HMRC phase 1: initial results

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UNITED KINGDOM · CHINA · MALAYSIA

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Introduction

Motivation: explore how different cluster mass measures recover mass.

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What we did:

provided mock galaxy catalogue { Centers: ra, dec, vres
Galaxies: ra, dec, vres, Mr, g-r colour

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What we asked for:

Halo ID	Center RA [rad]	Center DEC [rad]	Center V_{res} [km/s]	Mass [M_{solar}]	Velocity Dispersion [km/s]	Radius [Mpc]	N_{gal}
1	0.82	0.14	500	10^14	900	1	50

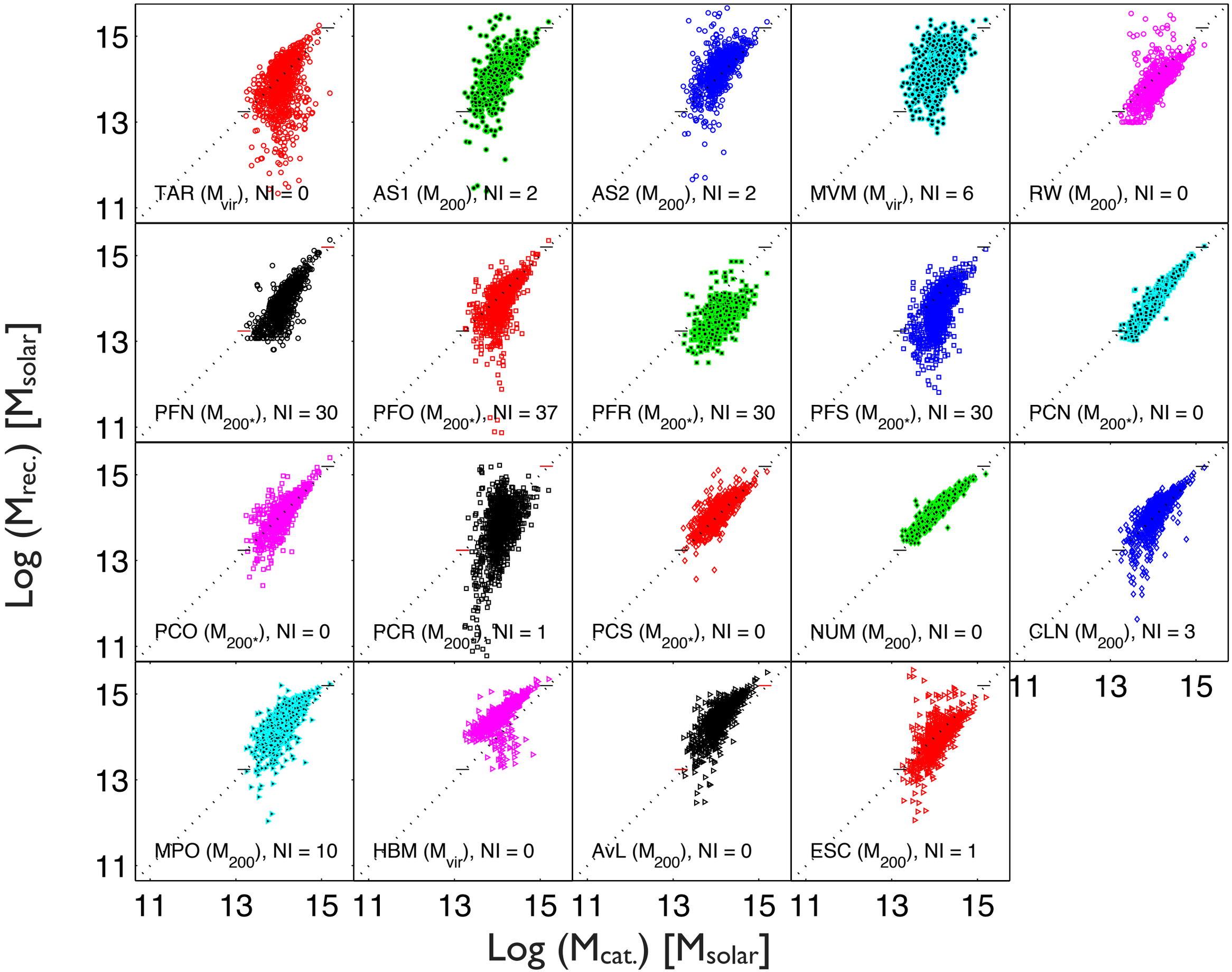
Halo properties

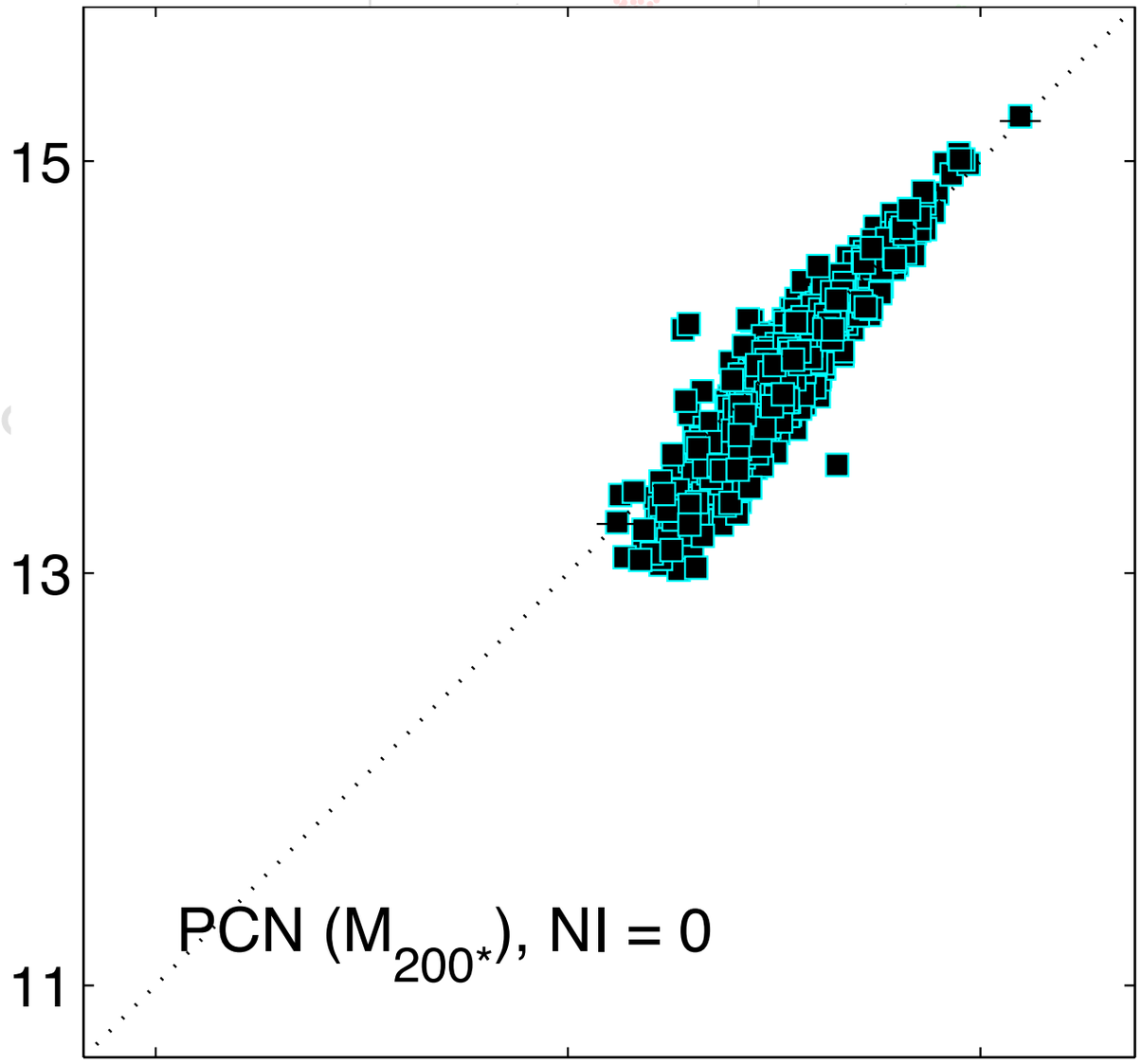
Halo ID	Galaxy ID
1	98673
1	45
1	485
:	:
2	4000

