AGN feedback models: SFR and accretion co-evolution

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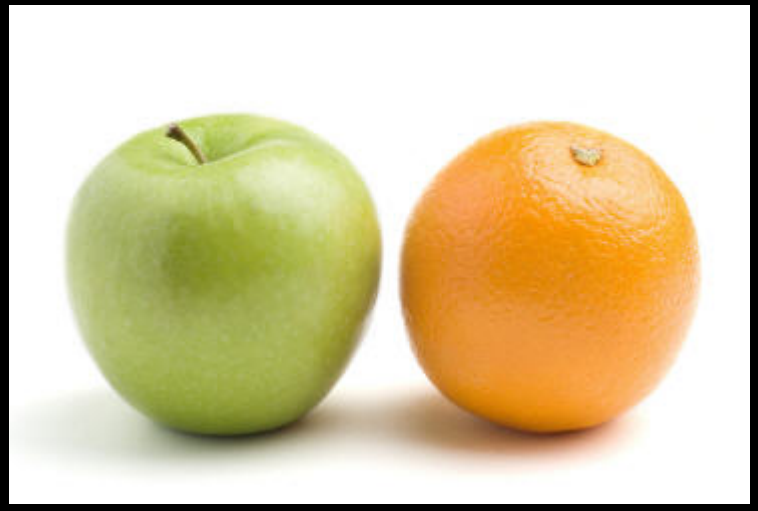
Credit where credit is due

- Main paper results rely upon J. Wurster's PhD simulations (now Monash), see poster +
- *Wurster & Thacker 2013a, MNRAS, 431, 539*
  Wurster & Thacker 2013b, MNRAS, 431, 2513

- Unpublished analysis by Maan Hani (MSc student)

