



An Introduction to photometry and spectroscopy with PACS

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&

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Outline of the Webinar



- Quick Instrument Overview: PACS photometer & spectrometer
- PACS Data: download and visualization in HIPE
- Review of PACS Products
- PACS Calibration
- When to reprocess PACS data
- How to reprocess PACS data
- Documentation & Additional Resources

Quick Instrument Overview

PACS (PI. Albrecht Poglitsch, MPE, Germany)

A Photodetector Array Camera & Spectrometer for Herschel



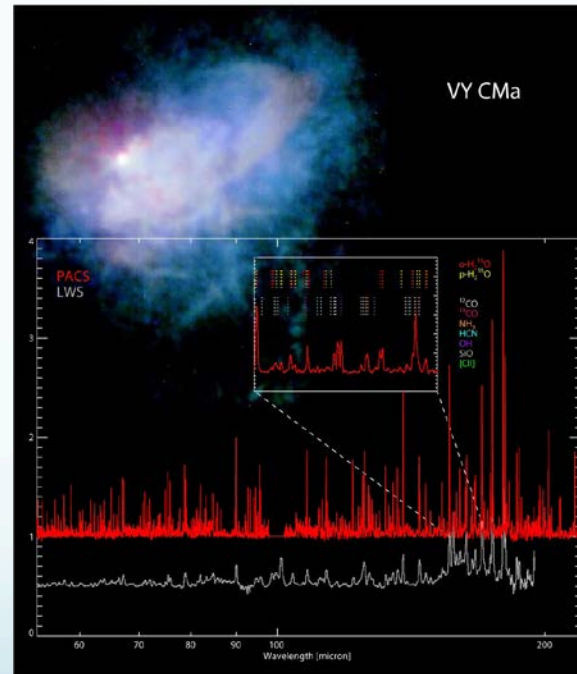
Image Credit: ESA and PACS Consortium



Imaging ↔ bolometers

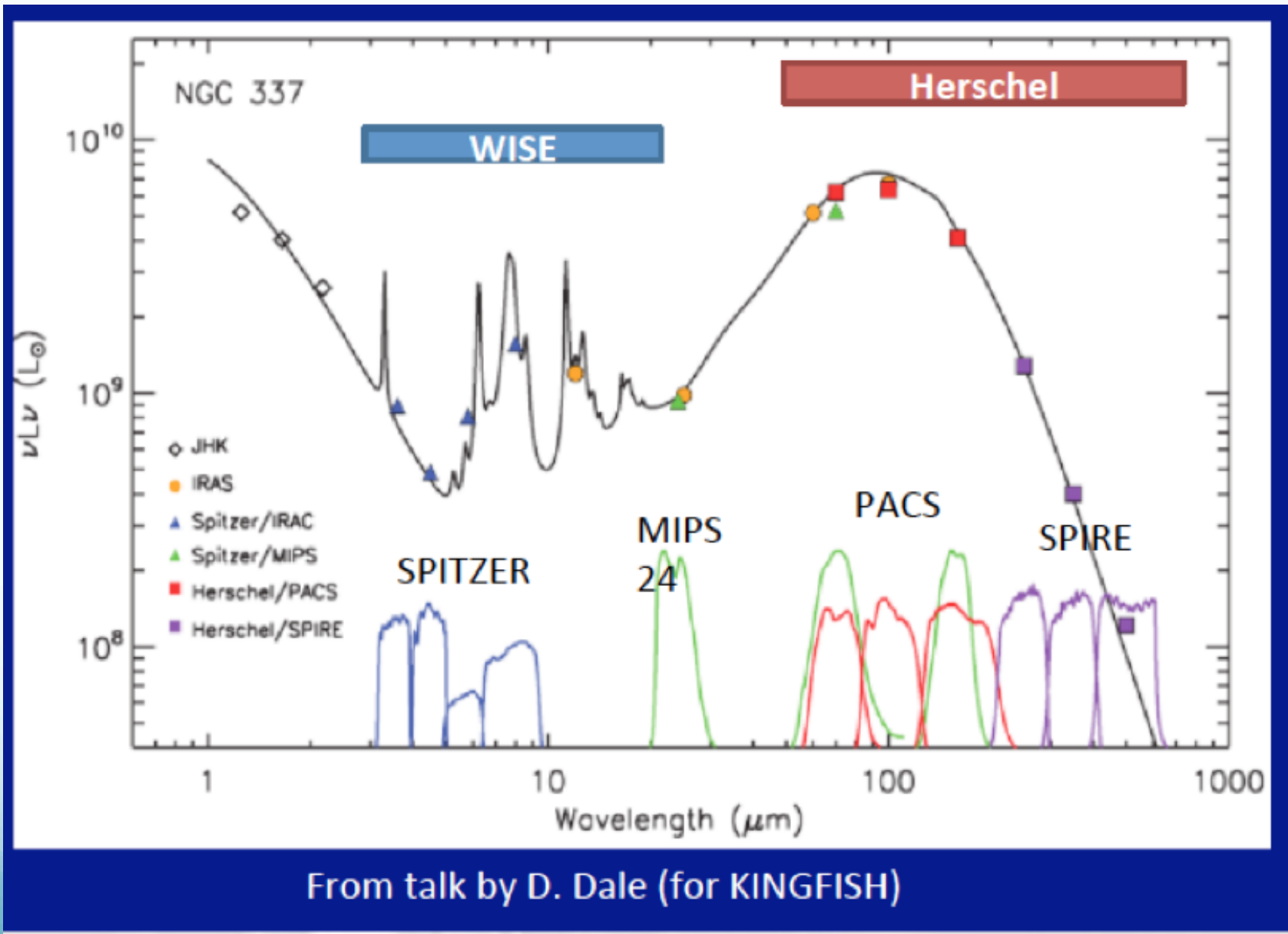


Image Credit: MESS Consortium



Spectroscopy ↔ Ge:Ga array

PACS Instrument Overview: photometer

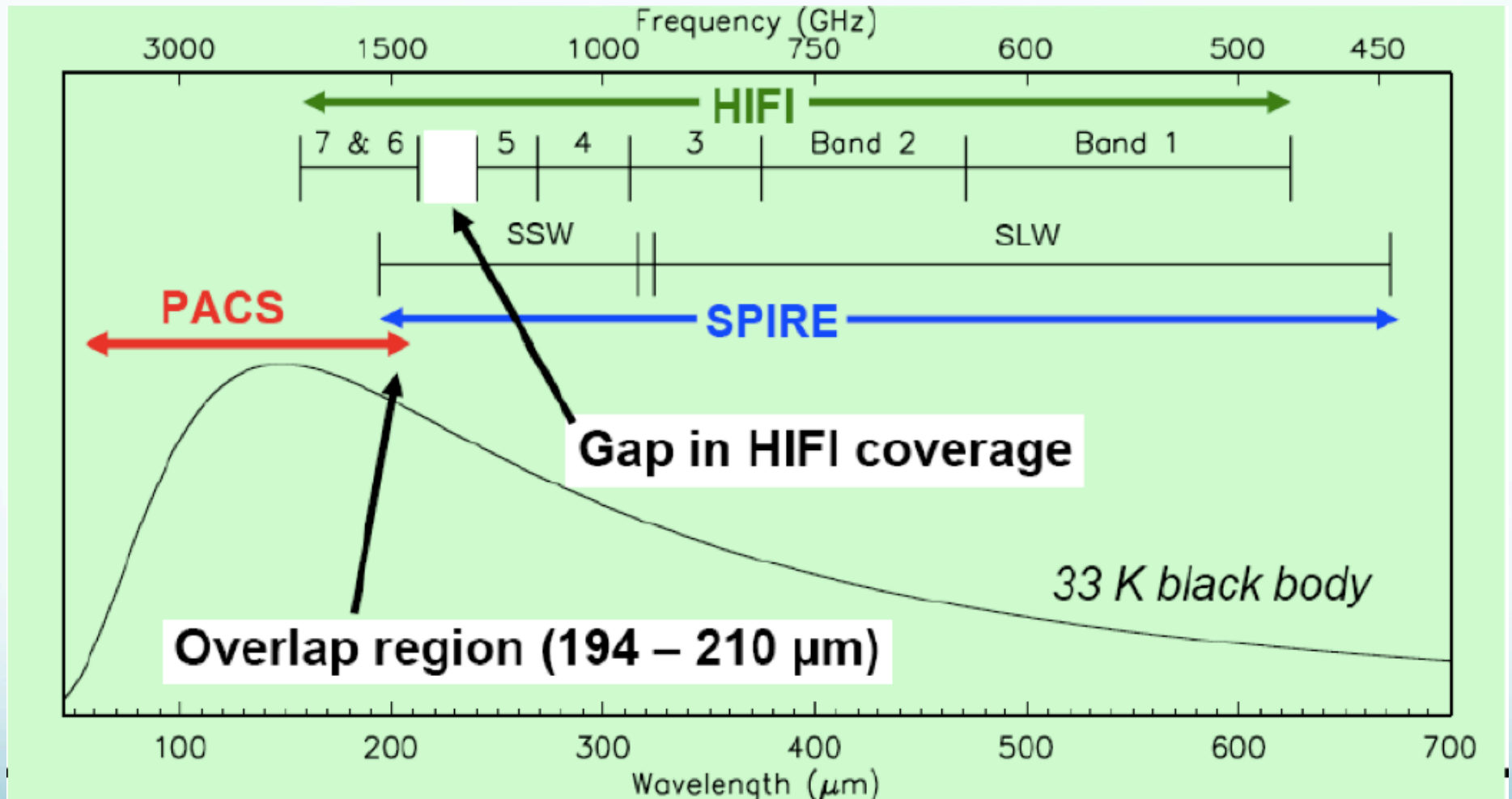


Wavelengths & Resolution: PACS photometer



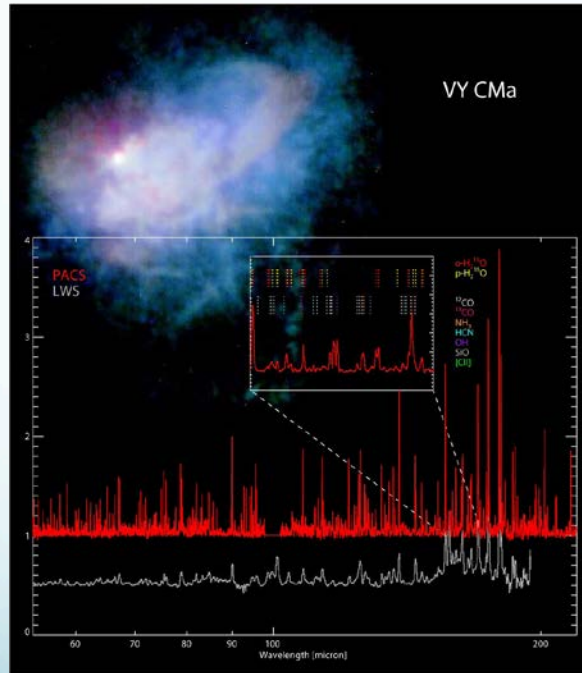
- Simultaneous (\rightarrow same FOV) 60-85 μm or 85-130 μm and 130 – 210 μm imaging
- FWHM: 5.5", 6.7", 11.5"
- 1.7' X 3.5' FOV with a 64 X 32 and 32 X 16 arrays
- Point source detection limit: $\sim 3\text{mJy}$ (5σ , 1h)

PACS Instrument Overview: spectrometer



(slide courtesy of David Ardila)

Wavelengths & Resolution: PACS spectrometer



“Integral Field” (IFU) Spectrometer (3D-spectroscopy)

- Simultaneous (\rightarrow same FOV) 57-105 μm (B3A, B2B) & 105-210 μm (R1) spectroscopy
- FWHM from 9.4” to 13”
- 47” X 47” FOV re-arranged via an image slicer on two 16 X 25 arrays
- $\lambda/\Delta\lambda \sim 1500$
- Sensitivity: $\sim 5 \times 10^{-18} \text{ W/m}^2$ (5σ , 1h)

Data Download and Visualization in HIPE

How do I find the PACS data I need ?

