



Herschel/HIFI Data Flow

Observation Planning and Data Processing

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Menu

- Herchel's data and development cycles
- AOTs, and Spectral Line DBs
 - Herschel's Observation Planning Tool and the Line DBs.
- Data Processing
 - General: Level 0, 1, 2 processing
 - Special efforts: HIFI Sideband Deconvolution
- NHSC: who we are what we do why we do it.

HIFI-centric

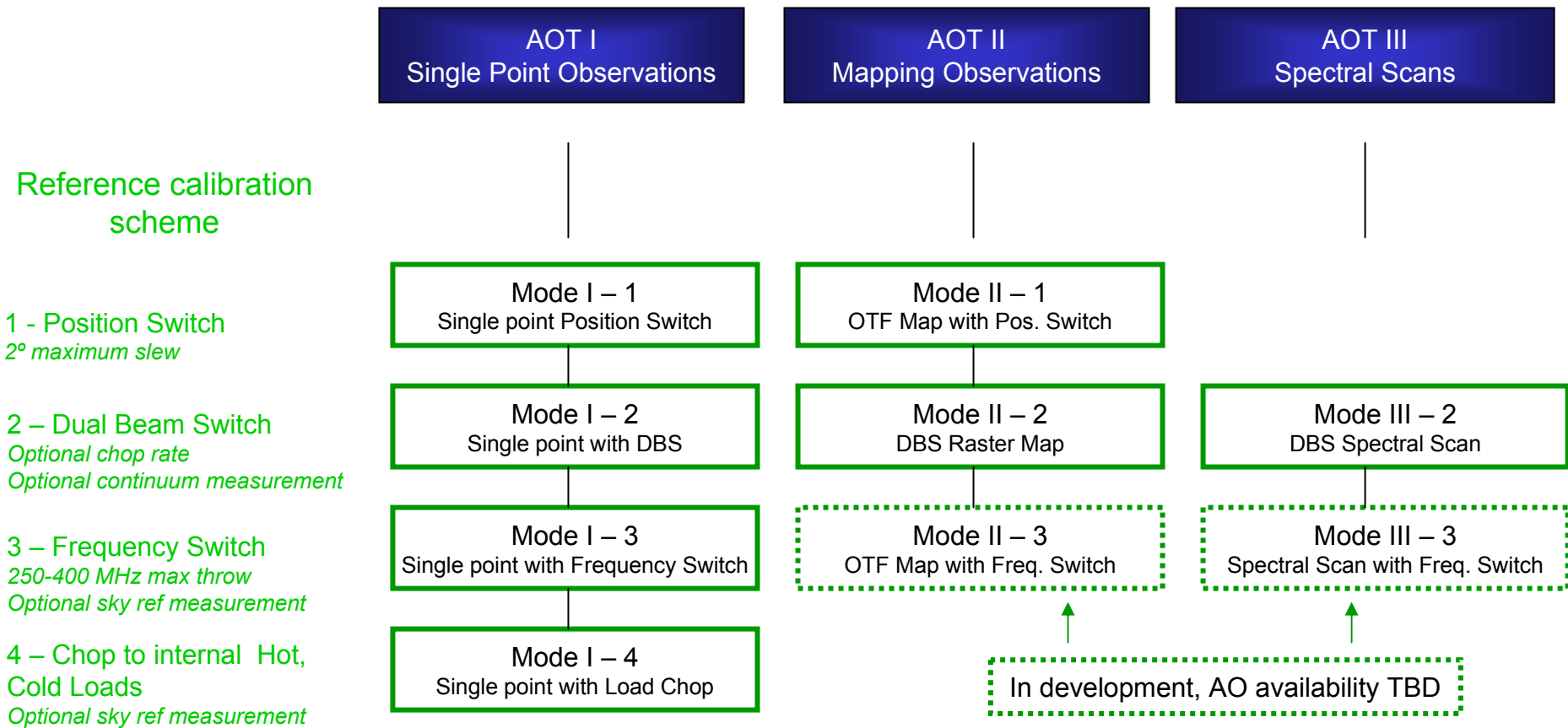




HIFI AOTs Schematically



Currently 12/16 schemes delivered to ESA






Line Databases and AOTs



Spectral databases have these key roles in Observation Mode development, testing, and science planning:

- Herschel's Science Planning and Observation Tool (Hspot): 
 - Spectroscopy AOTs for HIFI and PACS now incorporate the JPL and Cologne databases as defaults for “line editing”.
 - Stick diagrams only – no modeling involved. Completeness is not guaranteed.
 - User inputs allowed.
- Gas cell measurements in Instrument Level Tests: methanol, OCS, water, etc.
 - Spectral and radiometric performances
 - The Spectral Scan AOT: > 6 days planned to do full spectral surveys in the lab.
 - Laboratory knowledge of these species is already crucial in the instrument tests and data analyses.



JPL, CDMS, and User Lines Lists in Observation Planning



HIFI AOT with Freq Editor

PACS Line Spectroscopy AOT with Line Editor



Are line editing tools sufficient/helpful/worthwhile in observation planning?
User feedback is needed fairly soon.



Coming Features

T > Feb 2007 KP AO



- Clustering (a la Spitzer)
 - **Spatial:** combines several fixed positions within $4^\circ \times 4^\circ$ area at the same frequency in the same AOR (< 18h).
 - **Frequency:** combines several frequencies in the same LO band for the same fixed position in the same AOR (< 18h).

* Improves observing efficiency, reduces overheads, provides efficient data processing.

* Available for all 3 instruments (spatial clustering), driven by HIFI.

- Telescope tracking modes for SSOs / moving targets
 - Currently planning and time estimates must be based on treating SSOs as fixed targets (NAIF ID = 0). Applies to all 3 instruments.
- HIFI observing modes: Spectral Scan and OTFMap with ν -switching.
 - Development best-effort, *may* be accepted as delta delivery, ~12/06.





Radial Velocity Effects, w/ respect to using the Line db's for planning



- Radial Velocity corrections
 - Users are responsible only for target RVs. Adjustment is made at Hspot, visible to the user. LSR, Geocentric, Heliocentric frames allowed.
 - Spacecraft velocity (up to ~ 30 km/s) will be accounted for during scheduling with a commensurate observing mode command to recenter the input LO frequency and IF coverage.
 - This shift will be present in the data (no re-shifting in the standard data processing). Spacecraft RV information will accompany the data products.
 - Other motion such as slews will not affect the data. Scan mapping (OTF Map) is almost completely tangential, other components are negligible.





Data Processing in the HCSS

- Test data analysis and Pipeline development proceeding within the interactive Herschel Common Software System (HCSS) Data Processing environment.
 - Java is the basic language for Data Processing, i.e. pipeline code is written and delivered to ESA in Java.
 - A Jython scripting interface is provided to users.
 - The system is designed for commonality: all tasks, tools, procedures for the three instruments along with a general library of commonly needed functions (plotting, numerical applications) are available in a single environment.
 - One installation containing “DP-ALL”.
 - Connects with object-oriented Versant data bases, but not required.
 - Filled and accessed during instrument testing at instrument centers, and during Standard Product Generation (pipeline production) at ESA sites.





Standard Product Generation

- All data downlinked from spacecraft are processed at ESAC (formerly Vilspa):
 - Level 0: reformat raw data, set up instrument datasets for further propagation.
 - Level 1: Combine instrument data frames, housekeeping and proceed through “essential” calibration steps (HIFI example next slide).
 - Populate the external archive, accessible via the Herschel Archive Browser.
 - Based on ISO design.
 - FITS files for all products and ancillary data (e.g. pointing history).
 - Intended to be easily imported back into the HCSS/DP environment for interactive (re-)processing.





