

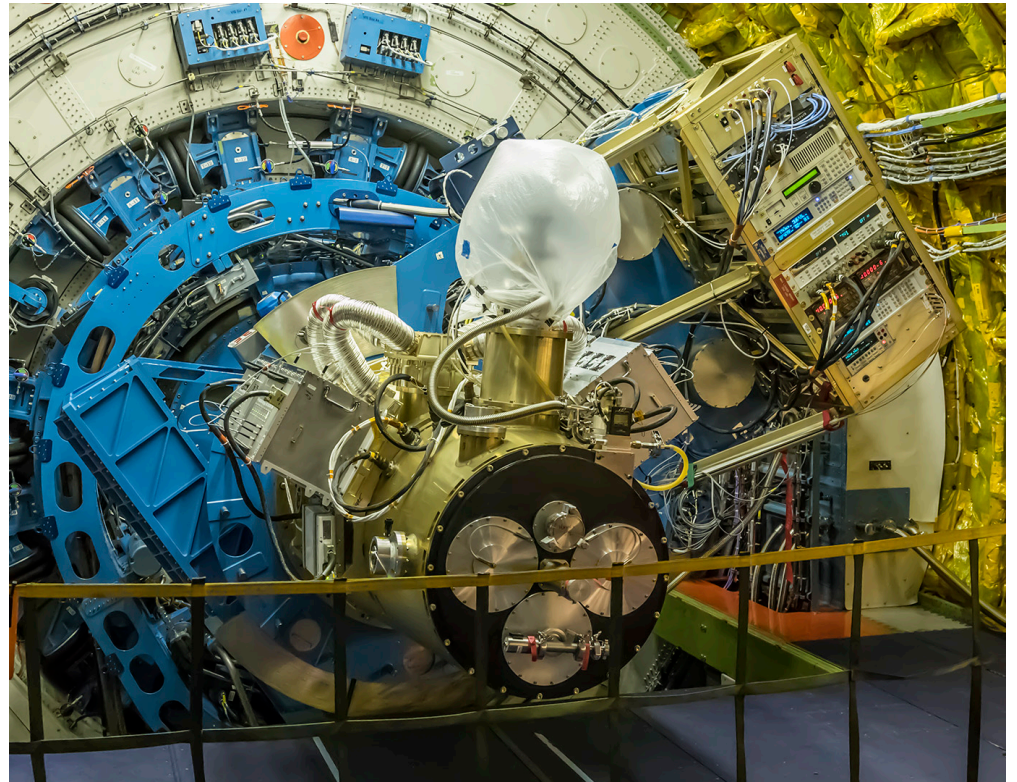
# HAWC+ Status for SOFIA Users Group

C. Darren Dowell for HAWC+ team  
2017 June 1

Note: This presentation contains preliminary commissioning and GTO science data. Please consult with HAWC+ P.I. before using or distributing this material.

