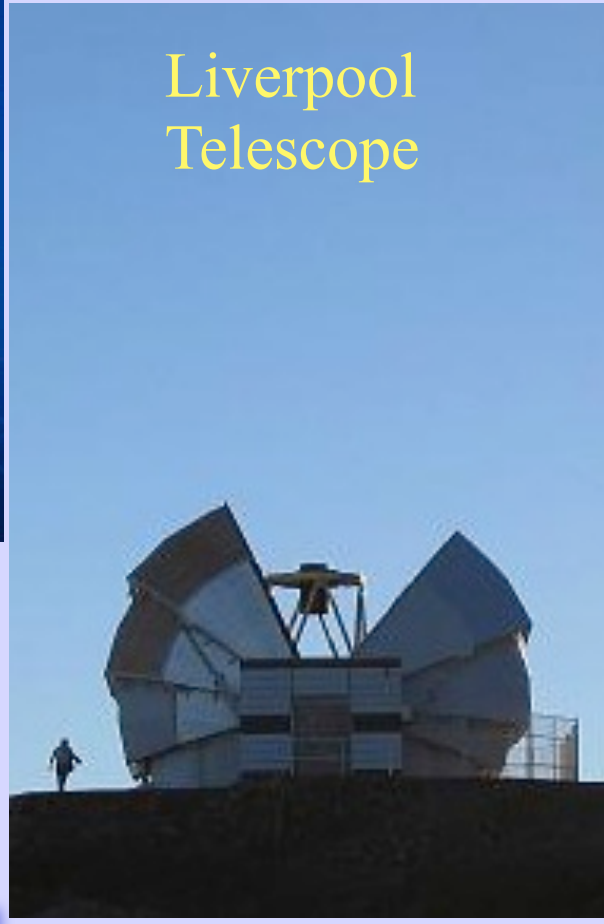


Bright nuclear transients
- what are they ?

July 2013 Andy Lawrence NAM St Andrews

with Suvi Gezari, Martin Elvis, Martin Ward
and
the Harvard and Belfast transient pipeline teams
(especially Stephen Smartt, Ken Smith, Darryl Wright)
and
the whole PS1 team

PanSTARRS-1

- 1.8m telescope on Hawaii with FOV 7 sq.deg
- Imaging in *g r i z y*
- Medium Deep Survey : 12 fields, 4 night cadence, g=25-ish
- 3Pi Survey : 30,000 sq.deg, 2 month cadence, g=22-ish
- Pipeline in Maui
- Transient pipelines in Harvard and Belfast
- 3 year survey started Jan 2011
- thousands of transients
- ~400 confirmed SNe

Bright Nuclear Transients

- aimed at finding the brightest TDEs

- trigger by 3Pi *vs* SDSS difference : choose
  - SDSS object=galaxy
  - distance <0.5"
  - Δm > 1.5 mag

