Target and Observation Managers

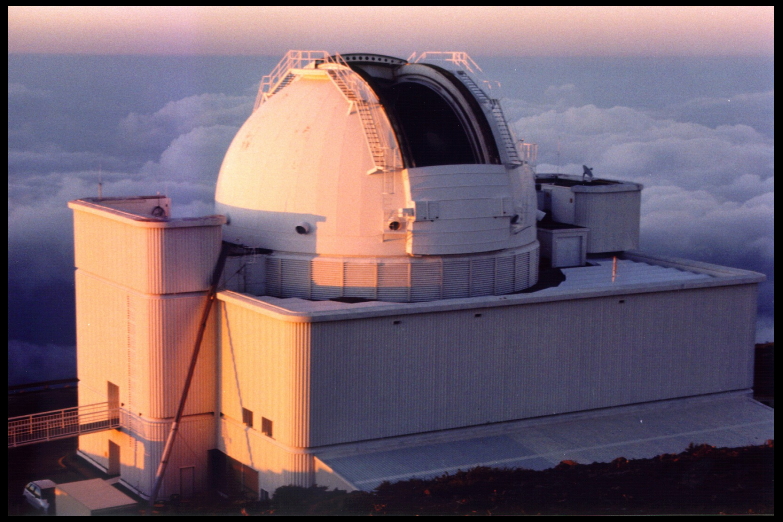
“TOMs”

What are they and why would I need one?

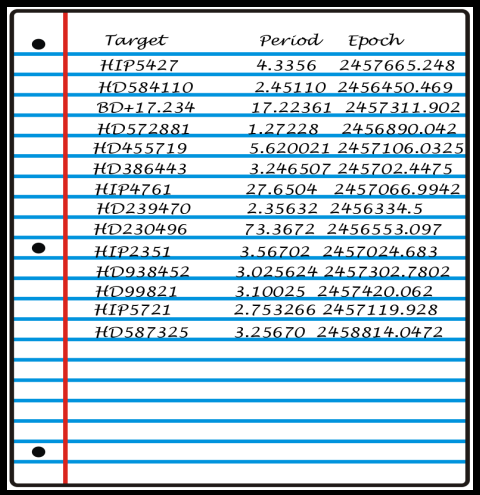
Rachel Street

Managing astronomical programs

Target	Period	Epoch
HIP5427	4.3356	2457665.248
HD584110	2.45110	2456450.469
BD+17.234	17.22361	2457311.902
HD572881	1.27228	2456890.042
HD455719	5.620021	2457106.0325
HD386443	3.246507	245702.4475
HIP4761	27.6504	2457066.9942
HD239470	2.35632	2456334.5
HD230496	73.3672	2456553.097
HIP2351	3.56702	2457024.683
HD938452	3.025624	2457302.7802
HD99821	3.10025	2457420.062
HIP5721	2.753266	2457119.928
HD587325	3.25670	2458814.0472



Managing astronomical programs



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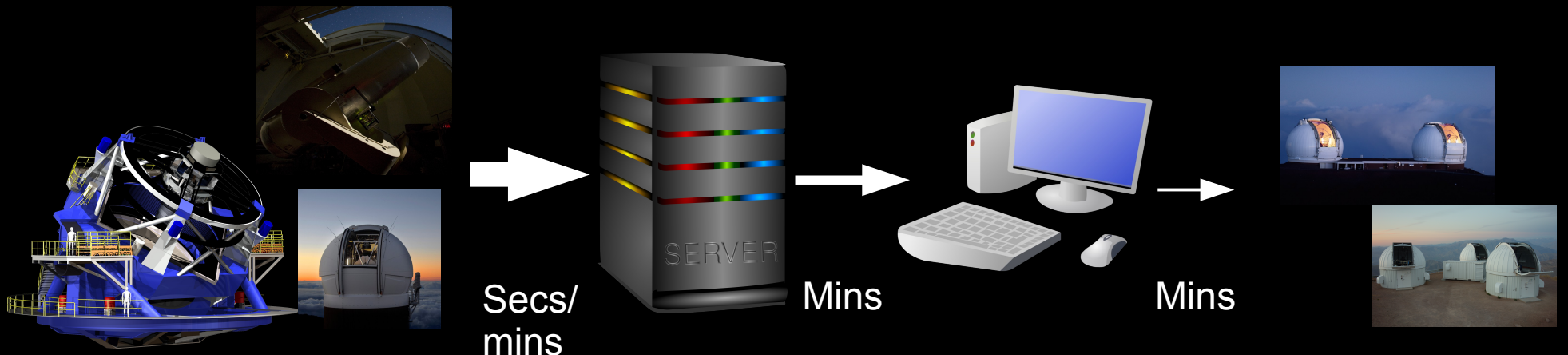
Works well for many programs

But challenging for programs with large or highly dynamic targetlists

Effort to coordinate across many facilities

...doesn't scale well to modern programs



- Extremely large target lists
- May or may not be known in advance
- Rapid alerts open up new science
- Rapidly changing priorities
- Large-scale follow-up for confirmation/characterization
- Large datasets
- Rapid feedback & re-evaluation

A number of science teams have developed tools to handle this

Not a new idea!

