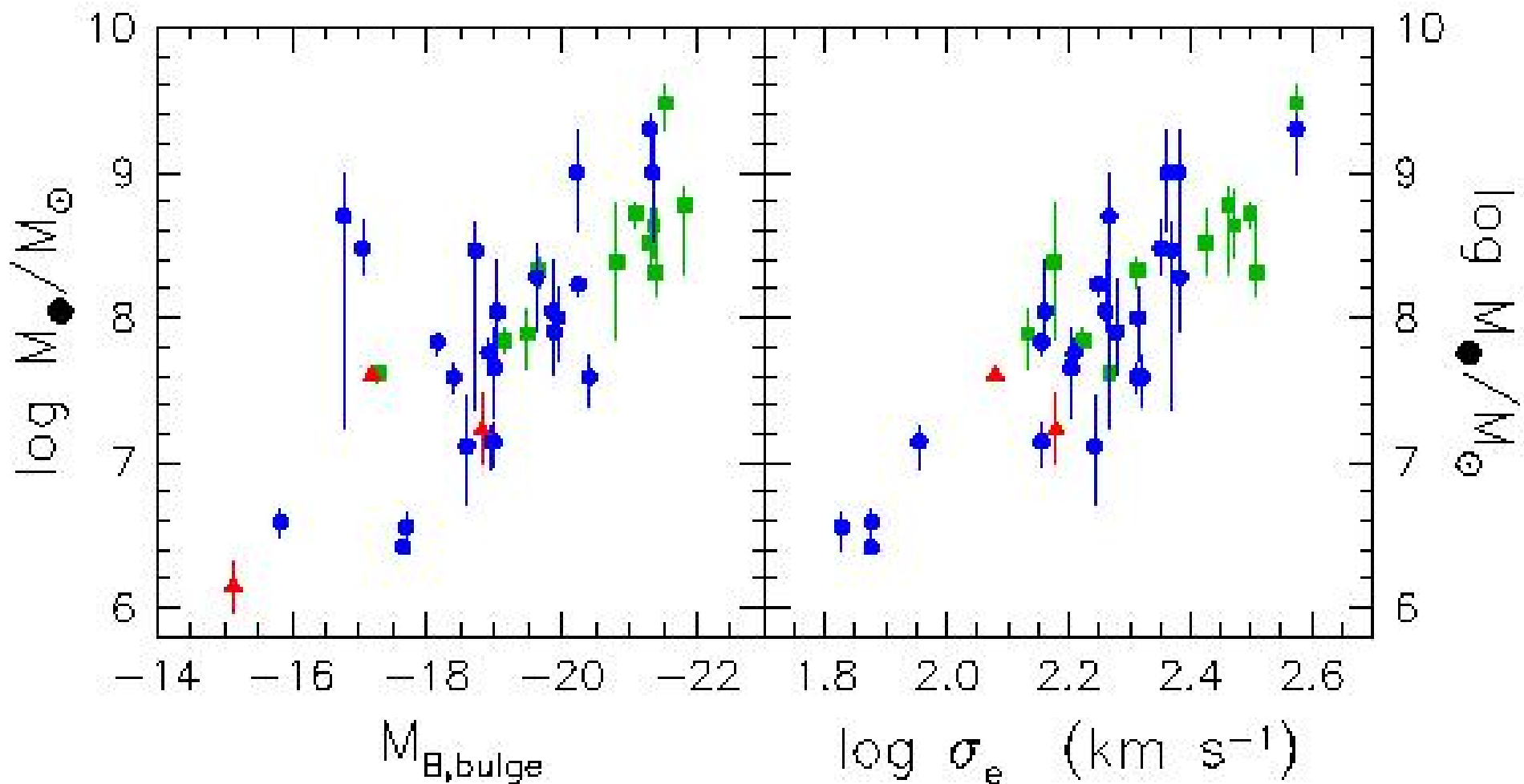


Observations of Stellar Processes in Active Galaxies

Nancy A. Levenson

University of Kentucky

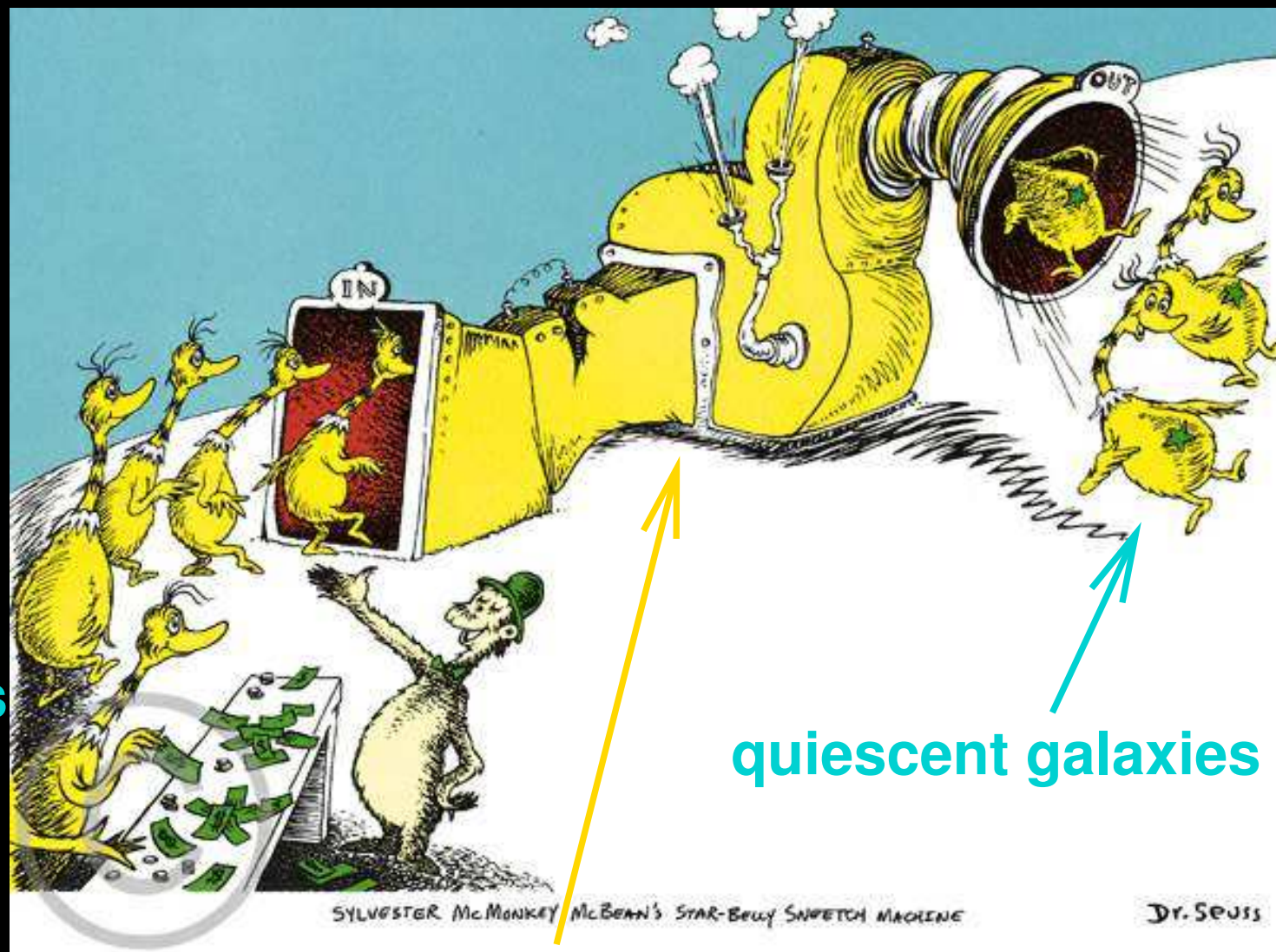
Motivation: Stars and Black Holes



(Kormendy 2003)

