The EUV/X-ray Astronomy Calibration and Testing Facility at the Osservatorio Astronomico di Palermo "G. S. Vaiana"

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ABSTRACT

We describe a facility set-up at the Osservatorio Astronomico di Palermo "G.S. Vaiana" for the development and calibration of instrumentation for EUV/X-ray astronomy.

The facility consists in a 16 meter long stainless-steel vacuum beam line, with a 1 meter diameter cylindrical test chamber opening to a class 1000 clean-room, equipped with sources, detectors and monochromators covering the energy range $\sim$ 0.005-10 keV (wavelenght range $\sim$ 1-3000 Å). It is presently being employed in the calibration of the UV/Ion shields of the High Resolution Camera (HRC) on board the Advanced X-ray Astrophysics Facility (AXAF).

Its potential applications range from the calibration and development of X-ray detectors and small telescopes to measurements of transmission and reflectivity of materials.

A more detailed description of the facility and current research projects can be found at the WWW address:

http://www.astropa.unipa.it/XACT/XACT.html

Vacuum Chamber

The vacuum chamber was manufactured by CINEL (Padova, Italy). It includes a 16 meter beam-line connecting the X-ray source to the test section, and the test section itself. The beam-line consists of 11 tubes, each 1 or 2 meter long, assembled together to reach the overall length of the pipe. The diameter of the pipe increases from the source end (150 mm) to the test section (630 mm). This configuration allows a a full area (630 mm diameter) illumination from the X-ray source minimizing the volume (and the internal surface of the pipe). The first 6 tubes (from the source end) are 1 meter long, and three of them can be removed reducing the length of the pipe to 13 meters. These three tubes can be used as vacuum chambers for independent experiments or to have an additional beam line after the test section, if a mirror assembly has to be tested.

The test section is a 1 m diameter, 1 m long stainless steel cylinder with several ports for inspection, instruments and feed-troughs, and a door in the back having the same diameter of the chamber. The test section can be isolated from the pipe by means of a sliding gate valve with the same diameter of the pipe (630 mm).

The internal surface of the pipe has been treated, like that of the test section, with quartz micro-spheres. The chamber (pipe plus test section) can reach a minimum pressure of 5×10^{-8} *mbar* (without operating gas flow counters), while normal operation is in the range $5 \times 10^{-7} - 5 \times 10^{-6}$ *mbar* scale, depending on the leak rate of the gas counter windows. The whole chamber is mounted on a stainless steel modular frame.

X-Ray Source

The X-ray source is a multi-anode micro-focus source manufactured by J.E. Manson CO., Inc. Electrons produced by a hot filament are accelerated by an electric field and impinge on an anode, producing X-rays. Six different anodes can be selected, without breaking the vacuum in the source chamber. The source also contains selectable filters that can be used to further define the beam spectrum. It can produce X-rays in the 0.1-10 keV band, with a spot size about 1 mm. Due to its high efficiency (it can be operated with only 5 watts), it produce, at 16 meters, a flux of the order of 10^5 photons per cm^2 per second. The quite strong X-ray flux of the source allows the addition of a monochromator (e.g. a transmission grating based device) to the system, and, in any case, permits calibration experiments with short exposures. The X-ray source system, producing two matched orthogonal beams, includes a Gas Flow Proportional Counter monitoring the flux of the secondary beam.

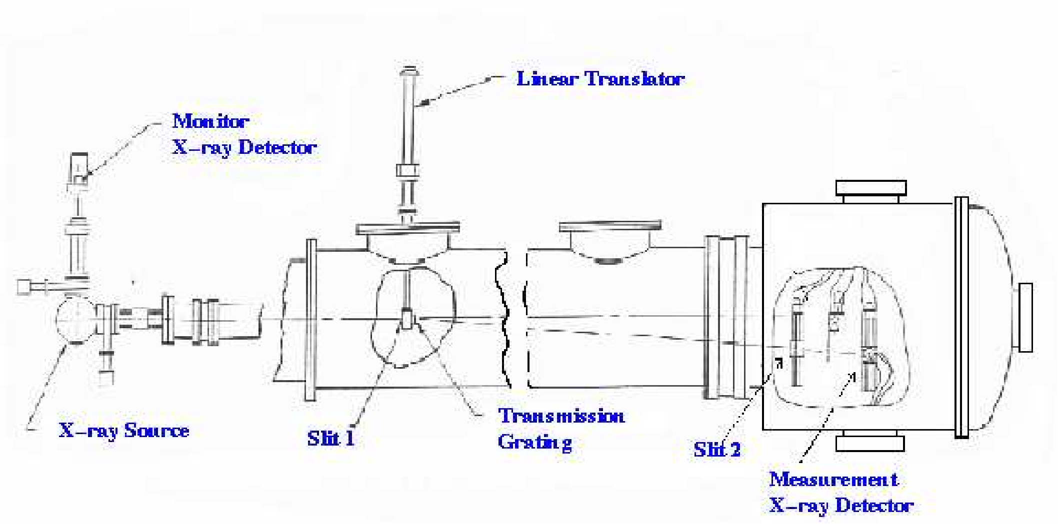
X-Ray Detectors

- Two commercial Gas Flow Proportional Counters (GFPC) manufactured by LND, and a Gas Flow Proportional Counters (GFPC) manufactured by J.E. Manson CO., Inc. with nearly 34% energy resolution at 1.5 keV.

