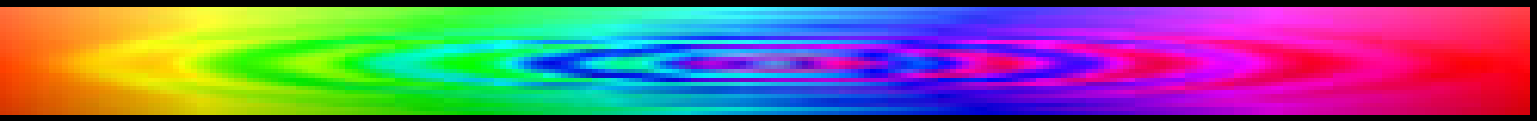
Faint Optical Transients in the Deep Lens Survey



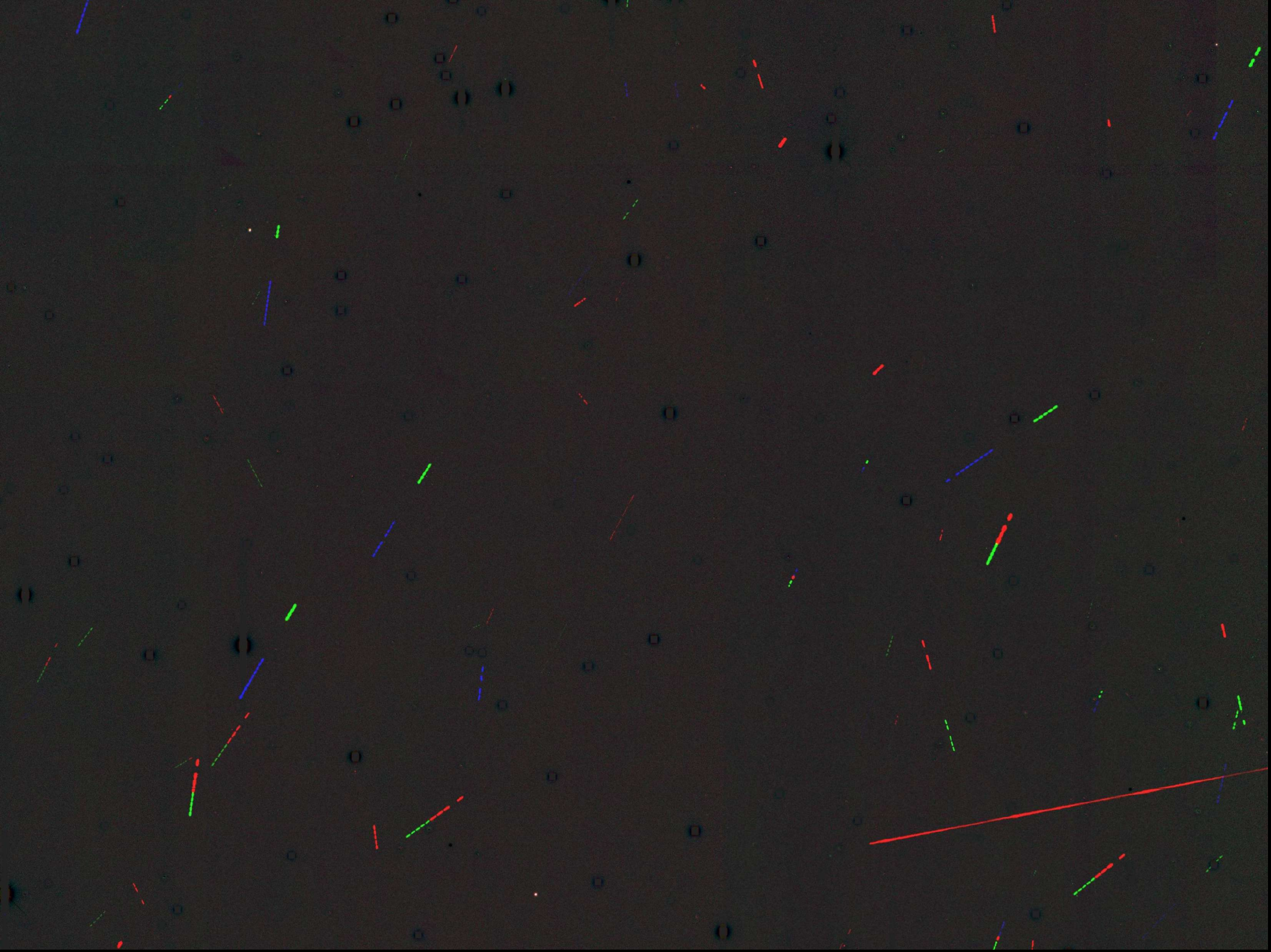
- Andy Becker

  U. Washington
- David Wittman, Tony Tyson, Vera Margoniner

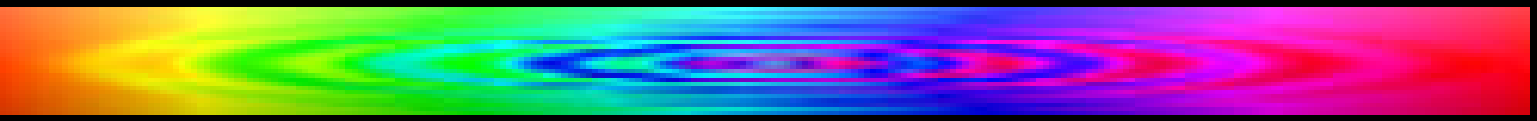
  UC Davis
- Dara Norman

  CTIO
- Ian Dell-Antonio

  Brown U.



