Example Science Cases and AORs for SPIRE II. Spectrometer

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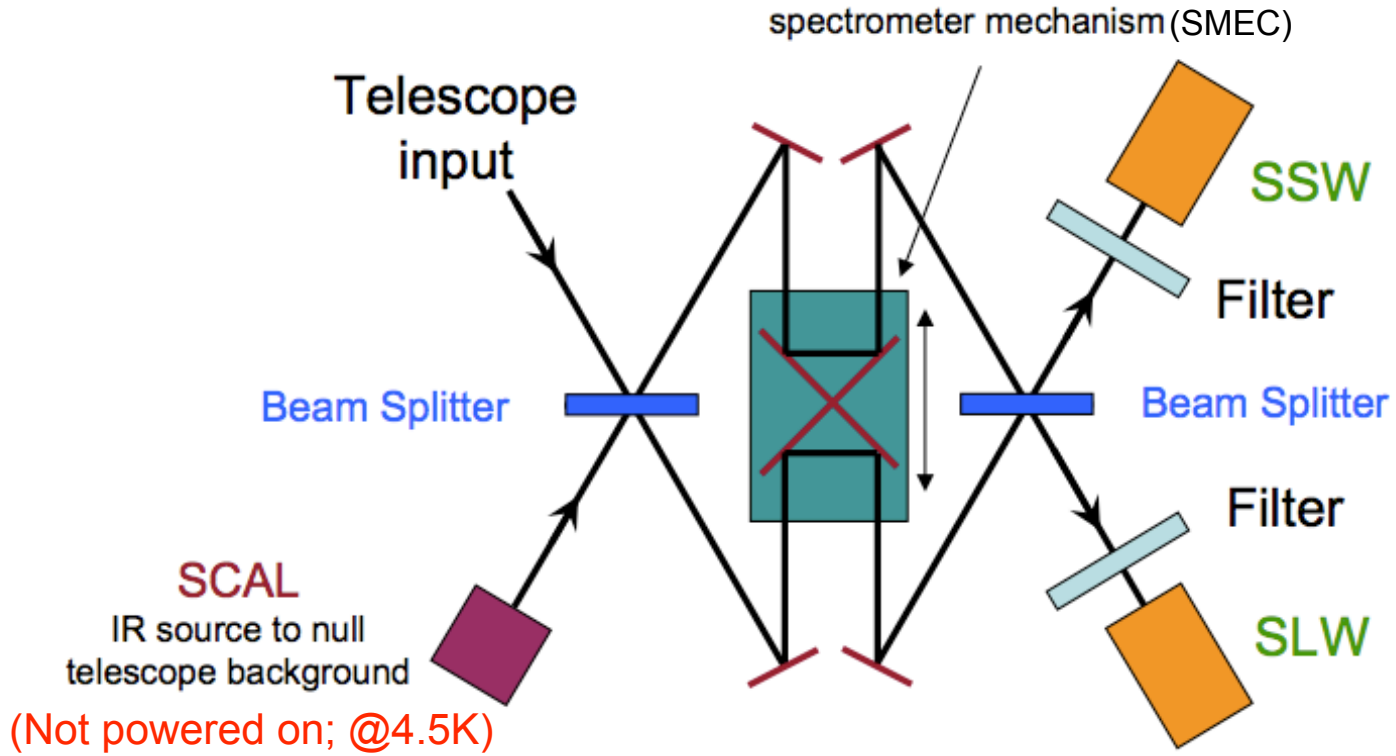
Covered Topics

- Overview of the spectrometer and its observing modes.
- HSpot demo: a single-pointing observation of the galaxy M82.
- HSpot demo: a raster map observation of the extended galaxy M81.
- Some considerations for your observational planning.

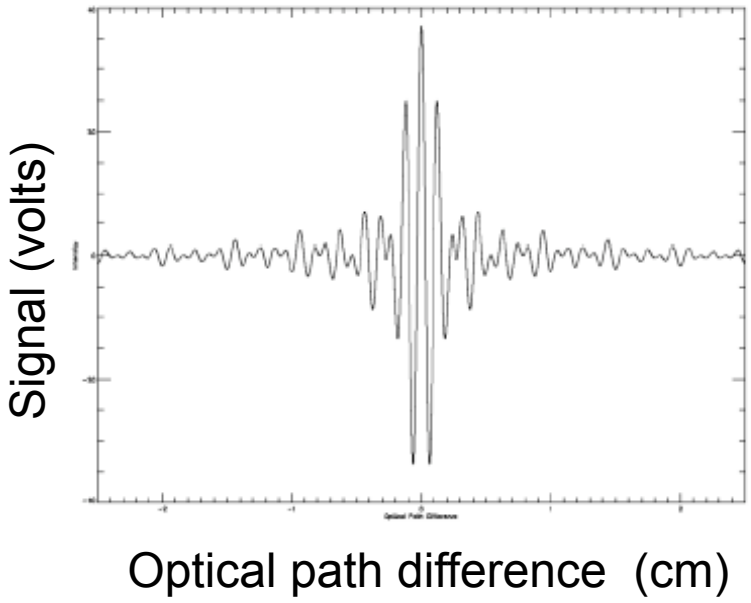
SPIRE Spectrometer

Fourier Transform Spectrometer (FTS): The entire spectral coverage of 194-671 micron is observed in one go!



