The clustering of narrow-line AGN in the local Universe

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Trigger of AGN activity?

- N-body/hydro simulations:
  - ◆ Interactions: gas ⟶ central regions ⟶ enhanced SF
  - ◆ Some of this gas ⟶ black hole ⟶ 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×2dFGRS (Croom et al. '05), SDSS narrow-line (Wake et al. '04), X-ray (Mullis et al. '05)
  - ◆ Yes: radio-lound (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[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, $<z> \approx 0.1$
  - ordered by decreasing L[O III]/$M_\bullet$
    "powful": top 25%; "weak": bottom 25%

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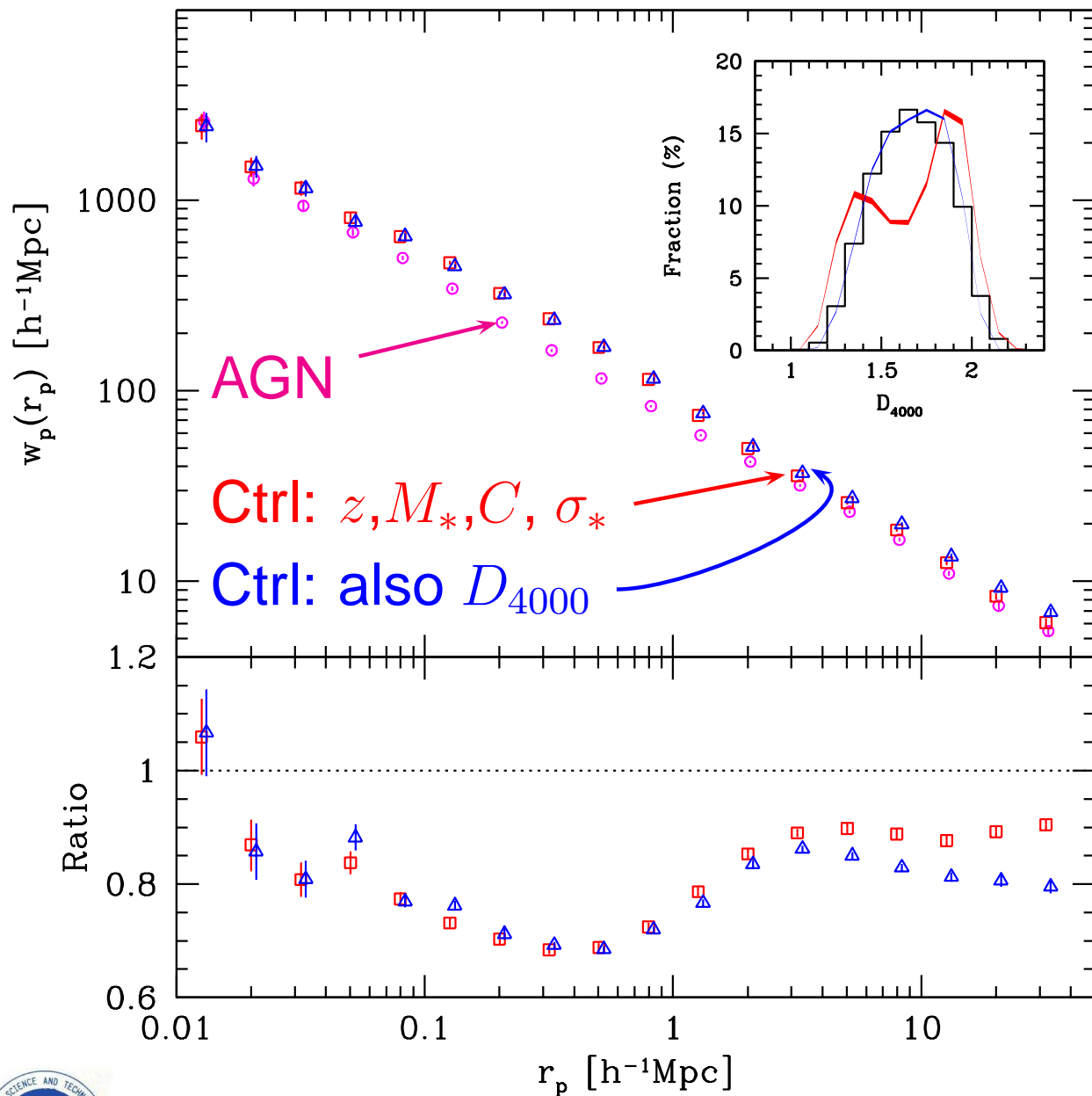 - Two sets, each consists of 20 samples
  - $\Delta cz < 500$ km s^{-1}, $\Delta \log M_* < 0.1$, $\Delta \sigma_* < 20$ km s^{-1} , $\Delta C < 0.1$
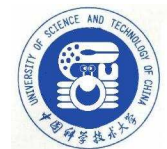 - in addition, $\Delta D_n(4000) < 0.05$

