MEASUREMENTS OF IMPURITY LINE EMISSION IN THE EUV ON NSTX

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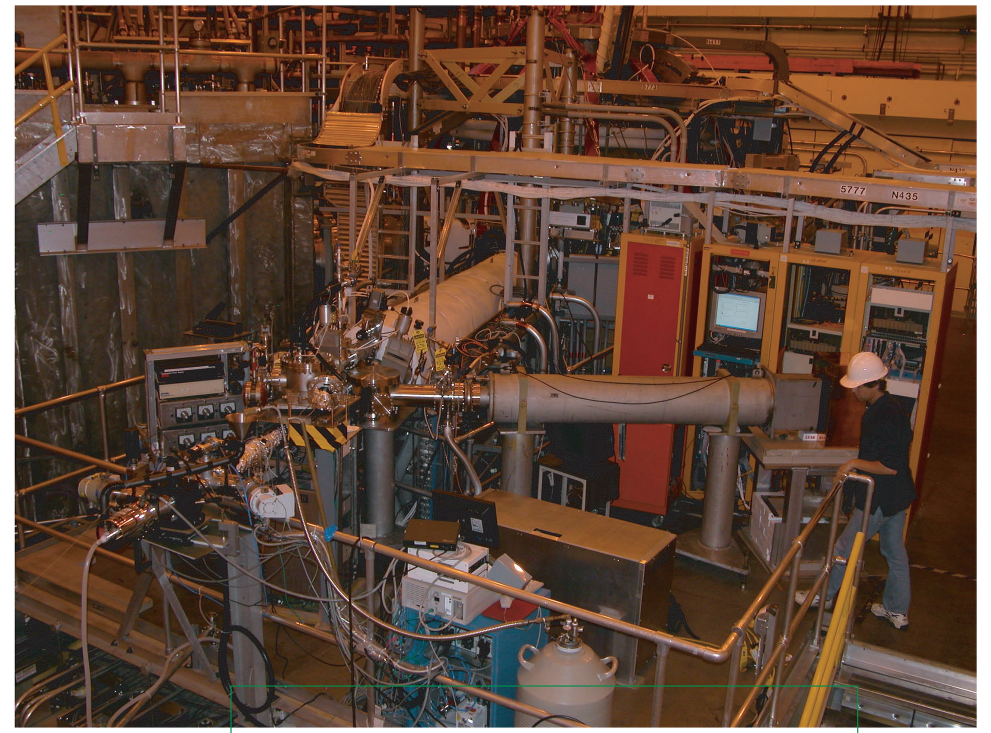
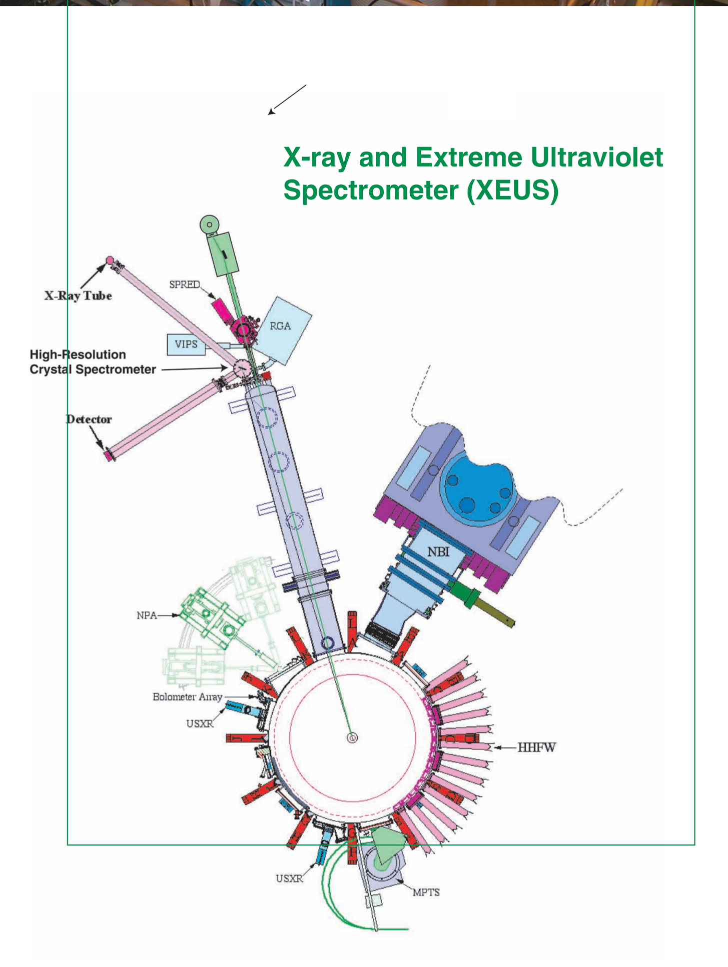
ABSTRACT

