ASTRON

Netherlands Institute for Radio Astronomy

LOFAR

Follow-up of LIGO/Virgo BBH mergers with LOFAR

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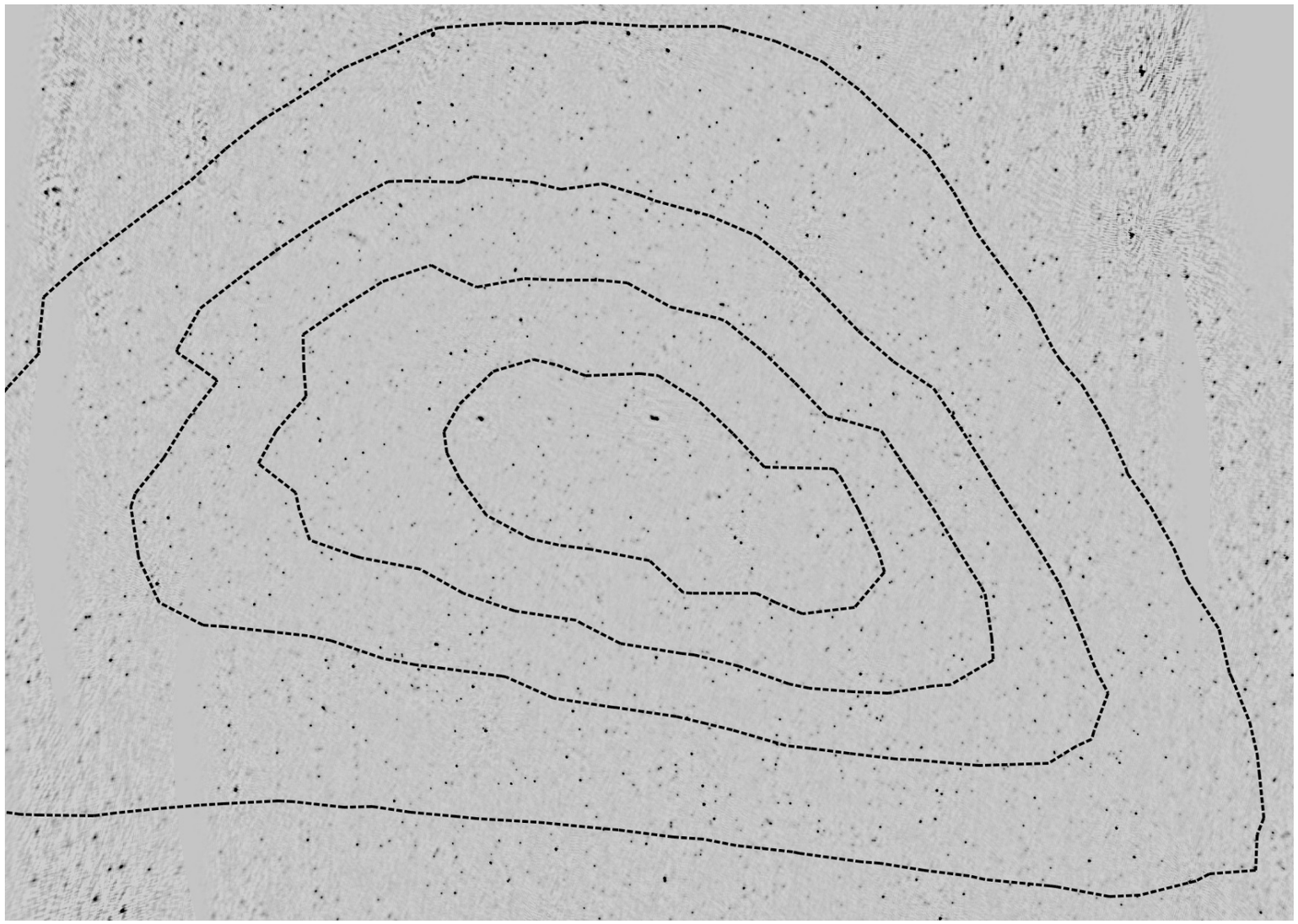
ASTRON is part of the Netherlands Organisation for Scientific Research (NWO)

GW150914 follow-up

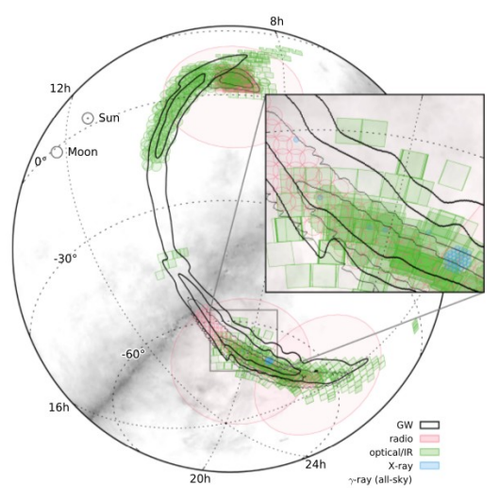
- Abbott et al. (2016a,b); Broderick et al. in prep.