- Each PACS data set (photometer or spectrometer) is uniquely associated with a **10 digit number, i.e. an OBSID.**
Ex: 1342191353
- Therefore, we always first need to identify the OBSID or list of OBSIDs which correspond to the data set we are interested in
- To this end, we go to the **Herschel Science Archive (HSA)**

PACS Data Download & Visualization

The screenshot shows the Herschel Science Archive (HSA) website. The browser address bar displays www.cosmos.esa.int/web/herschel/science-archive. The page header includes the 'herschel' logo and the ESA logo. A navigation menu contains 'COSMOS HOME', 'SCIENCE MISSIONS', and 'SCIENCE FACILITY'. The breadcrumb trail reads 'Cosmos » Herschel » Data Products » Herschel Science Archive (HSA)'. A sidebar on the left lists various sections: Home, General Information, Documentation, Observations, Data Products, Data Processing, Publications, User Services, and Herschel Helpdesk. The main content area features a red oval around the title 'HERSCHEL SCIENCE ARCHIVE (HSA)'. Below this, a text block explains that data products are generated by the 'Herschel Data Processing pipeline' and are available through the HSA. A blue box highlights the link 'Start the HSA User Interface using Java Web Start', with a blue arrow pointing to it from a separate box on the left that says 'Click here to start the HSA interface'. Other text includes 'The current HSA version is v6.0 which was released on the 30 June 2014.', instructions on how to run the HSA as a desktop application, and a link to 'HSA Troubleshooting FAQ'. At the bottom of the main content area, there are links for 'HSA Troubleshooting FAQ' and 'HSA News'.

Herschel > Herschel Science Archive (HSA)

www.cosmos.esa.int/web/herschel/science-archive

herschel

COSMOS HOME SCIENCE MISSIONS SCIENCE FACILITY

Cosmos » Herschel » Data Products » Herschel Science Archive (HSA)

Home

General Information

Documentation

Observations

Data Products

Data Processing

Publications

User Services

Herschel Helpdesk

HERSCHEL SCIENCE ARCHIVE (HSA)

Herschel standard data products were systematically generated by the [Herschel Data Processing pipeline](#) and made available to the users through the Herschel Science Archive (HSA) typically 1-2 days after an observation had been executed.

Today all Herschel science data (~23,400 hours of observing, ~37,000 AORs) are publicly available, and there are science calibration observations (~2600 hours of observing, ~6600 AORs) available too. In addition "[User Provided Data Products](#)" (UPDPs) are also being served by the HSA.

The current HSA version is v6.0 which was released on the 30 June 2014.

Access to Herschel Data

To Access the HSA through the **user interface** please use the following link:

Start the HSA User Interface using Java Web Start

To run the HSA as a desktop application, you must have Java Web Start enabled. First time you launch a Java Web start application? Please follow [these instructions](#). More details on what Java Web Start is can be found [here](#).

To access the HSA data **directly** through the Archive InterOperability System (HAIO) please use:

HAIO web interface

HSA Troubleshooting FAQ **HSA News**

Click here to start the HSA interface

PACS Data Download & Visualization

HSA Science Archive v6.0

File View Windows Account Tools Help

HERSCHEL ESA

Search

Query Panels

Query Cancel Clear

Main Query Panel

Observation Id Obs. List Choose

Proprietary Status

Geometry Panel

Target Multiple Target

Shape Circle Box

Resolve Name Equatorial Galactic Ecliptic

Centre Coordinates Target Radius

Instruments Query Panel

Instrument Obs. Type: Standard Data

All HIFI PACS SPIRE SPIREPACS

Single Point Mapping Spectral Scan **Pacs Photometer** Range Spectroscopy Line Spectroscopy Photometer Spectrometer Parallel Mode

Proposal Query Panel

Timing Constraints Query Panel

User Provided Data Products Panel (UPDP)

Query Cancel Clear

Log Console Not Logged In

Ex:
Search in the HSA for PACS photometer data for M16 within a 5' radius

PACS Data Download & Visualization

Result of the query:

HSA Science Archive v6.0

File View Windows Account Tools Help

HERSCHEL ESA

Search Observations #1

Observations

4 Results Page 1 of 1 Page Size: 25

Find: Find Next Find Previous

Filter Rows:

	Observation ID	Postcards	Target	RA/DEC	Instrument	Observing Mode	OD	Proposal ID	AOR
<input type="checkbox"/>	1342269246		LkHa 260	18h 19m 09.50s -13d 50' 29.50"	PACS	PacsPhoto	1,420	OT1_gmeeus_1	LkHa_260_PACSPHOT
<input type="checkbox"/>	1342269247		LkHa 260	18h 19m 08.55s -13d 50' 38.05"	PACS	PacsPhoto	1,420	OT1_gmeeus_1	LkHa_260_PACSPHOT
<input type="checkbox"/>	1342269248		LkHa 260	18h 19m 09.67s -13d 50' 30.08"	PACS	PacsPhoto	1,420	OT1_gmeeus_1	LkHa_260_PACSPHOT
<input type="checkbox"/>	1342269249		LkHa 260	18h 19m 09.23s -13d 50' 40.78"	PACS	PacsPhoto	1,420	OT1_gmeeus_1	LkHa_260_PACSPHOT

Log Console Not Logged In

esa

**Now that I have identified the OBSID/s I need:
how do I download the data?**

The best way to download PACS data is from **HIPE**

PACS Data Download & Visualization

Before showing how to download the data from HIPE, for completeness....

2. Click the download icon

1. Select the OBSID/s you want to download

Warning:
This method is NOT recommended: you will have to pay the price of a very long download time and you will get a very big .tar file

				RA/DEC	Instrument	Observing Mode	OD	Proposal ID	AOR		
<input checked="" type="checkbox"/>			UPDP	QUALITY REPORT	134226	h 19m 09.50s -13d 50' 29.50"	PACS	PacsPhoto	1,420	OT1_gmееus_1	LkHa_260_PACSPHOT
<input type="checkbox"/>			UPDP	QUALITY REPORT	134226	h 19m 08.55s -13d 50' 38.05"	PACS	PacsPhoto	1,420	OT1_gmееus_1	LkHa_260_PACSPHOT
<input type="checkbox"/>			UPDP	QUALITY REPORT	134226	h 19m 09.67s -13d 50' 30.08"	PACS	PacsPhoto	1,420	OT1_gmееus_1	LkHa_260_PACSPHOT
<input type="checkbox"/>			UPDP	QUALITY REPORT	1342269249	LkHa_260_28h 19m 09.23s -13d 50' 40.78"	PACS	PacsPhoto	1,420	OT1_gmееus_1	LkHa_260_PACSPHOT

What is HIPE ?

The **Herschel Interactive Processing Environment** (HIPE) is a software package that allows Herschel users to: 1) download; 2) visualize; 3) analyze the data

Where do I find it ?

- To download HIPE, go to:

<http://www.cosmos.esa.int/web/herschel/hipe-download>

- HIPE is developed for different platforms: Windows, MacOSX and Linux
- Installation instructions are provided at the above link
- During the Herschel mission (2009 – 2013), a new version of the software was released every six months (HIPE 1 to HIPE 11). Since September 2013, HIPE is released once per year. The current released version is HIPE 12.1. The next release will occur ~end of 2014

Always process your data with the last HIPE release

PACS Data Download & Visualization

The screenshot shows the HIPE 12.1.0 software interface. At the top, there is a menu bar with 'File', 'Edit', 'Run', 'Pipelines', 'Scripts', 'Window', 'Tools', and 'Help'. Below the menu bar is a toolbar with several icons. The main content area is titled 'Welcome' and contains the following text: 'Welcome to Herschel Interactive Processing Environment!', 'HIPE Version: 12.1.0', and 'Hover your mouse over one of the images below for more information.' Below this text are six icons arranged in a 2x3 grid: 'Access Data' (a stack of disks with an arrow), 'Documentation' (a book with a magnifying glass), 'Workbench' (a clapperboard with a play button), 'Preferences' (a key and a wrench), 'Updates' (a globe with a cable), and 'External Tools' (a blue sphere). The 'Workbench' icon is circled in red, and a red arrow points from it to a red-bordered box on the right. This box contains the text: 'Double click on this icon to get to the workbench (next slide)'. At the bottom of the window, there is a status bar with a user name 'rpaladin', a progress indicator 'Checking for updated PACS Calibration.. 100%', and a memory usage indicator '190 of 11737 MB'.

File Edit Run Pipelines Scripts Window Tools Help


HIPE 12.1.0

Welcome

Welcome to Herschel Interactive Processing Environment!
HIPE Version: 12.1.0

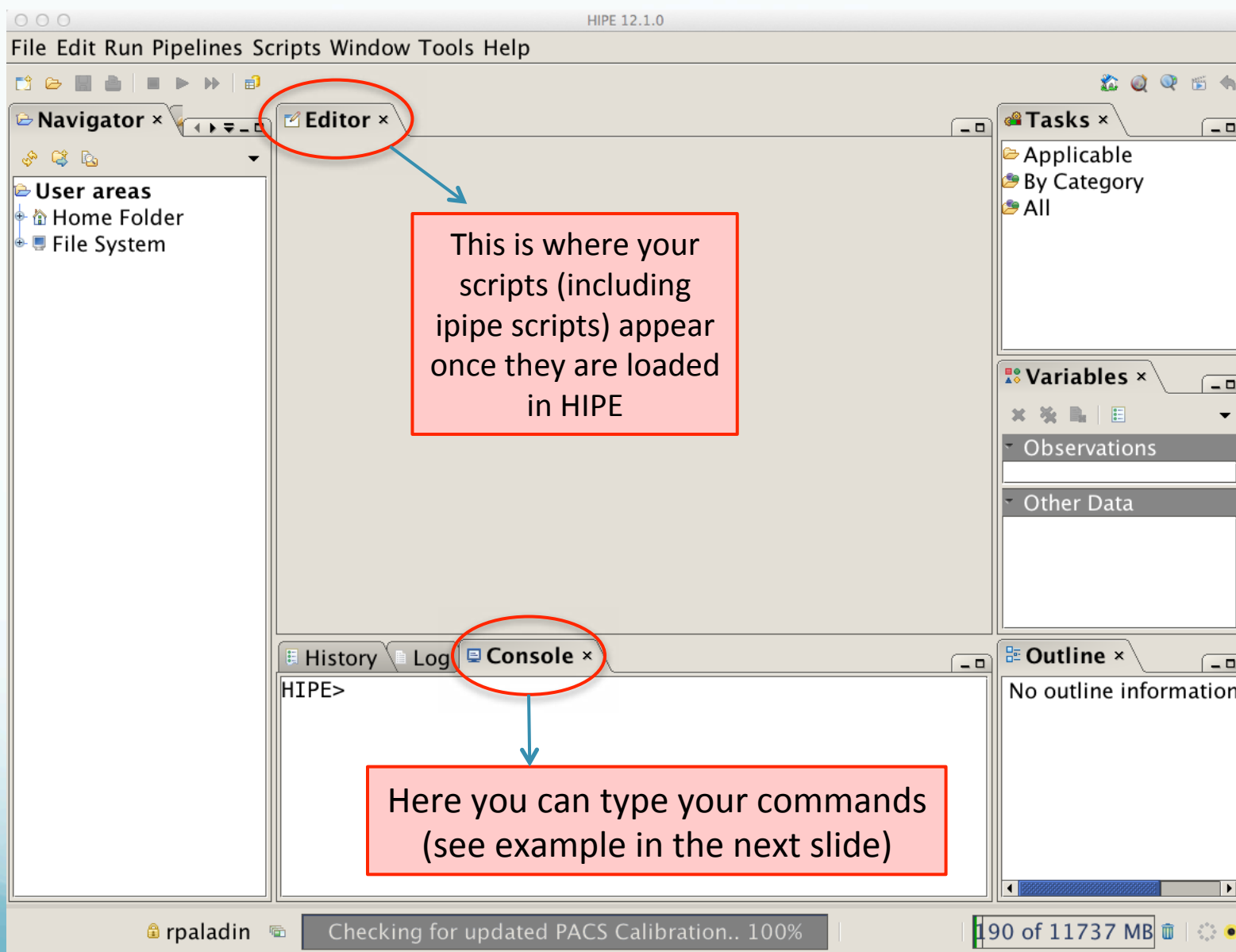
Hover your mouse over one of the images below for more information.

