# Recent developement of MPPC by Hamamatsu: possible applications to hadron calorimetry

## OUTLINE

- The Micro Pixel Photon Counter from Hamamatsu
- MPPC and calorimetry
- Characterization of MPPC in DESY: techniques and results
- Investigation of the direct readout of the scintillation light as an option for the future calorimeter design

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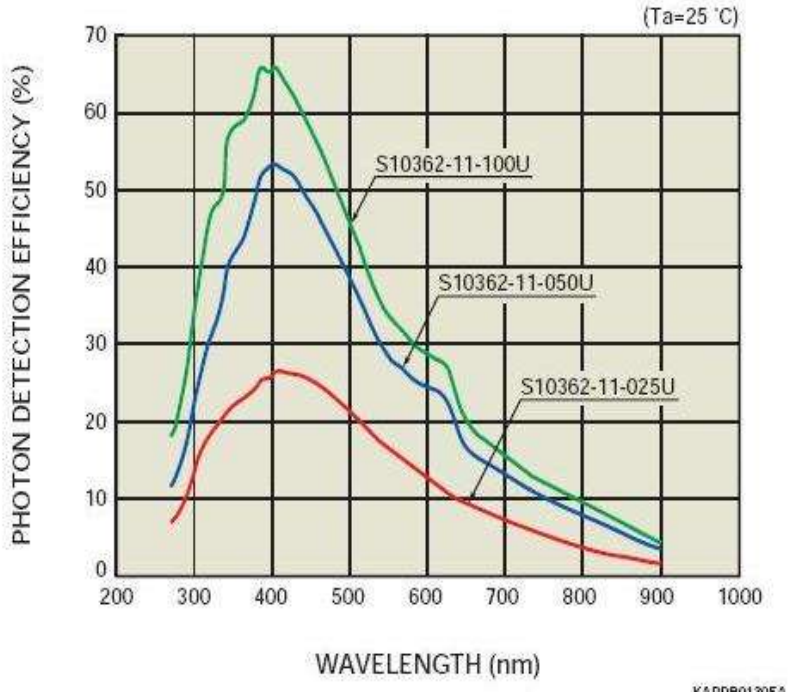
# The Micro Pixel Photon Counter from Hamamatsu

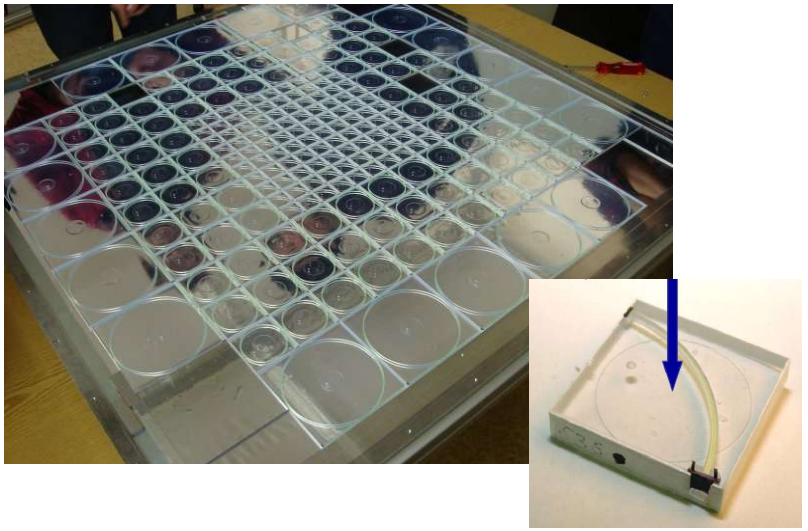


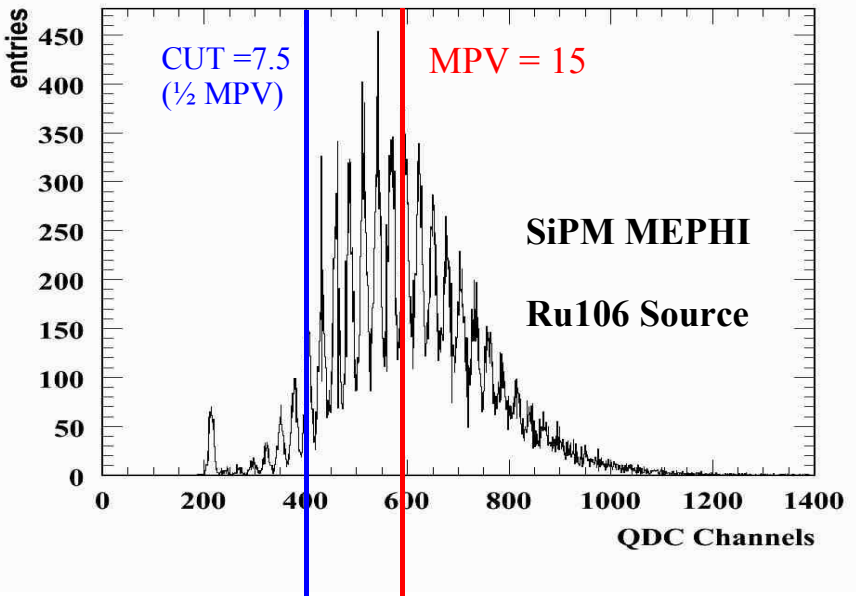

- Good efficiency in the blue region: ideal for the direct readout of plastic scintillator.
- Package: plastic protection
- Now commercial product !

