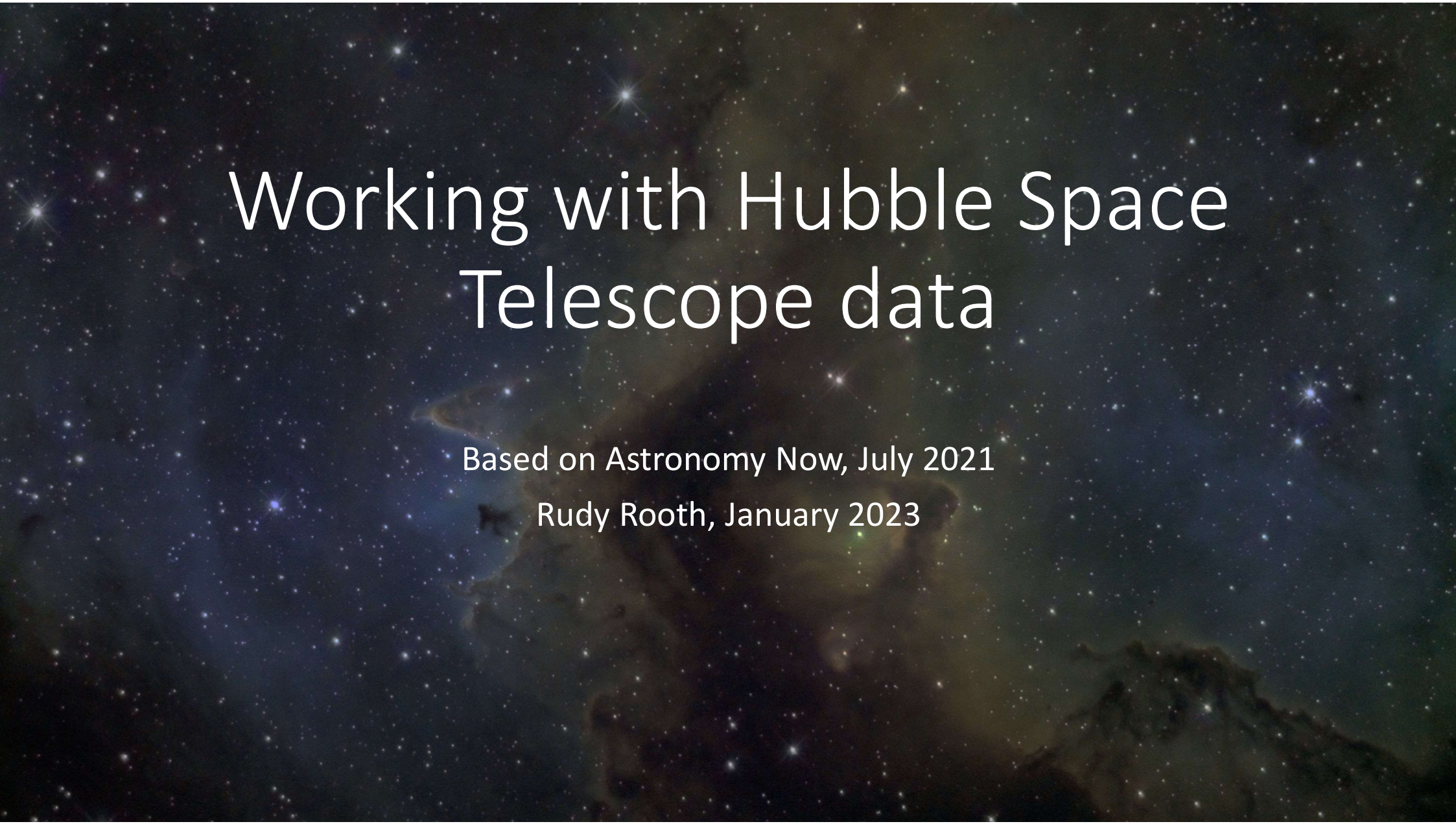


Working with Hubble Space Telescope data

Based on Astronomy Now, July 2021

Rudy Rooth, January 2023

Abbreviations

- HST Hubble Space Telescope
- STScI Space Telescope Science Institute
- MAST MIKULSKI ARCHIVE for SPACE TELESCOPES
- HLST High Level Scientific Product
- FTP File Transfer Protocol
- FITS Flexible Image Transport System

