The baryon acoustic oscillation peak is a flexible ruler

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Universe $=$ space–time


ΛCDM

$\Lambda = 0$

?
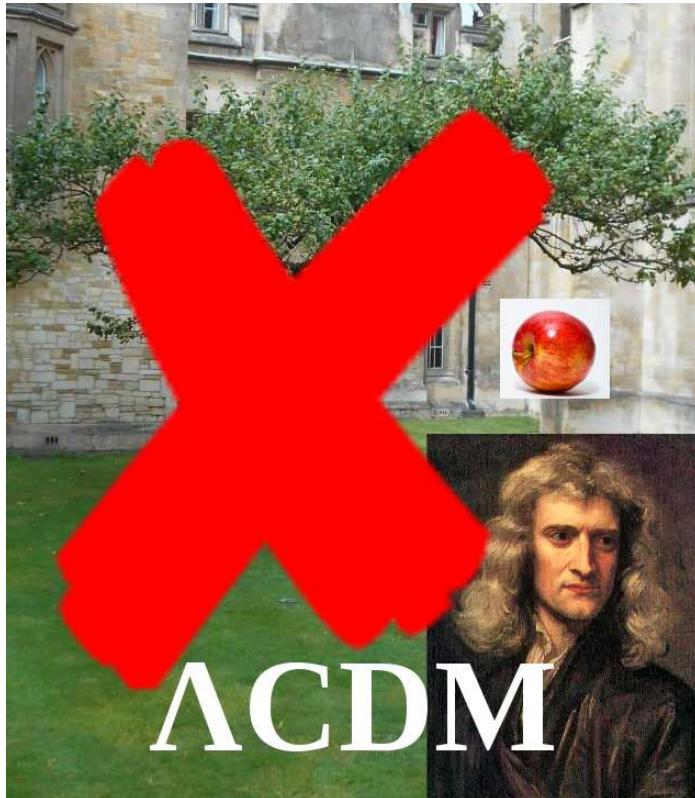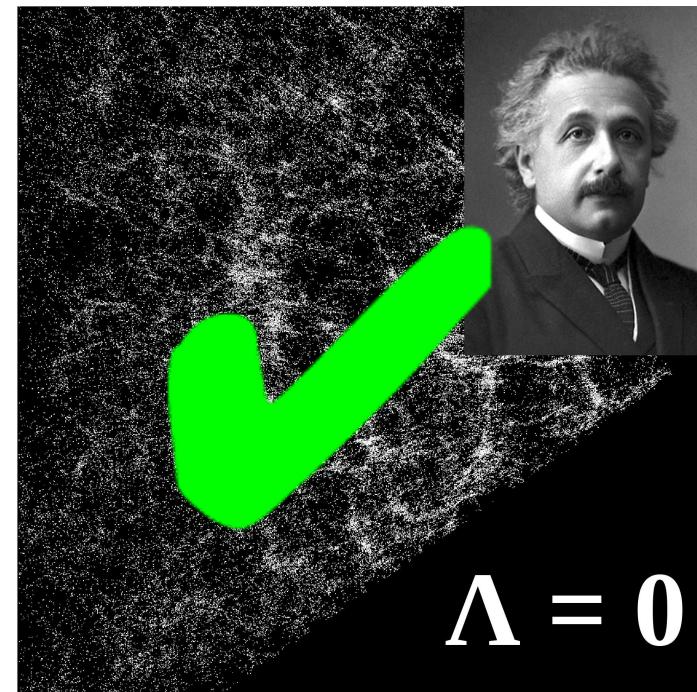
initial conds: ΛCDM proxy

obsvns $\Rightarrow H_0^{\text{eff}}, H_1^{\text{EdS}}, H_0^{\text{EdS}} = 67.74, 37.7, 47.24$ km/s/Mpc
(arXiv:1608.06004 Roukema+2016)
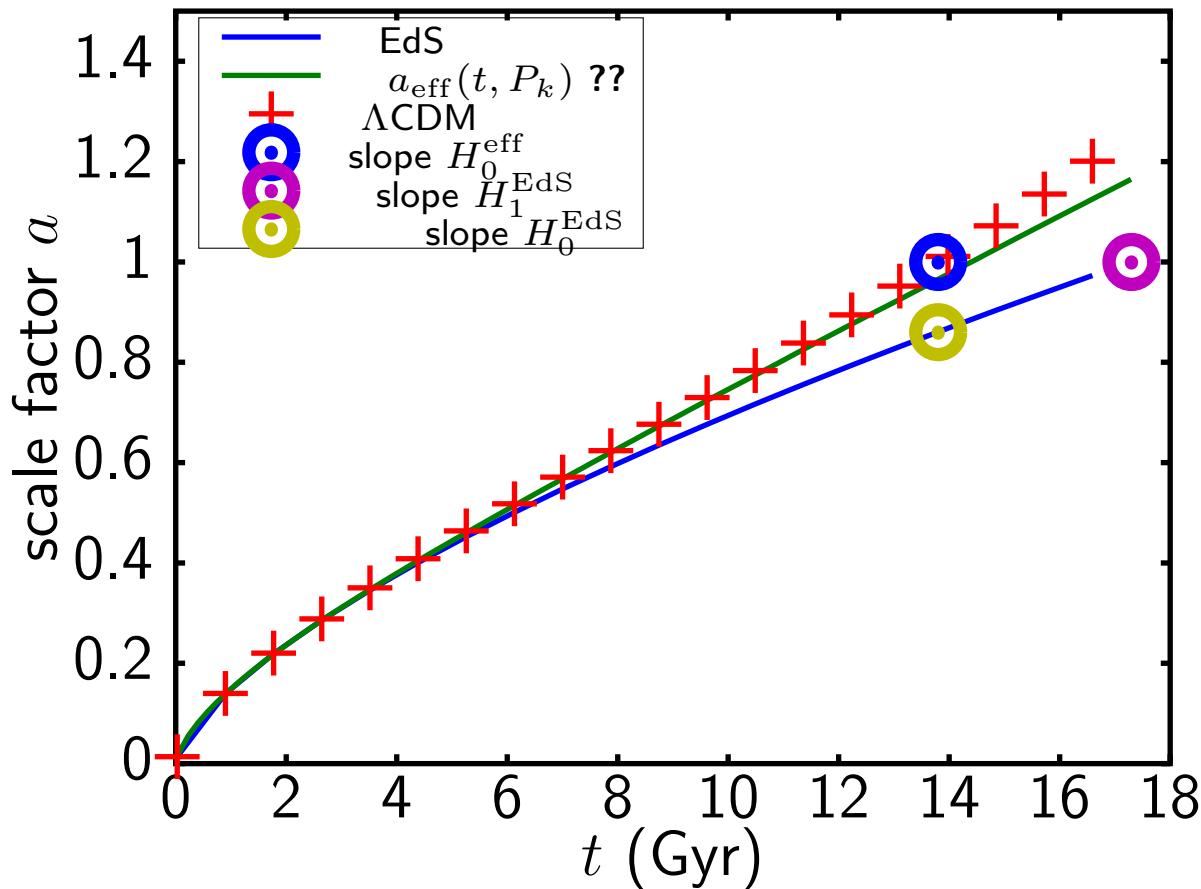
EdS +
VQZA$(P_k, L_\mathcal{D})$
$\Rightarrow$
$\sim \Lambda$CDM ?

RZA = relativistic Zel'dovich approximation (PRD arXiv:1303.6193)
VQZA: N-body init condns + RZA : arXiv:1706.06179

DE-free cosmo params

- key parameters of GR, DE-free cosmology are observationally realistic:

$$\frac{2}{3} \approx \frac{H_0^{\text{EdS}}}{H_0^{\text{eff}}} \gtrsim \frac{H_1^{\text{EdS}}}{H_0^{\text{eff}}} \approx \sqrt{\Omega_{\text{m0}}^{\text{eff}}} = \sqrt{1 - \Omega_{\mathcal{R}0}^{\text{eff}} - \Omega_{\mathcal{Q}0}^{\text{eff}}} \approx \frac{1}{2} \gtrsim \frac{H_{\text{pec,0}}^{\text{void}}}{H_0^{\text{eff}}} \approx \frac{1}{3}$$

- ΛCDM proxy: $a_{\text{EdS0}} = 0.860 \pm 0.007$
  today's scale factor only needs to be 14% super-EdS

- Roukema, Mourier, Buchert & Ostrowski (2017) A&A 598, A111
 Roukema, Ostrowski, Buchert (2013) JCAP, 10, 043

BAO peak—SDSS DR7

subset	D	R	ref
LRGs:			
dim	61899	3082871	Kazin2010 arXiv:0908.2598
bright	30272	1521736	Kazin2010
superclusters:			
dim + bright	235		NH2013 arXiv:1310.2791
$z < 0.6$	2701		Liivamägi arXiv:1012.1989
voids:			
dim + bright	83		NH2013

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$$\xi(s) = \frac{\text{DD}(s)/N_{\text{DD}} - 2\text{DR}(s)/N_{\text{DR}} + \text{RR}(s)/N_{\text{RR}}}{\text{RR}(s)/N_{\text{RR}}}$$

