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Neutron Emission Spectroscopy of Third Harmonic Radio-Frequency Heated Plasma with a NE213 Scintillator at JET

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PROCEEDINGS OF SCIENCE

Neutron emission spectroscopy of third harmonic radio-frequency heated plasma with a NE213 scintillator at JET *

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This paper presents the analysis of NE213 neutron pulse height spectra from the 2014 3rd harmonic RF heating experiment at JET. The focus is on the instrumental effects that need to be considered in order to obtain accurate results: gain drift, pile-up and uncertainties in the neutron response matrix. The experimental data and the expected spectra are shown to be in fairly good agreement.

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

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1. Introduction

Compact spectrometers such as NE213 scintillators are potential candidates for embedding neutron spectroscopy information in the channels of a neutron camera [1]. Therefore it is important to explore their potential and their limits in performing spectroscopic analysis.

In this work the spectroscopy capability of a NE213 during 3rd harmonic RF heating experiments at JET is studied.

The detector used consists of a small cylindrical active cell (12.3 x 8.4 mm) embedded in a aluminum case and coupled with a PMT (Hamamatsu R5611). Each scintillation pulse is digitized using a SP Devices ADQ214 digitizer (14 bit, 400 MSPS). The detector is located in the back of the MPRu spectrometer [2], along a tangential line of sight.

In section 2 the calculation of the detector response is presented; the corrections for gain drift and pile-up are described in section 3; in section 4 the measured NE213 spectra are compared with numerical calculations; finally the results are discussed in section 5.

2. Detector response

The neutron response of the detector was obtained with a combination of MCNPX [3] simulations and ohmic data. A proton light yield function from literature was assumed, since no measurement for the detector was available. The impact of this assumption on the analysis will be described in section 4.

The procedure for the calculation of the neutron response is described more in detail in [4].

3. Gain drift and pile-up correction

The short term gain drift due to high count rates is normally corrected using a LED signal as a reference. However the LED generator installed with the detector was not working properly during the experiments.

An estimate of the gain drift is extrapolated using data from the MAST neutron camera detectors [5]. These detectors have exactly the same PMT as the detector used in this work and they are operated at the same high voltage. The relative gain drift vs high voltage for the MAST detector is shown in Figure 1.

The pile-up is corrected using simple cuts in the pulse shape discrimination plot shown in Figure 2. In the figure one can identify the gamma events (cluster in the lower part of the plot) and the neutron events (cluster in the higher part of the plot). Most pile-up events end up in the region above the neutron cluster, therefore they can be easily rejected by appropriate cuts in the plot. This method works only if the count rate is not too high.

4. Results

Pulse height spectra from the 3rd harmonic RF experiment were analyzed. The expected neutron spectrum was obtained from a simple 1D Fokker-planck model [6][7]. The model depends on two variables that were optimized to fit well the data measured by the TOFOR spectrometer [8].

To compare it to the data, the modeled neutron spectrum was folded with the instrumental response of the detector. An example of the comparison between data and calculations is shown in Figure 3.

Three different response matrices were produced, using three different light yield functions that were measured for other detectors ("Hawkes", "Verbinski" and "ED") [9] [10] [11]. The chi-squared value extracted from the comparison between the data from JET pulse 86459 and the expected pulse height spectra obtained from the three different response matrices is shown in Table 1.

	Hawkes	ED	Verbinski
χ^2_{red}	2.46	2.12	2.68

Table 1: reduced chi-squared values obtained for JET pulse 86459 using the three different response matrices.

5. Discussion and conclusions

Instrumental effects such as gain drift and pile-up can have an impact on the results of the spectroscopy analysis of NE213 pulse height spectra. It has been shown that these effects can be properly accounted for.

Uncertainties in the proton light yield function also affect the agreement between measured and calculated spectra.

The pulse height spectra collected during the 3rd harmonic RF experiment at JET were reproduced fairly well by the model.

6. Aknowledgments

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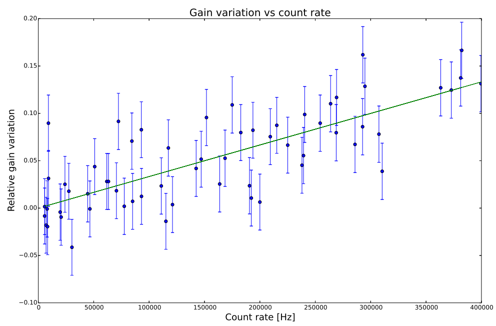

Figure 1: Relative change in the total charge of the gain vs count rate, measured by the MAST detectors.

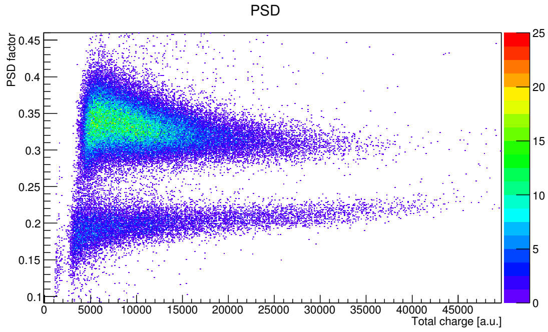

Figure 2: Pulse shape discrimination plot.

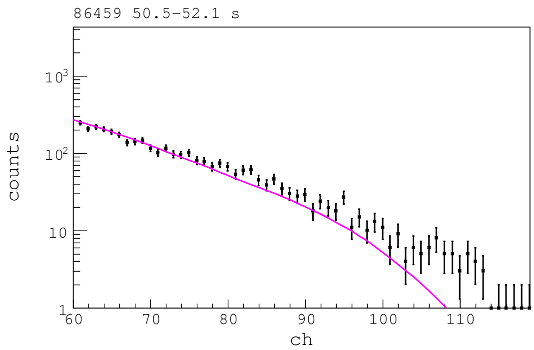

Figure 3: Fit (purple line) of the pulse height spectrum (points) for JET pulse 86459 from 50.5 s to 52.1 s.

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