Capabilities of a Diamond Detector matrix for neutron spectroscopy measurements at JET

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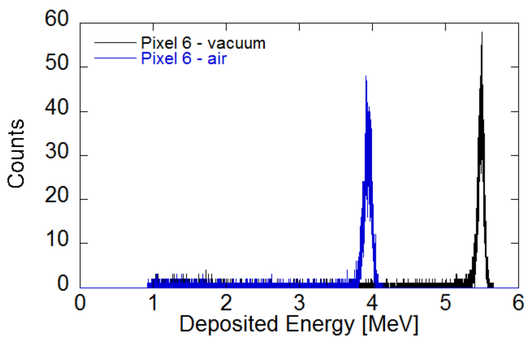
** See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia*

INTRODUCTION

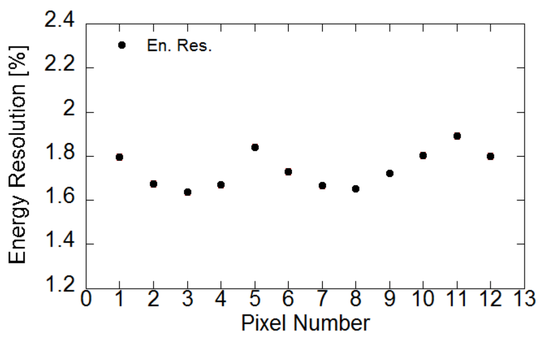
- New system based on a **12-pixels single crystal diamond detector** (**SDD**) **matrix** has been recently realized and has been installed at JET for neutron spectroscopy measurements
- Diamonds feature high radiation hardness, fast response, low sensitivity to magnetic fields and **compact size**
- n-α reaction $^{12}C(n,\alpha)^{9}Be$ allows direct **14 MeV neutron spectroscopy measurements**
- **2.5 MeV neutrons** can be detected by nuclear elastic scattering on carbon nuclei in the detector
- Calibration results of the **SDD matrix** with alpha particles in the laboratory and 14 MeV neutrons performed at the Frascati Neutron Generator will be presented.

ALPHA PARTICLE MEASUREMENTS

- In order to characterize and calibrate each single pixel with its own electronic chain, alpha particle measurements with a ^{241}Am source were performed in laboratory
- Measurements were performed in vacuum and then at atmospheric pressure.
- Each pixel was coupled to the ^{241}Am source thanks to 12 holes placed in front of each pixel which work as pinhole collimators
- The mean value of the energy resolution for the recorded peaks during the measurements in vacuum is **1.74 %** with a standard deviation of 0.08

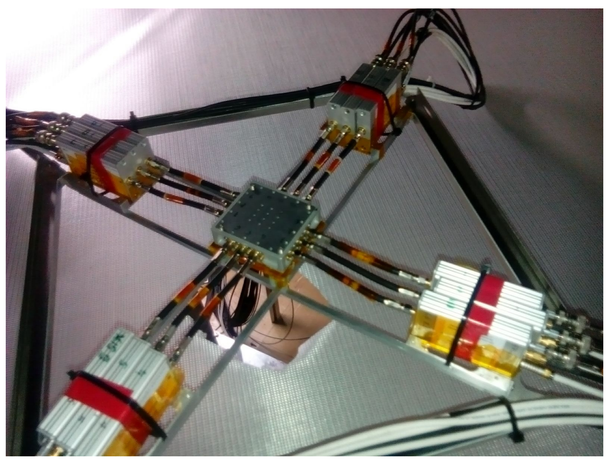


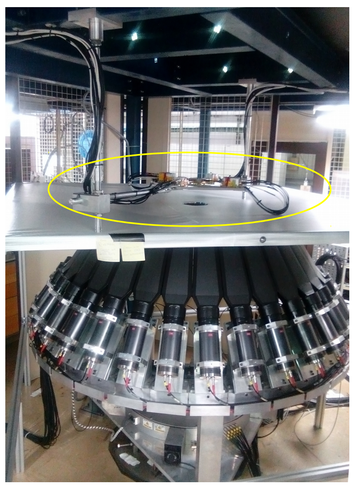
Pulse height spectra measured for Pixel 6 with 5.5 MeV alpha particles. Black spectrum represents the measurement performed in vacuum. The blue one is the measure at atmospheric pressure



