
There Will be Light !

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Various Aspects of **Light**

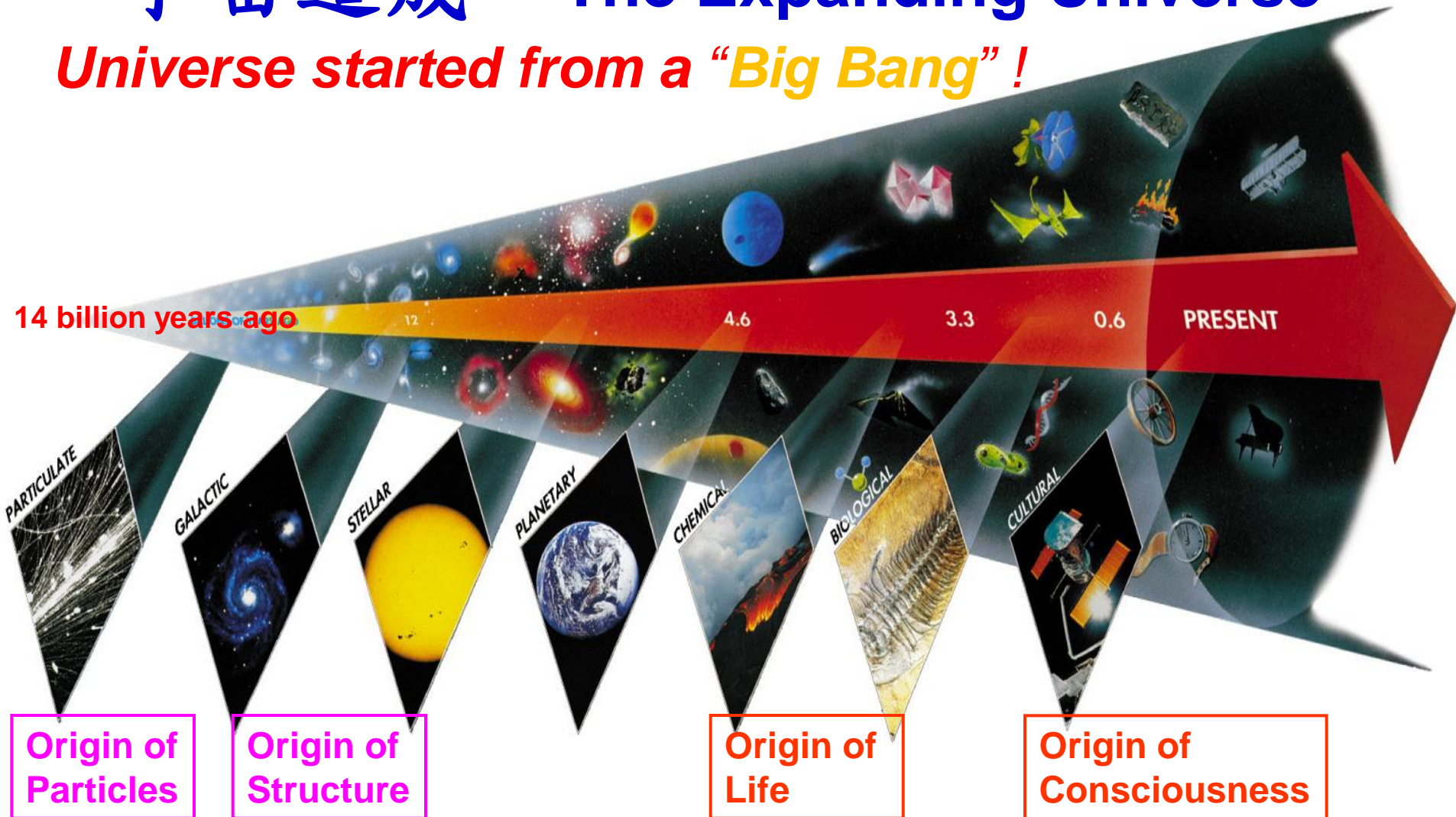
- ***Let There be Light !*** (創世紀, Genesis 1:3)
 - Big Bang & Cosmic Microwave Background (CMB)
- ***Light within Electromagnetic Wave (EM) Spectrum***
 - **Light** as Signal & Noise
- ***Light in Humanities***



宇宙造成

The Expanding Universe

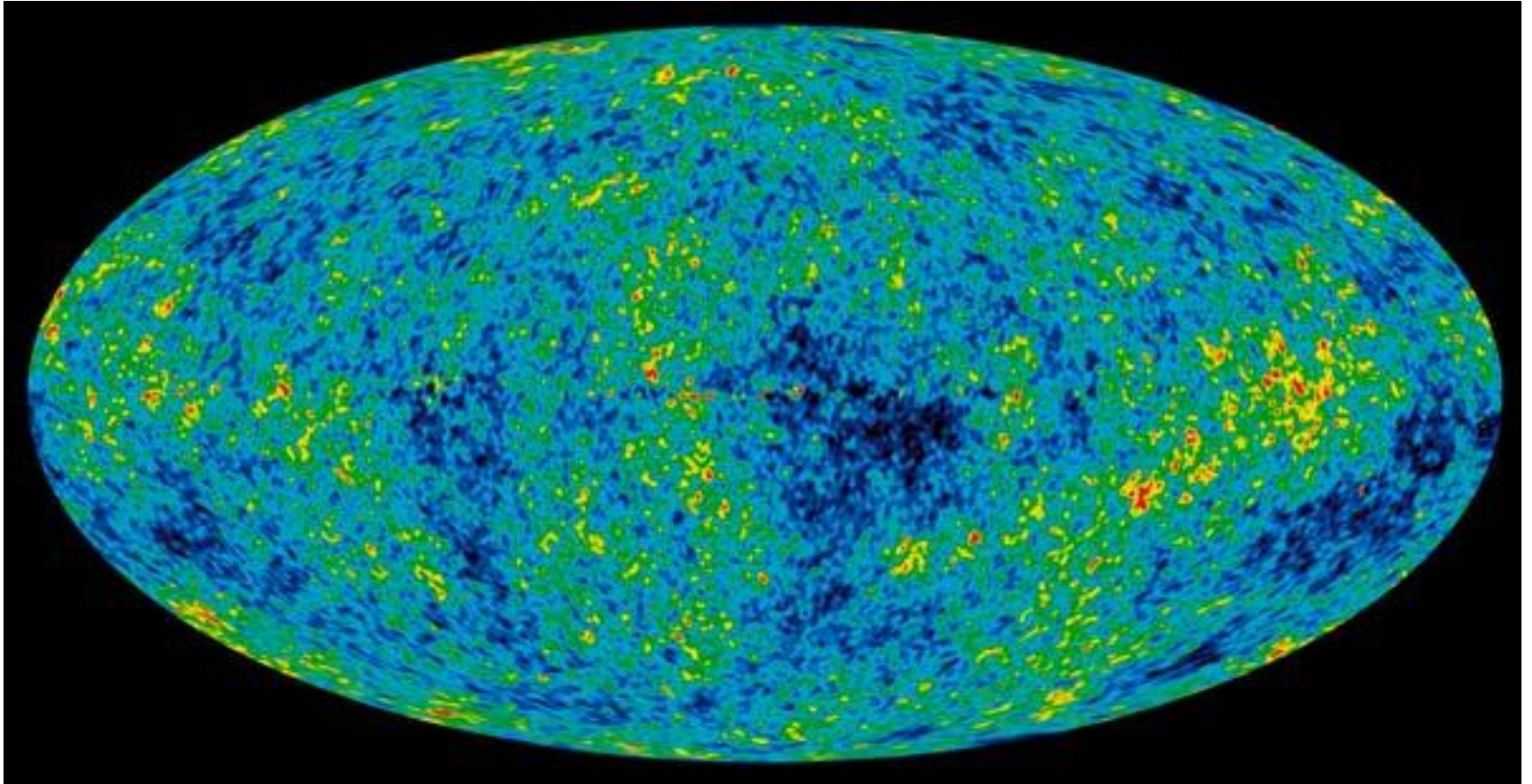
Universe started from a "Big Bang" !