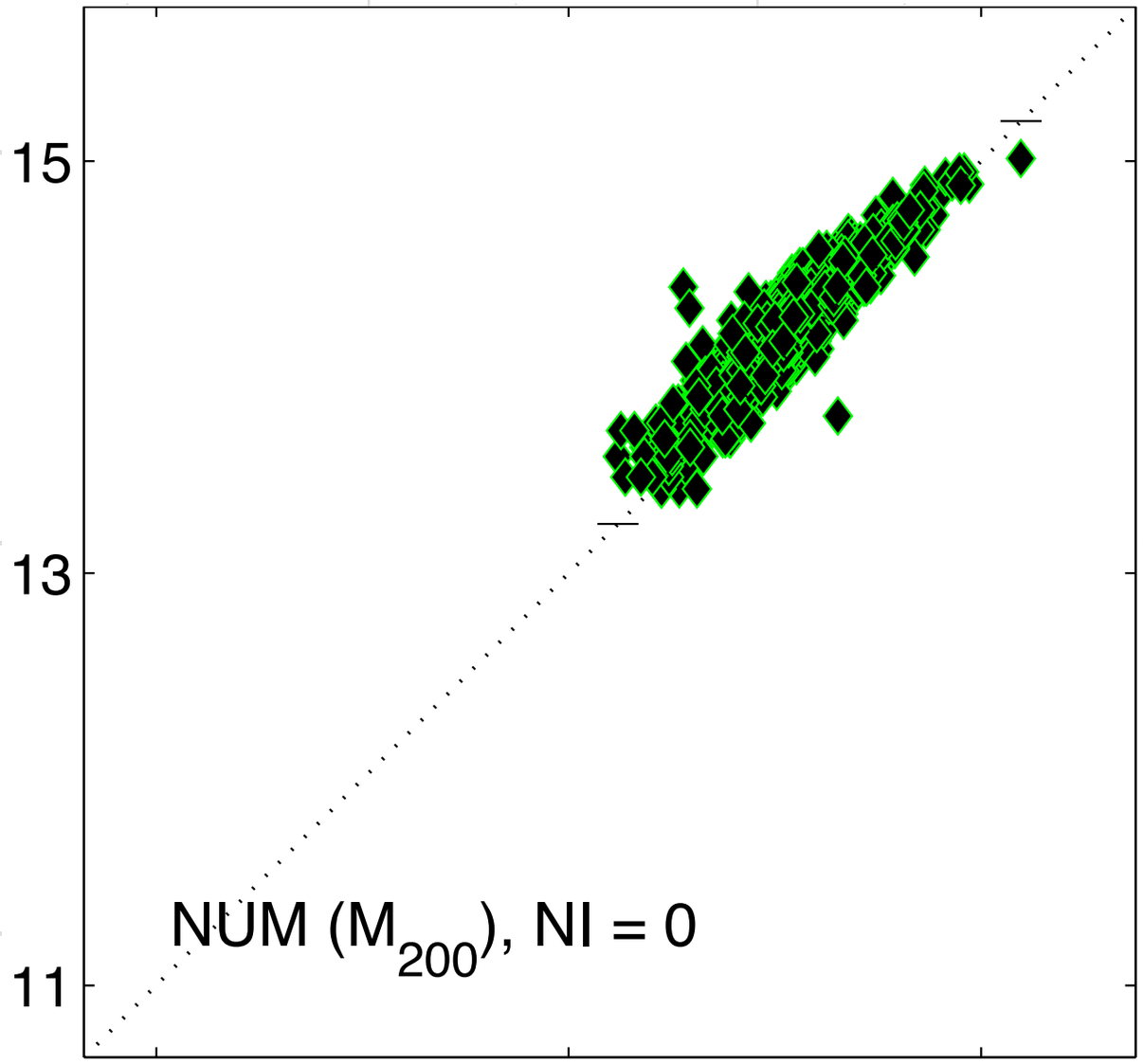
← Membership

Results

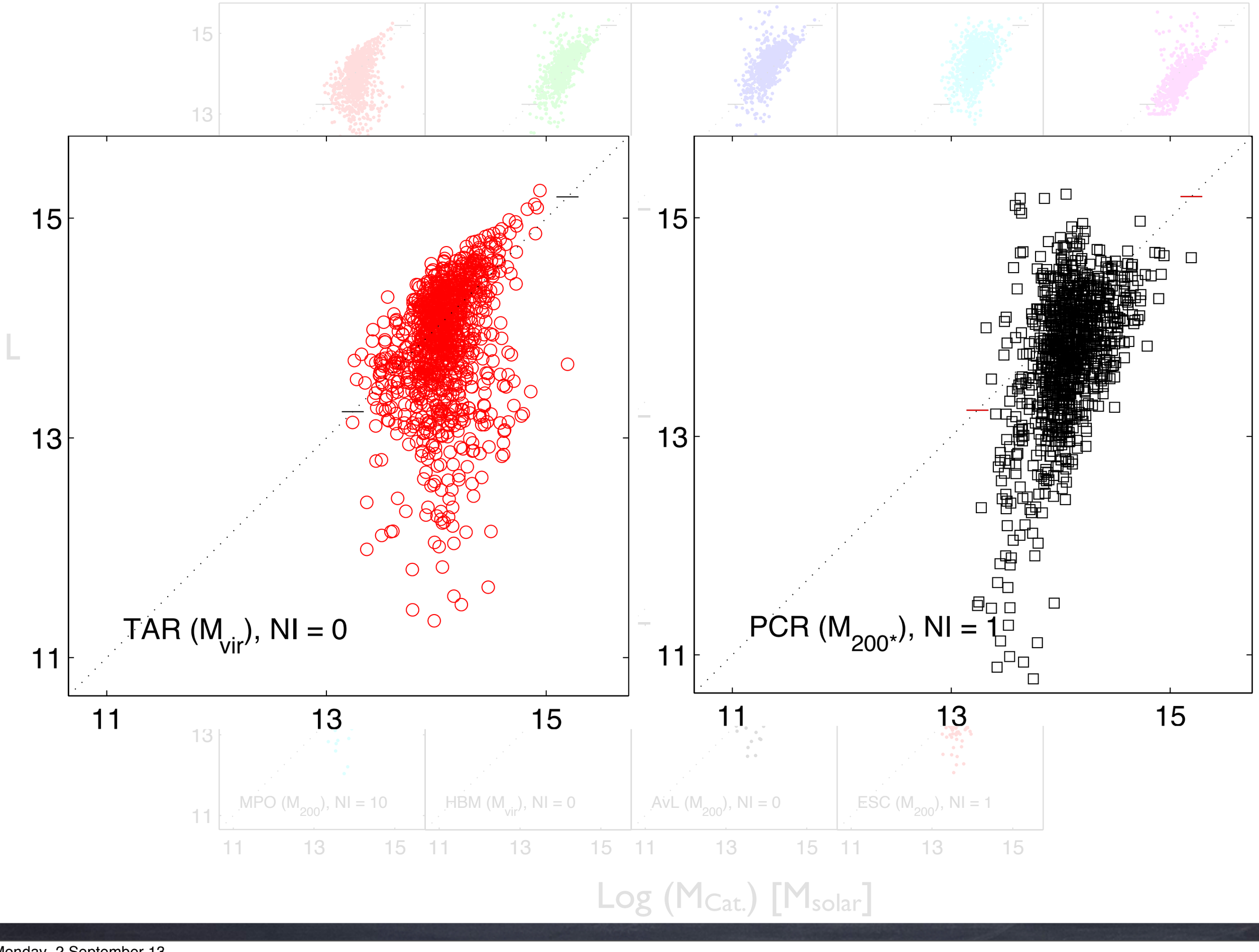
I: ‘True’ mass vs. recovered mass


TAR (M_{vir}), NI = 0
AS1 (M_{200}), NI = 2
AS2 (M_{200}), NI = 2
MVM (M_{vir}), NI = 6
RW (M_{200}), NI = 0
PFN (M_{200*}), NI = 30
PFO (M_{200*}), NI = 37
PFR (M_{200*}), NI = 30
PFS (M_{200*}), NI = 30
PCN (M_{200*}), NI = 0
PCO (M_{200*}), NI = 0
PCR (M_{200*}), NI = 1
PCS (M_{200*}), NI = 0
NUM (M_{200}), NI = 0
CLN (M_{200}), NI = 3
MPO (M_{200}), NI = 10
HBM (M_{vir}), NI = 0
AvL (M_{200}), NI = 0
ESC (M_{200}), NI = 1
11
13
15
Log ($M_{rec.}$) [M_{solar}]
Log ($M_{cat.}$) [M_{solar}]



