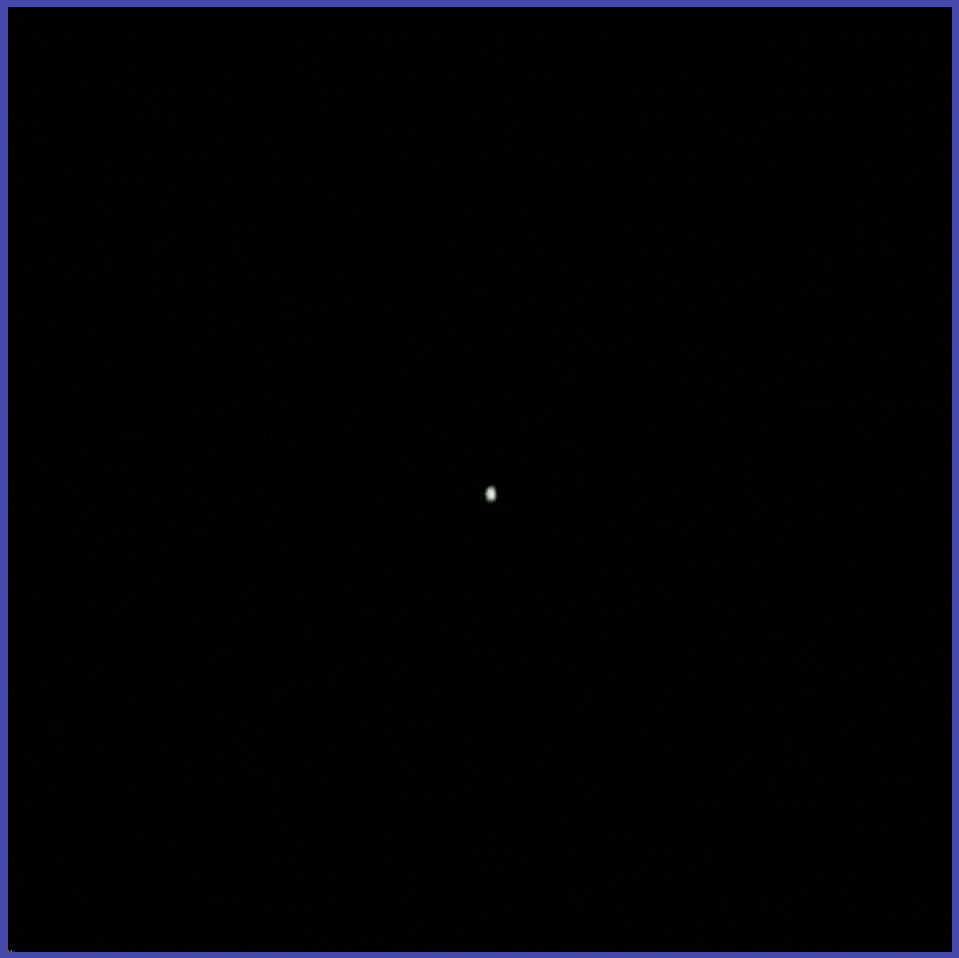
Chandra's Role in the Changing Face of AGN

Nuclear region of an AGN/Quasar



- View of Active Galaxy (AGN) depends on inclination
- Optical/UV light: obscured when edge-on
- Traditional surveys: optical/UV, soft X-ray
- Hard X-ray/IR/radio surveys see all

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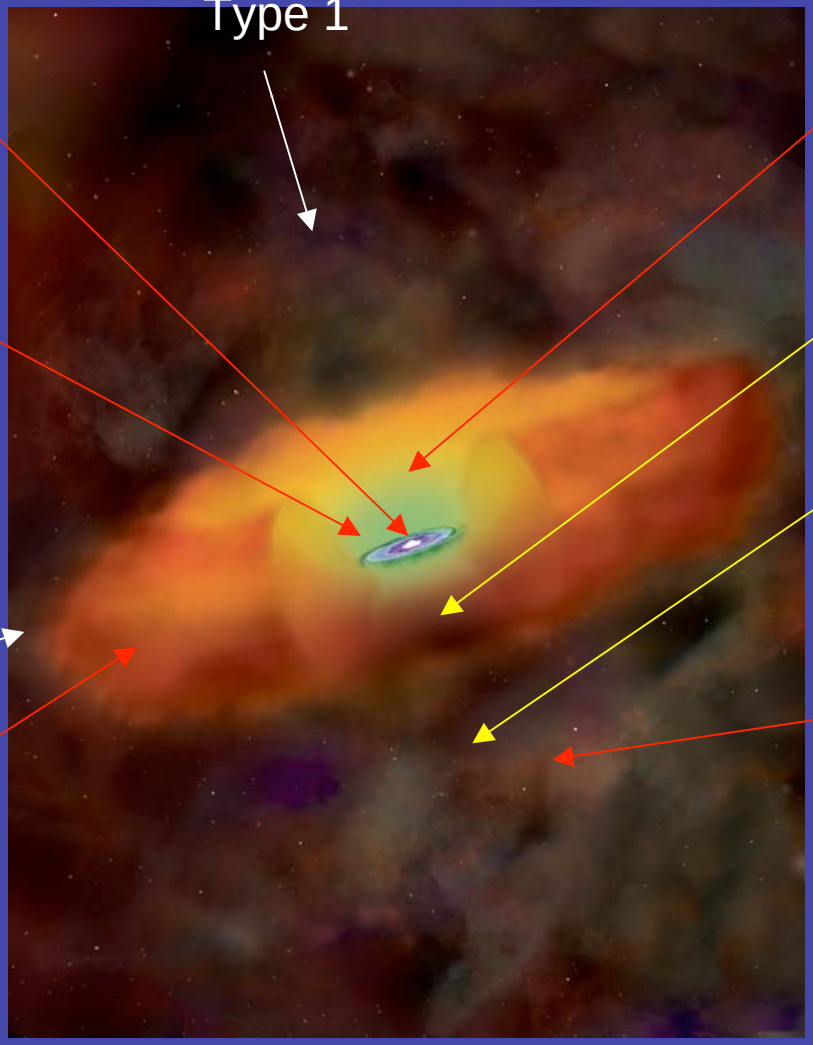
Unification Model: nuclear regions