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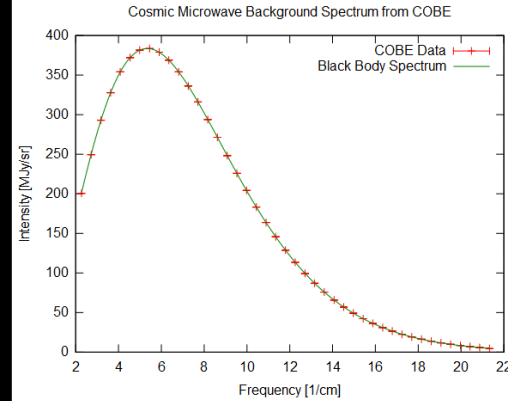
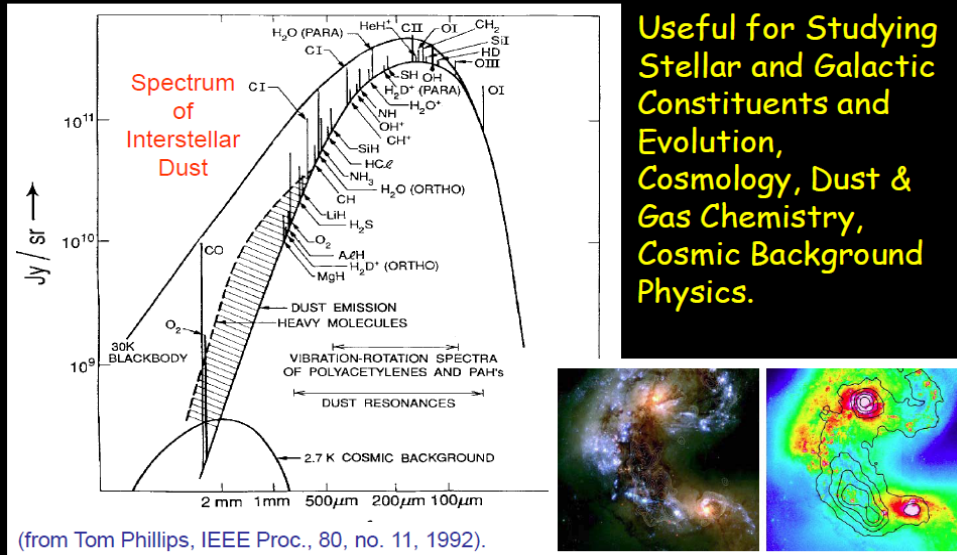
Cosmic Microwave Background (CMB)



Galactic Evolution Since Big Bang

Astrophysics Drivers for THz Sensors

THz is the primary freq. for line and continuum radiation from cool (5-100 K) gas (atoms and molecules) and dust.



