

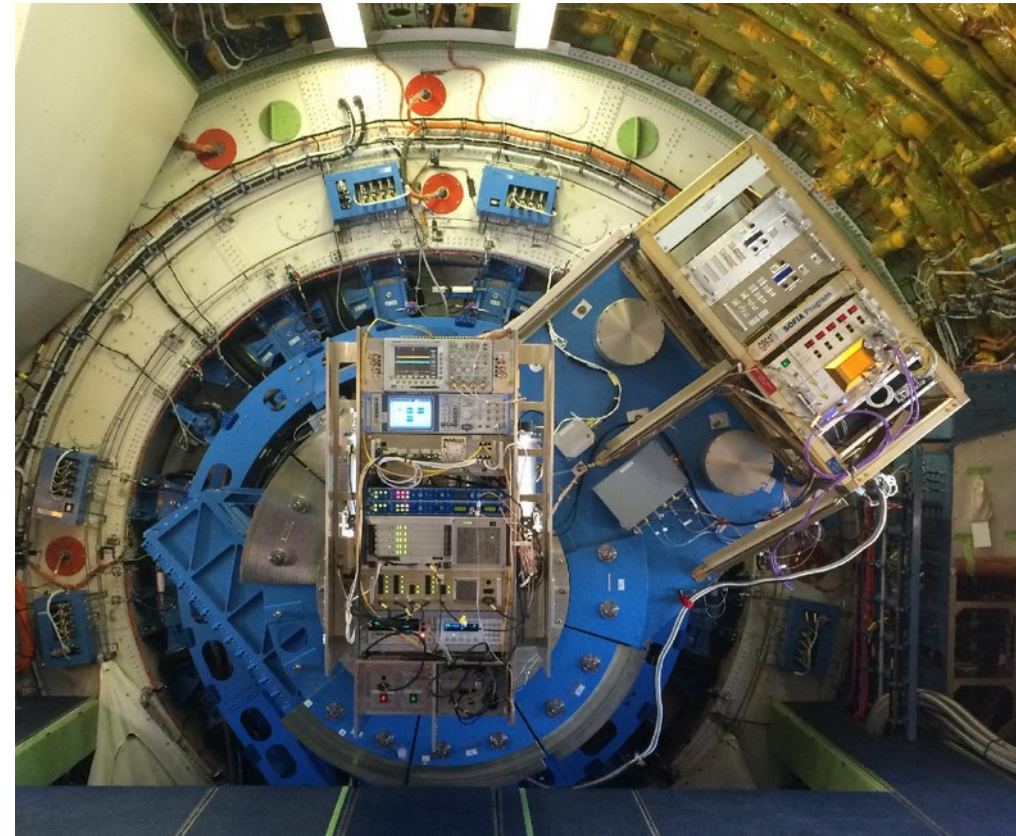


# How to observe with upGREAT on SOFIA



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- Main references
- What to observe?
  - Constraints
    - Instrument
    - Atmosphere
    - Flight tracks
- How to observe?
  - Noise
  - Observing modes
- How to use the data?
  - Data release
  - Data reduction





- SOFIA Observers Handbook
- <https://www.sofia.usra.edu/science/proposing-and-observing/observers-handbook-cycle-9>

A screenshot of the SOFIA Science Center website. The header includes the SOFIA logo and the text "SOFIA Science Center Stratospheric Observatory for Infrared Astronomy" with a "Home" link. A navigation bar contains links for "SOFIA Overview", "Proposing &amp; Observing", "Data", "Instruments", "Publications", "Meetings and Events", and "Announcements". A "Quick Links" sidebar on the left lists: "Subscribe to Newsletter", "Quick Guide", "Proposal Documents", "Current Flight Plans", "Data Archive", and "Help-Desk". The main content area shows a breadcrumb trail: "Home » For Researchers » Proposing and Observing » Observer's Handbook for Cycle 9". Below this is the title "Observer's Handbook for Cycle 9" and a link to "Download the PDF Version". A list of contents follows: "Changelog", "i. Table of Contents", "ii. Preface", "1. Introduction", "2. EXES", "3. FIFI-LS", "4. FORCAST", "5. FPI+", "6. GREAT", "7. HAWC+", and "8. The Data Cycle System". A "Changelog" link is at the bottom right of the list.

# SOFIA Toolbox

## Proposing & Observing

- ▶ [Proposal Calls](#)
- [Proposal Documents](#)
- [Proposal Tools](#)
- [Current Cycle Flight Plans](#)
- [Flying on SOFIA](#)

## Quick Links

- [Subscribe to Newsletter](#)
- [Quick Guide](#)
- [Proposal Documents](#)
- [Current Flight Plans](#)
- [Data Archive](#)
- [Help-Desk](#)

[Home](#) » [For Researchers](#) » [Proposing & Observing](#) » [Proposal Tools](#)

## Proposal Tools

### Unified SOFIA Proposal and Observation Tool (USPOT)

All proposals are to be prepared and submitted using the Unified SOFIA Proposal and Observation Tool (USPOT).

[Download USPOT](#)

### Exposure Time Estimation

Estimations of exposure times can be made using the SOFIA Instrument Time Estimator (SITE), a web-based tool that provides total integration time or S/N for a given instrument, filter(s), source type (point, extended, emission line), and water vapor overburden.

### ~~Atmospheric Transmission~~

~~The atmospheric transmission as a function of wavelength may be obtained using the on-line tool [ATRAN](#) developed and provided to the SOFIA program by Steve Lord. The use of ATRAN is *necessary* for planning SOFIA high-resolution spectroscopic observations.~~

**Not needed (integrated in SITE)**

### Target Visibility Tool

The target visibility for SOFIA can be determined using the [Visibility Tool \(VT\)](#), which is now **integrated in USPOT**

# Main source of info



- Data release
- Science archive at IRSA  
<https://irsa.ipac.caltech.edu/applications/sofia/>

A screenshot of the IRSA SOFIA Search web interface. The page has a dark header with the IRSA logo and navigation links: IRSA, DATA SETS, SEARCH, TOOLS, HELP. Below the header is a navigation bar with buttons for Search, Catalogs, Help, and Background Monitor. The main content area is titled 'SOFIA Search' and includes a link to 'Now includes Cycles 2-7, 7 instruments: important notes on archive completeness.' The 'Spatial Constraints' section is active, showing search criteria for 'NGC 1977' with a radius of 100 arcseconds. The 'Proposal Constraints' section shows 'Primary Investigator: Your name' and 'Plan ID: 09\_00200'. The 'Instrument Constraints' section shows 'GREAT' selected and 'Configuration: Very High Res. Spectroscopy (R ~ 1,000,000)'.

**IRSA** | DATA SETS | SEARCH | TOOLS | HELP

**SOFIA** Search Catalogs Help Background Monitor

### SOFIA Search

[Now includes Cycles 2-7, 7 instruments: important notes on archive completeness.](#)

**Spatial Constraints** Search for observations within a specified radius of a specified position. Enter search criteria below.

Object/Position      Name or Position:       Try NED then Simbad ▾

Multiple Positions

Solar System Target

Preccovery

All-Sky

**NGC 1977 resolved by NED**  
83.81582, -4.84434 Equ J2000 or 5h35m15.80s, -4d50m39.6s Equ J2000

Radius:       arcseconds ▾

Valid range between: 1" and 3600"

▼ **Proposal Constraints**

Primary Investigator:

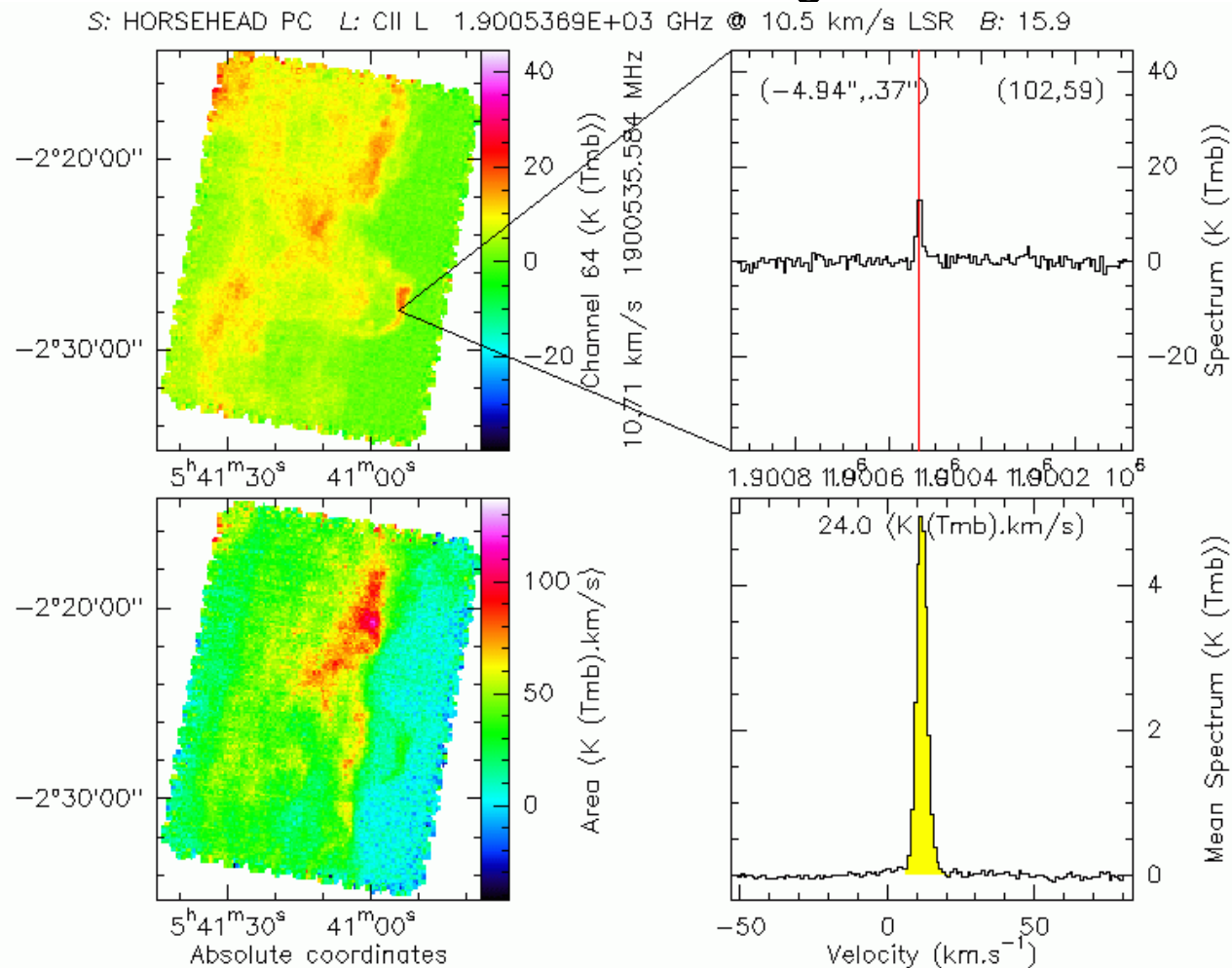
Plan ID:

► **Observation Constraints**

▼ **Instrument Constraints**

Configuration:

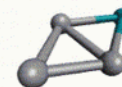
- Data release
- Data reduction: CLASS (GILDAS):
  - <https://www.iram.fr/IRAMFR/GILDAS/gildasli2.html>



## Good science driver is the key!

- What line(s) do I want to observe?
  - What is the line frequency?
- What source(s)?
  - coordinates, area
- What line intensity do I expect?
- Where is a good reference position?

