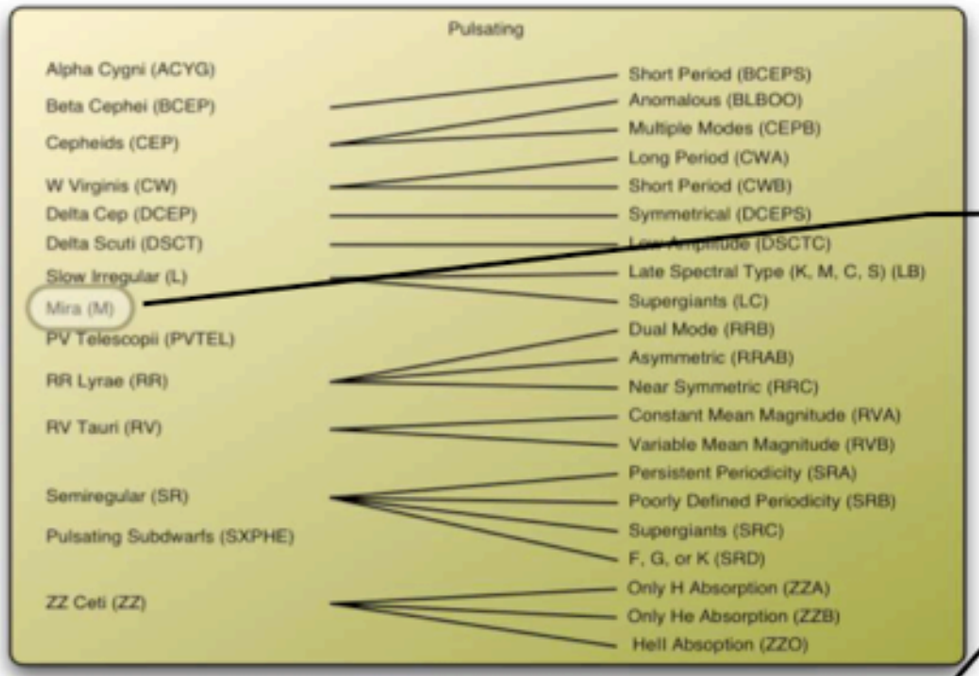
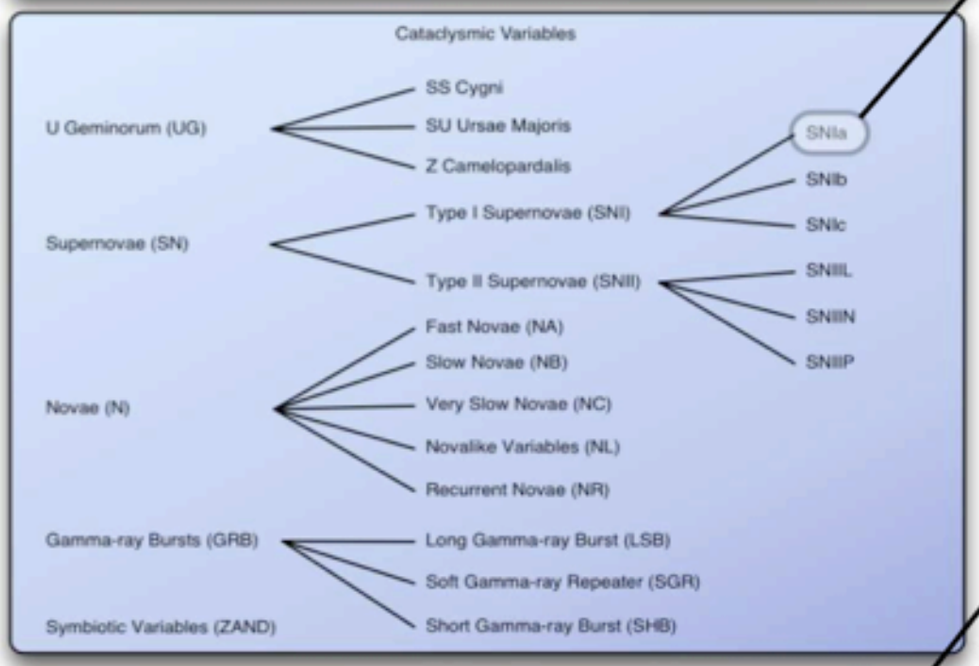
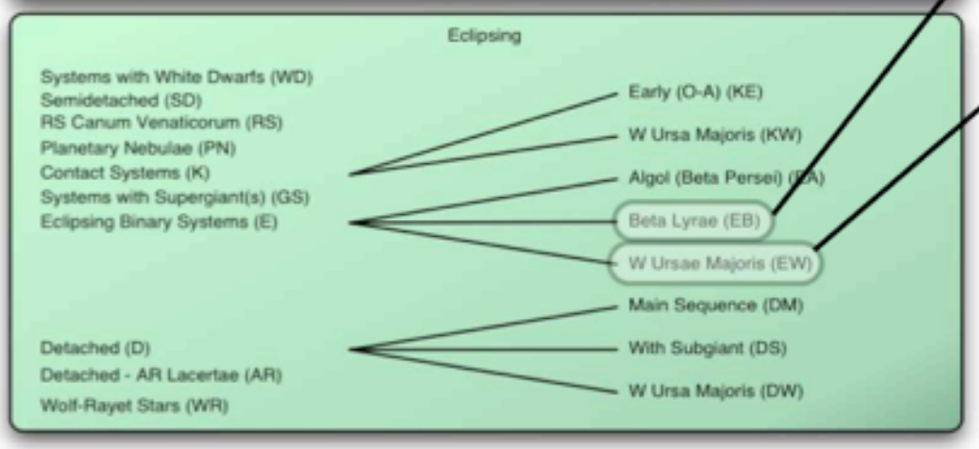
Pulsating Stars

