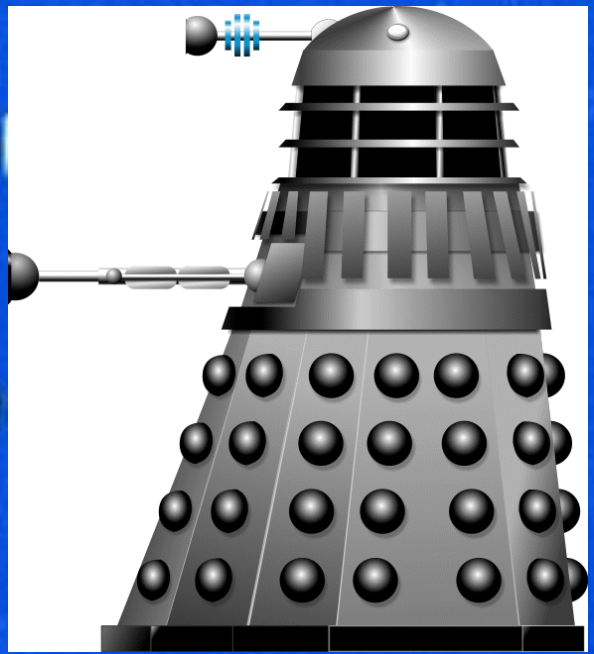
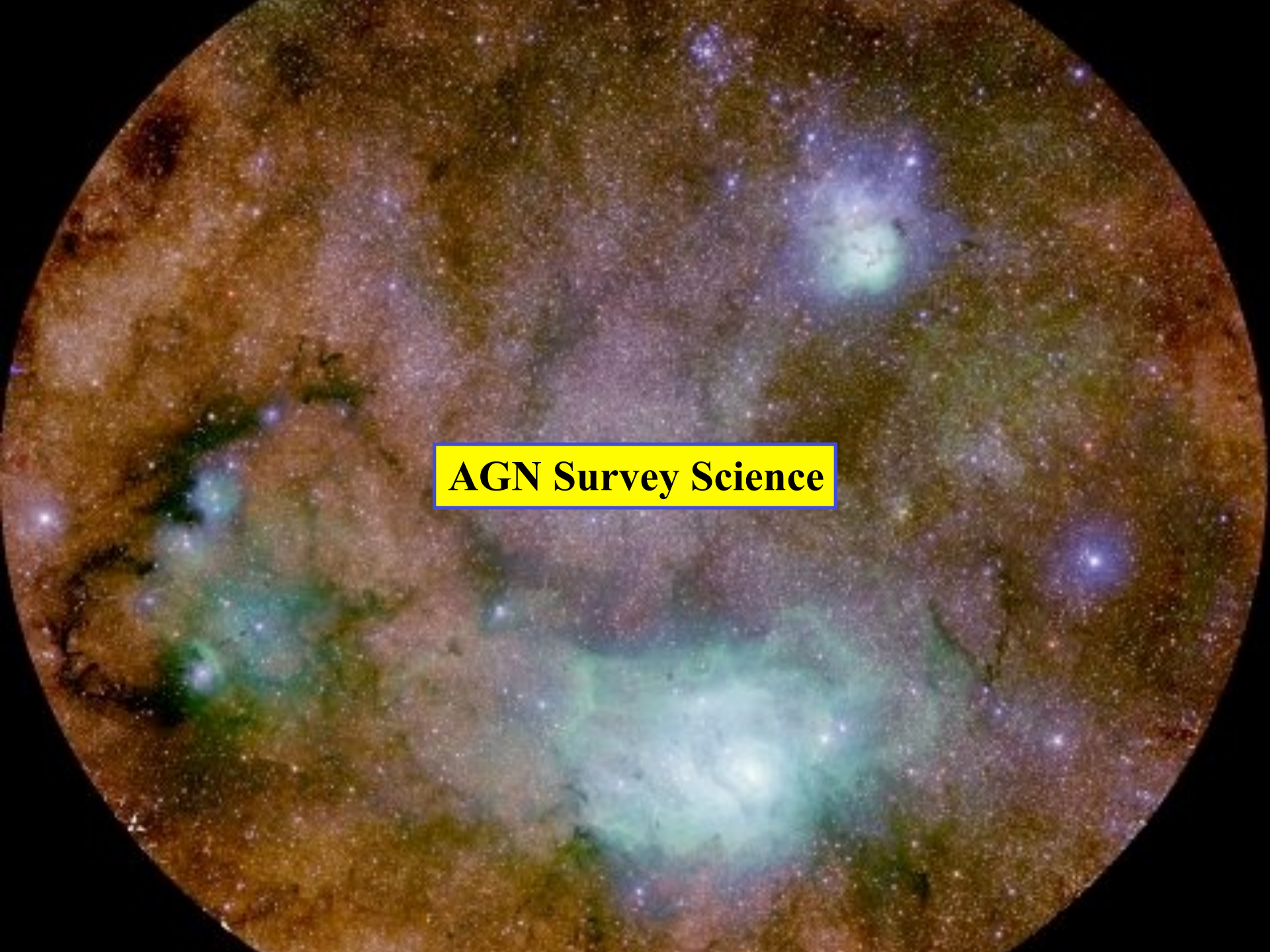
Clues to the structure of AGN through massive variability surveys

Oct 2015
Andy Lawrence
Byurakan




AGN Survey Science

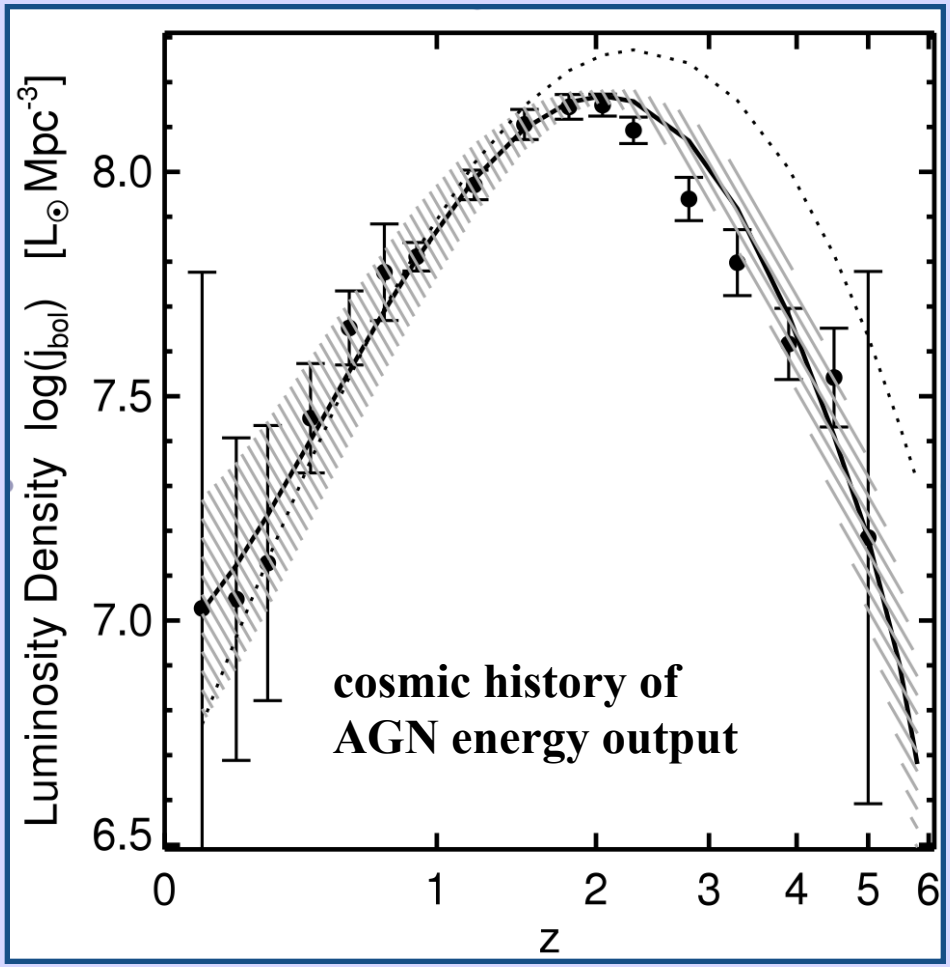
- Discovery
- Population studies
- Rare objects

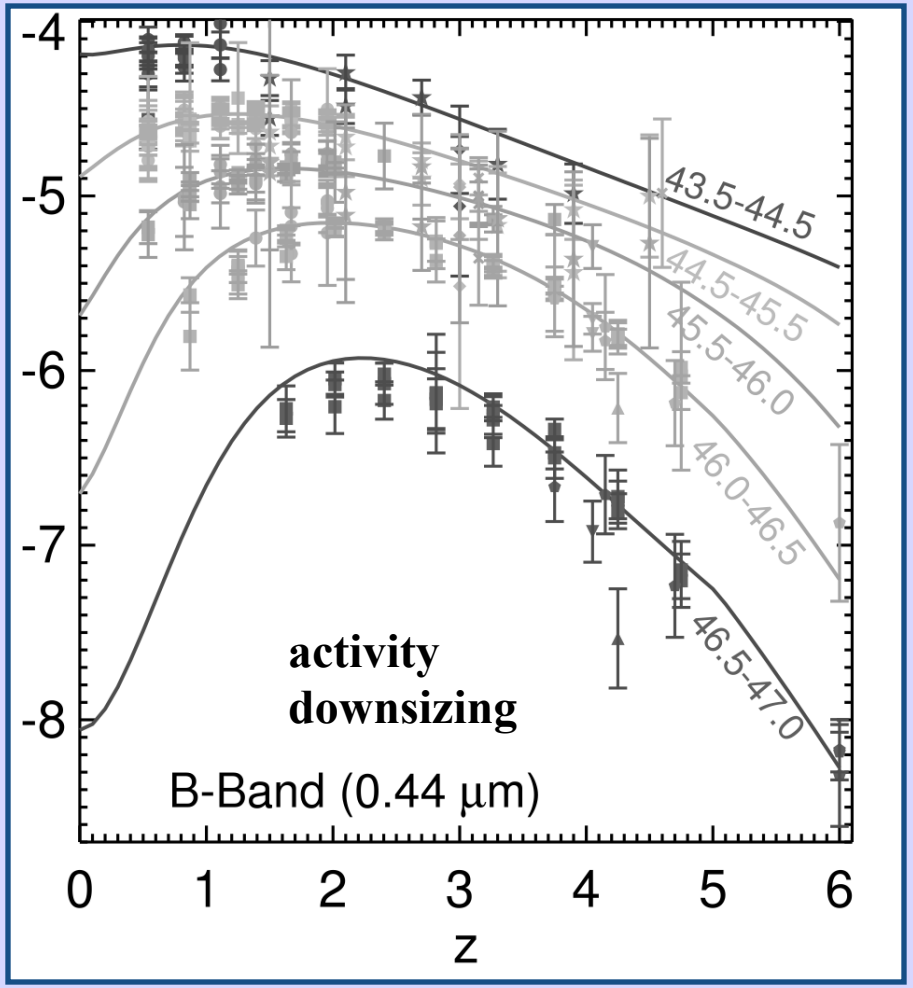
Discovery

Markarian objective prism survey
The beginning of serious AGN studies

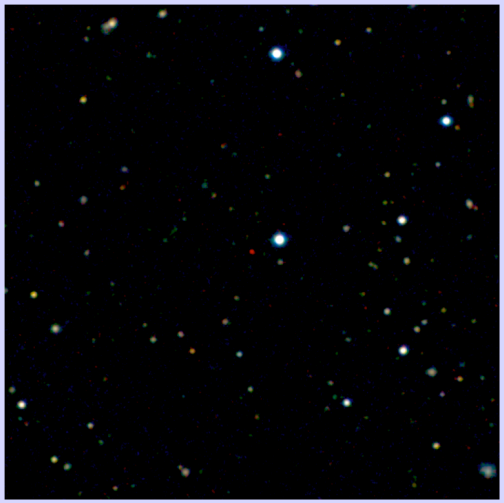
Population studies

Hopkins et al 2007





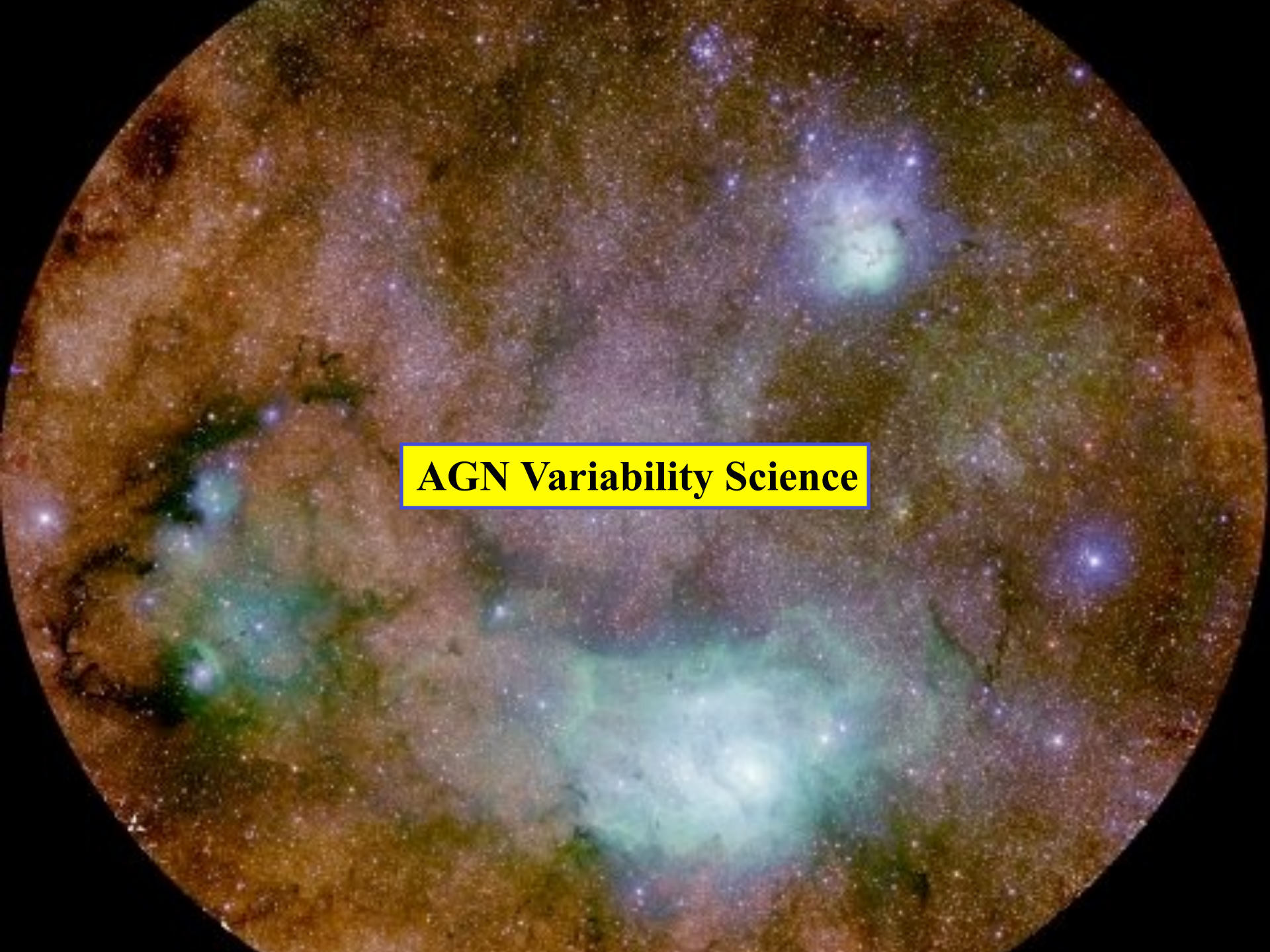
Black hole growth from combining multiple surveys



