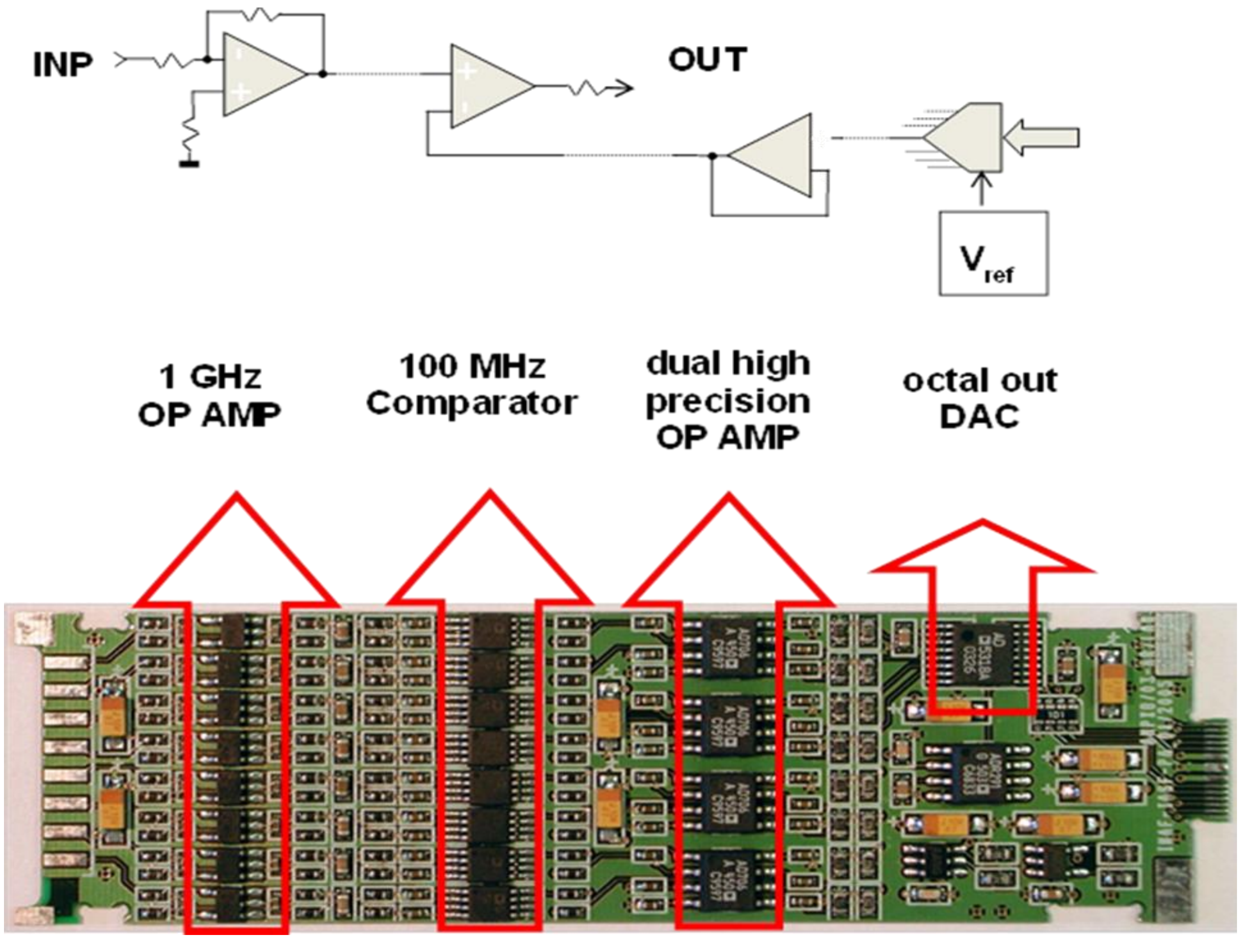


A little difference in efficiency is present among the inner pixels and those along the external perimeter. This is due to the photocathode extension, so that photoelectrons emitted at the border are focused to the outer pixels. Nevertheless, these values of the external frame can be corrected by using a gain uniformity map.

UVscope: instrument description - the FEE

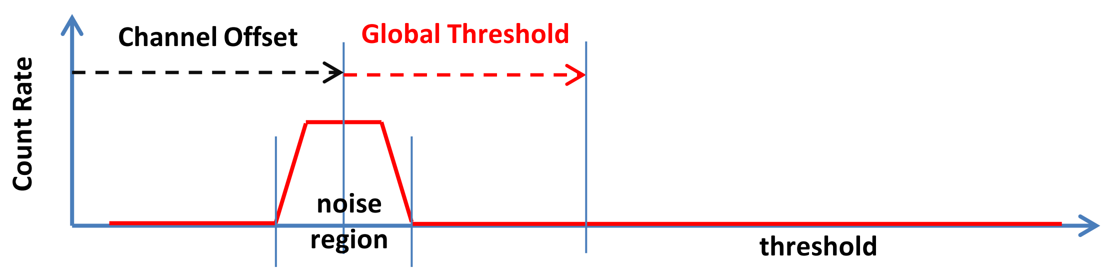
The FEE is allocated on 8 PCBs each one hosting 8 channel

- *64 Front End Channels (DC coupled)*
- *SPC mode (7ns double pulse resolution)*
- *64 discriminator channels (one for each channel) with thresholds individually programmable in step of 61 µV*
- *Low power active HV divider (5µA quiescent current)*
- *Programmable HV (up to 1KVolt 0.5 Volt step)*
- *Fast charge integrator for last dynode with fast ADC conversion (up to 200MS/s);*
- *Continuous monitor of the HV and the Last Dynode voltage*
- *Continuous monitor of internal temperature sensors*
- *5W power consumption*



Procedure for threshold equalization

- *Set HV = 0V*
- *Scan over thresholds (for all 64 channels)*
- *Maps the count rate mid points in a LUT*
- *Set the HV to the programmed value*
- *Set the Real Thr. = Ch.Offs. + Glob. Thr.*



UVscope: instrument description – the User I/F

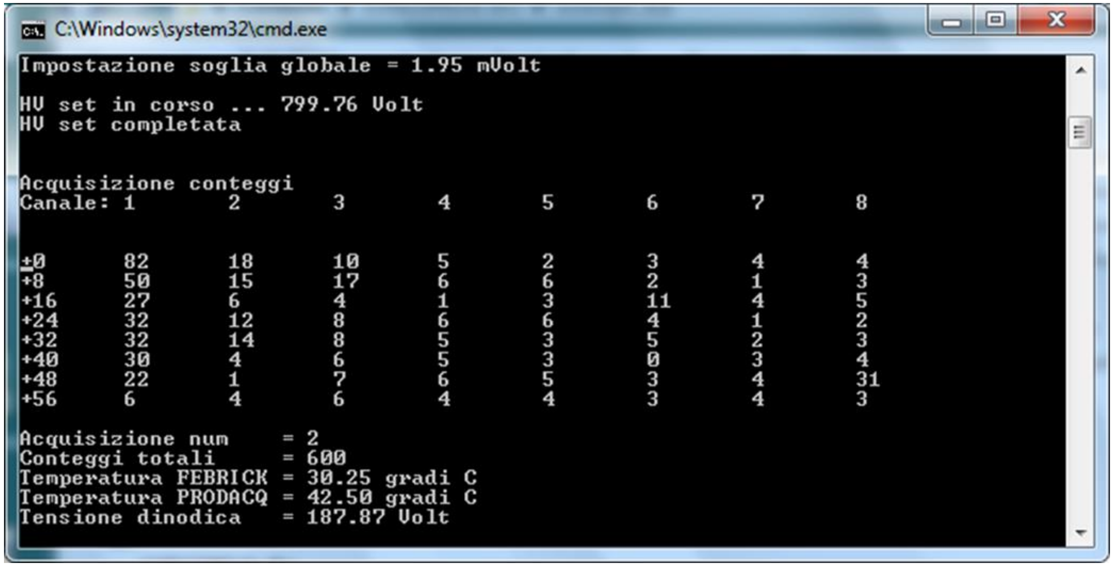
How UVscope communicates to the outside world :

