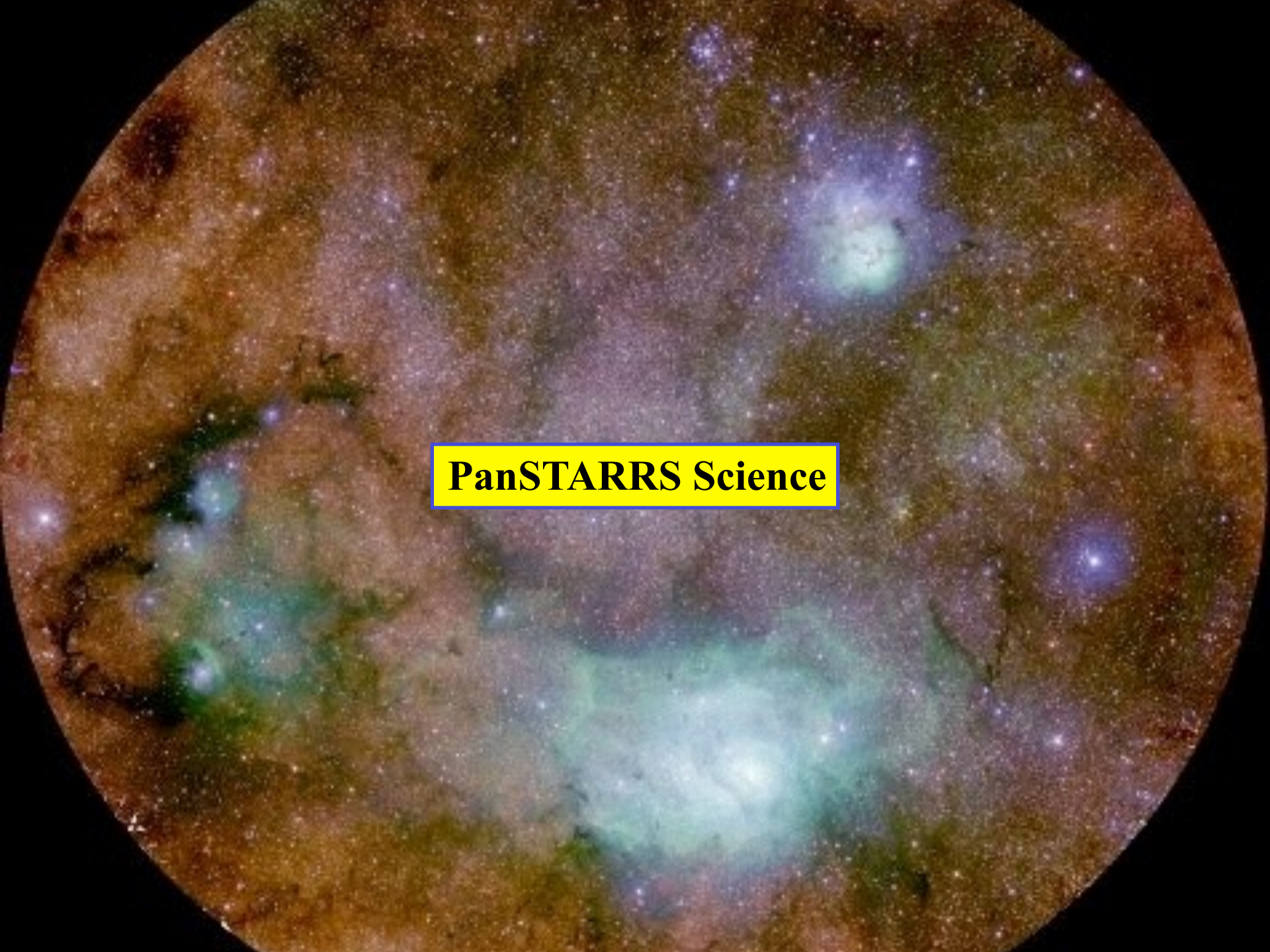
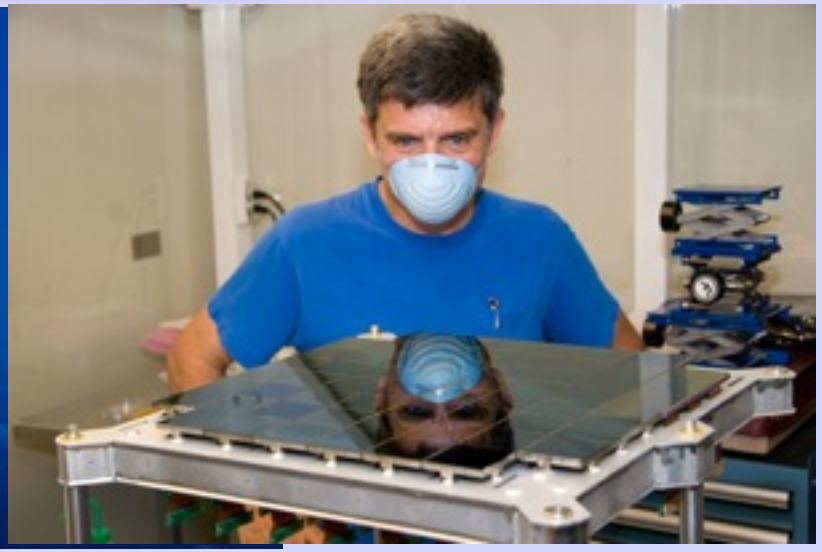
Time domain science issues

Dec 2015
Andy Lawrence
Trieste

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


PanSTARRS Science

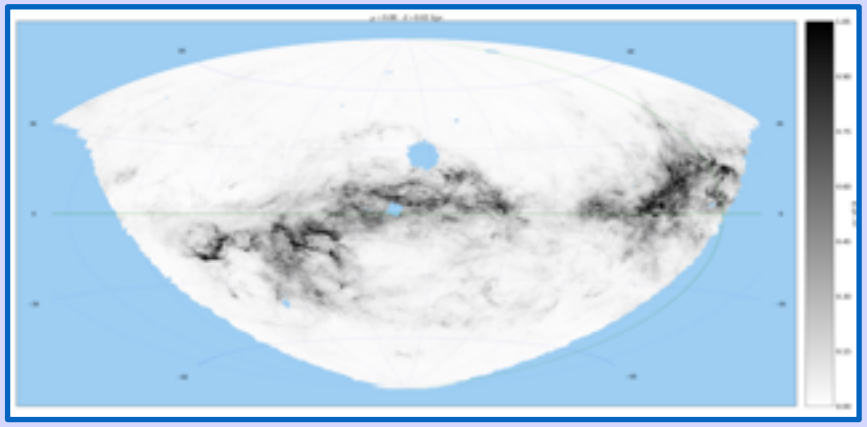
PanSTARRS-1

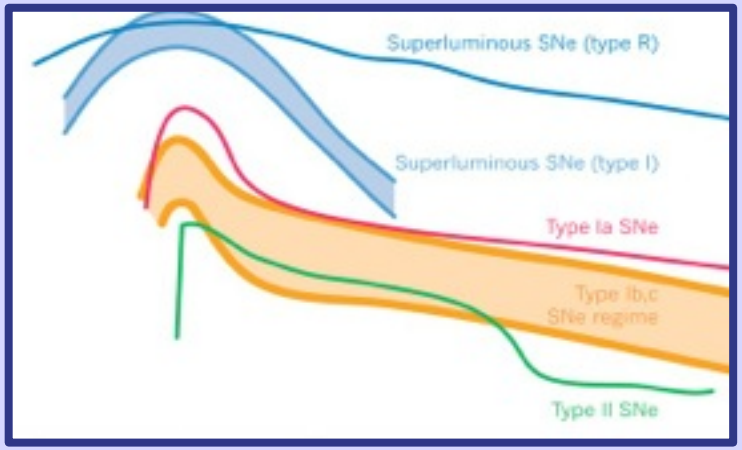


- 1.8m telescope on Haleakala
- Gigapixel camera
- *grizy* filters
- 7 sq.deg. FOV
- Prototype for PS-4
- Built by Univ.Hawaii
- operated by PS1SC
- survey Mar 2011-2014

