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Image credit: ICRAR/University of Amsterdam

MEERTRAP

radio interferometers and single pulse localisation

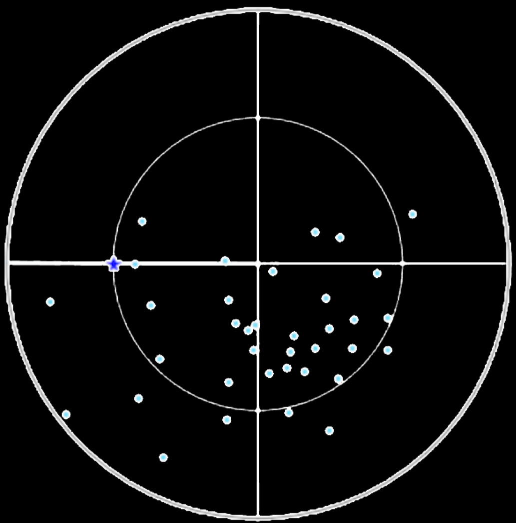
Abstract:

Unlike traditional, single-dish radio telescopes, interferometers combine the signals of multiple antennas. The result is a "fly's eye" view of the sky made up of many "beams" tiled over a relatively large field of view.

Transient surveys like MeerTRAP use interferometers to monitor the sky for brief flashes of radio waves from sources like the mysterious Fast Radio Bursts.

I show how single pulses from such sources can be localised to within a few arcseconds without imaging the region.