2.7K Cosmic Microwave Background from COBE

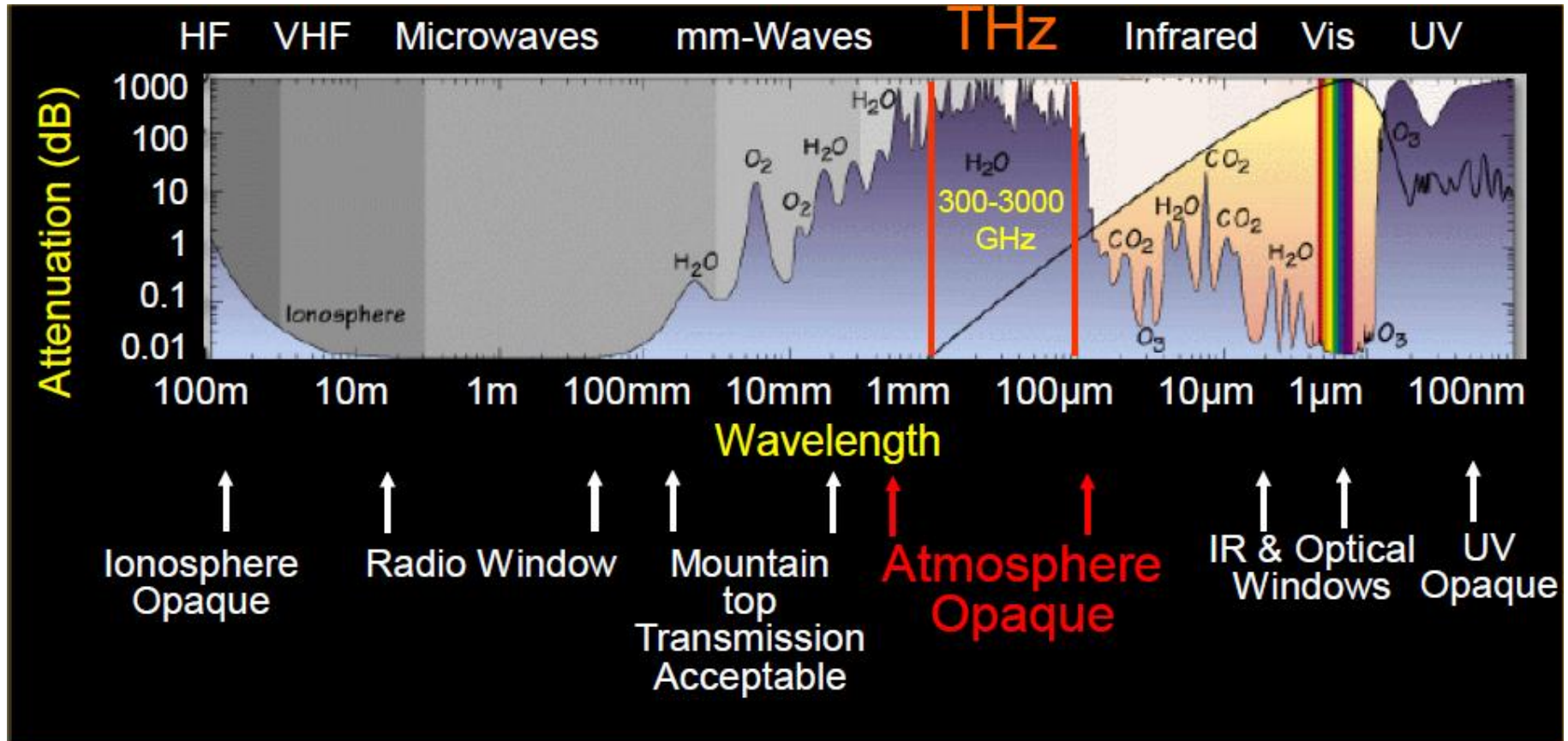


Penzias/Wilson Radiometer at Crawford Hill of ATT Bell Laboratories

Cosmic Microwave Background (CMB) was detected by Arno Penzias and Rob Wilson in 1964 by using a Radiometer



Electromagnetic Wave Spectrum



1 Tera-Hertz = 10^{12} /sec (one trillion cycles per sec)

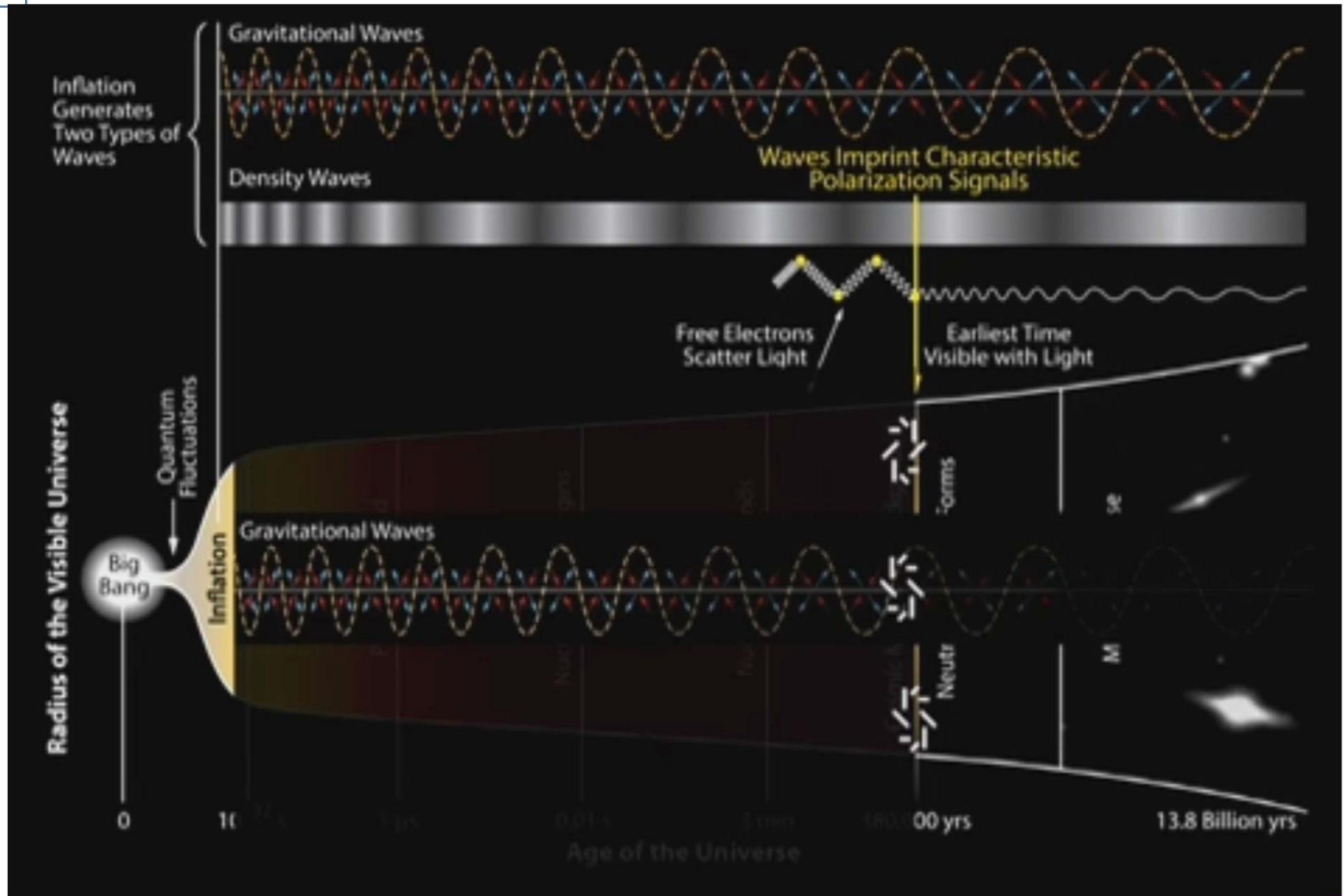
US National GDP \$14.2 trillion

(Courtesy JPL)