### The Cologne Database for Molecular Spectroscopy CDMS



[Documentation](#) [Entries](#) [Description](#) [Search](#) [Partition Function](#) [Archive](#)

See the [General](#) part for a description of the content and the [home](#) page for citation!

Entries having an asterisk after the version number have been included in the database after acceptance of our new article on the CDMS, *J. Mol. Struct.*, **742** 215–227 (2005), in January, 2005. It can not be ruled out completely that recent entries contain errors.

**Note:** Entries having an asterisk after the tag state the temperature independent  $S_{\mu}^2$  instead of the intensity  $I$  at 300 K !!

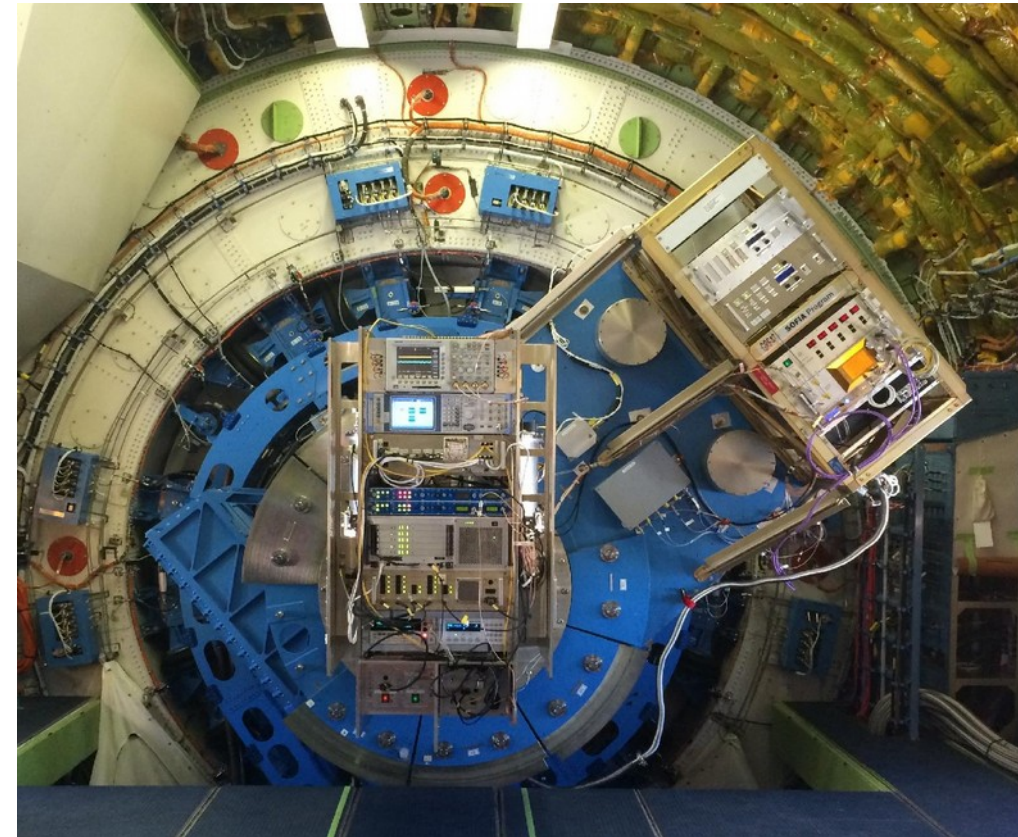
For some entries, where, for example, hyperfine splitting was important for the laboratory data, but is expected to be of minor importance for radioastronomical observations, separate predictions are available. Values of the partition function given in the respective documentation refer to the vibrational ground state only – unless stated otherwise.

Get one [list of partition functions](#) for the price of a half.  
Currently 1019 entries.

Tag	Name	# lines	Ver.	Catalog	Documentation	Date of entry	Entry in $\text{cm}^{-1}$
003501	HD	20	2*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e003501.cat</a>	Dec. 2011	<a href="#">w003501.cat</a>
004501	H <sub>2</sub> D <sup>+</sup>	196	3*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e004501.cat</a>	Mar. 2017	<a href="#">w004501.cat</a>
005501	HD <sub>2</sub> <sup>+</sup>	163	3*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e005501.cat</a>	Jan. 2018	<a href="#">w005501.cat</a>
005502	HeH <sup>+</sup>	18	1*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e005502.cat</a>	April 2008	<a href="#">w005502.cat</a>
012501	C	2	1*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e012501.cat</a>	Sep. 2005	<a href="#">w012501.cat</a>
012502	BH	15	1*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e012502.cat</a>	July 2008	<a href="#">w012502.cat</a>
012503	C <sup>+</sup>	1	1*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e012503.cat</a>	Aug. 2010	<a href="#">w012503.cat</a>
013501	<sup>13</sup> C	7	1*	<a href="#">HTML</a>   <a href="#">ASCII</a>	<a href="#">e013501.cat</a>	Sep. 2005	<a href="#">w013501.cat</a>

## German REceiver for Astronomy at Terahertz-Frequencies

- Heterodyne receiver
  - Dual channel
    - 2-5 frequencies simultaneously
  - 0.5 – 4.7 THz
    - in 6 frequency-bands

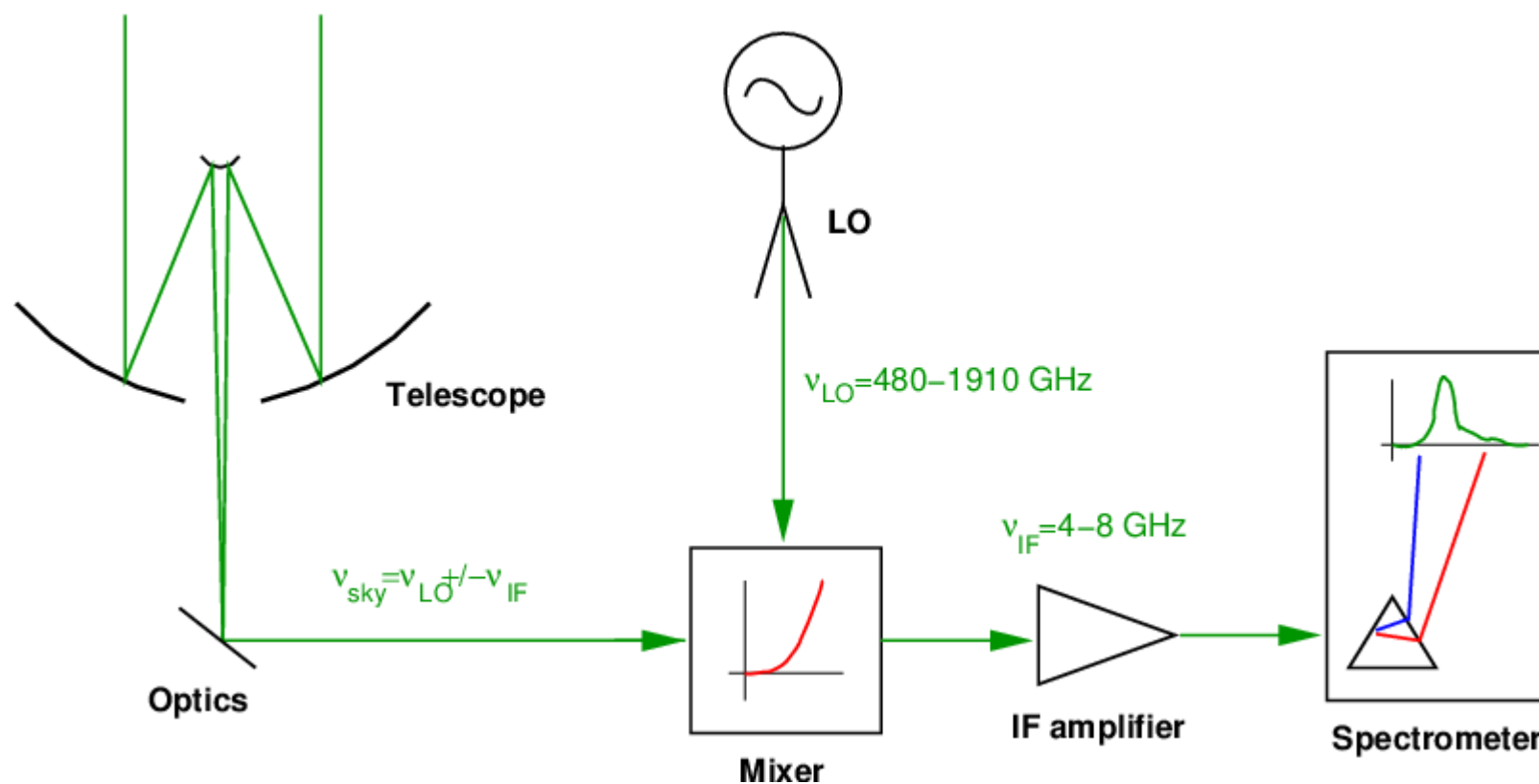


- Spectrometers: FFTS4G
  - 16k channels
  - Bandwidth: 4GHz
  - Resolution: 283kHz ( $R = 10^7$ )



## Heterodyne principle

- Mixing of sky signal with reference frequency
- Amplification of difference (IF) frequency



→ double-sideband sensitivity:  $\nu_{\text{sky}} = \nu_{\text{LO}} \pm \nu_{\text{IF}}$



## Radiometry

- Noise determined by
  - Forward efficiency, main beam efficiency  $\eta_{\text{fwd}} \approx 0.96$ ,  $\eta_{\text{mb}} \approx 0.7$
  - Receiver temperature (double sideband)  $T_{\text{rec,dsb}}$
  - Atmospheric transmission in signal + image sideband  $\eta_{\text{sky,ssb}}$ ,  $\eta_{\text{sky,isb}}$
  - Frequency resolution
  - Integration time

$$T_{\text{rms,ssb}} = \frac{T_{\text{sys,ssb}}}{\sqrt{t_{\text{int}} \times \Delta\nu}}$$

$$T_{\text{sys,ssb}} \approx \frac{2}{\eta_{\text{mb}} \eta_{\text{sky,ssb}}} \left[ T_{\text{rec,dsb}} + (1 - \eta_{\text{fwd}}) T_{\text{tel}} + \frac{1 - \eta_{\text{sky,ssb}}}{2} T_{\text{sky}} + \frac{1 - \eta_{\text{sky,isb}}}{2} T_{\text{sky}} \right]$$

