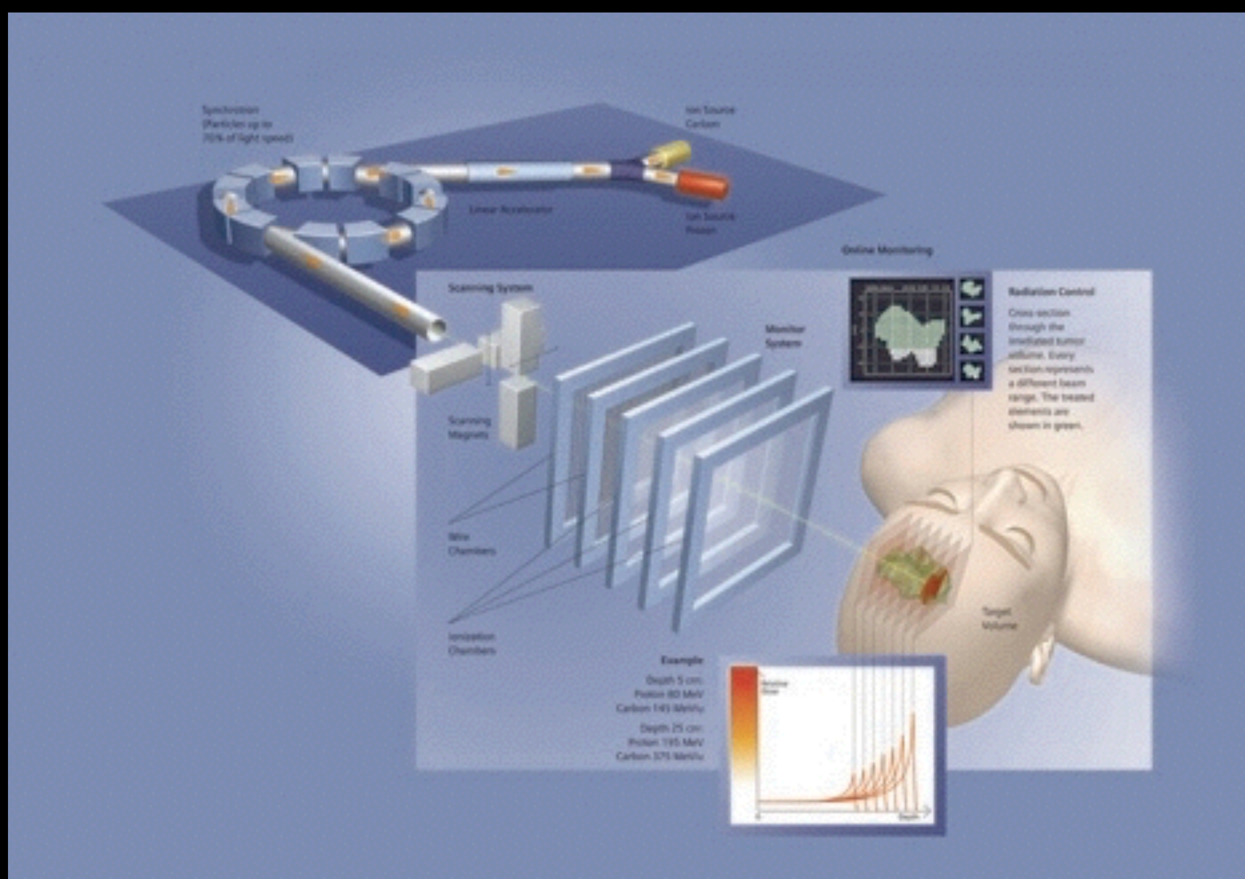
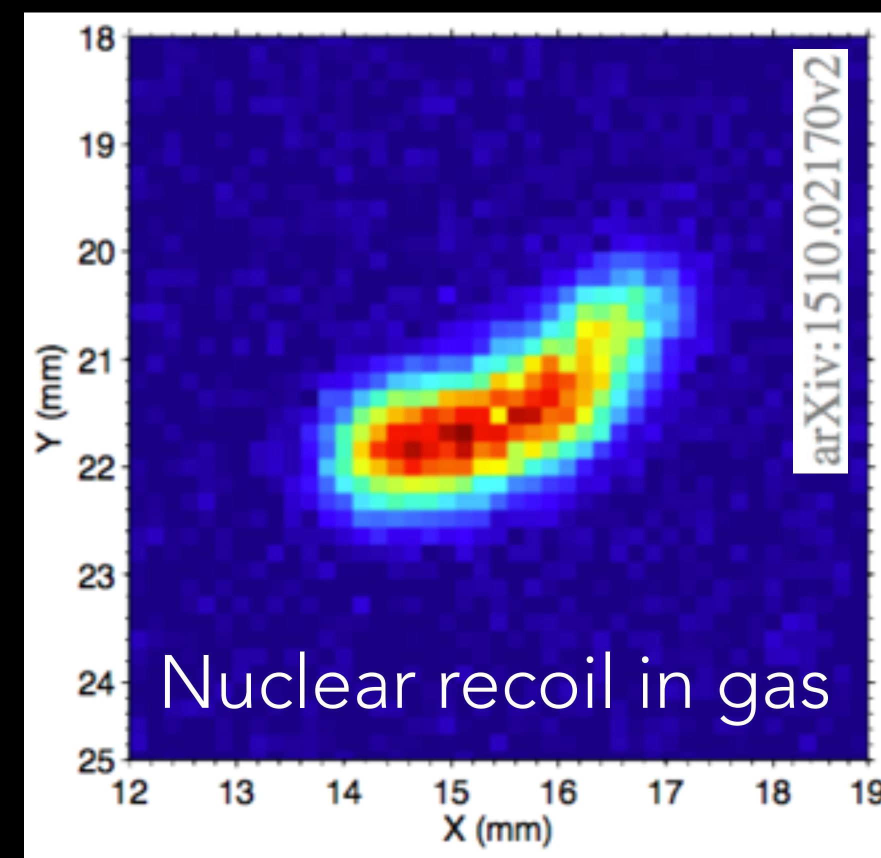
DAVIDE PINCI - INFN SEZIONE DI ROMA

ORANGE: TRACKING PARTICLES WITH OPTICAL READOUT GEM

TRACKING PARTICLES

A high precision tracking of low energy massive particles will play a key role in the future of fields ranging from Monitoring in Particle Therapy to the Dark Matter Search.

