# BUILDING NEW WAYS OF "PAYING ATTENTION": Interdisciplinary Astronomy, Physics, and Statistics

Ingrid Daubechies[1]: ``But I looked at it differently. A change of paradigm. Well, paradigm, I never know what that means. A change of ... a way of seeing it. A way of paying attention.''

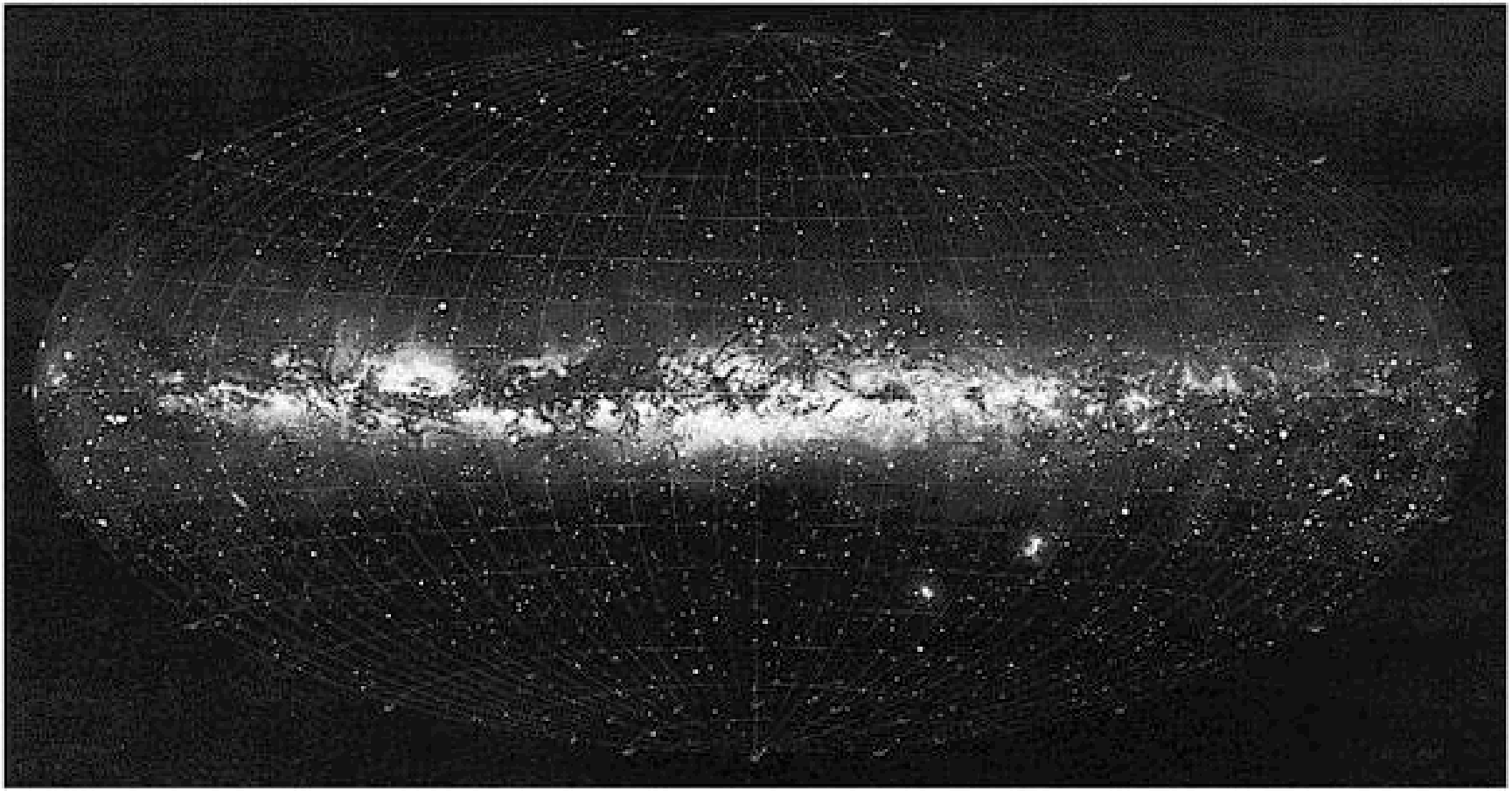
California-Harvard Astronomy and Statistics Collaboration
10 years and going ...

# Stories:

- Whirlwind History
- Sky of Many Colors
- Astronomy+Physics+Statistics
- CHASC: (brief!) History and challenges

# History:

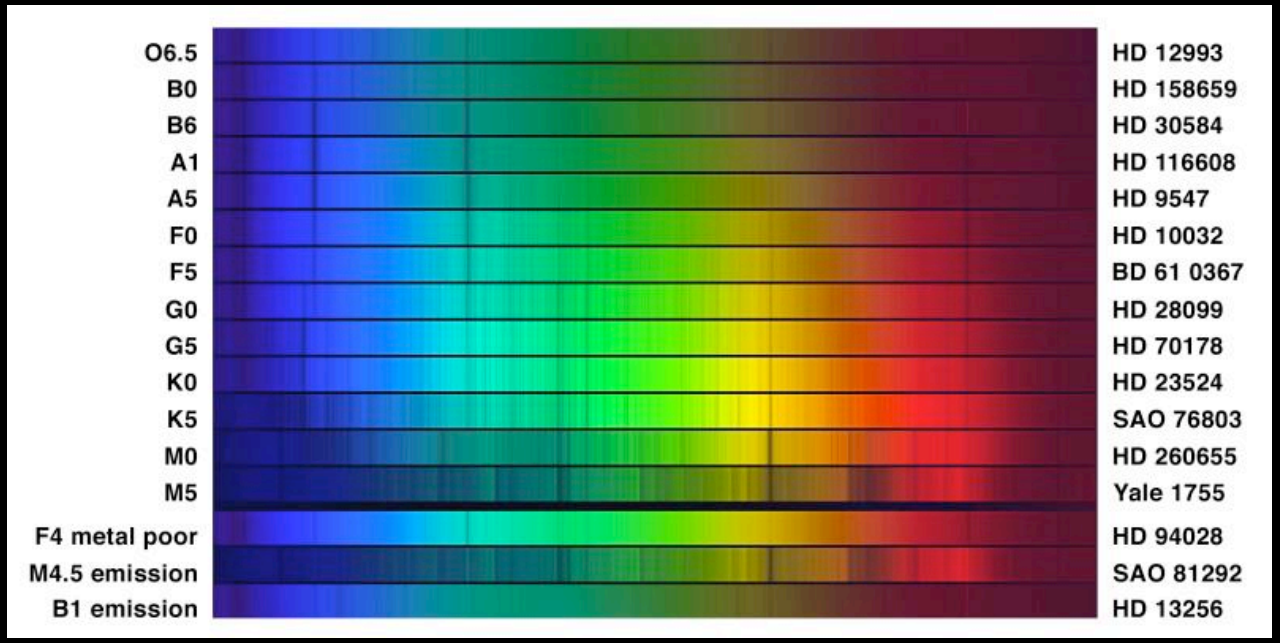
- Timing and Celestial Mechanics of planets, moons, asteroids, comets, ...
- Euler, Lagrange, Fourier
- Paris Prize Papers



