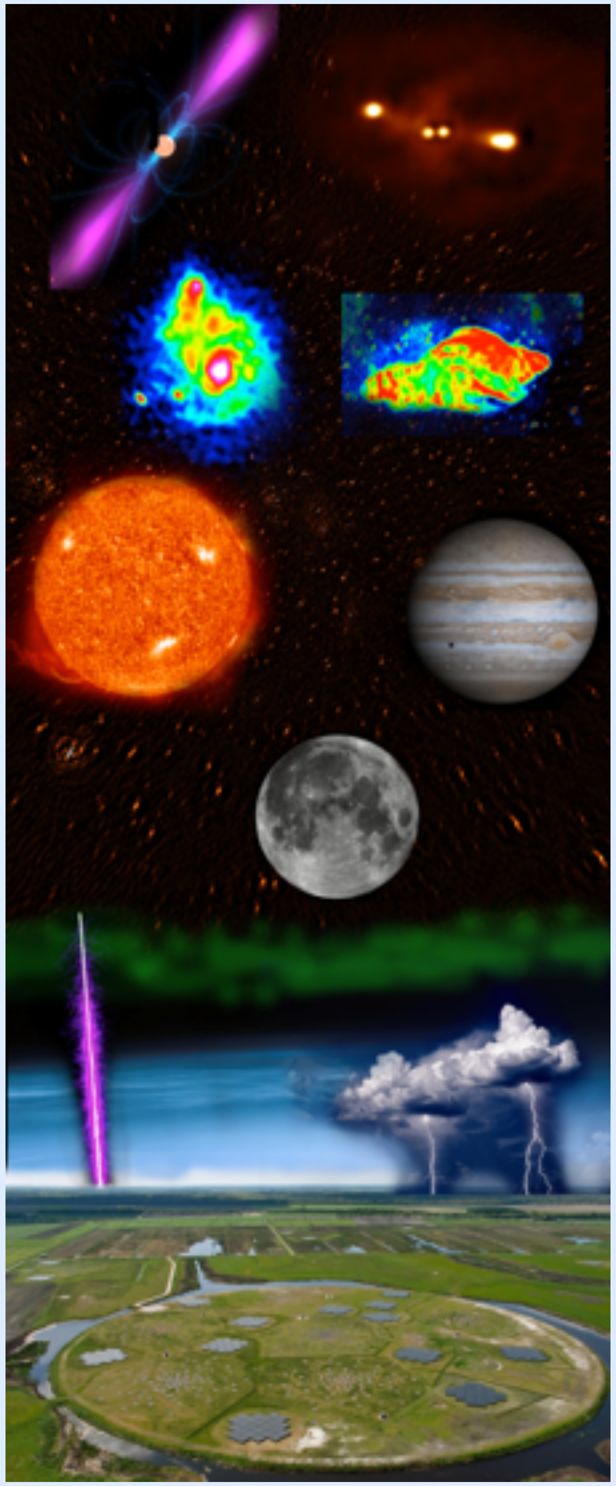
LOFAR, SKA
ASTRON contribution to Obelics

