AGN Ionization Echos --
Latest results from Gemini and Chandra

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How much do AGN vary on which time scales?

From minutes to years with classical monitoring ... but ...

AGN phases last ~100 million years!

Power Spectral Density

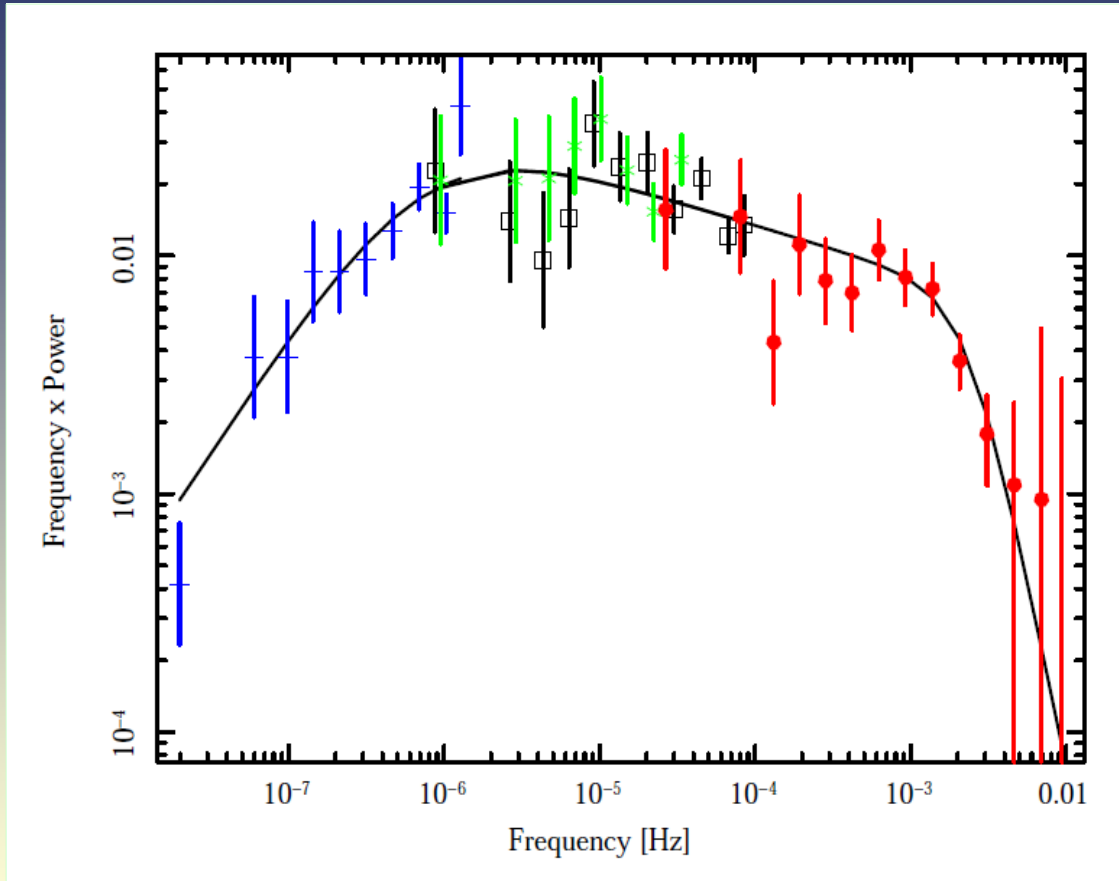

Figure credit: McHardy+07, about Ark 564

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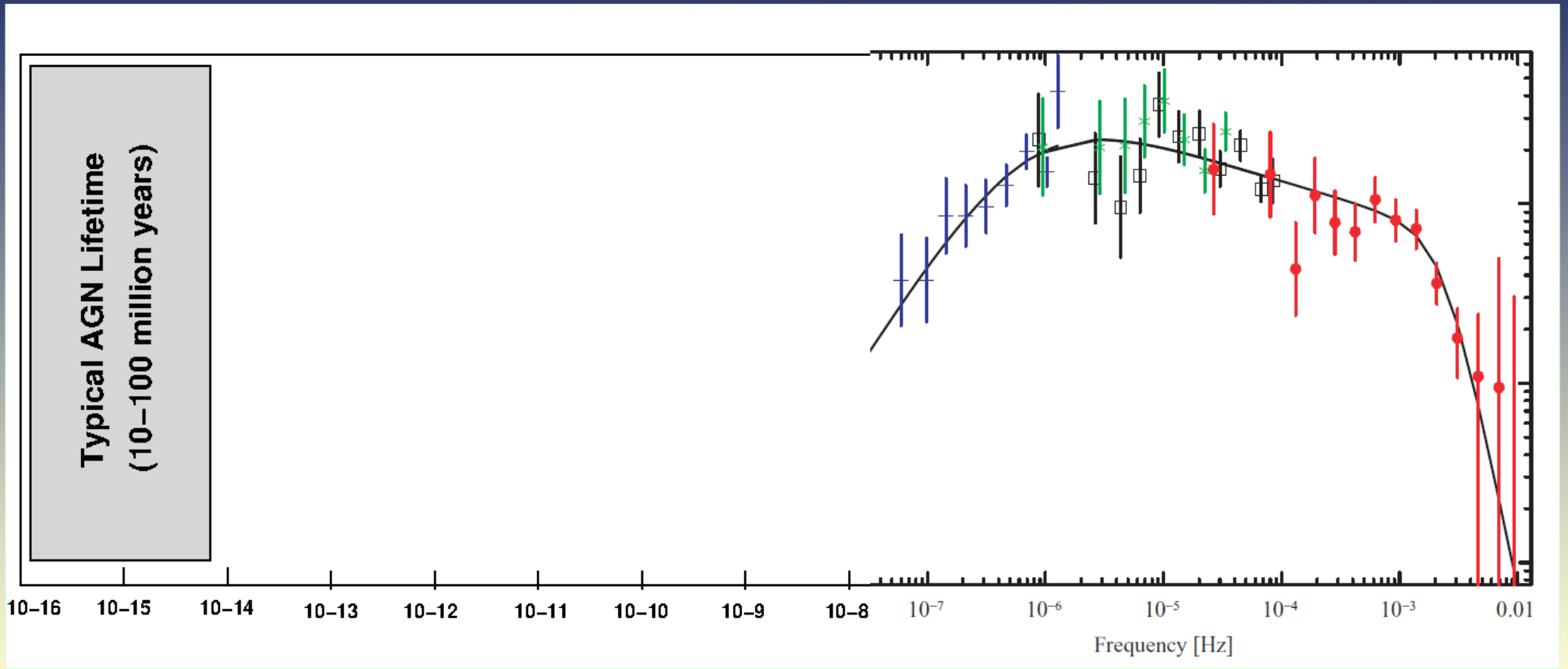