Motivation: Stars and Black Holes

protogalaxies



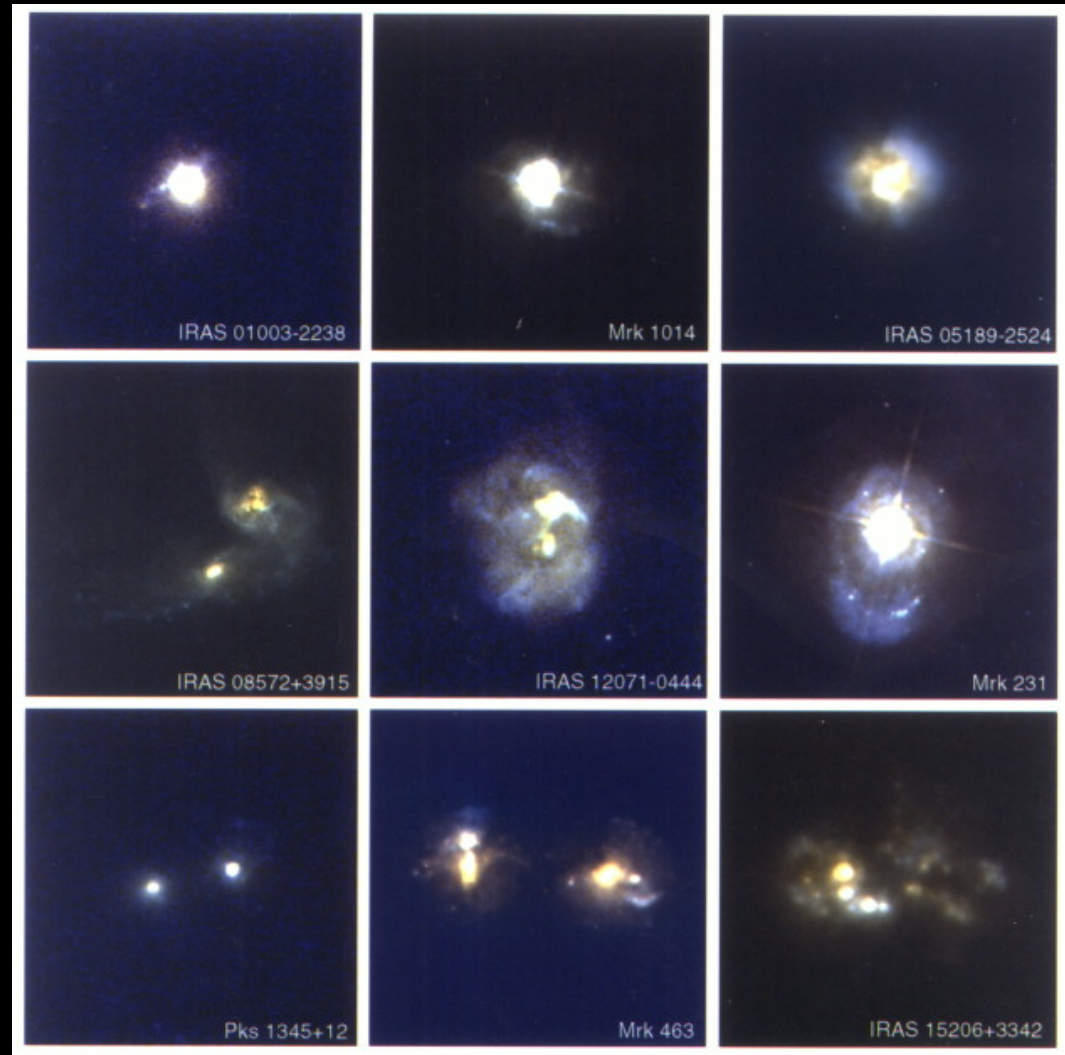
quiescent galaxies

**Sylvester McMonkey McBean's
star-bulge black hole machine**

(Geisel 1961)

Motivation: Ultra-Luminous Infrared Galaxies

- Dust emission
- What powers ULIRGs?
- Evolutionary models



(Surace et al. 1997)

Stars and AGNs

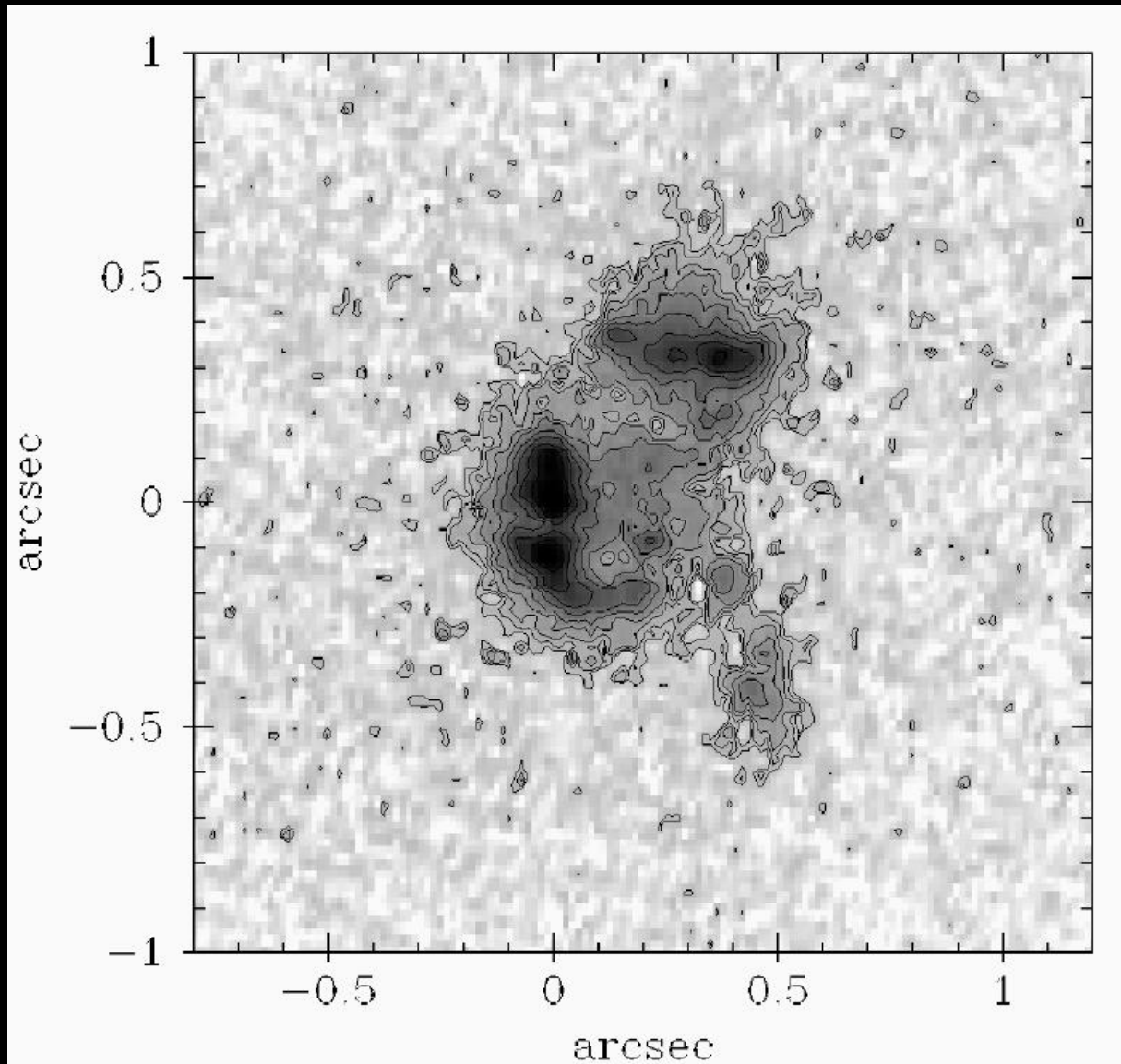
- Star formation may yield timescales
- Star formation is energetically significant
- Star formation contaminates AGN observations
- Emphasize young stars