Tammo Jan Dijkema & Sebastiaan van der Tol

Obelics F2F, Rome, 26 January 2016

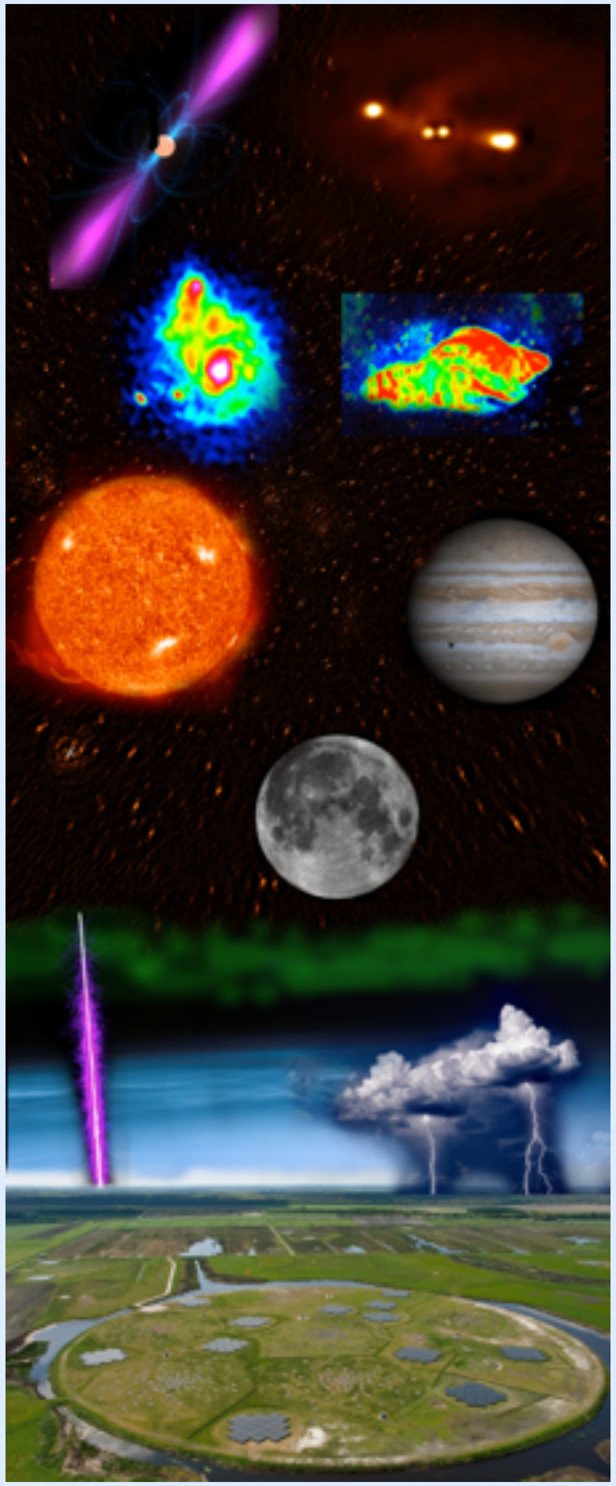
LOFAR introduction



Many types of science

- Epoch of Reionization
- Galaxies, AGNs
- Low frequency sky survey
- Pulsars
- Transients
- Interstellar medium
- The Sun, moon, planets
- Cosmic rays
- Ionosphere
- Lightning
- Earthquakes
- Etc.

LOFAR introduction



Key scientific figures:

- 5th observing cycle
- 5.000 hours observed
- ~ 100 refereed papers (several Science / Nature)
- PI's from >10 countries
- Oversubscription:
  - 2.0 (observe)
  - 1.5 (compute)

Why large radio telescopes

Diameter of telescope should be at least 10× the wavelength of the signal. At 30MHz, wavelength is c / 30MHz = 10 meter.

For sharp pictures, we want a high angular resolution

$$\text{pixel size} \sim \frac{\lambda}{D}$$

λ : wavelength of observed sky

D : diameter of telescope

So to have nicer pictures, we need larger telescopes!

