

12-15 MAY 2015 CANARY HOTEL SANTA BARBARA, CA

HOT-WIRING THE TRANSIENT UNIVERSE 4

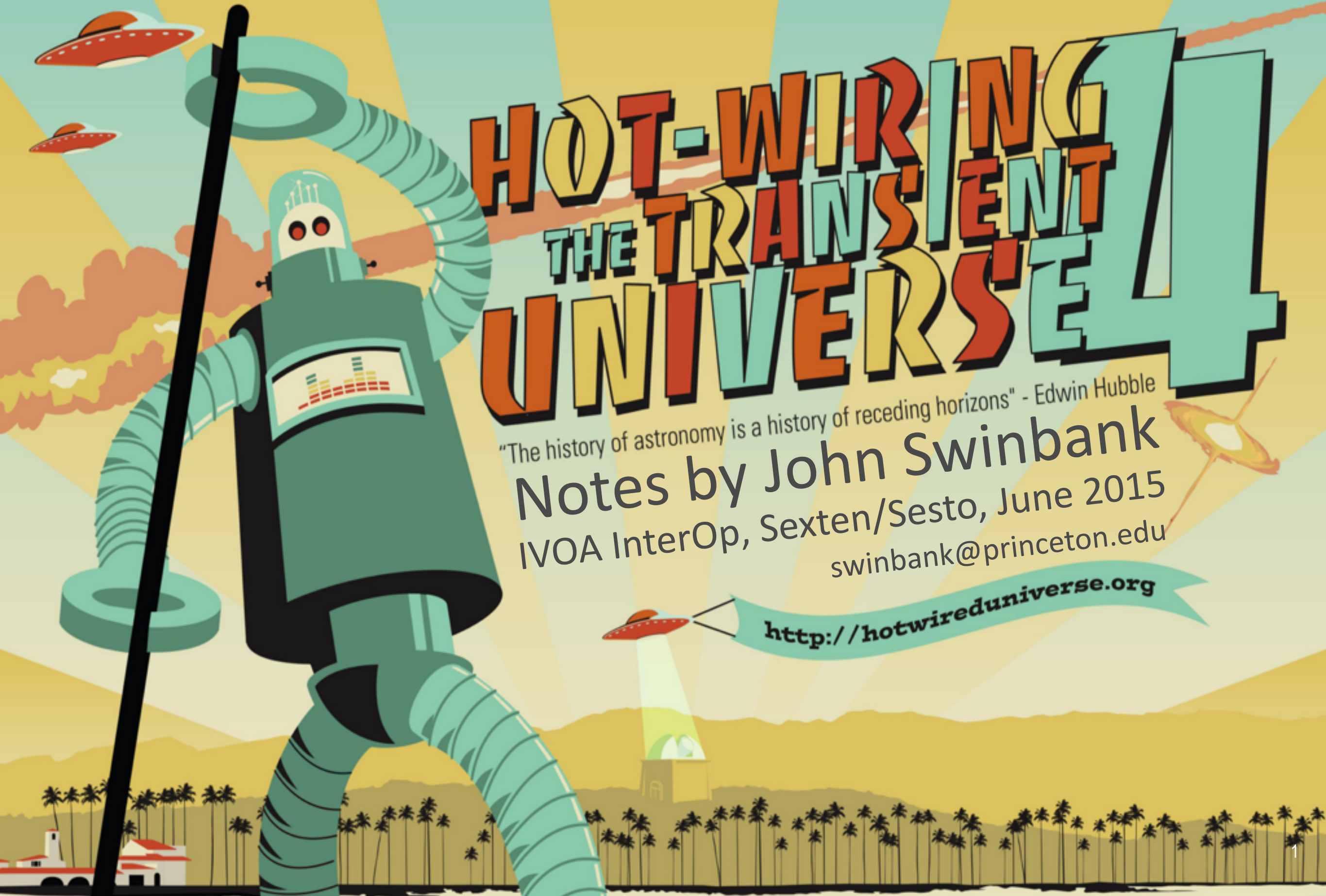
"The history of astronomy is a history of receding horizons" - Edwin Hubble

Notes by John Swinbank

IVOA InterOp, Sexten/Sesto, June 2015

swinbank@princeton.edu

<http://hotwireduniverse.org>



Hotwired IV Mission



- Discover and understand time-domain astrophysics
 - Interdisciplinary science & engineering
 - From solar system to cosmological distances
 - All bandpasses; multi-messenger
 - Maximize the science return
 - Efficient scheduling
 - Cutting-edge data science
 - Optimize observing campaigns
 - Both survey & follow-up
 - Coordinate resources, policies, funding, infrastructure



...in 20 minutes!

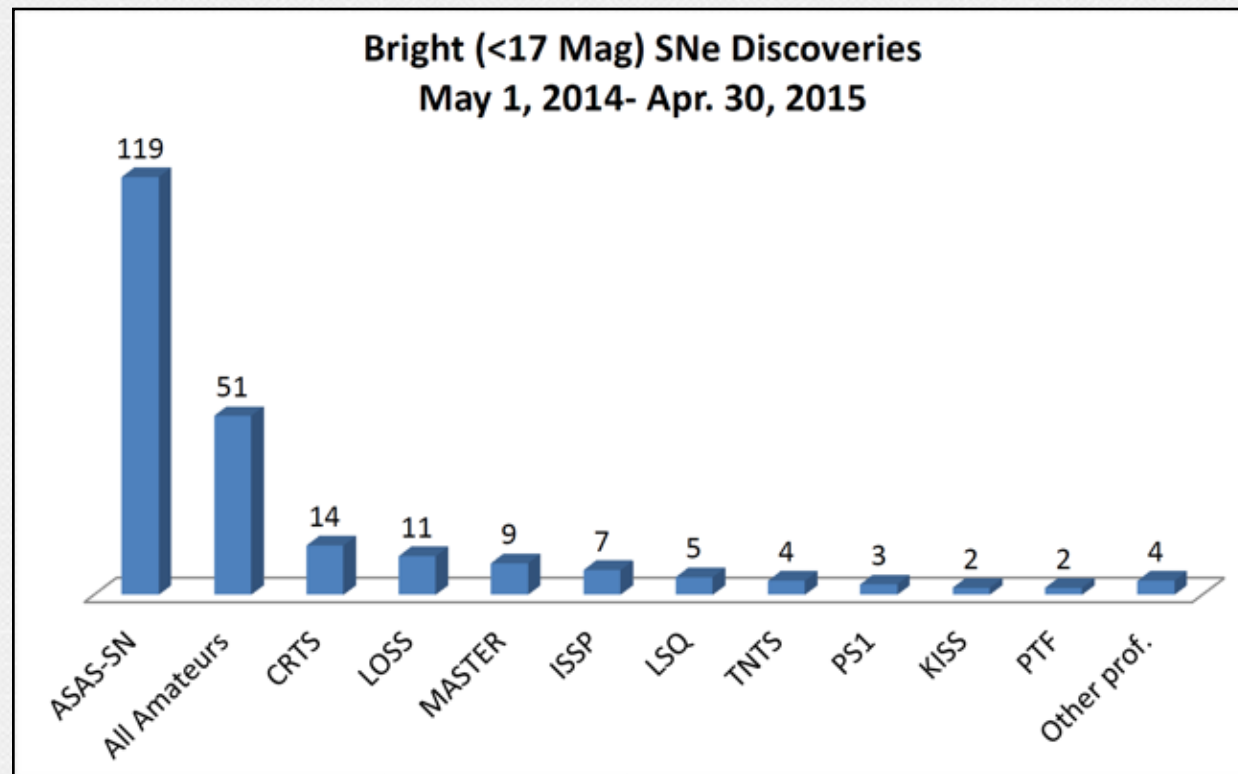


- The coming transient “deluge”:
 - Increasing volume
 - Increasing variety
- Handling the deluge:
 - Disseminating alerts
 - Filtering and understanding
 - Co-ordinating follow-up

