Rapid Response
Time-Domain Science
with Gemini

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Time-Domain Astronomy

**Optical:**
Evryscope, ASASSN, HATPI

ZTF, CSS-II, PS2, BG, ATLAS

DECAM, HSC, LSST

**Infrared:** SPIRITS, Palomar Gattini-IR, Polar Gattini-IR

**High Energy:** Fermi, Swift, Integral

**Radio:**
LOFAR, MWA and LWA: meter and decameter-mapping

Apertif, Meerkat and Askap: decimetric mapping

Mansi M. Kasliwal 1/9/18
Follow-Up is Key

Global Relay of Observatories Watching Transients Happen

GROWTH
Global Relay of Observatories Watching Transients Happen
Rapid Response Follow-up with Gemini

- Queue scheduling facilitates rapid response within minutes
- North+South: Anywhere in the Sky, Weather Hedge
- Instrument Availability without Lunation Constraints
- Gen4 Instrument: Octocam
1. Young Supernovae
Infant Type II Supernovae

Connecting the type of progenitor star to the type of core-collapse

Gal-Yam et al. 2014, Nature

See also Hosseinzadeh et al. 2018
Infant Type Ic Supernova

An ultra-stripped supernova that just formed a compact neutron star binary?

De et al. 2018, Science, submitted
Infant Type Ia Supernova

What is the companion of the exploding white dwarf?

Nugent et al. 2011, Li et al. 2011, Horesh et al. 2011, Bloom et al. 2011 + 122 more papers

Cao et al. 2015, Marion et al. 2015, Hosseinzadeh et al. 2017
II. Relativistic Explosions
Many years of GRB science including high-redshift GRBs
Orphan Afterglows

Also, ATLAS17aeu (Stalder et al. 2017)
III. Neutron Star Mergers
Cosmic Mines

Element Origins

Merging Neutron Stars
Dying Low Mass Stars

Exploding Massive Stars
Exploding White Dwarfs

Big Bang
Cosmic Ray Fission

Credit: J. Johnson
Kilonovae: Heavy Element Thumbprint

Red - Model Prediction from Kasen et al. 2013, Barnes & Kasen 2013
Black – Gemini-S/FLAMINGOS-2 Data

Kasliwal et al. 2017c
See also Chornock et al. 2017, Troja et al. 2017
Abundance of Heavy Elements

Rate / 500 Gpc$^{-3}$ yr$^{-1}$
X Ejecta / 0.05 Msun
= Observed Solar Abundance

LIGO lower limit: > 320 / Gpc$^3$ / yr
PTF upper limit: < 800 / Gpc$^3$ / yr

See Kenta’s talk
The NSM rate (90% conf.) is estimated as 320–4740 Gpc$^{-1}$.

Based on this first detected GW-event, uncertainties in the nuclear physics far from stability, this limit.

From Petrillo et al. (2013) and the LVC estimate based on the first detection study of Kim et al. (2015), the sGRB rates based on SWIFT data.

Fig. 5.

Fig. 4.

Needed event rates, scaled to an ejecta mass of 0.03 $M_{\odot}^{-1}$. A proof that their.

Just the first two peaks can explain the ground-based IR light curve?
Rosswog et al. 2017
Surprise: Too Bright and Blue at Early Time
A New Model: The Cocoon Breakout

Gamma-ray Modeling in Gottlieb et al. 2017b; More analytics in Piro & Kollmeier 2017
Cocoon for NS mergers: Lazzati et al. 2017a,b, Gottlieb et al. 2017a, Hotokezaka et al. 2015
TDA in the LSST era

PTF: $4 \times 10^4$ events/night
ZTF: $3 \times 10^5$ events/night
LSST: $2 \times 10^6$ events/night

<table>
<thead>
<tr>
<th>Technical</th>
<th>develop algorithms &amp; software for detection &amp; classification</th>
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<tbody>
<tr>
<td>Scientific</td>
<td>discover new transient &amp; variable phenomena</td>
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<tr>
<td>Organizational</td>
<td>organize collaborations and followup strategies with real data</td>
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GROWTH builds a global community ready to contribute LSST time-domain science.
Gen4 Gemini Instrument: OCTOCAM

Interim PI and PS: Alexander van der Horst
Gemini PM: Stephen Goodsell
Thank you