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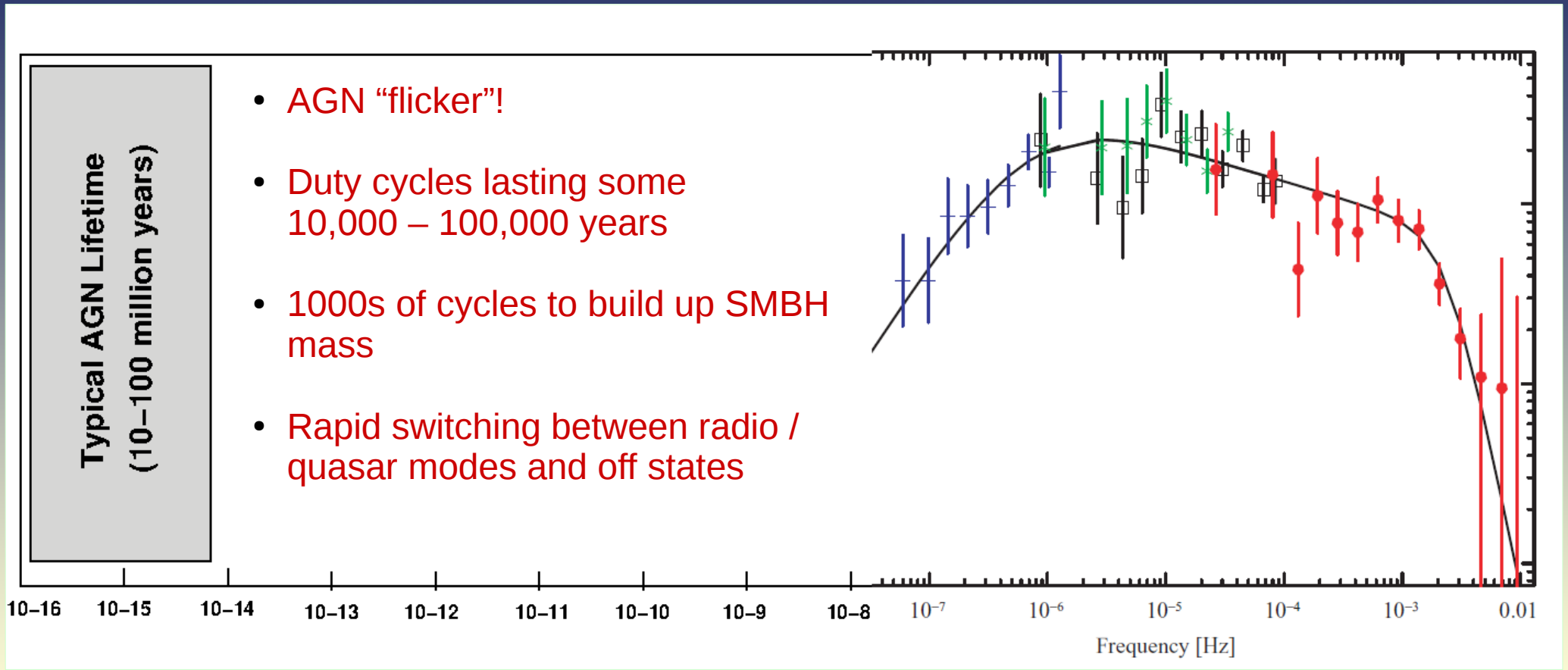
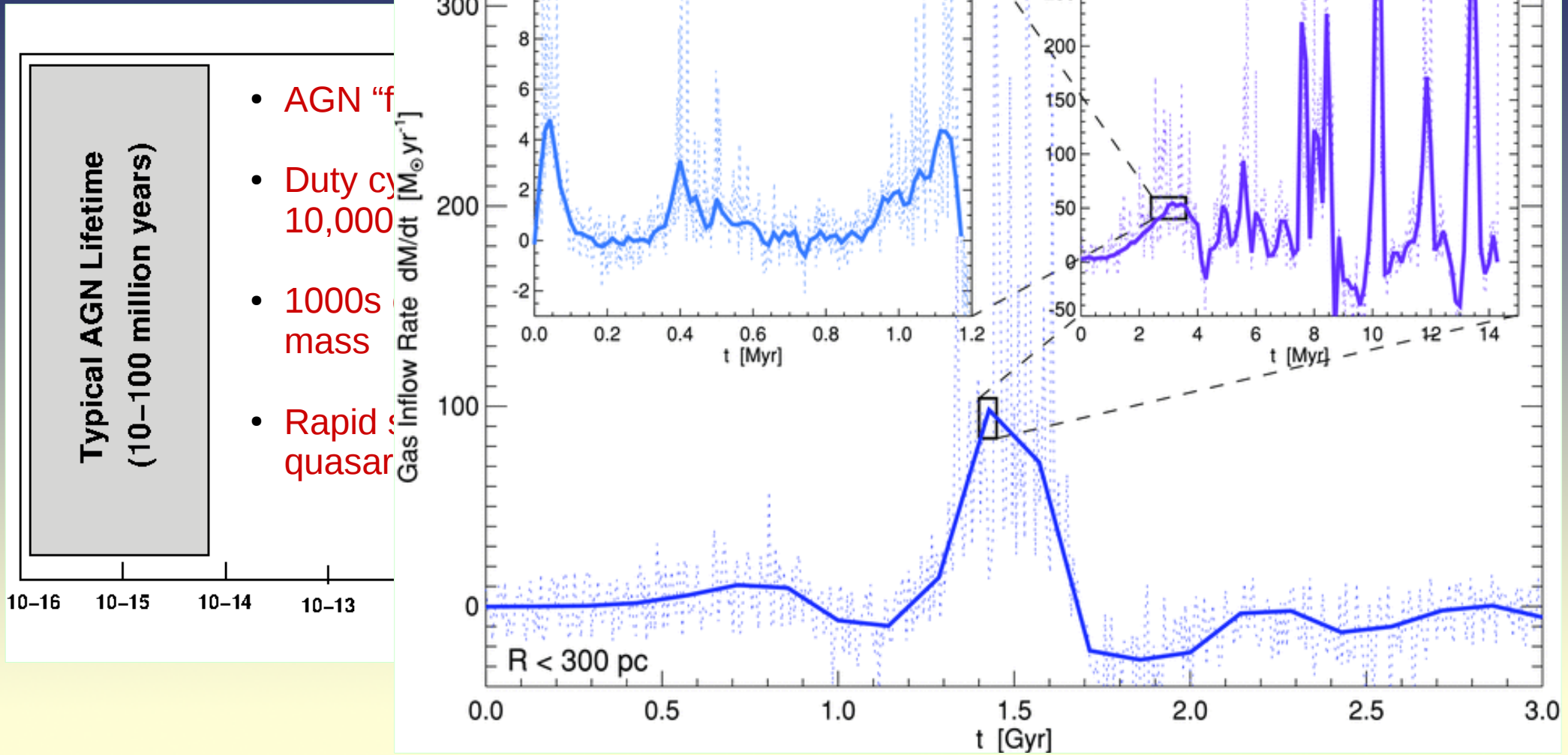


- AGN “flicker”!
- Duty cycles lasting some 10,000 – 100,000 years
- 1000s of cycles to build up SMBH mass
- Rapid switching between radio / quasar modes and off states

How much do AGN vary on which time scales?

Theoretical evidence:

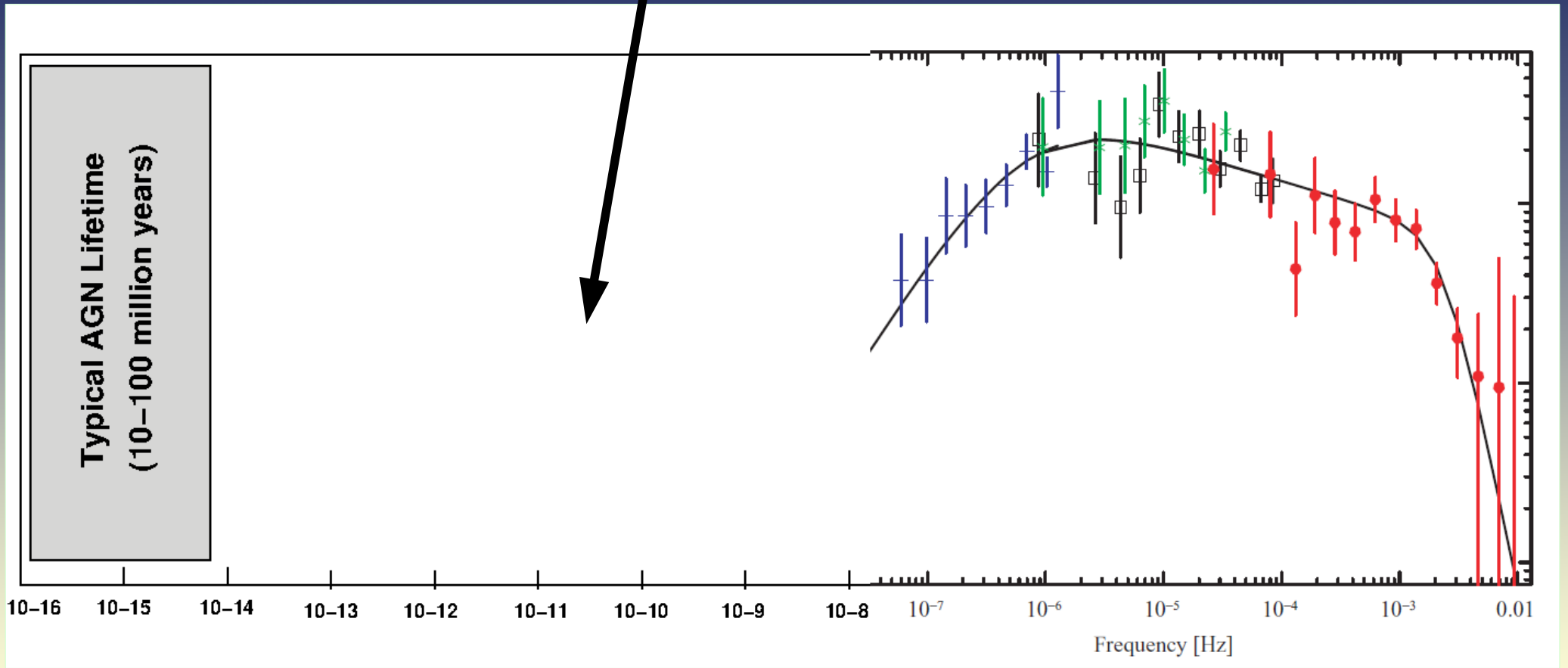


- AGN "f
- Duty cy
  10,000
- 1000s
  mass
- Rapid
  quasar

Figure stolen from: Hopkins & Quataert 2010

How much do AGN vary on which time scales?

Can we fill that gap observationally?



