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7.1 An Imaging Neutral Particle Analyzer for Precision Measurements of the Confined Fast Ions in Fusion Experiments

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A novel scintillator-based imaging neutral particle analyzer (INPA), which provides energy-resolved radial profiles of confined fast ions, has been designed and installed on the DIII-D tokamak. The system measures charge-exchanged energetic neutrals by viewing an “active” neutral beam through a 1D pinhole camera with a rear collimating slit that defines the neutral particle collection sightlines and radial positions probed in the plasma. The incident neutrals are ionized by ultra-thin carbon stripping foils of 10 nm thickness with the local tokamak magnetic field acting as a magnetic spectrometer to disperse the ions onto a scintillator. The strike position on the phosphor is determined by the fast ion energy and sightline, while the intensity of emitted light from the phosphor is proportional to the ion flux. Fast camera measurements of the scintillator provide 2D images of the escaping neutrals mapped to energy and radial position in the plasma. The INPA system images a broad radial range from the plasma core to edge and deuterium energies up to 80 keV, with energy resolution of ~ 7.5 keV and pitch resolution of $< 5^\circ$. Initial data demonstrates that the system has exceptionally good signal to noise and provides unprecedented details of phase space dynamics.

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