Gravitational wave optical counterpart searching based on GRAWITA and DLT40 project

Sheng Yang[1,2,3], Enrico Cappellaro[2], Stefano Valenti[3]

on behalf of GRAWITA and DLT40 project.

[1]Department of Astronomy, University of Padova

[2]Observatory of Padova, INAF

[3]Department of Physics, University of California, Davis

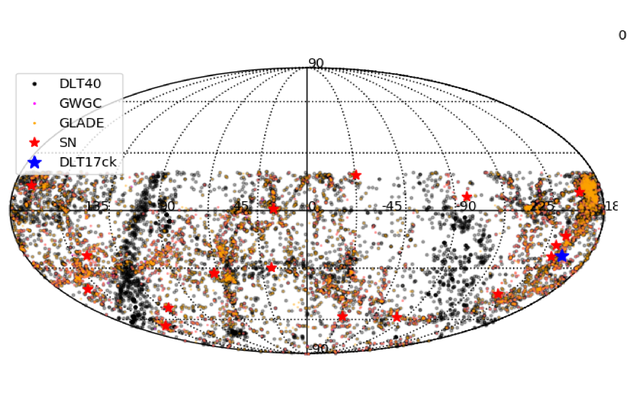
sheng.yang@oapd.inaf.it

sngyang@ucdavis.edu

Abstract: Two complementary approaches are used in order to search for EM counterpart of GW signal with large localization uncertainty: (1) wide-field search on high probability GW region, e.g. GRAWITA; (2) pointed search of selected galaxies in high probability GW region, e.g. DLT40.

DLT40 project: A one day cadence supernova search using a PROMPT 0.4m telescope with $10 \times 10 arcmin^2$ FoV. Single epoch integration of 45s can reach a limiting magnitude of r$\sim$ 19*mag* with filterless observations.

-surveyed almost all LIGO O2 triggers(Sheng et al, in preparation);
-contribute to detect the kilonova during GW170817, sss17a/DLT17ck(Valenti et al, APJL, accepted) and rate estimation(Sheng et al, in preparation).



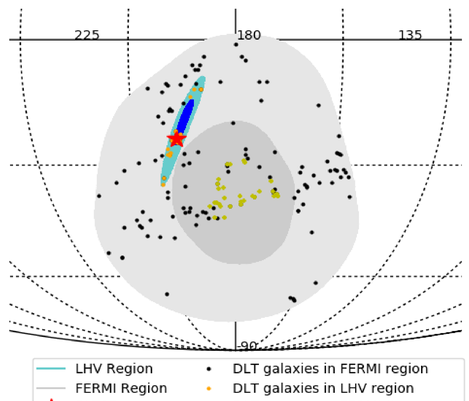


Figure 1. DLT40 galaxy catalogue map with all SN detected by DLT40 so far and DLT17ck.

Figure 2. The sky map region of GW170817 over-imposed on the Fermi GBM trigger 524666471/170817529. The red star marks the location of DLT17ck and the host galaxy NGC 4993.

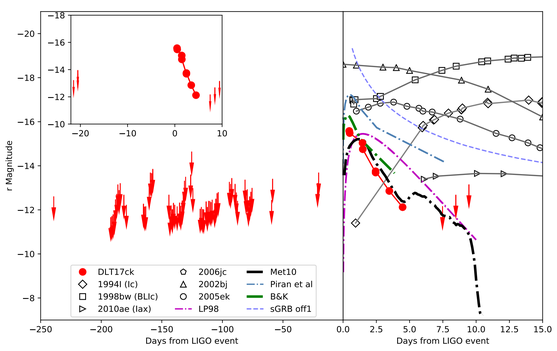


Figure 3. DLT17ck light curve(in red) over plotted with normal or fast-evolving SNe (in gray). Several NS-NS merger models, scaled to a distance of 40 Mpc, are shown as comparison.

