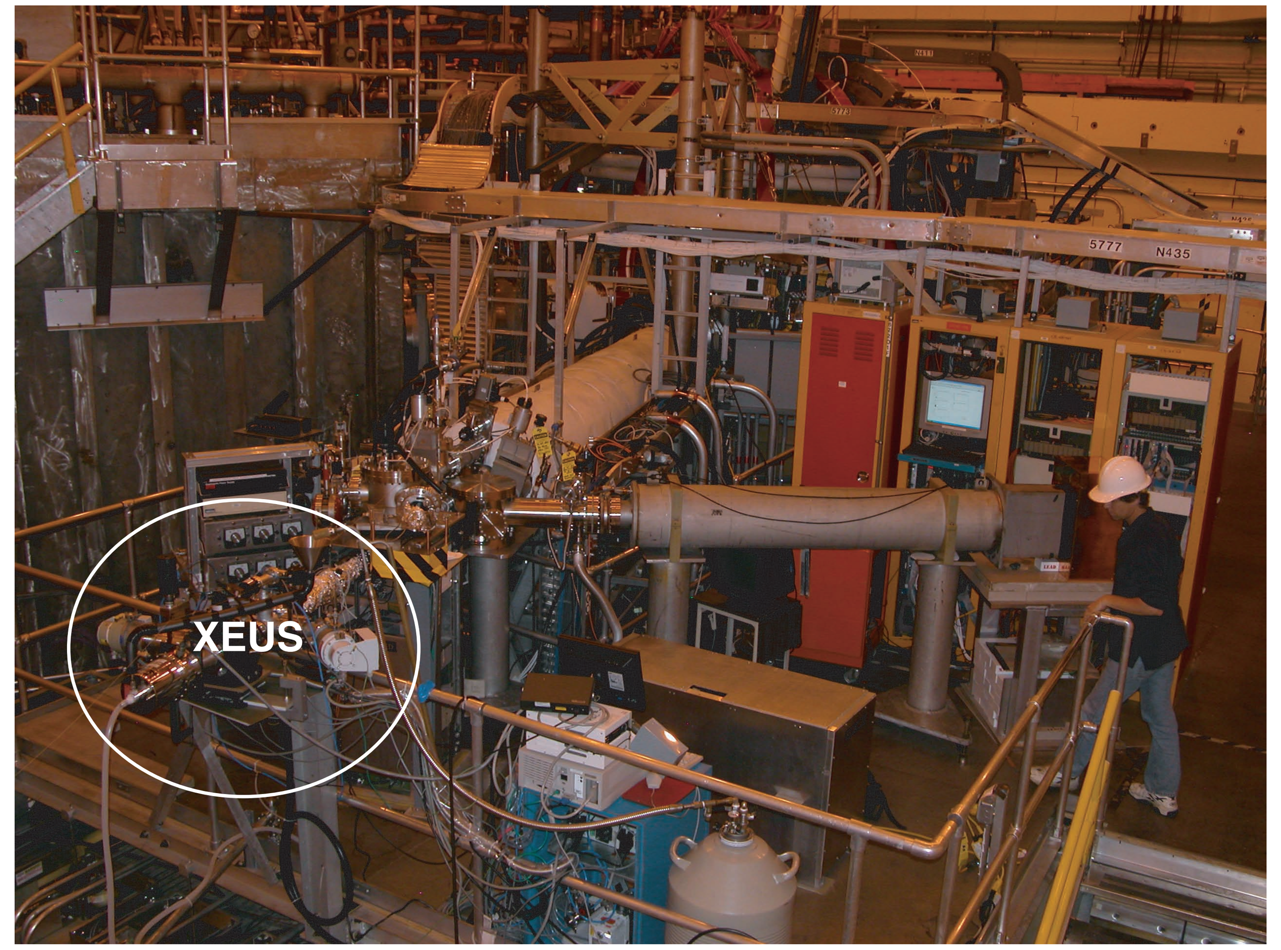
ABSTRACT

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 heliumlike and hydrogenlike B, C, N, and O. While C VI typically dominates the spectrum, unusually strong emission from N VII has been observed in multiple disharges during the past run campaign. In this case, the nitrogen concentration can exceed that of carbon by an order of magnitude. Time-dependent