X-ray source

Accretion Disk: OUV +soft X-ray emission

Dusty material: near+mid IR emission

X-ray reflection off cold/warm material

BROAD LINE REGION

NARROW LINE REGION

Scattered, polarized light

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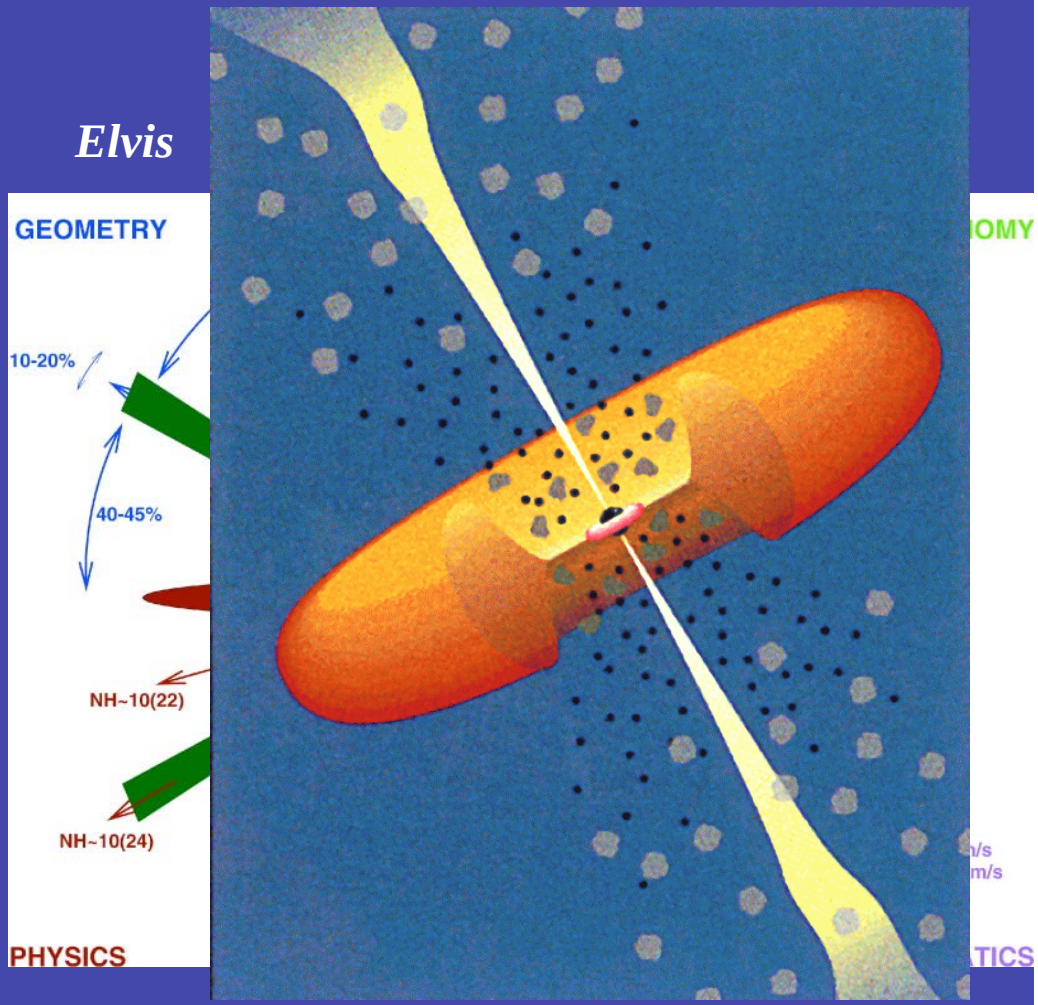
AGN Type and Obscuration

Urry & Padovani

- X-ray surveys generally find:
  - Type 1 AGN - unobscured
  - Type 2 AGN – obscured
  - Consistent with simple Unification models
- But MANY exceptions:
  - Red AGN
  - Intermediate types
  - BALs
  - XBONGs
- Disk-wind models *(Konigl & Kartje 1994)*



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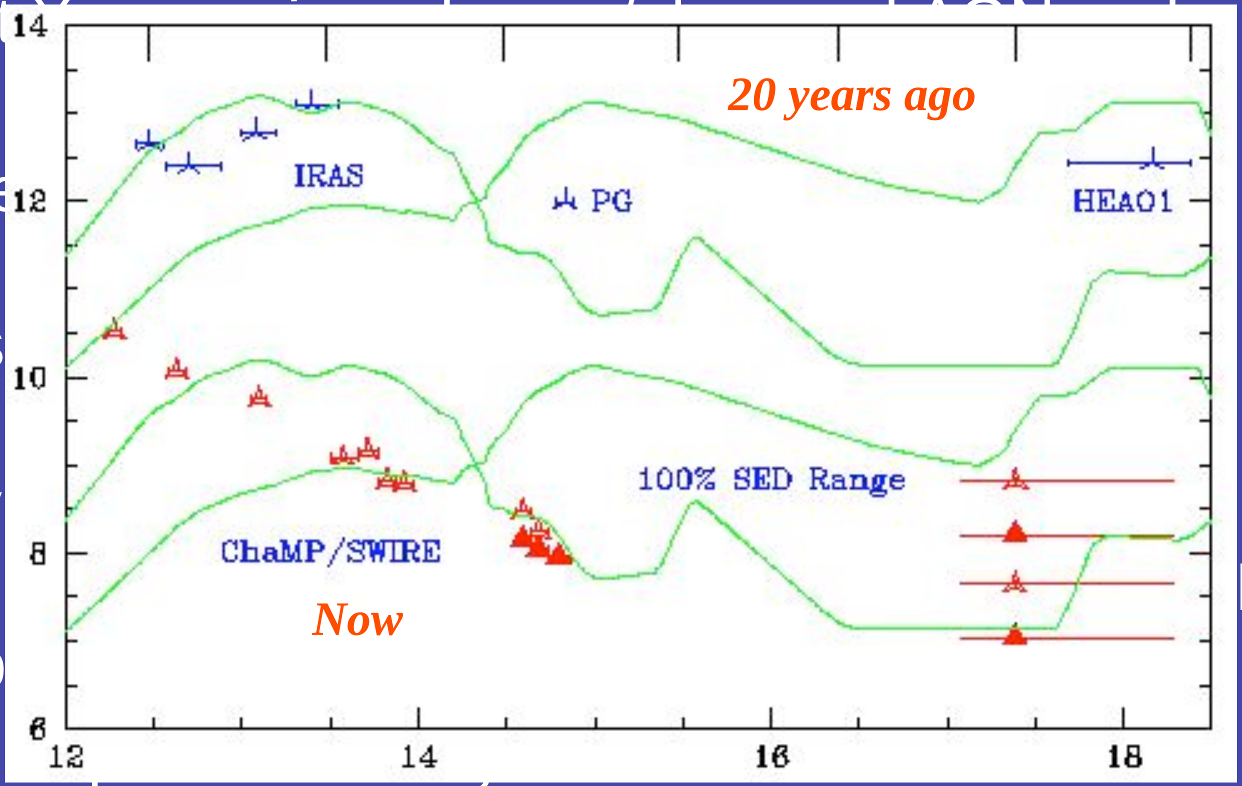
To View the Population

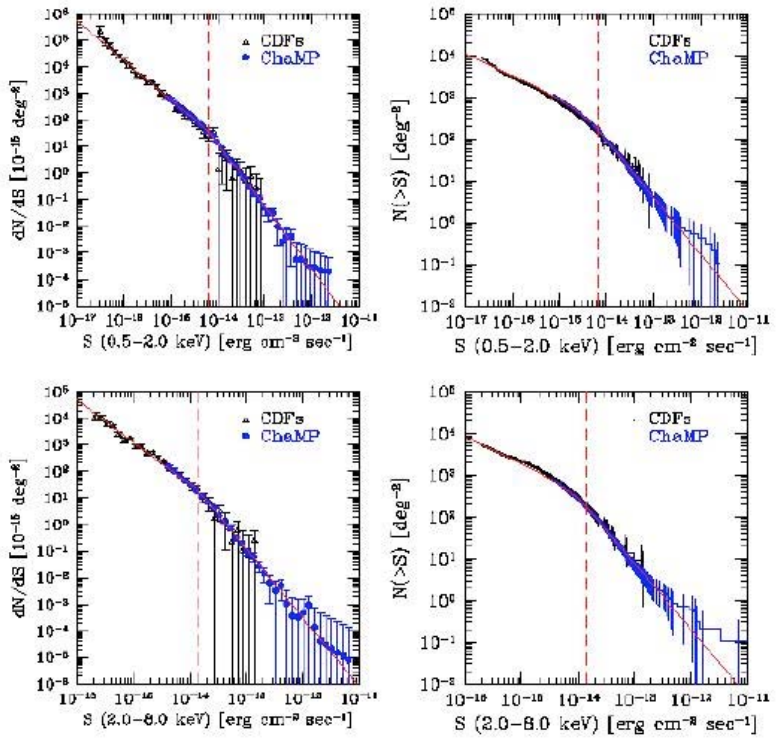
- Optical and soft
  quasars
- An unbiased vie
  - X-ray surveys:
  - Infrared (IR) S
  - Γ-ray: Integral
  - Low-frequency
- Many ongoing,
  range of possib
- Can Unification



