The Large Binocular Telescope in the Era of Gravity Wave Detection

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The Future: Gravity Waves

- ✧ In the next 5 years gravitational waves will be directly detected
- ✧ Advanced LIGO (aLIGO) with two detectors will begin science runs in 2015
- ✧ Advanced Virgo (AdV) in Europe will begin science runs in 2016
- ✧ Identification of "Electromagnetic" counterparts will be critical in confirming the GW transient and in interpreting the physics
- ✧ Seems far off, but this will happen fast and we need to be prepared

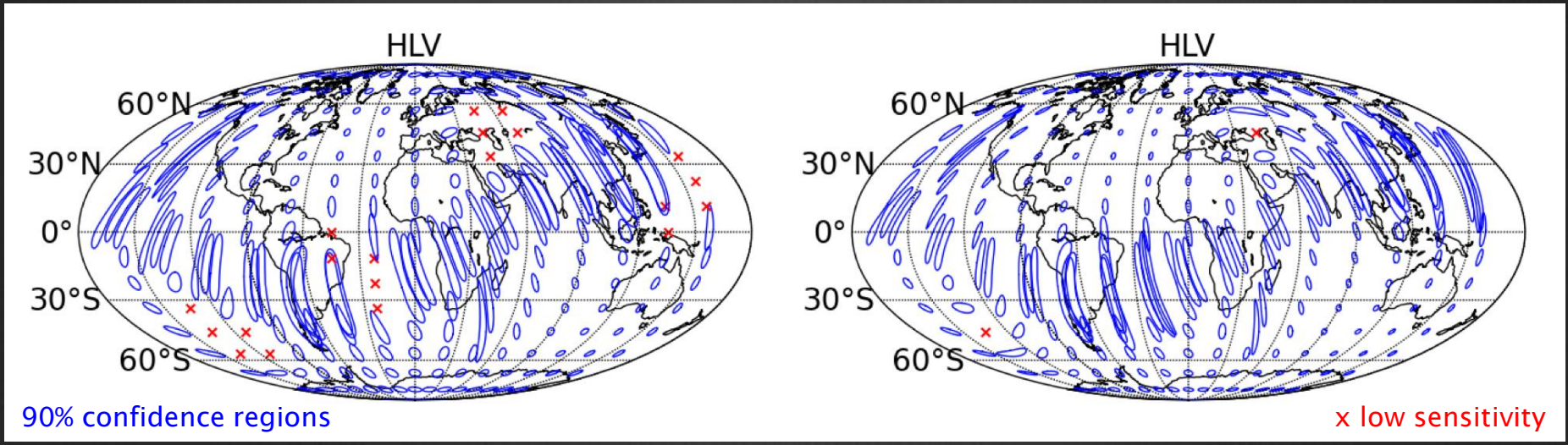
Epoch	Estimated Run Duration	$E_{GW} = 10^{-2} M_{\odot} c^2$ Burst Range (Mpc)		BNS Range (Mpc)		Number of BNS Detections	% BNS Localized within	
		LIGO	Virgo	LIGO	Virgo		$5\,\mathrm{deg}^2$	$20\,\mathrm{deg}^2$
2015	3 months	40 – 60	–	40 – 80	–	0.0004 – 3	–	–
2016–17	6 months	60 – 75	20 – 40	80 – 120	20 – 60	0.006 – 20	2	5 – 12
2017–18	9 months	75 – 90	40 – 50	120 – 170	60 – 85	0.04 – 100	1 – 2	10 – 12
2019+	(per year)	105	40 – 80	200	65 – 130	0.2 – 200	3 – 8	8 – 28
2022+ (India)	(per year)	105	80	200	130	0.4 – 400	17	48

Aasi et al. 2013

GW Localization

- ✧ 2015 (aLIGO only) localizations will be poor/distance range 40-80 Mpc
- ✧ 2016-21 (+AdV) 20 to 100 square degrees/ distance range 80-120 Mpc
- ✧ 2022- (+India) 10 to 50 square degrees / distance range 200 Mpc

2016-2017 **2017-2018**



90% confidence regions

x low sensitivity

Aasi et al. 2013

GW Transients: What to Expect in EM

Bursts

Core-Collapse Supernovae	- slowly rising optical, fast UV
Black Hole mergers	- very little EM?
Magnetar flare	- soft gamma-rays
Long GRB	- hard gamma-rays
Something New	- radio? X-rays? IR rich?

