SPIRE-UCF-MHO-002483

Photometer Simulator

Overview, status and some recent results

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Simulator Overview

- **Uses**
  - POF optimisation
  - Identification of observation limitations
  - Investigation of instrumental effects
  - Development of data reduction systems
- **Capabilities**
  - Performance of all SPIRE POFs outlined in the OMD
  - Generation of realistic output system timelines capable
  - Inclusion of all primary noise effects

Sources of noise and systematic effects

- Simple modelled beam profile
- Individual detector 1/f noise
- Correlated 1/f noise across all detector in a single array
- Absolute pointing error – RMS value input
- SRPE – assumed to be a linear drift for short scan lengths
- 5 Hz filtering and data sampling
- Glitches
- Detailed thermal model

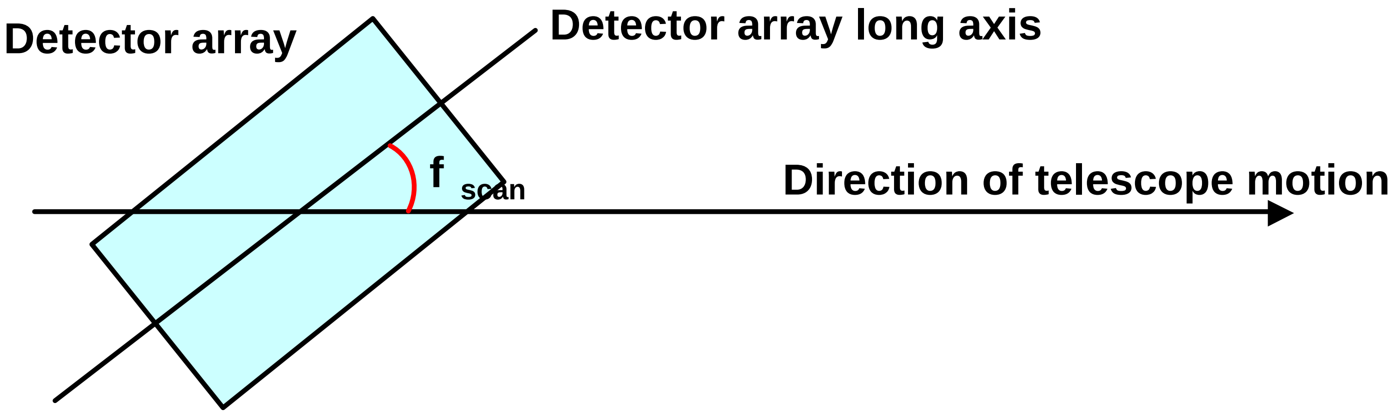
* Blue – not yet implemented

Planned Investigations

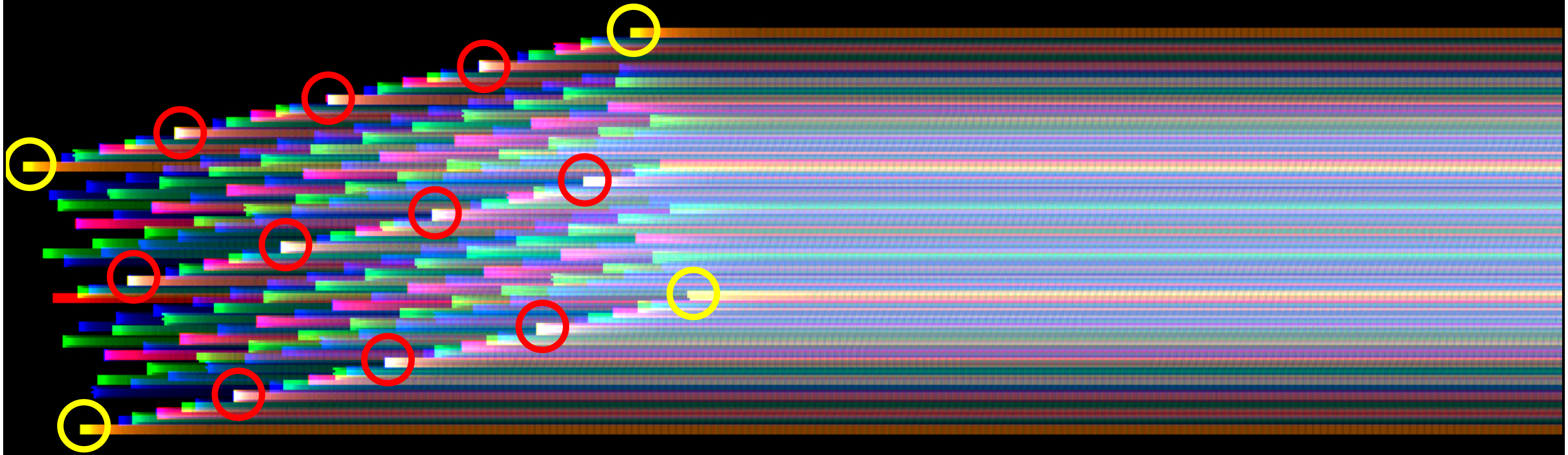
- Galactic Field
  - What are the effects of side-lobes on the extended emission?
  - 1/f noise limitations in the recovery of large-scale structure?
  - Effects of detector non-lineararity?
  - How will diffuse cirrus limit the planned surveys?
- Extra-galactic
  - Is the quoted limiting sensitivity reliable in a realistic system?
  - How accurately can we measure the SEDs of faint sources?
  - How can multi-wavelength observations be used to extract information that is fainter than the detection limit?
  - Can the SZ effect be measured by the PLW array?

POF 5 optimisation: Scan Direction

(also called scan angle)

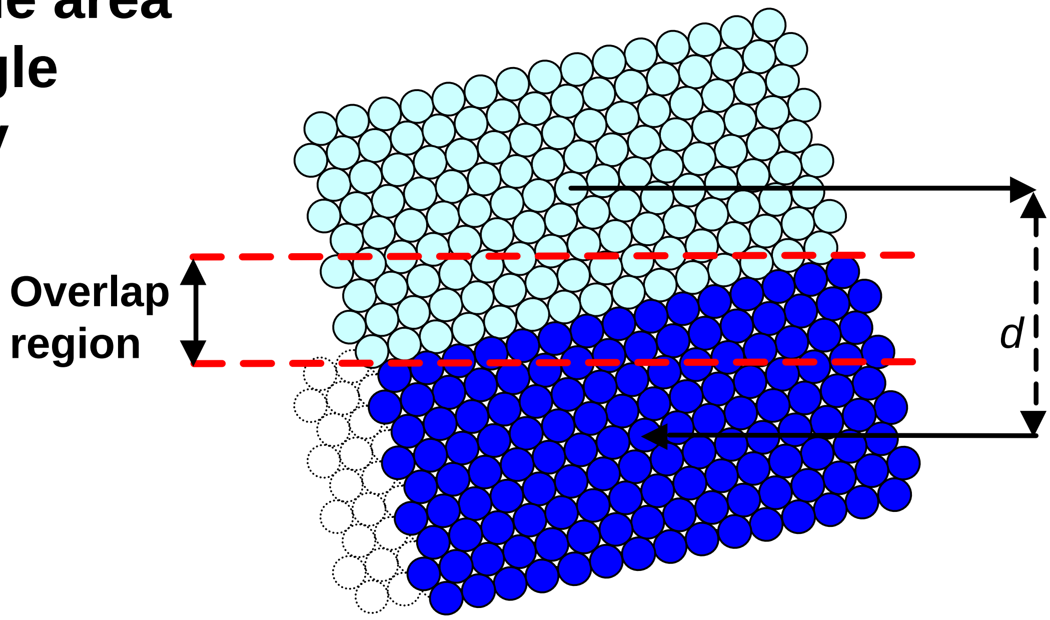


- Scan Direction – 12.4°
  - Fully sampled maps down to ¼ beam in all wavebands
  - Uniform map coverage

