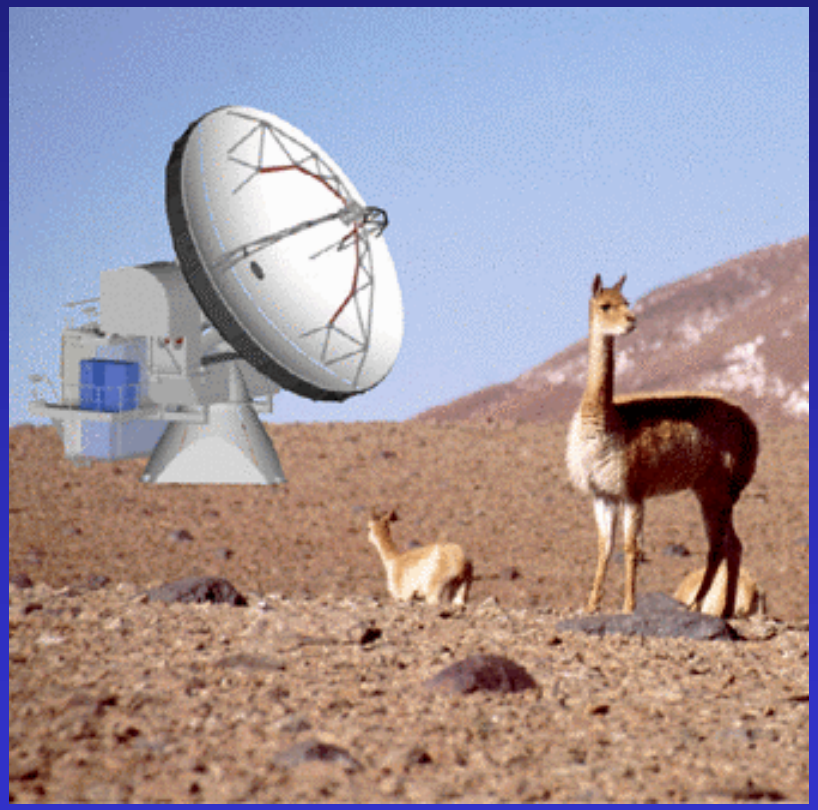
A Sunyaev-Zel'dovich Effect Survey with the APEX Telescope



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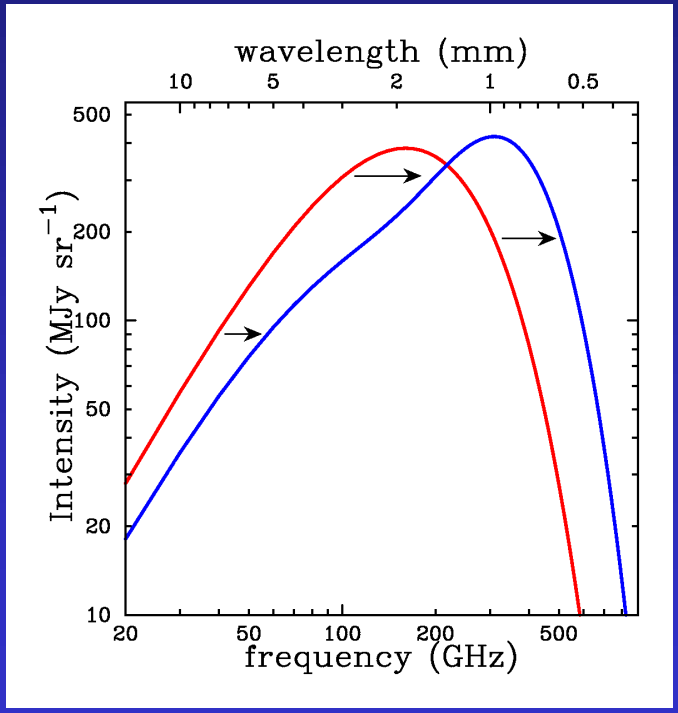
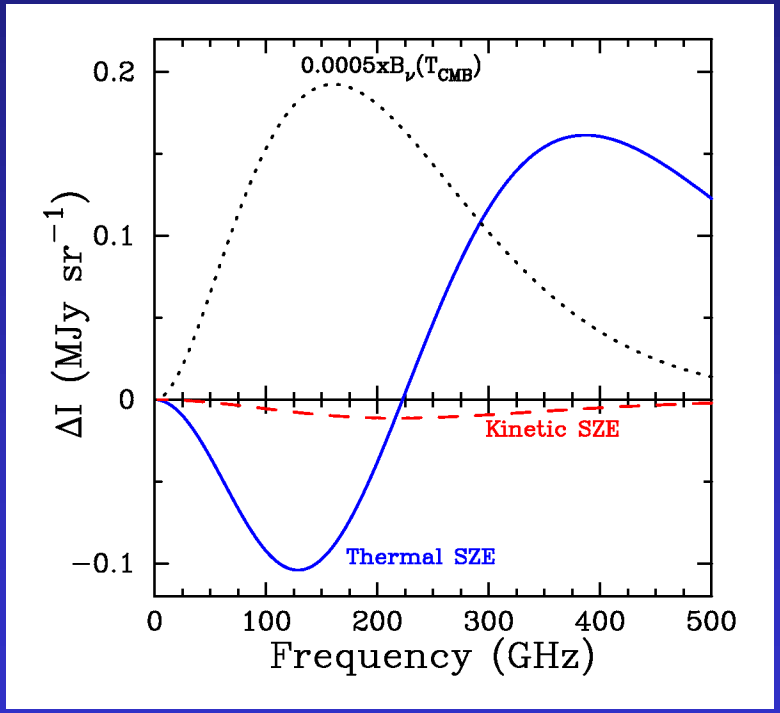
Science Goals