# Topics

- instrument status
- commissioning summary
- pipeline status
- GTO progress



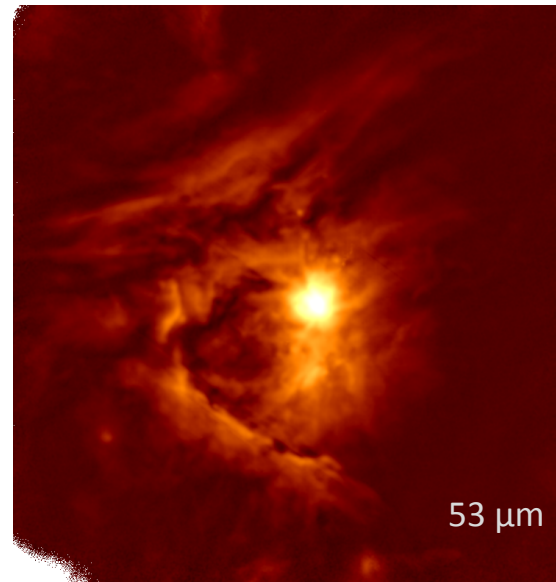
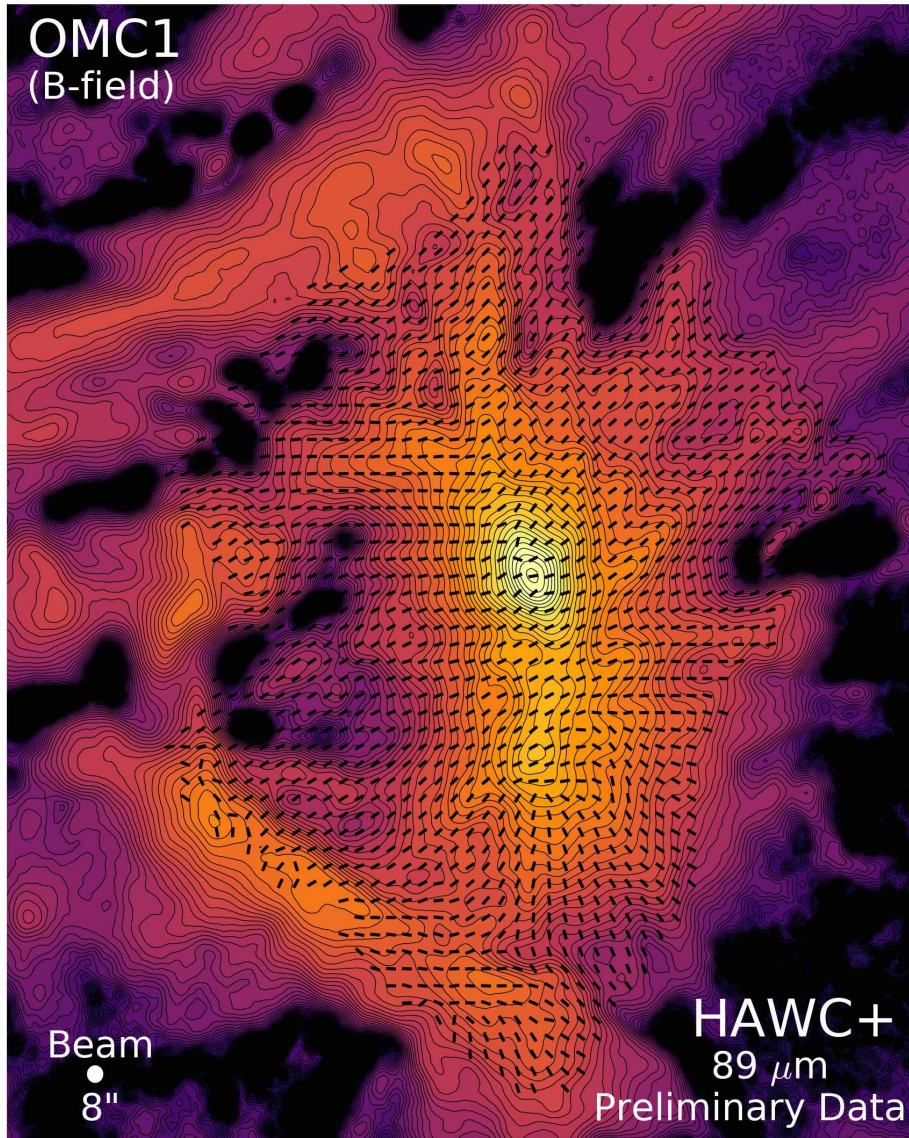
# Overall HAWC+ Instrument Status

- Work on instrument in July-August 2016 solved several thermal problems, but not all.
- October 2016: demonstration of science capability; continued commissioning
- December 2016: completion of commissioning; G.I. & G.T.O. science flights for Cycle 4
- May 2017: G.I. & G.T.O. science flights for Cycle 5
- June – July 2017: further work on cryogenic system, plus some other maintenance
- September 2017: next scheduled flights
- January 2018: target date for Acceptance Review

