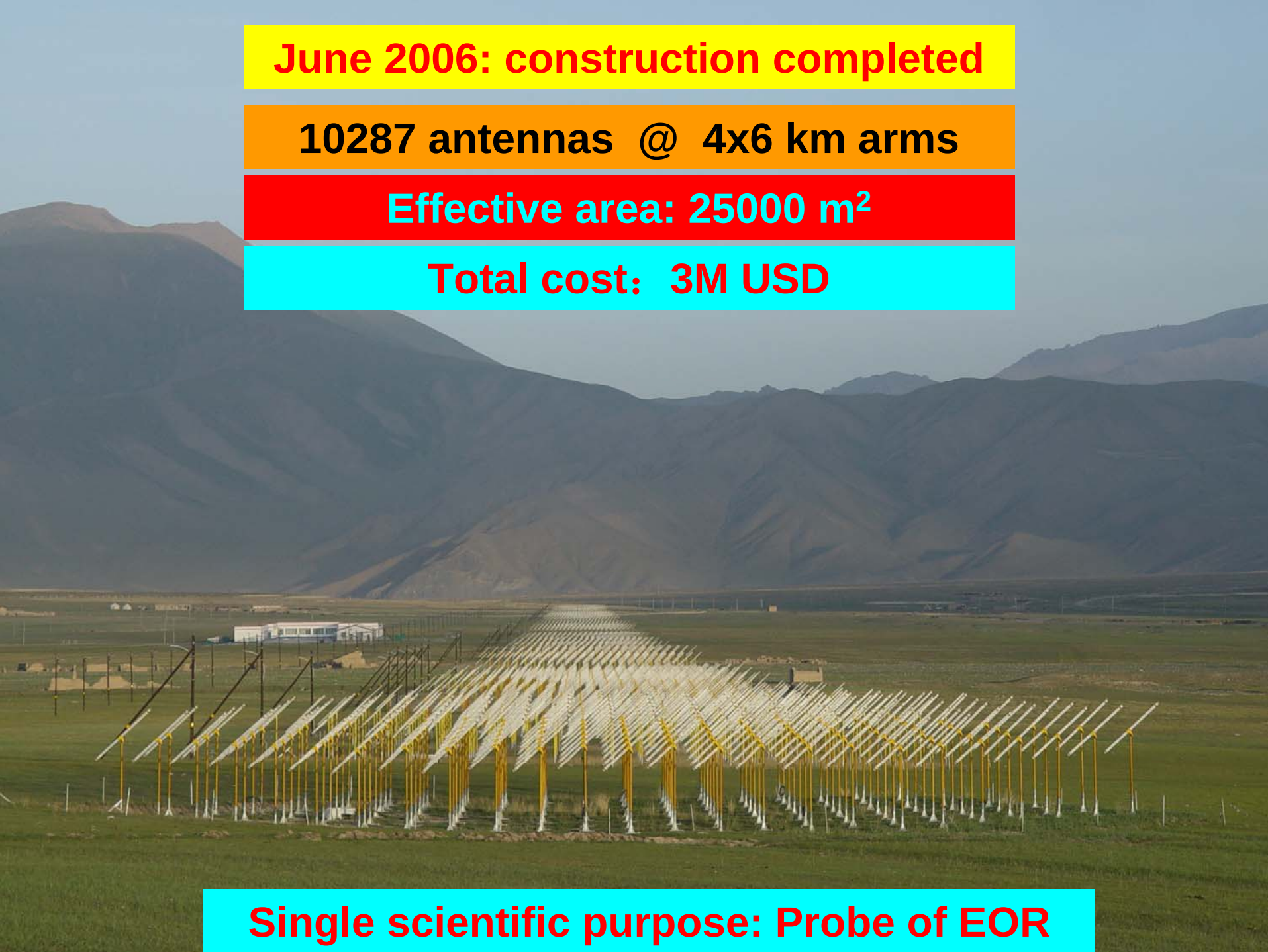
21 CentiMeter Array (21CMA)

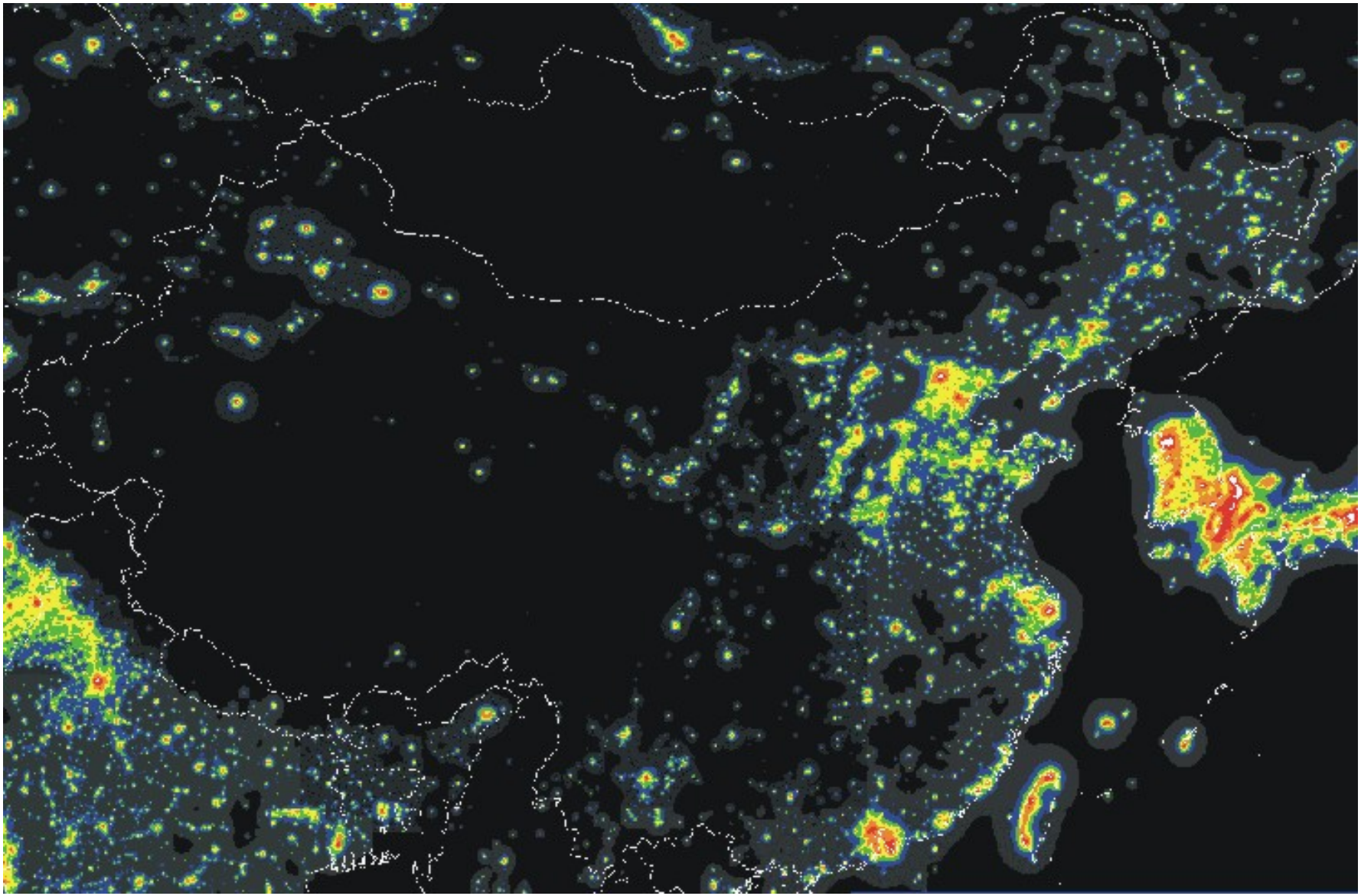
Current Status

Bo Qin on behalf of **Xiang-Ping Wu**
(NAOC)


June 2006: construction completed
10287 antennas @ 4x6 km arms
Effective area: 25000 m^2
Total cost: 3M USD
Single scientific purpose: Probe of EOR