"TOM" is just a catch-all name for a genre of systems performing similar functions*

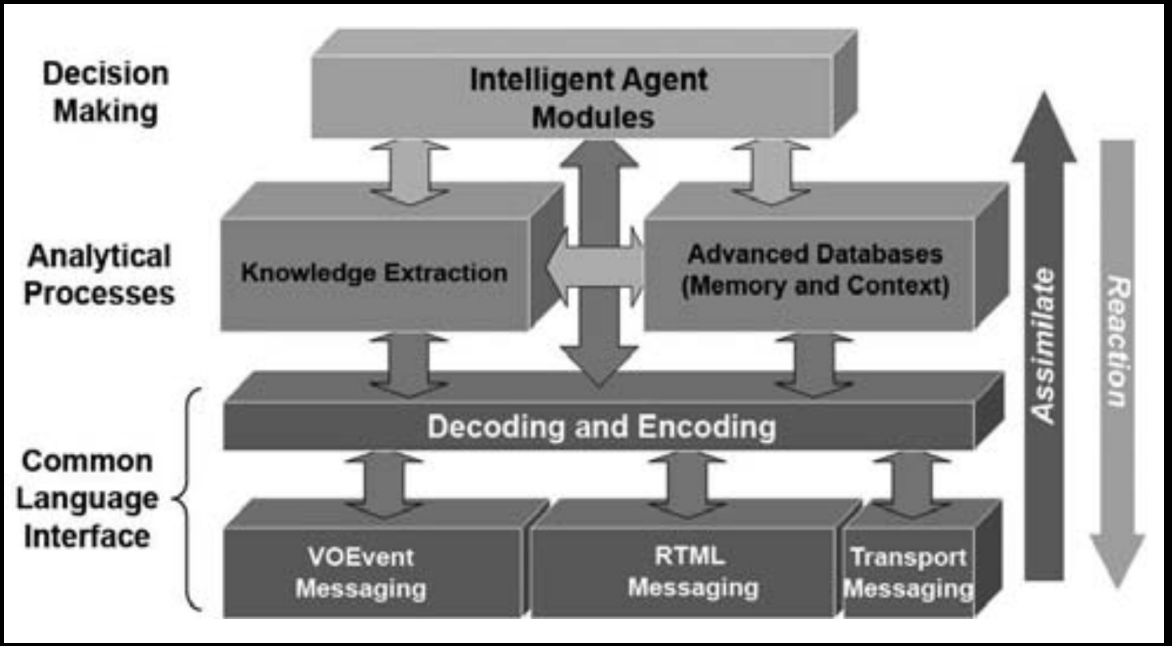
Analogous to role of agents in the Heterogenous Telescope Network model, e.g.

Examples of science teams developing similar systems for ~10-15 years

...almost all customised to purpose

"...agent(s) provide the decision making and overall analysis control...software modules that act as proxy for the scientists..."

White & Allen (2008)