Rare objects

First z=7 quasar

Mortlock et al 2007


AGN Variability Science

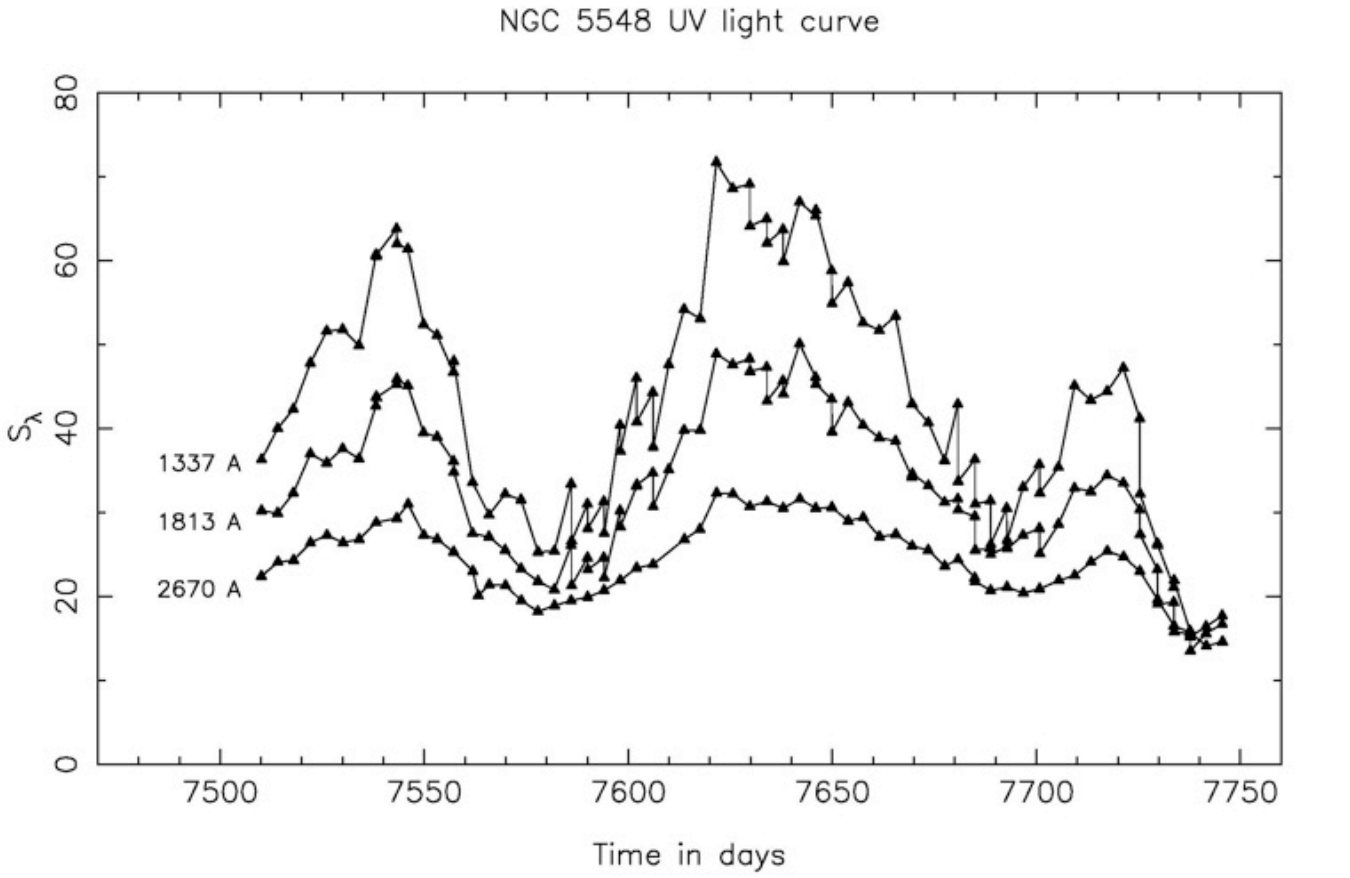
why does AGN variability matter?

For $M=10^8\ M_{sun}$ D=100 Mpc

		θ	t_{light}	t_{dyn}
disc	$100R_g$	1μas	13H	35 days
BLR	10^3R_g	10μas	6 days	4.3 yrs
torus	10^5R_g	1mas	1.6yrs	3100 yrs

viscous timescale ~10,000 yrs

optical-UV variability

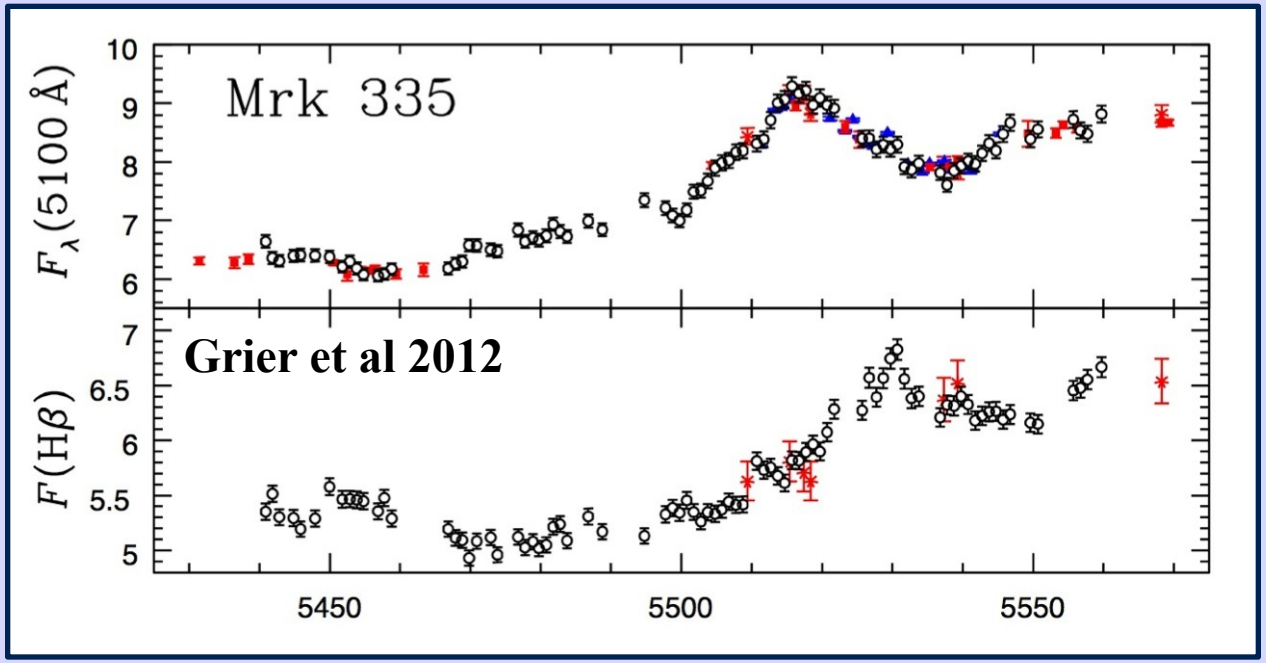


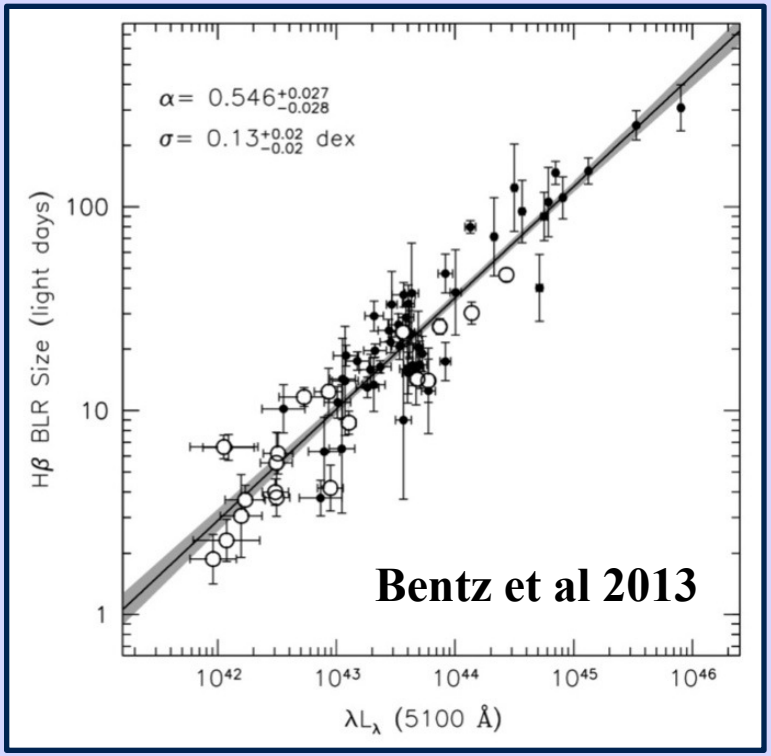
Clavel et al 1991
via Lawrence 2012

mix variable blue thing with constant red thing?

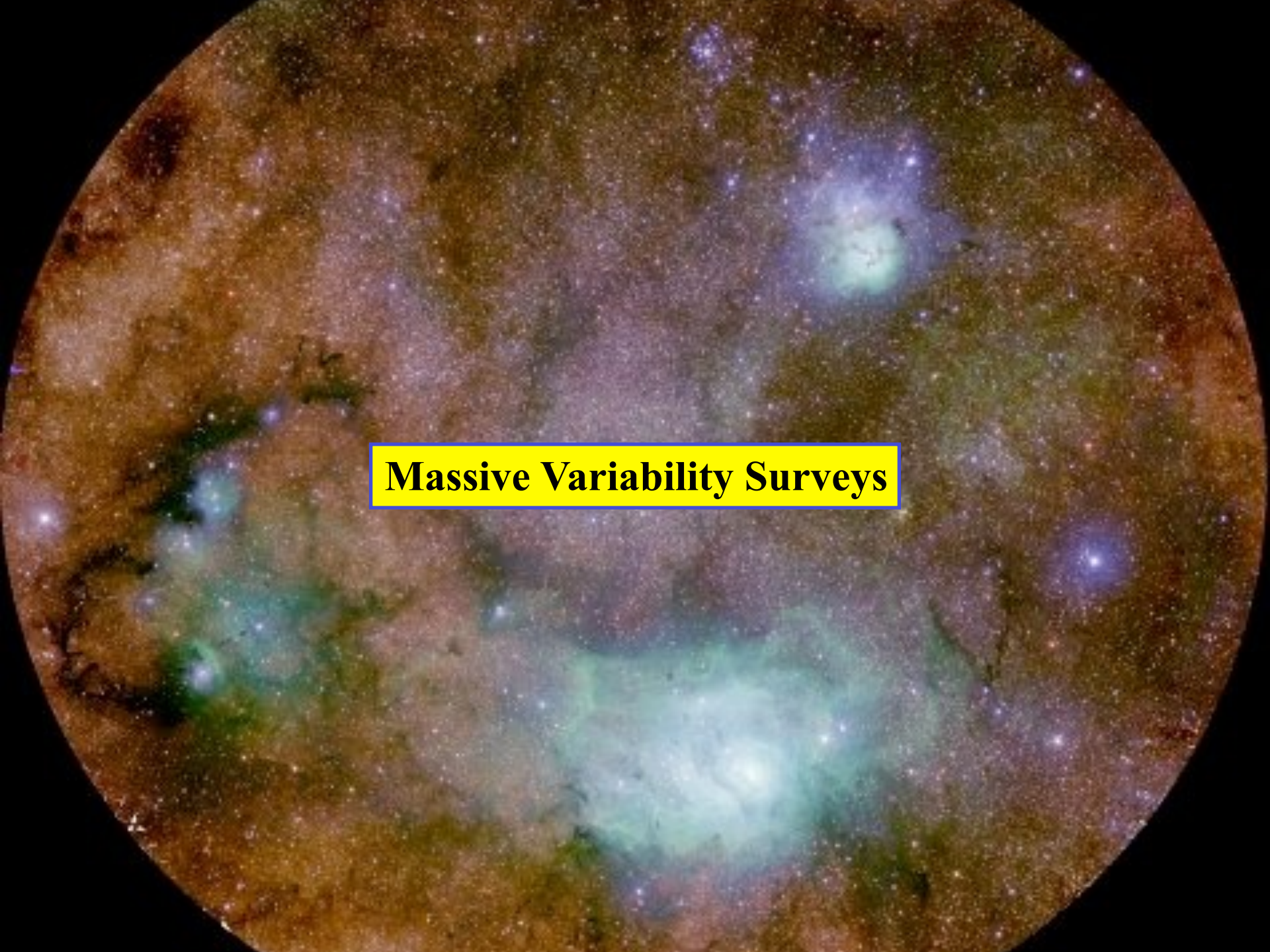
- varies on dynamical timescale
- bluer when brighter
- simultaneous at all wavelengths

