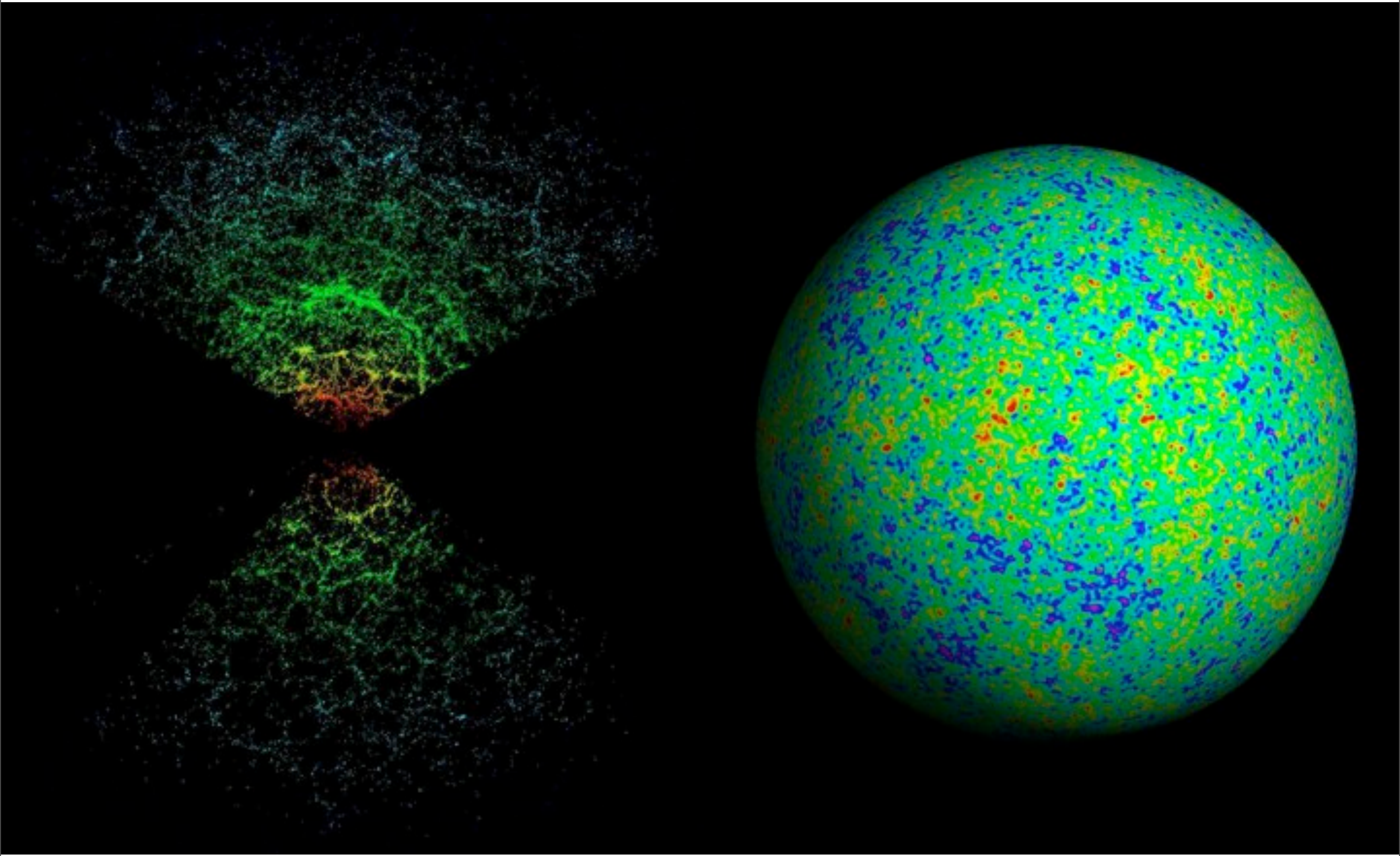
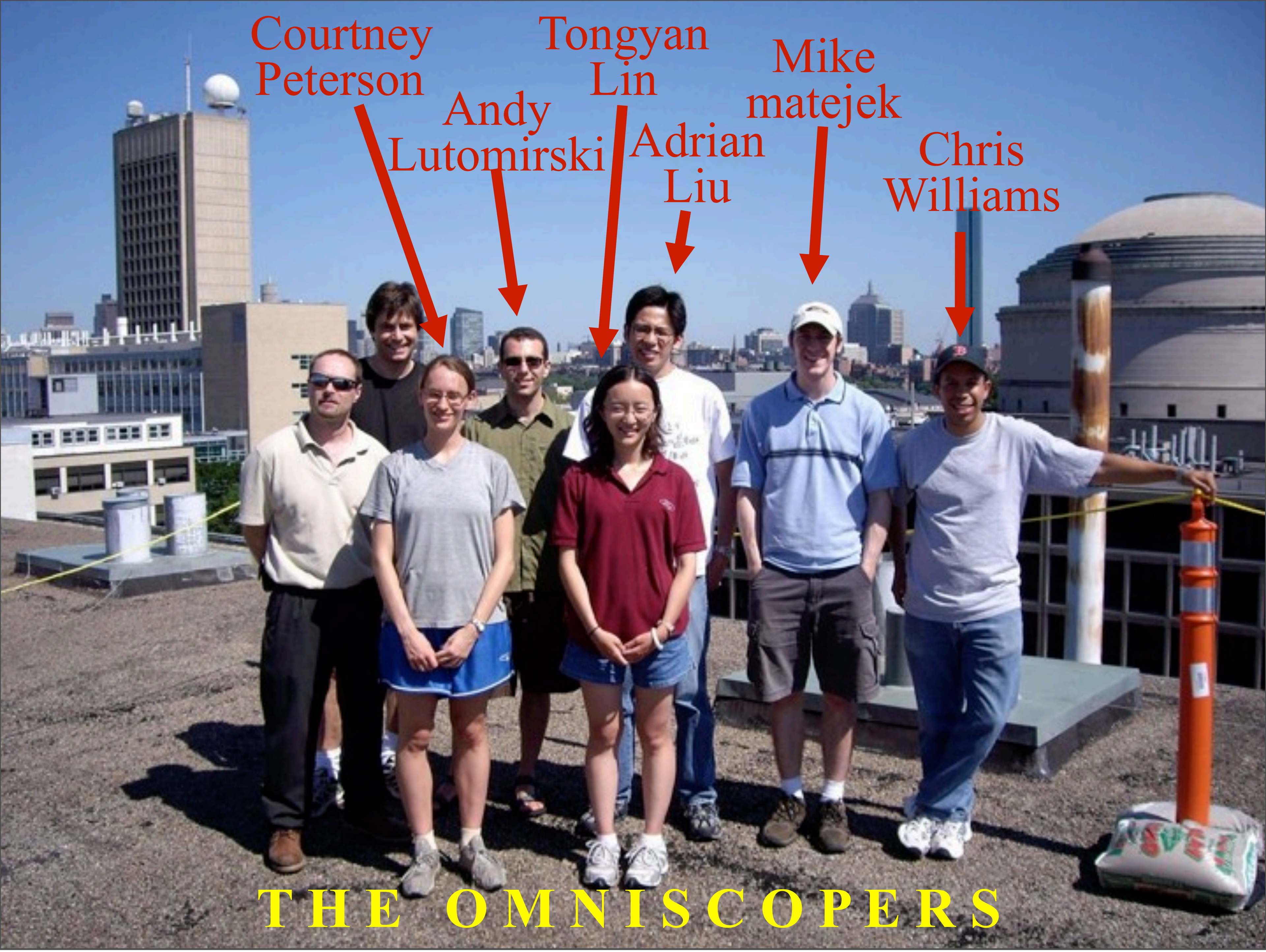
Omniscopes




Courtney Peterson
Andy Lutomirski
Tongyan Lin
Adrian Liu
Mike matejek
Chris Williams
THE OMNISCOPERS


