HIT-SI Soft X-ray Diagnostic

Written by Annamarie Askren, January 2006

This paper details the motivation, features, and design of the soft X-ray diagnostic. It serves as a source for future reference.

Overview of Soft X-ray Diagnostic

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 electrostatic shield. A hexagonal carousel filter mount has been built around the pinhole, allowing three filtering options. Thin metal film transmission filters on parylene backing have been designed and procured from the Lebow Company to reject radiation in the optical region and to pass low energy X-rays, ~150 eV. No filtering at all gives the option of multi-chord bolometry. The diagnostic uses a 16-channel AXUV photodiode array (IRD Company) and spans the plasma from the geometric axis to the outer shell. A custom vacuum port and housing have been designed to achieve the required 45-degree angular aperture.

Table of Contents

I. Introduction

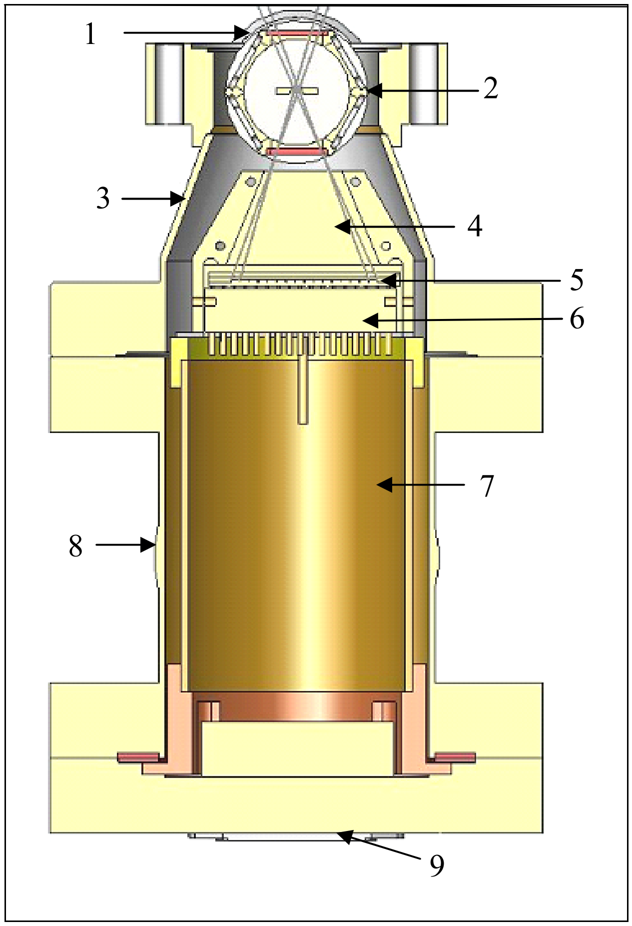
The purpose of the soft X-ray camera is to measure the emission of low-energy X-rays which correlates with electron temperature and density, as well as to monitor Magnetohydrodynamic (MHD) instabilities. The X-ray camera can be used in conjunction with a single time measurement diagnostic (Thomson Scattering) to give a qualitative plasma temperature vs. time. The 16-channel diagnostic will also provide a picture of emission vs. radius.

The soft X-ray diagnostic is able to gather data from 16 chords of light, which span an angular aperture from the machine center to the outer shell. The diagnostic has several notable features:

- Rotatable hexagonal carousel, allowing 3 filtering options
- 16-channel AXUV photodiode detector for 16 chords
- Electrostatic shield
- Thin metal filters, less than 1 micron thickness
- Custom port that allows for sharing with the Zeff diagnostic

II. Diagram of Diagnostic

The soft X-ray diagnostic was modeled in SolidWorks prior to construction. An overall section cut is shown in Figure 1. The components of the assembly are identified and described in this section.



Key:
1 – Metal Film Filter
2 – Filter Carousel
3 – 2.75” to 4.5” Conical Reducer (specially shortened)
4 – Copper Input Aperture
5 – 16-Channel AXUV Detector
6 – PEEK Detector Mount
7 – Electrostatic Shield
8 – Insulating Break
9 – Multipin Feedthrough

Figure 1. Cross-Sectional View of Diagnostic

A. Hexagonal Carousel

At the top of the camera, a hexagonal carousel is positioned inside the 2.75” conflat flange of the conical reducer. The carousel rotates about a pinhole aperture of dimensions 1 mm x 5 mm. Six sides were chosen in order to provide a 45° viewing aperture (see Figure 2). Mounted on the openings are thin metal films that block visible radiation but transmit low-energy X-rays that are detected. These metal films are only mounted on four of the six sides, leaving two opposing sides open to serve as a bolometer. The rotation of the carousel provides three viewing options for any shot without going up to air. This feature provides at least two independent filter measurements, which together can be used to calculate the electron temperature T_e. A copper input aperture (shown in Figure 1) prevents any stray light from reaching the detector.

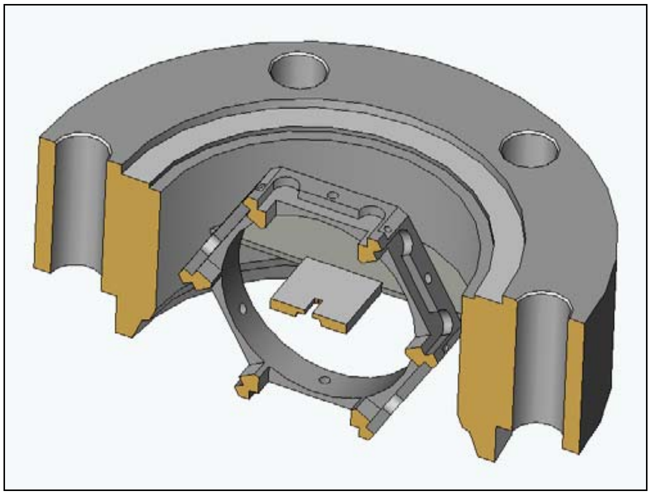


Figure 2. Section Cut View of Hexagonal Carousel with Pinhole Center
(without metal filter mounts attached)

B. AXUV Photodiode Detector

A 16-channel AXUV Photodiode Detector is mounted on an insulating PEEK platform. AXUV/UVG/SXUV series photodiodes can be used in air, in gas ambient like helium, argon, nitrogen, etc. and under vacuum lower than 10^{-10} torr. Devices with suffix EUT need to be selected for extremely low level vacuum applications like 10^{-10} torr. IRD photodiodes are ideal for many applications since they can be vacuum baked up to 200ºC. They can be operated in the temperature range of -200ºC to 70ºC. Some other characteristics of the AXUV detector are:

- Silicon surface
- Insensitive to magnetic fields
- Exhibit very low noise
- High quantum efficiency (see Figure 3)
- Large collection area to size ratio
  - One detector element (1 of the 16) has an area of 10 mm^2
- Uniform sensitivity to photons from 1eV-7keV (see Figure 4)

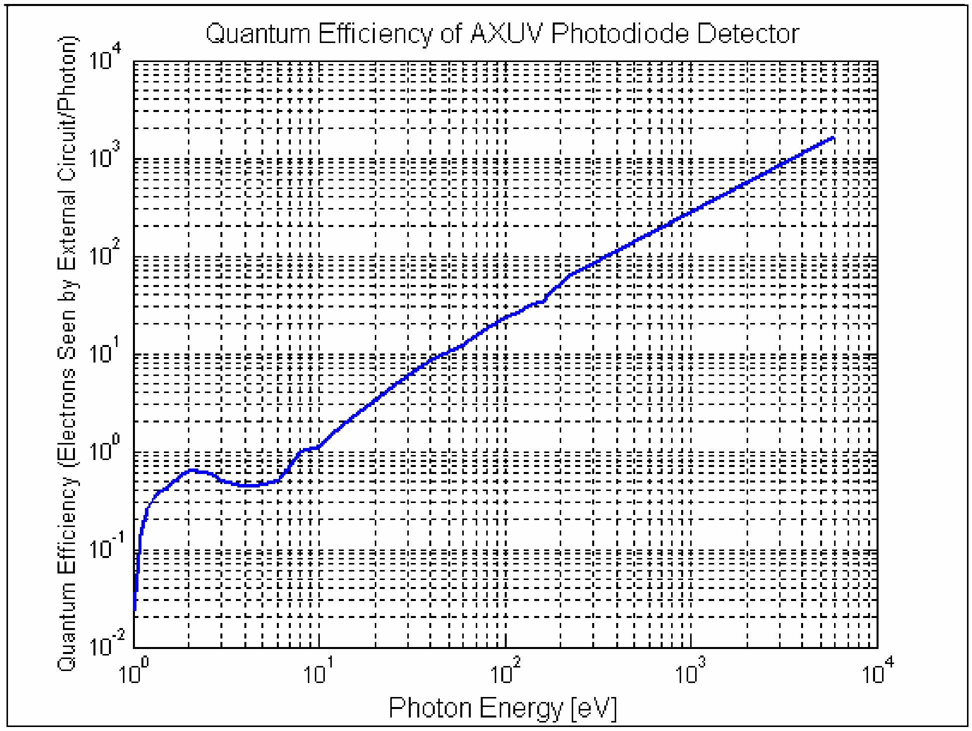


Figure 3. Quantum Efficiency of AXUV Photodiode Detector vs. Photon Energy
Courtesy of International Radiation Detectors Inc. (IRD)

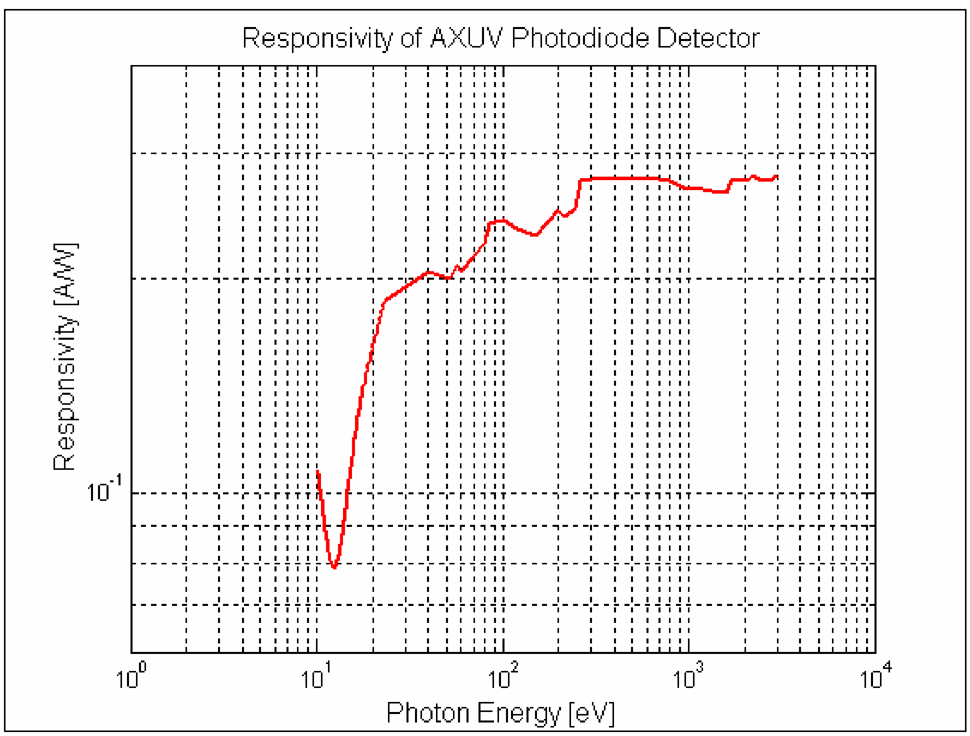


Figure 4. Responsivity of AXUV Photodiode Detector vs. Photon Energy
Courtesy of International Radiation Detectors Inc. (IRD)

C. PEEK Detector Mount

PEEK is a high temperature engineering thermoplastic, and it is an excellent material for a wide spectrum of applications where thermal, chemical, and combustion properties are critical to performance. Especially significant, in this regard, is PEEK's ability to retain flexural and tensile properties at very high temperatures -- in excess of 250ºC (482ºF). The addition of glass fiber and carbon fiber reinforcements enhances the mechanical and thermal properties of the basic PEEK material.

