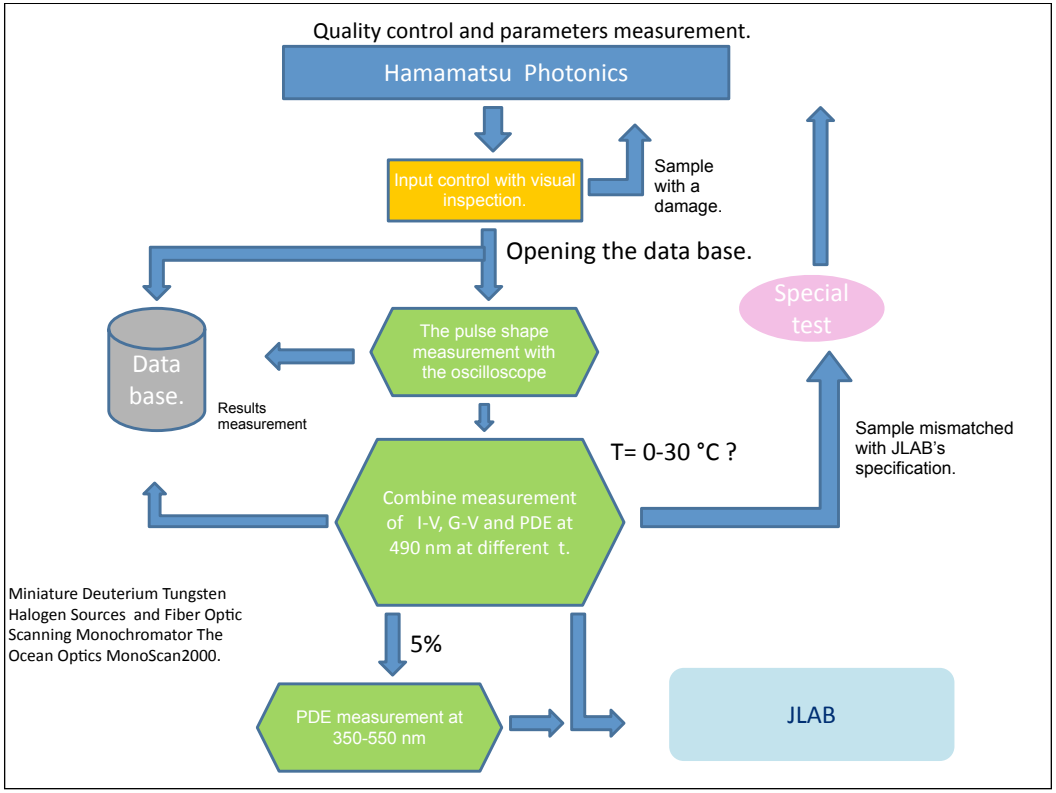
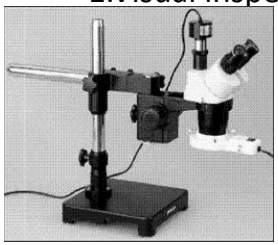
USM tests: the goals and methods of the tests, types and frequency of measurements.


Quality control and parameters measurement.
Hamamatsu Photonics
Input control with visual inspection.
Sample with a damage.
Opening the data base.
Special test
Data base.
The pulse shape measurement with the oscilloscope
Results measurement
T= 0-30 °C ?
Sample mismatched with JLAB's specification.
Combine measurement of I-V, G-V and PDE at 490 nm at different t.
Miniature Deuterium Tungsten Halogen Sources and Fiber Optic Scanning Monochromator The Ocean Optics MonoScan2000.
5%
PDE measurement at 350-550 nm
JLAB

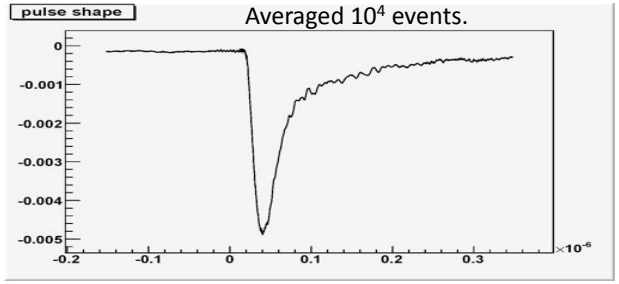
1.Visual inspection of each SIPM cell of the array.



