Development of MPPC-based detectors for high count rate DT campaigns at JET

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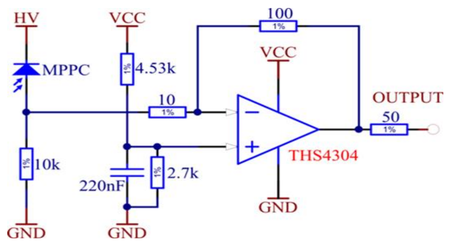
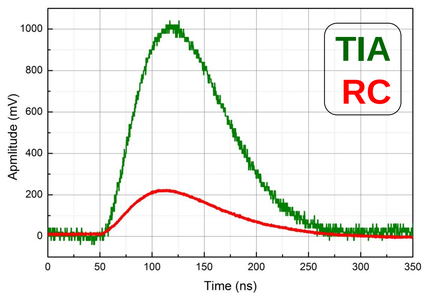
One of the methods for measuring products of fusion reactions at the Joint European Torus (JET) is based on registering of gamma-rays, originating from reactions between fast ions and plasma impurities. Gamma-ray detectors foreseen for measurements in deuterium-tritium (DT) campaigns have to be able to register spectra at high count rates, up to approximately 1 MHz.
For the Gamma-ray Camera at JET, a new setup will be based on scintillators with a short decay time, e.g., $CeBr_3$, and a multi-pixel photon counter (MPPC). To minimize the number of pile-up events at high count rates, a short detector output signal is necessary with as small as possible loss in amplitude. Due to space limitations at JET, a compact printed circuit board is designed to include all components on a single board.

Two methods for signal shortening

- **passive RC circuit**
  - shorter signal in cost of output amplitude
  - low signal-to-noise ratio may be unacceptable
  - simple, reliable solution - limited error prone elements
  - no additional heating source - no active elements
- **active transimpedance amplifier (TIA)**
  - high output amplitude with low time-constant
  - stable gain as a function of a rate
  - additional heating source

Transimpedance Amplifier (TIA)

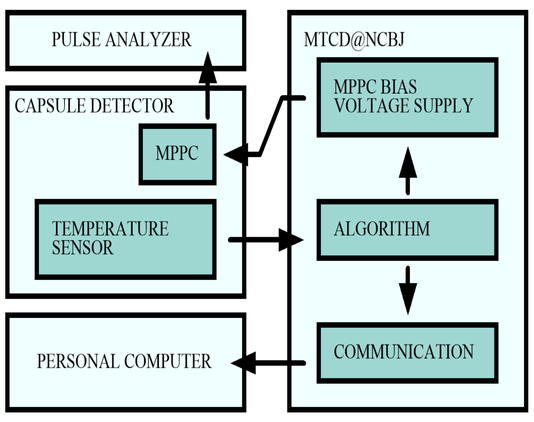




Amplitude for 175 ns signal:
TIA: 1000 mV
RC circuit: 210 mV

MPPC Temperature Compensation Device MTCD@NCBJ

a dedicated device designed and produced at NCBJ to maintain a constant value of a MPPC gain by using a measured dependence of a bias voltage on detector temperature

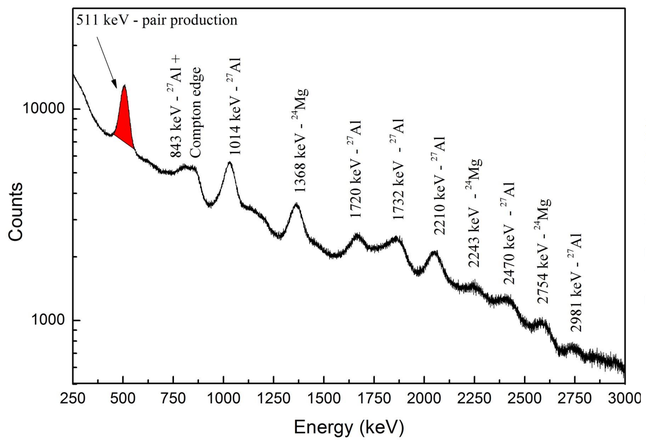


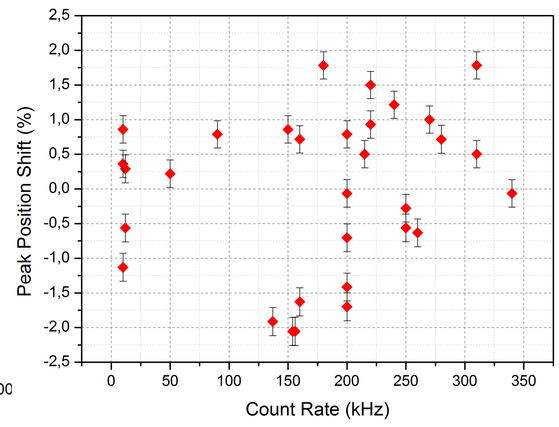
- setting of MPPC bias voltage
- integrated temperature sensor
- integrated power supply MAX1932
- advanced power supply closed loop control

$LaBr_3$ intrinsic activity

In the region at ~1460 keV a peak was fitted with three Gaussian distributions describing two contributions from ^{138}La (1440 and 1472 keV) and one from ^{40}K at 1461 keV.

Results from TANDEM-XTU at Legnaro 10 MeV protons on ^{27}Al target





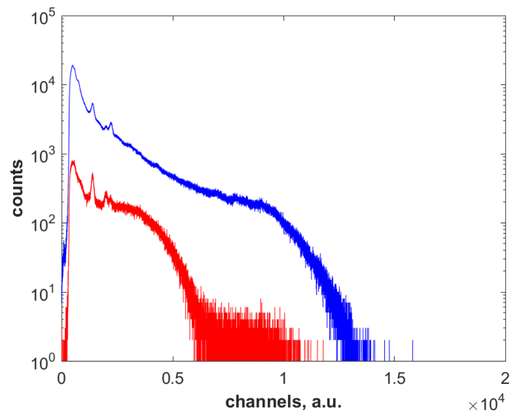
Spectrum obtained with 20x15 mm $CeBr_3$ and MPPC + TIA + MTCD measured at 30 nA current with a rate of ~340 kHz during 120 s

Dependence of 511 keV peak position on count rate

The peak position shift is less than 2.5% from the average value

Results from Frascati Neutron Generator: response to 14 MeV neutron irradiation

20x15 mm $CeBr_3$ with MPPC + TIA + MTCD



	All events		Last 10^7 events	
n/cm^2 ($\cdot 10^{10}$)	Peak position	FWHM, %	Peak position	FWHM, %
0.4	1402	9.1	1396	8.8
1.1	1396	9.8	1403	8.5
2.1	1374	9.9	1381	8.8
1.1	1332	10.9	1345	9.0
1.4	1342	11.2	1345	10.5
1.9	1148	14.9	1163	13.2

All events (blue) and last 10^7 events (red)

The continuous radiation, affecting the MPPC performance, results in wider FWHM for the same neutron flux.

Measurement with 20x15 mm $CeBr_3$ and MPPC + TIA + MTCD ~10^{10} n/cm^2 neutron flux during 600 s

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