Besides being able to withstand high temperatures, PEEK can also be easily machined. Its plastic composition makes it an excellent insulator, and PEEK is suitable for ultra-high vacuum environments.

A block of PEEK has been machined as a mount for the AXUV detector. A pattern of 2 rows of 17 holes with pressed connector inserts receive the pins of the detector. The edges of the PEEK mount are rounded to eliminate interference with the electrostatic shield.

D. Electrostatic Shield

Noise interference was detected in early trials of the soft X-ray Camera on the HIT-II machine. To reduce the effect of noise from the IGBT switching power supplies, an electrostatic shield was added to the HIT-SI design. The electrostatic shield was built primarily out of OFHC highly conductive, non out-gassing copper. The shield surrounds the detector and is grounded to the multipin feedthrough. The electrostatic shield also serves to define the entrance aperture for the camera. The components of the electrostatic shield are displayed in Figure 5.

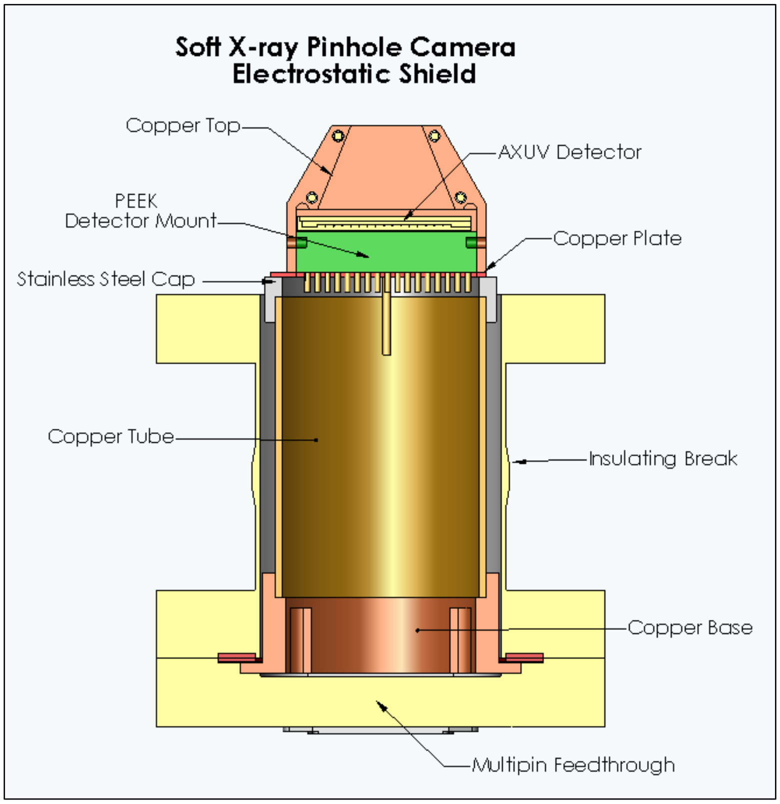


Figure 5. Sectional View of Electrostatic Shield

The electrostatic shield consists of the following components:

1. Copper Base

   The copper base connects the electrostatic shield to the vacuum feedthrough, which serves as the instrument ground. The base is bolted to the flange. Note the cut outs on the inside of the copper base that secure the PEEK multipin D-connector to the flange.

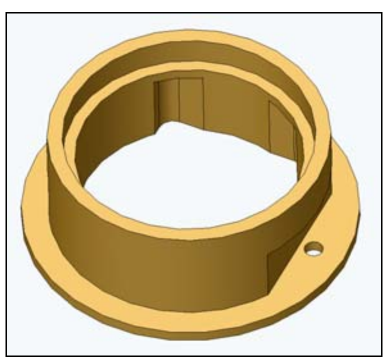


Figure 6. Copper Base

2. Copper Tube and Insulating Break

The copper tube connects the grounded part of the camera to the upper part of the electrostatic shield. The length of the flange was dictated by the 4.5" insulating break. The insulating break was custom shortened to reduce the distance between the detector and the preamplifier as well as minimize the effect of electromagnetic interference (EMI) on the signal wires.

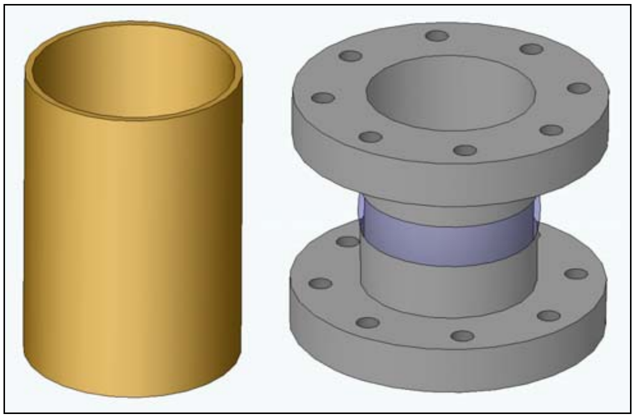


Figure 7. Copper Tube (left) and Insulating Break (right)

3. Copper Plate and Stainless Steel Cap

The stainless steel cap attaches to the copper tube. The stainless steal cap is wider than the mid-section of the insulating break but does not touch the sides. Once the cap is installed, the insulating break is captured. The copper plate is secured on top of the stainless steel cap and translates along two slots. These two slots allow the detector to translate inside the camera, thereby providing and adjustment to the viewing direction while still preserving the wide viewing angle. Changing the plate position, however, requires that the camera be disassembled.

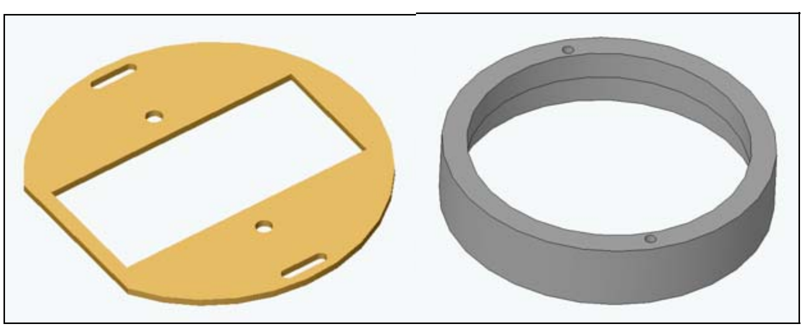


Figure 8. Copper Plate (left) and Stainless Steel Cap (right)

4. Copper Input Aperture

The copper input aperture completes the electrostatic shield and blocks X-rays outside the collection angle. The detector and its peek mount are housed securely inside the copper input aperture, and the light rays reach the detector through the rectangular opening. The copper aperture is split into two halves and bolted together once the detector is mounted inside. The PEEK detector mount is bolted in place and aligned with a pin from the side.

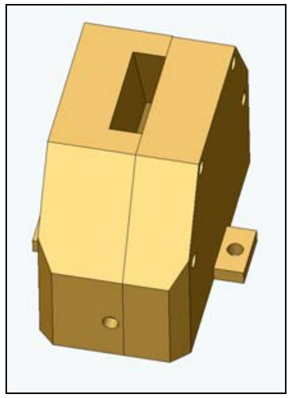


Figure 9. Two Halves of the Copper Input Aperture

E. Metal Filters

Each thin metal film comes mounted on its own frame. The frame is then inserted into a face of the carousel. This is done after the camera is assembled. These metal films eliminate radiation in the visible region while still transmitting X-rays. Three energy ranges were chosen by specifying three filter cutoff frequencies. The ultra-soft X-ray filters have the lowest cutoff photon energy level and pass X-rays as low as 100 eV to obtain temperature readings for the coldest plasmas. The soft X-ray filters (200-400 eVs) can be used to monitor the temperature of moderately hot plasmas. Hard X-ray filters transmit X-rays from 400-1000 eVs and can be used to monitor reconnection activity in plasma that produces energetic X-rays. The ultra-soft filter has already been designed and ordered. Bolometry data from the Soft X-ray camera will be important in determining the signal level and in deciding which filters can be used on HIT-SI.

1. Design of the Thin Metal Filters

a. Bremsstrahlung Radiation

The design process for the X-ray filter began by estimating how the amount of Bremsstrahlung radiation varies over the visible and X-ray energy ranges. The Bremsstrahlung radiation was calculated by using the following equation.

$$j(f)\left[W/_{m^3}\right] = 0.4877 \cdot Z_{eff} \cdot \left(\frac{n_e^{\ 2}}{10^{38}}\right) \cdot \sqrt{\frac{1}{T_e}} \cdot \exp\left(-\frac{f(eV)}{T_e(eV)}\right) \qquad \textit{Eq. 1}$$

The dependent variable is f , the energy of the emitted radiation in eV. In our evaluation of the formula, the photon energy varied from 1 to 1 keV. Incorporated into the formula is the solid angle symbol that directly affects the amount of Bremsstrahlung radiation collected. Note that the emission is strongly dependent on plasma density, n_e, and goes as $T_e^{-1/2}$. There is also a dependence on Z_{eff} which is the average ion charge state of the plasma.

A log-log plot of the Bremsstrahlung radiation is shown in Figure 14 for an ohmic plasma with Z_{eff} of 2, T_e of 10 eV, and n_e of 10^{19} electrons/m^3. The figure illustrates that the quantity of Bremsstrahlung radiation decreases with photon energy. The high level of visible radiation makes it imperative that the filter have high rejection in the visible region.

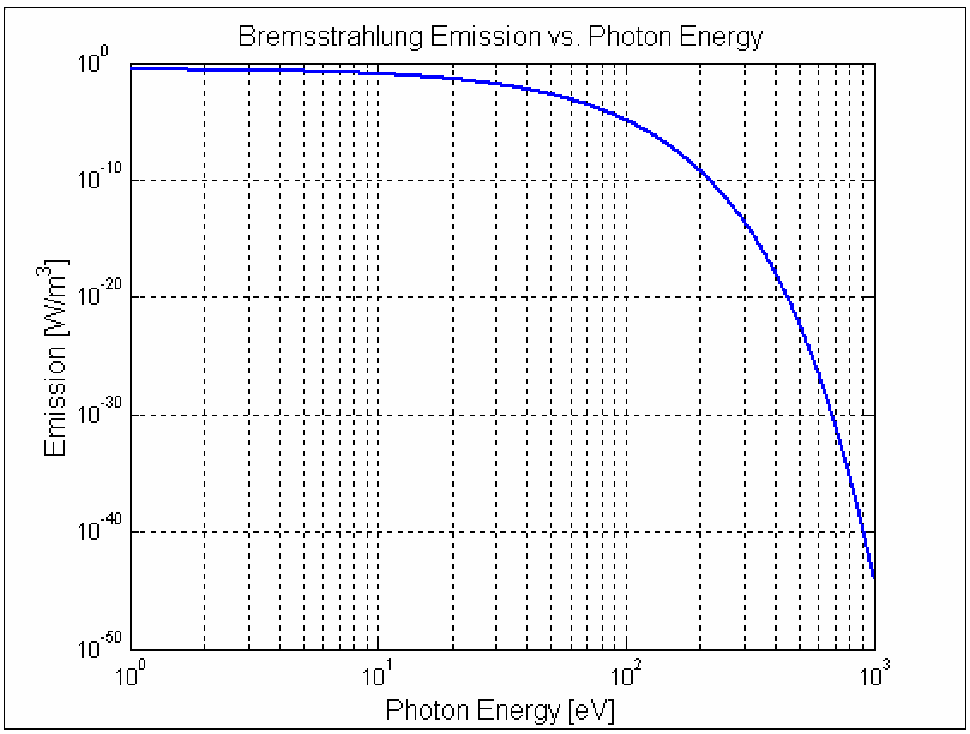


Figure 10. Predicted Bremsstrahlung Emission vs. Photon Energy for a 10 eV ohmic plasma

Similar plots are produced using the same density and Z_{eff} parameters but with the ohmic plasma temperature T_e at 30, 100, and 300 eV. The amount of radiation in the higher photon energy levels significantly increases with increasing plasma temperature, as should be expected.

