HAWC+ Status for SOFIA Users Group

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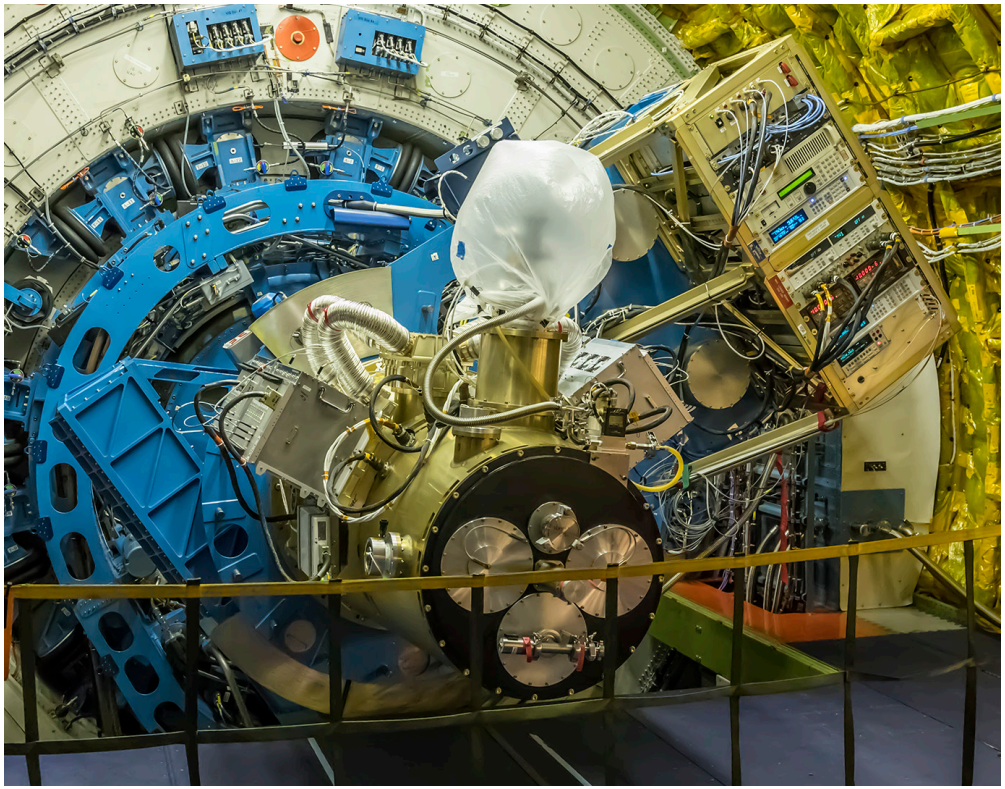
Note: This presentation contains preliminary commissioning data. Please consult with HAWC+ P.I. before using or distributing this material.

Topics

- instrument status
- observing modes
- first results
- pipeline status
- issues for the SUG



HAWC+ instrument: status

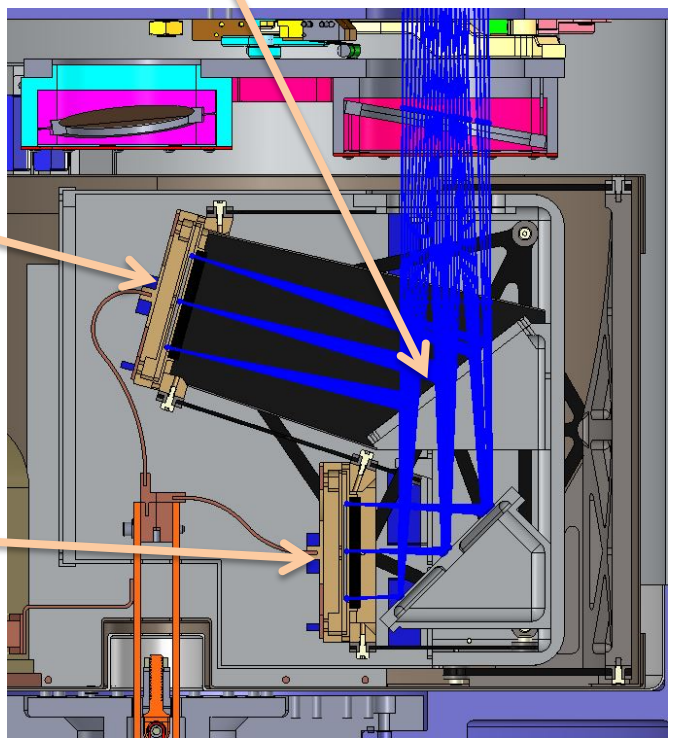
- Overall, Commissioning Part 1 was successful.
  - All subsystems functional and now demonstrated in flight.
  - All primary observing modes exercised, with data now in hand.
- However, a significant problem with the <1 K cooler will require further work on instrument before Commissioning Part 2.
  - Vibration during observing conditions is the cause, producing excess 0.2 mW on cooler (Adiabatic Demagnetization Refrigerator).
  - Cooler hold time was insufficient for full SOFIA flight.
  - Detector base temperature was high (~250 mK vs. planned ~150 mK) and strongly variable, which complicates the science analysis.
  - Cooling problem is solvable, but will require ~2 months of work on instrument.

