

The clustering of narrow-line AGN in the local Universe

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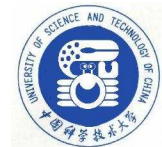
Peking University

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Trigger of AGN activity?

- N-body/hydro simulations:
 - ◆ Interactions: gas \longrightarrow central regions \longrightarrow enhanced SF
 - ◆ Some of this gas \longrightarrow black hole \longrightarrow nuclear activity ??
 - ◆ Little clear observational evidence !!
- Do AGN show excess near-neighbour counts relative to non-AGN?
 - ◆ Yes: Seyferts (Petrosian '82), quasars (Serber et al. '06)
 - ◆ No: Seyferts (Miller et al. '03), X-ray (Waskett et al. '05)
 - ◆ Different intrinsic luminosities?
- Are AGN more clustered than non-AGN?
 - ◆ No: 2QZ \times 2dFGRS (Croom et al. '05), SDSS narrow-line (Wake et al. '04), X-ray (Mullis et al. '05)
 - ◆ Yes: radio-loud (Magliocchetti et al. '04)
 - ◆ LINER/Seyfert (Constantin & Vogeley '06)
 - ◆ AGN not a random subsample of the galaxy population!



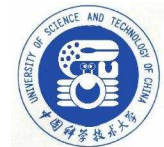
Our approach

■ Questions:

- ◆ How do **the locations** of galaxies inside/around DM haloes influence ongoing accretion onto BHs?
- ◆ Is AGN activity triggered by galaxy **interactions or mergers**?

■ Differences from previous studies:

- ◆ **AGN-galaxy cross-correlations** from ~ 10 kpc to ~ 10 Mpc: probing the detailed scale dependence
- ◆ The dependence of clustering on
 - ▶ M_{\bullet} : σ_*
 - ▶ **the accretion rate**: $L[\text{O III}]/M_{\bullet}$
- ◆ Well-constructed **control samples** of inactive galaxies: closely matched in z , M_* , **structure, mean stellar age**
- ◆ **Mock redshift surveys**:
how AGN trace the underlying galaxy and halo populations?



Samples

■ AGN sample

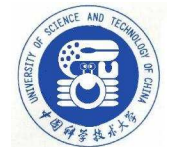
- ◆ $\sim 90,000$ narrow-line AGN from SDSS DR4, $\langle z \rangle \approx 0.1$
- ◆ ordered by decreasing $L[\text{O III}]/M_\bullet$
"powerful": top 25%; "weak": bottom 25%

■ Control samples of inactive galaxies

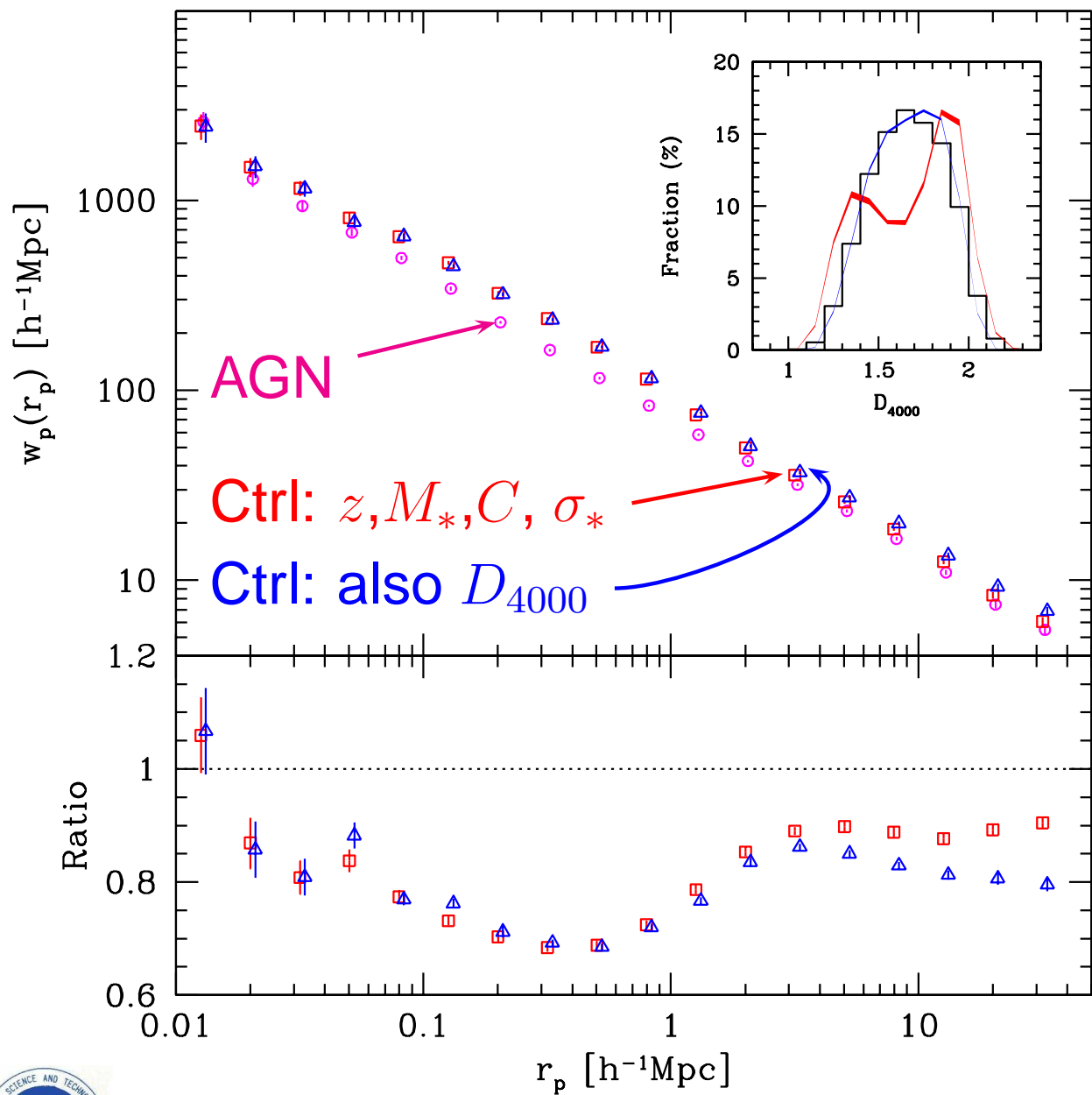
- ◆ Two sets, each consists of 20 samples
- ◆ $\Delta cz < 500 \text{ km s}^{-1}$, $\Delta \log M_* < 0.1$, $\Delta \sigma_* < 20 \text{ km s}^{-1}$, $\Delta C < 0.1$
- ◆ in addition, $\Delta D_n(4000) < 0.05$

