Quasar Ionization Echoes -- 100,000 Year Baseline AGN Light Curves

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et al.

Citation of published version:

Keel, W., et al. (2014): Quasar Ionization Echos -- 100,000 Year Baseline AGN Light Curves. *AAS Meeting #233*. Bibliographic Code: 2014AAS...22325011S

Quasar ionization echos – 100,000 year baseline AGN light curves

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Bill Keel (U of Alabama; low-z echos)
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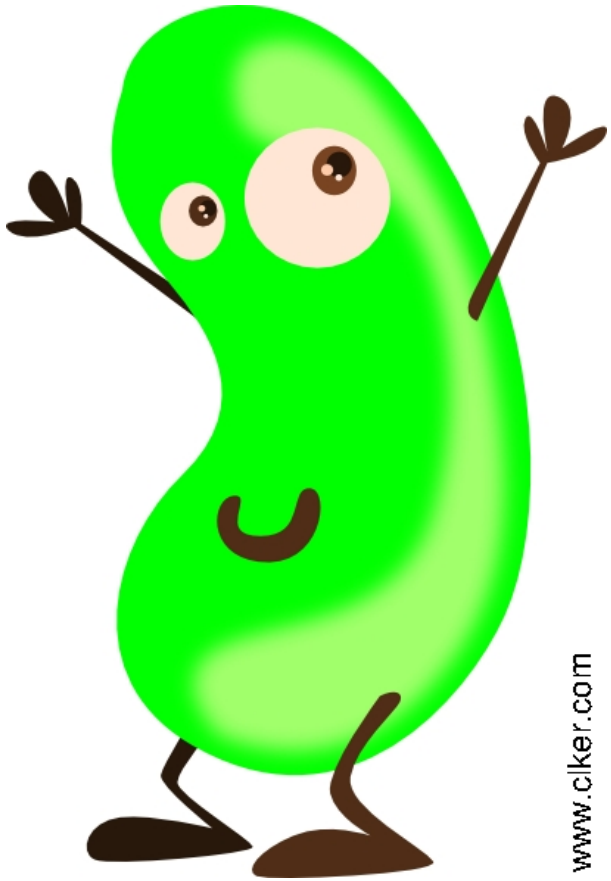
Hai Fu (UC Irvine; EELRs, PI models)
Nancy Levenson (Gemini; X-ray)
James Turner (Gemini; IFU)
Ruben Diaz (Gemini; Star burst)

Outline

1. Quasar ionization echos
2. The cosmic soup: Green Bean galaxies (Schirmer et al. 2013)
3. How to extract an AGN light curve from an ionization echo (i.e. a GB galaxy)



1. Quasar ionization echos

Hanny's Voorwerp (z=0.05, near IC 2497)

Credit: 3.5m WIYN, W. Keel

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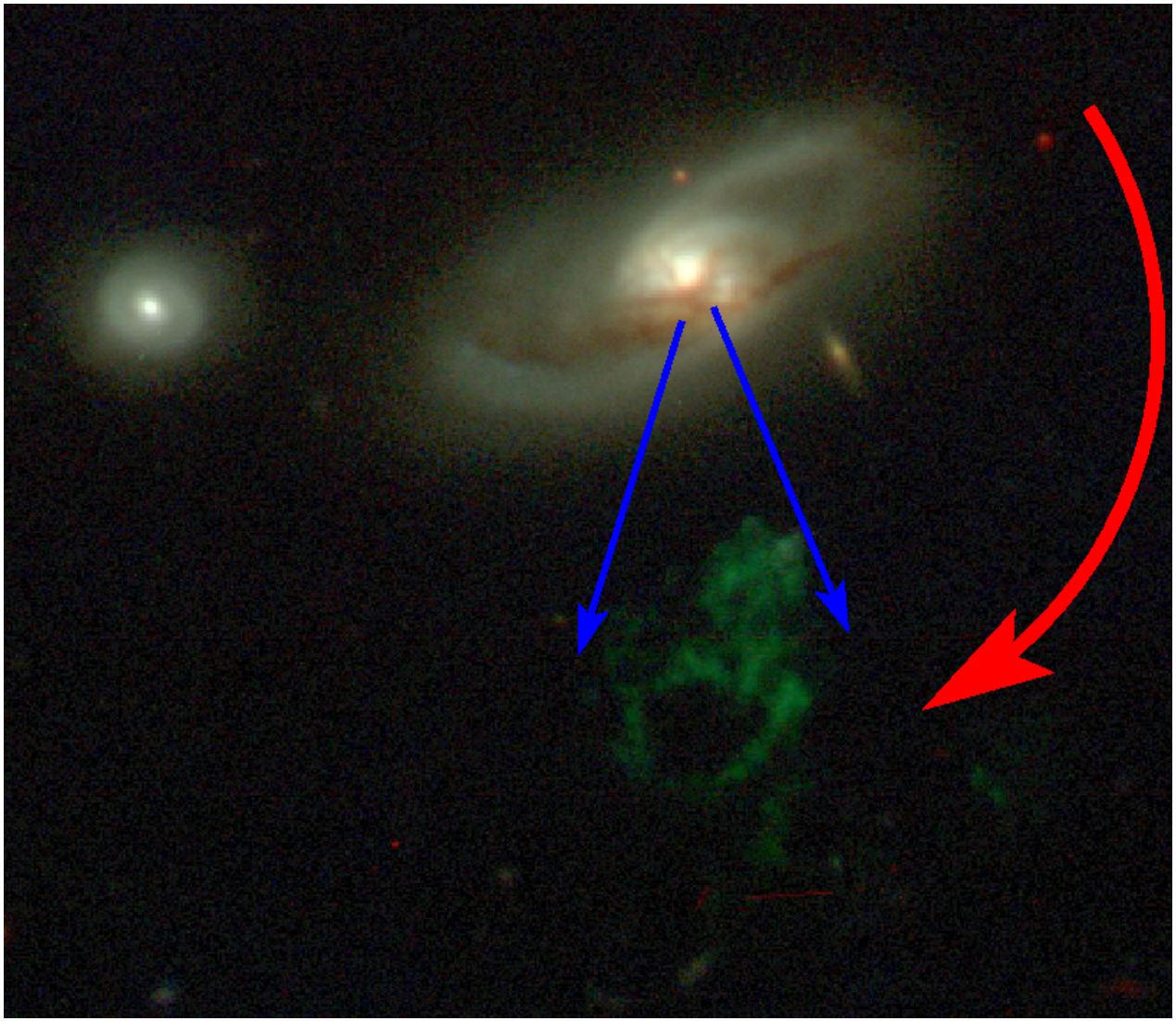