- Discover and catalog of order 1000 previously unknown galaxy clusters in a mass limited survey
- Observe evolution of structure, and test theories of structure formation
- Constrain mass density of the Universe Ω_m and dark energy equation of state w
- Measure Hubble constant H_0 and acceleration parameter q_0 independent of the distance ladder
- Study CMB secondary anisotropies – weak lensing, Ostriker-Vishniac effect

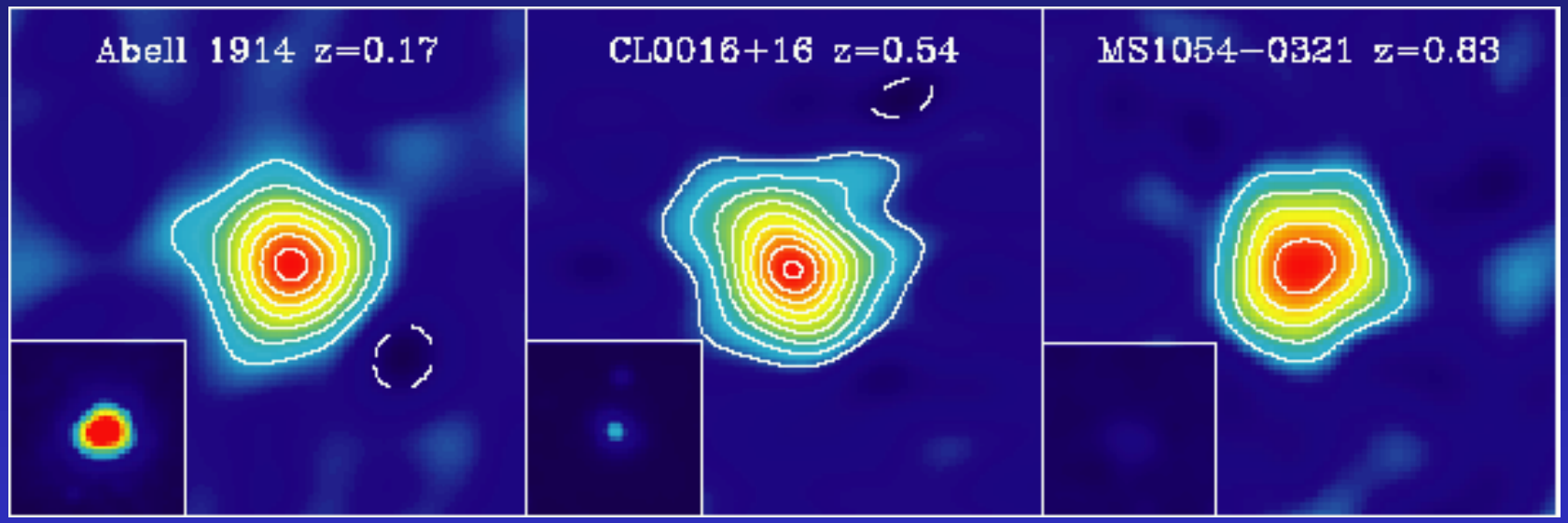
Sunyaev-Zel'dovich Effect





Carlstrom, Holder & Reese, ARAA, 2002

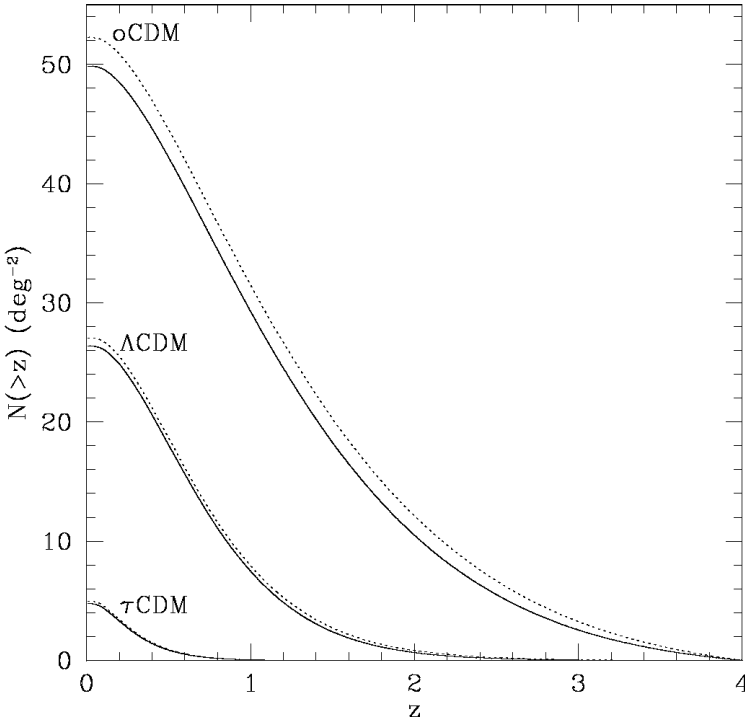
SZ Effect



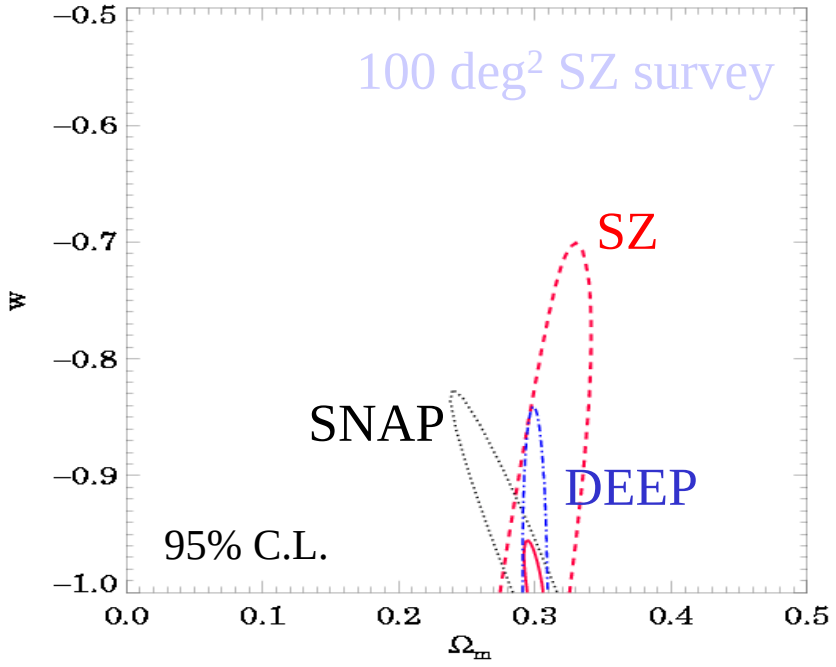
Courtesy of Carlstrom et al.

Differential surface brightness is independent of redshift.