Pictures of large telescopes

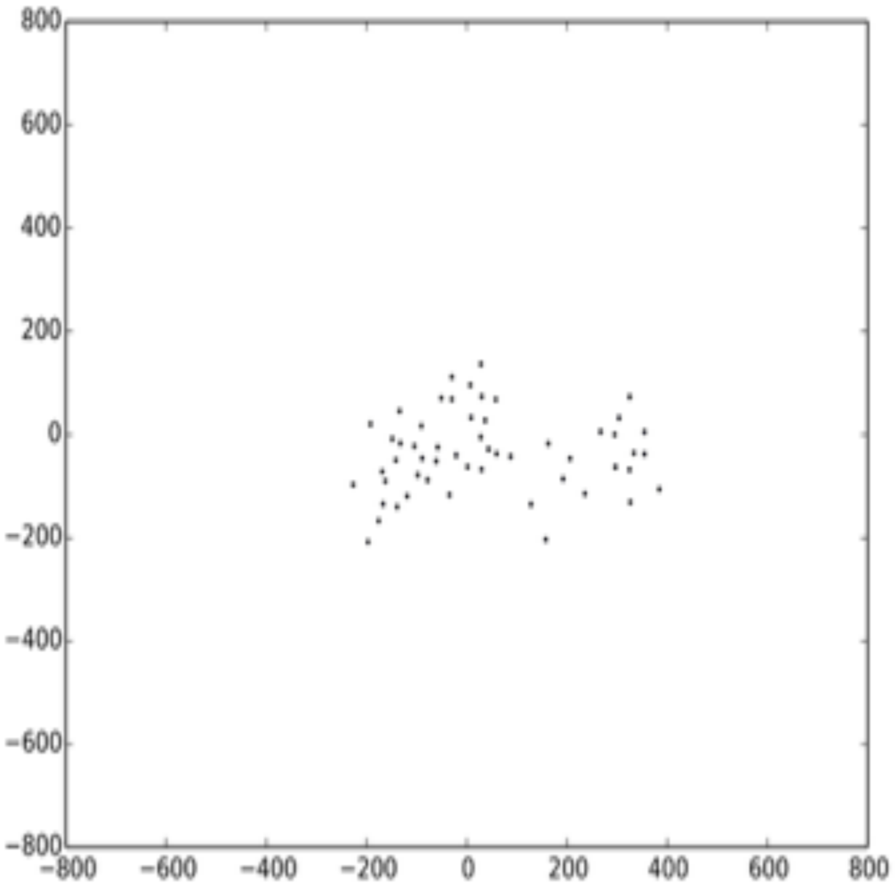
ASTRON

Effelsberg (1972)
100 meter

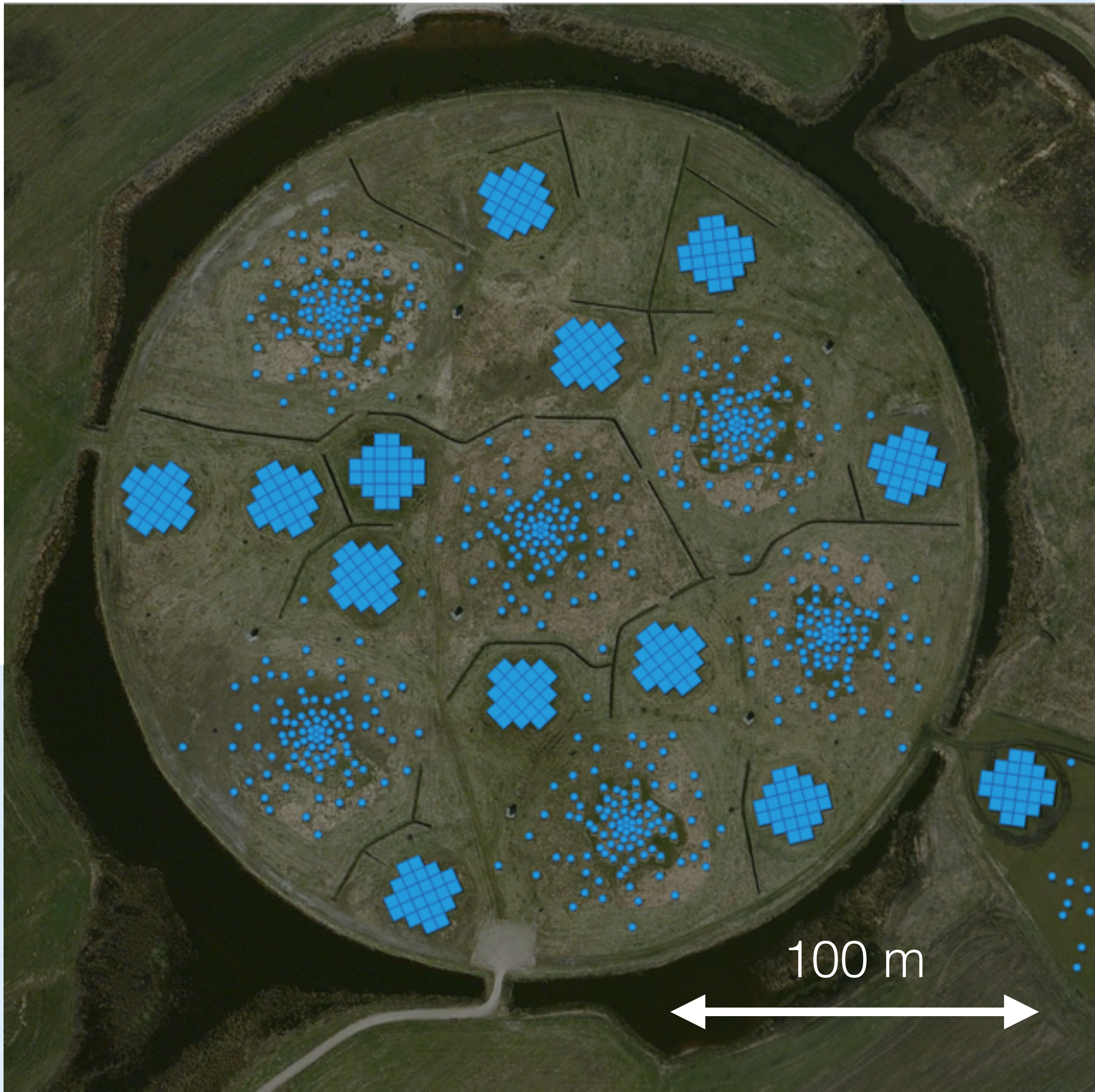
Arecibo (1963)