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1. Quasar ionization echos

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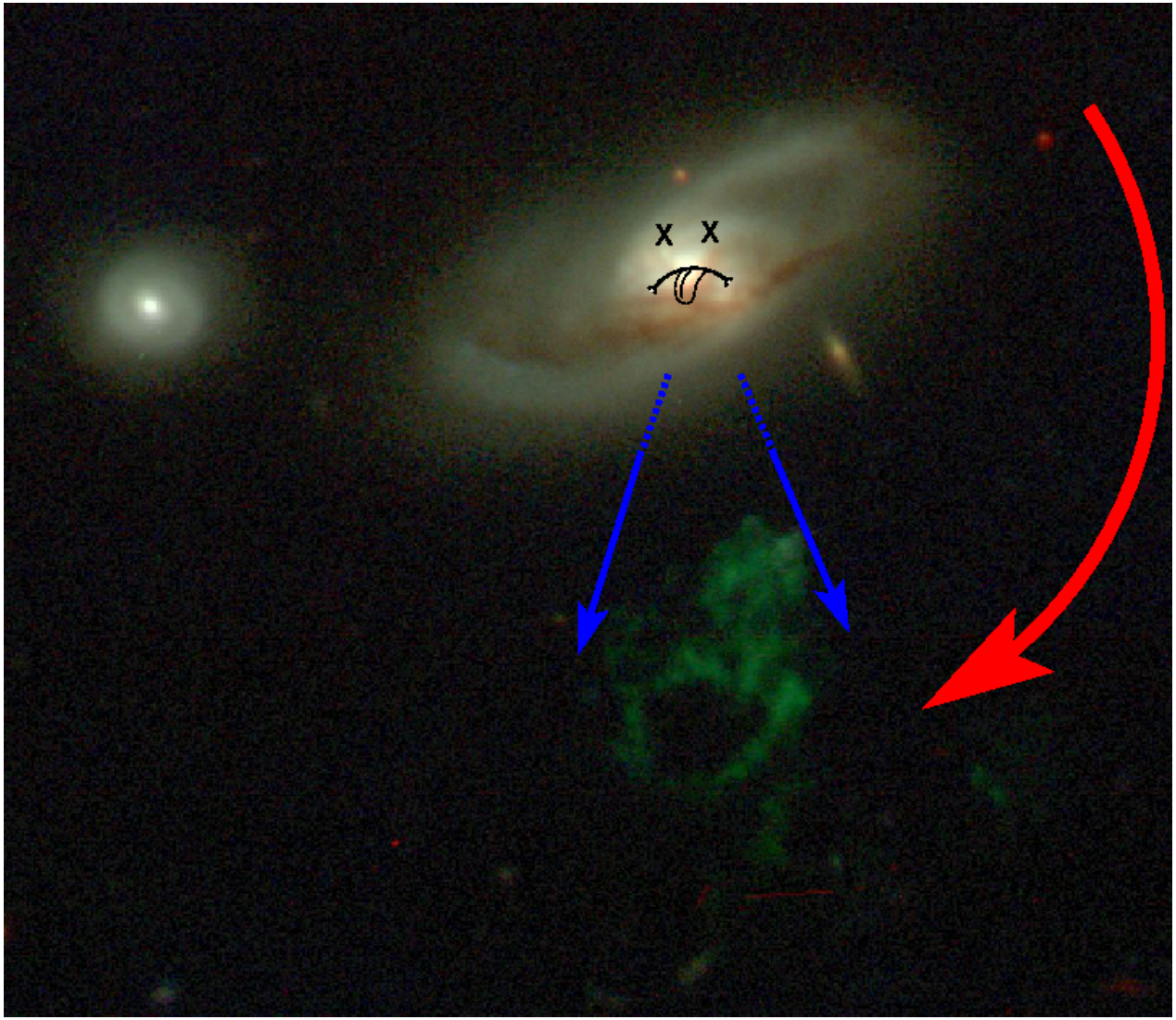
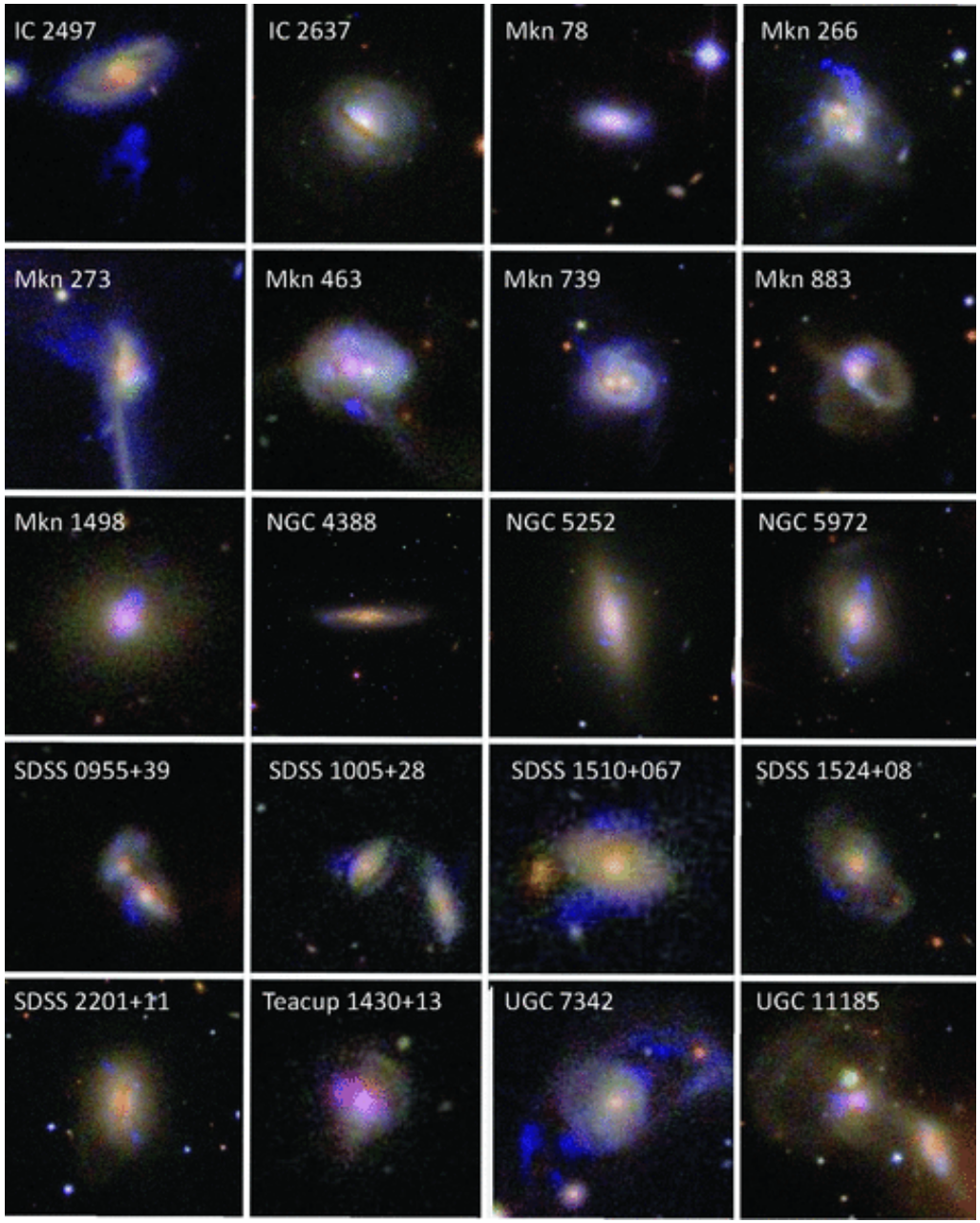


