Calibration box for the camera of Large Size Telescope

Cherenkov Telescope Array

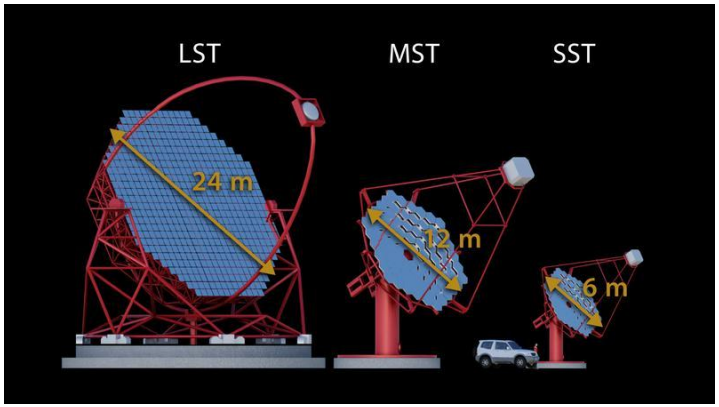
CTA is a future ground-based observatory (with two locations, in the northern and southern hemisphere) for the study of the very high energy gamma ray universe.

CTA Telescopes

Large Size Telescope (LST, 24m diameter)
Medium Size Telescope (MST, 12m diameter)
Small Size Telescope (SST, 6m diameter)

India CTA collaboration group

(TIFR, SINP, BARC, IIA)
Proposed for design and development of calibration box (nanosecond light flasher) for LST telescope.



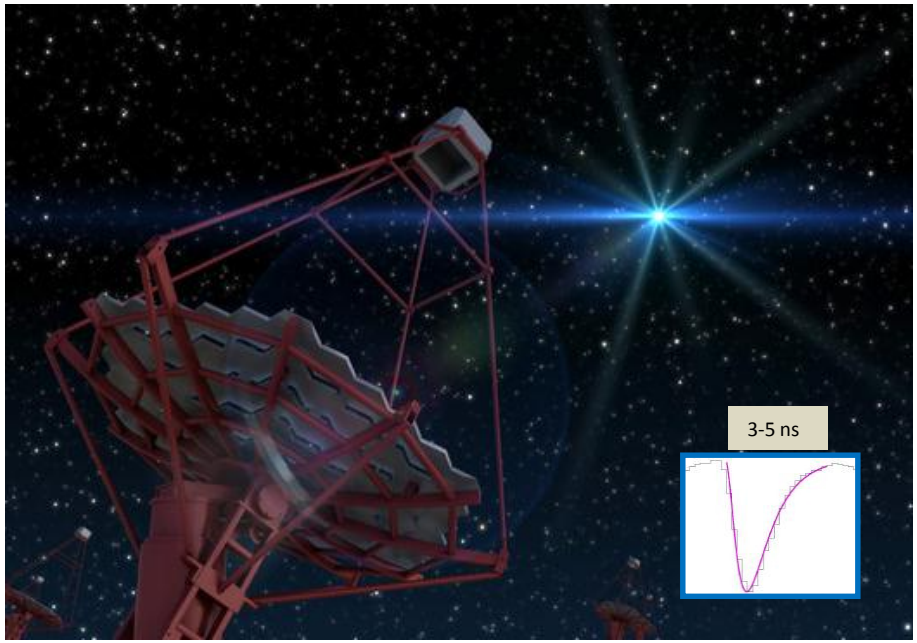
https://www.**cta**-observatory.org/

Large Size Telescope

Cherenkov light from air showers initiated by incident gamma rays is collected by large size (24 m) reflector and direct it onto the 'camera' comprising of many photomultiplier tubes and read out by flash ADCs.

Precise and regular calibration of PMTs with respect to standard light flux is necessary.

Camera calibration system



https://www.**cta**-observatory.org/

What we can do with the system

(a) Calibrate the pixel chain (ADC to phe) and linearity

Conversion factor : FADC counts (charge) to the number of photo-electrons.

