BigBOSS Workshop: Transients

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On behalf of the transients breakout session
September 14, 2011

Breakout Session Attendees

- Jeffrey Silverman
- Tom Matheson
- Stephen Bailey
- Steve Ridgway
- David Cinabro
- Jason Surace
- Bruce Grossan
- Joan Najita
- Carles Badenes (on skype)

Science Case for Transients

I. Before the Transient
   - A Nearby Galaxy Catalog – host redshifts matter

II. During the Transient
   - 100s of fibers e.g. Advanced LIGO, ICECUBE
     minutes response, unique capability, need FoV
   - 1 fiber, e.g. GRBs
     minutes response, low impact (Bruce)
   - 10s of fibers e.g. BigBOSS Transient Factory
     days response (David, Tom)

Science Case for Transients

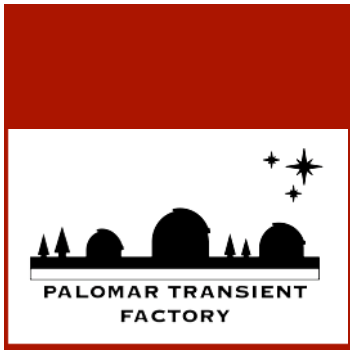
III. After the Transient: Environments, Redshifts, Quiescence

- Supernova Host Metallicities and Redshifts (Jeff, David)
- Cepheids – period-luminosity-metallicity (Tom)
- Galactic Variables, Strong H-alpha emitters/absorbers
- M31/M33 Variables
- Quasars Variability-Luminosity Relationship

IV. Time Resolved Spectroscopy (Carles)

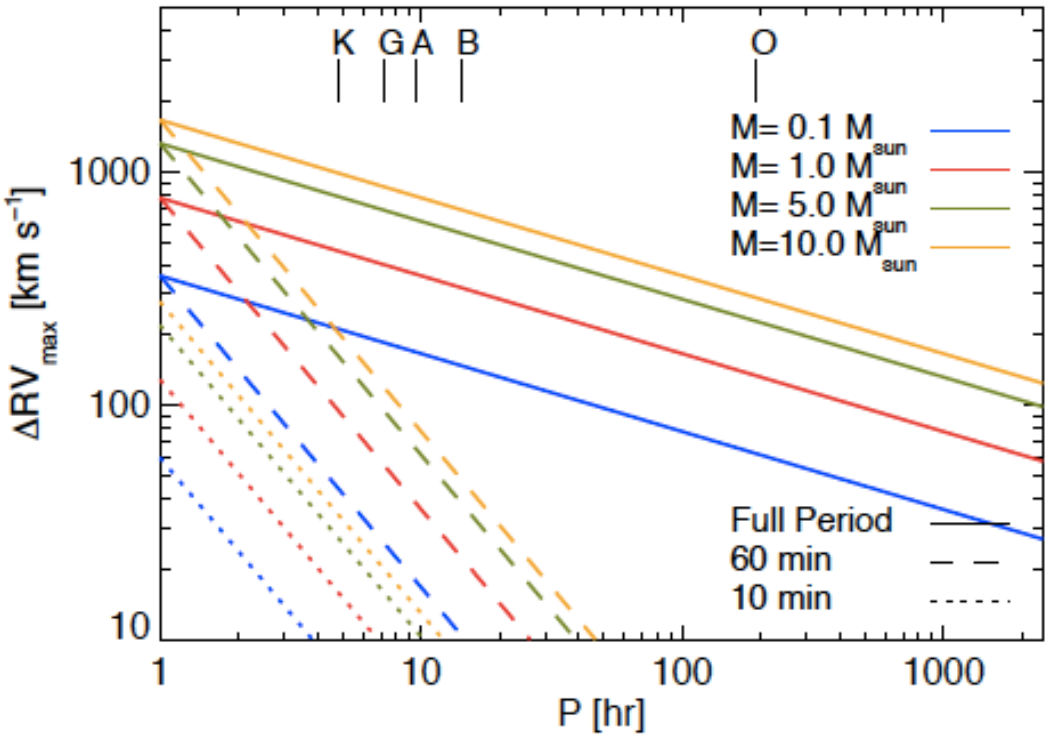
- 10x10min spectra of quasar candidates
- Calibration fields

