



Time domain science issues

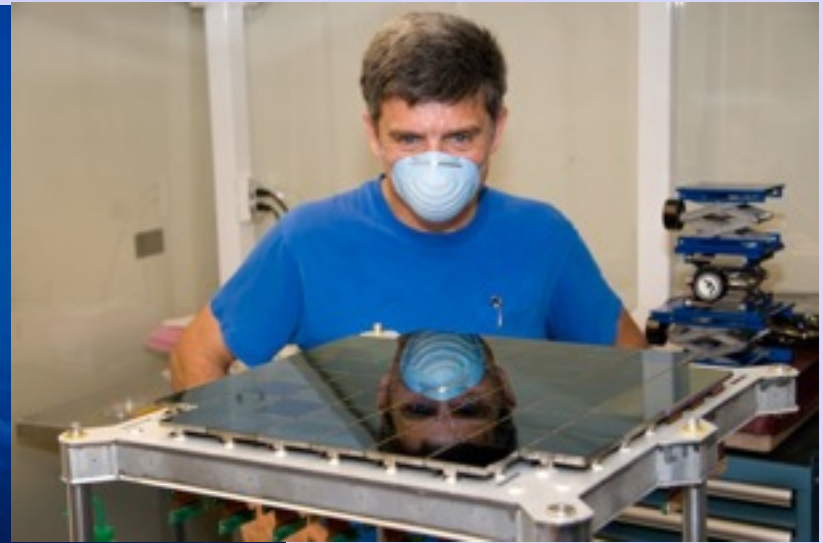
Dec 2015
Andy Lawrence
Trieste

- Science with PanSTARRS
- Transient pipeline
- LSST and the UK DAC
- What breaks?
- Standards landscape



PanSTARRS Science

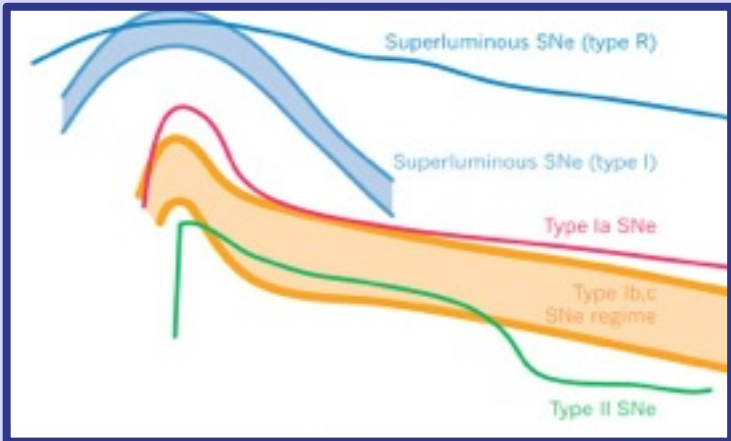
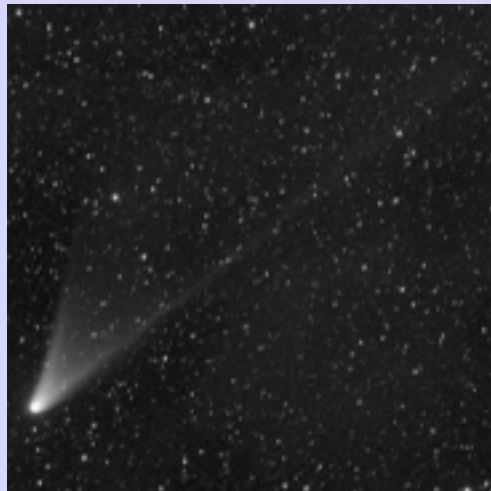
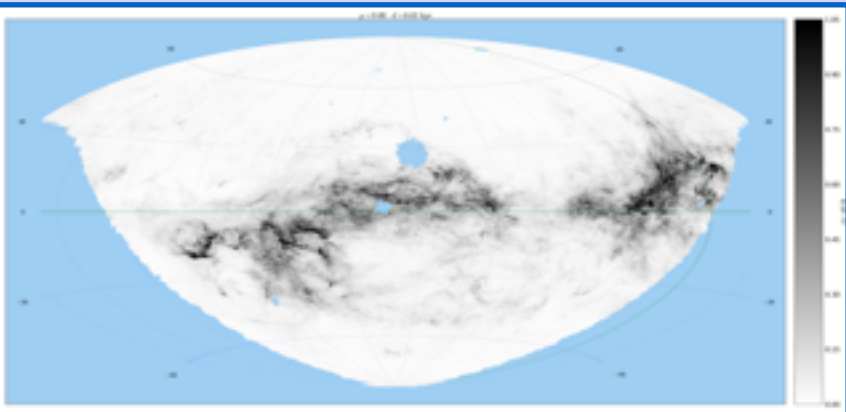
PanSTARRS-1



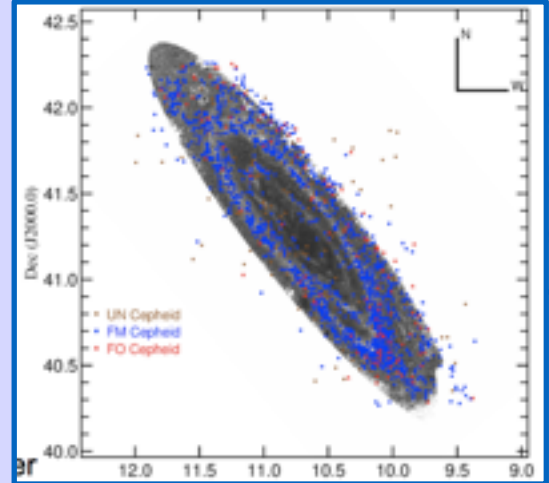
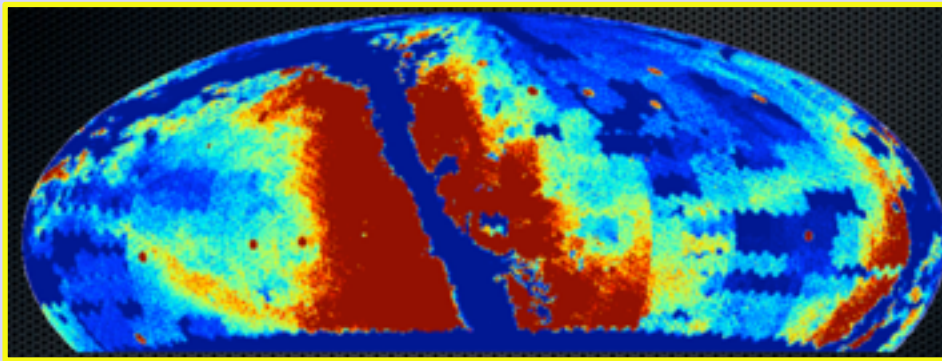
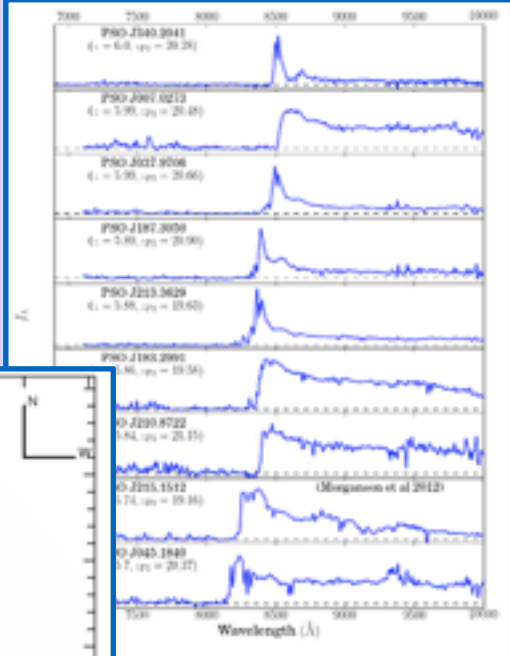
- 1.8m telescope on Haleakala
- Gigapixel camera
- *grizy* filters
- 7 sq.deg. FOV
- Prototype for PS-4
- Built by Univ.Hawaii
- operated by PS1SC
- survey Mar 2011-2014