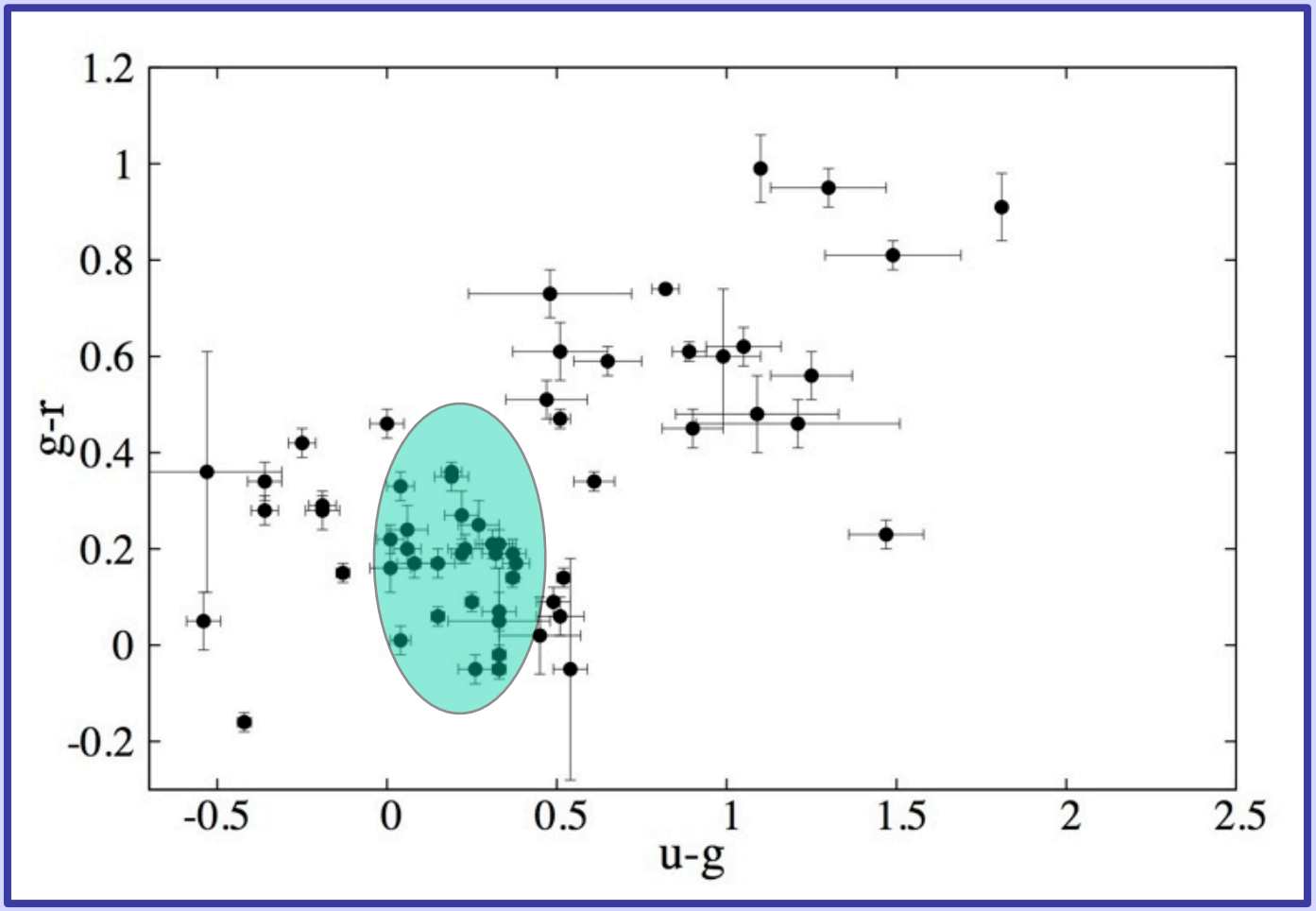
- 80 targets monitored on Liverpool Telescope at *u g r*
  - weekly at first then monthly
  - typically g(gal)=21-23 g(transient)=19-20