Wide-field optical instrumentation



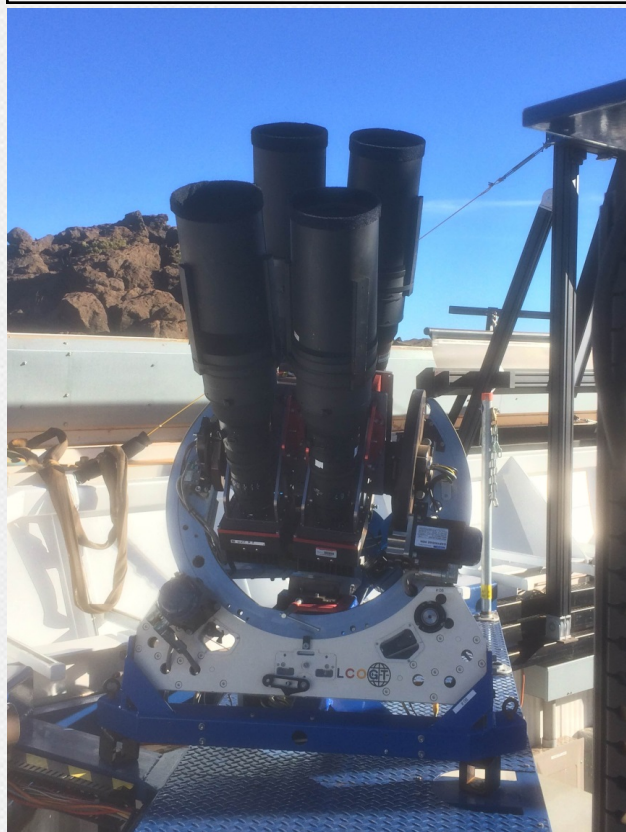
<http://www.astronomy.ohio-state.edu/~assassin/>



Hotwired/Devillepoix



<http://fireballsinthesky.com.au/>



Hotwired/
Shappee/
Elphick

Radio transients



JVLA/Hotwired/Law



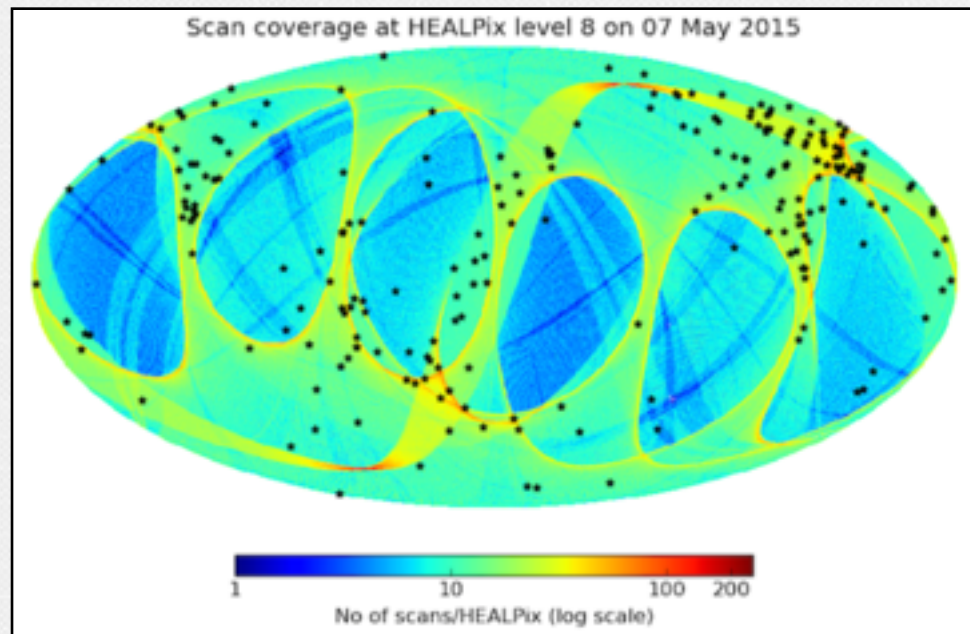
SKA/Hotwired/Law

Raw data rate from fast transient searches at JVLA is today comparable to the rate expected from LSST in 2022...

... but the event rate is modest. No fast radio bursts detected as yet.

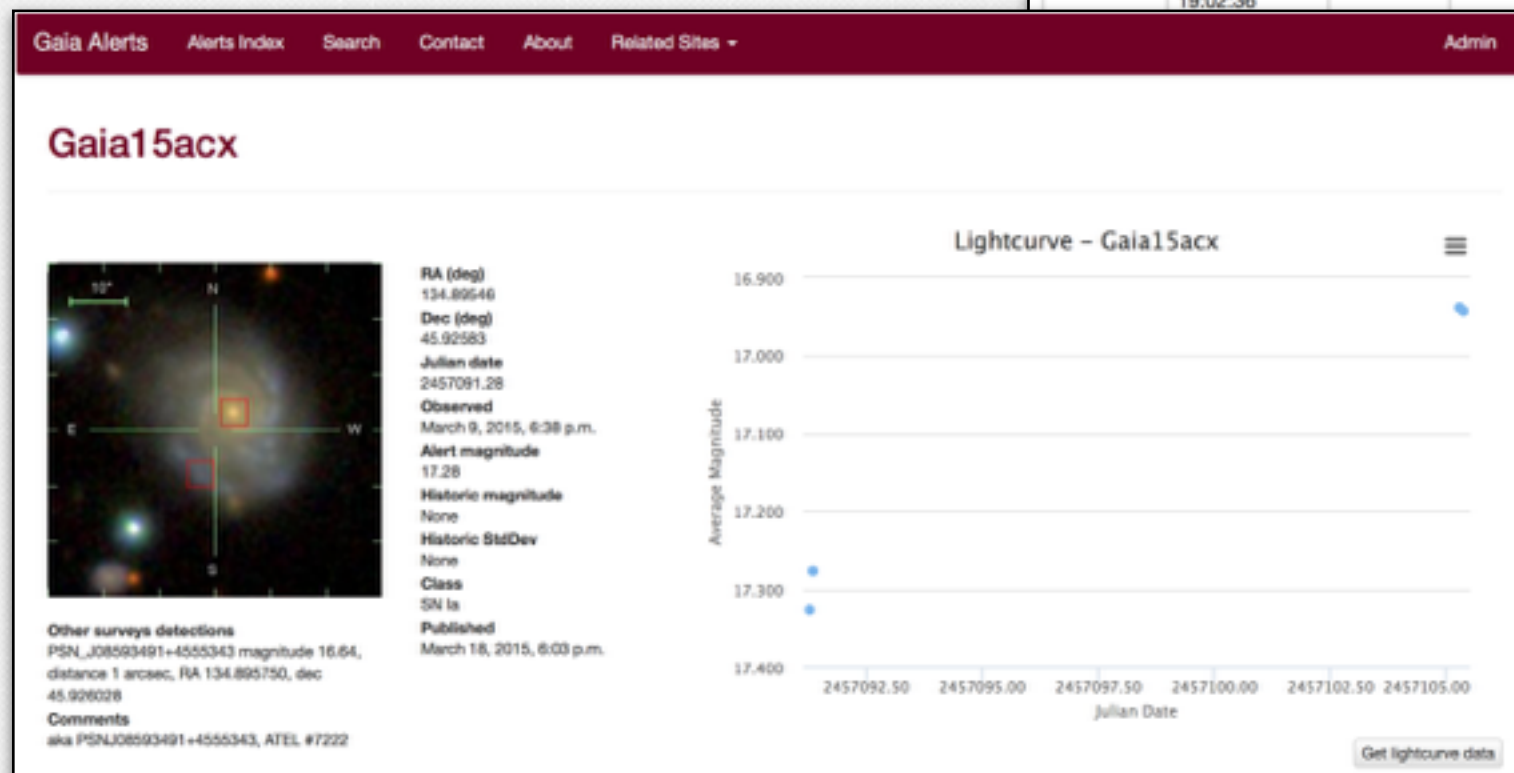
	Optical/High-energy	Radio
Method	Imaging	Lightcurve, Imaging
False +ve origin	Sky subtraction	RFI
Event rate	(Over)abundant	Low
Signal diversity	Moderate	High

Gaia: alerts on the web today



Rixon/Hotwired

Name	Observed	RA (deg.)	Dec. (deg.)	Magnitude	Historic mag.	Historic scatter	Class	Published	Comment
Gaia15aec	2015-04-13 18:13:43	65.42600	34.05784	18.17			unknown	2015-04-24 13:34:34	New source aka CSS090403:042142+CV
Gaia15aen	2015-04-13 11:07:53	99.63035	-22.86799	17.11			unknown	2015-04-23 22:05:52	Hostless blue transient at galactic lat
Gaia15aem	2015-03-25 08:01:31	226.12814	21.98797	18.48			unknown	2015-04-23 18:31:40	new source at G=18.5 near the centre galaxy
Gaia15ael	2015-03-30 09:12:25	203.34546	58.72538	17.27			unknown	2015-04-10 18:20:41	new source near SDSS galaxy, aka CSS150325:133323+584331
Gaia15aek	2015-03-30 02:29:03	101.76123	64.93435	17.73			SN IIP	2015-04-05 22:57:07	bright blue new source 7 arcsec from
Gaia15aej	2015-03-28 03:28:40	275.14162	-50.91538	18.66			unknown	2015-04-05 22:30:27	blue new source 5 arcsec from LEDA
Gaia15ael	2015-03-28 19:02:36	50.35316	-11.14574	18.39			unknown	2015-04-05 21:01:00	new source next to large LEDA galaxy
				18.06			unknown	2015-04-04 22:05:04	blue brightening on SDSS star - CV CSS110923:033711-065059
				18.95			unknown	2015-04-04 21:57:26	new source 5 arcsec from a galaxy
				18.58			unknown	2015-04-03 15:55:37	new blue source about 15 arcsec from