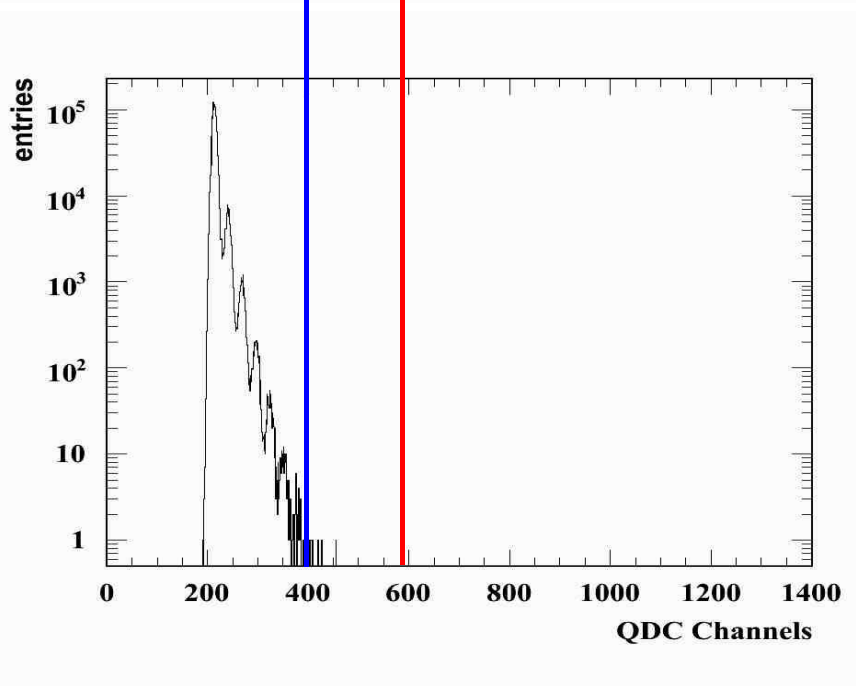
From datasheet:

| Pixels | Received | Sugg. op. Voltage | Sugg. op. Over Voltage | Dark Rate >0.5 pixels | Dark Rate >1.5 pixels | Gain (10^5) |
|---|---|---|---|---|---|---|
| 400 | 5 samples | ~76+-0.1V | ~2+-0.1V | 220K - 250K | 9K - 10K | 7.4-7.5 |
| 1600 | 5 samples | ~78+-0.1V | ~2+-0.1V | 50K - 60K | 0.05K - 0.09K | 2.6-2.7 |

