

Resolving the Mystery of Changing Look AGN with Responsive Follow-up Observations

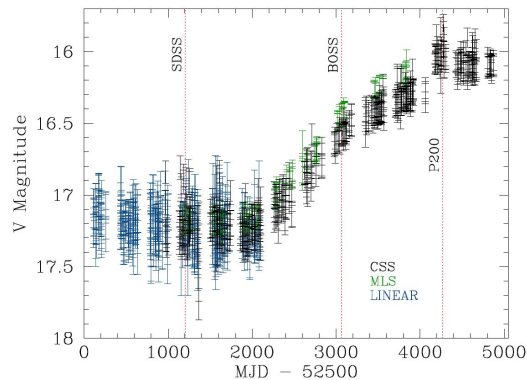
Benny Trakhtenbrot
Tel Aviv University

with: Iair Arcavi (TAU), Claudio Ricci (UDP), Erin Kara (MIT), Dan Stern (Caltech),
Andy Howell (UCSB), Griffin Hosseinzadeh (CfA), Chelsea MacLeod,
Lukasz Wyrzykowski, Mariusz Gromadzki, and Nada Ihanec (Warsaw),
Hagai Netzer (TAU), and many others...

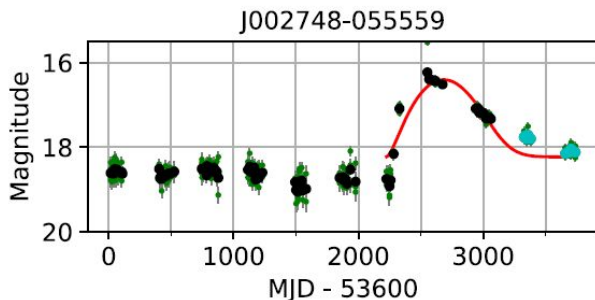
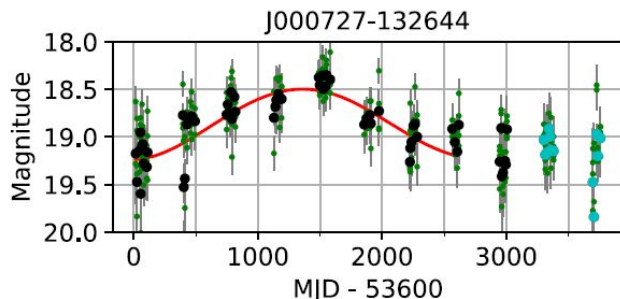
Gaia Alerts Workshop, 21 January 2021

New Surveys: *newly identified types of SMBH transients*

Changing look AGN

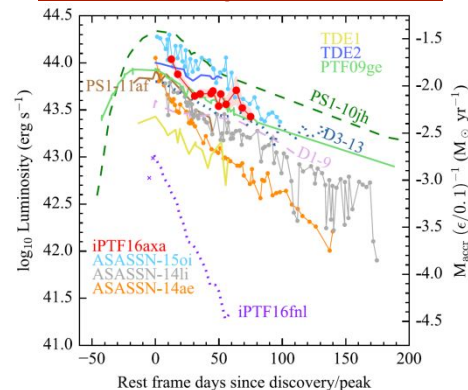


Extreme quasar variability



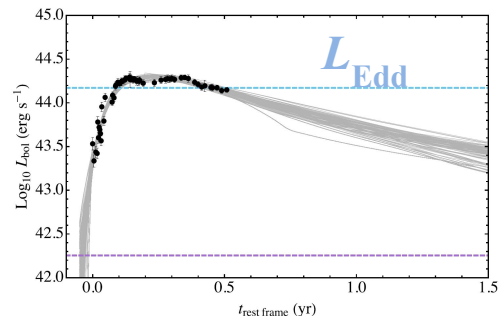
Graham+17 – Catalina (CRTS)

Tidal disruption events



Hung+17 – iPTF16axa

Other nuclear transients?



Blanchard+17 – PS16dtm

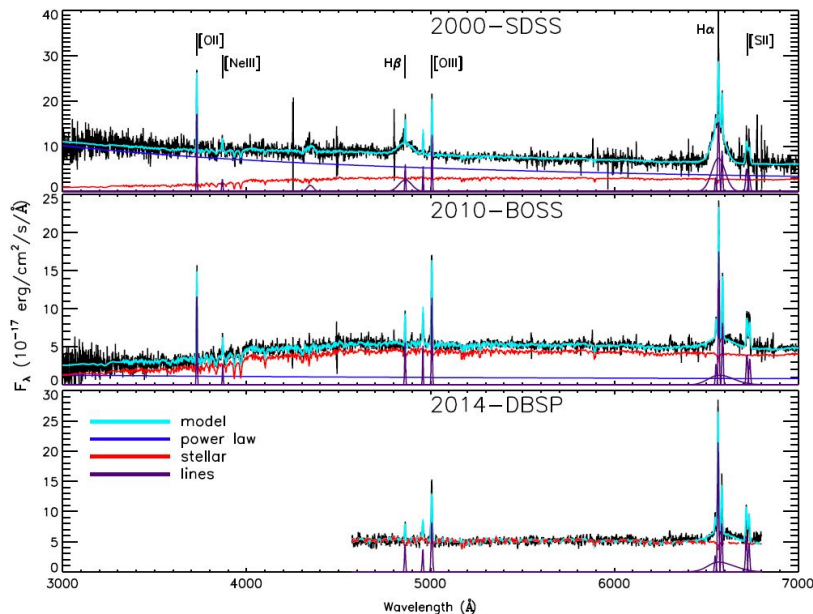
Stern+17 – CRTS J0841, CL-BAL-AGN?

