What impact does AGN activity have on star formation?

Or: "How can we disentangle two things we don't fully understand…"

Not exhaustive! (It's late!)

For, fence sitters, and against

- "Strong"

Shimizu, Dubois, Saintonge, Kocevski

- Hmm…

Hickox, Azadi, Juneau ("it's complicated"), Lamassa, Alonso-Herro, Lehnert ("may or may not")

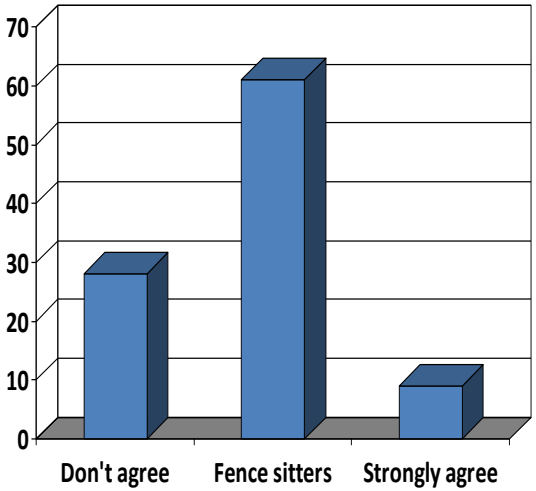
- "Not that much"

Gabor, Roos

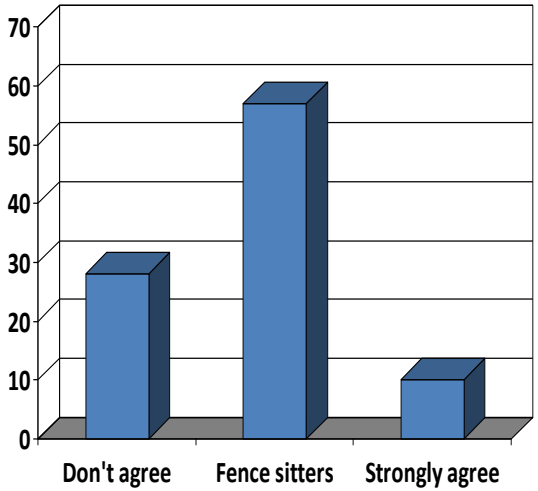
Results

- Do radio quiet AGN drive gas?
- Do radio quiet AGN prevent cooling?
- Do radio quiet AGN compress gas?

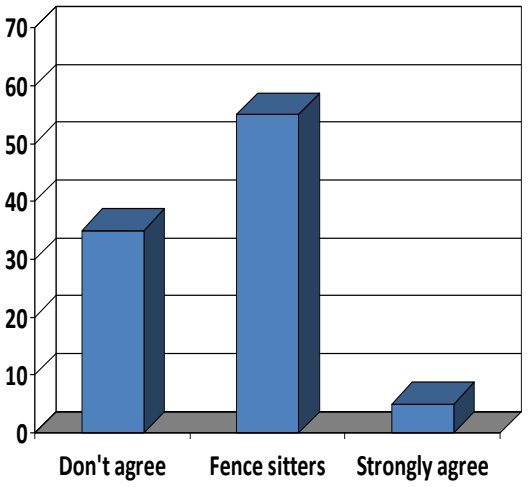
Drive



Prevent cooling



Compress Gas



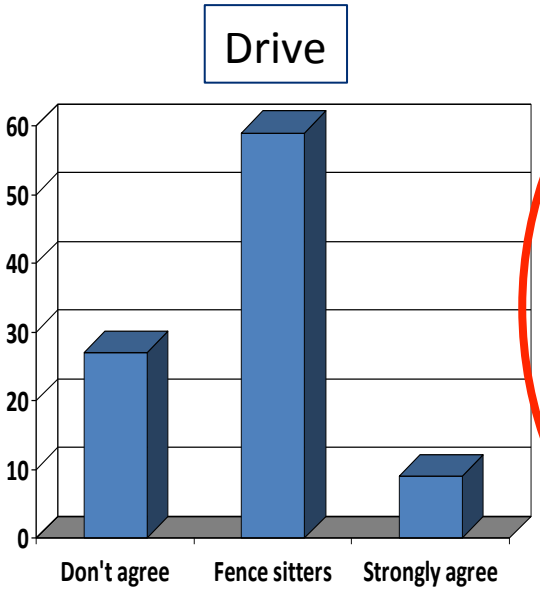
Statistically equivalent – but majority of presentations non-commital