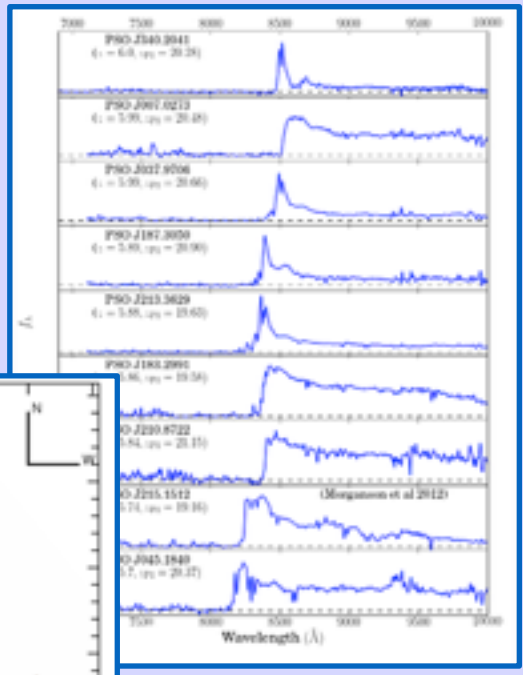
3π survey:
30,000 sq.deg
4 times/yr/filter

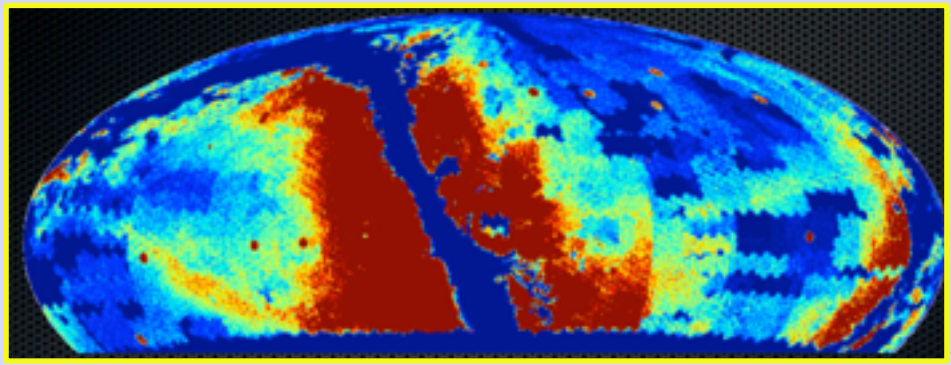
Medium Deep Fields
10 x 7 sq.deg
once every four days