3 x ~4 hr runs (each run 220 min on-source)

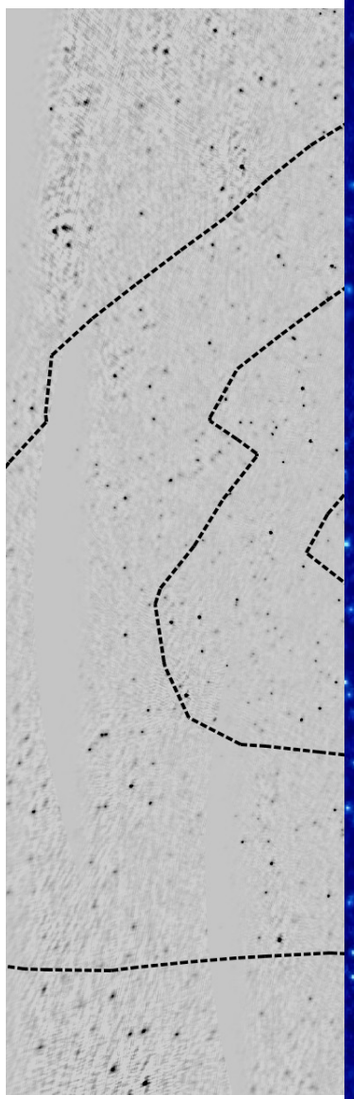
We concentrate on the LOFAR high band (110-240 MHz); sacrifice FoV for sensitivity/reliability.

- Mosaic of 8 simultaneous beams at 145 MHz with a bandwidth of 11.9 MHz
- Resolution ~50 arcsec
- Area ~40-50 deg^2
- RMS noise ~2.5 mJy beam^{-1} and >2000 sources
- Contours: cWB probability map
- Time-scales of 1 week, 1 month and 3 months



GW150914 follow-up

- Abbott et



3 x ~4 hr run

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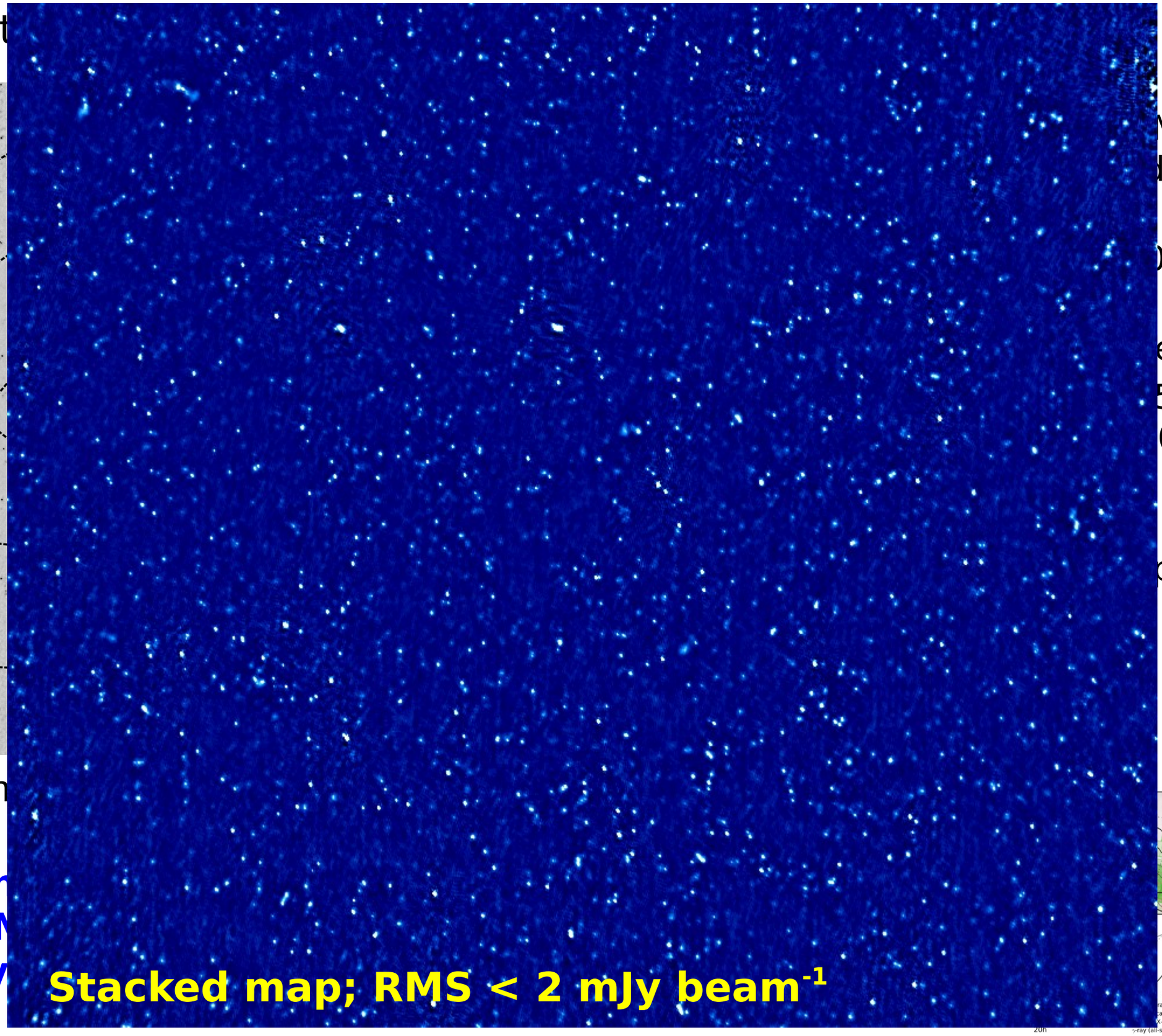