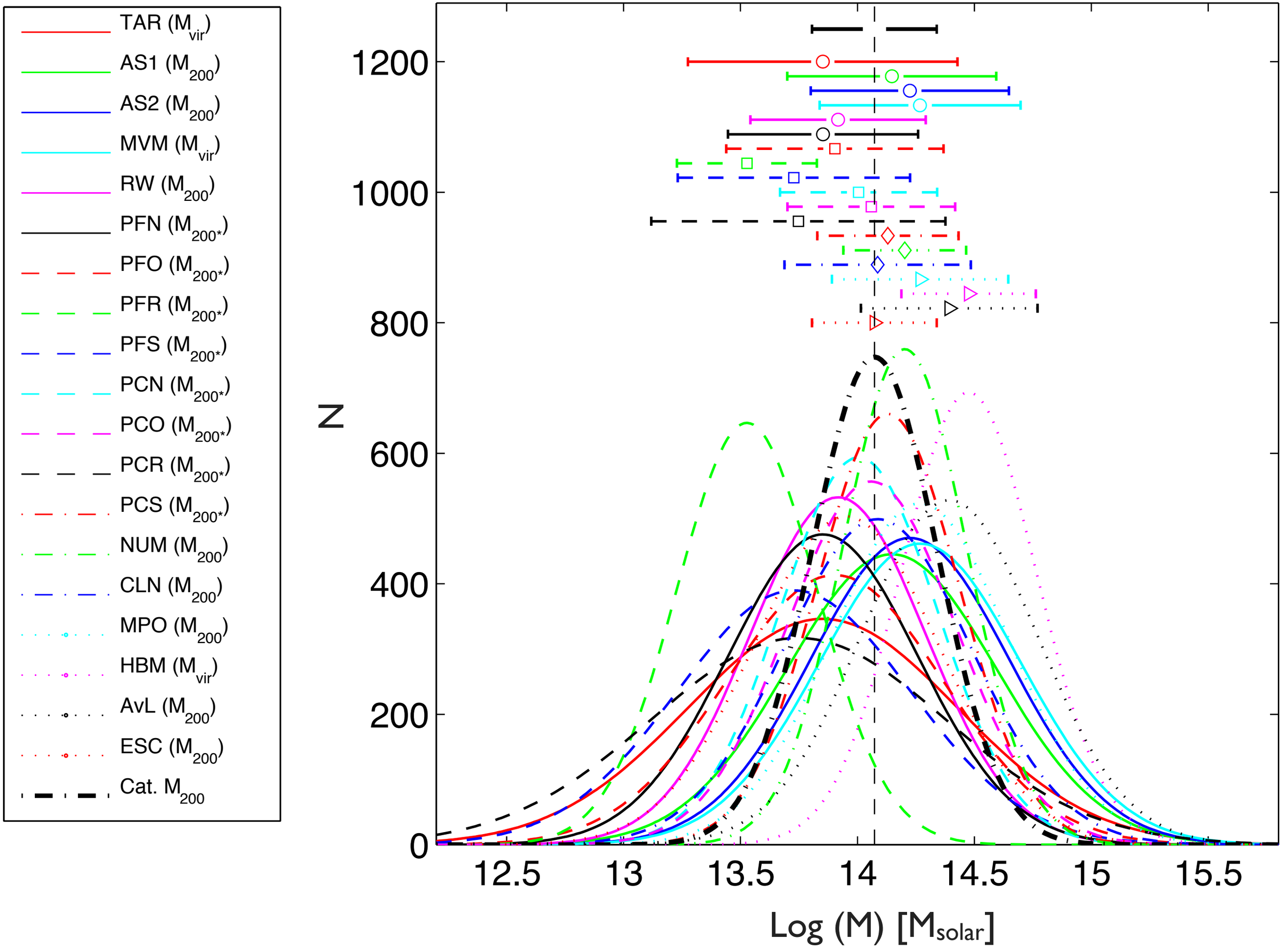


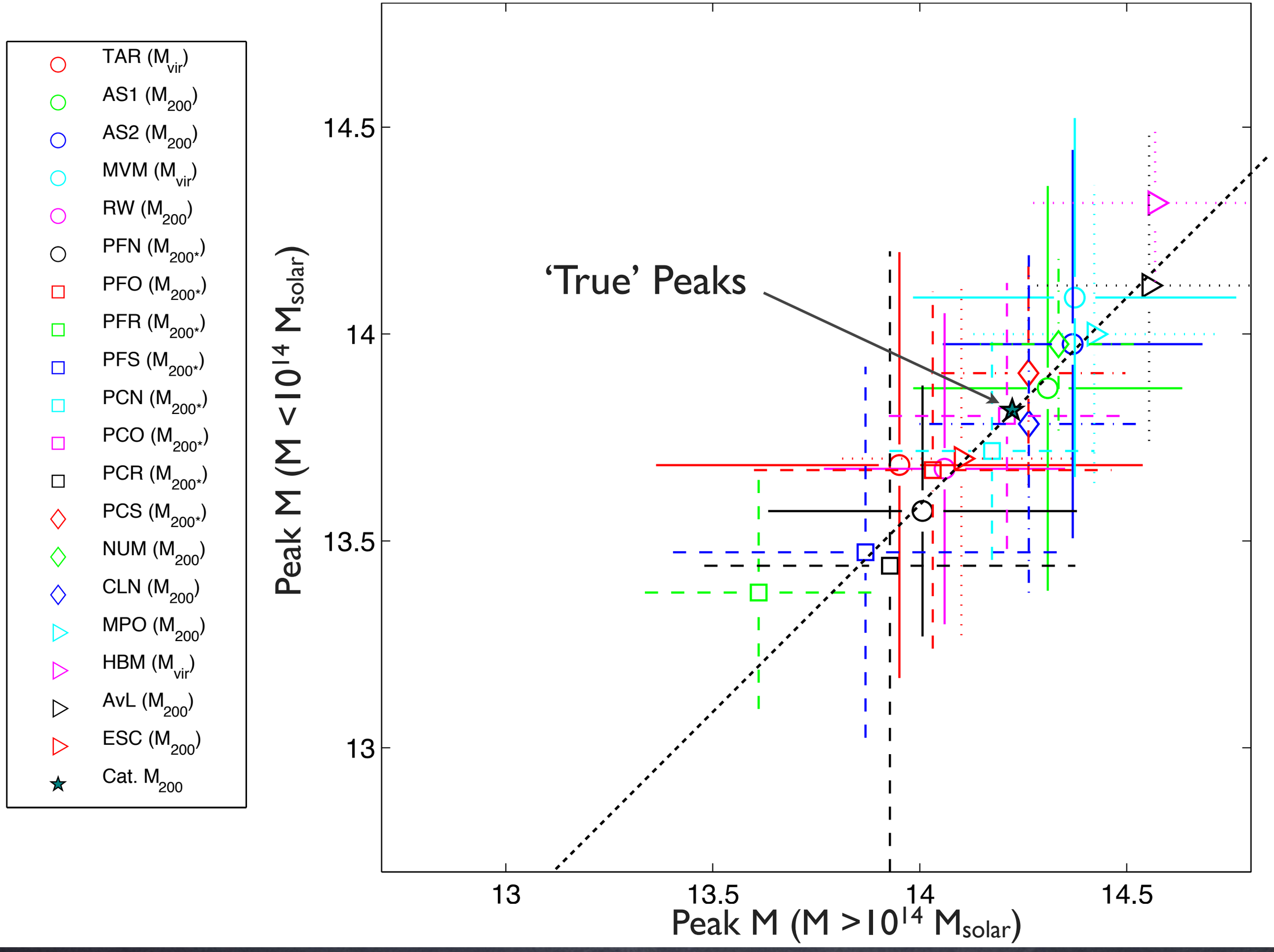
Log ($M_{Cat.}$) [M_{solar}]