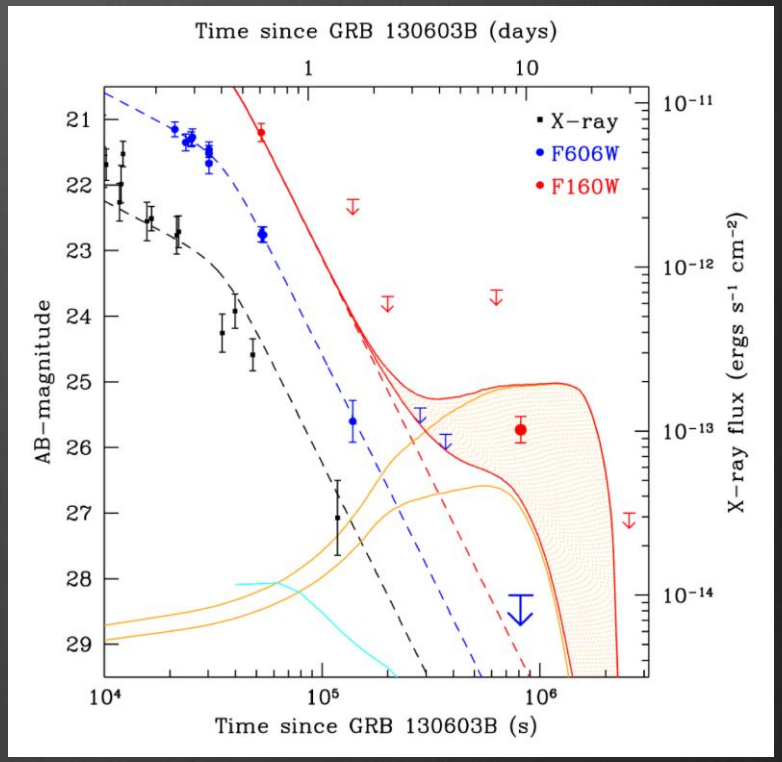
Chirps

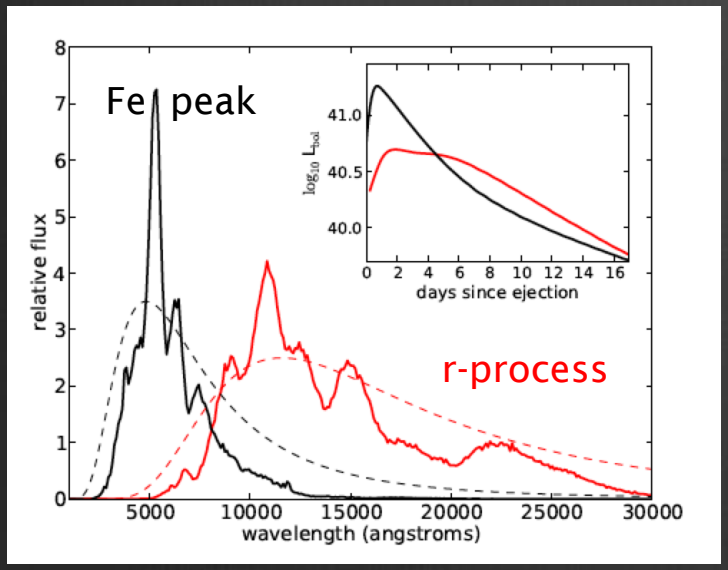
Compact Binary Coalescence	
Neutron Star Mergers	- short gamma-ray burst? Fast optical counterpart?

Best Guess EM

- The short/hard GRB e.g. 130603B
- Power-law decay in X-rays and optical
- Near-IR excess
- IR predicted by Kasen et al. (2013) – r-process in tidal debris of neutron star merger

