The South Pole Telescope

...a status update

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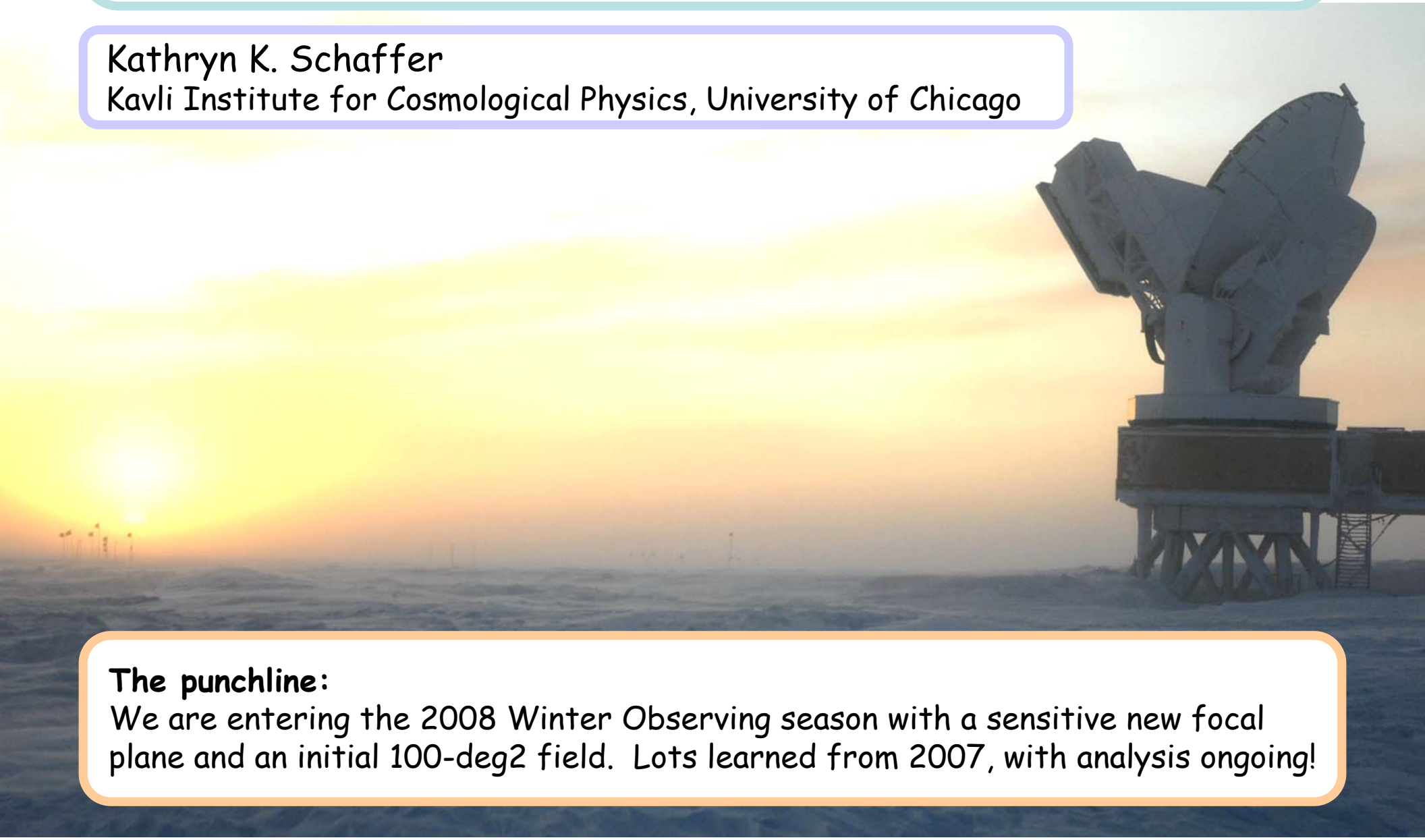

The punchline:
We are entering the 2008 Winter Observing season with a sensitive new focal plane and an initial 100-deg2 field. Lots learned from 2007, with analysis ongoing!

SPT Collaboration

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University of California

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Helmuth Spieler
Christian Reichardt
Bradford Benson
Martin Lueker
Jared Mehl
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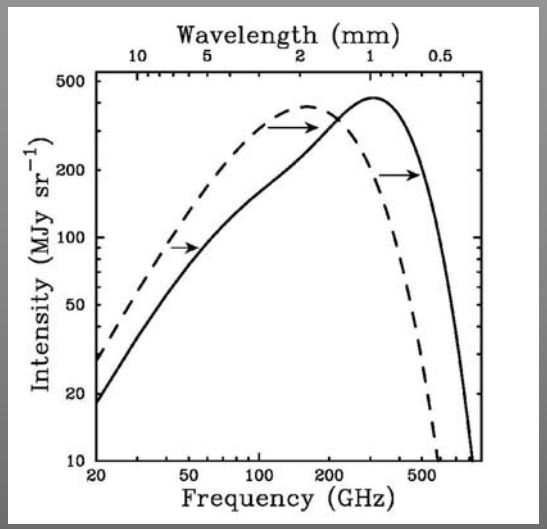
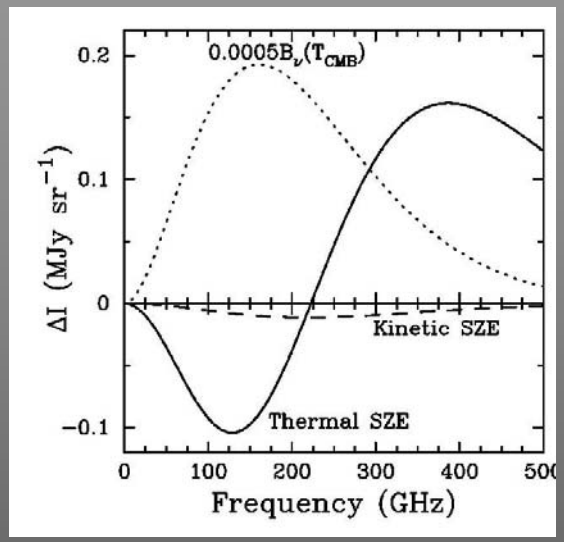
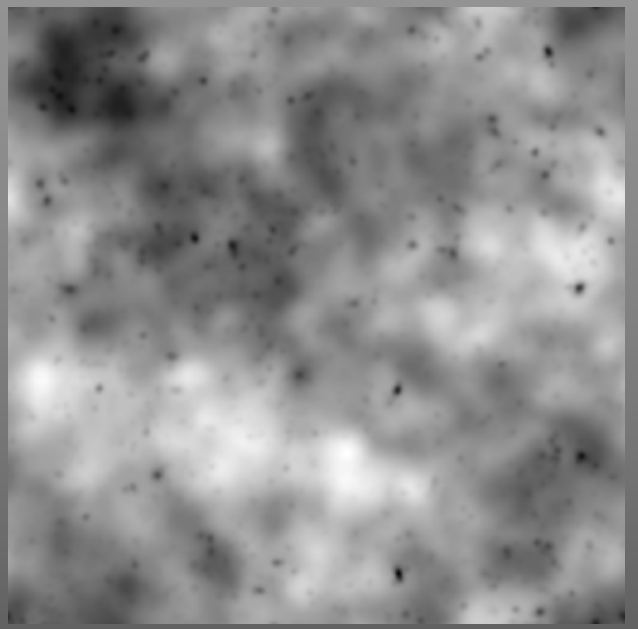
Science Goals of the SPT

