CRTS and the VOEvent Networks

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The Catalina Surveys

• Catalina Real-time Transient Survey (CRTS) is a Caltech operated transient survey that started in Nov 2007 using from the Catalina Sky Survey (CSS).

• CSS is an NEO survey that began operation in March 2004.

• CSS operates three telescopes.
  Two in Tucson AZ (0.7m+1.5m), one in Siding Spring, Aus (0.5m).
Observations

- All observations are taken clear.
- Observations 21 days/lunation.
- 4 visits per field over 30mins.
- Covers 2000 deg^2/night
- Total 30,000 deg^2.
- At mags of V=19 to 22.
- Each camera 4k x 4k.
Catalina Sky Coverage

CSS fields with > 20 observations.
Catalina Sky Survey Discoveries

Near-Earth Asteroid Discoveries
All Asteroids

Number Discovered

Half Year Intervals

LINEAR NEAT Spacewatch LONEOS Catalina all others

Catalina Sky Survey
The CRTS survey searches for highly varying (>1 mag) astronomical sources (“optical transients”).

Transient detection has run for three and a half years.
3.5 yrs 0.7m telescope, 1.5 yr 1.5m, 11 mths 0.5m.

Transients are found based on catalog comparisons
- CSS coadds, USNO-B, PQ, SDSS.

Same pipeline base code runs on data from all three CSS telescopes.

All data is fully processed within minutes of observation.

Discovery rate is ~ 1 OT /10^6 measurements.

Discoveries are made public instantly using VOEvent standard to enable rapid follow-up.
Supernovae
( > 700 discovered)
2009+2010 twice
number published by
any other group
(PTF, PanSTARRS,
LOSS, etc.).

Cataclysmic Variables
(> 500 discovered)
More than any past
survey (eg. SDSS).

UV Ceti stars
(flare stars)
~100 discovered

Blazars
~120 discovered
100’s other transient sources

- Variable stars (LPV, RR Lyrae)
- Active Galactic Nuclei
- Young Stellar Objects (FU Ori, T Tauri)
- High Proper Motion stars
- Classical Novae (CSS081007)
- Tidal disruption events (archival)
- Luminous Blue Variables

Transient wish list:
- Microlensing events, Type Ia SN, other new transient types.
Discovery Locations

Red=SN, Blue = CV, Green=Blazar, Magenta=Other
Event follow-up

Supervised follow-up strategy:
- Photometry first
  - P60, NMSU, DAO, CSS 1m (June 2011)
- Spectroscopy only for transients appearing unusual
  (avoid common SN like Ia’s based on colour normal luminosities).
  - Gemini N+S, Keck, P200, SMARTS, IGO, MDM.

External follow-up:
- Foster follow-up of other transients by open publication and collaboration.
Discovery Notification

- Three layers of event distribution.
  1) Real-time discovery (mins)
     - VOEvents
  2) Human classified (mins-hrs)
     - Event portfolios
     - HTML, iPhone, Circulars, Twitter
  3) Events of interest (mins-days)
     - Portfolios + follow-up
     - ATel, CBAT, VSNET

LSST/CRTS iPhone app
Evaluation of past information Including:
light curves, images, colours, nearby sources (eg. x-ray, radio, galaxies) -> classification.
Info on classification also published as VOEvents to SkyAlert.org.
Publications

- **CRTS Circulars (> 1500)**
  twitter.com/skyalert

- **Astronomer’s Telegrams (> 60)**
  www.astronomerstelegram.org

- **CBETS (> 90)**
  www.cfa.harvard.edu/iau/cbet/RecentCBETs.html

- **VSNET Alerts (> 100)**
  www.kusastro.kyoto-u.ac.jp/vsnet/

- **Journals (>20, mostly collaborative)**
  crts.caltech.edu/pub.html
CRTS Summary

- CRTS has discovered:
  ~3500 unique optical transients:
  (>700 SNe, >500 CVs, >120 Blazars, >100 Flare stars, ~500 High amp vars, AGN, HPM stars).

- CRTS discoveries are all made public immediately (cf. PTF, PanSTARRS).

- CRTS is making all past CSS survey data public.
  (500 million objects, 80 billion photometry points)

http://crts.caltech.edu/
CRTS is supported by NSF Grant No. AST-0909182
Alerting the World
The VOEvent Network

The VOEvent standard was introduced in 2005 to produce an open generalized method for alerting robotic and human users about astronomical events from diverse range of current and future transient surveys (SKA, LSST, LOFAR, PQ, Swift, Fermi…).

In order to transport these VOEvents the VOEventNet project was begun. This project has been replaced by the SkyAlert project.
• Standardized structured xml data packets.

