

WSRT for EVN science: calibration, polarization, and transients

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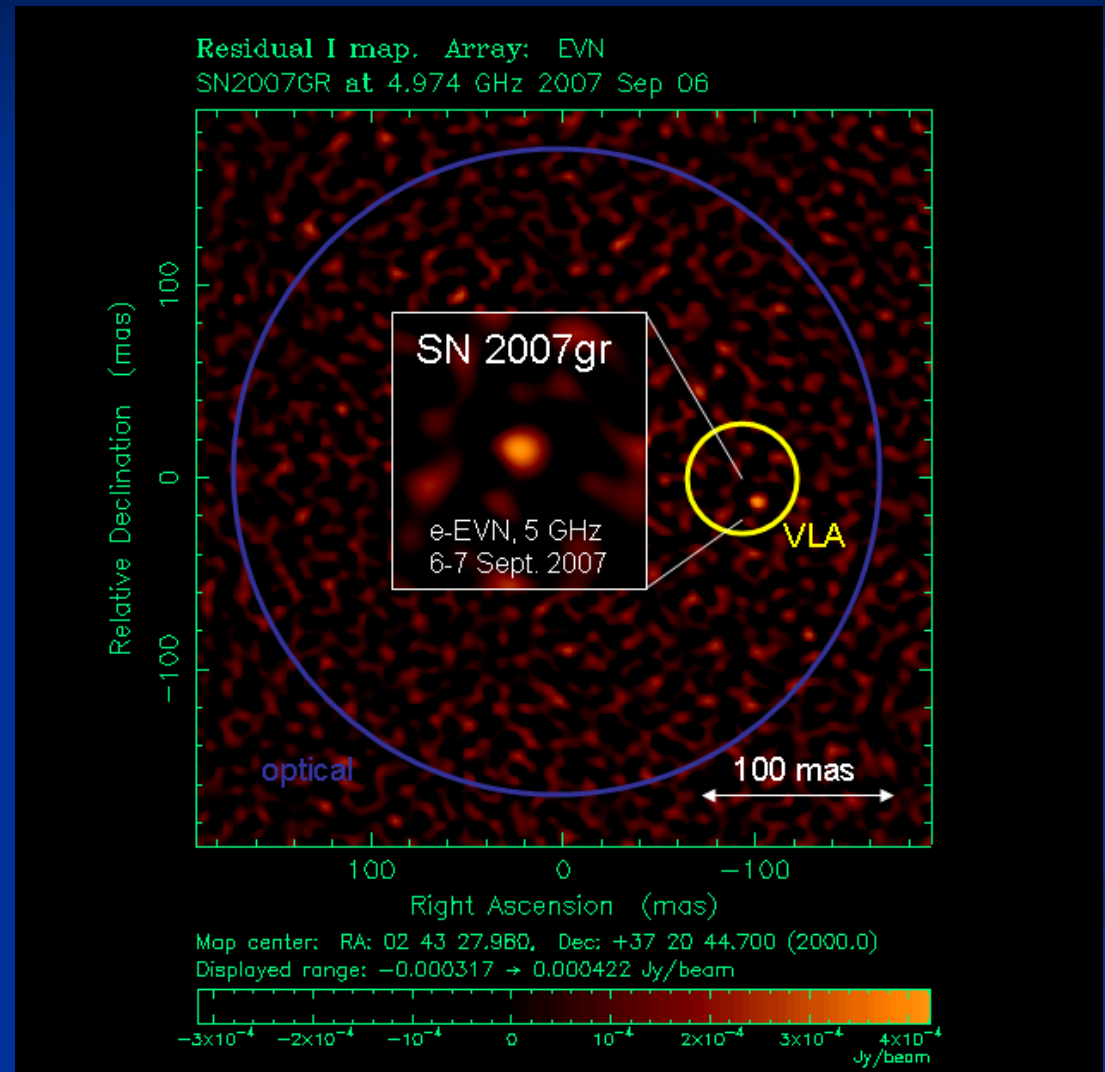
JIVE

Why WSRT is important for the EVN

- Facts: with 93m effective diameter, Westerbork is the second most sensitive element of the European VLBI Network
- Loss of sensitivity without the phased array Wb in an EVN run is $\sim 40\%$ in X-band, 20-30% (Jb1/Jb2) in C-band, 50% in L-band
- Could play a unique role in the absolute amplitude calibration and polarization calibration (including circular!)
- But it is true, because of limited FoV (few arcseconds) must use single dish in certain projects