Access Data Documentation Workbench Preferences Updates External Tools

Tip: To get back to this page, click the  icon in the toolbar.

rpaladin Checking for updated PACS Calibration.. 100% 190 of 11737 MB

PACS Data Download & Visualization



Example: M16 – OBSID: 1342269247

HIPE 12.1.0 - obs

File Edit Run Pipelines Scripts Window Tools Help

Editor x

obs x

ObservationContext for PACS data of observation 1342269247

Summary

AOR label:	LkHa_260_PACSPHOT - cross		
Instrument:	PACS	Obs. ID:	1342269247
Object:	LkHa_260	Obs. Date:	2013-04-02T16:38:11Z
AOT:	Photometer	Obs. Mode:	Scan map
RA Nominal:	18h 19m 9.39s	Dec. Nominal:	-13° 50' 41.1"
SPG Version:	SPG 1.1.0	Operational Day:	1420

Meta Data

Data

- obs
- History
- auxiliary
- browseImagePr
- browseProduct
- calibration
- level0
- level0_5
- level1
- level2
- level2_5
- level3

Variables x

Observations

- obs

Other Data

Outline x

- obs
- History
- auxiliary
- browseImageProd
- browseProduct
- calibration
- level0
- level0_5
- level1
- level2
- level2_5
- level3
- logObsContext
- quality

History Log Console x

```
HIPE> obs = getObservation(1342269247, useHsa=True)
getObservation is retrieving the observation from the HSA
HIPE>
```

rpaladin Jython Interpreter 100% 197 of 11720 MB

Double click on the "obs" variable

1

3

2

PACS Data Products: Photometer & Spectrometer

Note on PACS archived data

- Every time a new version of HIPE is publicly released, all the Herschel data in the archive (HSA) are reprocessed with it (→ Standard Processing Generation (SPG) *bulk-reprocessing*)
- the current version of the bulk reprocessing in the HSA is: SPG 11.1
- when you use PACS data for your science, always make sure you are using the last processed version
- this will assure that the data have been processed with the most updated calibration files and pipeline

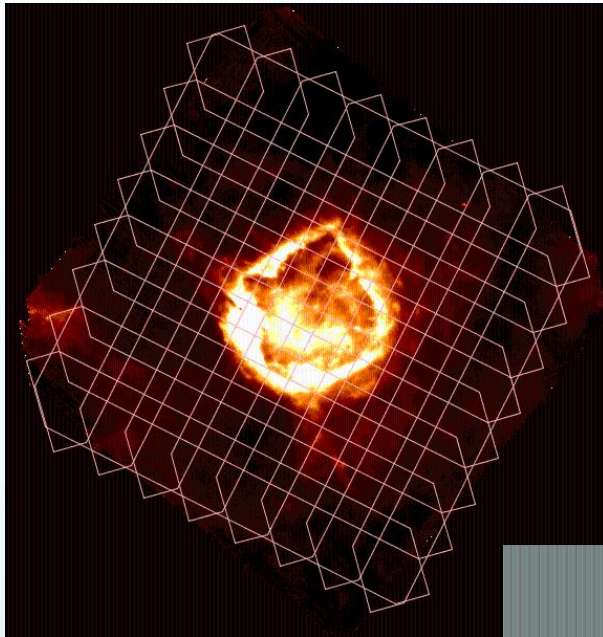
PACS photometer products

PACS Photometer Archived Products

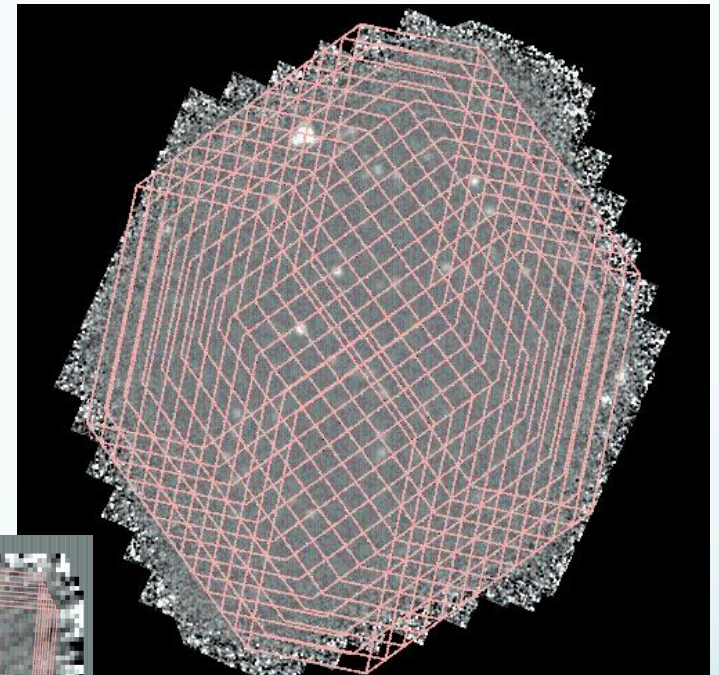
- There are 3 PACS photometer observing modes:
 - Chop-Nod mode → this mode was deprecated in Cycle 1/ Cycle 2 and only used for calibration purposes
 - Scan map mode
 - Parallel mode
- Here, we will only talk about these two modes
- For any observation performed in a given mode (scan map or parallel), the archive contains different *processing levels (level 0, level 1, etc.)* of the data

Scan Map Mode

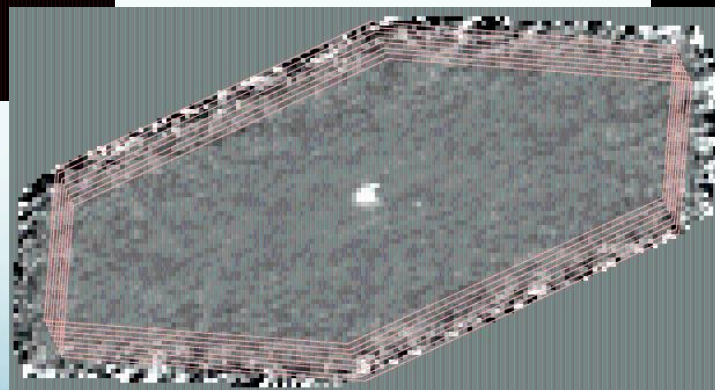
Large Galactic fields



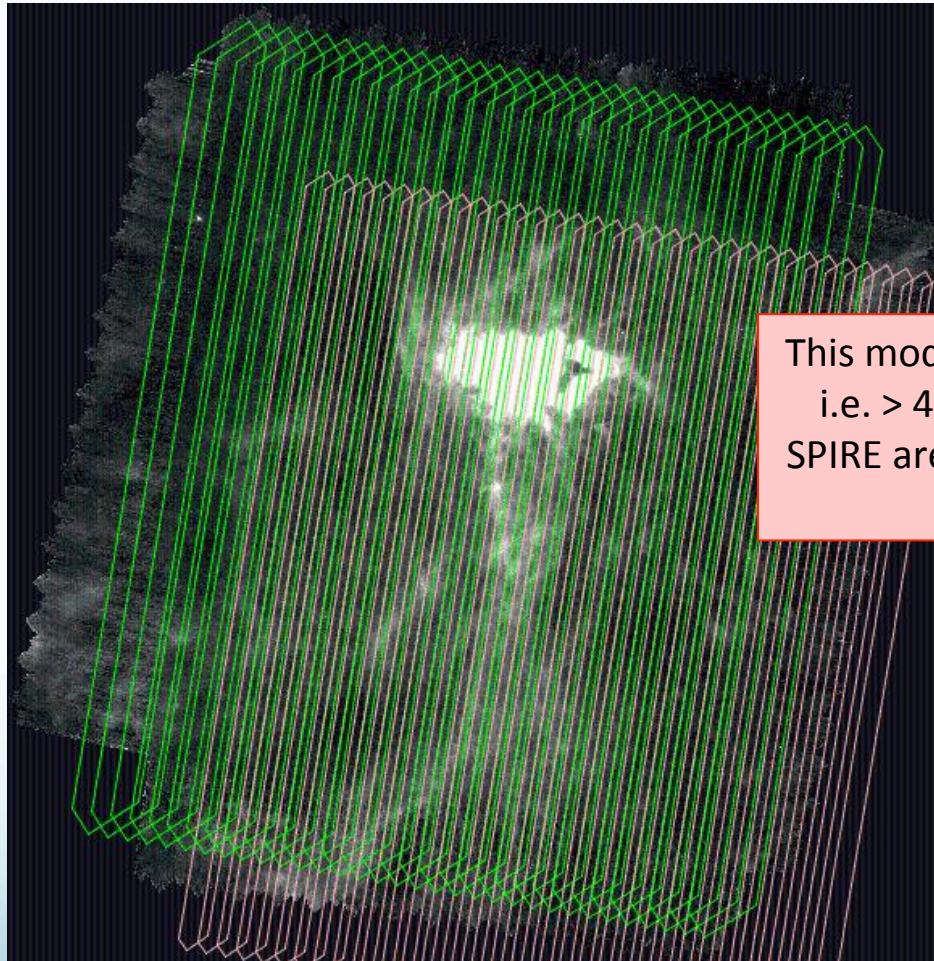
Deep cosmological fields



Small fields centered on point-sources



Parallel Mode: PACS & SPIRE



This mode is efficient for large maps, i.e. > 45 arcmin in size (PACS and SPIRE are separated by 21 arcmin on the focal plane)

Let's go back to our example: M16 – OBSID: 1342269247

HIPE 12.1.0 - obs

File Edit Run Pipelines Scripts Window Tools Help

Editor x

obs x

3

ObservationContext for PACS data of observation 1342269247

Summary

AOR label: LkHa_260_PACSPHOT - cross

Instrument: PACS Obs. ID: 1342269247

Object: LkHa_260 Obs. Date: 2013-04-02T16:38:11Z

AOT: Photometer Obs. Mode: Scan map

RA Nominal: 18h 19m 09.39s Dec. Nominal: -13° 50' 41.1"

SPG Version: SPG 1.1.0 Operational Day: 1420

Meta Data

Data

obs

History

auxiliary

browseImagePr

browseProduct

calibration

level0

level0_5

level1

level2

level2_5

level3

2

Variables x

Observations

obs

Other Data

Outline x

obs

History

auxiliary

browseImageProd

browseProduct

calibration

level0

level0_5

level1

level2

level2_5

level3

logObsContext

quality

1

Console x

```
HIPE> obs = getObservation(1342269247, useHsa=True)
getObservation is retrieving the observation from the HSA
HIPE>
```