“Changing Look” AGN

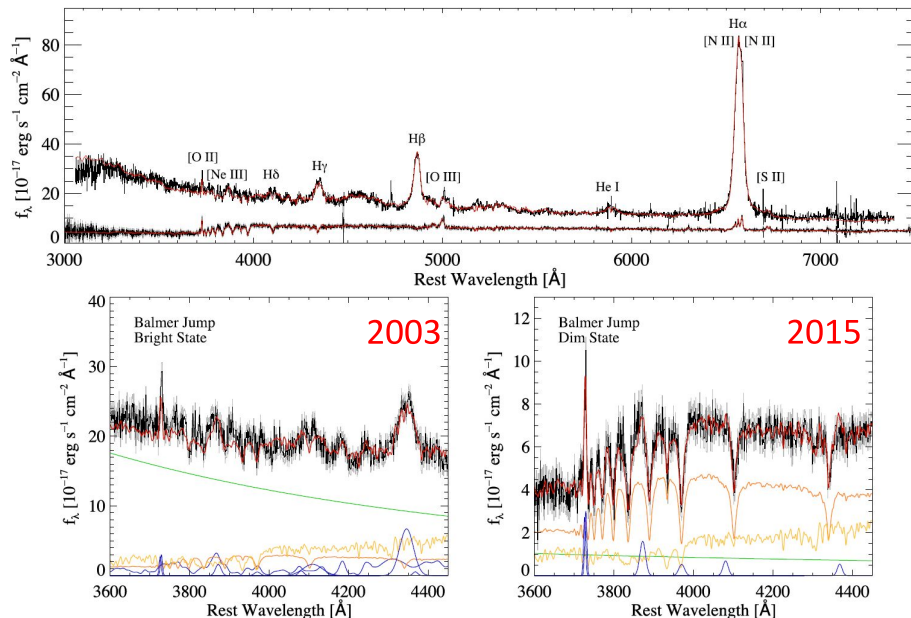
*accreting SMBHs (AGN) with dramatic changes
to their spectral appearance (and related classification)*

Changing-look AGN: *observational definition(s)*

- Optical: (dis-)appearance of blue continuum and broad line emission (typically: *years*)
- X-rays: significant changes to spectral shape, line-of-sight column densities

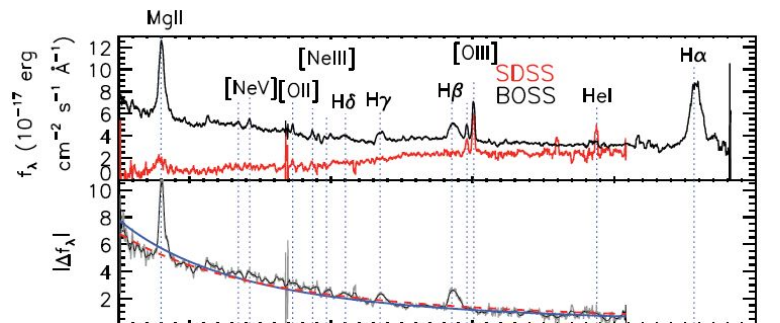


LaMassa+15 – the first “changing look quasar”?

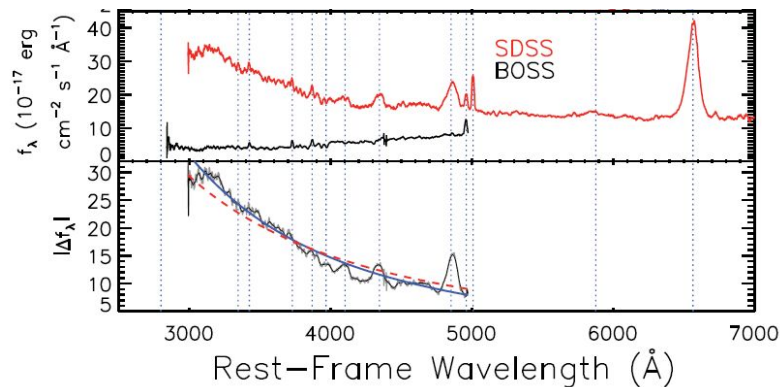


Runoe+15 – J1011+5442 – TDSS data

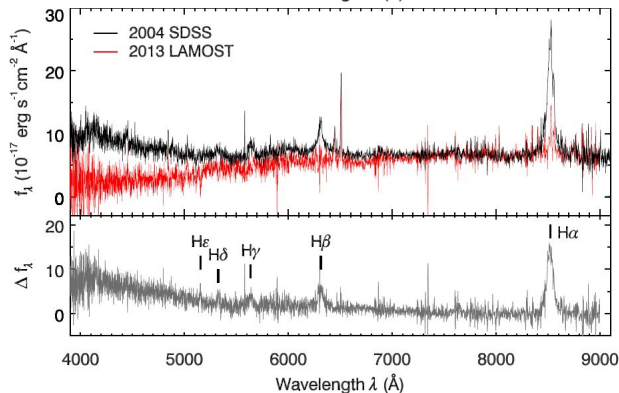
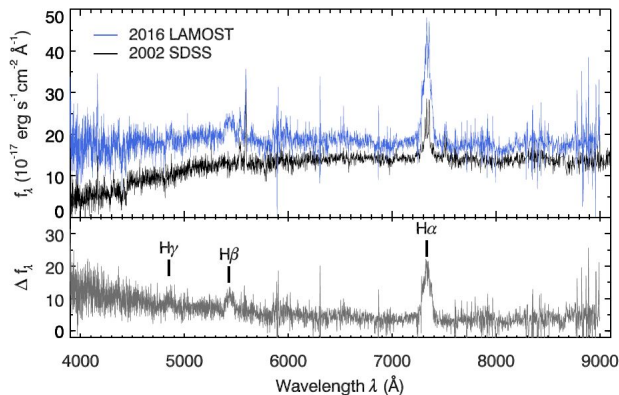
Changing-look AGN: *rare events* → *large samples*



“turn on”



“turn off”



MacLeod+16,19 – **27 new CL-AGN** (in SDSS/BOSS)

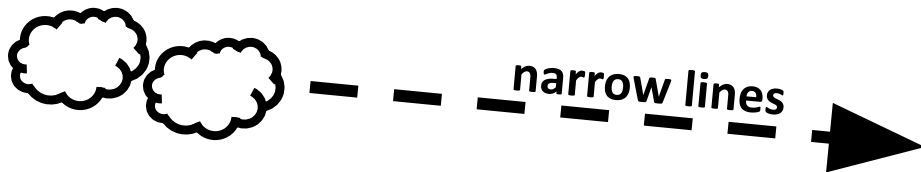
Wang+18 – **21 new CL-AGN** (w/LAMOST)