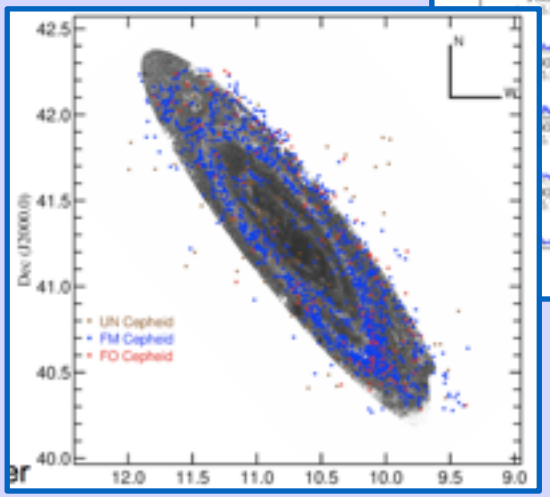




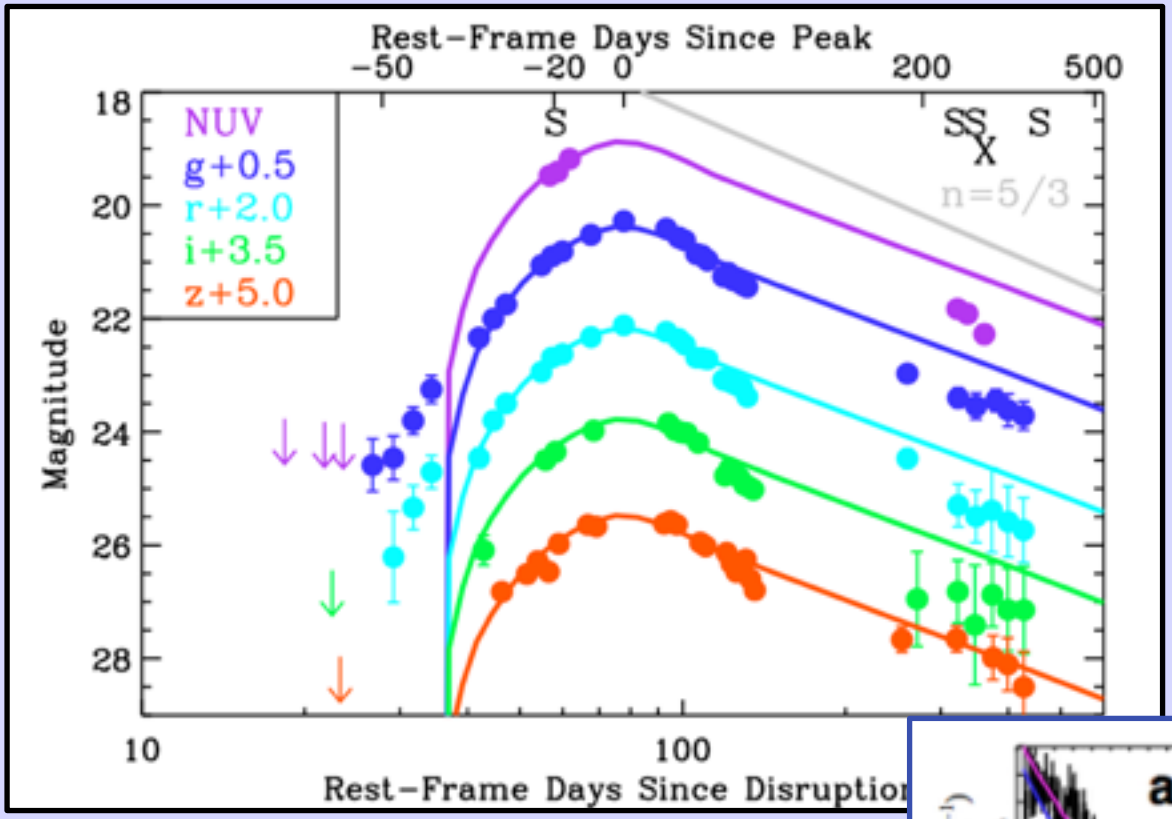
some PS1 science





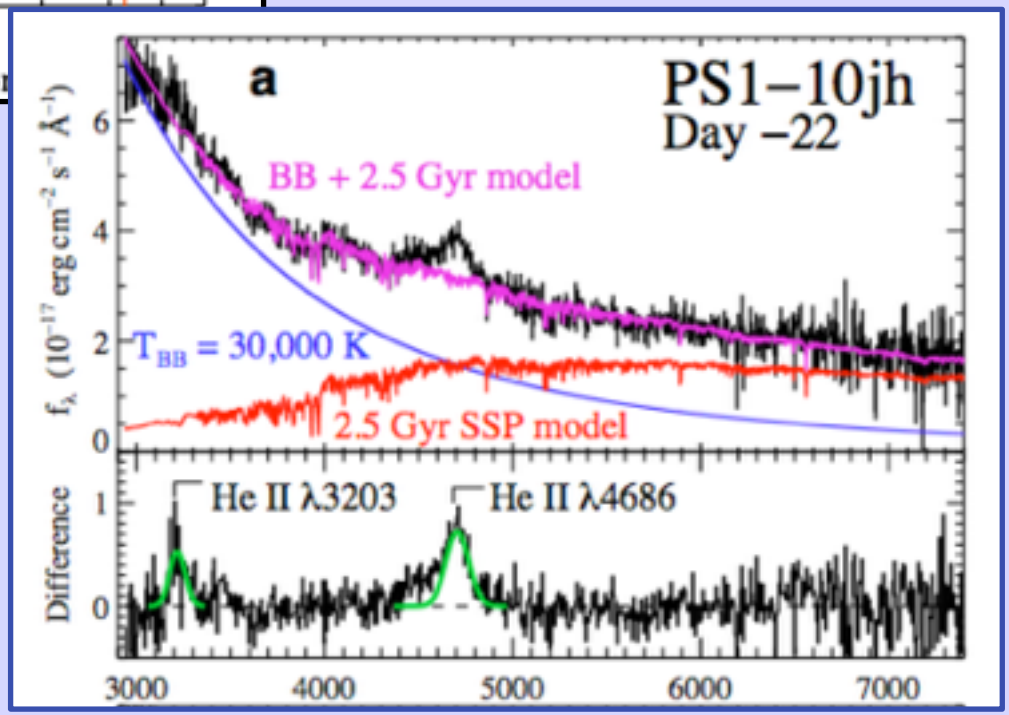


Tidal Disruption Events



Gezari et al 2012

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

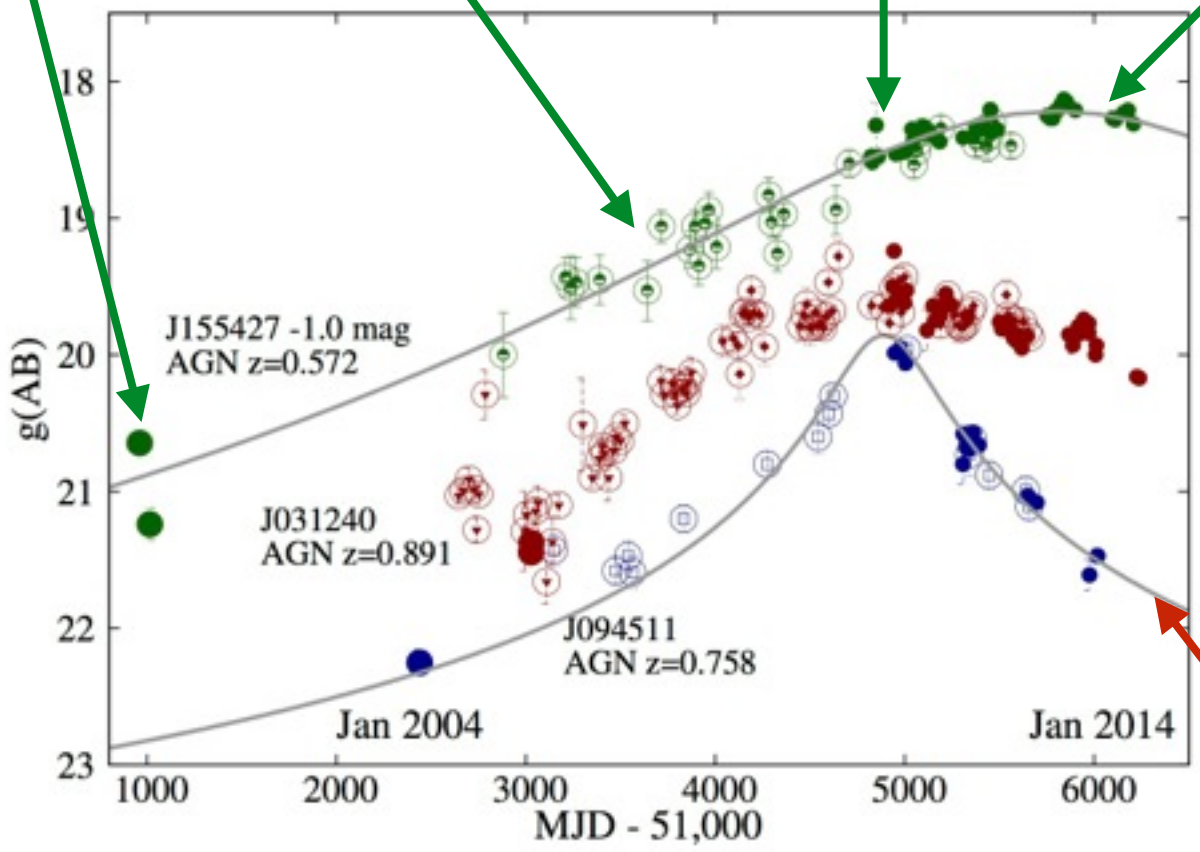


