News from the MONDO

Michela Marafini and
Davide Pinci

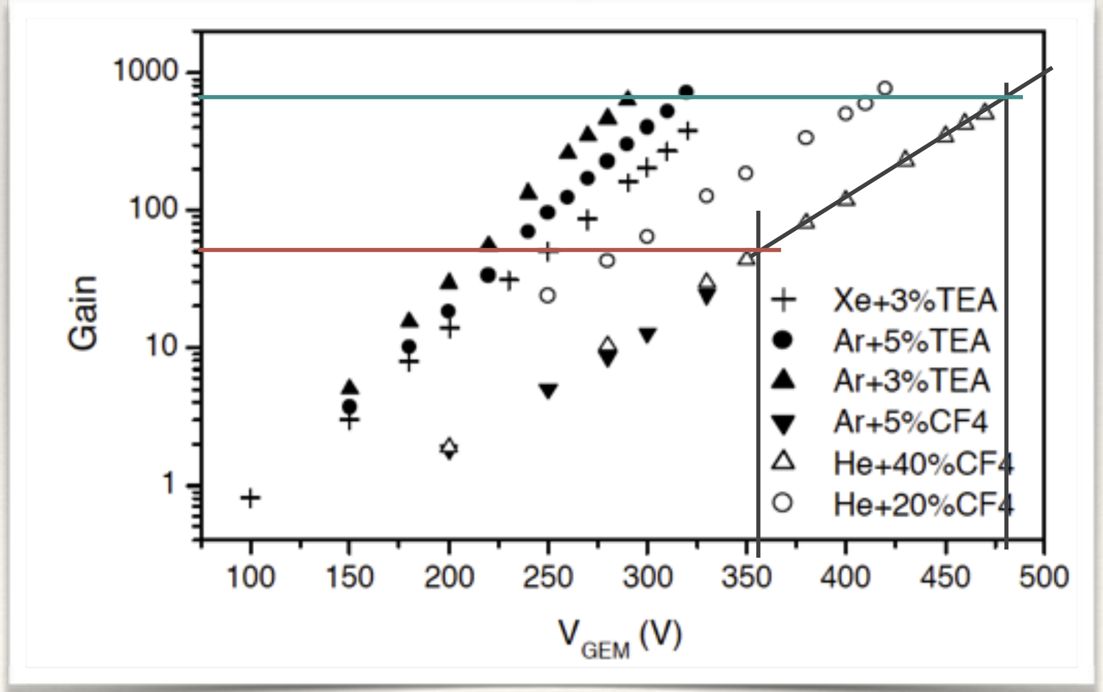
On behalf of MONDO collaboration

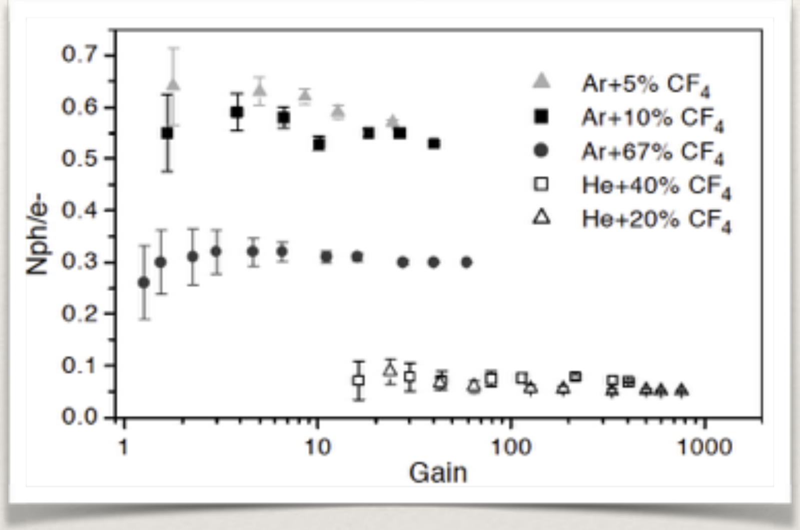
Conclusion of workshop talk

"… the light is not enough we'll try to increase the amount of CF_4 in the mixture or to add a fourth GEM to the stack;"

We started from the easiest: increase the amount of CF_4 in the mixture. We moved to an He/CF_4 60/40 (increase of CF_4 by a factor about 10);

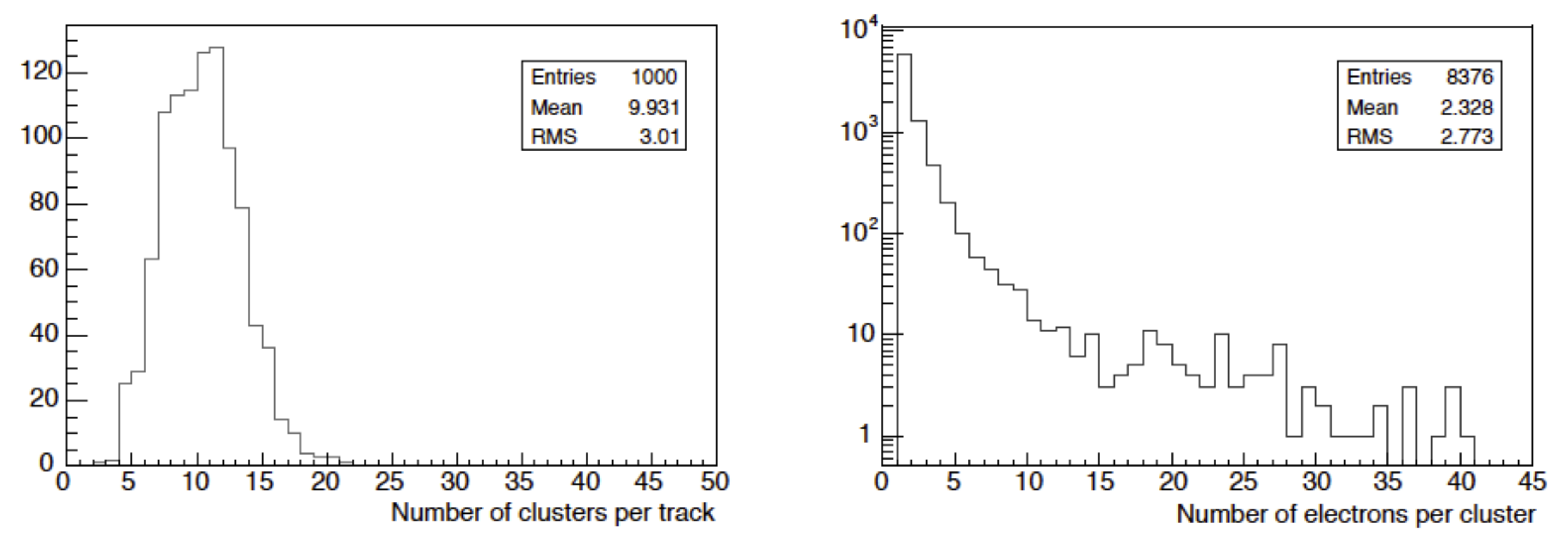
Vgem @ 480. Nominal gain 600 instead of 50;





