

A program for optical observations of advanced LIGO early triggers in the southern hemisphere

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Advanced LIGO and Gravitational Wave Detections

Binary Neutron Stars (NS-NS) and Neutron Star Black Hole (NS-BH) mergers are among the most promising candidates for producing gravitational-wave (GW) signals visible out to 300 Mpc with the advanced generation of the LIGO (<http://www.ligo.org>) and Virgo detectors (<http://www.ego-gw.it>). If a short gamma-ray burst (SGRB) is produced and beamed towards Earth, satellites like Swift or Fermi will detect a prompt high-energy electromagnetic (EM) emission that would most likely be a counterpart to a GW event¹ which lasts seconds. A longer-lived emission, may be detected out to a larger angle in X-ray, UV, optical, and radio bands. Furthermore, the mergers are expected to produce an isotropic optical/IR emission, called kilonova².

The Advanced LIGO detectors will start their first scientific run sometime near the end of the summer of 2015.

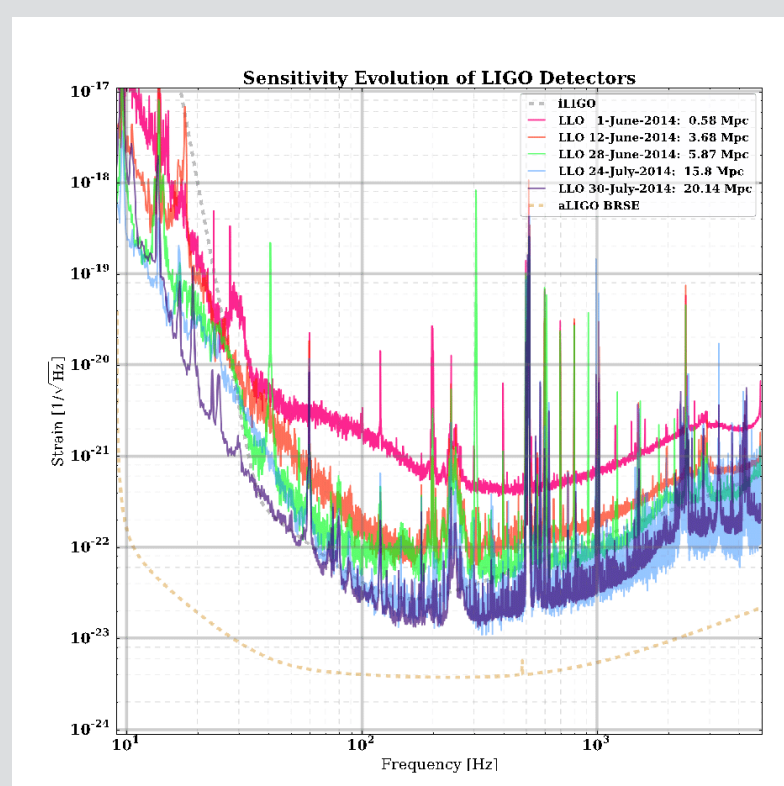
In July 2014 the detector at the Livingston Laboratory (LLO) achieved its longest lock, lasting three hours at a sensitivity that would detect GWs from coalescing neutron stars at a distance of more than 20 Mpc. This makes LLO the most sensitive gravitational wave detector ever put into operation.

The LIGO VIRGO Scientific Collaboration (LVC) has made public a plausible scenario for the operation of the LIGO-Virgo network over the next decade³.

One of the first three observing periods are scheduled in 2015 (3 month duration; with two LIGO detectors at early advanced sensitivity while Virgo is still in commissioning with a chance to join the run).

A call for proposals to sign a Memorandum of Understanding (MoU) with LVC to promptly obtain alerts to EM follow-up GW candidate events was opened on December 16, 2013 with deadline February 16, 2014. The TOROS (Transient Optical Robotic Observatory of the South) signed a Memorandum of Understanding with LVC to participate in the electromagnetic follow-up program.

TOROS (<http://toros.phys.utb.edu>) is a collaboration formed by scientists from The University of Texas at Brownsville, the Universidad Nacional de Cordoba, Texas A&M University and other universities in Europe who have partnered to develop an astronomical optical observatory in the Southern hemisphere dedicated to follow up triggers from aLIGO and aVIRGO.



The L1 DARM displacement spectrum from end July 2014 (source: <https://www.advancedligo.mit.edu>)

The plots near the bottom of the left column are estimations of NS-NS mergers events per year detectable as kilonovae at given magnitude in the visual and R band⁵. The TOROS site will be located in Co Macón, at latitude 24.61 South and longitude 67.32 West, at an altitude of 4,650 meters in the province of Salta, Argentina. The site was first surveyed by ESO as one of the candidates for the E-ELT telescope. Average seeing was measured as an annual average of 0.79 and a median of 0.55 arcsecs⁶. The long term goal of the TOROS collaboration is to build a facility capable of surveying ~50 square degrees per hour and provide a SNR=10 detection of a V=22 (I=21) mag transient in that time.