## Radiometry

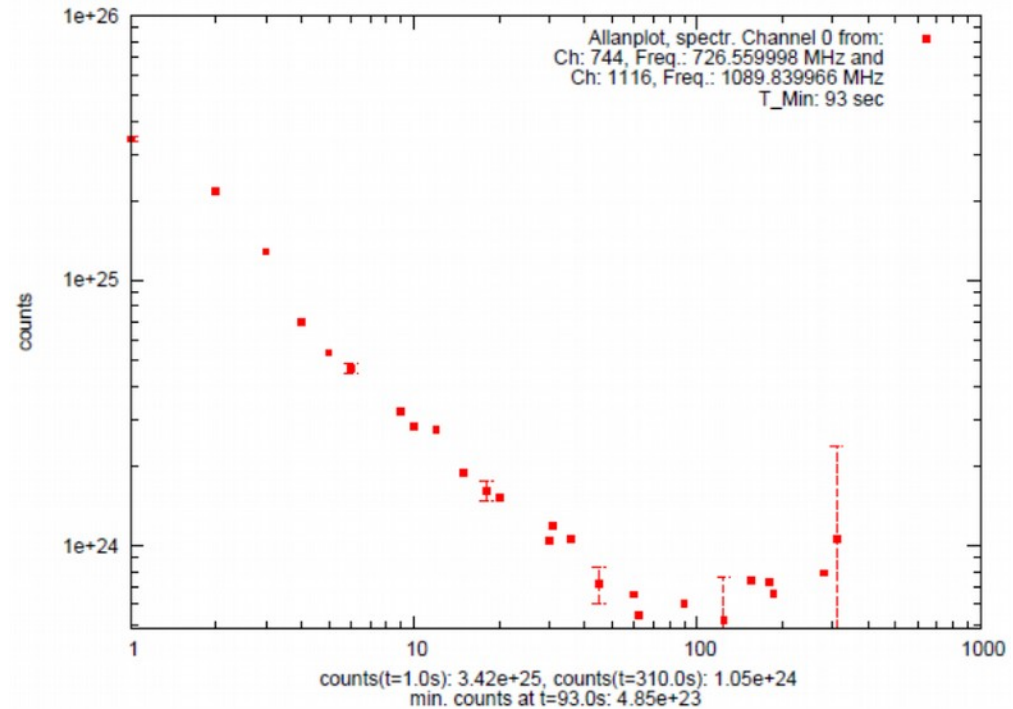
- Stability of heterodyne instruments ~ 100s

- Requires repeated OFF measurements

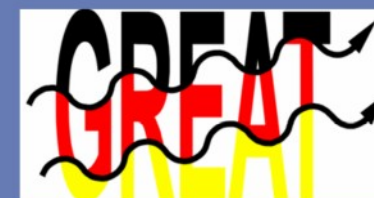
– Eat time and add noise

– Factor 2 for symmetric schemes with  $t_{\text{on}} = t_{\text{off}}$

$$T_{\text{rms,ssb}} = \frac{2 \times T_{\text{sys,ssb}}}{\sqrt{(t_{\text{on}} + t_{\text{off}}) \times \Delta\nu}}$$



4G3 stability Feb. 2018



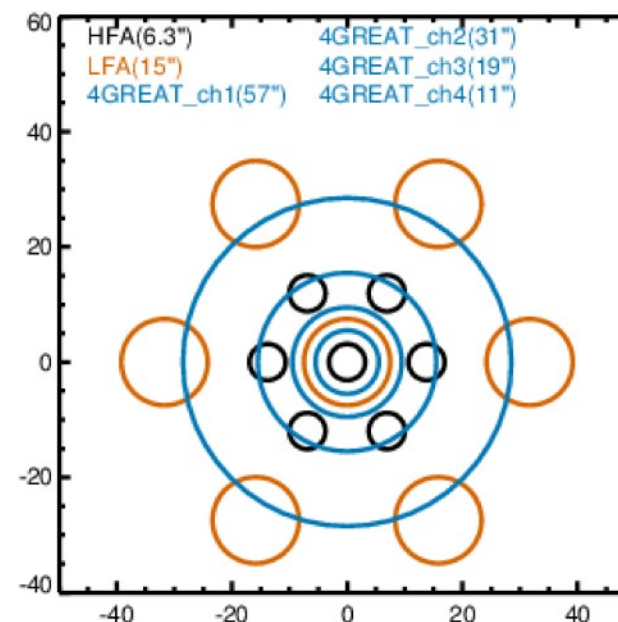
## Frequencies:

Channel		Frequencies [THz]	Pixels	Lines of interest	$T_{\text{rec,dsb}}$ [K]
4GREAT	4G1	0.491-0.555, 0.560-0.635	1	[CI], CH, CO, NH <sub>3</sub> , H <sub>2</sub> <sup>18</sup> O	120
4GREAT	4G2	(0.890)-0.984, 0.990-1.092	1	NH, OH <sup>+</sup> , CO, CS, HDO	350
4GREAT	4G3	1.2030-1.395, 1427-1.525	1	[NII], CO, OD, SH, H <sub>2</sub> D <sup>+</sup>	1100
4GREAT	4G4	2.490-2.590	1	OH	3300
upGREAT	LFA	1.835-2.007	2x7	CO, [CII], [OI], OH, CH	1050
upGREAT	HFA	4.74	7	[OI]	1250

Gaps in coverage from atmospheric blocking

- Beams:

- 57" (0.5 THz) ... 6.6" (4.74 THz):





## Tested lines (incomplete):

### 4G-1

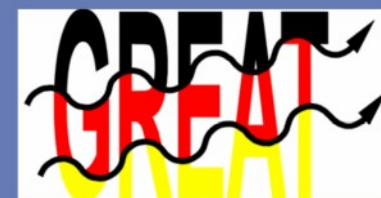
IF Offset 6		
Specie	Rest (GHz)	SB
HDO(110-101)	509.29242	
CH_559	536.7610	USB
H218O(110-101)	547.67644	USB
NH3(100-001)	572.49816	
CO J = 5-4	576.26793	
HCl(1-0)	625.91876	

### 4G-2

IF Offset 6		
Specie	Rest	SB
HDO(111-000)	893.63867	
OH+(10-01)	909.1588	
CO(8-7)	921.7997	
OH+(12-01)	971.8038	
NH	974.47861	USB
H3O+(000-101)	984.71191	USB
13CO(9-8)	991.32935	LSB
H218O(202-111)	994.67513	LSB
OH+(11-00)	1033.1186	USB
CO(9-8)	1036.9124	LSB
H2S(221-110)	1072.8365	LSB

- Check for your own lines of interest in covered frequency range

# Frequencies



MPIfR  
KOSMA  
MPS  
DLR-Pf

## 4G-3

IF Offset			2
Specie	Rest	SB	
HF(1-0)	1232.476		
HCN(14-13)	1239.890		
HCO+(14-13)	1247.735		
HCL(2-1)	1251.4519		
CO(11-10)	1267.0145		
H2O2(1274)	1274.577	USB	
H2O(743-652)	1278.265	USB	
H2O(827-734)_L	1296.4111		
H2F+(111-000)	1305.315		
HCN(15-14)_U	1328.3022	USB	
7LiH(3-2)_U	1329.414	USB	
PH3(5-4)_L	1333.2	LSB	
HCO+(15-14)_L	1336.7149	LSB	
6LiH(3-2)	1356.928		
H2D+(101-000)	1370.0849		
CO(12-11)	1381.9951		
SH	1383.08		
OD_LOW	1390.614	USB	
OD_HIGH	1391.4947	USB	

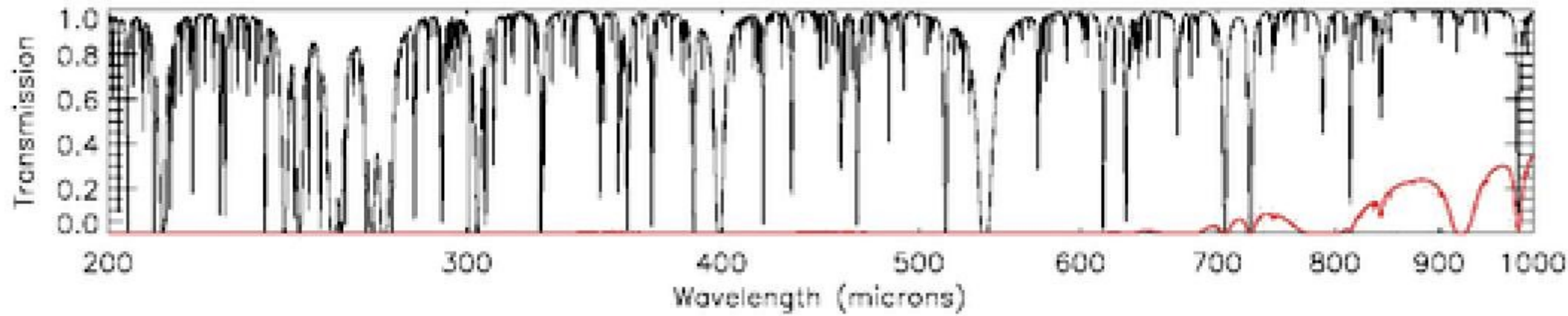
## 4G-4

IF Offset			2
Specie	Rest	SB	
18OH2PI32_L	2494.6951		
18OH2PI32_H	2498.9945		
OH2PI32_L	2509.949		
OH2PI32_H	2514.3167		
CO(22-21)	2528.1721		
HD(1-0)_L	2674.9861		

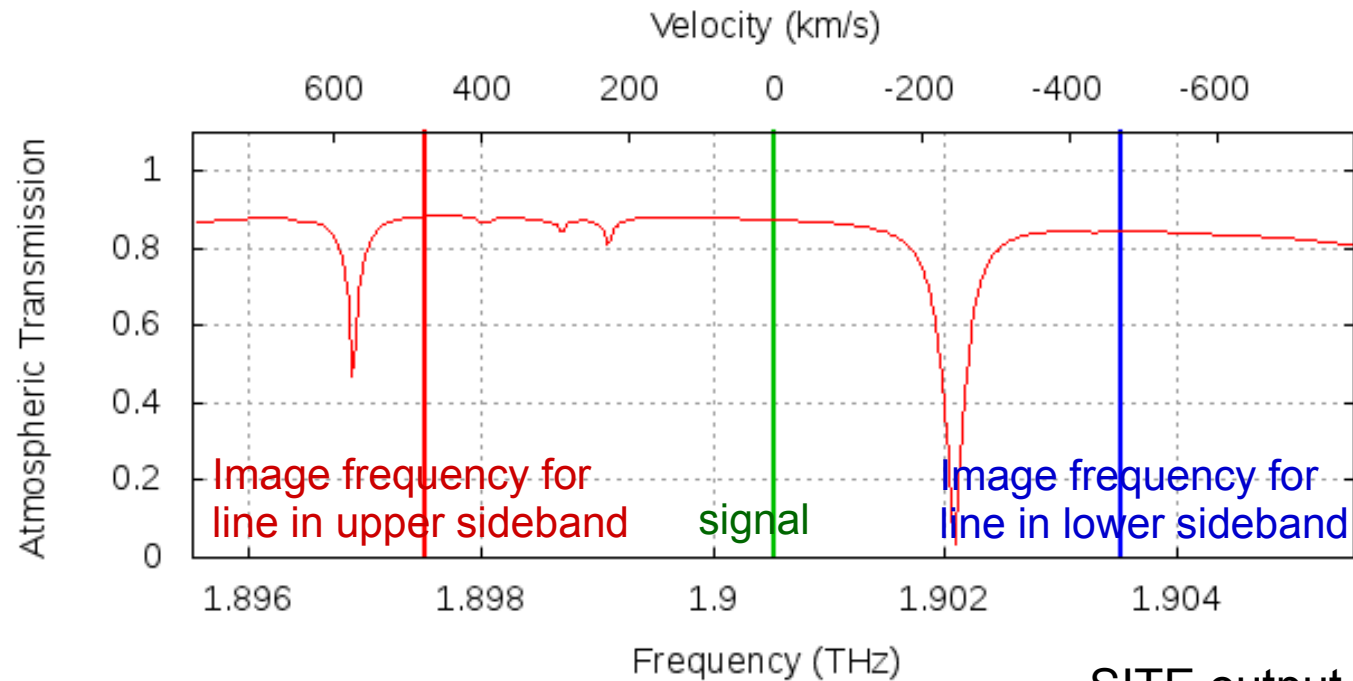
## LFA

IF Offset			1.5
Specie	Rest	SB	
HCN(14-13)	1239.8903	LSB	
HCO+(14-13)	1247.7350	LSB	
CO(11-10)	1267.0145	USB	
OD	1391.4947	USB	
CO(16-15)	1841.3455	USB	
CII	1900.5369	LSB	
CH_149	2006.7625	USB	
OI_145	2060.0688	USB	