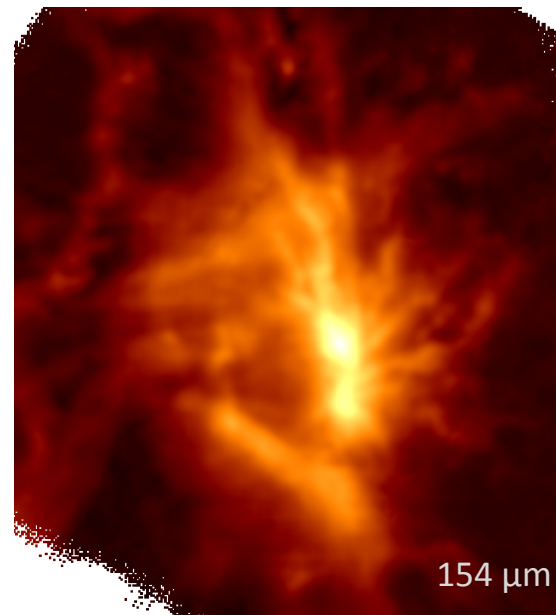
# Commissioning Summary

- Preliminary summary of commissioning was reported to NASA in February & March.
- All intended observing modes and configurations work well, except for saturated Band B (62  $\mu\text{m}$ ).
- *Polarization sensitivity to extended emission is at predicted value (Cycle 4-5) for Bands A (53  $\mu\text{m}$ ), C (89  $\mu\text{m}$ ), & D (154  $\mu\text{m}$ ). Preliminarily ~50% worse than prediction in Band E (214  $\mu\text{m}$ ).*
- Unfortunately, there appears to have been a factor of ~2 error in the point source sensitivity prediction for Cycle 4-5; updated (worse) sensitivity is making its way into future versions of the Observer's Handbook.
- Sensitivity for scan mode is less well determined, and it is likely to benefit from improvement to instrument thermal stability.
- Beam shape (diffraction-limited + small pointing jitter) is as predicted with only minor "ghost" images.
- Instrumental polarization has been measured with high precision, and we should be able to meet requirements for systematic error < 0.6% after subtraction.
- Cryogenic system does not have required hold time, and science flights have been typically planned for 8.5 hours total duration by necessity.

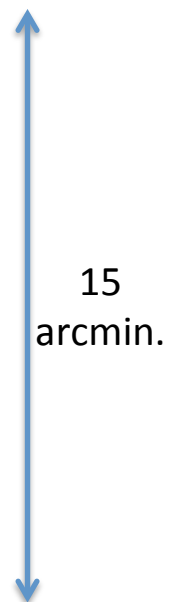
# HAWC+ Commissioning: Orion Molecular Cloud



8.7 min. (elapsed time)



1.8 min. (elapsed time)



15  
arcmin.

# Cooling System Performance

- Liquid helium system is working as designed: one fill/day, in the morning. No issues in flight.
- 1K cooler has held for all flights.
- 0.2K ADR cooler performance varies:
  - URD open run time in Oct. 2016: 5.3, >5.5 *hr*
  - run time in Dec. 2016: 5.3, 5.2, 4.7, 4.0, 5.6, 5.5, 6.0, >6.2 *hr*
  - run time in May 2017: >6.2, >6.1, >6.4, >>4.5, 6.0 *hr*
- Recovery plan:
  - Engineering analysis and redesign for past ~6 months.
  - Advised by NASA tiger team.
  - Implementing redesign now (June 2017).
    - Relatively simple, non-invasive approach.

# Cycle 4&5 HAWC+ Flights (so far)

- October & December 2016:
  - 11 flights planned, 1 canceled (instrument servicing problem), 10 completed successfully
  - ~60% of time was commissioning.
  - Remainder was G.I. & G.T.O. science and calibration.
- May 2017:
  - 10 flights planned, 5 canceled (aircraft), 5 completed successfully
  - 4 hours G.T.O. science
  - Remainder was G.I. science and calibration.

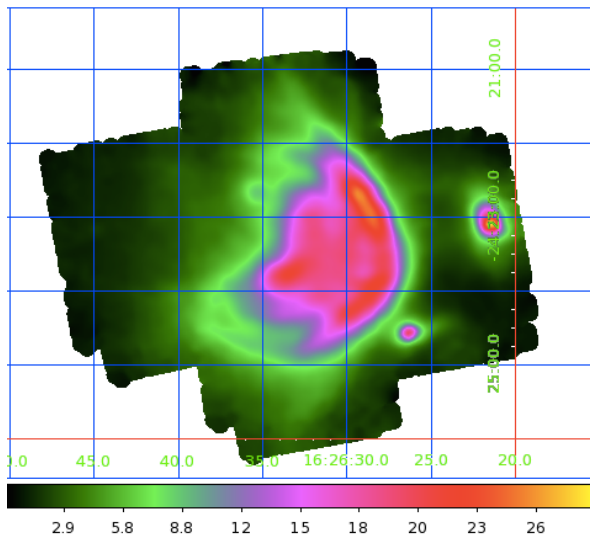
# Pipeline Status

- As of May 2017, in-flight pipeline is producing maps with good fidelity and providing useful feedback in near real time.
- SI team working with DPS team toward a first data release.
- All of the usable observations have been identified and processed.
- Many aspects of the data look good, including:
  - detector gain flatfielding
  - polarization reproducibility where S/N is high
- However, we are continuing to work on:
  - data cuts and measurement uncertainties
  - instrumental polarization (3 measurement methods)
  - flux calibration



