Observing the EoR with the MWA

Colin J. Lonsdale

MIT Haystack Observatory

For the MWA Collaboration

The Collaboration

The Collaboration

- Massachusetts Institute of Technology
  - Haystack Observatory (Project Office)
  - Kavli Institute

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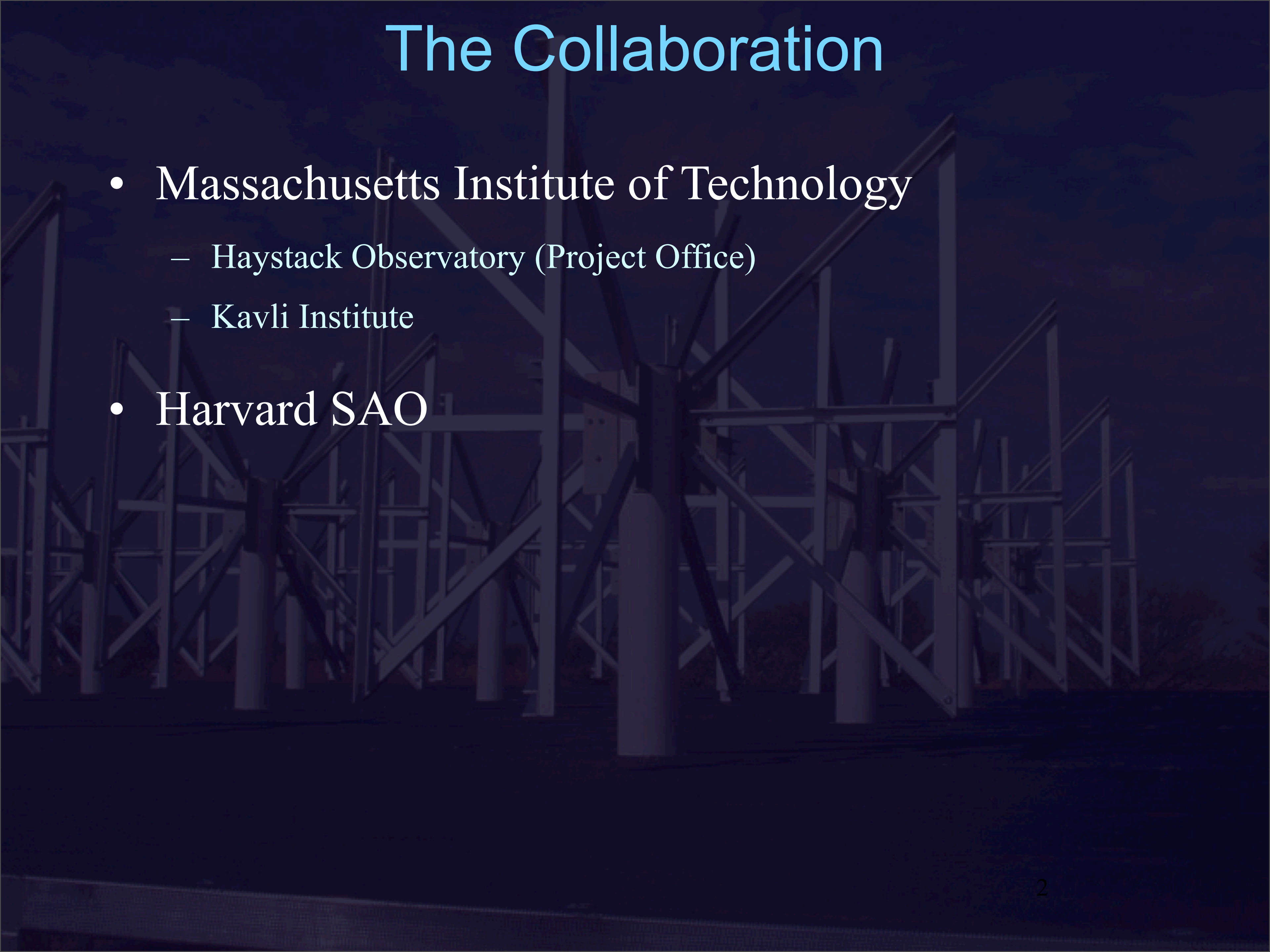

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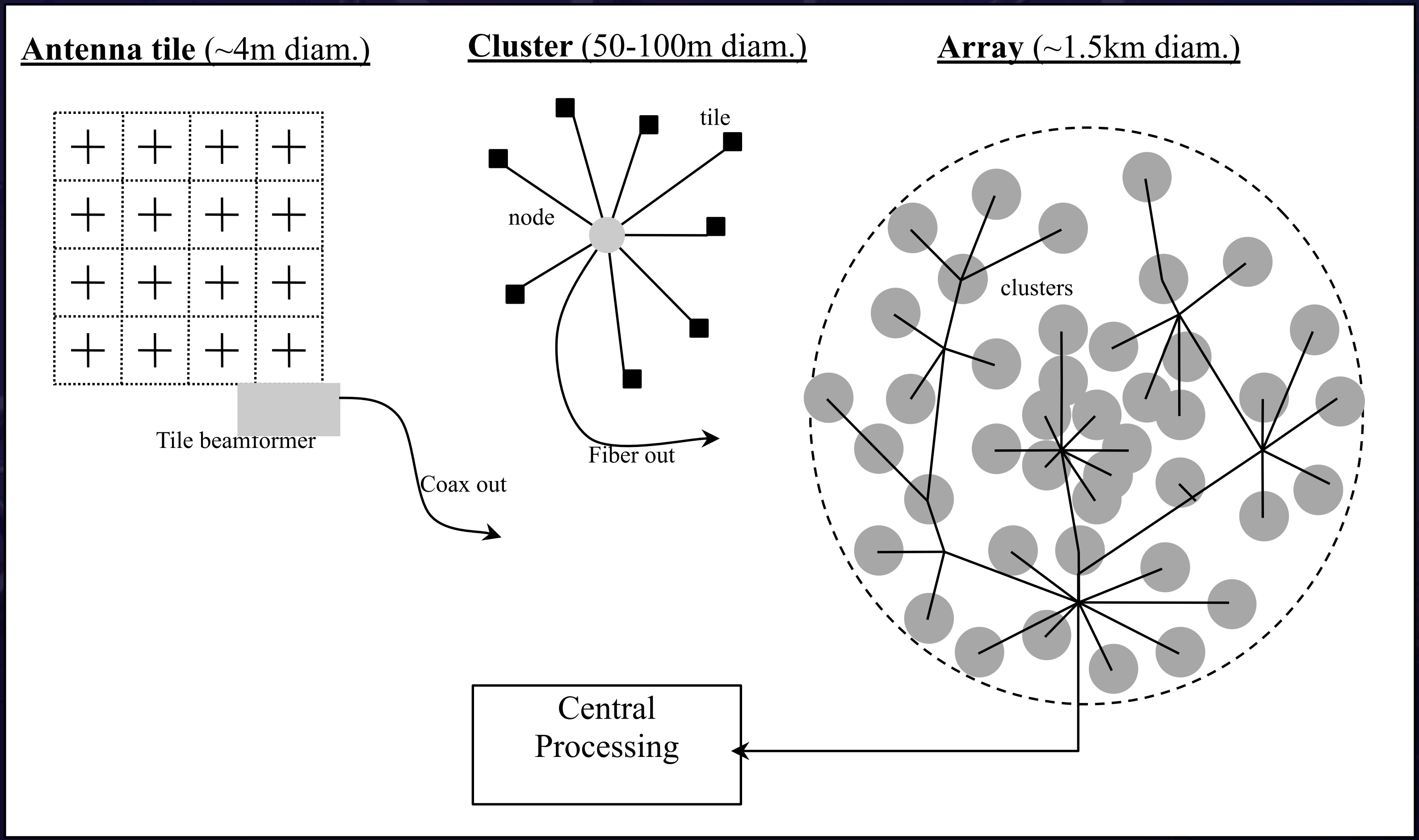
- Sydney, Tasmania, UWA, and others, ...
- Raman Research Institute, India

What is the MWA?

A wide-field, low-frequency imaging array

- Optimized for wide FOV, high survey speed
- Frequency range 80-300 MHz
- Three key science goals
  - Epoch of Reionization
  - Solar, Heliospheric and Ionospheric
  - Radio Transients
- Designed to exploit RFI-quiet site in Western Australia

Physical Layout



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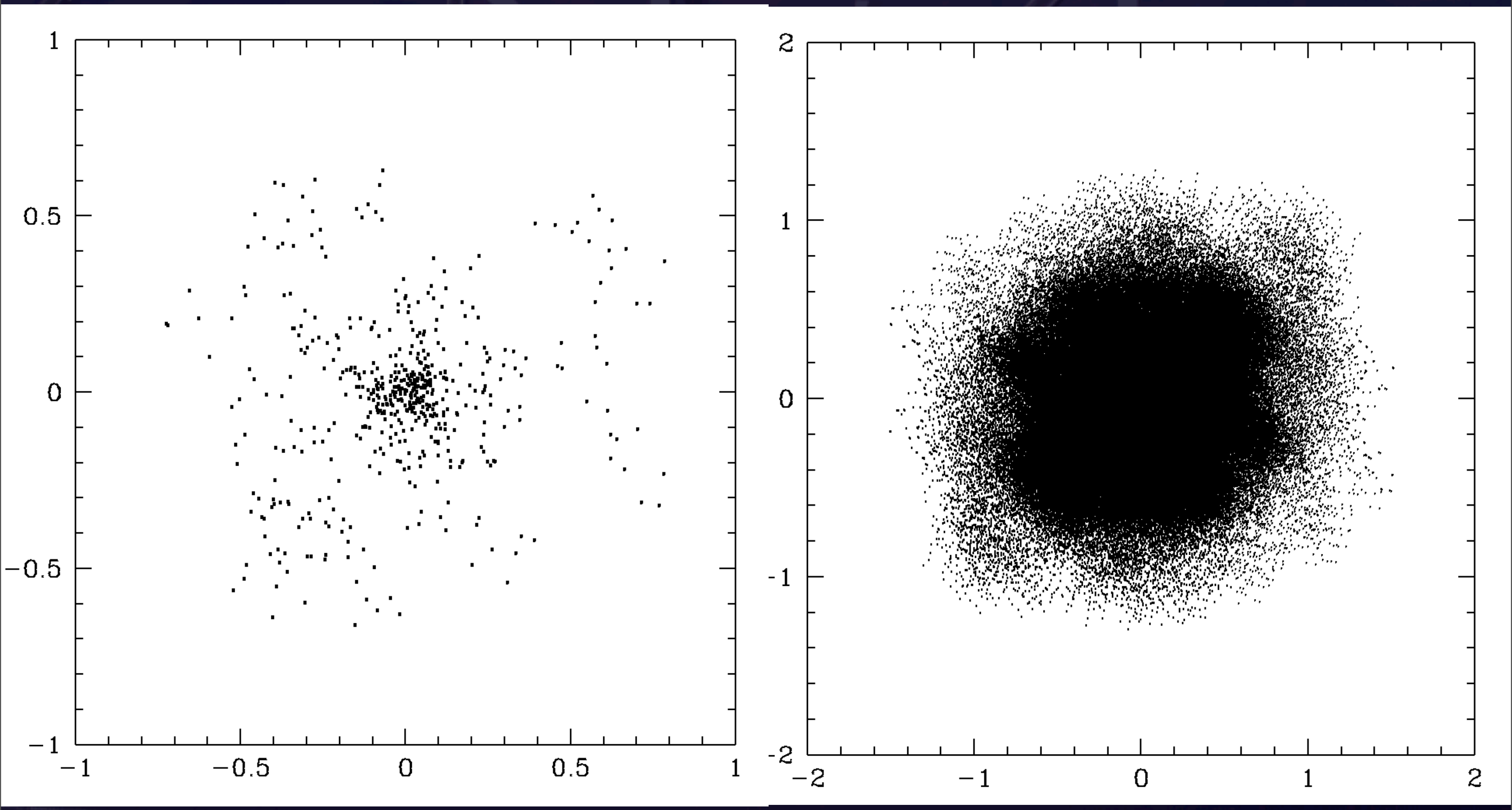
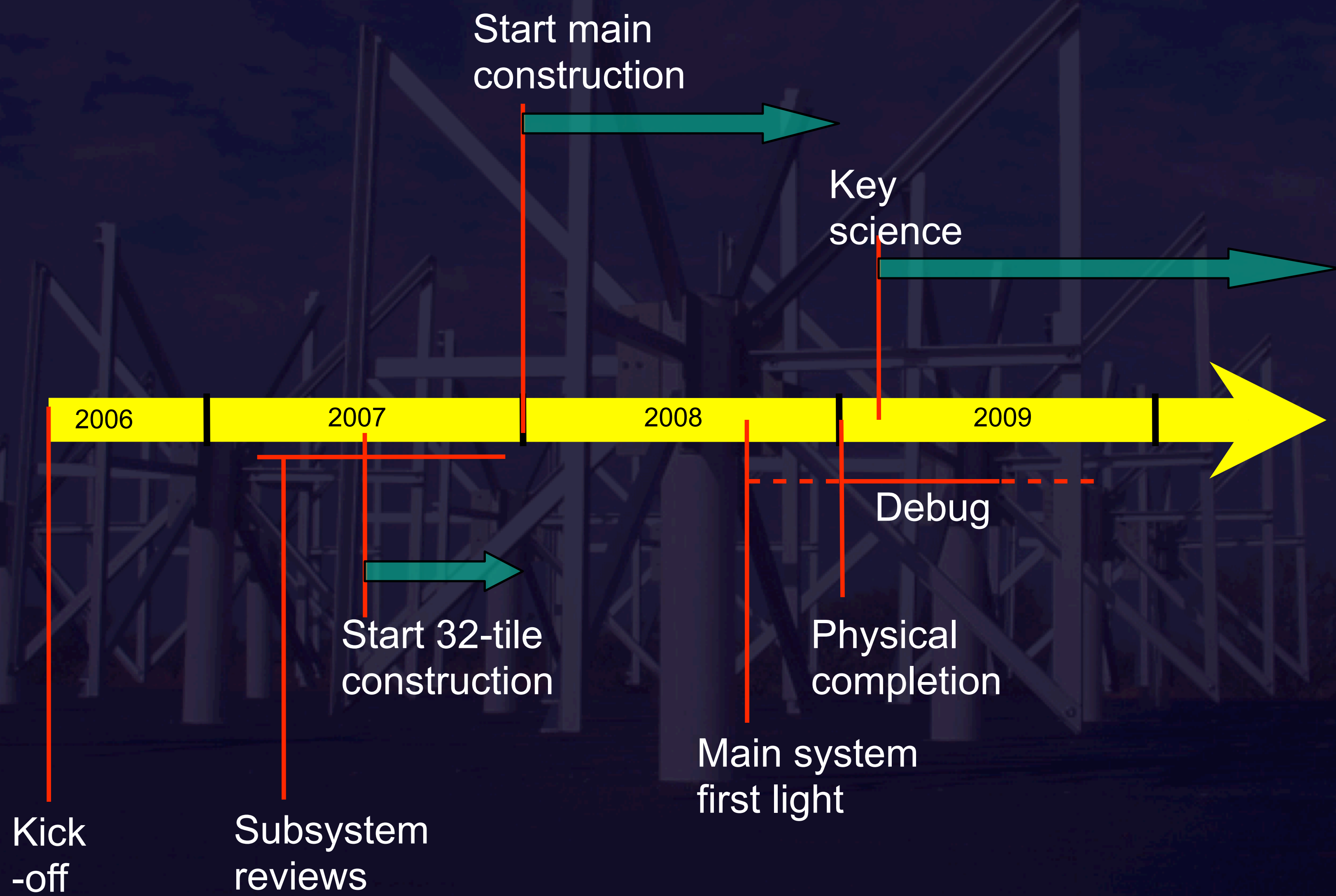