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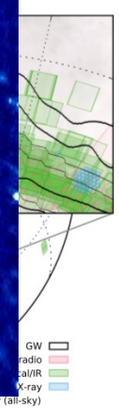
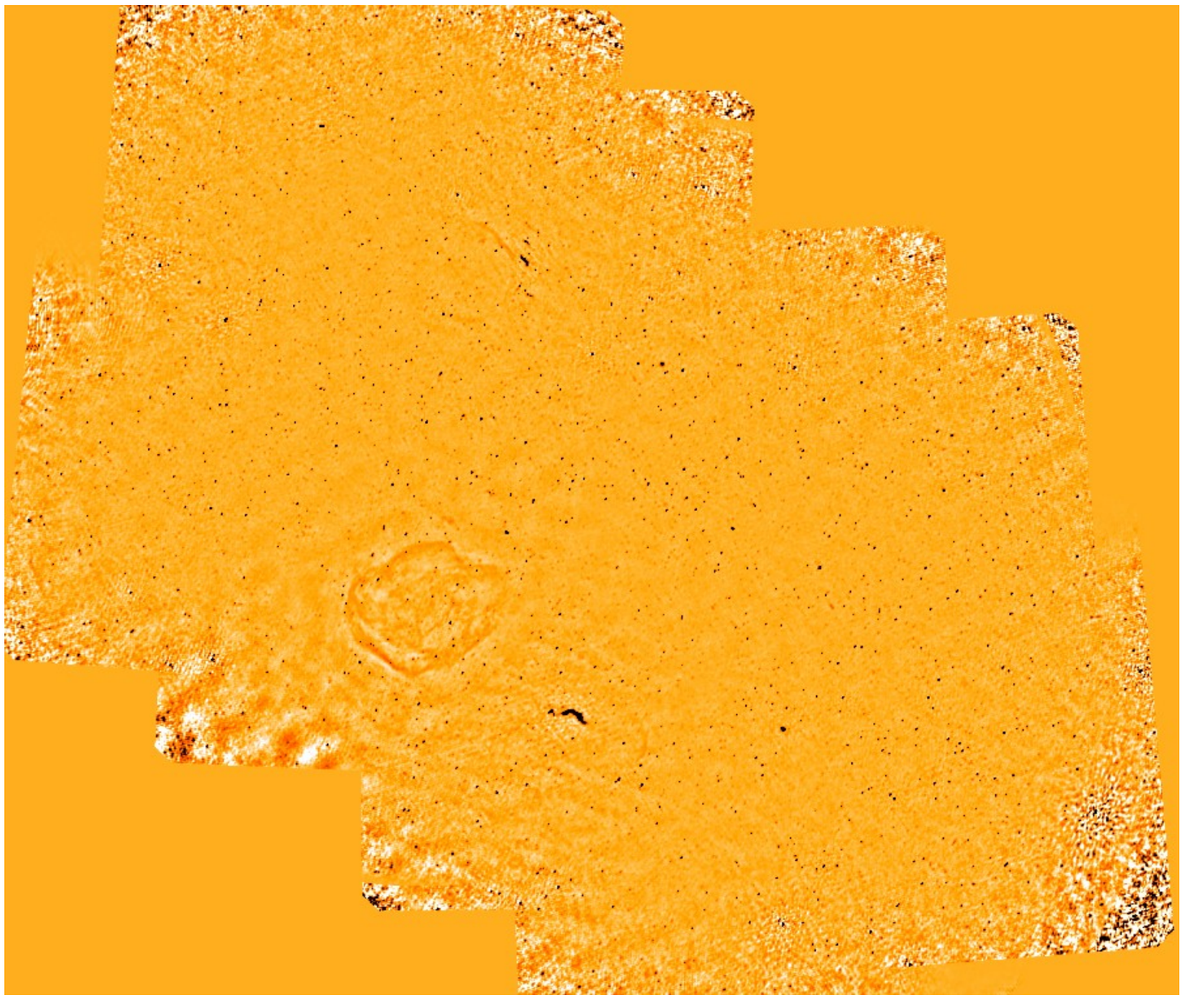


