HAWC+ Upgrade Roadmap

SOFIA Instrumentation Workshop

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HAWC+ Upgrade Paths

- Minor upgrades (~12-18 months)
  - Narrow-band filters
  - Tuning/optimization of cryo parameters
  - New observing modes
  - 4th array (?)

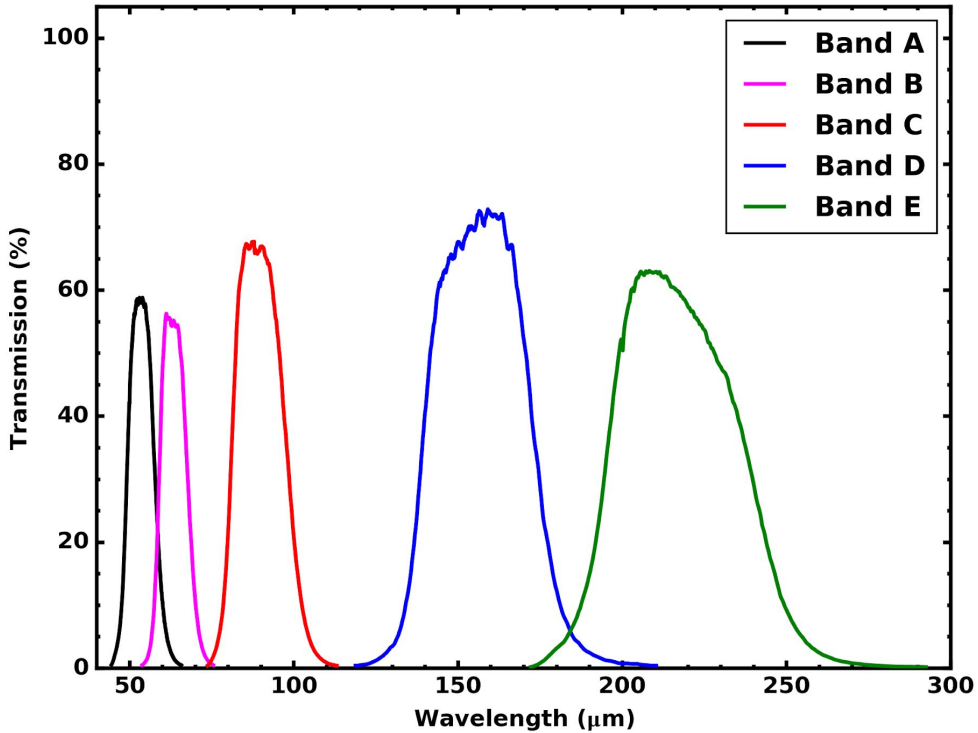
- Major upgrades (2-3 years)
  - 4 new arrays
  - BLAST-TNG kinetic inductance detector arrays

Narrow-Band Filters

Enabling new science

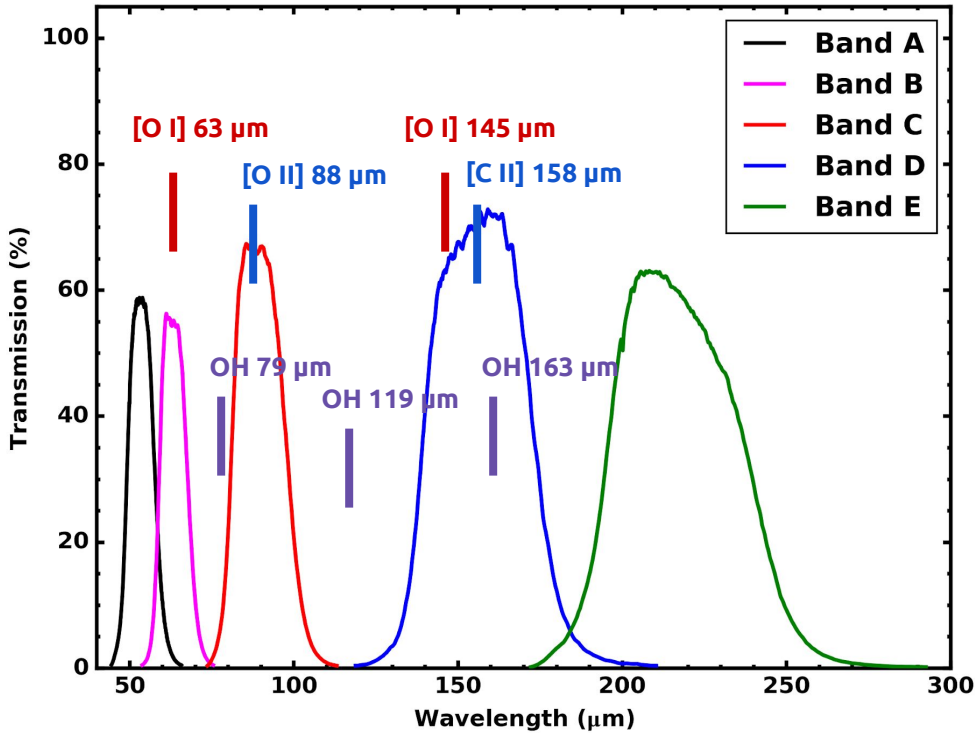
Narrow-band filters

- HAWC+ filter wheel currently has one open aperture
  - two if we remove Band B (Cycle 9 usage dependent)



