RIPTIDE

July 2024

Gen-Z **Learner's Dictionary**

BDE: acronym. *Term used for someone who exudes confidence and ease.*

Courtesy of E. Sanzani

RIPTIDE

1) Sensor characterization using diffraction pattern

1) Setup

Objective: to *estimate* the lowest amount of photons that is possible to detect in the sensor camera

1) Measured the total light exiting from the slit

2) Compared this value with the amplitude of the single diffraction peaks

- Distance slit-camera : 30.5 cm

CAMERA ASI533

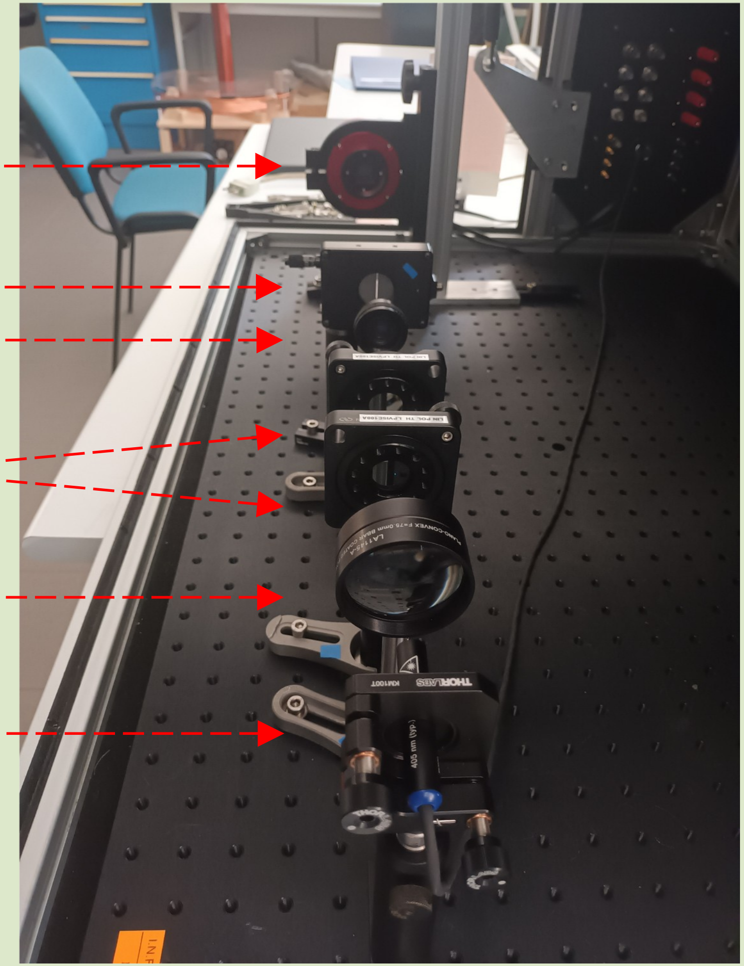
SLIT (278 μm)

DIAPHRAGM

POLARIZERS

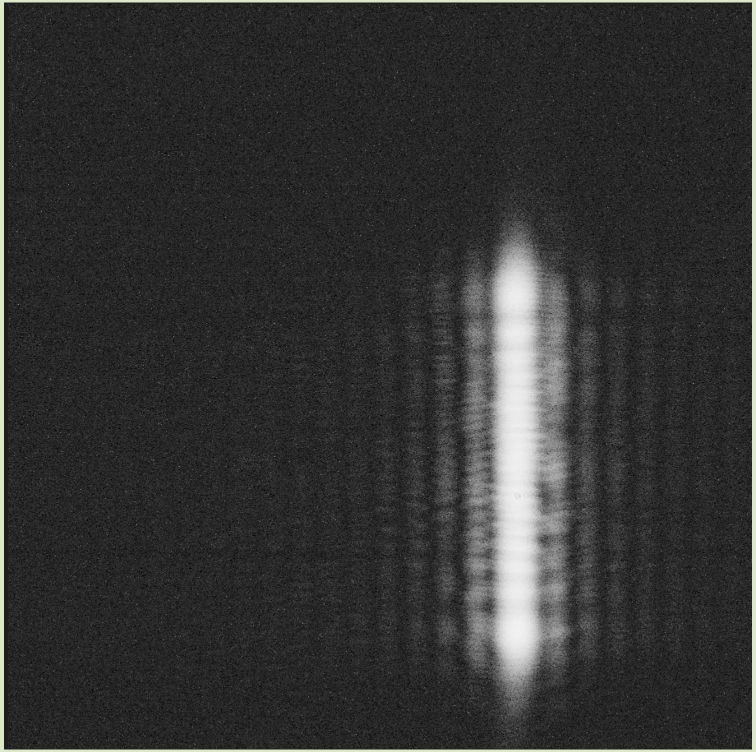
LENS F75mm

LED (405/635 nm)



2) LAB Data

Laser= 405 nm - Gain= 300 - expTime= 1 ms

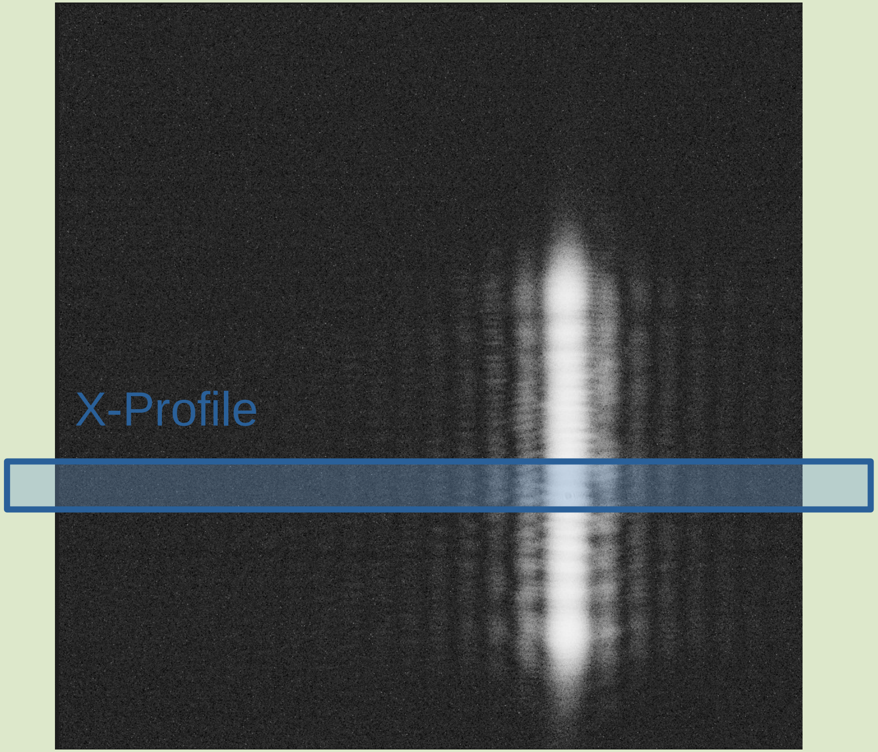


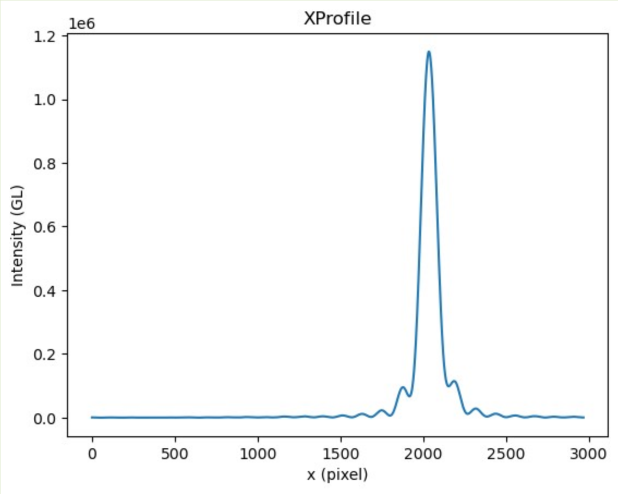
This is the raw data.

