CVD Diamond Detectors for Fast VUV and SX-Ray Tomography

Proposal for the ITPA Diagnostics Topic Group meeting

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Frascati, 5/10/2021

Proposal 22/09/2021

The excellent photon detection properties of Chemical Vapour Deposition (CVD) single crystal diamonds proved them highly suitable for Vacuum Ultra-Violet and Soft X-ray radiation in-vessel diagnostics of magnetically confined plasmas in a variety of applications [1]. Their radiation and temperature hardness, small size, and high-vacuum compatibility can be exploited for core and divertor tomography/bolometry for energies from 5.5 eV up to 30 keV; their fast response (in the ns range) can be applied to monitor fast plasma events, such as ELMs, MHD instabilities, ablation of pellets. The high-quality CVD diamond detectors developed and grown at "Tor Vergata" University in Rome have long been in use at JET and were more recently tested on FTU. Their deployment on DTT is under design, and their application on ITER can also be proposed.

[1] F. Bombarda et al., 2021 *Nucl. Fusion* in press https://doi.org/10.1088/1741-4326/ac233a

JET layout

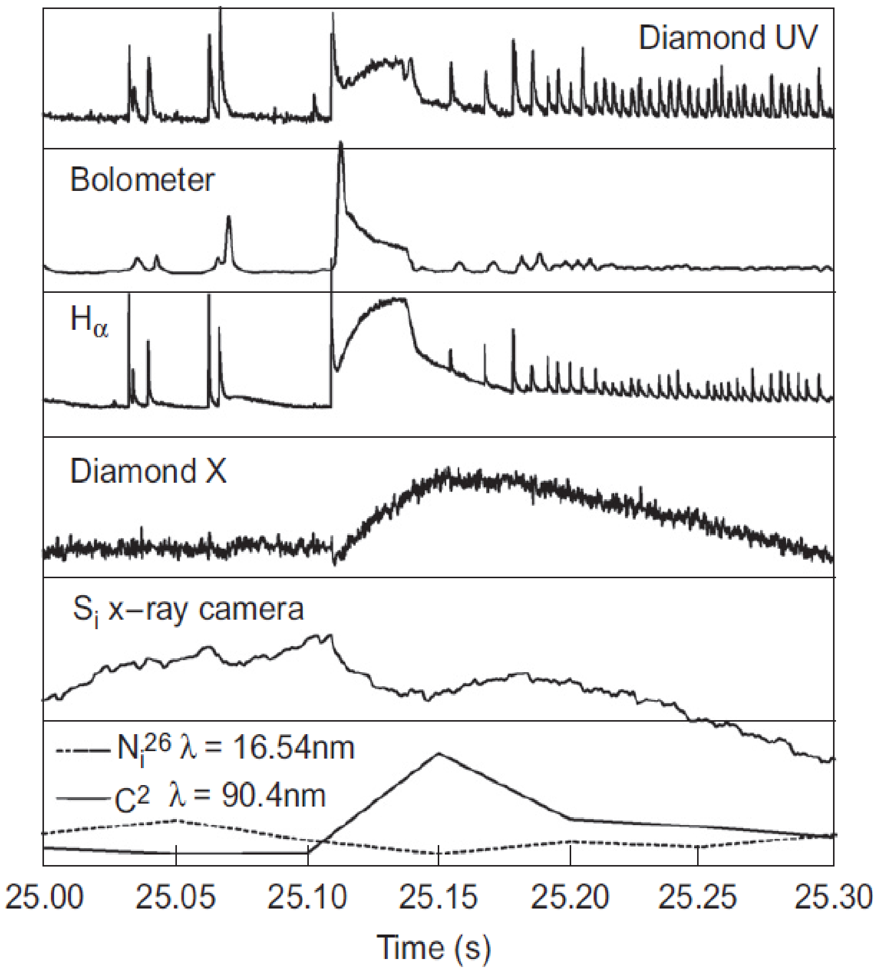

Fig. 5. Measurements during a carbon impurities influx.