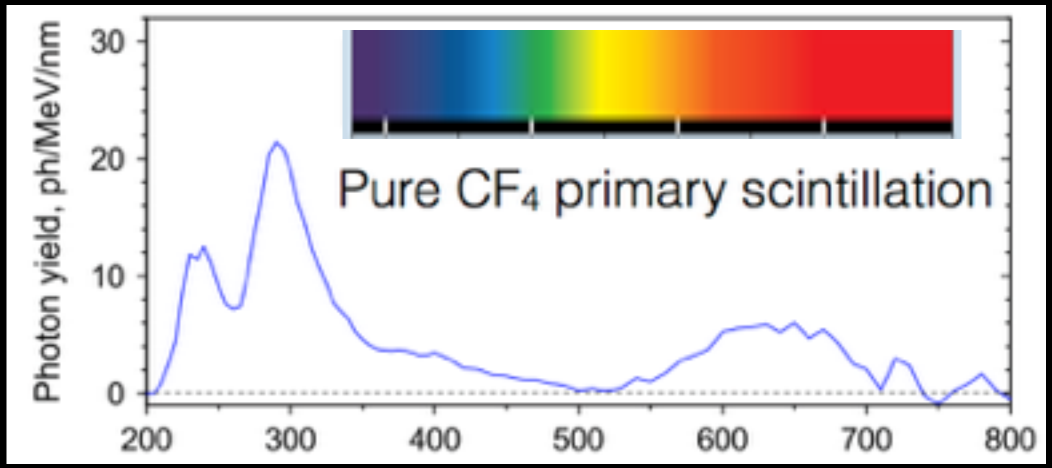




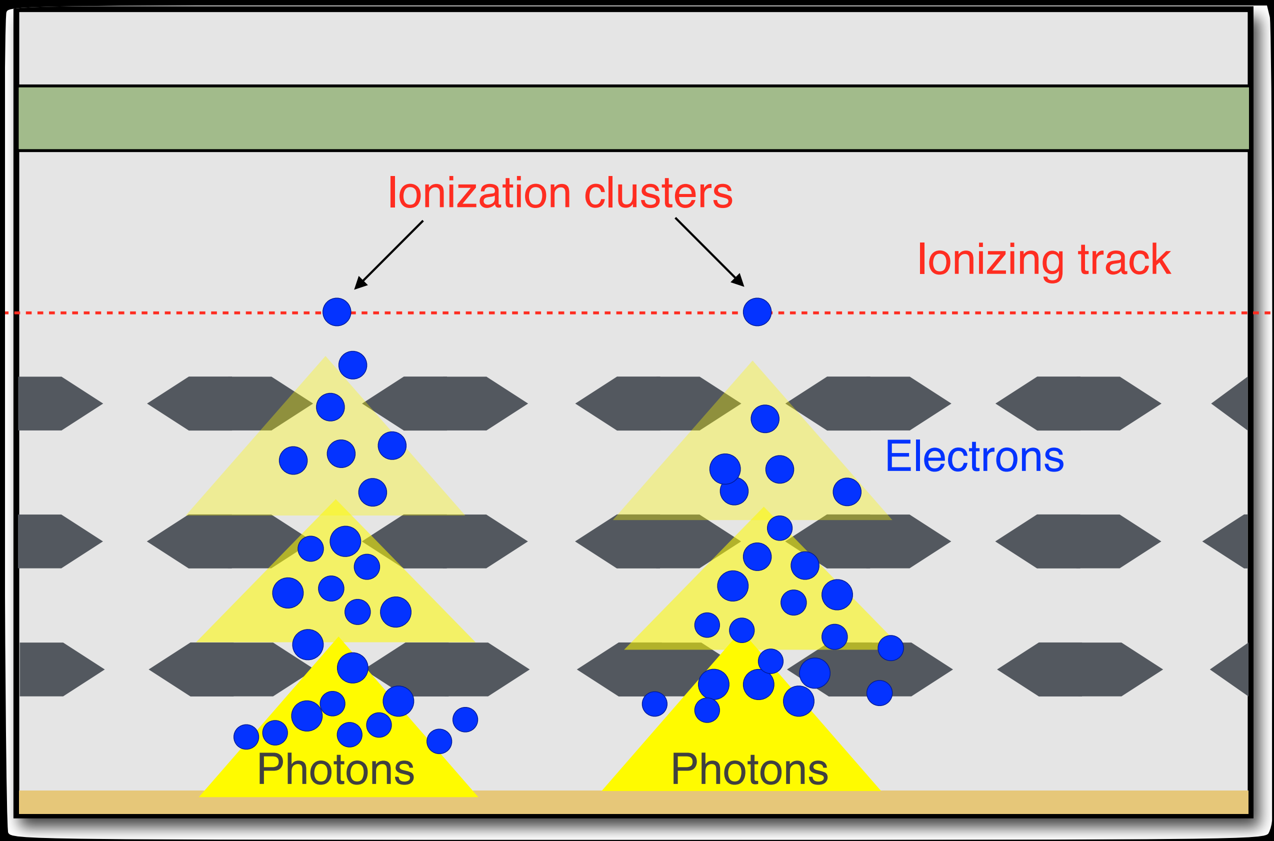
Gas based devices are natural candidates (low material budget, not expensive, high space and time resolution), but the increasing number of readout channels is becoming a bottleneck.