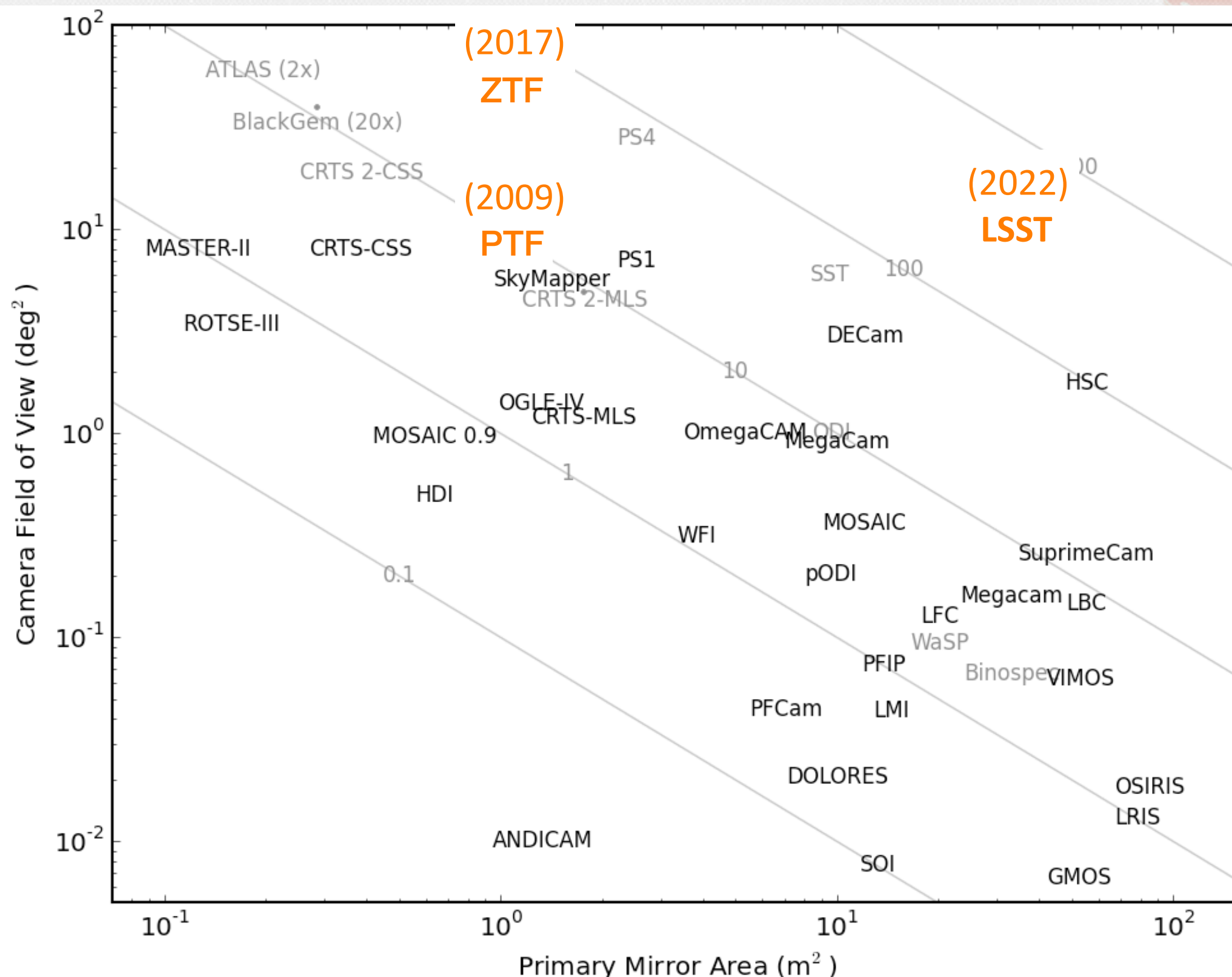
- Survey limit: all stars $g \approx 20.5$; transients $g \sim 19$
- Spectra, VOEvents coming Summer 2015

