EUVE Guest Observer Program Handbook

UCB/EUVE Call for Observing Proposals
97-EUVE-06
Appendix C

Extreme Ultraviolet Explorer

Guest Observer Center Documentation

The EUVE Guest Observer Center

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PREFACE

This *Handbook* will acquaint potential Guest Observers with the Extreme Ultraviolet Explorer (EUVE) Spectrometer, Scanning Telescopes, and Deep Survey Scanner. It should be used as a guide to preparation of proposals, and as a basic source of information about the EUVE mission and scientific payload. It does not contain statements of NASA policies concerning proposal evaluation, target selection or Peer Review processes. Anyone wishing detailed information about the rules and deadlines governing this program should consult the current UCB/EUVE Call for Observing Proposals for the EUVE Guest Observer Program, issued 15 October 1997, and available from the Center for EUV Astrophysics (CEA) at the University of California, Berkeley (UCB), at the address given in Chapter 1.

Fourth edition: July, 1995

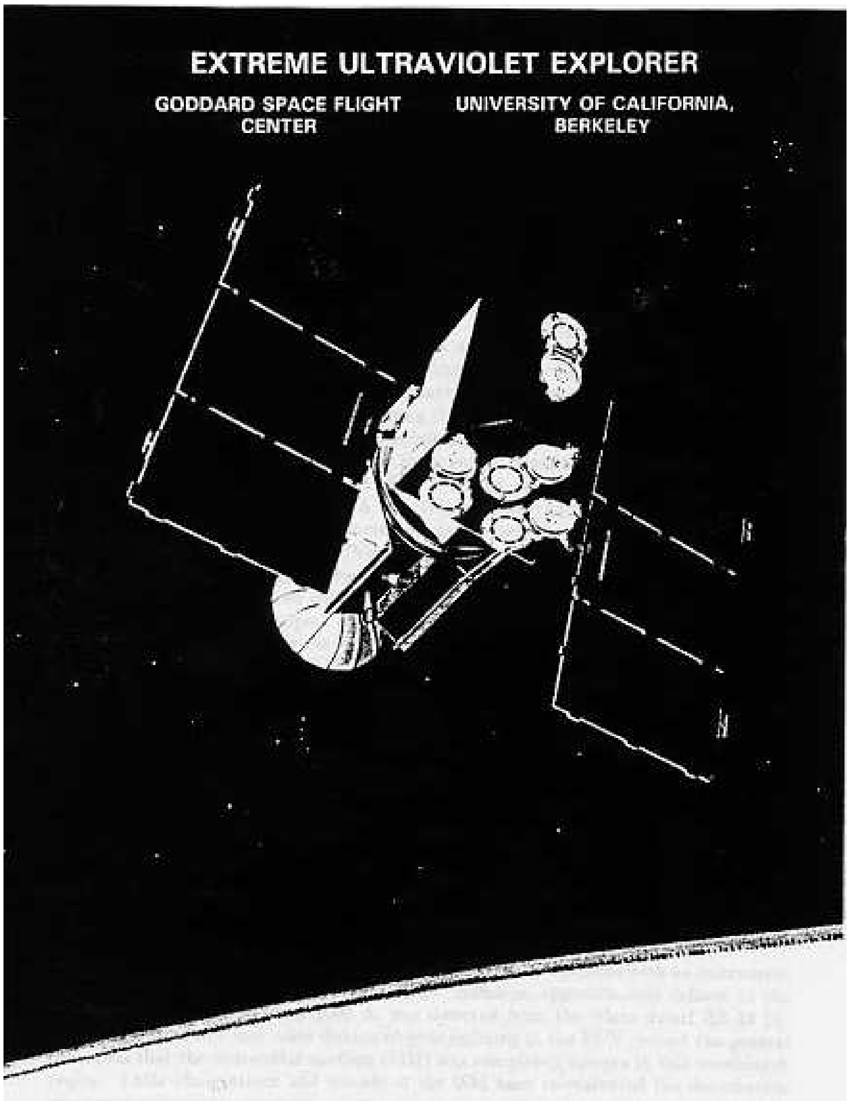
This is the fourth edition of the *EUVE Guest Observer Handbook*, released to accompany the fourth EUVE NASA Research Announcement (NRA) in July, 1995, and only updated slightly for the sixth announcement, released in October 1997. At this writing, the EUVE Guest Observer (EGO) Program is in its fourth year-long cycle of observations. The instrument characteristics and performance have remained stable throughout the last year. The material in this *Handbook* is therefore largely unchanged from that released for Cycle III in 1994. The most significant changes are:

a) References to names and locations of online resources.
b) Information on changes to EUVE's default operations configuration.
c) Deep Survey data are now routinely delivered to all GOs.
d) Spacecraft operation and GO program now run by the CEA.

