Radio follow-up of GW detections with NenuFAR ?

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with :

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IDENTIFICATION AND FOLLOW UP OF ELECTROMAGNETIC COUNTERPARTS OF GRAVITATIONAL WAVE CANDIDATE EVENTS

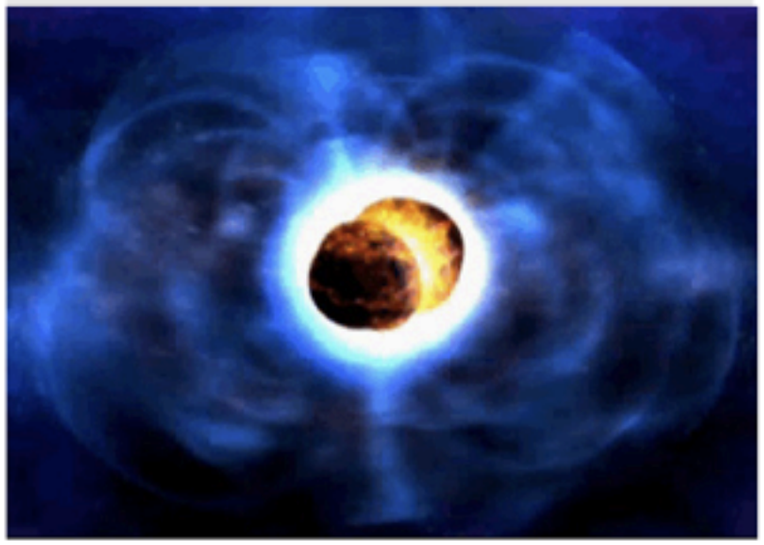
The LIGO Scientific Collaboration (LSC) and the Virgo Collaboration currently plan to start taking data in 2015, and we expect the sensitivity of the network to improve over time. Gravitational-wave transient candidates will be identified promptly upon acquisition of the data; we aim for distributing information with an initial latency of a few tens of minutes initially, possibly improving later. The LSC and the Virgo Collaboration (LVC) wish to enable multi-messenger observations of astrophysical events by GW detectors along with a wide range of telescopes and instruments of mainstream astronomy.

In 2012, the LVC approved a statement (LSC, Virgo) that broadly outlines LVC policy on releasing GW triggers (partially-validated event candidates). Initially, triggers will be shared promptly only with astronomy partners who have signed an Memorandum of Understanding (MoU) with LVC involving an agreement on deliverables, publication policies, confidentiality, and reporting. After four GW events have been published, further event candidates with high confidence will be shared immediately with the entire astronomy community (and the public), while lower-significance candidates will continue to be shared promptly only with partners who have signed a MoU.

Through June to October 2013, we organized rounds of consultations with groups of astronomers that have expressed interest in the GW-EM follow-up program. Thanks to these consultations, we could define the framework and guiding rules for this program that are collected into a standard MoU template.

OPEN CALL FOR PARTICIPATION TO GW-EM FOLLOW-UP PROGRAM, DUE FEB 16 2014.

On Dec 16 2013, we issued a call for proposals to sign standard MoU with the LVC. This call is open to all professional astronomers with demonstrated experience, and require that a partner bring some useful observing resource(s), not just astronomy expertise, to participate. GW triggers will be sent to groups that are in position to make observations in the course of next science runs circa 2015-2017 (arXiv:1304.0670, LIGO-P1200087, VIR-0288A-12). Our intent is to accept and sign MoUs with all qualified applicants. We expect to issue this call yearly in spring.