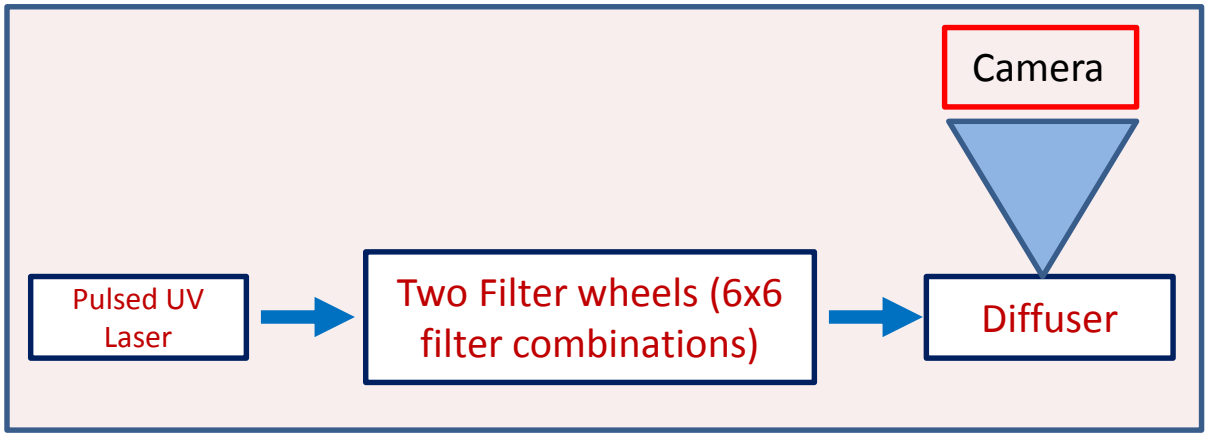
(b) To determine and monitor PMT gains

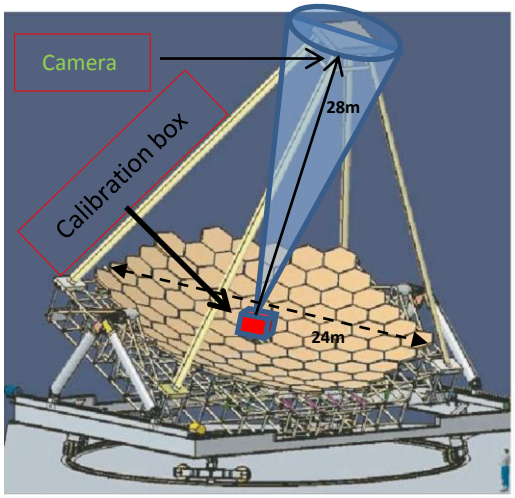
The high voltages of the individual PMTs will be adjusted so that the average pulse size in each channel is the same for all channels.

(c) Time calibration

The photo-multipliers introduce a time delay. They are calibrated relative to each other to obtain a correct time information for the analysis.

Basic Principle of Calibration box





Basic Components of calibration box

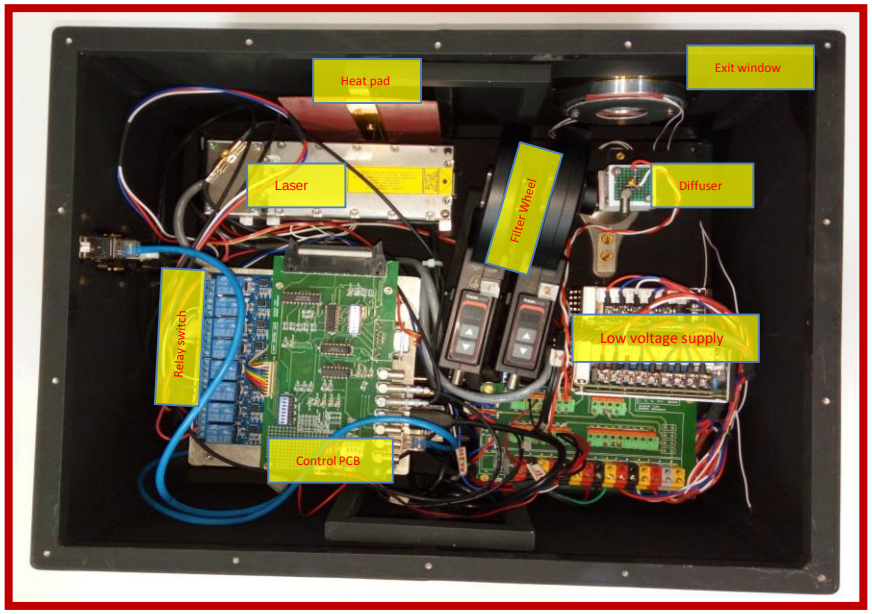
- Housing (water tight and light weight)
- Laser (350-400 nm)
- Two filter Wheels with different ND filter (OD=0 to 7)
- Light diffuser
- Control electronics