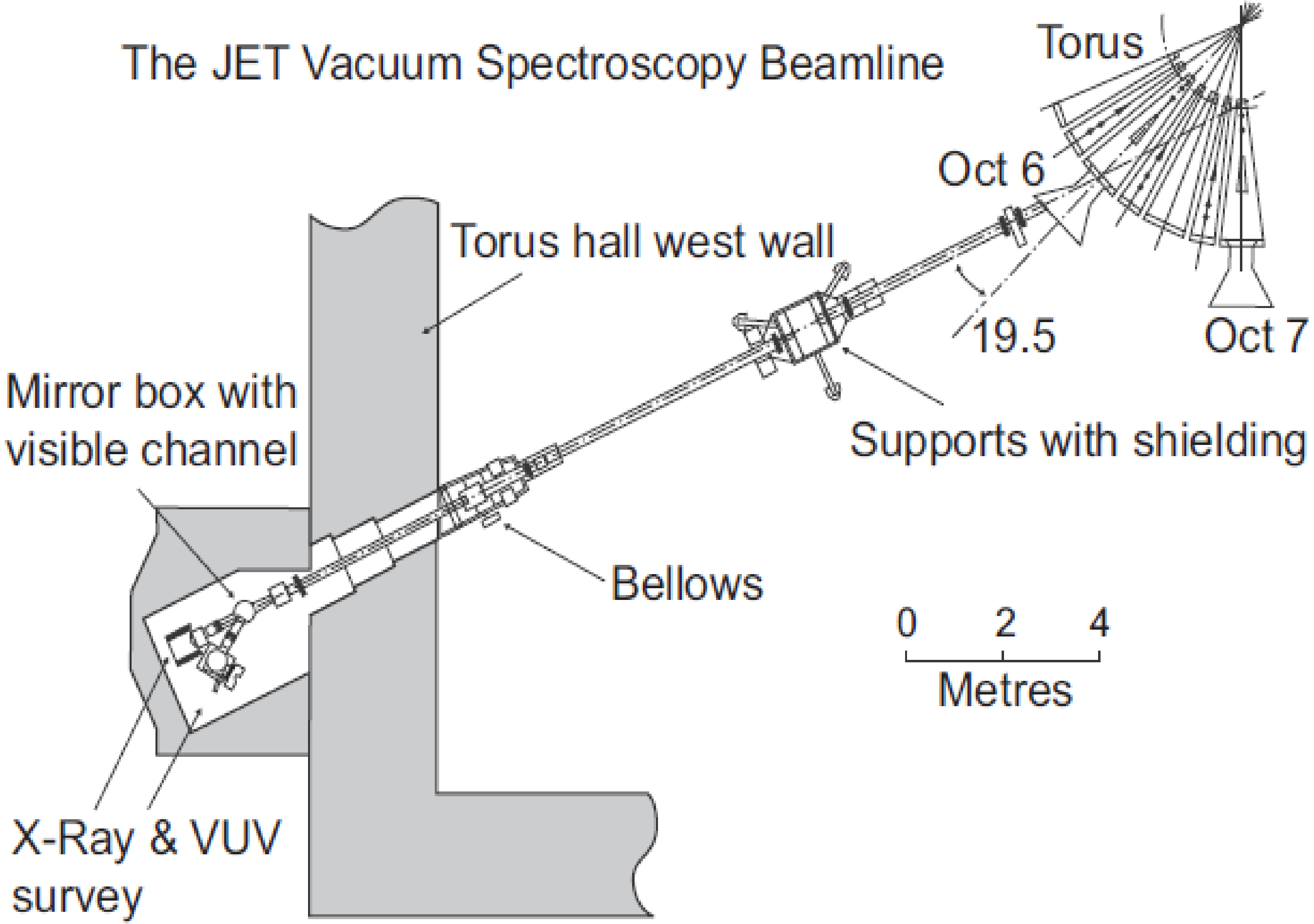

Fig. 3. Location of JET VUV and softX survey spectrometer. The bunker is shared with a Bragg rotor X-ray spectrometer and a visible channel.