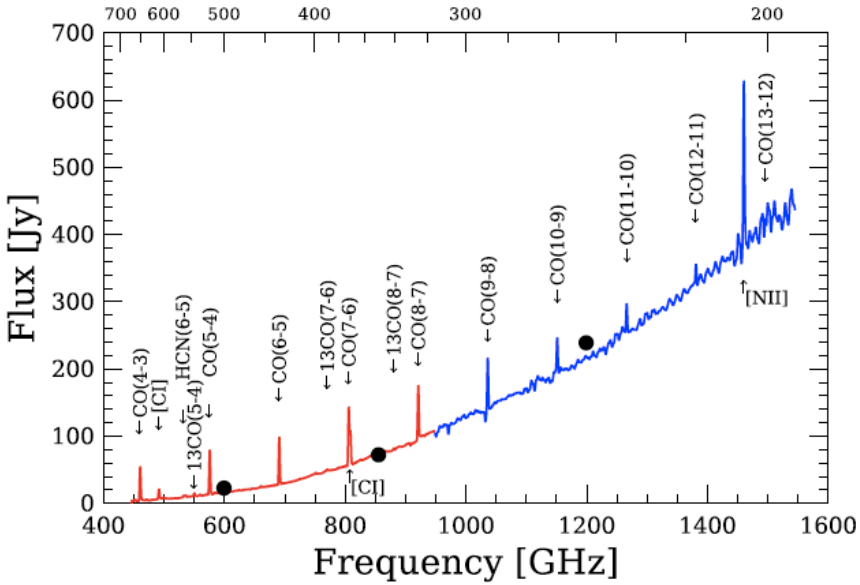
From Interferogram to Spectrum

Interferogram



Fourier Transform + Calibration

Source Spectrum

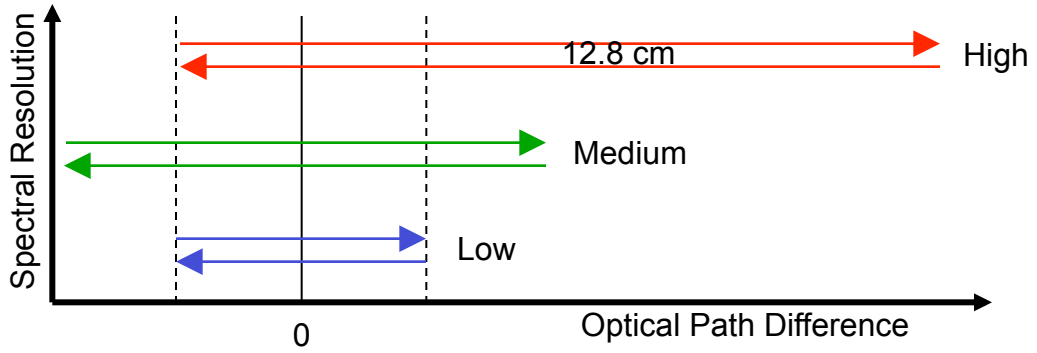


Just One AOT! But a few Options

- What spectral resolution do you need?
  (set the FTS scanning distance)
  - **Low** (0.83 cm^{-1}; 25 GHz)
  - **Medium** (0.24 cm^{-1}; 7.2 GHz)
  - **High** (0.0398 cm^{-1}; 1.2 GHz)
- What spatial sampling do you need?
  (set the number of BSM pointings)
  - **Sparse** (2 beam spacing)
  - **Intermediate** (1 beam spacing)
  - **Full** (1/2 beam, Nyquist)
- What is your source size?
  (set the number of telescope pointings)
  - **Single point** (1 FOV of 2' in diameter)
  - **Raster** (NxM FOVs)

Spectral Resolutions

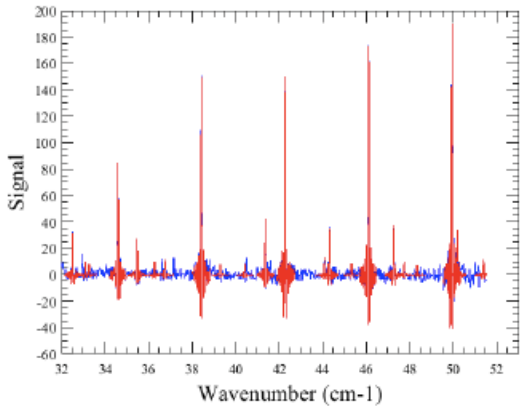
Mode	Δσ	R	Δv	What for?
High (HR)	0.04 cm^{-1} (1.2 GHz)	1290–370	230–800 km/s	Line spectroscopy; Line detection & fluxes;
Intermediate (IR)	0.24 cm^{-1} (7.2 GHz)	210–60	1410–4930 km/s	Line detection & fluxes; Excitation studies;
Low (LR)	0.83 cm^{-1} (25 GHz)	62–18	N/A	Continuum
High+Low	Both HR & LR scans in the same observation.			

