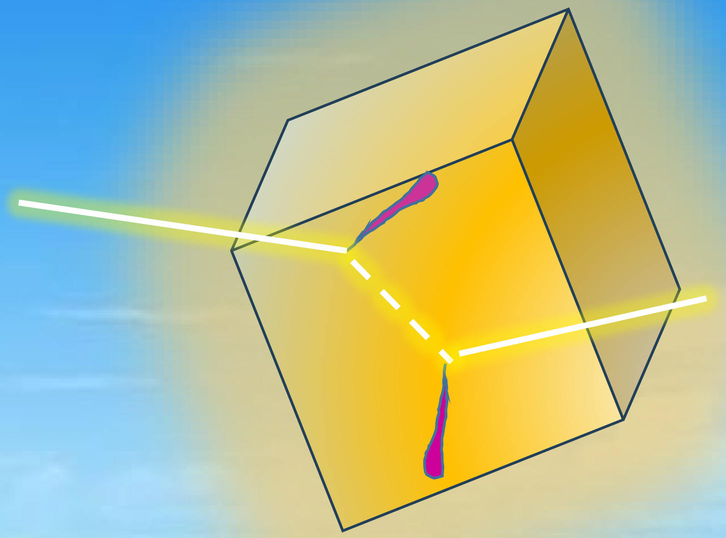
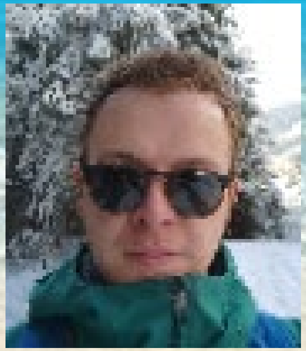
RIPTIDE: Recoil Proton Imaging Detector

Il gruppo (3.8 FTE)





Nome	Ruolo	FTE
Console Camprini P.	Ric ENEA	0.2
Giacomini Francesco	Pr Tecn CNAF	0.1
Lanzi Samuele	Dott	0.5
Massimi Cristian	Prof Ass	0.3
Mengarelli Alberto	Tecn INFN	0.2
Pisanti Claudia	Dott	1.0
Ridolfi Riccardo	Ass Ric	0.5
Spighi Roberto	Dir Ric INFN	0.5
Terranova Nicholas	Ric ENEA	0.5
Villa Mauro	Prof Ord	0
TOTALE FTE		3.8

Bologna, luglio 2025

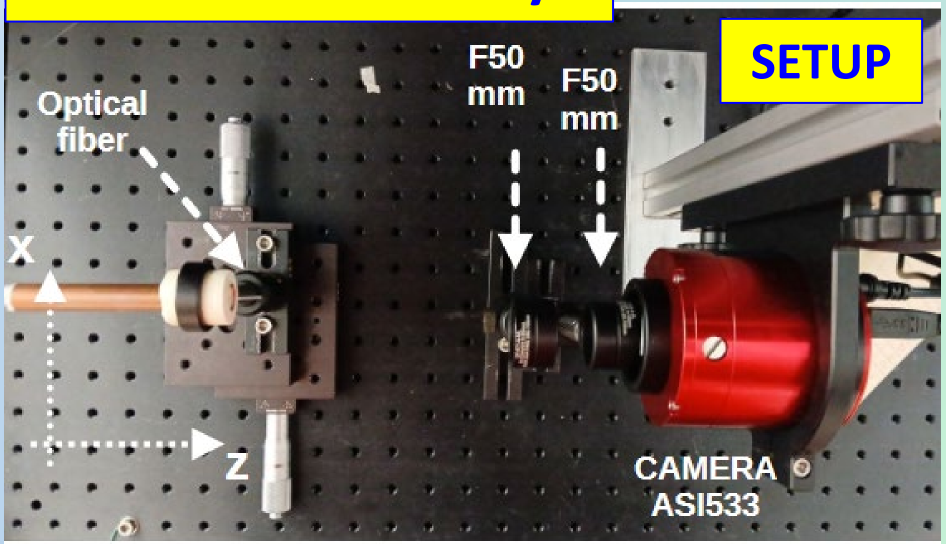
State of the art

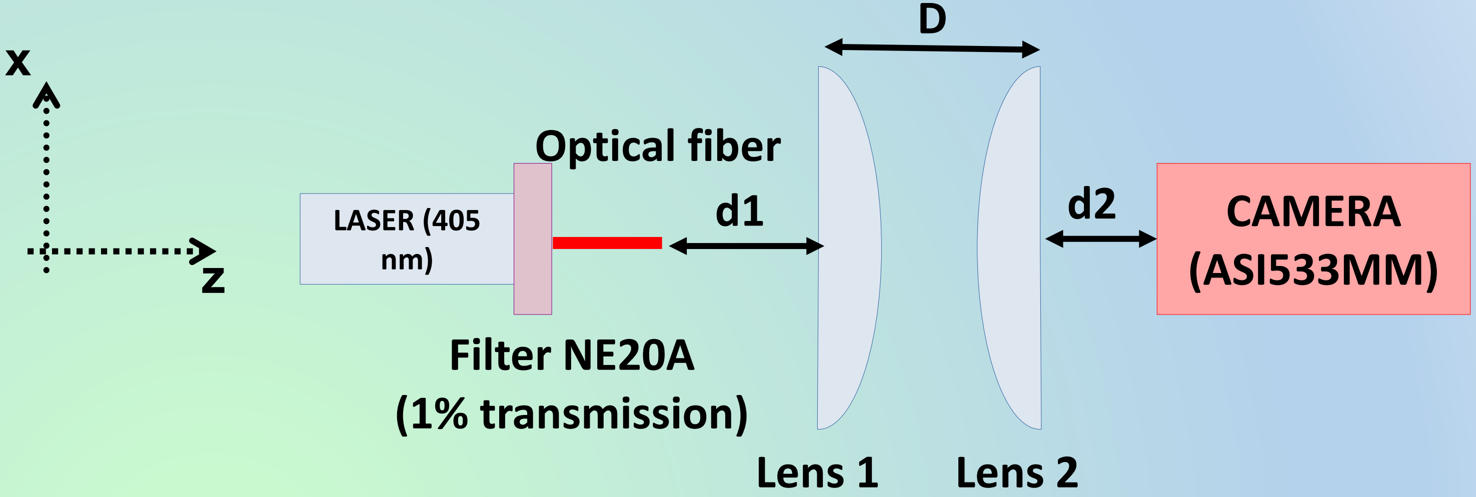
Update of the ongoing work

- **Optics definition**
  - **Depth of field**
  - **Field of view**
- **Characterization of different sensors**
  - **Noise level**
  - **sensitivity**
- **Measurement with high efficiency detector**
  - **Detection of Cosmic Ray muons**
  - **Detction of electrons from Sr source**
- **Unblock of SJ and Requests for 2026**