Salient features of calibration box

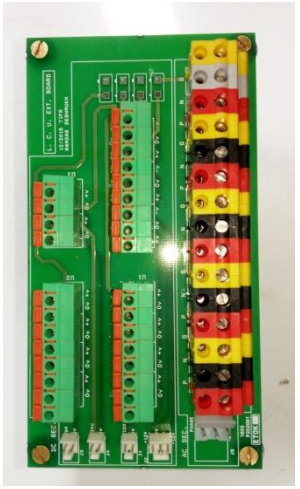
- Light intensity distribution better than 5%.
- Signal of 10-100 photoelectrons.
- Light stability better than 5%.
- Repetition rate (10Hz to 2KHz).
- Spectrum matching with Cherenkov
- Optical pulse shape (FWHM) 3-4 ns

Calibration Box

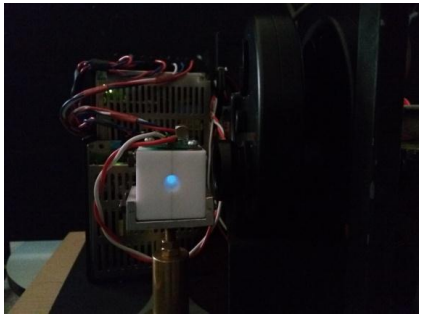
I/O



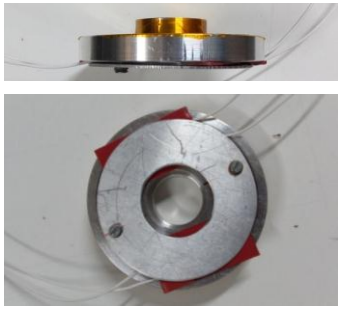
Dimension: 45 cm (L) x 35 cm (B) x 25 cm (H)



