

# Overview on Experimental Setups to Study SiPM Parameters Down to Cryogenic Temperature

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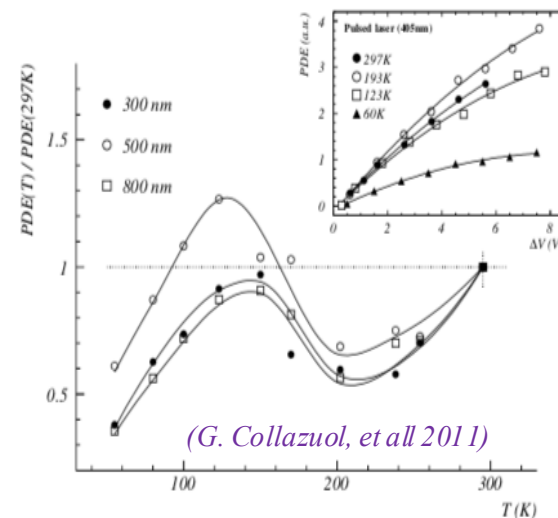
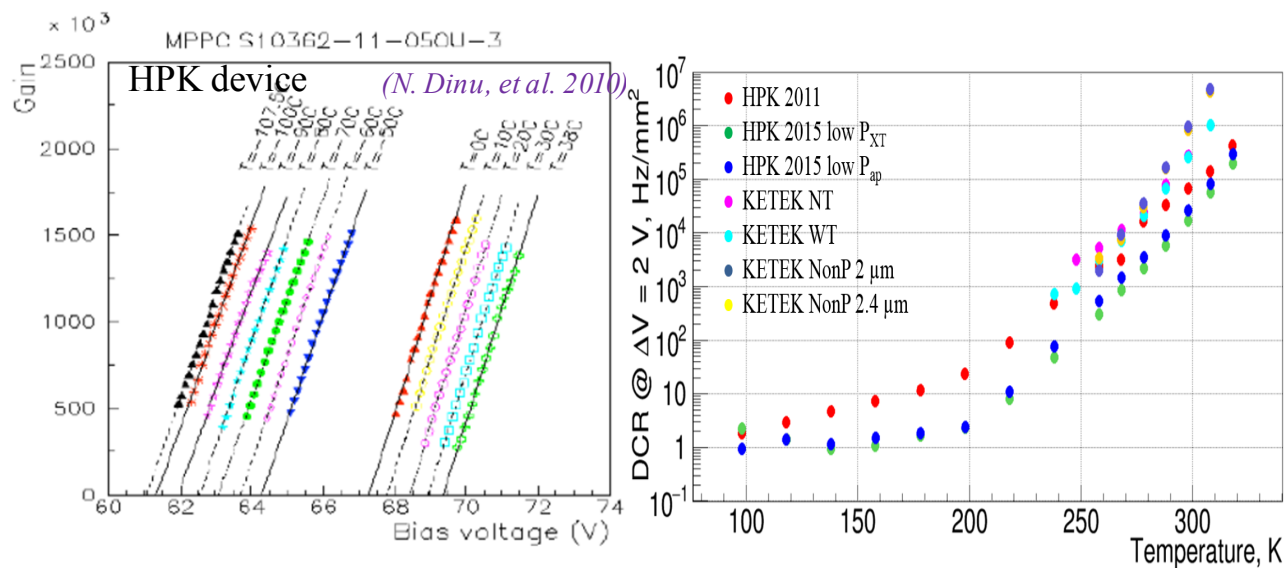


## Outline

- Short overview in exp. Setups;
- Our experience from building setup

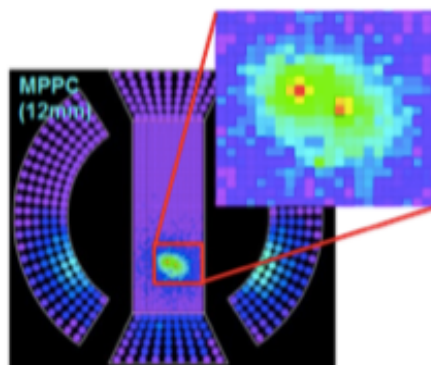


# Why do we need cryo set-up?



gas	T (K)
Xe	165.05
Kr	119.93
Ar	87.3
N <sub>2</sub>	77
He	4

LXe:

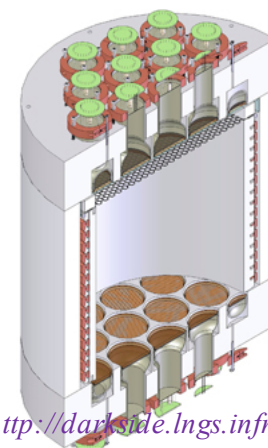


Kaneko, MEG. Nuclear Physics B

LAr:



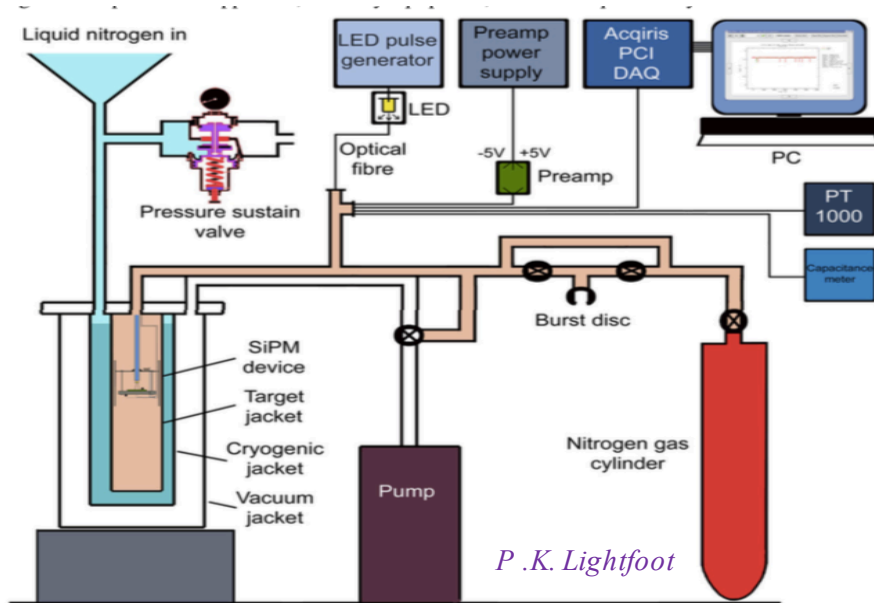
<https://www.mpi-hd.mpg.de/gerda/>



<http://darkside.lngs.infn.it>

# What type of set-up do you need?

## Cryostats:



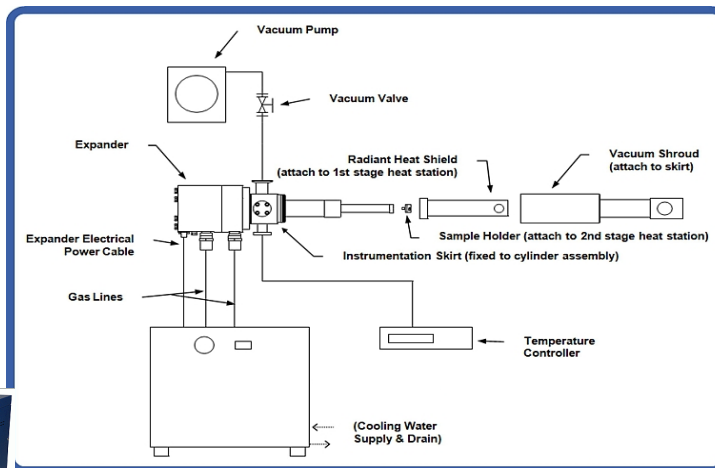
### Advantages:

- Cryostat can be found
- Relatively cheap
- Similar conditions to real exp.

### Disadvantages

- Liquid gaseous

## Closed circuit set-ups:



<https://www.arscryo.com/custom-cryogenic-solutions>

### Advantages:

- Almost ready to use
- Easy to operate
- Wide T range:  $10\text{K} < T < 350\text{K}$

### Disadvantages

- Price: > 20 K Euro
- Not light isolated
- Small volume



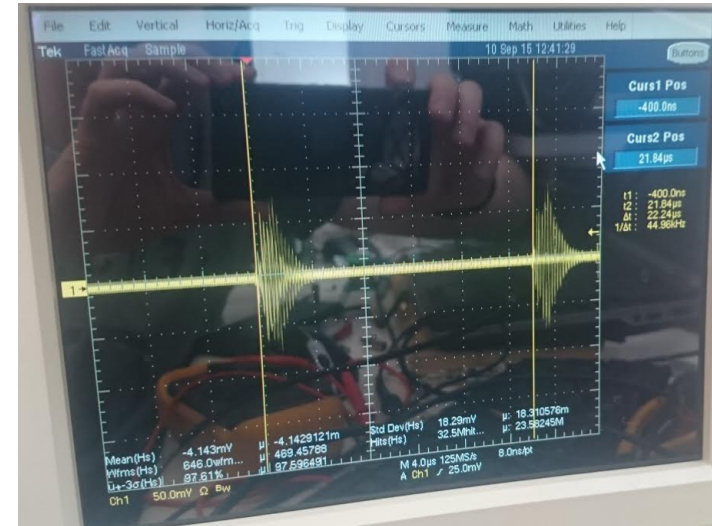
# Practical advises



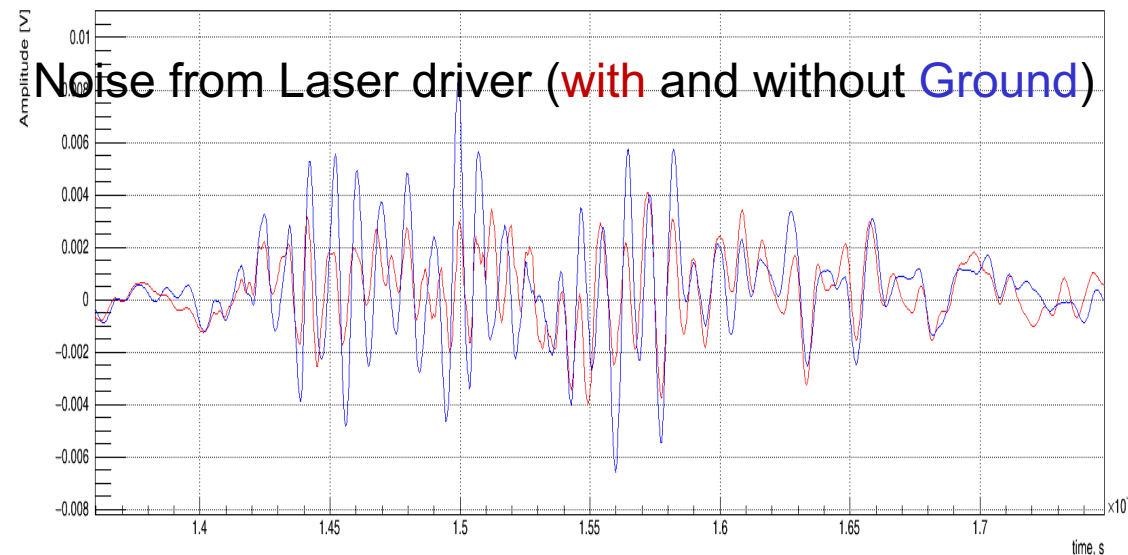
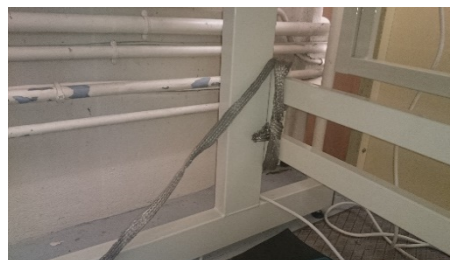