<http://gsaweb.ast.cam.ac.uk/alerts/alertsindex>

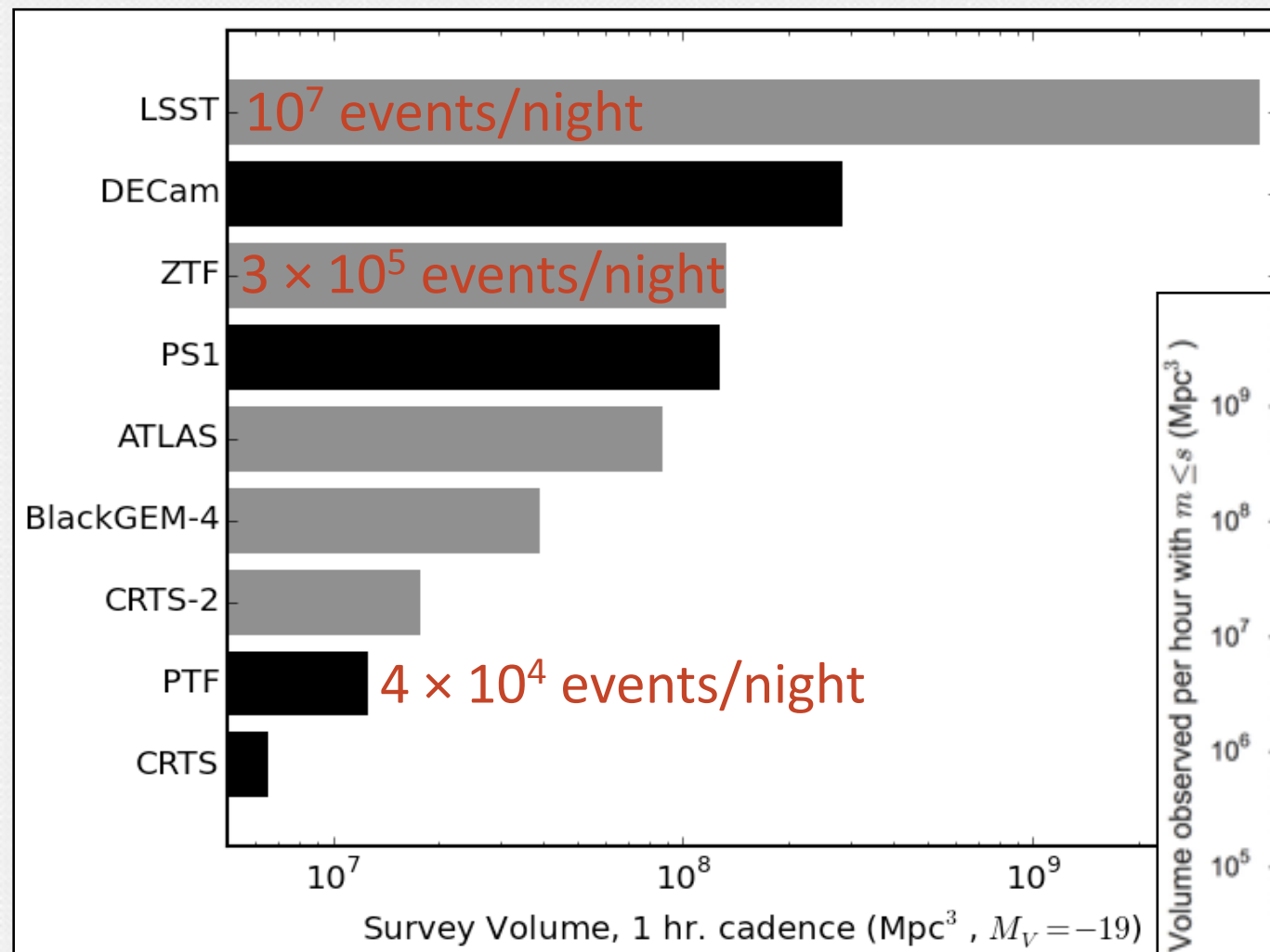
March of the mega-surveys



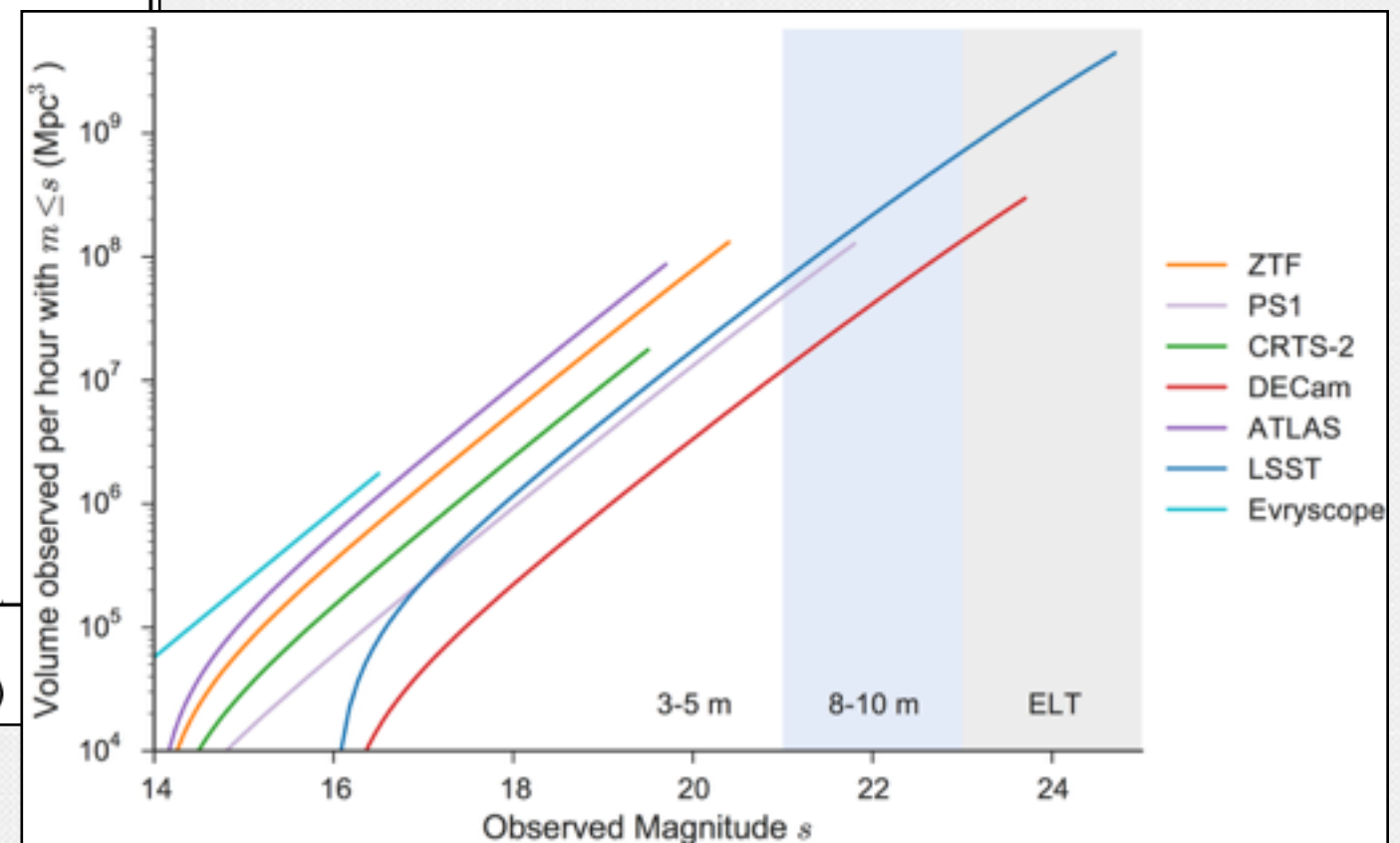
Adapted from
Hotwired talk by
Belm



March of the mega-surveys



Figures from Hotwired talk by Bellm

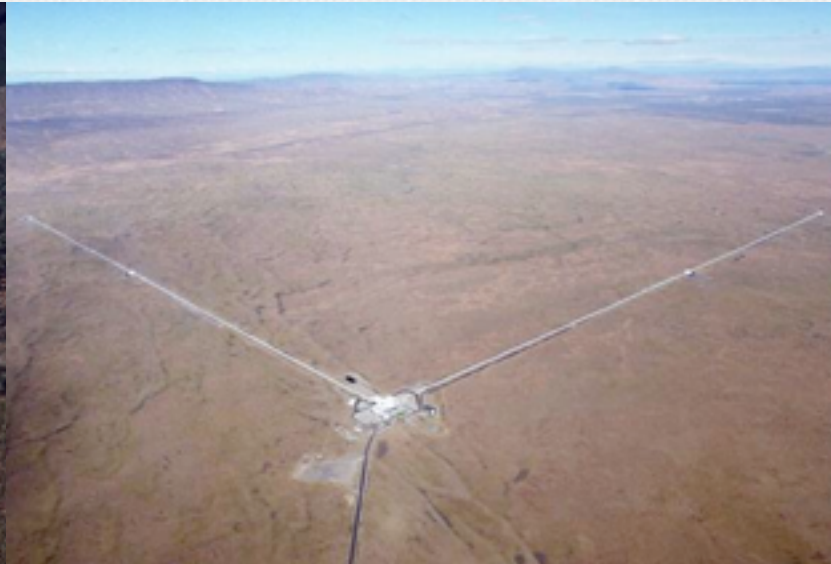


“Rate of discovery outpacing follow-up resources, long before LSST comes online”
— Law

LIGO



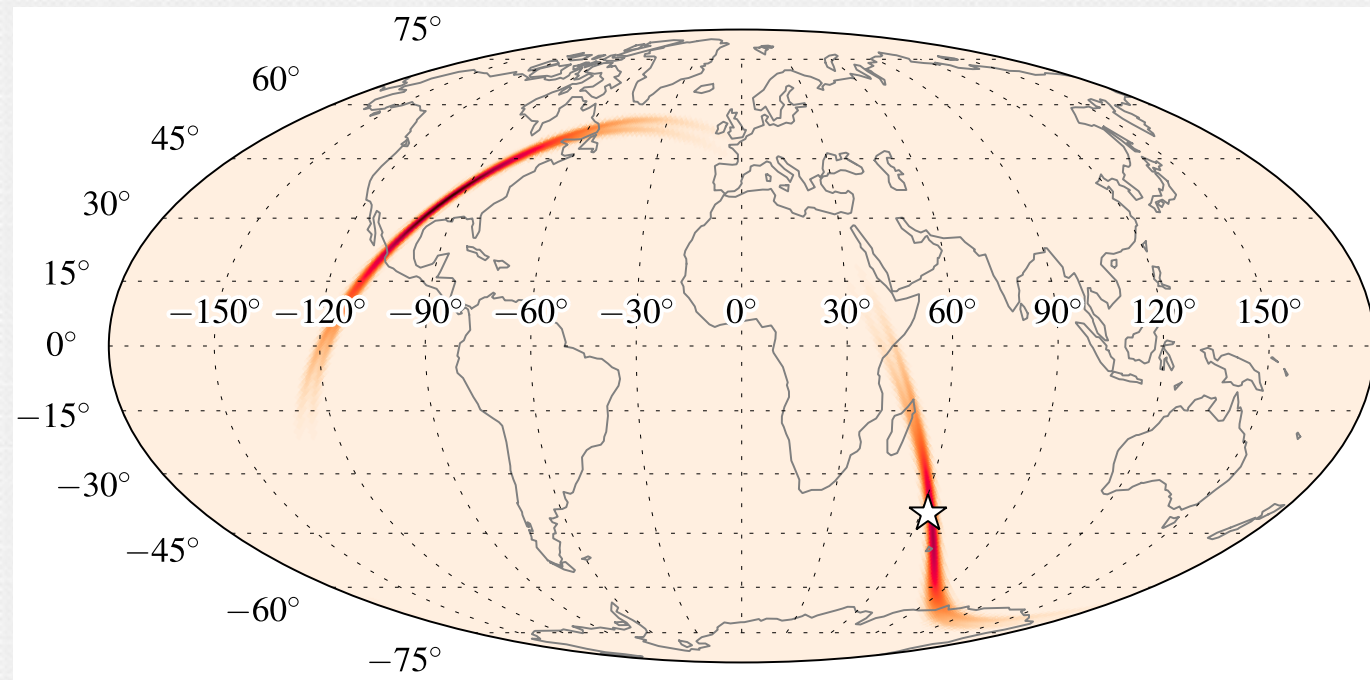
<http://www.ligo.org/multimedia/gallery/llo-images/Aerial%201%20small.jpg>



<http://www.l8.i2u2.org/elab/ligo/home/project.jsp>



<http://www.phys.ufl.edu/~bernard/IREU2008/images/largeimages/Virgo0.jpg>



LIGO event localization, Singer et al (2014)

- First Advanced LIGO science data late 2015/early 2016
- Alerts available with MoU only
- Elaborate infrastructure available to help follow-up observations, e.g.
 - Probability maps
 - Followup footprint server
 - Catalogues of likely sources
 - Light curve archives
- Information about EM followup compiled on LIGO servers