1. Explore dark energy using a galaxy cluster survey: 4000 deg^2 survey to detect clusters through Sunyaev-Zeldovich (SZ) effect. With redshifts from optical followup, use dN/dz to constrain dark energy.
2. Fine angular scale CMB anisotropy
3. CMB Polarization (SPT-Pol) ~2010

Detecting Clusters through the SZ effect







3 degrees at 90GHz
(Idealized! no noise, no atmosphere…)

Clusters from simulations by Martin White

Carlstrom, Holder, Reese Ann. Rev. Astron. Astrophys. 40:643-680, 2002

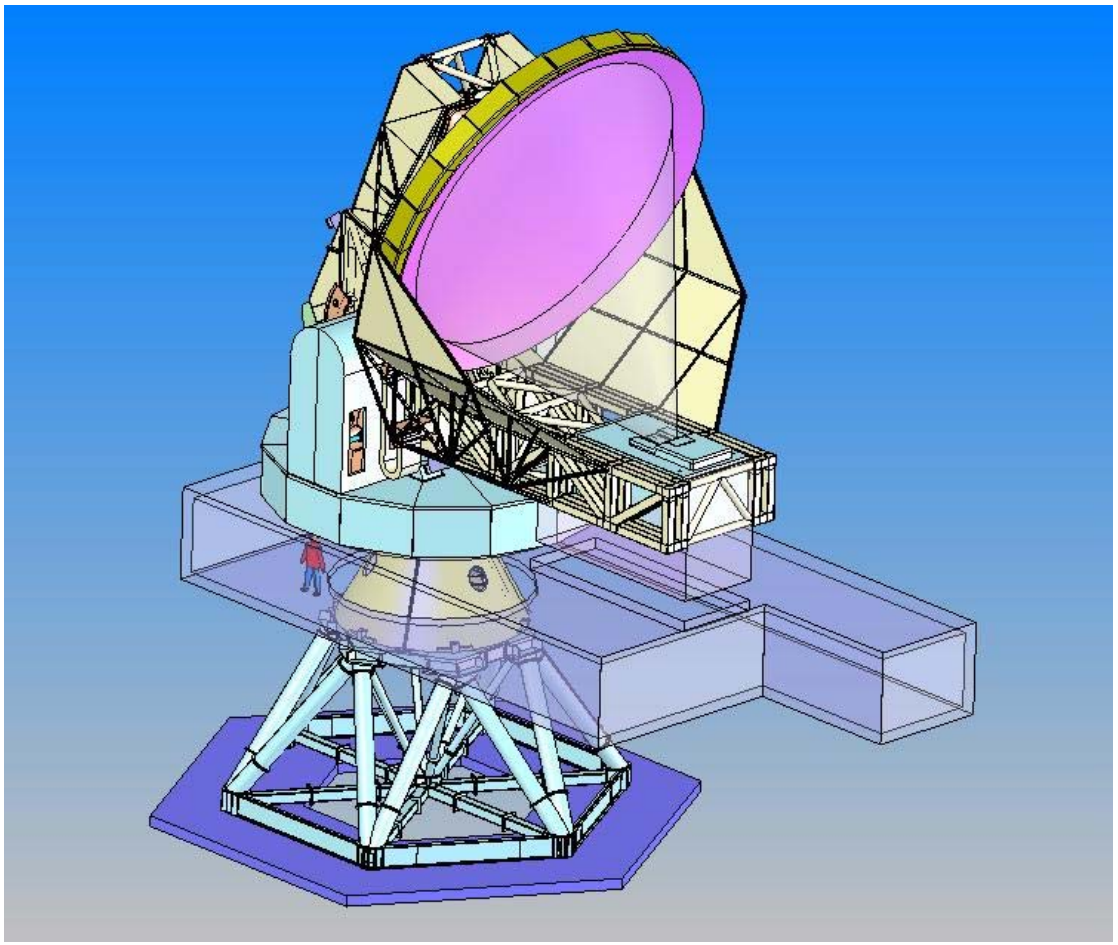
Features:

*Typical cluster sizes ~few arcminutes.
*Total SZ proportional to temperature-weighted mass.
*SZ effect is independent of redshift.
*Size of effect < 1mK

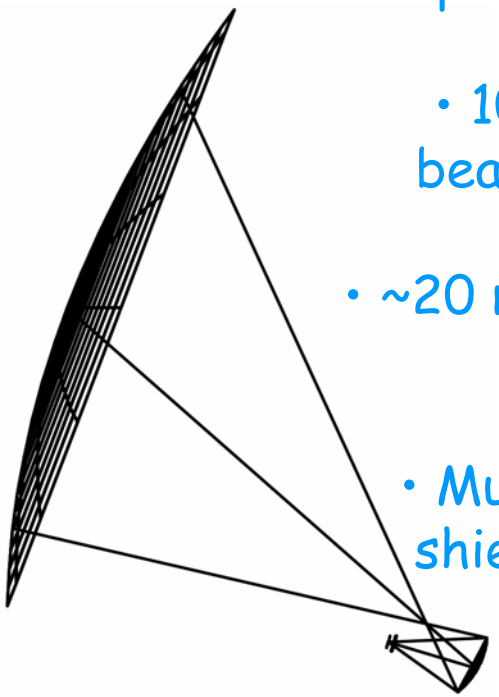
Challenges:

*Uncertainty in mass-observable relation
*Survey completeness/contamination: primary CMB anisotropy, radio galaxies, dusty galaxies, projection effects.