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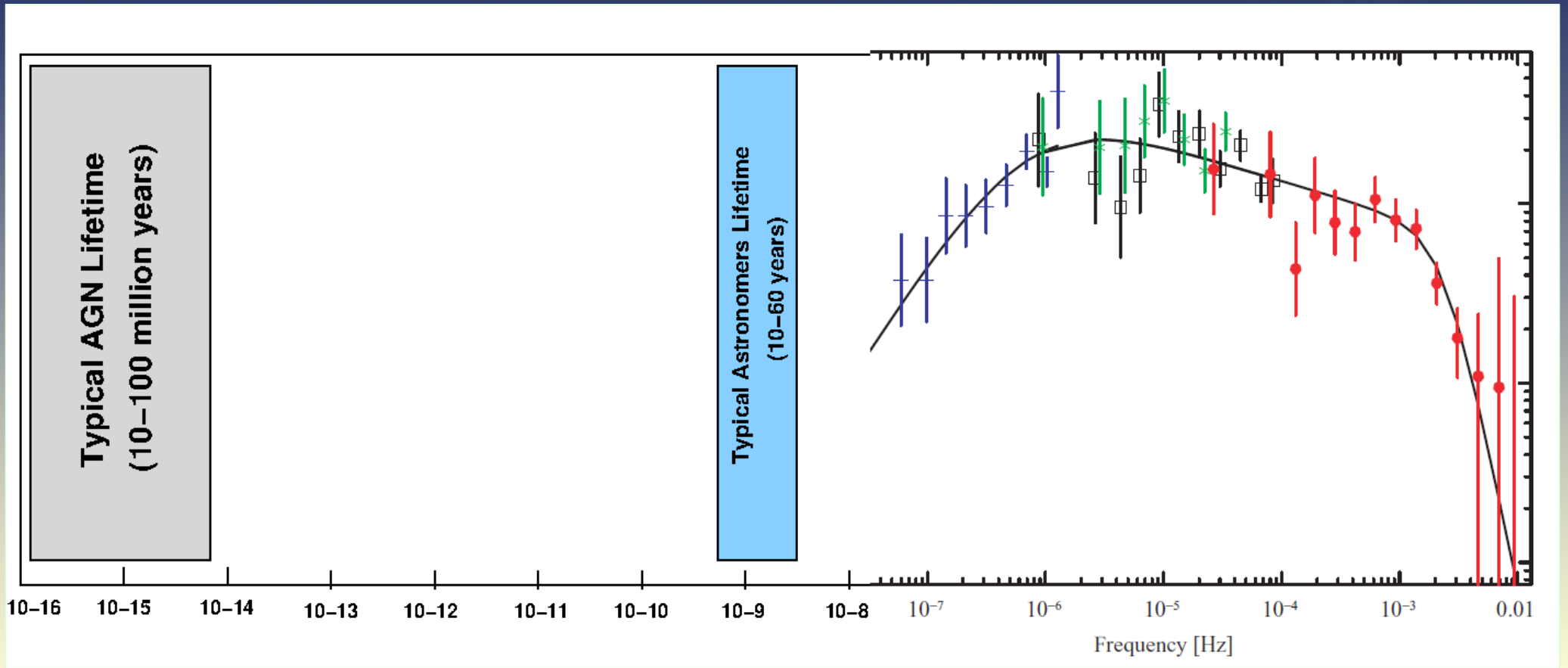

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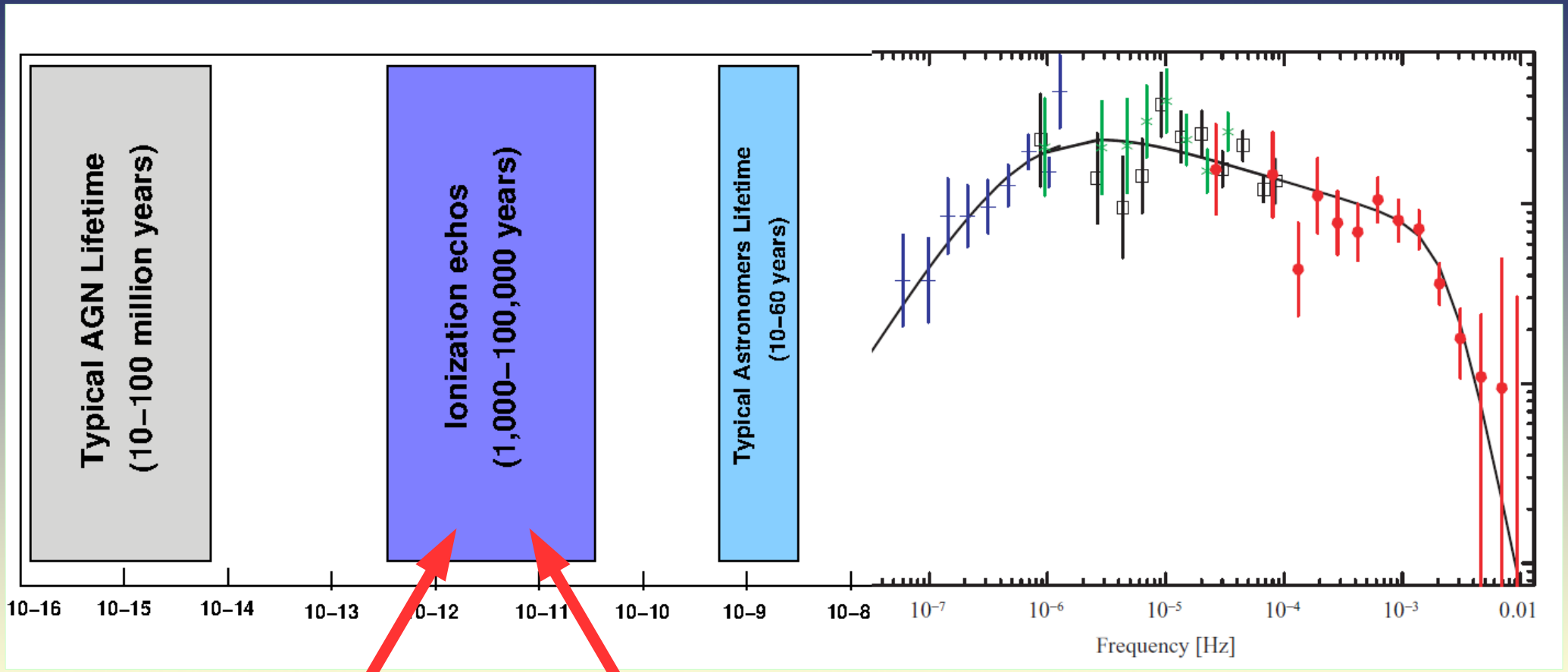
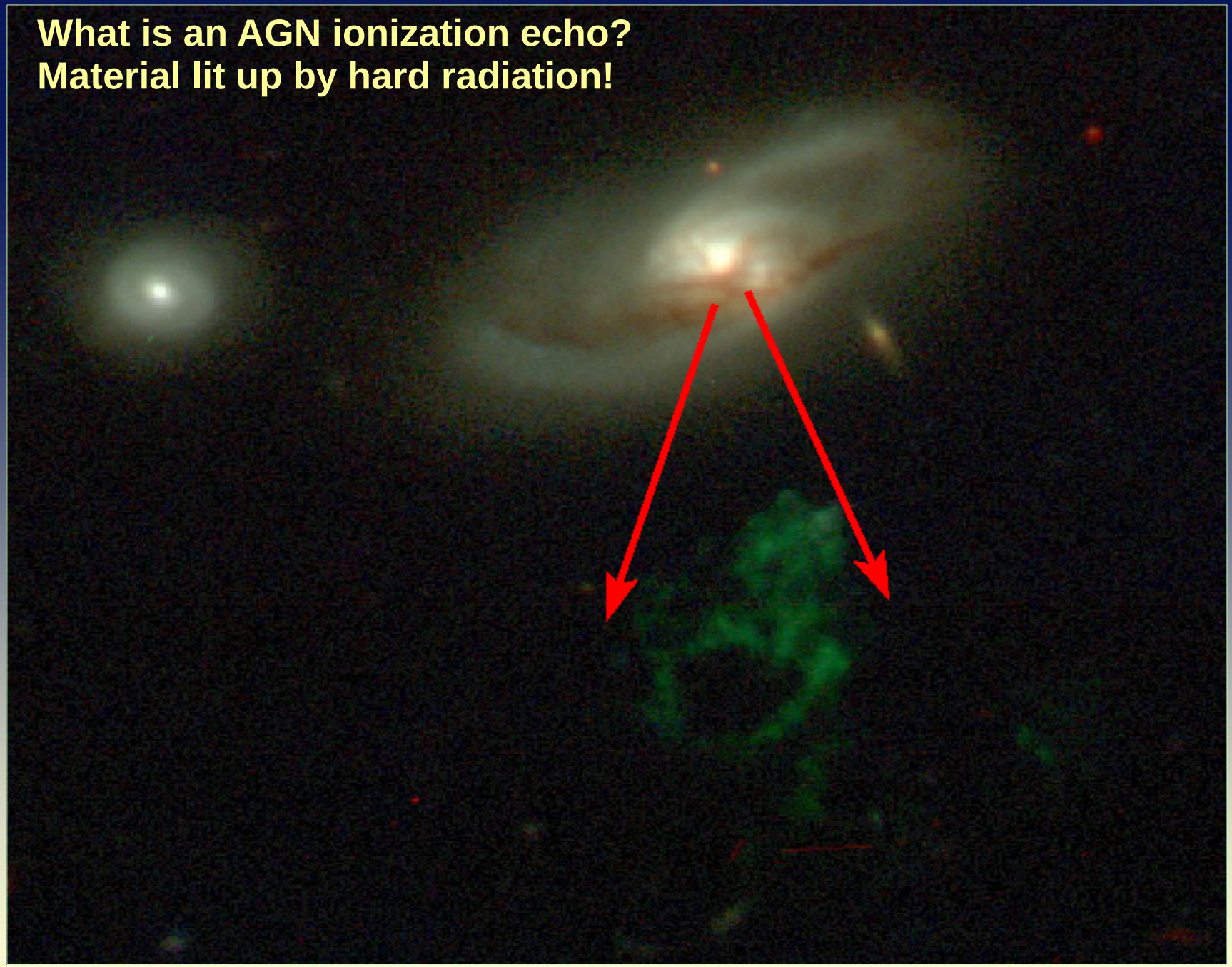


