Chapter 4

OBSERVING WITH THE EUVE SPECTROMETER

This chapter describes the interactions of Guest Observers with the EGO Center before, during, and after their observations are made. The EGO Center at CEA in Berkeley is responsible for conducting the technical review to assure the practicality of proposed observations, acquiring and reducing EUVE Spectrometer data, and for providing software tools and facilities for the completion of spectral reductions by Guest Observers. Specific sections include information on the technical review which is conducted by the EGO Center scientists, observation scheduling, data acquisition, nominal reductions, and delivery, and the facilities and services available to Guest Observers through the EGO Center.

4.1 Proposal Technical Review

Proposal review is performed under supervision of the EUVE Science Advisory Board (ESAB), and consists of a Technical Review, followed by the Scientific Peer Review. After proposals are received by the ESAB, the proposed observation plans are reviewed by EGO Center scientists, who review their feasibility and identify difficulties that might arise. Technical reviewers use the assumed flux at the telescope, the estimated source count rates and backgrounds, and the science goals, such as required signal to noise, or other expected results. The scientific material used to justify the estimates of source flux, hydrogen column density, and observed flux at the telescope are evaluated in the Scientific Peer Review only. During Technical Review, any reasons why the observations as proposed may not fulfill the scientific criteria are summarized, and adjustments may be suggested. The Reviews and any recommendations are passed to the EUVE Peer Review Panel for consideration in their evaluations of proposal scientific merit. Other details of proposal selection are described in Appendix A of the current UCB/EUVE Call for Proposals..

4.2 Observation Scheduling

The Berkeley operations team begins observation scheduling as soon as the details of the approved proposals become available. Scheduling is conducted in cooperation with the Flight Operations Team (FOT) at CEA. All observations are scheduled at least 4 weeks in advance, and science plans are approved by the FOT before implementation. Observation scheduling for the current Call for Proposals will begin sometime after February 1998, and these observations will commence in March, 1998.

4.2.1 Coordination and Communication with the GO

Most communications concerning target parameters, scheduling, and data acquisition take place between Guest Observers and the EGO Center. Proposers submit electronic target lists with their proposal, by which they confirm their target coordinates and other information such as special timing and pointing requirements. The EGO Center will help GOs to define pointing and timing requirements that support their stated scientific goals, but any substantial changes in observing programs must be approved on a case-by-case basis by the ESAB.

To assist GOs who will be making simultaneous observations with other instruments, tentative schedule information is made available well in advance through the CEA/EGO HomePage on the World Wide Web. Once observations are scheduled in an approved science plan, the EGO Center notifies each PI of the planned date and time of their observations, via electronic mail.

Observations of calibration targets may be scheduled independently by the EUVE science team as often as once per month. Proposers who wish to make new observations of calibration targets used in previous Cycles, or who wish to request that a particular target be observed for instrument calibration purposes, should acquaint themselves with the policies on data rights for calibration objects in the current UCB/EUVE Call for Proposals, Appendix A.

Unforeseen schedule changes are occasionally necessary for various reasons. Every effort is made to insure that GO science is not compromised.

4.2.2 Physical Pointing Constraints

There are several types of physical constraints that may affect the scheduling of any pointed spectroscopic observation. GOs are not expected to anticipate them, but should be aware that they may limit the times when a target can be observed, and the length of any single pointing. Constraints on EUVE may be of special concern to those whose programs require observations to be coordinated with other satellites or observatories.

The most important physical constraints are listed below. These and several less stringent conditions are all tested by the *Target Visibility* routine referred to in section 3.3.

- Spectrometers and Scanners must point no more than 90° from the anti-sun direction[1].
- Roll angles are usually restricted to a range of $\leq 33°$ in order to prevent overheating of the Modular Power Subsystem (MPS) and MACS portions of the PED. This requirement is balanced against the need to adequately illuminate the solar panels.
- At least one guide star, from among the on-board list of 1060 stars, must be in the star trackers' field of view, subject to the other constraints. Availability of guide stars may require changes in the spacecraft roll angle during any observation. Guide stars must be free from interference from nearby objects to be usable.
- The lunar disk must not be near the field of view of either the instruments[2] or the star trackers.