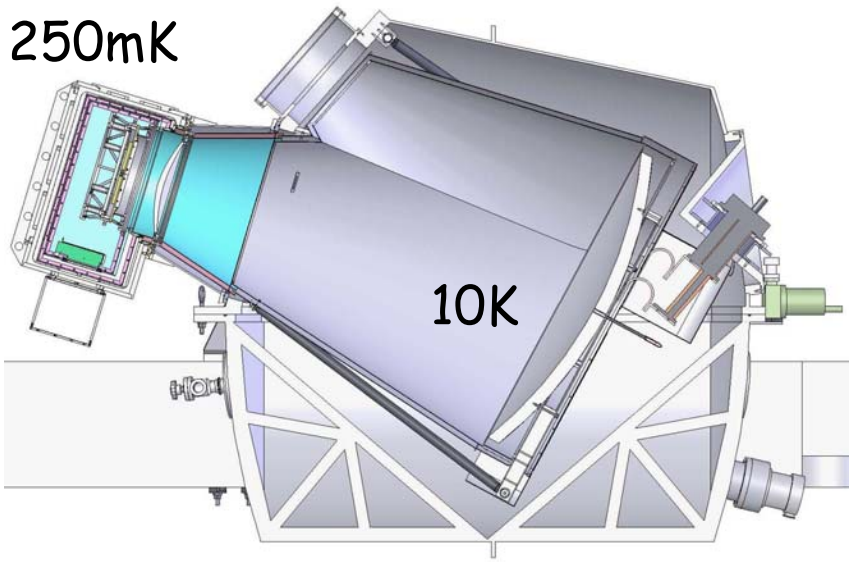
SPT Optical design



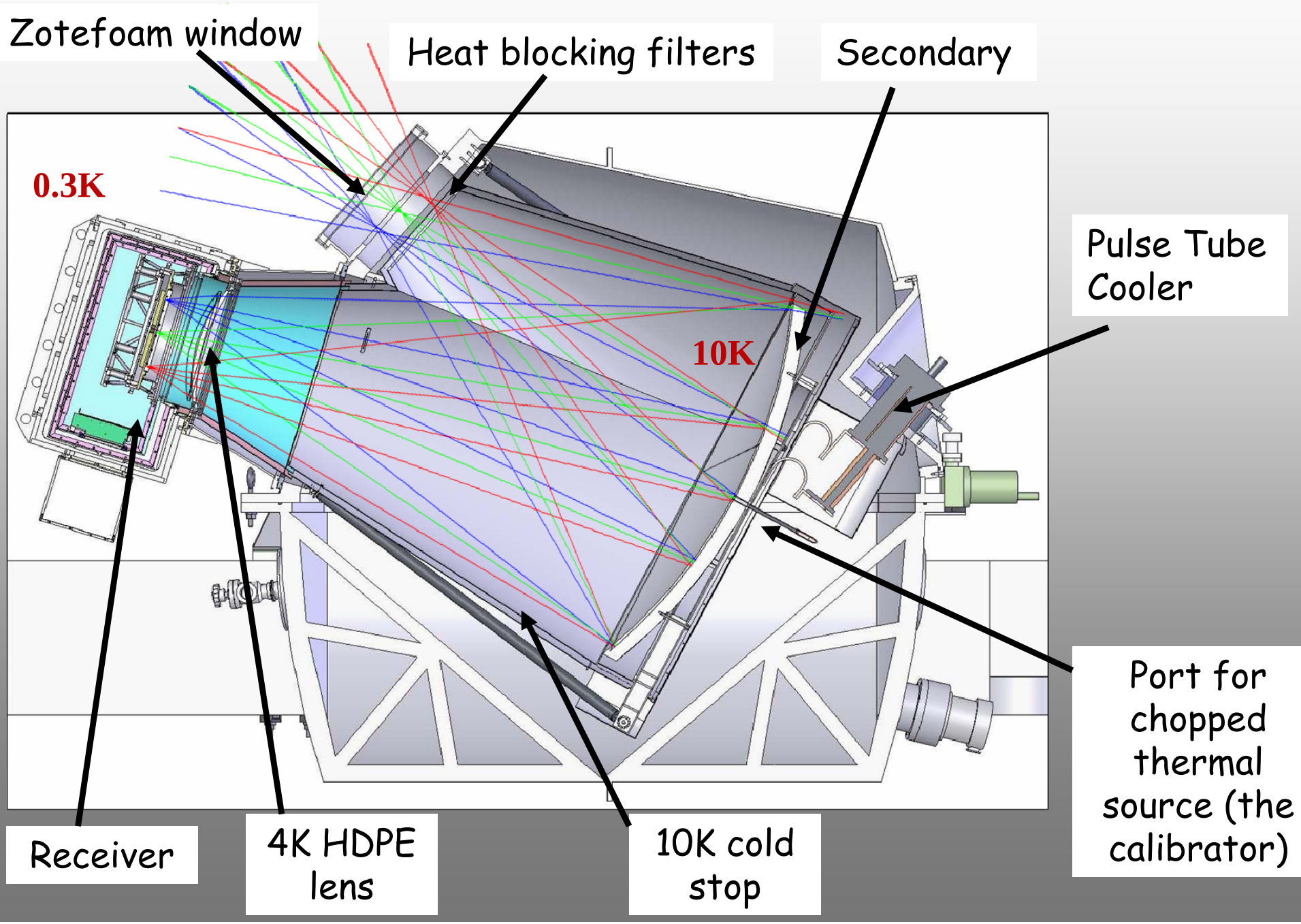
Schematic of the SPT, when Telescope is 'Docked' for access to the Receiver Cabin



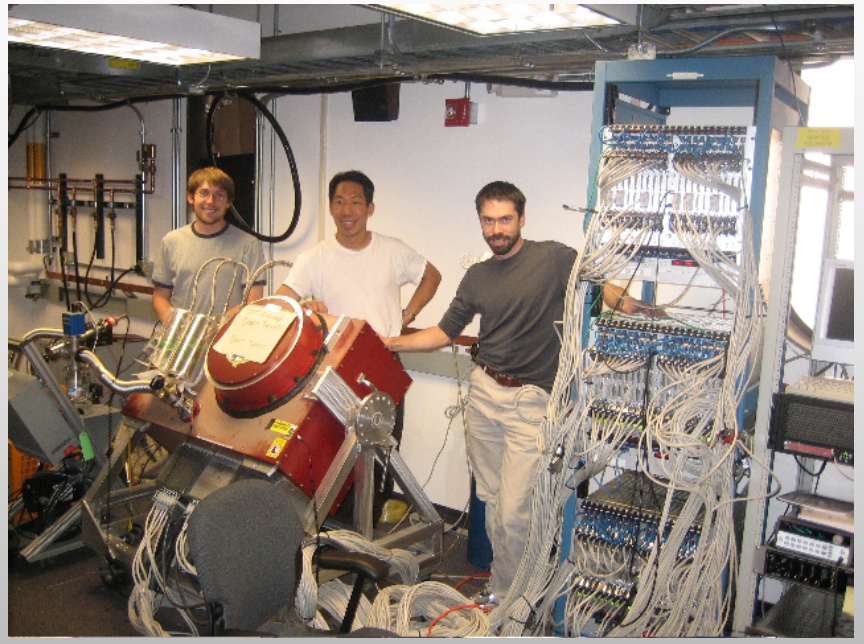
- Simple optical design
- 10m primary - 1' beams at 150GHz.
- ~20 micron surface accuracy
- Multiple levels of shielding in design