■ Reference samples

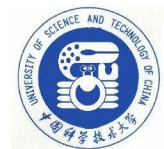
- ◆ **Spectroscopic**: $\sim 3 \times 10^5$, $14.5 < r < 17.6$, $-23 < M_{0.1r} < -17$
the projected AGN-galaxy cross-correlation function $w_p(r_p)$
- ◆ **Photometric**: $\sim 10^6$, $14.5 < r < 19$
counts of close neighbours around AGN



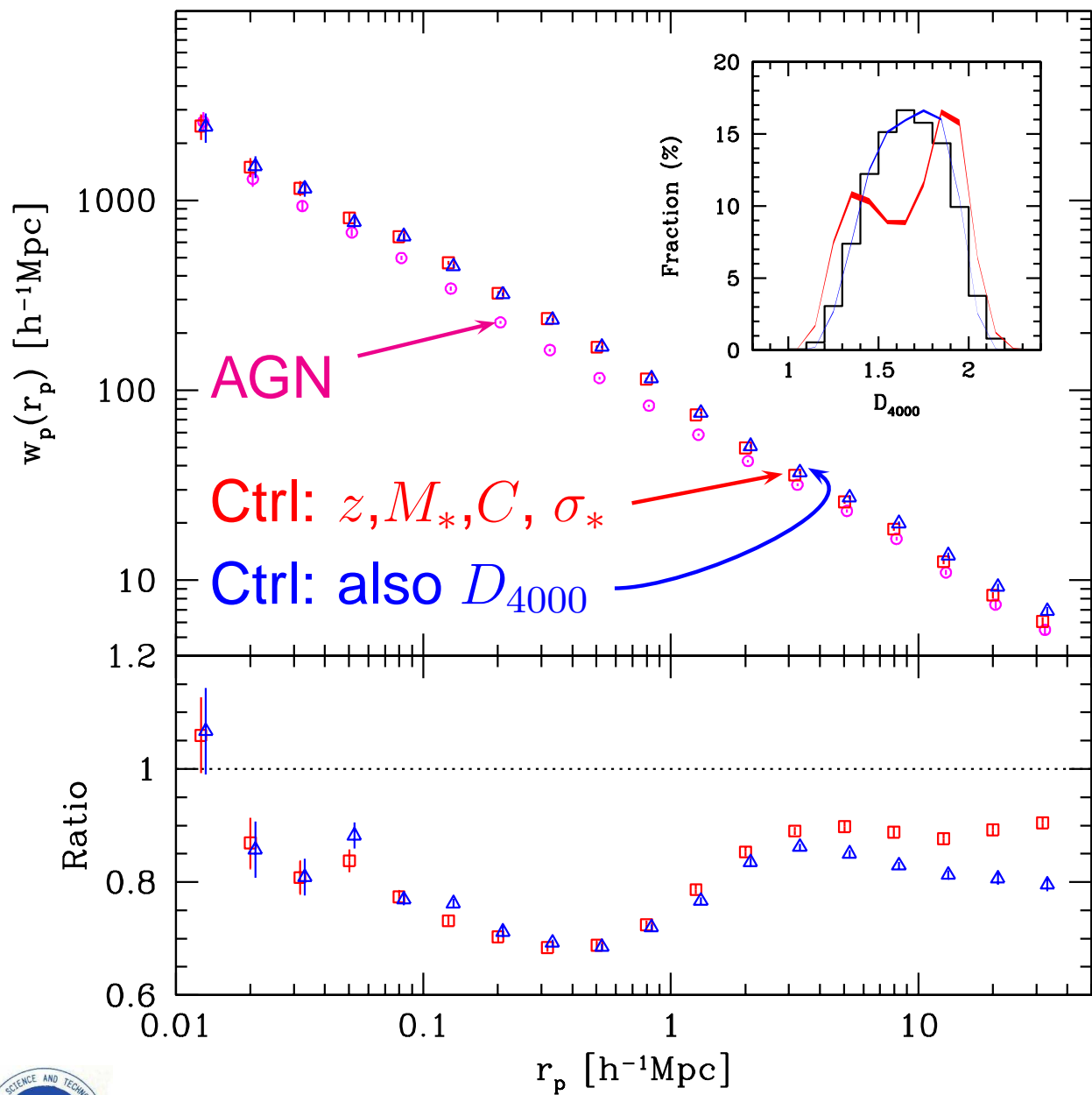
AGN bias



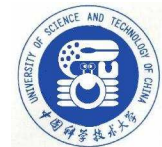
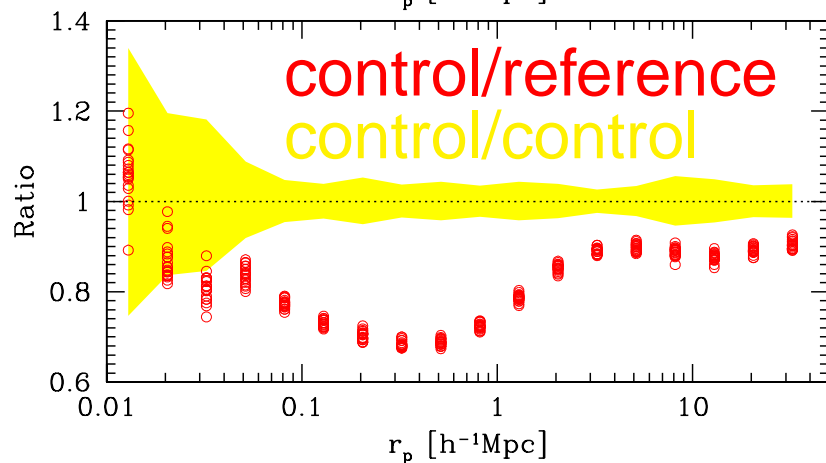
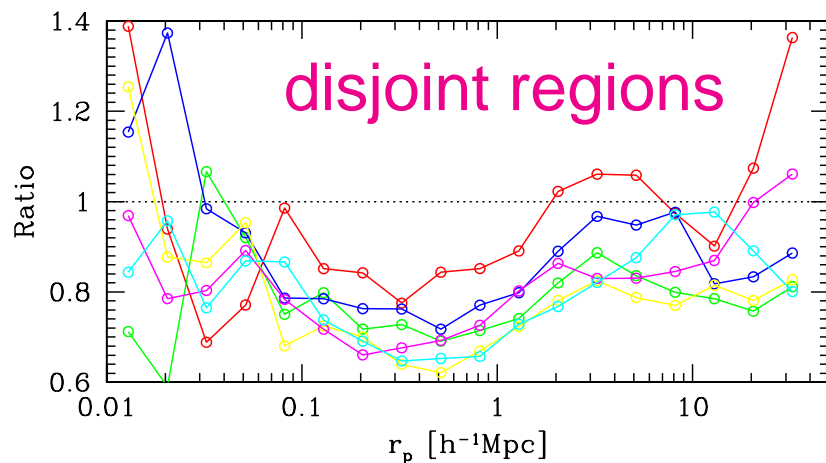
- A scale-dependent bias
- A "dip" at 100kpc - 1Mpc
- truly robust?



AGN bias

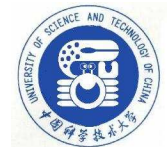
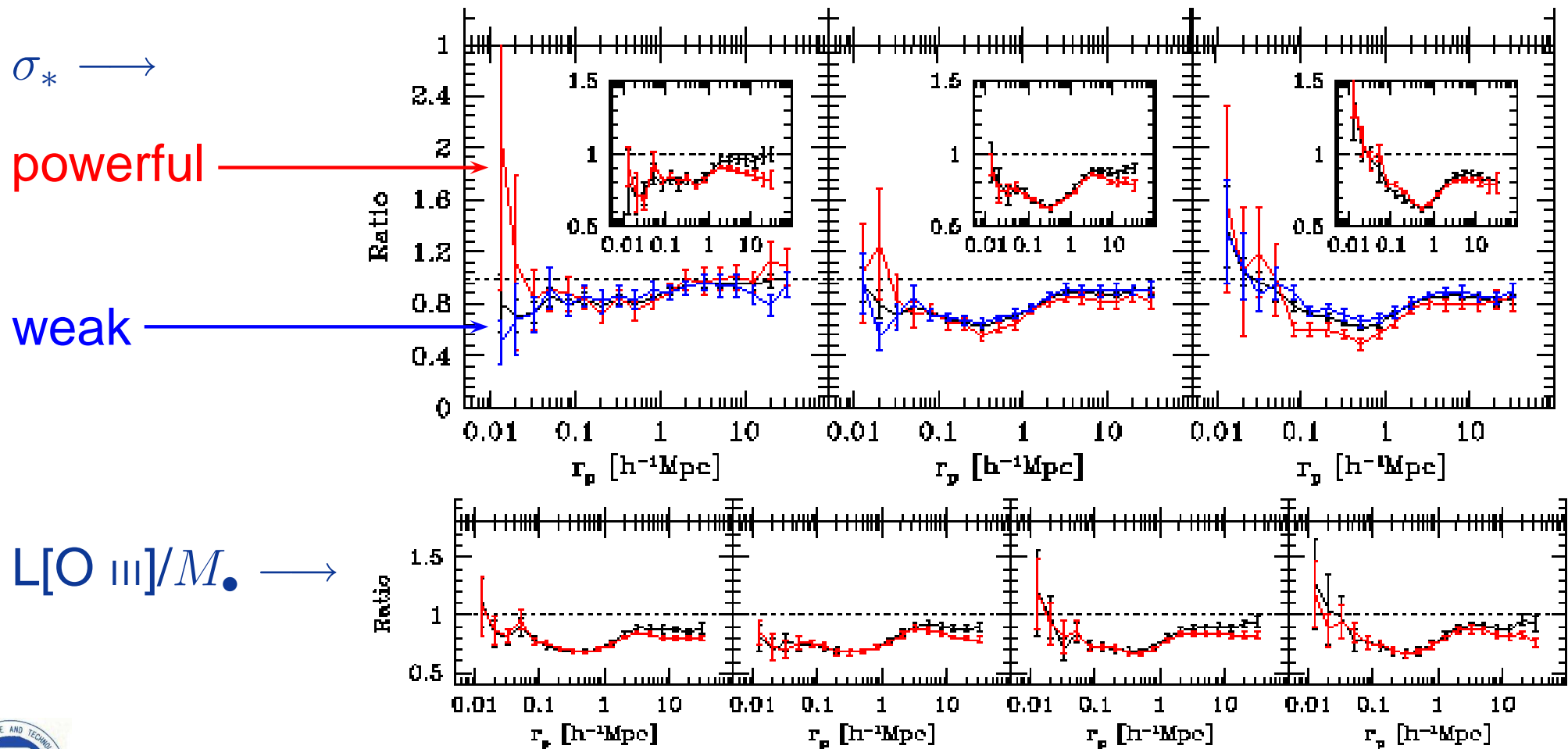


