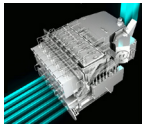


Handling HIFI special cases

Pat Morris, NHSC

Aims

- Recall that occasionally HIFI data may need interactive treatment for a range of possible artifacts, and combining data or other optimizations when the source environment allows.
  - Refer to slides 26 – 30 in the Introduction talk.

- We will focus on three most frequent cases:
  1. Inspection of sky reference OFF position for line contamination.
     - Chops into ON source data to produce false absorption.
  2. Spectral Scan data (re-)flagging and cleaning, and re-running doDeconvolution.
  3. Electrical Standing Wave removal.
     - Optical Standing Wave removal and baseline fitting is done as part of #1.

Testdata Obsids

Linked on the workshop agenda page

https://nhscdmz2.ipac.caltech.edu/workshop/Workshop_Oct2014/Spectroscopy/HIFI/data/

Each gzipped tarfile must be put into your lstore and decompressed (double-click on the *.tar.gz files, this opens a decompression tool).

- 1342251220 Point Pos Switch for OFF inspection.
- 1342190183 DBS OFF inspection
- 1342180473 Freq Switch OFF inspection
- 1342250414 Load Chop OFF inspection

HifiObsidsOffInspection.tar

- 1342192299 Point PSW band 6a HEB correction
- 1342216380 SScan load chop band 3b SScan workflow

HifiObsidsDataFlaggingCleanUp.tar

- 1342237005 SPIRE Point FTS Spectrum Explorer demo

SpireSEexample.tar

- 1342202064 Point water line 556.93599 SFG fitting
- 1342217736 OTF CO 10-9 1151.9854 SFG fitting to cube, and SE demo

HifiObsidsSpectrumFitting.tar

Data Inspection

To start, for any observation, always get familiar with the data first.

- Check the *observing mode* and possible associated caveats in the *Observing mode performance and release notes:*

  http://herschel.esac.esa.int/twiki/pub/Public/**HifiCalibrationWeb**/HifiObservingModesPerformance_110926a.pdf

- *Check the quality of the data:*
  - Visual check of the spectra (*Spectrum Explorer*)
  - Check the OFF data when possible/available.
  - Check the *Quality product and associated flags* that will inform about data features through various metrics.
    - Flags warning about processing failure, that could lead to e.g. improper calibration or impossibility to create deconvolved data
    - Flags informing about *instrument* (e.g. achieved vs targeted noise rms, efficacy of automatic correction, etc), or *spacecraft* performance.
  - There are also many flags that are only relevant to the instrument expert – see the *documentation* to figure out what does or not impact your data:

    http://herschel.esac.esa.int/hcss-doc-12.0/load/hifi_um/html/qf.html
  - Check the science data flags set by the pipeline, using the *flagTool*

OFF contaminations

- Observations using Position Switching, including OTF maps with sky reference measurements, or Dual Beam Switching may not have completely 'clean' OFF positions. E.g. extended CO 5-4, [CII], [NII] are common cases.

- Next: reminder of different kinds of Refs for HIFI
- How to inspect possible emission in OFFs
- Recipe per observing mode – *Demo*

Reference Schemes

HIFI observing modes makes use of a differencing scheme. The quick differencing schemes of Load Chop/Frequency Switch/ DBS correct for drifts in the instrument on a relatively short time scales.

- Load Chop look repeatedly at the cold load to reference ,
- Frequency Switch modulates the LO frequency
  - Standing waves and baseline instabilities in both Load Chop and Frequency Switch can be further corrected via a dedicated OFF observation on blank sky using the same mode.
    - Load Chop with OFF
    - FSW with OFF
- DBS uses the internal chopper to look fixed 3' off source, then a telescope slew. DBS will actually observe two OFF positions which are differenced and placed with the observation making off inspection easy.

OFFs in Position Switching

- Position switching is used with the Point AOT, and also in OTF mapping. It is a total power mode, no quick referencing.
- This means the OFFs are not independently calibrated. However inspection for contamination needs processing similar to the ON data.
- We can produce a “calibration” by reusing the cold loads.
  - This is a poor-man’s calibration and not proper, since the same cold loads are already used in the bandpass calibration.
  - At the end of level 1, the OFF data are bandpass corrected
  - We form OFF-cold/bandpass
- Further fitHifiFringe and fitBaseline will be needed to clean up these final OFF spectra.

