A UV/X-ray Census of Compact Groups of Galaxies: *Chandra* and *Swift*

SWIFT

CHANDRA
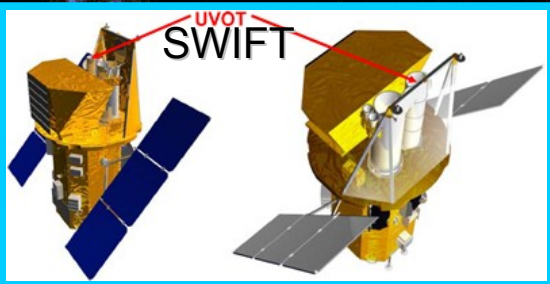
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Galaxies live together!

- CGs are a special category of poor groups where most galaxies are in the nearby Universe
    - Hickson 1982:
        - $\Delta mag_{max}=3$ for ≥ 4 galaxies
        - $\mu < 26$ } 100 HCGs
        - empty annulus
        - *Hickson 1997 ARAA: "...small, relatively isolated systems of typically four or five galaxies in close proximity to one another"*

Compact groups are highly interacting!

- **Environment**
  - galaxies within a few radii of each other
  - low σ (100's km/s)
  - high n_{gal} (10^8 / Mpc^2)
  - short t_{cross} (1/10 × Hubble time)