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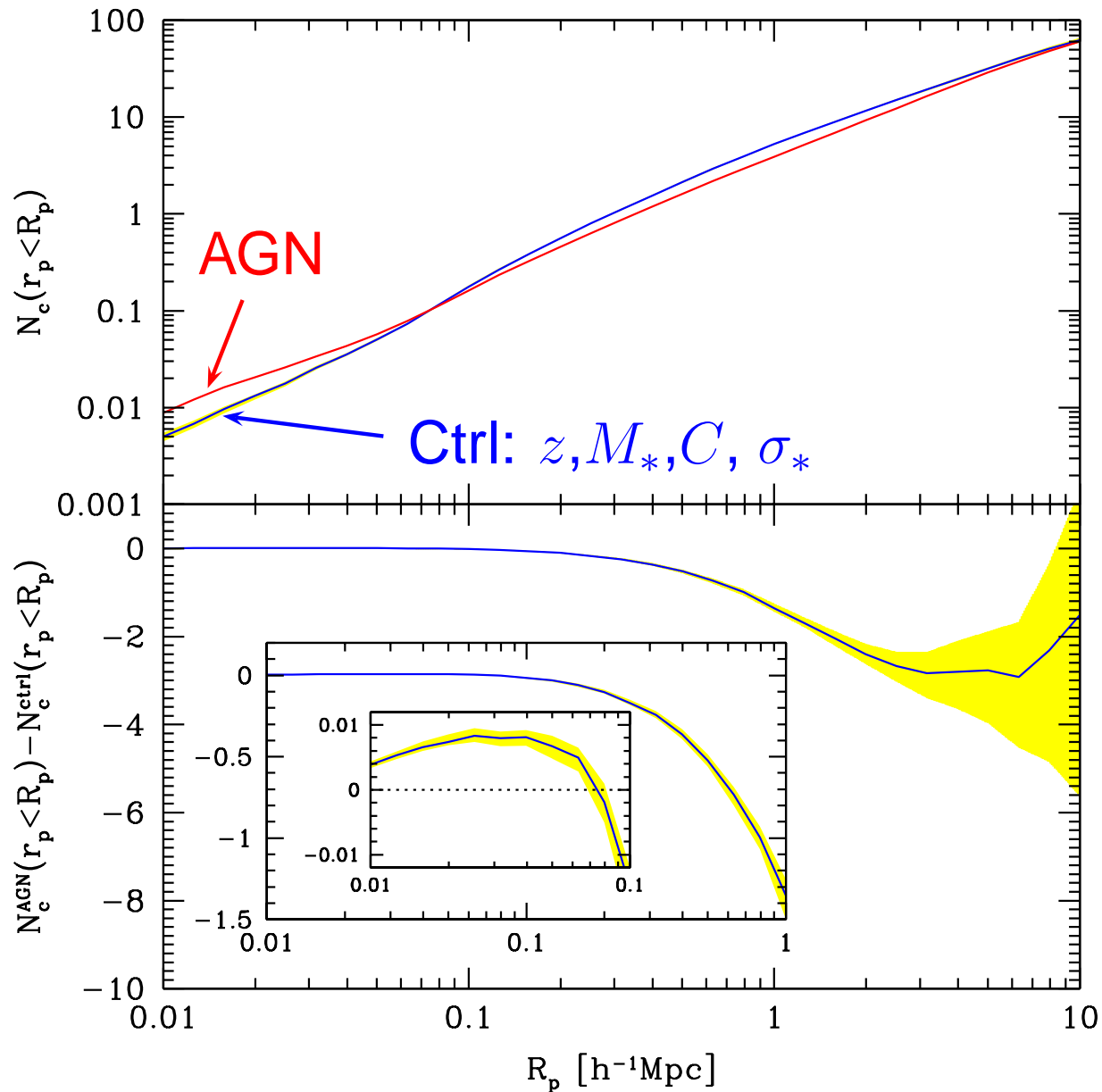


Dependence on BH mass and AGN power

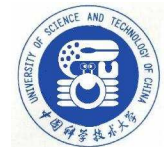
- the "dip": most pronounced at largest σ_* and highest $L[\text{O III}]/M_\bullet$.
- $r_p < 0.1\text{Mpc}$: more powerful, more strongly clustered
- NOT of high significance