Schedule Outline



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  - Prioritized science
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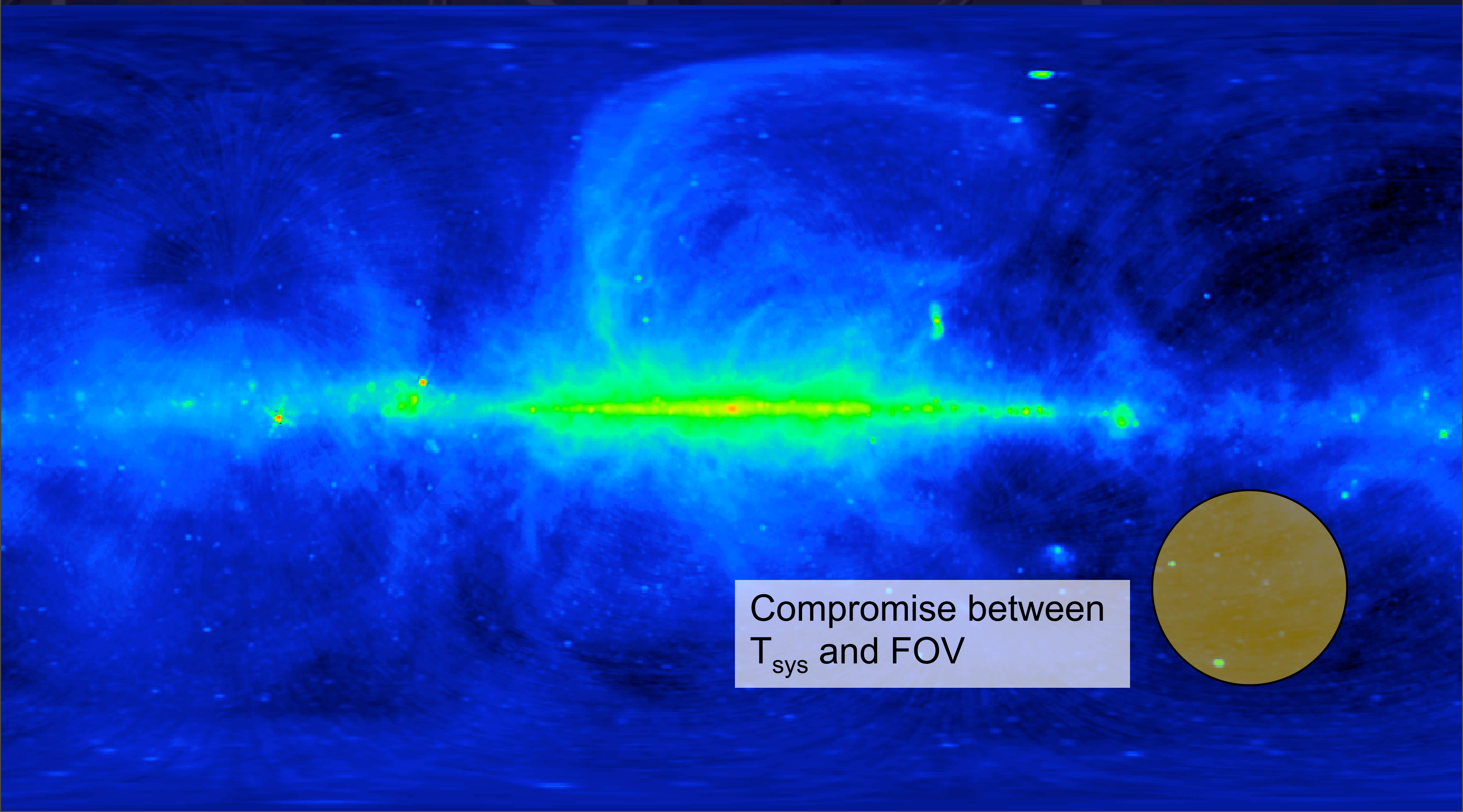

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- 500 Tiles
  - Enough to do key science well
  - Enough to generate superb PSF
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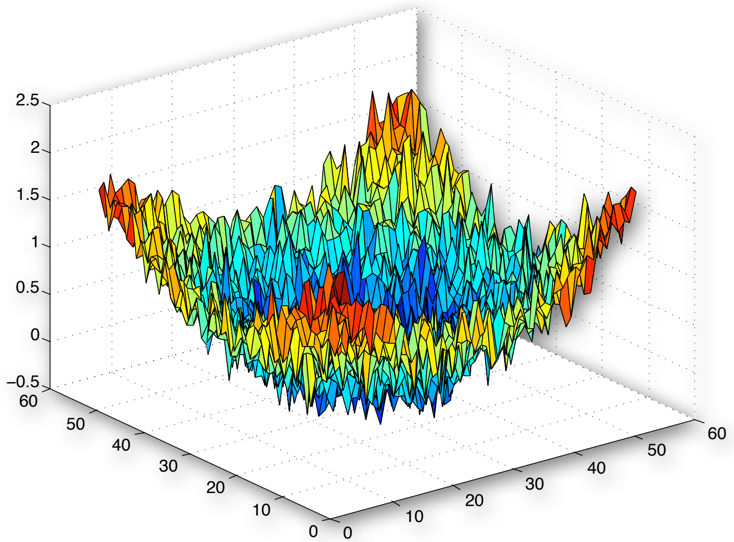
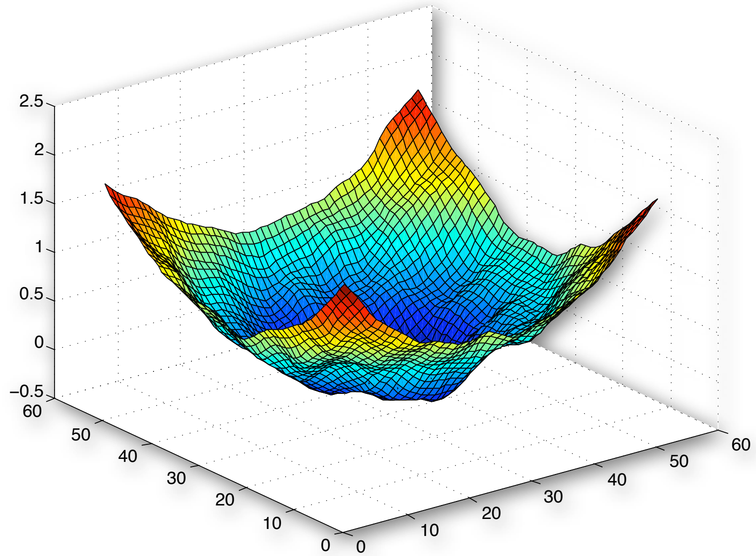
  - Enough to see lots of calibrators
- Full Cross-correlation
  - Many advantages, technological pathfinder

Systematics

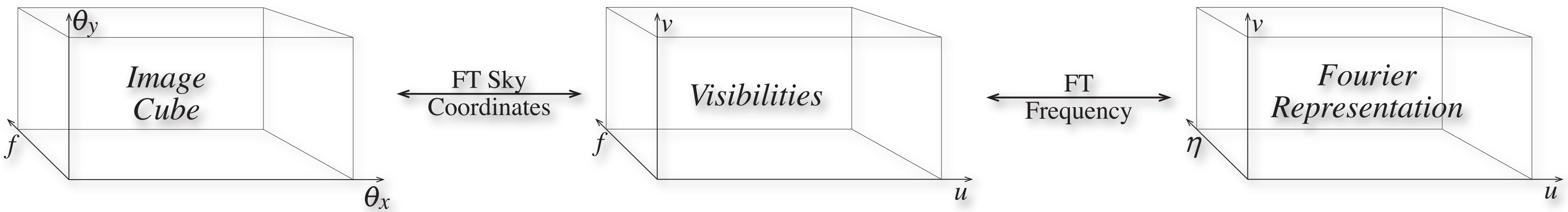
What we know about fitting algorithms is goodness-of-fit surface quality ⇒robustness

- Excellent instantaneous point spread function
- Data-rich observations & computation



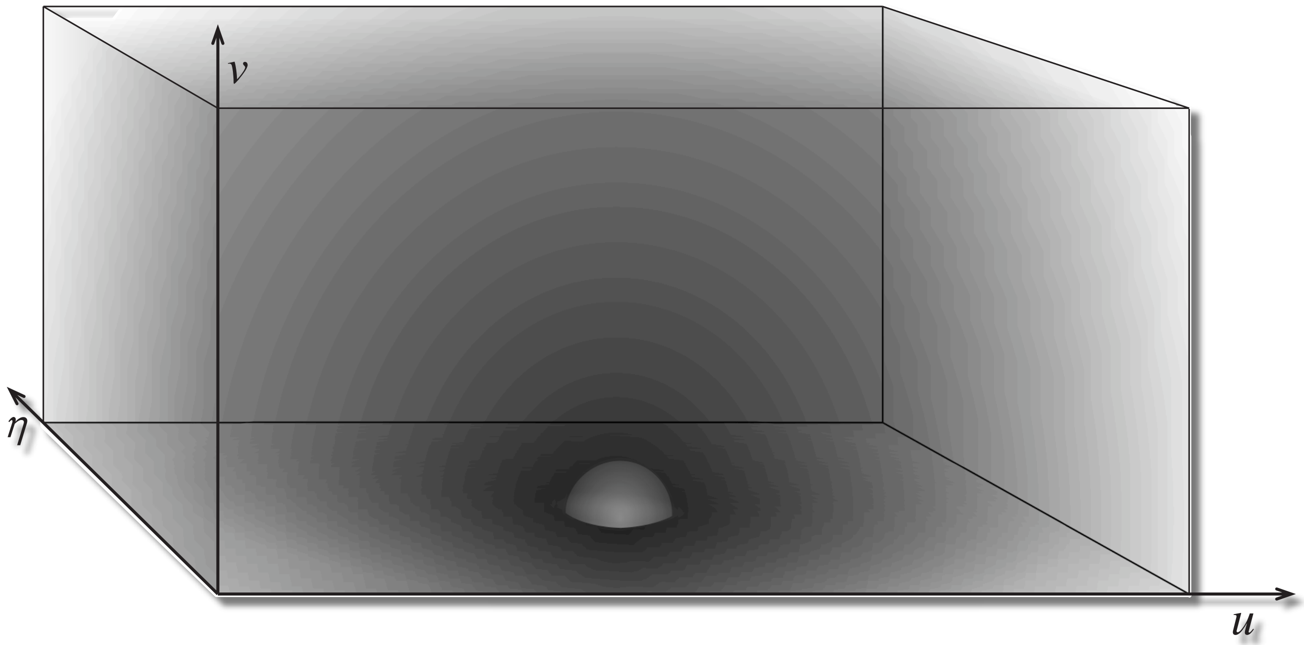


Statistical EOR detection



Morales & Hewitt (2004)

