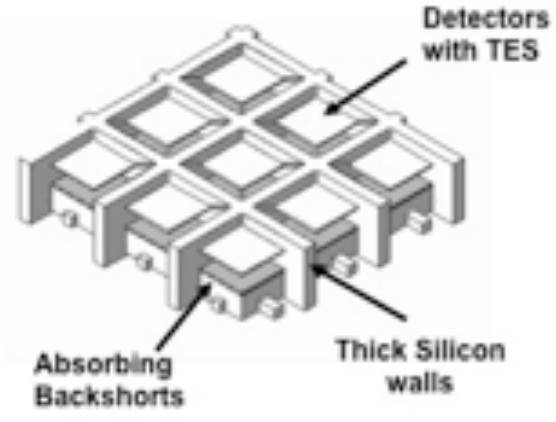
HAWC Upgrade Program

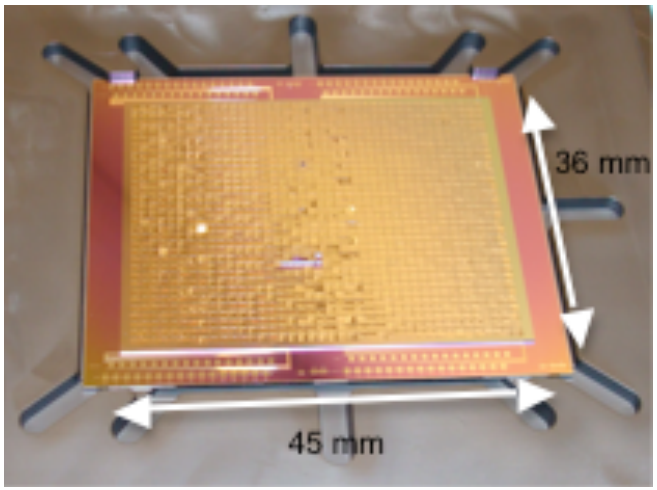
Darren Dowell (JPL)
and the HAWC+ team
2012 Sept. 17

HAWC+: an upgraded HAWC

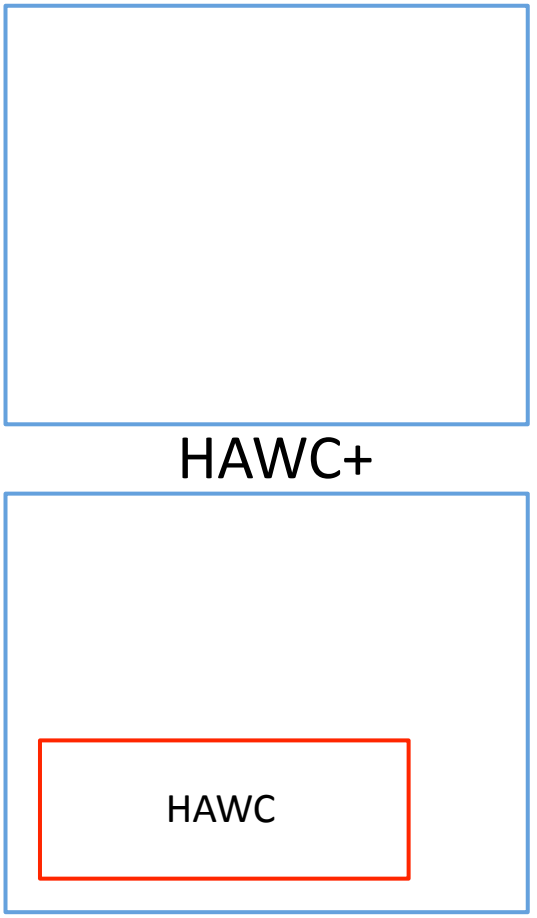
- NASA has conditionally selected an upgrade program for HAWC based on two proposals submitted last October:
  - "SOFIA Far-IR Polarimetry with the HAWC-Pol Upgrade" (Dowell, JPL)
  - "HAWC++: Wide Field Polarimetry of FIR Dust Emission and Fine Structure Lines in the ISM" (Staguhn, JHU&GSFC)
- JPL is tasked with combining the two proposals into one coherent project. Proposal currently under review by NASA HQ.