- 41 follow-up spectra, mostly WHT
  - 33 AGN
  - 6 SNe
  - 2 variable stars

colours

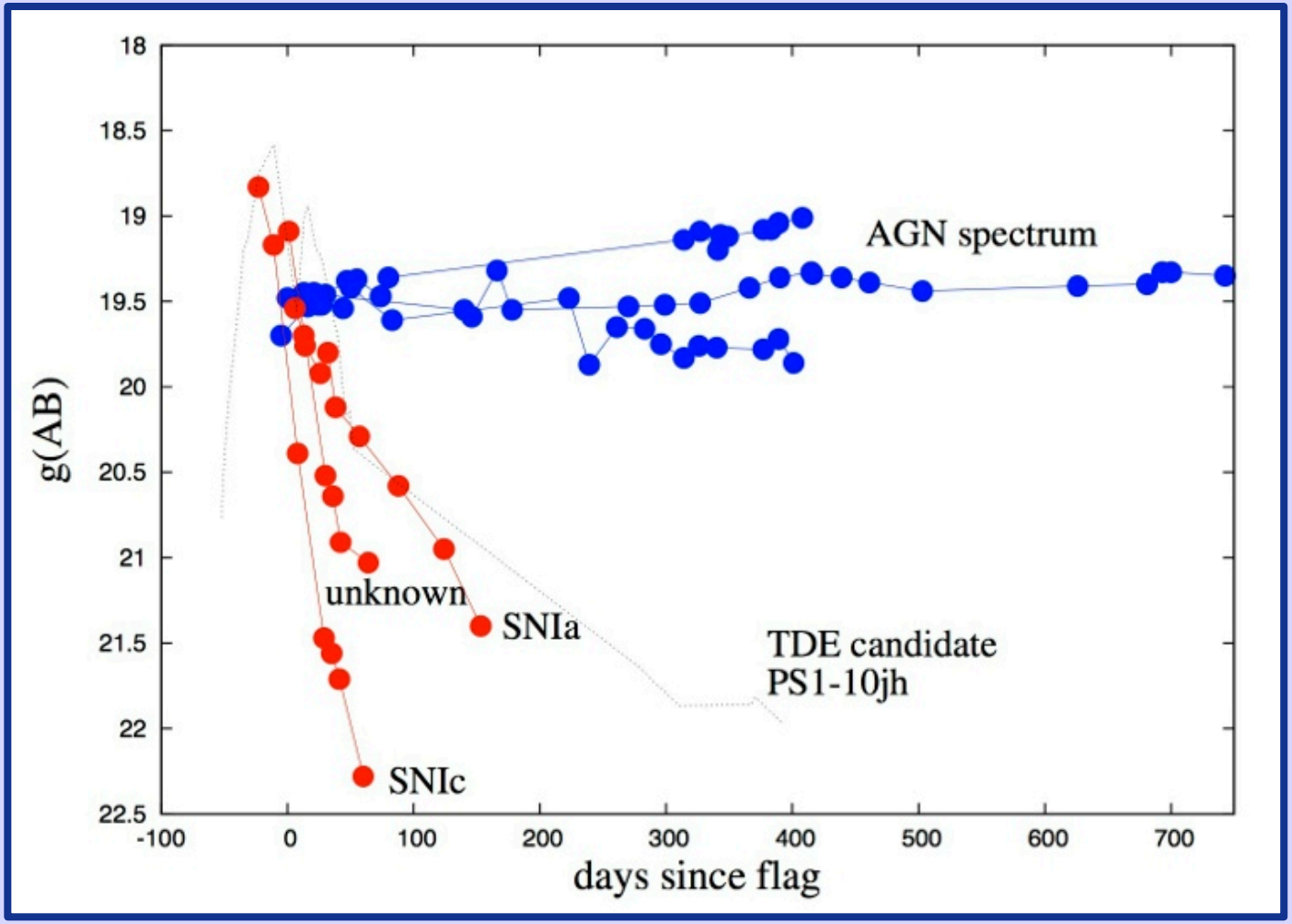
red objects always
turn out to be SNe

some ultra-blue
objects much
bluer than
normal quasars



most blue objects have