**But:** Be aware the atmosphere!



- Atmospheric lines cover parts of the bands
- Coverage depends on observing date
- Selection of the sideband where atmospheric noise from image sideband is minimized



SITE output



- Check the atmospheric transmission in the time estimator:
  - <https://dcs.arc.nasa.gov/proposalDevelopment/SITE/index.jsp>

### SOFIA Instrument Time Estimator (SITE)

**Please Check 'Notes and Known Issues' Before Proceeding**

---

**Spectroscopic Time Estimators and Tools**

FIFI-LS      FORCAST GRISM      FLITECAM GRISM      **GREAT**      EXES      ATRAN

**Imaging Time Estimators**

FORCAST      FLITECAM      FLITECAM\_HIPO      HAWC\_Plus      FPI\_Plus

The following four sections of this form are for imaging configurations: select the instrument, astronomical source, telescope, observing condition constraints and calculation method. Click on the  button to submit the parameters from all the sections to the server. The results are reported in a separate web page that can be resized and printed.

---

**Instrument properties**

**Instrument properties:** *(more info, input parameter details)*

Rest Frequency: ( GREAT Band Frequencies)	<input type="text" value="1.9005369"/>	(THz, use 7 decimals)
Frequency/Velocity Resolution:	<input type="text" value="1.0"/>	<input type="radio"/> MHz <input checked="" type="radio"/> km/s
Line Width (for averaging sky transmission):	<input type="text" value="500.0"/>	<input checked="" type="radio"/> MHz <input type="radio"/> km/s
Type of Observation:	<input type="radio"/> SinglePoint or BeamSwitch OTF/Raster Map	<input checked="" type="radio"/> TP OTF/Raster Map
TP OTF Map Size (X × Y in arcsec):	<input type="text" value="300.0"/>	× <input type="text" value="200.0"/>
N <sub>on</sub> :	<input type="text"/>	
Map Type:	<input checked="" type="radio"/> Classical OTF	<input type="radio"/> Array OTF



- Check the atmospheric transmission in the time estimator:

## Output Parameters

$N_{on}$	50
Rest Frequency of the line incl. Doppler correction	1.899933 THz
$V_{LSR}$	95.250 km/s
Single Sideband System Temperature (LSB tuning)	2795 K
Single Sideband System Temperature (USB tuning)	3412 K
Integration Time (LSB, ON source per map point)	37.4 seconds
Integration Time (USB, ON source per map point)	55.7 seconds
Mean Atmospheric Transmission (RestFreq)	0.87
Mean Atmospheric Transmission (USB)	0.83
Mean Atmospheric Transmission (LSB)	0.60

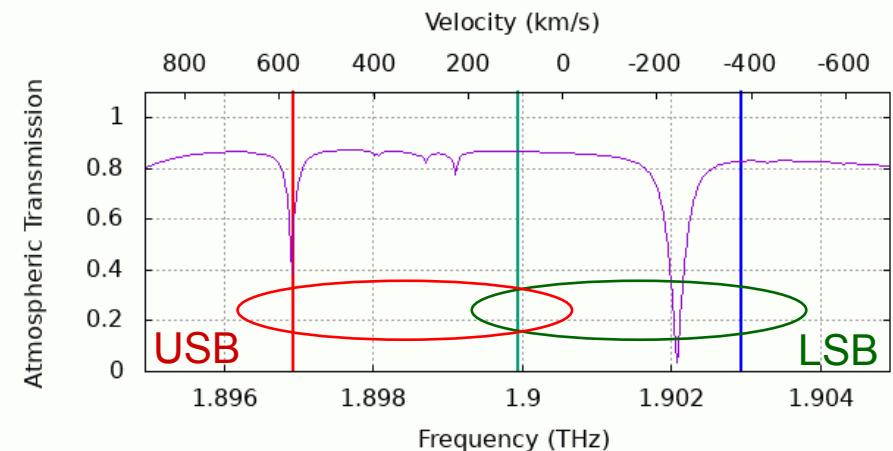
## Assumed Parameters

Ambient temperature for the atmosphere	178.0 K
Physical Temperature of the Telescope	188.0 K
Telescope Efficiency incl. ohmic losses and spillover	0.92
Double Side Band Receiver Temperature	1050.0 K
Forward Scattering Efficiency	0.97

## Input Parameters

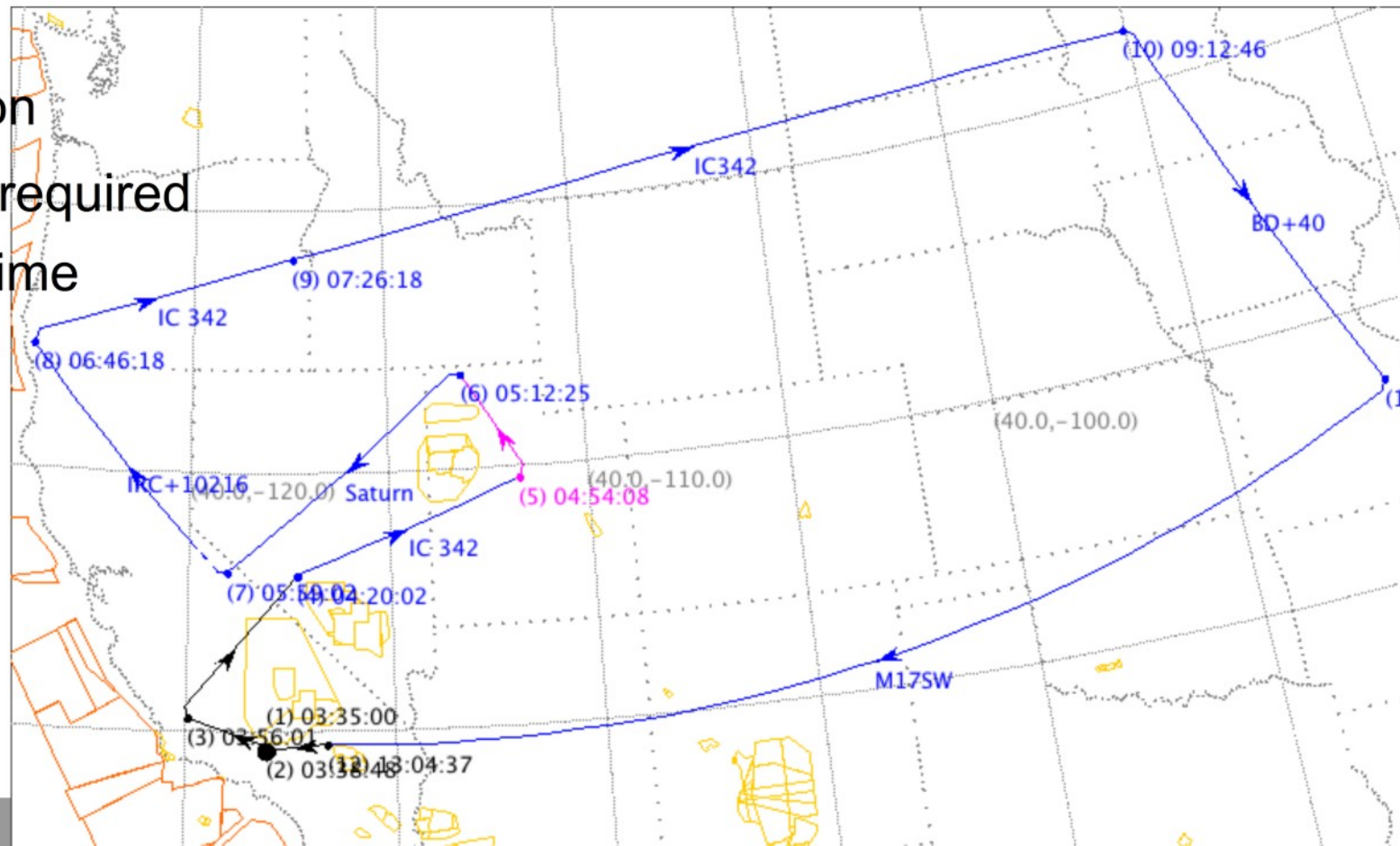
Observation Type	TP OTF Mapping
Rest Frequency	1.900537 THz
Spectral Resolution	1.000 km/s
Line Width	10.000 km/s
OTF Map Size	300.0 X 200.0 arcseconds
Map Type	Classical OTF
Calculation Method	Estimate Integration Time for given SNR and line strength
Total signal to noise	5.0
Brightness Temperature	1.0 K
Source Velocity	80.0 km/s
Observer Velocity Type - Computed value of 15.249691507352562 km/s based on	