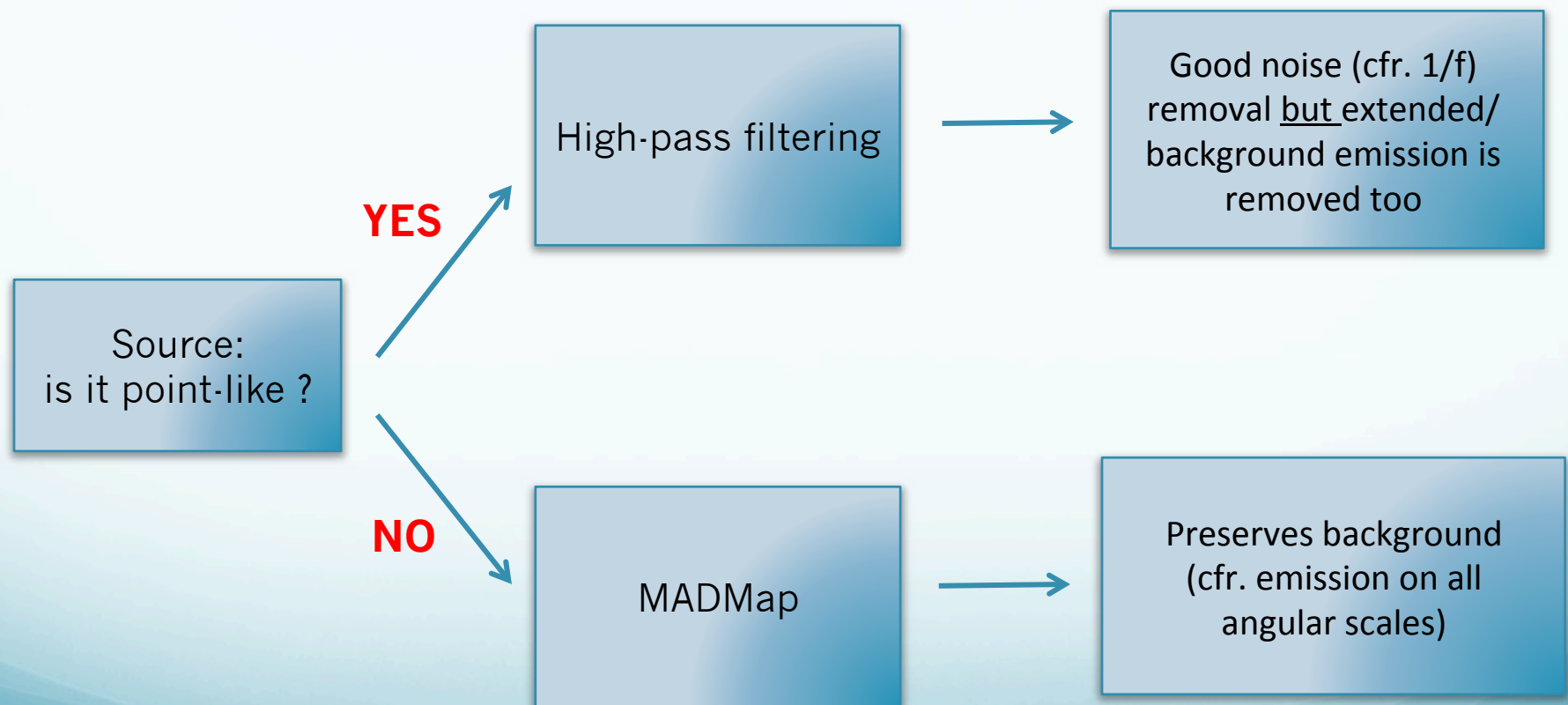
Double click on the "obs" variable

rpaladin Jython Interpreter 100% 197 of 11720 MB

Currently available from the HSA (SPG 11.1)

- ❑ **Level 0:** raw data cubes → we will not talk about these: users never need to go back to Level 0 in the case of PACS photometer data (..different story for the spectrometer)
- ❑ **Level 1:** data cubes calibrated in Jy/pixel, instrument effects removed and propagation of “flagged pixels” (cfr. masks). Astrometry (cfr. pointing) attached
NOTE: Level 1 is the typical starting point for re-processing
- ❑ **Level 2:** maps created by projecting high-pass filtered (HPF) data cube on a grid using pointing information
NOTE: one map per OBSID / extended emission is filtered out
- ❑ **Level 2.5:** maps obtained by combining *pairs* (cfr. Scan/X-scan) of OBSIDs – Both MADmap and HPF maps
NOTE: MADMap preserves emission on all angular scales
- ❑ **Level 3:** maps obtained by combining all observations of a given field from the same program – HPF only

The PACS photometer pipeline has 2 branches starting from Level 1:



Level 1: calibrated frames

The screenshot displays the HIPE 12.1.0 interface. The main window shows an **ArrayDataset** for observation 'obs'. The summary includes:

- AOR label:** LkHa_260_PACSPHOT - cross
- Instrument:** PACS
- Object:** LkHa 260
- AOT:** Photometer
- RA Nominal:** 18h 19m 9.39s
- SPG Version:** SPG v11.1.0
- Obs. ID:** 1342269247
- Obs. Date:** 2013-04-02T16:38:11Z
- Obs. Mode:** Scan map
- Dec. Nominal:** -13° 50' 41.1"
- Operational Day:** 1420

The **Data** tree on the left shows a hierarchy: `level0_5` (circled in red with an arrow) → `level1` → `History` → `HPPAVGB` → `MasterBlock` → `History` → `0` → `Signal` (highlighted in blue). Below this, `Status`, `Mask`, `BlockTable`, and `History` are listed, followed by `HPPAVGR`.

The central visualization shows a **Spatial frame at a time sample** (indicated by a red box). The frame is a 2D heatmap of the LkHa 260 region, with a small inset showing a zoomed-in view of the source. The axes are labeled with values like -0.6, 7.8 and N.A. / N.A.

The **Console** window at the bottom shows the following Python commands:

```
HIPE> frames = obs.refs["level1"].product.refs["HPPAVGB"].product.refs[0].product
HIPE> Display(frames.signal, depthAxis=2)
HIPE> # displayExplorer.setCutLevels(98.0)
HIPE>
```

This is the starting point for reprocessing your data

Spatial frame at a time sample

HIPE> frames = obs.refs["level1"].product.refs["HPPAVGB"].product.refs[0].product
HIPE> Display(frames.signal, depthAxis=2)
HIPE> # displayExplorer.setCutLevels(98.0)
HIPE>

Outline

Name	frames
Class	Frames
Package	herschel.pacs.signal
frames	
Signal	
Status	
Mask	
BlockTable	
History	

Level 2: per-OBSID map

The screenshot shows the HIPE 12.1.0 interface. The main window is titled "obs" and displays the following information:

Image Summary

- AOR label:** LkHa_260_PACSPHOT - cross
- Instrument:** PACS
- Object:** LkHa 260
- AOT:** Photometer
- RA Nominal:** 18h 19m 9.39s
- SPG Version:** SPG v11.1.0
- Obs. ID:** 1342269247
- Obs. Date:** 2013-04-02T16:38:11Z
- Obs. Mode:** Scan map
- Dec. Nominal:** -13° 50' 41.1"
- Operational Day:** 1420

The **Data** section shows a tree view with the following structure:

- calibration
- level0
- level0_5
- level1
- level2 (highlighted with a red circle and arrow)
 - History
 - HPPPMAPB
 - image (selected)
 - coverage
 - HPFmask
 - error
 - History
 - HPPPMAPB

The main image display shows a per-OBSID map of the LkHa 260 region. The image is titled "obs.refs[\"level2\"].product.refs[\"HPPPMAPB\"].product[\"image\"]". The image shows a bright, irregularly shaped region of emission against a dark background. A color bar at the bottom of the image indicates the intensity scale, ranging from 1.2 to -225.9. The color bar is currently set to "N.A. / N.A.". The console window at the bottom shows the following commands and output:

```

HIPE>
HIPE> obs = getObservation(1342269247, useHsa=True)
getObservation is retrieving the observation from the HSA
HIPE>
    
```

The status bar at the bottom of the window shows the user "rpaladin", the progress "Load SimpleImage 100%", and the memory usage "470 of 11645 MB".

Level 2.5: OBSID pair (scan/X-scan) HPF map

The screenshot displays the HIPE 12.1.0 software interface. The main window is titled "obs" and shows the following details:

- Image Summary:**
 - AOR label: LkHa_260_PACSPHOT - cross
 - Instrument: PACS
 - Object: LkHa 260
 - AOT: Photometer
 - RA Nominal: 18h 19m 9.39s
 - SPG Version: SPG v11.1.0
 - Obs. ID: 1342269247
 - Obs. Date: 2013-04-02T16:38:11Z
 - Obs. Mode: Scan map
 - Dec. Nominal: -13° 50' 41.1"
 - Operational Day: 1420
- Meta Data:**
 - Data tree showing a hierarchy: level1 > level2 > level2_5 > HPPPCOMB > HPPPCOMR > HPPPMOSB > photProject > image (highlighted with a red circle and arrow).
- Main View:** A large HPF map image showing a complex, multi-lobed structure in orange and red tones.
- Variables Panel:** Shows "Observations" with "obs" selected.
- Outline Panel:**

Name	obs.refs["level2_5"]
Class	ArrayDataset
Package	herschel.ia.dataset
- Console:**

```

HIPE>
HIPE> obs = getObservation(1342269247, useHsa=True)
getObservation is retrieving the observation from the HSA
HIPE>
                    
```

The status bar at the bottom shows the user "rpaladin", "Load SimpleImage 100%", and "493 of 11648 MB" of memory used.

Level 2.5: OBSID pair (scan/X-scan) MADMap map

The screenshot displays the HIPE 12.1.0 interface with the following components:

- Editor:** Shows observation details for 'obs' with a small thumbnail image.
 - Summary:**
 - AOR label: LkHa_260_PACSPHOT - cross
 - Instrument: PACS
 - Object: LkHa 260
 - AOT: Photometer
 - RA Nominal: 18h 19m 9.39s
 - SPG Version: SPG v11.1.0
 - Obs. ID: 1342269247
 - Obs. Date: 2013-04-02T16:38:11Z
 - Obs. Mode: Scan map
 - Dec. Nominal: -13° 50' 41.1"
 - Operational Day: 1420
 - Meta Data:** (Collapsed)
 - Data:** Shows a tree structure with 'level2_5' selected. A red circle highlights the 'level2_5' folder and its sub-items: 'HPPPCOMB', 'correctedmap', 'image', 'error', 'coverage', 'History', 'artifactmap', 'madmap', 'naivemap', 'HPPPCOMR', 'HPPPMOSB', 'HPPPMOSR', and 'level3'. A red arrow points to the 'level2_5' folder.
- Variables:** Shows 'Observations' with 'obs' selected.
- Outline:** Shows a table with the following data:

Name	obs.refs["level2_5"]
Class	ArrayDataset
Package	herschel.ia.dataset
- Console:** Shows the command history:

```
HIPE>  
HIPE> obs = getObservation(1342269247, useHsa=True)  
getObservation is retrieving the observation from the HSA  
HIPE>
```
- Bottom Panel:** Shows a large MADMap map of the LkHa 260 region. The map includes a coordinate grid and a color scale at the bottom with values: 64, -254, 0.39, -0.054, 99..., 0.13, and N.A. / N.A.