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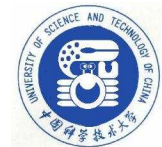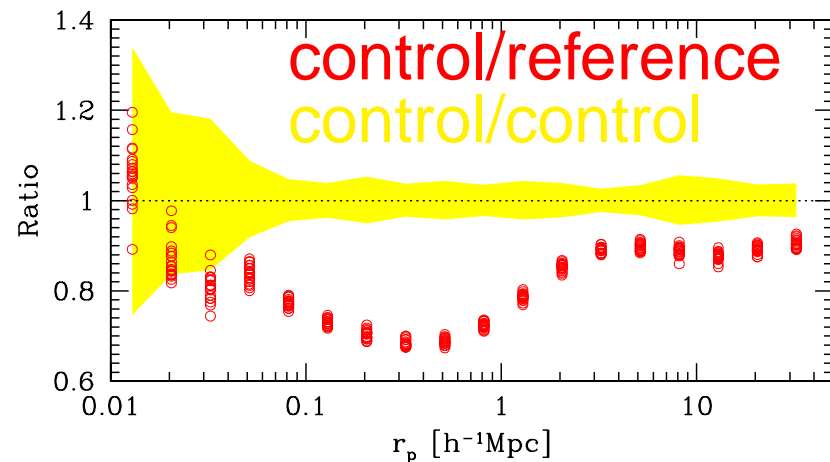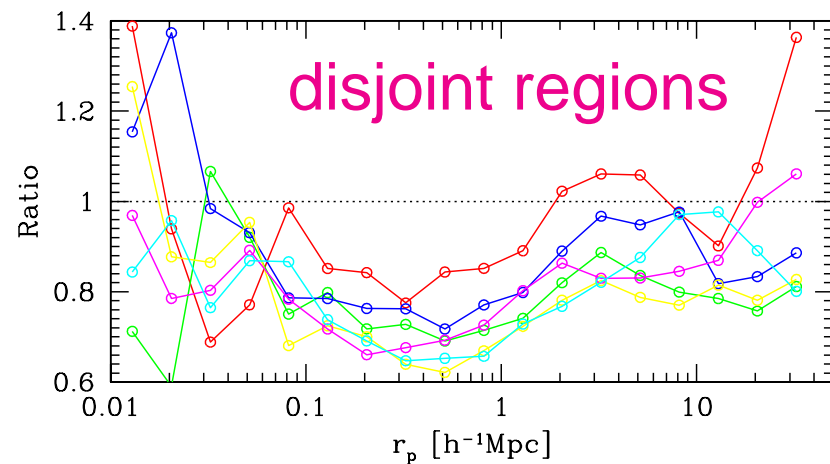   counts of close neighbours around AGN

AGN bias

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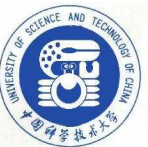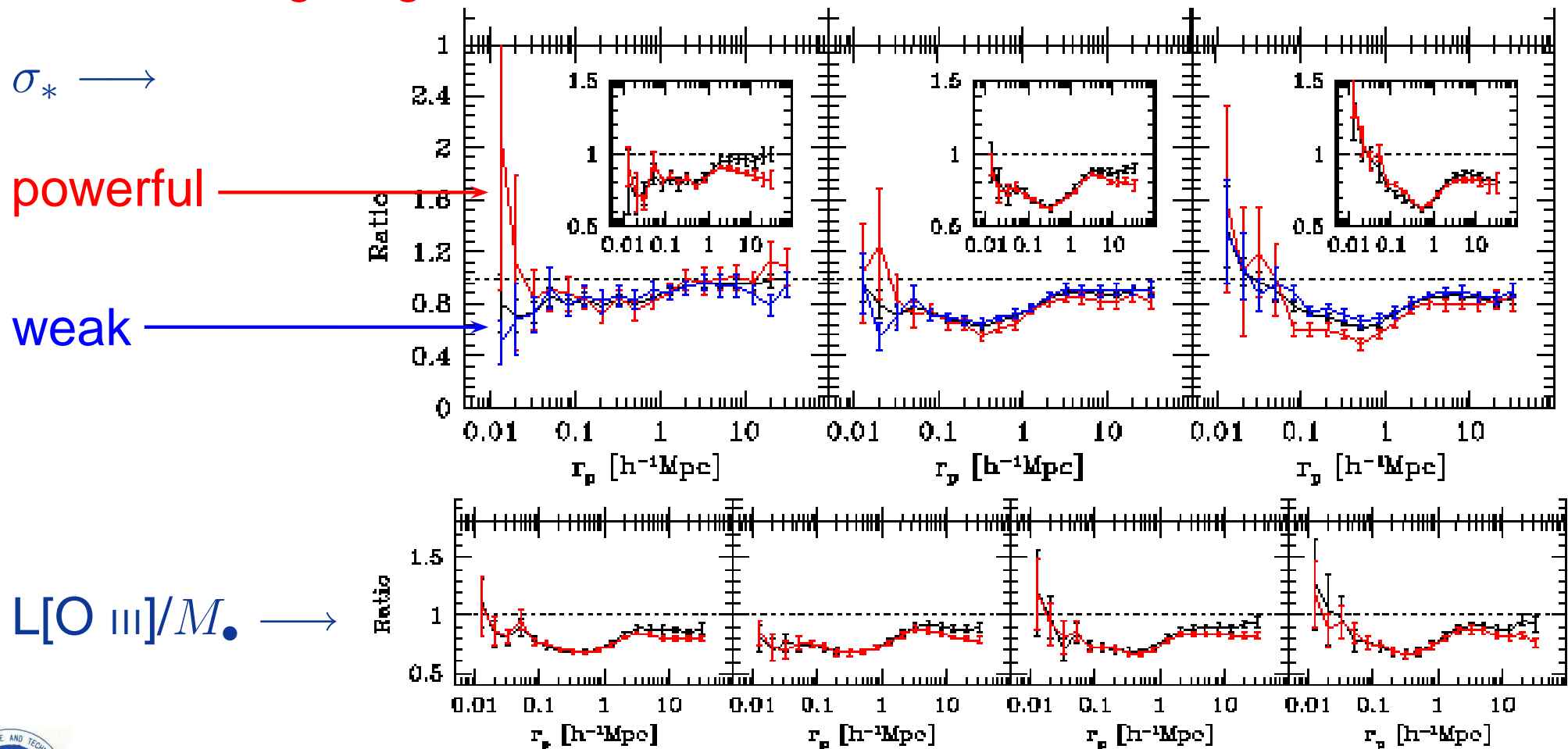- A "dip" at 100kpc - 1Mpc
- truly robust?

