

# Performance qualification of the detector on board the Spektr-UF (WSO-UV) Space Telescope

Ana I. Gómez de Castro, María Frutos, David Moya, Juan Carlos Vallejo, Ashley Thomson, Tom Conneely, James Milnes



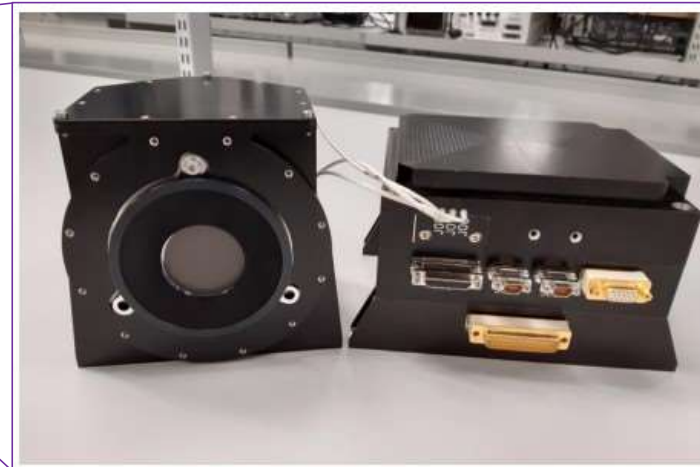
17 October 2024



## Field Camera Unit

- Near Ultraviolet Channel (NUV): 174–315 nm.
- Far Ultraviolet Channel (FUV): 115 and 180 nm.

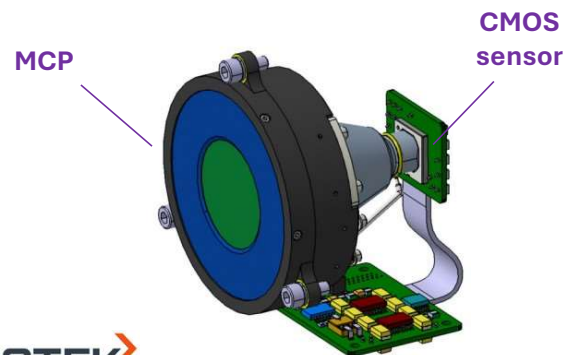
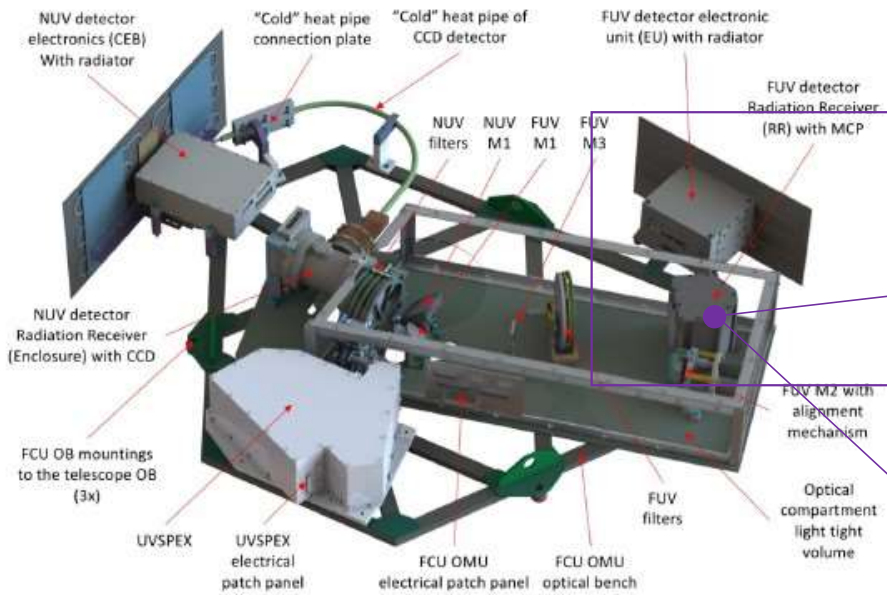
## Photon Detection Device