Level 3: all OBSID pairs from the same program / HPF

The screenshot displays the HIPE 12.1.0 interface with the following components:

- Editor:** Shows observation details for 'obs':
 - Image Summary:**
 - AOR label: LkHa_260_PACSPHOT - cross
 - Instrument: PACS
 - Object: LkHa 260
 - AOT: Photometer
 - SPG Version: SPG v11.1.0
 - Meta Data:**
 - Obs. ID: 1342269247
 - Obs. Date: 2013-04-02T16:38:11Z
 - Obs. Mode: Scan map
 - Dec. Nominal: -13° 50' 41.1"
 - Operational Day: 1420
 - Data:** A tree view on the left shows a hierarchy: level0, level0_5, level1, level2, level2_5, level3 (highlighted with a red arrow), HPPPMOSB, l3mosaicB, image (selected), coverage, History, HPPPMOSR, logObsContext, quality, and qualitySummary. The main window displays a large mosaic image of the LkHa 260 region.
- Variables:** Shows 'Observations' with 'obs' listed.
- Outline:** A table showing the current object's metadata:

Name	obs.refs["level3"].p
Class	ArrayDataset
Package	herschel.ia.dataset
- Console:** Shows the command history:

```
HIPE>  
HIPE> obs = getObservation(1342269247, useHsa=True)  
getObservation is retrieving the observation from the HSA  
HIPE>
```

Summary of PACS photometer archived products

➤ level 0:

HPENG: engineering

HPGENHK: housekeeping

HPPAVGB/HPPAVGR: Herschel PACS Photometer Averaged Blue/Red Data (→ “Signal” in /0)

HPPDMCB/HPPDMCR: raw data (blue/red)

HPPHK: housekeeping

➤ level 1:

HPPAVGB/HPPAVGR: Herschel PACS Photometer Averaged Blue/Red Data (→ “Signal” in /0)

➤ level 2:

HPPPMAPB/HPPPMAPR: Herschel PACS Photometer Phot-project Map Blue/Red
(→ “image”, “error”, “coverage”)

➤ level 2.5:

HPPPCOMB/HPPPCOMR: Herschel PACS Photometer Combined MADMap Blue/Red
(→ “image”, “coverage”, “error” in /correctedmap, /madmap, /naivemap)

HPPPMOSB/HPPPMOSR: Herschel PACS Photometer Phot-project Mosaic Blur/Red
(→ “image”, “coverage”, “error” in /photProject)

➤ level 3:

HPPPMOSB/HPPPMOSR: Herschel PACS Photometer Phot-project Map Blue/Red
(→ “image”, “error”, “coverage”)

Note about MADMap products (..this is a recurrent question)

Browse Product

Summary

AOR label:	LkHa_260_PACSPHOT - cross	Obs. ID:	1342269247
Instrument:	PACS	Obs. Date:	2013-04-02T16:38:11Z
Object:	LkHa 260	Obs. Mode:	Scan map
AOT:	Photometer	Dec. Nominal:	-13° 50' 41.1"
RA Nominal:	18h 19m 9.39s	Operational Day:	1420
SPG Version:	SPG v11.1.0		

Meta Data

Data

- level1
- level2
- level2_5
 - HPPPCOMB
 - correctedmap
 - madmap
 - naivemap
 - HPPPCOMR
 - HPPPMOSB
 - HPPPMOSR

obs.refs["browseProduct"].product

These 3 products are different flavors of MADMap maps and correspond to different levels of the MADMap processing

- **correctedmap:** MADMap map after PGLS correction
- **madmap:** MADMap map before PGLS correction
- **naivemap:** MADMap naïve map, i.e. map not corrected for uncorrelated 1/f noise but corrected for drift

Heads up: different photometer products in the HSA soon..

SPG 11
(currently in HSA)

Photometer Products:

- ✓ HPF (up to Level 3)
- ✓ MADmap



SPG 12
(end of Summer/Fall 2014)

Photometer Products:

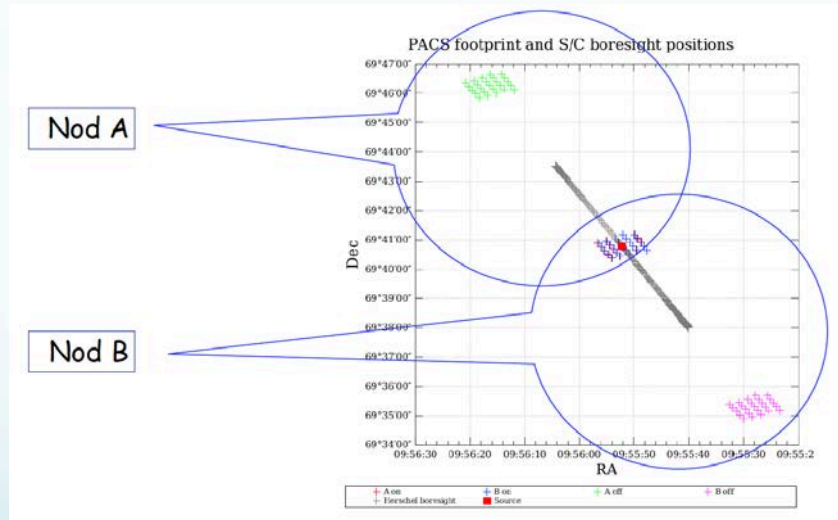
- ✓ HPF (up to Level 2.5)
- ✓ JScanam (up to Level 3)
- ✓ MADmap (up to Level 3)

PACS spectrometer products

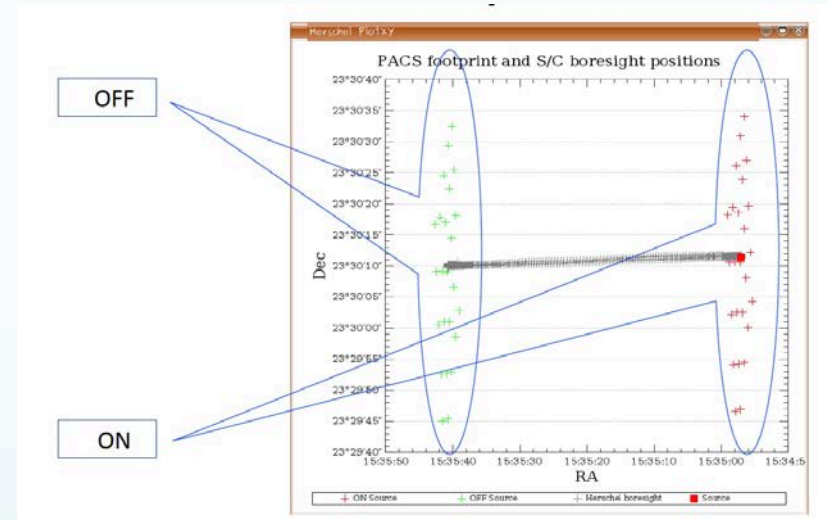
PACS Spectrometer Archival Products

- There are 2 PACS spectrometer observing modes:
 - Chop-Nod mode
 - Un-chopped mode
- For any observation performed in a given mode (chop/un-chopped), the archive contains different *processing levels (level 0, level 1, etc.)* of the data

Chop-nod



Un-chopped

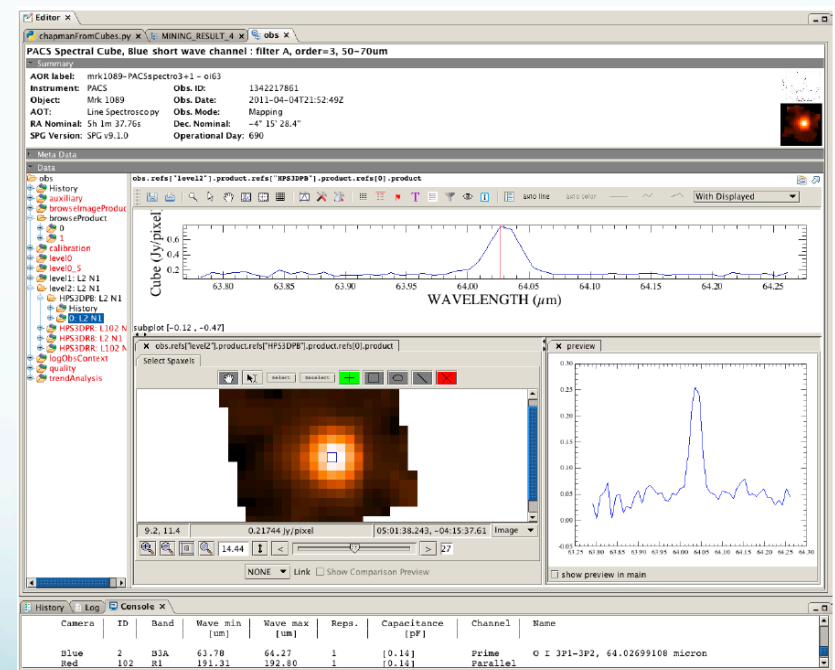
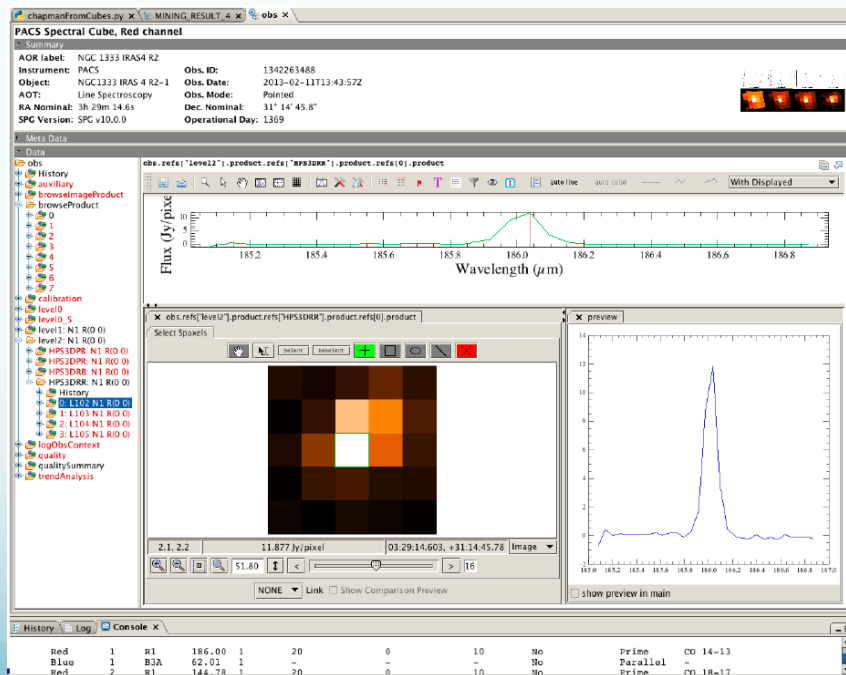


PACS Spectrometer: Products

Both chop and un-chopped observations can be pointed or mapping

Pointed

Mapping



Both chop-nod and un-chopped observations can be line or range

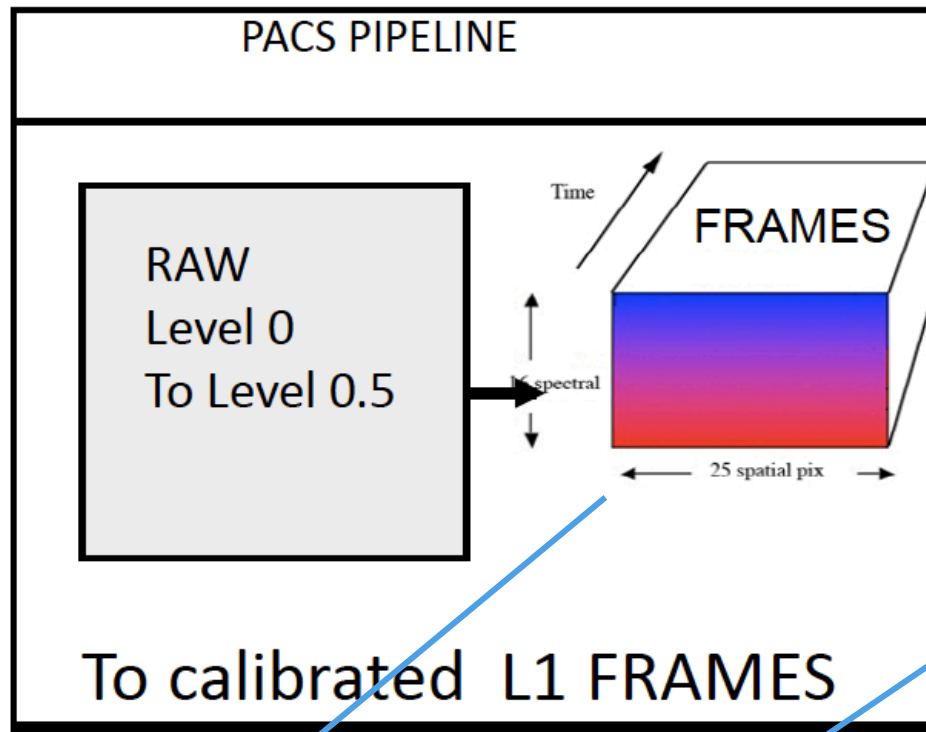
- Line Spectroscopy - short wavelength coverage, multiple lines
- Range Spectroscopy - broader wavelength coverage, multiple ranges