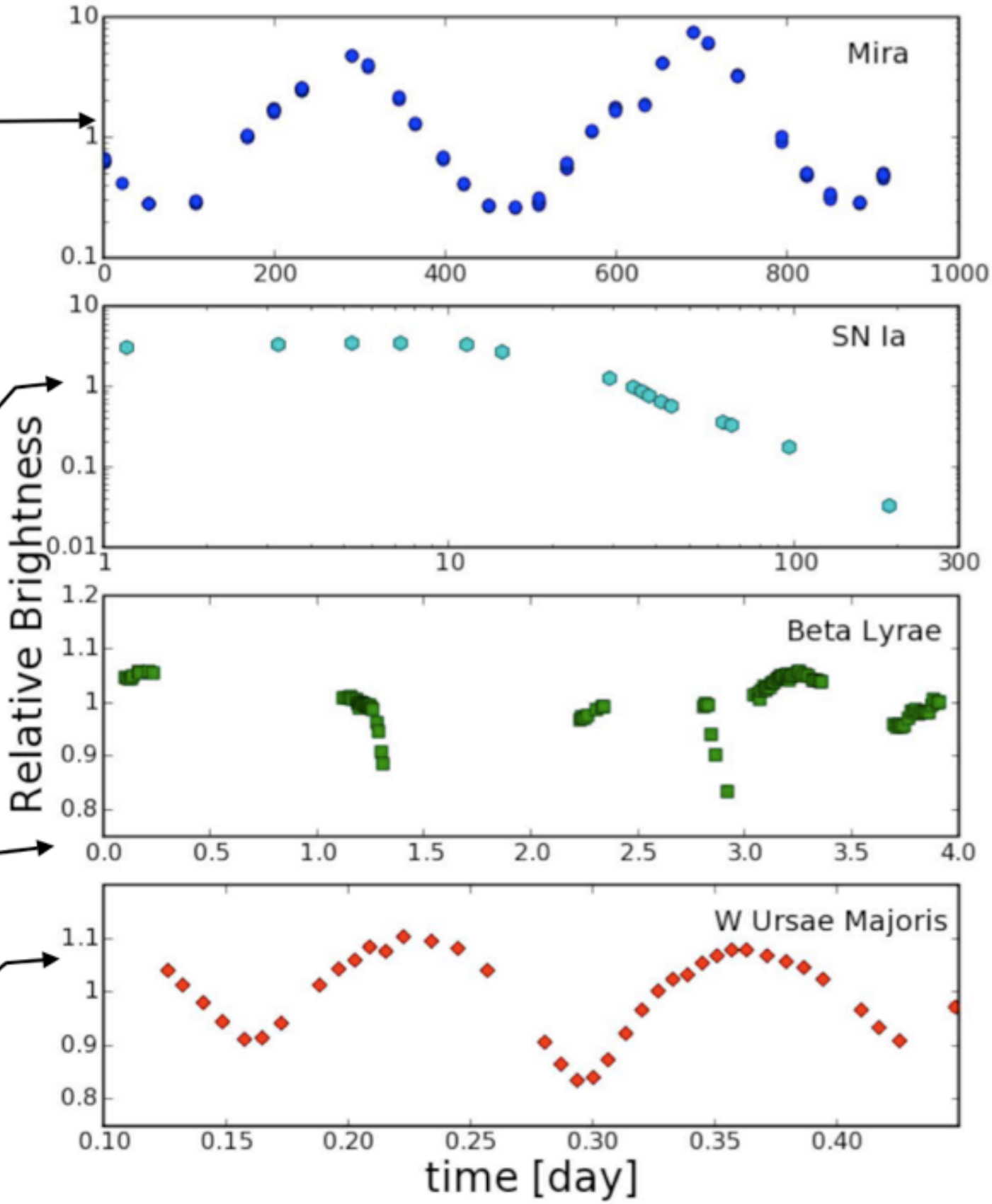


Cataclysmic Variables

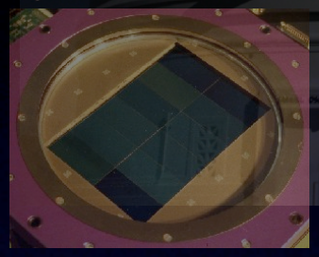


Eclipsing Systems





Transients Classification Pipeline



http://sites.google.com/site/dstarr1/tcp
http://tinyurl.com/tcp123

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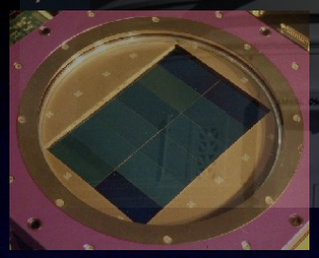
Transients Classification Pipeline



- <u>Goal</u>:
  - Science classification and assessment without immediate astronomer input
- <u>Why</u>:
  - Certain science requires rapid follow-up
  - Too much data for astronomers to assess.
- <u>How</u>:
  - TCP will identify and broadcast interesting transient sources to astronomers & telescopes
  - Palomar 48” & Mosaic camera commissioned in November 2008

