



PACS Spectroscopy Chop/nod LineSpec Demo

Herschel Science Demonstration Phase
Data Processing Workshop

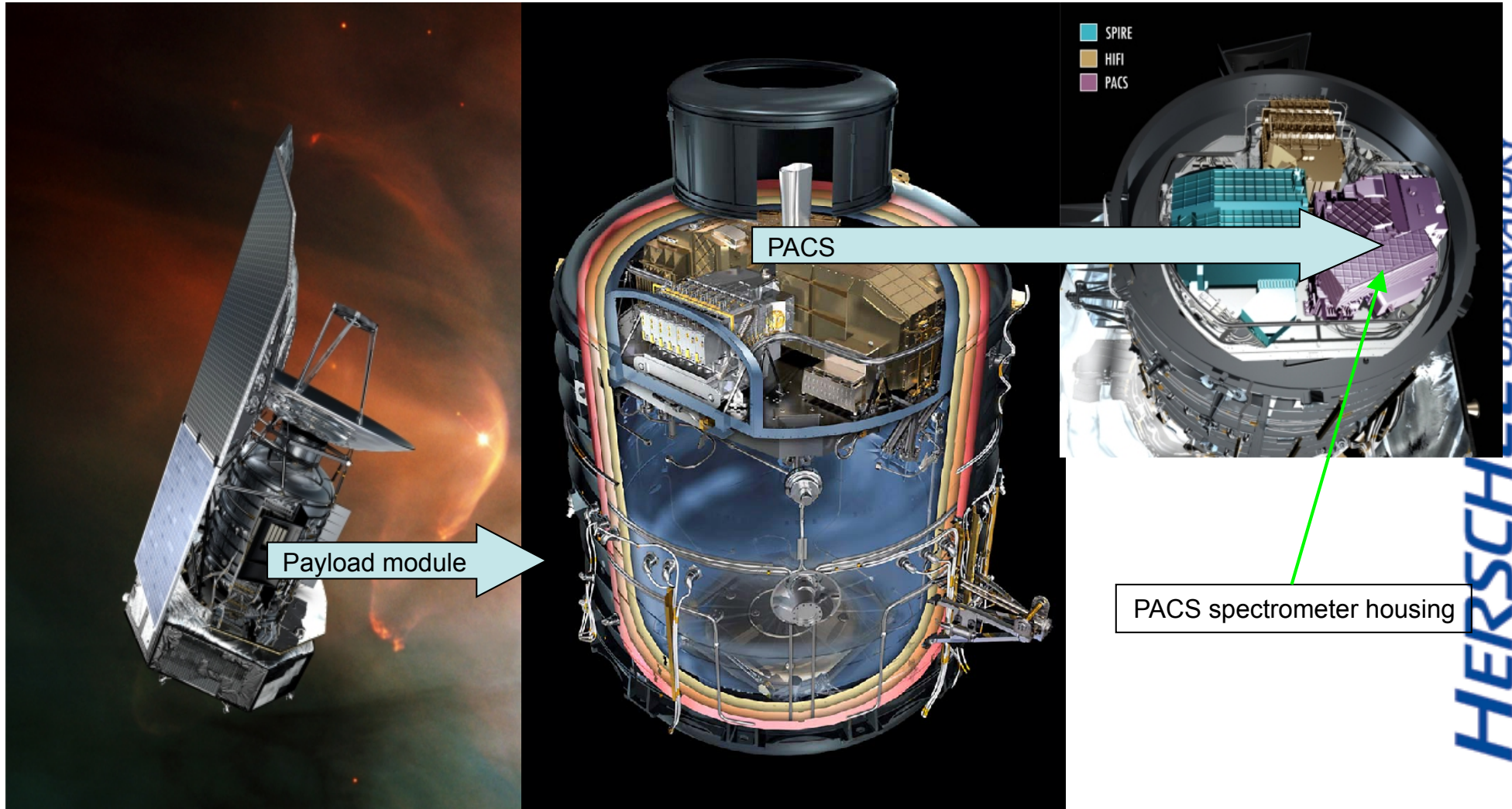
ESAC, Madrid, Spain
15 December 2009

Roland Vavrek (HSC)

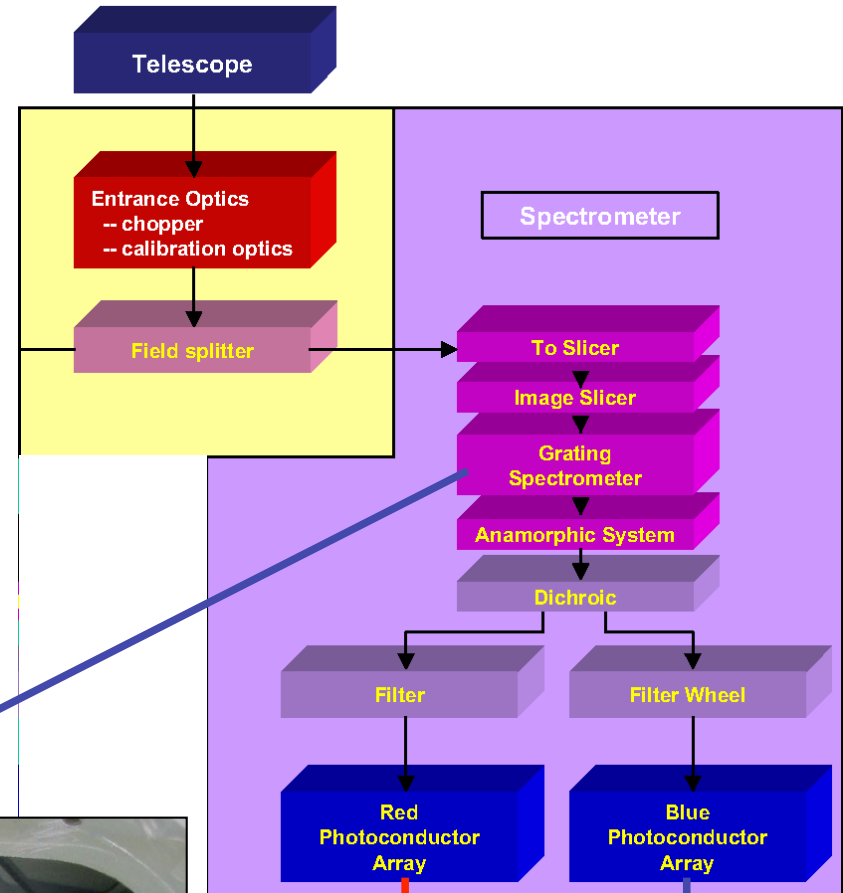
on behalf of the PACS ICC

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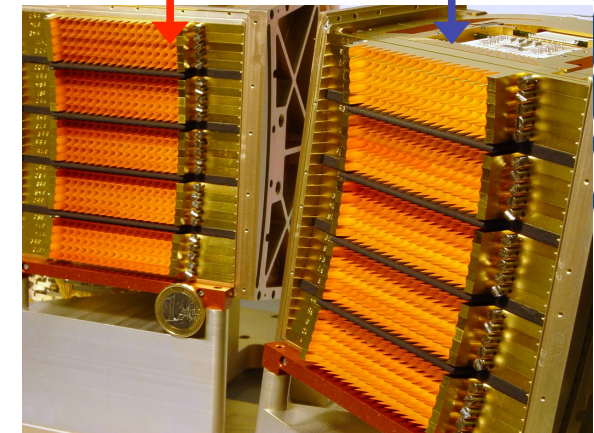
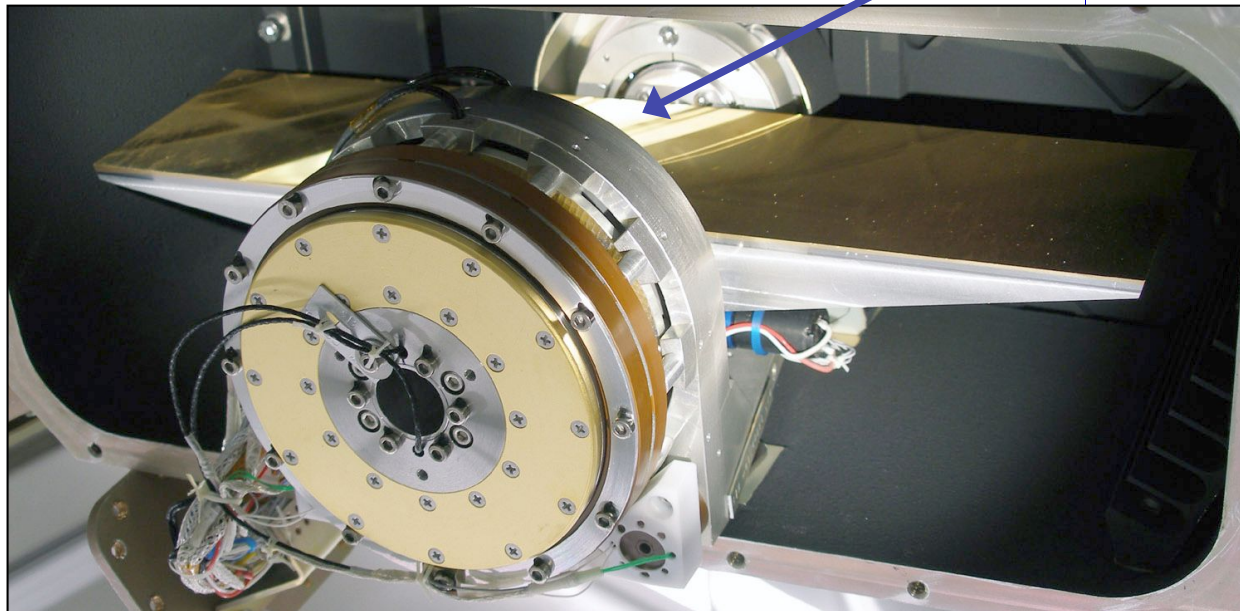
PACS Spectrometer concept



Diffraction grating spectrometer with high- and low-stressed Ge:Ga detector arrays