All proposers should have both the *Handbook* and *Addendum* for preparing their 1997 proposals.

The instrument calibration data available via the CEA *ftp* site and the WWW have not changed since Cycle IV, but their location has changed to a new directory. Please read about the potential for significantly lower backgrounds in future observations, as described in the *Addendum*.

The information in the *Handbook* reflects the EGO Center's current understanding of the instruments and is provided on a best-effort basis. The characteristics of the EUVE science instruments may change in the future. Questions concerning the contents of this document should be directed to the EUVE Guest Observer Center at the University of California, Berkeley.



The Extreme Ultraviolet Explorer

Chapter 1

THE EXTREME ULTRAVIOLET EXPLORER

1.1 Introduction

The Extreme Ultraviolet Explorer (EUVE) is a NASA explorer-class satellite mission devoted entirely to observations in the wavelength range from 70 to 760 Å. The science payload incorporates five separate instruments: four photometric imaging systems and a three-channel EUV spectrometer. During the first phase of the mission, the imaging instruments were used to conduct a complete sky survey in four different bands in the EUV. The survey results are available to the scientific community in the first EUVE sky survey bright source list and the first EUVE all-sky catalog. The second part of the mission has been conducted by NASA as a Guest Observer program, for which pointed spectroscopic observations are conducted for guest scientists under proposals submitted to NASA and supported by the EUVE Guest Observer Center at Berkeley. The mission lifetime will extend through at least a fifth year of observations. Further extensions of the EUVE mission will be partially contingent upon review processes. To support an extended mission, please contact the chair of the EUVE Science Advisory Board (ESAB)[1] or the EUVE Guest Observer Center (address below).

The EUVE Guest Observer (EGO) Program is supported by the EUVE Guest Observer Center (EGO Center) at the Center for Extreme Ultraviolet Astrophysics (CEA), at the University of California, Berkeley. The policies of the EGO Program are specified in the recent UCB/EUVE Call for Observing Proposals. This *Handbook* is produced by the EGO Center as a guide to choosing appropriate targets for observation and preparing proposals. The rest of this chapter gives a broad overview of the EUVE mission and the EGO Center.

1.2 The EUVE Mission

1.2.1 Scientific Background

The first non-solar observations in the extreme ultraviolet were made with an instrument on the Apollo-Soyuz spacecraft in 1975. EUV radiation, approximately defined as the wavelengths between 100 and 1000 Å, was detected from the white dwarf HZ-43 [3]. The discovery of this and other distant objects emitting in the EUV revised the general consensus that the interstellar medium (ISM) was completely opaque in this wavelength region. Later observations and models of the ISM have re-evaluated the distribution and EUV

[1] Dr. Steve Howell, University of Wyoming, Laramie, WY 82071; 307/766-5402; (showell@mothra.uwyo.edu).

photoabsorption of interstellar hydrogen and helium [15], [6]. They suggested that a sky survey might detect sources as far as 1000 parsecs from the sun, or farther in some directions, depending on the distribution of neutral interstellar material. The Voyager and EXOSAT missions and the ROSAT EUV all-sky survey and EUVE sky survey have since discovered other sources, making a list of more than 1000 objects that emit measurable radiation in the EUV. Types of objects that have been observed in the EUV are planetary atmospheres, hot stellar coronae, late type and cataclysmic variable (CV) stars, hot stellar remnants, and active galactic nuclei (AGN). The local ISM also emits measurable amounts of EUV radiation.