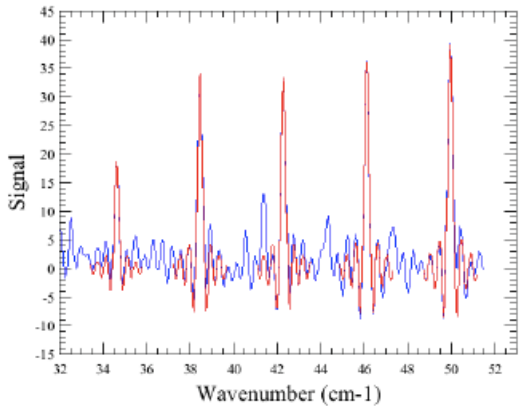


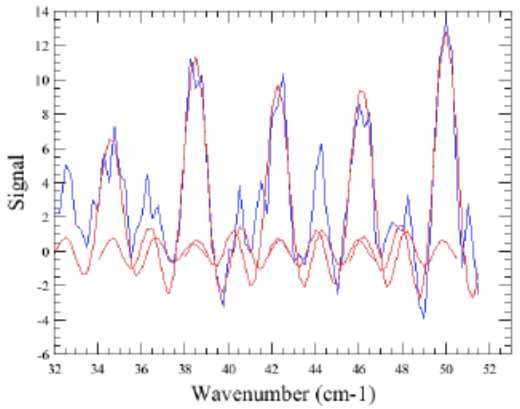
Spectral resolution depends on the FTS scan distance.

Spectral Resolutions (Cont.)

CO lines in the SSW band:







High: $\Delta\sigma = 0.04$ cm^{-1} (1.2 GHz)
230 – 800 km/s

Medium: $\Delta\sigma = 0.24$ cm^{-1} (7.2 GHz)

Low: $\Delta\sigma = 0.83$ cm^{-1} (25 GHz)

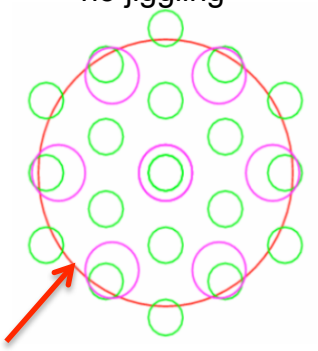
Blue curve: observed spectrum; Red curves: SINC function fits to CO lines.

Spatial Sampling Options

Jiggling the beam-steering mirror (BSM) allows for 3 spatial sampling modes:

Sparse
(2 beam spacing)

no jiggling

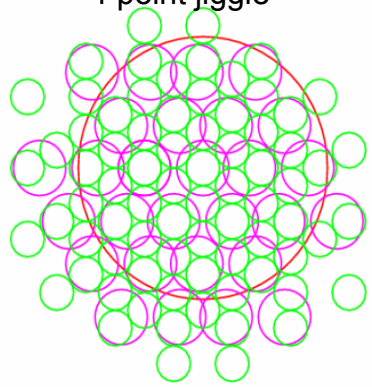


Circle of 2' diameter

- For point source observations.
- Most economic.

Intermediate
(1 beam spacing)

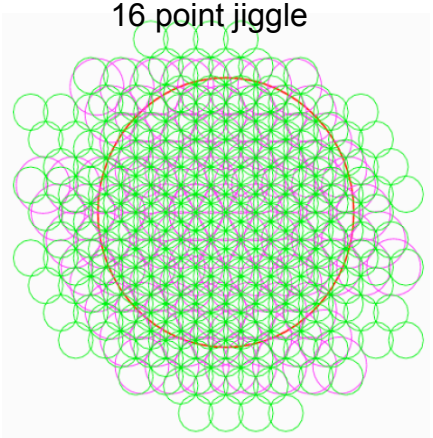
4 point jiggle



- Useful for larger maps by sacrificing some details.

Full
(half beam spacing)

16 point jiggle



- Detailed mapping of an area with Nyquist sampling.
- Time consuming though.