$\sim$ 70, 000 years ago, output drops by $\sim \times 10^4$

Other Voorwerpjes (from SDSS)



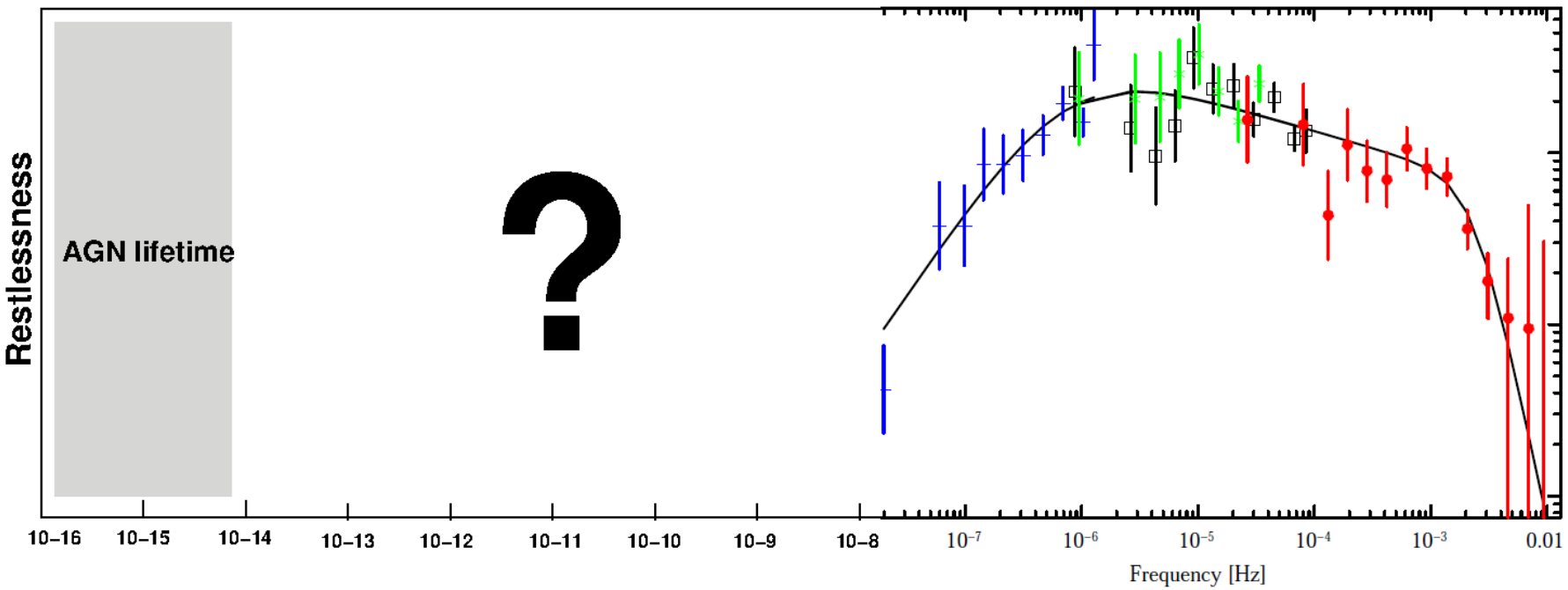
BLUE = [OIII] in *gri* poststamps

Keel, W. et al. 2012:

- $\sim$ 200 found by Galaxy Zoo
- 19 AGN ionized
- 7 good ionization echoes
- median redshift $z = 0.06$
- [OIII] luminosity:
  $(0.5 - 5) * 10^{41}$ erg cm^{-2} s^{-1}

AGN undergo luminous
$(0.2 - 2) \times 10^5$ year episodes.

