SPIRE Large (Scan) Map Mode

Tim Waskett
Cardiff University
Scan Map Mode - An Introduction (1)

• Otherwise known as ‘Large Map’ in HSpot
• The most efficient mode for large maps
• The current default is to use this mode for any map area larger than a 4’ diameter circle (although this may change slightly)
• The SPIRE arrays cover the map area by building up overlapping strips of data while scanning at a constant speed (without chopping)
• The telescope scans at an angle to the SPIRE array axis, to ensure that the map area is fully sampled by the unfilled arrays
• All three wavelengths are observed simultaneously in the same 4’x8’ FoV
Scan Map Mode - An Introduction (2)

- Default scan speed is 30”/s
- Maximum scan length is 1189’ = 19.82°
- Maximum cross-scan length is 240’ = 4°
- Scan legs follow great circles on the sky
- Current default is to use ‘long’ axis scanning (see later slides)
- User will have no control over the scan angle or scan speed (these have been fixed for optimum observing for most cases)
- Cross-linked observations are not currently implemented but will be at some point
- Sensitive to all spatial scales, up to the size of the map itself
A Typical Scan Map

- **Z-Axis**
- **Y-Axis**
- **X-Axis**

**Scanning angle between Z-axis and scan direction**

- **Scan leg start point** (at constant speed)
- **Scan direction**
- **Scan leg separation**

**Guaranteed map area** (rotation of scan pattern dependent on date)

**User requested map area**

Scan legs are slightly longer than the user requested length, to ensure the user requested area is properly covered.
Some Points to Note

- ‘On-source integration time’ in HSpot refers to the total time it takes to observe the map area (excluding overheads).
- This quantity does NOT determine the sensitivity.
- Sensitivity is governed by the number of ‘map repeats’.
- No matter how big or small a map is, a single map repeat has the same ‘effective integration time’ on the sky and so the same sensitivity (which is roughly uniform across the map area).
- This leads to discrete sensitivity levels as map repeats are added to the observation ($\Delta S \propto N^{-0.5}$).
- For rectangular maps it is more efficient for the scan leg length to be $>\text{the cross-scan length}$ (less turn around overhead) - Although this will be irrelevant once cross-linked observations are implemented.
Overheads (wake up in 1 min)

- Before each scan leg the Herschel spacecraft must accelerate up to the nominal scan speed (30”/s) and coast until the pointing accuracy has stabilised.
- Currently this coast time is very large but we are working to reduce it (no guarantees).
- After each scan leg the spacecraft decelerates and traverses to an off map point before accelerating again for the next scan leg.
- PCal calibration flashes are done about once per hour to keep track of the relative sensitivity of the detectors.
- The larger the map the more efficient the observation.
Possible Scan Directions

θ = 12.4° w.r.t symmetry axes for double Nyquist sampling (1/4 beam)

(250 μm array)

Current Default
(77.6° w.r.t. Z-axis)
‘Long’ Axis Scanning - current default
(77.6° w.r.t. Z-axis)

Uniform scan speed distance

235”

Scan leg
Map area covered to uniform sensitivity
SPIRE 250 µm array size
‘Diagonal’ Axis Scanning - for comparison

(42.4° w.r.t. Z-axis)
‘Short’ Axis Scanning - for comparison
(17.6° w.r.t. Z-axis)
## Current HSpot Sensitivities*
*(for long axis scanning at 30”/s)*

<table>
<thead>
<tr>
<th>Array</th>
<th>250 µm</th>
<th>350 µm</th>
<th>500 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective integration time per map repeat (s)</td>
<td>16.6</td>
<td>17.8</td>
<td>18.2</td>
</tr>
<tr>
<td>$\Delta S$ (5 $\sigma$) for one map repeat (mJy)</td>
<td>55</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td>Time to map 1 deg$^2$ to 3 mJy rms (hrs, excluding overheads)</td>
<td>8.6</td>
<td>15.3</td>
<td>11.7</td>
</tr>
<tr>
<td>Number of map repeats needed to reach 3 mJy rms</td>
<td>14</td>
<td>25</td>
<td>19</td>
</tr>
</tbody>
</table>

*likely to change by the time OT observations are performed but not by much*
1/f Noise

- Scan map mode is susceptible to 1/f noise, unlike jiggle map mode.
- Both correlated and uncorrelated 1/f noise will be present.
- Correlated 1/f noise can (will) be removed by the SPIRE data processing pipeline.
- If left untreated 1/f noise can appear like large scale structure in the map (and can affect point source detection).
- Uncorrelated 1/f noise can be dealt with (to a lesser or greater degree) by performing cross-linked observations.
- The SPIRE pipeline will include a map making stage that can take advantage of cross-linked observations to help reduce the effects of 1/f noise (based on the CMB code MADmap).
- Cross-linked observations are NOT currently possible in a single AOT but we are working to get this implemented.
1/f Noise

1/f knee frequency

Frequency
1/f Noise
Intended Cross-Linked Scan Directions

Symmetry axis

Cross-linked scan angles

95.2°

60°

‘Long’ scan direction

‘Diagonal’ scan direction

‘Short’ scan direction
Cross-Linking Example
More Details

• Refer to the AO for more details, including HSpot examples and how to implement a Large Map observation:

• http://herschel.esac.esa.int/Docs/SPIRE/html/spire_om.html

• Specifically:
  • Chapter 3, Chapter 3 ("General Performance")
  • Chapter 4, Section 4.1 ("Photometer AOT Modes")
  • Chapter 6, Sections 6.3 and 6.5 ("HSpot Components for Setting up a SPIRE Photometer Observation" and Example Photometer Observations)