We can identify two pattern

2) LAB Data

Laser= 405 nm - Gain= 300 - expTime= 1 ms



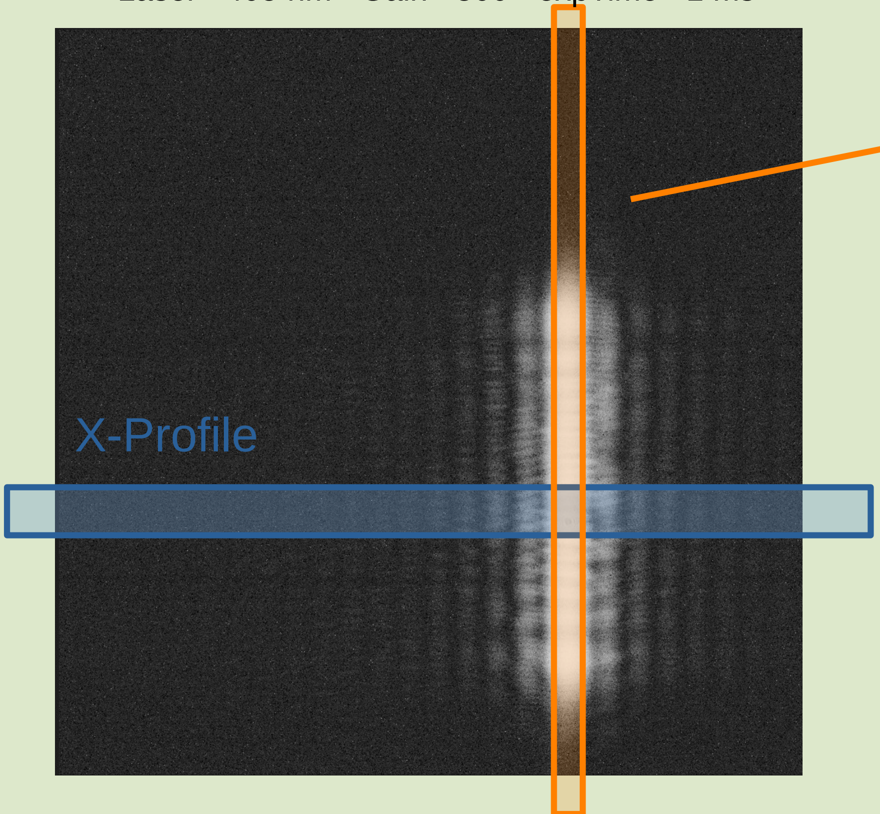


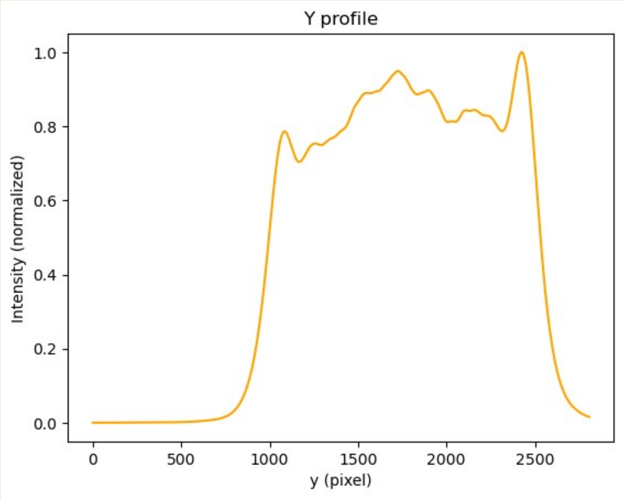
this nice shape is the diffraction pattern

2) LAB Data

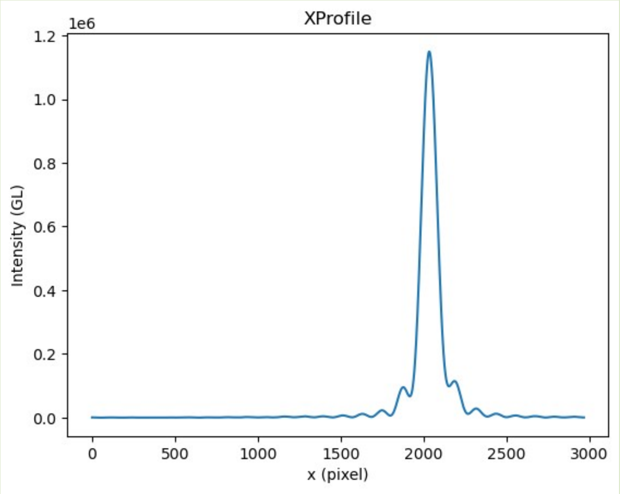
Y-Profile

Laser= 405 nm - Gain= 300 - expTime= 1 ms





this weird shape is intrinsic to the laser we used



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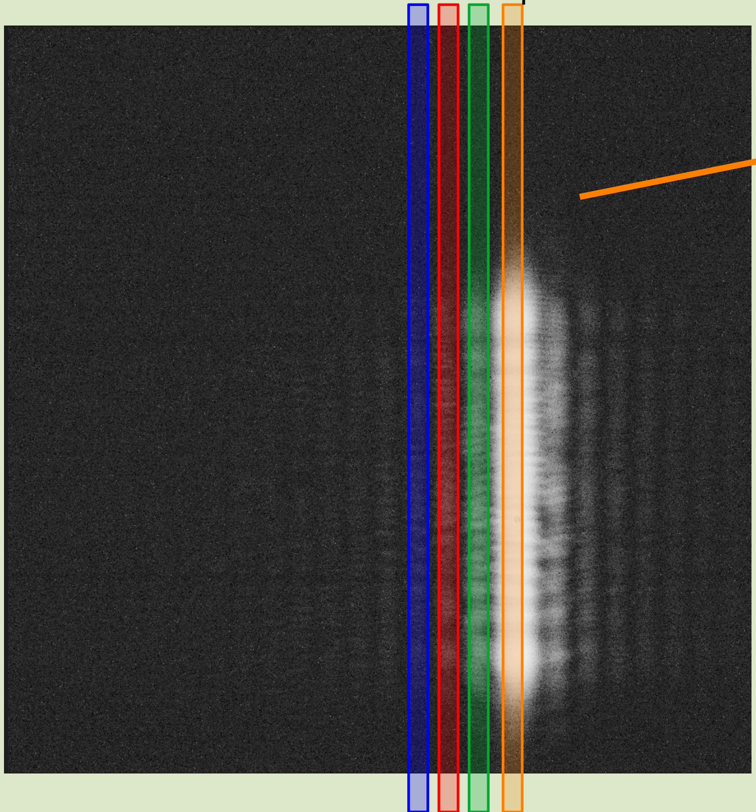

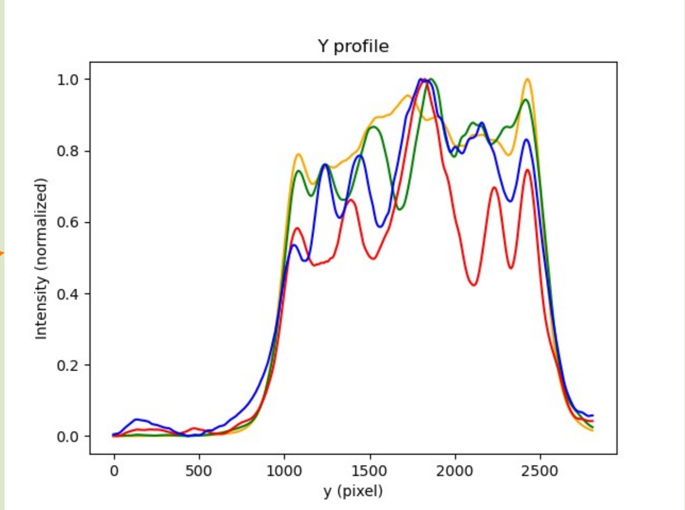

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Moreover, the Y-Profiles are different for each diffraction peak

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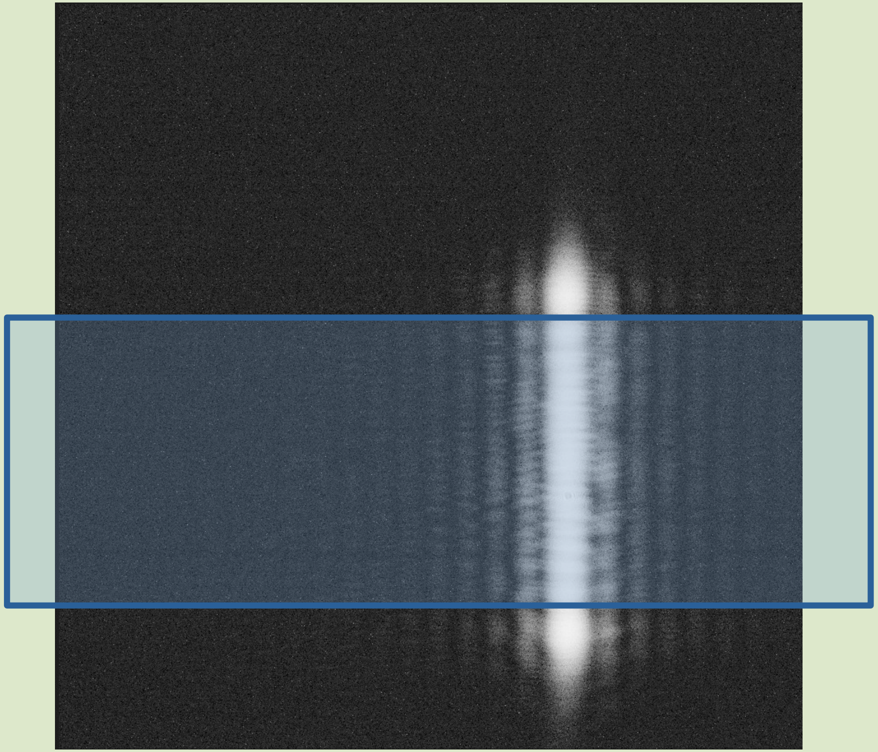
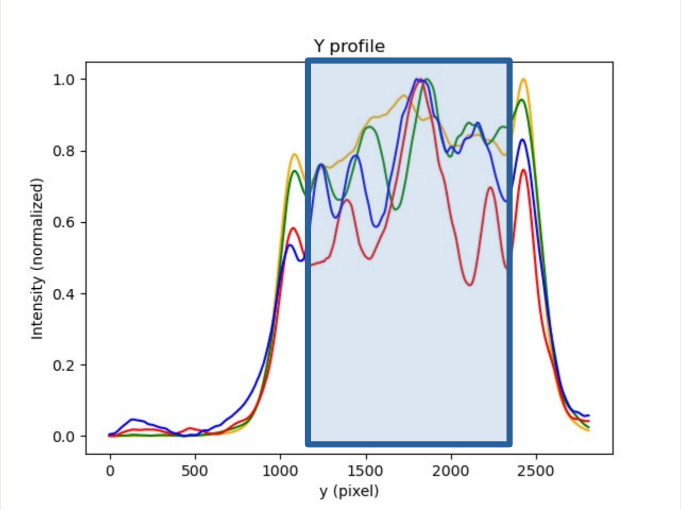




this weird shape is intrinsic to the laser we used

Moreover, the Y-Profiles are different for each diffraction peak

∴ Need to make the average of a bigger region in order to minimize the effect of the laser profile

3) Data analysis

The **main goal** is to compare the amount of light in the diffraction peaks with the amount of light measured by the photodiode.