→ Multiple interactions

- *How does this affect AGN and SF activity?*
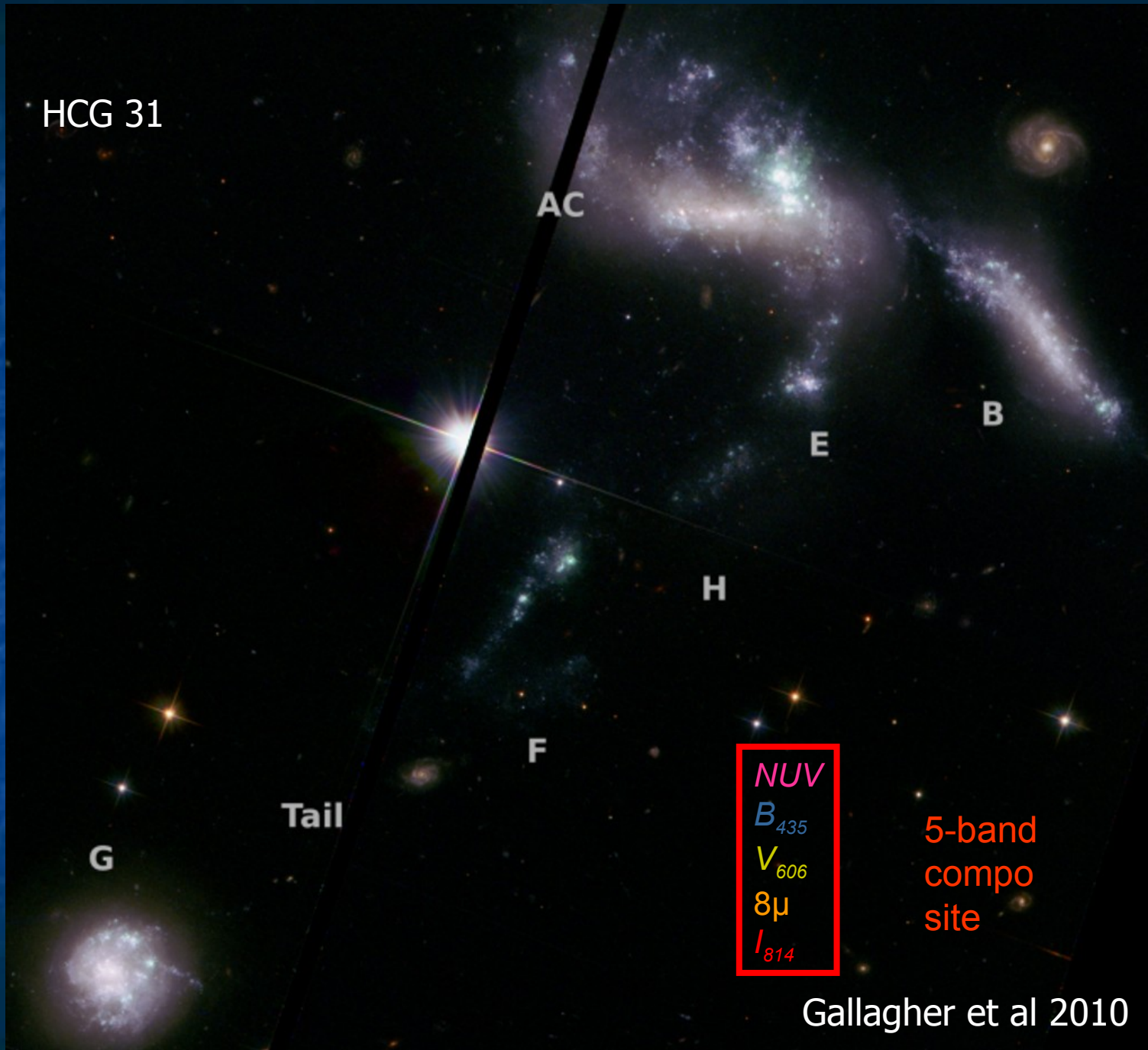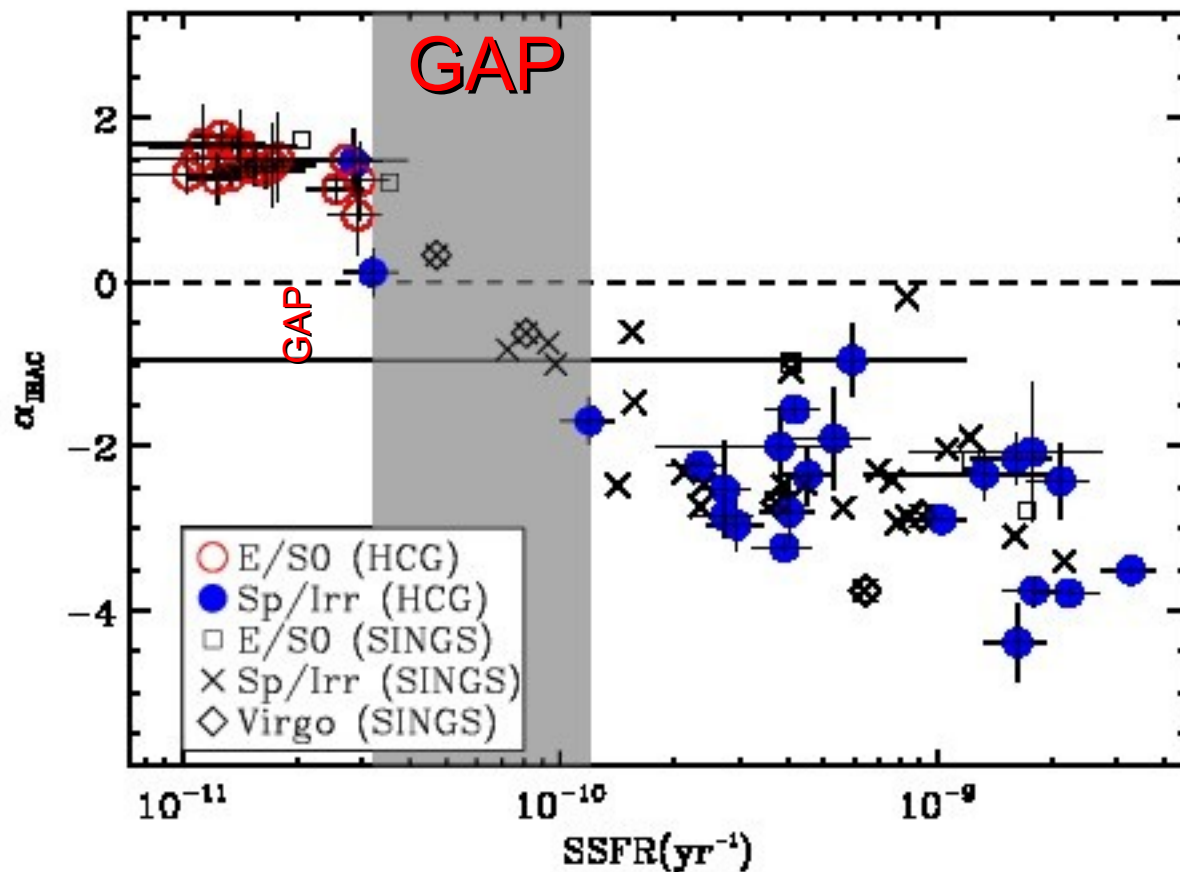
HCG 31