Courtney Peterson
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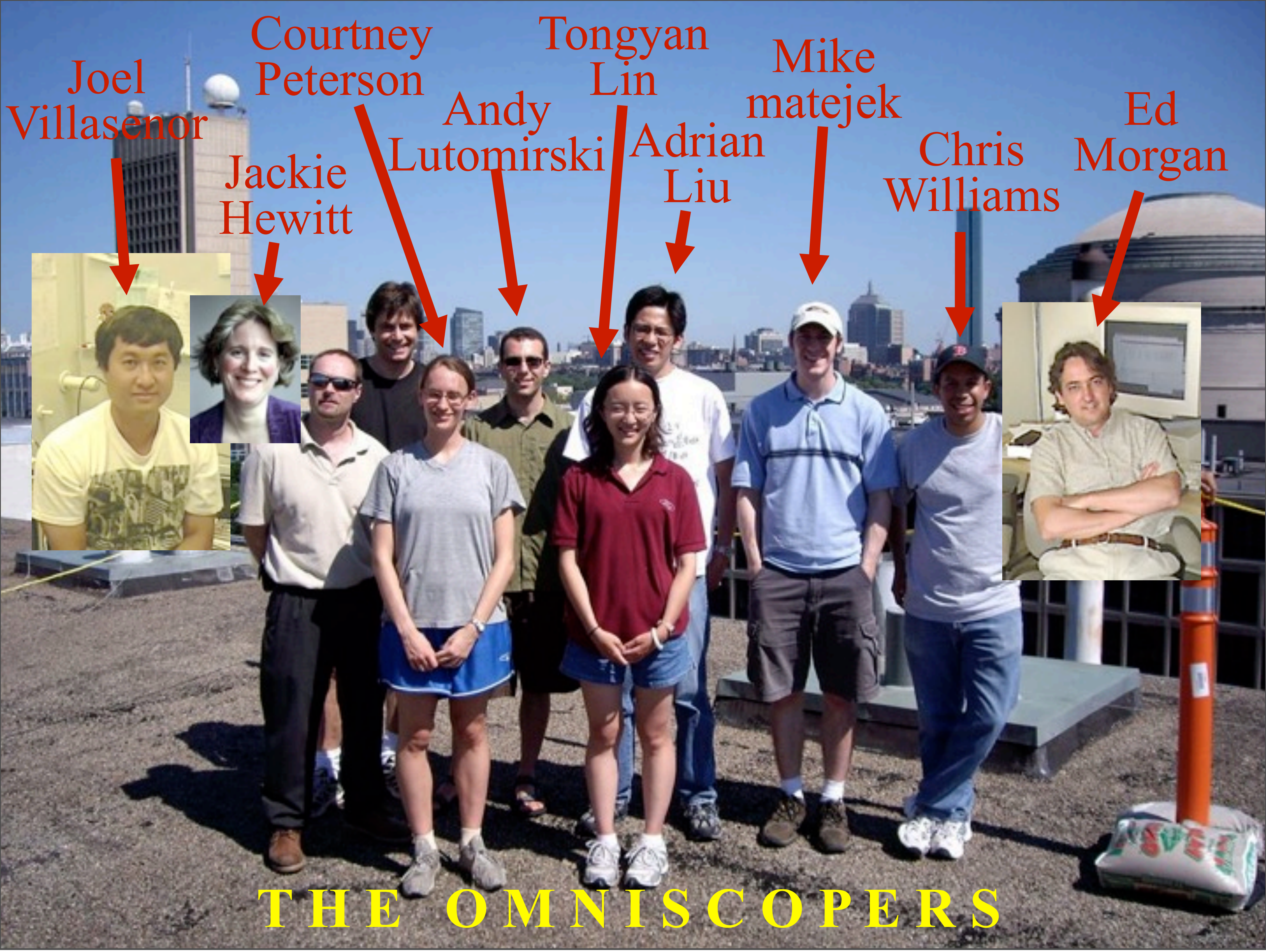
Joel
Villasenor
Jackie
Hewitt
Courtney
Peterson
Andy
Lutomirski
Tongyan
Lin
Adrian
Liu
Mike
matejek
Chris
Williams
Ed
Morgan
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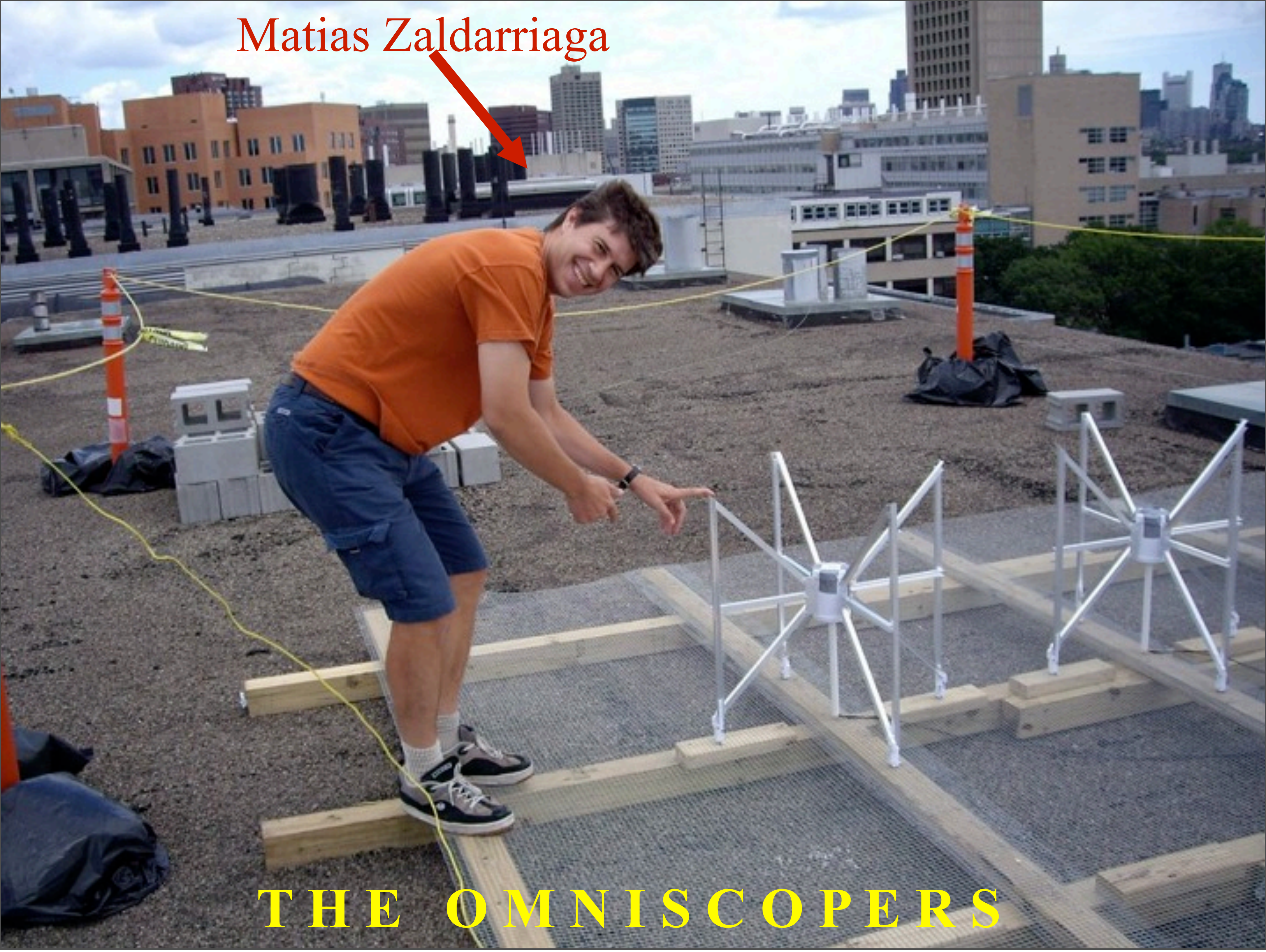
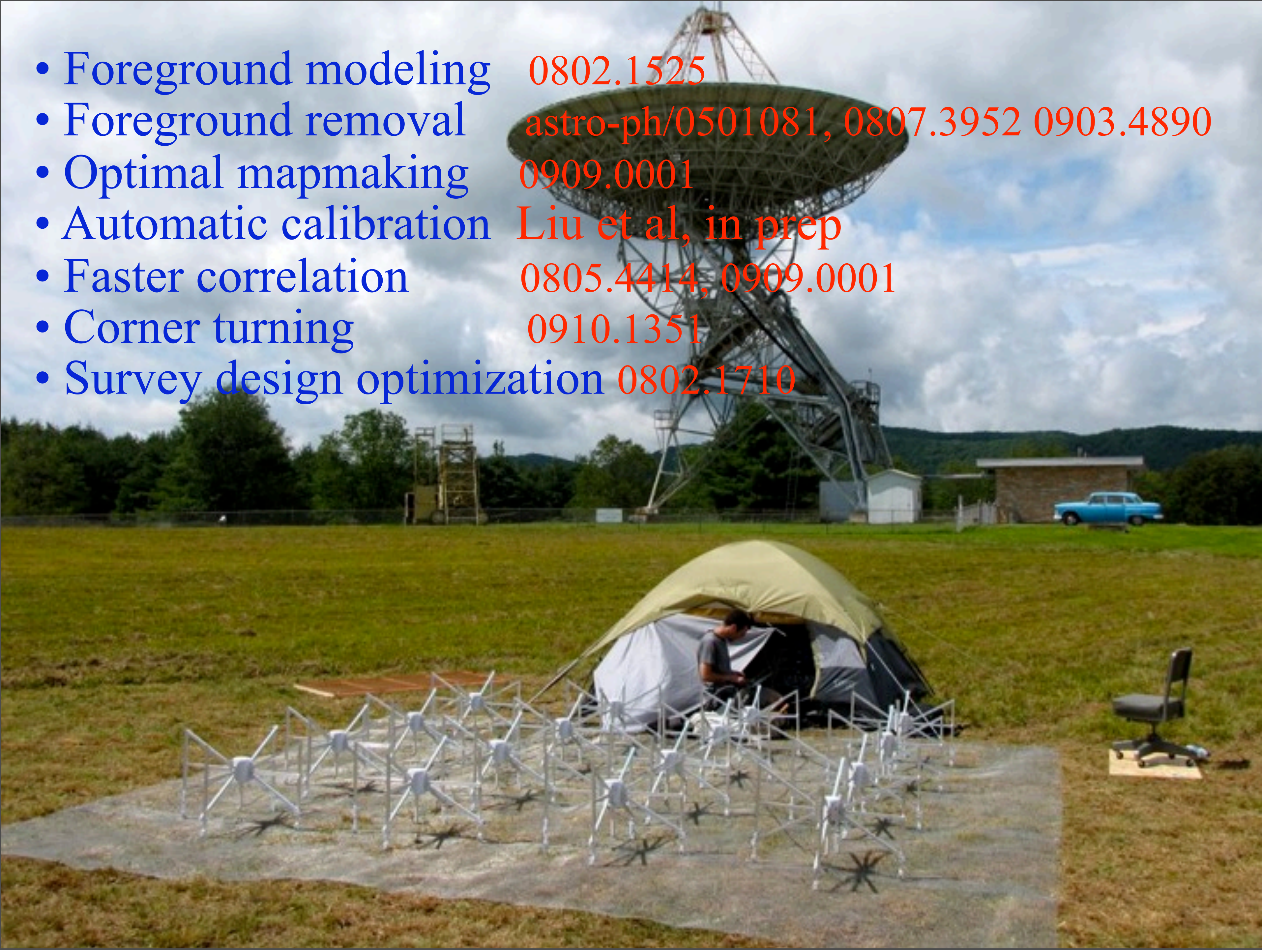
Scott
Morrison
THE OMNISCOPERS

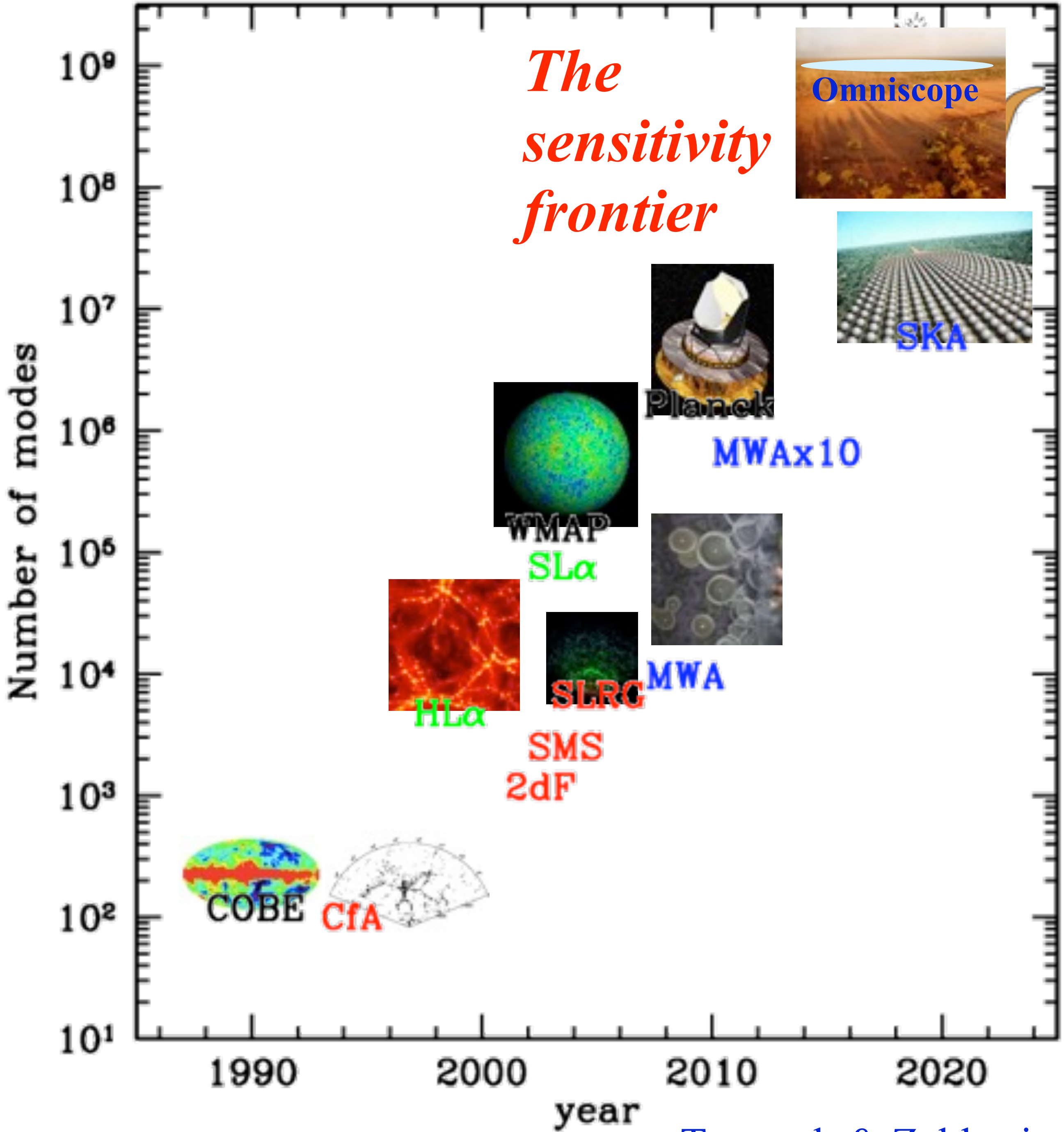

Scott
Morrison


Angelica de Oliveira-Costa
Scott Morrison
Nevada Sanchez
Joe Lee
Henrique Pondé Oliveira Pinto