WSRT as the key element of e-EVN

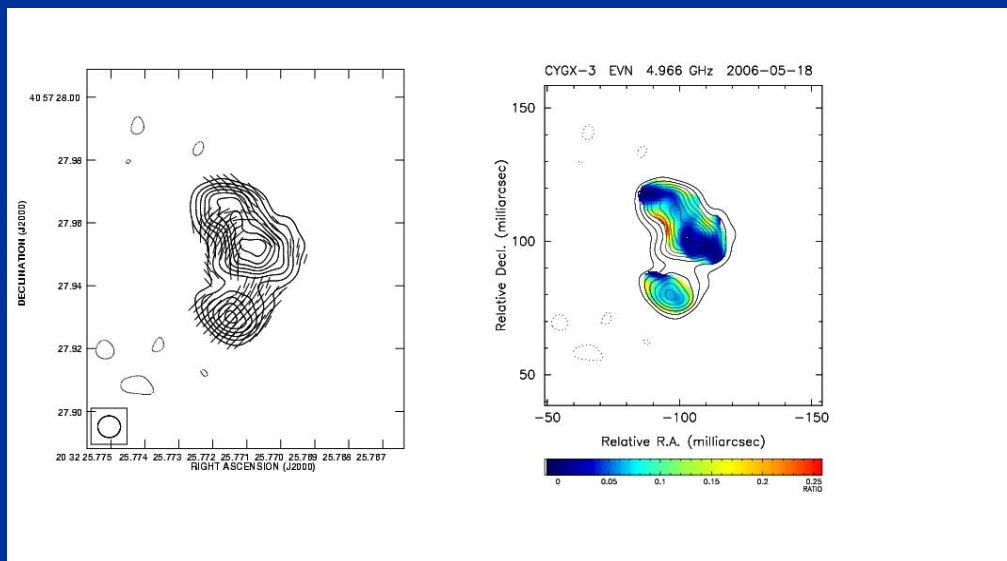
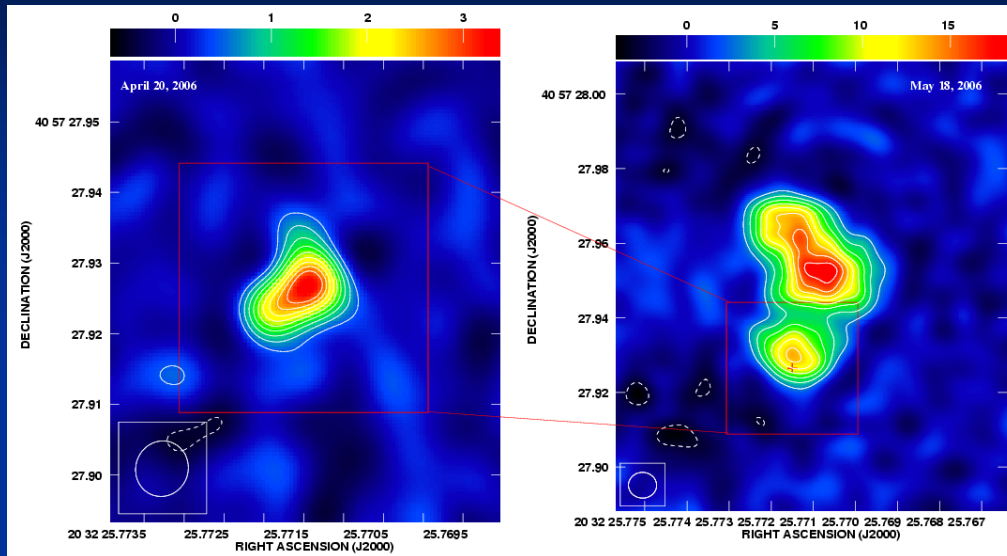
- One of the first telescopes with fibre connection to JIVE
- ~50% of the total e-EVN sensitivity came from Wb in the last few years, making possible sensitive observations!