In Summary:

A PACS spectrometer observation can be any combination of the following:

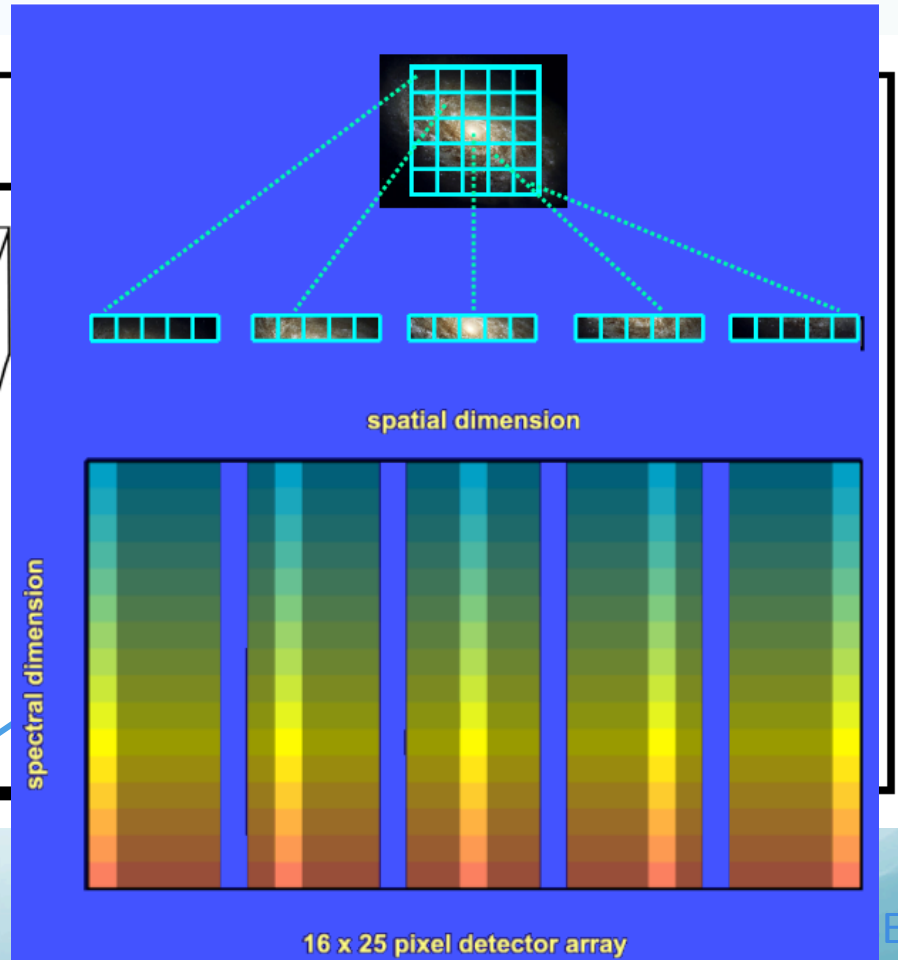
→ line/range, chop/un-chopped, pointed/mapping

PACS Spectrometer Archived Products



L1 pacsFrames

L1 pacsCUBE



Example: AFGL490 – OBSID: 1342191353

The screenshot displays the HIPE 11.0.0 interface with three main panels:

- Editor:** Shows the **ObservationContext for PACS data of observation 1342191353**. The **Summary** section includes:
 - AOR label: PACS setting 2 - AFGL490
 - Instrument: PACS
 - Object: AFGL490
 - AOT: Line Spectroscopy
 - RA Nominal: 3h 27m 38.4s
 - SPG Version: SPG v10.3
 - Obs. ID: 1342191353
 - Obs. Date: 2010-02-28T08:57:02Z
 - Obs. Mode: Pointed
 - Dec. Nominal: 58° 47' 8"
 - Operational Day: 290
- Console:** Shows the command `obs=getObservation(1342191353, useHsa=True)` and the output `getObservation is retrieving the observation from the HSA`.
- Variables:** Shows a list of variables under the **Observations** section, with **obs** selected.

Red annotations and arrows indicate the workflow:

1. A red circle highlights the `obs=getObservation(1342191353, useHsa=True)` command in the console.
2. A red circle highlights the **obs** variable in the Variables panel, with a text box stating: "Double click on the 'obs' variable".
3. A red circle highlights the **Obs. ID: 1342191353** field in the ObservationContext.

Level 1: PacsCube

PACS Spectral Cube

Summary

AOR label: PACS setting 2 - AFGL490
Instrument: PACS Obs. ID: 1342191353
Object: AFGL490 Obs. Date: 2010-02-28T08:57:02Z
AOT: Line Spectroscopy Obs. Mode: Pointed
RA Nominal: 3h 27m 38.4s Dec. Nominal: 58° 47' 8"
SPG Version: SPG v10.3.0 Operational Day: 290

Meta Data

Data

- obs
- History
- auxiliary
- browseImageProduct
- browseProduct
- calibration
- level0
- level0_5
- level1: N1 R(0 0)
- HPS3DB: N1 R(0 0)
- MasterBlockTable
- History
- 0: L2 N1 B R(0 0)
- 1: L2 N1 A R(0 0)
- 2: L3 N1 B R(0 0)
- 3: L3 N1 A R(0 0)
- 4: L4 N1 B R(0 0)
- 5: L4 N1 A R(0 0)
- 6: L5 N1 B R(0 0)
- 7: L5 N1 A R(0 0)
- 8: L6 N1 B R(0 0)
- 9: L6 N1 A R(0 0)
- NPS3DR: N1 R(0 0)
- HPSALB: L1 NO B R(0 0)
- HPSALR: L101 NO B R(0 0)
- HPSFITB: N1 R(0 0)
- HPSFITR: N1 R(0 0)

Mask selection

- *ALL*
- BLINDPIXELS
- SATURATION
- RAWSATURATION
- OUTFBAND
- NOISYPIXELS
- BADPIXELS
- UNCLEANCHOP
- GRATMOVE
- GLITCH

Update: (De)activate

Select	Id	NrIdx
<input checked="" type="checkbox"/>	SPEC CHO...	12288
<input checked="" type="checkbox"/>	SPEC CHO...	12288

```
HIPE> # displayExplorer.setCutLevels(95.0)
HIPE> # displayExplorer.setCutLevels(90.0)
HIPE> # displayExplorer.setCutLevels(95.0)
HIPE>
```

Spectrum Explorer Tool
(common to all Herschel
instruments)

Level 2: Rebinned Cube

The screenshot displays the HIPE 11.0.0 - obs interface. The main window is titled "PACS Spectral Cube, Blue short wave channel : filter A, order=3, 50-70um". It contains a "Summary" section with the following details:

- AOR label: PACS setting 2 - AFGL490
- Instrument: PACS
- Object: AFGL490
- AOT: Line Spectroscopy
- RA Nominal: 3h 27m 38.4s
- SPG Version: SPG v10.3.0
- Obs. ID: 1342191353
- Obs. Date: 2010-02-28T08:57:02Z
- Obs. Mode: Pointed
- Dec. Nominal: 58° 47' 8"
- Operational Day: 290

Below the summary is a "Meta Data" section and a "Data" section. The "Data" section shows a tree view of the observation products. A red circle highlights the "HPS3DRB: N1 R(0 0)" product, with a red arrow pointing to it. Other products in the tree include "level0", "level0_5", "level1: N1 R(0 0)", "level2: N1 R(0 0)", "HPS3DPB: N1 R(0 0)", "HPS3DPR: N1 R(0 0)", "HPS3DRR: N1 R(0 0)", "logObsContext", "quality", and "trendAnalysis".

The main plot area shows a spectral plot of "Flux (Jy/pixel)" versus "Wavelength (μm)". The plot shows a spectrum with a prominent peak at approximately 63.2 μm. The y-axis ranges from 0 to 600 Jy/pixel, and the x-axis ranges from 62.95 to 63.35 μm.

Below the spectral plot is a "Spaxel Viewer" window titled "obs.refs['level2'].product.refs['HPS3DRB'].product.refs[0].product". It shows a 5x5 grid of spaxels. The central spaxel is highlighted in white, and the surrounding spaxels are shaded in brown. The coordinates of the selected spaxel are "3.1, 5.1" and "β44, +58:46:56.30 Im...".

At the bottom of the interface is a "Console" window showing the following commands:

```
HIPE> # displayExplorer.setCutLevels(95.0)
HIPE> # displayExplorer.setCutLevels(90.0)
HIPE> # displayExplorer.setCutLevels(95.0)
HIPE>
```

The status bar at the bottom indicates "rpaladin" and "updating plot 100%". The system tray shows "645 of 11759 MB".

Spectrum Explorer Tool
(common to all Herschel
instruments)

Level 2: Projected Cube

The screenshot displays the HIPE 11.0.0 software interface. The main window is titled "PACS Spectral Cube, Blue short wave channel : filter A, order=3, 50-70um". The interface is divided into several panels:

- File Explorer (Left):** Shows a tree view of the data structure. The "HPS3DPB: N1 R(0 0)" folder is circled in red, with a red arrow pointing to it. Other folders include "obs", "History", "auxiliary", "browseImageProduct", "browseProduct", "calibration", "level0", "level0_5", "level1: N1 R(0 0)", "level2: N1 R(0 0)", "HPS3DPR: N1 R(0 0)", "HPS3DRB: N1 R(0 0)", "HPS3DRR: N1 R(0 0)", "logObsContext", "quality", and "trendAnalysis".
- Main Plot Area:** Contains two plots. The top plot is a spectrum plot showing "Flux (Jy/pix)" vs "Wavelength (μm)" with a red line and a peak at approximately 63.15 μm. The bottom plot is a spaxel viewer showing a 2D map of the field of view with a selected spaxel at coordinates (771, +58:46:59.65) and a flux of 2.1229 Jy/pixel.
- Console (Bottom):** Shows the following commands:

```
HIPE>  
HIPE> # displayExplorer.setCutLevels(98.0)  
HIPE> # displayExplorer.setCutLevels(95.0)  
HIPE> # displayExplorer.setCutLevels(90.0)
```

A red box on the right side of the interface contains the text: "Spectrum Explorer Tool (common to all Herschel instruments)".

Summary of PACS spectrometer archived products

➤ Level 0:

HPENG: engineering

HPGENHK: housekeeping

HPSDMCB/HPSDMCR: raw DecMec (blue/red)

HPSFITB/HPSFITR: Herschel PACS Spectrometer Fitted Blue/Red (→ “Signal” in /0)

HPPHK: housekeeping

HPSRAWB/HPSRAWR: raw data (blue/red)

➤ Level 1:

HPS3DB/HPS3DR: Herschel PACS Spectrometer 3D Spectral Cube Blue/Red
(→ “flux”, “wave”, “ra”, “dec” in, e.g., /0: L2 N1 B R(0 0))

HPSCALB/HPSCALR: calibration (response/dark)

HPSFITB/HPSFITR: fitted slopes

➤ Level 2:

HPS3DPB/HPS3DPR: Herschel PACS Spectrometer 3D Projected Cube Blue/Red
(→ “image”, “coverage” in, e.g., /0: L2 N1 A R(0 0))

HPS3DRB/HPS3DRR: Herschel PACS Spectrometer 3D Rebinned Cube Blue/Red
(→ “image”, “ra”, “dec”, “stddev”, “exposure”, “wavegrid” in, e.g., /0: L2 N1 R(0 0))

➤ Level 2.5: (only for range un-chopped): on and off positions are in different OBSIDs. In Level 2.5, the off is subtracted from the on

PACS Calibration

A word about calibration...