From this paper an increase of a factor 10 in gain and a lower ratio photons/electrons are expected;
The overall gain in light wasn't expected to be huge;

The gas mixture: Garfield



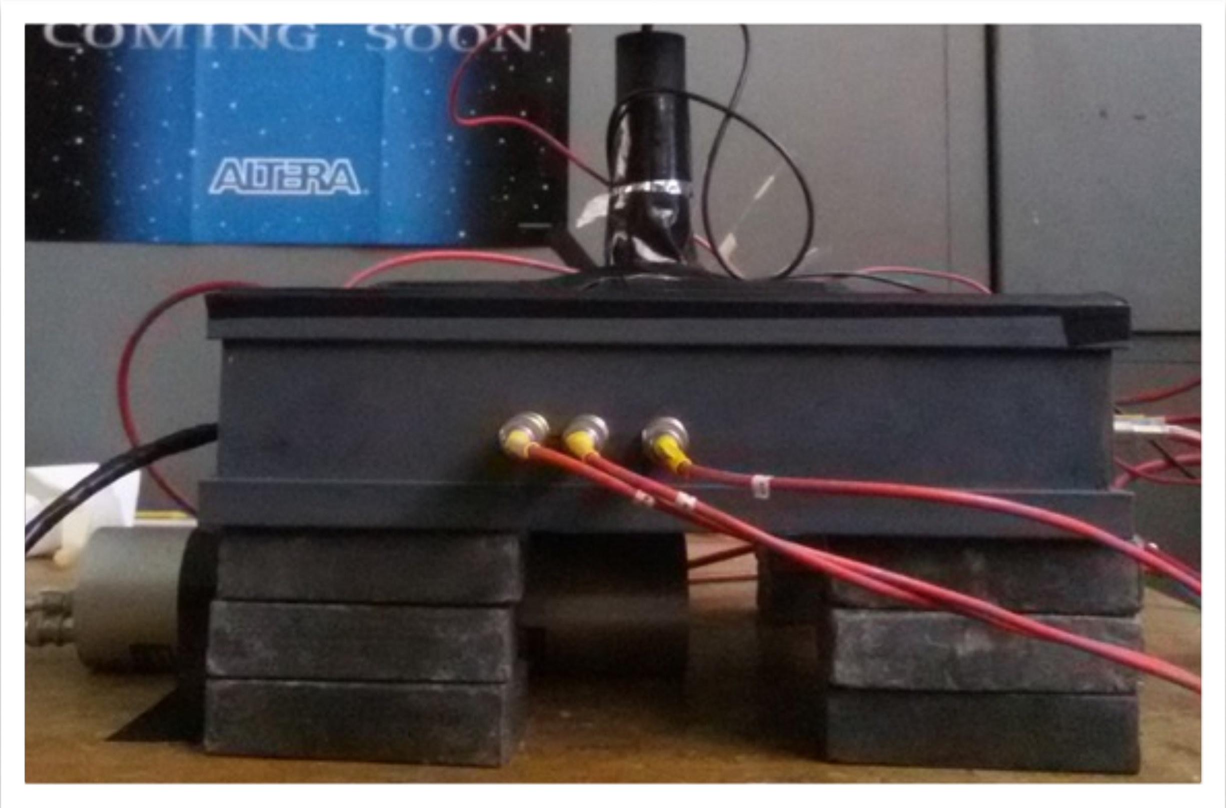
- The ionization due to the crossing of 2 GeV muons in the 3 mm drift gap were studied: muons produce about 10 clusters in average in the 3 mm drift gap. Therefore, the mean distance between two ionization points is about 300 µm.

- The distribution of the number of electrons per cluster has a mean value of 2.3.

- The total number of primary electrons due to a minimum ionizing muon crossing the drift gap perpendicularly to the GEM plane is thus expected to be around 20.

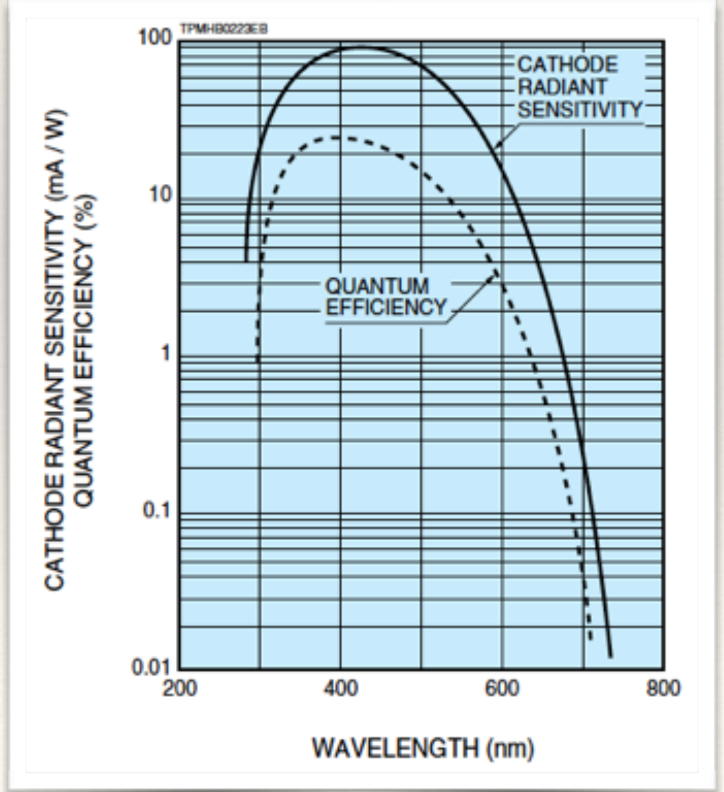
Experimental set-up: PMT

The light yield of the triple-GEM detector was measured by means of cosmic rays;



Two NaI scintillators used to trigger penetrating muon tracks;