BAO peak—SDSS DR7
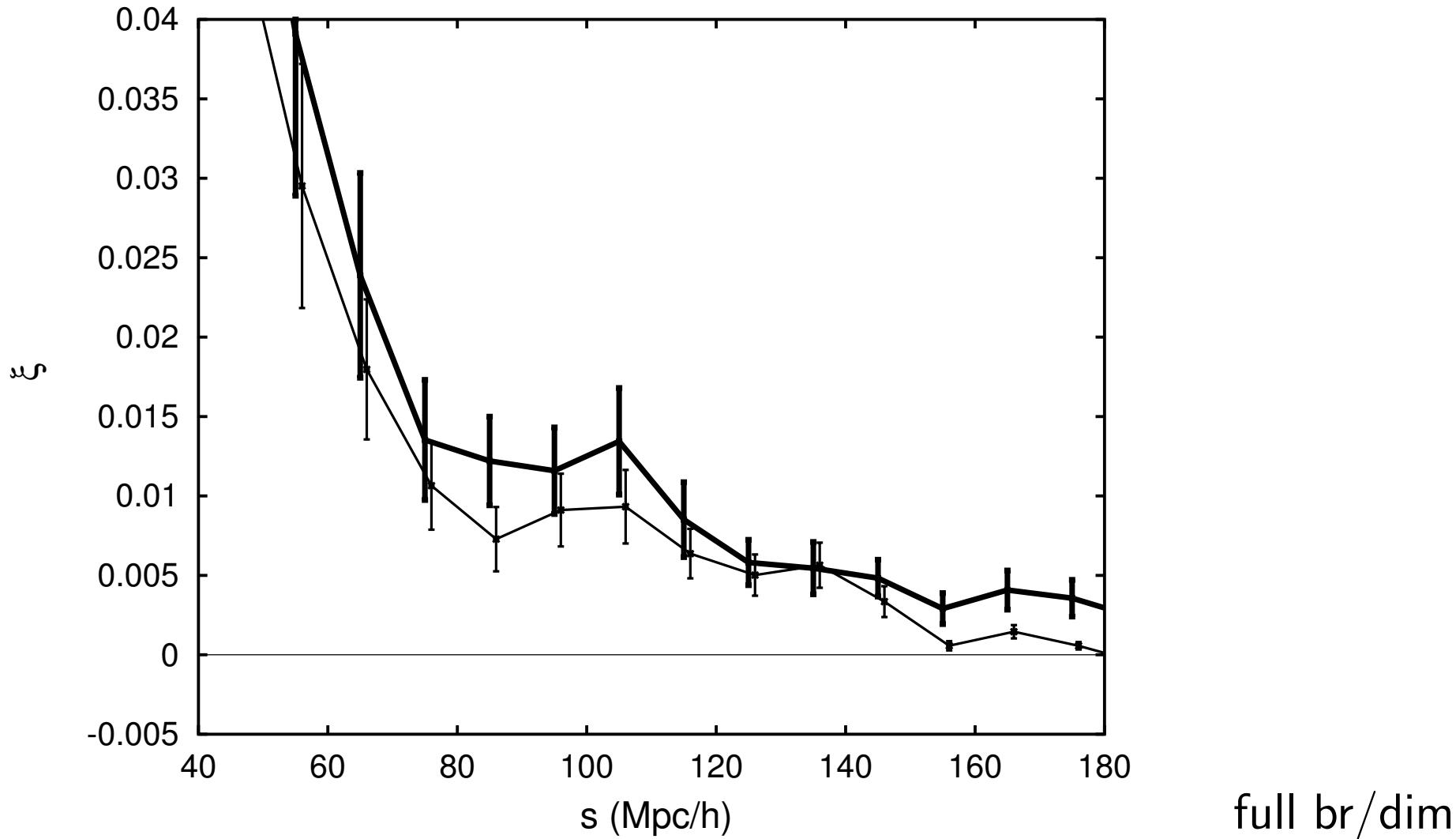
full br/dim

BAO peak—SDSS DR7
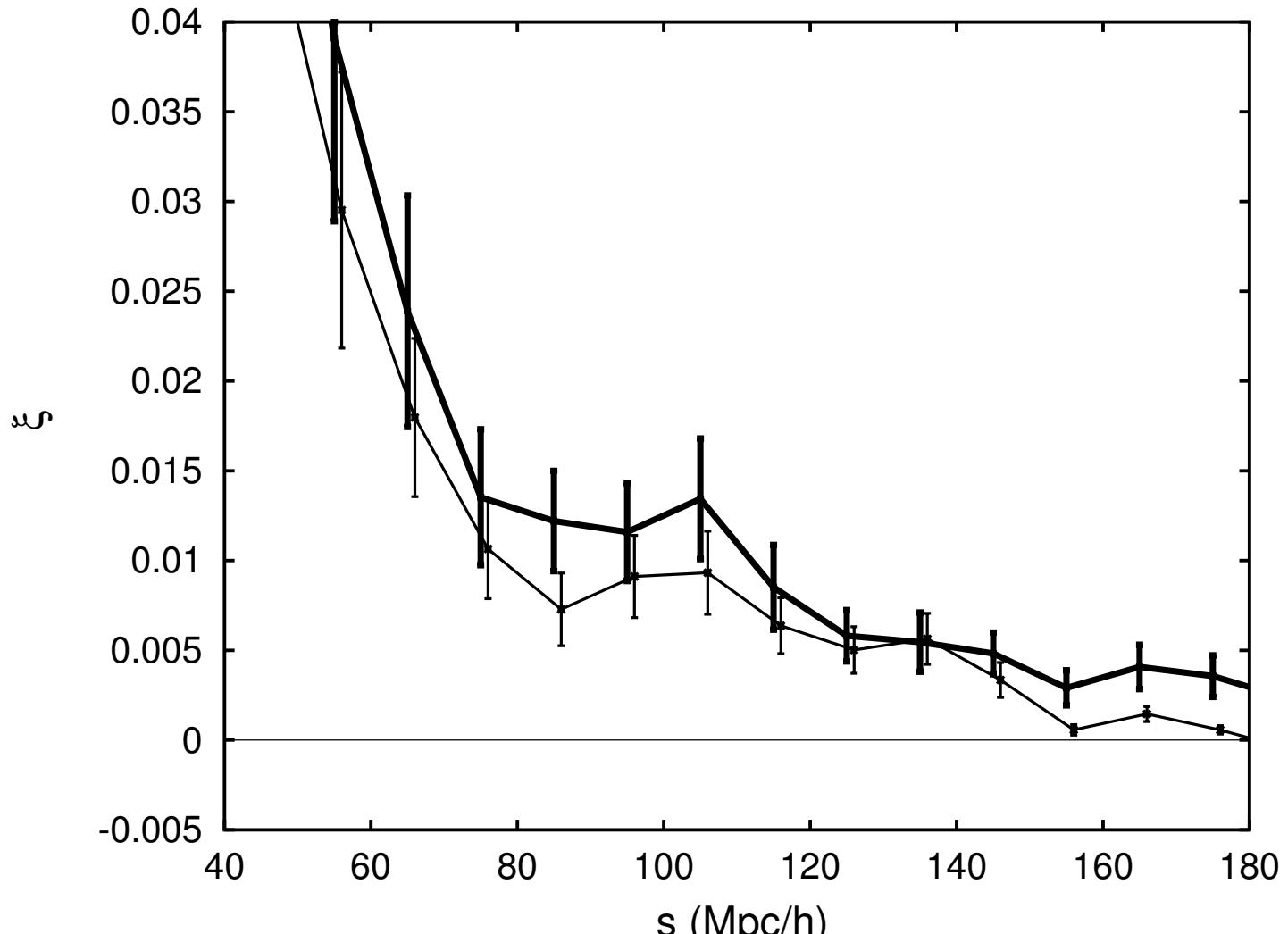
peak better defined in bright (bigger scale) sample

