SPIRE Fourier Transform Spectrometer Observing Modes

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The SPIRE Imaging FTS

- Fourier Transform Spectrometer → entire spectral coverage is observed in one go
- 2 Bolometer detector arrays for short and long wavelength bands

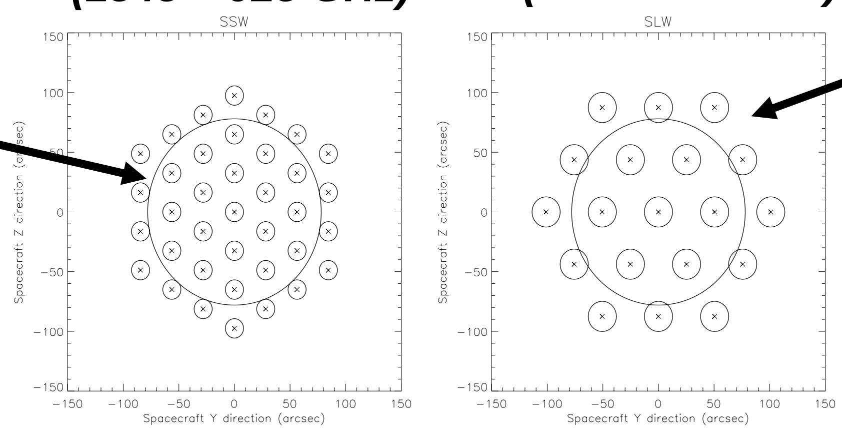
194 – 324 µm
(1545 – 925 GHz)

316 – 672 µm
(949 – 446 GHz)