3π survey:
30,000 sq.deg
4 times/yr/filter

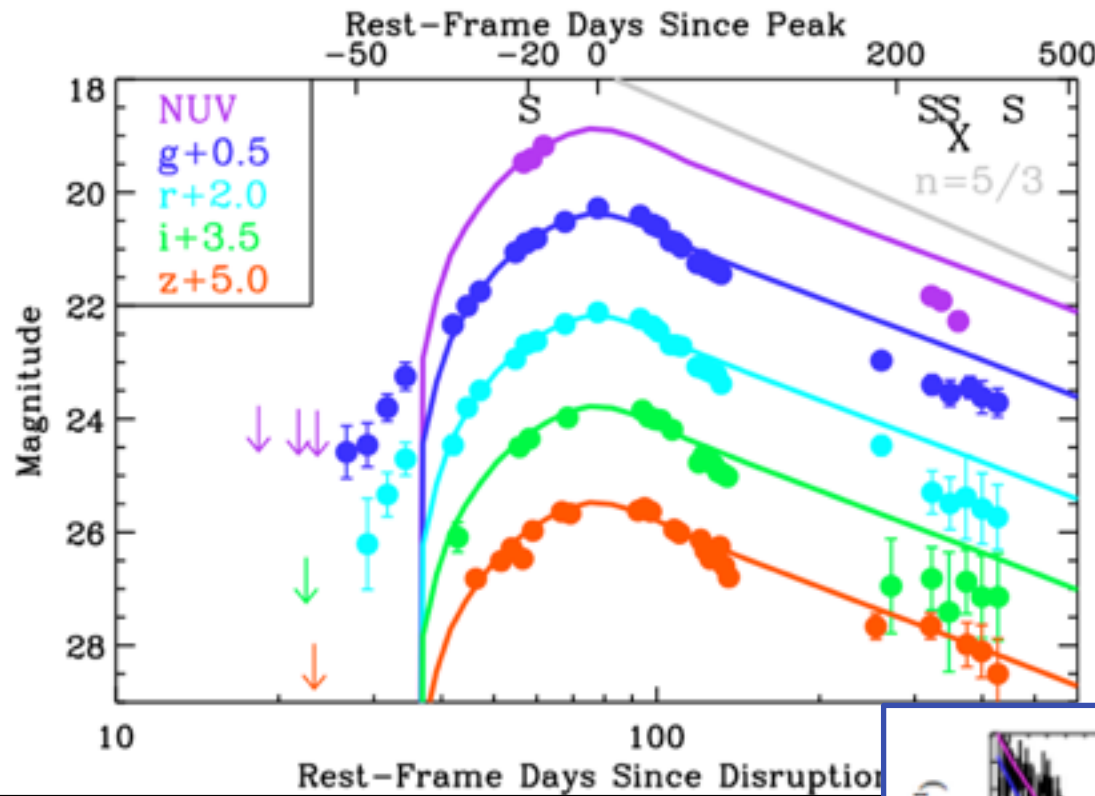
Medium Deep Fields
10 x 7 sq.deg
once every four days



some PS1 science

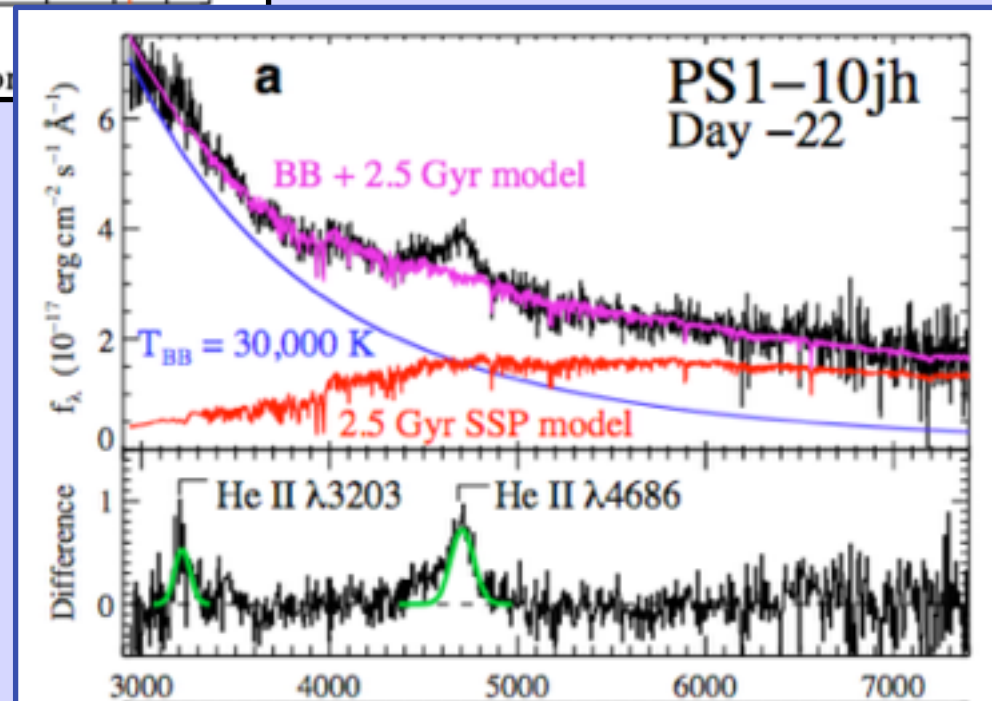


Tidal Disruption Events



Gezari et al 2012

caught *before* peak
 ==> crucial early spectrum
 ==> disruption of Red Giant core