[1] The anti-sun constraint may be violated under special circumstances, upon approvable by the observatory director.
[2] Unless, of course, it is the target!

The total number of observations with special pointing or timing requirements will of necessity be limited. Conflicts are avoided whenever possible during scheduling, but it is of the utmost importance for GOs to keep the EGO Center apprised of their progress in scheduling such observations, and to answer queries from the EGO Center as promptly as possible.

4.2.3 "Dithered" Observations

Since flat fields are not available for the Spectrometer, the effect of detector fixed pattern noise (see the box in section 2.2.4) is alleviated for bright continuum sources by pointing the Spectrometer at a series of randomly chosen locations near the target, rather than at a single location for the entire observation. This effectively washes out spatial QE modulations caused by the patterns of deformed micro-channels. The pointing changes are made during orbit daytimes, when the detectors are off. Any defocussing of the spectra is minimized by the EGO Program reduction software, which corrects event positions using the satellite aspect reports to produce the equivalent of an on-boresight observation.

Because the increased number of pointings has some impact on scheduling and operations, the final decision on which observations are dithered rests with the EUVE Project Scientist. Targets that warrant this treatment are identified by the EGO Center scientists using standard criteria, and the EUVE operations team at Berkeley creates a succession of different pointings in the schedule. However, given that this treatment can make a substantial difference in the quality of certain observations, it behooves proposers to identify any bright targets which they feel may be candidates for dithered observations in their Technical Justification.

4.3 Data Acquisition

All spectroscopic data is obtained during orbit nighttime, in periods of approximately 25 to 33 minutes. The observation begins when ESOC instrument controllers transmit the necessary pointing and instrument commands for a scheduled target to the satellite from the ESOC at Berkeley. One 24-hour period of pointed observation results in $\simeq$ 25,000 seconds of nighttime data acquisition. Guest Observers need not be present in the ESOC during data acquisition. The ESOC staff are advised, if necessary, by an EGO Center scientist who is assigned to supervise the observation and act on the GO's behalf.

4.3.1 Events That May Affect Data Acquisition

There are of course various types of unexpected events that may affect any observation. These phenomena do not require changing the Spectrometer pointing or schedules, but their effect on observing time is accounted for in the planning process whenever possible, and compensatory time is added to the observation.

- Earth occultation, may result in a temporary loss of source signal, but this time does not count against the approved exposure time as noted above.

- Transits of the South Atlantic Anomaly (SAA), cause automatic detector shutdowns.
- Interference from the moon and/or the planets in or near the field of view of any of the instruments is usually ruled out in the planning stages. If this were to happen accidentally, the telemetry stream could be saturated with flux from these intervening sources.
- Lapses in data acquisition may affect the observation of time-critical events. Review section 3.8 for more information on time-critical observations.
- Should any of the Spectrometer channels fail during an observation, the advising EGO Center scientist may recommend use of alternate targets, and/or alternate pointing positions, where second order ($n = -2$) spectra will be available off-axis (see section 2.2.3).
- Observations may also be interrrupted by TOOs or emergency instrument shutdowns.

Observers are notified if their observations must be interrupted for long periods, and interrupted observations are rescheduled for completion whenever possible. Observers are notified again when their observations are complete so that they may plan to start their analysis as soon as the nominally reduced data can be delivered.

4.3.2 Deep Survey Observations and Data

Data acquired during spectroscopy observations from the co-axial Deep Survey imaging instrument are now routinely made available to GOs. These data are provided in data formats similar to those used for spectroscopic data.

Since the Deep Survey instrument is co-aligned with the Spectrometer, The Deep Survey data taken during spectroscopy observations is rendered suspect by the central deadspot described in section 2.3. For this reason, all spectroscopy pointings are now routinely offset to avoid placing the Deep Survey image in the deadspot. Radial pointing offsets of $1.5 - 2$ arc minutes are the current norm, as derived from the most recent maps of the deadspot [22]. The shifts are corrected in event processing and do not defocus the spectra or change the bandpass appreciably.

