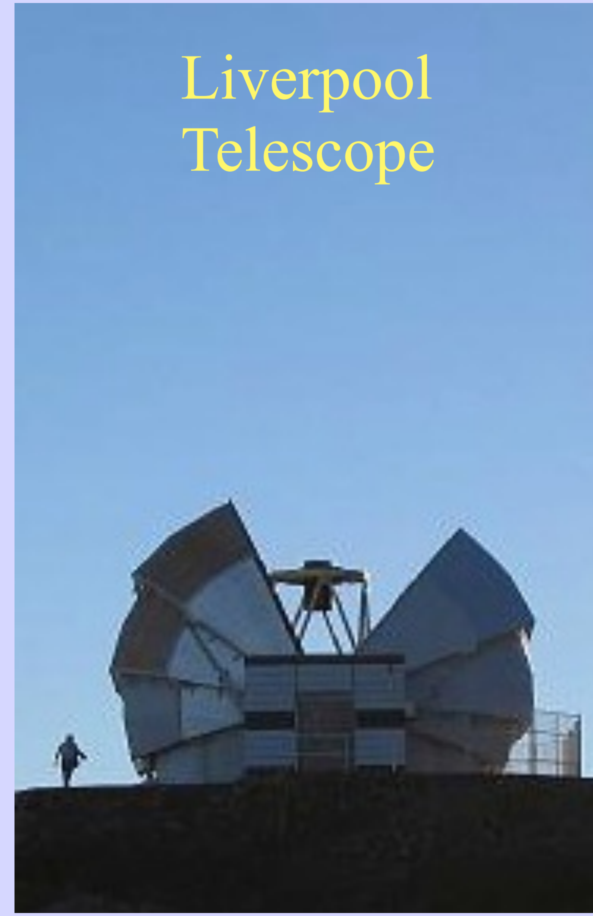
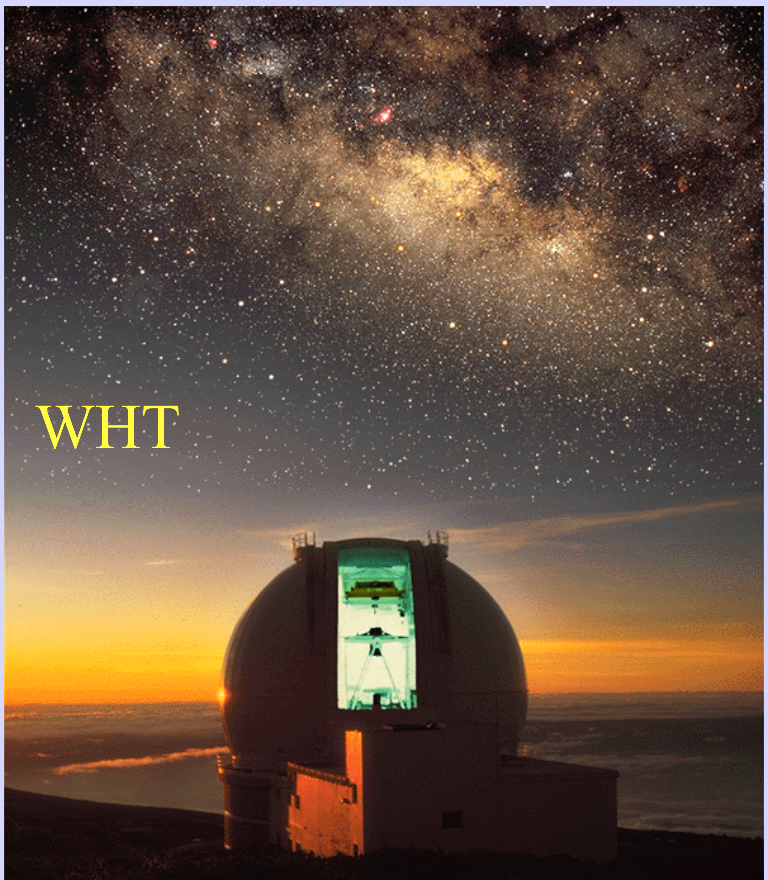


mapping the BLR with microlensing



Sept 2014
Andy Lawrence
Austin

Team

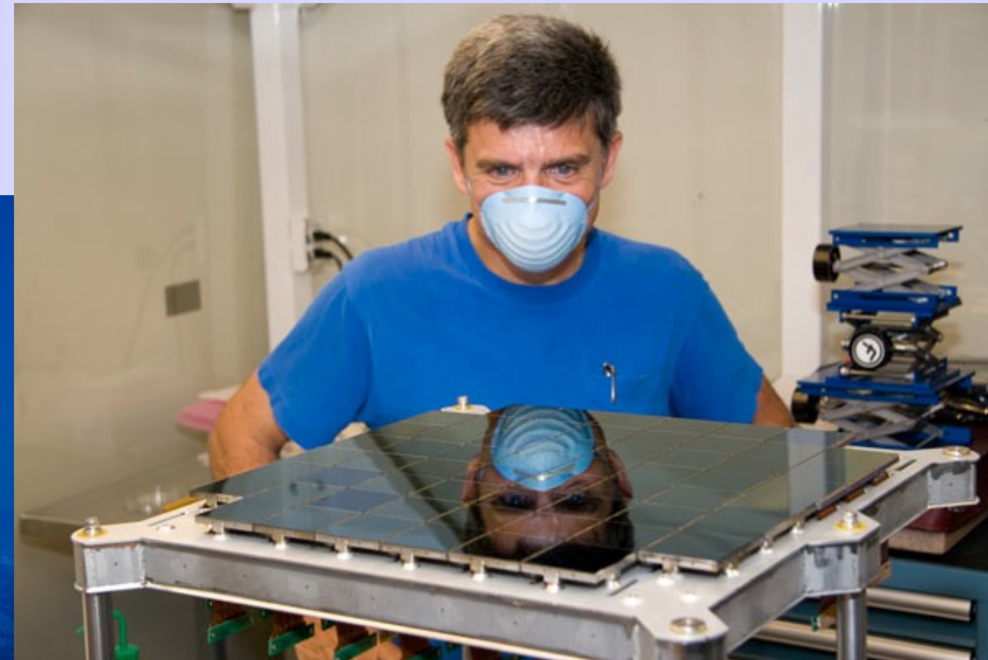
- Alastair Bruce, Chelsea MacLeod, Suvi Gezari, Martin Elvis, Martin Ward, James Collinson

  and

- the Harvard and Belfast transient pipeline teams (especially Stephen Smartt, Ken Smith, Darryl Wright) and

- the whole PS1 team

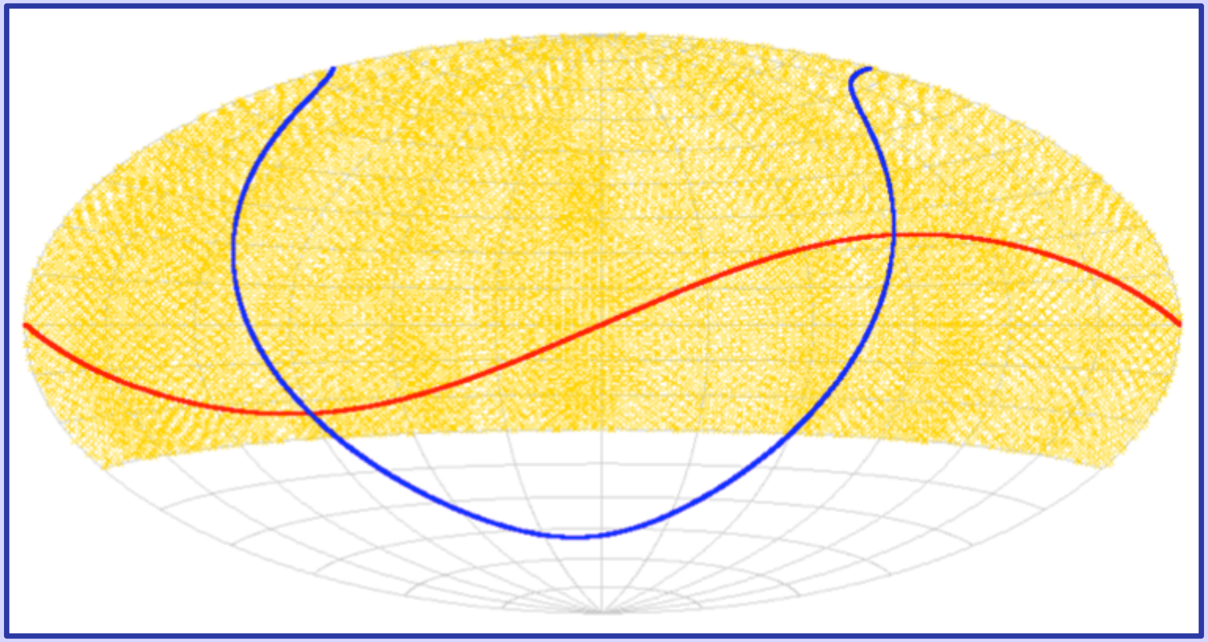
PanSTARRS-1

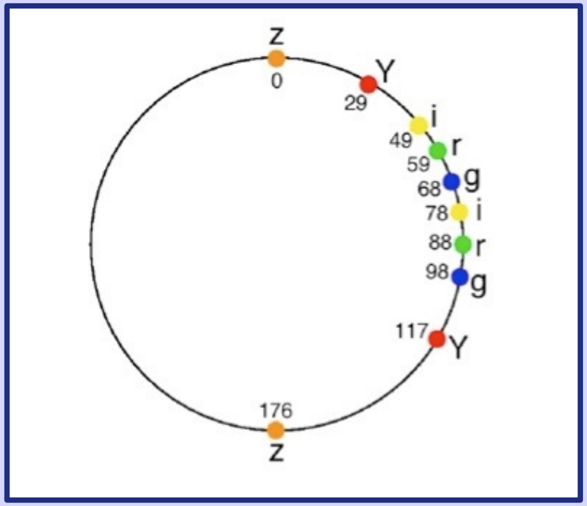


- 1.8m telescope on Haleakala
- Gigapixel camera
- *grizy* filters
- 7 sq.deg. FOV
- Prototype for PS-4
- Built by Univ.Hawaii
- operated by PS1SC
- survey Mar 2011-2014