AGN bias
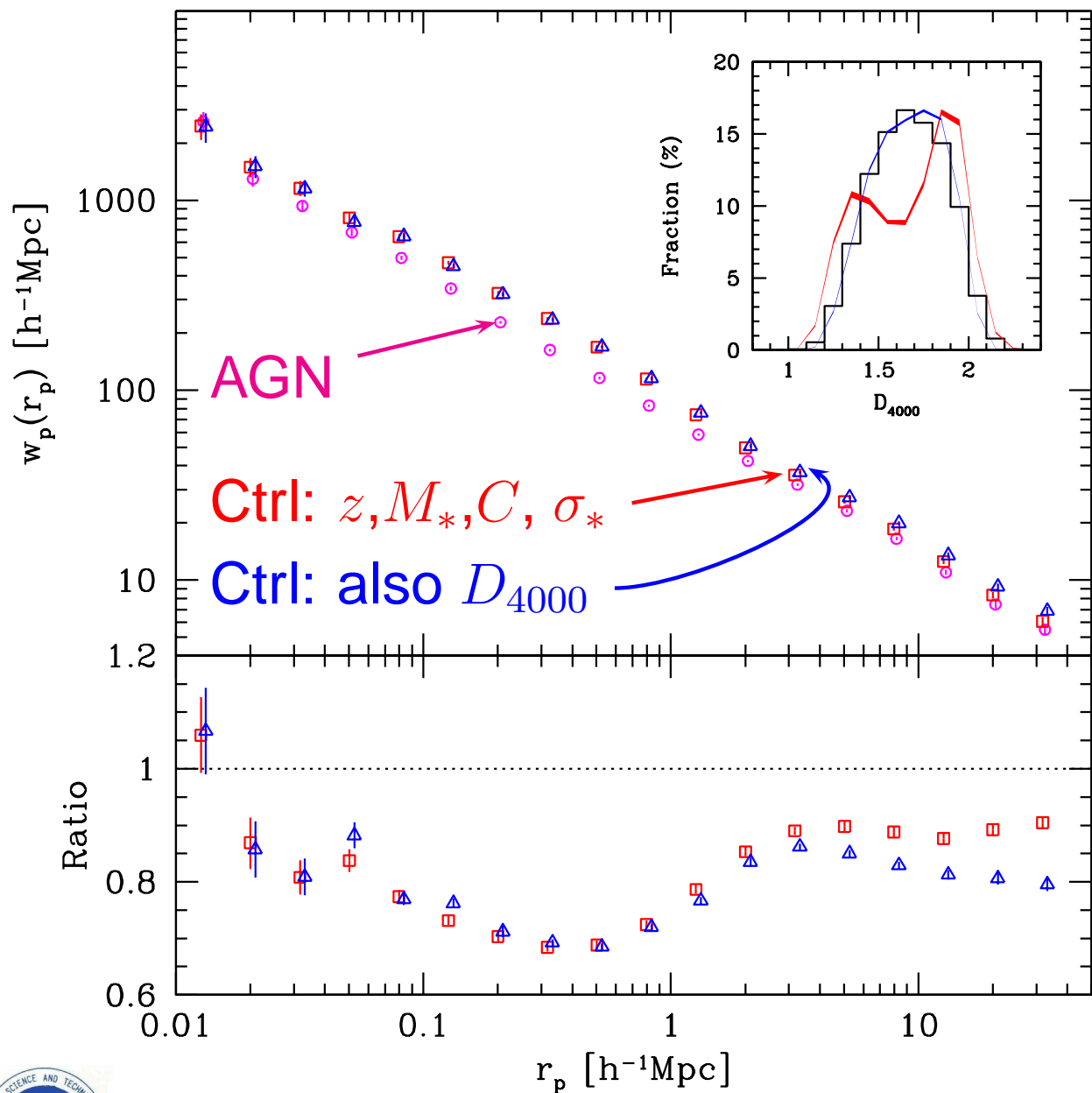
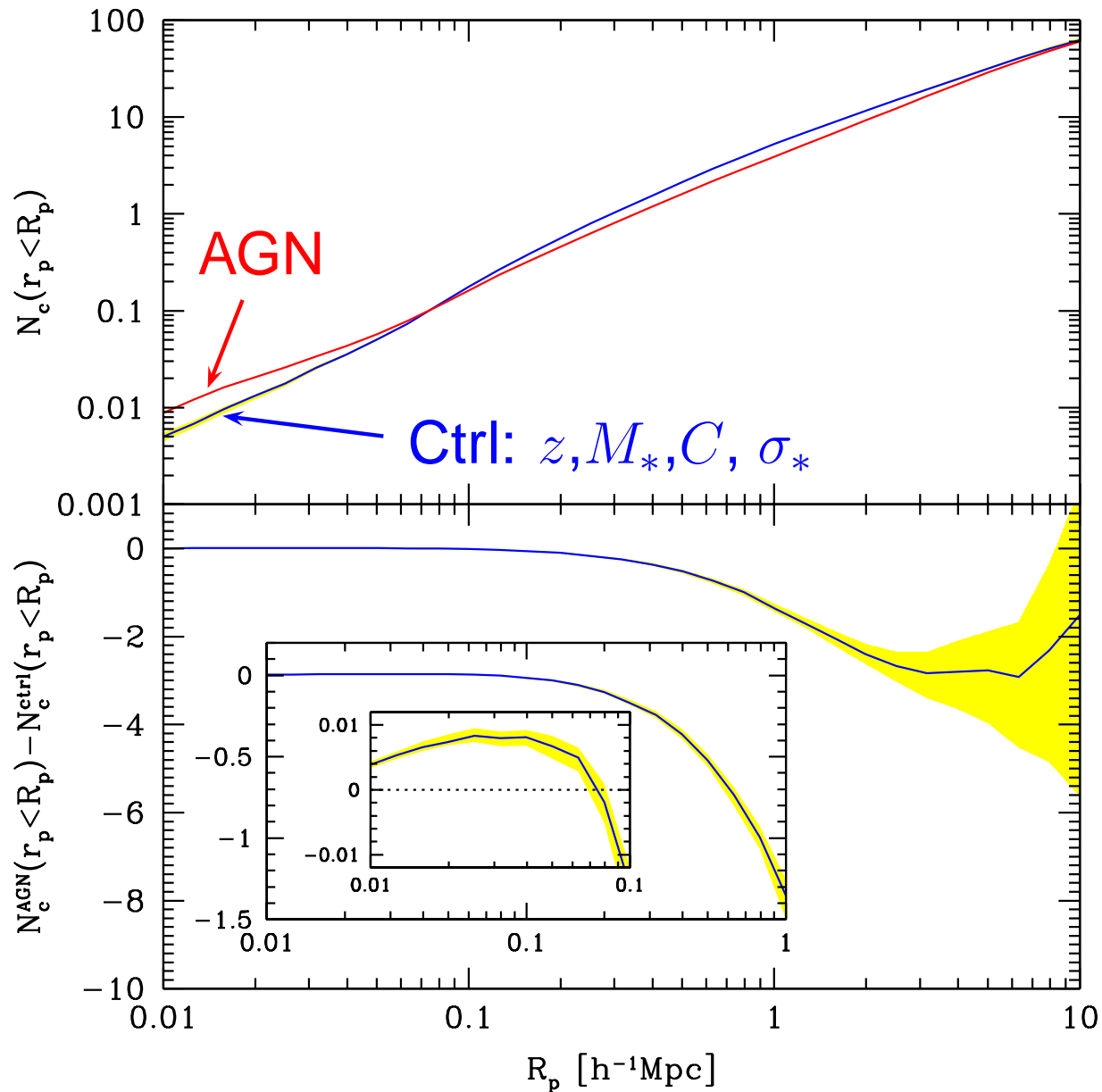- A scale-dependent bias
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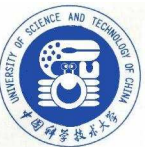- truly robust? !