AC

B

E

H

F

Tail

G

NUV
B_{435}
V_{606}
8μ
I_{814}

5-band
compo
site

Gallagher et al 2010

Rapid Transformations in CG environment
SSFR bimodality

Morphology

Tzanavaris et al 2010 ApJ
Gallagher et al 2008 ApJ
Johnson et al 2007 ApJ

No Luminous AGN in the CG Environment; optical – HI results

- Optical AGN classification:
  - Martínez et al. 2010   280 galaxies, 64 HCGs: 23% AGN but low Hα luminosity
  - Coziol et al 2004, 1998   67 CG galaxies, AGN low luminosity and preferentially found in E/S0s
- Lack of AGN fuel: CGs HI deficient as a class (Verdes-Montenegro et al 2001)

Measuring AGN and SF activity in HCG nuclei

- Explore properties of CGs using diagnostics complementary to those used so far
- X-ray regime: powerful tools for AGN *and* SF activity
  - Higher contrast between nuclear BH and surrounding galaxy
    - Optical:
      - Dilution by starlight
      - obscuration
  - luminous AGN identified if $L_x > 10^{42}$ erg/s
  - SF: LMXBs (E-types) HMXBs (L-types)

# Quantitative nuclear AGN and SF diagnostics

- X-ray loudness $\equiv$ X-ray – to "optical" spectral index $\equiv \alpha_{OX}$

  $$\equiv 0.380 \log (L_{v,\, 2\, keV} / L_{v,\, 2600\, Å}) \quad \text{Tananbaum et al 1979}$$

- SSFR = (SFR_{UV} + SFR_{IR}) / M_*

  - *Swift* UVOT, *Spitzer* MIPS, 2MASS *Ks*

- optical AGN – SF classification: Martínez et al. 2010

  - BPT (1981) diagrams, Veilleux & Osterbrock (1987), Kauffmann et al (2003), Kewley et al (2001)