Cosmology with SZ Surveys



Holder et al. 2000



J. Newman

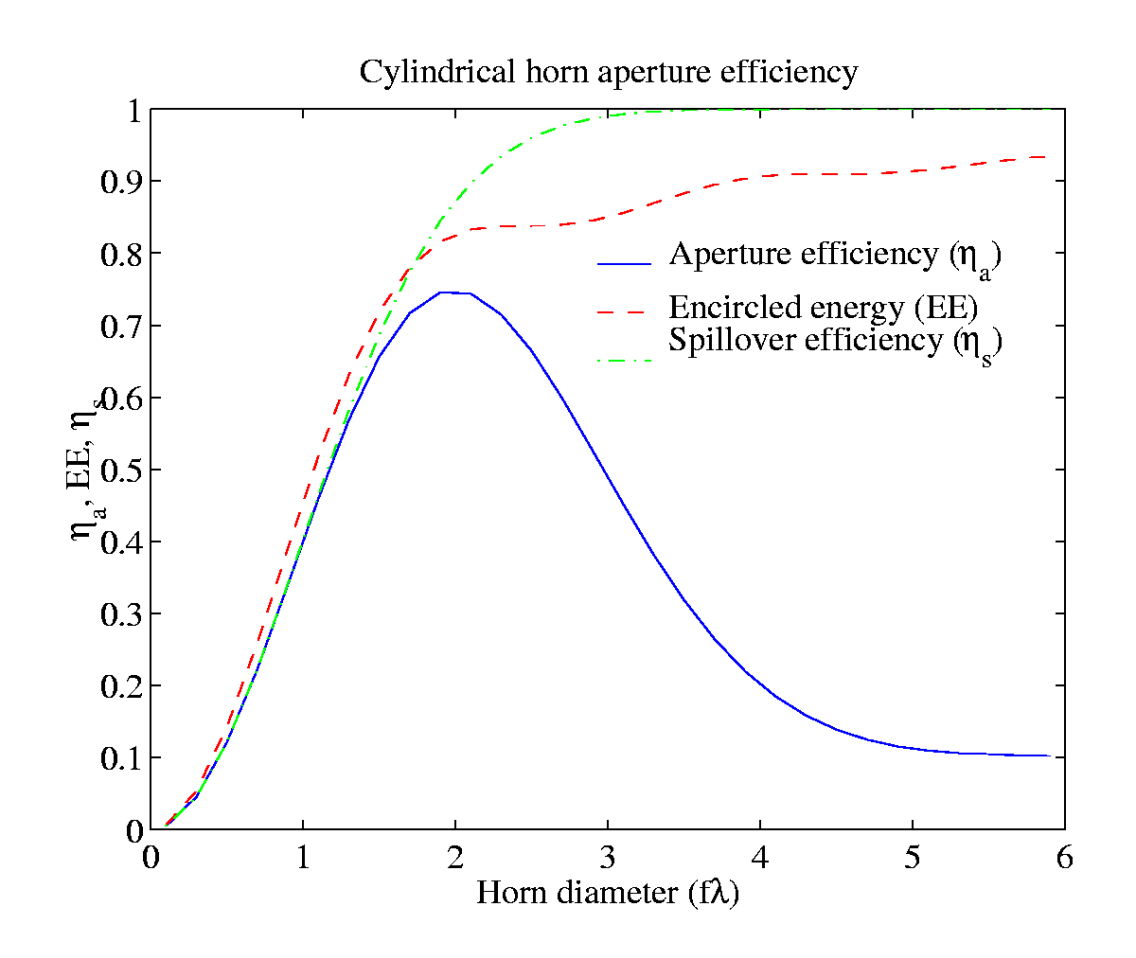
APEX SZ Survey Instrument

- 300 element bolometer array
- Single color observations at 2 & 1.4 mm wavelengths
- 0.4 degree field of view
- Survey 250 sq. degrees to 10 μK_{CMB} per 0.8' pixel in two seasons
- Drift scan observing strategy to reduce differential ground pickup
- Horn coupled array → RF and stray light shielding
- TES spider web bolometers, monolithic array
- Individual bolometer SQUID readouts
- Testing pulse-tube cooler to eliminate liquid cryogens

APEX Telescope

- 12 m on-axis ALMA prototype built by Vertex RSI
- Telescope fully funded by MPIfR/ESO/Onsala
- Parts under construction
- 18 μm surface accuracy goal
- 40” resolution @ λ = 2 mm, 6” resolution @ λ = 350 μm
- 0.5° maximum field of view
- To be sited at 16,500 ft in Chilean Andes
- First light mid 2003