Dissemination

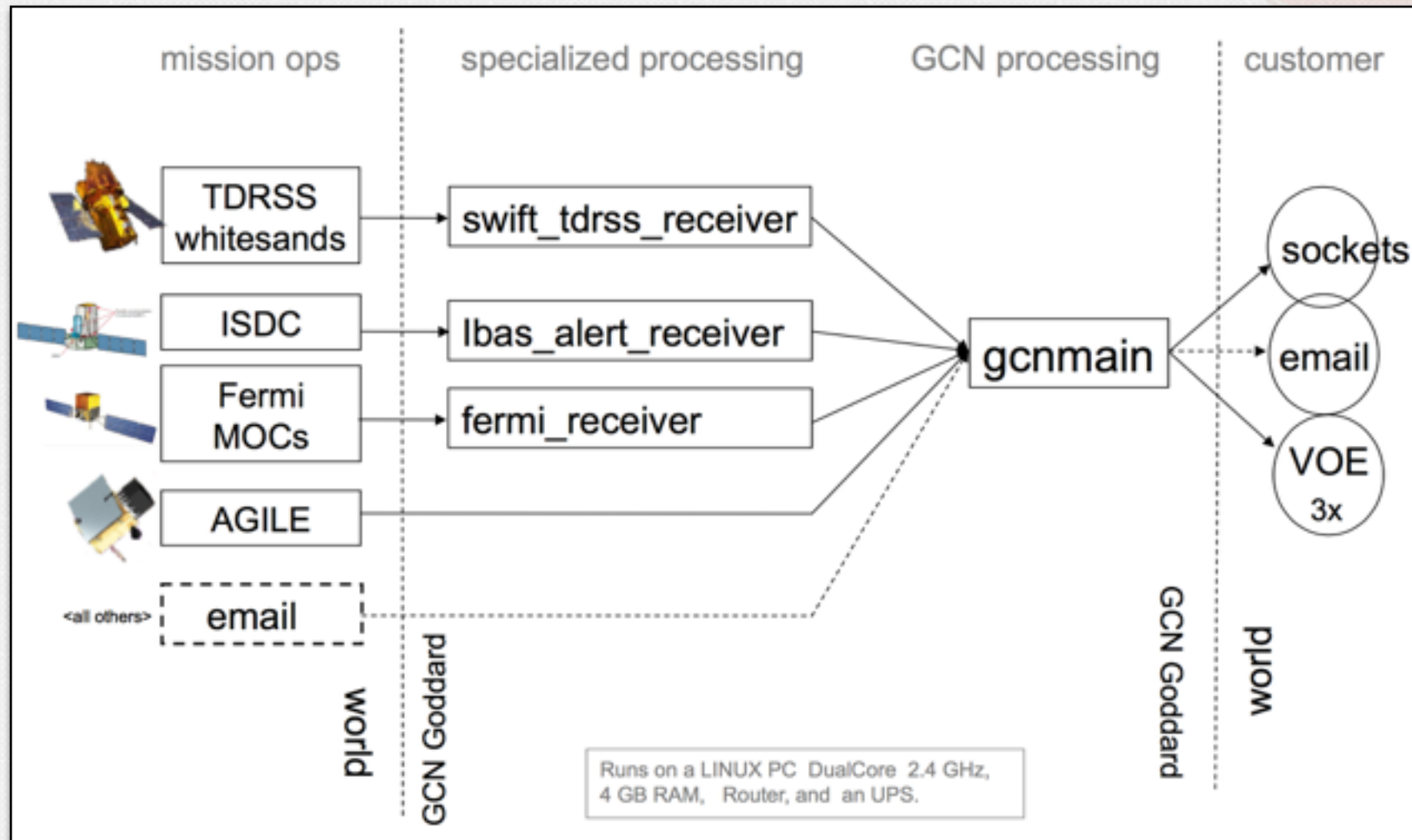
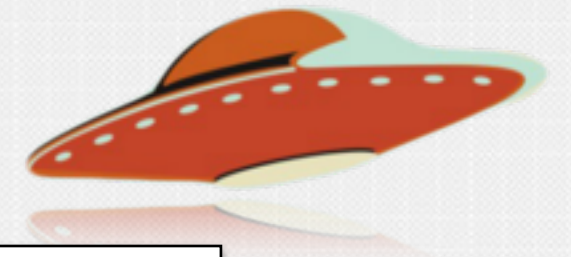
VOEvent tutorial



The screenshot shows a web browser window with the address bar displaying `voevent.readthedocs.org/en/latest/`. The page title is "Notes on VOEvent". The sidebar on the left contains a "Search docs" bar and a list of topics: "What is a VOEvent and why would I want one?", "Finding and installing useful tools", "A look inside a VOEvent", "Manipulating VOEvents in code", "Subscribing to VOEvent streams", "Distributing VOEvents", "Future challenges", and "Bibliography". The main content area has a heading "Notes on VOEvent" and a subheading "VOEvent is the International Virtual Observatory Alliance (IVOA) recommended mechanism for describing astronomical transients. Specifically, the VOEvent standard (Seaman, 2011)". It then defines the content and meaning of a standard information packet for representing, transmitting, publishing and archiving information about a transient celestial event, with the implication that timely follow-up is of interest. It also states that this document provides an introduction to working with VOEvents, is not normative, and represents the authors' own particular biases and experiences. This material is intended to accompany the "VOEvent Hands-On Session" presented at Hot-Wiring the Transient Universe IV (henceforth "Hotwired 4") in May 2015; we hope, though, that it will prove generally useful. It assumes a working knowledge of Python. A bulleted list of topics is shown at the bottom: "What is a VOEvent and why would I want one?", "The transient deluge", and "The VOEvent standard".

<http://voevent.readthedocs.org/>

NASA GCN

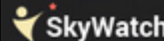


Hotwired/
Barthelmy

- Still the “gold standard” in terms of established, automated event distribution networks
- Expanding beyond the traditional high-energy space missions
 - To be used for distributing **LIGO** alerts
 - Actively soliciting new contributors
- GCN acts as a trusted broker for event distribution
 - Event authenticity, private networks
 - Contrast with the distributed model existing VTP networks use; is this the future?

Skywatch





SWIFT

Fermi

INTEGRAL

KONUS

MOA

Portfolio ID: 448657339445

5 seconds ago

A heads-up alert that the Fermi-GBM instrument found a transient.

Portfolio ID: 448657339445

5 seconds ago

A heads-up alert that the Fermi-GBM instrument found a transient.

Portfolio ID: 448657339445

5 seconds ago

A heads-up alert that the Fermi-GBM instrument found a transient.

Portfolio ID: 448657339445

5 seconds ago

A heads-up alert that the Fermi-GBM instrument found a transient.

Portfolio ID: 448657339445

5 seconds ago

A heads-up alert that the Fermi-GBM instrument found a transient.