BLR variability





- light travel delay time
- size of BLR
- constant U : physics of BLR


Massive Variability Surveys

New frontier is **repeating the sky**

- deep stacking
- moving objects
- transients
- variable objects

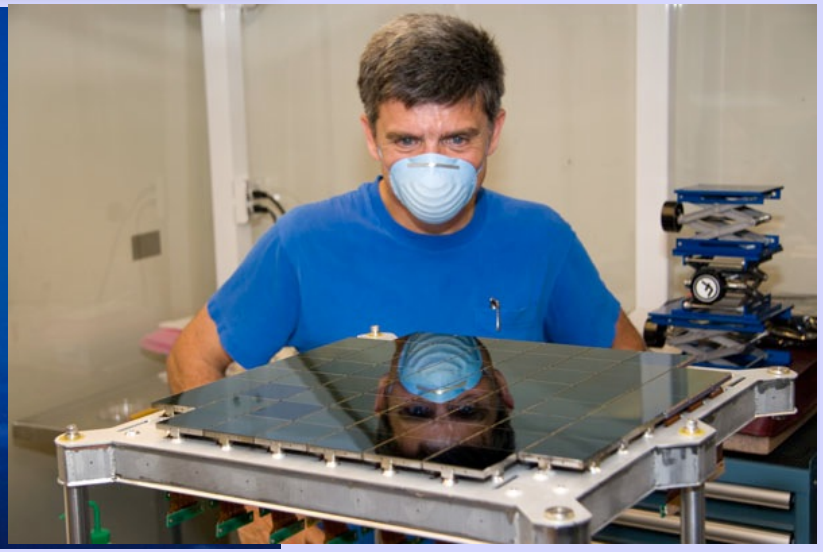
Schmidt (eg Hawkins F287)
Ogle, MACHO
SDSS overlaps and Stripe 82

PanSTARRS

→ LSST

note:
for 0.1” pixels,
sky requires
100TB/band/visit

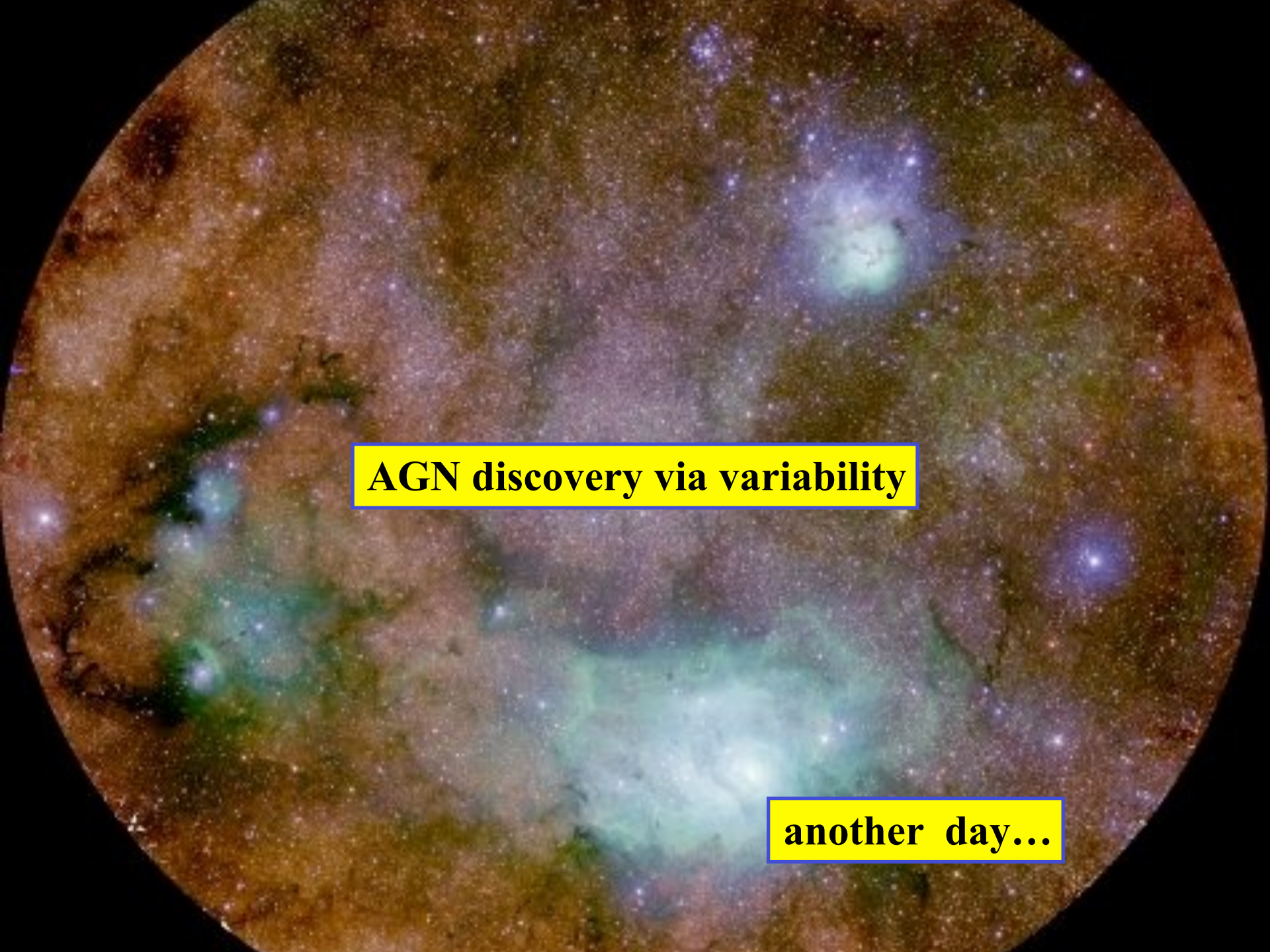
PanSTARRS-1

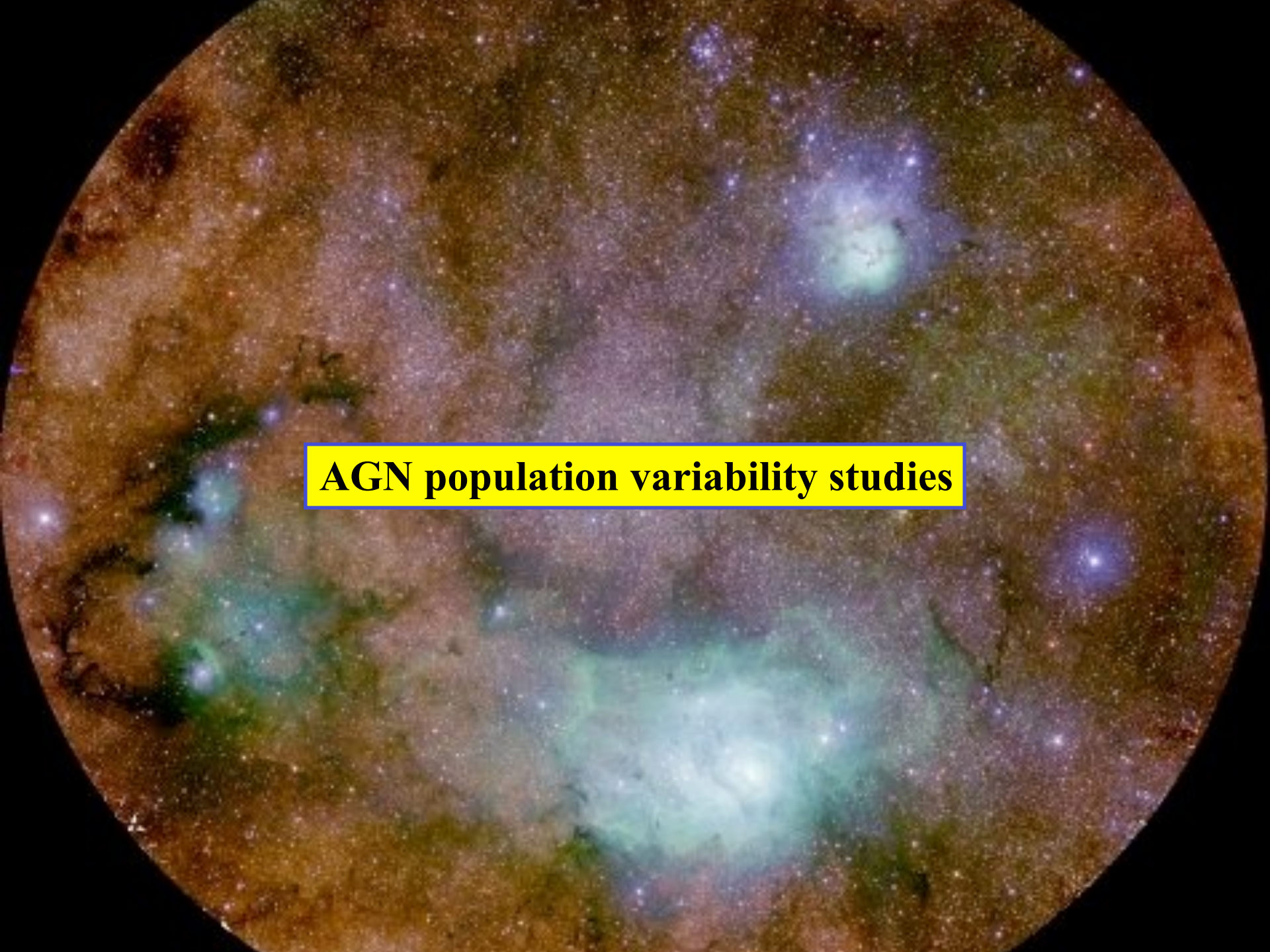


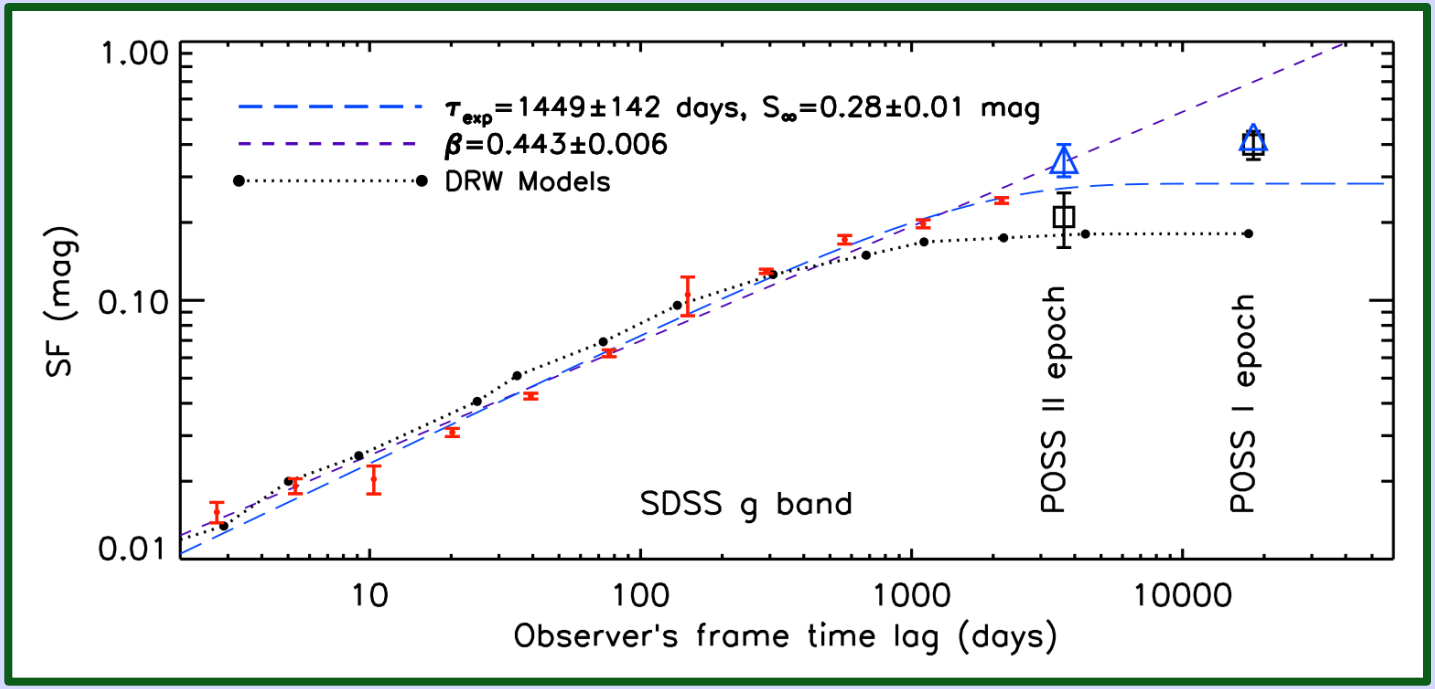
- 1.8m telescope on Haleakala
- Gigapixel camera
- *grizy* filters
- 7 sq.deg. FOV
- Prototype for PS-4
- Built by Univ.Hawaii
- operated by PS1SC
- survey Mar 2011-2014