Energy Resolution dispersion graph for measurements performed in vacuum

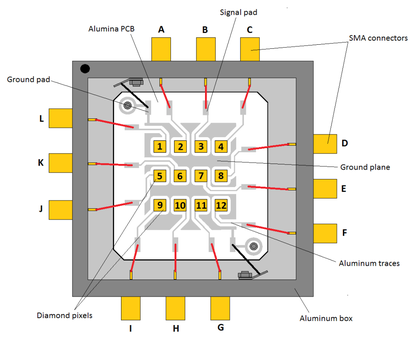
INSTALLATION at JET



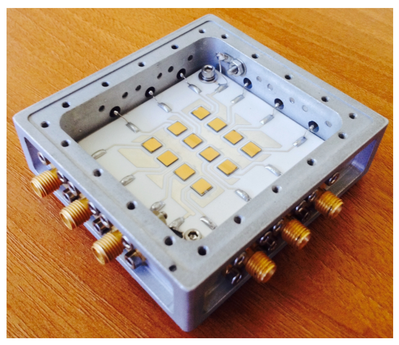


12-PIXELS SDD MATRIX, ACQUISITION CHAIN

- Each pixel is equipped with independent read-out electronic and high voltage supply
- Each pixel is coupled to a CIVIDEC C6 fast charge pre-amplifier which provides signal to a CAEN V1730B digitizer (16 channel, 14-bit, 500 MS/s)
- Read-out electronic was ad hoc built to combine the high counting rate capability with the good energy resolution



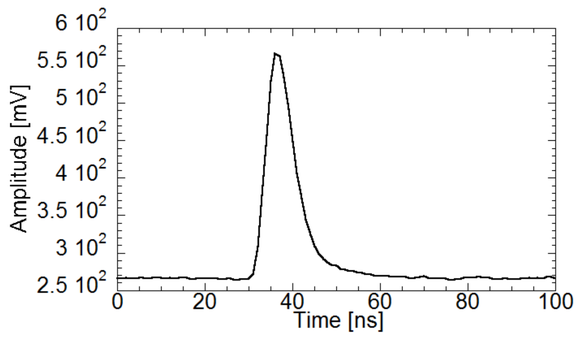
Schematic of the Printed Circuit Board together with each pixel output



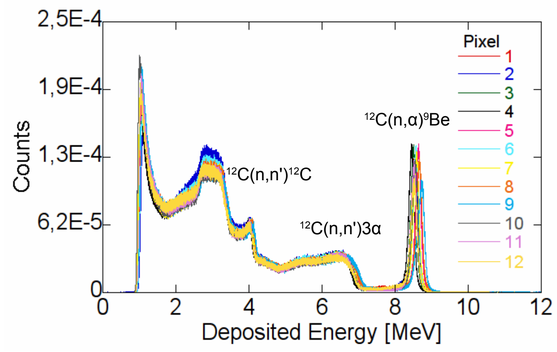
Picture of the 12-pixel diamond matrix without the top

14 MeV NEUTRONS MEASUREMENTS at FNG

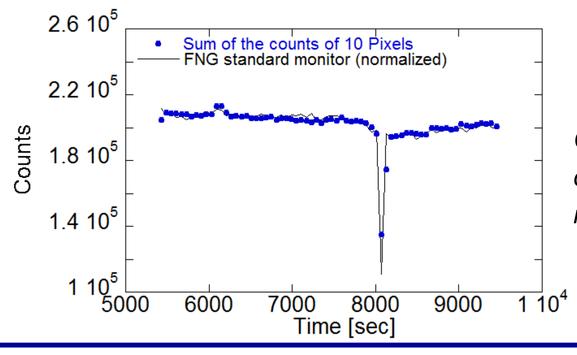
- Measurements of 14 MeV neutrons were performed at the ENEA Frascati Neutron Generator (FNG) aimed to evaluate the matrix detector response
- Neutrons production at FNG occurs by deuterium-tritium reaction
- SDD matrix was placed at 90° respect to the incoming deuterium beam at a distance of 22 cm from the target
- Mean value of the energy resolution for the 12 peaks is **1.3 %** with σ=0.2



Single waveform from a 14 MeV neutron interacting with a diamond detector



Calibrated pulse height spectra measured for each Pixel with 14 MeV neutrons at the Frascati Neutron Generator (FNG)



Counting time trace of 10 diamond detectors compared to the standard monitor of the FNG

CONCLUSIONS

- New system based on a **12-pixel SDD matrix** has been realized and proven to be a good neutron diagnostic for fusion plasmas
- Dedicated digital acquisition allows neutron spectroscopy measurements with simultaneously high energy resolution and high count rate capability (MHz)
- Response of the SDD matrix was measured with 14 MeV neutrons and α particles
- **Uniform response** of each pixel to radiation was observed: Energy resolution of 1.74 % and 1.3 % for 5.485 MeV α and 14 MeV neutrons was observed, respectively
- **SDD Matrix** has been installed at JET as a Vertical Neutron Spectrometer and it will take data in the next campaigns

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