Optics parameters definition, 1

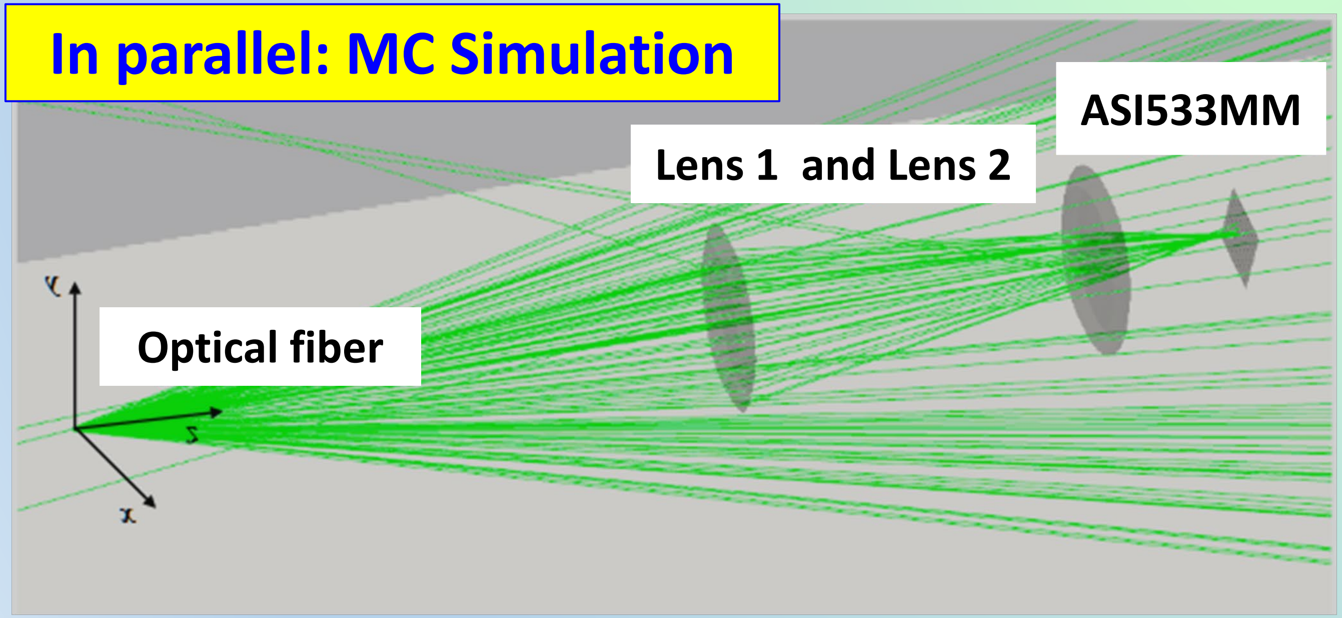
Tests in laboratory





Movement of the Laser in X (field of view) and Z (depth of field) direction

In parallel: MC Simulation



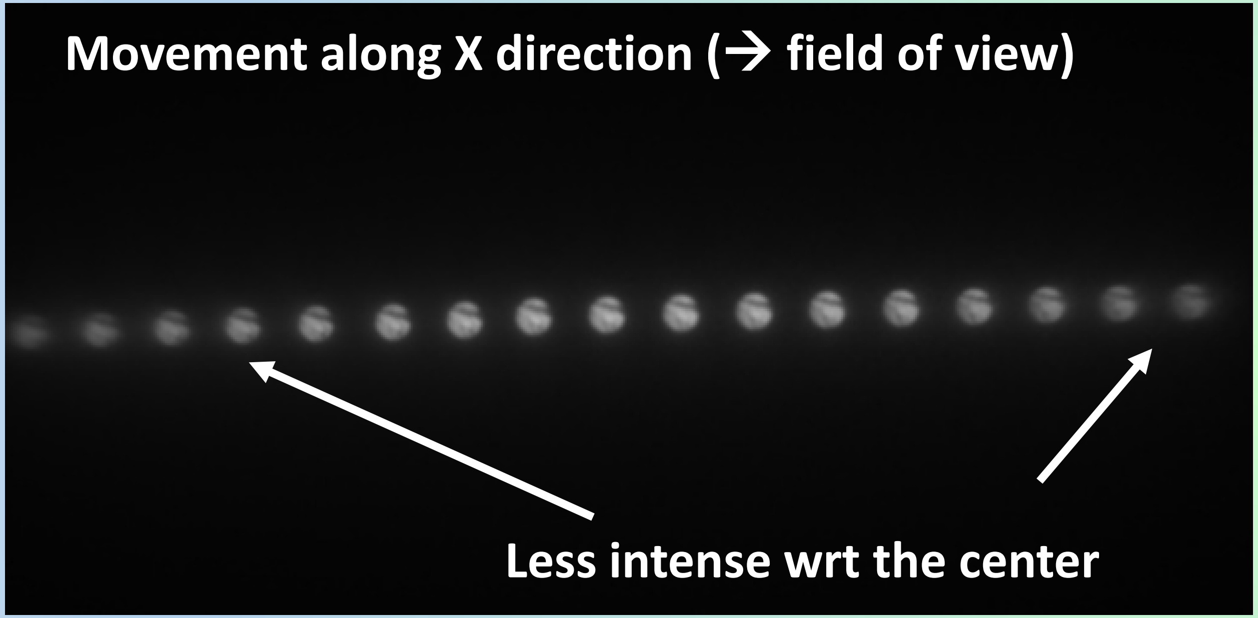
Tested various lens combinations

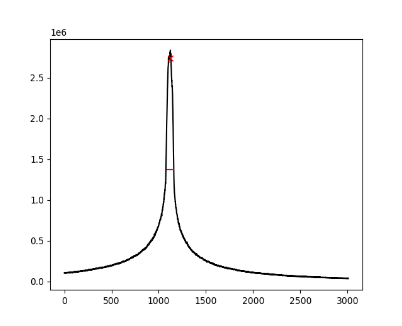
Lens1	Lens2	d1	d2	D
50mm	50mm	105mm	15mm	~50mm
50mm	50mm	80mm	30mm	~3mm
75mm	60mm	110mm	35mm	~3mm
Nikon optics		110mm	60mm	--