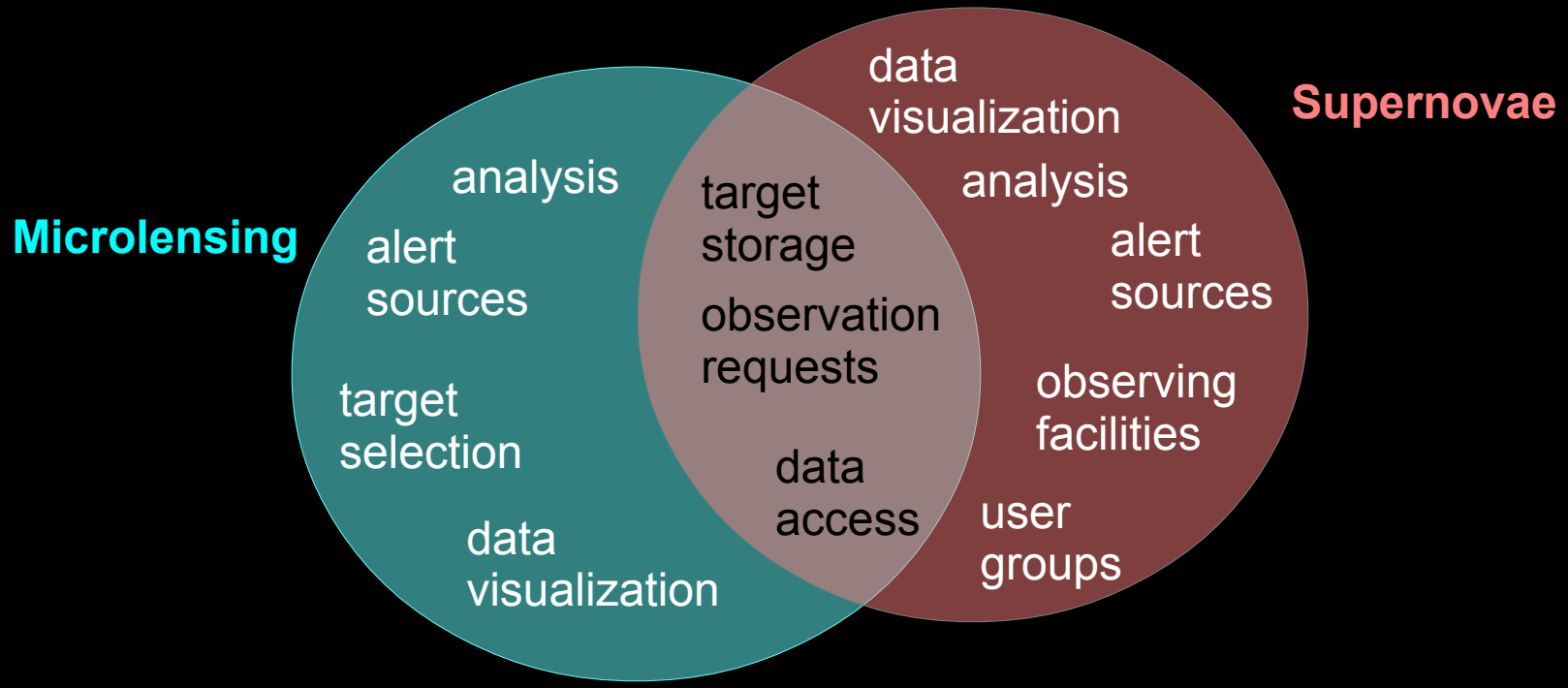


[*Alternative suggestions welcome]

Developing TOM Systems

TOM systems will be an essential component of the observing infrastructure in the LSST era

Many existing TOM-like system have overlapping functionality, but are generally customised to their science case



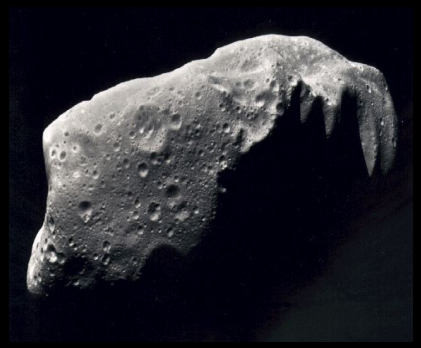
Example Science Use Cases

Supernovae

Spectra, multi-band imaging

ToO alert then Every 1-3d for >month

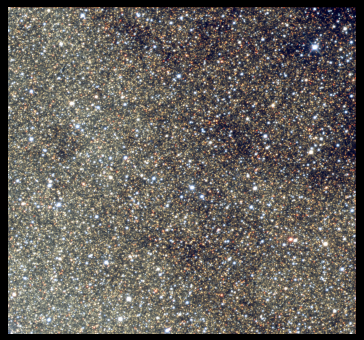
Near-Earth Asteroids



Short timeseries imaging

Rapid-response short (<1hr) series, daily for 1-3d

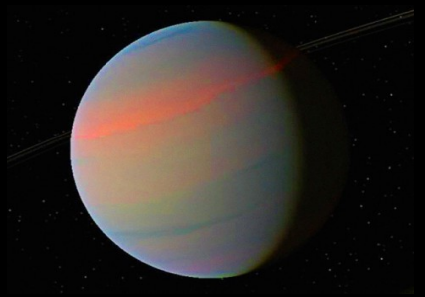
Microlensing



Timeseries imaging

Medium-high cadence continuous monitoring for weeks

Transiting exoplanets



Spectra, imaging

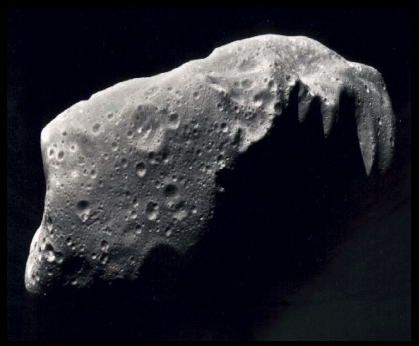
Phase-dependent continuous imaging, spectra monitoring for weeks-years