## Plot of Atmospheric Transmission

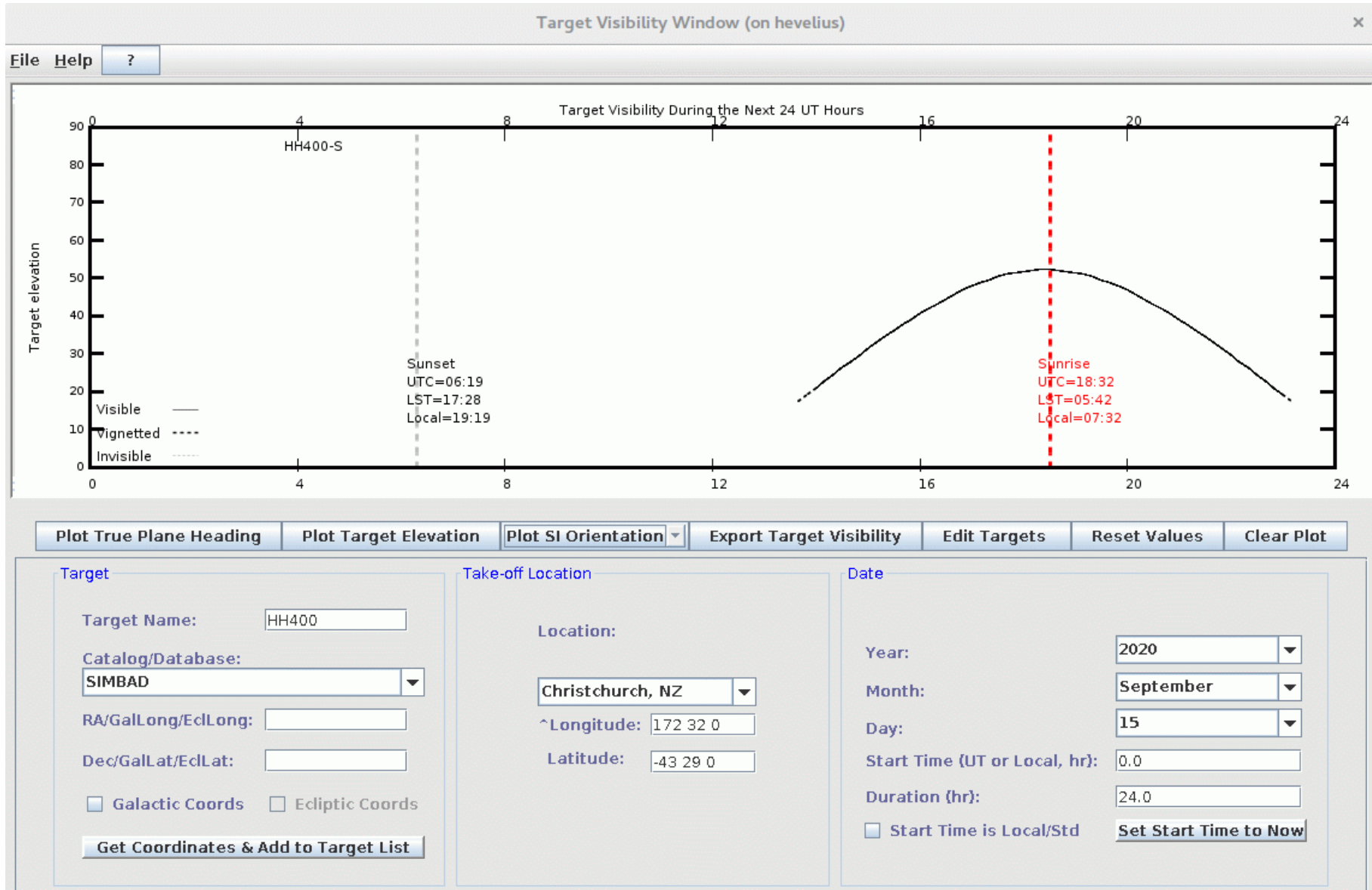


The green line shows the position of the line in the signal sideband.  
The red line shows where the image band would be if the line is placed in the upper sideband.  
The blue line shows where the image band would be if the line is placed in the lower sideband.

- Time constraints:
  - LSR velocity of source relative to atmospheric features
    - GREAT time estimator
  - Visibility at observing altitude
    - $20^{\circ}$ - $60^{\circ}$
  - Flight direction
    - Round-trip required
    - Maximum time per lag  $\sim 3$ h

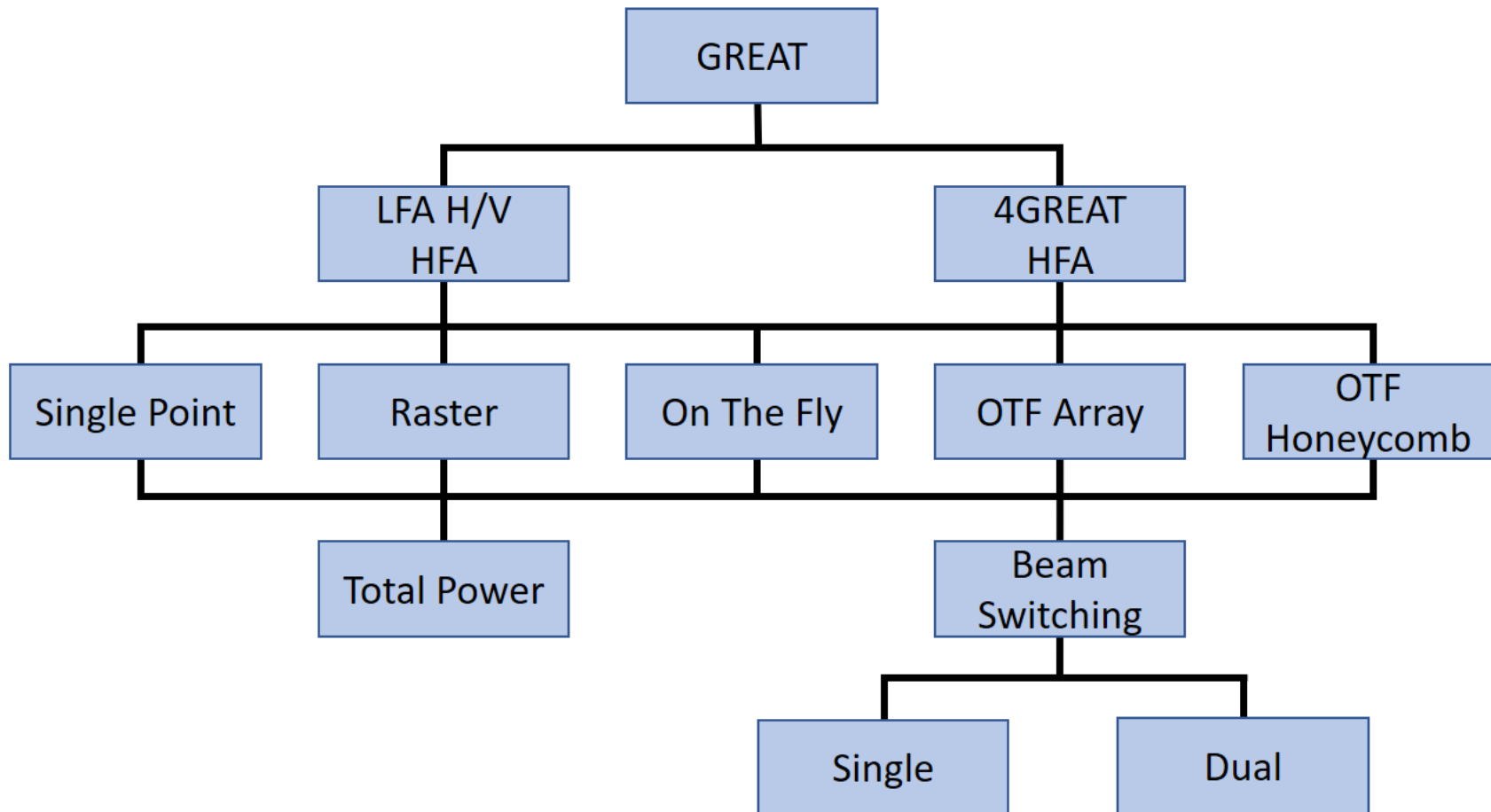


- Visibility Tool (in USPOT):





- Detector arrays only in fixed combinations offered:



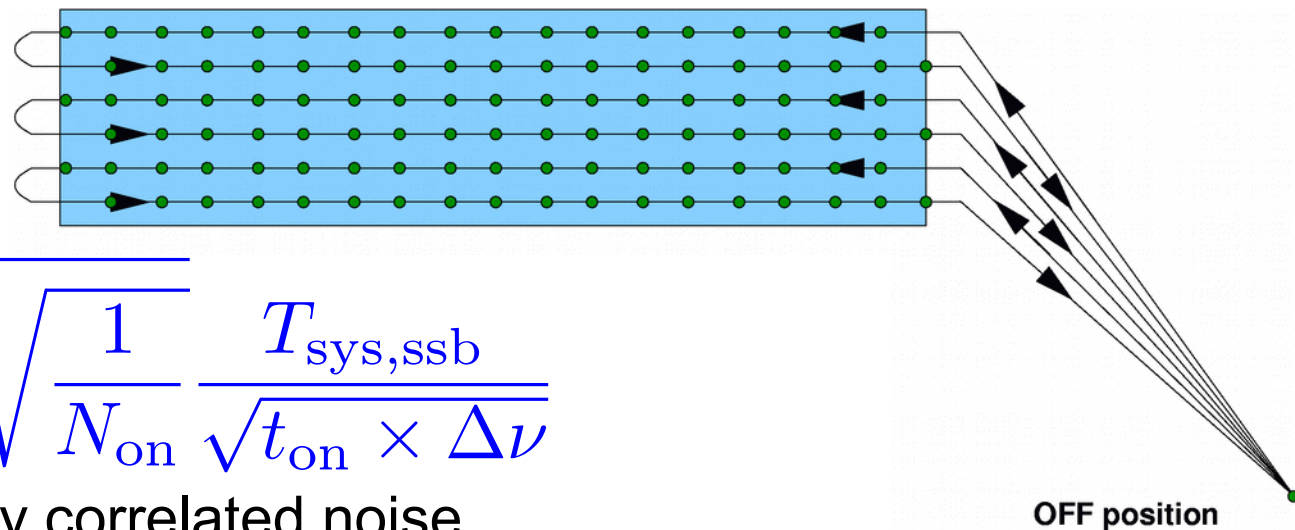
Instrument
Configuration
AOT
Mode
Mode Option

- Symmetric modes  $t_{\text{on}} = t_{\text{off}}$ 
  - e.g. double-beam switch (=chop-nod)
  - for broad lines/instable frequencies

$$T_{\text{rms,ssb}} = \frac{2 \times T_{\text{sys,ssb}}}{\sqrt{(t_{\text{on}} + t_{\text{off}}) \times \Delta\nu}}$$