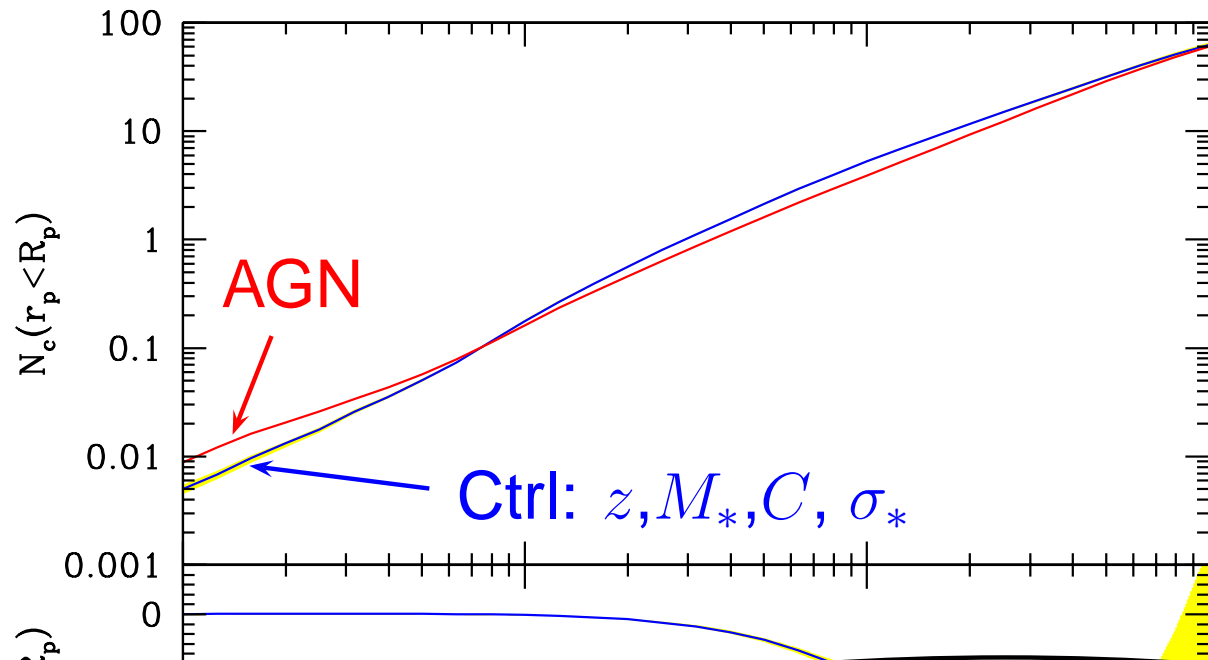
Close neighbour counts



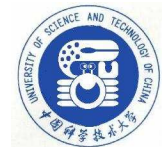
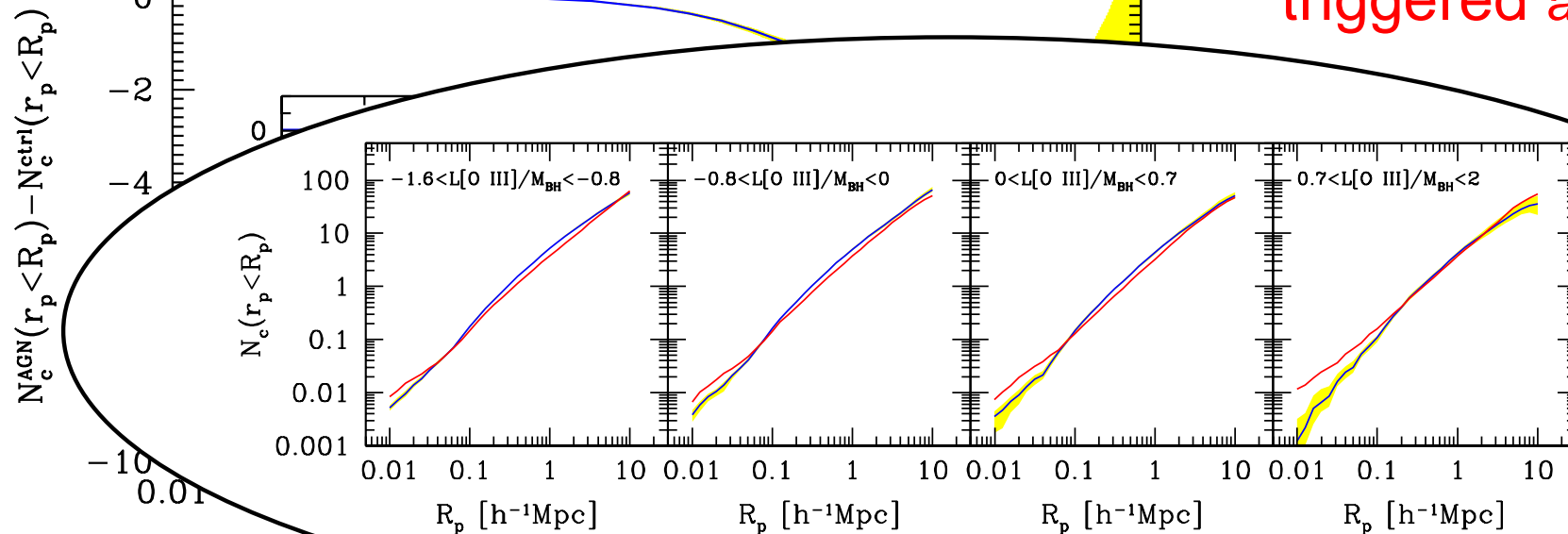
- A small excess at $<70\text{kpc}$
- ◆ $\sim 1\%$ AGN has an additional neighbour