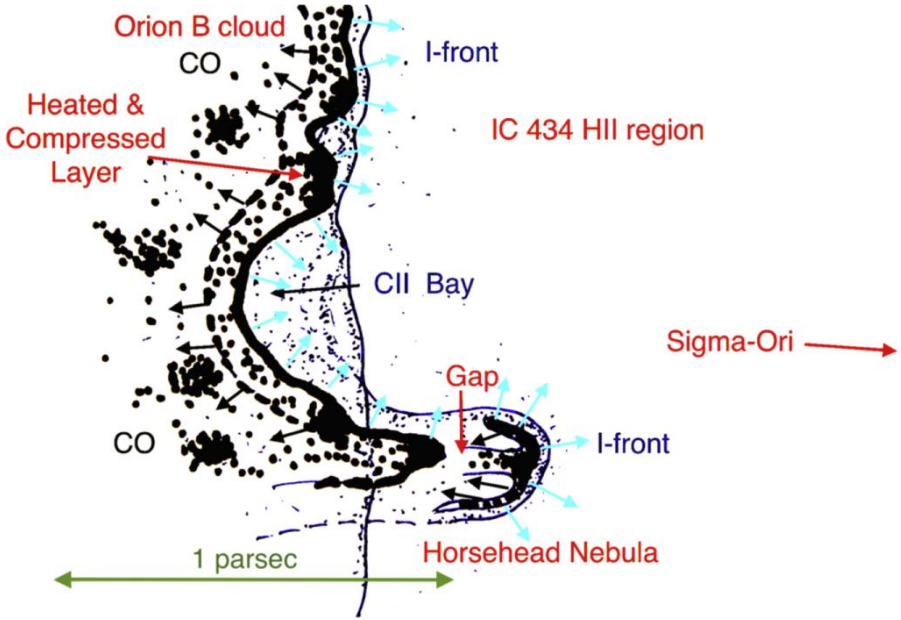
Narrow-band filters

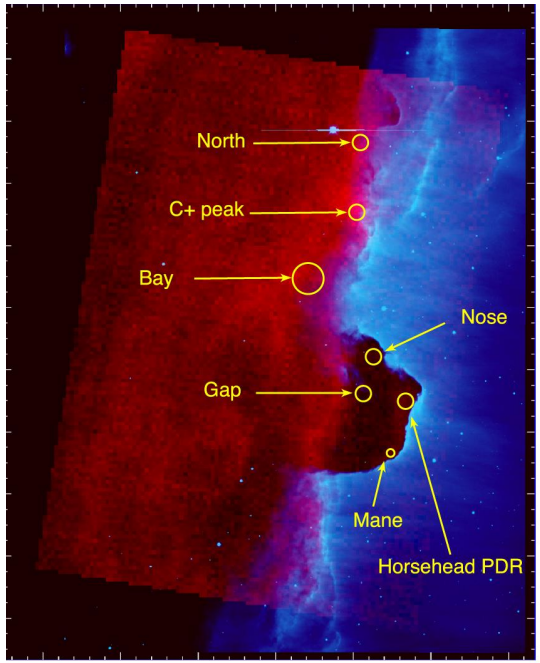
- Potential options include [O I], [O II], [C II], and OH



Narrow-band filters

- Synergies with other SOFIA instruments
  - GREAT, FIFI-LS
    - emission kinematics in [C II] or [O I]