UVscope has a peculiar I/F: the DELPHIN board (designed and realized at IASF-Pa) with these characteristics:

- *-it takes the data from the UVscope acquisition board*
- *-from the outside it is seen as a disk connected through a SCSI or USB interface*

in this way, any computer connected to UVscope simply takes the data from a file inside the DELPHIN board. No special s/w is required to do this job!

- *-to start an acquisition, you just open a DOS windows in your computer and run an exec file with a runstring that set all the parameters of the acquisition: HV, threshold, integration time, samples, etc..*
- *-as quick look, you can see all the 64 counts/time window , the sample number, temperature, etc..*
- *-to stop an acquisition, you just kill the process*



UVscope: instrument description – the GUI

There is also an easy way to interface UVscope: the Osvaldo GUI

PMT S.N.

acq. settings

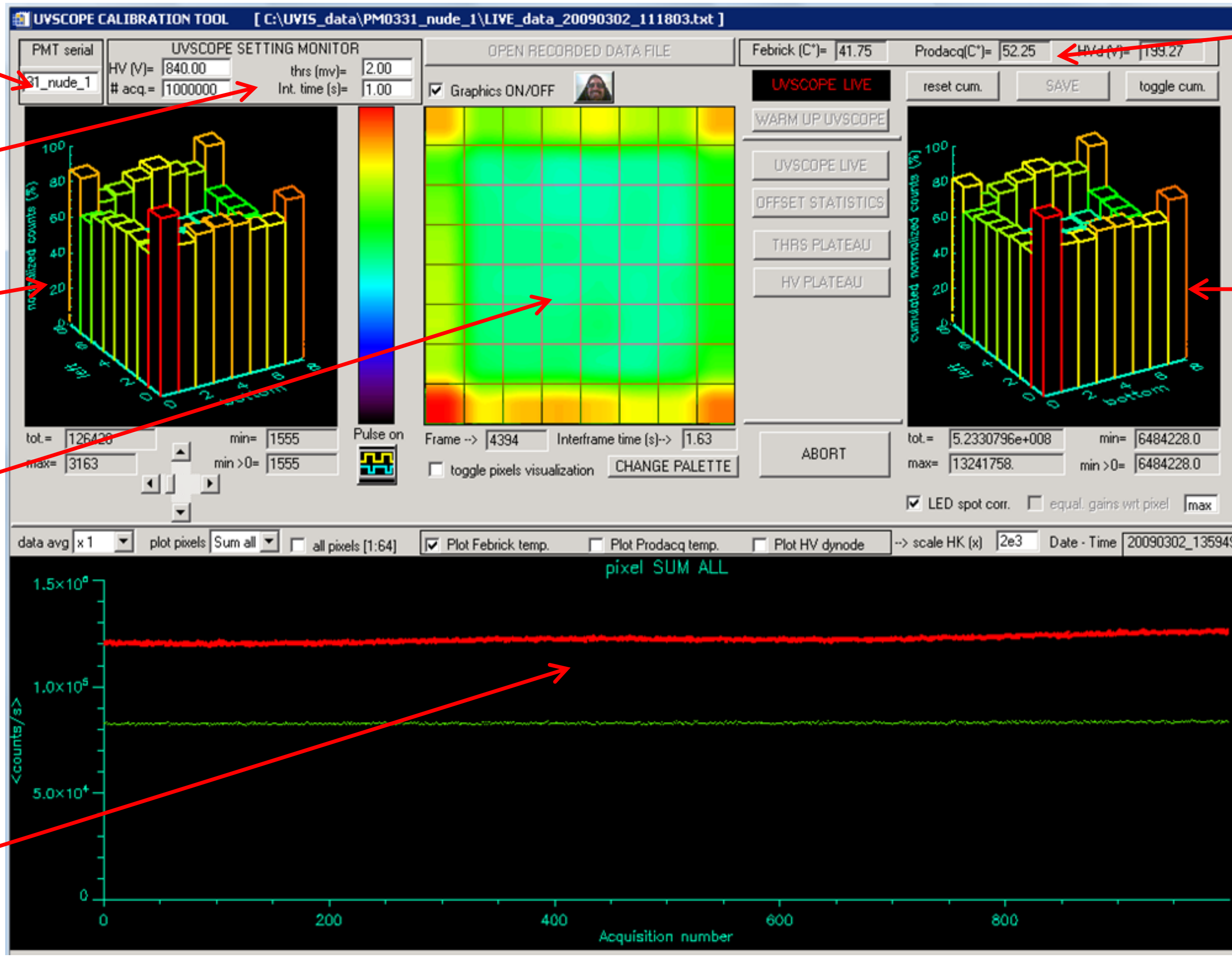
3D of last sample

2D of last sample

count rate vs. time

temperatures

3D of all samples

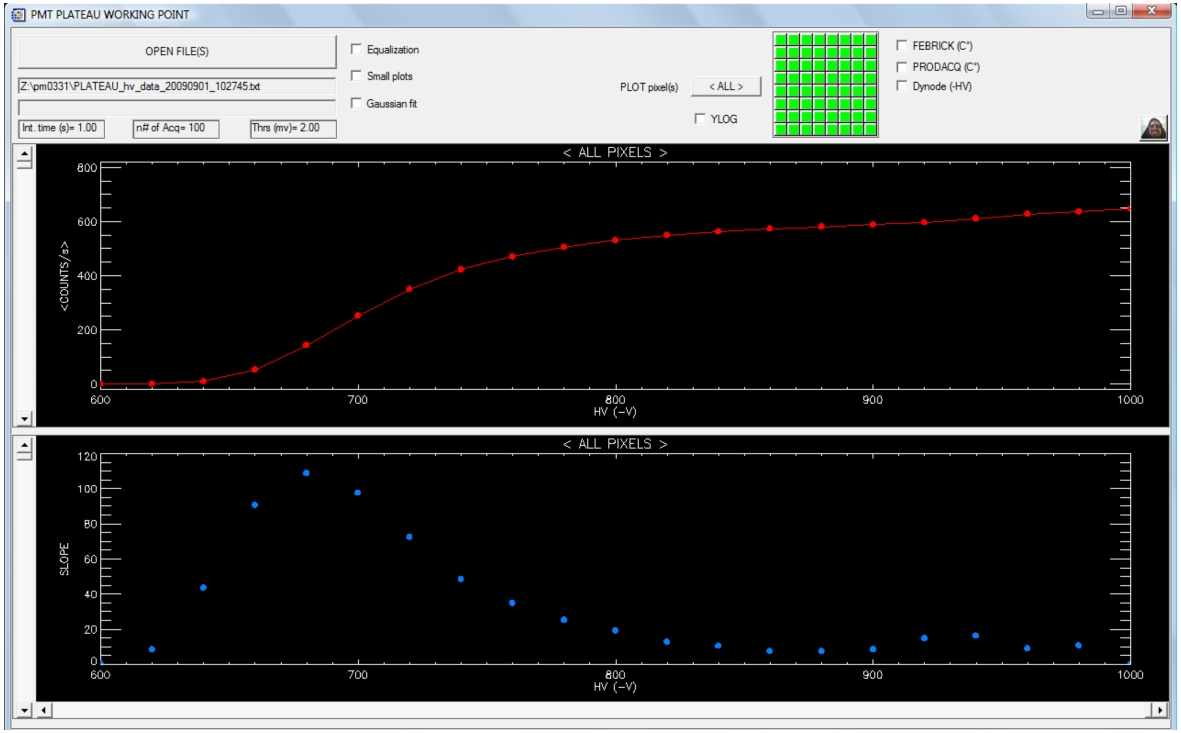