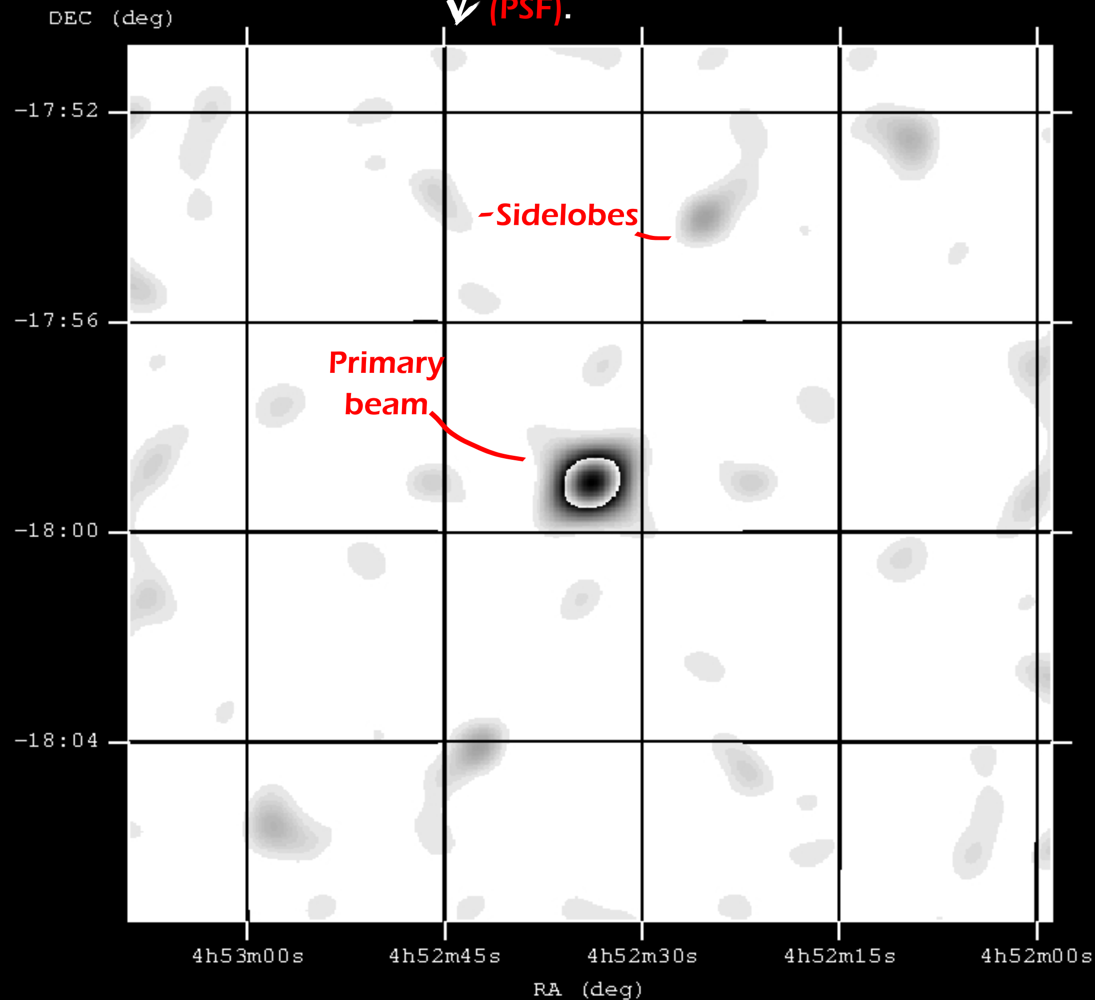
MeerKAT telescope, South Africa



By adding different delays to the signals received by each antenna before they are convolved, a coherent beam is focused at the desired position.

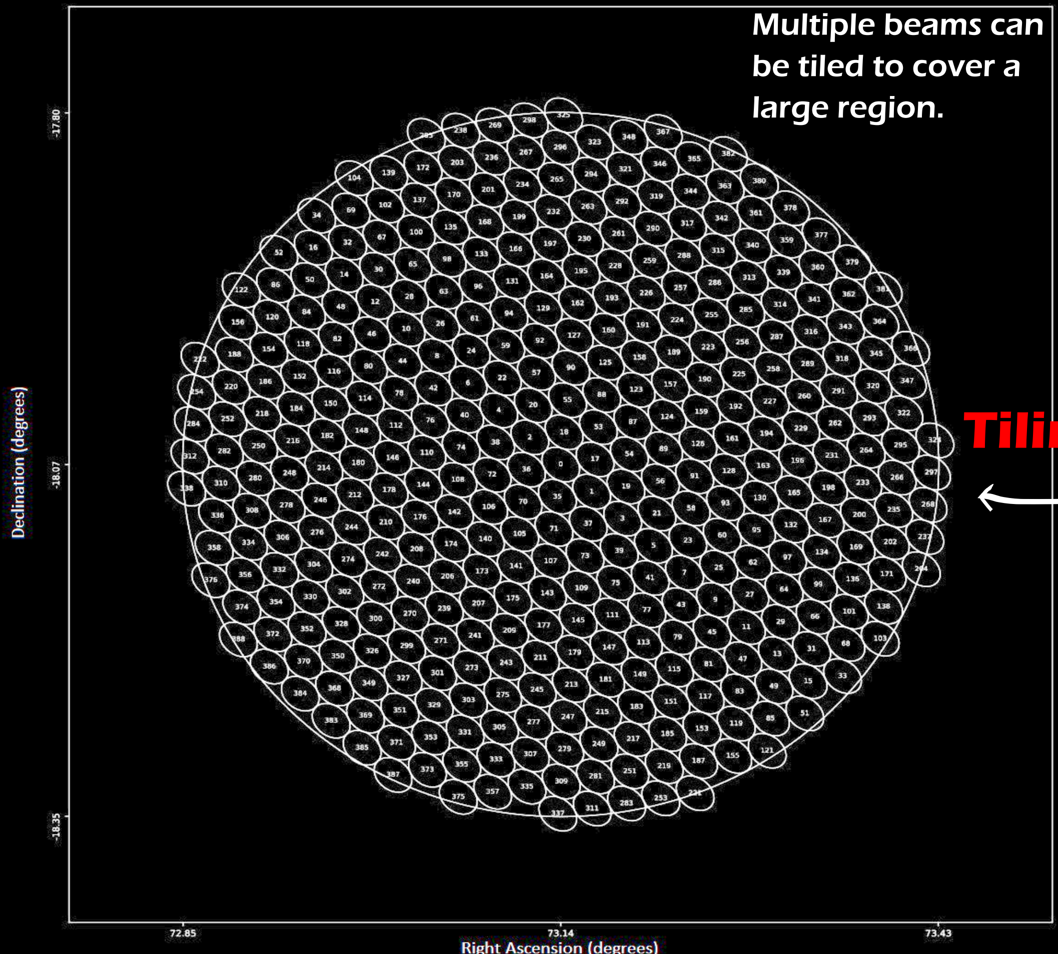
Beamforming

Knowing the setup of the telescope for a given observation, we can simulate the spacial dependence of a beam's sensitivity, or its Point Spread Function (PSF).



