Study of the MPPC performance

- R&D status for the GLD calorimeter readout –

http://ppwww.phys.sci.kobe-u.ac.jp/~kawagoe/gldcal/index.php?MPPC

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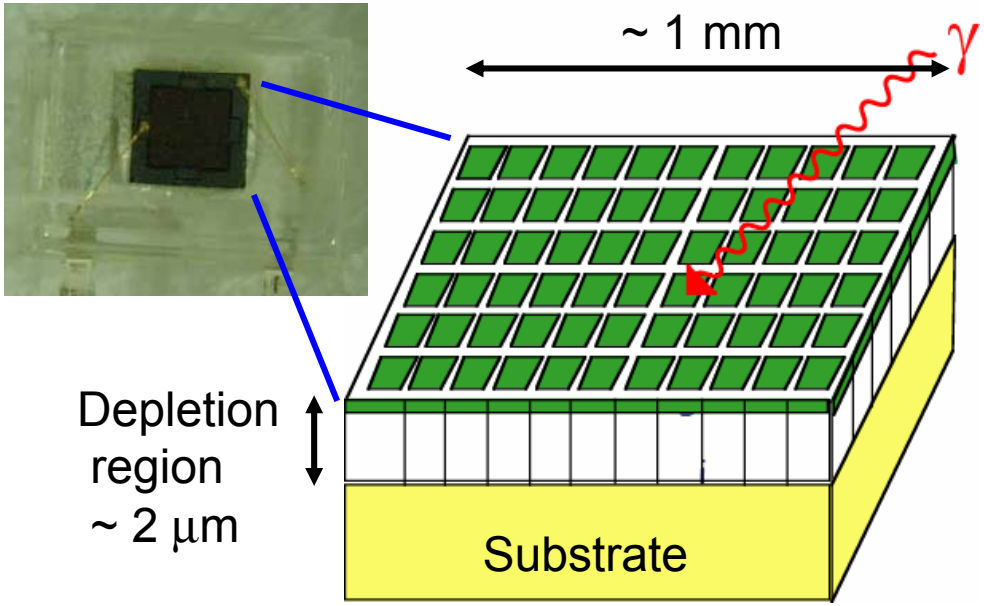
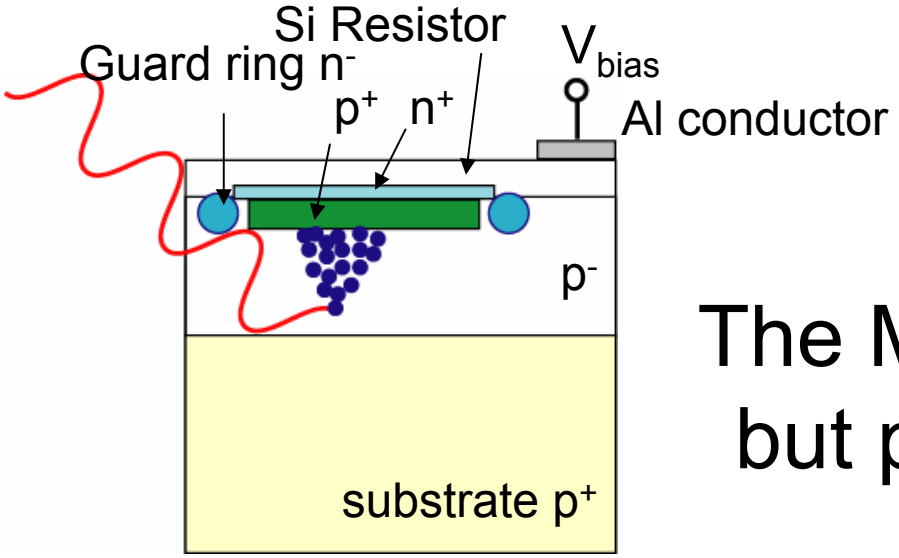
Valencia

The Multi Pixel Photon Counter (MPPC)

- A novel semiconductor photon sensor -





- High Gain (10^5~10^6)
- Good Photon Detection Efficiency (25~65%)
- Compact (package size ~ a few mm)
- Low Cost
- Magnetic-field tolerant
- High dark noise (order of 100-1000 kHz)
- Response against input light yield is non-linear

The MPPC is a still developing, but promising device !

The MPPC is drastically evolving …

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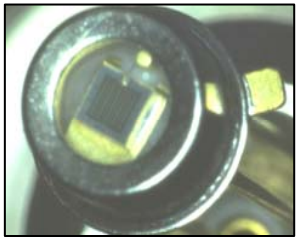
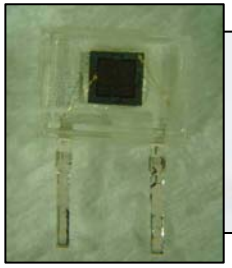
Mar. 2005
- 100/400 pixels
- First sample from Hamamatsu

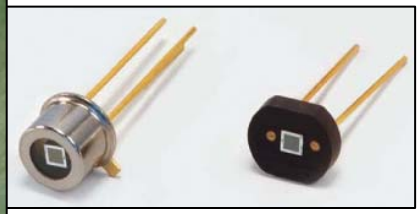
Jan. 2006
- 100/400/1600 pixels
- Smaller pixel size results in more number of pixels

Oct. 2006
- 100/400/1600 pixels commercialized
- Improved Gain and dark noise

Sometime in future
- Larger sensor area
- More number of pixels
- And perhaps more…