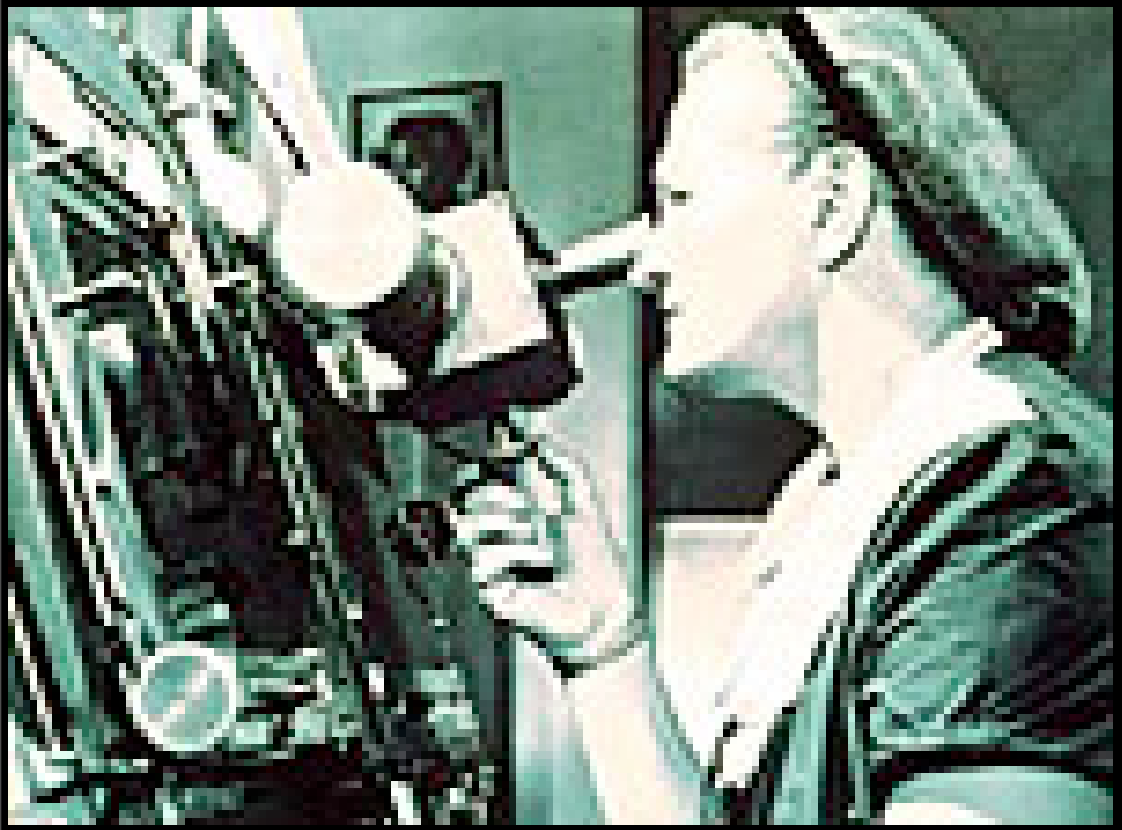
# Optical Sky (surfaces of normal stars, ~1000 K)

Milky Way was hand-drawn from many photographs by Martin and Tatjana Keskula under the direction of Knut Lundmark; courtesy of the Lund Observatory, Sweden.)

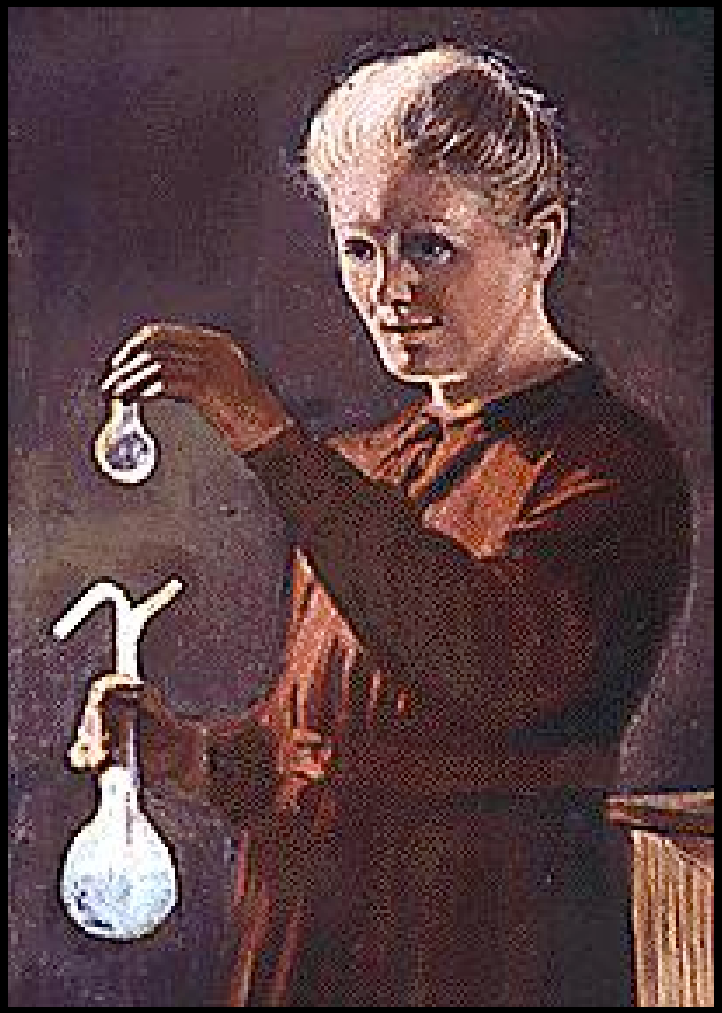
# The Sky of Many Colors Meets Modern Physics