Modes of Usage



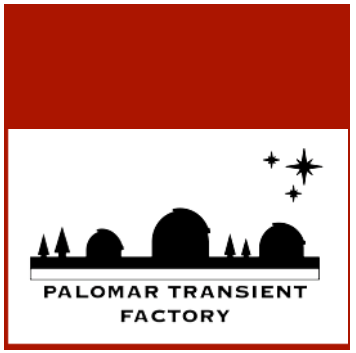
- Community Fibers (fiber allocation ONLY)
  - Host characterization e.g. Galaxy Catalog, Supernova Hosts
  - Dynamic assignment of streaming targets from transient surveys
- Targets of Opportunity (fiber allocation AND field sequence change)
  - Hundreds of events e.g. LIGO events, neutrino events – MINUTES
  - Tens of events e.g. supernovae, varstars – DAY
  - Single, rare events e.g. GRBs – MINUTES
- PI mode (specific fields, non-survey mode, NOAO time)
  - Galactic Variables e.g. Orion field
  - Fast Cadence Observations
  - M31/M33 Variables

Survey Design/Scheduling I



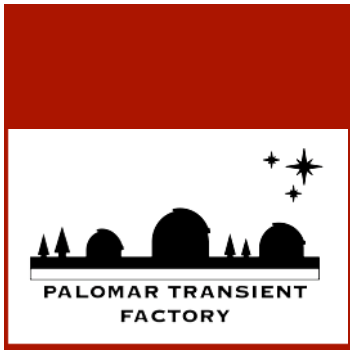
- NEED 2x10min instead of 1x20min (more sub-exposures better)
- Prefer cadence on 5 tiles of hour, week, month, year
- Calibration Fields/PI-fields
  - Cadence for time resolved spectroscopy
  - Where to point and which targets to include for a systematic survey

Survey Design/Scheduling II



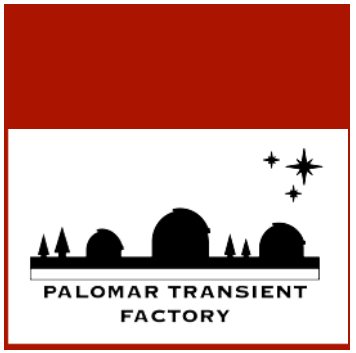
- Dynamic and intelligent scheduling to allow Targets of Opportunity to be nearly zero impact
- Availability of planned BigBOSS footprint a couple of days in advance to co-ordinate with synoptic surveys
- Happy with resolution, wavelength coverage and sensitivity

Pipeline Requirements



- Quicklook Spectra
  - All Target Of Opportunity Observations: real-time, minutes/hours
  - All sub-exposures to decide whether to get more spectra: days
- Sub-exposures
  - Each 10min spectrum should be flux & wavelength calibrated
  - Each 10min spectrum should be easily available
  - List of rejected candidates available
- Ease of adding code to pipeline e.g. to discover supernovae based on spectra of galaxies

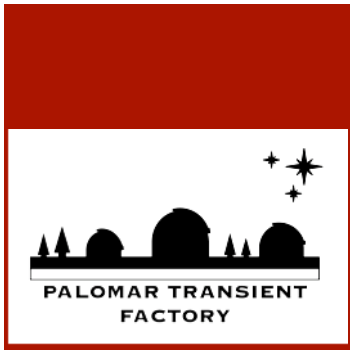
Contributed Slides



SN Host Follow Up

- - Follow up of SN Host Galaxies
- - Science case is to provide redshifts for photometric light curves
- - BigBOSS foot print overlaps ~1/2 of DES and LSST observing areas
- - Can expect ~5x10^3 DES and 2.5x10^4 LSST targets
- - Excellent Community Fiber project

BigBOSS Transient Factory



- Spectra of transient objects with little impact on the main survey
- - Intelligent scheduler to respond to ToO with minimal disruption of main survey
- - Potential high impact (Gravity wave events, SGRB, etc.)
- - Intelligent scheduler would be hard, must demonstrate low disruption
- - Dedicated search for transients in BigBOSS fields
- - Should have no impact on main survey needing ~100 community fibers/night
- - Requires auxillary instrument or partner
- - More thought on auxillary instrument capabilities to do science
- - Need a full list of science cases
- - Need to generate requirements for such an instrument
- - Can an existing instrument be re-purposed for this?
- - "Crazy"

Transient Survey Targets for Big Boss - 1

- Streaming targets
  - Big Boss publishes rough field sequence ~2-3 days in advance
  - Transient surveys target those fields in advance to find targets
  - Targets are streamed to Big Boss scheduling for inclusion
  - Targets may be classified high or nominal priority
  - Typical lead time ~1-2 days
  - Big Boss visit requires allocation of fiber, but does not require changing field sequence
  - Coordination of surveys leverages both