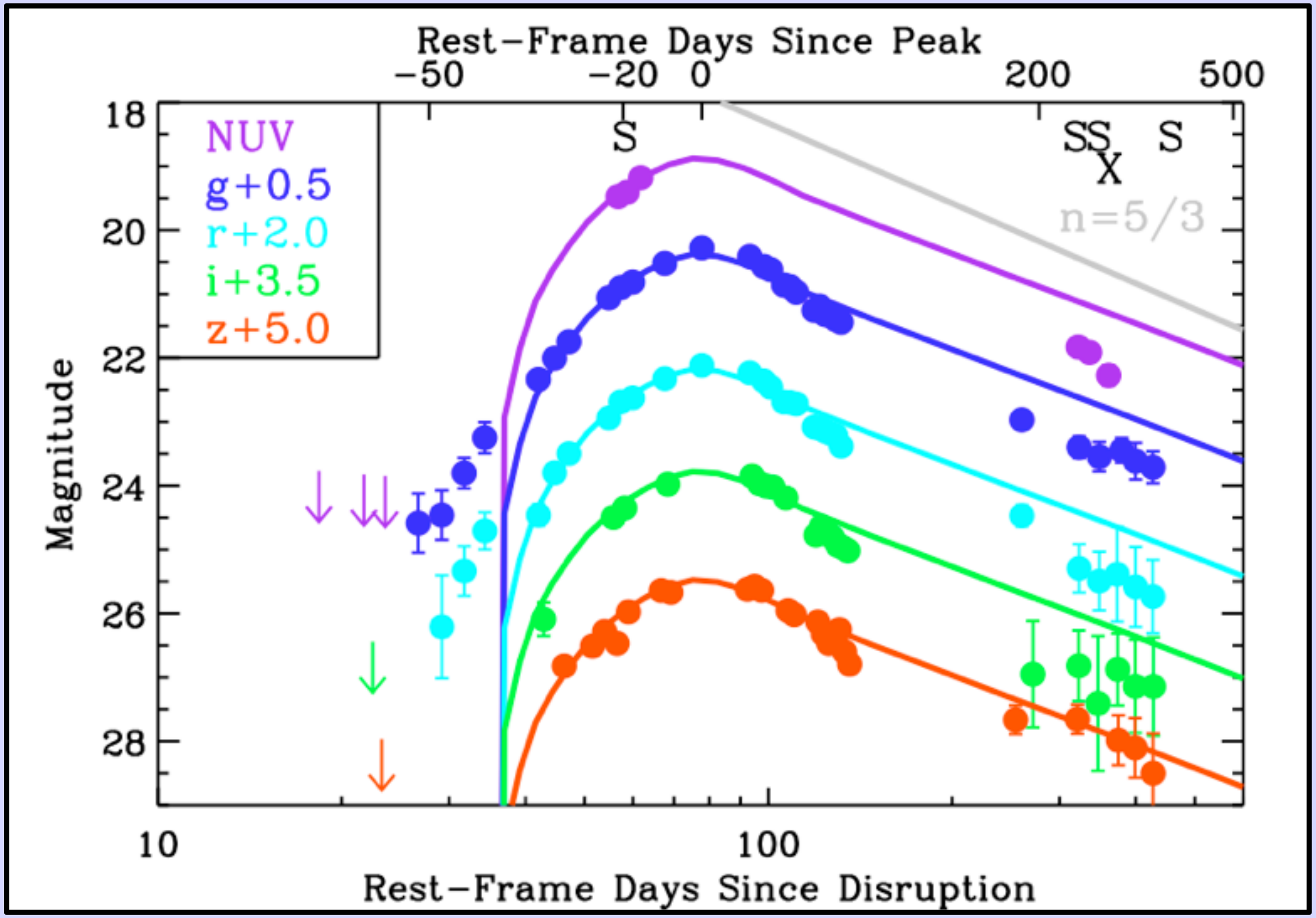
Survey

- 10 Medium Deep Survey fields : four day cadence
- g~23.5 per epoch; eventual g~26
- 3π survey *grizy* 4 times/yr; 20 visits/yr in some filter
- g~21.5 per visit ; stacked g~23
- seeing : mode 1.0" median 1.25"
- **public release April 2015 through MAST/STScI**