4.3.3 Data Transmission to the EGO Center

EUVE data are transferred to NASA ground stations via the Tracking Data Relay Satellite System (TDRSS). Figure 4-1 is a block diagram of the communications system between GSFC and the CEA, which relies primarily on a 1.5 Mb T1 NASCOM data line. During each TDRSS satellite contact, recorded data are downloaded, and science data and engineering monitors are transmitted in real time. EUVE telemetry is received by the ESOC at CEA and immediately archived as raw telemetry. Data from each "real time pass" (RTP) are immediately analyzed, displayed and inspected by the ESOC staff to assess instrument and satellite health. GOs are notified immediately in the event of any anomaly that requires an adjustment of the observing plan.

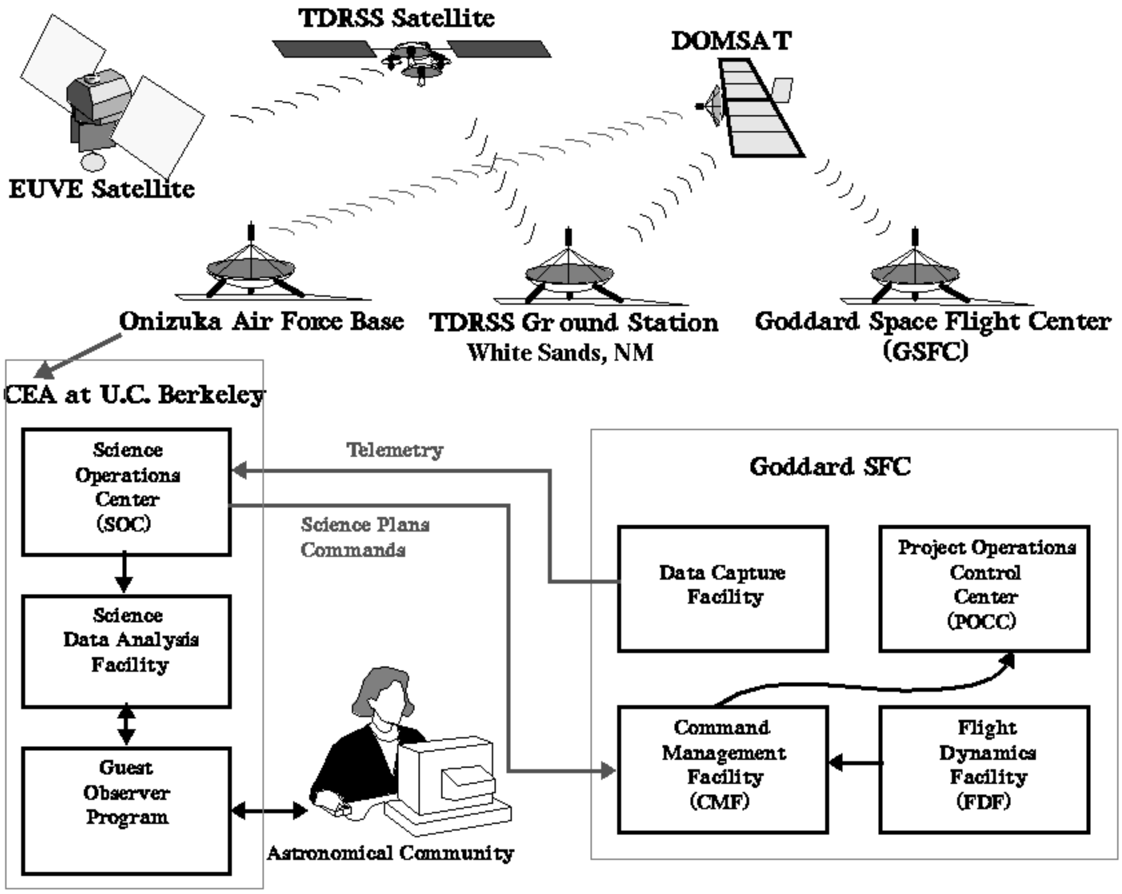

Figure 4-1: EUVE NASA–CEA communications network

4.4 EGO Center Data Processing and Delivery

Data is normally received from GSFC immediately after transmission via TDRSS. Telemetry is stored in raw format upon arrival in the EUVE telemetry archive before data reduction is performed. The steps of data reduction at Berkeley, from the satellite telemetry to nominally reduced spectra, are outlined briefly in this section, followed by a description of the data products delivered to GOs.

