OVERVIEW & GOALS

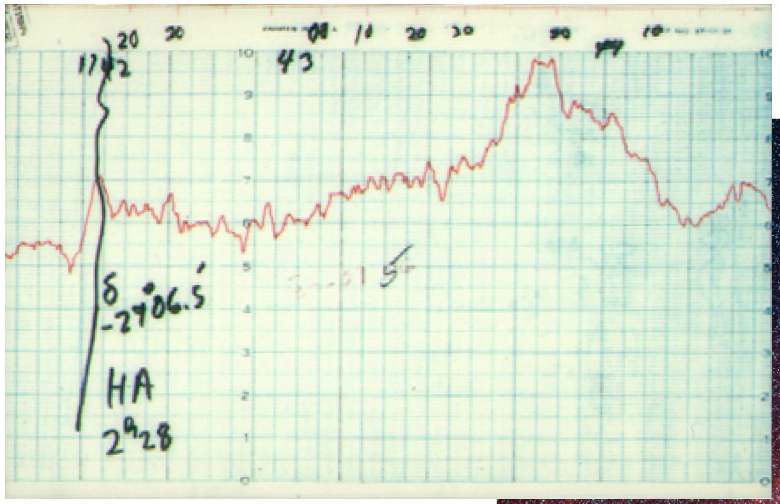
C. R. Lawrence, JPL

JULY 21–25, 2008

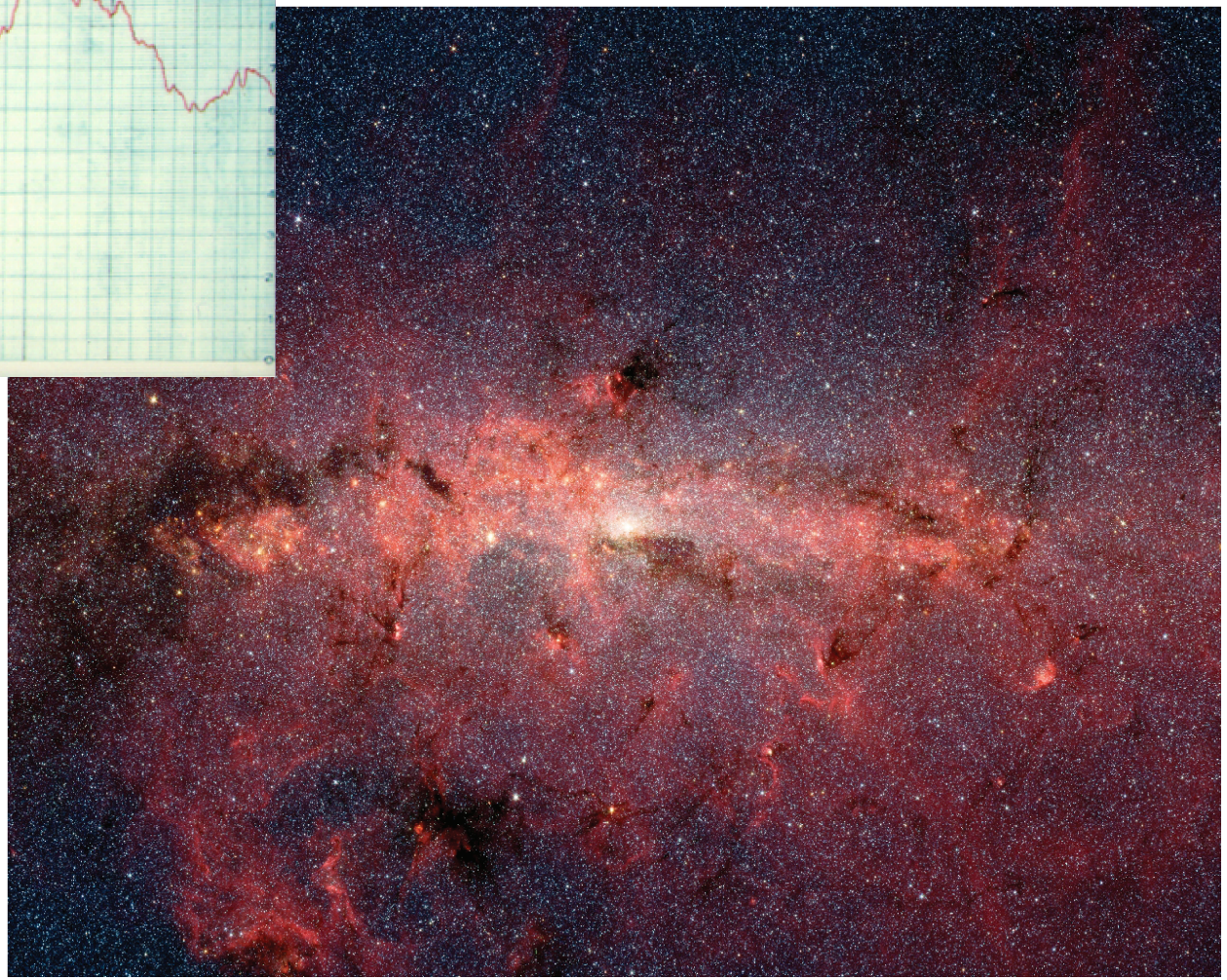
MMIC ARRAY RECEIVERS AND SPECTROGRAPHS WORKSHOP