Changing-look AGN: *changes in accretion flow or obscuration?*

Narrow Line

Region

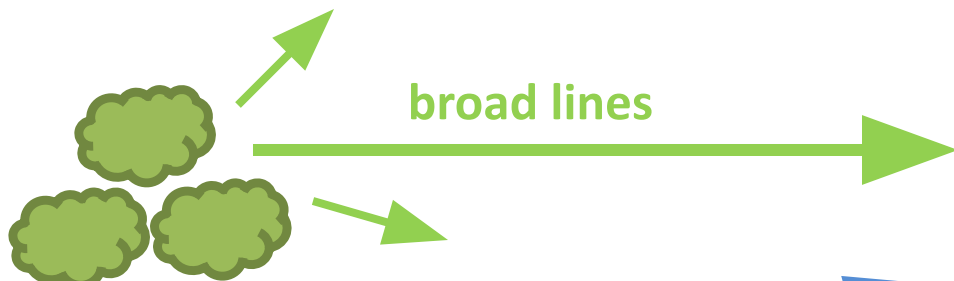
~500 km/s
> 100 pc
>>100 years



Broad Line

Region

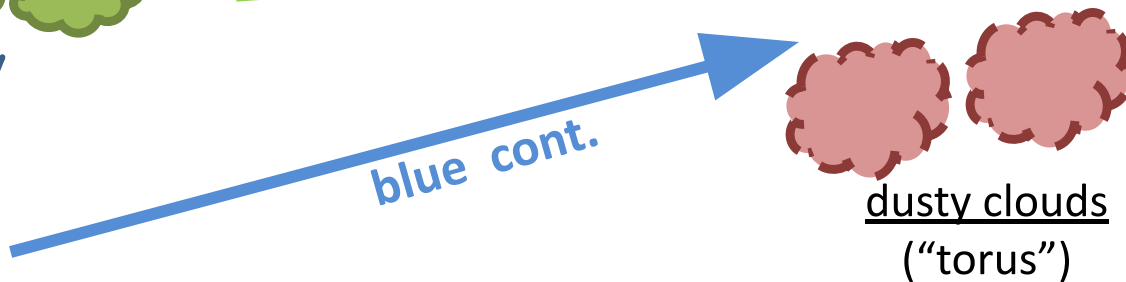
~5000 km/s
< 0.1 pc
10-100 days



BH

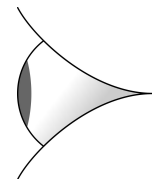


accretion flow



dusty clouds
("torus")

observer



Changing-look AGN: *changes in accretion flow or obscuration?*

Narrow Line

Region

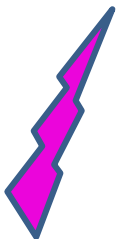
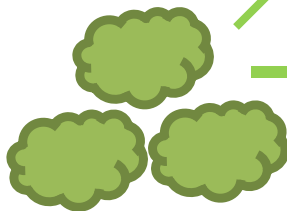
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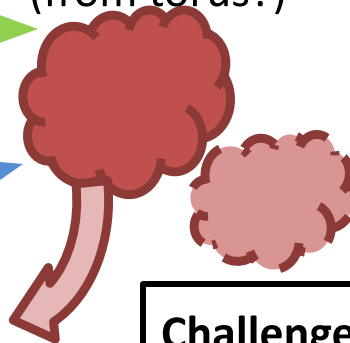
BH



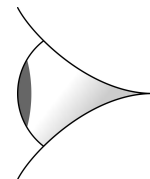
accretion flow



dusty cloud
(from torus?)



observer



Challenges:

- Hiding the entire BLR?
- Some CL-AGN with no obscuration variability

Changing-look AGN: *changes in accretion flow or obscuration?*

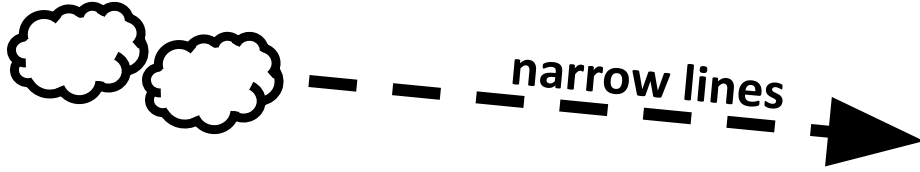
Narrow Line

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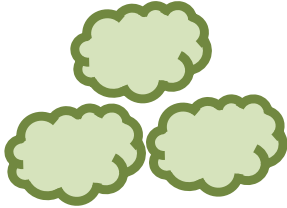
Broad Line

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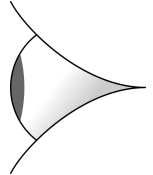


BH



accretion flow

observer



Changing-look AGN: *changes in accretion flow or obscuration?*

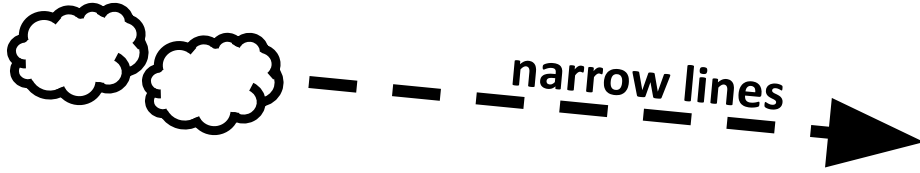
Narrow Line

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>>100 years



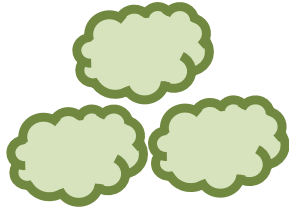
Broad Line

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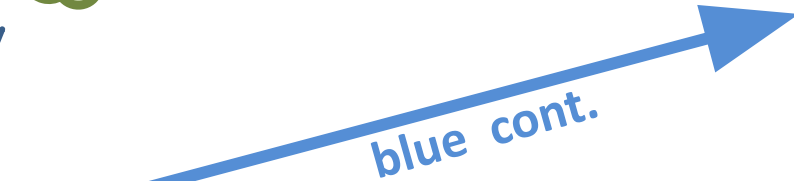
10-100 days