Spherical symmetry

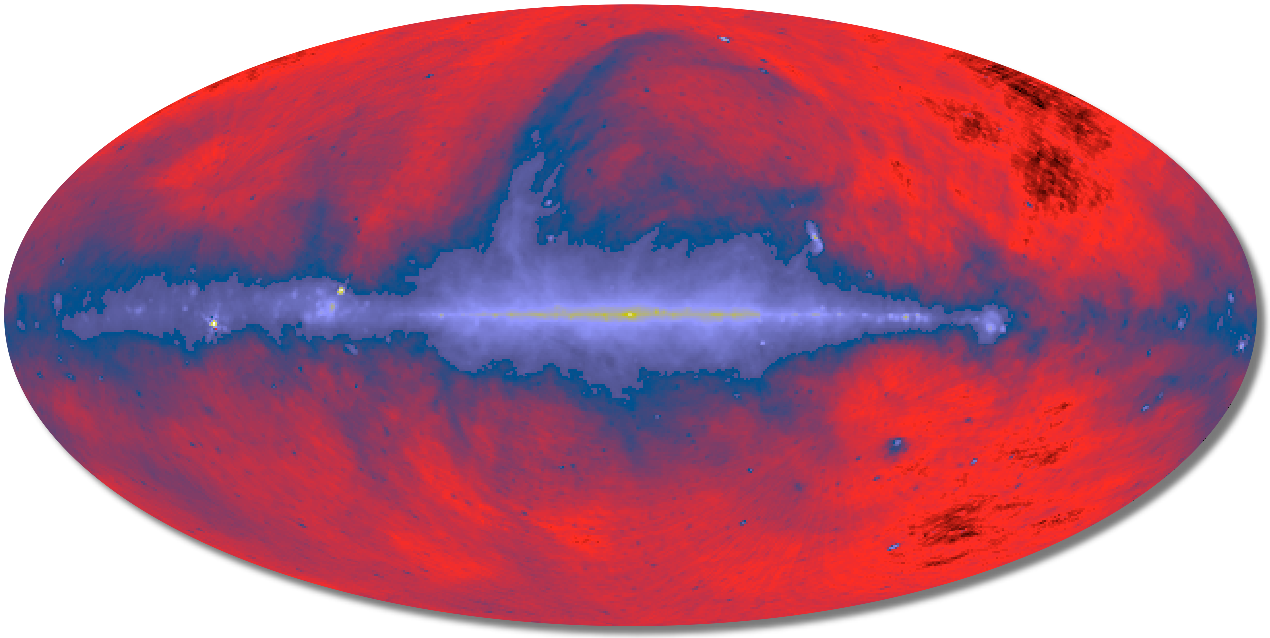


Morales & Hewitt (2004)

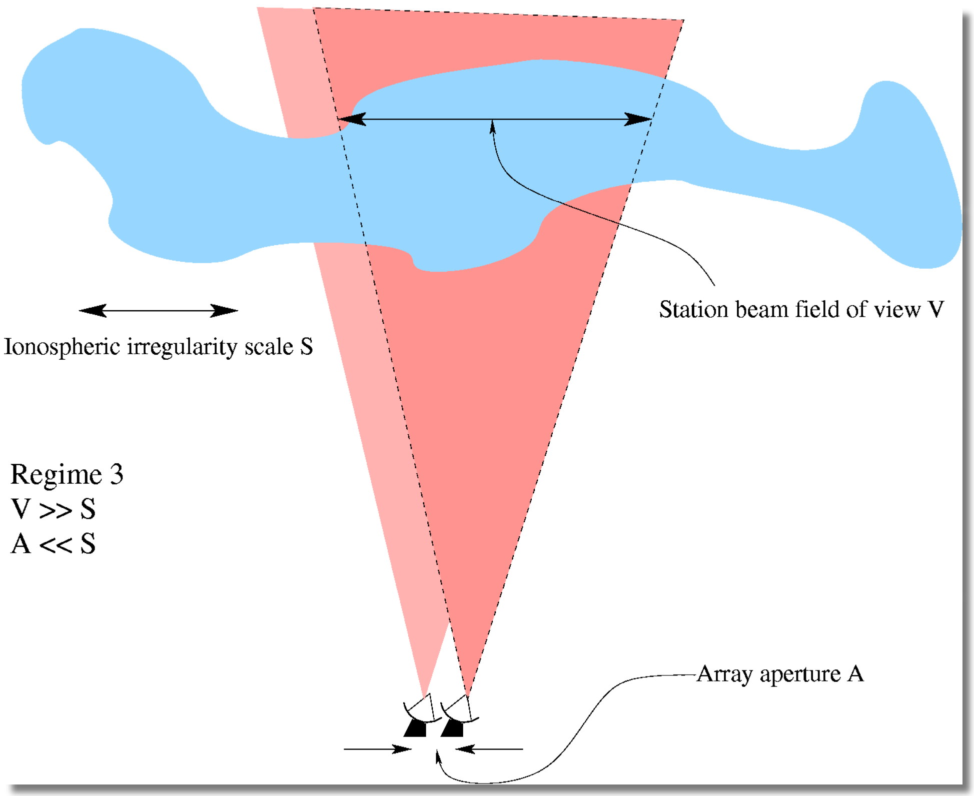
For understanding foreground, instrumental effects, this is useful space to work in

Foregrounds

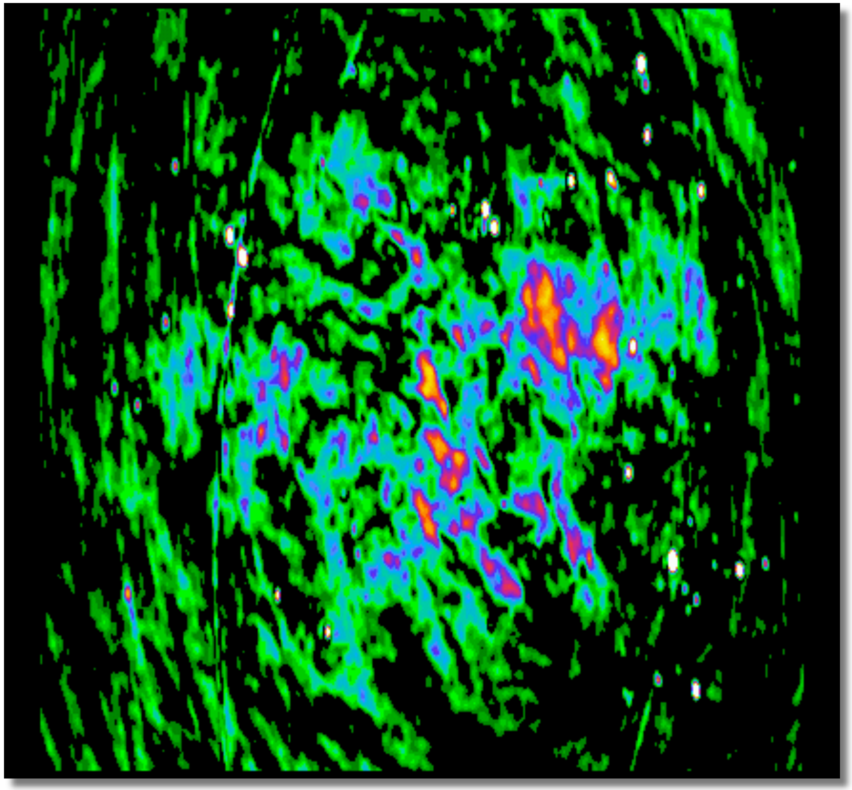
- Faint point sources
- Smooth galactic emission
- Galactic radio recombination lines
- RFI
- Others!



Ionosphere & Polarization



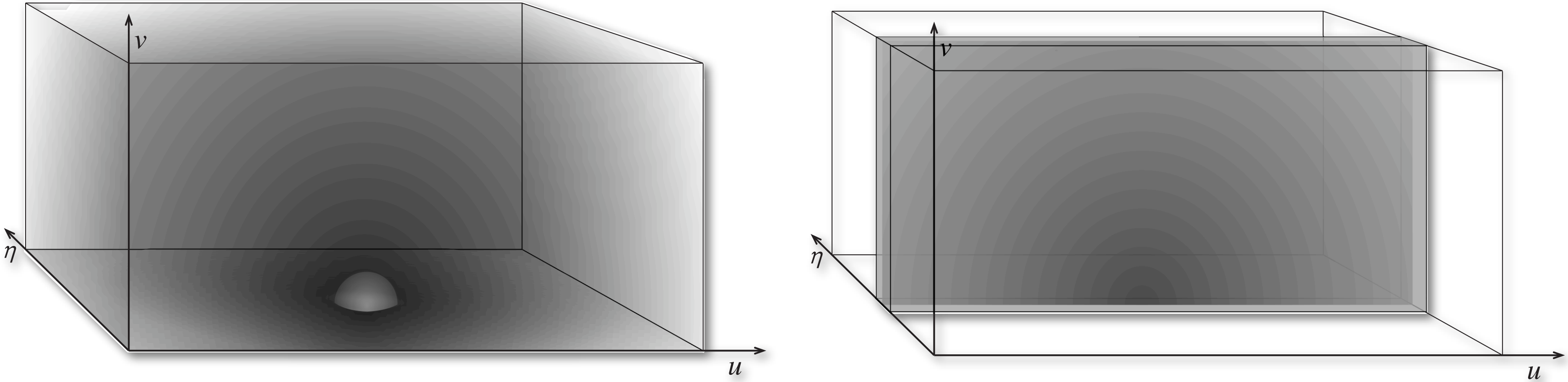
Lonsdale (2004)



325 MHz polarized flux, 6° x 6°,
4’ beam, 5 K peaks (de Bruyn)

Parameter fitting

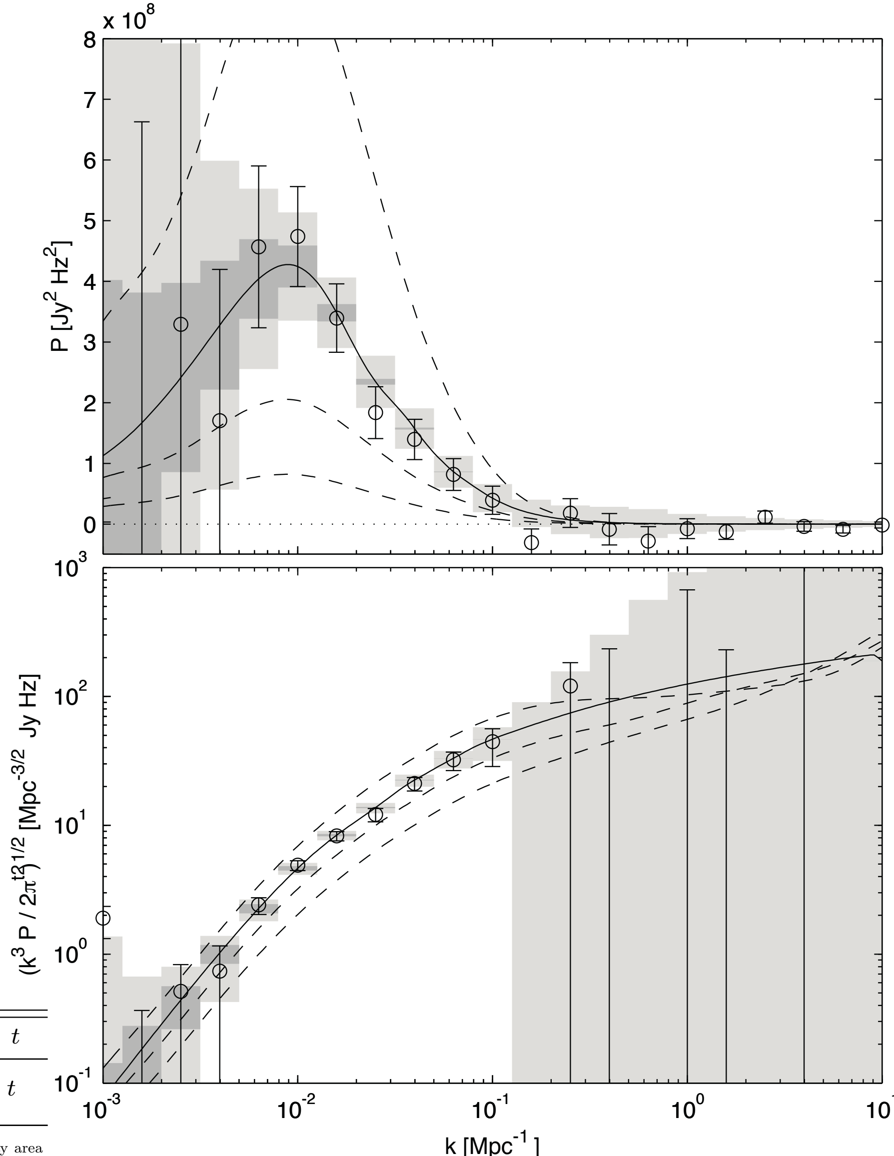
- Use templates to separate EOR signal from residual foreground subtraction errors
- Fit both local parameters & their ensemble errors



Morales, Bowman & Hewitt (2006)

