# SPIRE Spectrometer Data Reduction: Mapping Observations

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# Goals

- Overview of the SPIRE spectral mapping mode: AOR and the pipeline.
- SPIRE spectral cube visualization and analysis in HIPE (demo)
  - How to visualize the data?
  - How to extract a 1-d spectrum within an aperture?
  - How to generate a line intensity map?

# SPIRE FTS Observing Modes

**Spectral resolution:**

High Res:
1.2 GHz (0.04 $cm^{-1}$);
R= 1290 – 370;
ΔV = 230 – 800 km/s;

~~Medium:~~
~~7.2 GHz (0.24 $cm^{-1}$);~~
~~R = 210 – 60.~~

Low:
25 GHz (0.83 $cm^{-1}$ );
R = 62 – 18,

**Spatial sampling using an internal jiggle mirror (BSM):**

Sparse
(1 BSM pointing;
2 beam spacing)

Intermediate
(4 BSM pointings;
1 beam spacing)

Full
(16 BSM pointings;
1/2 beam spacing)

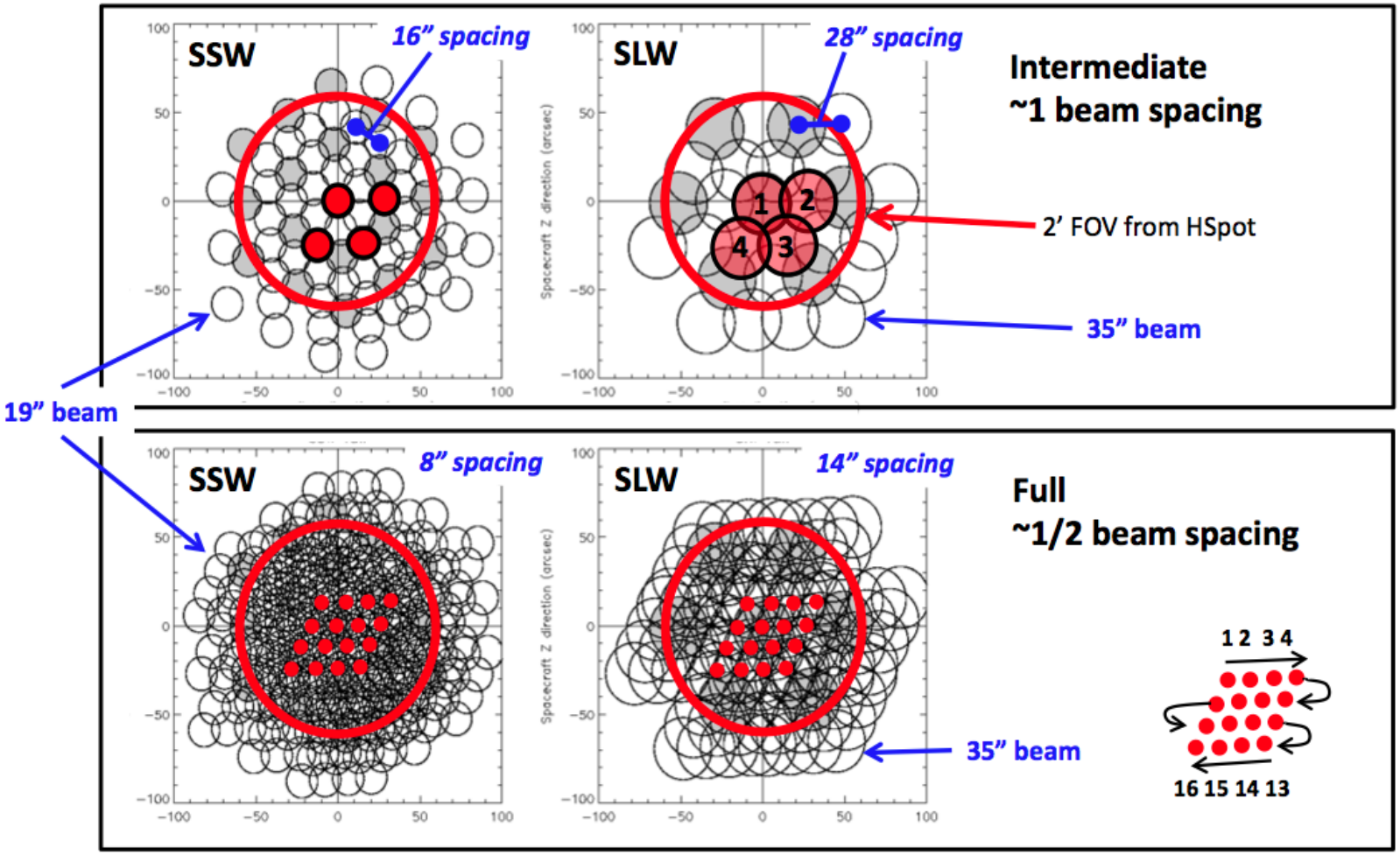
**Telescope pointing:**

Single Pointing

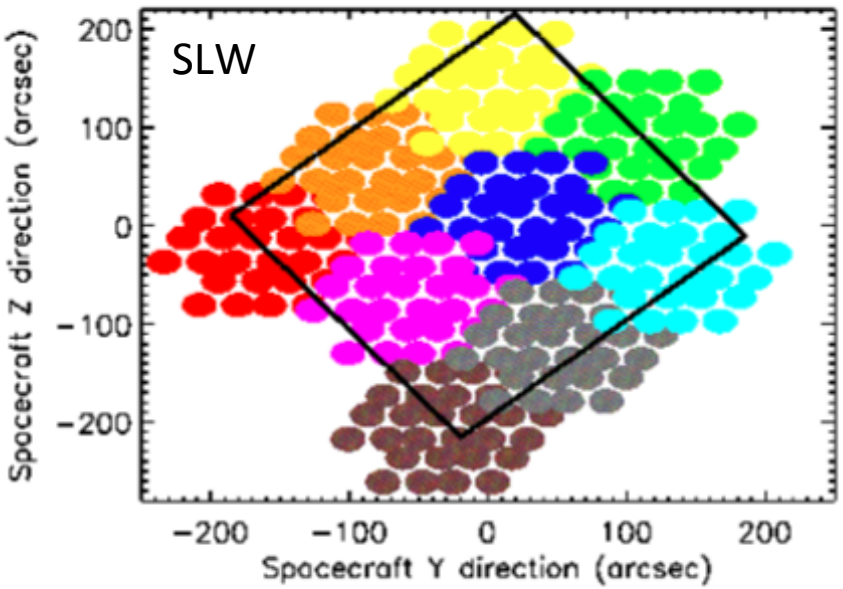
Raster (NxM)

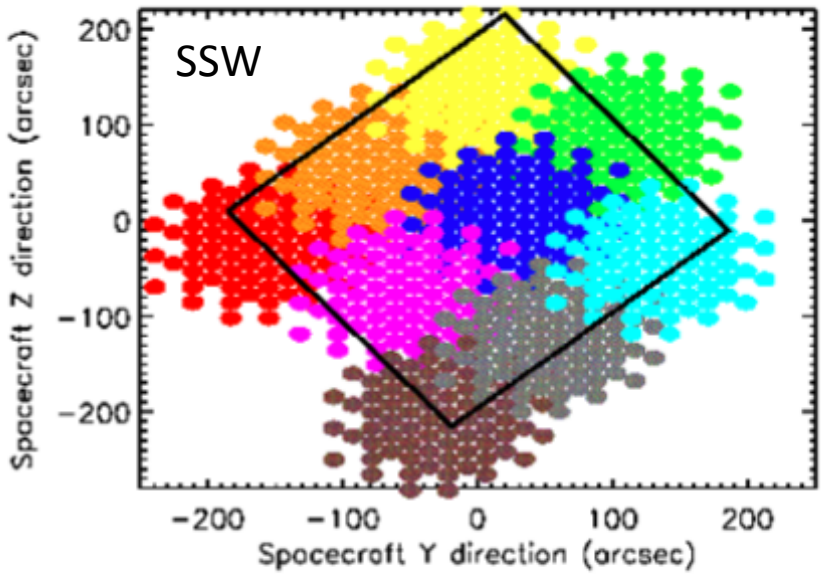
**Any observation involving either BSM jiggling or telescope raster is defined as a mapping observation.**

