HIFI Gas Cell Data in the HSA.

Version 0.3 of 2016-01-28, by Michael Olberg

Abstract

As part of the post-operations phase, the HIFI ICC have ingested their gas cell data taken during ILT into the Herschel Science Archive (HSA). This report describes the layout of the observation contexts containing these data, and which HIPE tasks can be used to work with them.

Technical Note: ICC/2014-05
10 pages

Introduction

The setup and measurement principles of the HIFI gas-cell campaign performed during ILT can be found in [1] and references therein. The collected datasets were processed in HIPE to produce full HIFI observation contexts, albeit with non-flight observation ids, following the following procedure:

1. Create an empty observing context with approriate meta data about creator, instrument etc.
2. Generate a level 0.5 product in the observing context by retrieving data from local pool of the original gas cell data.
3. Check for saturation.
4. Average spectra at level 0.5 per phase, i.e. cold/hot load, unfilled/filled gas cell.
5. Run spur finding algorithm on level 0.5 data and add resulting spur table to `Quality` product of the observing context.
6. Calibrate data: $C = (h_f - c_f)/(h_e - c_e)$, where h and c stand for hot and cold, and subscripts f and e for filled and empty, respectively.
7. Insert the calibrated dataset at level 1 of the observing context.
8. For HEB data, perform an ESW (electrical standing wave) correction.
9. Generate meta data for mean continuum and noise level from pre-calculated tables. If these deviate from band specific, expected values, generate a quality comments and add these to a `Quality` product of the observing context.
10. Generate frequency scales for upper and lower sideband, i.e. USB and LSB, do a frequency conversion of the level 1 data to these scales and generate products WBS-H-USB ... WBS-V-LSB at level 2. Note, that sideband gains are kept fixed at exactly 0.5, i.e. perfect balance between upper and lower sideband is assumed.
11. Rescale spectra at level 2 such that perfectly calibrated data will have a level of 1.0 for no absorption and 0.0 for fully absorbed spectral lines.

The original datasets from the ILT campaign contain both WBS and HRS data. However, here only WBS datasets were processed, there are no HRS data present in the resulting observing contexts.

Layout of the observation context

The layout of the observing contexts generated following the procedure described in Section is described in the following tree diagram. Note, that `History` entries, which appear at various levels, have been omitted.

```
obs
├── auxiliary (empty)
├── calibration (empty)
├── level0 (empty)
├── level0_5
│   ├── WBS-H
│   │   ├── summary
│   │   ├── 1 ...  There will typically be several datasets at level 0.5,
│   │   │          in level 1 and 2 these will be averaged into one.
│   │   │   └── dataset
│   │   ├── ...
│   │   │   └── dataset
│   └── WBS-V
├── level1
│   ├── WBS-H
│   │   ├── summary
│   │   ├── 1 ...  only one dataset at level 1.
│   │   │   └── dataset
├── level2
│   ├── WBS-H-LSB
│   │   ├── summary
│   │   ├── 1 ...  only one dataset at level 2.
│   │   │   └── dataset
│   ├── WBS-H-USB
│   ├── WBS-V-LSB
│   ├── WBS-V-USB
├── logObsContext
│   ├── LOG
├── quality
│   ├── comments
│   ├── SpurTable
│   │   ├── spur
```

Level 1 and 2 data

Each of the two acousto-optical backends (WBS-H and WBS-V) is represented by one dataset, which is of type WbsSpectrumDataset. At level two there are representations of

each of these on a LSB and USB frequency scale (WBS-H-LSB, WBS-H-USB, WBS-V-LSB, WBS-V-USB). Table 1 lists the meta data available in a gas cell observation context at top and htp level.