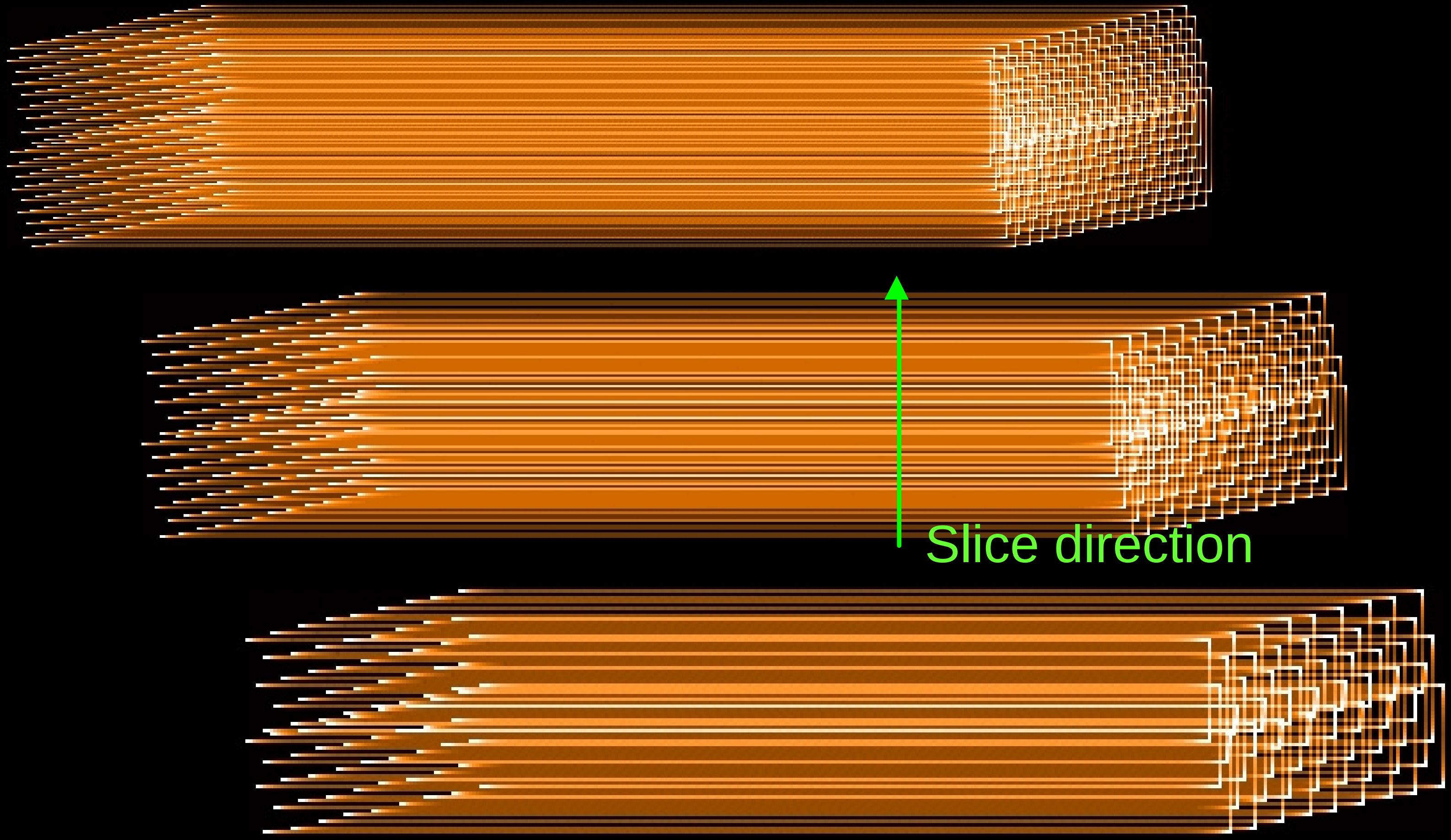


POF 5 optimisation: Line Separation

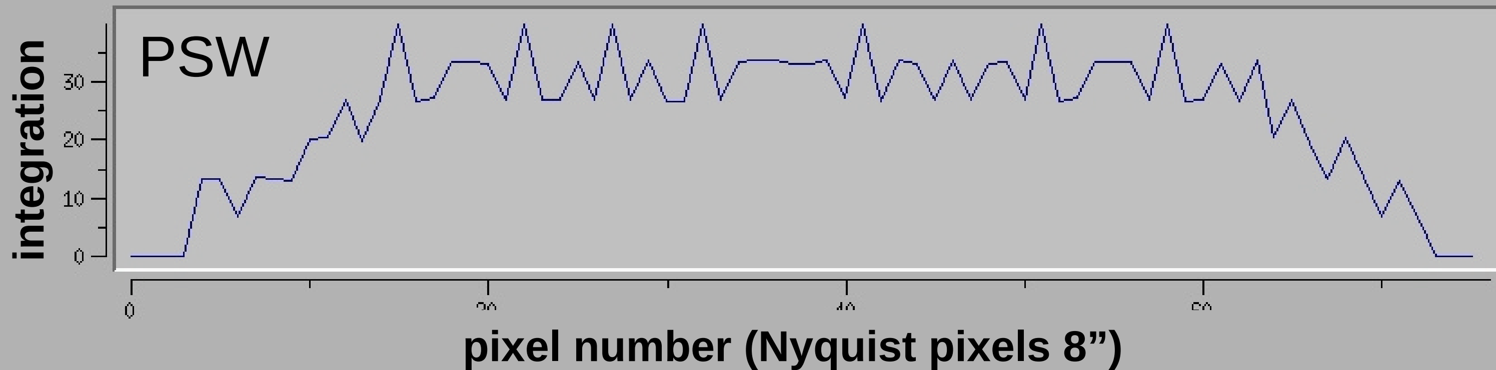
Overlap acts so as to effectively observe the area with a single large array