Optics Cryostat

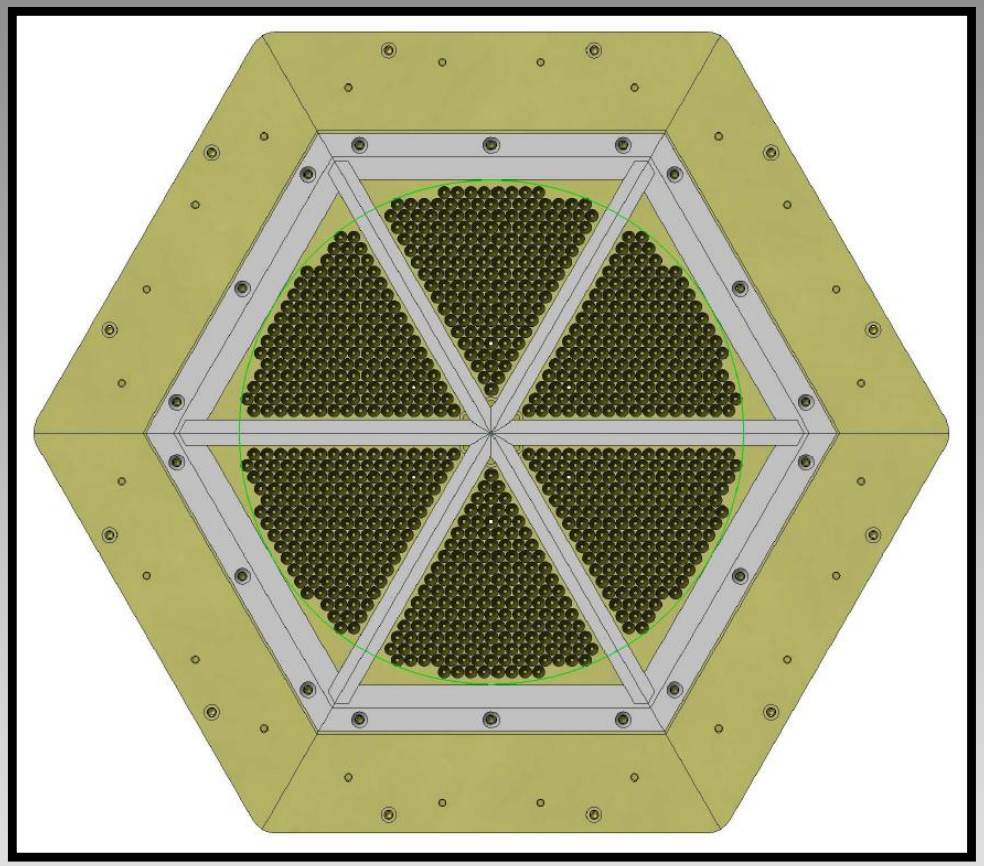


Optics Cryostat + Receiver

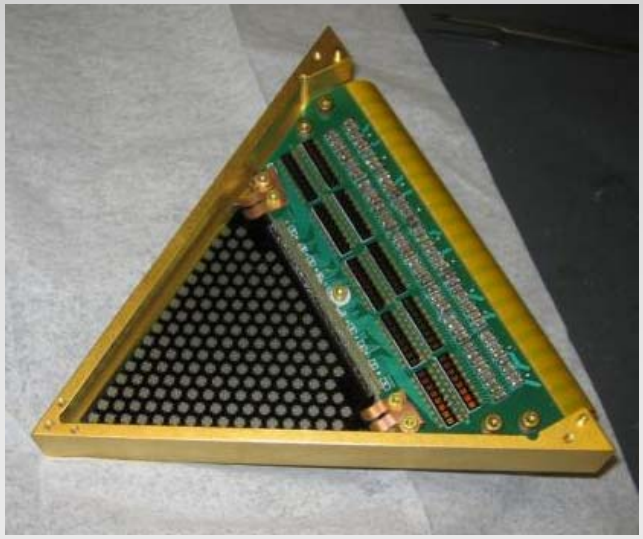


The SPT Receiver Array

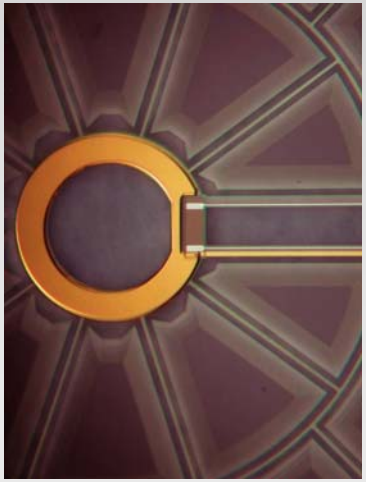
180 mm; ~1 degree on sky



(Holzapfel and Lee, UC Berkeley)



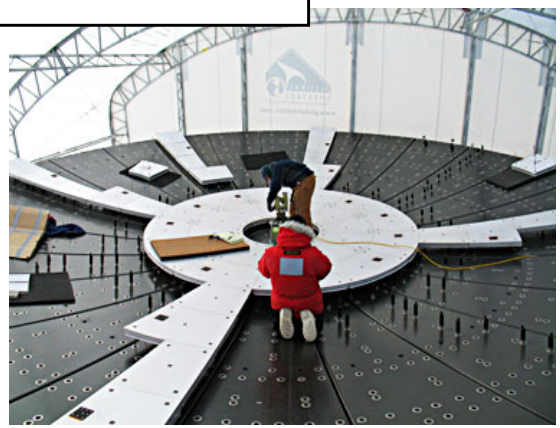
Al/Ti TES



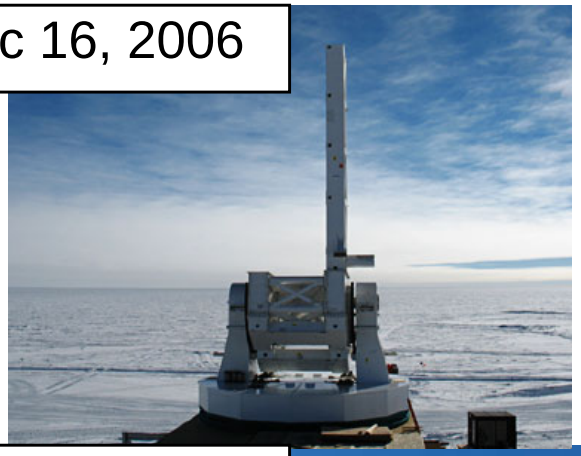
- 160 pixels on each wedge
- Transition Edge Sensor bolometers with Tc ~ 500mK
- 8 bolometers read out by a single SQUID using frequency-domain multiplexing