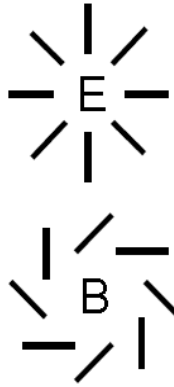


飲水思源

CMB Polarizations



Detect CMB B-Mode Polarization



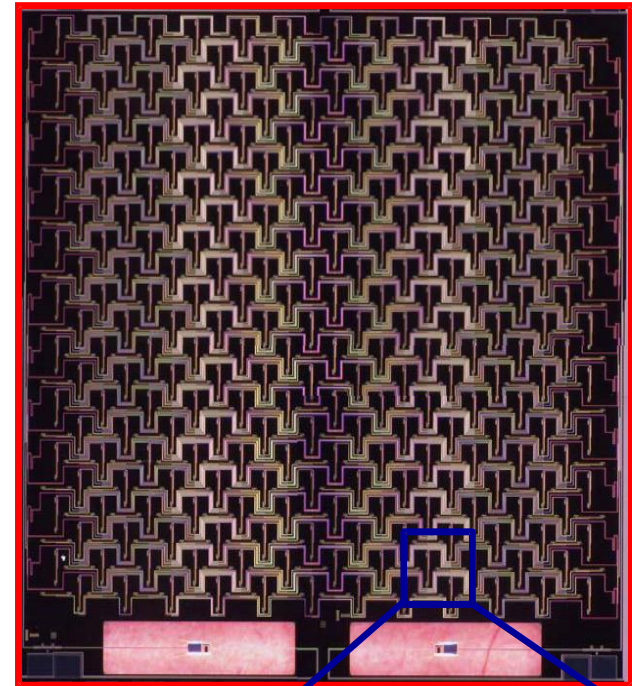
CMB polarizations modes

E-mode polarization: Density variation

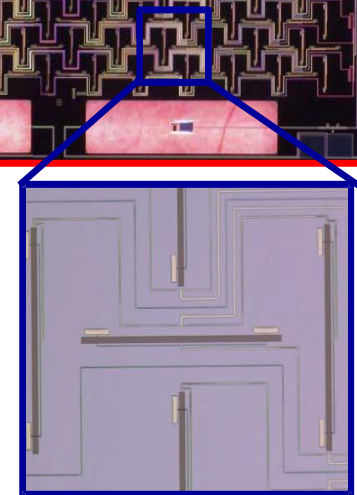
B-mode polarization: Gravitational waves

Planar Phased Arrays:

- Horn arrays are difficult to fabricate
- Planar arrays have fully occupied focal plane
- Easy integration with planar feeding lines
- Direct stray radiation coupling to the detectors



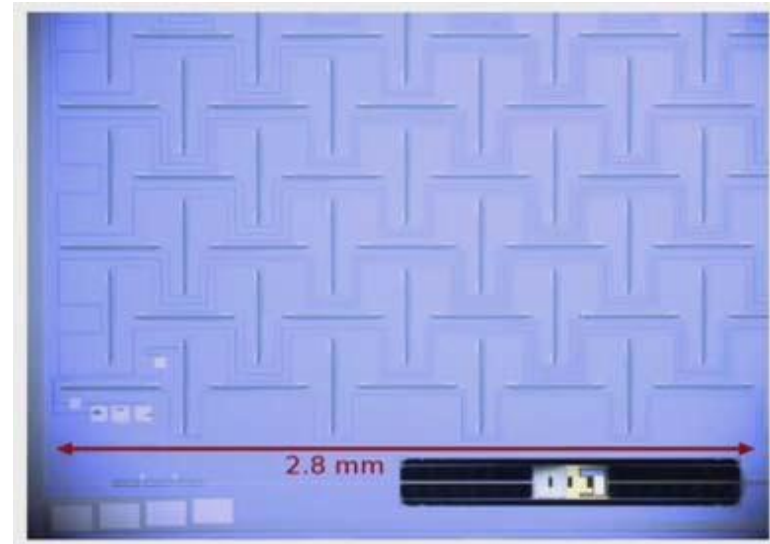
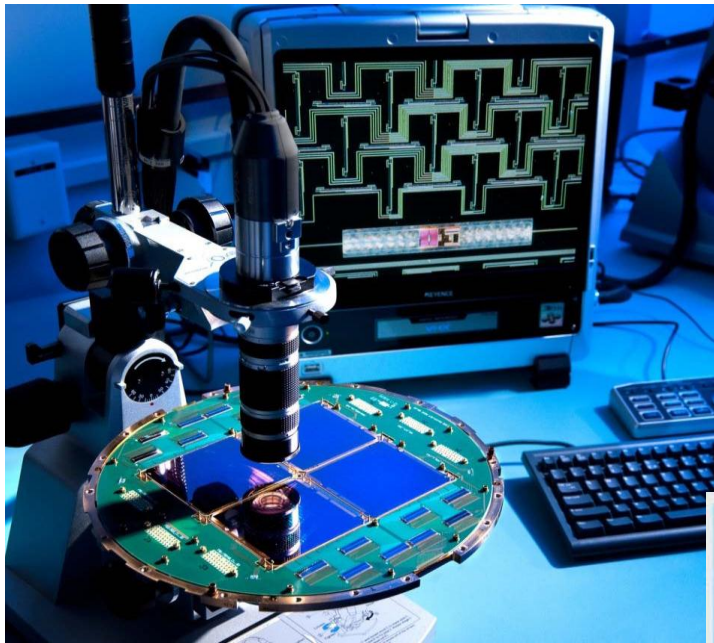
JPL SPIDER Phased Array



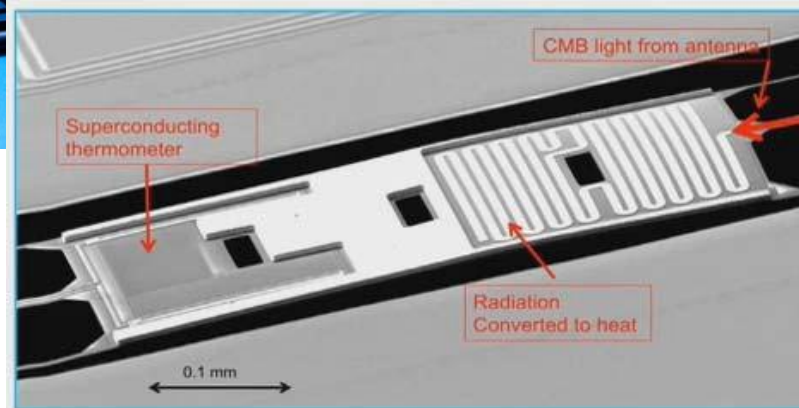
(Courtesy JPL)