The TORITOS Project

The TOROS telescope will not be operational before 2016. In consequence the TOROS collaboration will operate a smaller instrument at Co Macon to participate in the 2015 aLIGO first scientific run. The instrument, called TORITOS, consists in a 0.40 m Schmidt Cassegrain telescope with an Apogee Alta U16 CCD which has a 0.5 deg x 0.5 deg FOV with a 0.45 arcsec/pixel resolution. TORITOS will be capable of operating robotically during 2014-2015. Although quite limited in the sky area coverage, it can survey up to 12 square degrees per night and detect events with a SNR=10 of a V=20 mag transient (under median observing conditions).

The telescope will have four basic modes of operation: (1) follow up of gravitational-wave triggers; (2) follow up of gamma-ray burst triggers from Fermi, Swift, and other satellites; (3) baseline imaging of the entire surveyable area; and (4) search for short-duration transient events, variable sources and moving objects within the DES and VISTA-VIKING fields.

Additionally, the collaboration plans to execute its own photometric and spectroscopic followup of relevant transients. The photometric followup will make use of the ABRAS (<http://abras.oac.uncor.edu/en>) 1.1- m telescope expected to see first light early 2015, also to be located at Macón, and the Bosque Alegre 1.5-m telescope from OAC in Córdoba (<http://www.oac.uncor.edu/M2SM4.html>). The spectroscopic followup will be conducted using target-of-opportunity time on larger instruments.

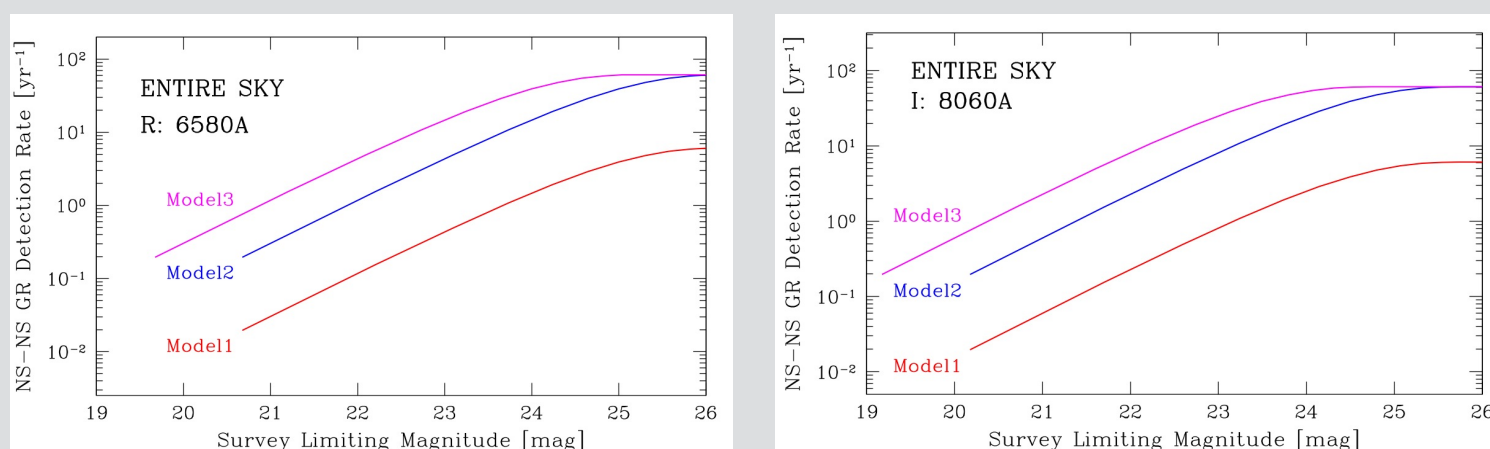


TORITOS building in the forefront. The ABRAS dome in the background



Carlos Colazo and Matias Schneider

The Expected Light Curves



The three models depicted in the plots above represent three possible event rates estimated from population synthesis predictions.

The electromagnetic signals associated with NS-NS merger events expected to be observed by aLIGO and AdVirgo will be faint and most likely with light curves as the ones observed recently for GRB 130603B⁴.

TORITOS First Light



NGC 5139 w/ Apogee AU10

The calibration and first operation of the instrument occurred in April 2014. Its first light on April 18, 2014 was an image of the Omega Centauri cluster which is shown on the left.

References

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