I need to know:

1) The amount of light reaching the photodiode:

$V_{measured}$ [V] = Power measured by the photodiode ((270±20)E-3 V)
Gain [V]/[A] = amplifier conversion factor (10^6 V/A)
S [mA]/[W] = Photodiode conversion factor (180 mA/W)
C [eV] / [J] = Joule to eV conversion (6.24E18 eV/J)
E_{photon} = energy of the single photon (3.06 eV for blue light)

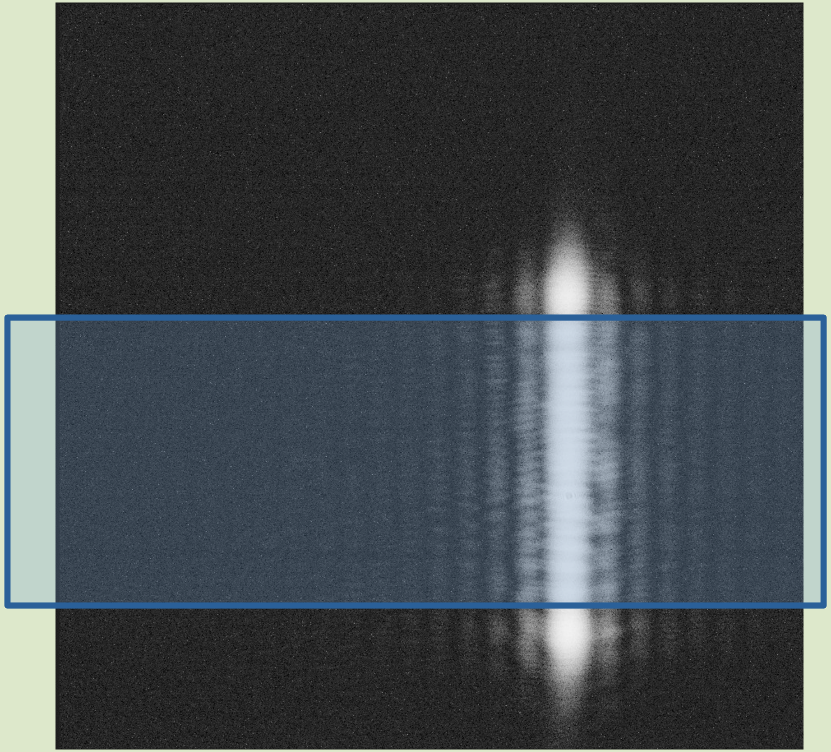
$$Photons\ per\ s = \frac{V_{measured}}{Gain \cdot S} \cdot \frac{C}{E_{photon}}$$

(3.1±0.2) E9 photons / ms

2) The ratio between the total area and the area of the single peak: (next slides...)

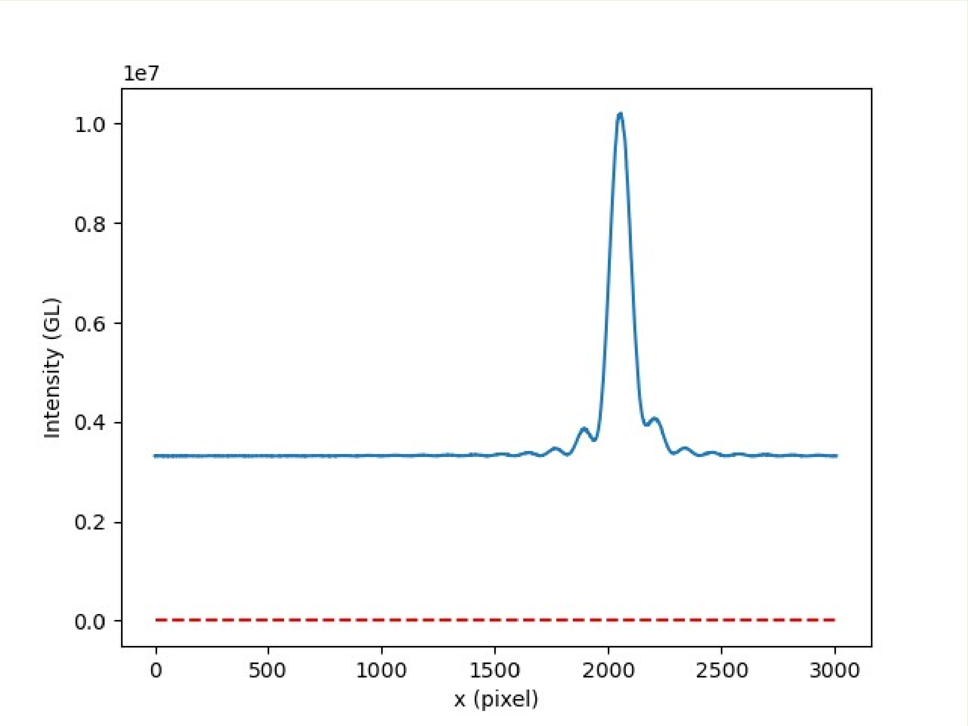
3) Data analysis

Laser= 405 nm - Gain= 300 - expTime= 1 ms



ythickness = 1200 pixel

my Y-Profile



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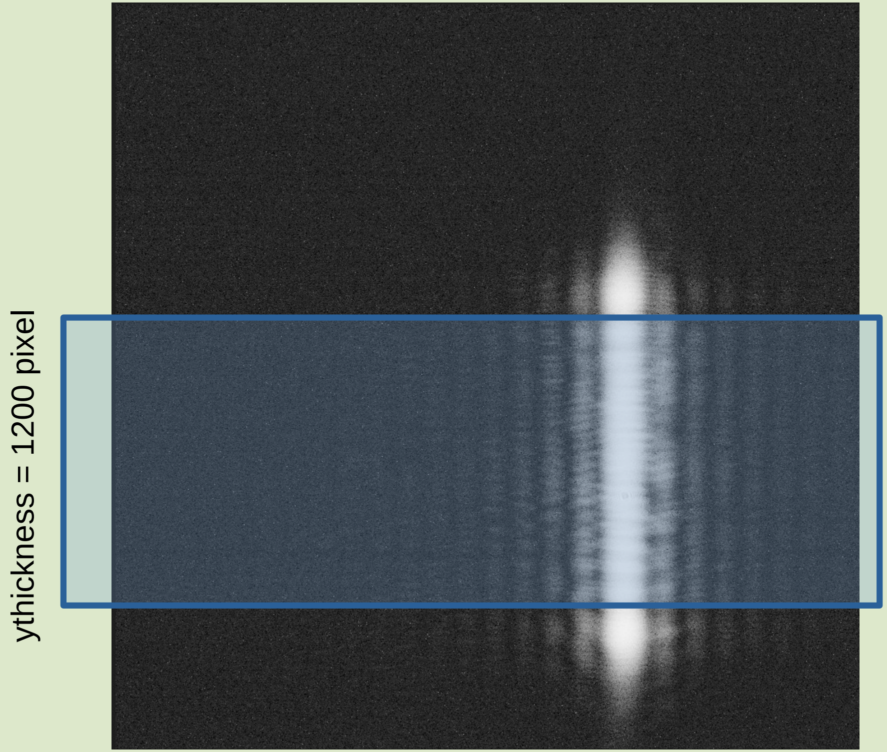
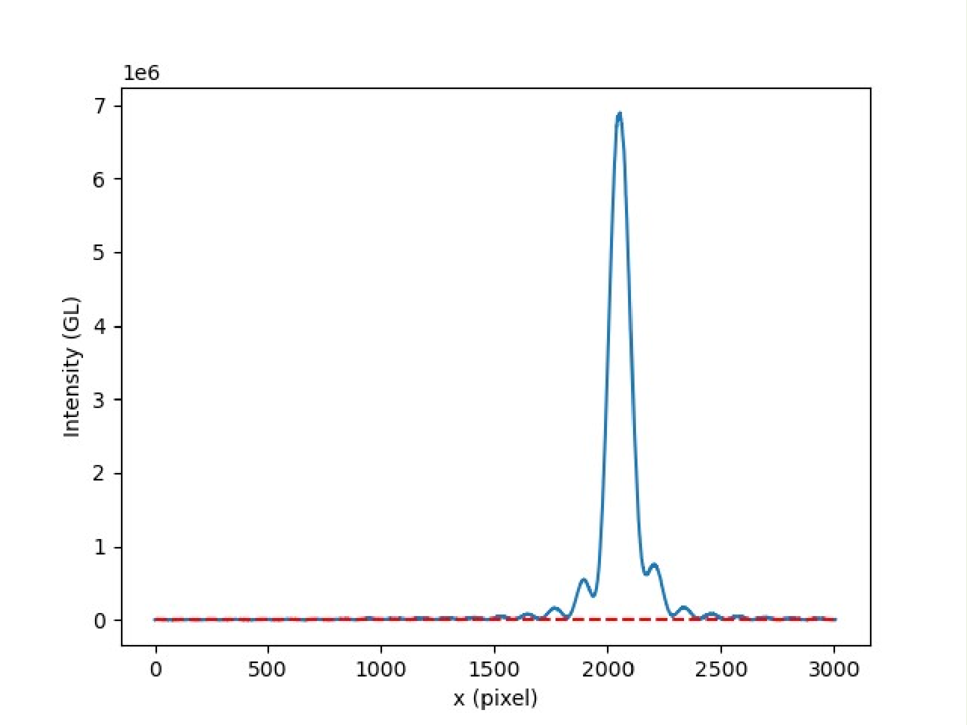


bias subtraction (2762 GL/pixel)