Westerbork – e-EVN as a unique instrument

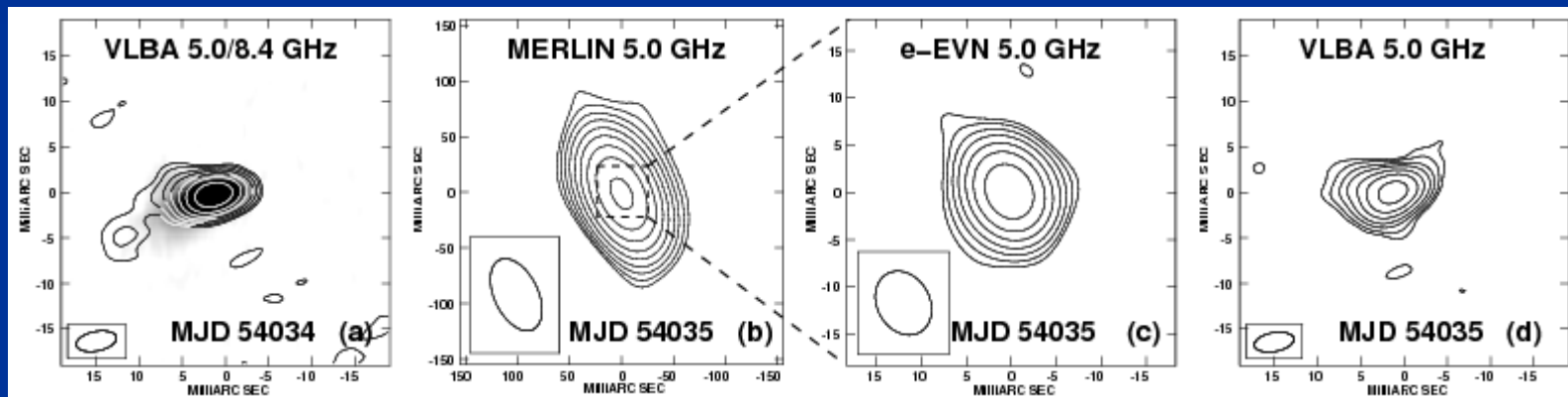
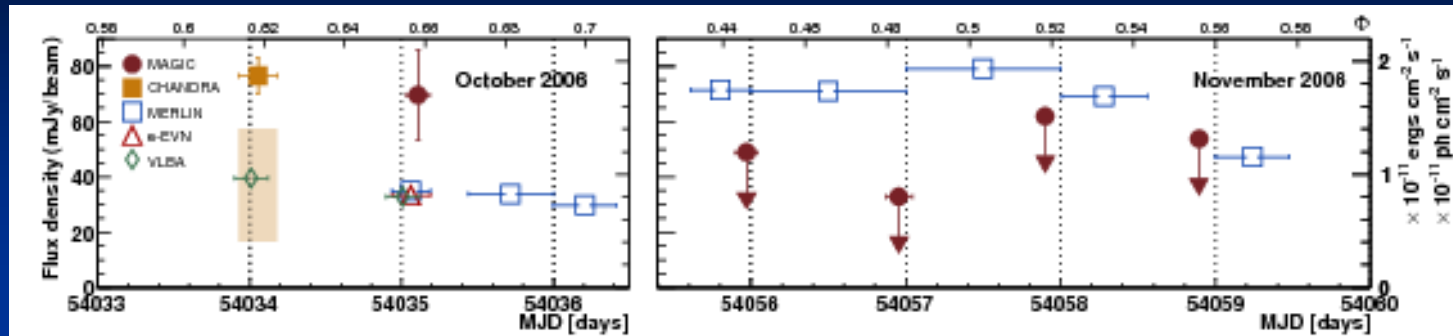
- Synthesis array data analysis of calibrators helps to determine flux scales on EVN maps
- Calibrator integrated polarizations with WSRT allow PA calibration of EVN maps
- Unique instrument to measure accurate circular polarization, and calibrate CP for the EVN
- Could use as a trigger instrument by providing flux measurements on targets prior to e-EVN runs
- Could provide accurate coordinates for e-EVN observations of gamma- (AGILE, GLAST) and X-ray transients (INTEGRAL, Swift ...)