B-Mode Detection Instrument

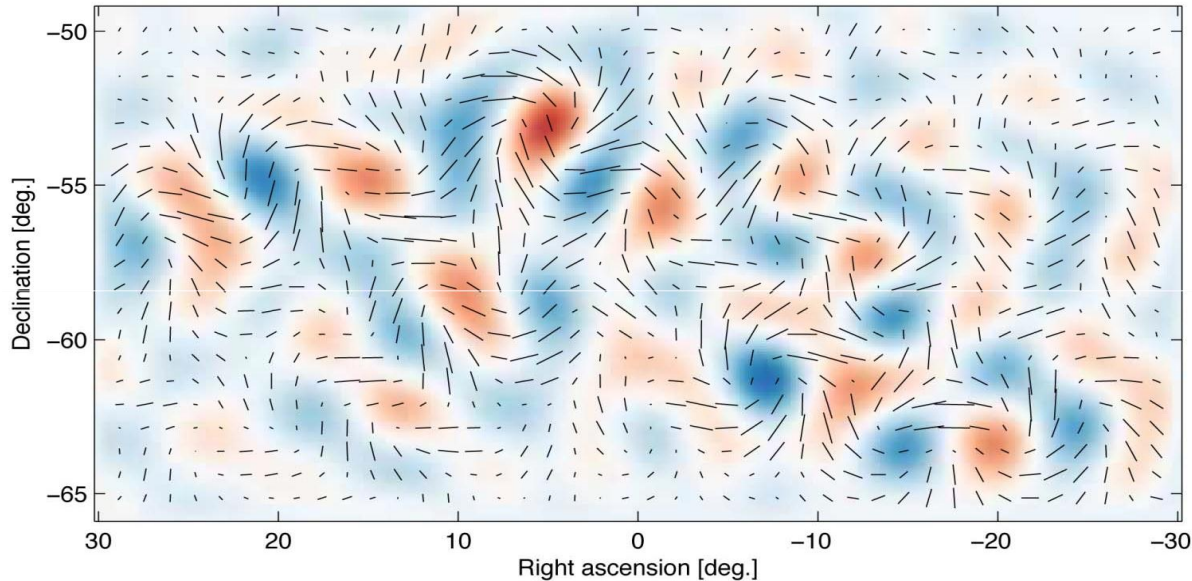
BICEP-2 Antenna



BICEP-2
Detectors



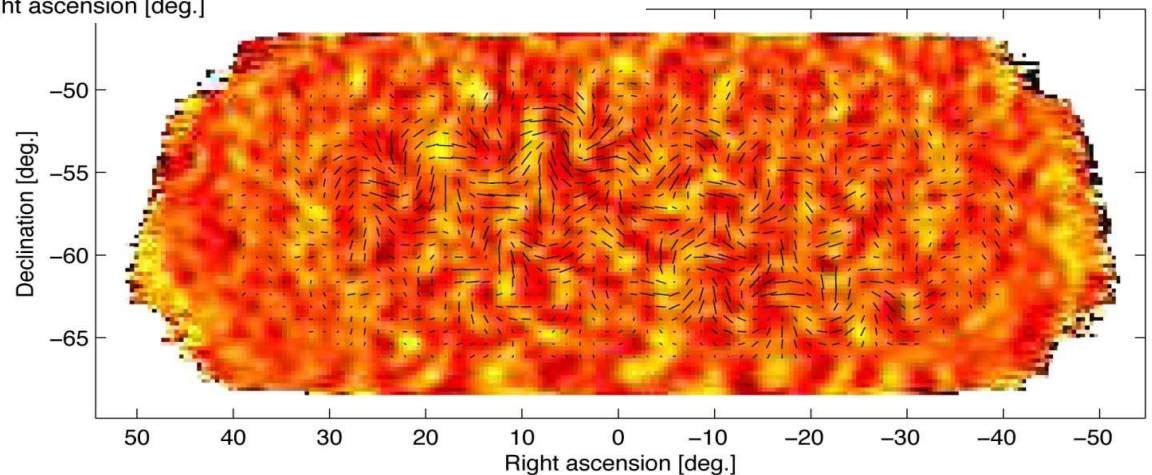
B-Mode CMB Polarization



**First Direct Evidence
of Cosmic Inflation??**

**BICEP-2 Data,
March 17, 2014.**

(Courtesy JPL)



Earth/Planetary Sciences **JPL**

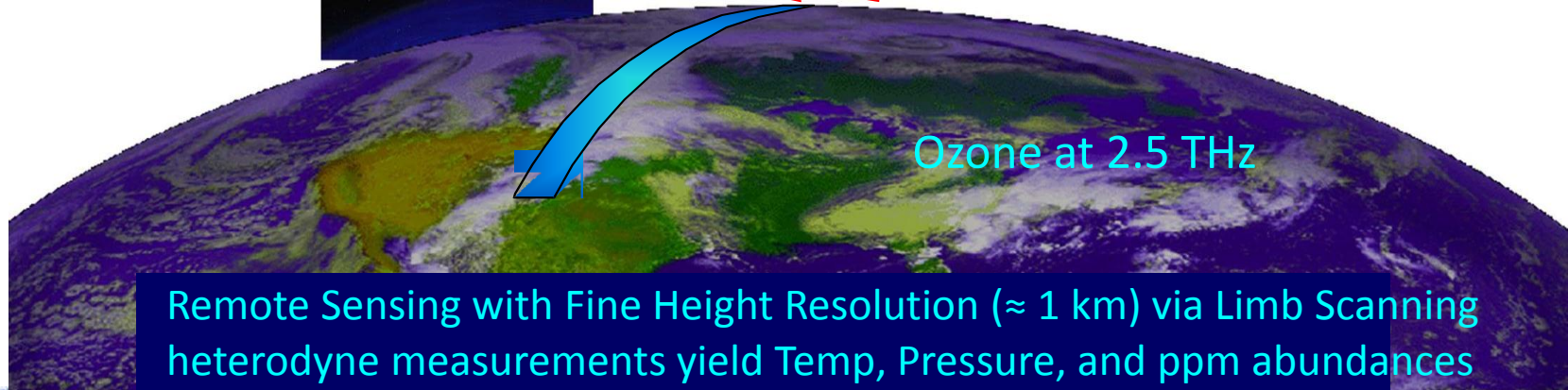
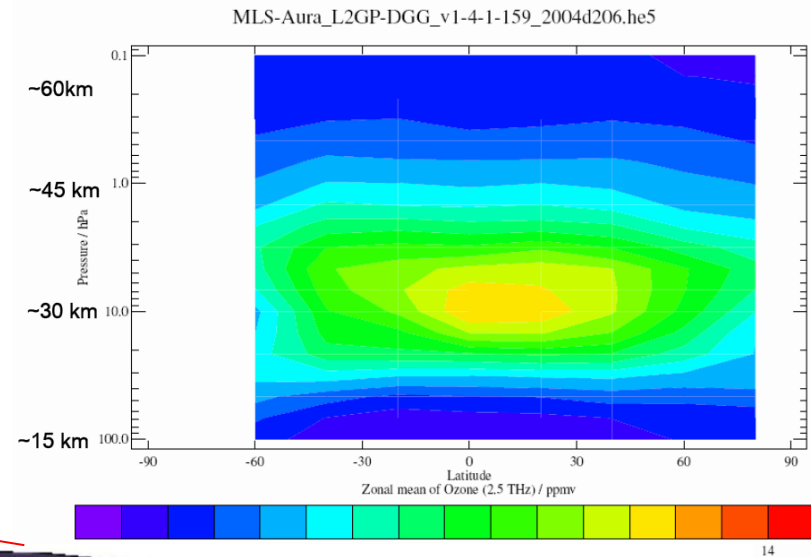
- **Stratospheric and Tropospheric Chemistry** Our first 2.5 THz O₃ retrievals

- ozone layer modeling
- economics vs. environment
- water distribution/pollutants

- **Clouds: Global Warming**

- ice crystal: size & distribution

- **Aerosols, Volcanism, Dust**



PISSARRO 600 GHz Spectrometer **JPL**



PISSARRO is a side-band separating, dual polarization **600 GHz Spectrometer** for many planetary missions and carries out several key science investigations highly desired by NASA.

