SOFIA Stratospheric Observatory for Infrared Astronomy

SOFIA Program Status Update

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Agenda

SOFIA Stratospheric Observatory for Infrared Astronomy

- Overall Program Schedule
- Aircraft Status
  - *Avionics Upgrade*
  - *MCCS Development*
- Telescope Status
  - *Mirror Crack Repair*
  - *Pointing Improvements*
- Instrument Status
  - *First-Generations Instruments*
  - *Second-Generation Instruments*

Development/Flight Plans and Milestones

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- Aircraft flew FORCAST, HIPO, and GREAT Early Science flights
  - *See next presentation for details*
  - *Early Science flights were shared risk – observatory development was not complete*
- Last Early Science flight was in December, 2011
- Aircraft has been in hanger since, while:
  - *MCCS development (mostly) completes*
  - *Avionics upgrades*
  - *TA mirror repair*
  - *TA pointing improvement*
  - *Modifications to TA cavity door to allow flights in rain*
- Functional check flights to check avionics upgrade scheduled late July

Development/Flight Plans and Milestones (2)

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- Will undergo formal observatory V&V in October before Cycle 1 science flights start in November
- Work in formal instrument commissioning with Cycle 1 science flights
- There may or may not be a southern hemisphere deployment in the summer of 2013 – if so there will only be one TBD instrument taken to Christchurch, NZ
- Other schedule milestones
  - *Potential mirror recoating early fall, 2013 – depends on reflectivity measurements*
  - *Routine 4-week aircraft maintenance downtimes roughly three times a year*
  - *Heavy aircraft maintenance (D-check) by Lufthansa in Germany, 12 weeks starting mid-June, 2014*

SOFIA Flight Rates

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- Are currently staffed to fly two flights a week
- Have begun staffing up and training personnel to be able to support 3 flights a week starting in June 2013, and 4 flights a week starting in November, 2013
- We have just enough funding to fuel the plane for this flight rate

MCCS Development

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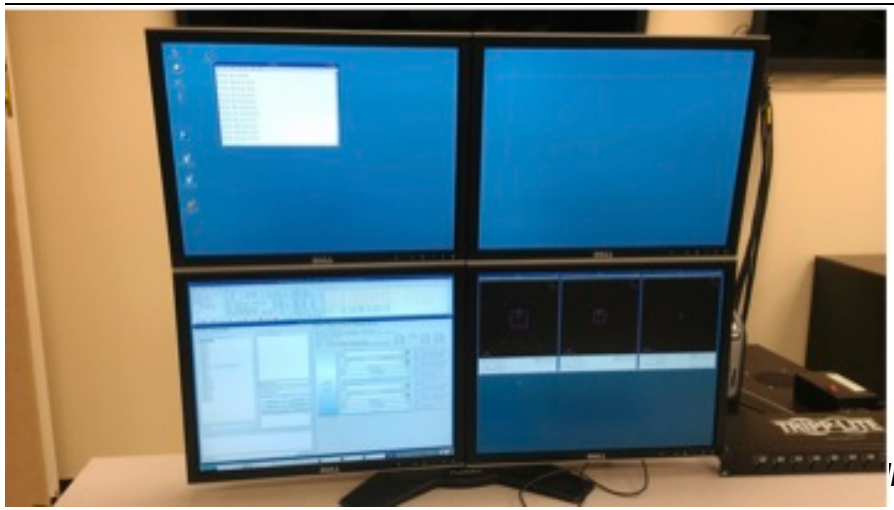
- The Mission Communications and Control System (MCCS) is the hardware/software system that links the different SOFIA components, i.e. the instruments, telescope, observers, etc. into an integrated observatory
- In Early Science the MCCS existed in a very rudimentary form, e.g.
  - *TA ran largely independently*
  - *Many instrument control functions were not implemented*
  - *Water Vapor Monitor could not communicate with MCCS and had to operate in a less-accurate stand-alone mode*
  - *Other sub-systems, i.e. Mission Audio Distribution System, Video Distribution System, were not complete*
- During the current downtime we are bringing the various parts of the MCCS on-line and in communication with each other

MCCS Software

– MCCS software is being developed in a series of engineering builds, with on-aircrafts tests in the hanger and on the flight-line to verify the results