in the last UVscope revision, the computer is put inside the box; the only connection to the outside world is a LAN

First of all, we have to find the working point in order to allow UVscope to work in SPC. This is, to find the best pair of values (High Voltage, Threshold)

The curve of the count rate vs. high voltage has been obtained by varying the HV in steps of 20 V.

<u>On top</u>: The measurements curve show a plateau that indicate the best HV setting.
<u>In the bottom</u>: The lower curve is the derivative, it's used to put in evidence the plateau.
Here, the minimum of the curve identifies the best working point of the PMT, that is around -850V.



The plots have been produced without dark subtraction being the dark negligible (few ct/s per pixel)

How to find the best threshold

The curve of the count rate vs. threshold has been obtained by varying the threshold in steps of 0.61 mV. In these measurements, the HV has been set to -850 V.

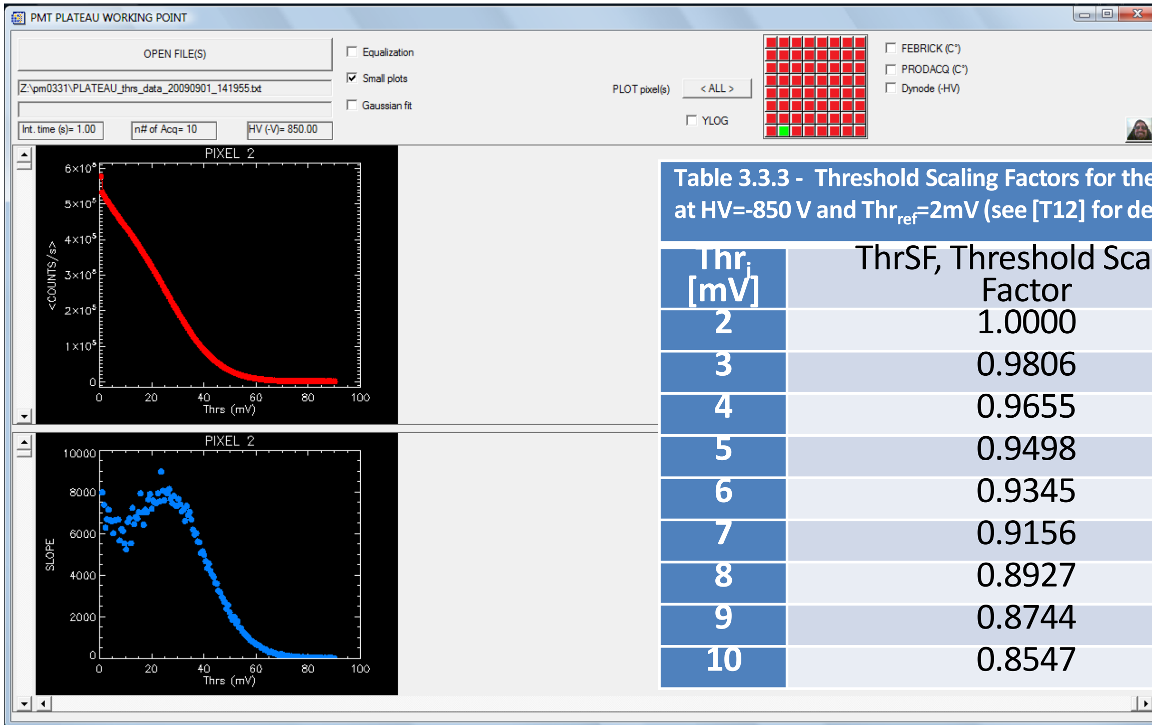
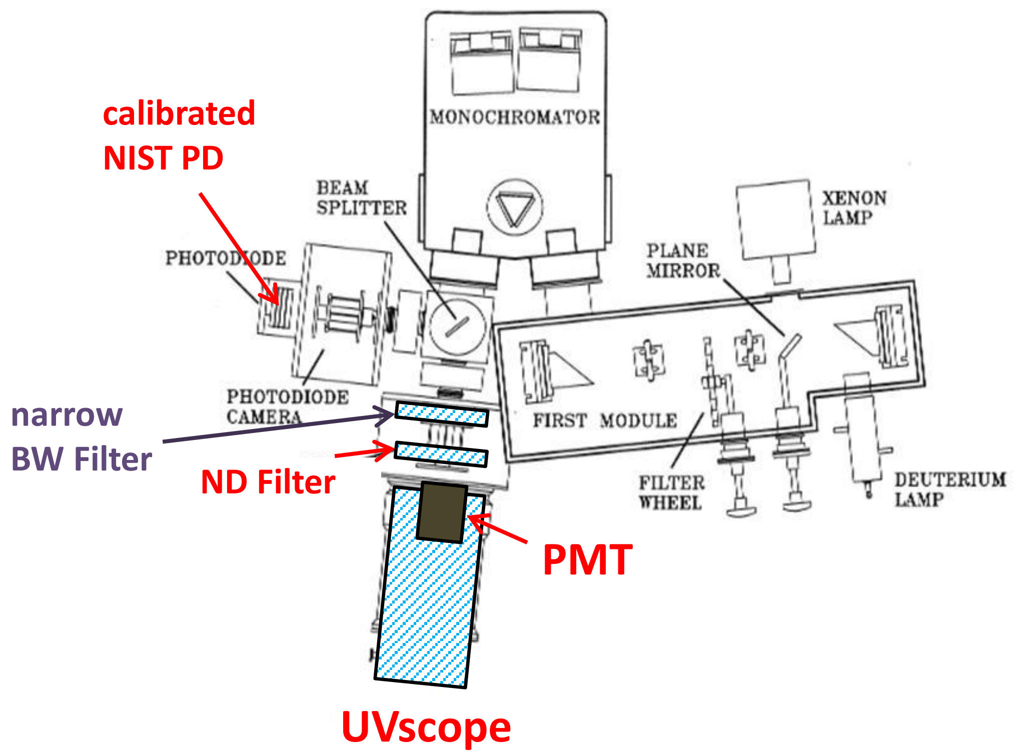


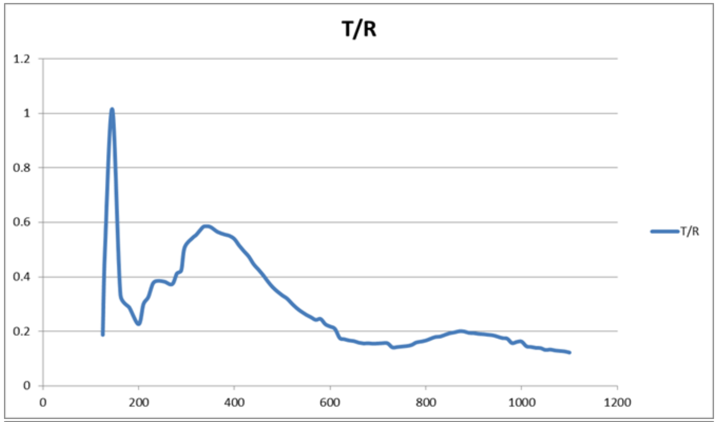
Table 3.3.3 - Threshold Scaling Factors for the PM0331 at HV=-850 V and Thr_{ref}=2mV (see [T12] for details).

