The different stages of procuring GREAT data

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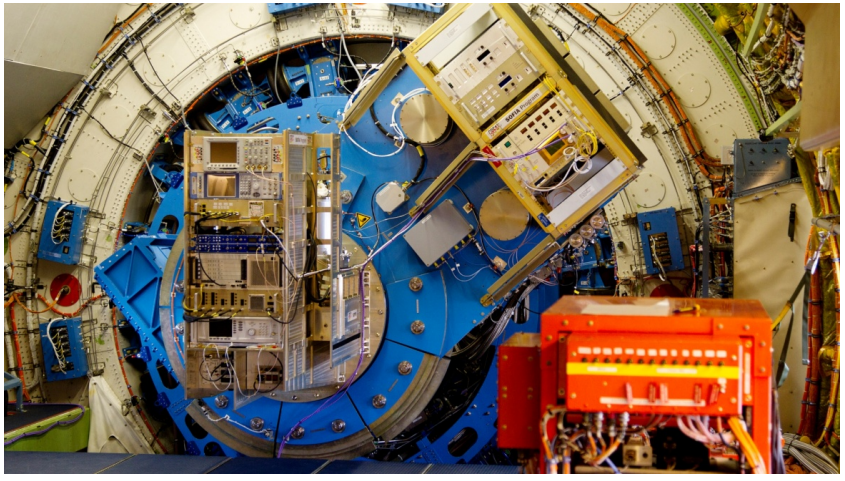
Overview of the GREAT instrument

German REceiver for Astronomy at Terahertz frequencies



Credits: Deutsches SOFIA Institut

- High resolution
  → Spectral resolution of 244 kHz
- Six frequency channels
  0.49-4.74 THz
- Multi-pixel, heterodyne spectrometer
- Available in two configurations
  LFA + HFA
  4G + HFA

(Risacher et al. 2018)

Duran et. al 2020
(submitted IEEE THz)

Channels		Frequency [THz]	Trec Double Sideband [K]	FWHM [´´]
upGREAT	HFA	4.7447	1250	6
	LFA-H	1.835–2.007	1000	15
	LFA-V	1.835–2.007 2.060–2.065	1000	15
4GREAT	4G4	2.490–2.590	3300	12
	4G3	1.240–1.395 1.427–1.525	1100	19
	4G2	0.890–0.984 0.990–1.092	>600	25
	4G1	0.491–0.555 0.560–0.635	300	50

Proposal writing - Important checks!

The pre-requisite would be a SCIENCE GOAL

Line(s) and Object(s) of interest

- Is the spectral line of interest covered by GREAT in the configurations offered in the current call?

  Check the Cycle 9 Call for Proposals (CfP) for this information
  https://www.sofia.usra.edu/sites/default/files/Other/Documents/SOFIA_Cy9_CfP.pdf

  (e.g. Sect.1.0 New Policies and Capabilities for Cycle 9 and Sect.3.2. Available Instruments and Observation Configurations)

- Does the sensitivity of GREAT, its IF bandwidth and resolution, meet your science requirements?

  Check using the SOFIA Instrument Time Estimator (SITE)
  https://dcs.arc.nasa.gov/proposalDevelopment/SITE/index.jsp

- Has this line been previously observed towards the proposed object(s)? What would be a good reason to carry out re-observations?

  Check the SOFIA science archive
  https://irsa.ipac.caltech.edu/applications/sofia/