Processing beyond Level 1

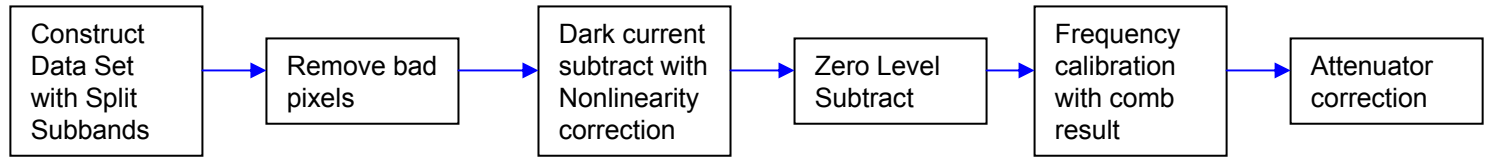
- Level 2 processing is considered interactive (offline) in the HCSS/DP environment, although it may still involve removal of instrument signatures, and then some. These are so-called extended data processing packages. E.g.,
 - HIFI Sideband deconvolution.
 - Ripple characterization/removal
 - Rebinning / image manipulation
 - Map making / mosaic tools
- } All 3 instruments
- Level 3 = Science Analysis Tools
 - Currently exo-HCSS: CASSIS (E. Caux), (X-)CLASS (P. Schilke), HICLASS (M. Perault)
 - Doorways are being devised to allow movement of products between environments (via FITS).



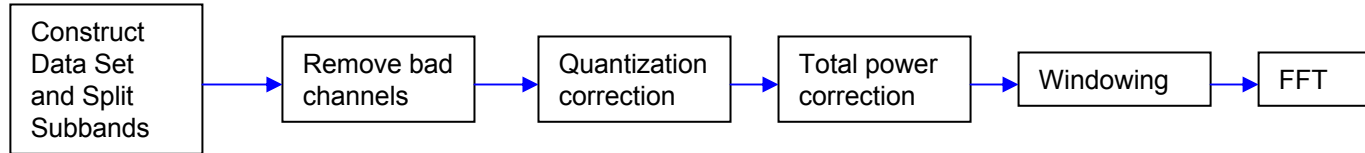
Level 1 processing - HIFI

Separate threads for WBS and HRS, then common calibration for both back ends. The following are highly abbreviated representations of the pipeline:

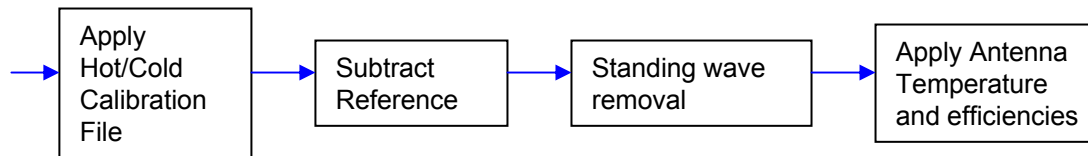
WBS



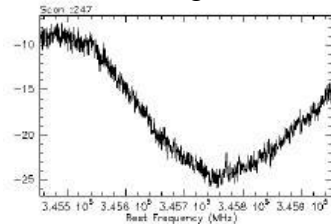
HRS



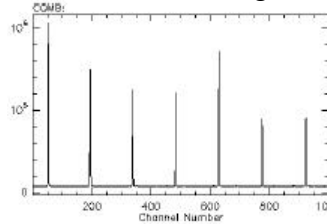
Common



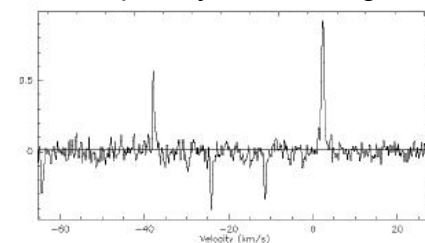
WBS, e.g.



Comb, e.g.



