**Design of a Multi-chord Soft X-ray Camera for the HIT-SI Spheromak Experiment**

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**Abstract**

The purpose of the HIT-SI experiment is to generate and sustain a Spheromak plasma by purely inductive means. A constant Helicity injection rate is achieved by an arrangement of two opposing flat magnets, electrically phased in quadrature. The confinement region is a Bottle shape for high beta. A soft X-ray diagnostic has been constructed as a monitor of MHD activity and electron temperature. The soft X-ray camera was originally based on equipment from the Culham Laboratory, but has been significantly modified. The camera is made from high vacuum components and incorporates an insulating break to provide an internal electronics shield. A hexagonal carousel allows the camera to be rotated for various views of the plasma. The camera is equipped with three different filter options: 3 – Metal Film Filter, 4 – Copper Input Aperture, and 5 – 15 Channel AXUV Detector.

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**Overview of Soft X-ray Diagnostic**

The soft X-ray diagnostic is a pinhole camera that measures the soft X-ray emission from the plasma. The diagnostic is composed of three main components: 1) a 15 channel AXUV detector, 2) a Metal Film Filter, and 3) an Electrostatic Shield. The design of the diagnostic allows for the measurement of the soft X-ray radiation emitted from the plasma.

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**Motivation**

The need for a soft X-ray diagnostic arises from the desire to measure the soft X-ray emission from the plasma. The diagnostic is designed to provide a measurement of the soft X-ray emission from a small region of the plasma. The diagnostic is composed of three main components: 1) a 15 channel AXUV detector, 2) a Metal Film Filter, and 3) an Electrostatic Shield. The design of the diagnostic allows for the measurement of the soft X-ray radiation emitted from the plasma.

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**Electrostatic Shield**

The electrostatic shield is a component of the soft X-ray diagnostic that is used to protect the detector from the high voltage environment of the plasma. The shield is made from a material that is capable of withstanding the high voltage environment and is designed to provide a barrier between the detector and the plasma.

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**Soft X-ray Diagnostic**

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**Metal Filters (Overview)**

Each thin metal film is mounted to a face of the carousel. These metal films are designed to block X-rays and allow visible radiation to pass through. The metal films are made from a material that is capable of withstanding the high voltage environment of the plasma.

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**Design of X-ray Metal Filter**

The Bremsstrahlung radiation formula is used to calculate the amount of Bremsstrahlung radiation emitted from the plasma. The formula is given by:

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\frac{d^2N}{dE d\Omega} = \frac{2e^4}{m_e^2c^6} \frac{N_e^2}{4}\frac{1}{E^2} \int dE' \int d\Omega' \frac{g_{ff}(E', \Omega', E, \Omega)}{E'}
\]

where:
- \(d\Omega\) is the solid angle for the detector.
- \(dE\) is the energy interval.
- \(g_{ff}\) is the Gaunt factor.
- \(N_e\) is the electron density.
- \(E\) is the energy of the photon.
- \(E'\) is the energy of the electron.
- \(\Omega\) is the angle of emission.
- \(\Omega'\) is the angle of detection.

The Bremsstrahlung radiation per unit steradian was calculated using the formula above.

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**Future Plans**

The soft X-ray diagnostic is in the final stages of construction. All of the components have been ordered or machined. The diagnostic will be incorporated into the port to prevent interference. The camera is made from high vacuum components and incorporates an insulating break to provide an internal electronics shield. A hexagonal carousel allows the camera to be rotated for various views of the plasma. The camera is equipped with three different filter options: 3 – Metal Film Filter, 4 – Copper Input Aperture, and 5 – 15 Channel AXUV Detector.

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**Summary**

The soft X-ray diagnostic will measure the soft X-ray emission from the plasma. The diagnostic will provide a measurement of the soft X-ray emission from a small region of the plasma. The diagnostic is composed of three main components: 1) a 15 channel AXUV detector, 2) a Metal Film Filter, and 3) an Electrostatic Shield. The design of the diagnostic allows for the measurement of the soft X-ray radiation emitted from the plasma.