LIGHT: A CHANGE OF PARADIGM

During the multiplication process, photons are produced along with electrons by the gas through atomic and molecular de-exitation; Amount and spectrum of emitted light depends on the gas mixture;



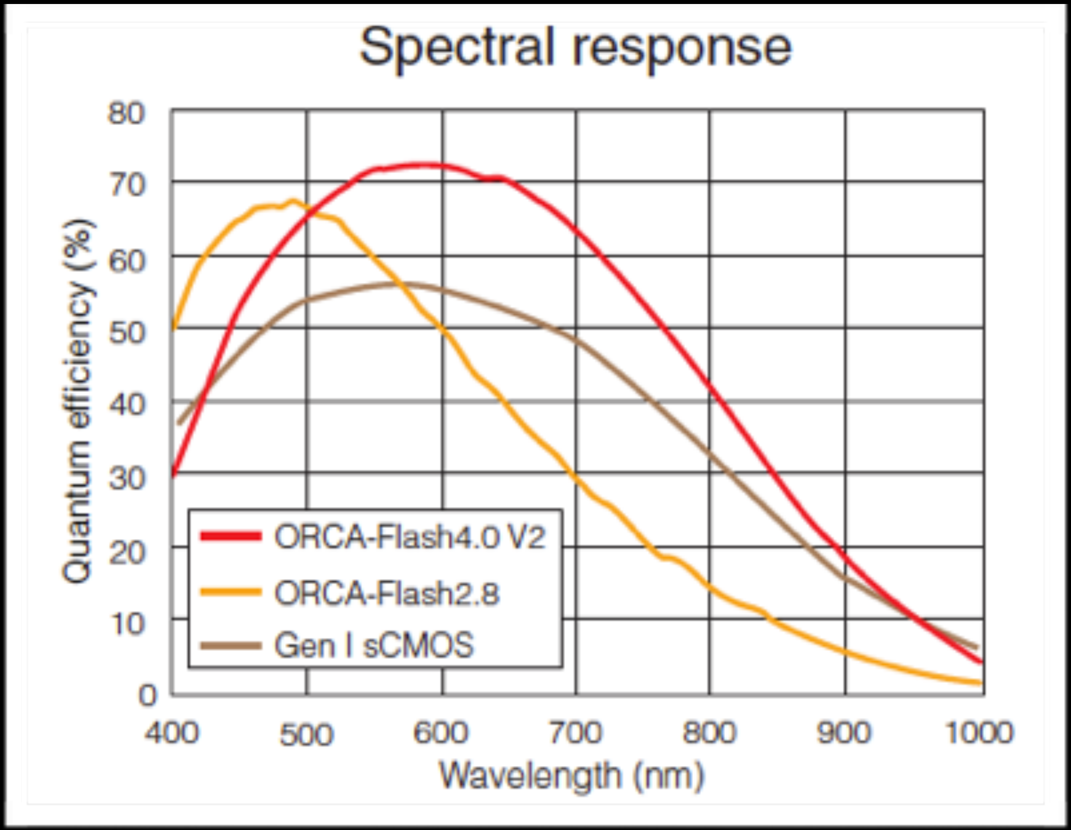
Clusters produced by an ionizing track in the drift gap of a Triple GEM will generate a lot of electrons and photons



Electrons can be collected by the last GEM electrode and photons can by "seen" through a suitable transparent window

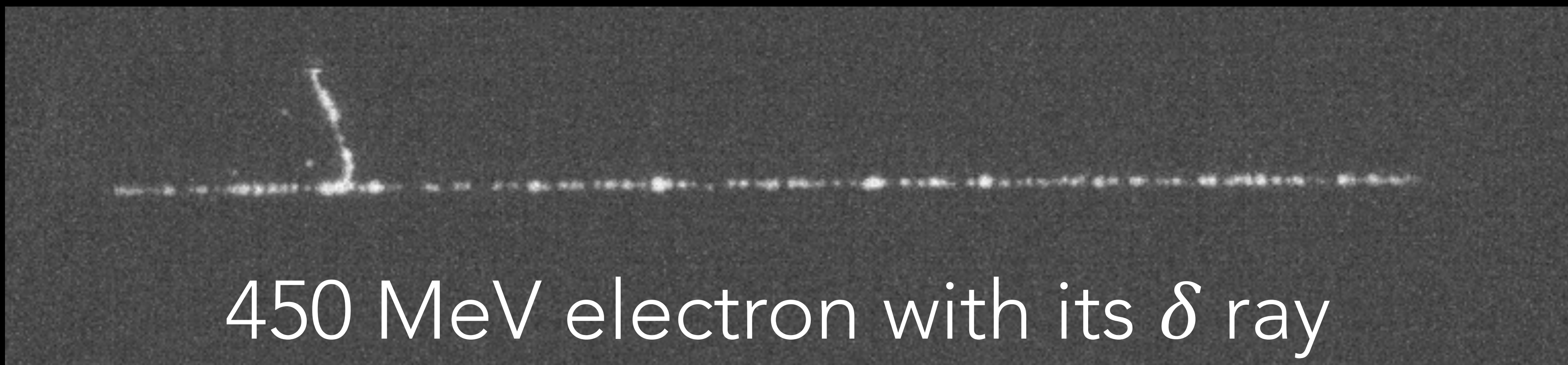
HOW TO READOUT THE LIGHT?

CMOS sensors provide very low noise together with high granularity and sensitivity