The X-ray and Extreme Ultraviolet spectrometer (XEUS) has been used to monitor the line emission from various impurity ions on NSTX, in particular the K-shell emission of B, C, N, and O. The wavelength range of the instrument has recently been extended from 65 Å to 135 Å allowing measurements of the K-shell emission of the Lyman lines of hydrogenlike Li ions following lithium deposition on the plasma-facing components as well as of he 2-2 transitions of L-shell Fe ions. The latter transitions are of special interest as diagnostics of stellar coronae and other astrophysical plasmas. Our measurements provide information on impurity behavior in NSTX plasmas under various discharge conditions. Moreover, they calibrate the intensities of astrophysical lines in an intermediate density regime not accessible by other laboratory sources such as EBIT.



NSTX test cell showing the location of XEUS

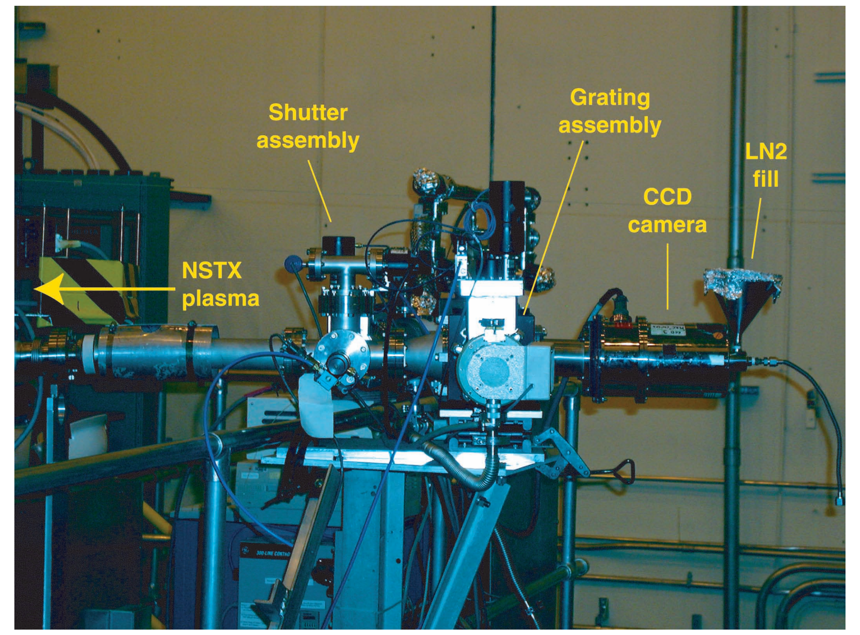


Layout showing XEUS at the end of the NSTX pump duct

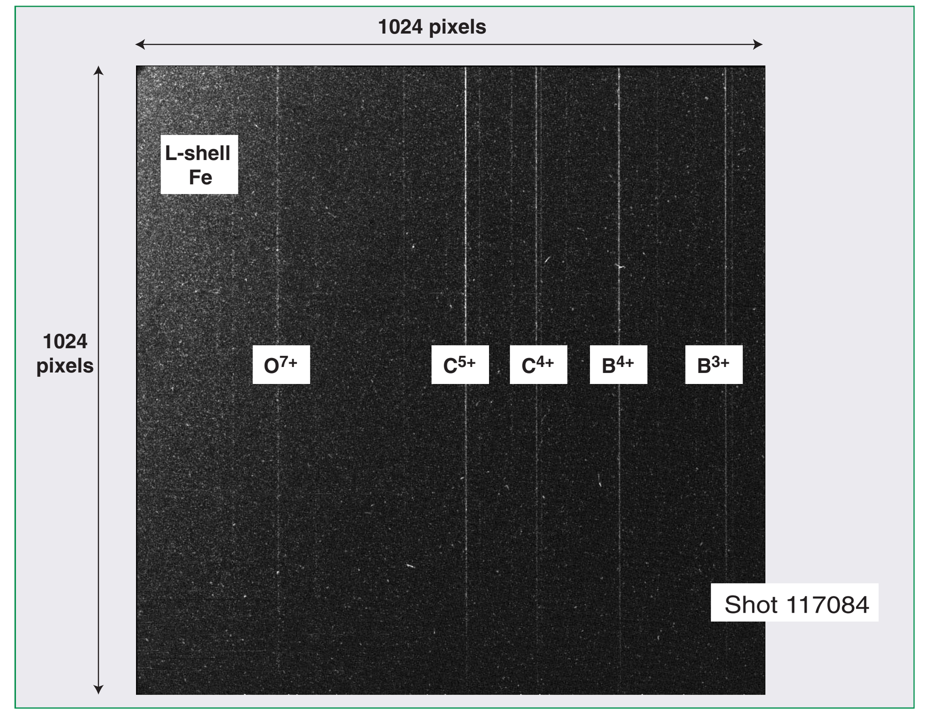
INSTRUMENT DESIGN:

The spectrometer employs a 3 cm x 5 cm ruled diffraction grating from Hitachi with variable line spacing and an angle of incidence of 1.3º. The average spacing is 2400 ℓ/mm. The variable spacing provides a nearly flat image field, and we use a thinned, back-illuminated charge-coupled device (CCD) detector from Phtometrics with 1024x1024 pixels of 25 µm x 25 µm area each. The camera is cooled with liquid nitrogen.

Either a 30 µm wide entrance slit that matches the pixels size of the CCD camera or a 100 µm entrance slit for better light collection is used. A pressure-driven shutter is used to gate the spectrometer. The response time is 30 ms, providing time slices as short as 60 ms.



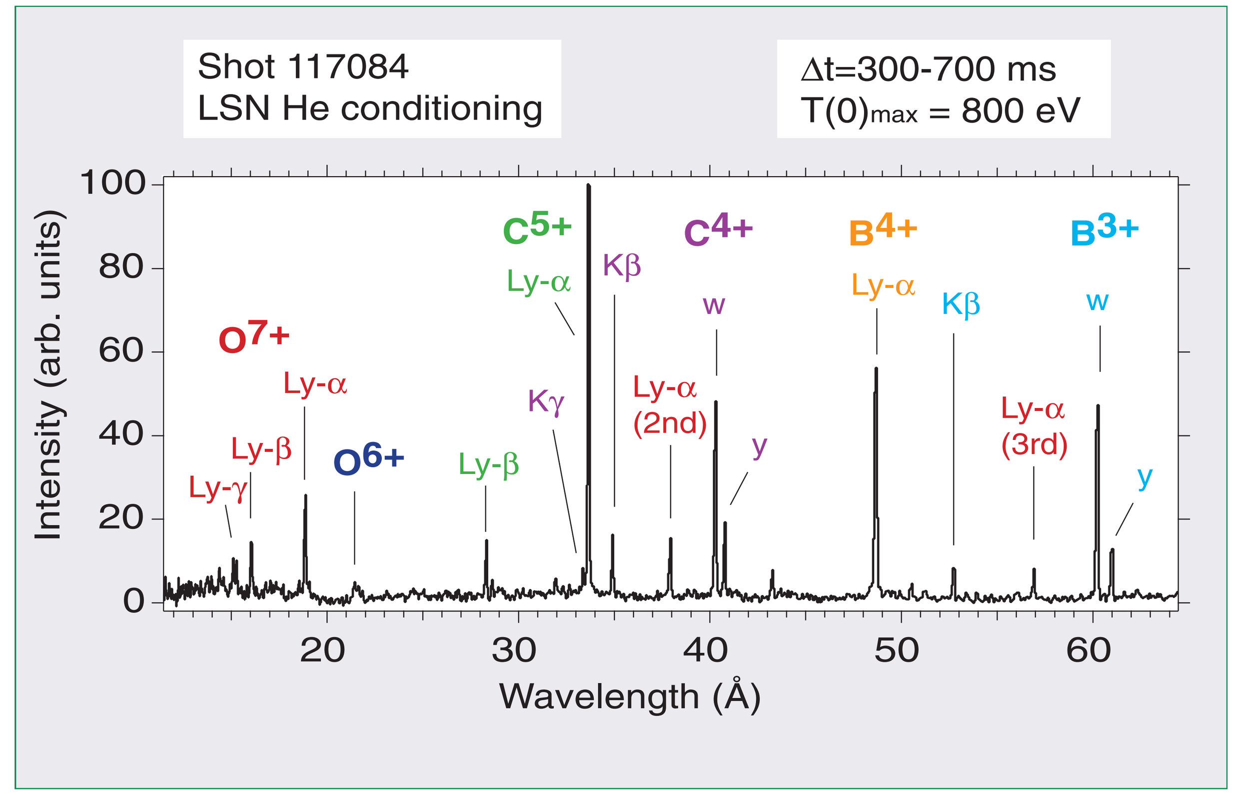
Close-up of the spectrometer



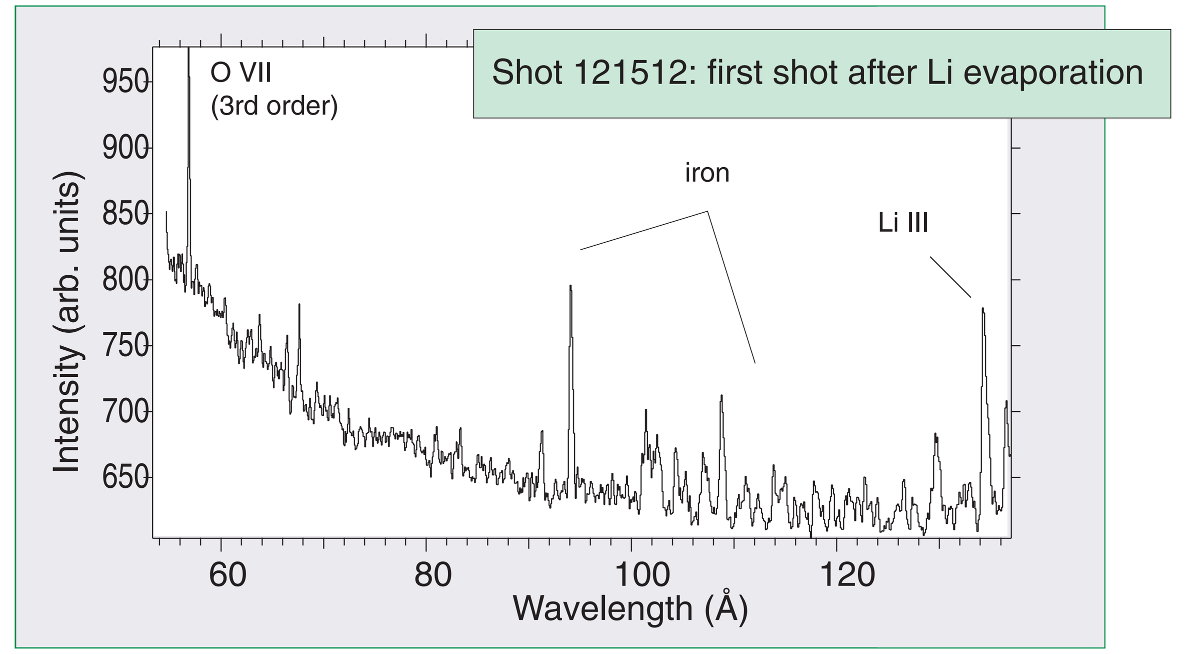
Typical spectral image obtained from one NSTX shot

PERFORMANCE:

A typical CCD image obtained during an NSTX shot is shown below. We make cuts from each two-dimensional CCD image and sum channels perpendicular to the dispersion direction in order to extract spectral information. For image manipulation we used IPLab software running on a G3 Macintosh computer, which is also used for data acquisition and camera control. Typical spectra display the K-shell lines of B, C, and O, as shown below.