normal quasar colours

example light curves

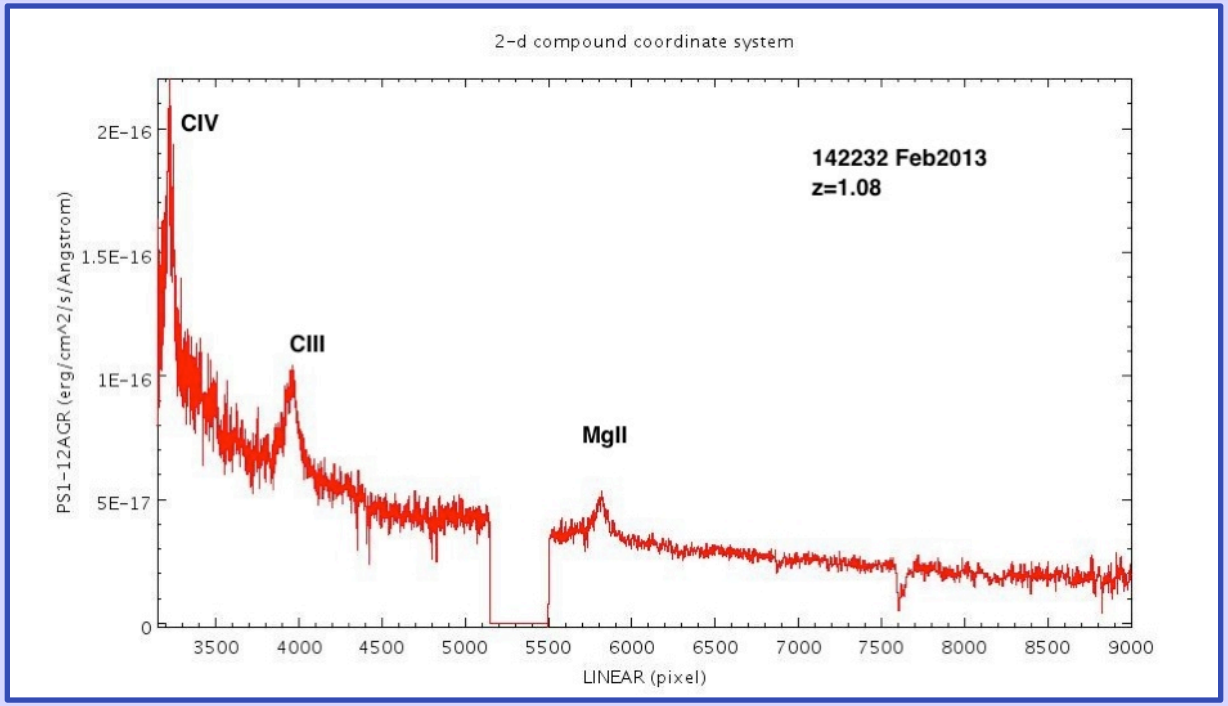


red = fast
($t_{1/2}$ ~ month)

blue = slow
($t_{1/2}$ ~ 1-3 years)
some seen rising

Much slower
than predicted
for TDEs

extreme quasar variability?