Schawinski+10
Keel+12ab

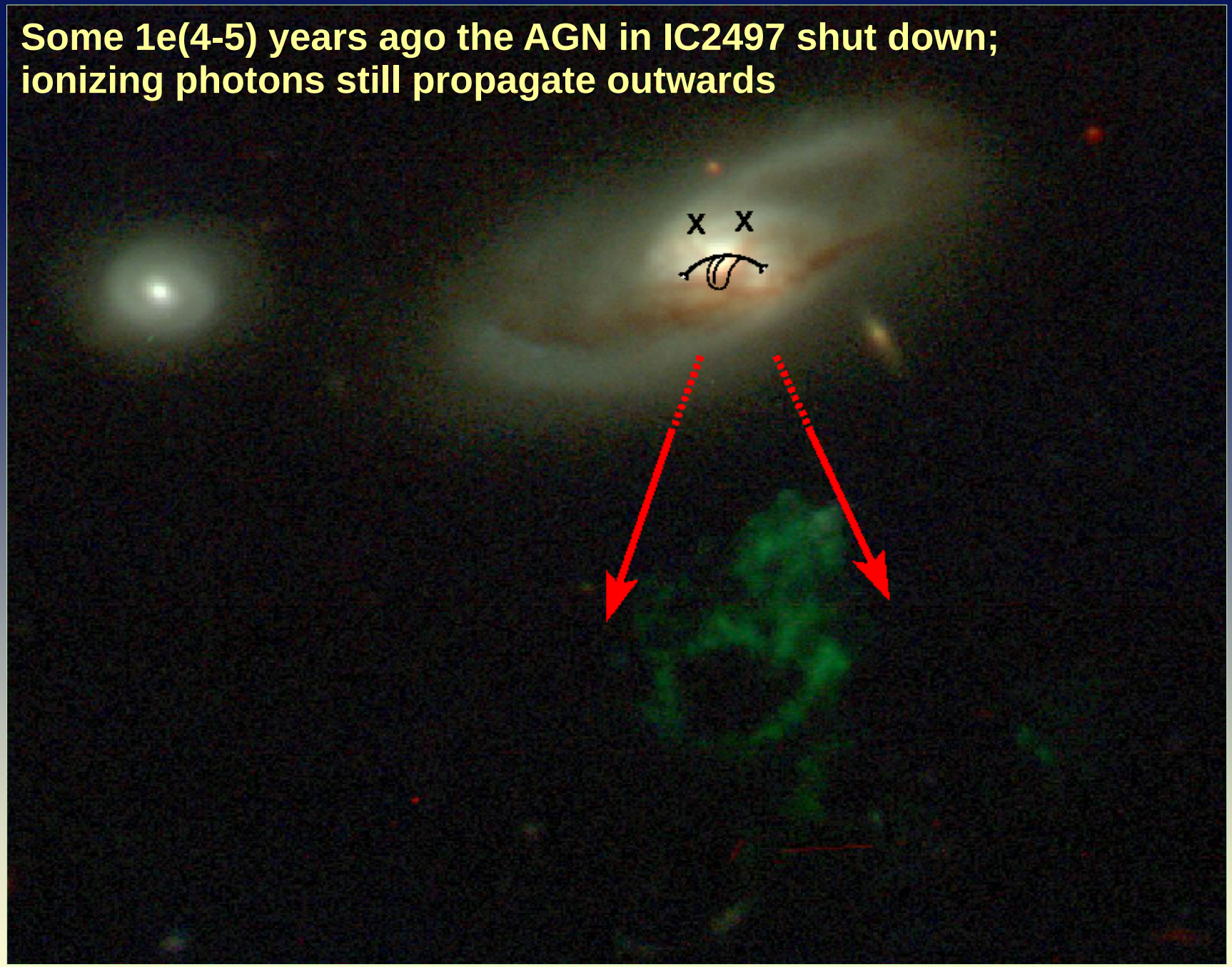
Schirmer+13
Schawinski+15

What is an AGN ionization echo?
Material lit up by hard radiation!



Hanny's Voorwerp, z=0.05, near IC 2497
Lintott+ 09, Schawinski+ 10, Rampadarath+ 10, Keel+ 12
Figure credit: 3.5m WIYN, W. Keel

Some 1e(4-5) years ago the AGN in IC2497 shut down; ionizing photons still propagate outwards



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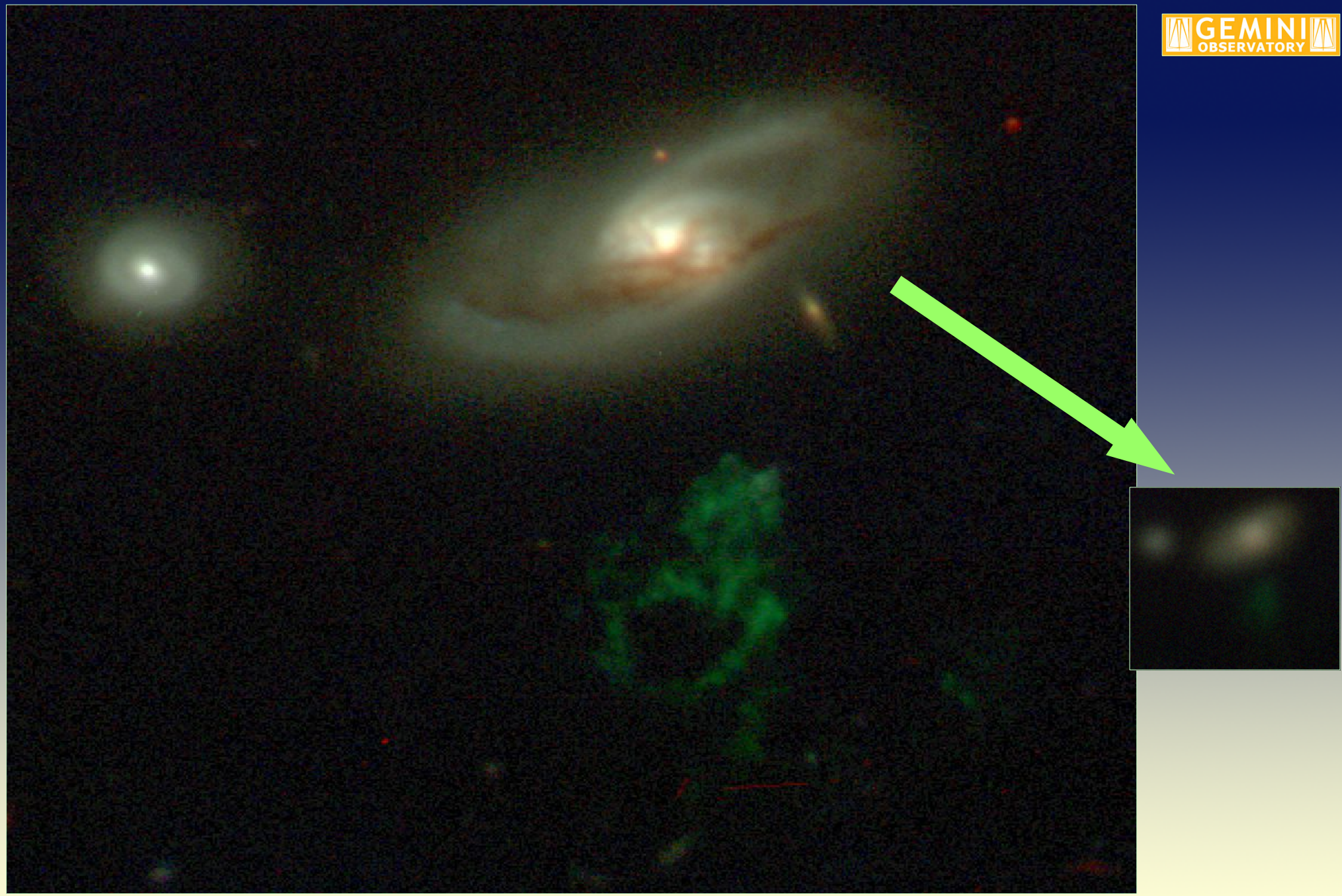
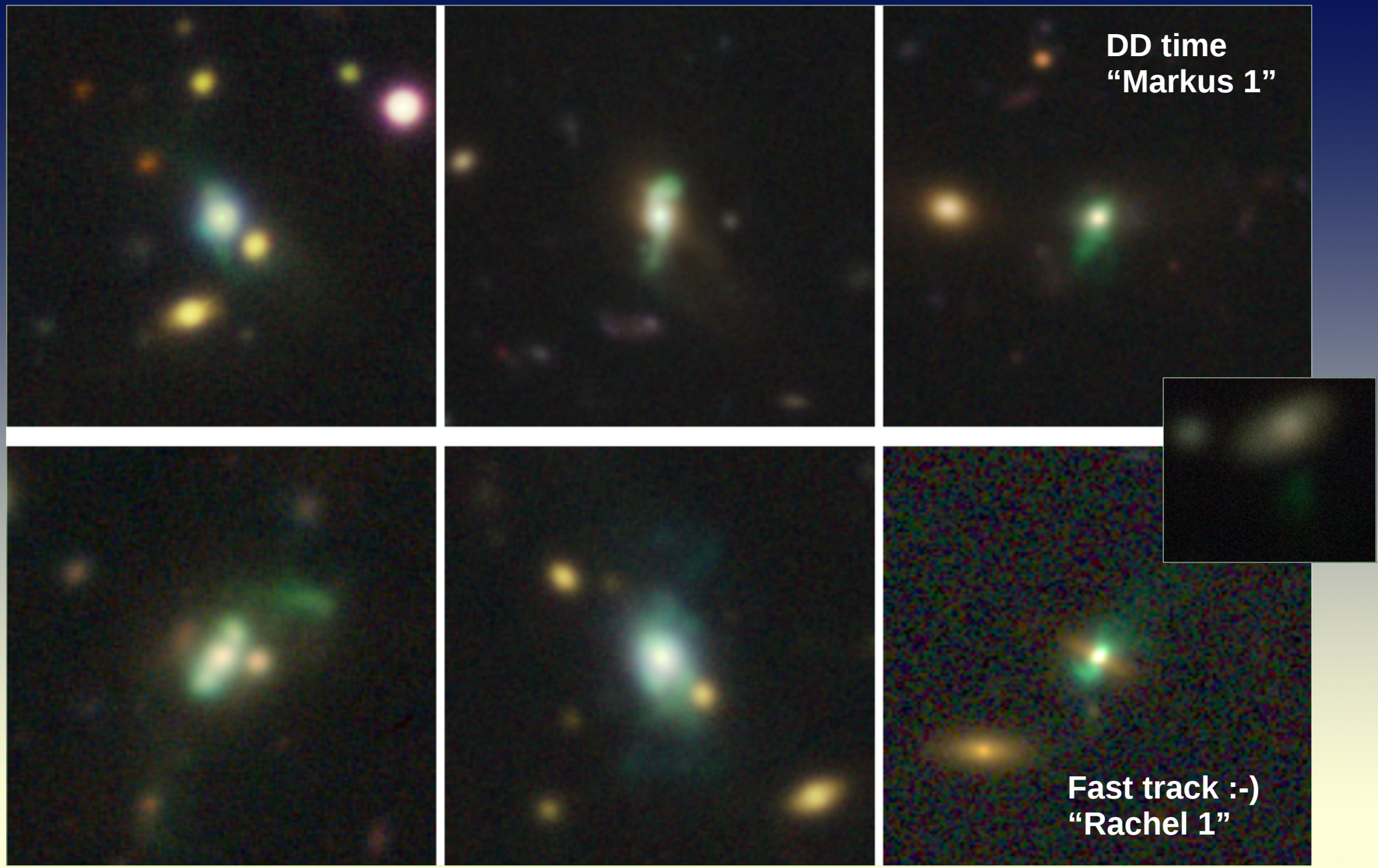