– The distributed software development team would also periodically get together into working prototyping sessions

New Telescope Operator display config



Prototyping session

MCCS Systems

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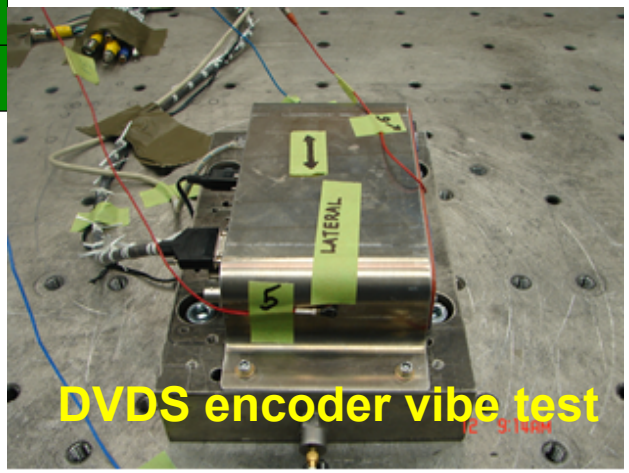
MCCS Status

	Lead	H/W rec'd	System Built-up	Ruggedized	Enviro Tested	Line Ops Software	V&V Software	Test Plan	Drawings	Functional Test	FMEA	Spare
Platform Interface System	Davis											
Data Acquisition System	Franz											
Archiver	Schnarr											
Digital Video Distribution System	Enga											
NTP Server	**Choi**											
Network	**Tucker**											
Workstation	Hench											
Water Vapor Monitor	Roellig											
Power Distribution System	Milsk											
Mission Audio Distribution System	Smith											

Received or complete	
In work	
Not started	
Schedule concern	
Major issue	
Not Applicable or completed in segment 2	

Development going well (almost all "green")



Avionics Upgrade

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- Original B747SP avionics (round “steam gauges”) were too old to support modern air traffic control standards
- Aircraft environmental data not available to MCCS
- Entire SOFIA cockpit is being reworked to address both of these issues, giving the cockpit displays a modern screen-based look (what the pilots call a “glass cockpit”)

SOFIA Cockpit Before Upgrade

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In-Progress Avionics/Flight Deck Upgrade

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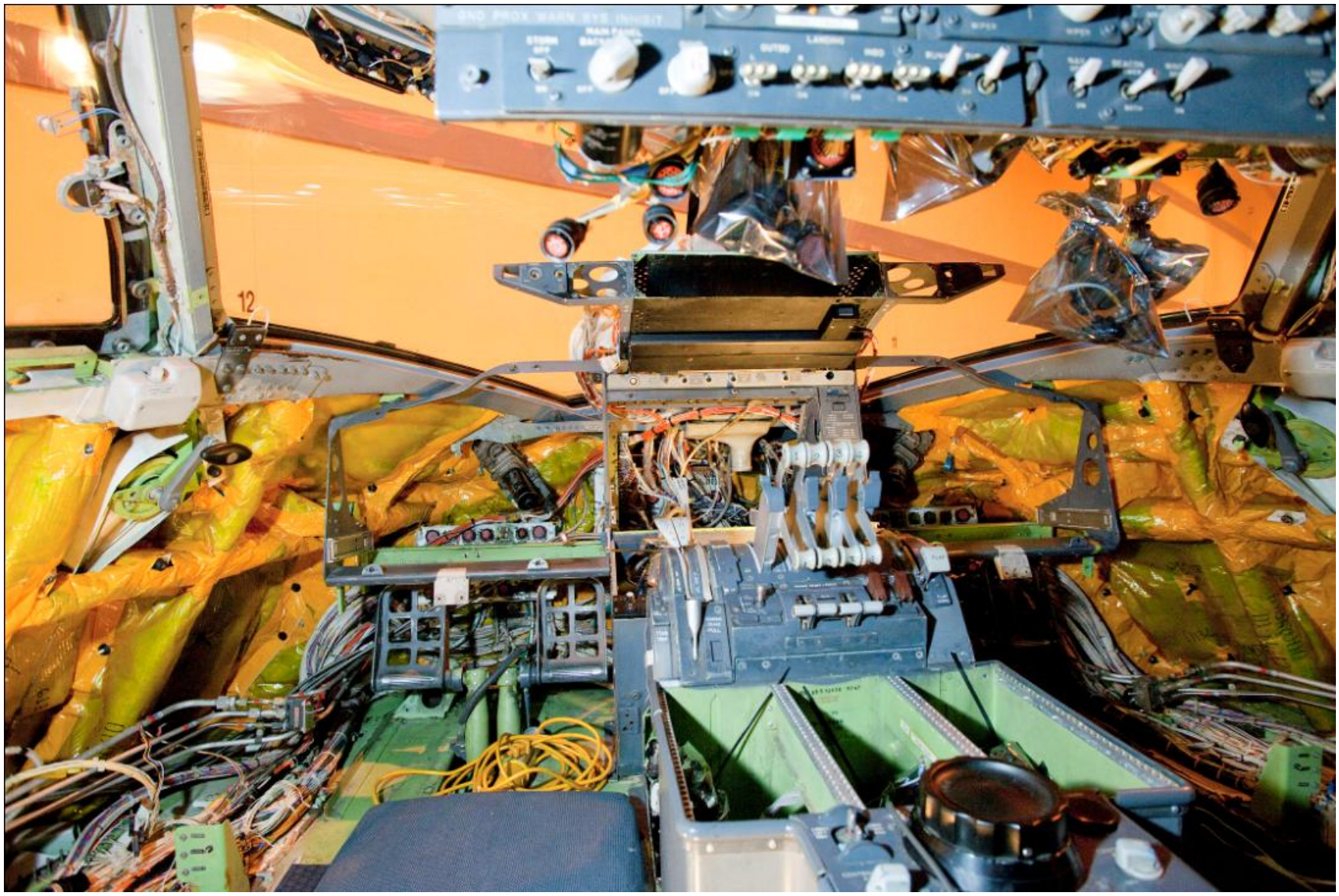