SDSS

CRTS archival data

PanSTARRS discovery

Liverpool Telescope monitoring



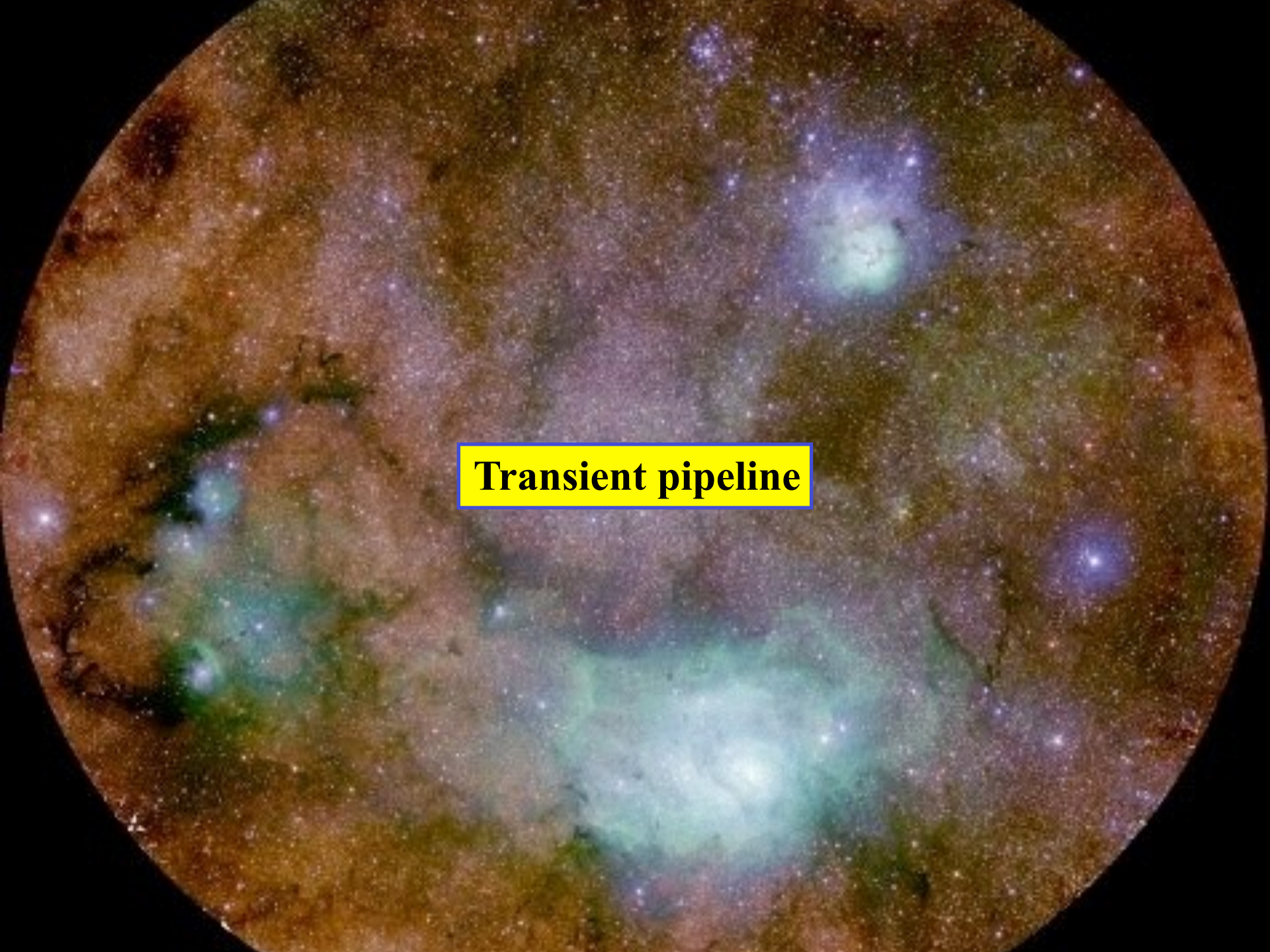
Lawrence et al 2015

smooth fifteen year outbursts

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

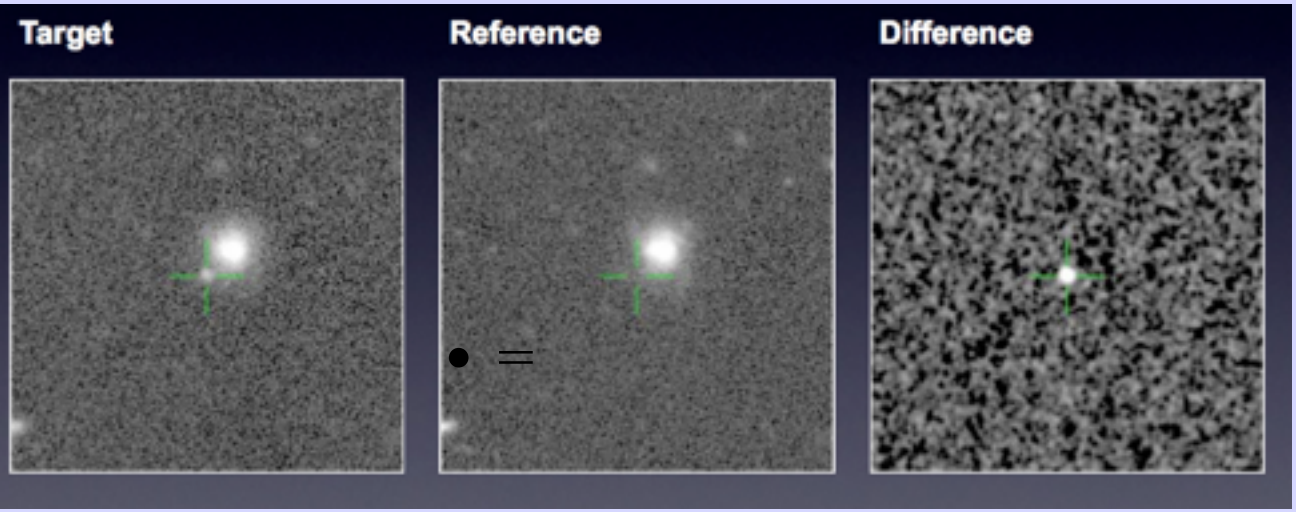
microlensing model fits