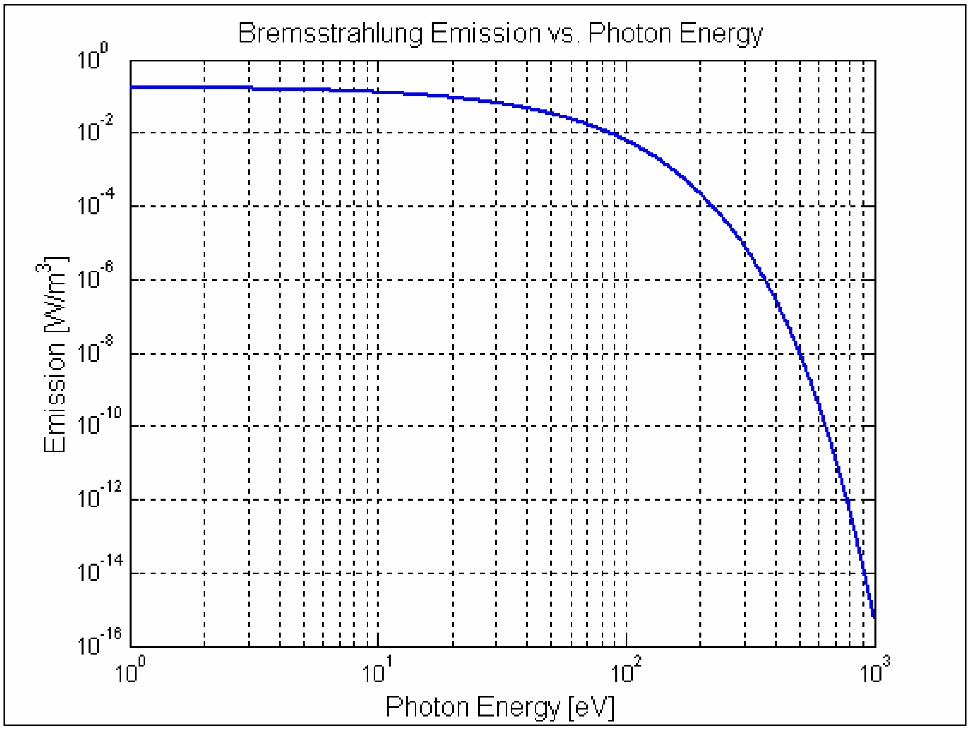


Figure 11. Predicted Bremsstrahlung Emission vs. Photon Energy
for a 30 eV ohmic plasma

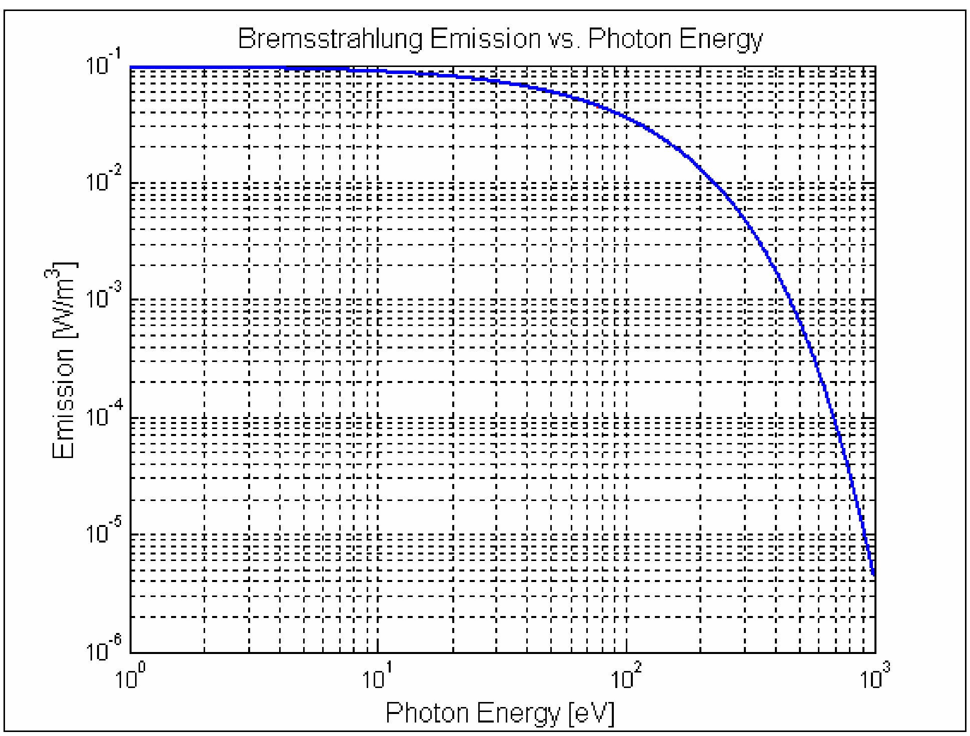


Figure 12. Predicted Bremsstrahlung Emission vs. Photon Energy
for a 100 eV ohmic plasma

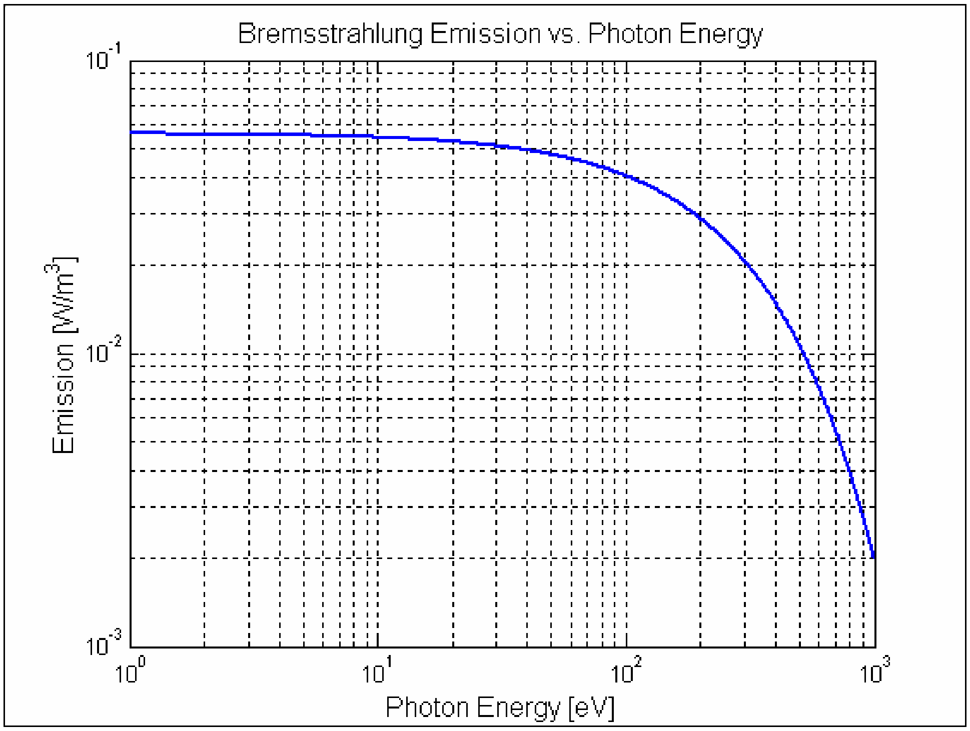


Figure 13. Predicted Bremsstrahlung Emission vs. Photon Energy
for a 300 eV ohmic plasma

To better test the effectiveness of the filters, a worst-case scenario was assumed that has a significantly higher level of radiation in the visible spectrum due to line radiation. The total assumed emission is shown in Figure 14. Plasma density and Zeff still have values of 10^{19} electrons/m^3 and 2.

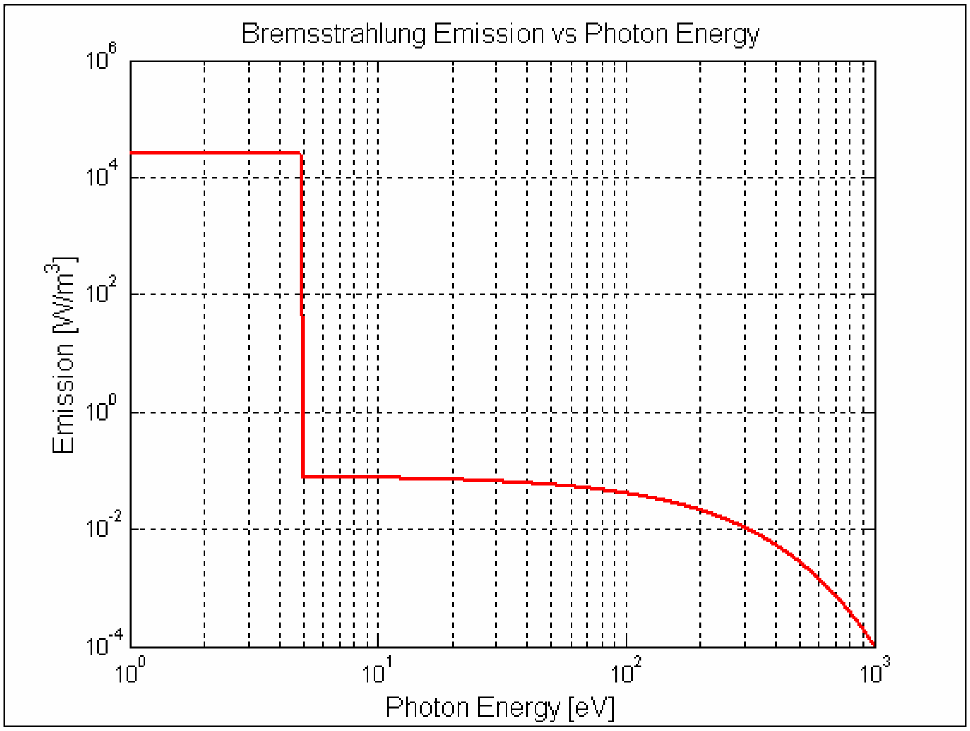


Figure 14. Worst-Case Scenario of Emission vs. Photon Energy
for a 150 eV ohmic plasma

b. Choosing the Metals

The factors considered in choosing the metals for the filters were:

- Reflectivity of the metal: Highly conductive metals (Cu, Ag, Au, Al) strongly reflect in the visible region but not in the X-ray region
- High discrimination ratio of X-rays versus visible light
- Vacuum compatibility: out-gassing, favorable magnetic properties
- Sharpness of the cut-off from X-ray region to visible region

Data on the responsivity of different metals was collected from the Advanced Synchrotron Light web site at the University of California, Berkeley. A filter program was coded in Matlab to determine how well certain metal filters affected the calculated Bremsstrahlung radiation. The best combination was a mixture of beryllium and copper on a parylene substrate. Because the metal films are so thin, they must have a backing for support. Parylene is a vacuum compatible substrate for the deposition of the metal films. The substance has no outgassing (NASA approved) and has uniform characteristics from -200 °C to 200 °C. Parylene's melting temperature is 280 °C. Vacuum tests conducted at the Jet Propulsion

Laboratory showed a weight loss of 0.12% for Parylene (type C) at 50 °C and 10^{-6} torr. These thin filters were made by the Lebow Company.

c. Thickness of Metals

The thickness of the metals was determined by first calculating the ratio of the Bremsstrahlung output integrated over the hard X-ray region to the Bremsstrahlung output integrated over the visible region. Different extinction ratios were calculated with various thicknesses of beryllium and copper. The higher the ratio was, the better the configuration. The amount of radiation actually detected by the detector was also considered since there must be a strong enough signal for detection. The best combination of detector power and ratio was then chosen.

d. Single versus Double Filters

The carousel design allows two filters in series. The effect, shown in Figure 15, is a better suppression of transmission in the visible range. A double filter, however, does not change the extinction ratio. The two filters unfortunately result in a lower transmission in the desirable 400-1000 eV range. The benefit is that a second reflective surface is added to better reject visible light. Two filters can be added because the carousel has both a top and a bottom mounting surface.