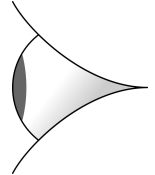
BH



accretion flow



observer



Changing-look AGN: *changes in accretion flow or obscuration?*

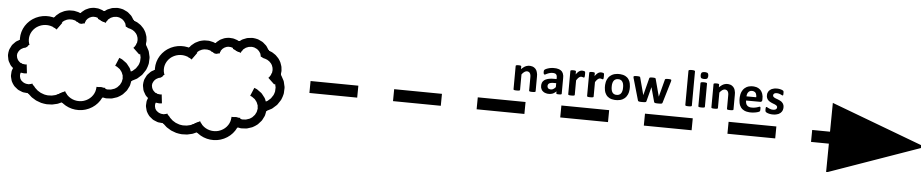
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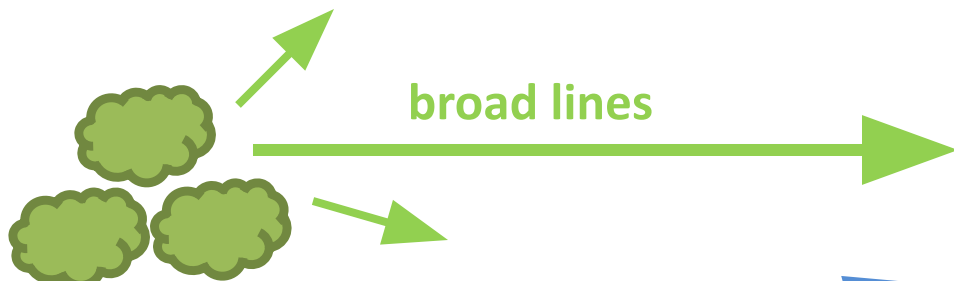
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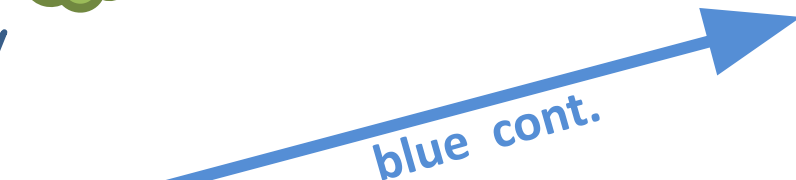
10-100 days



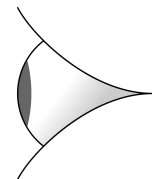
BH



accretion flow



observer



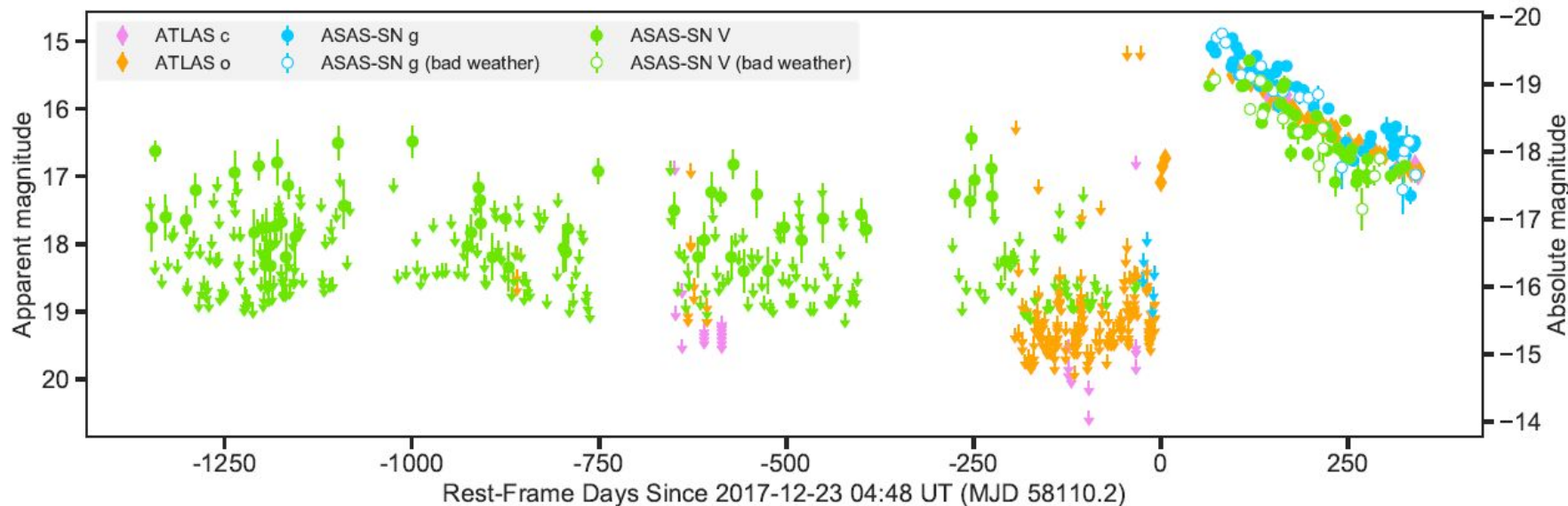
Challenges:

- Resolving the sequence
- Some CL-AGN with obscuration variability

1ES 1927+654: a changing-look AGN caught in the act

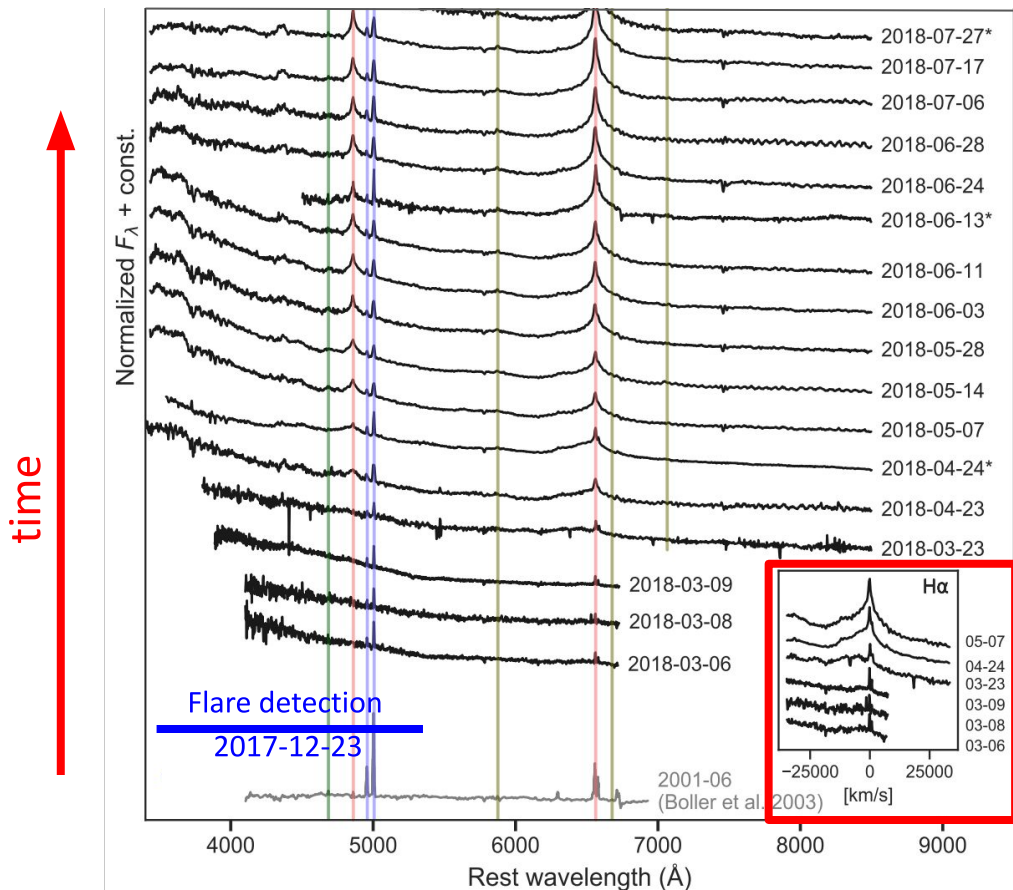
- Historically - a narrow-line (“true Type-2”) AGN; optical flare detected by 2017- Dec-23
- Sharp rise in ~ 1 month: **UV/opt increased by x40!**
- Then: a slow decline...