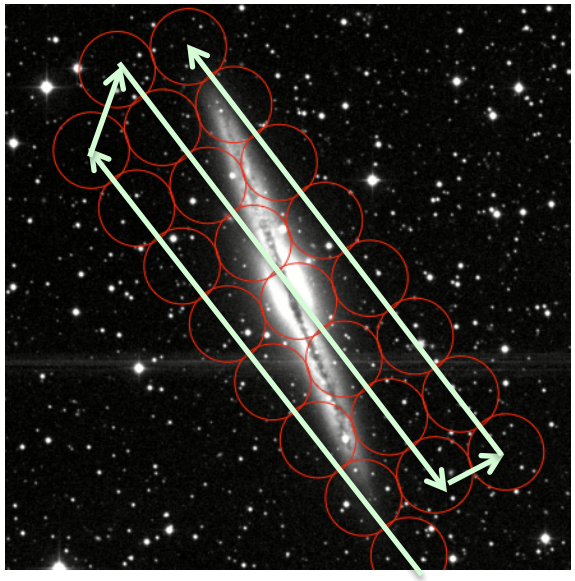
SSW
FWHM

SLW
FWHM

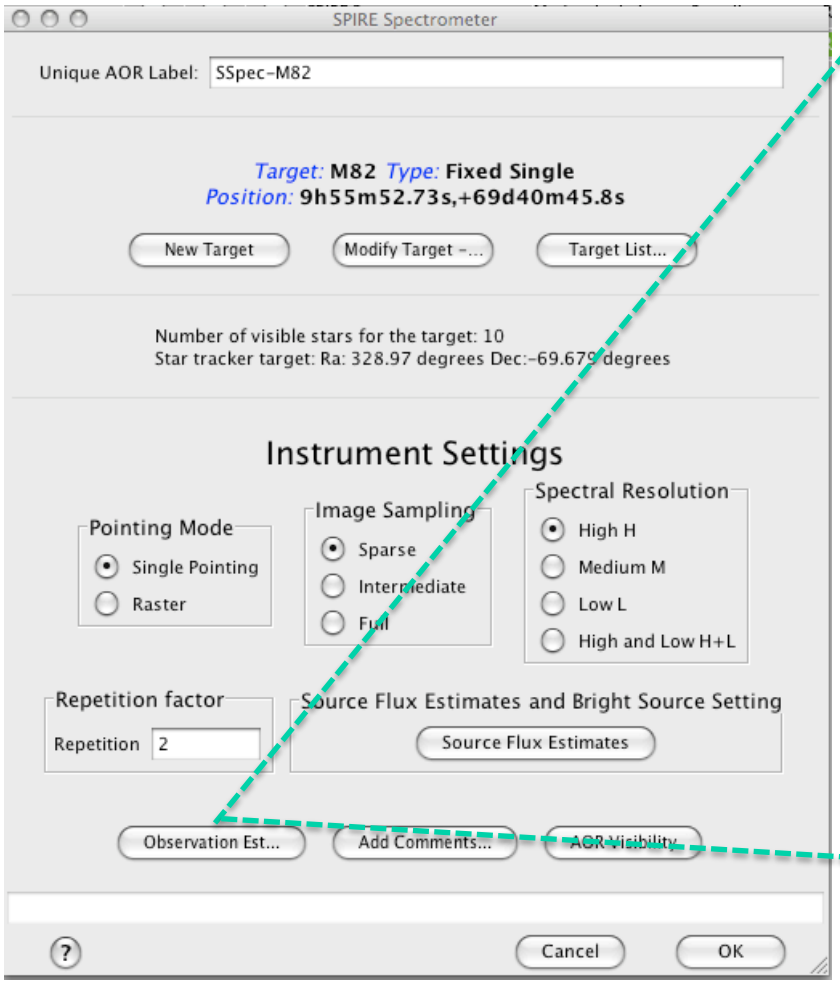
Raster Maps

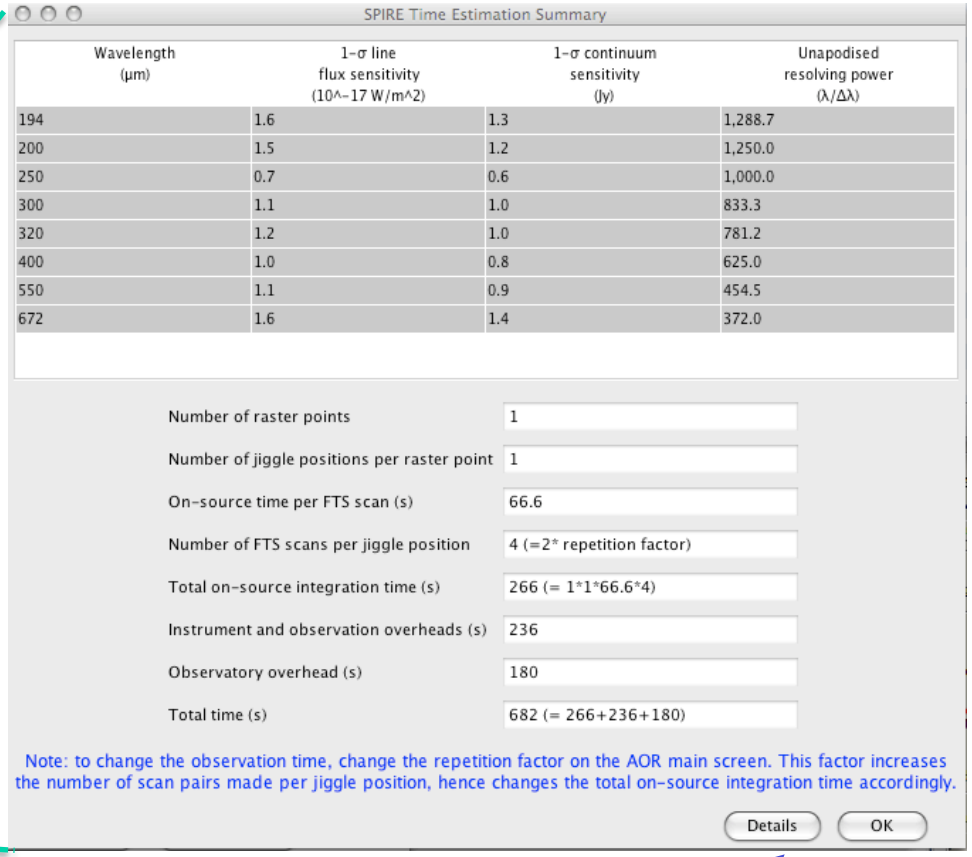
- Raster map (< 30'x30') is made of MxN *identical* individual fields of view, each with a *sparse*, *intermediate* or *full* *spatial sampling*.
- Step = 116 arcsec along raster rows or 110 arcsec across rows.
- Raster direction is fixed to spacecraft axes. So check the entire visualization range for adequate sky coverage, or set a time constraint for the observation.
- If necessary, may consider breaking up a large map into smaller maps to save time.