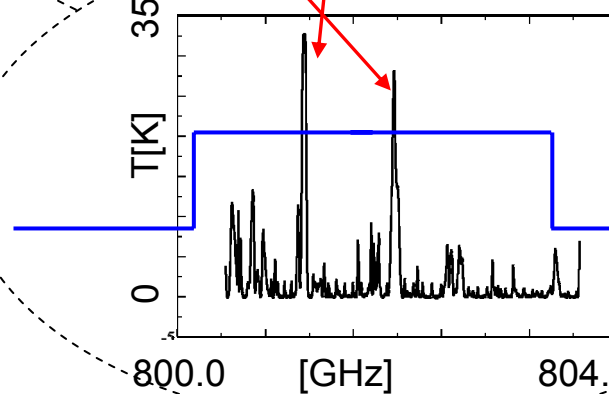
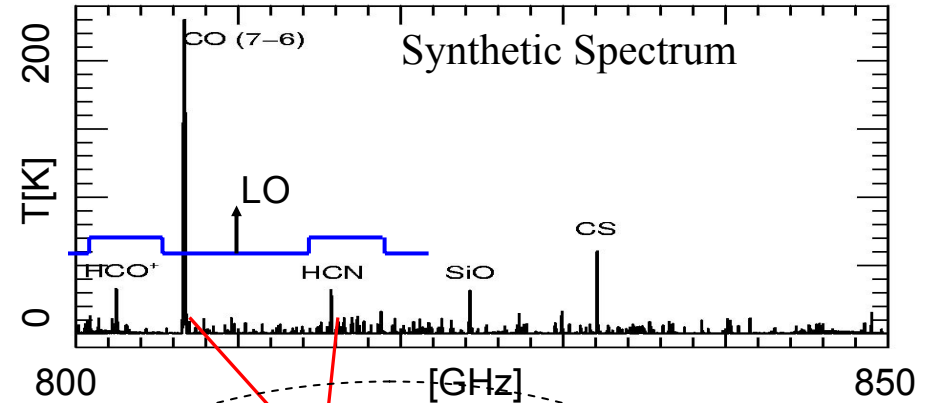
Frequency Switch, e.g.





Double Sideband Problem - Intro

- HIFI is sensitive to the two sidebands on either side of the local oscillator (LO).
- All HIFI spectra are DSB spectra.
- The SSB spectrum can be recovered using redundant observations at offset LO settings.
- Stepwise tuning of the LO moves the lines in opposite directions through the IF band.
- A CSO-tested deconvolution algorithm (Comito & Schilke 2002) is used to identify the proper sideband of each line.



816.0 [GHz] 812.

Double sideband spectrum

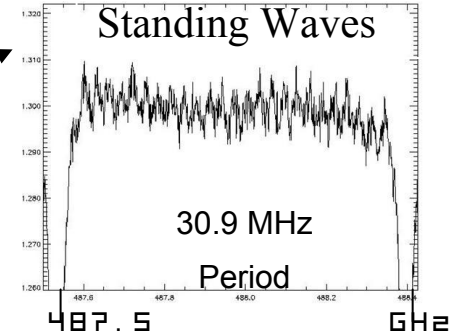
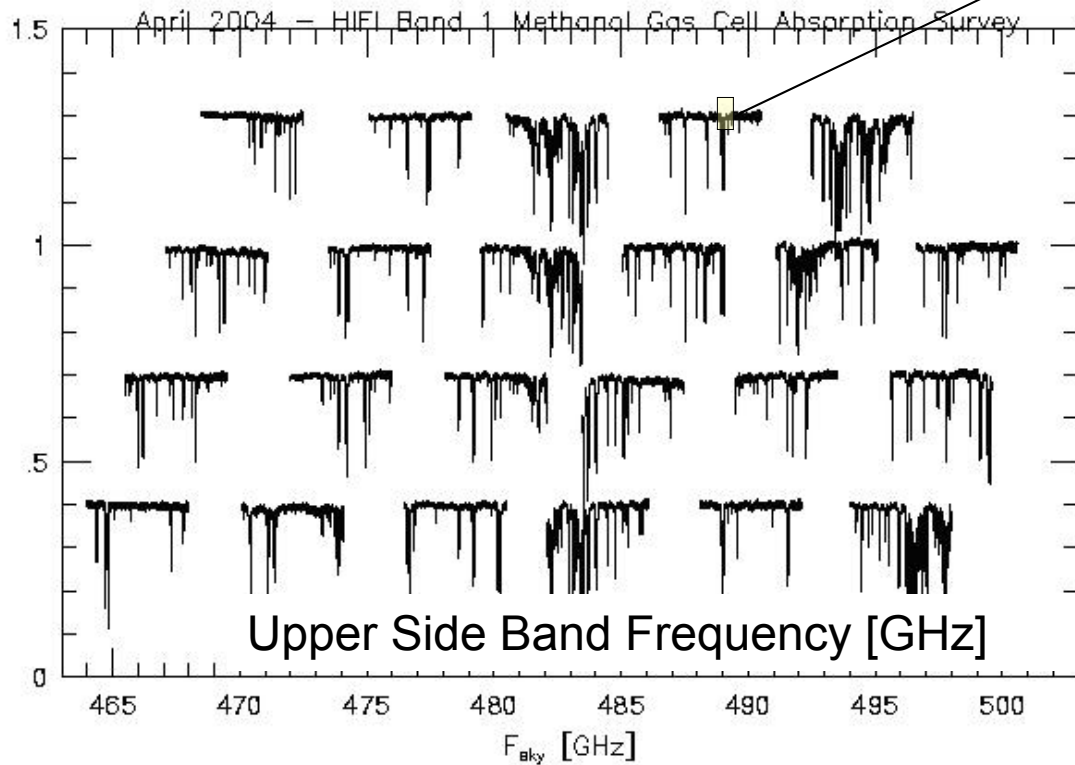