SPT 1st Year Deployment

Dec 14, 2006



Dec 16, 2006

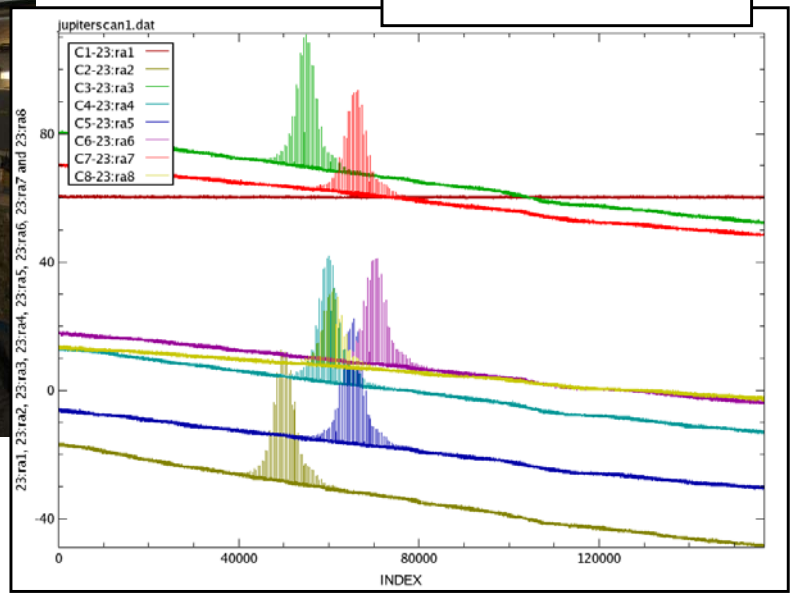


Jan 3, 2007

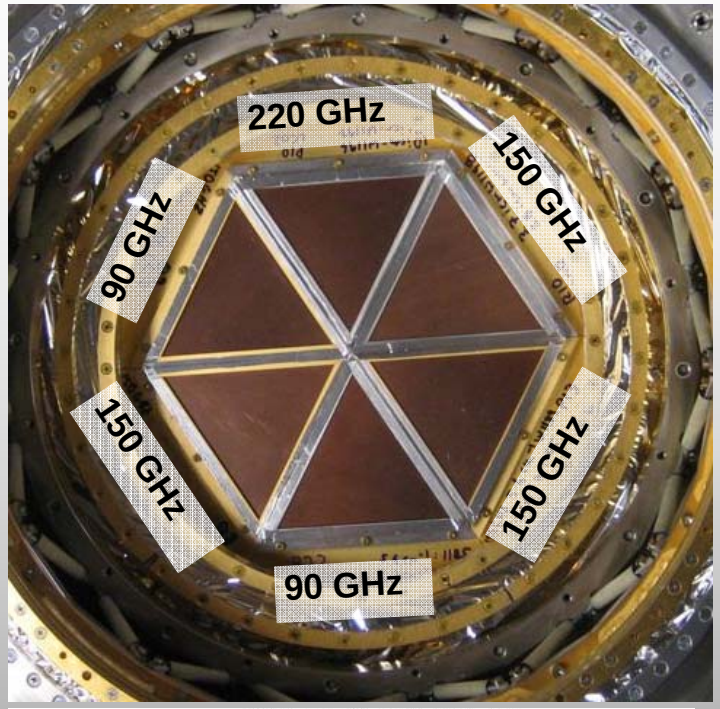
- Jan 3, 2007 – Reflector/Primary Mirror mounted on Telescope
- Feb 12, 2007 - Receiver mounted on Telescope
- Feb 16, 2007 - First Light = Scans of Jupiter
- Feb 17, 2007 - Kicked out of South Pole

