Elusive AGN: an overview

David M Alexander (Durham)

Overview

(1) What is an elusive AGN?

(2) Reasons why an AGN may be elusive

(3) Why should we care about identifying elusive AGN?

(4) Effective ways to find elusive AGN

What is an elusive AGN?

What is an elusive AGN?

e·lu·sive

/ēˈlo͞osiv/

adjective

difficult to find, catch, or achieve.
"success will become ever more elusive"
synonyms: difficult to find; evasive, slippery

The elusive active nucleus of NGC 4945⋆

A. Marconi[1], E. Oliva[1], P.P. van der Werf[2], R. Maiolino[1], E.J. Schreier[3], F. Macchetto[3,4], and A.F.M. Moorwood[5]

[1] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy
[2] Sterrewacht Leiden, P.O. Box 9513, 2300 RA Leiden, The Netherlands
[3] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[4] Affiliated to ESA science division
[5] European Southern Observatory, Karl-Schwarzschild-Strasse 2, 85748 Garching bei München, Germany

Received 27 July 1999 / Accepted 4 February 2000

Elusive active galactic nuclei

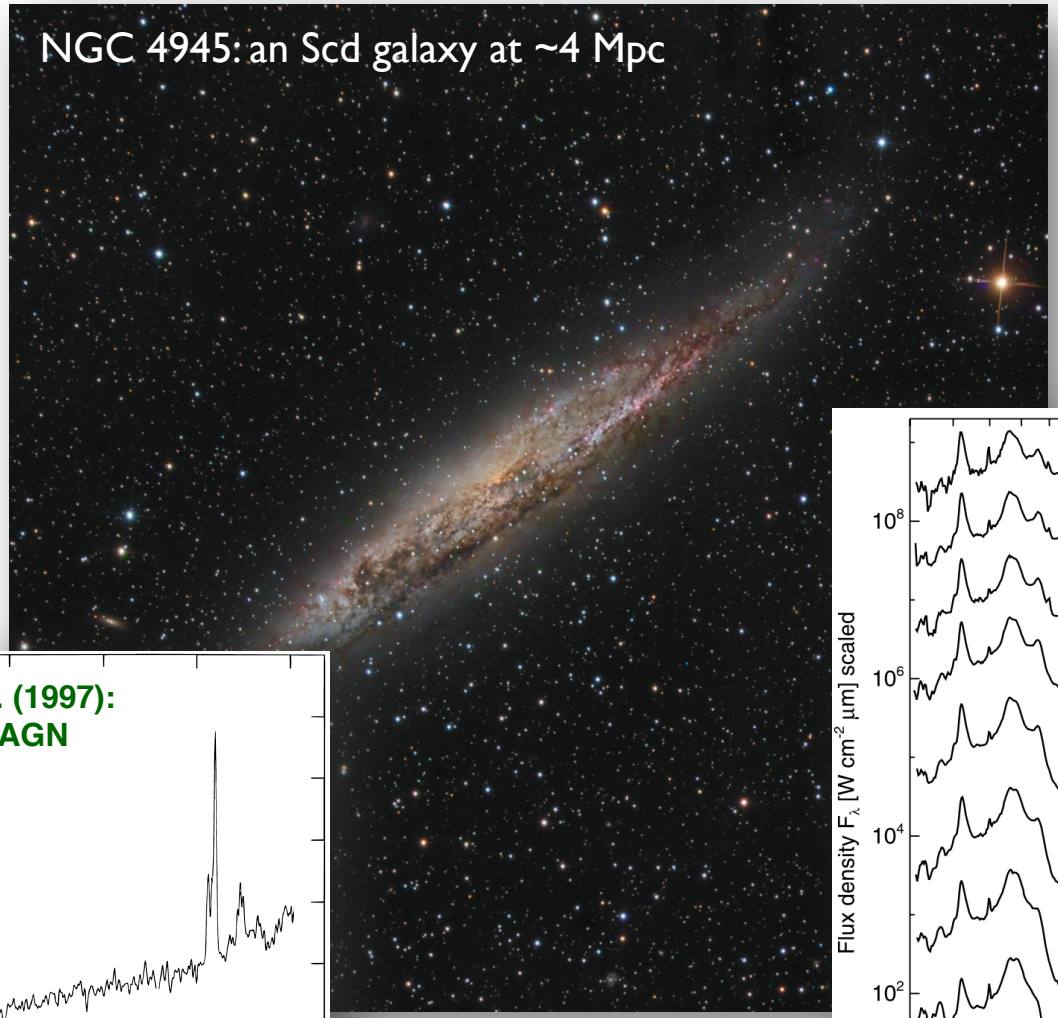
R. Maiolino,[1⋆] A. Comastri,[2] R. Gilli,[1] N. M. Nagar,[3] S. Bianchi,[4] T. Böker,[5] E. Colbert,[6] A. Krabbe,[7] A. Marconi,[1] G. Matt[4] and M. Salvati[1]

[1]*INAF – Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy*
[2]*INAF – Osservatorio Astronomico di Bologna, via Ranzani 1, I-40126, Italy*
[3]*Kapteyn Institute, University of Groningen, Landleven 12, 9747 AD Groningen, the Netherlands*
[4]*Dipartment di Fisica – Univ. degli Studi 'Roma III,' via della Vasca Navale 84, I-00146, Italy*
[5]*Astrophysics Division, RSSD, European Space Agency, ESTEC, NL-2200 AG Noordwijk, the Netherlands*
[6]*Department of Physics and Astronomy, Johns Hopkins University, Baltimore, MD 21218, USA*
[7]*University of California at Berkeley, 366 Le Conte Hall, Berkeley, CA 94720-7300, USA*

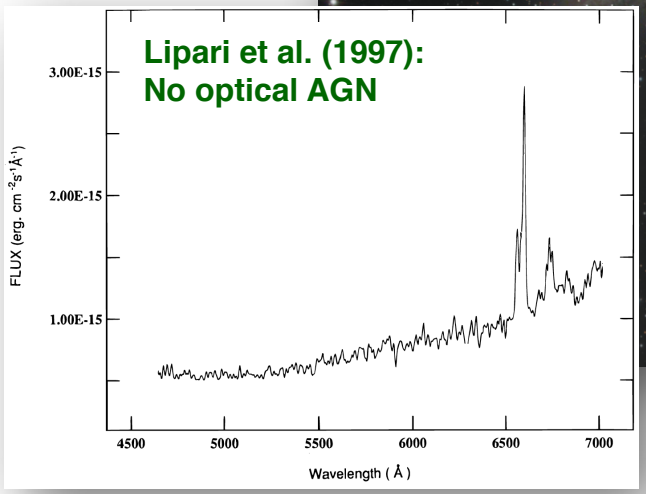
Accepted 2003 July 22. Received 2003 July 22; in original form 2003 June 11

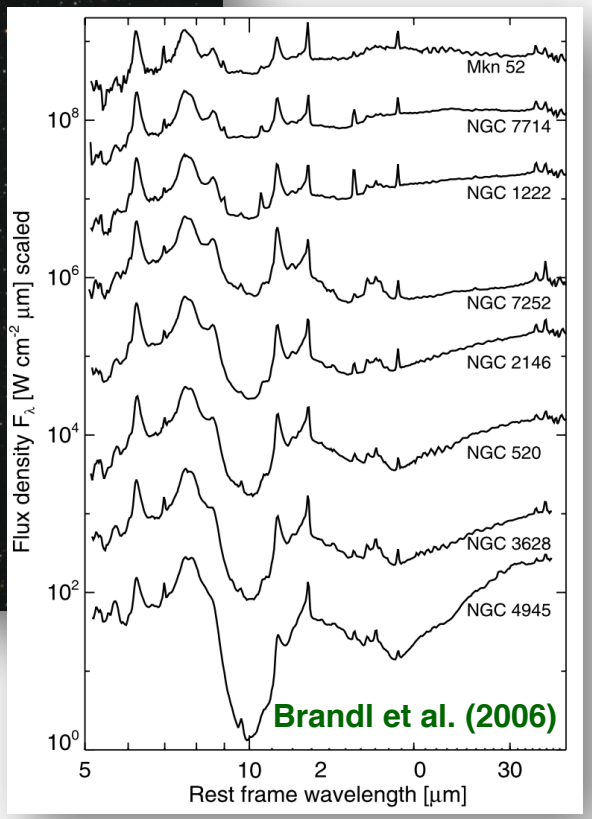
"Soft" definition: the lack of clear AGN signatures in the optical spectrum…
"Hard" definition: an AGN that is difficult to identify at any wavelength