For each test, Laser has moved on X and Z direction

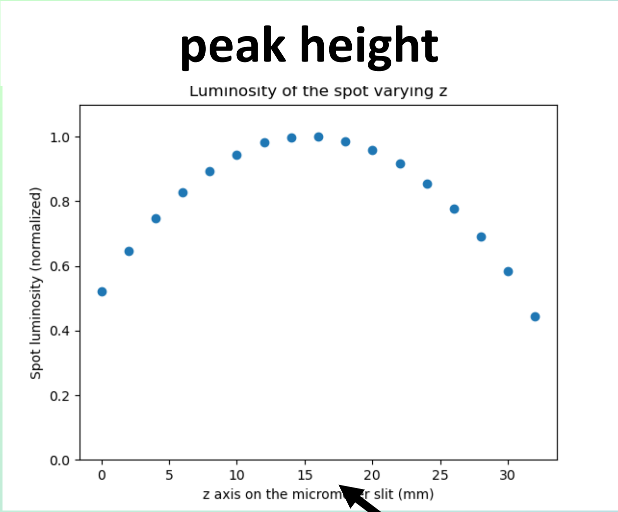
Optics parameters definition, 2

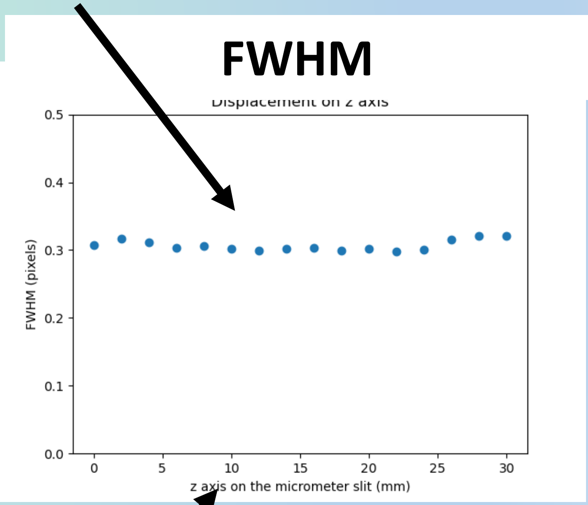
Study of the Depth of field





FWHM is constant → the image is always in focus



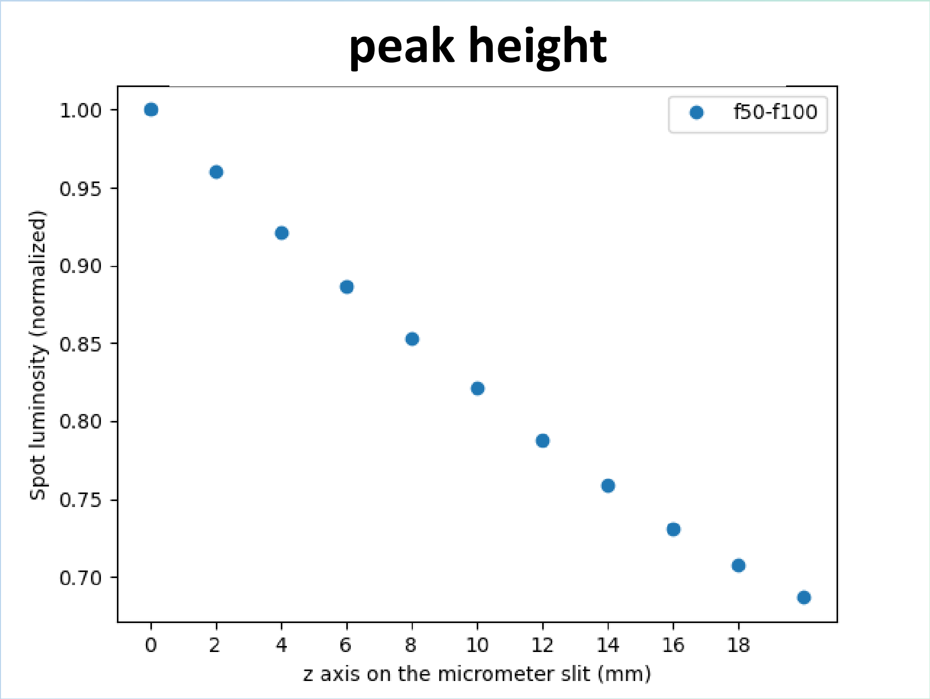


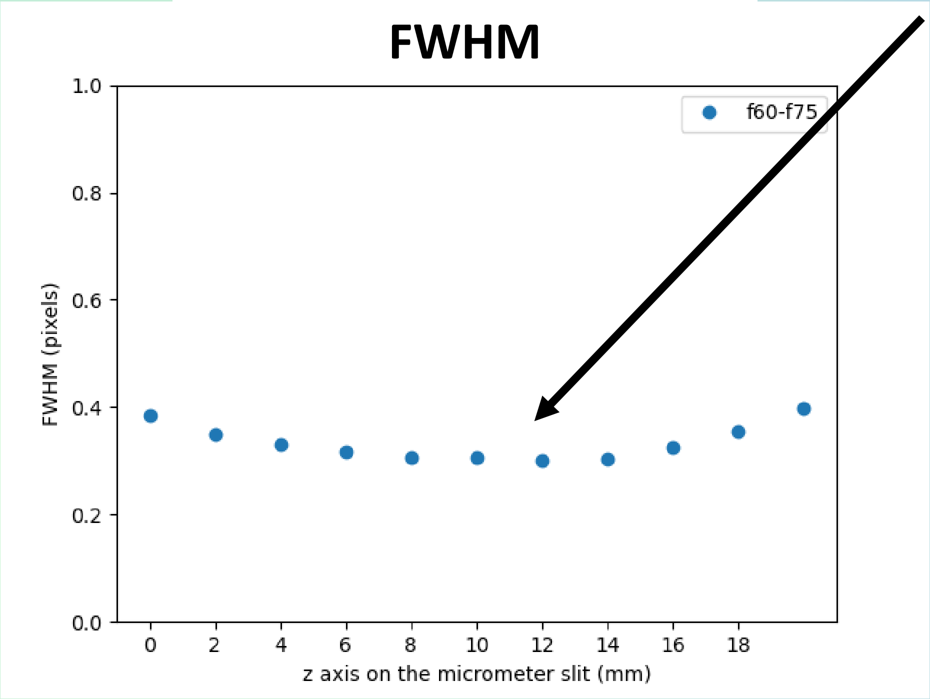
Field of view about 30 x 30 mm^2
sensor dimension 11x11 mm^2

Optics parameters definition, 3

Movement along Z direction → study of the field of view

FWHM is constant → the image is always in focus





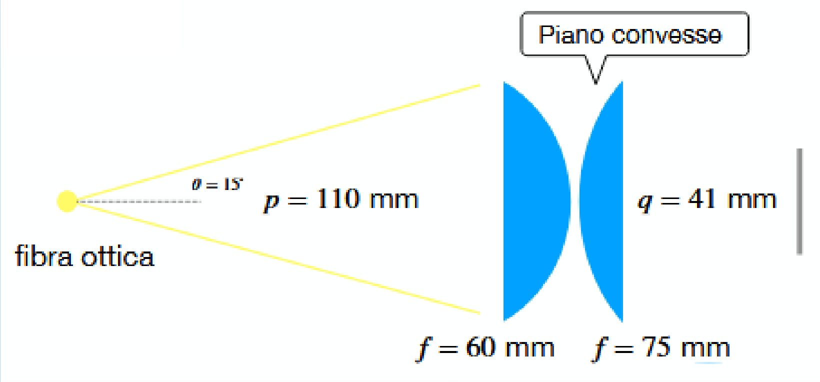
Tests done with all optics combinations

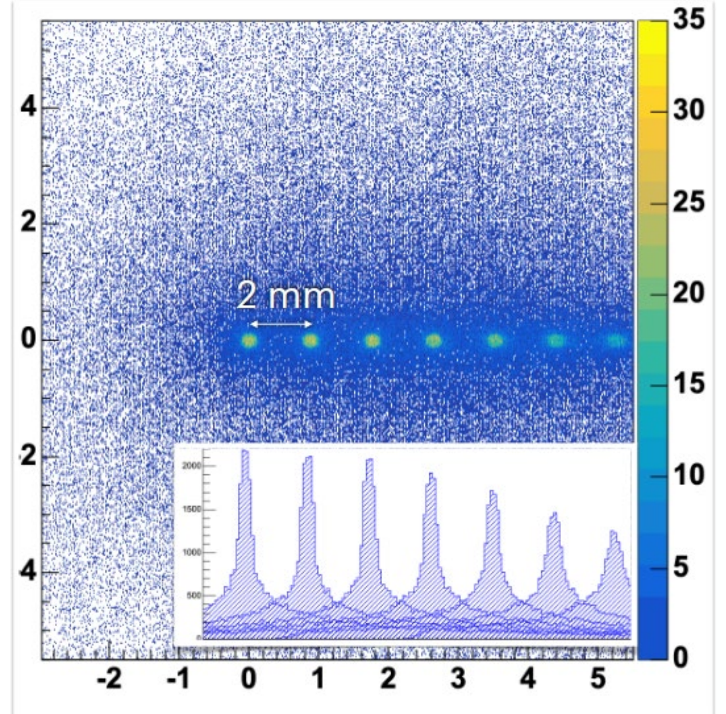
Lens1	Lens2	d1	d2	D
50mm	50mm	105mm	15mm	~50mm
50mm	50mm	80mm	30mm	~3mm
75mm	60mm	110mm	35mm	~3mm
Nikon optics		110mm	60mm	--