2.6' unvignetted beam footprint

Pixel spacing ~ 2 beam widths

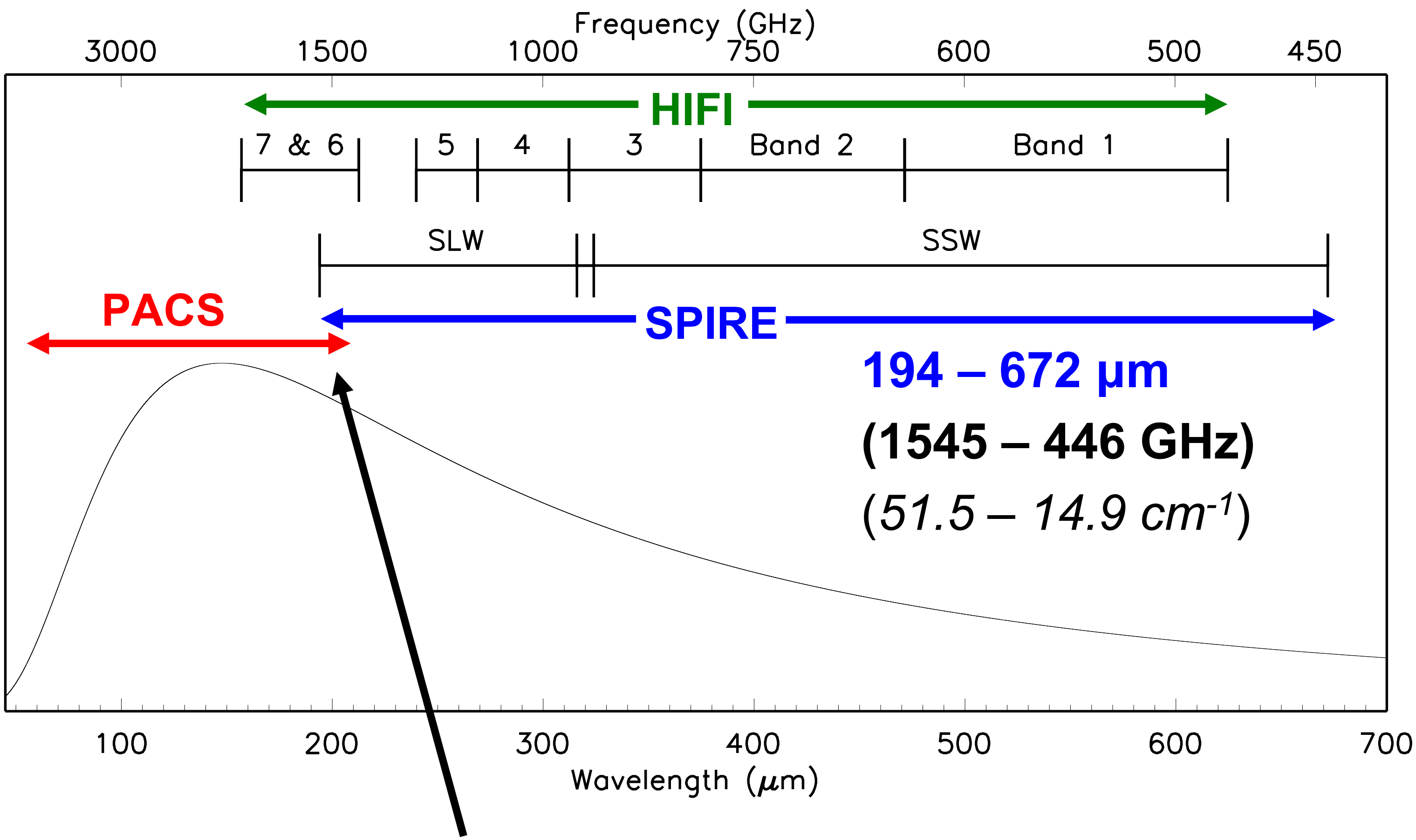
SSW



SLW

Beam FWHM ~ 16" **Beam FWHM ~ 34"**

Spectral Coverage



194 – 672 μm

(1545 – 446 GHz)

(51.5 – 14.9 cm^{-1})

Good overlap with PACS (194 – 210 μm)

Observing Choices

Source size

Single point
(1 FOV with diameter of 2')

Raster
(many FOVs)

Spatial sampling

Sparse
2 beam spacing

Intermediate
1 beam spacing

Full
½ beam spacing (Nyquist)

Spectral resolution

(unapodised)

High 0.04 cm^{-1} (1.2 GHz)

Medium 0.25 cm^{-1} (7.5 GHz)

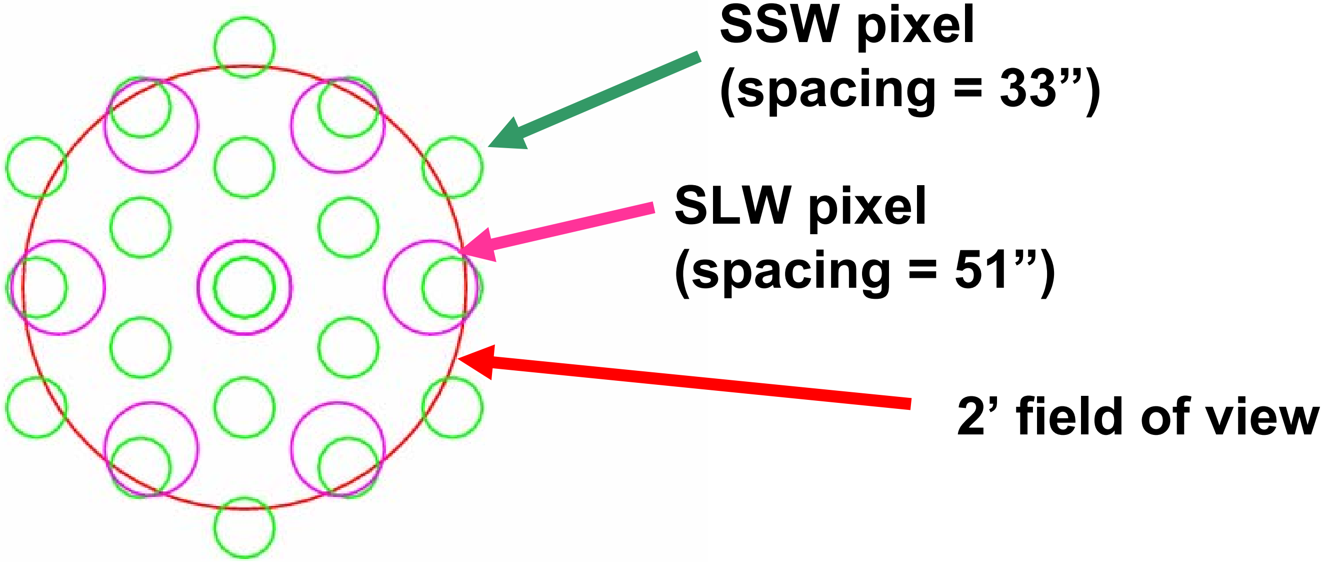
Low 1.0 cm^{-1} (30 GHz)