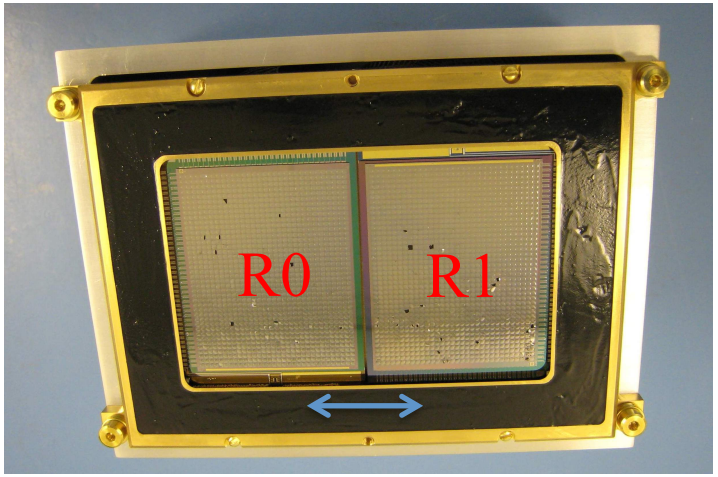
HAWC+ detector arrays

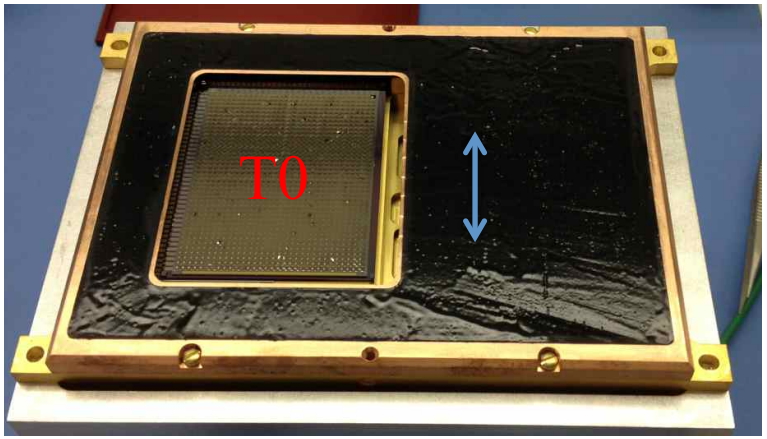
polarizing beamsplitter

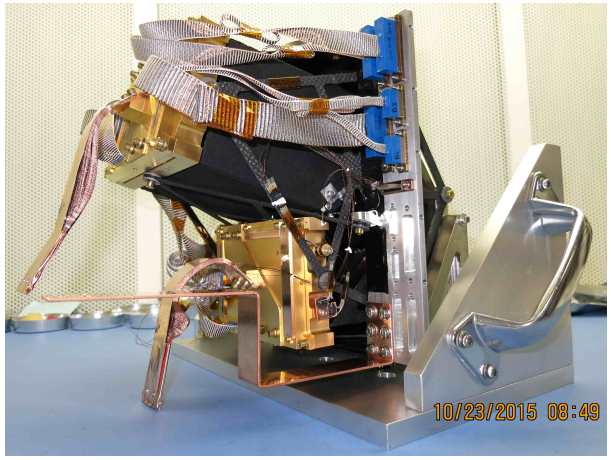
'R' detector array

'T' detector array







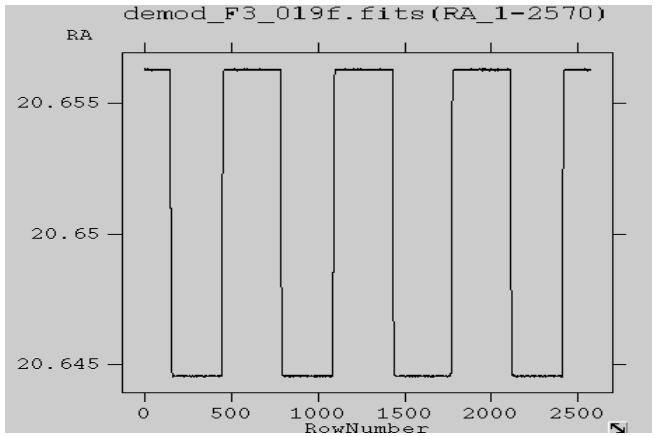


HAWC+ observing modes

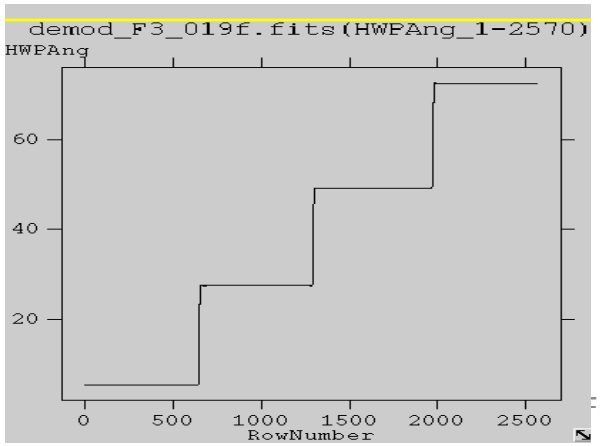