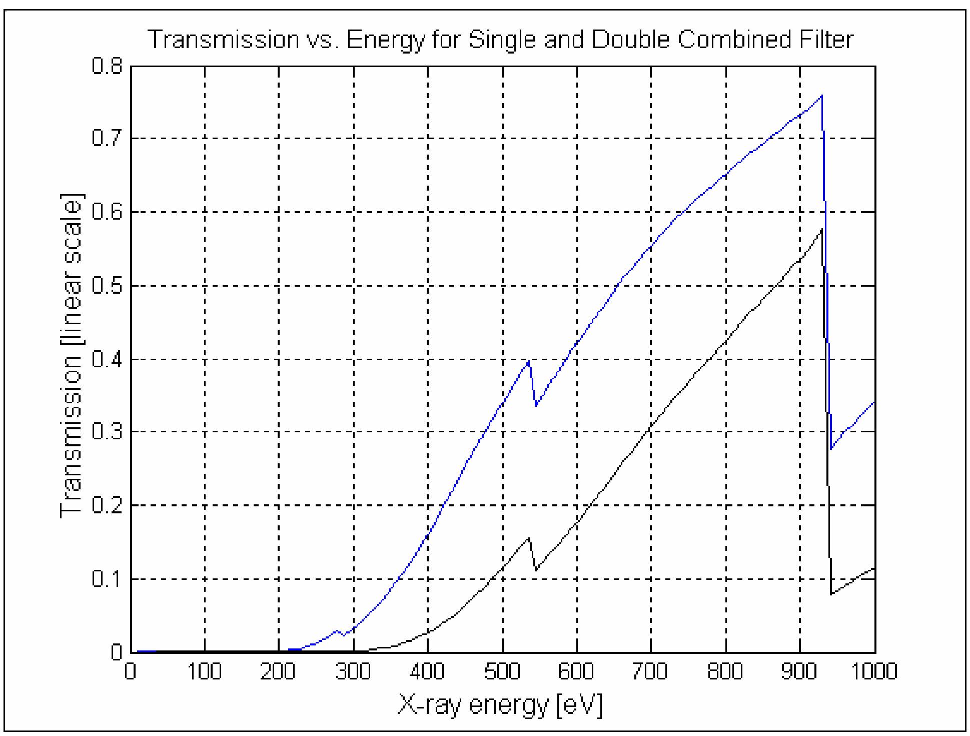


Figure 15. Transmission versus Energy for Single and Double Filters

e. Ultra-Soft X-ray Filter

The final configuration for the ultra-soft X-ray filter was 50 nm Cu on a 100nm parylene substrate and 250 nm of Be on a 100 nm parylene substrate. The beryllium filter will attach to one side of the carousel, and the copper filter will attach to the opposite side. Three of each were ordered from the Lebow Company. Each metal film had dimensions 5 x 10 mm. More specific results are provided in the following sections.

i. Copper-Parylene Filter

The worst-predicted visible and Bremsstrahlung radiation are given in Figure 16 by the red line. The radiation is filtered by a 50 nm Copper, 100 nm parylene metal filter (green). The data for the transmittance graph are provided by Advanced Synchrotron Light at the University of California, Berkeley. The filter transmittance also includes the effect of the Copper's reflectivity. The final emission after filtration is shown by the blue line.

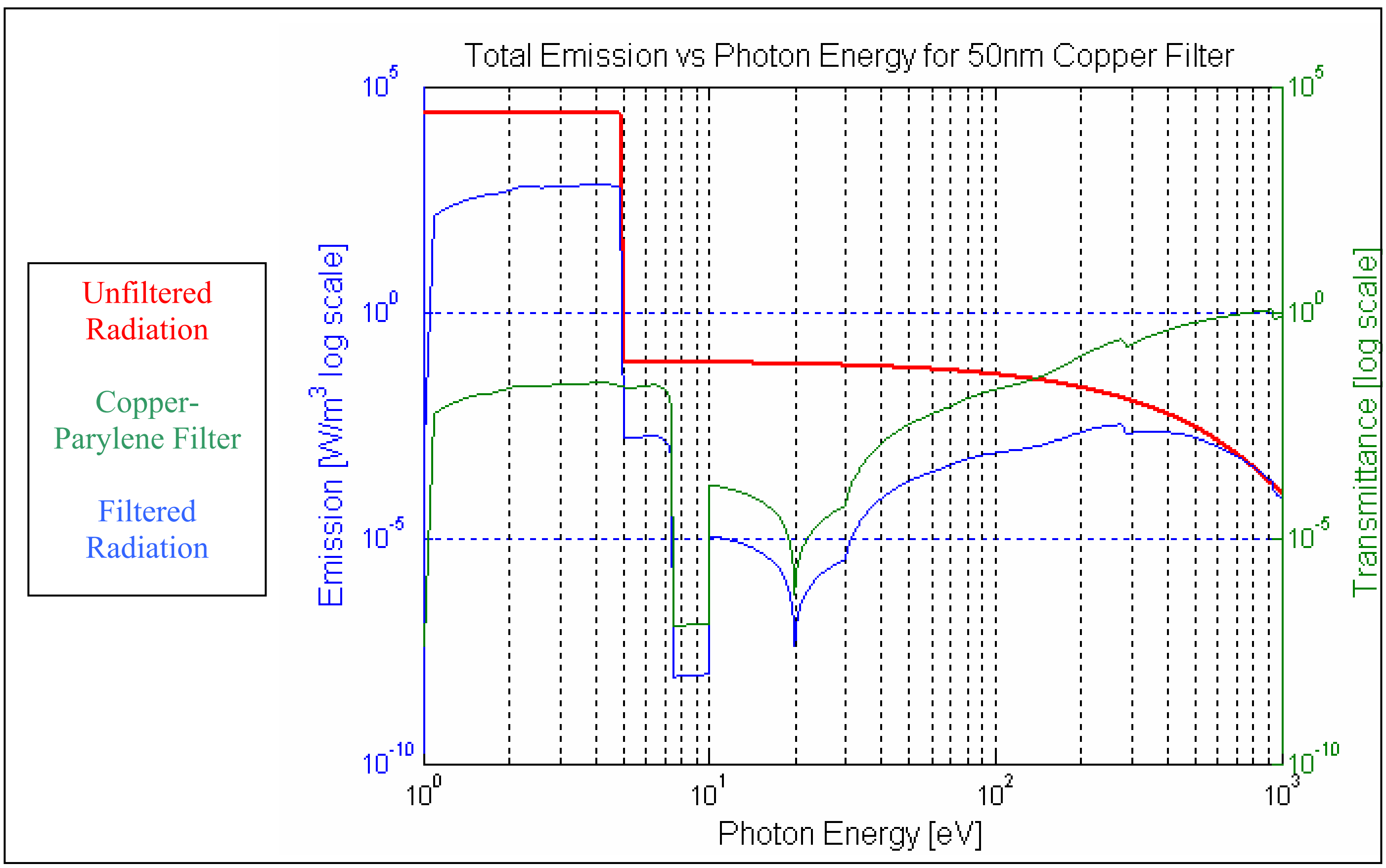


Figure 16. Incident Radiation Emission and Output Transmission using a 50 nm Copper-100 nm Parylene Filter (Transmittance Data Shown)

ii. Beryllium-Parylene Filter

The worst-predicted visible and Bremsstrahlung radiation are given in Figure 17 by the red line. The radiation is filtered by a metal filter (green) composed of 250 nm Beryllium deposited on 100 nm of parylene. The final emission after filtration is shown by the blue line.

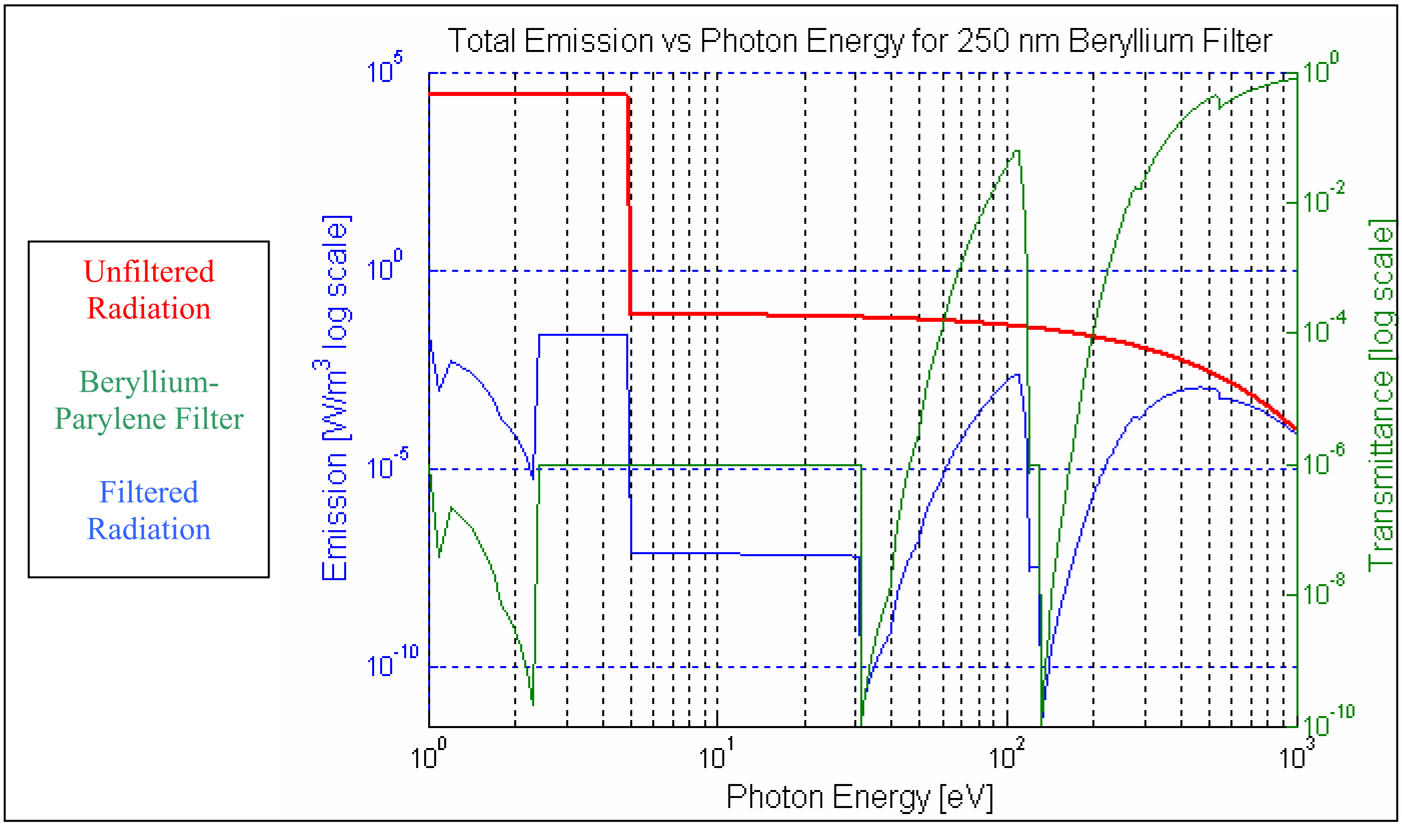


Figure 17. Incident Radiation Emission and Output Transmission using a 250 nm Beryllium-100 nm Parylene Filter (Transmittance Data Shown)

iii. Copper and Beryllium Parylene Filters

The combination of the two filters in section i and ii, one with 50 nm of Copper and the other with 250 nm of Beryllium, each on a 100 nm parylene substrate, yields the filter transmittance as shown in Figure 18 by the green line. The worst-case emission (red) is then filtered to give the transmitted radiation (blue). Note that the hard X-ray energy range (>400 eV) has significantly more outputted radiation than the other energy levels have.