8x3 raster



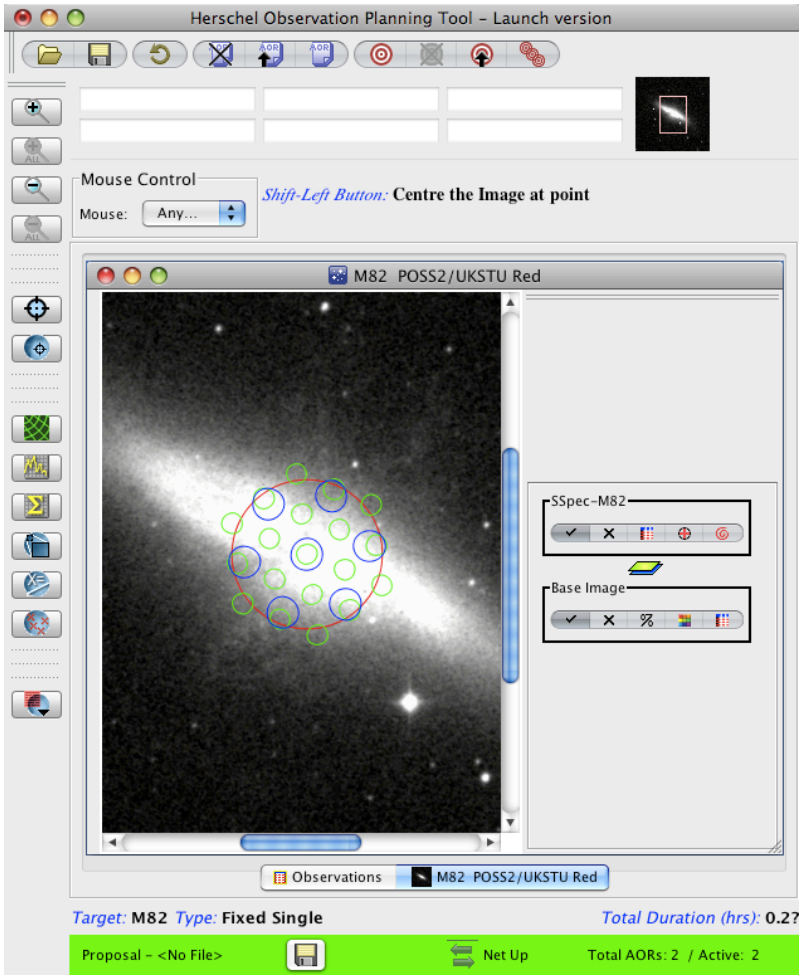
Hspot Demo: A Single Pointing Observation of M82