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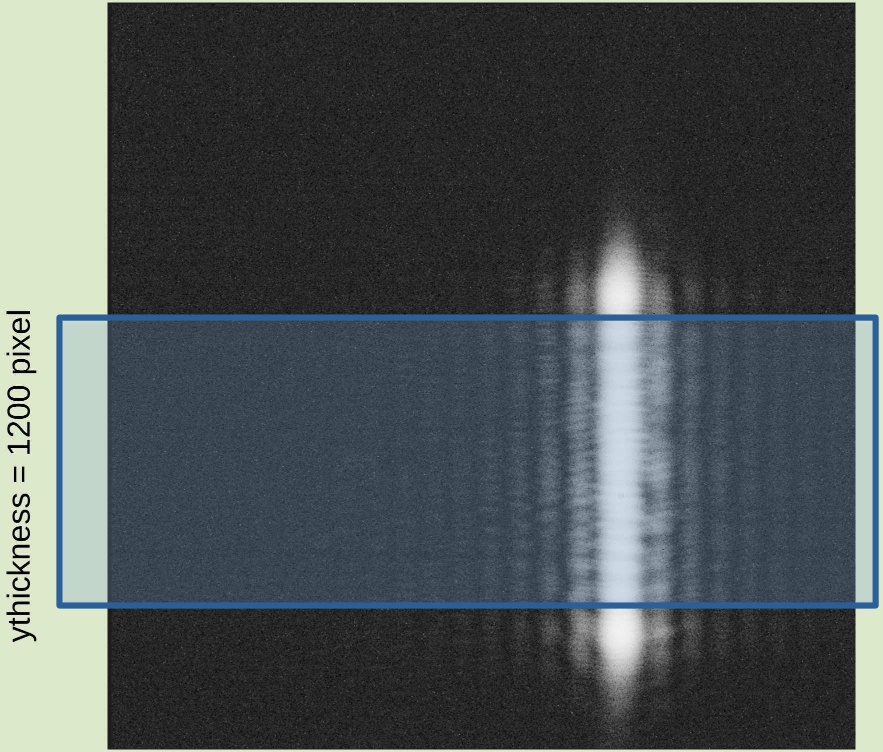
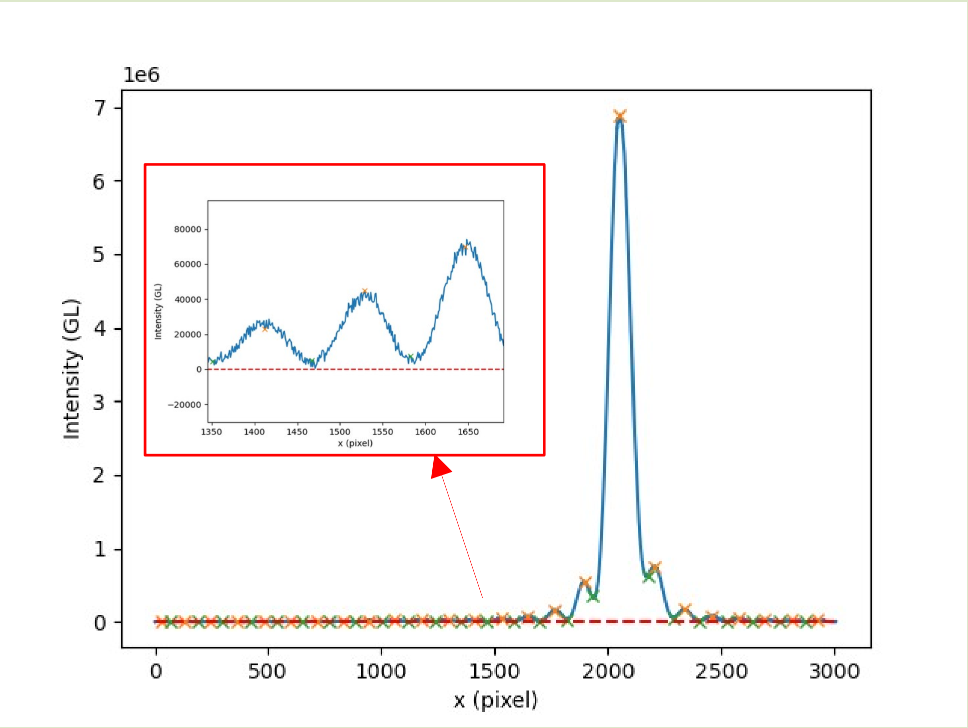


find diffraction peaks and valleys



3) Data analysis

For each diffraction peak:

- Select a region around the peak and summed al the GL of the pixels inside the region

- Compare this value with the total integral in GL

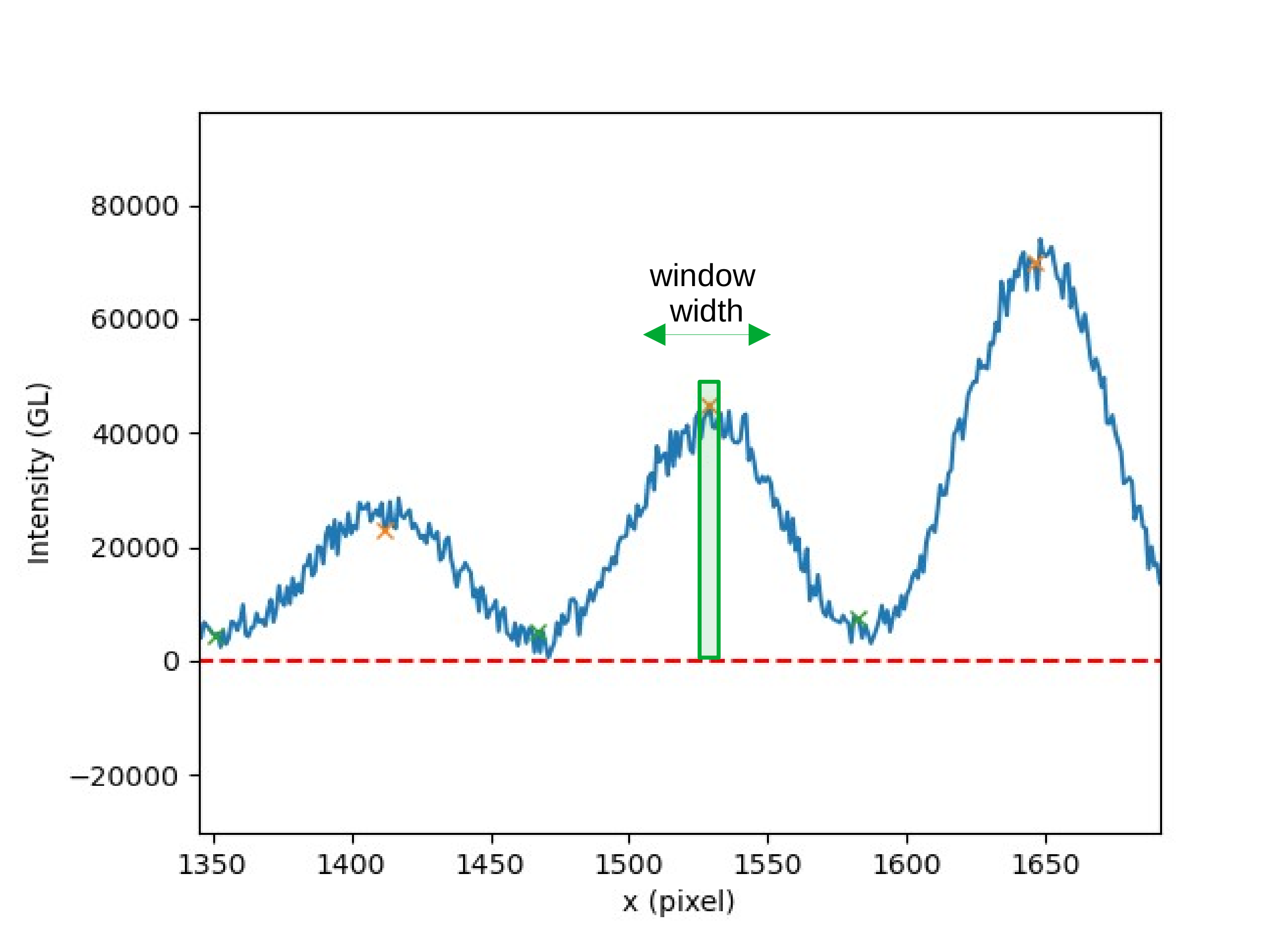
$$photons\ in\ peak = \frac{\sum GL_{peak}}{\sum GL_{total}} \cdot photons\ per\ millisecond$$

- Then estimate average photons per pixel

$$photons\ per\ pixel = \frac{photons\ per\ millisecond}{ythickness \cdot window\ width}$$

ythichness = 1200 pixels (see previous slide)
window width = [1, 2, 5, 10 ,20, 30, 50] pixels

