MCPSIM-PY

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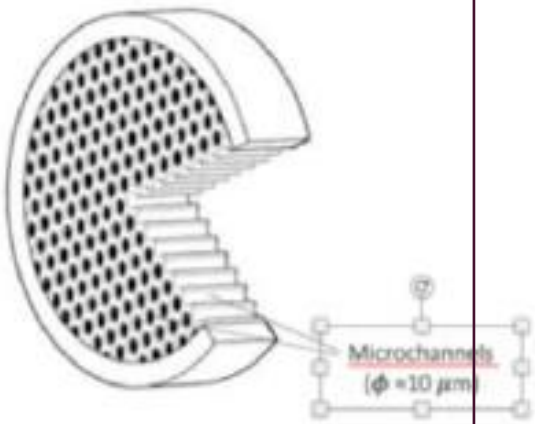
COMPONENTS OF THE MCP DETECTOR

1.Data input



2.MCP gain

3.Phosphor gain

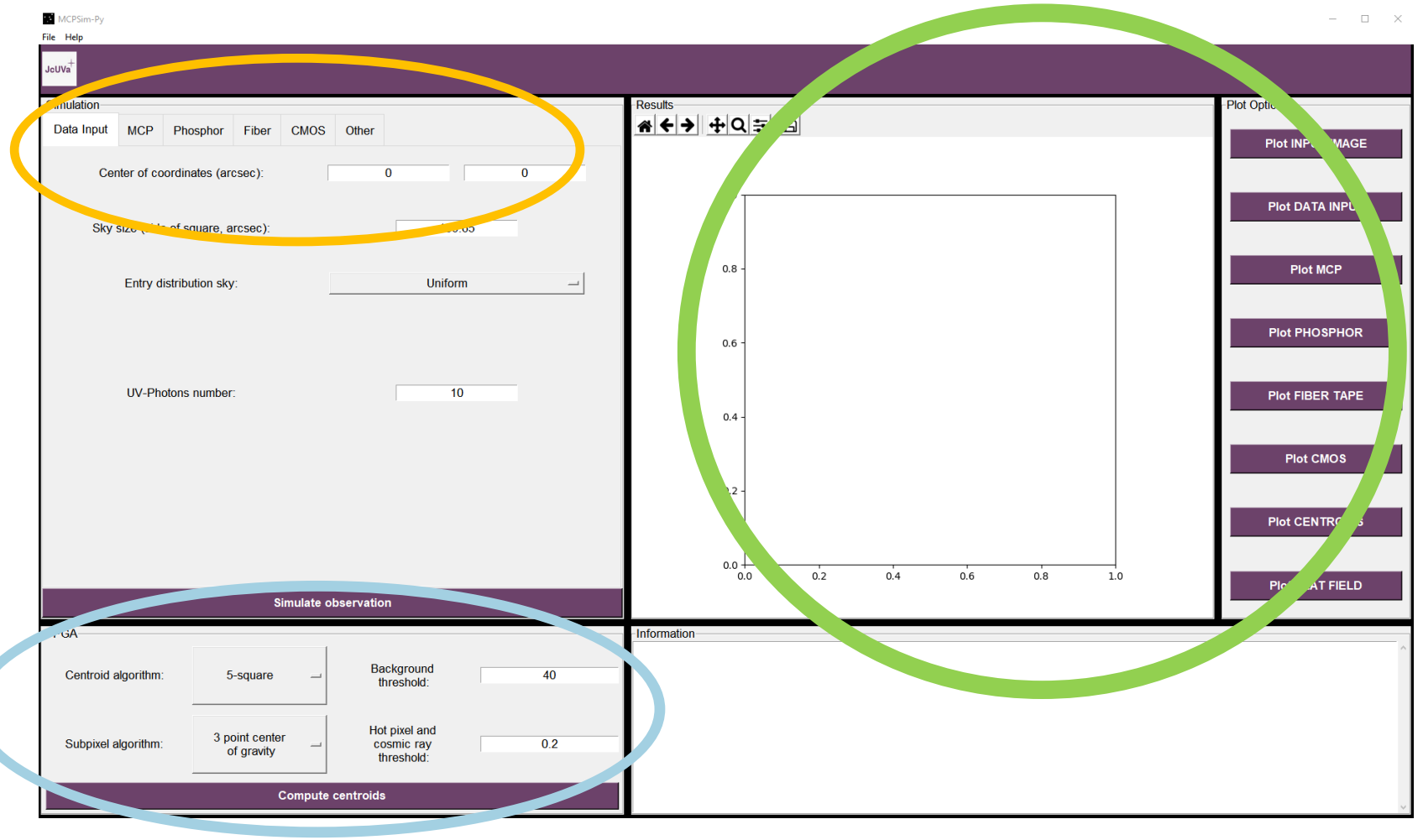
4.Fibers tape (compression)