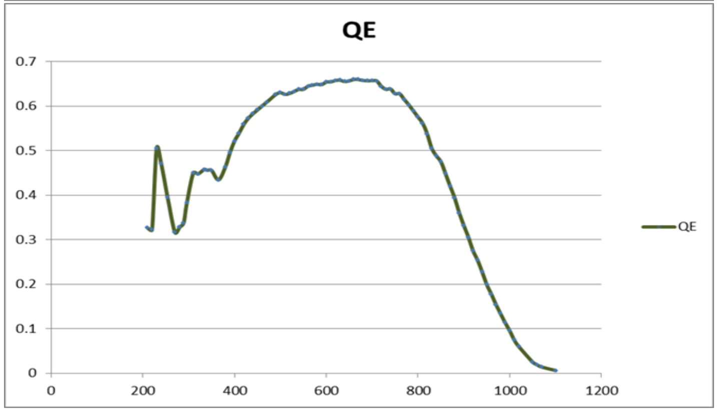
Thr_i [mV]	ThrSF, Threshold Scaling Factor
2	1.0000
3	0.9806
4	0.9655
5	0.9498
6	0.9345
7	0.9156
8	0.8927
9	0.8744
10	0.8547

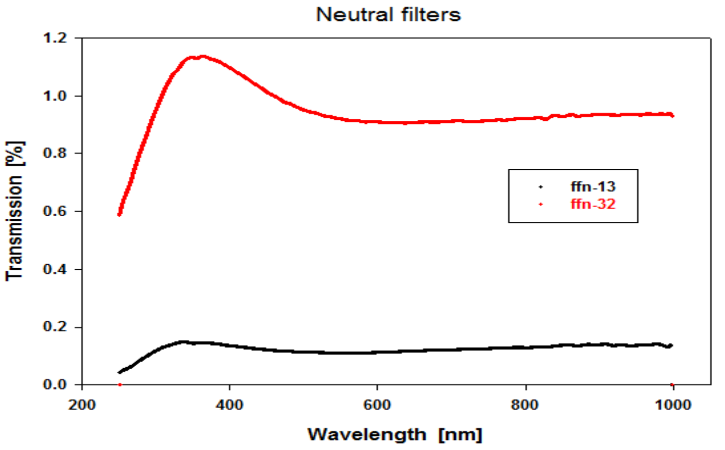
***On top*: The curve shows the count rate vs. threshold.**
***In the bottom*: the plot is obtained by differentiating the first one**
A valley is evident at around 6 mV, whereas the peak of the distribution is near 25 mV.
The value at the valley (6 mV) corresponds to ~ 1/4 of pe.

UVscope: Absolute Calibration @ COLD-Catania









The Test Facility COLD - Catania

It has been conceived for calibration and characterization of light sensors.

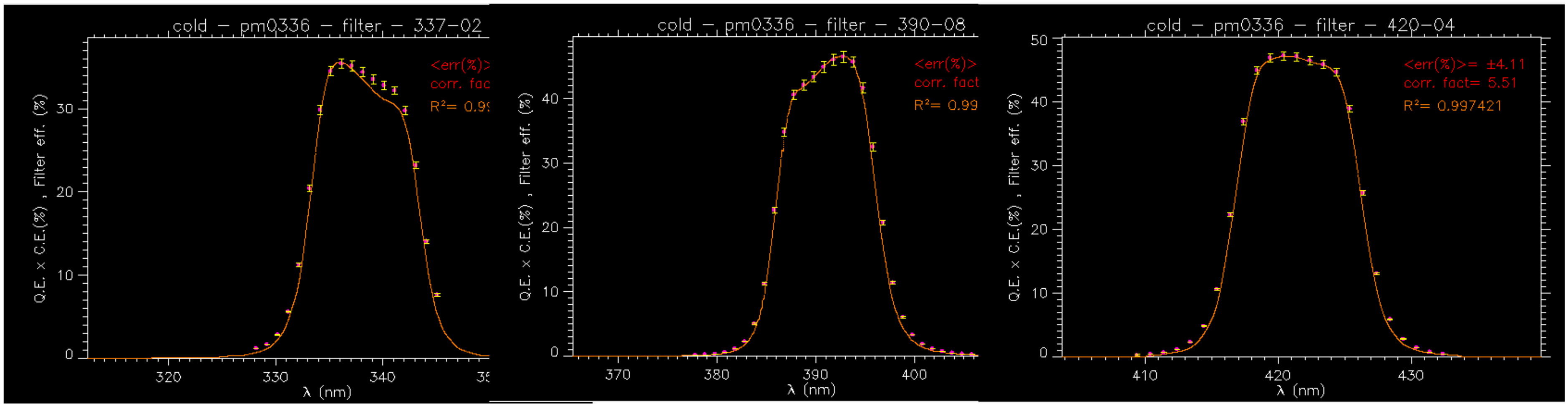
- *-130-1100 nm spectral range*
- *-Xenon Lamp or Deuterium Lamp*
- *-Prism Monochromator with double slit*
- *-Beam Splitter*
- *-reference PD (NIST calibrated)*