Example of Line Rich Source & the Sideband Problem



Methanol Survey – Gas Cell Observations,
Spectral Scans at stepped Local Oscillator frequencies



Band 1 Demonstration Model
(DM) : Gas Cell: CH_3OH
 H_2O , H_2CO , CH_3CH





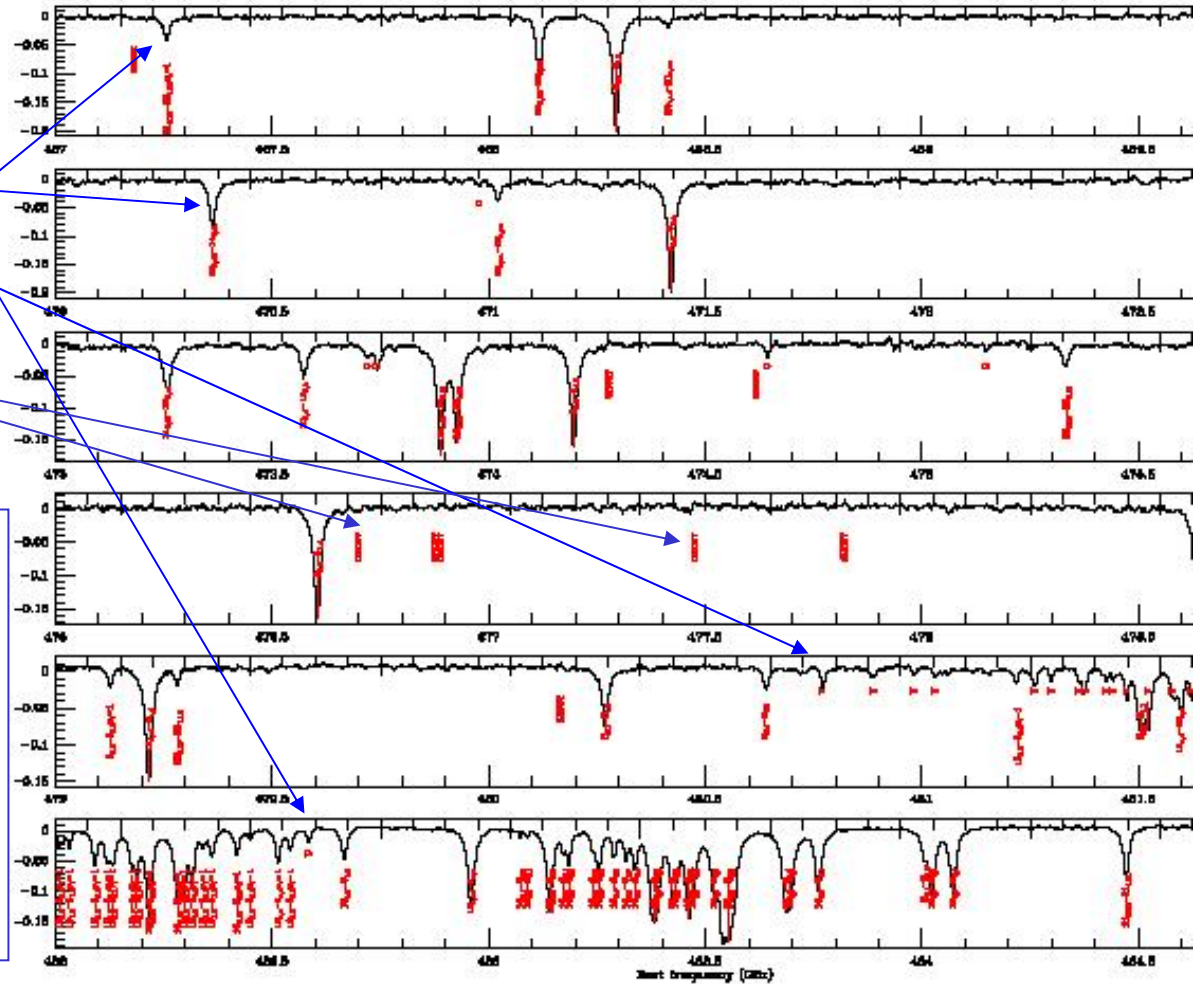
Methanol Survey Deconvolved

Contains:

- Identified Lines
- Unidentified lines
- Ghosts

The deconvolution requires interaction beyond standard (lights-out) pipeline processing.

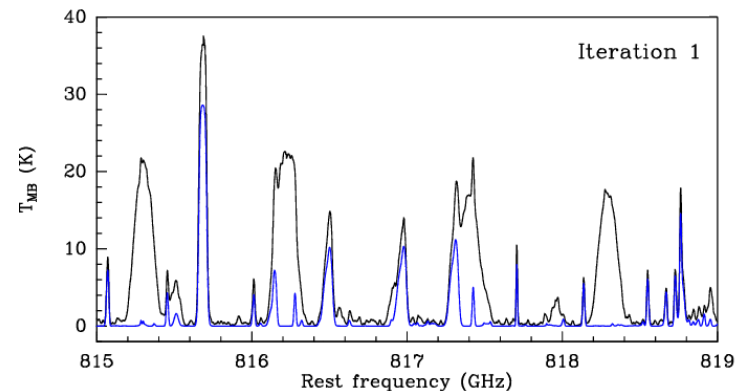
Judging efficacy depends crucially on the spectral databases!





Special Processing (at “Level 1”)

- Algorithm: Conjugate Gradient Method (standard numerical method, w/ or w/o max-entropy - Schilke & Comito 2002).
- Minimizes χ^2 of the DSB residuals using knowledge of the χ^2 gradients. Can maximize entropy simultaneously, and remove standing waves (but *very* time-intensive).
- The refinement of the methods (parameter fitting, rebinning) are in progress, and several issues affect HIFI’s spectral scan design:
 - Frequency switching vs DBS, LO tuning steps and redundancies (esp at band edges), survey width, effects of gain and bias drifts, pointing errors, etc.



The deconvolution tool (“engine” + GUI) will be available to users in the HCSS – prototype going in soon.



The NASA Herschel Science Center

- Ensure the necessary resources and tools are available to the US scientific community to take advantage of the scientific capabilities of the observatory in a timely manner.
- Ensure availability of Herschel science data for US archival research on timescales equivalent to ESA.
- Act as an interface between the ESA Herschel Project and the US-based scientific user community.
- Advocate US community needs with the HSC and ESA Project.
- Provide the US astronomical community with science and observational support throughout all phases of the Herschel mission, from pre-launch through to the transition to archival phase.
- Manage the US data analysis funding and provide funds for the US users.



What is the NHSC doing?

The NHSC is involved with the HSC and Instrument Control Centers, in the following activities that builds strong bases for community support:

- * Providing core code and support for the development of HSpot.
- * Serving of background and confusion estimation tools via HSpot.
- * Instrument testing and test data analysis and characterization (ground and flight).
- * Contributing to instrument AOT and instrument simulator development.
- * Developing and testing algorithms, and implementing code for data analysis tools, including:
 - + map making tools for the instrument imaging modes
 - + heterodyne side-band separation and spectral line disentanglement tools
 - + spectral defringing tools.
 - + numerical tools.
- * Providing an endless supply of advice based on key operational experience of our staff with ISO and Spitzer.