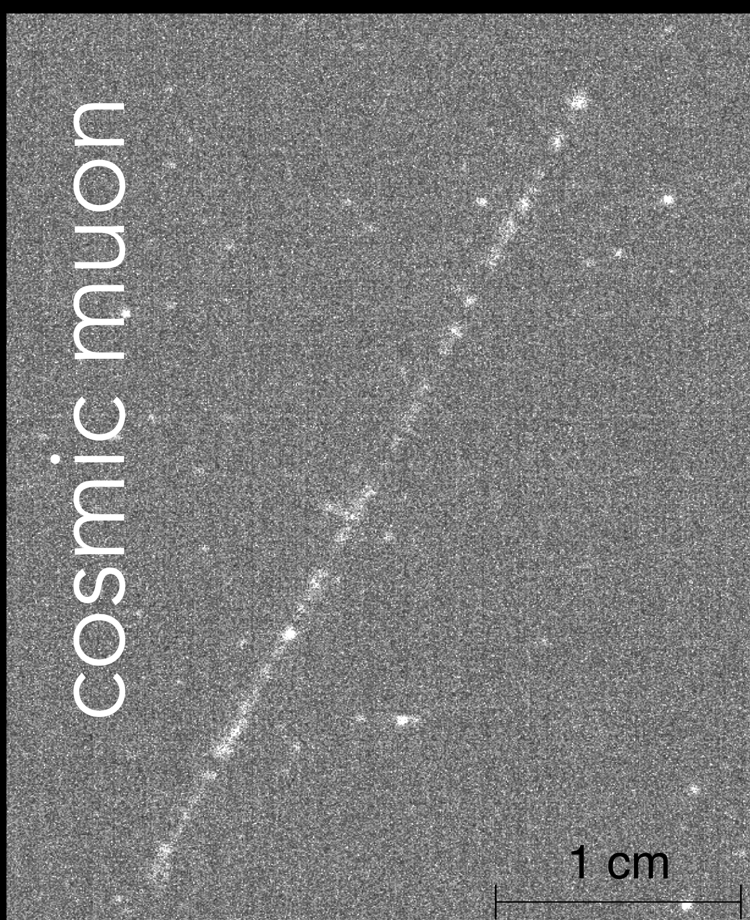


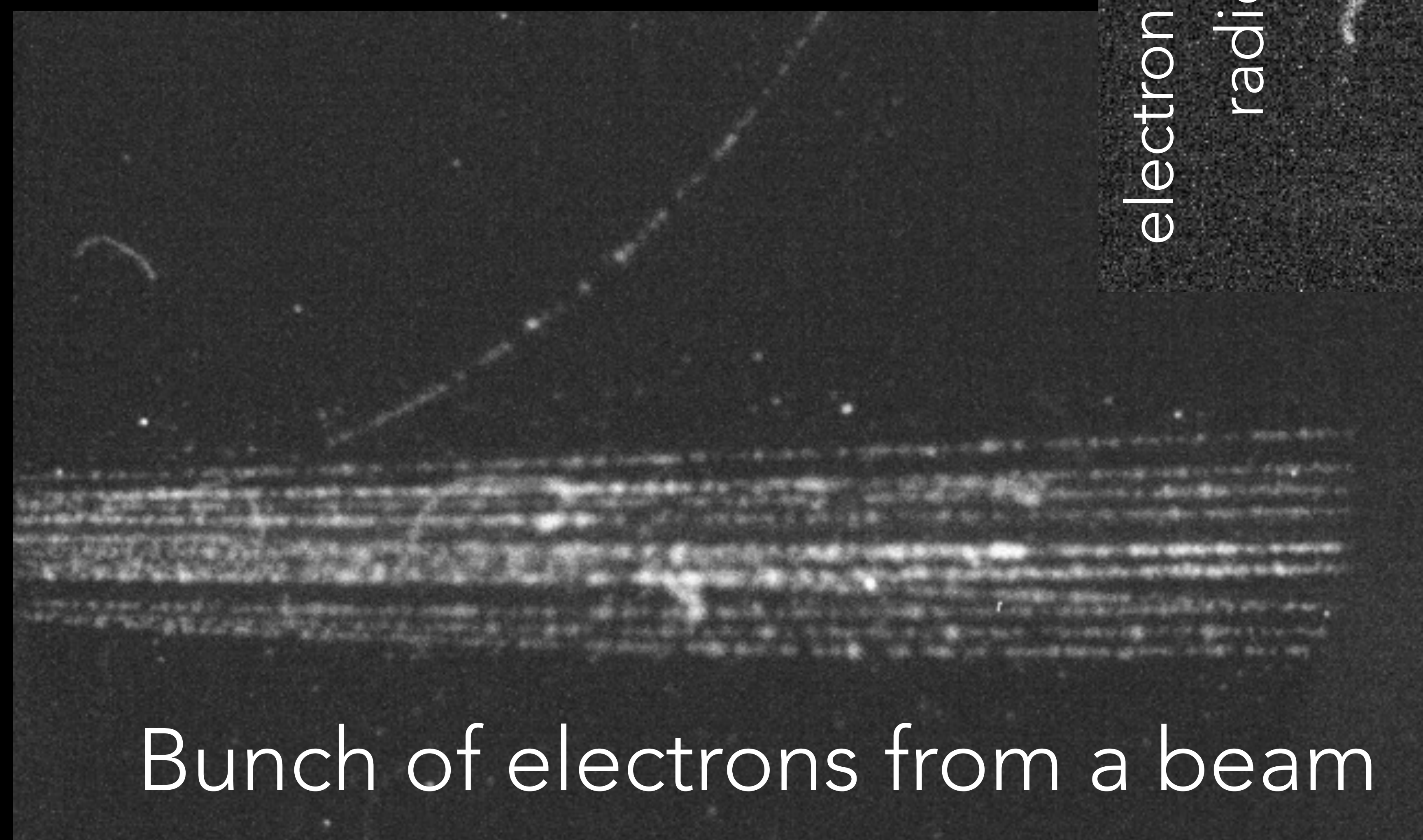
Equipped with a suitable large aperture (f/0.95) and a short focal lenght (20 mm) lens, it allows to get very clear images of particle tracks