MWA power spectrum sensitivity

z = 8, 360 hours of integration



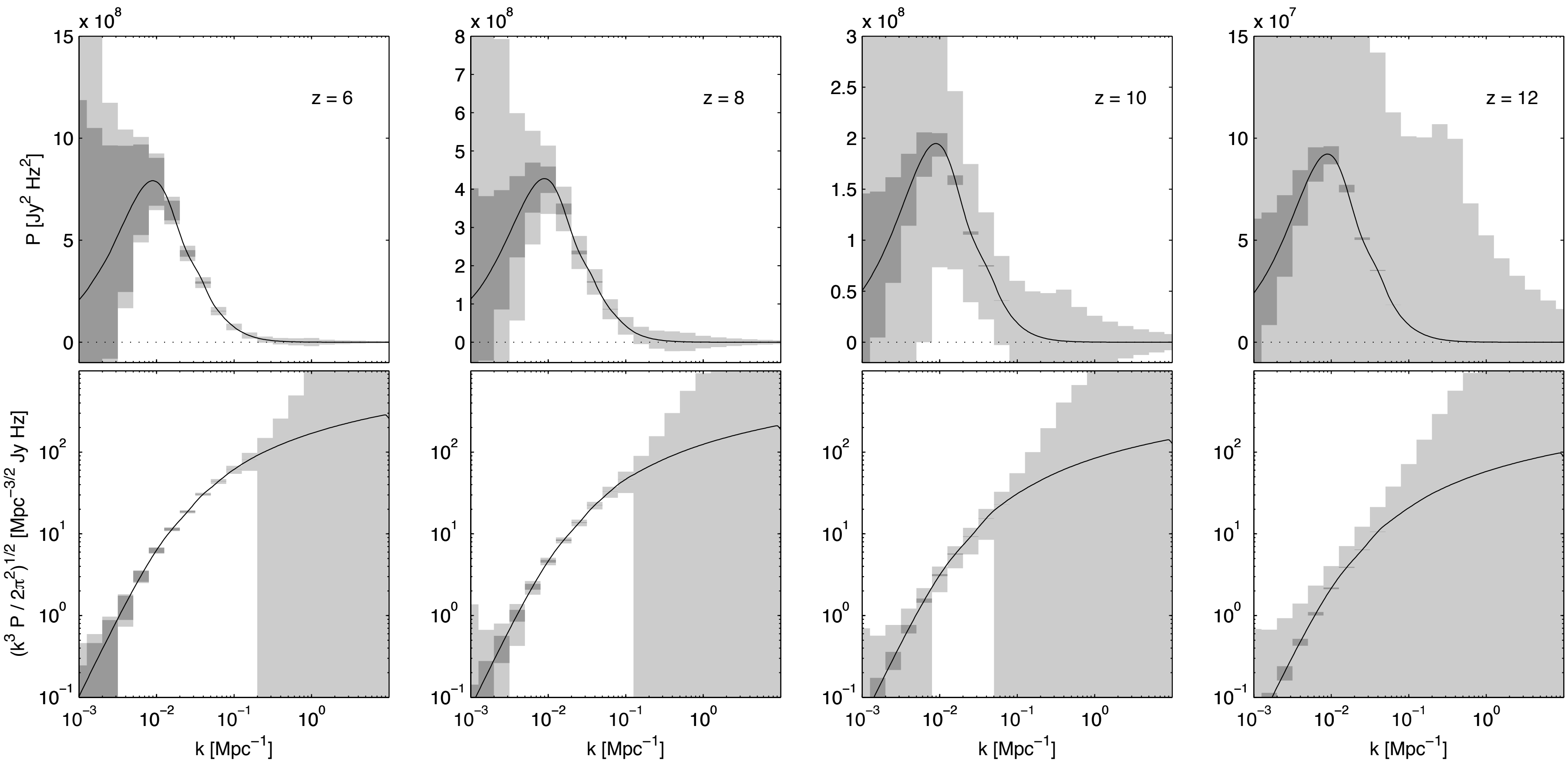
Bowman, Morales & Hewitt (2005)
Furlanetto, Zaldarriaga, Hernquist (2004a,b)
Kaplinghat (2005)

TABLE 1.

	$A_t\|_{dA}$	$A_t\|_{N_A}$	$dA\|_{A_t}$	B	$\|\mathbf{u}\|$	t
Power Spectrum S/N	A_t^2	$A_t^{3/2}$	$(dA)^{-1/2} \propto$ FOV	$B^{1/2}$	$\|\mathbf{u}\|\,\bar{n}(\|\mathbf{u}\|)$	t

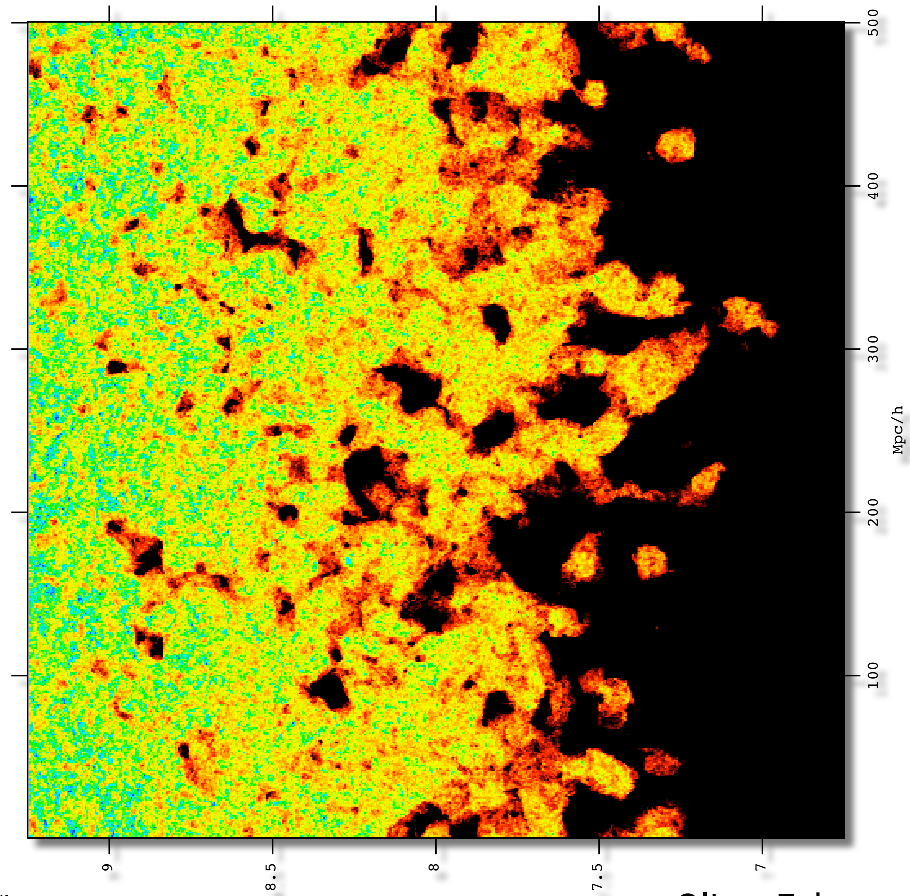
NOTE. — This table lists the scaling relationships of the key equations. In order, the variables in each column are: total array area holding the size of each antenna constant $A_t|_{dA}$ (adding antennas), total array area holding the number of antennas and distribution constant $A_t|_{N_A}$ (increasing antenna size), the size of each antenna with the total array area held constant $dA|_{A_t}$ (dividing area into more small antennas), the total bandwidth B, the sensitivity as a function of wavenumber length $|\mathbf{u}|$, and the total observing time t.

MWA sensitivity vs. redshift



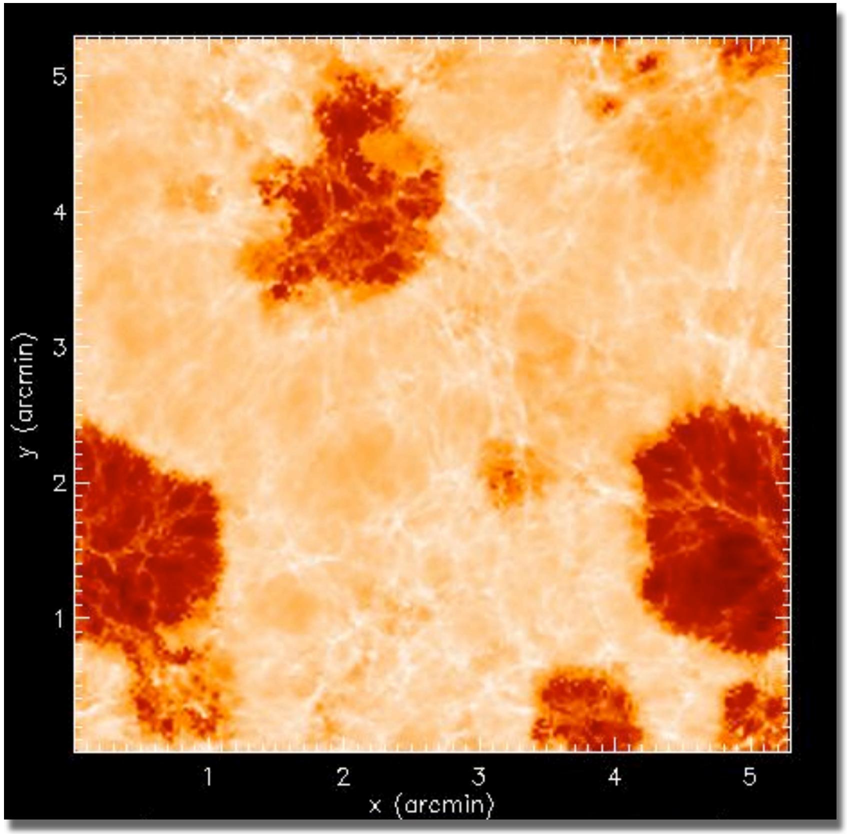
Bowman, Morales & Hewitt (2005)