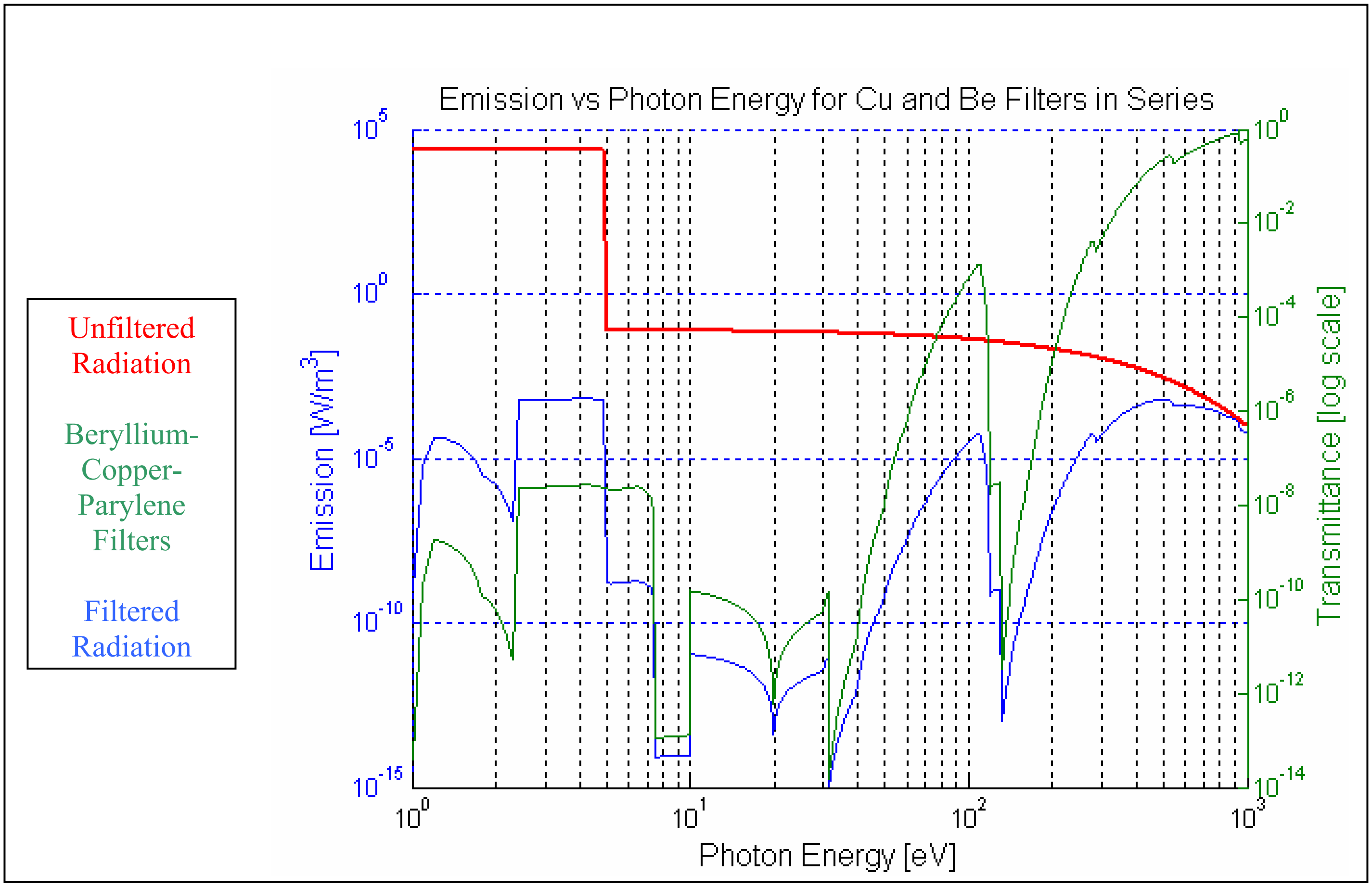


Figure 18. Incident Radiation Emission and Output Transmission using a 50 nm Copper-100 nm Parylene Filter combined in series with a 250 nm Beryllium-100 nm Parylene Filter (Transmittance Data Shown)

iv. Final Detected Signal

To predict the final output voltage, the chamber volume that the detector sees had to first be calculated. The volume is the product of the detector area, the solid angle, and a meter-long line of sight. The volume comes out to be approximately 2×10^{-10} cubic meters.

The registered signal is also affected by the quantum efficiency of the detector, as shown in section II B of this report. A total current of 1.16×10^{-11} Amps is generated in the detector over the frequency range from 1 eV to 1 keV. With the gain set to 100 kilo-ohms, the output voltage is predicted to be 1.16 micro-Volts. If the diagnostic is used as a bolometer, the voltage generated is approximately 0.3 Volts when the worst-case radiation output is used (higher than usual visible emission).

f. Lebow Company

Contact Information**:** Ed Graper, 5960 Mandarin Avenue
Goleta, California
805-964-7117(phone/fax)

g. Code Description

Two main code files exist in the following location: U:\askren\Soft X-Ray\Programs\. The code has been commented for easy reference.

i. AA.m

This program plots basic transmission curves of copper and beryllium to determine the preliminary choice and/or combination of metals. It was determined that copper and beryllium were the best choice for the filters. The second part of the file outputs the transmission data for a copper filter and for a beryllium filter, each with a thickness of 100 nanometers. Transmission data for films of differing thicknesses were calculated by raising the 100 nm data to a power. For example, transmission data for a 50 nm film is found by raising the 100 nm filter data to the ½ power. Similarly, filter data for 200 nm uses the power of 2. This data are later imported in the program Brems_vis_AA.m.

ii. Brems_vis_AA.m

This is the main code for the design of the filters. It provides the following:

1. Amount of integrated Bremsstrahlung radiation emitted at eV levels that span from visible to hard X-ray spectrum (1 eV-1keV)
2. Filter transmission of a single or double copper filter with parylene, the reflectivity of copper, and the responsivity of the AXUV detector all considered
3. Filter transmission of a single or double beryllium filter with parylene and the responsivity of the AXUV detector both considered
4. Filter transmission for a combination of beryllium and copper filters
5. Predicted Bremsstrahlung radiation detected, for separate or combined filters
6. Ability to vary the thicknesses of the metals
7. Ratio of transmitted Bremsstrahlung radiation in the x-ray region to that in the visible region
8. Power the detector sees in visible and multiple x-ray regions

III. Soft X-ray Diagnostic Port

Because the soft X-ray diagnostic shares a port with the Zeff diagnostic, a new port was designed to provide acceptable viewing apertures for both diagnostics. The new port, as shown in Figure 19, provides a wide viewing aperture by mounting the camera close to the machine.

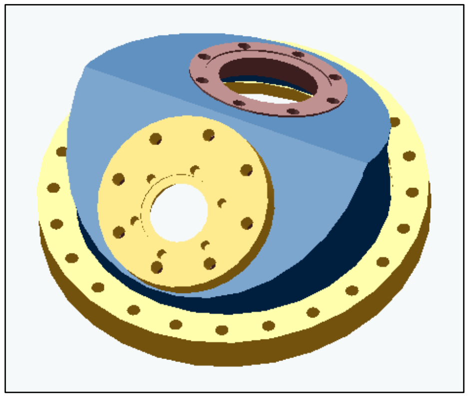


Figure 19. Soft X-ray Port Attachment
(Addition and Seal.SLDASM)

The port's cover plates are angled 28° degrees upward from the horizontal, allowing the soft X-ray diagnostic to view the machine from a line of sight that is tangent to the outer shell to just past the central axis (see Figure 23). The slope also ensures that the wide angle of view does not interfere with the sides of the machine.

The conflat fittings on the Soft X-ray port were made from two purchased 4.5" flanges that were reduced in diameter and welded to the plates. The top surfaces of the flanges are slightly higher than the stainless steel plates. Figure 20 shows the tapered inside hole and the blind bolt holes.

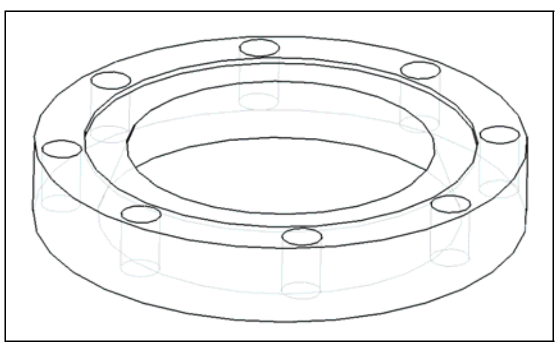


Figure 20. Wire-frame View of Tapered 4.5" Flange for Special Port
(4.5 reduced flange.SLDPRT)

The design incorporates a machined zero length adaptor to prevent interference between the lines of sight and the inner corner of the 10" CF port. The adaptor is shown in Figure 21. The flange inner hole is translated downwards so that the camera's wide viewing aperture is not obscured by the port's inner tube (refer to Figure 24). This 4.5" conflat flange also orients the camera downward so that the diagnostic looks at the desired region inside the HIT-SI chamber (shown in Figure 23). Mounting the soft X-ray camera to the adaptor requires blind holes and shortened bolts that are already captured in the carousel's flange.

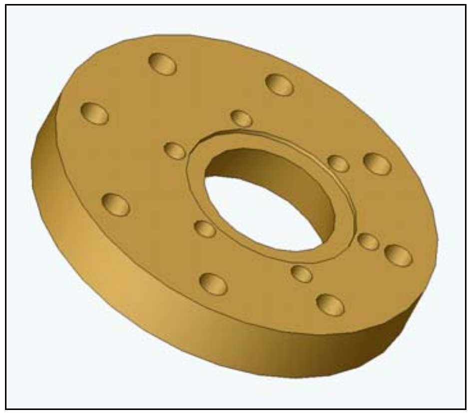


Figure 21. Special Translation Flange for Soft X-ray Port Attachment
(4.47 Zero Length Adaptor (SI).SLDPRT)

The camera's placement on the HIT-SI machine is shown in Figure 22.

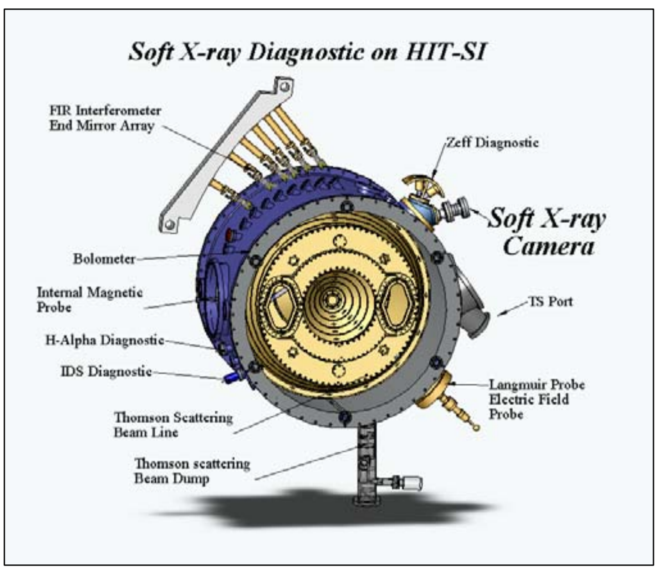


Figure 22. Diagnostics of the HIT-SI Spheromak
(HIT-SI Assembly_Main.SLDASM)

IV. Viewing Aperture

The viewing aperture of the soft X-ray diagnostic spans from the machine's axis to the outer shell. The viewing angle is 45° and is slightly adjustable by translating the detector. However, this would require disassembling the camera. Figure 23 is a SolidWorks capture of where the port attachment and the soft X-ray camera are located on the HIT-SI machine. The dashed lines were drawn outwards from the outer detector elements and project through the pinhole.

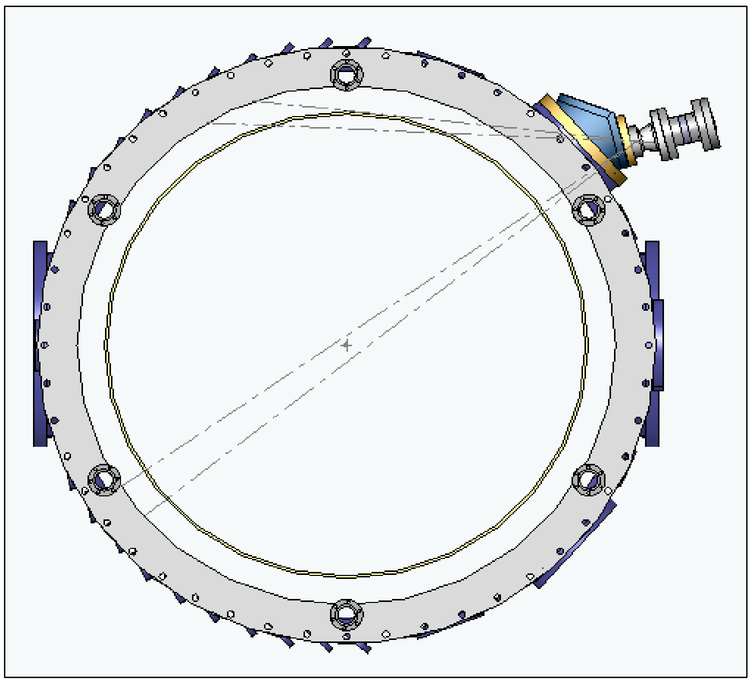


Figure 23. Viewing Aperture of Soft X-ray Diagnostic
(Hexagonal HIT-SI Assembly.SLDASM)

V. SolidWorks Drawings

All SolidWorks parts and assemblies are stored in the location S:\Askren\Soft X-Ray\Camera Model\Hexagonal Camera and backed up on a CD. The important files are described in this section.

