Characterizing the fragment plume of shattered pellets using laser curtain

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Shattered pellet injection is considered as the main disruption mitigation system (DMS) for ITER [1]. The ITER DMS requires large, 19x38 and 28.5x57 mm (diameter x length) cryogenic pellets, made of Hydrogen, Neon, or a mixture of those, accelerated to several hundred m/s velocity. An ITER DMS Support Laboratory was set-up at the Centre of Energy Research [2], to investigate the shattering process and characterize the resulting fragment plume for various shattering geometries and pellet velocities. Pellets are produced by cryogenic cooling in a well-localized region of the acceleration barrel, and they are released by a high-pressure gas pulse. After leaving the barrel, pellets pass through a ca. 20-cm-long free-flight region, where a shadowgraphy diagnostic is regularly operated [4], allowing for the measurement of pellet speed, and the inspection of pellet integrity. Passing a 3-m-long free-flight tube, the pellets arrive at the shattering head, located at the entrance of the fragment analysis chamber. This large vacuum chamber allows the fragments to travel freely in space, enabling us to determine the spatio-temporal distribution of the fragments' size and velocity using the laser curtain diagnostic system [5]: a 5-mm-thin plane is illuminated by a line laser source perpendicular to the flight direction of the fragments; fragments passing through this plane scatter light, which can be detected by fast cameras (Figure **1** left).

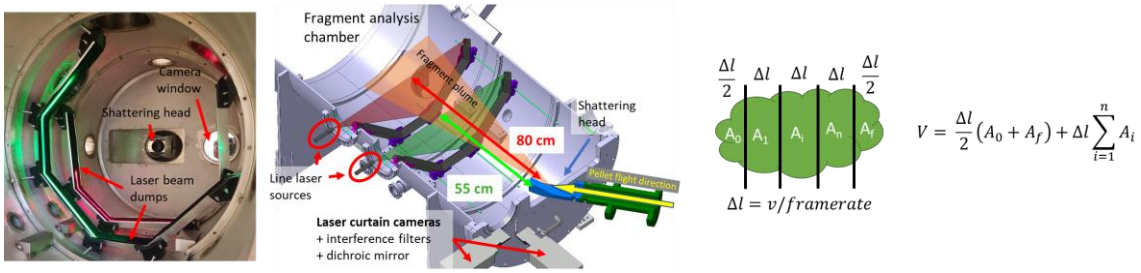

Figure 1. Laser curtain diagnostic (left), estimation of the volume of multi-frame fragments (right).

The key element of the fragment analysis procedure is a local thresholding algorithm, which is necessary as the image background intensity rapidly changes over both space and time. Additionally, a temporal filtering is applied for identifying fragments also along the time dimension: each pixel is regarded as a time-signal, and large second derivatives of these signals are promoted – this corresponds to time instants when a fragment is showing up on one frame and disappearing on the next frame. After thresholding, fragments are labelled also