Nuclear Instruments and Methods in Physics Research A 623 (2010) 726–730

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FTU pellet injection

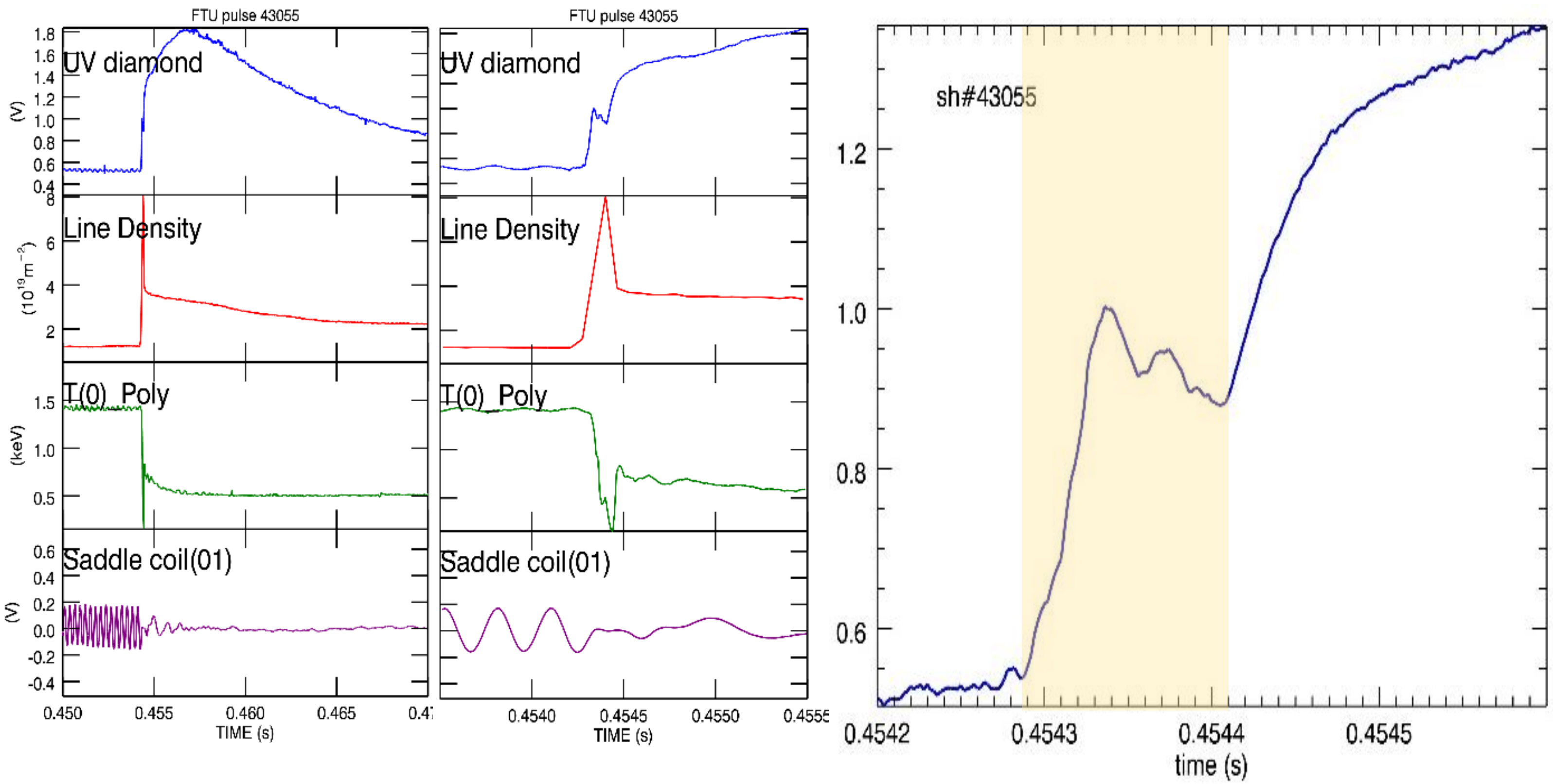


Figure 4 Ablation phase of a D pellet injected at about 1.2 km/s from the low field side midplane. The first column covers 20 ms from the injection trigger of the UV diamond signal, the line average density at R=1.1 m, the central channel of the ECE polychromator, and one of the saddle coils measuring the derivative of the radial magnetic field perturbations associated to MHD instabilities; the second column is an expanded view of the same signals; on the right 0.4 ms of the UV signal with the actual ablation phase occurring during the shaded area.