Tanvir et al. 2013; Berger et al. 2013





Kasen et al. 2013

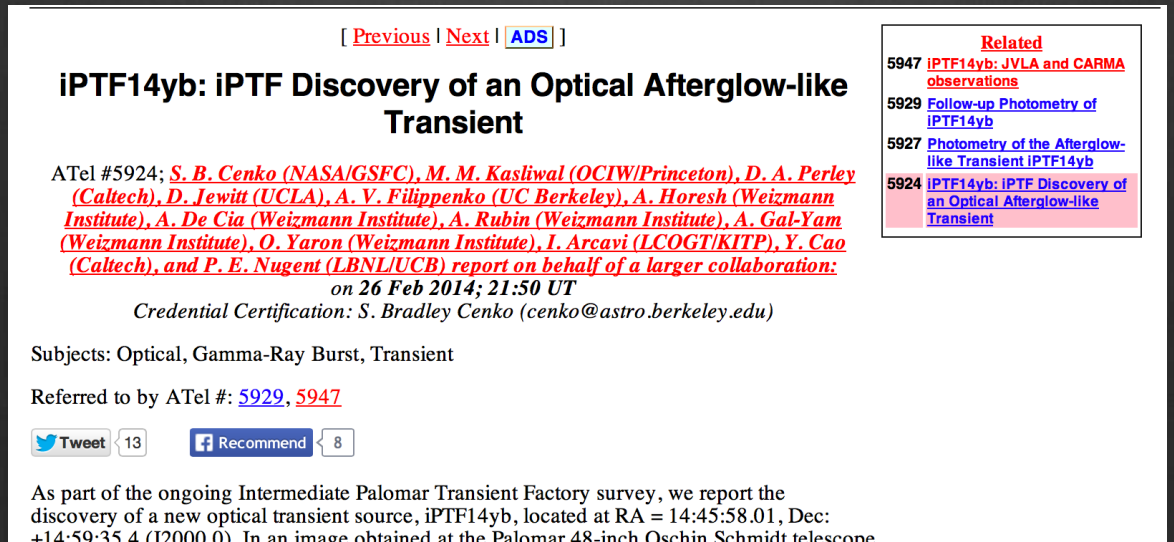
- aka "kilonova"
- Might miss gamma-ray beam

The Deal

- ✧ The aLIGO/AdV collaborations want EW follow-up
- ✧ But they worry about the race to publication and the possibilities of false alarms – including signal injections
- ✧ The first 4 GW alerts will be sent to groups that have signed MOUs - agree not to publish until the aLIGO/AdV groups are ready
- ✧ GW alert trigger at false alarm rate 10^{-2} /year or higher?
- ✧ After the first 4 alerts, all alerts will be made public (fun stuff done)
- ✧ How does this work for LBTO?

EM Follow-up

- GRB detection possible but not likely due to beaming
  - localizations accurate from minutes (Swift) to degrees (IPN)
- Most likely will depend on wide-field optical search
  - iPTF, Atlas, ASAS-SN, Dark Energy Survey, SkyMapper, Catalina…
- Many optical candidates in 100 square deg – mostly supernovae
  - use colors
  - decay rate
- Spectroscopic follow-up will be critical in sorting candidates



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iPTF14yb: iPTF Discovery of an Optical Afterglow-like Transient

ATel #5924; *S. B. Cenko (NASA/GSFC), M. M. Kasliwal (OCIW/Princeton), D. A. Perley (Caltech), D. Jewitt (UCLA), A. V. Filippenko (UC Berkeley), A. Horesh (Weizmann Institute), A. De Cia (Weizmann Institute), A. Rubin (Weizmann Institute), A. Gal-Yam (Weizmann Institute), O. Yaron (Weizmann Institute), I. Arcavi (LCOGT/KITP), Y. Cao (Caltech), and P. E. Nugent (LBNL/UCB) report on behalf of a larger collaboration:*
*on **26 Feb 2014; 21:50 UT***
Credential Certification: S. Bradley Cenko (cenko@astro.berkeley.edu)