NB: this is necessarly an underestimation of the number of photons per pixel



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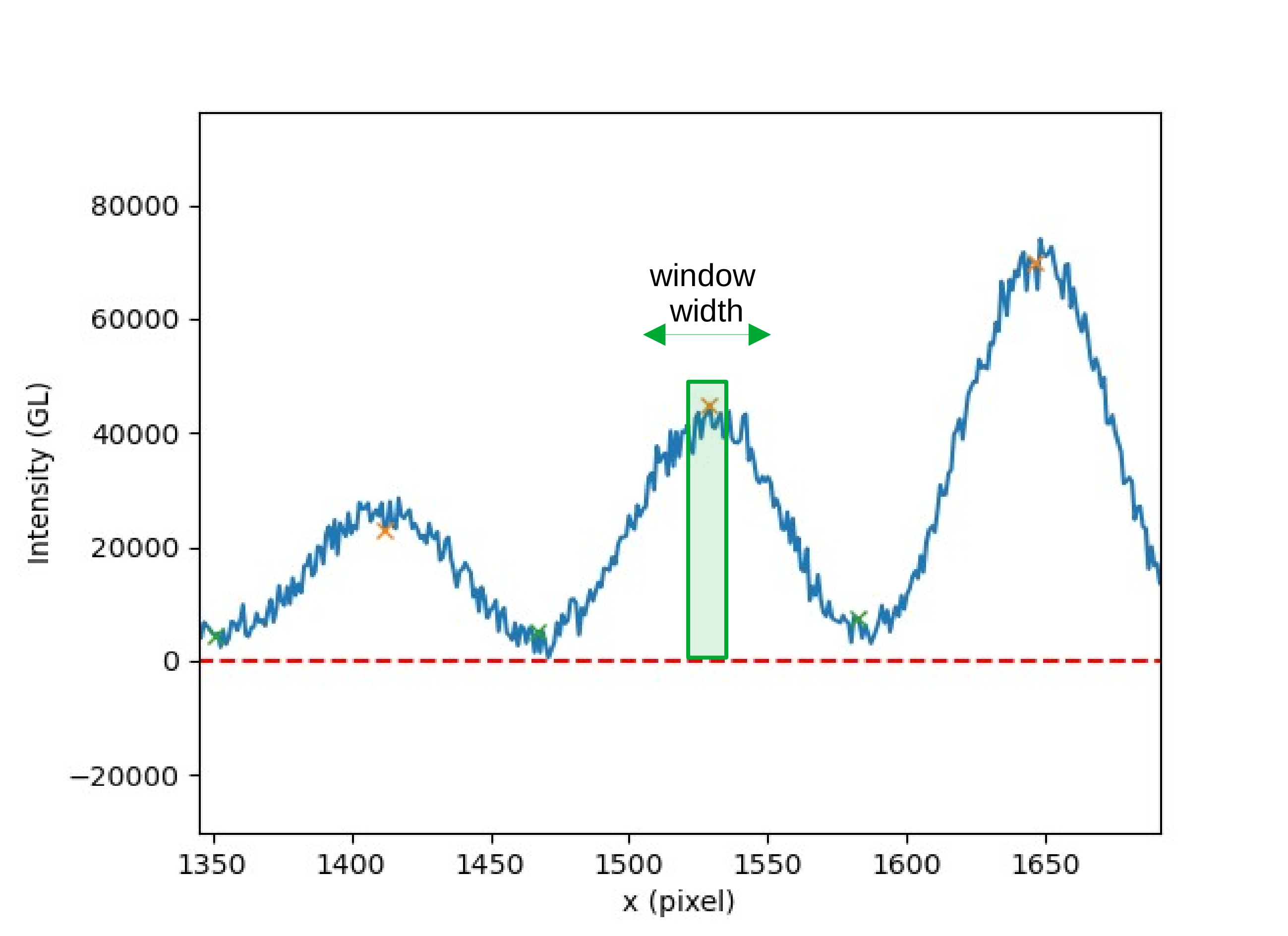

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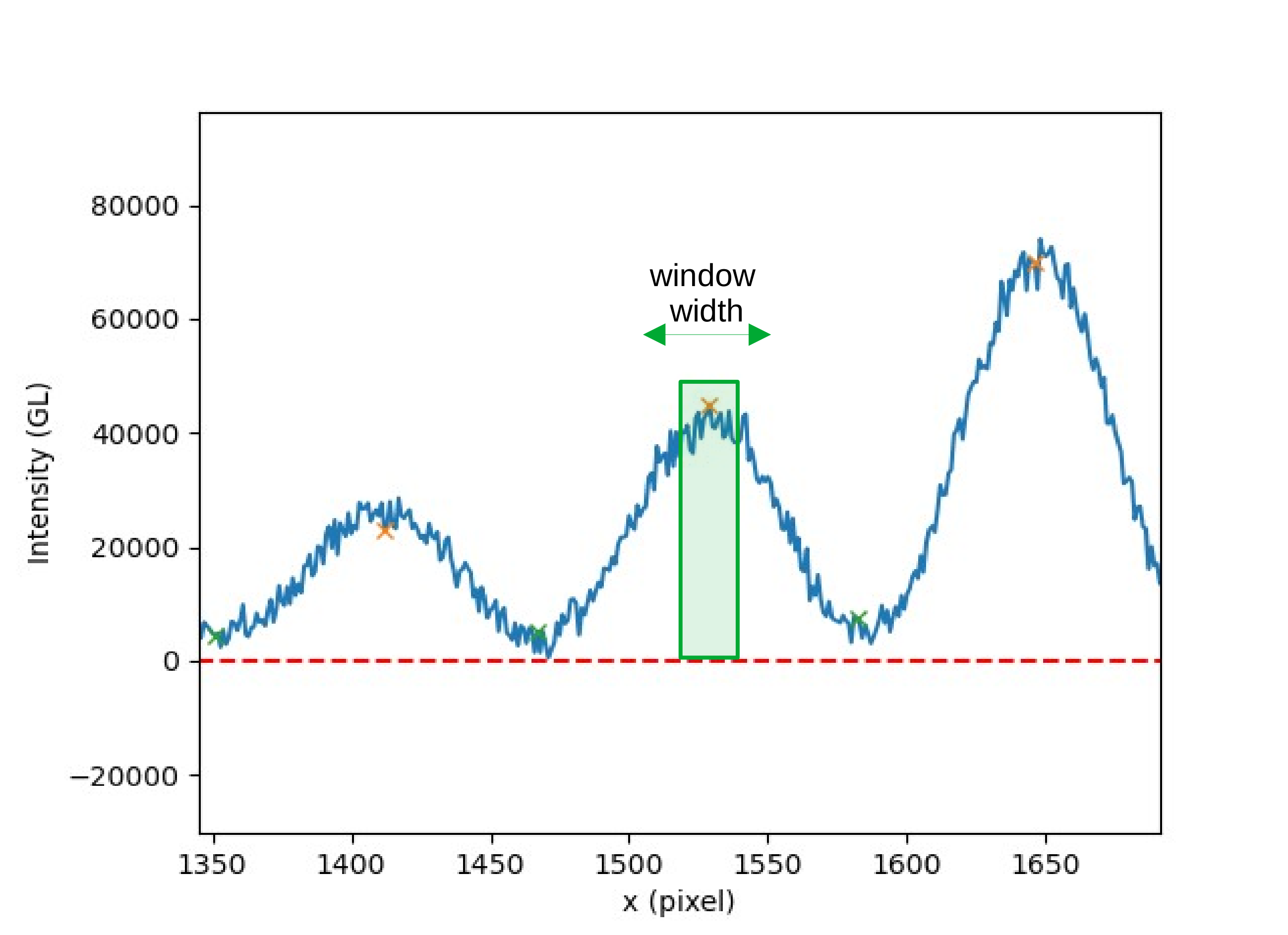