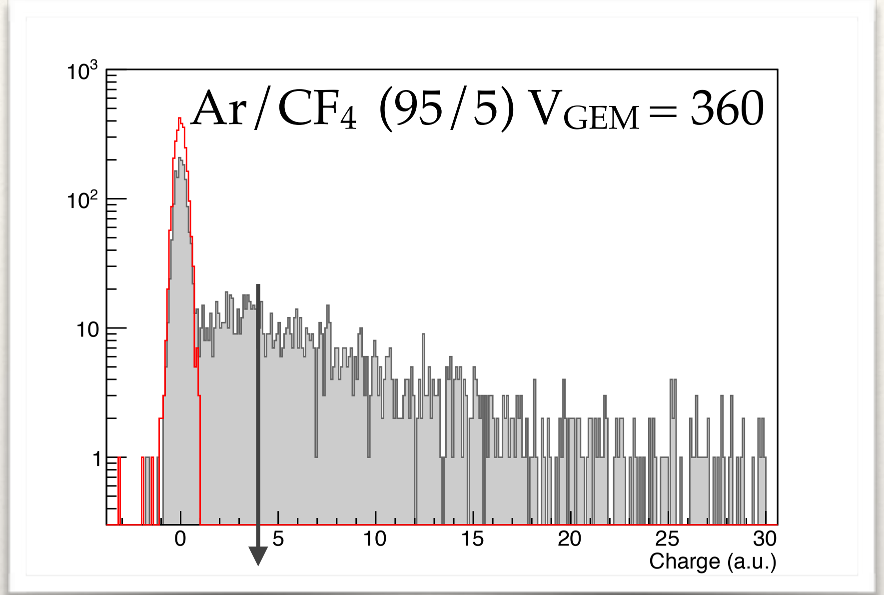
Light produced by the triple-GEM collected by a R9800 PMT;



A quantum efficiency below 5% is expected on the orange-red part;

Charge spectra: cosmic rays and PMT

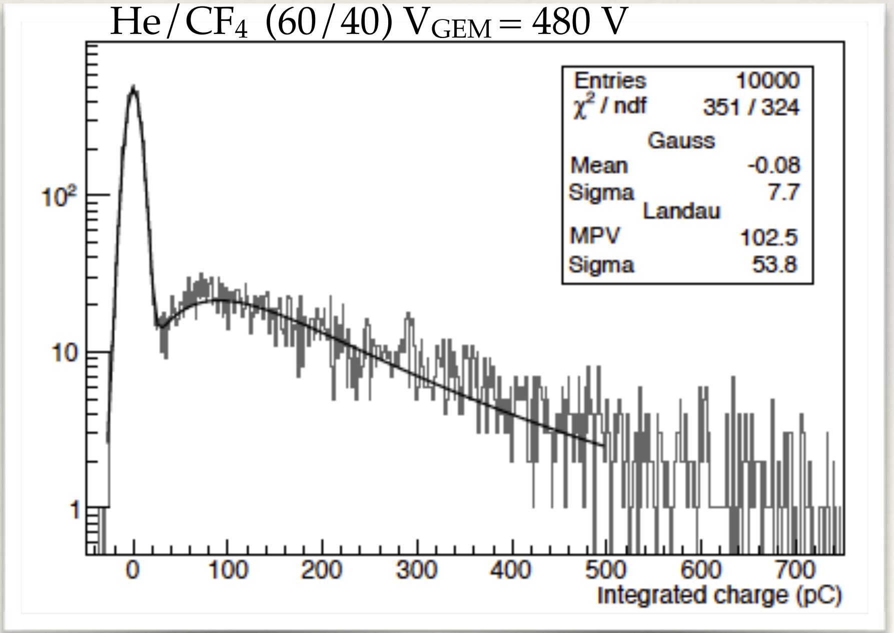
The waveforms were numerically integrated to evaluate the total collected charge



Equivalent to 1 pC

Example of the charge spectra obtained with the highest gain for stable operation;

The pedestal is evaluated in a similar gate before the trigger signal;



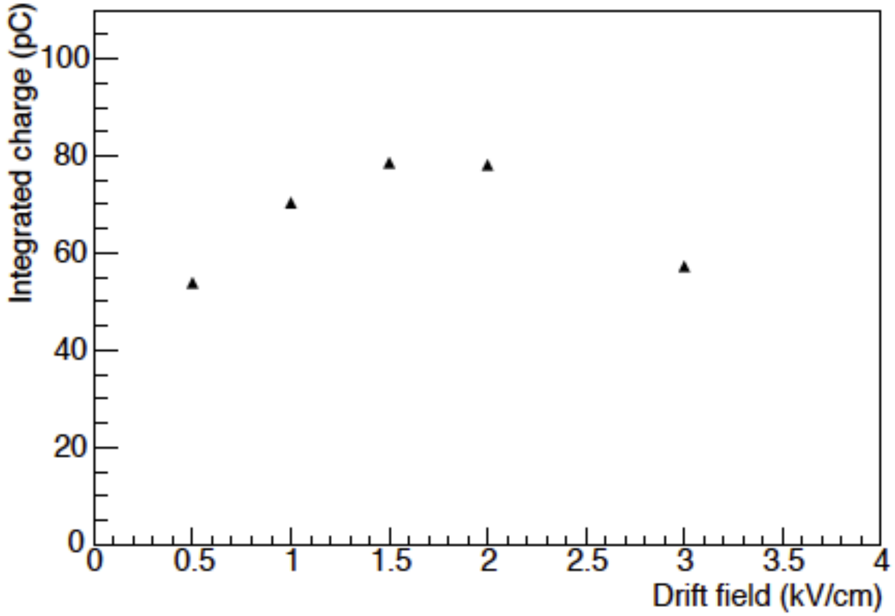
The total amount of light is 100 times higher;

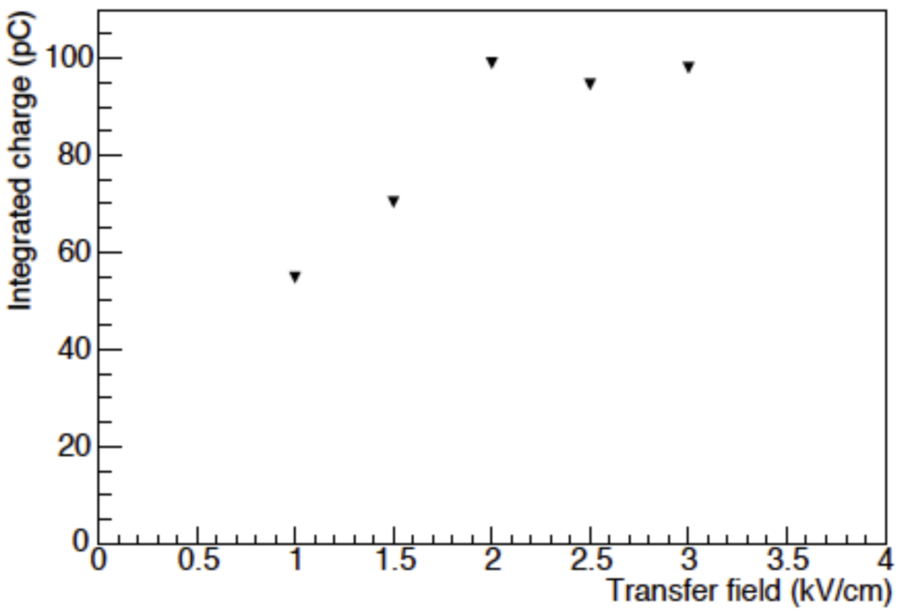
A huge increase not expected from published data;