(constant in frequency)

Point Source Spectrum

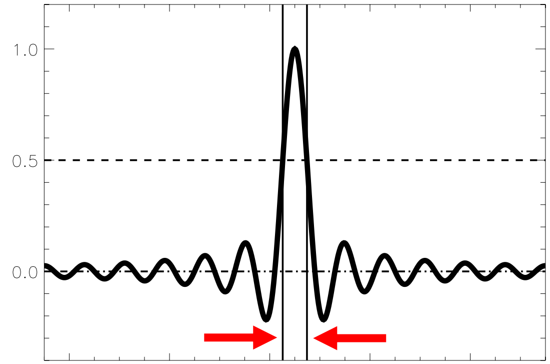
→ **SINGLE POINT: SPARSE**

- **Always get data from whole array**
- **HSpot shows location of array pixels for sparse mode**



Point Source Spectrum 2

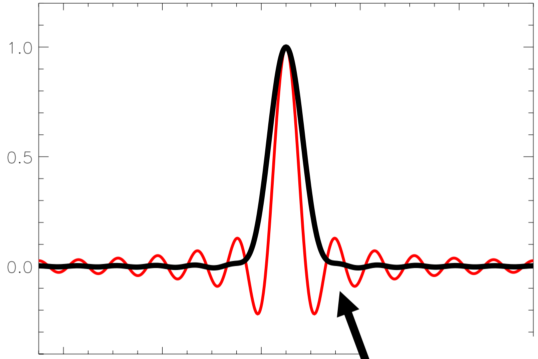
- Instrumental profile is a Sinc function



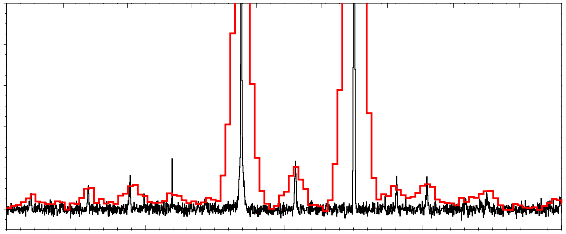
with a FWHM
1.2 x resolution

FWHM = 0.048 cm^{-1} = 1.4 GHz

- Apodisation reduces ringing in the side lobes



…but increases the line width by 20-30%



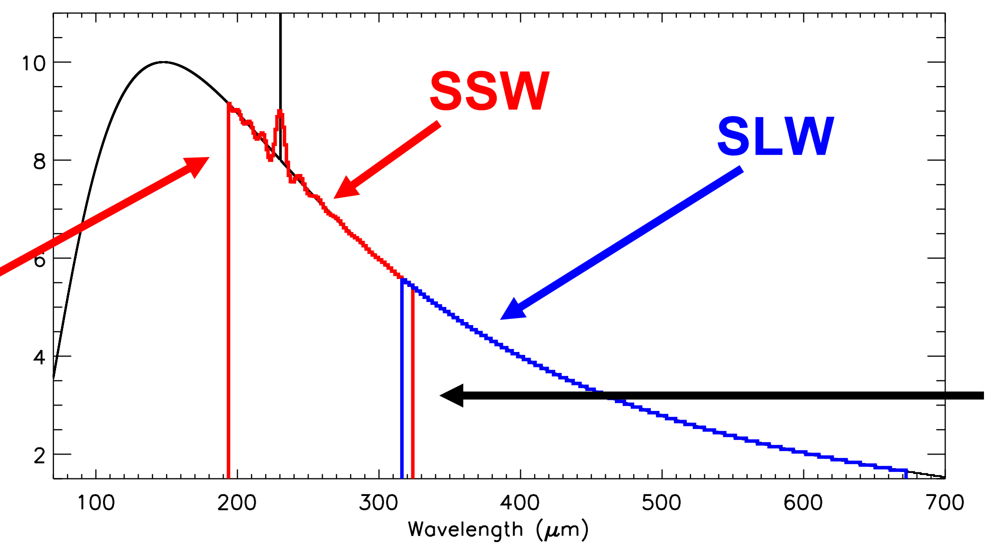
apodised line

Point Source Spectrum 3

LOW **$\Delta\sigma$ = 1.0 cm^{-1}** (30 GHz); ***R* = 52 – 15**

- **Continuum measurements**
- **36 resolution elements across the whole range (sampled at ¼ res. element)**