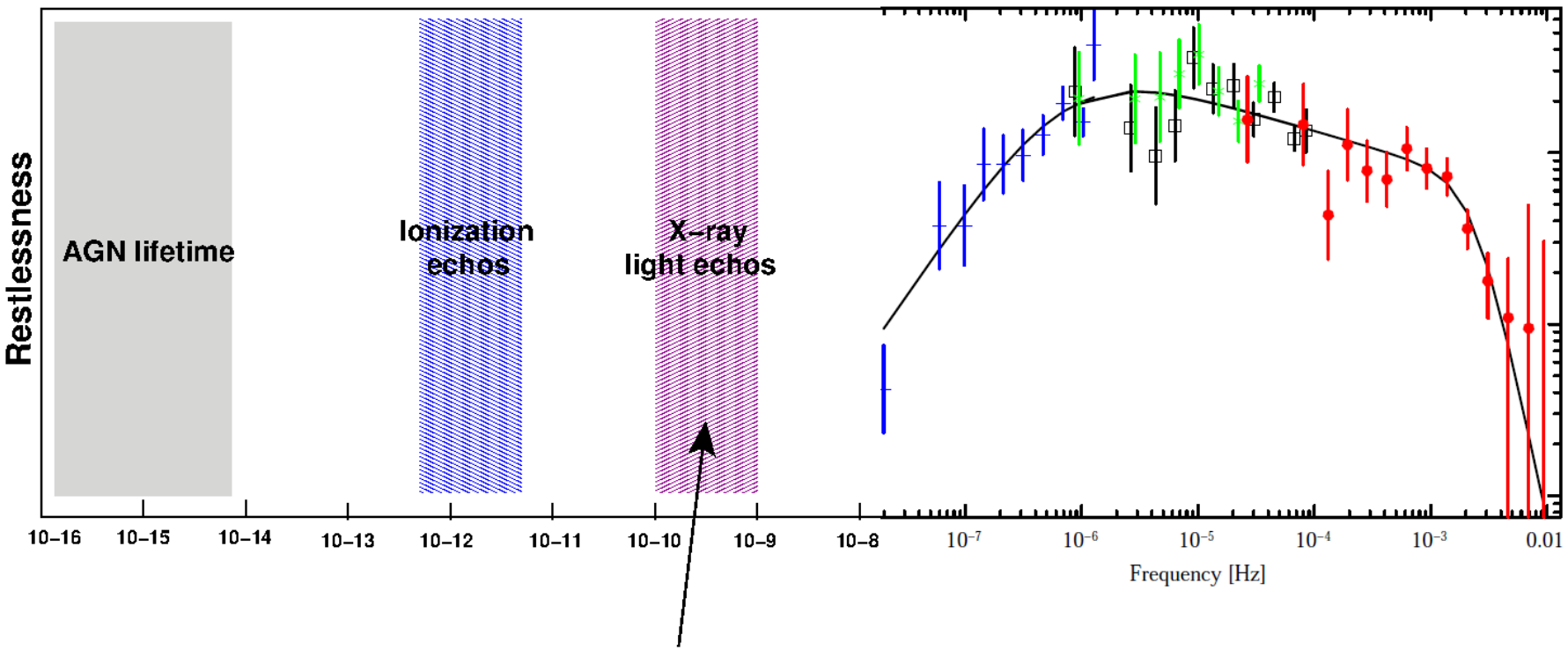
Lifelong restlessness ...



Credit: McHardy, I. et al. 2007

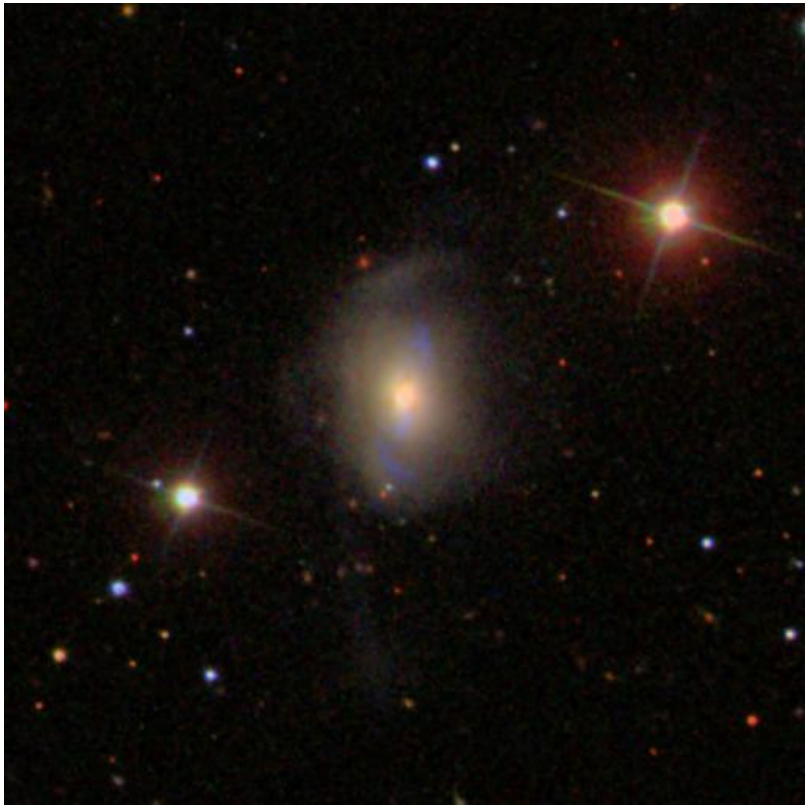
Martini, 2004; Bourneaud et al., 2011

Lifelong restlessness ...



See Gabriele Ponti's talk on Monday

2. Green Bean galaxies



NGC 5972 ($z = 0.029$, SDSS)
20×35 kpc
$L_{[\mathrm{OIII}]} = 1.5 \times 10^{41}$ erg cm^{-2} s^{-1}

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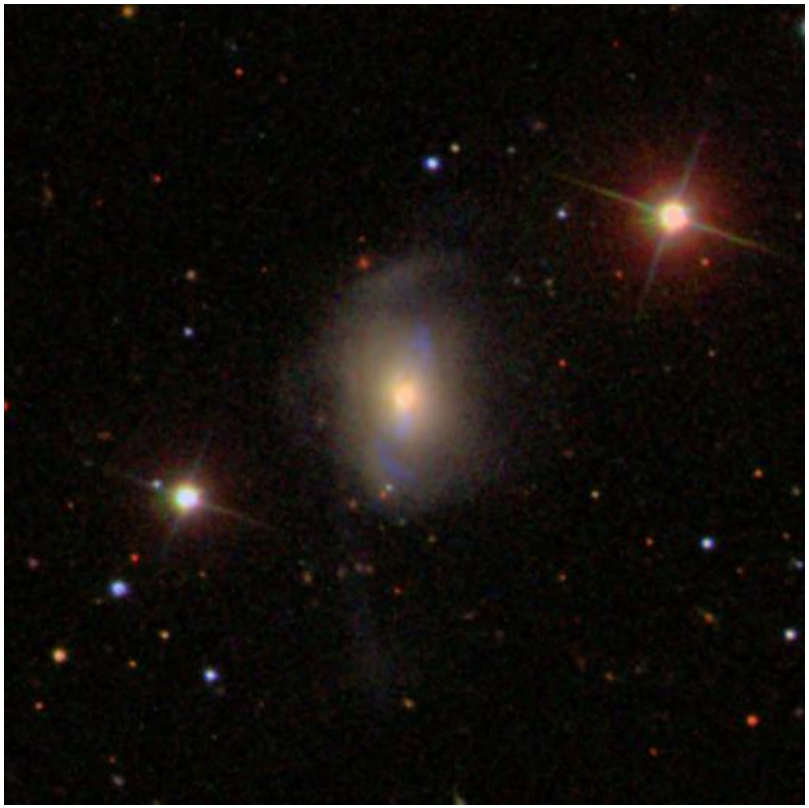