The larger pedestal is due to the different scale on the scope used for the DAQ;

Electric field optimisation

The dependence of the light yield on the electric fields was studied;





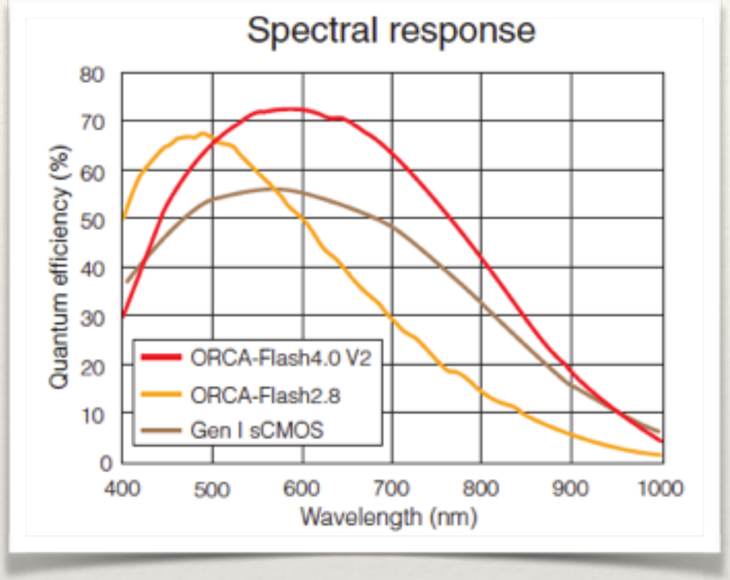
A maximum value found for drift field values between 1.5 kV/cm and 2.0 kV/cm

The light yield increases very rapidly while increasing the drift field while it is almost stable for values in the range 2.0÷3.0

We decided to operate with a drift field of 1.5 kV / cm and transfer fields at 2.0 kv / cm

The CMOS-Camera

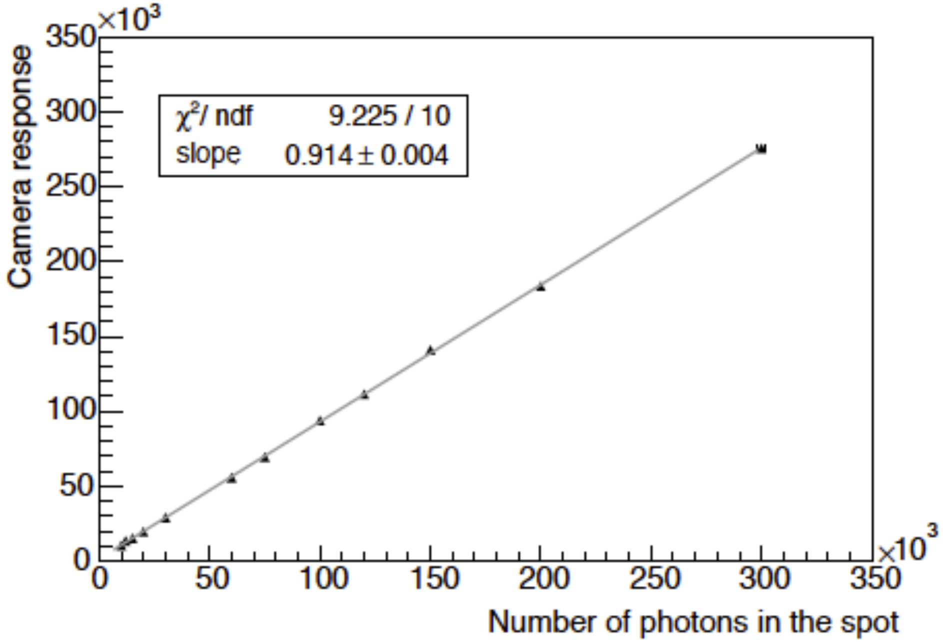
The PMT was replaced by an ORCA flash 4.0 camera that we instrumented with a Schneider bright lens

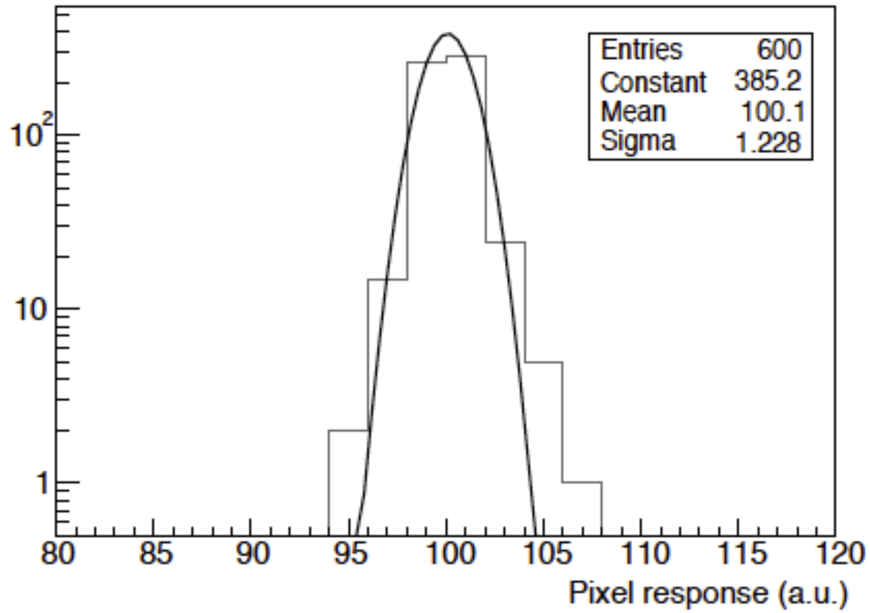


- low noise: nominal level lesser than 2 photons per pixel;
- high sensitivity: a quantum efficiency higher than 70% in the CF4 emission spectral range;
- high granularity: 2048 x 2048 pixels with an area of 6.5 μm x 6.5μm for a total sensitive surface of 13.3 mm x 13.3 mm.

