LSST TVS collaboration

federica b. bianco, NYU
The Transient and Variable Stars LSST Collaborations
Atacama Desert, Cerro Pachon
- effective aperture of 6.7 m
- FoV $9.6 \text{ deg}^2$
- large *etendue*
  (collecting area x FoV)
- effective aperture of 6.7 m
- FoV 9.6 deg$^2$
- large *etendue*
  (collecting area x FoV)

**Wide-Deep-Fast**

2022-2032
- effective aperture of 6.7 m
- FoV 9.6 deg$^2$
- large *etendue*
  (collecting area x FoV)

**Wide-Deep-Fast**

cover large swaths of sky

2022-2032
- effective aperture of 6.7 m
- FoV 9.6 deg²
- large *etendue* (collecting area x FoV)

**Wide-Deep-Fast**
cover large swaths of sky
to faint magnitudes
- effective aperture of 6.7 m
- FoV 9.6 deg$^2$
- large etendue
  (collecting area x FoV)

Wide-Deep-Fast
cover large swaths of sky
to faint magnitudes
in a short amount of time
Innovative Optical Design
Gemini South

8m diameter

8.4m diameter

MIRROR:

FIELD OF VIEW:

0.2 deg²

9.6 deg²

LSST
The LSST Data Stream
each night is 30TB data

- 30 Terabytes: 1,500,000 trees made into paper and printed;

The LSST Data Stream
each night is 30TB data

- 30 Terabytes: 1,500,000 trees made into paper and printed;

#OPENDATA  #OPENSCIENCE

The LSST Data Stream
the LSST data each night is 30TB data

At 1Gbps, 30TB would take 67 hours to download

**Long Haul Networks** to transport data from Chile to the U.S.
- 200 Gbps from Summit to La Serena (new fiber)
- 2x40 Gbit (minimum) for La Serena to Champaign, IL (protected, existing fiber)
The LSST Science
A stream of 1-10 million time-domain events per night, *detected and transmitted within 60 seconds of observation*. 

A catalog of orbits for 6 million bodies in the Solar System.

A catalog of 37 billion objects: 20B galaxies, 17B stars characterized in shape, color, and variability.

High resolution deep stacks that will allow measure weak lensing.
Science Drivers

- Dark energy and dark matter (via measurements of strong and weak lensing, large-scale structure, clusters of galaxies, and supernovae)

- Exploring the transient and variable universe

- Studying the structure of the Milky Way galaxy and its neighbors via resolved stellar populations

- An inventory of the Solar System, including Near Earth Asteroids and Potential Hazardous Objects, Main Belt Asteroids, and Kuiper Belt Objects
Science Drivers

- Dark energy and dark matter (via measurements of strong and weak lensing, large-scale structure, clusters of galaxies, and \textit{supernovae})

- Exploring the \textit{transient and variable universe}

- Studying the structure of the Milky Way galaxy and its neighbors via \textit{resolved stellar populations}

- An inventory of the Solar System, including Near Earth Asteroids and Potential Hazardous Objects, Main Belt Asteroids, and Kuiper Belt Objects
Survey Strategy

WFD:
a pair of image per field, repeated twice/night. ~85% of the observing time

DeepDrilling fields:
a pair of image per field, repeated >twice/night  5-10 DD fields

Galactic plane survey

South Celestial Cap

Northern Ecliptic
LSST Science Collaborations
There are currently ten LSST Science Collaborations. Additional information about their work and membership can be found at the links below or by contacting the individual chairs, or the LSSTC Science Collaborations Coordinator (LSSTCSC), Lucianne Walkowicz.