Examples: X-ray binaries



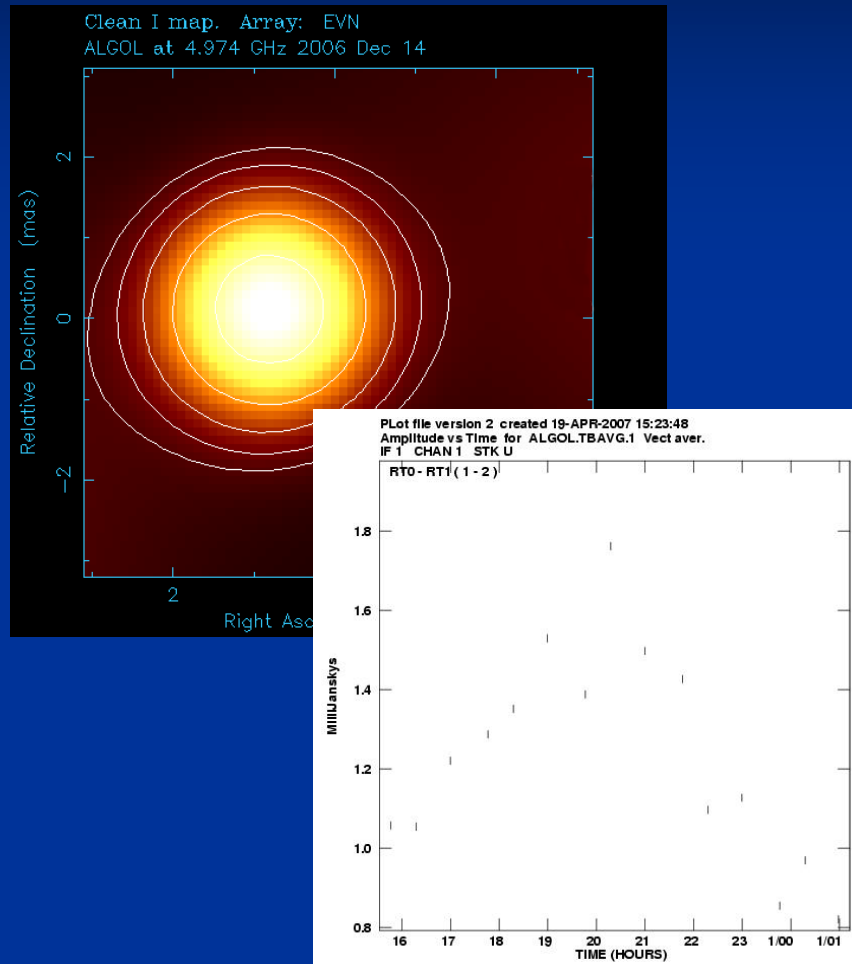
- Cyg X-3 has shown occasional violent bursts in the last two years
- First ever VLBI polarization maps were obtained for a microquasar with the e-EVN in 2006 (Tudose et al. 2007)
- Five more epochs data in 2007 and 2008
- Latest epochs show unusual burst behaviour (apparently no relativistic ejection)
- Besides the wealth of X-ray data, understanding of the various accretion disk states in XRBs will require more radio observations, especially VLBI
- Universal black hole activity plane relations: microquasars help understanding AGN as well
- We need to monitor a large sample of XRBs, WSRT could trigger e-EVN observations based on flux or polarization property changes

High energy sources: LSI +61 303



- MAGIC, CHANDRA, MERLIN, VLBA, e-EVN campaign in October 2006
- Source is still a mystery, nature of binary unknown (pulsar-wind / microquasar)
Albert et al. (2008), *Astrophys. J.* (accepted), astro-ph/0801.3150
- AGILE and GLAST will provide a number of transients for which WSRT could provide flux measurements and accurate coordinates, that makes VLBI follow-up possible