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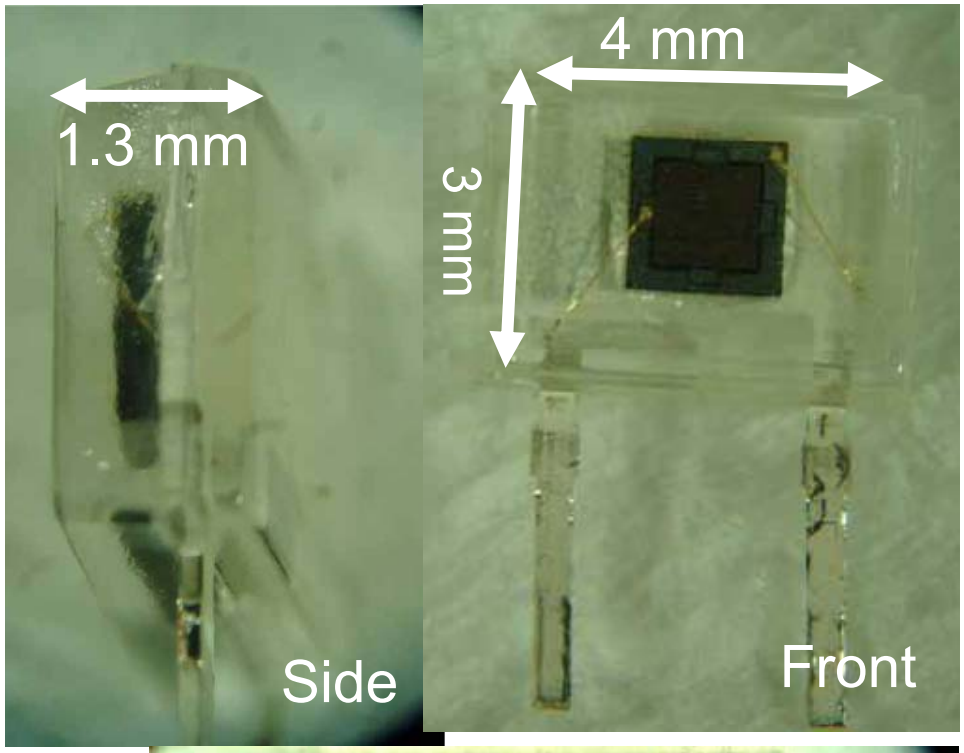
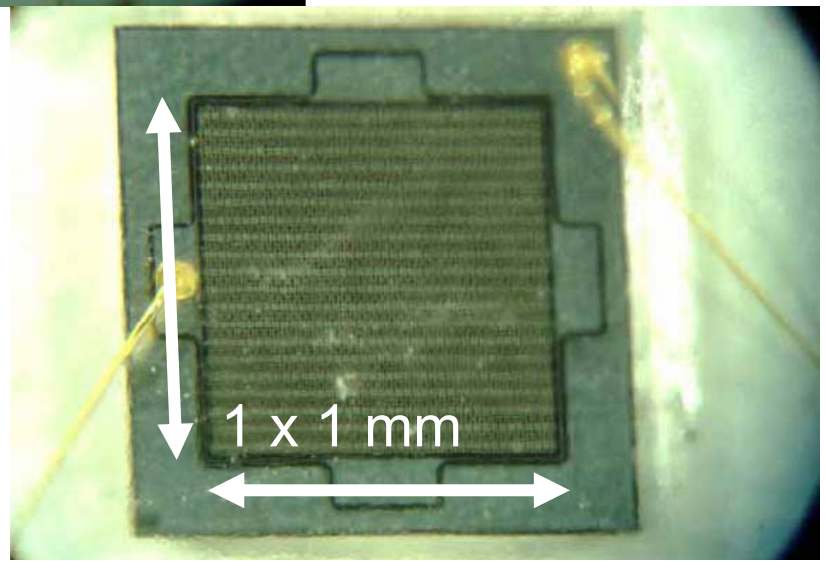
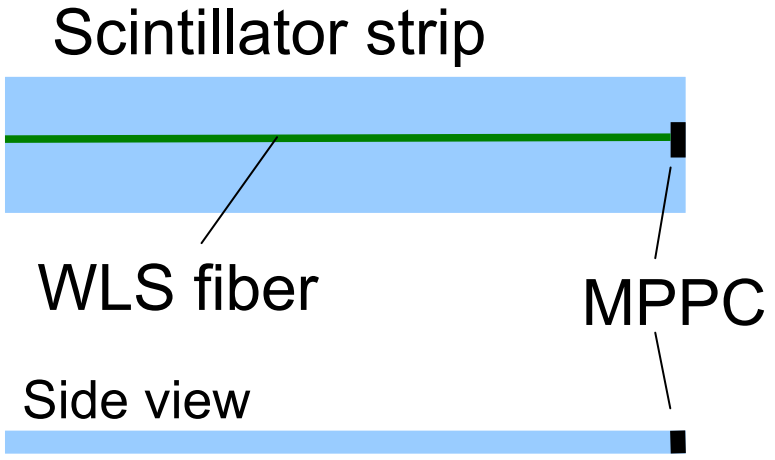
The New MPPC Sample