resolution 1.0 cm^{-1}



overlap between bands

Point Source Spectrum 4

INTERMEDIATE **$\Delta\sigma$ = 0.25 cm^{-1}** (7.5 GHz); ***R=200 – 60***

HIGH **$\Delta\sigma$ = 0.04 cm^{-1}** (1.2 GHz); ***R=1290 – 370***

- **Line spectroscopy**
- **Measurement of total integrated line fluxes**

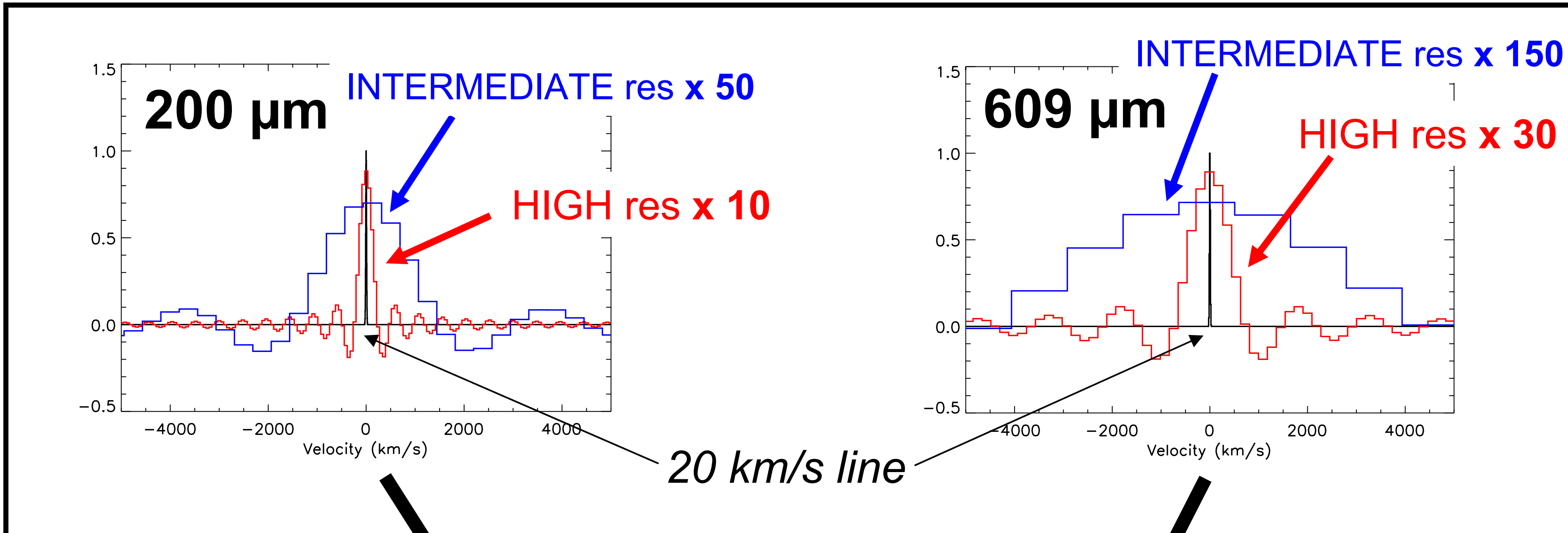
  (line widths 280 – 840 km/s in HIGH resolution mode)

HIGH + LOW

- **Line spectroscopy with high S/N continuum measurement**

  (number of HIGH and LOW resolution scans are set independently)