5.CMOS

6.FPGA: Centroid detection

THE SIMULATOR STEP BY STEP

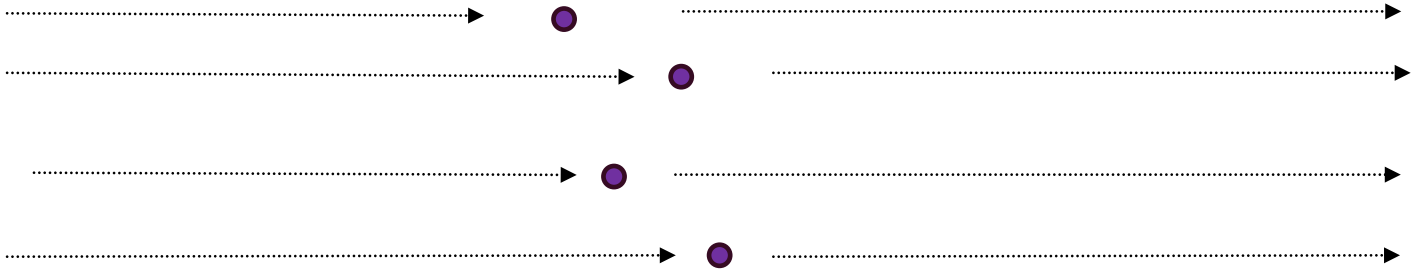
INPUT WINDOW
DATA
PARAMETERS



GRAPHIC
OUTPUT

CENTROIDING
ALGORITHMS
CONTROL

1. DATA INPUT: GENERATION (THREE MODES AVAIBLES)



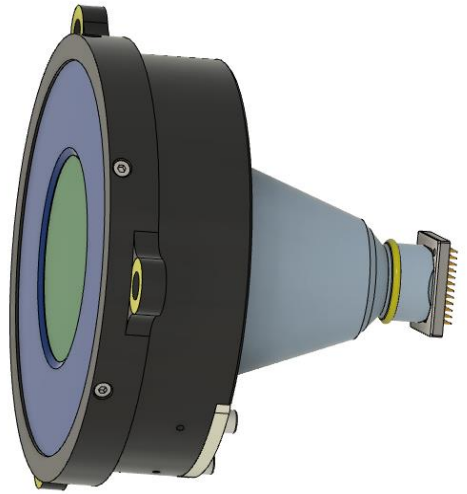


Image distribution

Uniform distribution

Two sources

THE LOCATION ON THE IMAGE AND THE TIMING OF THE SIMULATED PHOTONS IS DETERMINED STATISTICALLY

Center of coordinates (arcsec): 0 0

Sky size (side of square, arcsec): 166.65

Entry distribution sky: Uniform

UV-Photons number: 10

Center of coordinates (arcsec): 0 0

Sky size (side of square, arcsec): 166.65

