WPSA PPM, 5th – 9th September 2022

Gamma diagnostics

Preliminary technical specifications, required inputs

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Outline

- **Preliminary specifications on detectors**
- **Preliminary specifications on attenuators**
- **Input required for a more detailed evaluation**

A note: all of these considerations are based on experience, mostly at JET. A few options are outlined and can be selected once some input information is received for a quantitative evaluation of gamma-ray and neutron fluxes at JT-60SA.

Preliminary detector specifications

Option 1: gamma-ray measurements only

Detector type	$LaBr_3$(Ce)
Geometry	Cylinder
Size	1”x1” (min) 3”x6” (max)
Attenuator	PE or LiH, length to be assessed

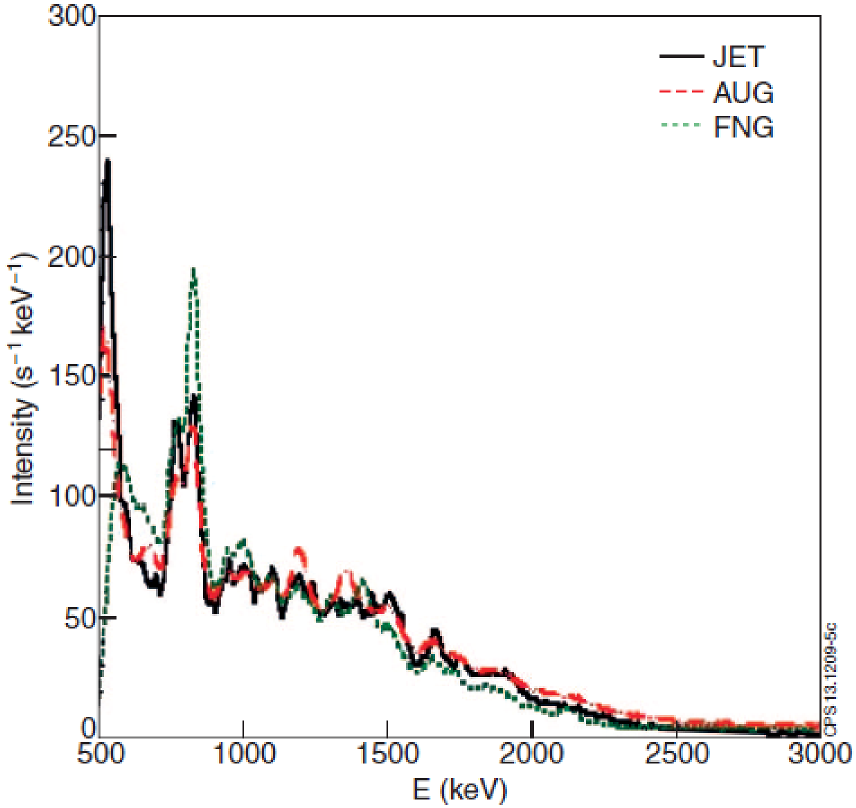
Pros: best tested gamma-ray spectrometer
Cons: no neutron spectroscopy capability

Option 2: combined neutron/gamma-ray measurements

Detector type	CLYC-7 (or Cl based scintillator)
Geometry	Cylinder
Size	1”x1” (min) 3”x3” (max)
Attenuator	PE or LiH, length to be assessed

Pros: combined neutron/gamma-ray spectroscopy
Cons: counting rate limit of ≈100 kHz if CLYC-7; higher if other materials used, but neutron capabilities to be assessed