FTU mode locking and MARFE

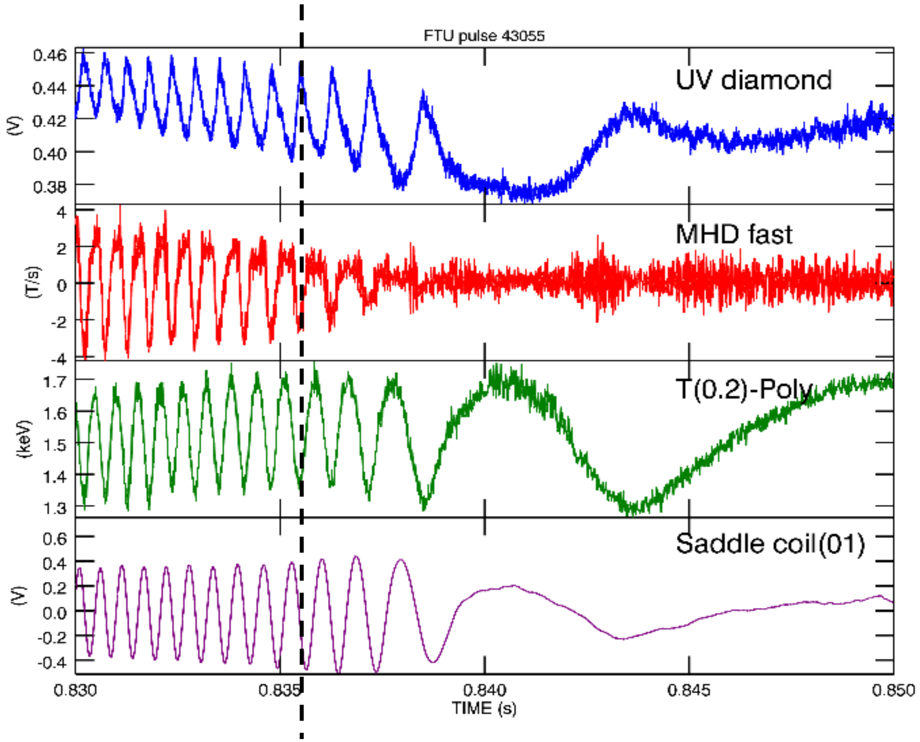


Figure 5 Example of rotating 2/1 tearing mode slowing down and locking as seen by different fast diagnostics. From the top: the UV diamond detector, a pick-up coil, the ECE polychromator temperature at r/a=0.2, and a saddle coil channel.