PASADENA, CA 91125

A Revolution



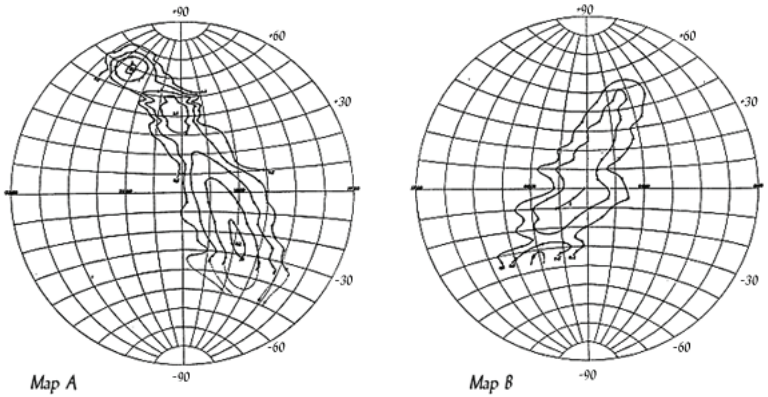
1967



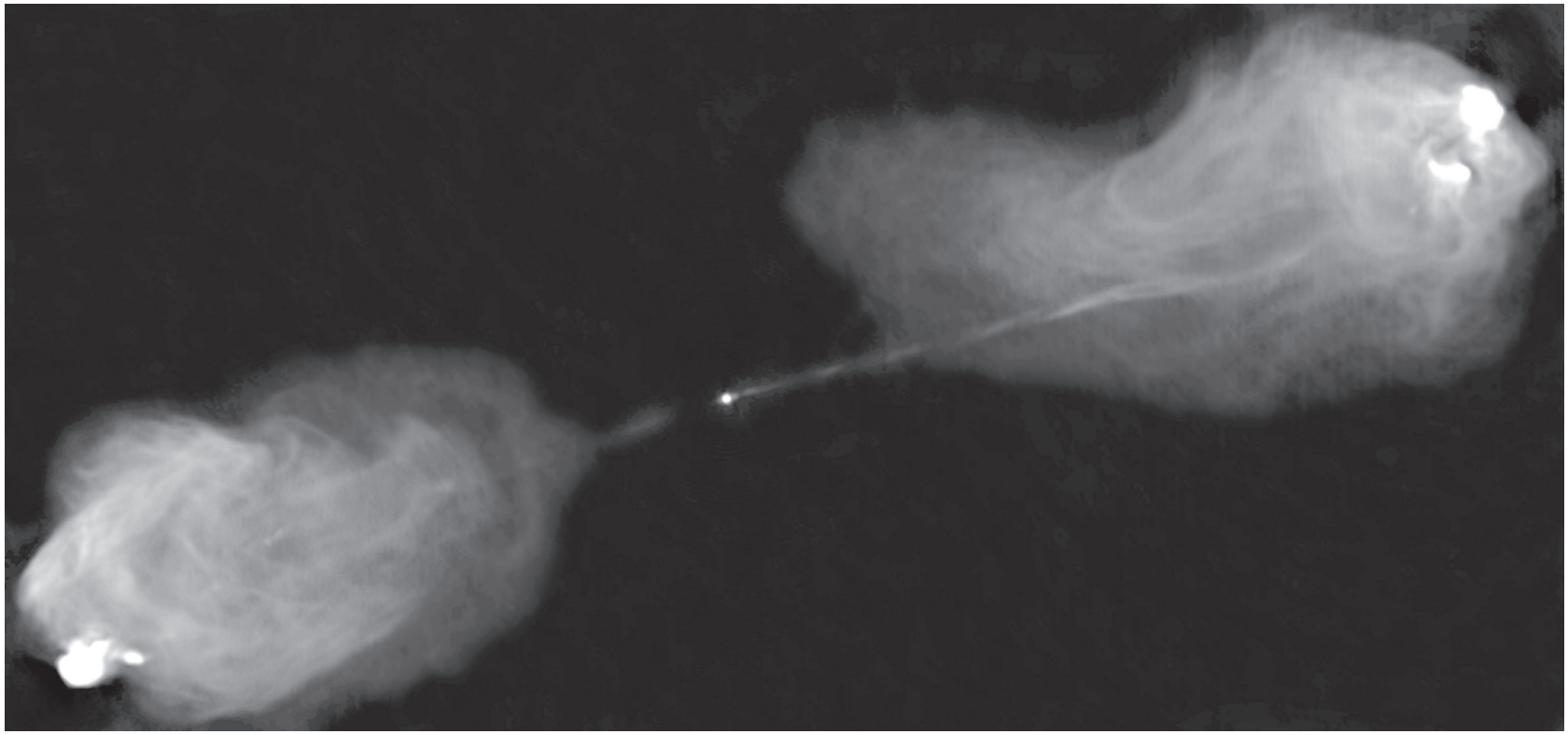
2006

"More is different." — Philip Anderson

An Earlier Revolution



Reber 1937(?)



Carilli, Perley, Dreher 1984

Opportunity

- Given n detectors with noise T, $\frac{T}{\sqrt{n}}$ will give the effective noise
- Win faster by reducing $T_{\rm sys}$ than by increasing n
- Until recently,
  - T has been quite a long way from fundamental limits
  - Large n has been prohibitively expensive

    $\$ \propto n$ is not attractive!
  - So concentrating on reducing the noise of individual detectors made sense
- Over the last decade the situation has changed dramatically
  - Breakthroughs have been made in both noise performance and packaging (the people in this room have led the way!)

INSTRUMENTS WITH BOTH LOW T AND LARGE n ARE WITHIN REACH AT AN AFFORDABLE COST

Opportunity — cont'd

- As will be detailed in presentations to come, the opportunity exists for
  - Continuum systems
  - Spectroscopy
  - Interferometry (especially with semi-filled arrays for low surface brightness objects, such as CMB/SZ, Earth)
- The frequency range of applicability can be taken as 15 GHz–5 THz
  - This week we will focus primarily (but not exclusively) on 15–300 GHz.
  - We are planning another workshop in ∼6–9 months that will concentrate on 300 GHz–5 THz

Opportunity — 2

- Sparse coherent arrays enable imaging with $N_{\rm pix} \gg N{\rm elements}$ for sources of high brightness temperature

  Nearly filled arrays have achieved good sensitivity even on the CMB, for $N_{\rm pix}$ closer to $N_{\rm elements}$, with all the advantages of interferometry

- But these advantages have been effectively limited to the ground by the high power requirement of digital correlators

- The speed of multiplier chips has been steadily increasing, and the power required has been steadily dropping. As a result

> IT IS NOW POSSIBLE TO PUT INTERFEROMETERS WITH LARGE n IN SPACE WITH DIGITAL CORRELATORS.

Synergies

- Astronomy, Earth science, and planetary science all benefit
- Up to hundreds of GHz at least, there are substantial and critical synergies with the commercial and defense/security worlds.