The elusive nature of NGC 4945



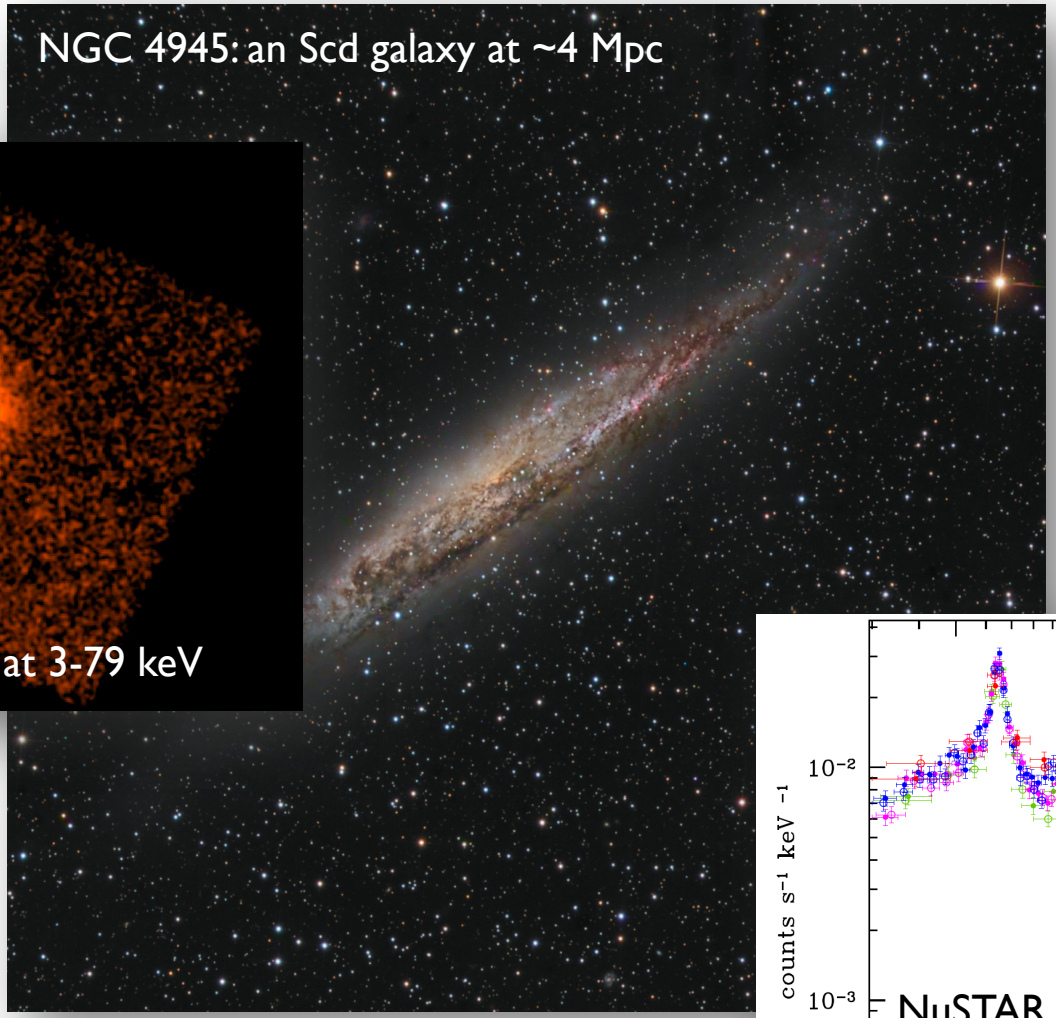
Mid-IR spectra of starbursts, inc NGC 4945

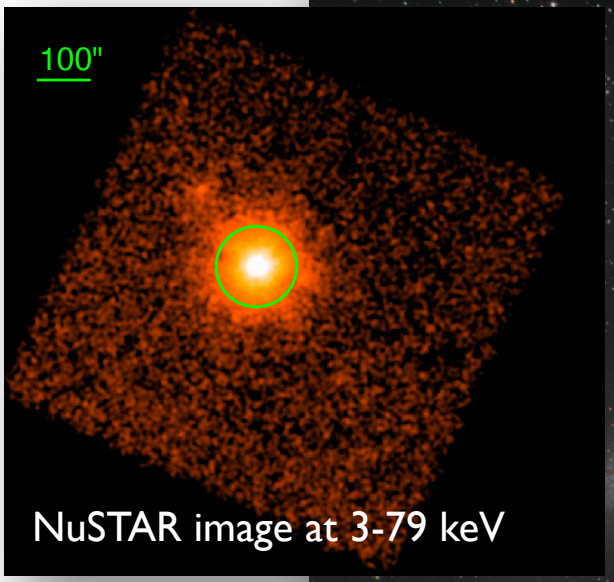




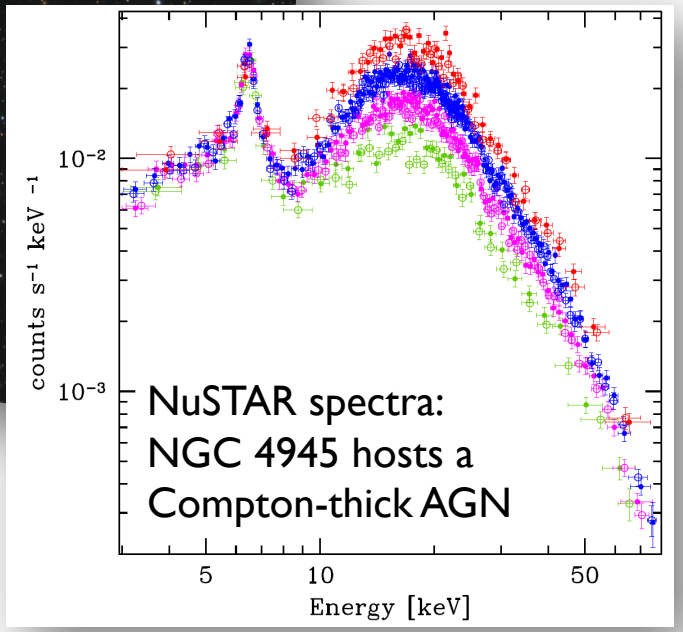
A reasonable conclusion: no AGN in NGC 4945

The elusive nature of NGC 4945





Puccetti et al. (2014)

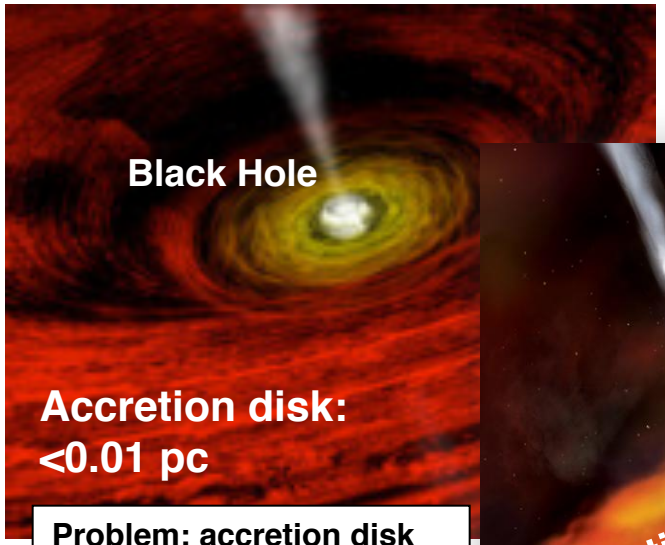


NGC 4945 is the brightest extragalactic source in the sky at ~100 keV!

One of the three closest AGN: elusive AGN are common!

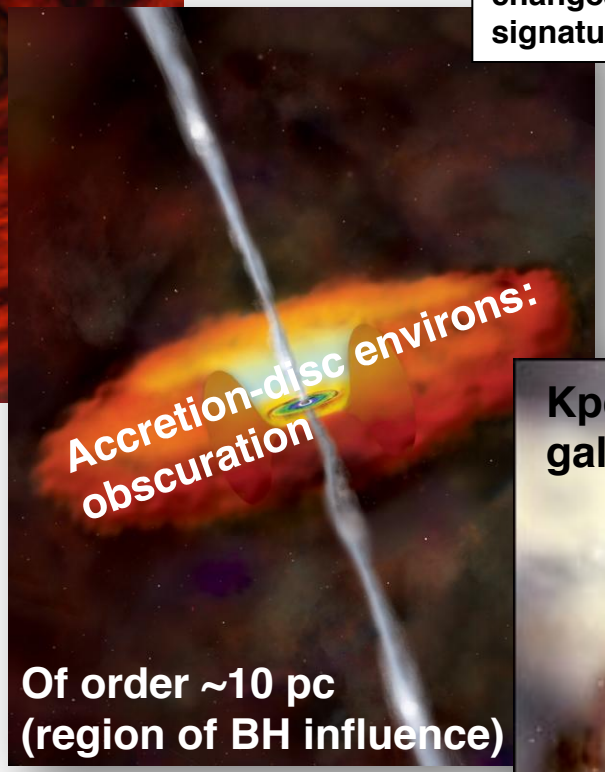
Reasons why an AGN may be elusive

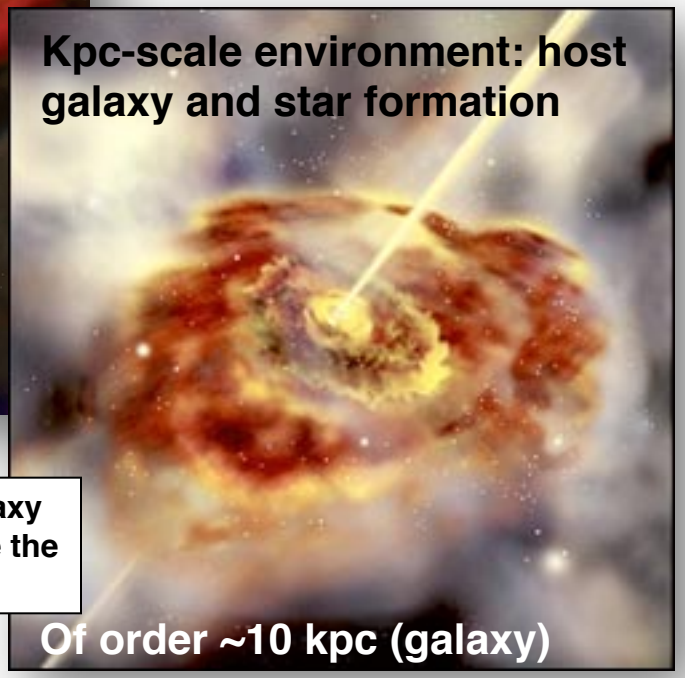
Find the AGN: a multi-scale, multi-component, multi-wavelength challenge



