Chapter #: Spectroscopic Measurements

#.# Spectrometer

The spectrometer used was produced by Ocean Optics, model USB-650. It has a wavelength range of 349nm to 999nm, with a resolution of 2nm (FWHM). It has 651 pixels and an adjustable integration time from 3ms to 65s.

#.# Optical Setup

The Helimak plasma was viewed through an optical port on the bottom of the machine as seen in figure #.#. The physical window was approximately 40cm wide, and gives a maximum effective viewing range of about 35cm for a 50mm lens. The lens was mounted on a ruled linear track which also served as a position measurement. The lens was connected to the spectrometer through an optical fiber of approximately 2m in length.

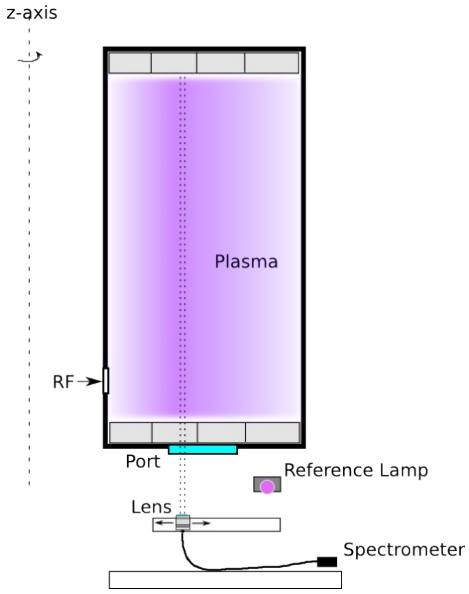

Figure #.#: Optical setup

#.# Lens, Fiber, and Spectrometer Calibration

Calibration of the combination of the lens, fiber optic, and the spectrometer where done by taking the setup and measuring a known calibrated lamp. The known spectral radiance profile of the lamp $L(\lambda)$, given in units of $[\frac{W}{cm^2 * sr * nm}]$, was used to calculate a calibration constant $K(\lambda)$ for the system in terms of the measured number of counts per wavelength received on the spectrometer, as can be seen in figure #.#.

$$K(\lambda) = \frac{N(\lambda)}{dt * L(\lambda)} \ [\frac{cm^2 * sr * nm}{W * s}] \ (\#.\#)$$

where dt = integration time

This constant can then be used to calculate the radiance of a the plasma from the number of counts on the spectrometer.

$$L = \frac{N}{dt * K} \ (\#.\#)$$

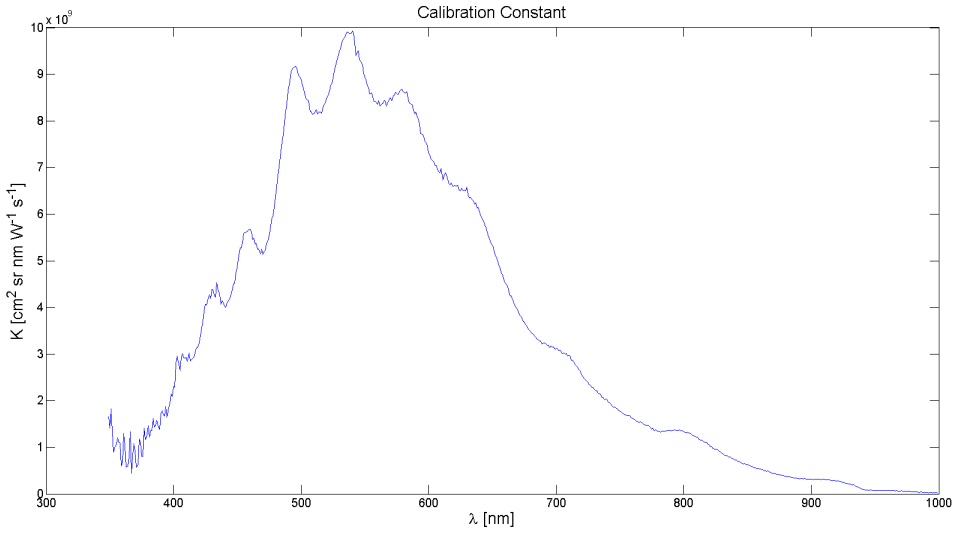

Figure #.#: Calibration versus wavelength

#.# Window Calibration

The optical transmission qualities of the port window where measured as a function of position along the width of the window to account for any variations. The window also has a copper mesh screen on top of it to prevent RF power from escaping through the port. Calibration was accomplished by removing the entire window and screen and mounting in on a linear track. A reference light source was positioned on one side and and the lens on the other, as seen in figure #.#.