Multiple beams can be tiled to cover a large region.

Tiling



Tied-Array Beam Localisation (TABLo) method

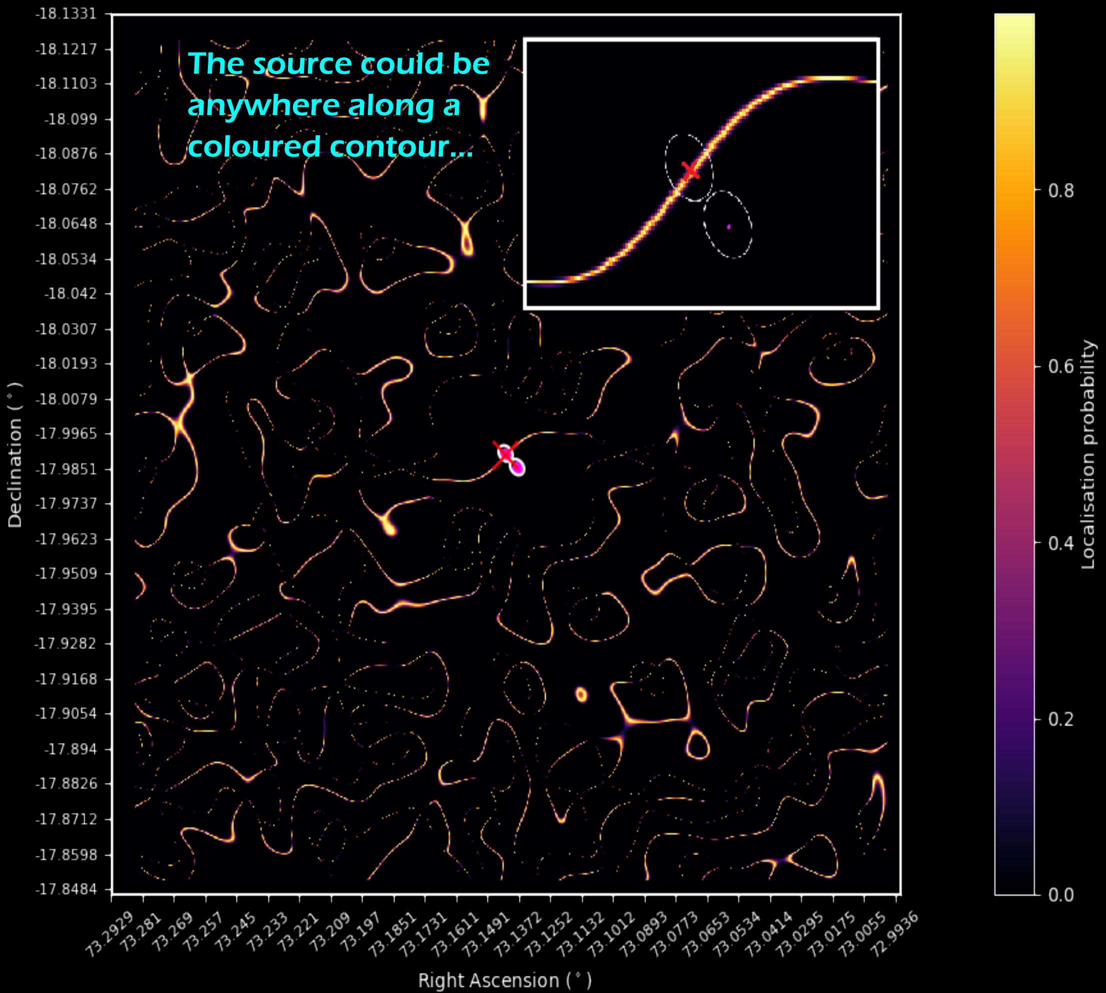
Suppose a source is detected with signal-to-noise ratios S_1 and S_2 in two beams with PSFs P_1 and P_2, respectively.