X-ray logN vs logS

(M. Kim et al., 2006)

- *Chandra* Multi-wavelength Project (ChaMP): Serendipitous X-ray Survey
- 5500 sources, 9.6 sq.degs., F>6x10^{-16} (cgs)
- Strongest constraints to date
- Combined w/CDFs, even better:
  - Soft: 1.49±.02 (faint); 2.36±.05(bright)
  - Hard: 1.58±.01 (faint) 2.59±.06 (bright)



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Resolution of the Cosmic X-ray Background

- ChaMP+CDFs sample *(M.Kim et al. 2006)*
  - Resolved fraction:
    - 78% (0.3-2.5keV)
    - 81% (2.5-8keV)
- Diffuse Background: 20% (*2-8keV*)
  Hickox & Markevitch 2006
- Galaxies dominate:

$$F_x(.5\text{-}2\text{keV}) < 2\times10^{-18}(\text{cgs})$$

D.Kim et al. 2006, ChaMP

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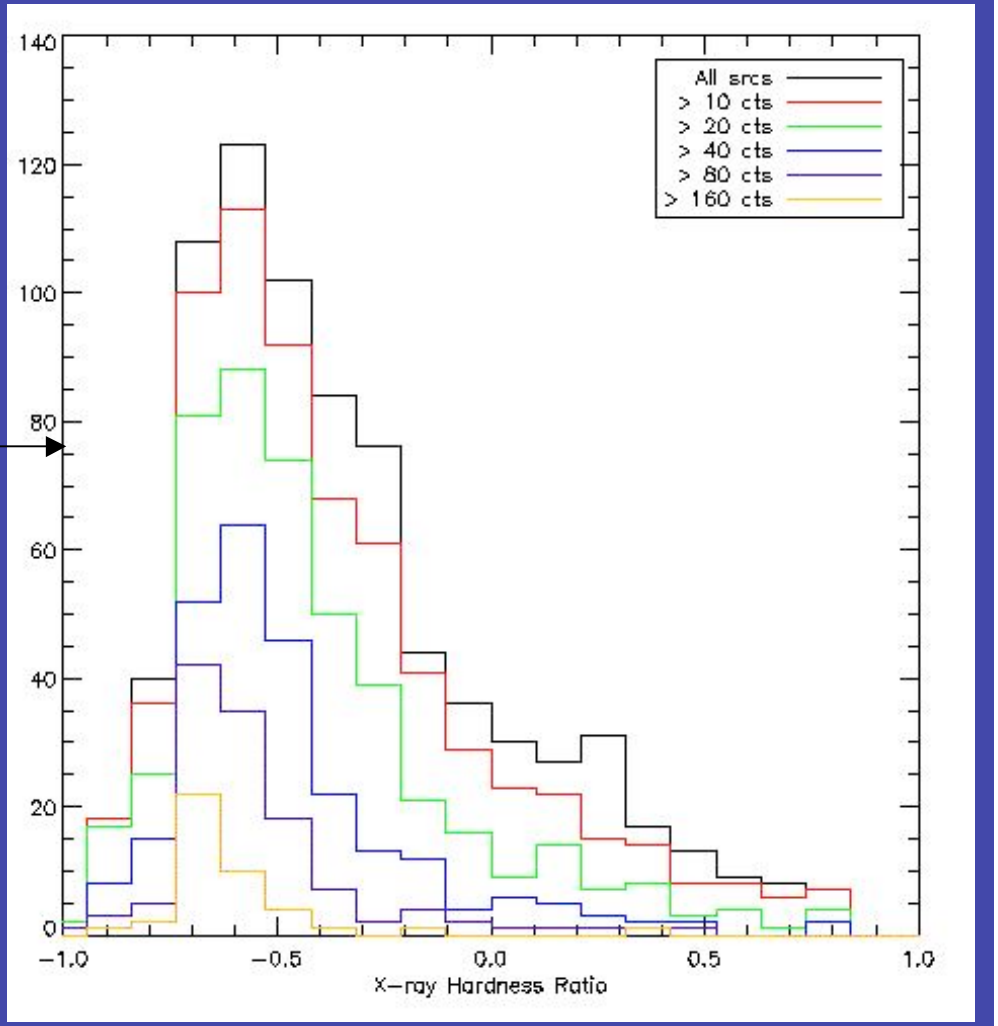
X-ray Surveys are finding Obscured Sources

- Fainter sources are harder
- Hardness: primarily due to obscuration *(Kim et al. 2004, ChaMP)*
- SWIRE/Chandra sample *(Wilkes, Kilgard et al. in prep)*
- Steep increase → L dependence of N_H *(Comastri 2004)*



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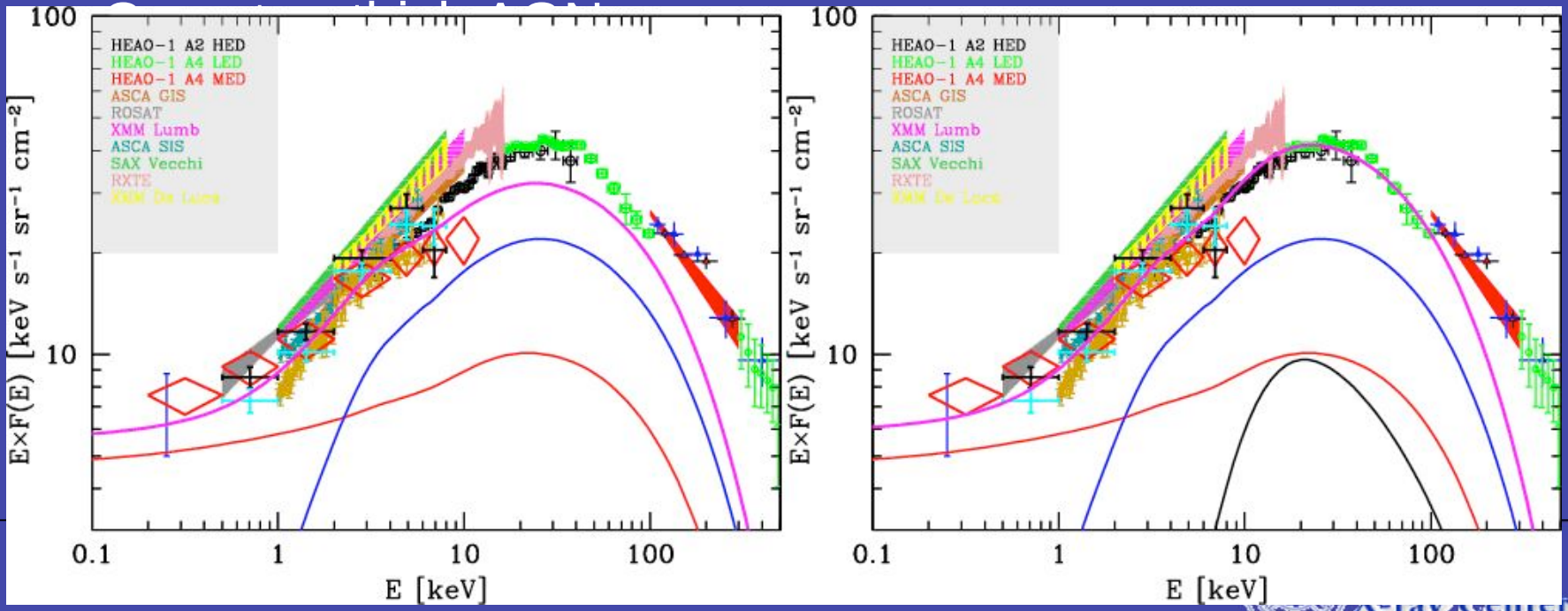
Current CXRB Models