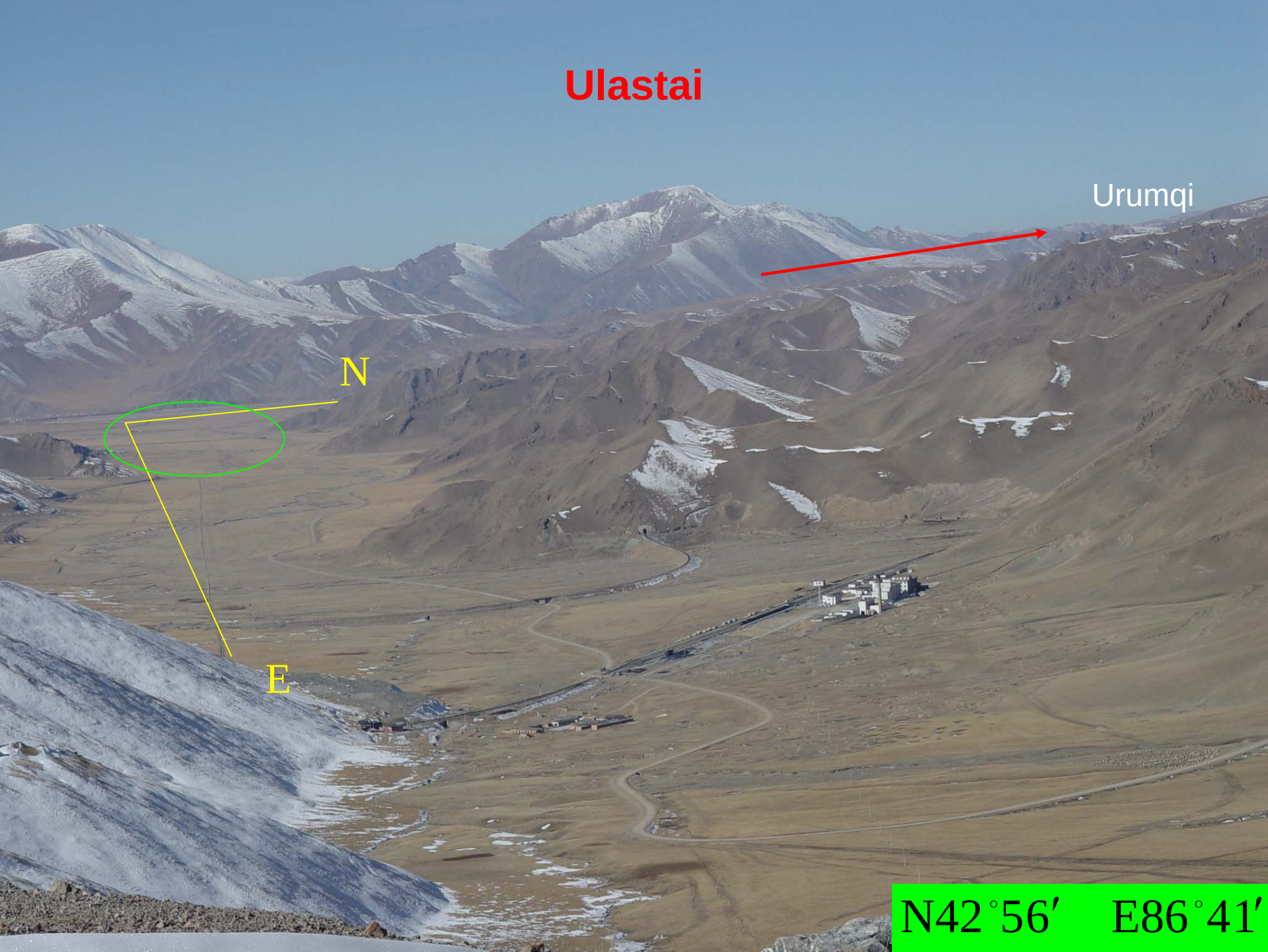
Base 802438 (545114) 2-96

West China: World's best clear dark sky




RUSSIA
KAZAKSTAN
MONGOLIA
XINJIANG
GANSU
QINGHAI
XIZANG
SICHUAN
INDIA
BURMA
THAILAND
China
International boundary
Province-level boundary
National capital
Province-level capital
Railroad
Road


VLBI
Shitizi
JUNGGAR
DI
Ürümqi
Microsoft MapPoint
Chaiwopu
Yongfengqu
Banfanggou
Miaorgou
43° 30
Yanhu
Panjiadi
Dabancheng
Daheyan
Houxia
Hougou
XINJIANG
UYGUR
AUTONOMOUS REGION
Baiyanghe
Turpan
Zhan
Xiaocaohu
Burjay
Ewirgol
TURPAN
Yilahu
Toksun
Ulastai
Bayan Gol
Ulanlinggi
Balguntay
PENDI
Bort
42° 30
Ma'anqiao
Hejing
Hoxud
Bayan
Kümüx
Tagarqi
Yushugou
Uxxaktal
©2003 Microsoft Corp
87°
87° 30'
88°
88° 30'
89°


Ulastai
Urumqi
N
E
N42°56′ E86°41′

S

N

W

E

control room

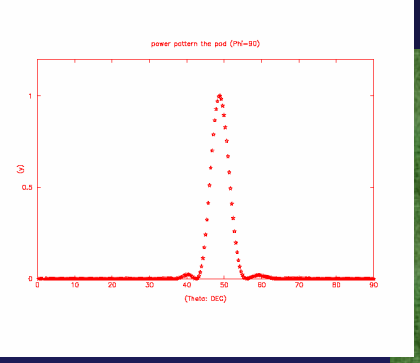
1 pod=127 antennas

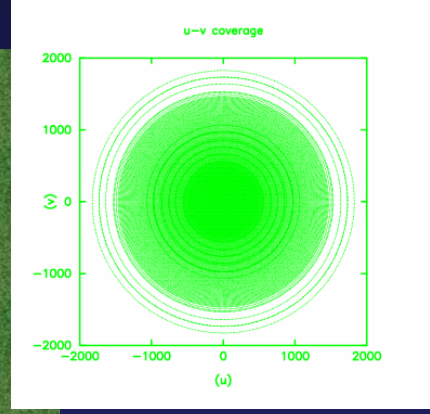
21CMA Layout

81 pods along two perpendicular arms (6km+4km)