# Application od MPPC to calorimetry



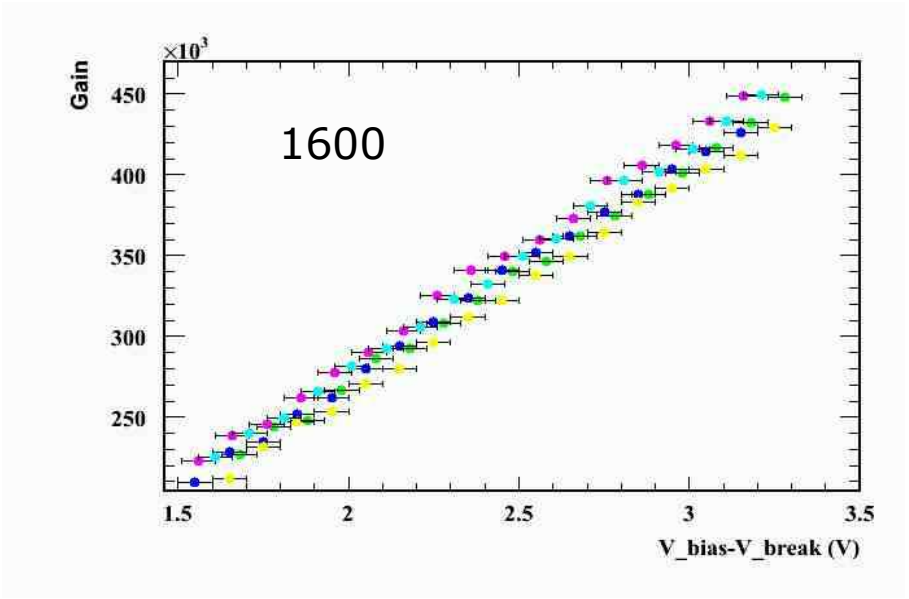


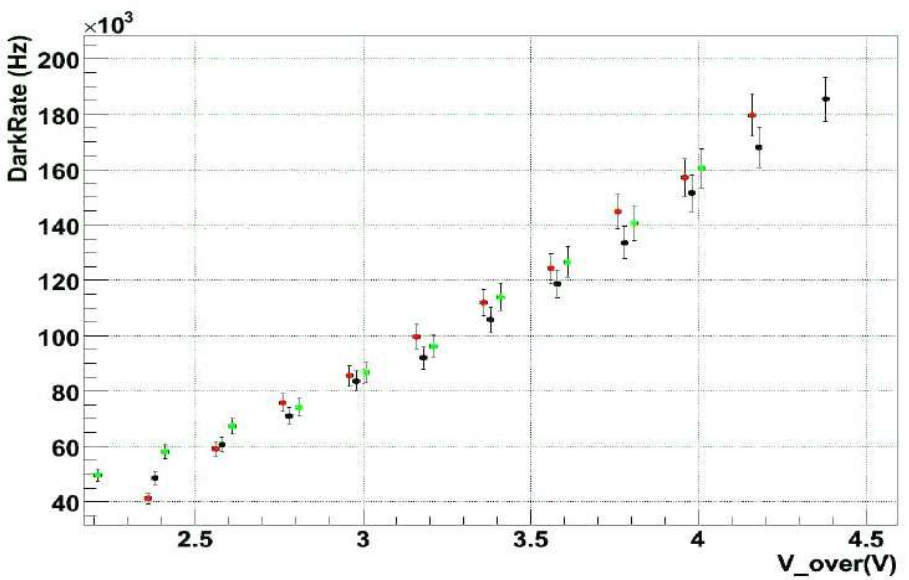



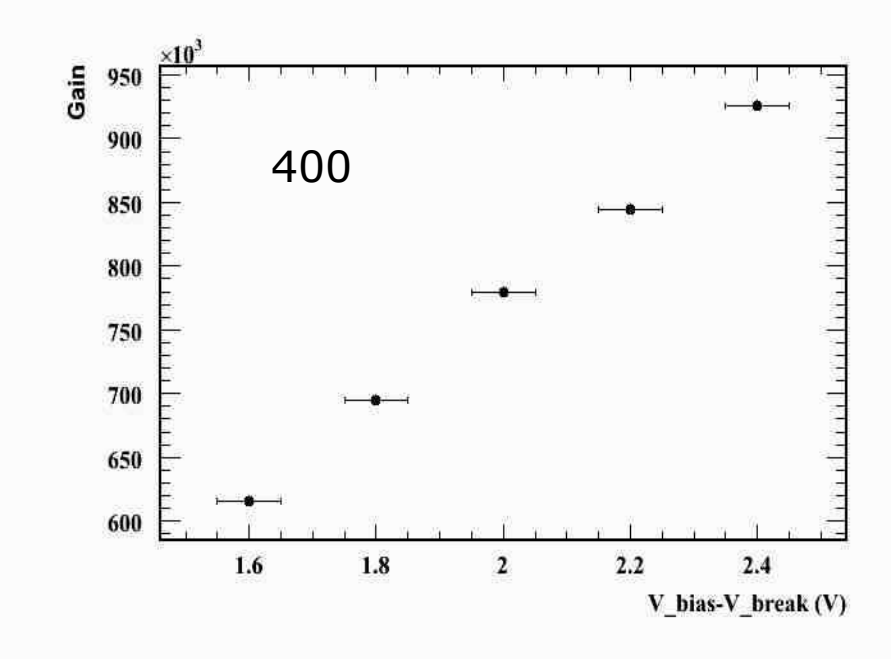

## REQUIREMENTS:

- Low cross talk and dark rate (<3 KHz)
- High signal efficiency in the cut (>95%)
- Dinamic range : ?
- Easy fabrication of the cells: direct coupling? Thinner scintillator?