Spectral resolution in HIGH & INTERMEDIATE modes

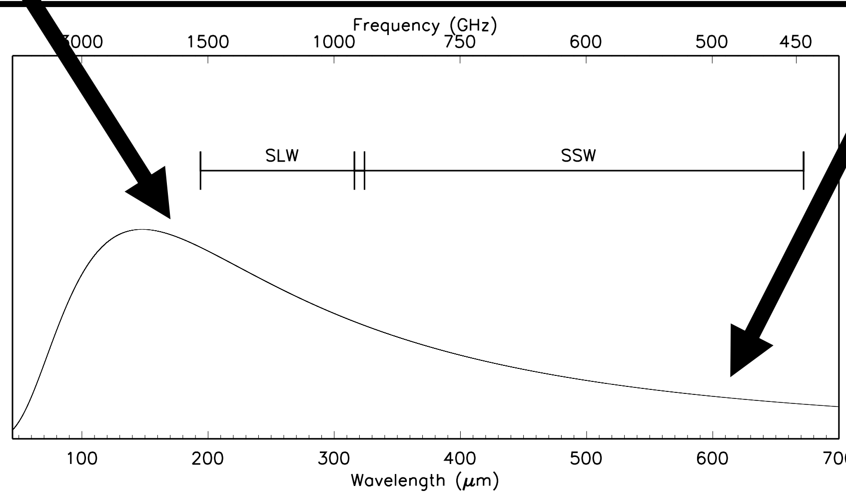


200 µm

(1499 GHz)

280 km/s (HIGH)

1810 km/s (INT)



609 µm

(492 GHz)

850 km/s (HIGH)

5510 km/s (INT)

Extended Source

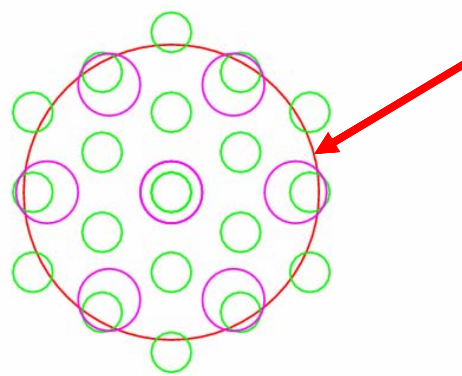
→ SINGLE POINT: SPARSE, INTERMEDIATE or FULL

SPARSE

2 beam spacing

SSW: 33”

SLW: 51”



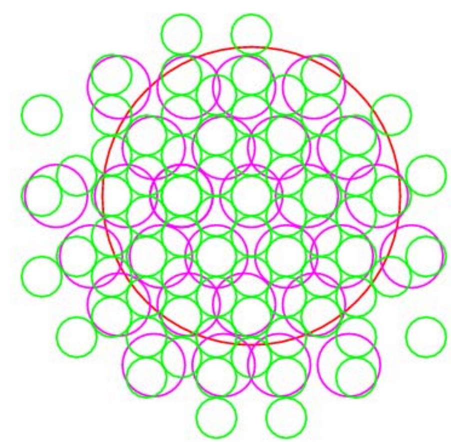
2’ field of view

INTERMEDIATE

1 beam spacing

SSW: 16”

SLW: 25”

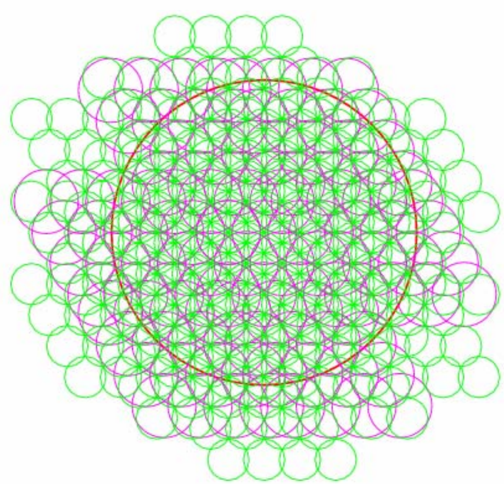


FULL

½ beam spacing

SSW: 8”