Each Guest Observer's data are selected from the data stream and batch-processed using the EUV layered software packages in IRAF (the Image Reduction and Analysis Facility).

The EGO Center software facilities are set up to do nominal data reduction in three separate phases:

1. Telemetry restructuring into Space Telescope (ST) format tables
2. Pipeline processing into Quick Position-Oriented Event (QPOE) files

3. Nominal extraction of raw count spectra into IRAF images using standard apertures

First, the telemetry is decommutated, photon events are separated from instrument health and satellite housekeeping data, and all the data are reformatted by specialized IRAF tasks into time-ordered ST tables.

Second, an automated "pipeline" program performs standard steps to remap events from spectrometer detector coordinates to wavelength (λ, corresponding to detector X) and imaging angle (Θ_i, corresponding to detector Y). The pipeline corrects event coordinates from spacecraft aspect reports and corrects for some instrumental effects, such as large-scale detector distortions. Wavelength and imaging angle scales are applied from a set of instrument reference data tables, derived from Spectrometer calibration observations (see section 2.2.5). Determination of λ and Θ_i for each event is done under the assumption that the target is a point source (no structure), and that all events result from first order dispersions. DS imaging events are remapped from detector coordinates to RA and Declination sky-coordinates.

The list of photon events for each detector is then resorted in position order and stored as an IRAF-compatible QPOE file for processing with IRAF/EUV tasks. The output QPOE file contains the arrival time, detector coordinates, aspect-corrected detector coordinates, and wavelength/imaging angle coordinates (for spectrometer data), for each event. The data in QPOE format may be selected and filtered to create various images. Two of the standard products delivered to the GO are (2048×2048) images made from the raw detector coordinates and the corrected coordinates, the latter of which includes the transformations to the wavelength and angle scales (spectrometer data) or sky-coordinate scale (imaging data), in the image header.

Figure 4-2 shows the flow of pipeline processing, and stages at which information from the spacecraft, instrument engineering monitors, and calibration data are input.