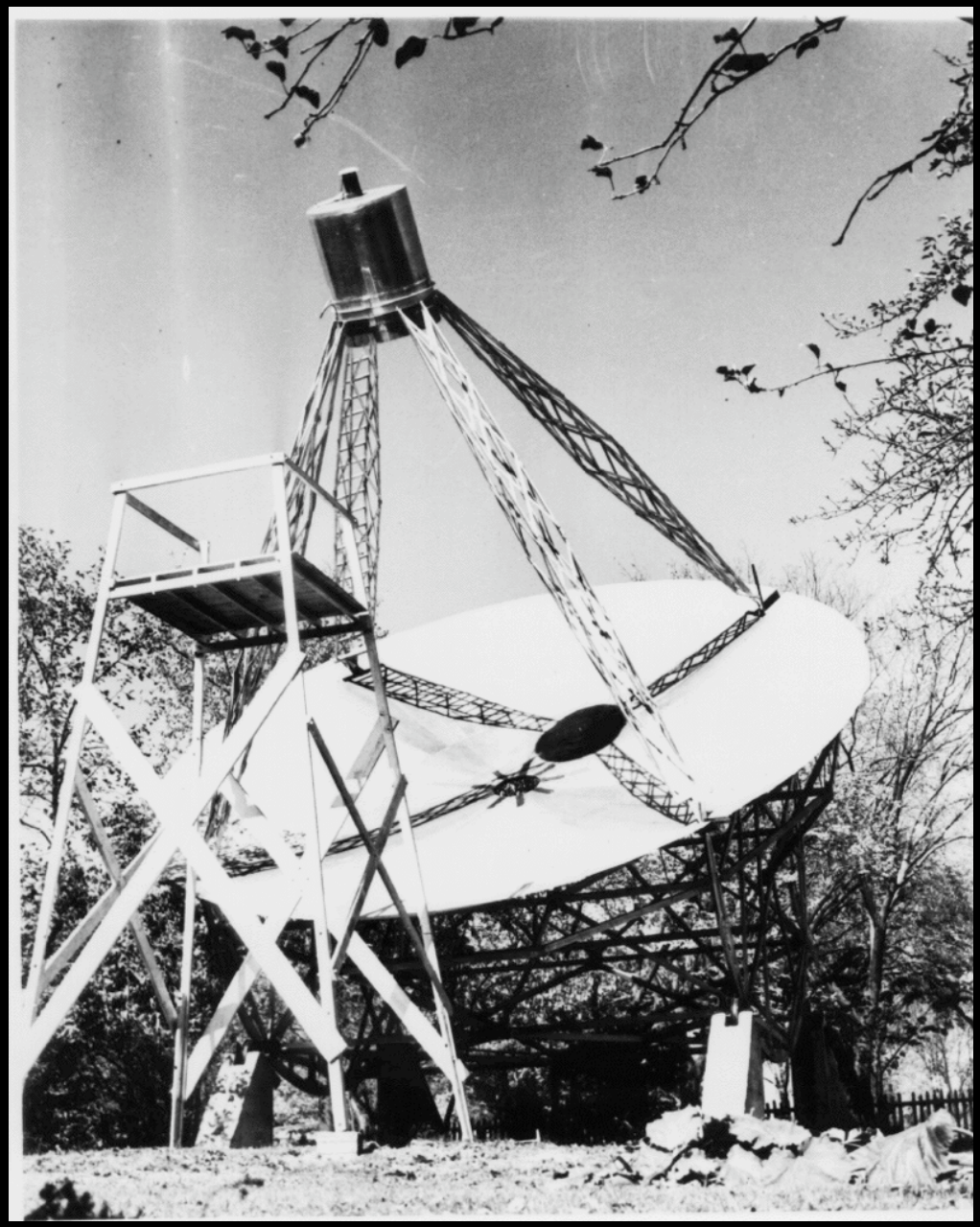

Annie Jump Cannon - Stellar Spectra By Eye and Hand



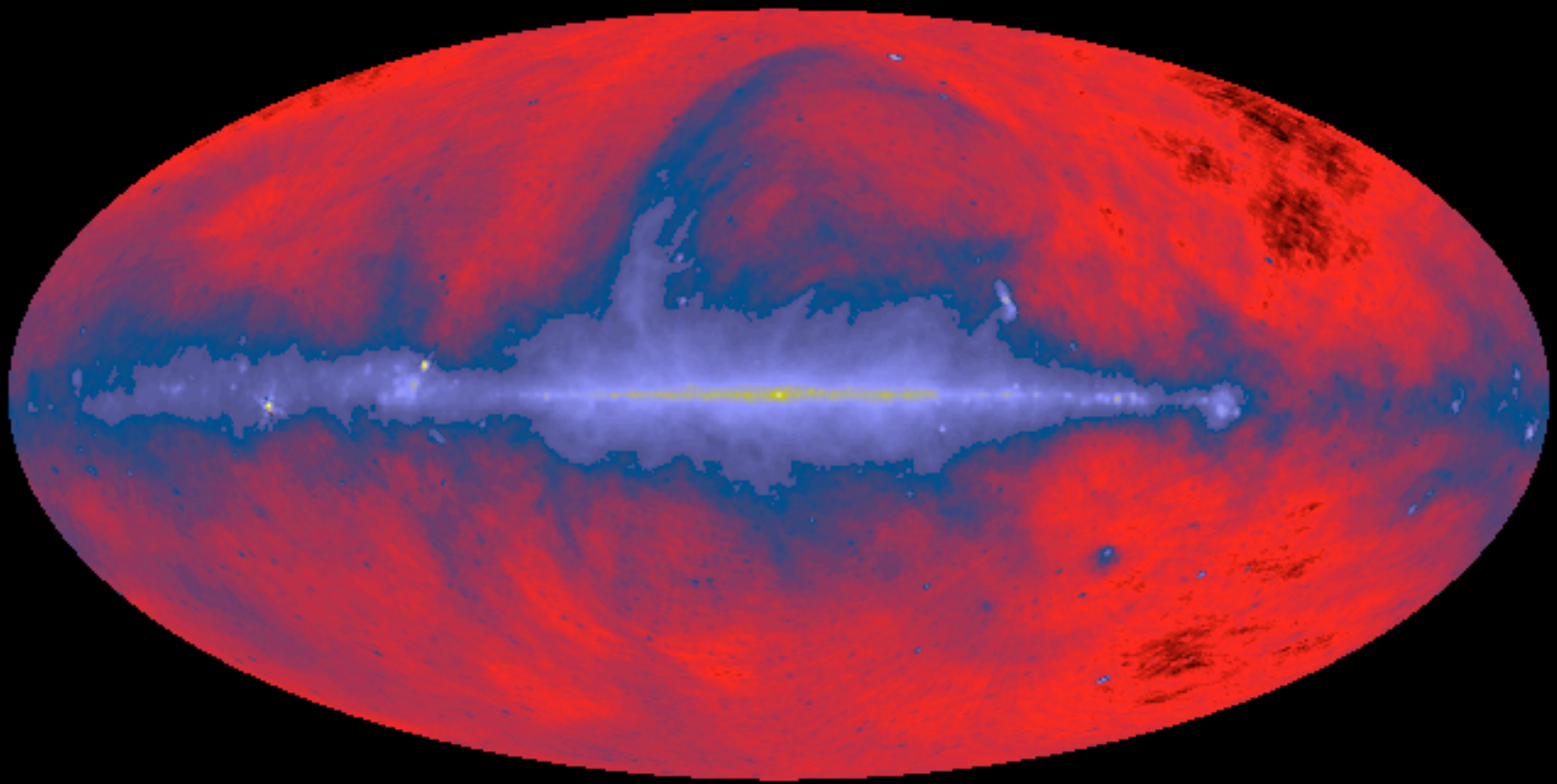
Cecelia Payne Gaposchkin



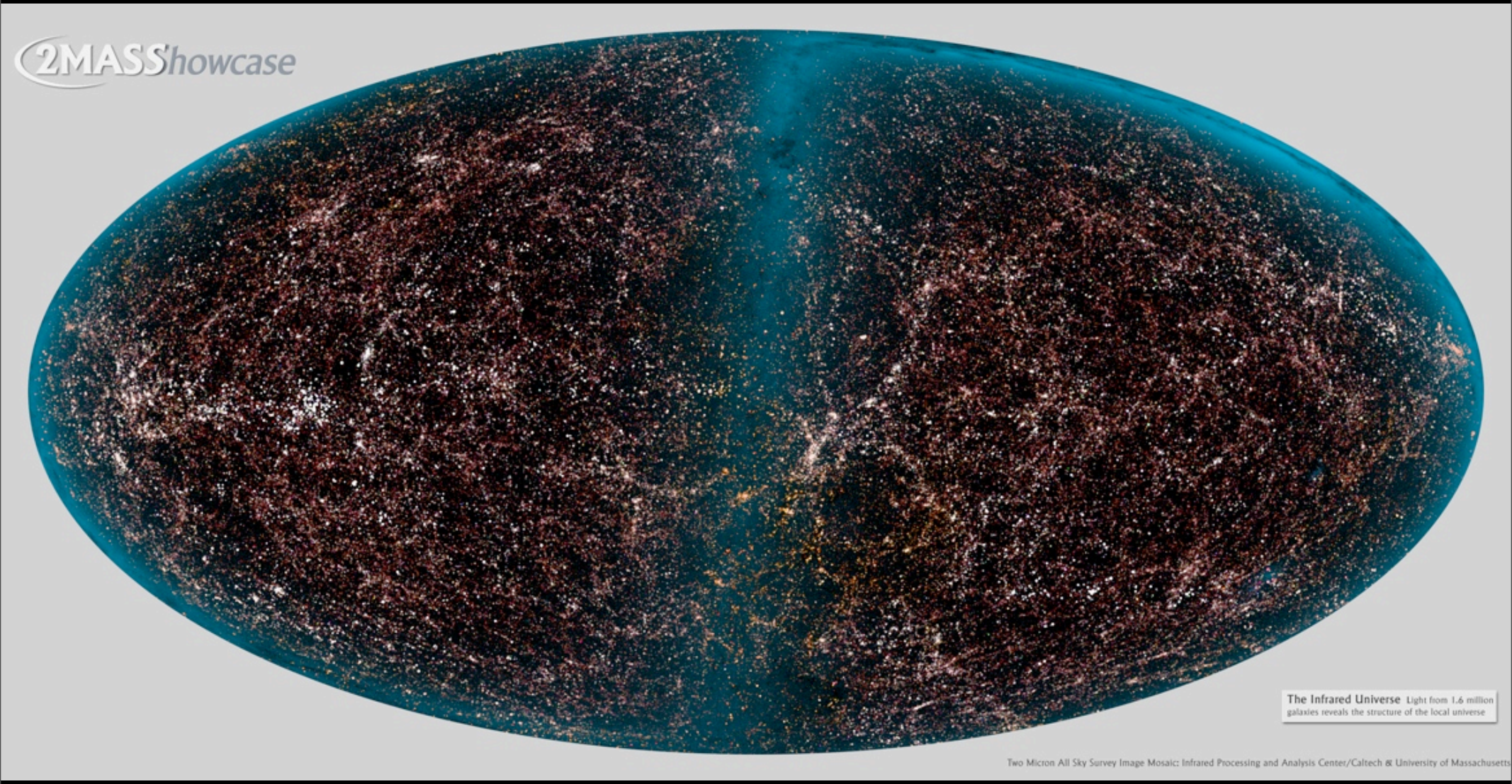
# Demo: "Corpuscular" Ionizing Radiation Detectors