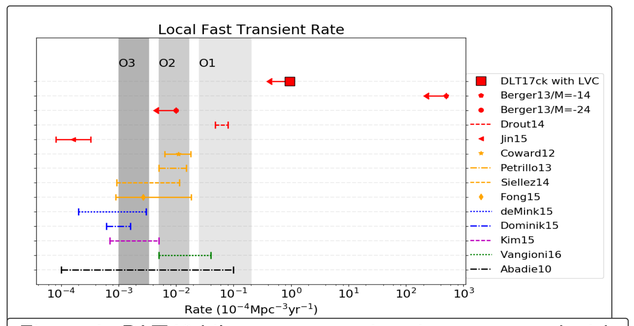


Figure 4. DLT40 kilonova rate estimation, compared with the rate of sGRB(orange), BNS merger from stellar evolution(blue), cosmic nucleosyntesis(green), galactic pulsar population(magenta), gravitational waves(black) and fast optical transients(red).

GRAWITA project: INAF GW EM follow-up team, from radio to high energy including VST 2.6m telescope with 1 square degree FoV. By dithering 2 images with 45s exposure can reach to a limiting magnitude of r=22 mag on average.

-surveyed GW150914, GW151226 in LIGO O1 run(Brocato et al 2017, MNRAS submitted) and GW170814 in O2 run;
-spectroscopic follow-up with NOT for iPTF15dld(SN Ic during LVT151012, Pian et al, MNRAS 466:1848) and sss17a/DLT17ck(kilonova during GW170817, Pian et al, Nature, accepted)

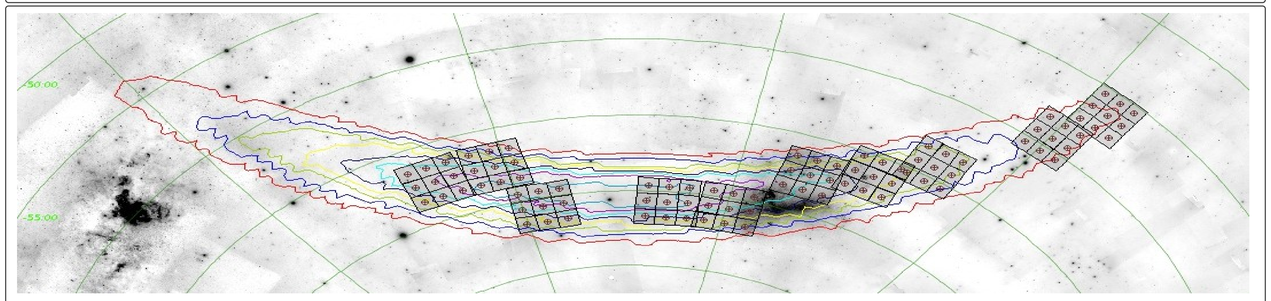


Figure 5. VST 1 square degree survey boxes(90 pointings, 6 epochs) scheduled for GW150914.

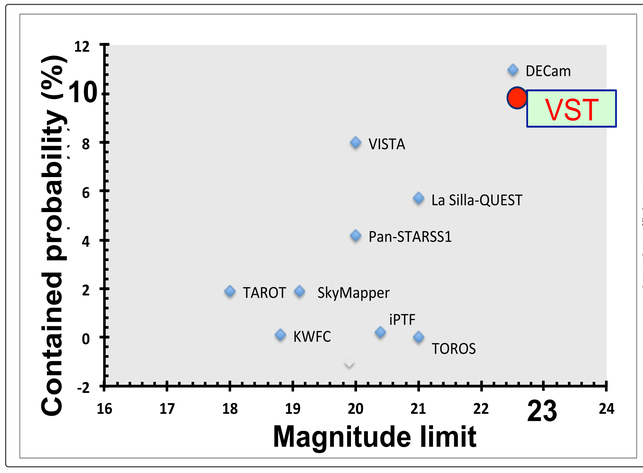


Figure 6. VST performance: VST could include 10% probability of GW map with 22 mag in r band on average.

