High-resolution radio imaging of a gamma-ray blazar candidate using very-long-baseline interferometry

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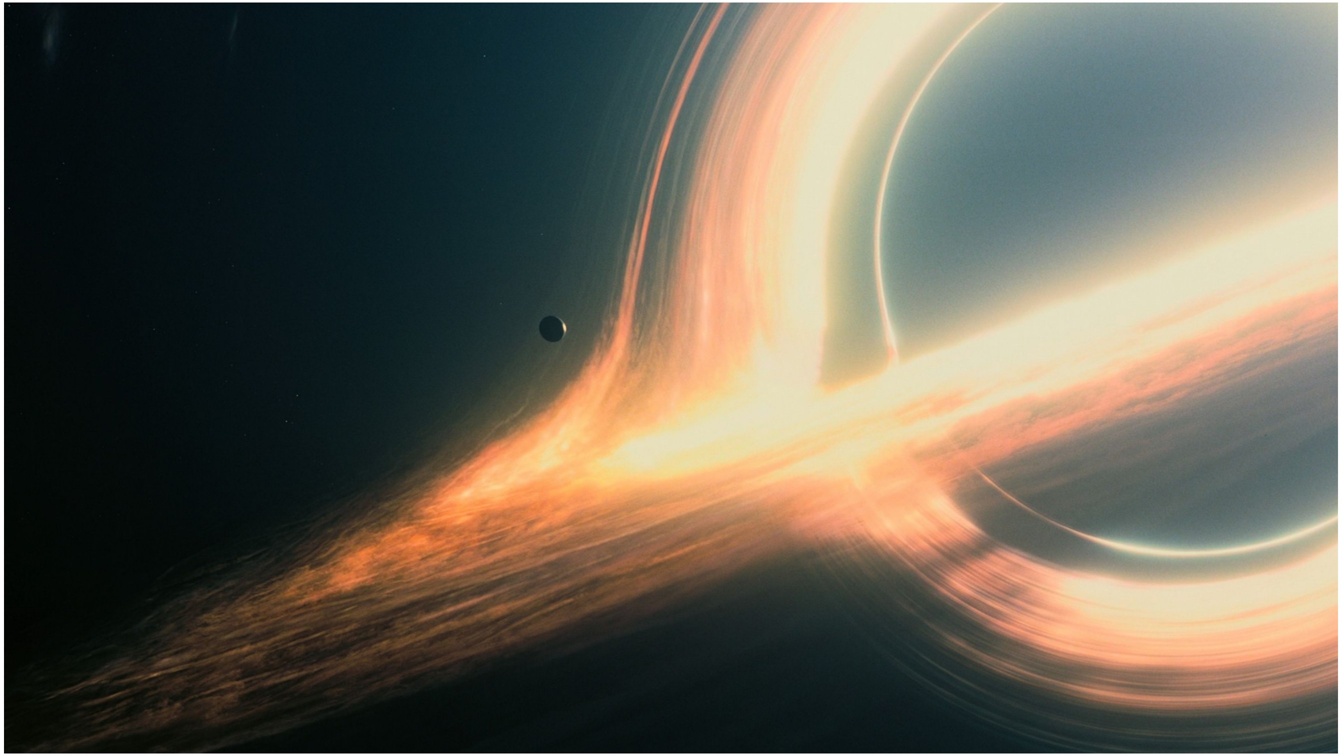
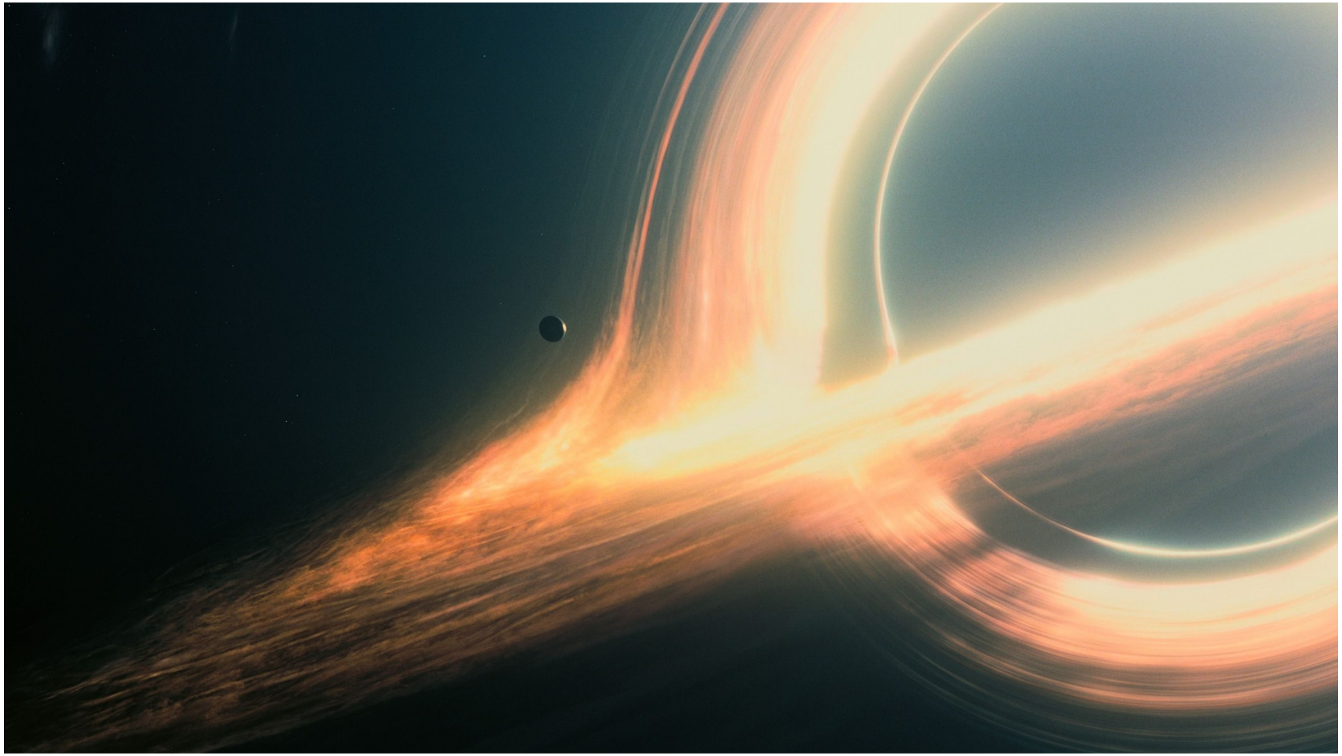
Active Galactic Nuclei (AGN)