- All intended science observing modes were exercised and successful.
  - Some calibration observations (e.g., sky dip) were not attempted.

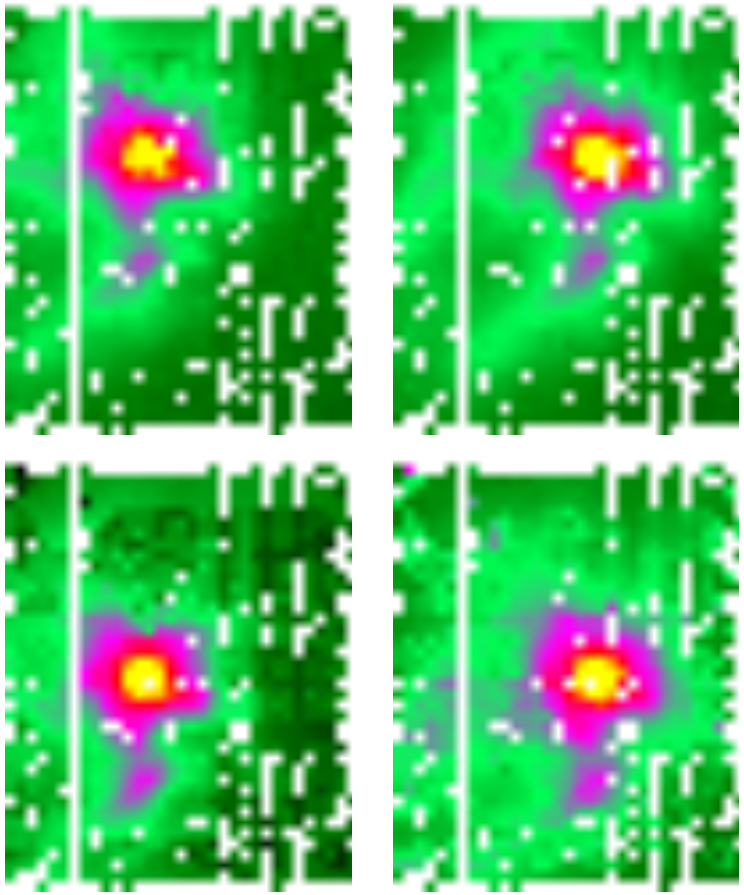
- **Chop-Nod-HWP Step-Dither**: only delivered mode for polarimetry
  - Stokes I also measured, in addition to Q, U