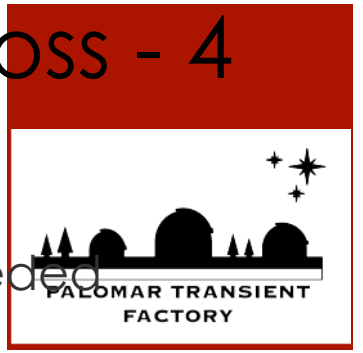
Transient Survey Targets for Big Boss - 2

- Targets of Opportunity
  - Surveys identify targets of exceptional priority
  - Targets handed off to Big Boss – in some cases within ~1 minute
  - Big Boss visit requires allocation of fiber AND changing field sequence
  - Time-scale for Big Boss follow-up depends on Big Boss support for TOO, and perhaps on priority of targets
  - Coordination of discovery and characterization leverages multiple surveys for observations that would otherwise be impossible

Transient Survey Targets for Big Boss - 3

- Survey product characterization
  - Use coordinated observing with surveys providing large numbers of targets (hundreds to thousands) in near-real time
  - Reasonably scheduled as competed-access to Big Boss instrument rather than as part of Big Boss survey
  - Valuable early in a deep survey where fields are not well studied
  - Jump-start characterization of sources in a new survey by providing reference data for large numbers of target types

Transient Survey Targets for Big Boss - 4



- Transient quiescent characterization
  - Pool of known transients for which quiescent data is needed
  - May be ordered by relative priority
  - Available targets for Big Boss community fibers
  - Possible serendipitous product if target is observed during a new transient

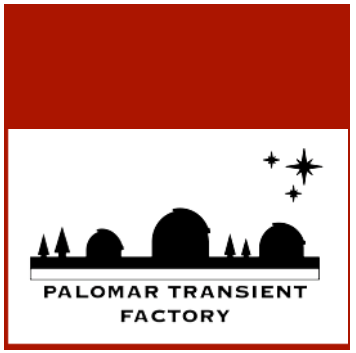
Cepheids

The universality of the Cepheid period-luminosity-color relation is a significant problem for the cosmological distance scale. With spectra of Galactic Cepheids from BigBOSS to study metallicity, parallaxes from GAIA to determine luminosity, one could refine the PLC relation.

Coordination of Time-Domain Experiments and BigBOSS

In order to maximize the effectiveness of community fibers available during the BigBOSS survey, time-domain surveys could be tuned to match (and anticipate) the footprint of BigBOSS. With this method, transient objects could be allocated fibers with minimal impact on the BigBOSS survey. This does imply a constraint on the survey in the sense that the schedule of fields needs to be published days in advance (2-3 at least) so that time-domain experiments can observe the same fields with the cadence necessary to find their targets. All parties will have to recognize that events (e.g., weather) could cause fields to change on short notice.

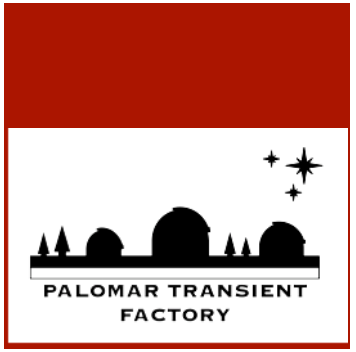
Supernova hosts I



- most metallicity measurements are done with resolutions lower than BigBOSS
- S/N might be an issue but 1x20min or 2x10min should be good for bright hosts
- 2 visits (i.e., 40 mins) should be good for fainter hosts, assuming
- emission line galaxies (i.e., CCSNe hosts); ~50 in the literature (M. Modjaz et al. 2011, ApJ, 731, 4)
- for relatively low-z hosts (maybe z~0.05), CCSNe are 0.5" to a few arcsec separation from nucleus so you can get a few fibers on different HII regions at once for the closer hosts to get a range of local metallicity measurements
- we can probably increase the number of host metallicities by a factor of 1000 to 2000 with BigBOSS

- Super Chandra Ia are found in faint dwarf hosts (possibly with weak emission), but 2 visits (i.e., 40 mins) might get a solid redshift and/or metallicity (J. M. Silverman et al. 2011 MNRAS 410 585, M. Childress et al. 2011 ApJ 733 3)