Trakhtenbrot+19 (ApJ, 883, 94)



host-subtracted light-curve; early “detections” in ASAS-SN data are likely spurious...

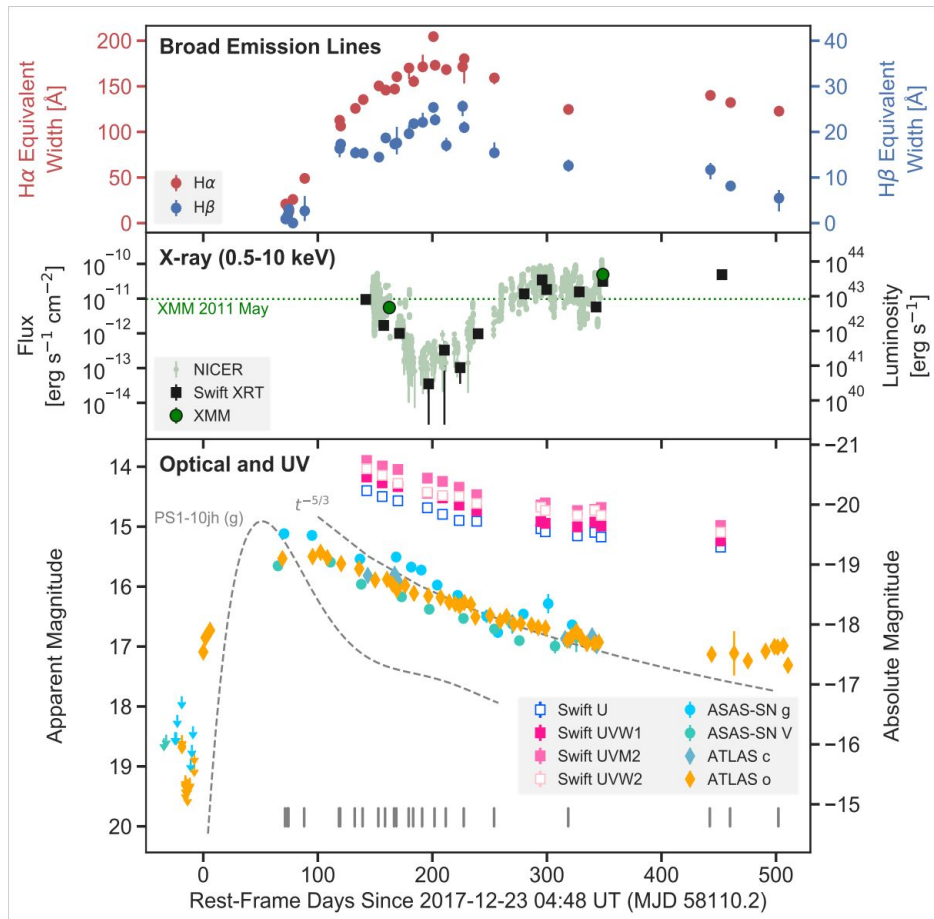
1ES 1927+654: *responsive follow-up optical spectroscopy*



- Historically: a narrow-line AGN
- Spectroscopic monitoring with:
LCO (robotic), MDM, Palomar, Keck
- Blue continuum appears first
 - Broad emission lines appear
~3 months after peak UV
 - Lag consistent with the BLR size!
as expected from reverberation mapping
scaling relations:

$$R_{\text{BLR}} = (32.9^{+2.0}_{-1.9}) \left[\frac{\lambda L_{\lambda}(5100 \text{ \AA})}{10^{44} \text{ ergs s}^{-1}} \right]^{0.700 \pm 0.033} \text{ lt-days}$$

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Changing-look state AGN: changes in accretion flow

Narrow Line

Region

~500 km/s
> 100 pc
>>100 years



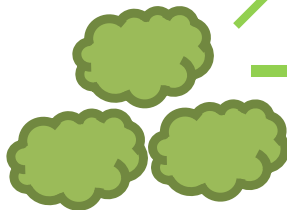
narrow lines

Broad Line

Region

~5000 km/s
< 0.1 pc

10-100 days



broad lines

BH

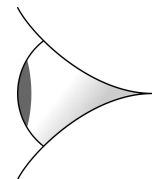


accretion flow

blue cont.



observer

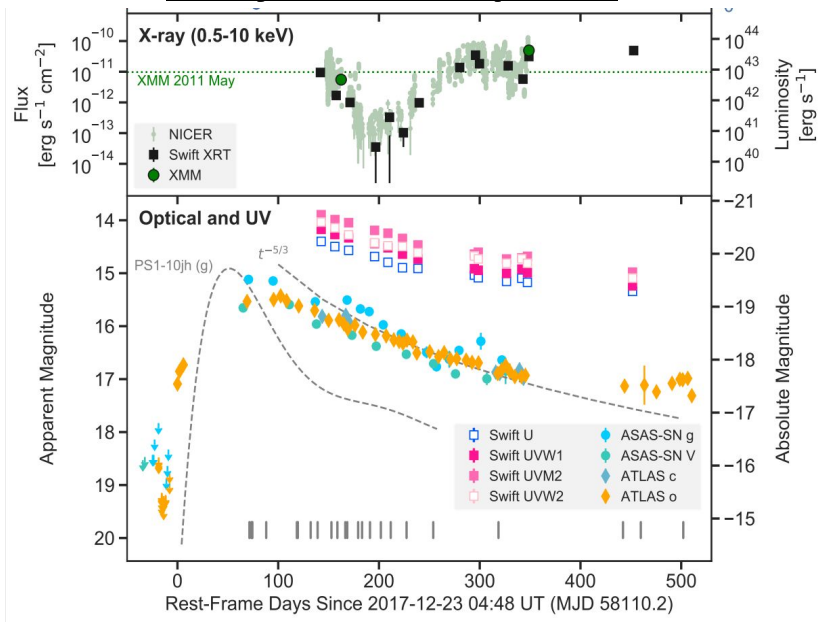


Challenges:

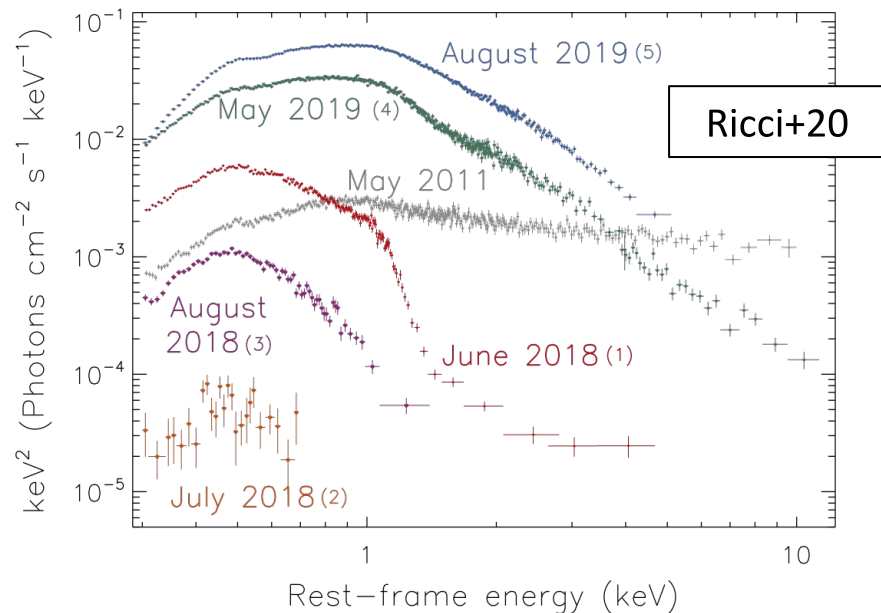
- ✓ Resolving the sequence
- Some CL-AGN with obscuration variability

1ES 1927+654: X-ray and UV light curves - wait, what?!

X-rays vs. UV-optical



X-ray spectral evolution

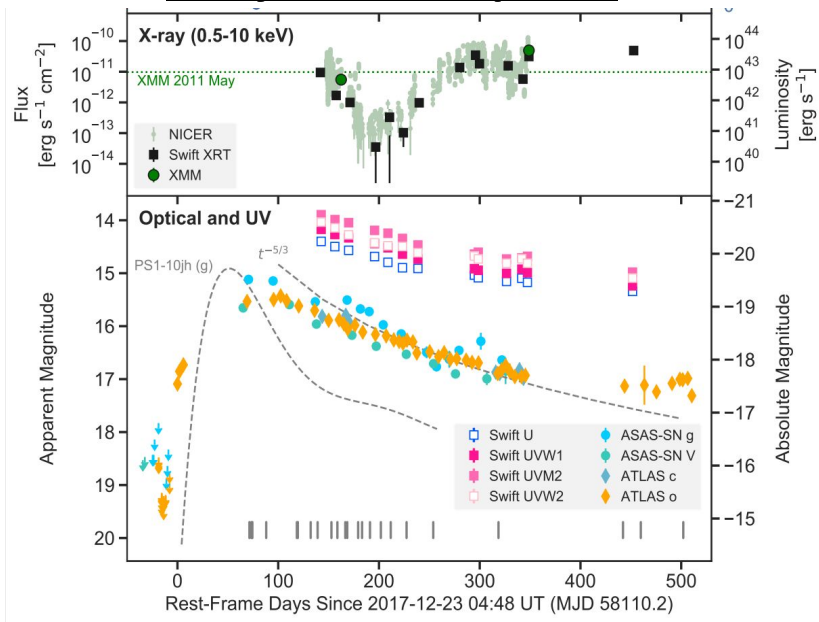


Challenge: X-rays drop by ~ 3 orders of magnitude, then go back up...

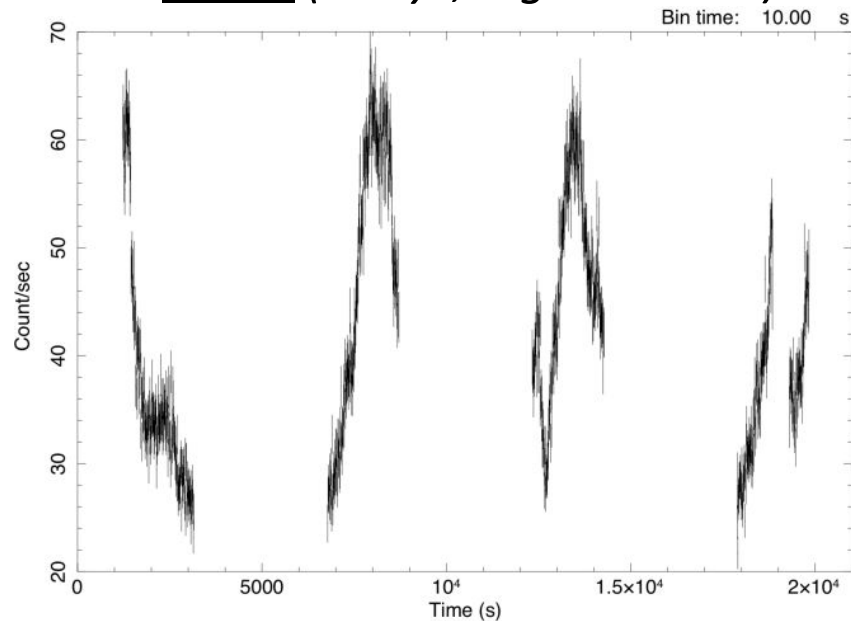
X-ray corona destroyed by UV “flash”, then re-forms? (Ricci+20)

1ES 1927+654: X-ray and UV light curves - wait, what?!