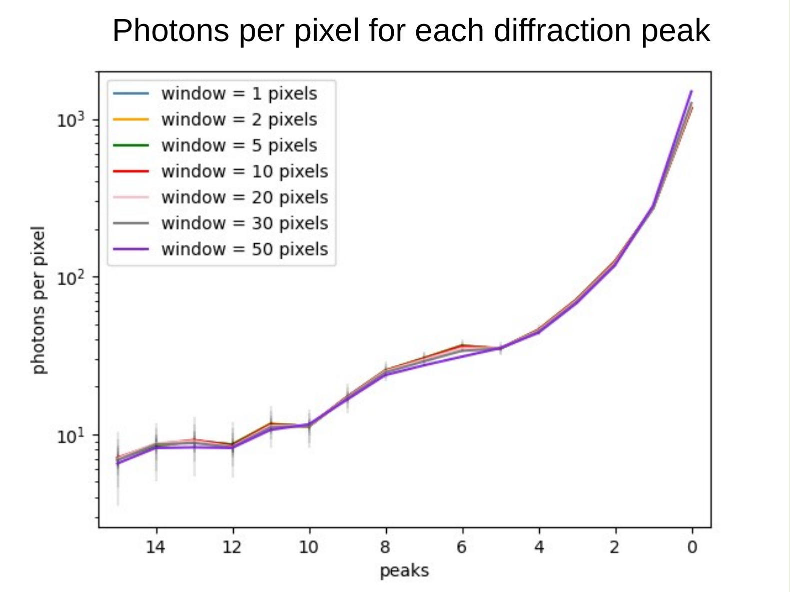
4) Results

Laser blu : 405 nm

Photons per pixel for each diffraction peak

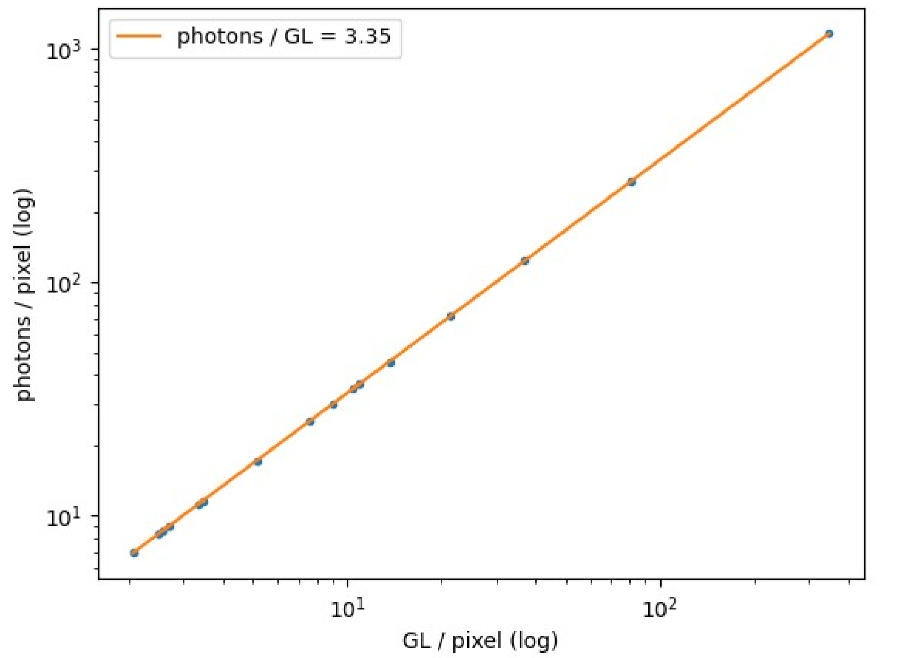
window width

peak	1	2	5	10	20	30	50
0	1156 ± 9	1156 ± 7	1158 ± 4	1164 ± 3	1189 ± 3	1240 ± 2	1456.8 ± 1.7
1	268 ± 4	268 ± 3	267 ± 2	267.0 ± 1.3	265.3 ± 1.0	264.1 ± 0.8	272.6 ± 0.7
2	119 ± 3	117 ± 2	118.5 ± 1.6	118.3 ± 1.1	117.3 ± 0.8	115.9 ± 0.7	115.9 ± 0.6
3	73 ± 3	73 ± 2	72.6 ± 1.4	72.3 ± 1.0	71.2 ± 0.8	69.5 ± 0.6	66.9 ± 0.5
4	44 ± 3	44 ± 2	44.0 ± 1.4	44.0 ± 1.0	43.4 ± 0.7	42.7 ± 0.6	41.7 ± 0.5
5	40 ± 3	40 ± 2	39.9 ± 1.5	39.6 ± 1.1	38.6 ± 0.7	37.4 ± 0.6	34.5 ± 0.5
6	31 ± 3	31 ± 2	31.3 ± 1.4	31.1 ± 1.0	30.7 ± 0.7	30.2 ± 0.6	29.5 ± 0.5
7	28 ± 3	28 ± 2	28.1 ± 1.5	28.0 ± 1.0	27.5 ± 0.7	26.8 ± 0.6	25.5 ± 0.5
8	22 ± 3	23 ± 2	22.6 ± 1.4	22.6 ± 1.0	22.5 ± 0.7	22.5 ± 0.6	22.5 ± 0.5
9	15 ± 3	15 ± 2	15.4 ± 1.5	15.4 ± 1.0	15.4 ± 0.7	15.3 ± 0.6	15.1 ± 0.5
10	11 ± 3	11 ± 2	11.0 ± 1.3	10.9 ± 1.0	10.7 ± 0.7	10.6 ± 0.6	10.3 ± 0.5
11	9 ± 4	9 ± 2	8.5 ± 1.4	8.4 ± 1.0	8.3 ± 0.7	8.3 ± 0.6	8.4 ± 0.5
12	8 ± 3	8 ± 2	8.5 ± 1.4	8.5 ± 1.0	8.0 ± 0.7	7.7 ± 0.6	7.0 ± 0.5
13	6 ± 3	6 ± 2	5.7 ± 1.4	5.8 ± 1.0	6.0 ± 0.7	6.0 ± 0.6	6.0 ± 0.5
14	7 ± 3	7 ± 2	6.9 ± 1.4	6.9 ± 1.0	6.7 ± 0.7	6.6 ± 0.6	6.2 ± 0.5
15	6 ± 3	6 ± 2	6.1 ± 1.4	6.2 ± 1.0	6.2 ± 0.7	6.3 ± 0.6	6.2 ± 0.5

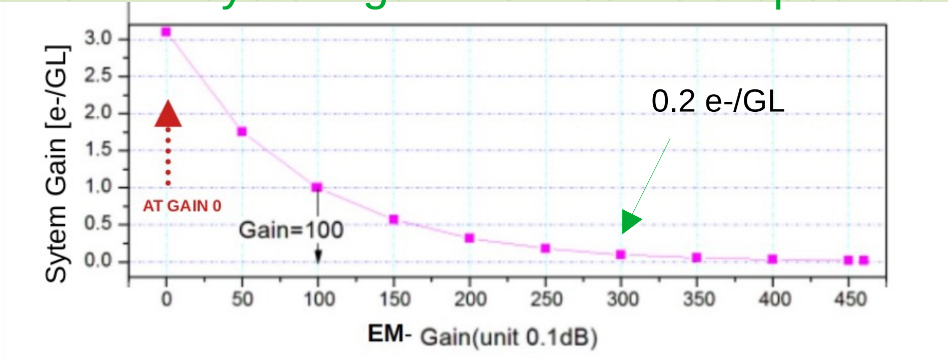


4) Results

Can obtain a calibration curve
(linear) (Gain = 300)



RECALL: system gain from camera specifics



$$\frac{photons}{GL} = \left(\frac{\cancel{\sum GL_{peak}}}{\cancel{Region\ Area} \cdot \sum GL_{total}} \cdot Photons/ms \right) : \frac{\cancel{\sum GL_{peak}}}{\cancel{Region\ Area}} =$$

$$= \frac{Photons/ms}{\sum GL_{total}}$$

These are constants in our setup.
∴ all points are in a straight line

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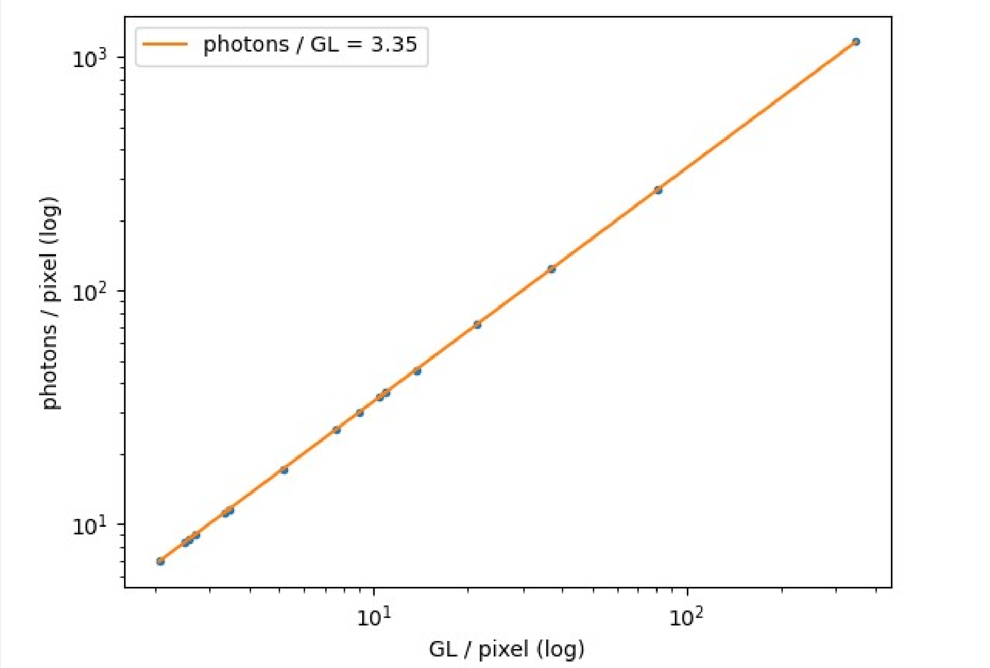
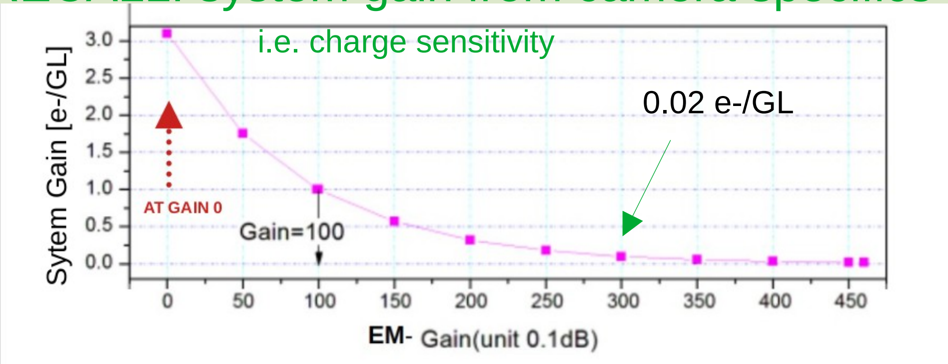
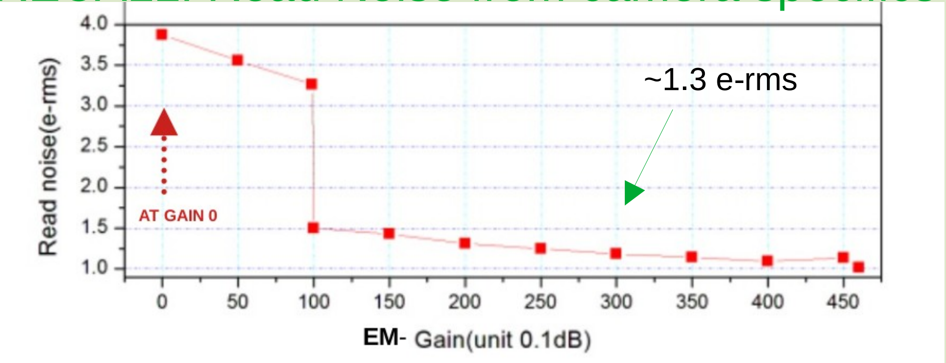