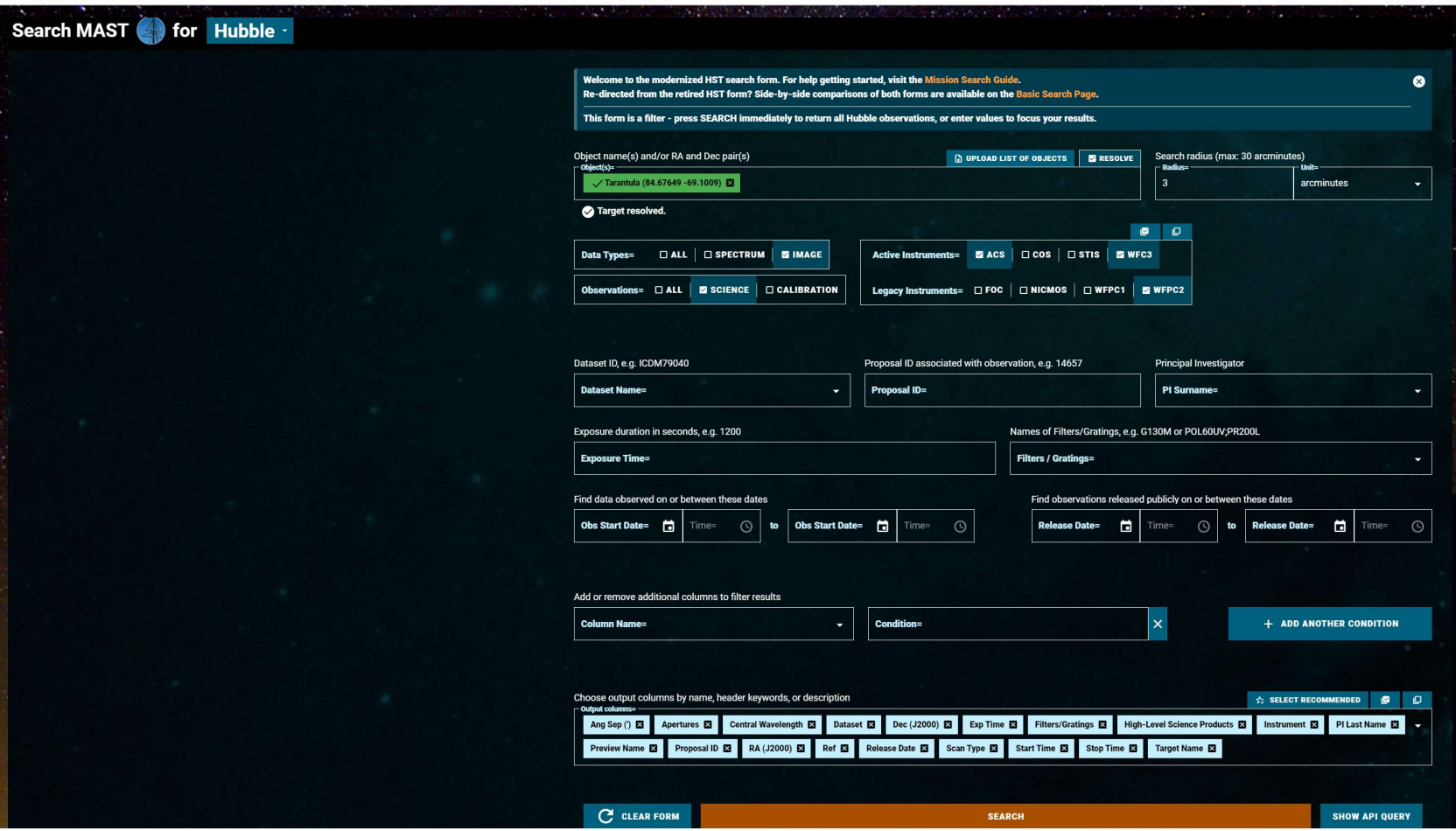
Hubble camera's

- ACS Advanced Camera for Surveys
- WFC3 Wide Field Camera 3

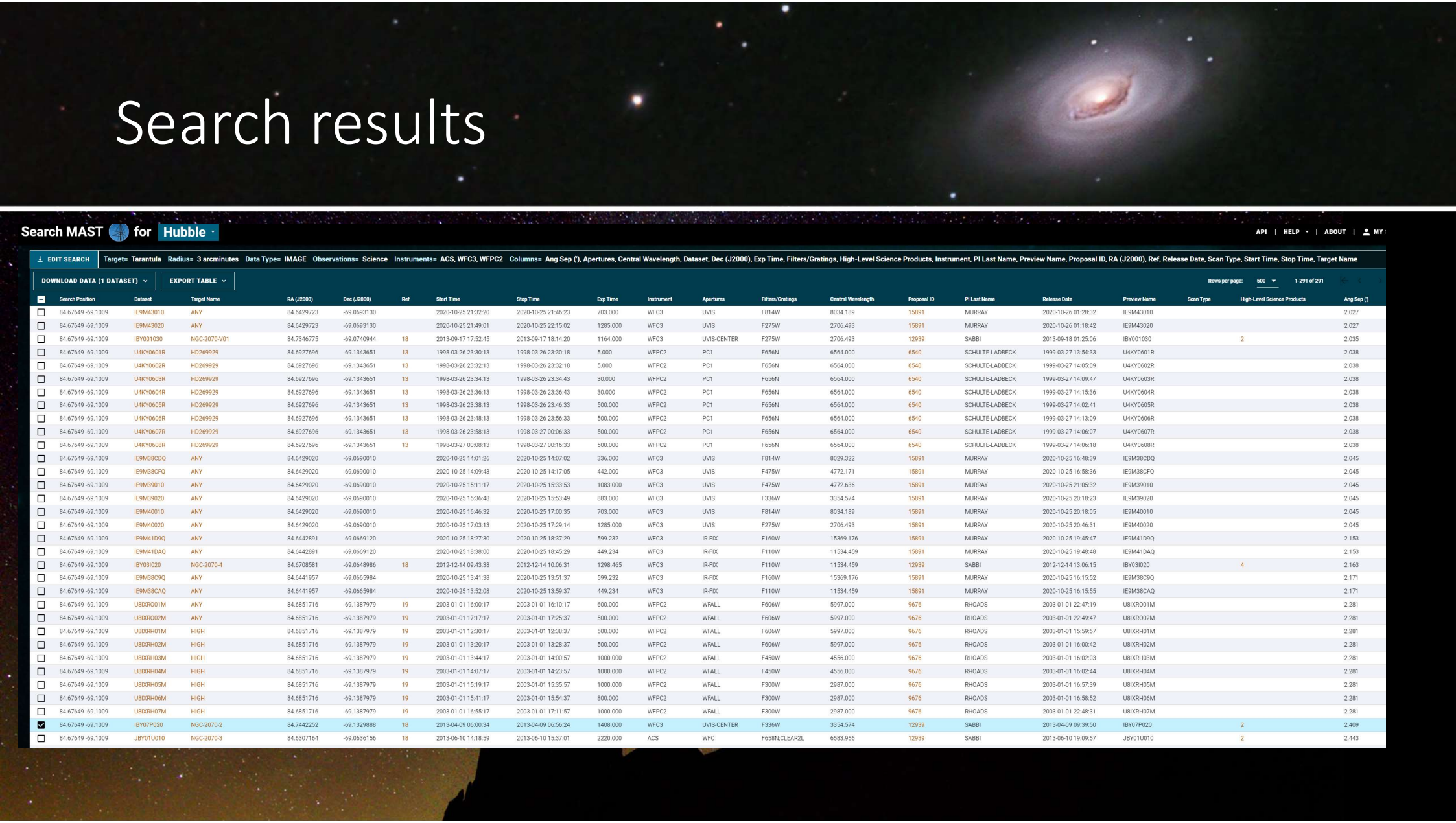
Relevant links

MAST Search facility	https://mast.stsci.edu/search/ui/#/hst
MAST filter list	https://archive.stsci.edu/hst/filterlist.html?style=Classic
HLST	https://archive.stsci.edu/prepds/heritage/

Screenshot MAST



Search results



Search MAST for Hubble

API | HELP | ABOUT | MY

EDIT SEARCH | Target= Tarantula Radius= 3 arcminutes Data Type= IMAGE Observations= Science Instruments= ACS, WFC3, WFPC2 Columns= Ang Sep ('), Apertures, Central Wavelength, Dataset, Dec (J2000), Exp Time, Filters/Gratings, High-Level Science Products, Instrument, PI Last Name, Preview Name, Proposal ID, RA (J2000), Ref, Release Date, Scan Type, Start Time, Stop Time, Target Name