Dependence on BH mass and AGN power

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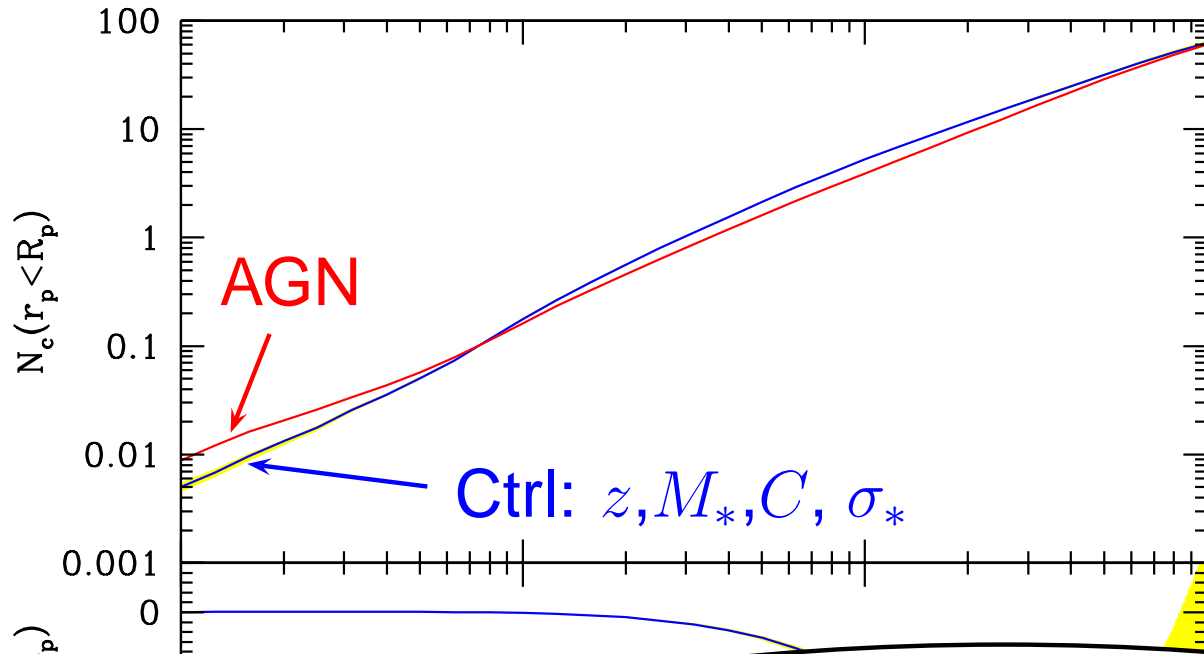- $r_p < 0.1$Mpc: more powerful, more strongly clustered
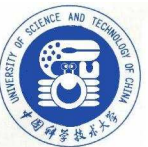- NOT of high significance