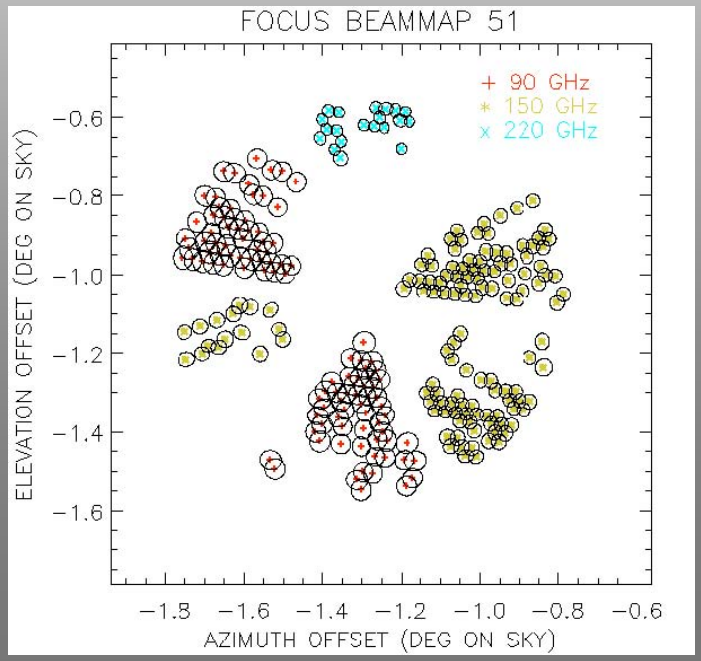
Feb 12, 2007

Feb 16, 2007



First Season Instrument: performance and challenges





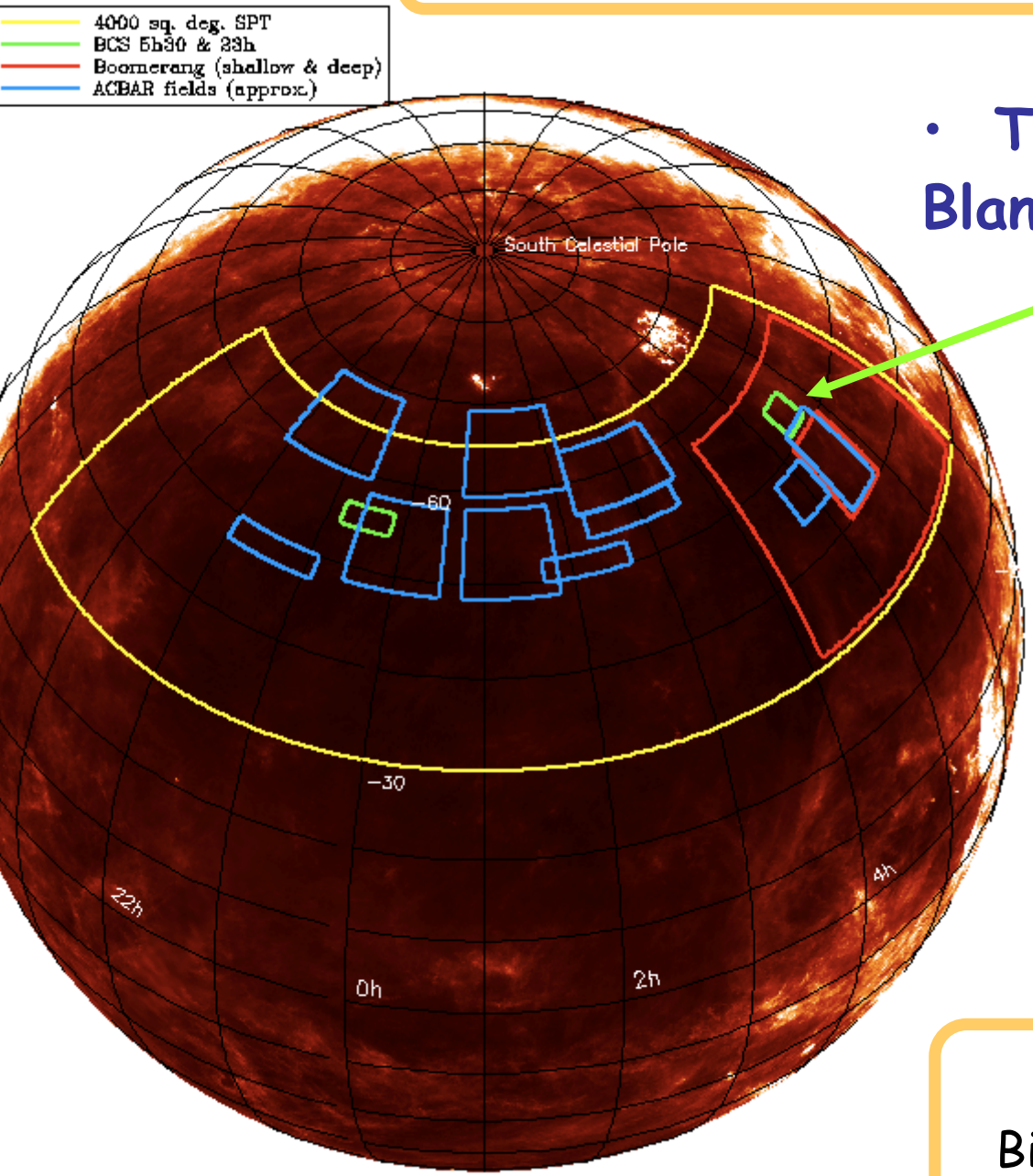
- NETs: ~1500 μK-CMB $s^{1/2}$
  - higher than optimal G and Tc
  - readout and G (thermal conductance) noise limited
  - high 1/f knee ~2-3Hz.
- Yield: max ~500 detectors, typical ~380.
  - detector instabilities
  - cryogenic loading heated the squids
- Time-on-sky: cryogenic duty cycle was only ~50%. Of the 50% of time that was used for observing, ~1/3 spent on calibration/pointing.
- Beam FWHMs: very close to expected

  95 GHz: 1.52 +/- 0.08′ (predicted *1.51*)

  150 GHz: 1.08 +/- 0.08′ (predicted *1.01*)

  220 GHz: 0.86 +/- 0.05′ (predicted *0.78*)

First season observing fields:



- **Two sub regions of the Blanco Cosmology Survey (BCS)**

Large field ~35 deg^2 (BCS 5h30)

- 300 hours integration time
- Useful for cluster finding
- Sensitivity should be ~ 40 μK / arcmin beam

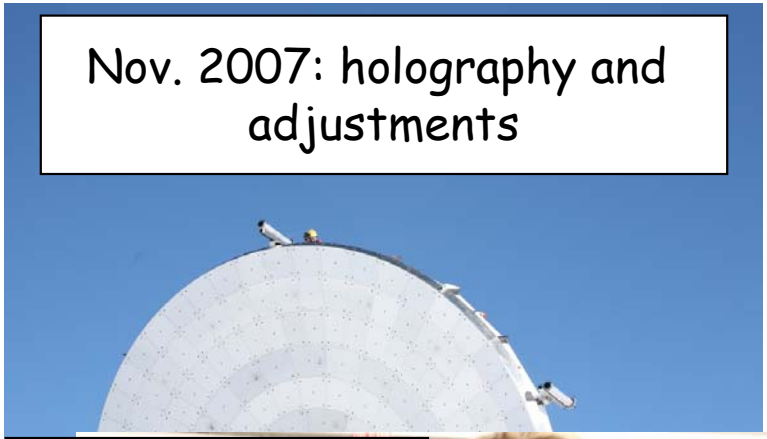
Small field ~6 deg^2

- Located inside the large field
- 200 hours integration time
- small scale (high l cmb) to ~ 20 μK / arcmin beam