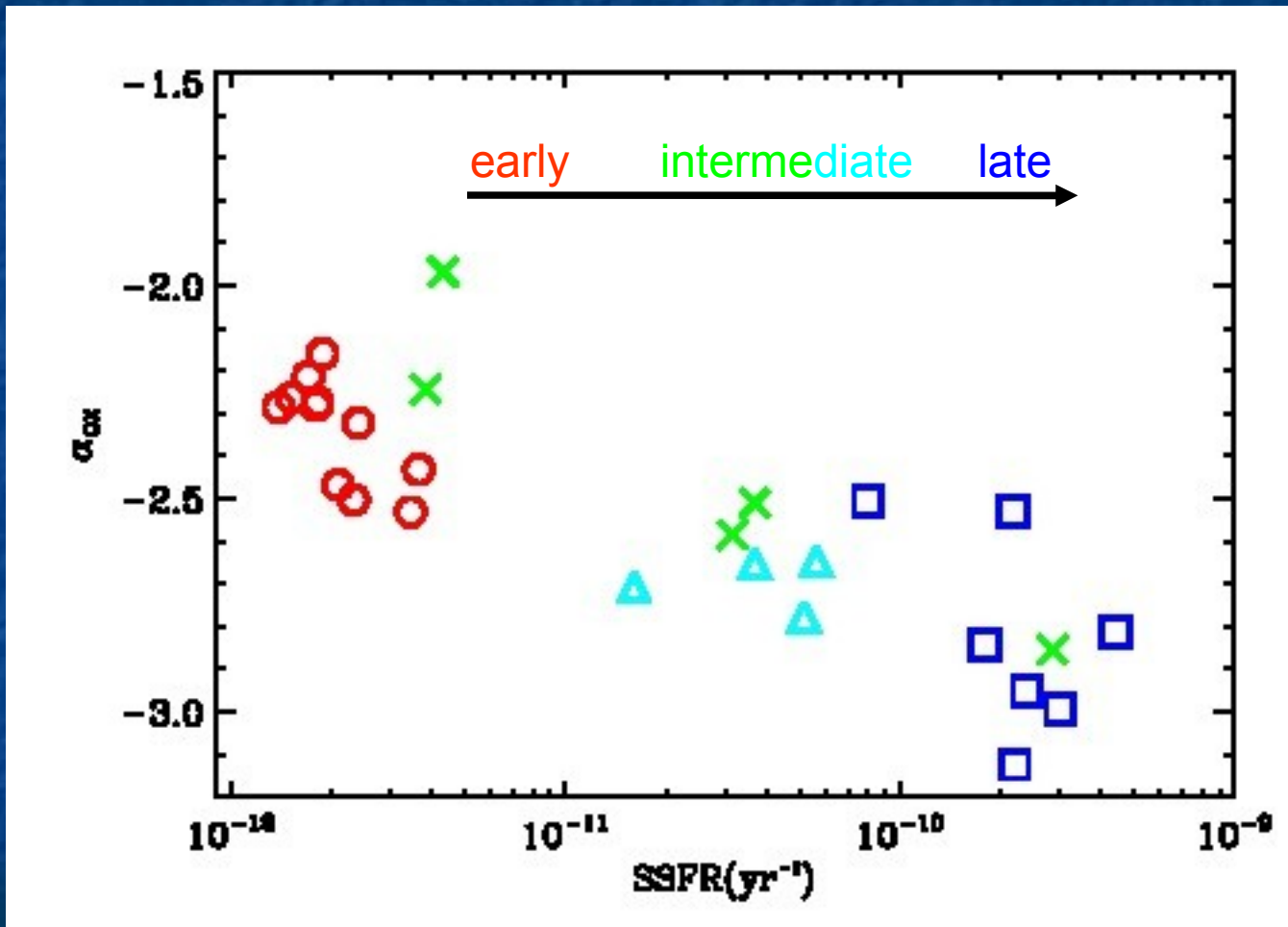# X-ray/UV flux ratio correlates with L_{UV} for strong AGN