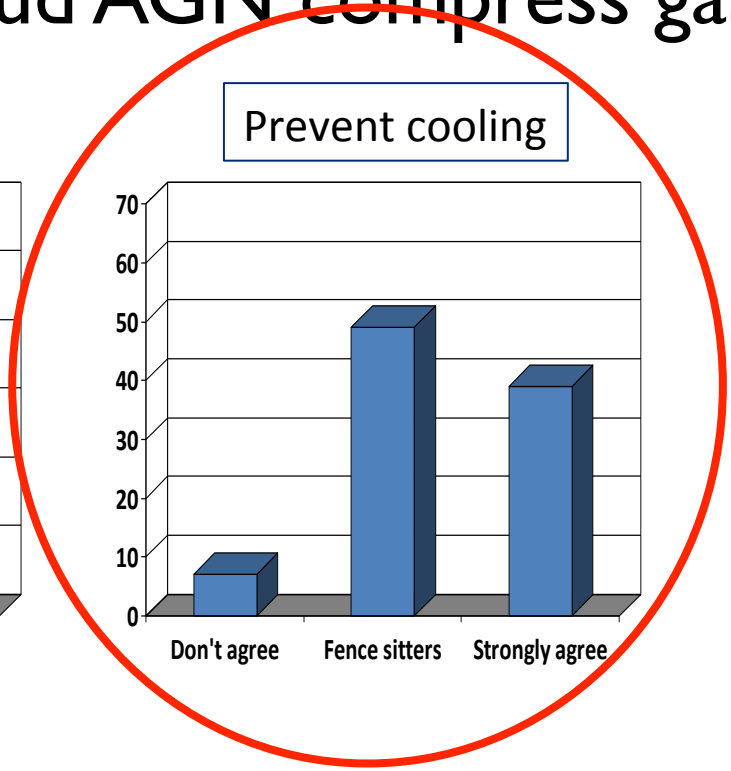
Do radio quiet AGN drive gas?

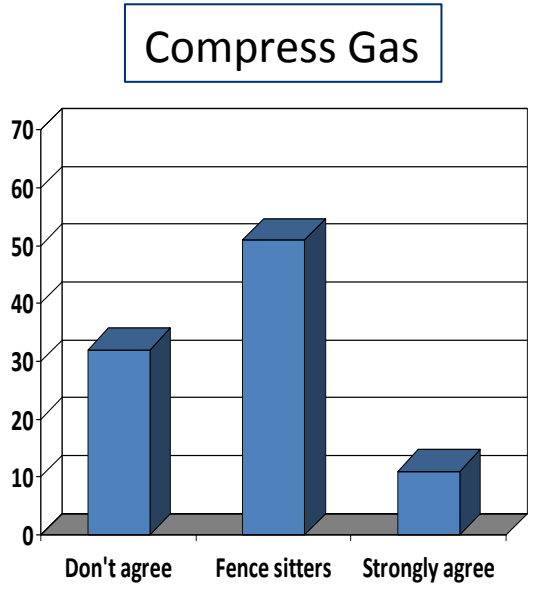
A. Don't agree
B. Agree

Results

- Do radio loud AGN drive gas?
- Do radio loud AGN prevent cooling?
- Do radio loud AGN compress gas?