➤ Photometer:

- Point-source flux calibration is estimated from a set of 5 fiducial stars (primary calibrators). Additionally, a set of asteroids and planets is also used (secondary calibrators);
- Based on this set of calibrators, the point-source flux calibration error is ~5% in all bands, with 1-2% reproducibility;

➤ Spectrometer:

- Flux calibration is estimated from a set of ~30 absolute flux sky calibrators (fiducial stars, asteroids and planets);
- Based on this set of calibrators (and using the *3X3 calibration block scheme*), the flux calibration error is ~7% in all bands, with 3-4% reproducibility

<http://herschel.esac.esa.int/twiki/bin/view/Public/PacsCalibrationWeb>

When to reprocess PACS data

IMPORTANT

One of the **most important reasons** to reprocess your PACS data is to make sure that you are using the **latest versions of the calibration files**. This is true for both the photometer and spectrometer

- To check the **calibration files version** of the data downloaded from the HSA, first load your OBSID into HIPE and then type the command below:

```
HIPE>
HIPE> obs=getObservation(1342204441, useHsa=True)
getObservation is retrieving the observation from the HSA
HIPE> print obs.calibration.version
56
HIPE>
```

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65					

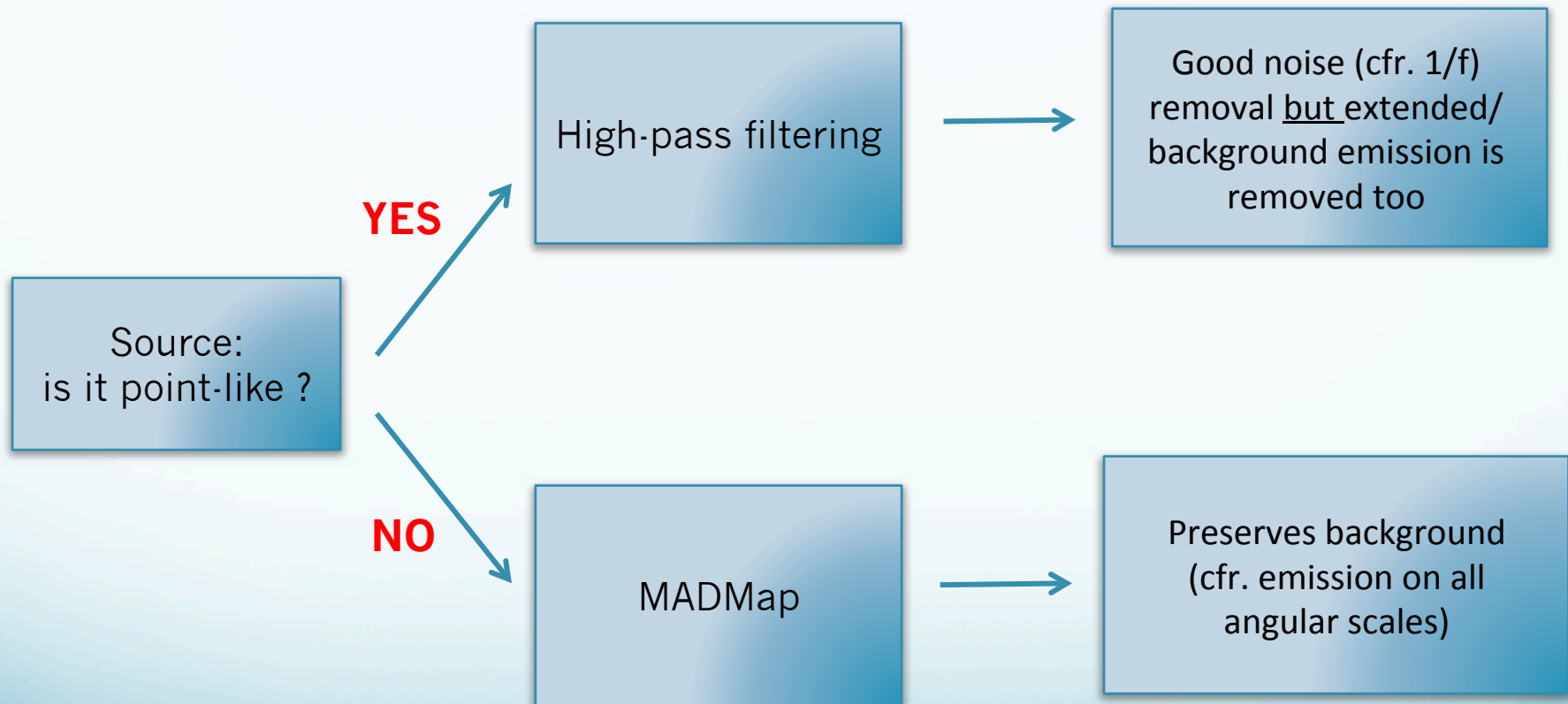
Compare the number you get (e.g. 56) from running the command above with the last number (e.g. 65) showing in the Calibration Sets table in HIPE



Window → Show View → Workbench → Calibration Sets

PACS Photometer

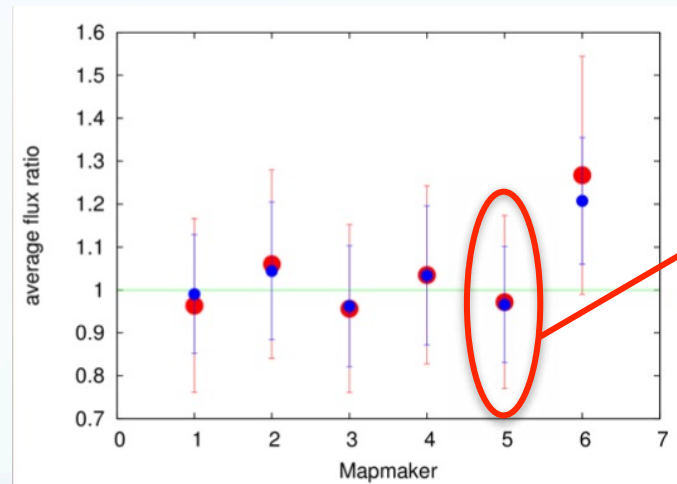
..we have seen that the photometer pipeline has 2 branches



PACS Photometer

Both HPF and MADMap products provide reliable point-source photometry

- 1) Scanamorphos
- 2) Jscanam
- 3) UNIMAP
- 4) Tamasis
- 5) MADMap
- 6) SANEPIC

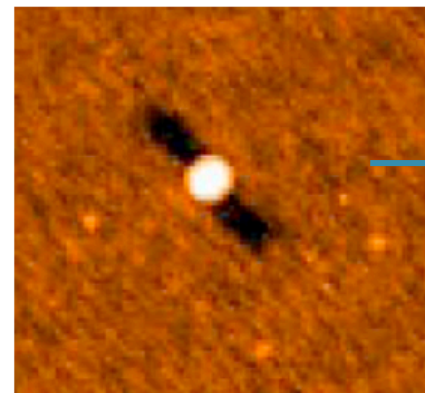
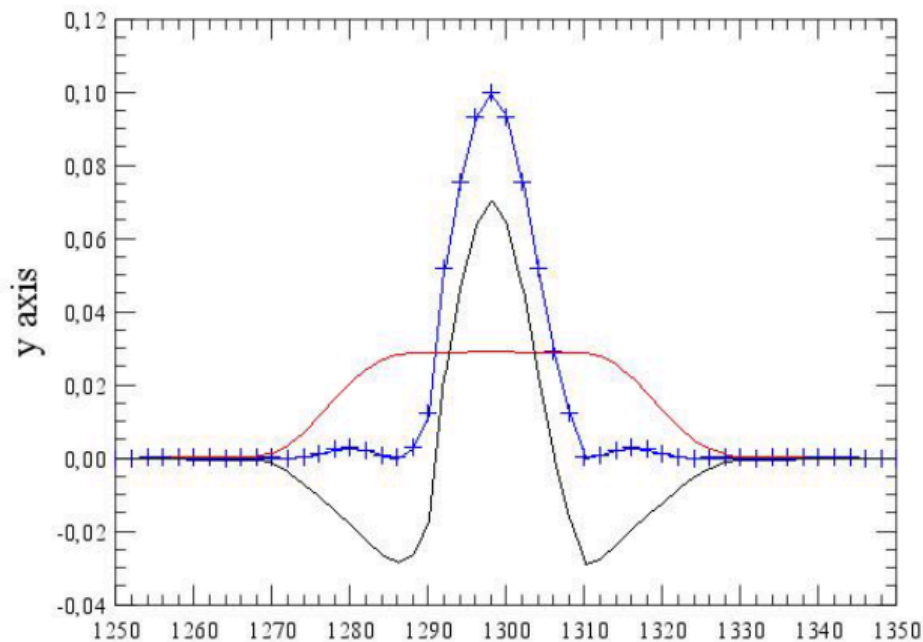


The aperture photometry ratio for calibration stars performed on HPF and MADmap maps is within 5%

NOTE: the agreement between HPF and the new MADMap released in HIPE 12 is even better: 1% !!

PACS Photometer

Signs I need to re-process my HPF map..



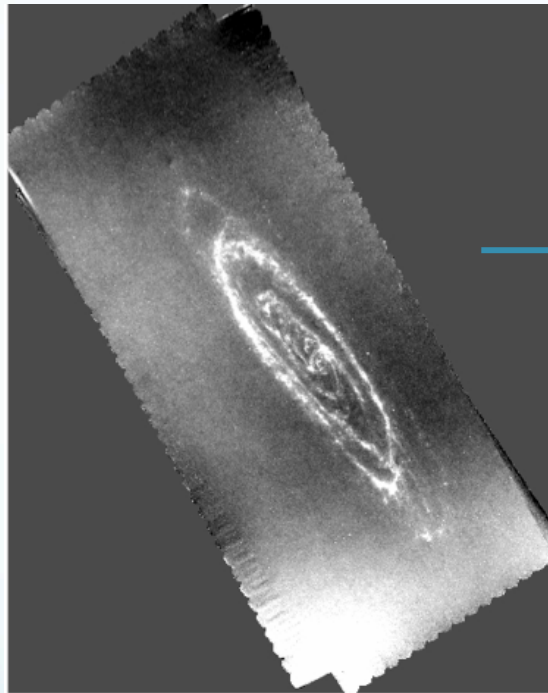
These dark blotches are due to a too small high-pass filter radius causing flux removal in the wings of the source

credit: Bruno Altieri

Solution: reprocess HPF map with larger filter radius (see slide)

PACS Photometer

Signs I need to re-process my MADMap map..



Gradient across the map due to inaccurate drift removal

Solution: reprocess with **new MADMap in HIPE 12.1** or with another mapper (Jscanam, Unimap, etc.)

PACS Photometer

If I do not need to reprocess my photometer data:

- I can use HPF Level 3 (if available) or Level 2.5 maps if I am interested in point sources
- I can use MADMap Level 2.5 maps if I am interested in both point sources and extended emission or extended emission only

NOTE ON EXTENDED EMISSION: the zero level of PACS photometer maps is not set. Therefore, if you are using MADMap/Jscanam/Unimap/etc. maps remember that the absolute level of the maps is arbitrary.

PACS Spectrometer

Signs I might have to re-process my spectrometer data ...