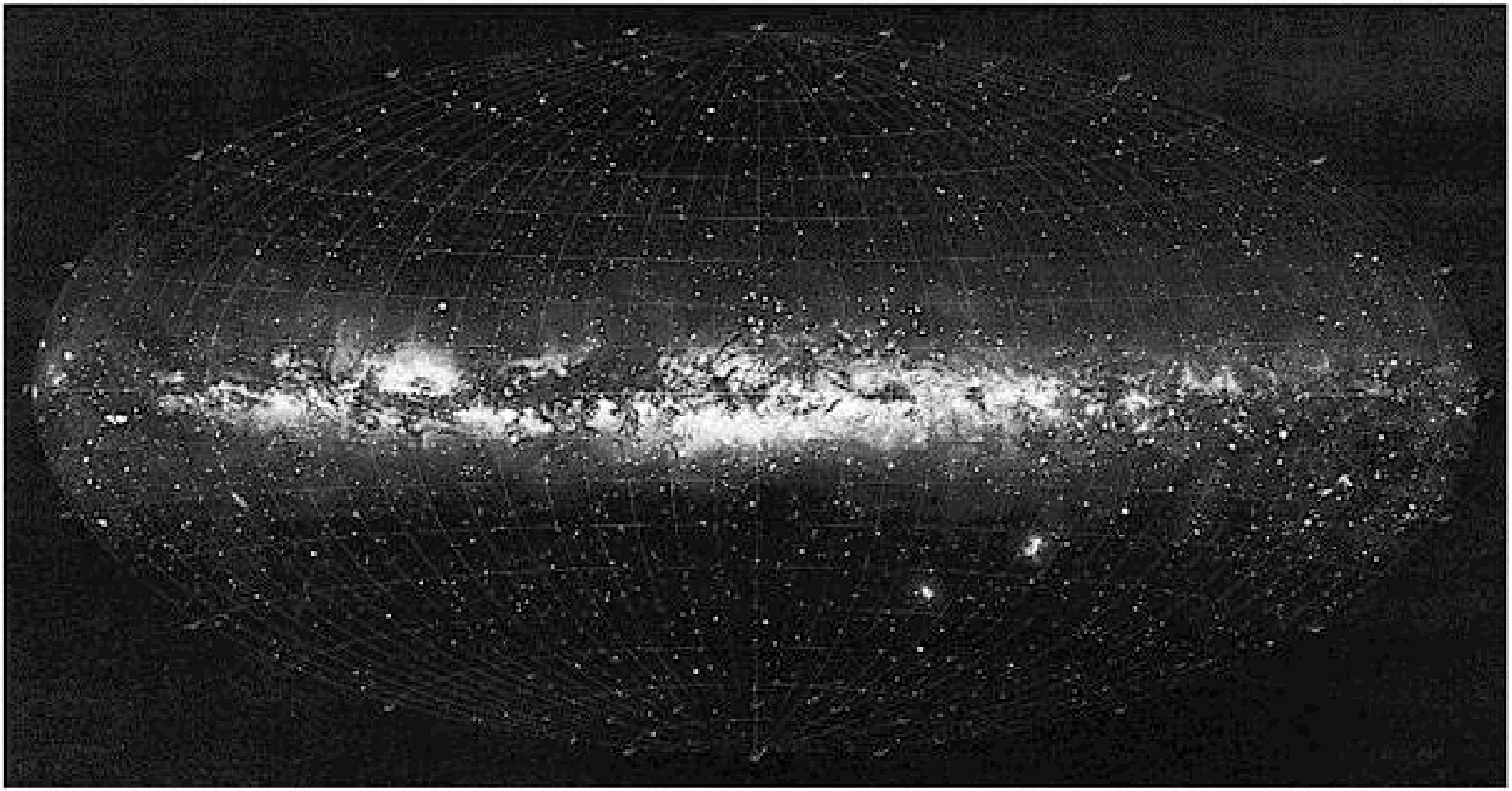

Grote Reber: Ham Radio Enthusiast builds First Radio Astronomy Telescope in His Back Yard, 1937



Radio Sky (Clouds of Gas, Magnetic Fields, Sun)