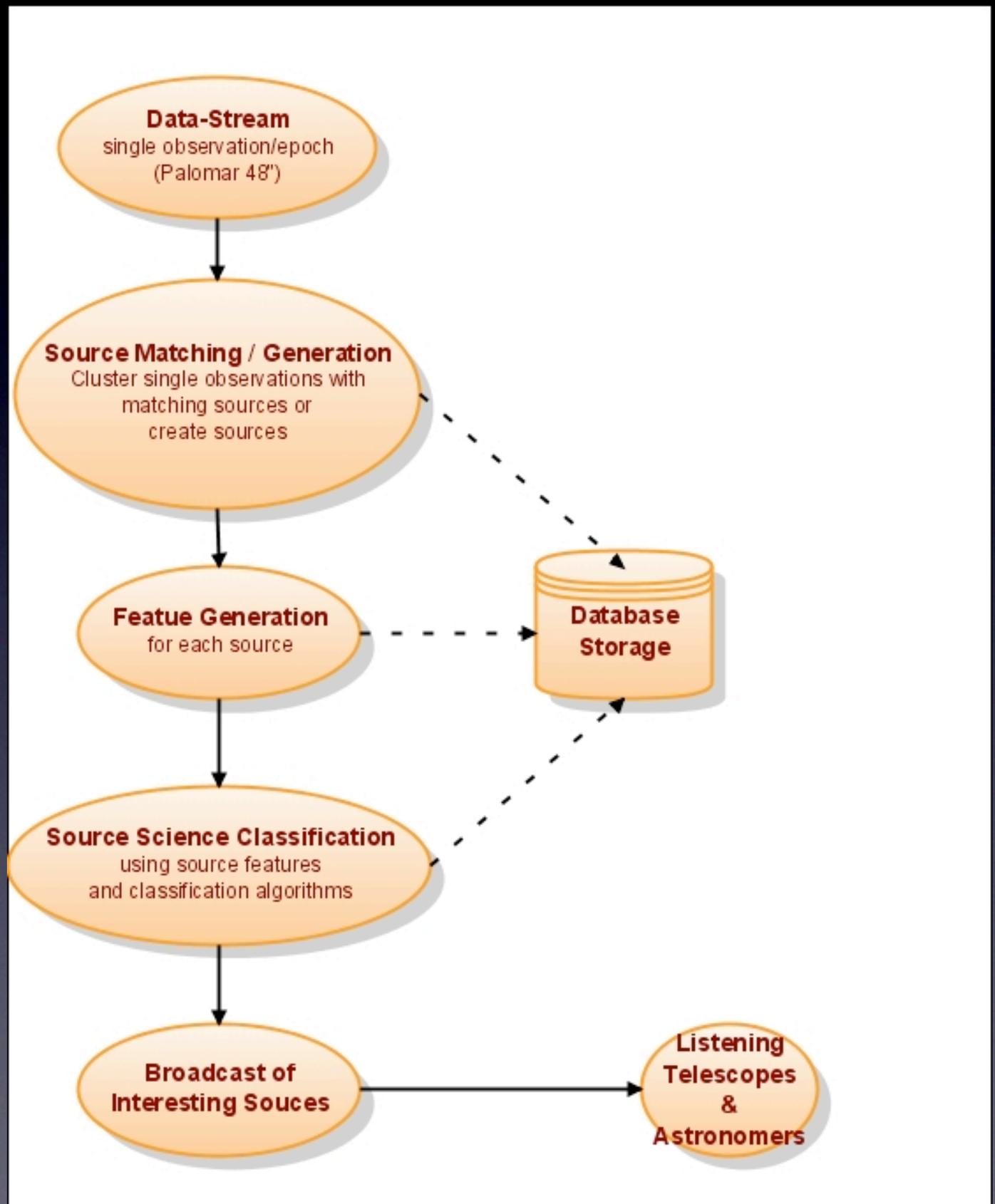
Telescope to Telescopes

- Palomar 48” : 100 Mpix, 7.8 sq-deg detector
- ~120s cadence : 192MB : <100GB/night
- 10-100k single observation objects / night
- Post filtering: ~1000s difference-objects / night

TCP

- PTF consortium
- Palomar 60”
- PAIRITEL, MDM, Wise, ...

Transients Classification Pipeline



Why Python?

- *An excellent glue*
- Rapid development
- Parallelizable tasks
- Python use:
  - minor planet filter
  - “feature” generators
  - building & applying science classifiers
  - data broadcast
  - flat and structured data storage
  - test suites

Rapid development using Python

- Useful packages
  - Scipy, numpy, matplotlib, ...
- Evolving constraints and architecture
  - Ex: added surveys/telescopes
  - Ex: evolving light-curve complexities (filters...)
  - Ex: need to cache external data sources (due to throttling, etc...)
- Allows contribution by less experienced programming community