Position Switch OFF demo

See HIFI_CheckOffPsw141006.py

Uses obsid 1342251220

- Data are in https://nhscdmz2.ipac.caltech.edu/workshop/Workshop_Oct2014/Spectroscopy/HIFI/data/**HifiObsidsOffInspection.tar.gz**

- Script is linked on the workshop agenda page item “HIFI Special Cases”, or https://nhscdmz2.ipac.caltech.edu/sc/uploads/Workshops/**HIFI_DataDemoScripts_141006.zip**

OFFs in DBS, FSW, LC

- **In DBS** mode there are two OFF positions observed.
  - These two OFF can be subtracted from each other to provide a calibrated and relatively clean reference spectrum which is found in the ObservationContext obs
  - obs → ["calibration"] → ["pipeline-out"] → ["ReferenceSpectra"]
- **For FSW** in the current pipeline (12.0) the OFF data are used to correct the ON and then discarded. The OFF spectra can be preserved after a re-running of the level 2 pipeline.
  - In HIPE 13.0 the OFF data will be saved in the observation like the DBS OFFs.
- **For LC**, currently OFF spectra similarly have to be re-generated in HIPE.
  - Data identifier (BBID) for OFFs in Point observations and OTF maps using LC is the same. The OFFs can be extracted and inspected in the same way.
  - **In HEB bands**, applying the electrical standing wave correction tool (hebCorrection) may sometimes correct the baselines better than using the OFF sky reference spectra in the standard pipeline (due to drift mismatch between ON and OFF). More later.

DBS OFFs demo

See HIFI_CheckOffPSW141006.py

Uses obsid 1342251220 CO 5-4

Load Chop and FreqSwitch examples (not demo'd)

HIFI_CheckOffLC141006.py

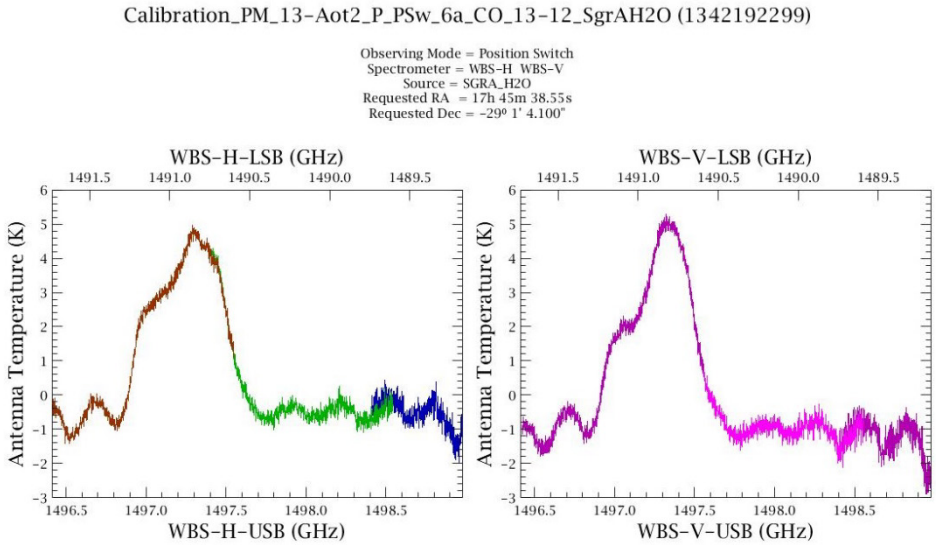
Uses obsid 1342250414 C+

HIFI_CheckOffFSW141006.py

Uses obsid 1342180473 H2O 101 - 110

- Data are in https://nhscdmz2.ipac.caltech.edu/workshop/Workshop_Oct2014/Spectroscopy/HIFI/data/**HifiObsidsOffInspection.tar.gz**
- Script is linked on the workshop agenda page item "HIFI Special Cases", or https://nhscdmz2.ipac.caltech.edu/sc/uploads/Workshops/**HIFI_DataDemoScripts_141006.zip**