Supernova Hosts II



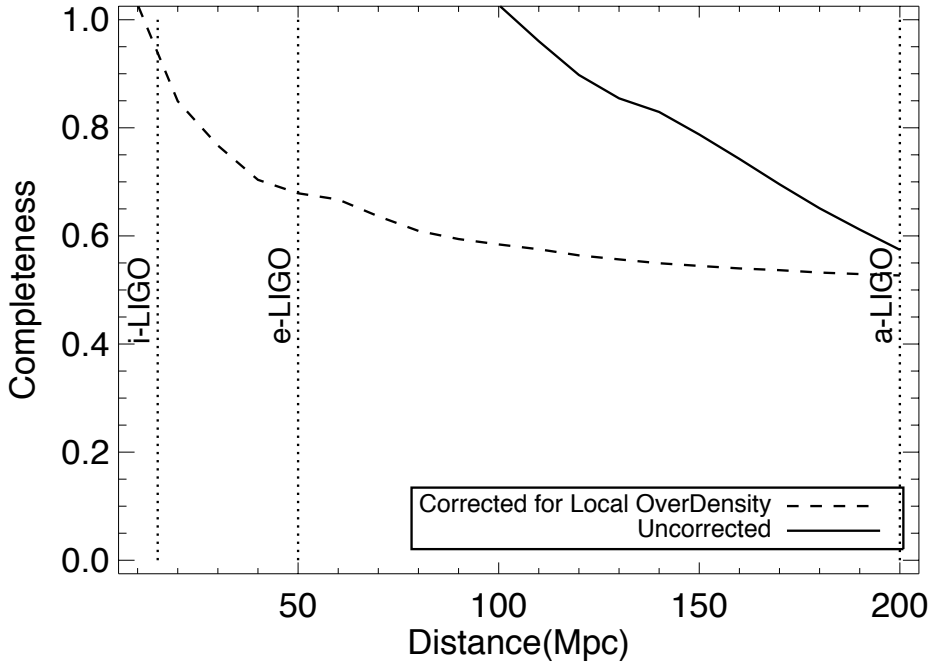
- Can also get more metallicity measurements in quite nearby hosts at a range of galactocentric radii that also have Cepheid distances (A. Riess et al. 2011 ApJ 730 119) to improve P-L relationship for Cepheids for H0 measurement)
- at z=0.05 the HII regions are separated by about 0.5"-1.5 , though this requires good imaging of the host (something like narrow band Halpha or something that will pick out HII regions as bright), currently we use HST, but could use JWST in the future? or relatively high resoltuion near-IR imagers?

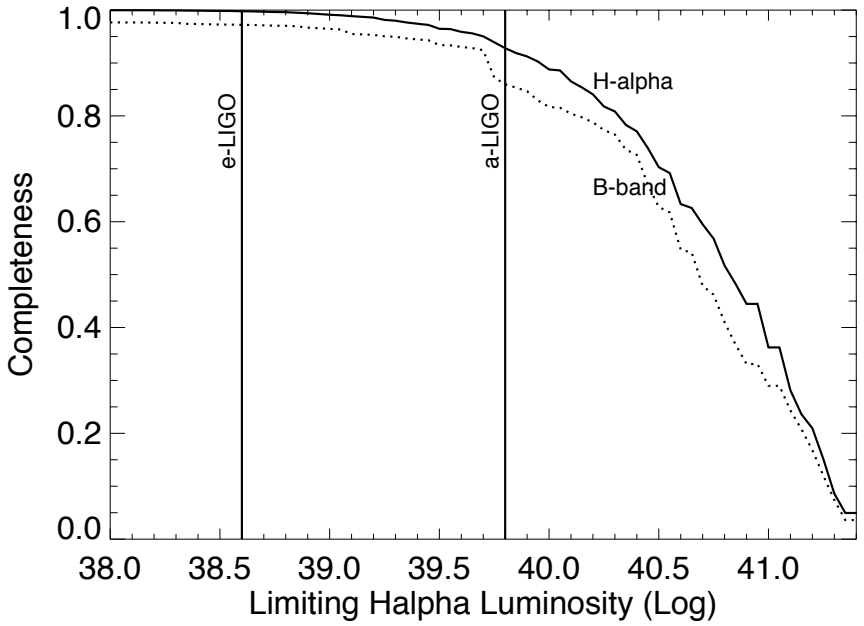
- get host spectrum for population synthesis and get mass/SFR
- requires a decent S/N spectrum (need to get a continuum and absorption lines)
- SDSS-II SN Survey got broadband photometry of hosts and had to fit SEDs to that data to get stellar masses and recent SFR (M. Smith et al. arXiv:1108.4923)
- having decent S/N spectra of these z~0.5 hosts will lead to better stellar mass and SFR determinations (I would imagine)
- SNe Ia appear to care about what kind/size/mass galaxy they explode in (M. Sullivan et al. 2010, MNRAS, 406, 782, Smith et al. arXiv:1108.4923)