# You will build a big antenna, & only after it can become a cryogenic set up))

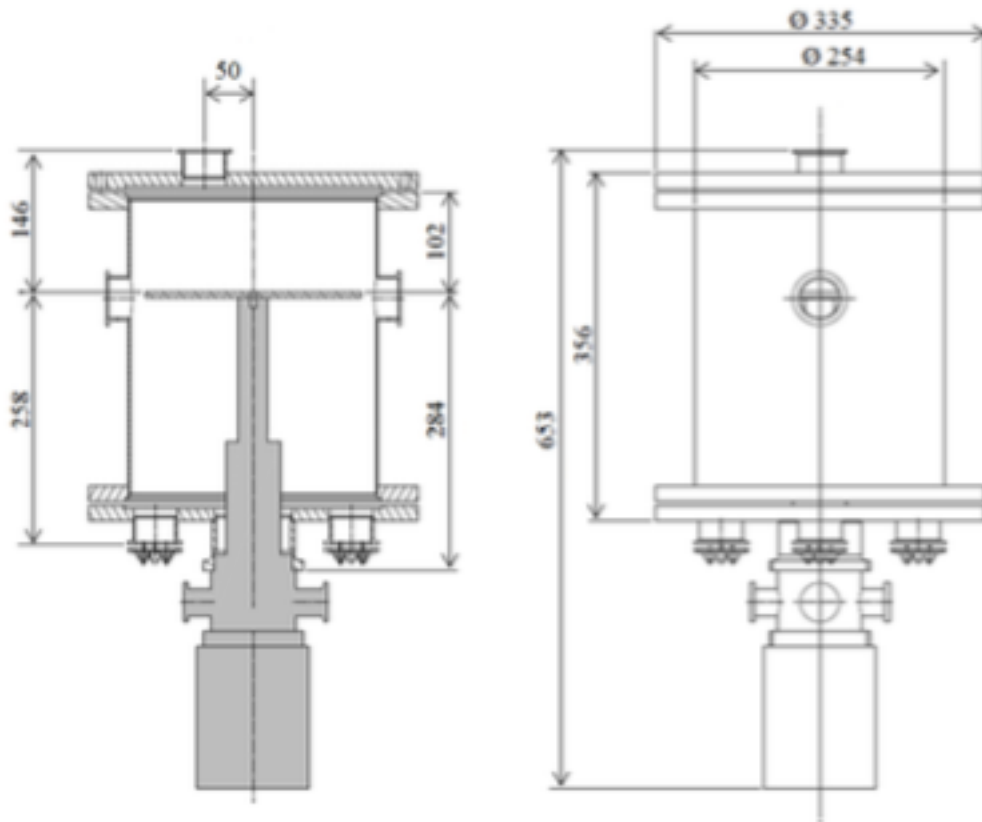
Additional noise coming from other envelopment in our room or even in neighbouring rooms was observed:



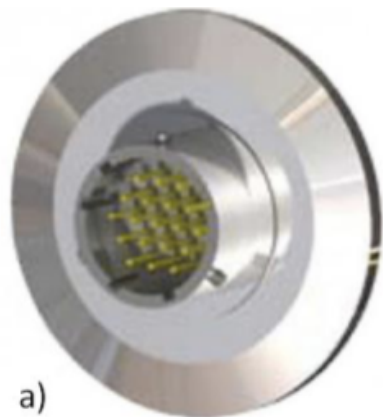
Ground connection: Chamber ↔ Chamber Support ↔ Table:



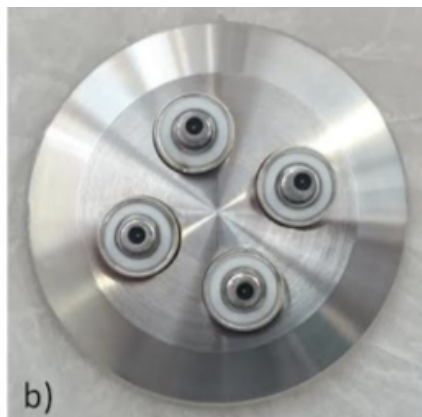
# Design your own vacuum chamber:



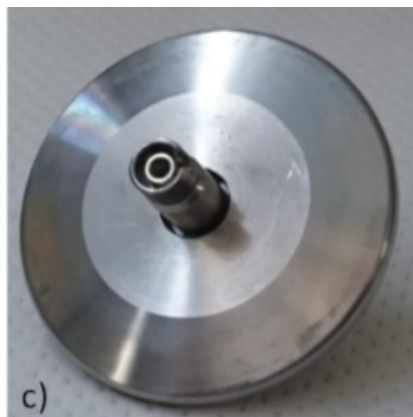
- As big as possible
- Easy access feedthrough
- Possibility to measure/fix as many SiPM's as possible
- Different feedthrough:
  - Optical
  - Electrical:
    - BNC
    - Pins



a)













b)



c)

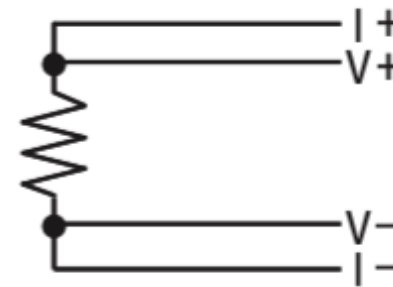
# Temperature Sensors:

		Temperature range
<b>Diodes</b>		
Silicon		1.4 K to 500 K
GaAlAs		1.4 K to 500 K
<b>Negative Temperature Coefficient RTDs</b>		
Cernox®		0.10 K to 420 K
Germanium		0.05 K to 100 K
Ruthenium Oxide (Rox™)		0.01 K to 40 K
<b>Other</b>		
Thermocouples		1.2 K to 1543 K
Capacitance		1.4 K to 290 K
<b>Positive Temperature Coefficient RTDs</b>		
Platinum		14 K to 873 K
Rhodium-Iron		1.4 K to 500 K
<b>Specialty</b>		
HR Series		20 K to 420 K

**HR** HIGH  
SERIES RELIABILITY

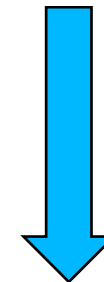
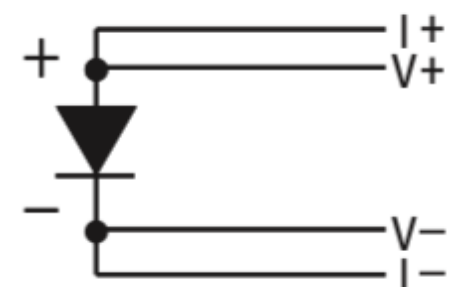
## Connection scheme:

Resistive sensor



Diode

(option only)