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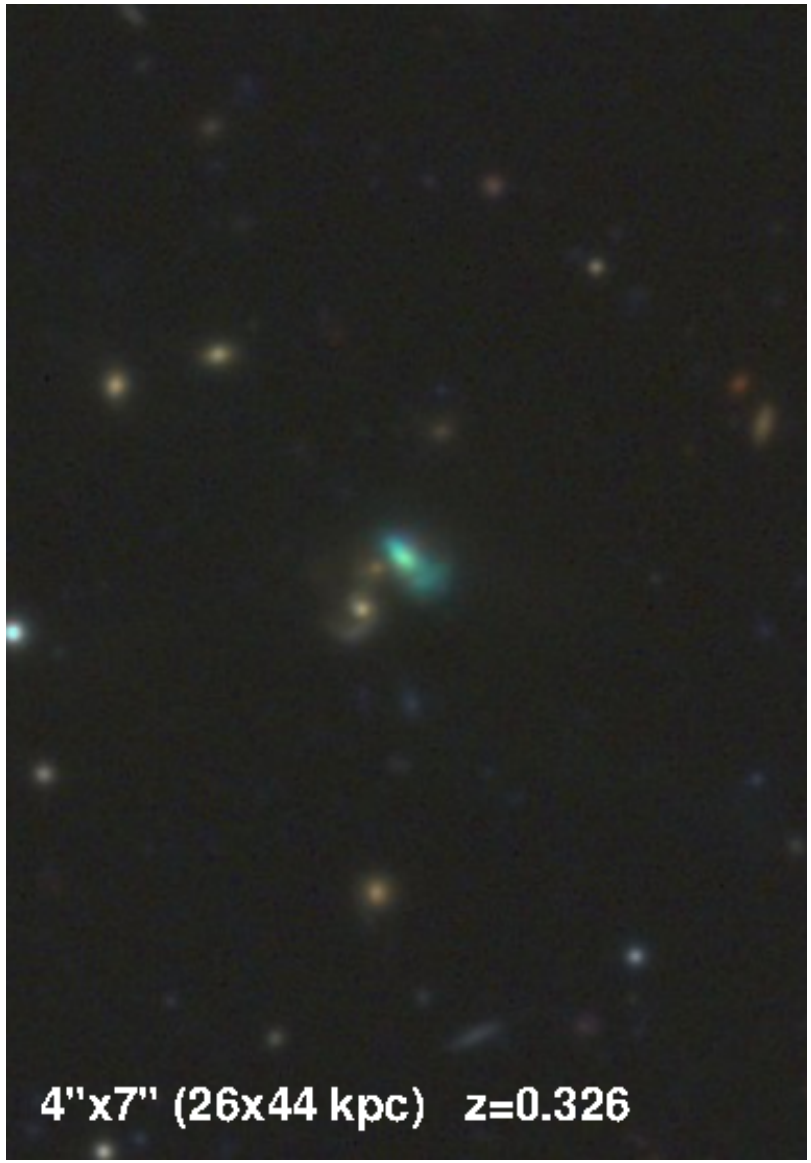

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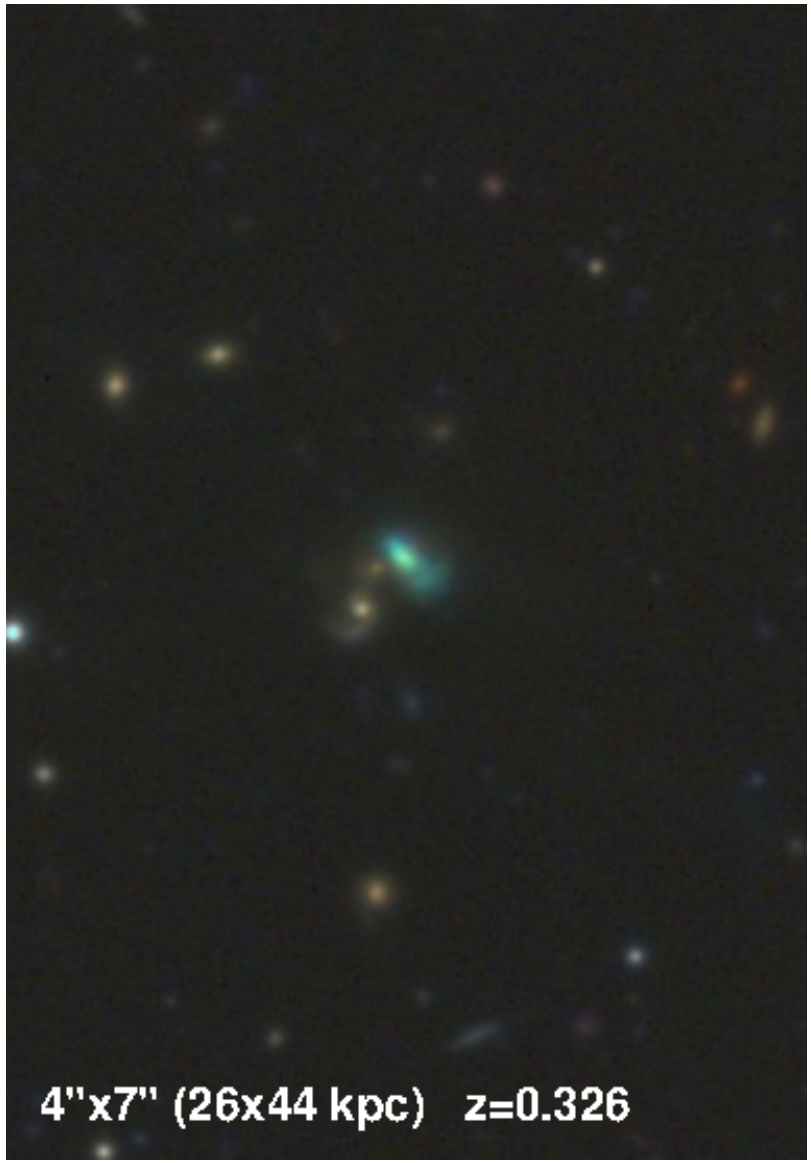


