WPJET4 Gamma Spectrometer Upgrade (GSU)

D09	Procurement of the elements for the DM2

1. Introduction

On JET the α-particle diagnostic is based on the nuclear reaction $^{9}Be(\alpha,n\gamma)^{12}C$ between confined α-particles and beryllium impurity ions typically present in the plasma, *see GSU Project Management Plan* and references therein. The applicability of gamma-ray diagnostic is strongly dependent on the fulfilment of rather strict requirements for the definition and characterization of the neutron and gamma radiation fields (detector Field-of-View, radiation shielding and attenuation, parasitic gamma-ray sources). For operating this diagnostic at the high DT neutron fluxes expected in the future high-power DT campaign on JET, specific improvements are needed in order to provide good quality measurements in the D-T campaign, characterized by a more challenging radiation environment.

In order to enable the gamma-ray spectroscopy diagnostic for α-particle diagnostic during the DT campaigns the following goals should be achieved:

- Maximization of the signal-to-background ratio at the spectrometer detector; this ratio is defined by terms of the plasma-emitted gamma radiation and the gamma-ray background.
- Establishing high count rate signal processing and energy-resolved gamma-ray detection.

In the DT experiments the gamma-ray detector must fulfil requirements for high count rate measurements. The existent BGO-detector with a relatively long decay time, about 300 ns, should be replaced by a new detector module (DM2) based on $CeBr_3$ scintillator, with an associated digital data acquisition system. The $CeBr_3$ scintillator are characterized by short decay time (~20 ns) and a high light yield about 45 000 photons/MeV. The coupling of the scintillators with photomultiplier tubes in specially designed detector modules will permit the operation at count rates over 2 Mcps. The $CeBr_3$ scintillator is an alternative to already tested at JET detectors based on $LaBr_3$:Ce.

The $CeBr_3$ scintillator was found to fulfil low noise measurement conditions. It shows 30 times reduction in internal activity in comparison with $LaBr_3$:Ce, see below. The $CeBr_3$ scintillator has a similar energy resolution, sensitivity and decay time as the $LaBr_3$:Ce scintillator. Moreover, the $CeBr_3$ scintillator seems to be more resistant for gamma radiation than $LaBr_3$:Ce. A 1 kGy dose of gamma radiation deteriorates the yield of $LaBr_3$:Ce by ~10% and worsens its energy resolution from 3.0 to 3.8%, while is almost negligible for $CeBr_3$.
$CeBr_3$ may also be more resistant to neutron radiation because of lower neutron capture cross section in Ce (~12 mb) than in La (~100 mb) at E_n ~30 keV.

These features make $CeBr_3$ an interesting alternative for JET plasma applications in spite of the excellent spectroscopic performances of $LaBr_3$:Ce scintillator.

2. Detector module DM2

2.1. Scintillator

In Fig. 1 a technical drawing of a detector ordered at Scionix is shown together with a photo of an already delivered detector.

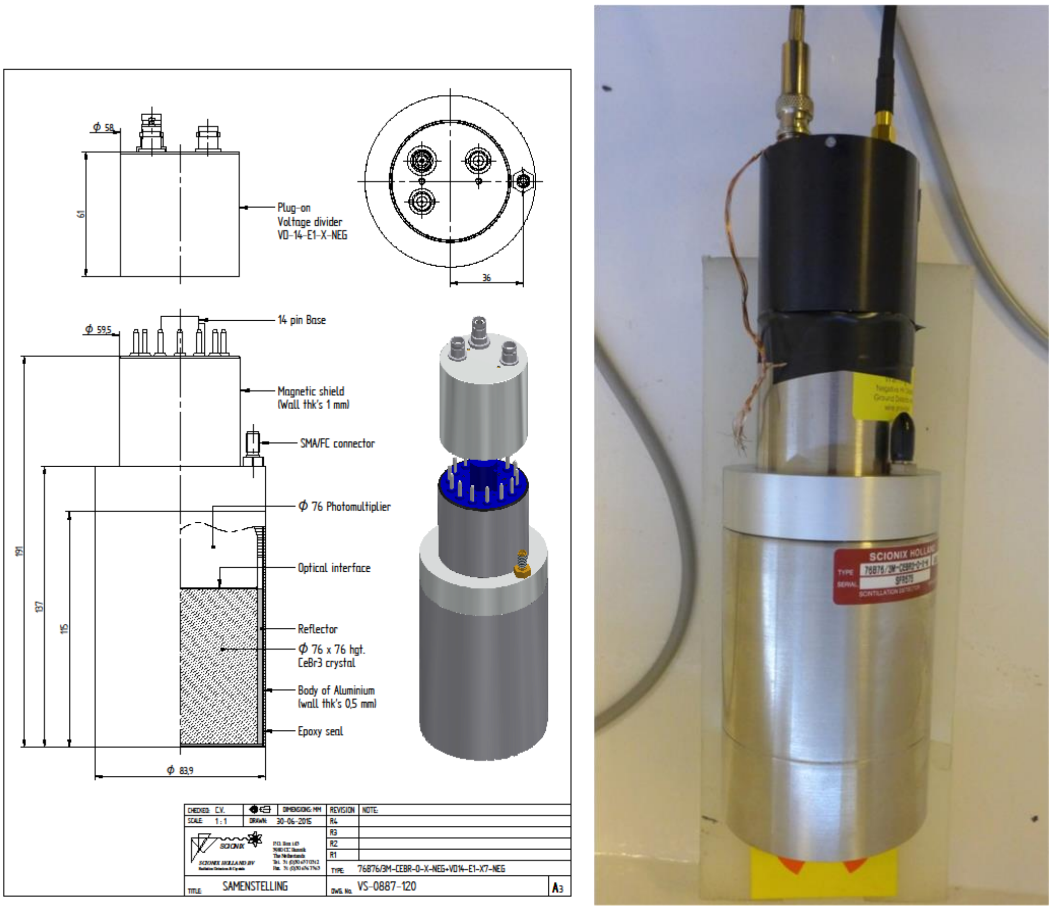

Fig. 1. 3”×3” $CeBr_3$ from Scionix: a technical drawing and a photo.

The specification of a detector based on $CeBr_3$:

- scintillator dimensions: 3”×3” (76 mm diameter, 76 mm high),
- low background,
- high resolution <4.3% FWHM at 662 keV scintillation crystal,
- 0.5 mm thick aluminium housing.

The photomultiplier R6233-100 PMT:

a 76 mm diameter PMT surrounded by an extra-long solid mu metal shield.

Additional features:

a fiber optics stabilization port with SMA connector.

Plug on voltage divider (Scionix model VD14-E1-X7-NEG):

- negative high voltage -700V,
- divider equipped with extra capacitors for high rate operation.

Active voltage divider designed at NCBJ:

A voltage divider (VD) has a significant influence on the performance of the PMT based detectors by interfering in its main characteristics, the gain control range and linearity. An active voltage divider ensures a constant gain. At NCBJ such a device was designed and produced. This fully active divider can be used up to 1.5 kV with a PMT 14 pin standard socket. It has easy removable components and has a direct output from both anode and last dynode.

Details about measurements performed with this detector are presented in the D18 report.

2.2. High voltage power supply

A CAEN N1470A high voltage power supply was purchased, see Fig. 2. All tests reported in the D18 report were performed with this device.

Fig. 2. CAEN N1470A high voltage power supply.

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