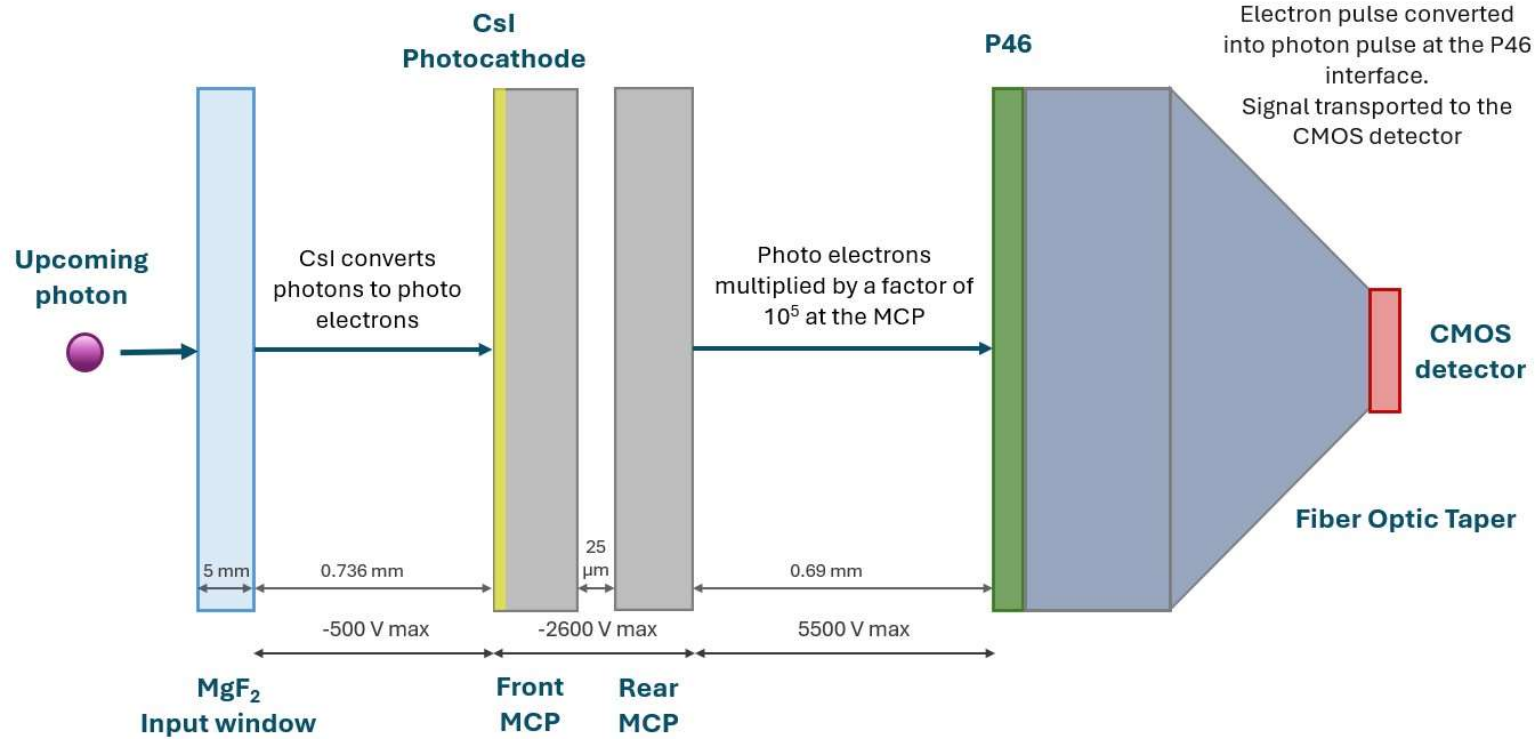


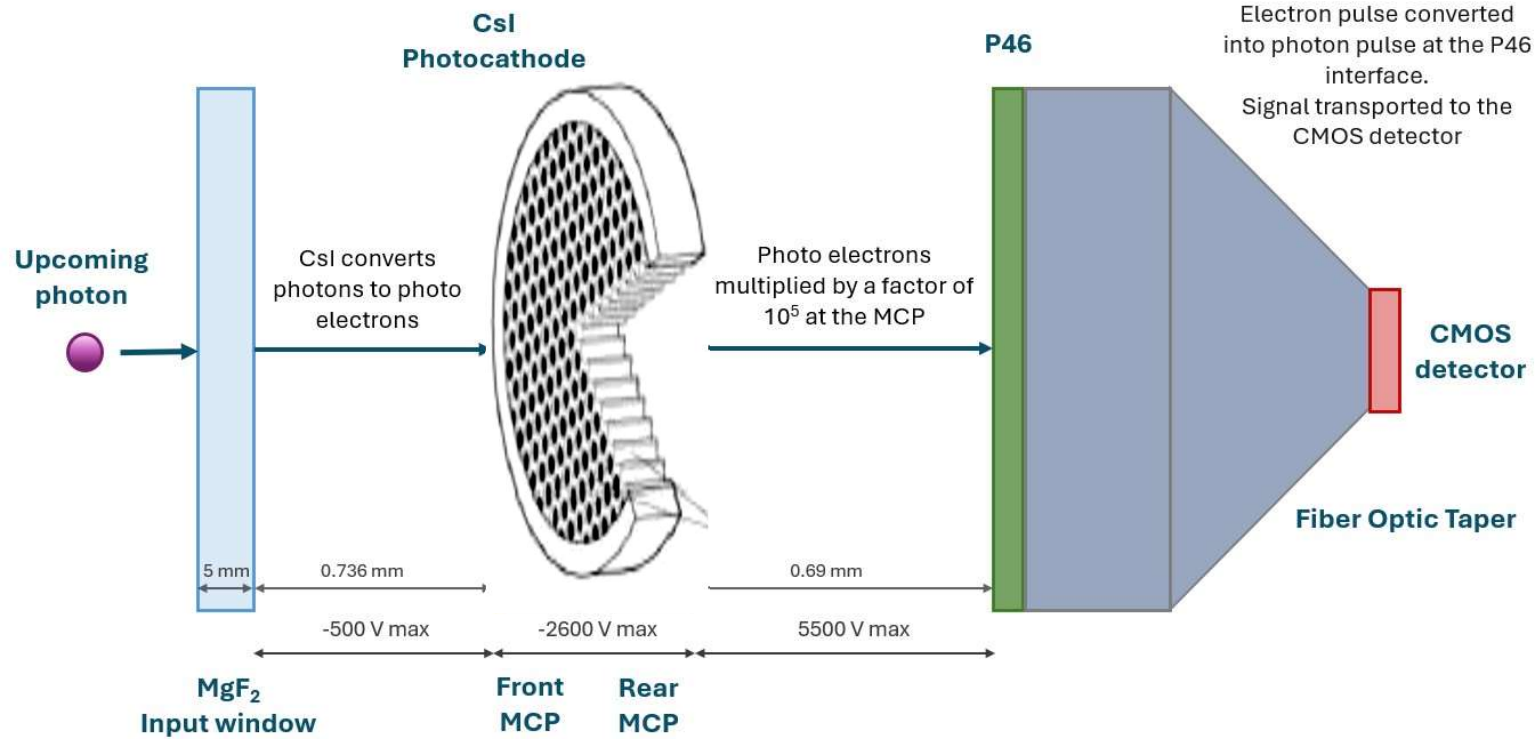
## Radiation Receiver + Electrical Unit

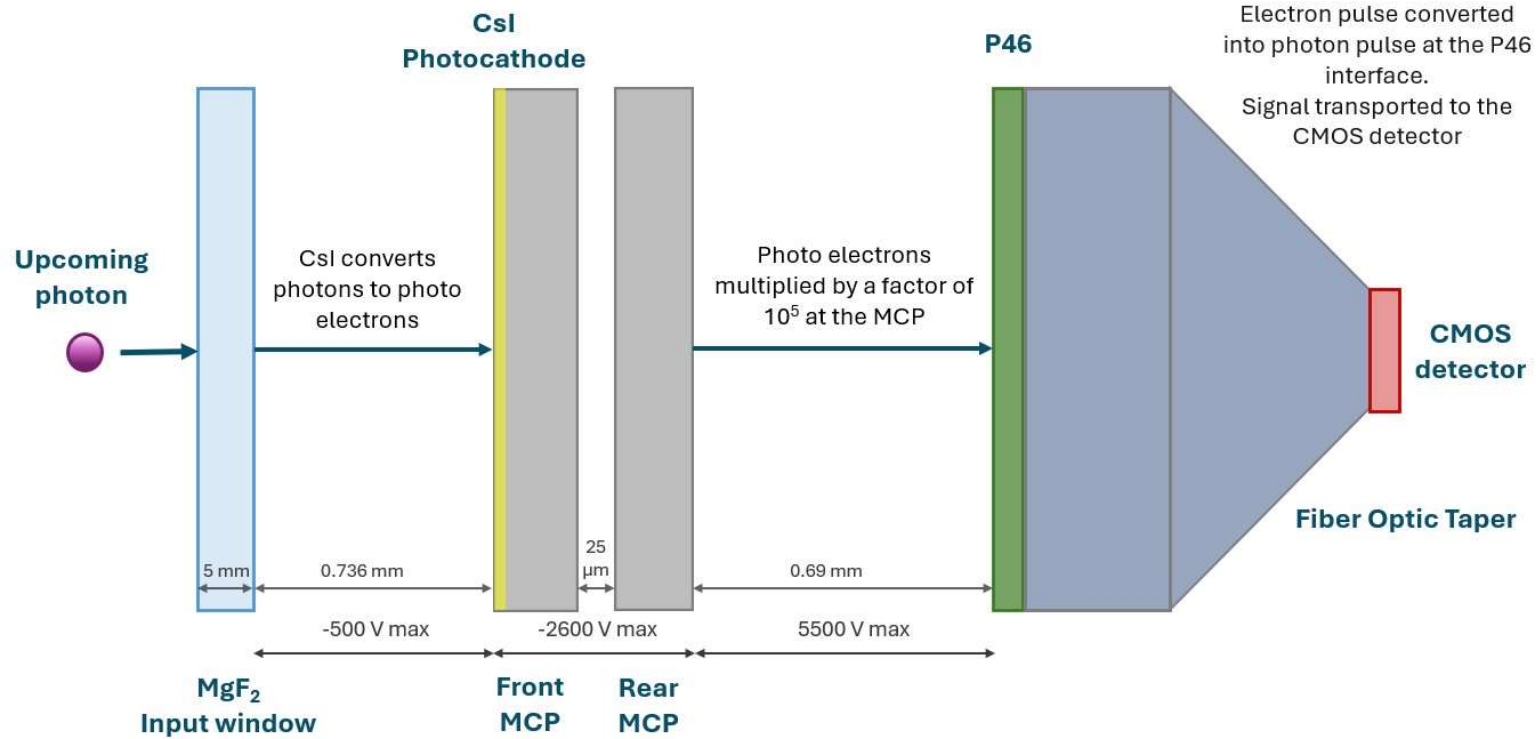
-Detection, amplification and conversion of FUV radiation into digital data

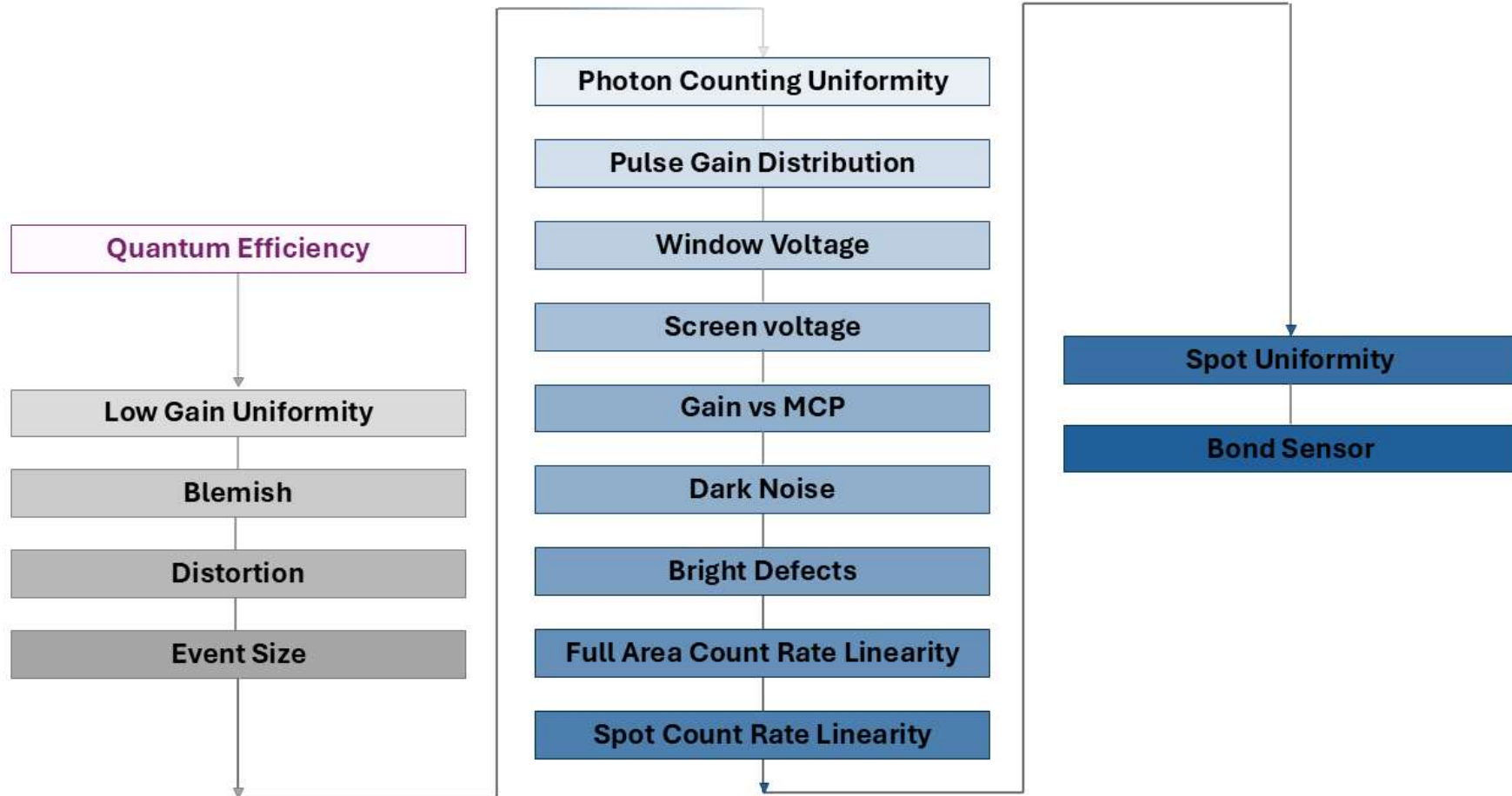
- Powering the RR
- Commanding the detector
- Acquiring and pre-processing images
- Managing communications with the Camera Control Unit