305 meter

FAST (2016)
500 meter

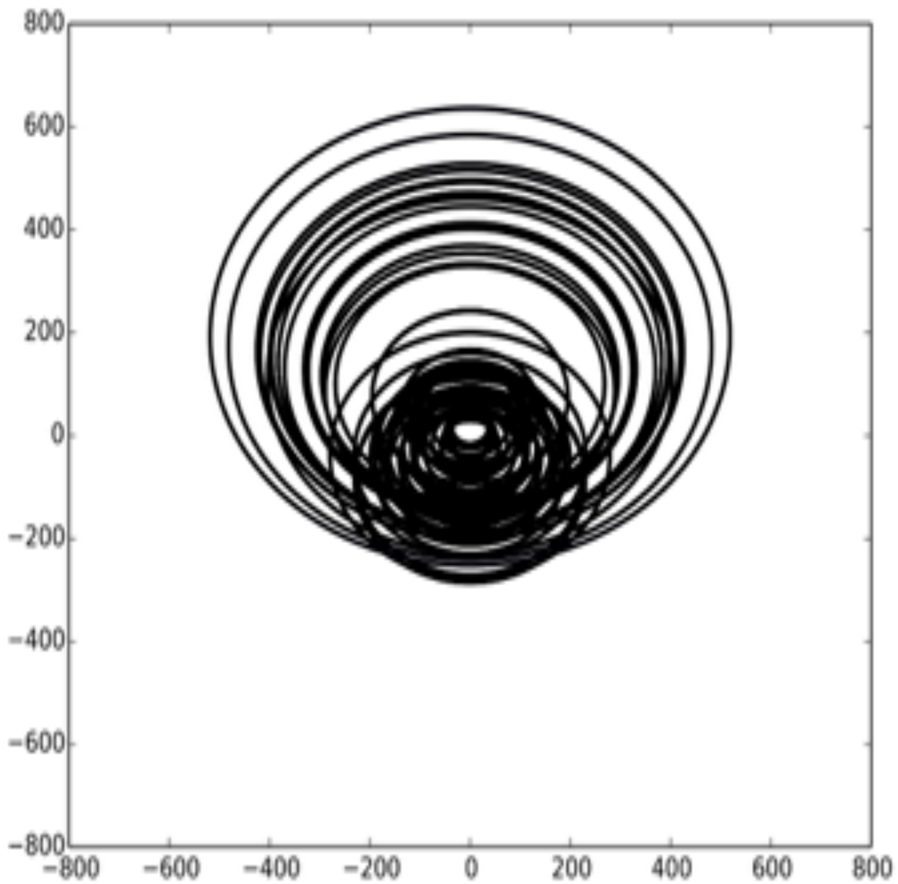
Filling the Fourier plane



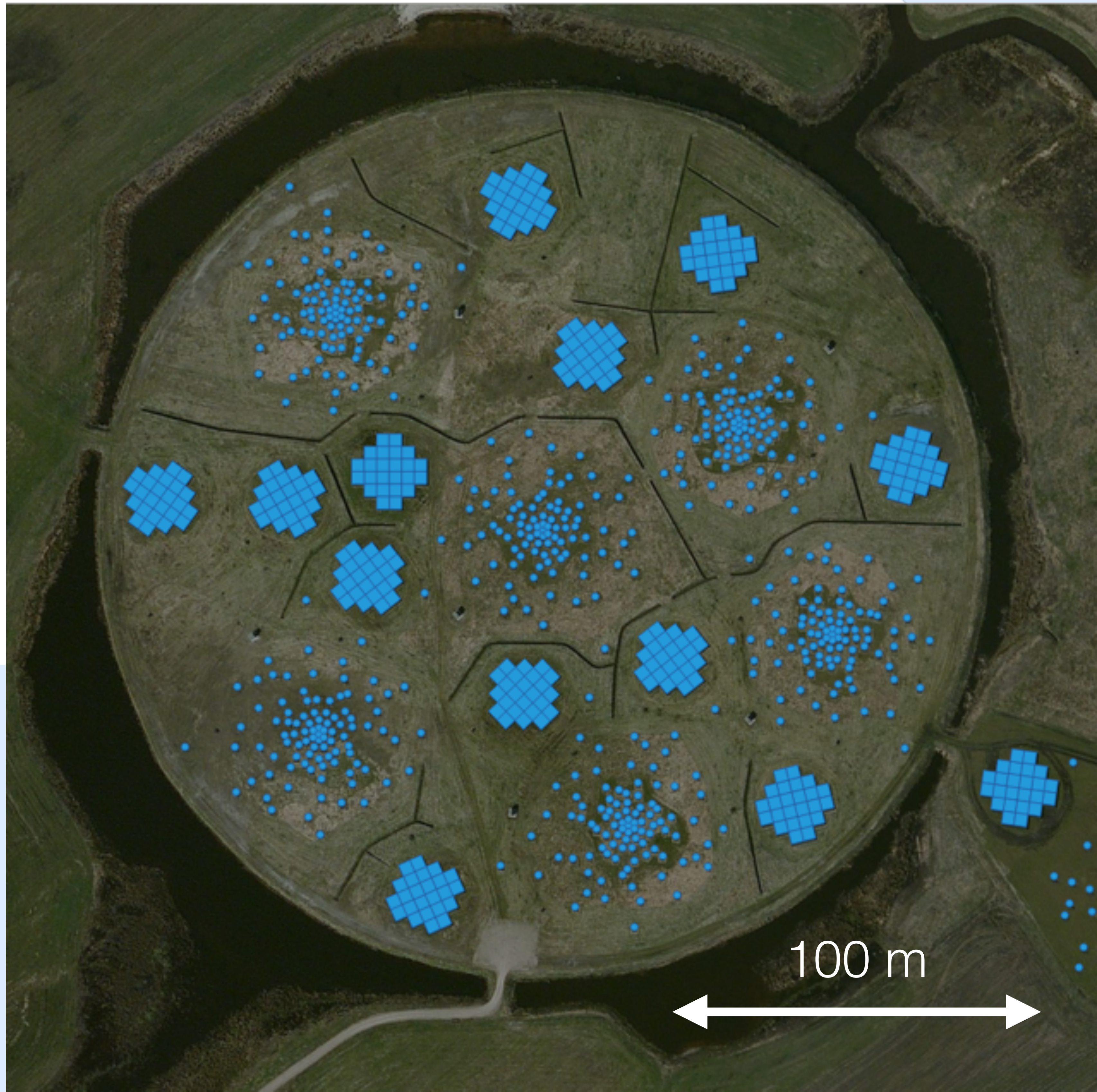
$\vec{b}$ (meter)