  - Ex: “feature” extraction algorithms

A need for parallelization

- Expanding data-stream
  - Palomar 48 inch telescope
  - SASIR, LSST?
- Immediate follow-up
  - GRB, supernova follow-up
  - Follow-up using robotic telescopes, etc...)
- “Ipython1” is a branch of Ipython (merged soon) which allows parallelization
- Ipython1 lets us load modules and initialize database connections only once on each node
- Tasks can be quickly delegated to free nodes

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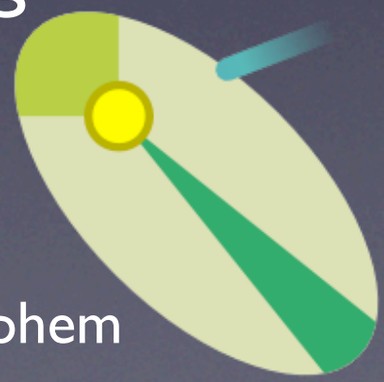
Minor planet ("asteroid") filter

- Minor planets pollute our stellar transient stream
- PyEphem: given orbital parameters, this estimates a MP's position at an arbitrary time
- For every transient source, TCP checks for nearby MPs, filtering out sources with close matches

- Currently we use 360,000 MPs
- As PAN-STARRs goes on-line, many more MPs will be cataloged
- Calculations are parallelized to handle increasing catalog size