Galaxies
Michael Cooper (UC Irvine); Brant Robertson (University of California, Santa Cruz);

Stars, Milky Way, and Local Volume
John Bochanski (Rider University); John Gizis (University of Delaware); Nitya Jacob Kallivayalil (University of Virginia);

Solar System
Lynee Jones (University of Washington); David Trilling (Northern Arizona University);

Dark Energy
Rachel Bean (Cornell University); Jeffrey Newman (University of Pittsburgh);

Active Galactic Nuclei
Neil Brandt (Pennsylvania State University);

Transients/variable stars
Federica Bianco (New York University); Ashish Mahabal (Caltech);

Large-scale structure/baryon oscillations
Eric Gawiser (Rutgers The State University of New Jersey); Shirley Ho (Carnegie Mellon University);

Strong Lensing
Phil Marshall (KIPAC);

Informatics and Statistics
Tom Loredo (Cornell University); Chad Schafer (Carnegie Mellon University);
The LSST Transients and Variable Stars collaboration focuses on the transient sky, including a large and diverse range of phenomena: variable events, periodic or not, explosive and eruptive transients, and geometric transients (e.g. eclipsing binaries and planets). Variability is a tell tale of the nature of the object observed, but it also enables galactic studies (the mapping of the galactic structure), extragalactic studies (the characterization of the intracluster medium), and cosmological studies. Because of their physical and phenomenological diversity, the object we study span a wide range of timescales, and present themselves in a range of brightnesses, and colors. LSST also holds great potential for discovery of new transient phenomena, especially at the very short and very long time scales.
Subgroups

- Cosmological
- Classification/Characterization
- Distance Scale
- Fast Transients
- Galactic
- Gravitational Waves
- Interacting Binaries
- Magnetically Active Stars
- Microlensing Subgroup
- Multiwavelength Characterization/Counterparts
- Non-degenerate Eruptive Variables
- Pulsating Variables
- Supernovae Subgroup
- Tidal Disruption Events
- Transiting Planets
Nearly 160 members!
Each member declares a *primary* affiliation and up to 3 *secondary* affiliations.
Roadmapping LSST to success

different variable and transient phenomena benefit from different observing strategies
our group is working to reconcile the differences & understand the existing tensions & overlap
The Time is Now!

we need a *science based evaluation*

of the baseline LSST observing strategy and its variants
Its a hell of a fight!
TRANSIENTS ⇔ CADENCE

VARIABLES ⇔ CADENCE
TVS ROADMAPPING MEETING

We are no longer accepting requests for financial travel assistance.

**Important Information**

All meeting attendees must register using the registration form in the left menu. Non-US citizens must complete the Argonne Visitor Registration form in addition to the meeting registration form. This is mandatory in order to guarantee site access.

A room block has been set up with the Argonne Guest House, please visit the accommodations tab for more information on reserving a room.

The workshop will be held in Argonne’s Theory and Computational Sciences (TCS) conference center in building 240.

**Meeting Overview**

This meeting is designed as a small collaborative workshop to shape the ongoing roadmap contributions into a coherent vision for the LSST TVS path to science, integrating the individual subgroup contributions into a comprehensive plan for the collaboration. At this time it is critical to discuss the impact of LSST strategic decisions on the diverse range of phenomena that our group studies, and to consolidate common goals.

https://indico.hep.anl.gov/indico/conferenceDisplay.py?oww=True&confid=968
OBSERVING STRATEGY WHITE PAPER

Science-Driven Optimization
of the LSST Observing Strategy

Prepared by the LSST Science Collaborations,
with contributions from the LSST Project.

Contributing Authors

how to contribute

we need a *science based evaluation* of the baseline LSST observing strategy and its variants

Observing Strategy White Paper Section 1.2
OpSim
LSST developed operation simulations (A. Connoly)
OpSim
LSST developed operation simulations
(A. Connolly)

MAF API
Metric Analysis Framework
(Peter Yoachim, Lynne Jones)

Getting Help in MAF
This notebook is a collection of snippets of how to get help on the various bits of the MAF ecosystem. It shows some of the tools that also uses the help function. The help function used below is a Python standard library function. It can be used on any module and should give clarity to the parameters used in associated functions. It will also list functions associated with modules and classes.

dir command which is another Python standard library function. This is useful for getting a list of names from the target object.