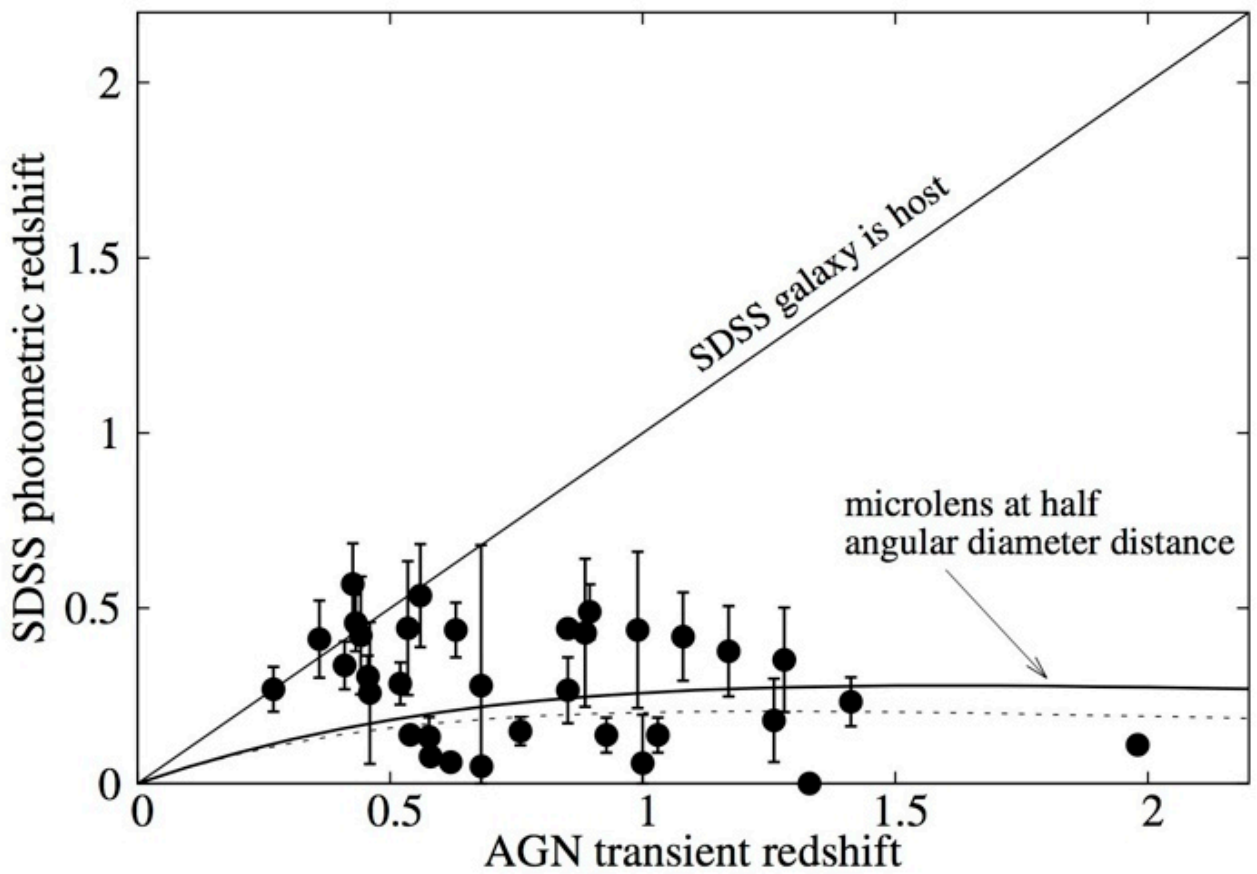


typical transient spectrum

- normal quasar variability $\Delta m \sim 0.3$
- SDSS repeats with $\Delta m = 2$: 0/25,000 (McLeod et al 2012)
- extrapolated from trends : predict 1/100,000 (ibid)

- rare but important extreme variability?
- accretion disc instability?

redshift anomaly



host photo-z < z_Q?

proposal :
background AGN
microlensed by
star in foreground
galaxy

- AGN not seen before event
- Seyfert-like rather than quasar (L~$10^{43\text{-}44}$ erg/s)

cf known microlensing

Lensed Quasars :