Gilli, Comastri & Hasinger 2007

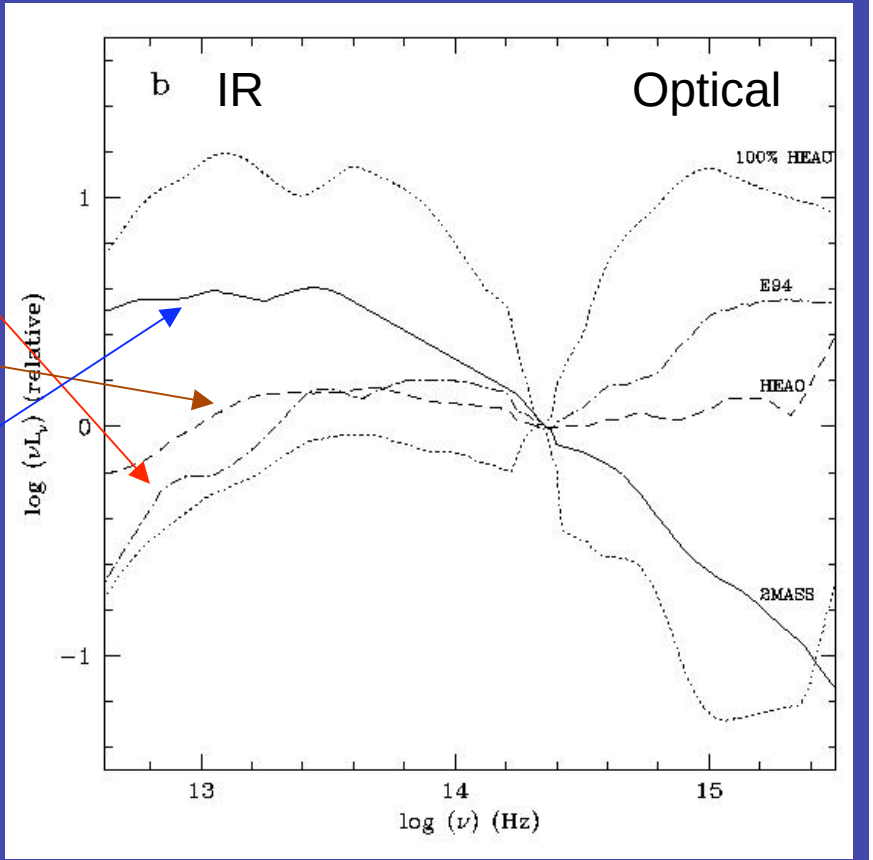
- R = obsc'd/unobs'd AGN
  - ~ 4, log L_x <42
  - ~ 1, log L_x >45
- $\Gamma = 1.9$, $\sigma_x = 0.2$
- ~ 20% unresolved CXRB



Current X-ray and IR Surveys

⟶ Broader range of SEDs

- Einstein-era: optically/radio-selected, blue bias *(Elvis et al. 1994)*
- HEAO: hard X-ray, reduces blue bias *(Kuraskiewicz et al. 2003)*
- 2MASS: J-K>2, red AGN, little/no blue bump *(Kuraskiewicz et al. 2007, Fig 4b)*



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Obscured AGN

log N_H ~ 21-24

- Potential:
  - Numbers: geometry of central regions
  - Properties: information on obscuring material
- No single population *(Alexander et al. 2003, Rosati et al. 2002):*
  - Type 2 AGN/QSOs *(Norman et al 2002, Kim et al. 2006)*
  - Compton-thick AGN *(Polletta et al. 2006)*
  - XBONGS *(Fiore et al. 2000, Kim et al. 2006)*
  - Obscured type 1 AGN *(Wilkes et al 2002)*
  - Optically Highly Polarized Type 1 AGN *(Smith et al. 2002)*
- Unbiased Survey?
  - X-ray + far-IR
  - 3CR, low frequency radio selected

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SWIRE/Chandra Survey

(w/Lonsdale, Kilgard, Polletta, Smith, Owen, et al.)

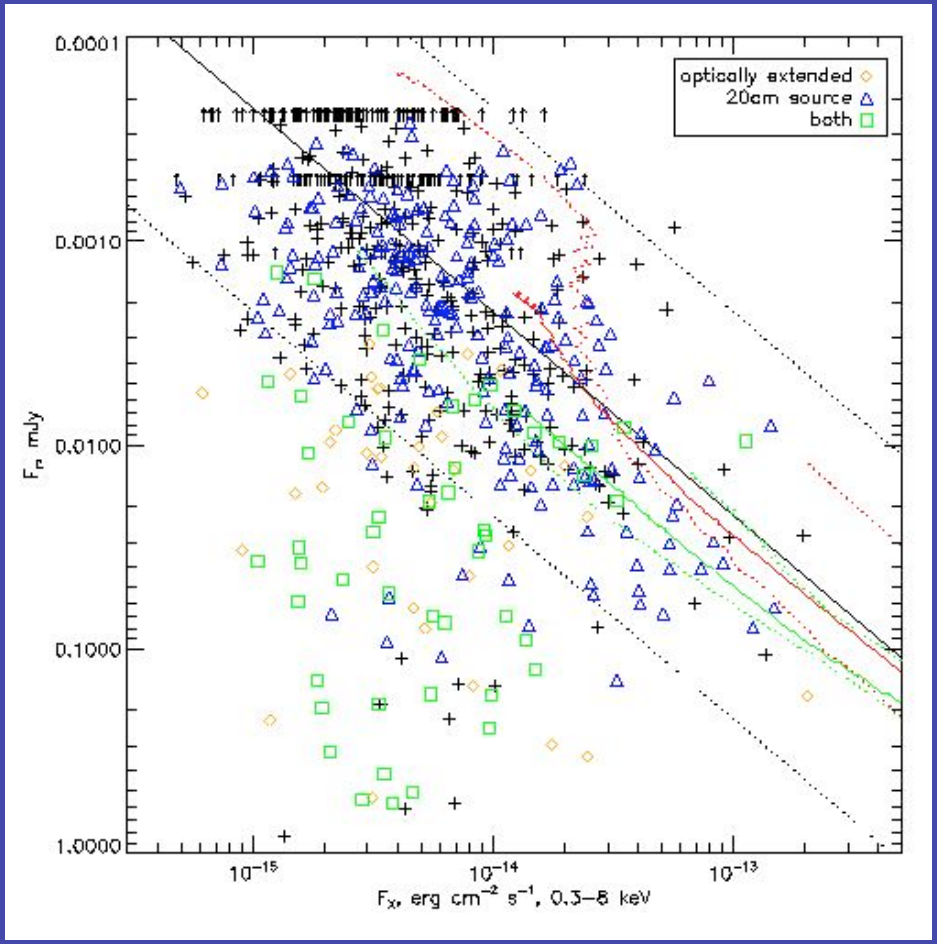
- 0.6 sq.degs. contiguous, 70 ksecs
- Lockman Hole region of SWIRE
- Centered on Deepest VLA image
- X-ray flux limit: 2×10^{-16} erg cm^{-2} s^{-1}
- Depth: distinction between AGN and starbursts (undetected)