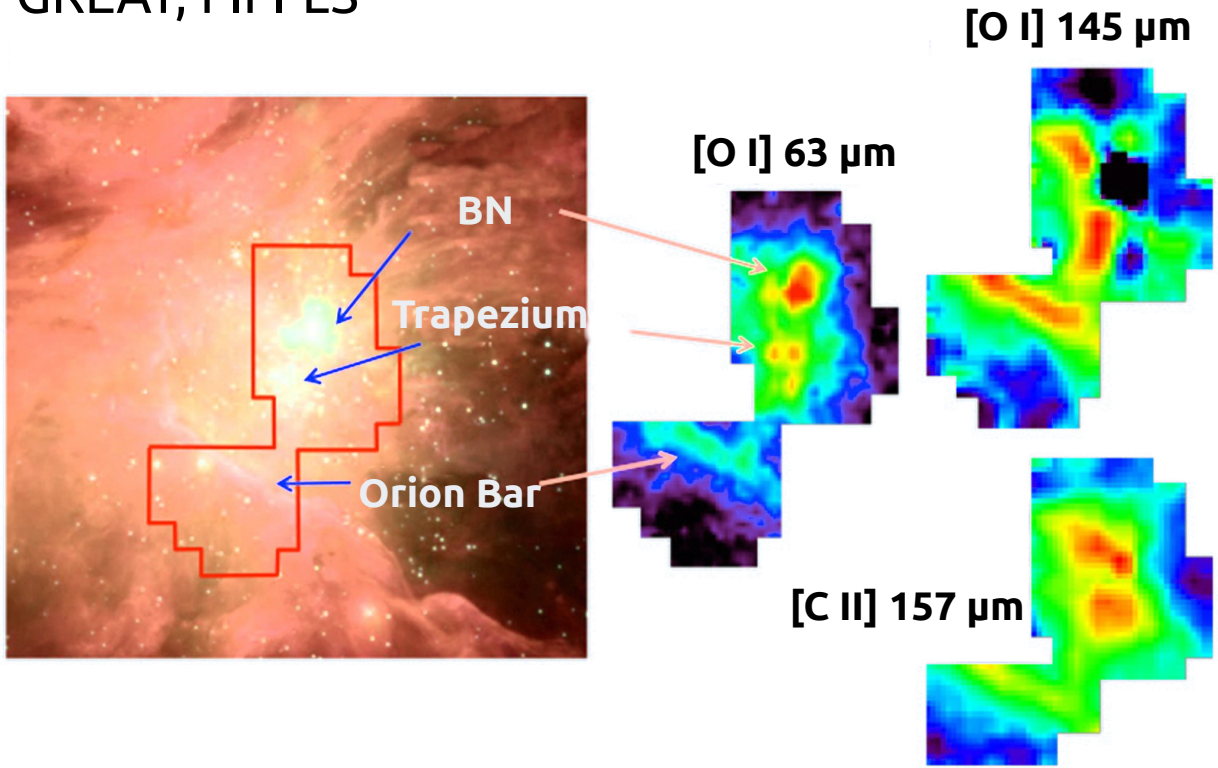


Narrow-band filters

- Synergies with other SOFIA instruments
  - GREAT
    - emission kinematics in [C II] or [O I]
    - Magnetic fields are aligned and compressed in PDRs in high gas and radiation pressure environments
    - Combine narrow-band polarimetry with continuum emission (~40 K) to trace both gas and dust

Narrow-band filters

- Synergies with other SOFIA instruments
  - GREAT, FIFI-LS



ADR Tuning

Better sensitivity

HAWC+ ADR Tuning

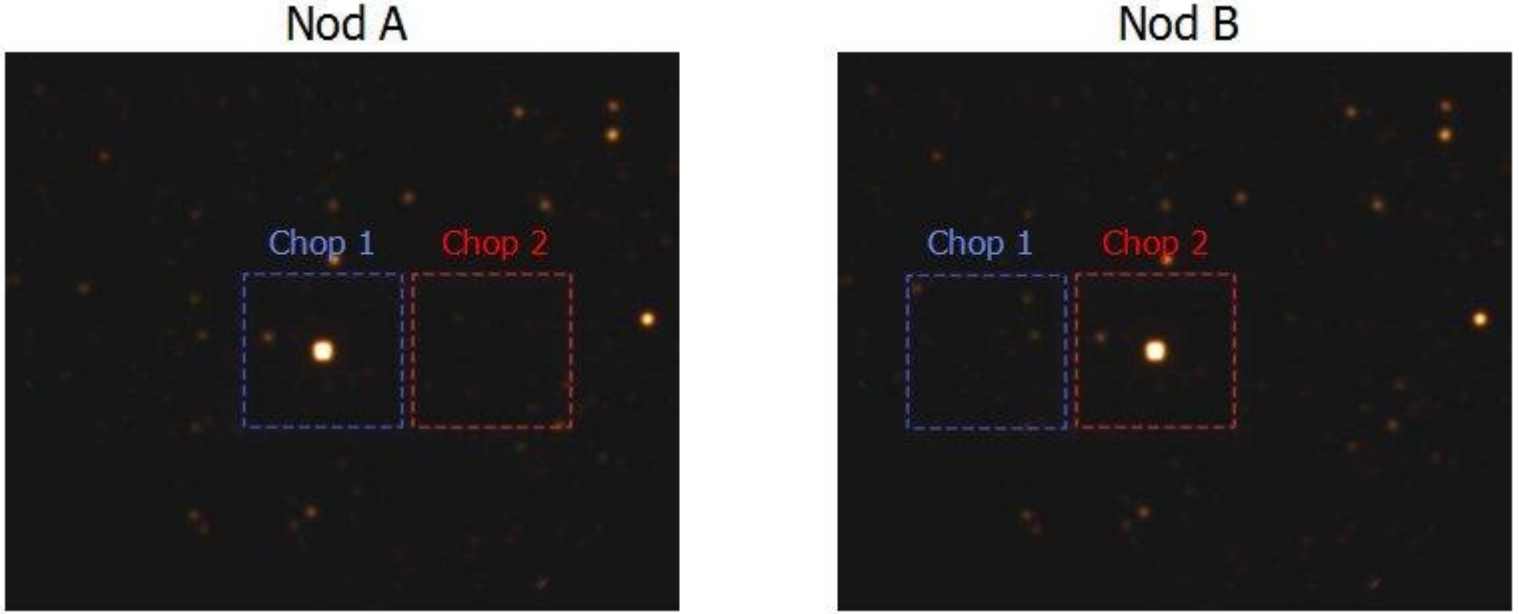
Detector Temp (K)	ADR initial current (A)	Expected initial current in flight (A)	Expected final current of a 10h flight (A)*	Expected hold time in flight (h)	Comments
0.20	2.02	1.72	0.47	13.8	Nominal ADR w/old HS.
0.17	2.02	1.34	0.09	10.7	Nominal ADR w/old HS.
0.15	2.03	1.19	-0.06	9.5	Nominal ADR w/new HS. Runout of ADR current by the end of flight
	2.46	1.54	0.29	12.3	Potential new temperature
0.14	2.46	1.41	0.16	11.3	Potential new temperature
	2.36	1.31	0.06	10.5	Potential new temperature
	2.41	1.36	0.11	10.9	Potential new temperature
0.13	2.00	0.94	-0.31	7.5	Runout of ADR current by the end of flight
	2.46	1.26	0.01	10.1	Runout of ADR current by the end of flight