UVscope: the monochromator alignment

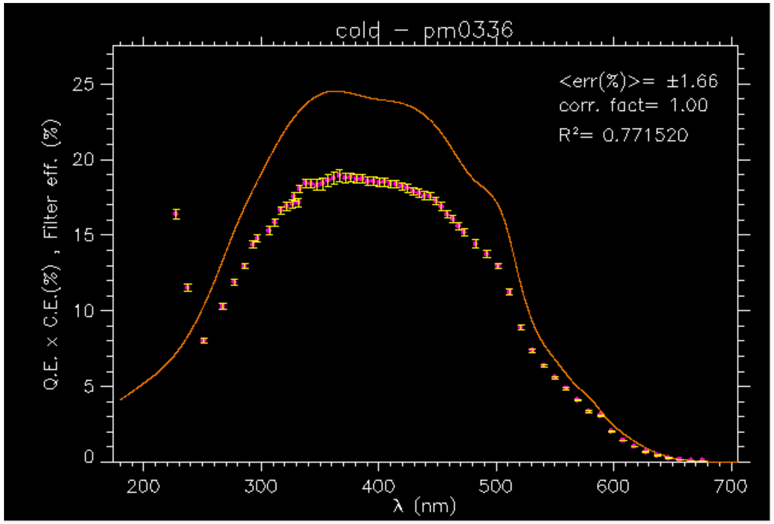
Monochromator alignment procedure

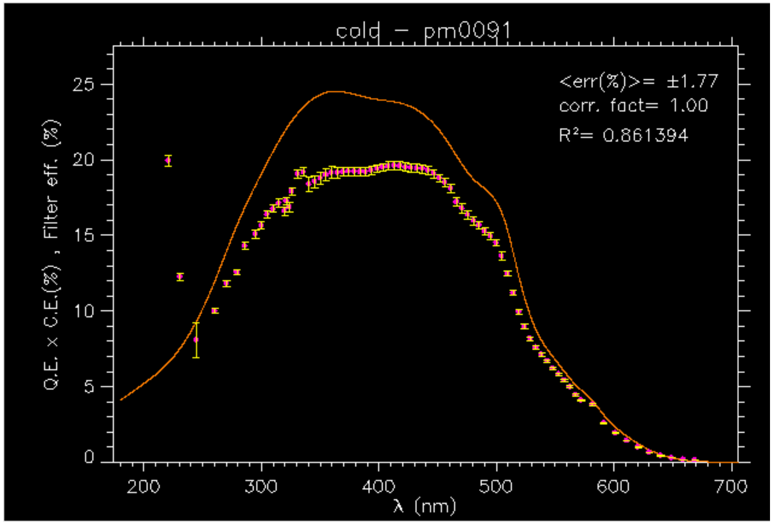
First of all, we measured the efficiency curve of some narrow bandwidth filter to be sure of the correct alignment of the monochromator
In our case we used interferencial filters from Andover Co. with center wavelenght 337nm, 390nm, 420nm (10nm FWHM)

we found a discrepancy of 5 nm between the value provided by the control SW of the monochromator and the edges of the efficiency curves
a new LUT in the SW corrected the difference, obtaining the curves below.



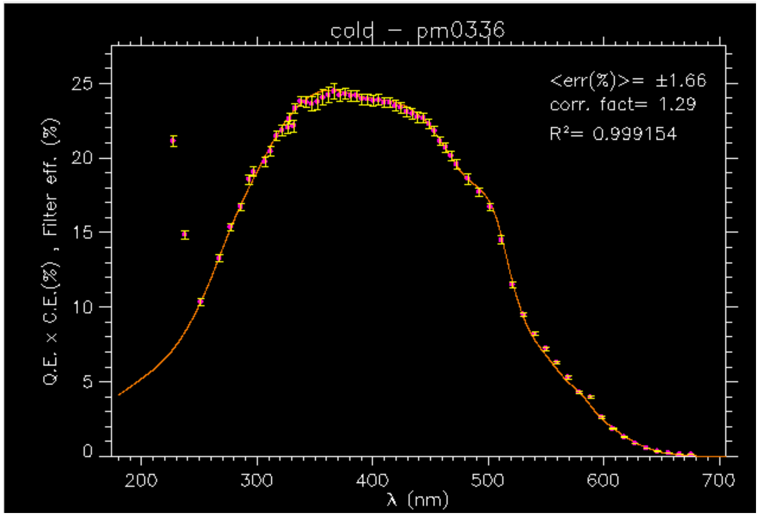
UVscope: the absolute calibration curve!

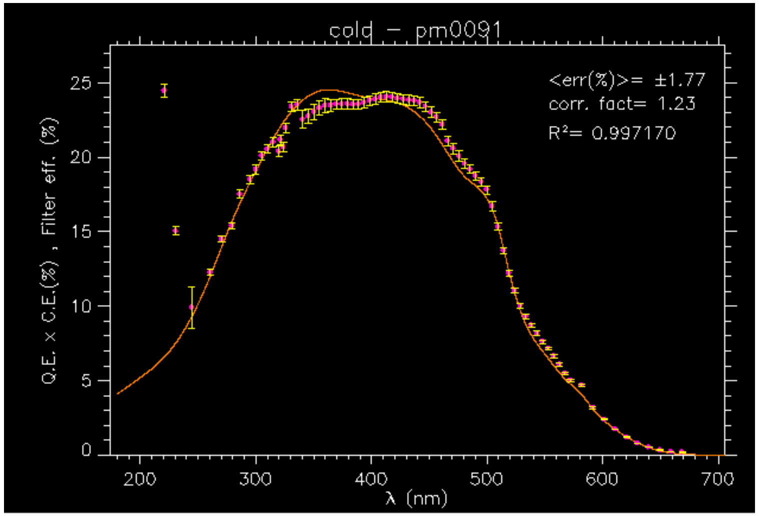




Final plots of the absolute calibration vs. wavelenght for 2 different PMTs

The plots on top show the points as obtained in lab wrt the QE provided by Hamamatsu. The difference is about 20-30% . This is due to to the fact that Hamamatsu doesn't take into account the collection efficiency as well as the trigger efficiency