LIKE THESE

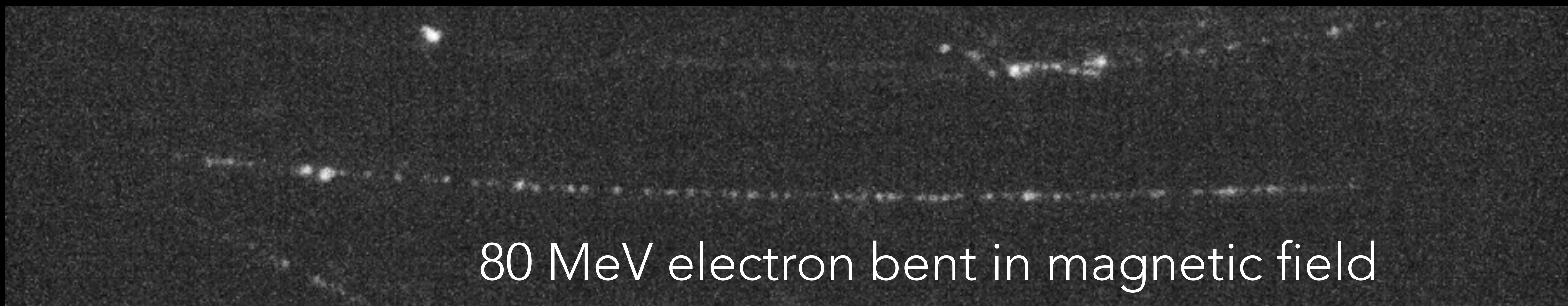

450 MeV electron with its δ ray

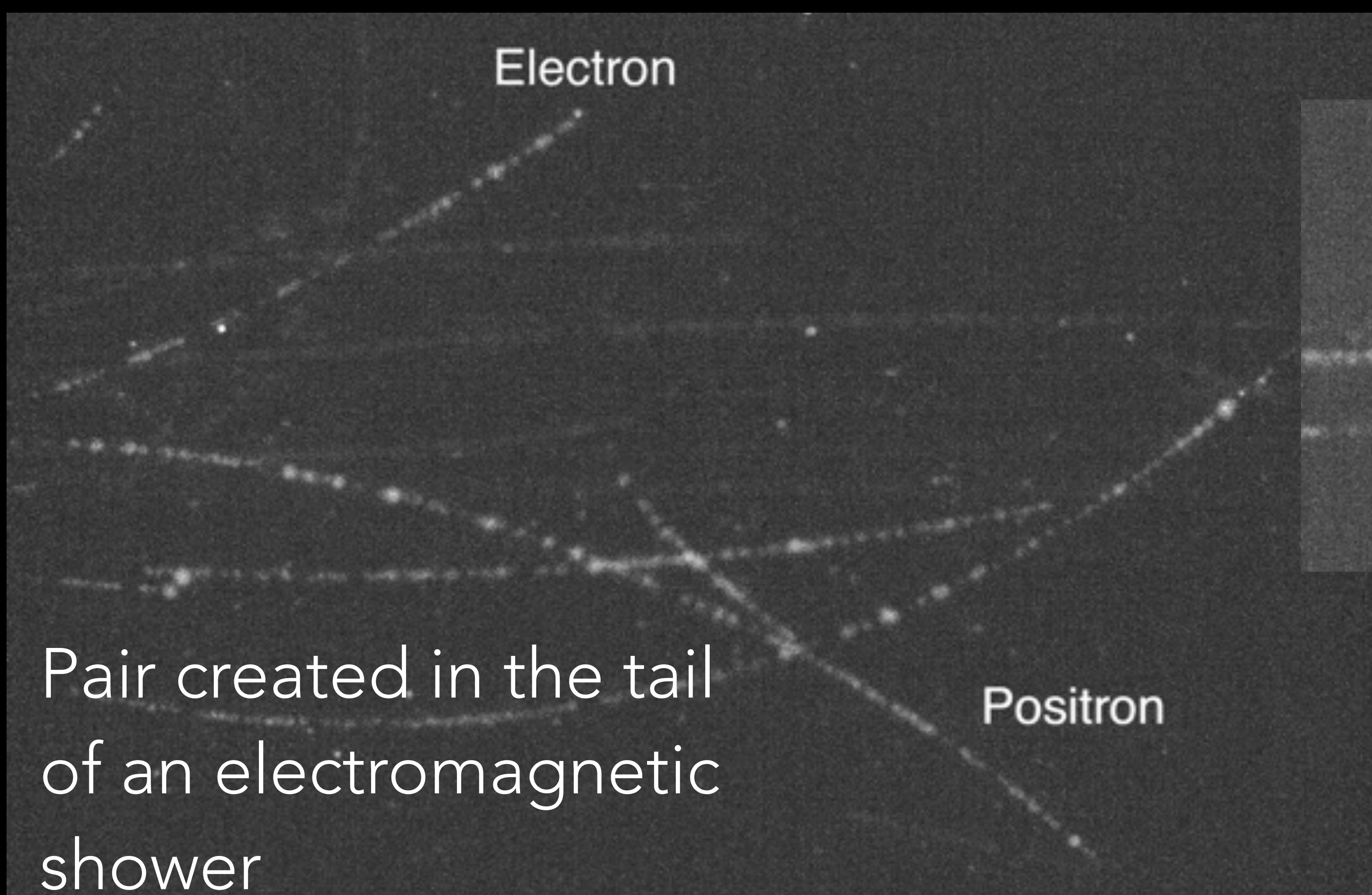

electron from natural
radioactivity


cosmic muon
1 cm

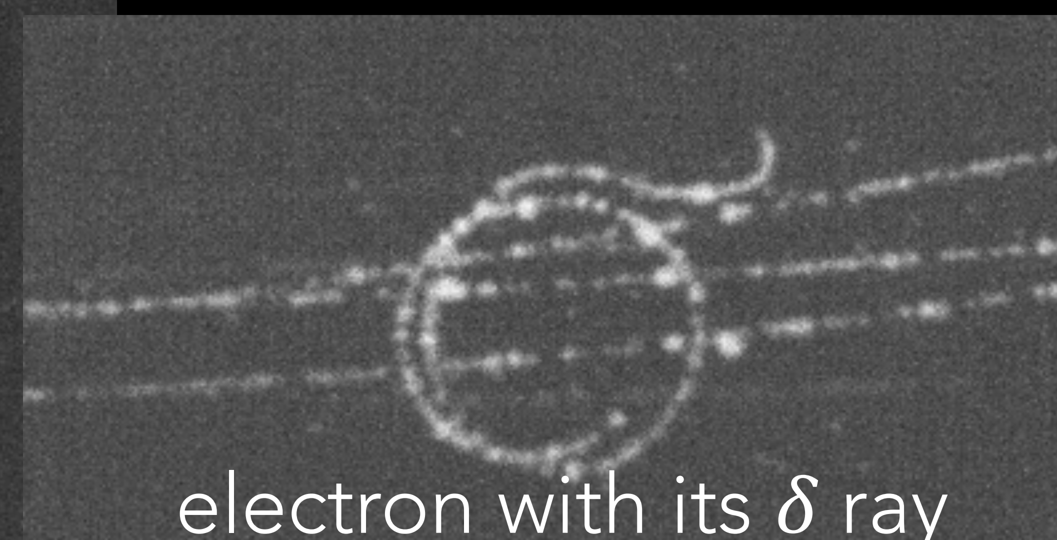

Bunch of electrons from a beam

OR THESE (0.2 T MAGNETIC FIELD)