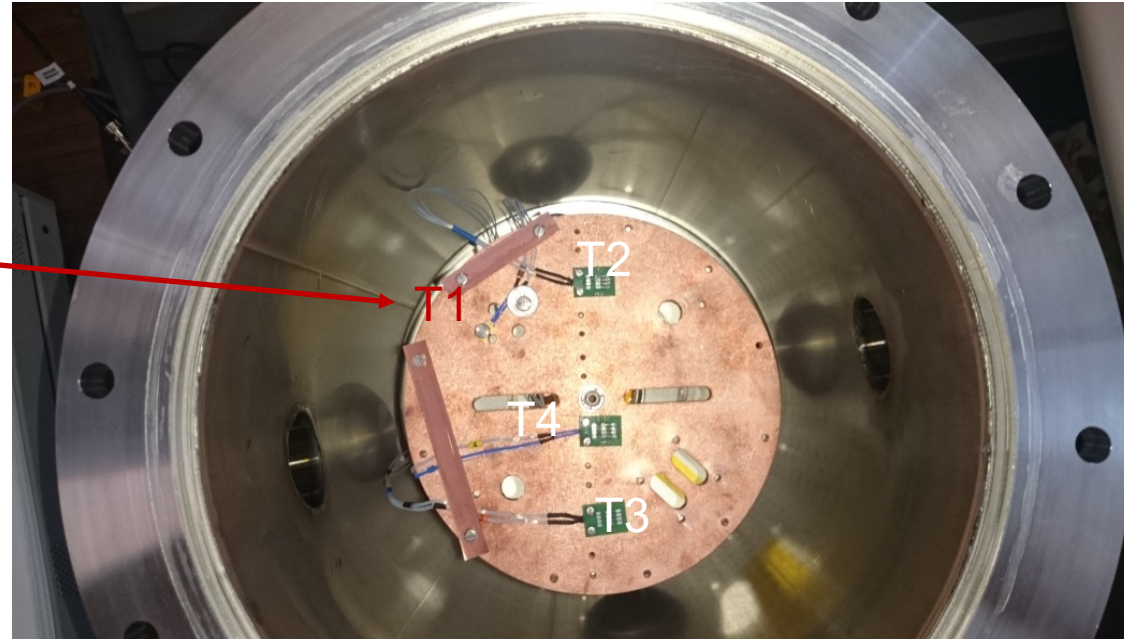
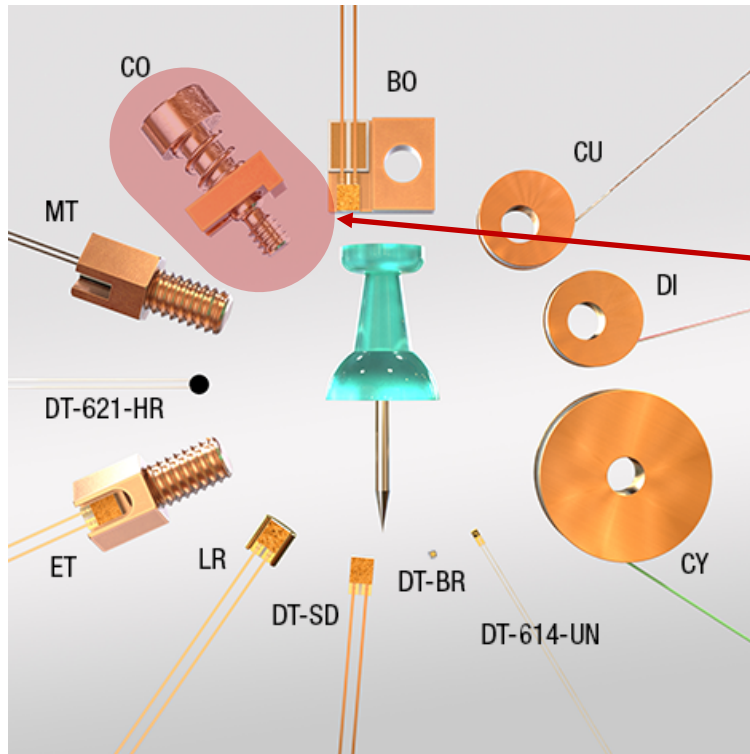
4 cables & feedthrough per sensor

<https://www.lakeshore.com/Products/Cryogenic-Temperature-Sensors/Pages/default.aspx>



# Fixation: T Sensor

Producer may provide:



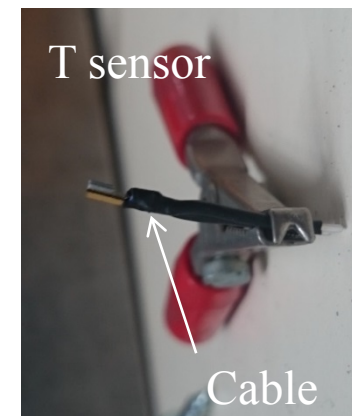
Results:

$T1 = 27.7K$

$T2 = 16.3K$

$T3 = 30.1K$

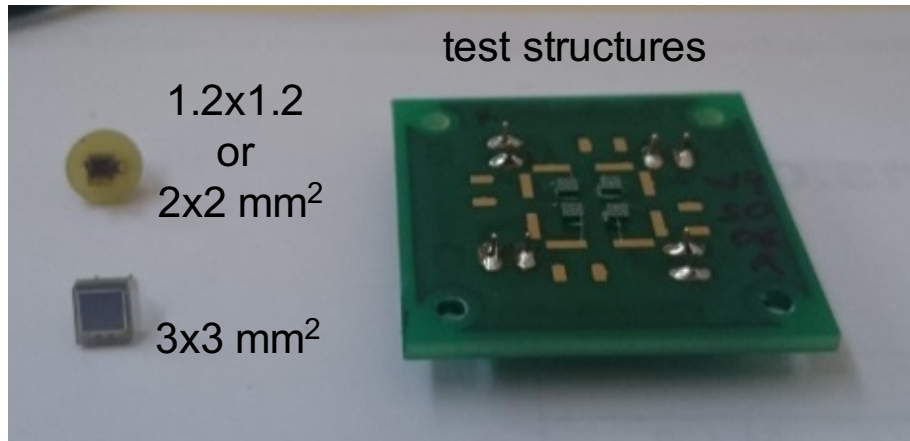
$T4 = 14.4K$



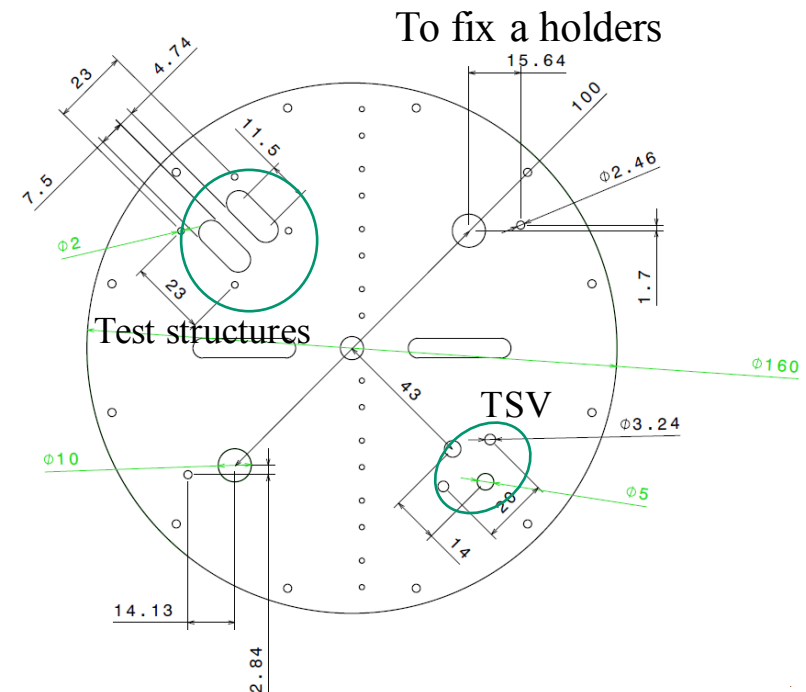
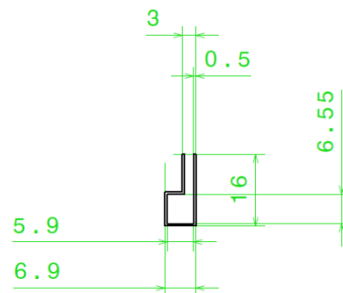
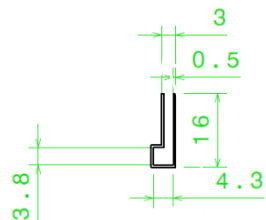
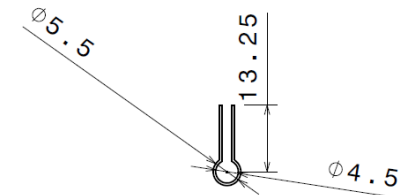
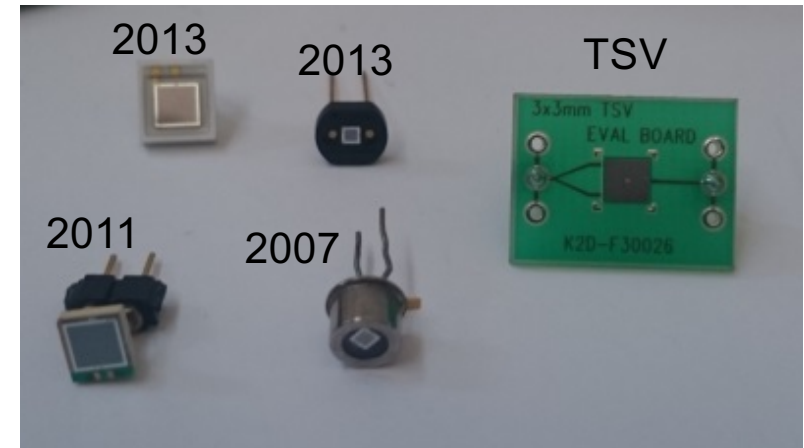
Mechanical fixation is important!

# Fixation: SiPM

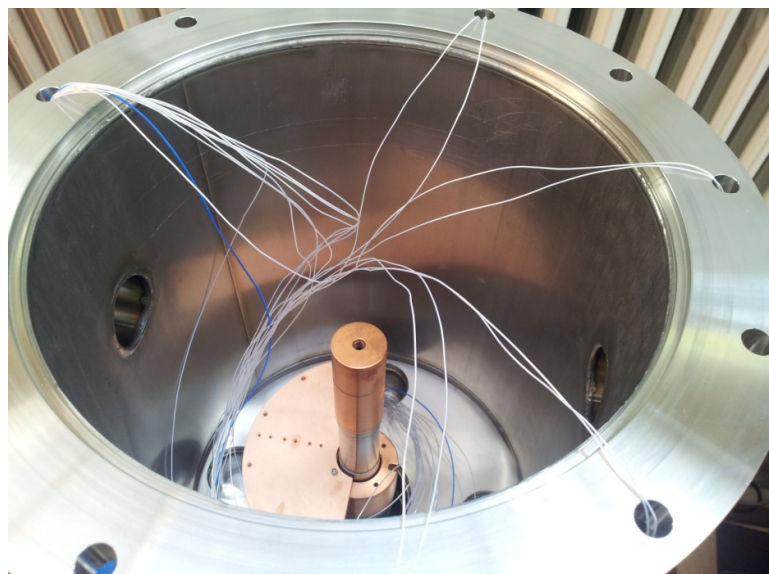
KETEK:



Hamamatsu:



# Number of Cables/Feedthrough:



2 for Heater

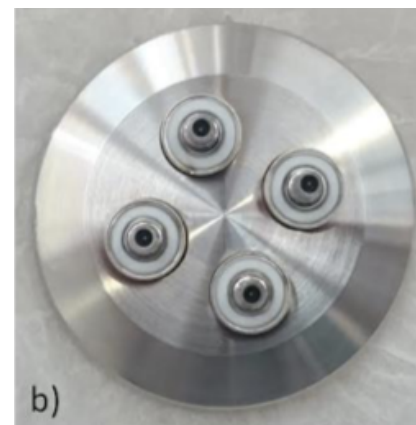
2 for SiPM

4 for T sensor

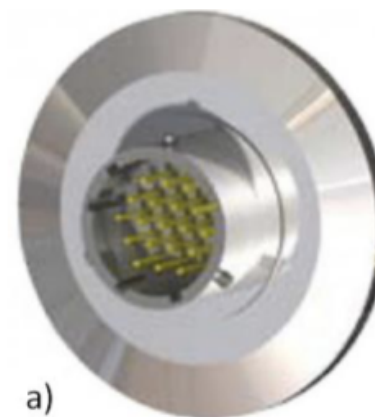
3 SiPM + 4 T sensors  
(1 reference + 3 for SiPMs)

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For SiPM:



For T sensors  
& heater:



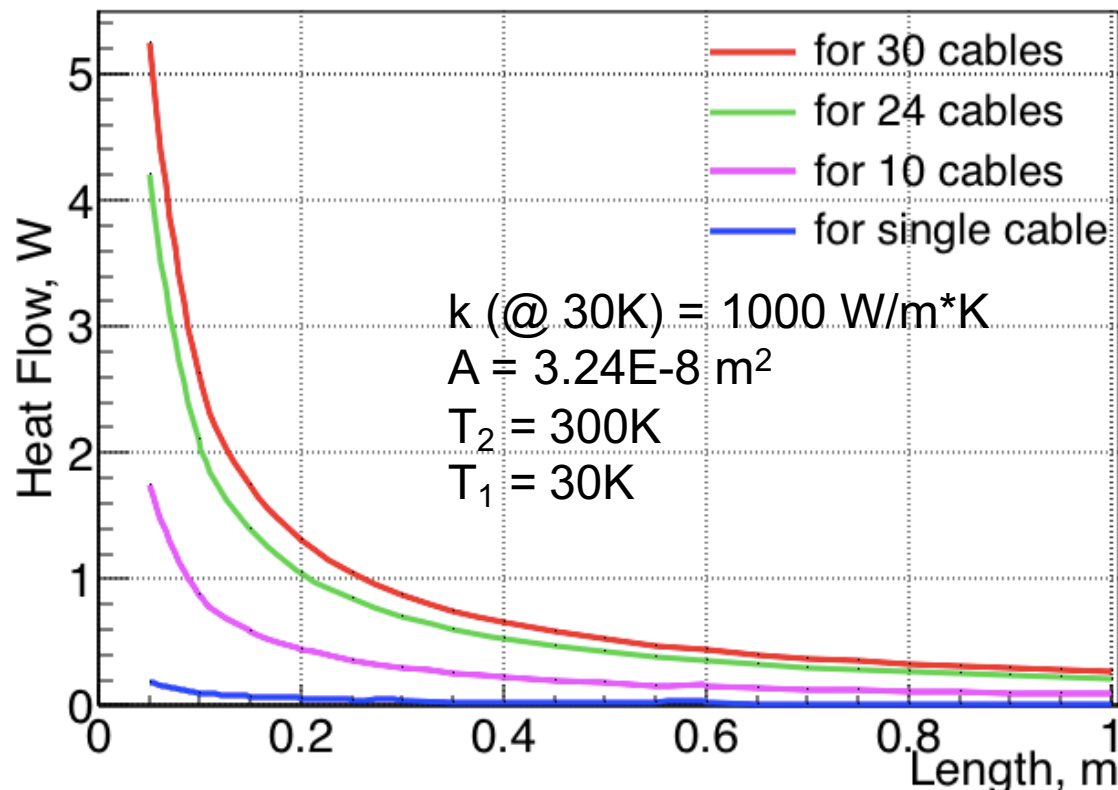


# Cables length calculation:

Heat flow through cable:

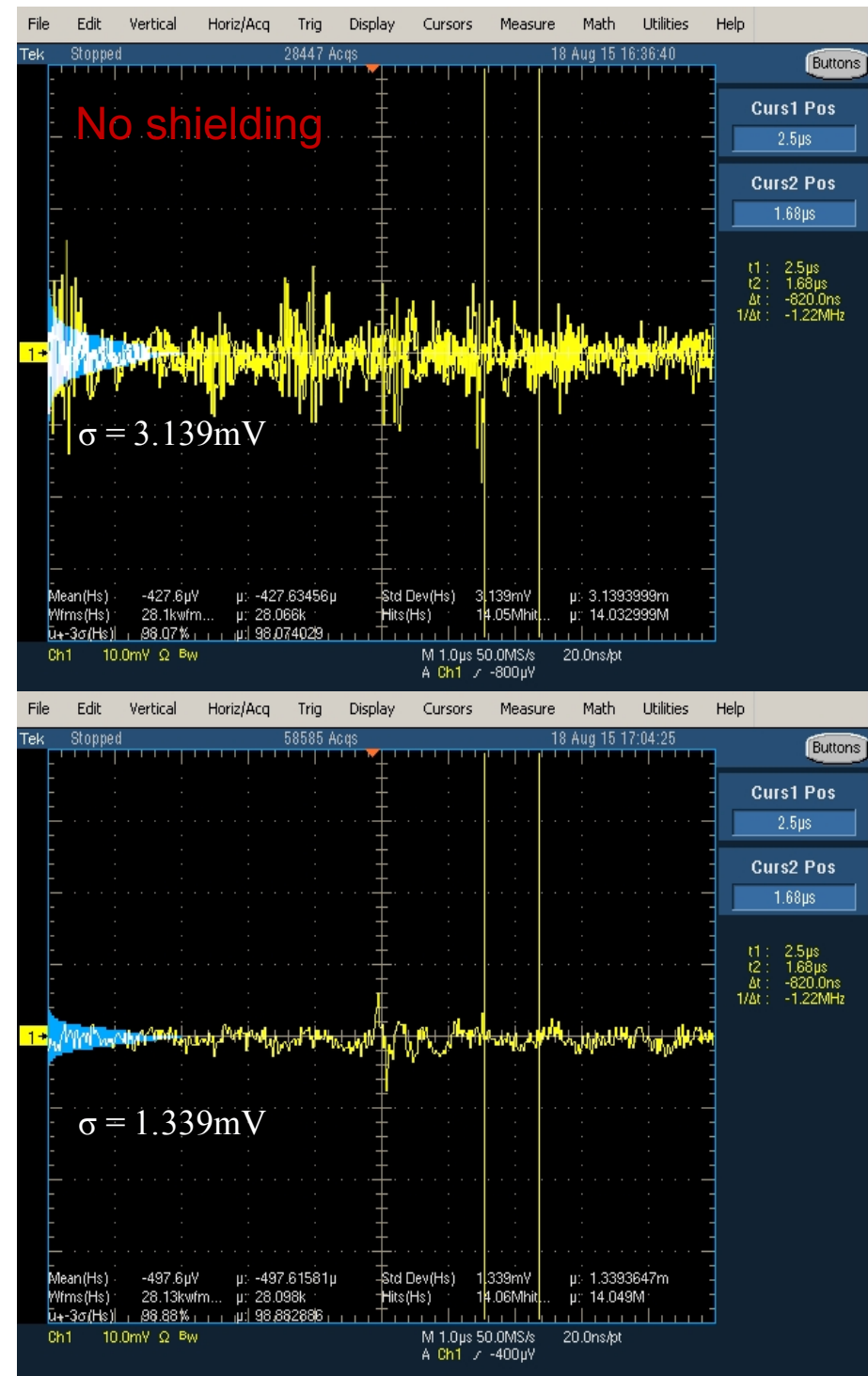
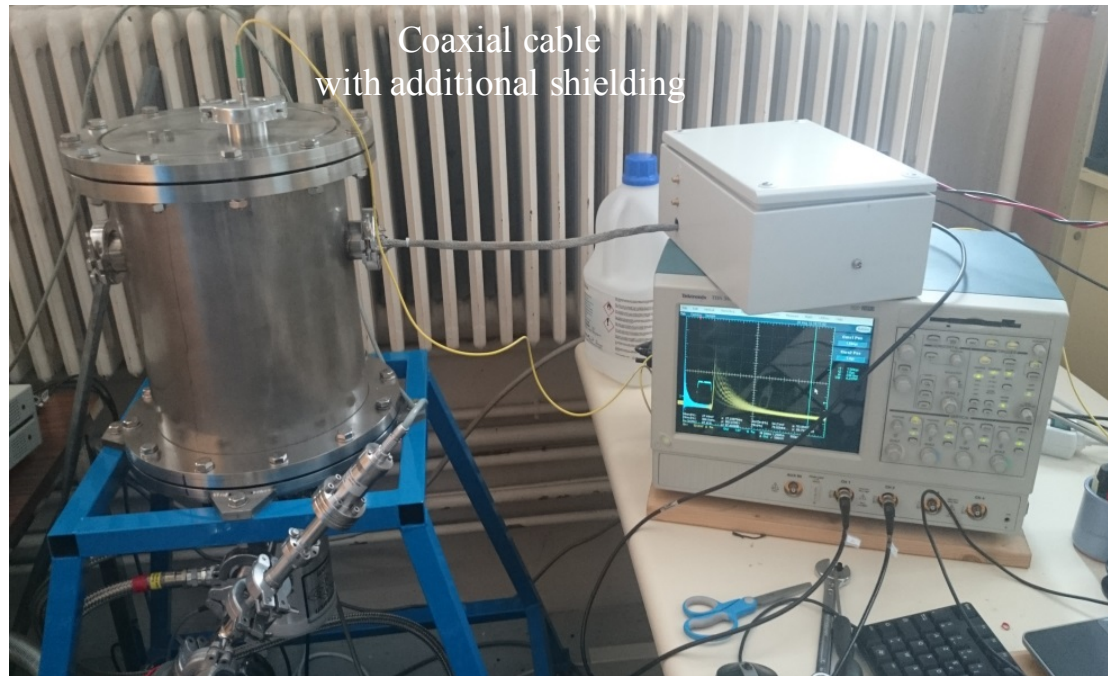
$$Q = k \times A \times \frac{T_2 - T_1}{L}$$