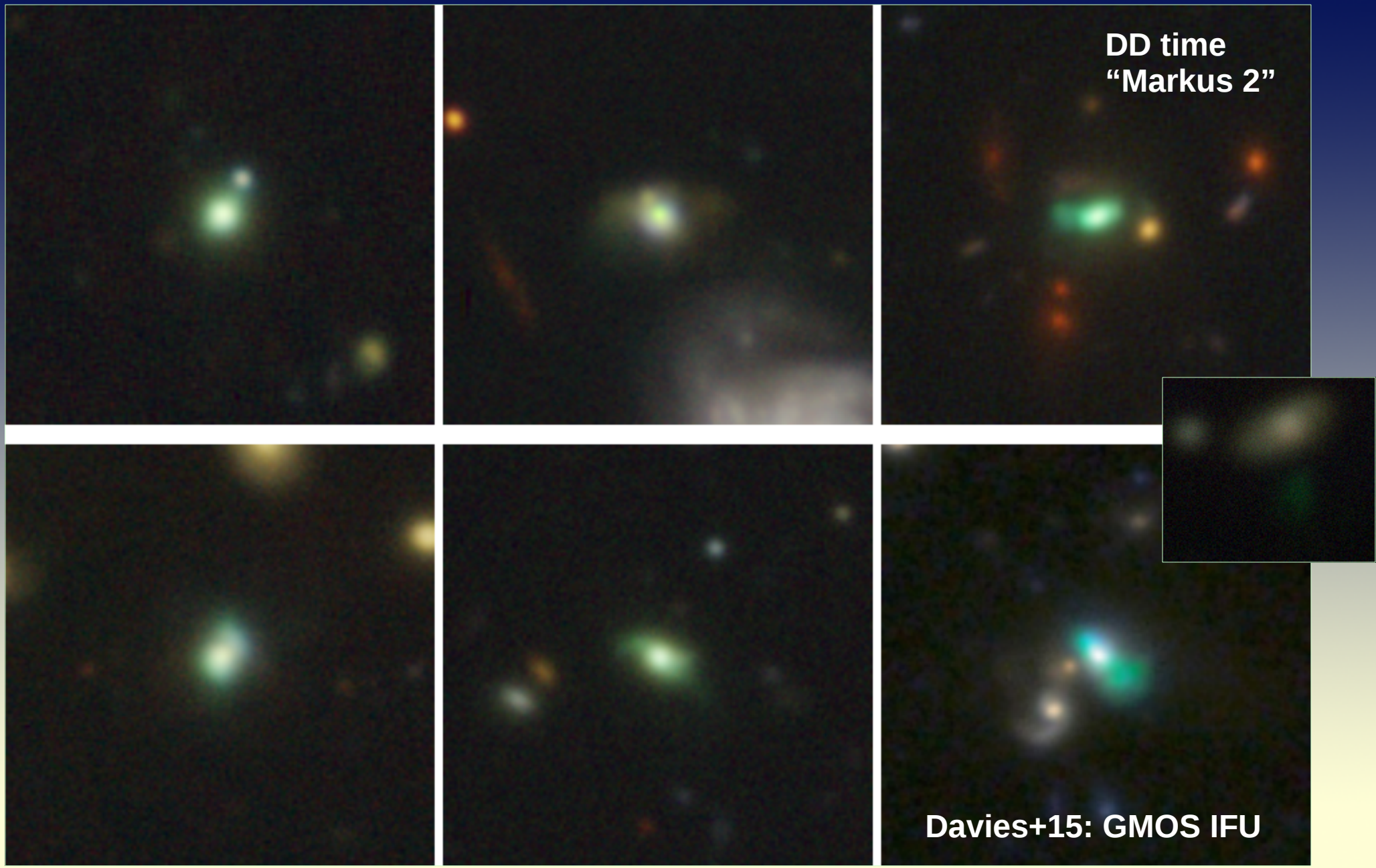
Let's redshift Hanny's Voorwerp from z = 0.05 → 0.3

GMOS N/S true color images of Green Bean Galaxies (extremely rare!) (discovered in CFHT and SDSS data; 1 every 1000 sq.deg.; Schirmer+13)



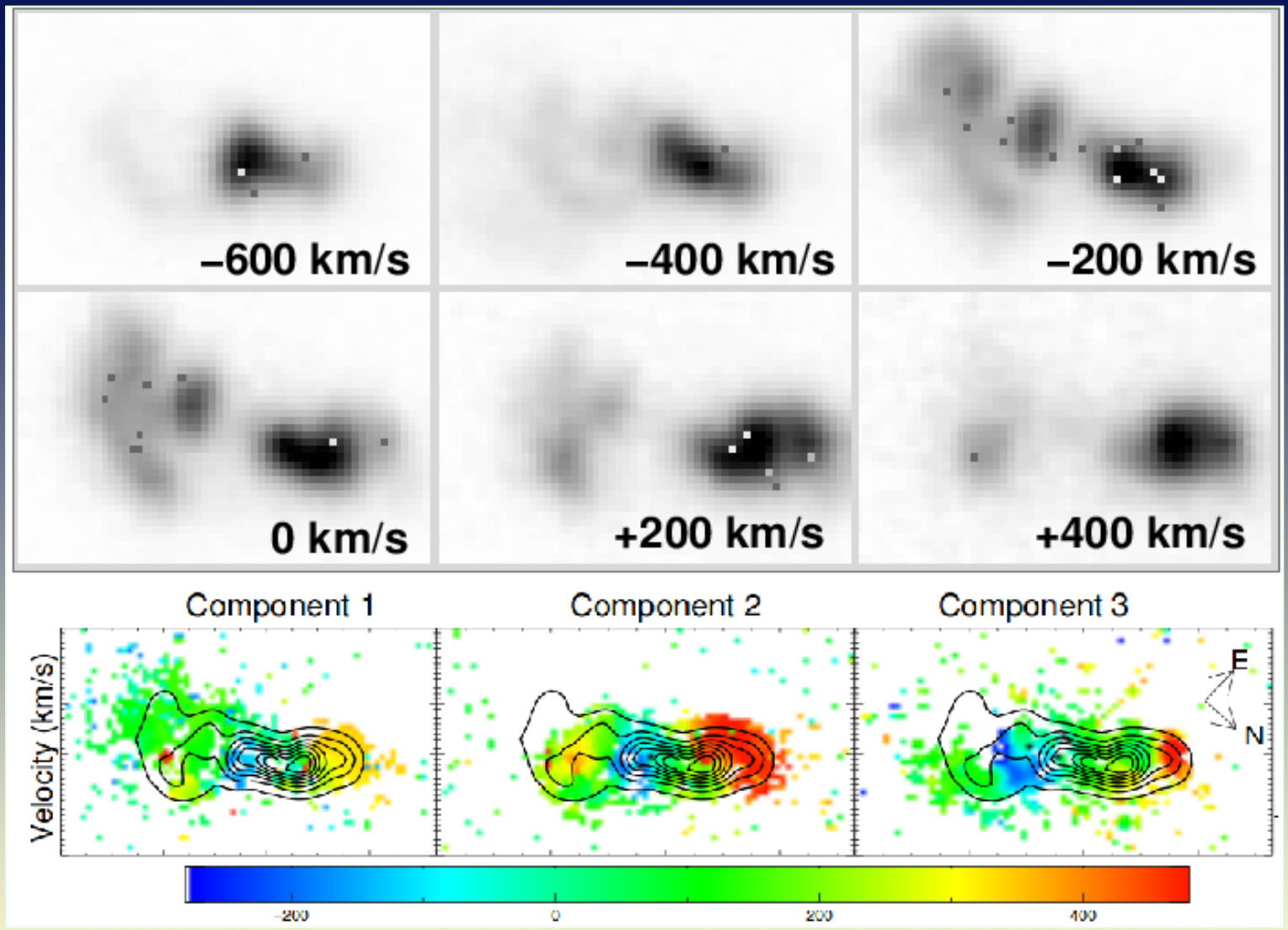
[OIII] emission overpowers galaxy. Are these also amazing ionization echos?