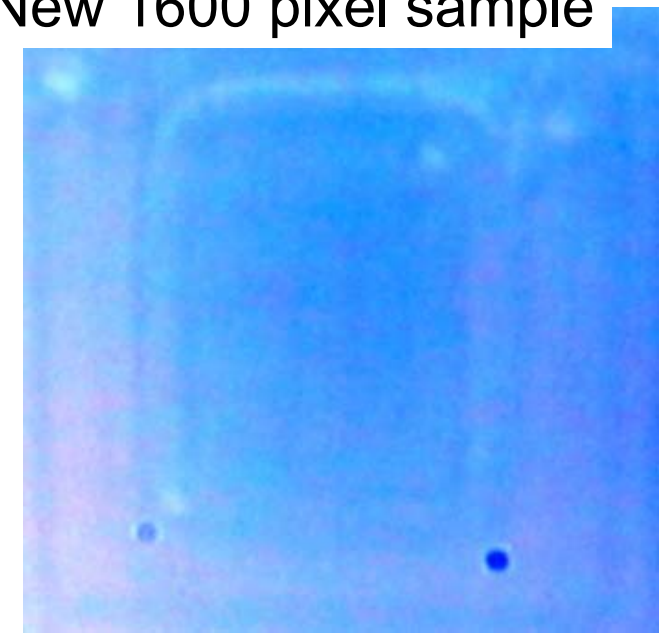




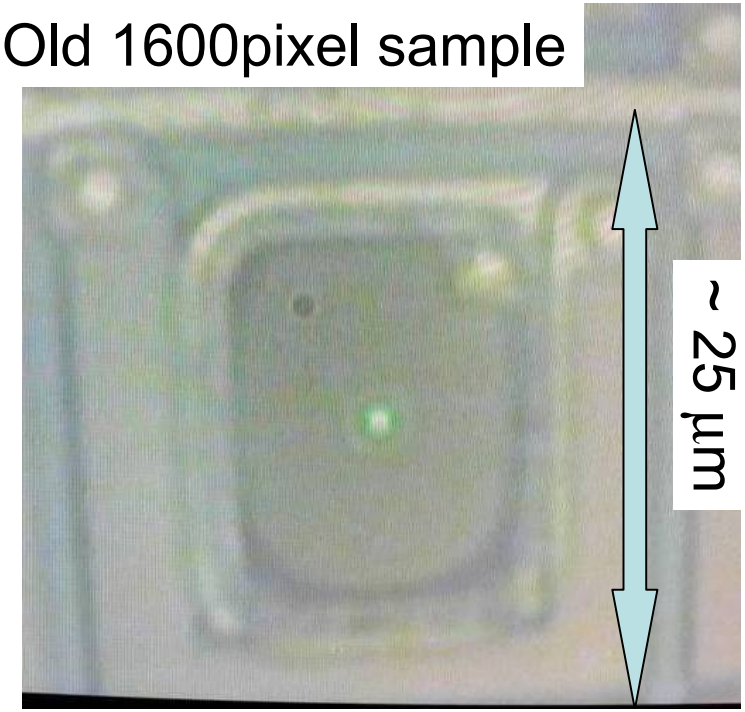
- Latest 1600 pixel MPPC
- 20 samples arrived in October.
- Very compact plastic package suitable for attaching to scintillator strips.
  (this package is customized for our ECAL module, and not going to be commercialized)
- Another 500 for ECAL beam test will be arrived in this month.