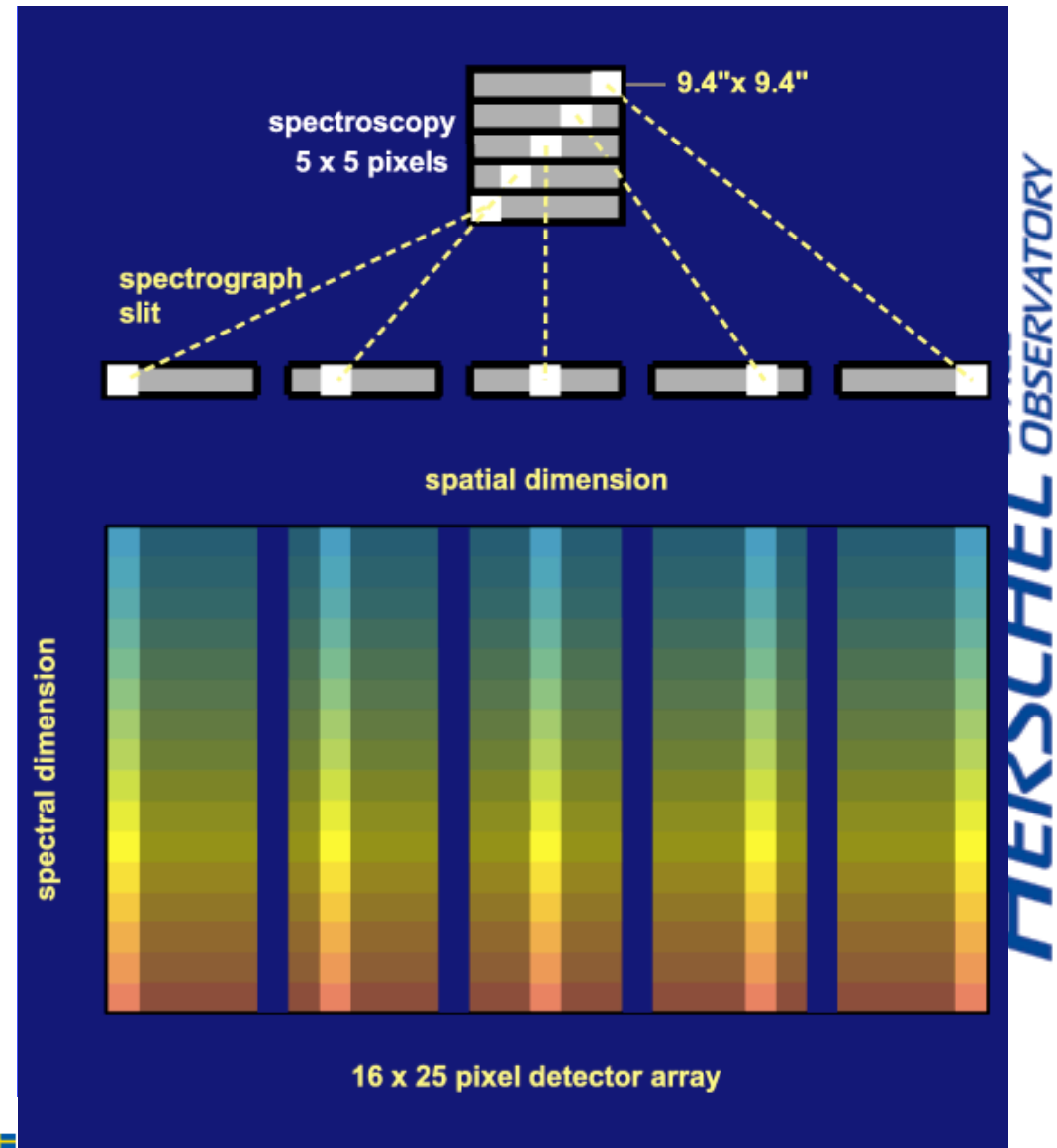
Grating: diffraction element used in 3 orders



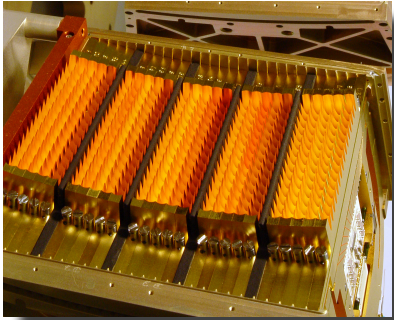
Integral-field concept



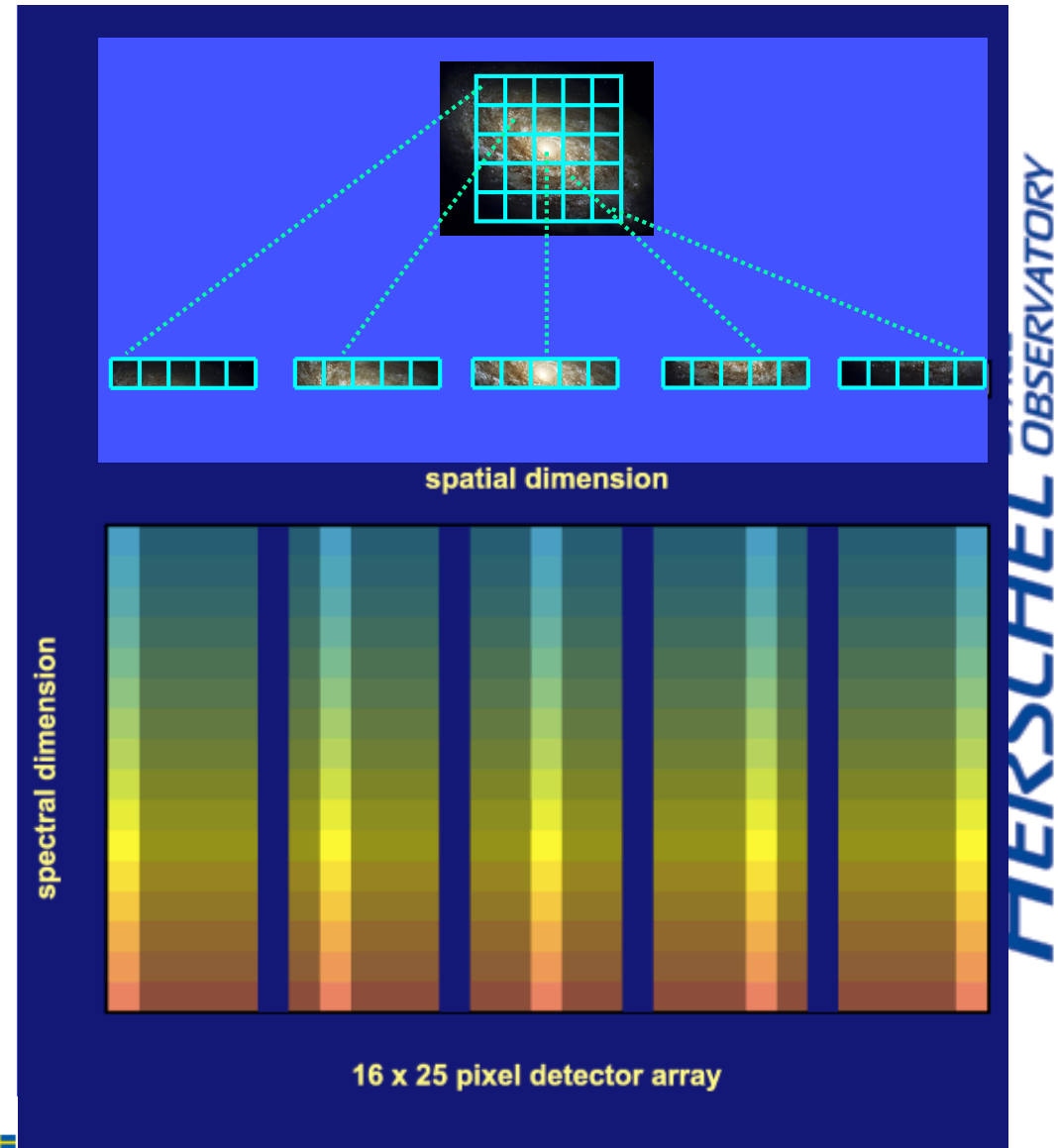
47" x 47" (5x5 pixels) FOV
rearranged via an image
slicer on two 16x25
detector arrays



Integral-field concept



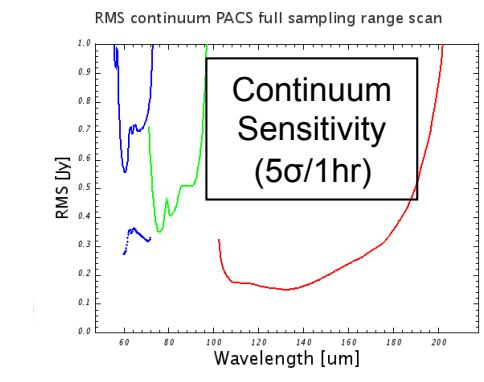
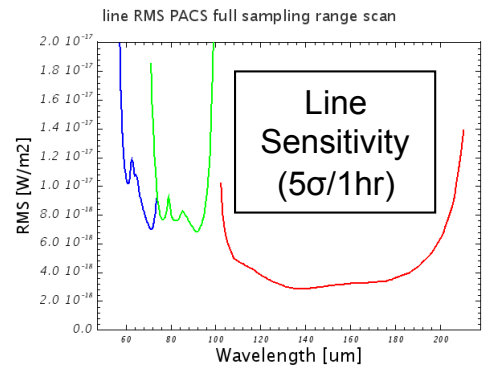
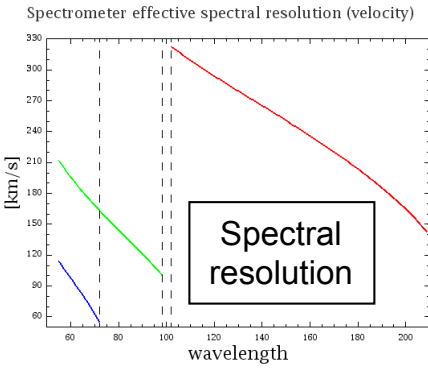
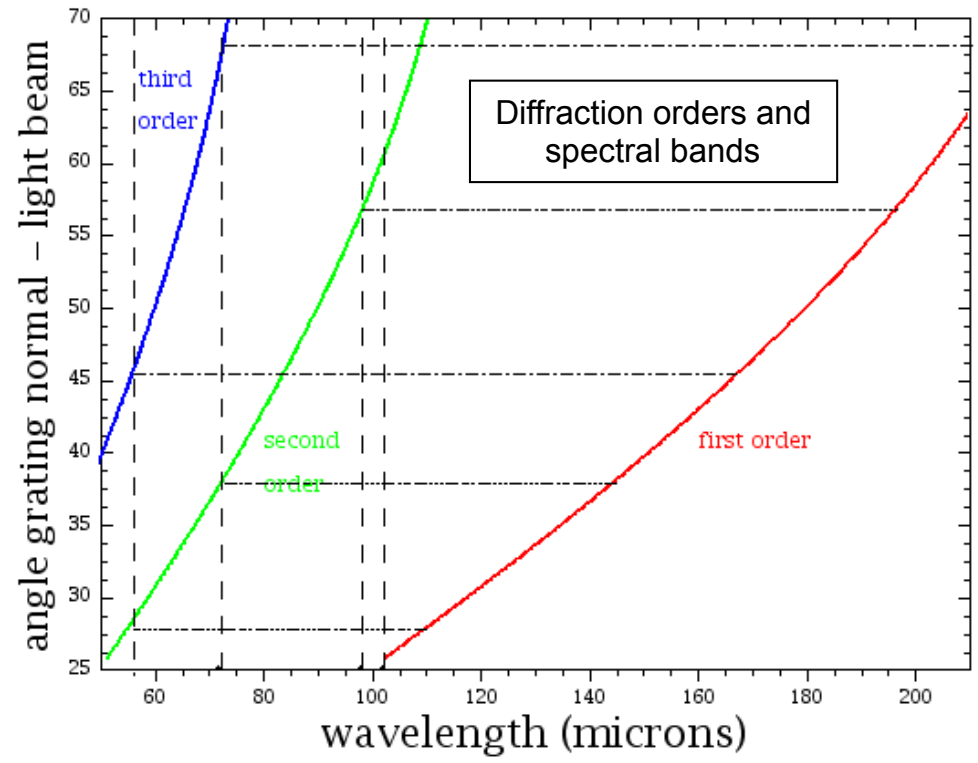
- Simultaneous 55-98 & 102-210 μm spectroscopy
- Performance:
 - $\lambda/\Delta\lambda \sim 1500$
 - Sensitivity: $\sim 5 \times 10^{-18}$ W/m² (5σ , 1h)



