BUILDING THE PIPELINE FOR HUBBLE LEGACY ARCHIVE GRISM DATA

M. Kümmel[1], R. Albrecht[1], R. Fosbury[1], W. Freudling[1], J. Haase[1], R.N. Hook[1], H. Kuntschner[1], M. Lombardi[1], A. Micol[2,1], M. Rosa[1], F. Stoehr[1], and J.R. Walsh[1]

[1]Space Telescope - European Coordinating Facility, Karl-Schwarzschild-Str. 2, D-85748 Garching b. München, Germany

[2]European Space Astronomy Centre, P.O. Box - Apdo. de correos 50727, 28080 Madrid, Spain

ABSTRACT

The Pipeline for Hubble Legacy Archive Grism data (**PHLAG**) is currently being developed as an end-to-end pipeline for the Hubble Legacy Archive (**HLA**). The inputs to **PHLAG** are slitless spectroscopic **HST** data with only the basic calibrations from standard **HST** pipelines applied; the outputs are fully calibrated, Virtuall Observatory-compatible spectra, which will be made available through a static **HLA**-archive. We give an overview of the various aspects of **PHLAG**. The pipeline consists of several subcomponents – data preparation, data retrieval, image combination, object detection, spectral extraction using the aXe software, quality control – which is discussed in detail. As a pilot project, **PHLAG** is currently being applied to NICMOS G141 grism data. Examples of G141 spectra reduced with **PHLAG** are shown.

Key words: Hubble Space Telescope; Technique: spectroscopic.

1. THE HUBBLE LEGACY ARCHIVE

The current Hubble Space Telescope (**HST**) data archives at the Space Telescope – European Coordinating Facility (ST-ECF), the Canadian Astronomy Data Centre (CADC) and the Space Telescope Science Intstitute (STScI) offer images with calibrated pixel values for download. Further processing, such as the coadding of single images, must be done by the archive researcher individually. After almost 17 years of **HST** observations, it is timely to start building a Hubble Legacy Archive (**HLA**) containing high level science data products for immediate scientific use ([1], [2]). The contribution of the ST-ECF to the **HLA** focuses on the area of slitless spectroscopy. Currently the archives deliver slitless data with only basic calibration applied (bias, dark), hence the improvements by providing fully calibrated spectra in the HLA is large. To generate high level science data products as input to the **HLA**, the Pipeline for Hubble Legacy Archive Grism (**PHLAG**) data was developed. In a pilot project, **PHLAG** is being developed and first applied to NICMOS G141 slitless spectroscopic data.

2. SLITLESS SPECTROSCOPY

Slitless spectroscopic data show some special features and properties which are absent in the usual spectroscopy with slits or masks. Due to the low spectral resolution, there are multiple spectral orders of the same object visible in a single field of view. The absence of slits makes contamination, which is the mutual overlap of spectra, an ubiquitous phenomenon. The contamination can occur in the spatial direction, in the dispersion and even across different spectral orders. The zero point of the wavelength calibration usually must be derived from the object positions on the direct image. Therefore a NICMOS G141 slitless spectroscopic dataset consists of a set of direct images and dispersed images, which were taken at the same positions on the sky, and the processing of the direct images is an integral part of any slitless spectroscopy pipeline such as **PHLAG** [3].

3. PHLAG

PHLAG consists of a series of modules with each performing a certain reduction step on the data. The pipeline is implemented in Python[1], but utilizes existing software (Pyraf[2], MultiDrizzle [4], SExtractor [5]) whenever possible. Important modules of **PHLAG** are:

- **data preparation**: In this step the data are prepared for the pipeline reduction. The direct images are

[1]http://www.python.org

[2]http://www.stsci.edu/resources/software_hardware/pyraf

grouped according to the filter. Every slitless image is paired with the direct image that was obtained with the smallest positional difference. The set of direct image – slitless image relationships created here is an essential input to the spectral extraction.

- **image combination:** To prepare for the object extraction, the filter images are combined to create a deep direct image. This is done using the MultiDrizzle software [4].
- **object detection:** The object detection software SExtractor [5] is run on the deepest direct image. Conservative parameter settings are used, and the prime aim is to detect all objects that also have detectable spectra in the slitless images.
- **spectral extraction:** The spectrum extraction package aXe[3] is used to extract the object spectra from the slitless images. The flatfielded 2D spectral stamp images extracted from the individual grism images are coadded using the aXedrizzle technique [6]. Deep 1D spectra are finally extracted from these combined 2D spectral images. For each spectrum, an estimate of the contamination caused by neighbouring objects is derived using the photometric information from the direct images.
- **metadata:** The spectra are post-processed and prepared for ingestion into the **HLA** archive. Metadata are collected (e.g., object positions, extraction geometry) or derived (e.g., signal-to-noise estimates for the spectra). To ensure compatibility with the Virtual Observatory (VO), we closely follow the rules and recommendations of the IVOA Spectral Data Model[4] in the selection of the metadata.
- **data ingestion:** This last module inserts the fully reduced, quality controlled and VO-ready spectra into the **HLA** archive.

4. RESULTS

Two complete test runs of **PHLAG** have been completed in December 06 and March 07 on all available (~ 1000) NICMOS G141 datasets. From the ~ 5000 grism images around 10,000 object spectra were extracted in one week of computing time. Figure 1 shows the spectra of bright objects as extracted by **PHLAG**. The individual scale factor is given in the sub-panels. The left column shows the spectra of two brown dwarfs in NGC 1333 (upper panels) and a field dwarf standard (lower panel). The spectra of standard stars and the planetary nebula HB12 are shown in the right column.

At the time of writing, **PHLAG** is in the late phase of development, testing and optimization. After the next production run on all data, a first release of NICMOS G141 spectra is expected in the second half of 2007. This released dataset is expected to become a formal part of the Hubble Legacy Archive and to be accessible through both custom interfaces and the SSA interface[5].

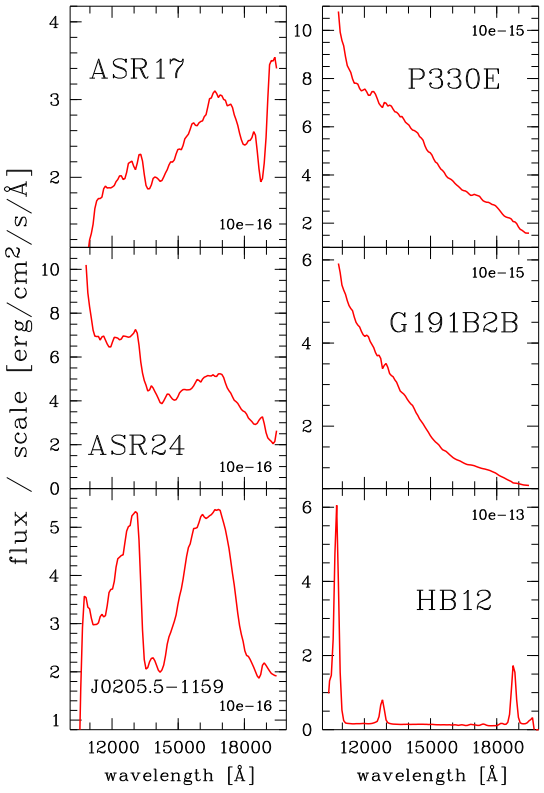

Figure 1. Spectra of bright objects as reduced by PHLAG.

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[3] http://www.stecf.org/instruments/ACSgrism/axe/

[4] http://www.ivoa.net/Documents/latest/SpectrumDM.html

[5] http://www.ivoa.net/twiki/bin/view/IVOA/SsaInterface