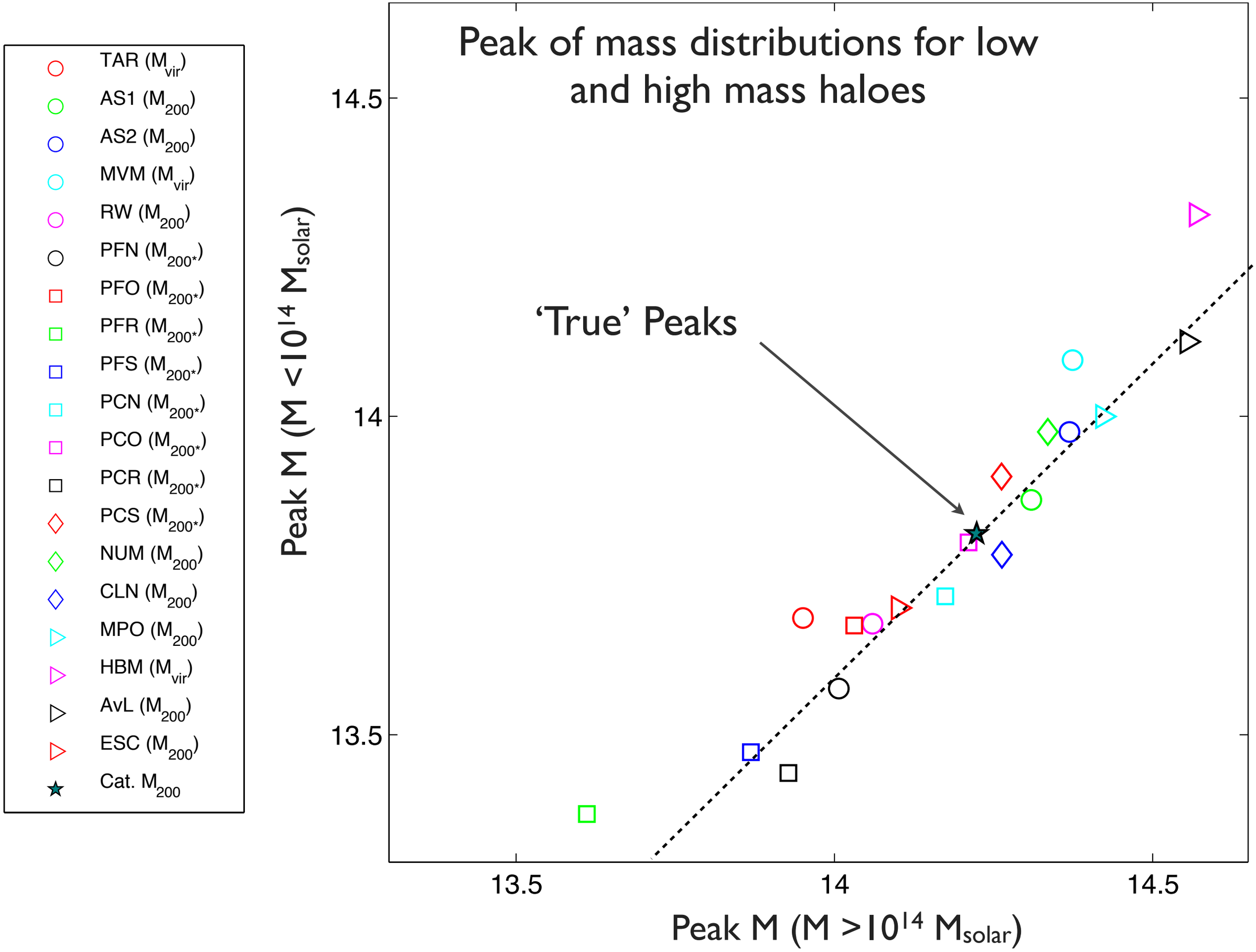

15
13
11
TAR (M_{vir}), NI = 0
PCR (M_{200*}), NI = 1
MPO (M_{200}), NI = 10
HBM (M_{vir}), NI = 0
AvL (M_{200}), NI = 0
ESC (M_{200}), NI = 1
Log ($M_{Cat.}$) [M_{solar}]