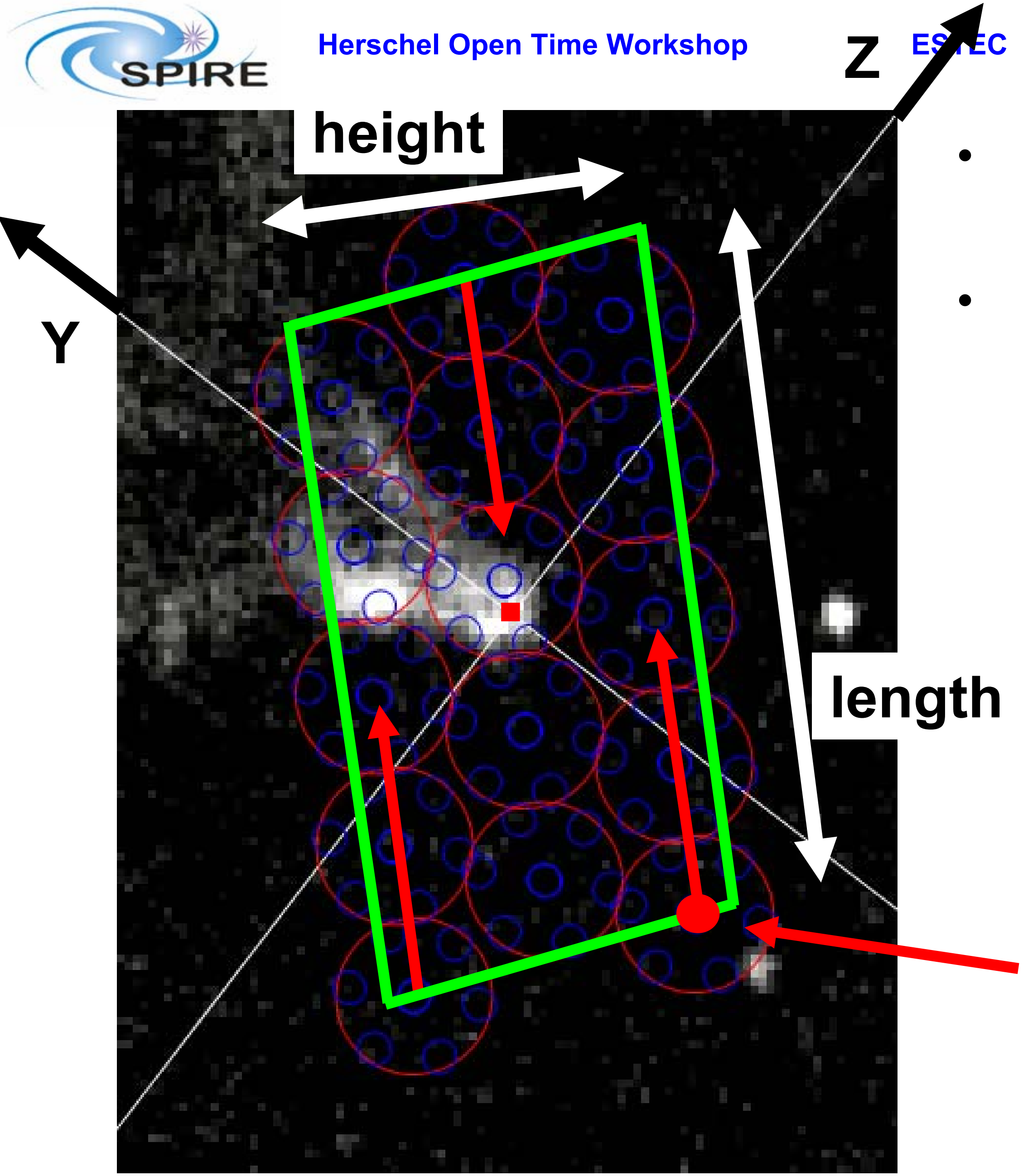
SLW: 12”