- OTF mapping

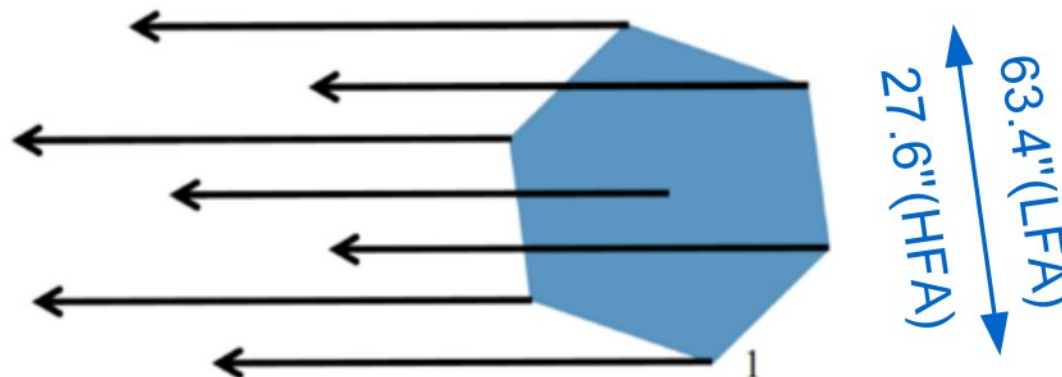
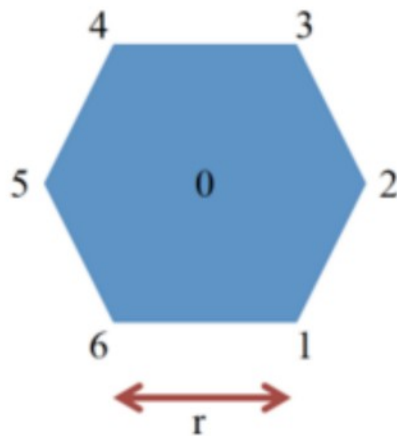
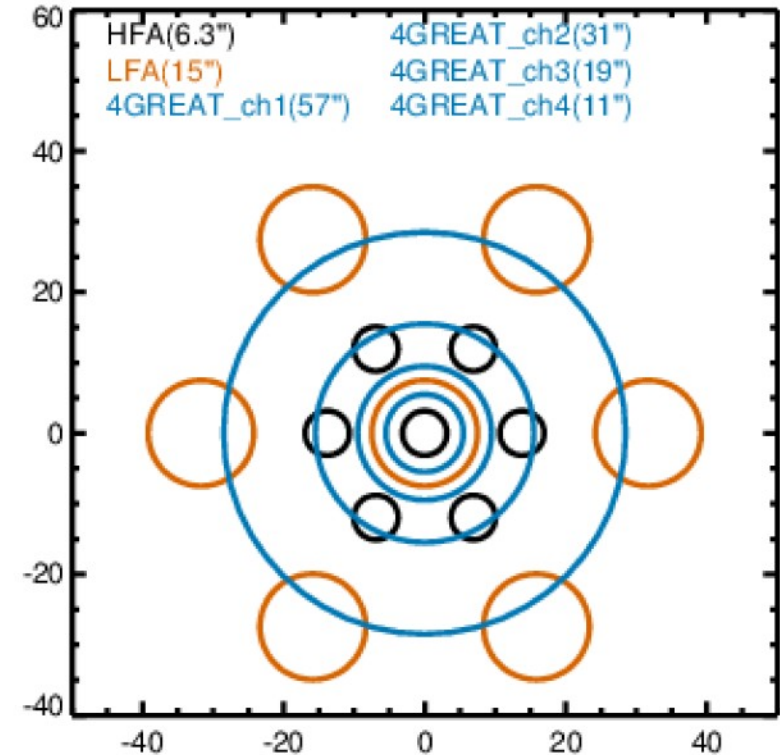
- Combines  $N_{\text{on}}$  map points with a single OFF measurement
- Saves time and noise



$$T_{\text{rms,ssb}} = \sqrt{1 + \sqrt{\frac{1}{N_{\text{on}}}} \frac{T_{\text{sys,ssb}}}{\sqrt{t_{\text{on}} \times \Delta\nu}}}$$

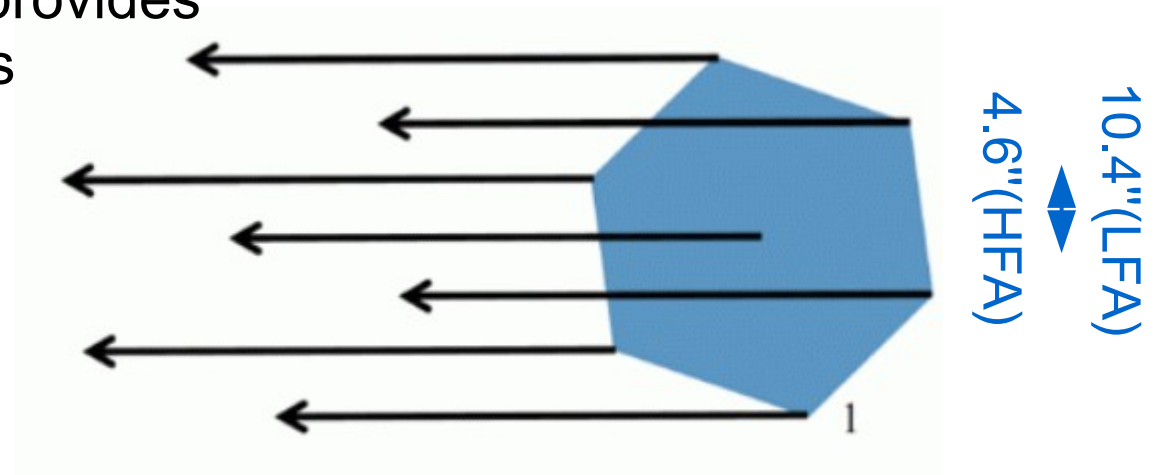
- But introduces spatially correlated noise

- Combine with receiver geometry
  - Single pixels (4GREAT)
    - Use Nyquist sampling or half-beam sampling depending on beam width
  - Array mapping (LFA, HFA)
    - Array tilt by 19.1 degrees provides equal spacing of scan lines

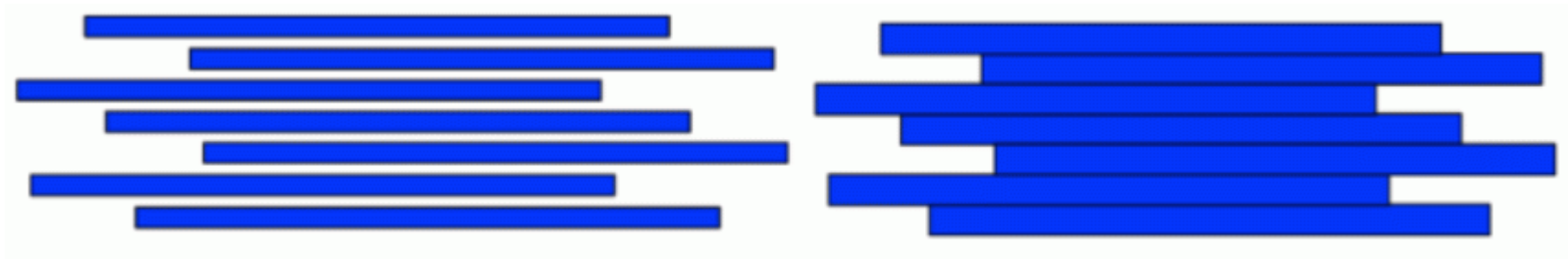


- Array mapping (LFA, HFA)

- Array tilt by 19.1 degrees provides equal spacing of scan lines



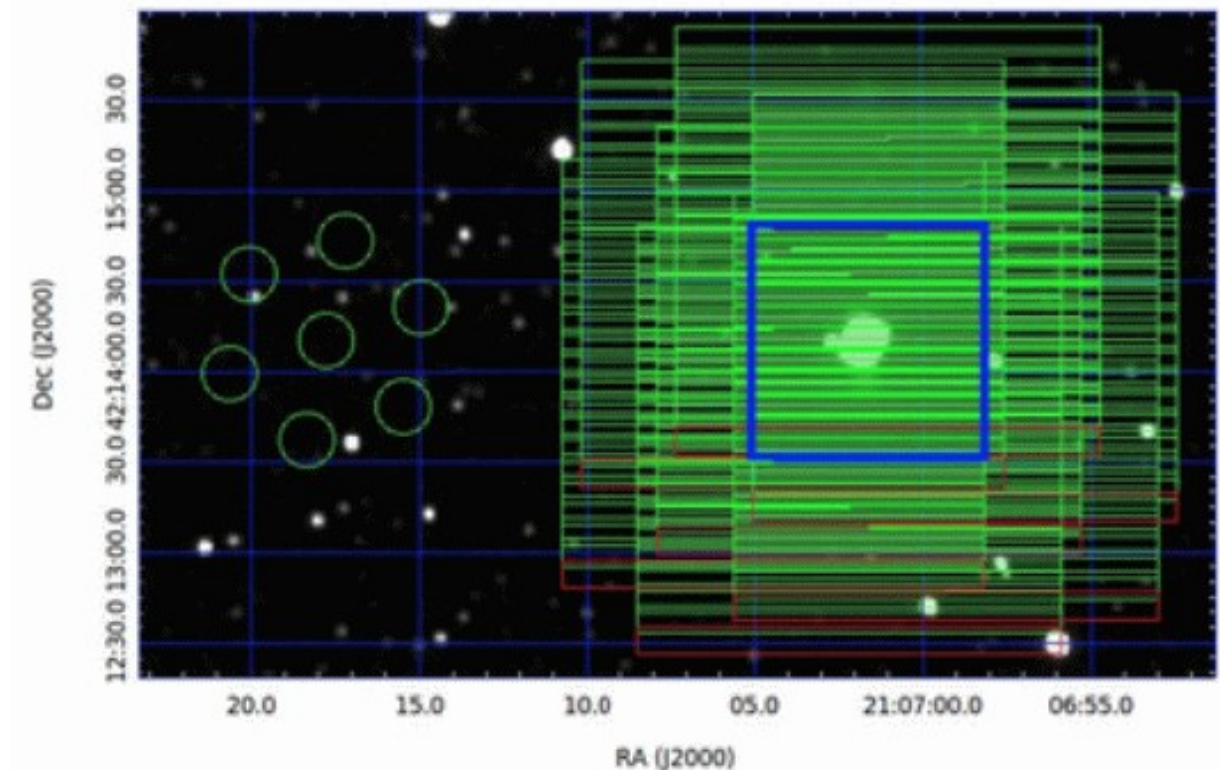
- Two adjacent scans provide fully sampled maps



- 5.2" spacing for LFA
- 2.3" spacing for HFA

- Classical OTF

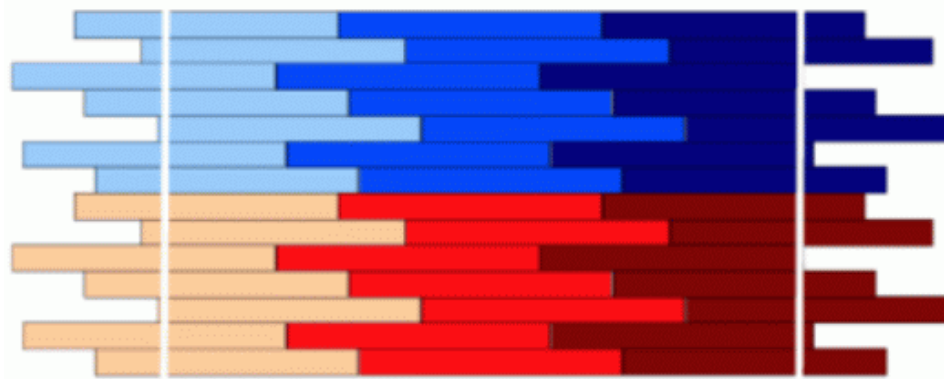
- Every pixel covers every part of the map
- Allows to compensate for different pixel sensitivities
  - Provides uniform noise over the map
  - Gradual increase at the edges
- Arbitrary map size
- Best mode for majority of observations