Apples and oranges

- We've compared temporal evolution with ensemble statistic

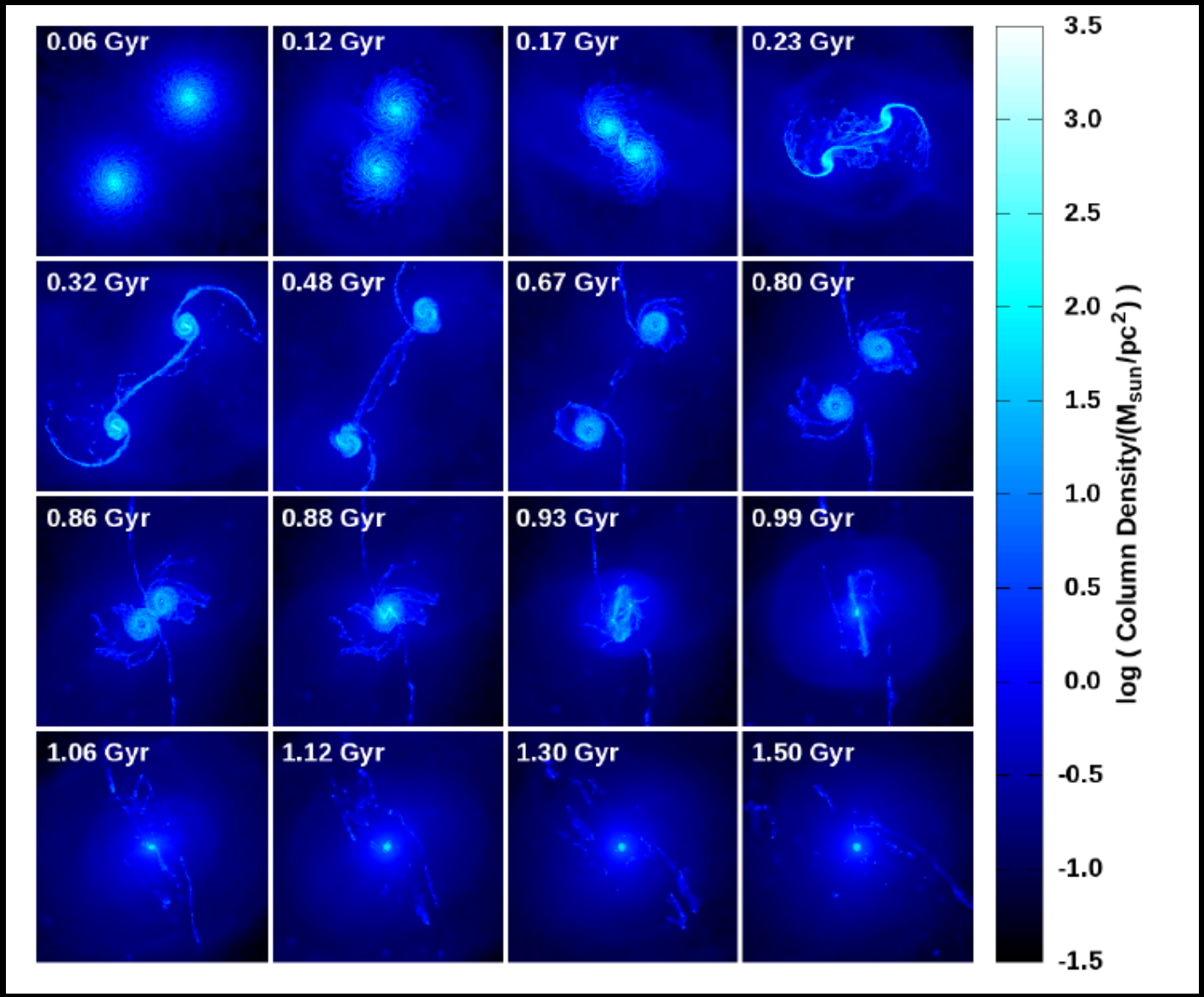


- Our goal was really to *quantify possible scatter* in BHAR-SFR correlations

Prototype merger

- Fiducial res
= 10^6+ per galaxy
(300k gas,
4×10^4 $M_\odot$)
120 pc softening

- Low res
= 2×10^5 per galaxy
(40k gas, 3×10^5 $M_\odot$)
300 pc softening

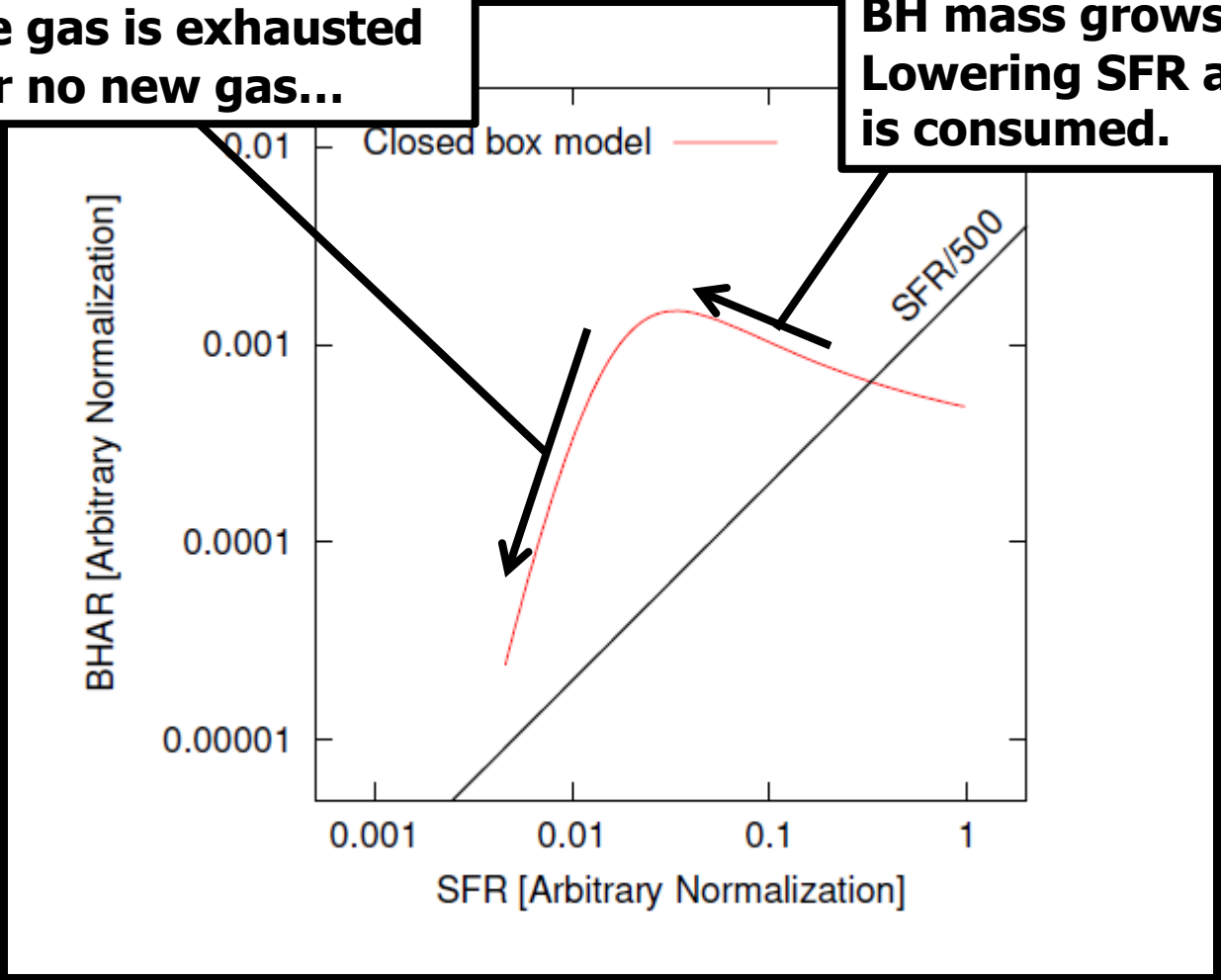


See also *Wurster & Thacker 2013b, MNRAS, 431, 2513*

Closed box expectations of BHAR-SFR coevolution (BHL+Schmidt Law)

BHAR turns off rapidly as available gas is exhausted - remember no new gas…

Increasing BHAR as BH mass grows. Lowering SFR as gas is consumed.



Skeletons in the cupboard…

- For a single merger we can *choose* model

Q.1: What evidence is there for a symbiotic connection between AGN activity and star formation?

BH-bulge - 8 (don't agree) 63 (moderately agree) 30 (strongly agree)
Vol AGN-SF- 11 (don't agree) 61 (moderately agree) 27 (strongly agree)
Theory/mod- 14 (don't agree) 73 (moderately agree) 7 (strongly agree)