Matias Zaldarriaga
THE OMNISCOPERS



- Foreground modeling 0802.1525
- Foreground removal astro-ph/0501081, 0807.3952 0903.4890
- Optimal mapmaking 0909.0001
- Automatic calibration Liu et al, in prep
- Faster correlation 0805.4414, 0909.0001
- Corner turning 0910.1351
- Survey design optimization 0802.1710



Tegmark & Zaldarriaga 2008

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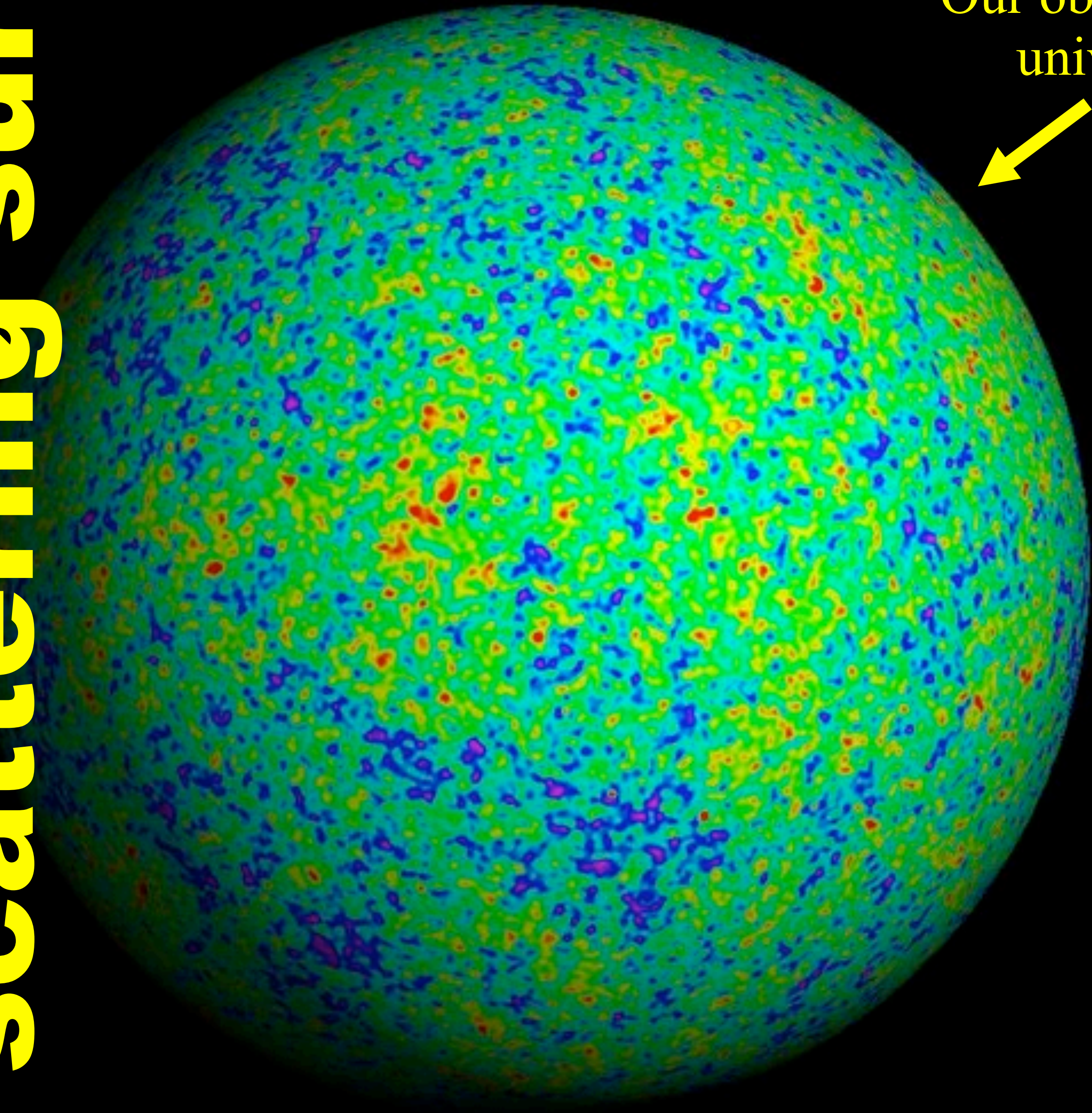
Dept. of Physics, MIT
tegmark@mit.edu
Fermilab workshop
October 9, 2009

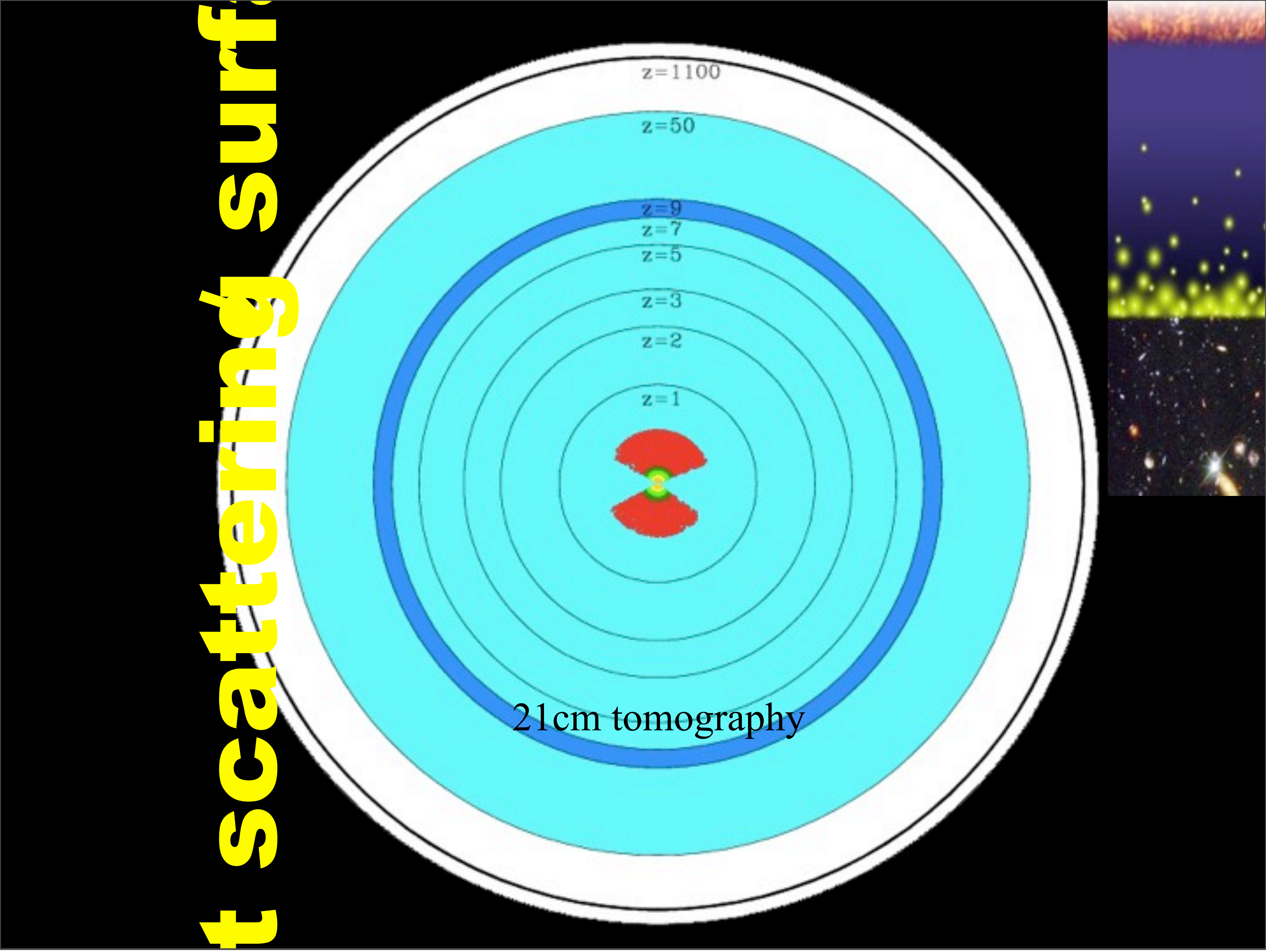
What are we so excited?

Our observable universe



t scattering surf

Foreground-cleaned WMAP map from Tegmark, de Oliveira-Costa & Hamilton, astro-ph/0302496


t scattering surf
z=1100
z=50
z=9
z=7
z=5
z=3
z=2
z=1
21cm tomography

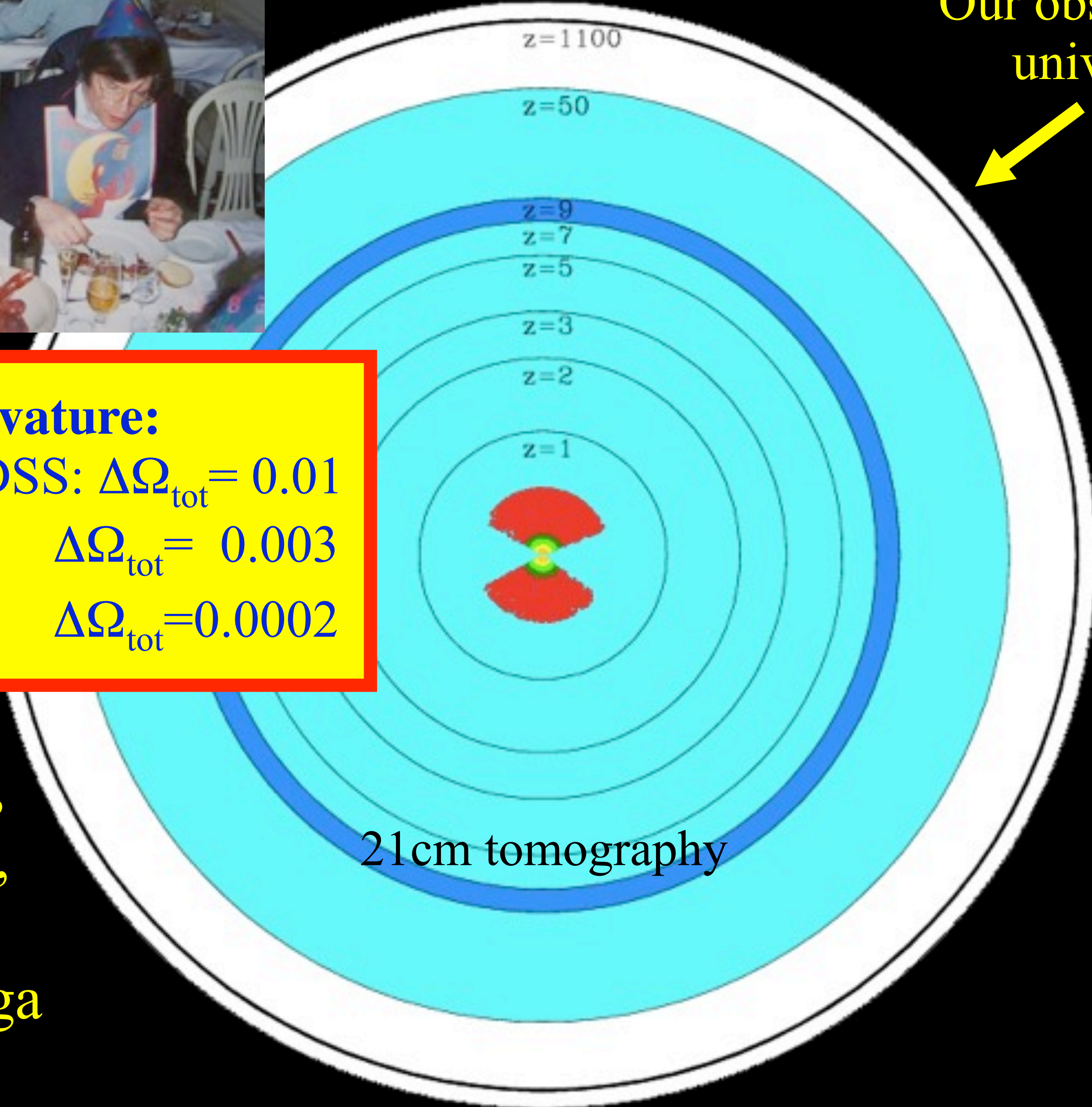
Spatial curvature:

WMAP+SDSS: $\Delta\Omega_{tot}$= 0.01

Planck: $\Delta\Omega_{tot}$= 0.003

21cm: $\Delta\Omega_{tot}$=0.0002

Our observable universe



Mao, MT, McQuinn, Zahn & Zaldarriaga 2008

Our observable universe

Spectral index running:

Planck: $\Delta\alpha = 0.005$

21cm: $\Delta\alpha = \mathbf{0.00017}$

ϕ^2-potential: $\alpha = -0.0007$

ϕ^4-potential: $\alpha = 0.008$

Mao, MT, McQuinn, Zahn & Zaldarriaga 2008

Neutrino mass:

WMAP+SDSS: $m_\nu < 0.3$ eV

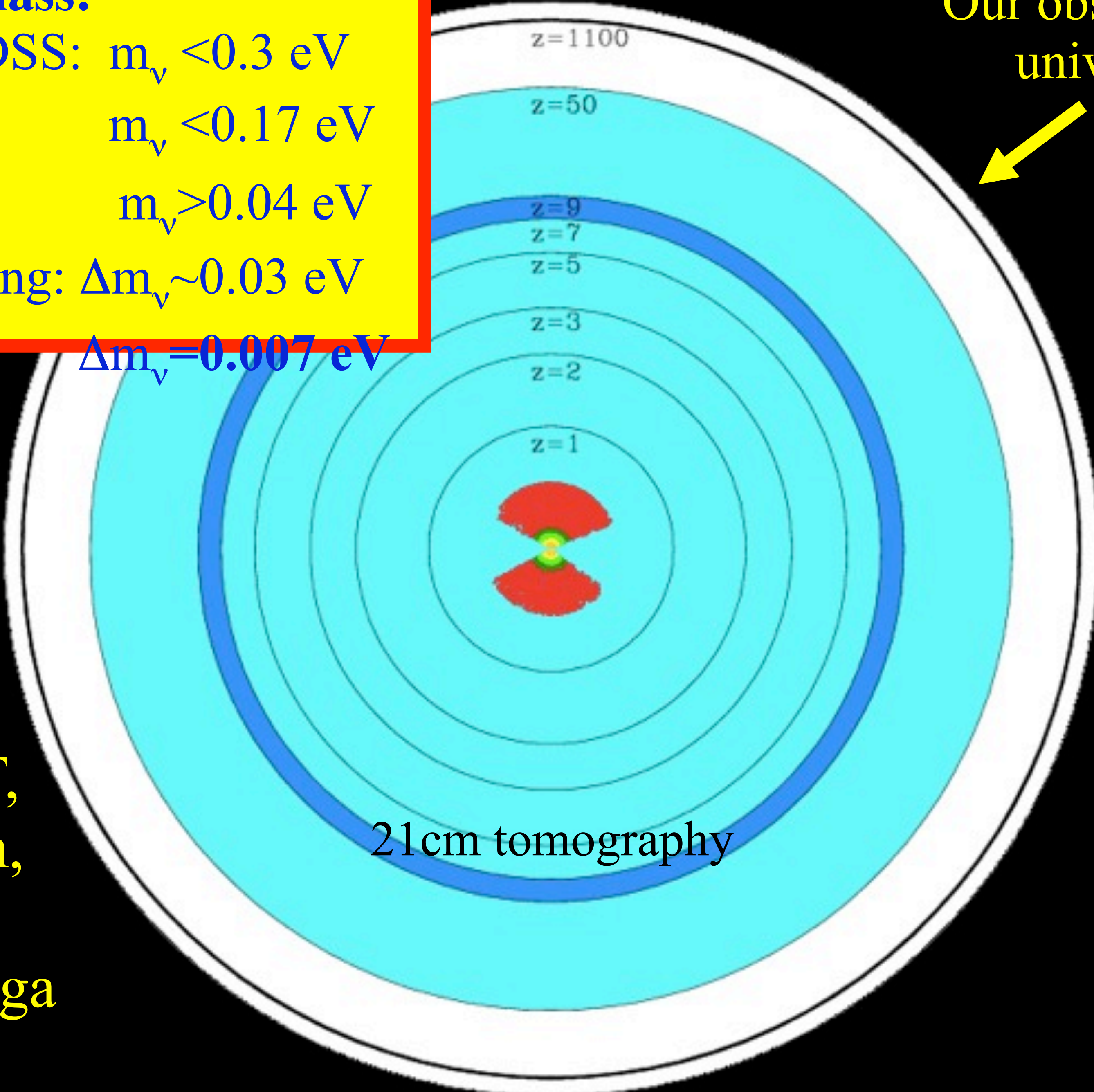
+LyαF: $m_\nu < 0.17$ eV

Oscillations $m_\nu > 0.04$ eV

Future lensing: $\Delta m_\nu \sim 0.03$ eV

21cm: $\Delta m_\nu = \mathbf{0.007}$ **eV**

Our observable universe



Mao, MT, McQuinn, Zahn & Zaldarriaga 2008

What can we build that's huge yet affordable?

Omniscopes: Large Area Telescope Arrays with only N log N Computational Cost

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Matias Zaldarriaga

arXiv:0909.0001

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How get huge sensitivity at low cost?

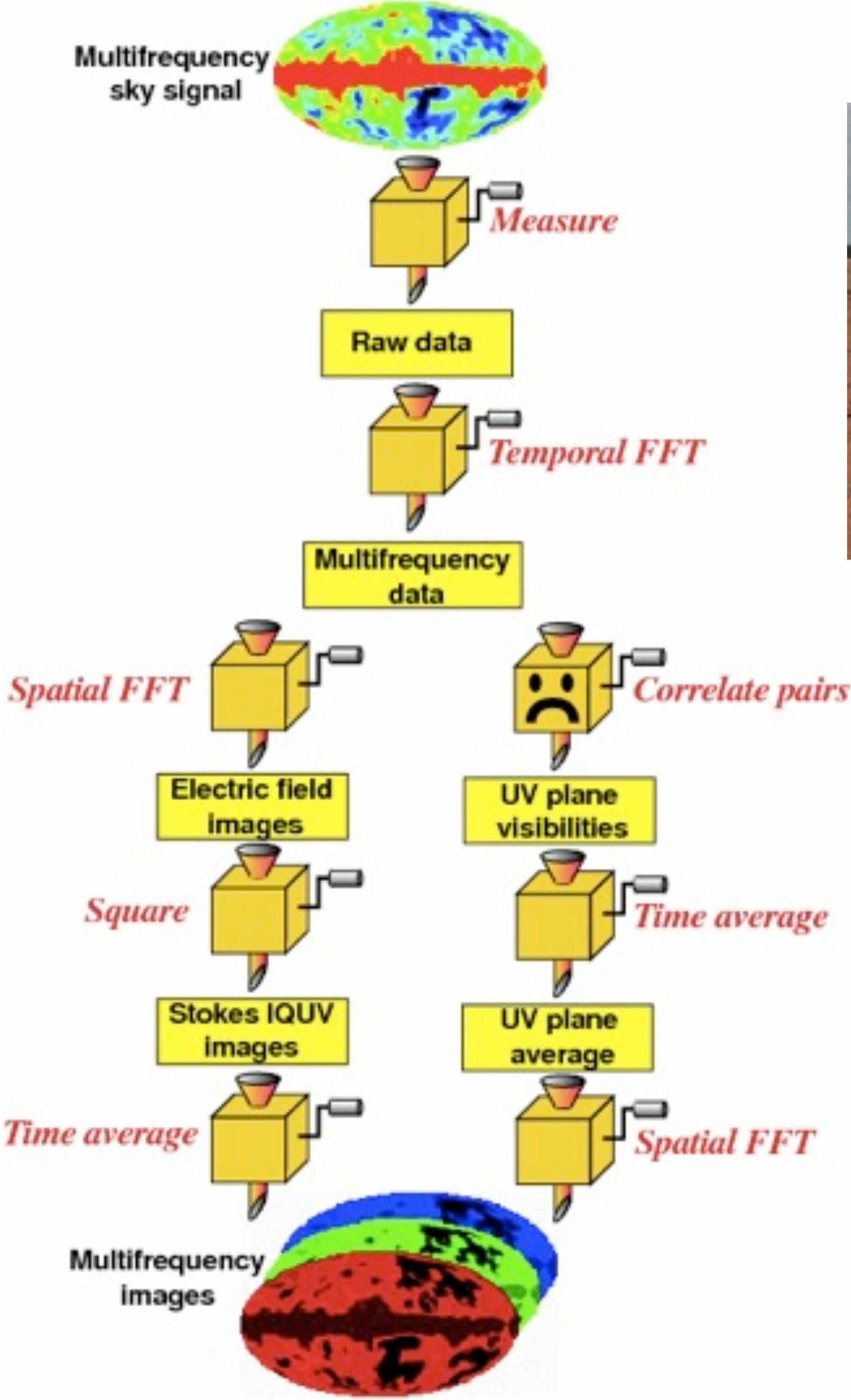
Sensitivity $\delta T \propto (A\Omega)^{-1/2}$