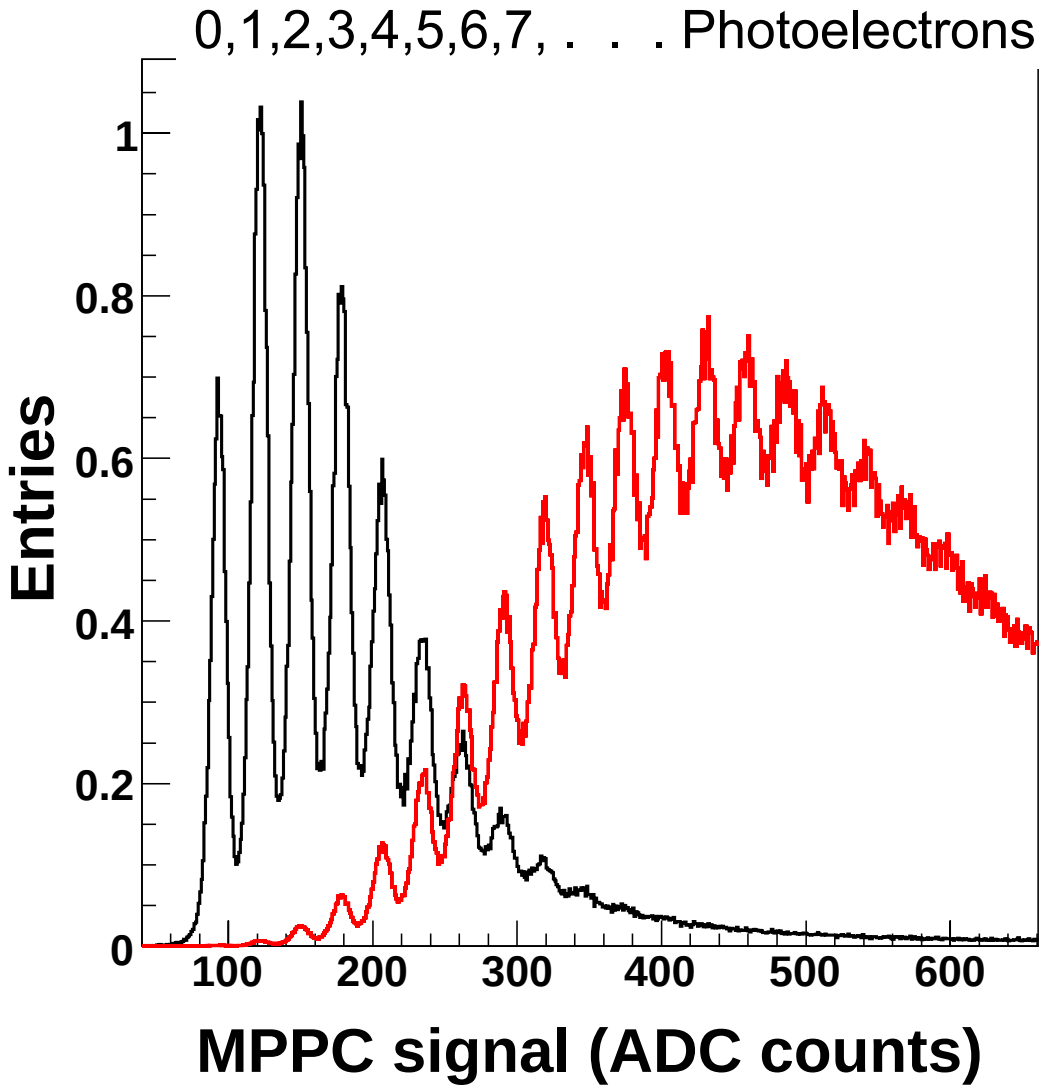
New 1600 pixel sample



Old 1600pixel sample



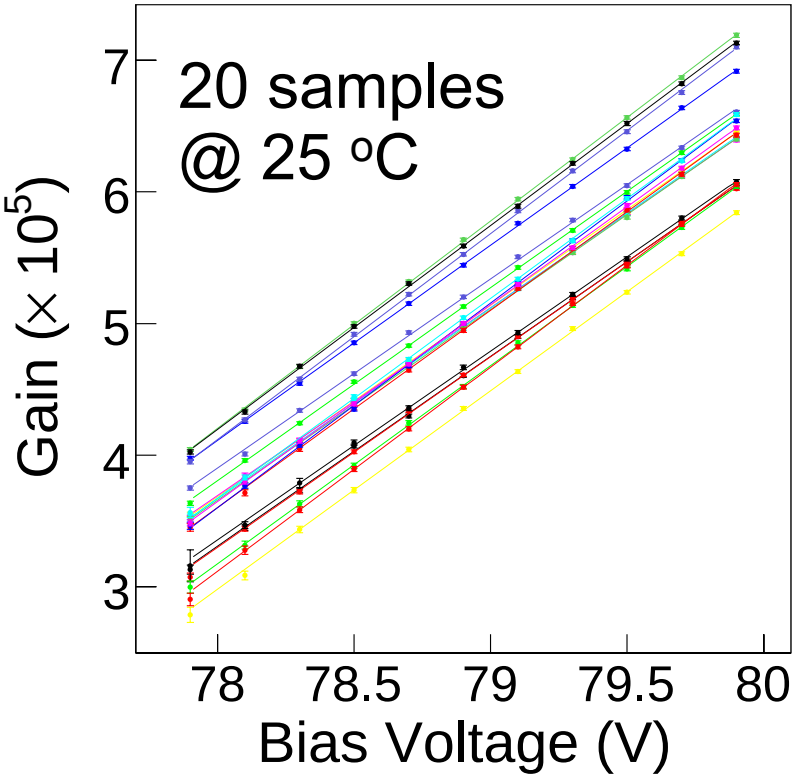
Excellent photon counting ability



Performance of the latest 1600 pixel MPPC

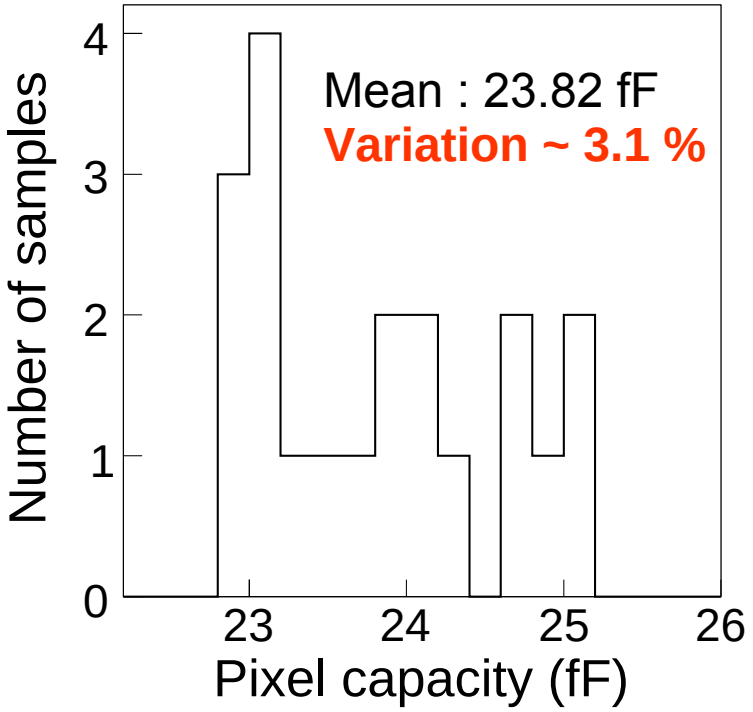
- Gain, Noise Rate, Cross-Talk
  - Device-by-device variation
  - Temperature dependence
- All results are yet preliminary