full br/dim
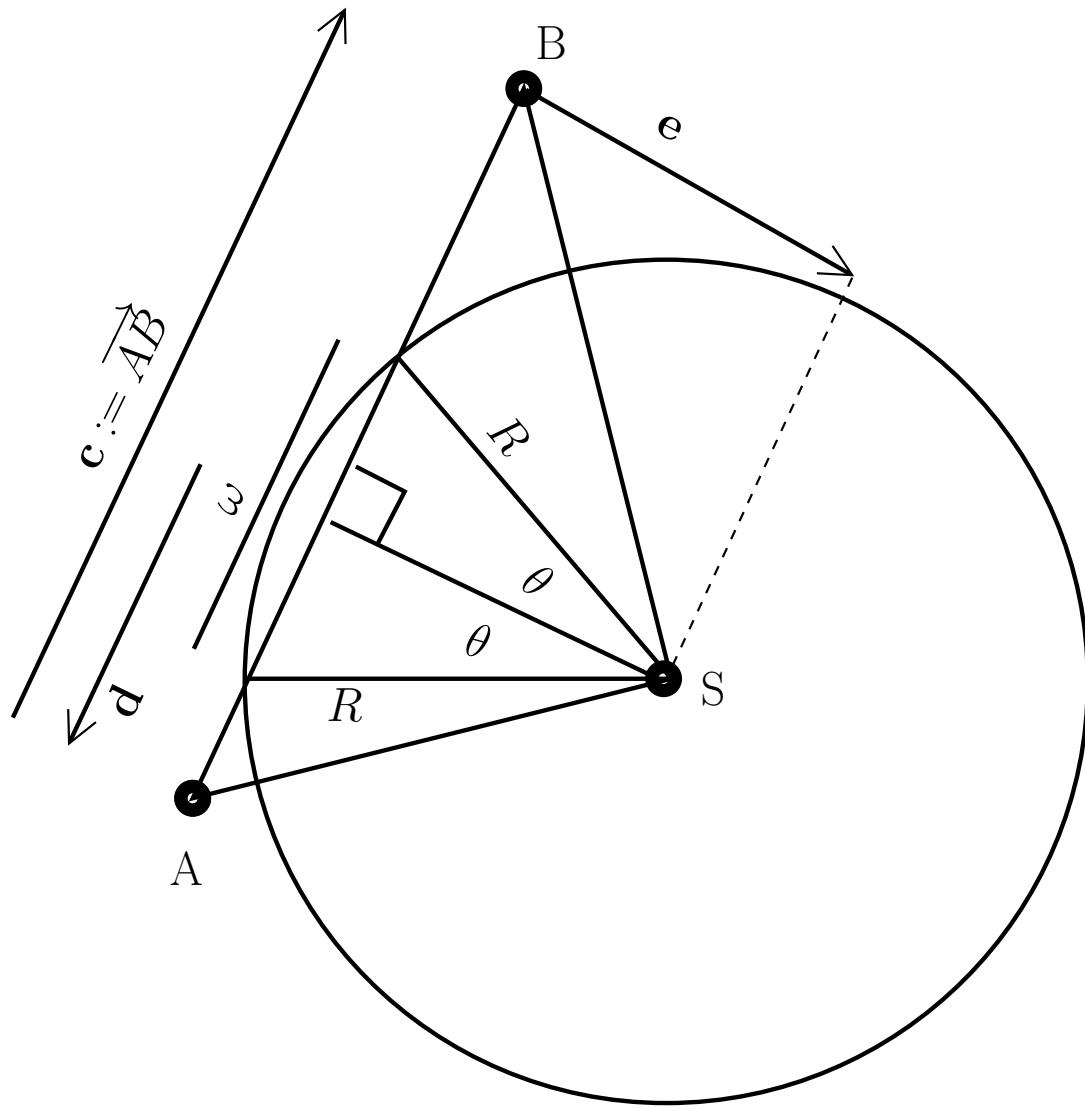
overlap defn

BAO peak: NH superclusters
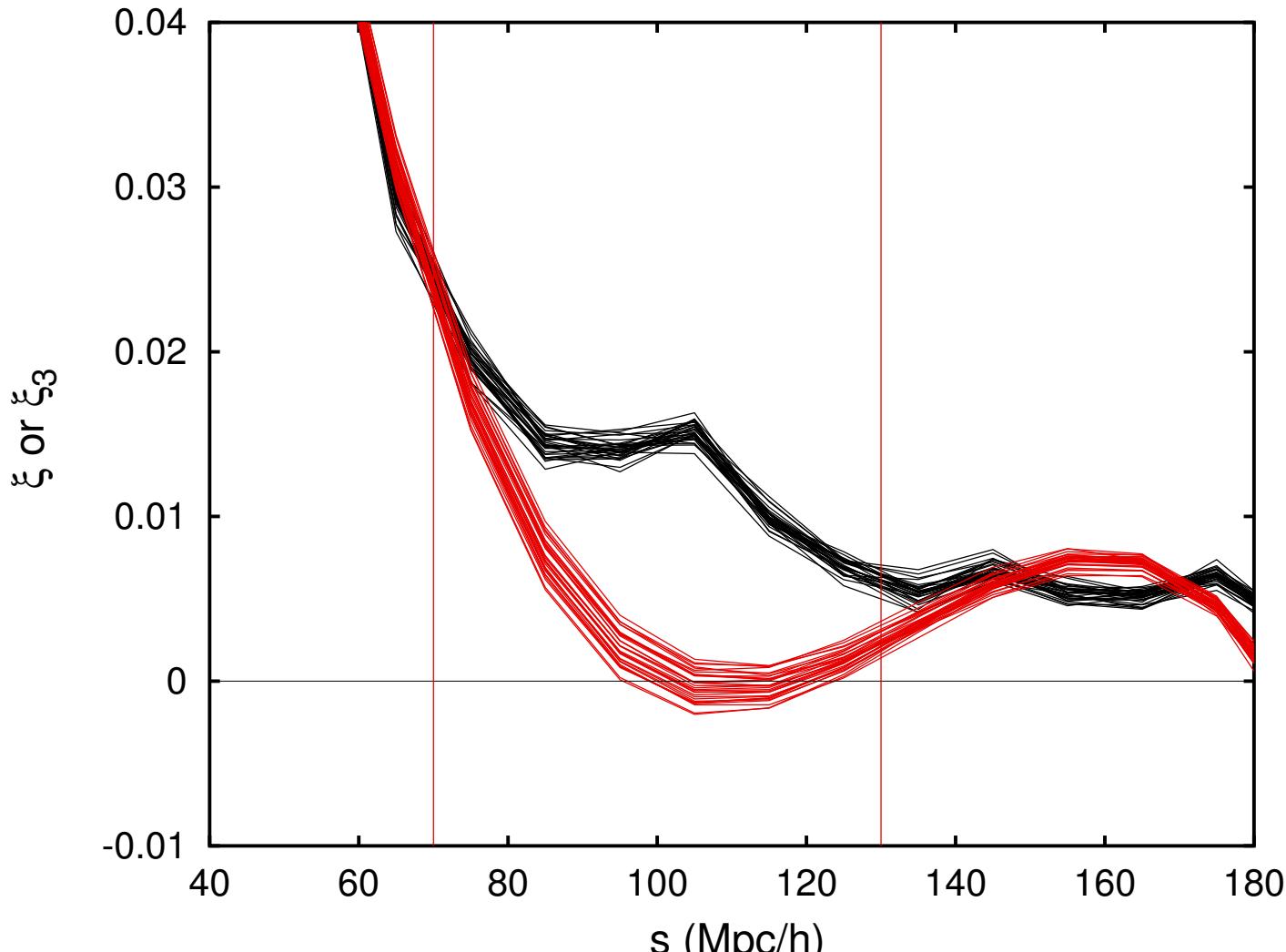

cubical fit $(< 70h^{-1}$ Mpc$) \cup (> 130h^{-1}$ Mpc$)$

BAO peak: NH superclusters

