

# Building the Pipeline for Hubble Legacy Archive Grism data PHLAG



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## 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 calibration applied; the outputs are fully calibrated, Virtually 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 - data and metadata - reduced with PHLAG are shown.

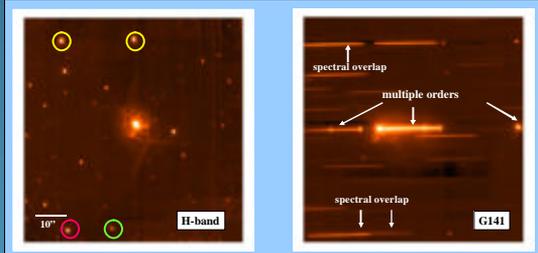


Figure 1: A basic dataset of slitless spectroscopic images (right) and their corresponding direct H-band (F160W) images (left)

## 2. Slitless spectroscopy

Slitless spectroscopic images show some special features and properties, which are depicted in Figure 1. The right and the left panels show a basic dataset consisting of slitless images and their corresponding direct images taken in the H-band (filter F160W). 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. There is contamination in the spatial direction, as can be seen in the dispersed image for the two objects in the green circle in Fig. 1, contamination in the dispersion direction with the object in the pink circle, and even contamination across different spectral orders, as it is the case for the two objects in the yellow circles. The zero point of the wavelength calibration must be derived from the object positions on the direct image. Therefore a slitless spectroscopic dataset consists always 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 [2].

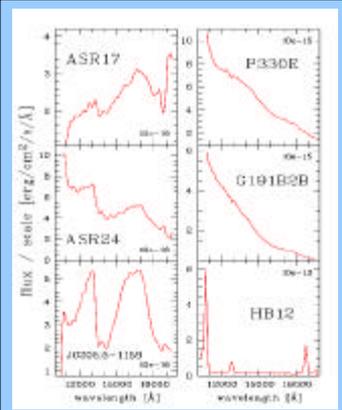


Figure 4: Spectra of PHLAG-reduced bright objects

## 4. Results:

Two complete test runs of PHLAG have been done in December 06 and March 07 on all available (~1000) NICMOS G141 datasets. From the ~5000 grism images around 40,000 object spectra were extracted in one week of computing time. Figure 4 shows the spectra of bright objects as extracted by PHLAG. Table 2 shows part of a spectrum in our internal ASCII format. The column definition is followed by the metadata and the data. The metadata resemble very closely the hierarchical structure defined in the IVOA Spectral Data Model, and a transformation from this internal to other formats for data distribution (XML, VOTable or FITS) is very easy. The column CONTAM, which contains an estimate of the contaminating flux from neighboring objects, was added to the "standard" columns in order to provide this additional information, which is essential for the interpretation of slitless spectra. As of now, 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 (HLA) and to be accessible through both, custom interfaces and the SSAP protocol.

Channel	Disperser	Wavelength Range [Å]	Resolution [Å/pixel]	FOV ["]
ACS/WFC	G800L	5500 – 10500	38.5	202x202
ACS/HRC	G800L	5500 – 10500	23.5	29x26
ACS/HRC	PR200L	1600 – 3900	20 [ @2500Å ]	29x26
ACS/SBC	PR130L	1250 – 1800	7 [ @1500Å ]	35x31
ACS/SBC	PR110L	1150 – 1800	10 [ @1500Å ]	35x31
NIC3	G141	11000 – 19000	80	51x51

Table 1: Some HST slitless modes under consideration for HLA activities

## 1. The Hubble Legacy Archive

The current Hubble Space Telescope (HST) data archives at the ST-ECF, the Canadian Astronomy Data Centre (CADC) and the Space Telescope Science Institute (STScI) offer the 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, a large amount of expertise has been accumulated for all past and currently active HST instruments, and it is the right time now to start building a Hubble Legacy Archive (HLA) containing high level science data products for immediate scientific use [1]. While the CADC and the STScI concentrate on providing image products (e.g. stamp images and cutout services), 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 of an HLA with science ready spectra 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. Table 1 lists slitless HST modes which could be reduced for the HLA. In a pilot project, PHLAG is being developed and first applied to NICMOS G141 slitless spectroscopic data.

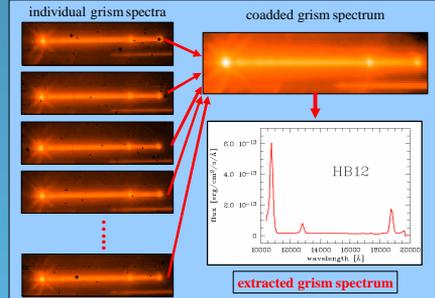


Figure 3: The aXe extraction process from the individual stamp images to extracted, deep spectra

```
# 1 LAMBDA
# 2 COORD
# 3 ERROR
# 4 FITS
# 5 FERROR
# 6 CONTAM
#Spectrum.DataModel = SPECTRUM 1.0
#Spectrum.Type = Slitless Spectrum
#Spectrum.CoordSys.SpaceFrame.Name = FK5
#Spectrum.CoordSys.TimeFrame.Name = TT
#Spectrum.CoordSys.TimeFrame.Zero = 2400000.5 ; as for all HST instruments
#Spectrum.Duration.Publisher = Space Telescope - European Coordinating Facility
#Spectrum.DataID.Title = HLA/ST-ECF NICMOS grism
#Spectrum.DataID.Creator = Space Telescope - European Coordinating Facility
#Spectrum.DataID.Version = 1.0
#Spectrum.DataID.Logo = http://www.stecf.org/img/stecflogocolor.gif
#Spectrum.TimeRef = T
.
.
#Spectrum.SpectralSI = 10-10 L
#Spectrum.FluxSI = 10-19W-17-3
#Spectrum.Char.FluxAxis.Name = FLUX
#Spectrum.Char.FluxAxis.Unit = erg/s/cm2/Angstrom
#Spectrum.Char.FluxAxis.Jed = phot.fluxes / em.wlstr.net
#Spectrum.Char.SpectralAxis.Name = WAVELENGTH
#Spectrum.Char.SpectralAxis.Unit = Angstrom
#Spectrum.Target.pos.ra = 351.56154101 ; the target name
#Spectrum.Target.pos.dec = 58.18210155 ; the target declination
#Spectrum.CoordSys.SpaceFrame.Equinox = 2000.0 ; coordinate equinox
#Spectrum.CustomParams.NumTrisImage = 15 ; Number of contributing grism images
#Spectrum.Length = 113
#Spectrum.DataID.Date = 2007-3-8T0:12:56 ; file creation date
1.050321e+04 1.674619e+01 7.258485e+02 6.882959e+14 3.285606e+16 5.449870e+18
3.058328e+04 3.281029e+01 6.939328e+02 6.340751e+14 2.364884e+16 9.115264e+18
.
.
1.988325e+04 1.639907e+02 8.015389e+02 2.855464e+14 5.878995e+17 9.886373e+19
2.946328e+04 9.384627e+01 6.736228e+02 2.870008e+14 6.097788e+17 1.775333e+18
```

Table 2: A spectrum in the internal ASCII format

## References

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- aXe webpage: <http://www.stecf.org/instruments/ACSGrism/aXe>
- Kümmel, M., Larsen, S.S., & Walsh, J.R. 2005, ST-ECF Newsletter 38, p. 8
- IVOA Spectral Data Model: <http://www.ivoa.net/Documents/latest/SpectrumDM.html>