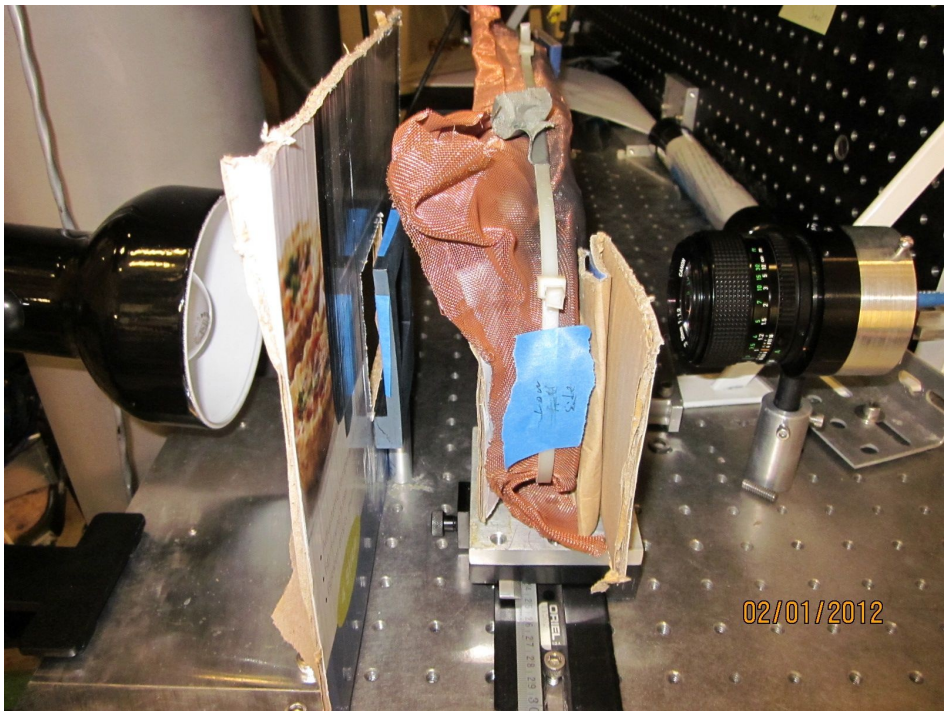

Figure #.#: Window Calibration Setup

The reference light source consisted of a standard light bulb and a diffusor made a piece of paper. A measurement of the light source was made without the window in place to serve as a reference, as well as a background reference. The cardboard served as a larger light block to prevent the light from reflecting off of other surfaces which might contribute to the measurements.

Measurements where made at 1cm increments along the length of the window. At each position, spectra was taken and averaged together. The transmission of the window versus wavelength is calculated by dividing the position measurements by the reference measurement. A sample of the transmission profile versus wavelength can be seen in figure #.# measured at position of 15cm from high field side. Figure #.# shows average transmission versus position.

This factor was included in the calibration constant for the lens/fiber/spectrometer by simply defining a total calibration constant where the window factor is $C(\lambda, x)$.

$$K_{tot}(\lambda, x) = C(\lambda, x)K(\lambda) \quad \text{(\#.\#)}$$

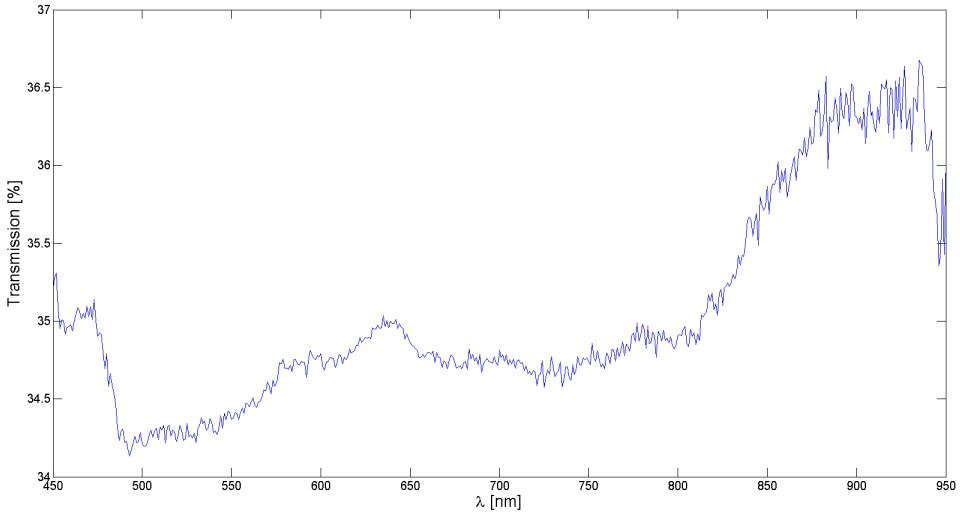

Figure #.#: Window transmission versus wavelength at x=15cm

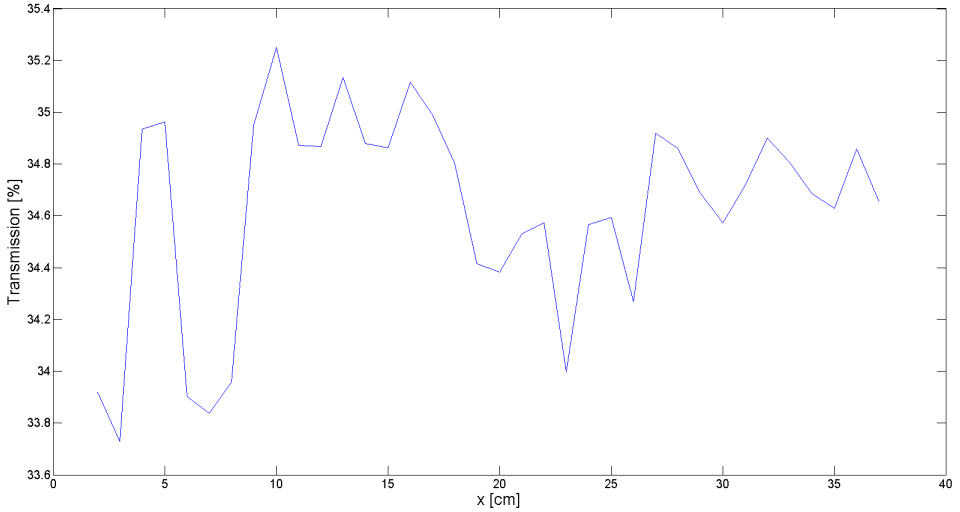

Figure #.#: Average window transmission versus position

#.# Data Acquisition