2MASS Infrared Sky (Dust, galaxies, cooler stars at ~ K)



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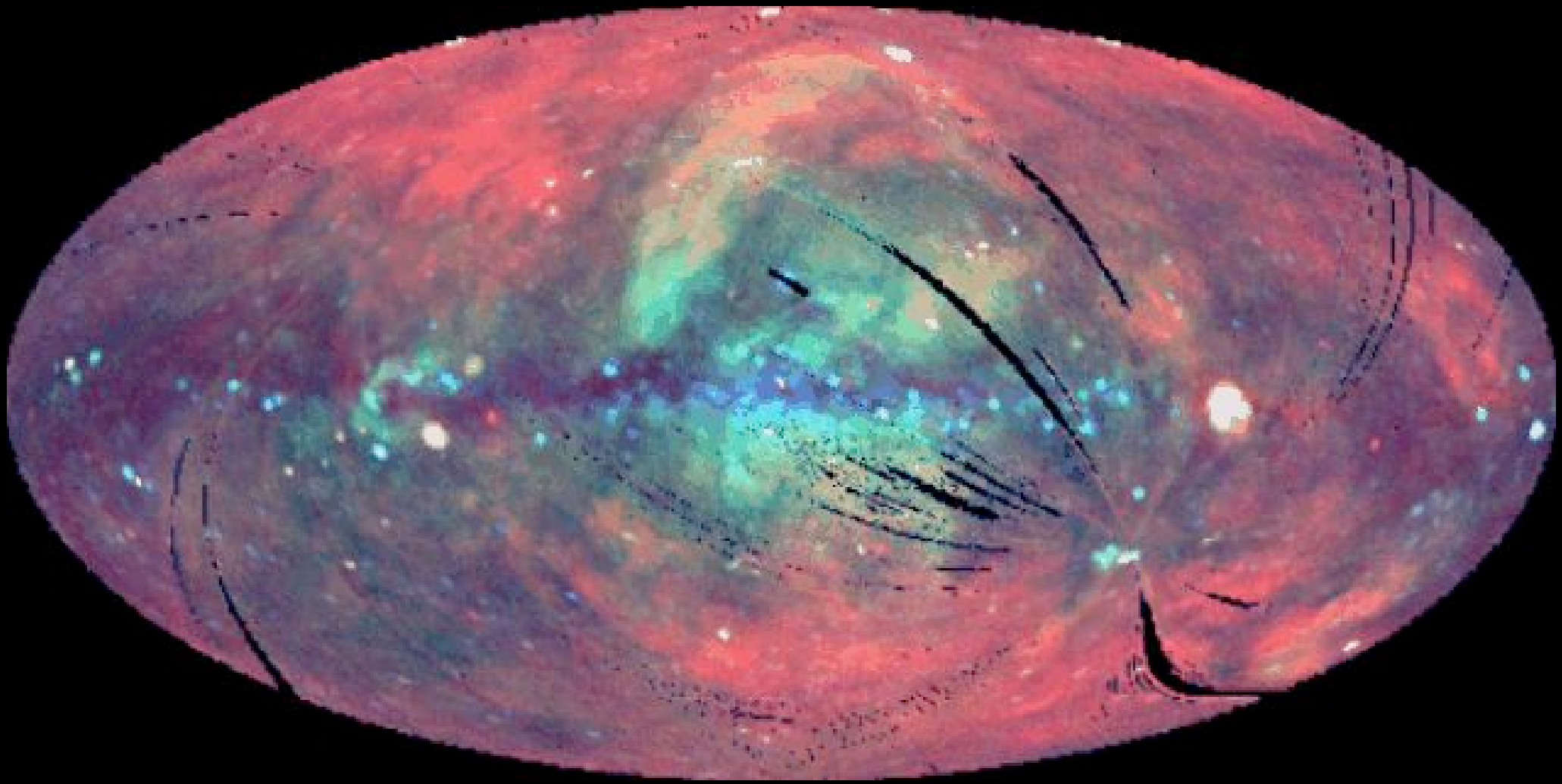
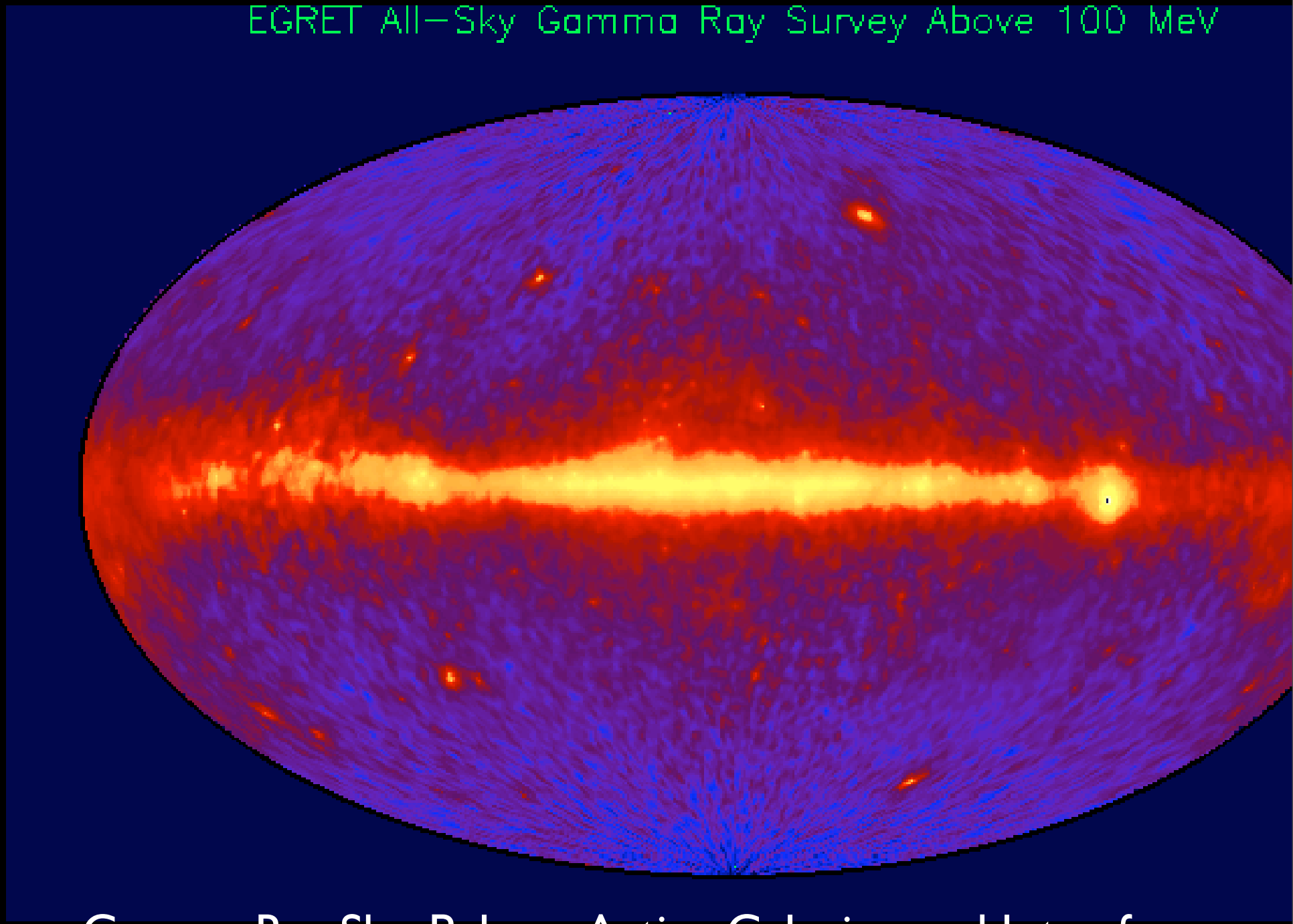