Telescope Mirror Crack Repair

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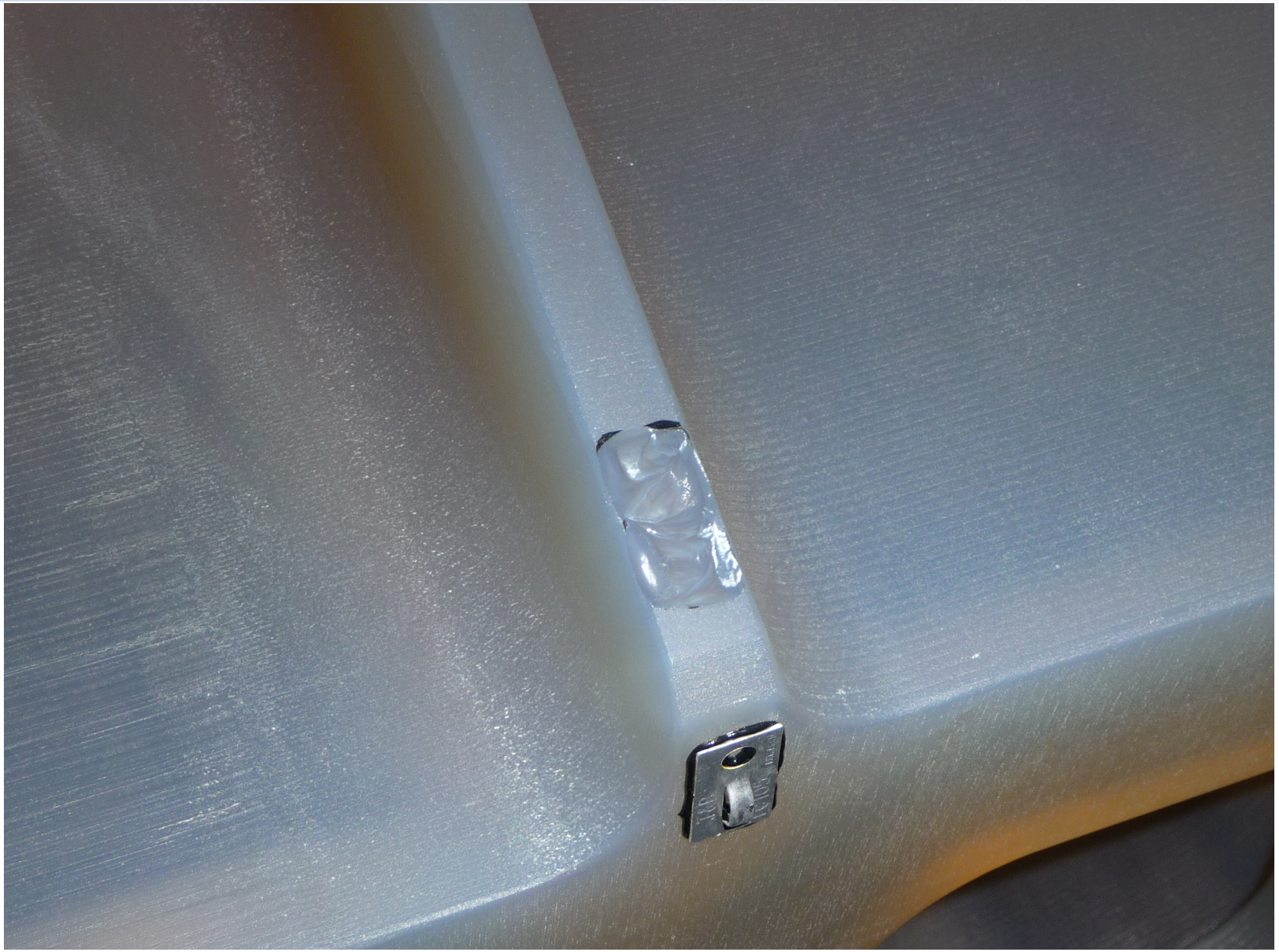
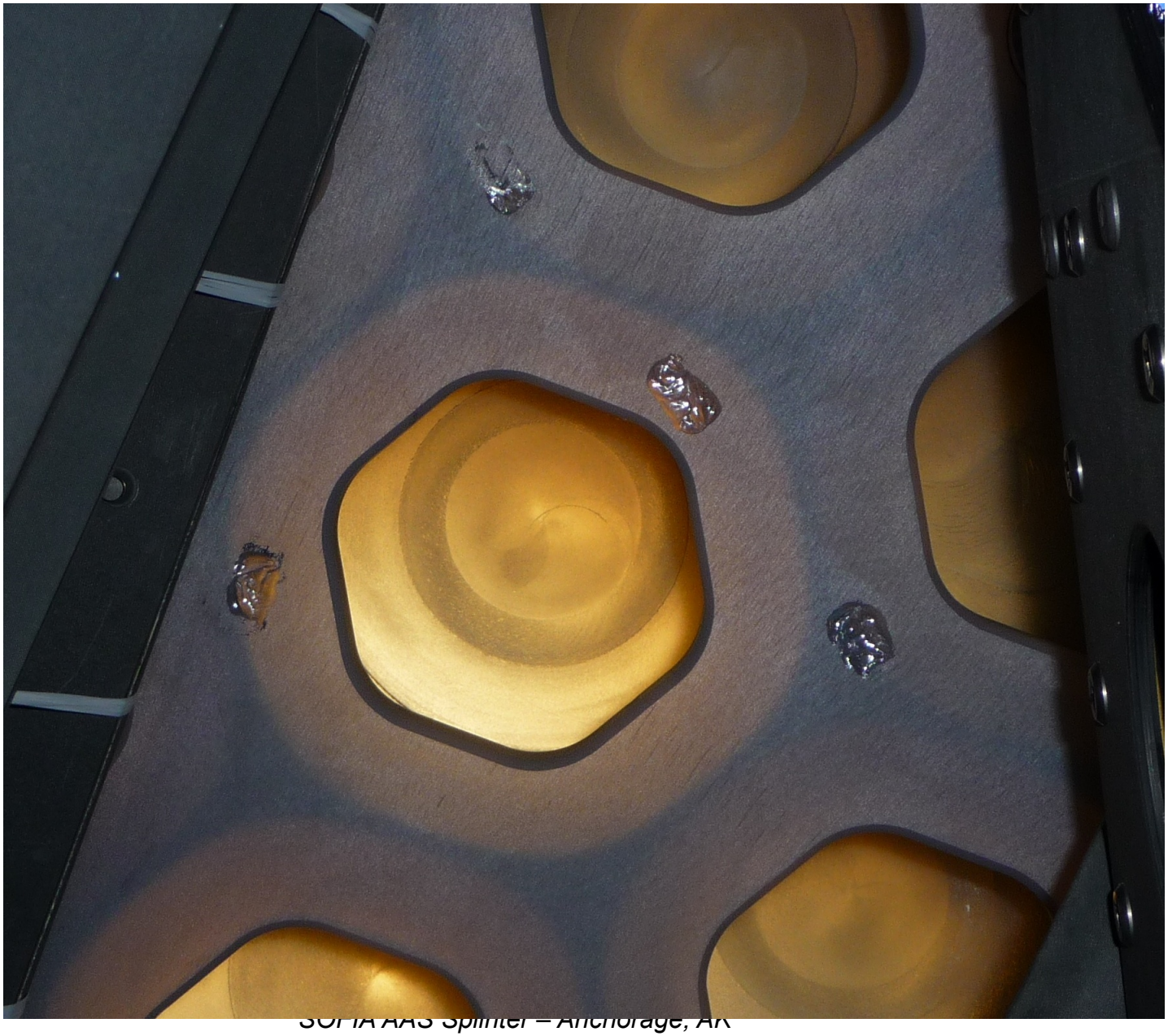
- Thermal mis-match between the aluminum cable ties glued to mirror and Zerodur mirror material caused some cracks in mirror
- There were already a few existing divots that had occurred during the mirror light-weighting
- Mirror was very carefully inspected, almost all cable ties were removed, and cracked areas were repaired
- Schott experts examined the repaired mirror, pronounced it “better than it ever has been”