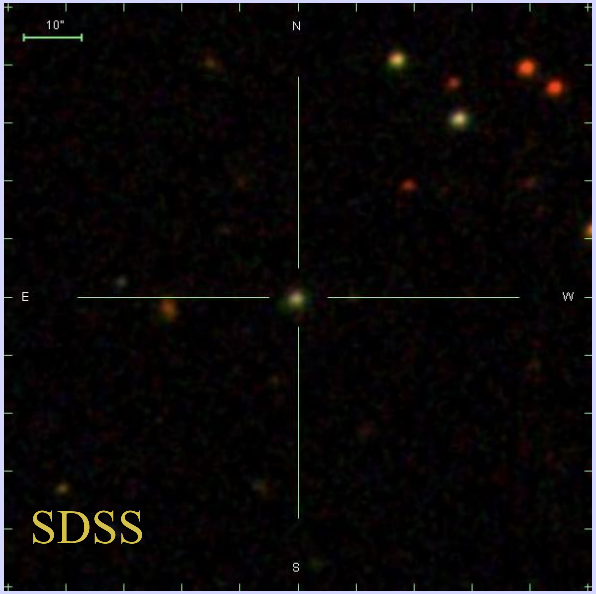


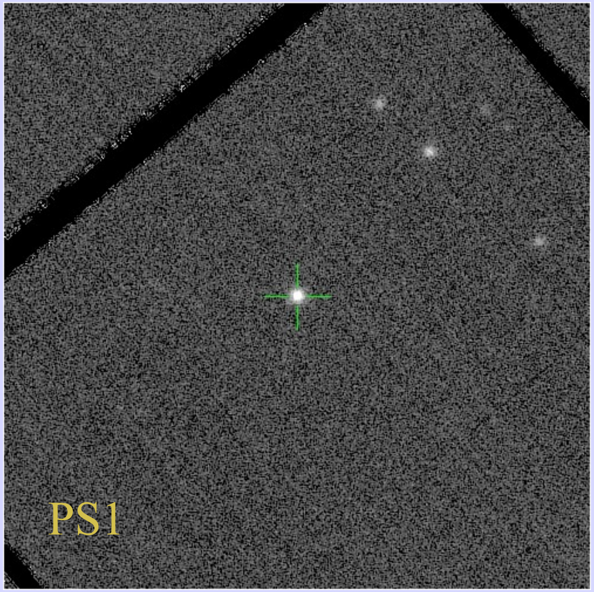
MDS results : TDEs



Small number of TDE candidates

Gezari et al 2012





First results:
Lawrence et al 2014 submitted

3pi Transients

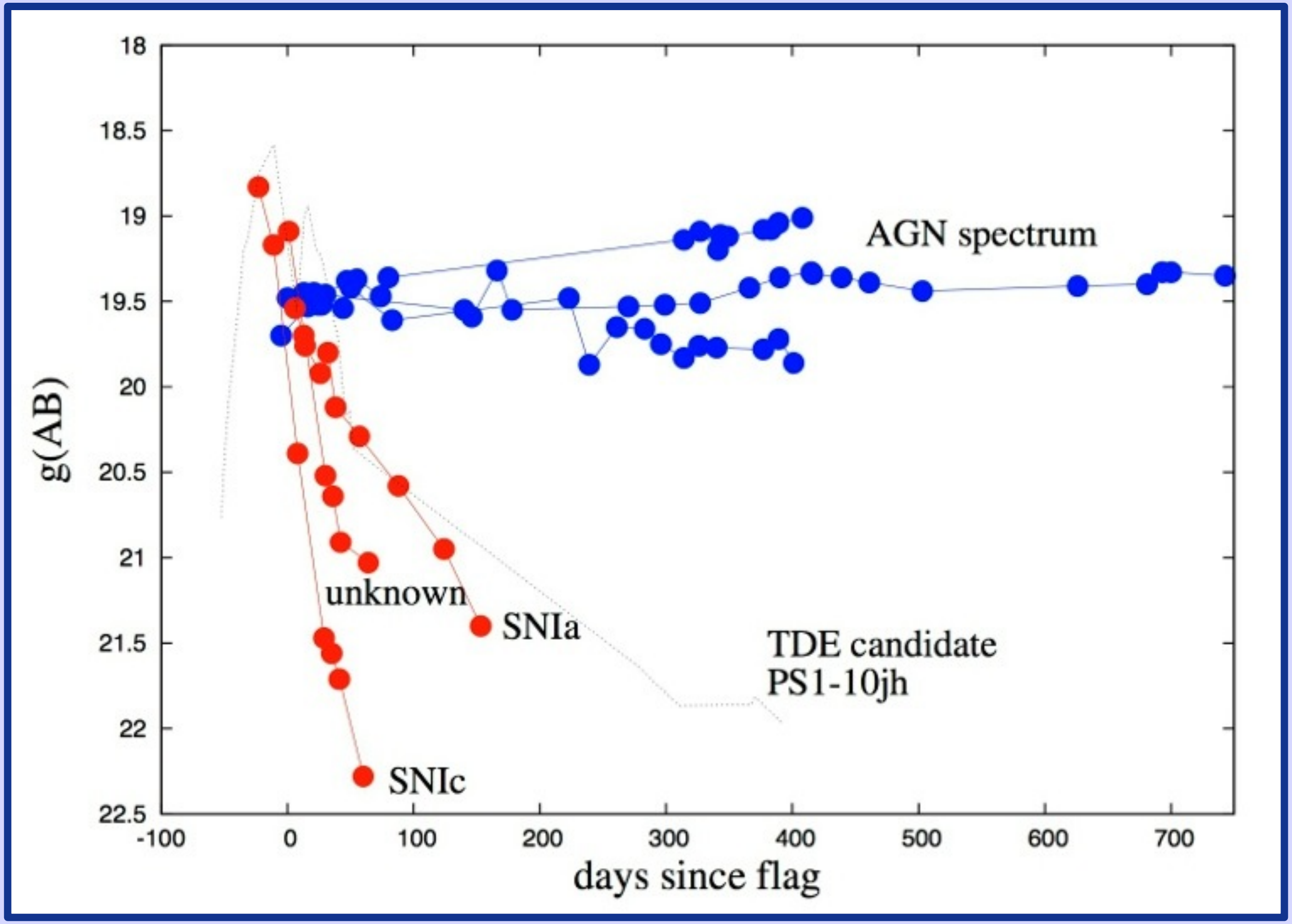
Triggered as m_{PS1}-m_{SDSS} >1.5
SDSS object = galaxy
monitored with Liverpool Telescope
gradually accumulating optical spectra

SDSS galaxy : g~21-23
transient : g~19-20

Initial sample:
76 targets
33 with AGN spectrum +20 probable AGN
6 with SN spectrum +17 probable SNe

Extended sample:
116 targets
48 definite / 81 probable AGN

example light curves

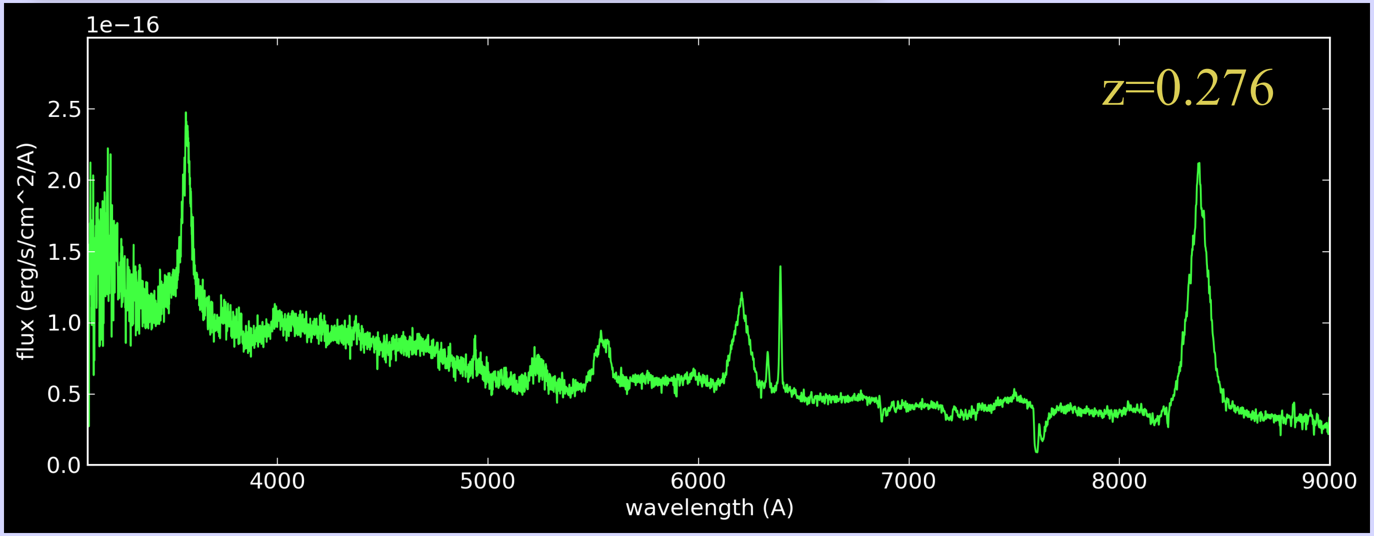


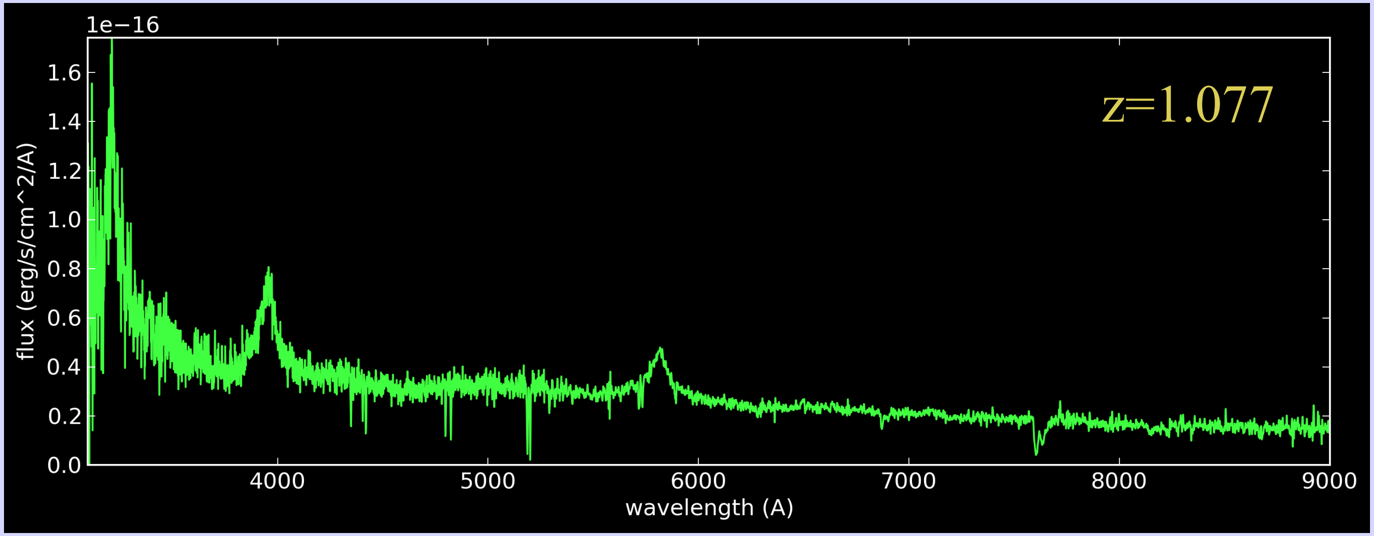
red = fast
($t_{1/2}$ ~ month)