BUGs for HAWC





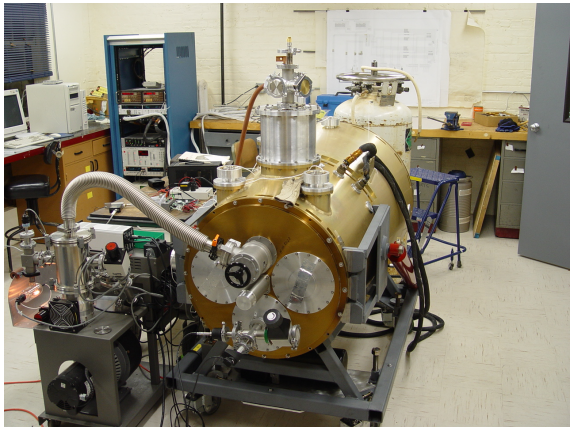
- Building on success with GISMO detector and instrument, Goddard detector group is making larger-format Backshort Under Grid detector arrays
  - Transition-Edge Sensors which hybridize with NIST SQUID multiplexers
  - 1.135 mm detector spacing
  - 32 × 40 detectors in each tile
- HAWC+: 2 tile field of view × 2 polarizations sampled



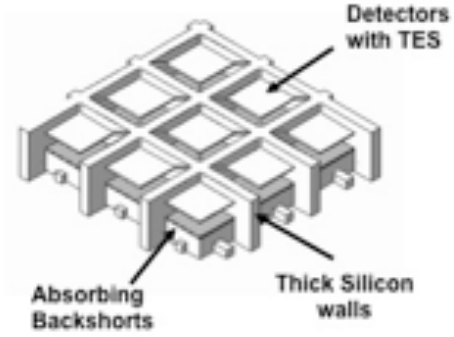
HAWC Upgrade Team

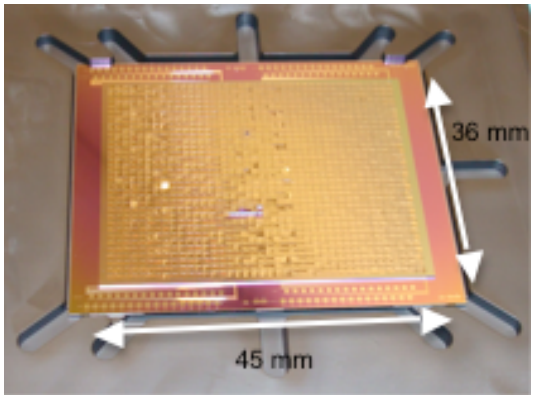
- HAWC+ partners:
  - **Jet Propulsion Laboratory** (Dowell, Hamlin, Runyan): polarimeter, integration & test, P.I. & project management
  - **NASA/GSFC** and **NIST** (Benford, Jhabvala, Chuss, Ames, Irwin): detector upgrade, integration & test support
  - **Johns Hopkins** and **U. British Columbia** (Staguhn, Halpern): detector test, readout electronics, integration & test support
  - **U. Chicago** (Harper, Berthoud, Sandberg, Wirth, et al.): HAWC instrument, control and analysis software
  - **Northwestern** (Novak, Chapman): analysis software
  - **Cornell** (Stacey): narrow-band filters
  - **U. Illinois** (Looney): cryogenic motor
  - **NASA/Ames** and **USRA** (Dotson, Vaillancourt): integration & test and commissioning support
  - a multi-institution, multi-disciplinary science team covering magnetic field and grain alignment theory, star formation, and ancillary observations

Elements of HAWC+

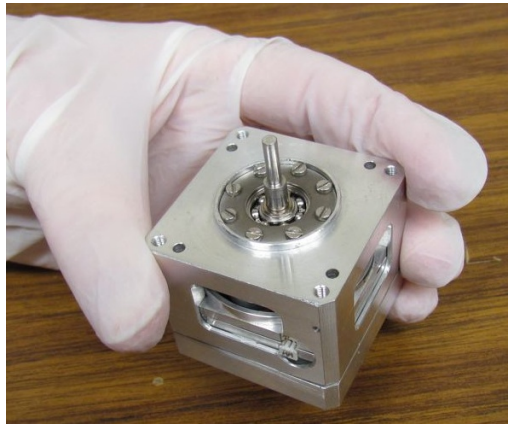


HAWC instrument (U. Chicago)