Close neighbour counts

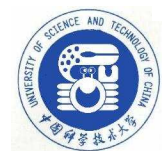
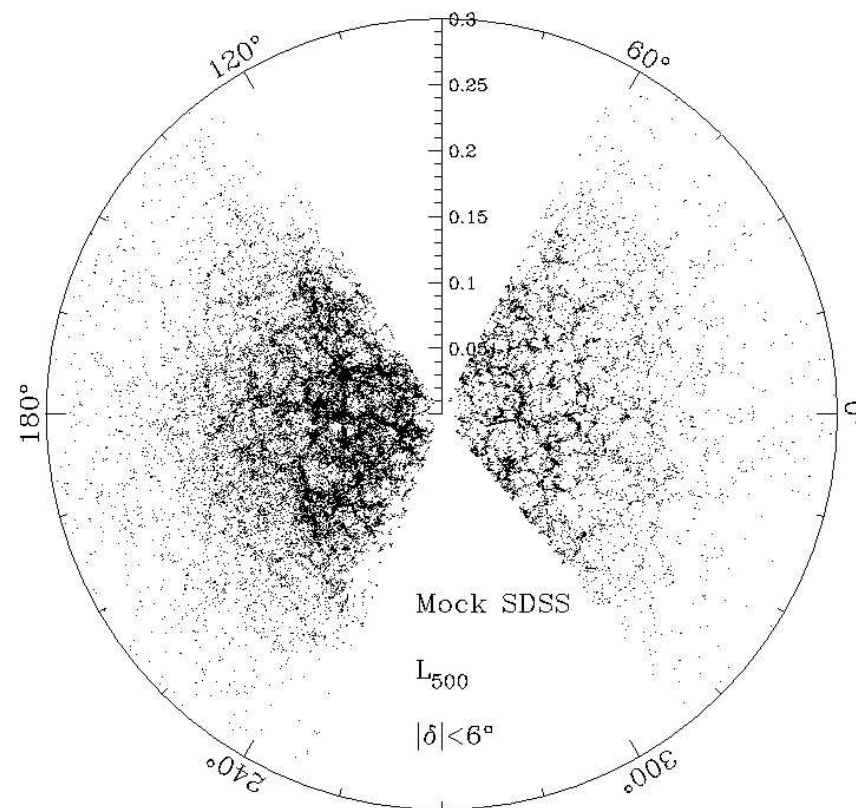
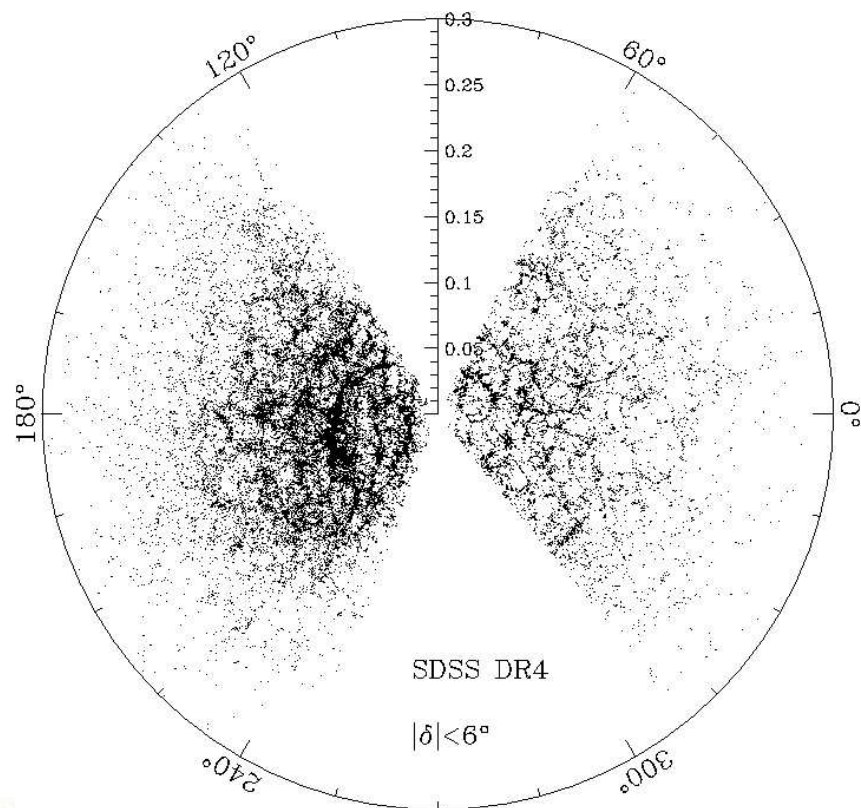


- A small excess at $<70\text{kpc}$
 - ◆ $\sim 1\%$ AGN has an additional neighbour
- The excess increases with $L[\text{O III}]/M_\bullet$
 - ◆ $< \text{a few percent}$
- **CAVEAT:**
triggered *after* merged?