Problem: accretion disk is small (unresolved) – the AGN can be variable

Problem: obscuration changes the observed AGN signatures

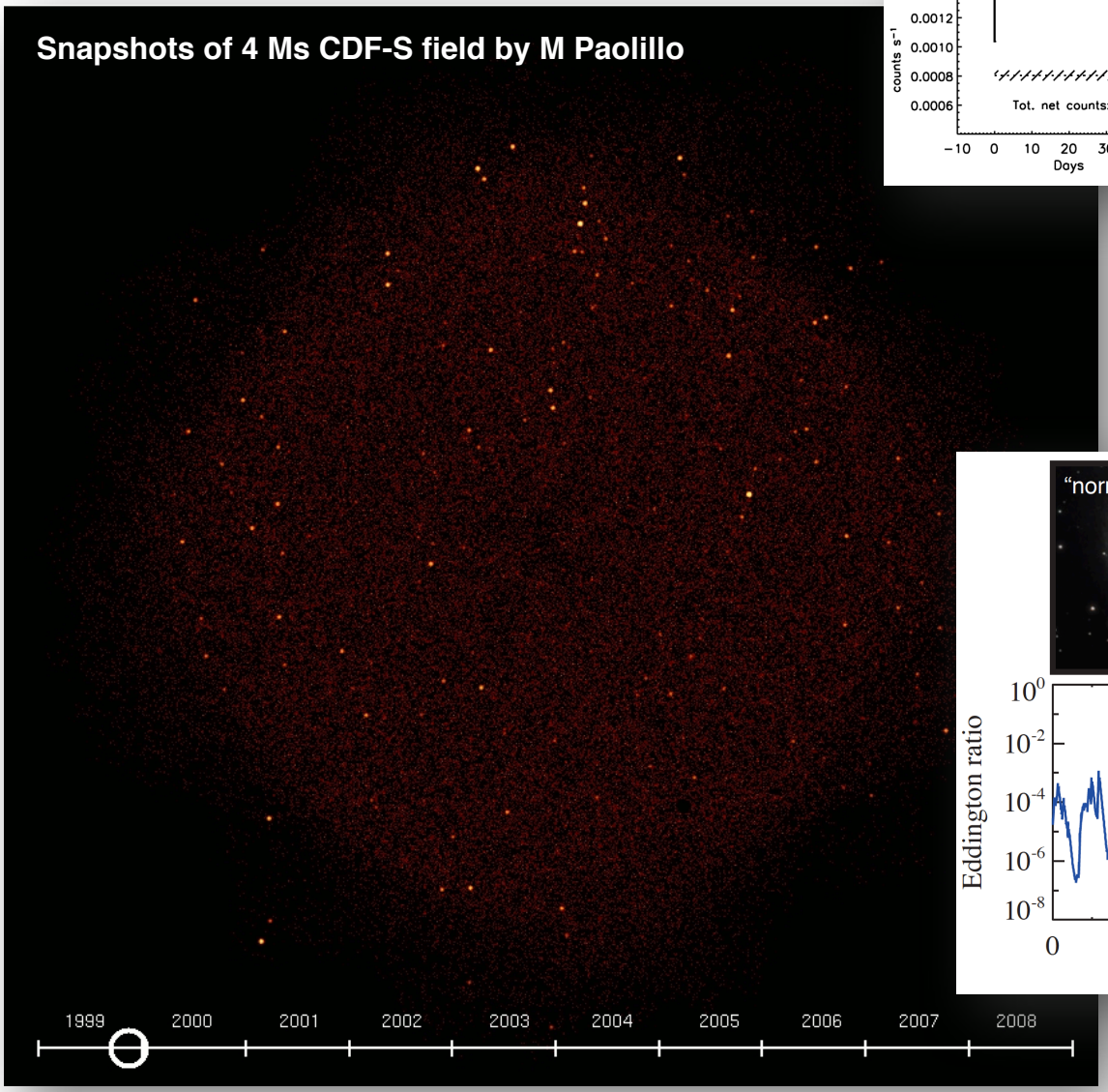




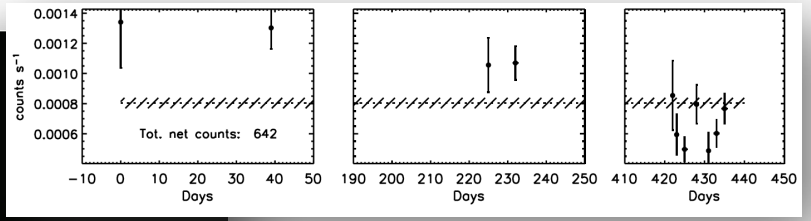
Problem: host galaxy can dilute/obscure the AGN signatures

Elusive AGN: variability

We know that the emission from AGN can vary

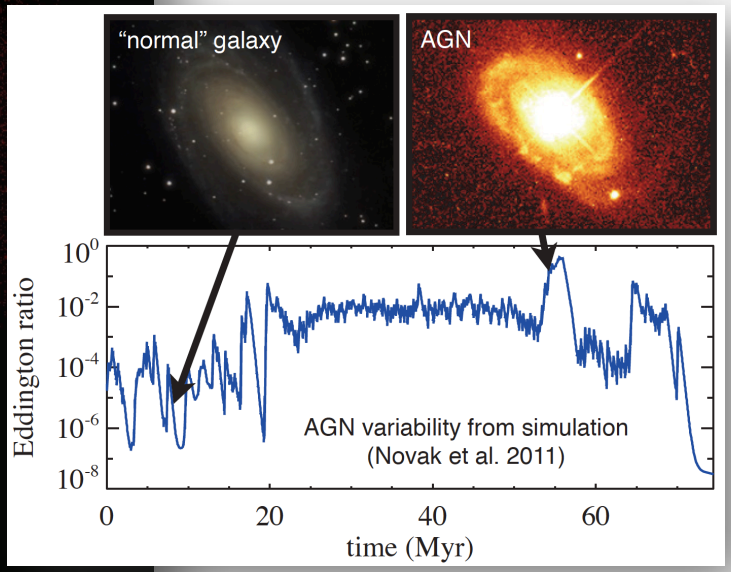


Example X-ray "light curve"



Paolillo et al. (2004)

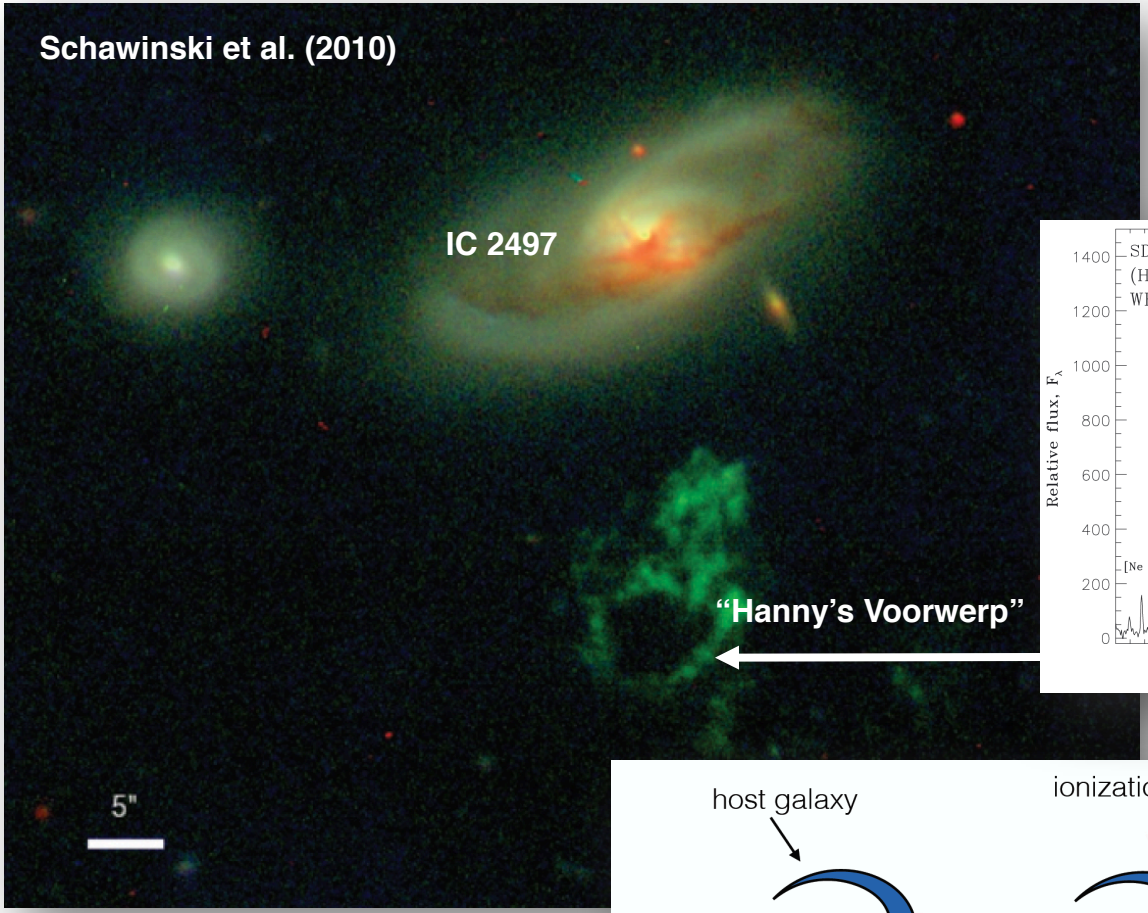
Longer timescales: AGN signatures can disappear/appear



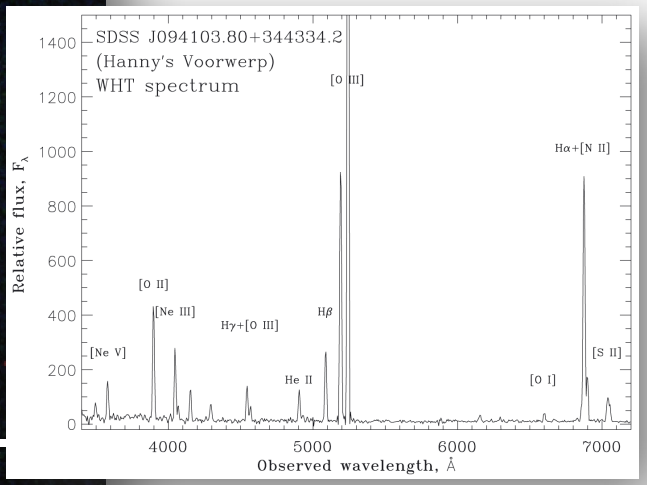
Novak et al. (2011);
Hickox et al. (2014)