Devour thy Neighbor: An artist's illustration of two neutron stars close to merger look misshaped, becoming more oblong the closer they get to one another. A black hole is then formed and gamma rays shoot out as a GRB. (Credit: NASA/Swift)

Roadmap for aLIGO & AdV

- **Construction:** installation and testing of the detectors. This phase ends with acceptance of the detectors
- **Commissioning:** detectors from their configuration at acceptance through progressively better sensitivity. Science runs will produce astrophysical results, including upper limits on the rate of sources and quite possibly the first detections of GWs. *Exchange of GW candidates with partners outside the LSC and Virgo collaborations will be governed by memoranda of understanding (MOUs)*
- **Observing runs:** detectors are at a sensitivity which makes detections likely. Gradual transition from the commissioning to the observing phases. *After the first four detections, free exchange of GW event candidates with the astronomical community and the maturation of GW astronomy*

LIGO Scientific Collaboration, Virgo Collaboration, arXiv:1304.0670

Searches for GW transients

- **Prompt notice of a potential GW transient by LIGO-Virgo:** enable follow-up observations in the electromagnetic spectrum
- **First follow-up program:** (including alerts to several observing partners -optical, X-ray, and radio) implemented and exercised during the 2009–2010 LIGO-Virgo science run
- **Latencies of less than 1 hour:** achieved and are expected to be improved in the advanced detector era
- **Increased detection confidence, improved sky localization, and identification of host galaxy and redshift:** benefits of joint GW-electromagnetic observations
- **Some GW searches are triggered by electromagnetic observations:** localization information is known a priori

Note : GW → Radio (less effective)

- too many GW candidates

- poor localization

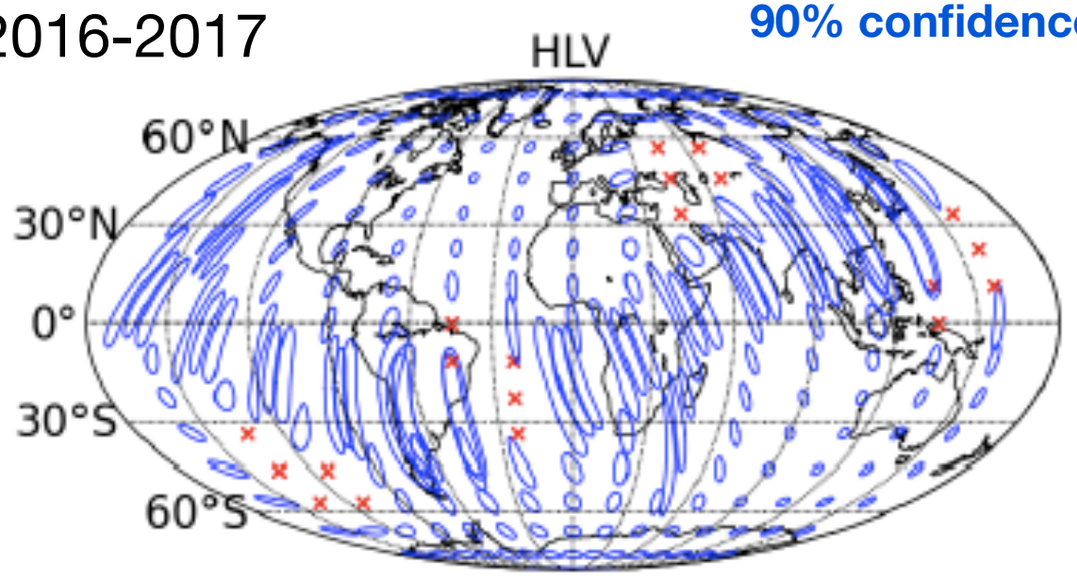
- limited storage of high-resolution radio data