mathematical sensitivity is still there

- *Can be quantified though (working on it)*

Five key components of the models

Model for BH accretion rate

SPH particle accretion algorithm

(Feedback) energy return algorithm

Black hole advection algorithm

Black hole merger algorithm

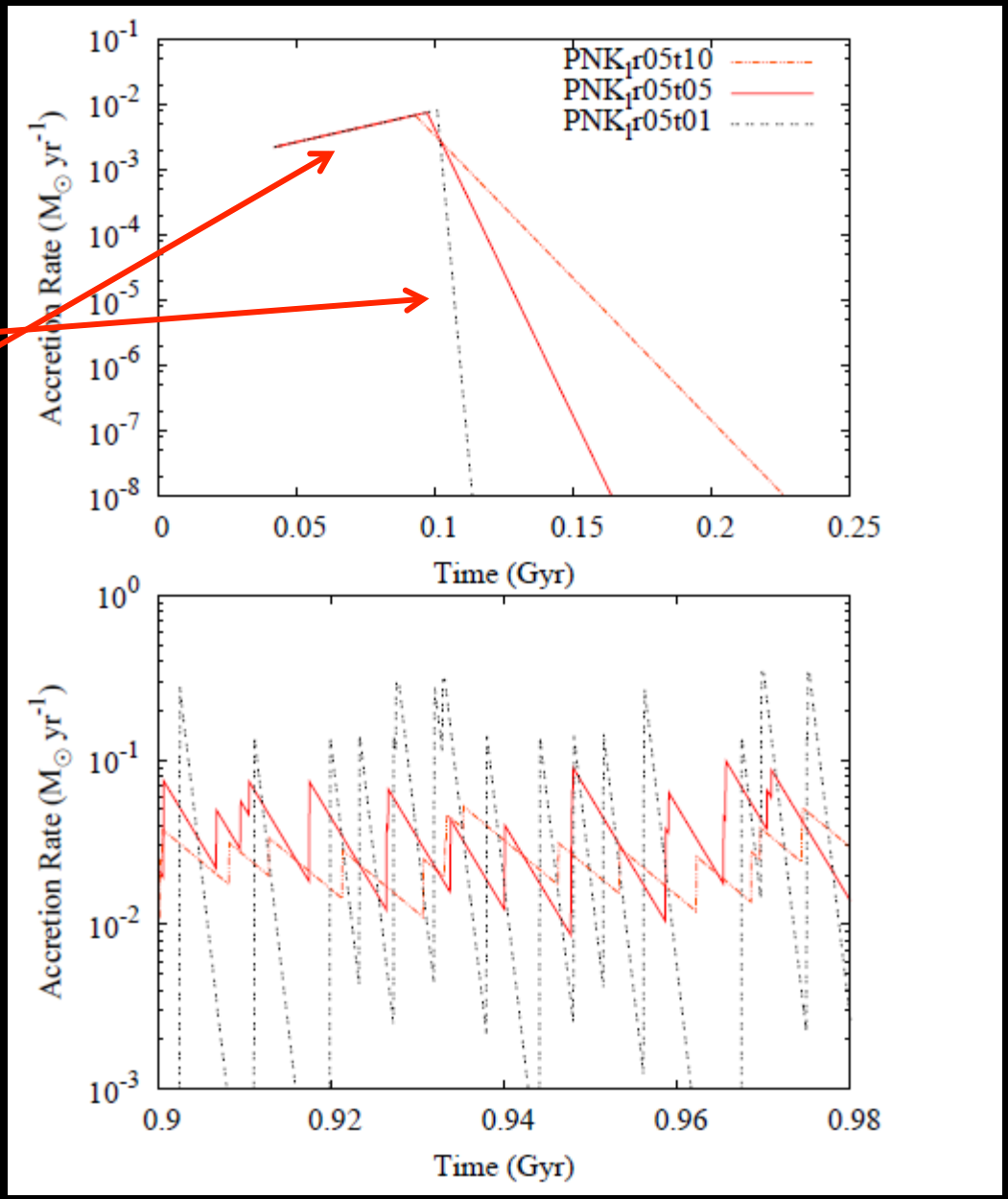
Summary(!) of implemented models

Model	Accretion model	SPH accretion	Feedback model	BH advection	BH merger
SDH05 (Springel et al 2005)	BHL	Classic probability	Heating	Lowest local PE	Sound speed criterion
BS09 (Booth & Schaye 2009)	BHL+alpha mod	Prob based on mass	Heating	Lowest local PE	Circular vel criterion
DQM11 (DeBuhr et al 2011)	Viscous timescale	Prob based on mass limit	Wind	Massive tracer	Distance only
ONB08 (Okamoto et al 2008)	Drag based	Prob based on mass	Halo heating	Toward max density	Grav bound
WT12	BHL	Local particles first	Heating	Toward max density	Sound speed criterion
PNK (Power et al 2011)	Accretion disk	Locality	Heating	Toward max density	Sound speed criterion
HPNK (Hobbs et al 2012)	Halo modified BHL	Local particles first	Heating	Toward max density	Sound speed criterion

t_{visc}: impact on BHAR

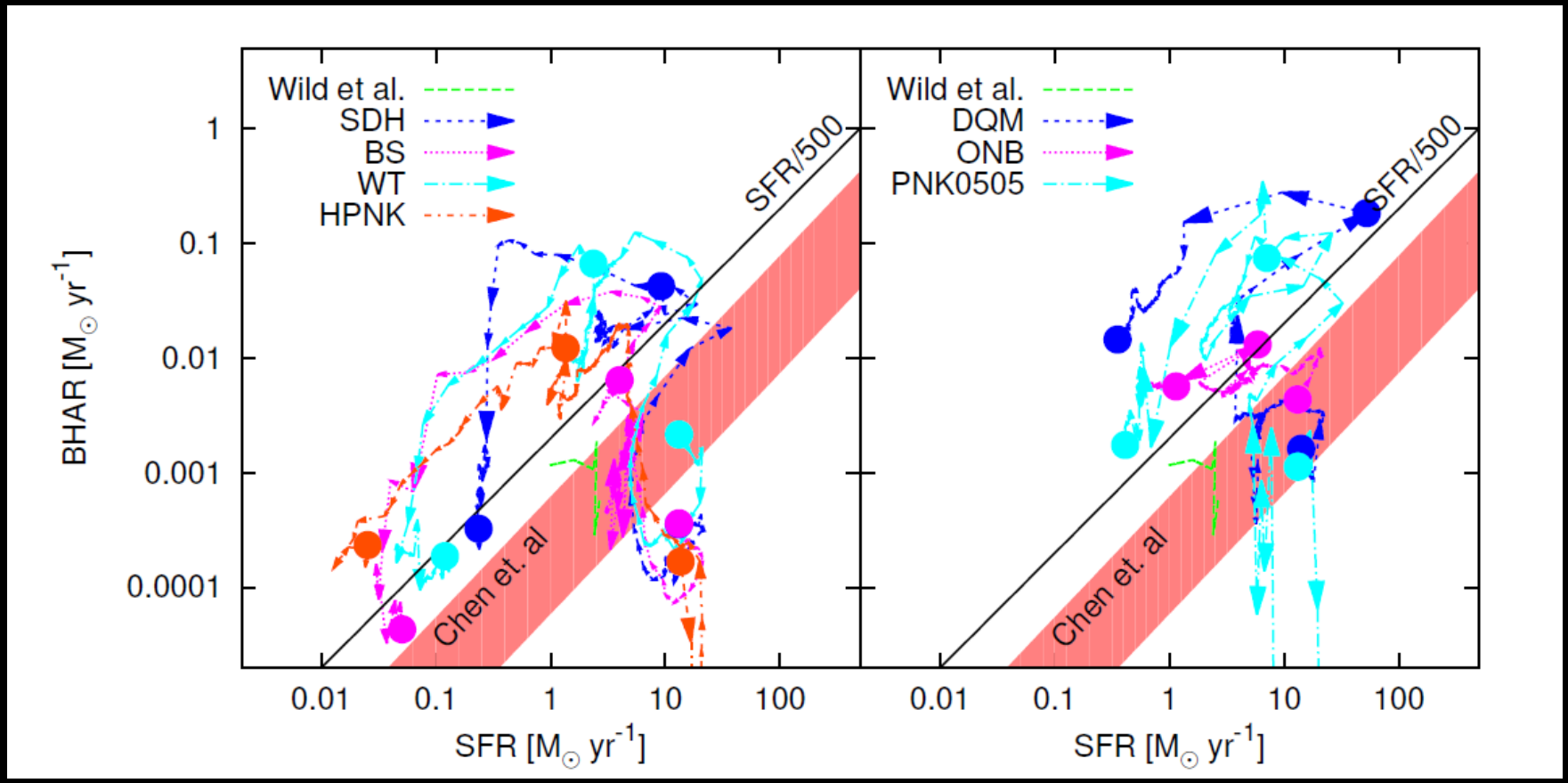
$$M\downarrow BH = \min(M\downarrow disc / t\downarrow visc , M\downarrow Edd)$$

