

Producing and Visualizing HIFI Data Cubes: Hands-on Session

1. Data Available

Obsid	Pool name	Notes
1342210099	1342210099_map_otf_1b	<ul style="list-style-type: none"> OTF map with Nyquist sampling Each OTF line consists of 8 readouts, with 16.2" spacing, covering 129.6". The observed map consists of 7 OTF lines, with 16.0" spacing, spanning 112.0" perpendicular to the line direction. The CO (5-4) line (576.268 GHz) is found in the USB, in subband 1 of the WBS and both HRS subbands
1342210097	1342210097_map_otf_1b_half beam	<ul style="list-style-type: none"> OTF map with half-beam spacing Same target as 1342210099 Each OTF line consists of 8 readouts, with 19.2" spacing, covering 153.6". The observed map consists of 6 OTF lines, with 19.5" spacing, spanning 117.0" perpendicular to the line direction The CO (5-4) line (576.268 GHz) is found in the USB, in subband 1 of the WBS and both HRS subbands
1342205474	1342205474_map_dbs_1b	<ul style="list-style-type: none"> DBS raster map consists of 3 lines with spacing 4.5", covering in total 13.5". Every line contains 3 raster points with 4.0" spacing, covering in total 12.0". The CO (5-4) line (576.268 GHz) is found in the USB, in subband 1 of the WBS and both HRS subbands Bug: the cubes produced by the standard pipeline for this observation cannot be viewed in Spectrum-Explorer or the CubeSpectrumAnalysisToolbox. When you make cubes yourself, these can be viewed.
1342205481	1342205481_map_dbs_7b	<ul style="list-style-type: none"> Same target as 1342205474 DBS raster map consists of 3 lines with a spacing of 4.5", covering in total 13.5". Every line contains 3 raster points with 4.0" spacing, covering in total 12.0". The CII line (1900.537 Ghz) is found in the USB, in subband 4 of the WBS and both HRS subbands

With these observations you can compare the flux captured in a fully Nyquist sampled map with that with half beam sampling with observations 1342210097 and 1342210099, respectively. The potential difference in baseline quality between total power modes (OTF) and chopping modes (DBS) can be compared with 1342205474 and 1342210099, however, it should be noted that these are observations of different sources. The Hot Electron Bolometer (HEB) bands of 6 and 7, particularly in the V-polarization, are subject to electronic standing waves not seen in the SIS bands (1-5) and this can be seen with observation 1342205481.

2. Expected Work Flow and Resources

The following is the expected workflow when dealing with data cubes in general, along with the location that help can be found in the documentation:

- Retrieve the observation from local store
 - "Getting HIFI data into HIPE" of the HIFI Cookbook (§1 of the HIFI Users Manual)**
- Inspect Level 2 HTP with SpectrumExplorer to assess need for spur, baseline and/or ripple correction. Compare H and V profiles.
 - §2.2.4 "Viewing a Spectrum" of the Herschel Data Analysis Guide (DAG)**
- Inspect cubes with either SpectrumExplorer or the CubeSpectrumAnalysisToolbox (CSAT) to assess if a re-gridding is needed. Cube creation in the HIFI pipeline is automatically performed using a square pixel with dimensions of half the beam, which may not be appropriate for the observation
 - §2.2.3 "Viewing a data cube" and §5.7 "The Cube Spectrum Analysis Toolbox" of the DAG**

- Flag spurs, if needed.
 - **Script and presentation from Spurious Features session**
- Correct ripples, if needed
 - **§12 “HIFI Standing Wave Removal Tool” of the HIFI Users Manual (HUM)**
- Correct baselines, if needed
 - **§13 “HIFI Baseline Removal” of the HUM**
- Re-grid data using appropriate pixel size and with any other desired options
 - **§16 “How to make a spectral cube” of the HUM**
- Inspect and analyze new cubes in SpectrumExplorer or CSAT
 - **§5.7 “The Cube Spectrum Analysis Toolbox” of the DAG**

3. Exercises

It is suggested that you try to apply what you have learnt at this workshop and what you can find in the documentation to carry out the exercises below and create your own script in the process. However, a script is provided (MapHandsOn.py) that steps through these exercises and can be used as a guide and reference.

Exercise 1: re-grid observation 1342210099 with the pixel size corresponding the the spacings used in the observation

You will need to:

- load the observation from local store
- extract the HTP
- run doGridding, setting the pixelSize and beam size to be appropriate values – you may also like to restrict the gridding to the subband in which the line appears, you can check which this is by plotting the HTP in SpectrumExplorer

Exercise 2: compare the signal in a fully Nyquist sampled map (1342210099) with that in a half-beam sampled (1342210097) map.

- repeat exercise 1 for observation 1342210097
- visualize the cube for one of the spectrometers and polarization in a subband in which a line is observed (say, WBS-H-USB subband 1)
- use the cube comparison tool in the CubeSpectrumAnalysisToolbox to compare with the equivalent cube from 1342210097
- Calculate the global average spectrum of both cubes and overplot them in SpectrumExplorer

Exercise 3: Make an integrated map for 1342210097 and then overlay contours on the resulting image. Compare the result obtained with that if baseline correction is done prior to gridding.

Total power modes (OTF) can exhibit baseline drift and this exercise demonstrates that. The creation of an integrated map can be quite slow and memory intensive, if you only wish to quickly practice using the CSAT for this purpose you may prefer to use one of the DBS raster map observations, which are smaller.

- Open the cube in the CSAT
- Make an integrated map, using the Integrated Map Task
- Send the resulting image of the integrated map to HIPE (Save as Product(s))
- Create contours (try 10) using automaticContour (see § 4.2.8 “Contour Plotting” in the DAG)
- Fit baselines to the HTP using fitBaseline then re-grid.
- Repeat this exercise for the baseline corrected data and compare the two sets of contour plots

Exercise 4: Make a line intensity map

You can also use the Line Intensity Map task of the CSAT to make a continuum subtracted map of the integrated flux of a line. This is useful if the baselines in your data only require a simple correction.

- Open a cube in the CSAT
- Use the Line Intensity Map task from the Analysis menu

4. Beam sizes and spacings

Band	Beam width (")	Nyquist spacing ("	Half-beam spacing ("
1a	43.5	18.4	22.0
1b	37.7	15.9	19.0
2	33.3	13.9	17.0
2b	29.8	12.5	15.0
3a	27.3	11.4	14.0
3b	24.9	10.4	13.0
4a	22.5	9.4	11.0
4b	20.8	8.7	10.0
5a	19.6	8.0	9.0
5b	18.6	7.8	9.0
6a	15.2	6.3	8.0
6b	14.0	5.8	7.0
7a	12.8	5.3	7.0
7b	12.2	5.2	6.0