80 MeV electron bent in magnetic field



Pair created in the tail of an electromagnetic shower


electron with its δ ray

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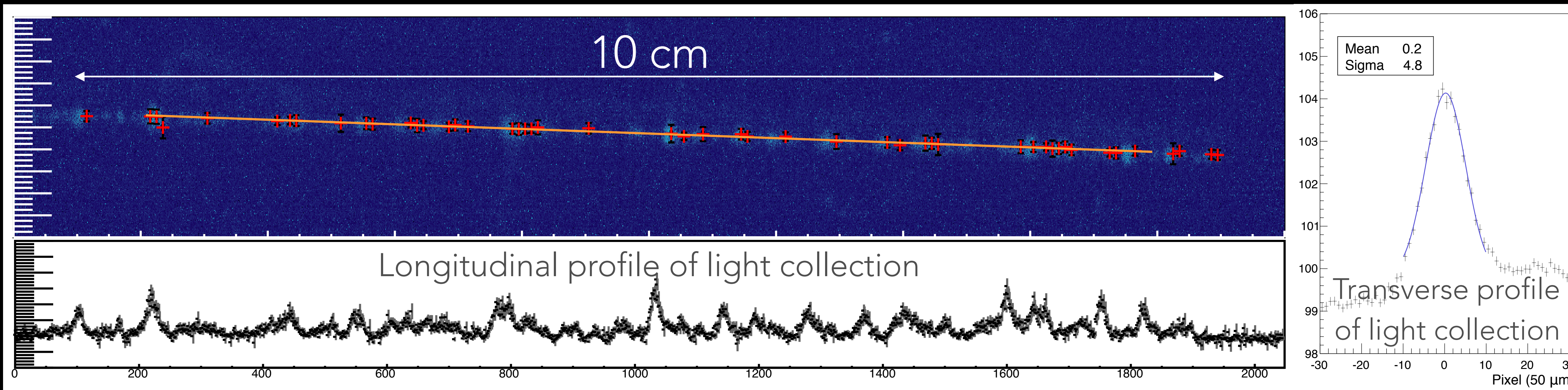
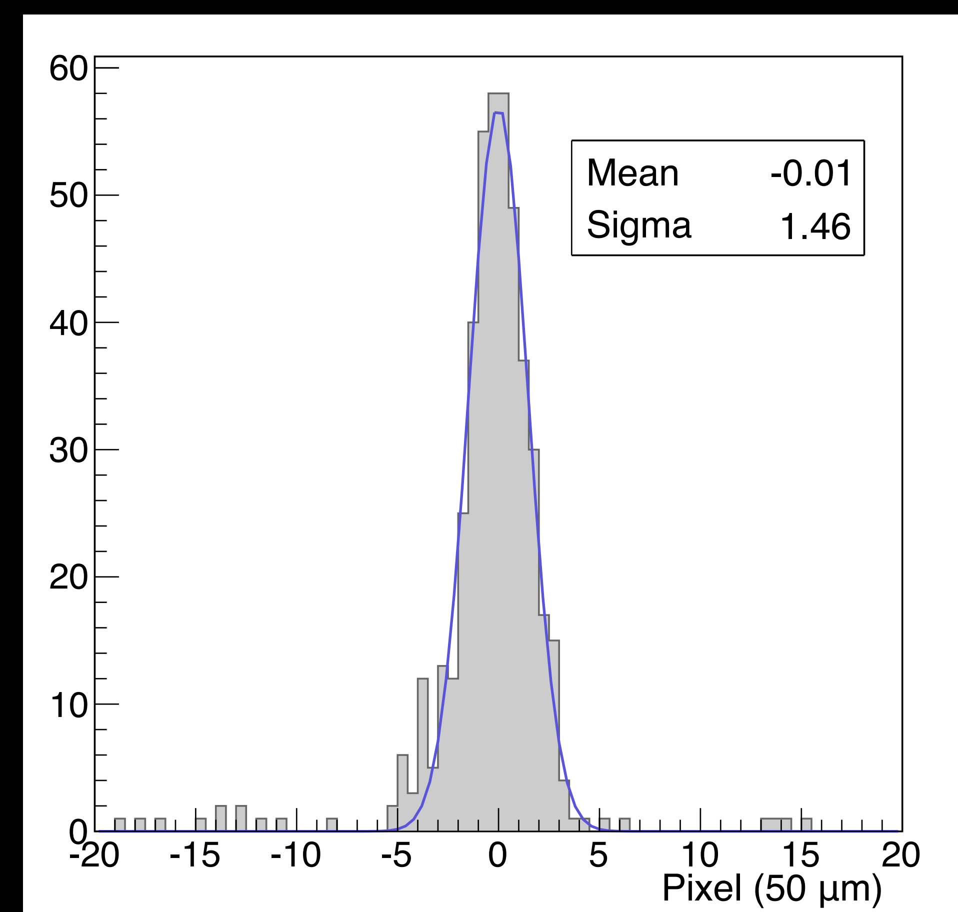
PERFORMANCE: TRACKING



About 1000 photons are detected per track millimeter. Cluster structure is visible.