Entry distribution sky: Image

Image path: ../../img/sky/205674main_m51.jpg Search

UV-Photons number: 10

Center of coordinates (arcsec): 0 0

Sky size (side of square, arcsec): 166.65

Entry distribution sky: Two sources

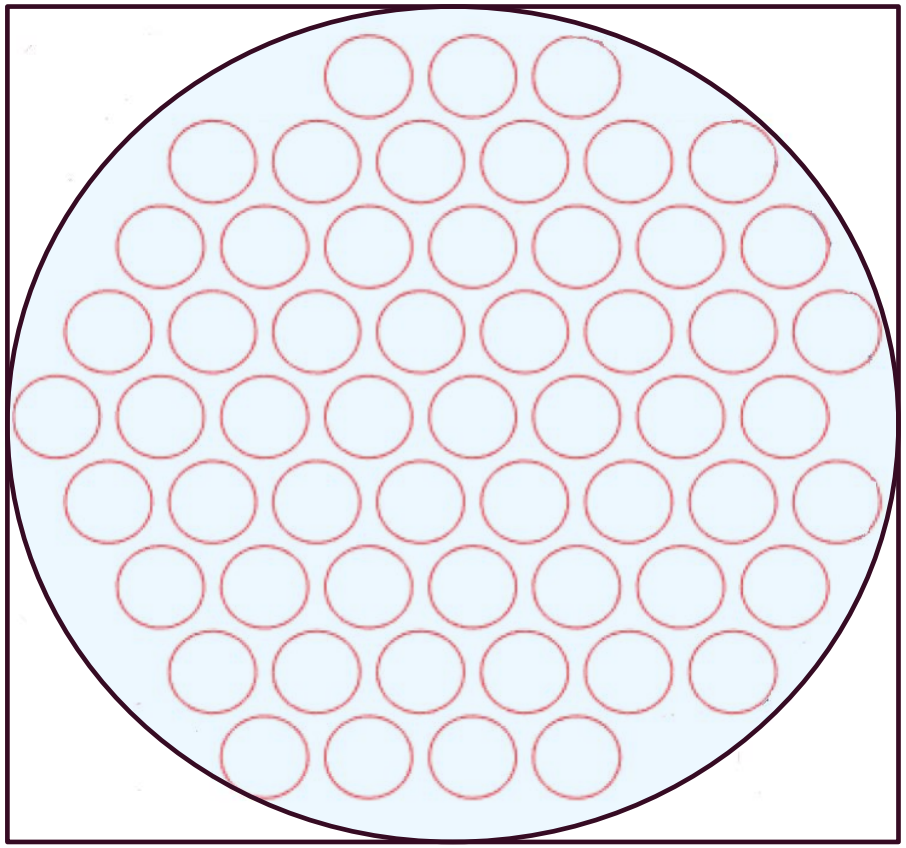
Source 1 (uv-photons/reading): 10

Source 2 (uv-photons/reading): 2

FWHM (arsec): 0.1

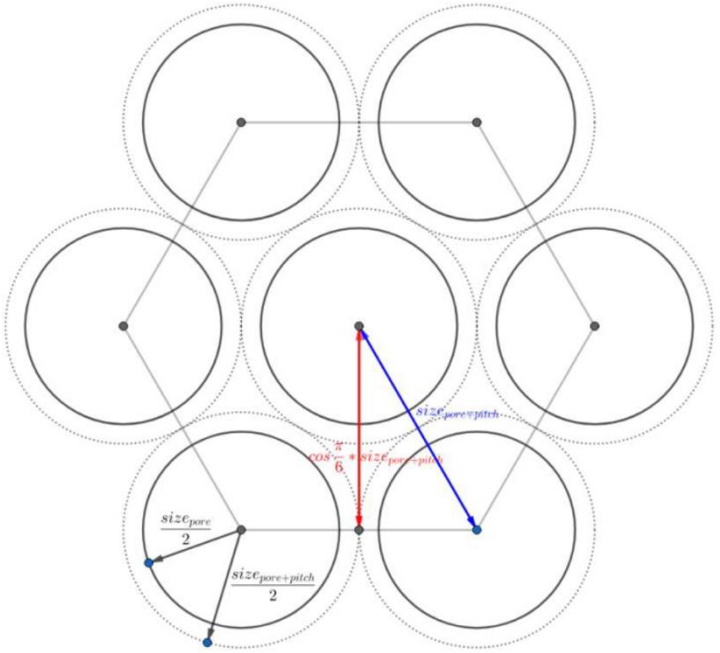
Distance between sources (arsec): 10

1. MCP ENTRANCE WINDOW



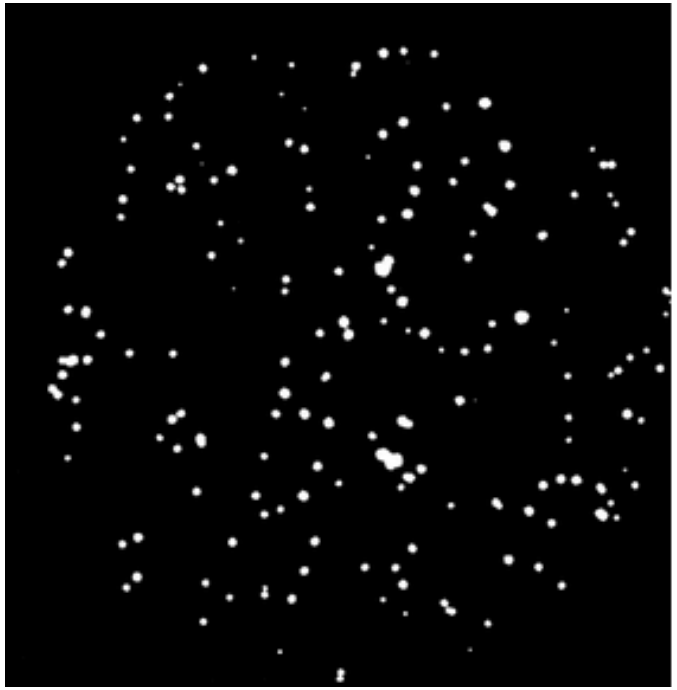
MICRO TUBES CHARACTERIZATION

- PORE DIAMETER
- PITCH
- GEOMETRY



2. MCP GAIN TRANSFER FUNCTION

SAMPLE IMAGE OF THE DETECTOR PERFORMANCE



IMPORTANT:
DUE TO THE STATISTICAL NATURE OF THE DETECTION PROCESS
SIMILAR EVENTS PRODUCE DIFFERENT SHOWERS

THIS STATISTICAL NATURE IS MODELLED
AND IMPLEMENTED IN THE SIMULATOR

STEPS TO CHARACTERIZE THIS BEHAVIOR

Image binarization

Elimination of all the showers with little size

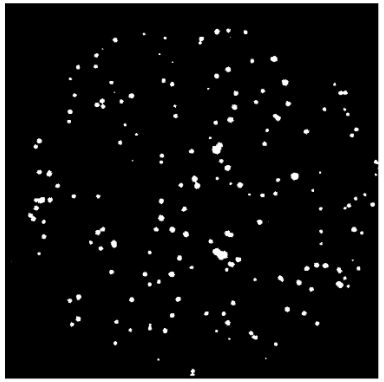
Connected regions detection

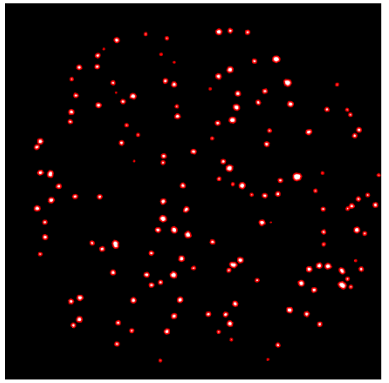
Elimination of showers with eccentricities that are bigger than a theshold value

Remove background noise

(minor than 4 electrons)

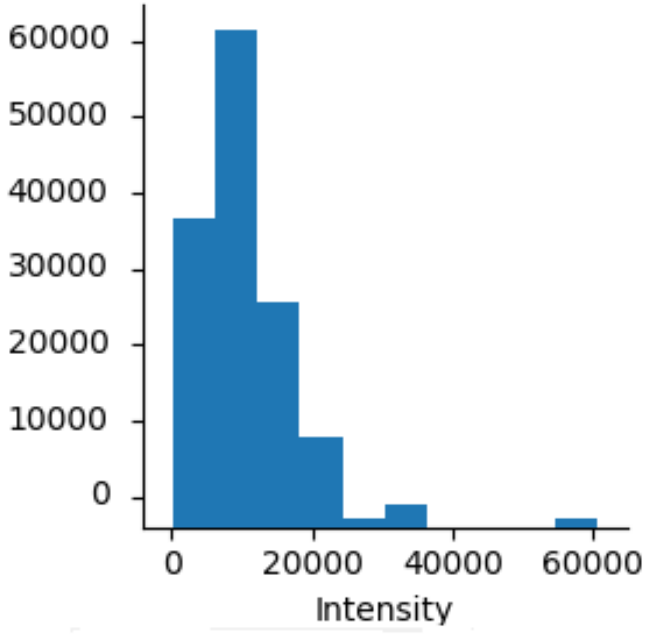
Calculate the mayor axis (a), minor axis (b) and the peak of each resultant shower