Baselines: 3240 Freq channels: 4096

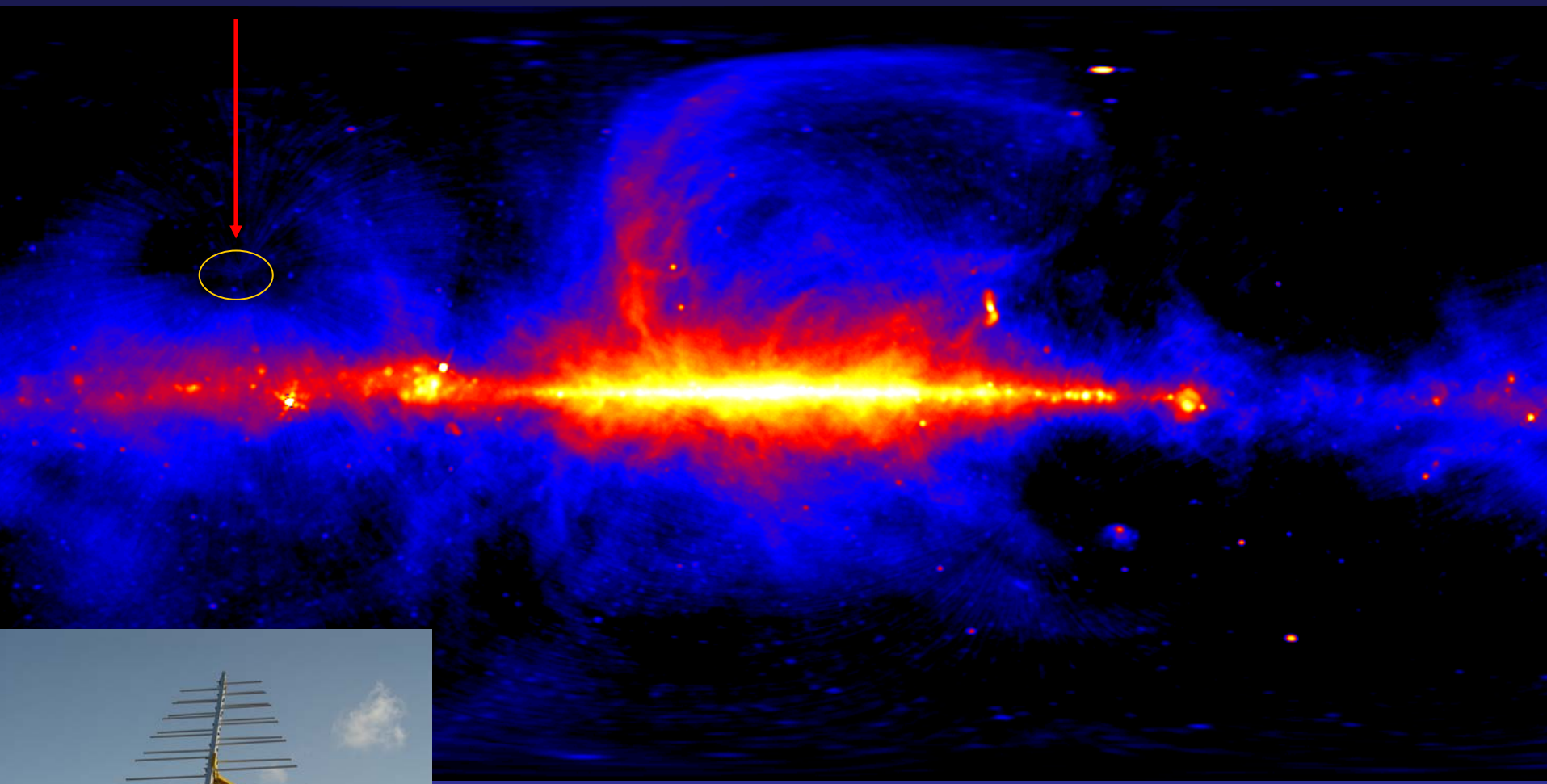
Total data size: 4 terabytes / day



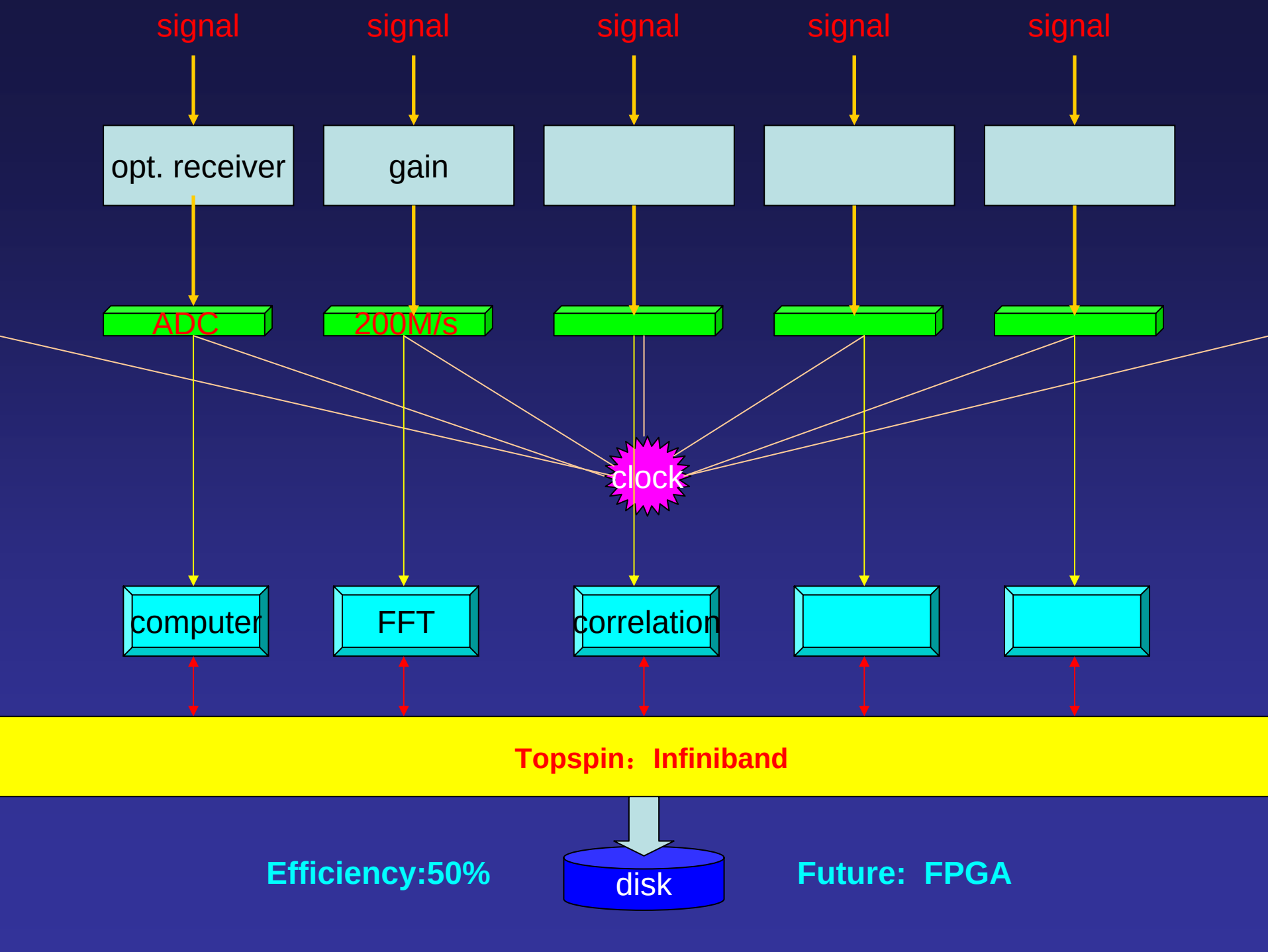


Log-Periodic Antenna

The VHF Sky Brightness



408MHz

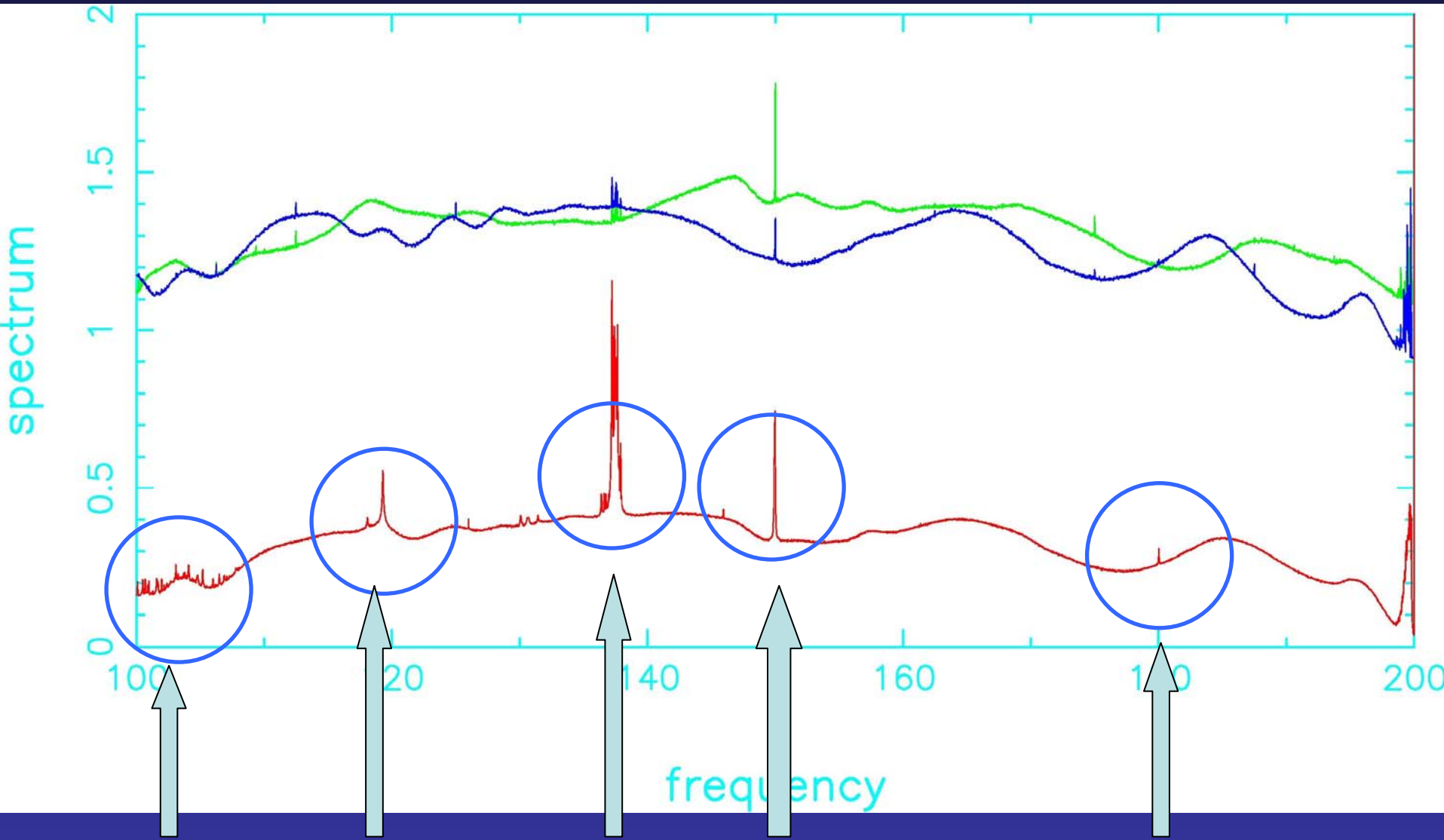

signal
signal
signal
signal
signal
opt. receiver
gain
ADC
200M/s
clock
computer
FFT
correlation
Topspin：Infiniband
Efficiency:50%
disk
Future: FPGA

