The Changing Looks of AGN

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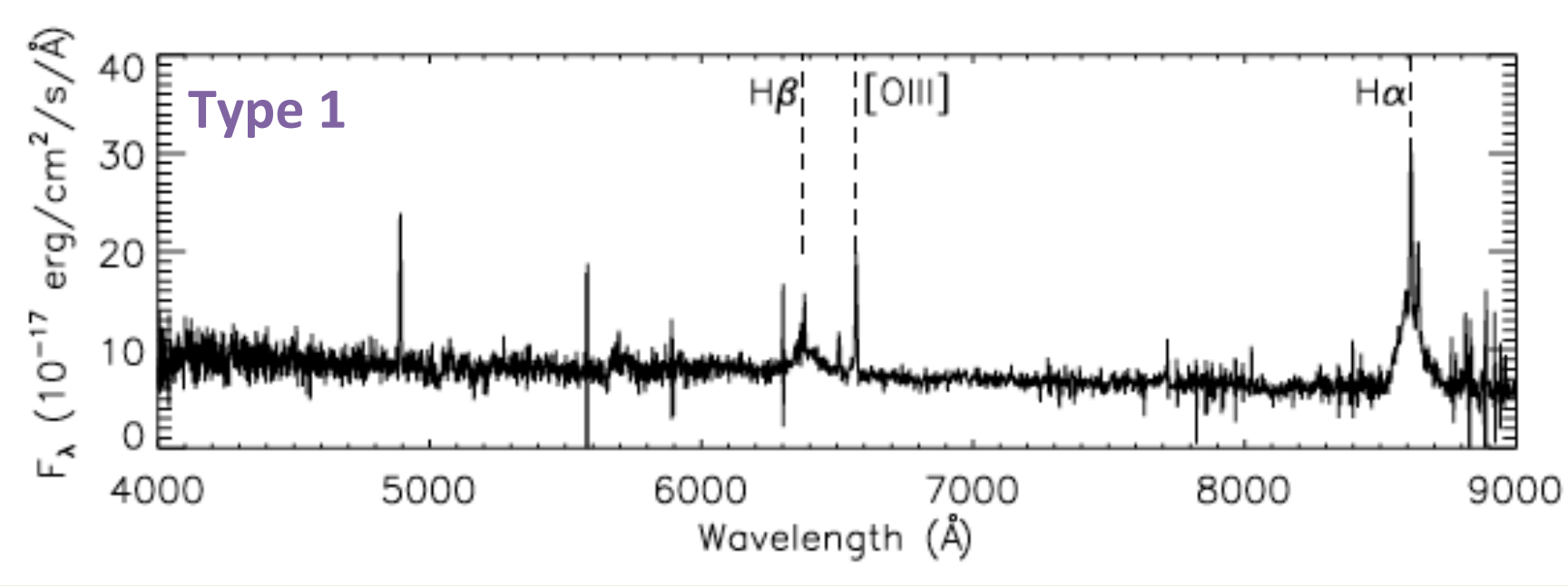
Defining AGN via Optical Spectra