A. Entire Assembly

The entire assembly is called the Hexagonal HIT-SI Assembly.SLDASM. This includes the diagnostic, the port attachment, the aperture rays, and the annulus and outer radius of the HIT-SI machine. If any individual SolidWorks parts or assemblies are changed, then the changes will automatically update in this file.

This file was created to determine the maximum allowable viewing aperture for the detector. Multiple points of interference can occur between the camera's outer sight lines-shown as dashed lines-and the walls of the machine. One interference location is shown in Figure 24, where the dashed line grazes the left top side wall of the chamber opening. The assembly was altered by various measures to meet these three main goals:

1. Maximize viewing aperture (preferably around 45 degrees)
2. Obtain a viewing angle from the center of the machine's axis to tangent to its outer shell
3. Minimize interference with machine's and port's walls

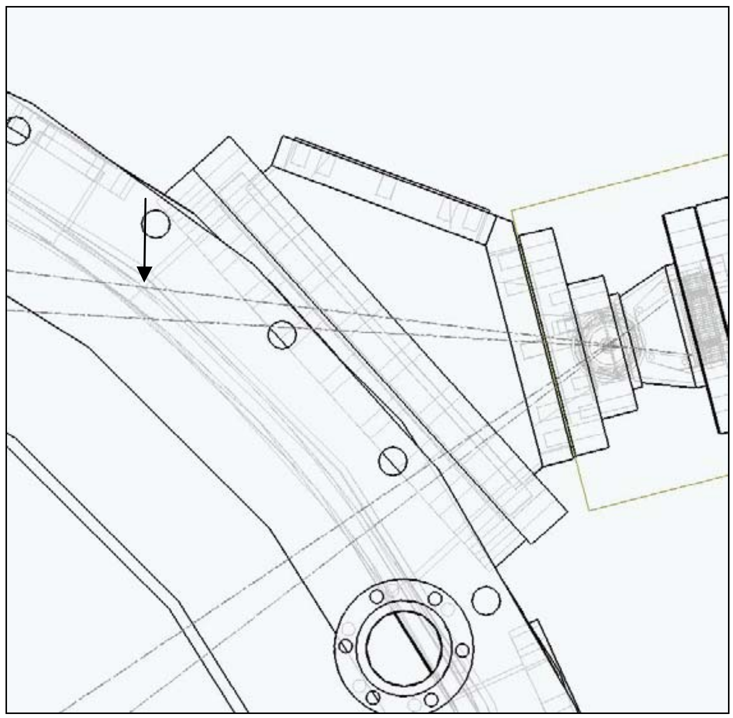


Figure 24. Interference between Annulus and Light Rays

The lines of sight are detailed in Figure 25. Each ray is drawn such that the maximum viewing angle is achieved without interference.

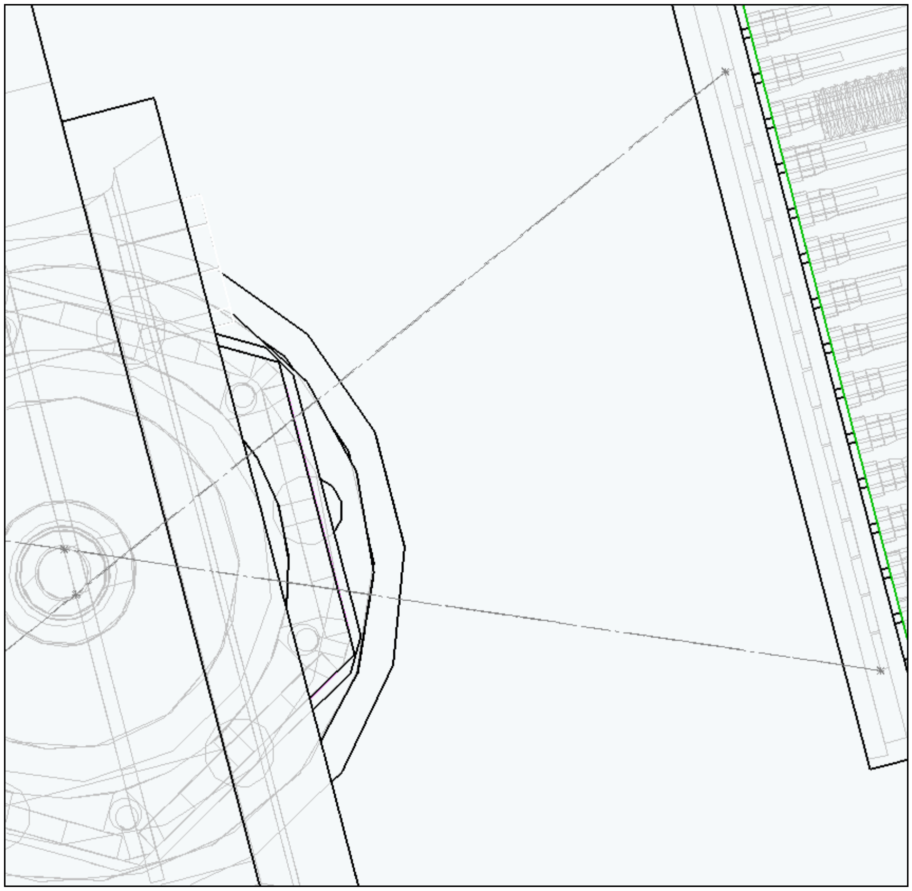


Figure 25. Ray Trace from Outer Detector Elements through Pinhole

B. Soft X-Ray Camera

The soft X-ray camera file is 'Hexagonal Soft X-Ray Camera.SLDASM.' The only available degree of freedom is translating the detector along the copper plate by modifying the sub-assembly 'Copper Top.SLDASM.'

VI. Electronics

A. Electronic Housing

The electronic housing for the diagnostic is an aluminum rectangular box. Inside it is a 16 channel pre amplifier board (from Culham Labs, UK), twisted pairs to double pin LEMO connectors, and a 25 pin connector (RS232) that interfaces with the camera's vacuum feed-through. Figure 26 shows twisted pair outputs, a ground wire from the enclosure, and a connection for biasing the diodes which is not used.

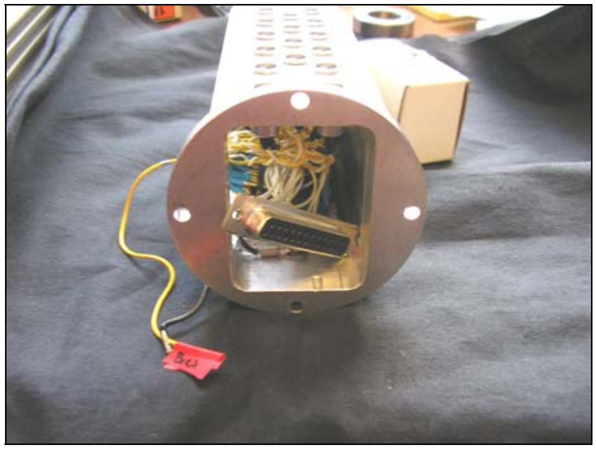


Figure 26. View of Electrical Housing from Vacuum Side

B. Ground and Signal Wires

High vacuum shielded twisted pair wires were ordered from Accu-glass. These wires are insulated with Kapton and also have connectors pre-attached. Two wiring options are shown in Figure 27 and Figure 28. Mostly option *A* was used since there were not enough connections in the 25-pin feedthrough. Because of the ground loops, all signal leads should be kept as close to each other as possible.

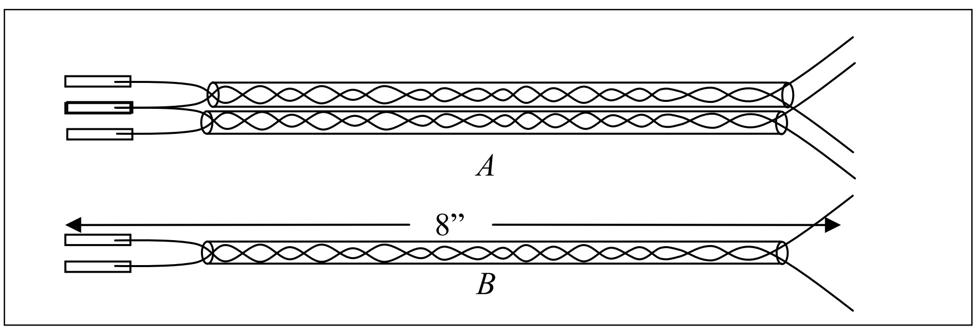


Figure 27. Pair with Common Ground (below) and Straight Pair (above), from Accu-Glass

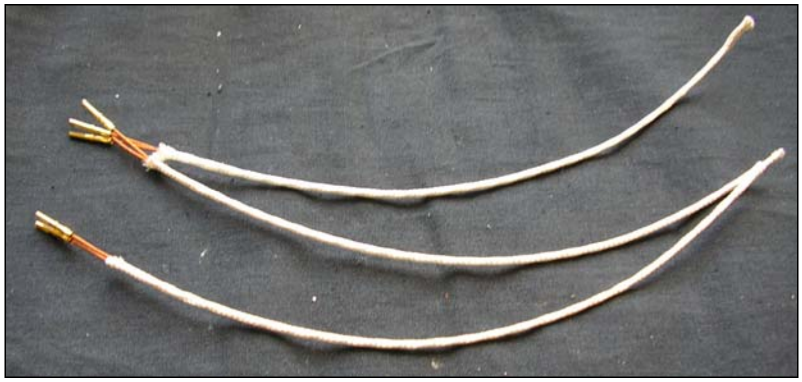


Figure 28. Pair with Common Ground (below) and Straight Pair (above), from Accu-Glass

C. Wiring Schematic

The wiring assembly is shown in Figure 29 as viewed from the wire side of the detector. The numbers refer to the detector elements. The same diagram applies to the feedthrough connector and RS232 when viewed from the backside. These numbers also correspond to those written on the pre-amplifier. 'GND' signifies ground.

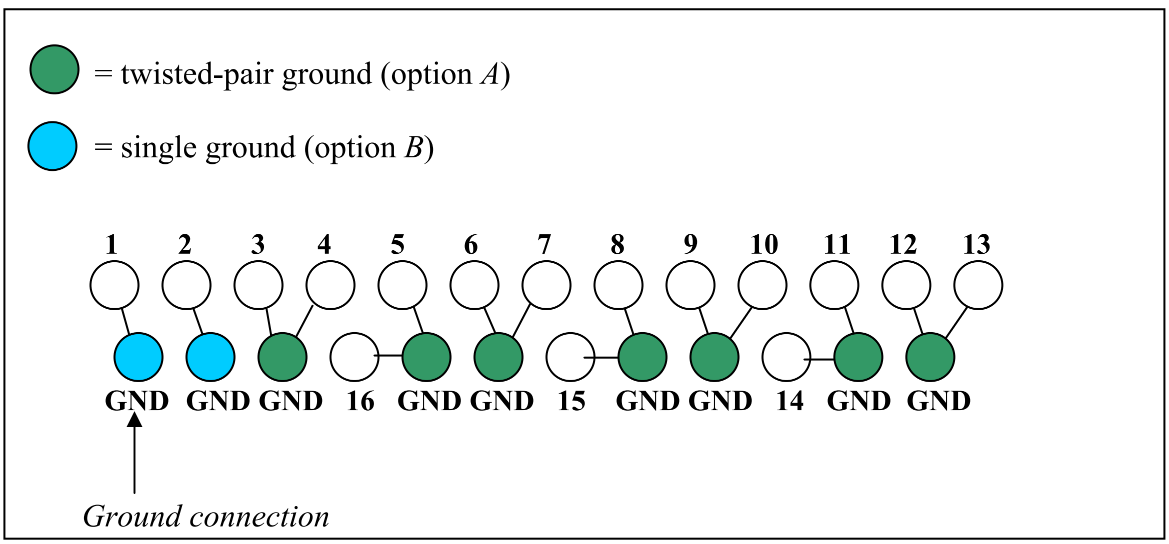


Figure 29. Connection Diagram for Detector, Pin Feedthrough, RS232 Connector

Two stainless steel posts are attached to the peek and serve as grounding posts. Eight ground wires are fed through each ground post and bolted together. See Figure 30.