LIGO Scientific Collaboration, Virgo Collaboration, arXiv:1304.0670

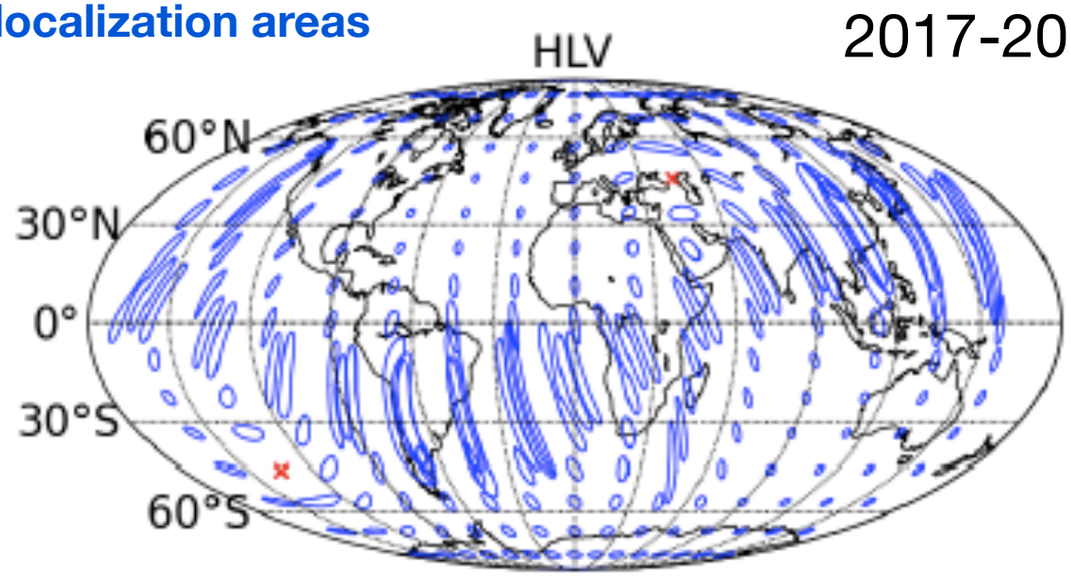
Localization & Accuracy for face-on Binary Neutron Stars Systems