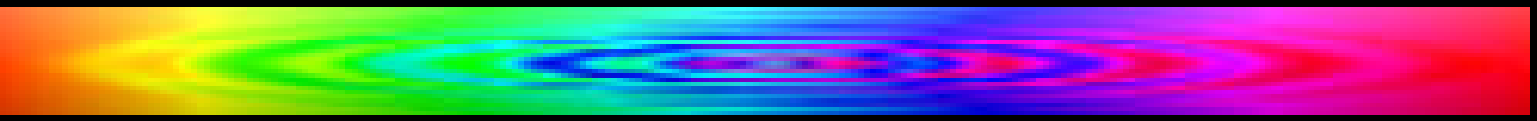
Deep Lens Survey

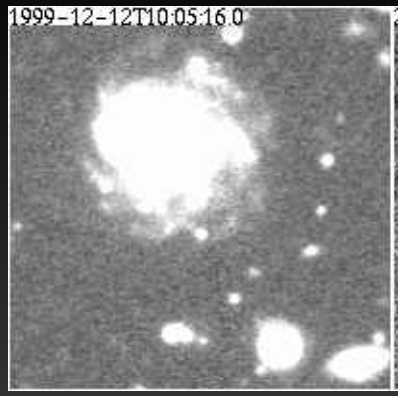
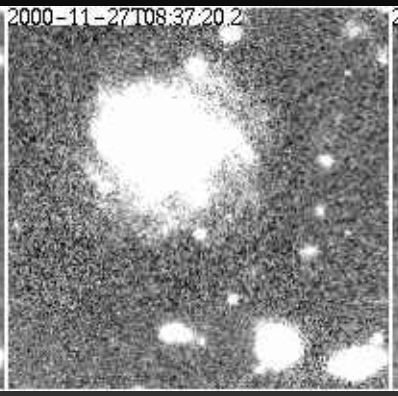
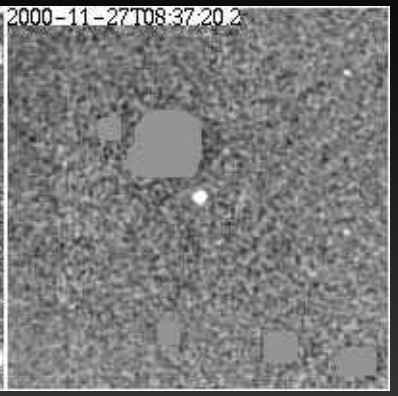
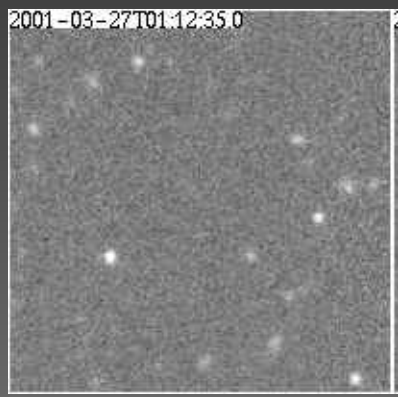
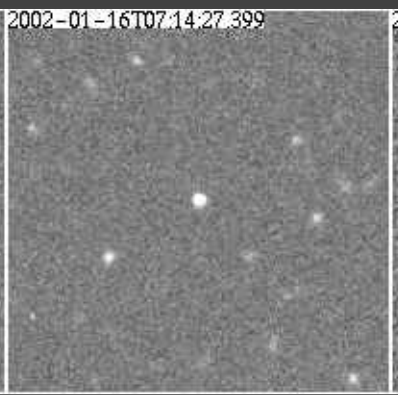


- 1999 - 2005
- Survey designed for weak lensing science
- DLS Transient Search
  - Custom built, near real-time difference imaging pipeline
  - Ran at the telescope (KPNO; CTIO)
  - Manual review and classification of candidates (at 3 a.m.)
  - Automatic release of information on publicly accessible website
  - http://dls.bell-labs.com

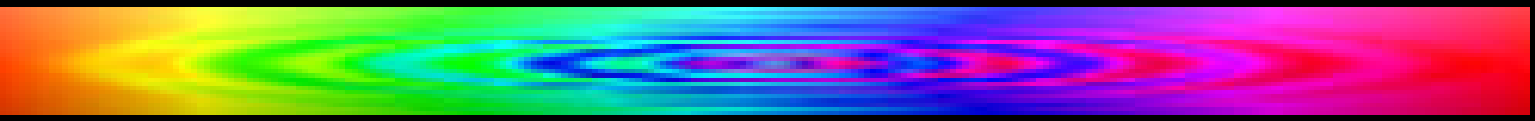
All transients classified and released

Long Timescale Transients

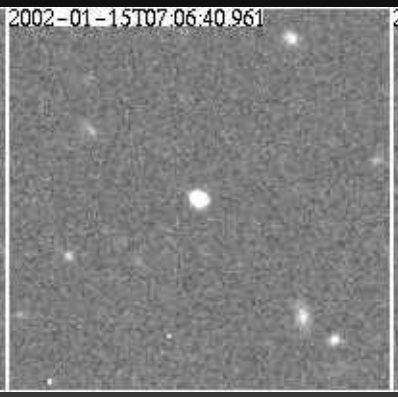


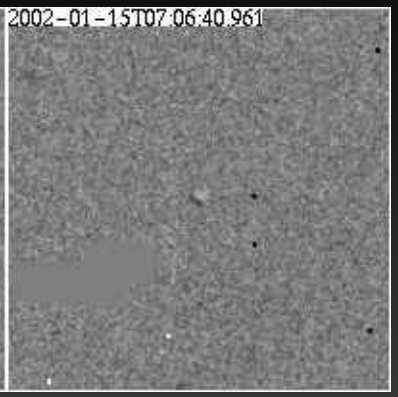
	Template	Science	DiffIm
Clear Host			
Faint/No Host			

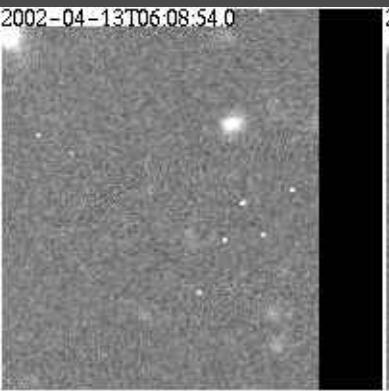
Short Timescale Transients

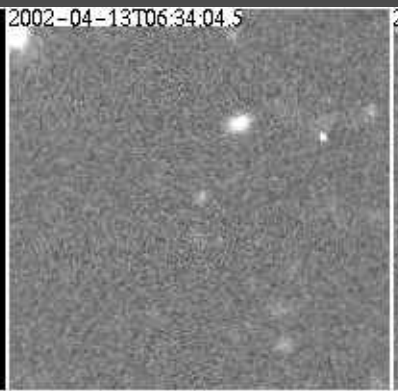


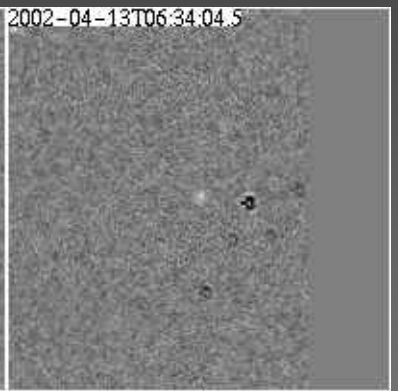
Template	Science	DiffIm1	DiffIm2	DiffIm3
		t0	t0 + 10 min	t0 +