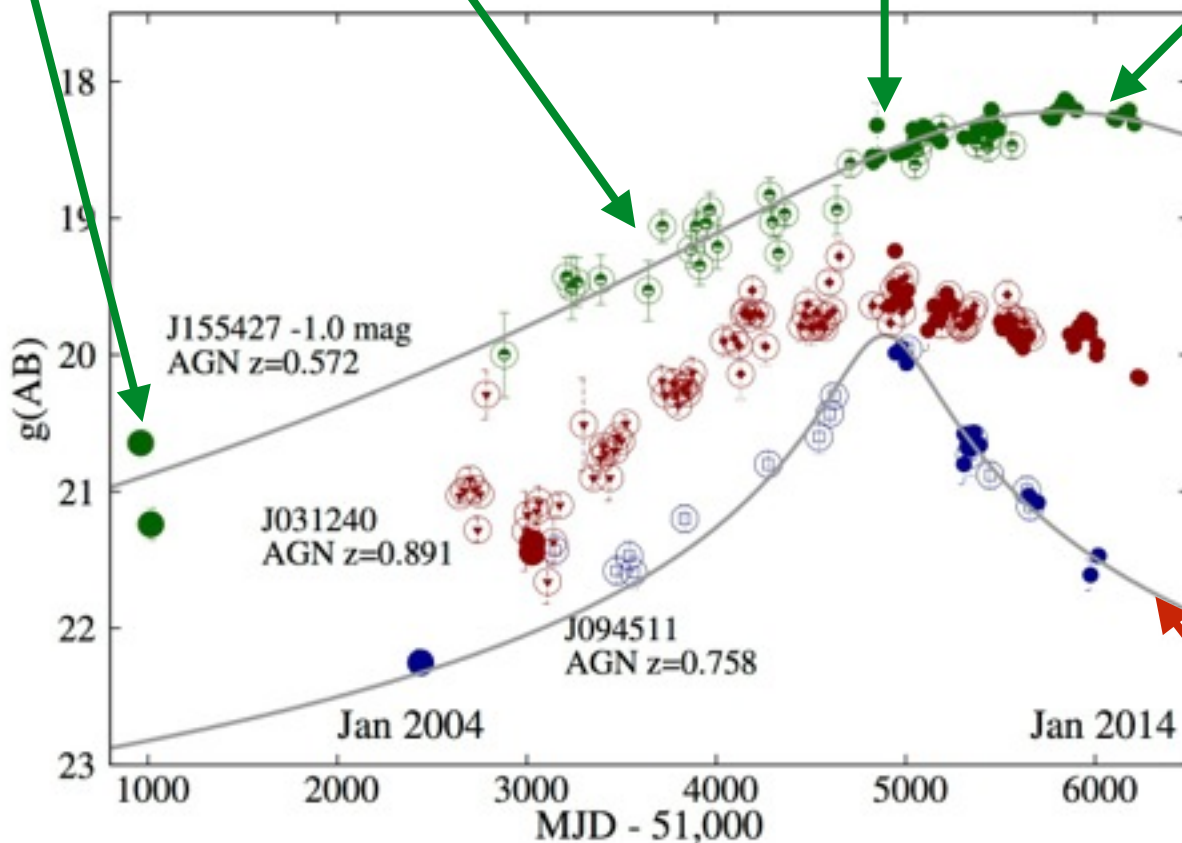


SDSS

CRTS archival
data

PanSTARRS
discovery

Liverpool Telescope
monitoring



smooth fifteen
year outbursts

- triggered by PS1
- followed with LT
- archival CRTS 1/c

Lawrence et al 2015

slow AGN hypervariables

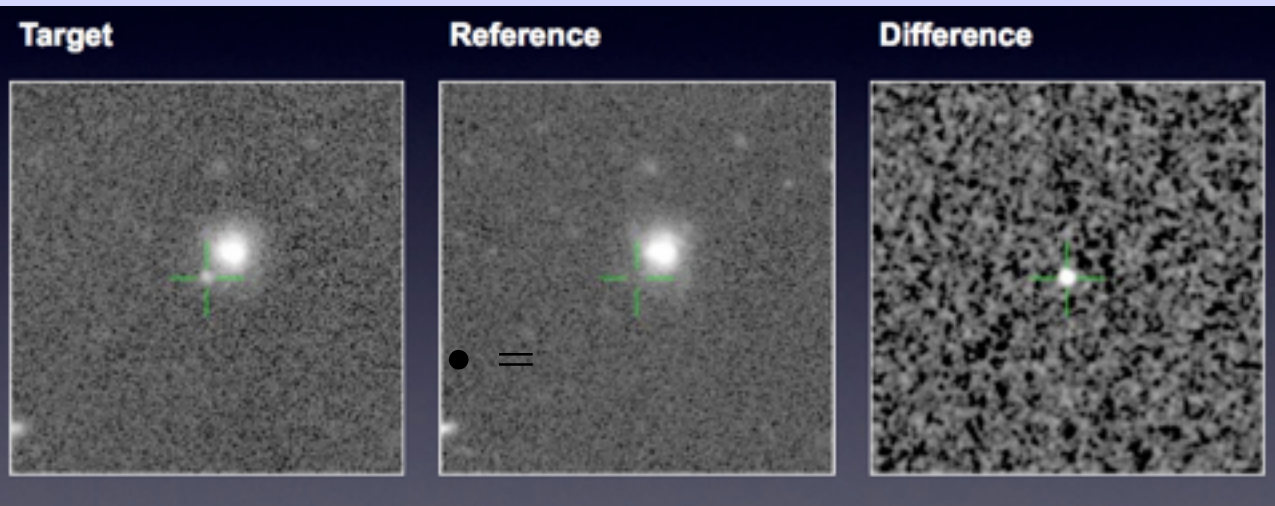
microlensing
model fits

A circular astronomical image showing a dense field of galaxies. The galaxies are primarily brown and orange, with some showing blue and green highlights, possibly indicating star formation or specific spectral features. A prominent, bright, greenish-white galaxy is visible in the lower center. A yellow rectangular box with a blue border is centered over the image, containing the text "Transient pipeline".

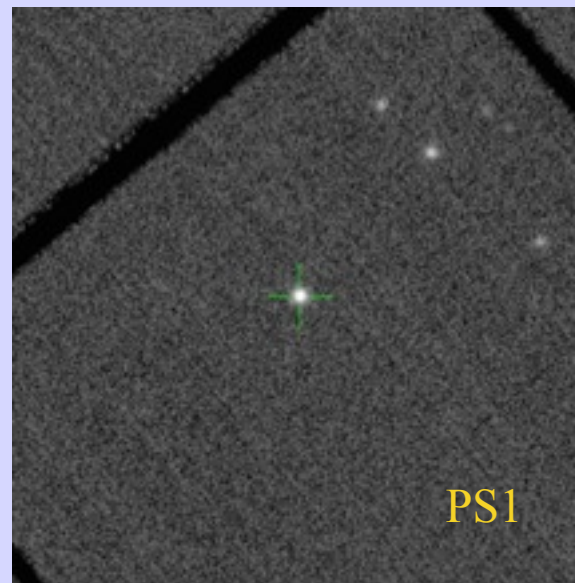
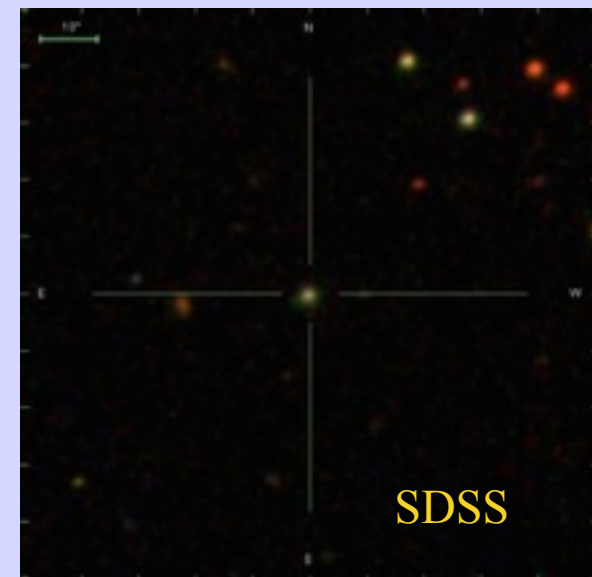
Transient pipeline

Transient detection

Maui pipeline
==> Belfast transient system



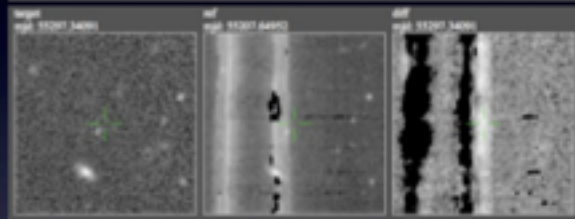
Difference imaging
internal to PS1



catalogue
comparison to SDSS



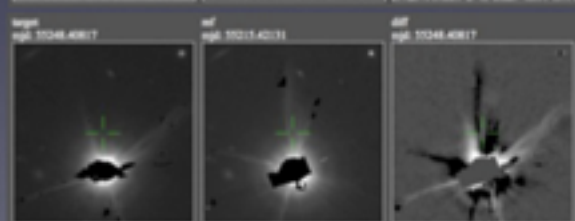
Bad Subtraction Kernel Parameters



Bad Template



Bad Registration - Dipoles



Bright Star artifacts

Weeding

In ten month period :