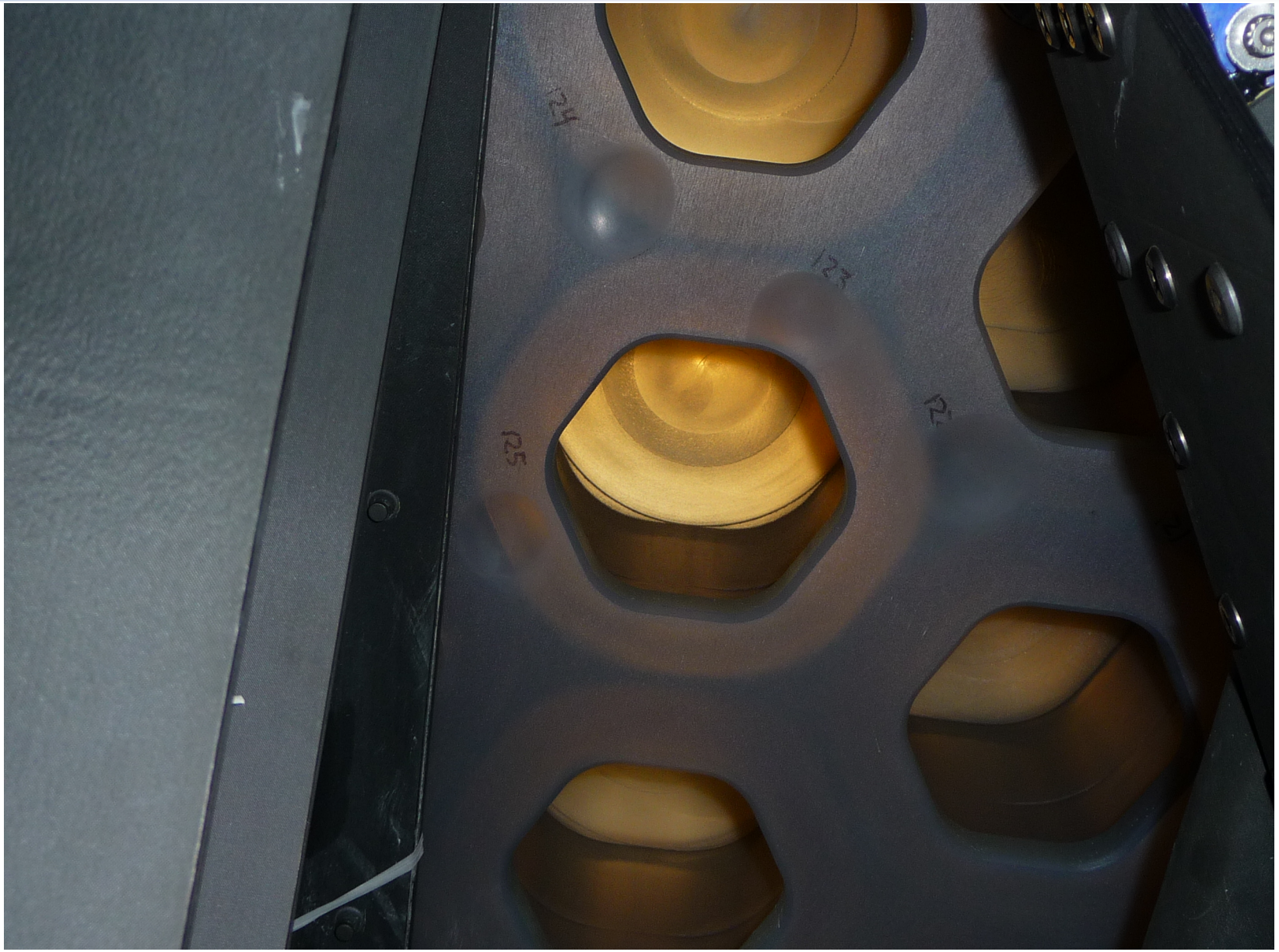
Mirror Crack and Cable Tie



Before Repair



After Repair



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Telescope Pointing and Image Quality

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- Met Early Science requirements but not our long-term goals for normal operation
- Undergoing a program to update pointing
  - *Upgraded software*
  - *Upgraded focal plane imager*
- Also working to improve image quality
  - *Active mass dampers to reduce vibration modes*