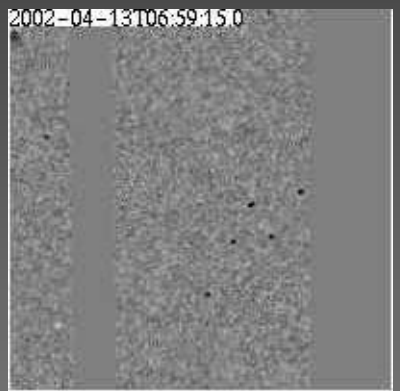




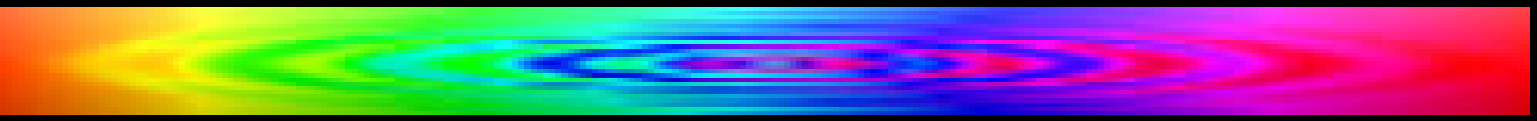






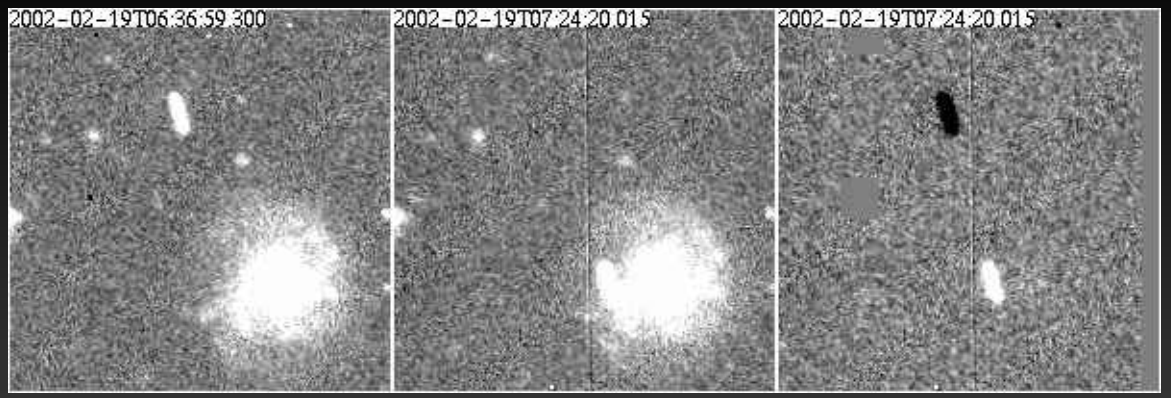


Moving Objects

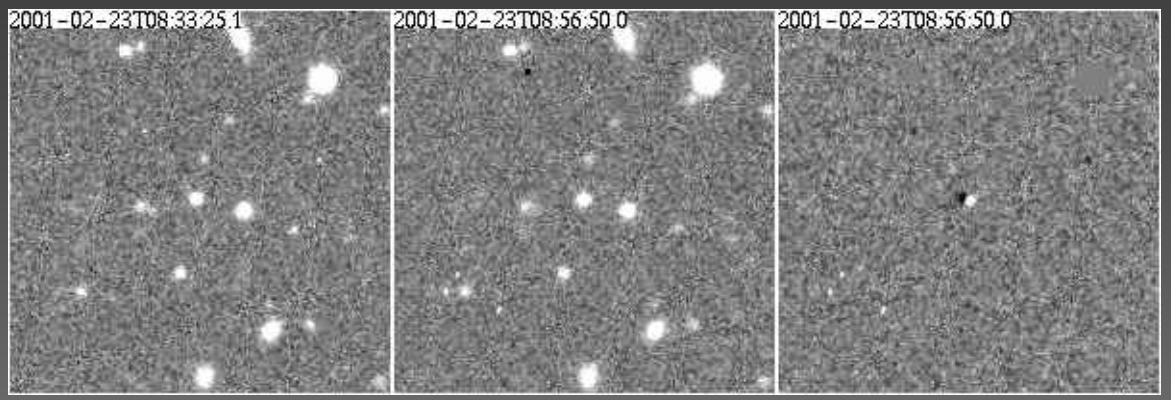


Template **Science** **DiffIm**

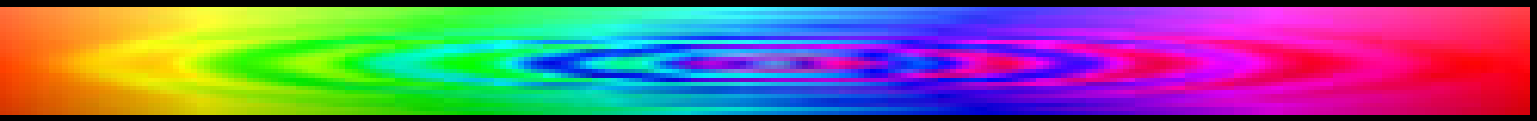
Asteroids



KBOs

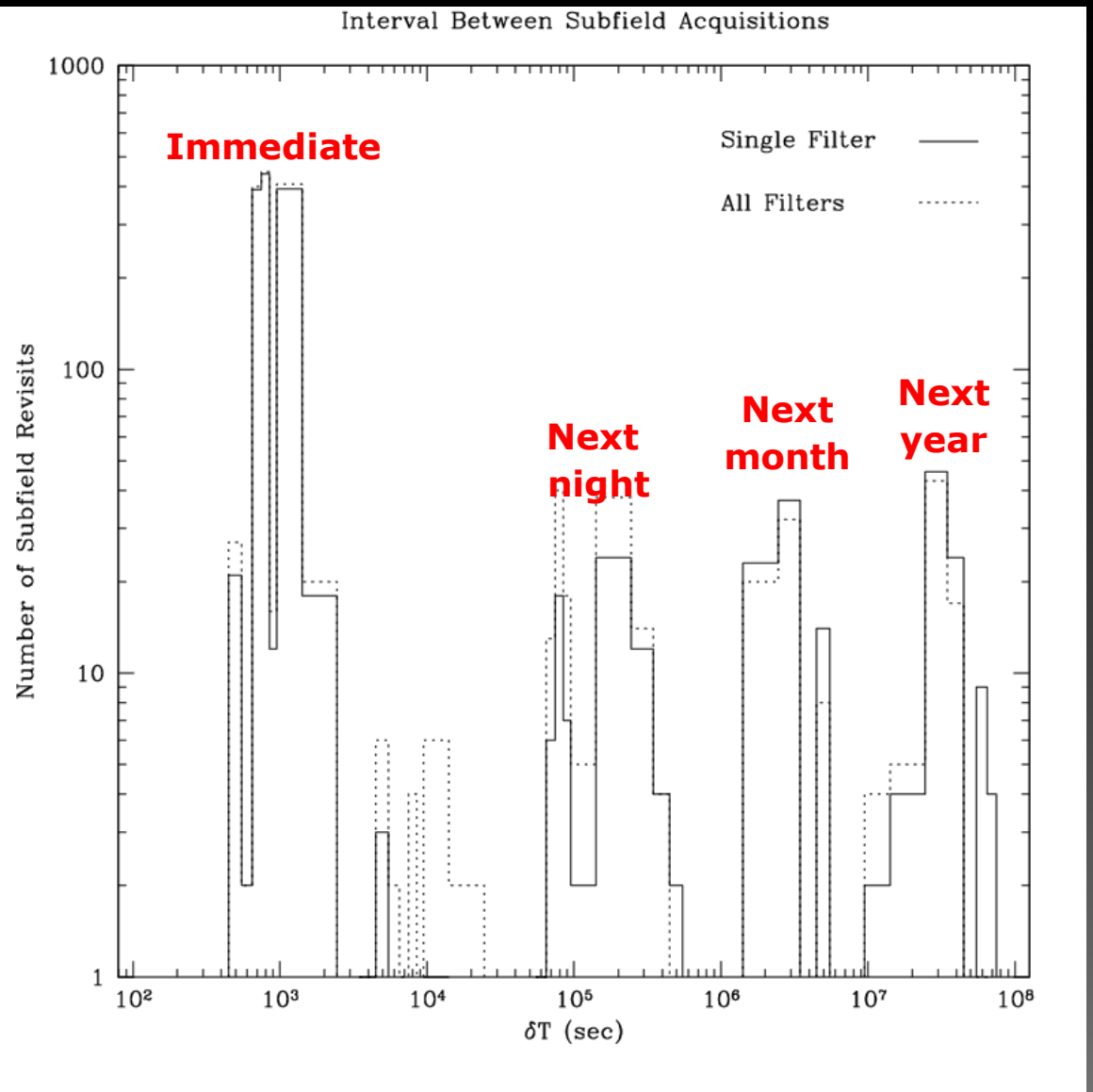


DLS Imaging



Entendue (AΩ)	3.5 m^2 deg^2
FOV/Survey	5 x 4 deg^2
FOV/Image	0.6 x 0.6 deg^2
Filters	B, V, R, z
Visits/SubField/Filter	20
Exptime	600s (B,V,z); 900s (R)
M_{lim}/Exposure	~23