measurements show that the nitrogen concentration builds up over the course of the discharge and coincides with a build up of boron. In a few cases we observed several unknown lines. These are clearly lines from heavy impurities. Some of these lines can be explained by the emission from Ti XIII and Mo XXV, XXVI.



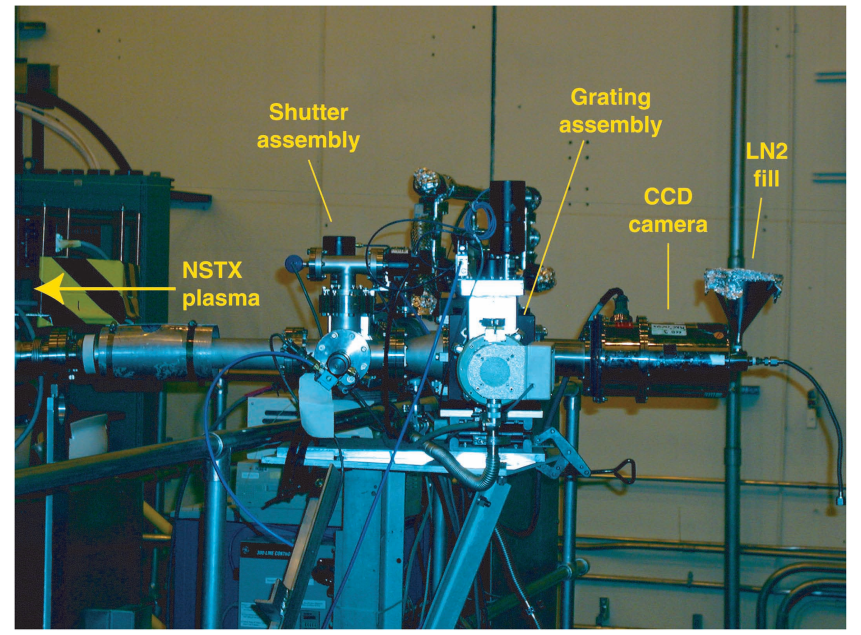
NSTX test cell showing the location of XEUS

XEUS:

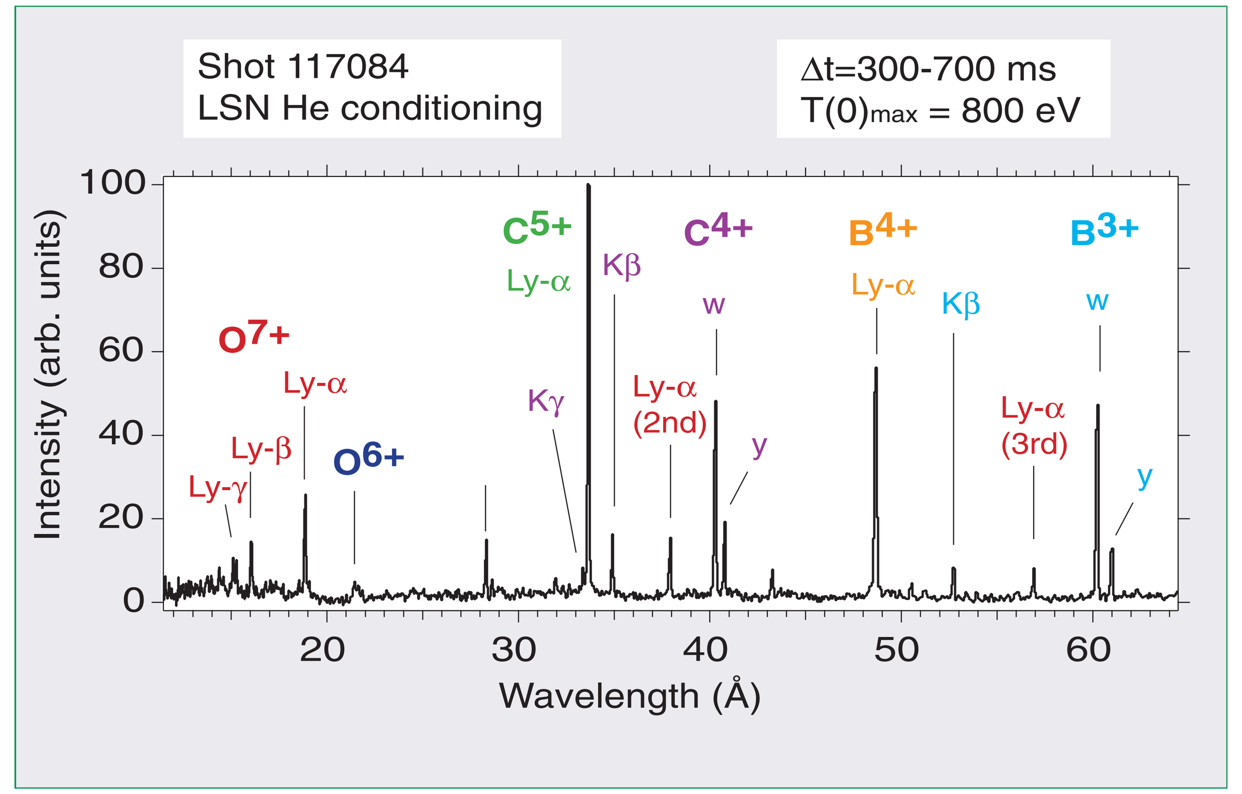
The spectrometer employs a 3 cm x 5 cm ruled diffraction grating from Hitachi with variable line spacing and an angle of incidence of 1.3º. The average spacing is 2400 ℓ/mm. The variable spacing provides a nearly flat image field, and we use a thinned, back-illuminated charge-coupled device (CCD) detector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

A 30 μm wide entrance slit that matches the pixels size of the CCD camera 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.

The wavelength range covered by XEUS ranges from 8 Å to 135 Å, depending on the camera setting. We can observe the K-shell lines of B, C, N, and O, as shown below. The K-shell lines of Li can be observed in a second setting.