  - *Figure out what do with the present baffle plate – loads induce vibration in the telescope head-ring*
- Currently do not support tracking to an ephemeris for a fast-moving Solar System object – although some non-sidereal observations may be possible but will have to be addressed in a case-by-case manner

80% Encircled Energy vs. Wavelength

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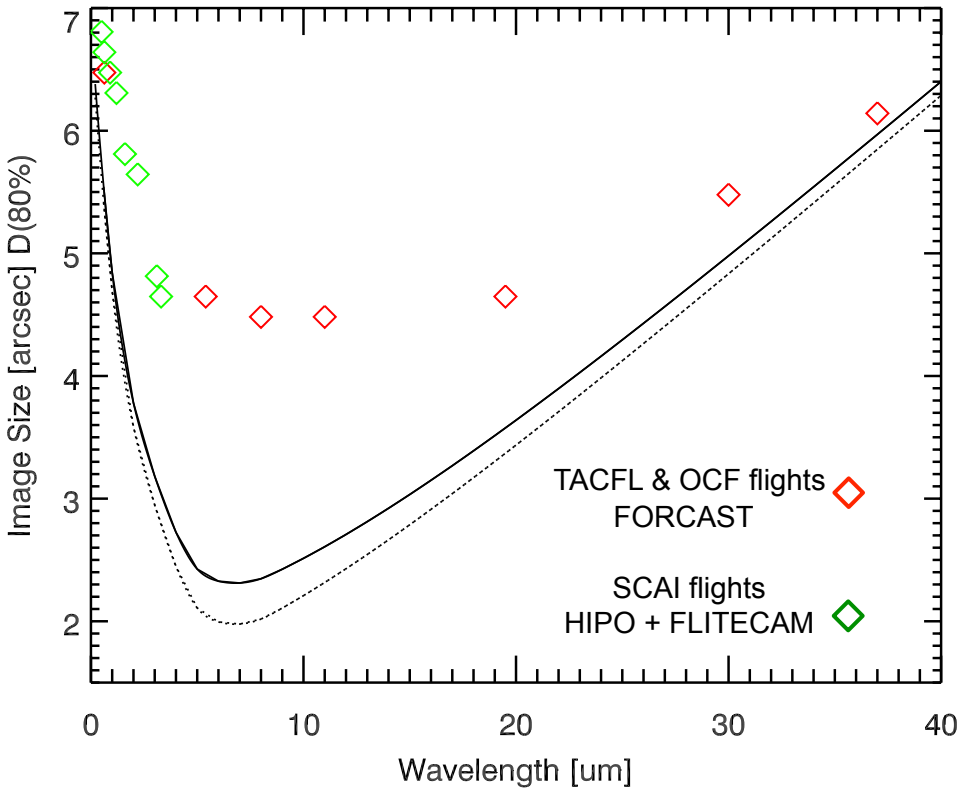

Total D80 image size, including diffraction and anticipated jitter and shear layer seeing, as a function of wavelength.

