Radio Astronomy Holography

Pedro P. B. Beaklini

28/09/2017

SPAnet Workshop of Radio Astronomy
September 28, 2017

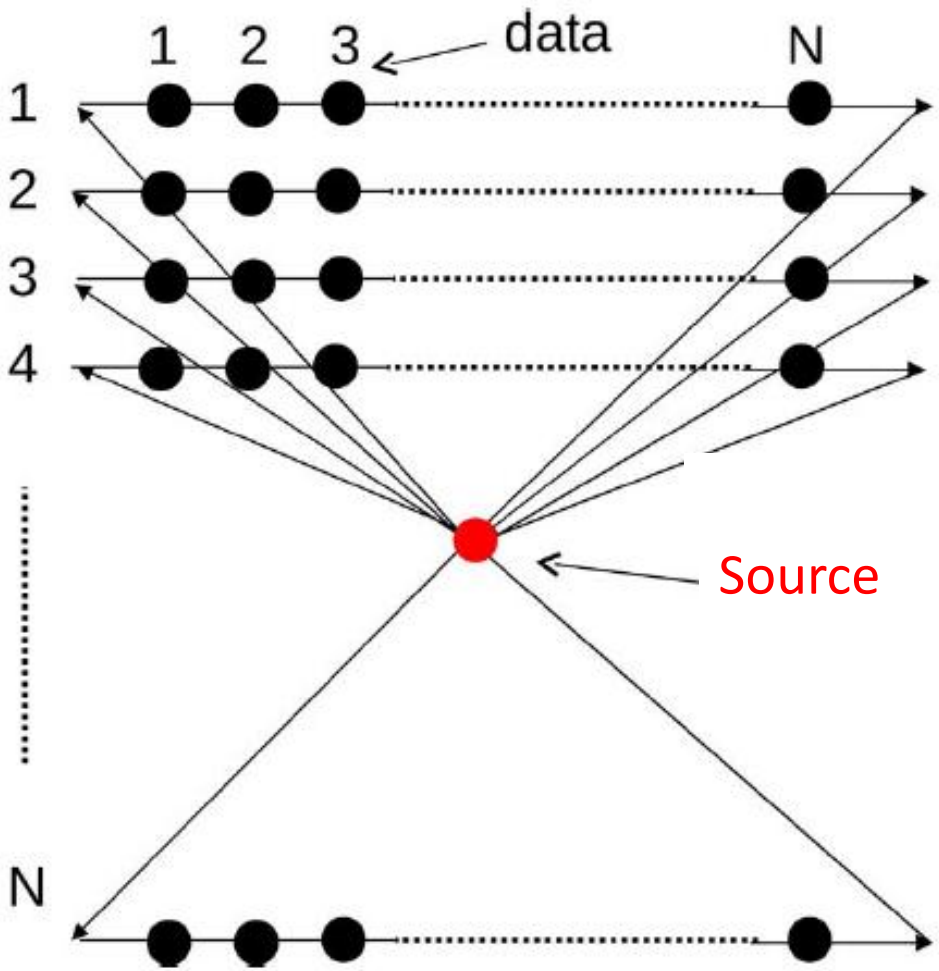
Technical Issues

- Surface Quality
  - How can we measure?
  - Can we improve it?
- Illumination and Aperture efficiencies
- Receiver offset
- Optical Problems (?)

How?

- Check the radiation response at each part of the dish:
  - Measuring amplitude and phase. How? Holography
- Holography technique consists to measure radiation pattern coming from different parts to determine large errors on its surface.

Scan



Baars et al. 2007

Observations

- Quasar Source (interferometric observations)
- Artificial Source:
  - Tower (Near-Field Approximation; Baars et al. 2007).
  - Geostationary Satellite (Far-Field Approximation; e.g. López-Pérez et al.2014).

For single dish:

- two horns receivers:

one pointed to the source

other to the dish

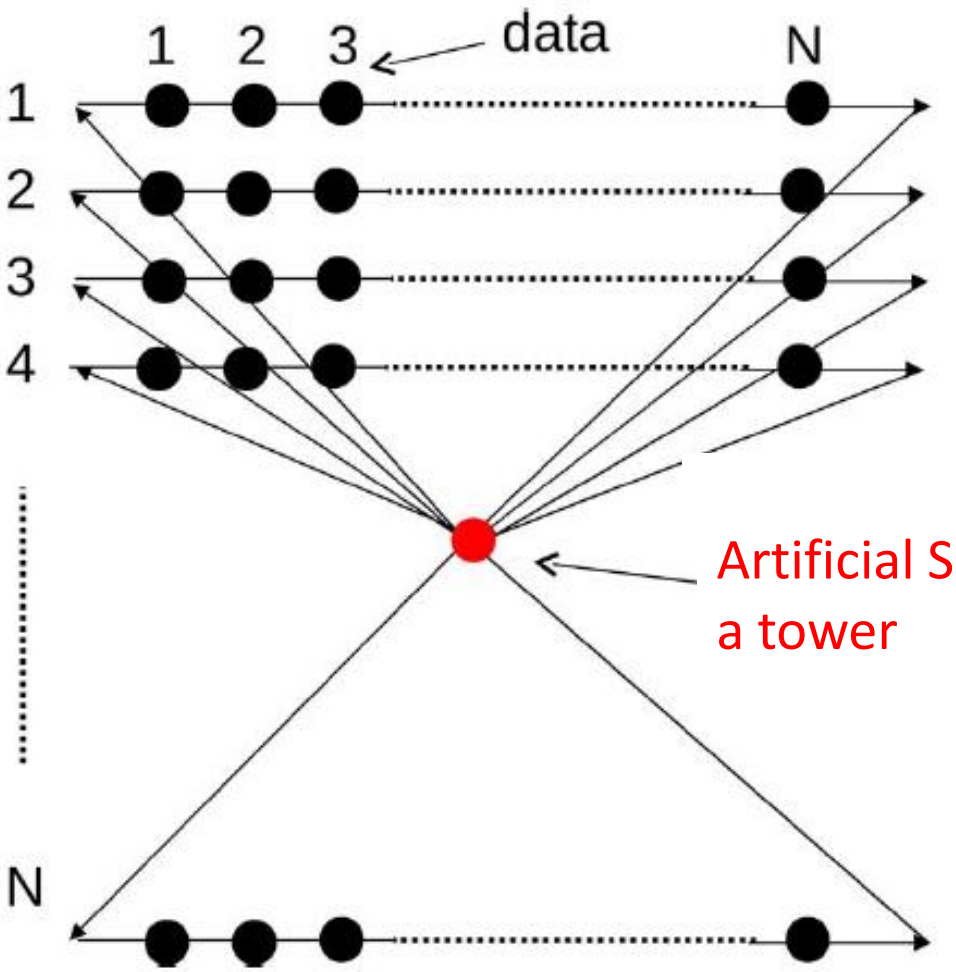
For arrays:

- at least 4 antennas.

Two antennas: scan the source

On antenna: on source on during the movement.