Evidence for Star Formation

Historic arguments: black hole vs. star formation

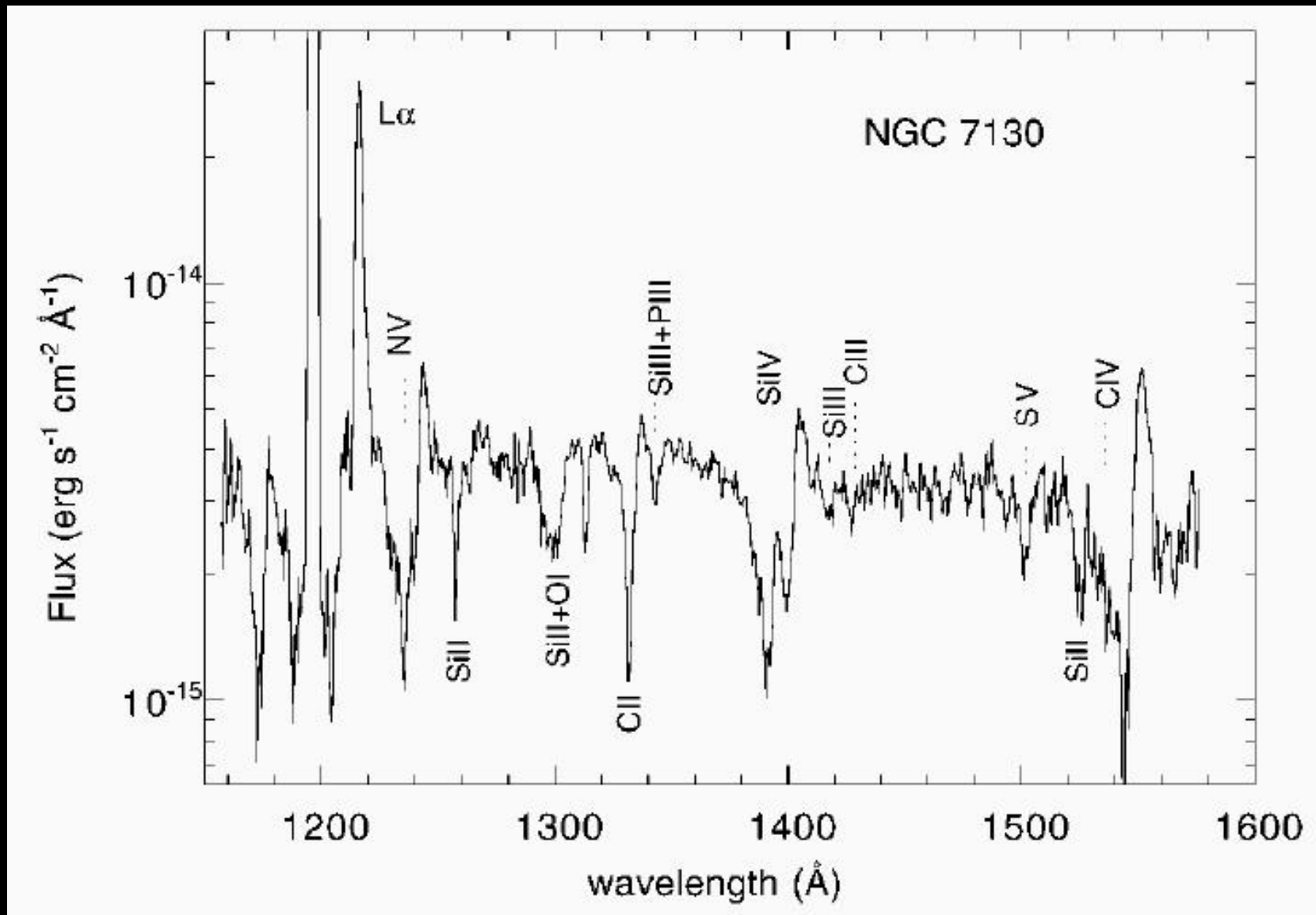
- energy from stars
- supernovae (for broad lines)
- “featureless blue continuum”

UV Imaging



(NGC 7130; Gonzalez Delgado et al. 1998)

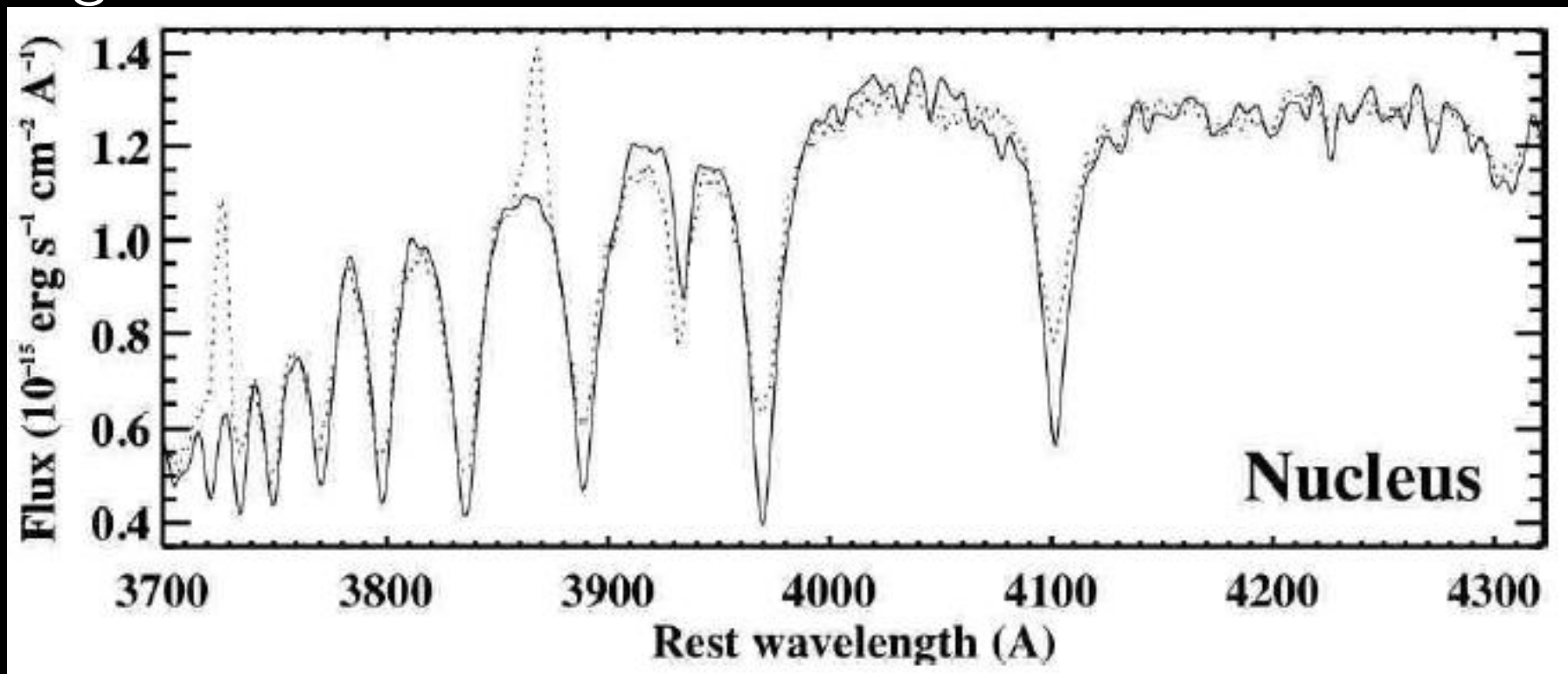
UV Spectroscopy



(Gonzalez Delgado et al. 1998)