- k - is the conductivity W/(m\*K)
- A - is cable cross-sectional area (m<sup>2</sup>)
- L - is cable length (m)
- T<sub>2</sub> - T<sub>1</sub> - is the T gradient across the wire



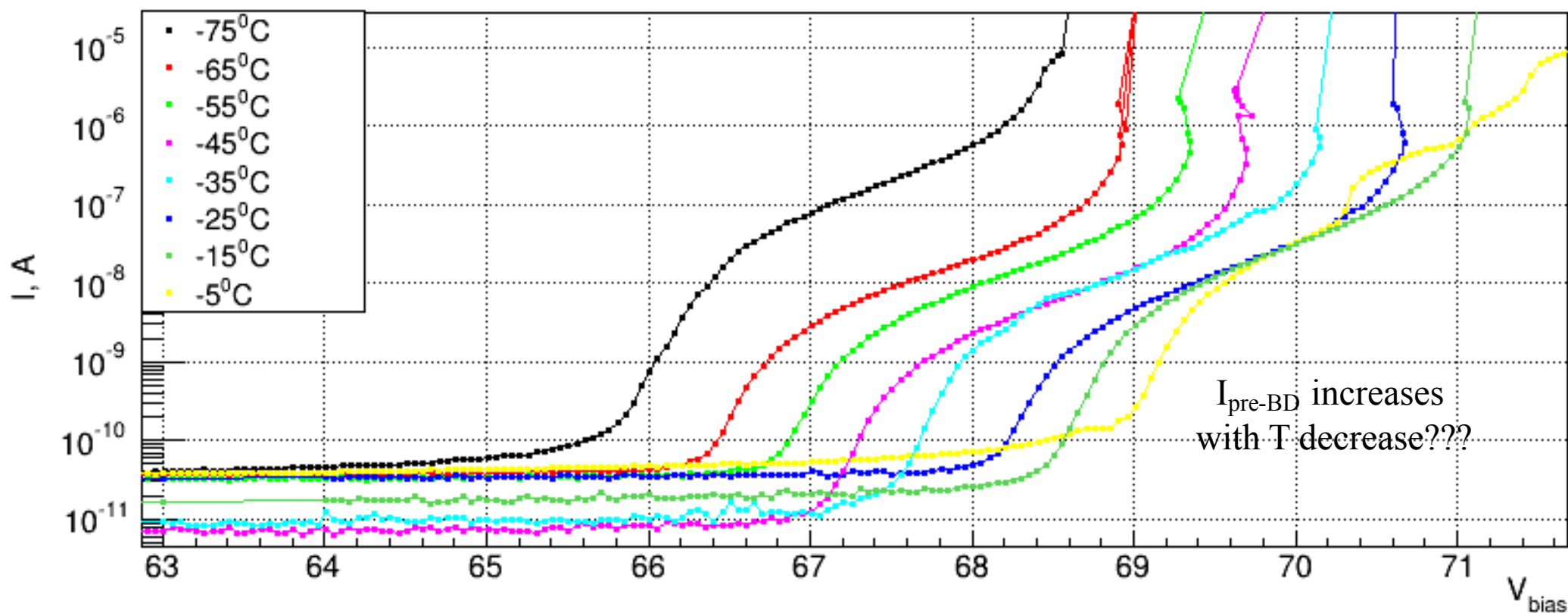
Cryocooler Model		DE-204AE	
	Frequency	60 Hz	50 Hz
Base Temperature		<9K	<9K
Cooling Capacity	4.2K	-	-
	10K	2W	1.6W
	20K	9W	7.2W
	77K	17W	14W
Radiation Shield Cooling Capacity		18W	14W
Cooldown Time	20K	30 min	36 min
	Base Temperature	60 min	72 min
Compressor Model		ARS-4HW	
Typical Maintenance Cycle		12,000 hours	