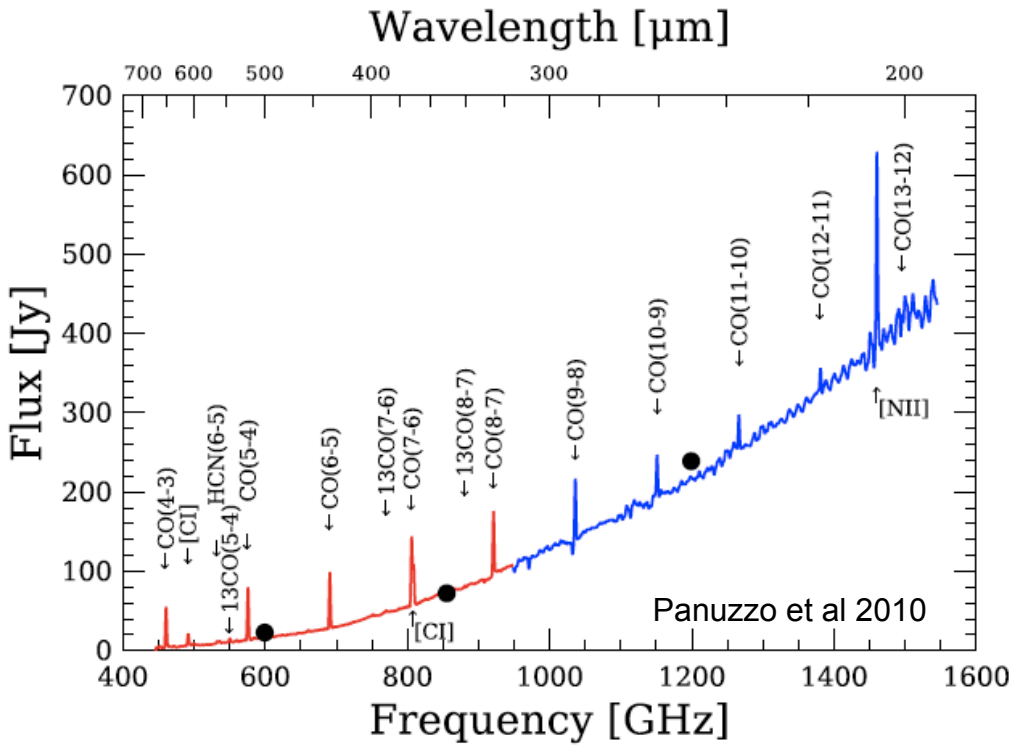




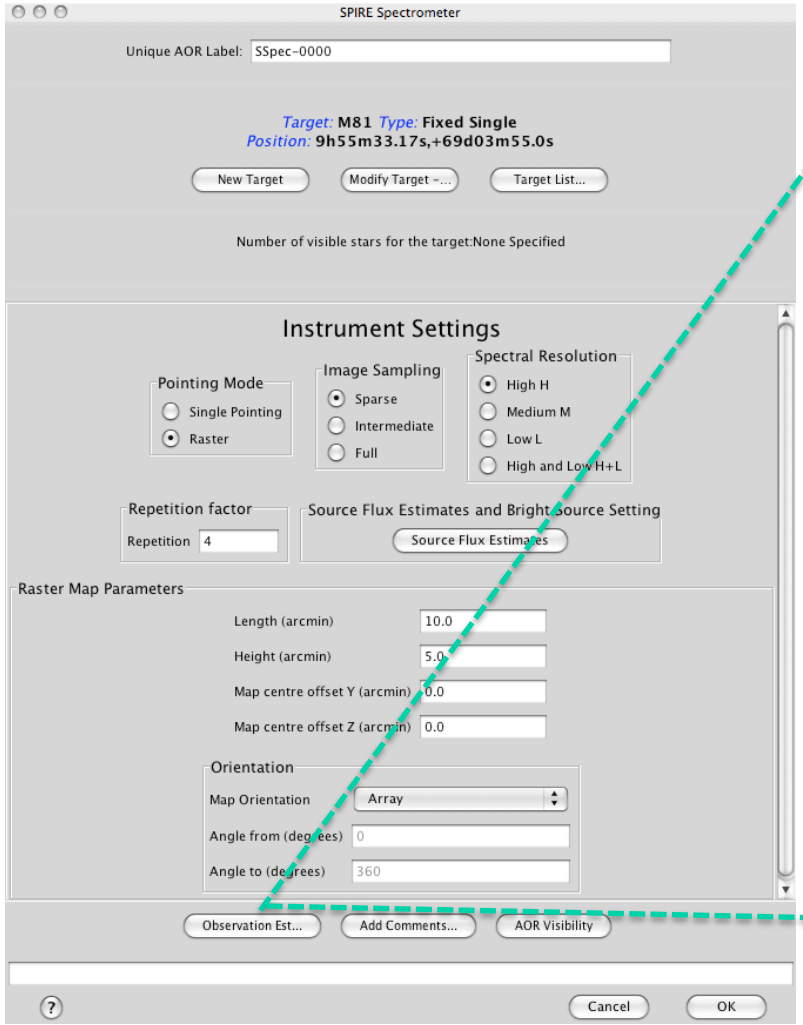
Detailed time line when clicked

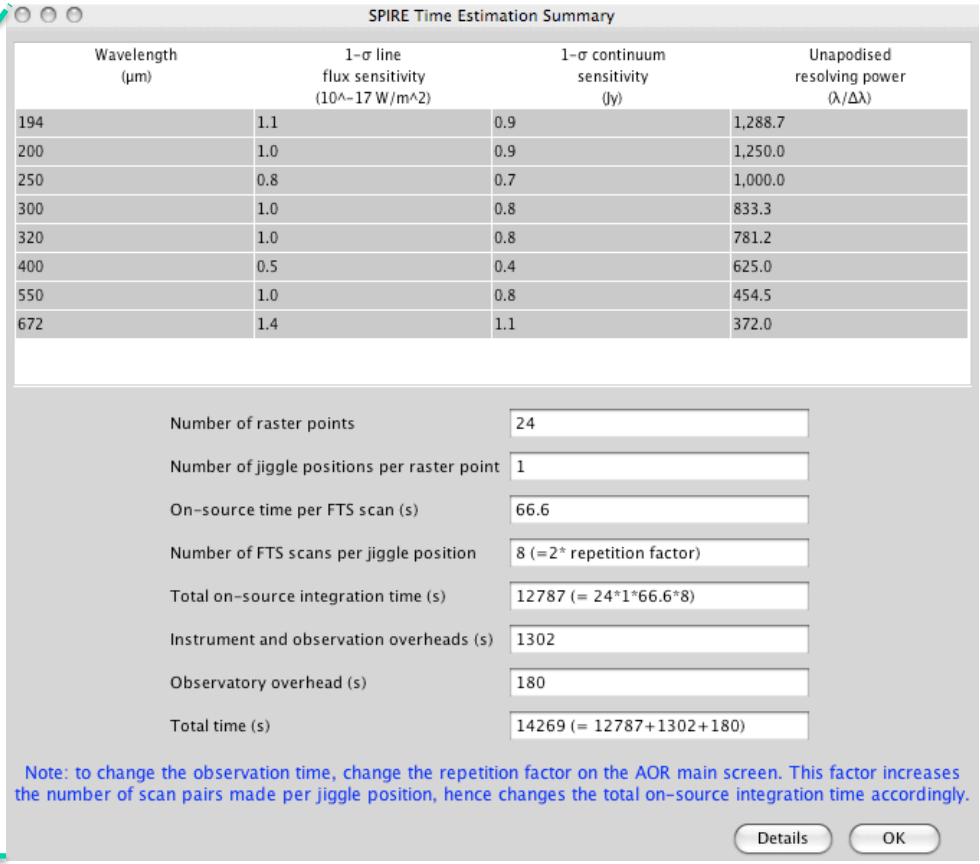
Hspot Demo: A Single Pointing Observation of M82 (Cont.)





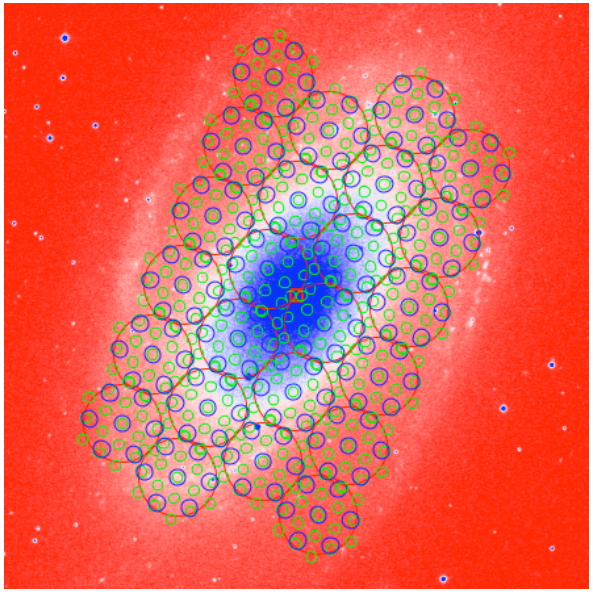
Hspot Demo: A Raster Map Example on M81



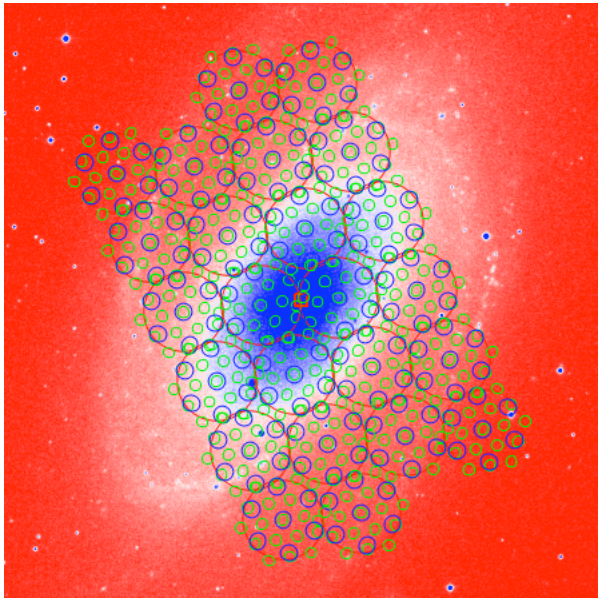


Wavelength (μm)	1-σ line flux sensitivity (10^-17 W/m^2)	1-σ continuum sensitivity (Jy)	Unapodised resolving power (λ/Δλ)
194	1.1	0.9	1,288.7
200	1.0	0.9	1,250.0
250	0.8	0.7	1,000.0
300	1.0	0.8	833.3
320	1.0	0.8	781.2
400	0.5	0.4	625.0
550	1.0	0.8	454.5
672	1.4	1.1	372.0

Hspot Demo: Raster Map Examples on M81



10’x5’ (6x4) raster
on 29 April 2012.