full
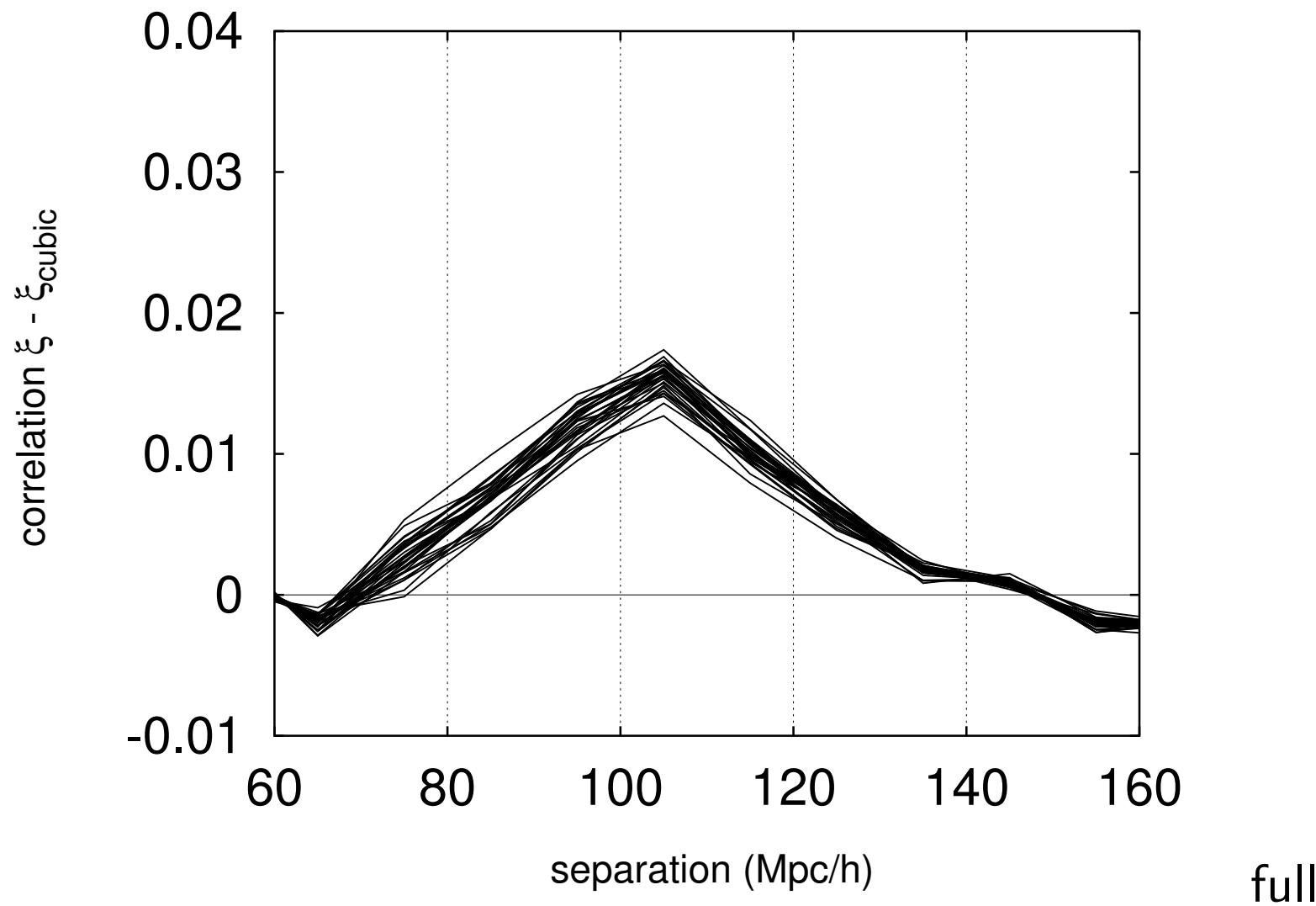
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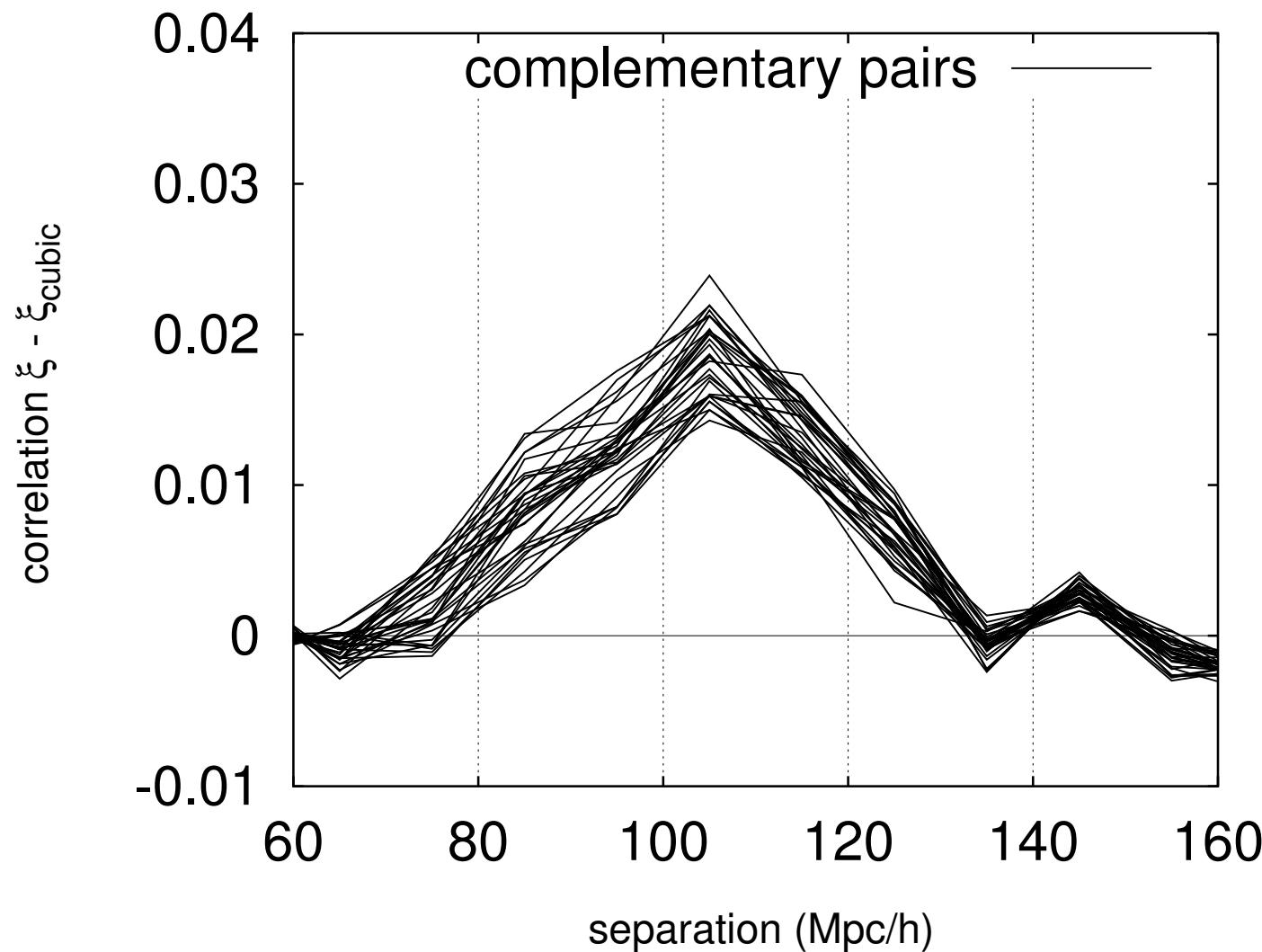
subset: LRG pairs that do **not** overlap with superclusters