- center of galaxies
- supermassive black holes with accretion disks

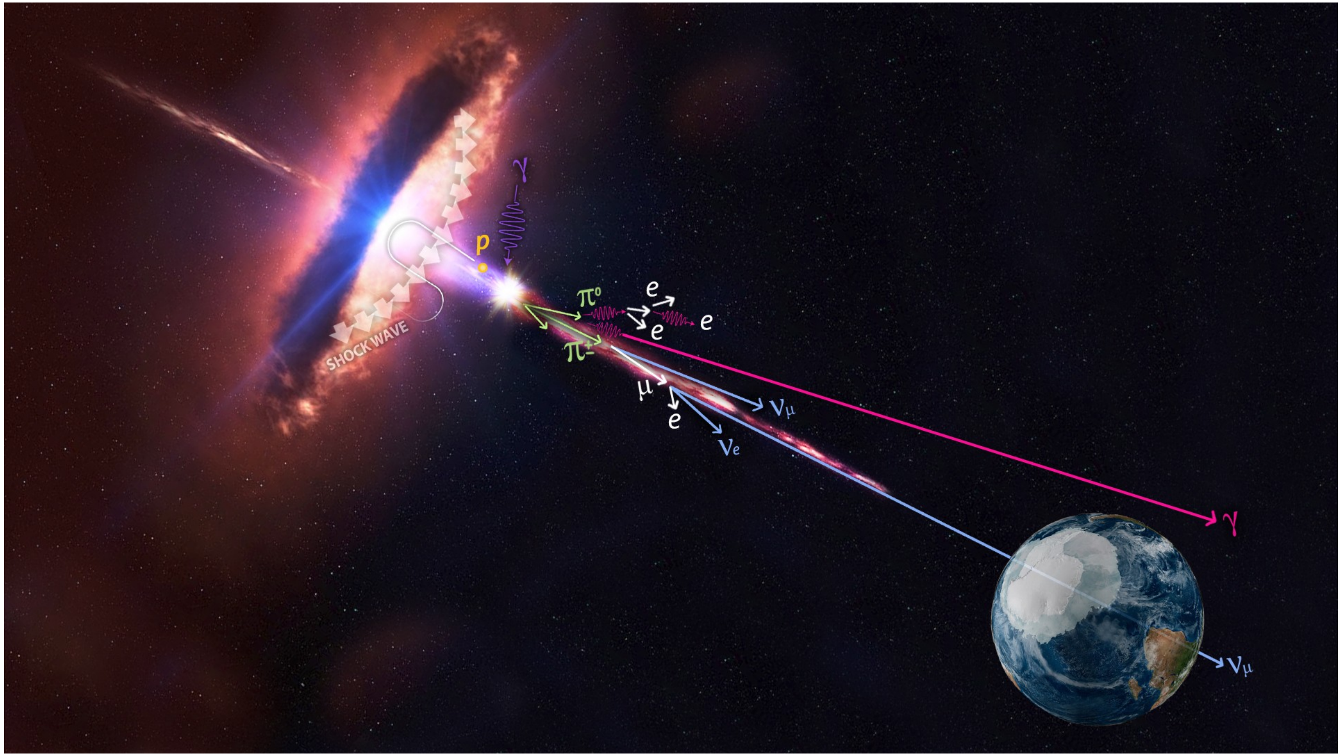
- most luminous persistent objects
- often variable
- bright in the entire electromagnetic spectrum

Active Galactic Nuclei (AGN)



Observed properties depend on:
- mass of the black hole
- rate of matter falling into the black hole
- presence of a jet
- orientation relative to the observer

Blazars



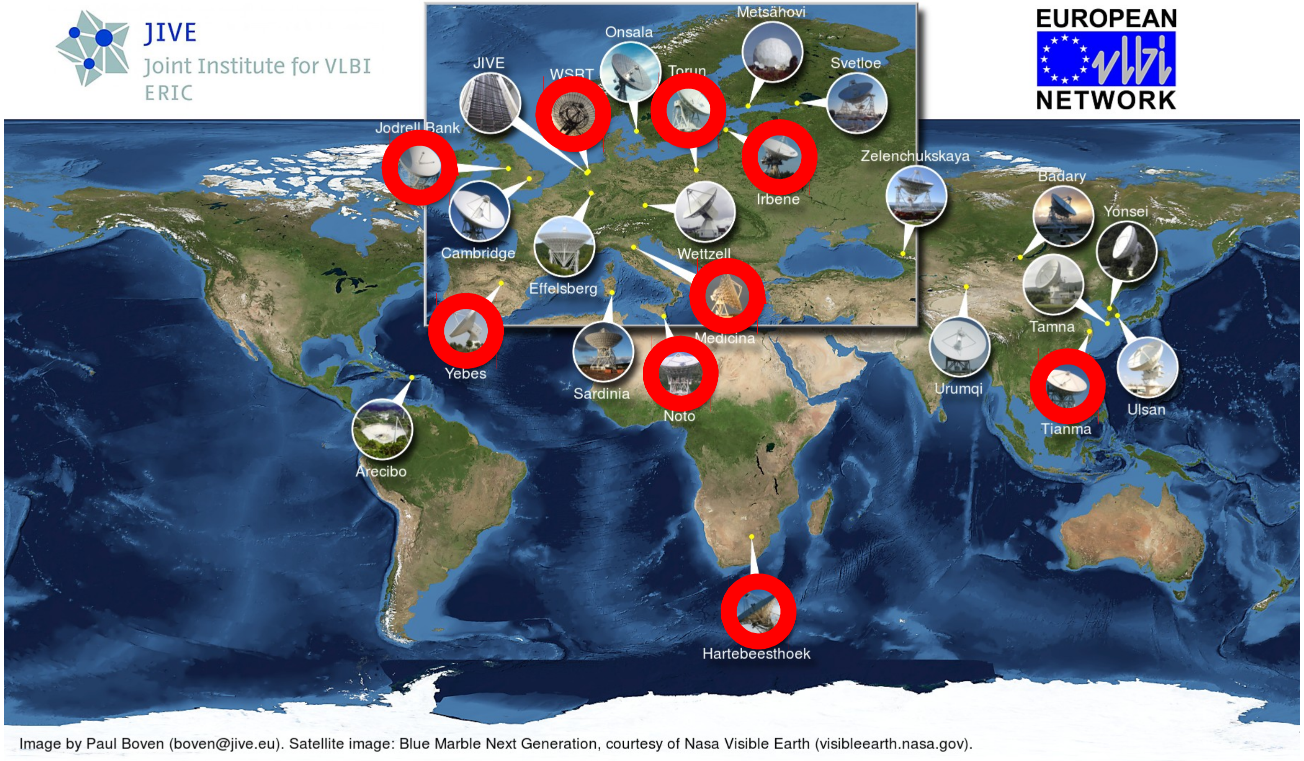
- special class of AGNs
- jets pointing in our line of sight
- relativistic beaming