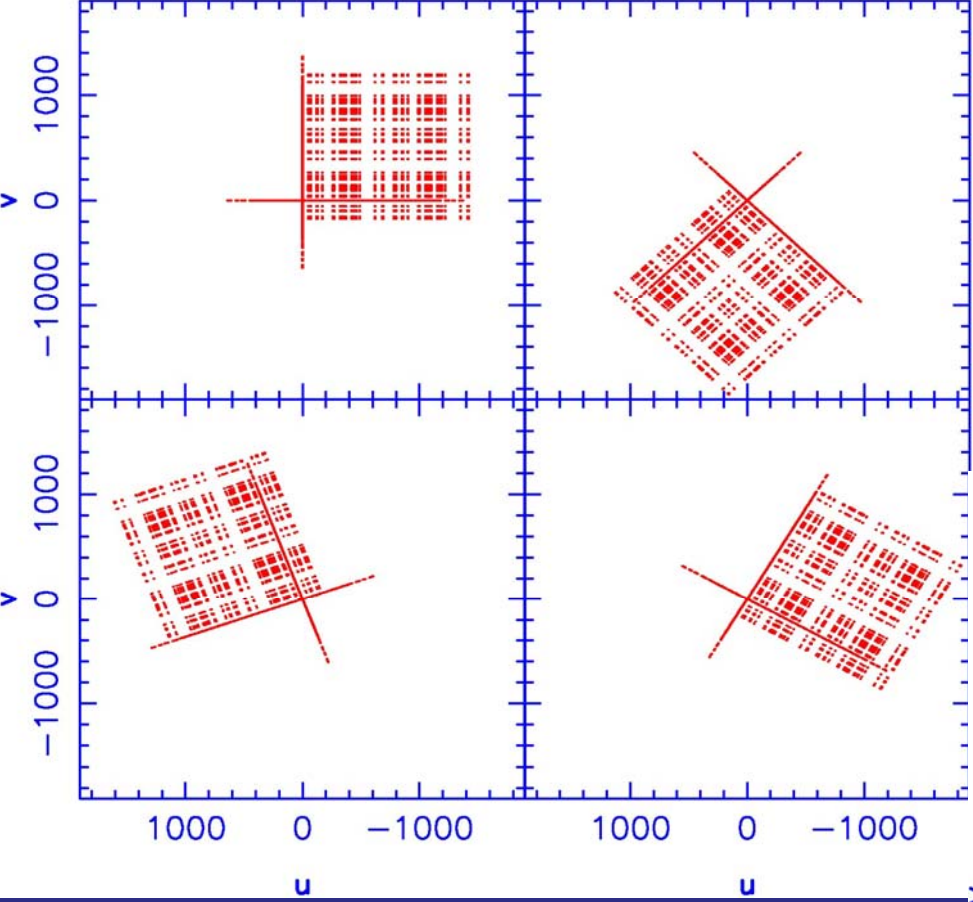
Optical Receivers

Data Acquisition System

Data processing system

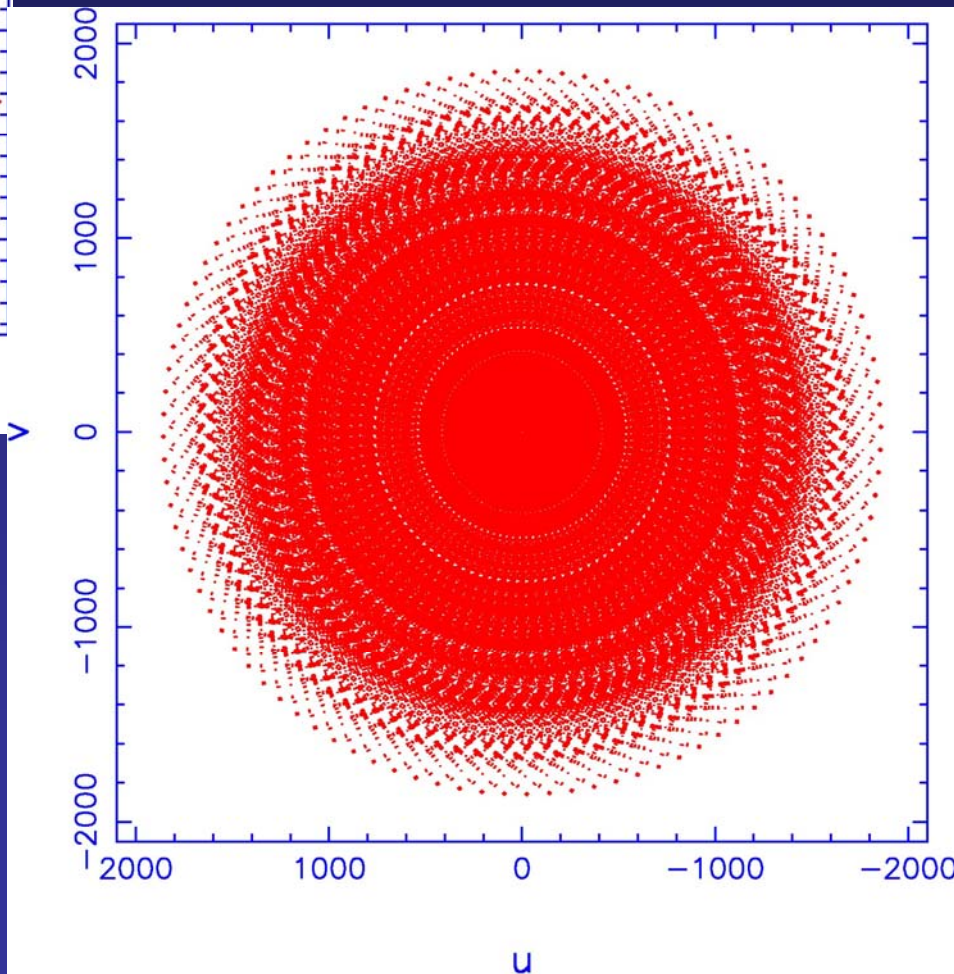
Ulastai Observatory


spectrum
2
1.5
1
0.5
0
100
120
140
160
180
200
frequency
FM radio
Aviation commu.
LEO Satellites
Satellite Beacons
LEO Satellites