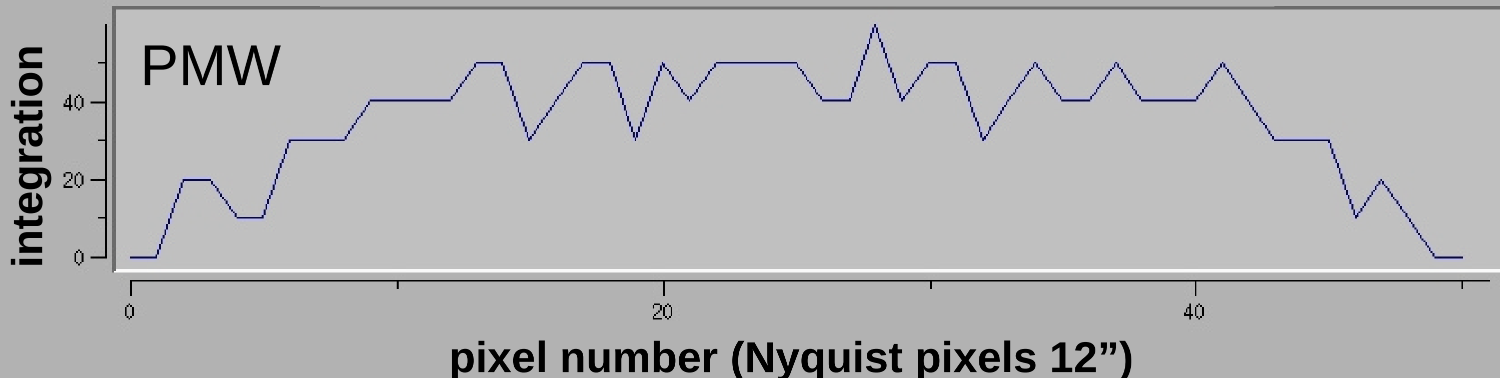


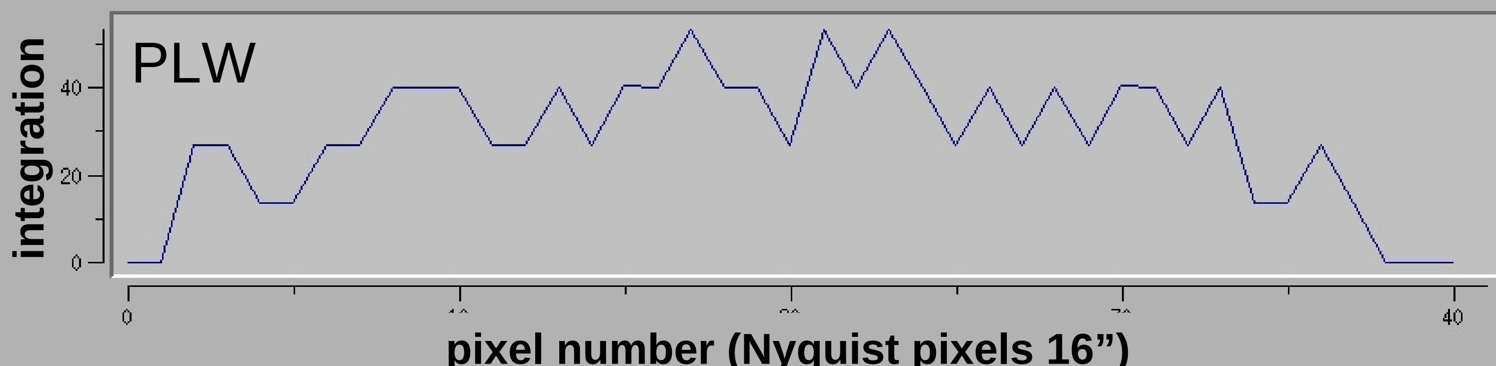
POF 5 optimisation: Line Separation



Uniform Overlap Region

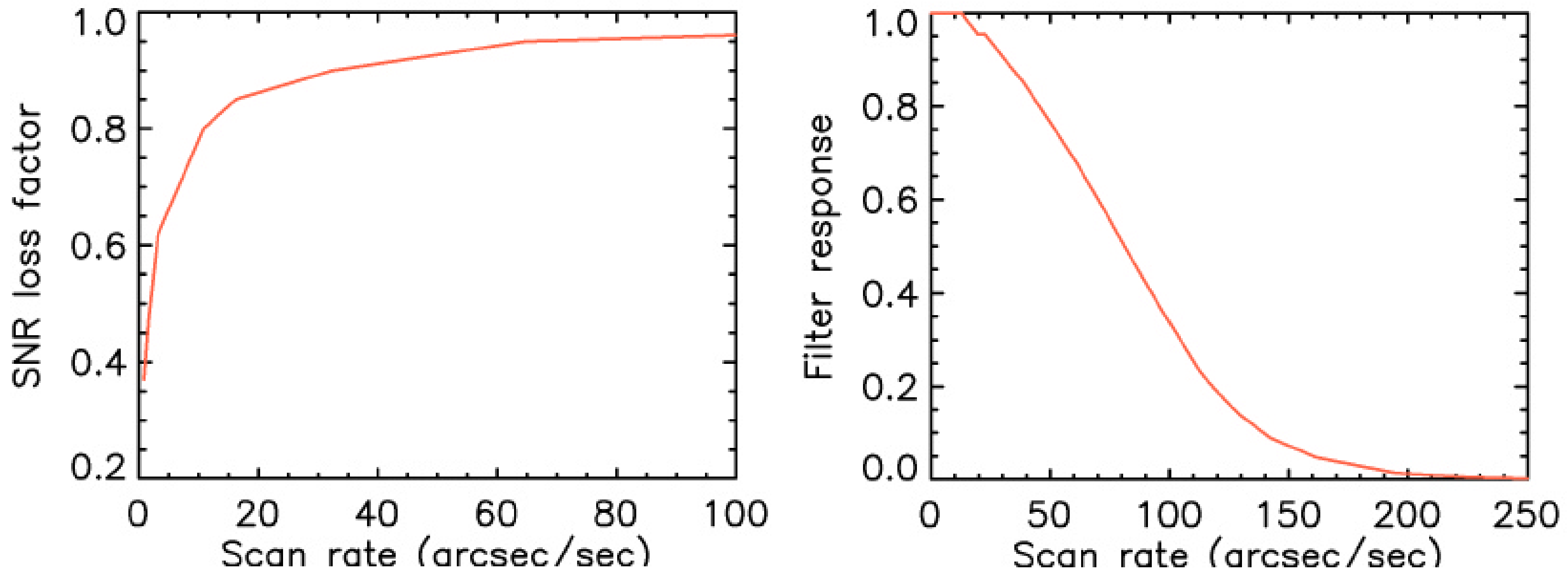






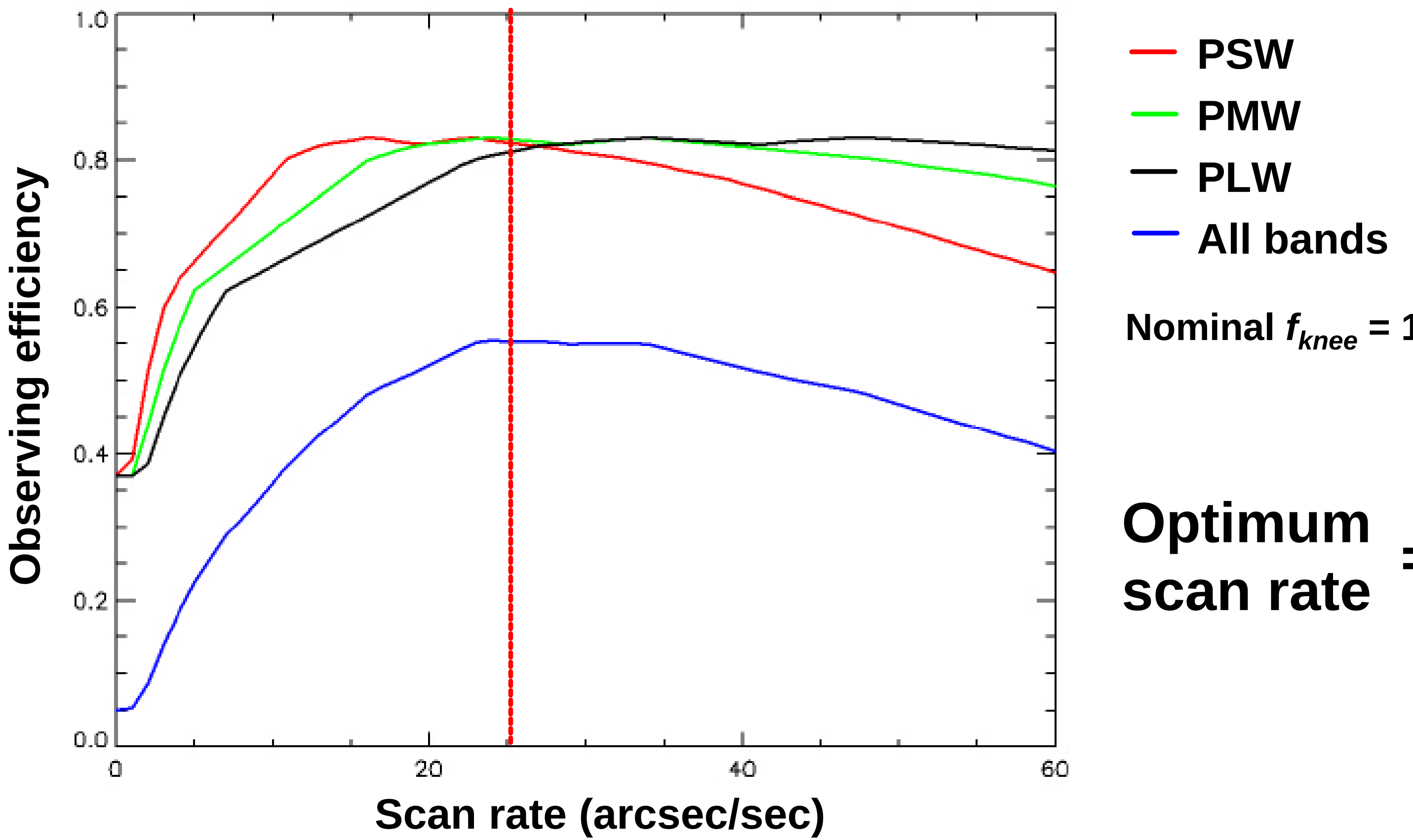
POF 5 optimisation: Scan rate

Loss in signal to noise ratio is effected by both the 5 Hz filter and 1/*f* knee frequency



$$h_{total}(\dot{q}, f_{knee}, FWHM) = h_{filter}(\dot{q}, FWHM) \times h_{1/f}(\dot{q}, f_{knee}, FWHM)$$