nod sequence



Half-Wave Plate seq.
4 angles, 60 sec each

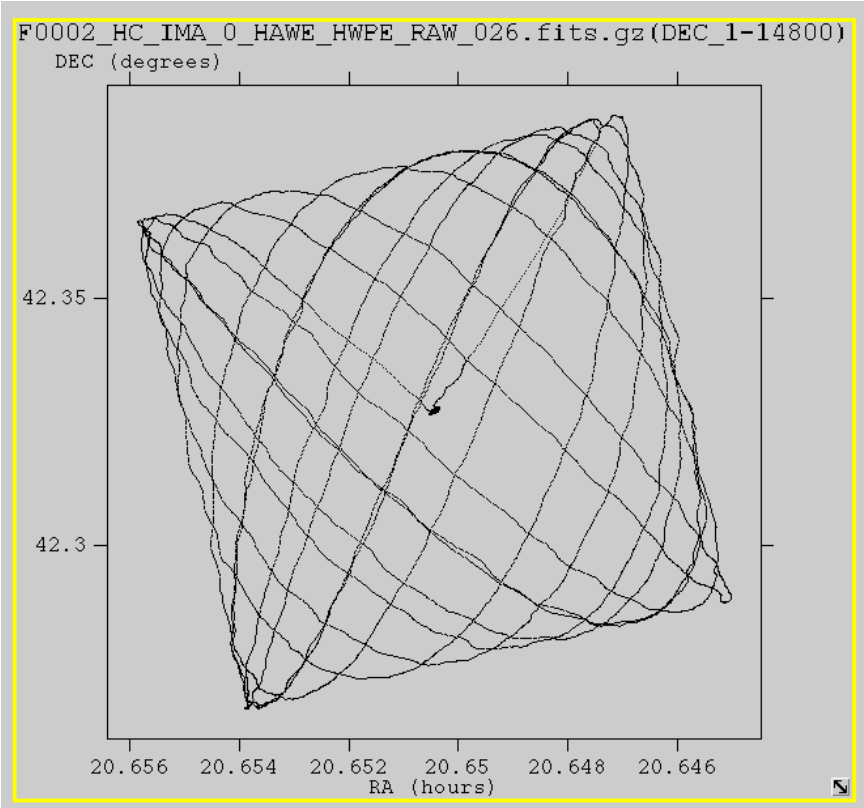


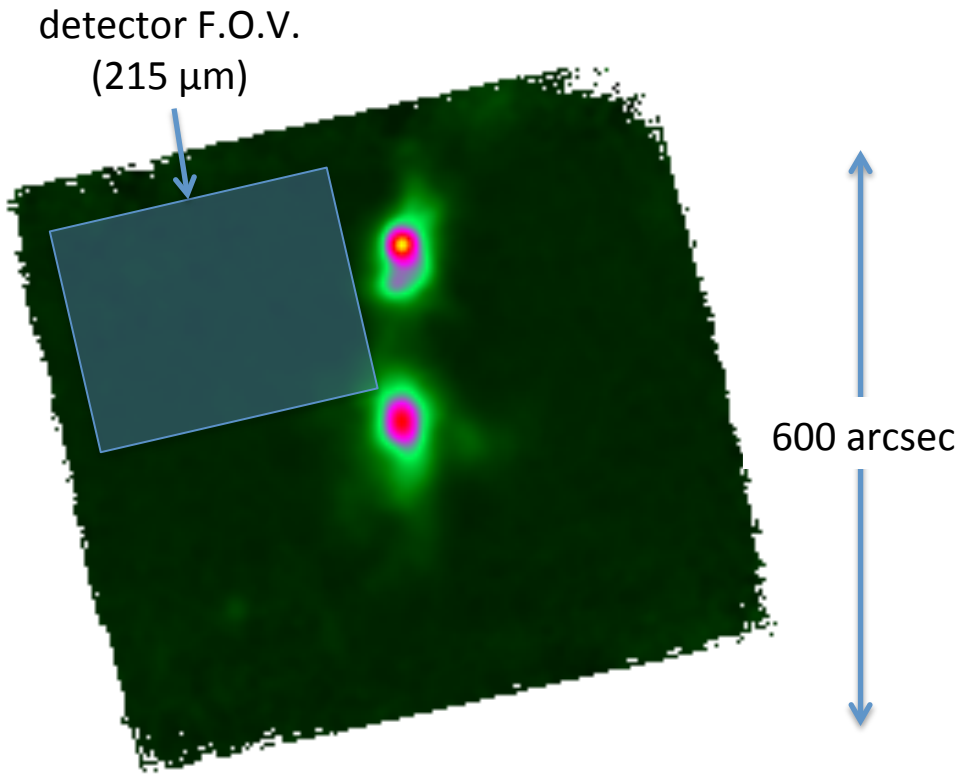


4-position dither sequence

HAWC+ observing modes

- **Lissajous**: recommended scan mode for imaging compact sources (< field of view)
  - Worked very well!