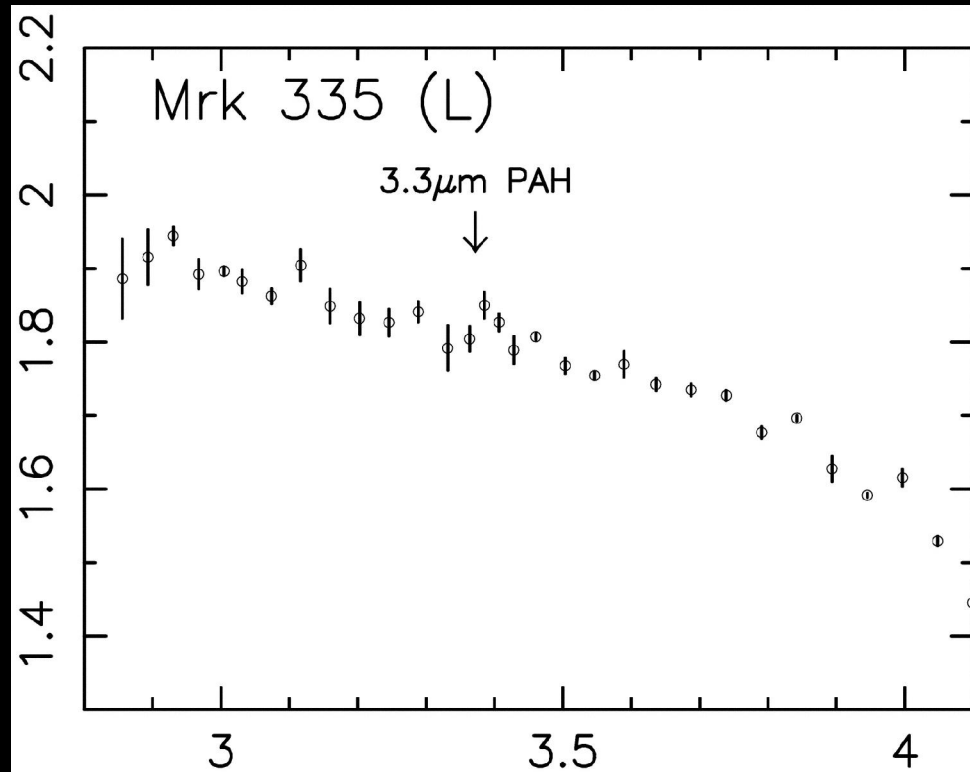
Optical Indicators

- Wolf-Rayet features
- [O II] emission
- Ca II triplet
- 4000Å break
- higher-order Balmer lines



Mid-IR PAHs

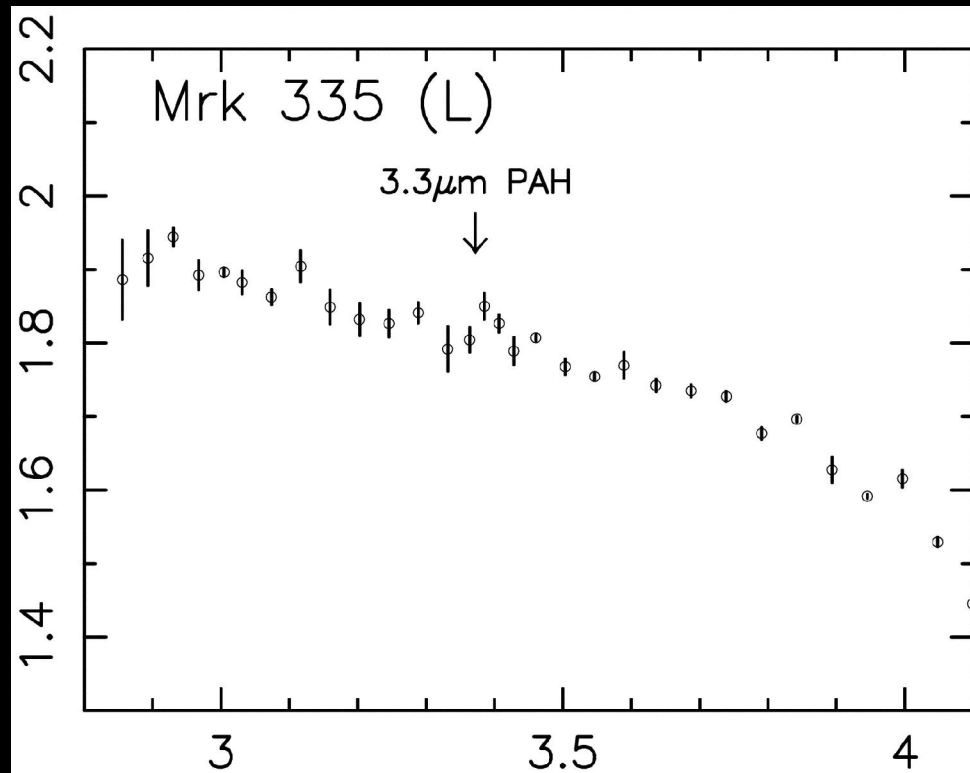
- PAHs are associated with star formation



(Imanishi and Wada 2004)

Mid-IR PAHs

- PAHs are associated with star formation



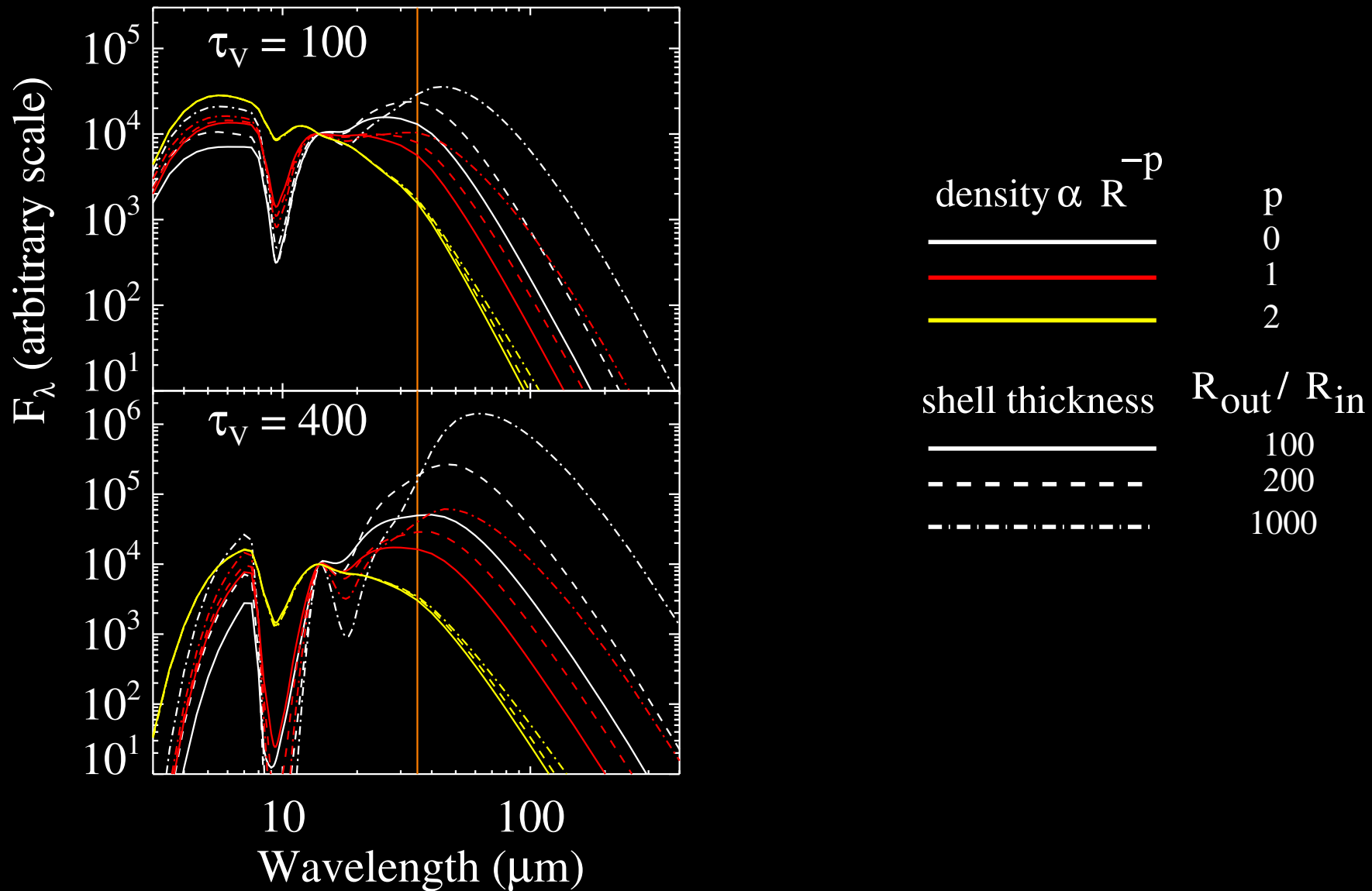
(Imanishi and Wada 2004)