The test will be done with:
20X-40X-80X TRINOCULAR STEREO MICROSCOPE BOOM + CAMERA, X-Y GLIDING TABLE - MANUAL STAGE FOR MICROSCOPES, FIBER OPTIC Y-SHAPE DUAL LIGHT MICROSCOPE ILLUMINATOR
The pictures will be store at the data base.

2. Pulse shape measurement with the digital oscilloscope (using a fast amplifier with low input impedance). The oscilloscope picture for each cell will be store at the data base. Fast LED (LED driver with a transistor in the avalanche mode) or laser (?). The light pulse should have rise time less then 1 nS (?).

The LeCroy WaveRunner Xi-A



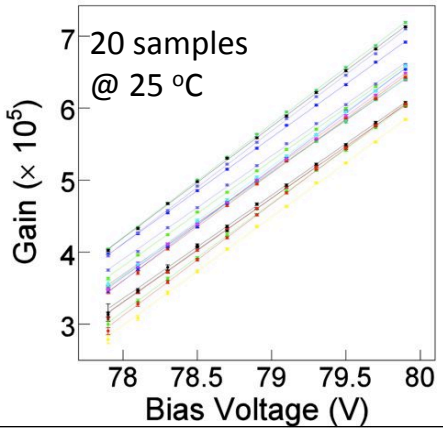
Combine measurement of I-V, G-V.

What should we measure? For MPPC characterization you need know just 2 parameters: breakdown voltage and dark current & breakdown voltage. So we need know the breakdown voltage for each cell of MPPC and dark current at working point (which will be selected after the test).

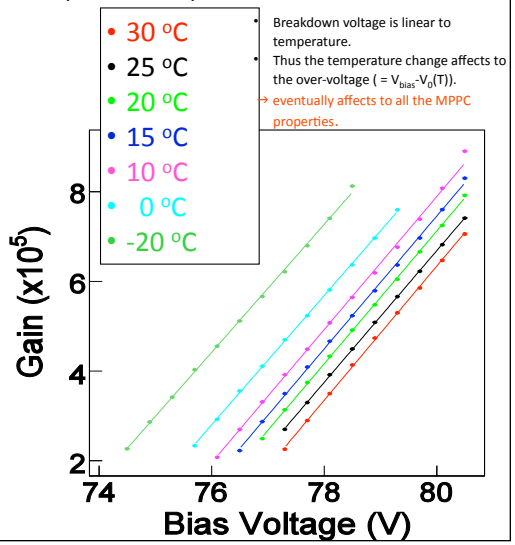
Variation of the Gain over 20 samples
MPPC (1x1 mm)

Gain = C (V_{bias}-V_0) / e

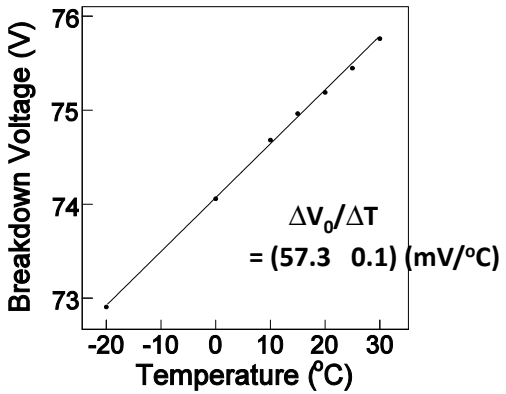
C : Pixel capacity V_0 : Breakdown voltage