- most extragalactic gamma-ray sources
- example: TXS 0506+056, simultaneous detection of a neutrino and gamma-ray flaring

Flaring from the binary DG CVn?

- 2014: gamma-ray burst, optical and radio counterparts
- more gamma-ray flares detected by the Fermi/LAT without counterparts
- possible association with a background quasar
- very-long-baseline interferometry

Very-long-baseline interferometry



- resolution of a telescope:

$$\theta = 1.22 \frac{\lambda}{D}$$

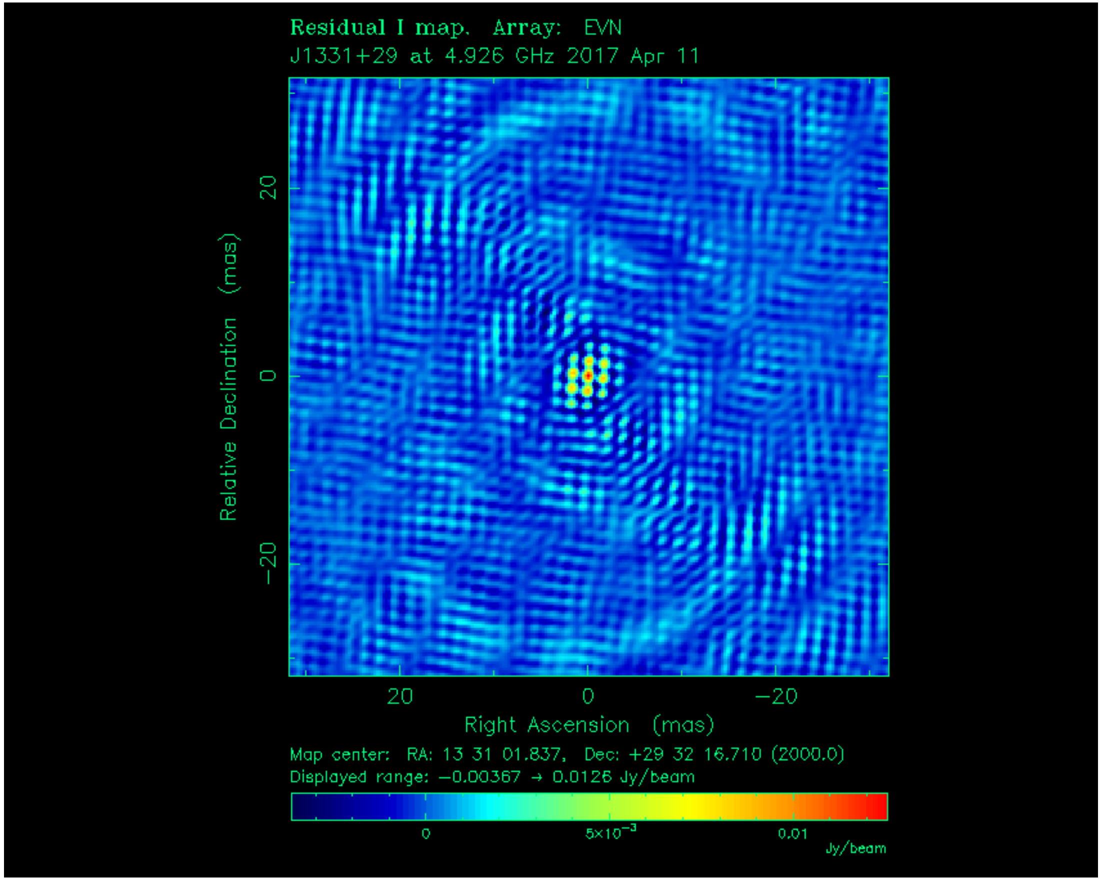
- many telescopes far from each other

- milliarcsecond (mas) resolution

Very-long-baseline interferometry

- 5GHz, 256MHz bandwidth
- Calibrator source
- position was determined with 0.5mas uncertainty
- self calibration and mapping with Difmap