The NHSC is working well with the HSC and ICCs, with a commitment to the US community for to exploiting the Observatory to achieve the best science results possible.





What about You and Herschel?

- Propose for Open Time Key Projects -- AO coming Feb '07!

NHSC issued its first eNewsletter on 19 Sept 06

If you did not receive it - subscribe to our email list by going to the Newsletters section of the NHSC web pages and follow the link.

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- Proposals will be submitted to the HSC via HSpot. A funding request will be required by the NHSC at the time of submission. Details are to be resolved.





Extra Slides





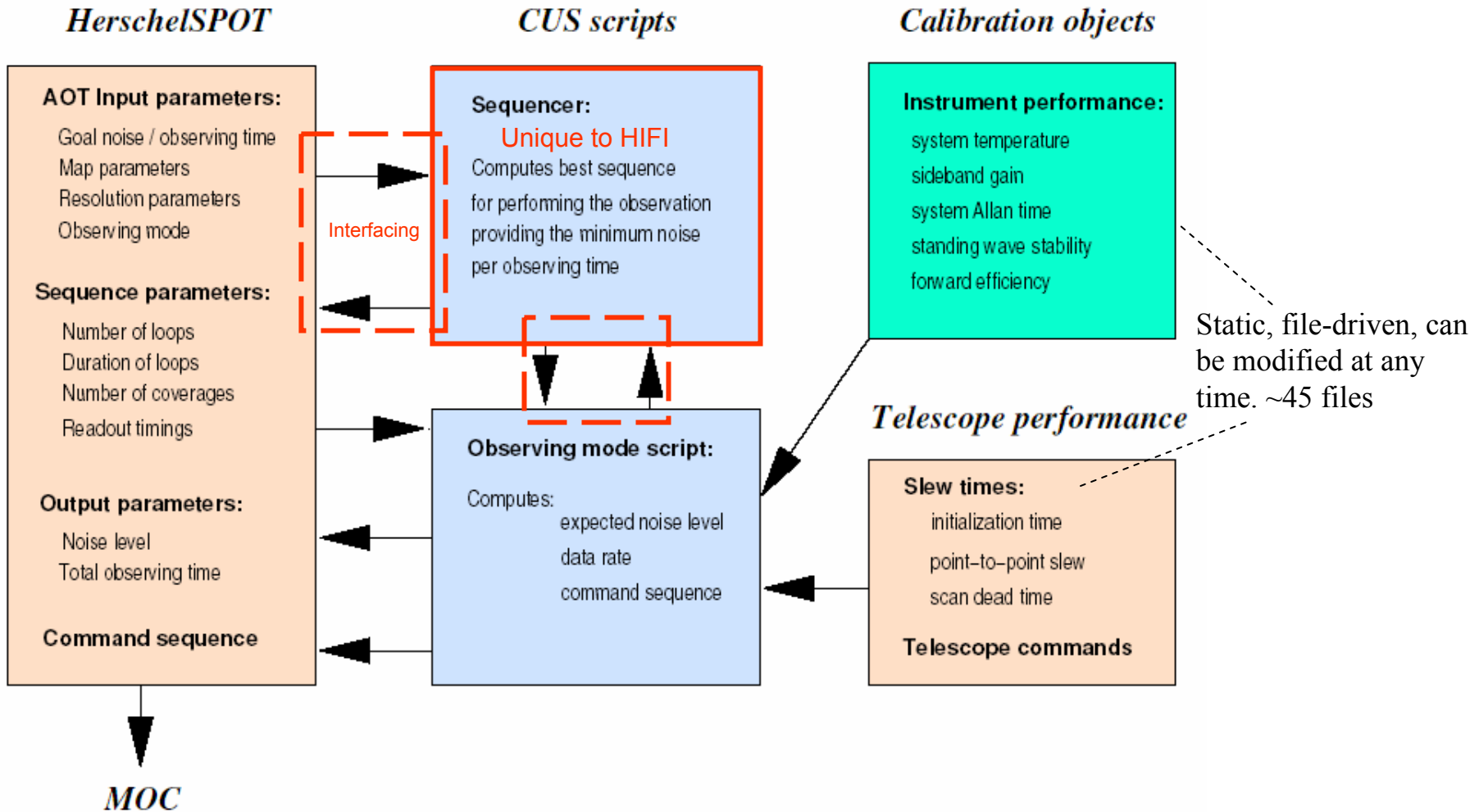
Components of Observing Mode Scripts (general to last bullet)