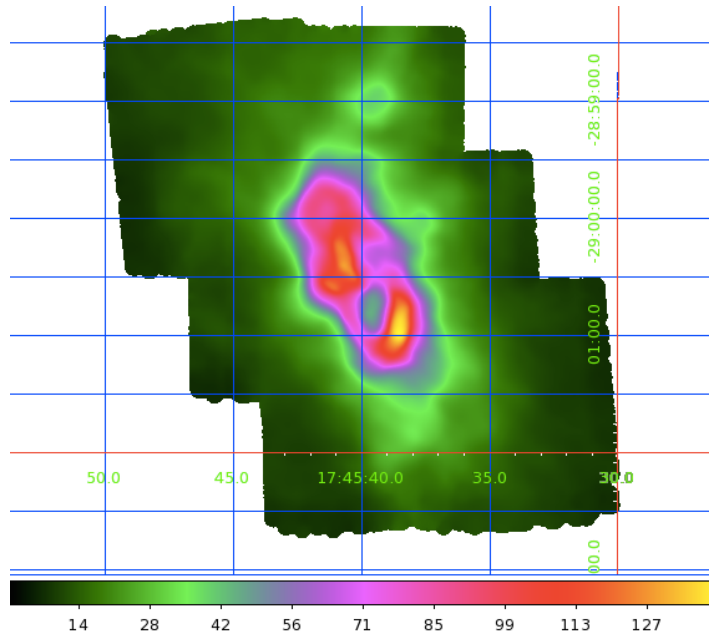
# HAWC+ G.T.O. Status and Plans

- G.T.O. targets to date (besides Orion) are in intensity images below. (~9 observing hours total)
- We have high S/N polarization maps for most of the targets; several publications are planned.