Figure 30. Wiring between Detector and Peek Connector

The 25-pin PEEK D-connection is shown on the right side of Figure 30. The wires are fed through the holes and captured by the PEEK comb panels, as illustrated in Figure 31. At this point, nothing was done with the shields; they are floating.

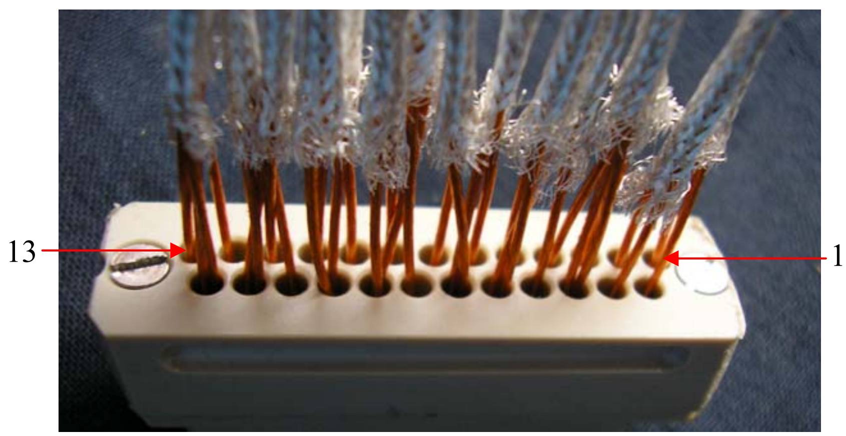


Figure 31. Ground and Signal Wires Fed into 25-pin PEEK D-Connector

VII. Assembly of the Soft X-ray Camera

The diagnostic is assembled from its parts in the following order:

1. Ultrasonically clean all assembly tools and any parts that are contaminated. Set up a clean work area. Wear gloves during assembly.

2. Installing the wires through the electrostatic shield
   a. Make sure that detector elements and wires are not damaged.

b. Check that the wires are connected as shown in Figure 29, Figure 29, and Figure 30.
c. Check that the wire connectors between the detector and the PEEK D-connector are not loose.

3. Connect the peek D-connector to the multipin vacuum feedthrough on the side opposite that with the punch-marked numbers (1 and 13). The connector is held in place by the copper base.

4. Being careful to not damage the detector or wires, attach the copper base of the electrostatic shield to the vacuum feedthrough. The connecting screws are 4-40, silver plated, and drilled out.

5. Add a new copper gasket.

6. Fit the copper tube inside the copper base of the electrostatic shield. Make sure that the punch-marked ‘A’ on the copper tube lines up with the one stamped on the vacuum feedthrough (see Figure 32). Use a silver plated 4-40 screw to secure.

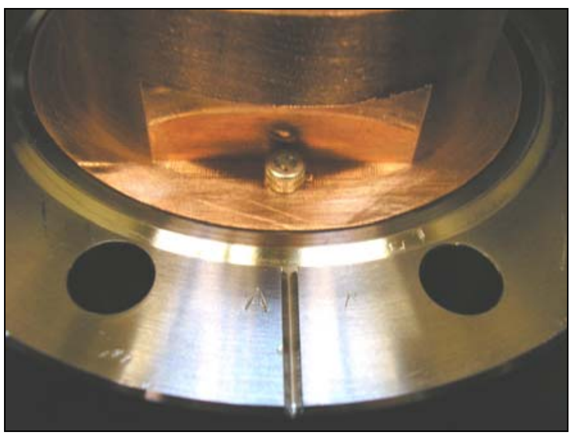


Figure 32. Orientation Set by Punch-Marked 'A'

7. Being careful to not bump the detector, slip the conflat insulating break over the copper tube.

8. Attach the stainless steel cap to the copper tube so that the punch-marked letters are in-line. Take special care to not drop the bolts on the detector when the silvered 4-40 screws are fed through from the inside. It is recommended that the camera be tilted to the side when inserting the screws. The setup so far should look like Figure 33, (minus the copper seal and insulating break).

Figure 33. Soft X-ray Diagnostic during Assembly

9. Place the copper plate on the stainless steel cap, making sure that the orientation is set by the punch-marked ‘A’. A small hollow pin in the SS cap should ride along a groove in the copper plate. Secure the plate with two silver-plated 4-40 screws so that the alignment pin lines up with the outer curvature of the plate as shown in Figure 34. It is also possible to translate this plate along the groove further to change the desired viewing direction as previously discussed.

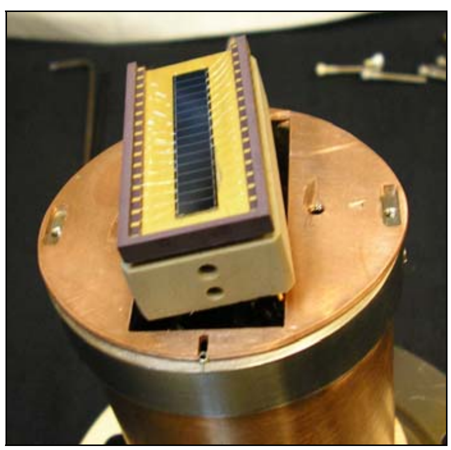


Figure 34. Top View of Detector and Copper Plate Alignment

10. The PEEK detector mount then attaches to one half of the copper aperture by means of an alignment pin and two drilled-out silver-plated 4-40 screws. See Figure 35.

Figure 35. Close-up of Alignment Pin and Screw for PEEK-Aperture Connection

11. Attach the other half of the copper aperture and secure both parts to the copper plate using silver plated 4-40 screws. The assembly should now look like that in Figure 36 (minus the insulating break).

Figure 36. Internal Electrostatic Shield

12. Add the metal seal/carousel assembly on top of the insulating break and secure with bolts and nuts. Check that the alignment of the carousel's face matches the dial on the rotary actuator. The diagnostic should look like Figure 37 without the flange at the top.

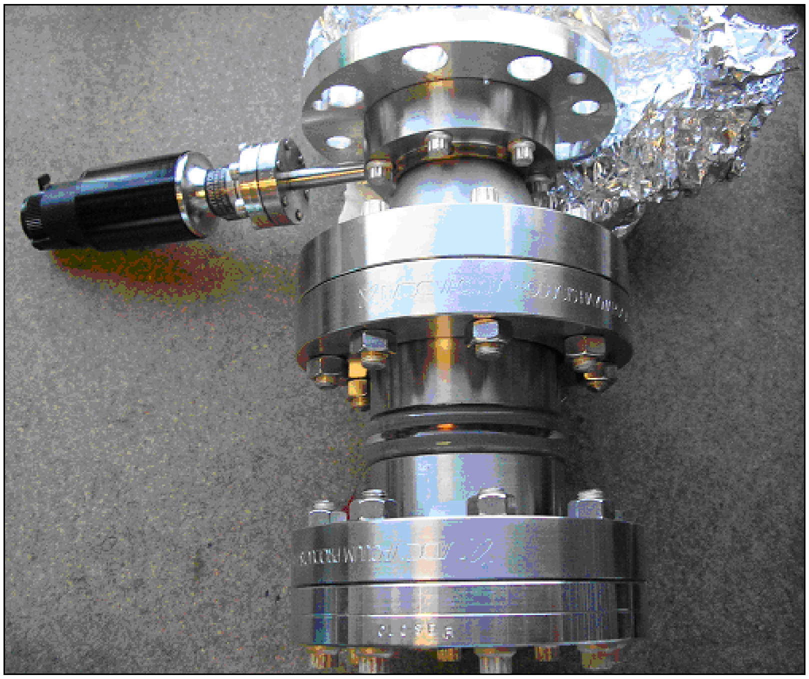


Figure 37. Assembled Soft X-ray Diagnostic

13. Mount the filter frames carefully. Use a tweezer to grab the frame's indentation and a small screwdriver to secure the frame to the carousel by means of a small flat-headed 0-80 screw (see Figure 38). The frames can be changed without having to disassemble the diagnostic.