name	value	description	where
type	OBS	Product Type Identification	both
creator	gas cell pipeline	Generator of this product	both
creationDate	2014-01-31T13:18:55	Creation date of this product	both
description	HIFI gas cell data ...	Name of this product	both
instrument	HIFI	Instrument attached to this product	both
modelName	GAS CELL	Model name attached to this product	both
startDate	2007-06-18T18:04:47	Start date of this product	both
endDate	2007-06-18T18:05:02	End date of this product	both
formatVersion	1.0	Version of product format	both
obsState	LEVEL2_PROCESSED		both
obsid	268511817	Observation identifier	both
odNumber	-1	Operational day number	obs
molecule	CH3OH	methanol	obs
aot	n/a	AOT identifier	obs
calVersion	n/a	HIFI calibration version	obs
object	gas-cell	target name	both
obsMode	DBS gas-cell	observing mode	both
Band	1a	Active band	both
count_ds	1	Number of datasets in this product	htp
last_ds	1	last dataset in this product	htp
level	20	Pipeline level	htp
apid	1030	Apid	htp
fileName	hhifiwbsh...	filename for exporting purposes	htp
sideband	lsb	(only at level 2)	htp

Table 1: Example of meta data in the gas cell observing context and its HIFI timeline products. These data are present at context (obs) or timeline product (htp) level, or both.

Tables 2 and 3 list the meta data and columns present in each dataset.

Table 2: Meta data of a dataset at level 1 and 2. Fixed values have been indicated in parantheses after the description.

name	*unit*	*description*
type	–	product type identification (`HifiSpectrumDataset`)
creator	–	generator of this product (`HifiPipeline`)
creationDate	–	creation date of this product
description	–	name of this product
instrument	–	instrument name (`HIFI`)
modelName	–	model name (`FM-ILT`)
startDate	–	start date of this product
endDate	–	end date of this product
formatVersion	–	version of the product format
DATE_OBS	–	start date of this product
apid	–	apid
obsid	–	observation id
backend	–	spectrometer
channels	–	number of channels
wavename	–	actual name of the wavecolumn (`frequency`)
wavedescription	–	description of wavecolumn (`Double Sideband IF`)
waveunit	–	units of the wavecolumn (`MHz`)
parameter_1...5	–	parameters of the wave model
rowflag_8	–	possible rowflags raised
OBS-revision	–	on board software revision
OBS-version	–	on board software version
OBS-patch	–	on board software patch level
Band	–	active band
author	–	author of this product
origin	–	site that created the product (`HIFI-ICC`)
telescope	–	name of telescope (`Herschel Space Telescope`)
odNumber	–	operational day number (`-1`)
AOT	–	observation template (`gas-cell`)
obsMode	–	observing mode (`DBS gas-cell`)
proposal	–	proposal identifier (`0`)
observer	–	proposer of the observation (`Unknown`)
object	–	target of observation (`Unknown`)
naifId	–	solar system object identifier (`n/a`)
ra	deg	actual RA (`0.0`)
dec	deg	actual Dec (`0.0`)
raNominal	deg	requested RA (`0.0`)

continued on next page

continued from previous page

decNominal	deg	requested Dec	(`0.0`)
raDeSys	–	coordinate reference frame	(`Equatorial`)
posAngle	deg	position angle	(`0.0`)
equinox	–	equinox of coordinate system	(`2000.0`)
version	–	version of the product	
fileName	–	filename for exporting purposes	
Pipeline applied	–	pipeline modules applied	
isMasked	–		
hassubbands	–	whether it has subbands	
subbandlength_n	–	length of subband ($n = 1 \ldots 4$)	
subbandstart_n	–	starting channel of subband ($n = 1 \ldots 4$)	
loFrequency	GHz	local oscillator frequency	
polarization	–	description of polarization	
sideband	–	description of sideband	(`dsb`)
sds_type	–	building block type	(`science`)
datasetNumber	–	Consecutive number of this dataset	
lsbGain	–	Sideband gain level applied. (*only at level 2*)	(`0.5`)