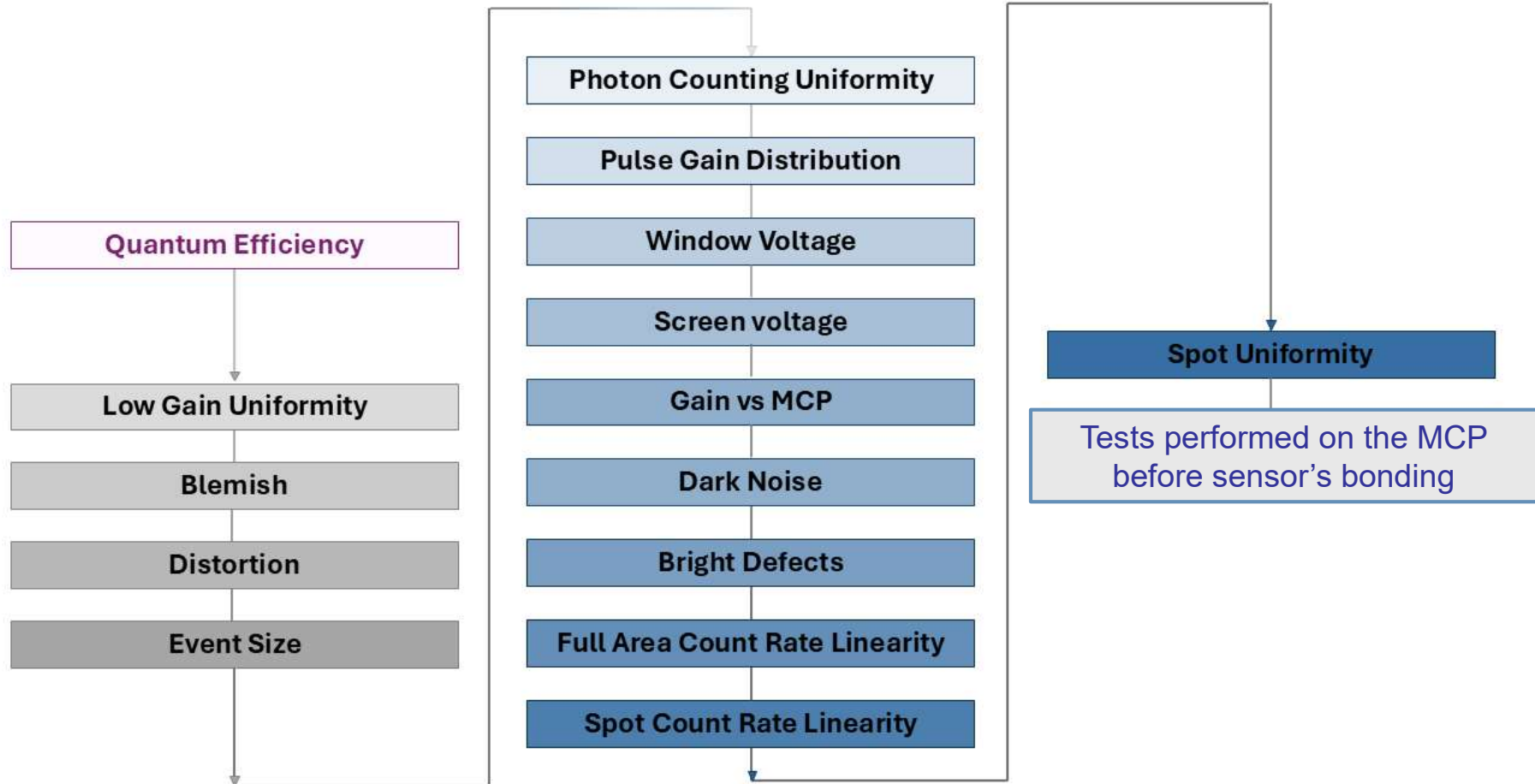






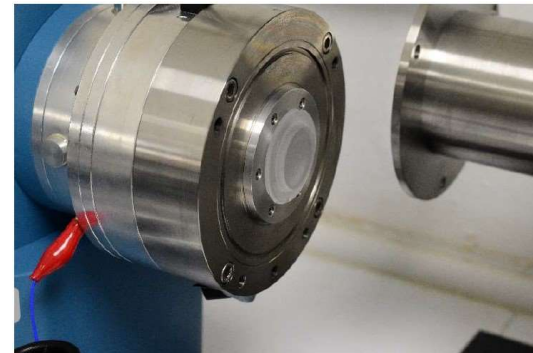
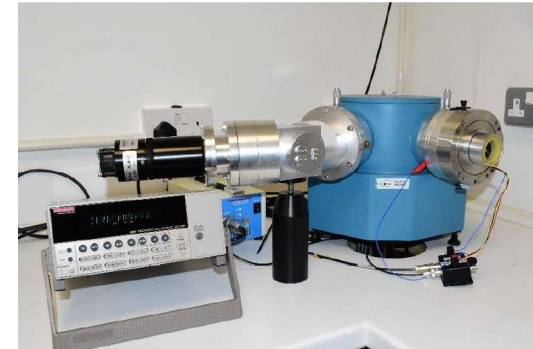
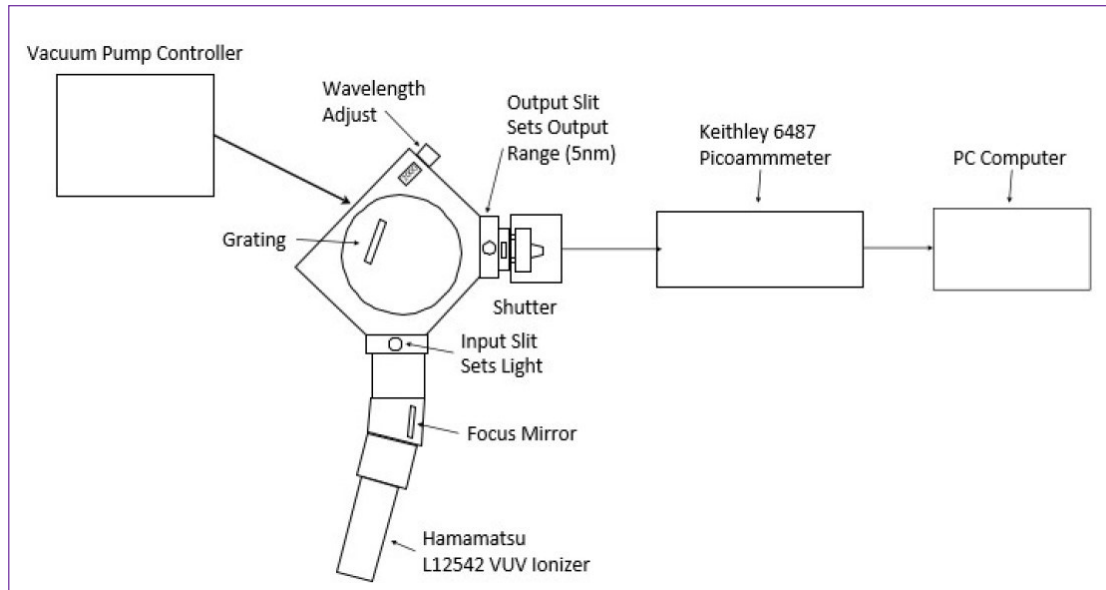








## Set up 1



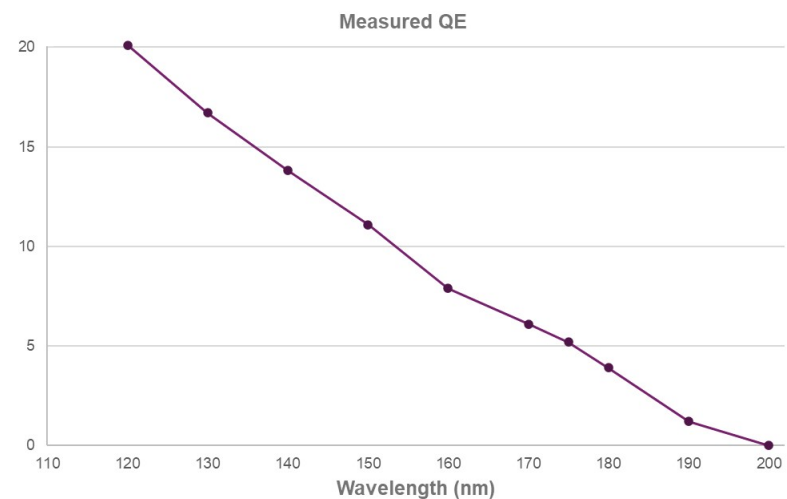
### Test

- 1.- The detector's photocurrent is measured at each of the wavelengths selected.
- 2.- Through comparison with an independently calibrated test cell, the detector's Quantum Efficiency is obtained.