- Produced by pipeline : several million
- Passing automated filtering : 30,716
- Passing eyeball examination : 3,277
- "Good" candidates : 1,807
- Confirmed SNe : 109

Good Candidates
(809)

Rank	Survey	Local Field	Local designation	PUL designation	RA	DEC	Machine Classification	Mag. Date	Revised Type	Current brand	Earliest mjd	Earliest mag	Earliest filter	Latest mjd	Latest mag	Latest filter	Catalogue	Nearest Object	Redshift (km/sec)	RR Factor	Palomar Crossmatch
37246	PGSS	3K37qj	PGS-13emp	23:26:33.51	+47:52:49.0	an	Box, T_1 , 2011	50662	59708	20.12	z	50620	19933	19.03	z		SDSS Stars & Galaxies (stars), $r = 16.60$, $g = 17.81$		0.12		
37164	PGSS	3K37qj	PGS-13temp	23:26:34.88	+47:58:30.5	unclassified	Box, T_1	50212	24734	16.08	z	50000	20000	16.11	g		SDSS Stars & Galaxies (stars), $r = 16.30$		0.08		

home confirmed **good** possible attic eyeball garbage custom

PS1-12hy

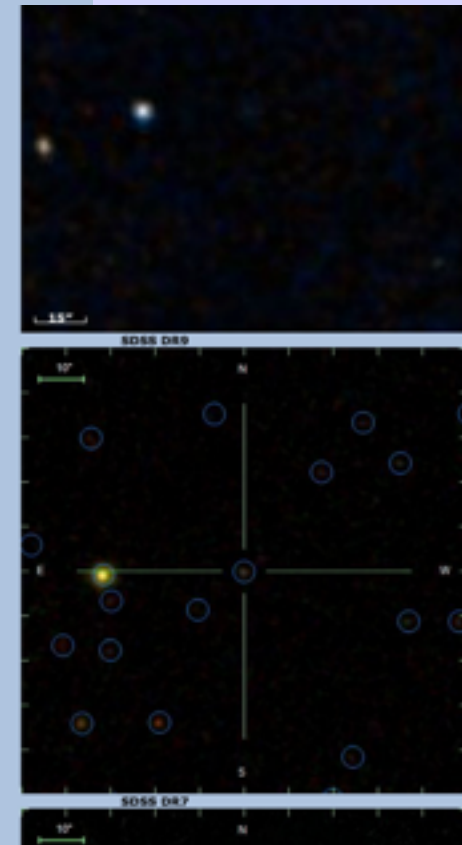
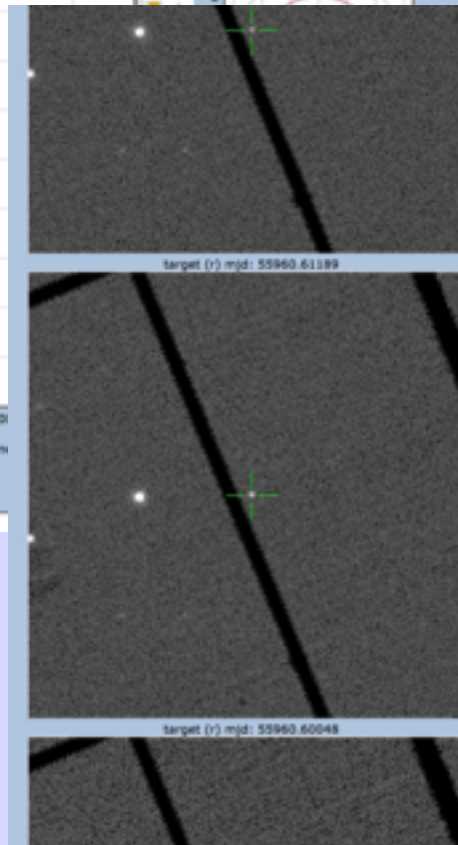
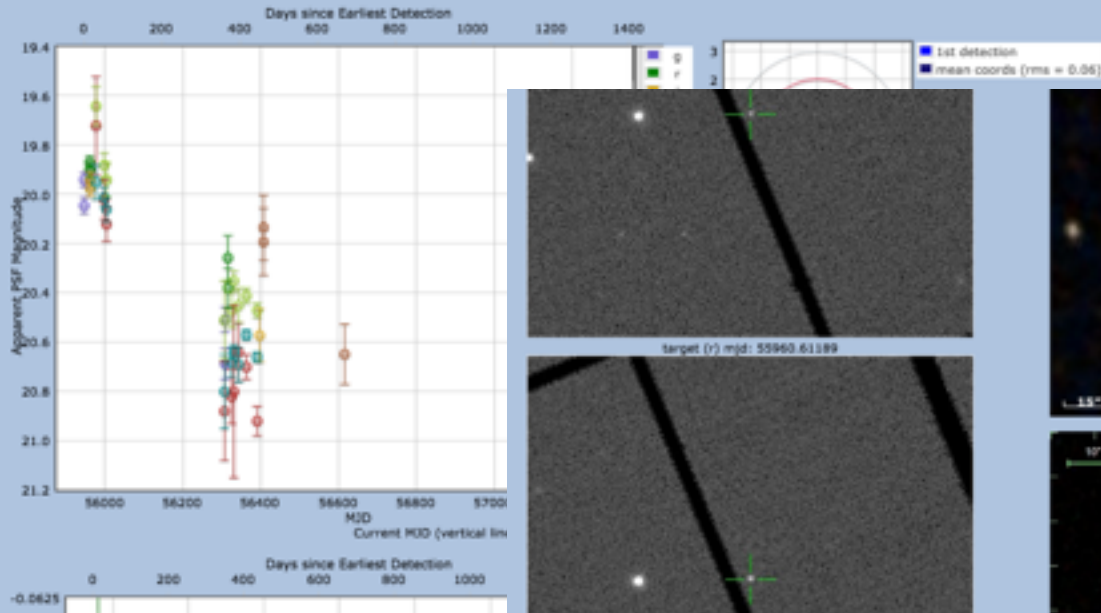
09:45:11.08 +17:45:44.7

Local Name: 283Feds
Flag Date: Feb. 7, 2012
Survey: FCSN
Processing Flag: locationmap

PSI Name: PSI-11hy
Number of Detections: 14
Object List: good
Spectral Type:

Internal Followup ID: 842
Internal ID: 1094511081174544800
Contextual Classification: #E
Crossmatch: [check here](#)