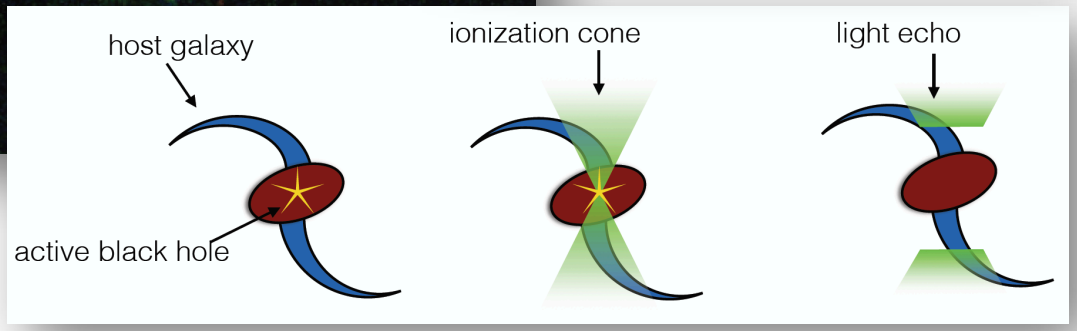
Elusive AGN: variability

Sometimes the light "echos" of past luminous AGN activity can be seen



Lintott et al. (2009)



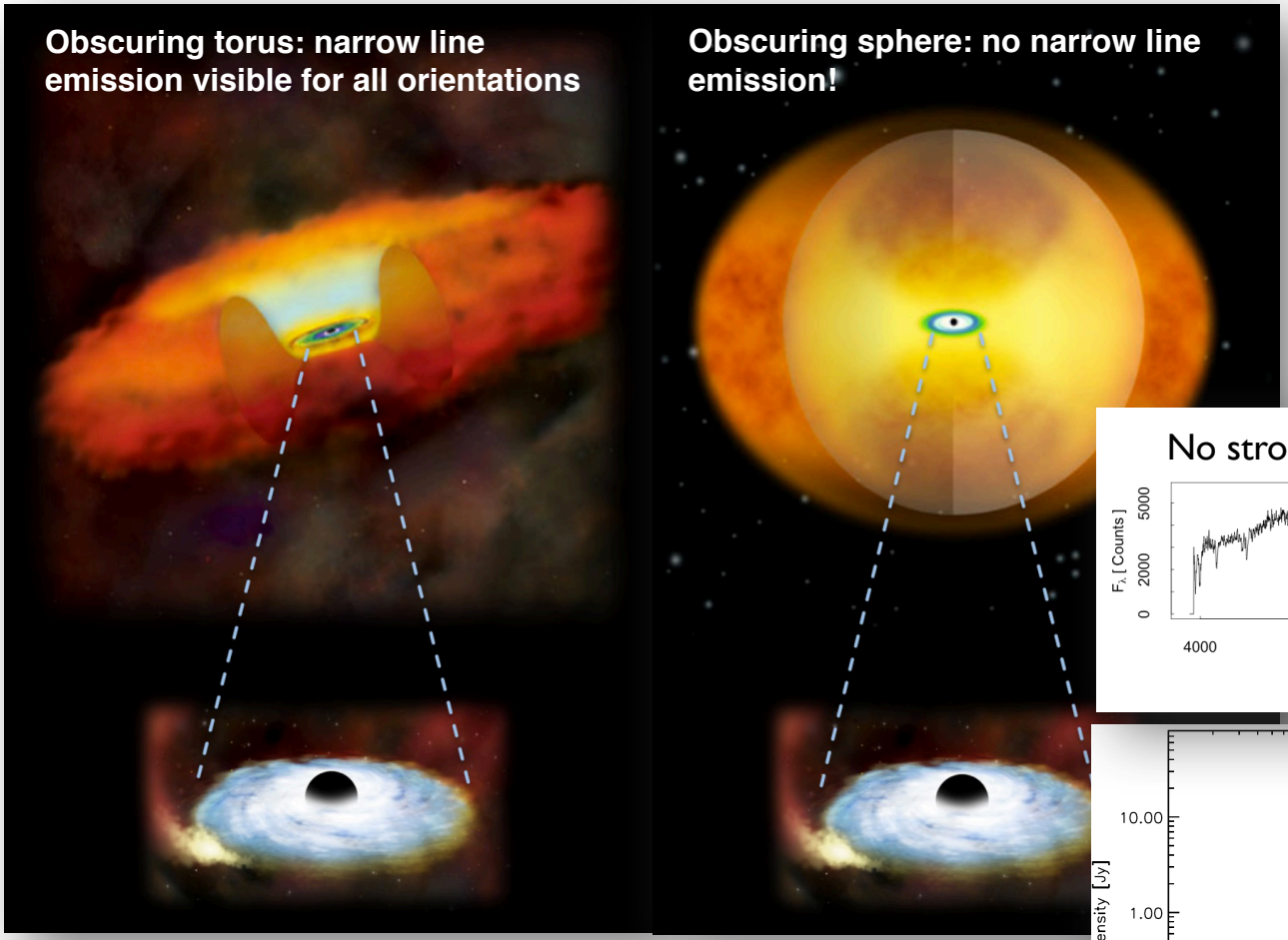


IC 2497 was ~100 times more luminous in the past

Schawinski et al. (2015)

Elusive AGN: obscuration

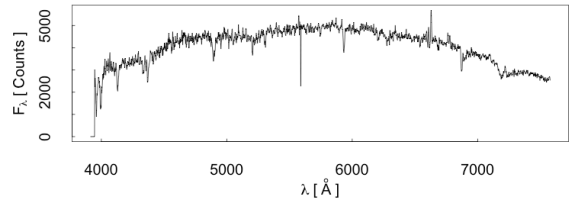
Covering factor of obscuring material effects the visibility of AGN signatures

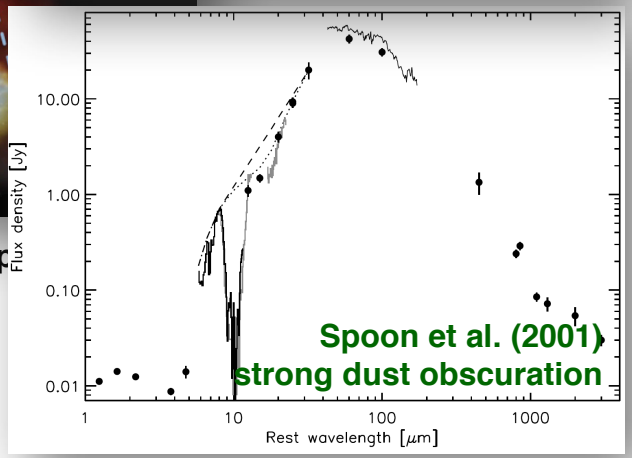


Credits: NASA/CXC/M.Weiss/National Astronomical Observatory of Jap

NGC 4418: spherical obscuration example?