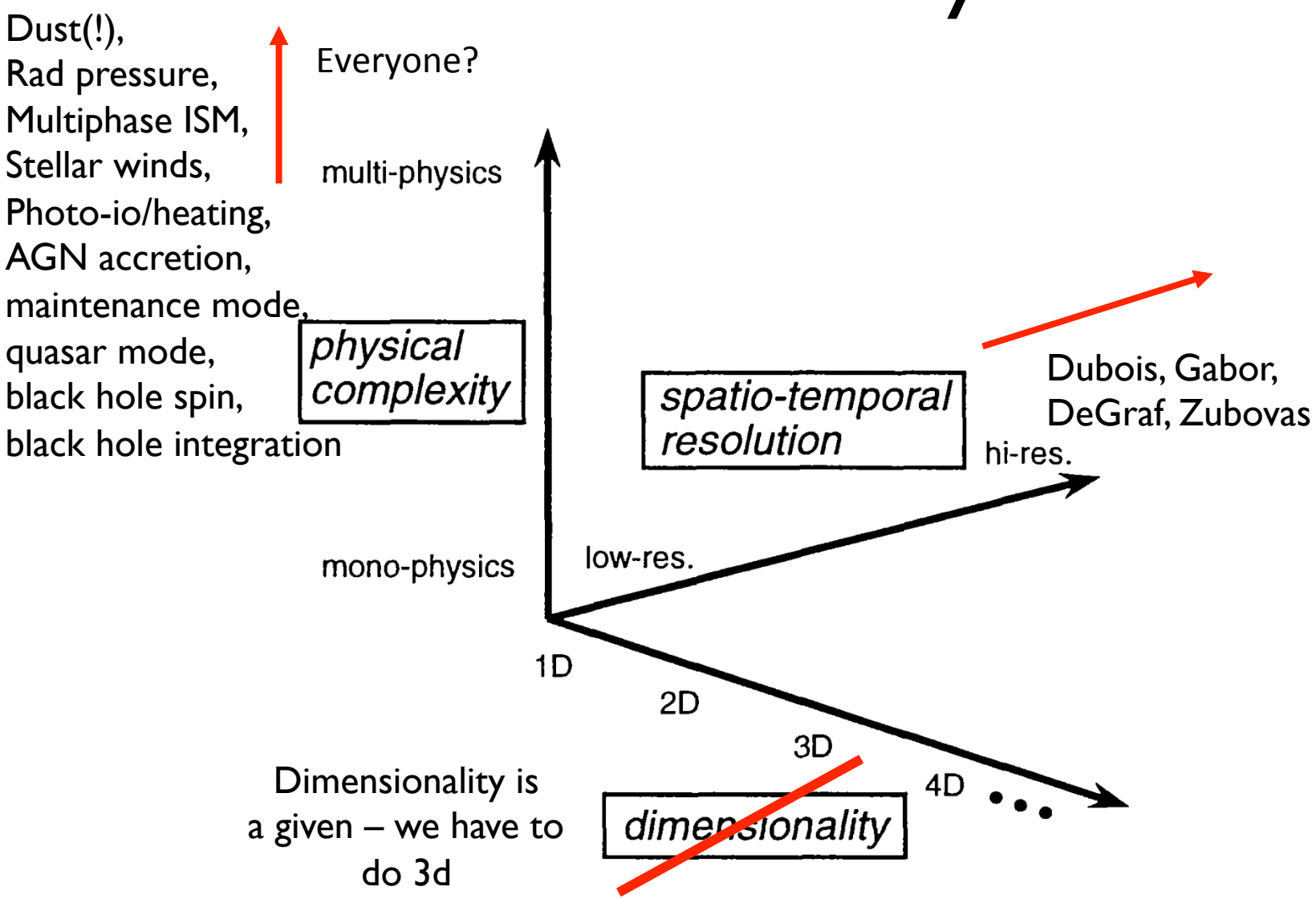




Do radio quiet AGN prevent cooling?

A. Don't agree
B. Agree

Model fidelity



Credit: Mike Norman

Resolution

- "As much as you can get" – fine, but often need statistics
- Inevitable that some scale is missed
  - At kpc scale – high z evolution is "spotty"
  - At 100 pc scale, still don't resolve down to Bondi radius or GMCs
  - Is 10 pc good enough?
- How much does the "last pc" problem matter to the development of the whole galaxy?