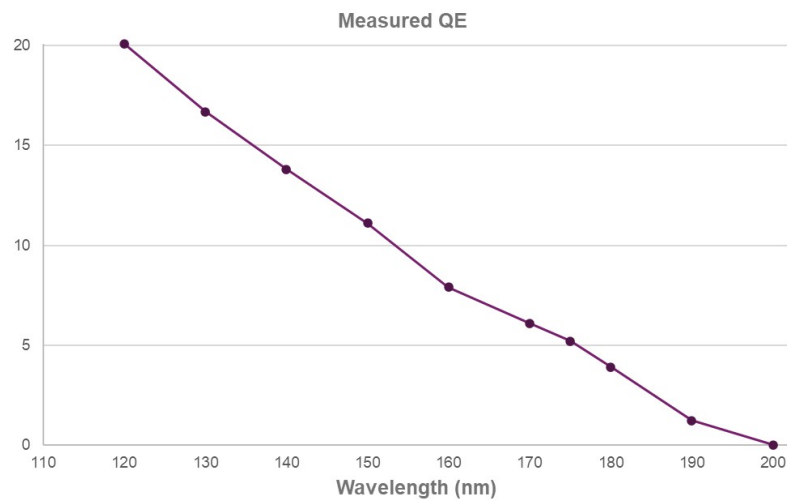
## FM1

Wavelength (nm)	Measured QE
120	20.1
130	16.7
140	13.8
150	11.1
160	7.9
170	6.1
175	5.2
180	3.9
190	1.22
200	0



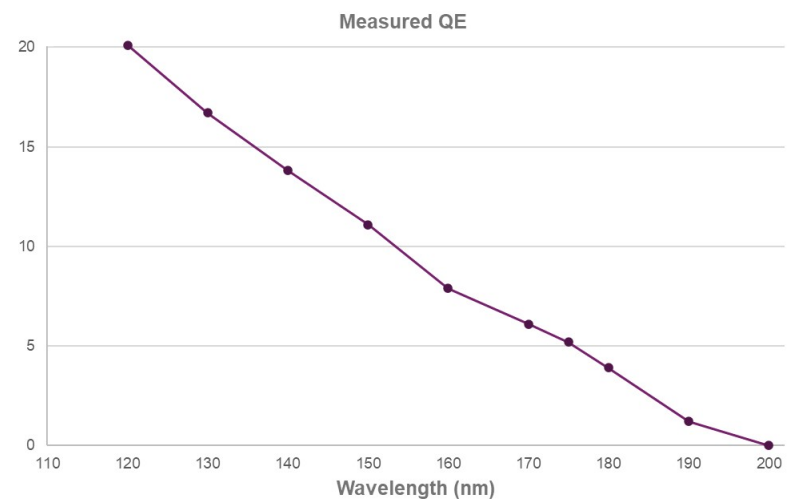
## FM2

Wavelength (nm)	Measured QE
120	20.3
130	17.6
140	14.5
150	11.5
160	8.2
170	6.7
175	5.2
180	4.3
190	0.2
200	0



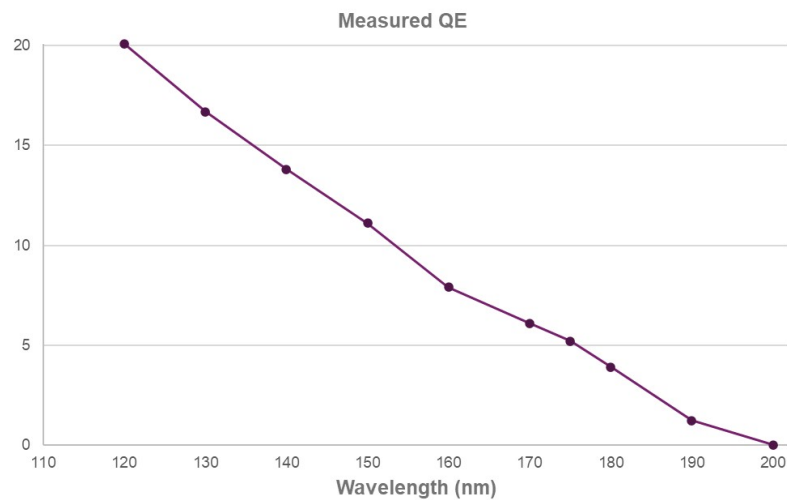
## FM1

Wavelength (nm)	Measured QE
120	20.1
130	16.7
140	13.8
150	11.1
160	7.9
170	6.1
175	5.2
180	3.9
190	1.22
200	0

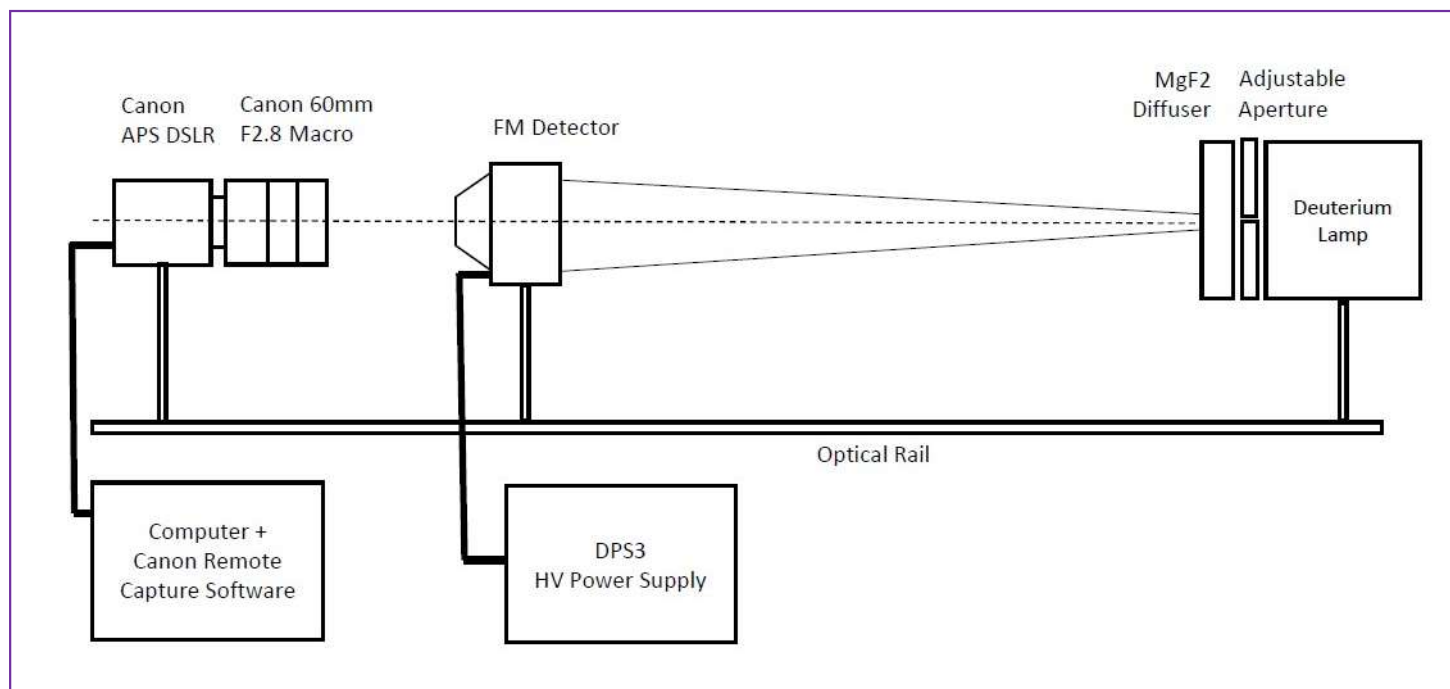


## FM2

Wavelength (nm)	Measured QE
120	20.3
130	17.6
140	14.5
150	11.5
160	8.2
170	6.7
175	5.2
180	4.3
190	0.2
200	0



## Set up 2



**Low Gain Uniformity**

**Blemish**

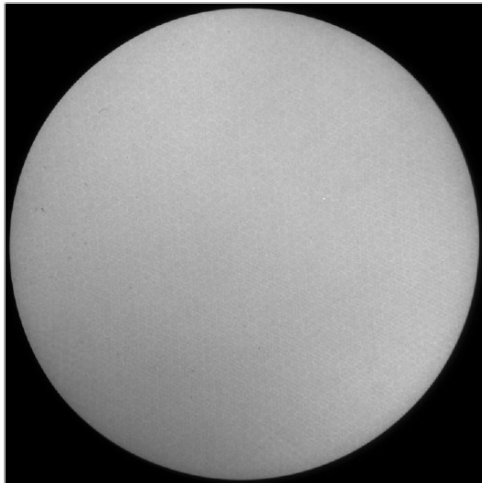
**Distortion**

**Event Size**

### Test

- 1.- The light source is placed at 1 m from the detector to ensure flat field illumination.
- 2.- Camera lens focused onto the output face of the MCP