GW151226 follow-up

- Broderick et al. in prep.



4 x 8 hr runs
(each 6-beam mosaic has 53 min integration time per run)

- Example mosaic of 6 simultaneous beams at 145 MHz with a bandwidth of 15.8 MHz
- Resolution ~50 arcsec
- 4 mosaics; total area ~300 deg^2
- RMS noise ~2.5-3.5 mJy $beam^{-1}$
- Along northern arc of probability map
- Timescales of 1 week, 1 month, 3 months and 1 year

Initial transient search

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Daily Image 25-08-2016

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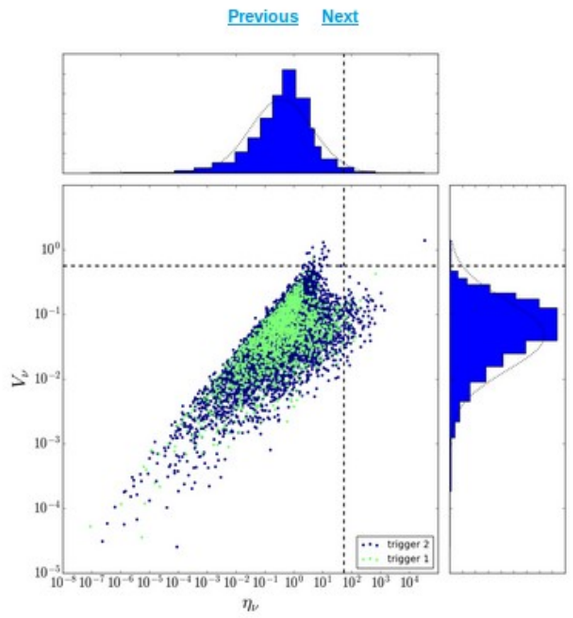
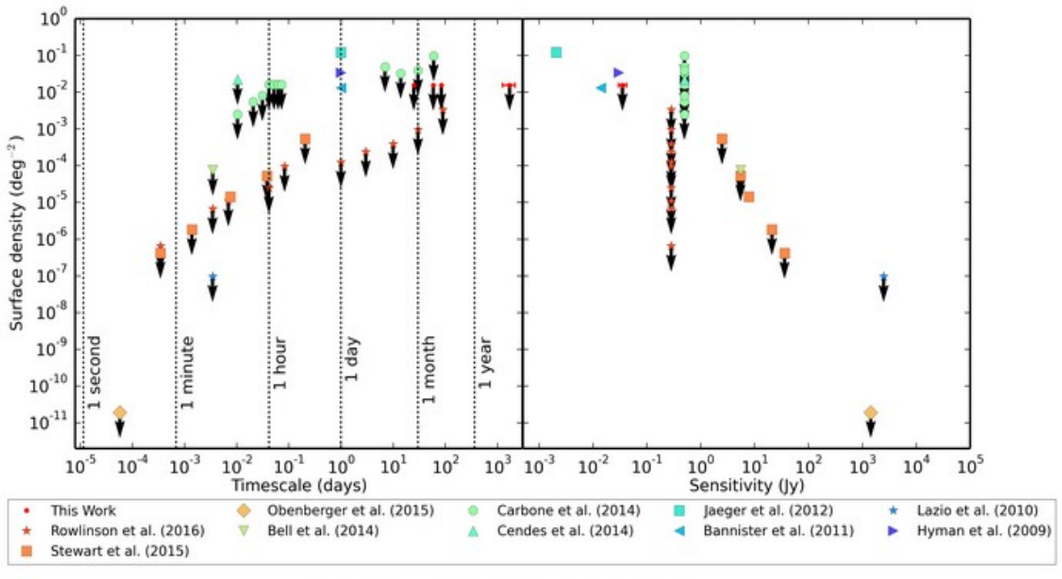