Green beans – rare but luminous

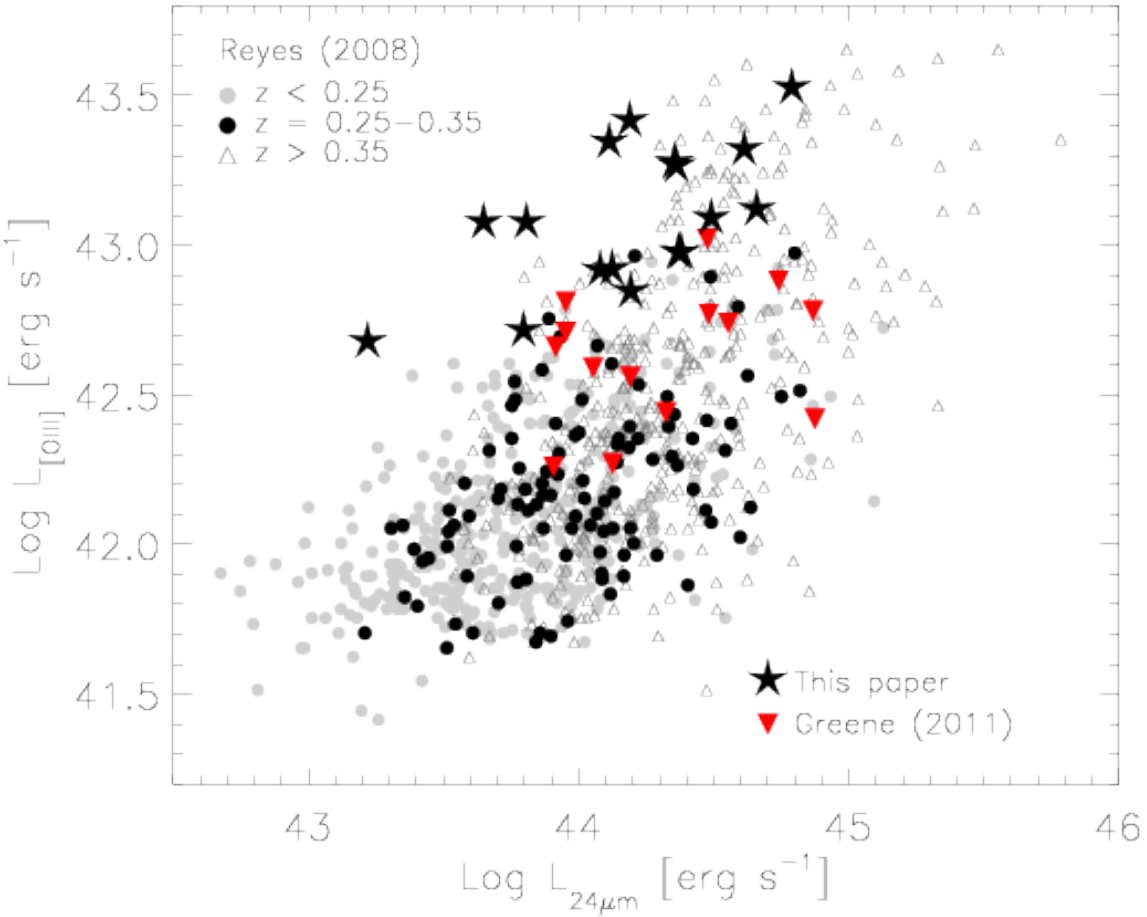
Color selection in SDSS-DR9 yields: 17 GBs in 14500 sq.deg.

#	Name	SDSS objID	r [mag]	R_r [″]	z	$\log\left(\frac{[\mathrm{O\,III}]}{\mathrm{H}\beta}\right)$	F_R [mJy]	$F_{24\mu m}$ [mJy]
001	SDSS J002016.4−053126	1237679077517557845	18.3	2.1	0.334	1.305 ± 0.005	9.38	11.7
002	SDSS J002434.9+325842	1237676441460474246	18.2	2.6	0.293	1.246 ± 0.003	···	25.4
003	SDSS J011133.3+225359	1237666091128914338	19.1	2.1	0.318	1.243 ± 0.016	···	23.1
004	SDSS J011341.1+010608	1237666340800364769	18.5	2.6	0.281	1.043 ± 0.006	1.18	39.7
005	SDSS J015930.8+270302	1237680284389015833	18.9	2.6	0.278	1.194 ± 0.004	···	18.1
006	SDSS J115544.5−014739	1237650371555229774	17.9	2.4	0.306	1.163 ± 0.006	undetected	16.9
007	SDSS J134709.1+545311	1237661386529374363	18.7	2.0	0.332	0.944	3.67	5.3
008	SDSS J135155.4+081608	1237662236402647262	19.0	2.1	0.306	1.161 ± 0.002	undetected	25.7
009	SDSS J144110.9+251700	1237665442062663827	18.5	2.2	0.192	1.086 ± 0.001	2.28	19.6
010	SDSS J145533.6+044643	1237655742407835791	18.5	2.0	0.334	1.151 ± 0.003	undetected	20.4
011	SDSS J150420.6+343958	1237662306730639531	18.7	2.2	0.294	1.004	undetected	7.6
012	SDSS J150517.6+194444	1237667968032637115	17.9	2.4	0.341	1.131 ± 0.001	4.89	49.9
013	SDSS J205058.0+055012	1237669699436675933	18.6	2.6	0.301	1.163 ± 0.003	···	49.5
014	SDSS J213542.8−031408	1237680191506678389	19.2	2.0	0.246	1.108 ± 0.004	···	3.2
015	SDSS J220216.7+230903	1237680306395415794	18.9	2.5	0.258	1.154 ± 0.006	···	24.8
016	SDSS J224024.1−092748	1237656538051248311	18.3	3.4	0.326	0.960 ± 0.003	2.85	37.4
017	SDSS J230829.4+330310	1237680503434445439	19.1	2.0	0.284	1.258 ± 0.010	···	13.9