# Characterization of the samples

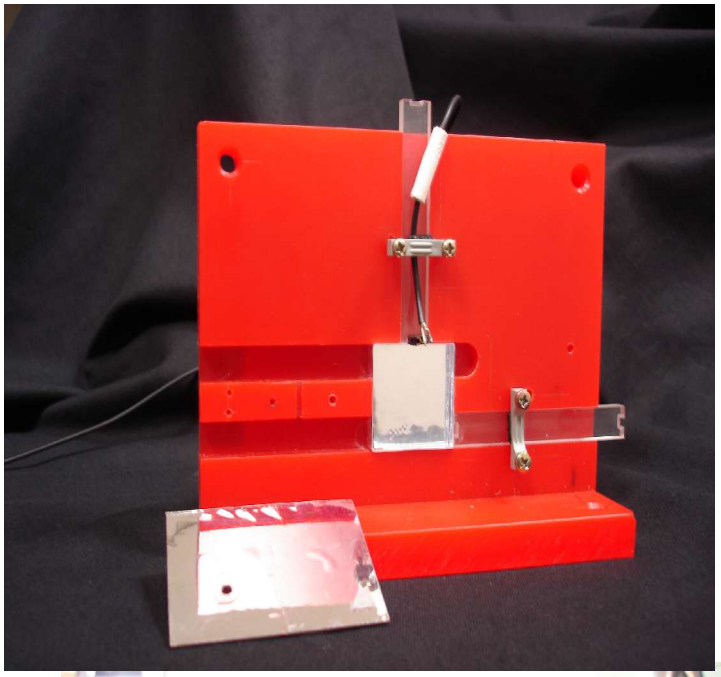


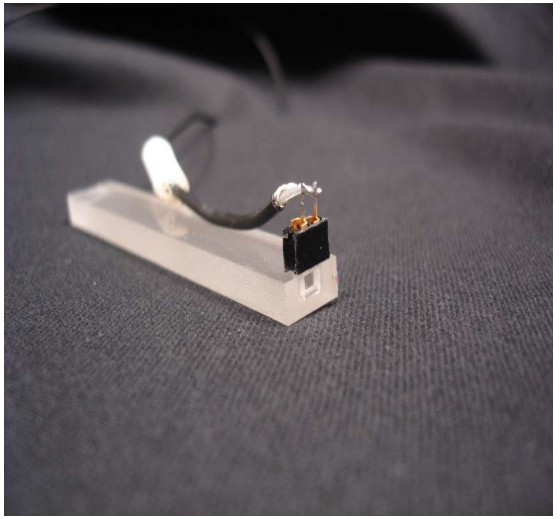



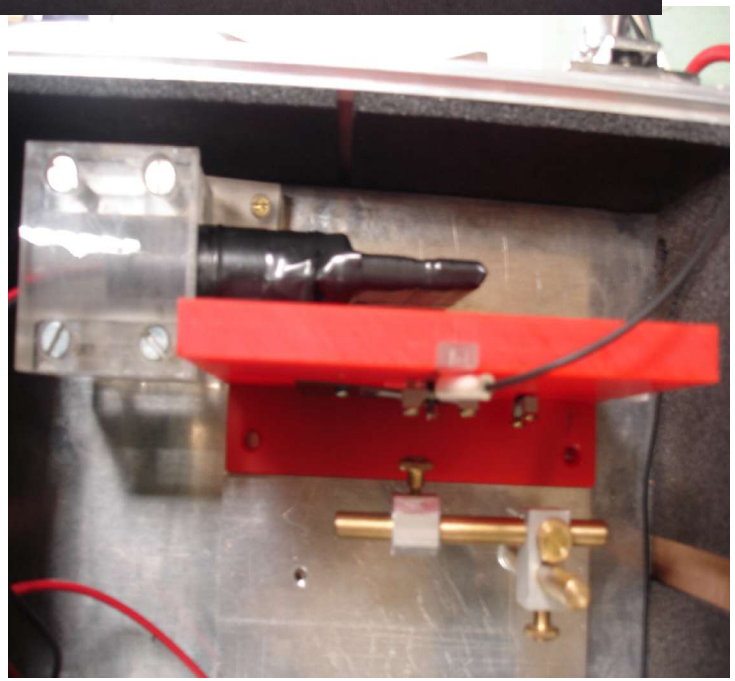




- Light response from LED
- 60 ns integration gate
- The measuremets show a good uniformity of the samples.
- Full characterization of 400 pixels samples to be terminated