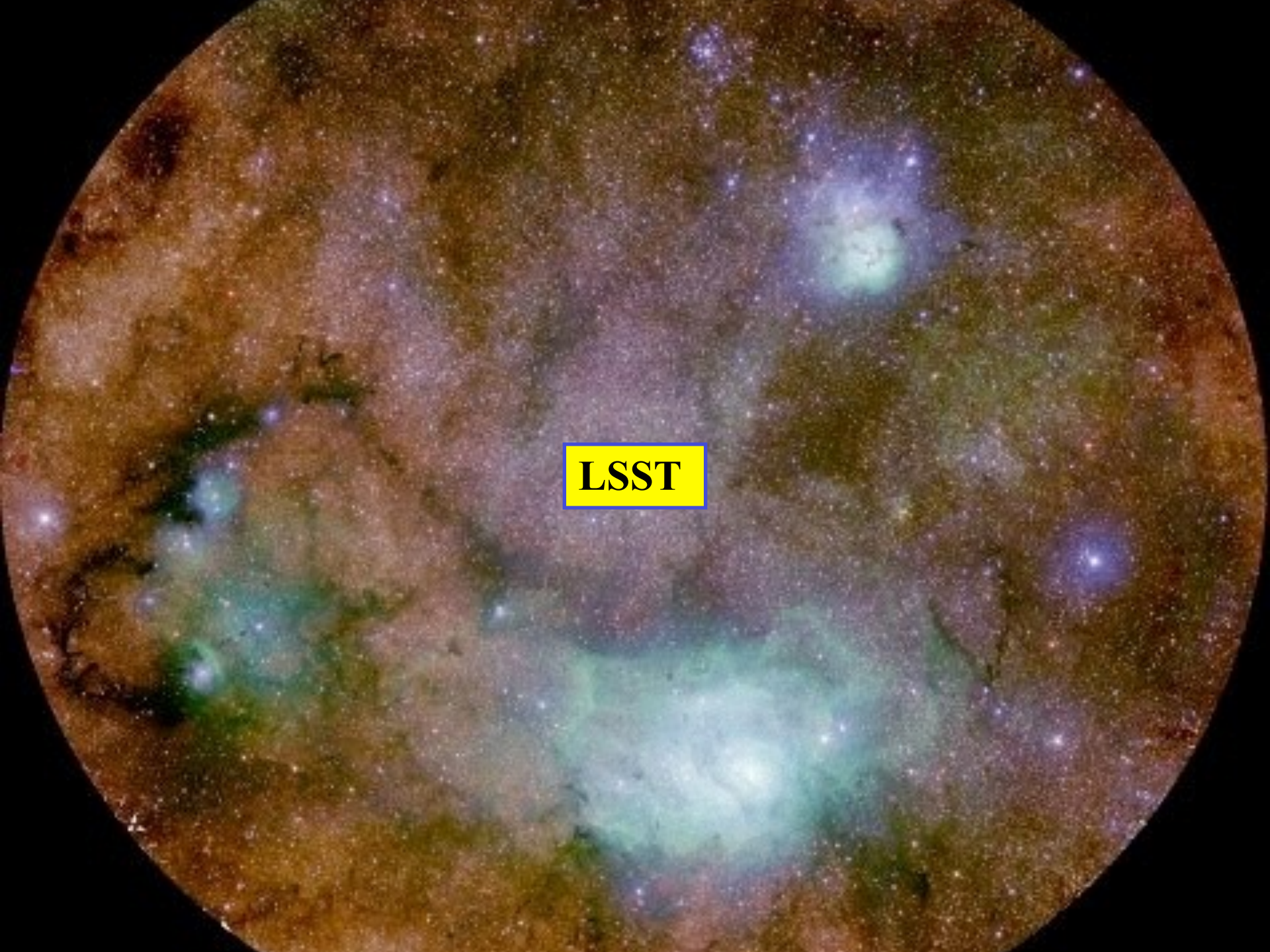
Comments: CRTS report as AGN: CSS111231:094511+174545



user
presentation

via dynamic web pages

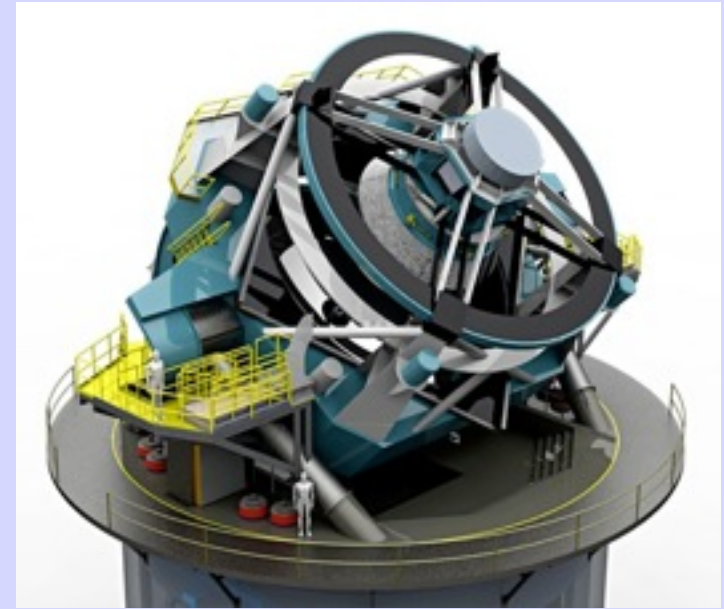
mixture of automated and manual selection



LSST

LSST basics

- US project*
- $D=8.4\text{m} / 6.5\text{m}$ effective
- $\text{FOV} = 10 \text{ sq.deg.}$
- u g r i z y
- Cerro Pachon
- Ten year programme
- Capital cost \$665M
- Operations \$37M/yr

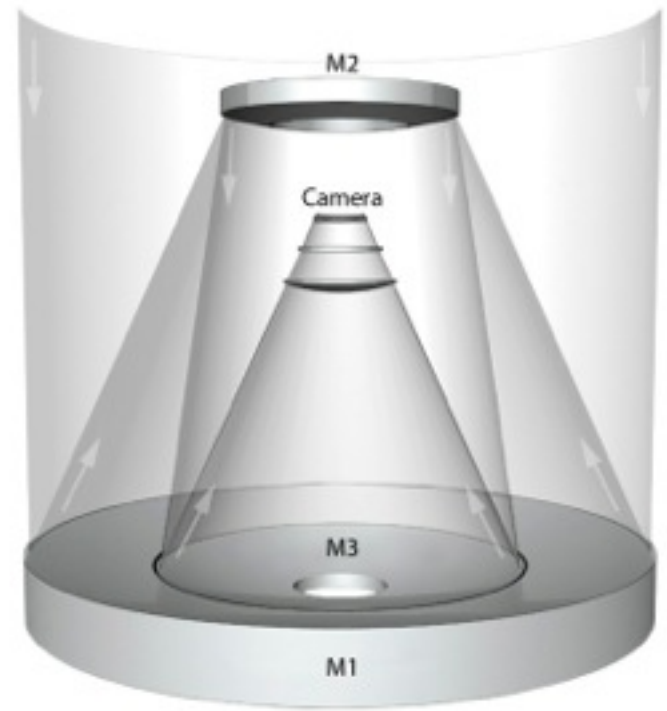


*a movie of the sky
with an 8m-class
telescope*

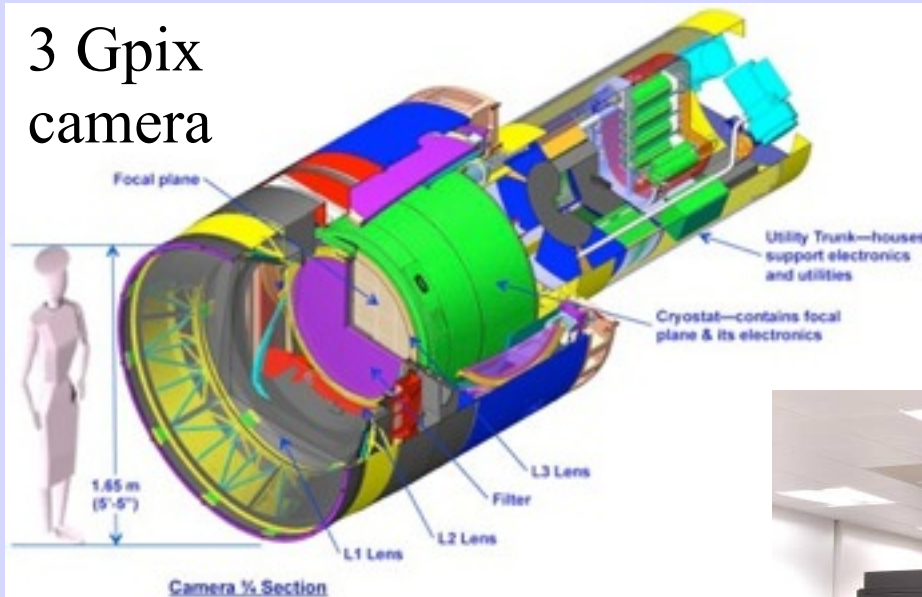
* but adding partners!