X-rays vs. UV-optical

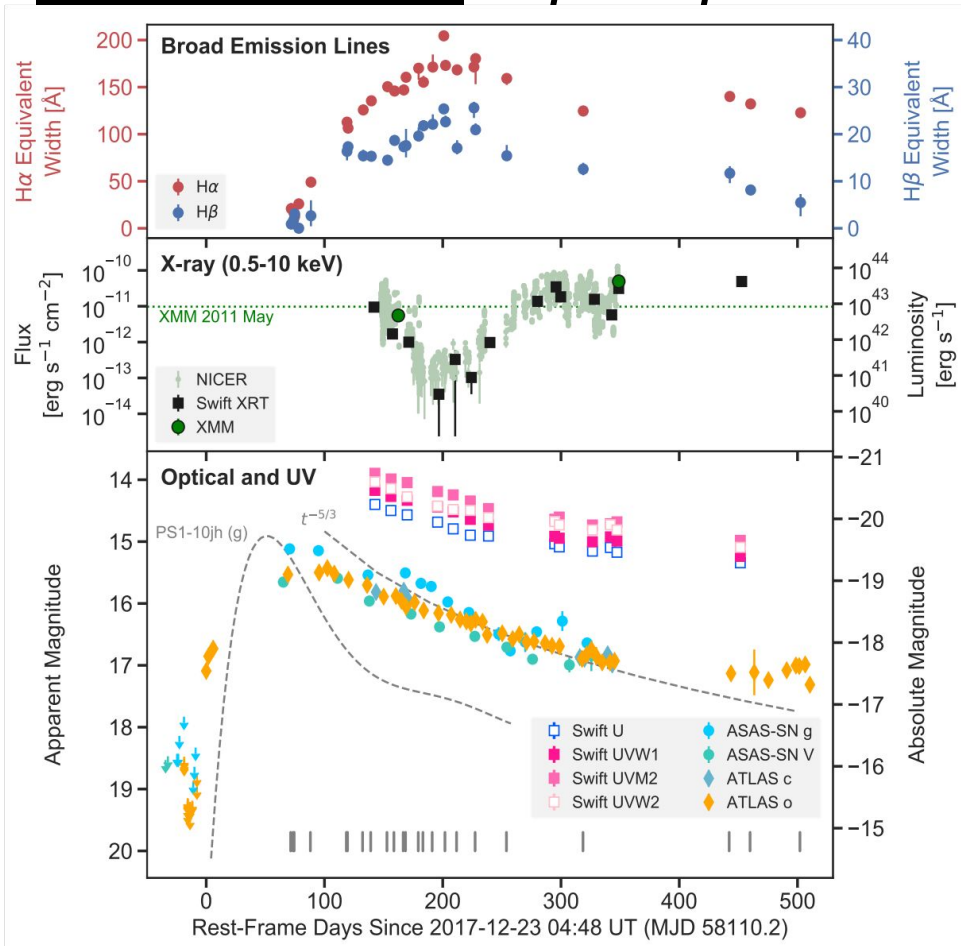


NICER (X-rays, high cadence)



Challenge: X-rays drop by ~ 3 orders of magnitude, then go back up...
with drastic spectral changes *and highly variable on $\sim$ hours timescales*

1ES 1927+654: Open questions



- What's the origin of the dense gas?
 - was it always there, and now got illuminated?

OR:

 - is the BLR gas “fresh”, linked to the accretion enhancement?
 - What initiated the event? perhaps a TDE in an AGN?
- see Chan+19,20, Ricci+20, and Tsvi Piran's talk after the break!

Changing-look AGN: *More alerts, more events ...*

AT 2019mto

ZTF → ePESSTO

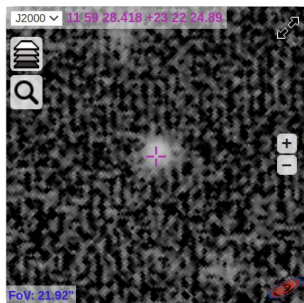
(6-Aug → 21-Oct)



Gaia21aen

Details

Follow-up



TNS ID
AT2020aee

RA - DEC
179.86841 23.37358
11:59:28.42 23:22:24.89

Galactic coords.
227.79704 77.67265

Alerting date
2020-12-06 22:24:34

Julian date
2459190.43

Alerting magnitude
18.99

Historic magnitude
20.40

Historic StdDev
0.22

Class
unknown

Publication date
Jan. 12, 2021, 6:37 p.m.

Other surveys detections

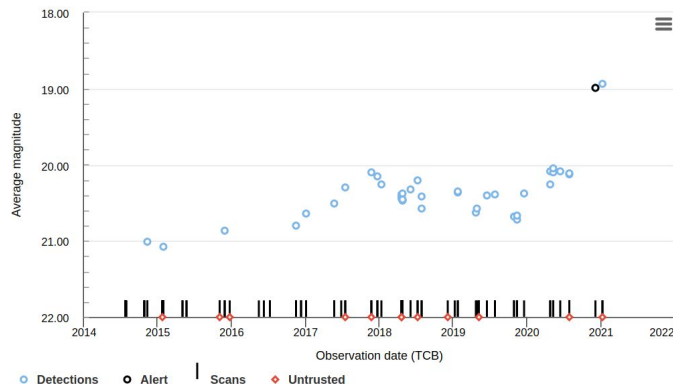
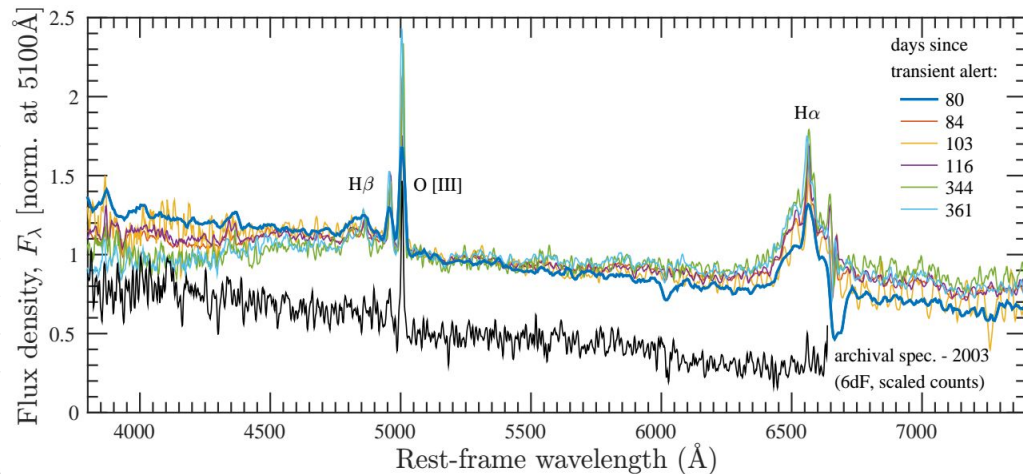
None

Comments

sharp rise of 1 mag on a steadily increasing Gaia, WISE and GALEX source, candidate QSO