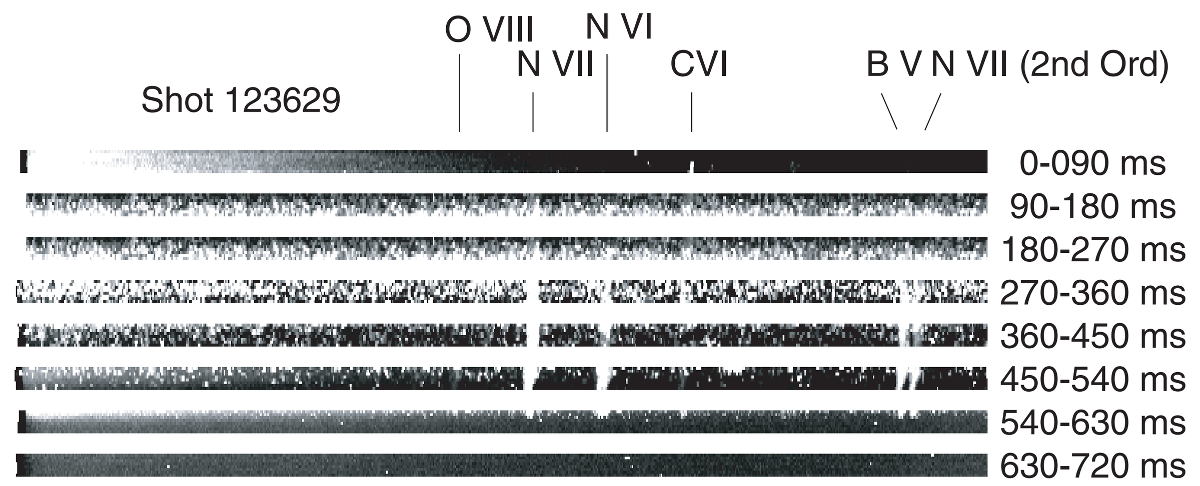
Close-up of the spectrometer



Typical K-shell emission observed on NSTX. Note that the spectrum is dominated by C VI.

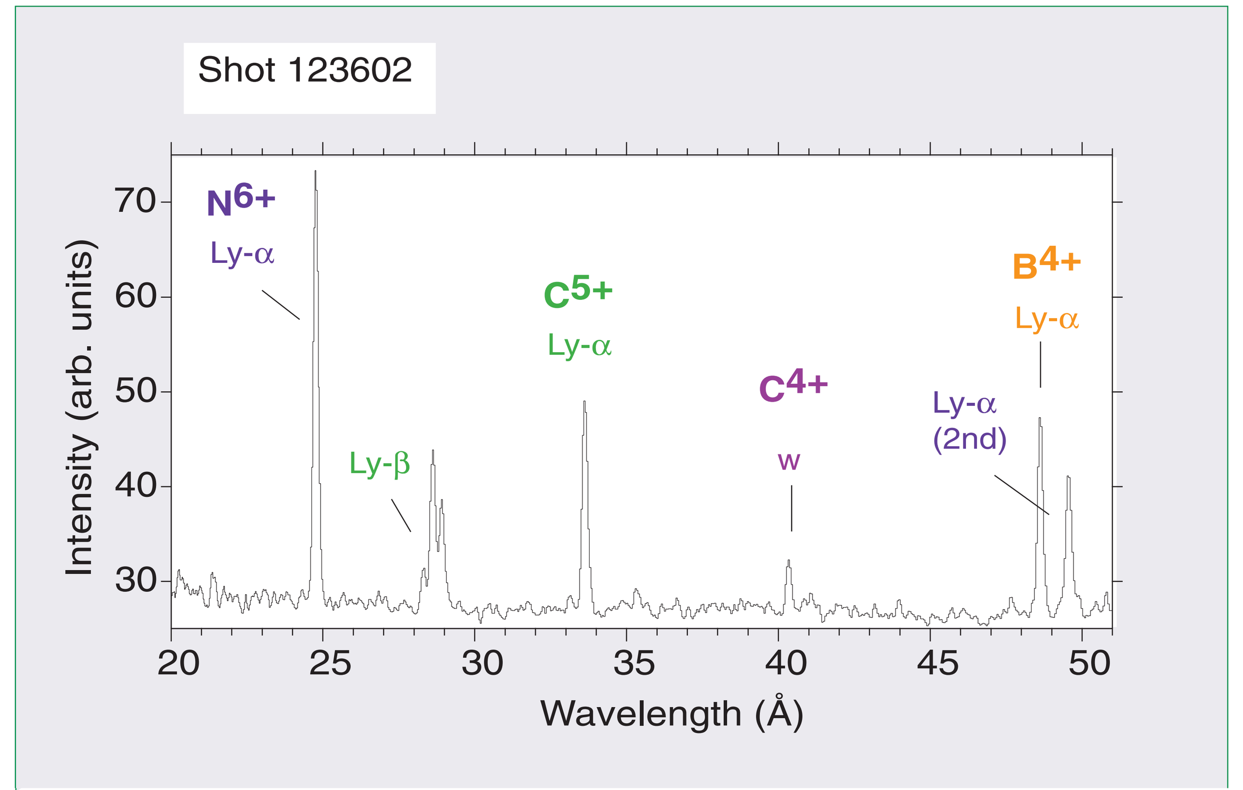
TIME-DEPENDENT SPECTRA:

Operating the CCD camera in fast read-out mode, we can acquire a spectrum in 90 msec (currently limited by the processor speed of the computer). Below we show the first eight spectra recorded for shot 123629.