key features

3-mirror design
for wide field



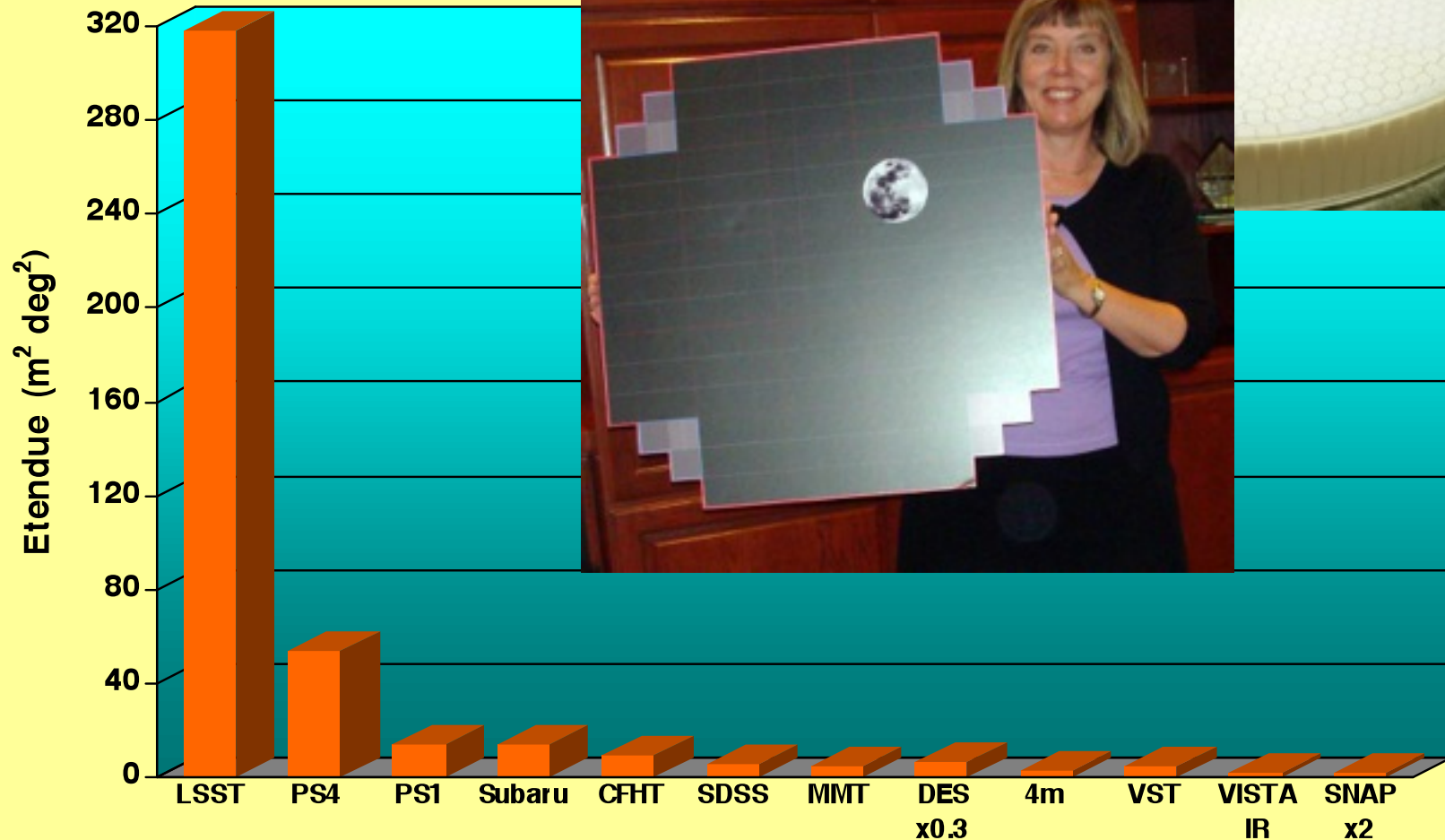
3 Gpix
camera



serious
approach to
data processing
and user tools



large mirror
+ large detector
means large grasp



Science impact

- 10^{10} stars, 10^{10} galaxies
- Photo zs for 3×10^9 galaxies
- 250,000 SNe/yr
- Orbits for 10^5 NEOs and 10^5 Trojans
- Gaia-quality PMs – 4 mags deeper
- Light curves for 2×10^6 low-z quasars
- 1000 quasars with $6.5 < z < 7.5$
- ...etc etc etc...
- plus The Transient Unknown

survey plan

Deep-Wide Survey : 18,000 sq. deg
pair of 15 sec exposures
repeat within hour
repeat within a few days
825 visits over ten years

g=24 night
g=27.5 final

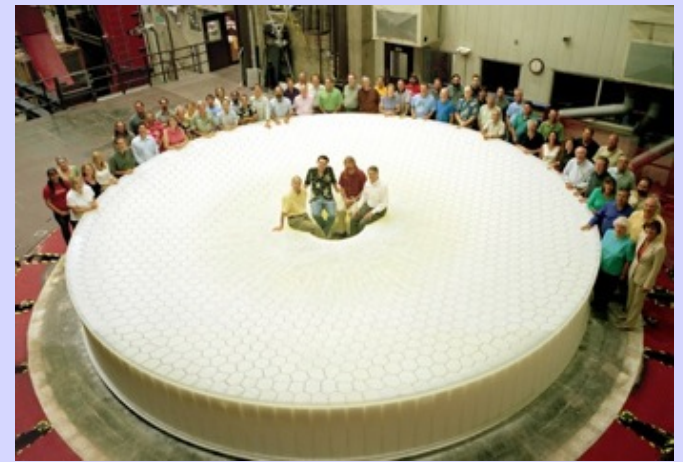
a million alerts/night
released within 60sec

Special regions + deep drilling fields
10% of time

status

M1/M3 and M2 cast
Camera construction started
Site levelled
construction underway