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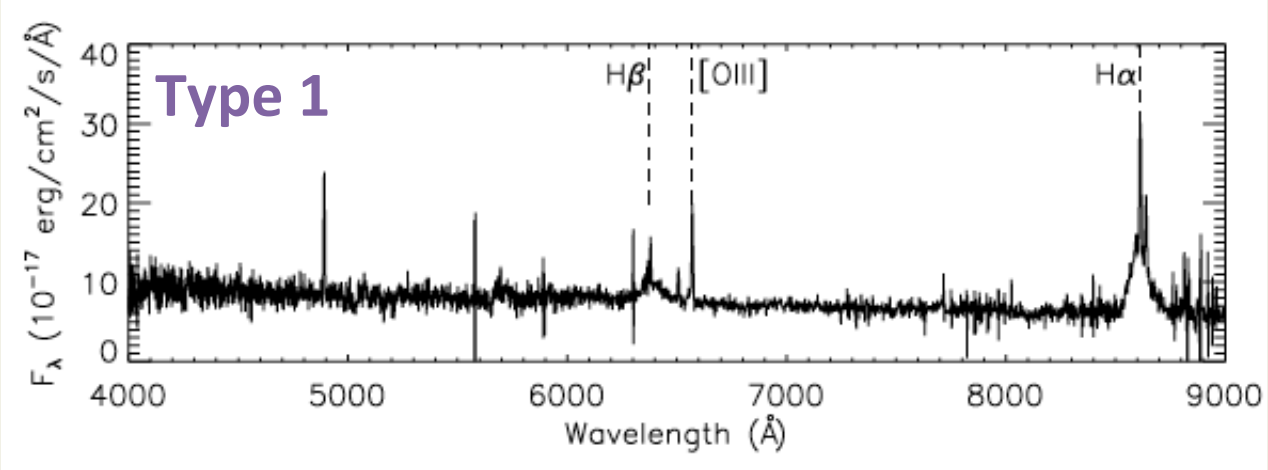
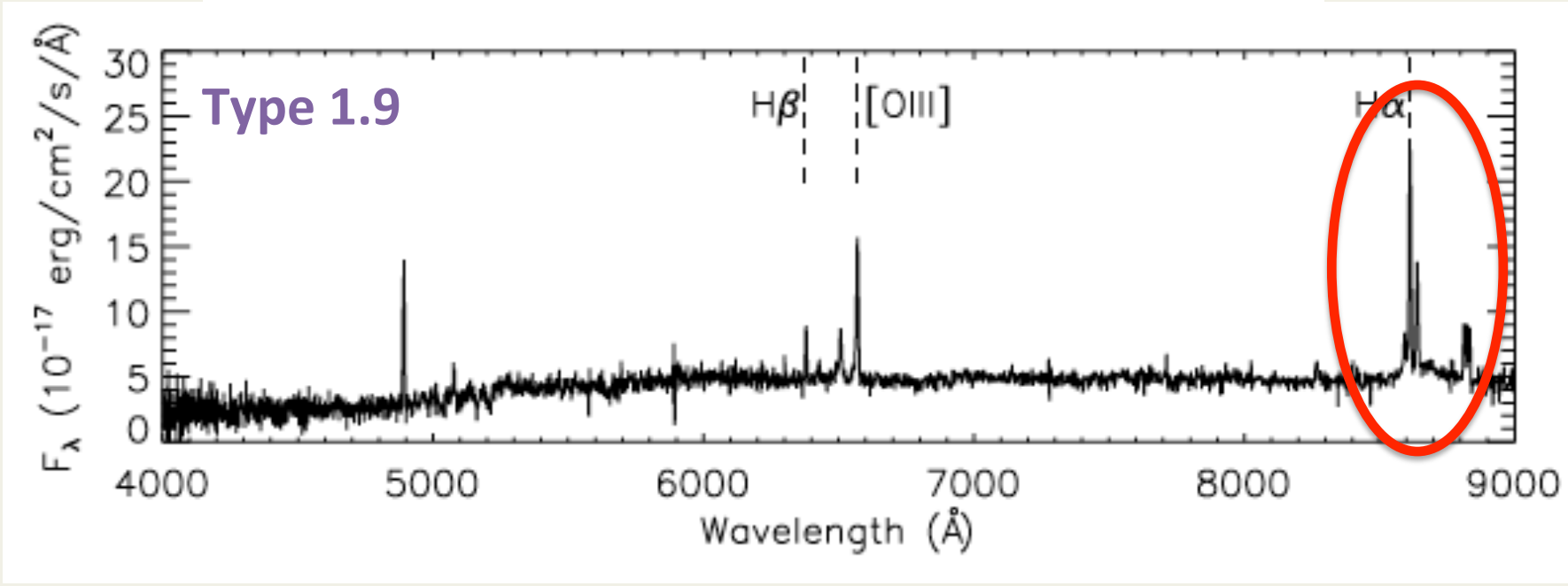
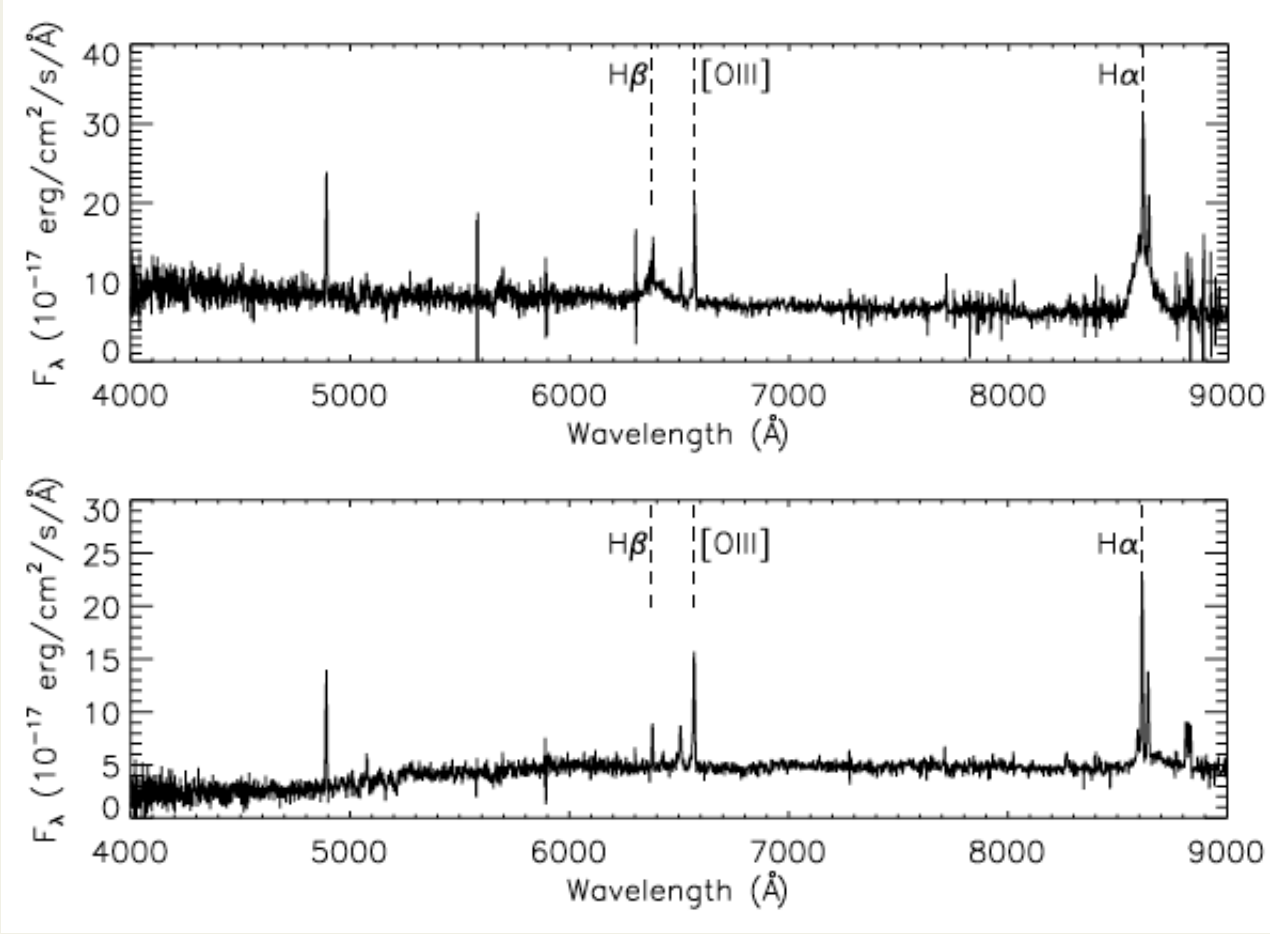