DLS Cadence and Exposure



3.7 deg² days at 10^3s

5 image dither

0.2 deg² days at 10^5s

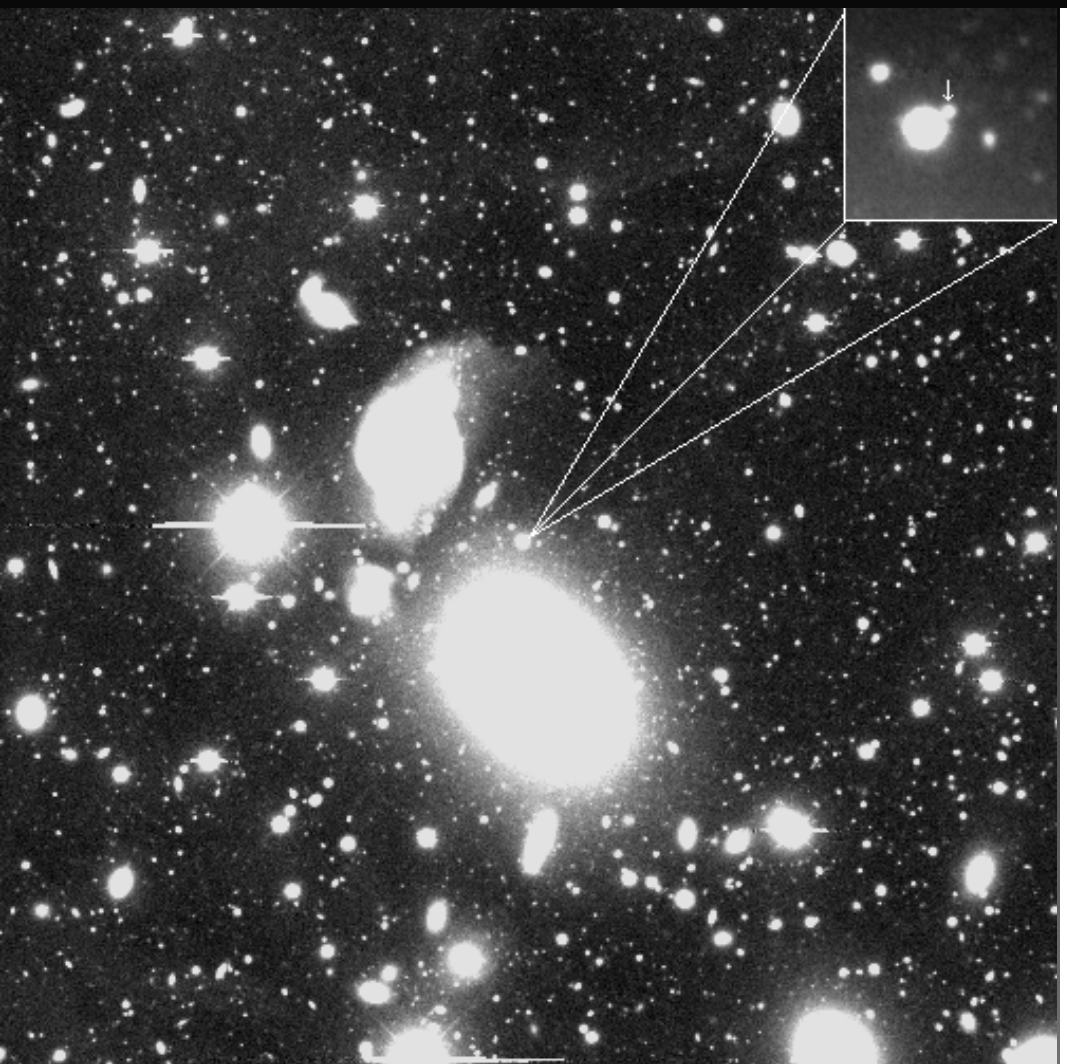
Return next night

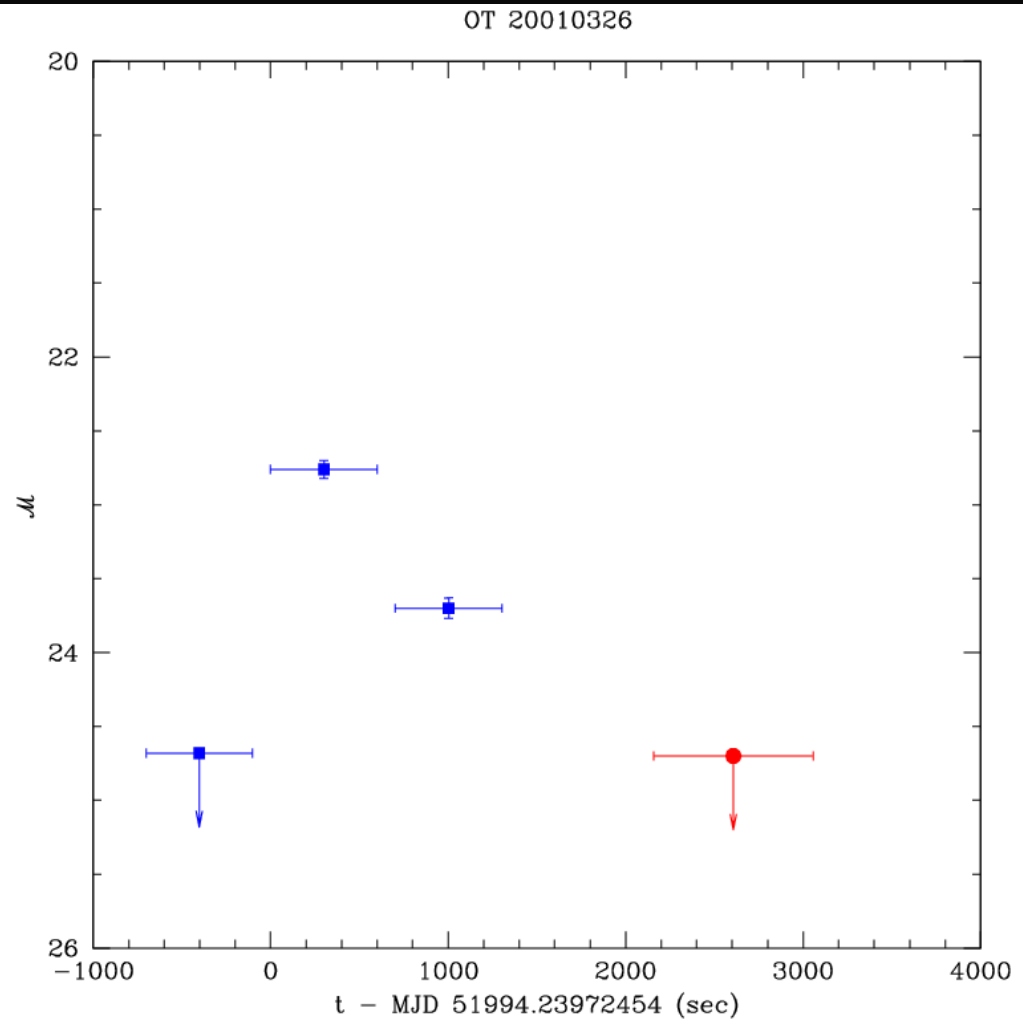
0.2 deg² days at 10^6s

Return next month