Statistical Results

- 775 unique X-ray sources to a limiting flux of 2×10^{-16} erg cm^{-2} s^{-1}
  - 765 with secure IR counterparts and 626 secure optical counterparts
  - >160 radio counterparts (analysis on-going)
  - 75 spec z (so far)
  - 49 X-ray sources coincident with optically extended galaxies
  - 2 extended X-ray sources (clusters)

SWIRE X-ray Sample

- Standard R vs X plot
- Blue lines indicate AGN region (not well-defined)
- Radio sources all over
- Extended sources in low L AGN region



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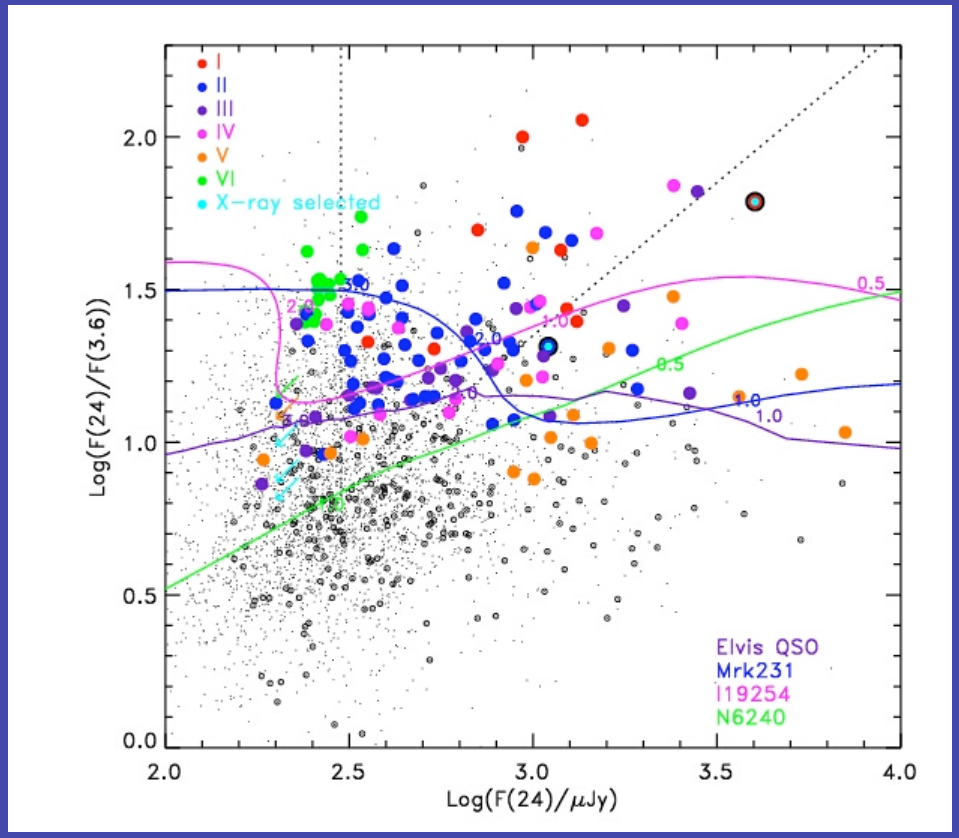
Compton-thick AGN

(Polletta et al. 2006)

- 5 hard X-ray selected (2 at z>2)
- 120 red, AGN-dominated, IR-selected: power-law SED, α_{IR}>1.0
- >25 Compton-thick AGN per sq.deg.
- 40% optical O/IR AGN, remainder host galaxy dominates
- 30% X-ray detected to F(.3-8)~10^{-15} (cgs)



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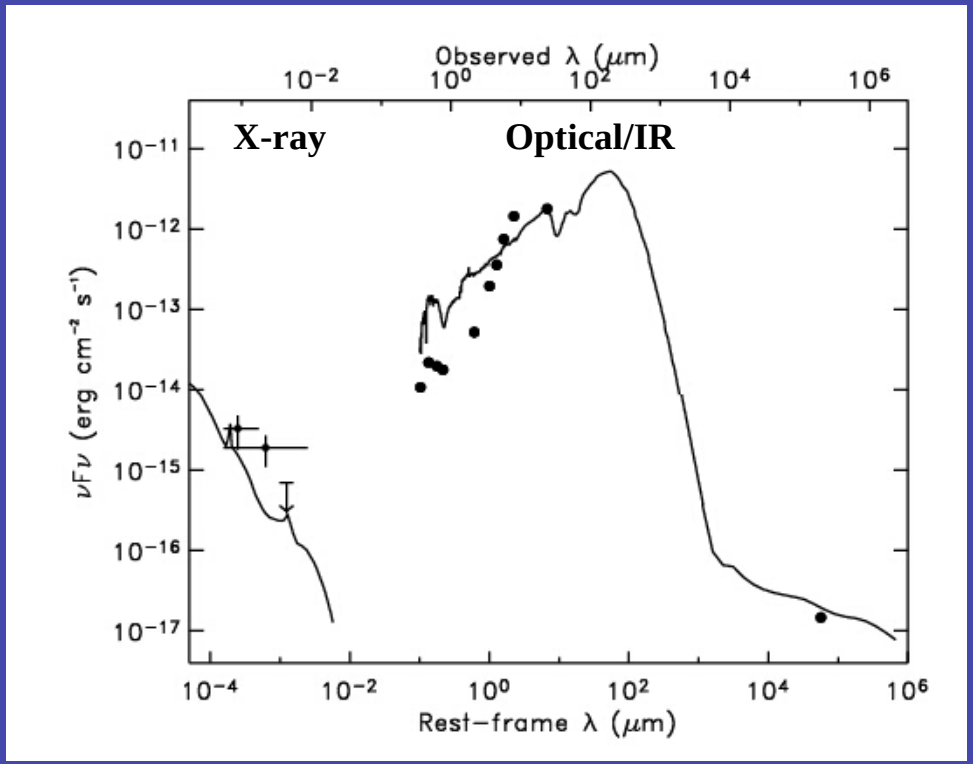
SWIRE: X-ray Compton-Thick QSO

(Polletta et al. 2006)

- SW 104409, z=2.54
- X-ray HR~0.85, 11 counts
- NLSy1 optical spectrum
- SED:
  - Obscured QSO, A_V=4
  - 0.6% QSO type 1