Applicable Tasks

1. We shall demonstrate some of the operations one can perform with the gas cell datasets, by extracting the two WBS spectrum datasets at level 1:

```
# get the WBS products ...
wbsH = obs.refs["level1"].product.refs["WBS-H"].product
wbsV = obs.refs["level1"].product.refs["WBS-V"].product
# ... and the corresponding datasets
sdsH = wbsH.refs["1"].product["dataset"]
sdsV = wbsV.refs["1"].product["dataset"]
```

2. To start with, the usual arithmetic operations will work:

```
# calculate an unweighted, unaligned average
A = (sdsH + sdsV)/2
```

3. You can use the spectrum toolbox to do this properly:

```
# stitch ...
stitchedH = stitch(ds=sdsH)
stitchedV = stitch(ds=sdsV)
# ... align ...
grid = 4000.0 + 0.5*Double1d.range(8000)
regriddedH = resample(ds=stitchedH, density=True, grid=grid)
regriddedV = resample(ds=stitchedV, density=True, grid=grid)
# ... and average
avg = AverageSpectrumTask()
A = avg(ds=[regriddedH, regriddedV], variant="flux")
```

4. Convert to a simple spectrum:

```
S = convertSingleHifiSpectrum(spectra=A)
```

5. Calculate spectrum statistics:

```
stats = mkRms(input=A)
```

6. Fit a baseline:

```
fitBaseline(data=A, domask=0)
```

7. Save to FITS:

```
# use the simpleFitsWriter task
simpleFitsWriter(product=A, file='hcss.fits')
# export to CLASS
hiClass(data=A, fileName='class.fits')
```

Figure 1 shows statistics on the quality of spectra per LO band and backend. For each of the spectral subbands, five statistical properties (min, max, mean, median, rms) were checked against reasonable expectation values[1]. For each criterion passed one point was awarded, so that good quality spectra will reach 20 and 15 points maximum for the SIS and HEB bands (due to fewer subbands), respectively.