# Setup for the light readout with a source

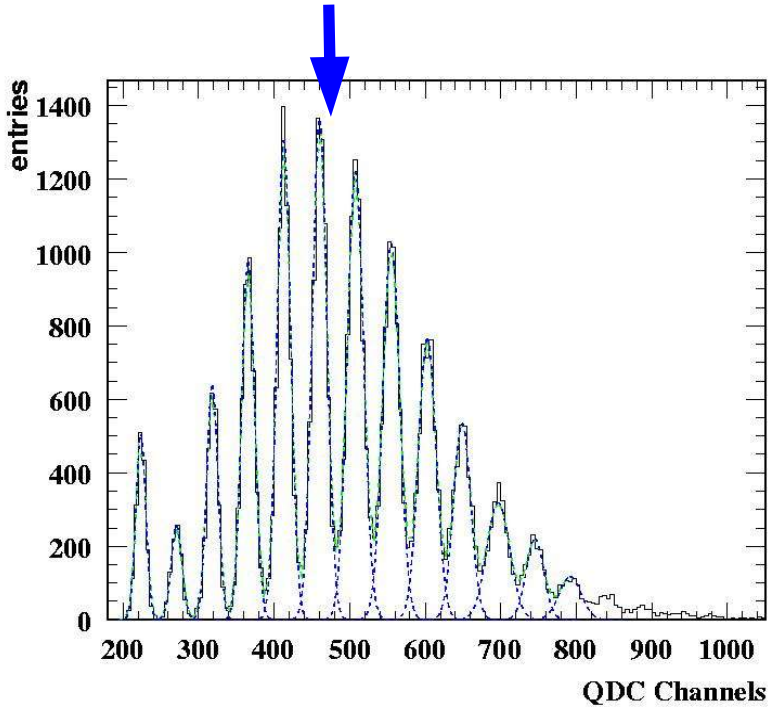


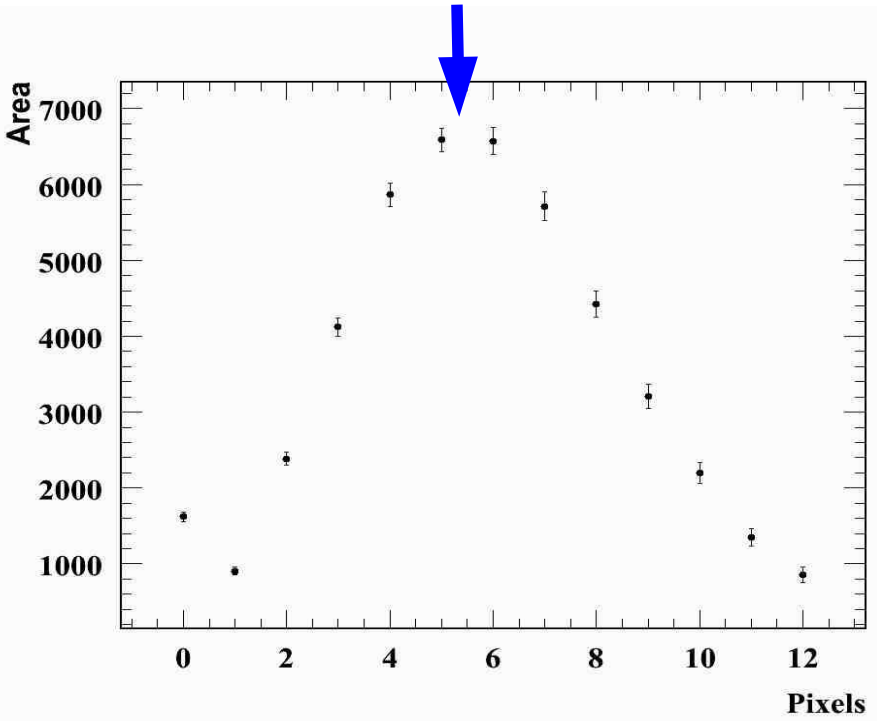




- Readout of a plastic scintillator light,  directly or with the standard green wavelength shifting fiber.
- Tile wrapped with 3M reflector. In case of the direct readout, only a window of 1mm x 1mm open in front of the MPPC
- Source:  Ru106 ($\beta^-$)
- Integration gate 80 ns
- External trigger (Photomultiplier tube)
- Reproducibility of the measurement +- 3% systematic (coupling, positioning etc ...)

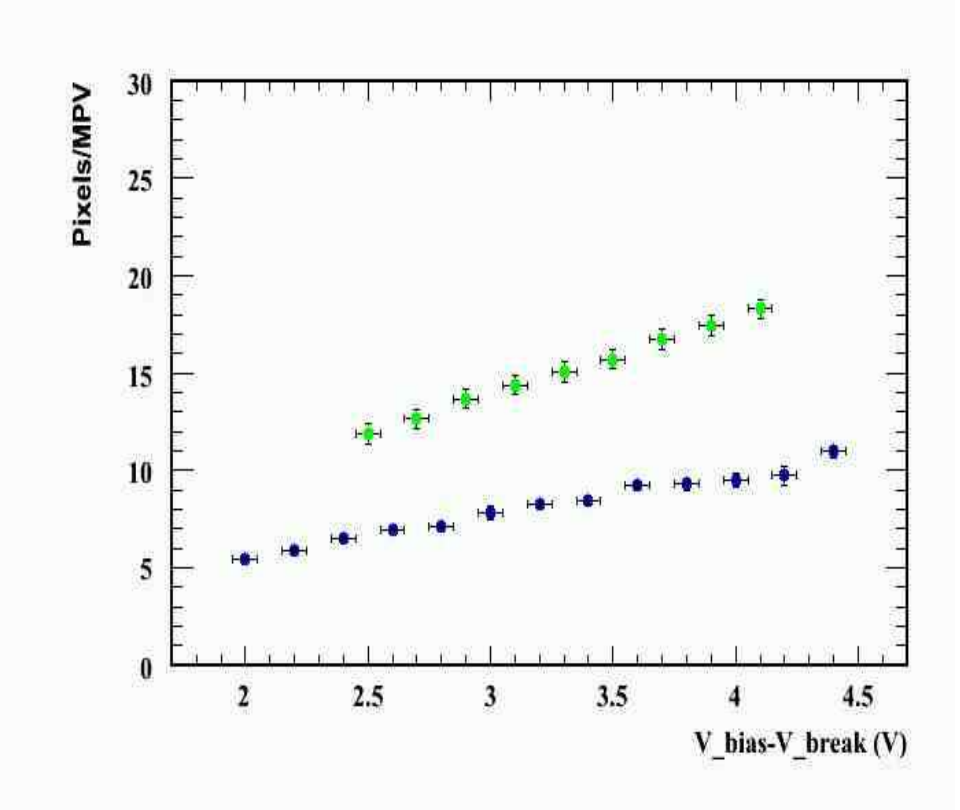
# Energy deposit spectra: method of analysis