By far, most luminous [OIII] sources known at z=0.2-0.4



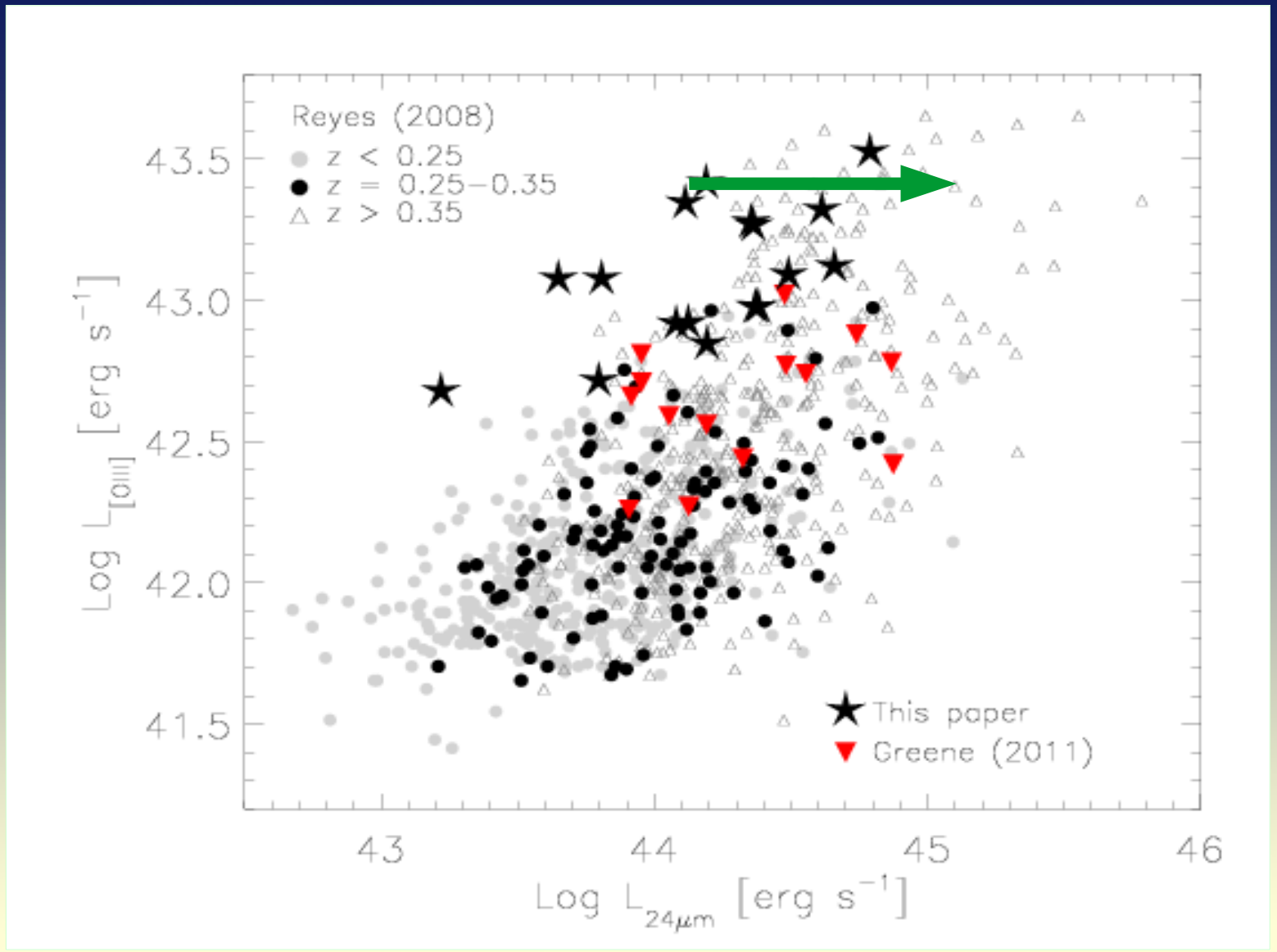
Bewildering range of morphologies. Field / low mass groups, 70% merger systems

Very complex line emitters (Davies+15; GMOS-S IFU)



Comp. 1: Enveloping gas cloud (T=10-15000 K)
Comp. 2: Co-rotating disk (T=10-15000 K)
Comp. 3: Hot turbulent gas energized by shocks (T=20-25000 K)

Are GBs AGN ionization echos?
Probing AGN activity – the MIR view (WISE 22microns)

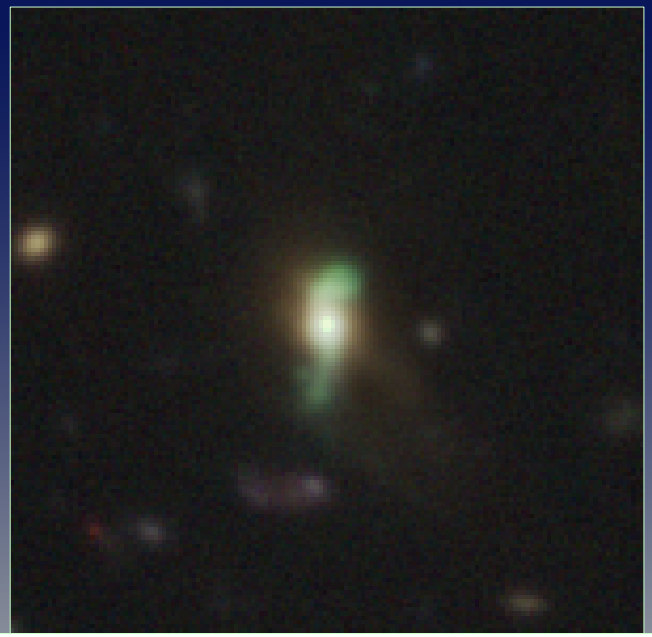


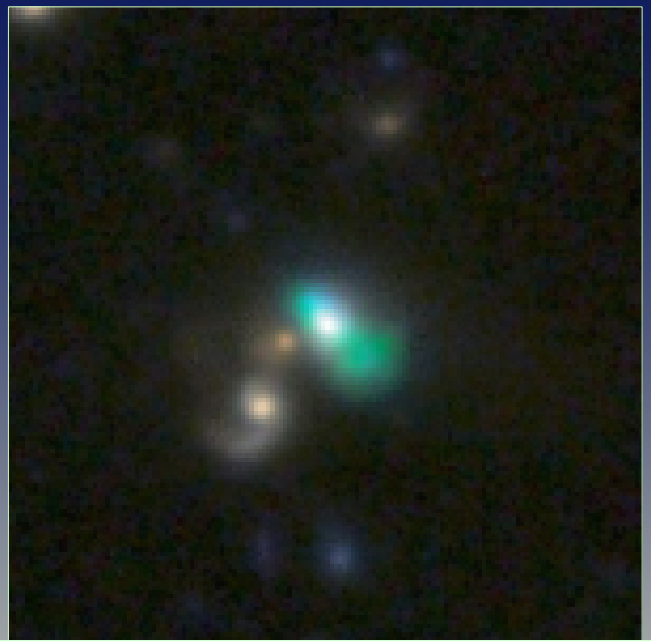
10x too faint in Mid-IR...