The source must be located somwhere that $P_1/P_2 = S_1/S_2$.

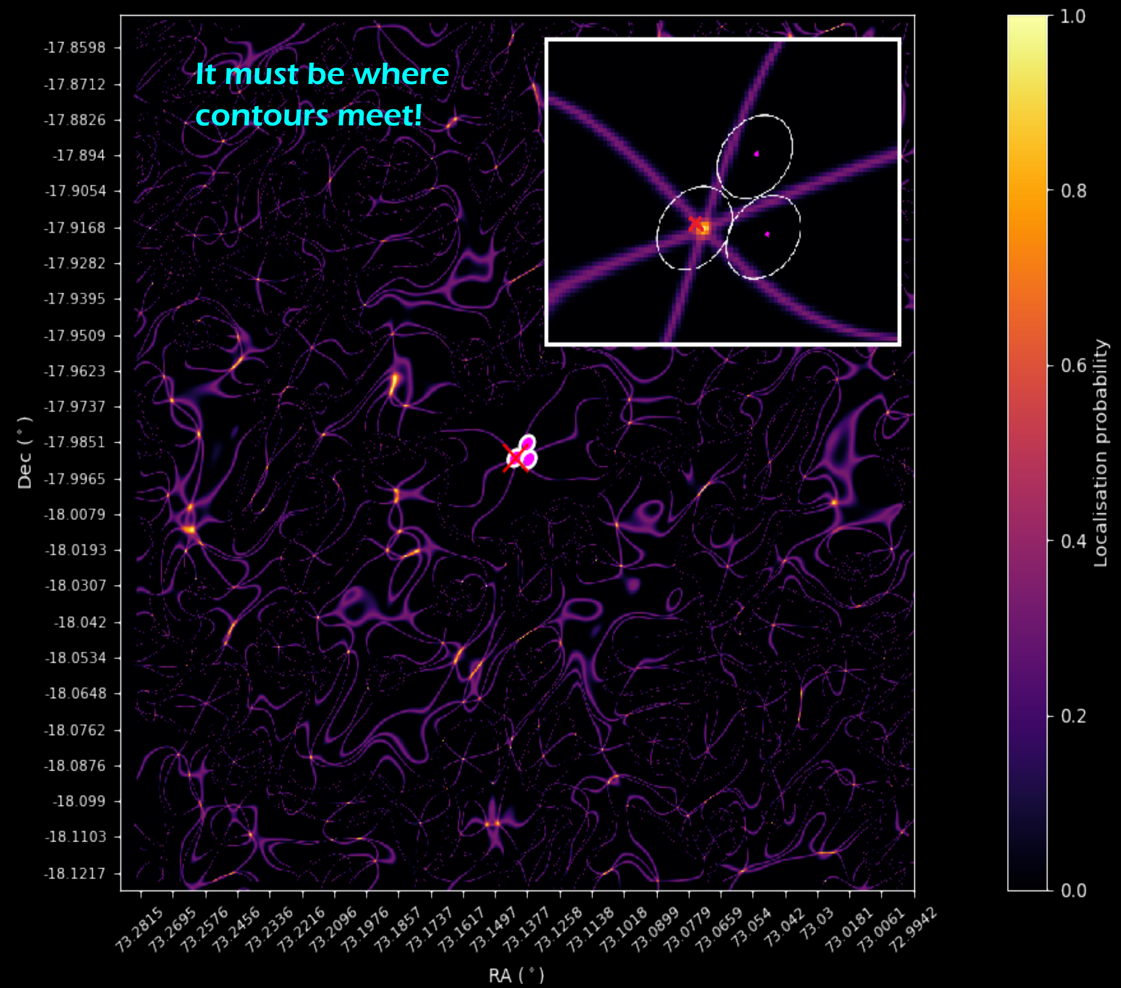
The coloured regions below show where P_1/P_2 is within 1-σ of S_1/S_2 for each pair of beams.