- Drift-less Gas Scintillation Proportional Counter (GSPC), developed in house, with nearly 16% energy resolution at 1.5 keV (Barbera et al. 1994c).

- Micro-channel plate based detector with resistive anode encoder and front plate coated with KBr (Quantar Technology Inc., Santa Cruz, CA, USA) with 25 mm active diameter, and 100 microns spatial resolution.

X-Ray Transmission Grating Monochromator



The transmission grating monochromator consists of an adjustable (5-2000 microns) entrance slit (slit 1) to focus the beam, an AXAF type LETG grating facet (1000 lines/mm), and an adjustable exit slit (slit 2) to select the energy of interest. The entrance slit and grating facet are mounted on a magnetically coupled linear translator with 30 cm linear travel. The monochromator provides a nominal spectral resolution of nearly 1 Angstrom.

In the picture below the adjustable entrance slit of the X-ray transmission grating monochromator with the grating facet on a stainless steel annular frame are mounted inside the vacuum pipe. This picture has been taken while the grating was illuminated by a laser beam during allignment procedure.

Ultraviolet Sources

- Hollow cathode gas discharge source (McPherson, Acton, MA, USA) sufficiently light and compact that it can be mounted on the movable slit assembly of the grazing incidence monochromator available at the XACT facility. The source produces a number of intense emission lines in the 200 - 2000 Angstrom range, by means of an electrically excited gas discharge within a hollow cathode. A high current (1 A), high voltage supply (5 kV), cooling water chiller, gases, and gas handling system are required to run the source.

- Pen-ray mercury discharge lamp (UVP, San Gabriel, CA, USA) that provides a useful calibration line at 2537 Angstrom. A HV power supply (2 kV) is required to run the source.

Ultraviolet Detectors

- Microchannel plate based detector with resistive anode encoder and front plate coated with KBr (Quantar Technology Inc., Santa Cruz, CA, USA) with 25 mm active diameter, 100 microns spatial resolution, and sensitivity up to 1200 Angstrom UV wavelengths.
- Photomultiplier tube with Cs_2Te photocathode and a MgF_2 window (EMR Photoelectric, Princeton, NY, USA) that provides efficient photon counting in the 1150-3550 Angstrom range.

Ultraviolet Grazing Incidence Monochromator

A 1 meter Rowland Circle mount grazing incidence monochromator McPherson model 248/310G (McPherson, Acton, MA, USA) is mounted on a lateral port of the test chamber of the XACT facility. It consists of an adjustable slit (5-3000 microns) that travels with the light source along the Rowland circle, a concave grating, and an exit adjustable slit (5-3000 microns). With two gratings 113 grooves/mm and 600 grooves/mm allows a spectral coverage of 10 - 3100 Angstrom. The monochromator provides a nominal spectral resolution of nearly 2 Angstrom with the adopted 133 grooves/mm grating.

Class 1000 Clean Room

The test chamber door opens to a 15 m^2 certified class 1000 clean-room according to federal standard 209/E. The entrance is through a small dressing-room where clean cloth (footwear, frocks, caps or hoods, gloves) are worn, and an air shower room. Six HEPA filters are located on the ceiling and the air volume in the clean-room is circulated about 70 times per hour. The Clean-room is also provided with a class 100 laminar flow clean bench, a dry Nitrogen cabinet for sample storage and a pass-thru with interlocked doors.

Other Tools and Accessories

Among other available tools at XACT facility are:

- Vacum compatible computer controlled micro-positioning system including linear, 2-D and rotary stages;
- Leak detector;
- Machine shop provided with a lathe, a mill, and other standard tools for machining various type materials;
- Facility for stretching polypropilene films for proportional counter windows;
- Computer controlled facility for winding proportional counter window meshes.

Main Current Research Project

The Osservatorio Astronomico di Palermo "G.S.Vaiana" is presently involved in the development and calibration of the AXAF High Resolution Camera (HRC) UV/Ion shields.