- But PAHs may be absent despite starburst

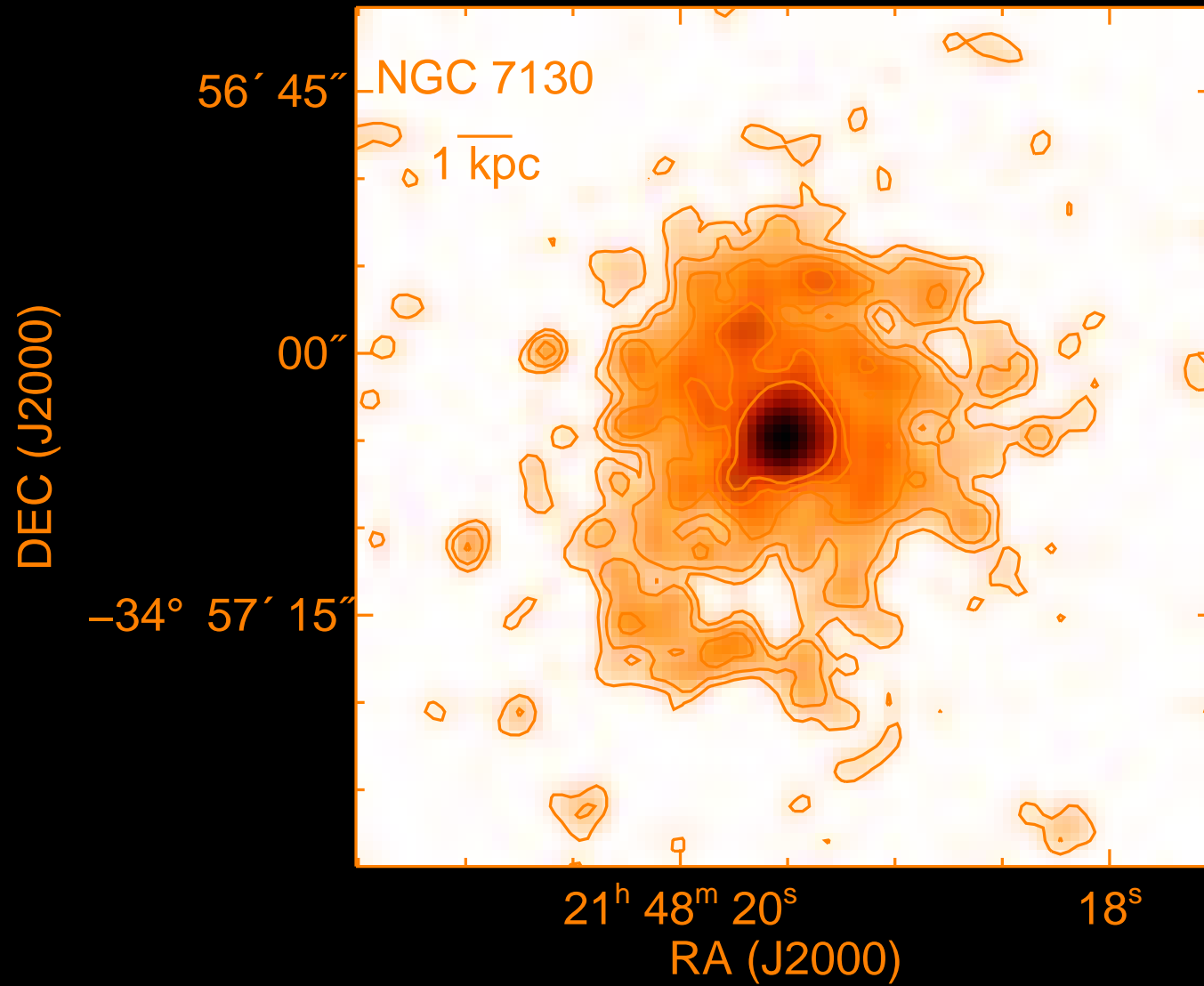
(Mason et al. 2006)

Far-IR

- Geometry, not source, determines FIR spectrum

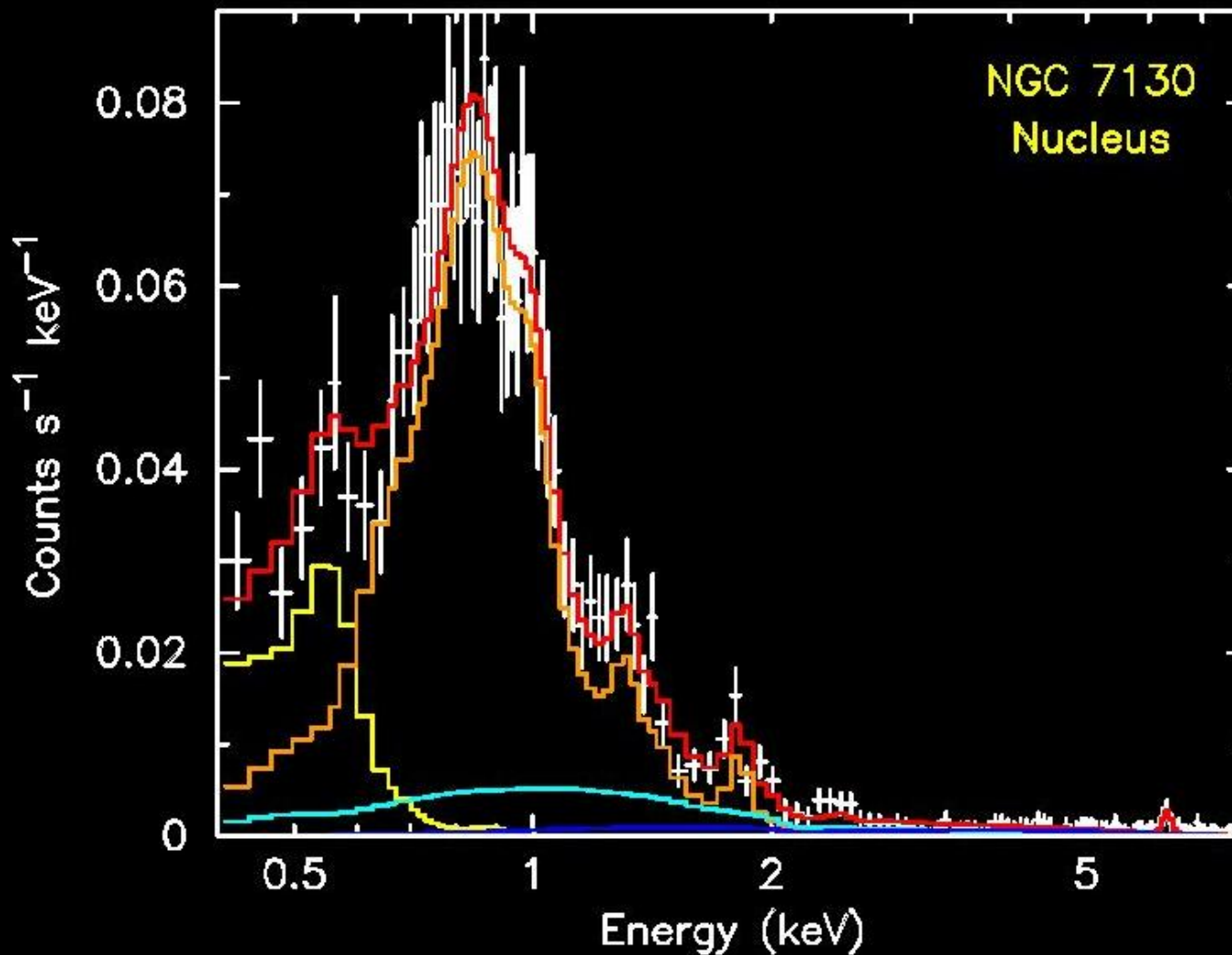


X-ray



(Levenson et al. 2005)