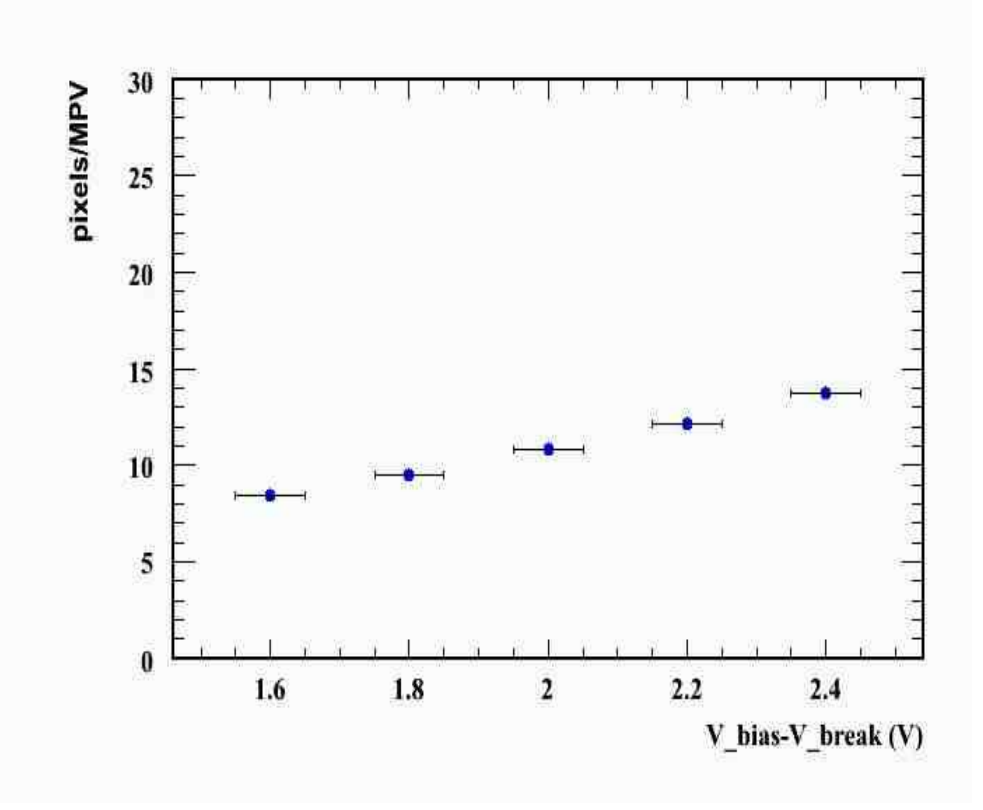



Fit: sum of gaussians. The area of the peaks is distributed according to a landau distribution (smeared by a poisson). The Most Probable Value (MPV) is determined with a gaussian fit around the peak of the area plot (right) .

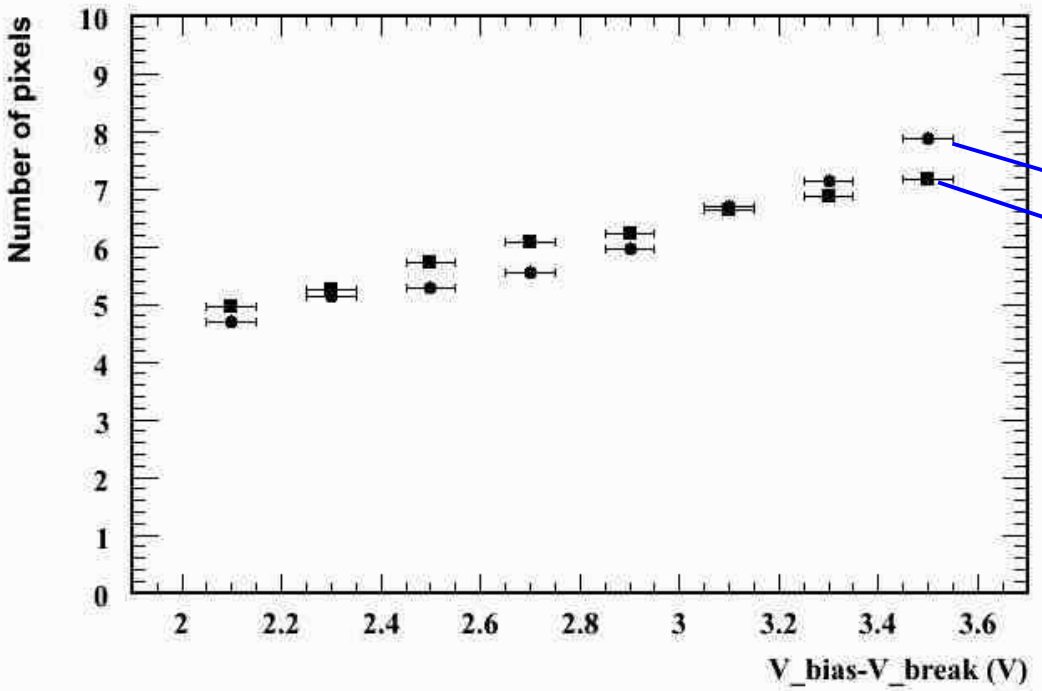
# Green fiber readout vv. direct coupling

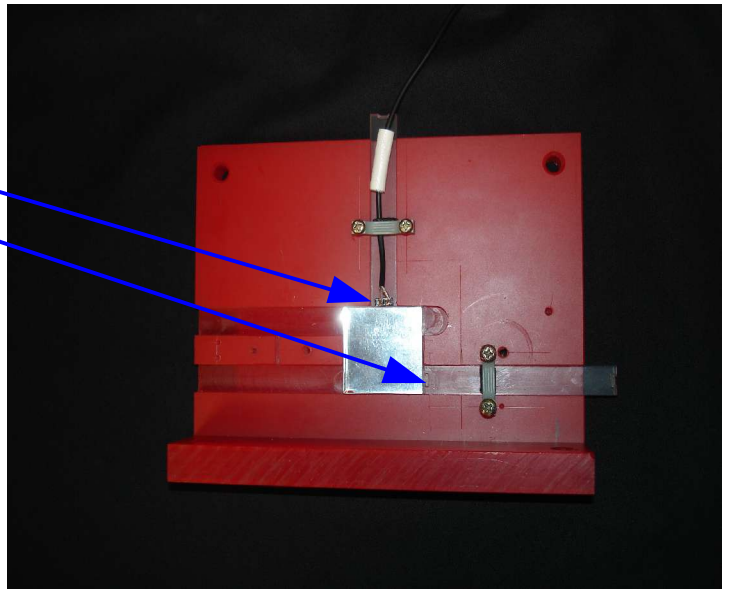



The MPPC shows a good efficiency in the blue light collection. As expected, the efficiency of the 400 pixels detector is higher (x2) than the one of the 1600 pixels .