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

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


AGN discovery via variability
another day…


AGN population variability studies



MacLeod et al 2012

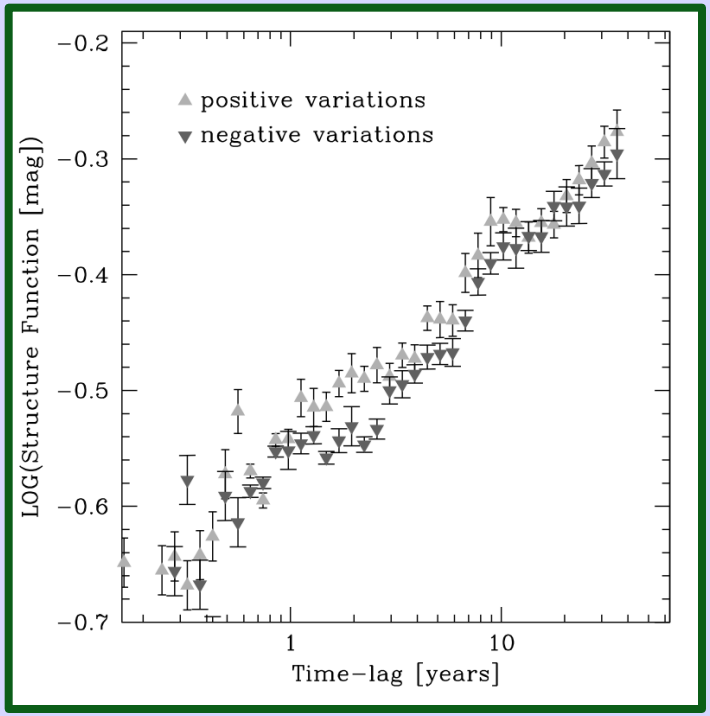
33,000 SDSS quasar repeats

quasars show ~30% flickering that is random walk-like

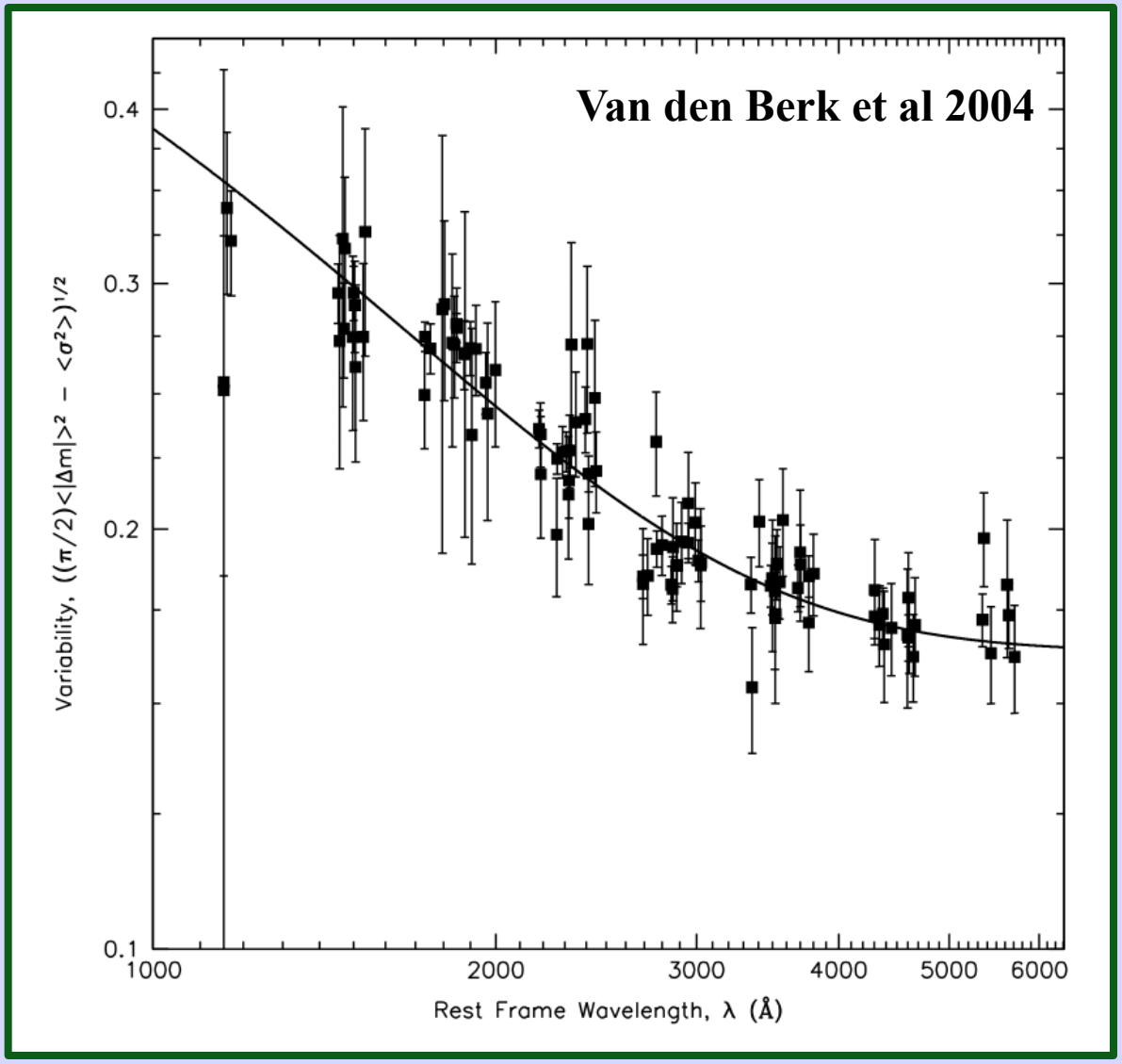
there *may* be a characteristic timescale of ~2 years

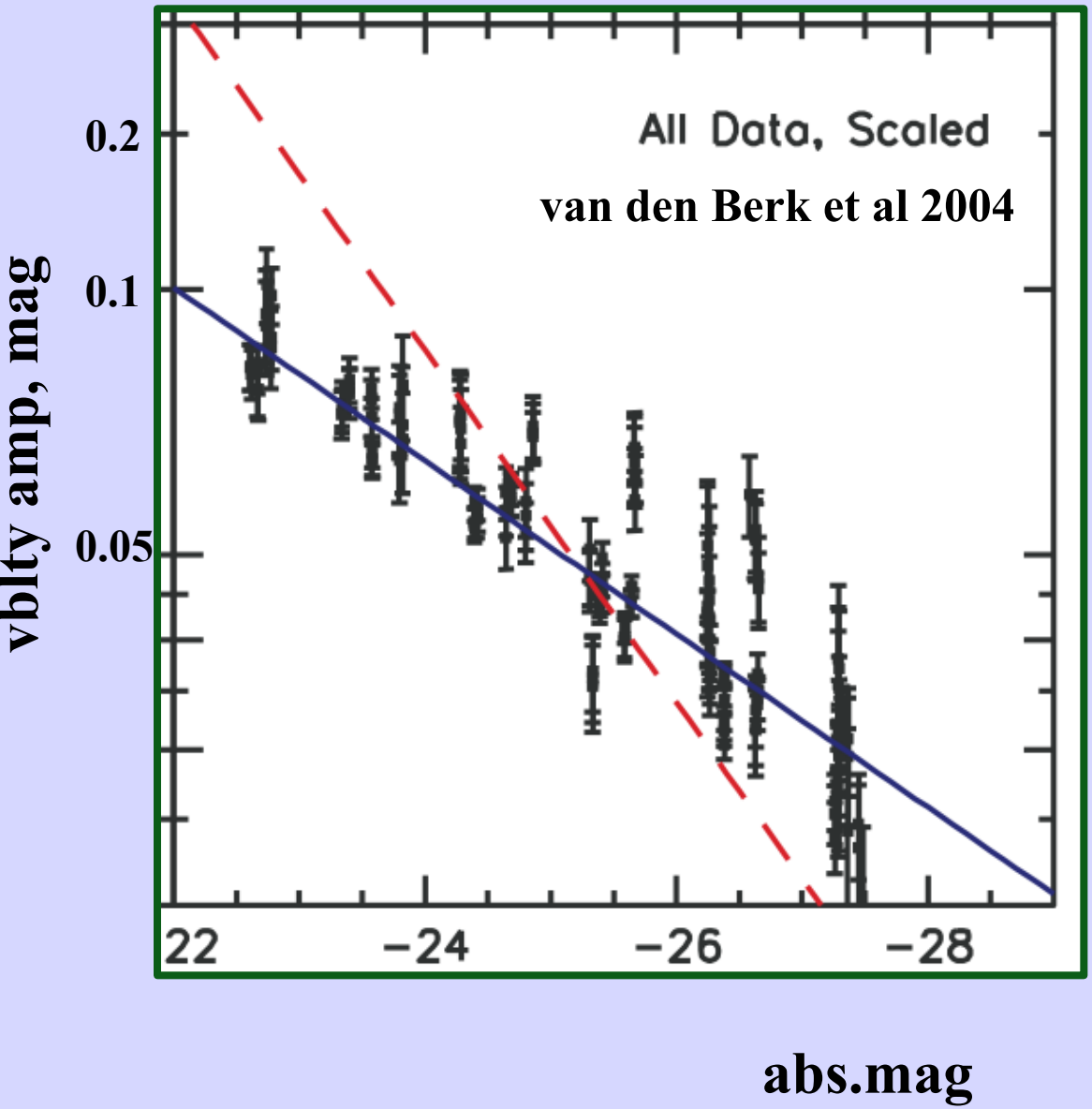
variations are statistically asymmetric

de Vries et al 2005



variations are strongly
dependent on wavelength

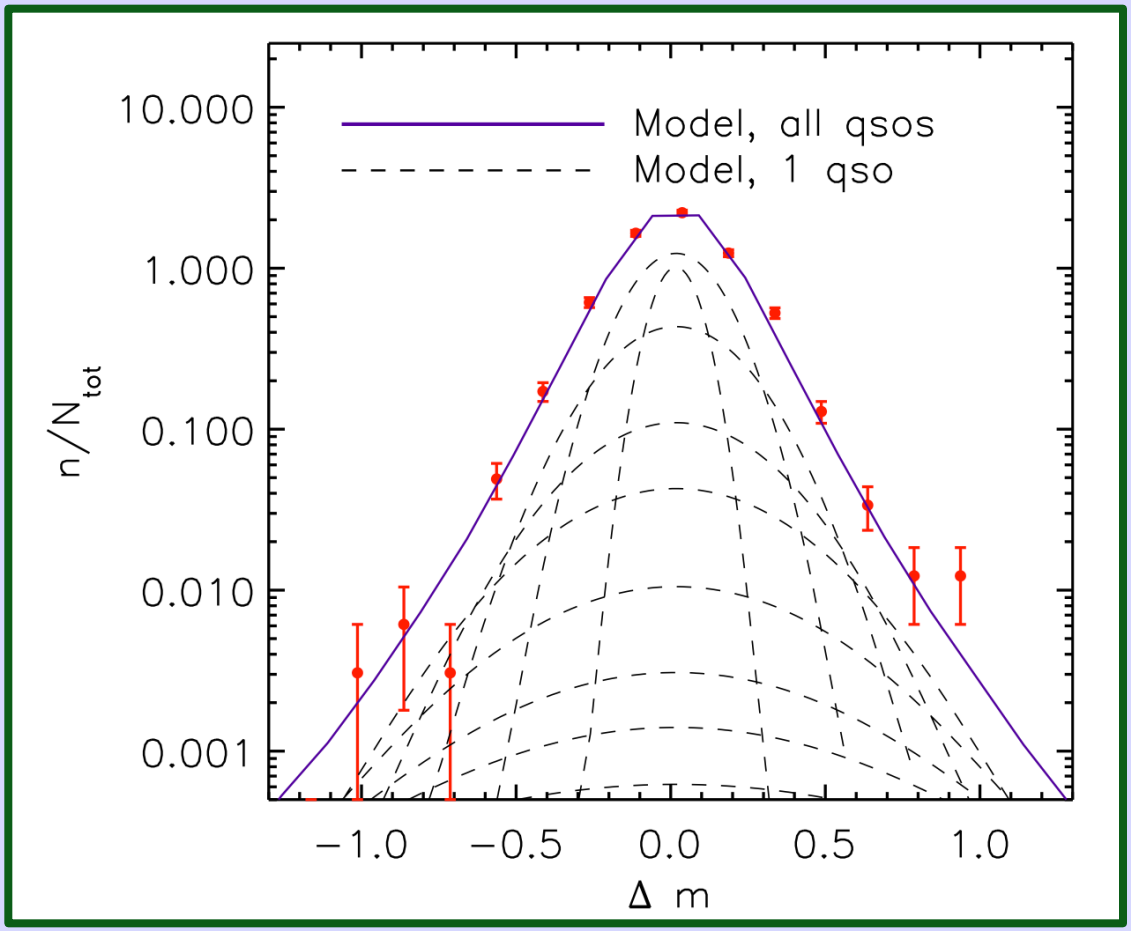




subtle luminosity effect

quasars 100 times more luminous vary by 6% instead of 15%

MacLeod et al 2004



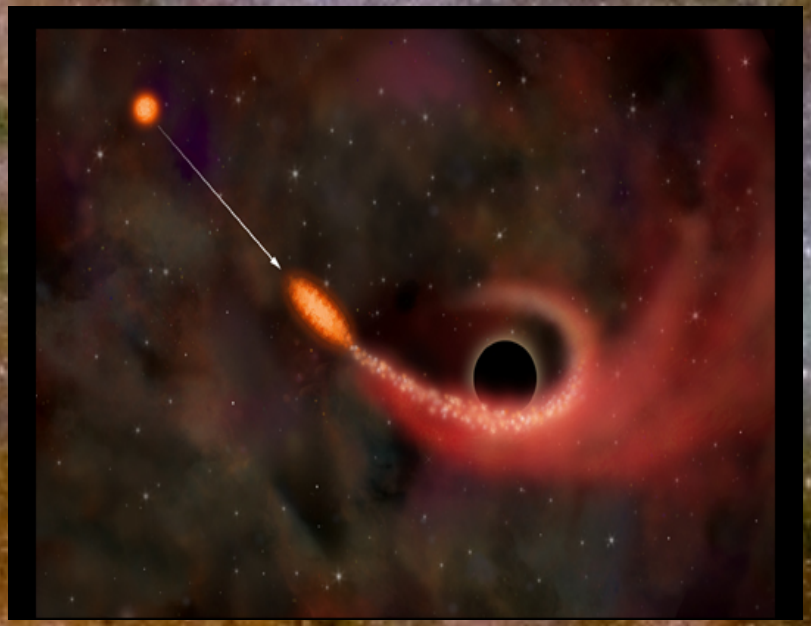
high amplitude variables rare
but could be important..