X-ray



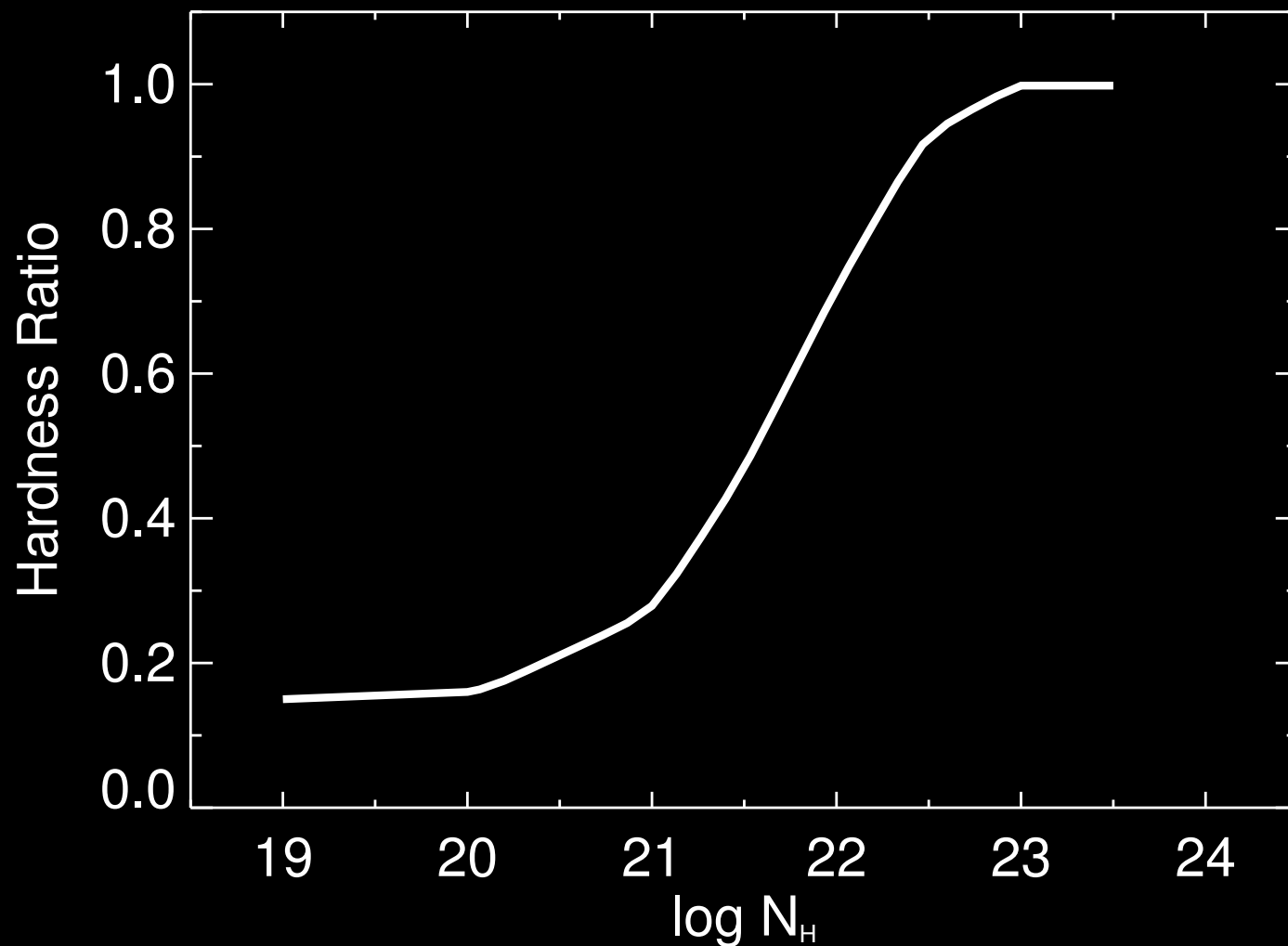
Two thermal components: $kT = 0.1, 0.6$ keV