The Target

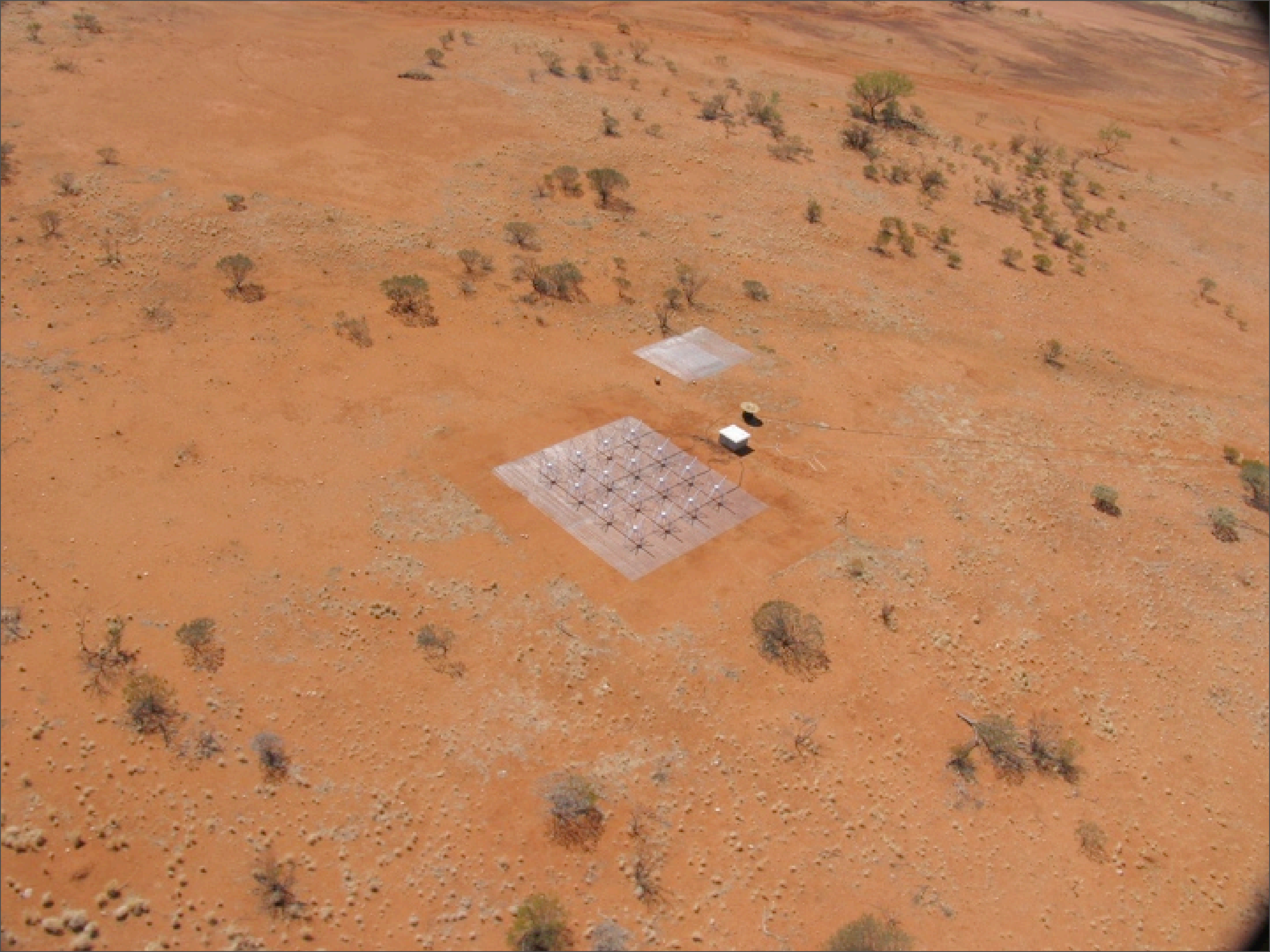


Oliver Zahn

z=9 8 7

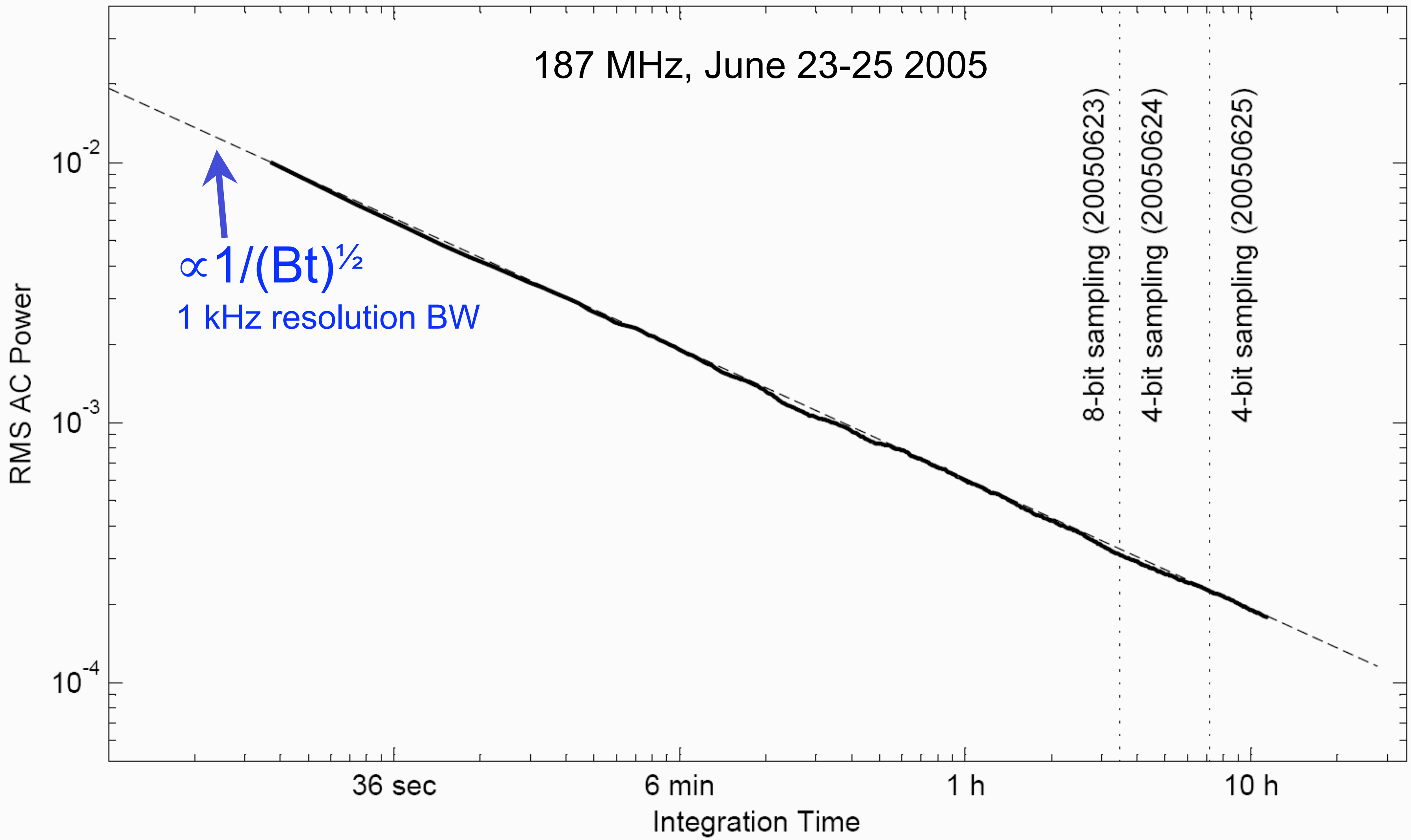


Sokasian, Furlanetto, Hernquist




D2

Deep Integration



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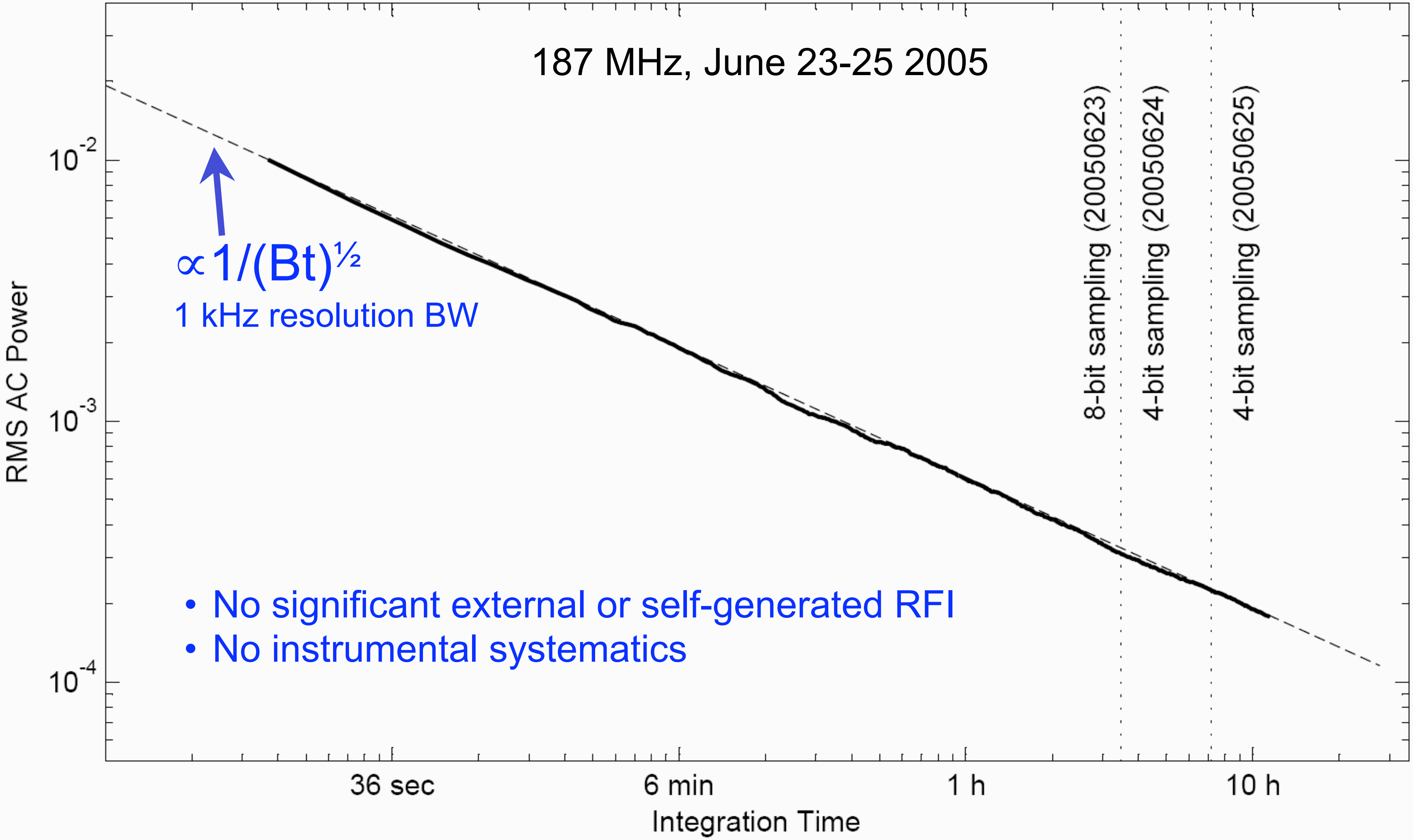
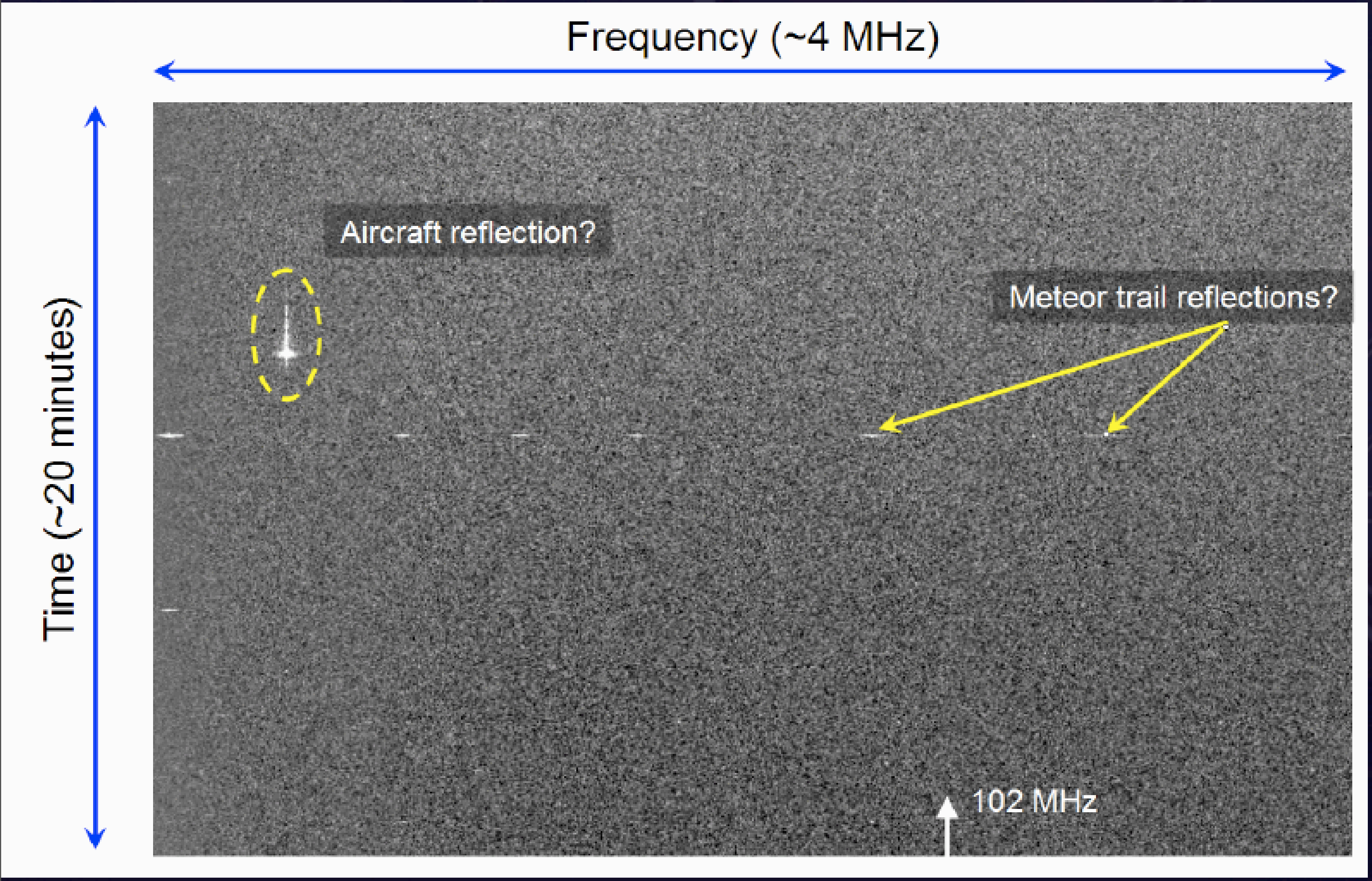


