An Edge Rotation Diagnostic on NSTX

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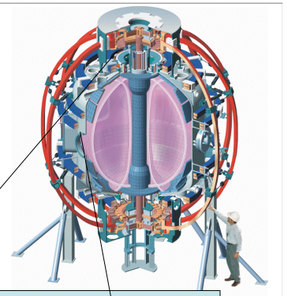

Abstract

A new diagnostic for the National Spherical Torus Experiment (NSTX) is described whose function is to measure the rotation of the plasma edge. The diagnostic is sensitive to C III and C IV ambient emission, covering (with down to ~1 cm spacing) a radial region of 15 cm at the extreme edge of the outboard midplane. Thirteen chords are distributed between toroidal and poloidal views, allowing the toroidal and poloidal rotation of the plasma edge to be characterized with 10 ms resolution. This measurement complements the toroidal rotation and carbon impurity temperature profiles, which will be measured by the NSTX Charge-Exchange Recombination Spectroscopy (CHERS) diagnostic. Combined with the local pressure gradient and EFIT reconstructed magnetic field profile, the edge flow will give a measure of the local radial electric field. The edge rotation diagnostic and CHERS have similar hardware, and were installed during the 2002 outage. Unlike CHERS, the edge rotation diagnostic does not require a neutral beam, and hence can provide measurements during a wider array of plasma conditions.

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Diagnostic Summary

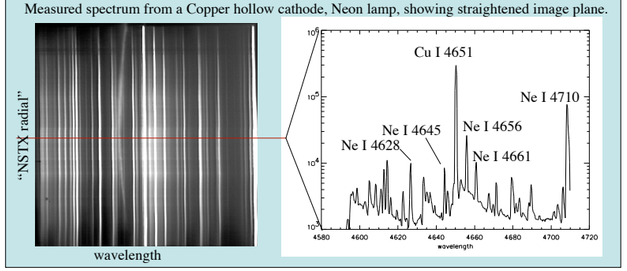
- •Measures plasma rotation in the outer 15 cm of NSTX plasmas.
- •Sensitive to C III (near separatrix) and C IV (inside, but weaker)
- •Does not require neutral beam.
- •7 toroidal and 6 poloidal rotatoin chords covering 140 to 155 cm
- •10 ms time resolution
- •Local $E_r = v \times B - \nabla p/eZn$
- •Cold plasma broadens C III emission shell, resulting in possible ∇E_r measurement.
- •Edge rotation measurement complements main CHERS.

Full-color reprints of this poster are available online:
http://w3.pppl.gov/~tbiewer/APS2002poster.pdf
Or sign up below for an email copy:

Spectral calibration in progress.

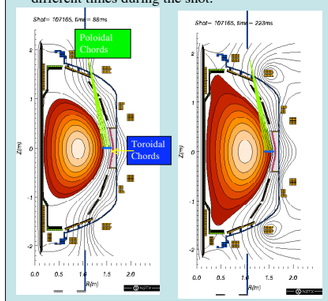
- •Diagnostic is installed on NSTX.
- •Spatial calibration is finished.
- •Spectrometer alignment and spectral calibration is in progress.
- •On schedule for late November NSTX pump-down.
- •Diagnostic will be available for the 2003 run campaign.

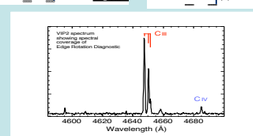
Measured spectrum from a Copper hollow cathode, Neon lamp, showing straightened image plane.



Rotation in the edge of the plasma will be measured.

A sample NSTX shot showing the intersection of the ERD sightlines with the plasma at two different times during the shot.



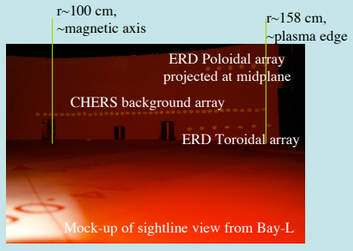


- •Plasma rotation has a stablizing influence on magnetic turbulence.
- •Rotation in the edge of the NSTX can be measured with the diagnostic described in this poster.
- •This diagnostic consists of toroidal and poloidal sightlines through the outer 15 cm of the plasma (from 140 to 155 cm).
- •Spatial localization of the measurement occurs at the intersection of the sightlines with the thin C III (and possibly C IV) ambient emission shell(s).
- •Since carbon ions are present as a contamination of the plasma and emit light through collisional excitation, a neutral beam is not needed to stimulate emission (as in Charge Exchange Recombination Spectroscopy.)
- •Magnetic field lines have ~45° pitch in the sampling volume of this diagnostic. Hence the toroidal and poloidal sightlines contain information on the parallel and perpendicular (to the flux surface) rotation velocities of the plasma.
- •Equilibrium reconstruction of the local magnetic field using EFIT can be combined with the measured plasma flow and temperature to estimate the local radial electric field: $E_r = v \times B - \nabla p/eZn$.
- •If the plasma is sufficiently cold, such that the C III emission shell is broad enough to be detected in neighboring sightlines, then a two-point gradient of the radial electric field can be measured.
- •The C III shell moves radially during ramp-up and sweeps through ERD sightlines.

Spatial calibration has been completed.

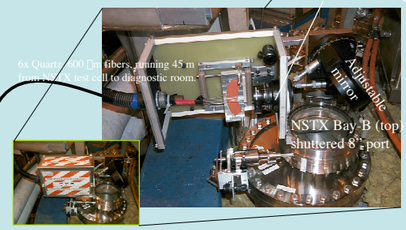
A calibrated measurement arm is used inside NSTX to locate the sightlines of back-projected ERD poloidal viewing locations.

A full scale, paper mock-up of the NSTX shows a projection of the CHERS and toroidal ERD sightlines, which share collection optics.
The poloidal ERD sightlines are projected onto the same screen for comparison purposes.



Hardware is compact and robust.

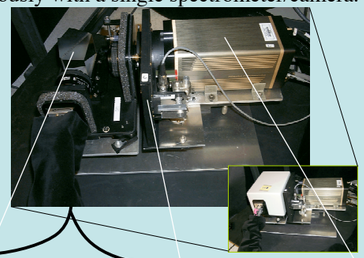
Input Optics (Poloidal View)



(Toroidal View)

Output Optics

Toroidal (7) and poloidal (6) views are captured simultaneously with a single spectrometer/camera.



Spectrometer
- •Kaiser Optical Systems HoloSpec f/2.2
- •Curved entrance slit corrects image curvature
- •85 mm f/1.8 Nikon input lens exactly matches light collection lens
- •High Dispersion grating @ 4650 Å
- •58 mm output lens

Camera
- •Roper Scientific PENTA-MAX CCD
- •Cooled to -40 °C for low dark current binning
- •6 ms minimum cycle time

Chopper
- •Scitec Instruments Model 300C
- •2 tab chopper synchronized to the NSTX shot clock and CCD Camera readout

Identical hardware to CHERS streamlines maintenance and data analysis.