Optimal Horn Diameter

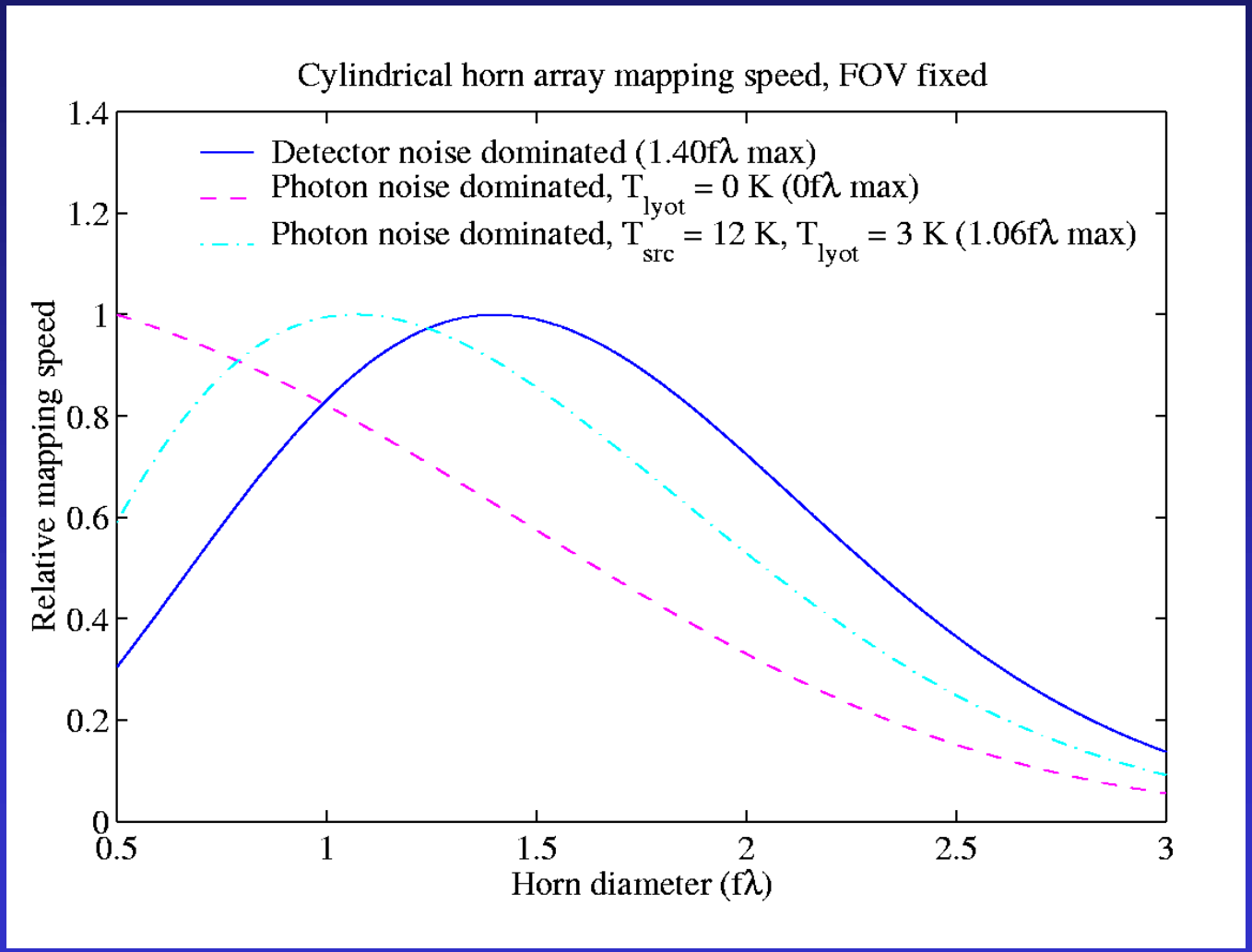


$$S \propto \frac{N\eta_a^2}{P_{\text{photon}}} \propto \frac{N\eta_a^2}{\eta_s B_{\text{ext}} + (1-\eta_s) B_{\text{int}}}$$