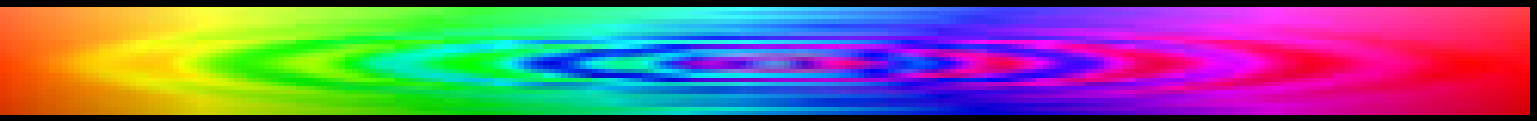
OT 20010326

Abell 1836 z = 0.037





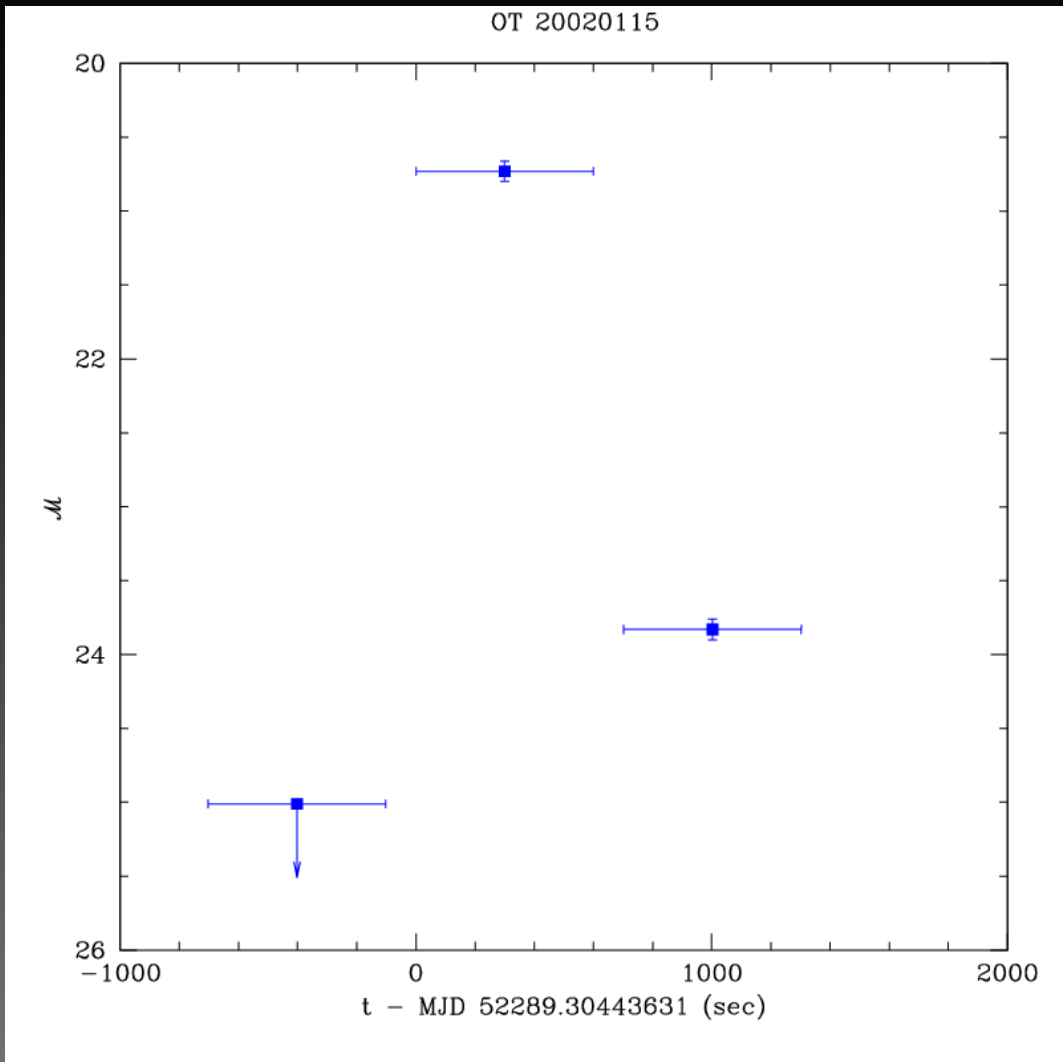
OT 20010326



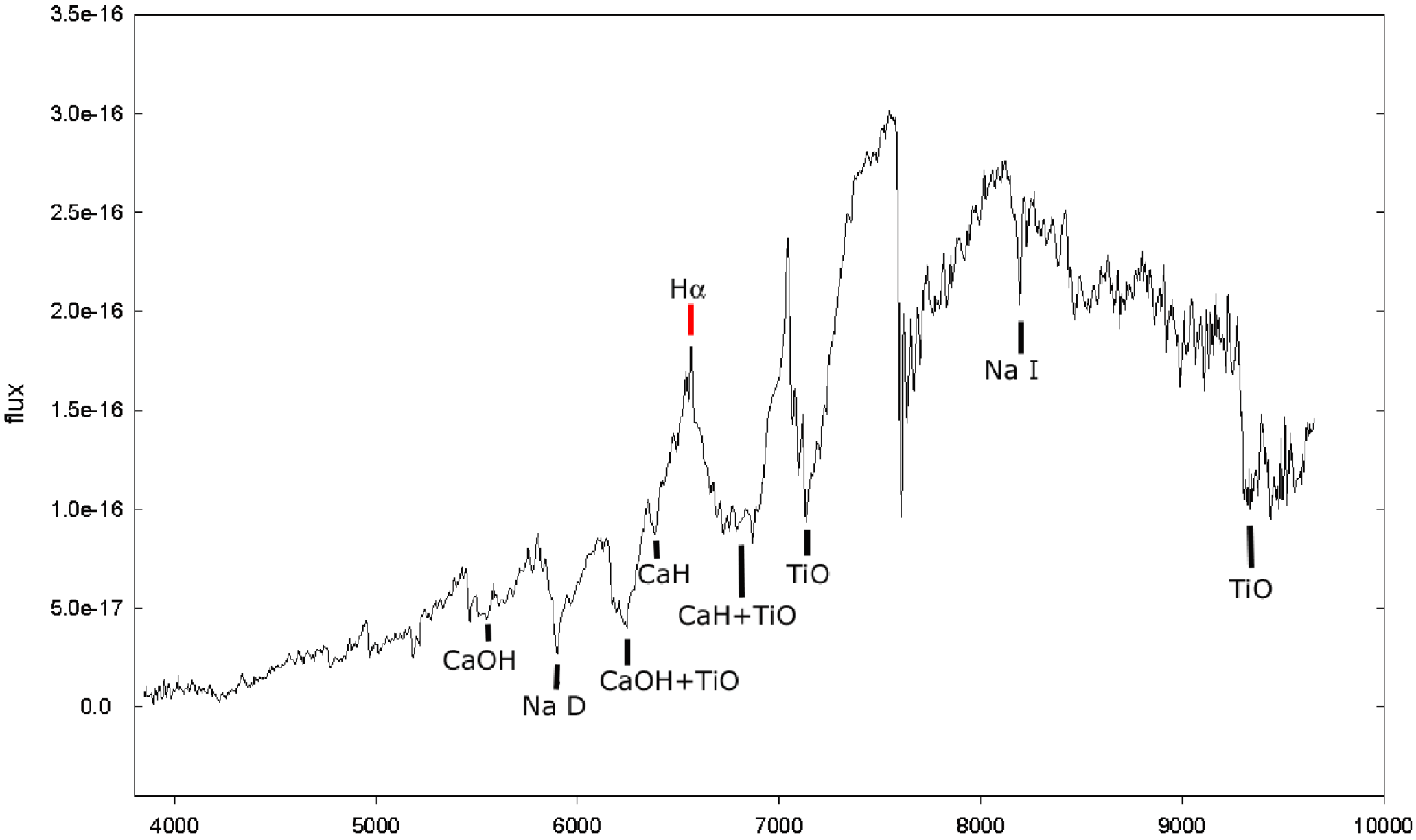
- Power law index for flux decay
  - $t^{-\alpha}$: $0.8 < \alpha < 1.2$
- Alert at t+0.2 days
- VLA followup at 8.5 GHz at t+4 days
  - -0.1 ± 0.3 mJy
- HST Archival observations of A1836
  - F606W, 1995
  - Host unresolved; proper motion 0.004” ± 0.004” / year
- Host red : ***B*** > 26.4; ***V*** = 24.5; ***V-R*** = 1.2