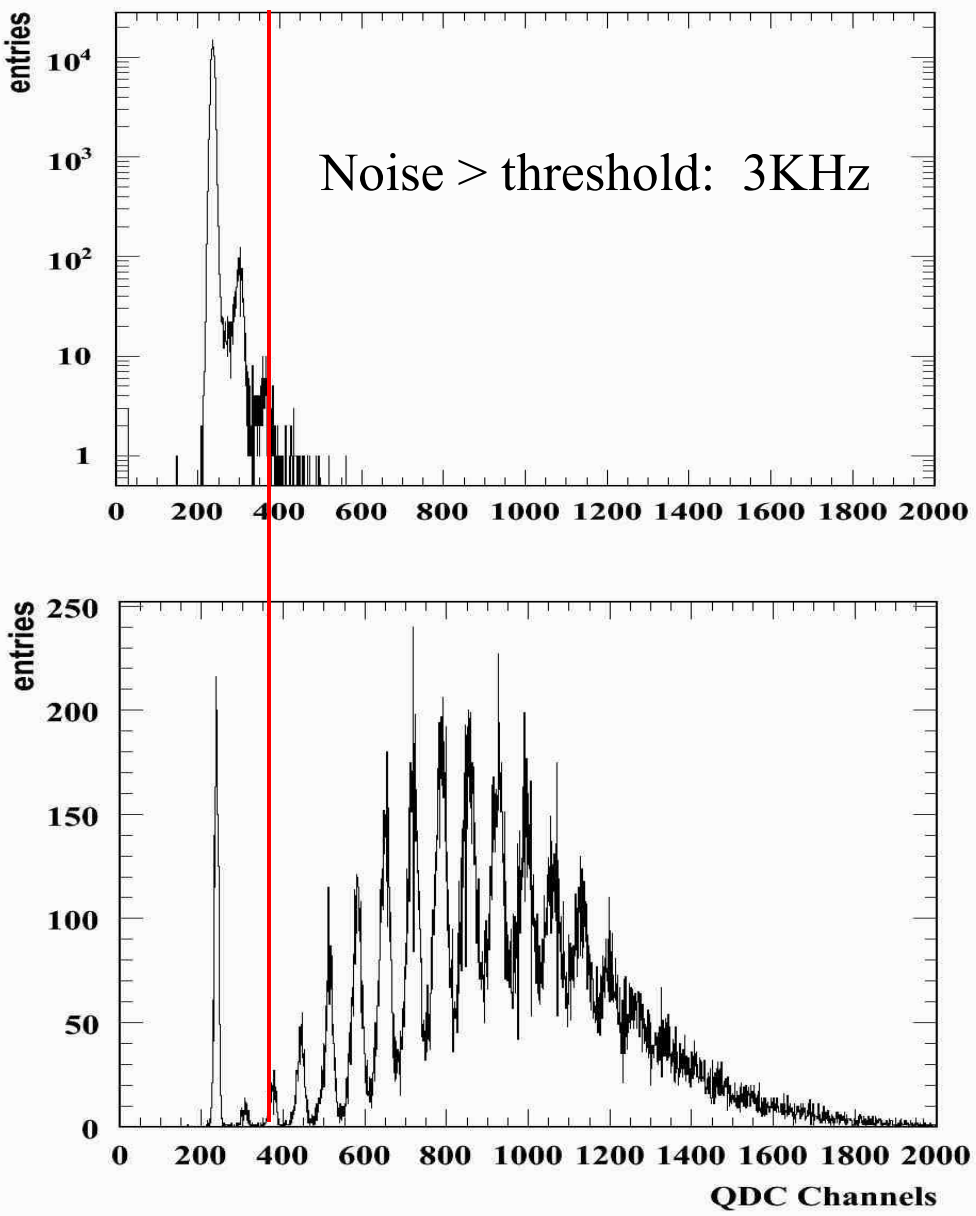
# Direct readout at the edge: middle and corner position



The difference of the most probable value obtained in the two position is of +-3% (value obtained repeating the same test on all the samples). This is coherent with the systematics of this measurement. No significative difference can be estimated!