DOWNLOAD DATA (1 DATASET) | EXPORT TABLE

Rows per page: 500 | 1-291 of 291

Search Position	Dataset	Target Name	RA (J2000)	Dec (J2000)	Ref	Start Time	Stop Time	Exp Time	Instrument	Apertures	Filters/Gratings	Central Wavelength	Proposal ID	PI Last Name	Release Date	Preview Name	Scan Type	High-Level Science Products	Ang Sep (')
84.67649 -69.1009	IE9M43010	ANY	84.6429723	-69.0693130		2020-10-25 21:32:20	2020-10-25 21:46:23	703.000	WFC3	UVIS	F814W	8034.189	15891	MURRAY	2020-10-26 01:28:32	IE9M43010			2.027
84.67649 -69.1009	IE9M43020	ANY	84.6429723	-69.0693130		2020-10-25 21:49:01	2020-10-25 22:15:02	1285.000	WFC3	UVIS	F275W	2706.493	15891	MURRAY	2020-10-26 01:18:42	IE9M43020			2.027
84.67649 -69.1009	IBY001030	NGC-2070-V01	84.7346775	-69.0740944	18	2013-09-17 17:52:45	2013-09-17 18:14:20	1164.000	WFC3	UVIS-CENTER	F275W	2706.493	12939	SABBI	2013-09-18 01:25:06	IBY001030		2	2.035
84.67649 -69.1009	U4KY0601R	HD269929	84.6927696	-69.1343651	13	1998-03-26 23:30:13	1998-03-26 23:30:18	5.000	WFPC2	PC1	F656N	6564.000	6540	SCHULTE-LADBECK	1999-03-27 13:54:33	U4KY0601R			2.038
84.67649 -69.1009	U4KY0602R	HD269929	84.6927696	-69.1343651	13	1998-03-26 23:32:13	1998-03-26 23:32:18	5.000	WFPC2	PC1	F656N	6564.000	6540	SCHULTE-LADBECK	1999-03-27 14:05:09	U4KY0602R			2.038
84.67649 -69.1009	U4KY0603R	HD269929	84.6927696	-69.1343651	13	1998-03-26 23:34:13	1998-03-26 23:34:43	30.000	WFPC2	PC1	F656N	6564.000	6540	SCHULTE-LADBECK	1999-03-27 14:09:47	U4KY0603R			2.038
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84.67649 -69.1009	U4KY0605R	HD269929	84.6927696	-69.1343651	13	1998-03-26 23:38:13	1998-03-26 23:46:33	500.000	WFPC2	PC1	F656N	6564.000	6540	SCHULTE-LADBECK	1999-03-27 14:02:41	U4KY0605R			2.038
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84.67649 -69.1009	U4KY0607R	HD269929	84.6927696	-69.1343651	13	1998-03-26 23:58:13	1998-03-27 00:06:33	500.000	WFPC2	PC1	F656N	6564.000	6540	SCHULTE-LADBECK	1999-03-27 14:06:07	U4KY0607R			2.038
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84.67649 -69.1009	IE9M40020	ANY	84.6429020	-69.0690010		2020-10-25 17:03:13	2020-10-25 17:29:14	1285.000	WFC3	UVIS	F275W	2706.493	15891	MURRAY	2020-10-25 20:46:31	IE9M40020			2.045
84.67649 -69.1009	IE9M41D9Q	ANY	84.6442891	-69.0669120		2020-10-25 18:27:30	2020-10-25 18:37:29	599.232	WFC3	IR-FIX	F160W	15369.176	15891	MURRAY	2020-10-25 19:45:47	IE9M41D9Q			2.153
84.67649 -69.1009	IE9M41DAQ	ANY	84.6442891	-69.0669120		2020-10-25 18:38:00	2020-10-25 18:45:29	449.234	WFC3	IR-FIX	F110W	11534.459	15891	MURRAY	2020-10-25 19:48:48	IE9M41DAQ			2.153
84.67649 -69.1009	IBY03I020	NGC-2070-4	84.6708581	-69.0648986	18	2012-12-14 09:43:38	2012-12-14 10:06:31	1298.465	WFC3	IR-FIX	F110W	11534.459	12939	SABBI	2012-12-14 13:06:15	IBY03I020		4	2.163
84.67649 -69.1009	IE9M38C9Q	ANY	84.6441957	-69.0665984		2020-10-25 13:41:38	2020-10-25 13:51:37	599.232	WFC3	IR-FIX	F160W	15369.176	15891	MURRAY	2020-10-25 16:15:52	IE9M38C9Q			2.171
84.67649 -69.1009	IE9M38CAQ	ANY	84.6441957	-69.0665984		2020-10-25 13:52:08	2020-10-25 13:59:37	449.234	WFC3	IR-FIX	F110W	11534.459	15891	MURRAY	2020-10-25 16:15:55	IE9M38CAQ			2.171
84.67649 -69.1009	U8IXRO01M	ANY	84.6851716	-69.1387979	19	2003-01-01 16:00:17	2003-01-01 16:10:17	600.000	WFPC2	WFALL	F606W	5997.000	9676	RHOADS	2003-01-01 22:47:19	U8IXRO01M			2.281
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84.67649 -69.1009	U8IXRH01M	HIGH	84.6851716	-69.1387979	19	2003-01-01 12:30:17	2003-01-01 12:38:37	500.000	WFPC2	WFALL	F606W	5997.000	9676	RHOADS	2003-01-01 15:59:57	U8IXRH01M			2.281
84.67649 -69.1009	U8IXRH02M	HIGH	84.6851716	-69.1387979	19	2003-01-01 13:20:17	2003-01-01 13:28:37	500.000	WFPC2	WFALL	F606W	5997.000	9676	RHOADS	2003-01-01 16:00:42	U8IXRH02M			2.281
84.67649 -69.1009	U8IXRH03M	HIGH	84.6851716	-69.1387979	19	2003-01-01 13:44:17	2003-01-01 14:00:57	1000.000	WFPC2	WFALL	F450W	4556.000	9676	RHOADS	2003-01-01 16:02:03	U8IXRH03M			2.281
84.67649 -69.1009	U8IXRH04M	HIGH	84.6851716	-69.1387979	19	2003-01-01 14:07:17	2003-01-01 14:23:57	1000.000	WFPC2	WFALL	F450W	4556.000	9676	RHOADS	2003-01-01 16:02:44	U8IXRH04M			2.281
84.67649 -69.1009	U8IXRH05M	HIGH	84.6851716	-69.1387979	19	2003-01-01 15:19:17	2003-01-01 15:35:57	1000.000	WFPC2	WFALL	F300W	2987.000	9676	RHOADS	2003-01-01 16:57:39	U8IXRH05M			2.281
84.67649 -69.1009	U8IXRH06M	HIGH	84.6851716	-69.1387979	19	2003-01-01 15:41:17	2003-01-01 15:54:37	800.000	WFPC2	WFALL	F300W	2987.000	9676	RHOADS	2003-01-01 16:58:52	U8IXRH06M			2.281
84.67649 -69.1009	U8IXRH07M	HIGH	84.6851716	-69.1387979	19	2003-01-01 16:55:17	2003-01-01 17:11:57	1000.000	WFPC2	WFALL	F300W	2987.000	9676	RHOADS	2003-01-01 22:48:31	U8IXRH07M			2.281
84.67649 -69.1009	IBY07P020	NGC-2070-2	84.7442252	-69.1329888	18	2013-04-09 06:00:34	2013-04-09 06:56:24	1408.000	WFC3	UVIS-CENTER	F336W	3354.574	12939	SABBI	2013-04-09 09:39:50	IBY07P020		2	2.409
84.67649 -69.1009	JBY01U010	NGC-2070-3	84.6307164	-69.0636156	18	2013-06-10 14:18:59	2013-06-10 15:37:01	2220.000	ACS	WFC	F658N;CLEAR2L	6583.956	12939	SABBI	2013-06-10 19:09:57	JBY01U010		2	2.443