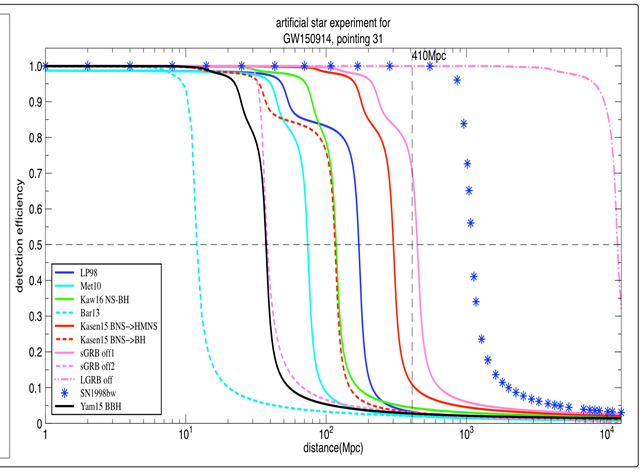


Figure 7. How far VST can reach? With artificial star experiment, we test different kilonova models to estimate the limiting distance of VST images.

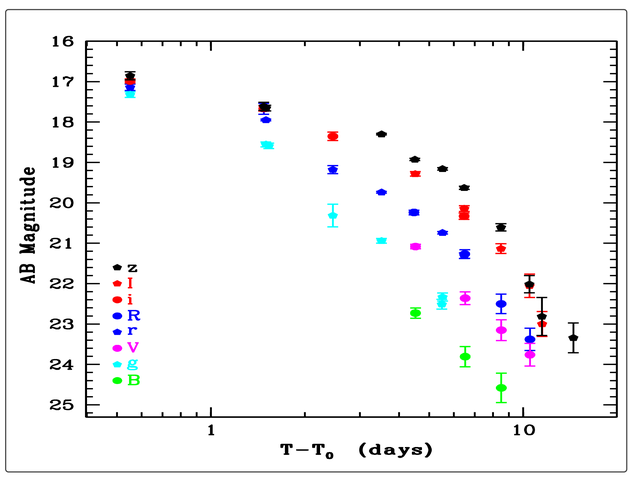


Figure 8. Optical light curves of SSS17a / DLT17ck, Pian et al, Nature, accepted

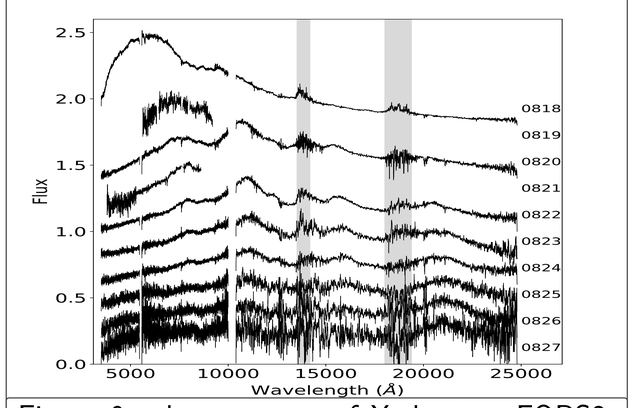


Figure 9. the sequence of X-shooter, FORS2, and GMOS spectra for SSS17a/DLT17ck, Pian et al, Nature, accepted.

Next:
- The era of multi-messenger astronomy has truly begun.
- With the expected increase in sensitivity of the LVC detectors, in O3 the volume where NS-NS mergers can be detected will reach 150 Mpc. At this distance, current galaxy catalogs are incomplete. The wide FoV strategies, like GRAWITA, would play more important role. DLT40 need to increase the exposure time to reaching binary neutron star mergers at this distance.
- With more interferometers joining in the future, the localization would be more certain and pointed search will become more effective.

present on behalf of GRAWITA and DLT40 GW EM follow-up project at International Astronomical Union 2017 Symposium Gravitational Wave Astrophysics