Analysis ongoing…
Biggest challenge: pointing models

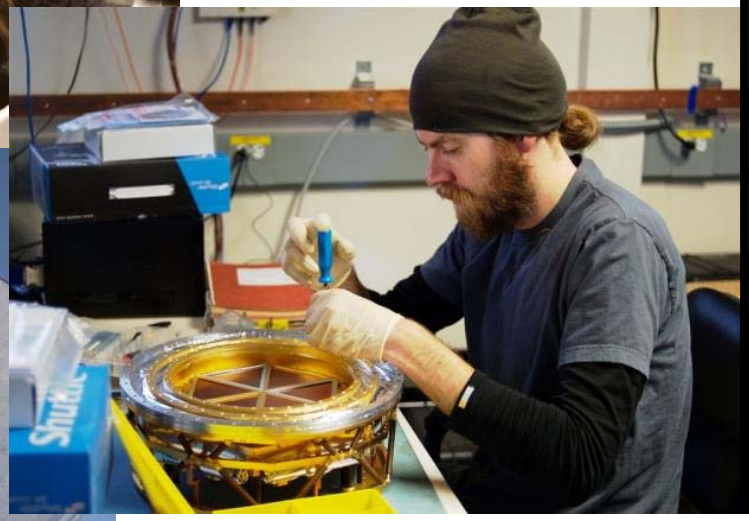
SPT 2nd Year Upgrades

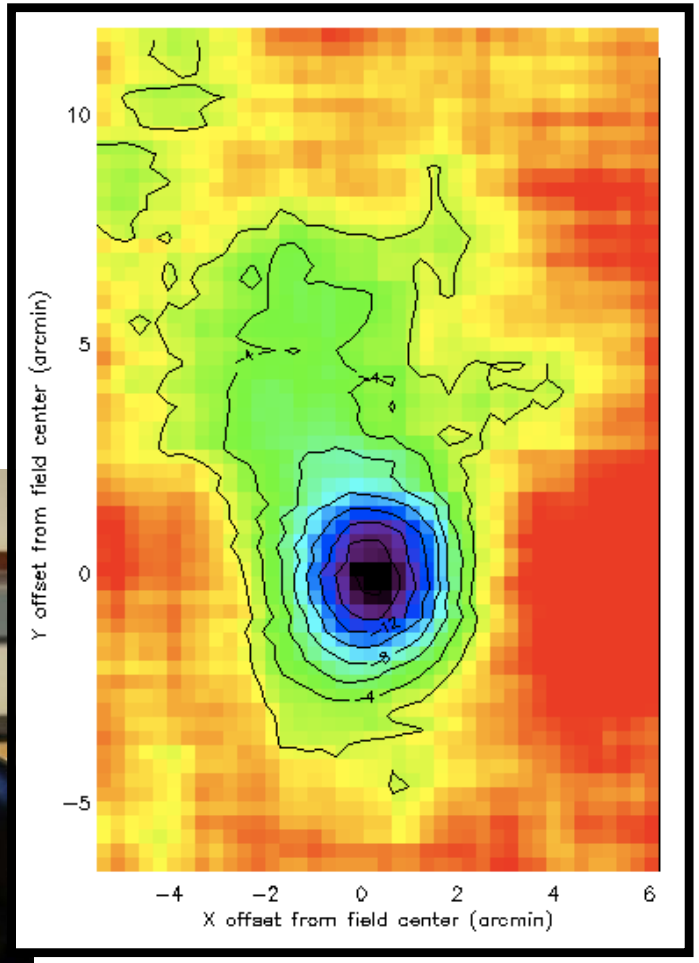
Nov. 2007: holography and adjustments



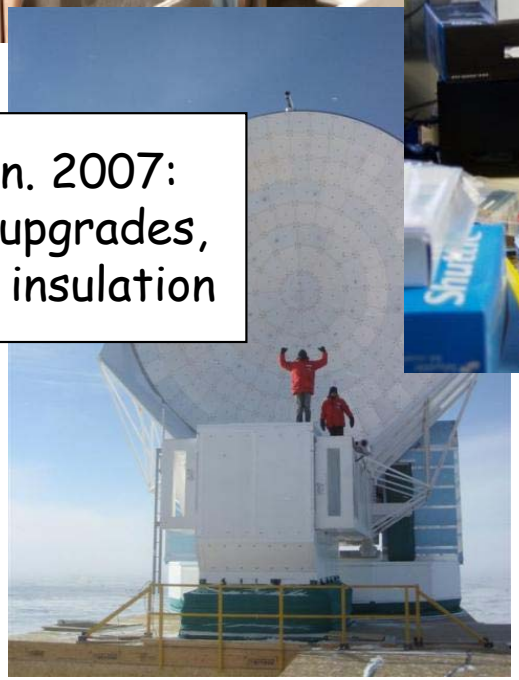
Nov./Dec. 2007: FTS

Feb. 2008
Final array installed





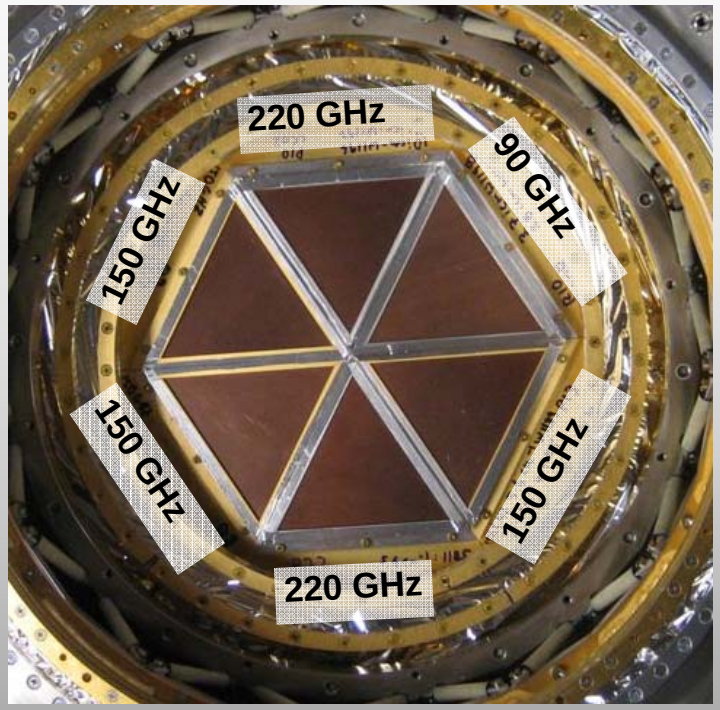
Dec./Jan. 2007: Receiver upgrades, telescope insulation



Feb. 14
Happy Valentines Day from SPT
(as1063 ~16 sigma detection
from 40-min observation, ~320 150GHz detectors)