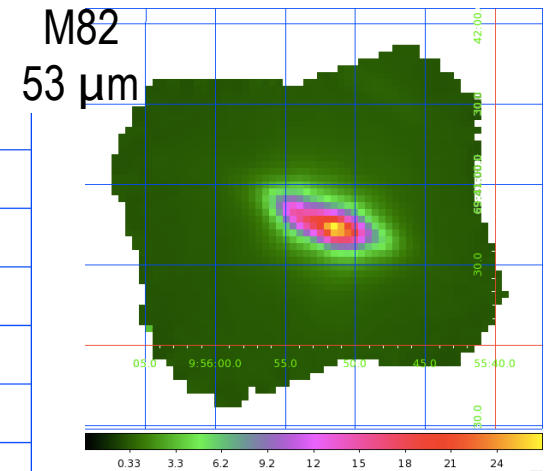
Rho Oph A  
89  $\mu\text{m}$

2017 June 1

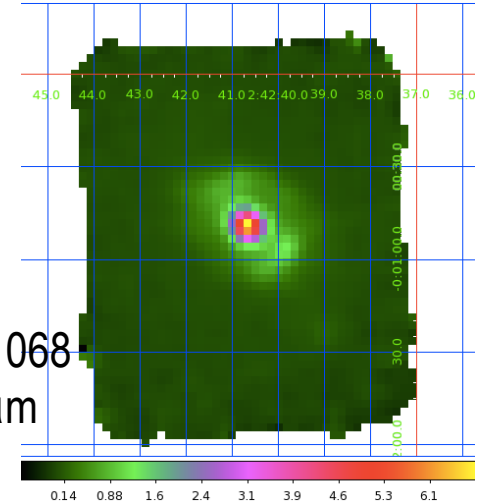


Sgr A CN  
53  $\mu\text{m}$

SOFIA Users Group / HAWC+ status



M82  
53  $\mu\text{m}$

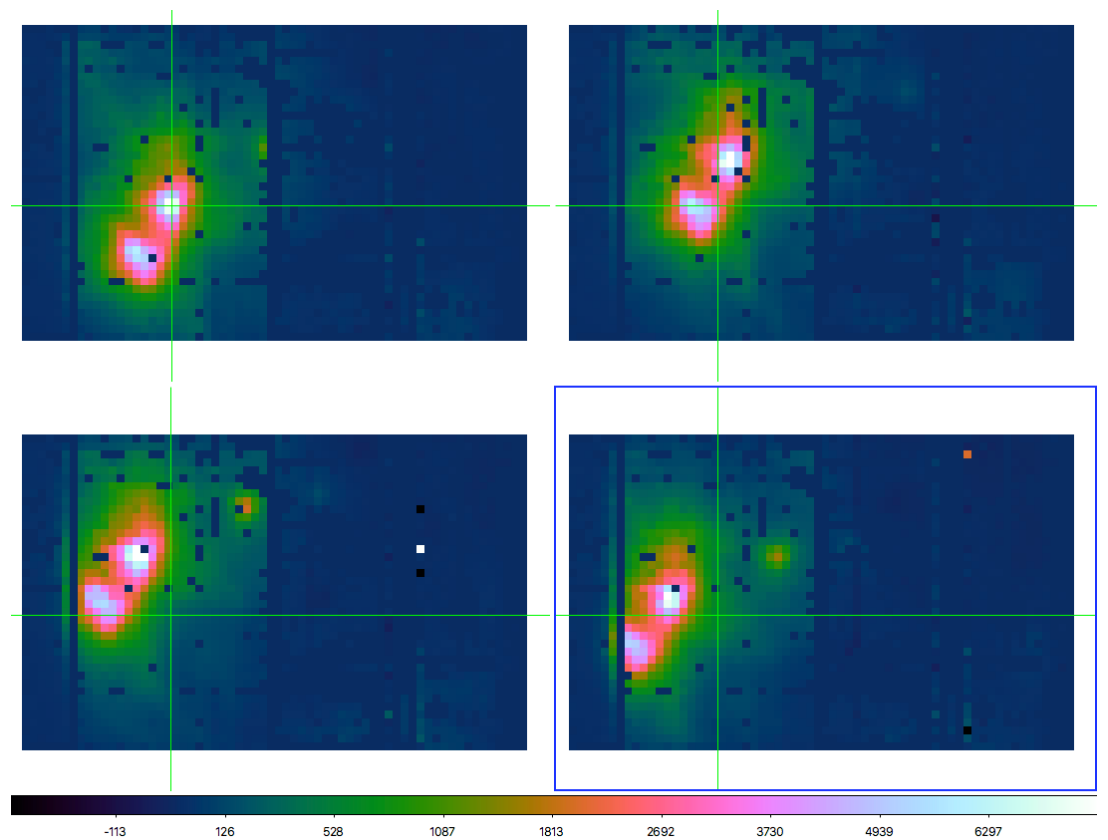
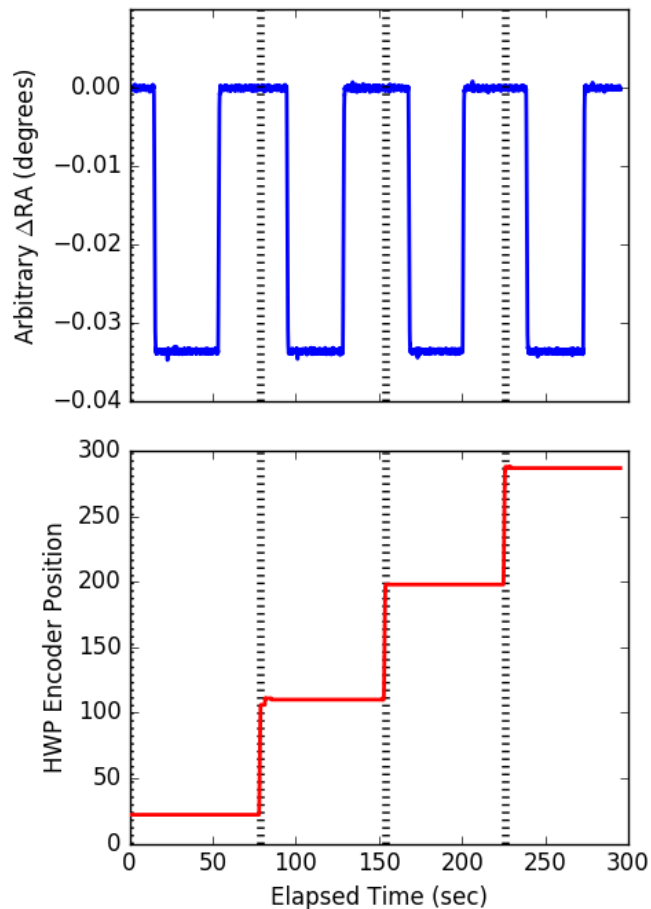