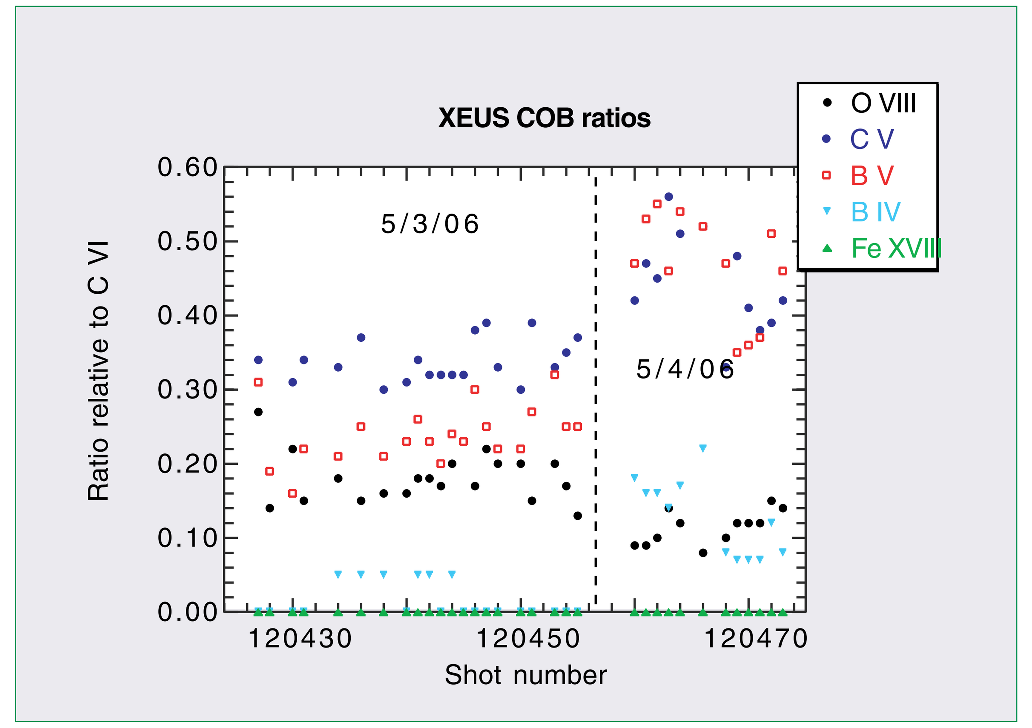


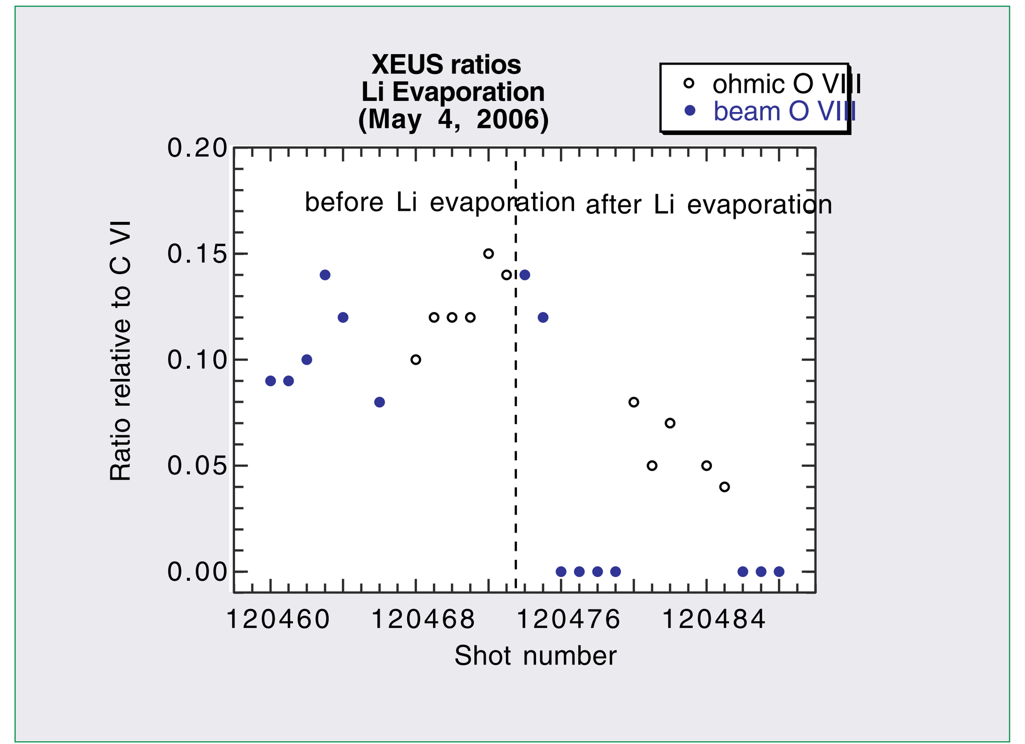
The spectrometer coverage was shifted toward 135 Å in order to be able to observe the Li III line near 132 Å after lithium evaporation.