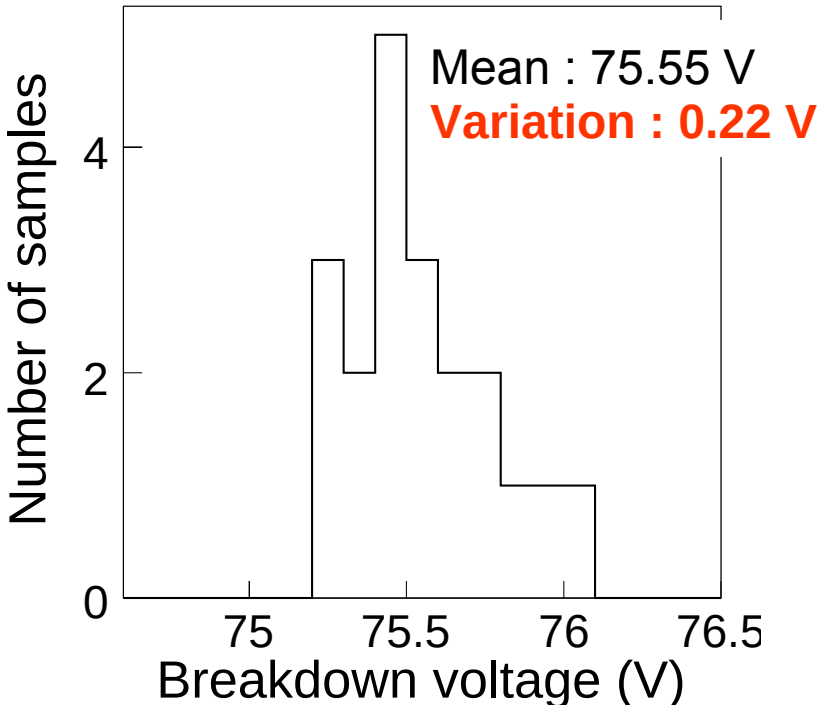
Variation of the Gain over 20 samples



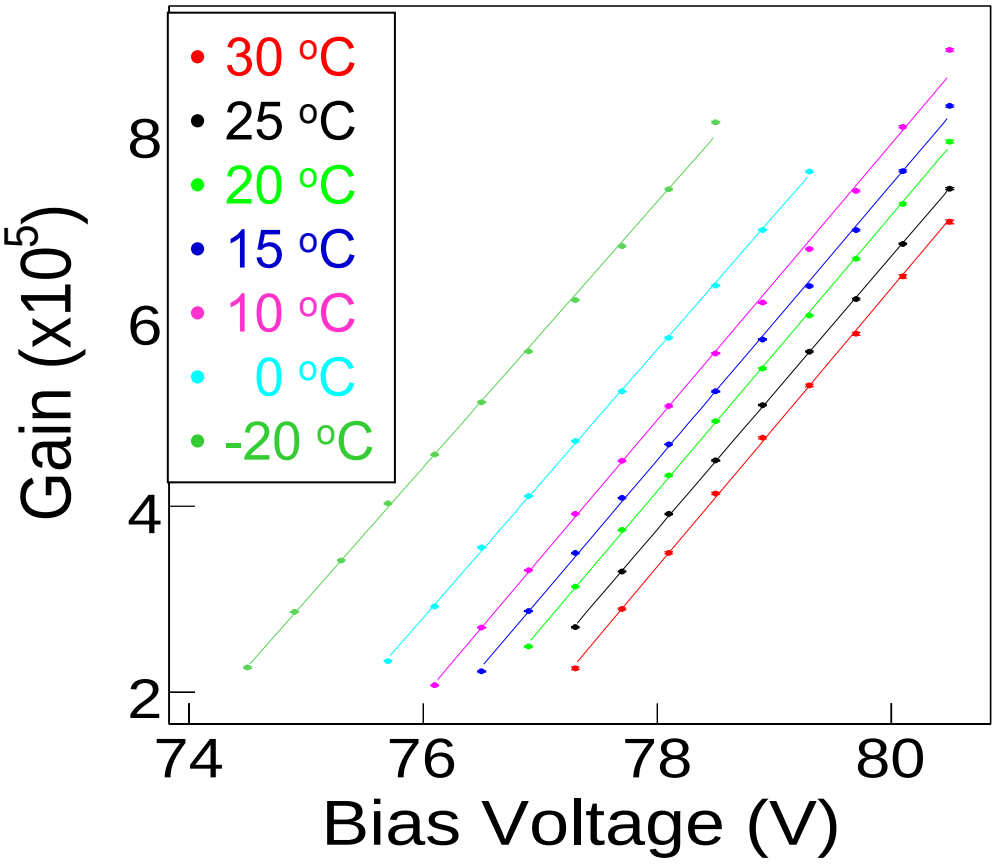
Gain = C (V_{bias}-V_0) / e
C : Pixel capacity
V_0 : Breakdown voltage