### Uniformity & Blemishes



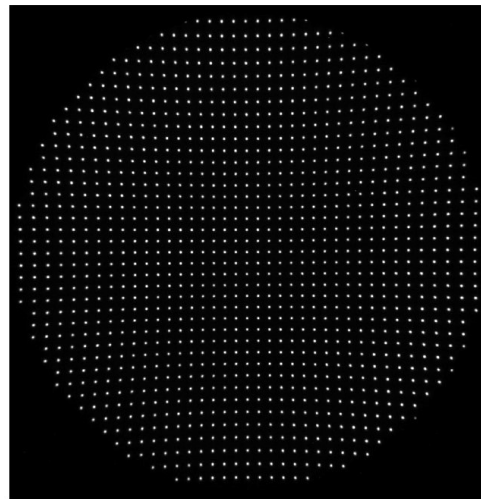
Standard deviation= 17

Mean= 17.5

SD/Mean= 10%

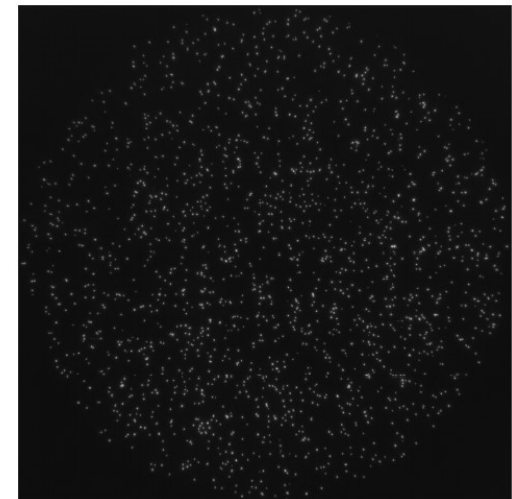
No recordable blemishes

### Distortion



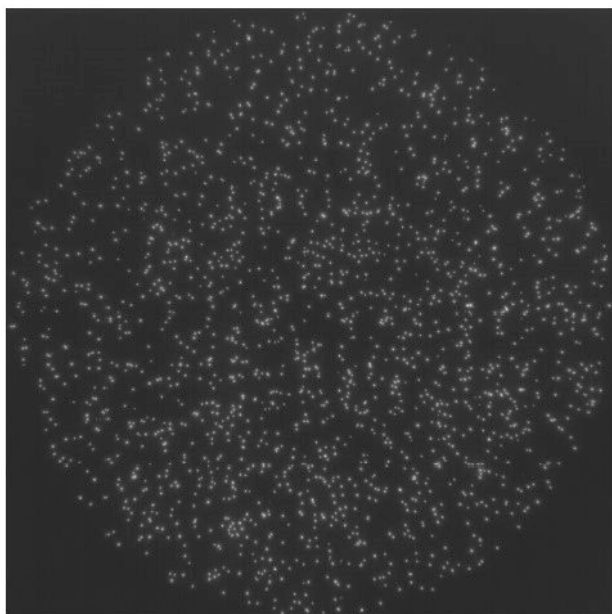
No significant distortion observed after placing a stainless steel mask on the detector's input window, with a regular grid of pinholes

### Single Photon Event Size

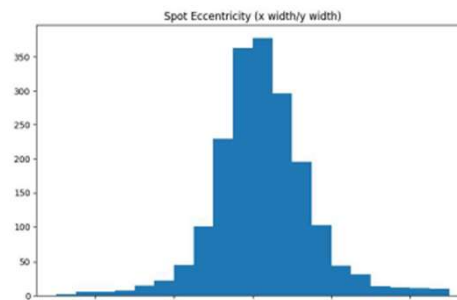
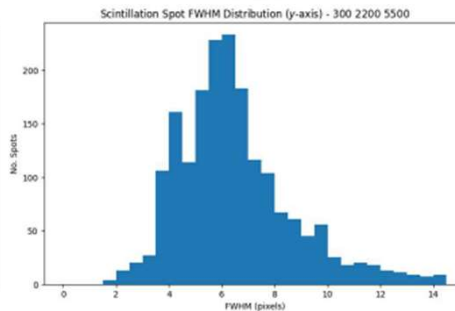
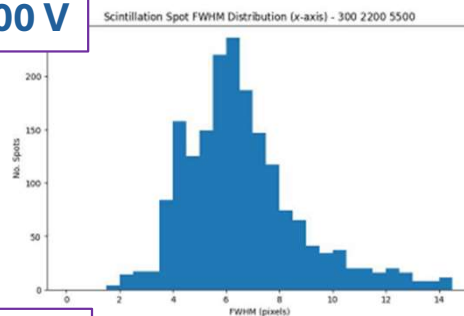


Signal spread over several pixels (to prevent saturation of the cell) but not over a too large number of pixels (to avoid a reduction of SNR)

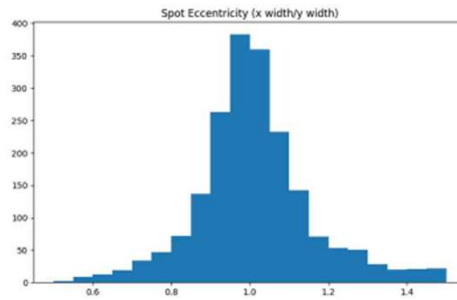
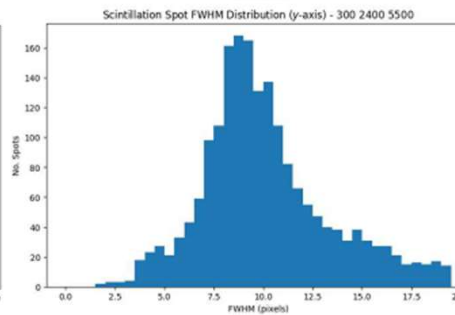
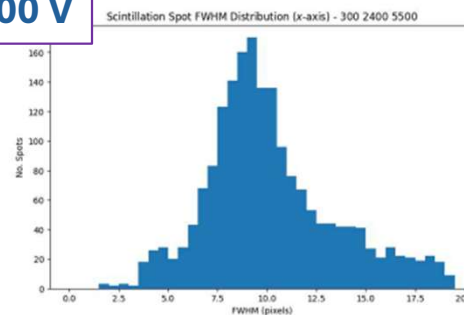
## Single Photon Event Size



**2200 V**



**2400 V**



### Distribution of the detected photons by size

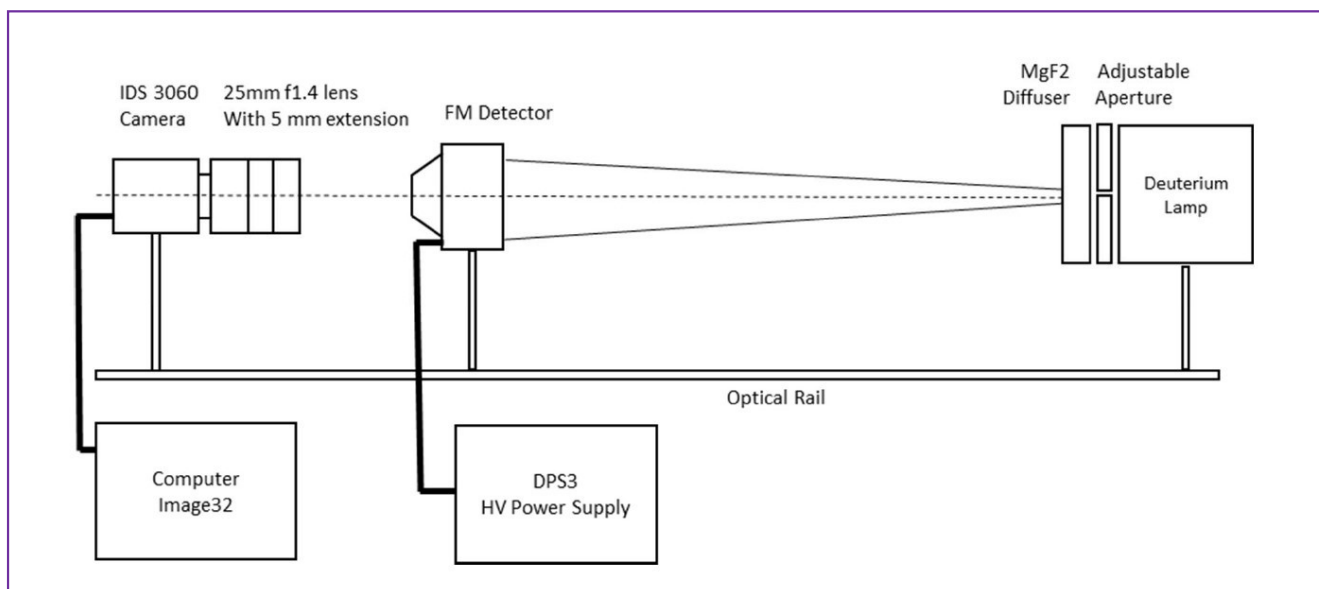
**Top: MCP voltage 2200 V**

- Average event size 6.94 pixels
- 1 Pixel 60  $\mu\text{m}$
- Event size 416.4  $\mu\text{m}$  FWHM