quasars not all the same

some more variable
than others

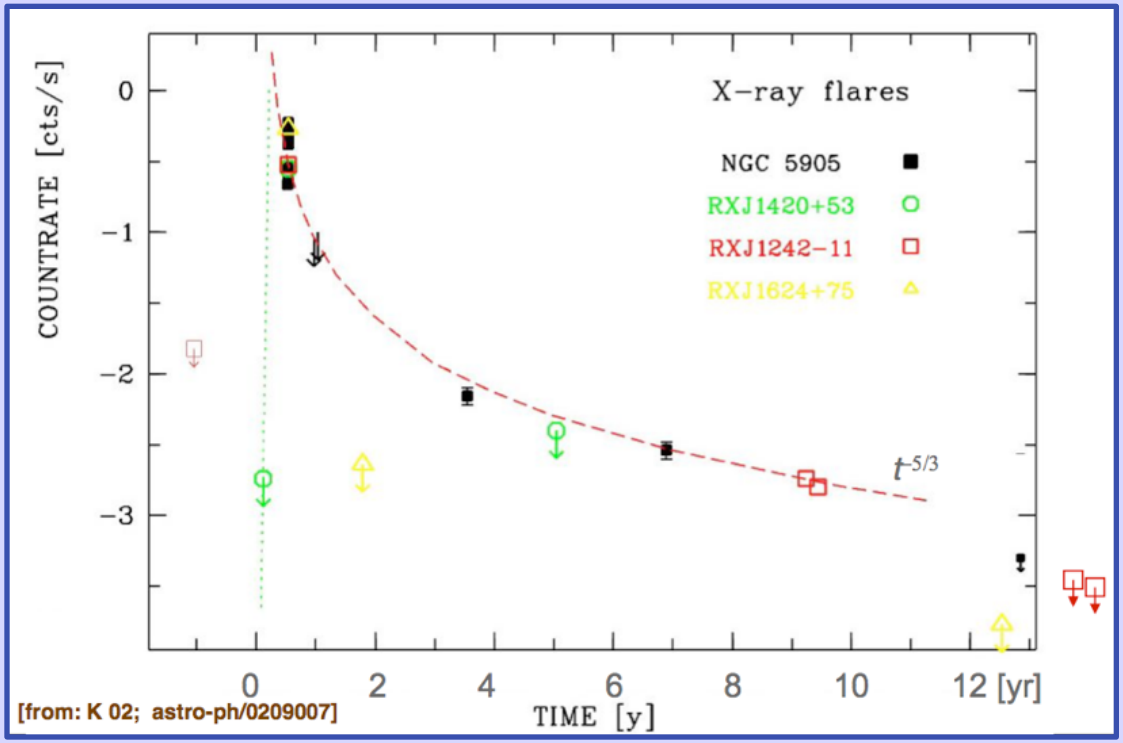
distbn exponential rather
than naively expected
Gaussian

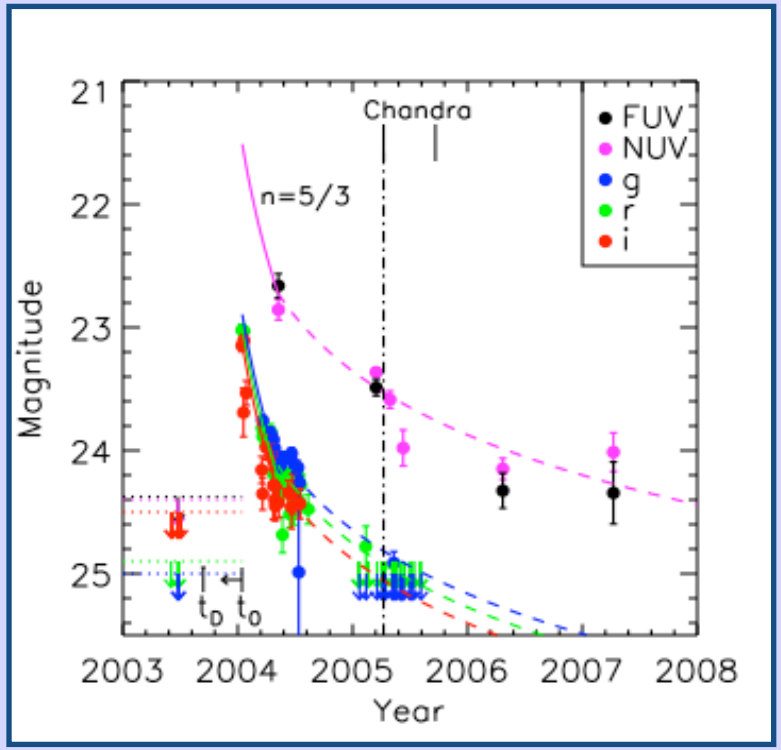
rare objects: TDEs



previous X-ray claims
from ROSAT and XMM

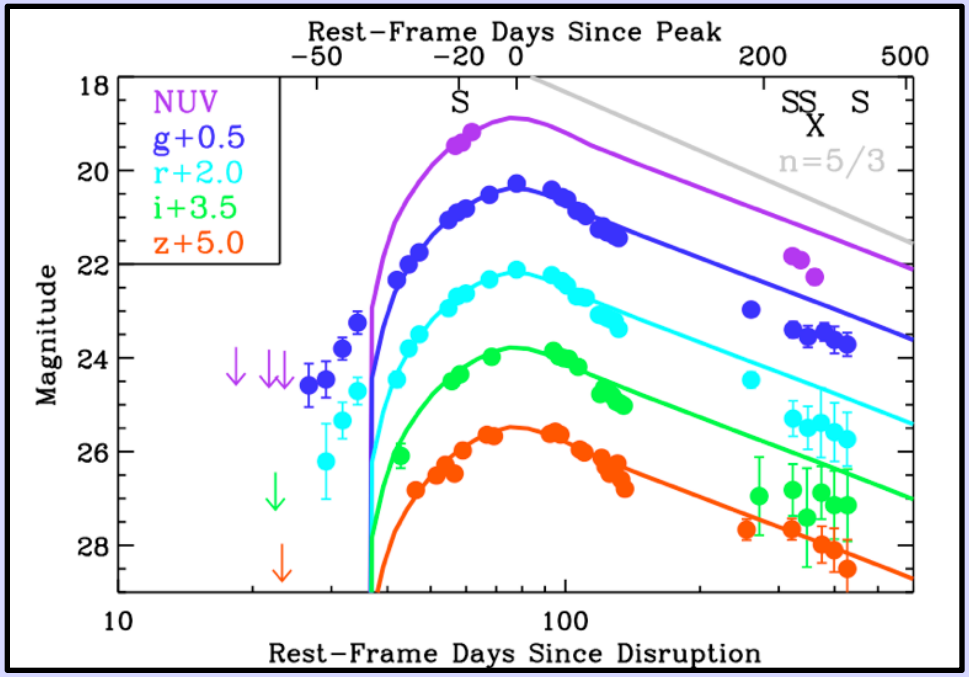
eg Komossa et al 1999,2009
Esquej et al 200x





previous opt-UV claims
from SDSS and GALEX

eg Gezari et al 2008,9
Van Velzen et al 2011



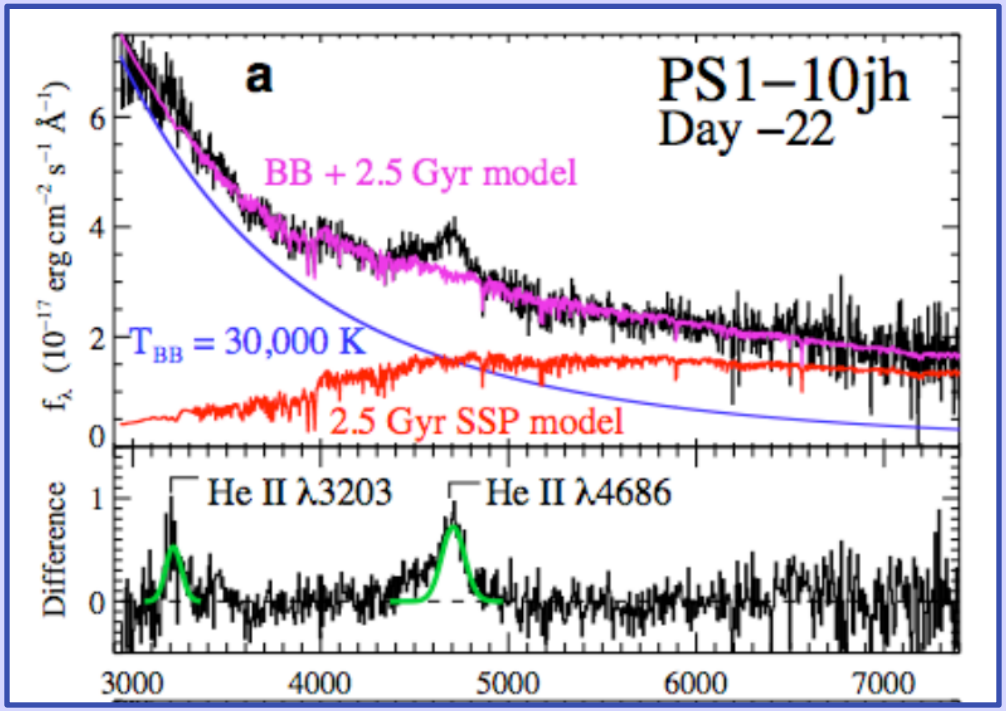
PS1-10jH
caught by PanSTARRS
medium deep field programme
… every four days
… first proper light curve

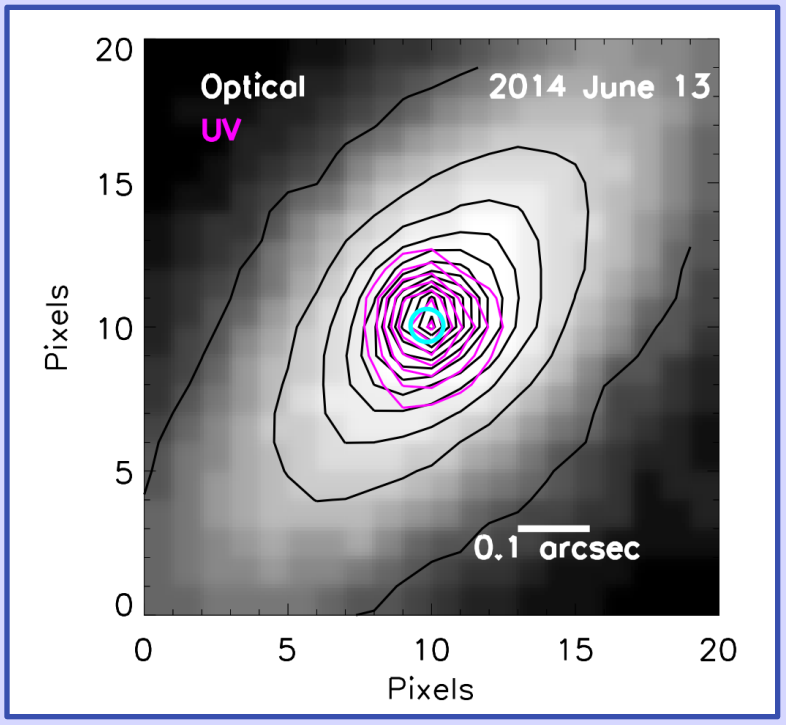
Gezari et al 2012

spectrum near peak shows
Helium lines only!