Current Science Use Cases

Supernovae

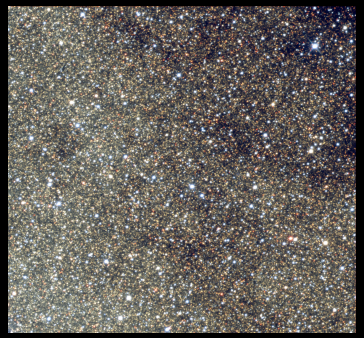
~7000

Near-Earth Asteroids



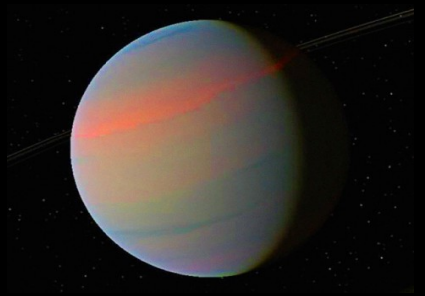
~5400

Microlensing



~2100

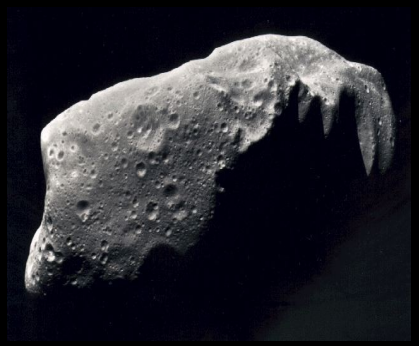
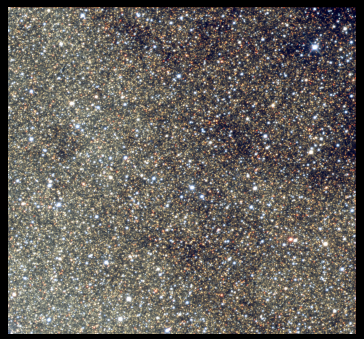
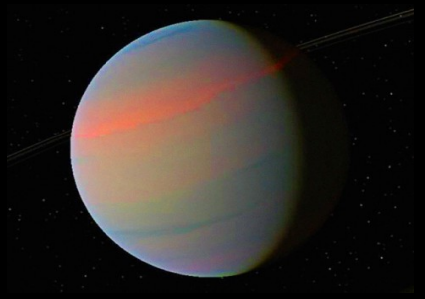
Transiting exoplanets



3486 confirmed
~4500 candidates

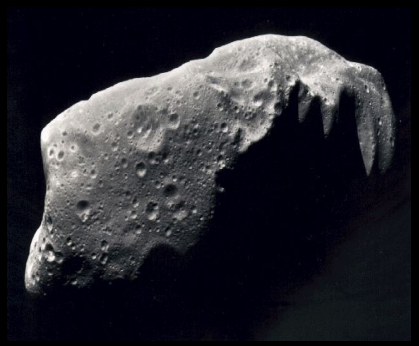
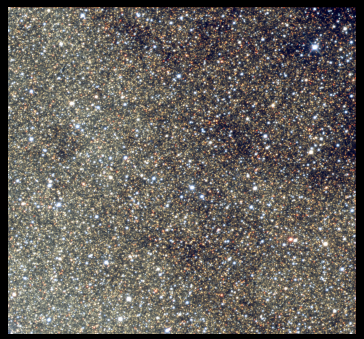
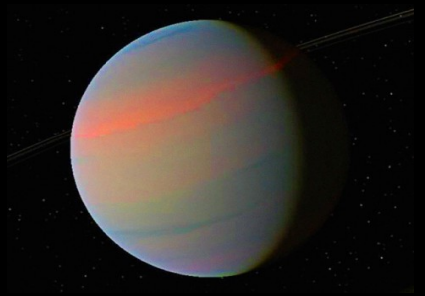
Total targets (per year for transient targets)

Current Science Use Cases

Supernovae	Near-Earth Asteroids	Microlensing	Transiting exoplanets
			
~7000	~5400	~2100	3486 confirmed ~4500 candidates
~20	~100	~8	Lots turn up at once

Total new targets per day

Current Follow-up Programs

Supernovae	Near-Earth Asteroids	Microlensing	Transiting exoplanets
			
~7000/year	~5400/year	~2100/year	3486 confirmed ~4500 candidates
~20/day	~100/day	~8/day	Lots turn up at once
40-60	~10	~10	<10-20

Targets being observed at any one time at LCO

Big surveys will exceed combined follow-up capability

Follow-up in a target-rich era

Already have more targets than programs can follow-up...and getting worse

Observe continuously

- *Need access to filterable target sources (catalog, transient streams)*
- *Need to develop prioritization criteria*

Often need real-time analysis:

- *To select targets*
- *Determine new priorities*
- *Decide future observations*