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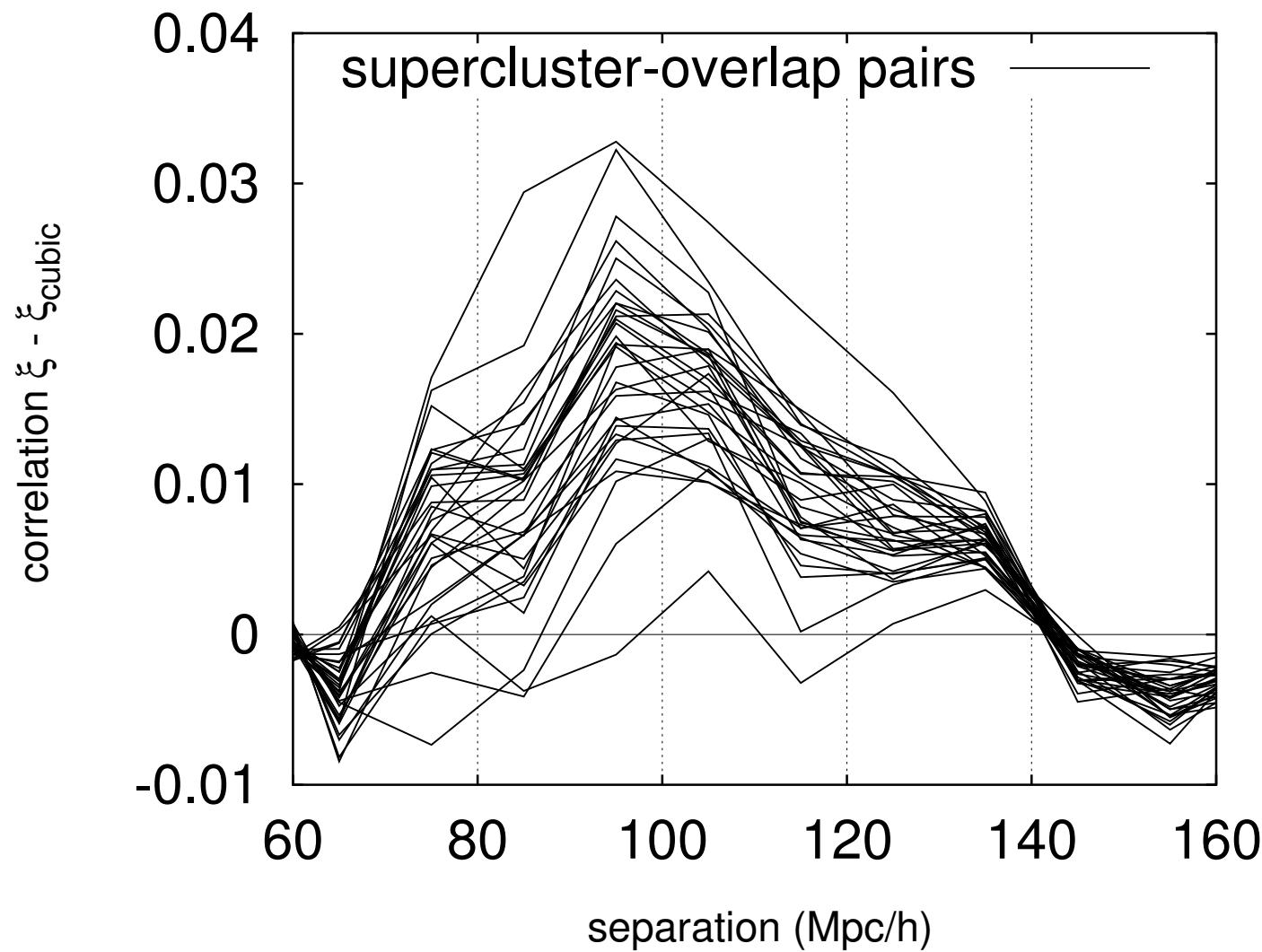
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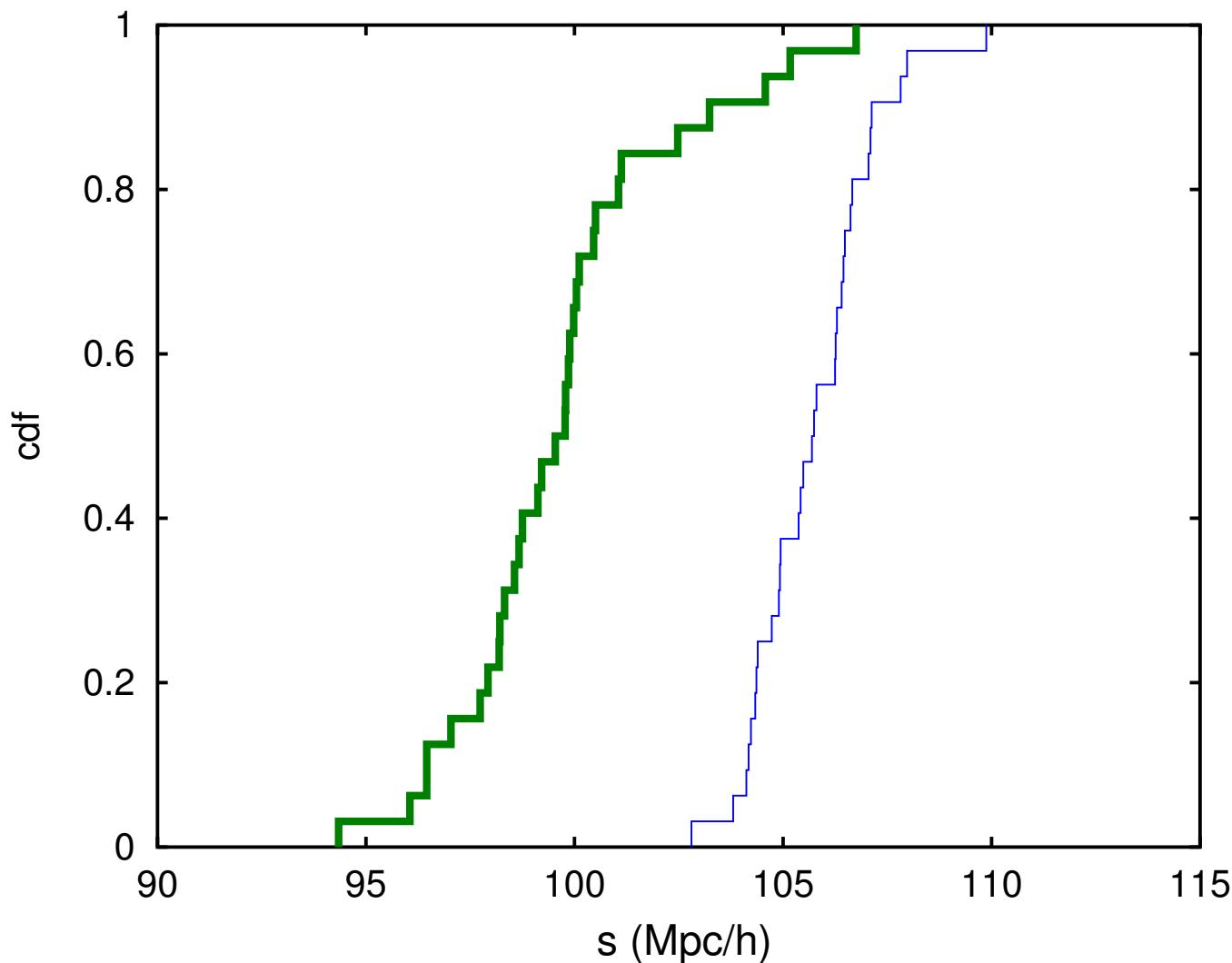
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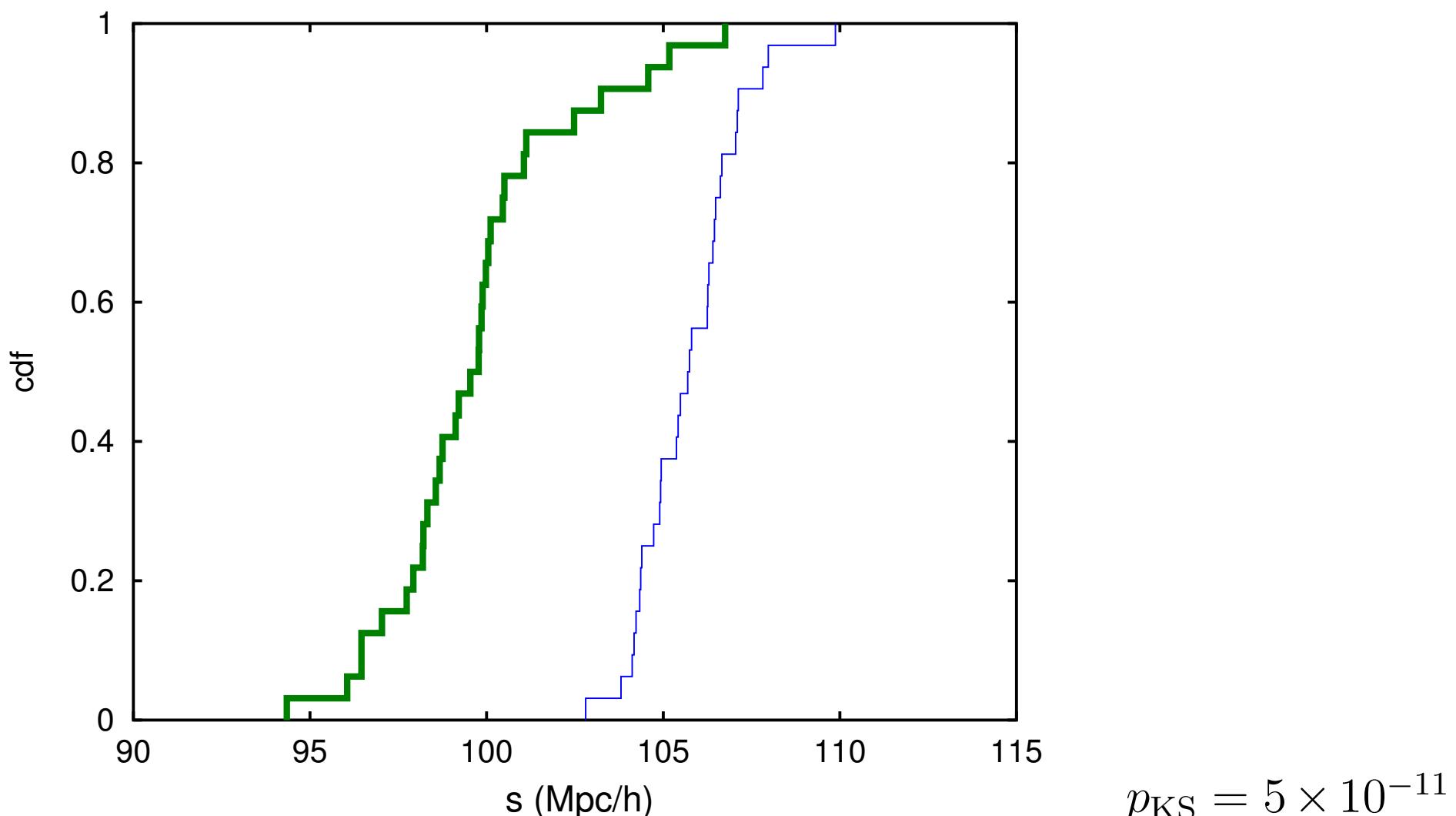
$p_{\mathrm{KS}} = 5 \times 10^{-11}$

environment-dependent BAO peak shift: 6% for SDSS DR7 LRGs

Roukema, Buchert, Ostrowski & France 2015 MNRAS, 448, 1660
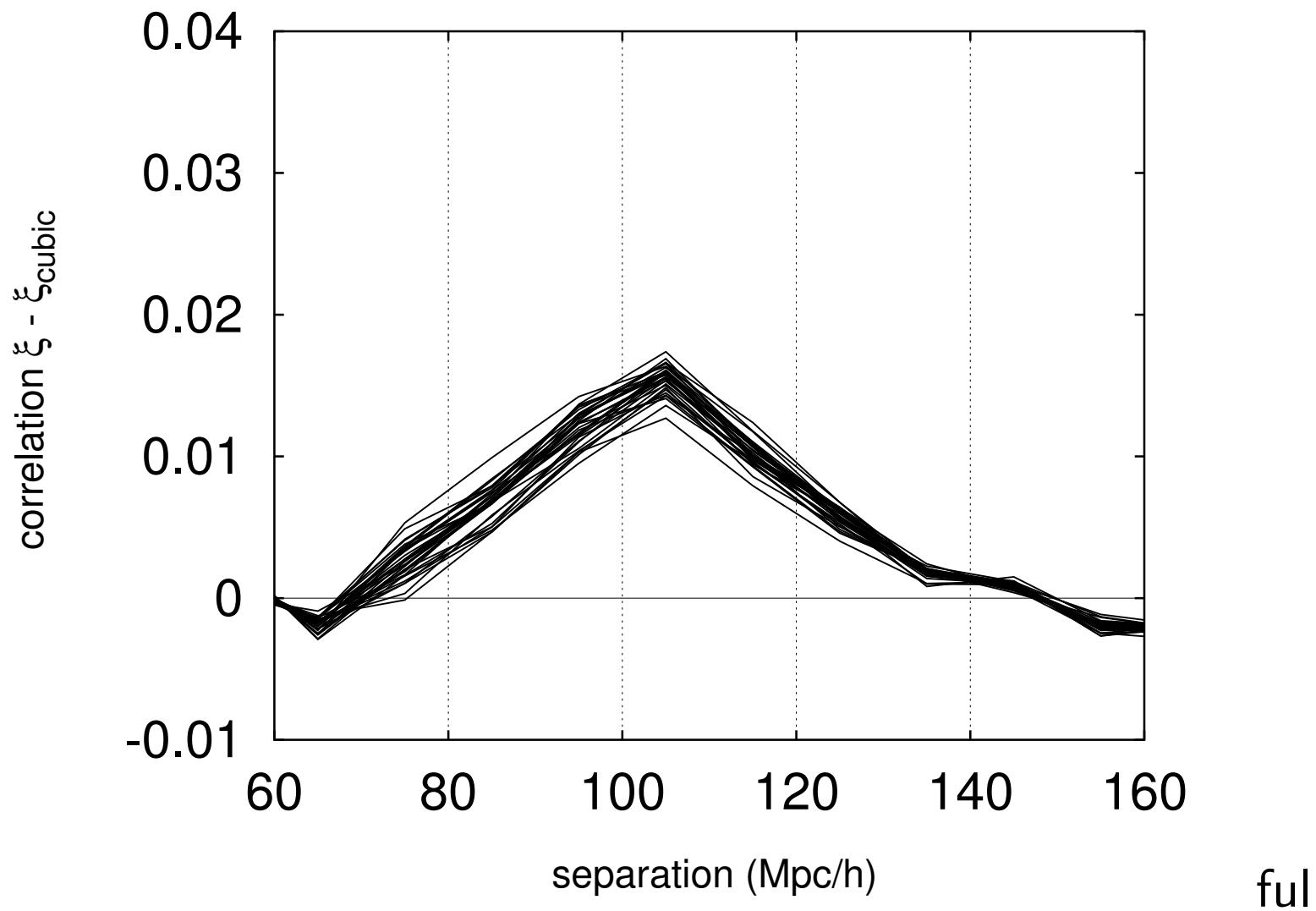
BAO peak: NH voids