Roughly speaking, longer t_{visc} delays and averages out accretion



Inferred evolution for starbursts from Wild et al 2010

BHAR-SFR coevolution for models

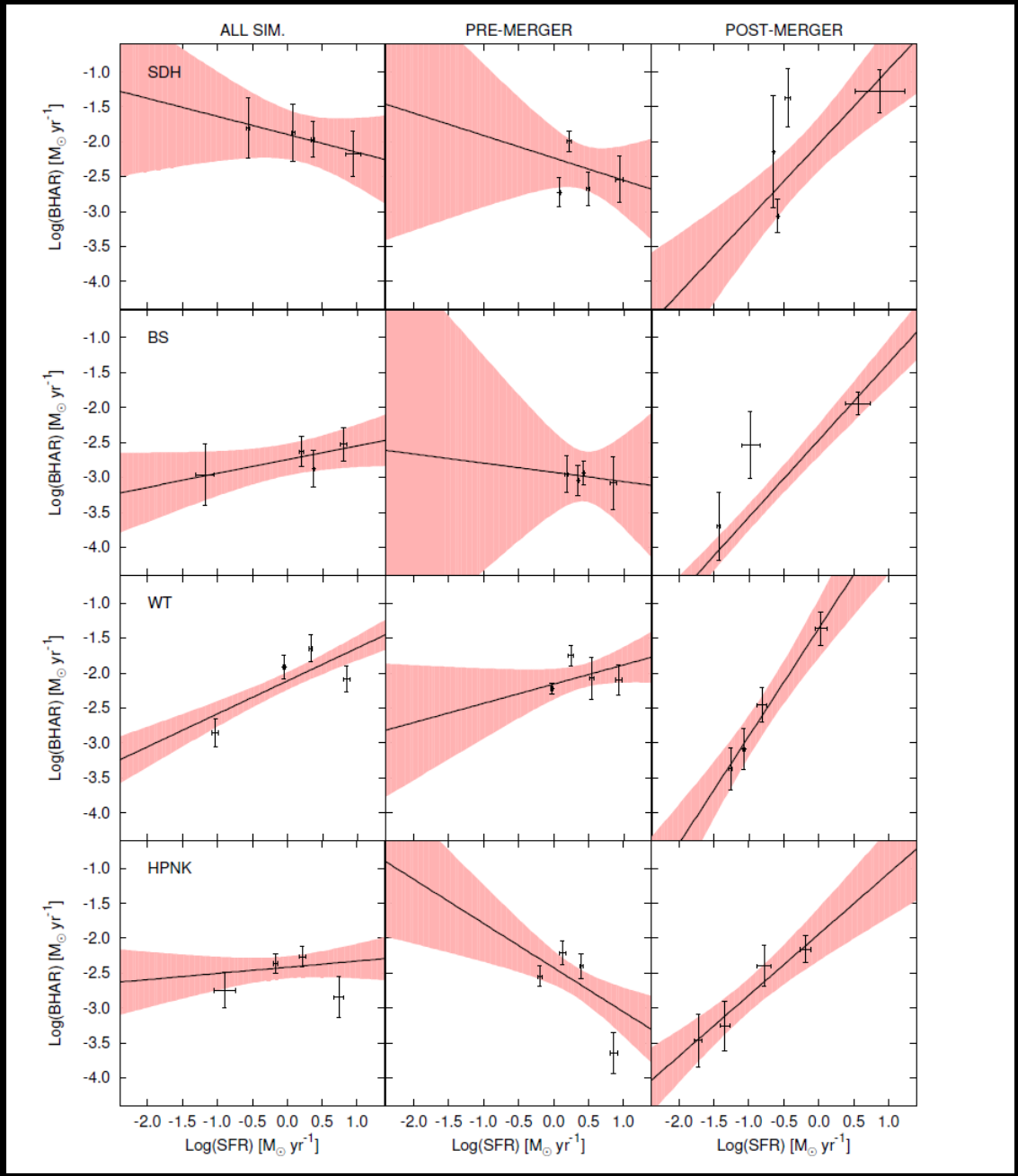


Each arrow is 20 Myr of evolution - full tracks are even more complex. Beginning, core merger, and final points are marked.