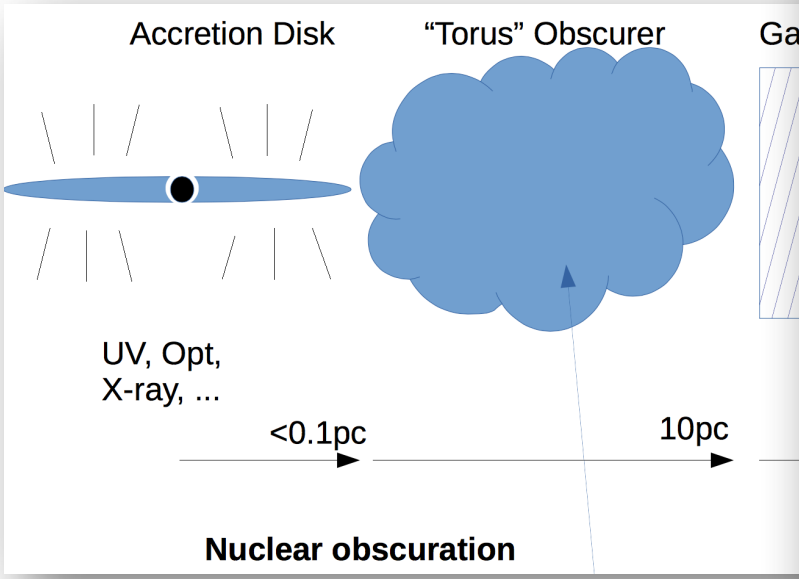
No strong optical emission lines





Elusive AGN: obscuration

The host galaxy can also obscure the AGN sig

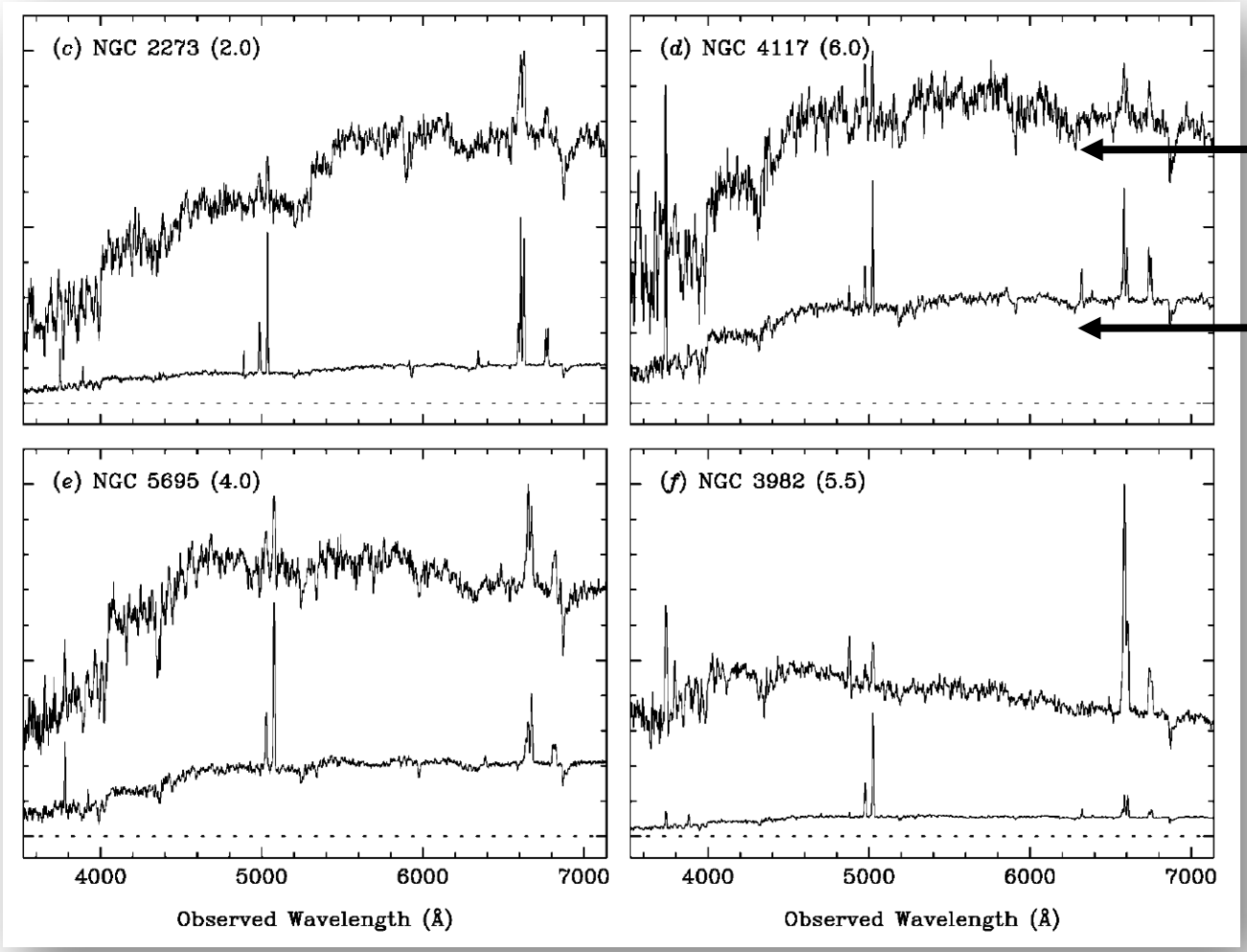


Credit: J. Buchner "Hidden Monsters" conference,

Goulding & Alexander (2009)

Elusive AGN: host galaxy dilution

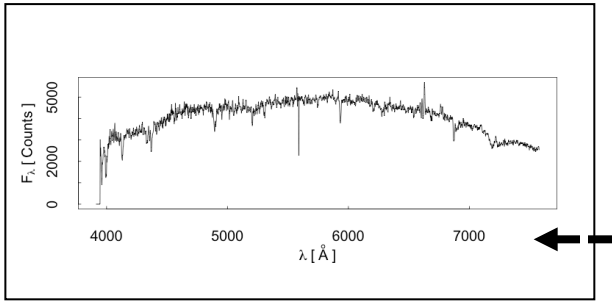
Strong host galaxy emission can swamp the AGN signatures

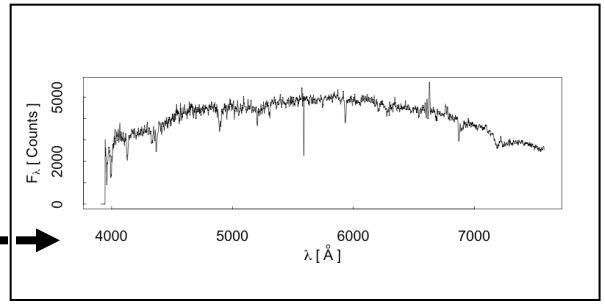


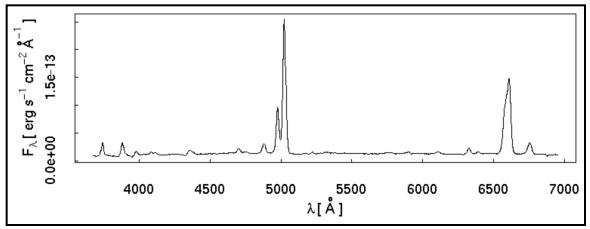
Moran et al. (2002)

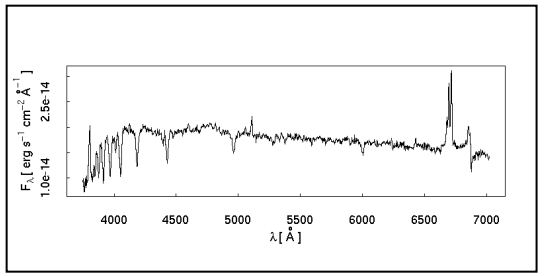
Factors that dictate AGN identification

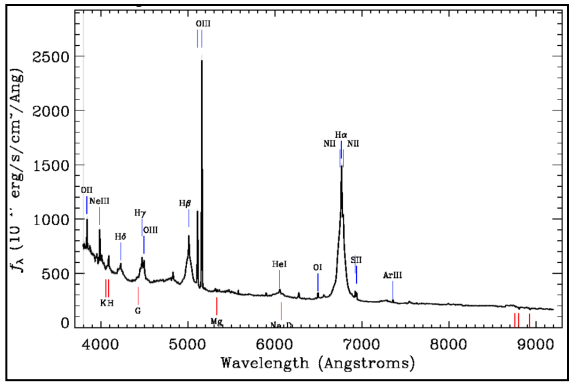
Optical spectra from Kim et al. (1995); Moustakas & Kennicutt (2006); SDSS archive

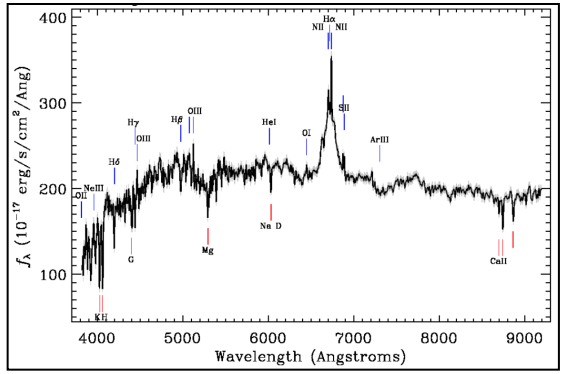












[Obscured]

Degree of obscuration

[Unobscured]

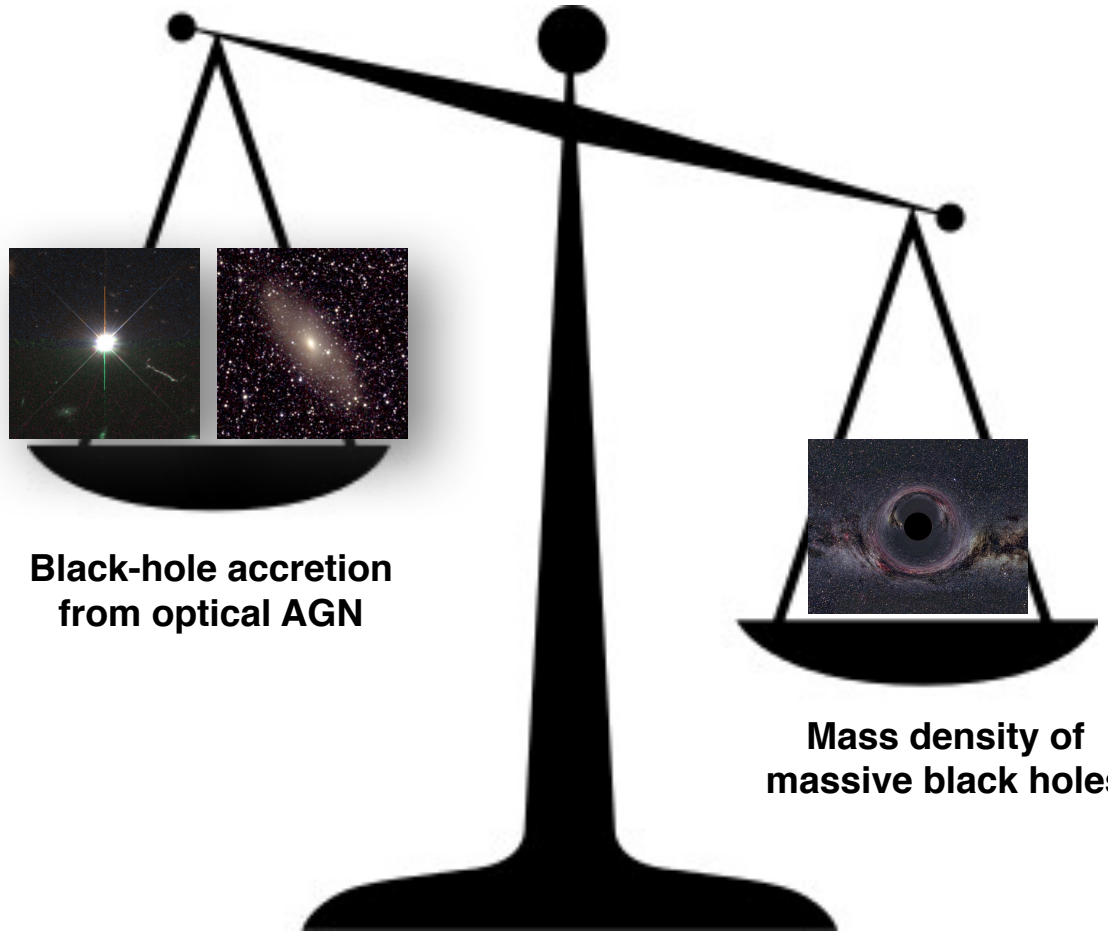
[AGN dominated]

Host/AGN emission ratio

[Host dominated]

Why should we care about elusive AGN?