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

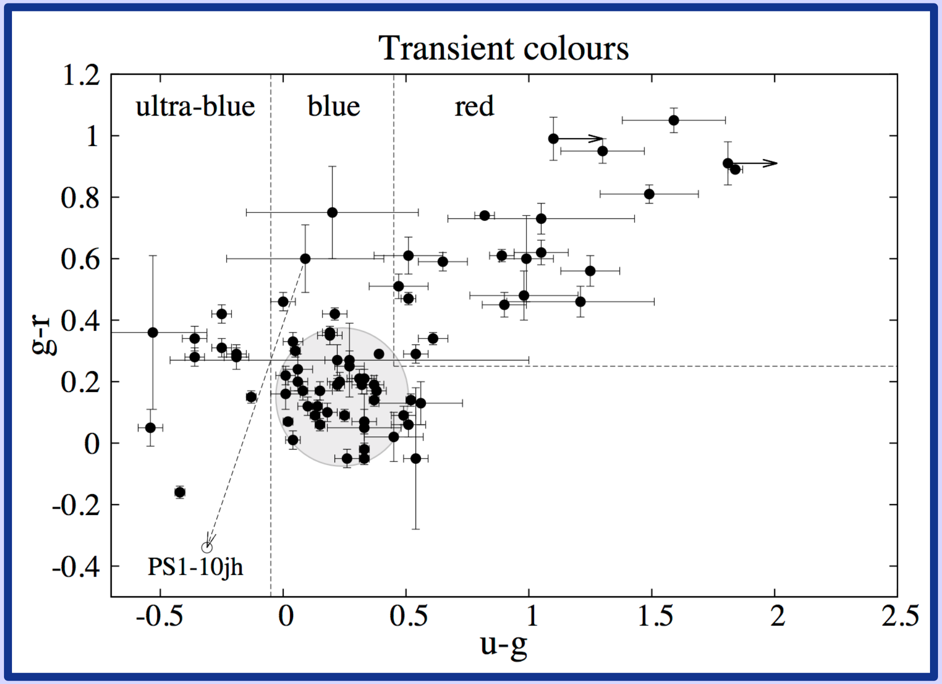
Much slower than predicted for TDEs

example spectra

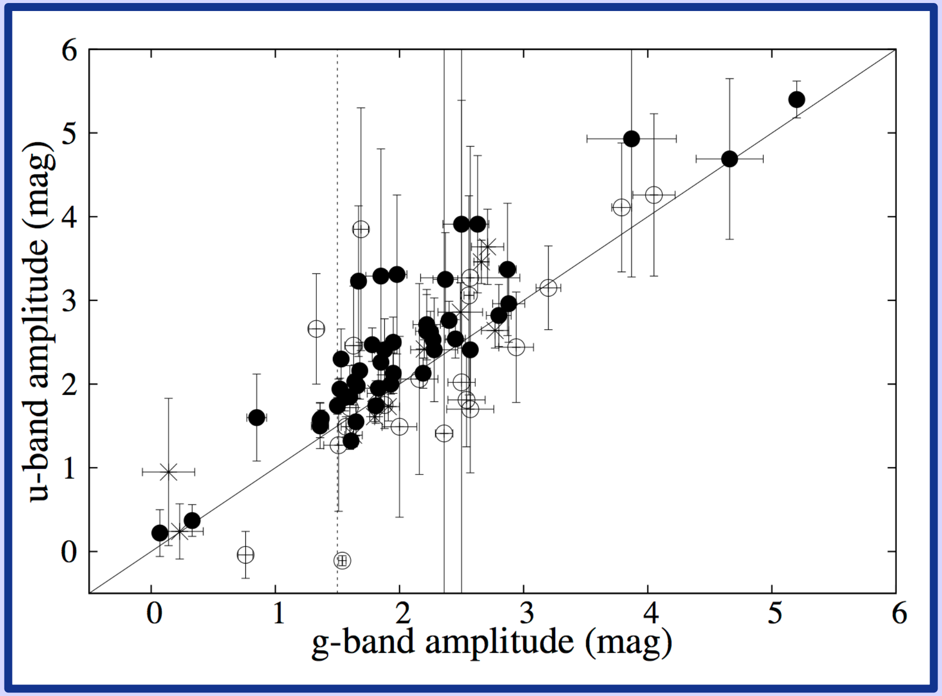




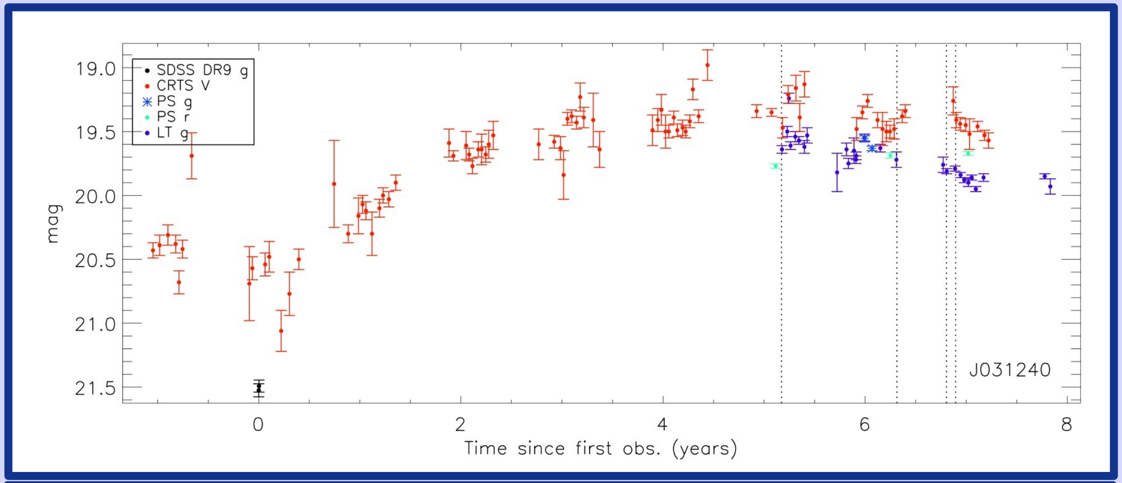
Forty-eight normal looking AGN at a range of redshifts

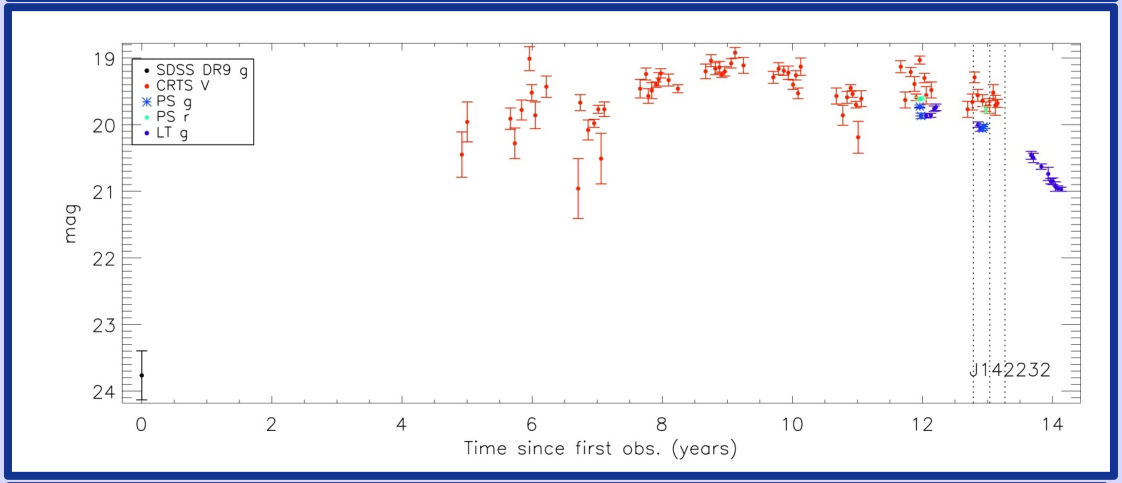


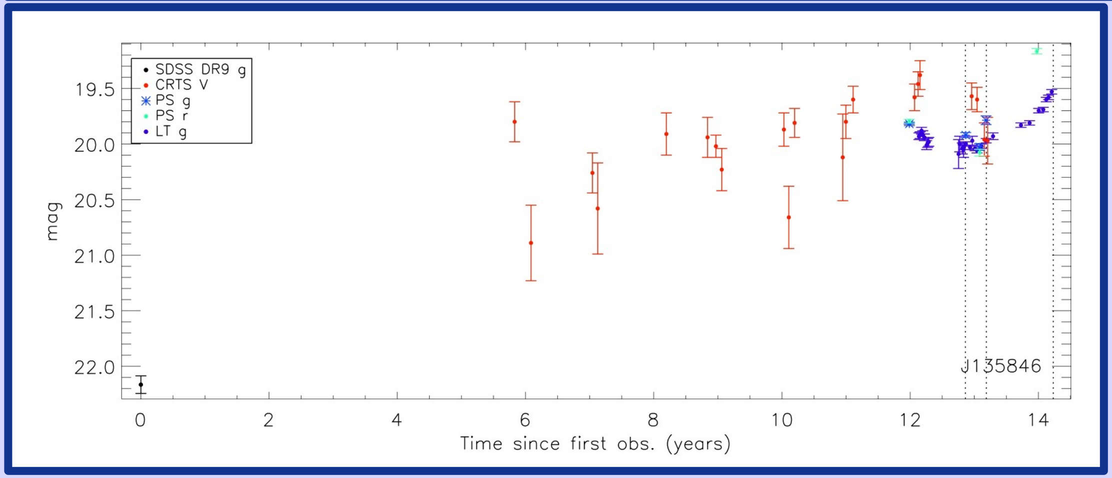
Some objects are ultra-blue



Median amplitude factor ten







Improved light curves with past CRTS data

Smooth slow outbursts

do AGN normally do this?