Time sequence of the K-shell emission.

Shot 123629 was one of several shots during the FY07 run period, which were dominated by nitrogen emission. The dominance of nitrogen can be seen in the spectrum from shot

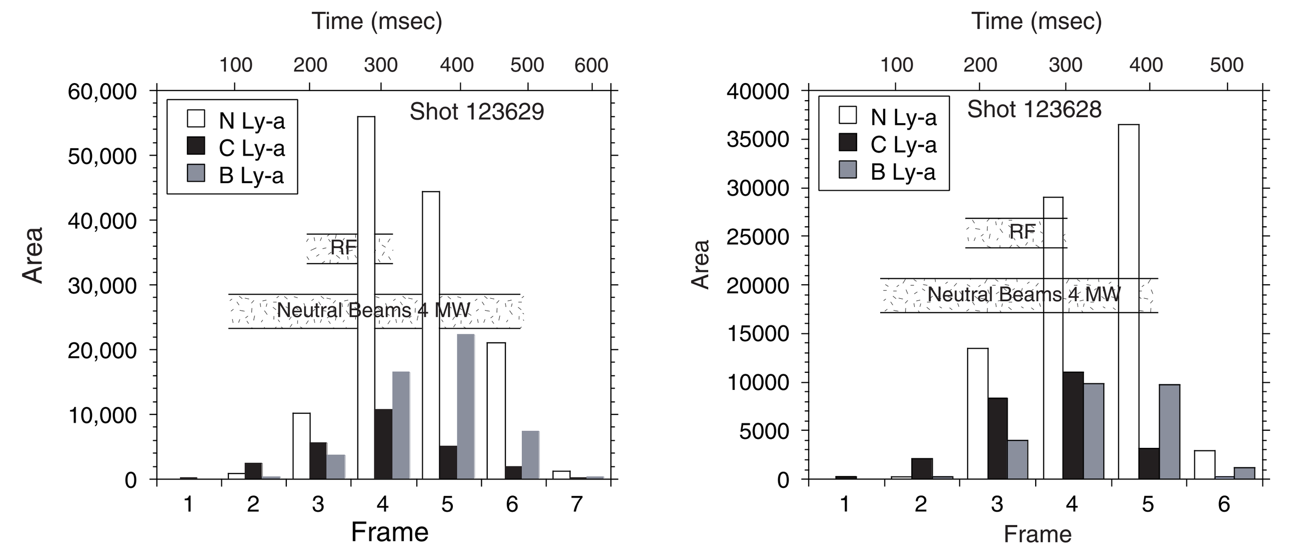


K-shell emission dominated by N VII.