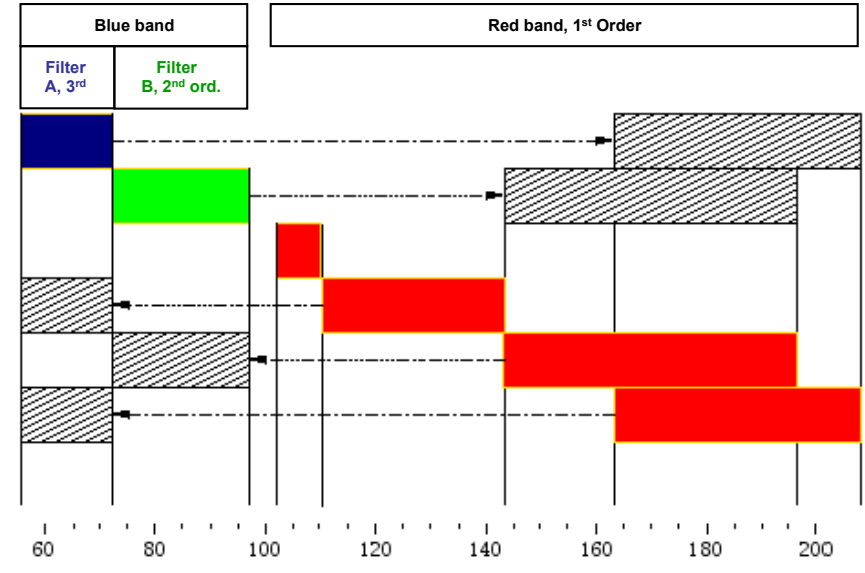
PACS spectral bands



Grating angle – wavelength relation in Littrow configuration



Nominal bands and parallel data





Spectrometer Astronomical Observing Templates (AOTs)

- **Line Spectroscopy AOT: observation of individual narrow lines:**

Signal modulation Techniques

- **Chopping/nodding**
 - Pointed, dithered and mapping modes
 - For isolated sources and rasters ≤ 6 arcmin
 - Variable grating sampling for faint and bright lines
- **Wavelength switching**
 - For mapping observations of crowded fields
 - Mandatory off-position

- **Range Spectroscopy AOT: observation of extended ranges, broad lines or continuum**

Range definition

- **Range scan** (same concept as Line Spectroscopy) *for broad lines*
- **SED mode** (1st and 2nd orders [71-105, 103-220 μ m] or 3rd order [51-73 μ m]) *for continuum*
- **SED blue sensitive mode** (extended 2nd order [51-73 μ m]) *for continuum*
- **Nyquist sampling** same as SED mode for restricted ranges *for continuum and bright lines*

Signal modulation Techniques

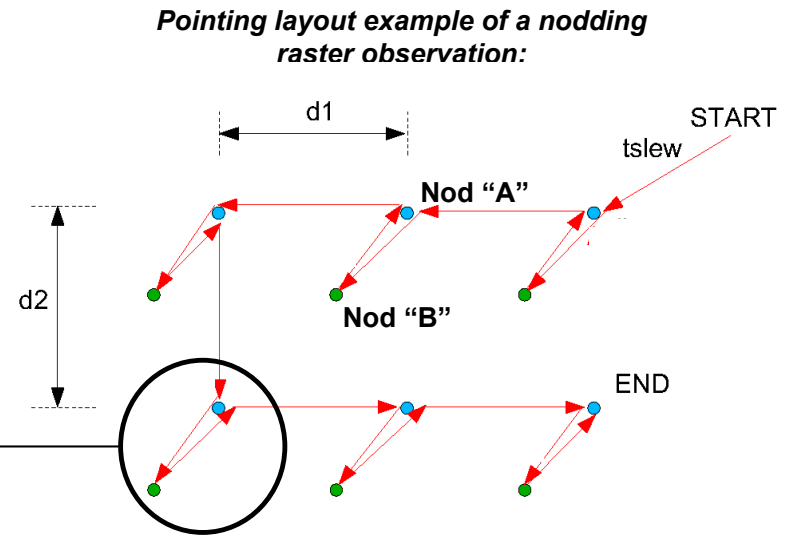
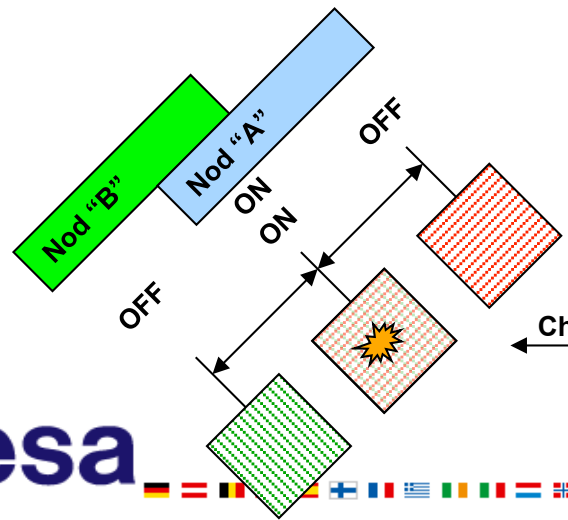
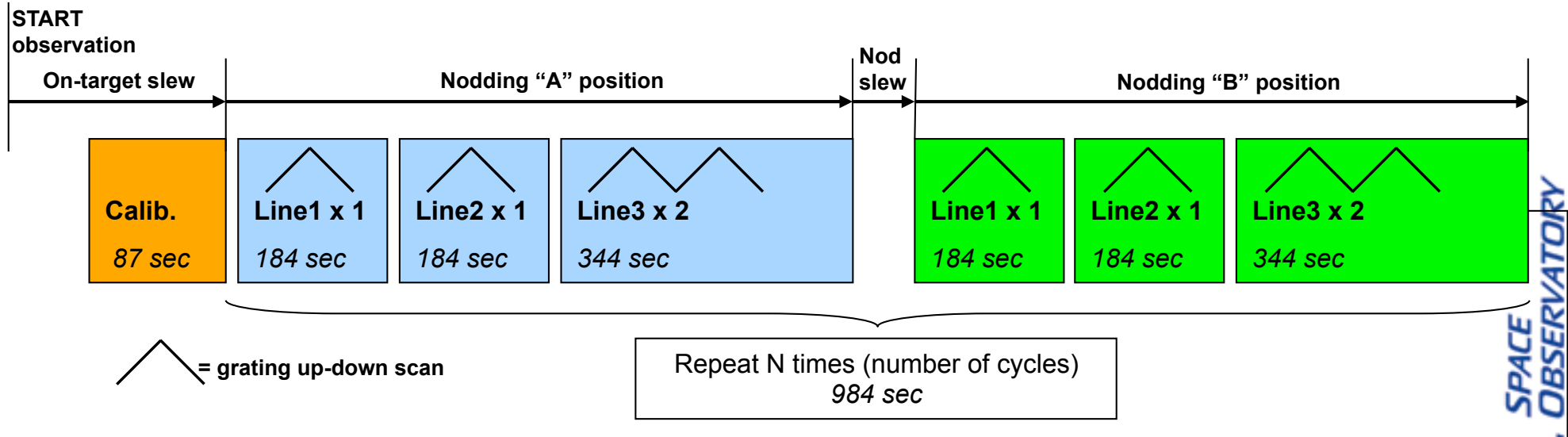
- **Chopping/nodding**
 - Pointed, dithered and mapping modes
 - For isolated sources and rasters ≤ 6 arcmin
 - For broad lines, multiple line coverage or continuum studies
- **Off-position**
 - For mapping observations of crowded fields

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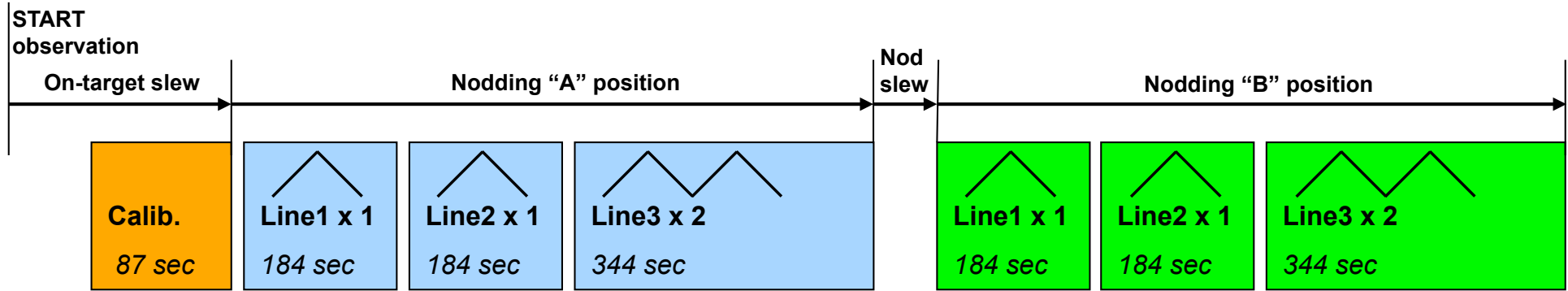
Chop/nod AOT blocks