slow AGN hypervariables

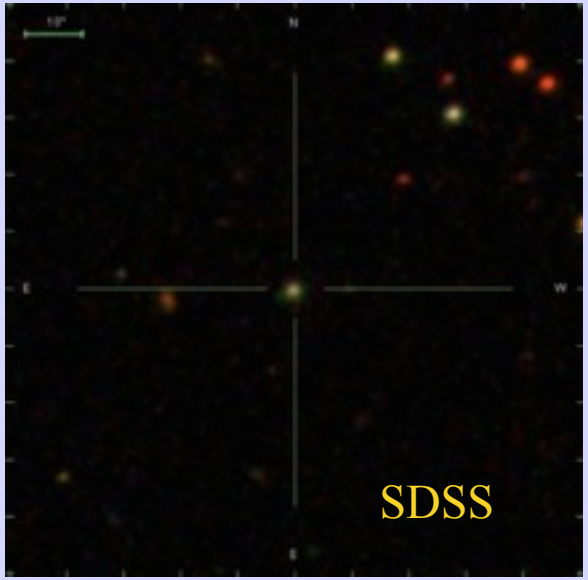

Transient pipeline

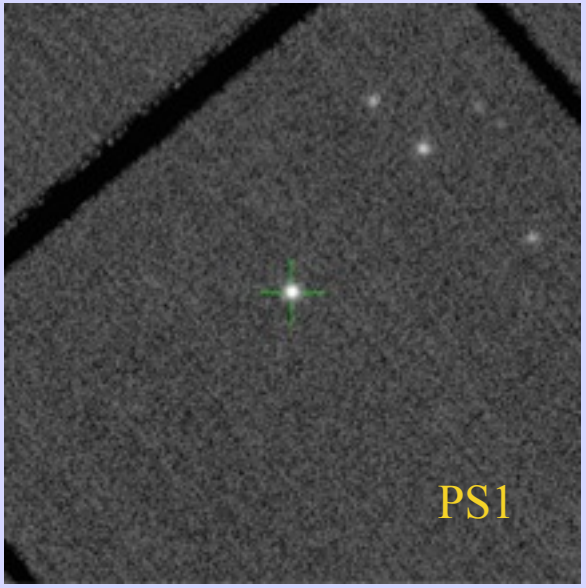
Transient detection

Maui pipeline
==> Belfast transient system

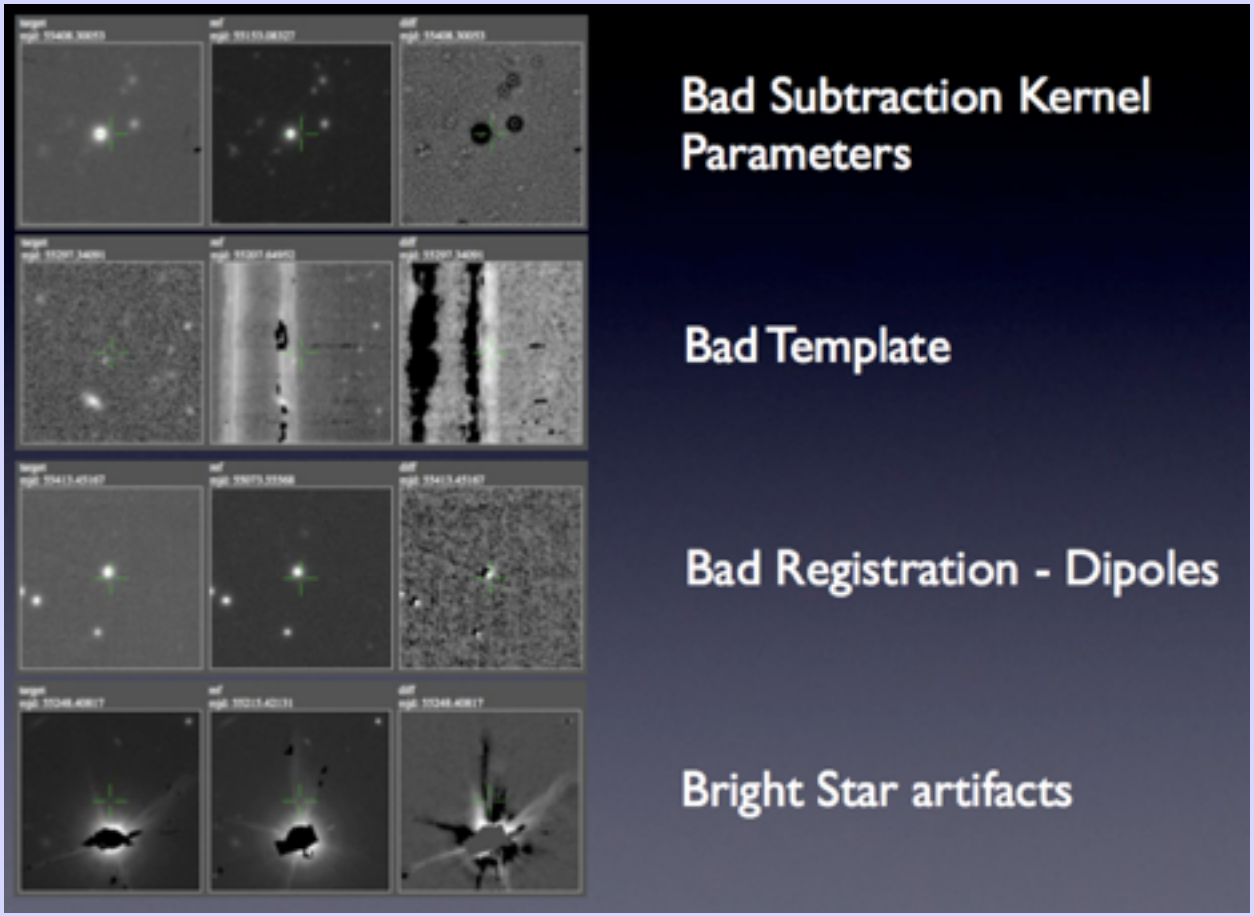


Difference imaging
internal to PS1