The EUVE instruments were built under contract from NASA Goddard Space Flight Center by the Space Astrophysics Group (SAG), which is part of the CEA. The science payload is integrated with the Multimission Modular Spacecraft (MMS), NASA's Explorer Platform,. It was launched on June 7, 1992, into a 550 km circular orbit with an inclination of 28°. After initial testing and calibration, the satellite started surveying the sky in great circles with the three co-aligned "Scanner" instruments at 3 revolutions per orbit (RPO). The survey observations were completed in January, 1993. At the same time, a parallel "deep survey" was conducted along a two-degree strip covering about half the ecliptic. The first year of pointed observations with the EUV spectrometer were begun immediately after completion of the all-sky survey.

EUVE Mission Timeline

- 1983: Fabrication of the instruments begins at Berkeley.
- 1989: Instruments and their electronics completed.
- 1990: Science payload calibrated and delivered to NASA-GSFC for integration.
- June 7, 1992 EUVE launched from Cape Canaveral Air Station aboard a Delta II launch vehicle.
- July 11, 1992 EUVE all-sky survey observations begin.
- January 22, 1993 Guest Observation Cycle I begins.
- August 17, 1993 First Target of Opportunity (TOO) observed: SS Cygni.
- August, 1993 Mini IOC and Thermal testing to determine effect of wider pointing range on the spacecraft and power systems.
- October, 1993 Pointing range increased to 90 degrees from antisun
- January 23, 1994 Beginning of GO Cycle II observations.
- February 20, 1995 Beginning of GO Cycle III observations.
- March 1, 1996 Beginning of GO Cycle IV observations.
- March 1, 1997 Beginning of GO Cycle V observations.
- March 1, 1998 Beginning of GO Cycle VI observations (planned).

1.2.2 Science Goals and Instrument Overview

The first scientific goal of the mission was to make a complete sky survey in four bandpasses between 70 and 800 Å that located sources to better than 1 arc minute and obtained absolute flux measurements. The three scanning survey instruments each comprise a grazing incidence telescope, a two-dimensional imaging microchannel plate (MCP) detector, and logic and event-processing electronics (see figure A-1 and A-4 in *Appendix A* of this *Handbook*). Two of the scanners, Scanners A and B, are identical short-wavelength imaging systems, each employing two filters between 70 and 290 Å. The third instrument, Scanner C, is similar, but operates in two longer-wavelength regions from 400 to 700 Å. Their principles of operation and design parameters are described further in chapter 2 and *Appendix A* of this *Handbook*. The resolution of the resulting sky map for fully scanned sources is approximately 2 arc minutes.

The sky survey observations were completed in January, 1993, and the list of optically identified bright sources [16] from the survey is available from the CEA/EUVE *ftp* site, or from the Astrophysics Data System (ADS). See also the First EUVE Source Catalog [2]. Average exposure times for the objects on the bright source list is 800 seconds, with the longest exposures at higher celestial latitudes.

In addition to the all-sky survey, a long-exposure "deep survey" was carried out during the scanning phase. The Deep Survey instrument uses half the light from the fourth of the telescopes, called the Deep Survey/Spectrometer (DS/S) telescope, which is mounted perpendicular to the scanner telescopes on the science payload (see figure 1-1). It is similar to the other scanners in design, and has two broad band spectroscopic filters similar to those of the short wavelength scanners, which cover two bandpasses between 60 and 285 Å (see figure 2-1).

The DS instrument was pointed in the anti-sun direction along the satellite's axis of rotation during the survey. As a result of this more restricted scanning pattern, long exposures on the order of 20,000 seconds/0.1° pixel over a $2° \times 180°$ swath of sky along the ecliptic plane were obtained. This produced a survey section with sensitivity greater than that of the other Scanners alone, by about a factor of about 10.

The second scientific goal of the mission is to make pointed spectroscopic observations in the EUV. The DS/S telescope also feeds light to the EUV spectrometer, which has three overlapping bandpasses covering the entire 70–760 Å window, with a resolution ($\lambda/\Delta\lambda$) of 100–400. Targets include sources discovered in the recent sky surveys, as well as previously known sources and other likely candidates. Individual spectral lines from point sources can be detected with a 3-σ threshold of approximately 7×10^{-4} photons/cm^2/second in 40,000 seconds. A more detailed description of the DS/S instrument and its calibration follows in chapters 2 and 3 of this *Handbook*.