Extended Source 2: Raster Map

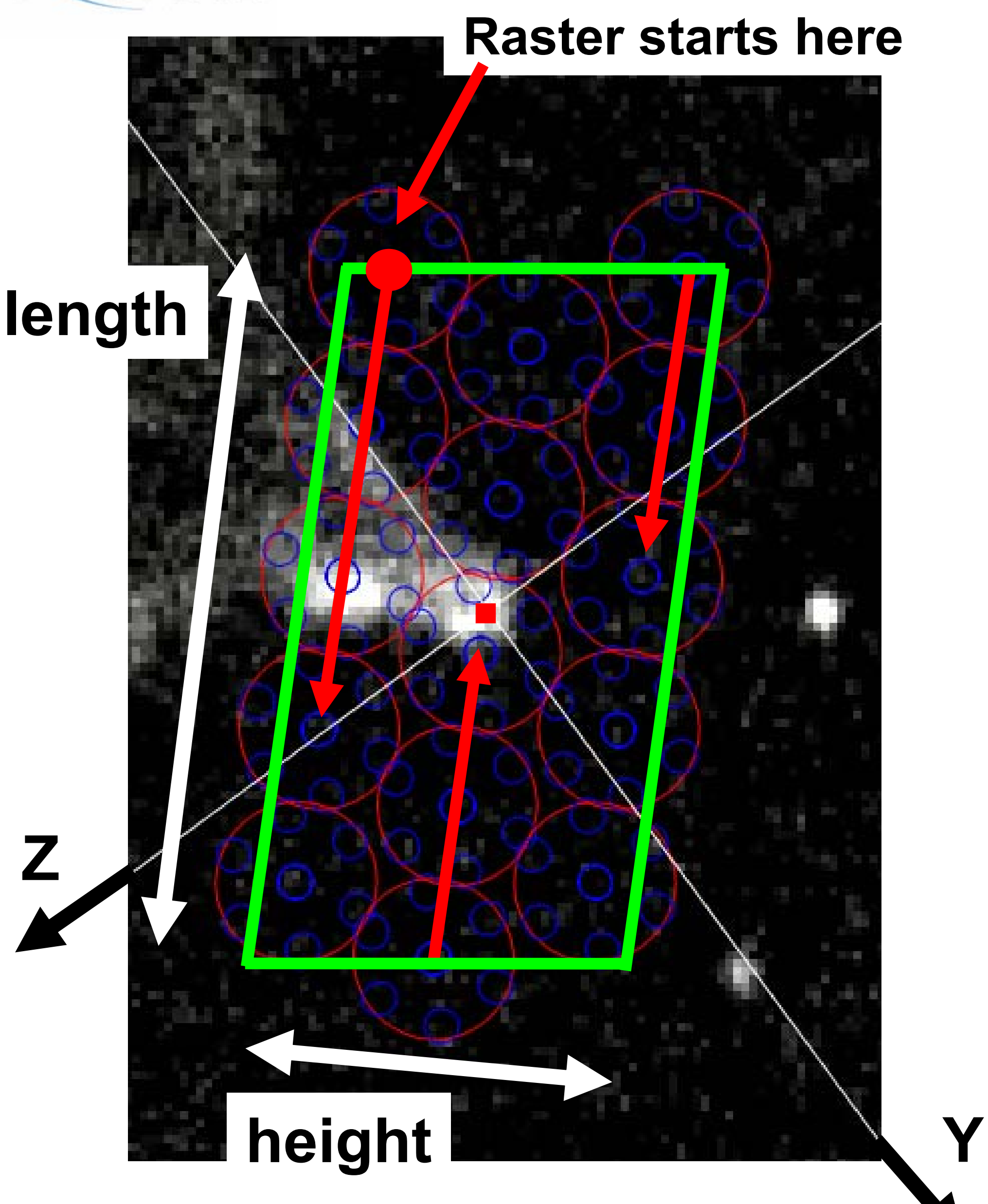
→ `RASTER: SPARSE, INTERMEDIATE or FULL`

- Raster map is made up from a combination of individual fields of view
- Raster direction is fixed to spacecraft axes not to sky coordinates → check visualisation!
- Coverage is a parallelogram on sky
- Split into separate observations to make more complicated shapes



- Raster is performed in <u>spacecraft coordinates</u>
- Therefore orientation on the sky changes depending on source position & visibility constraints

Raster starts here



- Raster is performed in <u>spacecraft coordinates</u>
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Sensitivity

- **Mechanism makes scans in pairs (forward & reverse)**
- **Integration time depends on repeats of scan pairs** (at least 2 repeats so glitches can be removed)
- **Average point source sensitivity (Low Res):**

~1.2 Jy (1σ in 1 sec) …….. *~100 mJy 5σ in 1 hour*

For variation of sensitivity with wavelength, see the SPIRE Observer's Manual

Note that all sensitivities are quoted for a point source on axis

Minimum times for each spectral resolution are:

LOW (30 GHz)	**26 sec** →	**0.24 Jy RMS**
MEDIUM (7.5 GHz)	**98 sec** →	0.5 Jy RMS → **3.6 x 10^{-17} W/m^2**
HIGH (1.2 GHz)	**269 sec** →	1.8 Jy RMS → **2.2 x 10^{-17} W/m^2**

Why use SPIRE for line spectroscopy?