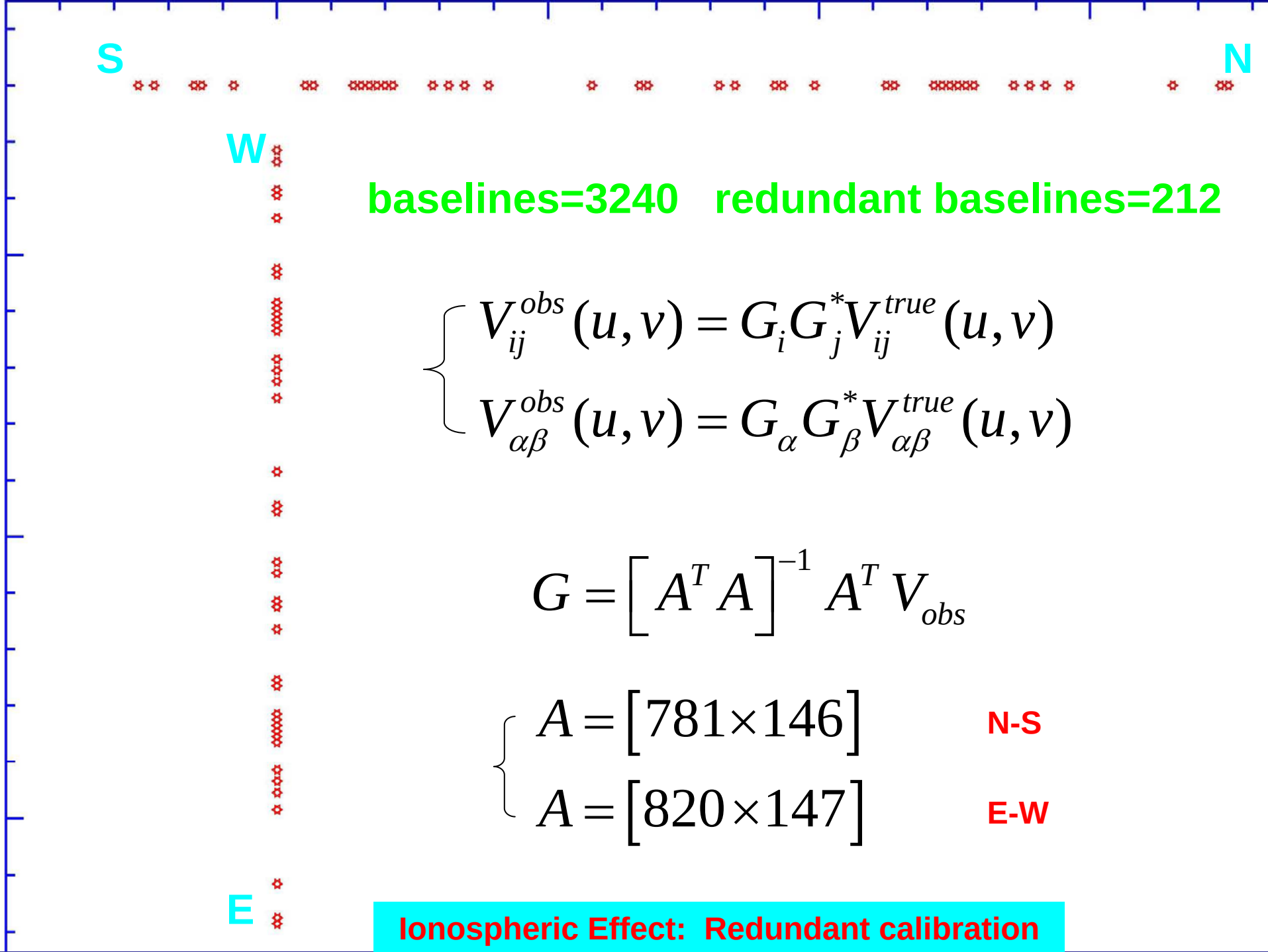


Instantaneous uv

24h uv



UV Coverage of 21CMA



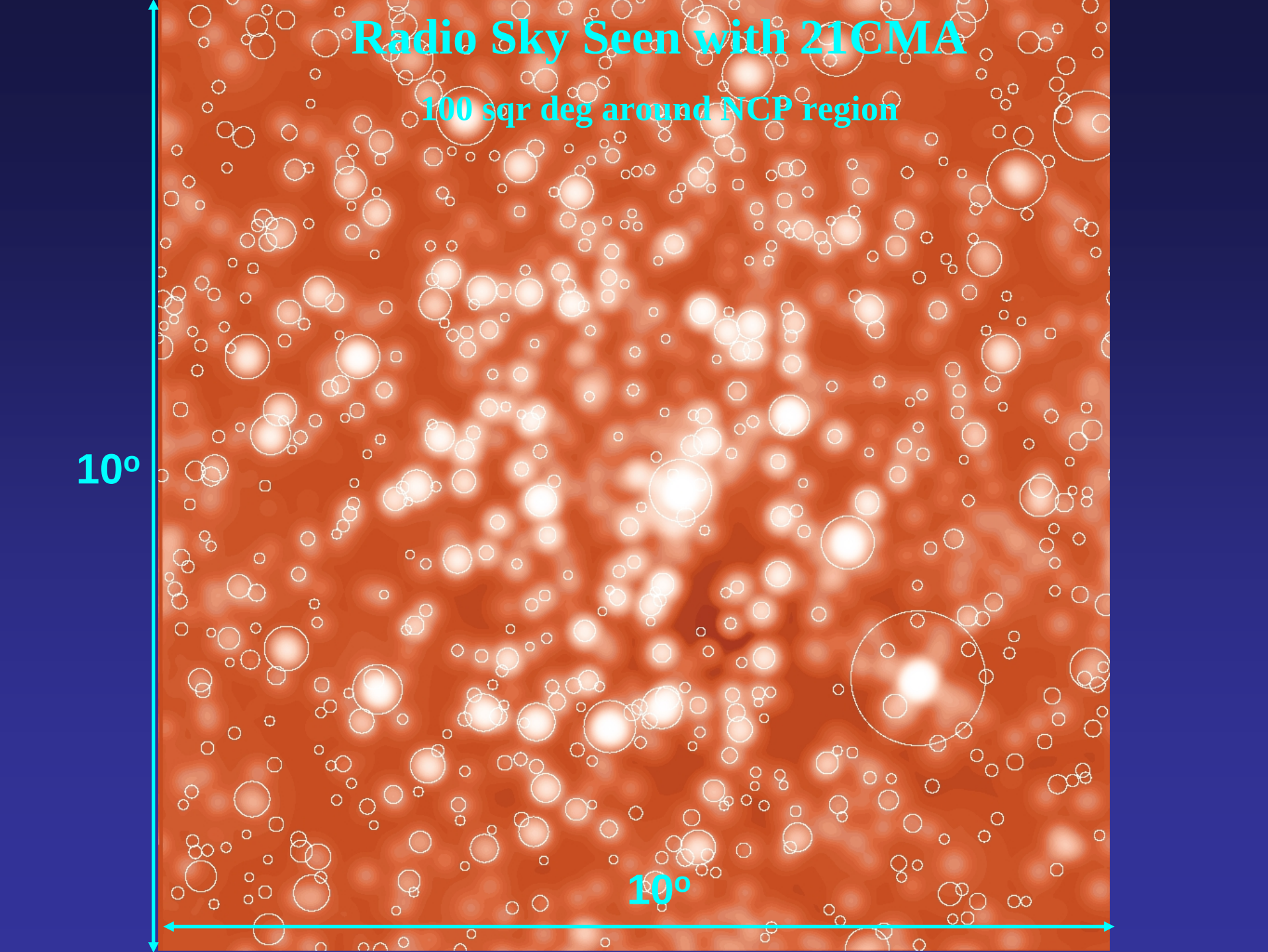
baselines=3240 redundant baselines=212

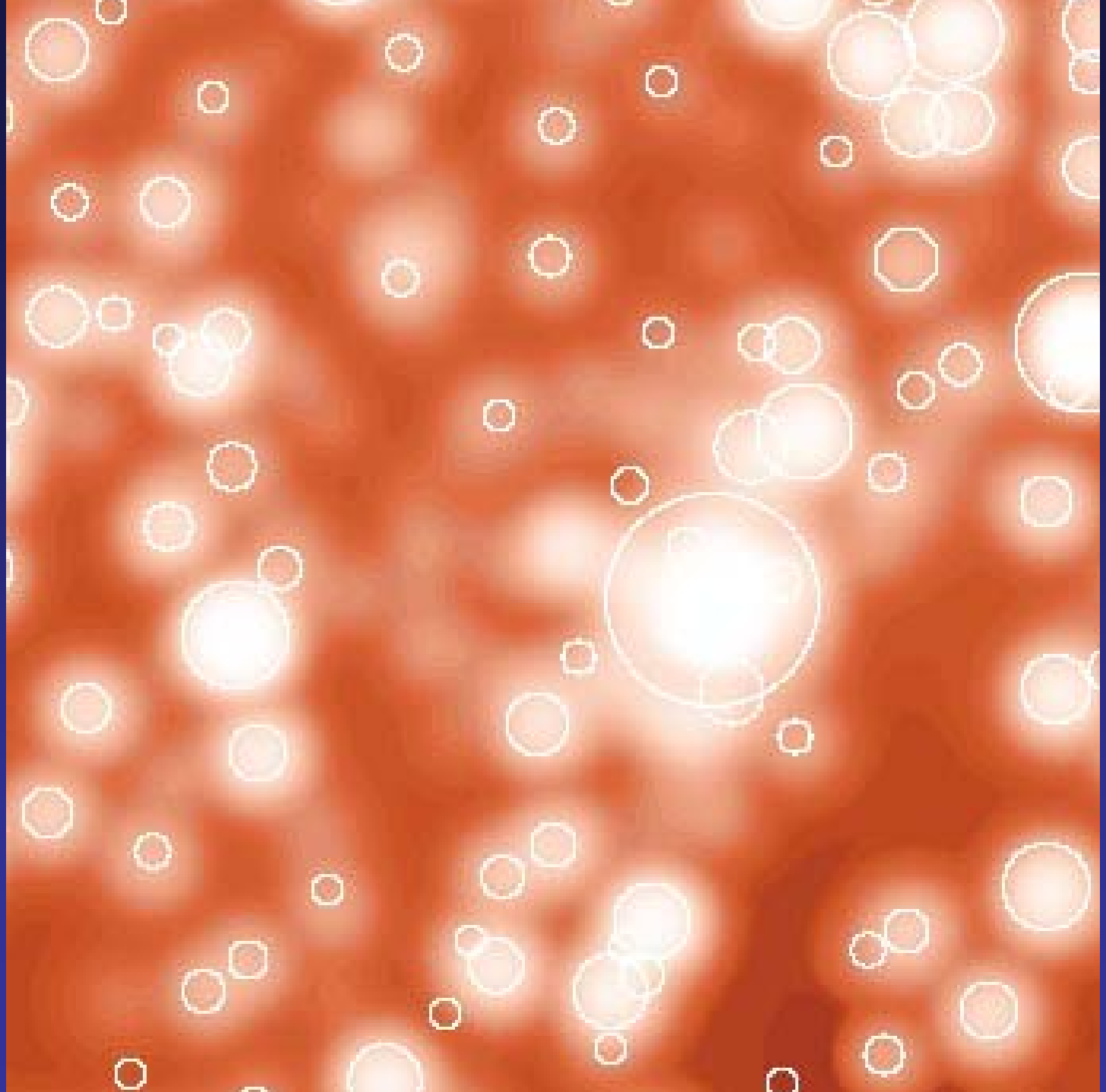
$$\begin{cases} V_{ij}^{obs}(u,v) = G_i G_j^{*} V_{ij}^{true}(u,v) \\ V_{\alpha\beta}^{obs}(u,v) = G_\alpha G_\beta^{*} V_{\alpha\beta}^{true}(u,v) \end{cases}$$

$$G = \left[A^T A \right]^{-1} A^T V_{obs}$$

$$\begin{cases} A = [781 \times 146] & \text{N-S} \\ A = [820 \times 147] & \text{E-W} \end{cases}$$

