Pellet image reconstruction for Optical Pellet Diagnostics Prototype developed for ITER

Student project description

TDK, BSc, MSc level

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ITER Organization collaboration

Status: Opened

Comments: paid internship position, participation in physics experiments SPI Laboratory in KFKI campus , AI in Physics

Keywords: experimental physics, image processing, ITER, AI

Project description

The field of magnetically confined fusion physics changes rapidly in these years. From the laboratory size experiments we move towards reactor size machines. ITER is being built now in France, which will be the first fusion reactor size experiment. It was designed to produce more fusion power, than it uses for heating and confinement. Fusion research globally focuses increasingly on technology development, and research institutes are playing important roles on developing concepts and prototypes for next generation of fusion devices. A key question towards the fusion reactors is to understand and experimentally verify how devices can be protected from plasma disruptions, which is the instantaneous loss of confinement.

Shattered Pellet Injection (SPI) is the baseline technology of the current ITER Disruption Mitigation System (DMS). The basic principle of the system is that cryogenically cooled large pellets are launched with velocities of up to 800 m/s, shattered on a structure and a collimated spray of pellet shards penetrates deep into the ITER plasma. As the DMS is a key for ensuring the lifetime of in-vessel components, the reliability of the successful pellet injection must be guaranteed. Altogether 27 injectors are planned to be brought into operation from the beginning of the pre-fusion power operation phase of ITER.

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A novel optical diagnostic system was developed for the DMS which will not only detect the successful pellet launch, but also will measure the basic parameters of the pellet (size, integrity, velocity). The main aim of the diagnostic is to detect whether the pellet is broken, spins or the flight path is tilted thus likely will not reach the shattering plate. An observation chamber was designed and manufactured ~2 meters from the pellet gun, where the pellet is monitored with a two view shadowgraphy method.

Detection is provided by an APDCAM-10G ultrafast camera system and three CMOS cameras. The APDCAM-10G camera continuously scans with 2 MHz frequency in 120 predefined spatial positions. The pellet is detected in real-time as it flies in front of the dedicated APDCAM-10G pixels. A high-power laser with 100 ns pulse length and three CMOS cameras are triggered as the pellet arrives to dedicated parts of the observation volume. The built and operational concept system provides 3 high resolution images of the pellet few centimetres apart as well as high temporal resolution APDCAM-10G signals, which can be reconstructed to lower spatial resolution pellet images.

In 2024 a consortium lead by HUN-REN Centre for Energy Research won the ITER tender for the development of the prototype OPD diagnostics for ITER. In this project the basic image processing tools will be improved and in collaboration of an industry partner Machine Learning methods will be applied. Both the fast detector signal and CMOS images are used for reconstruction of precise pellet parameters. The candidate will participate in the development and testing of these data analysis algorithms as well as can analyse real pellet measurements. It is encouraged to participate in the laboratory measurements in the CER SPI Support Laboratory. In the case of appropriate performance and interest paid internship position is available at CER. After the completion of this project internship positions at ITER (Cadarache, France) will also be available.

Prerequisite skills

python programming, English language skills, image processing or AI experience is an advantage

Application

Applications are open until the position is filled.
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