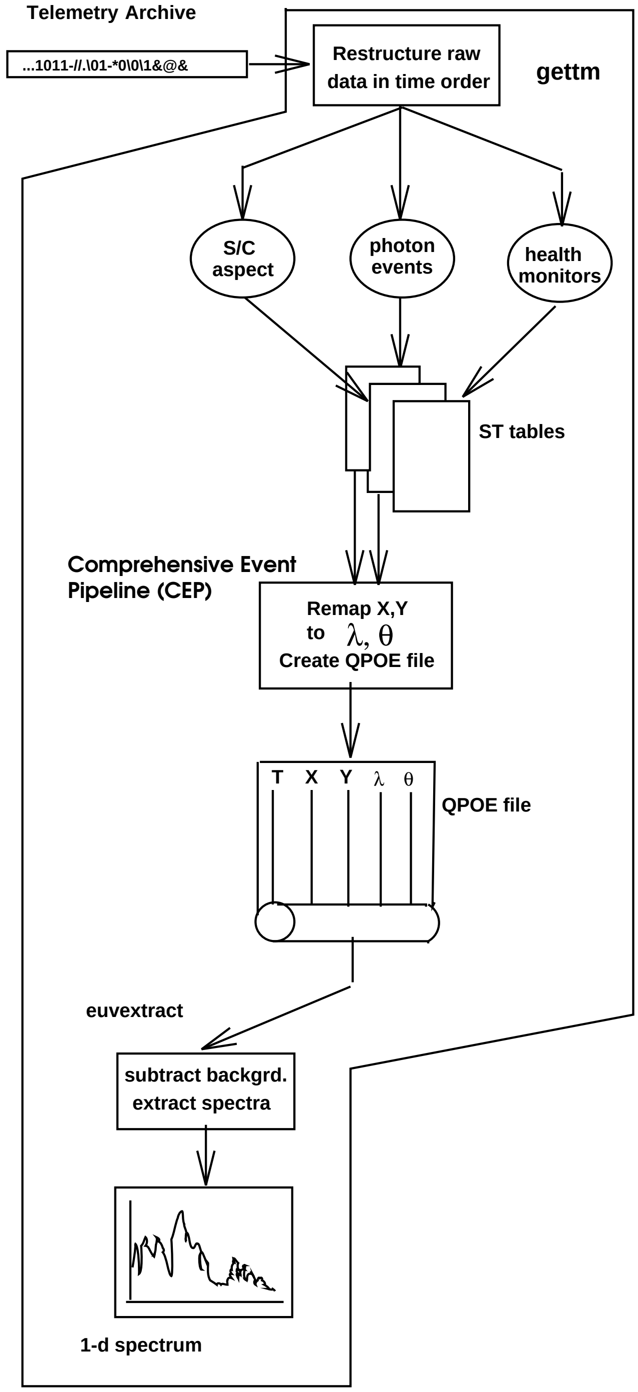

Figure 4-2: Spectrometer pipeline processing

After the spectrometer science data are sorted into separate QPOE files for short, medium, and long wavelength channels, preliminary spectra are extracted from the images using standard apertures and the background subtraction technique outlined in section 3.6. These spectra are not optimized, due to the use of a simple pre-programmed extraction algorithm. Each background-subtracted spectrum is stored as a 2048-pixel spectral image. The data reduction software and nominal data processing performed by the EGO Center is described in more detail in [1].

Data products are distributed on CD-ROM, so that analysis may be done at the Observer's home institution. All data products are delivered to the GO as FITS[3] files. Guest Observers receive a standard set of data products including:

- Raw telemetry tables
- QPOE format event files
- Two-dimensional raw detector images
- Two-dimensional imaging and spectral images
- Three Nominally extracted 1-d spectra

4.5 Guest Observer Data Analysis

The IRAF/EUV layered software package, which is tailored to perform most operations in the reduction of EUVE data, is available to GOs via CEA's *ftp*site, at ftp.cea.berkeley.edu. Observers may contact the EGO Center, via electronic mail at egoinfo@cea.berkeley.edu, to receive assistance in using the software and interpreting features in their data.

4.5.1 IRAF Reduction Tools

All EUVE spectral reduction tools provided by the EGO Center for use on EUVE QPOE and IRAF images are interactive IRAF tasks with on-line documentation. Any IRAF installation, with the addition of the **tables** package can be used to refine the analysis of the QPOE files, images and spectra.

The IRAF/EUV software enables GOs to preform specialized data filtering and selection using the instrument data in telemetry, to rerun the event pipeline with improved instrument reference data, and to produce light curves from the QPOE files.

The EGO Center Software User's Guide provides detailed descriptions of the software, and instructions for operations particularly useful in analyzing EUV data. Software, documentation, and assistance will be available for the basic processing tasks listed below. The basic operations are represented in figure 4-4, in relation to data flow.

- Creating wavelength-calibrated QPOE files from ST tables and instrument reference data
- Browsing and rebinning QPOE files
- Selecting data from "good times" based on instrument engineering monitors

[3] FITS: Flexible Image Transport System

- Calculating geophysical observation parameters from spacecraft housekeeping data
- Filtering and manipulating QPOE file event lists
- Time binning and making light curves
- Flux calibration and removal of higher orders
- Spectrum extraction the GO

The use of the tabular engineering data with IRAF/EUV data selection tasks allows GOs to create and analyze subsets of the original QPOE event listing, selecting data according to their criteria for instrument performance and/or observing conditions. Observers can select data from their observing run on the basis of count rates, pointing direction, time bracketing, or a number of other factors.

The EGO pipeline can also be run on the telemetry by GOs to produce new QPOE files when improved instrument reference data become available.

4.5.2 GO Facilities at CEA

Guest Observers may come to the EGO Center after their observations have been processed, in order to become acquainted with the software and their data. During the EUVE Extended mission, such visits may be contingent upon available resources, and GOs should check with the GO Center by sending electronic mail to egoinfo@cea.berkeley.edu. Computing facilities available to Guest Observers at the EGO Center include disk space for temporary data storage (1 Gig), color graphic workstations running IRAF under UNIX, and access to data reduction software. Guest Observer computer accounts are also available for remote usage. Requests for EGO Center visits or temporary computer accounts should be made via electronic mail to egoinfo@cea.berkeley.edu. Figure 4-3 shows the EGO Center computing network, the EUVE data storage facilities.