full

BAO peak: NH voids

NH non-voids
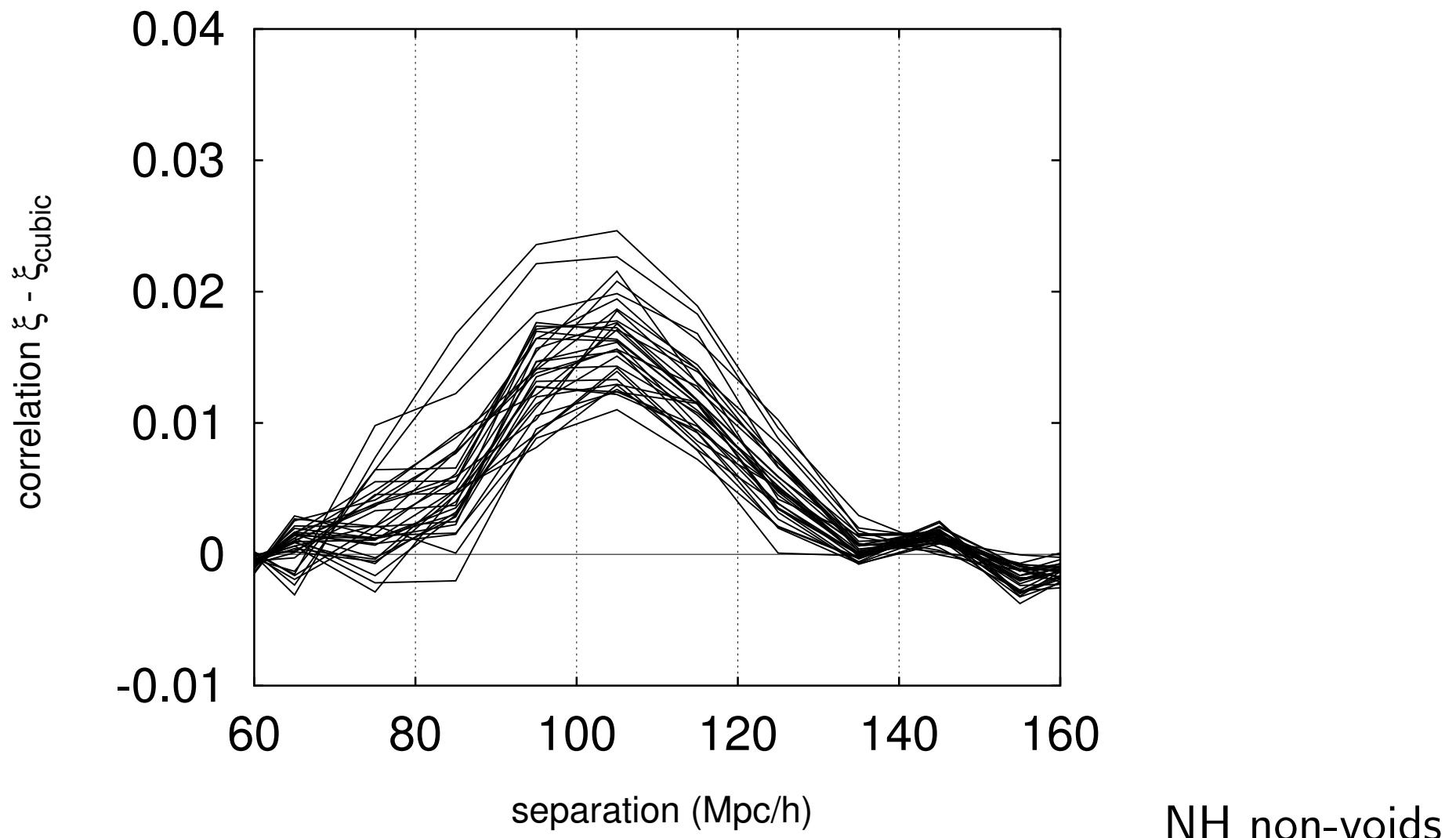
BAO peak: NH voids
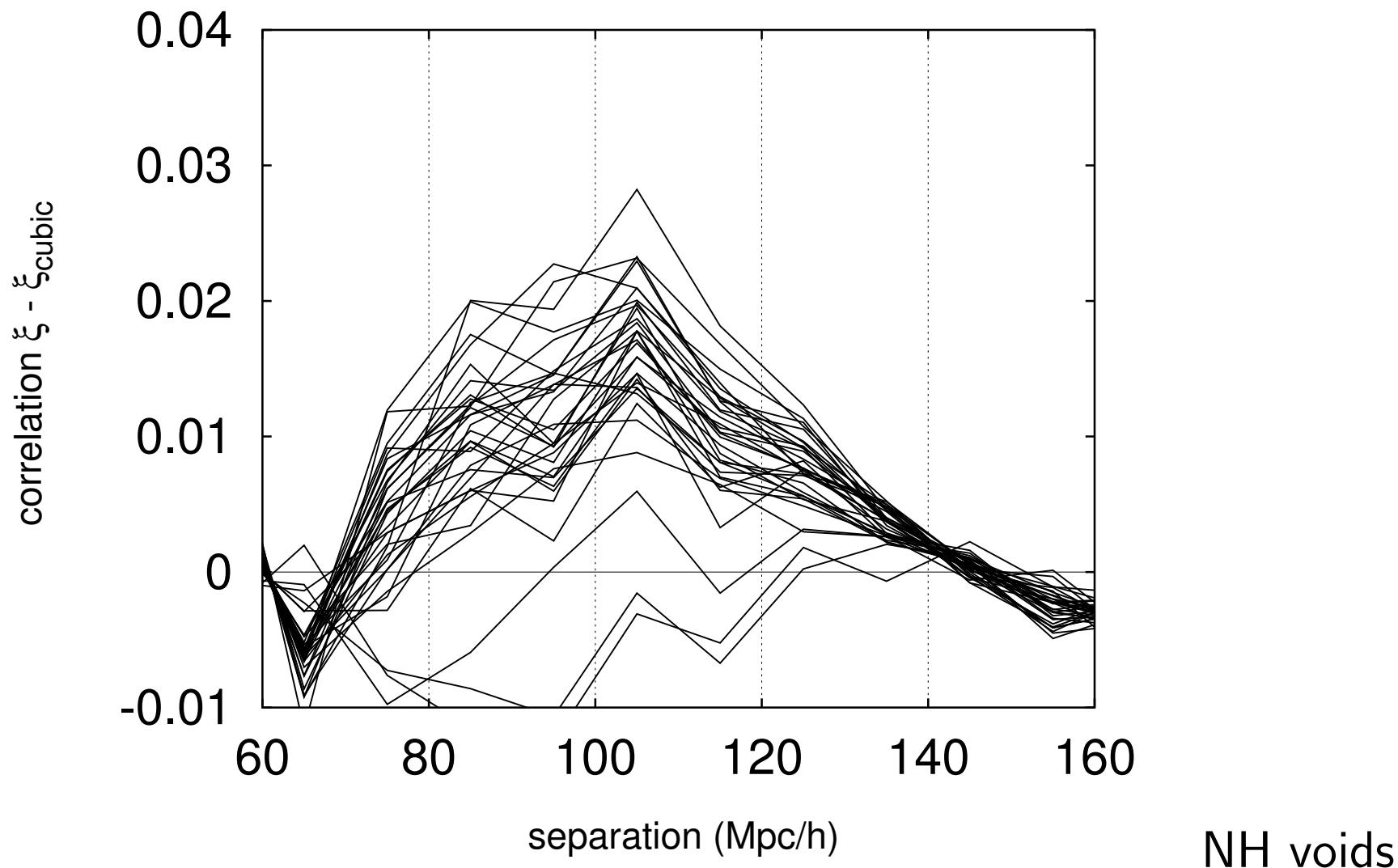
NH voids