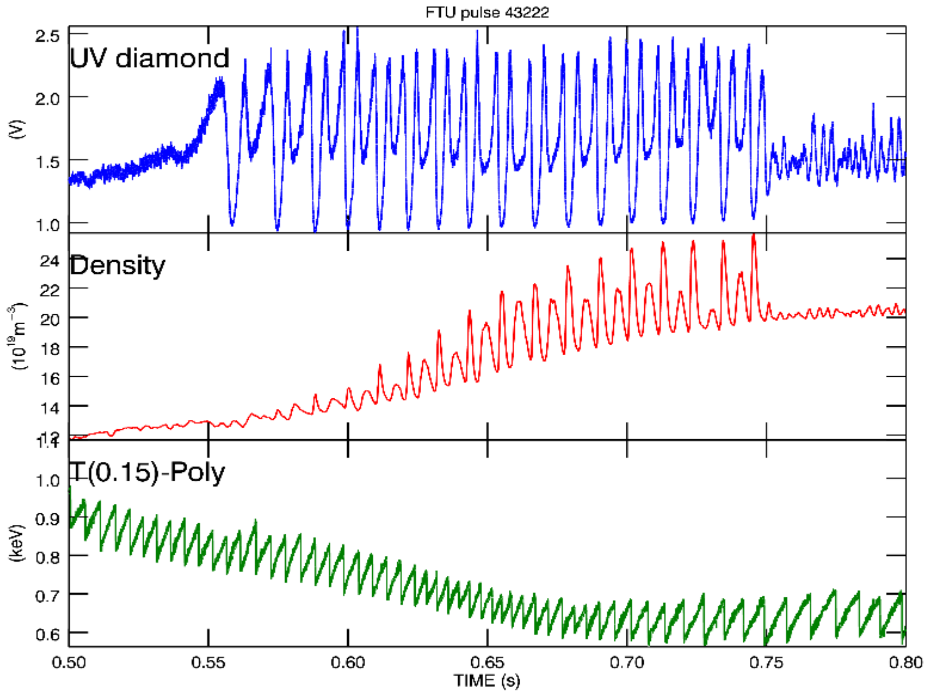


Figure 7 MARFE oscillations as observed by the UV diamond, the line average density measured by the vertical central chord of the interferometer, and the ECE polychromator temperature at r/a=0.15.