Aladin View of 448657339445

Profile Feedback Logout

← Back to Portfolio

Base Image Layer: 2MASS colored

Color Map: Native

Overlay Layers: Reticle HEALPix grid

DSS colored

2MASS colored

Fermi color

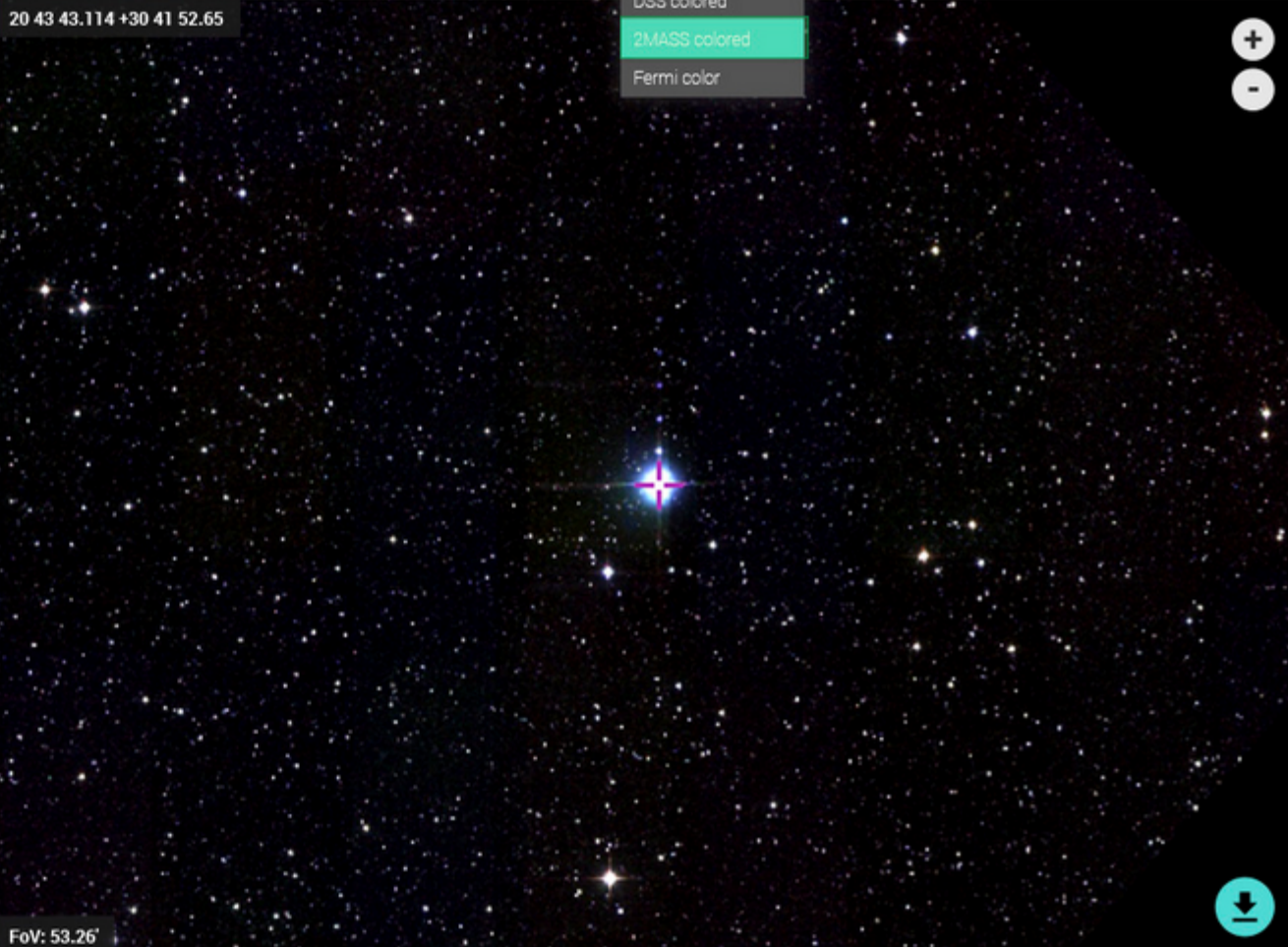
20 43 43.114 +30 41 52.65

+

-

FoV: 53.26'

Download icon



Hotwired/
Jagula



<http://skywatch.co/>

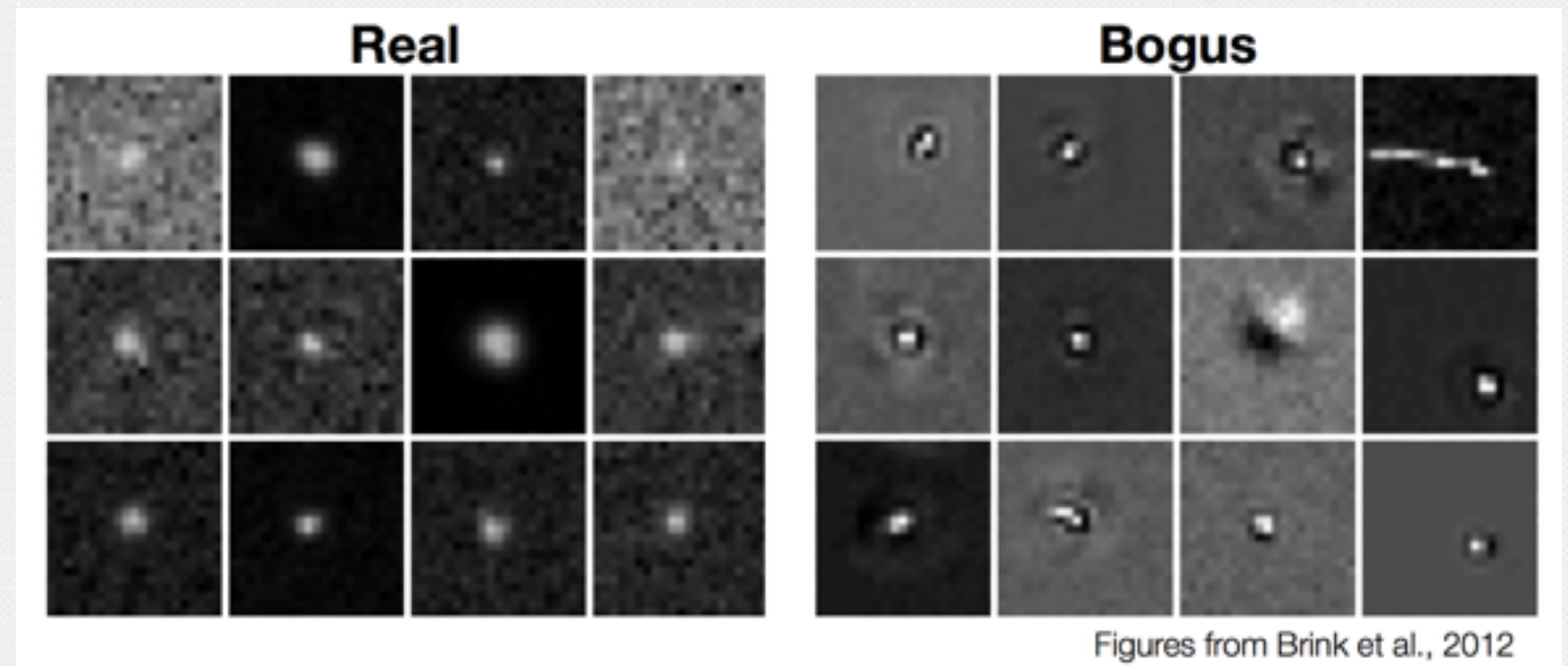


Understanding

Clean the stream



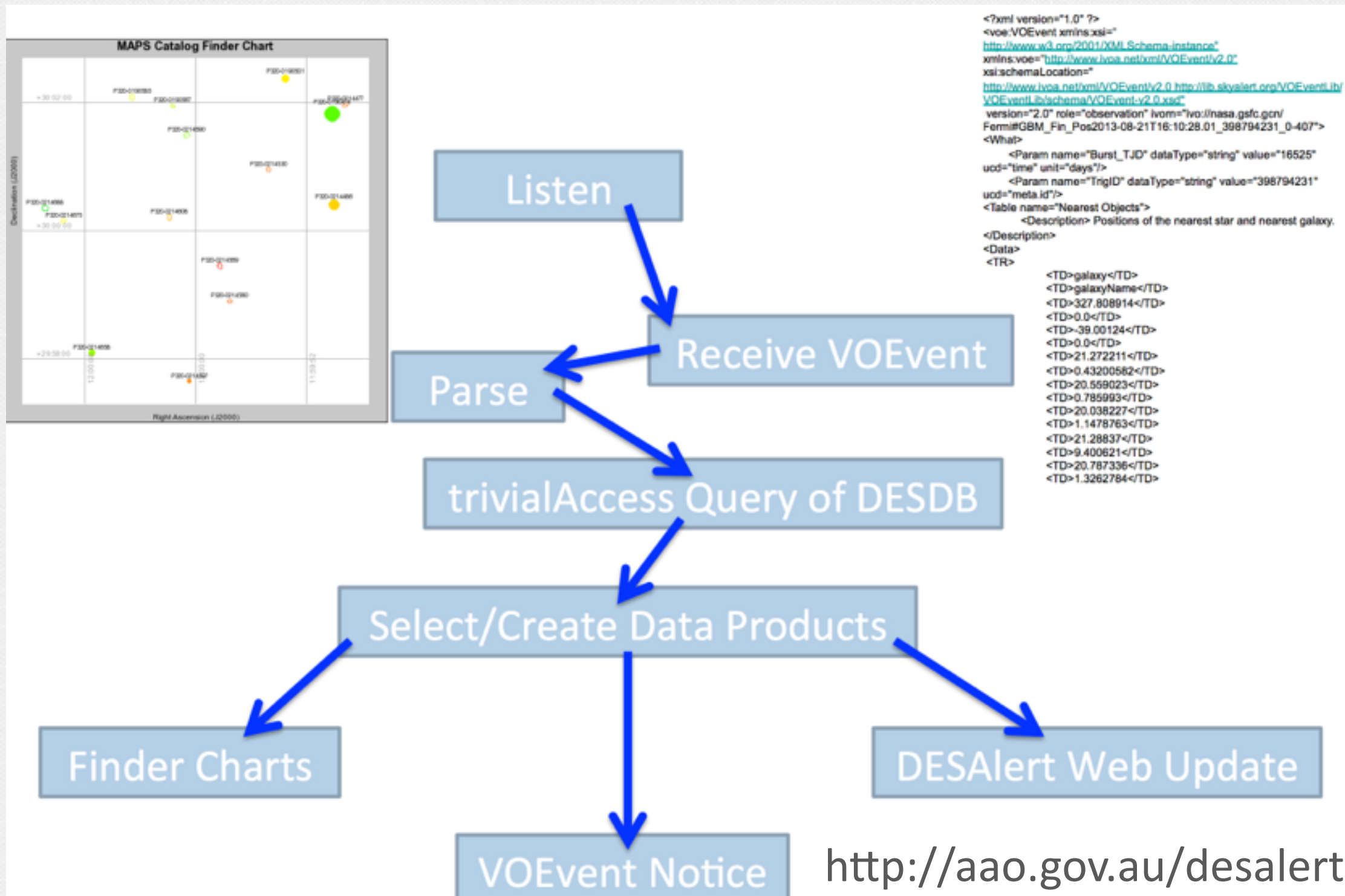
- Artefacts in difference images
 - Bad alignment
 - PSF convolution
 - Streaks
 - Bad gain matching
 - Ghosts, halos
 - ...
- Can dominate over true sources
- Two approaches
 - Use smarter image differencing algorithms (e.g. talk by Rebbapragada)
 - “Real-Bogus” classification of transient candidates (e.g. talk by Bue)
- Investment in both of these approaches likely will be necessary to minimize contamination of the LSST stream