Scientific and technical support is available to Guest Observers through the EGO Center during their visit, and throughout the data reduction process. The EGO Center's research associates support routine data processing and assist Observers in using the IRAF/EUV software packages. EGO Center scientists assist GOs in special cases. Products of reductions from EGO Center visits may be transferred to the Observer's home institution via CD-ROM, magnetic tape, or *ftp*.

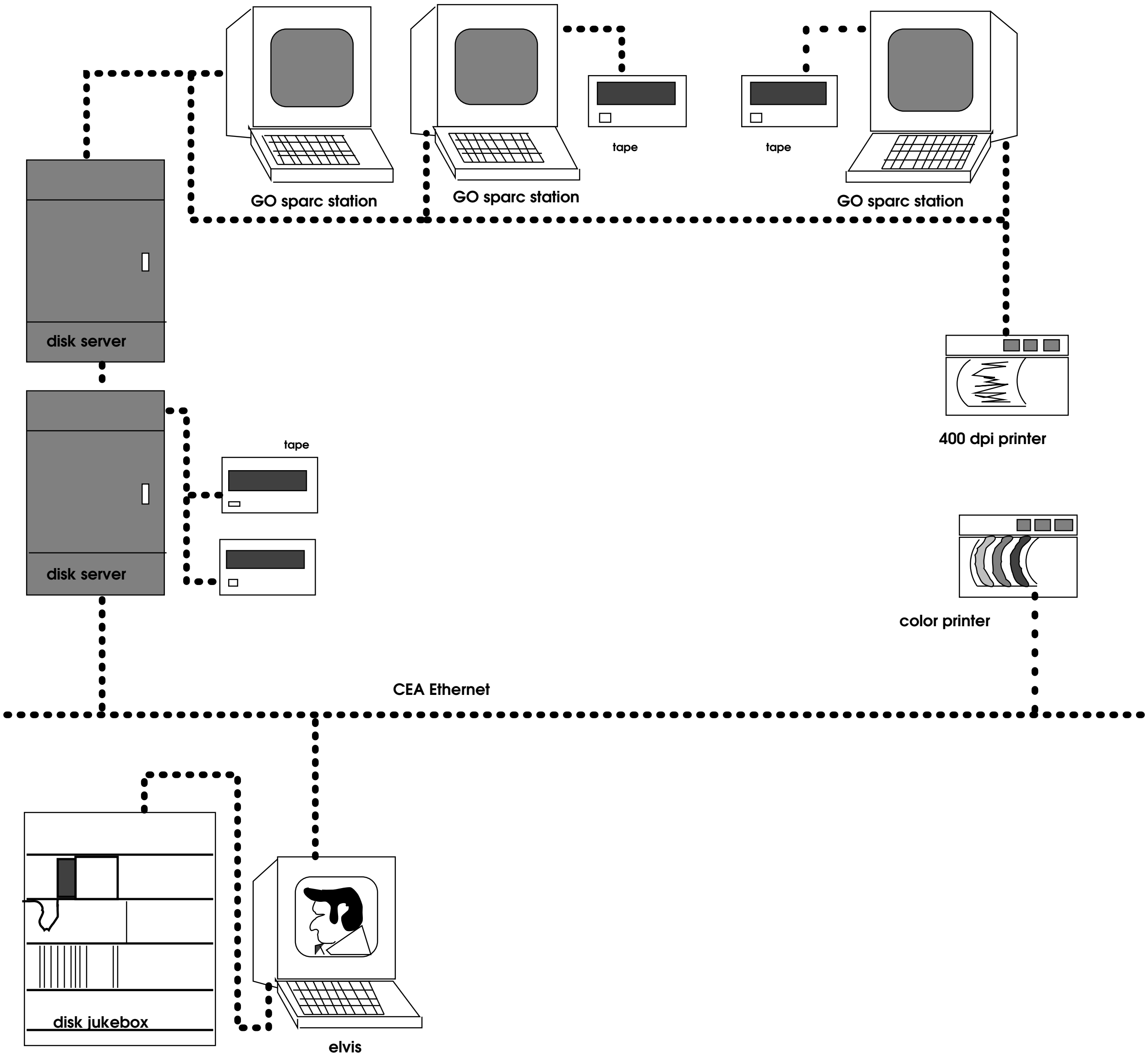

Figure 4-3: EUVE Guest Observer computing facilities

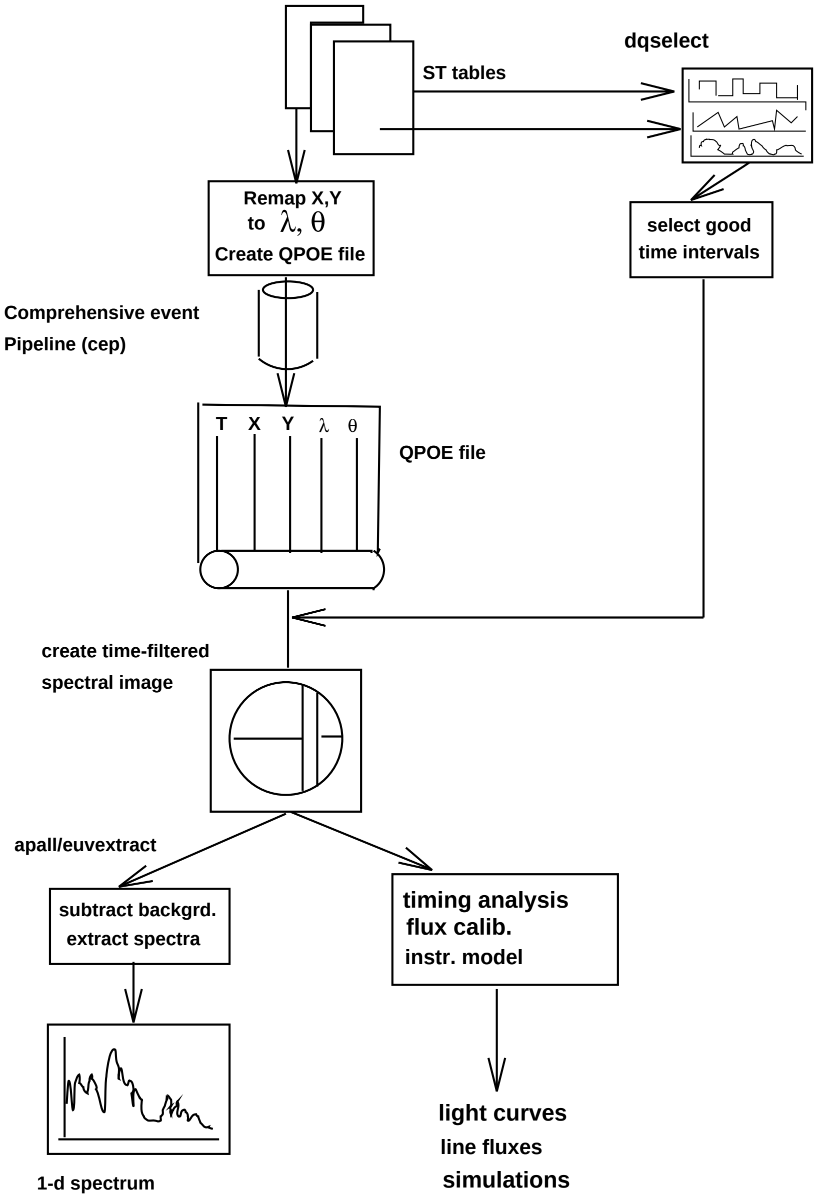

Figure 4-4: Interactive Guest Observer processing

4.5.3 Non-standard Data Reduction

The standard Spectrometer analysis system is designed to handle most observations proposed by EUVE Guest Observers. EUVE Guest Observers desiring complex data analysis may need to work closely with the EGO Center staff and scientists to ensure reliable results. Observations requiring time-resolved spectroscopy can be analyzed by partitioning the data in time, and repeating the analysis for each time interval. Additional tools to support timing analysis are provided, in the form of time-binning and deadtime correction tasks. In general, support for non-standard data analysis is handled on a case-by-case basis, and selected operations are sometimes earmarked for more complete treatment and the creation of specialized software tasks.

4.5.4 Archiving

All GO data products are archived on tape or CD-ROM at the EGO Center. When the GO proprietary period on any set of data expires, the data become available through the EUVE public data archive at the CEA. This archive is most easily accessible through CEA's *WWW* site at www.cea.berkeley.edu.