POF 5 optimisation: Scan rate



Nominal f_{knee} = 100 mHz

Optimum scan rate = 25”/s

POF 5 optimisation: Summary

<table>
<tr><th rowspan="2">Optimised parameter</th><th colspan="3">Individual Band</th><th rowspan="2" colspan="3">3 band simultaneous operation</th></tr>
<tr><th>PSW</th><th>PMW</th><th>PLW</th></tr>
<tr><td>Scan angle (degrees)</td><td>12.4</td><td>12.4</td><td>12.4</td><td colspan="3">12.4</td></tr>
<tr><td>Angular line separation (arcsec)</td><td>235</td><td>243</td><td>258</td><td colspan="3">235</td></tr>
<tr><td>Scan-rate (arcsec/sec)</td><td>25</td><td>40</td><td>60</td><td colspan="3">25</td></tr>
<tr><td>Time to map 1 sq. deg. (s)*</td><td>2572</td><td>1984</td><td>1670</td><td colspan="3">2572 (42m 52s)</td></tr>
<tr><td>Fraction of time on map</td><td>0.78</td><td>0.64</td><td>0.47</td><td colspan="3">0.78</td></tr>
<tr><td rowspan="2">5s detection limit in 1 sq. deg. map (mJy)‡</td><td rowspan="2">65.4</td><td rowspan="2">97.9</td><td rowspan="2">124.9</td><td>PSW</td><td>PMW</td><td>PLW</td></tr>
<tr><td>65.4</td><td>76.5</td><td>80.7</td></tr>
</table>

* - Times include telescope overheads

‡ - Values derived assuming a channel yield of 80 %, overall instrument efficiency of 80 %, and include signal to noise ratio loss factor

POF 5 optimisation: Implications

Survey	Area (sq. deg.)	Time (hours)	Limiting flux (mJy)		
			PSW	PMW	PLW
Wide	400	198	78.6	91.9	97.0
Deep	50	394	19.7	23.0	24.3
Ultra	1	201	3.9	4.6	4.8
Über	0.1	212	1.2	1.4	1.5

Not to be used for planning purposes!

Future Work

- Generation of more sophisticated synthetic sky inputs
- Study pointing error impacts on data quality
- Optimisation of further POFs
- Limited release of Simulator V1.0
- Implementation of science case investigations

Conclusions and recommendations

- Scan direction – **12.4°**
- Line separation – **235"**
- Scan rate – **25"/s**

- Time to map 1 sq. deg. (inc. overheads) – 43 min
- Observation efficiency – 78%
- 5s point source flux limit (PSW,PMW,PLW) – 65.4, 76.5, 80.7 mJy

SHIFTS – Simulating Herschel's Imaging FTS

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University of Lethbridge
Canada

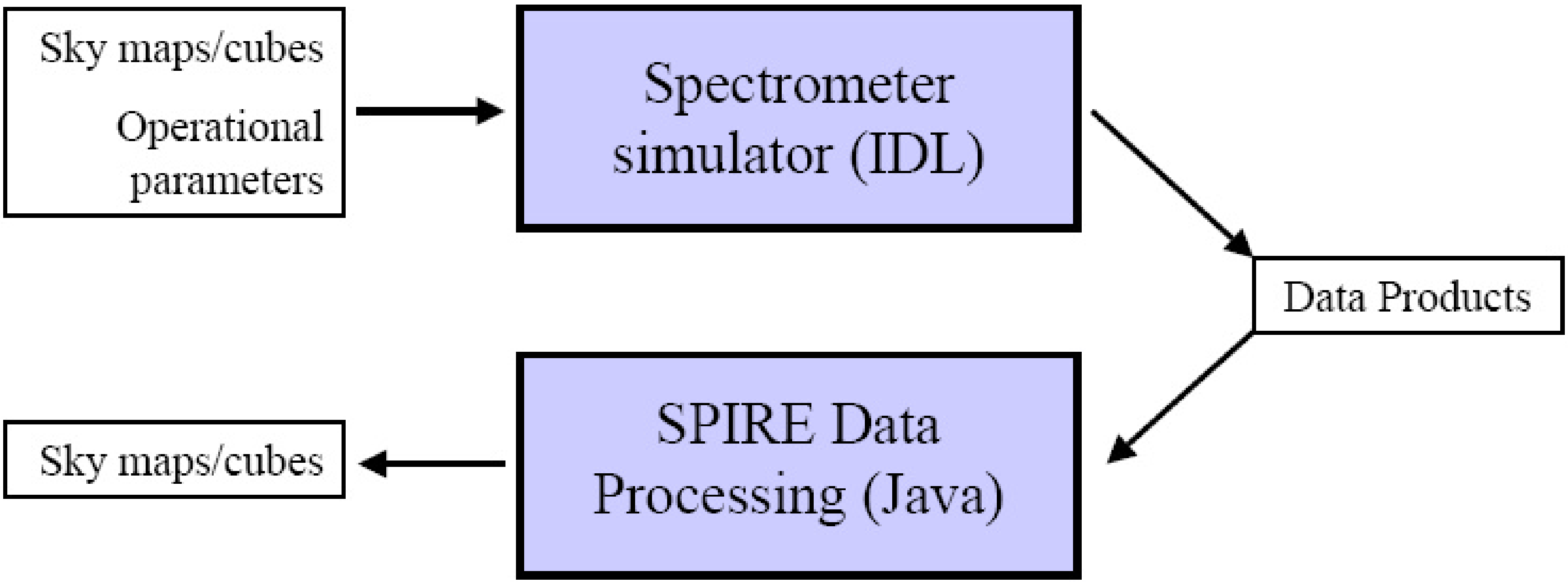
Goals of the spectrometer simulation

- **Users:**

Simulate what the SPIRE spectrometer can do
See for yourself how data processing works for the spectrometer

- **Instrument team:**

Simulate the performance of the SPIRE spectrometer



Components of the SPIRE simulator

A framework allows to model the following components of the spectrometer:

- Spacecraft pointing
- Thermal contribution from the telescope
- Spectrometer Calibration Source (SCal)
- Beam-steering mirror (BSM)
- Mirror stage mechanism (SMECm)
- Optical effects, such as mirror efficiency
- Beamsplitters
- Filter- & feedhorn-defined band edges
- Bolometer response
- Read-out electronics

Herschel: pointing & emission

Over the duration of the simulation run, the following drifts of the spacecraft/telescope are taken into account:

- **Pointing:** absolute pointing error within a defined range in a random direction [TBD]
- **Telescope temperature:** drift from nominal value of specified amplitude and period [TBD]
- **Telescope emissivity:** drift from nominal value of specified amplitude and period [TBD]

Beam Steering Mirror & Spectrometer Calibrator

- **BSM**

  Jitter along two axes (chop & jiggle) of specified amplitude and period: $\Delta\Phi$ < 0.2 arcsec/min per axis