BAO peak: NH voids

$p_{\mathrm{KS}} = 0.3$

BAO peak: Liivamägi sc's

correlation $\xi - \xi_{cubic}$

separation (Mpc/h)

full

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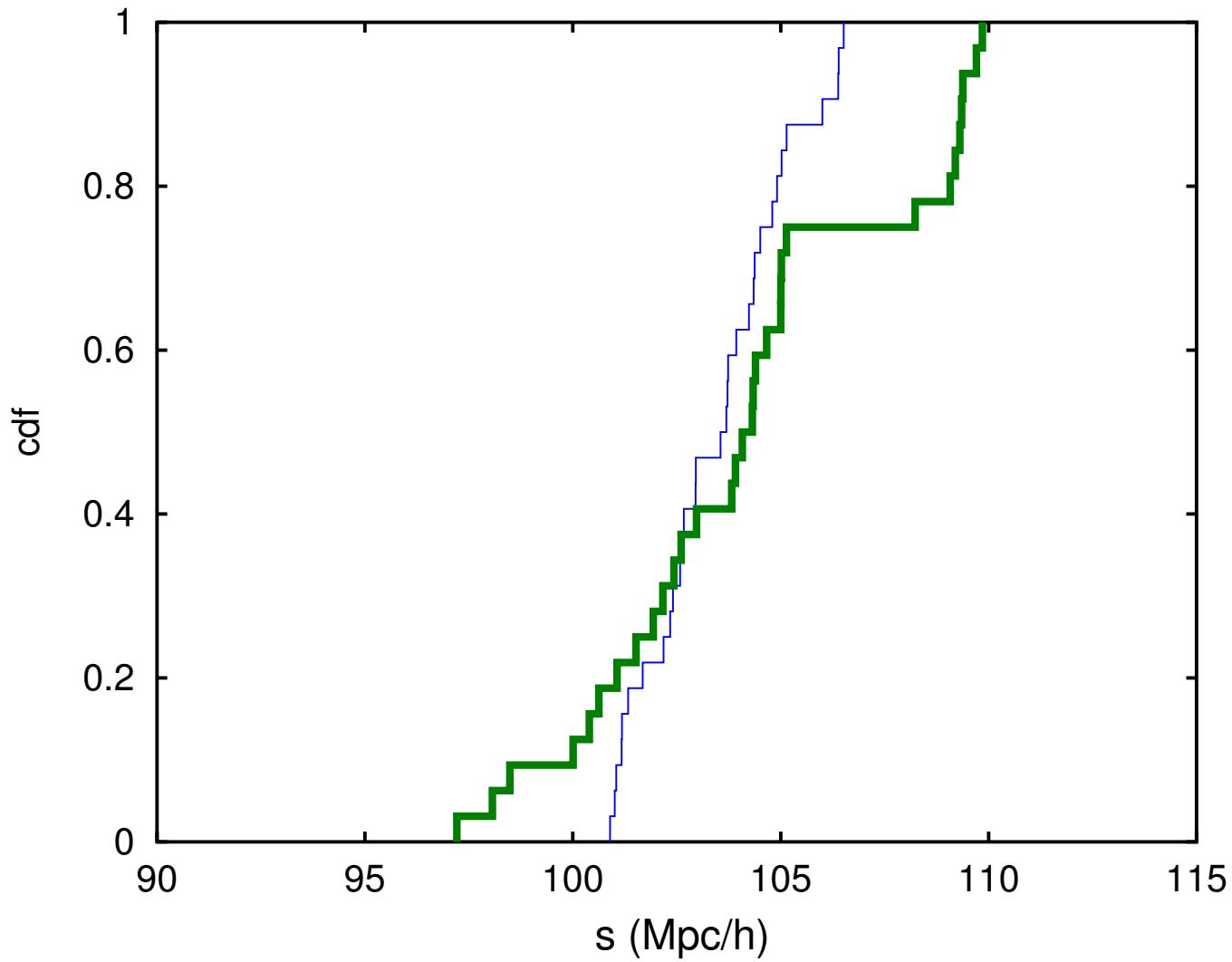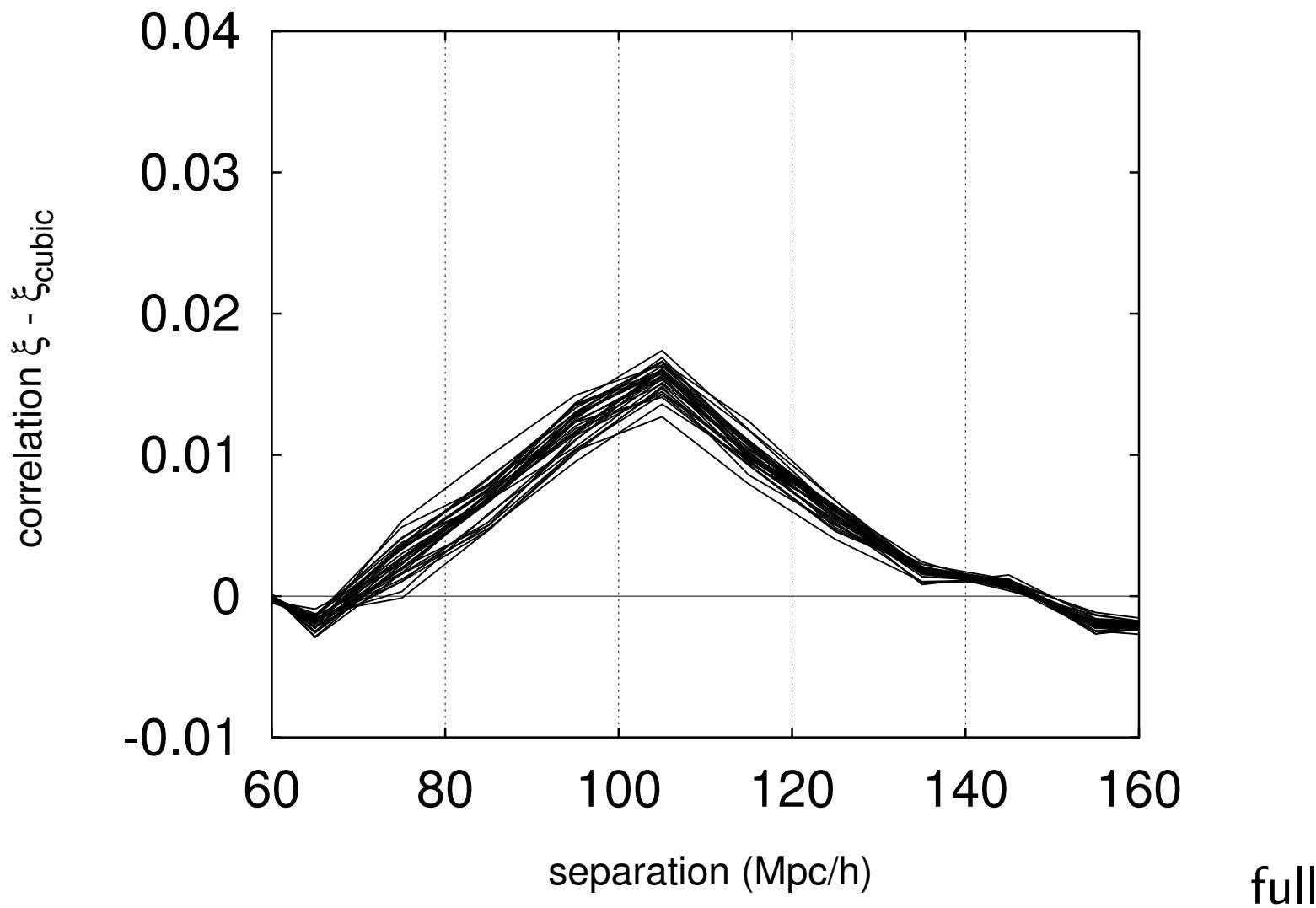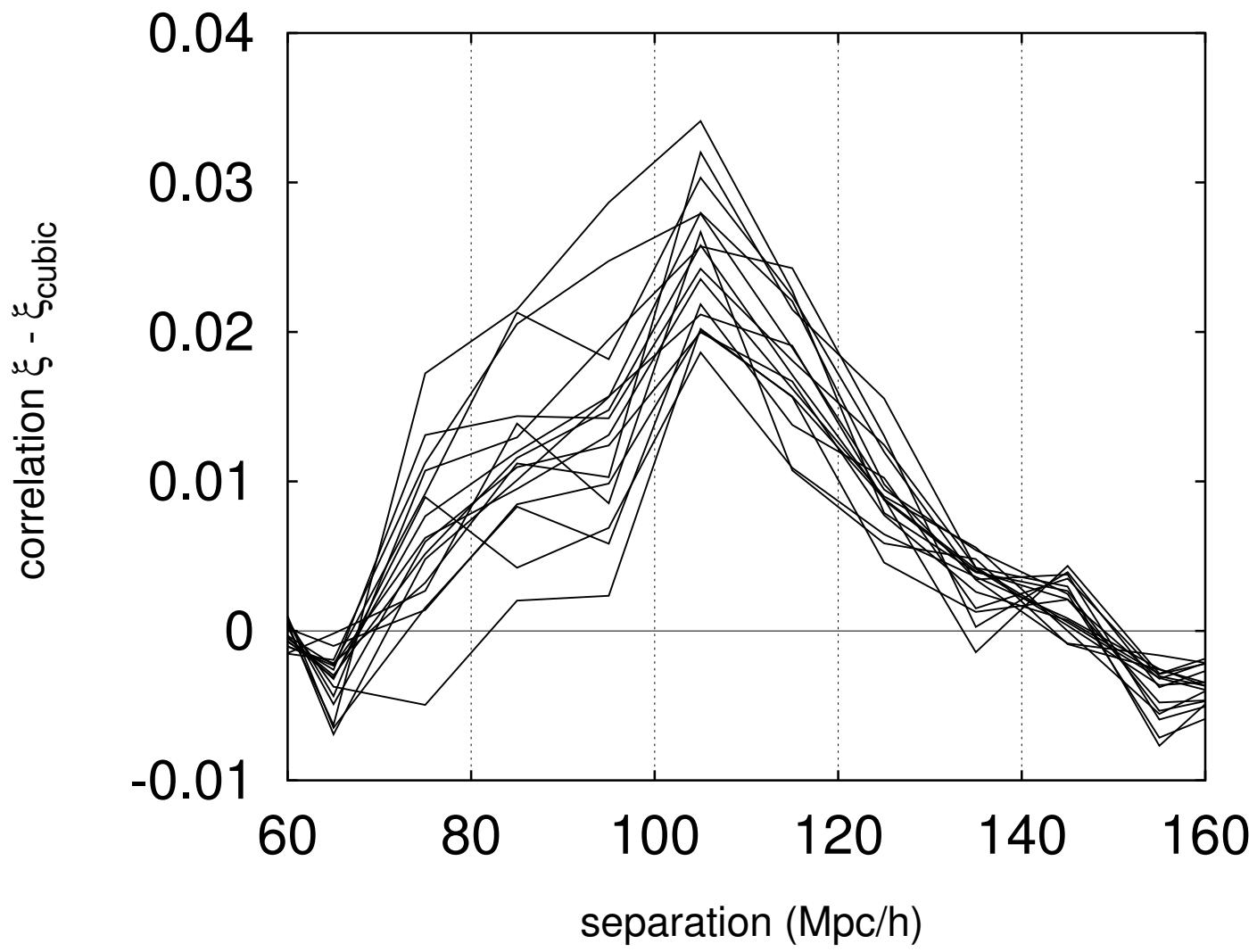
Liiv non-sc