Power distribution board



Light Diffuser



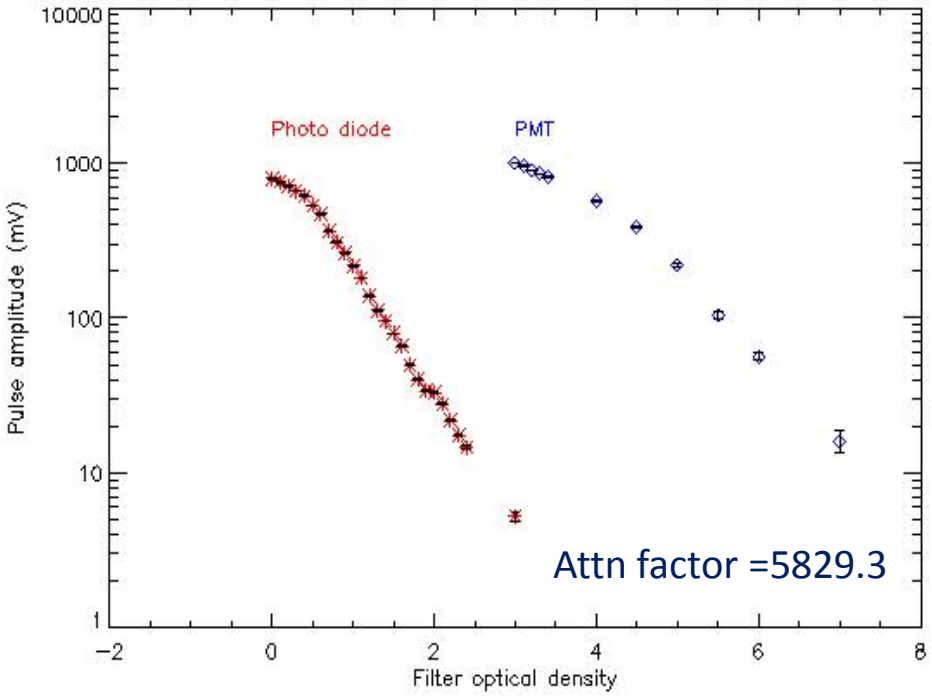
Exit window

Rasberry Pi microcontroller

Measurement and Results

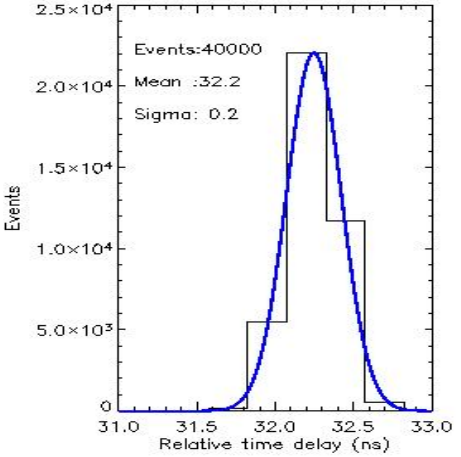
Filter wheel with ND filters

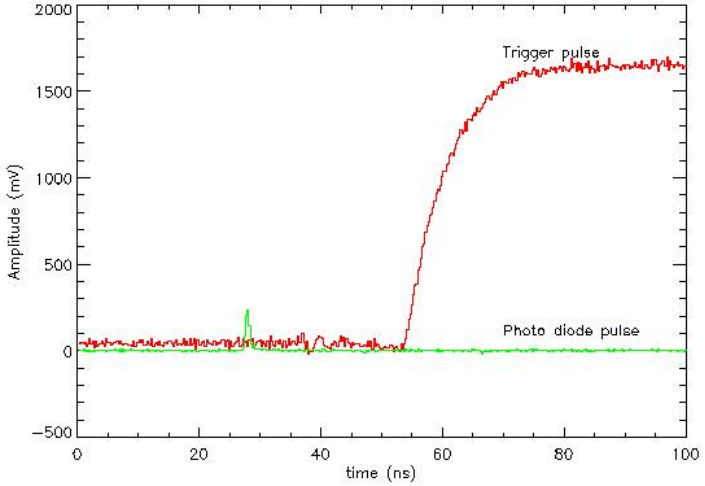
FW position	FW-1 OD	FW-2 OD
1	0.0	0.0
2	0.1	0.5
3	0.2	1.0
4	0.3	1.5
5	0.4	2.0
6	4.0	3.0