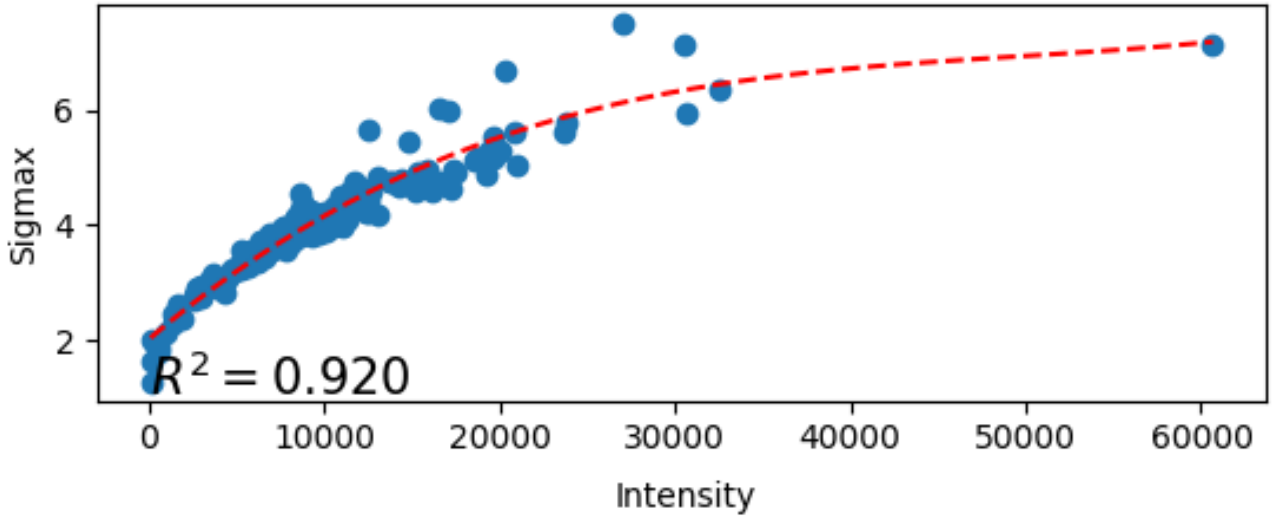


SHOWER PARAMETERS (TRANSFER FUNCTION)