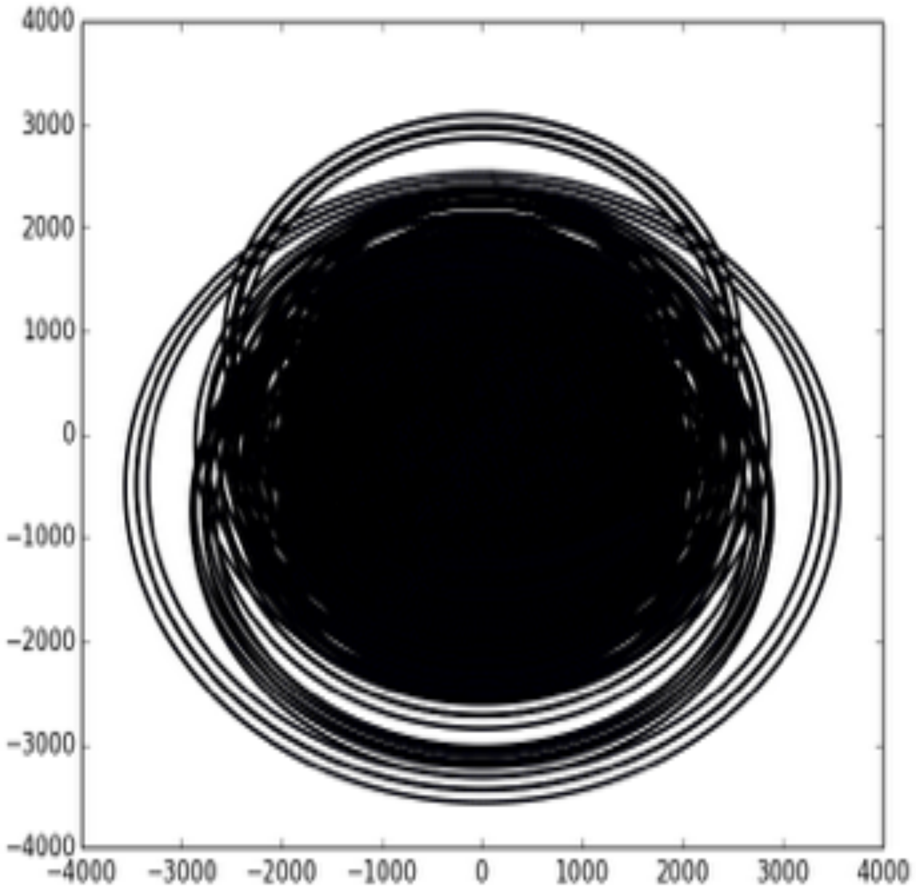
Filling the Fourier plane



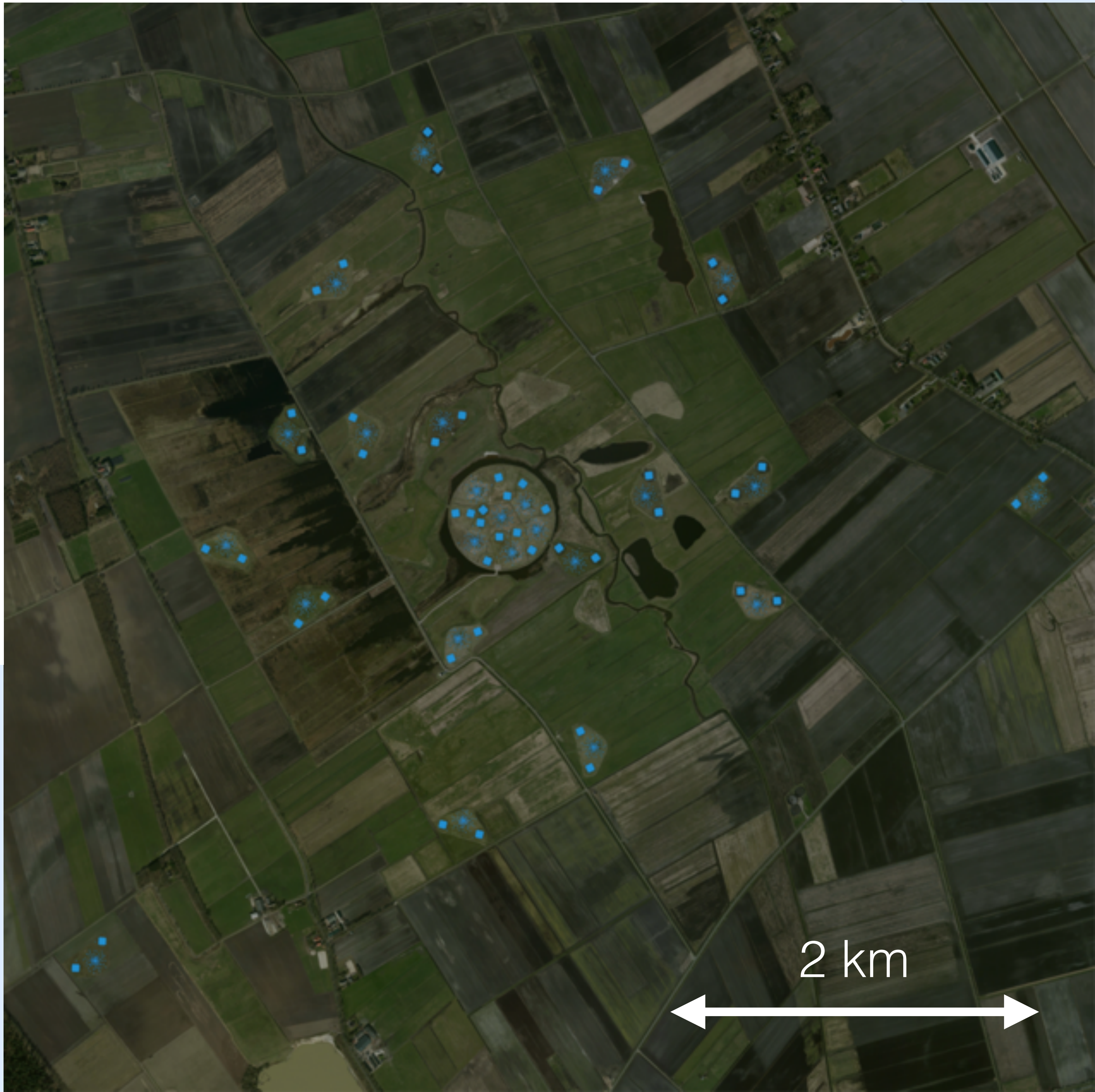
$\vec{b}$ (meter)