CVD diamond-based bolometry

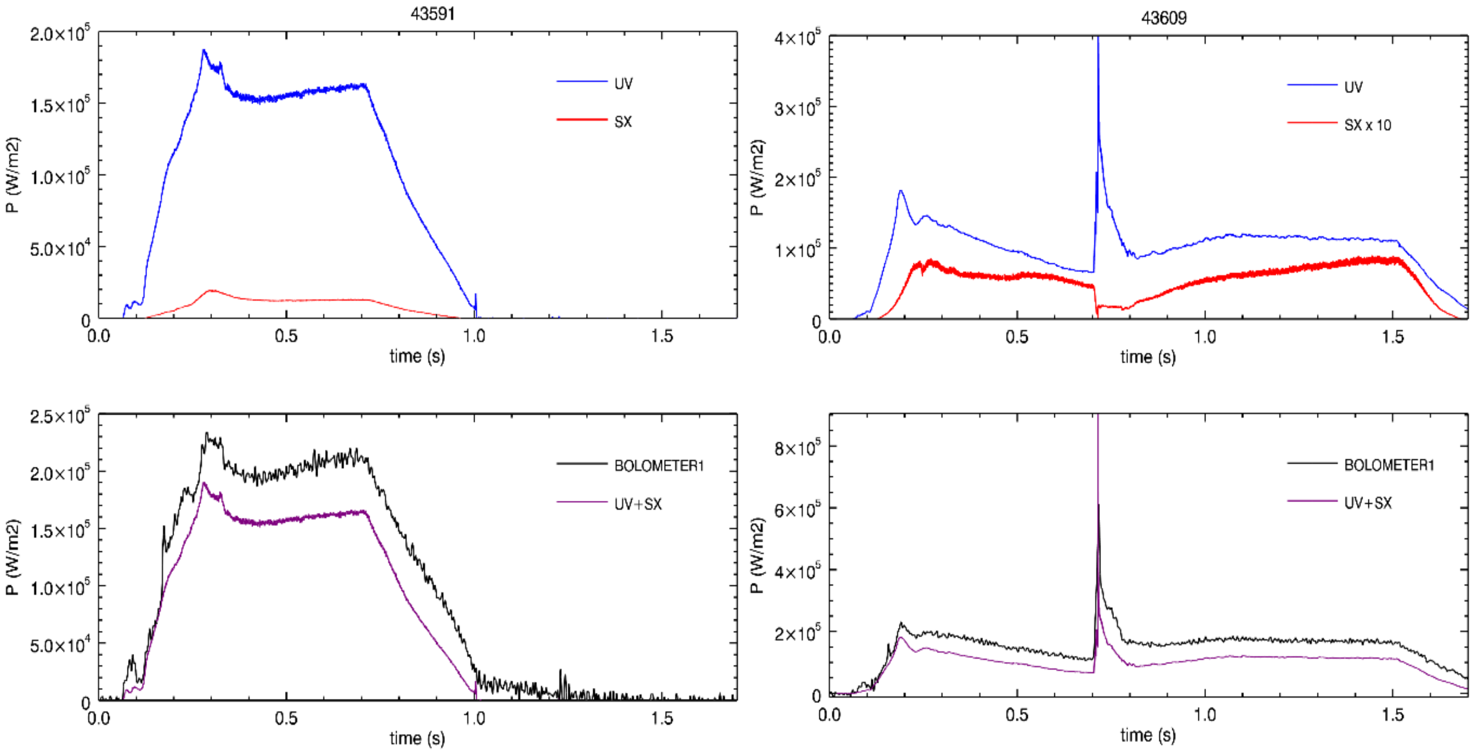


Figure 8 Comparison of radiated power densities from one of the calibrated bolometer channels and the combined signals from the UV and SX diamonds for two FTU discharges: a standard Ohmic discharge at 5 T, 550 kA, $n_e=5\times10^{19}m^{-3}$ (left), and one at 5 T, 360 kA, $n_e=1.3\times10^{19}m^{-3}$ with a single pellet injection (right). The top plots show the time traces of the two diamond detectors UV and SX, the bottom ones the comparison of their sum with the bolometer channel with a similar line-of-sight.

