# Real time monitoring of pellet delivery to facilitate burn control in EU-DEMO

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Efficient and reliable core particle fuelling, an essential task in EU-DEMO, relies on adequate pellet injection. These pellets, mm-sized bodies formed from solid hydrogen fuel, need to be launched via guiding tubes from the vessel inboard. However, pellets are fragile objects and their delivery efficiency can hardly be assumed to be unity. Thus, occasionally a requested pellet will be partially or fully lost. Using the flight simulator FENIX for modelling potential scenarios at a reactor grade level indicates such missed-out pellets do cause a considerable problem for keeping a burning plasma sufficiently stable. Missed-out pellets can cause a severe drop of plasma density which in turn results in a potential drastic loss of burn power. Hence, without an early detection of such missed-out events, the plasma control system will struggle to keep the plasma parameters within the designated operational range. Consequently, it is required to detect as early as possible pellets that are not launched or arriving with insufficient size in the plasma, and respond accordingly.

In order to develop an approach for handling this issue, a scheme is currently under development at ASDEX Upgrade (AUG) for monitoring of pellet launch requests and detection of successful pellet delivery into the plasma. Since the AUG system launches pellets via a guiding system at high speed from the torus inboard it provides indeed a reactor relevant configuration. Pellets are accelerated by a centrifuge so their velocity is precisely defined. Hence, arrival times can be predicted with less than 1 ms accuracy. This facilitates the real time identification of pellet arrival by detecting its impact on suitable monitoring signal. Providing an adequate monitor is considered challenging within a reactor environment. In our first proof-of-principle demonstration at AUG, pellet arrival is detected by the strong ablation radiation emitted inside the hot confined plasma. Real time examination of both the pellet announcement and the ablation monitor can then either confirm arrival of a sound pellet or identify a missed-out case. Losses can be compensated by either fast instant substitutions or an adaptation of the pellet flux requested by the control system. Yet, this method requires observation of a considerable fraction of the designated ablation region. However, analysis showed that a sufficiently large field of view cannot be covered with reasonable effort in EU-DEMO under current assumptions (pellet flight path, penetration depth and diagnostic lifetime) and is thus anticipated as being unsuitable. Consequently, alternative methods need to be investigated in parallel. As one option, magnetic pickup coils mounted in a DEMO-like configuration at the vessel exterior of AUG were successfully tested. Despite their moderate sensitivity and temporal resolution, missed-out pellets were well identified, even in plasmas with strong ELM activity.

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