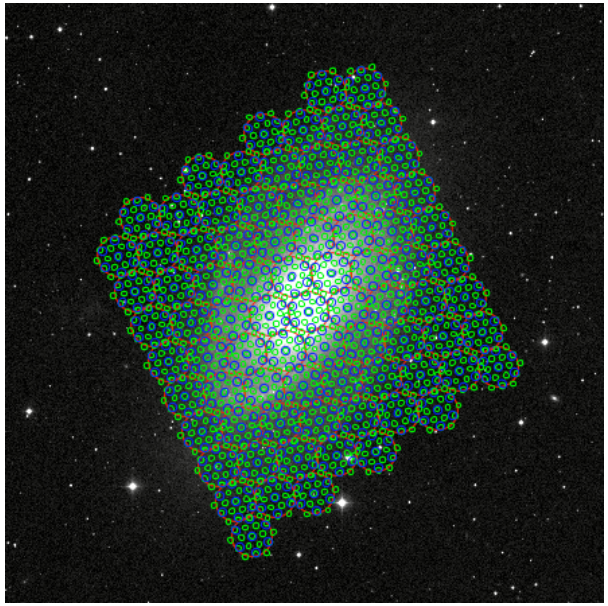


10’x5’ (6x4) raster
on 01 March 2012.

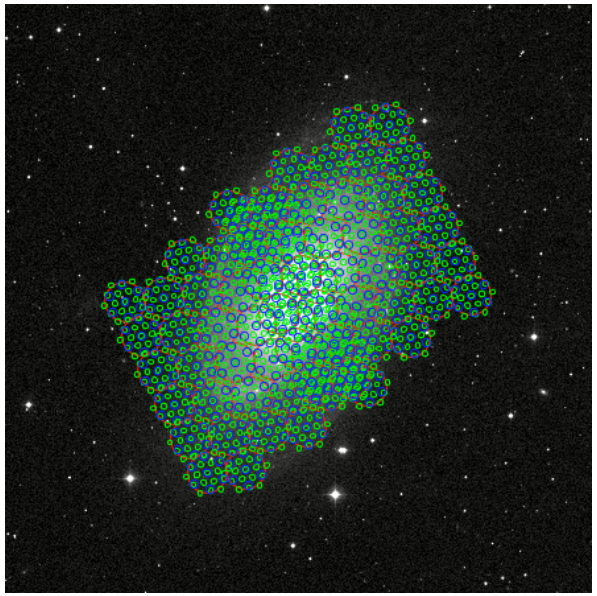
Check representative map orientations over all possible future visibilities! If necessary/possible, make your map larger (thus, more costly), impose time constraints (thus, reducing chance for scheduling) or break a large map into smaller maps.

May Want to Break a Large Raster Map into Smaller Maps

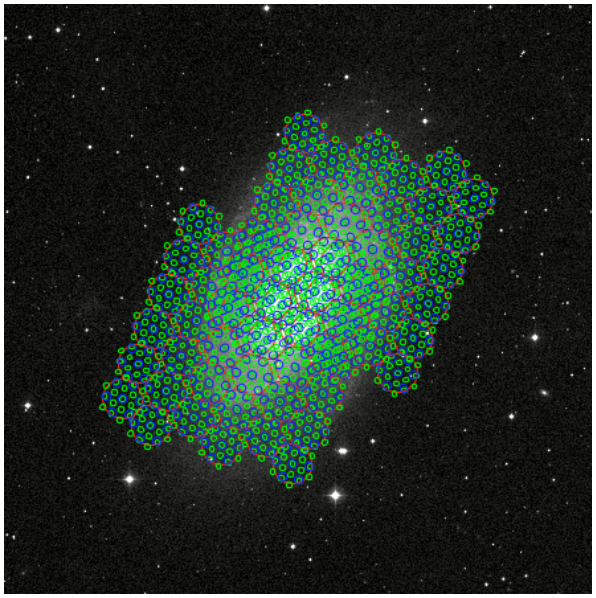
All using 4 FTS scan repeats, sparse sampling, high spectral resolution



One 9x9 raster;
Total time = 13.1 hrs



Two 6x6 rasters;
Total time = 11.7 hr
(on 01 Mar 2012)



Two 6x6 rasters;
Total time = 11.7 hr
(on 29 Apr 2012)

Some Planning Considerations

- Good for line detection, but not ideal for resolving lines (e.g., suitable for gas excitation study).
- Very efficient for multiple line emission mapping (e.g., suitable for gas outflow or velocity field study).
- Telescope background (~ 500/1000 Jy in SSW/SLW) dominates. A photometer companion observation is highly recommended in cases of spectroscopy of a faint continuum (< a few Jy). Line spectroscopy is less affected by telescope background.
- On the other hand, if your target is (unfortunately) very bright (> 400/200 Jy for SSW/SLW; e.g., Galactic center), you may consider using the bright-source detector setting.

Some Planning Considerations (cont.)

- For point source observations, it is best to place the target on the central detectors, which are still best calibrated at this point.
- Line blending could be a problem in hot molecular cores even with the high resolution mode.
- Even a small raster observation using high spectral resolution and full spatial sampling could be quite costly.
- If you can, a higher scan repetition is always desirable for better deglitching using scan redundancy (e.g., a repetition of 4 is better than 2).
- A large map with time constraints may make your observation not schedulable at all. You may want to break it into smaller maps.