ON THE MISSING HEAVILY OBSCURED AGN POPULATION

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Introduction - I

X-rays are very effective in finding AGNs as they can penetrate large column densities

- detect AGNs up to high redshifts
- large number of obscured (Compton-thin) AGNs
- ~100% of the X-ray background resolved at E<5 keV
- only very few Compton-thick AGN

Why looking for heavily obscured AGN?

- AGNs are a phase in the evolution of BH and galaxies
- The majority of the accretion is obscured by large amount of dust and gas within the galaxies
- Possibly Compton-thick AGN are a different evolutionary phase → associated to major mergers

→ Tracing accretion at all z is essential to prove the evolution scenario
→ Understand the link between BH and galaxy
Some progresses… but still not enough

Also optical spectroscopy or MIR spectroscopy (e.g. Polletta et al 2006; Alexander et al 2008; Gilli et al 2010, and next talk; Vignali et al 2010)
Introduction - III

New techniques to find the most heavily obscured AGNs are needed.

Infrared band $\rightarrow$ peak of the dust emission

![Graph showing infrared and X-ray emission peaks](image-url)

**Infrared**

**X-ray**

Infrared band $\rightarrow$ peak of the dust emission
GOODS-Herschel

X-ray: *Chandra* GOODS-North 2Ms, 0.5-8 keV (Alexander et al. 2003)

Infrared: *Spitzer* 8, 16, 24 µm + *Herschel* PACS-100, 160 µm + SPIRE-250, 350, 500 µm (Elbaz et al. 2011)

Radio: deep VLA data (Morrison et al. 2010), $S_R>20$ uJy (1.4 GHz)

333 sources with z-spec or z-phot: $z=0.1-3.0$
AGN + host galaxy templates (Mullaney et al. 2011) → $\lambda = 6$–1000 um (MIR-FIR)

Starburst templates extended to 3 um (Dale et al. 2001) and to radio band ($f_\nu = \nu^{-0.7}$)
Application: Radio-excess AGN

✦ FIR/radio relation for SB galaxies $q \approx 2.2$

✦ 64 radio-excess sources ($q < 1.68$; 19%)
  previous study on the GOODS-N field (Donley et al. 2005), but used $f_{24\mu m}$ as proxy for FIR ➔ significant limitations

✦ IR AGN significantly detected in 42% of the radio-excess sample (only 20% in the “radio normal” sources)
■ 47% of the radio-excess sources are detected in X-rays

■ Their fraction increases with X-ray luminosity

■ Correlation between X-ray and radio luminosity (Merloni et al. 2003; Falcke et al. 2004)

■ Probably heterogeneous mix of sources
IR properties of the sources

- Some sources are dominated by stellar emission → “dead” galaxies

- These could be low accretion rate type systems (e.g. RIAFs, ADAFs)
Heterogeneous population

- X-ray and IR AGN: 33%
- IR AGN, X-ray undet: 9%
- IR undet AGN: 45%
- Low accretion rate: 13%
X-ray and IR AGNs: how many may be C-thick?

- The majority of the X-ray AGNs follow the local $L_{6\mu m}$-$L_X$ relation (Lutz et al. 2004)
- At $L_{6\mu m} > 10^{43}$ erg/s, ~50% are Compton-thin and ~50% are Compton-thick AGN candidates
- Of the C-thick candidates, 50% are X-ray detected and 50% are undetected
CONCLUSIONS

- Detailed mid-far-IR SED analysis of 333 VLA/GOODS-Herschel sources
- 19% have excess of radio emission, indicating the presence of a hidden AGN
- Only 47% of the radio excess-sources are detected in X-rays
- The fraction of radio-excess AGN increases with X-ray luminosity → relation between radio and X-ray power
- Heterogeneous population → X-ray AGN, Compton-thick AGN, but also low accretion rate sources (e.g. RIAF, ADAF)
- The fraction of Compton-thick AGN candidates is ~25-50% at \( L_{6\mu m} > 10^{43} \text{ erg/s} \) (intrinsic \( L_X > 4 \times 10^{42} \text{ erg/s} \))