Motivated by Chen et al 2013

Total SFR vs BHAR

- Lag. bin averaging
- Premerger – slight anticorrelation
- Post-merger close to linear

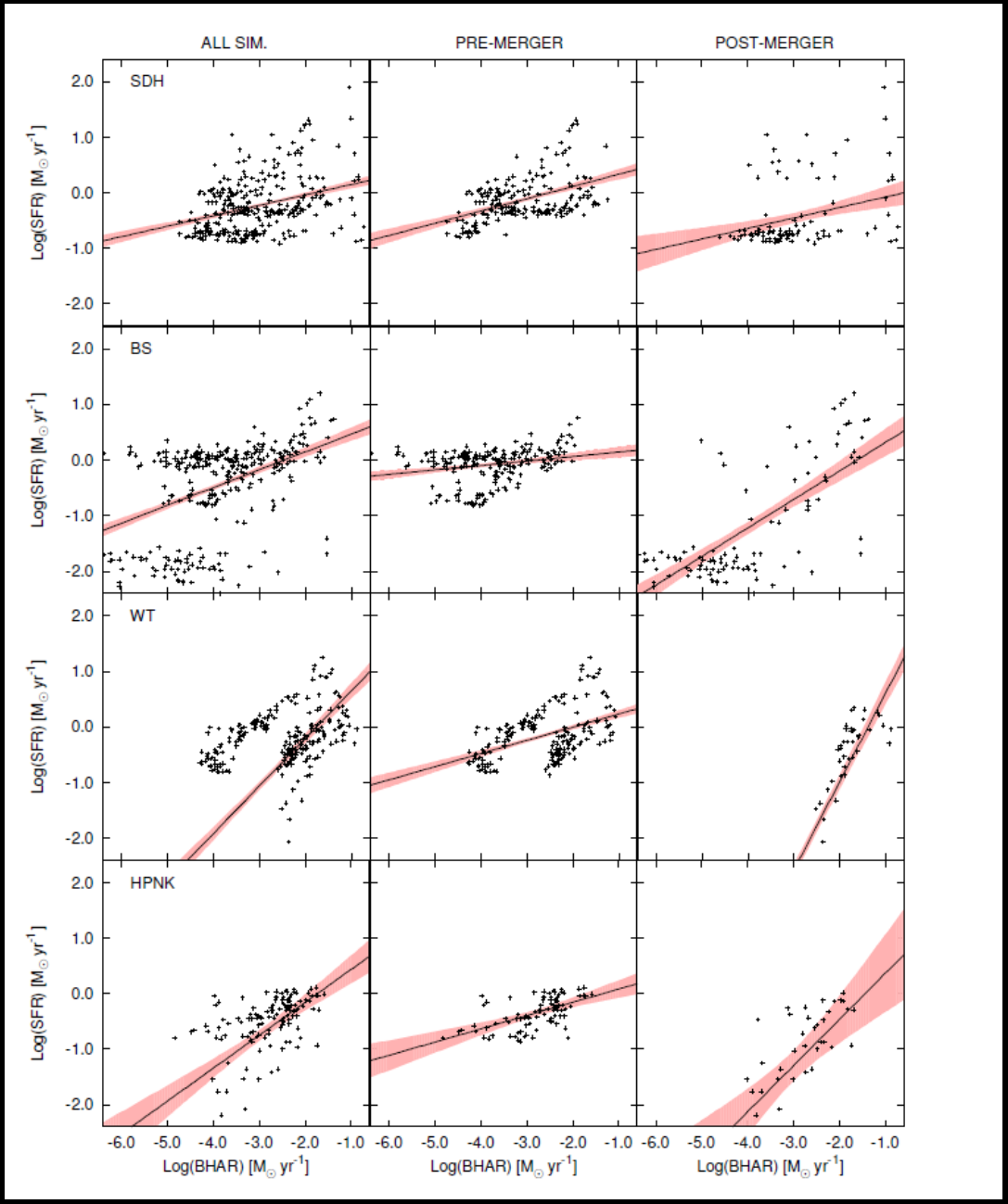


Four BHL-type variants

See e.g. Diamond-Stanic & Rieke 2012, Lamassa et al 2013

Nuclear BHAR vs SFR

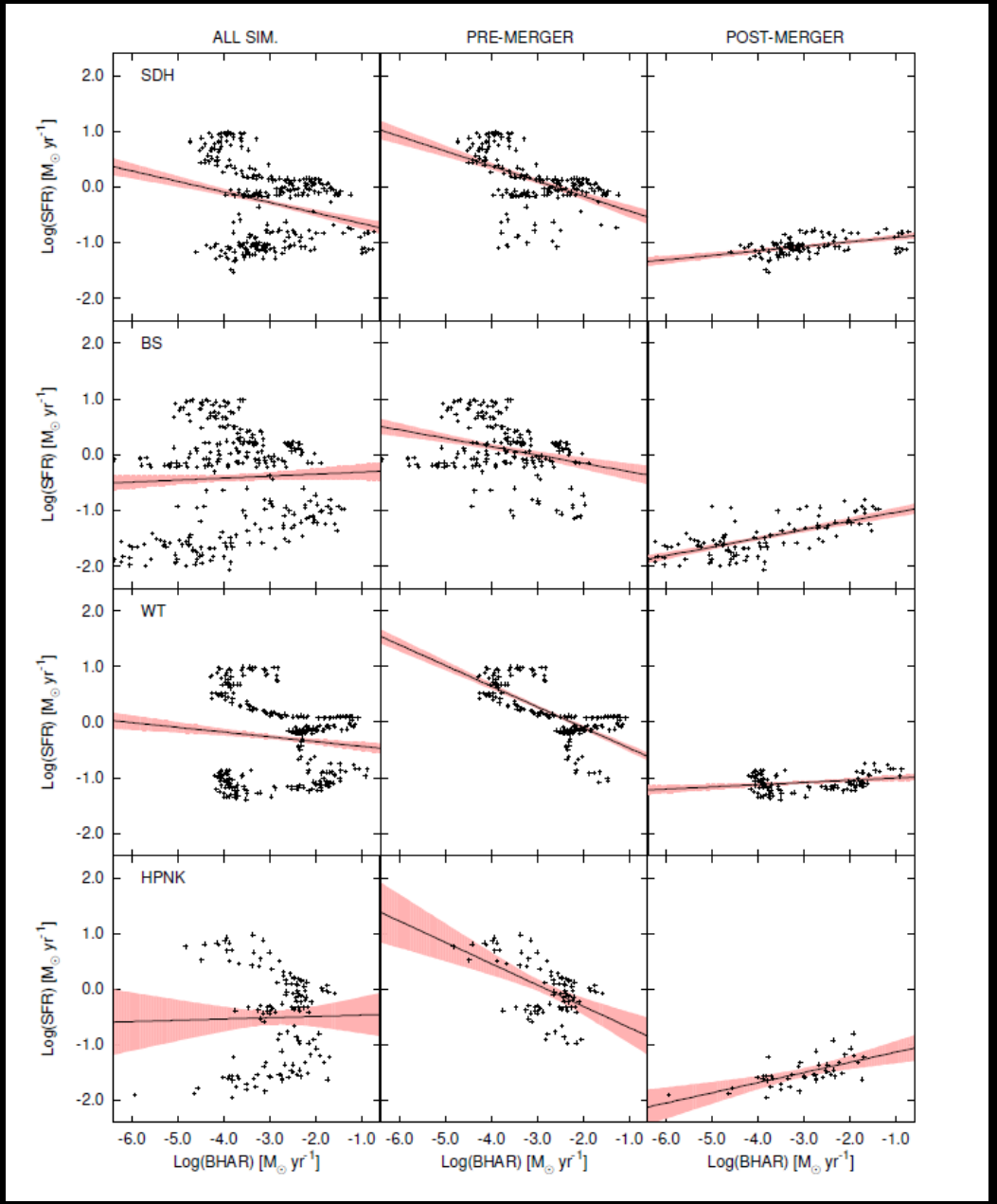
- 2 kpc diameter
- Premerger – slight correlation
- Post-merger much stronger correlation
- Unexpected?