Statistical distribution by intensity



Statistical distribution by width

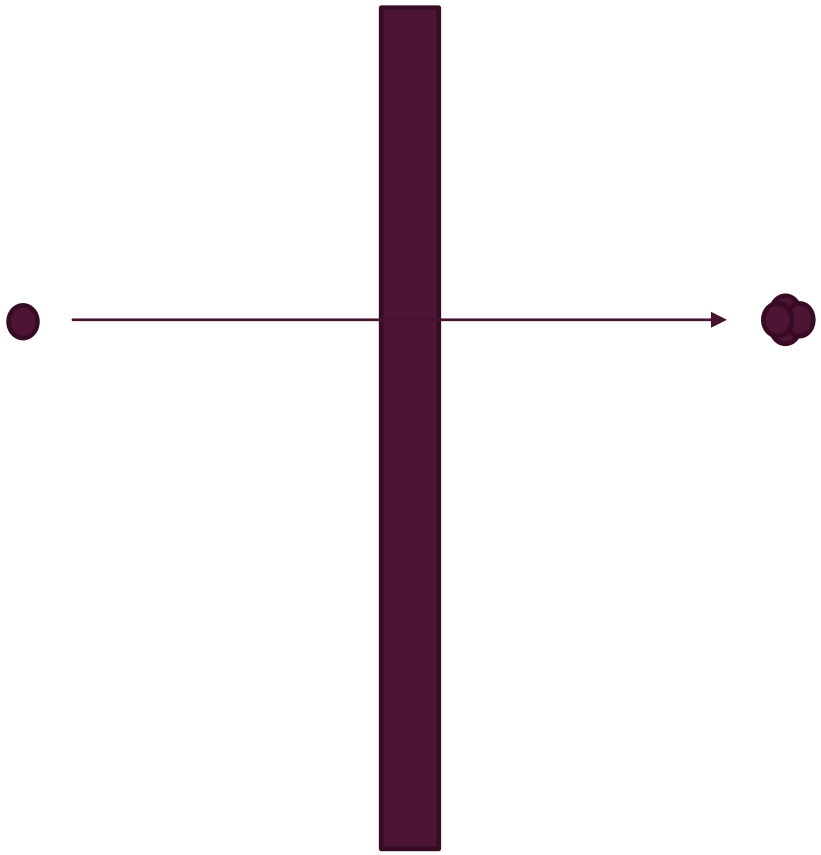


MCP Gain:	100000
Simple transfer function (normal deviate of the showers):	0.106

☑ MCP-specific transfer function:	../../img/mcp/	Search
Eccentricity filter:	0.7	

Pore diameter on MCP (microns):	10
Pore pitch on MCP (microns):	12

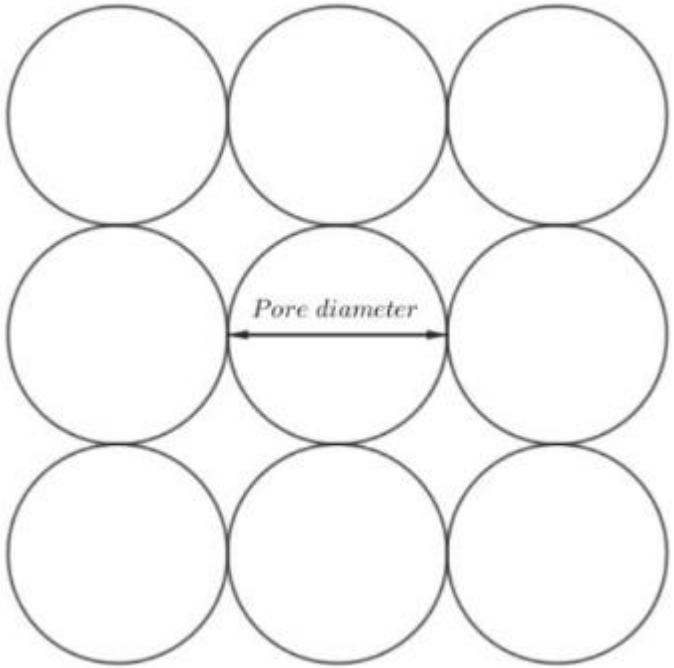
3.PHOSPHOR GAIN



Phosphor Gain: 40

Example: x4 phosphor gain

4.FIBERS TAPER



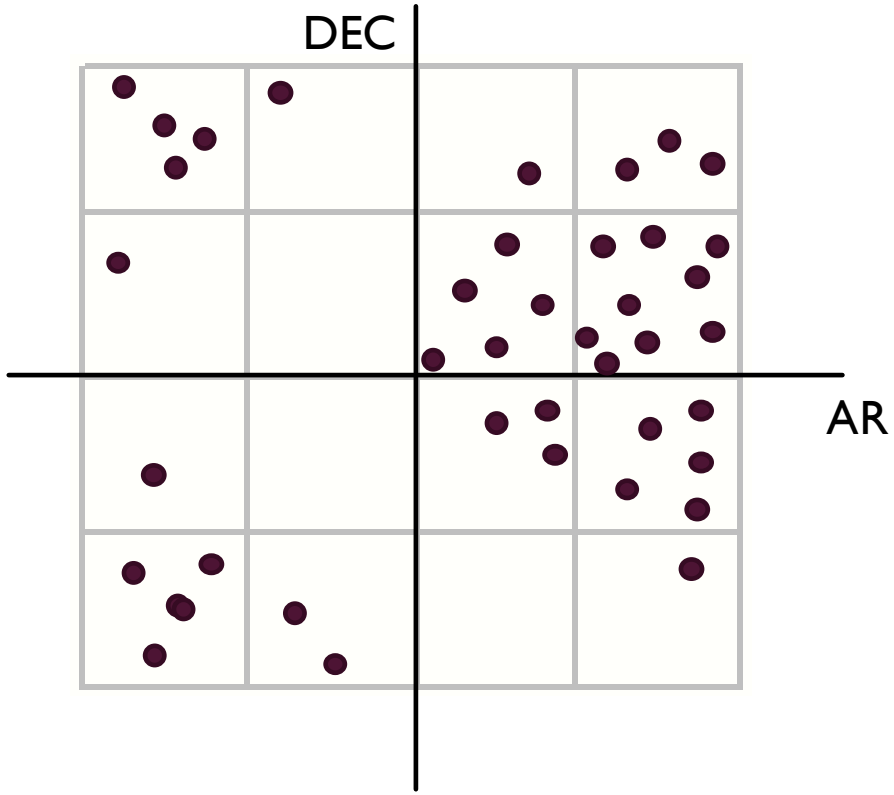
Steps:

- Filter photons that do not go through the fibers.
- Apply a spatial uniform distribution inside each tube

$$Loss\ factor = \frac{Circle\ area}{Square\ area} = \frac{\pi * R^2}{4 * R^2} = \frac{\pi}{4}$$