ROSAT All-Sky ~1.5 KeV (Digel and Snowden):
Black Holes, Neutron Stars, Active stars ---
and local glowing gas




Gamma-Ray Sky: Pulsars, Active Galaxies, and lots of (nonthermal) glowing gas

# Ways of Paying Attention: Astronomy Perspective to 1980
## After a good beginning, Isolated

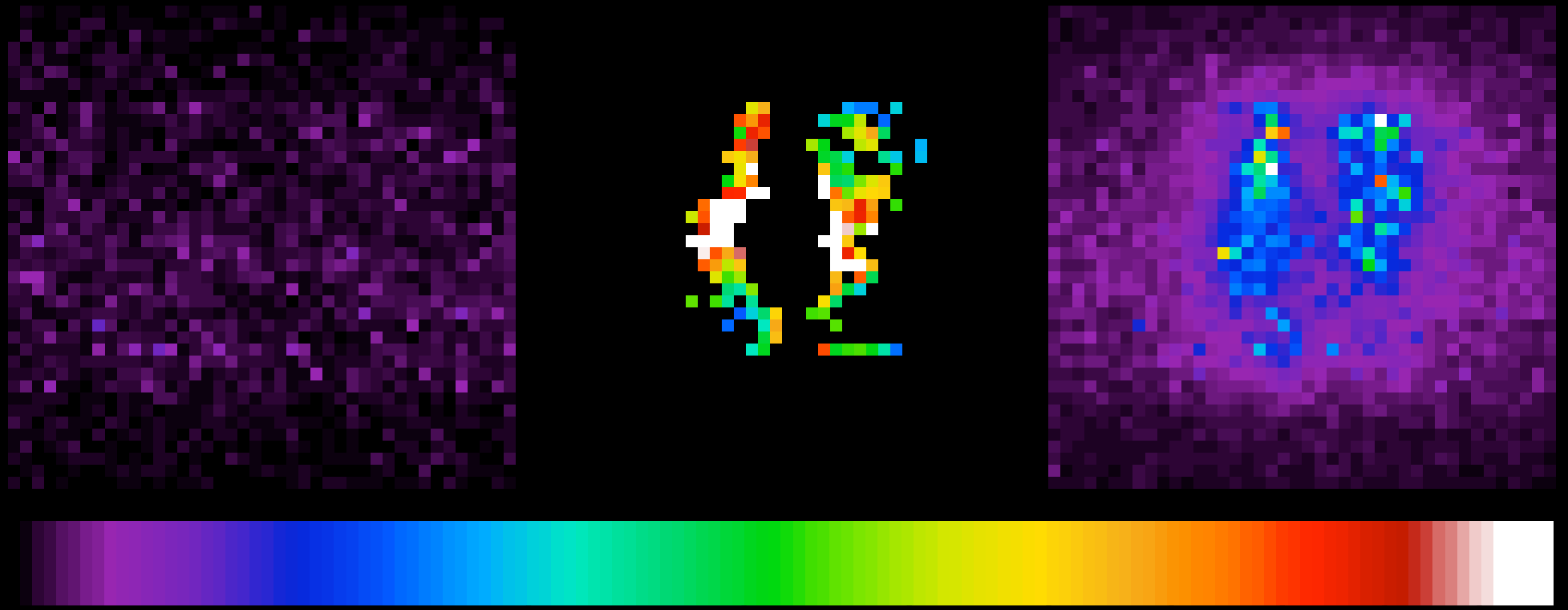
- Started out together (Kepler, LaPlace, ...)
- Interesting independent methods, i.e. MC
- BUT ISOLATED: "Astronomers and Physicists know a few methods (Chi-Square, FFT, KS....) and use it for EVERYTHING"
- All assumes Gauss-Normal holds
- "Well it's not exactly *wrong*..." --- BUT sometimes it is!

# Astrostatistics with CHASC: Explicit Examples

- "But... but ... you can't do that" 1st year grad student to astrophysics community
- Hardness ratios: simple but important
- Highly Strucured Models: i.e. explicitly modeling all intrument properties
- How can you tell if this "blob" is significant at the "n sigma" level

New Ways of Seeing: Astronomy Perspective > 1980
Consciously Working Across Disciplines

- Ed Jaynes: Statistical Mechanics, Entropy, Bayesian Methods (Bretthorst, Bijaoui, Loredo, MaxEnt Skilling, Gull, ... Strong, Diehl...)
- Feigelson and Babu: Concerted effort to bring (frequentist) statisticians and astronomers together
- Long-Term, Education, Cooperation
- Not just isolated problems, but learning to talk across cultures.