DESAAlert



Hotwired/
Kuehn



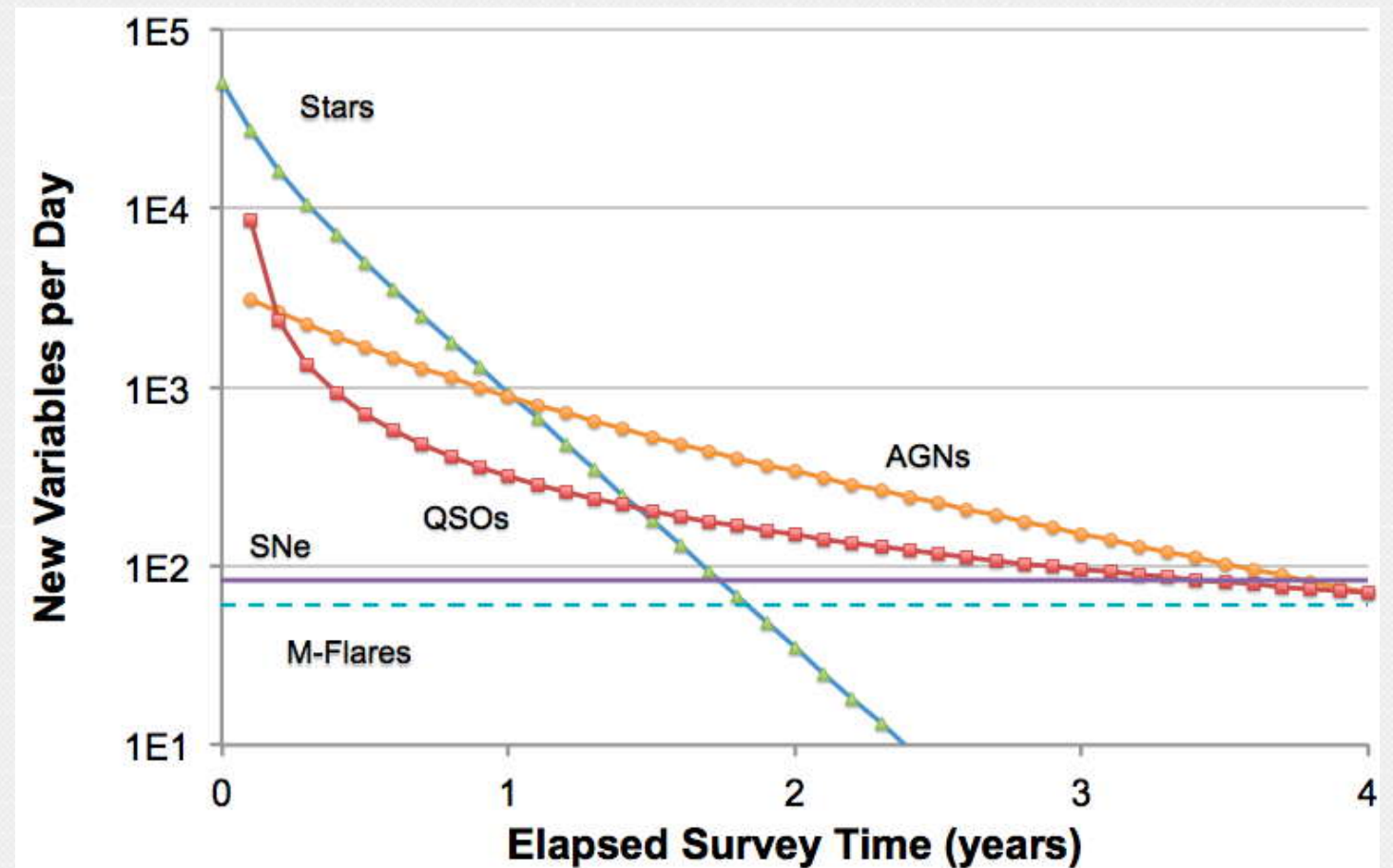


- Under construction now
- Development continues through 2016
- Expecting to target live alert streams in 2017
- Soliciting contributions from the community
 - Describe your favourite transient

...is there really an issue?



- LSST will alert on any significant change detected in a difference image
- The number of true variables in the sky is finite
- The number of **new** variables in the LSST “deluge” will rapidly become quite modest



Ridgway/Hotwired

“The alert rate on new discoveries will drop quickly to $\sim \text{few} \times 1000$ per night.”
Ridgway



Acting

Real-world problems



1. Communicating discoveries

- IAU
- ATEL
- Web pages

Look no VOEvent!

2. Sharing information in real time

- Scheduling resources e.g. I'm going to observe this tonight
- Here's the redshift, type, and spectrum
- **Here are the light curve points in all wavelengths**
- Social media type interactions