**Bottom: MCP voltage 2400 V**

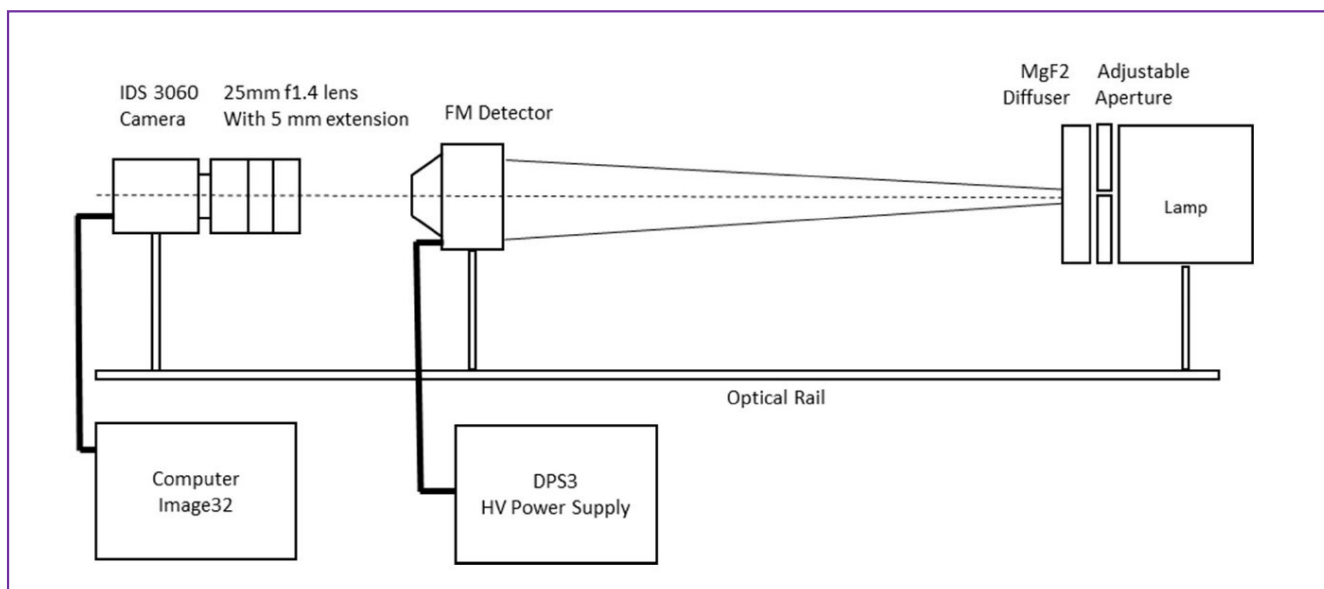
- Average event size 10.9 pixels
- 1 Pixel 60  $\mu\text{m}$
- Event size 654.0  $\mu\text{m}$  FWHM

## Set up 3



- Photon Counting Uniformity
- Pulse Gain Distribution
- Window Voltage
- Screen voltage
- Gain vs MCP
- Dark Noise
- Bright Defects
- Full Area Count Rate Linearity
- Spot Count Rate Linearity

# Set up 3

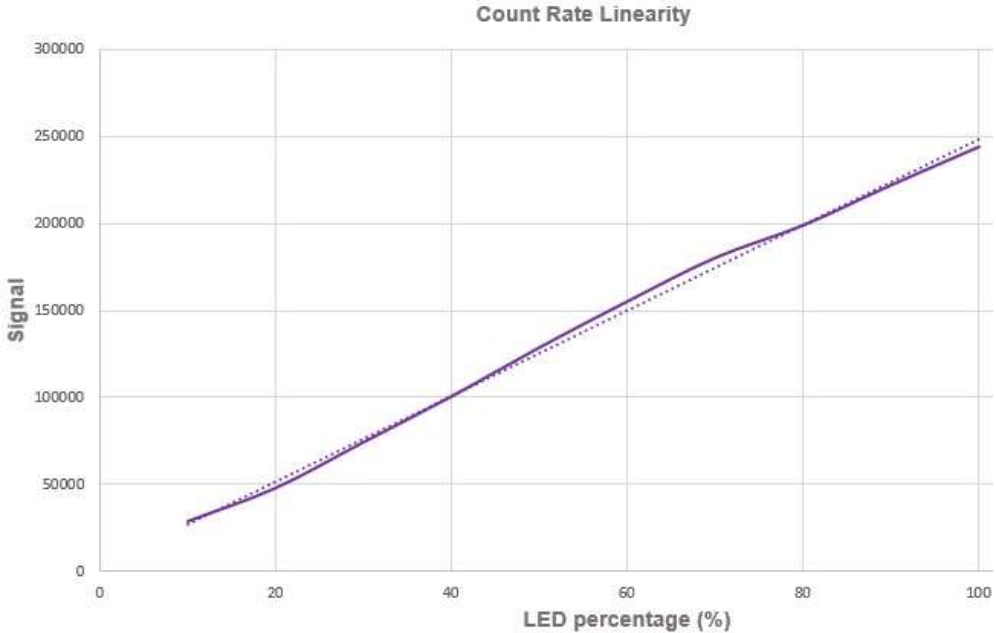


- Photon Counting Uniformity
- Pulse Gain Distribution
- Window Voltage
- Screen voltage
- Gain vs MCP
- Dark Noise
- Bright Defects
- Full Area Count Rate Linearity**
- Spot Count Rate Linearity**



- Test**
- 1.- Voltage at the MCP adjusted to a photon rate over 200.000 cps.
  - 2.- Light level of the Adjustable Led Source decreased in intervals of 10%

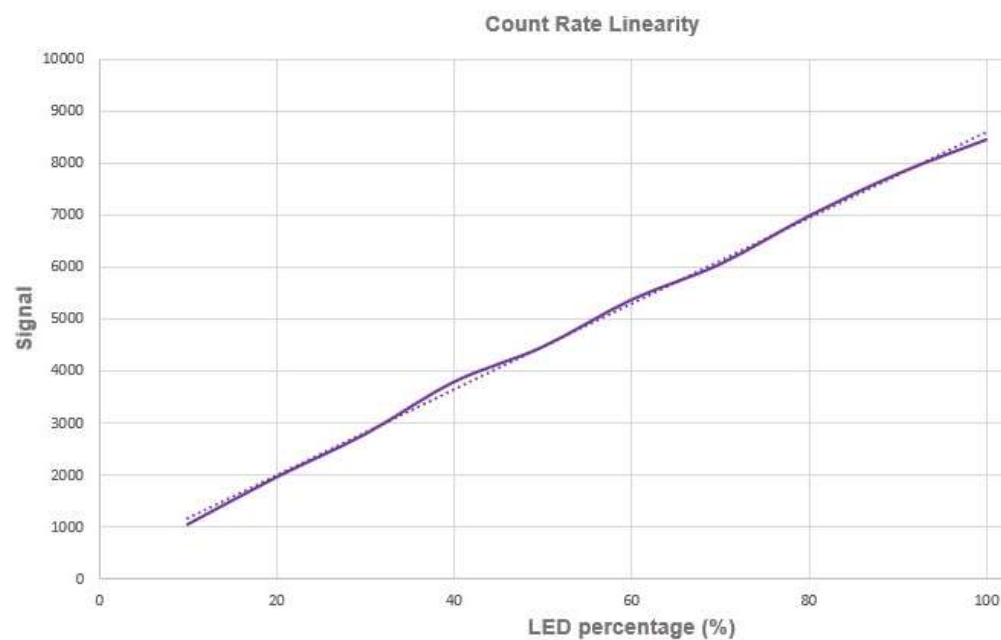
LED Percentage	Signal	Deviation
10	28501	-3.7
20	47701	8.4
30	74151	3.2
40	100482	0.7
50	128691	-2.3
60	155210	-3.2
70	180352	-3.1
80	199076	0.2
90	222254	0.8
100	244299	1.8