In [1]: # Need to import everything before getting help!
import lsst.sims.maf
import lsst.sims.maf.metrics as metrics
import lsst.sims.maf.slicers as slicers
import lsst.sims.maf.stackers as stackers
import lsst.sims.maf.plots as plots

In [2]: # Show the list of metrics with a little bit of documentation
metrics.BaseMetric.List(doc=True)

------ AveSlewMetric ----- -
None ------ BinaryMetric ----- -
Return 1 if there is data.
------ CoordSampMetric ----- -
Calculates the coadded m5 value at this gridpoint.
------ CompletenessMetric ----- -
Compute the completeness and joint completeness
------ CountMetric ----- -

https://github.com/LSST-nonproject/
OpSim
LSST developed operation simulations  
(A. Connoly)

MAF API
Metric Analysis Framework  
(Peter Yoachim, Lynne Jones)

![Diagram of SN Alert Fraction](image)

Figure 2.10: The fraction of simulated Type Ia SNe at a redshift of 0.5 detected pre-peak in any filter for candidate Baseline Cadence minion_1016. About 40% of all such SNe from the main survey will be detected before their maximum brightness.
Figure 6.2: Histograms of median intra- (left) and inter- (right) night visit gaps for any filter for several OpSim runs.

Figure 6.3: Histograms of median r-band intra- (left) and inter- (right) night visit gaps for several OpSim runs.
transients and variables
from the Observing Strategy White Paper
preliminary results
different variable and transient phenomena benefit from different observing strategies
our group is working to reconcile the differences & understand the existing tensions & overlap

Tensions:

- color or sampling? (SN/GW vs GRB)
- dense sampling or duration? (SN vs TDE)
- Rolling cadence?
- ToO?
5 Variable Objects

Chapter editors: Ashish Mahabal, Lucianne Walkowicz.

Contributing authors: Michael B. Lund, Stephen Ridgway, Keaton J. Bell, Patrick Hartigan, C. Johns-Krull, Peregrine McGehee, Shashi Kanbur
Science-Driven Optimization
of the LSST Observing Strategy

5.5.2 Probing Planet Populations with LSST

Michael B. Lund, Avi Shporer, Keivan Stassun

This section describes the unique discovery space for extrasolar planets with LSST, namely, planets in relatively unexplored environments.
6 Eruptive and Explosive Transients

Chapter editors: *Eric C. Bellm, Federica B. Bianco*

Contributing Authors:

*Iair Arcavi, Laura Chomiuk, Zoheyr Doctor, Wen-fai Fong, Zoltan Haiman, Vassiliki Kasogera, Ashish Mahabal, Raffaella Margutti, ??, Stephen Ridgway, Ohad Shemmer, Nathan Smith, Paula Szkody, Virginia Trimble, Stefano Valenti, Bevin Ashley Zauderer*
Non-Time-Critical
6.3 Supernovae as Transients

Federica B. Bianco

constraint RG progenitor systems to <20%
(Bianco+ 2012, 3 year of SNLS data)
LSST 3 month -> 1%
6.3 Supernovae as Transients

Federica B. Bianco

constraint RG progenitor systems to <20%
(Bianco+ 2012, 3 year of SNLS data)
LSST 3 month -> 1%

also:
shock breakout, IIB double peaks
6.3 Supernovae as Transients

Federica B. Bianco

Figure 6.6: A normal SN Ia lightcurve at $z=0.5$ showing interaction with a RG companion as seen from the most favorable viewing angle: the effect of interaction as simulated by Kasen (2010) is added on top of a lightcurve simulated from the Nugent et al. 2002 templates. The data points represent one possible set of LSST observations of this transient, obtained by running the transientAsciiMetric. This particular event is detected in $g'$, $r'$, and $i'$ within the first 10 days.
6.3 Supernovae as Transients

Federica B. Bianco

![Graph showing supernovae detections](image)

Figure 6.7: Normal SN Ia lightcurve at $z=0.5$ detected by the **minion 1016** cadence in 3 months, 6 months, and 1 year, that provide color information useful to constrain the progenitor distribution. Lines are third-degree polynomial fits.