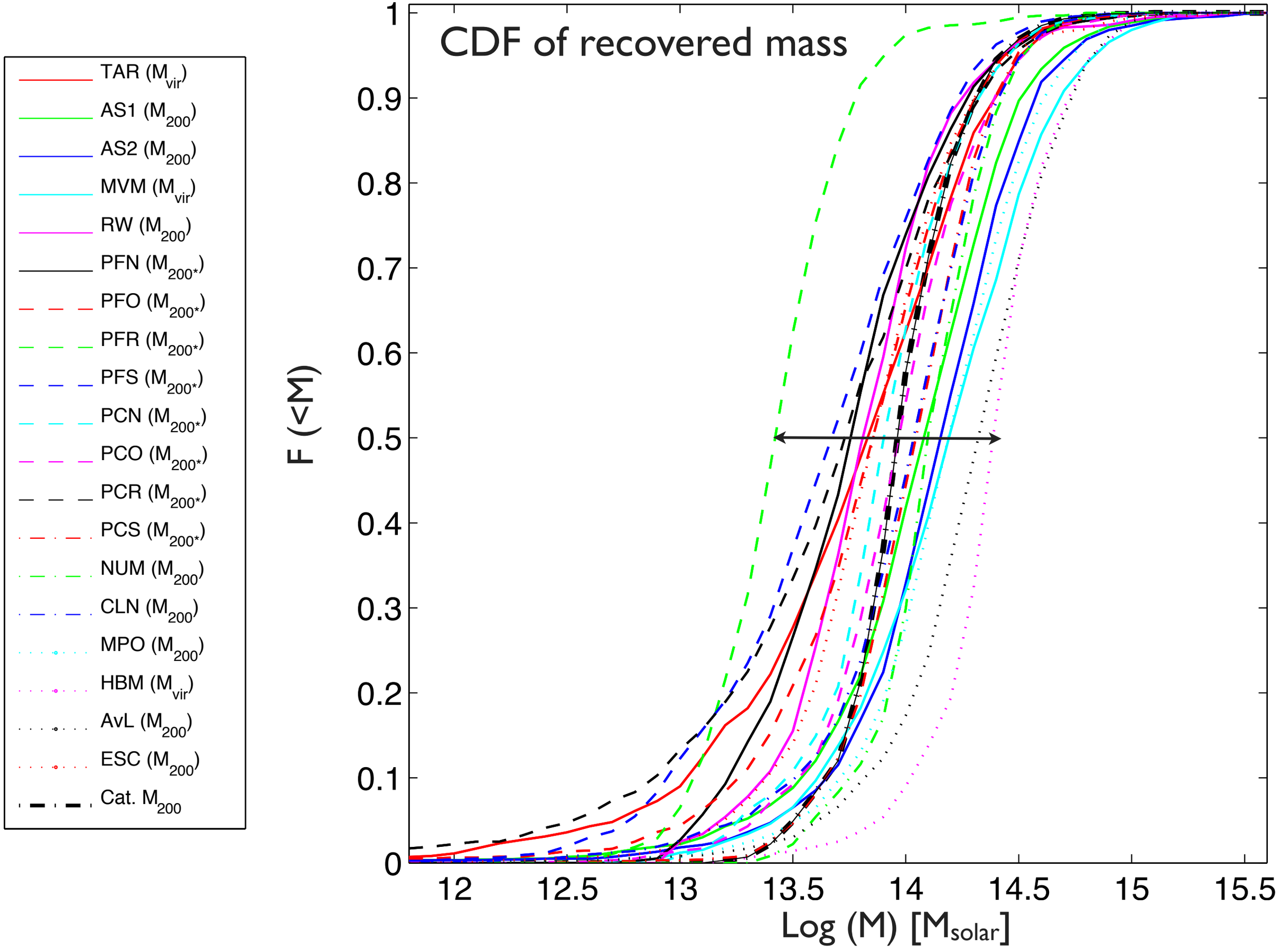
Results

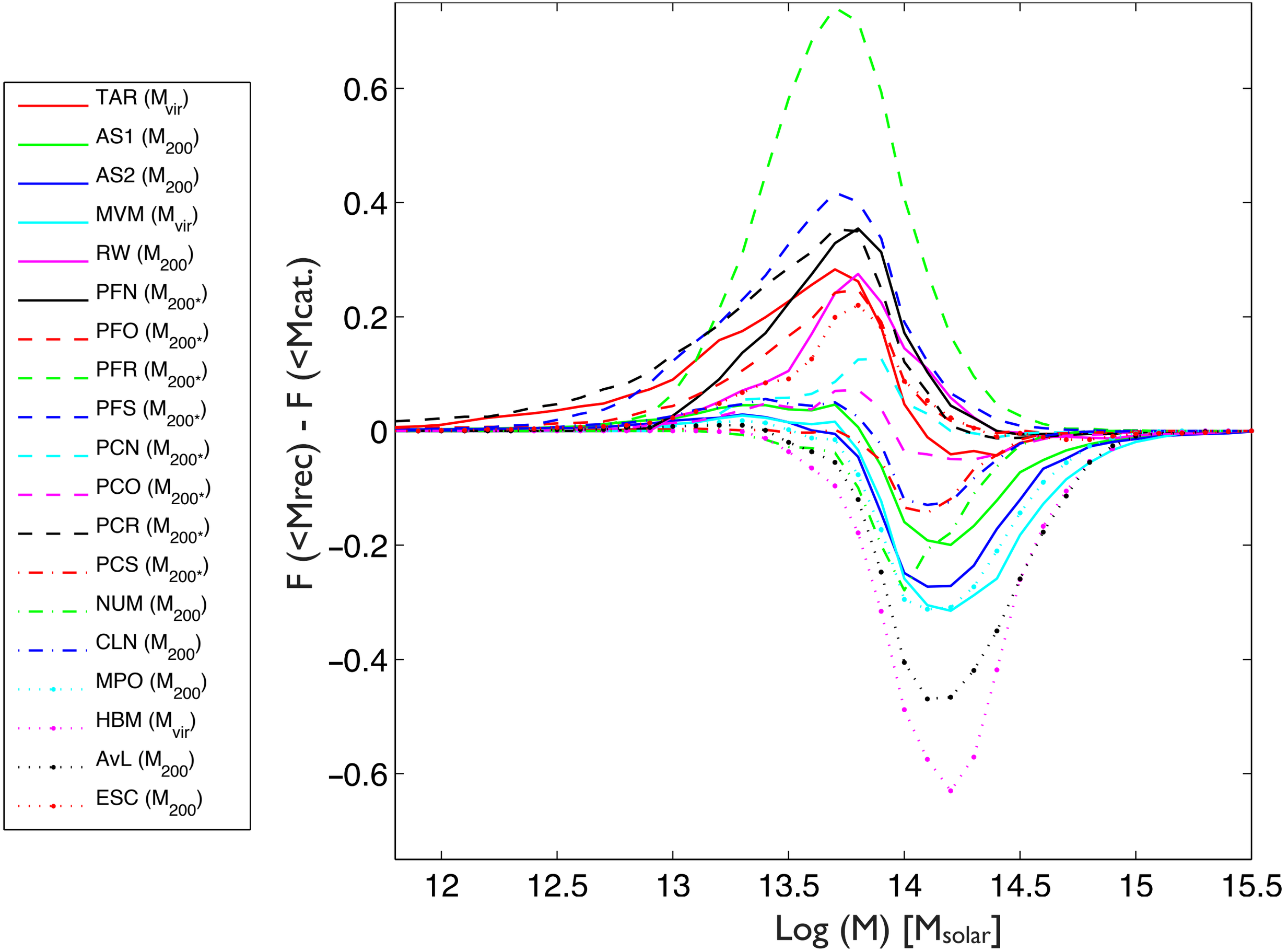
II: Recovered mass distributions


TAR (M_vir)
AS1 (M_200)
AS2 (M_200)
MVM (M_vir)
RW (M_200)
PFN (M_200*)
PFO (M_200*)
PFR (M_200*)
PFS (M_200*)
PCN (M_200*)
PCO (M_200*)
PCR (M_200*)
PCS (M_200*)
NUM (M_200)
CLN (M_200)
MPO (M_200)
HBM (M_vir)
AvL (M_200)
ESC (M_200)
Cat. M_200
N
0
200
400
600
800
1000
1200
12.5
13
13.5
14
14.5
15
15.5
Log (M) [M_solar]


TAR (M_vir)
AS1 (M_200)
AS2 (M_200)
MVM (M_vir)
RW (M_200)
PFN (M_200*)
PFO (M_200*)
PFR (M_200*)
PFS (M_200*)
PCN (M_200*)
PCO (M_200*)
PCR (M_200*)
PCS (M_200*)
NUM (M_200)
CLN (M_200)
MPO (M_200)
HBM (M_vir)
AvL (M_200)
ESC (M_200)
Cat. M_200
'True' Peaks
Peak M (M <10^14 M_solar)
Peak M (M >10^14 M_solar)
13
13.5
14
14.5


Peak of mass distributions for low and high mass haloes
'True' Peaks
TAR (M_{vir})
AS1 (M_{200})
AS2 (M_{200})
MVM (M_{vir})
RW (M_{200})
PFN (M_{200*})
PFO (M_{200*})
PFR (M_{200*})
PFS (M_{200*})
PCN (M_{200*})
PCO (M_{200*})
PCR (M_{200*})
PCS (M_{200*})
NUM (M_{200})
CLN (M_{200})
MPO (M_{200})
