Fast neutron spectroscopy with very high energy and time resolution for diagnosing fusion DT burning plasmas

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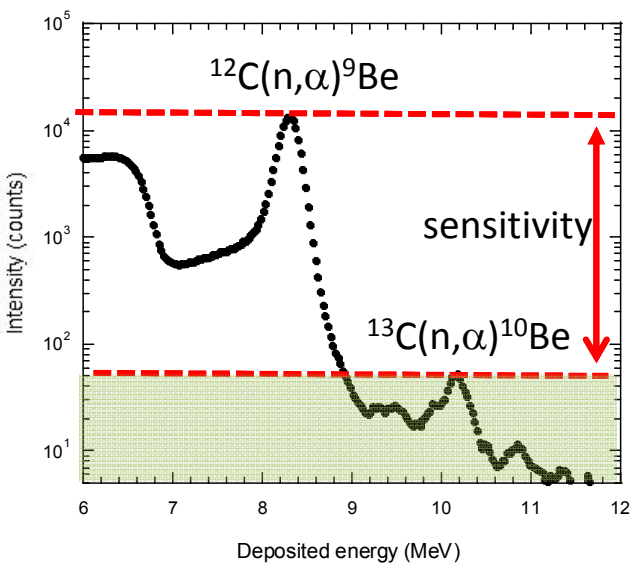
Introduction

The road to power production through nuclear fusion needs reliable diagnostics of the magnetically confined DT plasma. Diamond-based detectors have the highest potential as neutron spectrometers. Today's diamond neutron spectrometers combine very high energy resolution (FWHM<1%@14 MeV) and MHz counting rate capability (which allows for 10-100ms time resolution).

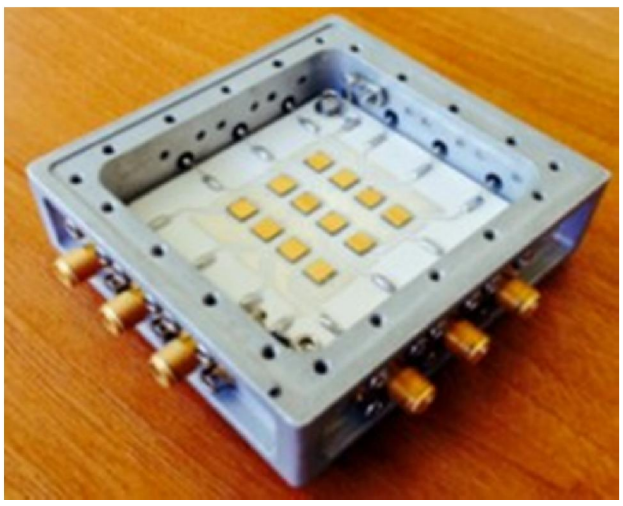
The sensitivity of the todays' diamond detectors to weak spectral components is limited by the presence, in "normal" diamonds, of ^{13}C along with ^{12}C. The resulting effect is to mask the high energy region of the main 14 MeV neutron peak which contains important inforrmation on the plasma, e.g. the fuel ions D and T ratio.



Neutron emission spectrum from 14 MeV neutrons recorded with a CVD diamond spectrrometer.

The sensitivity of present diamond neutron spectrometers to weak components in the neutron spectrum is today limited to ~1%.

There are two competitive reactions of neutrons in the MeV energy range, namely $^{12}C(n,\alpha)^{9}Be$ which is used for spectroscopy, and $^{13}C(n,\alpha)^{10}Be$, the latter featuring a Q value of about 2 MeV lower than the first reaction.



A 12-pixels CVD diamond detector matrix developed by IFP/UNIMIB and installed at the JET torus in Culham for the future DT experiments.

You wanted a (one-humped) dromedary, you got a (two-humped) camel!!!!

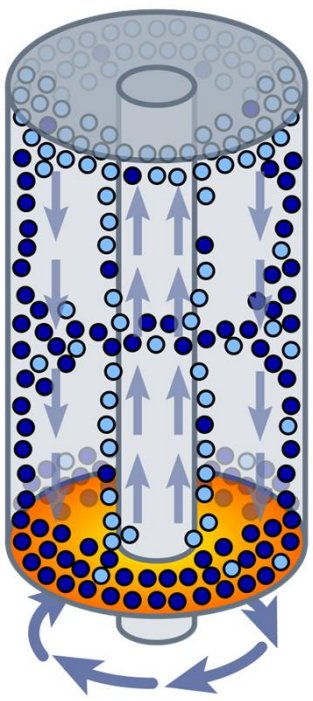
The Idea/Concept

Target goals of this proposal is the realization of a prototype diamond based neutron spectrometer which features:

* **signal to background >10^4** in the neutron energy range 12-20 MeV.
* **energy resolution<0.5% @ 14 MeV,**
* **counting rate capability up to 5 MHz**

This will be realized with the development of:

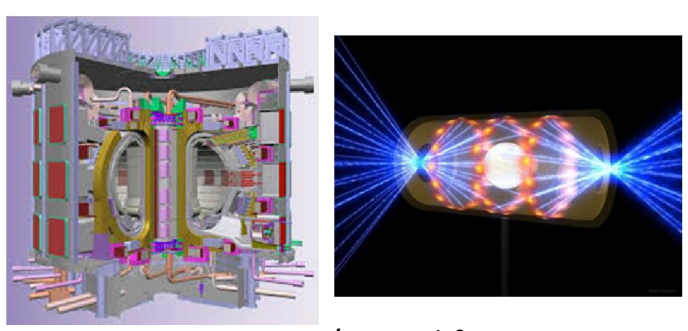
1) ^{13}C-free diamond spectrometer grown with the CVD techniques
2) custom low noise/fast spectroscopy electronics



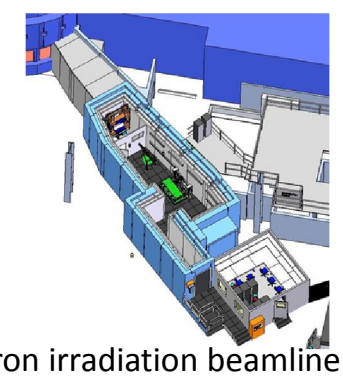
The well-known working principle of a gas centrigue. Fast rotation and heating of a gas cause separation of molecules with different weight (and thus isotopical composition).

Potential Impact

High rate/high energy resolution/high sensitivity neutron spectrometers will find application at fusion burning plasma experiments (such as ITER or DEMO) and on fast netron irradiation beamline



Plasma diagnostics in magnetic/inertial fusion energy experiments



CHIPIR fast neutron irradiation beamline at the STFC spallation neutron source