- **HIPO and FLITECAM images sizes:**
- SCAI flights show the evidence for the wavelength dependence of Shear Layer and Cavity Seeing
- There is a clear trend that shorter wavelengths have larger image size.
- The effect can be seen in individual images
- The 1.25μm image is larger and rounder
- The 3.6μm image is sharper and elongated in the cross elevation direction (90 Hz spider motion)

Pointing and Image Improvements

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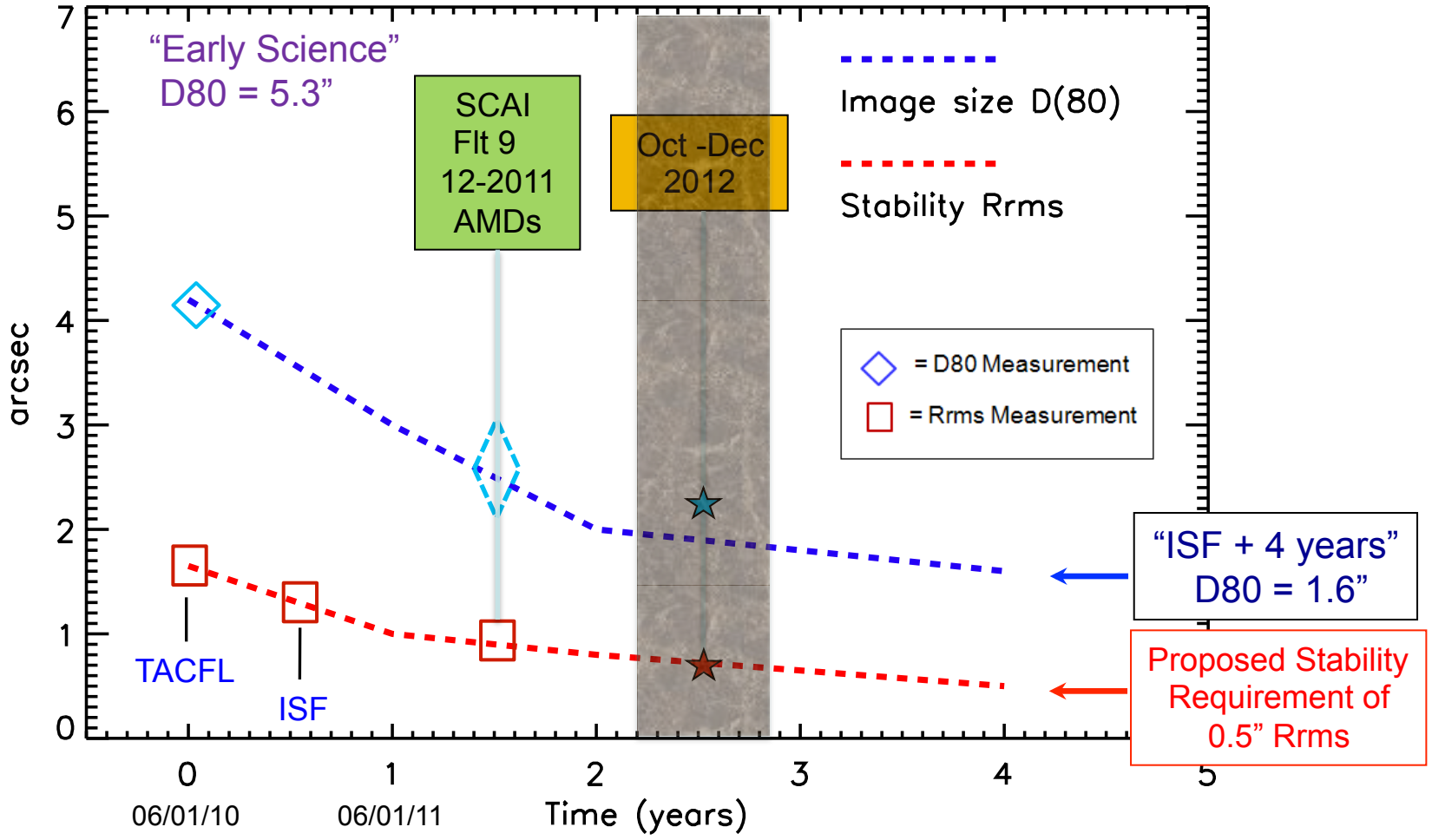