* assumes current burn rate of 0.125 A/h

New Observing Modes

Improved efficiencies

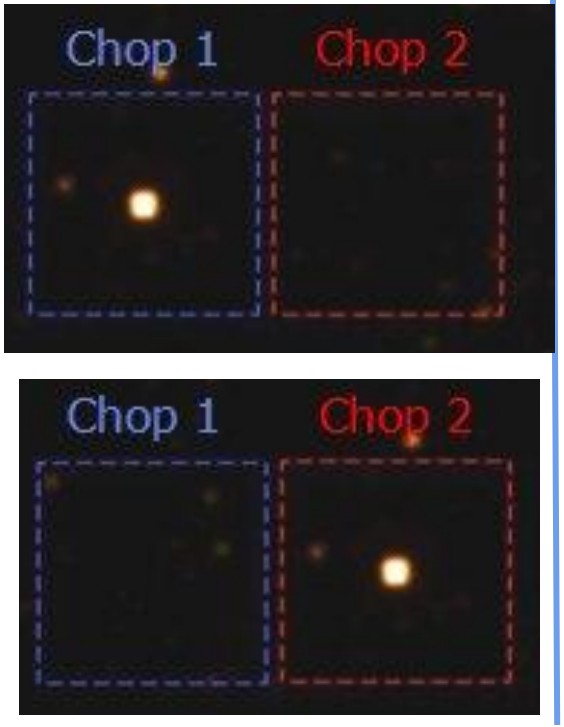
Symmetric Chop/Nod



Symmetric Chop/Nod

Issues:

- ~50% observing efficiency

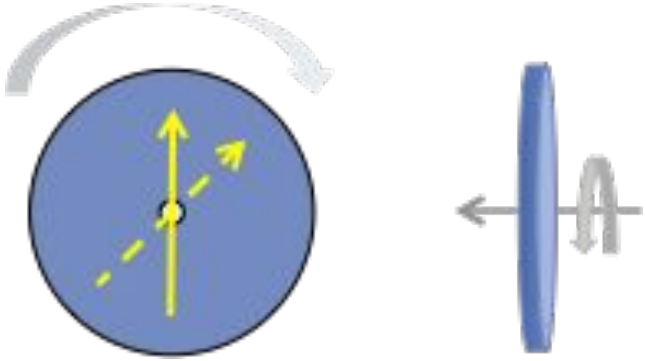


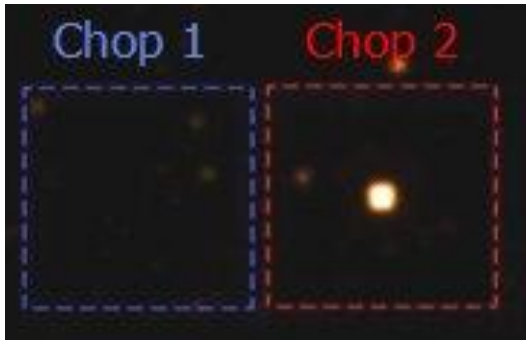
Symmetric Chop/Nod

Issues:

- ~50% observing efficiency
  - For polarimetry:

    Chop-nod @ 4 HWP positions





Symmetric Chop/Nod

Issues:

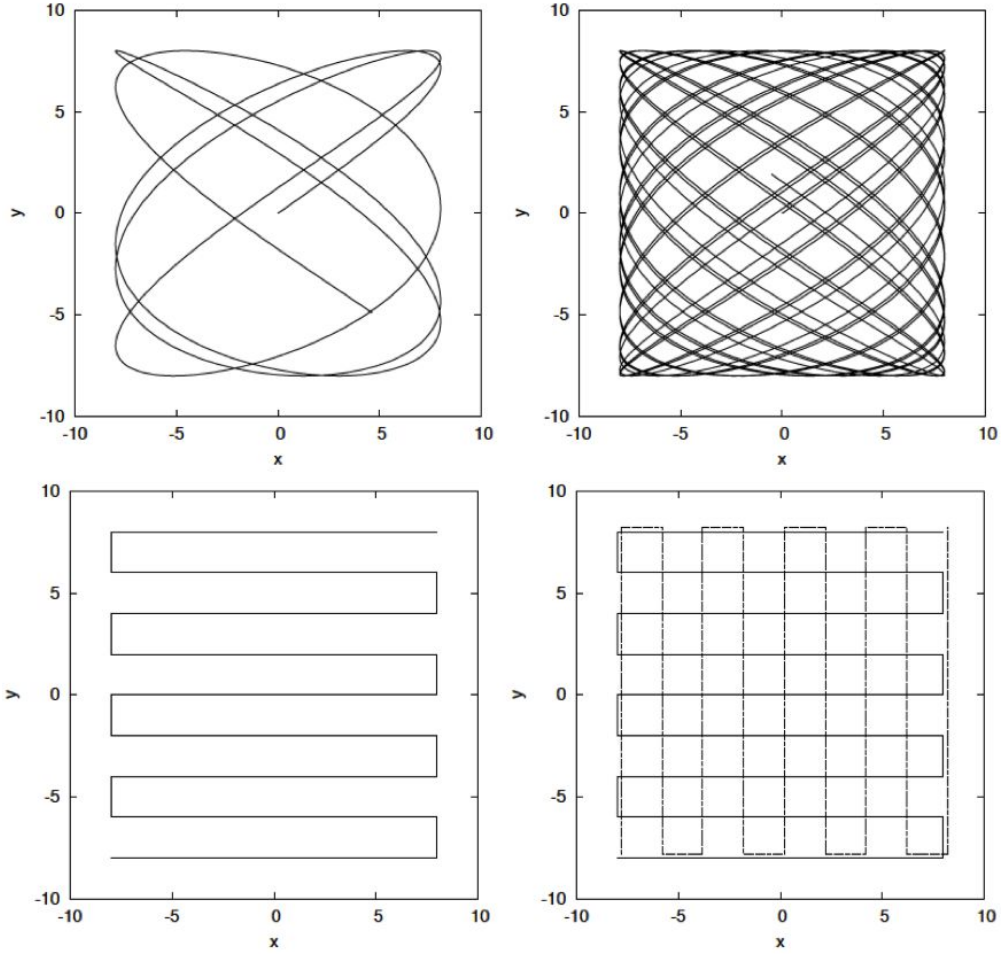
- ~50% observing efficiency
- Requires clean “off” position