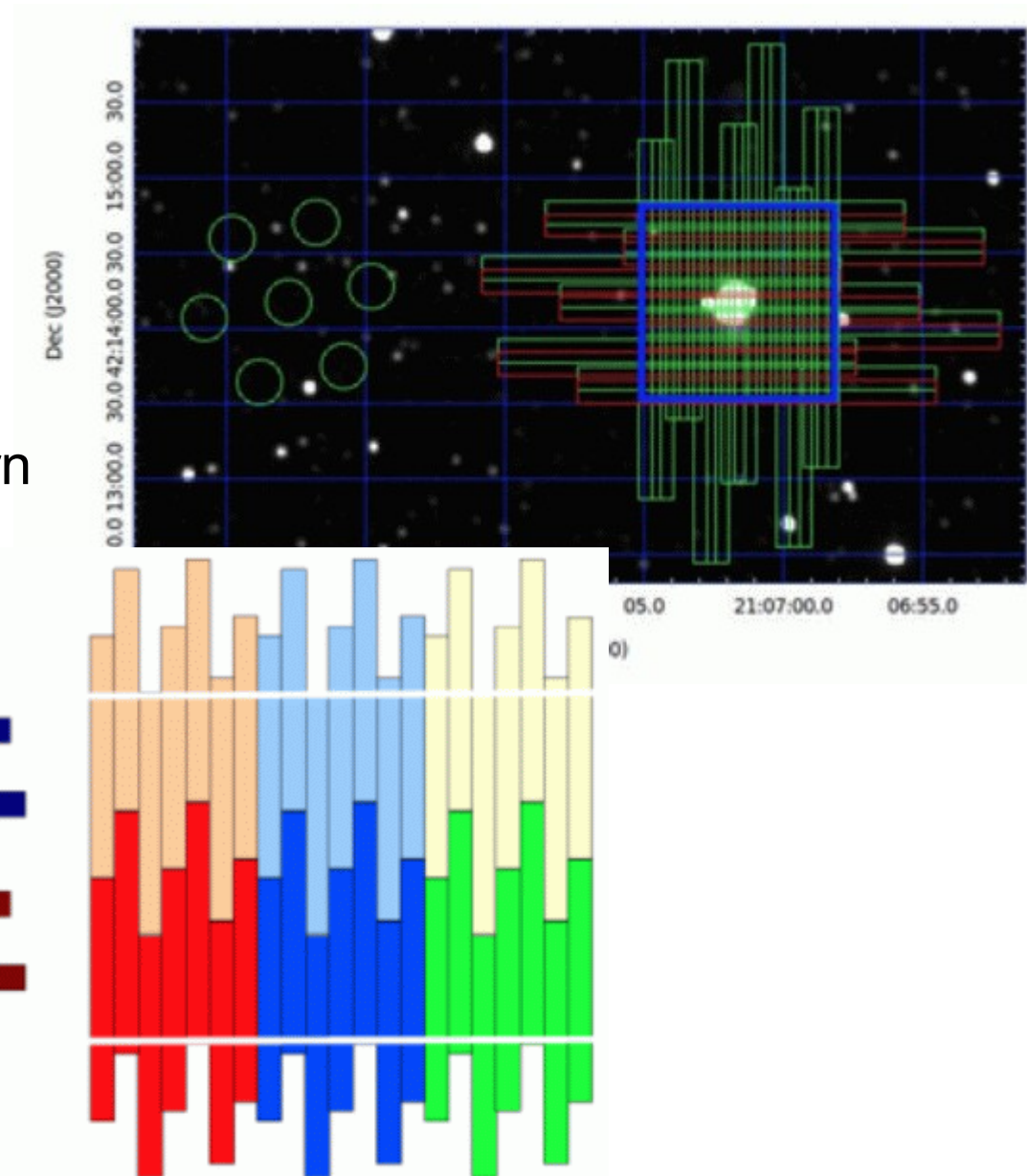


- Array OTF

- Assembly of map from fastest array coverages
- Mosaicing for large areas
  - 73.8" (LFA), 32.2" (HFA)
- Possible stripes in noise pattern for varying pixel sensitivities
- Not in HFA-LFA combination

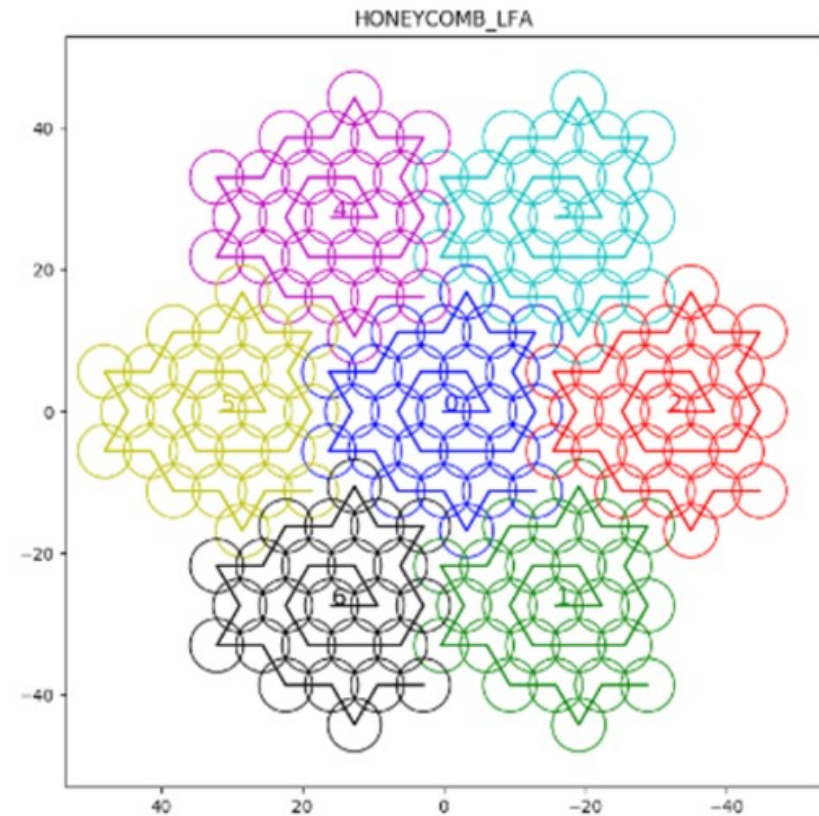


- For strong extended sources with short integration time



- Honeycomb-OTF

- Fills in the spaces between the array pixels by quasi-spiral motion
- Avoids irregular map edges
- Hexagonal pattern
  - Mosaicing for larger areas possible
- Patchy noise pattern possible in case of varying pixel sensitivities
- Not in HFA-LFA combination
- Ideal for sources with about the size of the arrays





- USPOT (4.3.1):

Unified SOFIA Planning Tool (USPOT) (on hevelius)

File Edit Targets Observation Tools Images Overlays Options Window View Help

Observations

### Astronomical Observation Requests (AORs)

Label	Target	Position	Instru...	Duration	Stat	On	Mode	Ex...	Filter 1	Filter...	Slit	Ch...	Ch...	No...	No...	a
S235A	S235A	5h40m52.8000s, +35d4...	GREAT OTF	861	new	<input checked="" type="checkbox"/>	Total_Power	371	GRE_HFA	GRE_LFA	0.0	0.0				08_
S235C	S235C	5h40m52.2000s, +35d3...	GREAT OTF	861	new	<input checked="" type="checkbox"/>	Total_Power	371	GRE_HFA	GRE_LFA	0.0	0.0				08_

Unique AOR Label: GREAT\_OTF-S235A

Target: S235A Type: SOFIA Fixed Single  
85.220000, 35.700000 Equ J2000 or 5h40m52.8000s, +35d42m00.000s Equ J2000

New Target Modify Targ... Target List...

#### Observing Condition & Acquisition / Tracking

**Instrument Parameters**

- \* Velocity (km/s) [-26.000]
- \* HFA Frequency (GHz) [1,744.777490]
- \* 4G Frequency 4 (GHz) [1,514.316705]
- \* 4G Frequency 3 (GHz) [1,267.014490]
- \* 4G Frequency 2 or LFAH Freq. (GHz) [1,900.536900]
- \* 4G Frequency 1 or LFAV Freq. (GHz) [1,060.141000]
- \* Primary Frequency [HFA]
- \*\* Tracking required in off position [FFI]
- \*\* ID String (SMO Only) [ ]
- Desired Resolution (km/s) [0.200]
- Expected Linewidth (km/s) [3.000]
- \* Mixer 1 [GRE\_HFA]
- \* Mixer 2 [GRE\_LFA]

\* Instrument Mode [Total Power]

Chop Throw (arcsec) [0.000]

Chop Angle (deg) [0.000]

Chop Angle Coordinate [Sky]

Reference Position

Ref Type

By Offset

By Position

Reference Name [ ]

RA Offset (arcsec) [600.000]

Dec Offset (arcsec) [180.000]

RA (deg) [85.425298]

Dec (deg) [35.750000]

Position: 5h41m42.0715s, +35d45m00.000s

Choose Position

**Mapping Parameters**

Array Rotation Angle (deg) [-19.000]

Exposure Time Per Cycle (sec) [674.34]

\* On-source Exp. Time Per Point (sec) [0.2]

\* Cycles [4]

Min Contiguous Exp Time (sec) [0.000]

Map Offset RA (arcsec) [0.000]

Map Offset Dec (arcsec) [0.000]

Step size in the x-direction (arcsec) [2.600]

Step size in the y-direction (arcsec) [2.600]

\* Num Steps in the x-direction [61]

\* Num Steps in the y-direction [49]

ScanDirection [x direction]

\*\* ScanDirectionVector [+1]

\*\* ScanOrder [-1]

\*\* Scan Lines Per Off [1]

MapAngle (deg) [0.000]

\*\* Number of off measurements per load [5]

\*\* Number of OTF lines per load [5]

(\*\* = Advanced) (\* = required for Phase I)

recompute): 61 min Awarded: 30 min

Observation Est... Comments... Proposal Info...

- Classical OTF:

### Mapping Parameters

Array Rotation Angle (deg)	-19.000
Exposure Time Per Cycle (sec)	674.34
* On-source Exp. Time Per Point (sec)	0.2
* Cycles	4
Min Contiguous Exp Time (sec)	0.000
Map Offset RA (arcsec)	0.000
Map Offset Dec (arcsec)	0.000
Step size in the x-direction (arcsec)	2.600
Step size in the y-direction (arcsec)	2.600
* Num Steps in the x-direction	61
* Num Steps in the y-direction	49
ScanDirection	x direction
** ScanDirectionVector	+1
** ScanOrder	-1
** Scan Lines Per Off	1
MapAngle (deg)	0.000
** Number of off measurements per load	5
** Number of OTF lines per load	5

(\*\* = Advanced) (\* = required for Phase I)

The screenshot shows the KOSMA software interface. At the top, there is a menu bar with options: File, Edit, Targets, Observation, Tools, Images, Overlays, Options, Window, View, Help. Below the menu bar is a toolbar with various icons. The main window displays a star field with a red OTF pattern overlaid. The OTF pattern consists of several overlapping red rectangles centered on a bright star. The interface also shows a status bar at the bottom with the text: Proposal Observations 2MASS- k, S235A. On the left side, there is a vertical toolbar with icons for zooming, panning, and other navigation functions. The main window also displays a coordinate grid with labels such as 5h41m12s, 5h41m04s, 5h40m56s, 5h40m48s, 5h40m40s, 5h40m32s, 5h40m24s, 5h40m16s, 5h40m08s, 5h40m00s. The status bar at the top of the main window displays: Flux: 266.43054 DN, EqJ2000 RA: 5h40m44.72s, X: 348.50000, 1 Pixel: 1.00000", EqJ2000 Dec: +35d42m39.3s, Y: 289.50000. Below the status bar, there is a section for mouse controls: Mouse Con... Meta-Left Mouse Button: Drag to adjust bias (horizontally) and contrast (vertically); double-click to r... Mouse: Shift-Left Mouse Button: Shift the center of image.