need three photons
for each GL step

RECALL: system gain from camera specifics



RECALL: Read Noise from camera specifics



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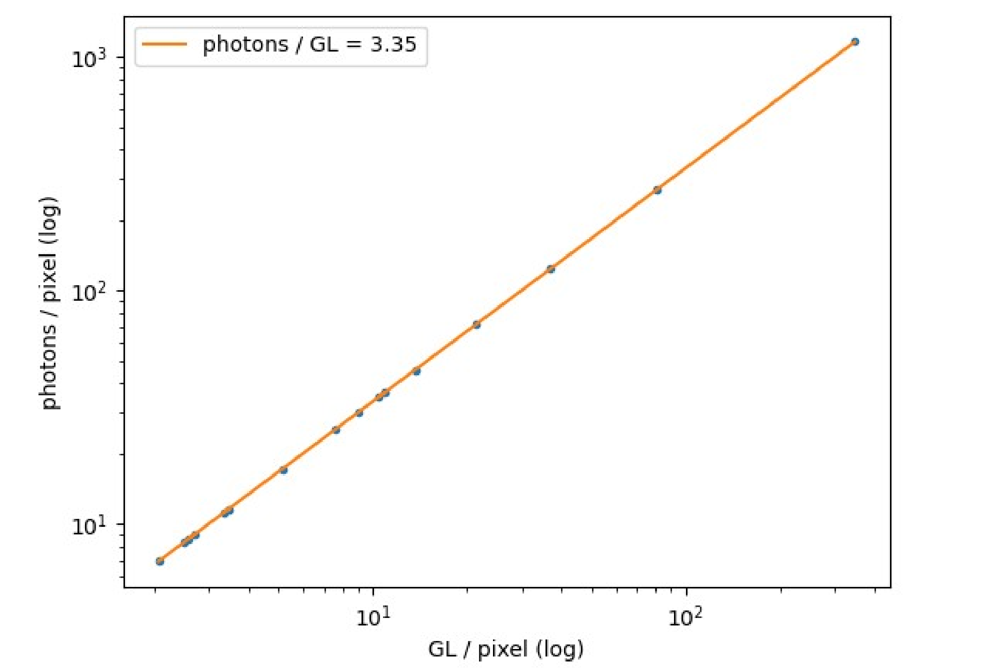

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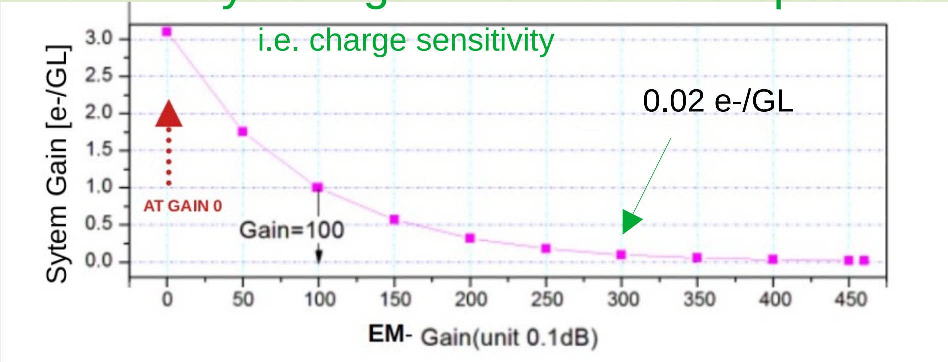

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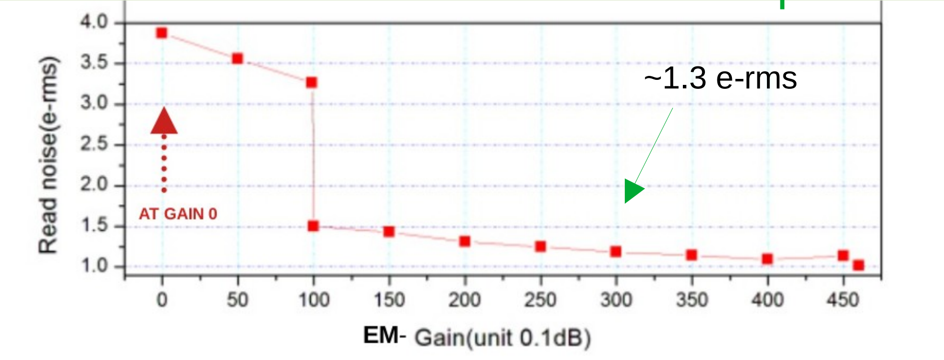


1.3 e-rms correspond to a std of 50 GL :(

THE END

CONCLUSION

- Need to ‘amplify’ the camera by a factor x100 in order to have a single-photons count

TO DO

- Repeat the same analysis with the other cameras.

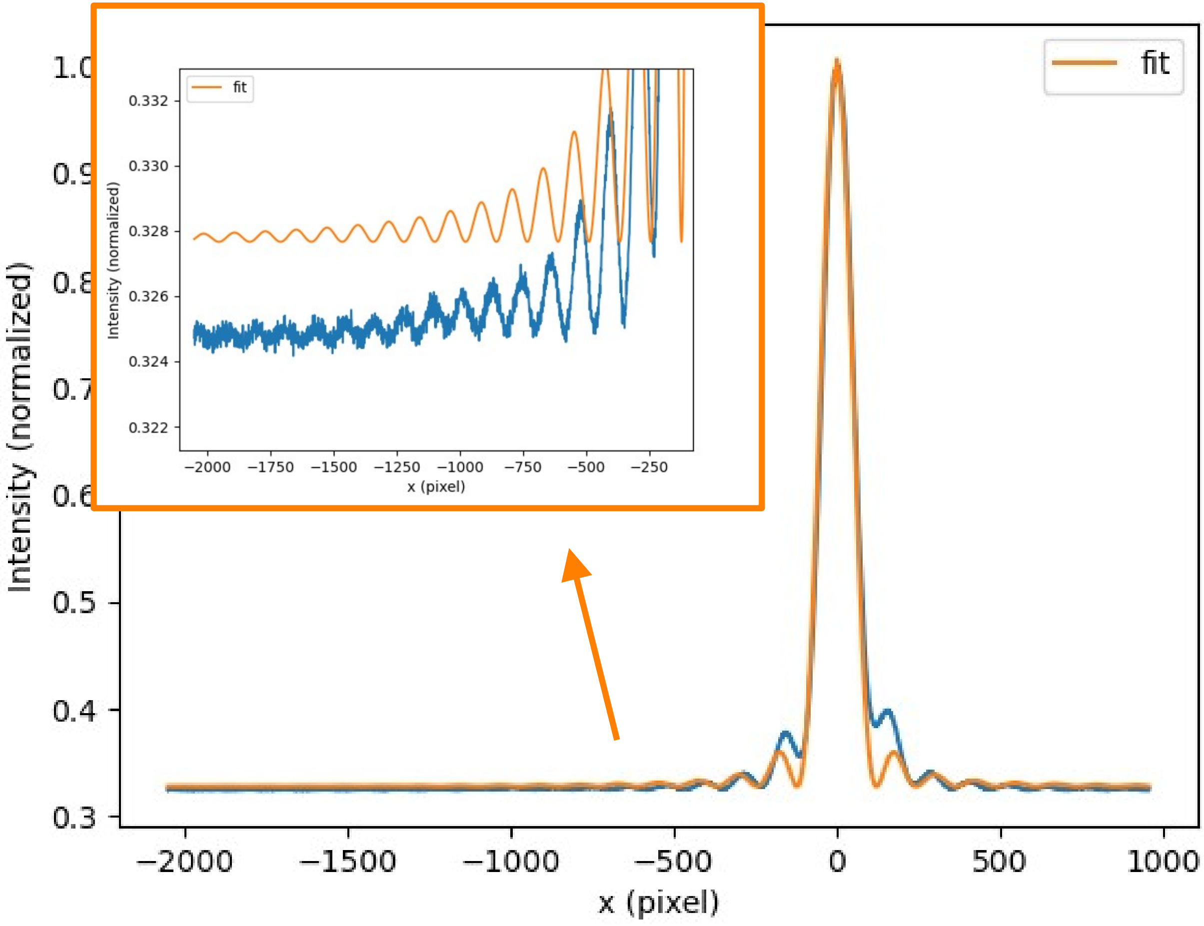
- Next time we could try with diffraction hole instead fo slit to reduce the effects of the laser dis-uniformities

Q&A

Perché non hai fatto un fit?