Additional continuum

characteristic of unresolved X-ray binaries

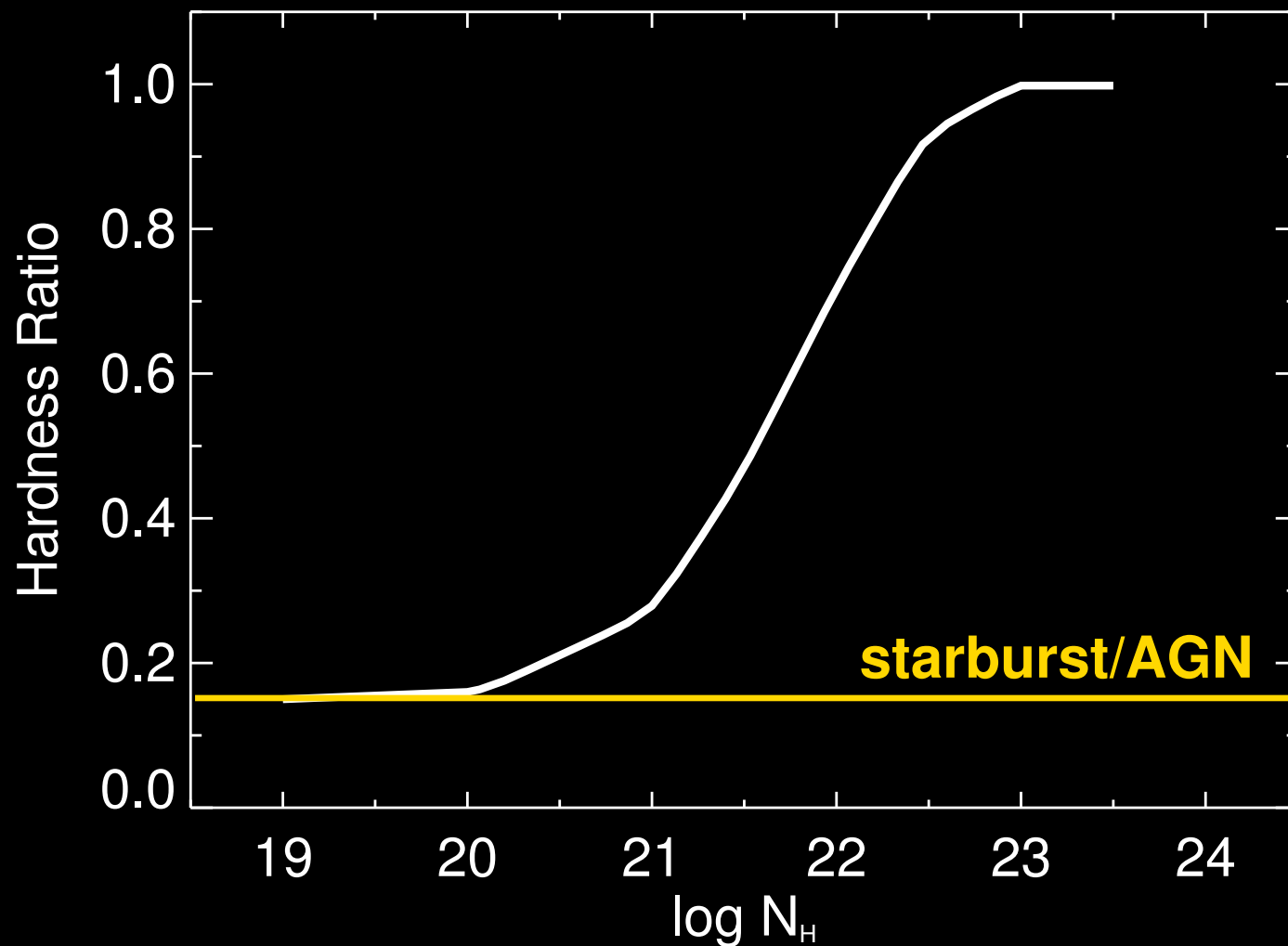
X-ray

- Star formation contaminates hardness ratio

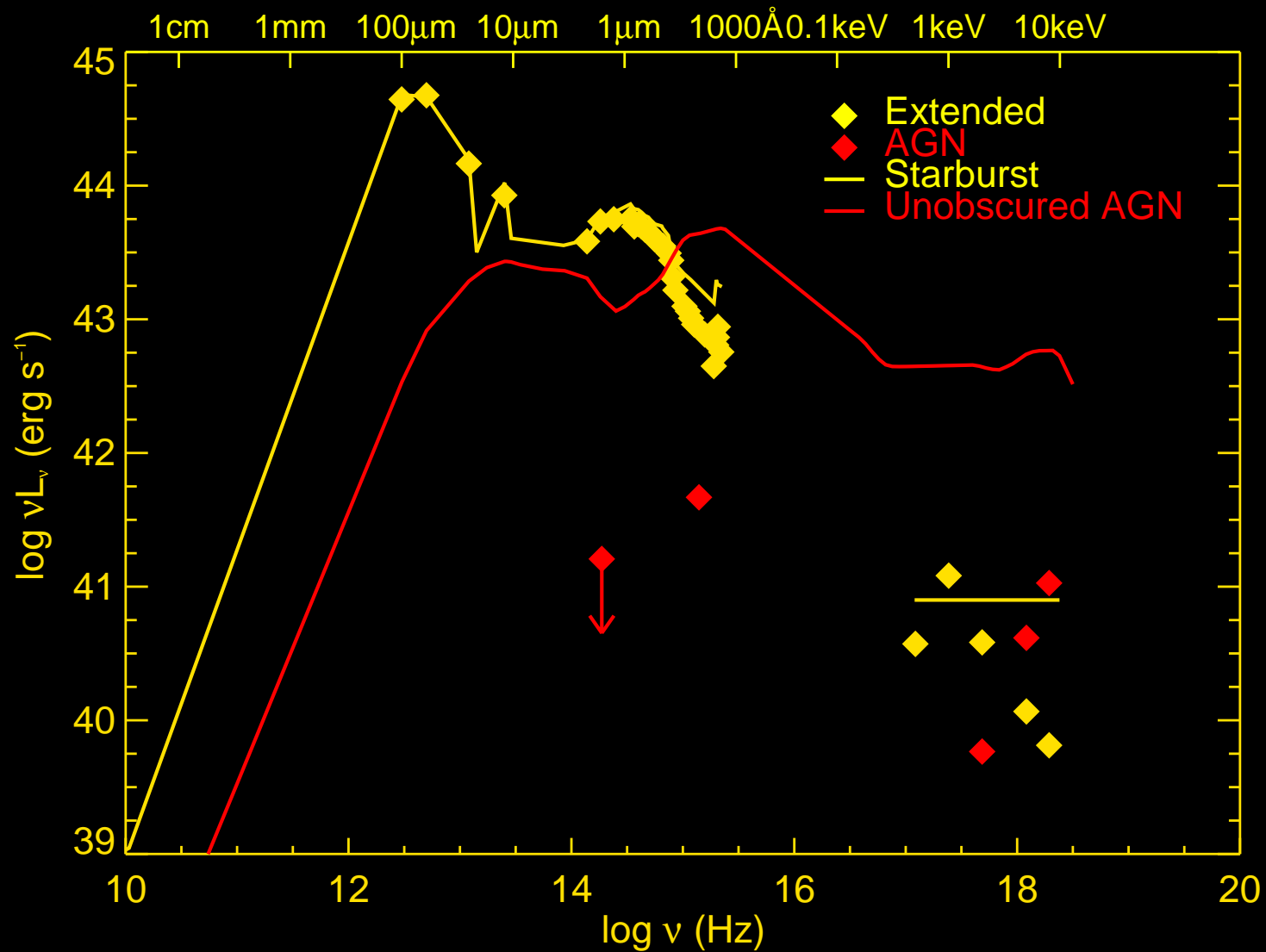


X-ray

- Star formation contaminates hardness ratio



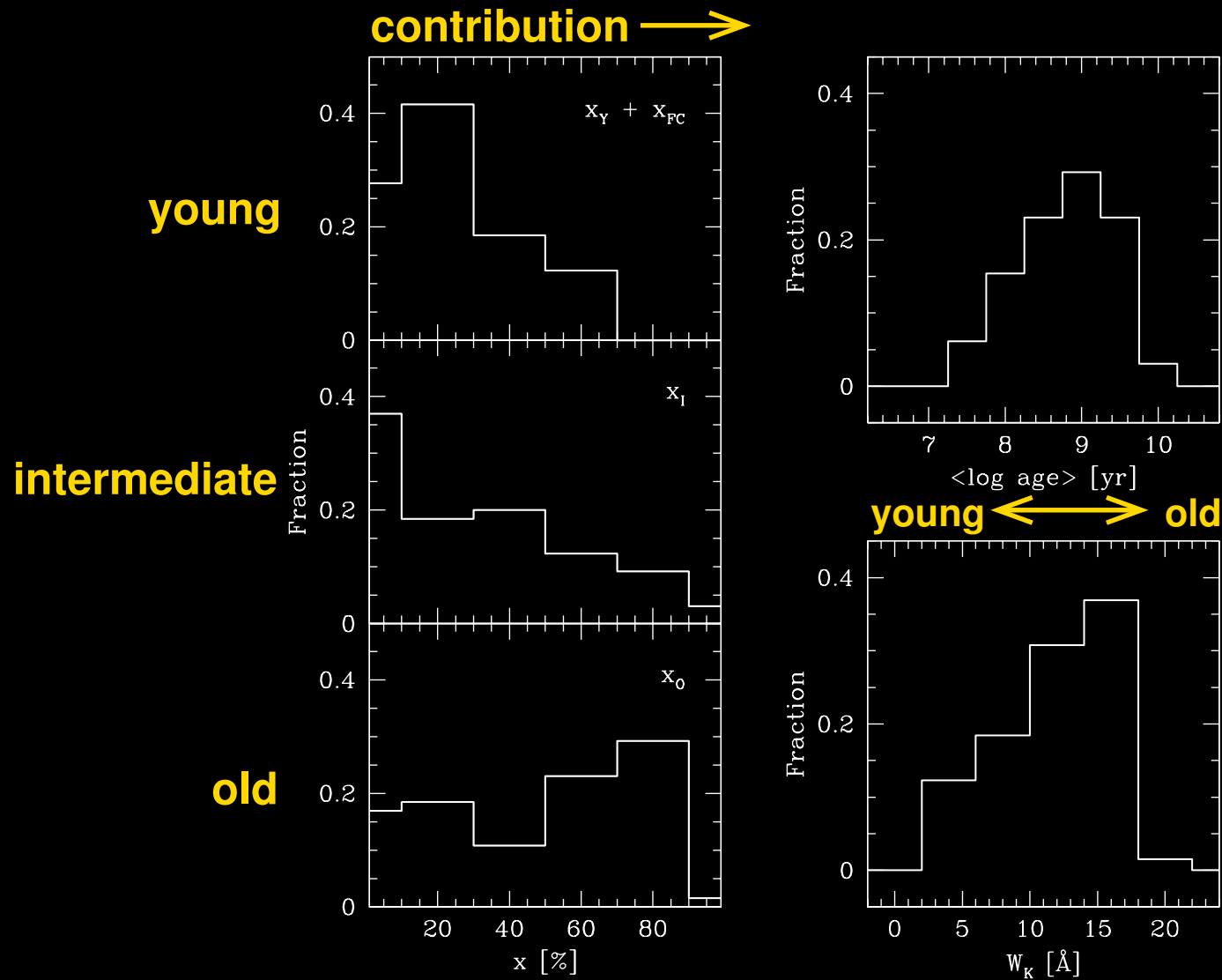
Stellar Contributions



NGC 7130

(Levenson et al. 2005)