The Camera performance

The performance of the photo-sensor were studied by means of a calibrated light source;



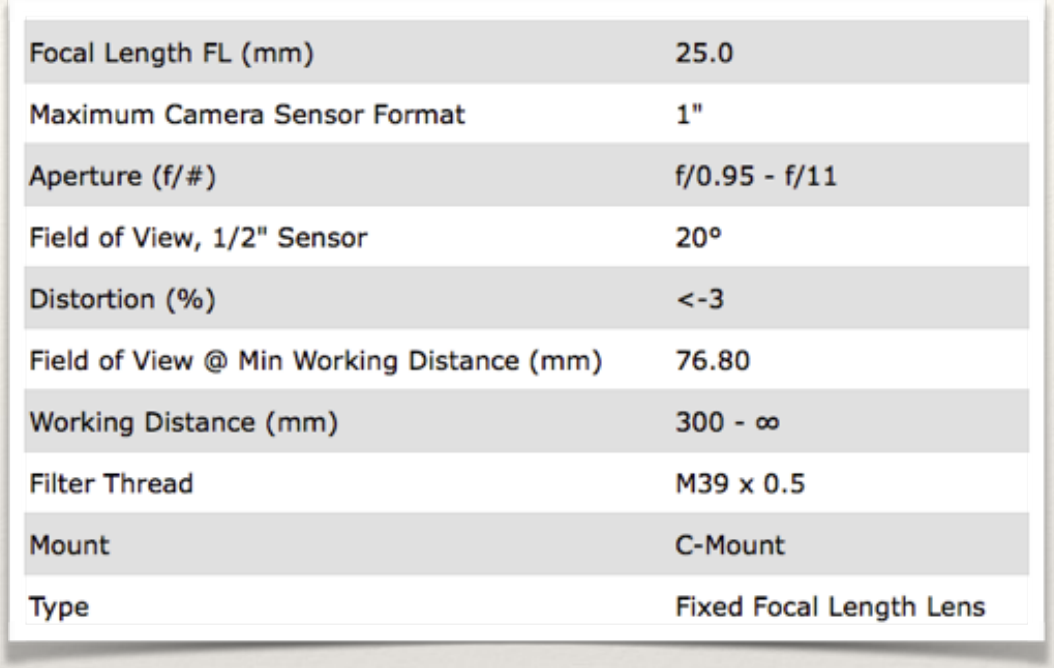


The camera behaviour is well linear in the whole studied range with a response of 0.91±0.01 counts

In order to evaluate the noise level, the response of a pixel was acquired several times while the camera was kept in the dark.
Fluctuations of the pedestal are lower than 2 counts, i.e. lower than two photons per pixel in good agreement with the expectations

The lens

The PMT was replaced by an ORCA flash 4.0 camera that we instrumented with a Schneider bright lens



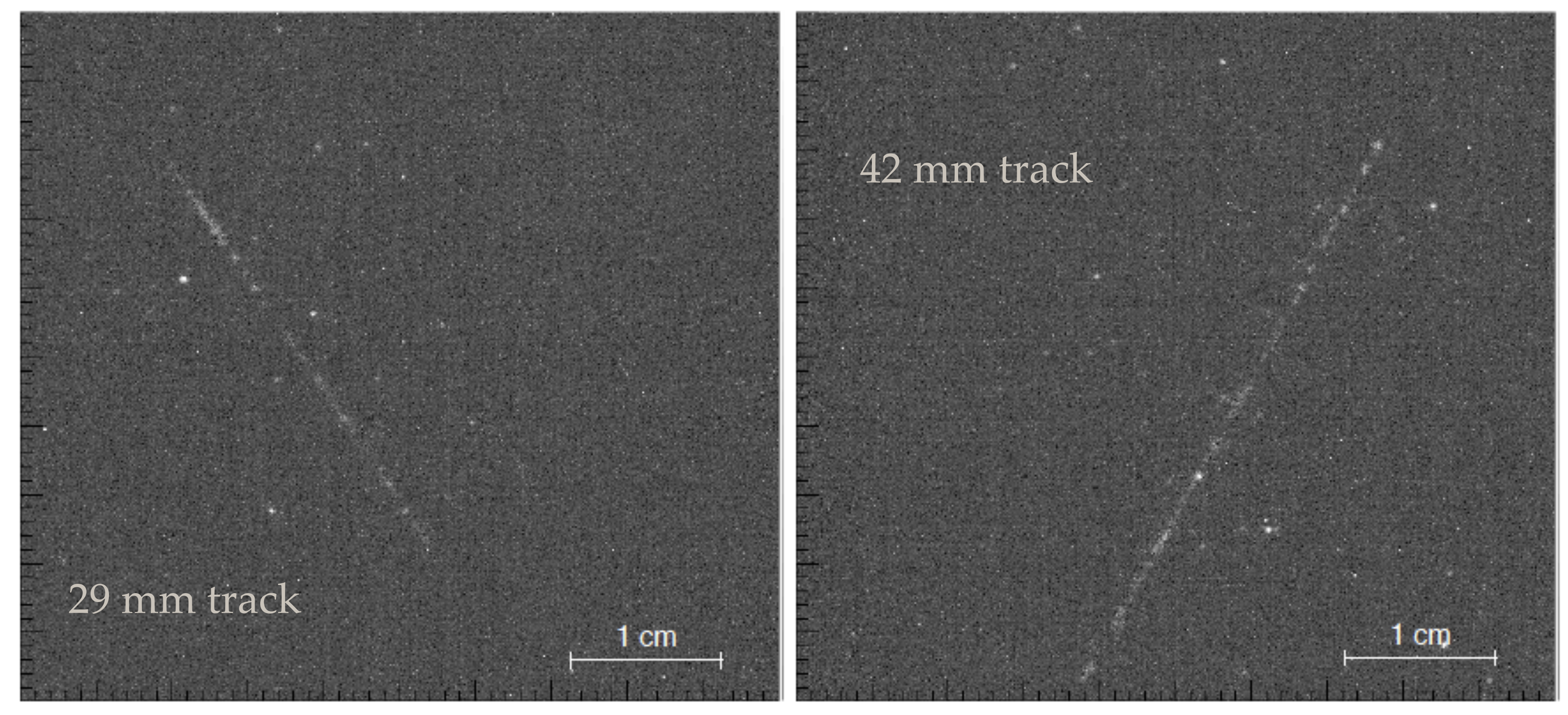
Focal Length FL (mm)	25.0
Maximum Camera Sensor Format	1"
Aperture (f/#)	f/0.95 - f/11
Field of View, 1/2" Sensor	20°
Distortion (%)	<-3
Field of View @ Min Working Distance (mm)	76.80
Working Distance (mm)	300 - ∞
Filter Thread	M39 x 0.5
Mount	C-Mount
Type	Fixed Focal Length Lens

By inserting a 1.0 mm spacer between the camera and the lens we were able to work at a distance of about 20 cm with with a field of view of about 10x10 cm^2;

A de-magnification of a factor about 10 was obtained;

Each pixel looked at a 50 μm x 50 μm surface;

Muon tracks



By means of this setup we were able to acquire several images of long and straight tracks as the above ones.