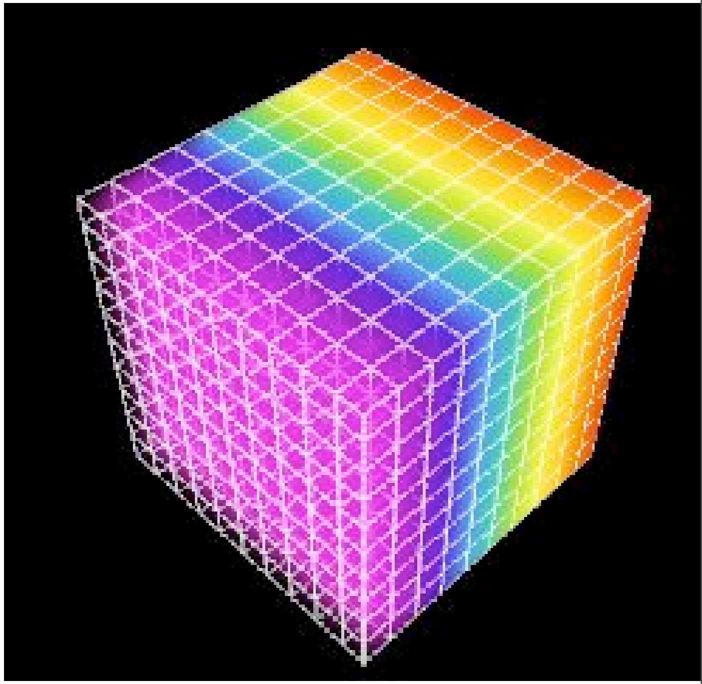
Single-dish telescope:
cost $\propto A^{1.35}$

Interferometer:
cost $\propto N^2 \propto A^2$

FFTT telescope idea:
cost $\propto A$, $\Omega \sim 2\pi$

Telescopes as Fourier transformers





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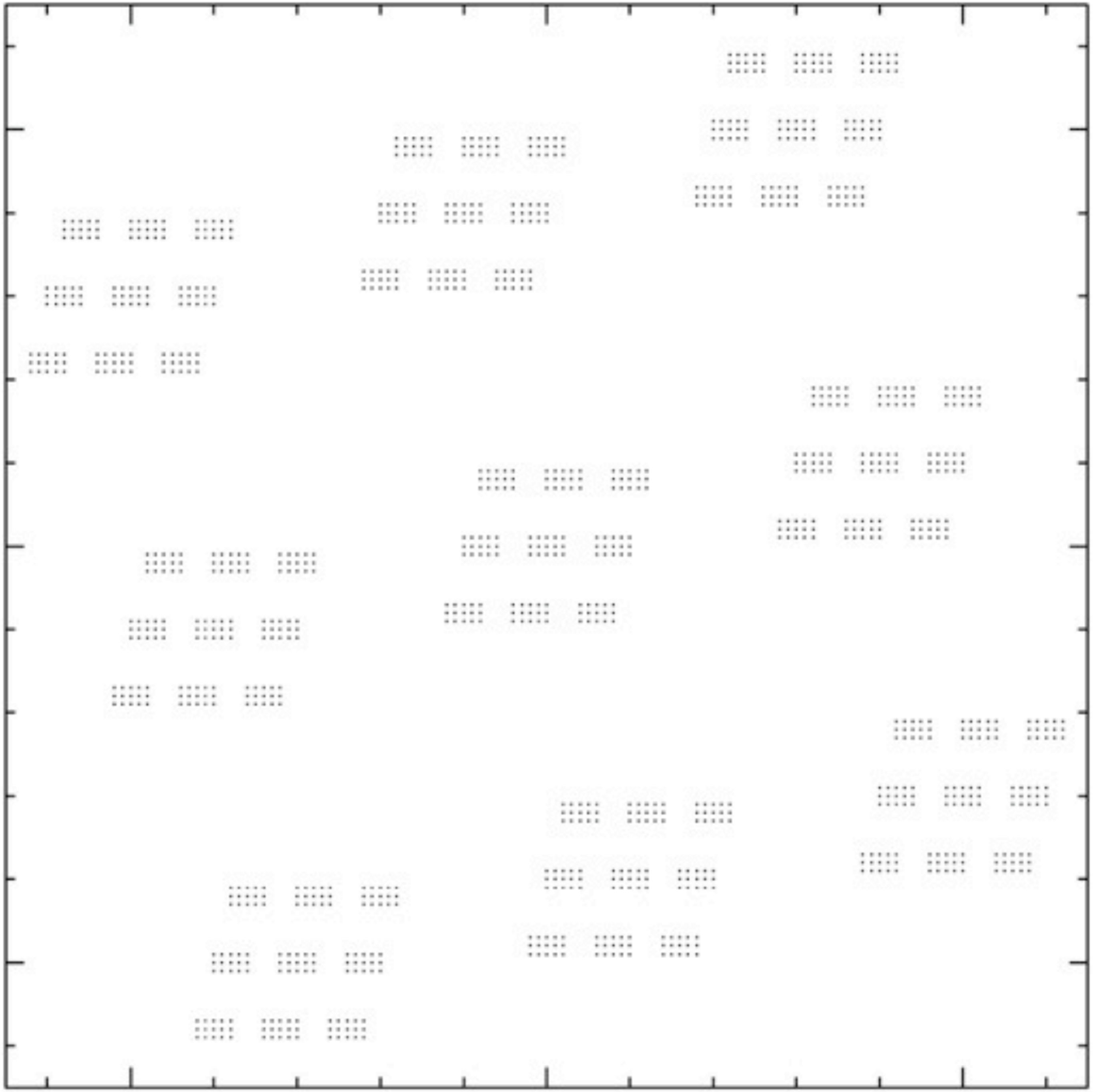

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Correlate this:

1 2 3 0 0 0 4 5 6

$$
\begin{aligned}
\mathbf{g} &= (1\ 2\ 3\ 0\ 0\ 0\ 4\ 5\ 6) \star (6\ 5\ 4\ 0\ 0\ 0\ 3\ 2\ 1) \\
&= (6\ 17\ 32\ 23\ 12\ 0\ 27\ 58\ 91\ 58\ 27\ 0\ 12\ 23\ 32\ 17\ 6)
\end{aligned}
$$

However, by instead arranging the measured data in a 2D array, we can obtain the same answer by performing a 2D convolution exploiting 2D FFTs:

$$
\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{pmatrix} \star \begin{pmatrix} 6 & 5 & 4 \\ 3 & 2 & 1 \end{pmatrix} = \begin{pmatrix} 6 & 17 & 32 & 23 & 12 \\ 27 & 58 & 91 & 58 & 27 \\ 12 & 23 & 32 & 17 & 6 \end{pmatrix}. \qquad (2)
$$