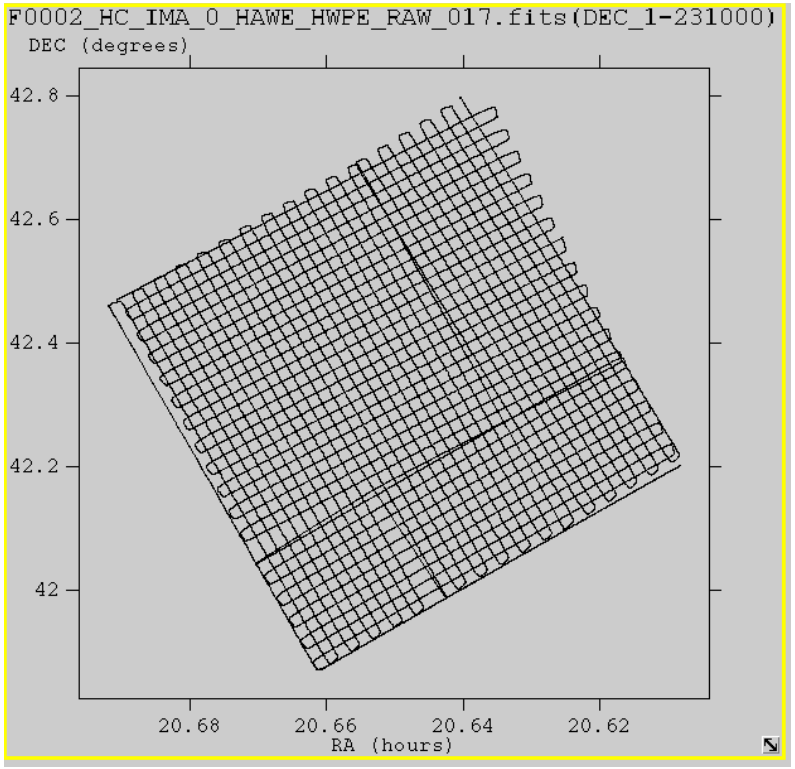




360 arcsec pk-pk, 200 arcsec/sec, 60 sec duration

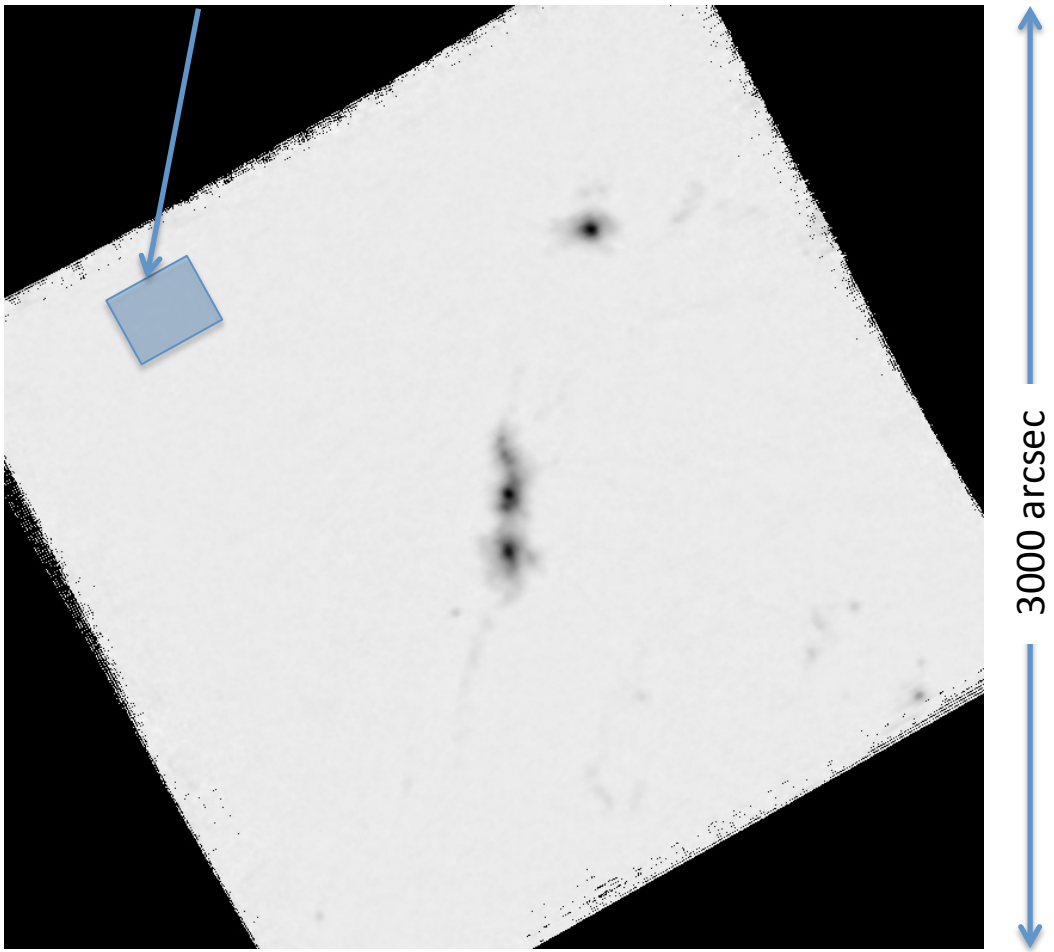
HAWC+ observing modes

- **raster (lawn mower)**: reasonable scan mode for imaging larger fields