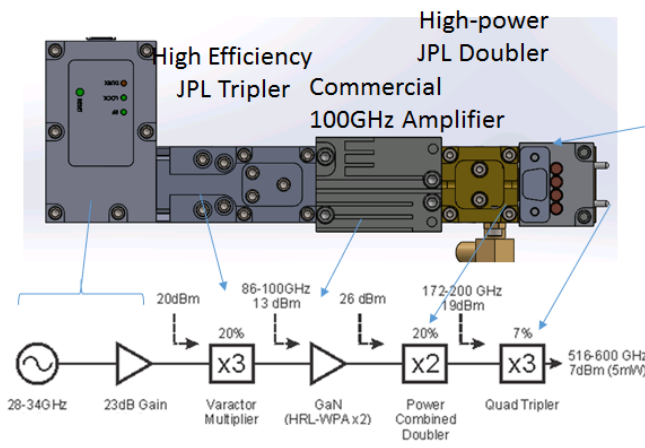
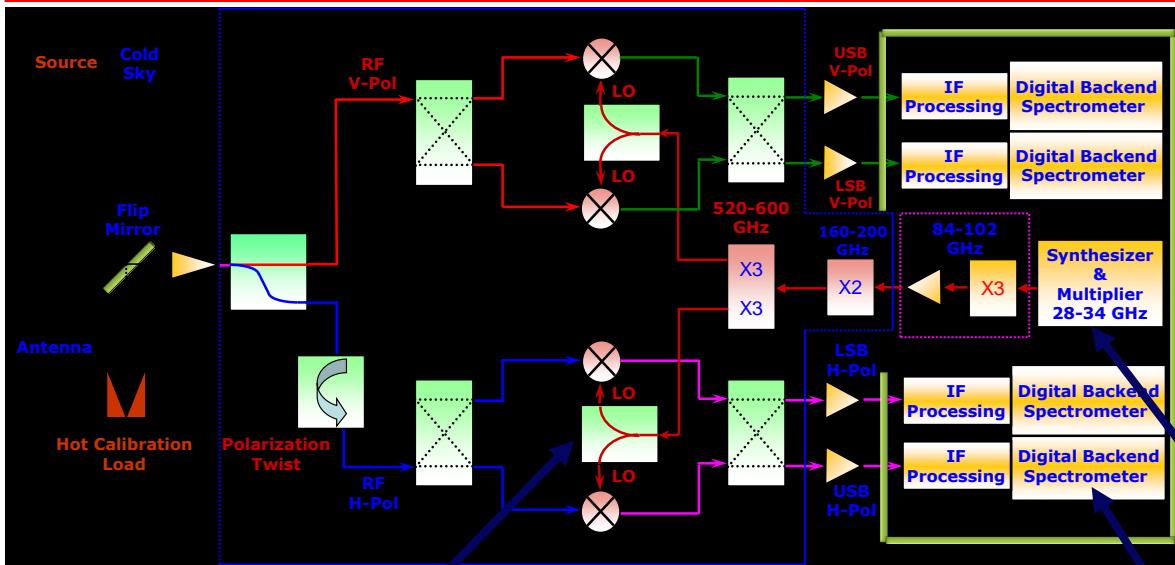
Mostly developed with moons like Europa (Jupiter's moon) and Titan in mind.

Some of PISSARRO's Science Objectives to Characterize

1. Distribution of shallow subsurface water and structure of icy shells
 2. Correlate surface features material exchange of surface, ice shell, and ocean
 3. Gas phase molecules
 4. Details of sputtering process in water
 5. Temperature and diurnal effects
 6. Escape probability in sputtered water
 7. Specific chemical compounds
8. Isotopic ratio and enrichment rates in water to "date" the immediate surface



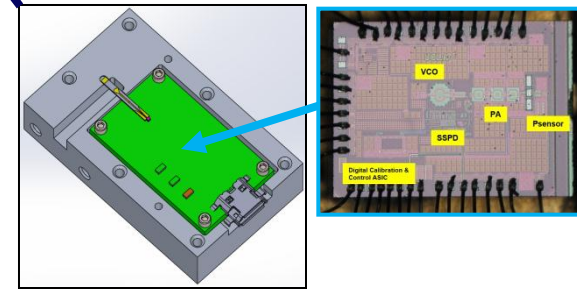
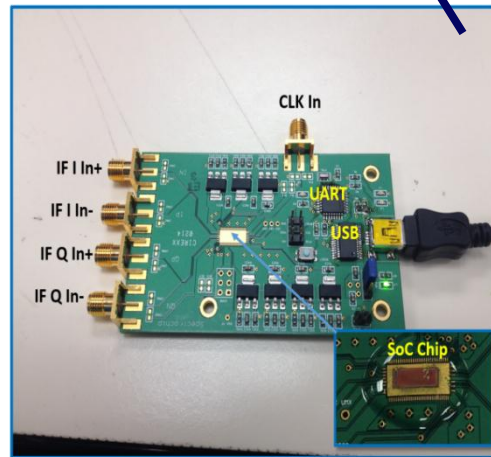
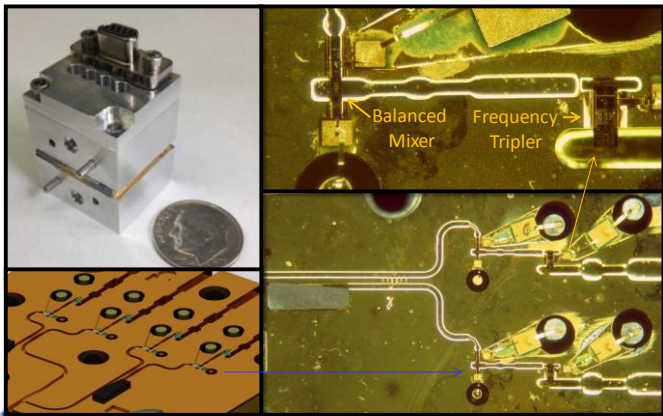
PISSARRO 600 GHz Spectrometer