- Volume density ($0.19 < z < 0.34$) : 4.4 Gpc^{-3}, 1 in $z < 0.1$
- $L_{[OIII]} = (0.6 - 5.7) \times 10^{43}$ erg s^{-1}
- Most [OIII] luminous type-2 AGN known

Proving ionization echos: Assess SMBH activity

- Directly, in X-rays (not yet)
- Indirectly, in the mid-IR (reprocessed X-rays in dusty torus)
- 5 — 50 times brighter in [OIII] at given L_{22} than comparison sample



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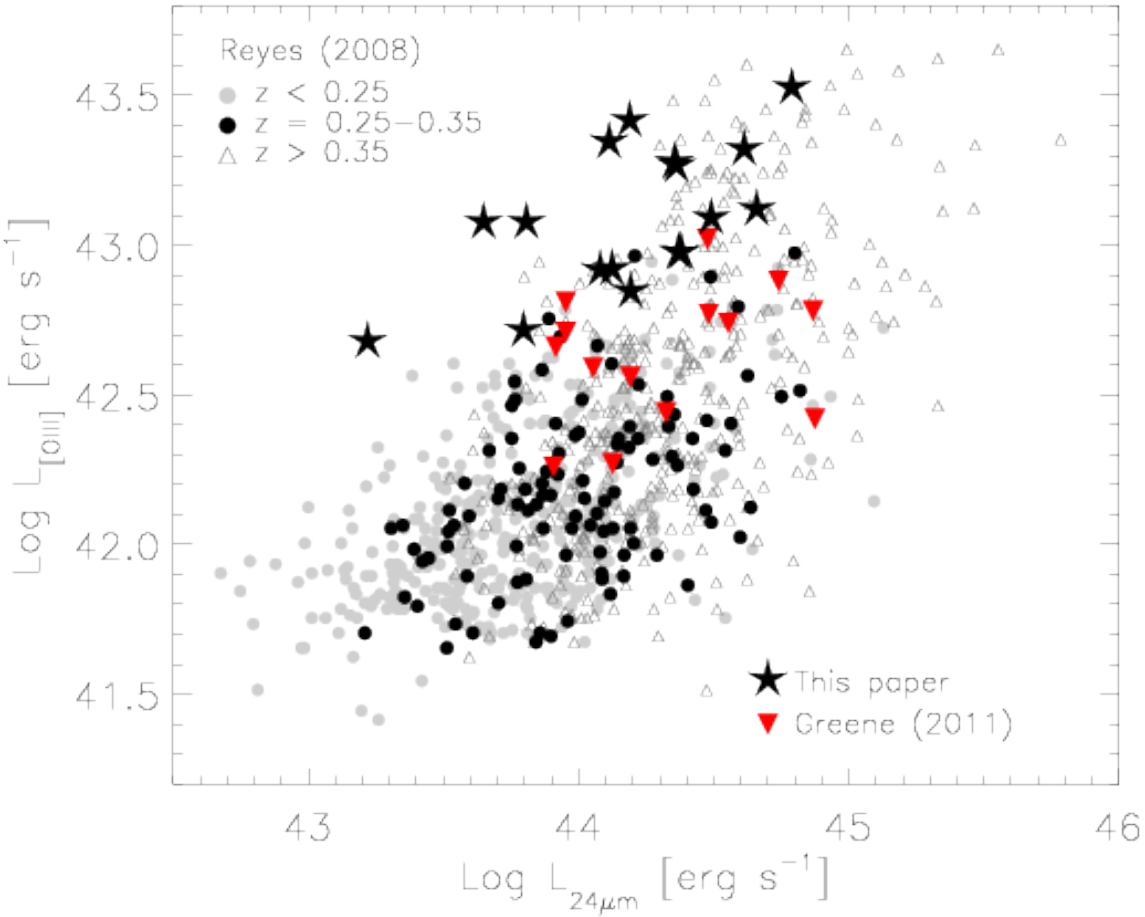


- Torus emits disprop. less IR at given L_{BOL}?
- [OIII] is not a faithful probe of L_{BOL}?

Not explicable by our broad-band selection. Violates mid-IR-X-ray and [OIII]-X-ray relations.

BUT: GBs are ionization echos nonetheless! Imprint of past AGN luminosity.

GBs: Where do they come from, what do they tell us?