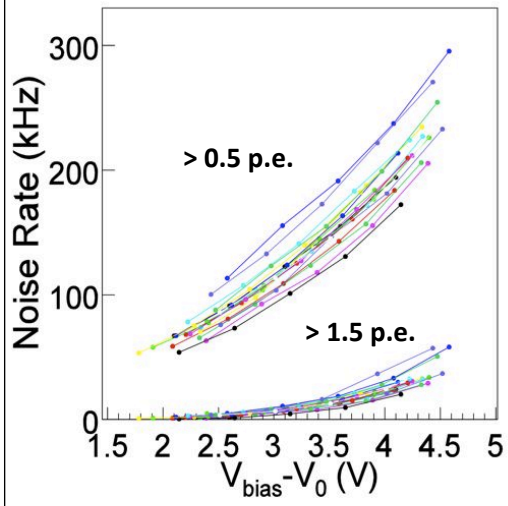


Temperature dependence of the Gain

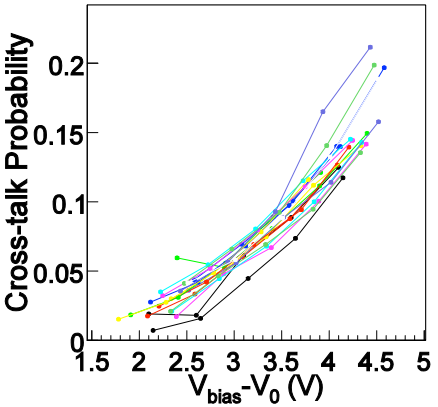


Breakdown voltage is linear to temperature.
Thus the temperature change affects to the over-voltage (= V_{bias}-V_0(T)).
→ eventually affects to all the MPPC properties.

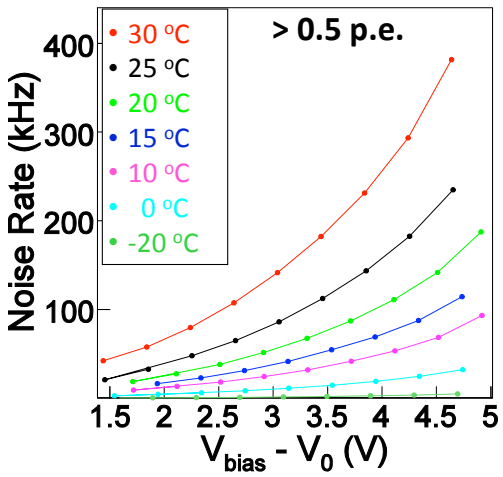

Breakdown Voltage (V)
76
75
74
73
-20
-10
0
10
20
30
Temperature (°C)
ΔV0/ΔT
= (57.3 0.1) (mV/°C)

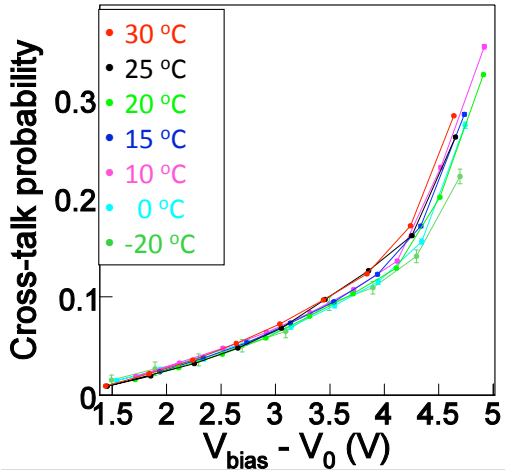


$$P_{crosstalk} = \frac{\text{Noise Rate}(>1.5\text{ p.e.})}{\text{Noise Rate}(>0.5\text{ p.e.})}$$



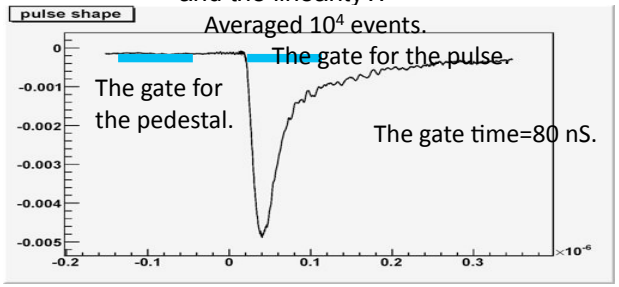
Temperature dependence of the Noise Rate / Cross-talk