OT 20020115

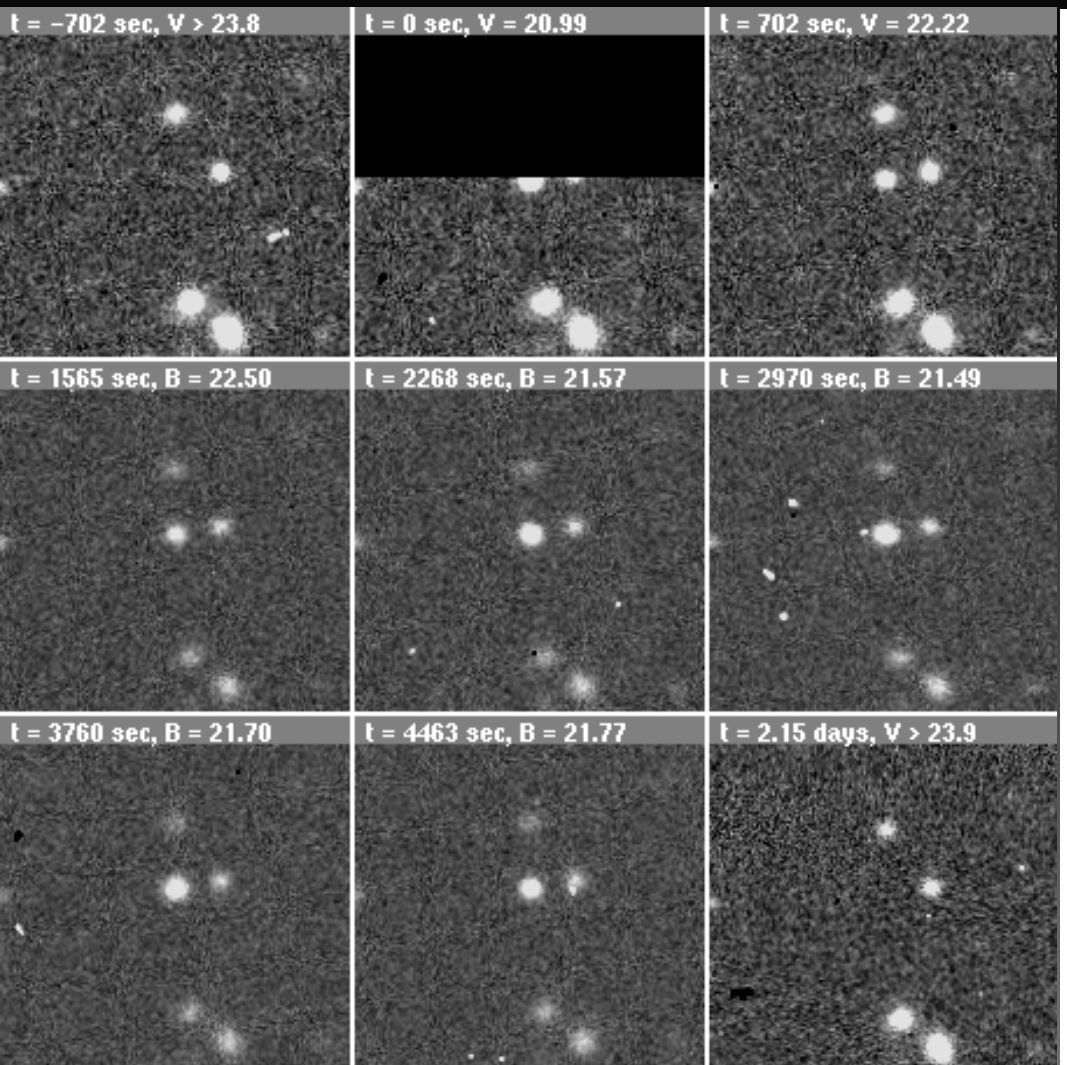
- Release alert to GCN
  - GCN 1217
- Spec followup
  - t + 3 days

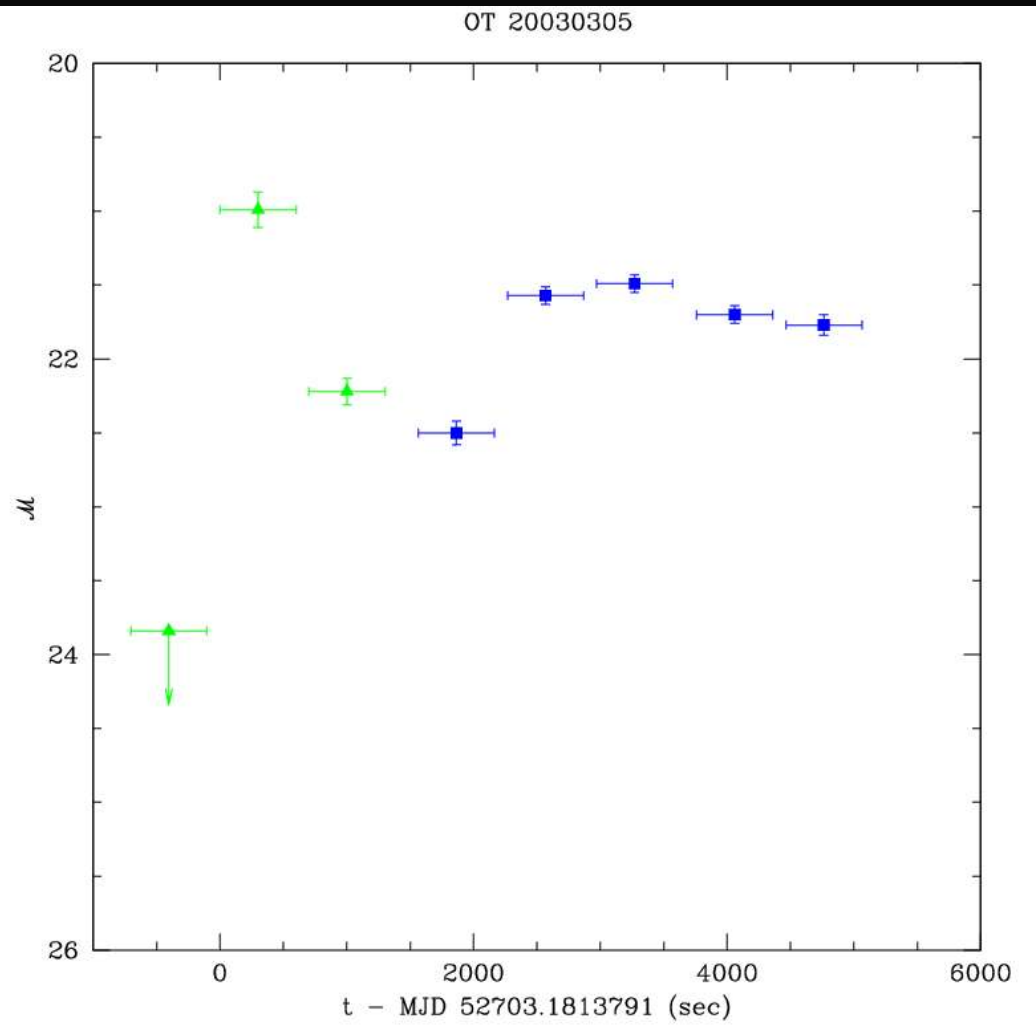


OT 20020115


3.5e-16
3.0e-16
2.5e-16
2.0e-16
1.5e-16
1.0e-16
5.0e-17
0.0
flux
4000
5000
6000
7000
8000
9000
10000
Hα
CaOH
Na D
CaOH+TiO
CaH
CaH+TiO
TiO
Na I
TiO