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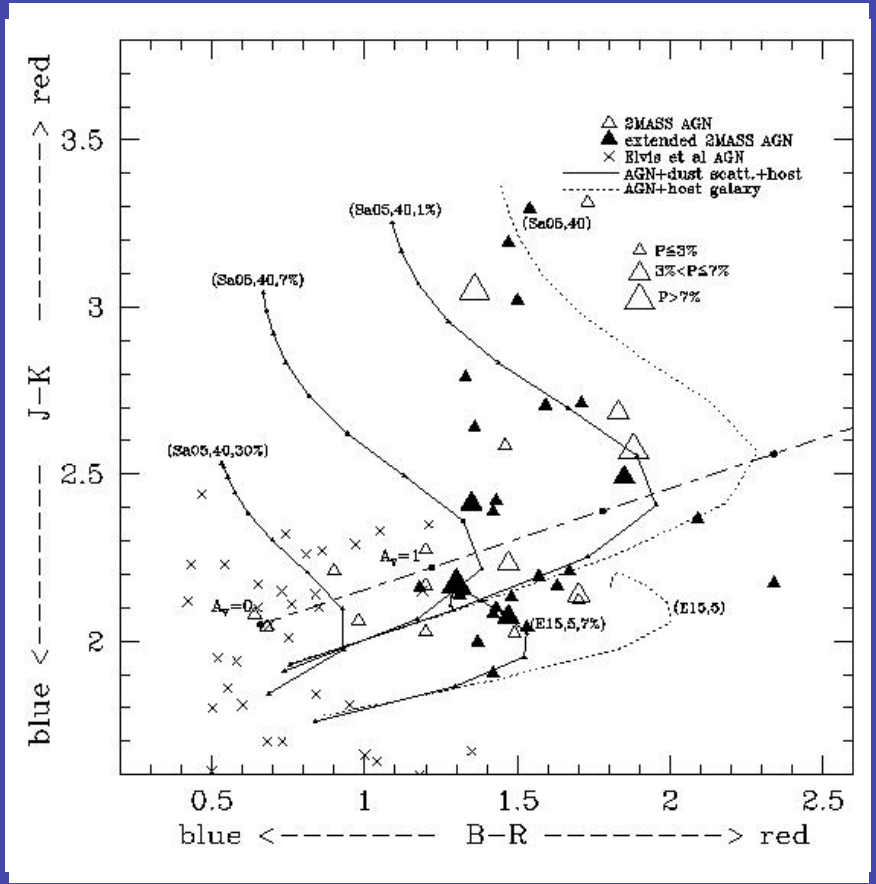
Unusual OIR Colors: Red 2MASS

(w/ **Kuraskiewicz,** Cutri, Schmidt, Smith, Nelson)

- Not pure obscured AGN
- Explained by:
  - "Normal" AGN
  - Obscuration (by dust)
  - Host galaxy
  - Scattered AGN
- Any systematics?



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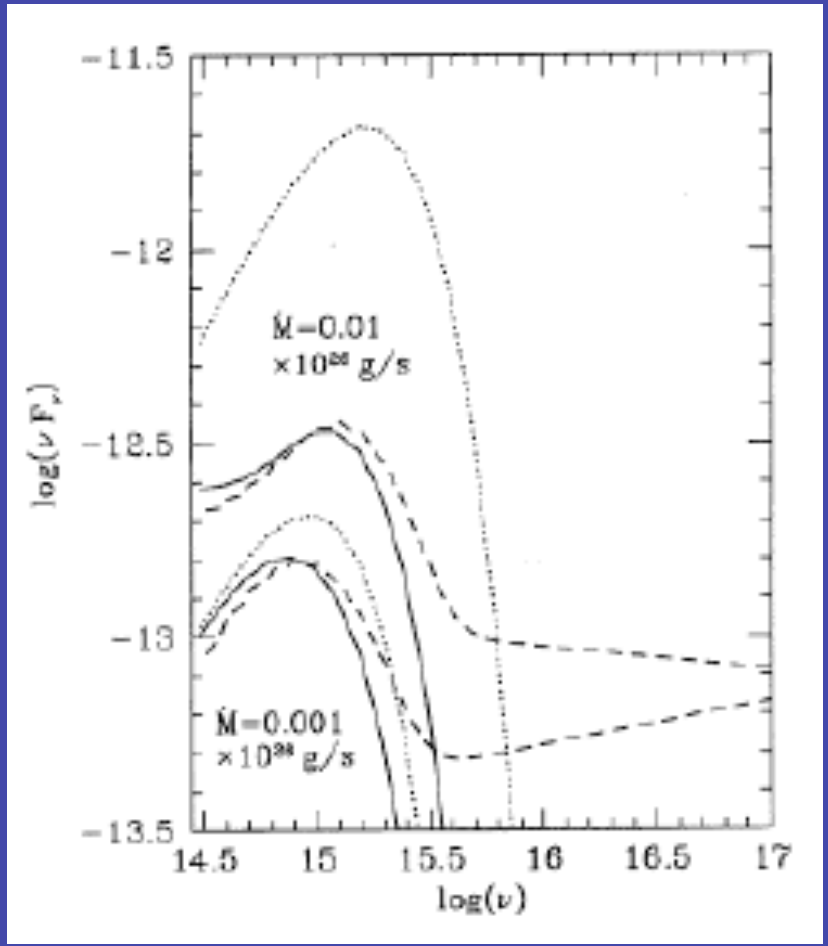
IR-X continuum and emission line PCA

Kuraskiewicz et al 2007

Czerny et al 1997

- EV1 (33%):
  - X-ray to OIR flux ratios
  - → accretion rate
- EV2 (18%):
  - OIR colors
  - Host Galaxy contribution (+A_V)
- EV3 (12%):
  - X-ray N_H and optical NL reddening
- EV4 (8%):
  - Polarized light + broad Hα/Hβ
  - Dust between BLR and NLR

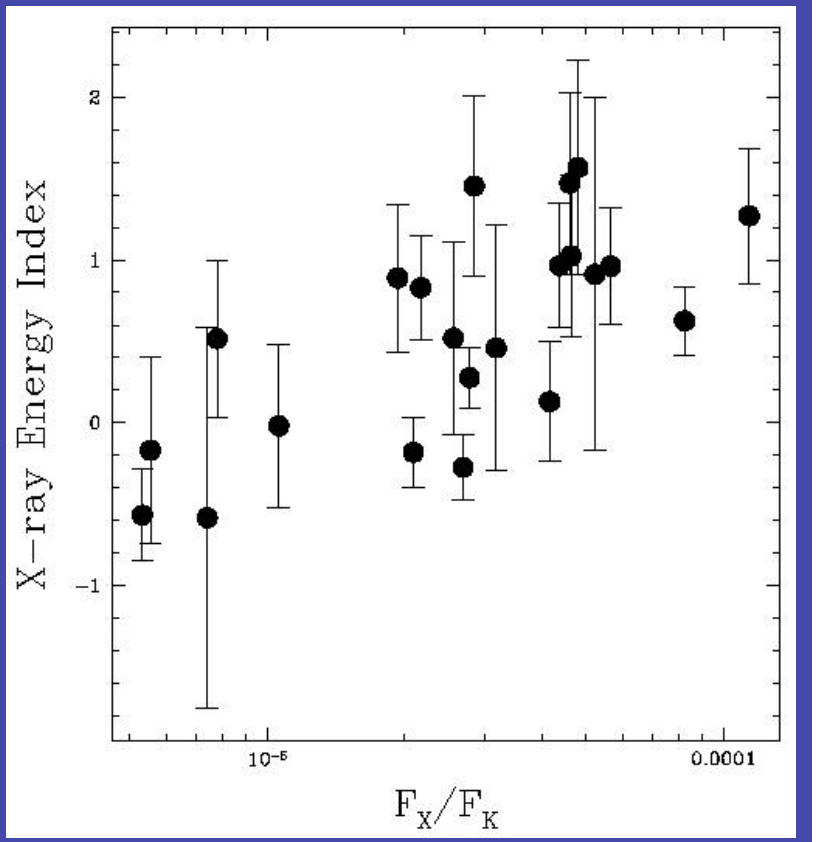


Chandra X-ray Center

Complex X-ray Spectra

Chandra data: Wilkes et al., in prep

- 44 2MASS Red AGN w/Chandra
- 21 spectra fits:
  - Log N_H~22
  - PL slope flatter for weaker X-rays