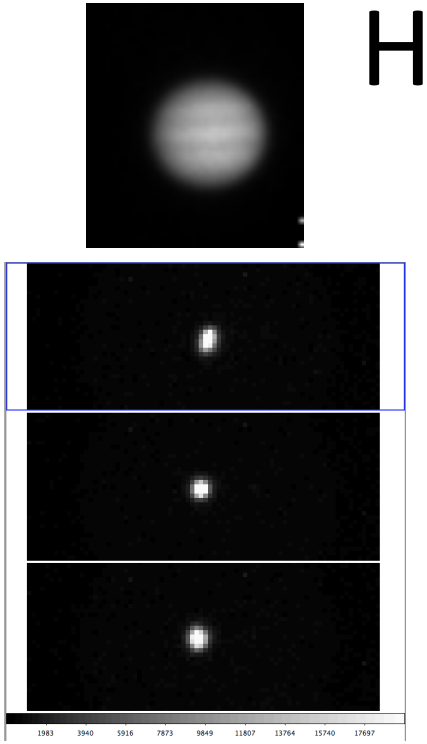


200 arcsec/sec, 19 min. duration
5 pauses to cross-check gyros vs. star tracking

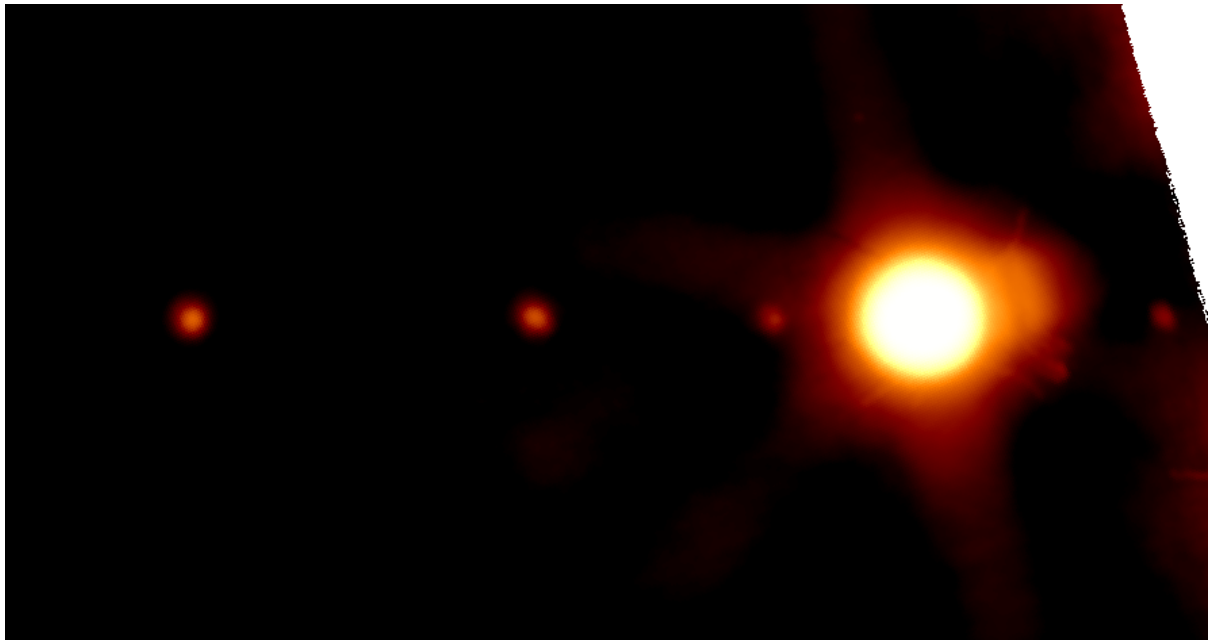
detector F.O.V. (215 µm)