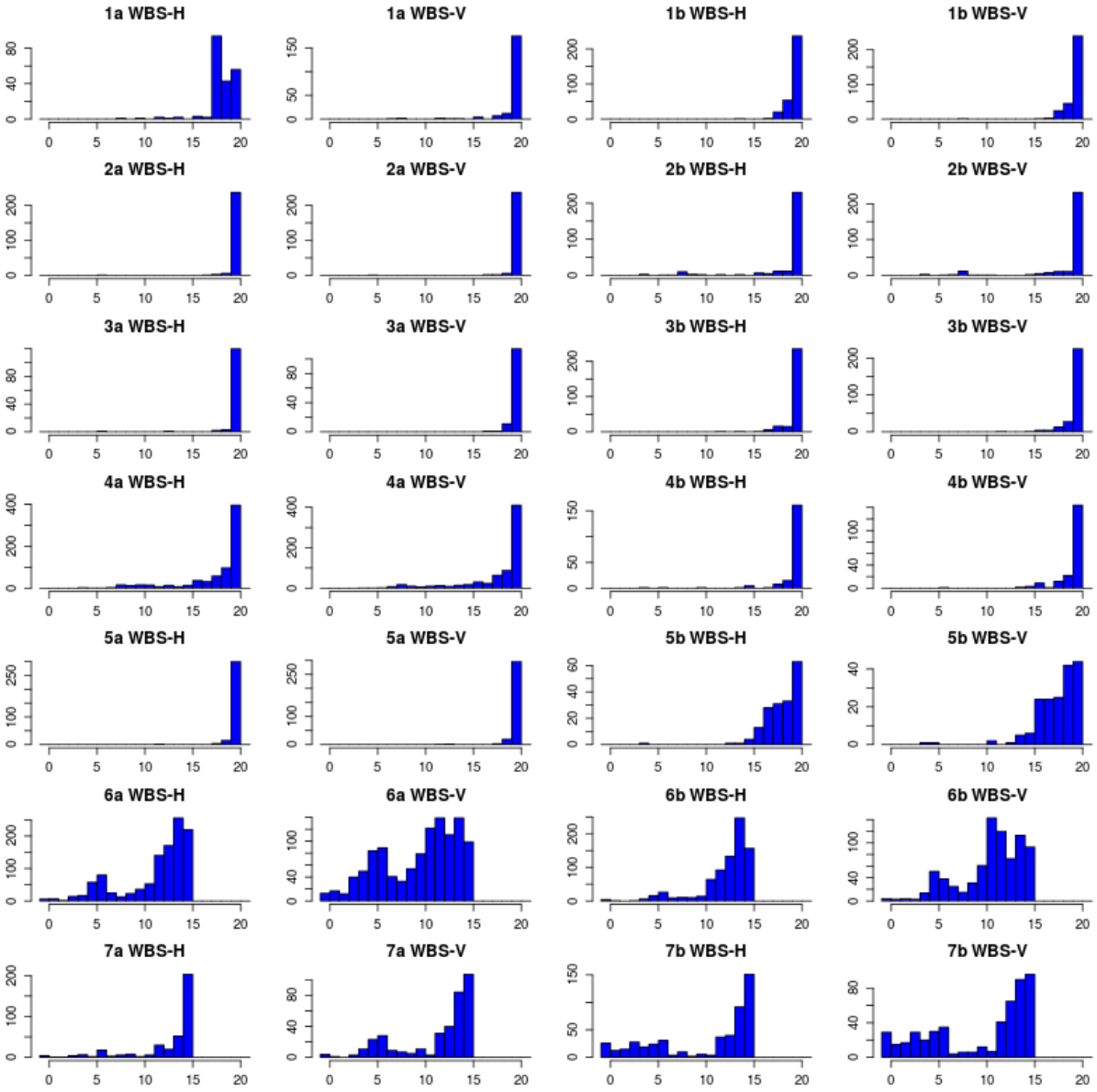

Figure 1: Statistics on quality of spectra per LO band and backend.

[1]Basically we expect all calibrated intensities at level 1 to fall in the intervall 0.5–1.0 with some tolerance.

name	*unit*	*description*
flux_n	–	flux ($n = 1 \ldots 4$)
flag_n	–	bitwise flag ($n = 1 \ldots 4$)
{lsb,usb}frequency_n	MHz	frequency scale ($n = 1 \ldots 4$)
weight_n	–	channel weights ($n = 1 \ldots 4$)
IN_ATT	–	–
bitshift	–	bit shift
rowflag	–	dataframe flag
bbtype	–	building block type
Chopper	–	actual chopper positions
nrbytes	–	number of bytes
cmd_chopper	–	commanded chopper positions
hot_cold	K	hot and cold temperatures of the calibrator
LoFrequency	GHz	local oscillator frequency
LOF_code	–	encoded info on local oscillator frequency
integrations	–	number of integrations
packet time	–	packetization time
buffer	–	integration buffer
Band_ATT	–	–
scancount	–	integrated scan count
integration time	s	–
obs time	–	observation time
bbnumber	–	building block number
hot/cold_diff_empty	–	mean (hot − cold) for the empty cell
hot/cold_diff_full	–	mean (hot − cold) for the full cell
badLo	–	set of raised LO flags (for each subband).
room_temperature_samples_nb	K	number of room temperature HK packets
room_temperature_min	K	minimum room temperature
room_temperature_max	K	maximum room temperature
room_temperature_med	K	median room temperature
room_temperature_avg	K	average room temperature
room_temperature_std	K	room temperature standard deviation
room_temperature_rms	K	room temperature root min square
room_temperature_ske	K	room temperature skewness
gascell_pressure_empty	mbar	gascell pressure at beginning of empty phase
gascell_pressure_full	mbar	gascell pressure at end of full phase
gascell_pressure	mbar	gascell pressure during full phase

Table 3: List of columns in the datasets at level 1 and 2.

References

[1] Teyssier, D., 2008, *HIFI FM Gas-cell measurements*, SRON-G Technical Report SRON-G/HIFI/TR/2008-002, 2008.