Chasing circular polarization

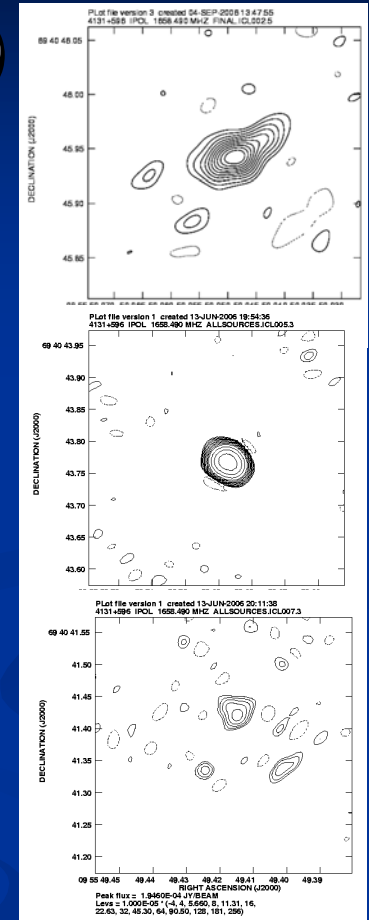
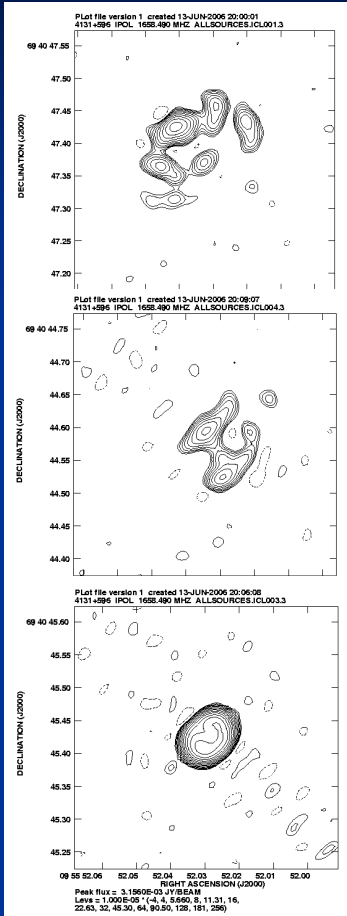
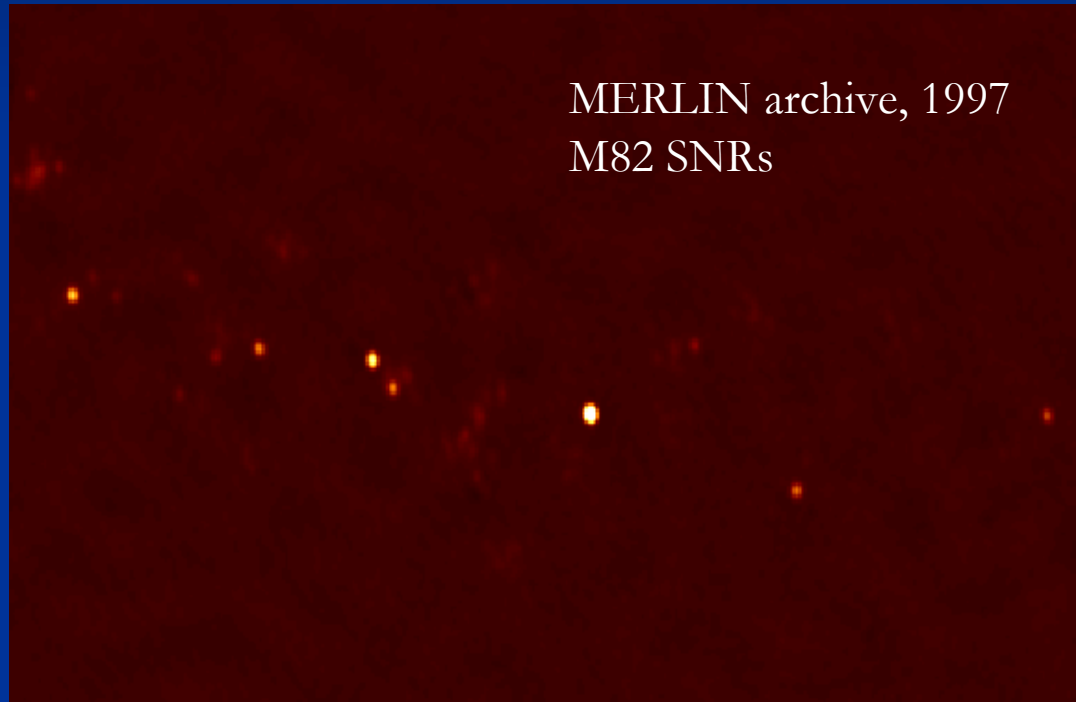


- Accurate CP measurements with VLBI are very challenging, need to observe tens of calibrators...
- WSRT-EVN offers an alternative: a single calibrator is enough for which is calibrated using WSRT phased array data (linear feeds!!!)
- Example to the left: Algol with the e-EVN, variable CP emission observed during a radio flare
- CP studies are still sparse for AGN and microquasars, but they may help identify the nature of their jets (baryonic/leptonic)
- Little explored area, much to be done here!

What would Apertif mean to the EVN?