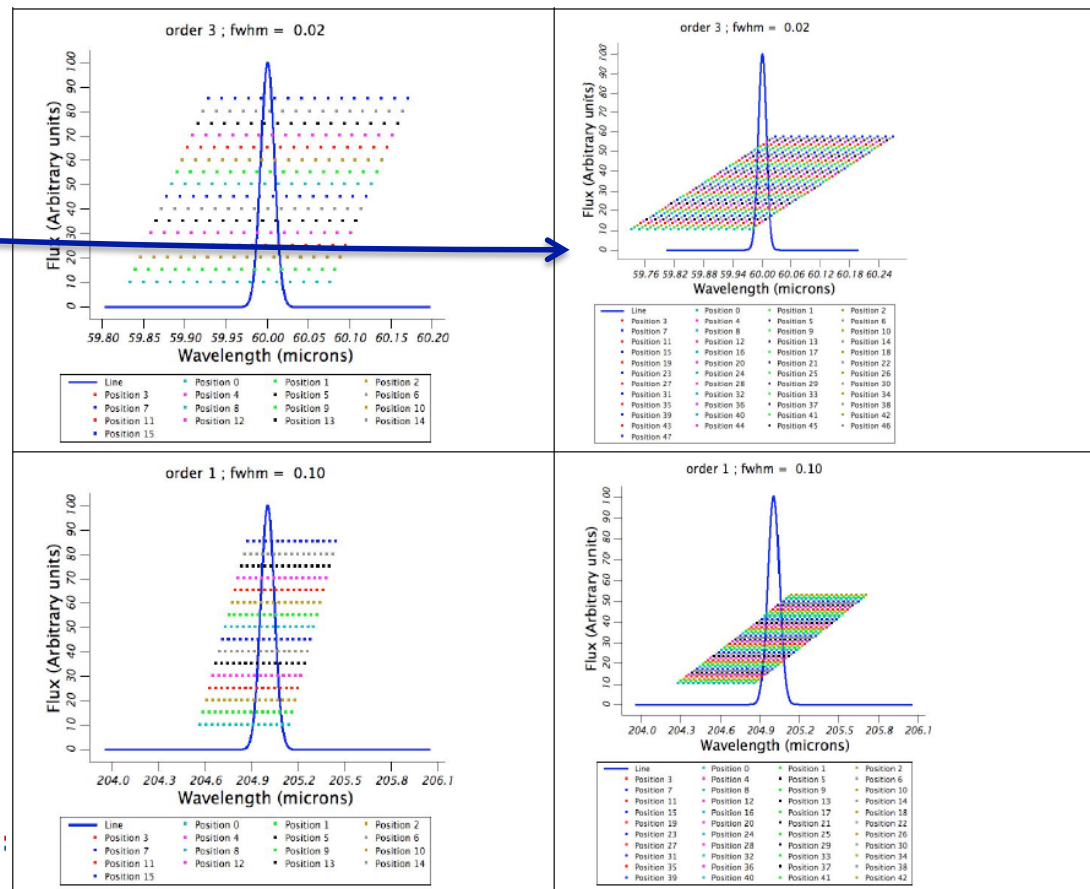
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Chop/nod AOT blocks

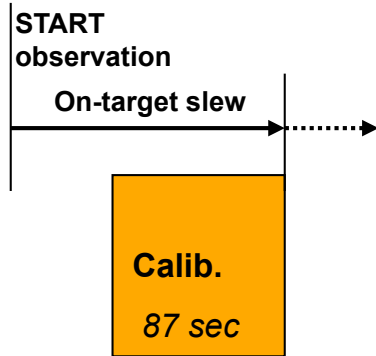


Grating sampling in a single up-scan for bright line and high sampling modes

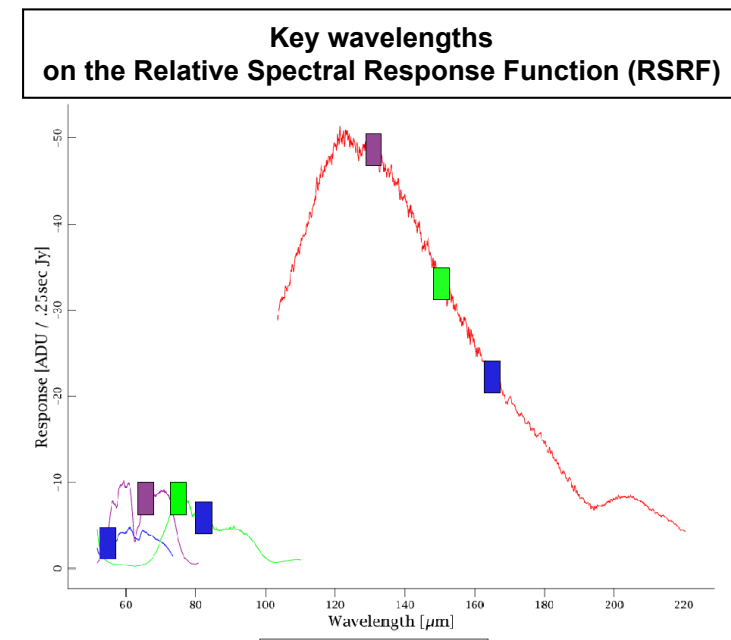
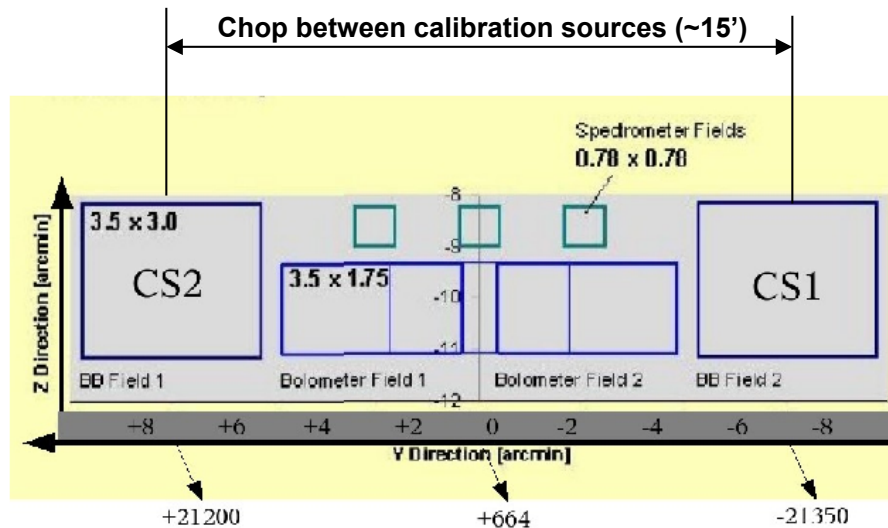


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AOT calibration block



- On-target slew calibration block(s) on key wavelengths
- Calibrate the response on one point of the RSRF, we believe the RSRF does not change (a lot) over the mission lifetime
- Chopping between the calibration sources and grating up/down scans
- Homogeneous dataset over the entire mission lifetime
- One key wavelength per diffraction order:
 - flat part of the RSRF
 - close to the most frequently used lines



... and how blocks are defined in HSpot



Nodding blocks

Pointing blocks

PACS Line Editor

Unique AOR Label: PSpecL-0000

Target: NGC7027 Type: Fixed Single
Position: 21h07m01.59s, +42d14m10.2s

Number of visible stars for the target: 23
Star tracker target: Ra: 136.757 degrees Dec: -42.236 degrees

Wavelength Settings
Selection of wavelength ranges
Wavelength ranges [73-98] and [103-210] microns (2nd + 1st orders)

Line Id	Wavelength (µm)	Redshifted Wav.	Line Flux	Line Flux Unit	Continuum Flux	Line Width	Line Width Unit	Line Repetition
Line 1	97.00	97.00	0.00	10 ⁻¹⁸ W/m ²	0.00	0.00	km/s	1
Line 2	80.00	80.00	0.00	10 ⁻¹⁸ W/m ²	0.00	0.00	km/s	1
Line 3	158.000	158.00	0.00	10 ⁻¹⁸ W/m ²	0.00	0.00	km/s	2

Observing Mode Settings
Nodding/wavelength switching cycles
Number of cycles: 2

Herschel Observation Planning Tool - KP OT version

Observing Modes
None selected | Pointed | Pointed with other | Mapping

Observing mode selection
* Chopping/nodding
Chopping/nodding bright line
Wavelength switching

Observing mode parameters
Chopper throw: Small, Medium, Large
Chopper avoidance angle: Angle from degrees, Angle to degrees

Observations: ISSA- 25 µm, ngc7027
Target: ngc7027 Type: Fixed Single
Total Duration (hrs): 2.47

PACS Range Editor

Unique AOR Label: PSpecR-0000

Target: ngc7027 Type: Fixed Single
Position: 21h07m01.70s, +42d14m11.0s

Number of visible stars for the target: 23
Star tracker target: Ra: 136.757 degrees Dec: -42.236 degrees

Wavelength Settings
Range scan or SED mode
Range mode [Range scan in [55-73] and [102-210] microns (Grd + 1st orders)]

Range ID	Blue Edge (µm)	Red Edge (µm)	Reference wav.	Line Flux	Line Flux Unit	Continuum Fl.	Line Width	Line Width Unit	Range Repet.
Range 1	55.00	73.00	55.00	0.00	10 ⁻¹⁸ W	0.00	0.00	km/s	2
Range 2	102.00	210.00	210.00	0.00	10 ⁻¹⁸ W	0.00	0.00	km/s	1

Instrument Settings
Range sampling density: Nyquist sampling

Observing Mode Settings
Nodding or map repetition cycles
Repetition: 1

Depth of the observation is set via repetition factors:

- Line/Range repetition for relative Line/Range strength, total number of repetitions is ≤ 10 to limit the maximum block duration
- Single repetition in SED mode block
- Nodding/switching/mapping cycles define how many times a block has to be repeated
- Overlap between pointing blocks (d1, d2 step size < 47")

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Data Structure (Obs. Context)



o Level-0

- + instrument detector readout timeline
- + instrument housekeeping
- + other instrument-specific data

o Auxiliary

- + Pointing
- + Orbit
- + spacecraft housekeeping
- + ...