Non viene
neanche se considero
solo i massimi

(sen²(x)/x² = 0)

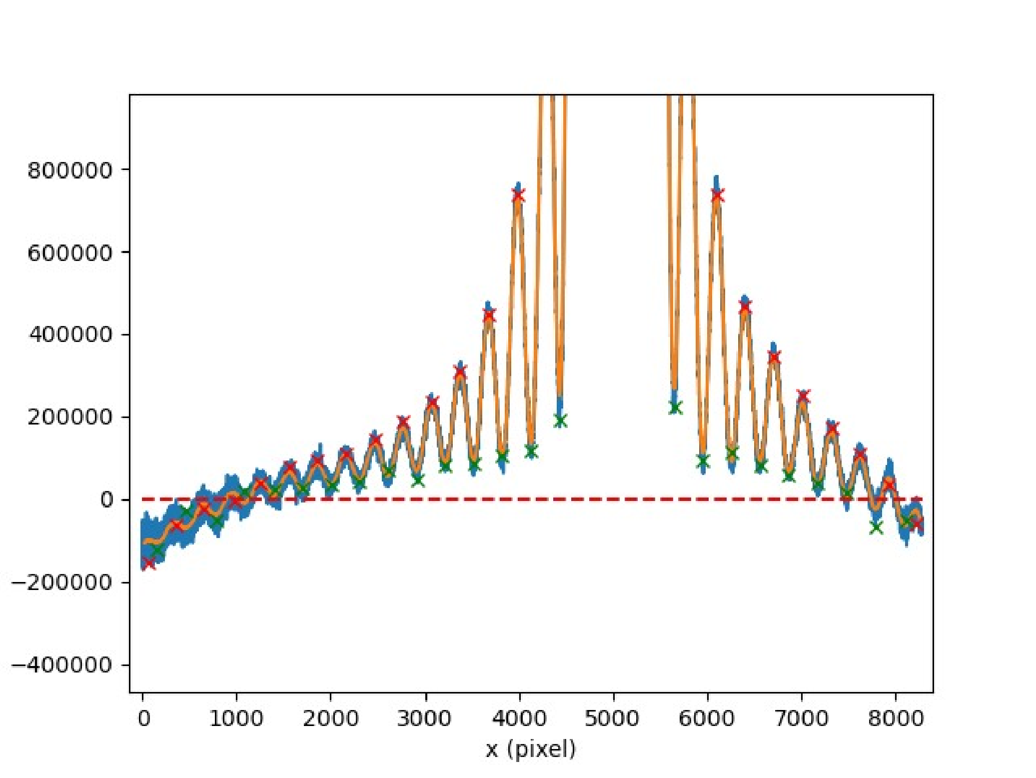


Q&A

E i setup con il laser rosso?

Lo stesso setup è stato ripetuto anche con un laser rosso (635 nm)

window width = 50



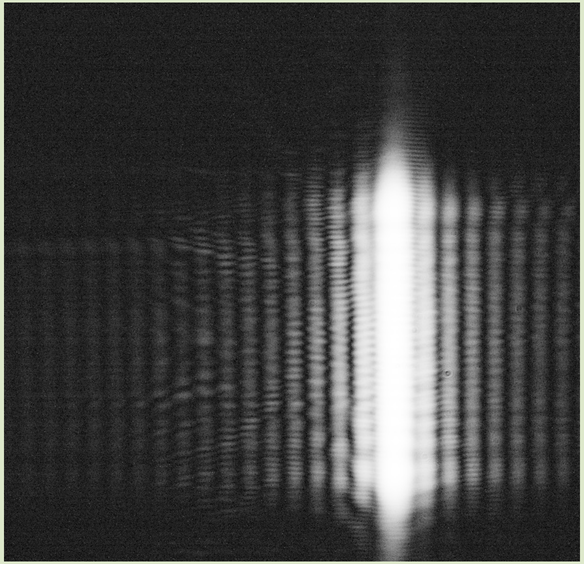
	Gain 0	Gain 300
	309.2 ± 1.7	315.0 ± 0.9
1	104.4 ± 1.6	96.0 ± 0.7
2	62.2 ± 1.5	58.8 ± 0.7
3	53.7 ± 1.5	47.9 ± 0.7
4	45.3 ± 1.5	34.4 ± 0.7
5	44.3 ± 1.5	33.7 ± 0.7
6	40.0 ± 1.5	32.1 ± 0.7
7	38.4 ± 1.5	26.7 ± 0.7
8	31.7 ± 1.5	19.8 ± 0.7
9	28.1 ± 1.5	15.5 ± 0.7
10	18.1 ± 1.5	11.3 ± 0.7
11	9.9 ± 1.6	7.4 ± 0.7
12	7.9 ± 1.6	1.6 ± 0.7
13	-4.4 ± 1.6	-4.3 ± 0.7
14	-10.1 ± 1.6	-10.6± 0.7
15	-30.8 ± 1.6	-18.9± 0.7
16	-48.1 ± 1.6	-28.4± 0.8
17	-60.9 ± 1.6	-43.0± 0.8
18	-82.2 ± 1.7	-56.5± 0.8
19	-105.5 ± 1.7	-72.5± 0.8

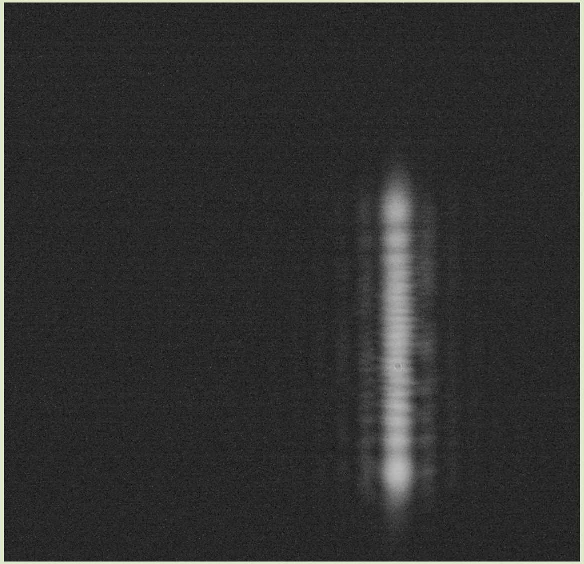
Q&A

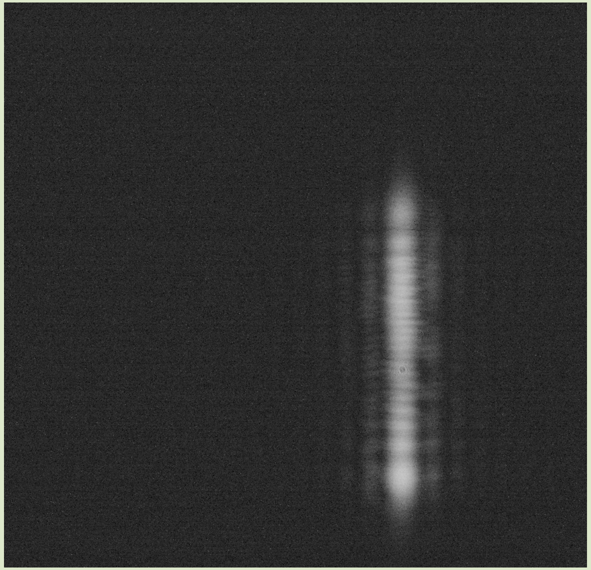
Perché non c’è l’analisi con Gain 0 anche per il laser blu?

Perché l’intensità del laser non era cosante

Laser blu, camera ASI533, Gain = 0



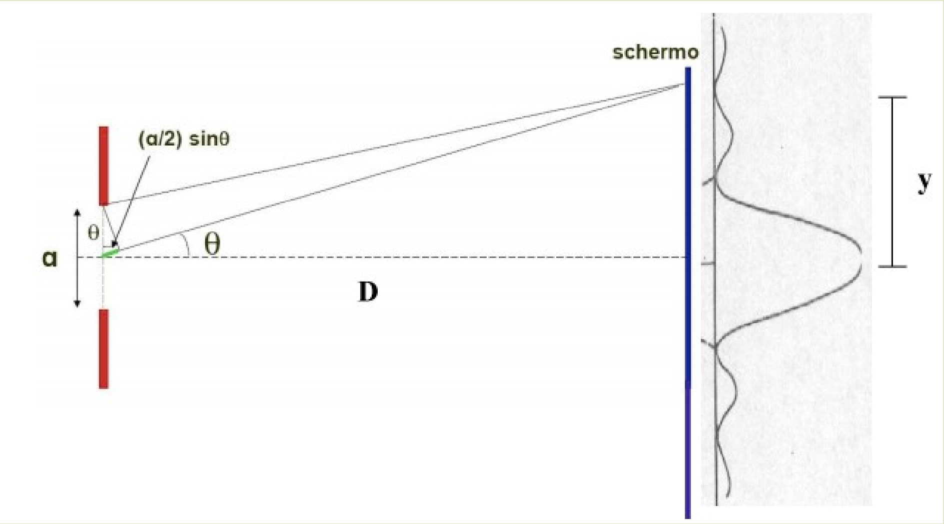




Q&A

E lo spessore della fenditura?

è stato calcolato dalla nota relazione tra i minimi della figura di diffrazione, λ laser (noto) e la distanza (D) tra fenditura e schermo



$$I(u) = I_0 \frac{sen^2(u)}{u^2}$$

$$u = \frac{\pi}{\lambda} a\theta = \frac{\pi}{\lambda} a \frac{y}{D}$$

$$a = \frac{n\lambda D}{y}$$

λ = 405 nm
D = 30.5 cm

a = 278 μm

NB: questo è solo un esercizio di stile. Non è utile ai fini della stima del numero di fotoni

THE END

stavolta per davvero