1.2.3 Explorer Platform and Mission Operations

The Explorer Platform used by EUVE consists of the Multimission Modular Spacecraft (MMS) and accompanying Platform Equipment Deck (PED). The MMS is a 3-axis stabilized, zero-momentum satellite with a stellar reference attitude control system, manufactured by the Fairchild Space Company [7]. The PED forms the interface between the spacecraft and scientific payload. It incorporates solar panel modules, antennae, and other mission-specific equipment. In this section the MMS/PED combination will be referred to as "the spacecraft." Figure 1-1 shows the configuration of the science payload and its relation to the spacecraft in the integrated EUVE satellite.

The satellite attitude, or "aspect" is continually reported and is periodically adjusted by the modular attitude control system (MACS). The MACS can point the spacecraft using guide stars in its two fixed-head star trackers (FHST's) or one guide star and a digital fine sun sensor (DFSS) as reference points. To maintain pointing, the system updates attitude estimates obtained from the satellite inertial reference unit (IRU) gyros with information from the guide star positions in the star trackers, according to the stars' recorded positions. The satellite can be pointed and maintained with an accuracy of at 10–60 arc seconds (3σ), depending on the number of reference stars available for a given pointing. It refers to an onboard catalog of over 1000 guide stars. Aspect reports is updated in the telemetry every 1.024 seconds.

Pointing and other instrument commands are relayed from the EUVE Science Operations Center (ESOC) at CEA to the satellite via GSFC and TDRSS satellite links. Command uplink capability and real time data transmission occur in contacts of 16 minute duration as often as twice per orbit. Transmissions are received by the spacecraft command and data handler (C&DH), which directs spacecraft commands to the on board computer (OBC) and payload commands to the payload's command and data processor (CDP). At the same time, data from the spacecraft are received on the ground for use in verifying source intensities and spacecraft health and aspect information.

All satellite telemetry is transmitted via TDRSS satellite and NASCOM link to the satellite communications station at Goddard Space Flight Center (GSFC). The spacecraft C&DH module creates the telemetry (TM) stream by interleaving the scientific data with science payload engineering analog voltages with spacecraft housekeeping information in a standard digital transmission format. The spacecraft has two tape recorders for telemetry storage between data transmissions. Each has a capacity of $1{\times}10^9$ bits. The TM transmission rate is 32 KBPS, of which one half is allocated to the science instruments. After the telemetry is received by Goddard via TDRSS, the scientific and instrument health data are separated and relayed to the ESOC at CEA in batch mode every three hours. The total time elapsed from satellite recording to receipt of data at Berkeley is roughly eight hours.

1.3 EUVE Guest Observer Center

The EUVE Guest Observer Center was formed under a contract between NASA and UCB to support all activities of the mission's pointed phase which involve the Guest Observer directly. The EGO Center provides this *Handbook* and other informative material to proposers, facilitates proposal processing, and conducts technical reviews of proposals before they are submitted to the Peer Review Panel. After the proposal selection process, the EGO Center is responsible for data acquisition and preliminary processing, and provides the data, software tools, and support to GOs throughout their analysis [17]. The EGO Center provides direct assistance to proposers and GOs at all times.