Influence of AGN

Towards GR models

AMR model resolution

EAGLE resolution

10^{-1} pc

10^{1-3} pc

10^{3-4} pc

[M/H] and $\vec{B}$

Self-reg & Eddington limiting

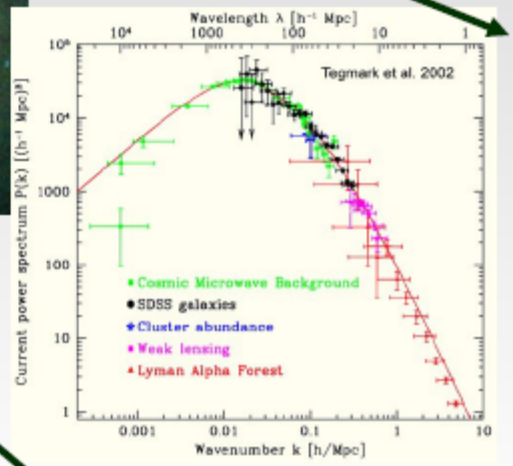
M_{BH}-σ & mass disposal

10^{4-6} pc

Regulate ISM Galaxy formation

10^{6-8} pc

Heat halo & cluster gas



LSS

Dynamical evolution of galaxy centers & star-clusters

Matt Lehnert

If you can only choose one…

A. More/better physics in models
B. More/better resolution in models

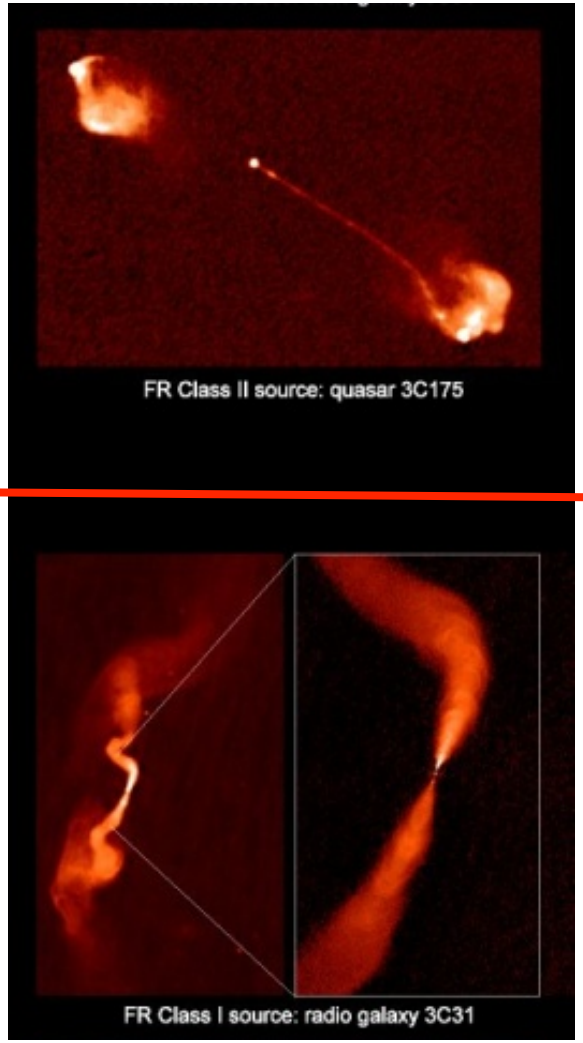
AGN Feedback - how to make it "better"?

- How should we implement it?
  - Schaye & collaborators: turn up the temperature to avoid energy being radiated away
    - AGN feedback temperature at $10^{8.5}$ K (~30 keV)
    - High enough on cooling curve not lose energy immediately
    - No wind/jet distinction
  - Gabor, Roos, Dubois, Zubovas: "Need the resolution"
  - DeGraf "Fix lower resolution accretion issues"

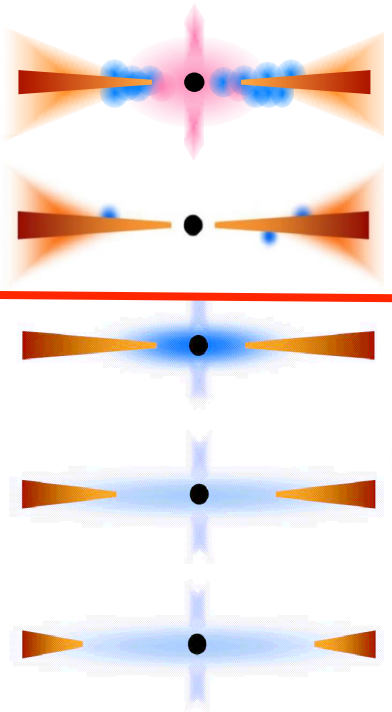
Getting more sophisticated

- What about more sophisticated implementations?
  - How can we incorporate FR-I & FR-II?