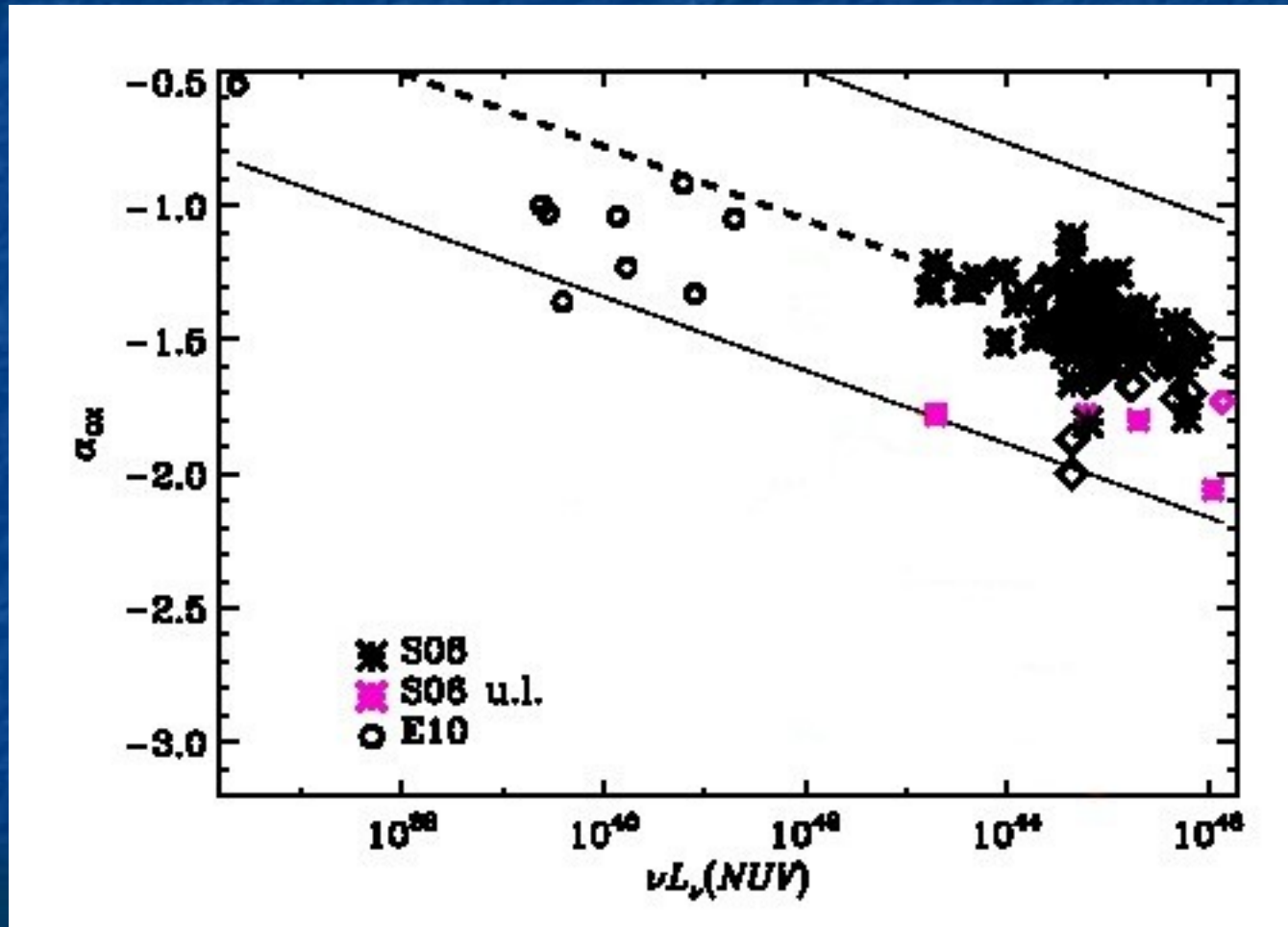
Steffen et al 2006
Eracleous et al 2010