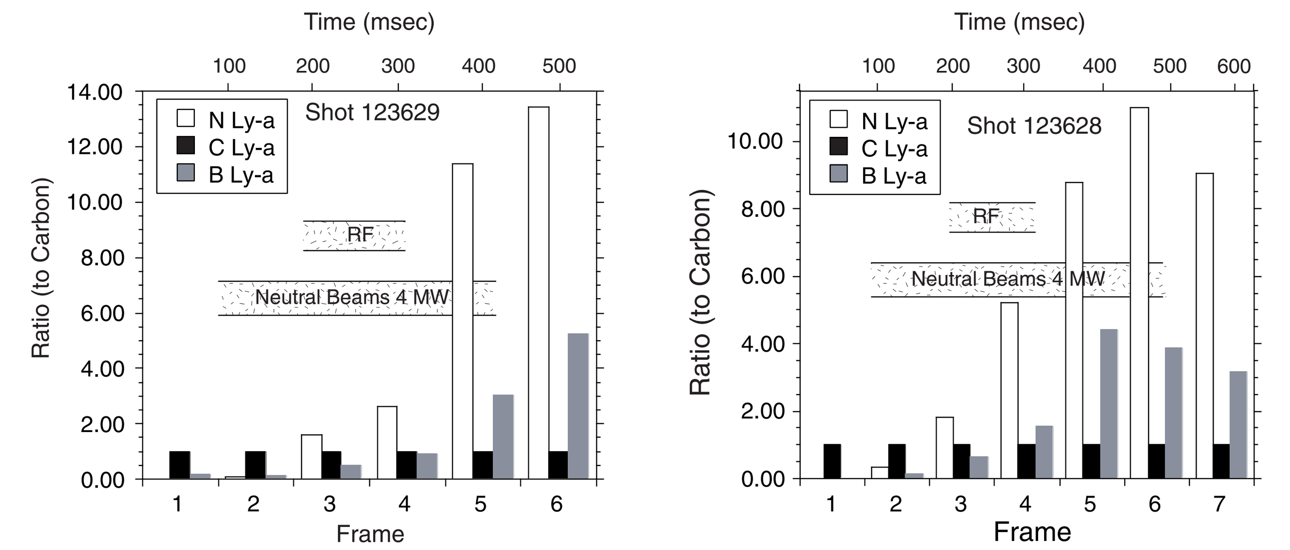
N VII - ENHANCED SPECTRA

The time dependence enabled us to determine that the enhanced nitrogen emission was coupled to enhanced boron emission. Both occurred later in the discharge. Boron nitride is used for shielding various components inside the discharge vessel, including the RF antenna shields. A strong enhancement of nitrogen and boron indicates that the plasma is eroding some of the boron nitride coating.

Time -dependent lineouts of the B V, C VI, and N VII lines



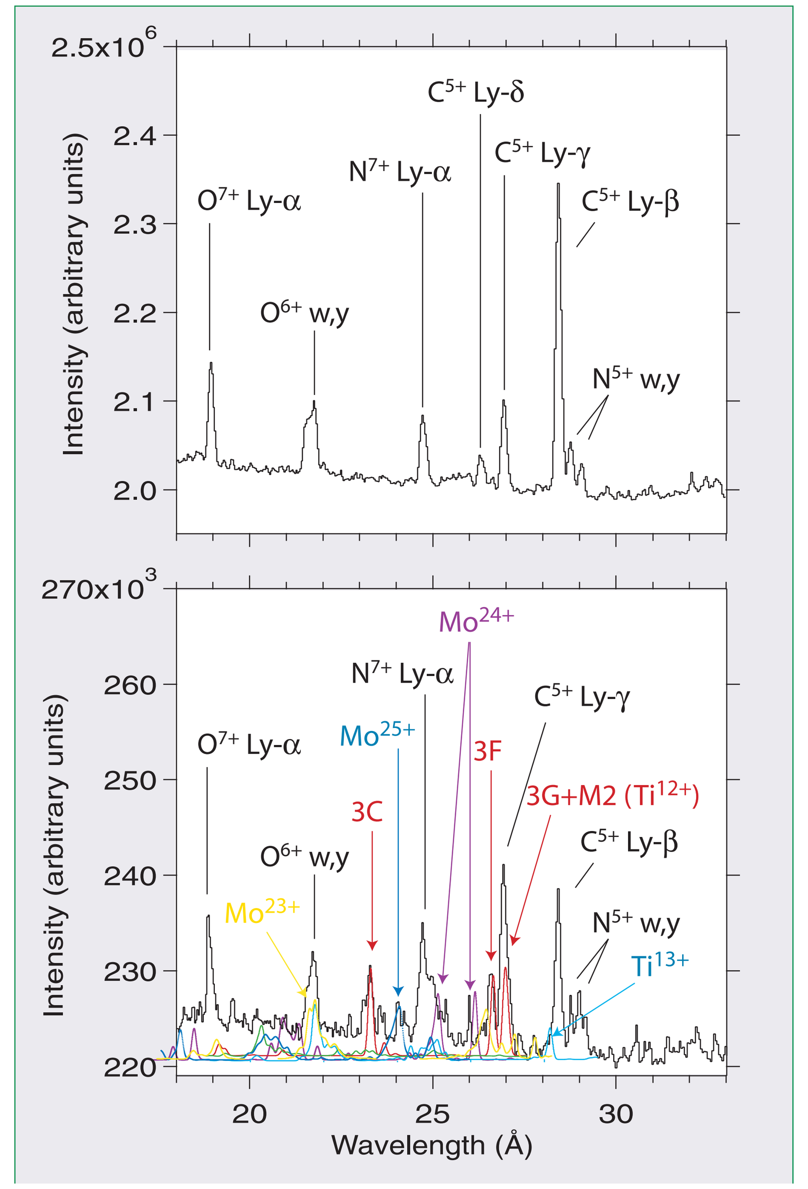
Same as above, but normalized to the C VI line