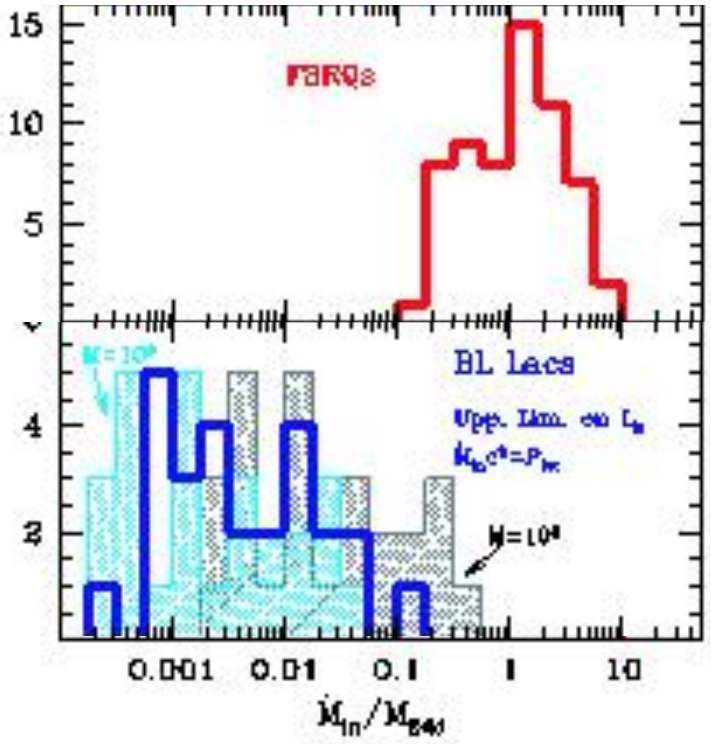
FRI is top of ADAF branch (low/hard state BHB) but Γ=15!