# Application to calorimetry



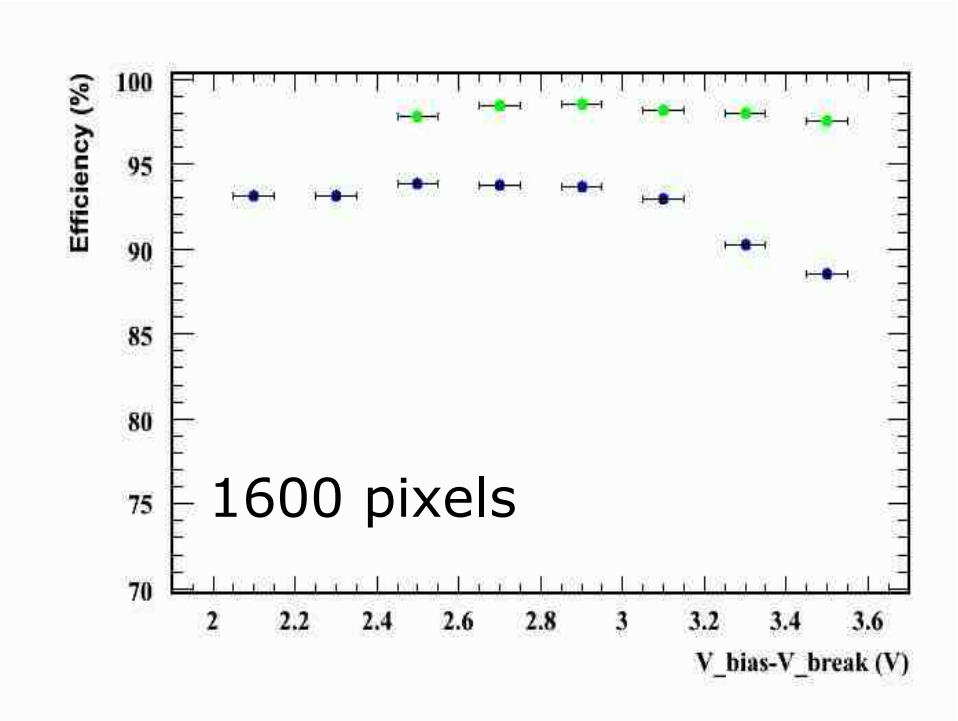

- Scan over different thresholds until the integral over threshold = 3KHz (Red line)
- Define the efficiency as the normalized integral above the fixed threshold, excluding the pedestal.

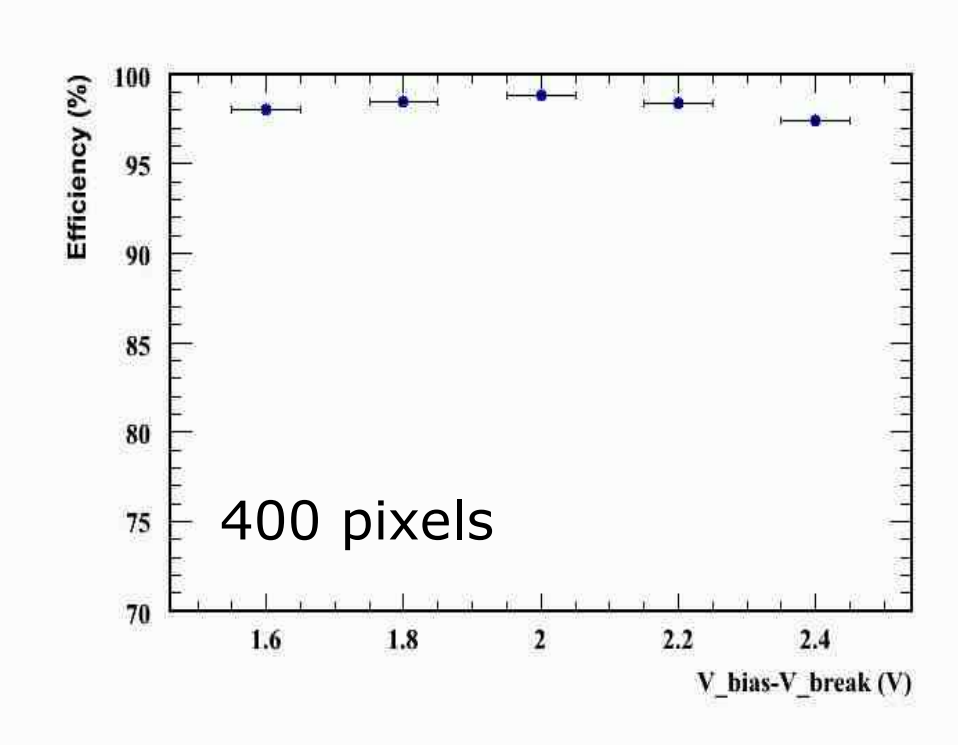
In this particular example:

The cut is extabilished at 2 pixels, where the noise corresponds to 3 Khz.

The efficiency is 98%

# Application to calorimetry: efficiency scan




- Direct coupling with 1600 pixels: suggested 2.2-2.4 V over voltage. Cut at ~1.5 pixels. ~7 pixels/MPV
- Green fiber readout with 1600 pixels : suggested 2.2-2.6 V over voltage. Cut at ~1.5 pixels. ~12 pixels/MPV
- Direct readout with 400 pixels: 1.6 V - 2 V overvoltage, cut at ~2 pixels. ~10 pixels/MPV

# Conclusions

- **The wavelength shifting fiber readout system is reproducible:**
  - With Hamamatsu MPPC 1600 pixels:
    - Operating at an overvoltage of ~2.6 V an efficiency of the signal collection of ~98% is achieved. This is an improvement respect to the actual system.
    - The Most Probable value of the landau is 12 photoelectrons: the dynamic range is also larger than the actual one (1156 pixels, MPV=15).
    - These devices fit well also in a possible design where the thichness of the scintillator is reduced, imporving the compactness of the calorimeter.
- **The direct coupling solution with the MPPC is possible:**
  - With Hamamatsu MPPC 1600 pixels:
    - Operating at an overvoltage of ~2.2V, an efficiency of the signal collection of ~94% is reached, making the system equivalent on the present one.
    - The Most Probable value of the landau is 6 photoelectrons: the dynamic range increases respect to the present one used in the calorimeter.
  - With Hamamatsu MPPC 400 pixels
    - Operating at an overvoltage of ~2V, an efficiency of the signal collection of ~98% is reached, making the system equivalent on the present one.
    - The Most Probable value of the landau is ~11 photoelectrons: the dynamic range can be problematic...
  - The direct readout system is easier to produce, and less expensive than the present one.
  - Light collection uniformity still to verify.
  - Physics input in order to set the bounds on the required dynamic range.