Click on dataset results in preview

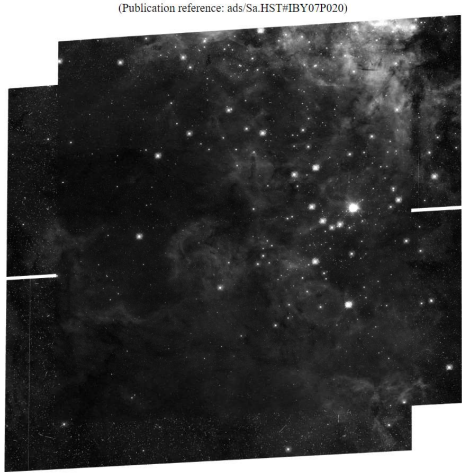
Barbara A. MIKULSKI ARCHIVE FOR SPACE TELESCOPES

MAST | STScI | Tools | Mission_Search | Tutorial | Site Search

About MAST | Getting Started

Preview for IBY07P020

(Publication reference: ads/Sa.HST#IBY07P020)



Previews provided by STScI for diagnostic/quick-look purposes.

interactive display

Exposure Information

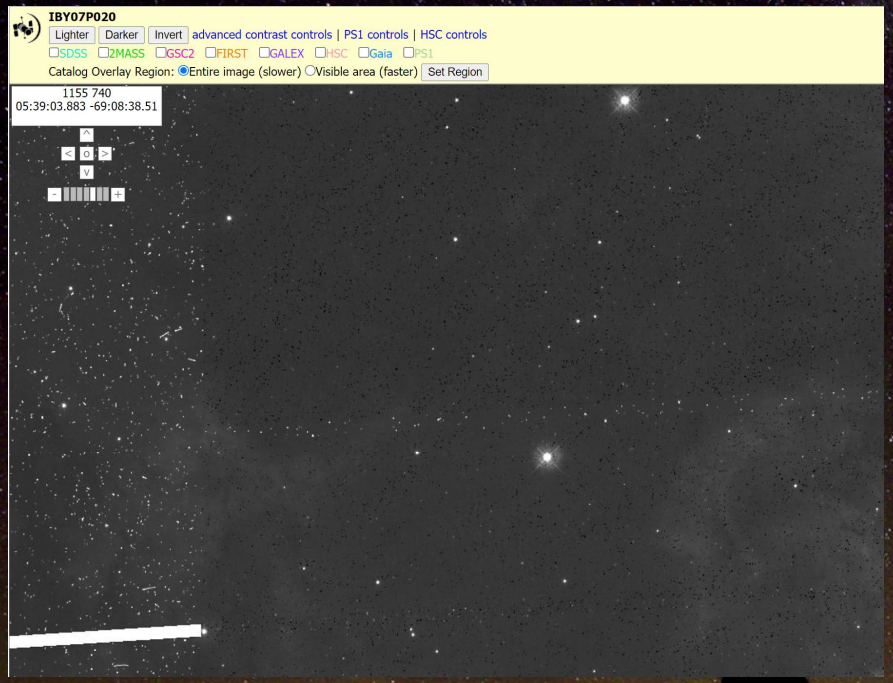
Target Name: NGC-2070-2
RA: 05 38 58.61
Dec: -69 07 58.76
Data Quality:
Quality Comment:

Observation Date: Apr 9 2013 6:00AM
Exp Time: 1408.0
Release Date: Apr 9 2013 9:39AM
Mode: ACCUM

Instrument: WFC3
Filter/Grating: F336W
Aperture: UVIS-CENTER
Config: WFC3/UVIS

Original observing program:
12939 - Sabbi, Elena - Space Telescope Science Institute
Hubble Tarantula Treasury Project {HTTP: unraveling Tarantula's web}
RESOLVED STELLAR POPULATIONS - Cycle 20 - Status: completed

Further info from the preview display



Interactive display

HST proposal info

Barbara A. MIKULSKI ARCHIVE FOR SPACE TELESCOPES

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Hubble Tarantula Treasury Project {HTTP: unraveling Tarantula's web}
HST Proposal 12939

Elena Sabbi (publications @ ADS)
Space Telescope Science Institute

Cycle: 20
Category: RESOLVED STELLAR POPULATIONS
Proposal type: GO
Status: completed

HST Proposal Information:
- about this proposal
- about other proposals by this PI

Proposal Abstract

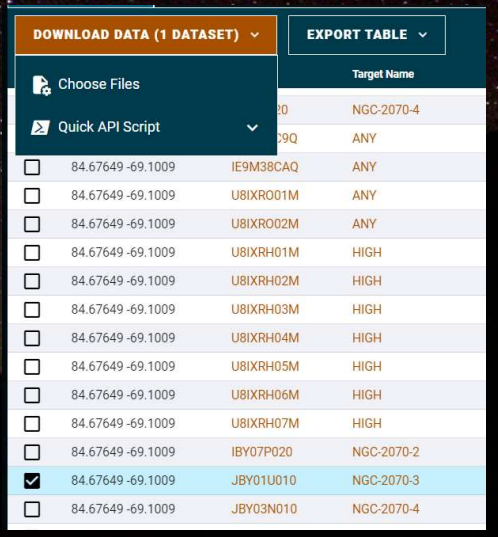
The Tarantula Nebula is the nearest and only starburst that can be studied down to the sub-solar mass regime {<0.5Mo}, and thus it offers us the rare opportunity to investigate the process of star formation in an environment that resembles in metallicity, dust content, and star formation rate, the extreme conditions of the early universe. Its importance to astronomy is reflected in the fact that it has been subject to large-scale multi-wavelength studies from the other Great Observatories. However less than 10% of the region has been studied with HST. With HTTP we will take advantage of the full power of HST using ACS and WFC3 in parallel to study this unique object over its entire extent {~200x200 pc} in the near-UV {F275W and F336W}, optical {F435W and F658N} and near-IR {F110W and F160W}, building on an existing HST monochromatic {F775W} proper-motion survey. By dissecting its stellar populations and inferring an accurate description of its anatomy, we will reconstruct for the first time the temporal evolution of a prototypical starburst on a <2 pc scale. This study will serve as a touchstone for all future work on the Tarantula Nebula in particular, and on starbursts in general. We will deliver a unified star catalog for all the filters, accompanied by artificial-star tests to quantify completeness and crowding effects. Co-registered stacked images in all filters, maps for the differential reddening and ages and a catalog with the properties of all the star clusters and stellar associations will also be released in a timely fashion. As a treasury survey HTTP will become the definitive catalog of the field, and have lasting value for future studies with ALMA and JWST.