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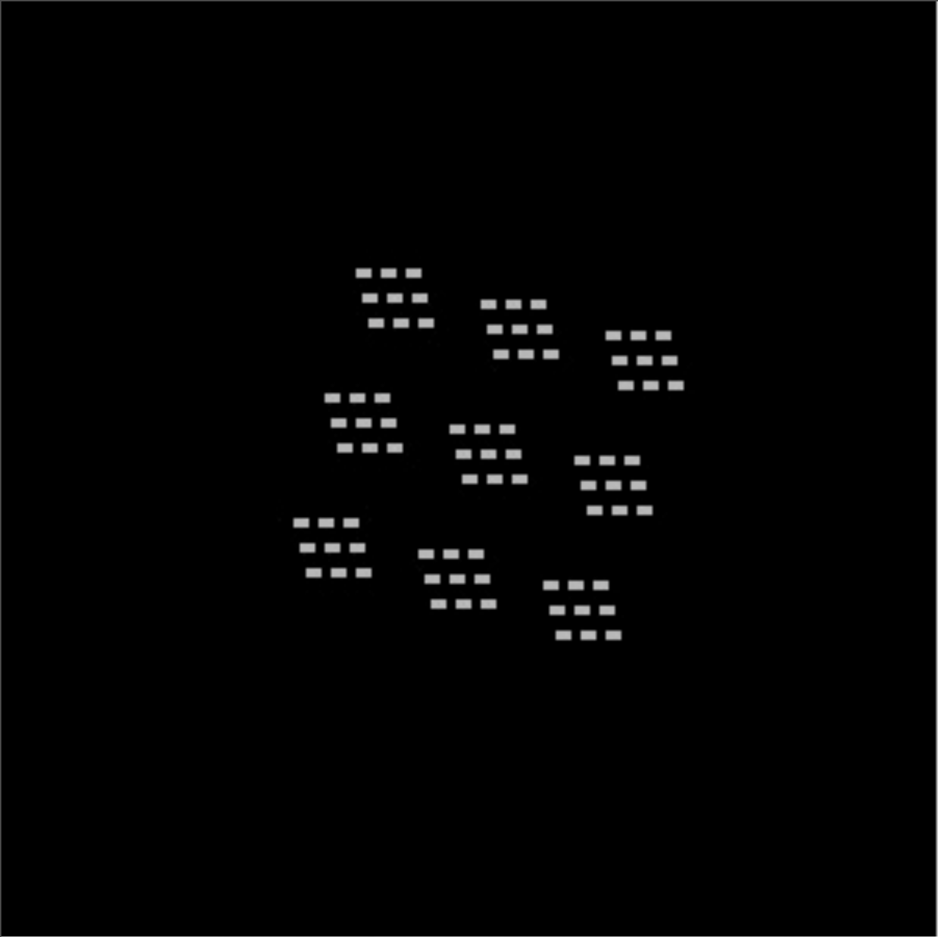
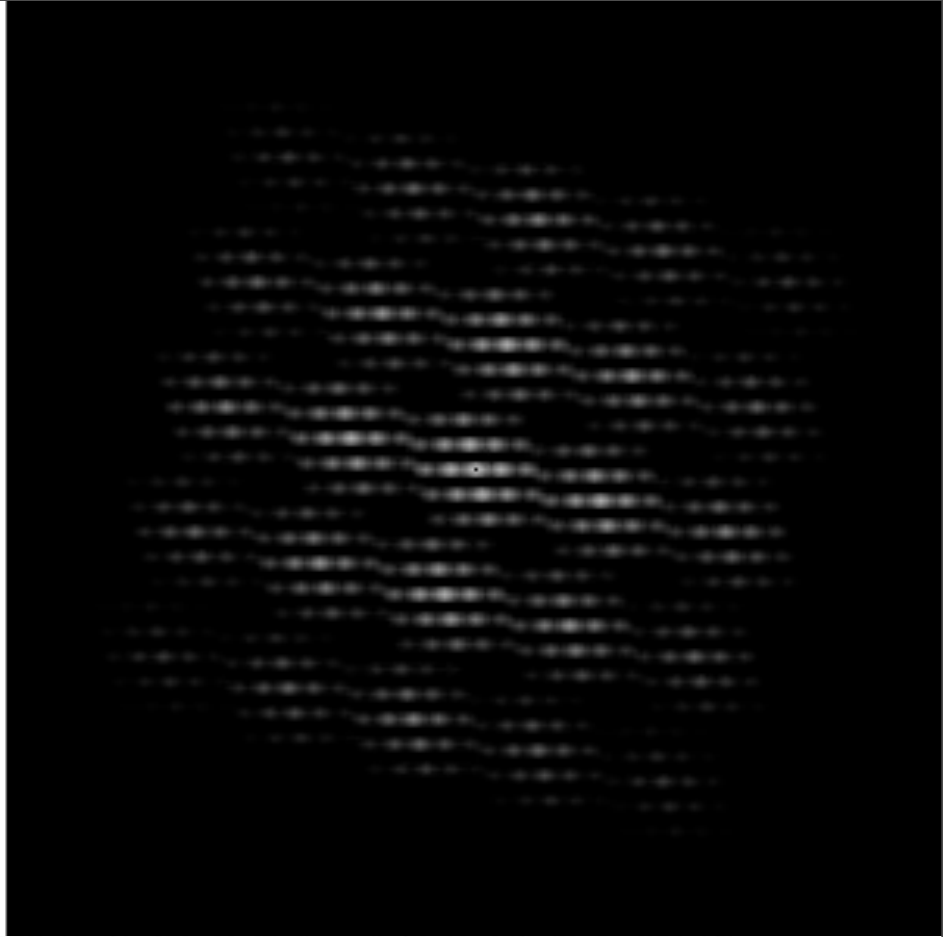
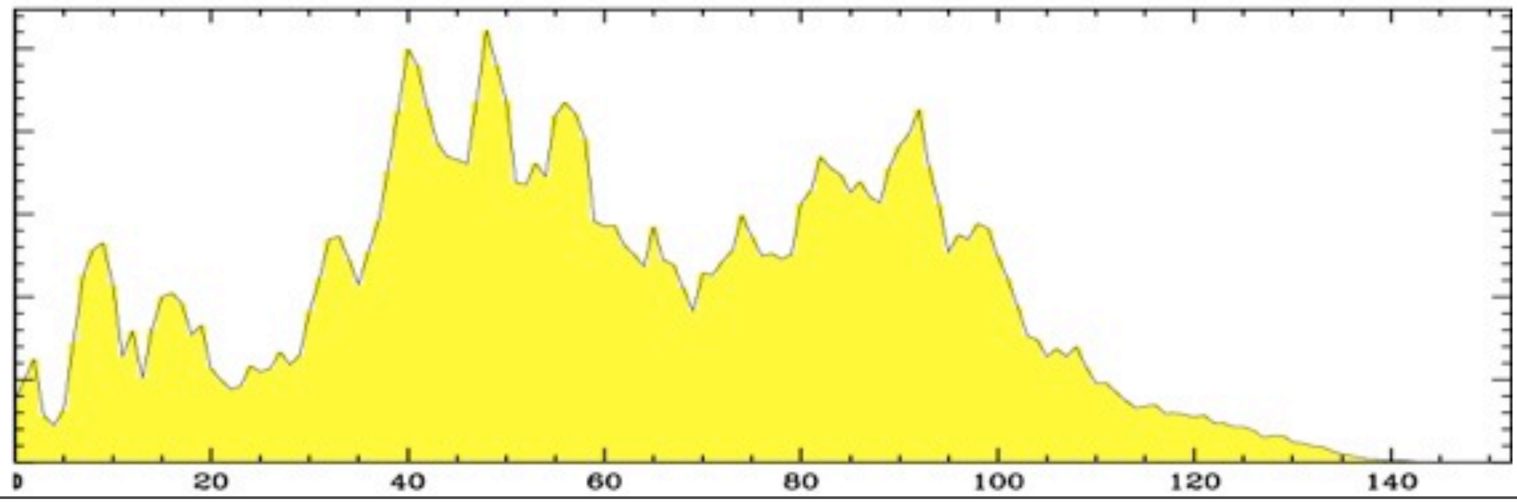
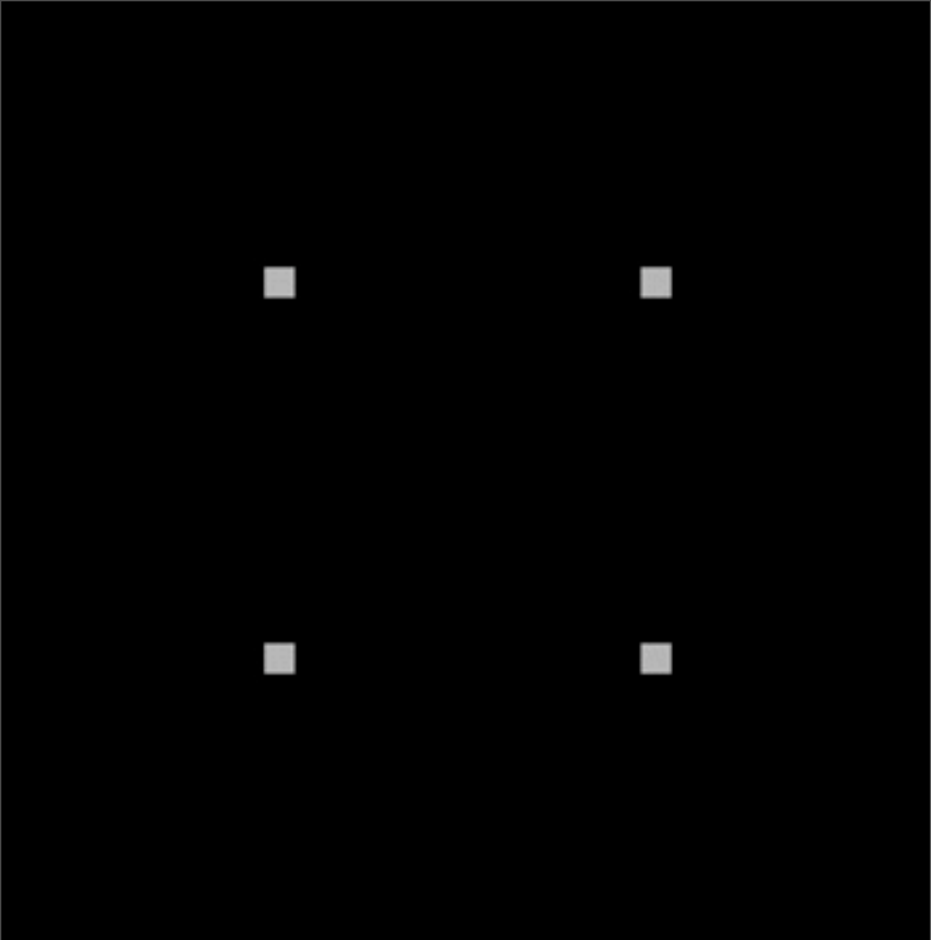
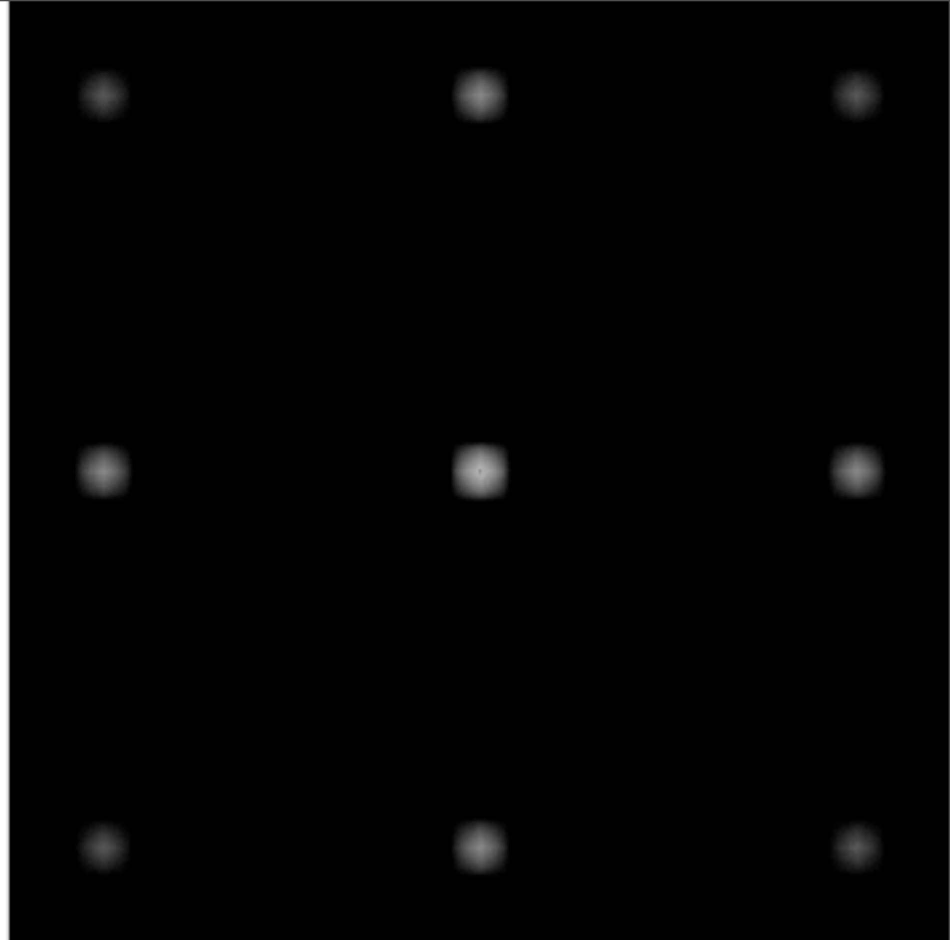
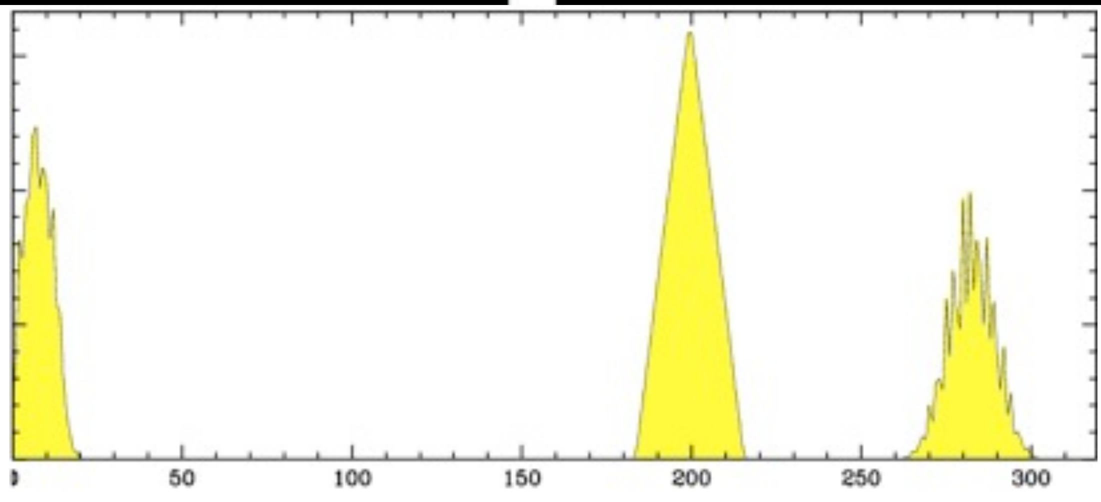