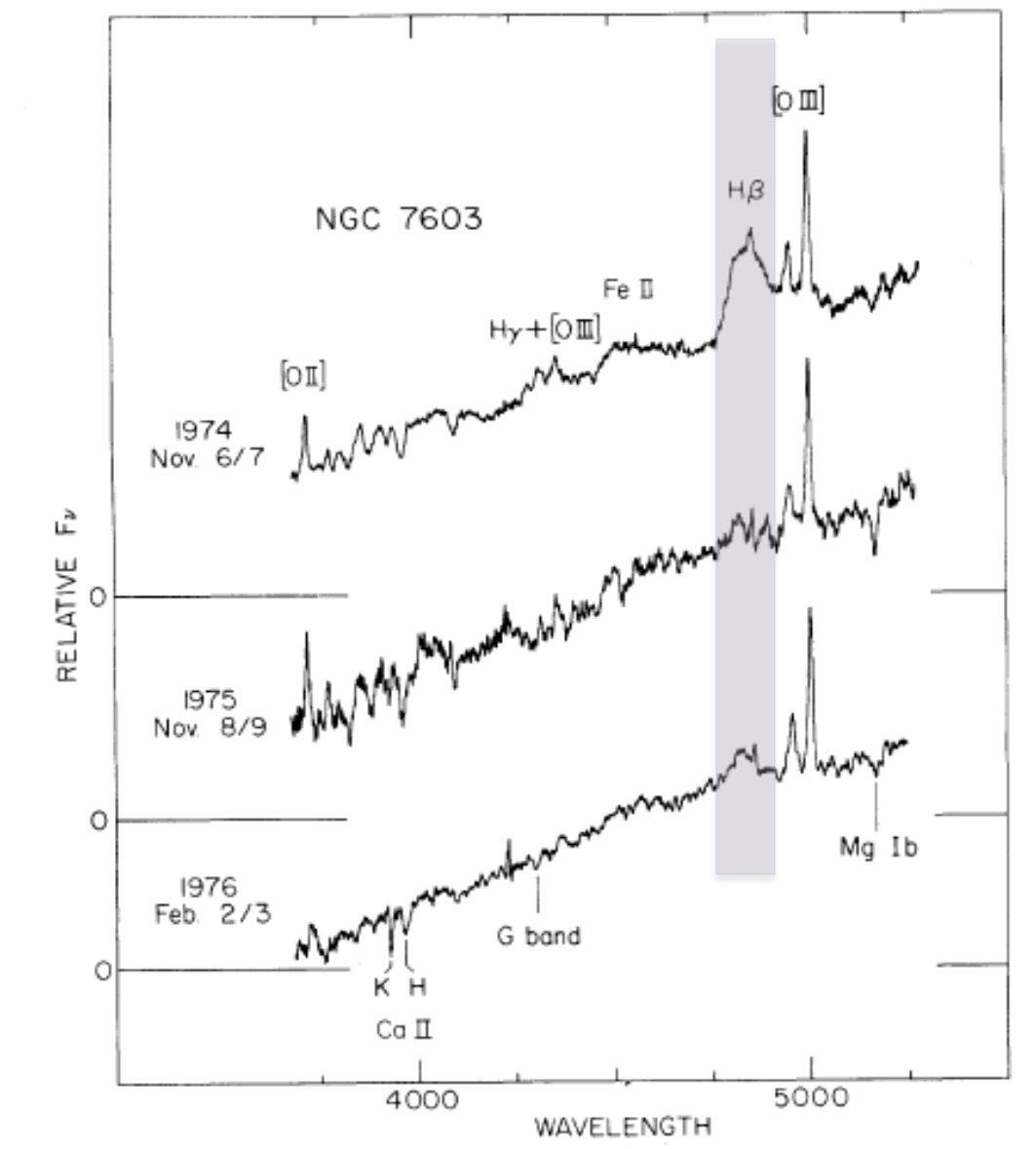
SDSS J015957.64+003310.5



2000 (SDSS)
Type 1

2010 (BOSS)
Type 1.9

Changing-Look AGN History

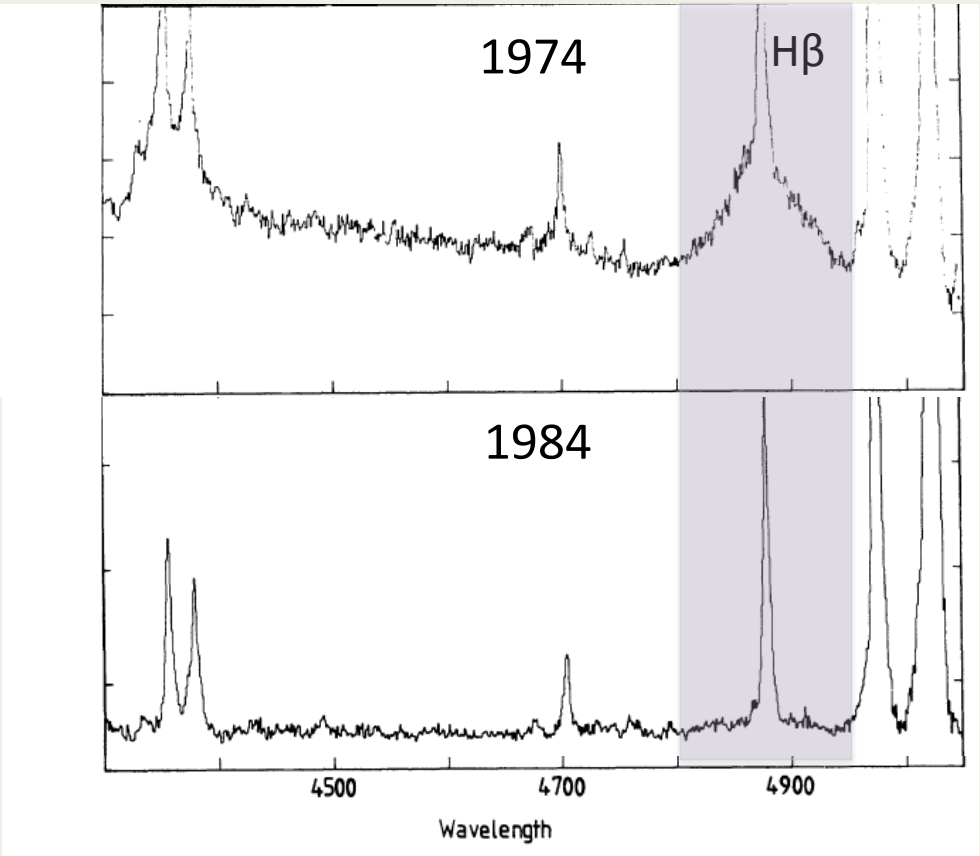


NGC 7603

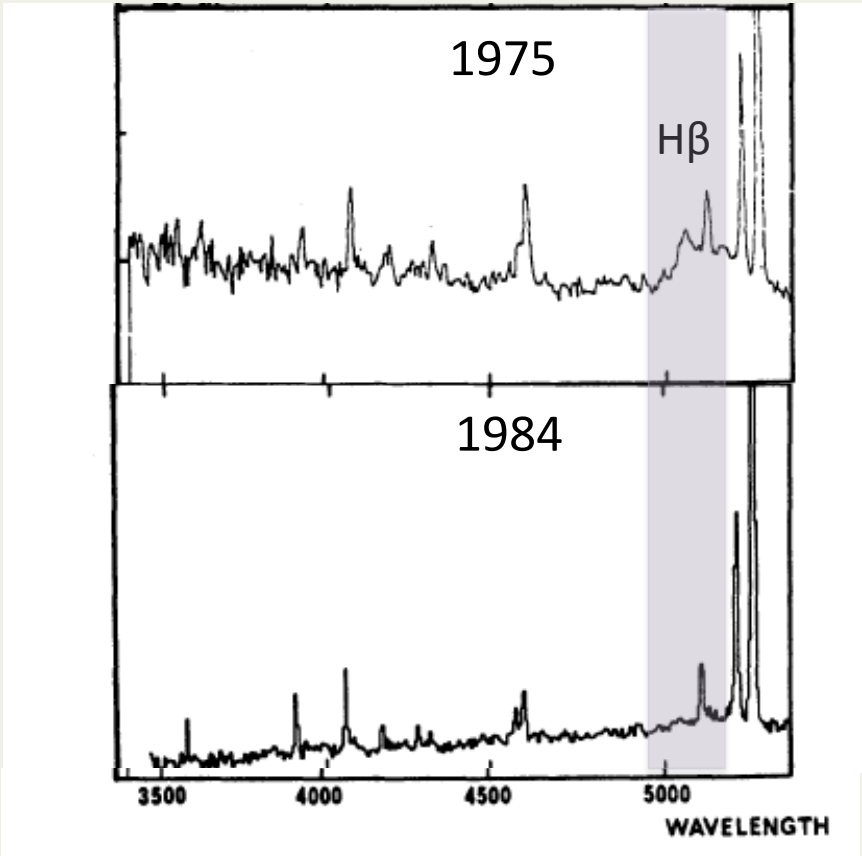
Tohline & Osterbrock ‘76

Disappearance of Broad Lines

NGC 4151