Publications referencing this proposal

1. **Hubble Tarantula Treasury Project: Unraveling Tarantula's Web. I. Observational Overview and First Results**
   Sabbi, E. et al. 2013AJ....146...53S
2. **ALMA Resolves 30 Doradus: Sub-parsec Molecular Cloud Structure near the Closest Super Star Cluster**
   Indebetouw, R. et al. 2013ApJ...774...73I

Procedure for retrieving data

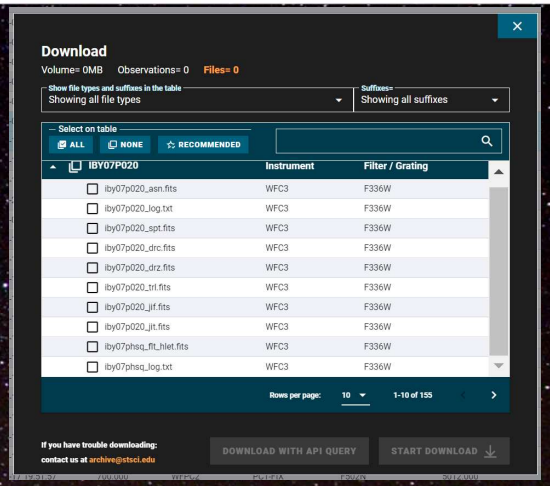
1. Visit MAST
2. Select a target and, as much as hou know already, e.g. camera, filters, exposure time
3. Inspect available data, access data previews by clicking on an item in the dataset column
4. Make a final selection by clicking desired data in the far left column
5. Click “download data” at top of list and then “choose files”

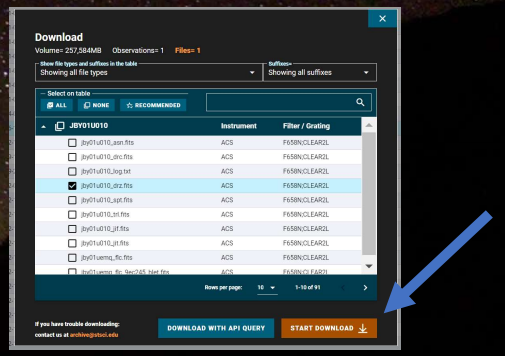


File selection

Note:

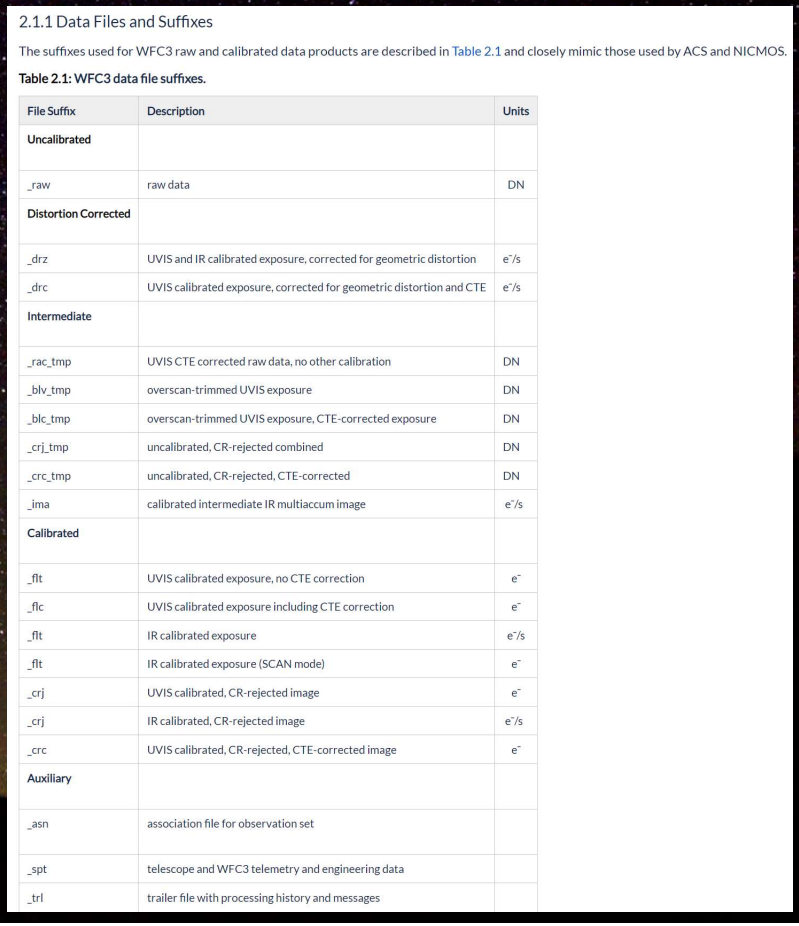
- Downloads can be very large, in attached example without further selection there are 155 files
- Select relevant file types, images are ususally FITS, see Hubble data handbook https://hst-docs.stsci.edu/hstdhb
- https://hst-docs.stsci.edu/wfc3dhb/chapter-2-wfc3-data-structure/2-1-types-of-wfc3-files
- Data are downloaded in a zip file