No!
typical AGN variability $\Delta m \sim 0.3$ mag

fraction with $\Delta m > 2$ is $\sim 10^{-5}$ (MacLeod et al 2012; SDSS repeats)

blazars can be large amp but erratic
and shorter timescale

Tidal Disruption Events?

unlikely

total flare energy 50 times too large

timescale years c.f. months

Accretion disc instability?

unlikely

expected timescale ~10^4 years

duty cycle bizarrely small

Foreground microlensing

see Lawrence et al 2014
for details

AGN at z~1
foreground galaxy in ~ 1/500 cases

Amplitude x30 ==> θ/θ_E~0.03
Once every ~ 14,000 years

On-fraction ~0.04%

Faint AGN/sq.deg ~15,000

Predict a few tens “active” in PS1

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

size/timescale

$z_s=1$, $z_l=0.25$, $m_l=1M_{sun}$

For A=30 (u_{min}=0.03):
Angular scale ~ 97 nas
Linear scale ~ 80 AU

For transverse velocity 300 km/s

t_E ~ 33 years

$t_{1/2}$ ~ 2 years

see Lawrence et al 2014
for details

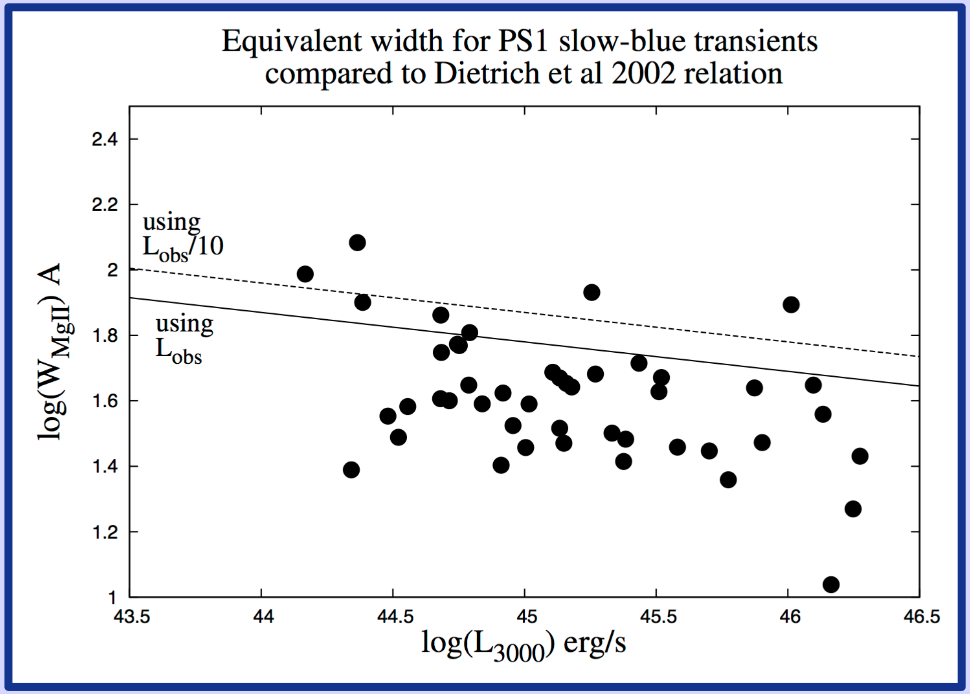
Diagnostic power

z_s=1, z_l=0.25, m_l=1M_{sun}

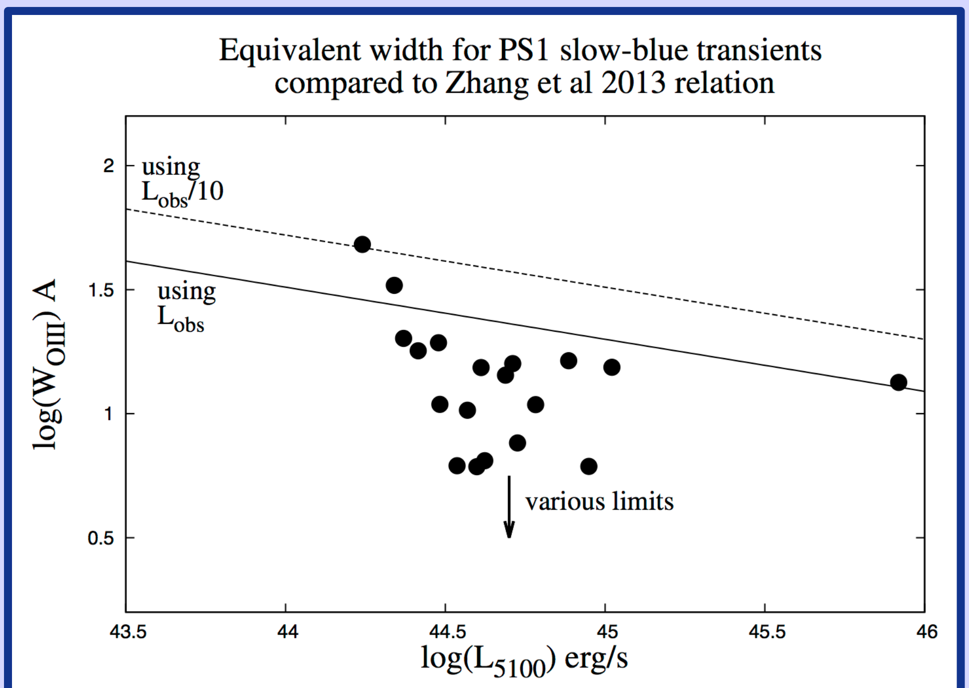
disc ~ 12 R_{10} M_8 nas
lens ~ 97 A_{30}^{-1} nas
BLR ~ 1200 M_8 nas

Disc usually unresolved but will sometimes show colour effects
BLR should be significantly less amplified
Spectral changes across event could measure AGN structure

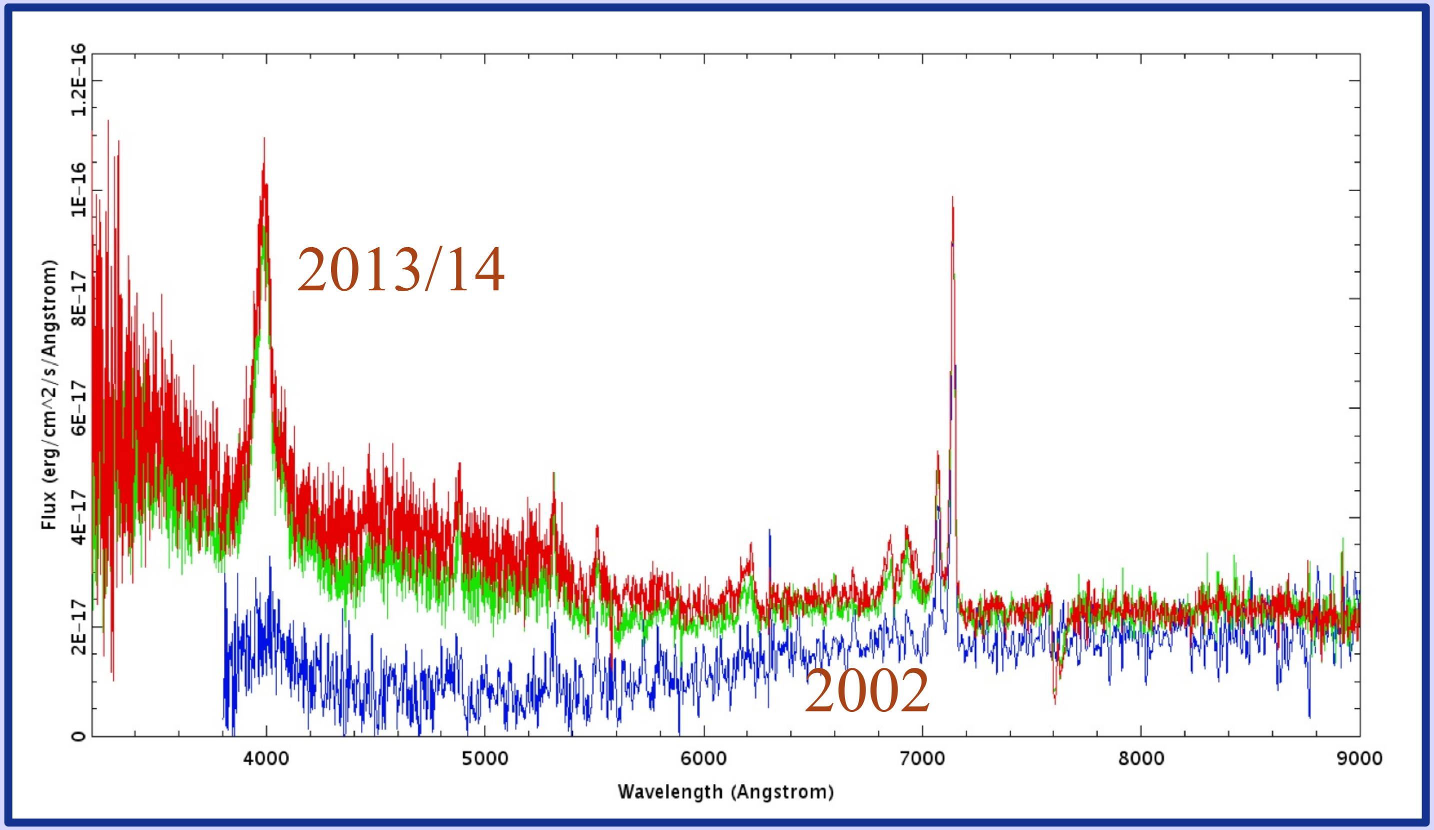
- sensitive to impact parameter, lens mass, BH mass
- but in very interesting regime!