Close neighbour counts
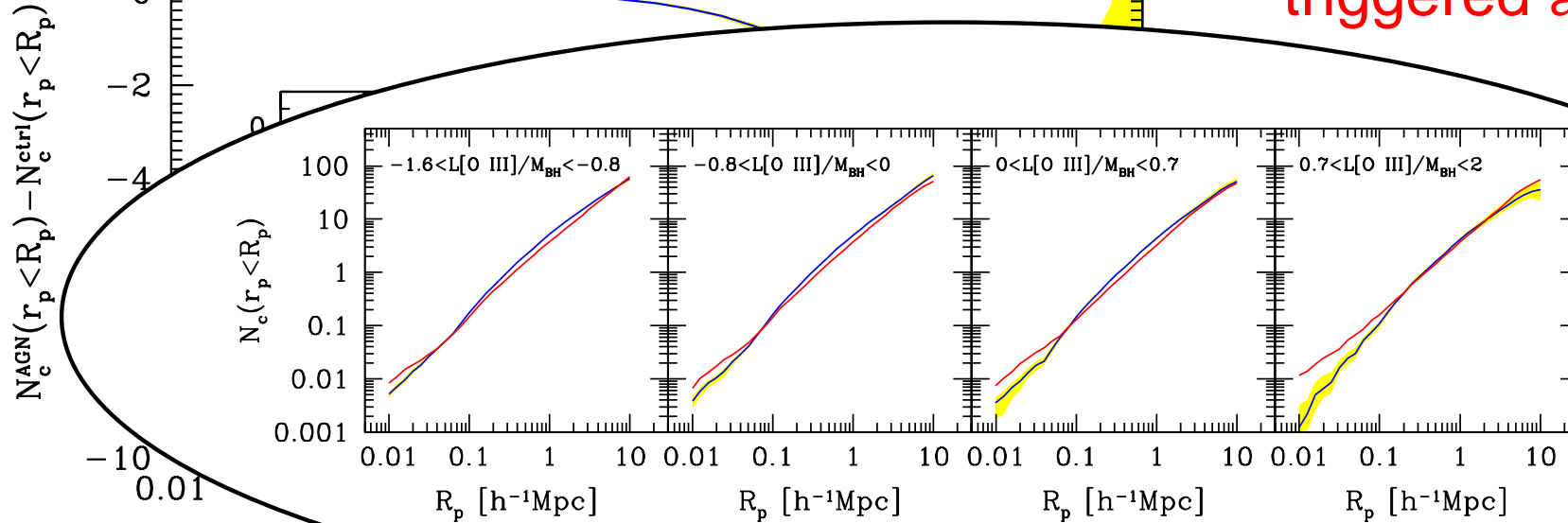

- A small excess at <70kpc
  - ◆ $\sim 1\%$ AGN has an additional neighbour

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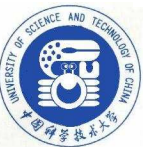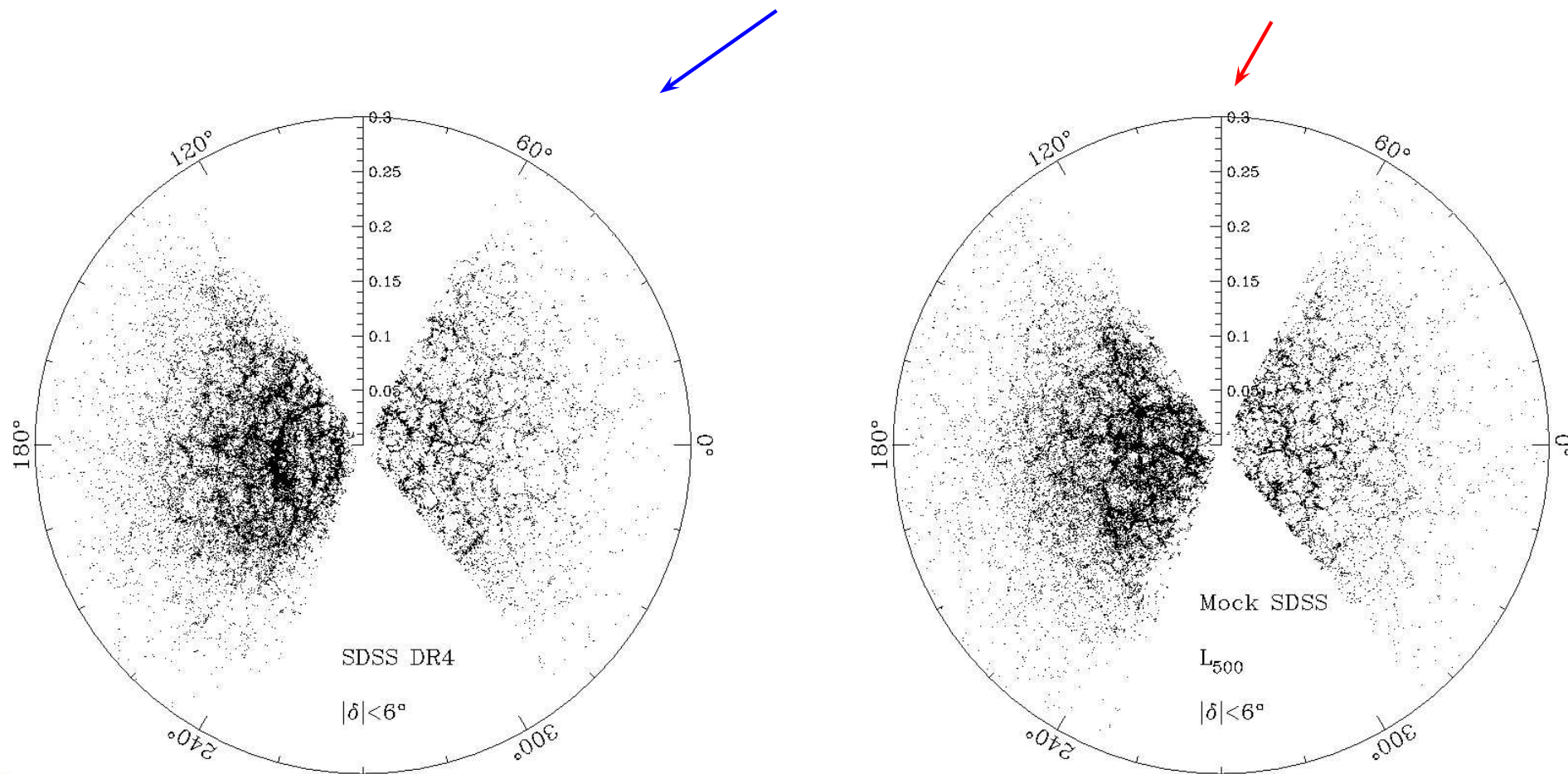