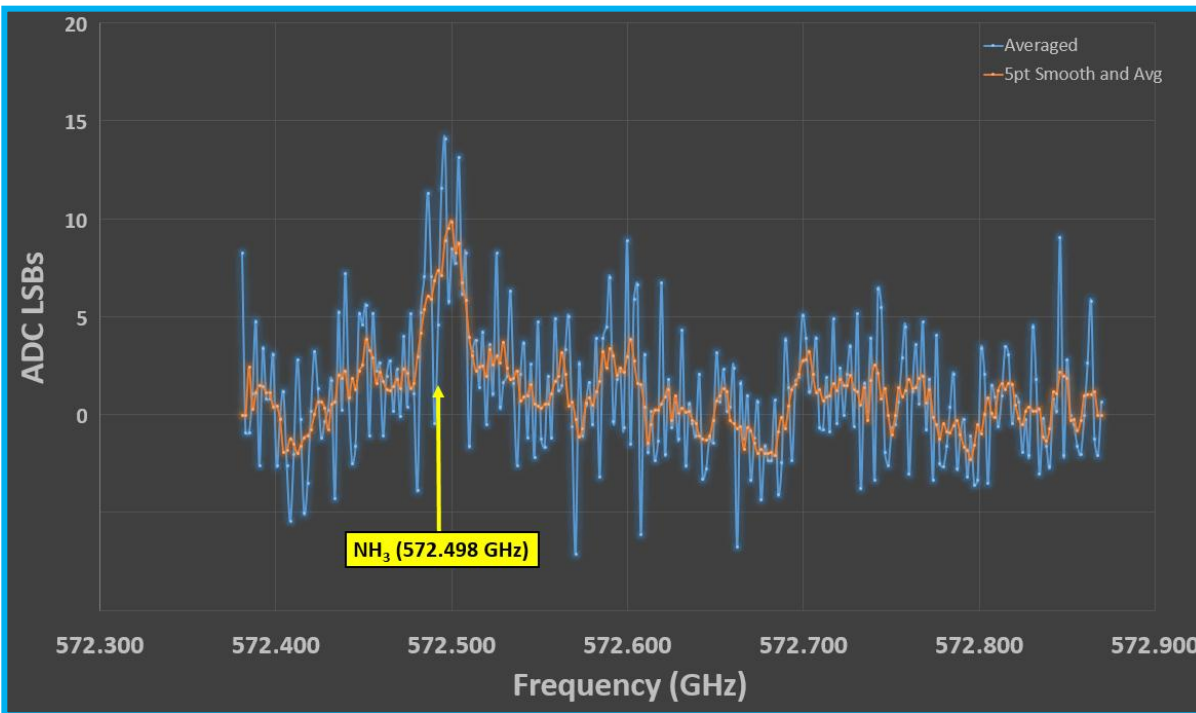


600 GHz Fully-Integrated THz Front End Si-micro-machined

CMOS Spectral Processor SoC

K_a Band Self-Calibrating CMOS Synthesizer SoC





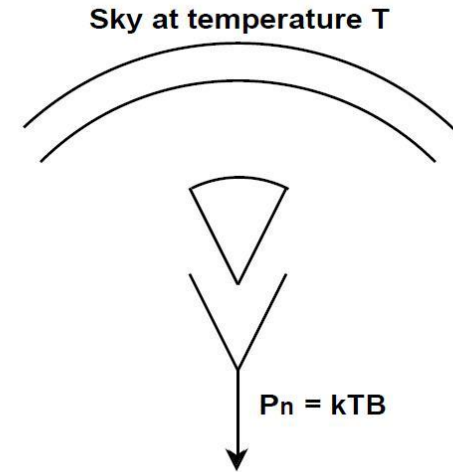
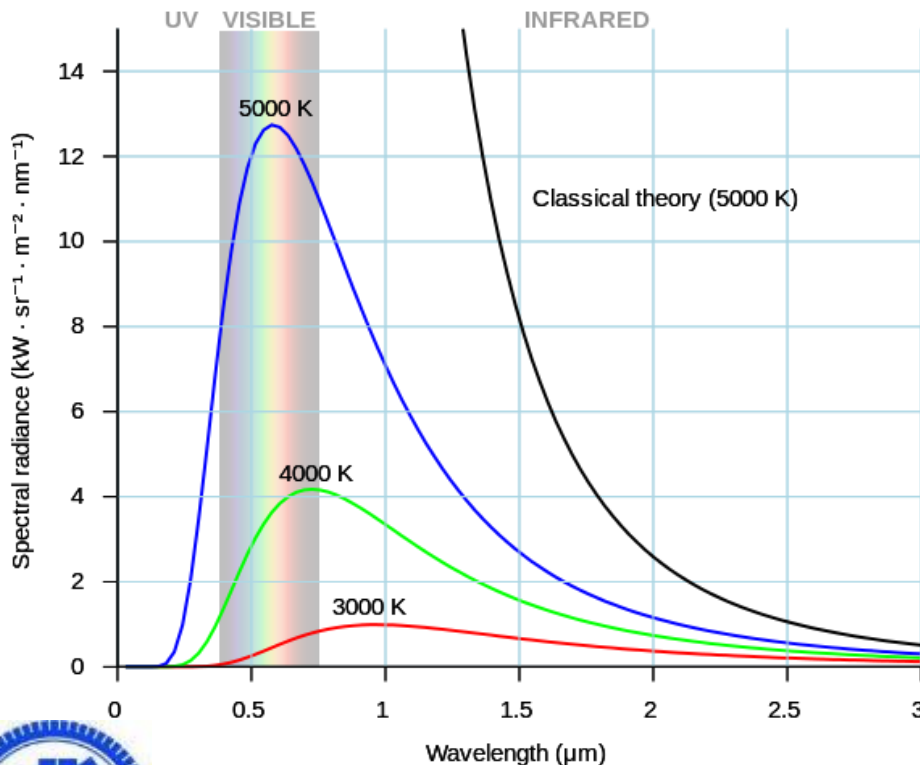
Metric	Performance
Expected Bin	193
Peak Bin	193
SNR (Linear)	$9.86 / 2.65 = 3.7$

The first demonstration of a CMOS-based spectrometer instrument capturing real science data...