- **In HIGH resolution mode (min length 269 sec), *RMS* in line flux is 2.2×10^{-17} W/m^2**
- **What does this integrated flux mean in terms of temperature units?**
  - ***Depends on intrinsic line width***

Wavelength	535 µm	200 µm
Frequency	560 GHz	1499 GHz
T_{rms} (20 km/s line)	**0.13 K**	**0.03 K**
T_{rms} (5 km/s line)	**0.51 K**	**0.14 K**

intrinsic line width

CONCLUSION

SPIRE is useful for *integrated flux* measurements of *BROAD lines*, particularly at high frequencies

Aditional advantages:

- always observes full spectral range simultaneously
- always get a sparse map of the source

HSpot

Source size

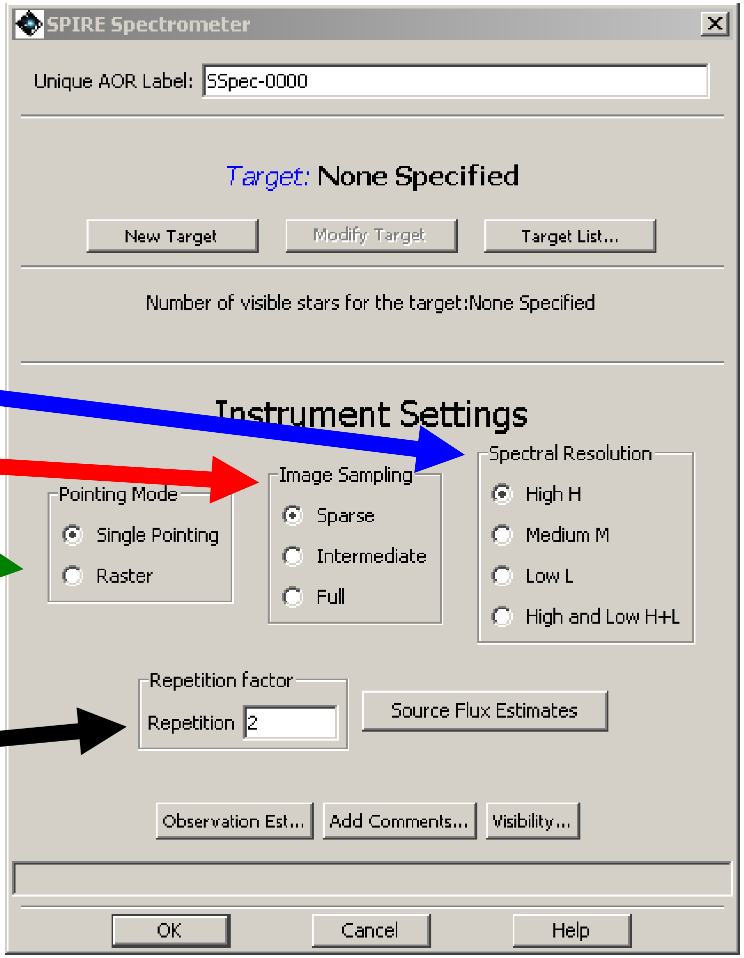
1 FOV
Raster

Spatial sampling

2 beam
1 beam
½ beam

Spectral resolution

High
Medium
Low



Number of repeated Spectrometer mechanism scan pairs (minimum 2)

ie. this sets the integration time per point

More Details

Refer to the AO for more details, including HSpot examples:

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

Specifically:

- **Chapter 2,** Section 2.3 ("*Spectrometer*")
- **Chapter 3,** Section 3.1 ("Sensitivity")
- **Chapter 4,** Section 4.2 ("*Spectrometer AOT Modes*")
- **Chapter 6,** Section 6.4

  ("*HSpot Components for Setting up a SPIRE Spectrometer Observation*")