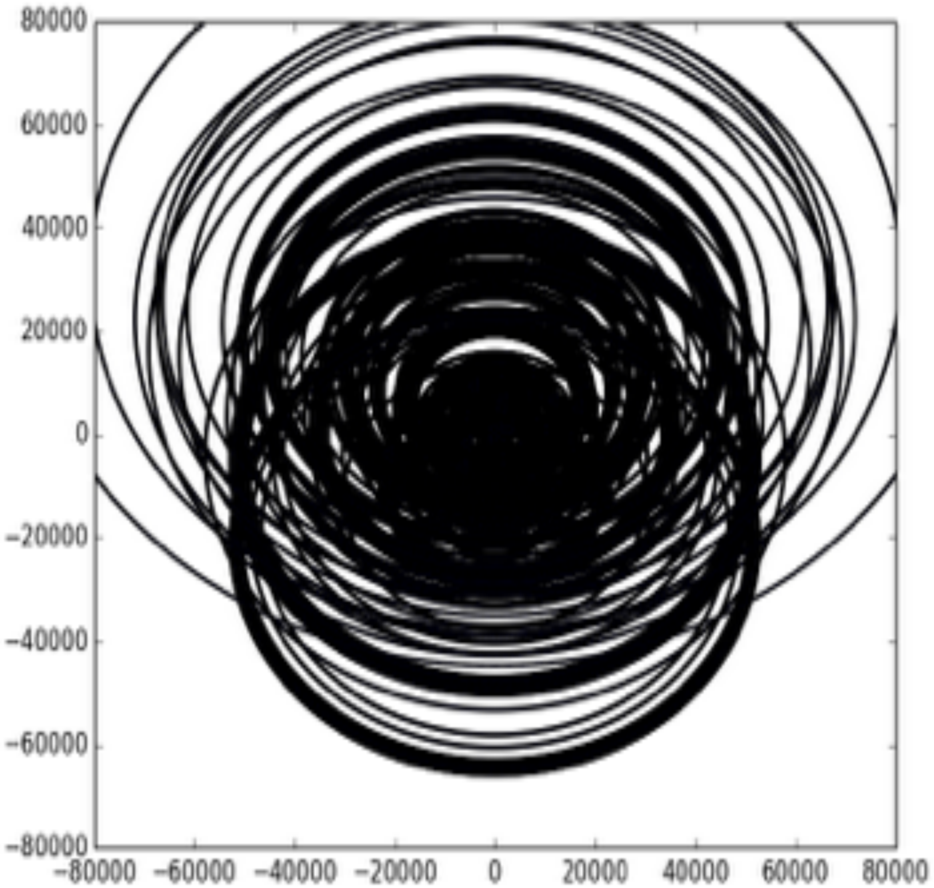
Filling the Fourier plane



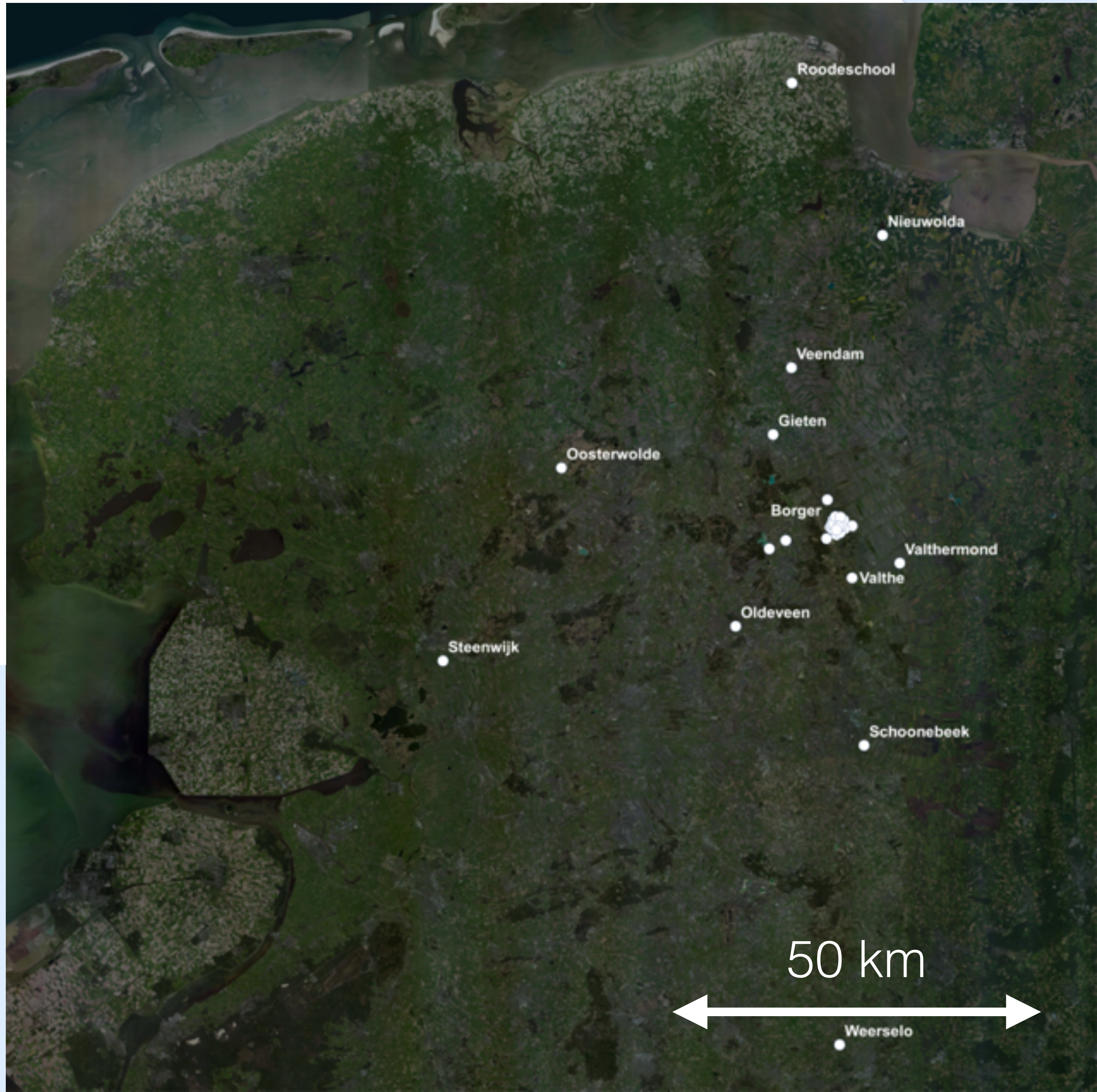
$\vec{b}$ (meter)