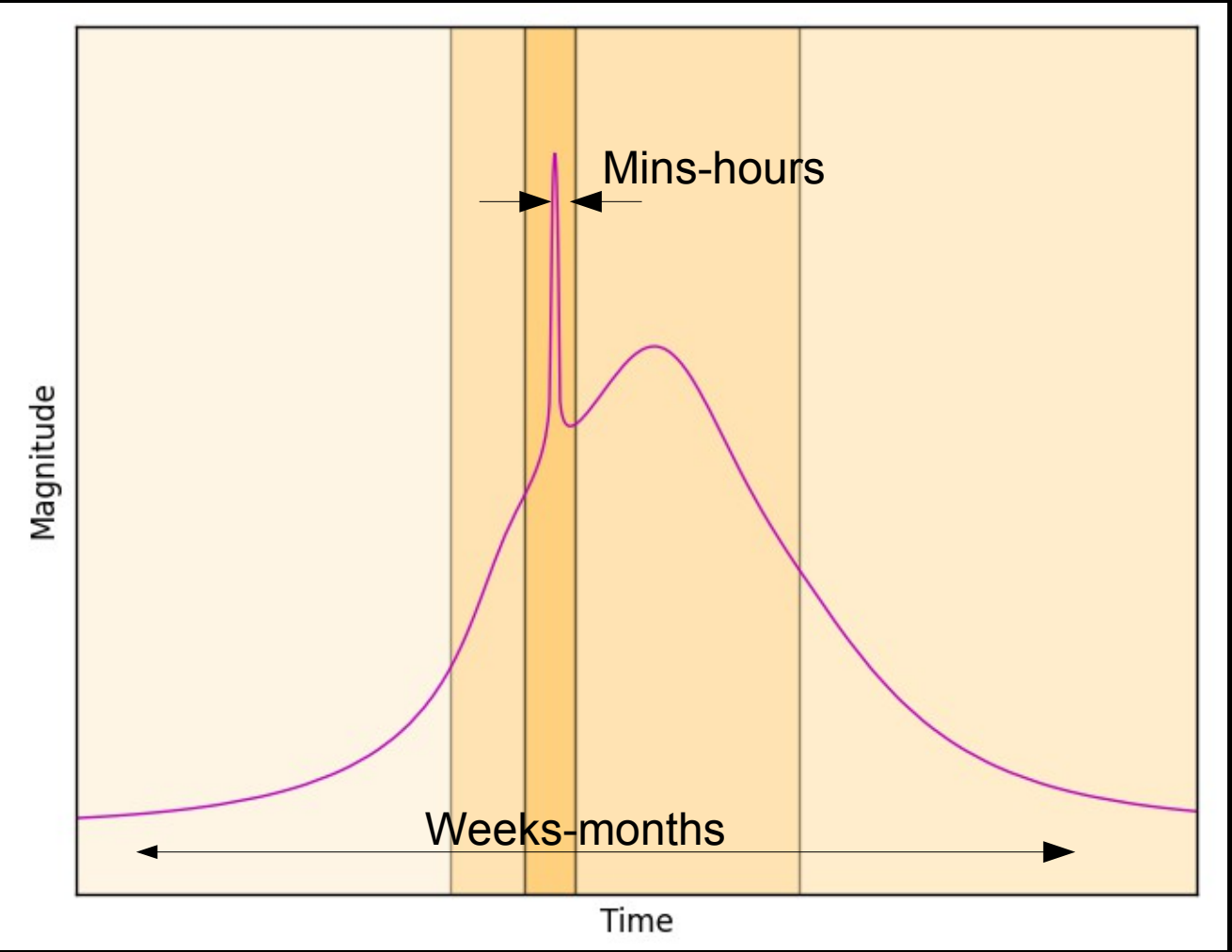
Follow-up is a function of time

Handle many targets in different states simultaneously

- *New alerts*
- *Reconnaissence phase*
- *Intensive phase*
- *Long-term monitoring*

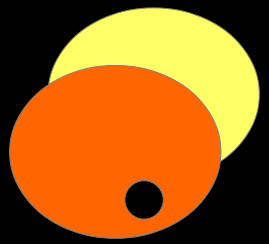
Observe on a range of timescales, cadences, facilities

