<u>Visualisation and Manipulation Tools</u> <u>for Herschel Spectra</u>

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Outline

- Goal of Spectral Tools
 - Why develop common tools
 - Guidelines for functionality/requirements
 - Answering user scenario: our requirements
- Spectral Display: The SpectrumExplorer
 - What is it and what does it do
 - Selections: choosing which spectrum to view
 - Displaying options of the explorer.
- Sample of spectral manipulation tools
 - Selecting, arithmetic operations, statistics on spectra
- An example of JCMT data
- Current status and future directions





<u>Commonality Among Herschel</u> <u>Instruments</u>

- All three Herschel instruments produce spectra
- Goal is to build a foundation for displaying and manipulating spectra which can be extended by each instrument for its own use.
- **Display and Inspection** of Herschel Spectra
- Tools operating **between spectra**
 - Arithmetic operations: addition/subtraction/multiplication/division
 - Selecting groups of spectra for further analysis
- Tools on a specific spectrum
 - Statistics (Average, Standard Deviation, Moments)
 - Selecting spectral regions of interest
 - Masking regions





Why a Spectral Tool Box?

- Herschel spectra from any instrument have a large overlap in requirements
 - Display
 - Spectrum manipulation (co-adding, statistics, etc.)
 - Simple explorations (line and feature fitting, integration under the line, etc.)
- Provide a common approach
 - Easier to learn one system than three
 - Improve stability of software
- **Instrument specifics** are extensions of common functionality.
 - Differences in Header information to be displayed
 - Differences in what is displayed (for example: HIFI upper or lower sideband)
 - Differences in manipulation (example averaging) tools



End User Scenarios: Line Observation

- Requirements beyond functionality
 - Identify how the DP software will be used:
 - Flow of use
- One example: Line Observations
 - Retrieval from archive (HSA Access in HIPE)
 - levels 0, 0.5, 1 and 2 and auxiliary satellite data
 - Inspection of Data (Spectrum Explorer in HIPE)
 - Pipeline results (at all levels).
 - Report on quality of automated processing.
 - Processing of Data (Instrument Pipelines in HIPE)
 - Pipelines starting at any level.
 - Performing pipeline steps "by hand".
 - Deeper "playing" with Spectra (Spectral Tools in HIPE)
 - Statistics/smoothing/spectral feature measurements
 - Measurements spectral features, line identification
 - Saving: Plots, Processed Data, Scripts (Basic HIPE facilities)



- HIPE becomes the Spectral Toolbox when spectra are present
- Activated by ALL Herschel spectral data types
- Configurable for instrument specifics

- Zooming, panning, region and data point selection and masking abilities
- Displays standard header information



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• Simple navigation through spectra

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 Simple navigation through spectra

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Manipulation of Spectra: Selection

- Selection tool:
 - To identify spectra or parts of a spectrum
 - Spectral attributes (wavelength range or instrument attribute)
 - Spectral index (for a spectrum having more than one piece or segment)
 - Provide means to extract selected data
 - Parts for use in next step
 - Parts to be omitted in next step







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Selection Results

 Selection from GUI or Command line: GUI interactions are captured in command line syntax for later reuse. Resulting "cold" spectra





Selection Results

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Resulting "cold" spectra





Console X

IA> plot1.setTitles(coldload)
IA> plot2 = splot()

IA> plot2.setTitles(hotload)

IA> plot3.setTitles(hotload)

IA> plot3 = splot()

Manipulation: Arithmetics

Spectral Tools provides simple means of adding, subtracting, multiplying, dividing spectra F - Herschel Interactive Processing Envir

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Manipulation: Arithmetics - 2

- Some mathematical operations are directly defined for spectra:
- +, -, /, and *
- Example: the previous division can be simply written as
 - ratio = hotload/coldload (where hot load and cold load are the spectrum variables). Note that ratio is still a "spectrum variable"





Spectral Statistics

- Predefined functions:
 - Average, Standard deviation, Median, Upper lower quartiles
 - If others are needed these can be included
- Create averages of selected parts of "ratio" spectrum





"playing" with your data

- Example:
 - JCMT data
 - Integrations in separate FITS files
 - HIPE provides FITS reader
 - I write data into a Herschel Spectrum.
 - SpectrumExplorer to view my data



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<u> "playing" with your data – clean up</u>

• Clean up the spectra

- S258 and s259 are unusable spectra (standing waves and strange mixer behavior)
- Remove constant offset from each remaining (using Spectral Toolbox Maths)







<u>"playing" with your data:</u> measuring spectral features

• Clear spectral line seen after clean up.





TBDs and Next Steps

- Herschel Products to be developed
 - "SpectralCube" product
 - Needed for PACS, SPIRE and HIFI cubes
 - Bridge between spectra and cubes
 - Results of line fitting will be place into a "LineList" product. This product is still to be implemented and integrated with Spectral Fitter
 - DP plotting module to be upgraded to fully support SpectrumExplorer
- Spectral Fitter to be fully integrated with Spectrum Explorer
- Testing and Verification of user environment





Status and Plans

- **HIPE** is the **Spectrum Toolbox**
- Functionality **available** in HIPE:
 - Spectral display
 - Spectral feature fitting
 - Spectral arithmetics
 - Spectrum statistics
- Defining/implementing interface between Cubes and Spectra
- User interface for Spectral Tools requires further design and testing
 - Defining how the tools should work together
 - Capturing detailed user scenarios and feed back to ensure the software works smoothly from the user perspective
- Goal: Stable, integrated, well tested and documented software by end of PV.