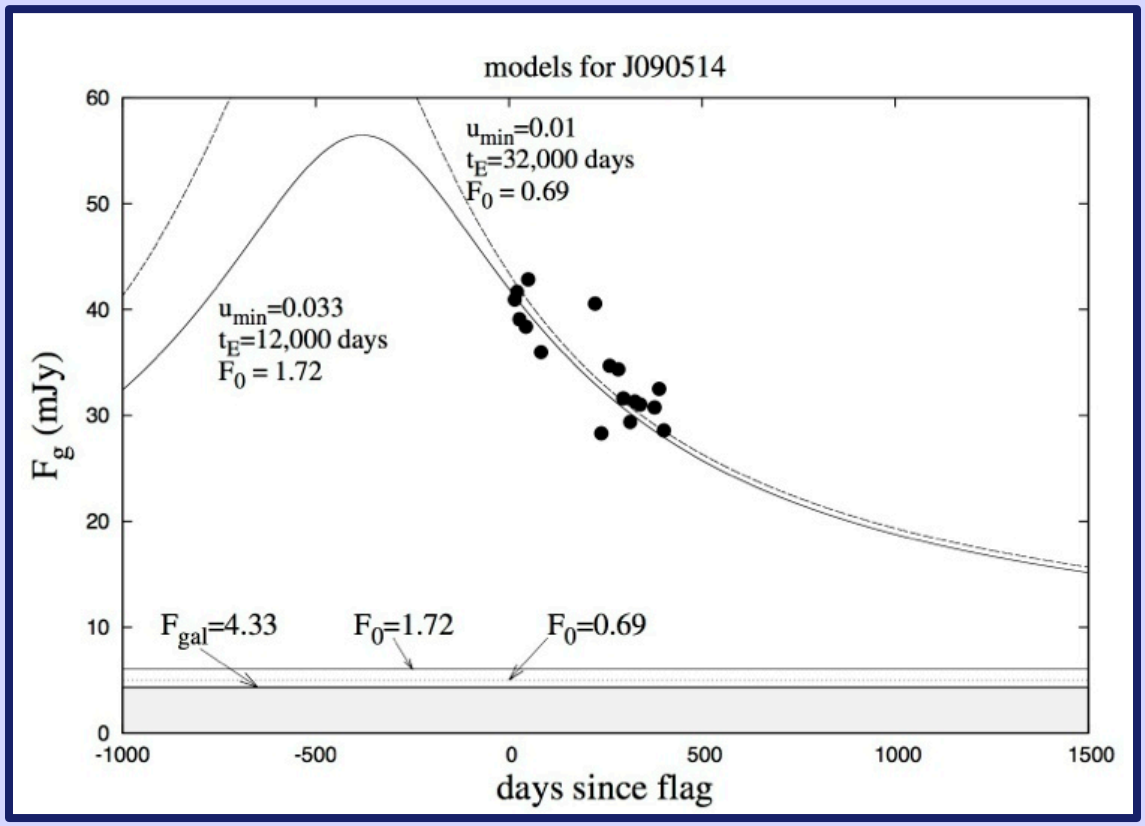
- differential flickering in multiple components (Irwin et al 1989)
- massive galaxy
- strong macrolensing
- significant optical depth ==> continual low level flickering

PS1 transients :

- smaller galaxy
- little macrolensing
- small optical depth

==> rare high amplification single star events

light curve fit



Fit parameters
base level F_0
impact param. $u_{min} = \theta_{min}/\theta_E$
crossing time t_E

note $t_{1/2} \approx 2\ u_{min}\ t_E$
and amp $\approx 1/u_{min}$

$t_{1/2}$ reasonably measured
but F_0 poorly known

==> range of possible
t_E/u_{min} values

Model with F_0 1 mag below galaxy :
$u_{min} = 0.033$, A = 30
t_E = 12,000 days = 33 years
$t_{1/2} \approx$ 2 years

expected values

For z_s=1 z_l=0.25 z_{ls}=0.6 and solar mass lens :

$\theta_E = 2.91 \mu\text{as}\,(M/M_\odot)^{1/2}$ r_E=2326 AU u_{min}=0.033 ==>r_{min}=77 AU

For relative motion 300 km/s

$t_E = r_E/v = 36.8\ \text{years}\,(M/M_\odot)^{1/2}\,(v/300)^{-1}$

$t_{1/2} = 893\ \text{days}\,(M/M_\odot)^{1/2}\,(v/300)^{-1}\,(u_{min}/0.033)$

For Milky Way like galaxy covering f~10^{-4}

$t_{rpt} \sim 6000\ \text{years}\,(M/M_\odot)^{1/2}\,(v/300)^{-1}\,(u_{min}/0.033)^{-1}$

Surface density of distant AGN ~ 1 arcmin^{-2}

==> 0.03% of foreground galaxies have a background AGN

10^8 galaxies at g=22

==> a few tens in "outburst" at any one time

resolution effects

For $M_{BH}=10^8$; accn disc ~10 R_S ; BLR ~1000 R_S ; z=1; $u_{min}=0.033$

disc=12nas lens=10nas BLR=1200nas

Disc should show slight resolution effects
BLR should be significantly less amplified
Spectral changes across event could measure AGN structure

- sensitive to impact parameter, lens mass, BH mass
- but in very interesting regime!

FIN