HAWC+ first-light results



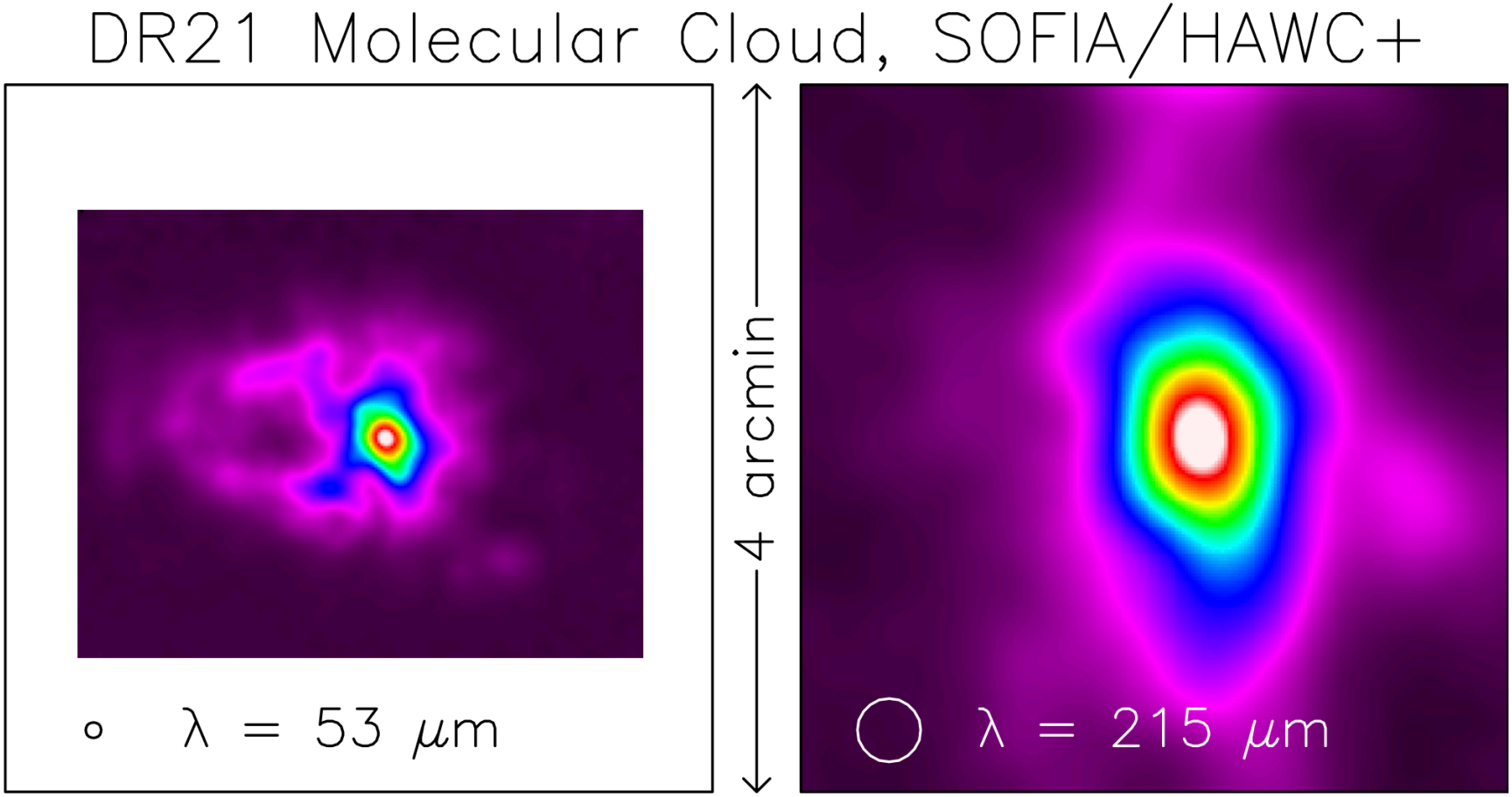
optical boresight camera



Jupiter and 4 moons, May 5 UT, λ = 53 µm (log scale)

Band / Observation	Measured FWHM	Predicted FWHM
53 µm / Ganymede Lissajous	6.1 arcsec	4.9 arcsec
53 µm / Callisto chop-nod	7.0 arcsec	4.9 arcsec
154 µm / Ganymede Lissajous	13.5 arcsec	14 arcsec

HAWC+ first-light results



- These images demonstrate that the HAWC+ bands will be able to distinguish warm and cold dust components of clouds.

HAWC+ first-light results

- Polarization observations were collected for Jupiter, Jovian moons, and DR21 core in multiple bands.
- Polarization signals are expected to be weak (~1% of total intensity), so we will need to treat the detector noise and gain fluctuations caused by variable base temperature carefully.
- Preliminary upper limit of 4% on polarization caused by telescope+instrument at 53 μm.

HAWC+ first-light results

- Very preliminary analysis indicates that despite the problems with cooling the detector adequately, the sensitivity is within a factor of 2 of pre-flight predictions.
  - Relies on removing temperature fluctuation noise which is correlated from detector to detector; we presume this noise will be much reduced after improvements to cooling system.

HAWC+ data analysis pipeline: status

- Commissioning Part 1 testing: All parts of the data reduction software – the pipeline core, nod-pol pipeline, CRUSH, automatic in-flight reduction and web viewer – have been tested and run successfully during recent flights.
- HAWC+ data was automatically transferred to the MCCS for archiving.
- Development and delivery of core, nod-pol, automatic reduction and web viewer:
  - Pre-flight version of the software was completed in April and has been delivered to SOFIA SW team.
  - The software is being improved based on experiences from recent commissioning flights. This version will be delivered to SOFIA SW team before Commissioning Part 2.
- Final software will be delivered to SOFIA SW team once it has been validated using data from the remaining commissioning flights.
- Documentation:
  - Users manual / Programmers manual: Several versions for core package and nodpol pipeline have been delivered to SOFIA SW team for review. Updated versions that include changes needed based on recent flights will be submitted with the software for Commissioning Part 2; a preliminary version will be available in June.
  - CRUSH is the most extensively documented routine in the HAWC+ data reduction package. For example, see: http://www.submm.caltech.edu/~sharc/crush/ . However, about one month of work remains to be done to convert this documentation to the HAWC+ specific format and to incorporate the changes made during the adaptation of CRUSH to the needs of HAWC+.

HAWC+ / SOFIA Users Group

- Cycle 4 shared-risk science with HAWC+:
  - Timing of instrument work is made challenging by personnel availability (summer vacations, SOFIA deployment) and GSE readiness/B703 processes.
  - The most optimistic scenario has HAWC+ in improved condition and ready for Commissioning Part 2 in August. Could follow with shared-risk science.
  - There are several factors which could each cause ~1 month slips to that schedule.

- The HAWC+ team had a very positive experience working with the Observatory staff, and we look forward to many happy returns.