FRII/FSRQ



FRI/BL Lacs



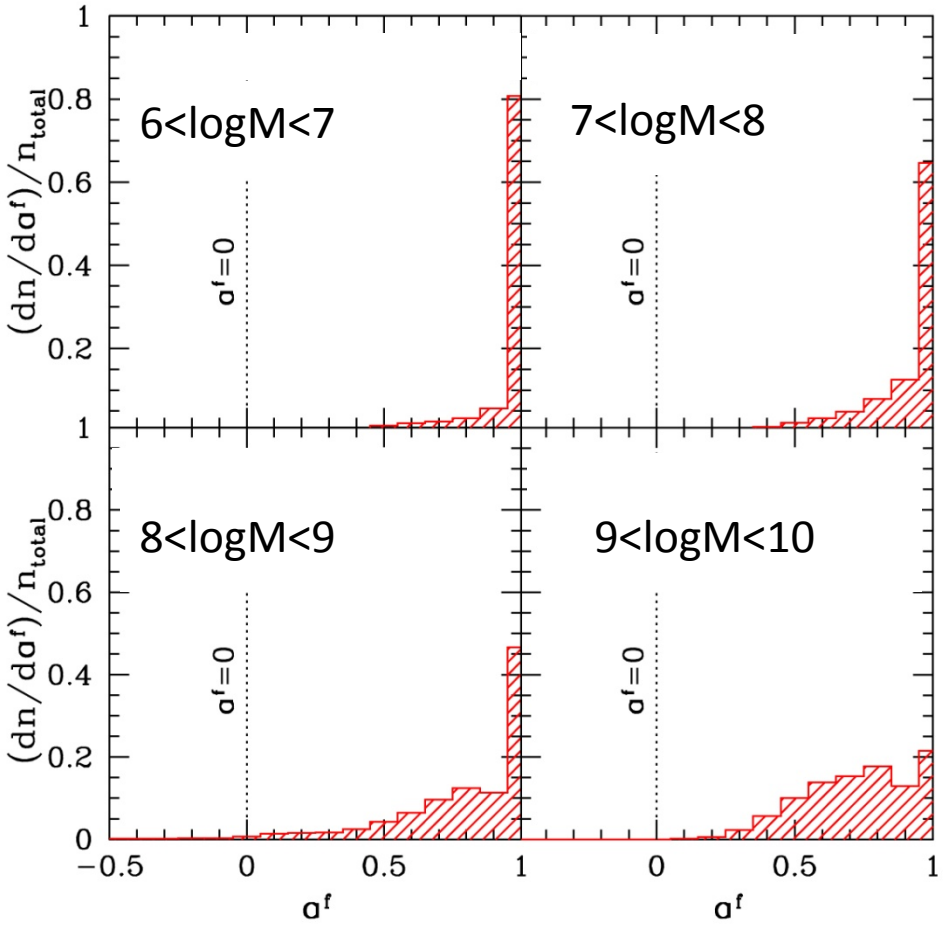
Ghisellini et al 2010

What about spin?

- c.f. Dubois talk
- Radiative efficiency increases by ~6 from Scharzwschild to maximal spin (a=0.998)
- Is it "impossible" to make statements about accretion at R_s?
  - Chaotic? (e.g. King & Pringle 2006) Would keep spins low and allow rapid growth
- And what about jets removing spin?

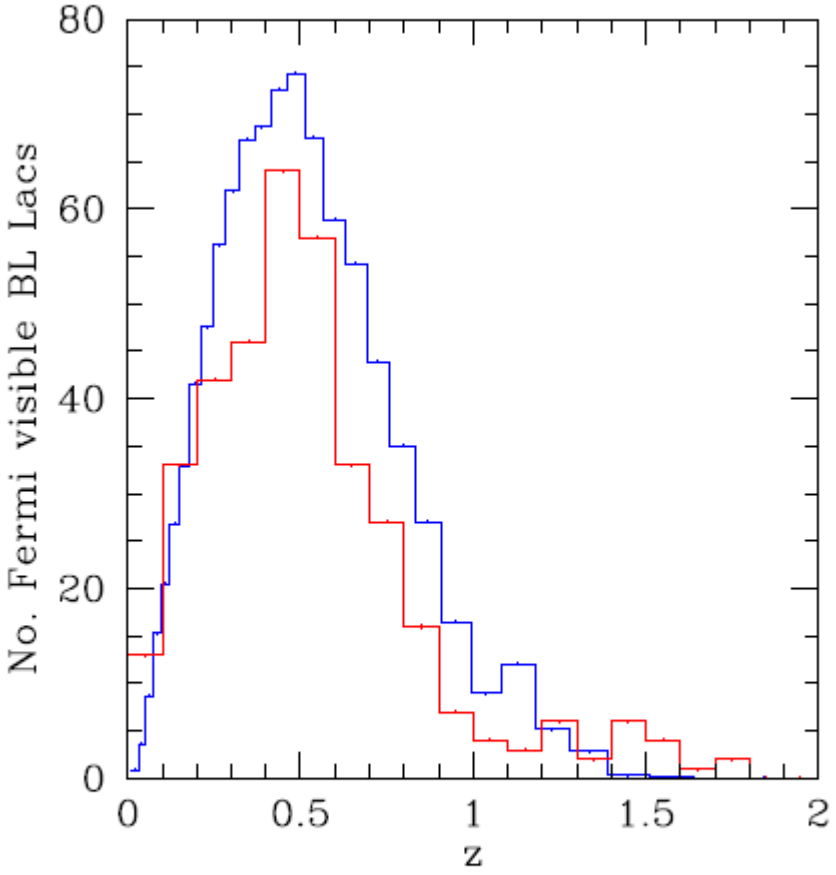
1000x more Fermi BL Lacs!!