They are very likely due to cosmic rays;

(We are having some problems in converting these heavy images in png format without loosing in “clearness”…)

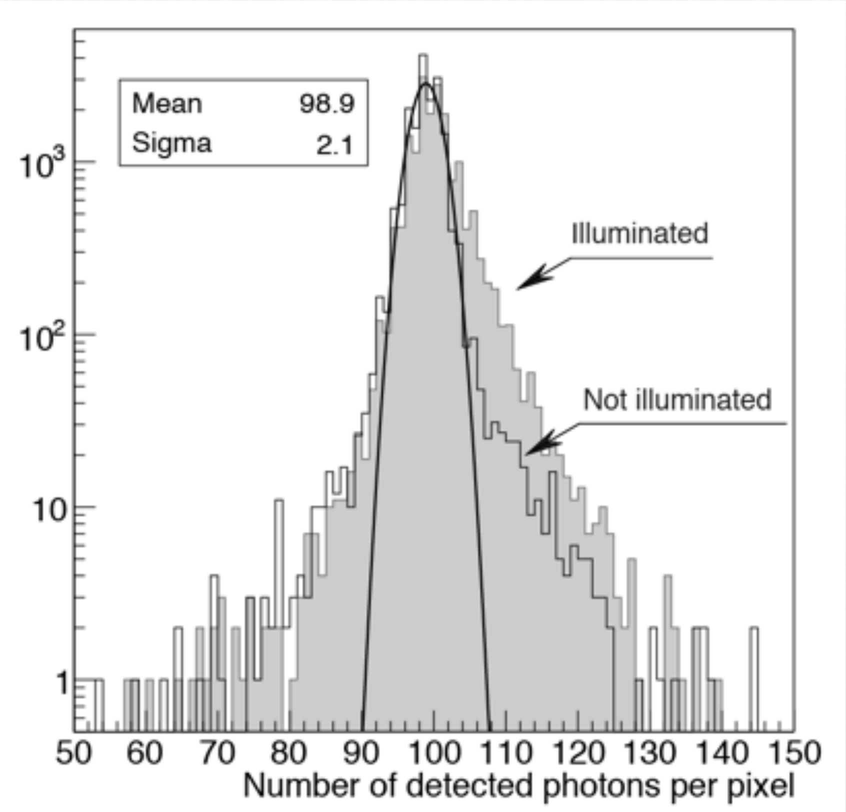
Light collection

To study the collection of the light by the sensor a simple analysis was performed;

The response distribution of the pixel along the track was compared with the one obtained in a similar non illuminated area;

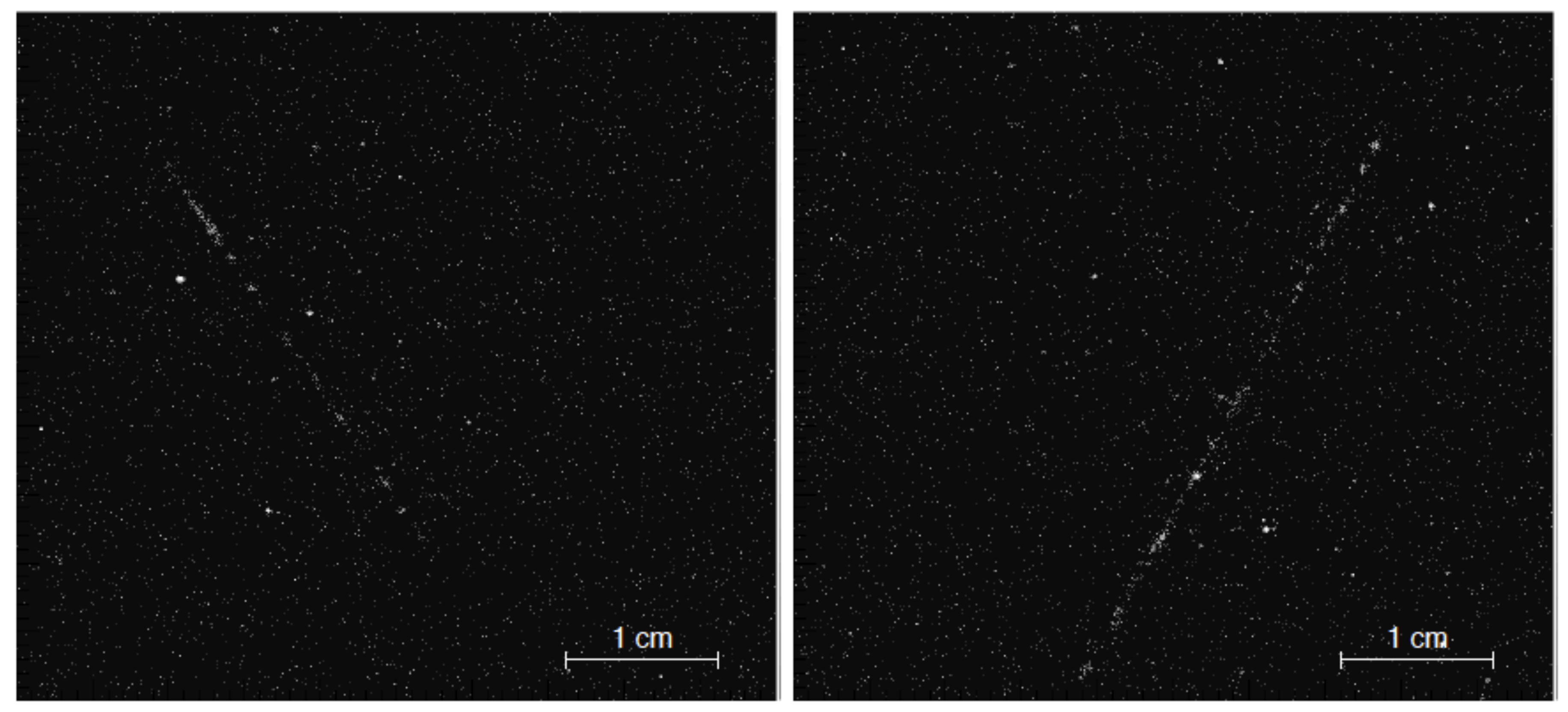
In the not-illuminated region a response 99 ± 2 was found, in good agreement with the measurements performed in the dark conditions;

A large amount of pixels with a response up to 30 photons above the pedestal was obtained in the illuminated region.