Follow-up observations often evolve with time and target behavior



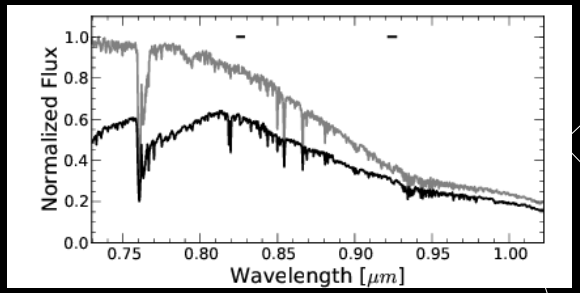
Photometric cadence

Follow-up observations coordinated across a range of facilities

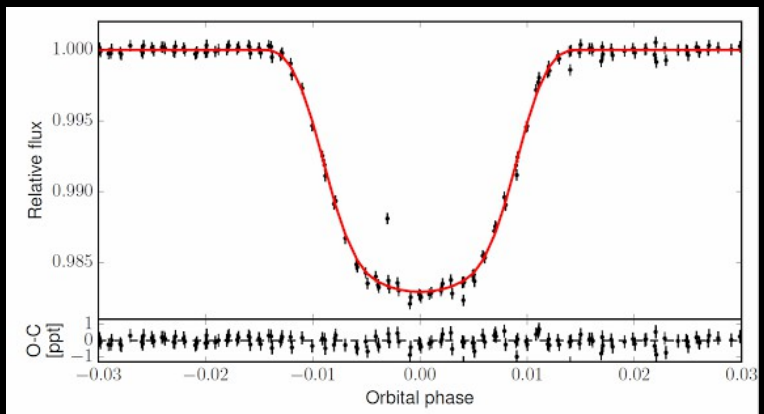


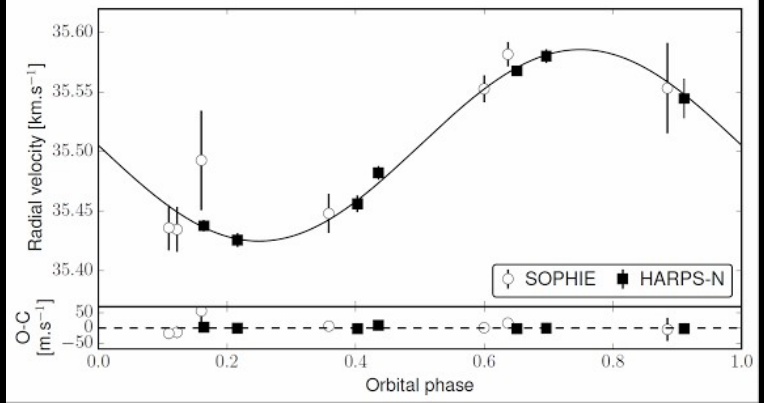
Eliminate double-lined stellar binaries

Reconnaiscence spectrum

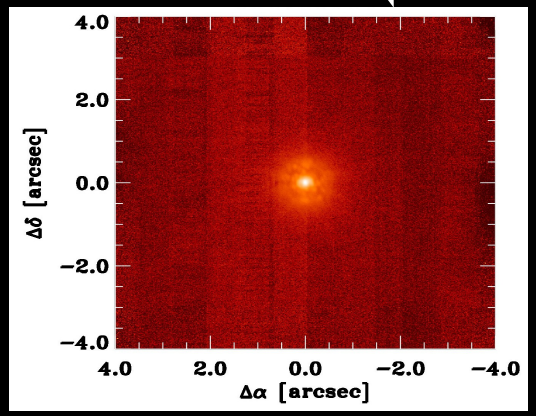


Transit photometry





Radial velocities



AO imaging
By D. Ciardi

From Lillo-Box et al. (2016)

Follow-up Data Rate

Generate thousands of observations and TB of data

E.g. Microlensing Key Project		Per year	Project (3yrs*)
~15,000	Images @ ~90MB each	~1.3 TB	~4TB
	Reduction products	~4 TB	~12 TB
	Discrete observation requests	~900	2,631