“Dirty” map



- the aperture is not filled

- interference pattern

- convolution of source and dirty beam

Self calibration

- Path length differences introduce errors

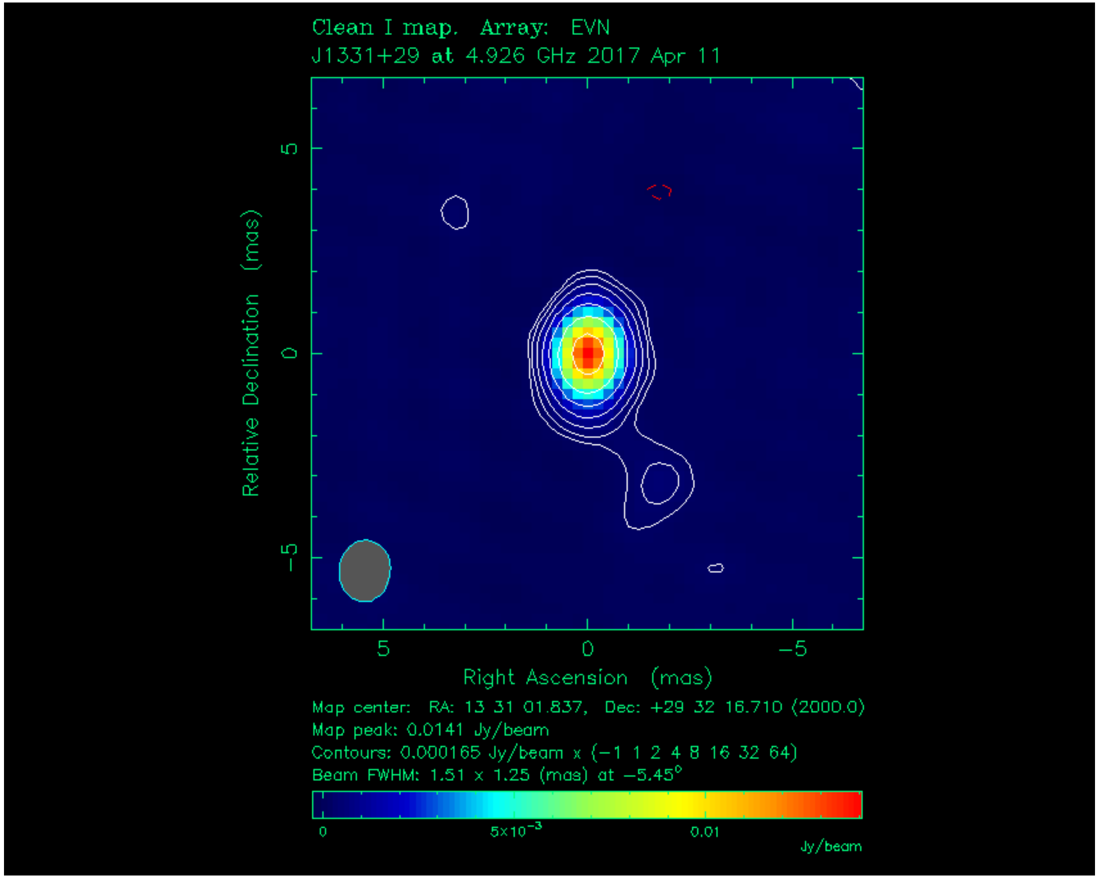
- N telescopes

- N(N-1)/2 baselines

- Errors can be corrected for an assumed model of the source