PyEphem

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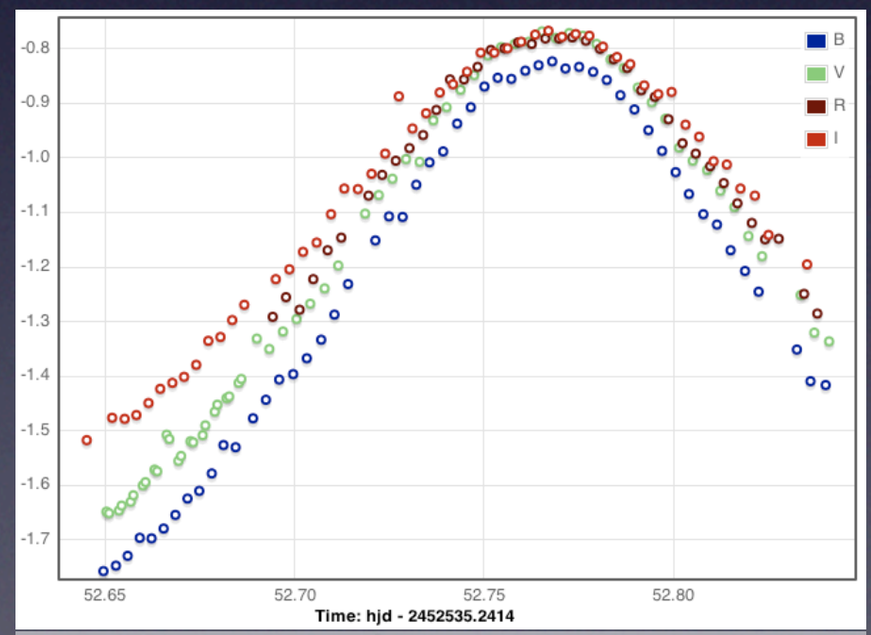
Generated “Features”

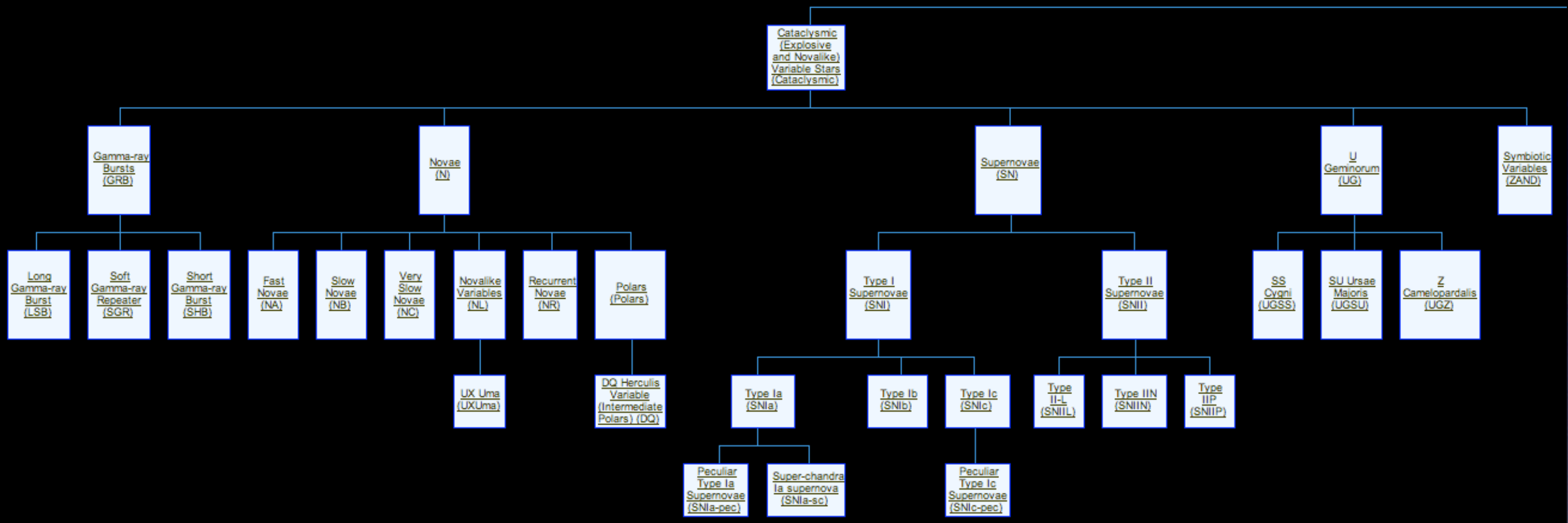
- “Features” : real number metrics
  - <u>Metrics derived from time-series light-curves</u>:
    - Ex: time-series period, amplitude, frequency components
    - Ex: period folded statistical modes
    - Ex: metrics representing “goodness-of-fit” to various models
- <u>Intrinsic properties</u>:
  - Ex: distance, color differences
- <u>Context information</u>:
  - Ex: nearest galaxies, galactic latitude