the chosen optics

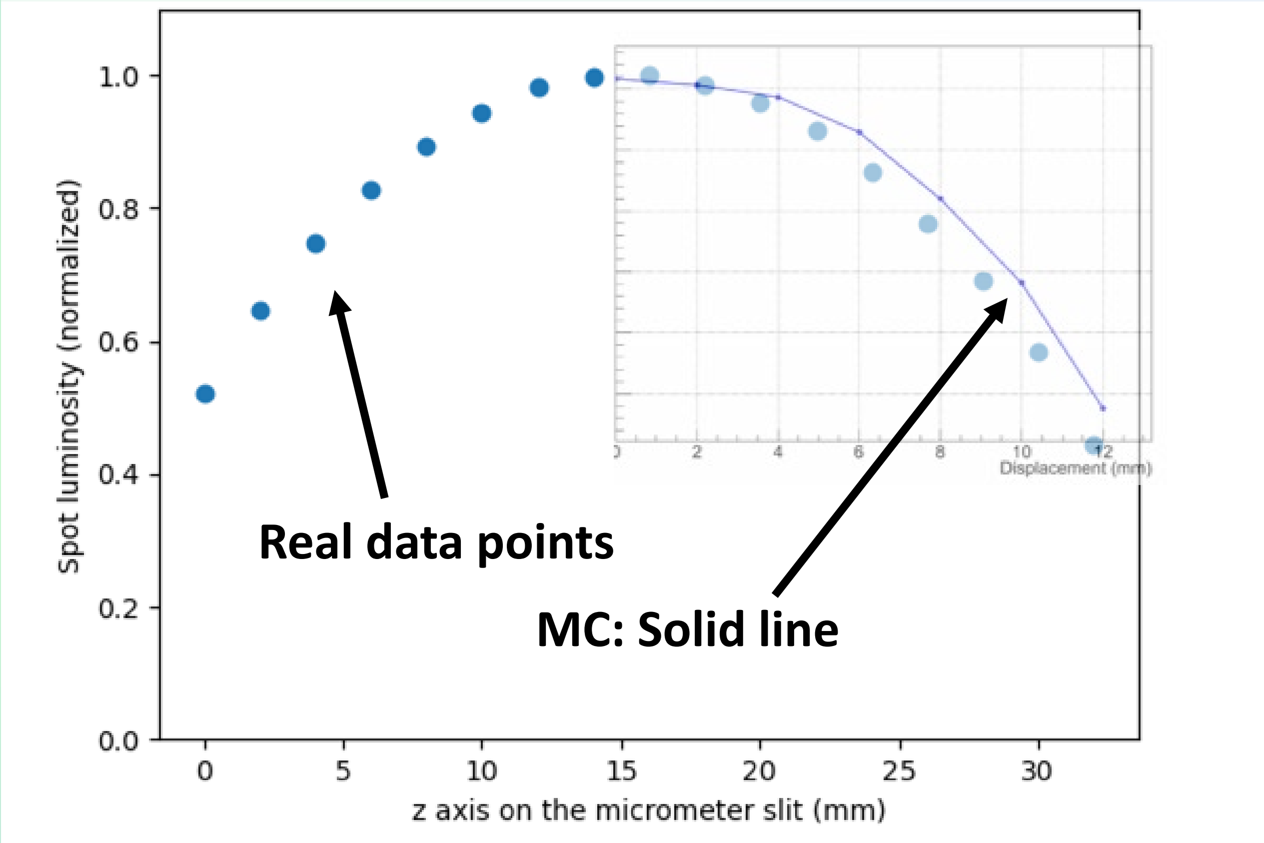
Optics parameters definition, 4

MC Simulation





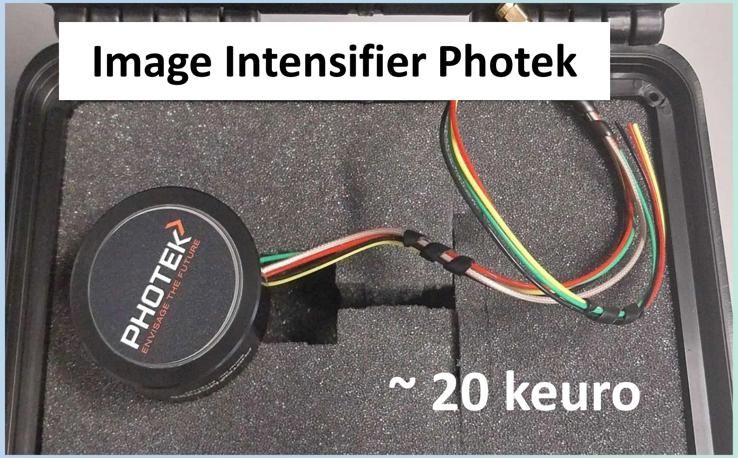
Comparison with the MC Simulation



MC Simulation is in agreement with the measurements in laboratory

Tests of different objects present on the market

STRATEGY: we borrowed several sensors to be able to choose the one best suited for our purpose

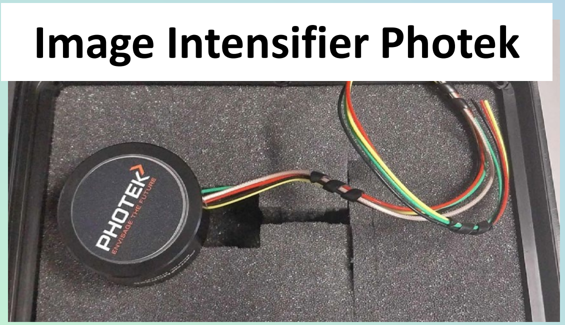


Only MCP and phosphor screen coupled to our sensor ASI-533

Gamma sensor for the single photon detection (very low noise level, without MCP)

Out of budgets, tested to see the limits that can be reached (complete object, MCP+sensor see next slides)

Characterization of different sensors



Sensors:

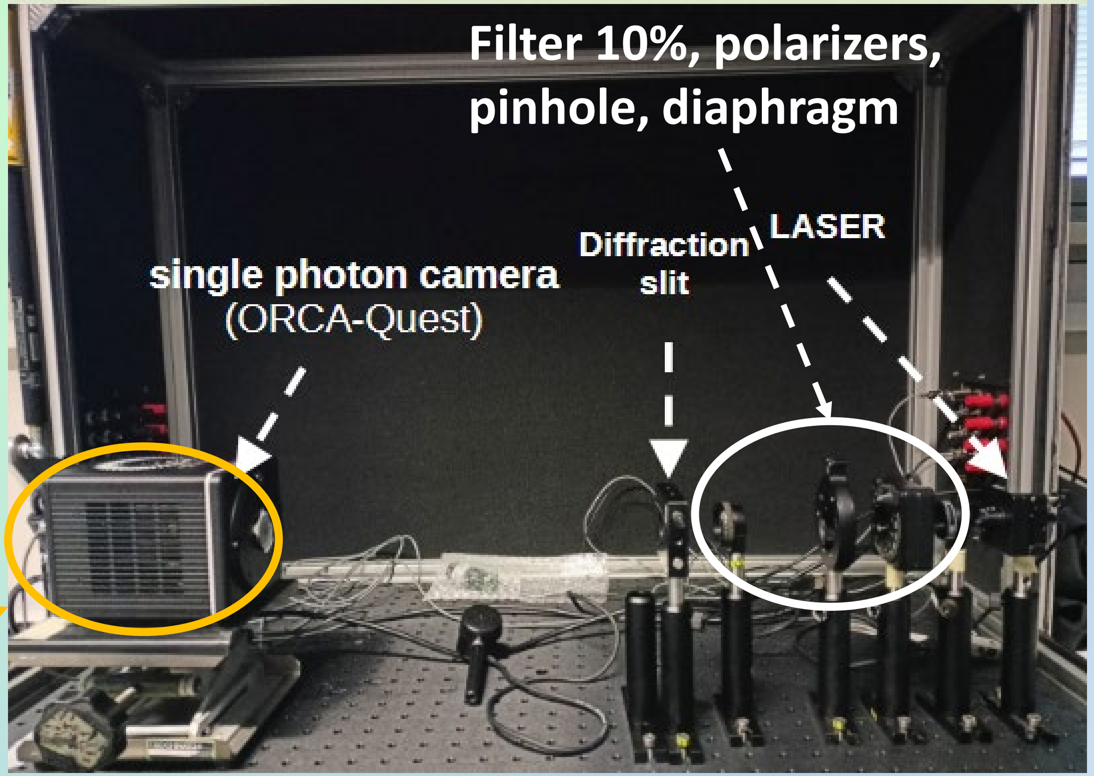
- ASII-533: **OWNED**
- Image intensifier: Photocathode, Double stage MCP and Phosphor screen (Photek): **LOAN**
- Single Photon Camera ORCA QUEST (Hamamatsu): **LOAN**

GOAL:

- **Measure the photon sensitivity** (minimum number of photons that can be detected)
- **Measure the noise level**

METHOD:

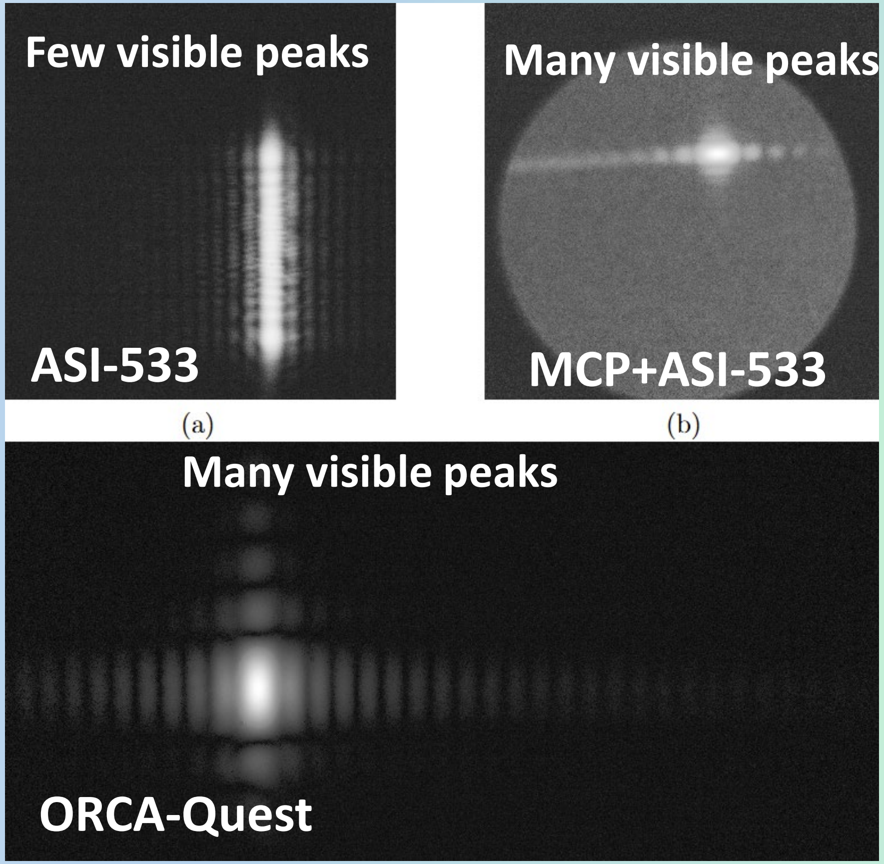
- Through a diffraction figure

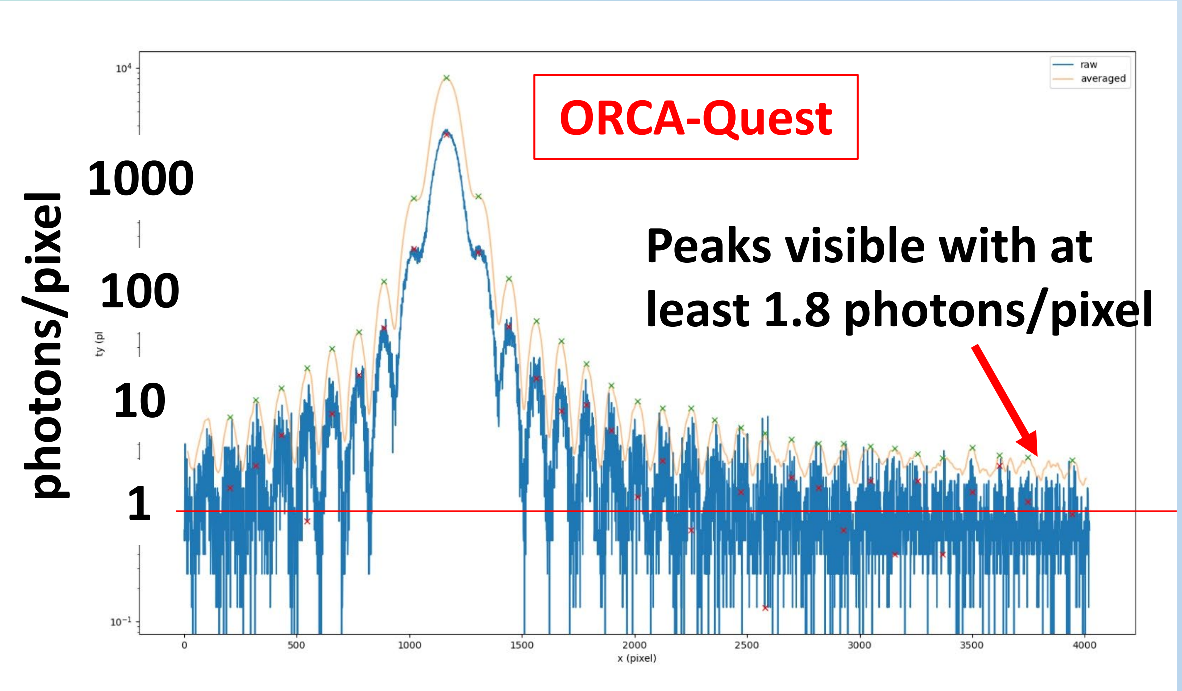


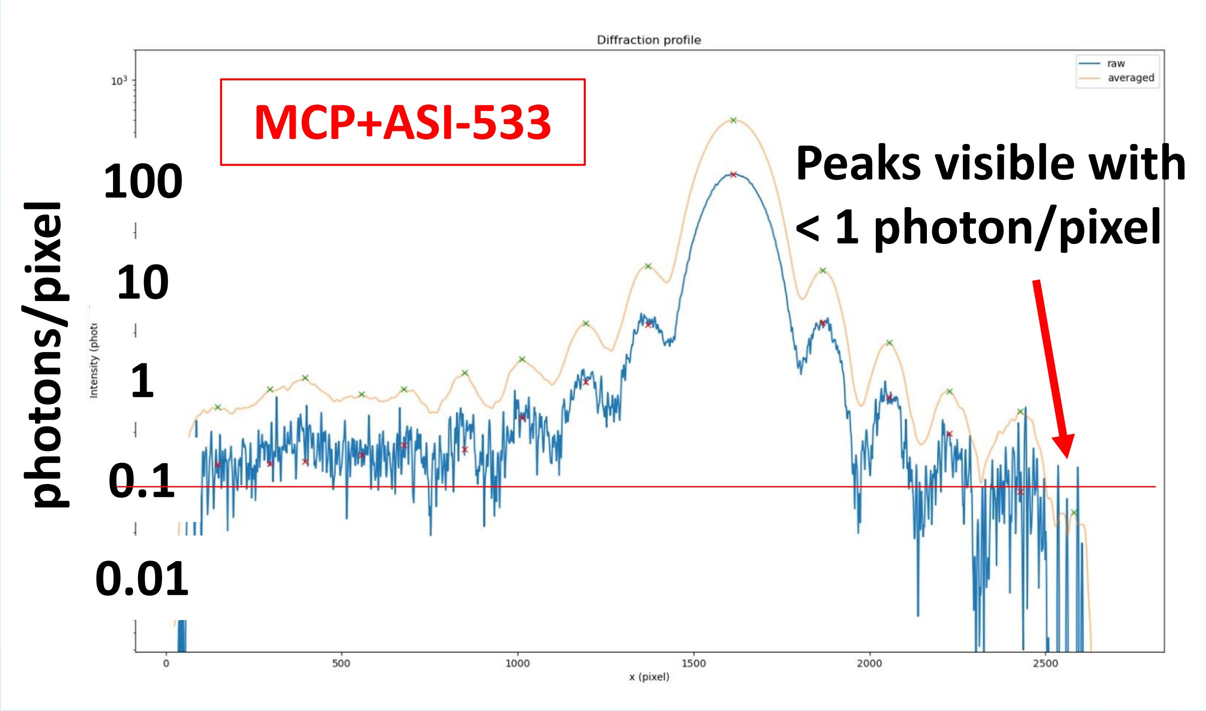
3 different sensor setups tested

- ASI-533
- ASI-533 + Image intensifier (Photek)
- Single Photon Camera ORCA-Quest (Hamamatsu)

Diffraction Figures







	ASI-533	MCP+ASI-533	ORCA-Quest
Noise level Phot/pixel	7.8	0.44	0.33
sensityvity	low	high	high

Best choice: MCP coupled with a sensor

Measurements with high efficiency complete detector, 1

LOAN: 11-24 June 2025

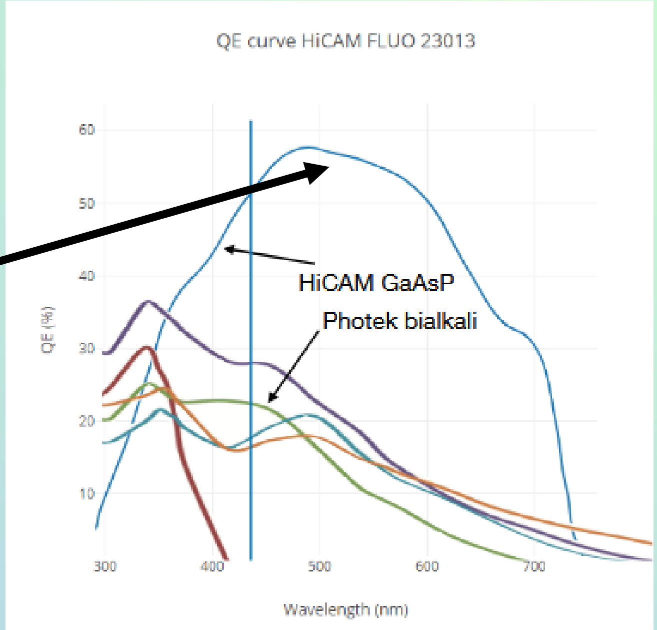
HiCM Fluo (Lambert)