  over the entire FOV

HAWC+ Scanning Modes

- SOFIA/HAWC+ scan mapping has two modes:
  - Lissajous: for small fields comparable to the FOV
  - Raster: for large mapping areas

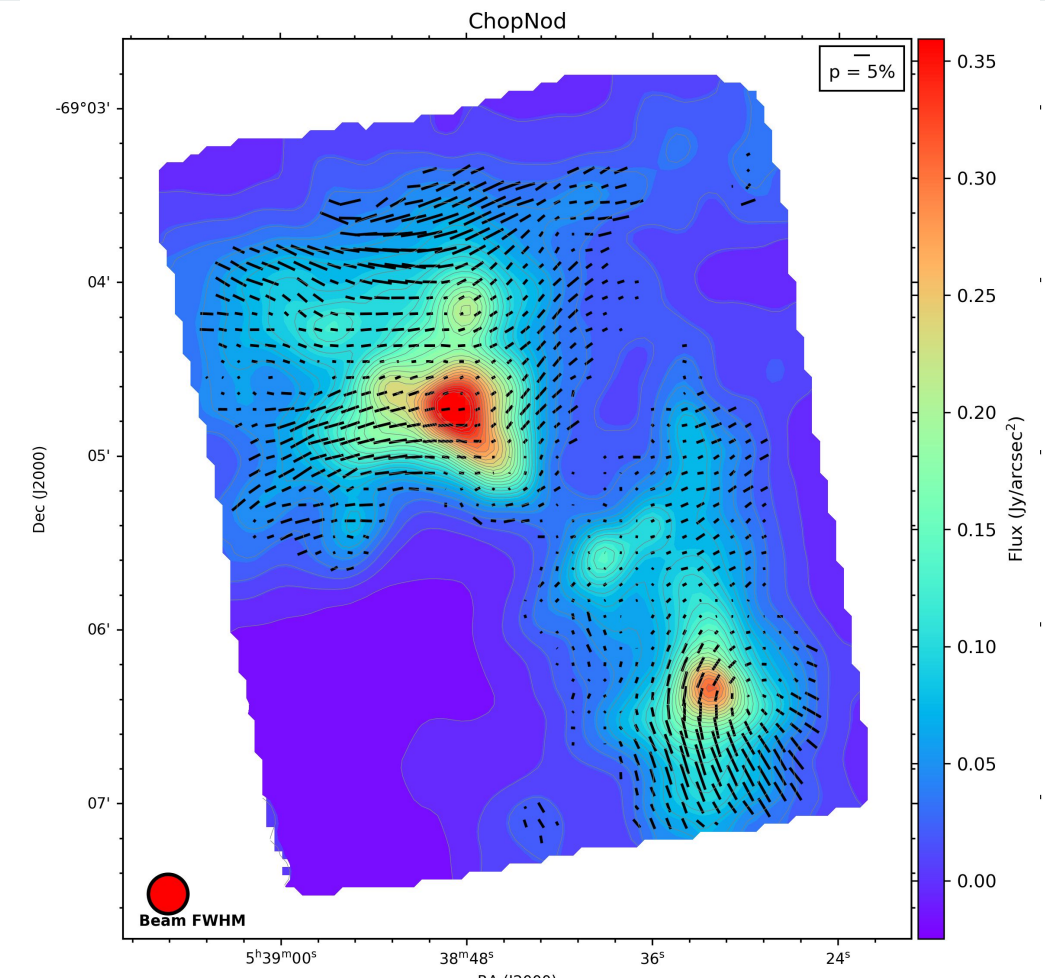
- Scan speeds up to 200 arcsec/s

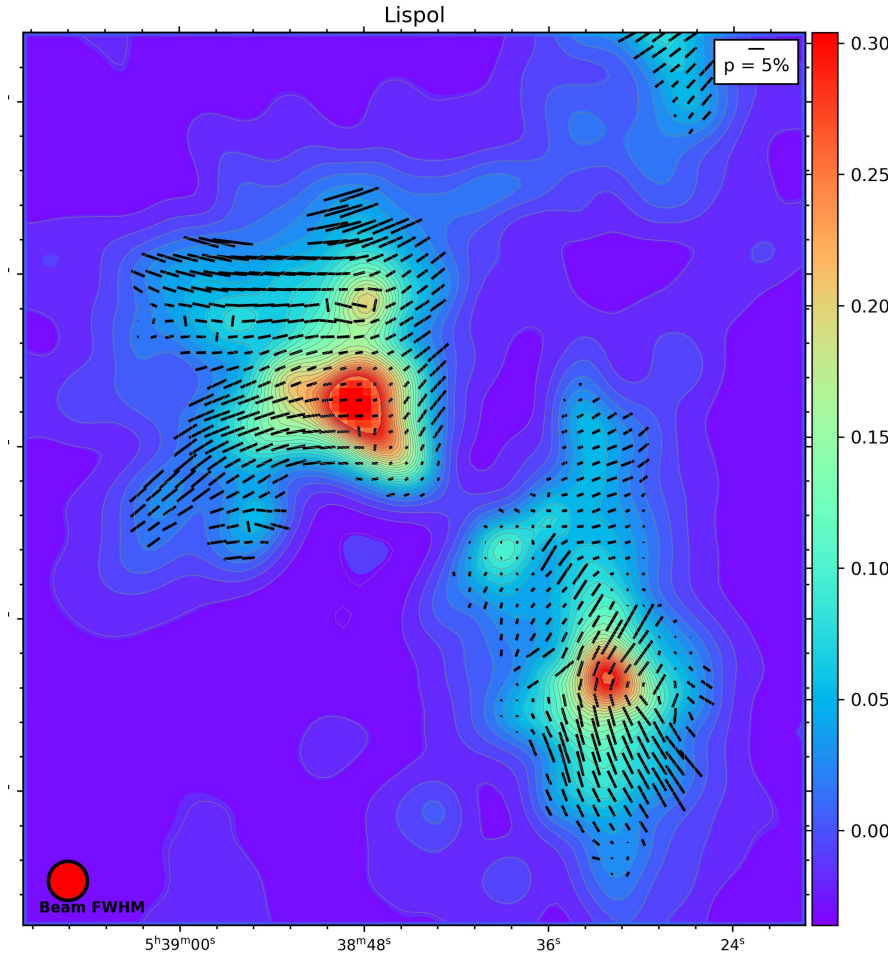


ScanPol Mode

- Scan-mapping:
  - extremely efficient for total intensity imaging of extended and point sources
- Scan-polarimetry:
  - now offered as shared risk observing mode for SOFIA Cycles 8 & 9 (2019-2021)
  - Great for point sources. Accurate pol angle for all spatial scales
- Ongoing Work
  - Re-characterize instrumental polarization in scan mode
  - Correct polarization bias in low surface brightness regions

Imaging Polarimetry of 30 Dor





New Arrays

Improved mapping speed, sensitivities, FOV

Current Instrument Parameters

Band / Wavelength	Δλ̃/λ̃	FWHM (arcsec)	Total Intensity FOV (arcmin)	Polarization FOV (arcmin)
A / 53 μm	0.17	4.7	**2.7 × 1.7**	1.3 × 1.7
B / 63 μm	0.15	5.8	**4.2 × 2.6**	2.1 × 2.6
C / 89 μm	0.19	7.8	**4.2 × 2.6**	2.1 × 2.6
D / 154 μm	0.22	14	**7.3 × 4.5**	3.6 × 4.5
E / 214 μm	0.20	19	**8.0 × 6.1**	4.0 × 6.1
PACS / 60-200 μm		~5–12	**3.5 × 1.8**	