- A small excess at <70kpc
  - ♦ $\sim 1\%$ AGN has an additional neighbour
- The excess increases with L[O III]/$M_\bullet$
  - ♦ < a few percent
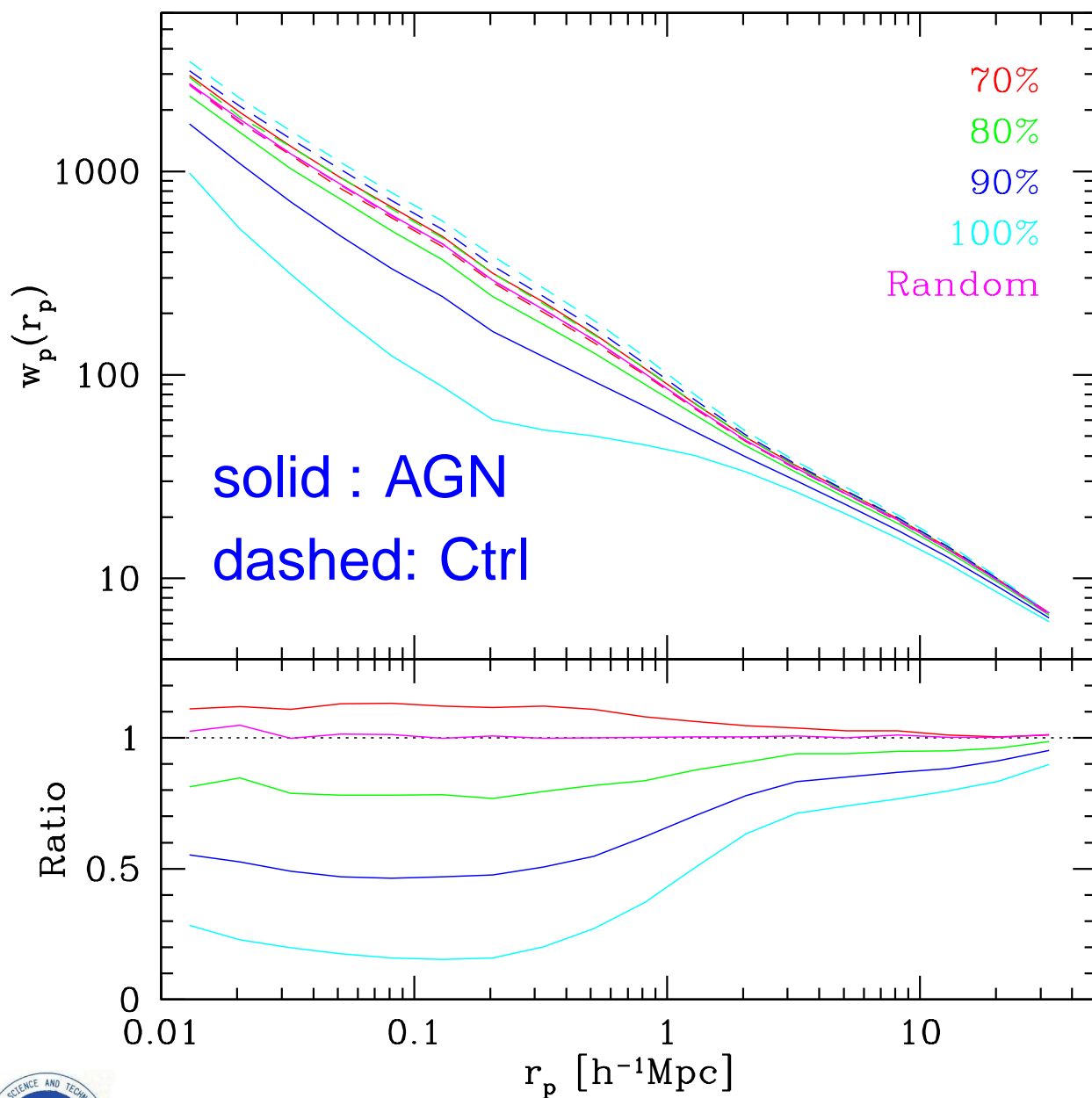- CAVEAT: triggered *after* merged?