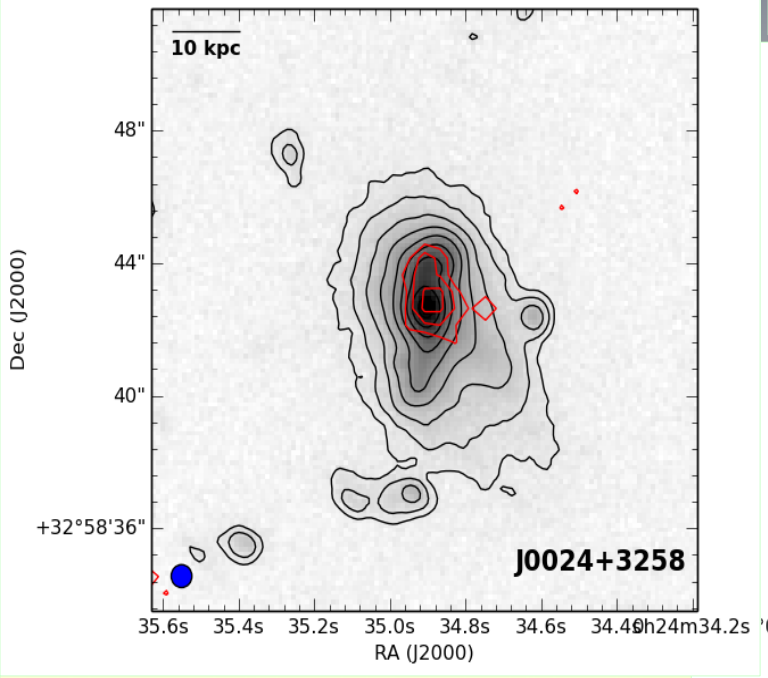
How about X-rays?

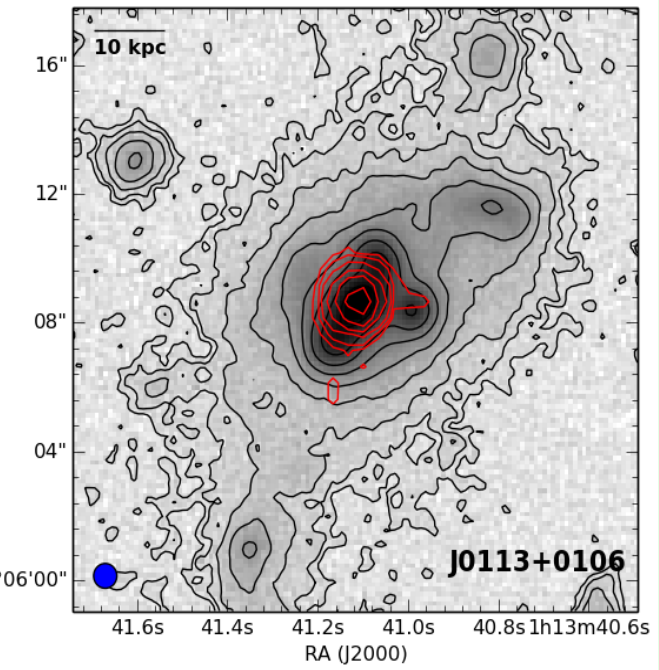
Comparing GBs against Type-2 SDSS quasars (Reyes+08; Greence+11)

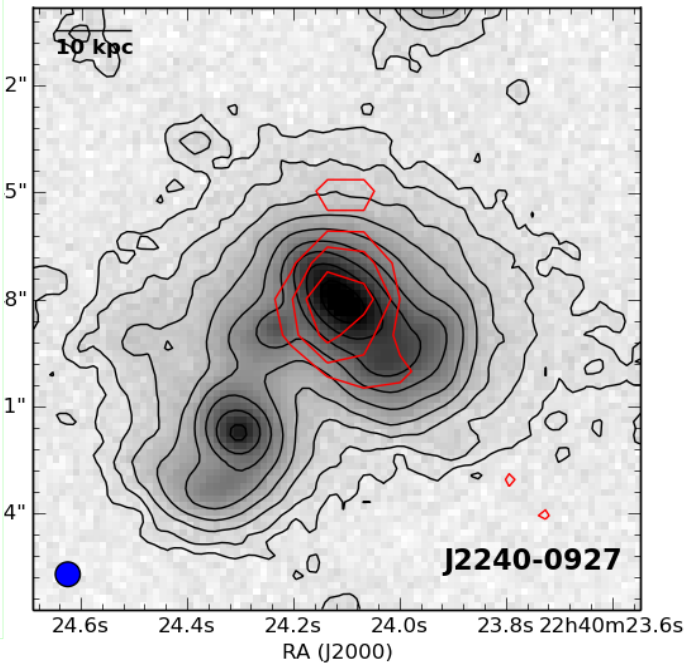
The X-ray view:
Chandra Cycle 15 survey of 9 GBs: all very weak!