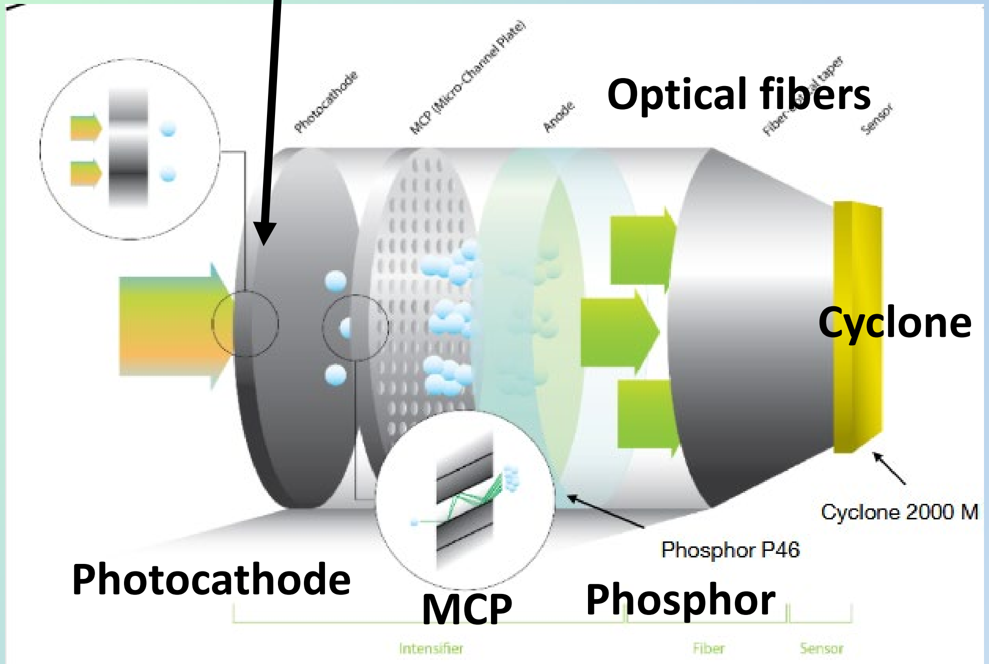
High Speed Camera for Fluorescence Imaging

- Photocathode
- Image Intensifier (Double Stage MCP)
- Phosphor screen
- Optical fibers
- CMOS Sensor (Cyclone 2000 M)

HiCM Fluo (Lambert)

Photocathode Quantum efficiency double than the standard



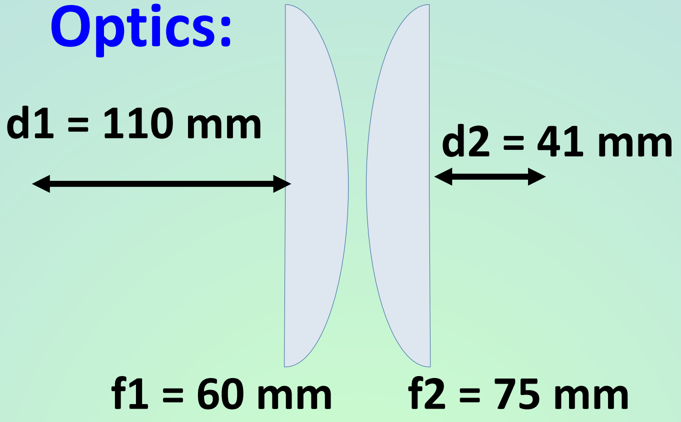


Measurements with high efficiency detector, 2

MEASURE with different SOURCES:

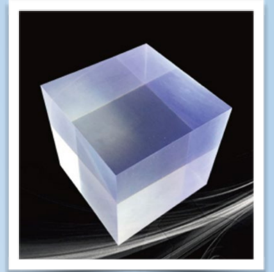
- Cosmic muon
- Am241 (α)
- Sr90(β)
- Cs137(γ)

Optics:



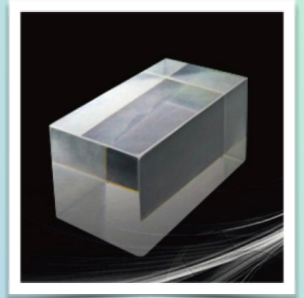
MEASURE with different SCINTILLATORS:

- PVT (BC-408): 4x4x4 cm^3
- GAGG: 1x1x1 cm^3
- CsI(Tl): 2x2x2 cm^3

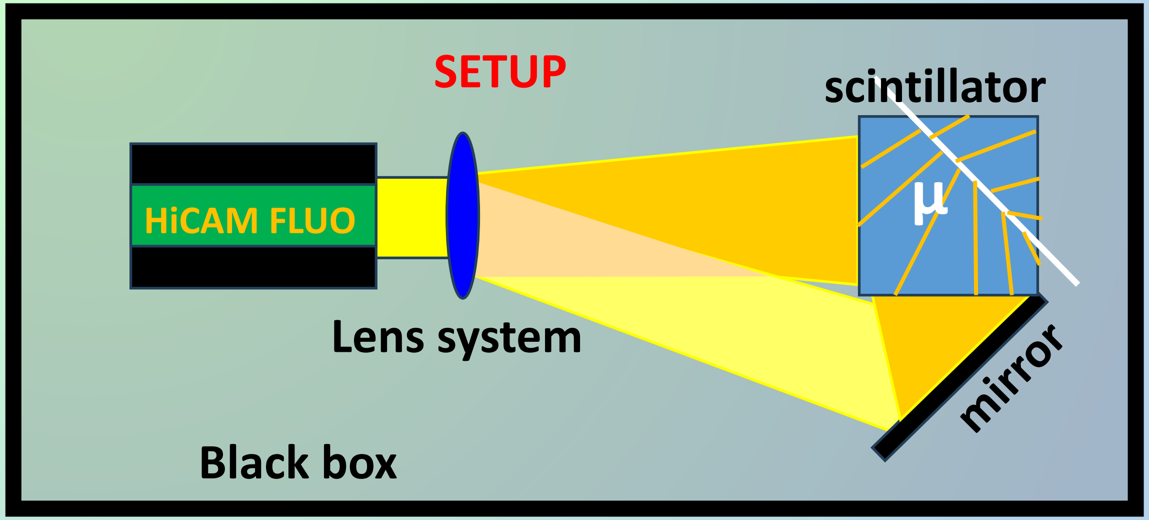


PVT

GAGG



CsI(Tl)

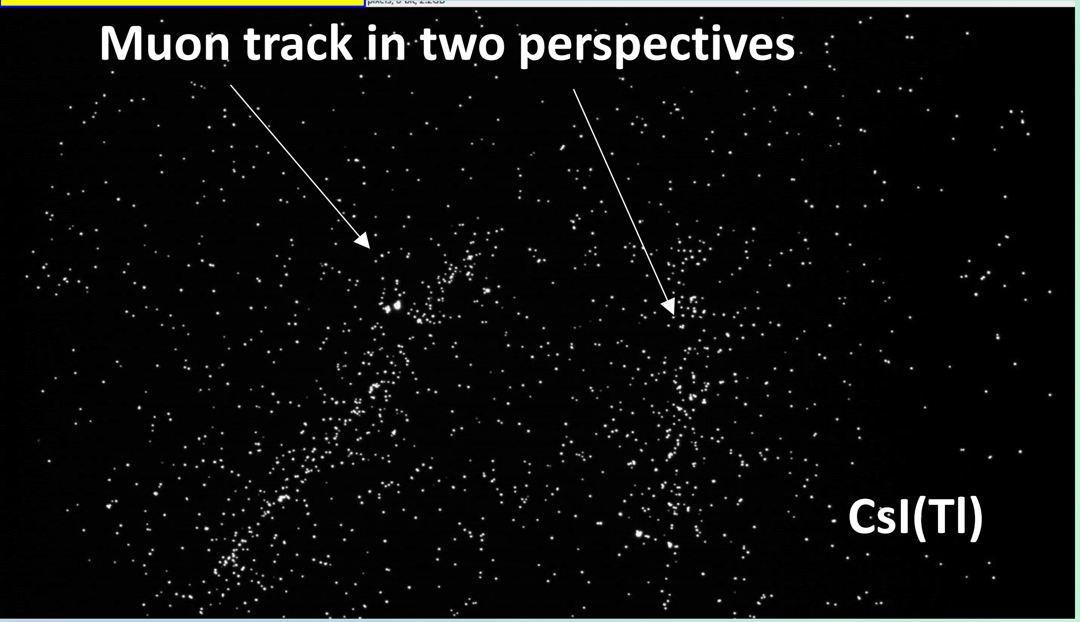


Use of a mirror to have 2 plane projections on the same sensor

Measurements with high efficiency detector, 3

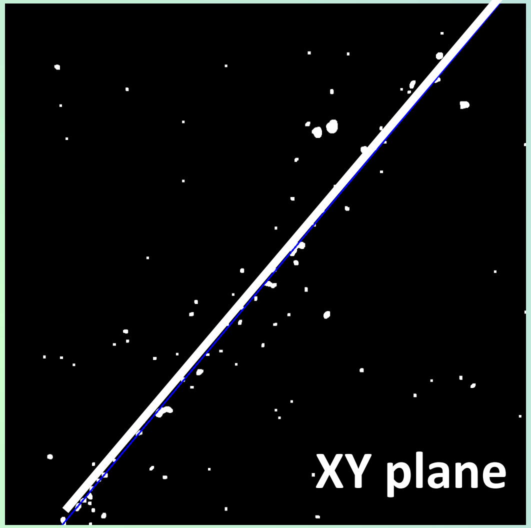
Muon tracks visible only with GAGG and CsI(Tl) scintillators