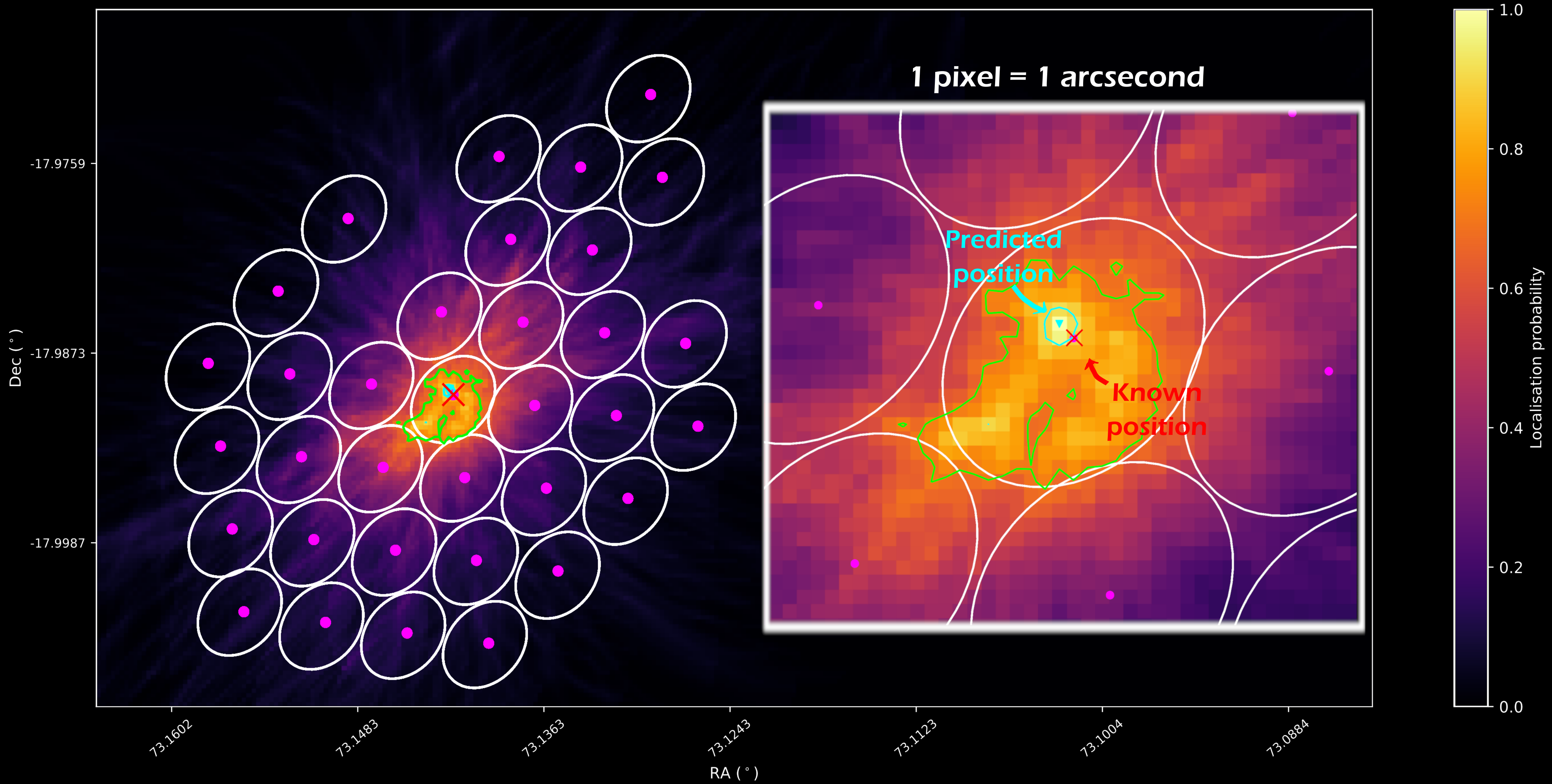
Incorporating more beams adds more contours that overlap to narrow down possible locations.

2 beams



3 beams





PSR B0450-18

This pulse from PSR B0450-18 was detected using the MeerTRAP single pulse detection pipeline in 34 beams at once (561 beam pairs).

Adding the curves together and finding the maximum gives a localisation to a precision of a few arcseconds.

This is unprecedented precision for single-pulse localisation without recourse to imaging.