NGC 1068  
53  $\mu\text{m}$



# HAWC+ observing modes

- **NMC/C2N - Chop-Nod-Dither-Pol**
  - ABBA nod sequence with 4 HWP positions (left) at each dither position (right)
  - Only delivered mode for polarimetry - Stokes I measured, in addition to Q, U

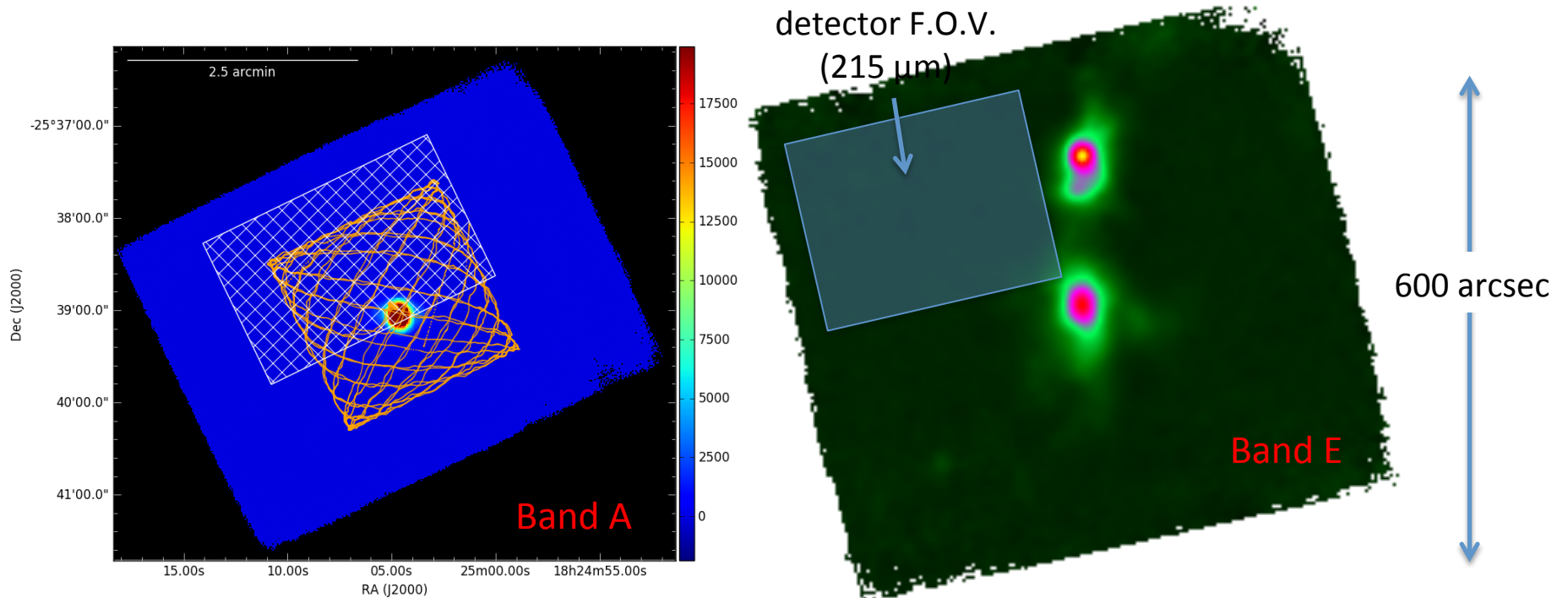


4-position dither sequence

# HAWC+ observing modes

- **OTFMAP – Lissajous**

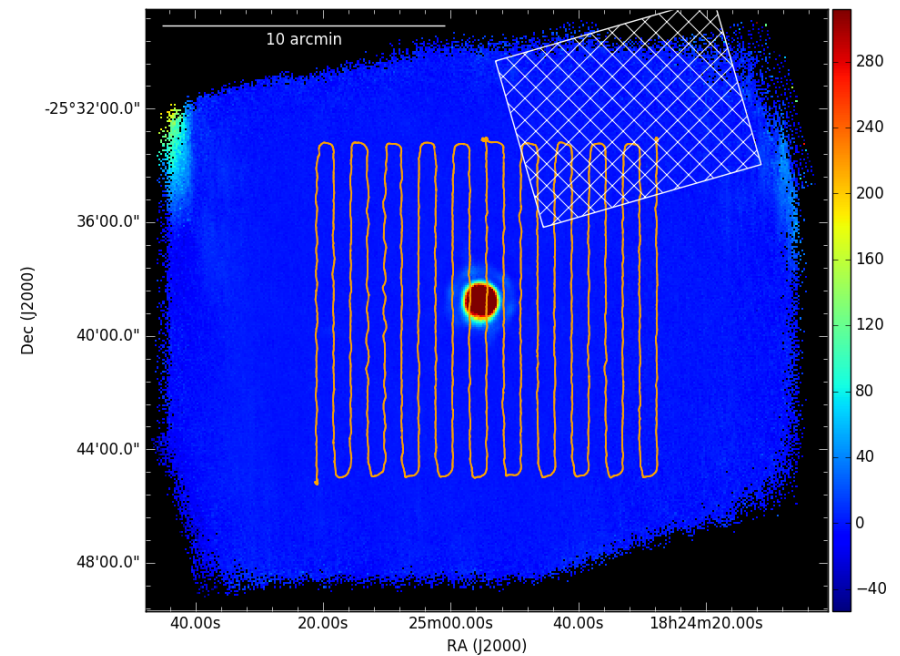