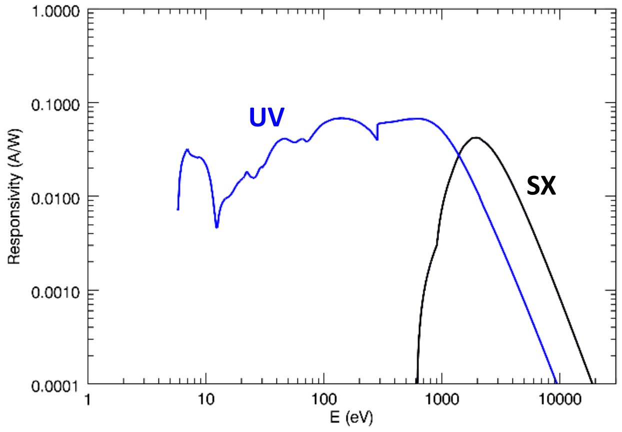
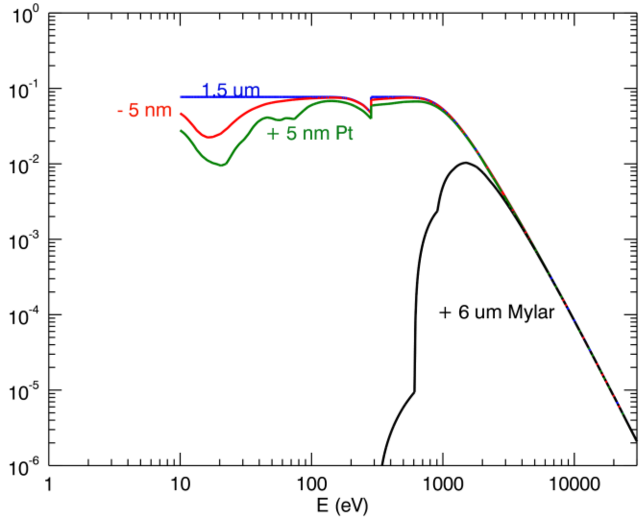
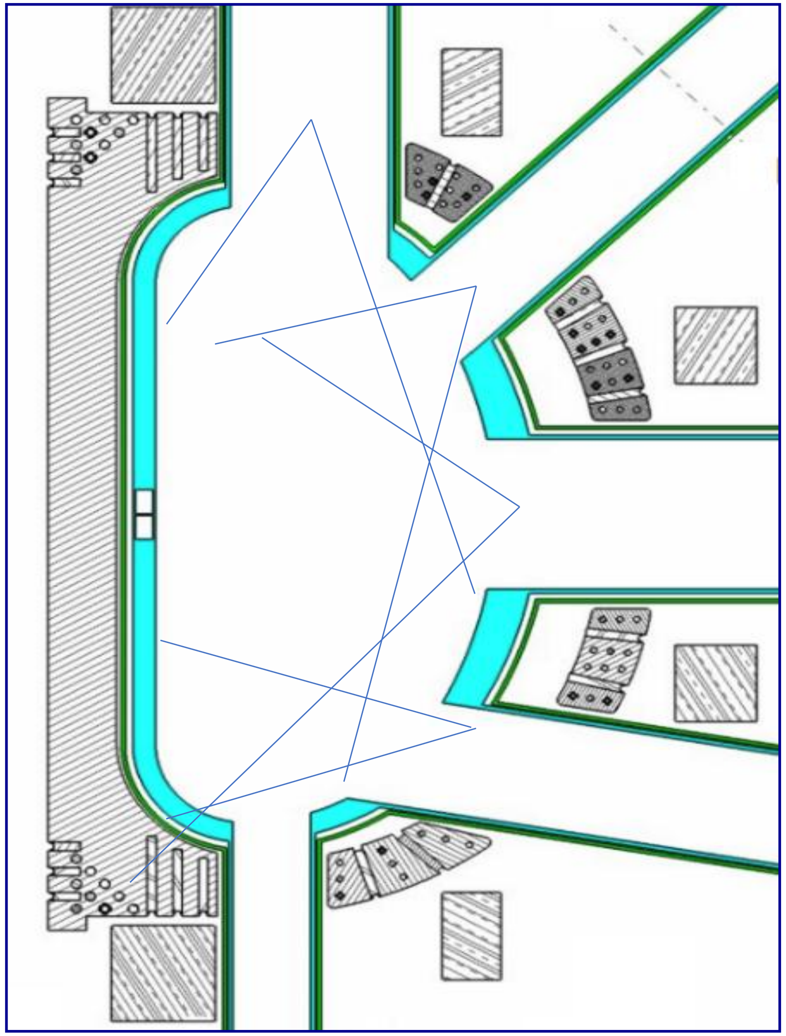
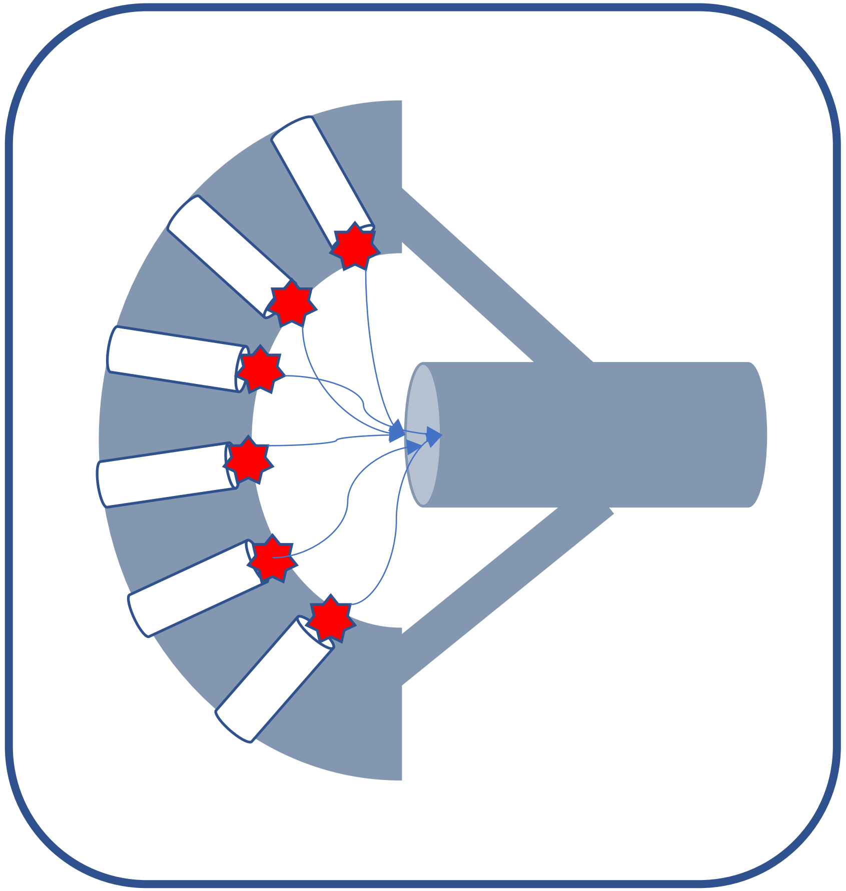


Figure 2 Calculated responsivity curves for the actual geometry of the detectors used on FTU; the calculation includes the Pt and Cr 5 nm contact layers, and the 6 mm Mylar filter for the SX detector.



iDTT Tentative layout





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