- No significant external or self-generated RFI
- No instrumental systematics

Instances of RFI



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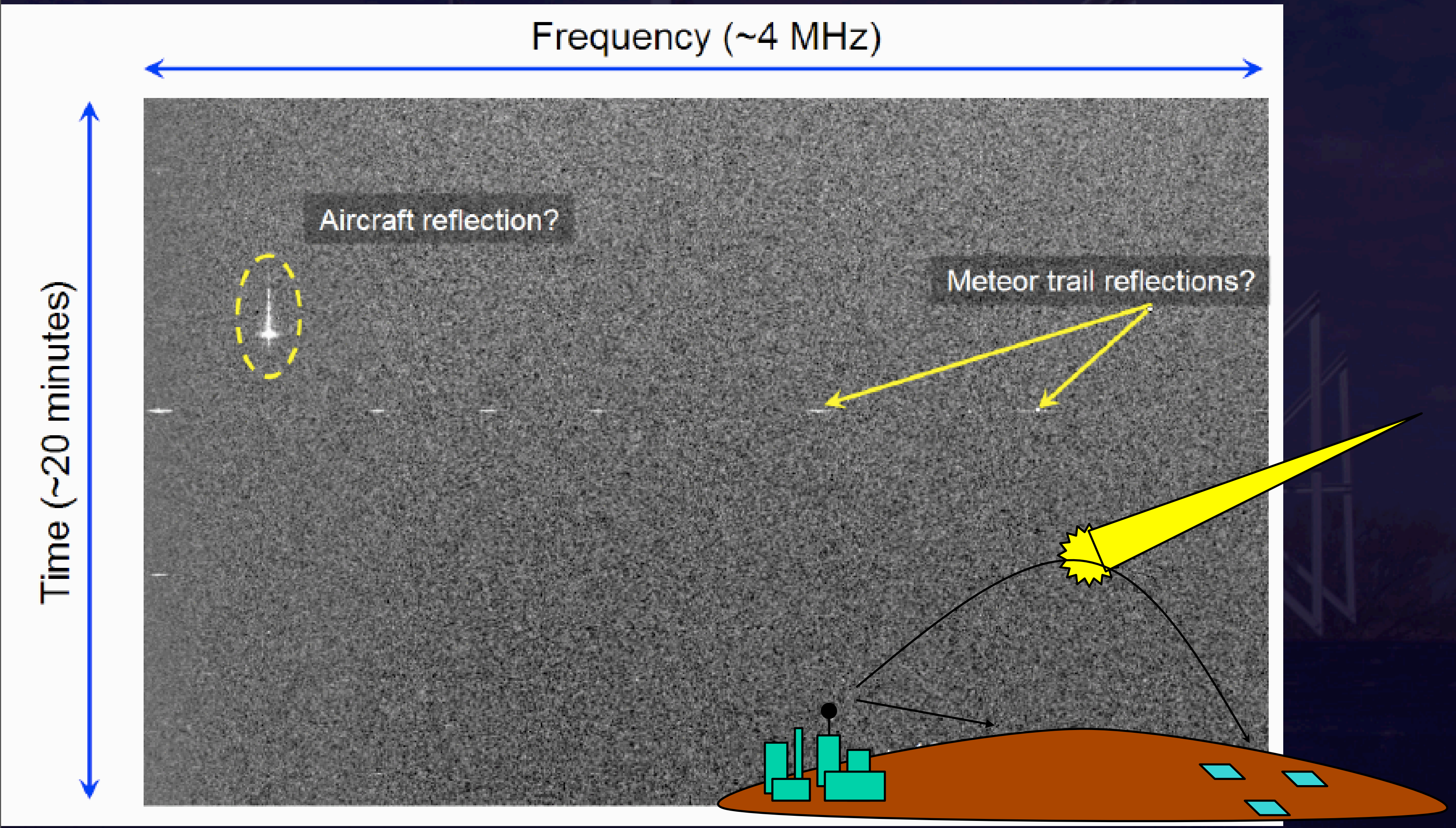
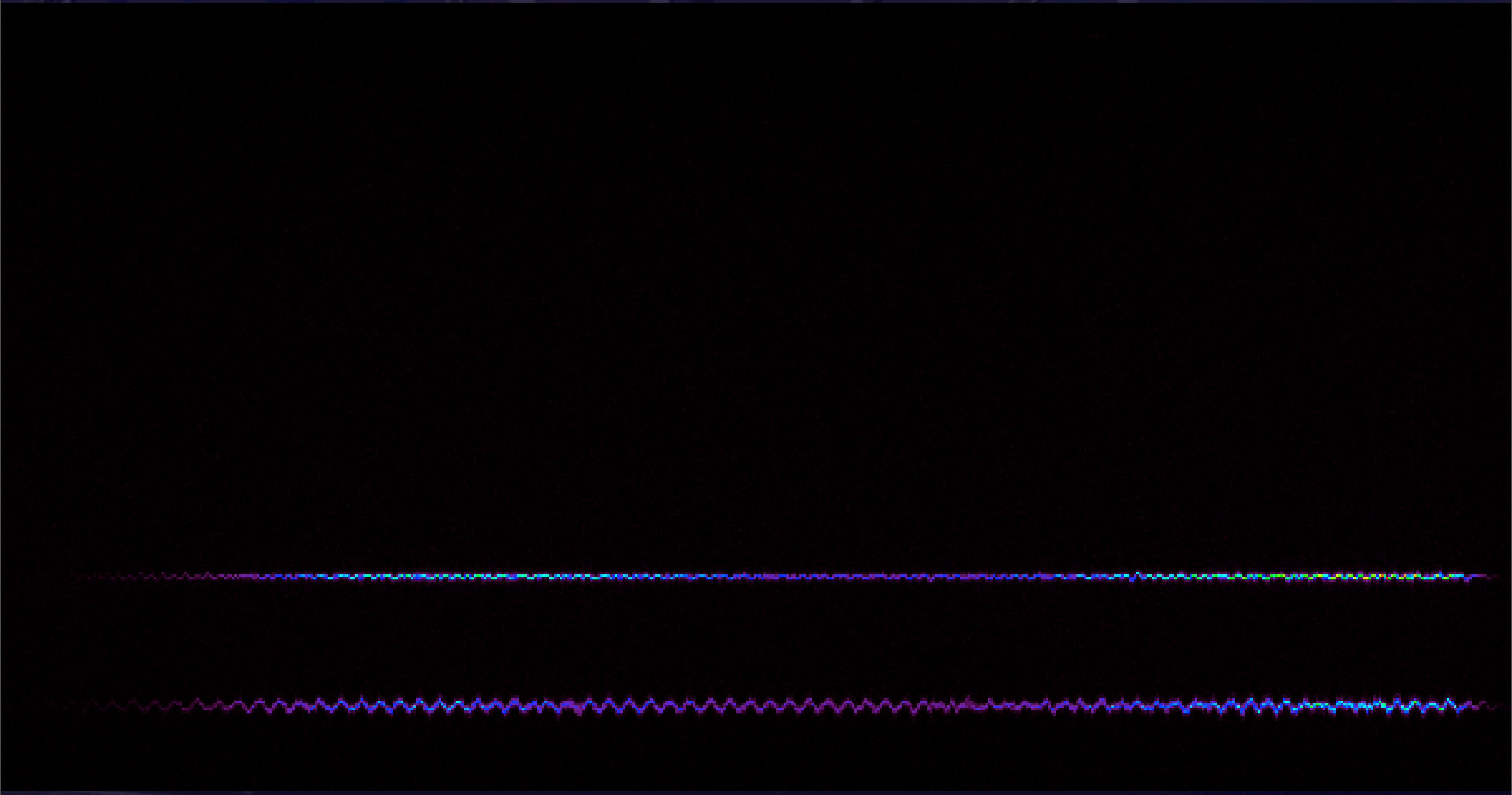


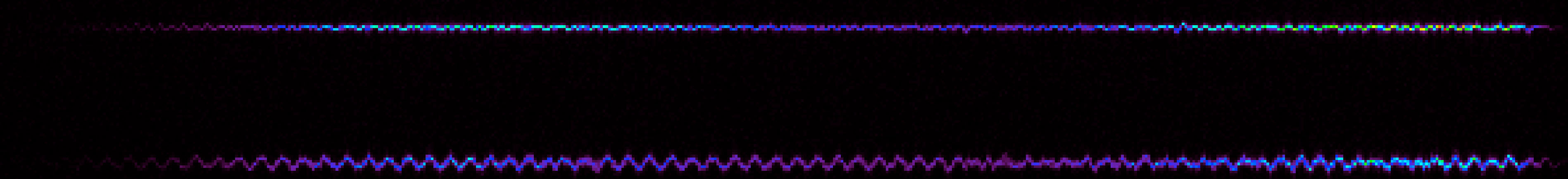
Heavenly music



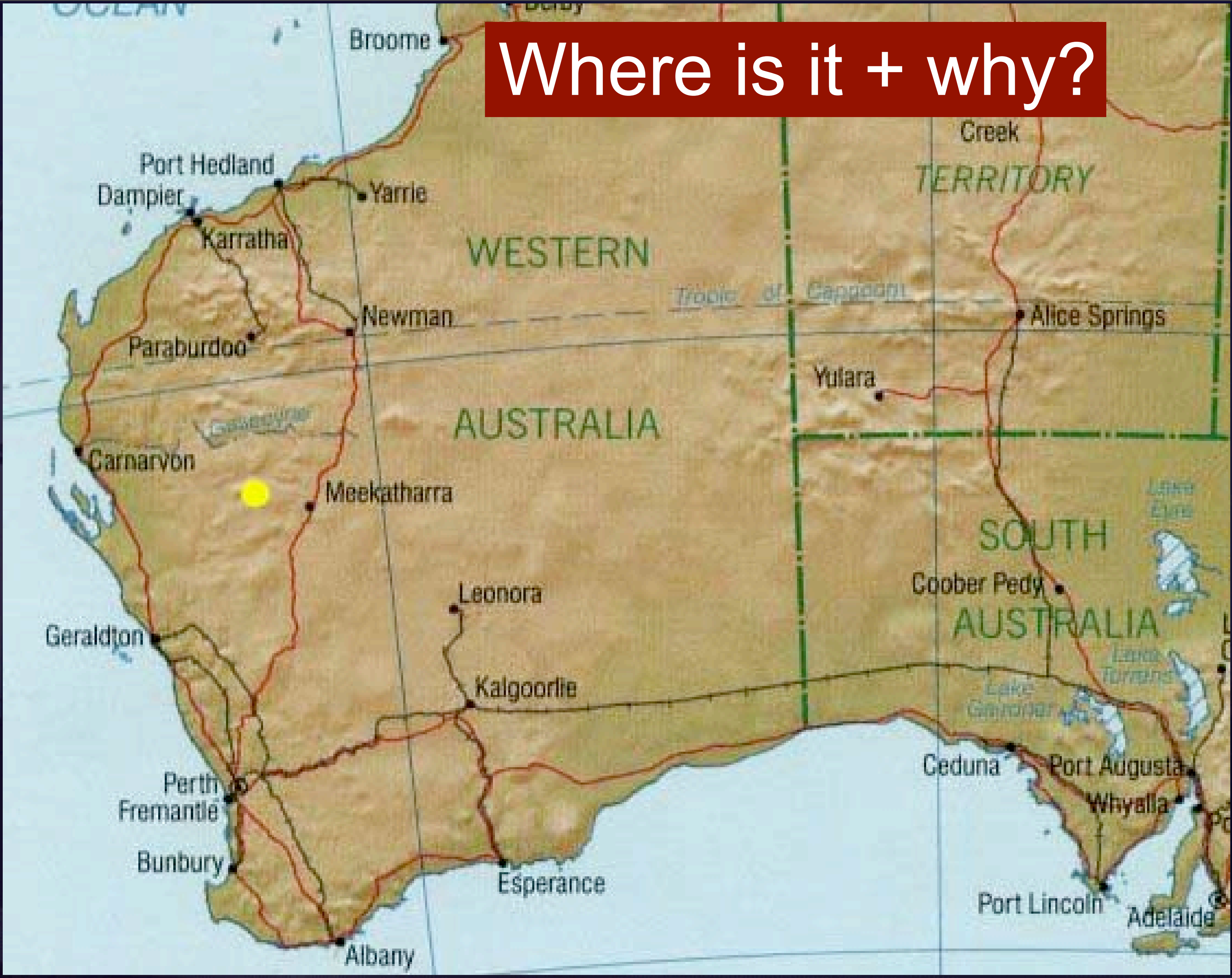
Heavenly music

Detected loud and clear in 1 msec, 1 kHz by 1 tile

We will integrate our signals for ~3×10^9 msec
with 500 tiles and 10^4 kHz



Where is it + why?



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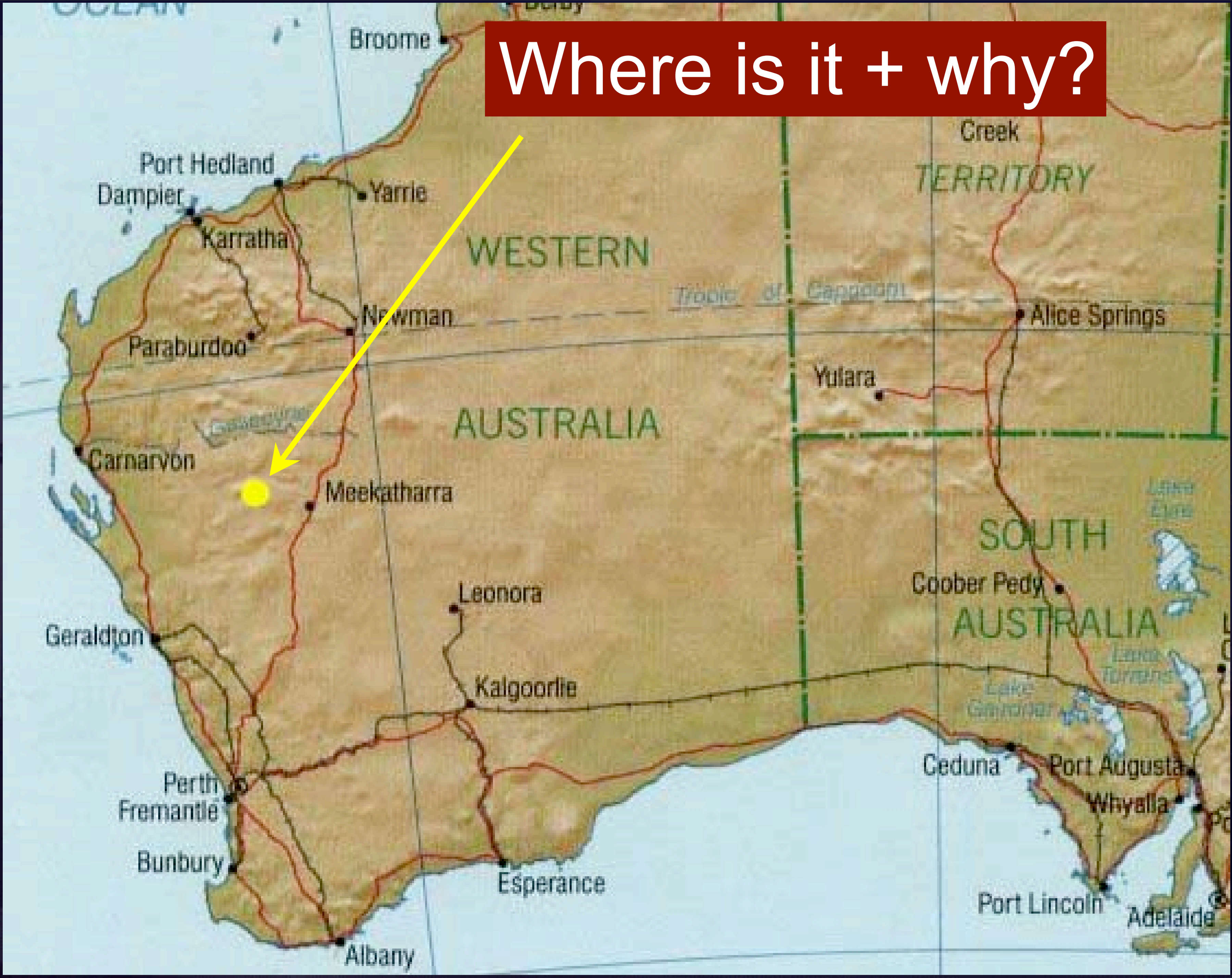