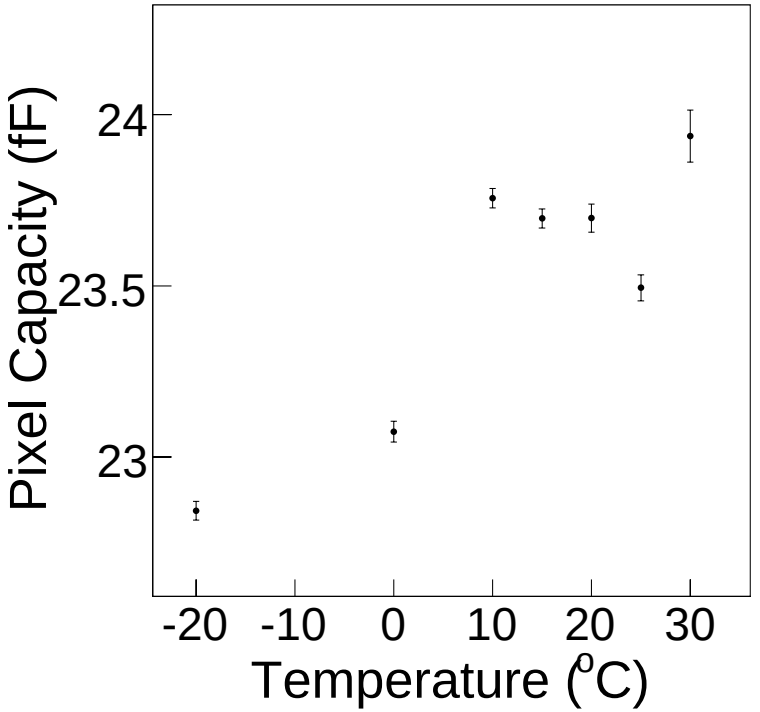
Good Uniformity !

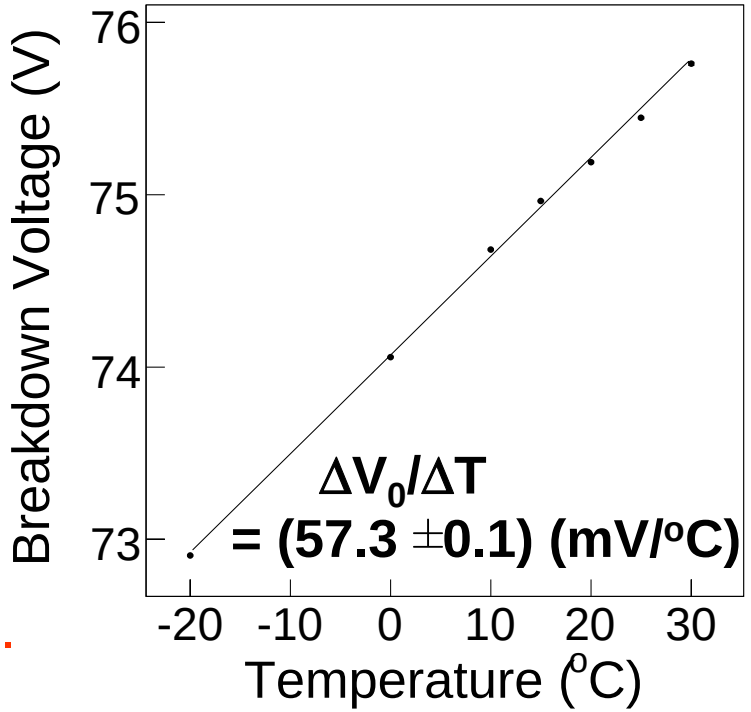




Temperature dependence of the Gain







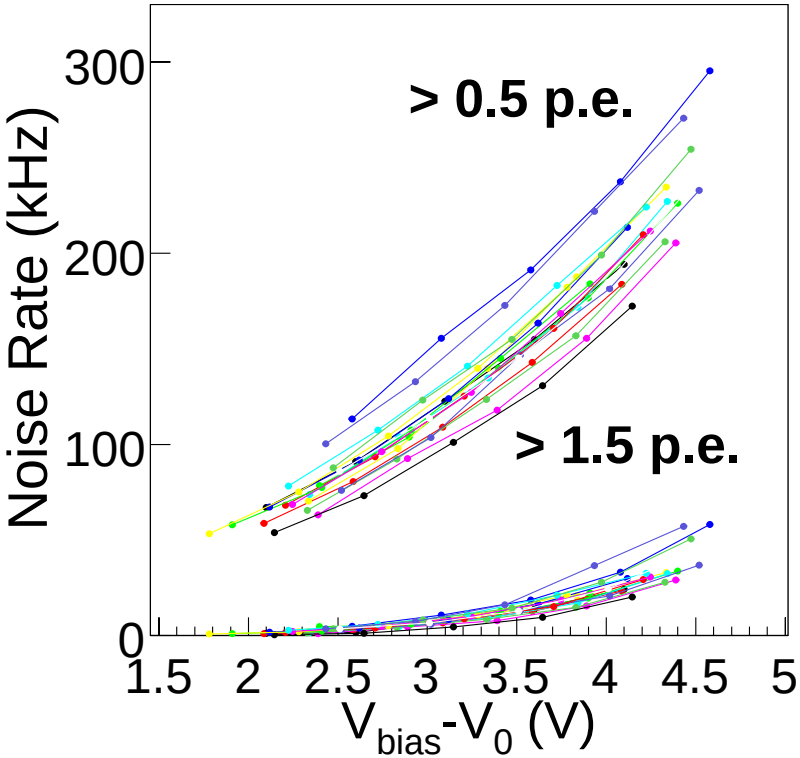
- Breakdown voltage is linear to temperature.
- Thus the temperature change affects to the over-voltage (= V_{bias}-V_0(T)).

→ eventually affects to all the MPPC properties.