Neutron background – $LaBr_3(Ce)$

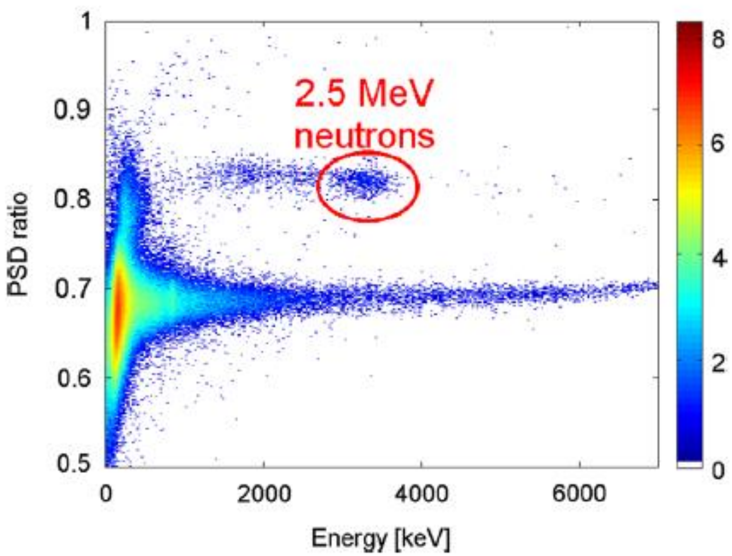


C. Cazzaniga et al. RSI 84 123505 (2013)

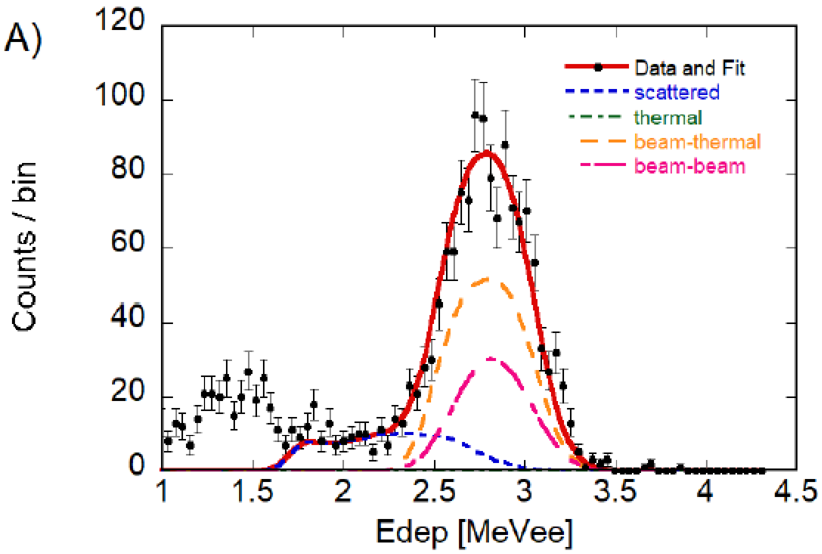
$LaBr_3(Ce)$ is sensitive to 2.5 MeV neutrons, which are a measurement background.
Experience at JET shows that this does NOT limit measurements in D plasmas, however.

Neutron background – CLYC-7

A. Giaz *et al* 2016 *NIMA* **810** 132



D. Rigamonti *et al* 2019 *JINST* **14** C09025



CLYC-7 is sensitive to 2.5 MeV neutrons, which are a measurement background, but also a signal due to n+^{35}Cl reactions, leading to a neutron induced peak.
Tests of CLYC-7 as a neutron spectrometer made at EAST and, more recently, at AUG (COSMONAUT diagnostics)

Neutron attenuators

Type	Polyethylene	LiH
Pros	Standard, easy to manufacture. ≈20 cm OK for all D plasma scenarios at JET.	Best neutron attenuation with only little gamma-ray attenuation; no added gamma-ray background
Cons	Added gamma-ray background (2.2 MeV; 4.44 MeV) Non negligible gamma-ray attenuation.	Non standard, few suppliers

Experience with measurements in D plasmas at JET suggests that PE should be sufficient; added gamma-ray background not a concern; LiH t.b.c. only if PE found insufficient.

No or less attenuation if ^{35}Cl rich scintillator is used?

Identified installation position

Based on the interaction with the QST team during the RCM in October 2021, the detectors could be installed in **some channels of the existing neutron emission profile monitor**.

Required inputs

We need the following input information to advance the conceptual design / decide among the options shown:

1) Information on **the geometry of the neutron profile** monitor, including collimator size, available space, existing detectors and their position, existing attenuators and their dimensions. A CAD/CATIA model would also be welcome.
2) Distribution function of deuterons from NBI (eg. TRANSP or ASCOT) in a relevant scenario.
3) Distribution function of protons (eg. TRANSP or ASCOT) from NBI in a relevant scenario.
4) Some reasonable assumptions on the runaway electrons (eg. RE current and tentative guess on their distribution or representative energies)

Conclusions

- Preliminary technical specification for gamma-ray (or combined neutron/gamma-ray) detectors at JT-60SA have been made based on demonstrated JET measurements.

- Input information is required to progress the design / choose among options suggested by experience.

THANK YOU FOR YOUR ATTENTION