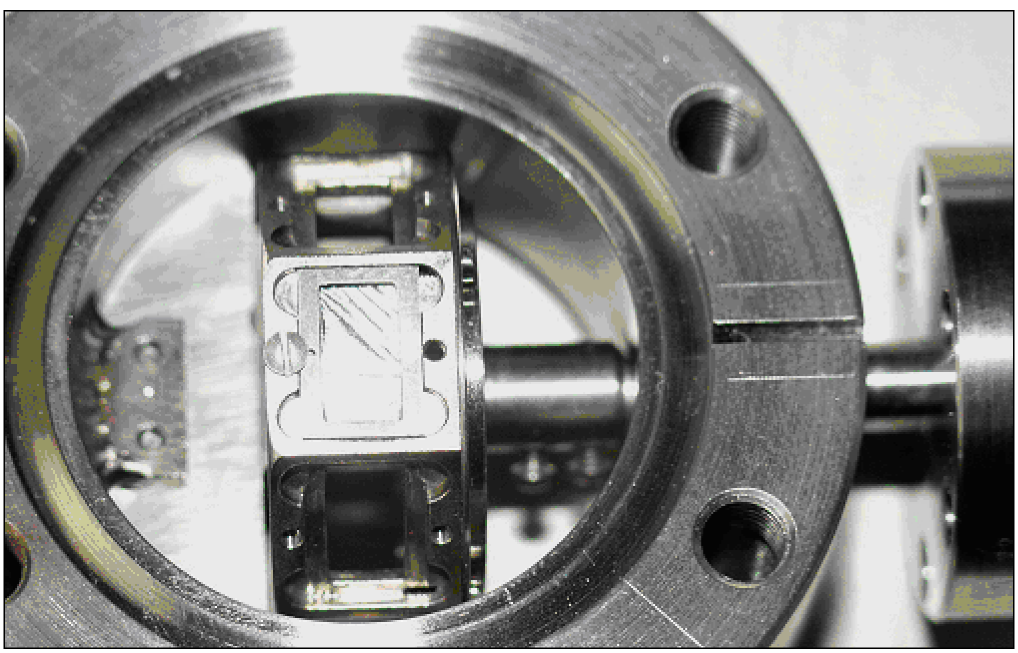


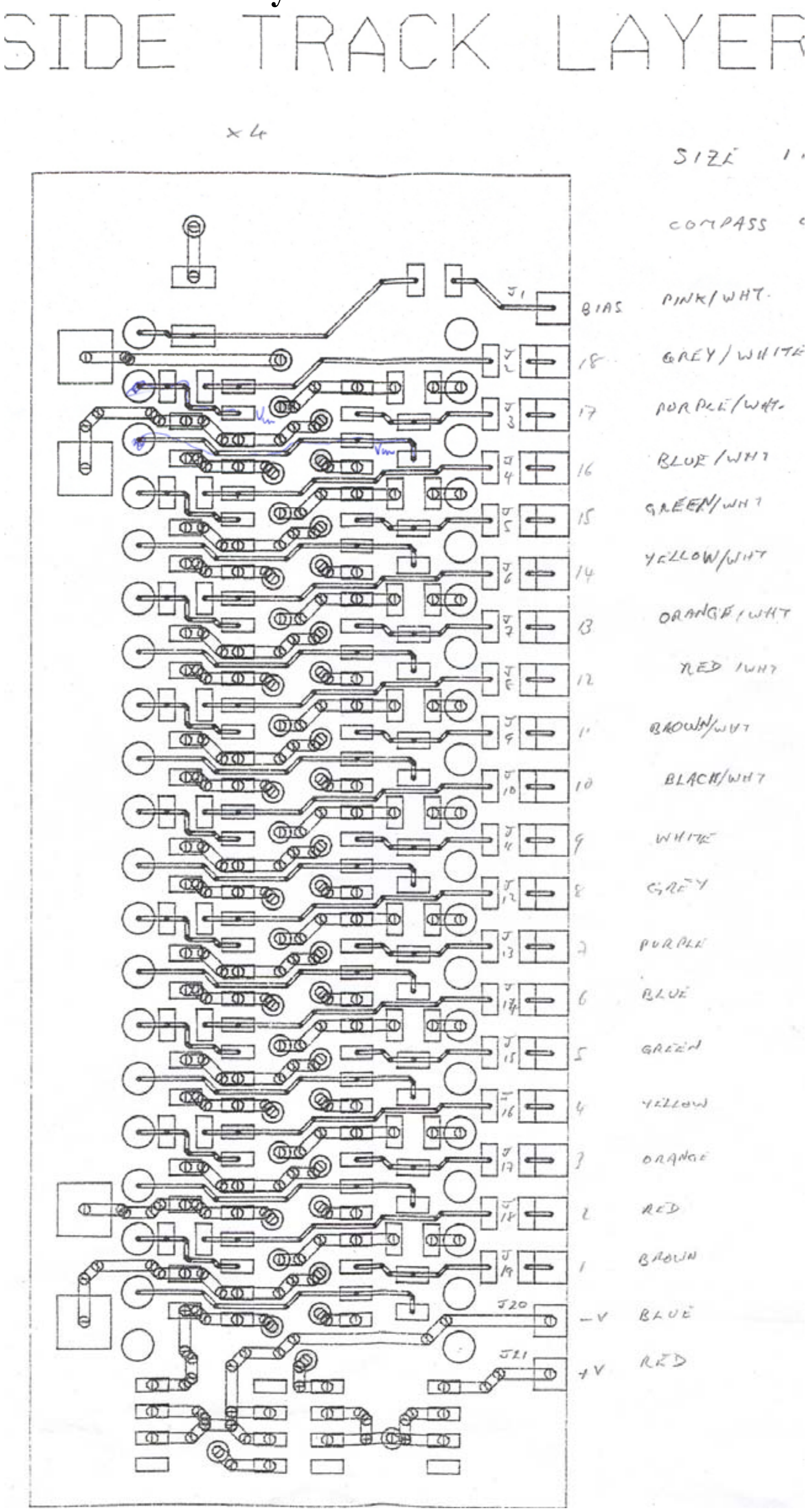
Figure 38. Metal Film Mounted on Carousel

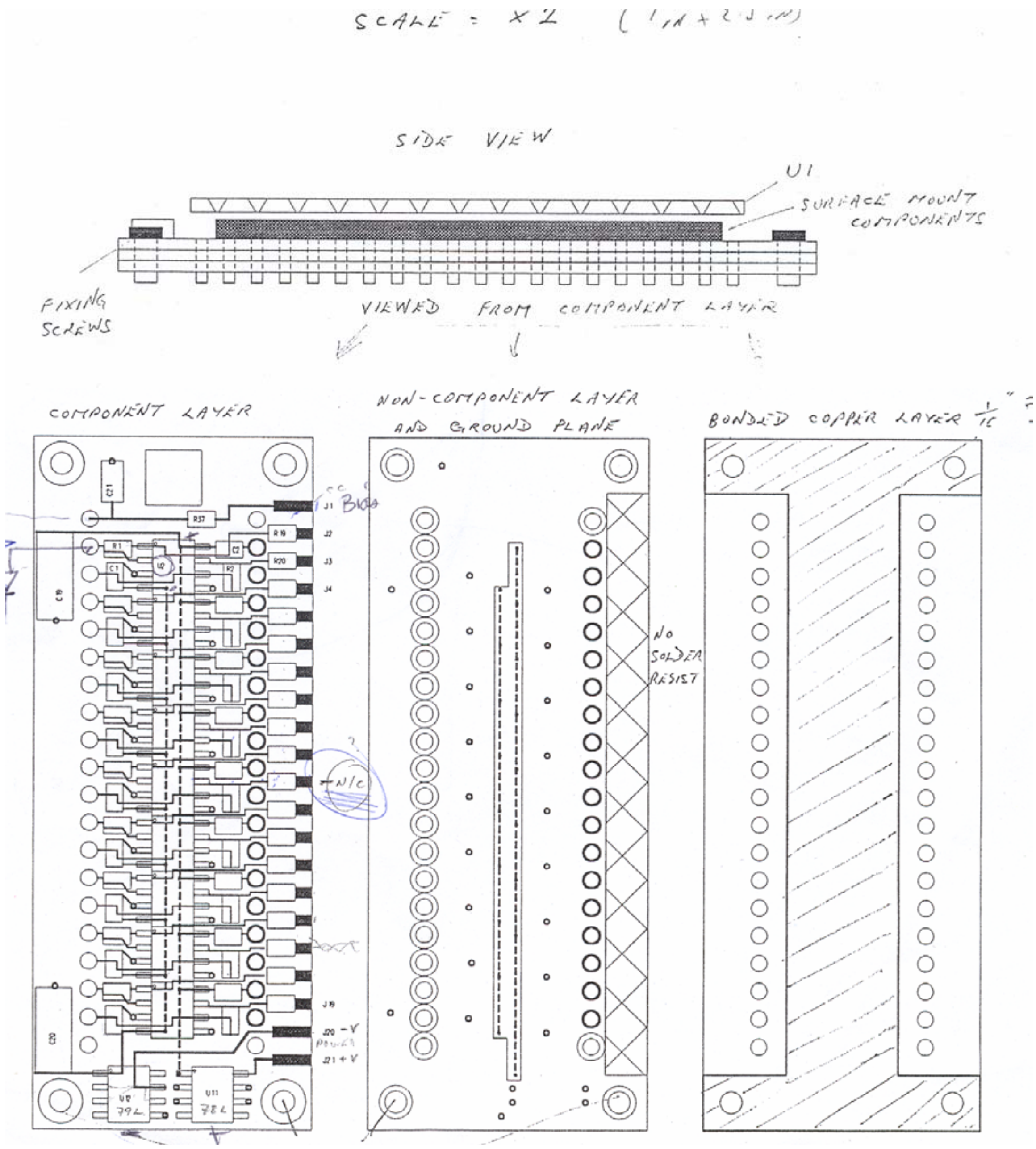
14. Connect the camera to the zero-length adaptor flange by using the captured bolts in the diagnostic's 2 ¾ conflat flange.

VIII. Data

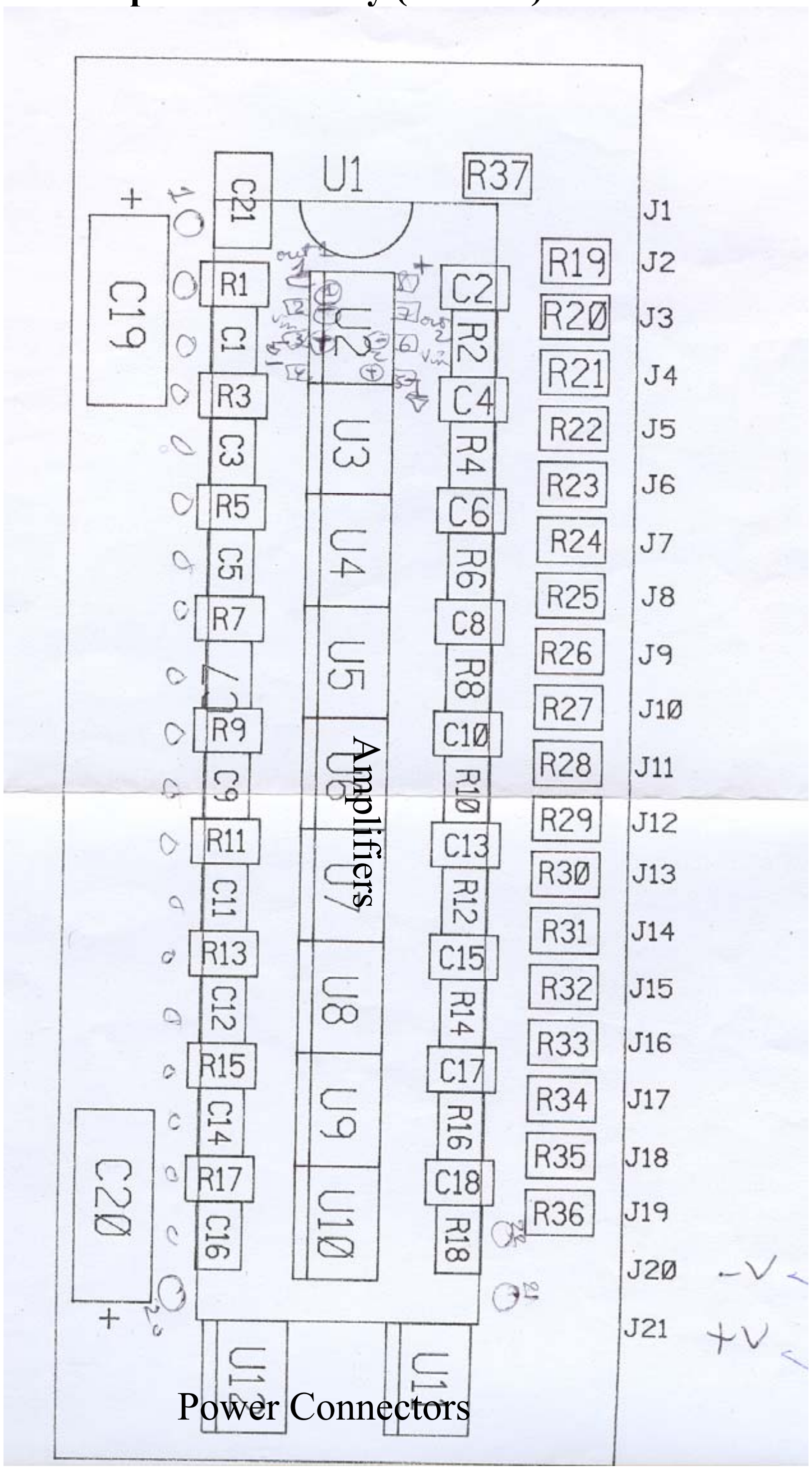
IX. Appendices

Detector Circuitry




SCALE = X 2
SIDE VIEW
U1
SURFACE MOUNT COMPONENTS
FIXING SCREWS
VIEWED FROM COMPONENT LAYER
COMPONENT LAYER
NON-COMPONENT LAYER AND GROUND PLANE
BONDED COPPER LAYER
NO SOLDER RESIST
N/C

Pre-Amplifier Circuitry (95-8716)



Specification

Electrical

Number of channels	18
Input current range	+/- 10 uA max
Output	+/- 1 V (for max. frequency, min distortion) +/- 2 V max.
Gain (transimpedance)	100 k ~~Ohms~~ V/A
Bandwidth (1V p to p)	100 KHz (options for lower bandwidth possible)
Accuracy	+/- 1% of full scale
Linearity	+/- 0.1%
Noise	10uV p to p (amplifier only)
Offset	10mV max
Diode bias	external connection common to all diodes
Power supplies	+/- 8 V (+/- 12 V max)
Power consumption	1W
Operating temp. range	0 C to +40 C

NB. This specifiation is for a "typical" design various parameters can be optimised for a given application .

Mechanical

Input	40 pin dil 0.6 in. socket
Output	edge connector type for soldering wires
pcb	1 in x 2.5 in
Storage temp. range	-40 C to +125 C

Notes
START mechanical connections –

Die cast aluminium box 115mm x 90mm with 18 off 2 pole Lemo connectors and 1 off 4 pole Lemo connector.

Power		4 pole Lemo size "O" (1 off)
	Pin 1	positive supply + 8 volts
	2	negative supply – 8 volts
	3	0 volts
	4	0 volts
Output		2 pole Lemo size "O" (18 off – 6 x 3)
	Pin 1	output for head amplifier channel
	2	0 volt

M.E.U.Smith
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ext 3719

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