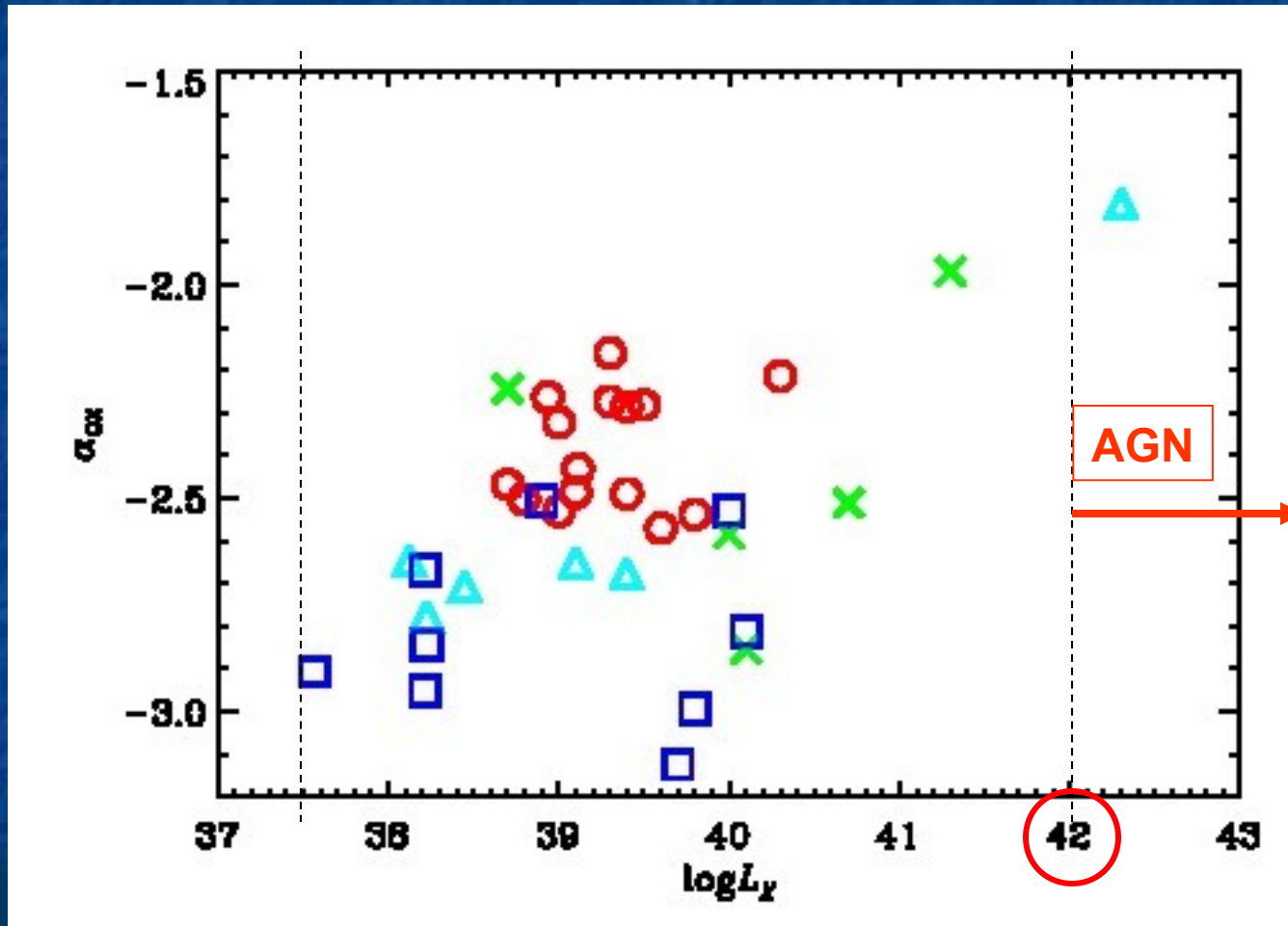# X-ray/UV flux ratio correlates with L_{UV} for strong AGN
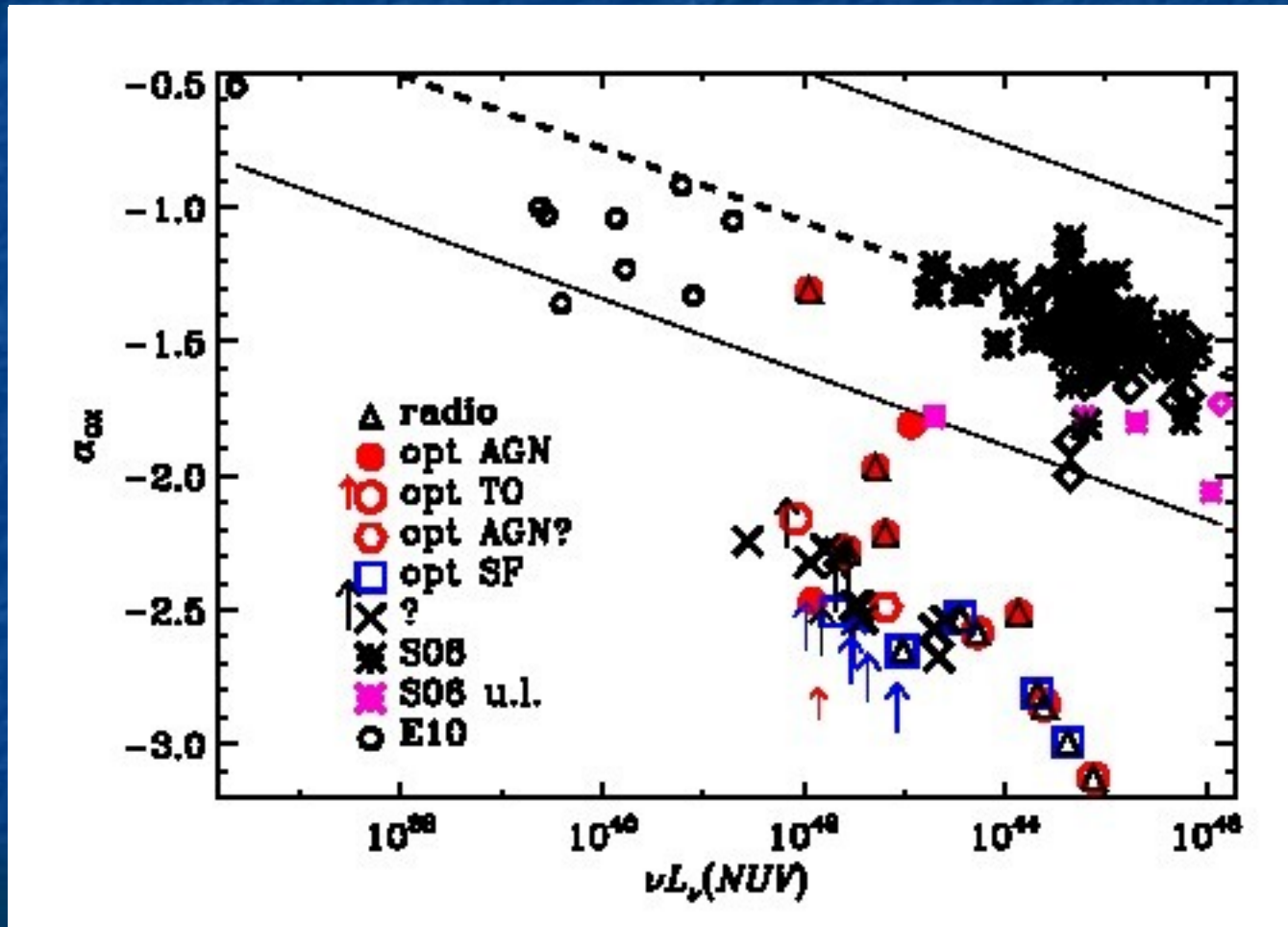
Tzanavaris et al 2012
(in prep)

AGN activity anticorrelates with SSFR

Most HCG nuclei have *low* X-ray luminosities
SF and LLAGN dominate

Summary of Results

- Main result: *No strong AGN in CGs* *

  - * except when they *are* strong!

- α_{OX} discriminates SF – AGN:

  - α_{OX} more +ve ≡ less SF – close to correlation ≡ earlier types and less H I

  - α_{OX} more -ve ≡ more SF – away from correlation ≡ later types and more H I

- L_X does *not* discriminate as strongly : LLAGN – SF

- Stay tuned! 380 ks *Swift* UVOT data – PI Tzanavaris