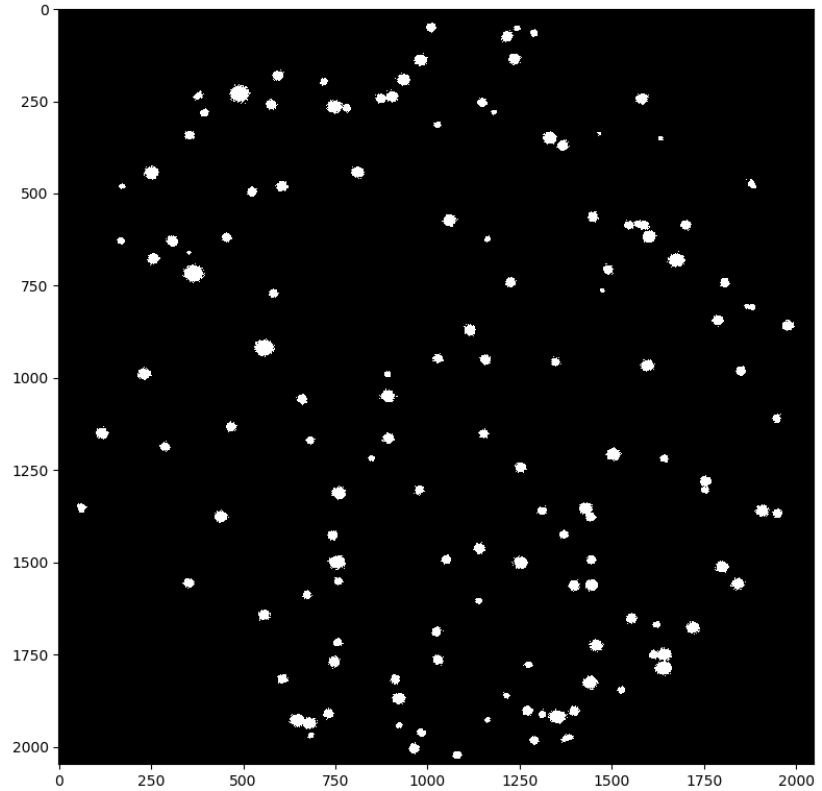
Pore diameter on fiber inlet (microns):	10
Factor (demagnification factor):	3.55
Fiber transmittance:	0.0331
Flux loss factor (geometry):	*0.7854*
*Flux decrease in the fiber tape (geometry factor * fiber transmittance):*	*0.026*

5.GENERATION OF THE CMOS IMAGE



4	1	1	3
1	0	5	9
1	0	3	5
5	2	0	1

OUTPUT EXAMPLE



Pixel size (microns): 5.5

Full well capacity (e-/pixel): 13500

Gain (e-/ADU): 1.6

Quantum Efficiency: 0.6

☐ Hot pixels Percentage (%): 0.001 Hot pixel value: 13500

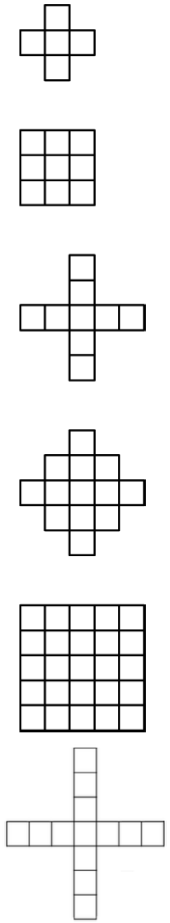
☐ Flat field Image path: ../../img/flatfield/flat_field_1.jpg Search

☐ Readout noise Value (e-/pixel): 6

6.FPGA: CENTROID DETECTION

Centroid algorithms

- 3-cross
- 3-square
- 5-cross
- 5-circle
- 5-square
- 7-cross

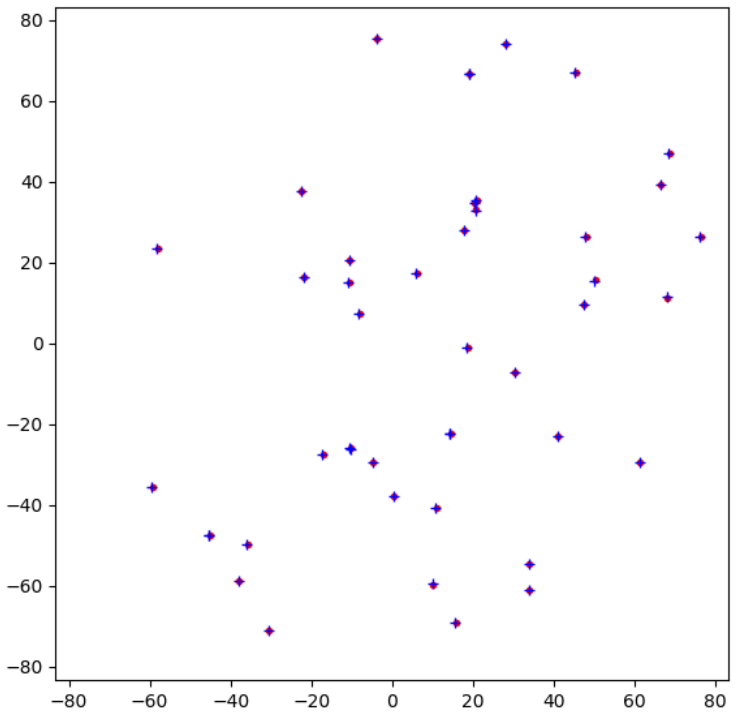


Subpixel algorithms

- 3-point center of gravity
- Gaussian
- Lorentzian
- Parabola
- 5-point center of gravity
- 7-point center of gravity