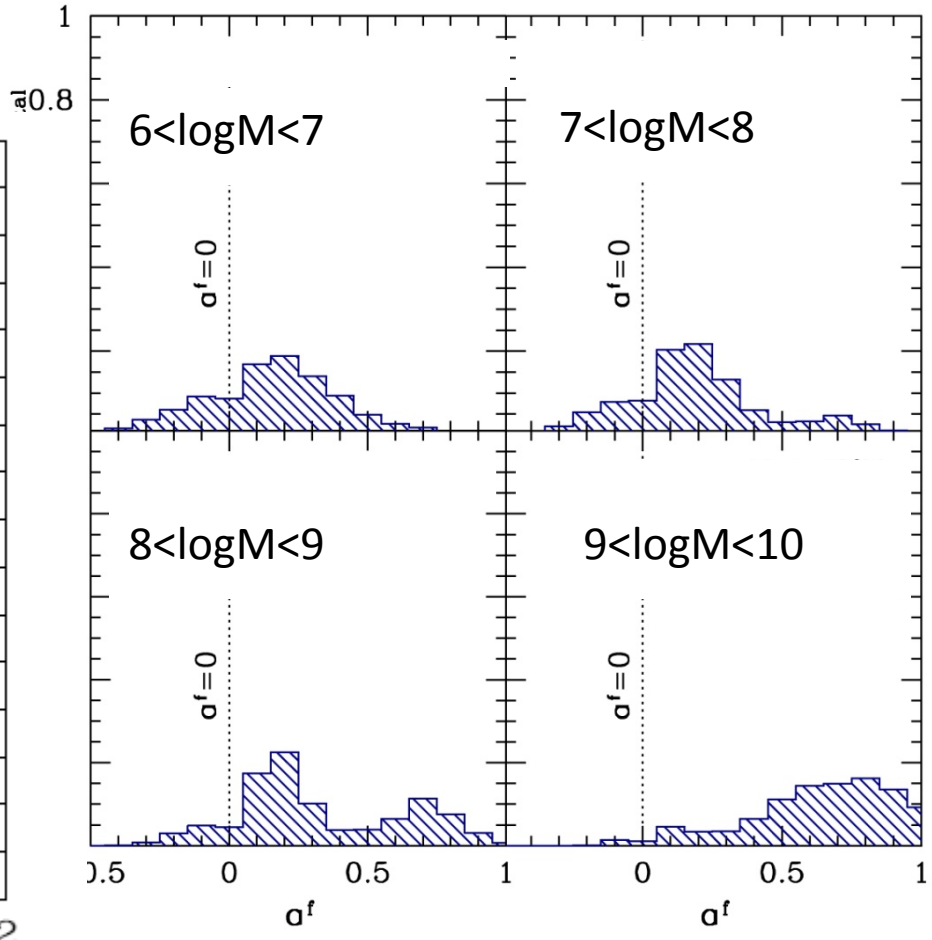
- Maybe only highest spin have jets – but requires that high spin is RARE
- NOT true in prolonged accretion



Get Fermi number and distribution for chaotic accretion and a>0.8!!