o Level-1

- + All instrument effects taken out

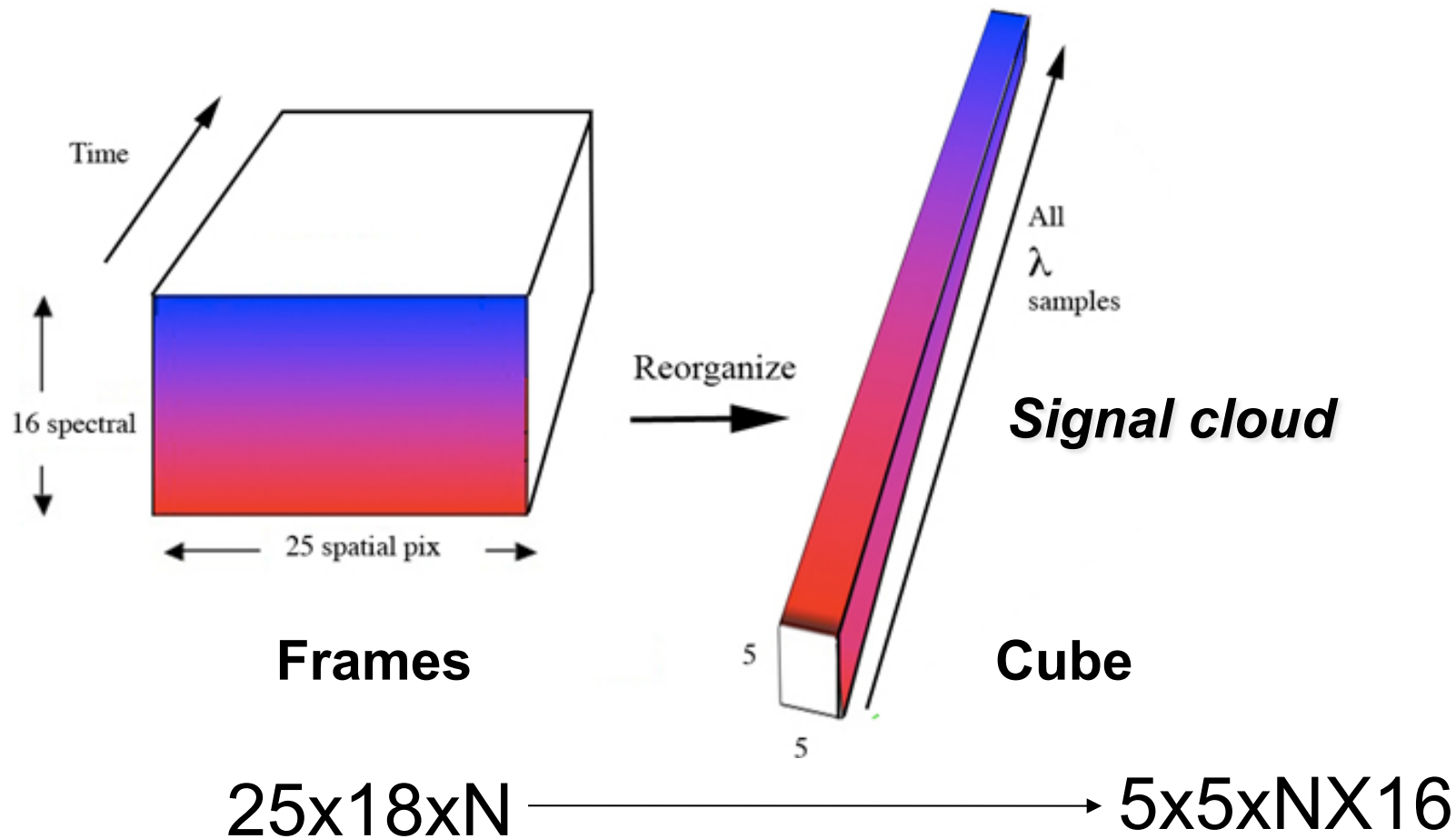
o Level-2

- + Rebinned, publishable products

o Calibration

- + Calibration products used to process level-1 and level-2 delivered by the HSA

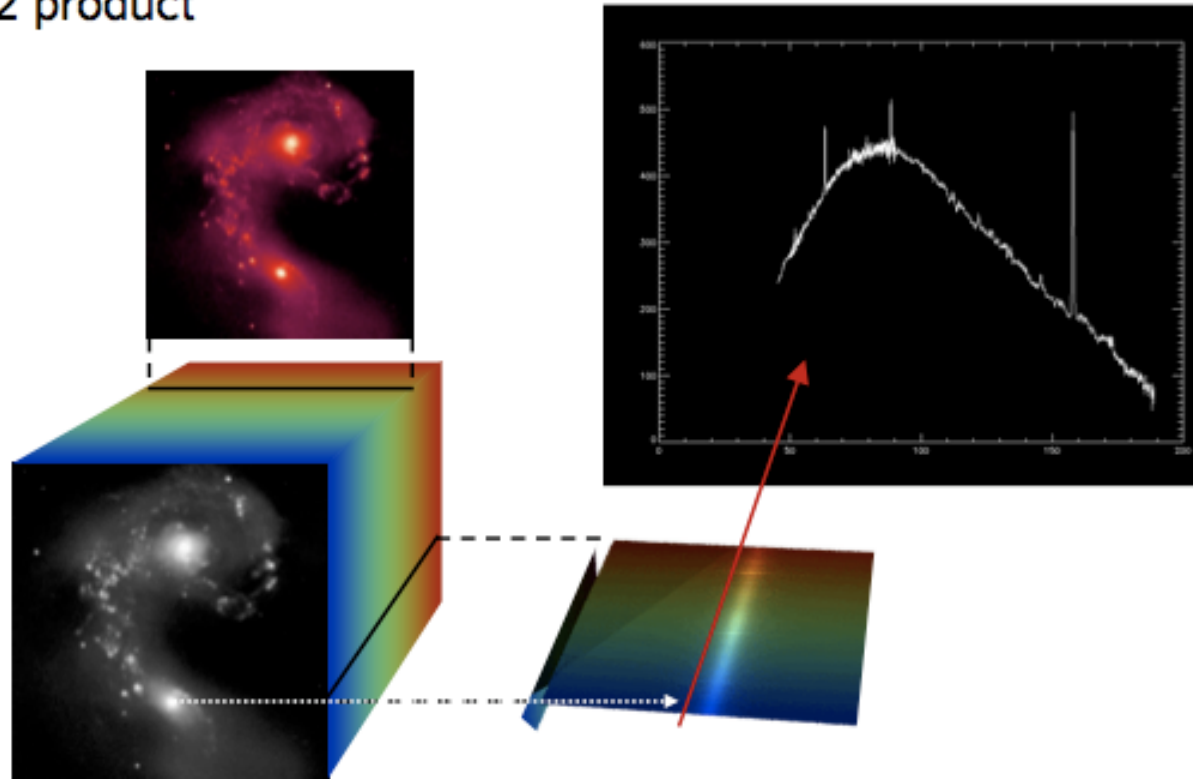
PACS frames and cube – Level 1



Rebinned cube and projected cube – Level 2



Level 2 product



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Demo package on your machine



➤ */home/.hcss/lstore/1342187201*

- */home/.hcss/lstore/1342187202*
- */home/.hcss/lstore/1342187203*
- */home/.hcss/lstore/1342187204*

➤ */IN/YOUR/WORK/DIRECTORY/*

- *demoPacsSpectro_chopNod_ipipe_15DEC2009.py*
 - Change “homedir” in the script to */IN/YOUR/WORK/DIRECTORY/*
- *demoPacsSpectro_chopNodSED_ipipe_15DEC2009.py*
- *demoPacsSpectro_chopNod_tools_15DEC2009.py*
- *gridFunctions.py*
- *pdrp.pdf* DOCUMENTATION / PIPELINE HOWTO

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Documentation: pdrg.pdf

PACS Data Reduction Guide

Issue dev, Version 1.2, Document Number:
09 Dec 2009

In the Beginning is the Pipeline. Spectroscopy

```
titleText="title",line=0
p.xaxis.title.text="Wavelength [μm±m]"
p.yaxis.title.text="Signal [Jy]"
```

Now, depending on what type of observation you are looking at (e.g. SED vs. line scan) and at what stage you are looking at your plotted spectrum, it is possible that you will see something that does not look quite like right. When you plot using the command above, you are plotting everything that is in your dataset. This can include: data from the calibration sources (take at the key wavelengths only); multiple spectra/spectral lines if your observation includes more than one field-of-view (for rastered/dithered observations); data taken while the telescope was slewing; data from the two chop positions and from the two nod positions (chops and nods are not combined until the next stage of the pipeline). In addition, if you have several grating runs (if you sampled the wavelength domain more than once), then each spectrum will be multiple and it is possible that the spectra from multiple grating runs will not be exactly at the same "counts" levels. So, if you have a line scan and you see this:

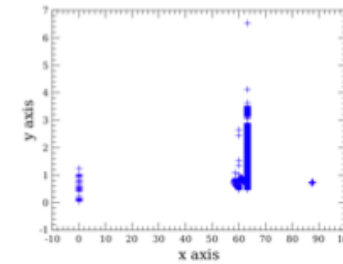


Figure 3.2. Level 0.5 line scan spectrum: entire dataset

try to zoom in on the wavelength you requested in your AOR, when you should see this:

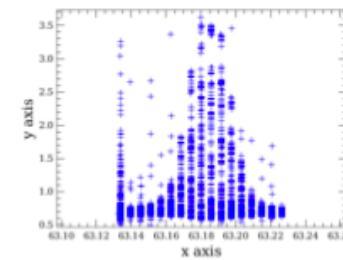
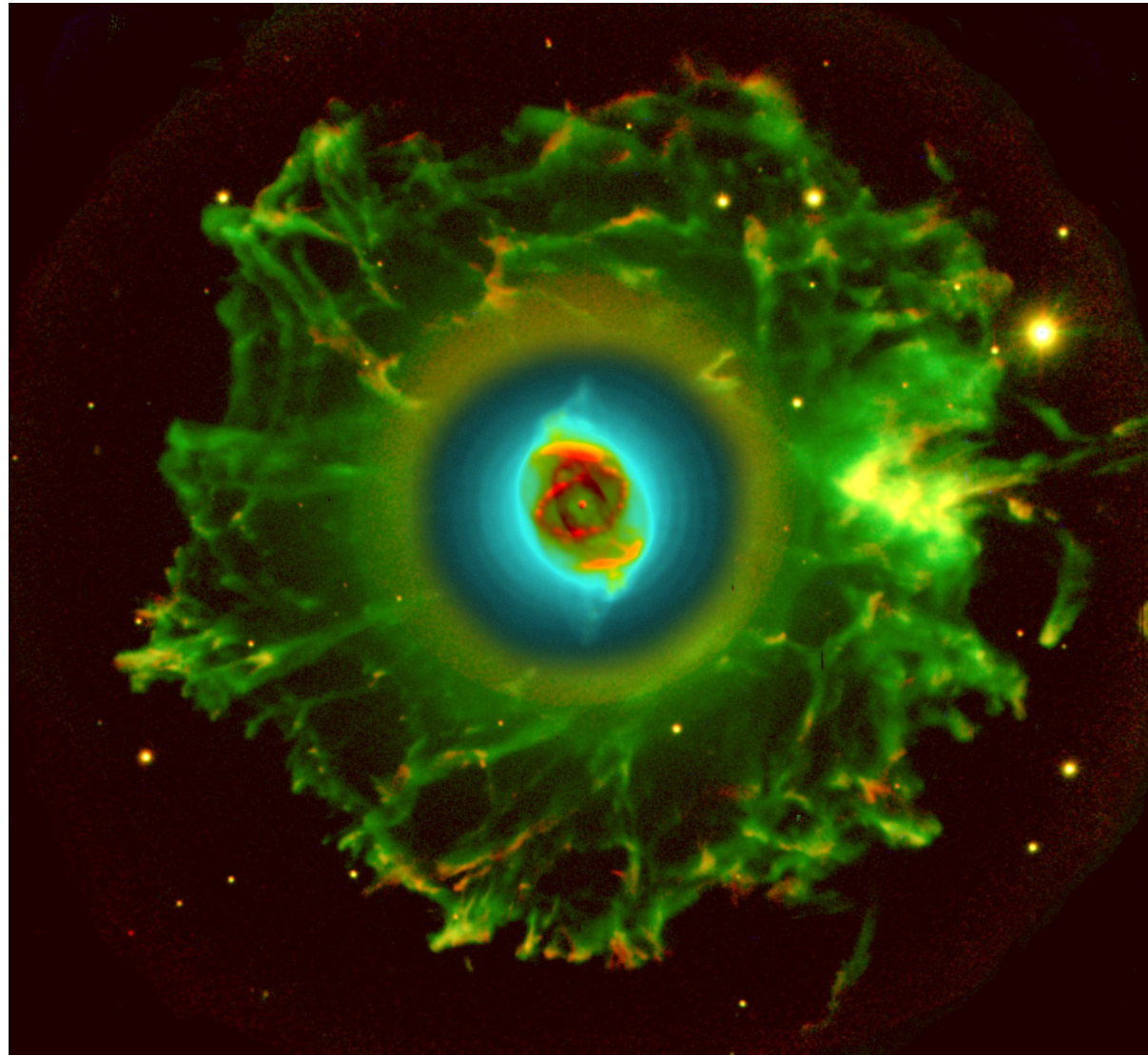