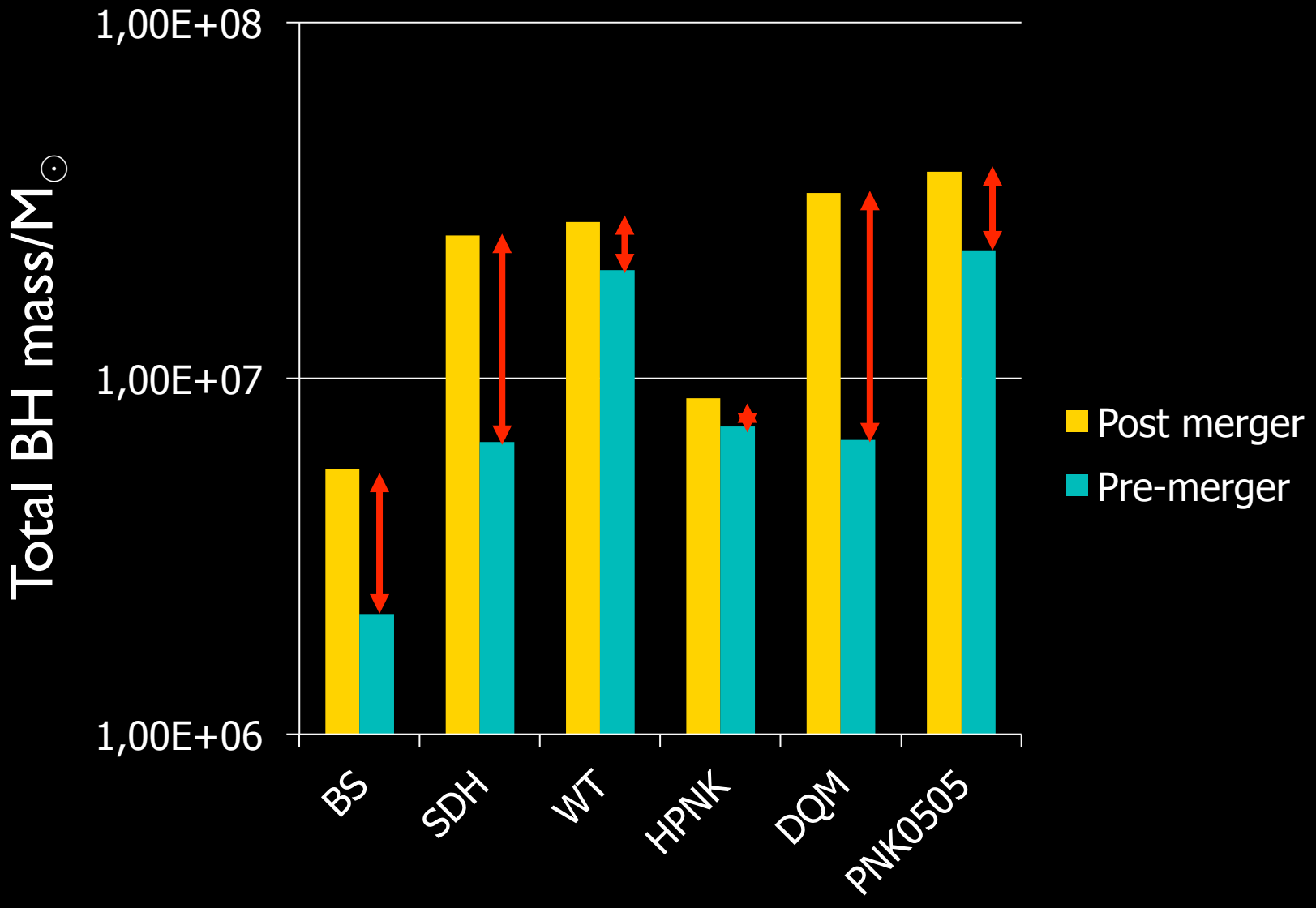
Note axes are swapped compared to previous