- With respect to photometer data, PACS spectrometer data do not show *evident signs* that I need to re-process them
- However, this does not mean that “since the data look fine, *they are fine*”
- In general, **we always recommend re-processing PACS spectrometer data**

PACS Spectrometer

Reasons I always need to reprocess my spectrometer data:

- In the SPG bulk-reprocessing (i.e. the data in the HSA), only *one flavor* of the spectrometer pipeline per observing mode (e.g. chop nod) is run
- However, *other flavors* of the pipeline might be more appropriate for your specific science case (depending on the brightness of your source and duration of your observation)
- Also, for a given pipeline flavor, not all tasks are run in the SPG bulk-reprocessing (e.g. drizzling)

PACS Spectrometer

Different pipeline flavors (for chop-nod modes)

- **lineScan:** calibration blocks + RSRF flux calibration (this is the standard pipeline run in SPG bulk reprocessing) → *recommended for bright sources*
- **Background Normalization:** uses telescope background for flux calibration → *recommended for faint sources or long duration observations or when broad band features are present*
- **Split On-Off:** allows to compare on-source/off-source spectra
- **Point Source Background Normalization:** uses telescope background for flux calibration + correction for pointing jittering → *recommended for very bright point sources*

NOTE: for the unchopped mod, line or range, there is only one *flavor* of the pipeline and this is run in the SPG bulk reprocessing (→ but the transient correction task is not automatically run)

PACS Spectrometer

Not all pipeline tasks are run in the bulk reprocessing

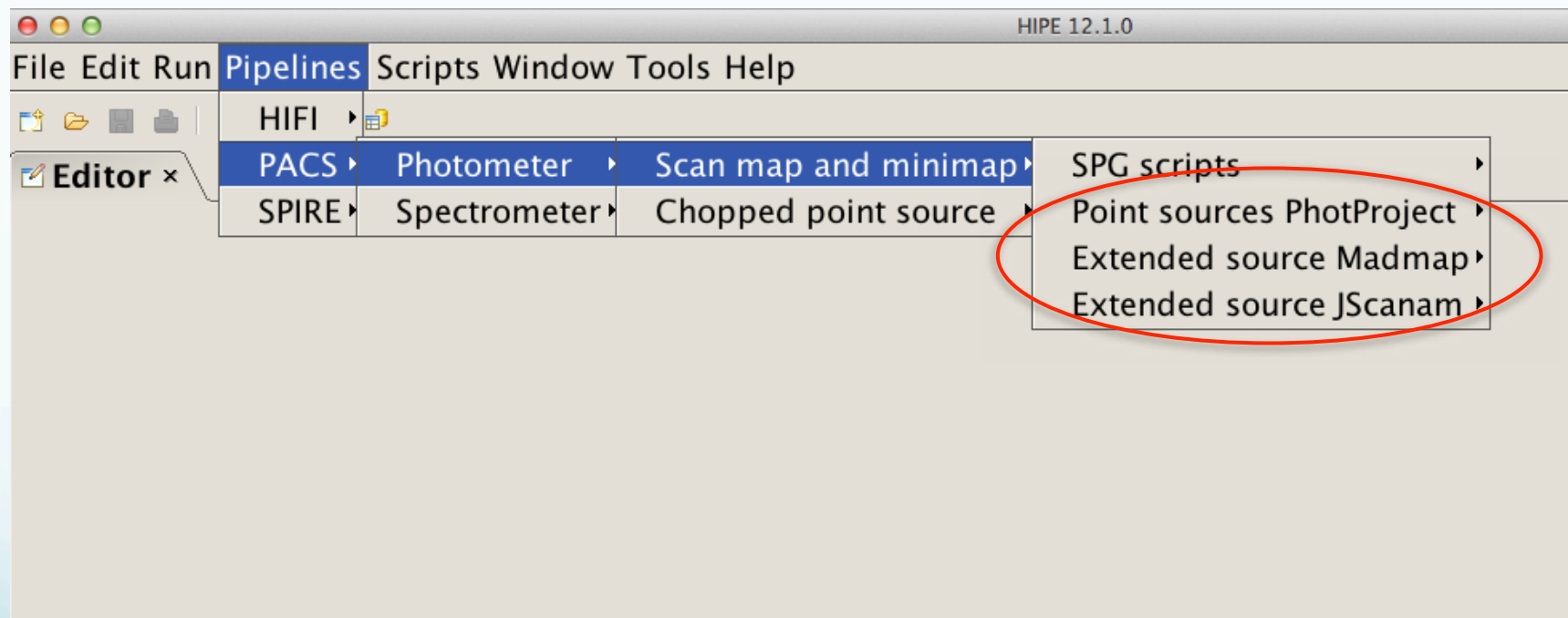
- **Point sources:** the re-binned cubes (HPS3DRB/R) are calibrated for extended emission by default. For point sources centered in the IFU (i.e. on spaxel (2,2)) run the task *extractCentralSpectrum*. The task works well for bright sources, i.e. continuum flux level in the range 5 – 10 Jy
- **Slightly Extended Sources:** the re-binned cubes (HPS3DRB/R) are calibrated for extended emission by default. For slightly extended sources (slightly bigger than the beam size at a given wavelength) centered in the IFU (i.e. on spaxel (2,2)), apply the task *pacExtendedToPointCorrection*. You need to know the geometry of your source to successfully apply this task
- **Extended sources – mapping:** for well-sampled (i.e. Nyquist) line or short-range raster observations, the best projected cubes are obtained by running the *drizzling* task which is not automatically run in the SPG bulk reprocessing

NOTE: for extended sources observed without mapping (i.e. in pointed mode), use the rebinned cubes to extract your science, NOT the projected cubes.

How to reprocess PACS data

PACS Photometer

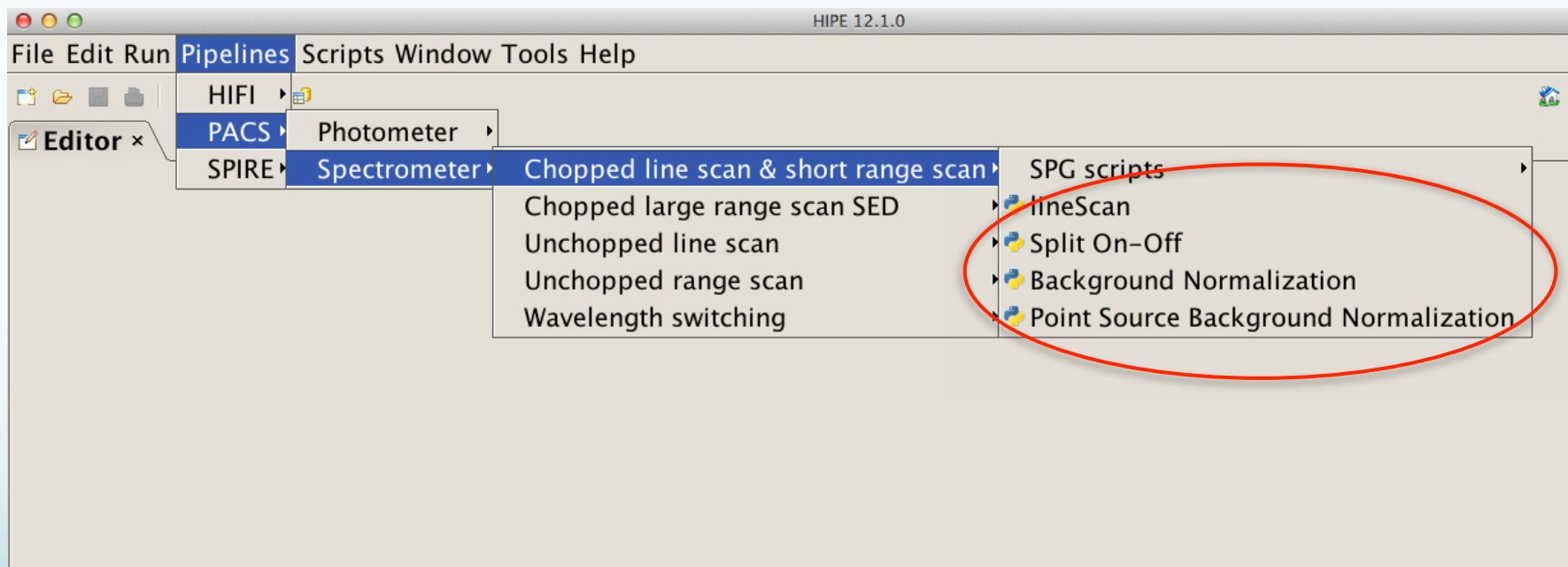
PACS photometer *ipipe* scripts



NOTE: ipipe scripts are in jython

PACS Spectrometer

PACS spectrometer *ipipe* scripts



NOTE: ipipe scripts are in jython

Ex: ChopNodLineScan.py (*flavor* of spectrometer pipeline)

The screenshot shows a Python script editor window titled "HIPE 12.1.0 - /Users/paladini/Documents/PACS/HIPE/hipe_v12.1.0/scripts/pacs/scripts/ipipe/spec/ChopNodLineScan.py". The menu bar includes "File", "Edit", "Run", "Pipelines", "Scripts", "Window", "Tools", and "Help". The toolbar contains icons for file operations and execution. Three callout boxes provide instructions:

- A box pointing to the double arrow icon: "Click the double arrows to run the whole script at once".
- A box pointing to the single arrow icon: "Click the single arrow to run the script one line at a time".
- A box pointing to the line `obsid = 1342188943`: "These are parameters you can change (obsid #, etc.)".

```
108
109 # -----
110 # GET THE DATA
111 # -----
112 #
113 # First, set the obsid to process.
114 # CHANGE THE OBSID HERE
115 #
116 # As this script is also run as part of the ChopNod multiObs script(s), the
117 # following "if" tests for the existence of a variable called multiObs, which
118 # will be present if you are running the multiObs script. If multiObs is
119 # present, the obsid will have been set already, and if not then the obsid is set
120 # here. (If you get a NameError, then the obsid had not been set.)
121 if ((not locals().has_key('multiObs')) or (not multiObs)):
122     obsid = 1342188943
123
124 # Next, get the data
125 useHsa = 0
126 obs = getObservation(obsid, verbose=True, useHsa=useHsa, poolLocation=None, poolName=None)
127 #if useHsa: saveObservation(obs, poolLocation=None, poolName=None)
128
129 # Show an overview of the uplink parameters of this observation
130 if verbose: obsSummary(obs)
131
```

PACS

Documentation & Additional Resources

PACS Documentation

(updated in Jan – Mar '14)

- PACS Observer's Manual (last update: July '13)
http://herschel.esac.esa.int/Docs/PACS/pdf/pacs_om.pdf
- PACS Data Reduction Guide: Photometer
http://127.0.0.1:8082/print/pacs_phot/pacs_phot.pdf#pacs_phot
- PACS Data Reduction Guide: Spectrometer
http://127.0.0.1:8082/print/pacs_spec/pacs_spec.pdf#pacs_spec
- NHSC PACS tutorials:
<https://nhscsci.ipac.caltech.edu/sc/index.php/Pacs/DataProcessing>

PACS @ NHSC

Roberta Paladini (Lead, calibration scientist, photometer)

Dario Fadda (calibration scientist, spectrometer)

Jeff Jacobsen (developer, spectrometer)

Cate Liu (developer, photometer)

Yi Mei (system engineer, photometer & spectrometer)

Dave Shupe (calibration scientist, spectrometer)

For any questions and help with your PACS data, contact the NHSC Help Desk:

<http://nhsc.ipac.caltech.edu/helpdesk/index.php>

Additional Resources

- Processing large PACS data sets, especially for the photometer, requires large memory allocations (64 GB or more). You can request a remote user account on our virtual system at NHSC. For more information, visit:

<https://nhscsci.ipac.caltech.edu/sc/index.php/CompSupport/ExternalUsers>

- Our remote user accounts come automatically with a multi-threaded version of the PACS spectrometer pipeline. This means that you can speed up your spectrometer data processing by a factor 4 !
- For PACS photometer data processing, we encourage the use of SIMPLE (*Simplified Interface Making PACS Look Easy*). For ore information, visit:

<https://nhscsci.ipac.caltech.edu/sc/index.php/Pacs/Simple>

NOTE: SIMPLE will be extended to the spectrometer pipeline in the near future.

Thank You !