Gain stabilization system in MPPC-based scintillation detectors for gamma–ray diagnostics at JET

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MPPC - Multi-Pixel Photon Counter – is a silicon-based monolithic array of micro-pixel avalanche diodes operating in a Geiger mode.

MPPC is characterized by large internal gain, high photon detection efficiency, high-speed response, excellent time resolution, wide spectral response, immunity to magnetic fields, resistance to mechanical shocks, low power/ voltage operation and compactness.

MPPC is therefore an alternative to a photomultiplier tube if operating at high count rate in harsh radiation environment.

Due to the fact that properties of MPPC are strongly affected by temperature, it is necessary to stabilize MPPC operation under temperature variations.

MPPC Temperature Compensation Device

At the National Centre for Nuclear Research (NCBJ) a MTCD@NCBJ device for real-time temperature monitoring and MPPC gain stabilization was designed and produced for use in gamma ray diagnostics in plasma experiments.

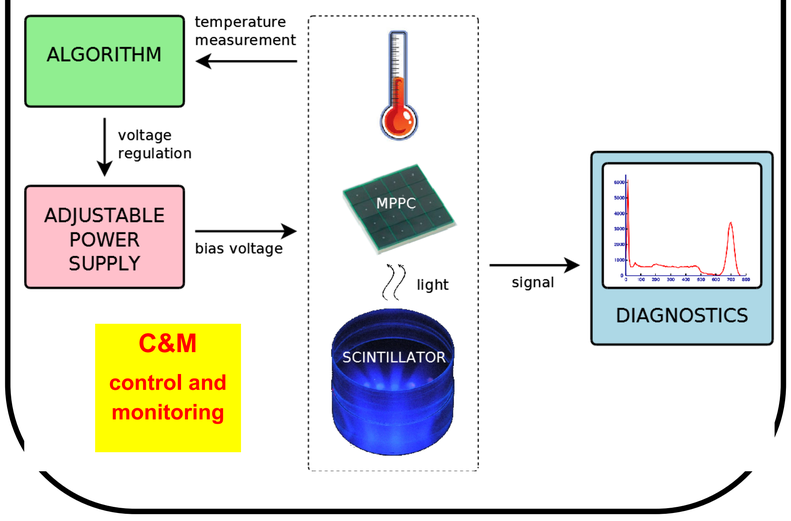
MTCD@NCBJ provides a current limitation and filtering of the MPPC bias voltage.

The device can supply an output voltage up to 80 V.

All functions are controlled from a personal computer.

MPPC detector specifications:

S12642-040PA-50 from Hamamatsu
Number of channels: 4×4
Photosensitive area per channel: 3×3 mm
Low voltage operation 65 V
High gain: 10^5-10^6



JET REQUIREMENTS

1. limited space for a MPPC–based scintillation detector → dedicated detector setup fitted to "old" CsI capsules
2. new electronics using existing cabling: 80 m long cables, four wires in a cable
3. power supplies and control system put in one box

NCBJ SYMPOZJUM 2015
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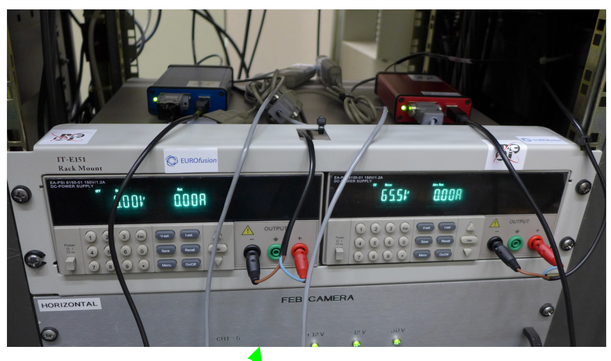
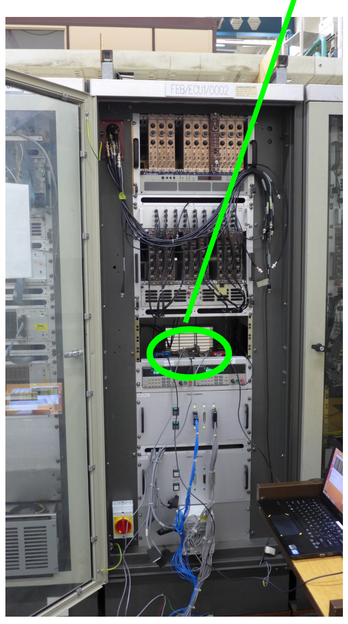
MTCD@NCBJ FOR GAMMA DIAGNOSTICS AT JET





Two MTCD@NCVJ installed in the Gamma Camera at JET (May 2015)

MTCD@NCBJ, a temperature compensation device, is based on an Atmega128 microcontroller, controlling an EA-PSI6150-01 power supply by an opto-isolated serial interface.