- **SCal**

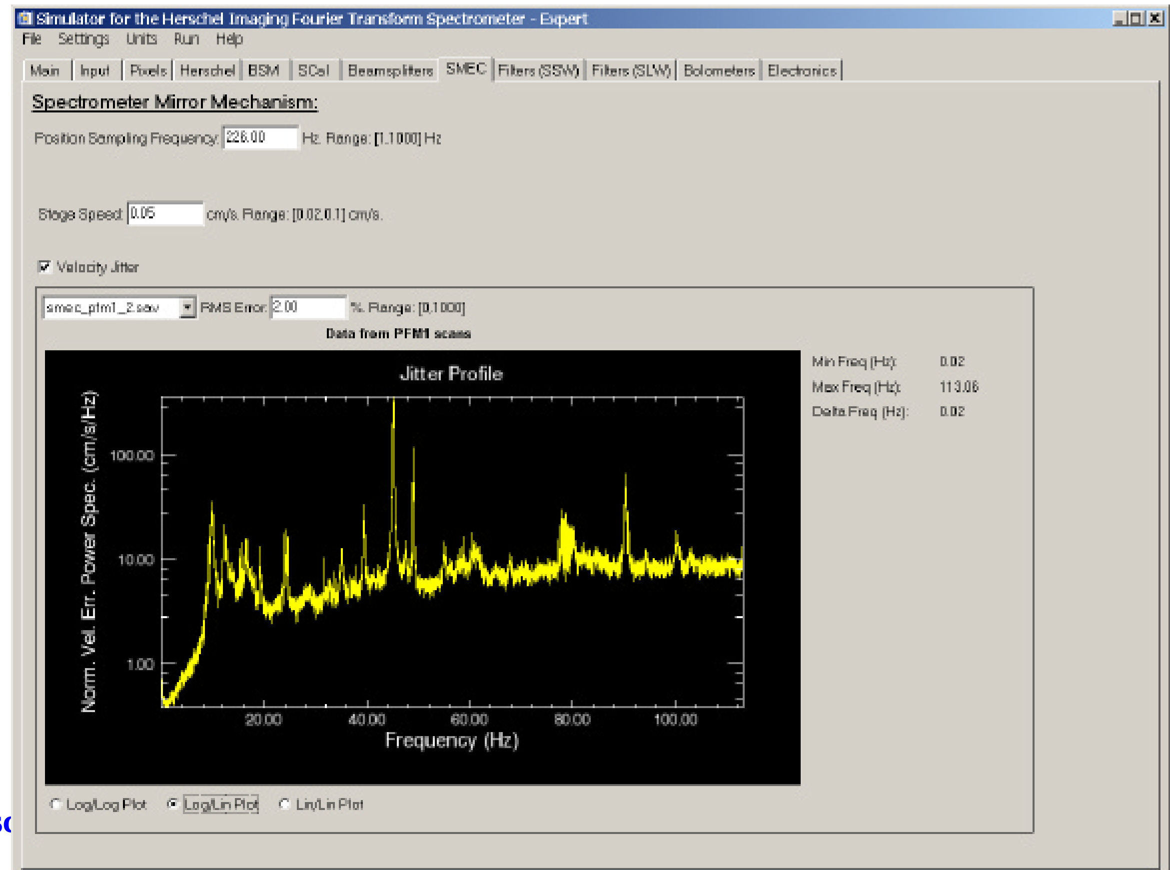
  Temperature settings separate for SCal1 and SCal2

  Drift profile defined by 1/f-like (TBC) power spectrum

  Drift amplitude specified by RMS

Mirror stage mechanism

- Stage speed and sampling frequency.
- Velocity jitter from a given profile and a specified RMS



Optics, beamsplitters, filters

Beamsplitters:

The two beamsplitters are specified (separately) as the amplitude and phase of transmission and reflection.

Filters:

The cut-off from the 300mK filter assembly is specified as the amplitude and phase of transmission. Measurements from Cardiff.

Feedhorns:

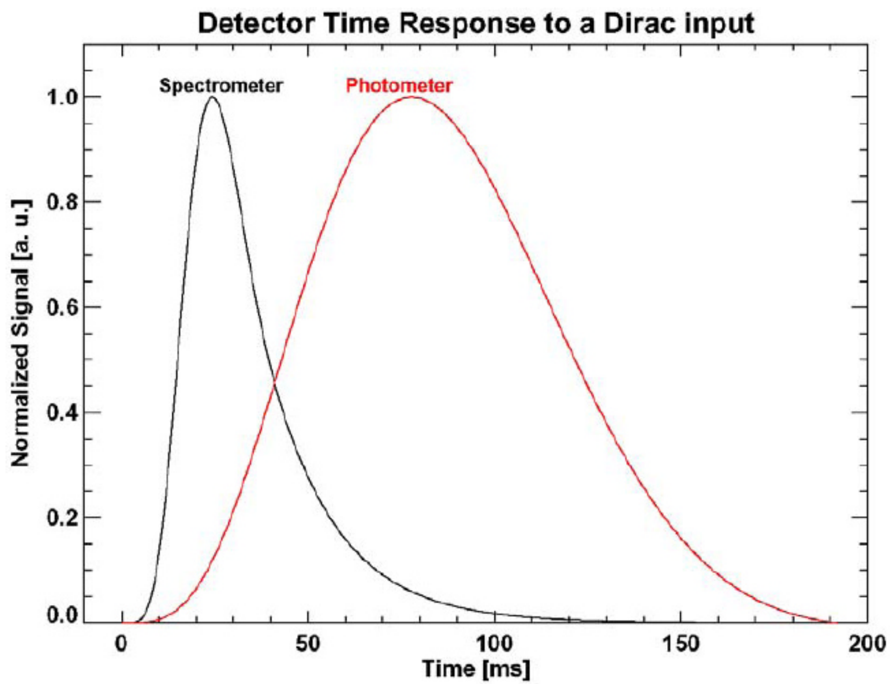
The cut-on from the conical feedhorns is specified as the amplitude and phase of transmission. Measurements from PFM1 test campaign.

Quantum efficiency:

The quantum efficiency is specified as the amplitude and phase of transmission.