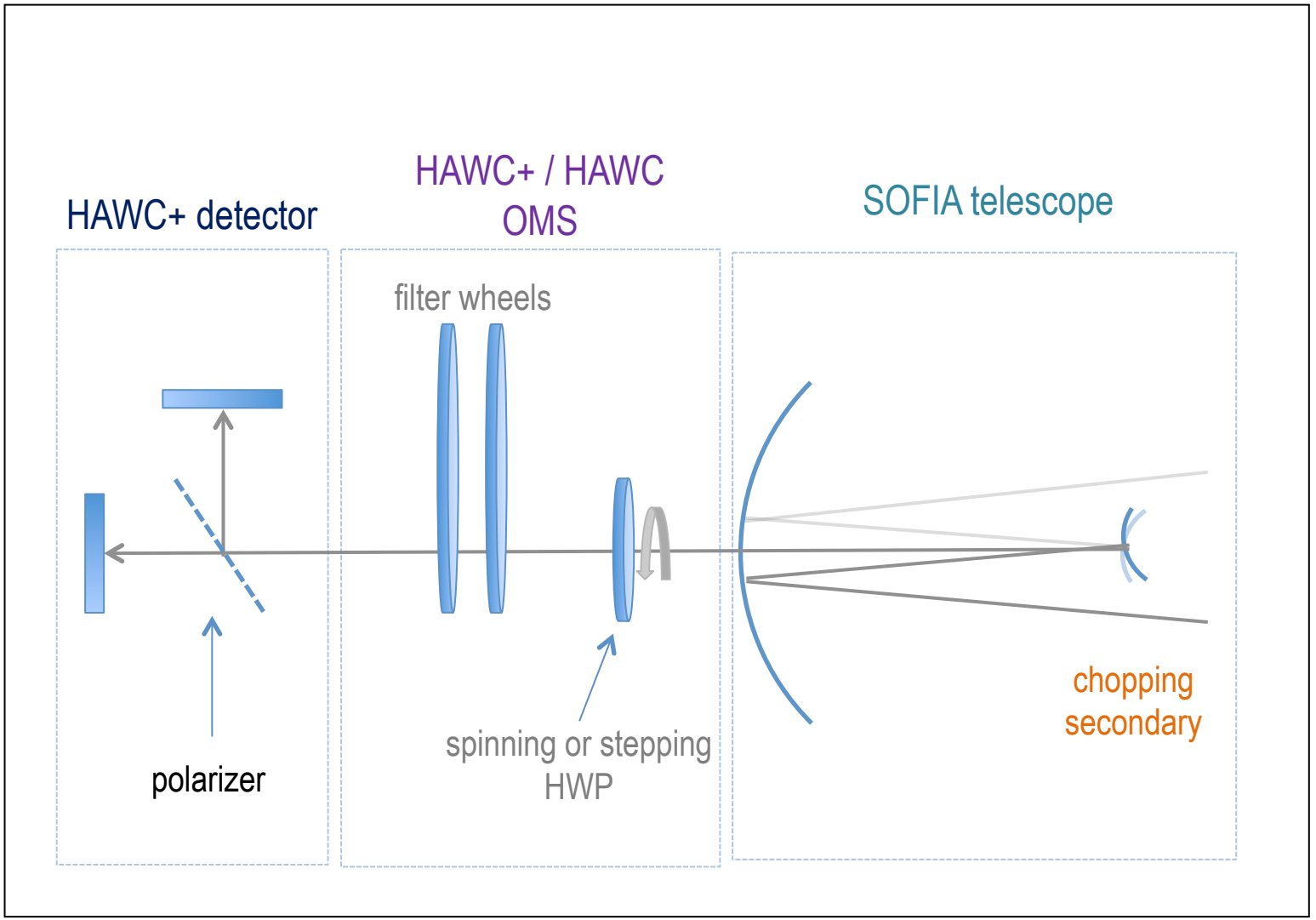
Two 64x40 TES detector arrays (GSFC, JHU): 9× increase in field of view



polarimeter (JPL, U. Illinois): in advanced state of development; continuous and stepped rotation of quartz half-wave plates

Fabry-Perot filters (Cornell): 5 fixed-tuned filters covering [OI], [CII], [OIII], [NII] far-IR lines