Impurity ratios after lithium evaporation

We have been monitoring the O VIII to CVI ratio before and after lithium evaporation in May 2006. This ratio had been declining for several weeks befor the May experiments, dropping from about 0.8 early April to 0.2 early May. Below is the O VIII to CVI ratio before and after lithium evaporation on May 4, 2006. Two shots seems to be needed to distribute the lithium in the vessel, then oxygen seems to vanish for the subsequent seven beam-heated discharges. The

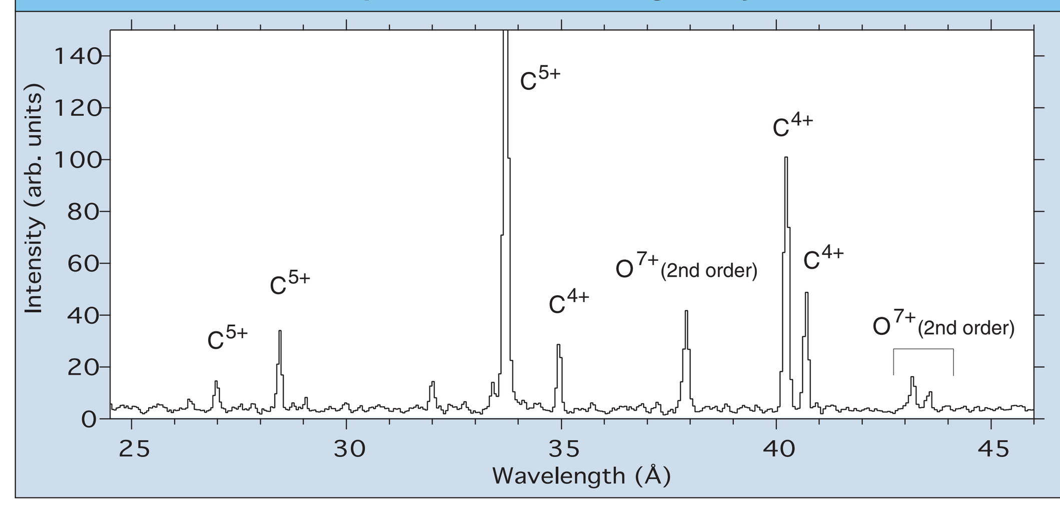




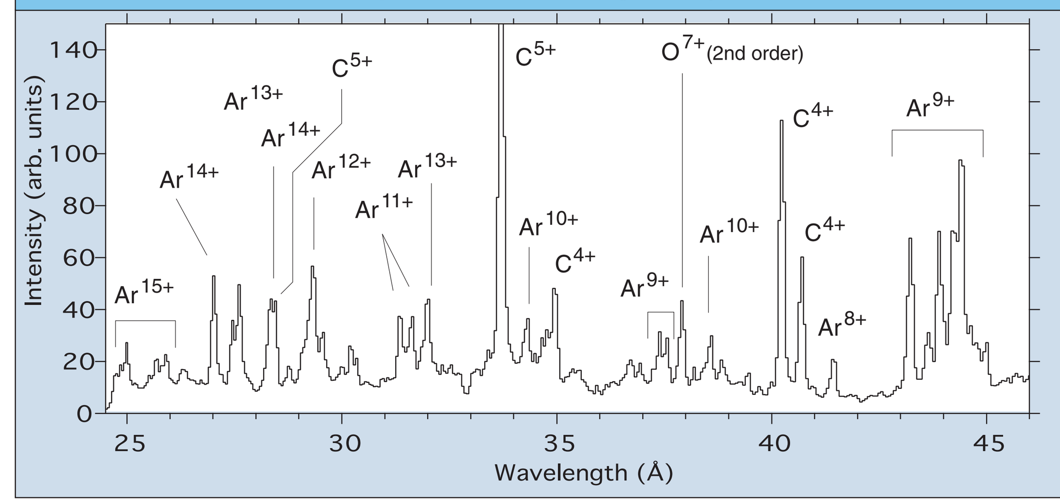
L-SHELL ARGON EMISSION

Argon has been injected into NSTX in order to use its K-shell emission for ion temperature measurements of the plasma core. We have observed the Ar L-shell emission with our instrument, as shown below. The higher density of the NSTX measurements allows us to calibrate astrophysically important density-sensitve line ratios in a way not afforded by EBIT sources. Using data from both sources thus provides definitve calibrations of such line ratios in regimes relevant to solar flare densities.

Spectrum without argon injection



Spectrum with argon injection



Calibration of the Ar XIV line ratio