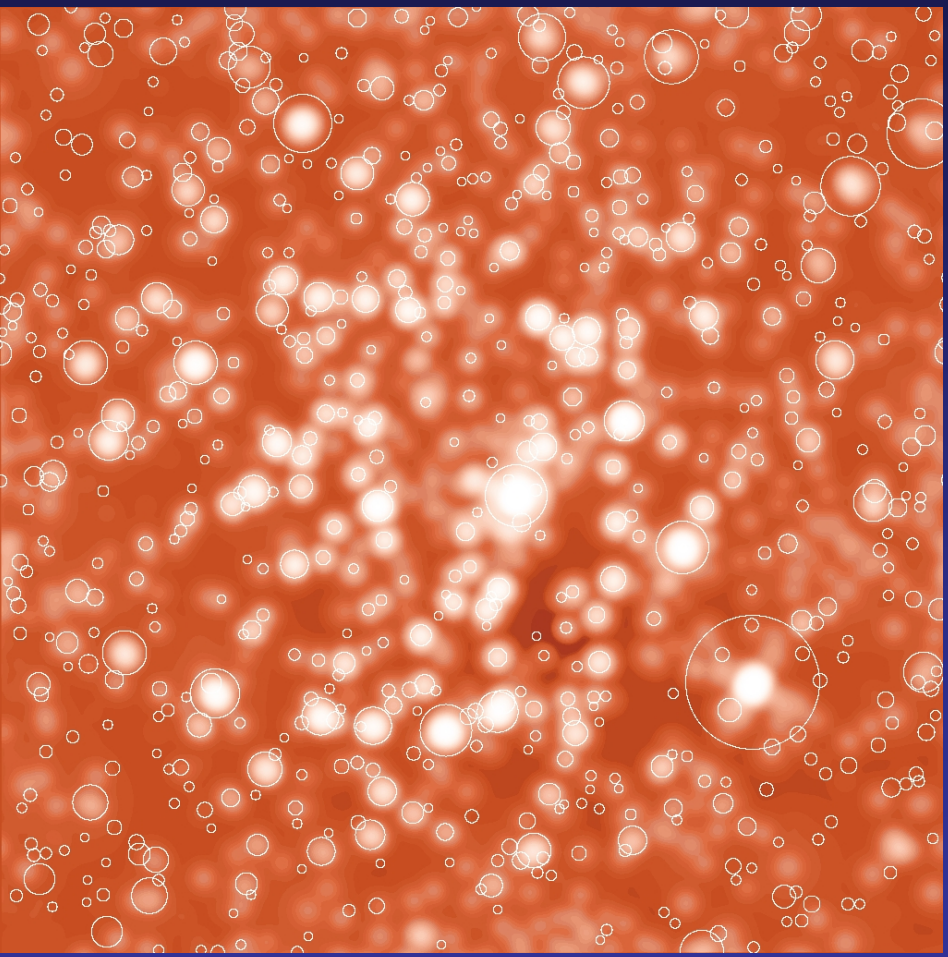
Ionospheric Effect: Redundant calibration