Detection: bolometers & read-out electronics

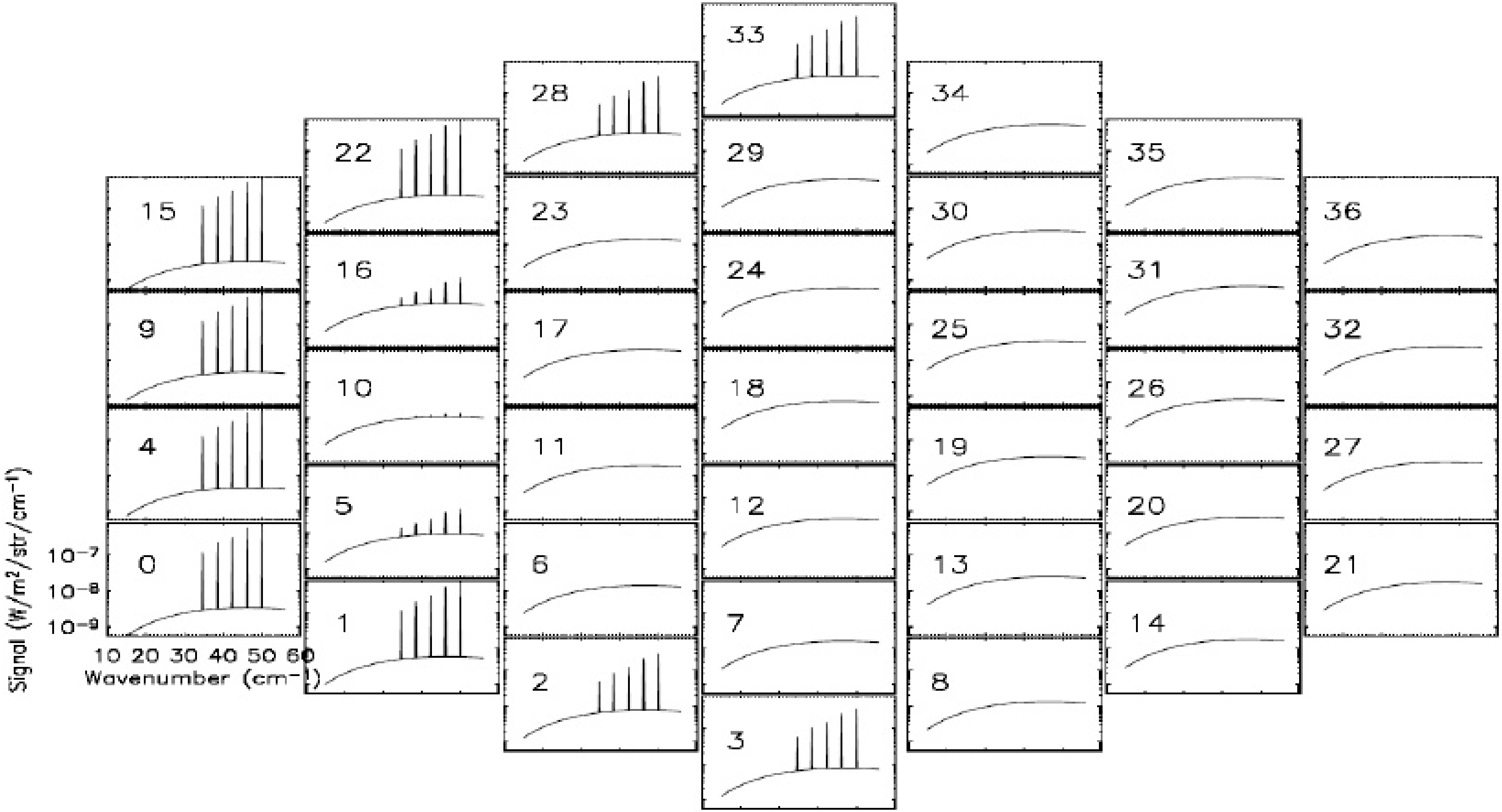
- **Bolometers:**
  - Sampling frequency f = 80 Hz.
  - Bolometer response modeled as an RC-circuit of a given time-response τ = 8 ms.
  - Photon noise
- **Electronic filtering:**
  - Electrical filtering with a 6-pole Bessel filter
  - White electrical noise of a given amplitude.



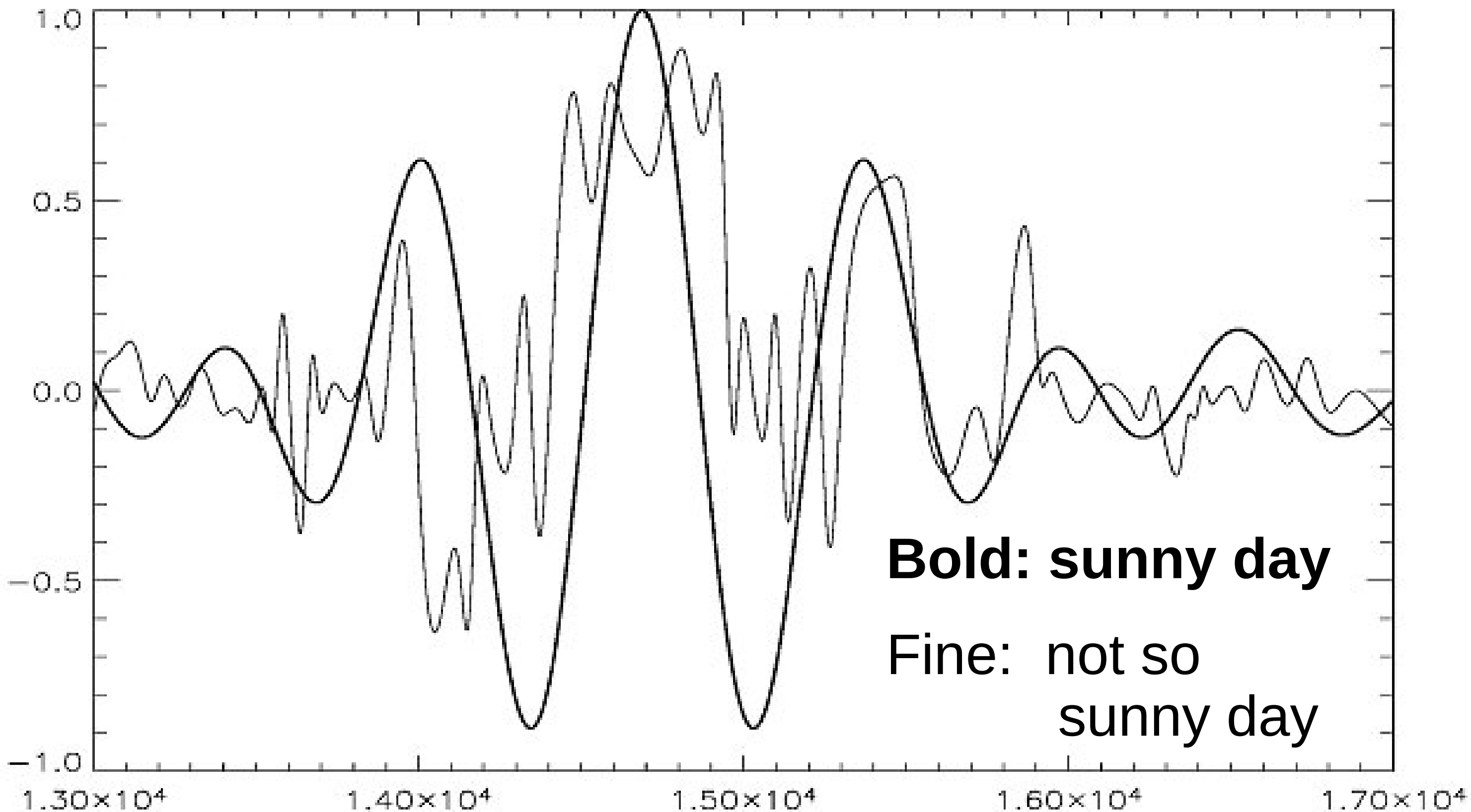
Limitations

- **At this time only one of the four operating modes implemented: single point, continuous scan.**
- **Hi-resolution scans for all pixels will take considerable amounts of time.**
- **Not everything has been/can be simulated, e.g. non-linearity of bolometers, variation of time-constant between pixels, glitches, …**

