Large Synoptic Survey Telescope Letter of Intent to collaborate with LVC for the EM identification and follow-up of candidate GW events

Key people and their expertise:

LSST EM/GW Working Group:

* Likely to attend one of the meetings

- Ashish Mahabal - Caltech - *Sky Surveys; Classification; EM follow-up coordination*
- Lucianne Walkowicz - Princeton - *Optical/UV studies of variables and transient events*
- Andy Becker - University of Washington - *Fast transients*
- * Edo Berger - Harvard - *optical searches and studies of transients; multi-wavelength studies of short-duration GRBs.*
- Josh Bloom - UCB - *Robotic telescopes, automating discovery and classification of transients, GRB observations and inference*
- S. Bradley Cenko - NASA/GSFC - *multi-wavelength studies of gamma-ray bursts and other time-domain phenomena; lead of PTF program to search for optical afterglows of poorly-localized gamma-ray bursts detected by the GRB Monitor on-board the Fermi satellite.*
- Kem Cook - Academica Sinica - *Transients*
- Brenda Frye - University of Arizona - *photometric surveys at low Galactic latitudes, focus on identification of nearby dim, dark objects via long duration transient events.*
- Daniel Holz - University of Chicago - *Multi-messenger astronomy, especially with gamma-ray bursts; standard siren measurements of cosmology*
- Zeljko Ivezic - U of Washington - *Sky surveys; transients*
- * Mansi Kasliwal - Carnegie Observatories/Princeton - *Discovery and panchromatic follow-up of all types of optical transients in the local universe; Completing the catalog of galaxies in the local universe*
- * Shri Kulkarni - Caltech - *GRBs; Pulsars; PTF*
- * Samaya Nissanke - Caltech - *GW physics and source characterization (modeling and parameter extraction), electromagnetic counterparts & compact object astrophysics, multiwavelength electromagnetic follow-up of GW mergers*
- Eran Ofek - Caltech - Search in large area regions
- Abhijit Saha - NOAO - *crowded field / faint photometry and calibration; detection and characterization of photometric variability; stellar populations and variable stars; distance-scale and near field cosmology; LSST observation scheduling and observatory operations.*
- Rob Seaman - NOAO - *NOAO Science Data Management, lead author of the VOEvent standard*

Facilities and capabilities:

The Large Synoptic Survey Telescope (LSST) is a 8.4m telescope that will be built on the summit of Cerro Pachon (Chile). LSST will observe the sky in 6 bands (between 0.3 and 1.1 microns), reaching a single visit depth of r~24.5 over a 9.6 degree field of view. LSST will produce alerts within 60 seconds for transient and variable objects, and these alerts will be

publicly available to the global community. The LSST alert stream will likely comprise a major impetus for transient observing in the next decade, and along with the increasingly deeper co-added images, will provide an important catalog of galaxies in the nearby universe. But well before LSST's first-light, starting from about 2014, many other facilities that plan to co-observe or perform triggered follow-up on alerts of interest will start to ramp up their efforts in order to characterize the variable/transient sky, form follow-up networks, event brokers and related automation components. As a result, we anticipate having a more holistic understanding of the transient sky over a wide range of wavelengths, as well as coordination infrastructure.

The main LSST survey will comprise roughly 1000 visits over the entire sky during the course of the 10 year survey (the detailed cadence of how the main survey will be carried out is still being finalized, but nominally consists of "visits" of image pairs and revisits on timescales of a few days). LSST will also have a number of specialized cadences, whose details are being worked out. One of these is to respond to Targets of Opportunity that require wide-field imaging, which will enable the survey to accommodate observing of gravitational wave (GW) triggers.

While the exact nature of the EM counterparts of GW events is as yet unknown, current predictions indicate that peak brightness may be quite faint, and the localization uncertain. LSST's instantaneous field-of-view, aperture, speed, and wavelength coverage make it one of the few facilities capable of tiling the error region to the required depth for early LIGO GW events. Furthermore, LSST's ability to characterize the faint variable sky will significantly improve the ability to identify potential EM false positives.

Scientific deliverables:

The LSST data will be immediately public to the US and Chilean communities, as well as to global LSST partner institutions. At present, LSST is expected to see first light in 2021, well *after* the anticipated first events from Advanced LIGO. Additional GW detectors (e.g. Kagra and others) are expected to be online when the LSST survey starts. The GW sky localization would then be expected to be within a single pointing of LSST in many cases thus making it much easier and feasible to carry out ToO observations with the LSST. The exact fraction of time that can be allocated to ToO interrupts is not clear at the present time. The Transients and Variable Stars science collaboration (represented by the EM/GW working group signatories on this Letter) will be working to immediately analyze transient and variable events with LSST, and we anticipate that the collaboration will be able to provide counterpart identification and false positive vetting for potential GW counterparts.

The survey observations and associated products like list of alerts, deep co-added images, and galaxy catalog as well as simulations of the deep sky leading to the start of the survey are contributed deliverables, whereas ToO follow-up will be part of coordinated deliverables.