First-Generation Instrument Status

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- HIPO
  - *Flew in Early Science for Pluto occultation*
  - *Still has yet to undergo formal commissioning but will do so as part of the observatory V&V and with FLITECam in FLIPO configuration*
- FORCAST
  - *Flew in Early Science*
  - *Since then has upgraded detectors and added grisms*
  - *Still has to undergo formal commissioning, will do so in two stages in early Cycle 1*
- GREAT
  - *Flew in Early Science*
  - *Plans to add mid-frequency channel for Cycle 1*

First-Generation Instrument Status (2)

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- FLITECam
  - *Flew in Early Science*
  - *Still has yet to undergo formal commissioning but with do so both by itself and also with HIPO in FLIPO configuration*
- HAWC
  - *In development*
  - *Before commissioning will be upgraded with a bigger detector array and polarization capabilities (see next slide)*
- EXES
  - *In development*
  - *Requires better pointing and image quality to use its slit*
- FIFI-LS
  - *In development*
  - *Development will be completed in Germany and delivered in December, 2013 to be operated as a Facility Class Instrument*

Second Generation Instruments

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- Call for upgrades and new second-generation instruments issued June 24, 2011
- Selections announced April 17, 2012
- Two upgrades selected, both for HAWC
  - *HAWC++ Johannes Staguhn, JHU: Larger detector array*
  - *HAWC-POL Darren Dowell. JPL: adds polarimetric capabilities*
  - *HAWC development will finish up at the same time as the two upgrades are added*
- Although there were also highly-rated new facility science instrument proposals, the new instrument funding profile was such that their development start would have been delayed, so the decision was made to use this money to accelerate the call for the third-generation instruments (see SOFIA web site for more details)

2nd Generation Selections

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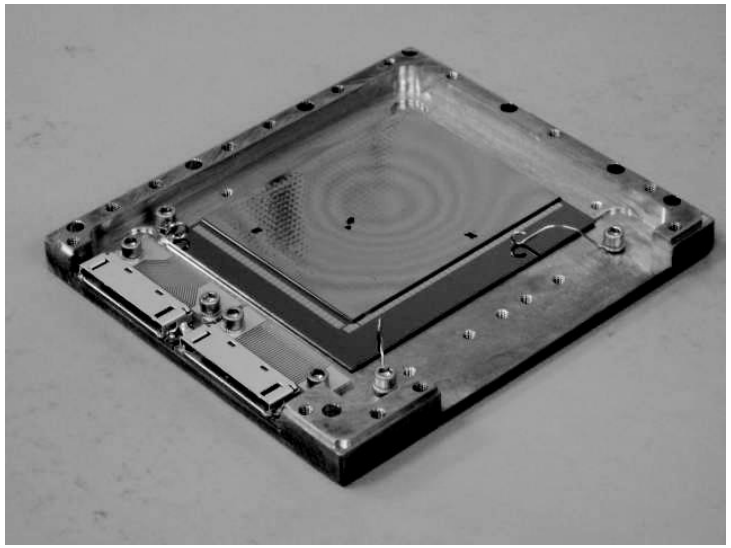
- HAWC-POL
- PI- Darren Dowell (JPL)
- Polarizer mechanism replaces existing pupil wheel on HAWC

HAWC-POL Mechanism
Novak & Dowell (2009)

- HAWC++
- PI Johannes Staguhn (Johns Hopkins)
- Increases detector format on HAWC above the current 384 pixels



Similar PIPER 32x40 Prototype detector
Chuss et al. (2010)