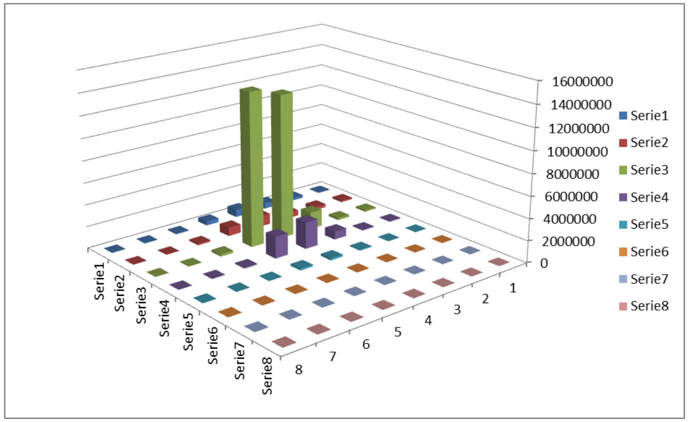




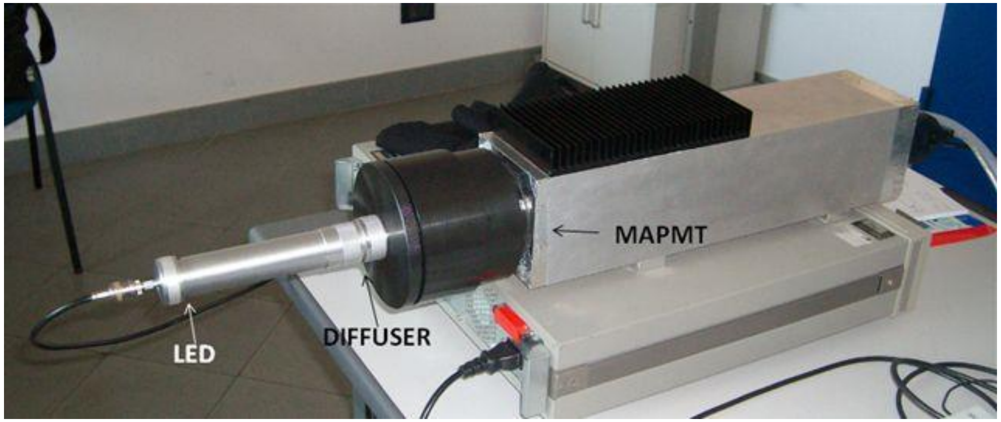
UVscope: relative calibration

Now there is one more step to do: a relative calibration

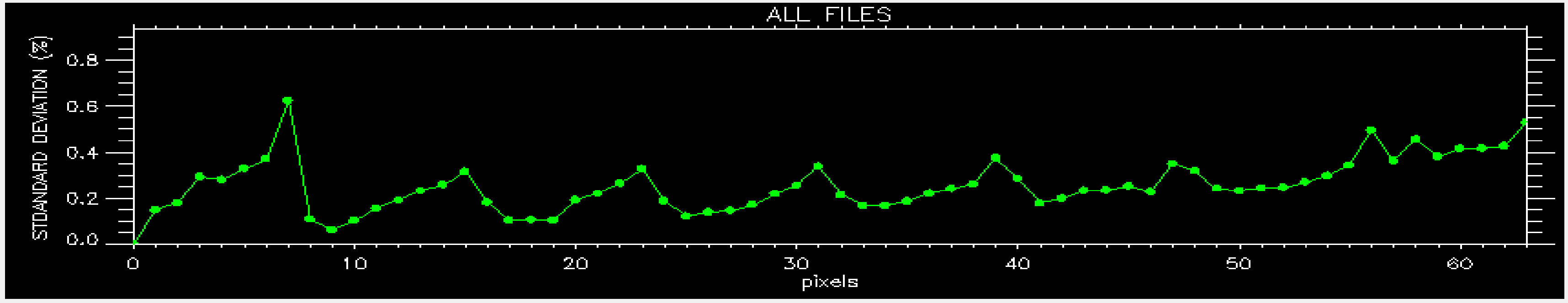
To be sure that all the light is collected by the PMT the photons are focused so that only few pixels are hit



To perform the relative pixels gain measurement it is needed a light uniformly distributed hitting the PMT photocathode.

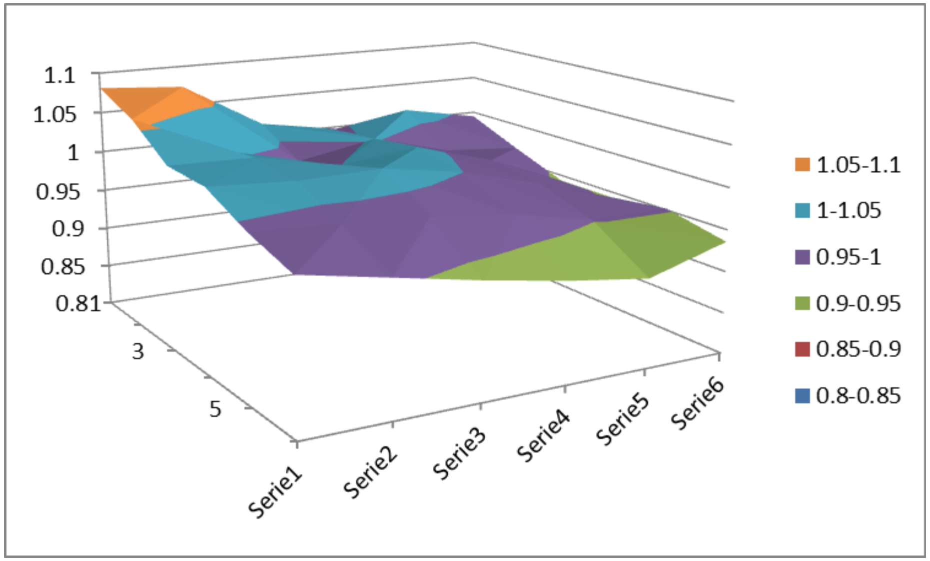


To verify that the uniformity of the light reaching the MAPMT does not depends by the geometry, a series of acquisitions have been done, rotating by 45° the tube containing the diffuser. The analysis of the data shows that for circular symmetry, no-uniformity is within less than 1% as shown in the figure below (-850 V ,2mV).

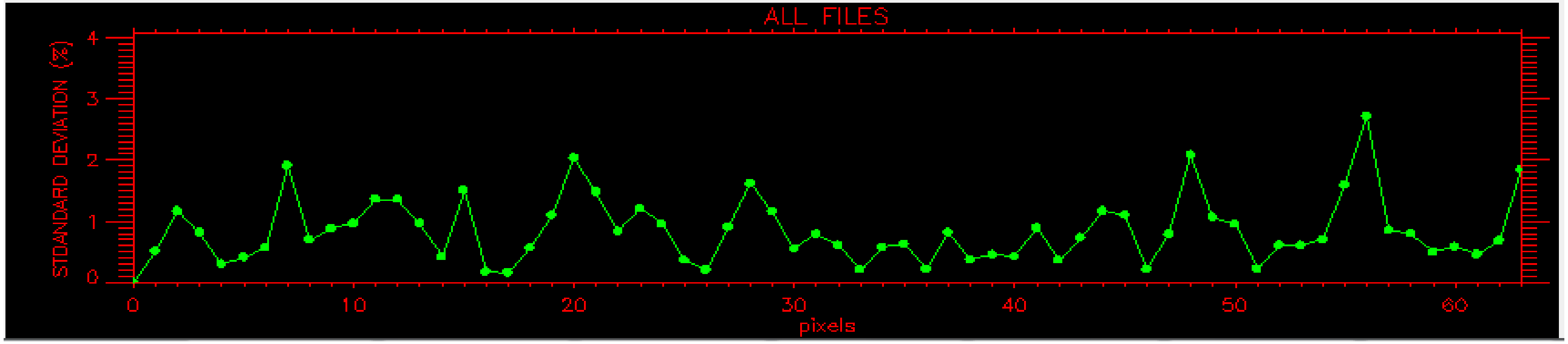


UVscope: relative calibration

The results of the relative calibration of the pixels show that most of the pixels have a gain that is contained inside a +/- 5%

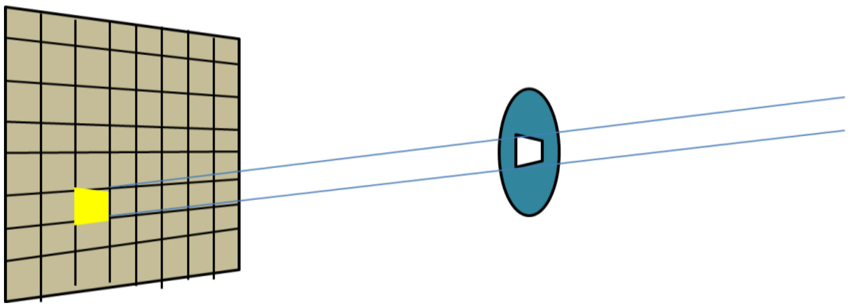


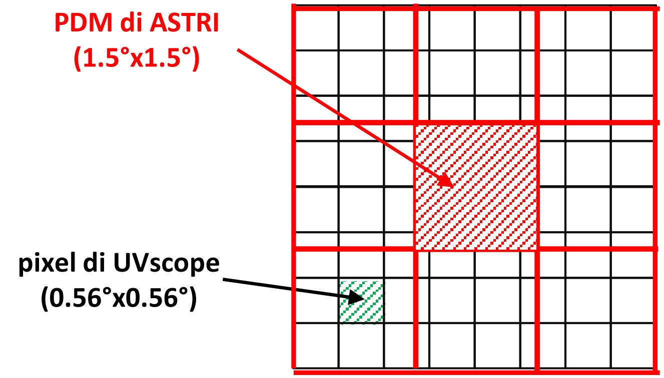
To evaluate the goodness of our measurement, the data taken in lab has been compared with a previous measurement carried out at Los Leones for a portion of almost-dark sky (stars of magnitude > 8)
The results show that the Lab measurements of the relative pixels gain are reliable within 3%.