Map made by Tom Crawford

Second Season Instrument: upgrades and initial performance

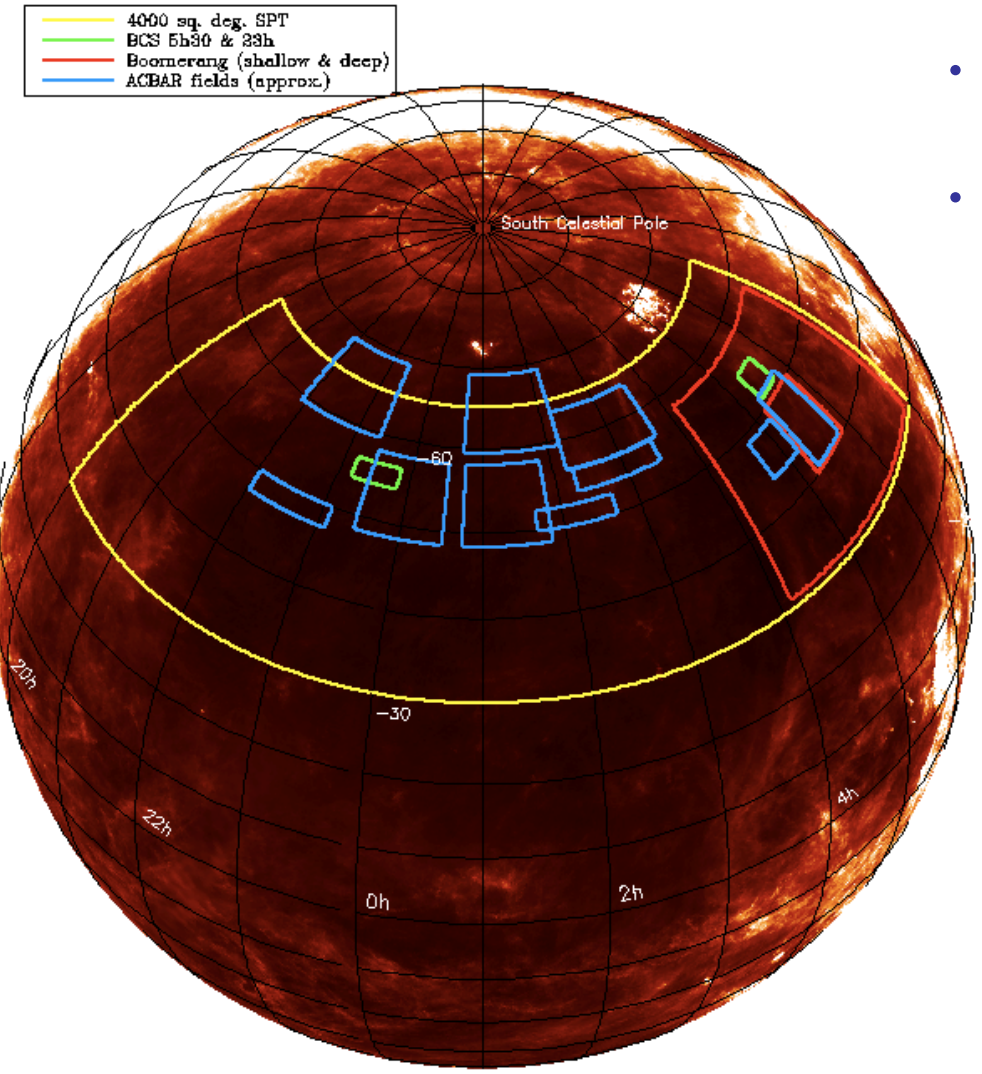


- Lower G detectors – better noise/sensitivity
- Detector design changes improved detector stability; also improved setup scripts for better yield, faster tuning
- Widened the bands for 150 and 220 GHz to ~45 GHz and ~50 GHz respectively (from ~30 and ~40GHz)
- Major cryo upgrades – new PT415, better heat strapping, better wiring heat sinking… current cycles last >36 hours.

Band:	#Bolos:	NET (μKs$^{1/2}$-CMB)
90 GHz	~350	~1000+
150 GHz	~350	~400
220 GHz	~200	~800

Preliminary Estimates

Initial field for season two:



(also PISCO, SCS …)

- A ~100deg2 patch including the BCS 5h30 field
- Then, start hammering away at the final 4000-square-degree cluster survey region

Completing the cluster survey:

Stage I: Blanco Cosmology Survey (BCS)

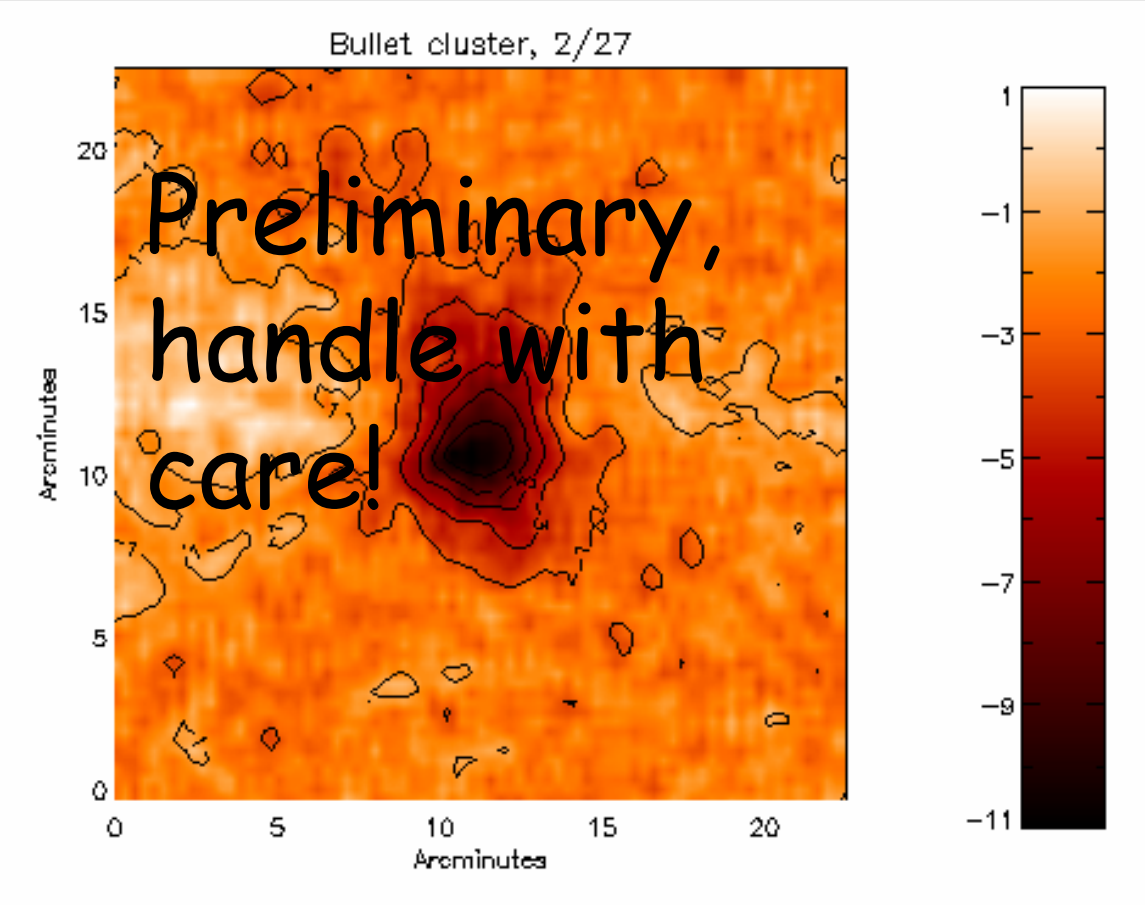
- A 45 night program that began fall 2005 to survey 100 square deg (2.5 pct of SZ survey size) at Blanco 4m on Cerro Tololo
- http://cosmology.uiuc.edu/BCS

Stage II: Dark Energy Survey (DES)

- 5000 square deg G, R, I and Z bands
- 2005-2010: Construction of a new 3 square deg camera for the Blanco 4m
- 2010-2015: Survey Operations
- https://www.darkenergysurvey.org/

Warm-Fuzzy-Feeling Slide #1

Bullet cluster – 1es0657
2.25 hours observing time with ~300 150GHz detectors
minimally processed



Map made by Tom Plagge

Warm-Fuzzy-Feeling Slide #2

Map made by Christian Reichardt

~60 hours of observing the ~100 square degree field.

Coadded 150GHz only, with uncorrected pointing

RMS in map compared to L/R difference map suggests some of this structure is real…

Prospects pretty exciting for this season's instrument!

Conclusions and Future Plans

- Successful first commissioning season – Telescope built, tested new technologies (PT, fMUX, large-format arrays) and learned a lot. Plus, science coming soon!
- 2008 instrument is sensitive enough to do some very interesting science

Upcoming:

- Install more 90GHz detectors next Austral Summer
- Continue cluster survey for 2+ more years (total)
- Install ground shield over the next two seasons
- Funded for 1000-element polarization sensitive instrument for early 2010

The South Pole Telescope Team

http://spt.uchicago.edu