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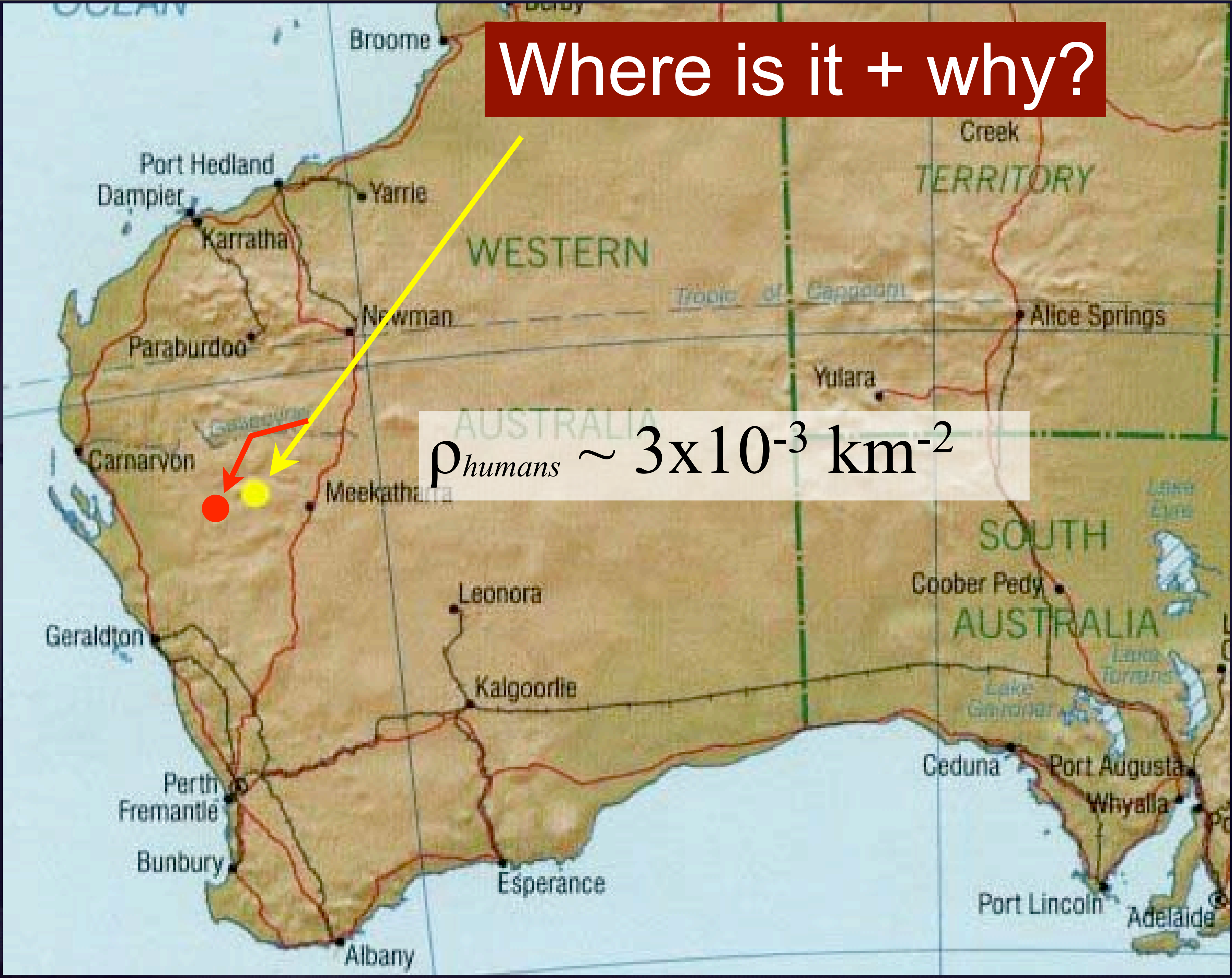
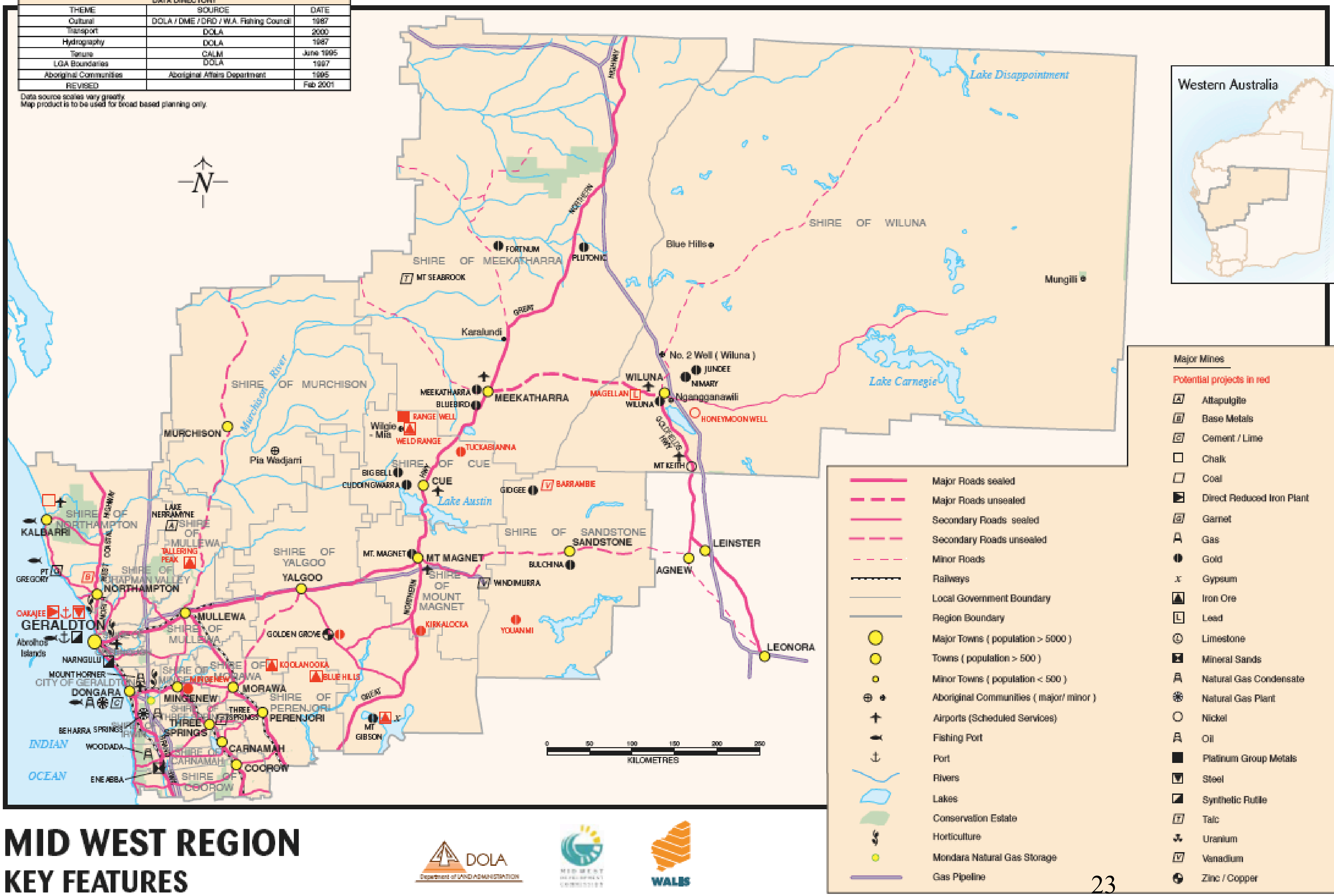


$\rho_{humans} \sim 3\text{x}10^{-3}\ \text{km}^{-2}$

DATA DIRECTORY		
THEME	SOURCE	DATE
Cultural	DOLA / DME / DRD / W.A. Fishing Council	1987
Transport	DOLA	2000
Hydrography	DOLA	1987
Tenure	CALM	June 1995
LGA Boundaries	DOLA	1997
Aboriginal Communities	Aboriginal Affairs Department	1995
REVISED		Feb 2001

Data source scales vary greatly.
Map product is to be used for broad based planning only.