LLAMA



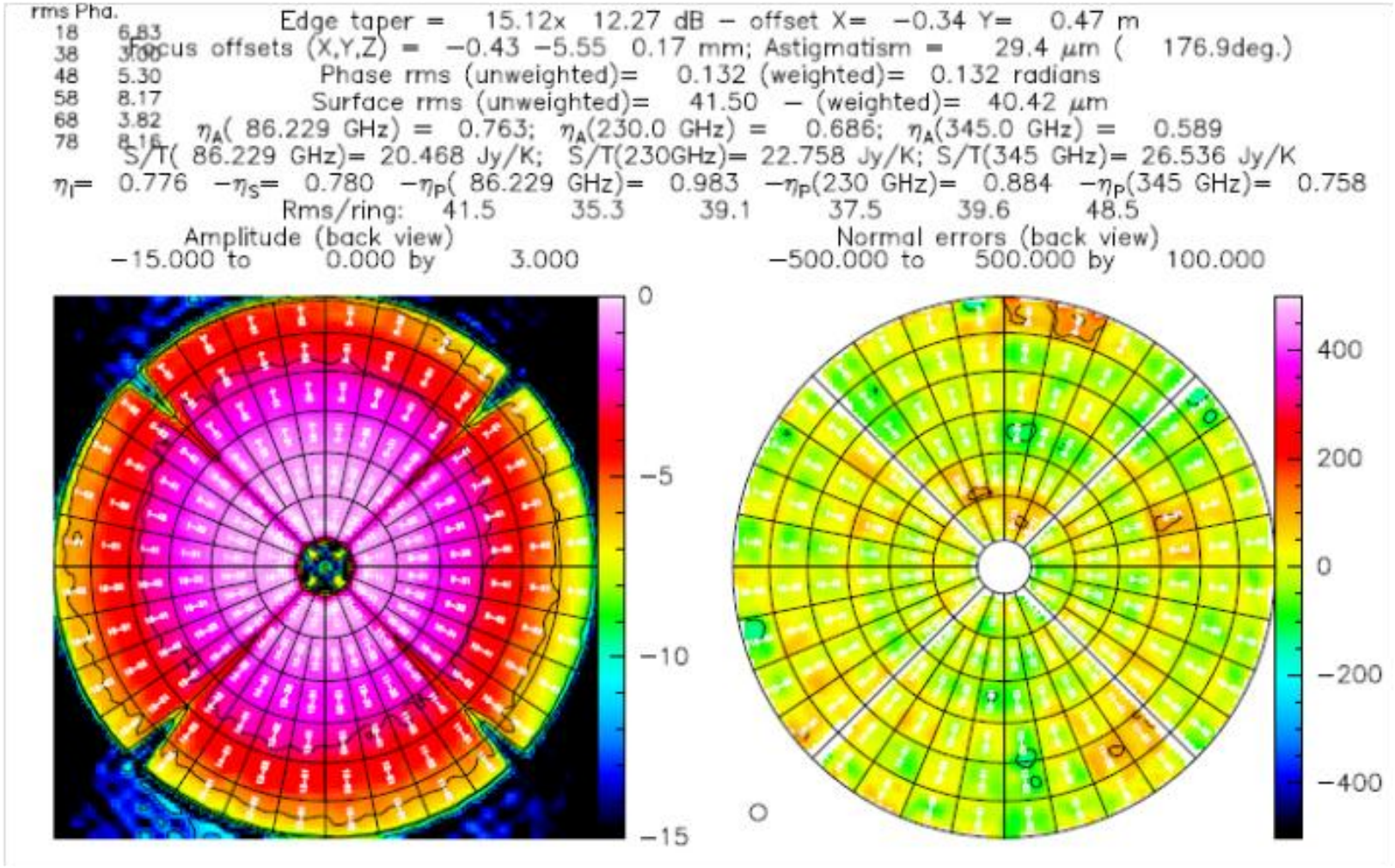
Baars et al. 2007

NOEMA Holography results

- NOEMA = NOrth Extended Millimeter Array

Plateau de Bure Inteferometer (PdBI – 6 antennas)
NOEMA = PdBI+6 antennas. Now they are 9.

NOEMA


rms Pha.
18 6.83
38 3.66
48 5.30
58 8.17
68 3.82
78 8.16
Edge taper = 15.12x 12.27 dB – offset X= −0.34 Y= 0.47 m
Focus offsets (X,Y,Z) = −0.43 −5.55 0.17 mm; Astigmatism = 29.4 μm (176.9deg.)
Phase rms (unweighted)= 0.132 (weighted)= 0.132 radians
Surface rms (unweighted)= 41.50 – (weighted)= 40.42 μm
ηA(86.229 GHz) = 0.763; ηA(230.0 GHz) = 0.686; ηA(345.0 GHz) = 0.589
S/T(86.229 GHz)= 20.468 Jy/K; S/T(230GHz)= 22.758 Jy/K; S/T(345 GHz)= 26.536 Jy/K
ηl= 0.776 −ηS= 0.780 −ηP(86.229 GHz)= 0.983 −ηP(230 GHz)= 0.884 −ηP(345 GHz)= 0.758
Rms/ring: 41.5 35.3 39.1 37.5 39.6 48.5
Amplitude (back view)
−15.000 to 0.000 by 3.000
0
−5
−10
−15
Normal errors (back view)
−500.000 to 500.000 by 100.000
400
200
0
−200
−400