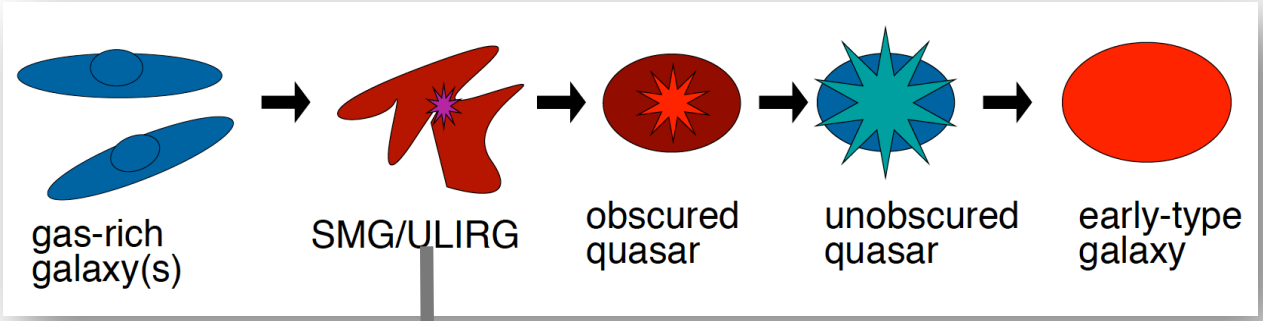
Find elusive AGN and complete the AGN census



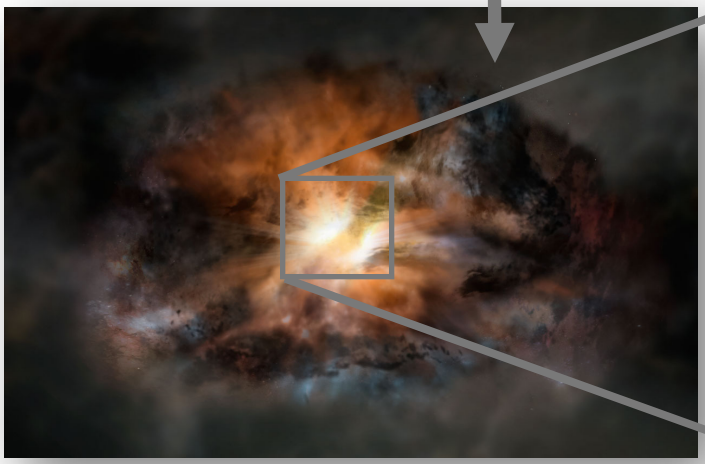
The AGN activity required to balance the scales would be optically elusive…

…balancing the scales provides insight on mass accretion parameters (e.g., accretion efficiency)

Elusive AGN may reside in specific environments: major mergers and rapid growth phases

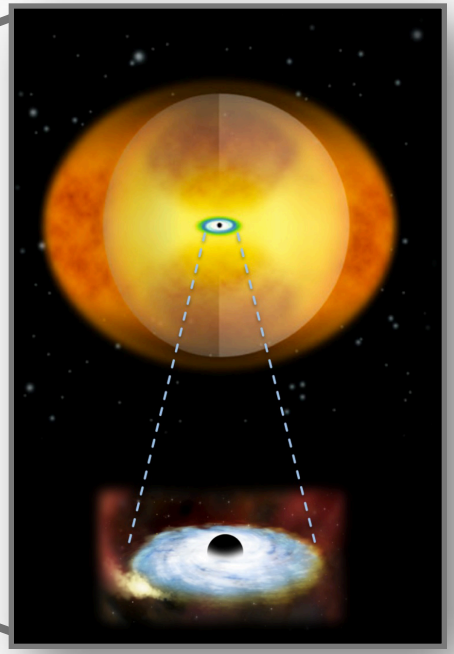


Alexander & Hickox (2012) schematic of Sanders et al. (1988) evolutionary model



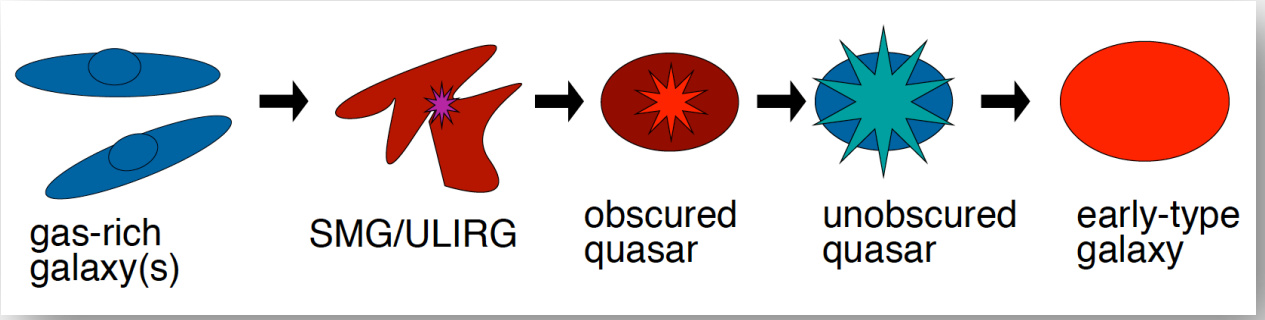
Credits: NRAO/AUI/NSF; Dana Berry/SkyWorks; ALMA (ESO/NAOJ/NRAO)

?



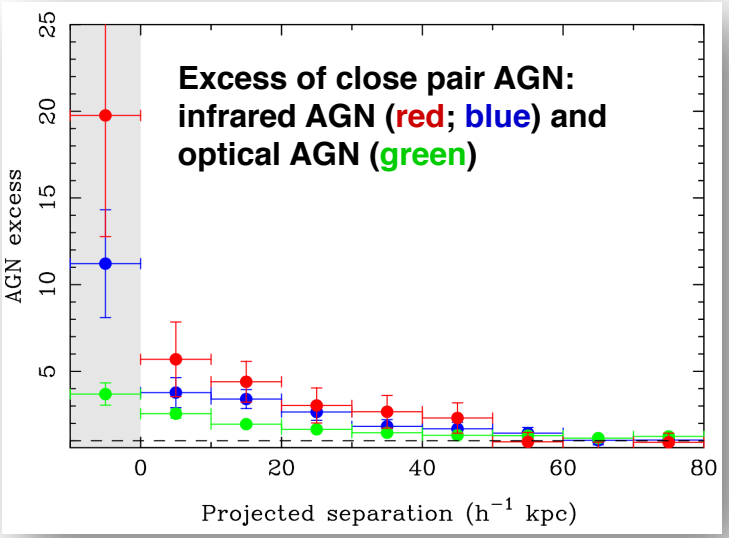
Credits: NASA/CXC/M.Weiss/National Astronomical Observatory of Japan

Elusive AGN may reside in specific environments: major mergers and rapid growth phases



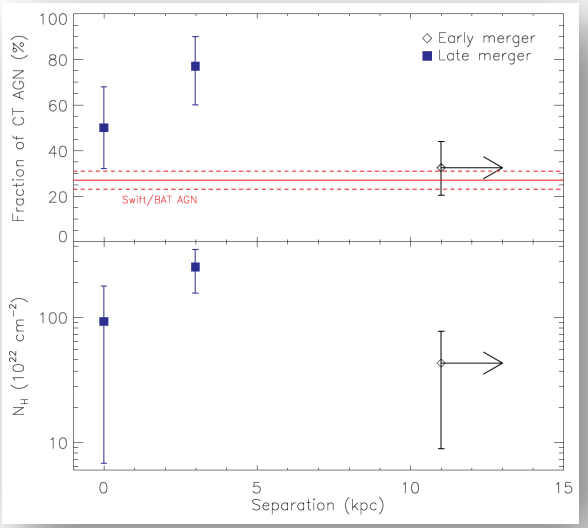
Alexander & Hickox (2012) schematic of Sanders et al. (1988) evolutionary model

Larger fraction of elusive AGN in close pairs



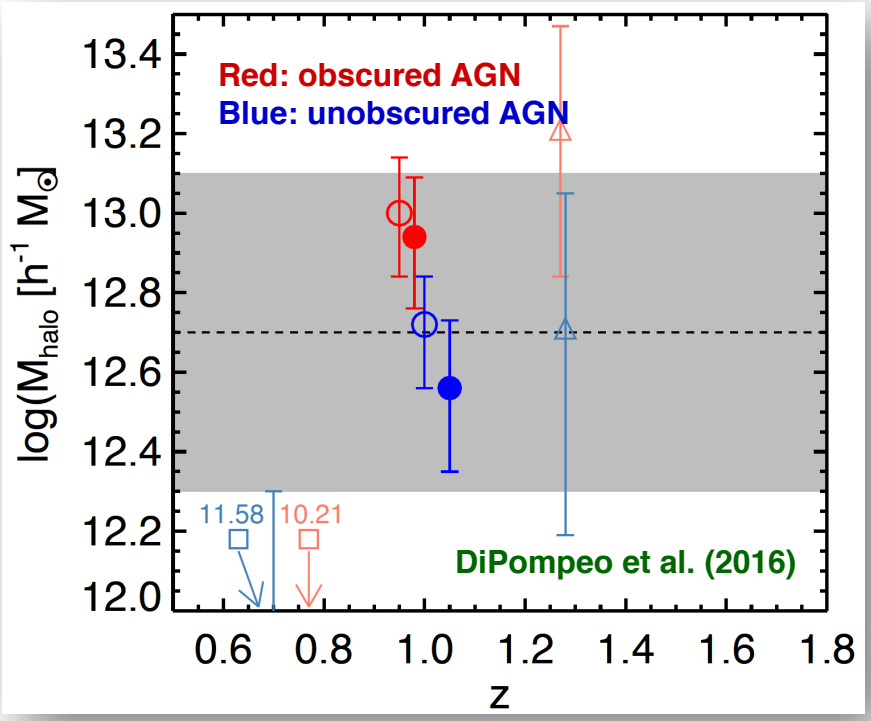
Satyapal et al. (2014); Ellison et al. (2013)