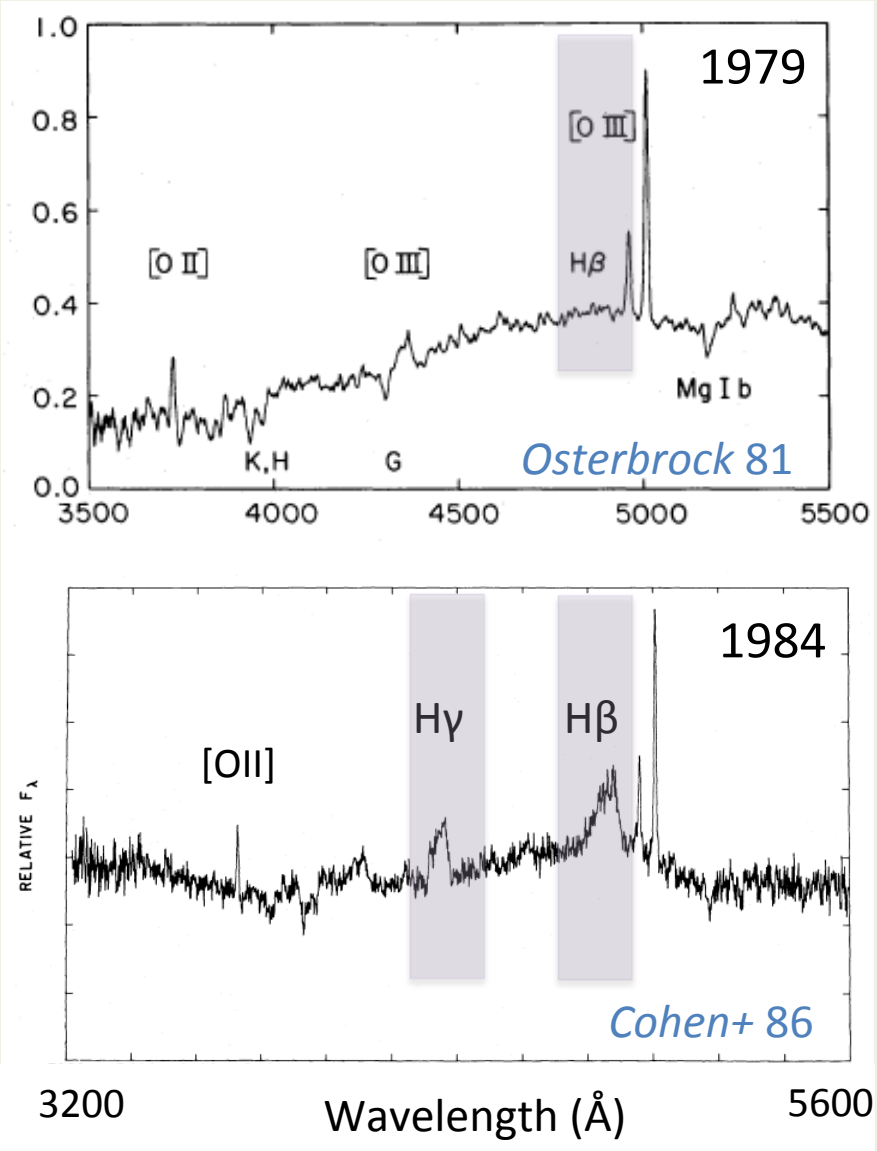
3C390.3



Penston & Perez 84; see also *Goodrich* 95

Appearance of Broad Lines

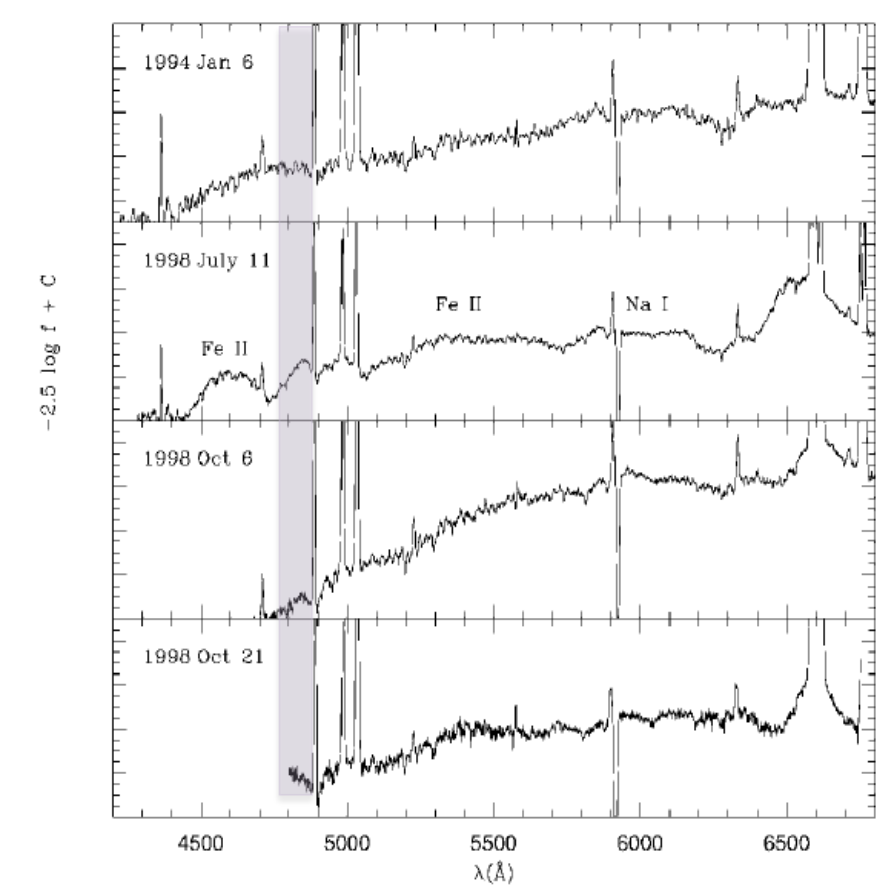
Mrk 1081



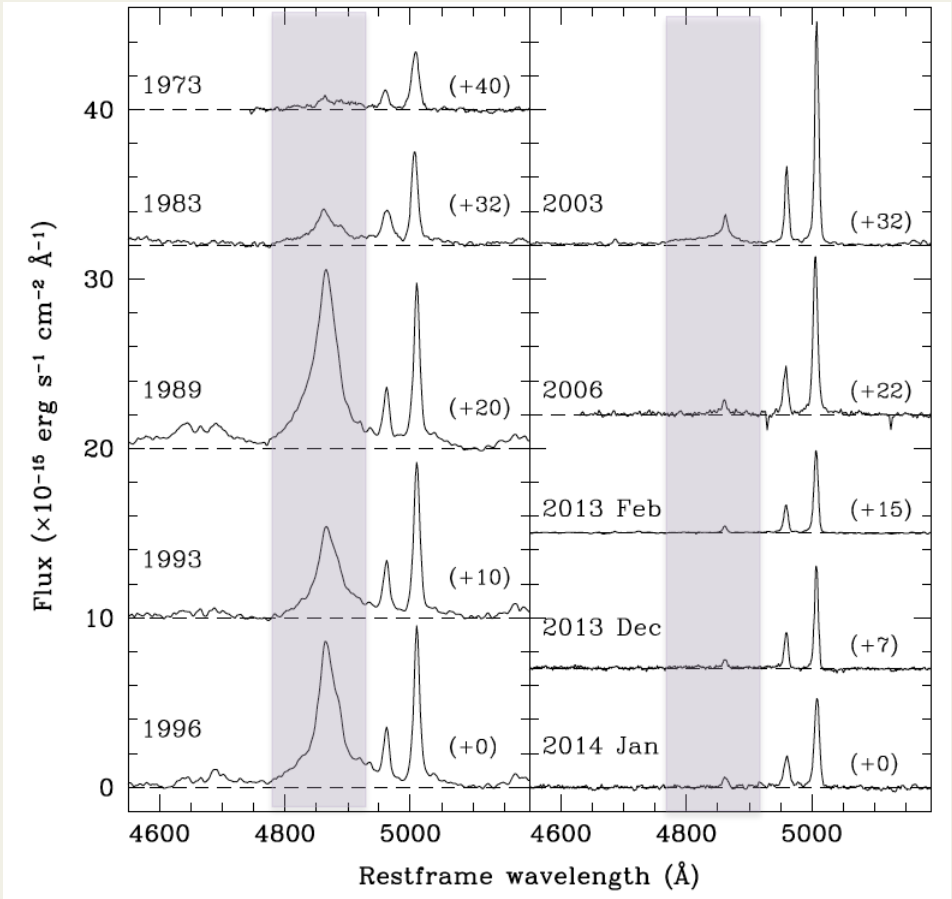
See also *Tran+* 92, *Storchi-Bergmann+* 93, *Goodrich+* 95, Eracleous *& Halpern* 01, *Shappe+* 14