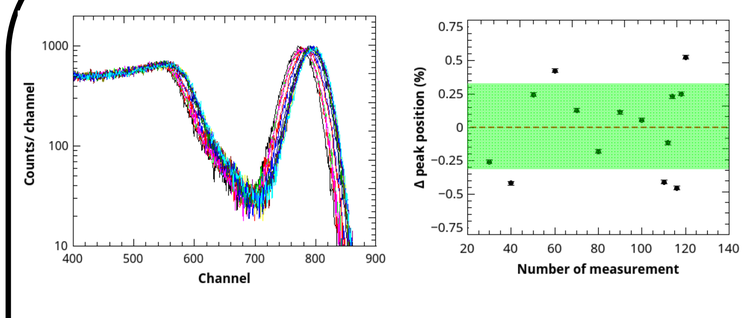
Temperature of the scintillator is measured by a TSIC506F digital thermometer integrated with the detector. The thermometer has an accuracy of ±0.1 K in a temperature range from +5 to +45°C.

To keep constant value of the gain at varying temperature, our device is setting a MPPC bias voltage using linear equation.

MEASUREMENTS at NCBJ

Measurements were performed with a ^{137}Cs source emitting 661.7 keV gamma line.

A 20x15 mm $CeBr_3$ scintillator coupled to MPPC was used.



- *661.7 keV gamma line measured with $CeBr_3$ scintillator*
- *120 measurement sessions, each lasted 500 s of live time*
- *17 hours of measurements during day and night with* ΔT = 2-3° C
- change in Full Energy Peak (FEP) position below 1%

DETECTOR SYSTEM FOR GAMMA DIAGNOSTICS AT JET

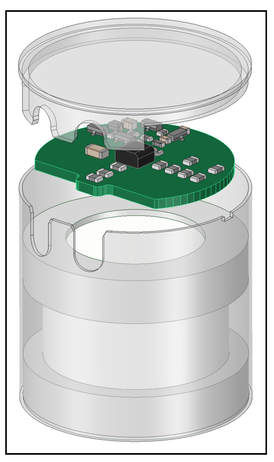
Existing cylinder detector capsules

Φ 35 × H 35 mm

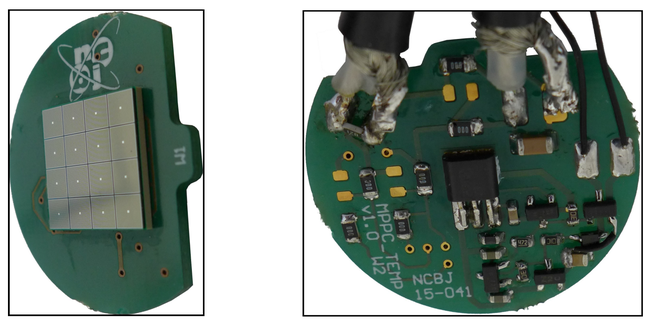
mounted on a slider to be used with new scintillators.

At JET in four conductors of 80 m long electrical cables, 2 conductors were chosen to be used only for MPPC power supply.

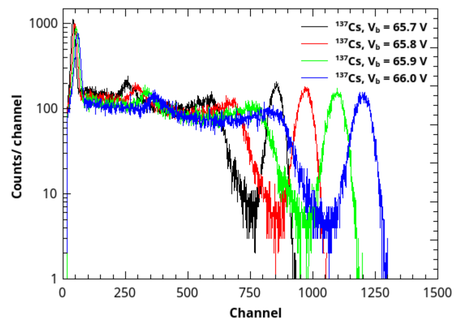
Two other conductors were used to send measured temperature values to a C&M system from MTCD@NCBJ.



Technical drawing of a capsule with dedicated printed board.



Dedicated MPPC PCB for detectors installed at JET (May 2015).



^{137}Cs spectra measured at constant room temperature at different MPPC bias voltage
ΔU_b =100 mV → ΔFEP ≈ 100 channels
ΔT = 1°C → ΔU_b =70 mV

CONCLUSIONS

1. **MTCD@NCBJ optimises a detector operation in varying temperatures.**
2. **MTCD@NCBJ is easily extended to a setup for 19 detector system.**
3. **19 MPPC power supplies will be integrated in C&M box.**
4. **measured temperature values will be off-line available for further use, including date and time information.**

Acknowledgement

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