ATels

None

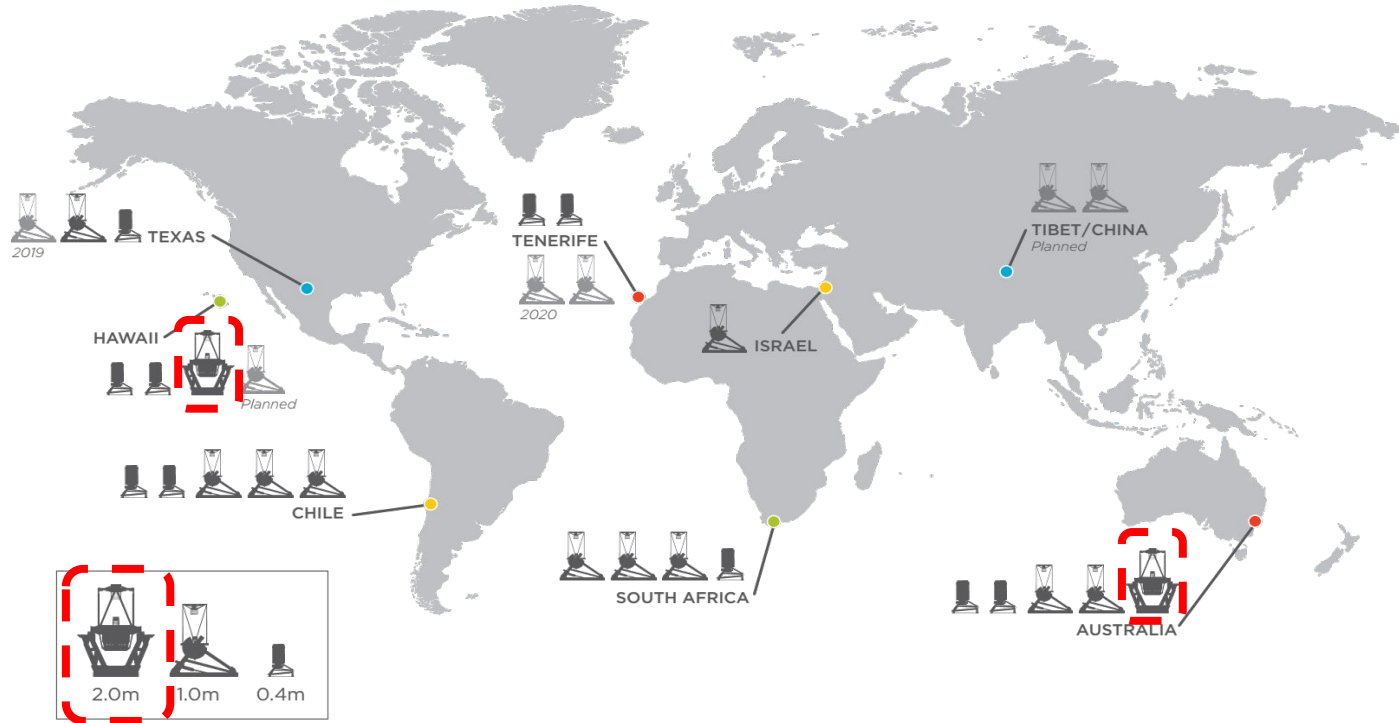


See [here](#) for an explanation of lightcurves.

Get lightcurve data

Follow-up Facilities: *responsive follow-up spectroscopy*

LAS CUMBRES OBSERVATORY GLOBAL TELESCOPE NETWORK

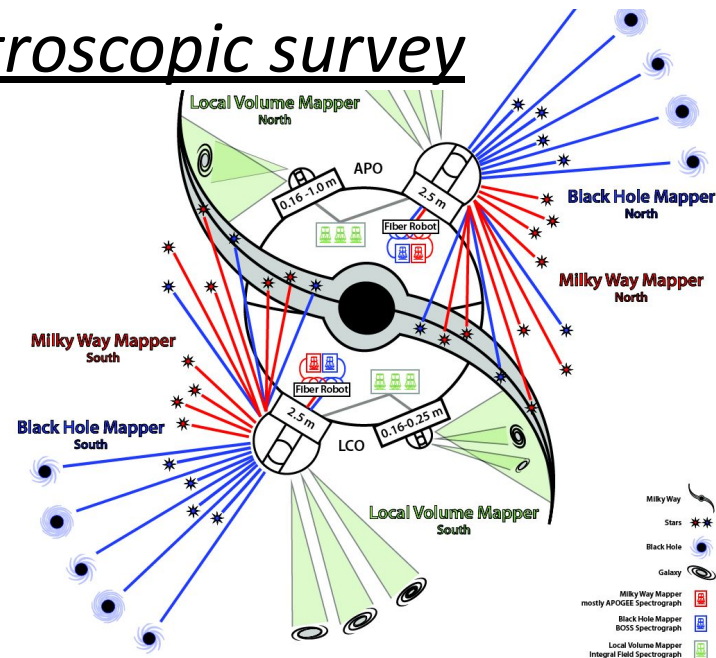


SDSS-V: an all-sky, multi-epoch *spectroscopic* survey

- Galactic & extra-galactic science
- All sky: from US (20) & Chile (21)
- Future ToO-like capabilities?



Du Pont 2.5m,
Las Campanas



SDSS-V Black Hole Mapper Targeting				
Science Goals	Primary Selection	Density [deg^{-2}]	N_{targets}	N_{epochs}
Reverberation mapping, BH masses	Optical QSOs, $i < 20$	30–50	1,500	174
BH accretion and outflow astrophysics, changing look quasars	Optical QSOs, $i < 19$	10	25,000	3–13
<i>eROSITA</i> follow-up, AGN, X-ray binaries, galaxy clusters	$f_{X\text{-ray}} \geq 2.5 \times 10^{-14} \text{ erg s}^{-1} \text{ cm}^{-2}$, $i < 21.5$	20–50	400,000	1–3

Kolmeier+17 White Paper
(arXiv: 1711.03234)

Summary

1. New surveys provide samples of extreme events related to SMBH accretion
2. Changing-look/state AGN can serve as labs for (extreme) accretion physics (inc. super-Eddington), AGN unification, etc. etc.
3. A Changing-look AGN caught in the act...
 - CL-AGN driven by changes in accretion flow
 - multi-wavelength behavior is still puzzling
 - several interesting & outstanding issues:
 - the hot X-ray corona - destroyed & recreated?
 - the dense (BLR) gas - was it always there?
 - *what drove the event: a TDE in an AGN? (after the break...)*
4. Upcoming surveys will turn the trickle into a flood ...
 - we need responsive follow-up (spec. & multi- λ) capabilities
 - SDSS-V will survey such events, measure rates & links to SMBH properties