There & Back Again

NGC 7582 *Aretxaga+ 99*



Mrk 590 *Denney+ 14*



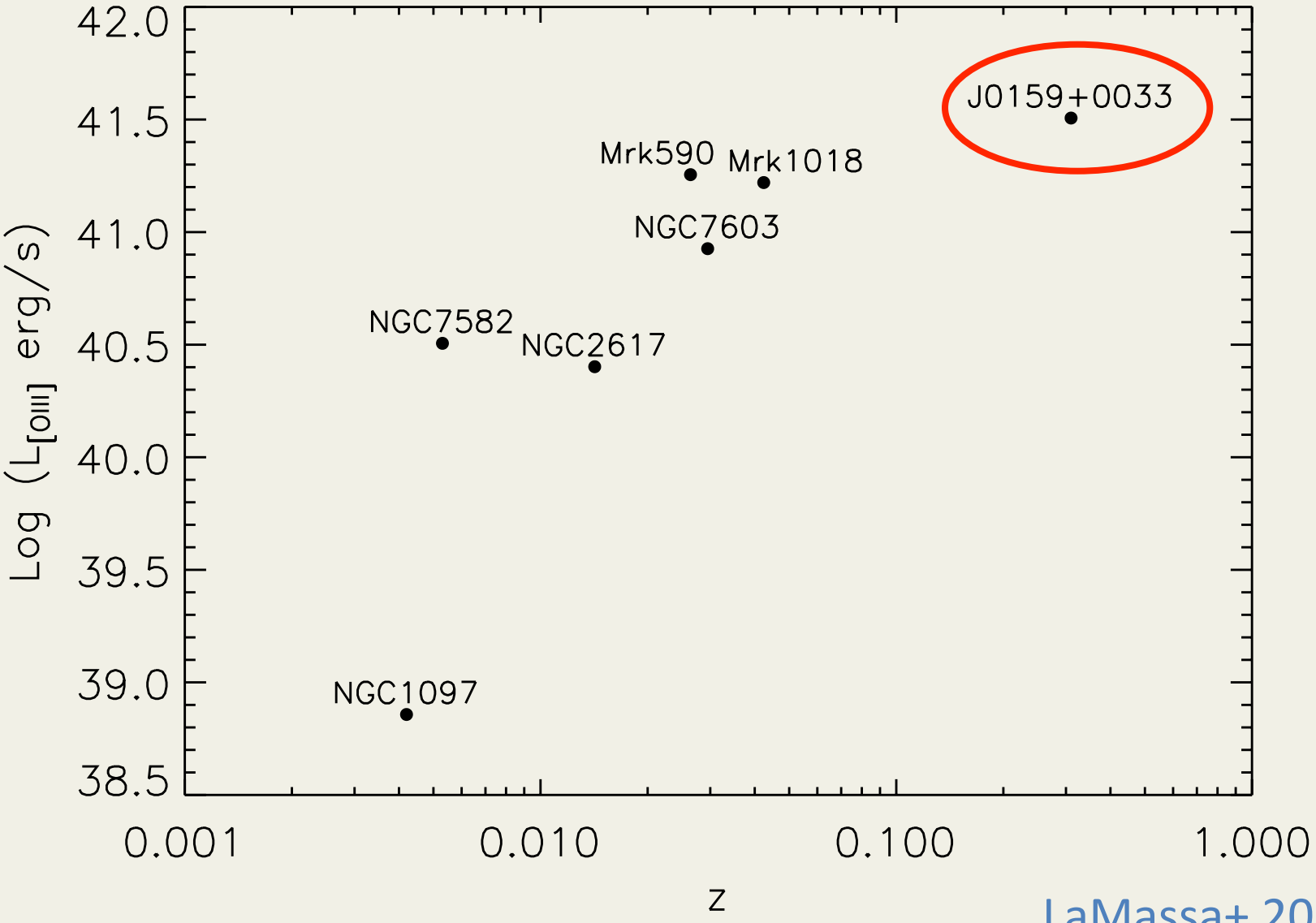
Changing-Look AGN Causes

- Variable absorption Mrk 1018, Mrk 993, NGC 7603, NGC 1097, NGC 7582 (?)
- Ionizing continuum change Mrk 590, NGC 2617, Mrk 883, NGC 3065, J0159+0033
- SN NGC 7582 (?)
- TDE NGC 3065 (?), NGC 7582 (?), J0159+0033 (?)

Case Study: J0159+0033

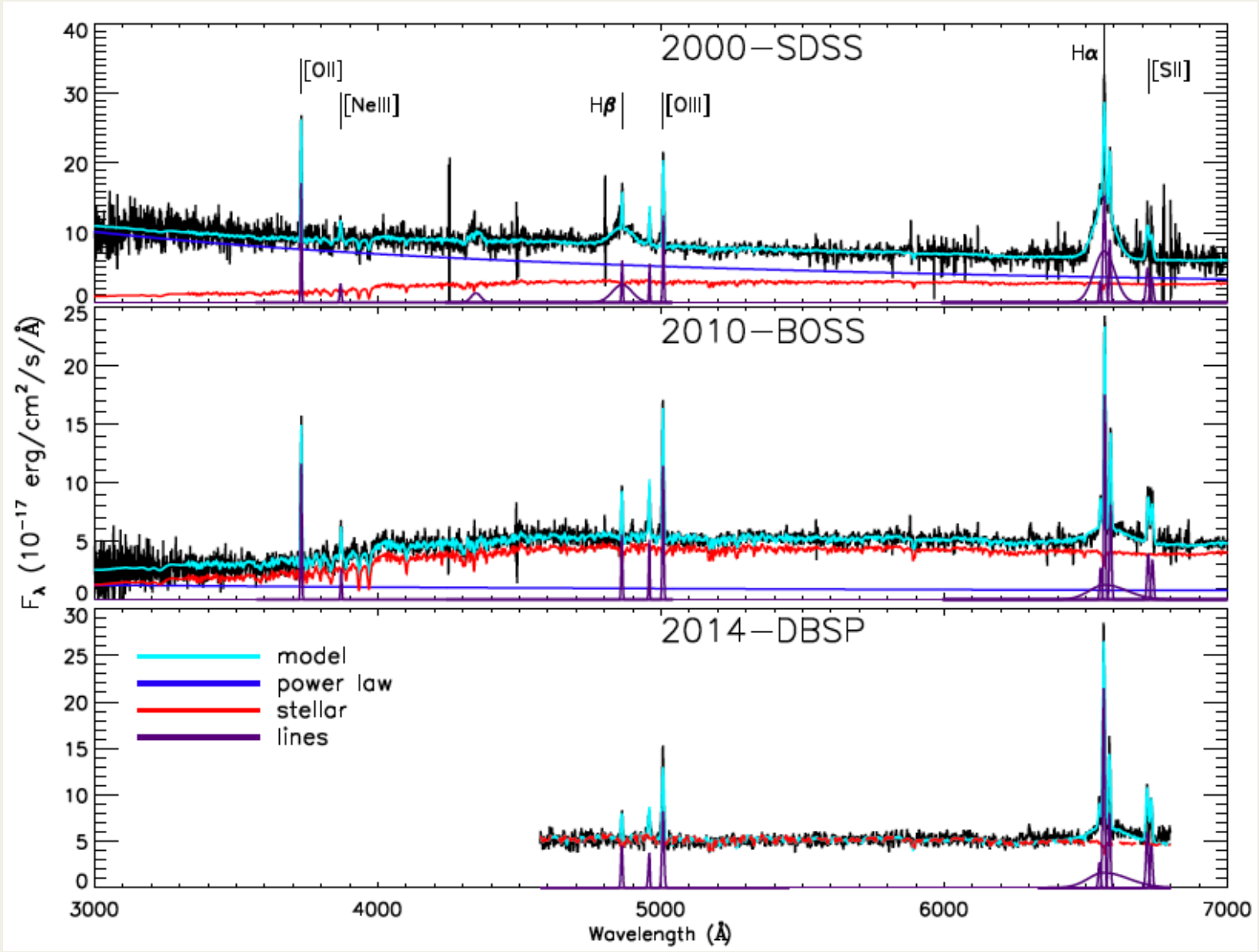
- Discovered in ~31 deg^2 Stripe 82 X-ray survey (LaMassa+ 2013b,c,2015a; see also Merloni+ 2015)
- z = 0.31
- “Quasar” in 2000