Problem Data Case 2: Electrical Standing Waves in Bands 6, 7

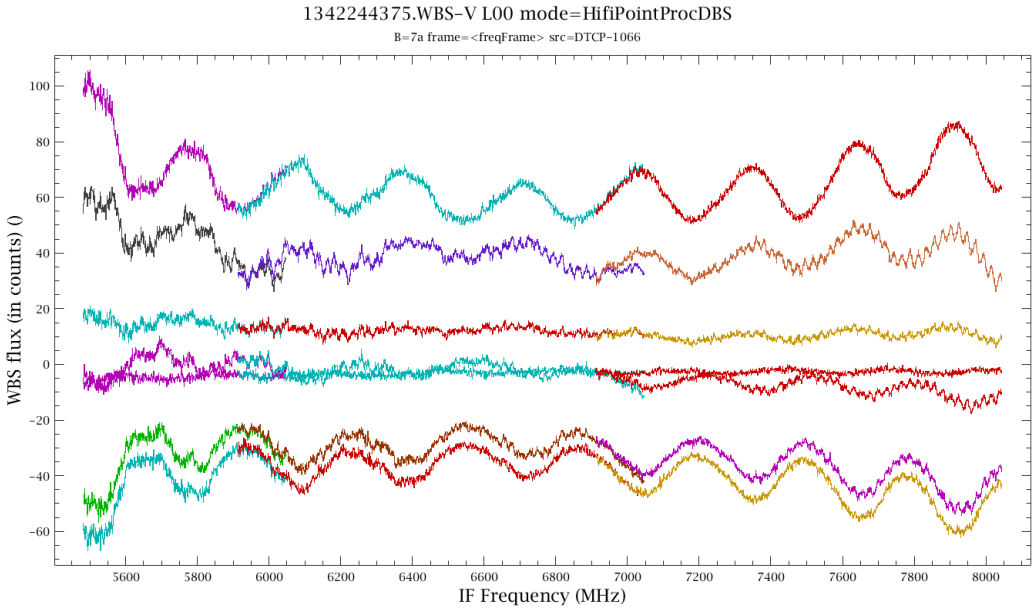


- Electrical Standing Waves in the HEB mixer bands are caused by multiple reflections between mixers and low-noise amplifiers at intermediate frequency. No isolators are present to suppress this.

- Non-optical in origin, they are not purely sinusoidal - but often this approximation is not too bad. When instrument drift is high (short Allan times are typical of the HEB bands), the shape of the ripples becomes more non-sinusoidal.
- Short Allan times means standard correction schemes using sky references are often leaving residuals, due to impedance mis-match.

ESW mitigation approach

- While the blank sky may not match the drift characteristics of ON-source spectra, they can be used to construct a catalog of line-free ESWs.
- The hebCorrection task in it's fundamental form is a fit of ESW spline curves from such a catalog to the science data in an observation. OFF spectra can be fit as well.



- Source continuum emission levels are unreliable until the ESW corrections are applied, since the drift component is also removed.

Notes about the hebCorrection task

- Corrects Level1 HTP ON-source data, all observing modes supported.
- Can be used to fit, or to re-apply previous solutions.
- HRS is automatically corrected based on WBS result.
- Recovers the drift-free continuum level.
- Robust fitting of the ESW down-weights frequency regions with strong lines
- Requires ESW model set as FITS file, available from the HifiCalWeb page
  http://herschel.esac.esa.int/twiki/bin/view/Public/HifiCalibrationWeb
  - Will be automatically fetched from calTree in HIPE 13.
- **Caveats**:
  - The models are not yet complete. It might fail to correct or correct spuriously some number of spectra.
  - Examine the Level 1 results and consider manual line exclusion or flagging your data if some spectra are very wrong --- e.g., line masking is not foolproof.
  - **RAM- & CPU-intensive**. Although it should work within your computer's limits, more of both helps. The task in HIPE 13 will provide better progress status (some jobs can take hours and hours).

ESW Correction Demo

See

HIFI_ESW_hebCorrectionExample_141006.py

Uses obsid 1342192299 Band 6a

- Data are in https://nhscdmz2.ipac.caltech.edu/workshop/Workshop_Oct2014/Spectroscopy/HIFI/data/**HifiObsidsOffInspection.tar.gz**

- Script is linked on the workshop agenda page item “HIFI Special Cases”, or https://nhscdmz2.ipac.caltech.edu/sc/uploads/Workshops/**HIFI_DataDemoScripts_141006.zip**

Cleaning up SScans before deconvolution

- Based on inspections, three steps should be considered for Spectral Scan data
  - *Flagging of spurious signals and (strong) lines*
  - *Standing wave removal*
  - *Baseline correction (subtract or division), if continuum is not important.*

- In Spectral Scans these have a direct effect in the Single Sideband solution computed by the **deconvolution** algorithm. Spurious information, line or spur ghosting, etc, can propagate at multiple places of the level 2.5 products.

- Flagging should be done first since its output is directly honoured by tasks such as *fitBaseline*, *fitHifiFringe* or *doDeconvolution.*

- *In HIPE 13 and 14, it is the intention that Spectral Scan data come with an a priori list of (manually assigned) flags – the flagging need from a user perspective should be greatly relieved*

SScan Workflow demo

SScan flagging, baseline cleanup, sideband deconvolution demo

See HIFI_SScanWorkflow_141006.py

Uses obsid 1342216380 Orion Bar band 3b