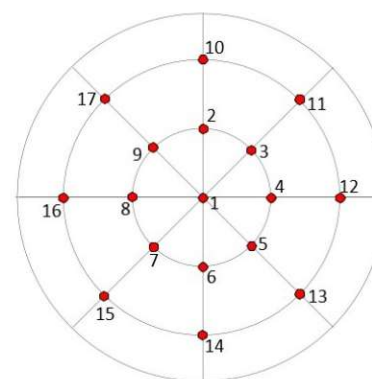
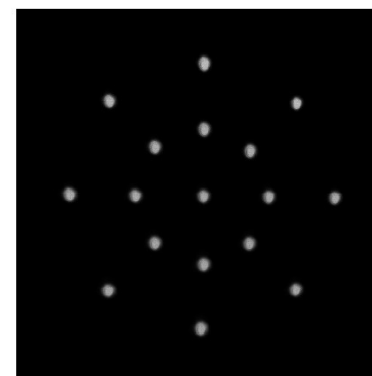
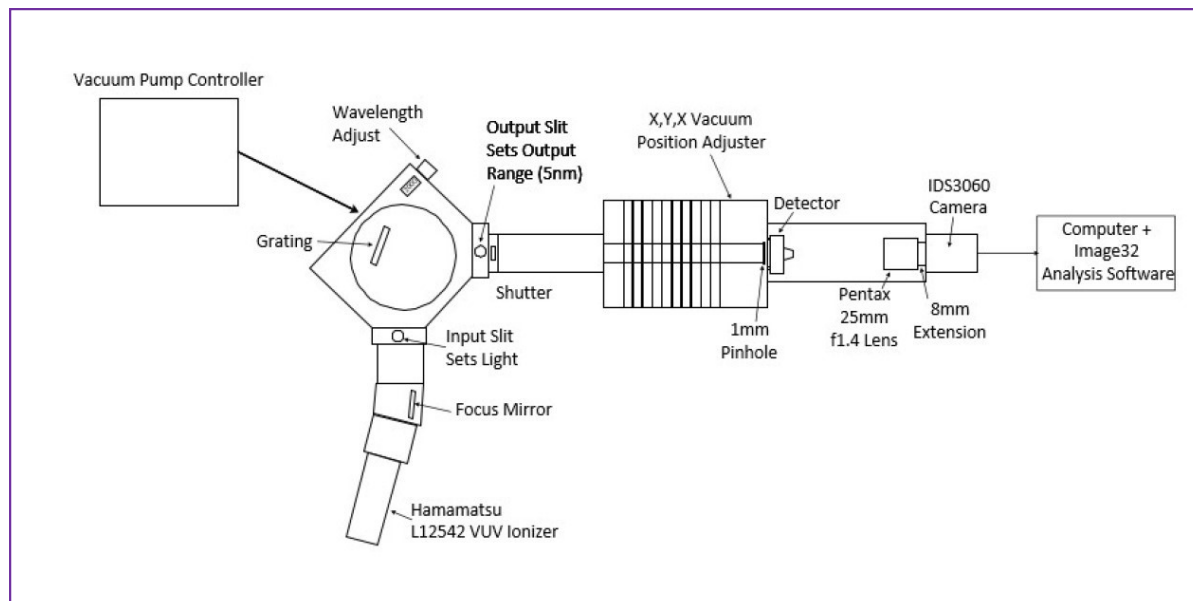
## Test

- 1.- 210  $\mu\text{m}$  diameter pinhole placed before the detector.
- 2.- Voltage at the MCP adjusted to a photon rate over 8.000 cps.
- 3.- Light level of the Adjustable Led Source decreased in intervals of 10%

LED Percentage	Signal	Deviation
10	1050	6.71
20	1959	-0.09
30	2789	-0.01
40	3795	-4.82
50	4470	-0.4
60	5379	-1.8
70	6065	0.82
80	6993	-0.66
90	7805	-0.34
100	8464	1.7



## Set up 4



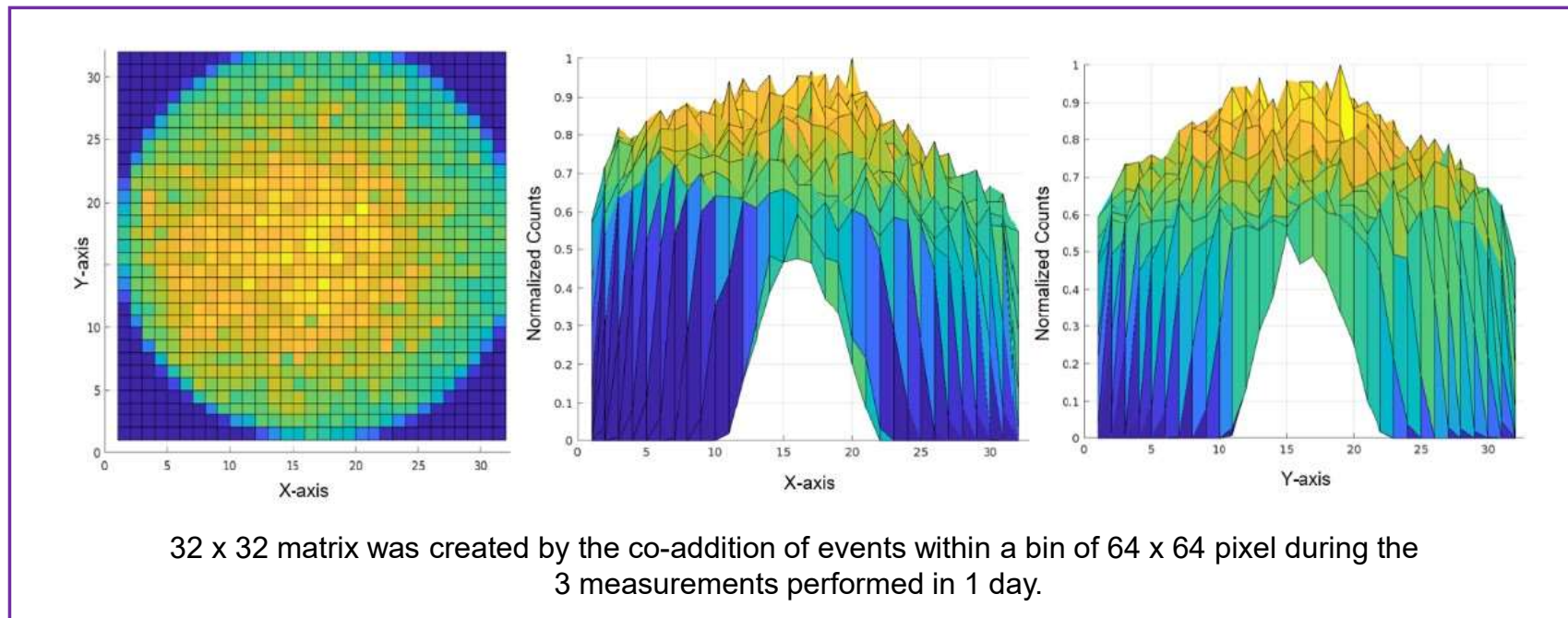
Position	Result	Deviation
1	46202	-1.4
2	46250	-1.3
3	46702	-0.3
4	46890	0.1
5	46073	-1.7
6	46779	-0.2
7	46441	-0.9
8	45905	-2
9	45486	-2.9
10	48309	3.1
11	48227	2.9
12	46875	0
13	46590	-0.6
14	48505	3.5
15	48111	2.7
16	47061	0.4
17	46653	-0.4
<b>Mean</b>	<b>46886</b>	-

### Test

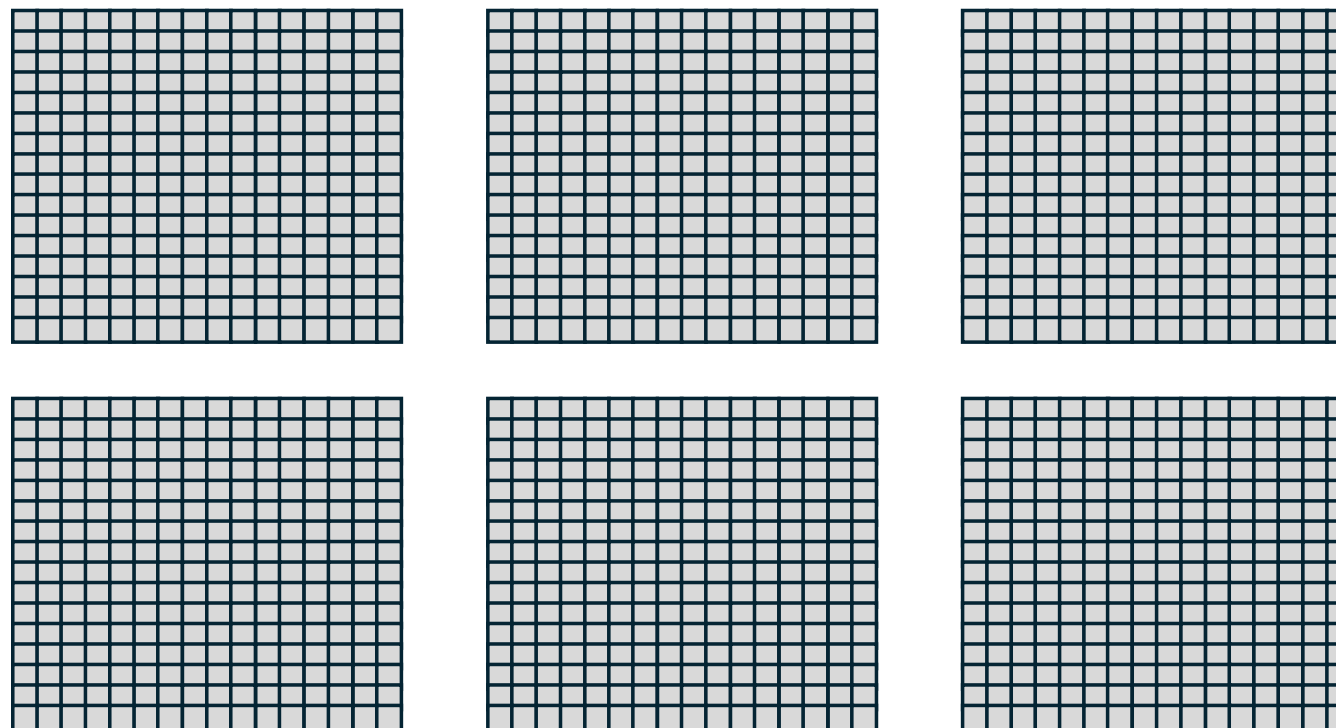
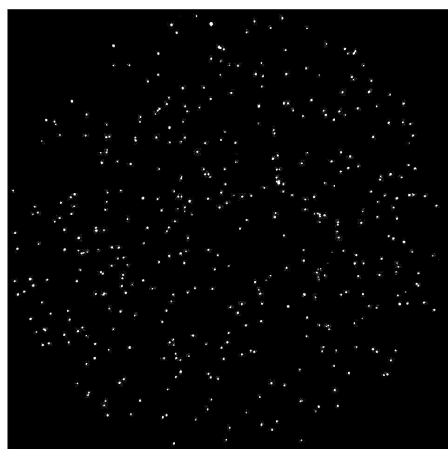
- 1.- The light beam passes through a 1 mm diameter pinhole.
- 2.- Photon-counting integration.
- 3.- Pinhole moved to another position of the detector's surface.
- 4.- Measurement repeated.
- 5.- Calculation of mean and standard deviation.