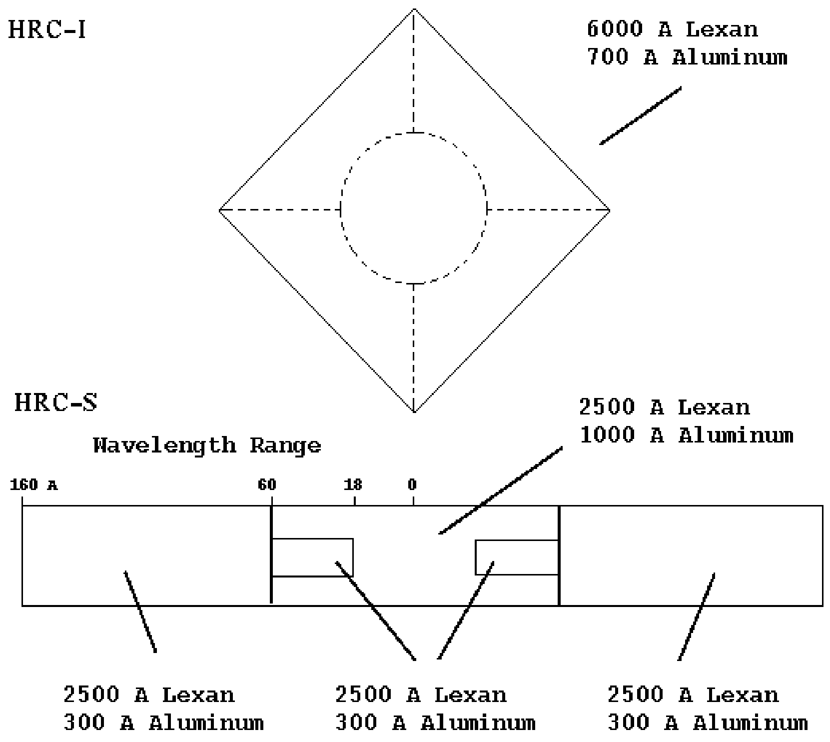
The HRC , being developed by Smithsonian Astrophysical Observatory (SAO), will be one of the two detectors to be used in the focal plane of AXAF (launch 1998). The HRC is designed to perform high spatial resolution imaging (approx. 0.5 arc seconds FWHM) using a pair of 100 mm X 100 mm MCP's in a chevron configuration with the front plate coated with CsI (referred to as HRC-I) and to readout AXAF's Low Energy Transmission Grating's (LETG) high resolution spectra (approx. 0.05 Angstrom) with an array of 3 pairs of MCP's each 20 mm X 100 mm in a chevron configuration with the front plates coated with KBr (referred to as HRC-S).

In the framework of the development study of the HRC UV/Ion shields, UV transmission measurements (256.3 - 2301.6 Angstrom) have been conducted at Space Science Laboratory University of California at Berkeley for different plastic materials, namely Lexan (the present baseline material), Polyimide, Parylene-C, and VYNS. Linear attenuation coefficients have been calculated for the four plastic material in the surveyed UV wavelengths. VYNS and Parylene-C have been ruled out as alternative to Lexan being too transparent in the UV. Polyimide turned out to be a possible alternative, being more opaque than Lexan in the UV region where Lexan is known to have a leak (near 1500 Angstrom), and at wavelengths longer than 2000 Angstrom (Barbera et al. 1994a).

Soft X-ray transmission measurements have been conducted using electron impact X-ray sources at SSL (Berkeley) and XACT facility in Palermo (108.7 - 1490 eV). Transmission data have been fitted with a model transmission to determine areal densities of sample films, and densities of the plastic materials (Barbera et al. 1994a).

X-ray transmission measurements of Lexan plastic film samples have been conducted at the National Synchrotron Light Source (Barbera et al. 1994b) in order to define an accurate X-ray transmission model as a function of incident photon energies. Likely extended X-ray absorption fine structures (EXAFS) have observed in the oxygen edge of Lexan (Barbera et al. 1994b). Further synchrotron transmission measurements at higher energy resolution to better define the trasmission model near the absorption edges will be conducted at BESSY sinchrotron (Berlin) in January-February 1996.

Acoustic and vibration tests of baseline design UV/Ion shields' samples, simulating the instrumentation stresses during a Shuttle launch, have been conducted at the Marshall Space Flight Center (MSFC) and have proven the feasibility of the unsupported shield design.



The baseline design (above figure) of the UV/Ion shield for the HRC-I consist of a film of Lexan 6000 Angstrom thick coated with 700 Angstrom of aluminum. The outer segments and part of the inner segment of HRC-S UV/Ion shield consist of a film of Lexan 2500 Angstrom thick coated with 300 Angstrom of aluminum, while the remaining area of the inner segment has a thicker aluminum coating (1000 Angstrom) to optimize the soft X-ray response but still retaining the ability to use the HRC-S detector as a backup to the HRC-I.

The calibration measurements on flight and back-up UV/Ion shields that will be conducted at the XACT facility (Palermo) starting October 1995 will include:

- X-ray transmission measurements with 1 mm spatial resolution of all the UV/Ion shield area at nearly four energies in the range 0.109 - 1.5 keV;
- X-ray transmission measurements with 1 mm spatial resolution at about 100 positions uniformly distributed along the filter at nearly 6 energies in the range 0.109 - 2.98 keV, using the transmission grating monochromator;
- UV transmission measurements (upper limits) with variable spatial resolution (1 cm spatial resolution where the UV transmission is below the minimum detectable limit) at few UV wavelentghs in the range 256.3 - 2537.0 Angstrom.

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