Figure 3.3. Level 0.5 line scan spectrum: zoom

Demo data: NGC 6543



The “Cat eye” planetary nebula



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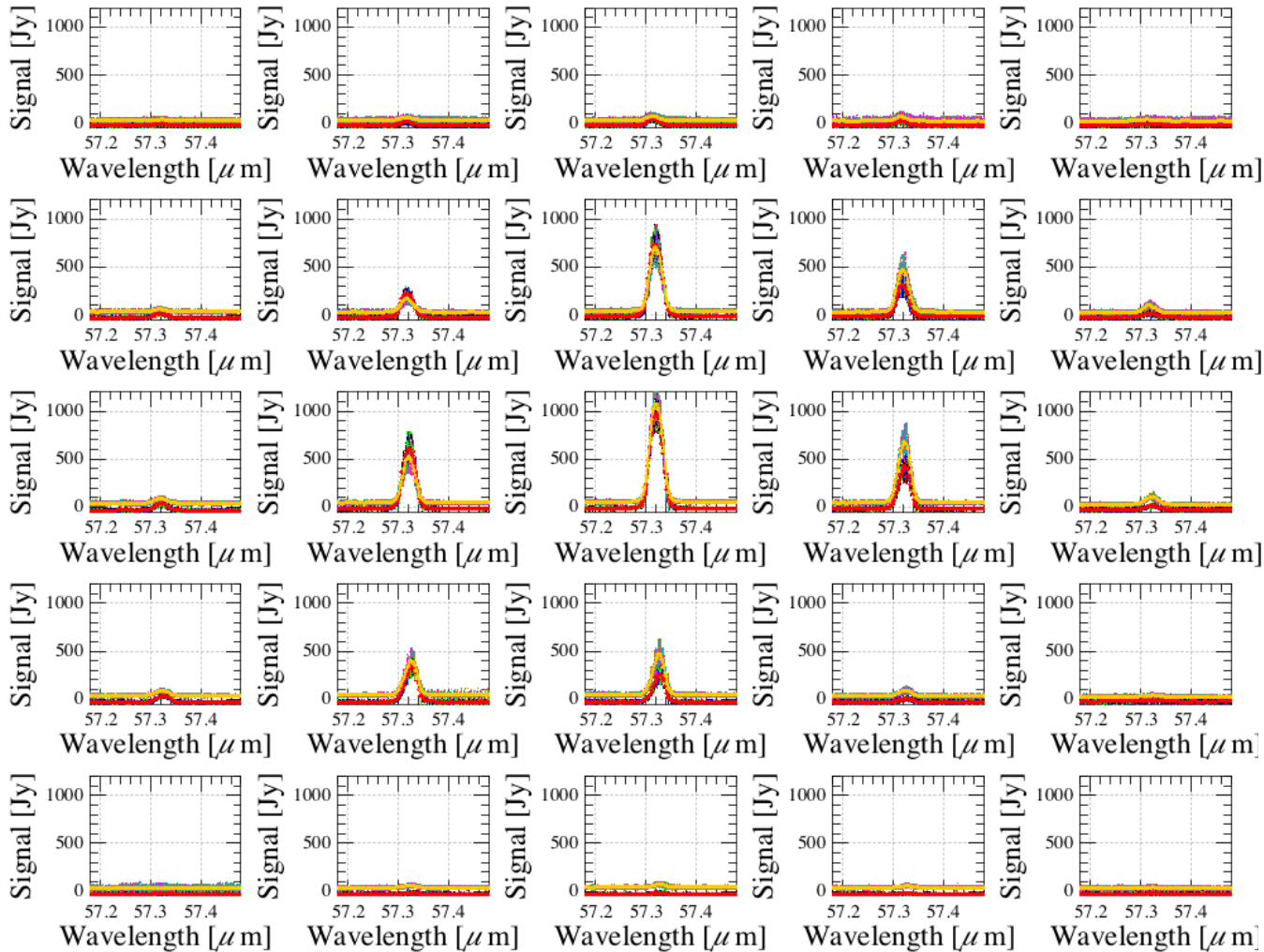