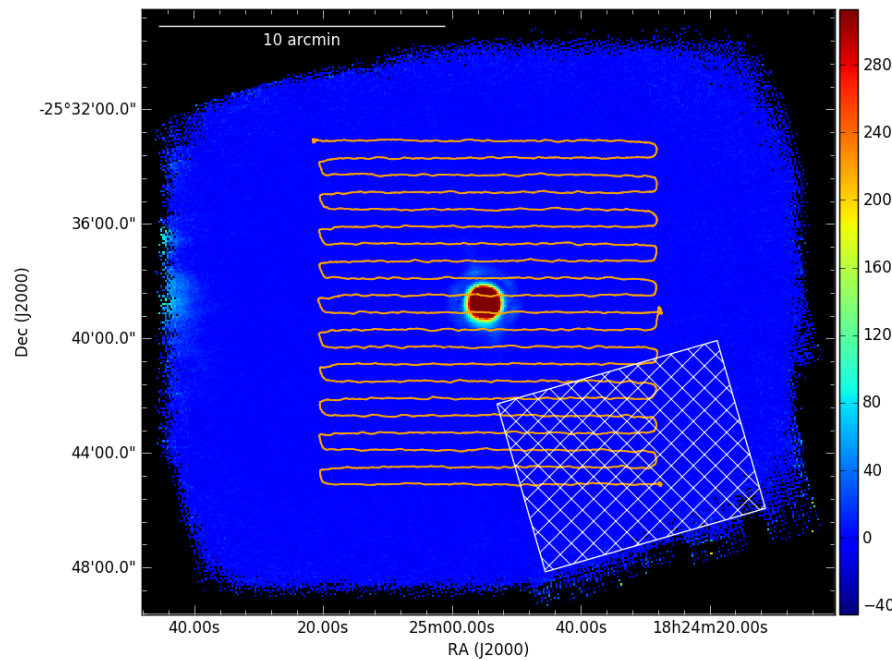
- Recommended scan mode for imaging compact sources
- Works very well!
- Mars (left) from October; DR 21 (right) from April



360 arcsec pk-pk, 200 arcsec/sec, 60 sec duration

# HAWC+ observing modes

- **OTFMAP – Box (a.k.a. raster, waffle)**
  - Recommended scan mode for imaging large sources
  - Works very well!
  - Mars (Band E) shown below



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