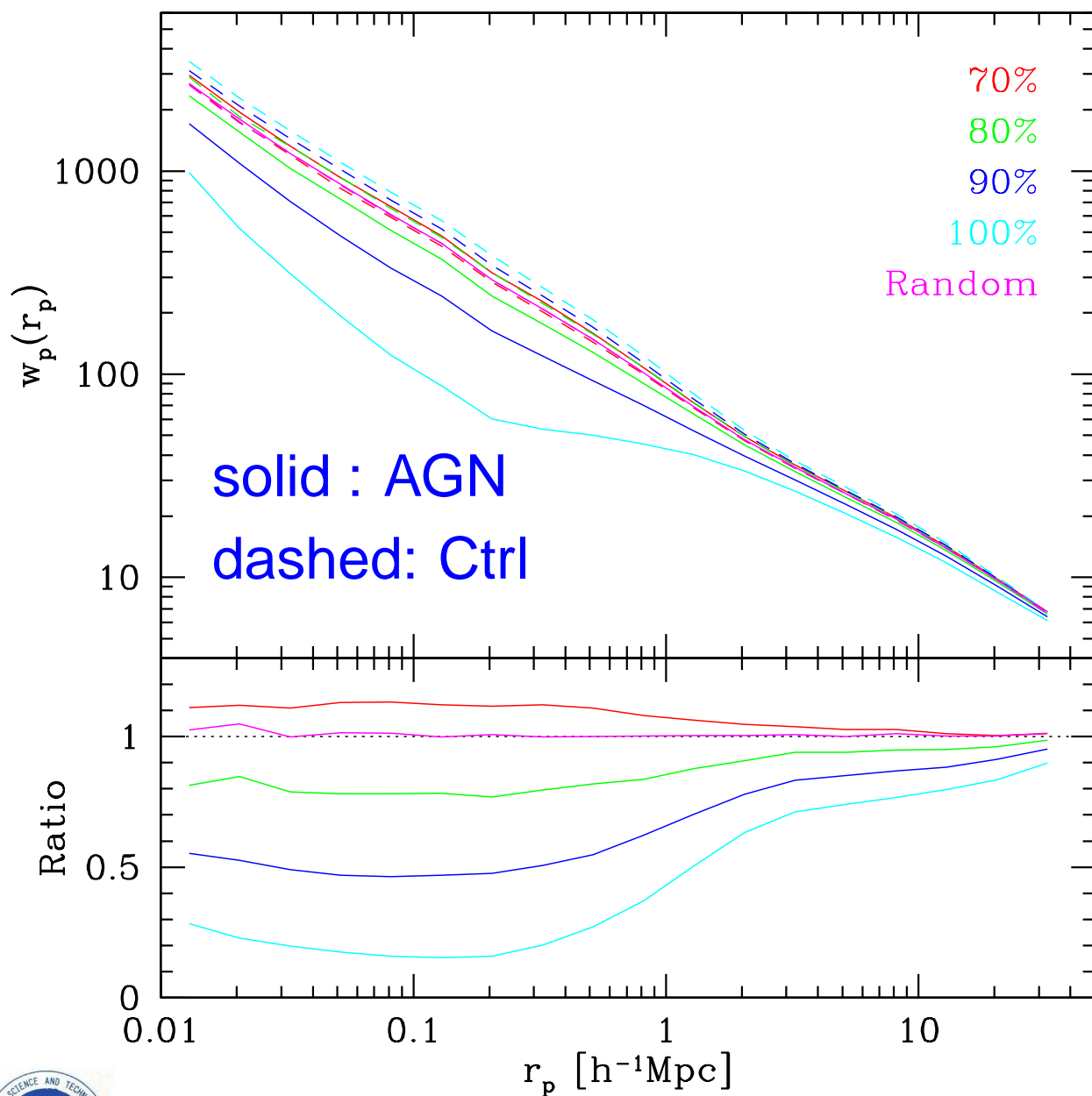


Constructing mock catalogues

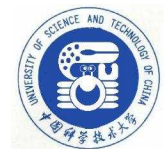
- Millennium Simulation (Springel et al. 2005)
- Semi-analytic models (SAM, Croton et al. 2006)
- The same selections as the SDSS DR4 → **Mock catalogues**



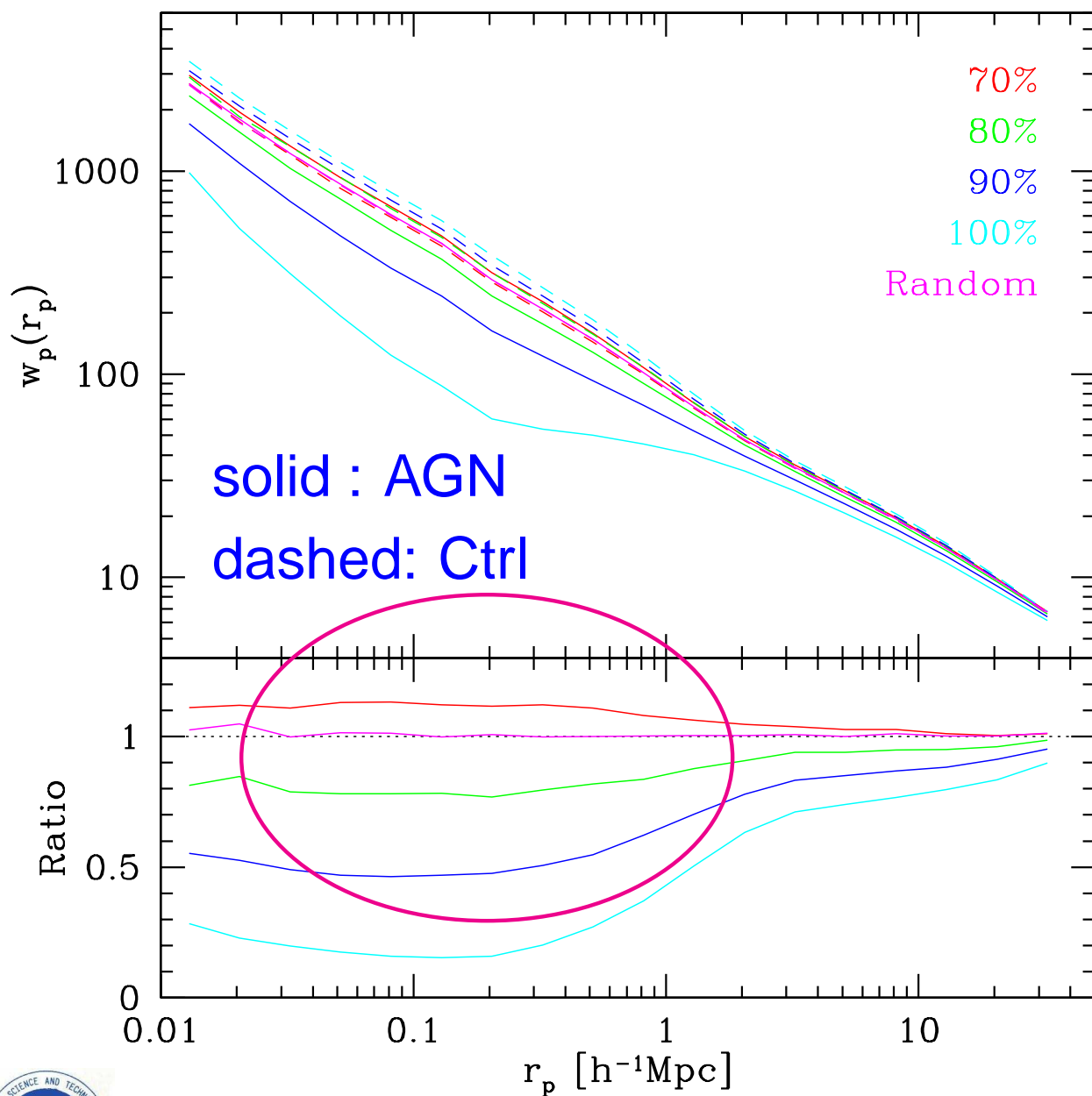
A simple HOD model



- Preferred positions within DM haloes?
- The halo centre?
 - ◆ gas: cool efficiently
 - ◆ mergers: majority
- Mock AGN
 - ◆ f_c : fraction of AGN that are central galaxies
 - ◆ matched by M_* , z