catalogue
comparison to SDSS

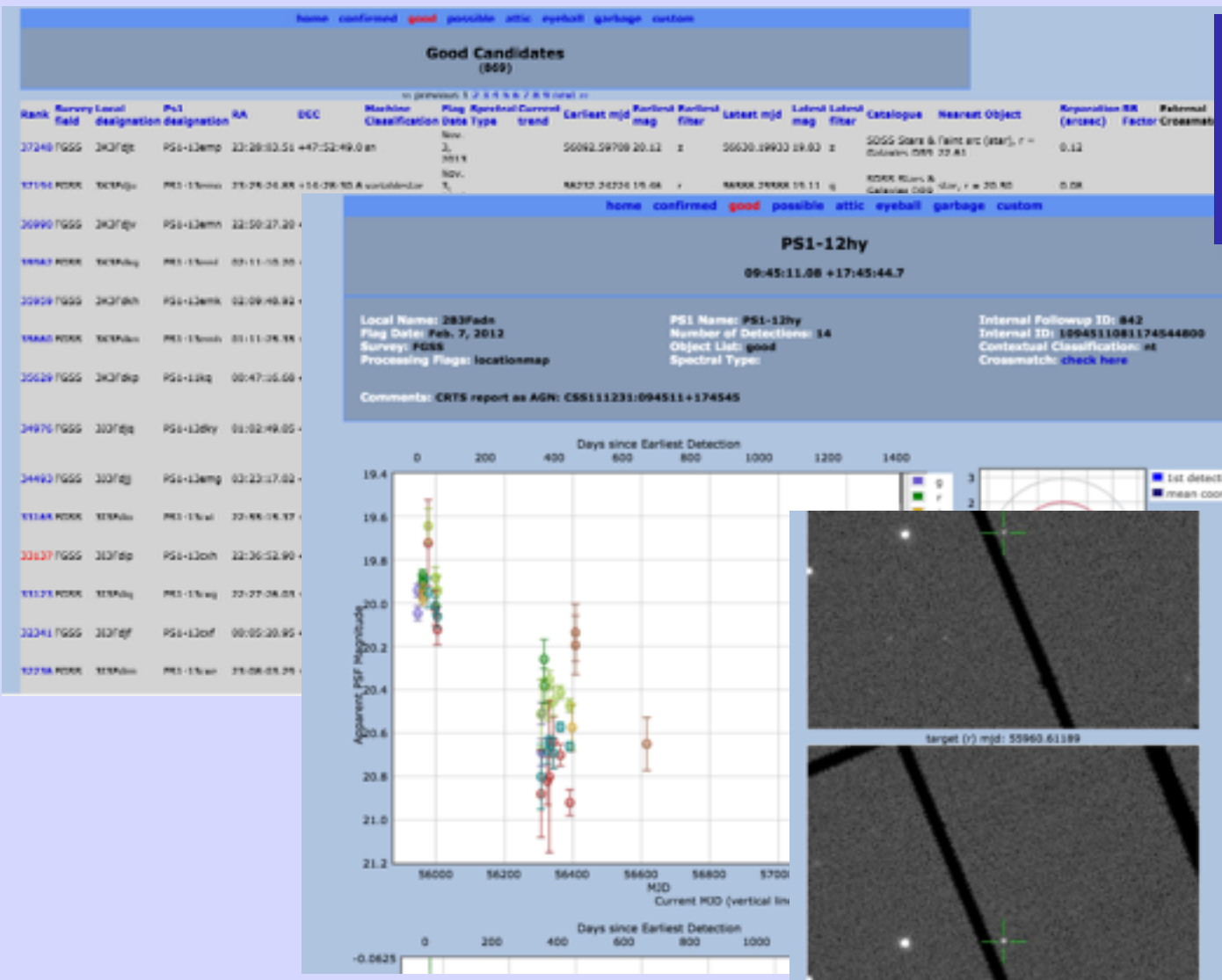


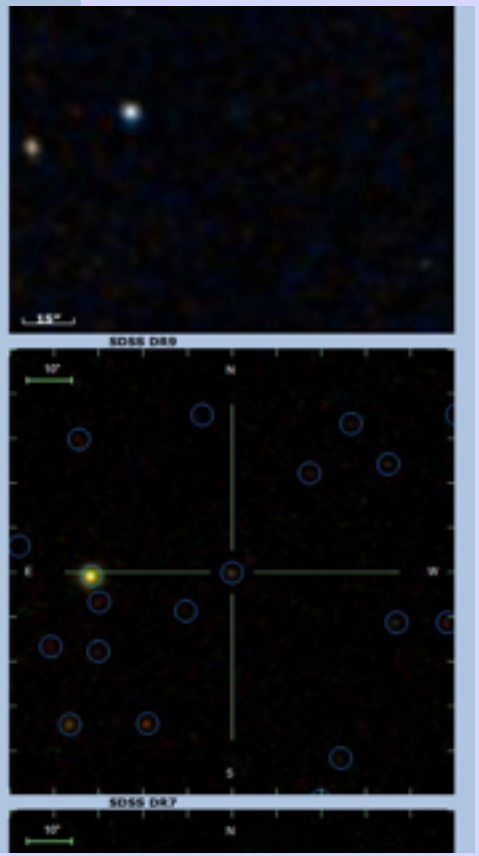
Weeding

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

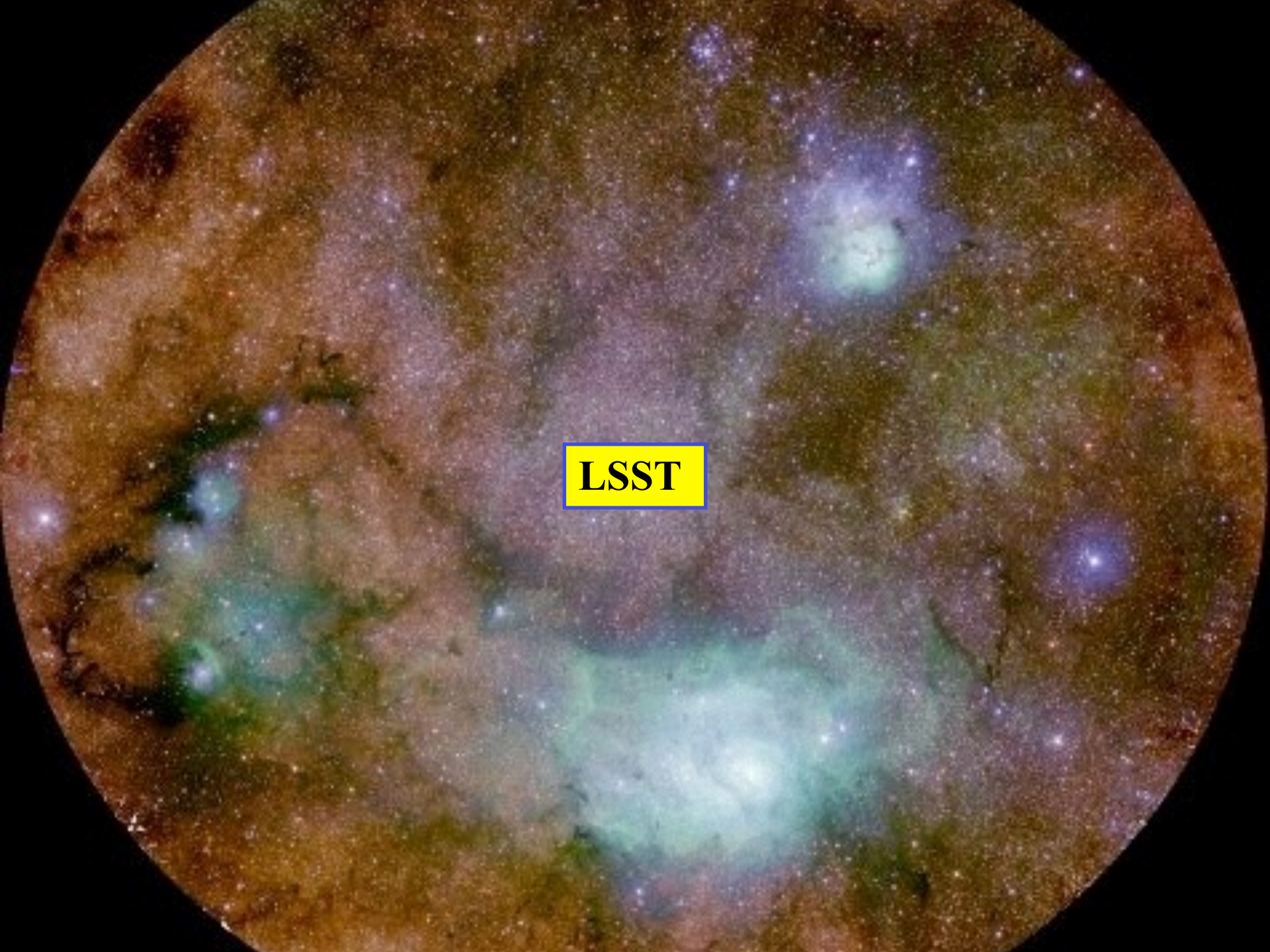
user presentation





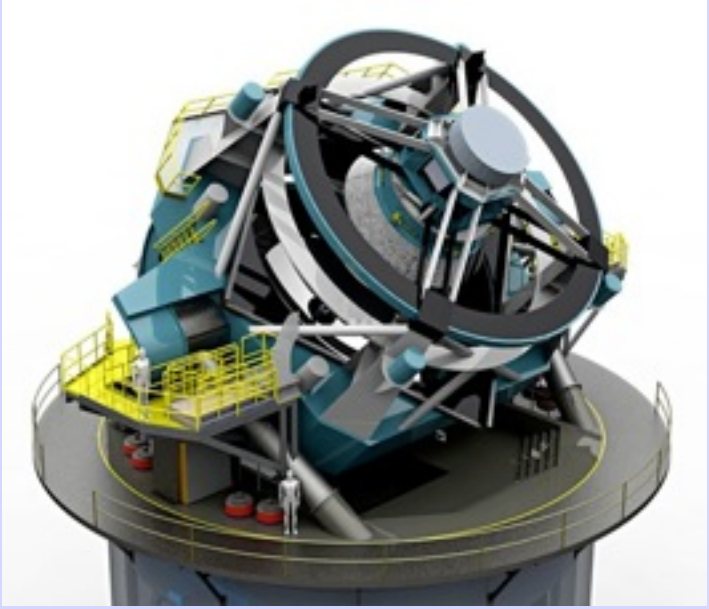