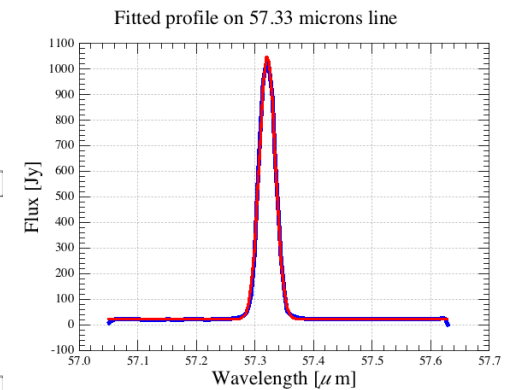
Demo data: NGC 6543

Demo observation

1342187201 Calibration_PVSpecWave_2-PVSpecWave_421D_StdLS_NGC6543_A_0001



57.3 microns:
N III 2P3/2-2P1/2

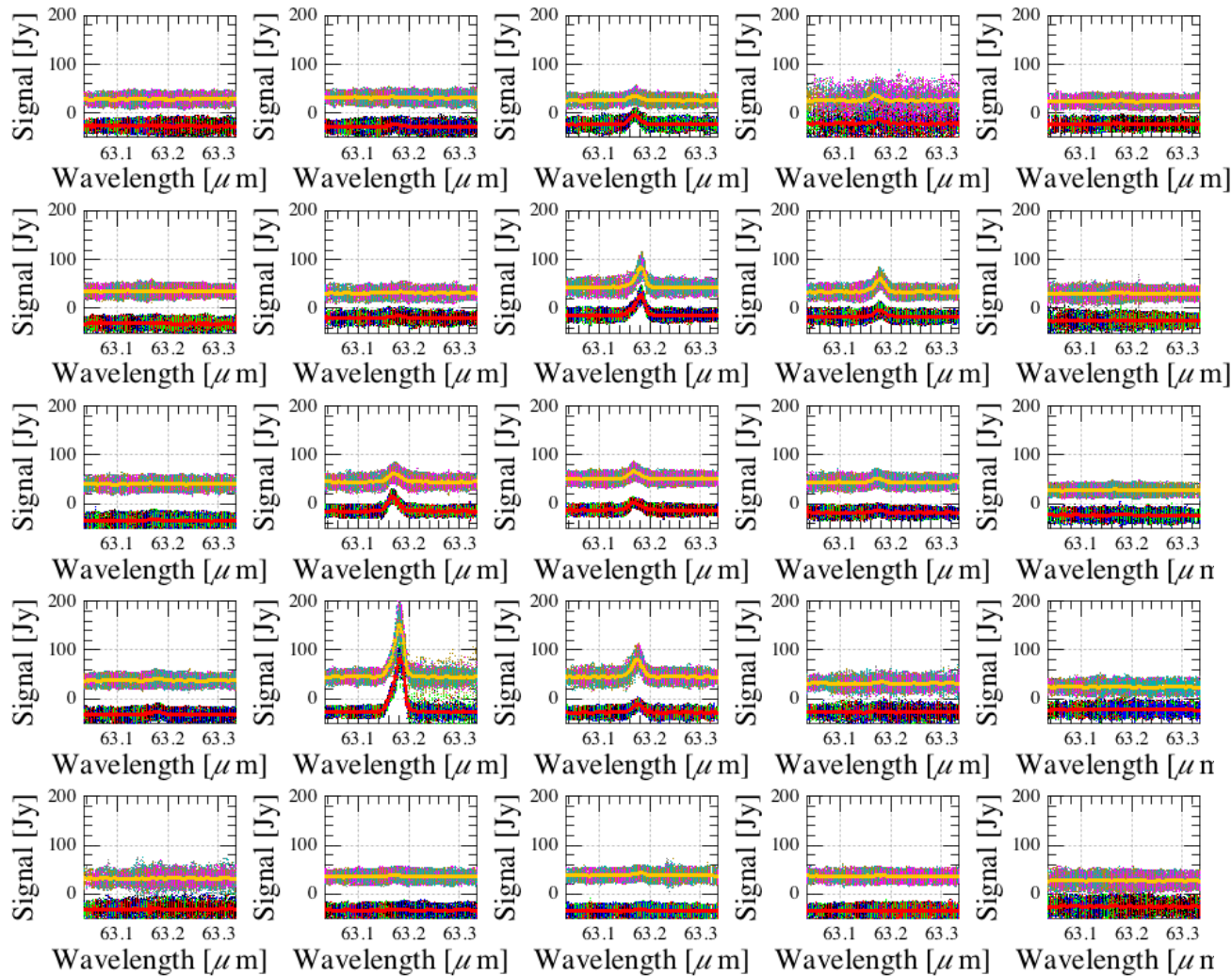




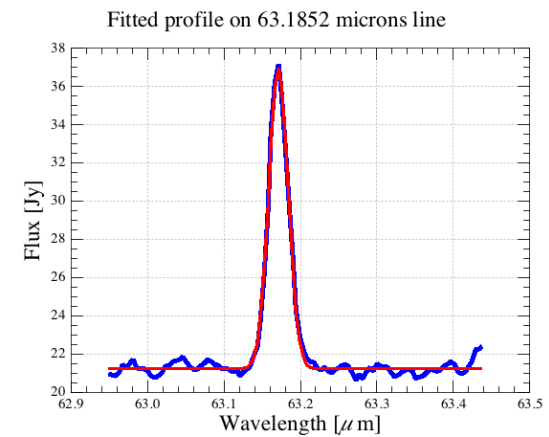
Demo data: NGC 6543

Demo observation

1342187201 Calibration_PVSpecWave_2-PVSpecWave_421D_StdLS_NGC6543_A_0001



63.18 microns:
O I 3P1-3P2

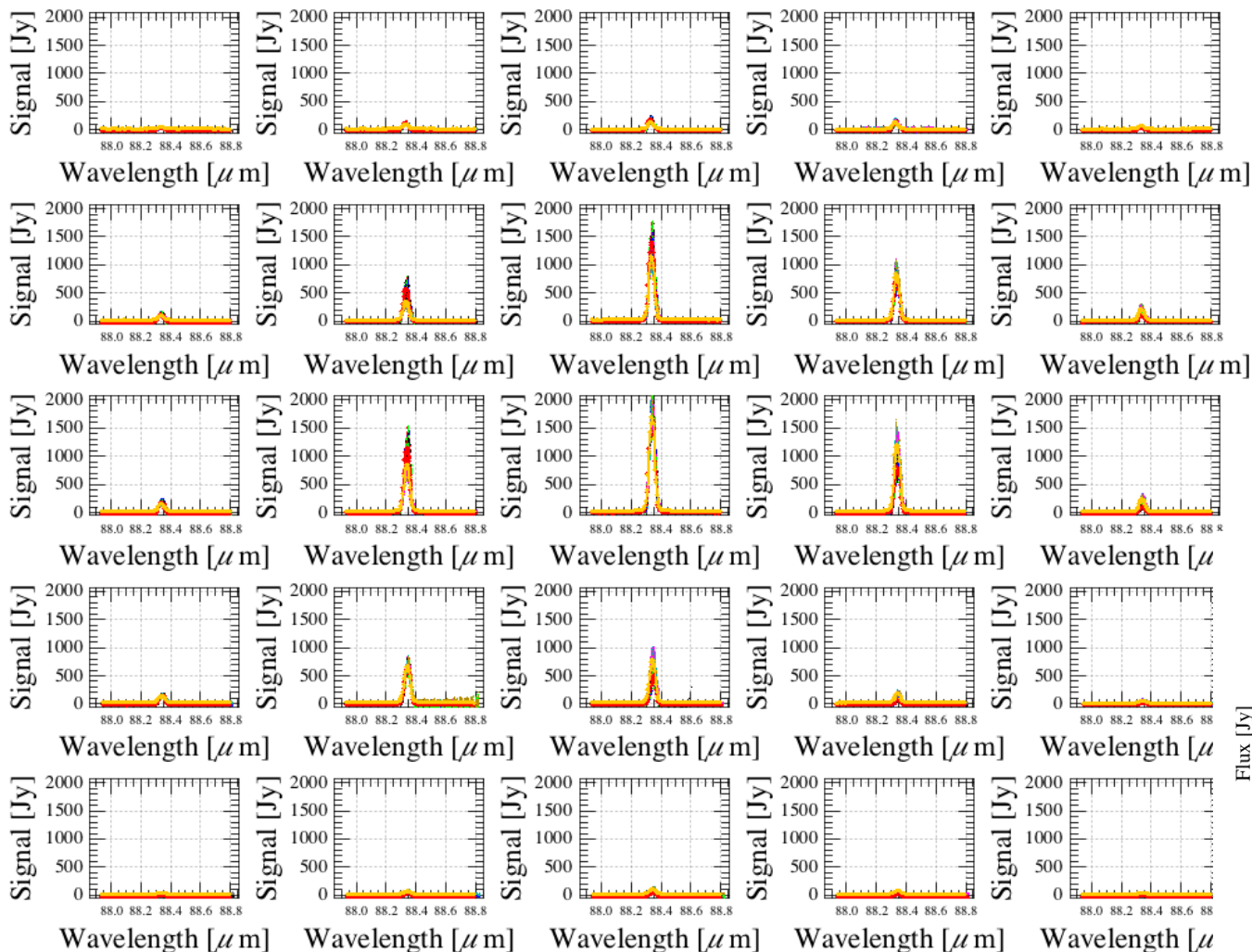




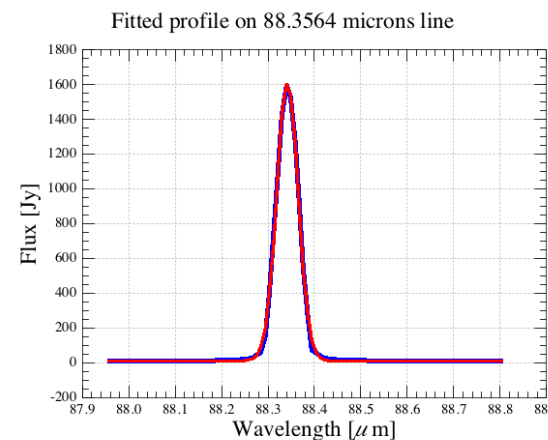
Demo data: NGC 6543

Demo observation

1342187202 Calibration_PVSpecWave_2-PVSpecWave_421D_StdLS_NGC6543_B_0001



88.36 microns:
O III 3P1-3P0



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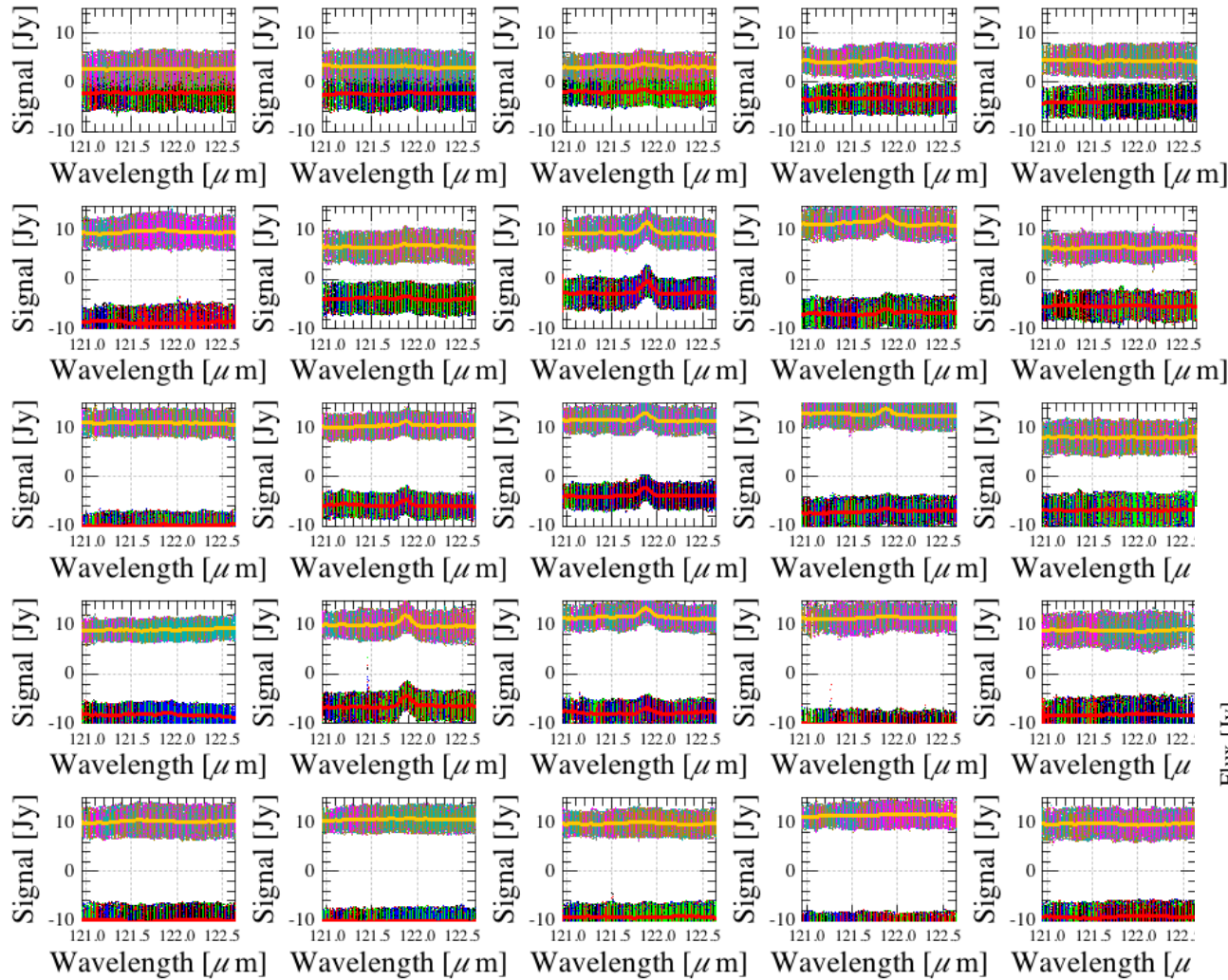




Demo data: NGC 6543

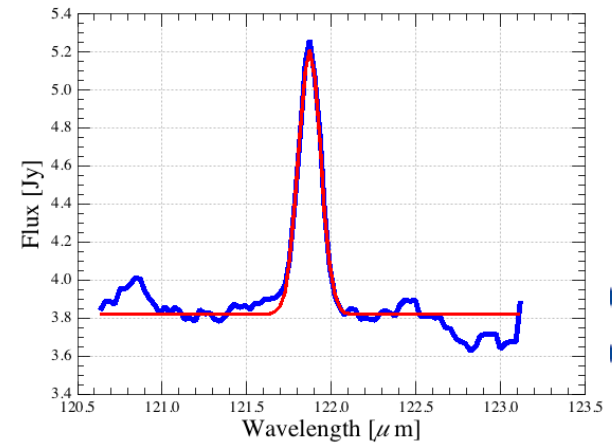
Demo observation

1342187202 Calibration_PVSpecWave_2-PVSpecWave_421D_StdLS_NGC6543_B_0001



121.8 microns:
N II 3P2-3P1

Fitted profile on 121.8 microns line



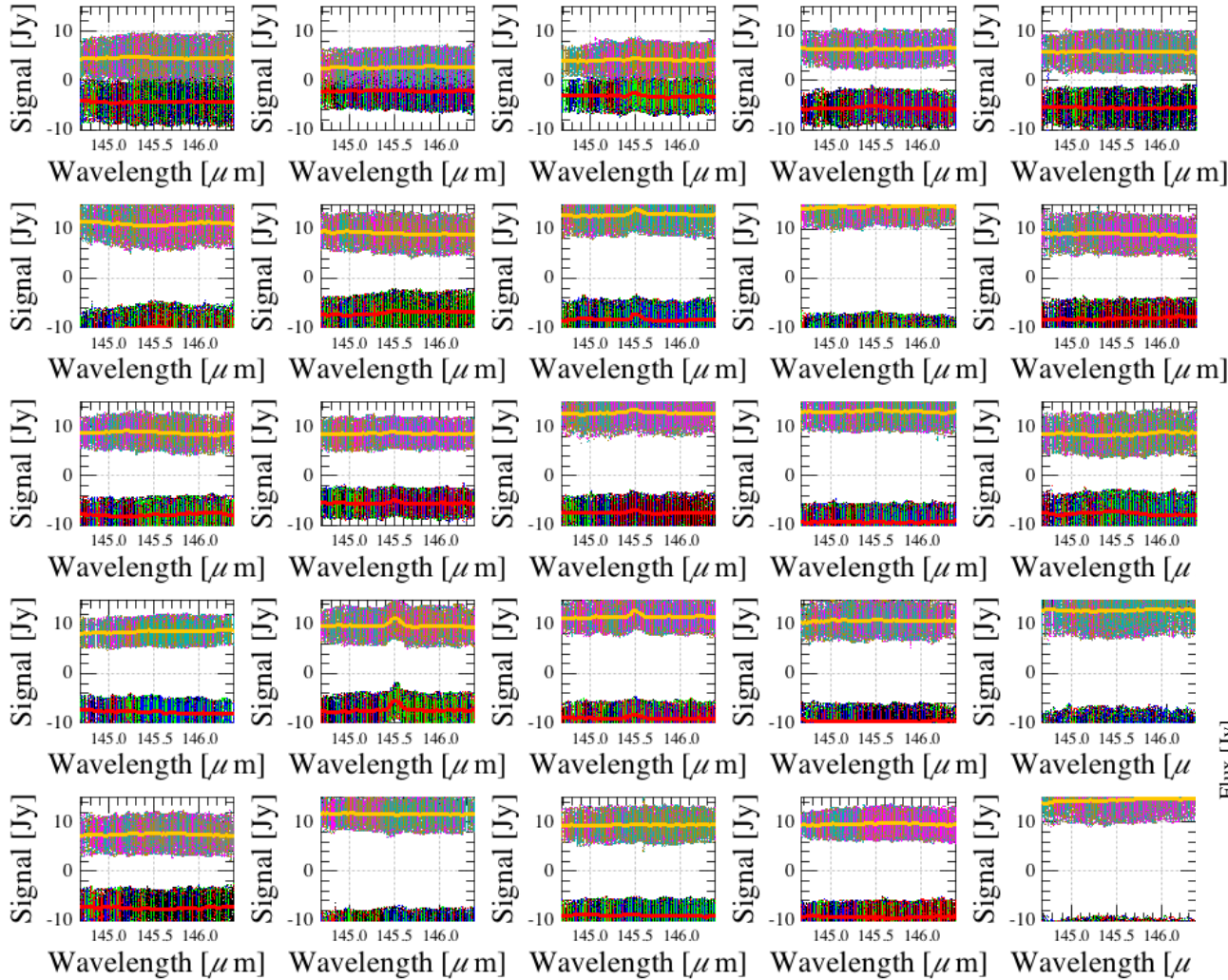
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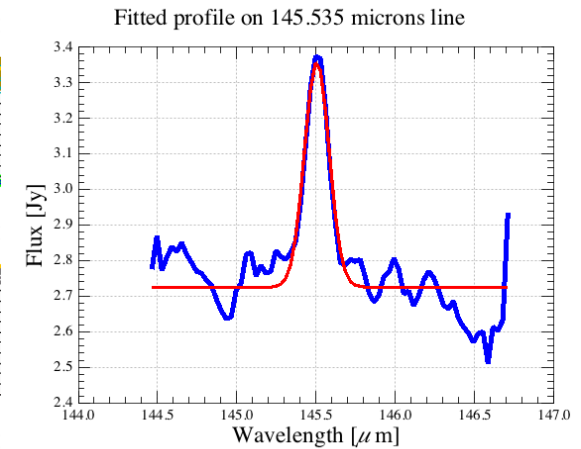
Demo data: NGC 6543