HAWC+ schematic optical path

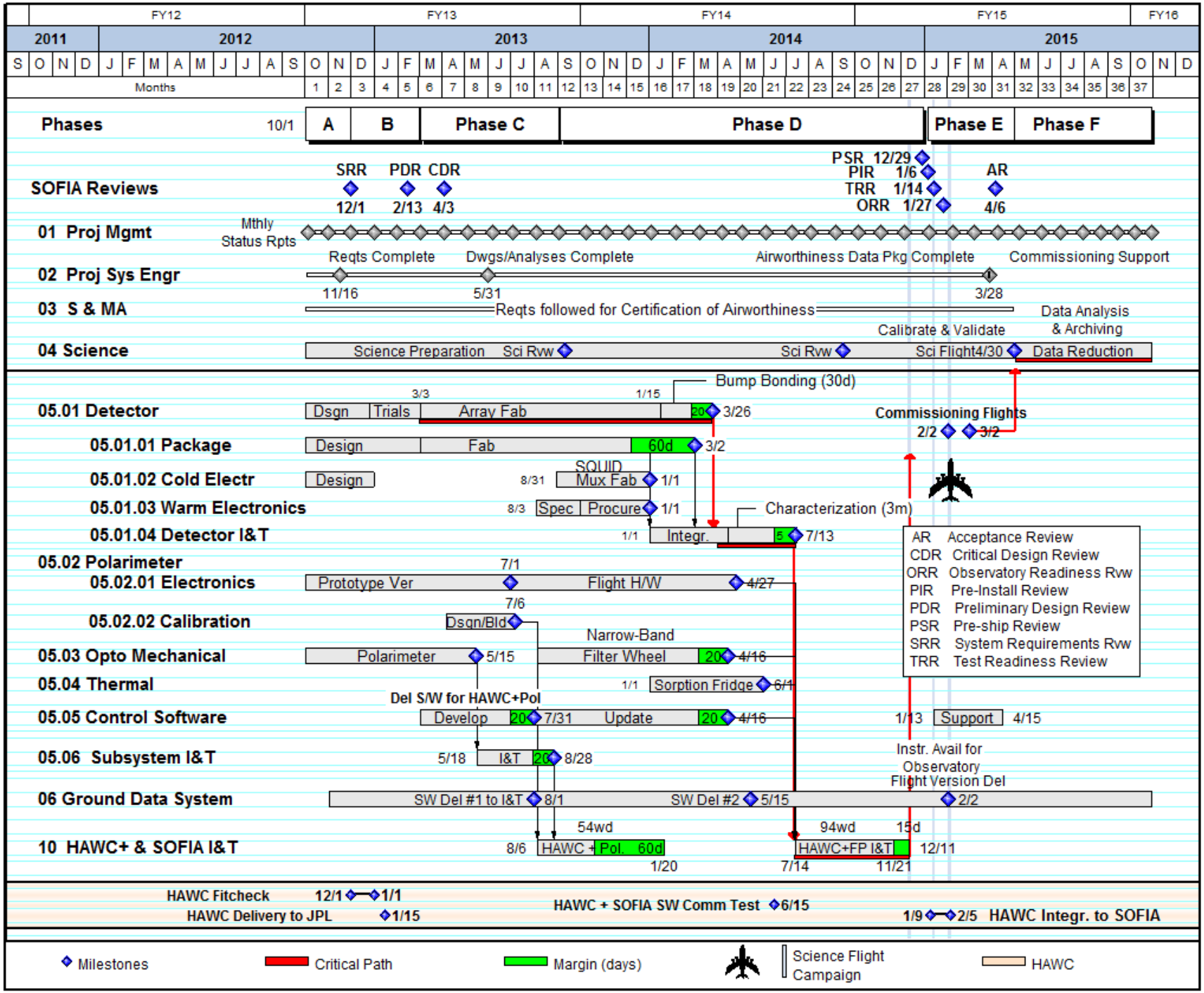


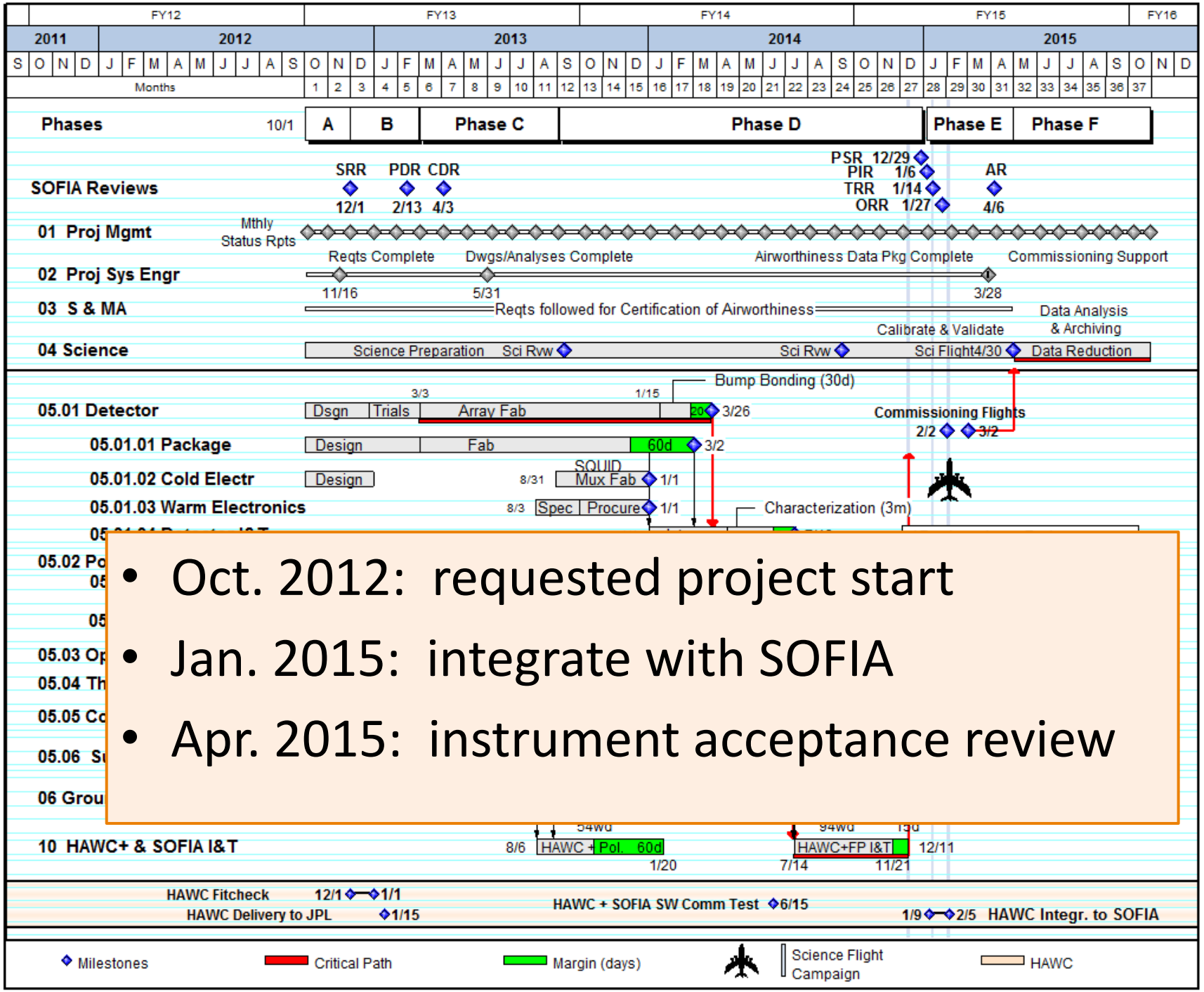
HAWC+ builds on HAWC

What's the same as HAWC

- instrument name and philosophy
- cryostat, including ADR
- housekeeping system for cryostat control
- filter/lens wheel
- window and IR blocking filters