Outer SFR vs BHAR

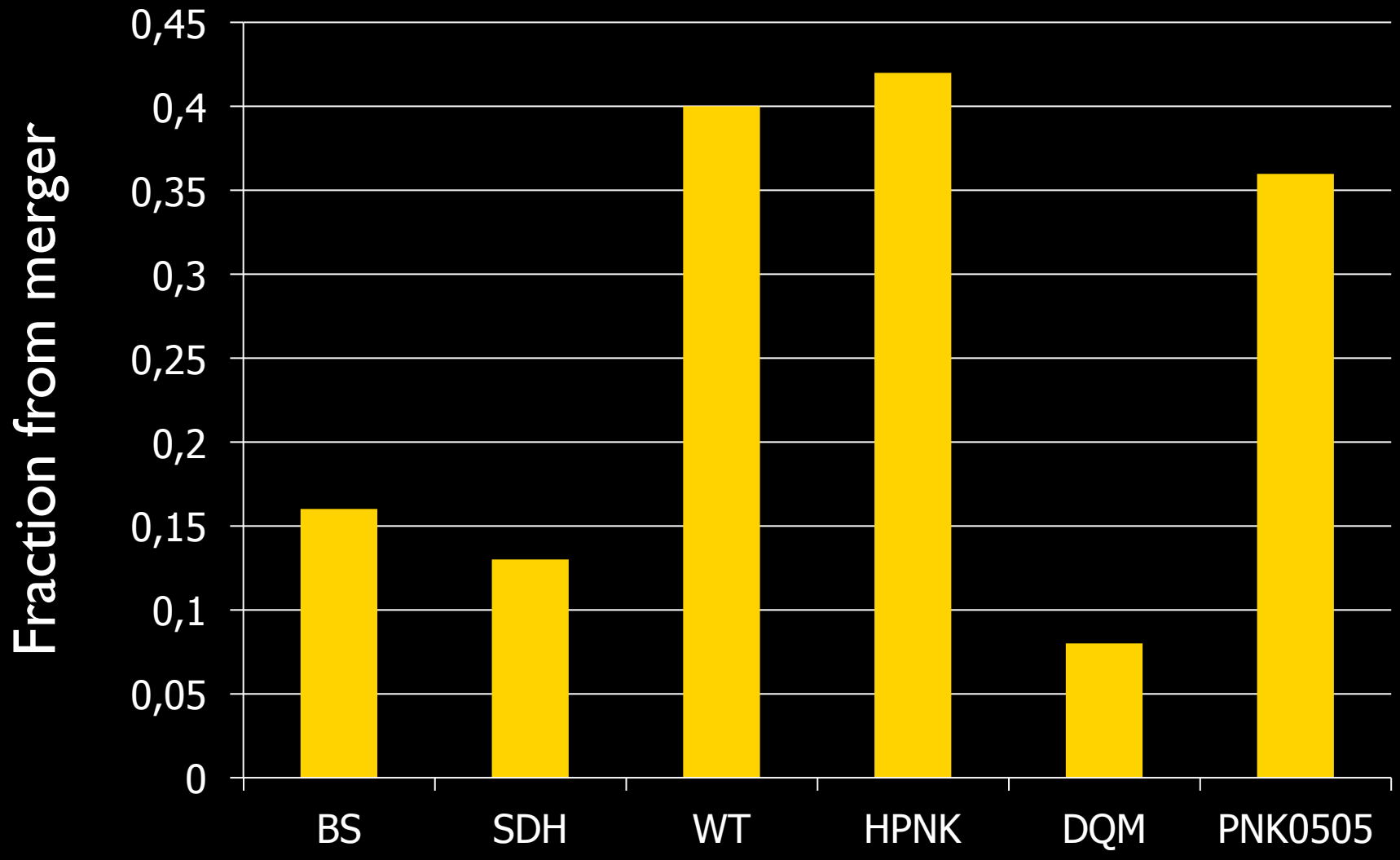
- Weaker correlations
- Outer regions less impacted by nuclear activity
- Qualitative agreement with obs (*i*.e. nuclear more strongly correlated)



Post merger mass growth



Mass contributions from mergers



What would really help the models?