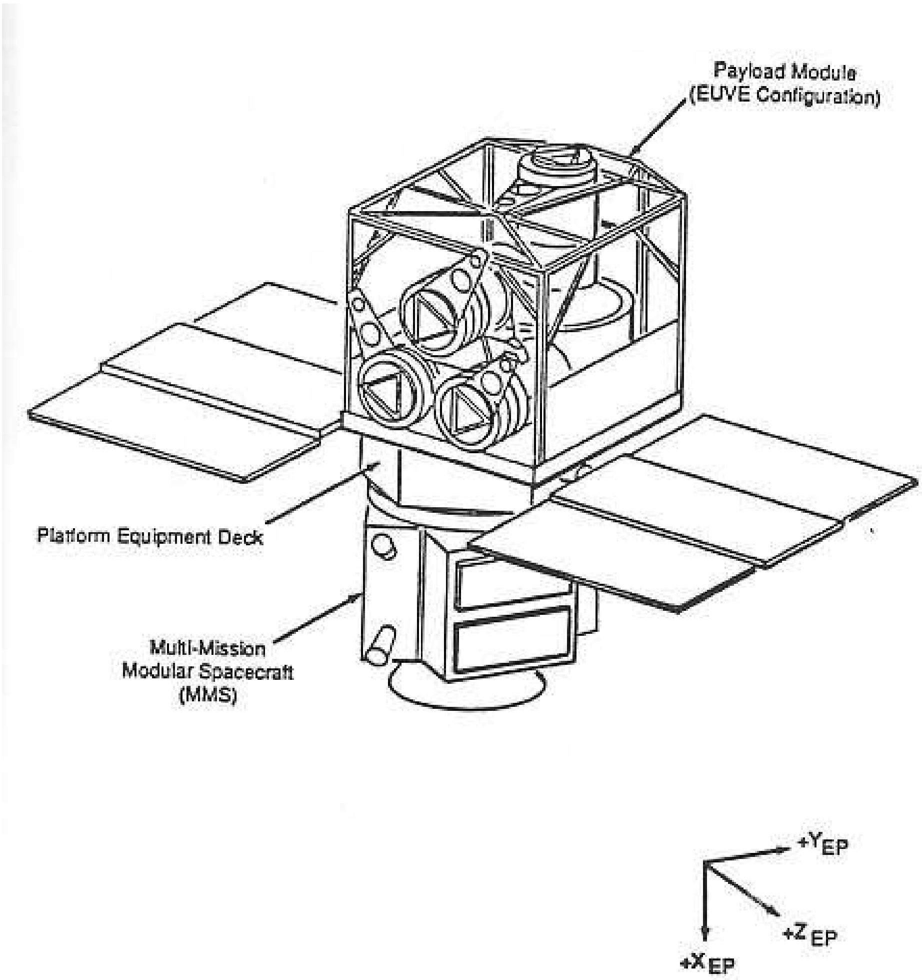


Figure 1-1: EUVE-Explorer Platform configuration

The Technical Justification section of each proposal is reviewed by EGO Center scientists to verify projected throughputs, and analysis goals in terms of the most current knowledge of instrument and to flag special pointing and timing requirements. The Peer Review Panel, assembled by NASA from various related fields, judges the proposals on general scientific merit, and selects those technically approved proposals thought to promise the best scientific returns. After both reviews are complete, a Peer Review Panel meeting is held to combine the information and make final decisions on awards of time. The Review Panel also determines target priorities: high scientific priority (type 1) and other approved targets (type 2), as described in Appendix A of the UCB/EUVE Call for Observing Proposals. The EGO Center provides the Peer Review Panel with technical support and information about the scheduling process.

Proposals for Targets of Opportunity (TOO), which are not part of the regular proposal cycle, may be honored under the rules given in the Call for Observing Proposals. The projected response time is now on a best-bet effort after TOO request approval. See sections 3.9 and 4.2 for more details on TOO's and scheduling.

After telemetry is received in the Berkeley ESOC, it is immediately stored on tape and later transferred to optical disks. The appropriate telemetry for each observation is then selected from storage by the EGO Center and restructured to separate photon data and collate relevant engineering quantities. Photon event data are processed to remove the primary instrument effects, and first-cut spectra are extracted for the GO. All photon data taken from the three spectrometer channels during pointed observations are proprietary to the Guest Observers named in the applicable proposal for a standard interval, given in the Call for Proposals.

After the Guest Observer proprietary period, data enter the public domain and are accessible through the EUVE public data archive [23]. The archive is most easily accessed via the CEA *WWW*site. See section 1.4.1 below, for URL information.

1.4 Using This Manual

The previous sections have given only a brief description of the EUVE mission and the EGO Program. The balance of this *Handbook* describes the EUVE spectroscopic and photometric instruments in more detail, and provides information on resources and services to be provided for Guest Observers. Chapter 2 begins with a brief overview of the basic components and operating principles of the instruments for those unfamiliar with the methods of EUV instrumentation, and describes the design of the EUVE Spectrometer and its calibration. The Deep Survey imaging system is also described. More detailed descriptions of the survey instruments are deferred to *Appendix A*.

Chapter 3 contains more precise information characterizing the Spectrometer's performance, and presents formulas for use with source models in planning observations. The functions and formulas provided should be sufficient for assessing the scientific viability of various types of observations, estimating count rates from prospective targets, calculating exposure times, and completing part 2 of the Target Summary Form. Chapter 3 ends with a look-up guide to the symbols and formulas used in the text.