# BSM Jiggle Patterns



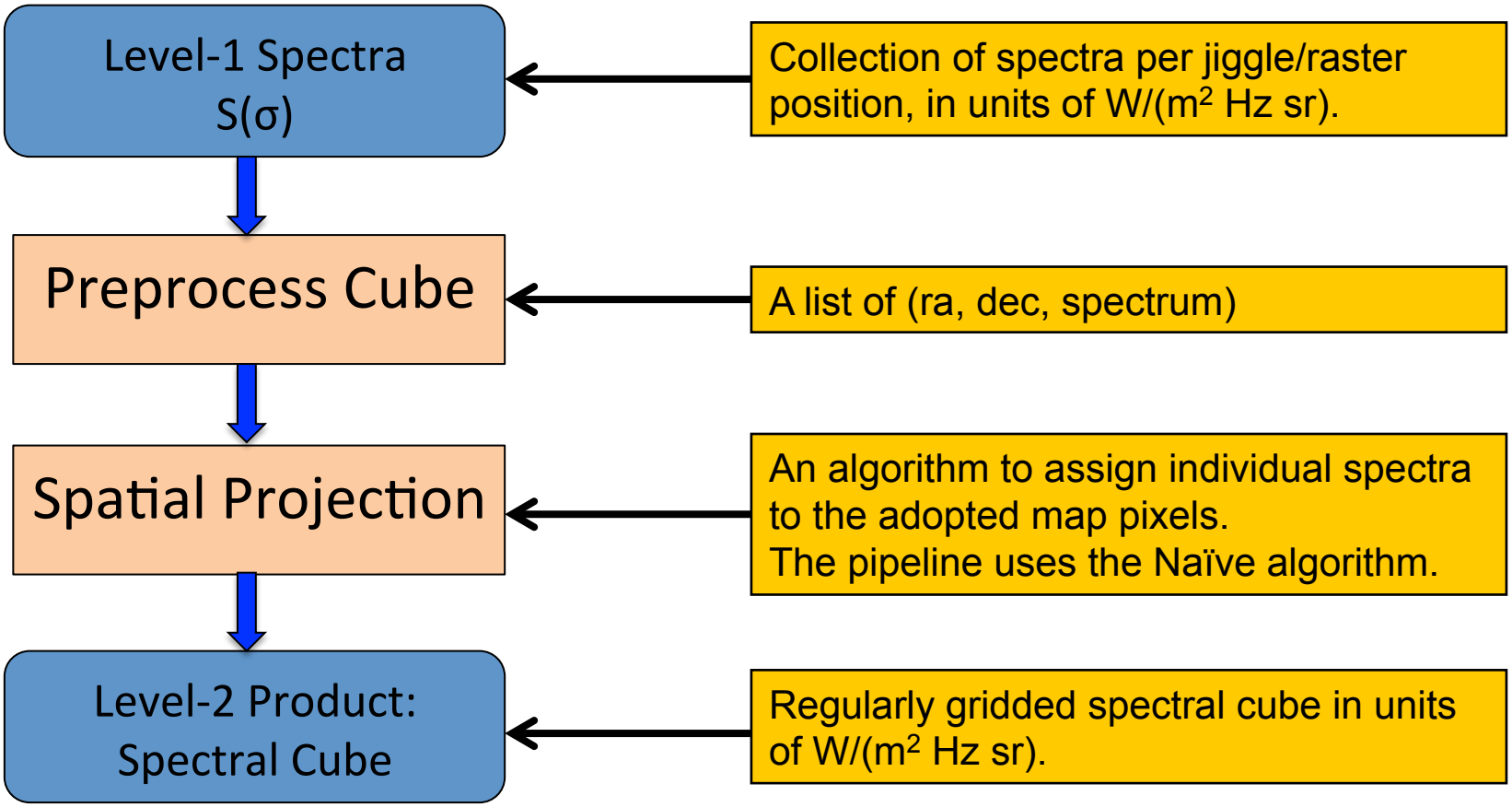
# Telescope Raster Maps



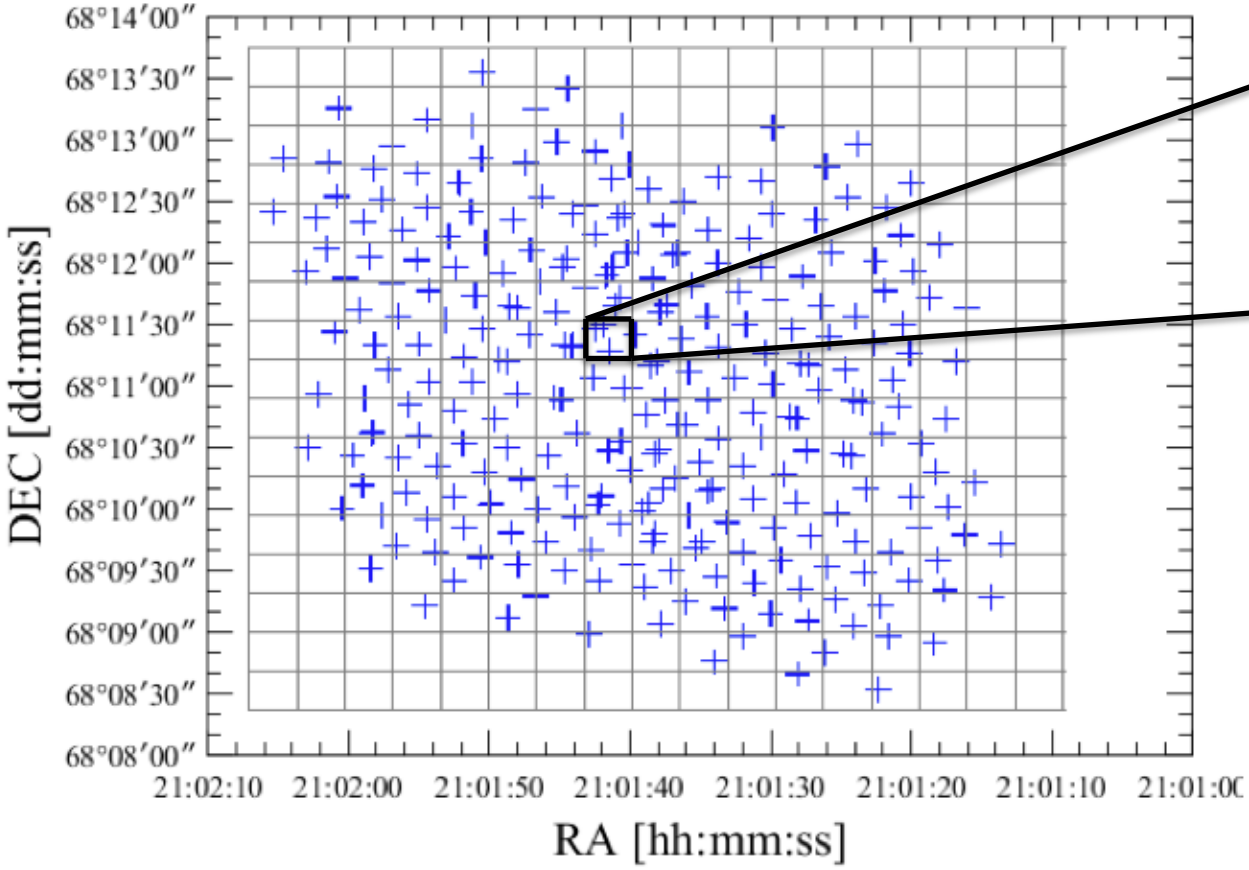

A 3x3 telescope raster with BSM in intermediate spatial sampling

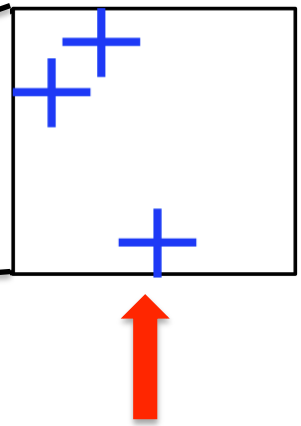
# Pipeline for Mapping Data



# The Naïve Projection in the Pipeline

SSW: 2x2 raster with intermediate spatial sampling

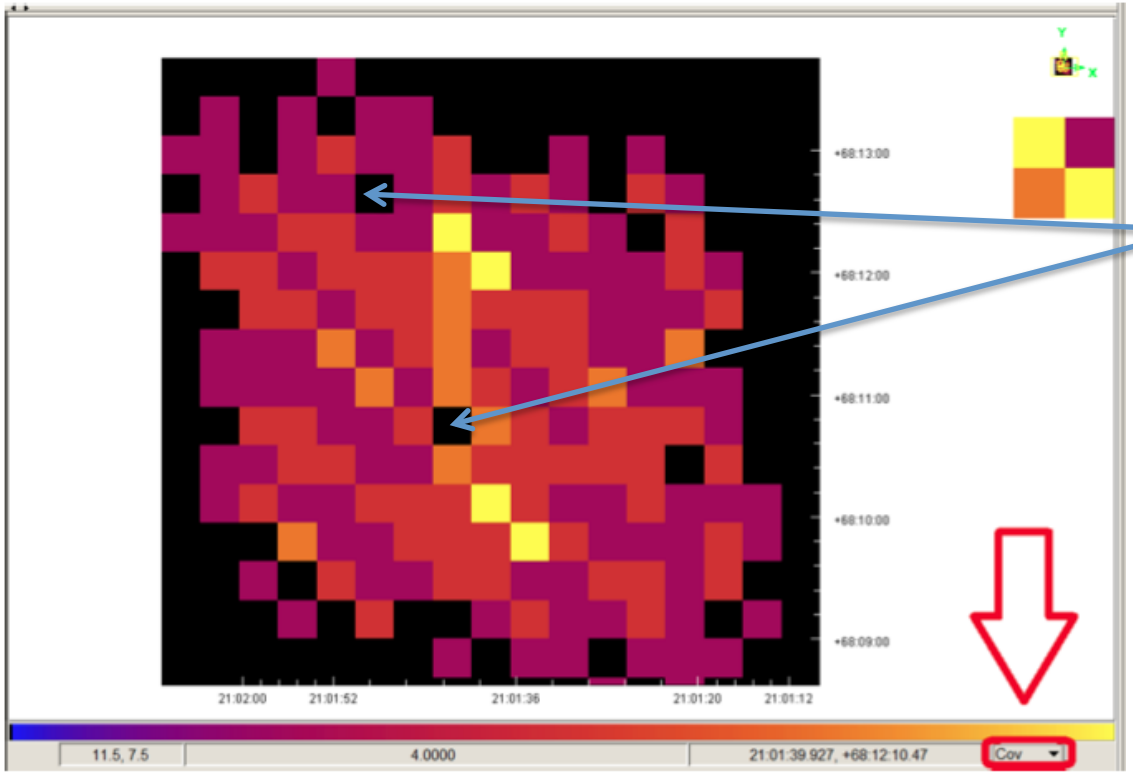


The average of spectral scans from the 3 independent pointings is taken to be the spectrum for this map pixel of 19”x19” (SSW).

# Coverage Map

SSW coverage map in terms of spectral scans




There could be holes, as a result of dead detectors.

These map pixels have spectral values of NaN.

Holes can be eliminated by making map pixel size larger.

# Remarks

- By default, the outmost, vignetted detectors are not used in cube construction.
