Overview
The Lyman-alpha camera is intended to provide an improved characterization of neutrals in DIII-D.

- Deuterium Lyman-α brightness profiles are measured and Lyman-α emissivity is determined using an Abel inversion.
- The emissivity is used to calculate neutral density and ionization profiles in the pedestal and scrape off layer.

Plasma Views

- The HFS (red) and LFS (blue) fan of views are horizontal to exploit toroidal symmetry for the Abel inversion.
- A top-down view of camera coverage. The HFS relies on the LFS data to perform the inversion. Tangency radius is shown in green.

The camera is designed to investigate divertor leakage, main chamber fueling and radial particle transport. Installation and operation is planned for 2019.

Lyman Alpha Camera Components

- The system consists of two cameras providing toroidal fans of views at ~0.72 m below the midplane covering the scrape-off layer and pedestal region on both the high field side (HFS) and low field side (LFS). The targeted spatial resolution is ~8 mm at tangency radius with each array of views covering 214 mm radially.

- The view location provides constraints for modeling of divertor leakage, the formation of dense cold plasma regions [1], and pedestal fueling.

Optical Filtering

- The Lyman-α line is isolated through a combination of reflective (yellow) and transmissive (blue 10x) filter.

Signal Estimates

- Simulated SOLPS Emissivity (top) is converted to brightness (middle) through an Abel inversion. The signal from the resulting brightness is analyzed for the DIII-D pinhole camera geometry. The resulting signal (blue bottom) is sufficiently larger than that from C-I (green); the error bars represent the expected electrical noise.

- Using SOLPS simulations [5][6] of the edge Lyman α emission, the proposed views were determined to provide significant signal levels for detection above background noise. Contamination by a neighboring carbon line is also sufficiently reduced through optical filtering.

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References


Commercial Products

Development of 1-D Pinhole Lyman-alpha Cameras for Neutral Fueling and Particle Transport Studies on DIII-D

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Lyman Alpha System

- The DIII-D Lyman-α system is adapted from successful designs on C-Mod [2] and NSTXU [3].
- Due to the strong absorption of Lyman-α light in any vacuum window, the optics and detectors need to be placed in vacuum increasing the engineering challenges.

Ionization Rate and Neutral Density Attained through Abel Inversion

- The system will be absolutely calibrated using a Lyman-α source and benchtop etendue measurements.
- Data analysis assumes toroidal symmetry and is simplified by the line integral approximation.
- Using Thomson Scattering data and rate coefficients, the neutral density and ionization rate can be extracted.

(Left) Demonstrations of data analysis procedure from C-Mod [2] on a low field side camera. (Right) UEDGE simulation of the flux of neutrals as a function of poloidal position without and with drift[8]. The Lyman-α system targets the area of greatest variability to constrain simulations.

References