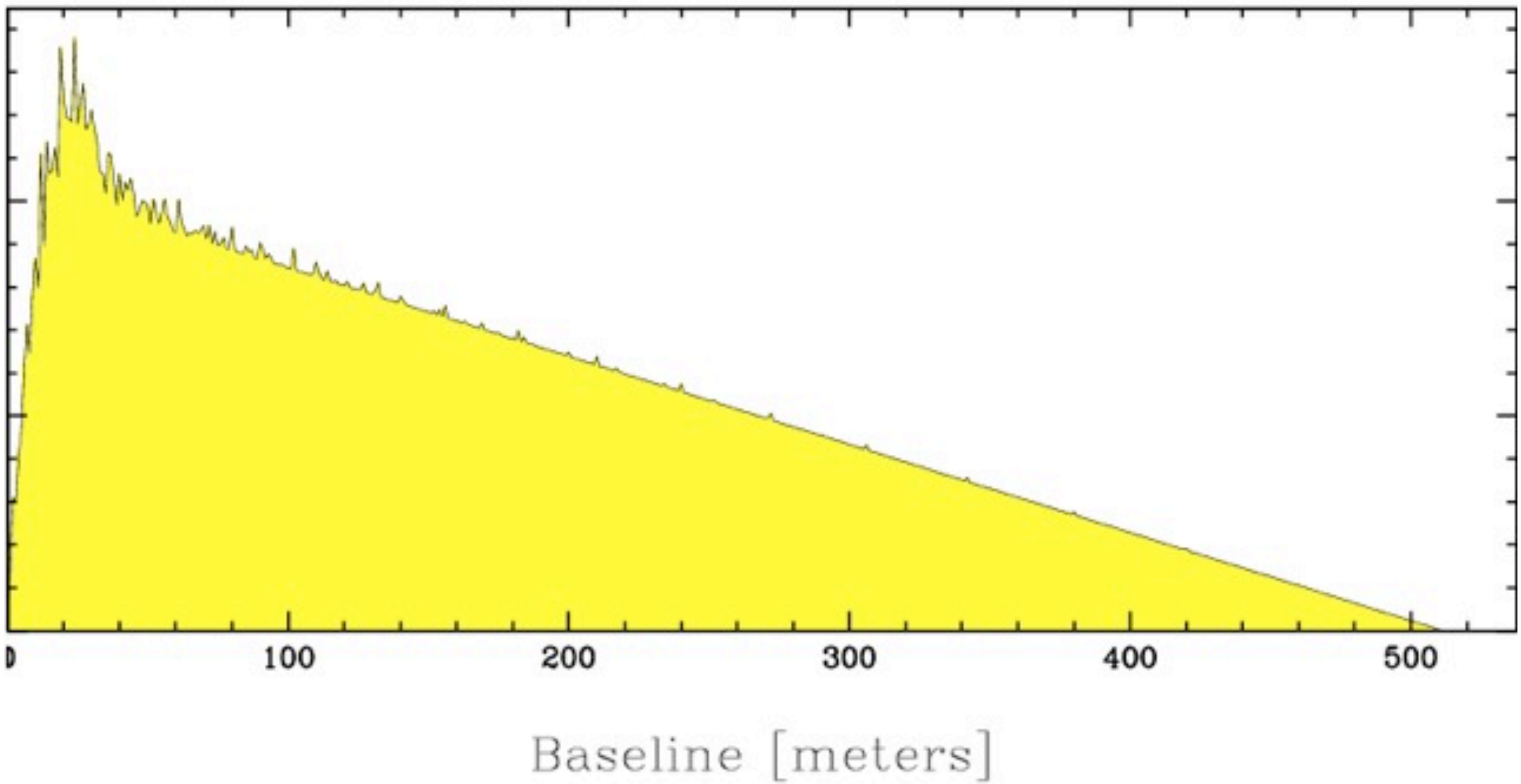


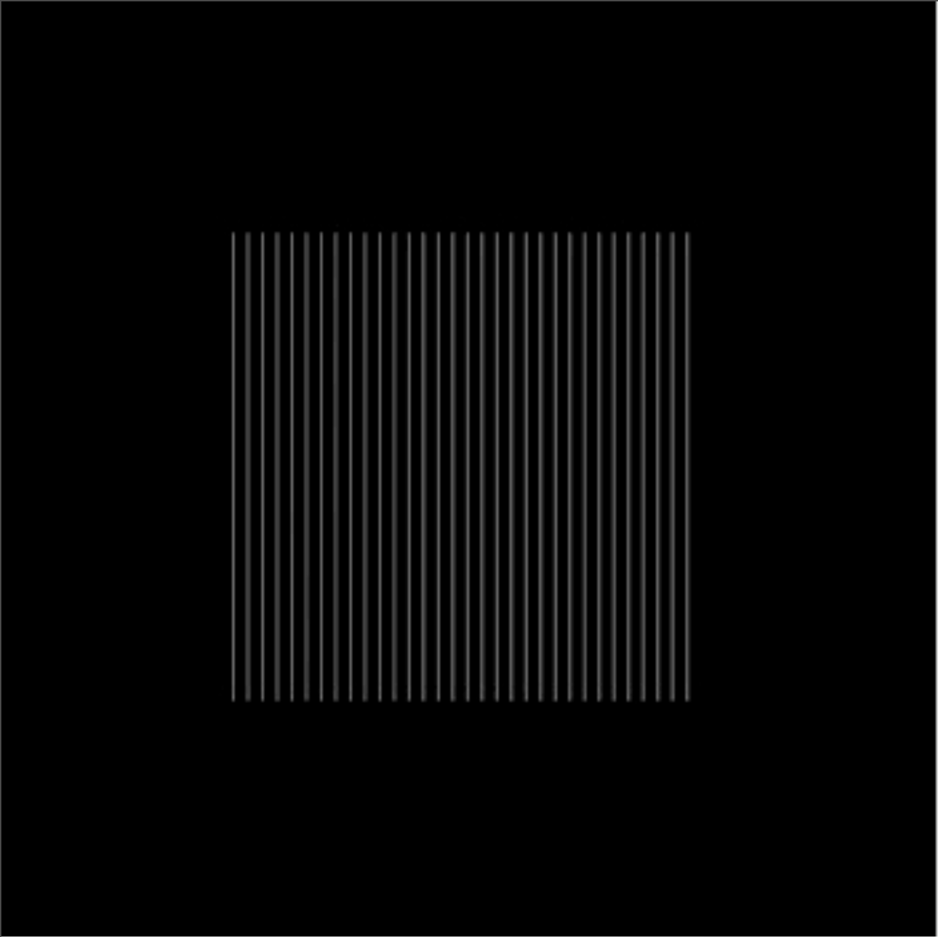

0
20
40
60
80
100
120
140

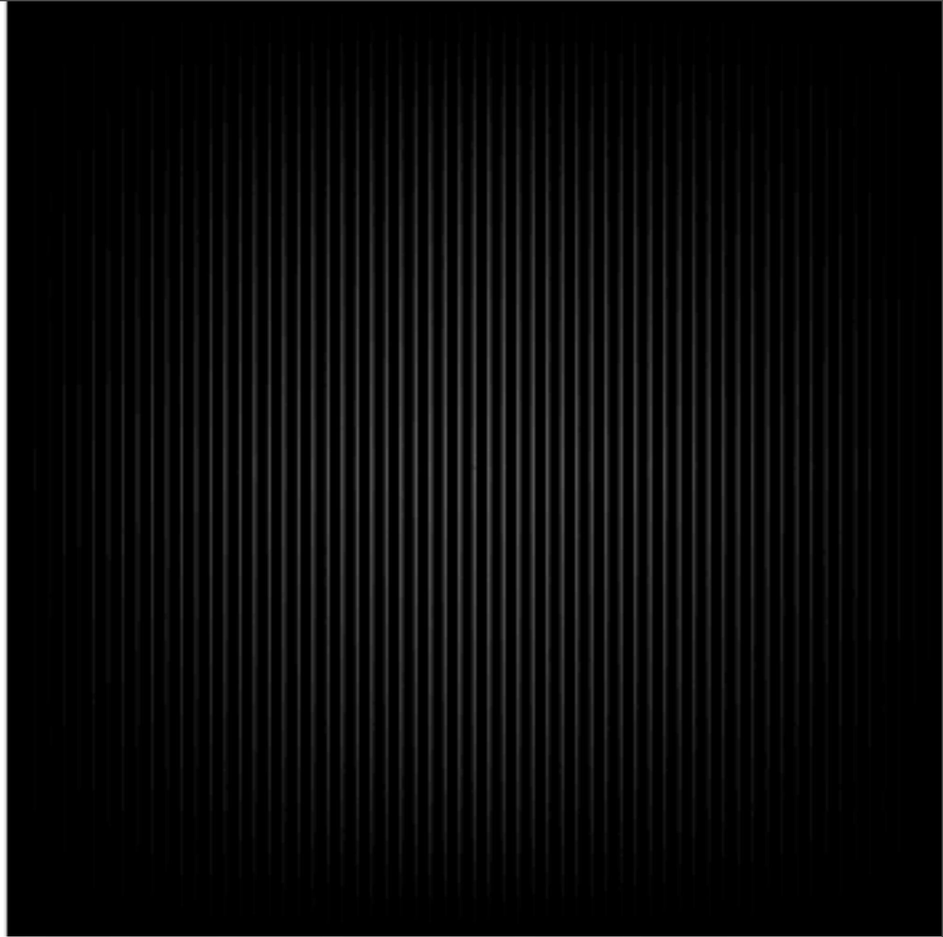


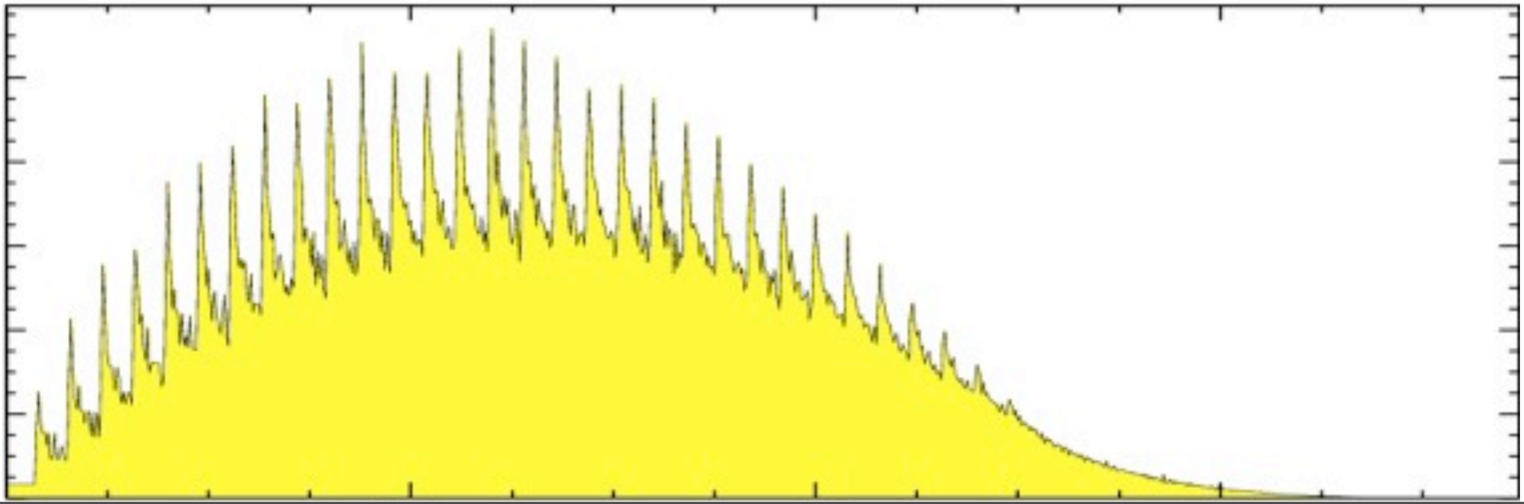


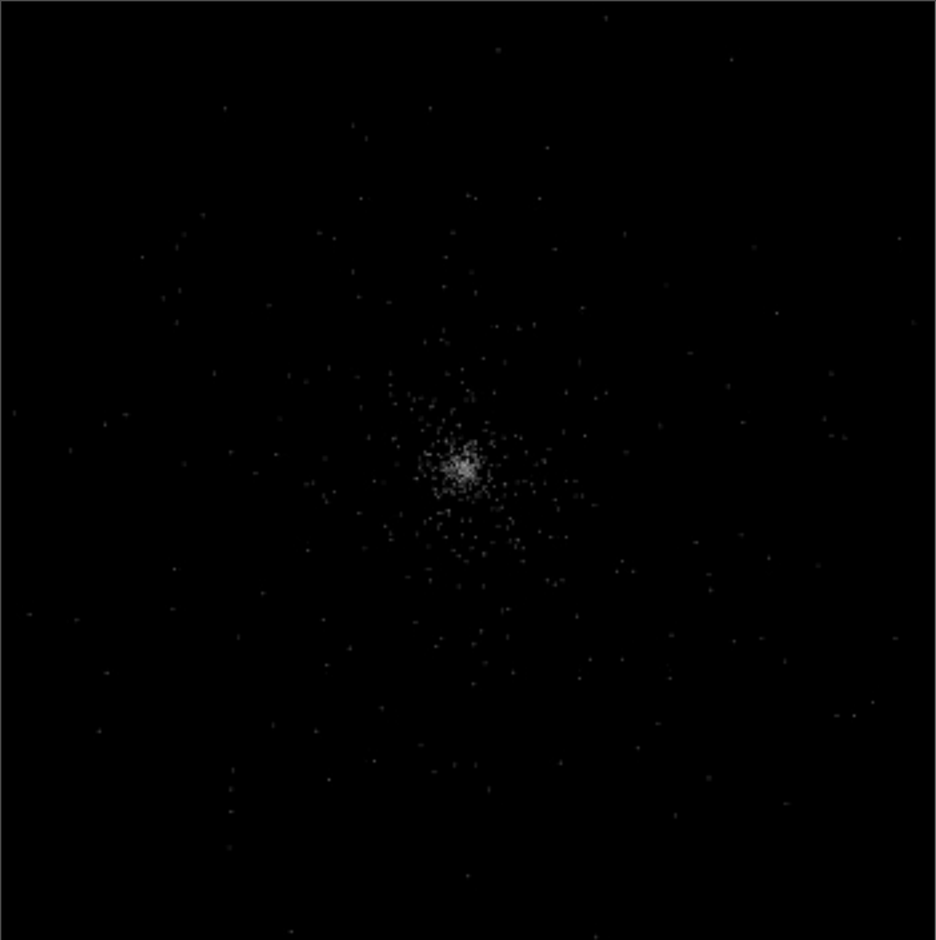

0
50
100
150
200
250
300