2014-19 construction
2020-21 commissioning
2022-32 operations



LSST partners

Project looking for 30% of ops costs from partners

Many individual institutions paid to join

France national member (through IN2P3) for many years

- collaborating on camera
- second Archive Centre in Lyons

UK on point of signing MOA

UK in LSST

UK LSST Consortium

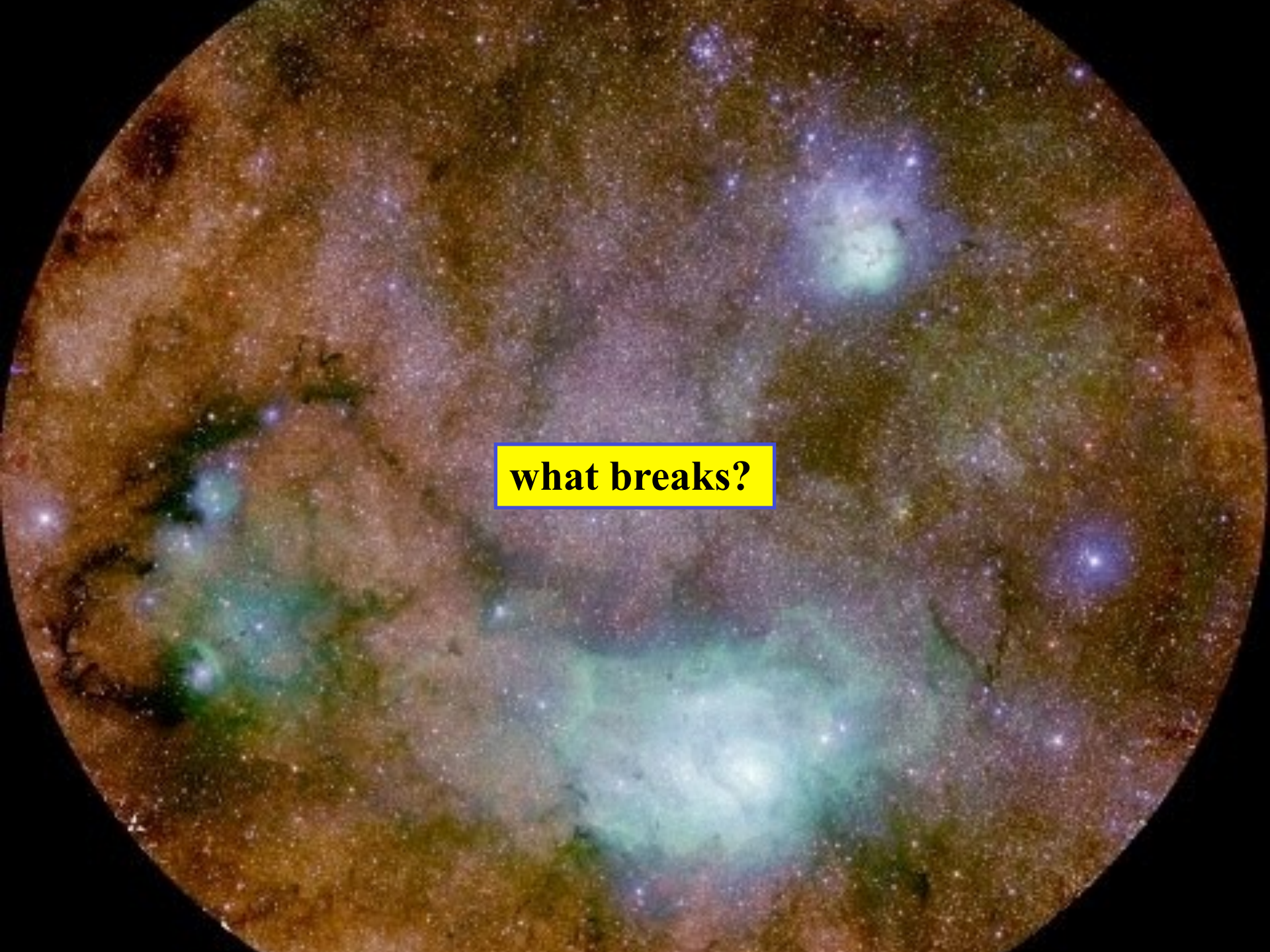
- 33 institutions
- funded by STFC

MOA on point of signing

- but still have to name 100 PIs

UK will build a second Data Access Centre in Edinburgh

- to 1st approx: clone of US-DAC
- to 2nd approx: tuned to UK requirements
- works with consortium astronomers to make L3 s/w
- e.g. weak lensing pipeline; transient server



what breaks?

What increases with LSST, SKA, Gravy

Event rate

Response speed

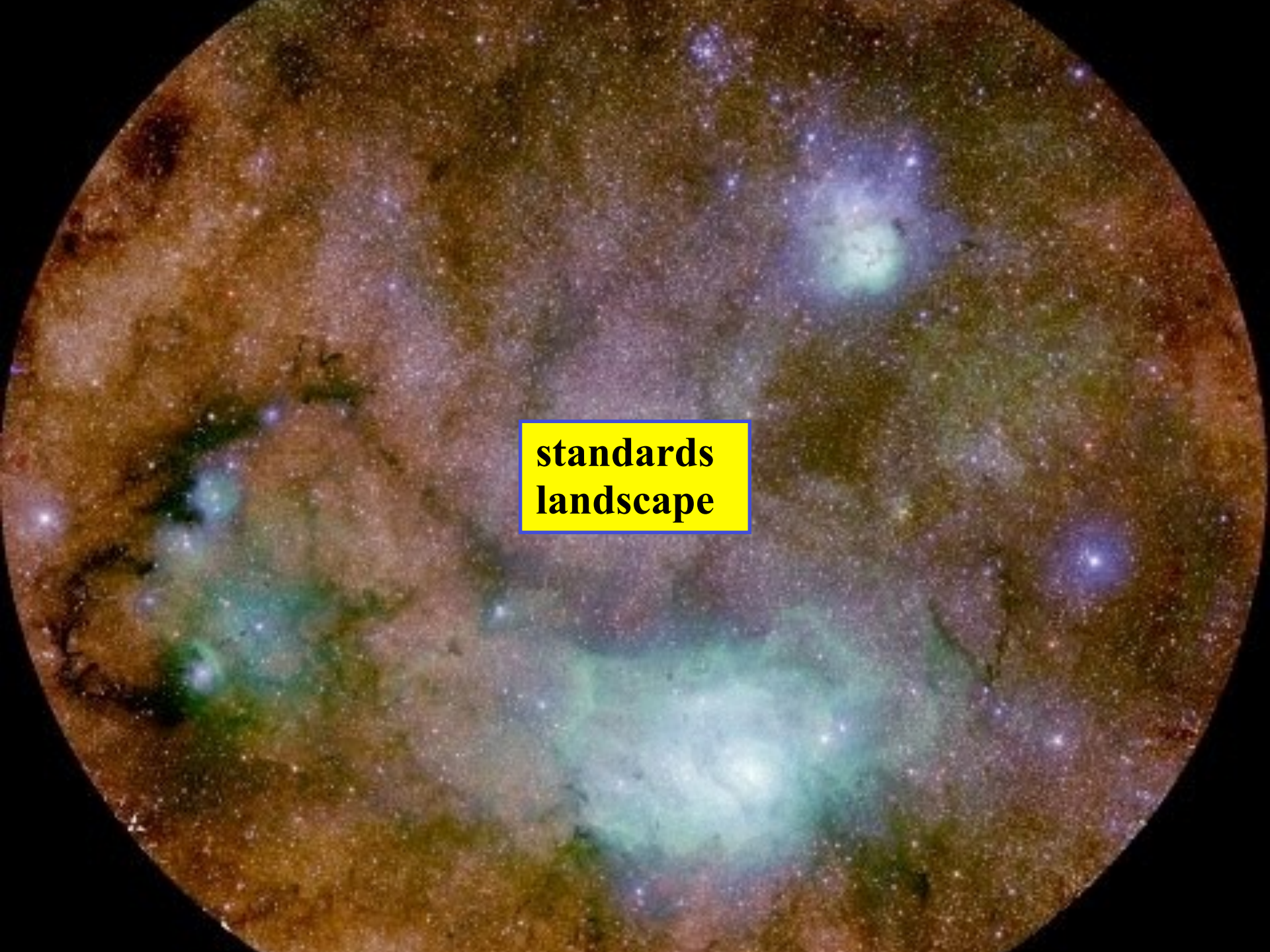
Multiple facility follow-up

PS1 habits that break

Semi-automated junk filtering

Semi-automated event selection

Manual feed-through to follow-up



**standards
landscape**

Events

VO Event

VTP

VO Event Registry Extension

VOEvent

version, ivorn,
role = test, observation,
prediction, utility

Who
What
WhereWhen
How
Why
Citations
D, R

WhereWhen

longitude, latitude, positionalError,
time, timeError
*observatory, coord_system **
** equivalent information*

How

D, R

VOEvent2 in a Nutshell

Who

AuthorIVORN or
Author

title, shortName, logoURL,
contactName, contactEmail,
contactPhone, contributor

Date
D, R

Why

importance, expires
Name
Concept
Inference
probability, relation
Name, Concept, D, R
D, R

Citations

EventIVORN
cite = followup,
supersedes, retraction
D

What

Param
name, unit, UCD,
dataType, utype, value
Value, D, R

Group
name, type
Param, D, R

Table
name, type
Param, Field, Data, D, R

Field
name, unit, UCD,
dataType, utype, value
D, R

Data
TR
TD
D, R

Reference

uri, meaning, mimetype

Description

Elements in black
Attributes in green
D = Description
R = Reference

VO Event Issues

verification
discoverability
speed
tools
XML verbosity

GCN version

```
TRIGGER_NUM = 114299 RATE_SIGNIF = 20.49 GRB_INTEN = 73288
```

VOTable version

```
<Param name="TRIGGER_NUM" value="114299" ucd="meta.id" />  
  <Param name="RATE_SIGNIF" value="20.49" ucd="stat.snr" dataType="float">  
    <Description>Best significance after trying all algorithms</Description>  
    <Reference uri="http://gcn.gsfc.nasa.gov/swift.html"/>  
  </Param>  
  <Param name="GRB_INTEN" value="73288" ucd="phot.count" dataType="int"/>
```

Time Series

standards

no data model or transfer protocol yet

- adapt SSAP?
- make new DM/TP?