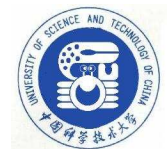
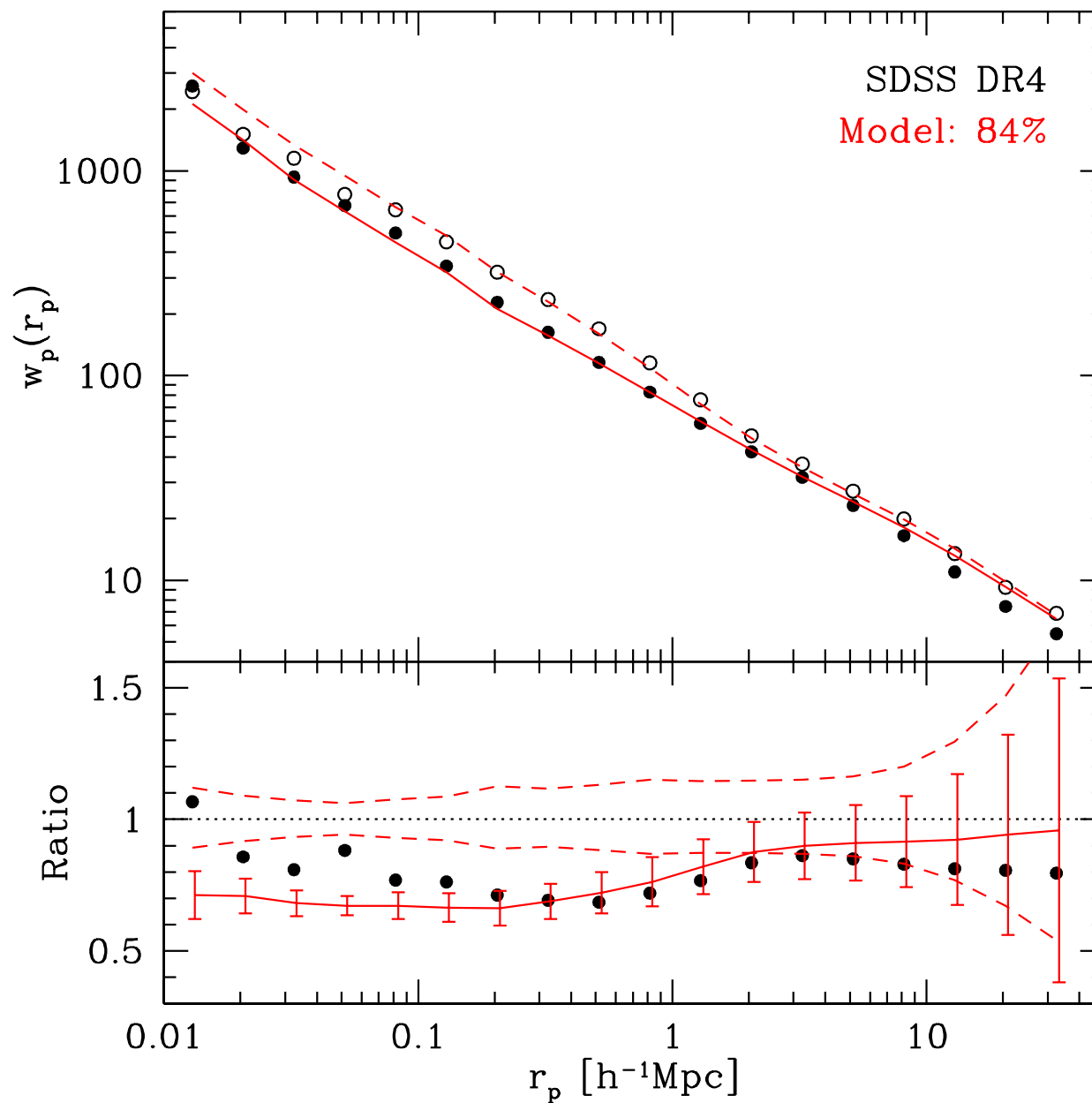
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 - ◆ **gas**: cool efficiently
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- Mock AGN
 - ◆ f_c : fraction of AGN that are central galaxies
 - ◆ matched by M_* , z
- Larger $f_c \longrightarrow$ more pronounced dip



Comparison with the observation



Summary

■ Conclusions

- ◆ **> a few Mpc**: does not differ significantly
- ◆ **100kpc - 1 Mpc**: antibias → halo centers
- ◆ **< 70 kpc**: a small excess of close companions
→ an alternative mechanism rather than interactions

■ Why halo centres?

- ◆ **mergers?**: rather weak evidence
 - ▶ offending satellites already swallowed?
 - ▶ too low intrinsic luminosities?
- ◆ **gas cooling?**
 - ▶ X-ray: also elusive (Benson et al. '00, Pederson et al. '06)
 - ▶ GALEX: extended disks (Kauffmann et al. '06)
 - ▶ Theoretical: disks **form** and **survive for longer periods** at halo centres (Mo, Mao & White '98, Cayatte et al. '94)
- ◆ **dynamical perturbations driven by the dark matter**
→ gas inflows and fuelling of BH (Gao & White '06)



THANK YOU!