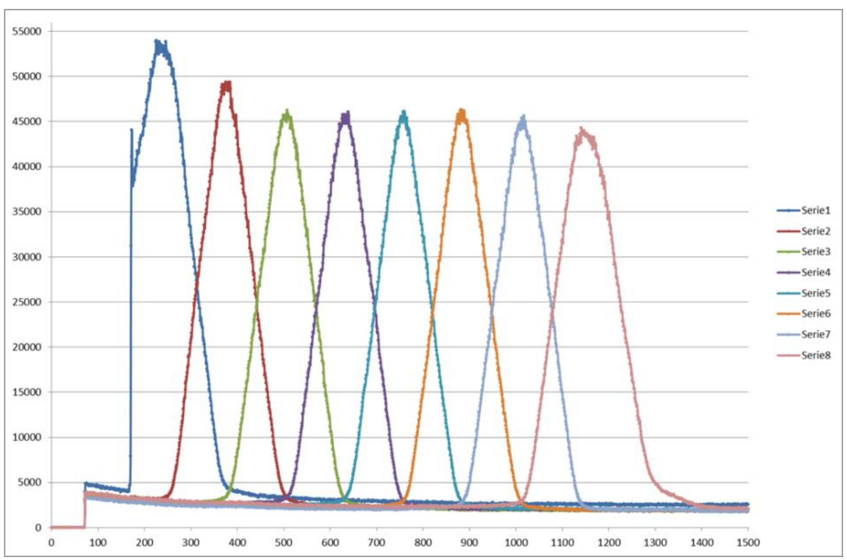
Status of UVscope

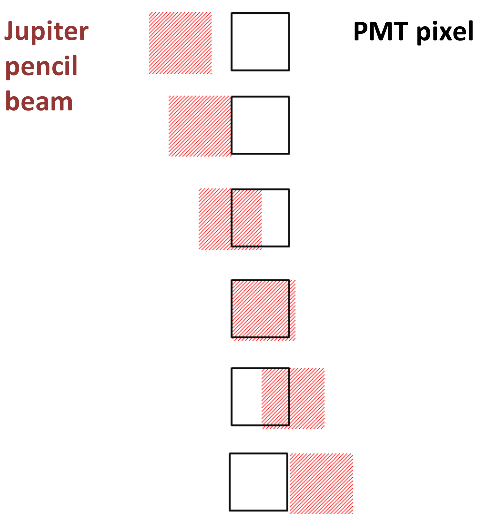
The first prototype of UVscope was installed on the ASTRI telescope structure at Serra La Nave observatory (mount Etna)

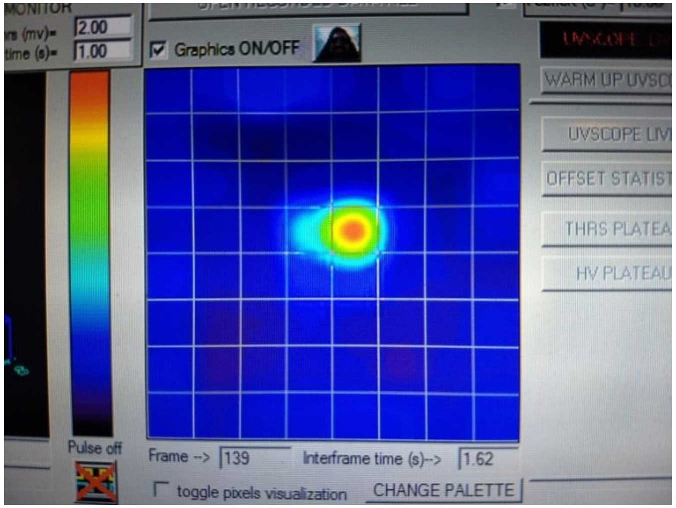




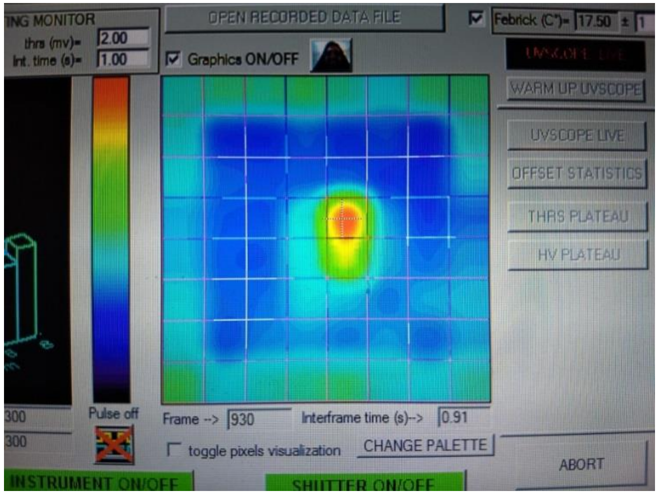
Some preliminary measurements were carried out in stand alone and in pair with a the ASTRI star tracker. First of all it was observed the passage of Jupiter.