- foreoptics
- lab assembly cart
- instrument control software (IRC)
- framework for data analysis pipeline
- basis for airworthiness
- basis for instrument documentation

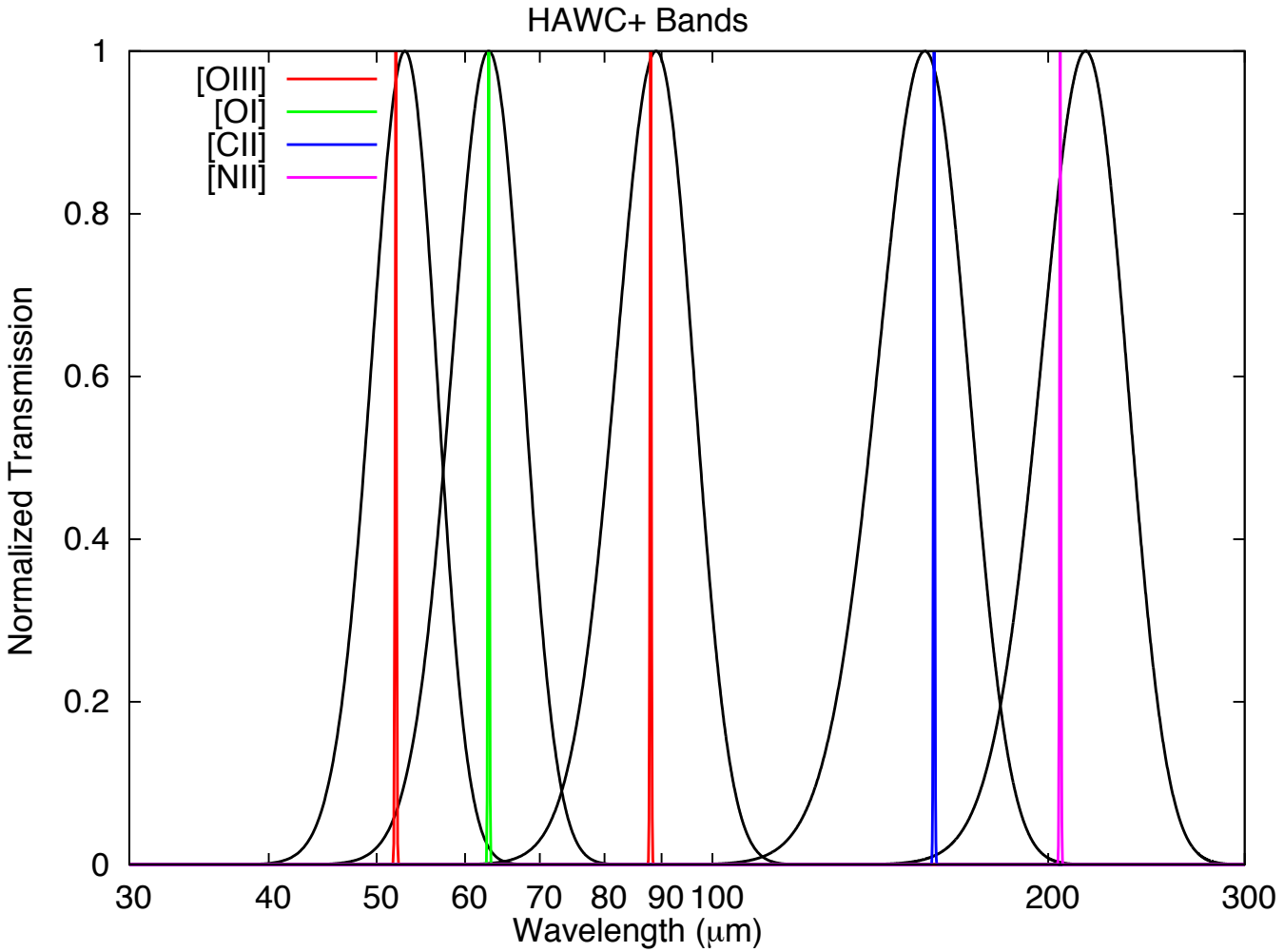
- (Existing detector system has an important role to characterize polarimeter early in upgrade program.)