Response of laser light through ND filters

Distribution of drift delay

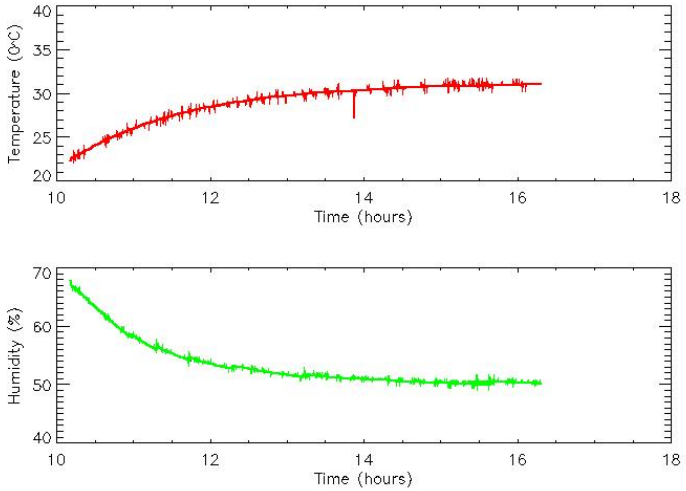




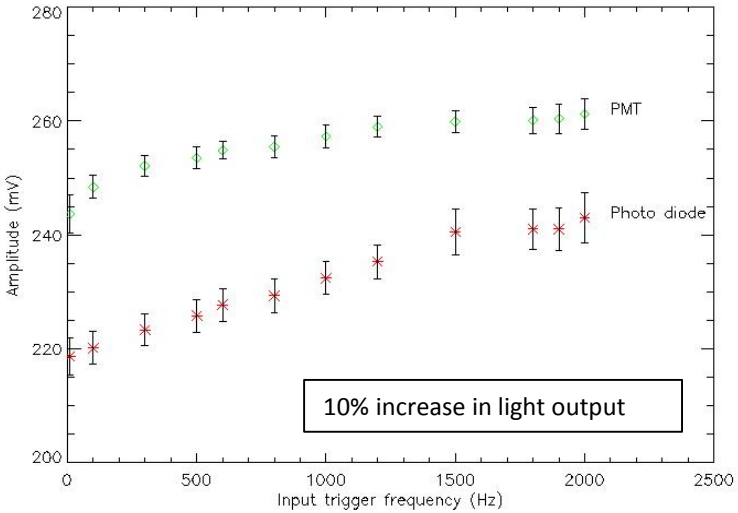
Trigger and photo diode pulse

Measurement and Results (cont.)