# Triaxial cable is your friend



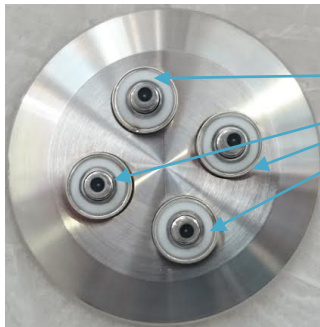
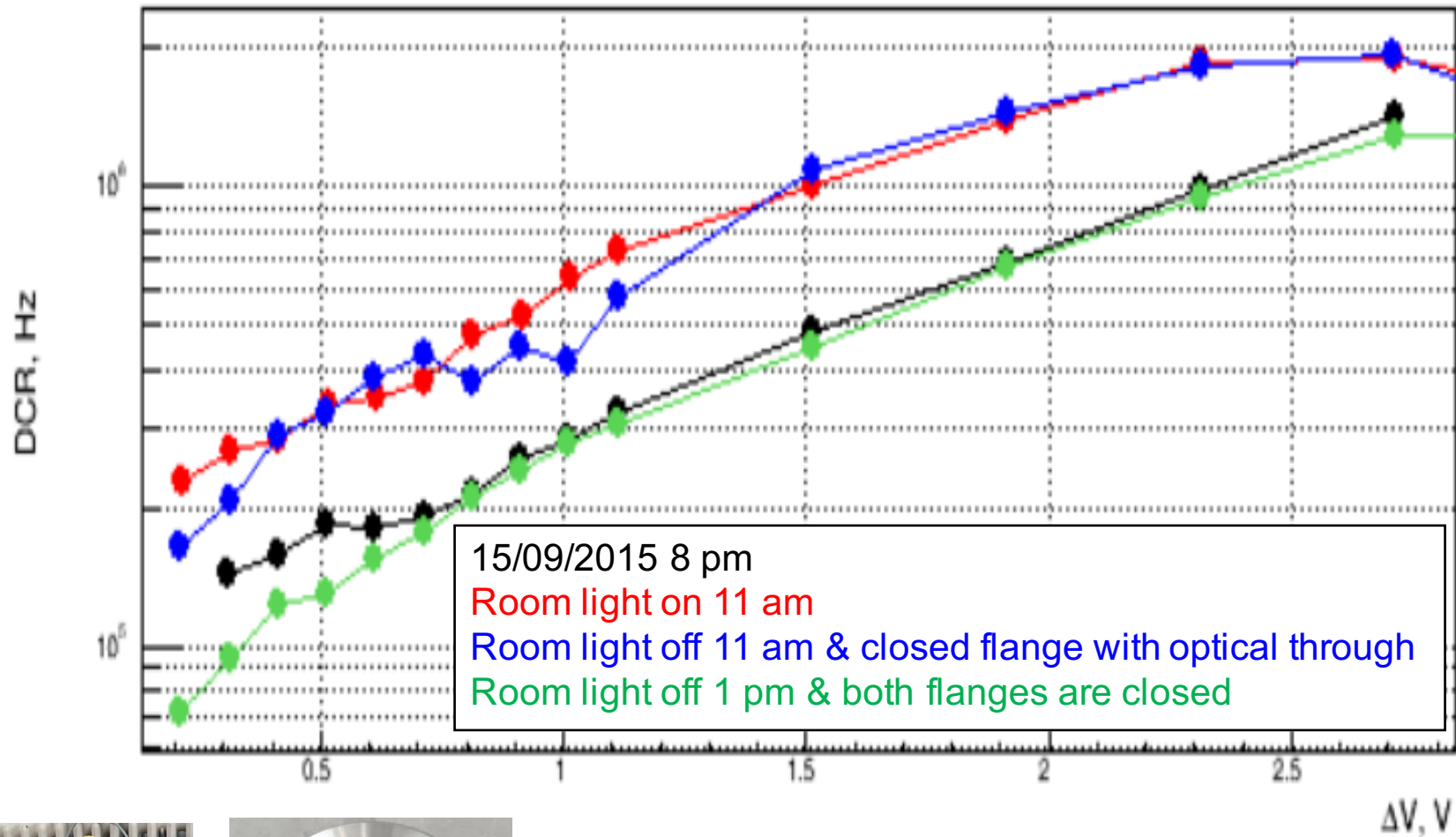
# Be ready to strange results)))

Hamamatsu  $3 \times 3 \text{ mm}^2$



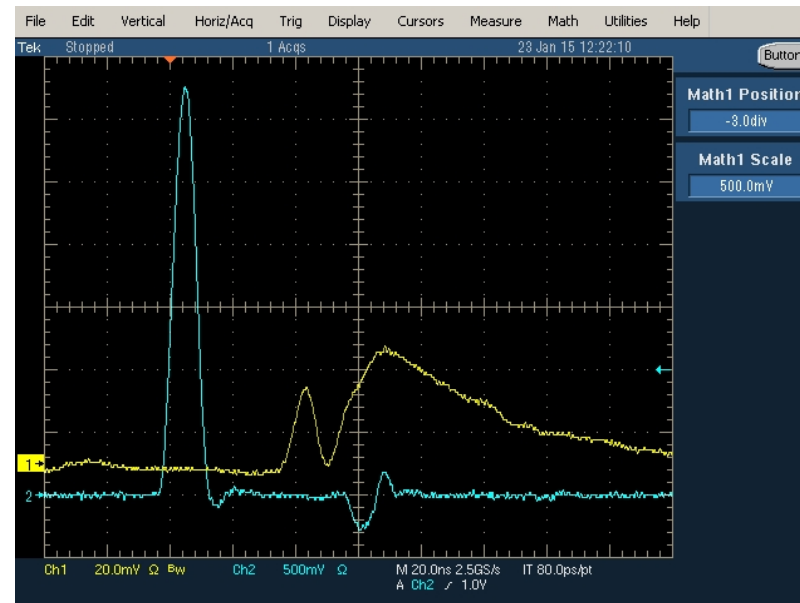
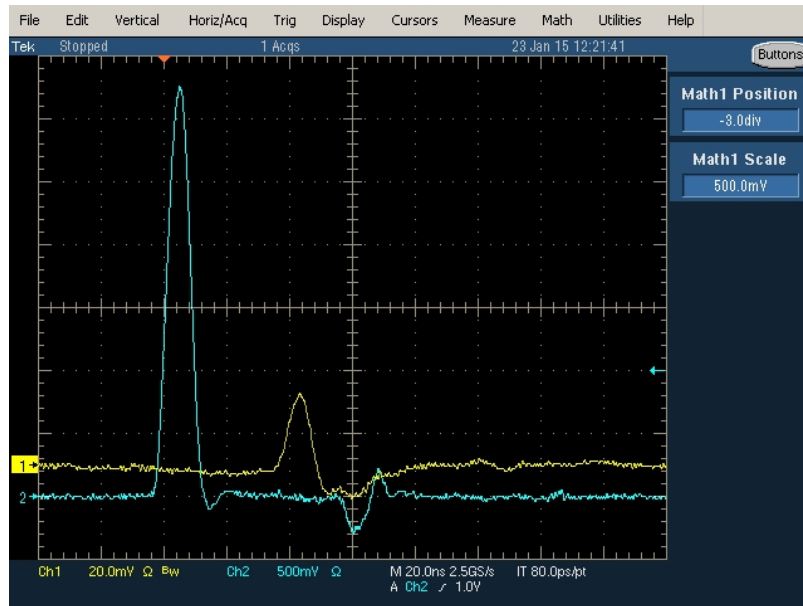


# Vacuum does not mean light tight!



Is transparent for light

# Laser or LED is a source of noise!!



Mean Waveform,  $V_{\text{Bias}}$  : 20.01 [V]