J0159+0033 in Context



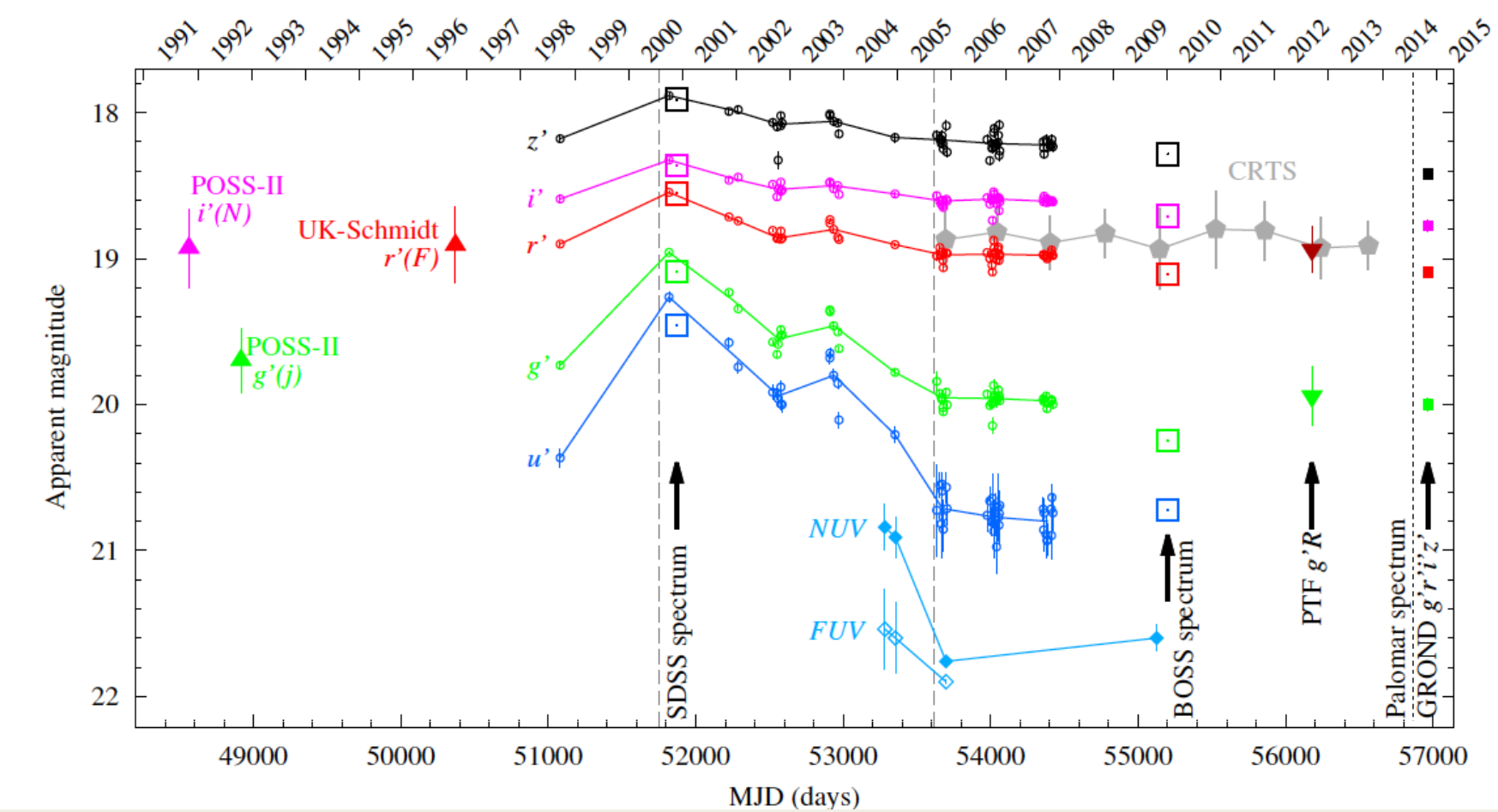
LaMassa+ 2015a

1st "Changing-Look" Quasar



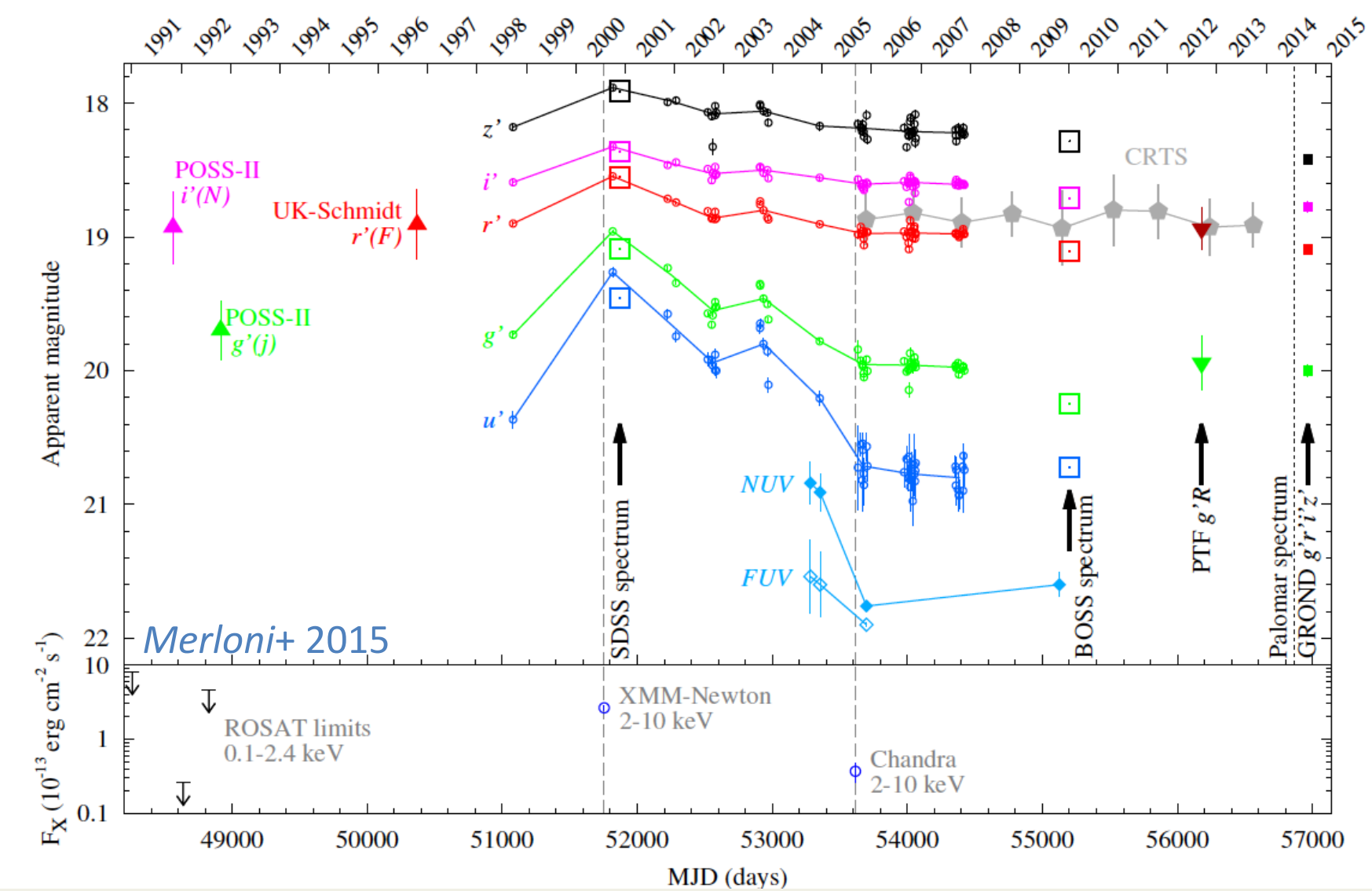
LaMassa+ 2015a

Brightness Variations

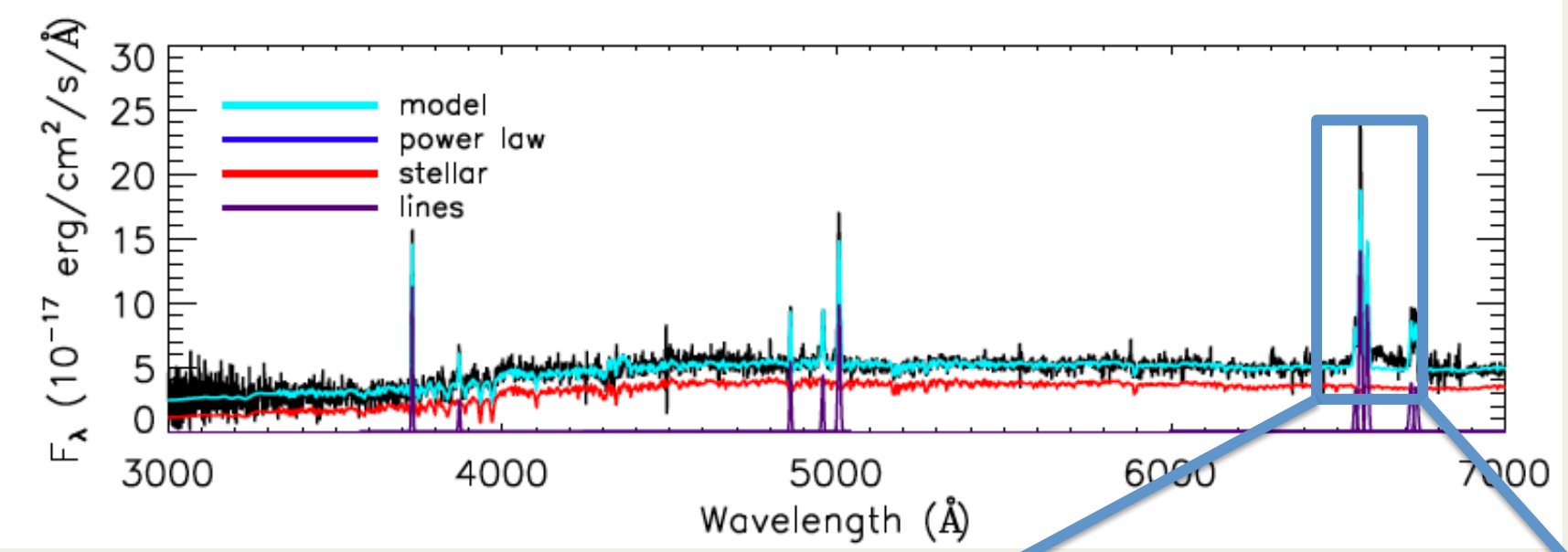