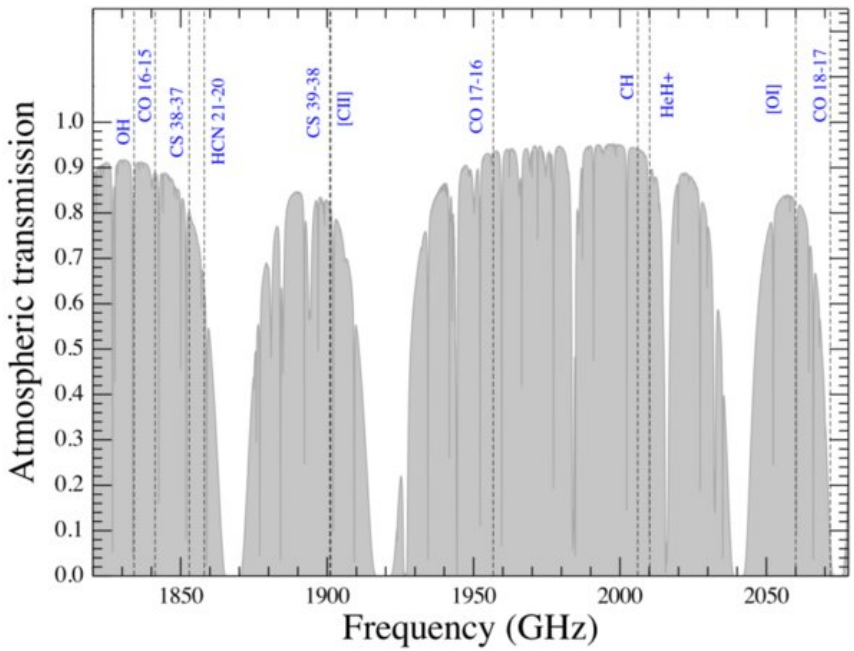
  Duplication checks can also be made using USPOT See Sect.3
  https://www.sofia.usra.edu/science/proposing-and-observing/uspot-manual

- Does this fall under the reserved observations? See Sect.3.1.2 and Appendix A of the Cycle 9 CfP

Proposal writing - Feasibility of the observations

- The frequency bands also cover several atmospheric lines

  $\Rightarrow$ influences sideband selection



Typical atmospheric transmission at 43000 feet with 15μm water vapour for LFA/upGREAT. Taken from Risacher et al. 2018.

- The atmospheric transmission as a function of wavelength for different observing conditions can be obtained using ATRAN

  https://atran.arc.nasa.gov/cgi-bin/atran/atran.cgi

- The Target Visibility Tool (VT) can also be used to determine when the target is visible within the 20°– 60° elevation range from different deployment locations.

  https://dcs.arc.nasa.gov/observationPlanning/installVT/

Proposal writing - GREAT observing modes

Single point observations

- **Position switching (PSW)**

  Telescope nods between target and 'clean' reference position

  Smaller nod $\Rightarrow$ better receiver stability (baseline)

  $\Rightarrow$ extended sources

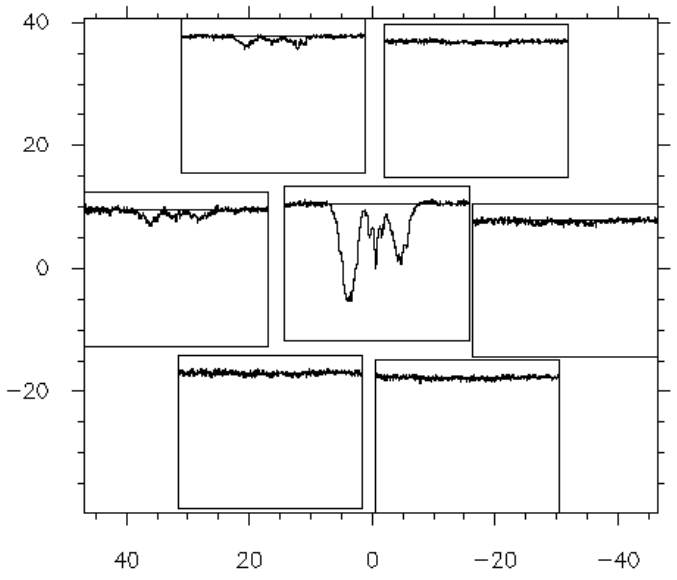
- **Beam switching (BMSW)**

  Secondary mirror chops between the source and reference position

  Typically the chop throw is $<200''$ away from source

  (chop throw = $2\times$ chop amplitude)

  $\Rightarrow$ compact sources



CH 149μm spectra observed with the upGREAT/LFA-H towards star-forming region W49N. Observations were performed in double-beam chopped mode, wobbling at a rate of 2.5 Hz with a throw of $160''$. Taken from Wiesemeyer et. al. 2018.