Science classification

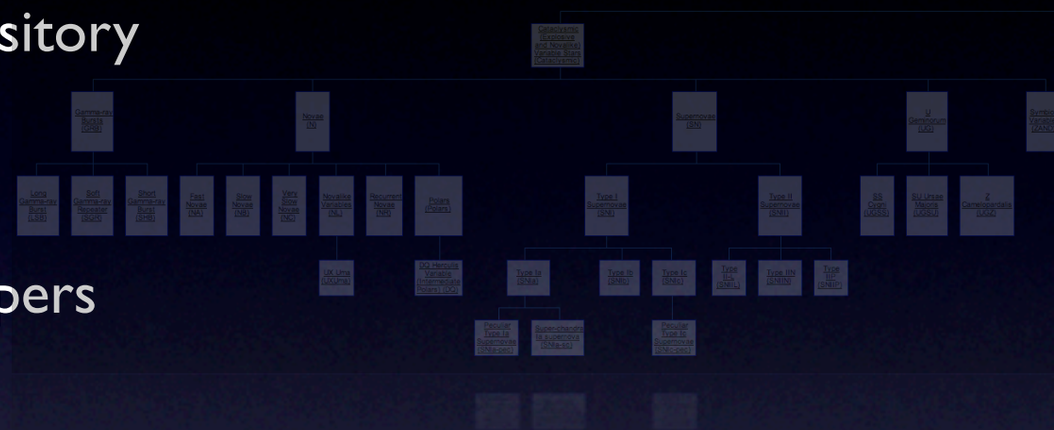
- Need knowledge of most variable science
  - Build warehouse of example light curves
- Generate “priors” / algorithms characterizing each science class
- Apply “priors” / algorithms to new or updated sources, to determine their most probable science class

Science classes

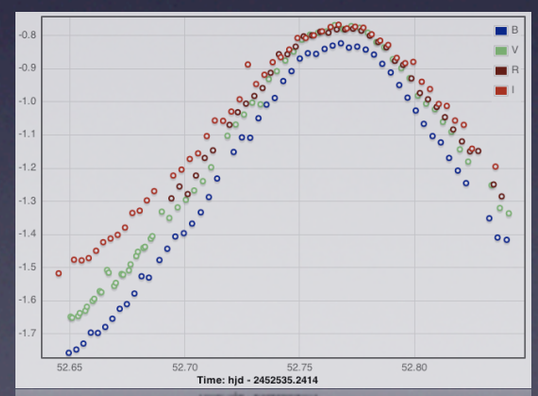


Building science classifiers

- Berkeley's variable light-curve repositories
  - TCP-TUTOR : internal, evolving repository
    - ~150 science classes
    - ~14,000 sources from ~87 papers
  - (Future) : http://dotastro.org
    - Any astronomer may add light-curves & science classes



- Resample light-curves to better represent
  - data-stream observing cadences
  - each instrument's capabilities, noise



- Build science priors / classification algorithms using resampled light-curves

Applying science classifiers

- Source classification occurs at multiple points
  - Sources from real-time data-streams
  - Sources identified during ingestion of a survey
  - Sources re-evaluated by autonomous agents
- Classification algorithms implemented using a couple languages
  - R : used by Berkeley statistics collaborators, execute scripts using Python's Rpy
  - WEKA : Java based, but Jython can be used. Can also wrap via shell.
  - Future ML algorithms (preferably Python/C++)

Data access and broadcast

- Push:
  - Broadcast XML via smtplib, socket, jabber
  - Broadcast sources matching astronomer predefined constraints
    - Broadcast to robotic telescopes for immediate follow-up
    - VOEvent XML packets
- Pull:
  - Web interface
  - Allow source retrieval using custom queries

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  - test suites

Data Storage

- Simple Data
  - MySQL : SDSS-II : 750M row tables
  - SQL retrieval of Palomar 48” object stream
- Structured Data
  - VOEvent XML
  - VOEvent contains different sub-elements for different instruments and follow-up groups
  - Store XML using Berkeley-DB XML, query using dbxml and Xpath / XQuery

Testing

- Self contained pipeline test framework deployable on development machines
- Currently use “unittest” package and a custom testsuite
- Future: try using the “nose” testing framework

Transients Classification Pipeline

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http://tinyurl.com/tcp123

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