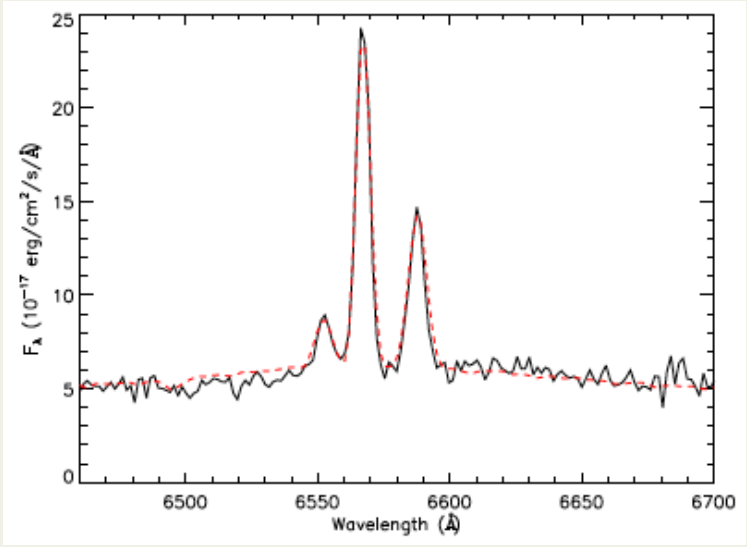
Merloni+ 2015

Brightness Variations

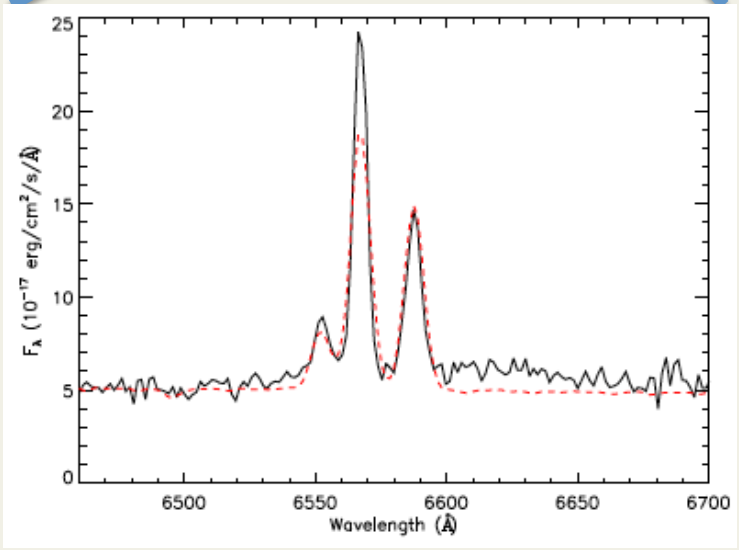


Variable Absorption?





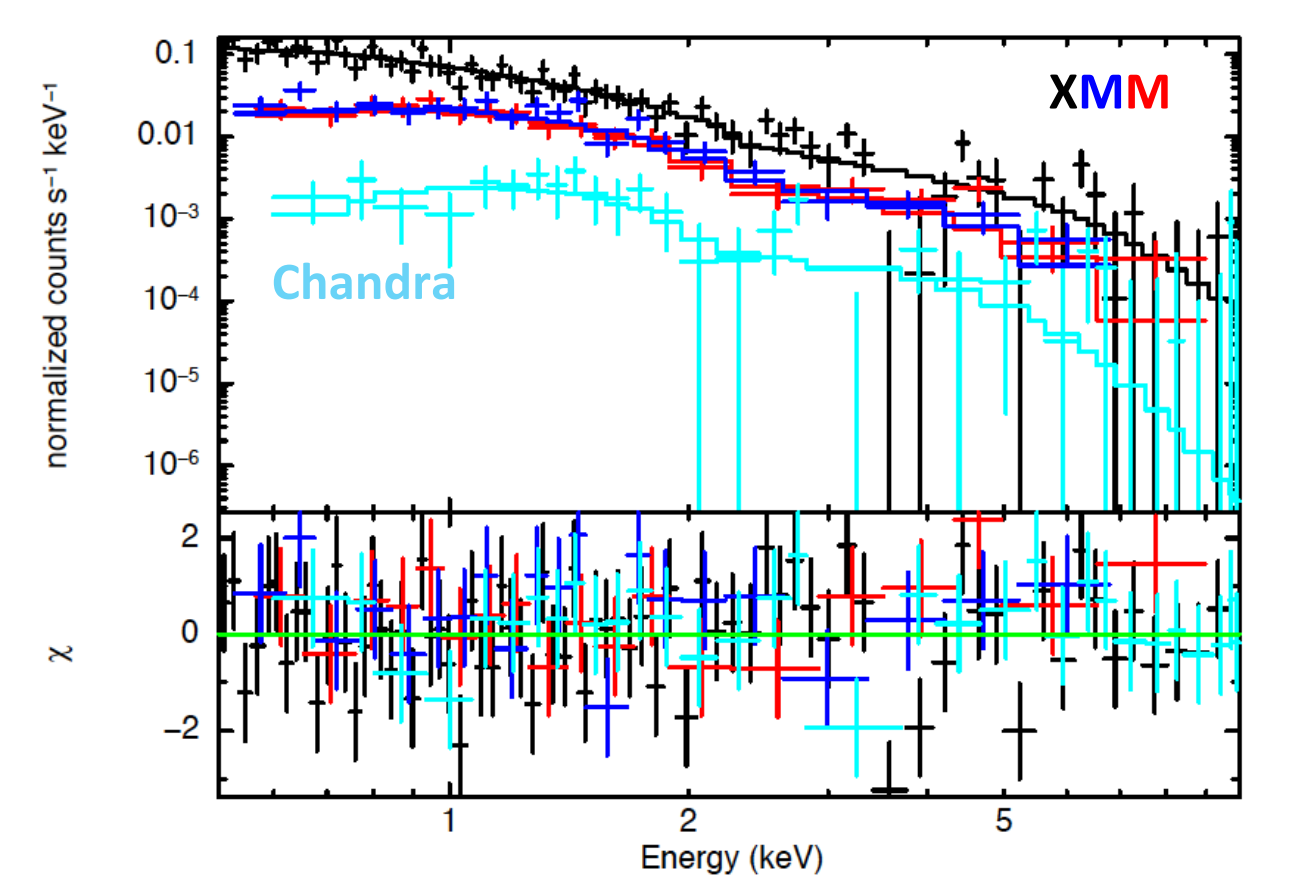
vs.