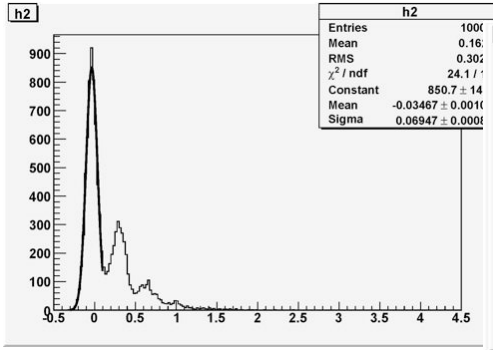


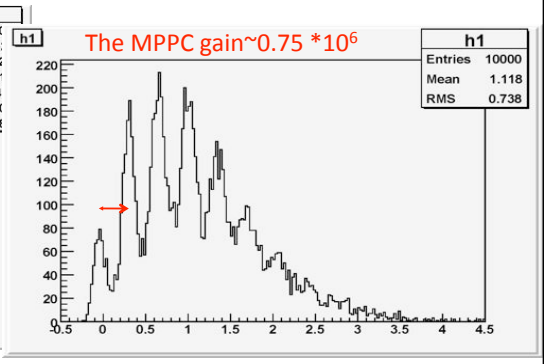


- Lower temperature → lower dark noise
- Cross-talk is not affected by temperature change.

The gain, PDE and dark pulses rate and the linearity?.

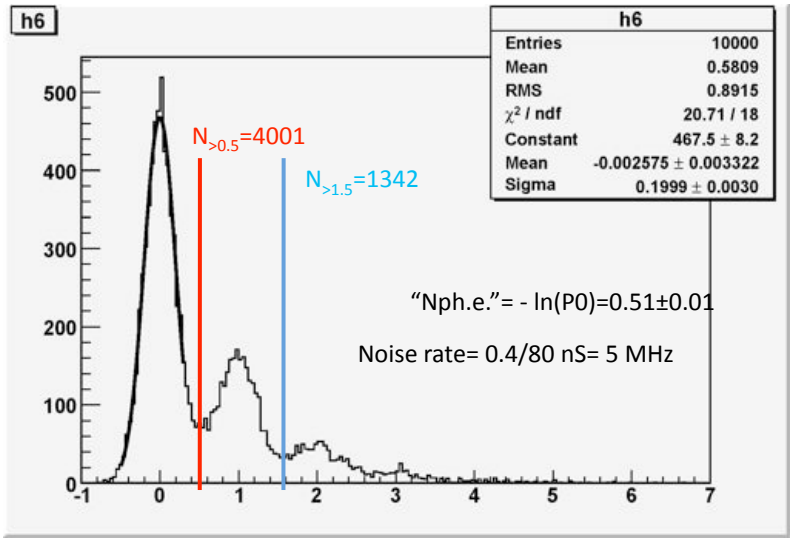




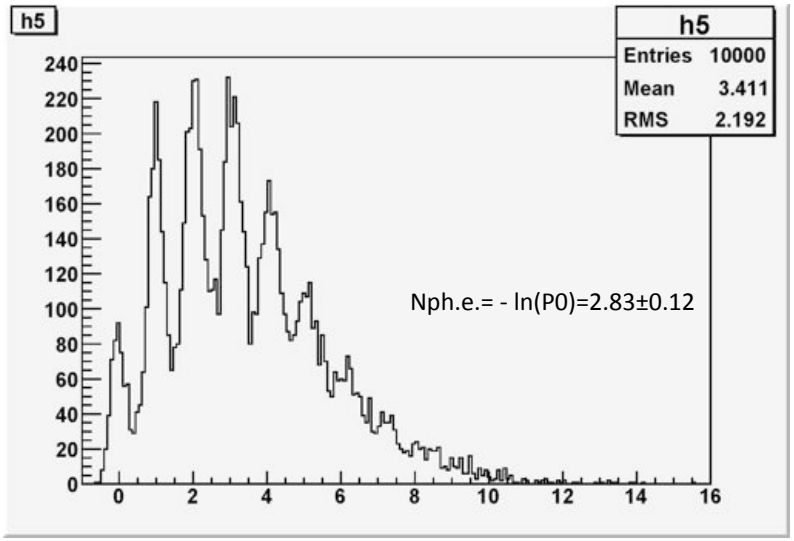


"Q"=Vinp*200

The pedestal in ph.e..