FY12
FY13
FY14
FY15
FY16
2011
2012
2013
2014
2015
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Months
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Phases
10/1
A
B
Phase C
Phase D
Phase E
Phase F
SOFIA Reviews
SRR 12/1
PDR 2/13
CDR 4/3
PSR 12/29
PIR 1/6
TRR 1/14
ORR 1/27
AR 4/6
01 Proj Mgmt
Mthly Status Rpts
02 Proj Sys Engr
Reqts Complete 11/16
Dwgs/Analyses Complete 5/31
Airworthiness Data Pkg Complete 3/28
Commissioning Support
03 S & MA
Reqts followed for Certification of Airworthiness
Data Analysis & Archiving
04 Science
Science Preparation
Sci Rvw
Sci Rvw
Calibrate & Validate
Sci Flight4/30
Data Reduction
Bump Bonding (30d)
05.01 Detector
3/3
Dsgn
Trials
Array Fab
1/15
20
3/26
Commissioning Flights
2/2
3/2
05.01.01 Package
Design
Fab
60d
3/2
05.01.02 Cold Electr
Design
8/31
SQUID Mux Fab
1/1
05.01.03 Warm Electronics
8/3
Spec
Procure
1/1
Characterization (3m)
05.01.04 Detector I&T
1/1
Integr.
5
7/13
05.02 Polarimeter
7/1
05.02.01 Electronics
Prototype Ver
Flight H/W
4/27
7/6
05.02.02 Calibration
Dsgn/Bld
Narrow-Band
05.03 Opto Mechanical
Polarimeter
5/15
Filter Wheel
20
4/16
05.04 Thermal
1/1
Sorption Fridge
6/1
Del S/W for HAWC+Pol
05.05 Control Software
Develop
20
7/31
Update
20
4/16
1/13
Support
4/15
05.06 Subsystem I&T
5/18
I&T
20
8/28
Instr. Avail for Observatory Flight Version Del
06 Ground Data System
SW Del #1 to I&T
8/1
SW Del #2
5/15
2/2
54wd
94wd
15d
10 HAWC+ & SOFIA I&T
8/6
HAWC + Pol.
60d
1/20
7/14
HAWC+FP I&T
11/21
12/11
AR Acceptance Review
CDR Critical Design Review
ORR Observatory Readiness Rvw
PIR Pre-Install Review
PDR Preliminary Design Review
PSR Pre-ship Review
SRR System Requirements Rvw
TRR Test Readiness Review
HAWC Fitcheck 12/1 1/1
HAWC Delivery to JPL 1/15
HAWC + SOFIA SW Comm Test 6/15
1/9 2/5 HAWC Integr. to SOFIA
Milestones
Critical Path
Margin (days)
Science Flight Campaign
HAWC



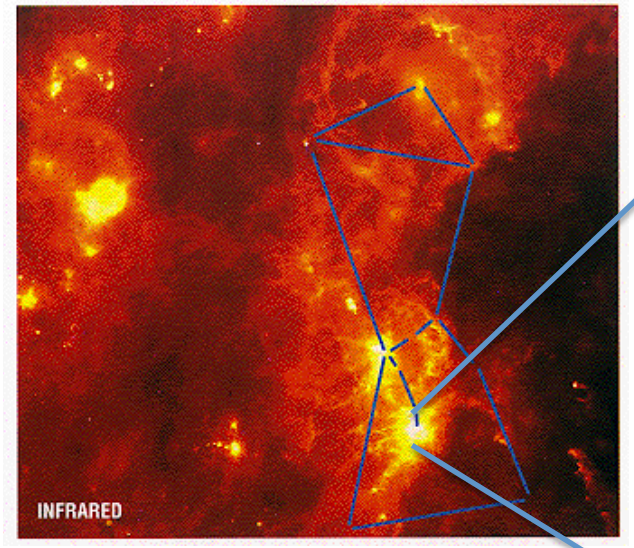
- Oct. 2012: requested project start
- Jan. 2015: integrate with SOFIA
- Apr. 2015: instrument acceptance review