**(and we only observe during the northern summer!)*

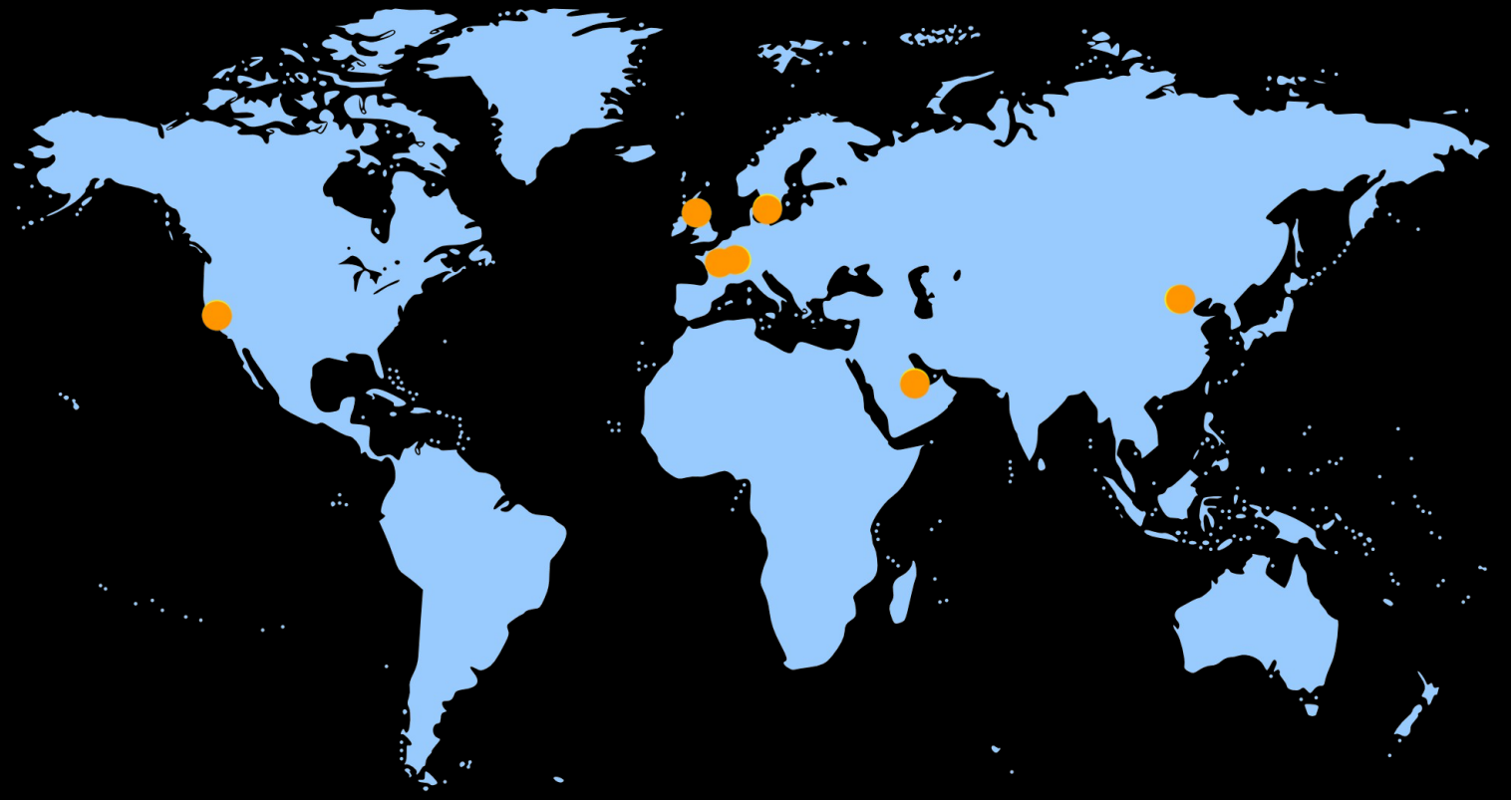
Follow-up Teams

Large collaborations, often international

- but operations/development team usually small

Coordination is important

- geographically-separated team helps, but implies infrastructure needs to facilitiate sharing of data



Keeping track is going to get harder

Current and near-future surveys will generate target catalogs of unprecedented size

Rapid alerts and rapid follow-up increasingly possible and desirable

Managing observations and data is already a major challenge and going to get worse

LSST-era infrastructure needs to address this

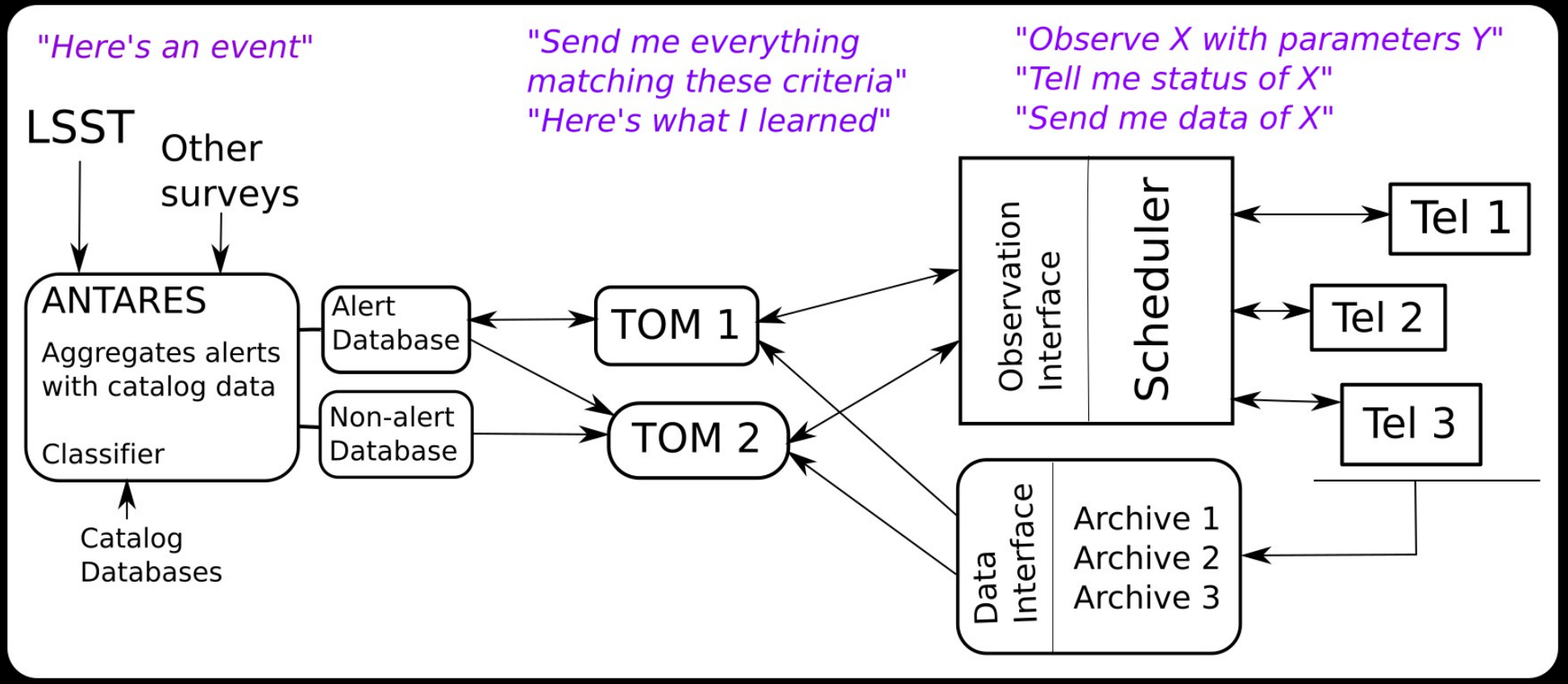
Goals of TOM System

- Coordinate programs where the workload of keeping track of targets, observations and data products would otherwise be onerous