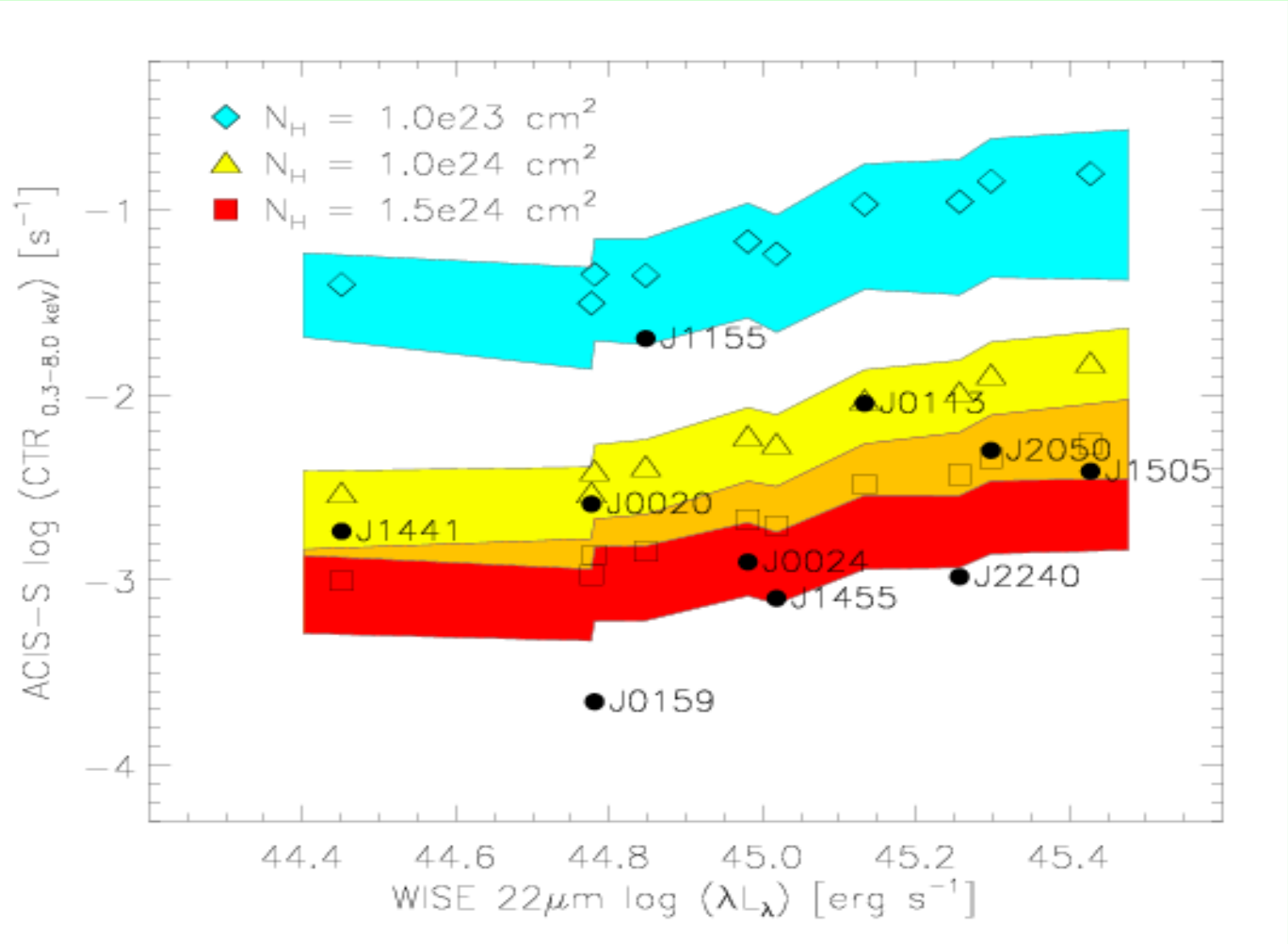








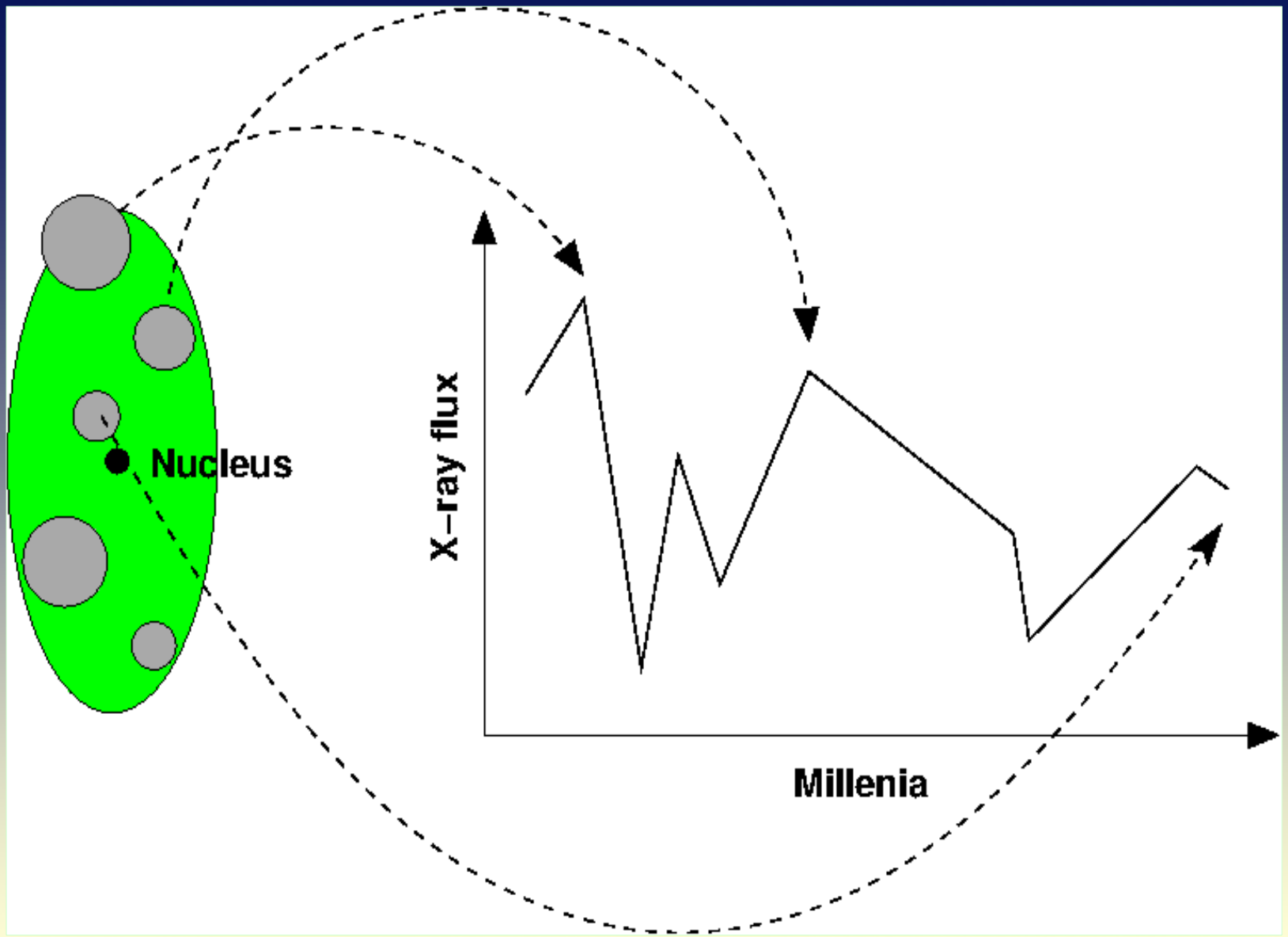
PIMMS predicted count rates (based on MIR flux) for a power law: Compton-thick or weak?



Count rates predicted on mid-IR X-ray scaling relation for AGN (Ichikawa+12)

No iron Kα line → suggests weak (not C-thick) → excellent echos!

Reconstructing 100,000 year AGN light curves (very much simplified)



- Use photo-ionization models to infer incident X-ray flux.
- Distance to nucleus yields time passed and luminosity.

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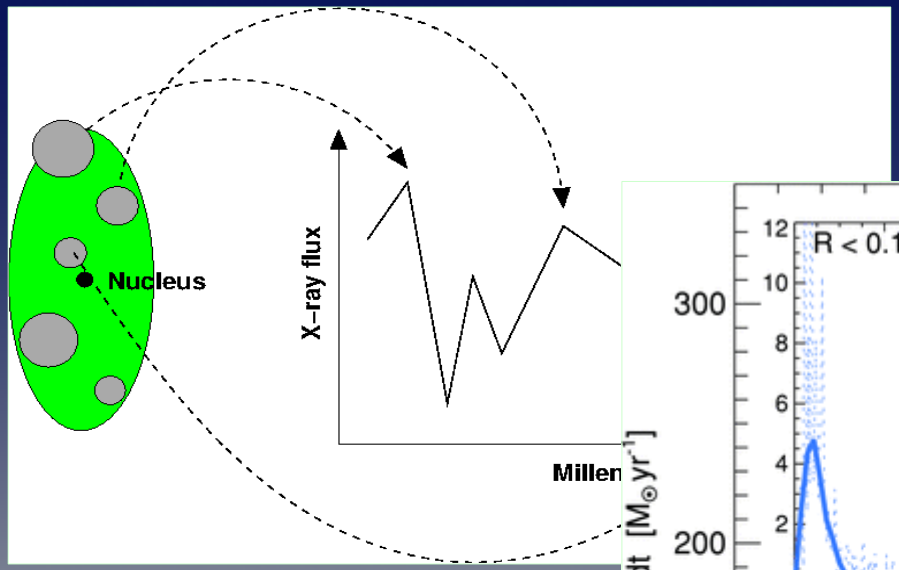

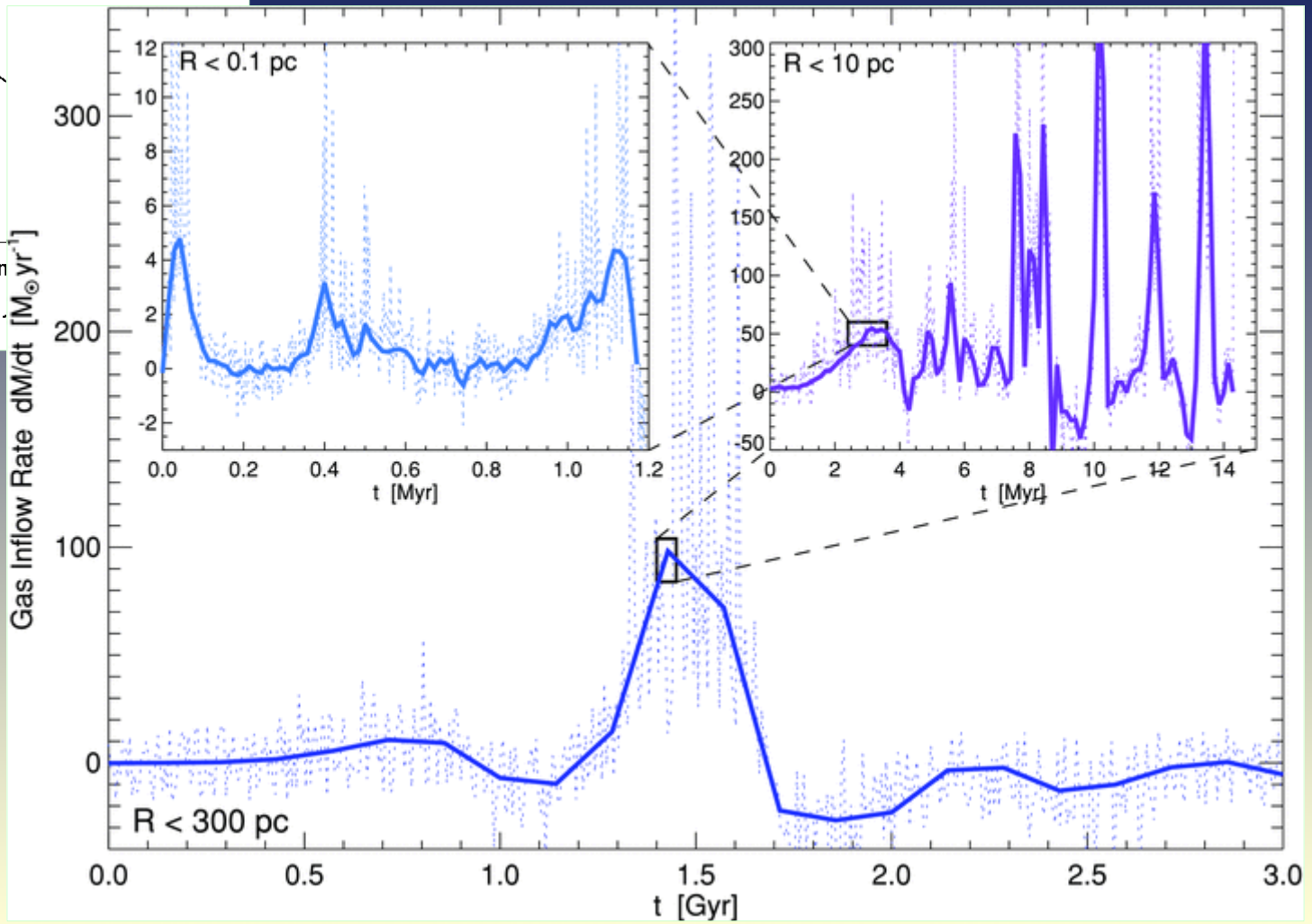

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Summary

- Discovered the most luminous and largest [OIII] emitters in the low redshift Universe
- Extremely rare (1 every 850 square degrees)
- High res imaging with GMOS-N/S reveals wide range of morphologies and possible formation scenarios
- Mergers likely play crucial role in formation of outflows
- Evidence for repeated radio / quasar mode switching, possible SMBH spin flips
- AGN faded by 3-4 orders of magnitude over light crossing time

Results published soon in Schirmer+15