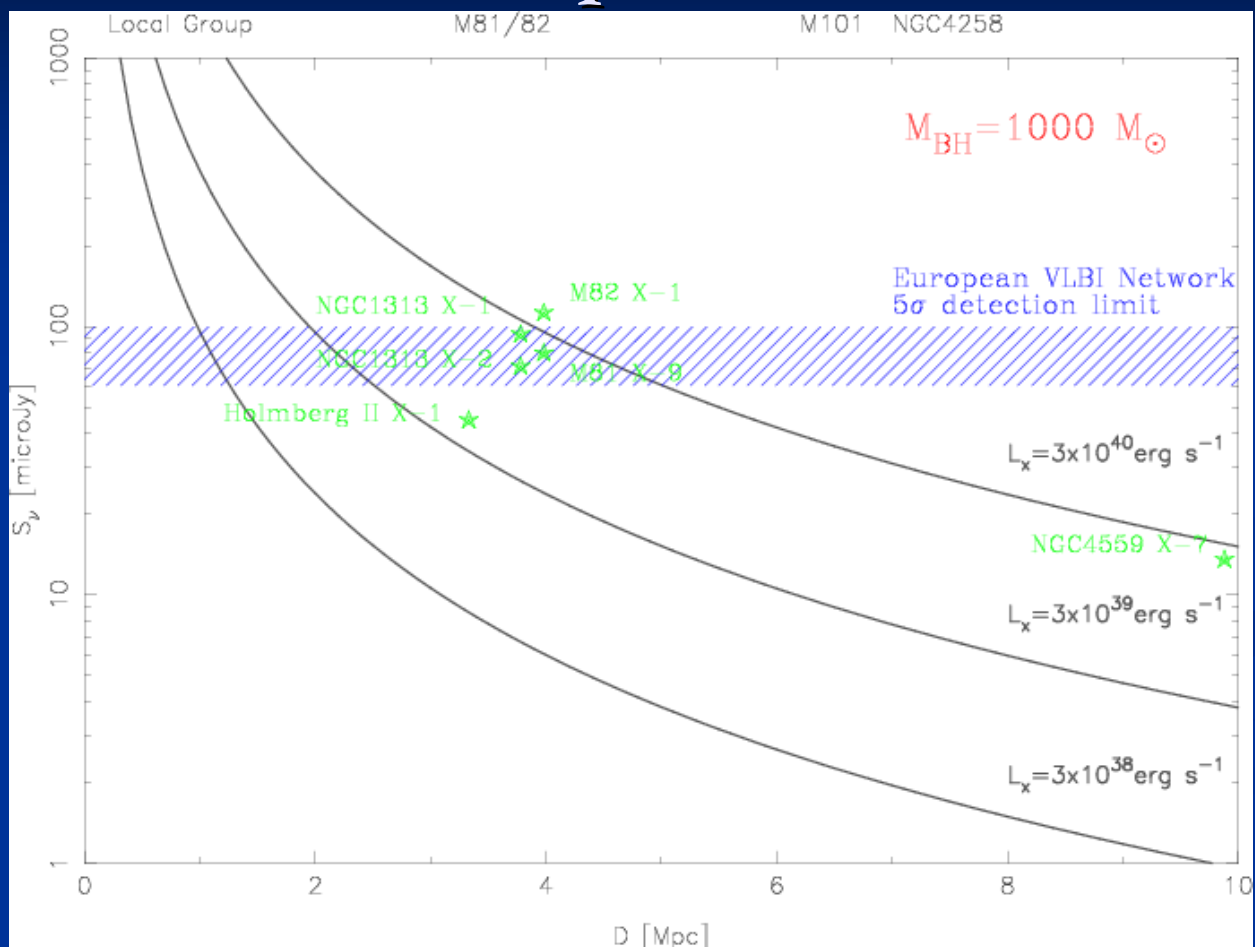
- In the SKA era the number of radio transients detected will increase by orders of magnitude, likely new type of sources will be discovered
- We do not know what to expect exactly, and it is unclear how we will deal with the wealth of data
- VLBI could play a vital role in pinpointing exact locations and help cross-identification with optical counterparts (e.g. GRB/XRF/SNe progenitors)
- VLBI can immediately decide on Galactic nature if source structural evolution is seen on timescales of days
- We need **trigger machines** for the EVN, like LOFAR and a high FoV WSRT
- A minor point: LOFAR and WSRT with Apertif are operating at low frequencies, while most transients show up first at high frequencies (and time really matters for Galactic transients!)