A light yield of about 600 photons per track millimetre was evaluated

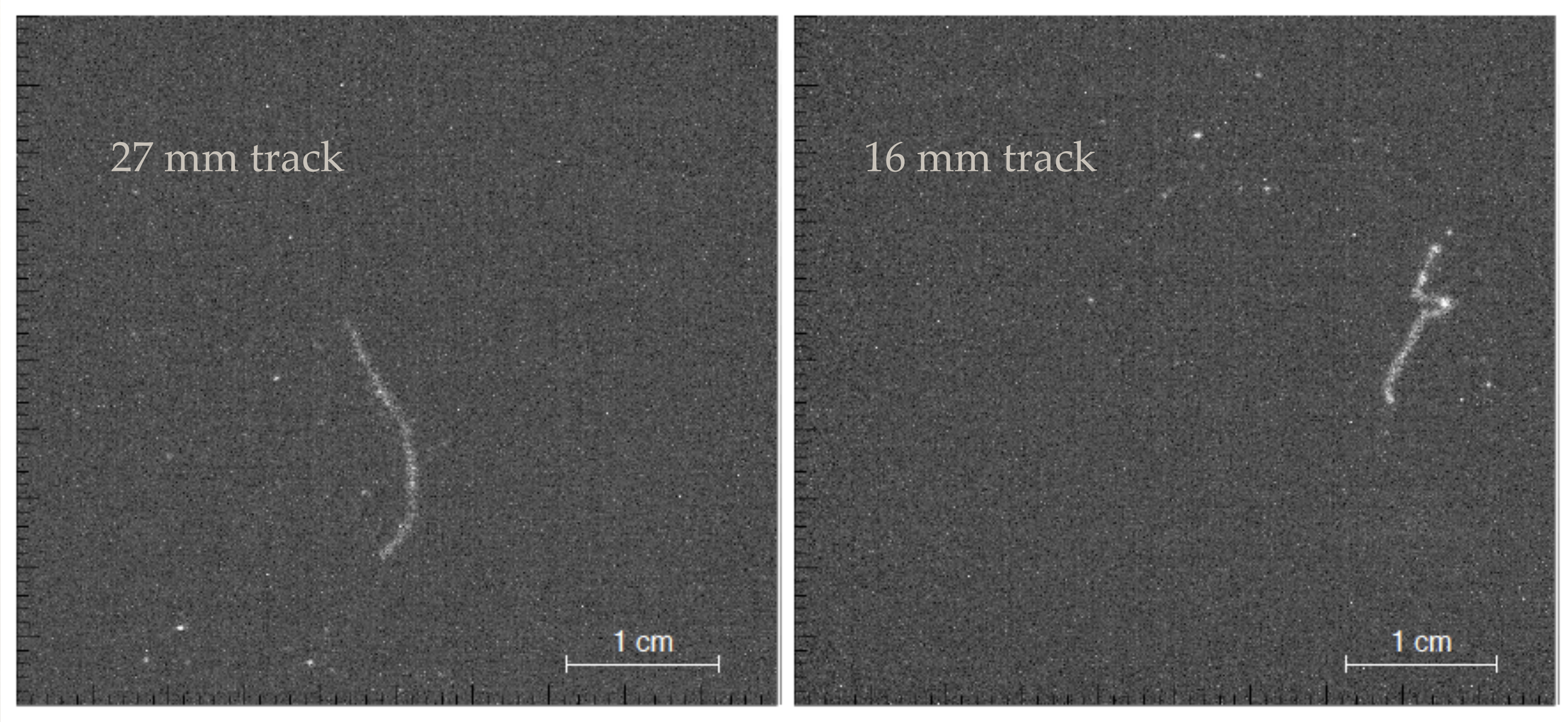
Efficiency



These figures show the maps of the pixels with a response three sigmas larger than the pedestal (i.e. higher than 105 photons);

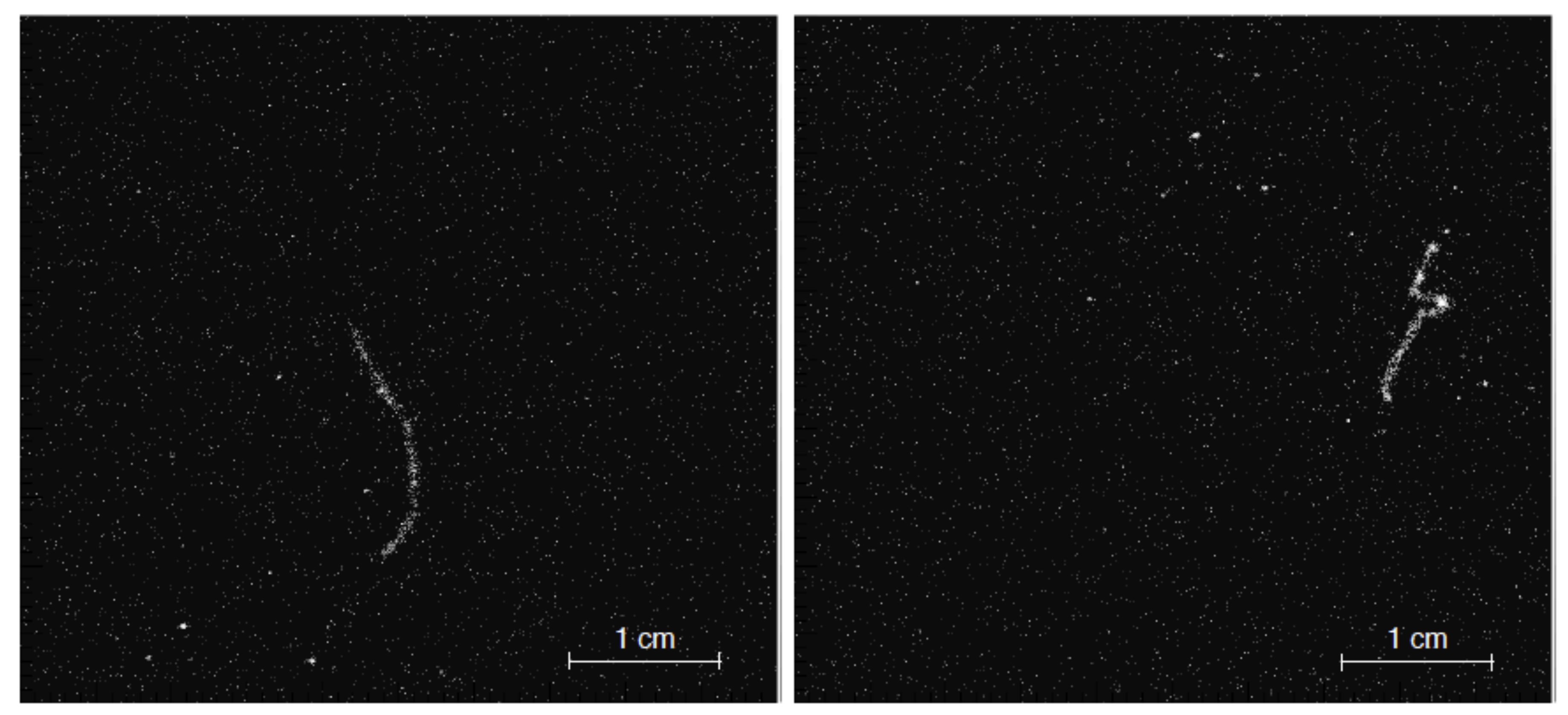
An amount of 40±5 pixels satisfying the above requirement per track millimetre was measured.