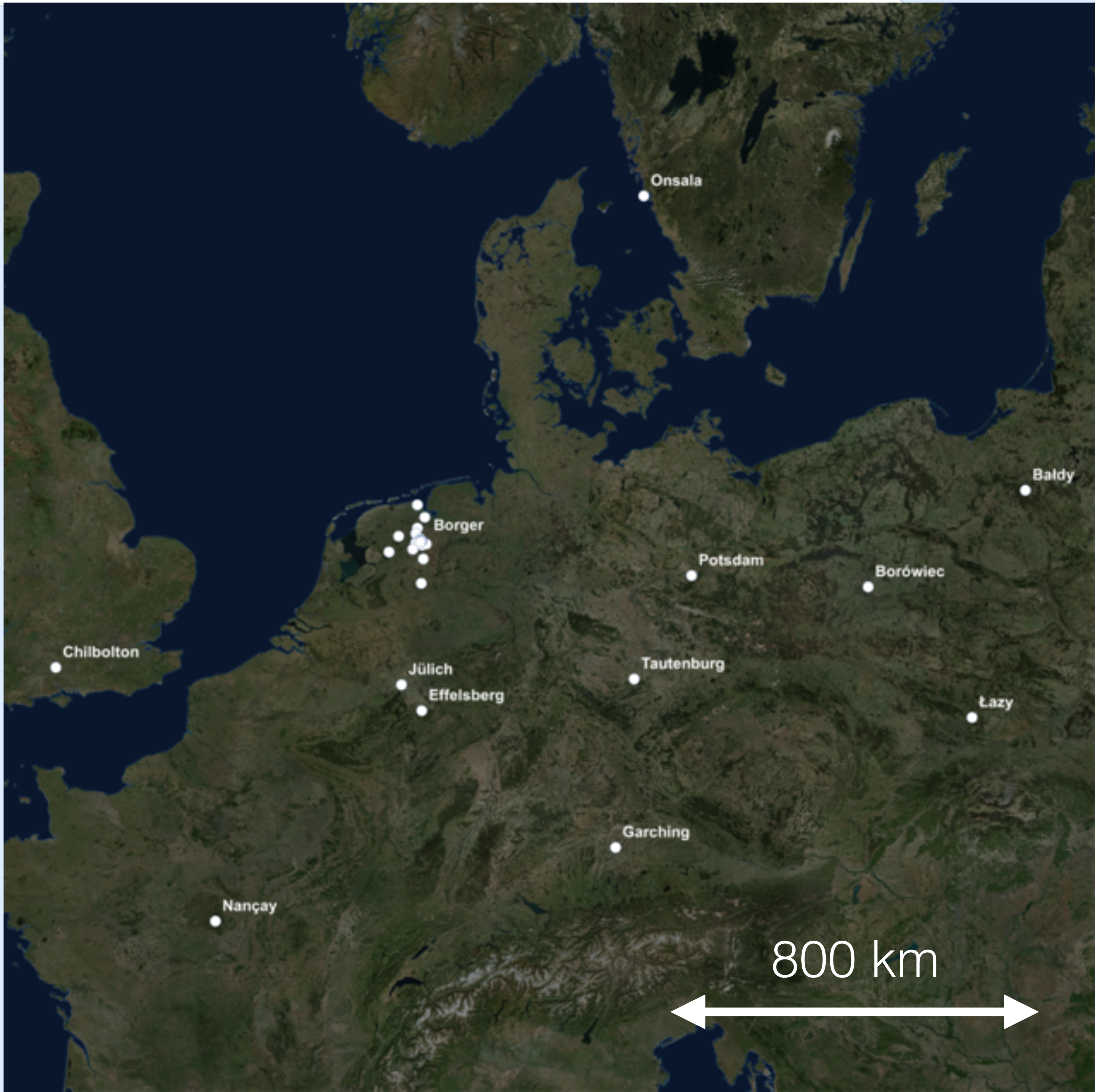
Filling the Fourier plane



$\vec{b}$ (meter)