More sensitive large FoV EVN imaging (in the L-band)



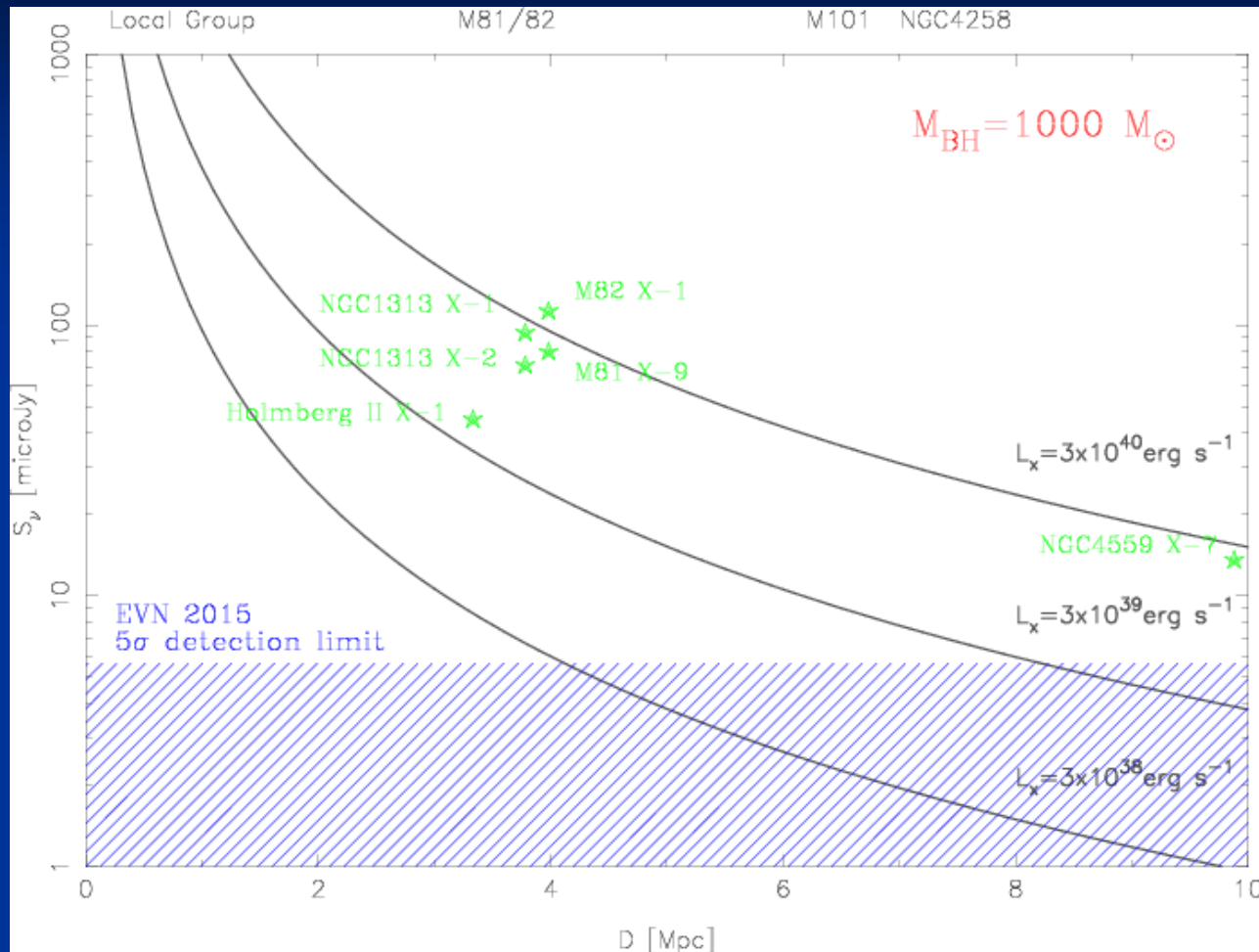
- Phased array WSRT at 18cm could be part of projects requiring large FoVs, e.g. imaging ULXs and SNR in nearby galaxies, gravitational lenses etc.

Looking to the future of the EVN Science example: ULXs now...



- EVN could play an important role to constrain ULX black hole masses by radio flux measurements –note that resolution is important to distinguish nebulae from compact-jet emission.

ULXs with EVN2015



- WSRT has a great contribution to this predicted sensitivity.

Apertif: yes or no?

- Introduction of Apertif will limit EVN capabilities in all bands except for L-band.
- However it could be very useful for supplying triggers to the (e-)EVN
- Let us hope for a solution that brings new opportunities, but allows to do a variety of science with the WSRT