Conceptual design of a Cherenkov based gamma-ray diagnostic for measurement of 17 MeV gamma rays from $T(D,\gamma)^5He$ in magnetic confinement fusion plasmas

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At present, the only method for assessing the fusion power throughput of a reactor relies on the absolute measurement of 14 MeV neutrons produced in the D-T nuclear reaction. [1]
For ITER and DEMO, however, at least another independent measurement of the fusion power is required.

The $^5He^*$ nucleus produced in the D-T fusion reaction has two de-excitation channels. The most likely is its disintegration in a particle and a neutron, $D+T\rightarrow{}^5He^*\rightarrow\alpha+n$, by means of the nuclear force. There is however also an electromagnetic channel, with a branching ratio $\sim 10^{-5}$, which leads to the emission of a 17 MeV gamma-ray, i.e. $D+T\rightarrow{}^5He^*\rightarrow{}^5He+\gamma$. [2] The detection of this gamma-ray emission could serve as an independent method to determine the fusion power. In order to enable 17 MeV gamma-ray measurements, there is need for a detector with some coarse energy discrimination and, most importantly, capable to work in a neutron rich environment.
Conventional inorganic scintillators, such as $LaBr_3(Ce)$, have comparable efficiencies to neutrons and gamma rays and they cannot be used for 17 MeV gamma-ray measurements without significant neutron shielding.

In order to overcome this limitation, we here propose the conceptual design of a gamma ray counter with a variable energy threshold based on the Cherenkov effect and designed to operate in intense neutron fields.
The detector geometry has been optimized using Geant4 so to achieve a gamma-ray to neutron efficiency ratio better than 10^5. The design is based on a gas Cherenkov detector and uses a CsI coated scintillating GEM *(Gas Electron Multiplier)* as photon pre-amplifier, together with a wavelength shifter to minimize the sensitivity to neutrons.
Photons produced in the GEM are collected by an optical window and a bundle of optical fibers, which guides them towards an array of silicon photomultipliers (SiPMs) located further away from the plasma, in a region at low nuclear radiation.

References

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