*interim “Simple Time Series”
used by a few providers*

use cases

what do we actually *need*?

tools

do we need light curve
analysis tools?

```

<?xml version="1.0" encoding="UTF-8"?>
<SimpleTimeSeries xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://dotastro.org/simpletimeseries http://dotastro.org/simpletimeseries/simpletimeseries.xsd"
  xmlns="http://dotastro.org/simpletimeseries">

  <DESCRIPTION>
    Minimal SimpleTimeSeries Example
  </DESCRIPTION>

  <TIMESYS>
    <TimeType ucd="time;pos.frame;pos.heliocentric" unit="day">hjd</TimeType>
    <TimeZero ucd="time.epoch;arith.zp" unit="day">0</TimeZero>
    <!-- describe the progress of the time axis -->
    <TimeUnits ucd='time.epoch' datatype='float' unit='day' />
    <TimeWidthDefault ucd="time.period" unit="seconds">10.0</TimeWidthDefault>
    <TimeSystem ucd="frame.time.scale">UTC</TimeSystem>
  </TIMESYS>

  <BAND ucd="instr.filter;em.opt" bandid="I" description="This is the Johnson-Cousins I-band">I</BAND>
  <BAND ucd="instr.filter;em.opt" bandid="V">V</BAND>

  <FIELD fld="imag" bandid="I" ucd="opt;phot;i" datatype="float" unit="mag">I-band photometry</FIELD>
  <FIELD fld="vmag" bandid="V" ucd="opt;phot;v" datatype="float" unit="mag">V-band photometry</FIELD>

  <SERIES>
    <ELEM>
      <TIME><T>2448919.8</T></TIME>
      <MAG fld="imag"><VAL>17.535</VAL><ERR>0.03</ERR></MAG>
      <MAG fld="vmag"><VAL>17.327</VAL><ERR>0.03</ERR></MAG></ELEM>
    <ELEM>
      <TIME>2448920.72</T>
      <MAG fld="vmag"><VAL>17.37</VAL><ERR>0.036</ERR></MAG></ELEM>
    <ELEM>
      <TIME><T>2448922.82</T></TIME>
      <MAG fld="imag"><VAL>17.697</VAL></MAG>
      <MAG fld="vmag"><VAL>17.424</VAL></MAG></ELEM>
    </SERIES>
  </SimpleTimeSeries>

```

STS

HOW STANDARDS PROLIFERATE:

(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC.)

SITUATION:
THERE ARE
14 COMPETING
STANDARDS.

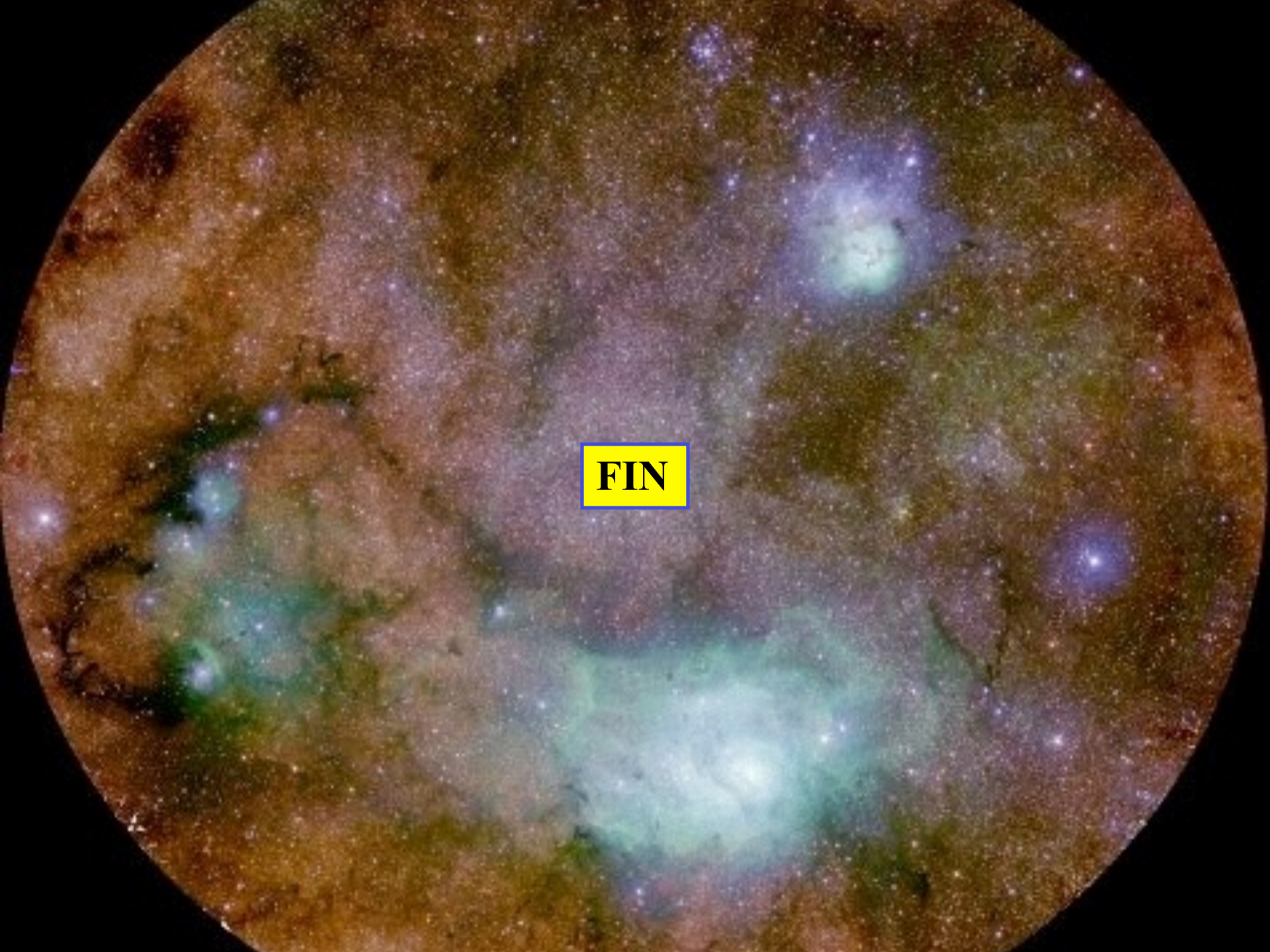
14?! RIDICULOUS!
WE NEED TO DEVELOP
ONE UNIVERSAL STANDARD
THAT COVERS EVERYONE'S
USE CASES.



YEAH!

SOON:

SITUATION:
THERE ARE
15 COMPETING
STANDARDS.



FIN