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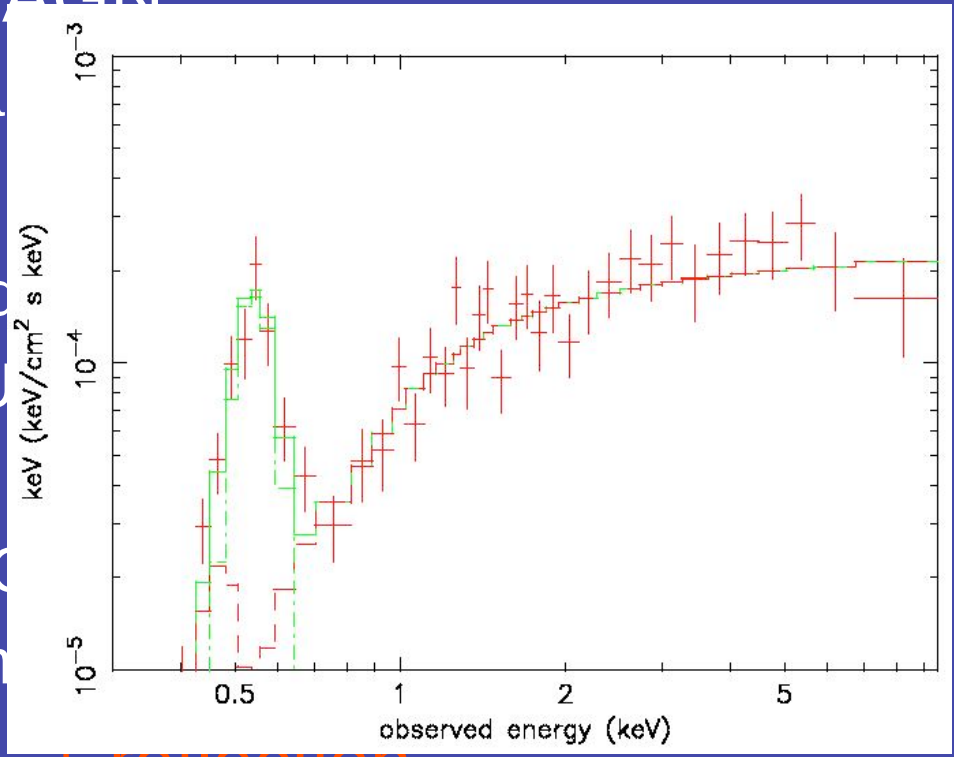
Complex X-ray Spectra

- XMM-Newton: 8 X-ray bright 2MASS AGN
- Range of optical types and Chandra HRs
- Variety of properties:
  - Type 2: log N_H~22, normal spectral index
  - Type 1-1.5: absorbed PL, reflection, soft excess
  - No systematic errors in Chandra results but low S/N data misleading
  - Harder X-ray likely due to reflection

XMM-Newton Observations

(Wilkes, Pounds et al. 2005, 2007)

- 8 X-ray-bright, 2MASS AGN:
  - Range of optical types a
- Variety of results:
  - Complexity in type 1 and
  - Type 2 consistent with U
  - Variation in 3 (1 of each
  - No ***systematic*** error in C
  - ***BUT*** low S/N data are m
- Harder X-ray: due to N_H + reflection



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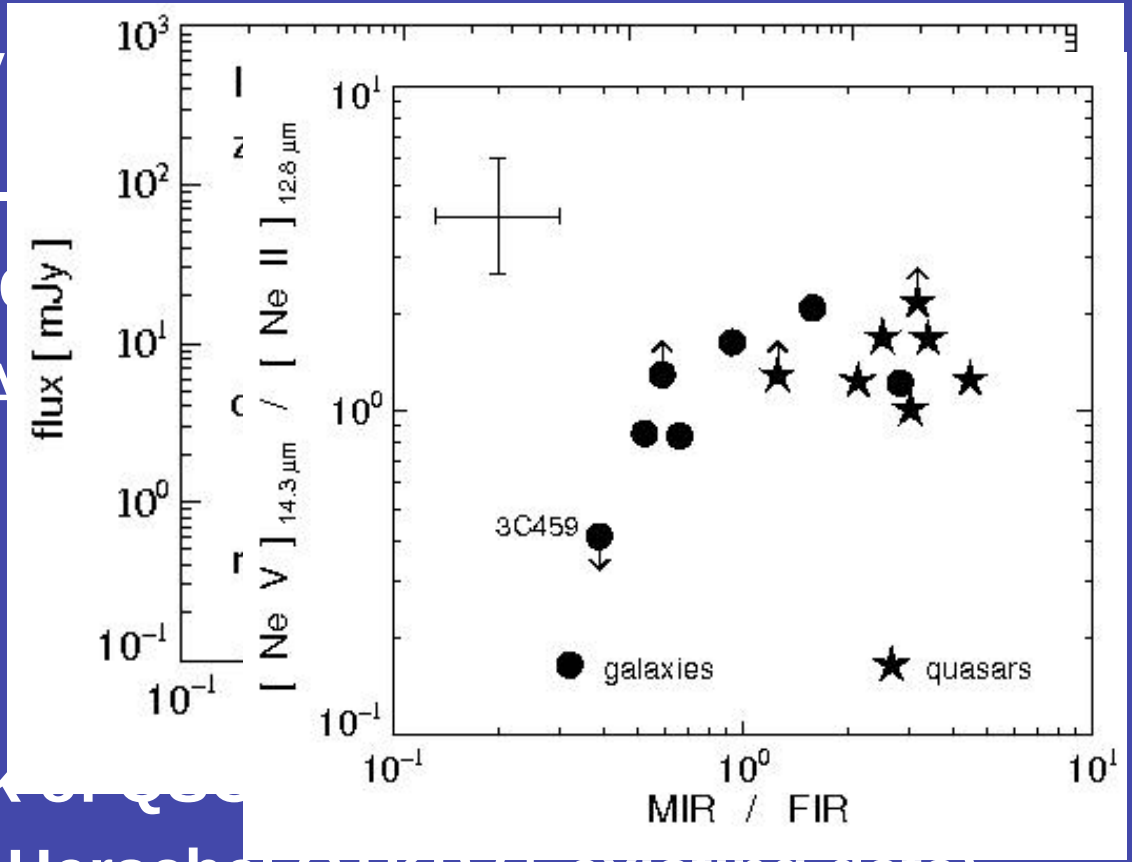
3CR: Infrared SEDs

Haas et al. 2004, 2005

- X-rays: miss highly
- Isotropic: Low-freq.
- Mid-IR SEDs differ
- Emission lines → A
  - Galaxies obscured