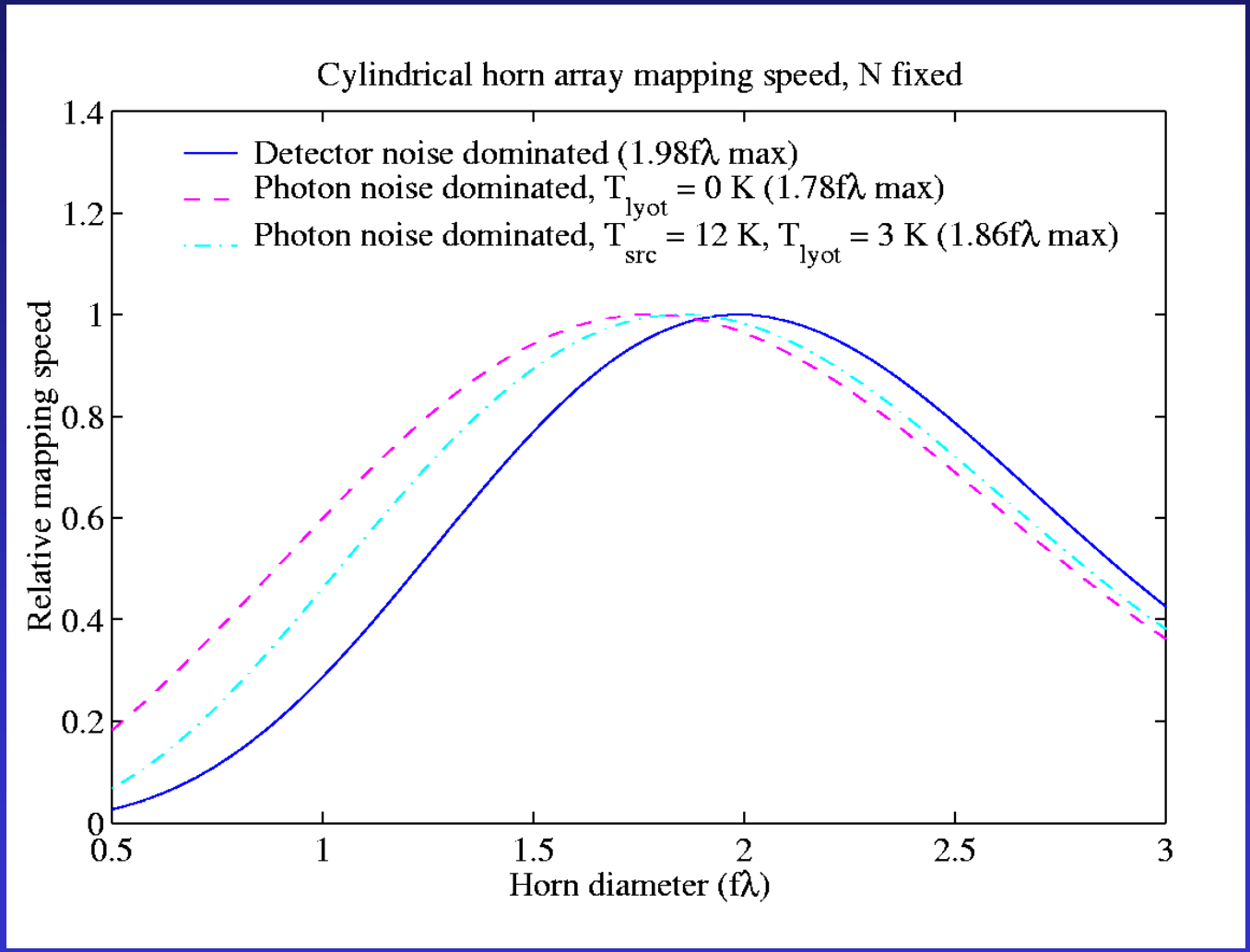
Mapping speed

See also Griffin, Bock & Gear, 2002

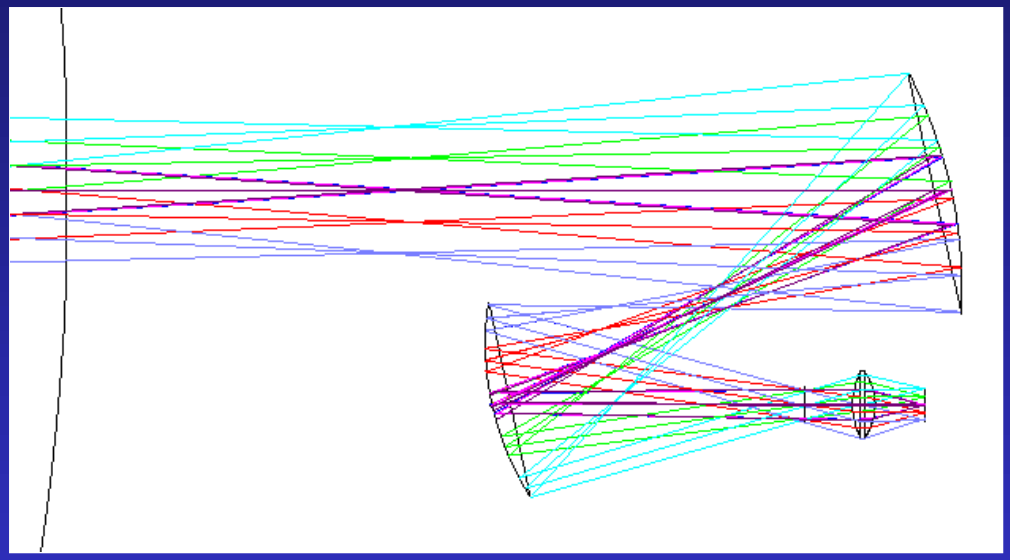
Mapping Speed, FOV Fixed



Mapping Speed, N fixed



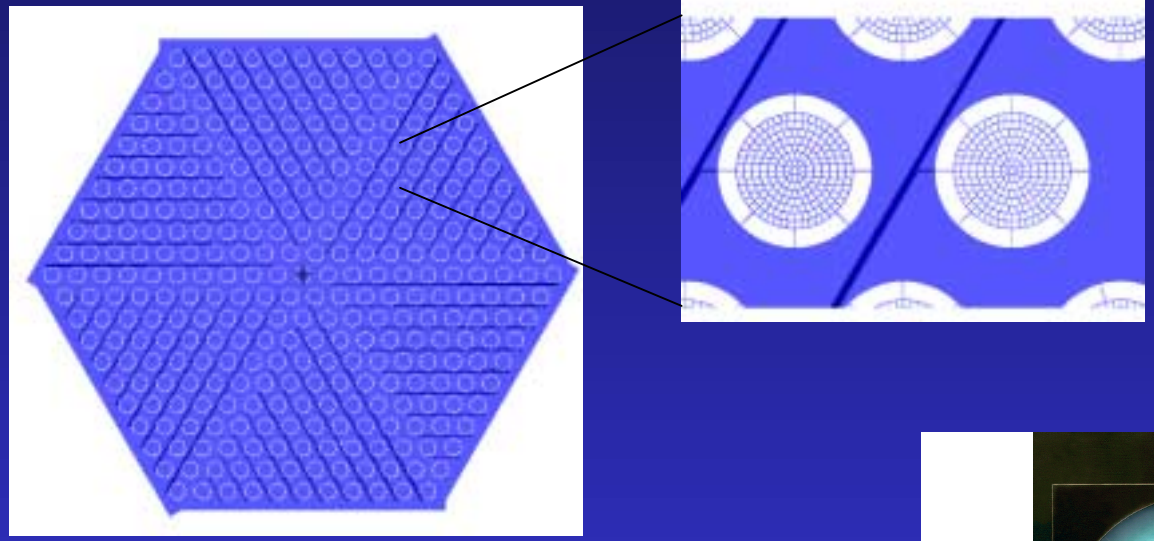
SZ Survey Instrument Optics



Strawman optical design

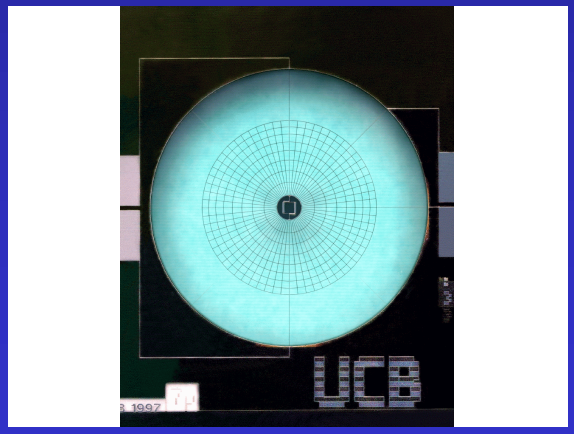
- 300 element array
- 2fλ horn diameter
- 24’ (0.4 degree) field of view
- 15 cm max array diameter → f < 1.75
- Cold Lyot stop
- Cold lens