A basic VOEvent contains:

<VOEvent>
  <Who> Author Data </Who>
  <What> Parameters Measured </What>
  <WhereWhen> Coords and Time </WhereWhen>
  <How> Instrument Setup </How>
  <Why> Reason for Alert </Why>
</VOEvent>
Candidate new Transient

Author:

Author IVORN: ivo://nvo.caltech/voeventnet</AuthorIVORN>

Author:

shortName: LPL and Caltech<shortName>

contactName:
Andrew Drake (for the Catalina Real-time Transient Survey)

contactEmail: ajd@cacr.caltech.edu<contactEmail>

Date: 2011-04-05T11:15:13

Group name: Asteroid params

Parameter:

Param unit="mag" value="17.702600" ucd="phot.mag;em.opt.R4" name="magnitude"

WhereWhen:

ObservatoryLocation xlink:href="ivo://STClib/Observatories#TOPOCEN" xlink:type="simple" id="TOPOCEN"

ObservationLocation:

AstroCoordSystem xlink:href="ivo://STClib/CoordSys#UTC-FK5-TOPO/" xlink:type="simple" id="UTC-FK5-TOPO"

Time Instant:

ISOTime: 2011-04-05T11:04:44

Position2D unit="deg"

RA: 237.6261300

Dec: -0.2381300

Inference probability="0.1"

Concept: Newly discovered Transient
Transporting Events

Two Methods:

Jabber IM (via JEP-060):
secure, reliable, scalable,
native xml, open.

VTCP:
Simple, closed network.

Both require custom software.
Event Transport

VOEvent network running Jabber servers (Ejabberd or Openfire):

- Caltech
- LIGO (x2)
- MOA
- LSST
- SVOM
Event Services

Connection to Jabber servers.

Require custom clients that understand PubSub XMPP xml stanza.

Clients are available in Java, C, Perl, Python.
PubSub

- Server mediates connections.
- Publishers send data to node.
- Core protocols include end-to-end signing and object encryption via TLS and SSL.
- Servers can keep record of sent events.
- Affiliations to, subscribe, publish, purge items, config a node, delete a node.
- Users can be publishers, subscribers, or blocked.
- Message nodes can be discovered by clients.
- Subscription can be open, list, authorized.
The Event Network

Event Publisher
- Caltech
- SkyAlert
- LSBT
- OGLE III
- GALEX TDE
- CRTS/CSS
- Fermi/SWIFT
- MOA
- NZ
- Human Users

Event Receiver
- NMSU
- CANDELS
- AMUSE
- South
- Australia
- Telescope
- iPhone

Event Archive
- ATel
- VST
- VST
- ESO
- LSST
- Hubble
- Caltech
- Harvard
- NMSU
- iPhone Users

Other
- eSTAR
- POLO
- Collaboration
- NED, etc.

- Event Publisher
- Event Receiver
- Event Archive
SkyAlert

Sponsored by the National Science Foundation

Recent Events

In the picture below, time is measured with "right now" at the right. Ages of recent events -- the last 200 received -- are shown by stream. Click on an event to bring up a new window with detailed portfolio.

About Skyalert

SkyAlert collects and distributes astronomical events in near-real time. Each event belongs to a stream of events that come from a common source, with a common vocabulary of parameters for each event. You can browse event streams and the events themselves, at the links below. You can set up "alerts" which decide which events you find interesting, that comes with an Atom feed of those that pass the selection. You get only the events you want -- no more, no less.

- Skyalert News
- Feeds of interesting astronomical events
- Browse event streams that skyalert is monitoring
- Recent events as a table
- Recent events with WorldWide Telescope
- Recent events Facebook page
- Recent events with Twitter
- Build a custom feed

<-- Time since now (2011/04/05 2:22 PDT)
Events at SkyAlert

Current Event Streams:

- CRTS (OTs)
- CSS (NEOs)
- MOA (Microlensing)
- CBAT (SN, Novae)
- OGLE (Microlensing)
- GALEX (UV transients)
- Fermi (GRB, etc.)
- SWIFT (GRBs)
- HST_MCT (Candels SNe)
- AAVSO (CVs, Novae)
CRTS + SkyAlert

Discovery data -> VOEvent xml. Notices published over VOEventNet to SkyAlert, etc. Automated discovery agents create a portfolio from VO services (SIMBAD, NED, etc.) & catalogs (SDSS, NVSS, etc.)
SkyAlert Portfolios

First observation
Later observation
Is it in the archive yes: NED and SIMBAD
Telescopio followup

Classification as blazar outburst

Data from many sources joined to initial event
Computer can understand it and make selection
More info about VOEvent

http://hotwireduniverse.org
Free download!

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Since time domain astronomy is a moving target, planning is already underway for a 2nd edition.