EMC2 Mean Results: Null vs Interesting

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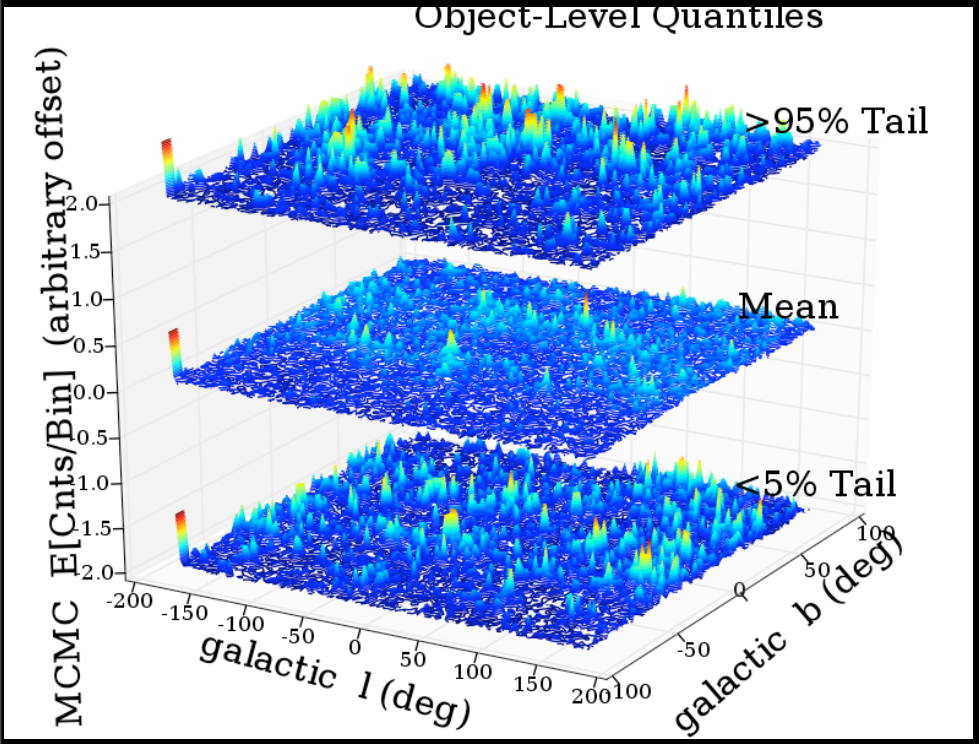
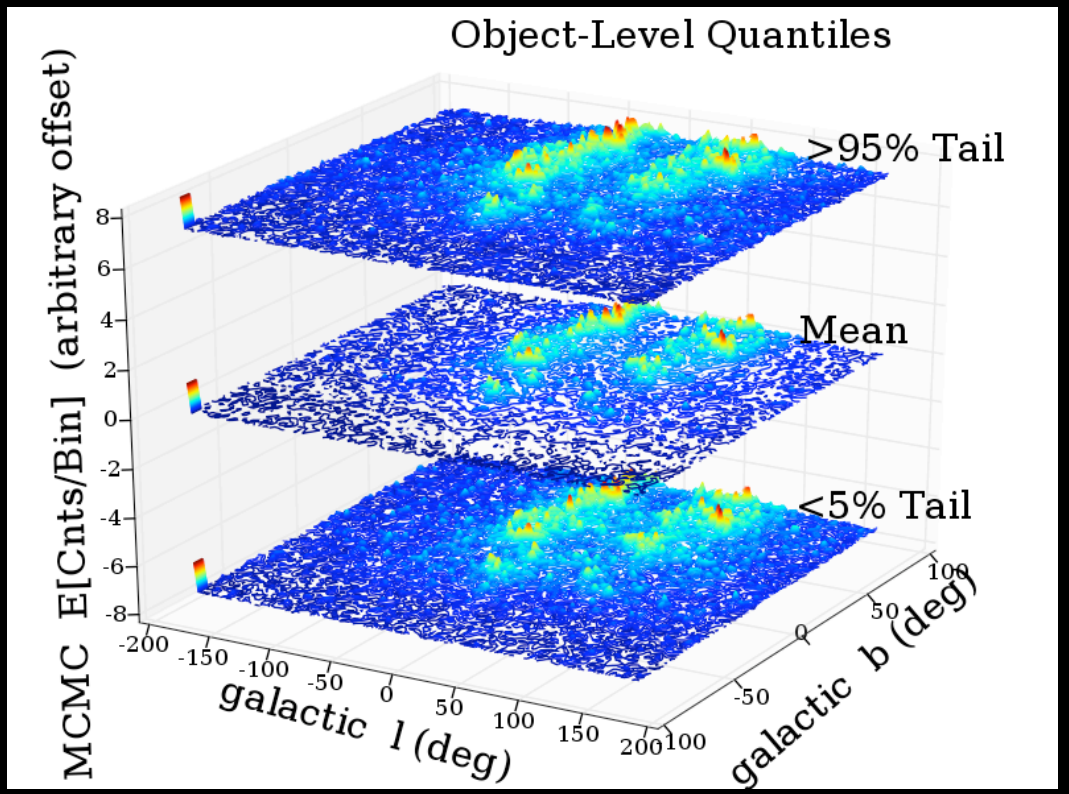
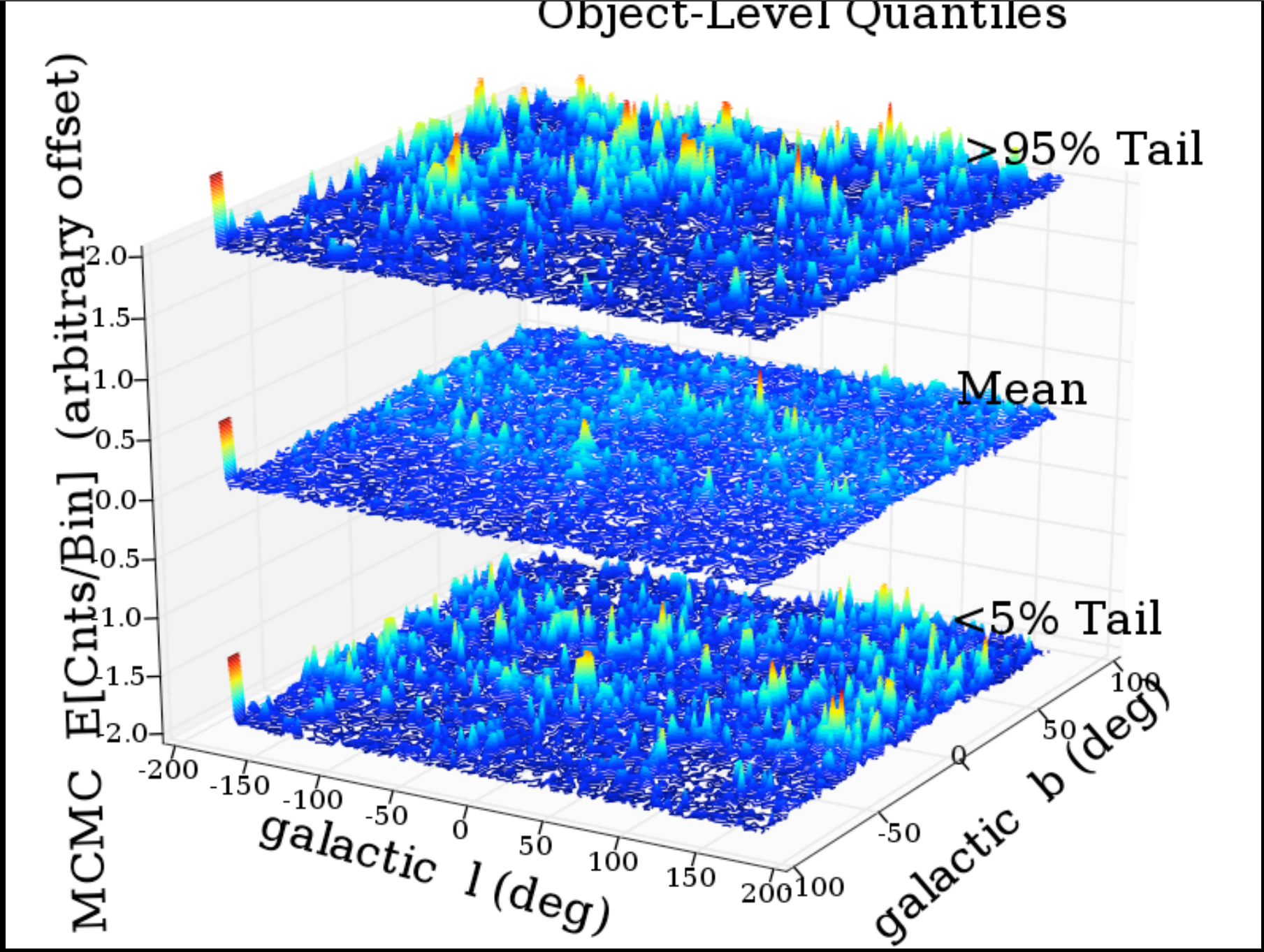
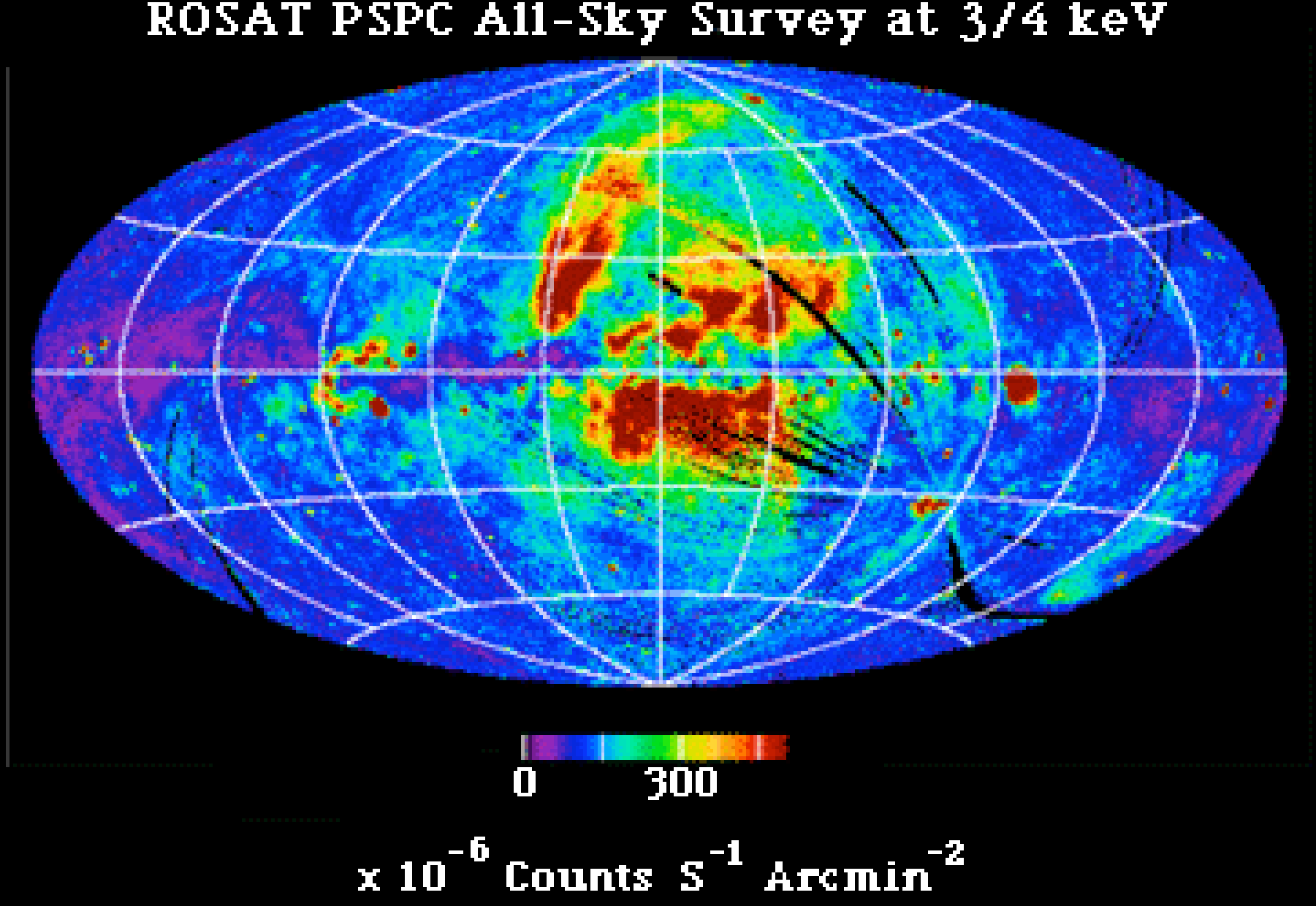



# Null vs 'Interesting' Data: Object Level Quantiles


Object-Level Quantiles
>95% Tail
Mean
<5% Tail
MCMC E[Cnts/Bin] (arbitrary offset)
2.0
1.5
1.0
0.5
0.0
0.5
1.0
1.5
2.0
-200
-150
-100
-50
0
50
100
150
200
galactic l (deg)
100
50
0
-50
100
galactic b (deg)

Null




Soft X-Ray/Extreme Ultraviolet Sky (local "warm fuzz" around our solar system: glowing warm gas) Snowden 1995