N.Pixels	NAME OF ALGORITHM	1-axis (X-axis) centroid	GRAPHIC LAYOUT
3	3-point center of gravity	$x_c = \frac{c-a}{a+b+c}$	a b c
	Gaussian	$x_c = \frac{\ln(c) - \ln(a)}{2(2\ln(b) - \ln(a) - \ln(c))}$	
	Lorentzian	$x_c = \frac{c-a}{2\left(c+a-\frac{2ac}{b}\right)}$	
	Parabola	$x_c = \frac{c-a}{2(2b-a-c)}$	
	Hyperbolic cosine	$x_c = \frac{ln\left(\frac{2\sqrt{\frac{b}{a}}+\sqrt{\left(\sqrt{\frac{b}{a}}+\sqrt{\frac{b}{c}}\right)^2-4}}{2\sqrt{\frac{b}{c}}+\sqrt{\left(\sqrt{\frac{b}{a}}+\sqrt{\frac{b}{c}}\right)^2-4}}\right)}{2ln\left(\frac{1}{2}\left(\sqrt{\frac{b}{a}}+\sqrt{\frac{b}{c}}+\sqrt{\left(\sqrt{\frac{b}{a}}+\sqrt{\frac{b}{c}}\right)^2-4}\right)\right)}$	
5	5-point center of gravity	$x_c = \frac{2e+d-b-2a}{a+b+c+d+e}$	a b c d e
7	7-point center of gravity	$x_c = \frac{3g+2f+e-c-2b-3a}{a+b+c+d+e+f+g}$	a b c d e f g

Results



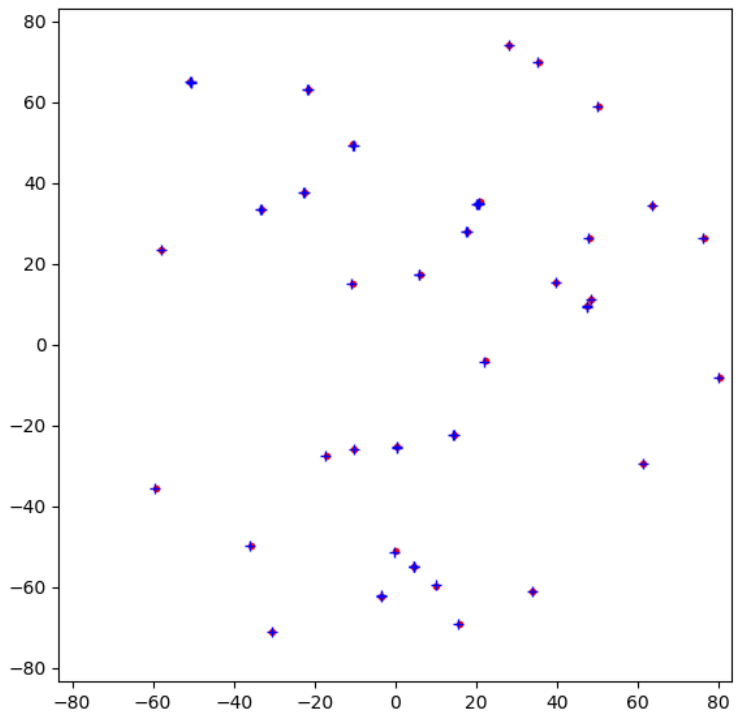
Information

Data_input (uv-phothons): 100
MCP-in (uv-photons): 41
MCP out (electrons): 1079577
Phosphor (photons): 43183080
Fiber Tape (photons): 1086953

Centroids info:

Real events: 41
Detected events: 45

Results



Information

Data_input (uv-phothons): 100
MCP-in (uv-photons): 36
MCP out (electrons): 934908
Phosphor (photons): 37396320
Fiber Tape (photons): 949437

Centroids info:

Real events: 36
Detected events: 52