MgII broad line weaker than normal by a factor 2-3

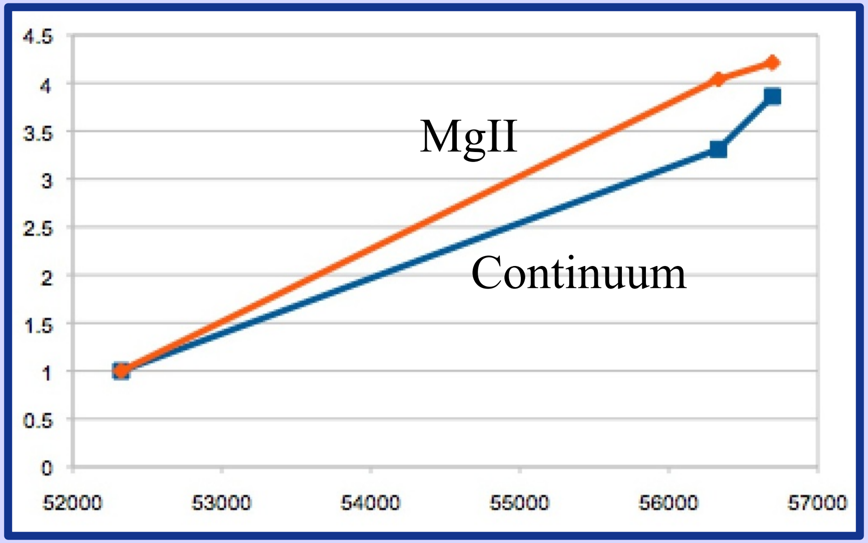


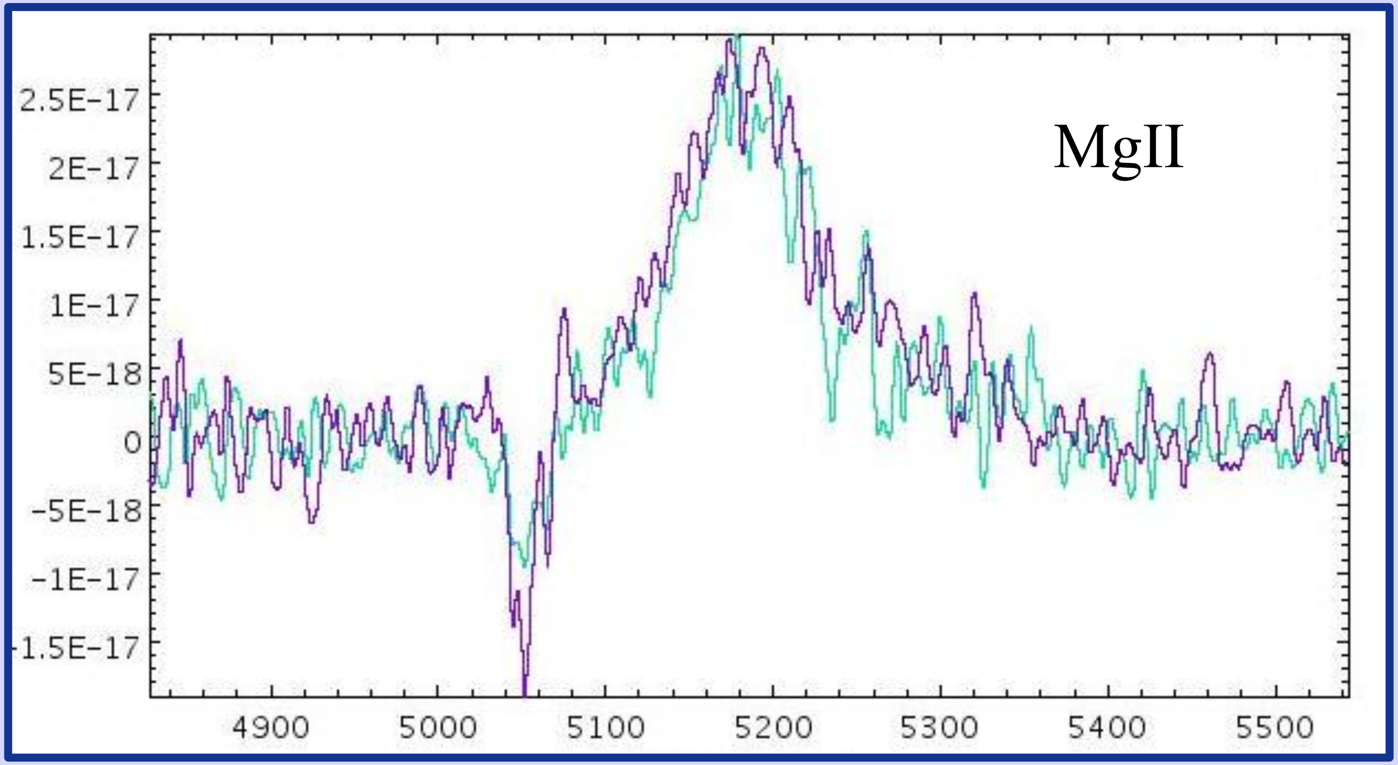
OIII narrow line weaker than normal by a factor 8



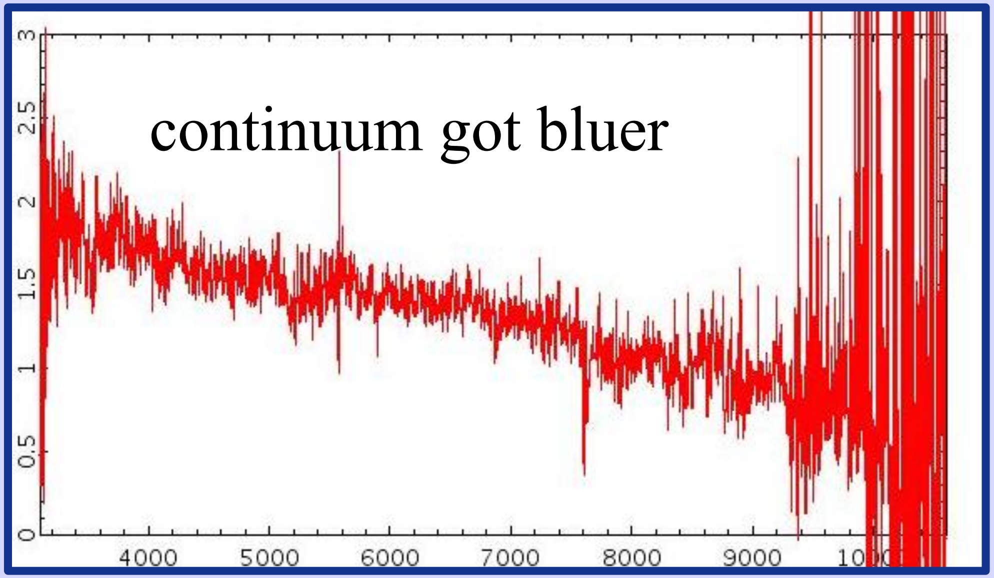
J0181916 changed from Sy 2 to Sy 1

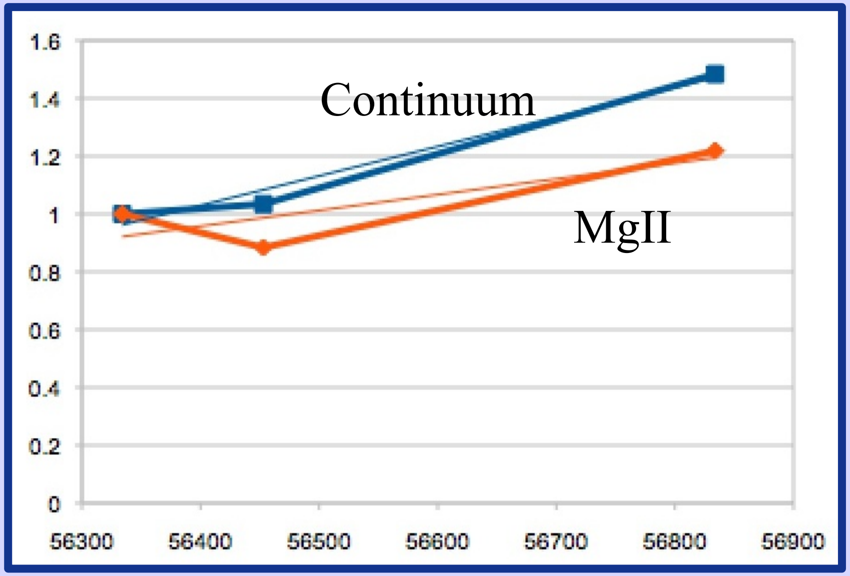
Over a decade,
line has tracked continuum