Proposal writing - GREAT observing modes

Mapping

- **Raster Map**

  Small map or strip with one reference long exposure (>30s) on-positions ⇒ collection of single point observations (Total power (TP) mode)

  Can also be mapped in BMSW mode i.e., with a chopping secondary

- **On-the-fly (OTF) Map**

  Classic OTF Map

  Telescope scans along rows of constant latitude separated by half the beam size in longitude

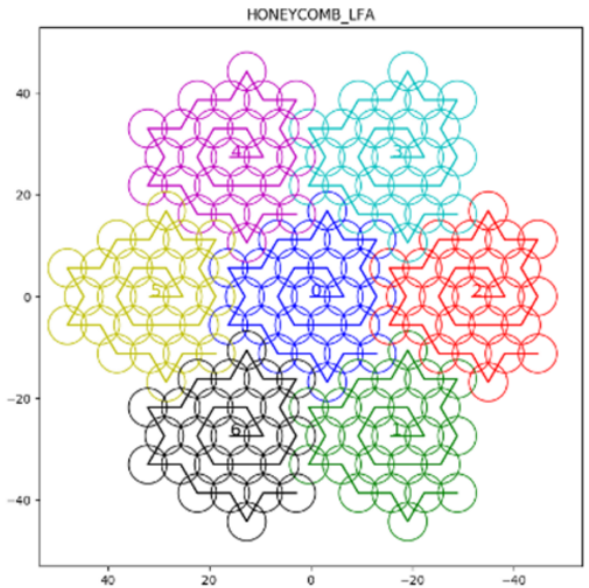
  Offered in both TP and BMSW modes

The Unified SOFIA Proposal and Observation Tool (USPOT v.4.3.1_1) can be used to visualise the map footprint https://dcs.arc.nasa.gov/observationPlanning/installUSPOT/uspotDownload.jsp

NEW

Honeycomb OTF Map

Creates fully-sampled maps of an area comparable in size to GREAT receiver arrays (HFA or LFA) at the resolution of the array.



Proposal writing - Time estimation

- With knowledge of the
  - expected source brightness temperature
    $\rightarrow$ the value used should be justified
  - required resolution, map size and signal-to-noise ratio

  $\Rightarrow$ SOFIA Instrument Time Estimator (SITE) can be used to get an estimate of the ON source integration time

  https://dcs.arc.nasa.gov/proposalDevelopment/SITE/index.jsp

- Overheads are typically twice the (ON+OFF) time

  $\rightarrow$ overheads are computed in USPOT

- General timing constraints
  - observing legs are limited to a maximum of $\sim$2-3 hrs max per flight
  - limited number of flights per instrument per cycle
    (GREAT committed 40 flights in the current cycle)

Proposal writing - Summary and tips

- Read the proposal call carefully and look out for updates or changes
- By addressing the What, Why, and How demonstrate
  - the scientific impact of your science goal and
  - the role of SOFIA's unique capabilities in fulfilling them
- Can this work be a multi-wavelength study forming synergies between different observing facilities?
- Detail your plans to carry these observations to a successful conclusion and publication
- To thoroughly prepare your proposal use the different tools available

  (SITE, VT, ATRAN, USPOT, etc)
- In case you have questions contact the GREAT liaison at the SOFIA Science Mission Operations (SMO)

Data Reduction

The GREAT team

- releases validated and calibrated (level 3) GREAT science data
- not later than 3 months after the end of each flight series

The Data

- is calibrated using the latest version of the GREAT calibrator (KALIBRATE) (for more info see Guan et. al. 2012)
- and reduced using the GILDAS/CLASS software https://www.iram.fr/IRAMFR/GILDAS/
- for queries contact your GREAT data processing liaison

Alternatively, GREAT fits cubes can also be analysed using SOFIA SPectral EXplorer (SOSPEX) https://github.com/darioflute/sospex/blob/master/README.md
NOTE: This data will also be uploaded to the SOFIA Science archive but will only be publicly available after a year

Publications

There are almost 200 refereed publications that have made use of SOFIA data
→ https://www.sofia.usra.edu/science/publications/sofia-publications

So don't forget to follow-up your investigations with timely publications

Good luck for the upcoming Cycle 9 proposal call
Deadline September 4, 2020, 21:00 PDT (1 July, 2020)