Filling the Fourier plane



Processing overview

ASTRON

Antennas / Stations

on-site reduction

200 Gbit/s

Realtime System

8 node GPU correlator

80 Gbit/s

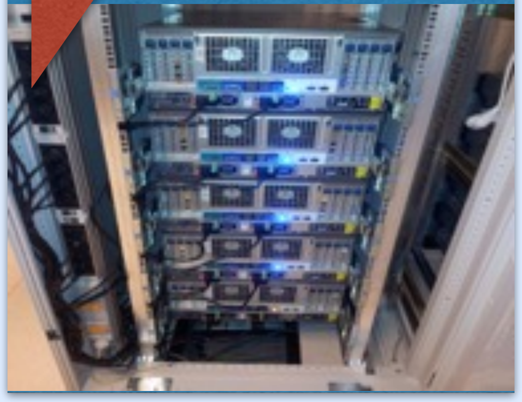
Offline Processing

~ 100 node CPU cluster

2 Gbit/s

Long Term Archive

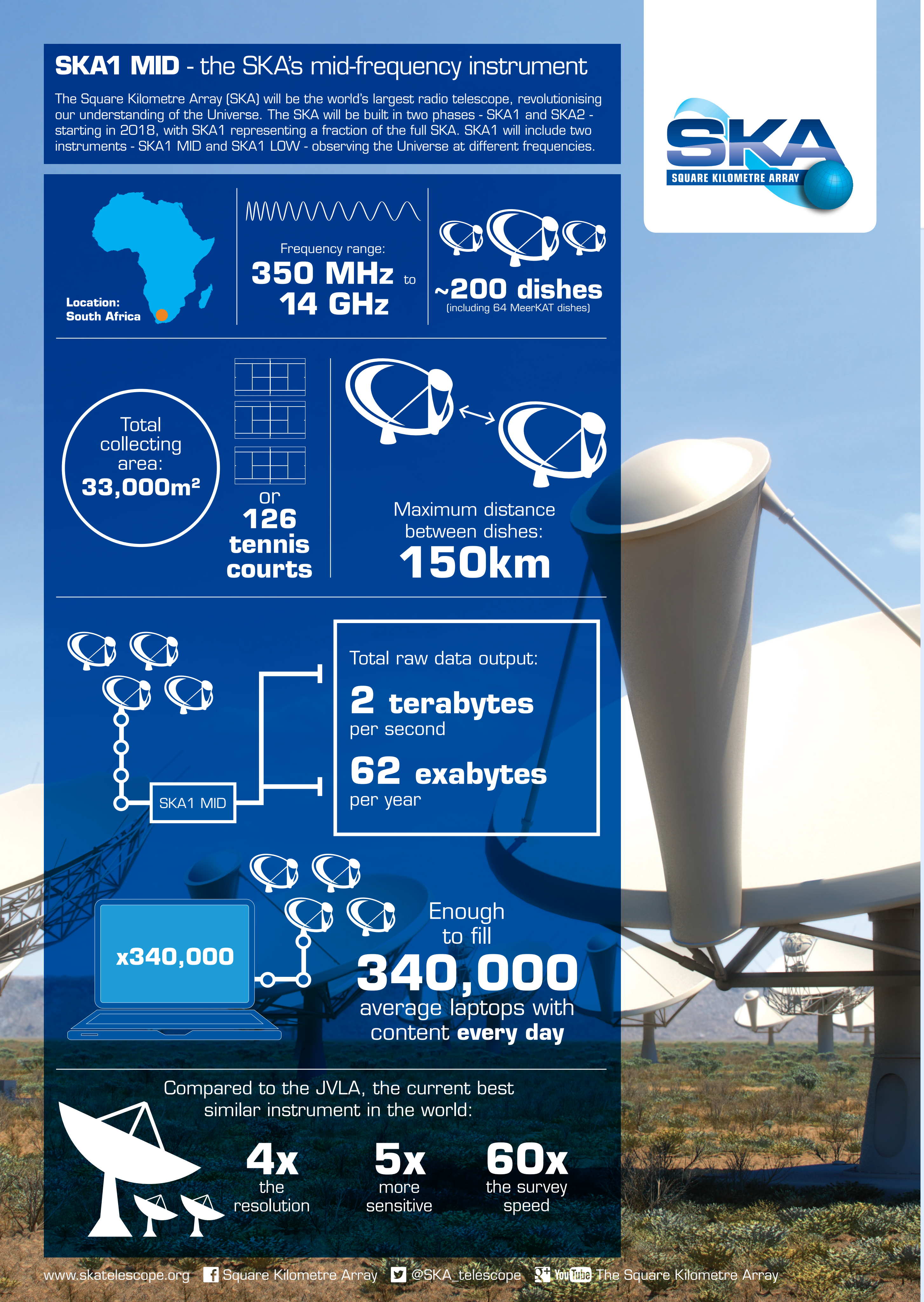
4 grid sites ~20 Petabyte



Offline data reduction challenges

ASTRON

- **Calibrate** the instrument (using model sky)
  - Efficient parameter fitting
  - Algorithms SAGECAL, STEFCAL
  - Program DPPP, streaming framework
- Recover an **image** of the sky:
  - Efficient gridding of UV data on GPUs
  - Fourier Transform
  - Deconvolution algorithm CLEAN
  - Program AWIMAGER, using CASA



LOFAR

52,000m^2 collecting area
~ 50,000 antennas
Operational now

SKA1 LOW

419,000m^2 collecting area
~ 130,000 antennas
Based in Australia

SKA1 MID

33,000m^2 collecting area
~ 200 dishes
Based in South Africa