Chapter 4 is an introduction to observing with EUVE and doing data reduction at the Center for EUV Astrophysics. The processes of technical review, schedule planning, data acquisition, and interaction of Guest Observers with the EGO Center are briefly described. Data analysis facilities and programming support are outlined.

The appendices include descriptions of the survey instruments, a partial list of project acronyms, and a detailed bibliography on the interstellar medium (ISM).

This *Handbook* is Appendix C to the UCB/EUVE Call for Observing Proposals for the EUVE Guest Observer Program. Copies of the Call for Proposals may be obtained from the CEA-EUVE *WWW* or *ftp* site, listed in section 1.4.1 below, or from the EGO Center:

EUVE Guest Observer Center
University of California at Berkeley
The Center for EUV Astrophysics
2150 Kittredge Street
Berkeley, CA 94720
(510) 642-3032
FAX: (510) 643-5660
email: egoinfo@cea.berkeley.edu

The reader should refer to the current EUVE Call for Proposals for schedules, proposal due dates, forms, submission instructions, and policies specific to proposal preparation. The UCB/EUVE Call for Observing Proposals, also provides contact information for other questions in these areas. If in any instance the language of this *Handbook* conflicts with that of the Call for Proposals, statements in the current UCB/EUVE Call for Observing Proposals take precedence. Questions on the instrumentation that are not answered by this *Handbook* should be directed to:

EUVE Guest Observer Center
c/o Dr. Damian Christian
University of California at Berkeley
Center for EUV Astrophysics
2150 Kittredge Street
Berkeley, CA 94720-5030
email: egoinfo@cea.berkeley.edu

All *egoinfo* mail is answered promptly by the appropriate EGO Center scientist or staff person.

1.4.1 Electronic Access to NRA Materials

Both the EUVE *ftp* and *WWW* sites contain copies of all appendices and forms for this Call for Proposals, and tabulated calibration data in this *Handbook*, as well as other information relevant to the EUVE mission.

The easiest way to list and view the available materials is to use the World Wide Web (abbreviated *WWW*). The *WWW* Uniform Resource Locator (URL) of the CEA Home Page is:

http://www.cea.berkeley.edu/

Materials specifically regarding this Call for Proposals are available via CEA's *WWW* site at URL:

http://www.cea.berkeley.edu/nra97

For FTP access to this Call for Proposals, on the CEA Home Page select the highlighted item labeled **"FTP Access"**. This will list the top level directory of the CEA *ftp* site. Select the directory *nra97* to view the Call for Proposals materials. Be sure to view the file *README* in this directory to get the most up-to-date instructions and information on the these materials. Note that any World Wide Web client can be used.

If you wish to use standard *ftp*, the **Internet** address for the CEA/EUVE *ftp* site is:

EUVE NRA materials on *ftp*:

ftp.cea.berkeley.edu
or
128.32.154.12

In the following command examples, a percent sign (%) is used to indicate a prompt in the user's operating system. Start the *ftp* program by typing:

% `ftp ftp.cea.berkeley.edu`

to open the CEA/EUVE *ftp* site. Use the login name "anonymous" and give your full **Internet** address as the password. The Call for Proposals materials are in the subdirectory *pub/nra97*. You can always go to this directory with the *cd* command:

ftp> `cd /pub/nra97`

The command *ls* will list the directory's contents. The file *README.txt* contains information about each of the files in the directory. All users should read *README* to get the most up-to-date instructions on the Call for Proposals materials.

The way to read a file in *ftp* is to transfer it to your system using the command *get*, and view it in your local operating system. Make sure to select "binary mode" before transferring any files by typing the command *bin*. For example, to obtain a copy of *README.txt*, set *ftp* to binary transfer mode, and use the *ftp* command *get*:

ftp> `bin`

ftp> `get README`

Use the information in *README* to decide which files you want. You can obtain any of the other files with a similar command. Always make sure that *ftp* is set to binary transfer mode before using *get*. To obtain all the Call for Proposals materials in a single compressed tar file, *get* the file *nra.tar.Z* (this file is rather large):

```
ftp> get nra.tar.Z
```

The EUVE public archive site is also accessible at the same *ftp* address, or via the *WWW* at CEA's HomePage. The public archive contains software, EUVE news, sample extracted spectra, bright source lists, and numerous publications.