TES Bolometer Array



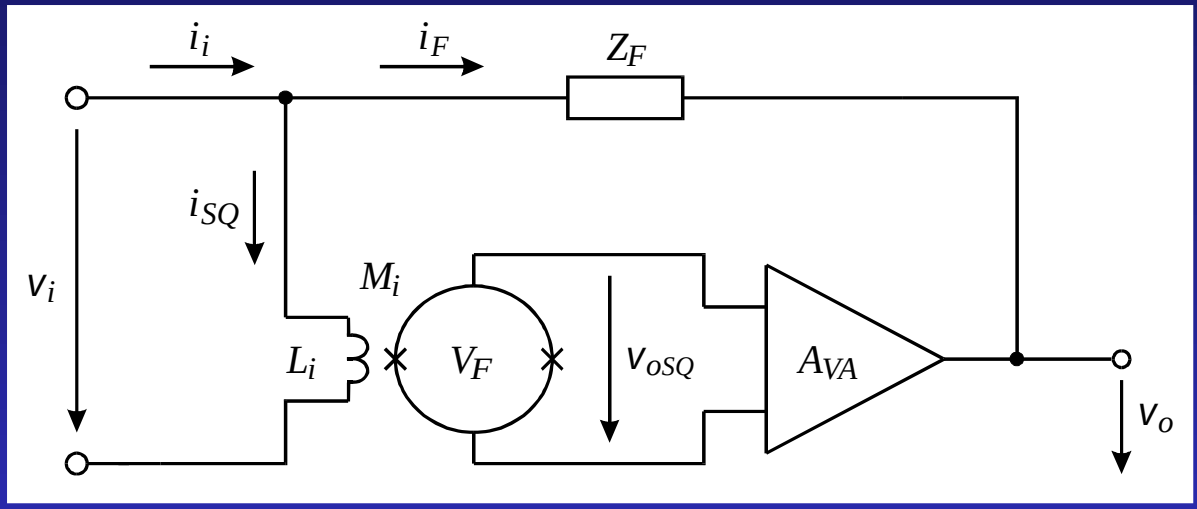
300 element mask

Spider web TES bolometer



3.5 mm

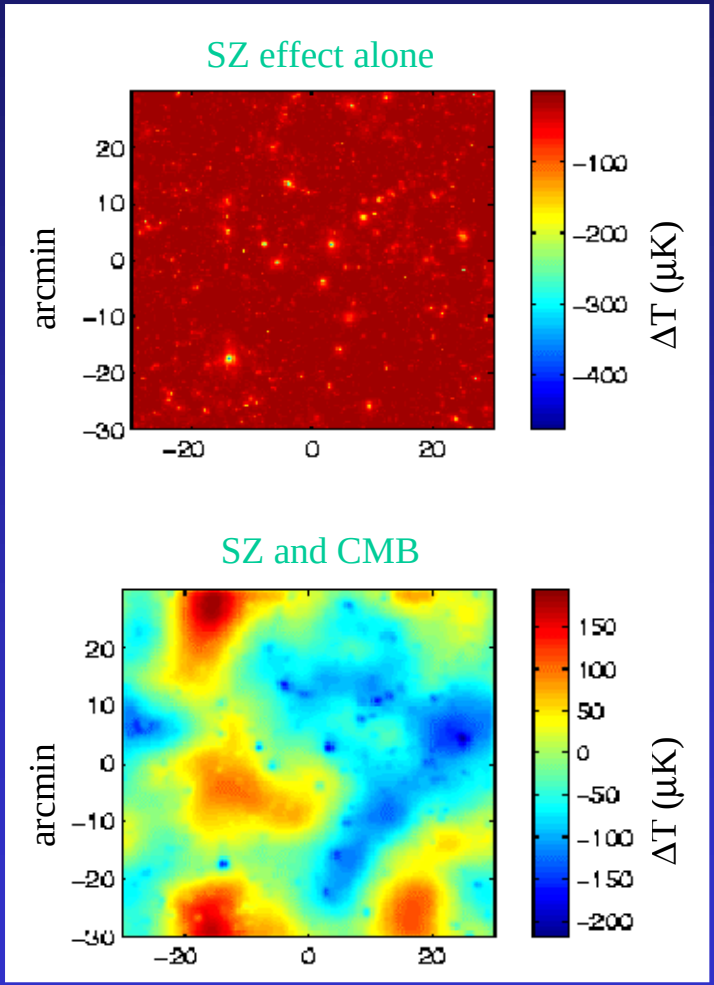
SQUID Readout Electronics



Shunt feedback SQUID amplifier

- Low input impedance to maintain constant voltage bias of bolometers
- Large dynamic range to accommodate AC bias up to several hundred kHz

Data Analysis Challenges



Simulations courtesy M. White

- Source confusion
  - CMB
  - Point sources
  - Filamentary SZ
- Completeness
- Y-distortion – mass relation
- Redshift information
- Etc …

Project Status

- Telescope under construction
- APEX-SZ receiver funded and under development
- Tertiary optics: diffraction limited designs achieved
- Cryogenic testing of pulse tube cooler and microphonics in progress
- Single TES bolometer demonstrated, array design and fabrication underway
- SQUID readout prototype fabricated and under test