Subjects: Optical, Gamma-Ray Burst, Transient

Referred to by ATel #: 5929, 5947

Tweet 13 Recommend 8

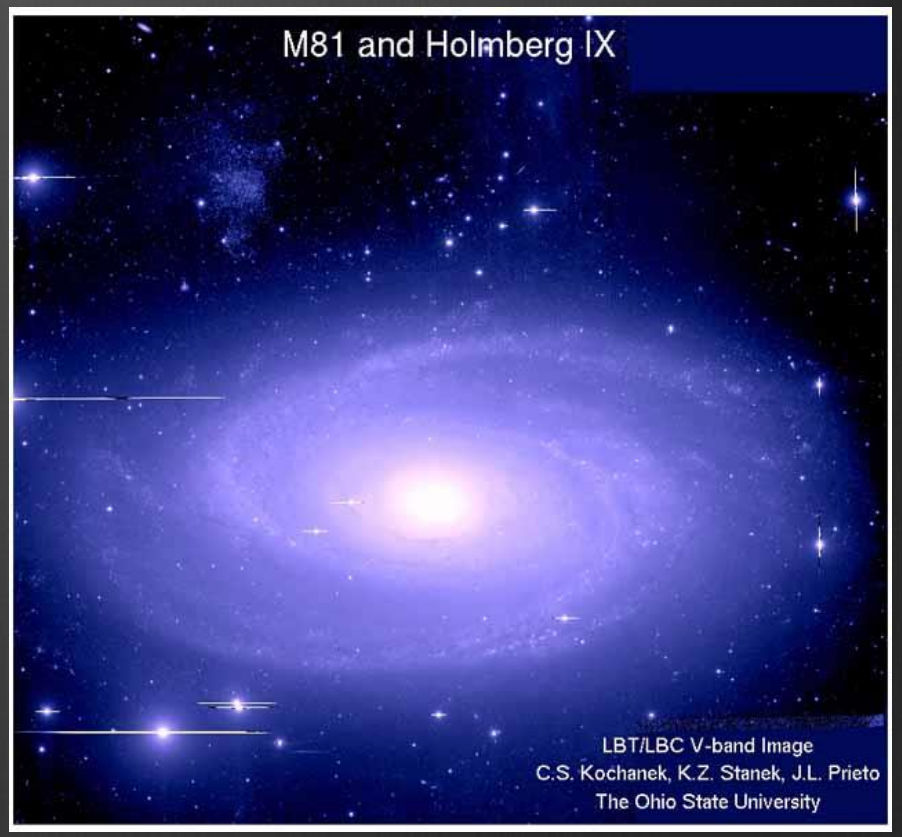
As part of the ongoing Intermediate Palomar Transient Factory survey, we report the discovery of a new optical transient source, iPTF14yb, located at RA = 14:45:58.01, Dec: +14:59:35.4 (J2000.0). In an image obtained at the Palomar 48-inch Oschin Schmidt telescope

Related

5947 iPTF14yb: JVLA and CARMA observations
5929 Follow-up Photometry of iPTF14yb
5927 Photometry of the Afterglow-like Transient iPTF14yb
5924 iPTF14yb: iPTF Discovery of an Optical Afterglow-like Transient

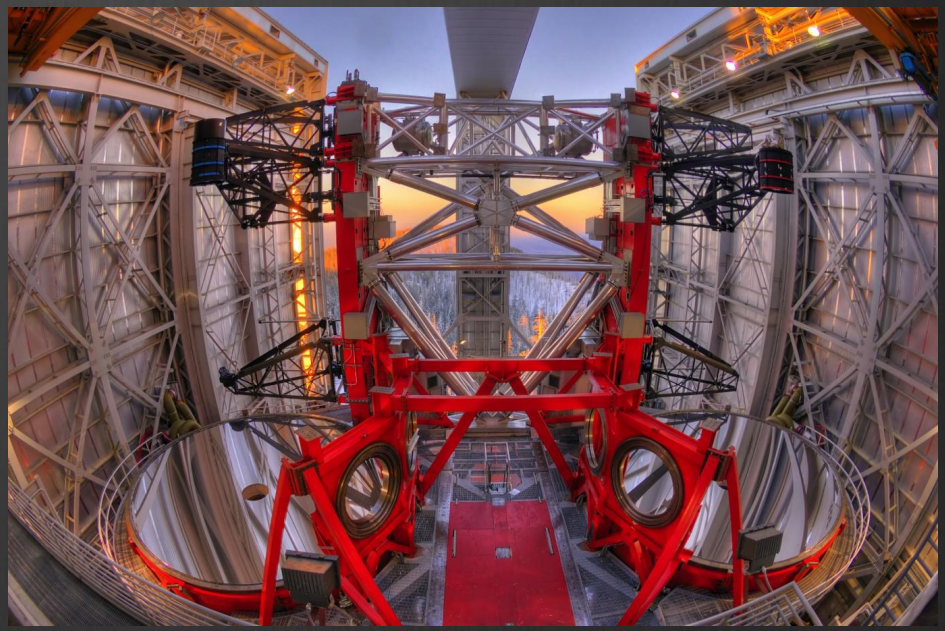
LBT Role

- ✧ LBC can image nearby galaxies in localization region
  - get color efficiently
  - multiple visits on a single night
  - auto script generator
  - fast subtractions
- ✧ MODS spectra of candidates fed by wide field searches
- ✧ LUCI imaging/spectra of candidates, r-process?