via dynamic web pages

mixture of automated and manual selection


LSST

LSST basics

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

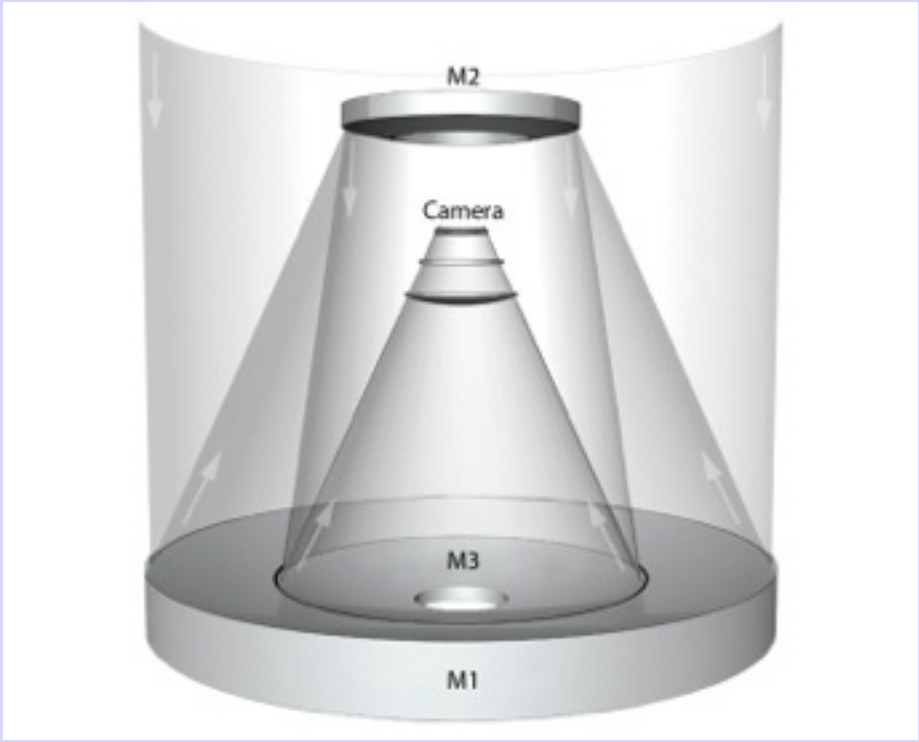


a movie of the sky with an 8m-class telescope

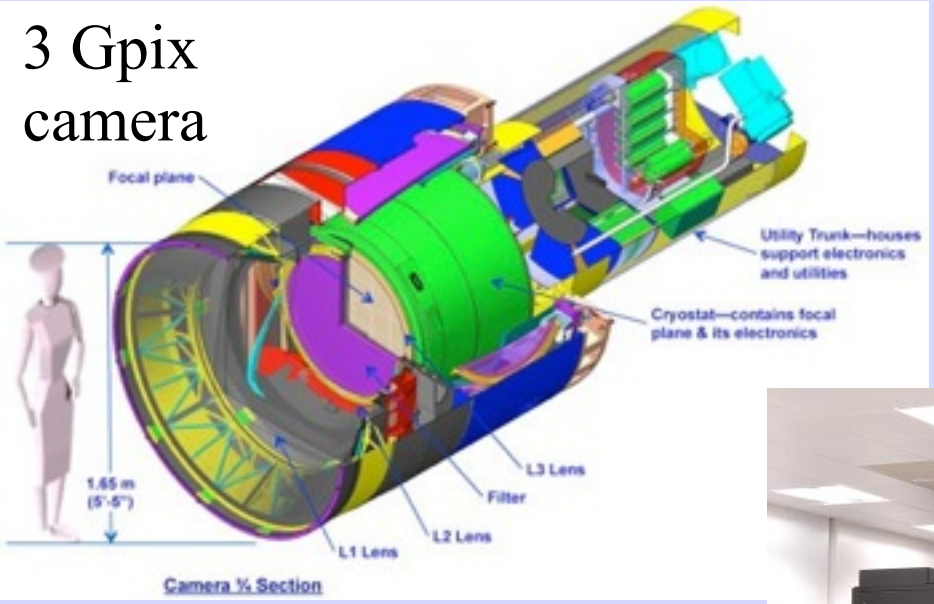
* but adding partners!