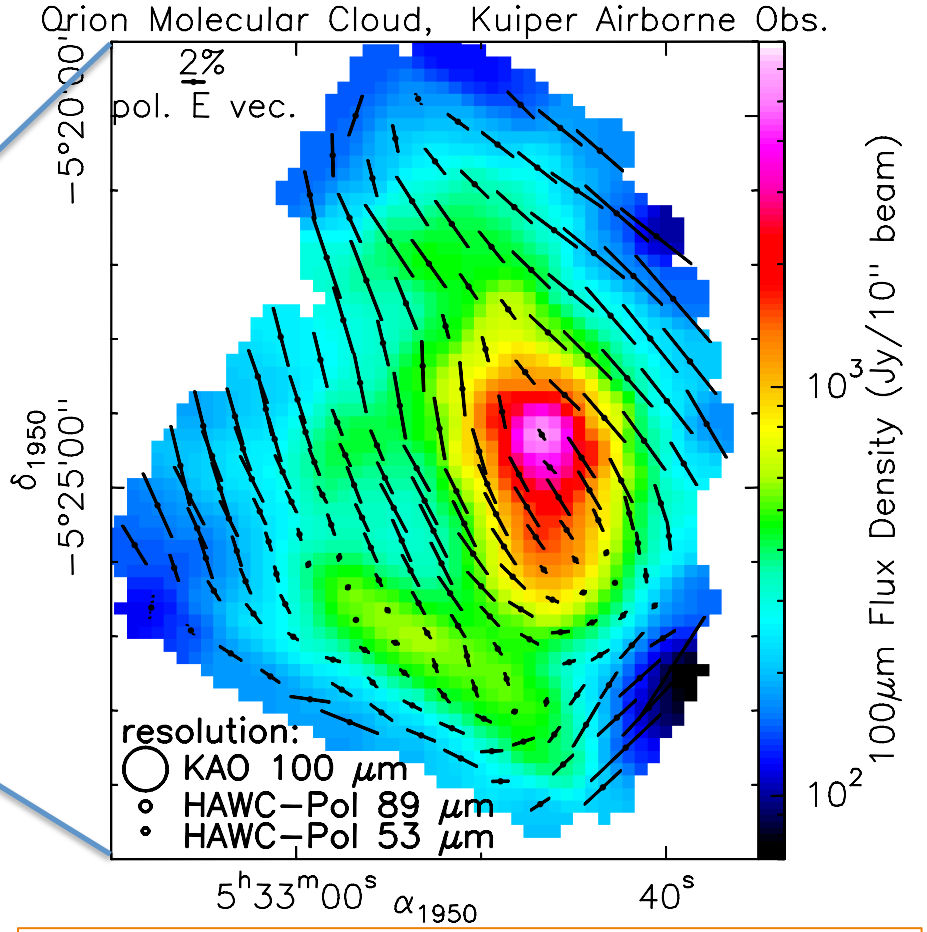
HAWC+ Capabilities



- 0.5 – 0.9 Jy $s^{0.5}$ sensitivity for continuum imaging and polarimetry
- 3×10^{-16} – 1×10^{-15} W/m^2 $s^{0.5}$ sensitivity for imaging and polarimetry through $\lambda/\Delta\lambda$ = 300 filters