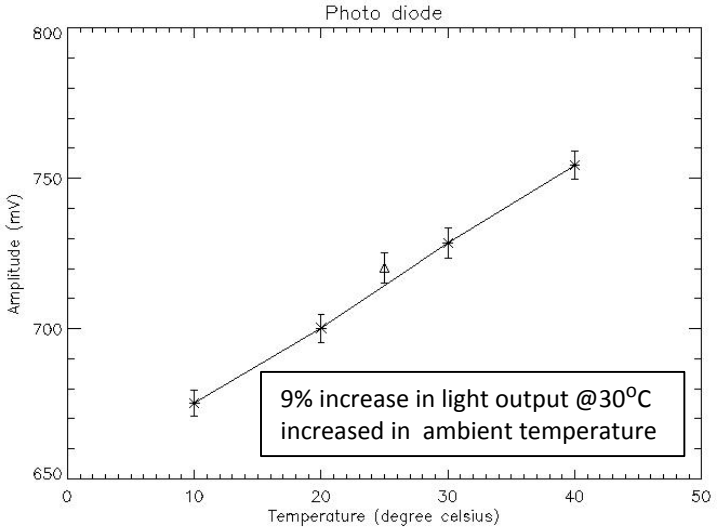
Temperature and humidity



Laser light output vs trigger rate

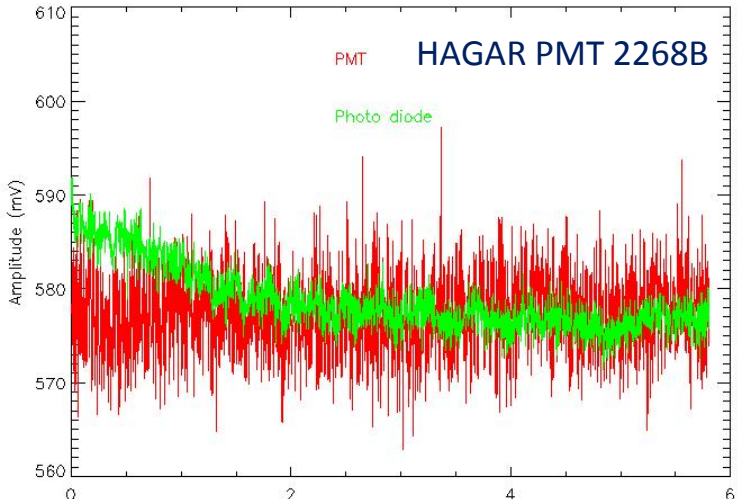


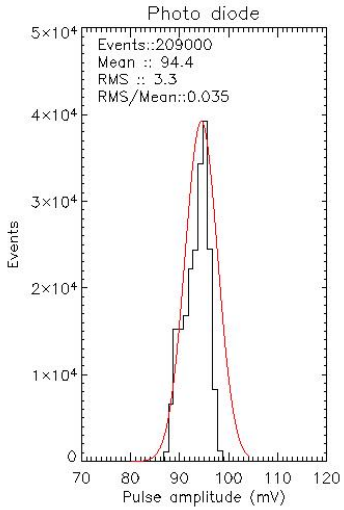
Laser light output vs temperature

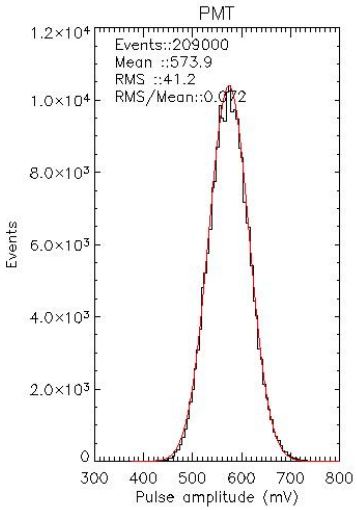


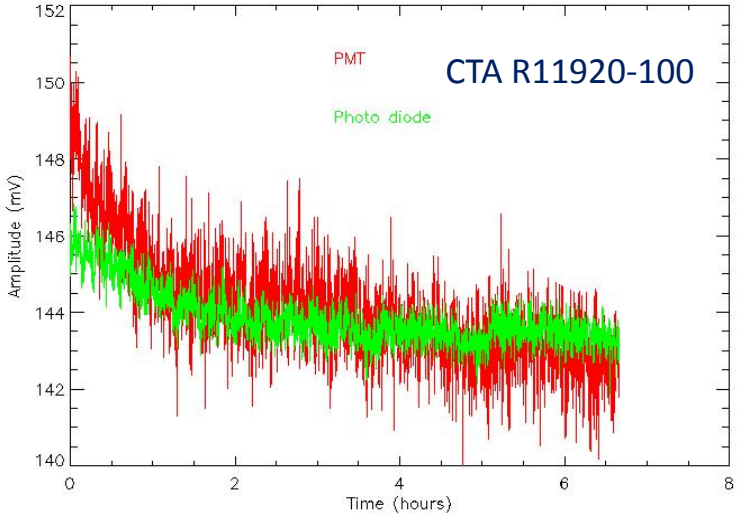
Measurement and Results (cont.)