Demo observation

1342187201 Calibration_PVSpecWave_2-PVSpecWave_421D_StdLS_NGC6543_A_0001



145.53 microns:
O I 3P0-3P1

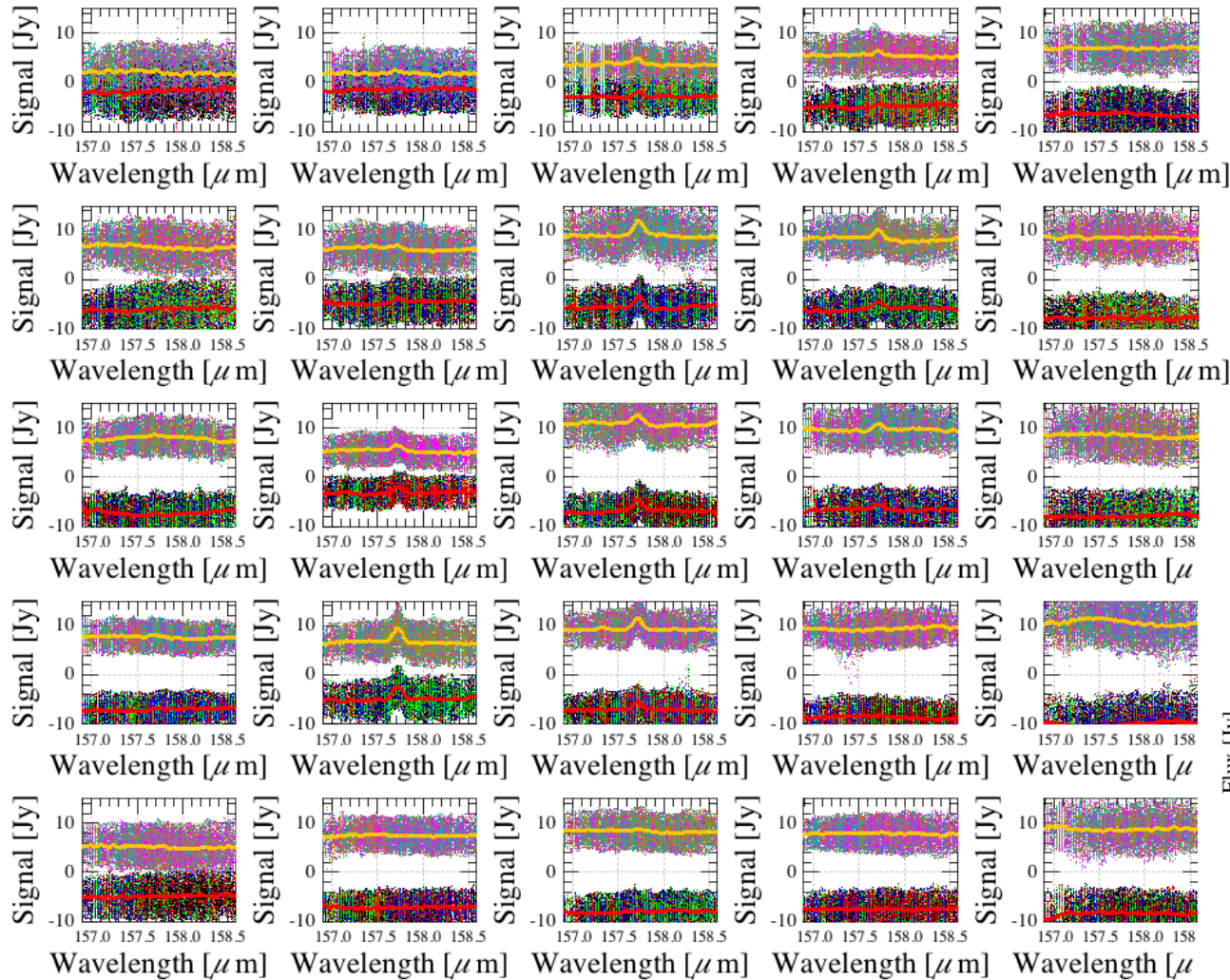




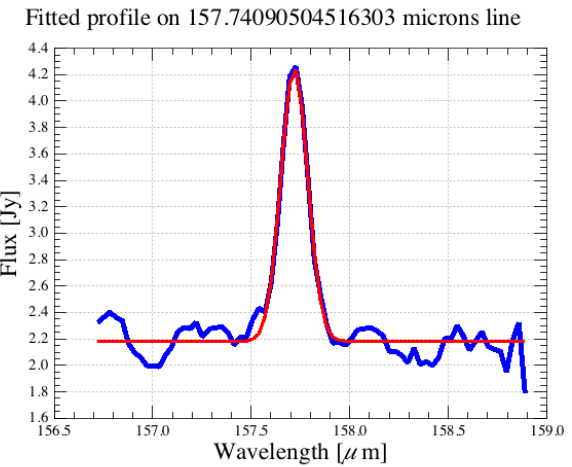
Demo data: NGC 6543

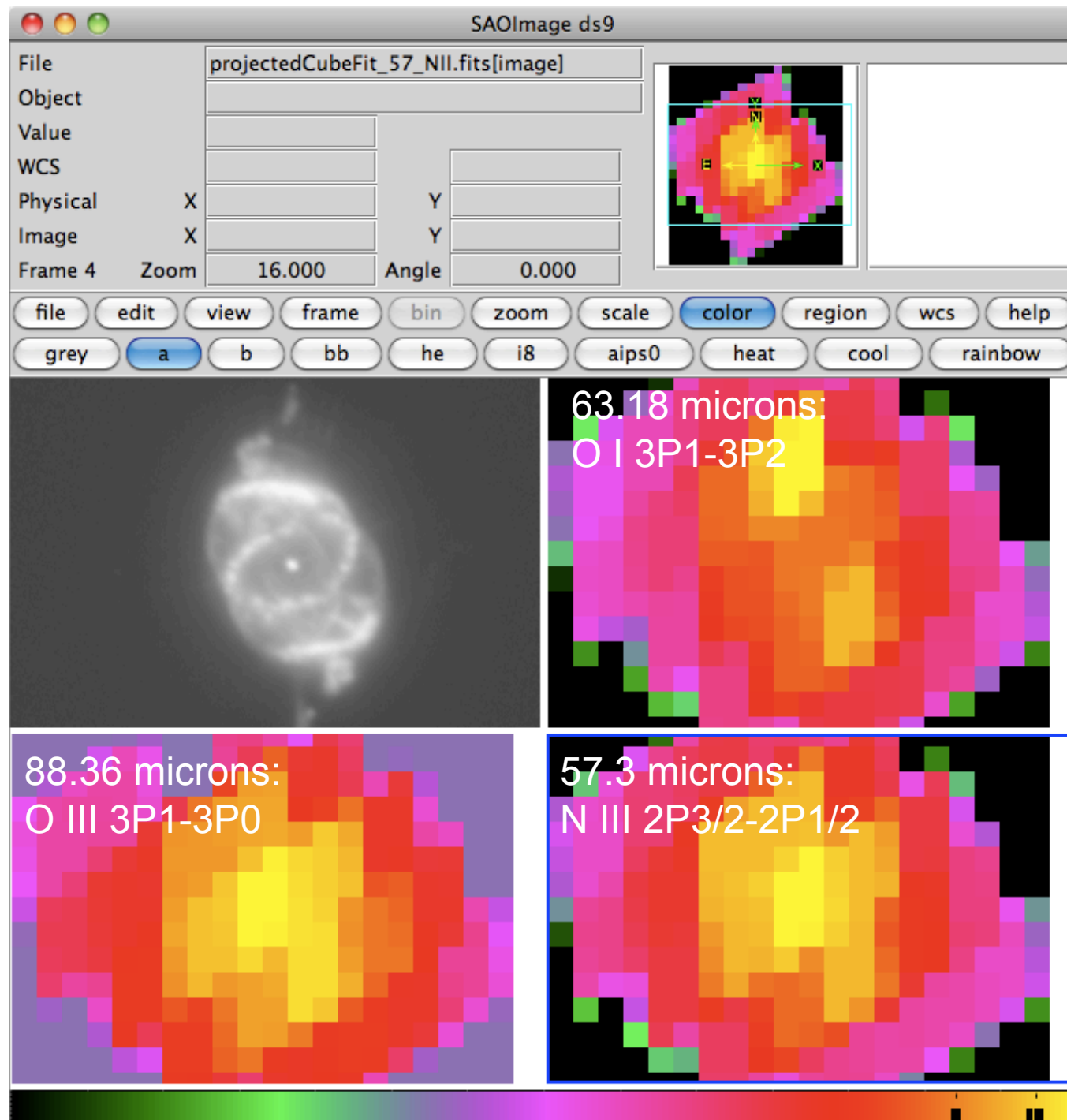
Demo observation

1342187202 Calibration_PVSpecWave_2-PVSpecWave_421D_StdLS_NGC6543_B_0001



157.74 microns:
CII C+





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