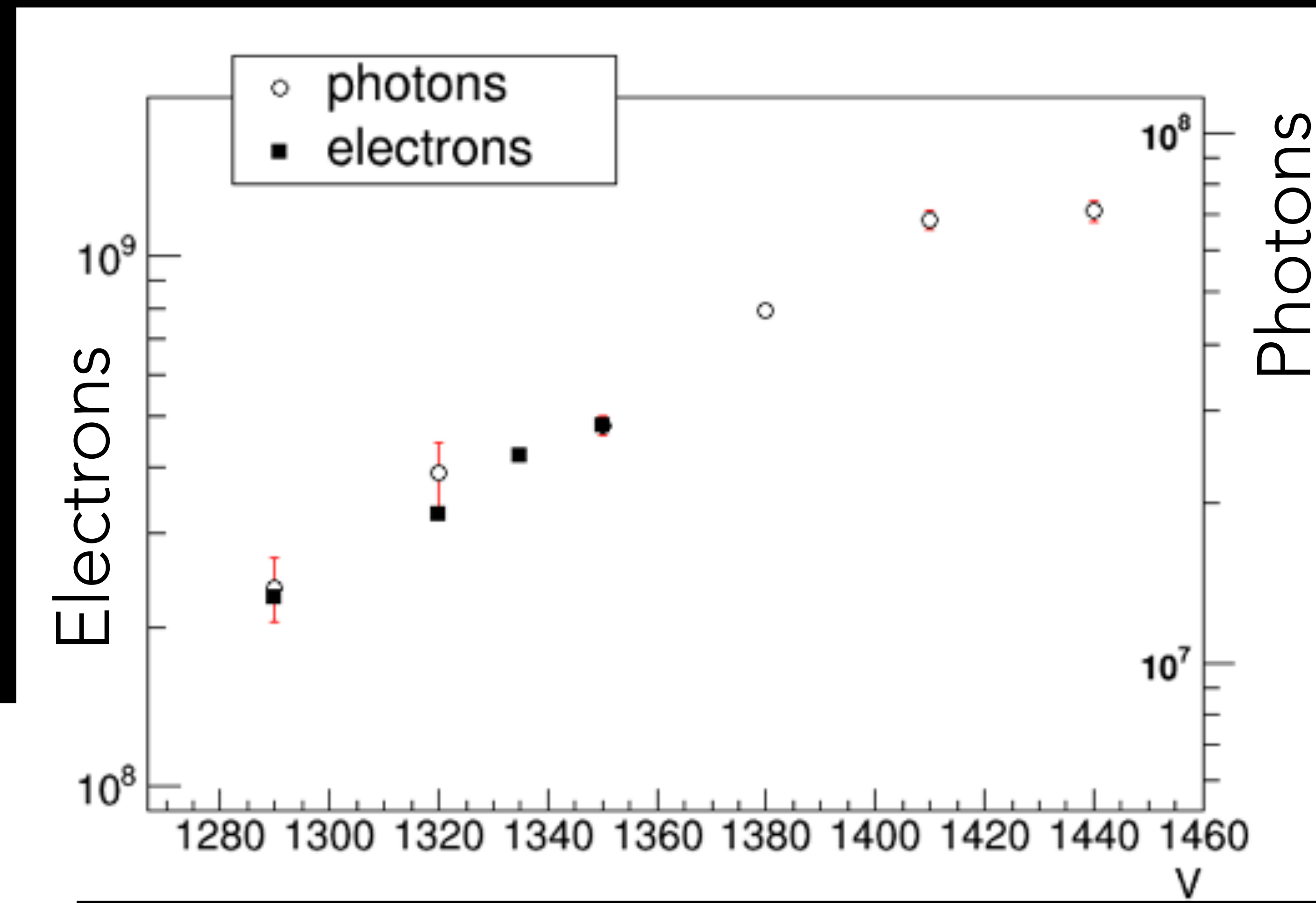
Transverse light collection has a good gaussian shape with a sigma of 250 μm.

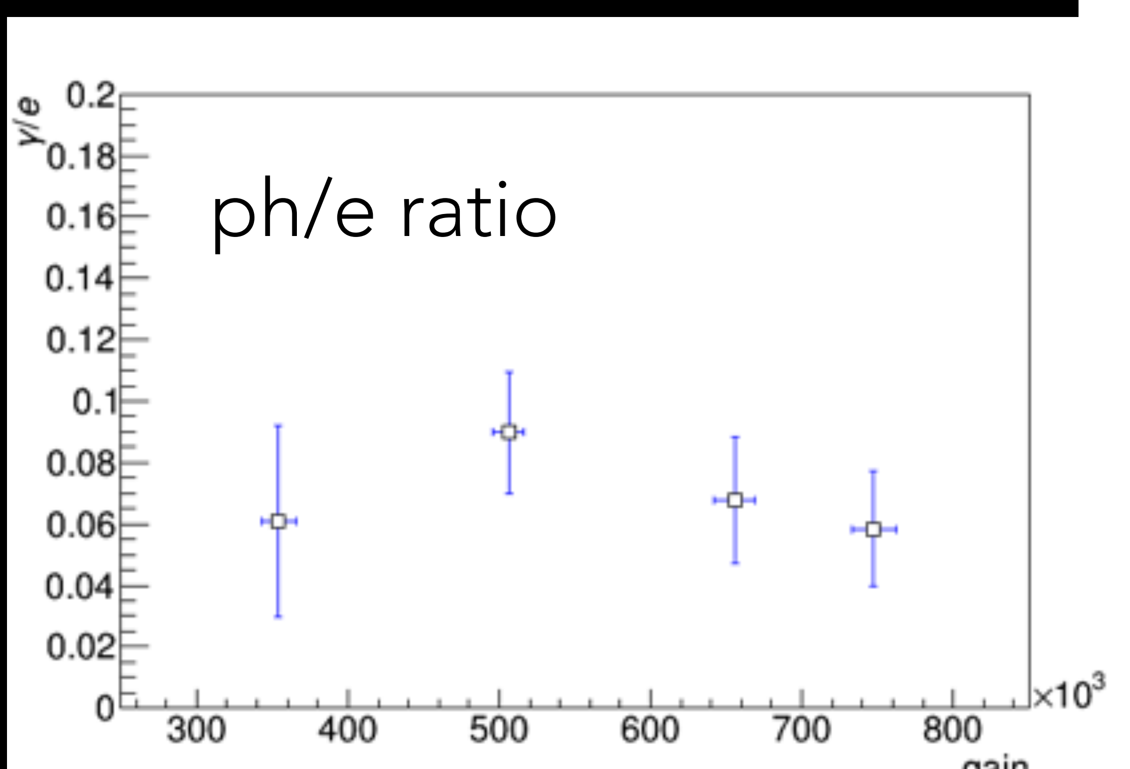


Distribution of residuals from the track has a sigma of 70 μm.

PERFORMANCE: LIGHT YIELD

The number of produced photons and electrons was evaluated for different GEM voltages