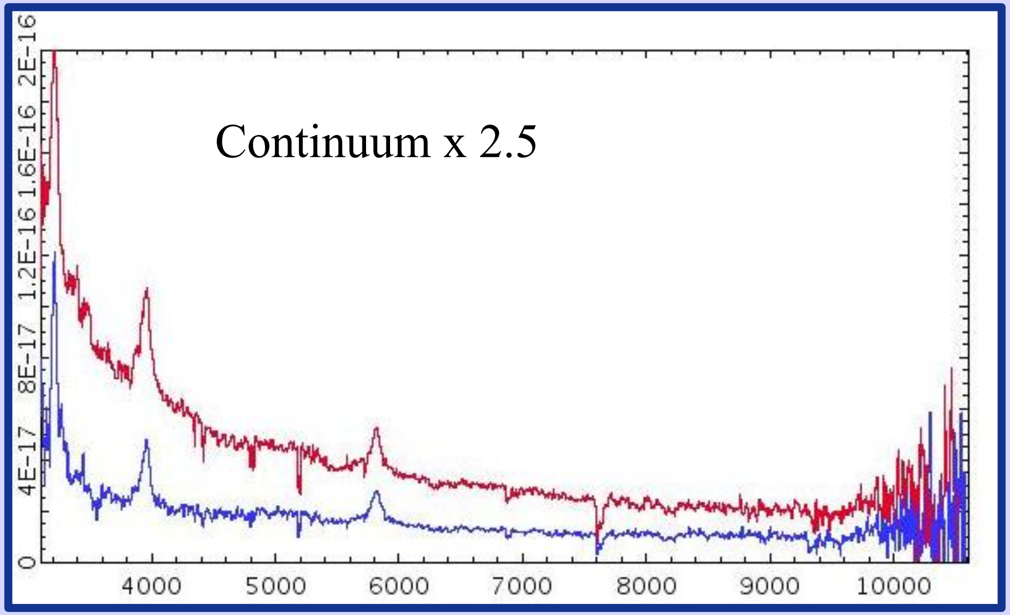


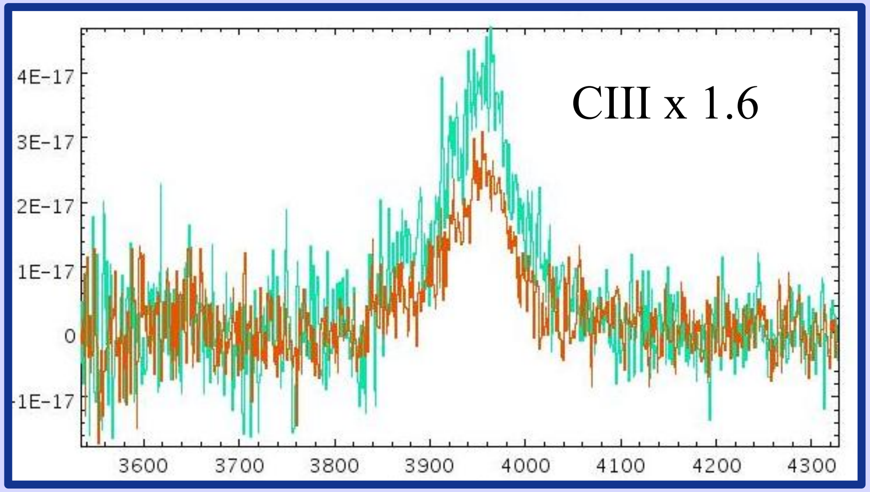


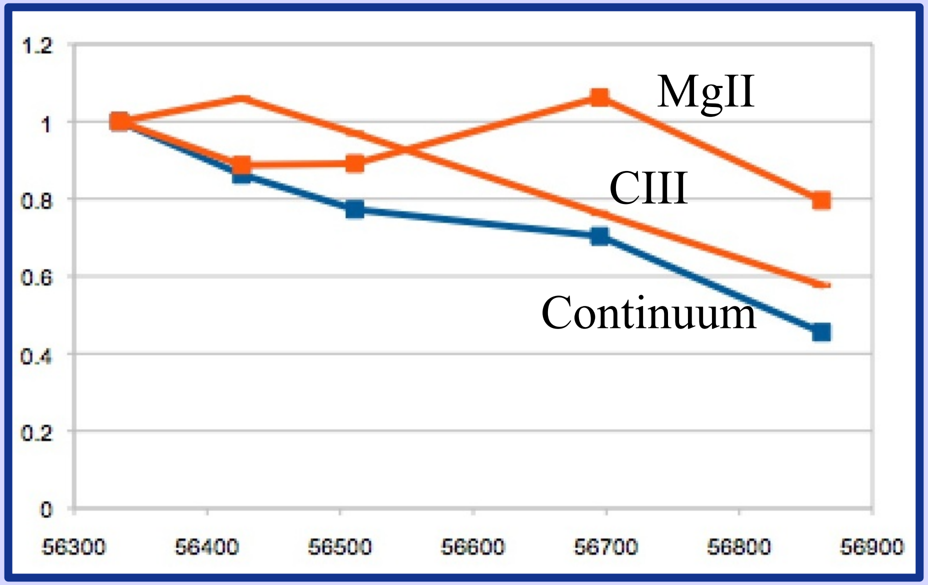
J135846
line change
smaller than
continuum