AGN in close pairs more obscured



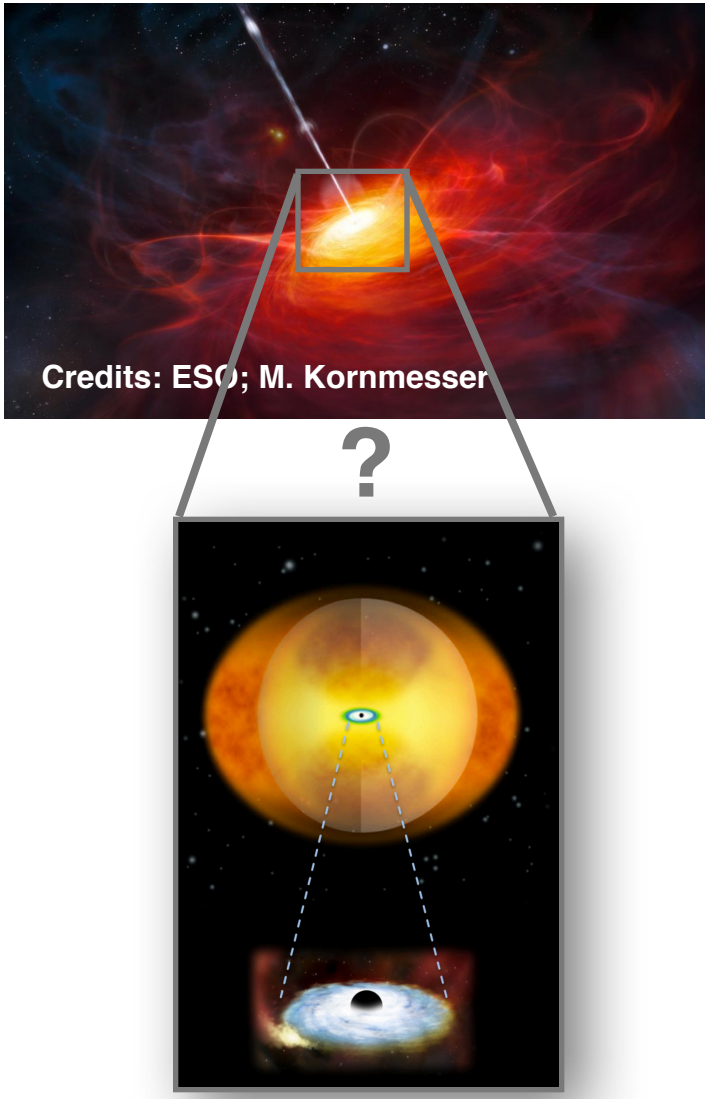
Ricci et al. (2017)

Elusive AGN may reside in specific environments: dark-matter haloes and first AGN



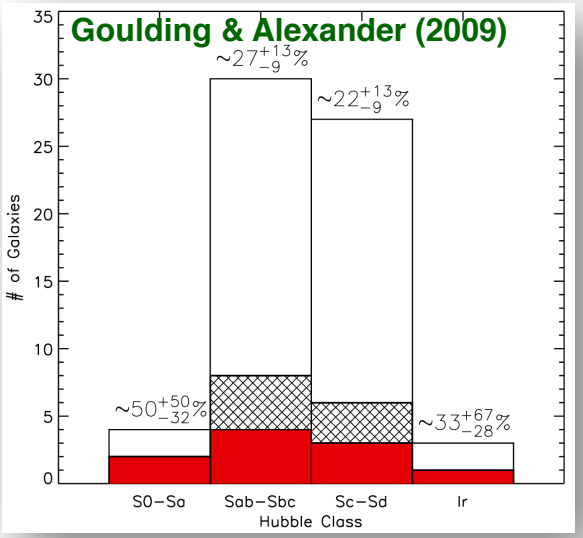
AGN type may also have an association with large-scale environment: dark matter haloes

First quasars: rapid black-hole growth

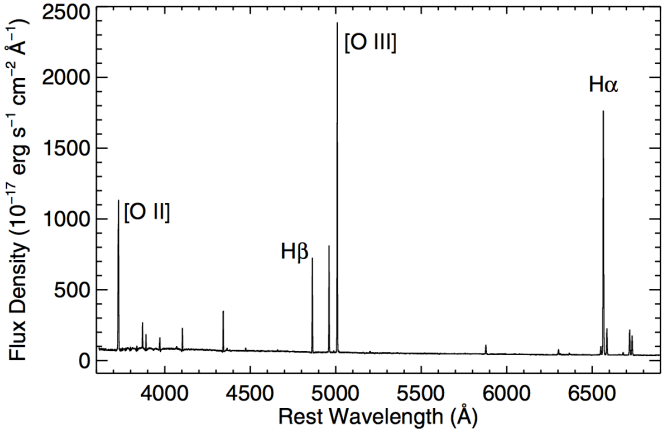


Elusive AGN may reside in specific environments: dwarf galaxies

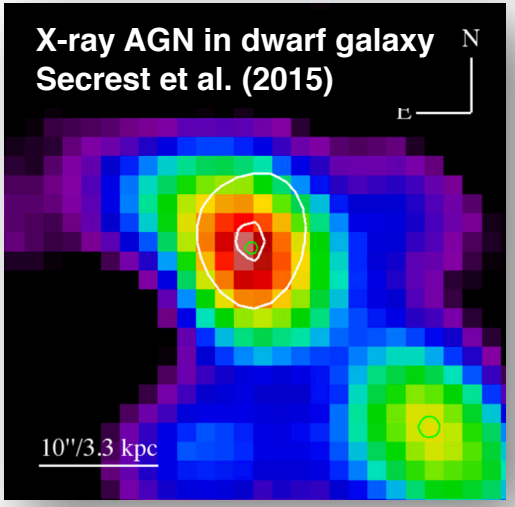
Many optically elusive AGN (red) reside in low mass/pseudo bulge galaxies

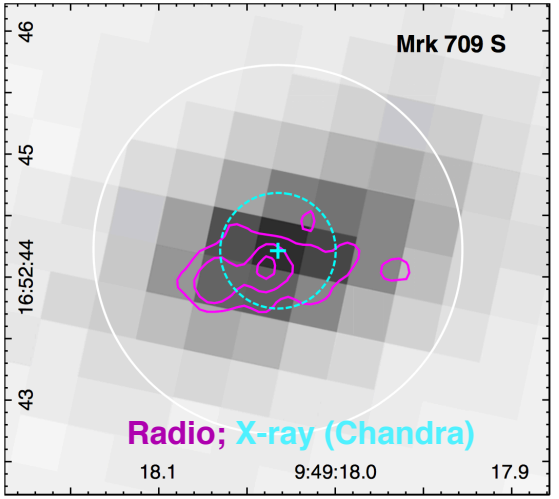


Low metallicity dwarf galaxy hosting an optically elusive AGN: Mrk 709



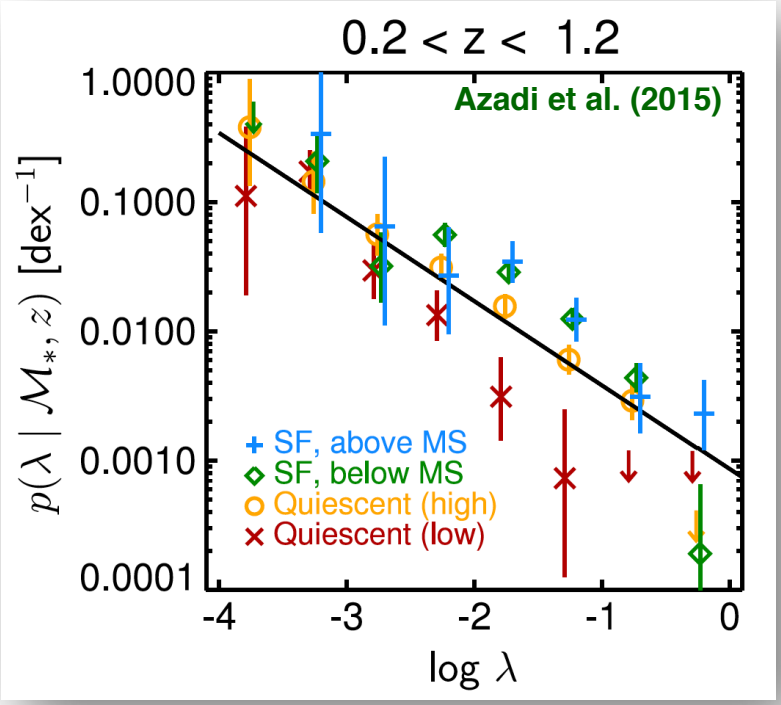
Reines et al. (2014)