The response from LED in ph.e..



Combine measurement of I-V, G-V and PDE at 490 nm at different T.

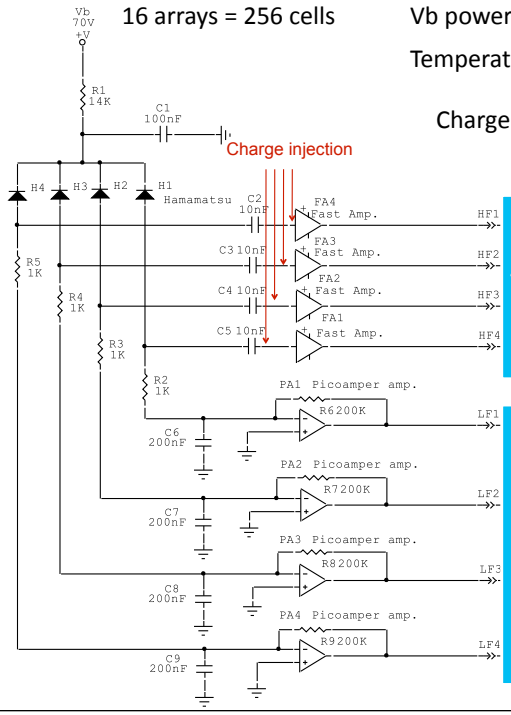
16 arrays = 256 cells

Vb power sources ?

Temperature control?

Charge injection system.

CAEN VME V792 QDC
32 channels, 12 bits



7 ½
Digital Multimeter with GPIB or USB Interface like Keithley 2010

We are going to measure:

- The response of each cell of the array for LED pulses at different temperatures. We should measure a charge in the gate (gate time?) For gain determination we need measure photo electron peak position. We need to measure linearity region using a reference photo detector.
- The pedestal or noise measurement in the gate at the selected temperatures.
- The dark current measurements.
- All these measurements should be combined into one procedure, because the temperature stabilization is most important limiting factor.
- Temperature region is 0-25 °C: how many points ??? 2°C;5°C;10°C;15°C; 20°C;25°C.
- It mean that we need one day for one bunch of the arrays.
- To be in the schedule we have to test 16 arrays in parallel and make a set up for the test of 16 x 16=256 SiPM.

Table 1. Technical requirements for Silicon photomultiplier arrays for the Hall D BCAL. All requirements must be met at the nominal operating voltage and at a specified temperature in the range between 5 and 30^{o} C.
There is a tradeoff between specific values of PDE and dark current to obtain a fixed detector resolution.
The tradeoff is made explicit in the following equation:
PDE > 0.0518 + $\sqrt{}$(0.002685 + 0.01629•DR(MHz)/100), where the dark rate DR is given in MHz;

Property	Specification
Gain at nominal operating voltage	(0.5–2)x10^{6}
Photo-sensitive area	>140 mm^{2}
Macroscopic active area coverage	> 75%
Number of micro-pixels	> 56000
Sensitivity to magnetic field	< 1% gain change at 3 T
PDE at 490 nm	> 19 % [Note 1]
Dark rate	< 100 MHz [Note 1]
Dark current	< 15 μA
Sensitivity to temperature	< 10% charge amplitude change/deg C
Output variation between tiles within one array	<10%
Variation of outputs between arrays	<10%
Nominal operating voltage	25-80 V
Nominal operating voltage above breakdown voltage	0.9–2.5 V
Fraction of multiple photoelectrons in dark noise	< 5% (preliminary)
Maximum package dimensions	< 16x21 mm^{2} x 9 mm high
Package substrate	$Al_{2}O_{3}$
Minimum area on back accessible for cooling	> 7.5 x 15 mm^{2}
Inputs	Positive bias voltage
Outputs	16 individual outputs
Output connector	Cu alloy pins on 0.05" centers
Rise time 10%–90%	< 15 ns
Pulse width 10%–10%	< 100 ns
Sensitivity to radiation	< 1%/Gy