- Hybrid mapping

“Clean” map



- peak brightness: $S = 14.08\, mJy\, beam^{-1}$

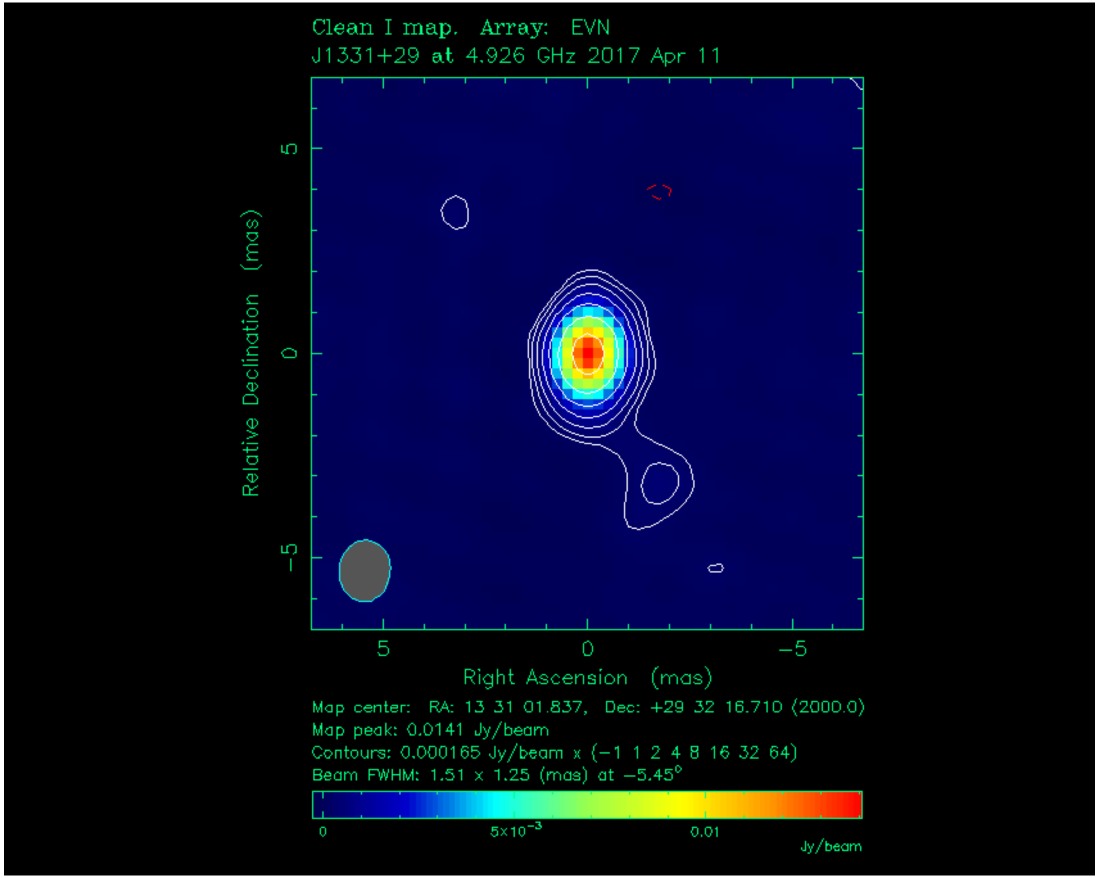
  $1\, Jy\, (jansky) = 10^{-26}\, W\, m^{-2}\, Hz^{-1}$

- Gaussian model fitted shrank to a point

- Upper angular size limit:

  $\theta < 0.09\, mas$

“Clean” map



Brightness temperature:

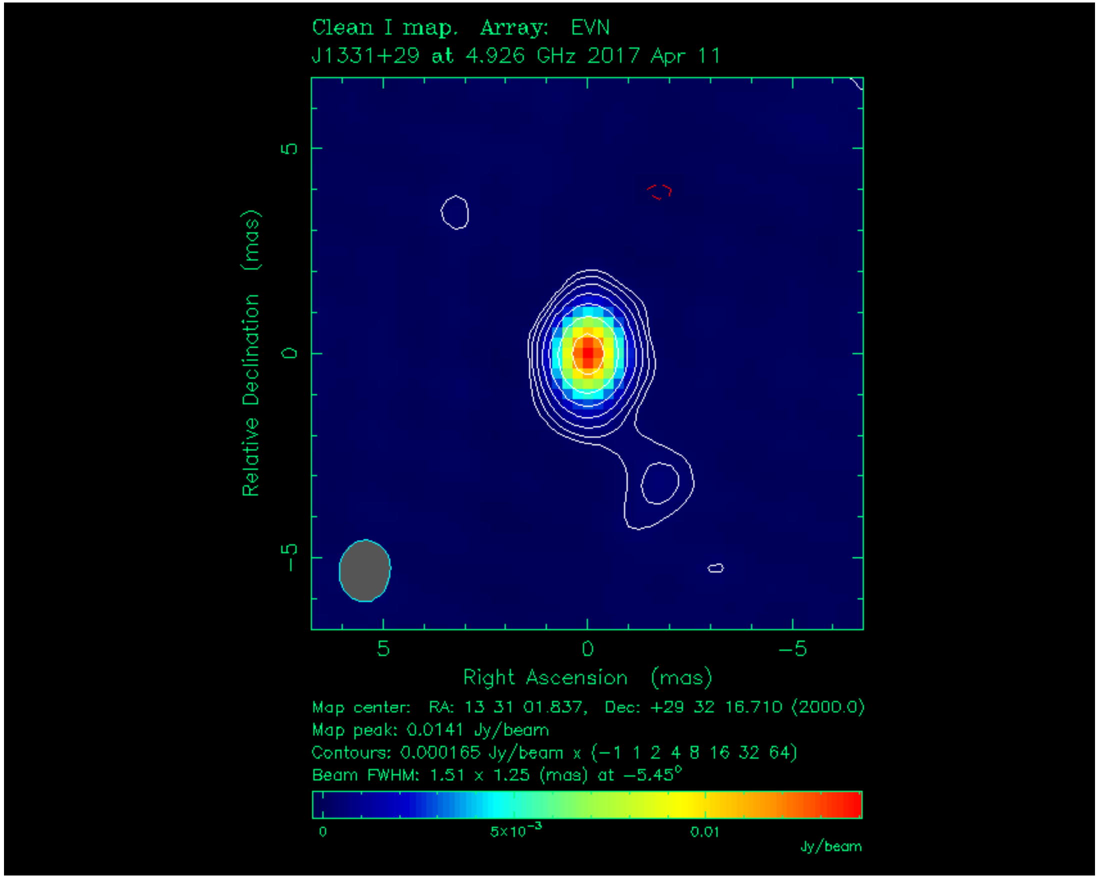
$$T_B = \frac{2\ln 2}{\pi}\frac{c^2 S}{k_B \nu^2 \theta^2}(1+z)$$

Lower limit:

$$T_B \geq 1.3\times 10^{11}\,K$$

Assuming a typical intrinsic brightness temperature of $T_i = 3\times 10^{10}\,K$, the Doppler factor is $\delta = T_B/T_i \geq 4.3$.

“Clean” map



Assuming a typical Lorentz factor of $5<\gamma<15$, the jet inclination angle can be estimated:

$$\delta=\frac{1}{\gamma\left(1-\beta\cos\varphi\right)},$$

yielding $\varphi<14°$.

Further proof

- High flux density variations in infrared (Wide-field Infrared Survey Explorer (WISE) satellite)

- WISE colors are close to typical values for blazars

- Several supernova candidates

Summary

- European VLBI Network

- High-resolution radio interferometric measurements of a blazar candidate

- Accurate position

- Compact, bright

- High brightness temperature indicates relativistic beaming

- We conclude that the source is indeed a blazar

Thank you for your attention!