- Timing computer
 - Performs consistency checks, obtains internal parameters, timing loops
 - Performs time estimation (total observing time)
- Telescope commanding
 - Emits S/C commands describing all telescope motion
- Instrument command generation
 - Expands a time sequence of instrument commands, synchronized with pointing commands
- Noise evaluator
 - Computes expected noise from the timing parameters for both sidebands at selected LO settings and frequency resolutions. Based on parameterized (configuration file) noise model of the instrument



General AOT Architecture





HIFI “Sequencing”

- HIFI's instabilities and drifts are short compared to normal observing times.
 - It is not feasible to expect astronomers to pick operating parameters producing the **lowest output noise** at a **desired observing time** (or the converse) with the **highest possible efficiency**.
 - With an observational setup and instrument configuration, **sequencer code finds the best key instrument parameter values**, calls AOT logic for time and noise estimates.
 - A χ^2 minimization in a discretized space of instrument parameters, guided by instrument performances (configurable noise models).
- *Theoretically* guarantees the most efficient way to observe, and reduces (perhaps eliminates!) risk of failed observations because of poor or unintentional choice of instrument operating parameters.



HSpot in HIFI Diagnostic Mode

HIFI Mapping

Unique AOR Label: HIFIM-0000

Target: NGC2359 Type: Fixed Single
Position: 7h18m30.00000s,-13d13m48.0000s

Number of visible stars for the target: 18
Star tracker target: Ra: 289.625 degrees Dec:13.23 degrees

Instrument Settings

Mixer settings: Mixer band: I/b, Low limit (GHz): 1056, High limit (GHz): 1113

Redshift selection: Radial Velocity: redshift, Redshift: 0.000000, Frame: LSR

Spectrometer choice: Select the spectrometer to use: WBS & HRS, WBS Resolution (MHz): 1.10, Separate setup for each polarization of HRS sub-bands?: No, The HRS Mode for H or both polarizations: High resolution, HRS Resolution (MHz) for H or both polarizations: 0.135, The HRS Mode for V polarizations: Nominal Resolution, HRS Resolution (MHz) for V polarization: 0.000

Frequency Settings | **Observing Mode Settings**

Frequency Settings: Set the observing frequencies

Observing mode settings: Set the mapping mode

Buttons: Observation Est..., Add Comments..., Visibility..., Star Tracker...

Buttons: OK, Cancel, Help

Hifi Time Estimation

Estimate Type: Time

Total Estimated Time (s): 0

LOF	Highest Resolution (MHz)	Goal Resolution (MHz)	Time (s)	Noise (K)
LOF 1	0.135	1.100	10000	0.000

Buttons: Estimate, OK, Cancel

Hifi Observation Breakdown

Observing Mode Breakdown

LOF	Time (s)	Noise - USB high res (K)	Noise - USB goal res (K)	Noise - LSB high res (K)	Noise - LSB goal res (K)
LOF 1	35112	1.589	0.565	1.589	0.565

Observatory Overhead (s): 180
Total Time (s): 35292

Buttons: Show sequence parameters, Show messages

Name	Value
Number of map coverages	1
Supersamplingfactor	1
Number of data dumps for the OFF integration time	3
Number of lines between two OFFs	1
chunk size given by the data rates and optimum speed	4
load period = f(band_number, lo_freq, effResolution(1))	1250

Statistics: Initial/final overhead 180s
Statistics: Total overhead 5580s
Statistics: Total time efficiency 84.107997265892%
Statistics: Total noise efficiency 62.16646012911242%
Statistics: Drift noise contribution 11.576248016223376%

The following parameters were passed from HSpot to the sequencer code:
(fe_hrs4_h_freq_0=NaN, onPositionRaRadians=1.9133171924987837, fe_hrs3_v_trans_0=-No Lines-, fe_hrs3_h_freq_0=NaN,

Buttons: OK, Cancel