90% confidence localization areas

2016-2017

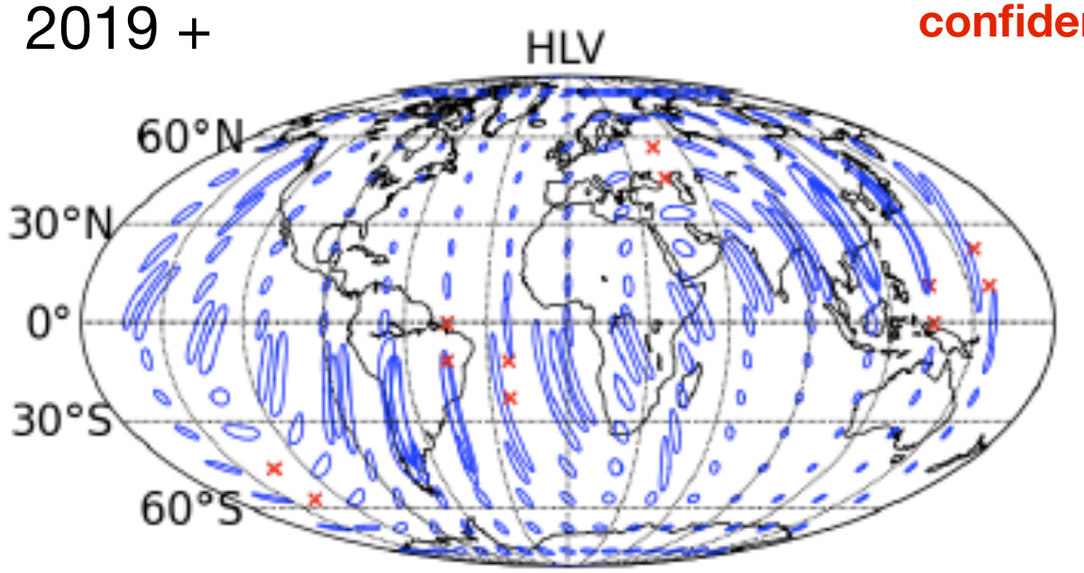


2017-2018

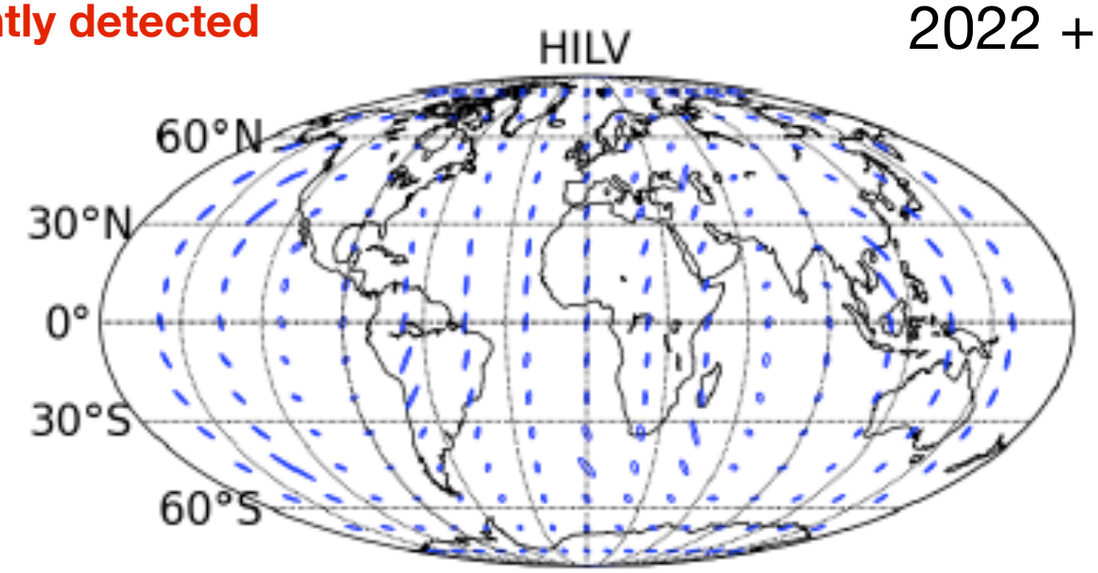


regions where the signal would not be confidently detected

2019 +



2022 +



LIGO Scientific Collaboration, Virgo Collaboration, arXiv:1304.0670

Conclusions from the GW side

- Electromagnetic follow-up of GW candidates may help confirm GW candidates that would not be confidently identified from GW observations alone

- Such follow-ups would need to deal with large position uncertainties, with areas of many tens to hundreds of square degrees. This is likely to remain the situation until late in the decade

- **Optimizing the EM follow-up and source identification is an outstanding research topic**

- **Triggering of focused searches in GW data by EM-detected events can also help in recovering otherwise hidden GW signals**

LIGO Scientific Collaboration, Virgo Collaboration, arXiv:1304.0670

The LOFAR Transient Key Project

- The LOFAR Transients Key Science Project (TKSP) is one of six approved Key Science Projects on the LOFAR telescope
- Jointly led by the Universities of Southampton/Oxford, Manchester and Amsterdam. Over 50 members from across the globe
- The LOFAR TKSP is interested to carry out follow-up observations in response to the announcement of a (candidate) GW event on a best effort basis
- **LSC-triggered ToO observations simultaneously in imaging and beamformed modes:** calibrated images with a time resolution of seconds (standard imaging) & variability information of sources in the LOFAR field of view with a time resolution of milliseconds (beamformed, 'pulsar mode')
- **LOFAR: big FoV!**
- **Latencies to be improved**

LOFAR source finders Working Group (imaging data)

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Trace: » commissioning:source_finders

A ***'Source finders Working Group'*** was formed and started his activities.