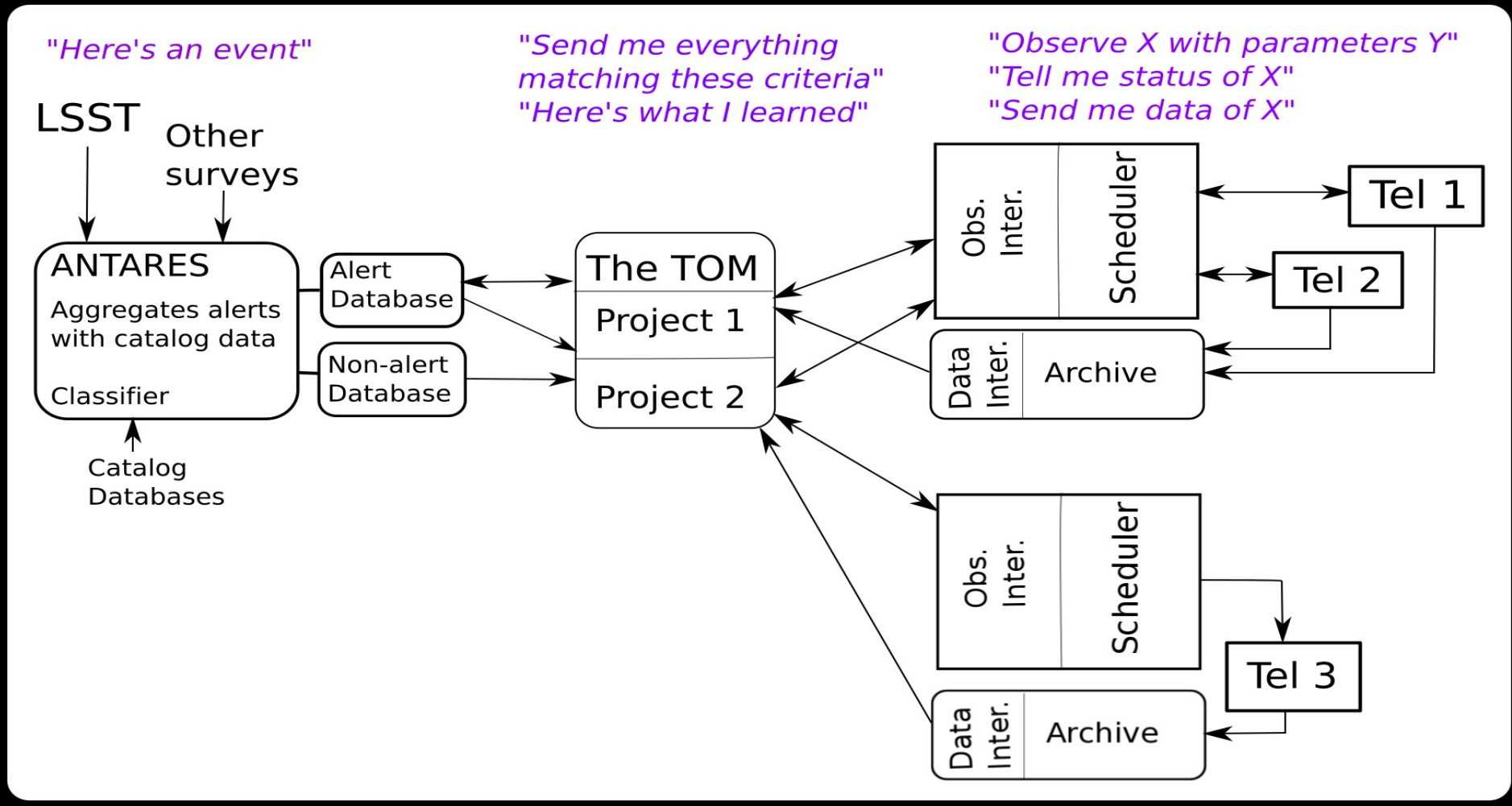
- A framework for science-specific analysis to be conducted

- A framework to interact with external services
  - harvesting alerts, target and catalog information
  - submiting observation requests
  - obtaining feedback from telescope facilities
  - accessing data archives
  - coordinating with other TOMs

Role of a TOM in the Ecosystem



Role of a TOM in the Ecosystem



Questions to consider during the session

- Are there science programs whose workflow or requirements we haven't covered?
- Which sources of targets/alerts should be subscribed to?
- Which observing facilities will scientists need to interface with? On what timescales, and by what mechanisms?
- What data retrieval facilities will they need to interface with?
- Should teams with similar science goals coordinate? If so, how?