Further evidence against obscuration

LaMassa+ 2015a

- No absorption signatures in X-ray spectrum



Further evidence against obscuration

LaMassa+ 2015a

- No absorption signatures in X-ray spectrum
- Similar drop in optical & X-ray fluxes

$(\lambda L_{5100,bright}/\lambda L_{5100,dim})$ = 5.5

$(F_{2\text{-}10keV,bright}/F_{2\text{-}10keV,dim})$ = 7.2

Further evidence against obscuration

LaMassa+ 2015a

- No absorption signatures in X-ray spectrum
- Similar drop in optical & X-ray fluxes
- Similar BH masses in bright & dim states

$$M_{\rm BH} = 9.7 \times 10^6 \left[\frac{\rm FWHM(H\alpha)}{1000\ \rm km\ s^{-1}}\right]^{2.06} \left[\frac{\lambda L_{5100}}{10^{44}\ \rm erg\ s^{-1}}\right]^{0.519} \rm M_\odot$$

$M_{BH,bright} = 1.7 \pm 0.1 \times 10^8\ M_\odot$

$M_{BH,dim} = 1.6 \pm 0.4 \times 10^8\ M_\odot$

Further evidence against obscuration

LaMassa+ 2015a

- No absorption signatures in X-ray spectrum
- Similar drop in optical & X-ray fluxes
- Similar BH masses in bright & dim states
- Hα profile change cf. λL_{5100} change

  FWHM ~ $R_{BLR}^{-1/2}$; R_{BLR} ~ $L^{1/2}$ (e.g. Bentz+ 06)

  ➔ FWHM ~ $L^{-1/4}$

Further evidence against obscuration

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➔ FWHM ~ $L^{-1/4}$

$(FWHM_{H\alpha,bright}/FWHM_{H\alpha,dim}) = 0.67$

$(\lambda L_{5100,bright}/\lambda L_{5100,dim})^{-1/4} = 0.65$

Further evidence against obscuration

LaMassa+ 2015a

- No absorption signatures in X-ray spectrum
- Similar drop in optical & X-ray fluxes
- Similar BH masses in bright & dim states
- Hα profile change cf. λL_{5100} change
- t_{cross} for cloud to eclipse BLR

$$t_{\rm cross} = 0.07 \left[\frac{r_{\rm orb}}{1{\rm lt}-{\rm day}}\right]^{3/2} M_8^{-1/2} \arcsin\left[\frac{r_{\rm src}}{r_{\rm orb}}\right] \ {\rm yr}$$

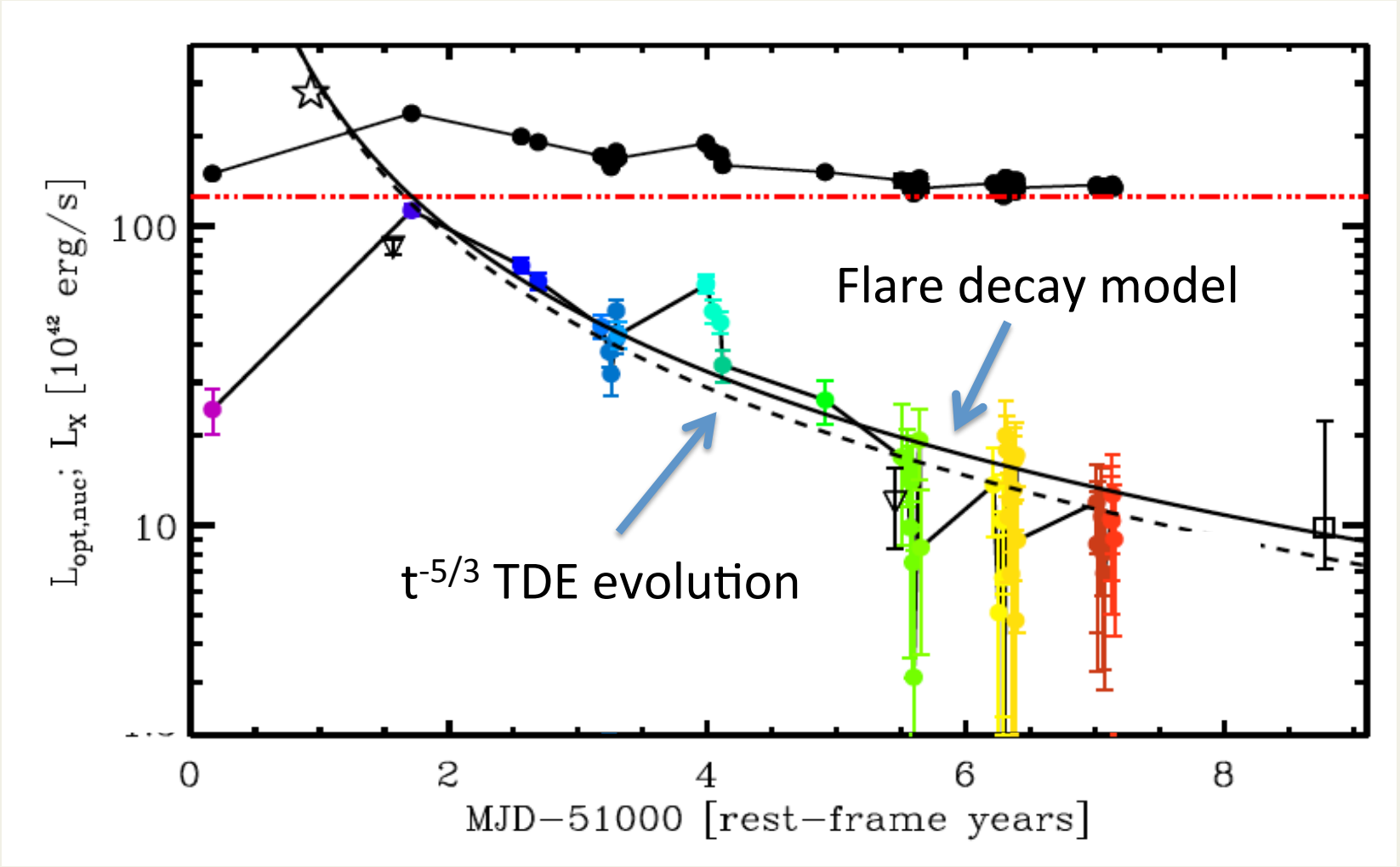
t_{cross} > 10-20 yrs

t_{change} ~ 3 yrs

Driver: Change in Ionizing Continuum

- Viscous time scale? *may need additional angular momentum loss (e.g., waves in inner disk, hydromagnetic winds)*
- Thermal time scale of inner disk or corona?
- Evolutionary sequence (Elitzur + 2014): Type 1 → Type 1.2/1.5 → Type 1.8/1.9 → Type 2 (see Stern+ 2012)
- TDE? *Merloni*+ 2015

Driver: TDE?



Merloni+ 2015

Changing-Look AGN:

- Opportunity to study AGN lifetime/ intermittency
- Rare, but more being discovered

➔ Jessie Runnoe's talk