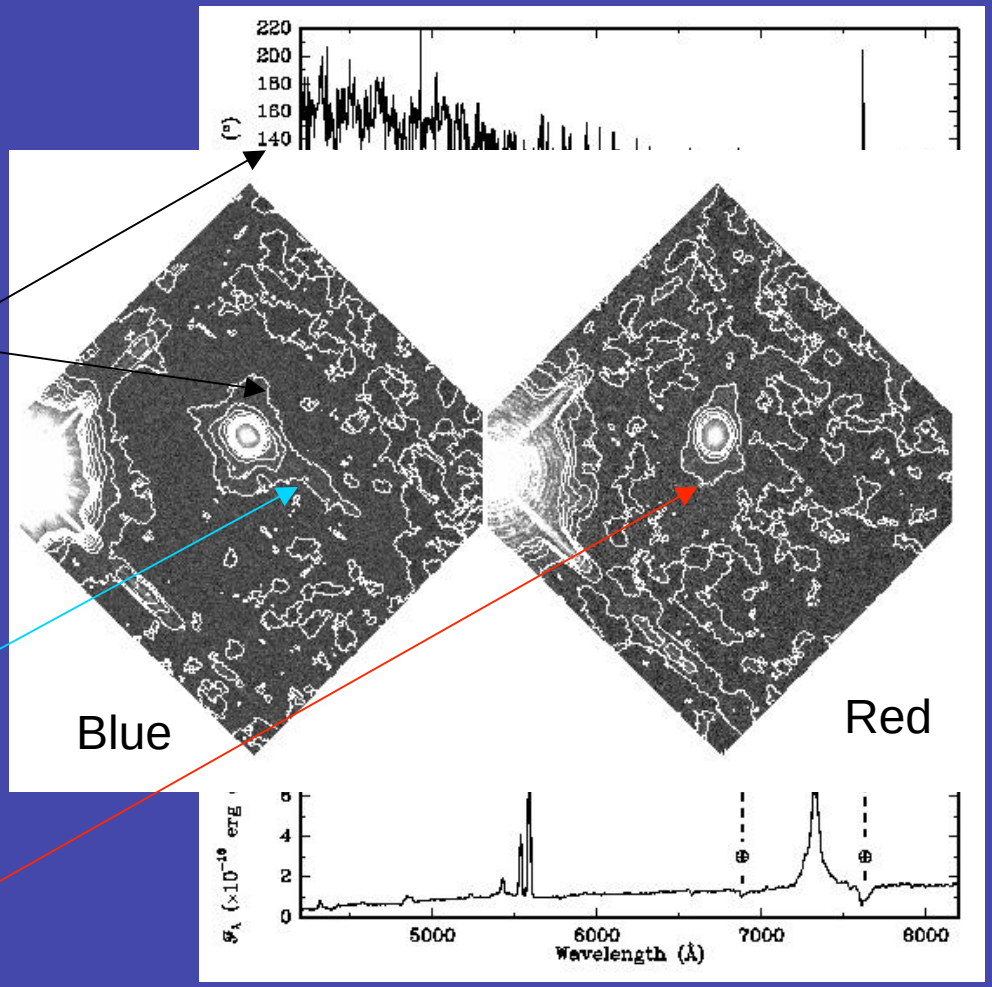
- **Multi-wavelength**
  - **3CRs, 1<z<2, peak of QSO**
  - **Spitzer, Chandra, Herschel OTKP (+ existing data)**
  - **Well-observed, bright, unbiased sample**

Chandra X-ray Center

A Particularly Complex Source: 2M1049+5837

Schmidt et al 2007

- Optical Type: 1.8
- X-ray hard (HR=0.6)
- 2 scattering regions:
  - Blue: thin, small dust grains
  - Red: dusty region, red due to obscuration
  - Starlight dilution
- HST imaging:
  - Blue fan
  - Red fringe (polar)



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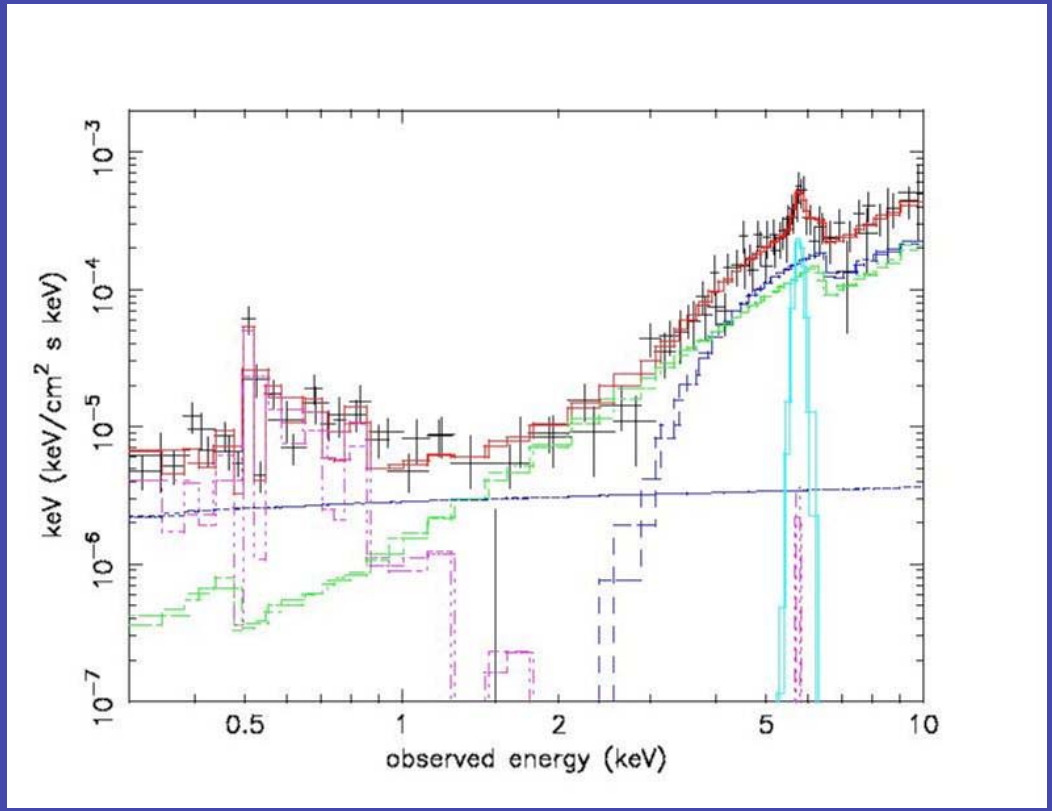
2M1049+5837 *(Schmidt et al 2007)*

- Suggest it is unusually dusty
- Dusty AGN rarely remain type 2 even when edge-on, due to scattered light
- X-rays confirm it is unusual

XMM-Newton Data

Wilkes, Pounds, Schmidt, in prep.

- Unusually hard 2-10 keV spectrum
- Requires:
  - **Compton-thick PL**
  - **Unabsorbed Cold Reflection**
  - Soft excess: warm ionized region
  - Scattered power law ~1.7%



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Testing AGN Unification

- Can all differences be explained in terms of orientation? ……. No
- What are other dependencies: L, $\dot{M}$?
- What is the role of dust, mergers and/or star-formation?
- Do we require any fundamental differences to understand the new AGN? …….not yet!