Input data for SHIFTS



The two modes of SHIFTS



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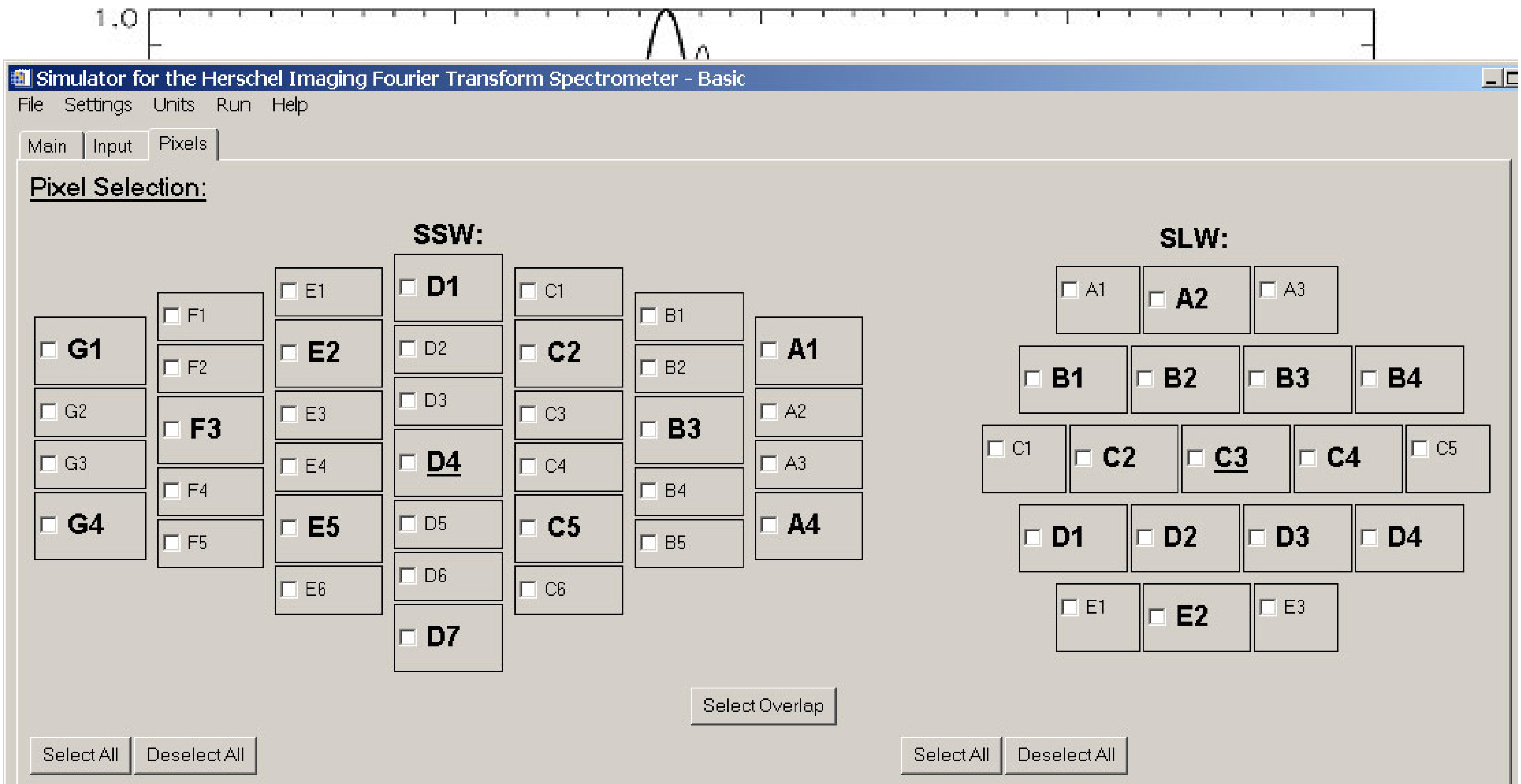
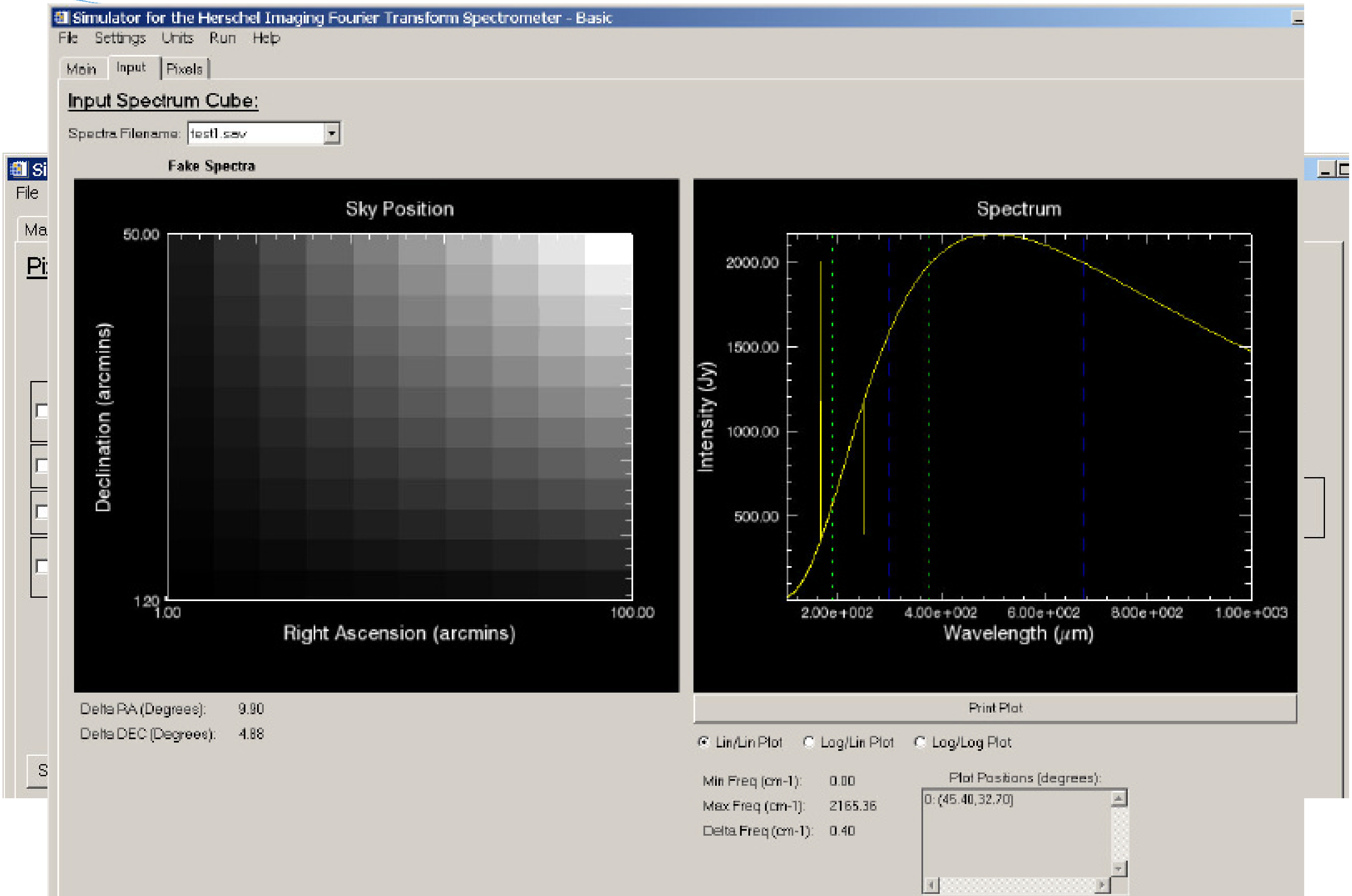
- All parameters can be changed to explore scenarios for instrument performance

The two modes of SHIFTS



All parameters can be changed to explore scenarios for instrument performance


Simulator for the Herschel Imaging Fourier Transform Spectrometer - Basic
File Settings Units Run Help
Main Input Pixels
Input Spectrum Cube:
Spectra Filename: test1.sav
Fake Spectra
Sky Position
50.00
1.20
1.00
100.00
Declination (arcmins)
Right Ascension (arcmins)
Spectrum
2000.00
1500.00
1000.00
500.00
Intensity (Jy)
2.00e+002
4.00e+002
6.00e+002
8.00e+002
1.00e+003
Wavelength (µm)
Delta RA (Degrees): 9.90
Delta DEC (Degrees): 4.88
Print Plot
Lin/Lin Plot
Log/Lin Plot
Log/Log Plot
Min Freq (cm-1): 0.00
Max Freq (cm-1): 2165.36
Delta Freq (cm-1): 0.40
Plot Positions (degrees):
0: (45.40,32.70)