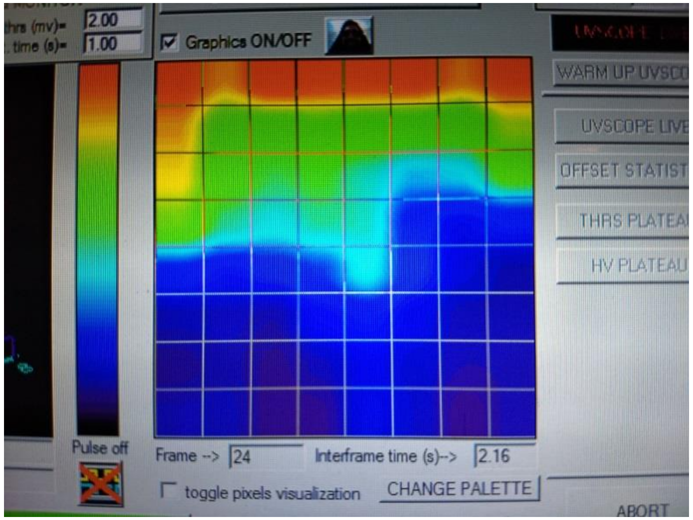




Deneb



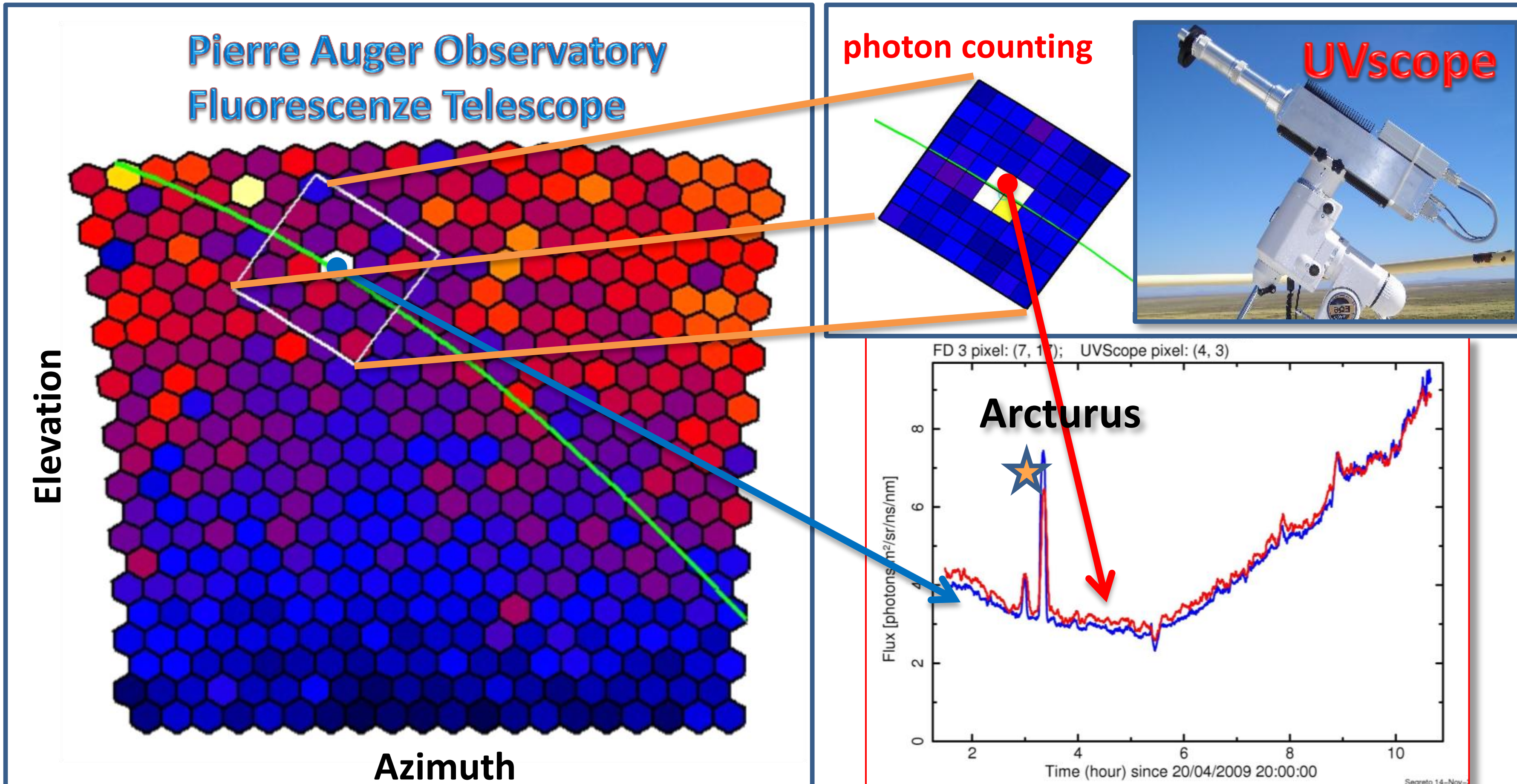
a 2.6 mag star



trees, volcano and sky..

Other measurement are expected as soon as the ASTRI camera will be again on site (mid Oct.)

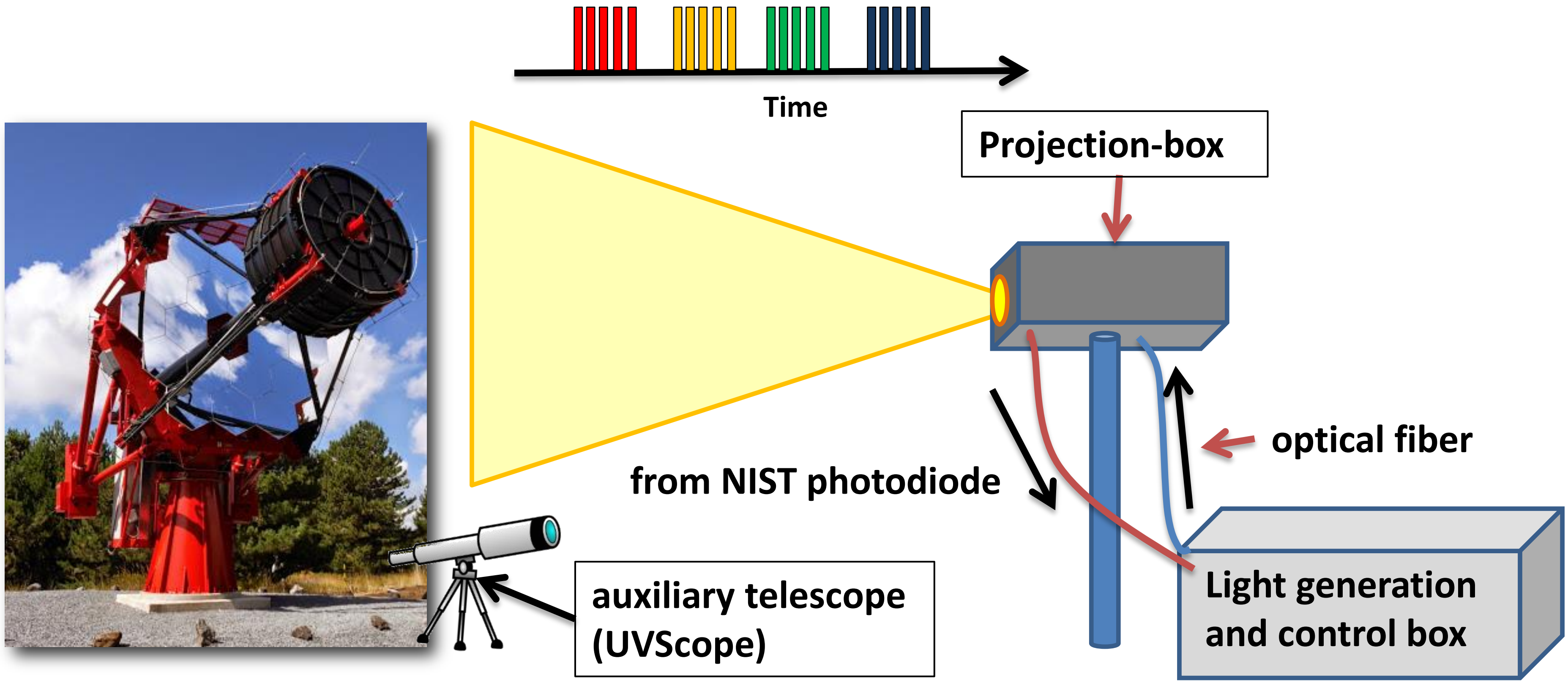
can UVscope be used inside CTA Observatory?



Measurements of the NSB flux obtained by the Fluorescence Telescope of the Pierre Auger Observatory and UVscope.
(Ref.: A. Segreto, for the Pierre Auger collaboration, Proc. ICRC 2011, Beijng)

can UVscope be used inside CTA Observatory?

A. Segreto/G. La Rosa CTA Calibration Meeting Barcelona, 26-28 October 2015



- Light is generated inside the control box and delivered to the projection box through an optical fiber
- A NIST calibrated photodiode inside the projection box is used to monitor the ouput light flux
- A calibrated auxiliary telescope (UVscope) placed near the telescope aperture, allows to completely eliminate the uncertainty due to the atmospheric transmission

thanks!