138
Time-Critical:

CLASSIFICATION: young/old

FAST TRANSIENTS: GRB

GW: counterpart discovery
6.2 Realtime Identification of Young Transients

Stefano Valenti, Federica B. Bianco

Figure 6.4: Left: $r'$-band light curve for representative transients as function of the phase from the beginning of the transient outburst/explosion for the first few days of the transient life. Right: slope of the transient evolution. Data from: SN Ia, Olling et al. (2015); SNII, Rubin et al. (2016); SN Ia, Shen et al. (2010); SN Ib, Valenti et al. (2011), Cao et al. (2013); SN Ic, Mazzali et al. (2002); CV, Sokoloski et al. (2013), Finzell et al. (in prep), SN Ia+interaction (see Section 6.3)
Days since explosion
Gap between observations

Delta mag

Days since explosion

0.5 hours
2.0 hours
5.0 hours
24.0 hours

SN Ia
SN Ib
SN II
SN Ic
CV
SN II
SN Ib
CV

Different
Same
Different
Same
Different
Same
Different
Same

federica bianco NYU
### 6.4 Gamma-Ray Burst Afterglows

*Eric C. Bellm*

<table>
<thead>
<tr>
<th>FoM</th>
<th>Brief description</th>
<th>minion 1016</th>
<th>enigma 1281</th>
<th>kraken 1043</th>
<th>minion 1020</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.4-1</td>
<td>GRBTransientMetric, nPerFilter = 1</td>
<td>0.17</td>
<td>0.16</td>
<td>0.20</td>
<td><strong>0.21</strong></td>
<td>Fraction of GRB-like transients detected in at least one epoch.</td>
</tr>
<tr>
<td>6.4-2</td>
<td>GRBTransientMetric, nPerFilter = 2</td>
<td>0.12</td>
<td>0.10</td>
<td>0.09</td>
<td><strong>0.14</strong></td>
<td>Fraction of GRB-like transients detected in at least two epochs in any single filter.</td>
</tr>
<tr>
<td>6.4-3</td>
<td>GRBTransientMetric, nPerFilter = 3</td>
<td>0.05</td>
<td><strong>0.08</strong></td>
<td>0.04</td>
<td>0.04</td>
<td>Fraction of GRB-like transients detected in at least three epochs in any single filter.</td>
</tr>
</tbody>
</table>
### 6.5 Gravitational Wave Sources

*Raffaella Margutti, Zoheyr Doctor, Wen-fai Fong, Zoltan Haiman, Vassiliki Kalogera, Virginia Trimble, Bevin Ashley Zauderer*

Median Intra-Night Gap in hours

...require 2 observations in 1 week after GW detection (Coperthwaite & Berger 2015)

1. $A_{sky}$ only covers $P \sim 7\%$ of the sky. The probability that the entire GW localization region is contained, by chance, within $A_{sky}$ is thus very small.

2. Even if LSST is able to cover a meaningful portion of the GW region, we would still not have color information, and we would thus be unable to filter out contaminating transients.

We conclude that relying on the serendipitous alignment of the LSST fields with the GW localization map is not an effective strategy to follow up GW triggers and identify their EM counterparts. We thus strongly recommend a ToO capability as part of the baseline LSST operations strategy.
Science-Driven Optimization
of the LSST Observing Strategy

9 Accurate Cosmological Measurements on the Largest Scales

Chapter editors: Eric Gawiser, Michelle Lochner.

9.5 Supernova Cosmology and Physics

*Jeonghee Rho, Michelle Lochner, Rahul Biswas, Seth Digel.*
9.5 Supernova Cosmology and Physics

Jeonghee Rho, Michelle Lochner, Rahul Biswas, Seth Digel.

Figure 9.12: An example of a light curve, in six filter bands, of a SN Ia from a DDF in enigma.1189.