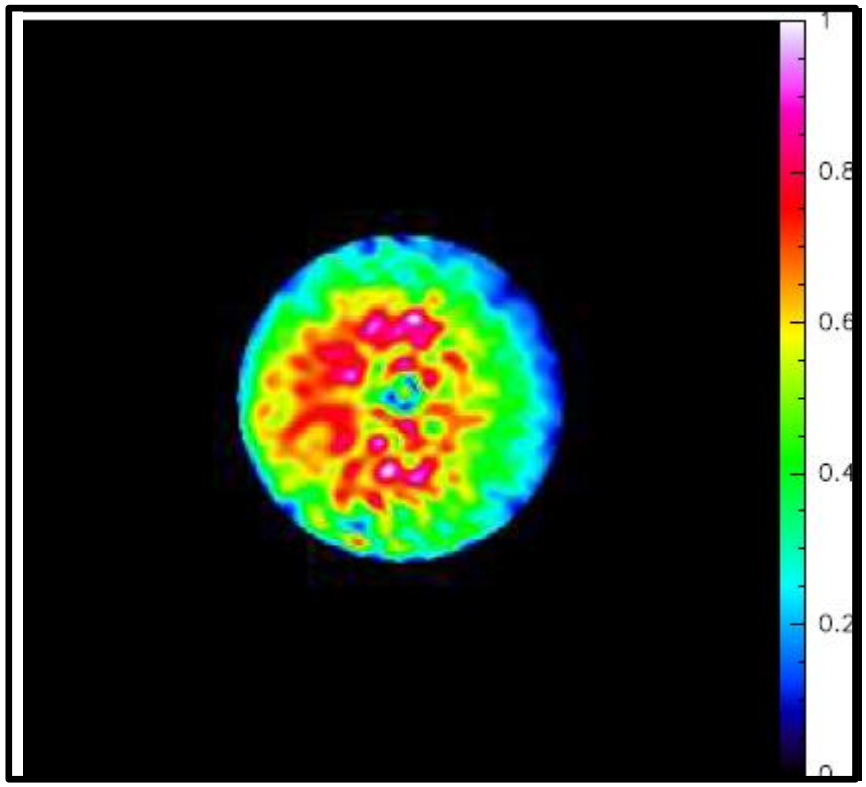
Gaussian Fitting

$$F = e^{-\alpha r^2}$$

$$\alpha = \frac{T}{20} \ln(10)$$

- Receiver Taper (T)
- Receiver Offset
- Surface rms

Efficiency



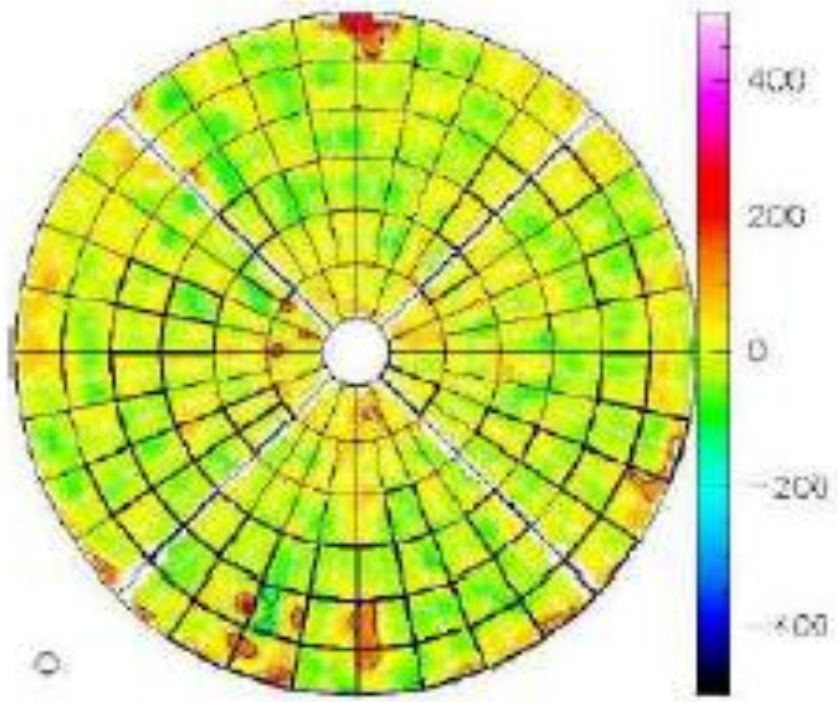
$$\eta_i = \frac{\int (F dA)^2}{\int F^2 dA}$$