- 9 measurements: 3 measurements/day taken during 3 consecutive days.
- Frame rate: 60 FPS.
- 198 frames/measurement.
- Events extracted frame by frame and classified in a list showing the x and y coordinates of the centroids.
- Matrices have been created by the co-addition of events within a bin of the adequate size to reach suitable photon statistics.

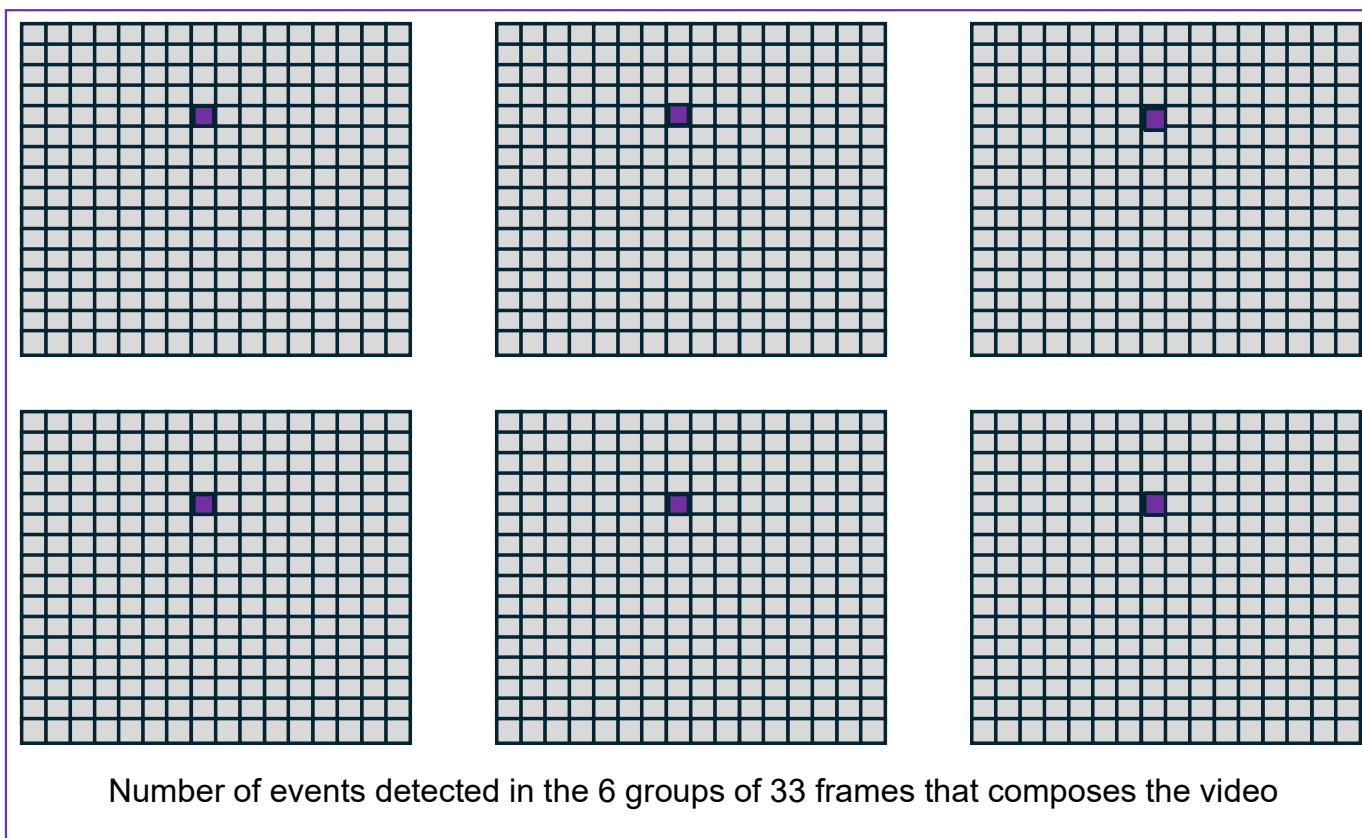
## Spatial Uniformity. FM1



## Temporary Stability. FM1

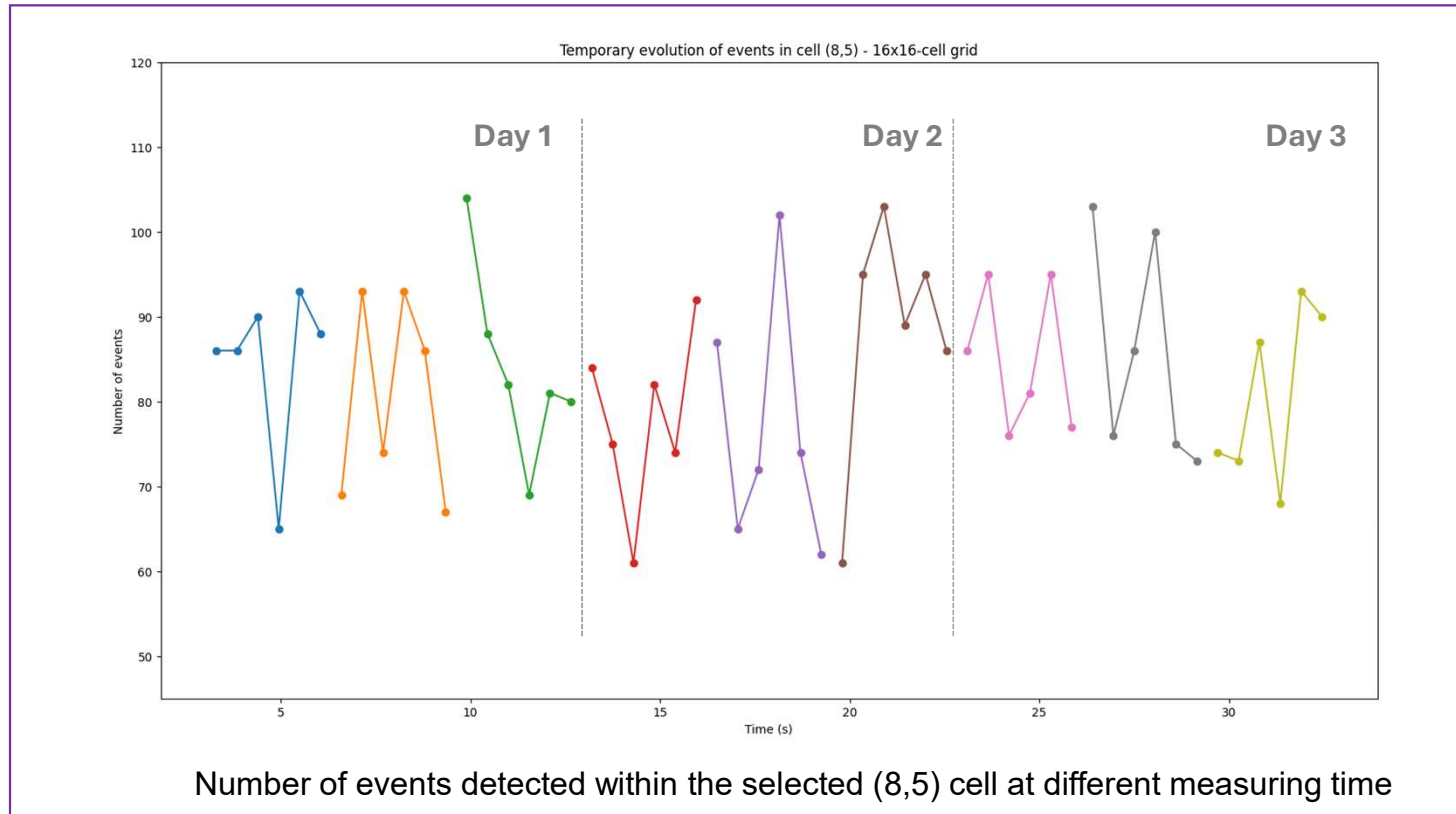


16 x 16 matrices were created for each measurement after the co-addition of the extracted events every 33 frames within a bin of 128 x 128 pixel



**3 measurements/day**  
**3 days of measurements**





No significant variations were observed in the number of events detected every 33 frames, in all the cells generated during the three days of measurements

- Both photon counting detector units have been completely qualified.
- Their performance meets the technical requirements of the WSO-UV scientific project.
- Environmental and Mechanical Tests have been successfully performed.
- The CMOS sensors have been bonded.
- Pending electronical integration and validation.

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