Figure 9.13: An example of a light curve, where only four filter bands are available, of a SN Ia from the WFD survey in enigma.1189.

Wide Deep Fast
Results from the Supernova Photometric Classification Challenge

Richard Kessler,1,2 Bruce Bassett,3,4,5 Pavel Belov,6 Vasudha Bhatnagar,7 Heather Campbell,8 Alex Conley,9 Joshua A. Frieman,1,2,10 Alexandre Glazov,6 Santiago González-Gaitán,11 Renée Hložek,12 Saurabh Jha,13 Stephen Kuhlmann,14 Martin Kunz,15 Hubert Lampeitl,8 Ashish Mahabal,16 James Newling,3 Robert C. Nichol,8 David Parkinson,17 Ninan Sajeeth Philip,18 Doví Poznanski,19,20 Joseph W. Richards,20,21 Steven A. Rodney,22 Masao Sako,23 Donald P. Schneider,24 Mathew Smith,25 Maximilian Stritzinger,26,27,28 and Melvin Varughese29

Received 2010 August 06; accepted 2010 October 01; published 2010 November 19
Transients Classification challenge

in 2009 Kessler+ issued s SN classification challenge.

Results from the Supernova Photometric Classification Challenge

Richard Kessler,1,2 Bruce Bassett,3,4,5 Pavel Belov,6 Vasudha Bhatnagar,7 Heather Campbell,8 Alex Conley,9 Joshua A. Frieman,1,2,10 Alexandre Glazov,6 Santiago González-Gaitán,11 Renée Hlozek,12 Saurabh Jha,13 Stephen Kuhlmann,14 Martin Kunz,15 Hubert Lampeitl,8 Ashish Mahabal,16 James Newling,3 Robert C. Nichol,8 David Parkinson,17 Ninan Sajeeth Philip,18 Dovi Poznanski,19,20 Joseph W. Richards,20,21 Steven A. Rodney,22 Masao Sako,23 Donald P. Schneider,24 Mathew Smith,25 Maximilian Stritzinger,26,27,28 and Melvin Varughese29

Received 2010 August 06; accepted 2010 October 01; published 2010 November 19
we have learned a lot since 2010!
<table>
<thead>
<tr>
<th>#</th>
<th>Reference</th>
<th>Date</th>
<th>Type</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2016arXiv160507442C</td>
<td>06/2016</td>
<td>A</td>
<td>Deep Recurrent Neural Networks for Supernovae Classification</td>
</tr>
<tr>
<td>3</td>
<td>2016arXiv160300882L</td>
<td>03/2016</td>
<td>A</td>
<td>Photometric Supernova Classification With Machine Learning</td>
</tr>
<tr>
<td>4</td>
<td>2016AJ...151...47R</td>
<td>02/2016</td>
<td>A</td>
<td>Erratum: “Two SNe Ia at Redshift ~2: Improved Classification and Redshift Determination with Mee</td>
</tr>
<tr>
<td>5</td>
<td>2015MNRAS.454.2026D</td>
<td>12/2015</td>
<td>A</td>
<td>Machine learning classification of SDSS transient survey images</td>
</tr>
</tbody>
</table>

Michelle Lochner+ 2016
Anais Moller+ 2016
Gautham Narayan, Tom Matheson working on **ANTARES**
Kevian Stussen @**Vanderbilt** working on classifiers
Transients Classification challenge

Results from the Supernova Photometric Classification Challenge

RICHARD KESSLER,1,2 BRUCE BASSETT,3,4,5 PAVEL BELOV,6 VASUDHA BHATNAGAR,7 HEATHER CAMPBELL,8

SNLS, SDSSII CSP

<table>
<thead>
<tr>
<th>Non-Ia subtype</th>
<th>Fraction</th>
<th>No. of measured templates</th>
<th>No. of composite templates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibc</td>
<td>0.29</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>II-P</td>
<td>0.59</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>II-L</td>
<td>0.86</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>IIn</td>
<td>0.04</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>