File extensions

- .drz and .drc are image files to look for (lower level data are geometrically distorted by Hubble characteristics
- See the Hubble instrument handbooks, e.g for WFC3 https://hst-docs.stsci.edu/wfc3ihb



2.1.1 Data Files and Suffixes

The suffixes used for WFC3 raw and calibrated data products are described in Table 2.1 and closely mimic those used by ACS and NICMOS.

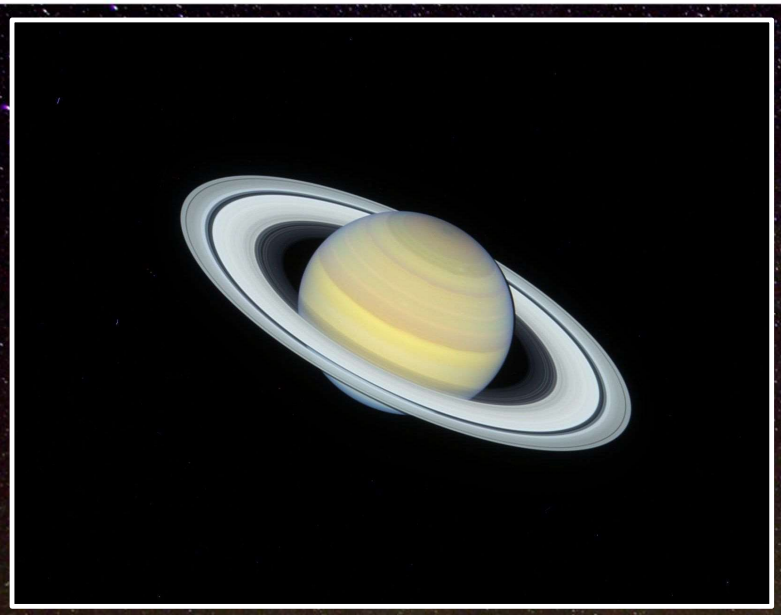
Table 2.1: WFC3 data file suffixes.

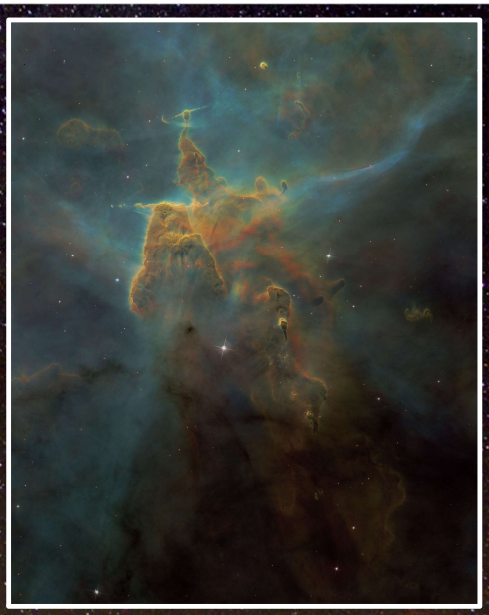
File Suffix	Description	Units
Uncalibrated		
_raw	raw data	DN
Distortion Corrected		
_drz	UVIS and IR calibrated exposure, corrected for geometric distortion	e^-/s
_drc	UVIS calibrated exposure, corrected for geometric distortion and CTE	e^-/s
Intermediate		
_rac_tmp	UVIS CTE corrected raw data, no other calibration	DN
_blv_tmp	overscan-trimmed UVIS exposure	DN
_blc_tmp	overscan-trimmed UVIS exposure, CTE-corrected exposure	DN
_crj_tmp	uncalibrated, CR-rejected combined	DN
_crc_tmp	uncalibrated, CR-rejected, CTE-corrected	DN
_ima	calibrated intermediate IR multiaccum image	e^-/s
Calibrated		
_flt	UVIS calibrated exposure, no CTE correction	e^-
_flc	UVIS calibrated exposure including CTE correction	e^-
_flt	IR calibrated exposure	e^-/s
_flt	IR calibrated exposure (SCAN mode)	e^-
_crj	UVIS calibrated, CR-rejected image	e^-
_crj	IR calibrated, CR-rejected image	e^-/s
_crc	UVIS calibrated, CR-rejected, CTE-corrected image	e^-
Auxiliary		
_asn	association file for observation set	
_spt	telescope and WFC3 telemetry and engineering data	
_trl	trailer file with processing history and messages	