GRB TOO are DIFFERENT

- Why BigBOSS?
  - GRB _can_ be observed with very low impact; for example, they could be observed with the same tiling as the normal survey.
  - -technical questions arise as to _how_ low impact; these should be addressed by survey operations plan
  - GRB _do_ take advantage of BigBOSS wide lambda coverage; all of it is needed for z and Lya-forest measurements. They are well-matched to BB z-finding goal
  - many GRB are m≤ 21.1 _if_ observed in the first few hours_ (S/N / channel gt 3.5 @8500 Å, 1200 s
- Why Not Other Telescopes?
  - BigBOSS is available in the correct observing mode 100% of time - few 4 m telescopes are
  - BigBOSS can nominally respond in ≤ 20 min + Slew time; response time critical to detection, few other 4m could make this possible regularly.
  - The BigBOSS program covers so much area that a low-impact program restricted to survey regions would still yield several GRB spectra/year

I. Before the Transient: A 200Mpc Galaxy Catalog





95% complete catalog requires 300,000 galaxies i.e. limiting mag of B<20

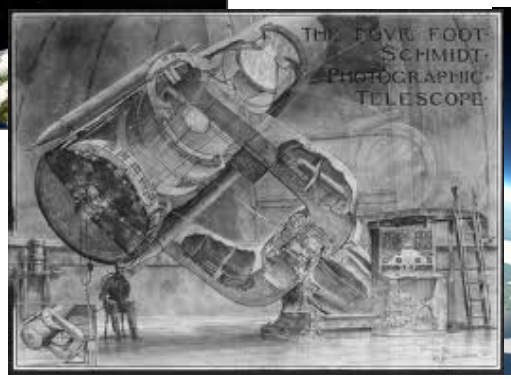
Step 1. Narrowband survey with PTF.

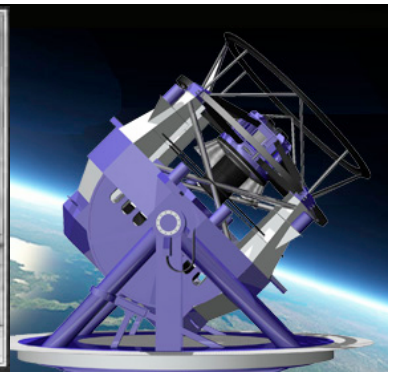
Step 2. BIGBOSS spectra of H-alpha candidates

II. During the Transient: Only where FoV is necessary

Gravity Waves, TeV Neutrinos & Gamma Rays

Optical Follow-Up



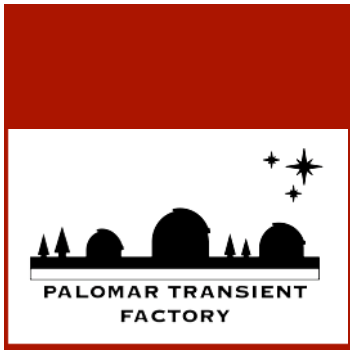


BIGBOSS & Target of Opportunity

How quickly can the fibers be re-positioned to a new field?

How flexible is the scheduling? Known footprint of fields?

III. After the Transient: Systematic follow-up



- Quasar Variability-Luminosity Relationship
- Supernovae Host Properties esp. Metallicity
- M31 Variability Characterization & background quasars
- Galactic Variables: Systematic Follow-up
  - ~3% of sources are variable. ~50-500 per sq deg
  - Compact Binaries: ~10 per sq deg WD-dM binaries, ~1 per sq deg for Cataclysmic Variables, ~0.2 detached WD-WD binaries
  - RR Lyrae to map Galactic structure
- Strong H-alpha emitters or absorbers

IV. Time Resolved Spectroscopy

- SWARMS (Carles Badenes)
  - Backyard neutron star or black hole?
  - What is the rate of white dwarf mergers as a function of their mass?
  - Can white dwarf mergers result in Type Ia supernovae?
  - The Zoo of Compact Binaries
  - What is the binarity fraction given a stellar type?
- BIGBOSS
  - Separating and calibrating each sub-exposure
  - Cadence of sub-exposures:
    - few min, few hours, few day, few month, few years