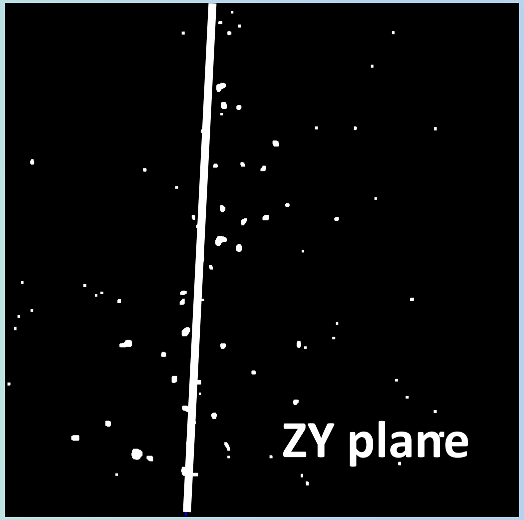
Real Data



~ 400 tracks to analyze (ongoing)

Image reconstructed with the Hough Transfor





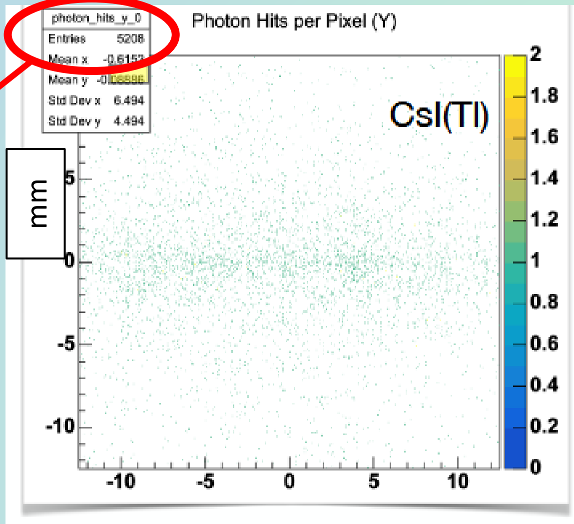
With a very efficienty detector (and very expensive)
it is possible to see very weak signals (MIP)

CsI(Tl) not usable to detect neutrons (it does not contain hydrogen), but from this information, through the MC Simulation, we can understand if recoil protons are detectable with BC-408 (see next slides)

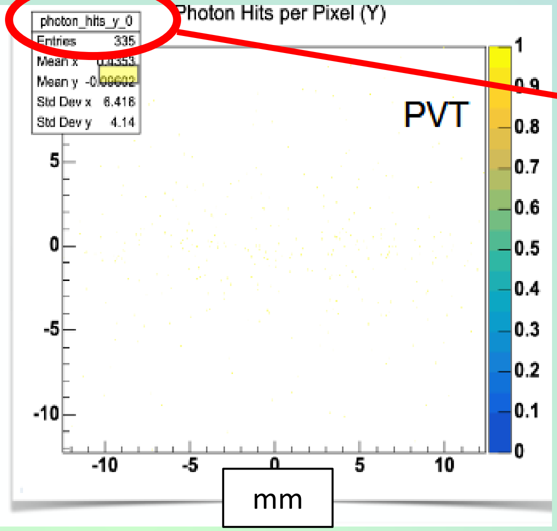
Measurements with high efficiency detector, 3

MC Simulation of photons reaching the MCP surface

Muons



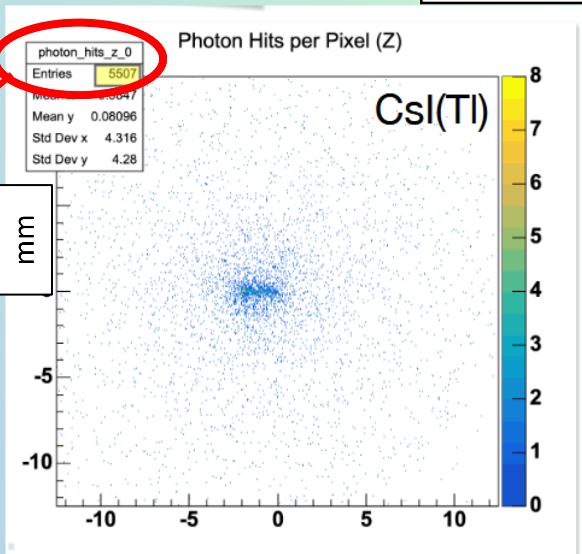
in CsI(Tl) 1 muon → 5000 photons



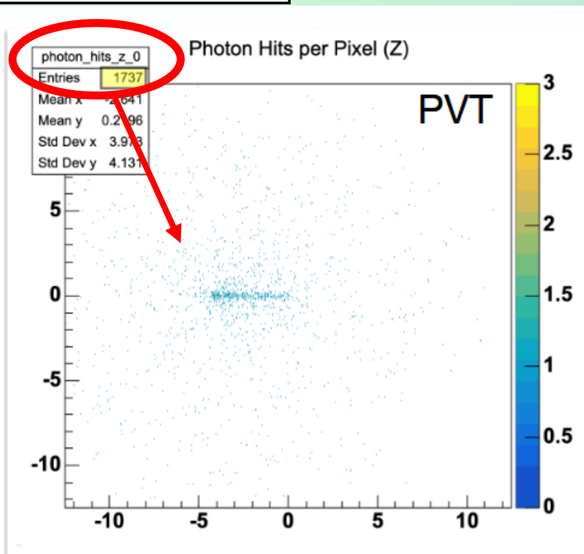
In PVT a muon → 330 photons (factor of 15 fewer wrt CsI(Tl))

MC simulation foresees not visible signal

Protons (30 MeV)



in CsI(Tl) 1 proton → ~ 5500 photons in a lower range



in PVT 1 proton → ~ 1700 photons (more photons per unit lenght wrt muons in CsI(Tl))

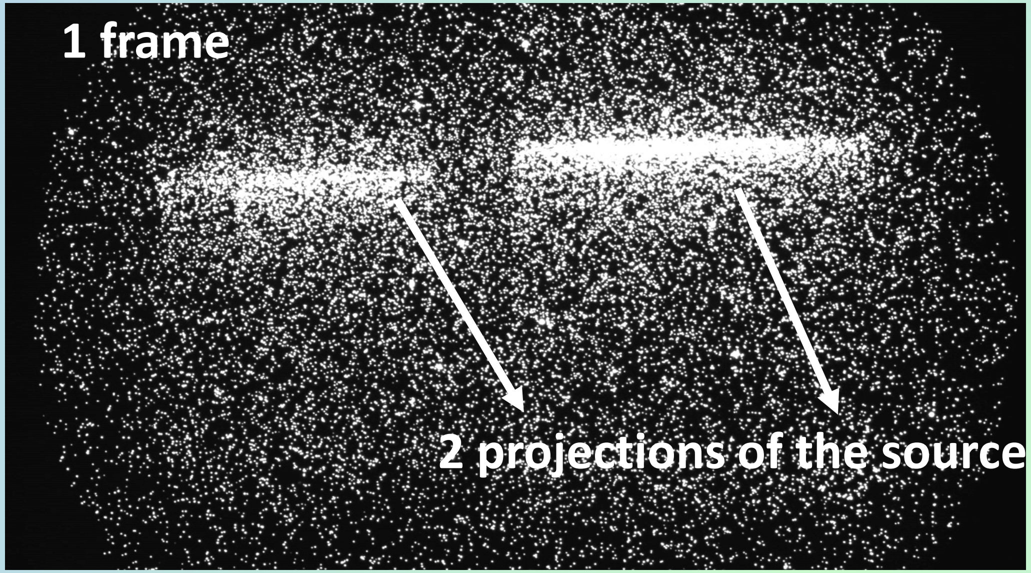
μ signal is visible in CsI(Tl) → protons will be visible in PVT