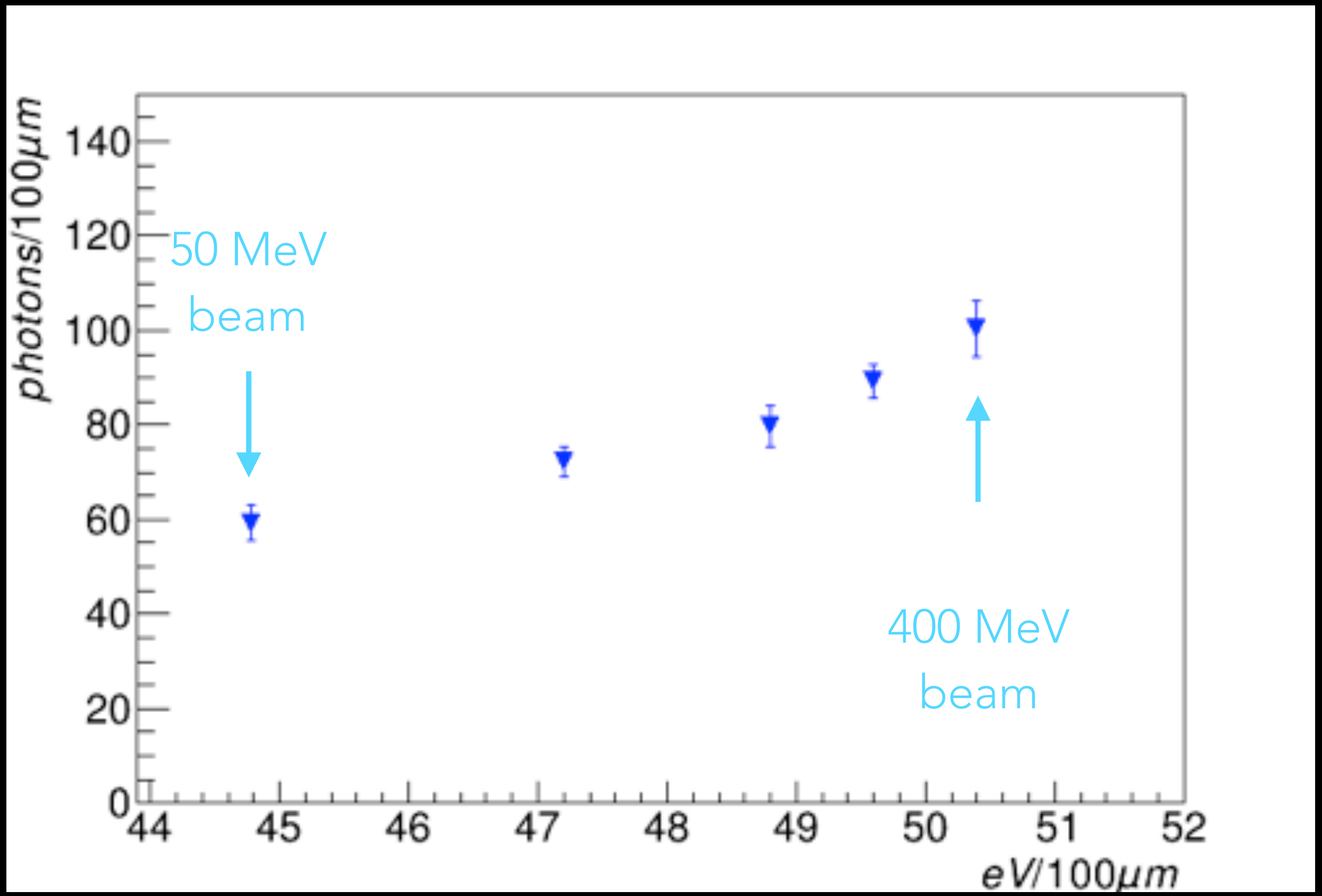




A constant ratio of about 0.07 photons per electron was found in the whole studied range.

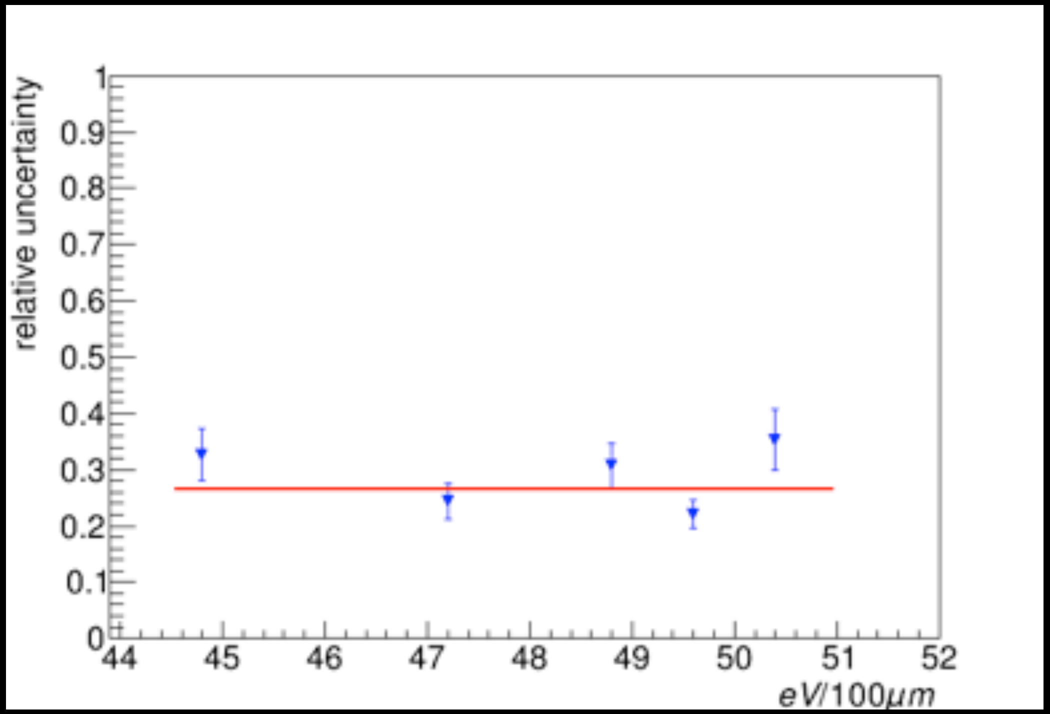
PERFORMANCE: ENERGY MEAS

The energy release density (dE/dx) was measured for different beam energies in 100 μm long slices.



The measured number of photons per slice increases following the energy release calculated with a Garfield simulation

A dE/dx resolution of about 30% was found in the whole measured range.



CONCLUSION

Tracking devices based on the optical readout of gas detector provides:

- very low material budget and large volumes;
- high granularity, low noise and high sensitivity;
- the read-out can be physically separated from the sensitive gas volume and "coupled" to it via a suitable lens;

In particular in ORANGE:

- about 200 photons are collected per primary electron, i. e. more than 1.000 photons per track millimeter for mips;
- space resolution well below 100 μm and good sensitivity to dE/dx;

Very promising for high resolution tracking.

Thank you!