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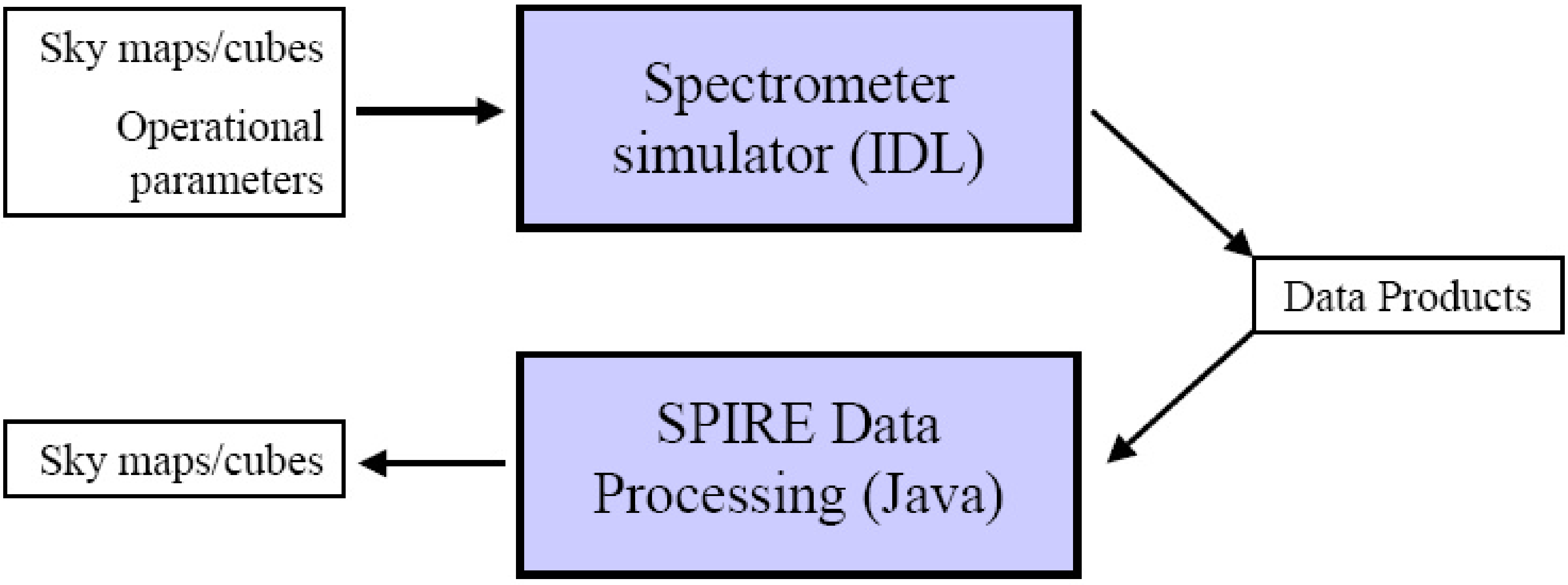


Data Processing

Input: Three data-products from the detectors (SDT), the stage (SMEC), plus housekeeping (HKT)

• Interpolate 2x	cubic spline (TBD: sinc or adjusted sinc)
• Remove drift	remove an n’th order polynomial fit
• Deglitch	compare interferograms to find outliers
• Correct phase	n’th order polynomial fit
• Apodize	optimal Norton-Beer functions
• Fourier transform	FFT

Output: One data-product that contains a series of spectra (SDS)

NB: Data Processing grows as we learn more about the instrument

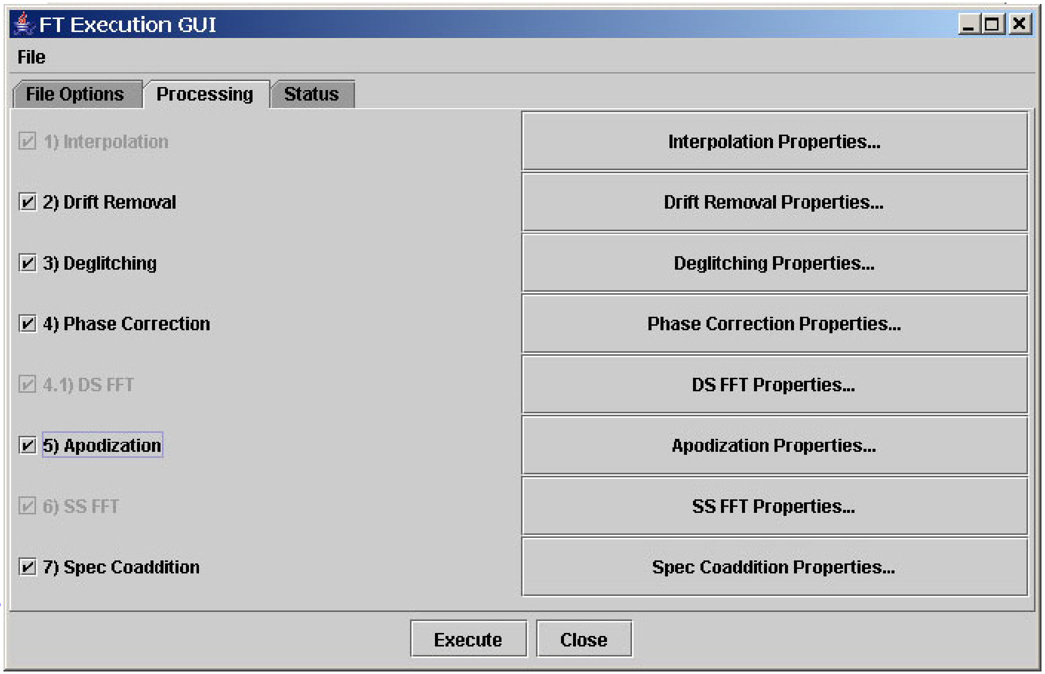
The two modes of Data Processing

- **GUI:**

Pretty and like a pipeline: GUI to inspect and store final and intermediate products

- **Script:**

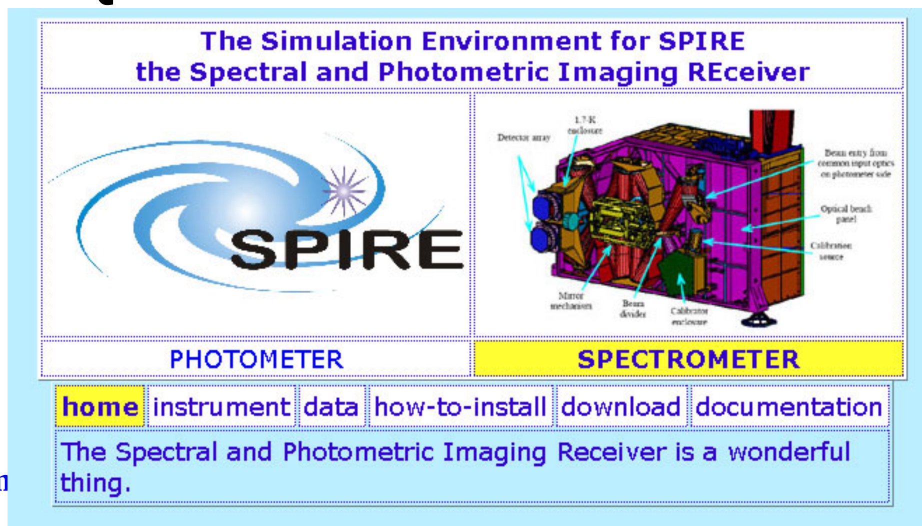
Ugly and flexible: Jython script through the QLA console



Do it all on your computer!

- Website to download spectrometer (and photometer?) simulator: http://www.tbd.net
- Unzip and play on Windows (and UNIX)
- SHIFTS implemented in IDL®
  → freely distributed on a virtual machine
- Data Processing implemented in Java

  → download Herschel Common Science System which includes the QLA console and the GUI



When can you start?

- **Current status: Alpha version 0.3 of engine and GUI**
- **NOW: give input on functionality, interface, data, etc. via email to peter.davis@uleth.ca**
- **Alpha version 0.4 in August**
- **John Lindner to complete his MSc ‘later this year’**
- **First release version ‘later this year’ ~ Oct/Nov 2005 (?)**

SHIFTS - Summary

- By the end of this year, you will be able to **try out** the SPIRE imaging FTS simulator to see whether it is the right instrument for your science.
- Working with the simulator will be **time well-spent** as you get to use the same Herschel Common Science Software that you will use for the reduction of actual data during operations.
- The simulator is **easy to install** (Win, UNIX), **easy to run** (VM IDL & Java), and **flexible** (calibration tables & added functionality).
- You will have **support** available through the website because we will continue to develop the simulator.