Constructing mock catalogues

- Millennium Simulation (Springel et al. 2005)

- Semi-analytic models (SAM, Croton et al. 2006)

- The same selections as the SDSS DR4 $\longrightarrow$ Mock catalogues

A simple HOD model

solid : AGN
dashed: Ctrl

70%
80%
90%
100%
Random

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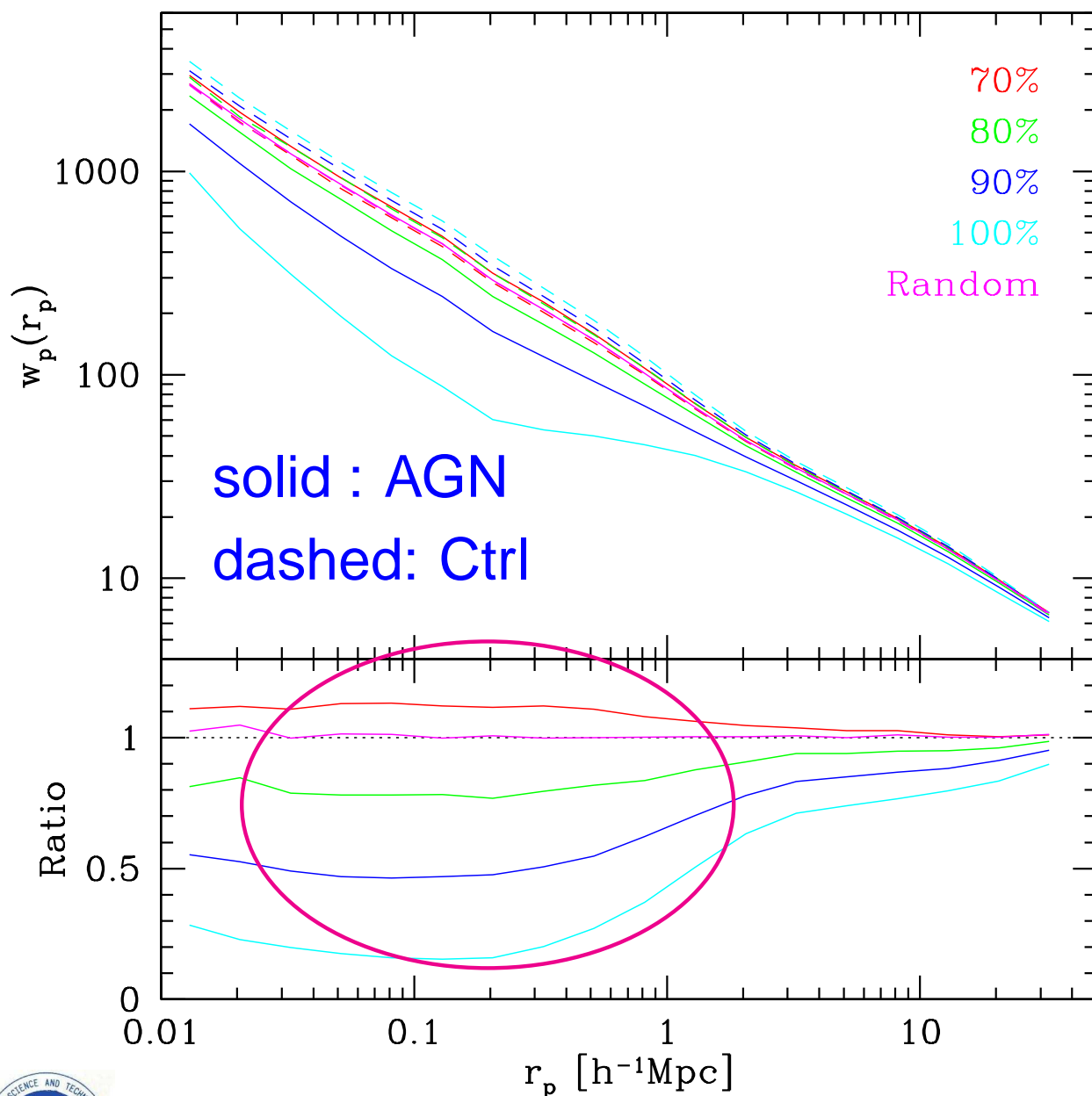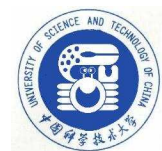 - matched by M_* , z