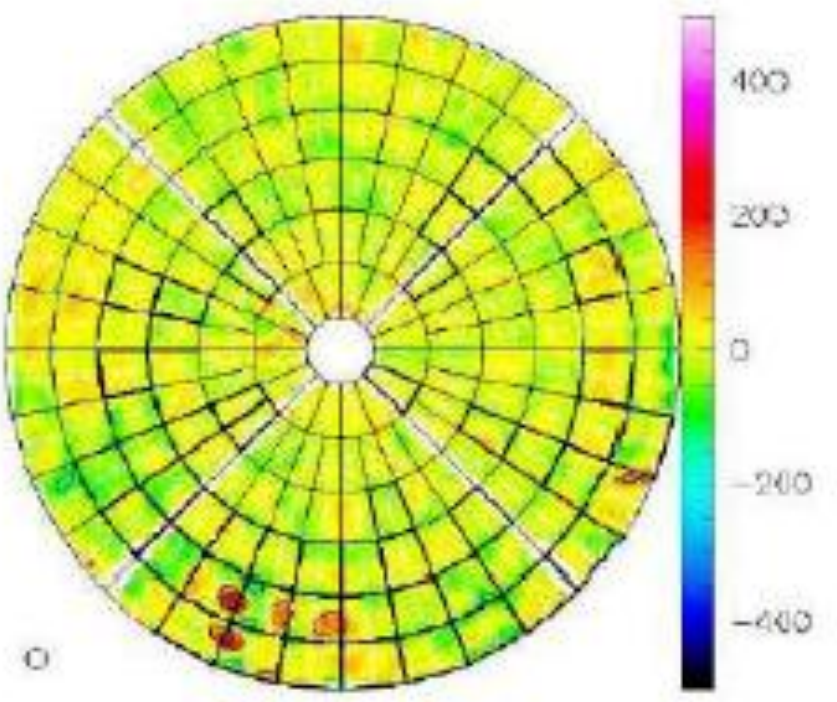
Silver 1949, Baars 2007

$$\eta_a \sim \exp\left(\frac{-16\pi^2\sigma^2}{\lambda^2}\right)$$

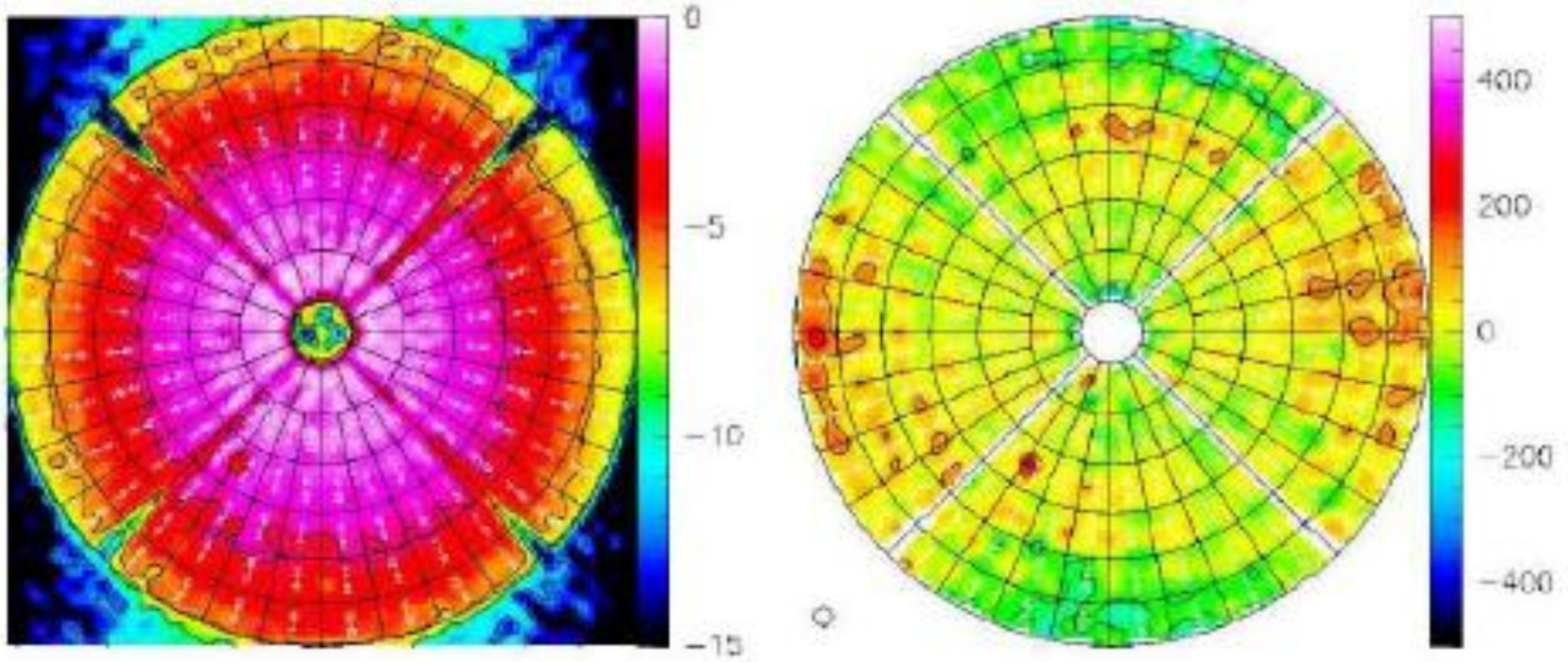
Roze equation
(Roze 1966)

Panels Adjustment





Astigmatism



LLAMA Holography

- During commissioning:
  - We will use ALMA equipment: tower and receiver
- Short future
  - We will make our own artificial source to make holography measurements regularly.