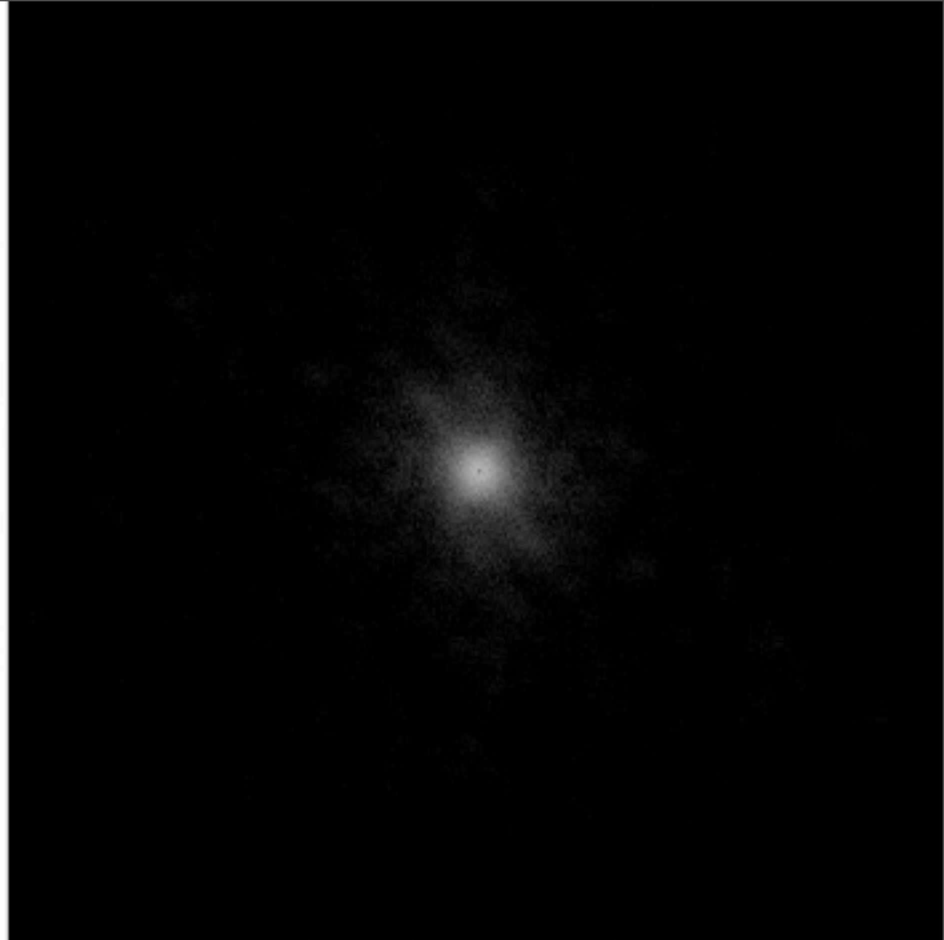

0
100
200
300
400
500
Baseline [meters]

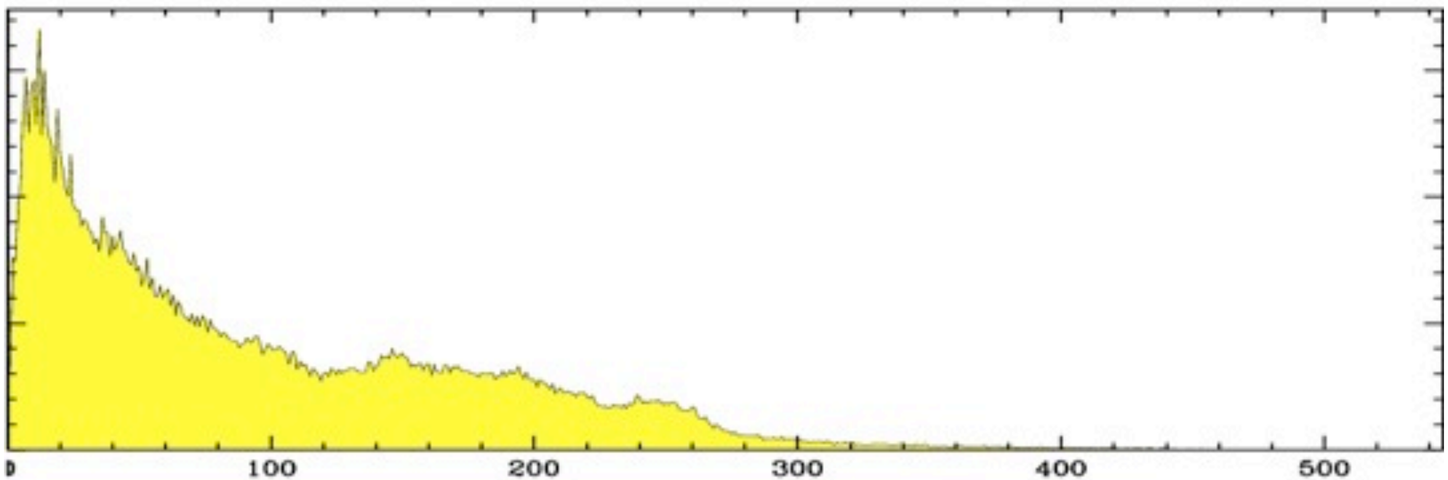




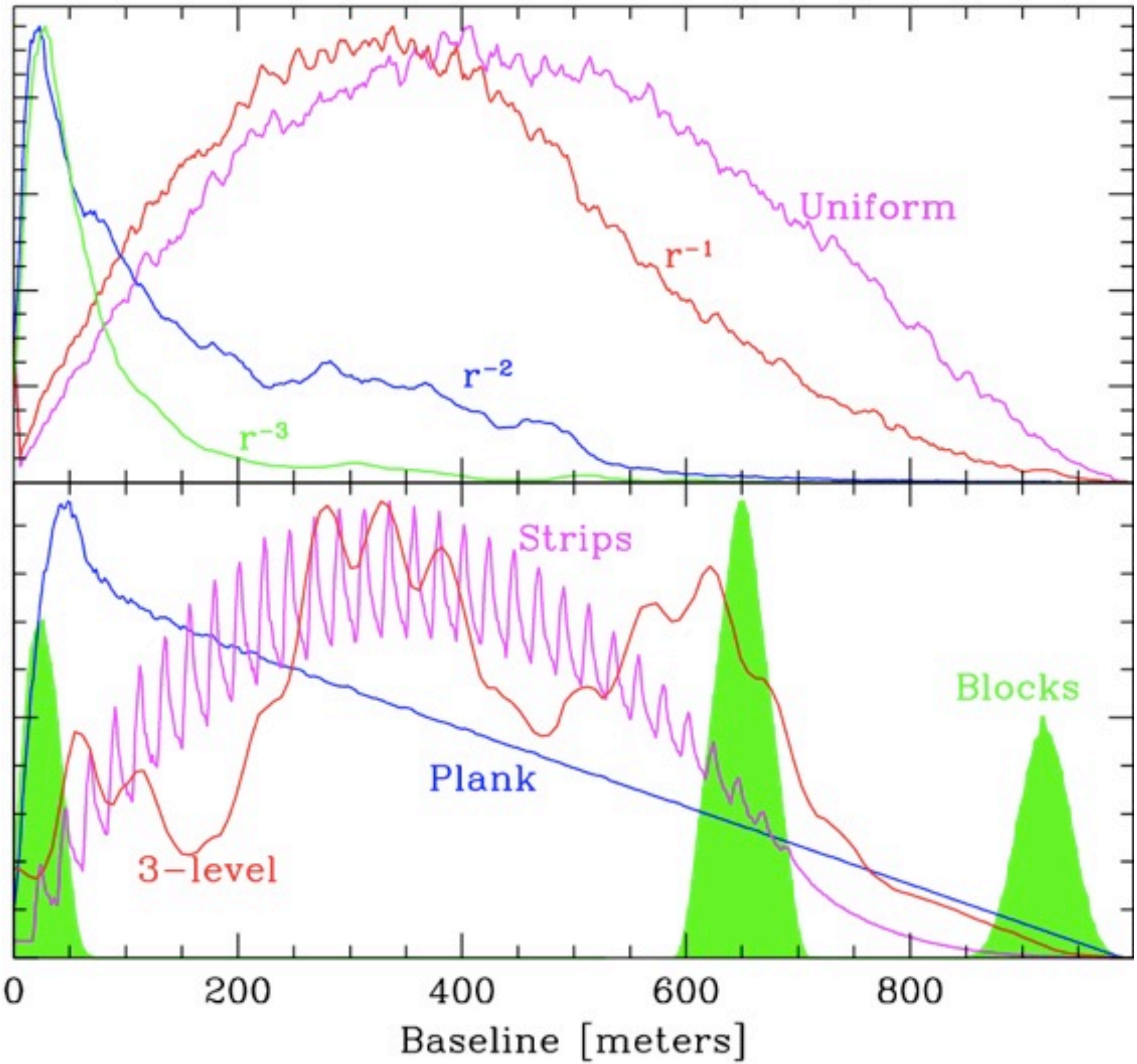








0
100
200
300
400
500


Uniform
r⁻¹
r⁻²
r⁻³
Strips
Blocks
Plank
3-level
0
200
400
600
800
Baseline [meters]