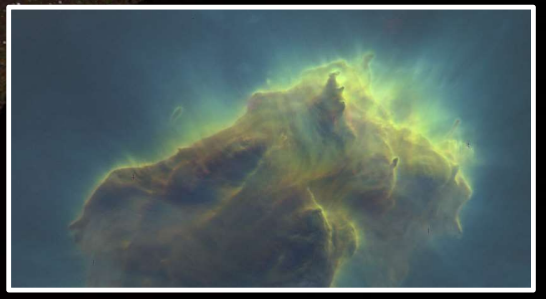
Alternative routes

- In Astronomy Now, July 2021, it was stated that the selected files were put on a STScI file server, from which they could then be downloaded by FTP, based on emails with access codes. This now seems obsolete. FileZilla is an example, free, FTP program.
- All websites contain extensive cross-links to detailed information
- Hubble also provides higher level output, known as HLST (High Level Scientific Product, see https://archive.stsci.edu/prepds/heritage/ and https://archive.stsci.edu/hlsp/http (Hubble Tarantula Treasure Project)
- Pillars of Creation example from the heritage project, three files of 260 Mb
  - hlsp_heritage_hst_wfc3-uvis_m16_f502n_v1_drz
  - hlsp_heritage_hst_wfc3-uvis_m16_f657n_v1_drz
  - hlsp_heritage_hst_wfc3-uvis_m16_f673n_v1_drz

Example results

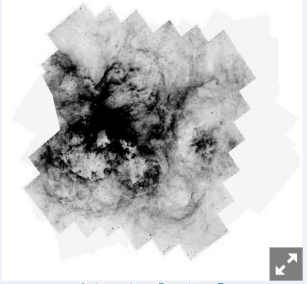


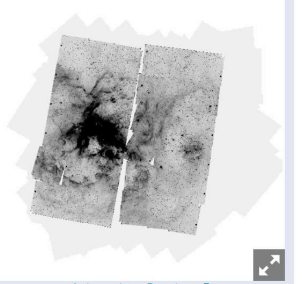




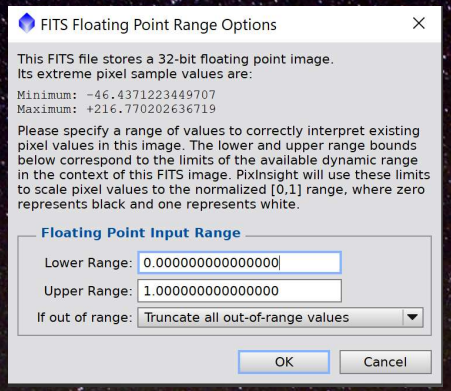
Recommendations

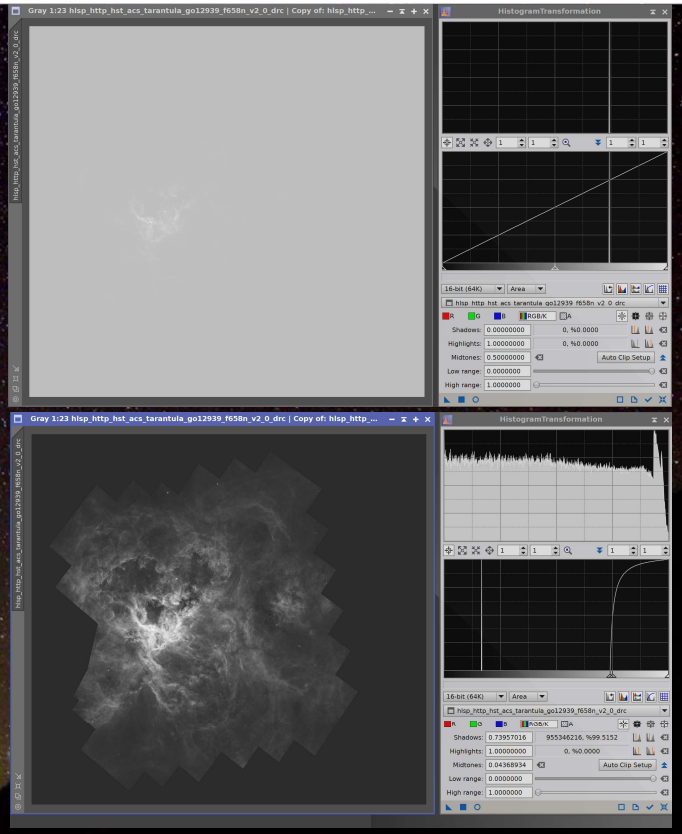
- Make sure you have the software to process FITS files, e.g. dedicated astrophotography image processing software. Or a program to convert to lossless formats as TIFF, e.g. FITS liberator
- Most tedious part is to find useful datasets. Mosaics are for example sometimes missing parts etc. One may want to start with HLSP

F658N	• hlsp_http_hst_acs_tarantula-go12939_f658n_v2.0_drc.fits (4.4 GB) • hlsp_http_hst_acs_tarantula-go12939_f658n_v2.0_wht.fits (4.4 GB)	 Interactive Display

F110W	• hlsp_http_hst_wfc3_tarantula-go12939_f110w_v2.0_drz.fits (4.4 GB) • hlsp_http_hst_wfc3_tarantula-go12939_f110w_v2.0_wht.fit (4.4 GB) • hlsp_http_hst_wfc3_tarantula_f110w_v1.0_drz.fits (4.2 GB) • hlsp_http_hst_wfc3_tarantula_f110w_v1.0_wht.fits (4.2 GB)	 Interactive Display

A note on FITS files of Hubble





- Range is not confined to 0:1
- 32-bits
- Uncommon histogram
- Import entire range if possible and create blackpoint just left of peak to avoid posterization