MID WEST REGION
KEY FEATURES

DOLA
Department of LAND ADMINISTRATION
WALIS

MT SEABROOK
GREAT
Karalundi
Jack Hills
SHIRE OF MURCHISON
Murchison River
MEEKATHARRA
MEEKATH
BLUEBIRD
RANGE WELL
Wilgie - Mia
WELD RANGE
MURCHISON
Pia Wadjarri
TUCKABIANNA
SHIRE OF CUE
BIG BELL
CUDDINGWARRA
CUE
HWY
GIDGEE
Lake Austin
SHIRE OF NORTHAMPTON
KALBARRI
HIGHWAY
COASTAL
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TALLERING PEAK
SHIRE OF YALGOO
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NORTHAMPTON
SHIRE OF MOUNT MAGNET
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NORTHERN
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GERALDTON
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Abrolhos Islands
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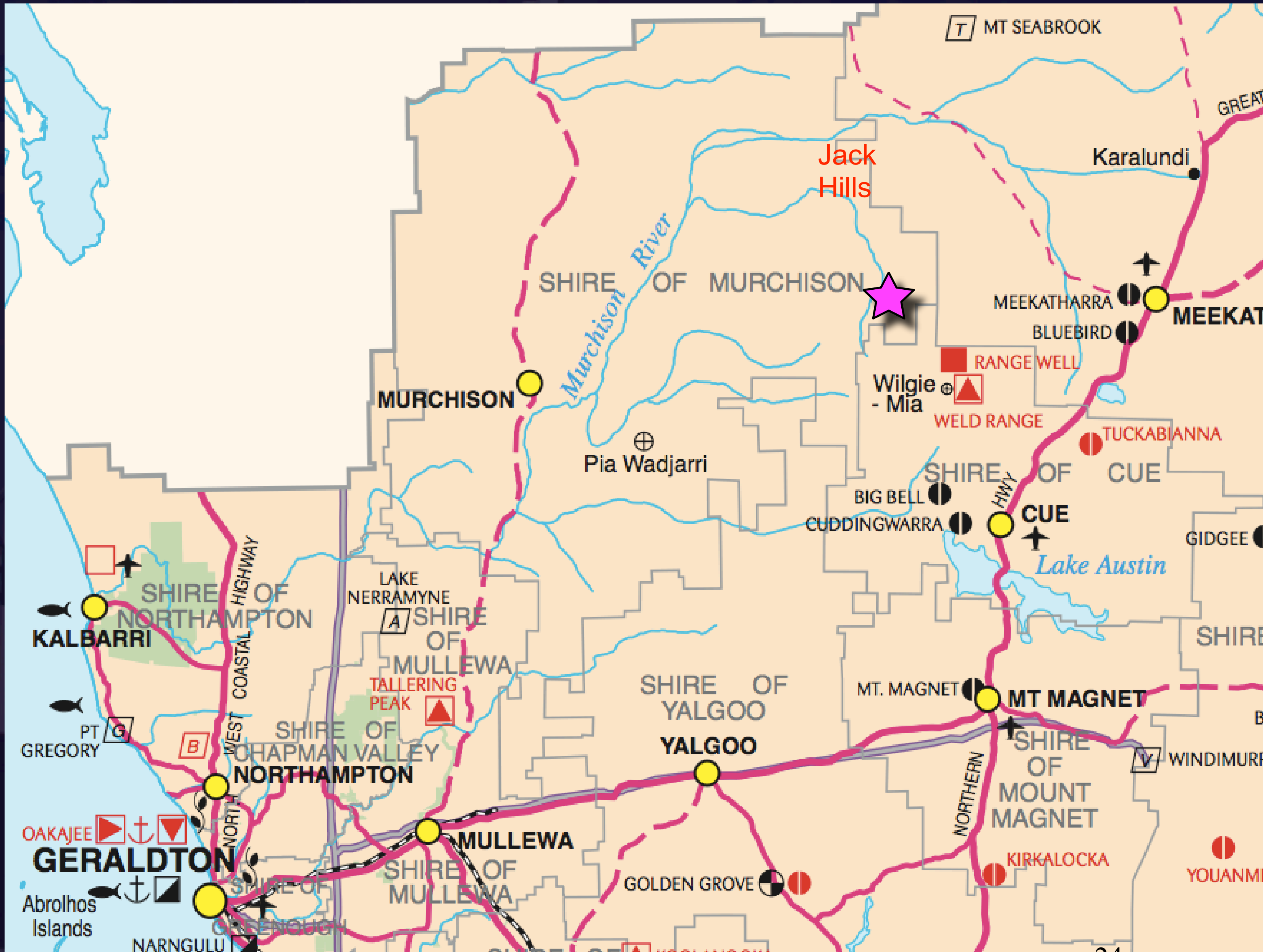
NARNGULU
KOOLANOOKA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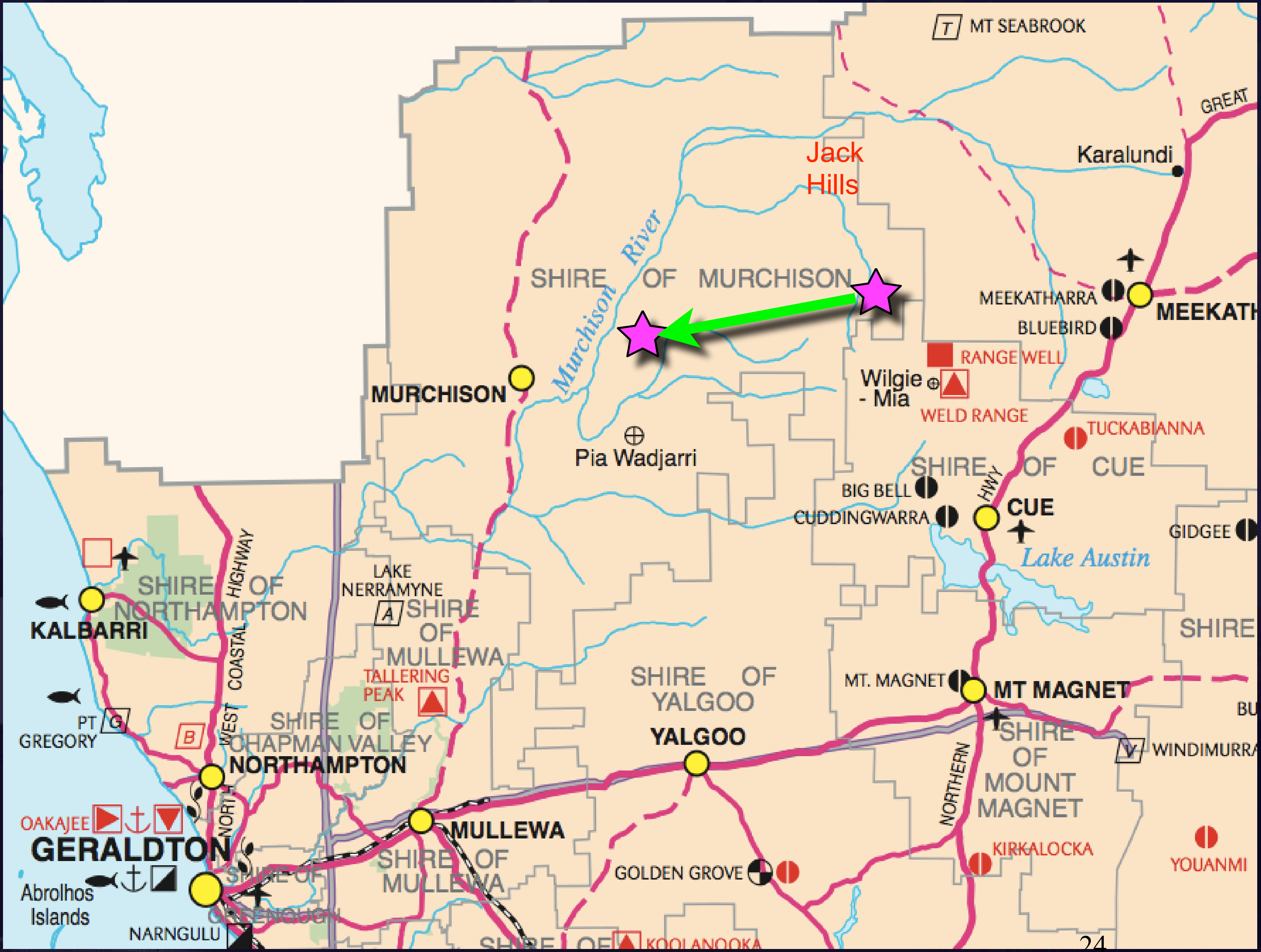
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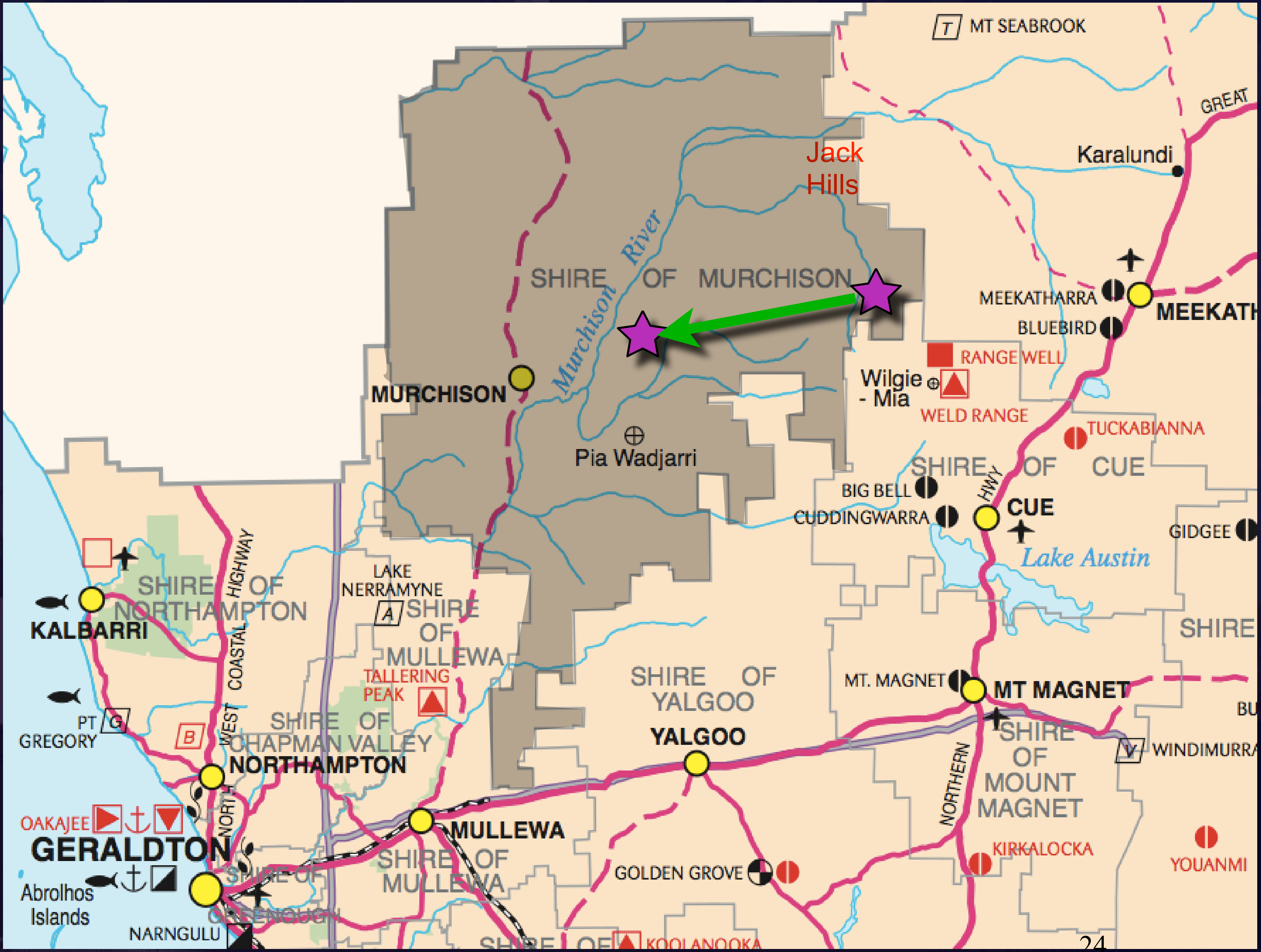
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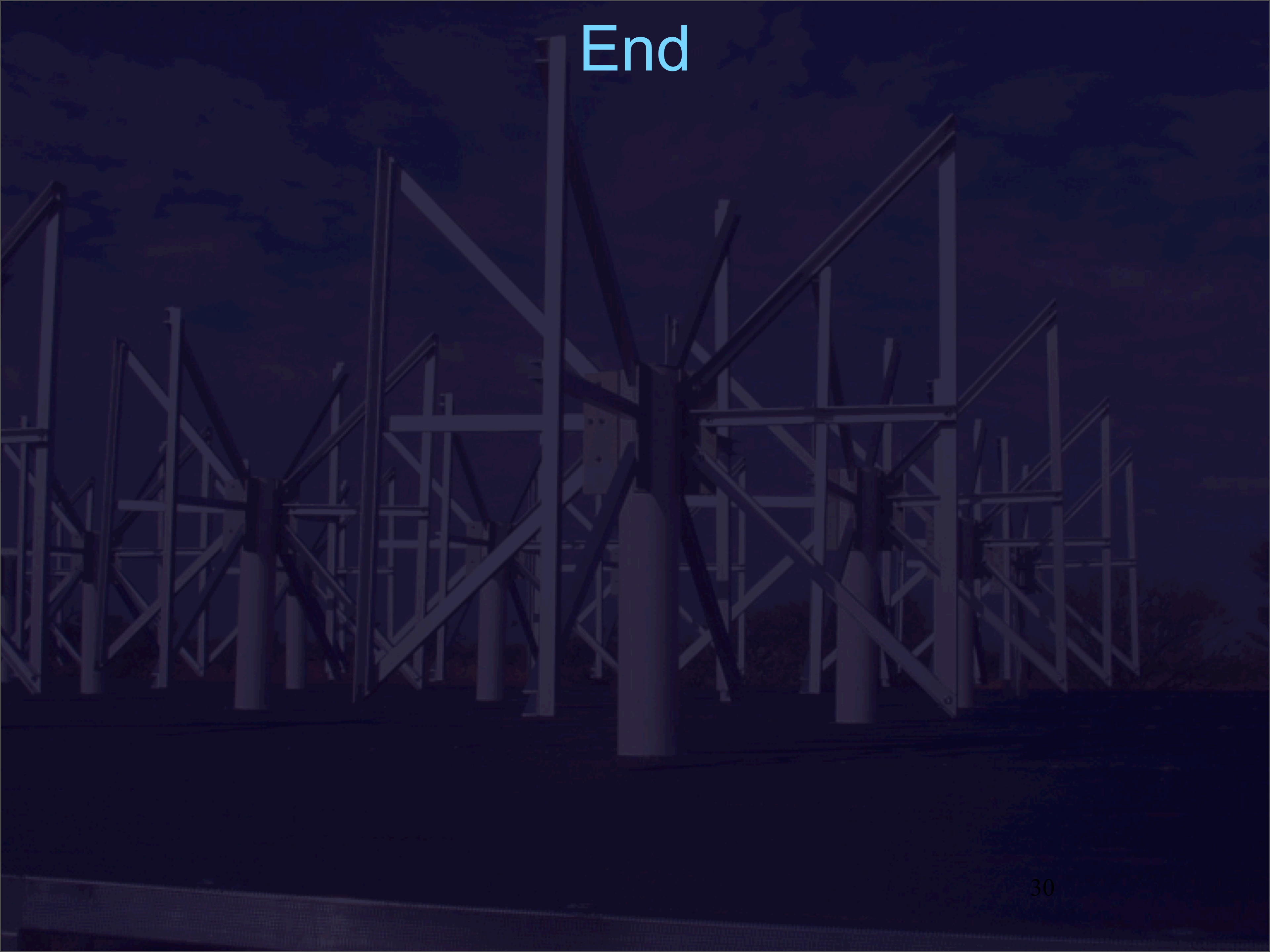
DANGER

Status

- Funded, full scale design effort in progress
- Production prototype tile on-site since March
- First 32 tiles arrive in ~6 weeks
- Lots of activity in coming months
  - 32T antennas + first prototype receiver ~August
  - Expansion of field activities 3Q and 4Q
  - Full 32T system running by ~end of year
  - Preparation for major procurement/deployment in 2008
- On track for EoR observations in 2009
- Optimize array behavior based on experience

End



In case you were confused ...