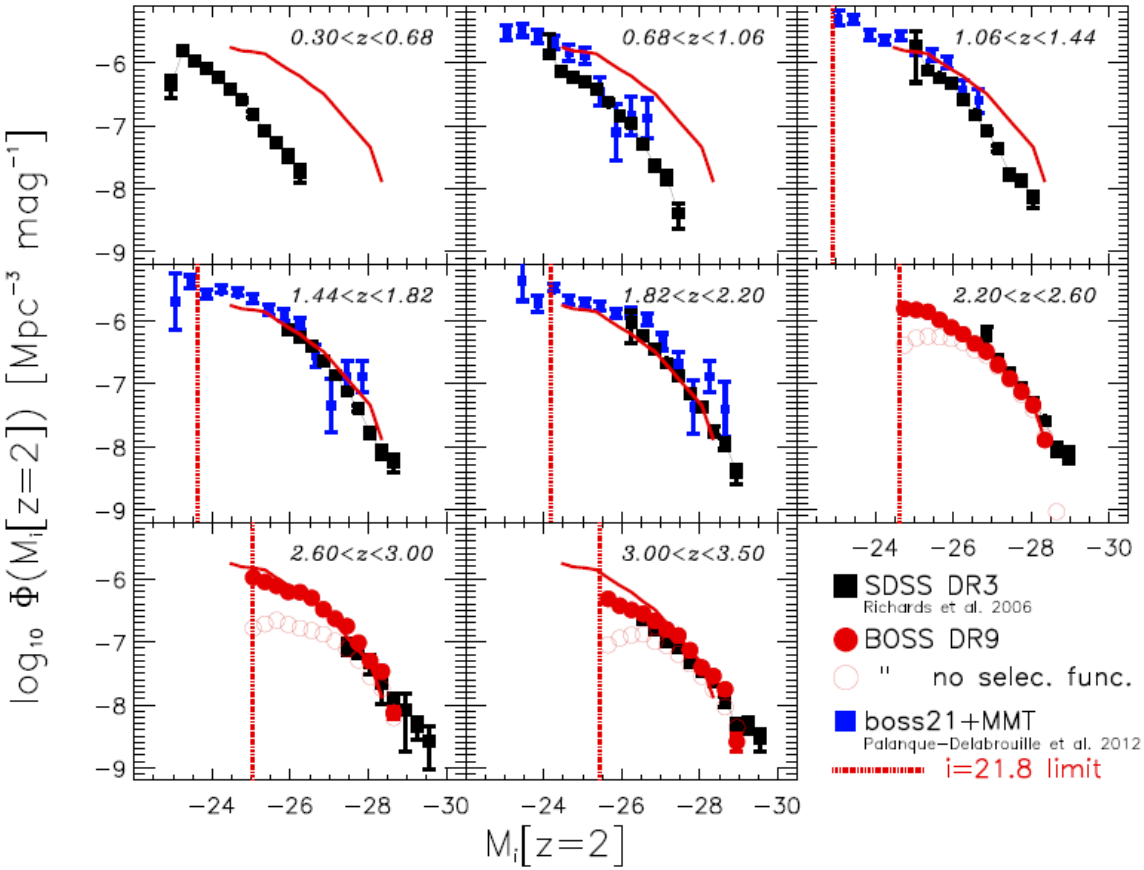
- At least 2/3 show merger signatures
- Very gas rich
- Live in the field or very small groups, not in clusters
- Exlusively radio-quiet

Some Questions (out of many):

- Formed from gas from rich, instable disks (feeders of AGN; Bournaud et al., 2011; 2012); fires up the BH, massive blowout, AGN feedback (Somerville et al., 2008; Schawinski 2012) shuts it down?
- Rare only because extremely short-lived?
  Is this how most luminous quasars die?

Quasars, soon to be extinct

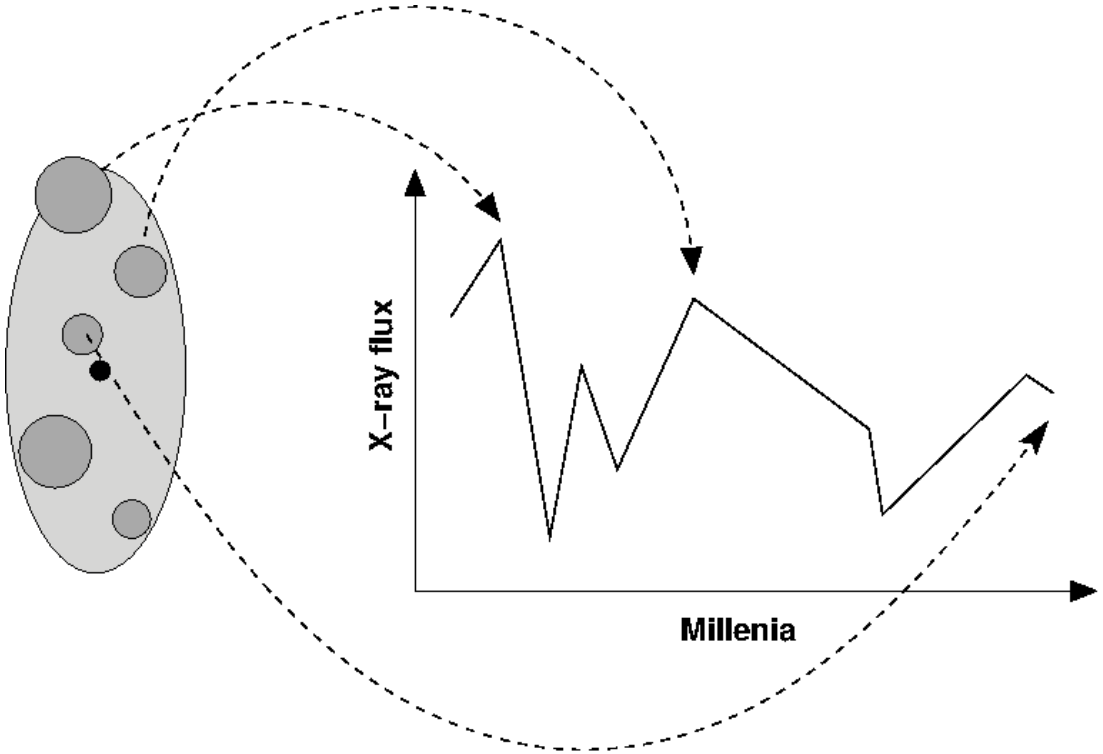
Quasar luminosity function (Paris et al., 2012):



$z = 2 \rightarrow z = 0.5$: Number of bright quasars reduced 100 times

3. Reconstructing 10e5 year AGN light curves

In principle straight forward:
run photoionization models, and infer X-ray luminosity



Expect about 10-20 statistically independent measurements per galaxy and light curve.

Some pre-requisites

1. 10 GBs
2. Optical integrated field spectroscopy for gas properties (T, n, U, extinction, shocks, velocity); 10h per GB with 8m telescopes
3. HST narrow-band imaging in [OII], [OIII]: clear view, ID bad regions; 2-3 orbits per target)
4. Chandra, internal obscuration, slope of ionising spectrum, *current* activity; 30 ks with ACIS-S per target

Obstacles (only some of them!):

- Deprojection, for correct distances and time delays: Doppler mapping with IFU+HST (Keel et al., 2012)
- Missing control sample! Internal control: independent PI models using CLOUDY and MAPPINGS
- Variable long-term (10^4 years) AGN absorption?

Summary

1. Quasar ionization echos probe a previously uncharted regime in AGN variability, on scales quasars are expected to shut-down.
2. Green Bean galaxies are very rare ionization echos, but (optically) luminous and offer unique laboratory.
3. Formation process of GBs is still largely unknown, but will be answered with the data proposed for.
4. Reconstructing 10^{4-5} AGN light curves is hard, yet feasible.