disruption of Red Giant core

can't be accretion disc flare up

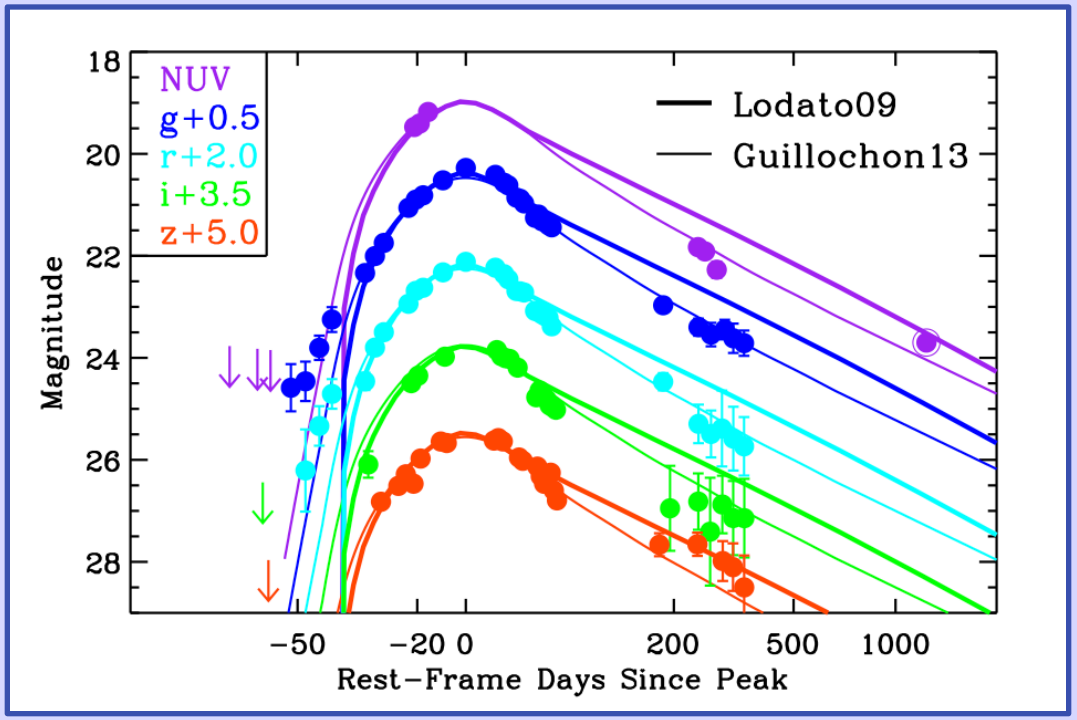


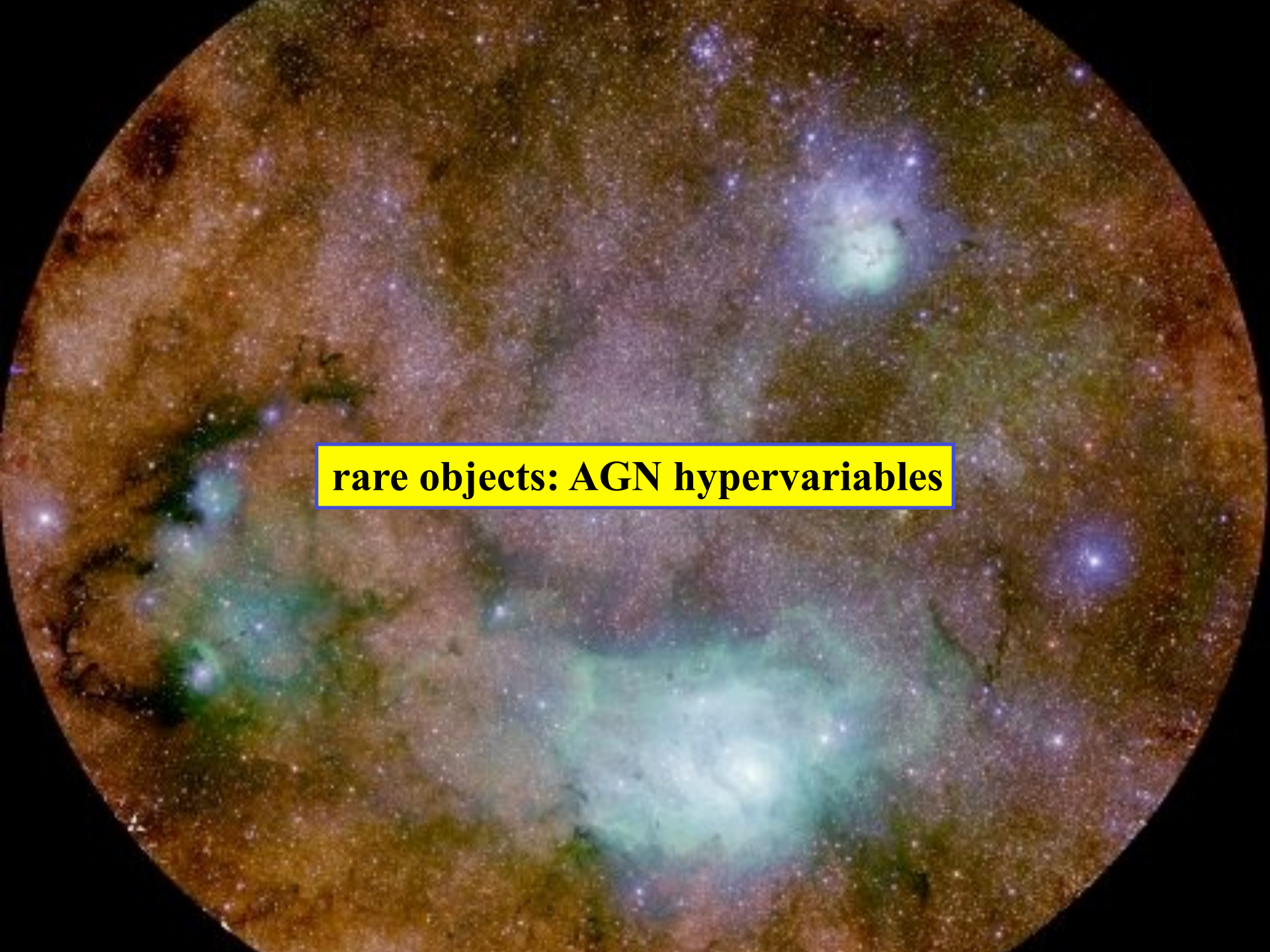


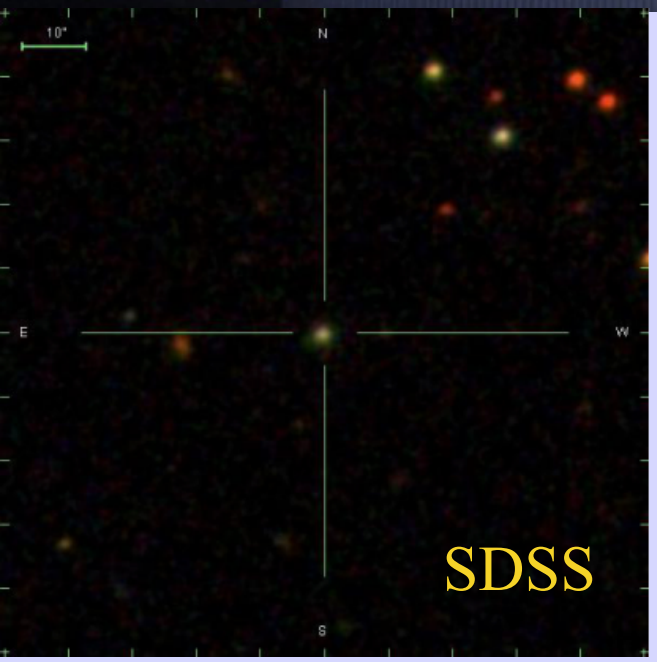
HST sees very faint nuclear UV source three years later

Gezari et al submitted

late time flux reasonable fit to naive "fall-back" prediction



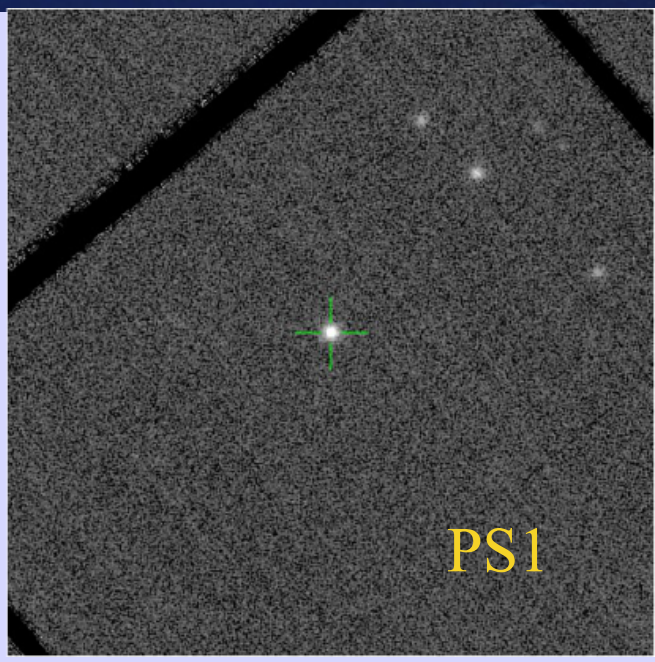

rare objects: AGN hypervariables



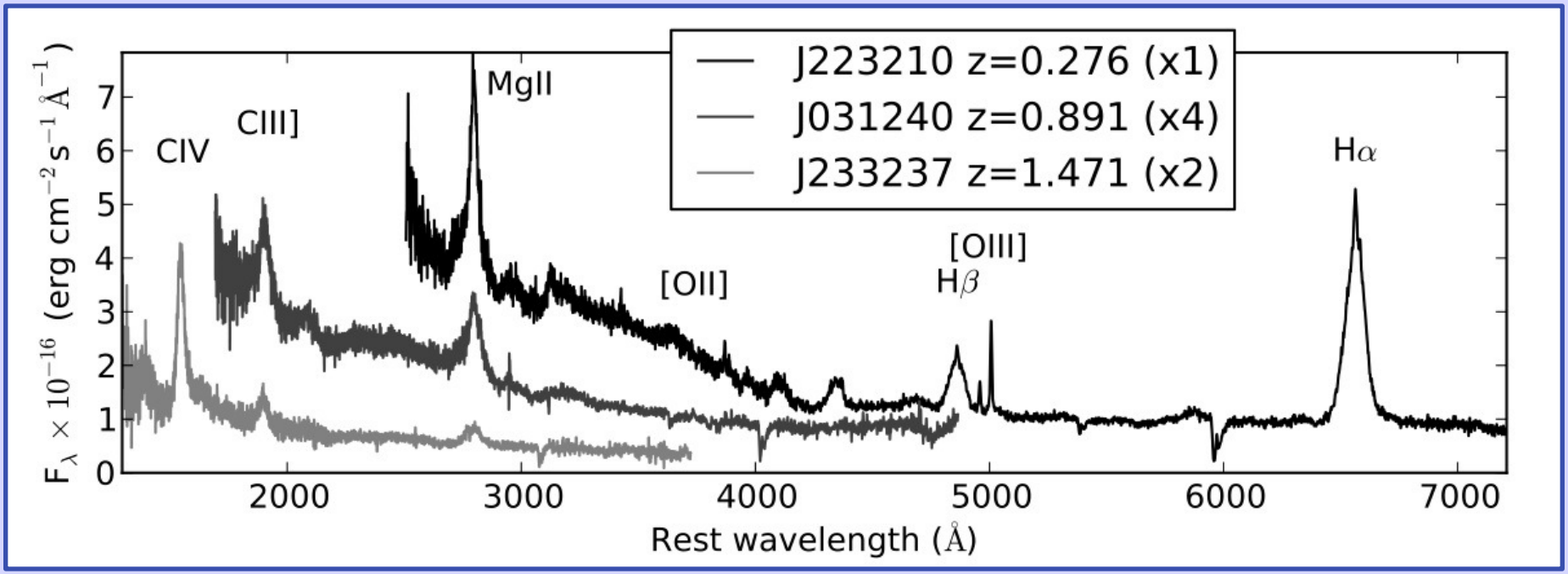
Transient selection:

$\Delta m > 1.5$
in g/r/i

within 0.5” of
SDSS galaxy



some supernovae
some blazars
some flare stars
but most quasars at z~1



Lawrence et al 2015

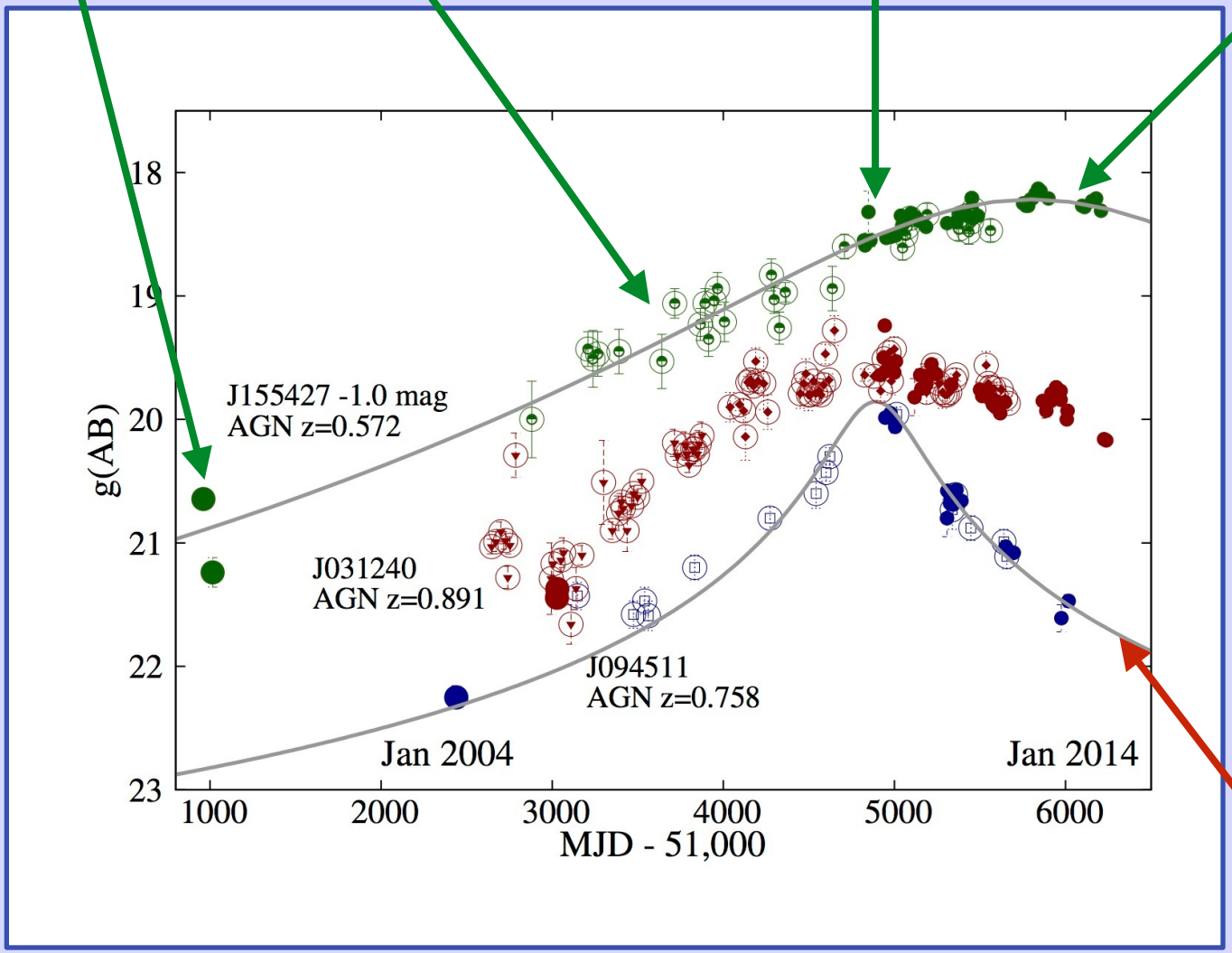
68 examples so far

SDSS

CRTS archival data

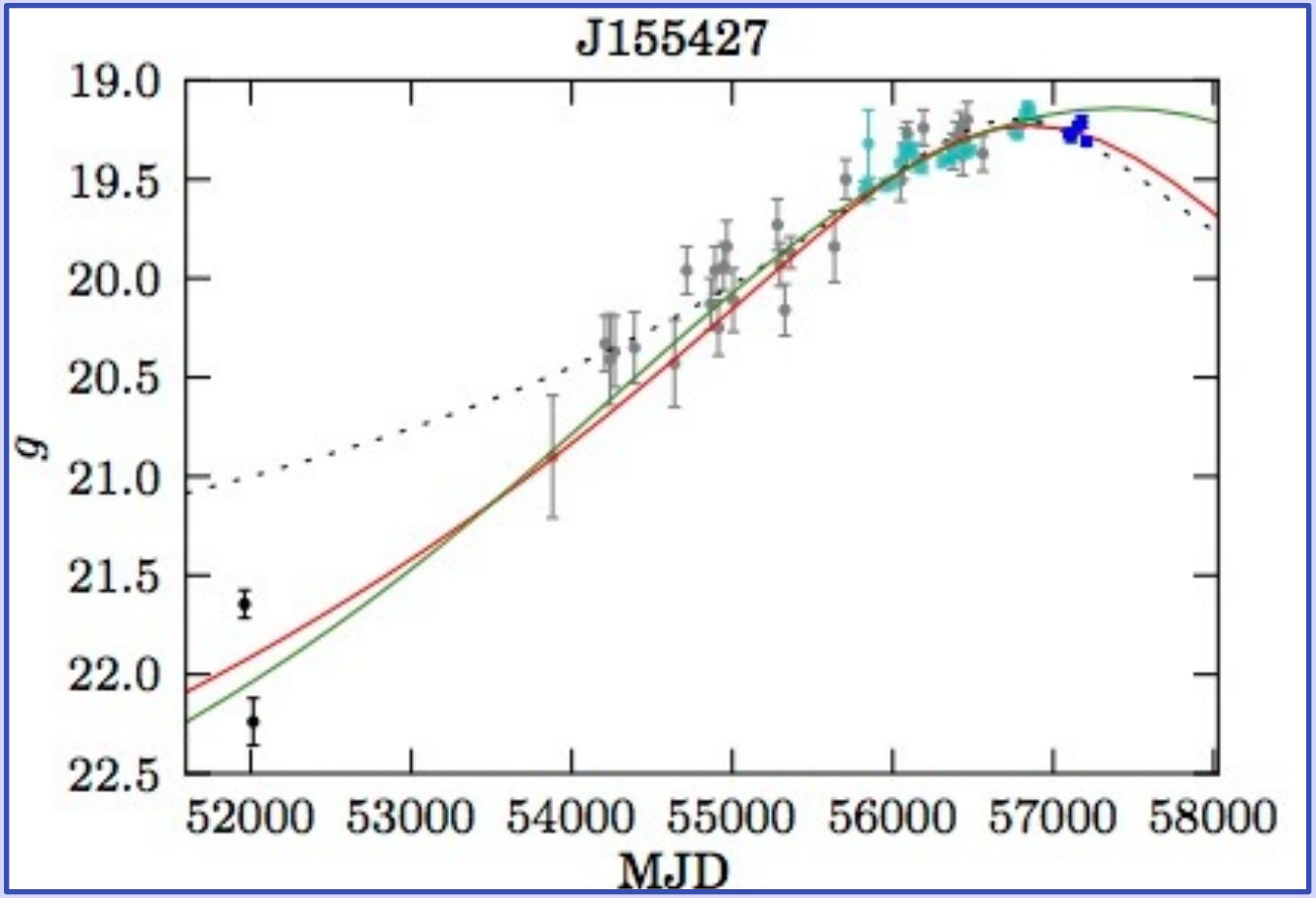
PanSTARRS discovery

Liverpool Telescope monitoring



smooth fifteen year outbursts

microlensing model fits

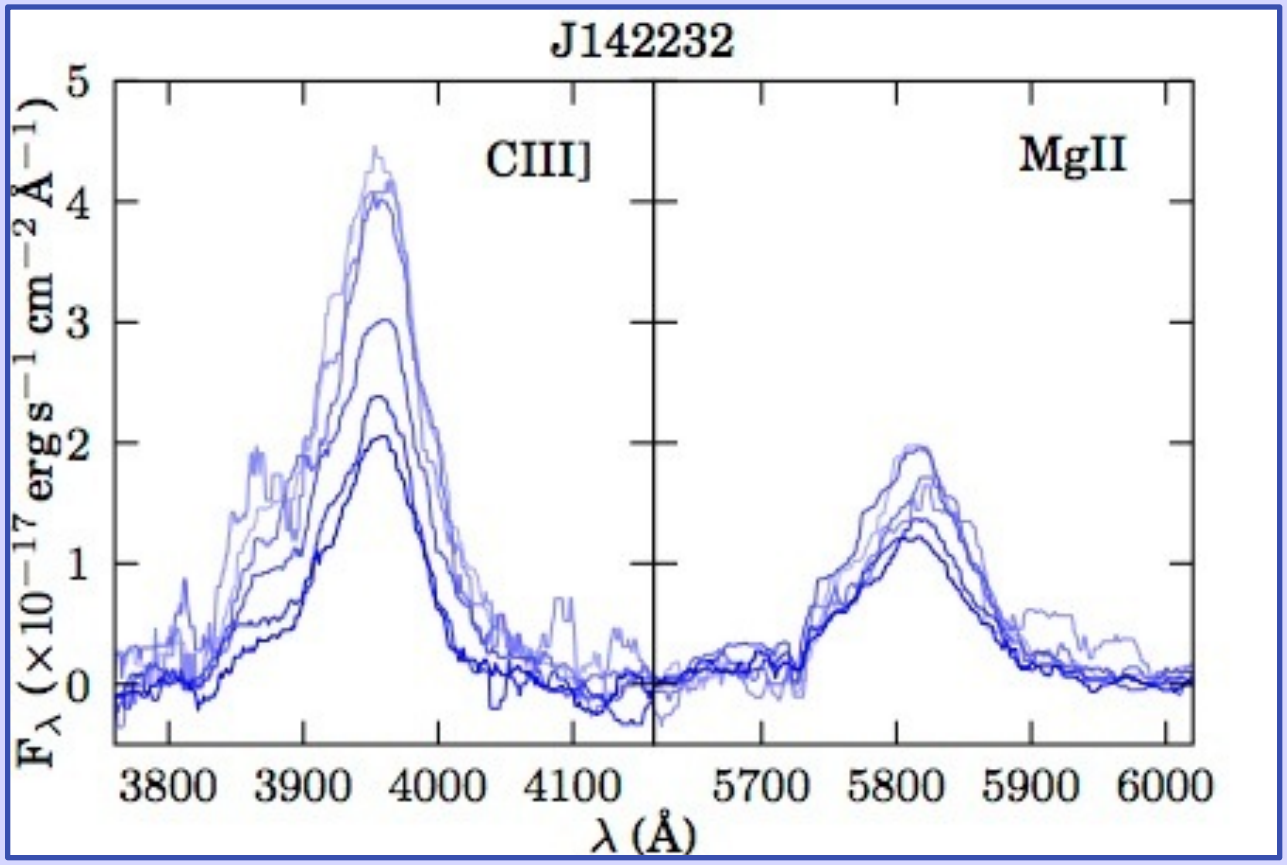


$M=10^8\ M_{sun}$

$R_{1/2} = 400\ R_g$
$R_{1/2} = 100\ R_g$

A few sources do not fit a point source model

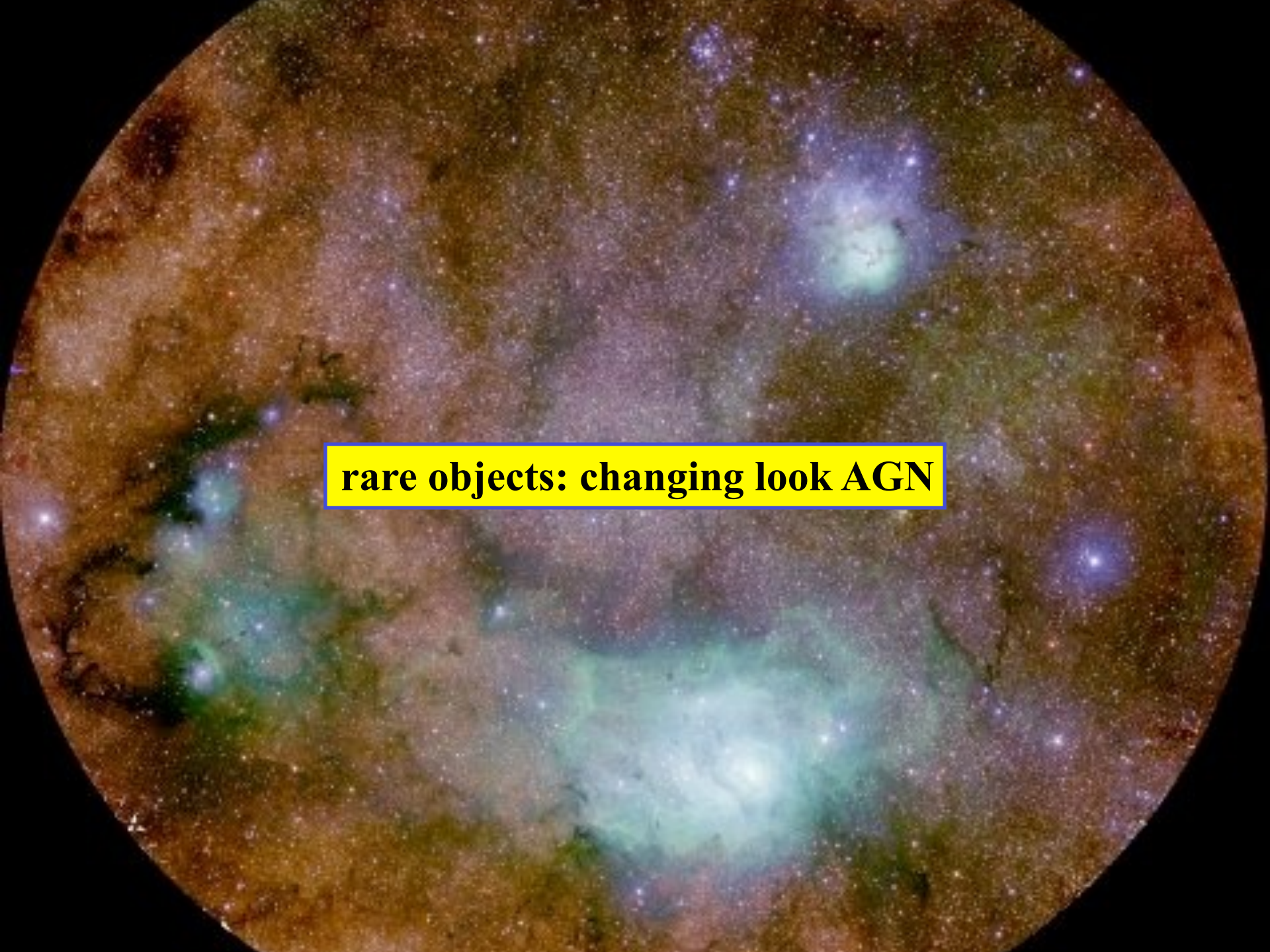
Spectroscopic monitoring



Bruce et al in prep

MgII barely changes
CIII] tracks continuum
- and changes profile!

==> MgII extended, CIII/CIV compact (<7 light days)

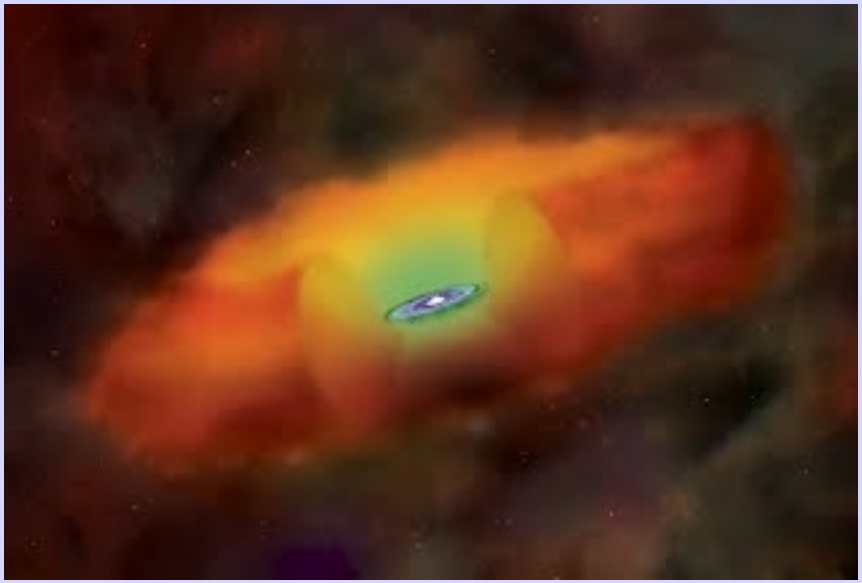

rare objects: changing look AGN

First division into Type I vs Type II

A SPECTROSCOPIC STUDY OF LUMINOUS GALACTIC NUCLEI*

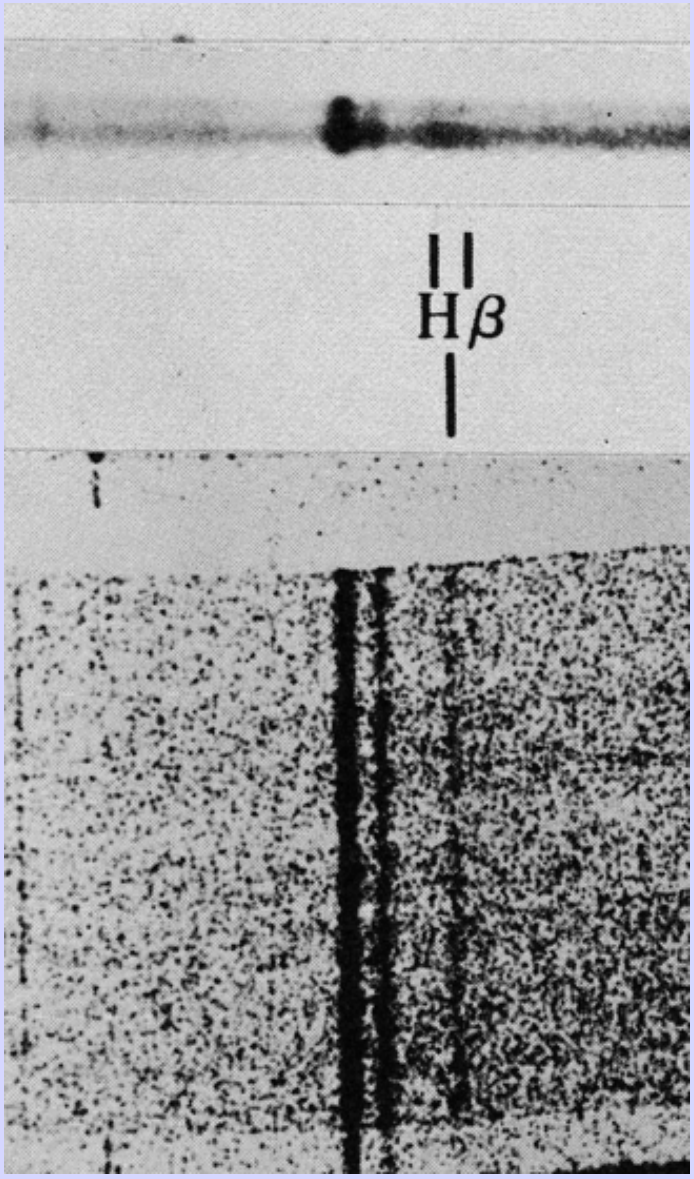
É. Ya. Khachikyan and D. W. Weedman†

Spectroscopic observations of a sample of galactic nuclei from the lists of Markaryan and Seyfert are presented in order to consider the nature of nuclei with broad emission lines. It is found from photographic spectrophotometry and emission line profiles that such galaxies can be consistently classified into two classes: objects like NGC 5548 that are found to have small, dense nuclei containing low velocity gas and objects like NGC 1068 with larger nuclei containing gas of lower density but higher velocity. The observational data favors broadening by electron scattering for the Balmer lines in the first class, and the absolute luminosity in $H\beta$ is generally greater in the first class than in the second. From the extreme spectroscopic and morphological similarity of all galaxies in the second class, it is concluded that the outflow of gas from the nucleus has affected the structure of the entire galaxy.