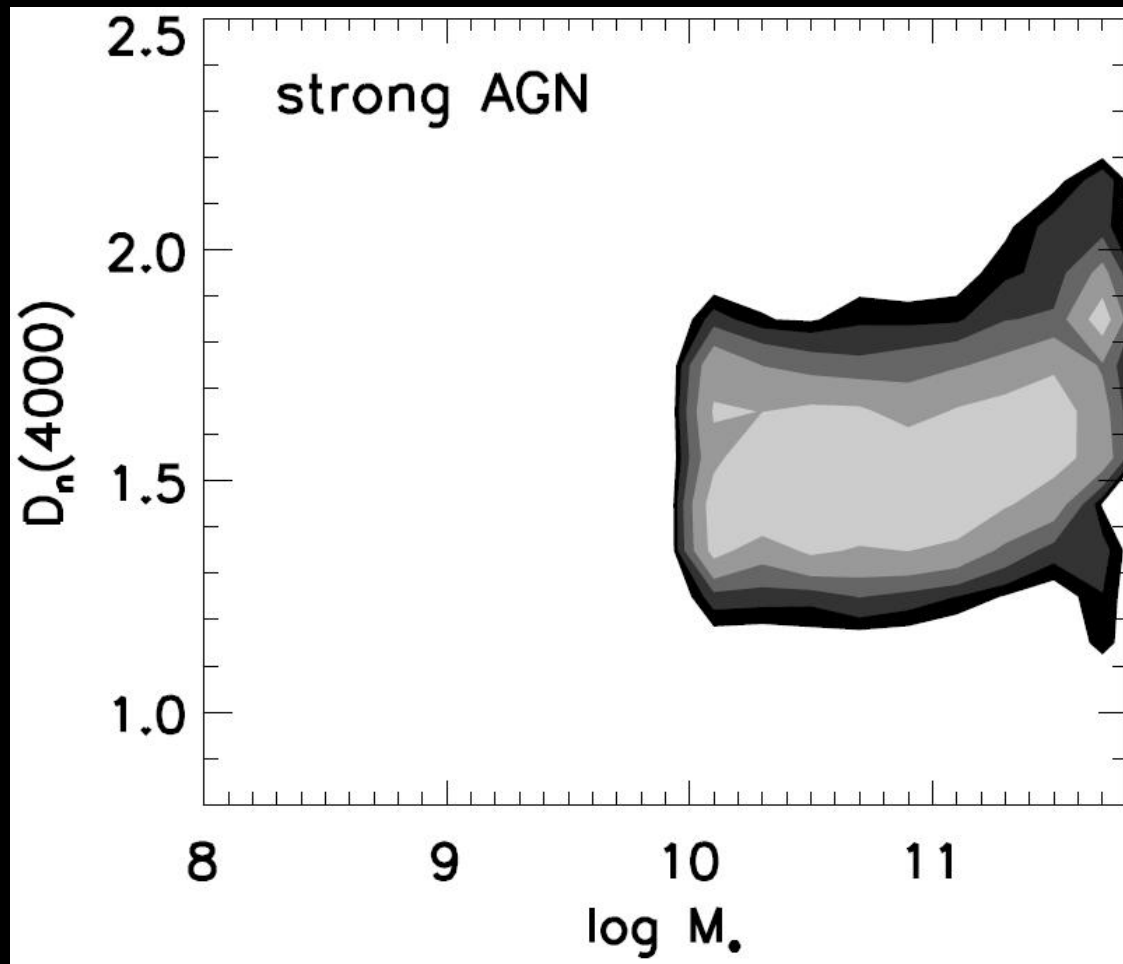
Star Formation in AGNs – Surveys



(Cid Fernandes et al. 2004)

- Young populations in 1/3 – 1/2 of Seyfert 2s

Star Formation in AGNs – Surveys



(Kauffmann et al. 2003)

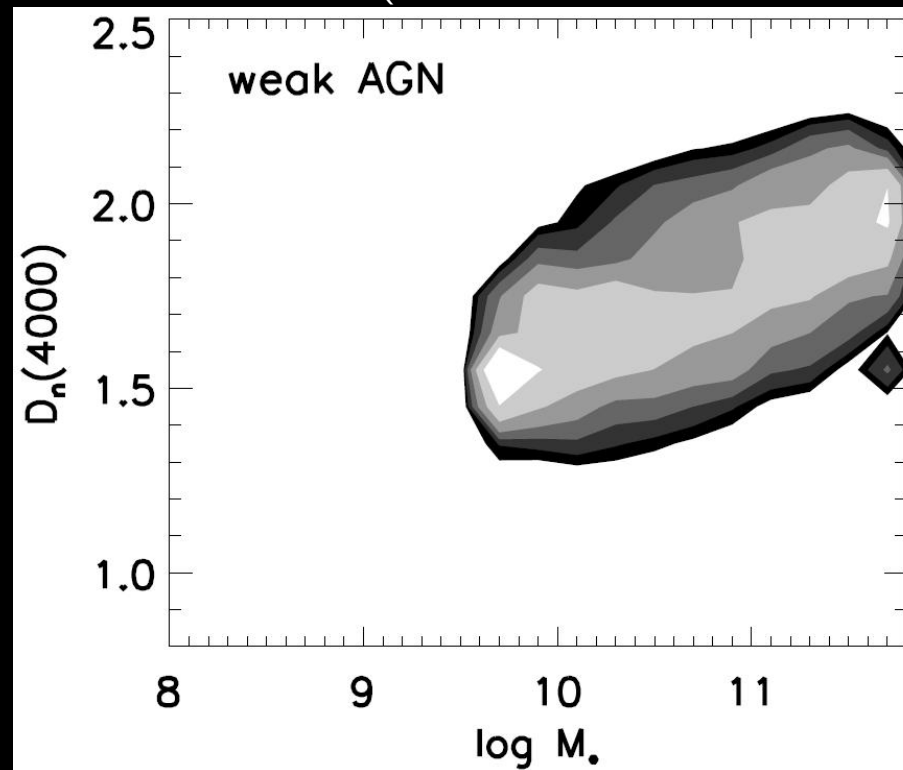
- Recent ($t < 1$ Gyr) bursts of star formation are common in AGN hosts
- Similar stellar light in comparable broad-line AGNs

Star Formation in AGNs – Caveats

- Trends with luminosity

older stellar populations in lower-luminosity AGNs
and LINERs

(Kauffmann et al. 2003, Cid Fernandes et al. 2004)



less star formation in very high luminosity AGN

(Ho 2005)

Conclusions and Future Prospects

- Star formation is often evident and energetically significant in moderate-luminosity AGNs
- Star formation contaminates AGN measurements
- Future: confirm results at extreme AGN luminosity
- Future: quantify ULIRG energy sources
- Future: test evolutionary predictions