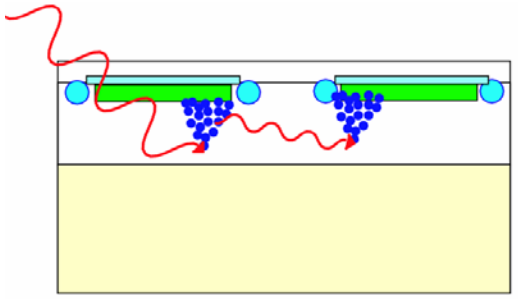
Variation of the

Noise Rate

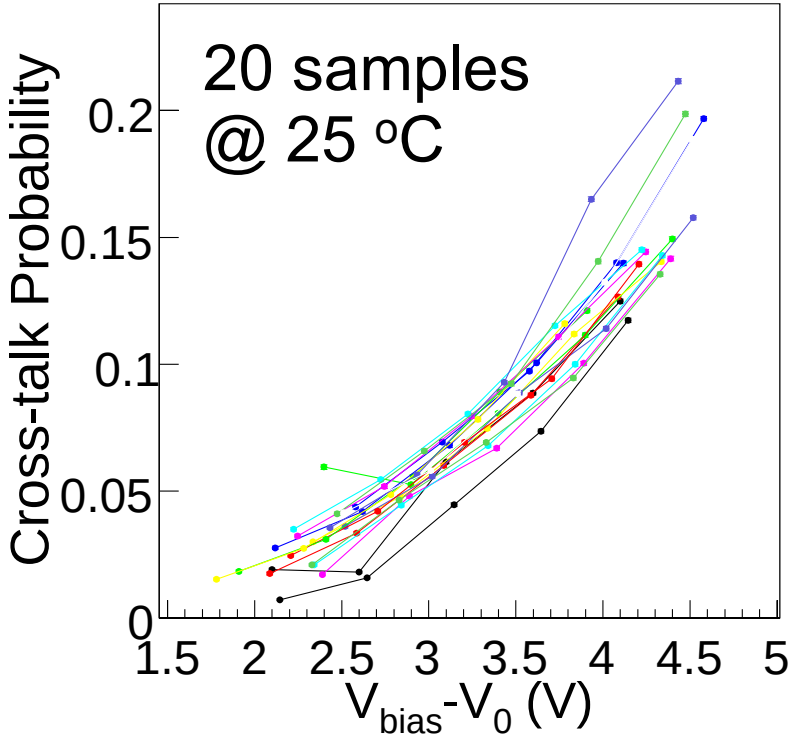
- Dark counting rate with threshold of 0.5 and 1.5 photoelectron.
- Test 20 samples @ 25 °C