Click here or on the picture for a full size image.

Searching for gravitational wave radio counterparts with LOFAR

No LOFAR detections (yet) from GW150914 & GW151226; 10σ upper limit ~25-40 mJy beam^{-1} [Anjali Piette, Cambridge, (ASTRON summer student 2016)]

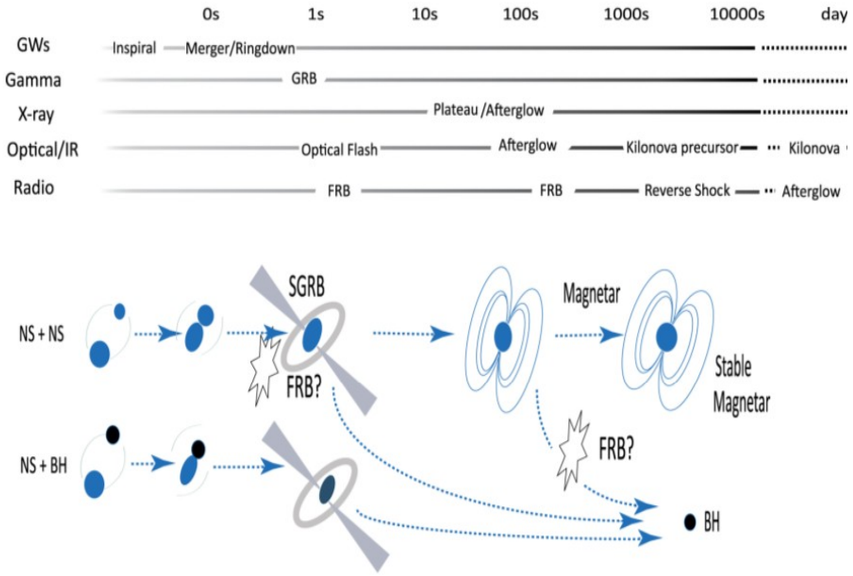
TGSS survey (Intema et al. 2017) used as a reference catalogue

Of course really want NS-NS and NS-BH follow-up!

Current/future practical challenges

- New LOFAR rapid response mode (imaging+beamformed; currently < 5 min). Every second counts – need accurate parameter estimates + localization as fast as possible. LOFAR FoV large, but sometimes the updated localizations change enough to require re-tiling.
- Need to routinely achieve 'Tier 1' depths (RMS ~ 100 μJy beam^{-1}), or better, for late-time follow-up. Manageable with some care, but are the corresponding reduction techniques reliable for transients? And what does the low-frequency transient sky actually look like at very faint flux densities (although very quiet at mJy-Jy levels)? What about 'ghosts' (e.g. Grobler et al. 2016) and other artefacts?
- May not always have access to sufficiently deep reference maps for late-time follow-up (LOFAR Tier-1 Survey only ~15 per cent complete at present).
- Indeed, it takes a long time to survey the sky to Tier-1 depths (typically 8 hr per individual field). To properly follow up several GW triggers per 6-month LOFAR cycle, we really need several hundred hours of observing time. This is a significant chunk of the total available time. Concentrate on rapid follow-up instead?
- Much larger instantaneous FoV in LOFAR low-band (30-80 MHz) – but can we go deep enough for late-time follow-up? May need LOFAR 2.0 upgrade. Could be worthwhile trying rapid follow-up in the low band (e.g. we have previously found a bright, ~4 min transient at 60 MHz – Stewart et al. 2016).

Chu et al. 2016



Hotokezaka et al. 2016