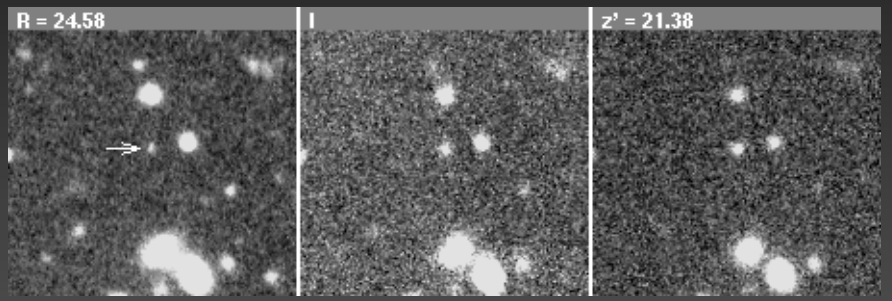
OT 20030305


t = −702 sec, V > 23.8
t = 0 sec, V = 20.99
t = 702 sec, V = 22.22
t = 1565 sec, B = 22.50
t = 2268 sec, B = 21.57
t = 2970 sec, B = 21.49
t = 3760 sec, B = 21.70
t = 4463 sec, B = 21.77
t = 2.15 days, V > 23.9


OT 20030305
20
22
24
26
M
0
2000
4000
6000
t − MJD 52703.1813791 (sec)

OT 20030305

- Back-to-back observations in ***V*** and ***B***
- Released via IAUC
  - Too conservative!!!

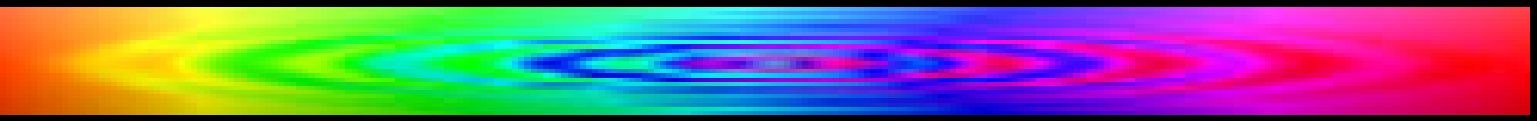


- Host extended...
  - Adaptive 2nd moments
  - Inconsistent with R-band PSF at 99% confidence
- And red
  - ***V*** > 27.1; ***R*** = 24.6; ***R-z*** = 3.2

Constraints on 1000s OTs

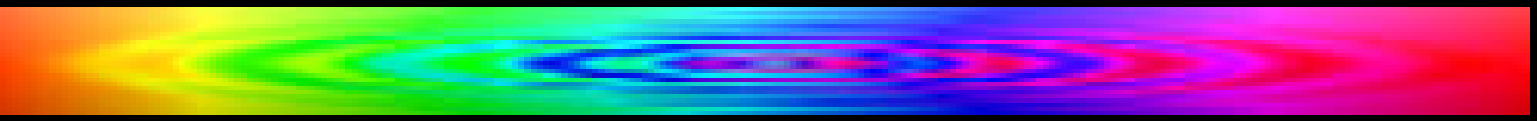
- Known unknowns
  - Precursors faint and red
  - Events faint and blue
- $18.6 < B < 23.8$
  - η = 4.3 OTs / sq deg / day
  - η = 2.2 flares / sq deg / day
- $18.8 < V < 23.3$
  - η = 2.1
- $19.5 < R < 23.4$
  - η < 5.2 (95%)

Full DLS Dataset



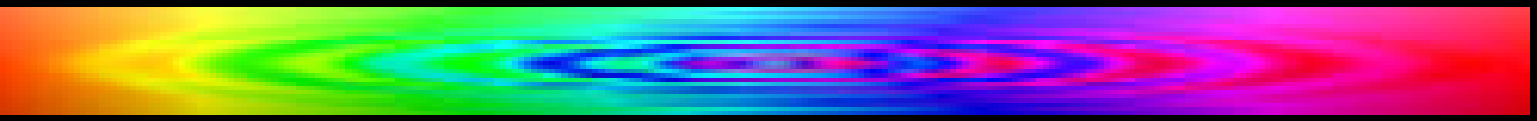
- Analysis only includes ~40% of data
- Global reanalysis is underway
  - Should reveal several new OTs
  - Including z-band
- More importantly, more hosts
  - What fraction are flaring dwarf stars?
  - Bright enough for follow-up?
  - Still don't know energy budget for these events

Lessons Learned



- Need to reject prosaic variability
  - Variable stars, asteroids, etc
  - In particular flare stars (GCN 2849)! And KBOs
  - Requires real-time detection *and classification*
- Event rate is low compared to entendue
  - Can't guarantee targets
  - Can't pre-schedule spectroscopic followup
  - Informal followup arrangements inadequate
- VOEvent would have helped immensely!
  - Spec followup still an issue

Lessons Learned



- Optically transient events *are* out there
  - Temporally resolved (small numbers → uncertain rates)
  - Temporally unresolved (even more difficult to quantify rates)
  - Next gen surveys should find hundreds / night
- Need to quantify brightness and timescale distributions
  - What is the optimal survey strategy?
  - Spend time going deeper; or
  - Spend time going wider

CFHT + MegaCam Campaigns

- 4 x 4 x 16 exposures
  - 4 allocated runs
  - Cycle between 4 fields
  - 16 times in an evening
  - 185s exposures in r'
  - P.Price PI
- TALCS
  - Cycle between 12 fields
  - 20s exposures in g' and r'
  - R. Jedicke PI

Next Generation Surveys

Expect hundreds per night at 1000s timescales

- at 100s? at 10s?

Must enable immediate spec followup

Alerts must encode confidence levels

- e.g 50% OT, 10% SN, 15% KBO
- Caveat Emptor

http://dls.physics.ucdavis.edu