- Array OTF:

Parameters for Scans Mapping

Parameters for scans in x direction

- \* Scan length in units of array size (31.6" or 72.6")
- \* Number of blocks in scan direction
- \* Number of blocks perpendicular to scan direction
- \* Exp. Time per Point (sec)

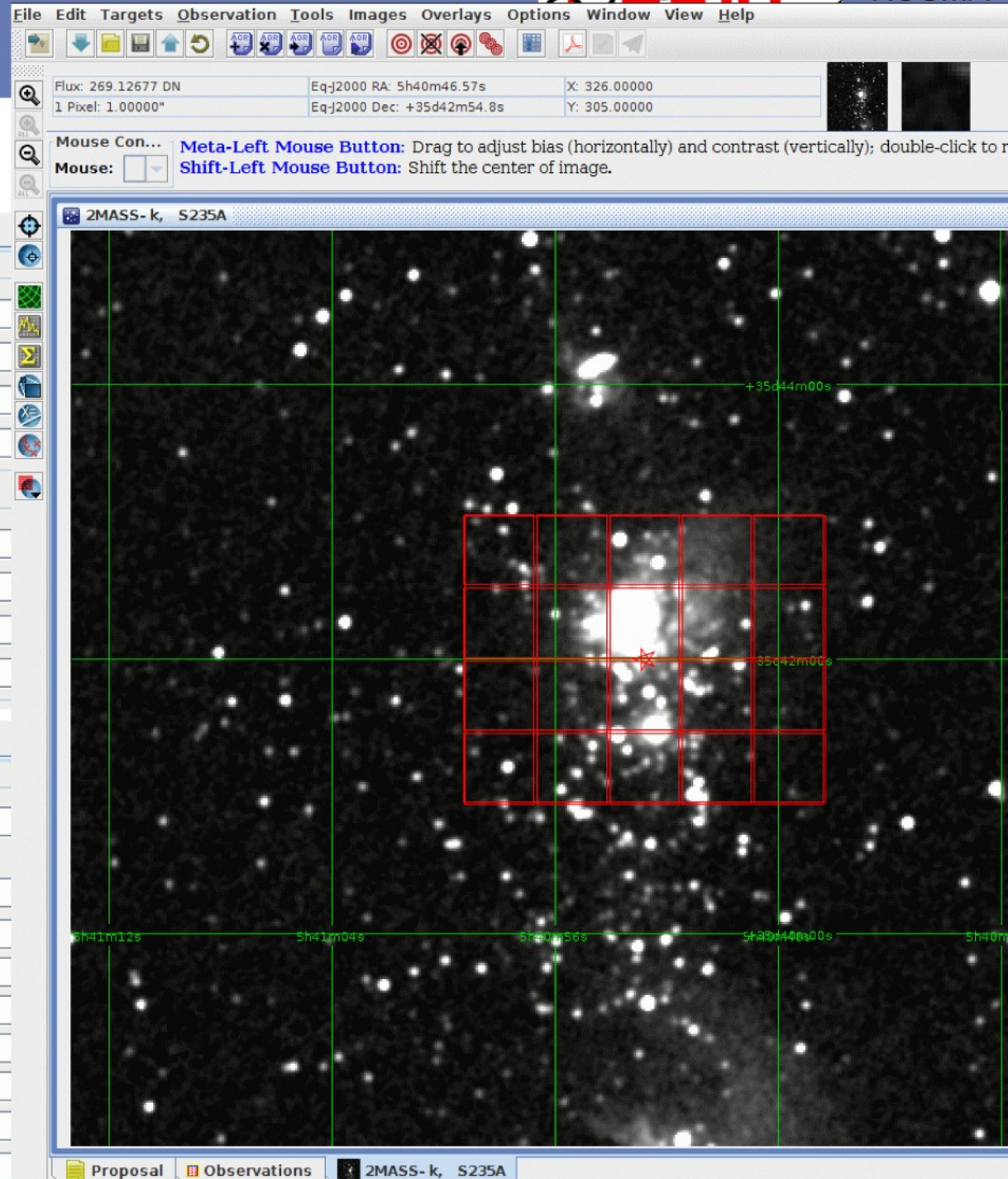
Parameters for scans in y direction

- \* Scan length in units of array size (31.6" or 72.6")
- \* Number of blocks in scan direction
- \* Number of blocks perpendicular to scan direction
- \* Exp. Time per Point (sec)

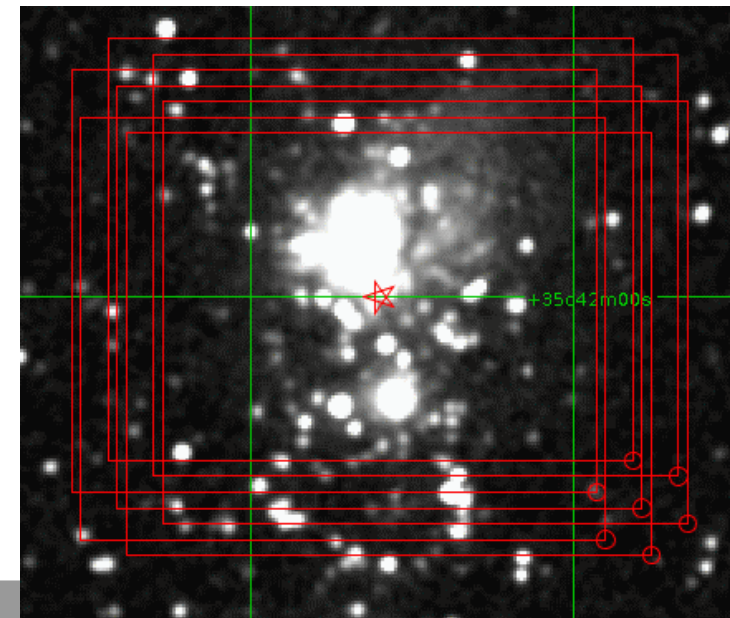
Parameters for Scans Mapping

Mapping Parameters

- Array Rotation Angle (deg)
- Exposure Time Per Cycle (sec)
- \* Cycles
- Min Contiguous Exp Time (sec)
- MapAngle (deg)
- Map Offset RA (arcsec)
- Map Offset Dec (arcsec)
- \*\* Number of OTF lines within one block
- \* Step size along OTF line
- \*\* Scan Lines Per Off
- ScanDirection



- Output from SITE for GREAT → USPOT (4.3.2)
  - Single point observations
    - Use  $t_{\text{on}+\text{toff}}$  in USPOT as given by time estimator
  - Single beam switch / double beam switch mapping
    - Divide  $t_{\text{on}+\text{toff}}$  by 2 for input as  $t_{\text{on}}$  in USPOT
  - Array-OTF
    - Use  $t_{\text{on}}$  in USPOT as given by time estimator
  - Classical OTF
    - Divide  $t_{\text{on}}$  from time estimator by number of pixels for central area
      - 1/14 for LFA
      - 1/7 for HFA
    - But: unavoidable increase of noise at edges





- Release:

Proposal Identification	75_0015	
Project Title	Horsehead and the IC434 PDR interface	
Principle Investigator	E. Young	eyoung@sofia.usra.edu
SMO contact person	G. Sandell, E. Chambers	gsandell@sofia.usra.edu, echambers@sofia.usra.edu
GREAT processing liaison	D. Riquelme (MPIfR)	riquelme@mpifr-bonn.mpg.de

Observations			
Mission Identification	2015-12-11-GR_F266		
Flight date	2015 December 11		
GREAT configuration <sup>(1,2)</sup>	front-ends: LFA	back-ends: 4GFFT spectrometers	
Astronomical Sources	Horsehead, IC434	Scans: 12715-12790	lines: CII

Calibrated data products based on: kosma\_calibrator ver. December 2015, GILDAS software ver. Nov15a

product level	file name	description
3a	Cycle3_GR_DDT_75_0015_EYoung_Ta.great Cycle3_GR_DDT_75_0015_EYoung_Ta_reduced.great  Cycle3_GR_DDT_75_0015_EYoung_Tmb_CII.great	Calibrated to $T_A^*$ scale ( $\eta_f = 0.97$ ). Calibrated to $T_A^*$ scale, baselines removed as explained in the Data Reduction letter. All scans quality validated. Calibrated <sup>(3)</sup> to $T_{mb}$ scale, using $\eta_{mb}$ (LFA-V) = (0.67, 0.71, 0.71, 0.70, 0.65, 0.66, 0.71) $\eta_{mb}$ (LFA-H) = (0.66, --, 0.60, --, 0.66, 0.68, 0.70). Pixel H1 and H3 are not included. Independent fit of dry & wet atmosphere. Created with Cycle3_GR_DDT_75_0015_EYoung.class.
3b	Cycle3_GR_DDT_75_0015_EYoung_CII.lmv  Cycle3_GR_DDT_75_0015_EYoung_CII.fits Cycle3_GR_DDT_75_0015_EYoung_CII_final.fits	Gridded map for CII ( $1/\sigma_{rms}^2$ weighting of individual spectra, $\sigma_{rms}$ baseline noise). See the attached CLASS script for details of the data processing.  Equivalent map in fits format, and with an outer rim (45") removed.



- **Release:**

The data were acquired on Dec 11 (SOFIA flight #266), the observing scripts are described in the GREAT flight dossier GP9700066. The large area to be studied was divided into 4 slightly overlapping sub-fields, each field was covered several times (scanning in orthogonal directions), then repeating the cycle with the array orientation rotated by +60 deg. The final map reveals a very uniform noise distribution ( $\sim 2$  K for a spectral resolution of 0.19 km/s). Data was taken fast “on-the-fly” (dump times 0.3-0.4 sec) on a 6" grid (the half-power beam width of upGREAT at the [CII] frequency is 15.1"). The on-sky reference position was at offset -733,+27.5" (RA,Dec) to the nominal center position of the map.

The data has been processed with the latest version of the GREAT calibrator. The data package (attached as .tar file) does contain

- an overview, providing basic information about your project
- data product level 3, containing
  - (a) the calibrated spectra in standard CLASS format, and
  - (b) the final data product (map) as “lmv”-data cube.
- the \*.class script used in CLASS to process the data.
- a read-me file with details of the data reduction
- a brief log of the observations.

If you have questions about the data, the way they were processed or the observations proper, feel free to contact D. Riquelme ([riquelme@mpifr-bonn.mpg.de](mailto:riquelme@mpifr-bonn.mpg.de)), your data processing liaison.





- **GILDAS (CLASS):**

- Change spectral and/or spatial resolution
- Baseline subtraction
- Inspection / export

```
file in Cycle3_GT_DDT_75_0015_EYoung_Tmb.great  
find  
list /toc
```

```
file out Horsehead_smoothed.great s /o  
for i 1 to found  
  get next  
  smooth box 5  
  base 1  
  write  
  next
```

```
file in Horsehead_smoothed.great  
find
```

```
set weight sigma  
table Horsehead_DDT_CII new /range -50 80 v /nocheck  
let map%beam '15.1'  
let map%cell 6.0 6.0  
xy_map Horsehead_CII
```

```
let name Horsehead_CII  
let type lmv  
go view
```

# Example



MPIfR  
KOSMA  
MPS  
DLR-Pf

let name Horsehead\_CII  
let type lmv  
go view

S: HORSEHEAD PC L: CII L 1.9005369E+03 GHz @ 10.5 km/s LSR B: 15.9