Light as the Source of Noise

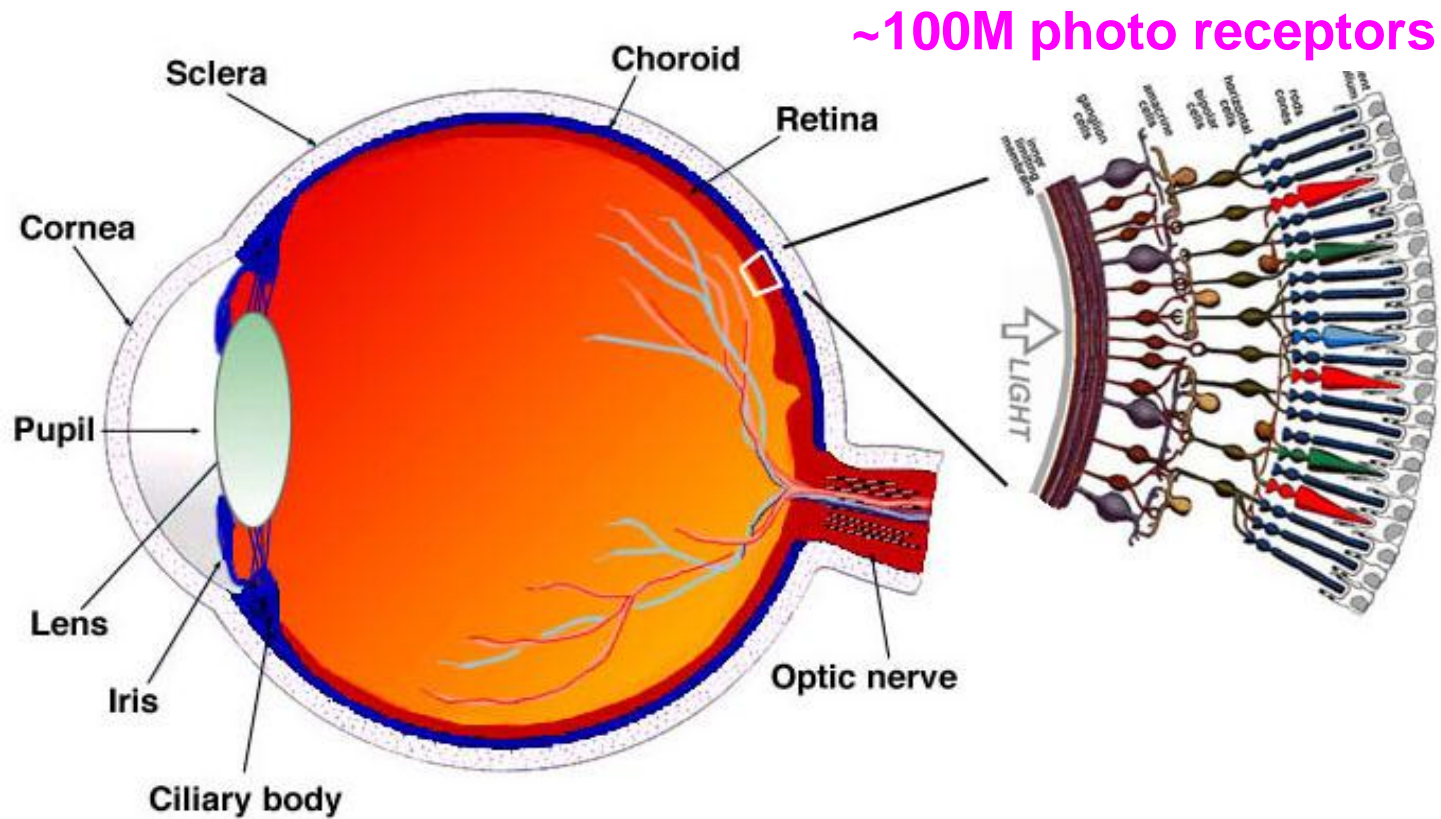
Black-body radiation is the type of electromagnetic radiation within or surrounding a body in thermodynamic equilibrium with its environment,



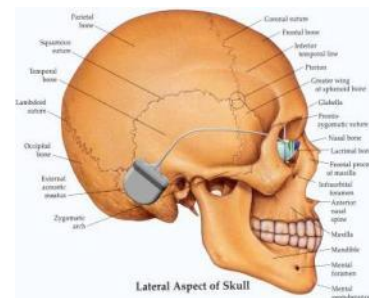
Noise power
 $P_n = kTB$ Watts
(In long-wavelength limit)
k: Boltzmann constant
($1.38 \times 10^{-23} \text{ J/k}$)
T: Temperature in Kelvin
B: Bandwidth (Hz)



視覺傳感 (Human Sight)



Goal of Retinal Prosthesis at UCLA/USC

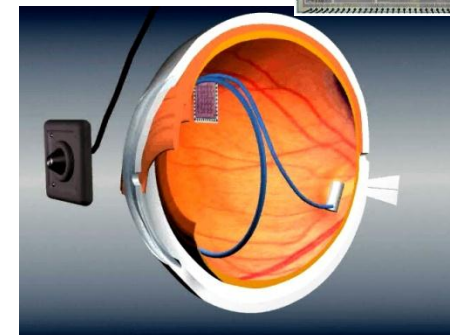
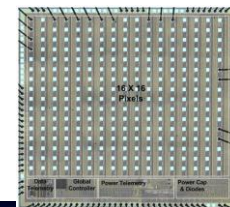
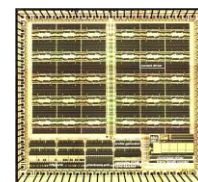
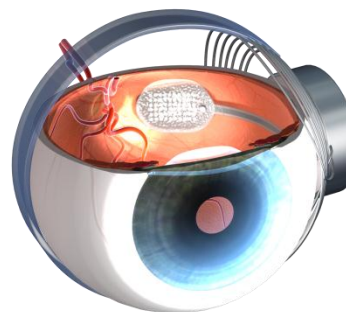


■ **Model 2 (Argus 2 - 60 pixels; mobility aid)**

- Received CE Mark and USA FDA Approval
- Implantable chips designed by UCLA team
- Patients with hand motions or worse vision

■ **Model 4 (1000+ pixels; reading/face recognition)**

- Expect prototype device (2014)
- Implantable chips designed by UCLA team
- Patients with 20/200 or worse vision
- Patients with retinal blindness (macular degeneration)



Courtesy Prof. Wen-Tai Liu, UCLA

Light in University Mottos

Light!

耶魯大學



Light and Truth !
光明與真理

加州大學



Let there be light !
要有光, 就有了光.

Truth!



Light in Humanities

- Hope is being able to see that there is **light** despite all of the darkness ([Desmond Tutu](#))
- Darkness cannot drive out darkness: only **light** can do that. Hate cannot drive out hate: only love can do that ([Martin Luther King Jr.](#))
- We can easily forgive a child who is afraid of the dark; the real tragedy of life is when men are afraid of the **light** ([Plato](#))
- There is a crack in everything. That's how the **light** gets in ([Leonard Cohen](#))



There Will be
Light
in driving out
Fear, Hate, Darkness and
through Cracks