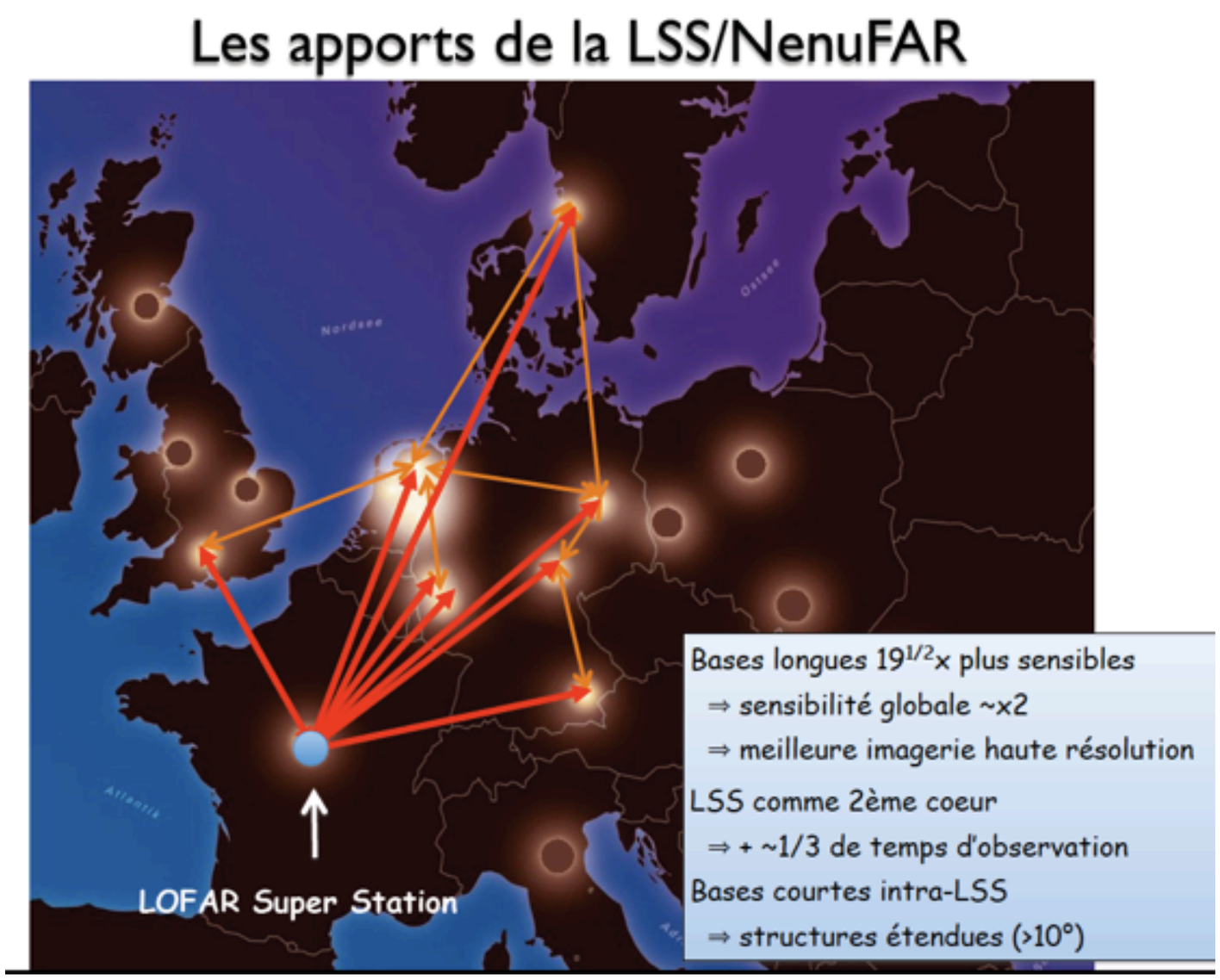
The group is leaded by *C. Ferrari* and currently hosts (in alphabetic order): *R. Breton*, *D. Carbone*, *P. Carroll*, *A. Dabbech*, *H. Garsden*, *A. van der Horst*, *G. Macario*, *A. Mints*, *R. Paladino*, *D. Rafferty*, *A. Rowlinson*, *A. Shulevski*, *J. Swinbank*, *S. van Velzen*. Updates on the activities of the Source finders WG will be given regularly at the LSMs and at the Busy Thursdays. If you would like to join the group or for any question, please contact chiara.ferrari@oca.eu.

Main current aims

- report bugs and needs to developers of available source finders
- provide support to LOFAR users
- LOFAR representative in the international radio source finding joint discussion
- identify the best settings for automatically run source finders in LOFAR / MSSS pipelines

A future MoU with NenuFAR?

- Are the NenuFAR capabilities adapted for helping in the identification and follow up of electromagnetic counterparts of gravitational wave candidate events ?
- What is the best observational strategy ?
- What is the best strategy for following-up with the full LOFAR array possible candidates ?
- How any NenuFAR follow-up could be organized ?
- **Discussions & help welcome!** (see e.g. Ismaël Cognard)



Courtesy: P. Zarka