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

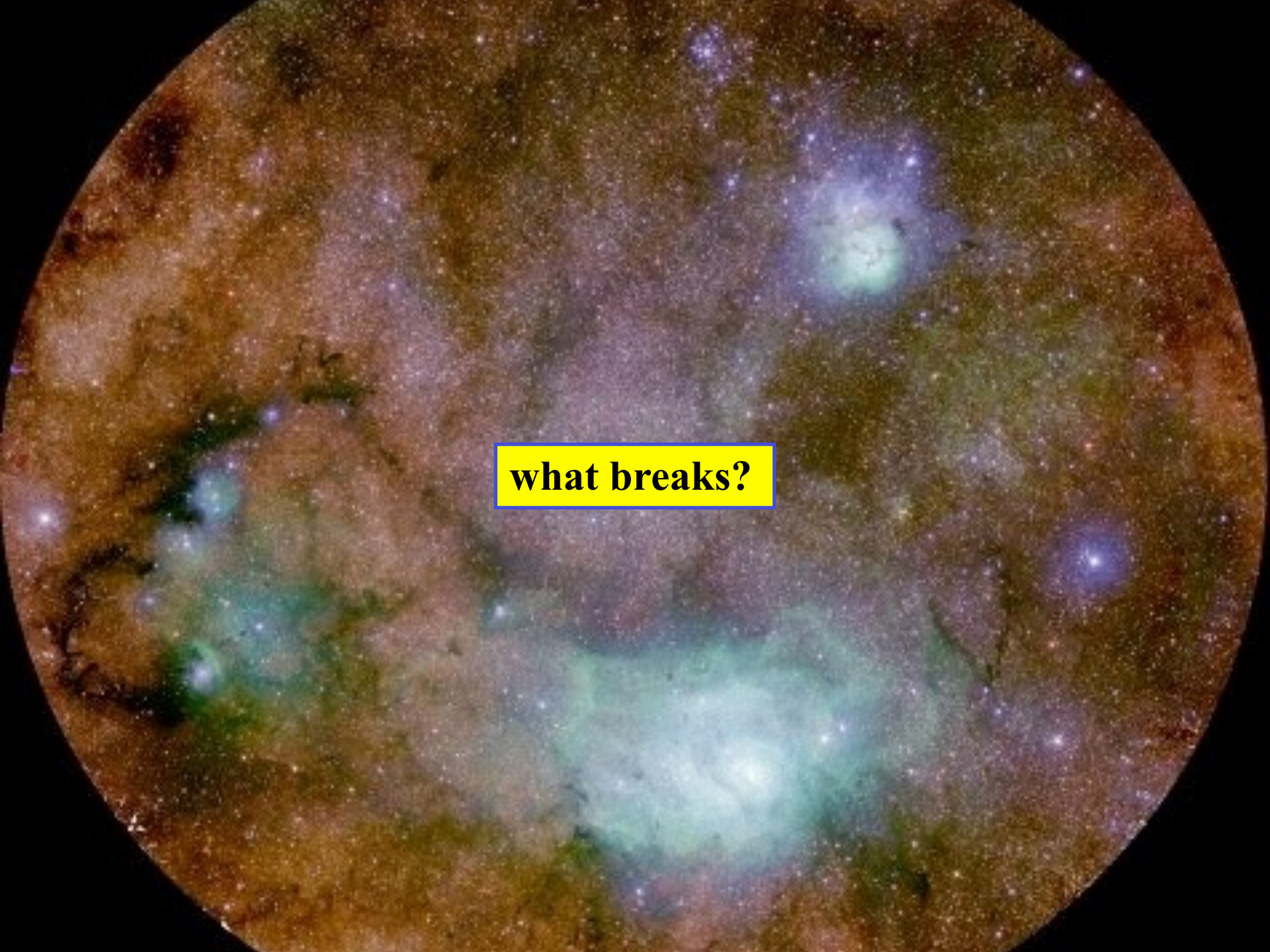
UK on point of signing MOA

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

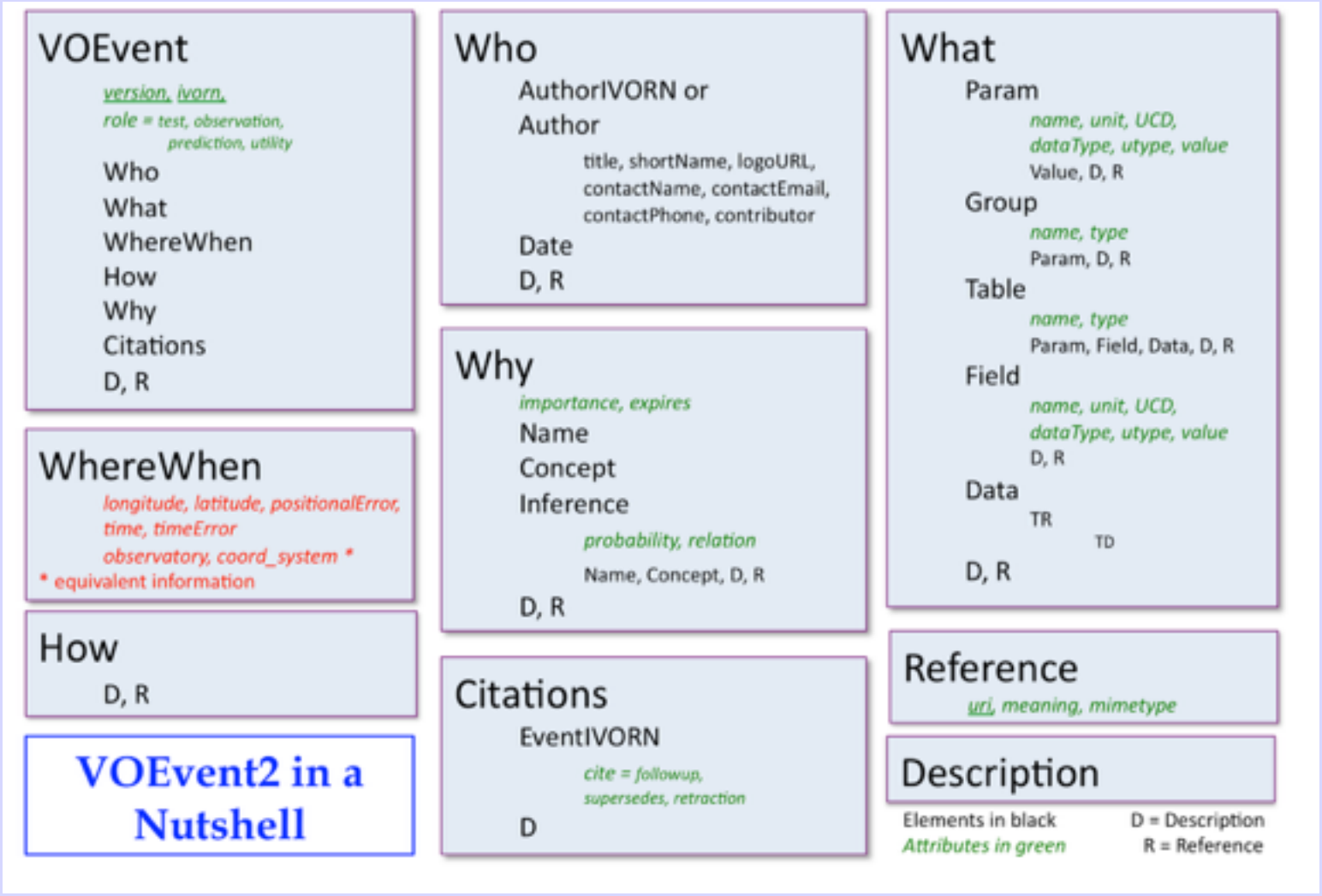
Semi-automated event selection

Manual feed-through to follow-up


standards
landscape

Events

VO Event
VTP
VO Event Registry Extension



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>
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           <MAG fld="vmag"><VAL>17.424</VAL></MAG></ELEM>
    </SERIES>
</SimpleTimeseries>
```

STS

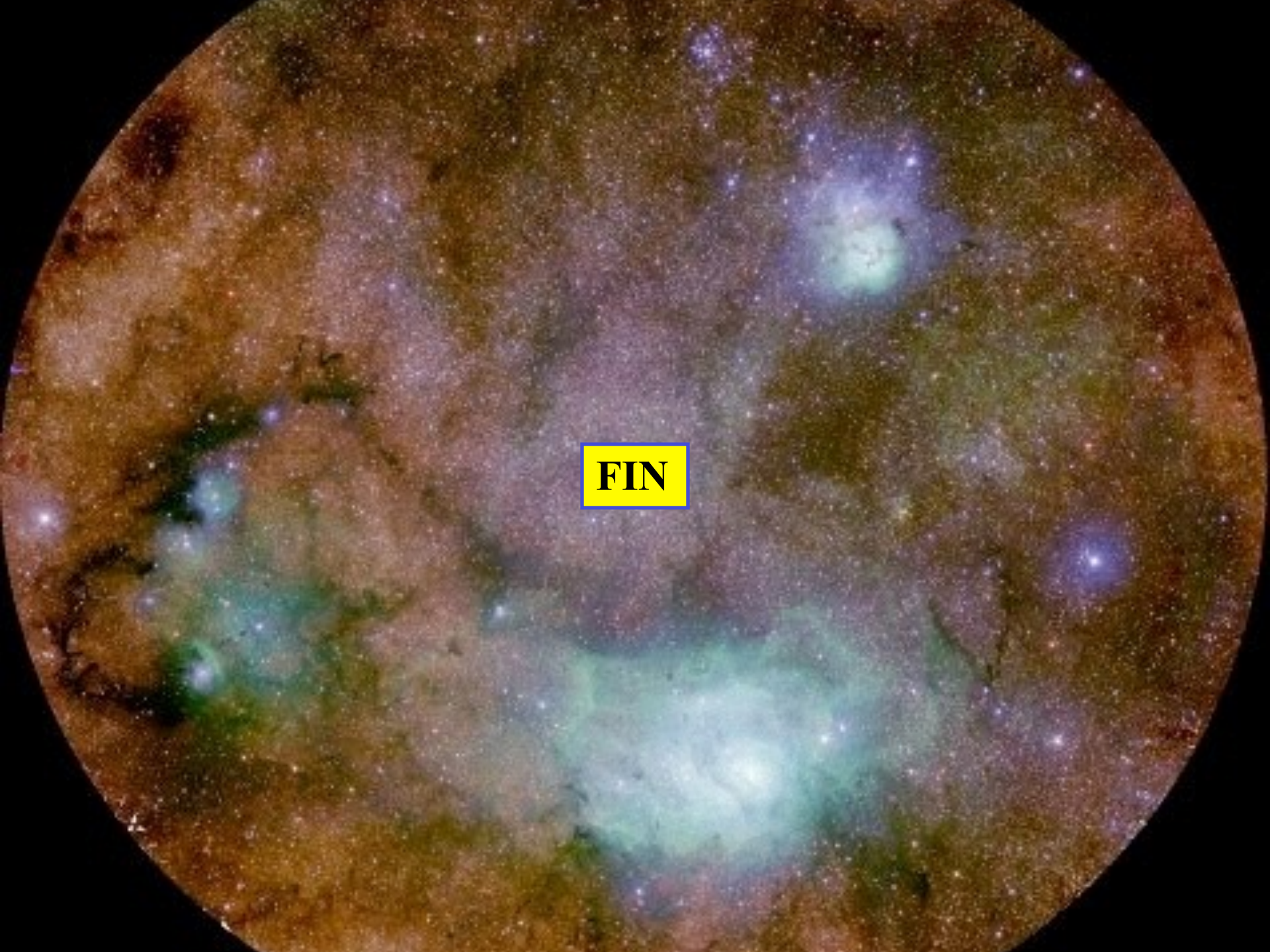
HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)

SITUATION:
THERE ARE
14 COMPETING
STANDARDS.

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

SOON:

SITUATION:
THERE ARE
15 COMPETING
STANDARDS.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