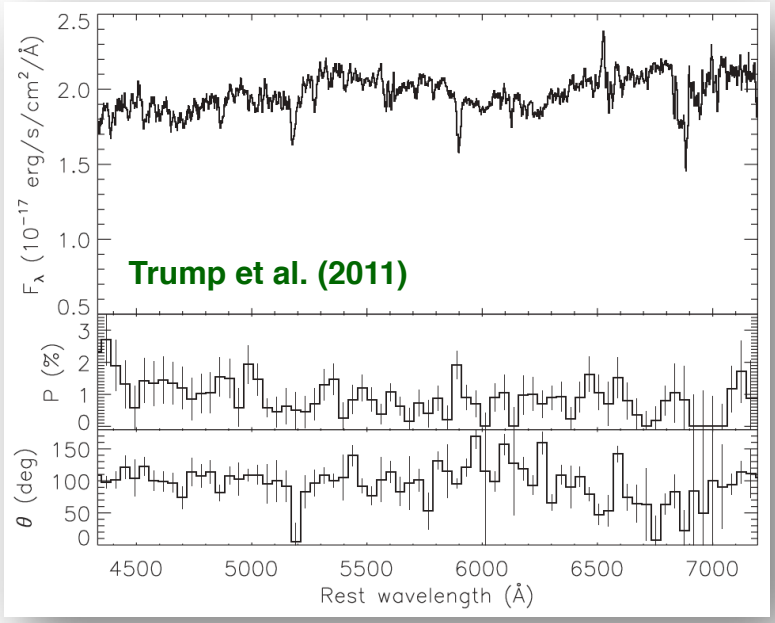


Elusive AGN may provide insight on lowest accretion rates

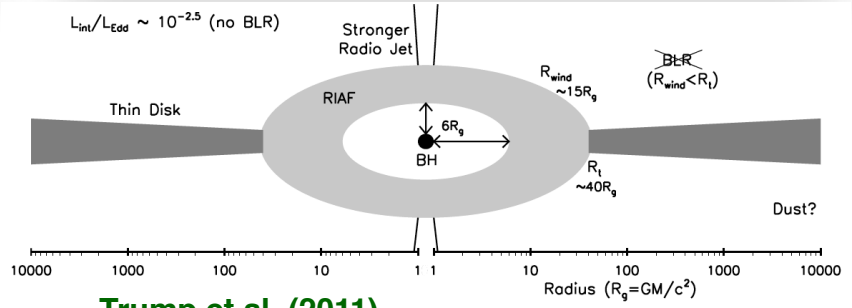
Inferred Eddington ratio distribution for X-ray AGN



Some may be radiatively inefficient AGN



Elusive AGN may contribute to the tail of the distribution (e.g., MacKenzie et al. 2017)

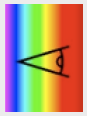
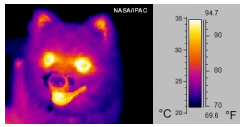
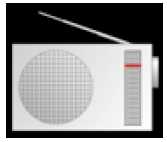


Trump et al. (2011)

Effective ways to identify elusive AGN

Effectiveness of different wavelength selections

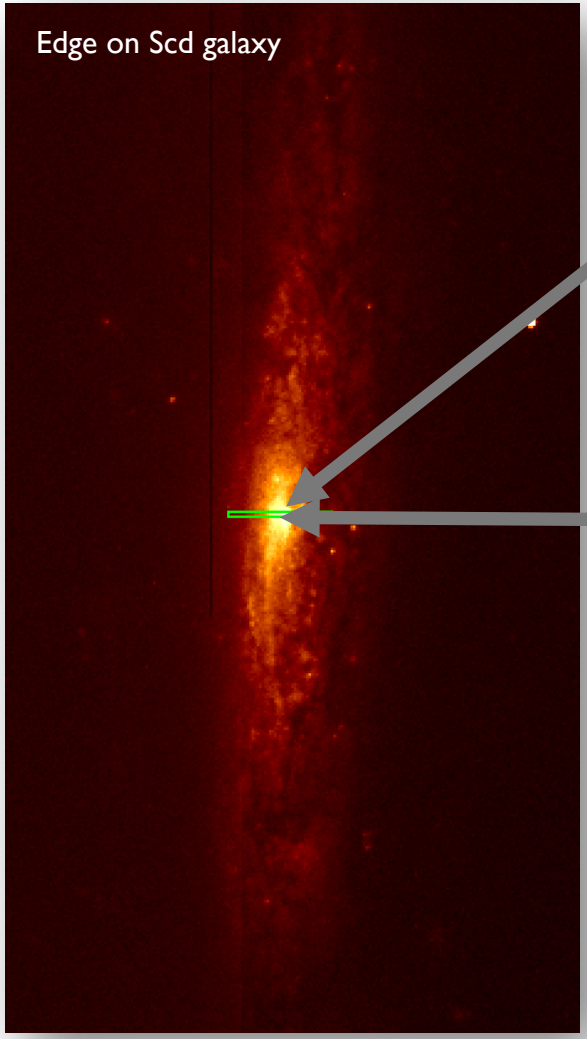
The pros and cons of different approaches to identify AGN

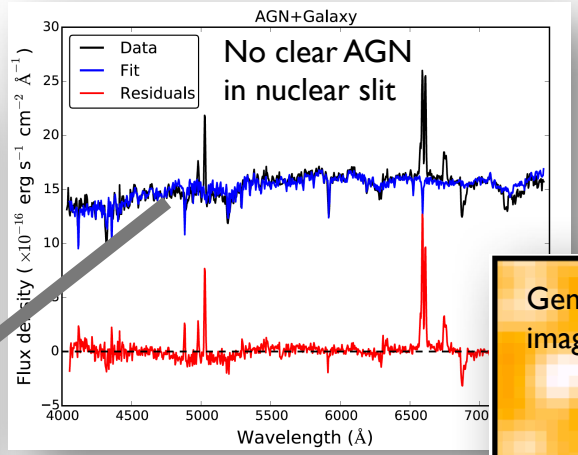
Waveband	Pros	Cons
Optical 	High reliability	Low luminosity and obscured AGN
Infrared 	Low obscuration bias	Star-formation dominated AGN and dust poor AGN
X-ray 	High reliability; low host contamination and low obscuration bias	Very low luminosity and heavily obscured AGN
Radio 	No obscuration bias	Host contamination; requires radio AGN emission

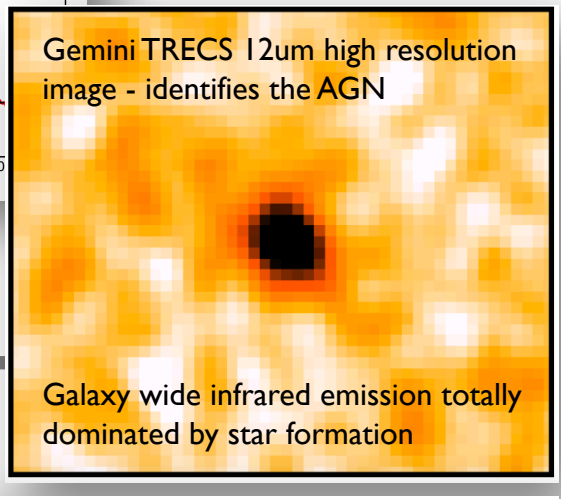
Adapted from Padovani et al. (2017) review and "Hidden Monsters" conference, Dartmouth 2016

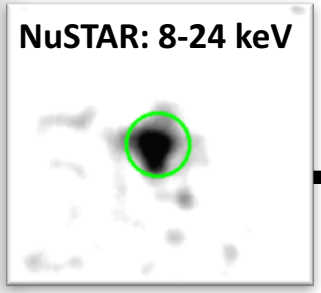
NGC1448: case study

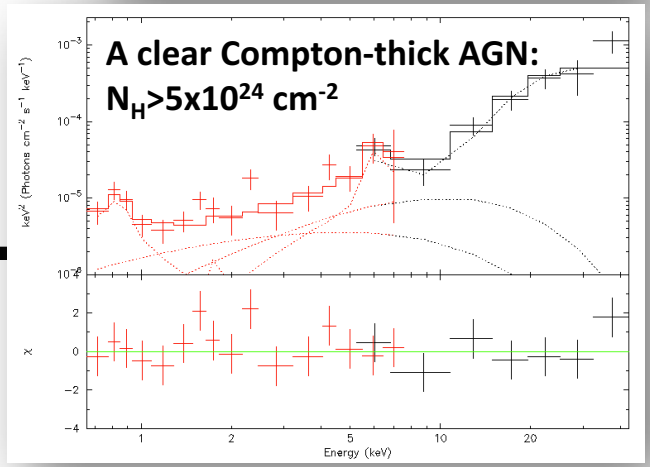
A late-type galaxy at d~12 Mpc





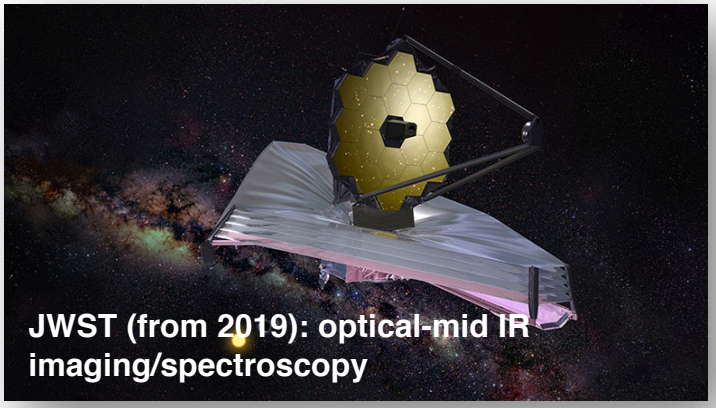


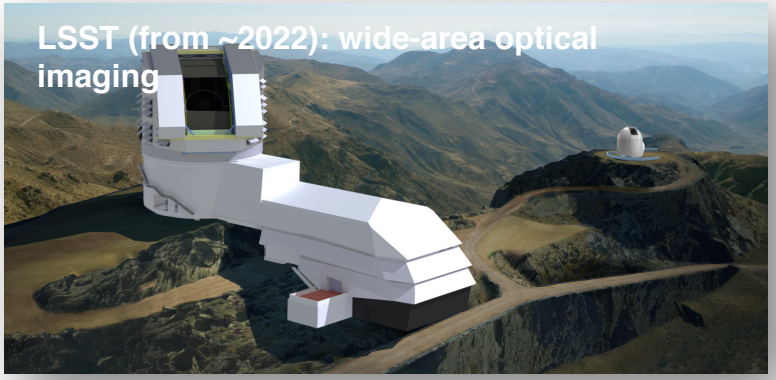




Annuar et al. (2017)

New and future facilities





…and many exciting radio facilities (LOFAR; ASKAP; MeerKAT; SKA)

Key questions and conference sessions

(1) How do elusive AGNs impact our understanding of SMBH 'seed' models?

(2) What fraction of SMBH growth is currently being missed and what impact does this have?

(3) What physical properties influence AGN detectability and what are the best techniques to find them?

(4) Elusive AGNs at high redshift? Prospects for future facilities

(5) Elusive AGNs and the role of mergers