3. Iterating the above (based on latest LC point and redshift, this object is...)

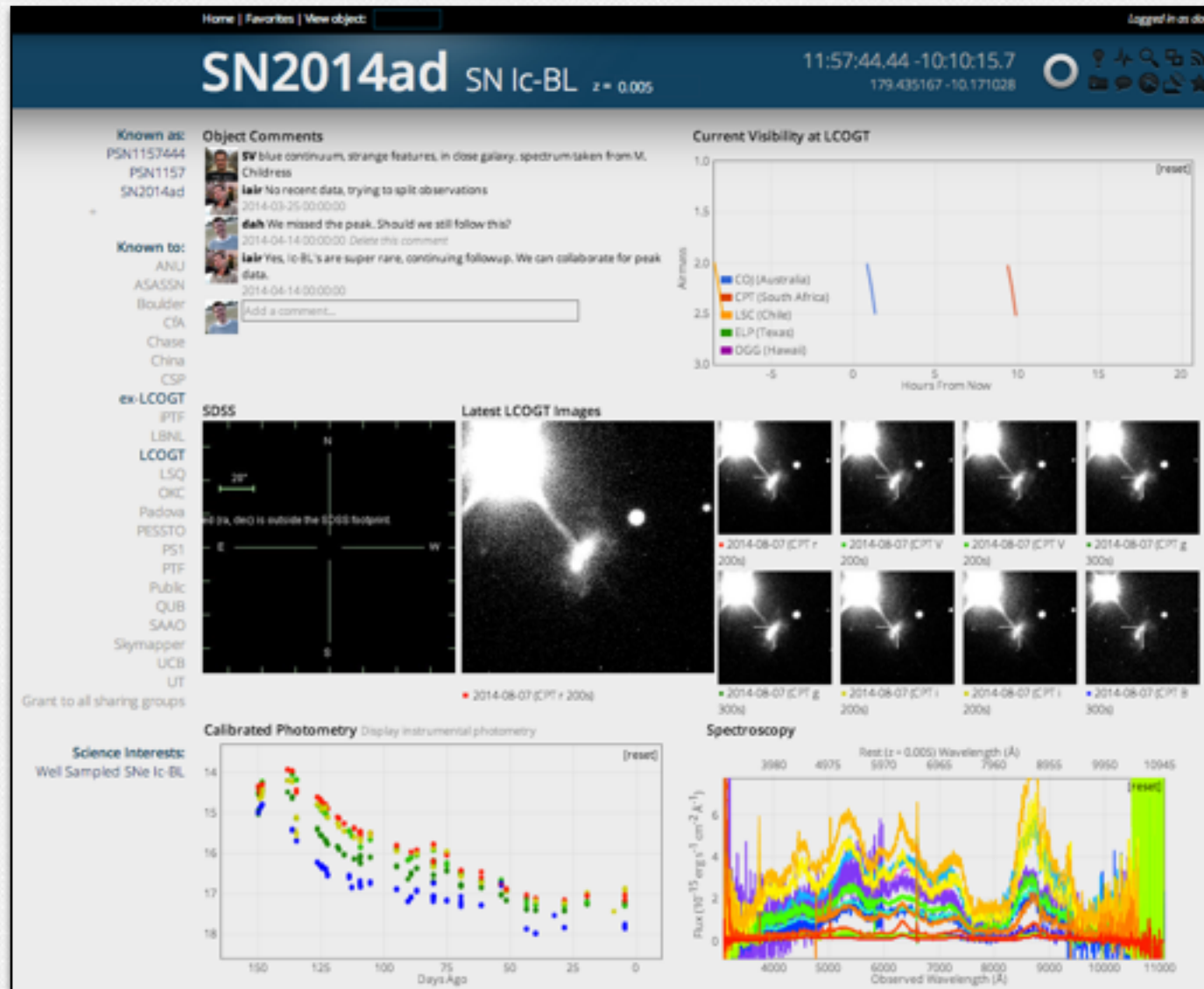
4. Automated telescope triggering

5. Naming schemes

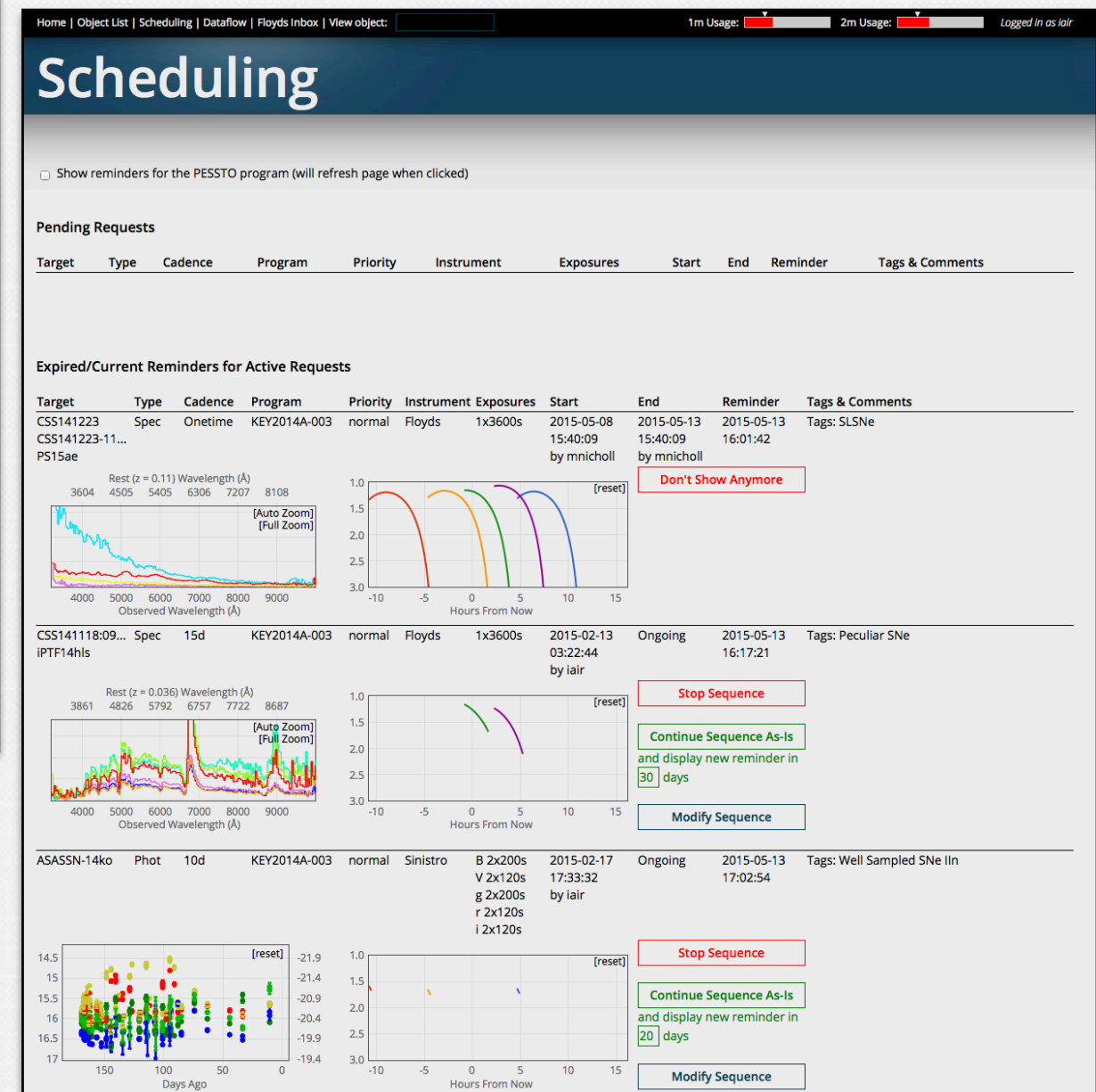
- Name server?
- Specific to event subtypes?

Adapted from material
by Howell at Hotwired

Supernova Exchange

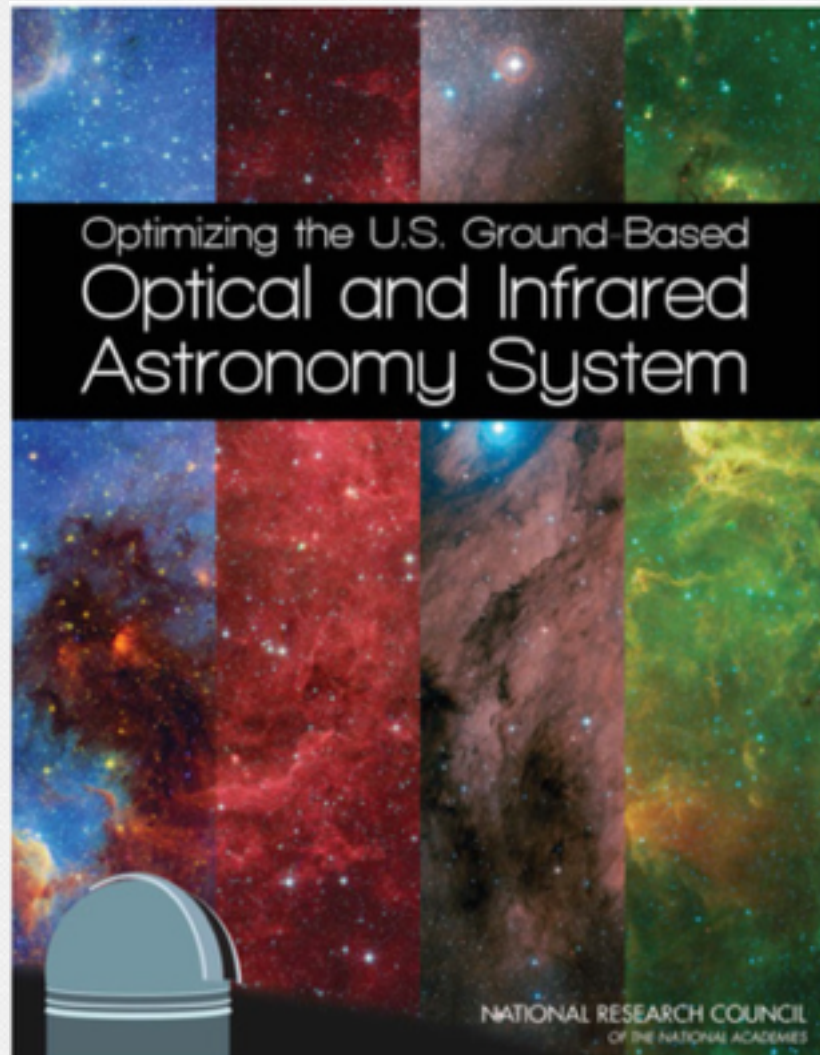


Arcavi/Howell/Hotwired





Final thoughts



Elmegreen et al



CONCLUSION: Plans for coordination and communication of transient events are currently inadequate.

CONCLUSION: Coordination is required to maximize the scientific yield from transients in the LSST era. There is a need for dedicated telescopes and instruments, a system of telescopes, and software to respond efficiently to transients.

RECOMMENDATION: The National Science Foundation should help to support the development of event brokers, **which should use standard formats and protocols**, to maximize LSST transient survey follow-up work.



Extra slides

What is a broker?



- A tool for distributing VOEvents?
 - (Or whatever your alert format of choice is)
 - Comet, Dakota, etc
- A machine learning/classification system?
 - ANTARES
- A filter?
 - LSST “minimal broker”
- A forum for user-driven commenting on and follow-up of transients?
 - Gaia Marshall
- All of the above?

Scheduling



- Essential for efficient follow-up
- Staley discussed Bayesian decision theory as a basis for scheduling observations
- Saunders discussion of the scheduler for LCOGT
 - “Beliefs which are wrong: an easy-to-state problem has an easy solution”
 - There are formal approaches, largely from outside astronomy, which can be adopted to make the problem tractable — convert your astronomy specific goals to an integer programming problem
- Where does the control reside?