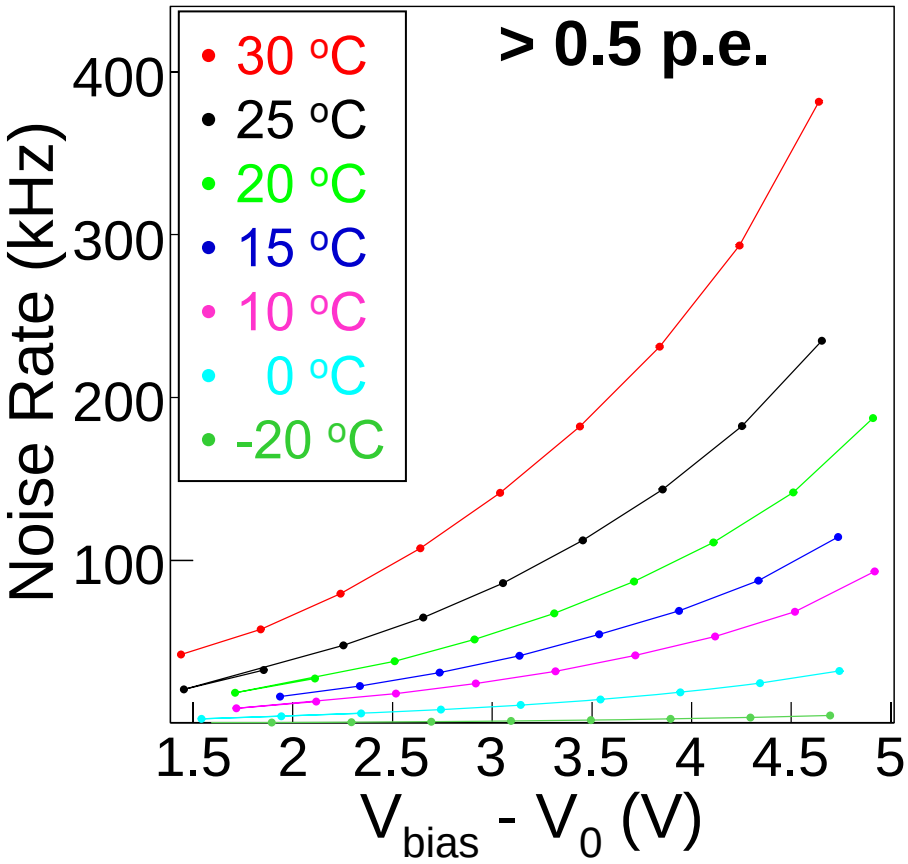
Cross-talk

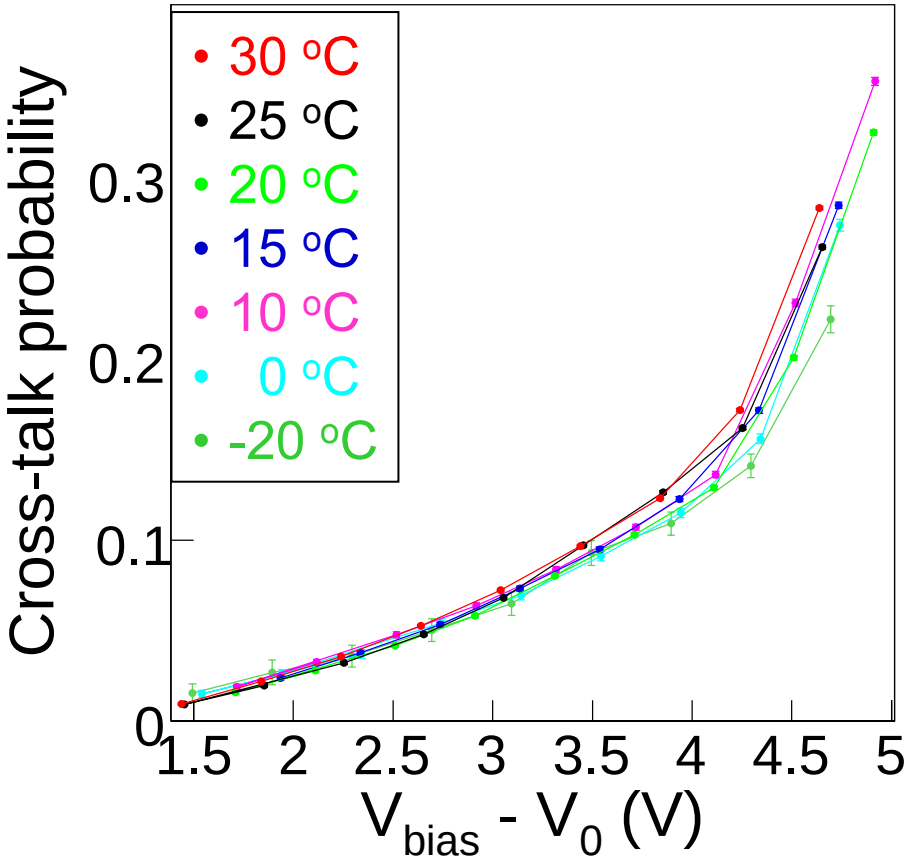


$$P_{crosstalk} = \frac{\text{Noise Rate}(>1.5\ \text{p.e.})}{\text{Noise Rate}(>0.5\ \text{p.e.})}$$



Temperature dependence of the Noise Rate / Cross-talk





- Lower temperature → lower dark noise
- Cross-talk is not affected by temperature change.

KEK Detector Technology Project
Photon Sensor Group

(http://rd.kek.jp/)

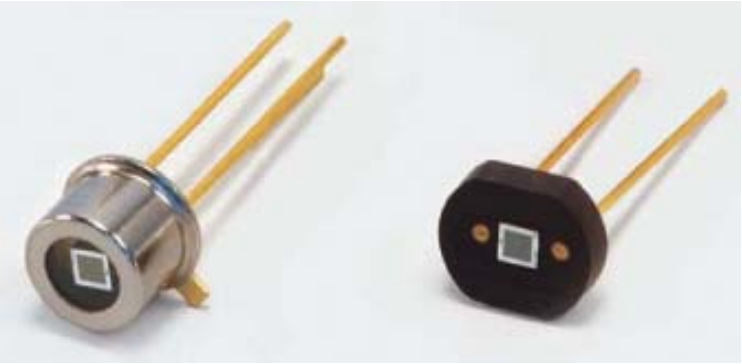
(KEK, Kobe, Kyoto, Nagoya, Nara-WU, NDA, Shinshu, Tokyo/ICEPP, Tsukuba)

- Develop and study the MPPC with Hamamatsu
- Aiming to have satisfactory performance to use at :
  - GLD calorimeter
  - T2K near detector
  - Belle Aerogel Cerenkov Counter
- Provide important feedbacks to Hamamatsu for improvement of fundamental properties

News : The MPPCs are finally on catalog !

Number of pixels	100	400	1600
Sensor size	1 x 1 mm^2		
Nominal Bias Volt.	70 ±10 V		77±10 V
Gain (x 10^5)	24.0	7.5	2.75
Noise Rate (kHz)	400	270	100
Photon Detection Efficiency	65 %	50 %	25 %
Temperature dependence ($\Delta V_0/\Delta T$)	50 mV / ^oC		

(Numbers from HPK catalog)



- Hamamastu will start to deliver the MPPC in early 2007.
- See following page for more information:

http://jp.hamamatsu.com/en/hamamatsu/press/2006/2006_10_26.html

Summary

- We now have the new 1600 pixel MPPCs for the GLD EMCAL test module.
- Performance of the new MPPC is sufficient for EMCAL beam test.
  - Gain (2-8)x$10^{5,}$ Noise Rate 50-300kHz, Cross-talk prob. < 2-20%
  - However properties are sensitive to temperature change.
    → Need temperature control / monitoring at practical use.
- The MPPC is being commercialized soon !

Plans

- Measure properties of 500 samples used for the scintillator-W EMCAL module (will arrive in this month).
- Practical use for the calorimeter readout at the coming beam test (→ next talk)
- The MPPC R&D will be continued until we achieve the necessary performance for the GLD calorimeter readout.
  - Improvement of the dynamic range (num. of pixels) is especially important!
- Also need to measure non-linearity, stability, robustness to have deeper understanding of the device.