- *Figu* *rs*
  - *P*
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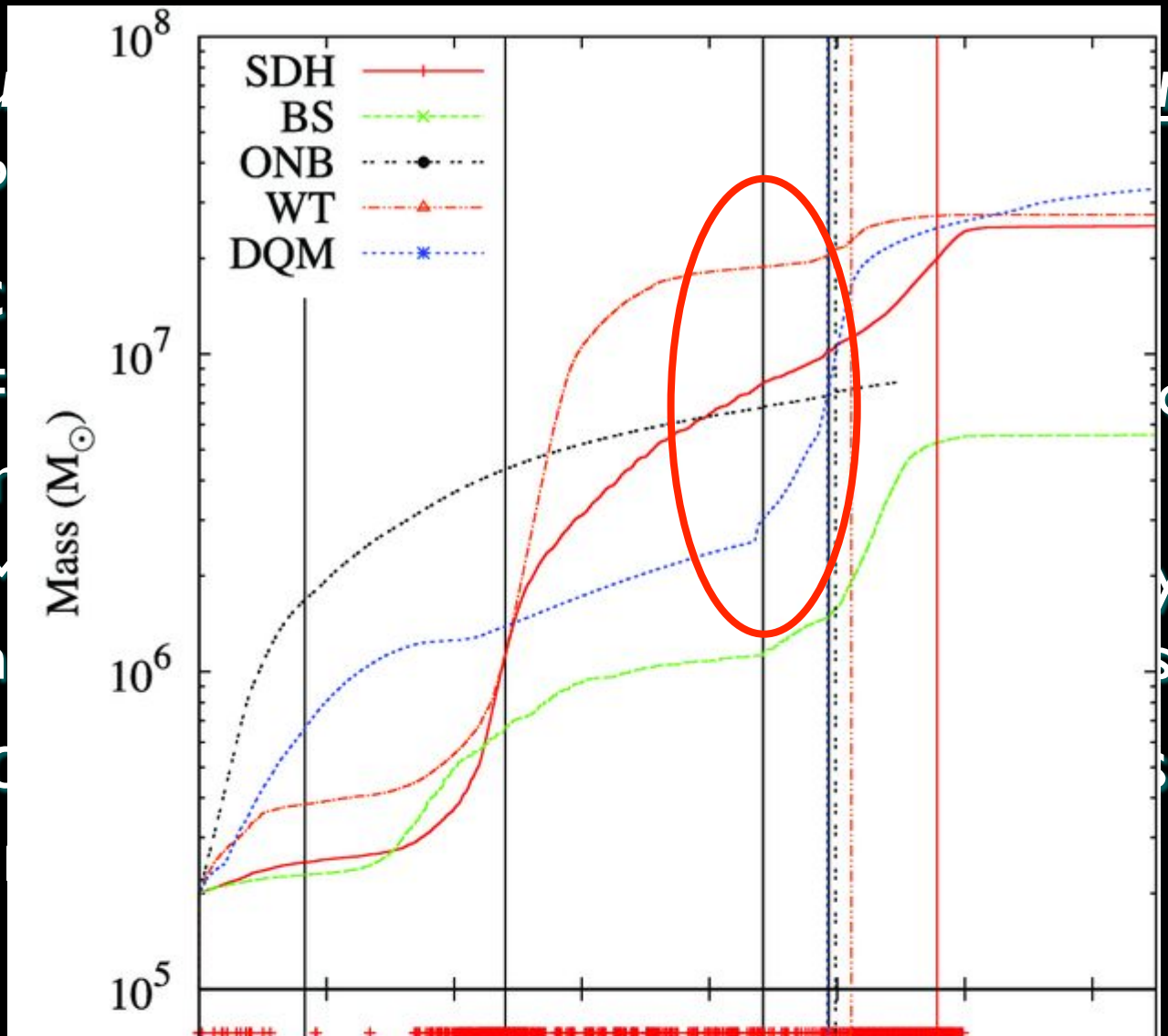
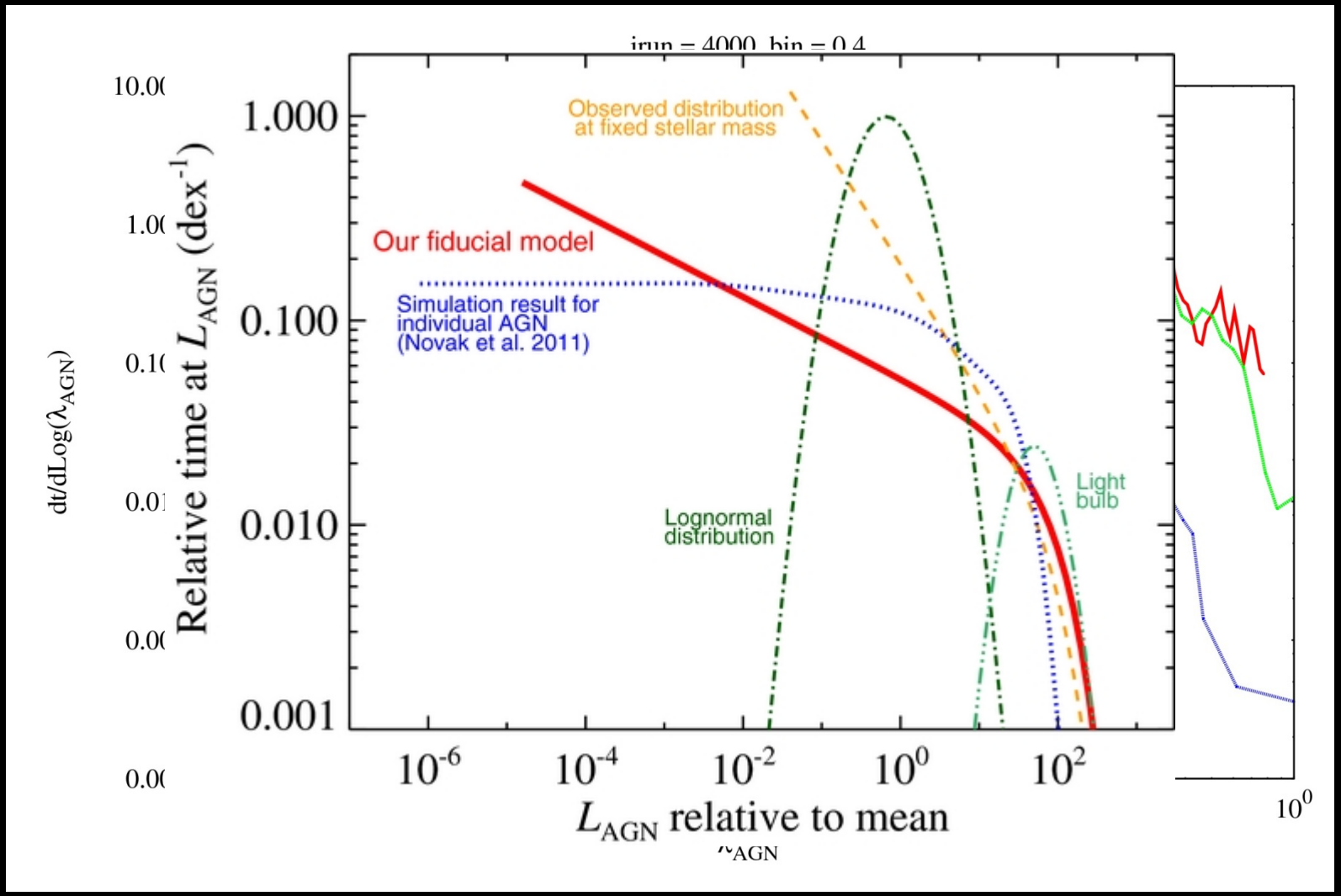


“Activity functions” (in progress)



Conclusions

- SFR-BHAR coevolution has an inherently complex track (no surprise there!)
  - "Classes" of models qualitatively similar
- Close to linear correlations in some post-merger systems
- BH intermediate mass evolution can still vary considerably even though final M-σ matches
- Significant variation in contribution of mergers to final BH mass

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