today always explained by viewing angle towards a thick dusty structure

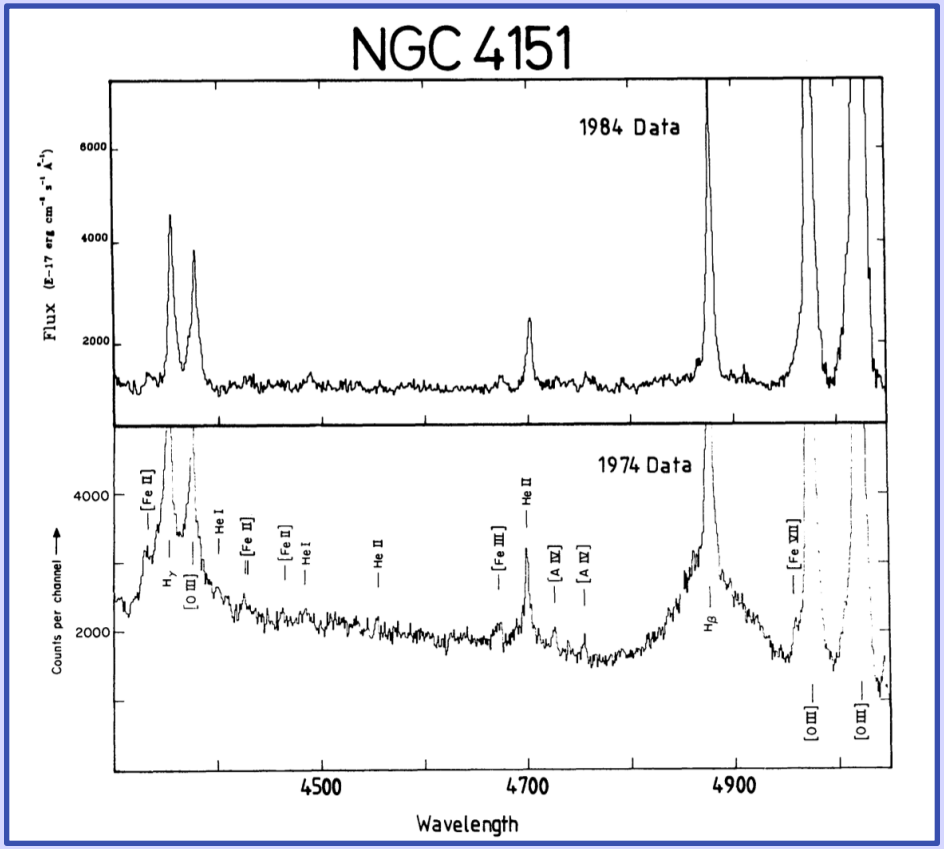
Khachikian and Weedman 1971b
MKN6



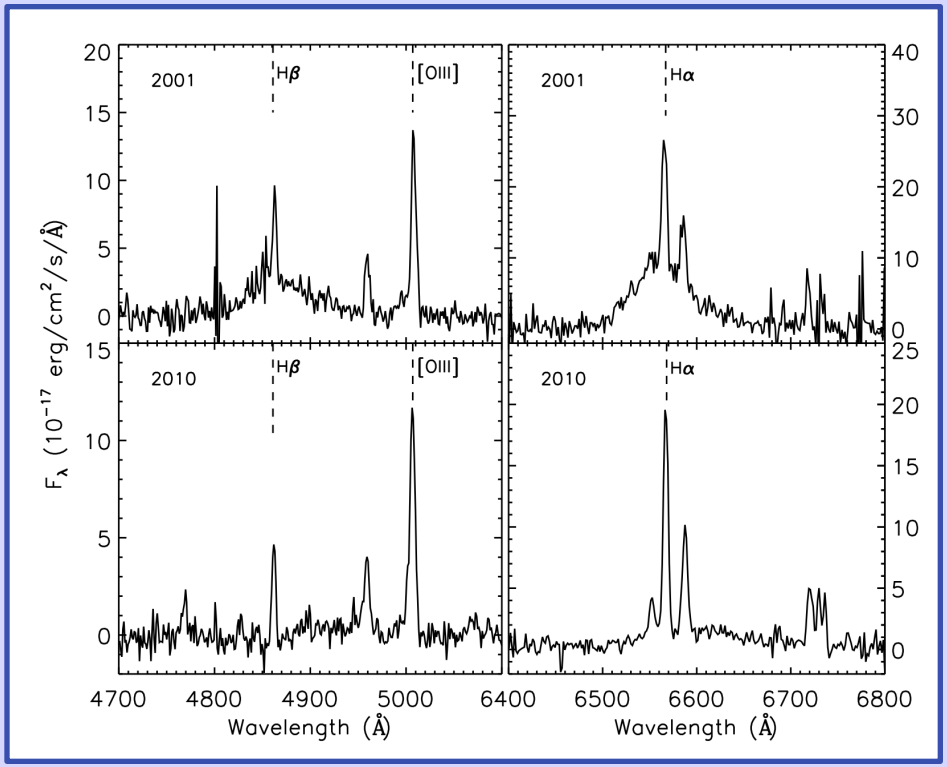
1970 broad and narrow Hβ

1967 narrow Hβ only

AGN can change type

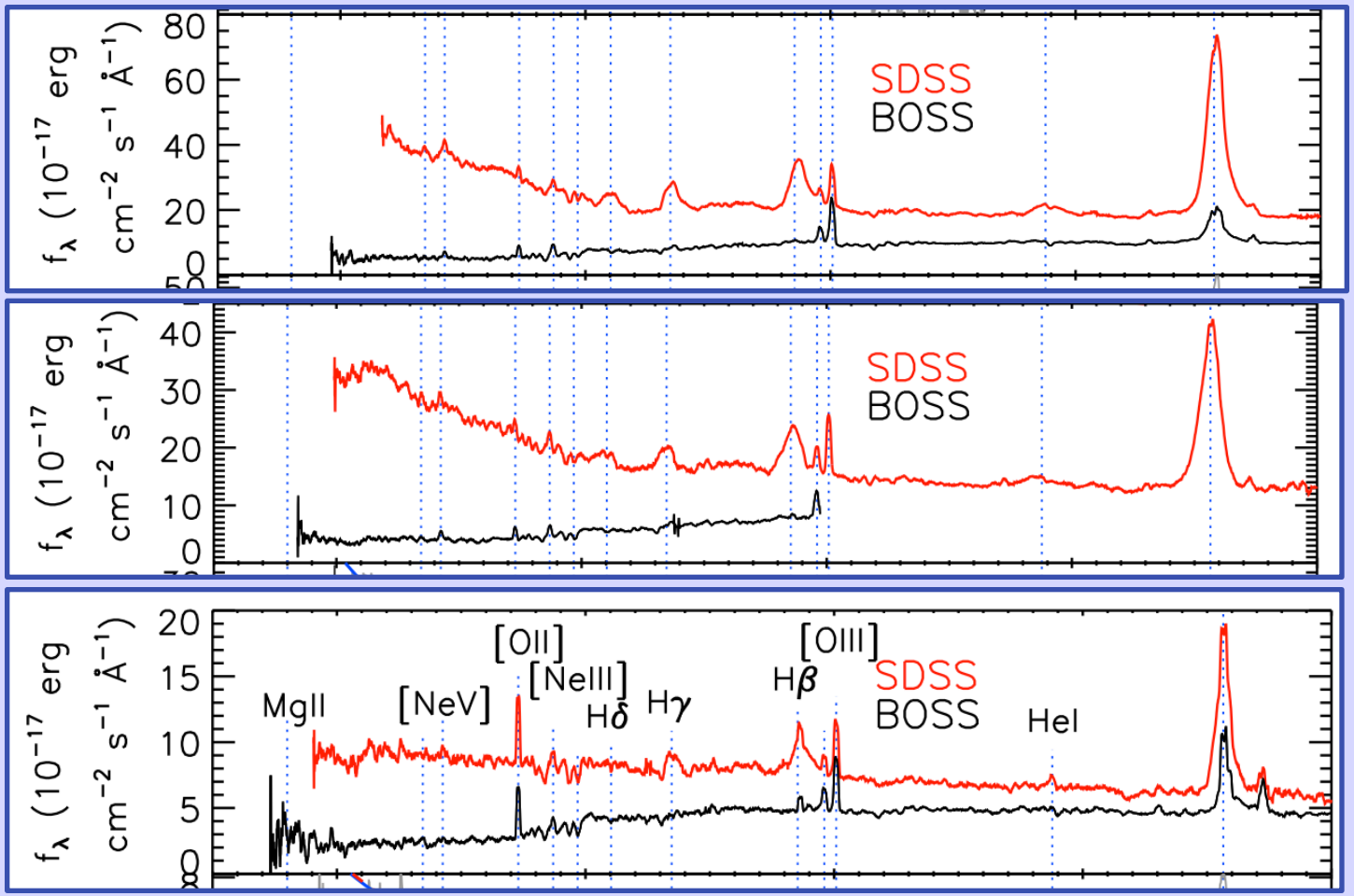


Penston and Perez 1984



A handful of other cases have emerged

LaMassa et al 2014



but now we can search for them systematically

MacLeod et al 2015

SDSS vs PS1 : 105,783 quasars

15% have repeat spectra with BOSS

6% have $\Delta g > 1.0$ over a decade

→ 1011 potential CLQs

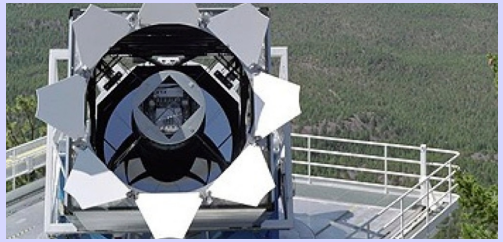
→ 10 found

c.f. BLR dynamical timescale of years


where next?

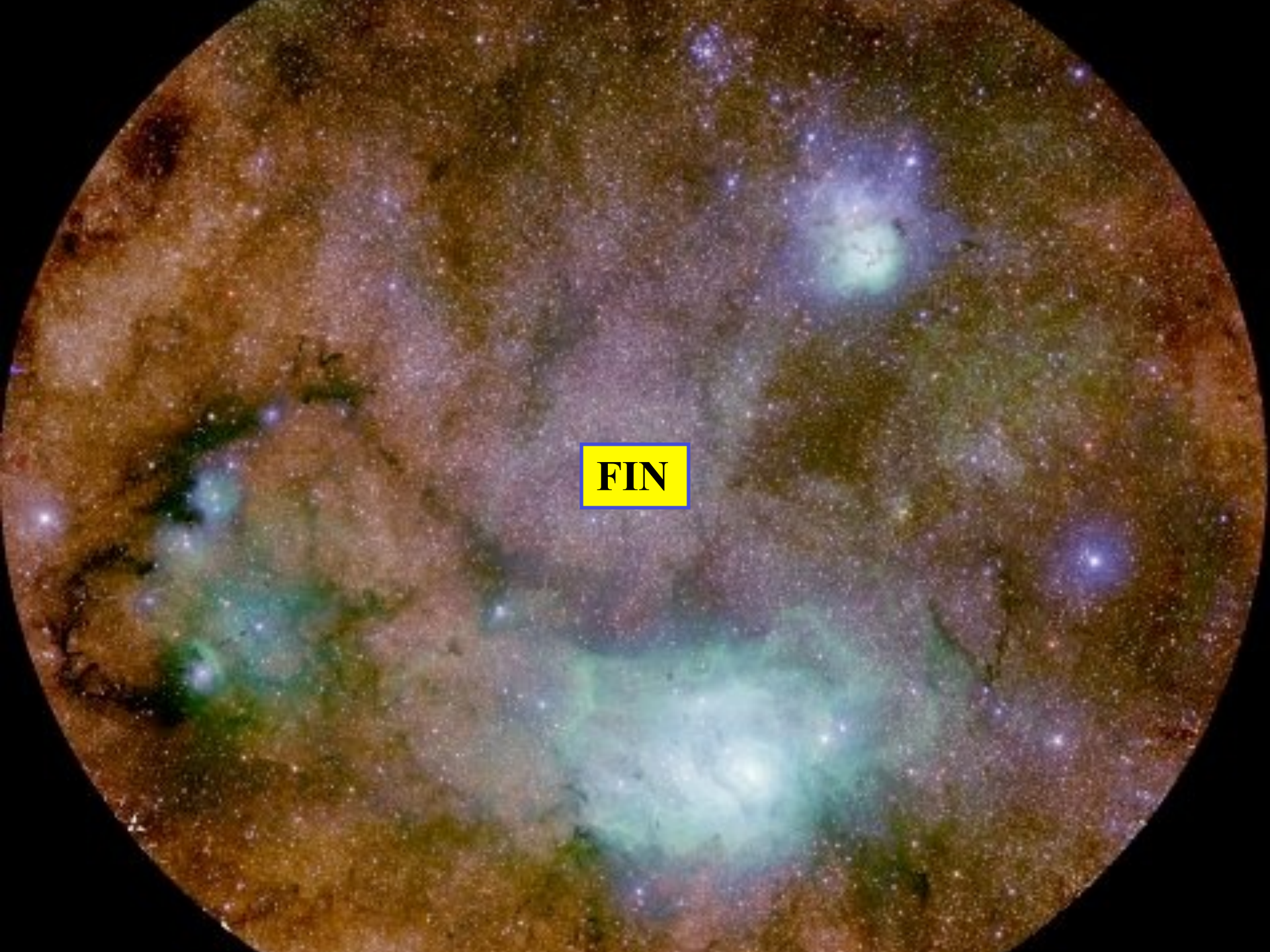
LSST
wider, deeper, faster

TDSS
systematic spectroscopic
survey of variable objects



massive spectroscopic variability survey

??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