  - The partnership between JPL and industry (primarily but not exclusively TRW/NGST) started in 1994 has been an essential element in the spectacular progress made since then.
- The 10s and 100s of $M that have gone into basic processing facilities and technology starting with the development of GaAs transistors in the 80s and 90s have been commercially and DoD provided.
  - NASA and the NSF alone could not have funded this development
- But "science" money plays a crucial role in the push for and achievement of ultimate performance, cryogenic applications and techniques, and testing and characterization with an eye toward ultimate performance.
  - Commercial and DoD funding will not produce the arrays needed for science

Opportunities — cont'd

- We are on the brink of great things for science.
- But serious work is required on multiple fronts, as well as serious money, to bring this promise to reality.
  - NASA support essentially disappeared years ago with the death of the cross-cutting technology program.
  - Government funding agencies have poor mechanisms for appropriately recognizing and supporting technologies that are important for astrophysics, Earth science, planetary science, communications, and defense/security applications.
- The Keck Foundation, through KISS, provides an opportunity to help us undertake these great things.
  - Multi-disciplinary benefit is recognized as an important plus
  - KISS is funded!

OUR GOAL THIS WEEK, IN THIS INAUGURAL WORKSHOP OF BOTH KISS AND THE COHERENT ARRAY PROGRAM, IS TO LAY OUT A ROADMAP FOR THIS ACTIVITY.

Key Points

- None of this is a foregone conclusion, or already decided.
- KISS funding cannot by any means do everything. Think of it as critical seed money. We must work hard to obtain funding from all available sources.
- We need your candid and critical participation.

Remember, this week will focus on 15–300 GHz, but we are interested in higher frequencies up to say 5 THz as well, and will have another workshop to concentrate on that range later.

Also, while KISS is eponomously concerned with space, we won't be shy talking about ground possibilities as well. That's OK.