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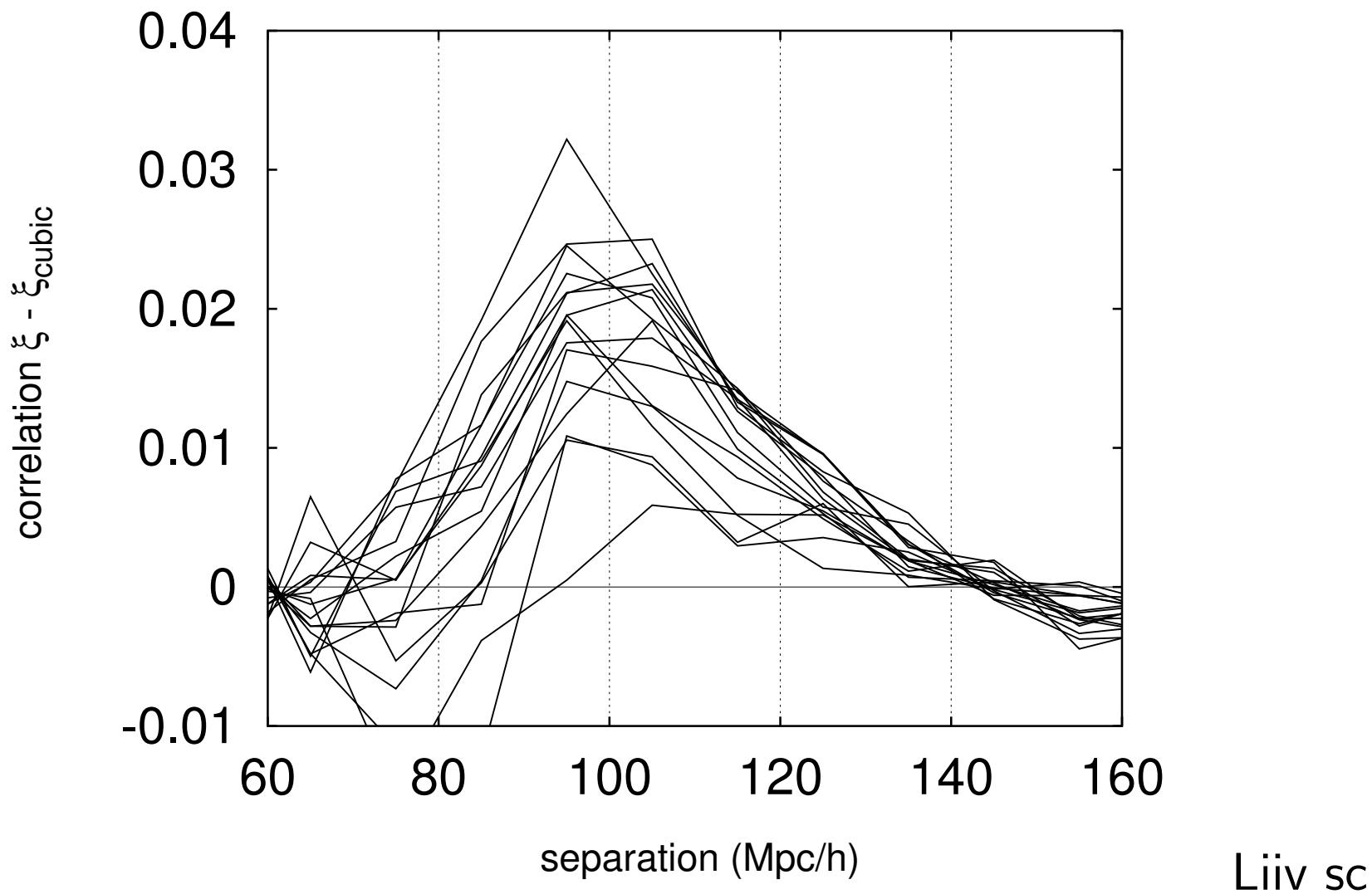
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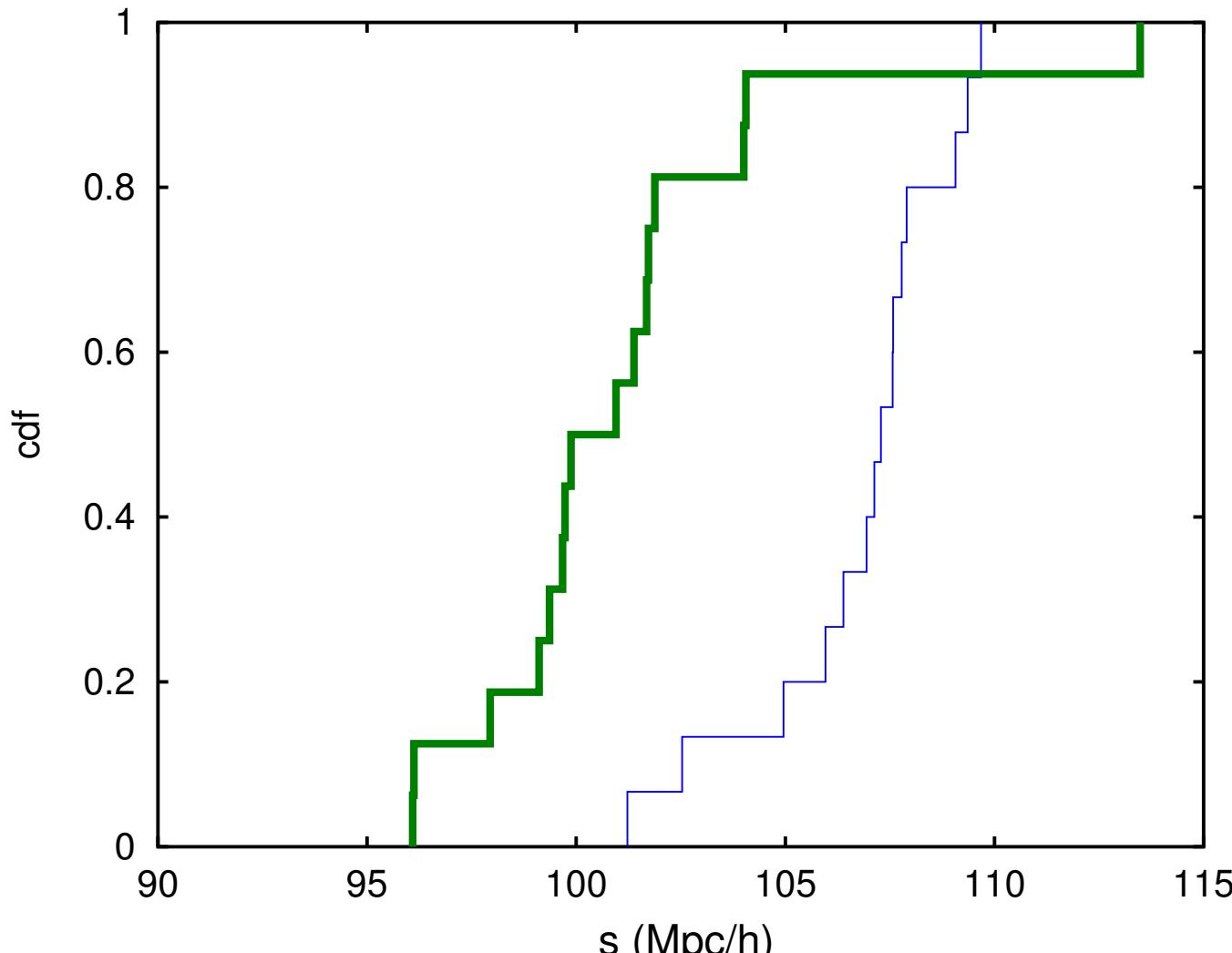
$$p_{\mathrm{KS}} = 3 \times 10^{-5}$$

$\Delta s(\omega_{\min})$ **relation**

Roukema, Buchert, 藤井 [Fujii] & Ostrowski 2015 MNRAS

BAO results

catalogue	$r_\perp^0 - r_\perp^{\mathrm{sc}}$	$r_\perp^{\mathrm{non-sc}} - r_\perp^{\mathrm{sc}}$	$r_\perp^0 - r_\perp^{\mathrm{void}}$	$r_\perp^{\mathrm{non-void}} - r_\perp^{\mathrm{void}}$
N&H	4.3 ± 1.6	6.6 ± 2.8	-0.2 ± 4.0	-1.1 ± 5.5
LTS	3.7 ± 2.9	6.3 ± 2.6	all in h^{-1} Mpc	

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  [cf Cold Spot C_l shift Chiang (2018) ApJ   arXiv:1805.06636]

Community organising

- newsletter:

  https://cosmo.torun.pl/listinfo/inhom

- workshop: 16–21 Sep 2018@Kraków

  http://th.if.uj.edu.pl/indico/event/8/