Electrons



During the data taking, several images of short, intense and curved tracks were acquired;
These tracks (as the ones shown in Fig. 10) are very likely due to ionizing electrons produced by natural radioactivity and traveling within the drift gap;

Efficiency for electrons



These figures show the maps of the pixels with a response three sigmas larger than the pedestal (i.e. higher than 105 photons);

An amount of 300 pixels satisfying the above requirement per track millimetre was measured.

Conclusion and future steps

The use of more CF_4 allowed to increase the light production;

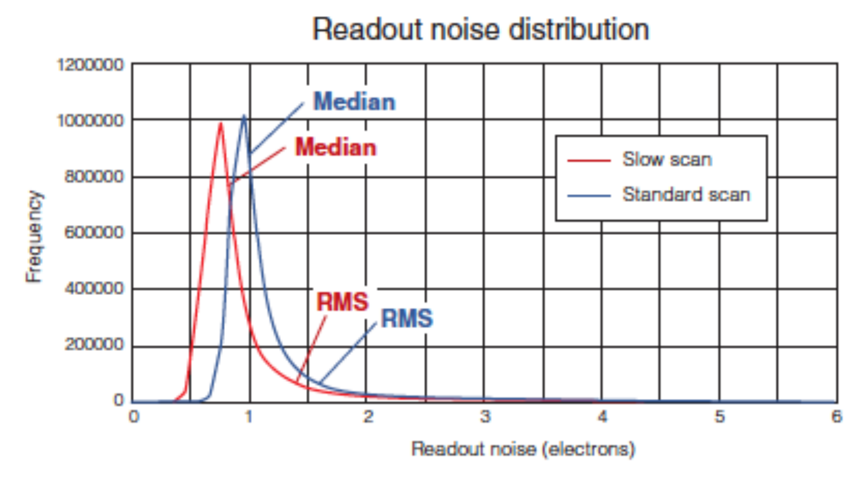
For muon tracks an amount of 600 photons/mm were collected;

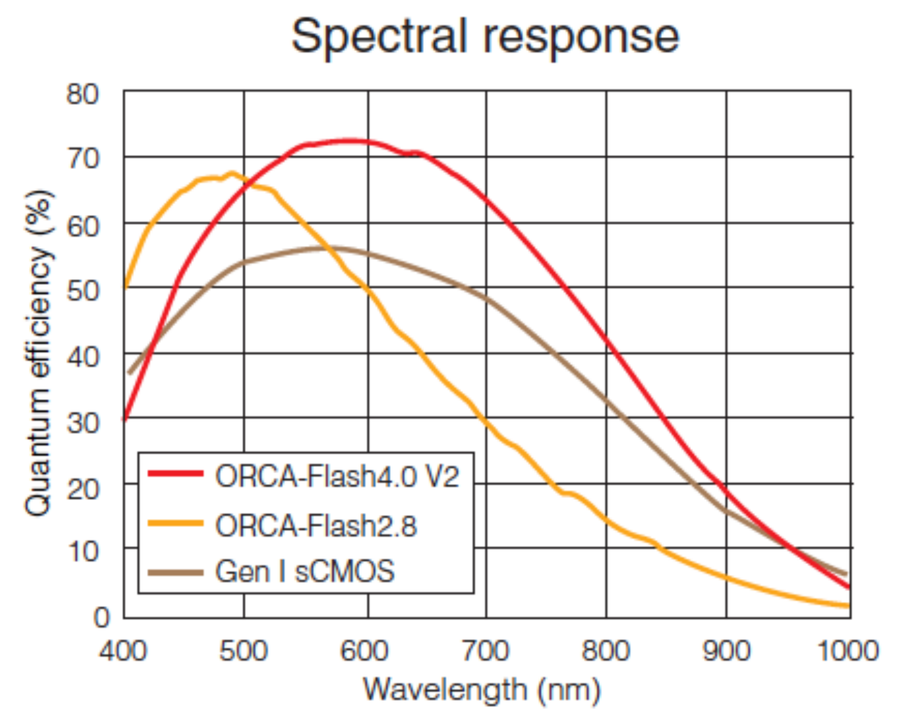
For electrons tracks about ten times more;

We intend to:

- Assembly new detector with larger drift gap (1 cm) and smaller GEM holes;
- Test new gas mixture with a larger amount of CF_4 (60%);
- Perform the same tests at the Frascati electron beam (BTF) in November;

ORCA Flash 4.0





Product number		C11440-22CU (ORCA-Flash4.0 V
Imaging device		Scientific CMOS sensor FL-400
Effective number of pixels		2048(H) × 2048(V)
Cell size		6.5 μm × 6.5 μm
Effective area		13.312 mm × 13.312 mm
Full well capacity (typ.)		30 000 electrons
Readout time	Standard scan (at 100 frames/s)	10 ms
	Slow scan (at 30 frames/s)	33 ms
Readout noise	Standard scan (at 100 frames/s, typ.)	1.6 electrons rms (1.0 electrons median)
	Slow scan (at 30 frames/s, typ.)	1.4 electrons rms (0.8 electrons median)
Dynamic range (typ.)*2		37 000:1
Quantum efficiency		Over 70 % at 600 nm and 50 % at 750 nm

Cooling method	Dark current (typ.)	Sensor temperature (nominal)
Forced air (Ambient at +20 ℃)	0.06 electrons/pixel/s	–10 ℃
Water (+20 ℃)	0.02 electrons/pixel/s	–20 ℃
Water (+15 ℃)	0.006 electrons/pixel/s	–30 ℃