- Unlike photometer, there is only up to a few detectors within any map pixel. Thus, detector-to-detector calibration difference (i.e., flat fielding) is more important here.
- Residual telescope emission (of 0.5-1 Jy as of HIPE 9.1) could be still present in the continuum of a spectral cube.
- It is still a work in progress as to how to properly measure the flux of an aperture-extracted spectrum for a discrete source (e.g., a small galaxy) in the map.
  - Surface brightness of a discrete source is always somewhat underestimated in a map. As a result, a flux extracted within a *finite* aperture needs a further aperture correction that depends on aperture size and the detailed (wavelength-dependent) beam profile.
  - For a point source in the map, its photometry is best done by going back to the appropriate Level-1 spectrum that centers on the target, and performing a point-source flux calibration.

# Demo on Spectral Cube Analysis Tool

- Described in some detail in Herschel Data Analysis Guide, Chapter 6, that comes with your HIPE 9.1.
- It works on 3-d data cubes of data type “SpectralSimpleCube” or “SimpleCube.”
- What can you do with this tool? We demonstrate some of its capabilities:
  - Cube visualization and cropping.
  - Extract a 1-d spectrum of data type “Spectrum1d” from a spectral cube. The result can be, as you learnt in one of our previous webinars, analyzed using HIPE Spectrum Toolbox (e.g., to fit a spectral line).
  - Extract a 2-d spatial image of data type “SimpleImage” from a spectral cube. The result can be analyzed easily in HIPE or any existing tools outside HIPE. As an example, we will extract a CO line intensity map here.

# Demo on Spectral Cube Analysis Tool

- We use the following sample data:
  - OBSID = 1342198923
  - NGC7023;  HR, 2 repeats, full spatial sampling.