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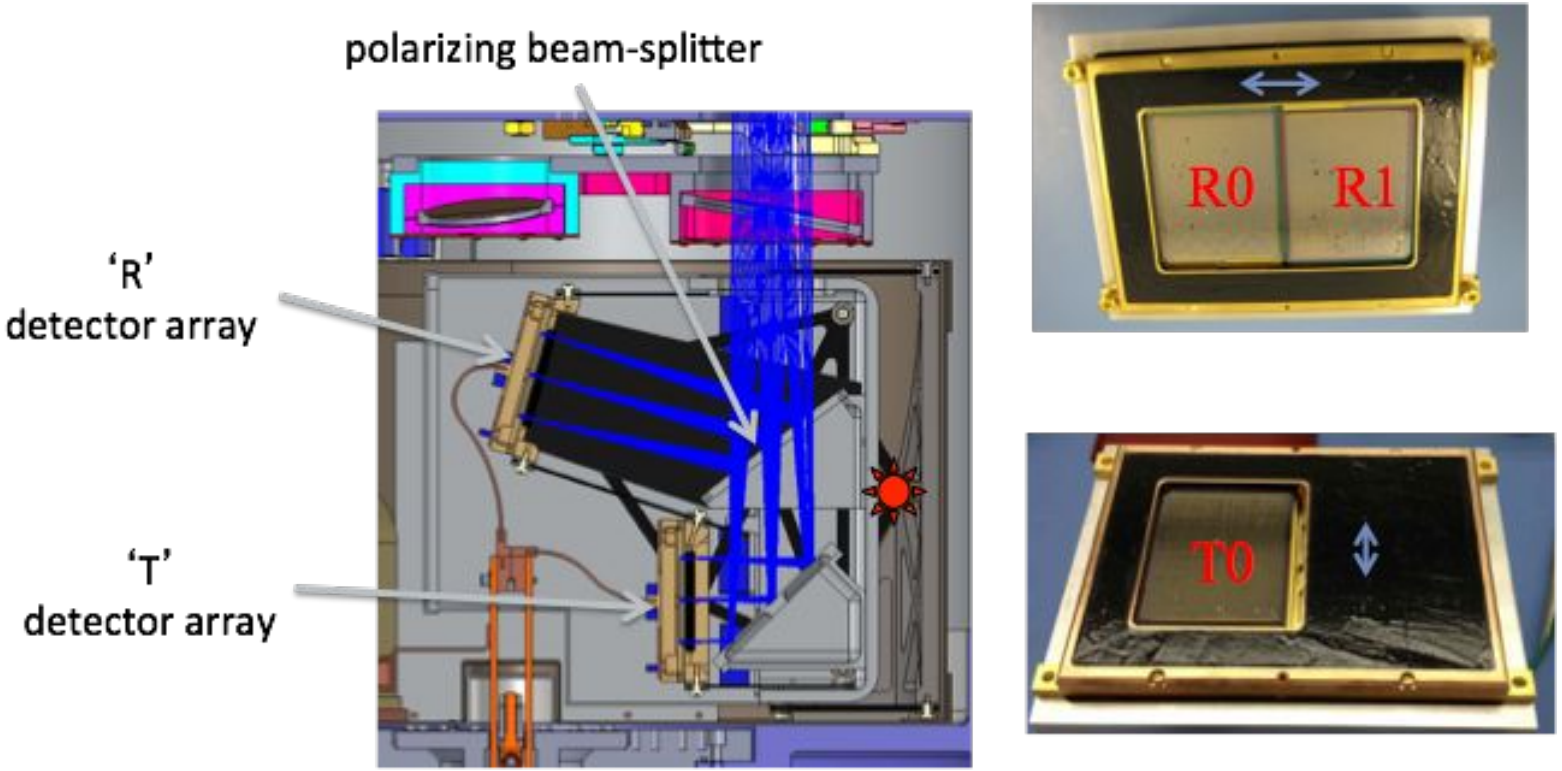
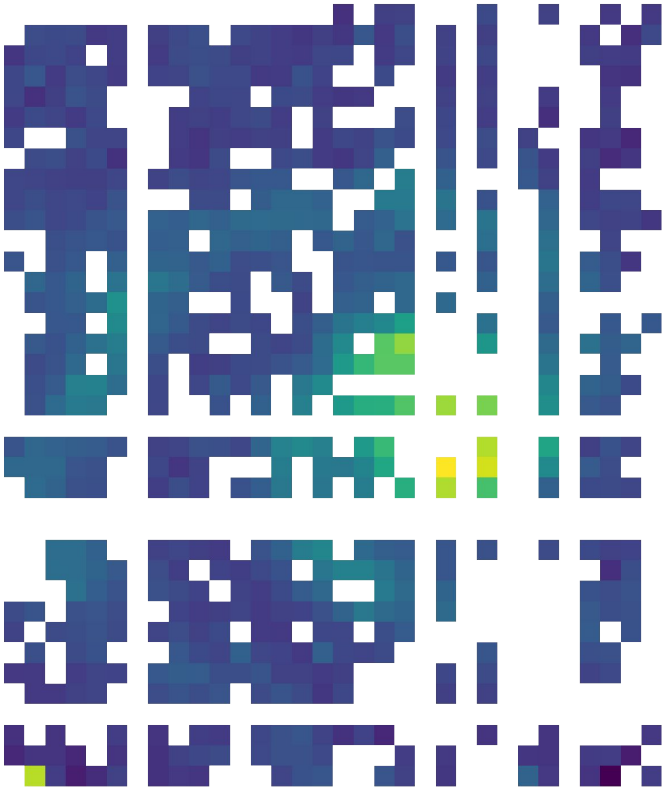
HAWC+ Imaging Polarimetry