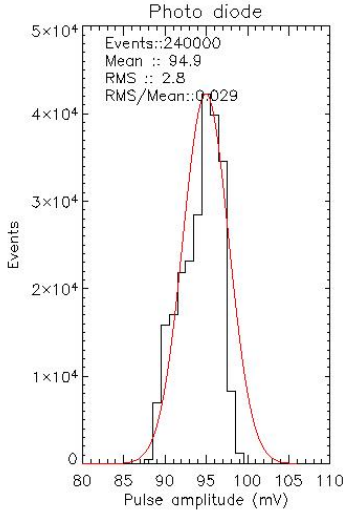
Stability of Laser light

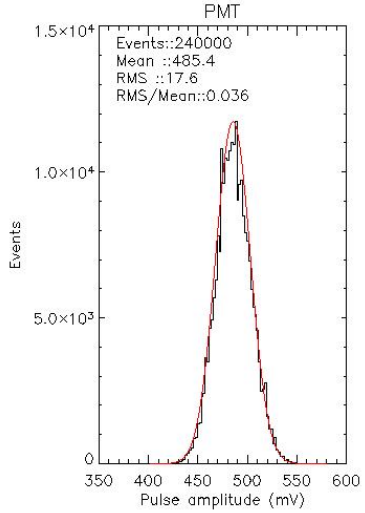








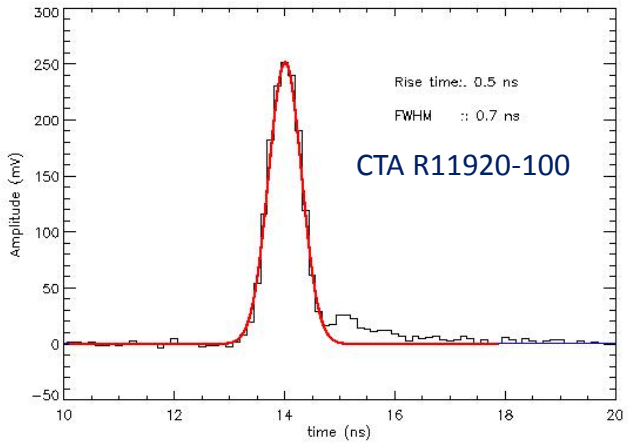


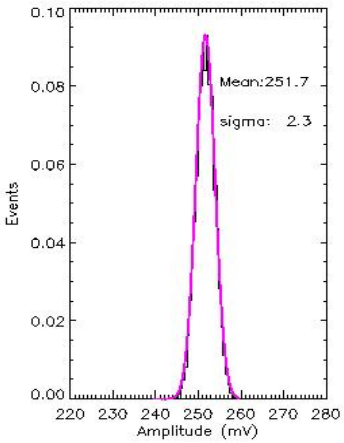


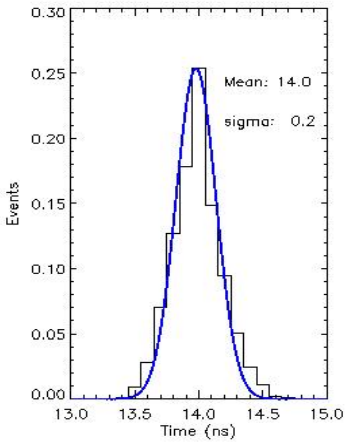
Measurement and Results (cont.)

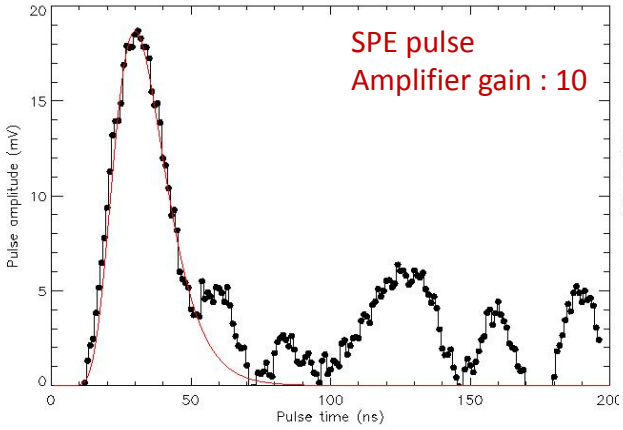
Estimation of Photo electrons/pixel

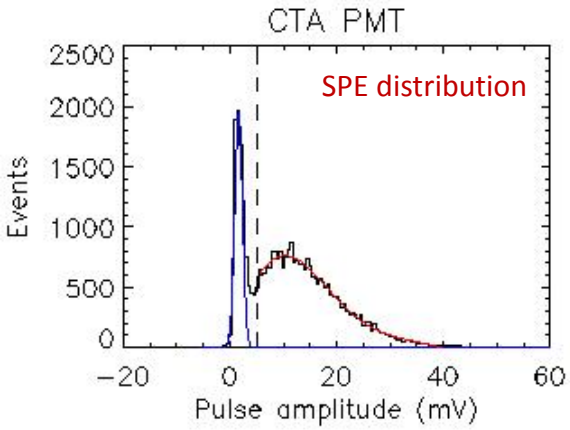
PMT at 60 cm distance with OD=7











SPE amplitude : 0.89 mV @ 1100V
Pulse amplitude at 60 cm distance: 43.7±5.2 mV @ OD=7
No of photo electrons at 60 cm distance : 49 @ OD=7
Attn factor =5829.3
Photo electrons without ND filter=285636.7
Photo electrons at 28m = 131 pe

Summary

- Drift between light output and trigger is less than 200 picoseconds.
- Light stability is better than 4% over 5 hours of operation.
- Maximum increase in temperature due to heat dissipation is $10^{o}C$ for 5 hours of operation.
- 10% change in laser light intensity for $30^{o}C$ increase in ambient temperature.
- Maximum p.e. at 28m distance : 131