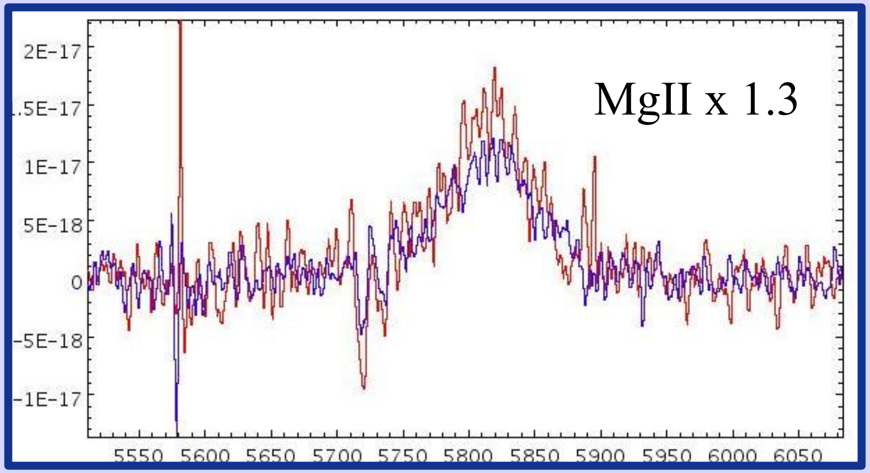




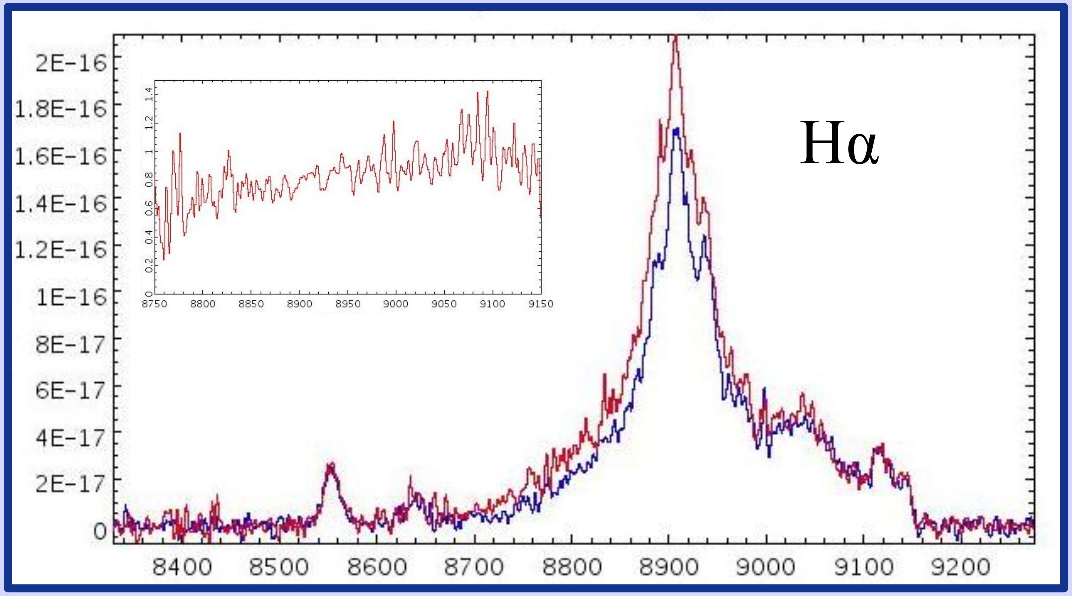


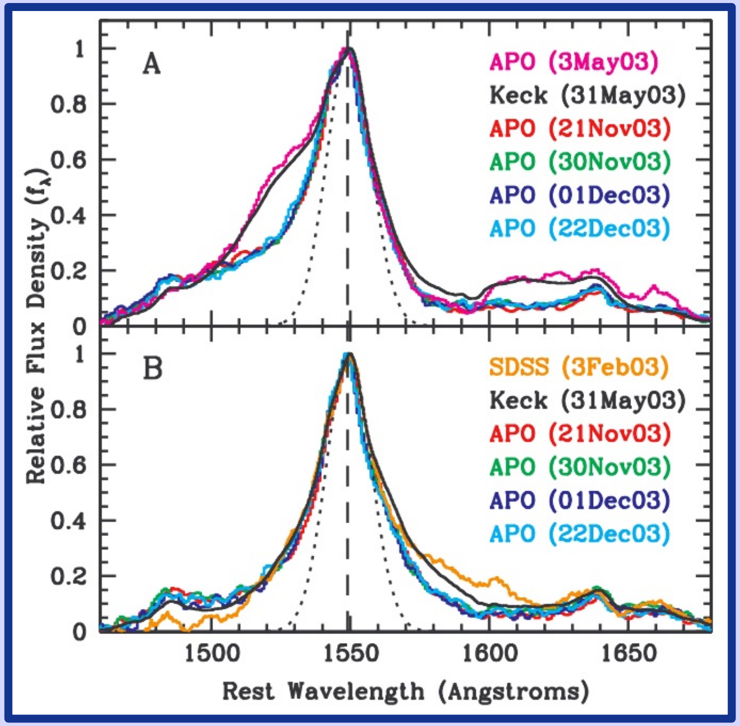




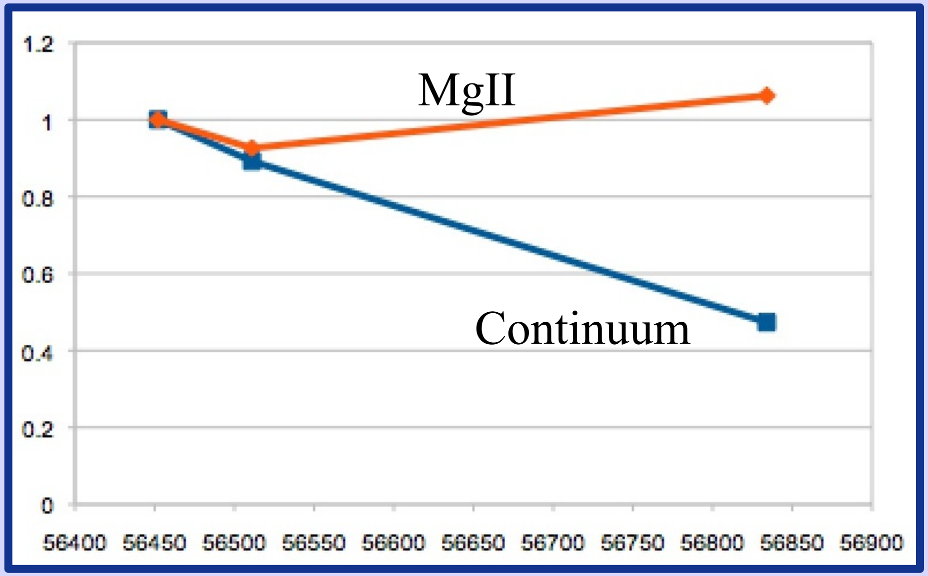


J142232 differential variability





cf Richards et al 2004



J13304 blue wing change

prospects

differential BLR-continuum variability exists

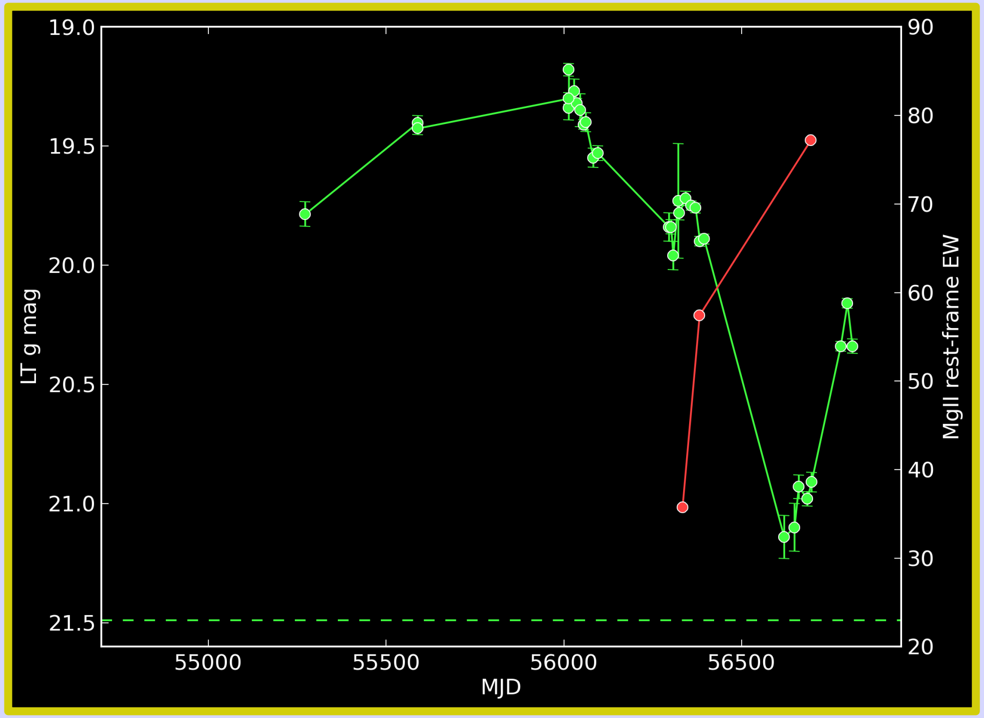
constrain size / structure / kinematics of BLR

reverb: radial structure
lensing: transverse structure

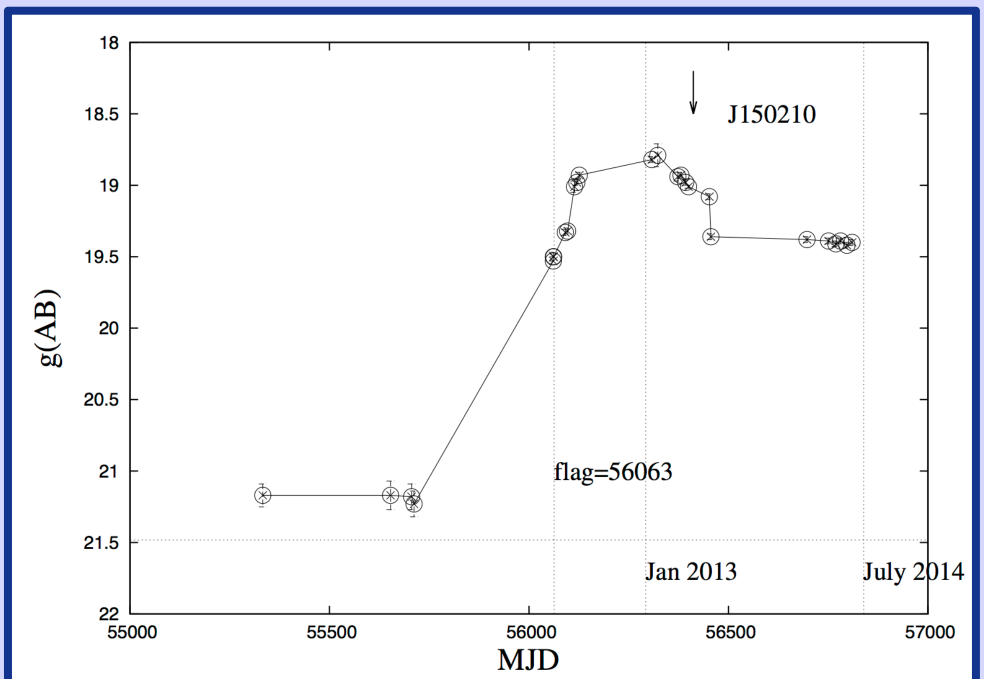
but needs long comprehensive campaigns
with 4m telescopes or better

need to catch on rise and observe over the peak

cute addendum



Second peak



Asymmetric light curve

Either
- not microlensing
or
- binary star lenses

FIN