HAWC+ Science Goals / Magnetic Fields in ISM

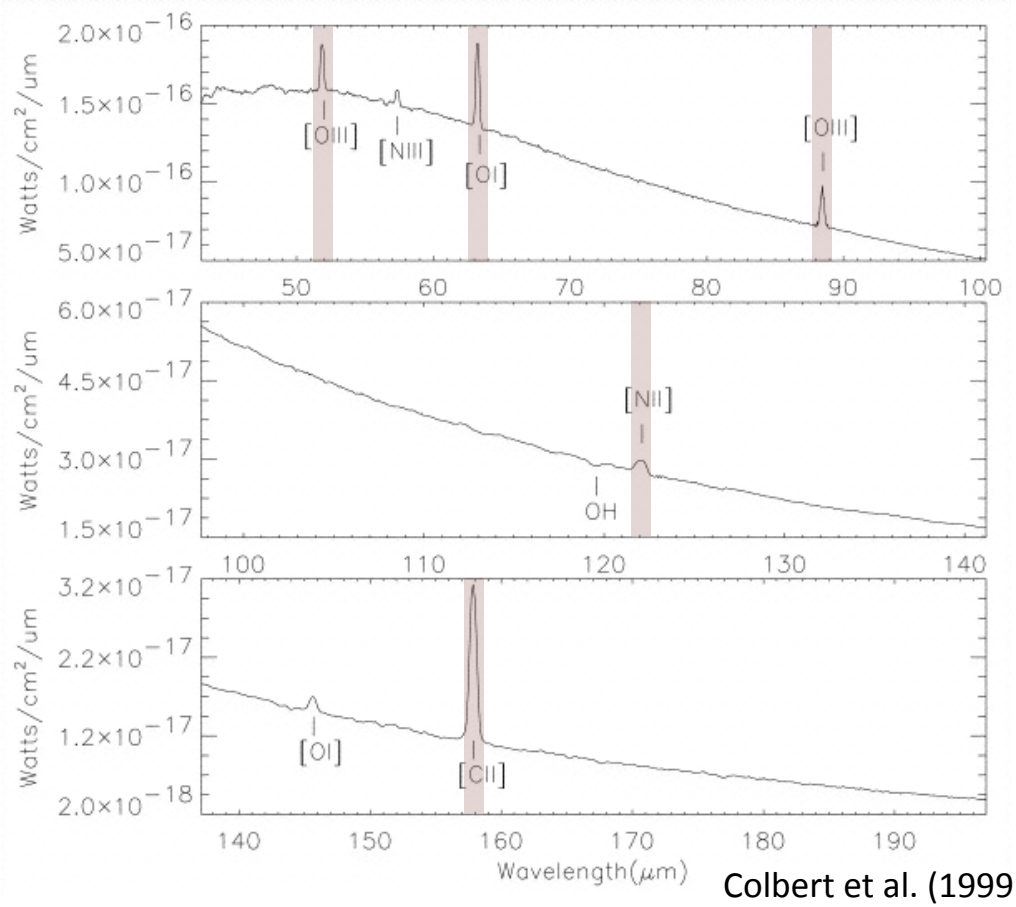




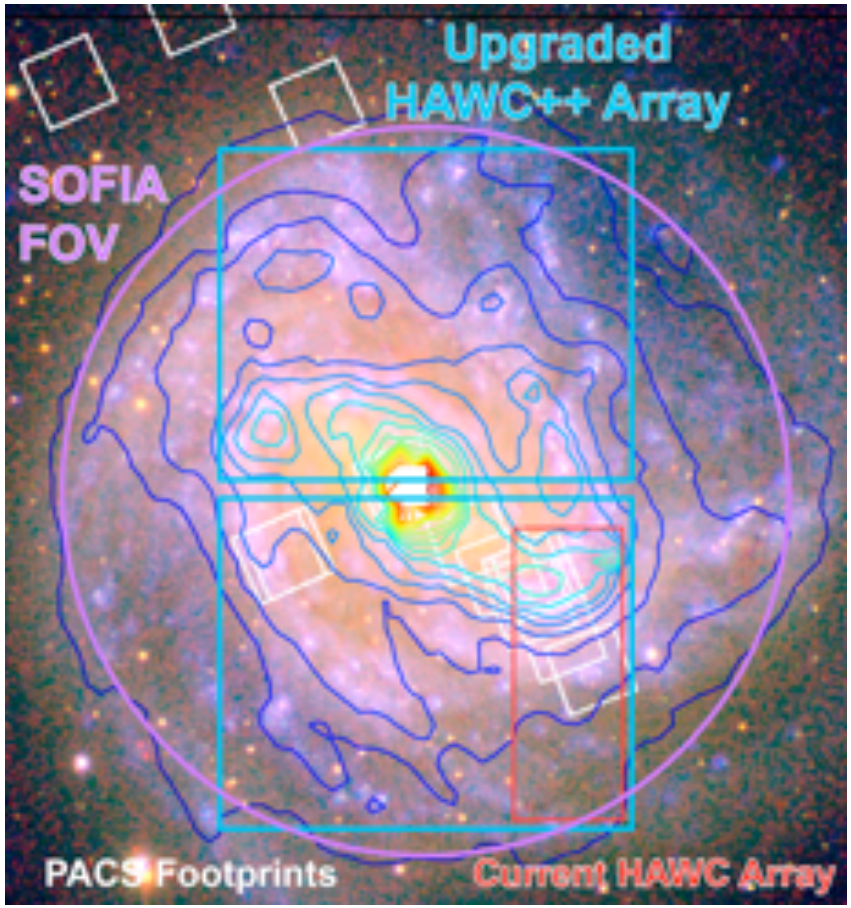
- Compared to previous facilities:
  - 7× more sensitive to extended emission (can reach $A_V \approx 1$)
  - 50× more sensitive to point sources
  - 10× better areal resolution
  - 20× as many imaging elements
  - 5 wavelength bands instead of 1

- tests of (ordered) magnetic field models
- statistical estimation of field strength (Chadrasekhar-Fermi)
- tests of grain alignment theory (Radiative Torque alignment)

HAWC+ Science Goals/Imaging of Gas Phases



Colbert et al. (1999)



- Due to large detector array in HAWC+, mapping speed for fine structure lines is as good as Herschel.