LINES FROM HEAVY-ION IMPURITIES

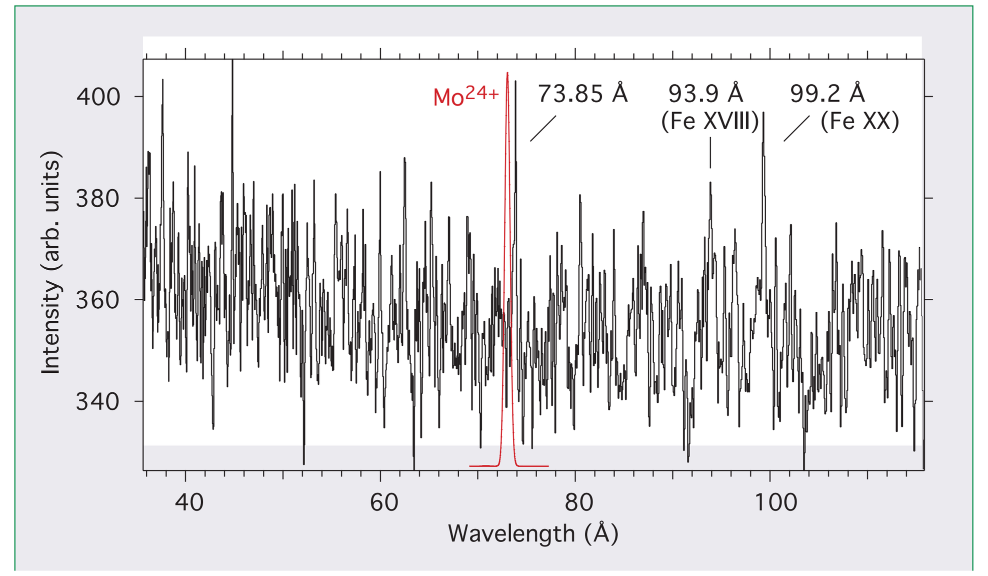
Apart from enhanced nitrogen and boron, spectra were seen in the FY07 run period with lines not seen in earlier years. If the boron nitride coating of the RF antennae were eroded by the plasma, the underlying titanium and molybdenum might be exposed. In shot 123721 we indeed found lines that might be explained by the emission from Ti XIII and Ti XIV as well as by Mo XXIV, Mo XXV, and Mo XXVI.

The Mo XXV spectrum has a strong line predicted at 73 Å. We shifted the detector to find this line. Indeed, a candidate line appeared in shot 125036.



Typical emission of shots before and after shot 123721

Emission of shot 123721 shows additional lines, which are fitted by theoretical predictions.



Emissio of shot 125036 shows a line at 73.85 Å, which cannot be explained by the usual impurity lines. It matches the predicted wavelength of the strongest Mo XXV line. This line confirms our identifications in the 20 Å region.