Multi-wave characterization/ counterparts SubGroup

(LSST Argonne Meeting)

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1. Two Major Directions

- Finding counterparts (radio, X-ray, gamma-ray, neutrinos, GW) of transients discovered by LSST

⟹ LSST= discovery machine (mode A)

- LSST Follow up of transients discovered elsewhere

⟹ LSST = follow-up machine (mode B)

1.1 Science Drivers

(1-B) EM counterparts to GW triggers [kilonova signature + other if BH-BH produce something]

(2-AB) TDE science

(3-AB) Mass-loss from massive stars

(4-B) Stellar progenitors through shock break out and/or SN shock interaction with the companion

(5-AB) Short and Long GRB jet opening angles and rates through off-axis afterglow signature

1.2 Major Observational Challenges

VERY DIFFERENT TIME SCALES of the phenomena we would like to constrain

Average distance of LSST-discovered transients is too large for radio and X-ray follow-up. → challenge= we need large discerning power

Limited resources for multi-wave follow-up vs. number of LSST transients

Our recommendations (1)

For GW follow-up: a **ToO program** needs to be in place (expected median localization is ~20deg2)

Key capabilities/challenges for LSST follow-up of GW events include:

- rapid ToO (with reaction time of 5-10 days)
- Algorithms in place to be able to identify kilonovae/off-axis afterglows
- For larger error boxes, a LSST galaxy catalog with rough photometric redshifts would be extremely useful for defining follow-up (and also useful for follow-up with other facilities)
- Ideally, the ToO capability will include the possibility to designate a desired set of filters to have color information

This applies to any search for LSST counterparts of fast evolving transients with non-optimal localization

Our recommendations (2)

For SN physics: **non-uniform** survey strategy (deep drilling fields and rolling cadence to lower the cadence) with **color information** to be able to:

- Discover SNe at a very early stage
- Filter out interesting targets ONLY for follow-up (i.e. nearby events for radio and X-ray follow-up or intrinsically interesting targets like SLSNe). NB: nearby events might saturate LSST!

At the moment LSST would not be able to do shock break out science and/or SN shock interaction with the companion science

1.3 What's unique about LSST

- Accurate and DIRECT sampling of the pre-SN life of stellar progenitors in the ~10 years before collapse, which means accurate (and statistically meaningful) measurements of eruption time scales and luminosity increase associated with the eruptive **mass-loss episodes**
- LSST, with its the wide FOV and extension to ~1 micron, is an extremely unique position to identify **counterparts to gravitational wave events**. There are only a handful of facilities that will actually be able to perform meaningful follow-up and LSST is one of them.

Point (2) would be heavily compromised in the absence of a specific ToO capability

Other wide-field facilities

- Highly desirable to have a gamma-ray instrument still flying
- Wide field UV monitor (everything has been turned down so far)
- Wide field soft X-ray monitors (some will be proposed in the upcoming months -e.g. StarX-, some have been turned down)
- SKA

What needs to be discussed here

- LSST **ToO** capabilities
- Current cadence is far from being optimal for studies of transients with time scales of ~1-2 months
- Central coordination of the multi-wave follow-up by LSST. What are the real benefits and what are the cons?
- What is the current discerning power of LSST?