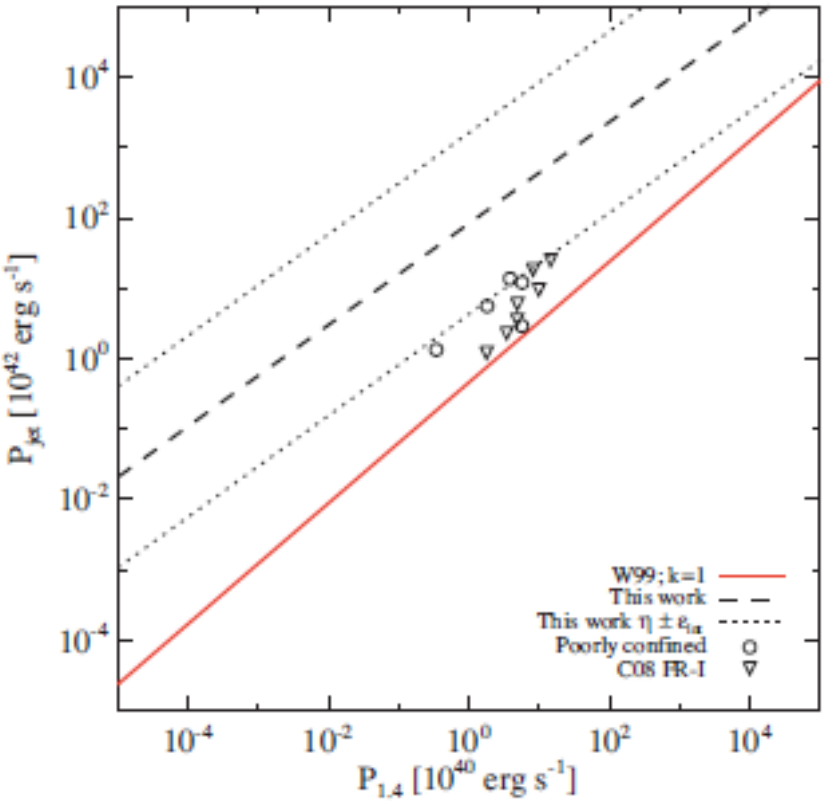
Gardner & Done 2013



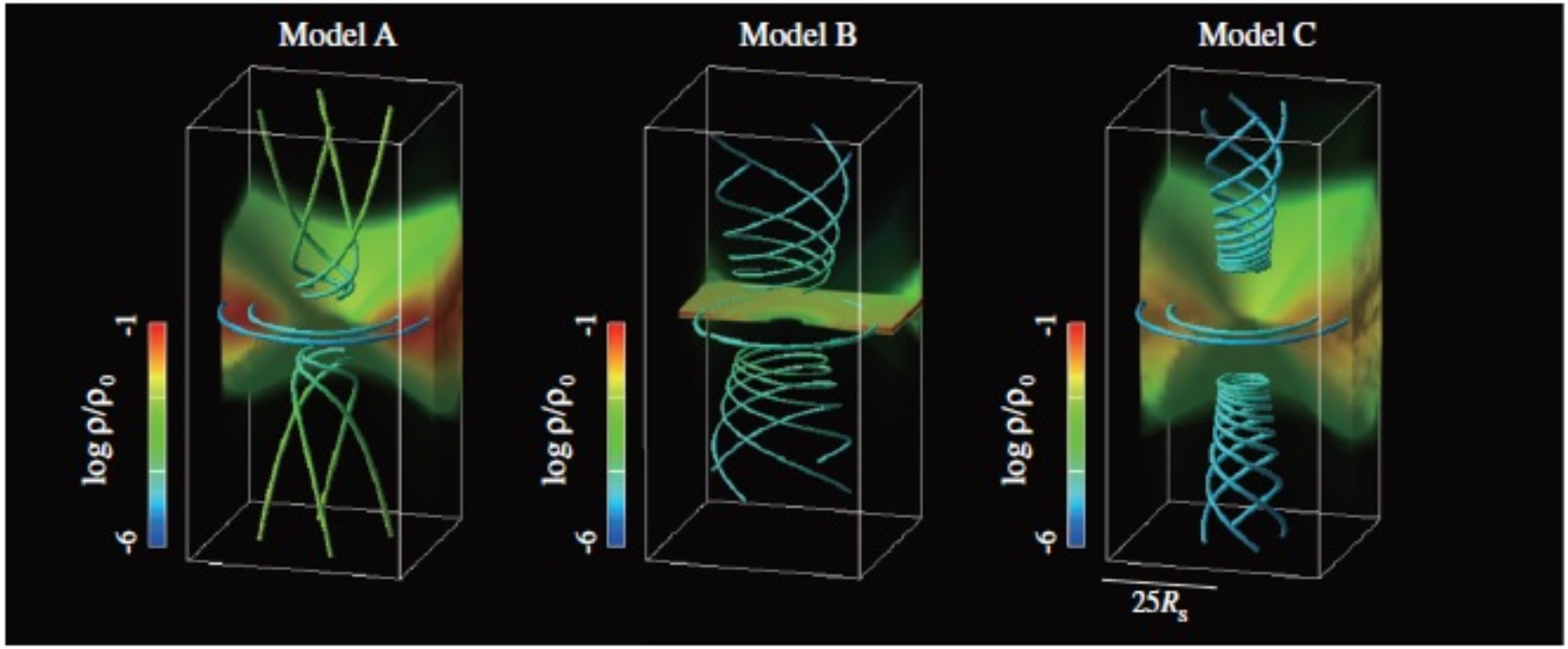


Getting more sophisticated

– Is cluster pressure enough to constrain jet and deposit energy (c.f. Cavagnolo et al 2010)
– Implications for high z



What about super-Eddington accretion?



Mdot<0.01 0.01<mdot<1 mdot>>1

RMHD Ohsuga et al 2011 BAL QSO/UFOs??

Observational constraints on feedback

- SZ measurements on individual stacked large early types?
  - Energy input correlates directly to energy injection
- Variability? How do we pin this down?
- Ensemble vs phenomenology