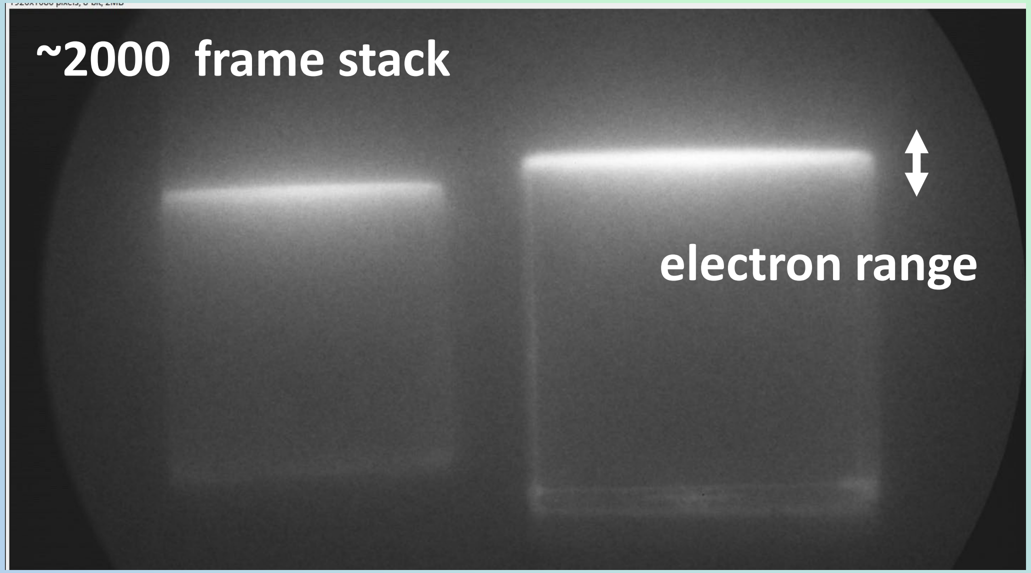
Measurements with high efficiency detector, 3

MEASURE with different SOURCES:

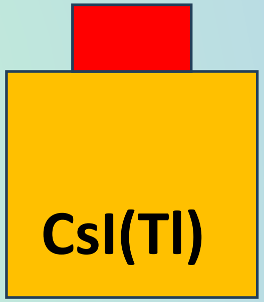
- Sr90(β)

Real Data





Source supported on the scintillator



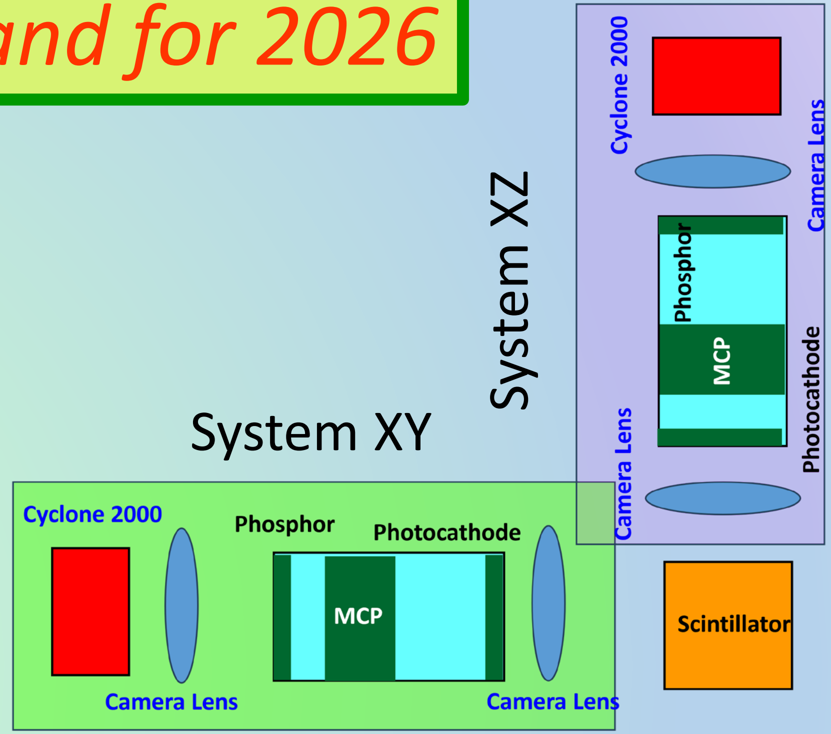
The signal from electrons is visible, the range is measurable

Requests for SJ unblock and for 2026

ECONOMIC SITUATION 2025:

- 28k euro AVAILABLE
- 20k euros SJ,

2025-26: Our goal is to have two systems (for XY and YZ planes)



Request for 2025

- 28k euro → we will buy a MCP Photek or Hamamatsu
- 20k euros SJ, we ask to unblock:
  - 1 computer for daq acquisition (3k euros) *
  - 1 camera lens to join to the cyclone 2000 (1k euro)
  - 1 cyclone 2000 (7.5k euro) *
  - 1 frame grabber interface cyclone-PC (2k euro) *
  - Cables 1k euro

TOT: 14.5k euro

* See the offers in the attached files

Request for 2026

- **Attrezzature scientifiche**: MCP (35 keuro) *
- **Consumo:** Scintillators, Lenses, mirrors and cables: 2k euro
- **Missions**: in presence meetings: 1 k euro

Conclusion

Update of the ongoing work

- **The optics has been defined**
- **Characterization of different sensors**
  - ➡ **Best solution is to use an Image Intensifier**
- **Measurements with high efficiency detector**
  - **Detection of Cosmic Ray muons**
  - **Detection of electrons from Sr source**
- **MC simulation well describes the Real data**
- **Requests to unblock SJ of 2025 and for 2026**

Backup slides

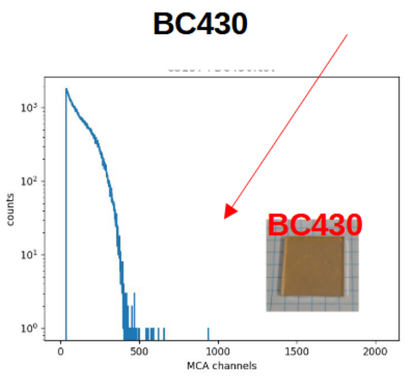
Test of different scintillators

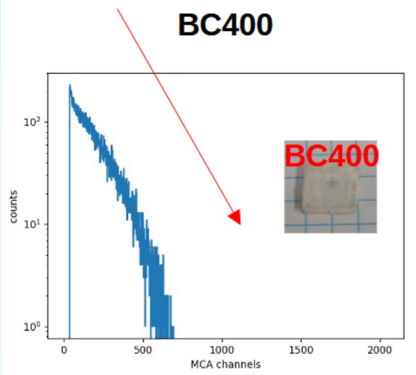
SCINTILLATORS:

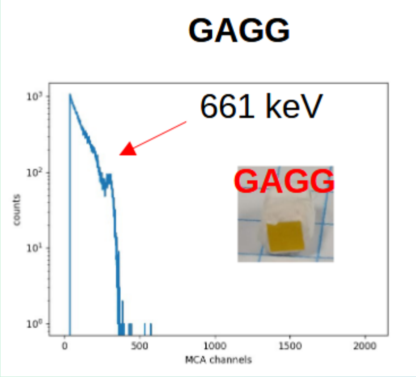
- **BC-400: 13k photons/MeV**
- **BC-430: 9k photons/MeV**
- **GAGG** Gd Al Ga Garnet **: 30k photons/MeV**
- **CsI: 54k photons/MeV**

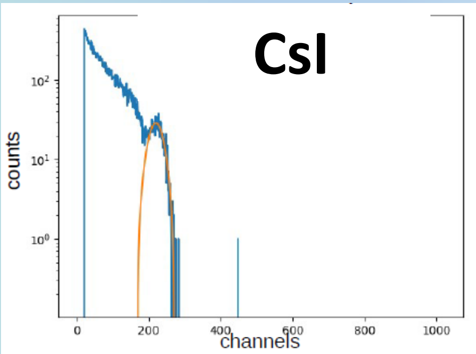
NOT VISIBLE

Cs137: β emitter and γ (661 KeV)









Am241:α (5.5 MeV) emitter and γ