A simple HOD model

- **Preferred positions within DM haloes?**
- **The halo centre?**
  - ◆ **gas**: cool efficiently
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- **Mock AGN**
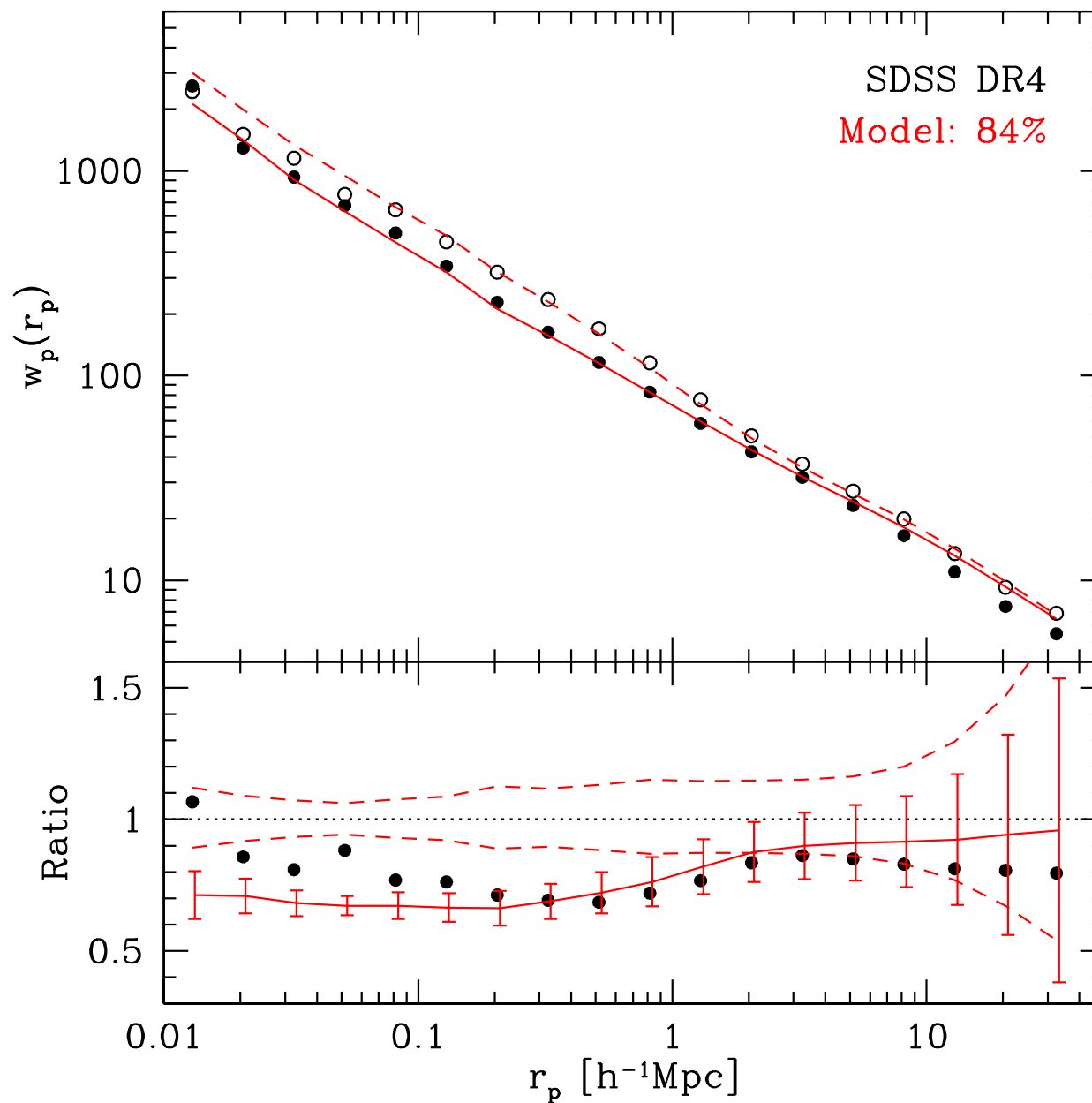 - ◆ f_c: fraction of AGN that are central galaxies
  - ◆ matched by M_*, z
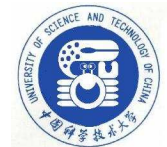- **Larger $f_c \longrightarrow$ more pronounced dip**

Comparison with the observation

Summary

- **Conclusions**
  - ◆ $>$ a few Mpc: does not differ significantly
  - ◆ 100kpc - 1 Mpc: antibias $\longrightarrow$ halo centers
  - ◆ $<$ 70 kpc: a small excess of close companions $\longrightarrow$ 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 $\longrightarrow$ gas inflows and fuelling of BH (Gao & White '06)

THANK YOU!