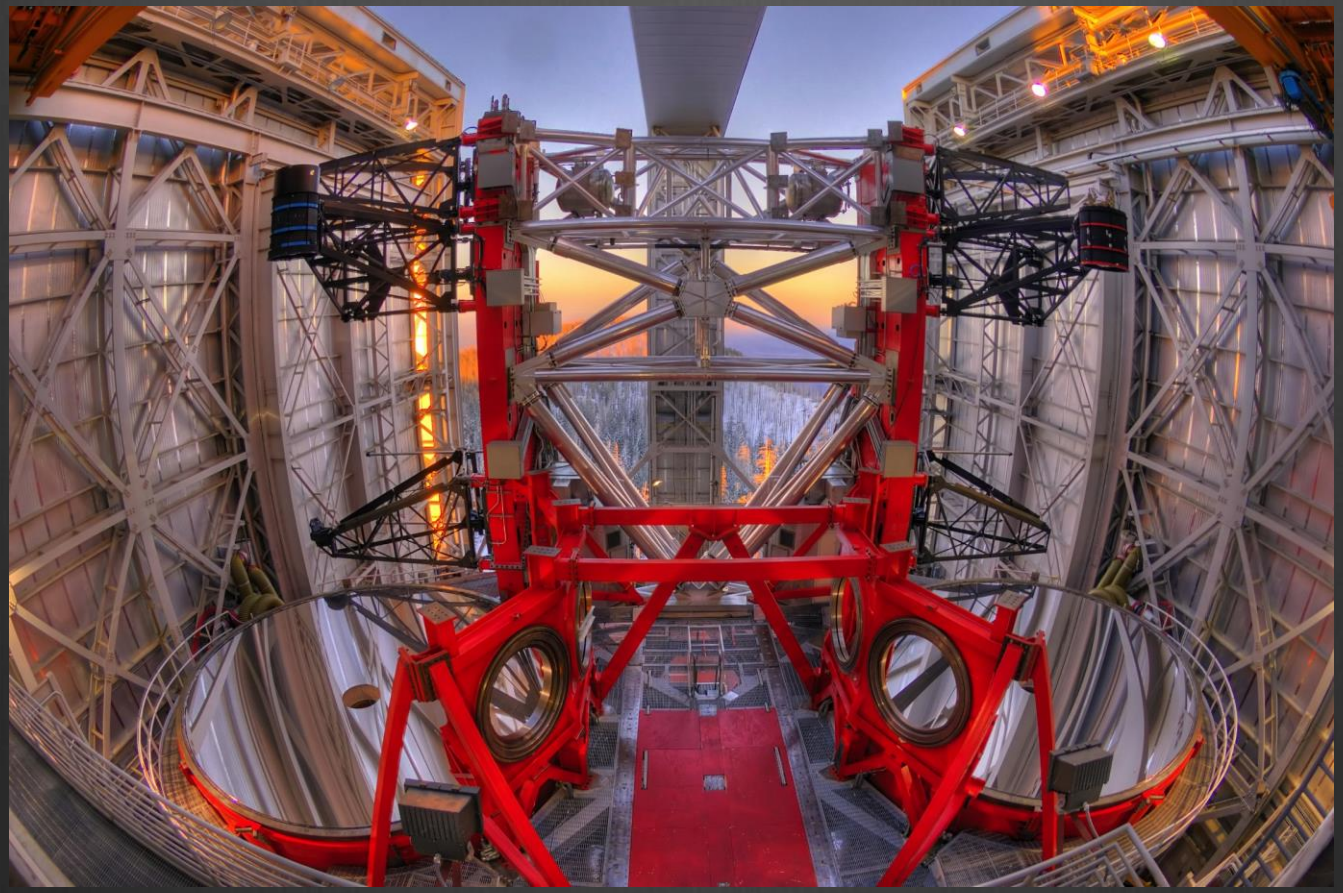


LBT & Time Domain

- How can LBTO contribute to GW/EM identification?
- Need a transient/time domain plan
- Director's Discretionary time with interruption during any block?
- Unified observing queue?
- Collaboration developed over all partner blocks?



Large Binocular Telescope



Two 8.4-m mirrors on the same mount – future interferometry
Now: Two large telescopes with complementary instruments

Follow-up

- Large Binocular Camera: Red-optimized on the right, Blue-optimized on the left
- 23'x23' field of view – enough to cover a nearby galaxy in a single image
- Simultaneous 2-filter imaging to search for transients with interesting colors
- MODS dual channel spectrograph – cover 320 nm to 1 micron at moderate resolution
- LUCIFER near-IR imaging/spectrograph 0.8 to 2.3 microns (two grating settings)
- Simultaneous UV, Optical, near-IR spectroscopy of a transient with MODS (left) and LUCIFER-II (right)