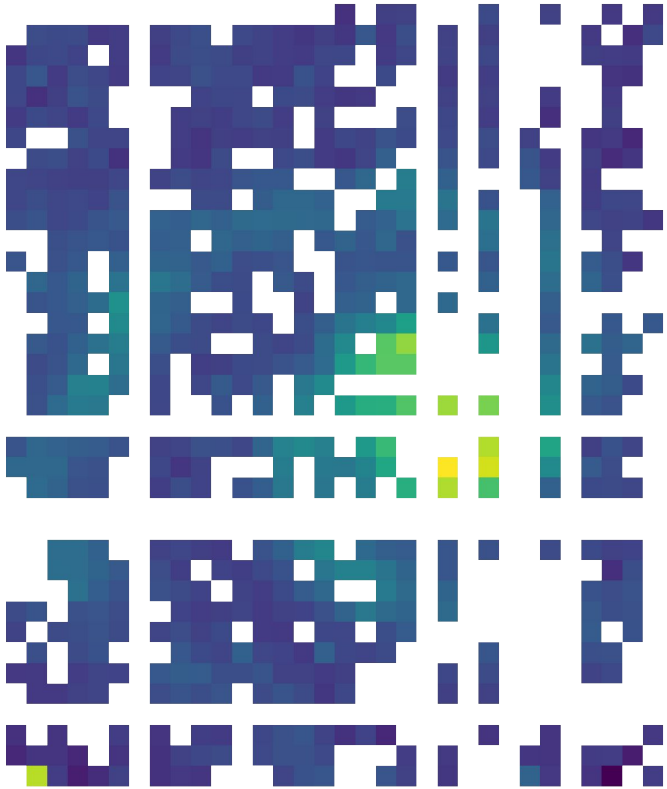


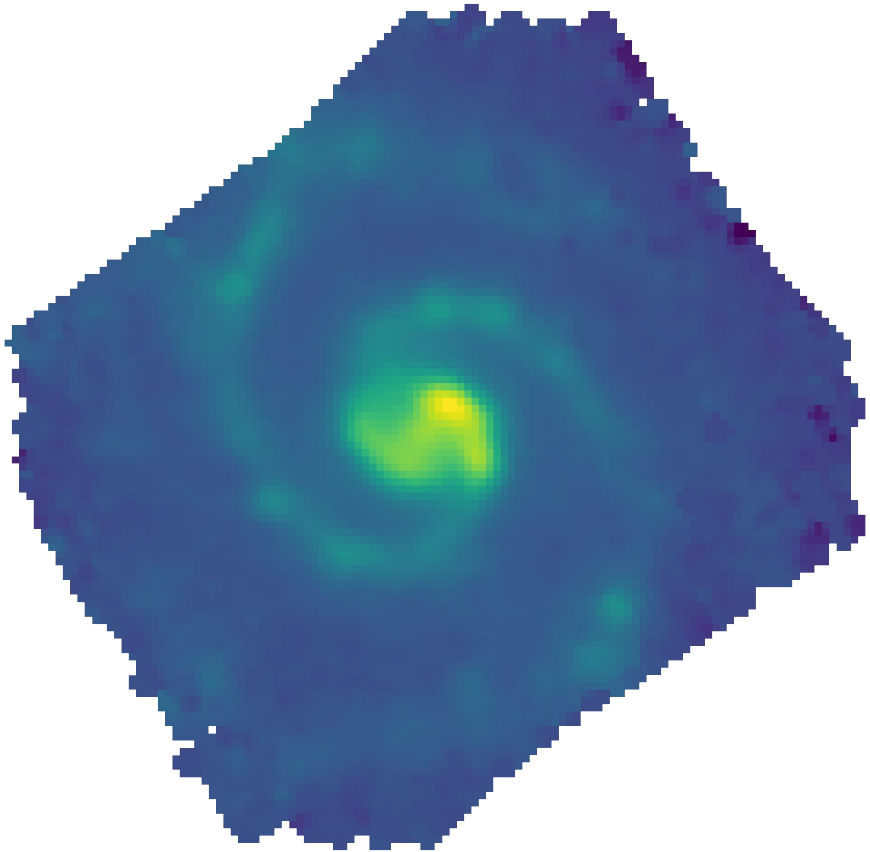
Bad Pixels



- **~54%** of the pixels on the R0, R1, T0 arrays are ***unusable***

Bad Pixels are *Bad*

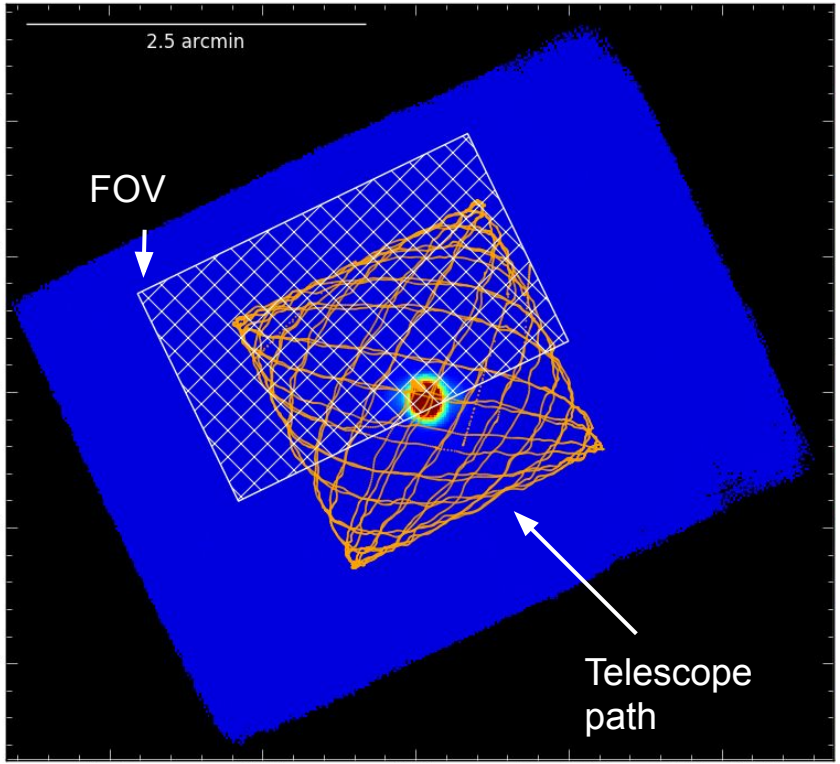




Additional Arrays

- Four arrays (two in R, two in T) allows for doubling our FOV in polarimetry
- For scanpol, this effectively doubles our scan-speed

- Caveats:
  - Requires fabrication
  - Uncertain if Goddard has maintained that capability
  - Unknown expense/timeline for 4 high-quality 32x32 arrays



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  - Narrow-band filters
    - Enables new science
  - Cryo tuning/new observing modes
    - Sensitivity and overhead improvements
  - 4th array
    - Increase mapping speed and FOV

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