Radio Sky Seen with 21CMA
100 sqr deg around NCP region
10°
10°

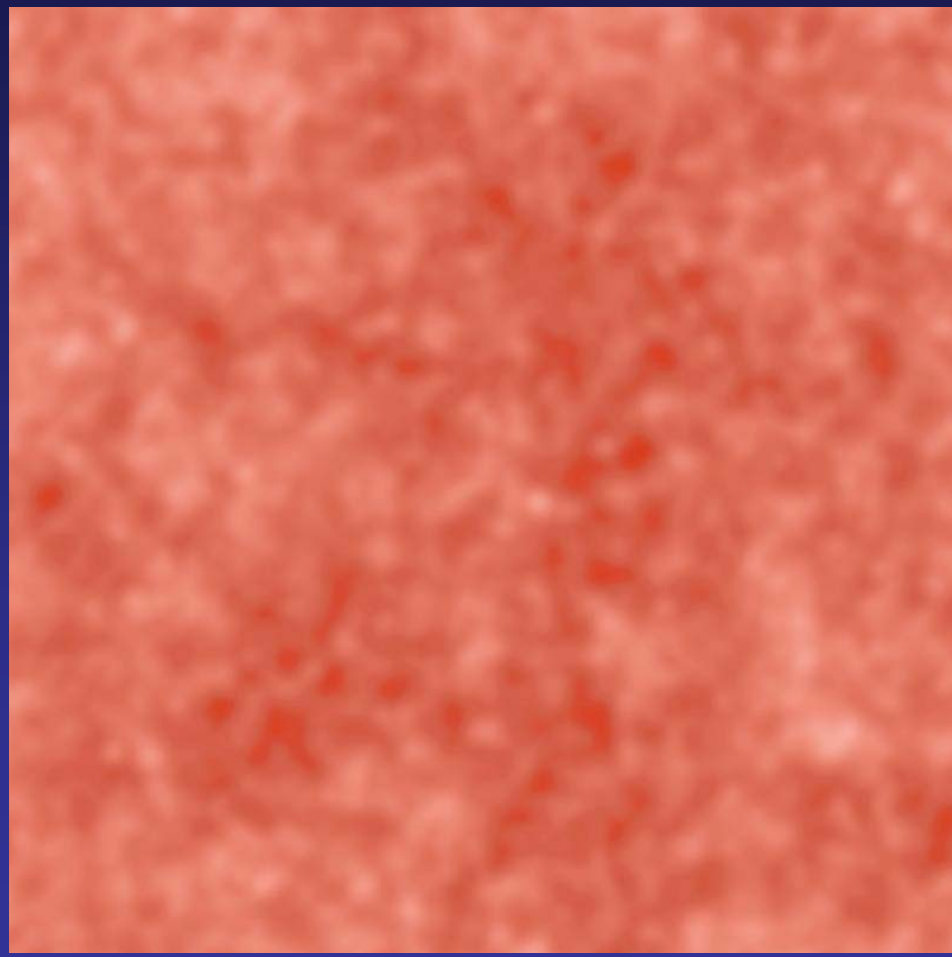


6C
sources

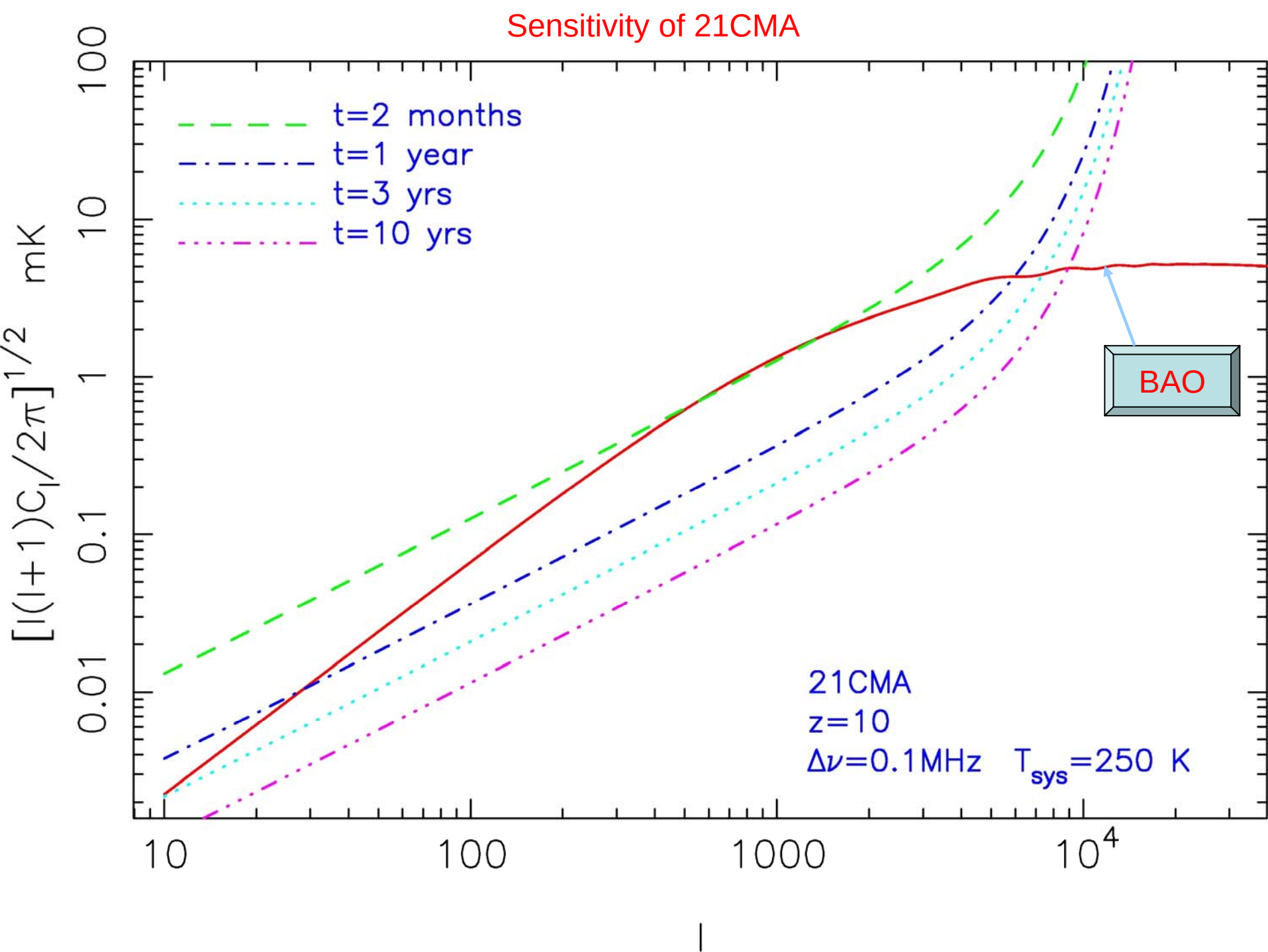
point sources



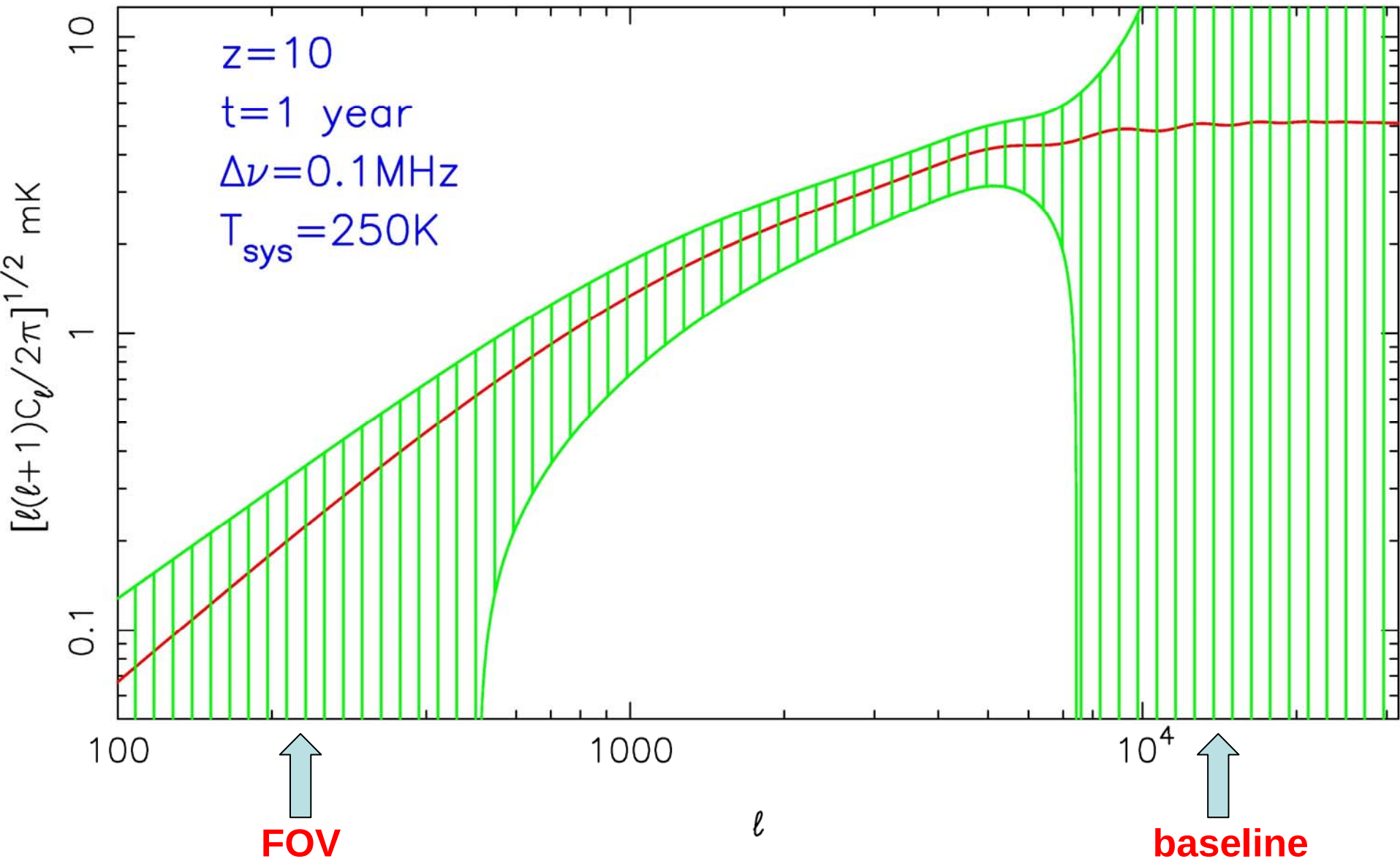
background

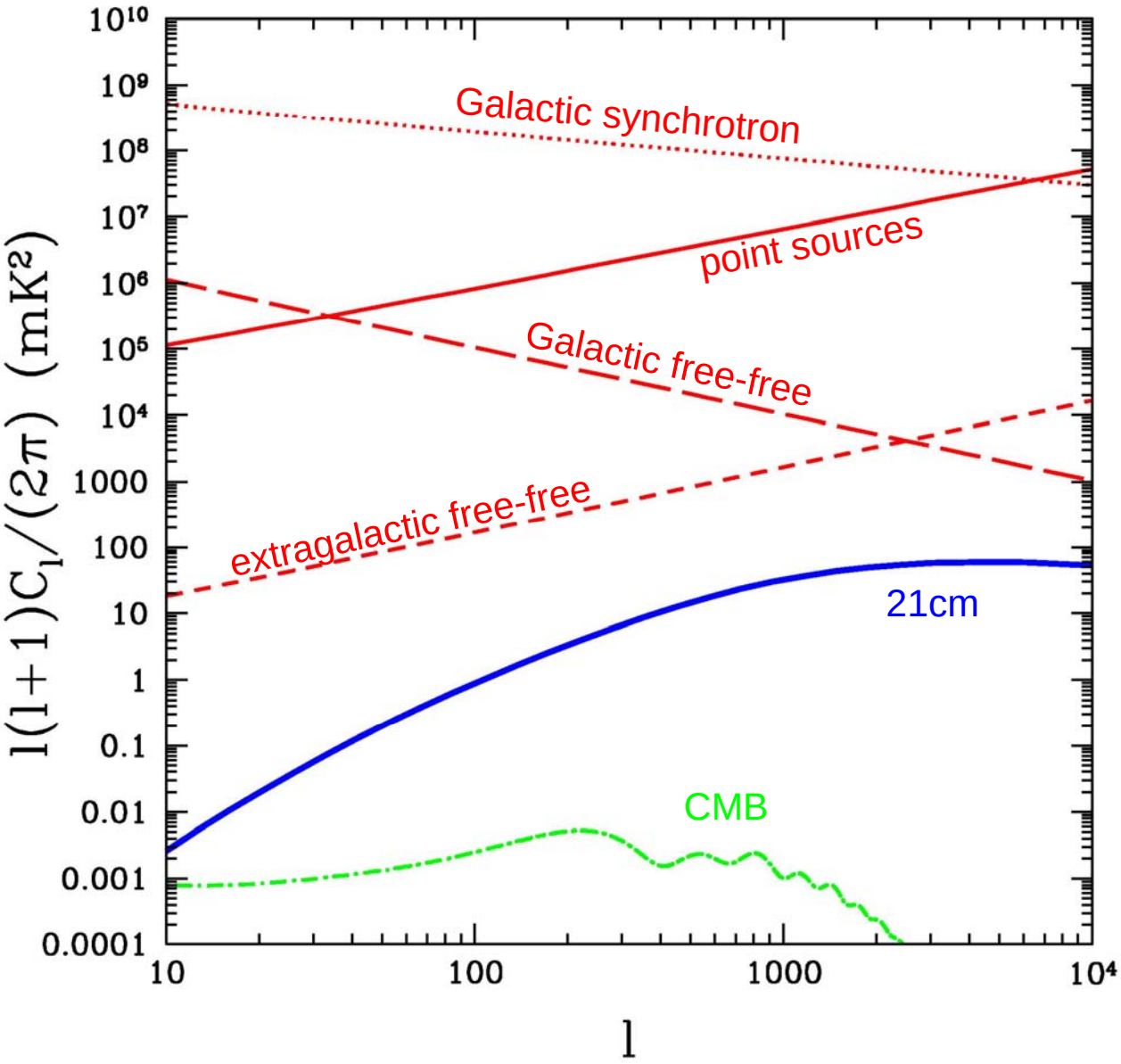


Sensitivity of 21CMA

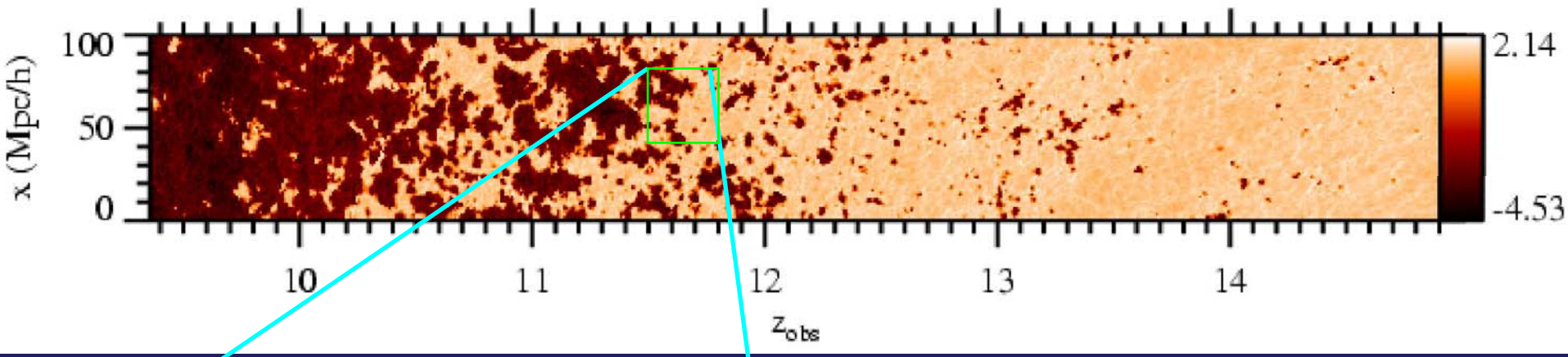


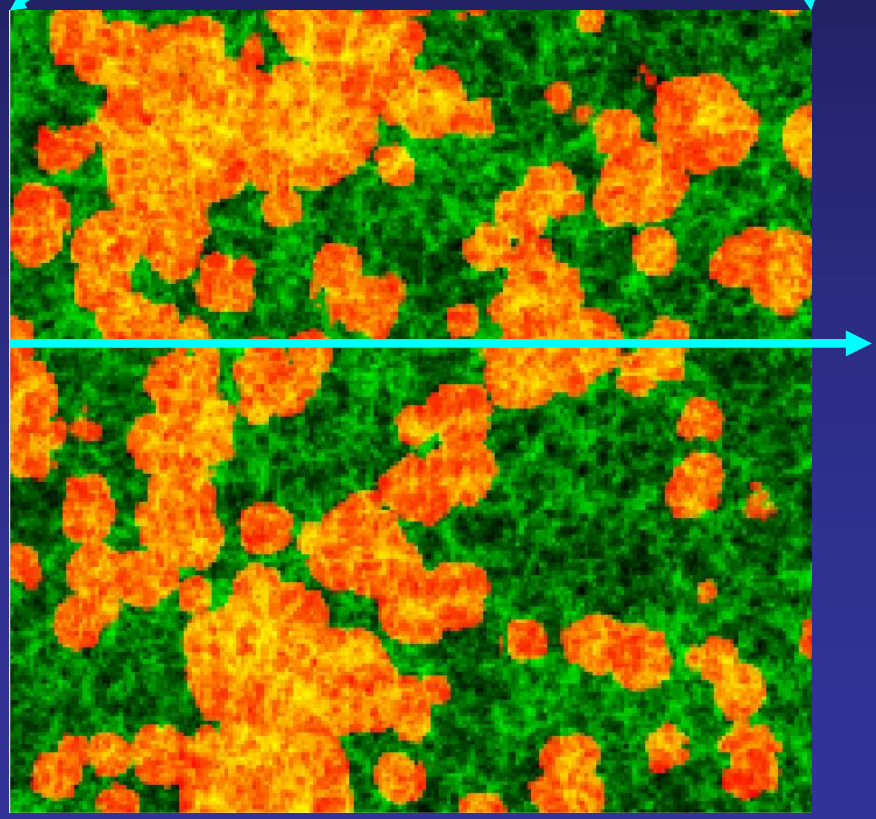
21CMA: Measurement Errors

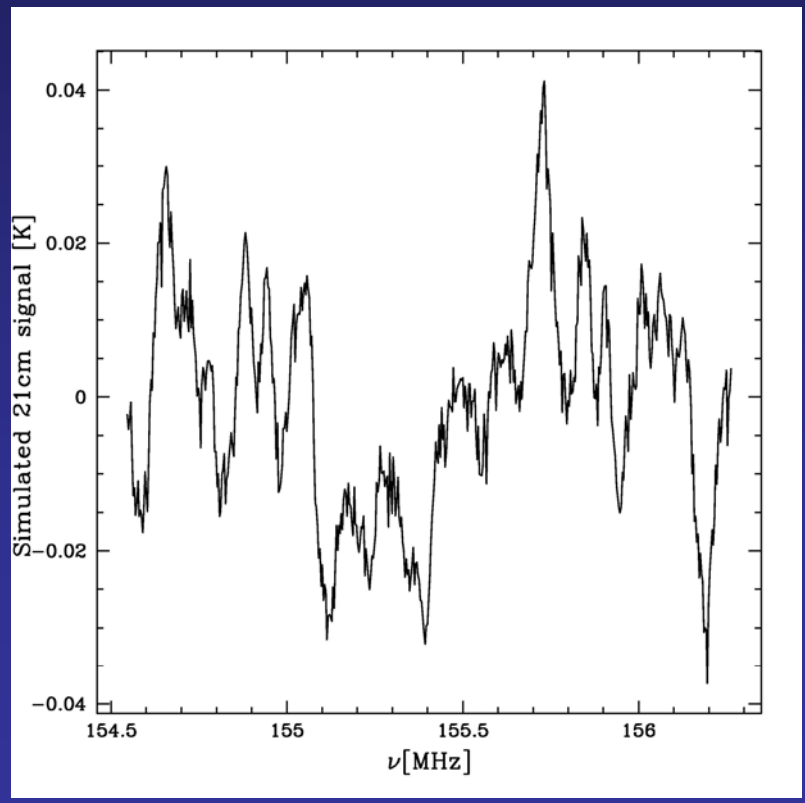




The 21cm power spectrum at z=9.2 (freq=140MHz) (Santos, Cooray & Knox 2005)







Iliev et al. (2005)

Wang, Tegmark, Santos & Knox (2006)

$$T_{\rm tot} = T_{21cm} + T_{syn} + T_{ff} + T_{ps} + T_{noise}$$

$$\frac{\Delta T(\hat{n})}{\bar{T}} = \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} a_{\ell m} Y_{\ell m}(\hat{n})$$

$$a_{\ell m}(\nu) = a_{\ell m}^{f}(\nu) + a_{\ell m}^{21cm}(\nu) + a_{\ell m}^{noise}(\nu)$$

$$C_{\ell}^{tot}(\nu_1, \nu_2) = C_{\ell}^{f}(\nu_1, \nu_2) + C_{\ell}^{21cm}(\nu_1, \nu_2) + C_{\ell}^{N}(\nu_1, \nu_2)\delta_{12}$$

Byproducts @ 21CMA

1. Ionosphere & the Milky Way
2. QSOs at Low Frequencies
3. Transient Sources (eg GRBs)
4. Cosmic Ray Air Showers
5. Meteors


Current Biggest Problems: Funds
1. Operation and maintenance
2. Data storage (4T/day) -$30k/month
3. 10000 LNAs ($3M) – (system noise)
Operated for three months only so far !


Welcome To Ulastai Observatory
Thank You