HBM (M_{vir})
AvL (M_{200})
ESC (M_{200})
Cat. M_{200}
Peak M ($M < 10^{14}$ M_{solar})
Peak M ($M > 10^{14}$ M_{solar})
13.5
14
14.5


CDF of recovered mass
TAR (M_vir)
AS1 (M_200)
AS2 (M_200)
MVM (M_vir)
RW (M_200)
PFN (M_200*)
PFO (M_200*)
PFR (M_200*)
PFS (M_200*)
PCN (M_200*)
PCO (M_200*)
PCR (M_200*)
PCS (M_200*)
NUM (M_200)
CLN (M_200)
MPO (M_200)
HBM (M_vir)
AvL (M_200)
ESC (M_200)
Cat. M_200
F (<M)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
12
12.5
13
13.5
14
14.5
15
15.5
Log (M) [M_solar]


TAR (M_{vir})
AS1 (M_{200})
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MVM (M_{vir})
RW (M_{200})
PFN (M_{200*})
PFO (M_{200*})
PFR (M_{200*})
PFS (M_{200*})
PCN (M_{200*})
PCO (M_{200*})
PCR (M_{200*})
PCS (M_{200*})
NUM (M_{200})
CLN (M_{200})
MPO (M_{200})
HBM (M_{vir})
AvL (M_{200})
ESC (M_{200})
F (<Mrec) - F (<Mcat.)
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
12
12.5
13
13.5
14
14.5
15
15.5
Log (M) [M_{solar}]

Results

III: Fractional deviation

Fractional deviation: $\max(\frac{\mathrm{M_{rec}}}{\mathrm{M_{cat}}}, \frac{\mathrm{M_{cat}}}{\mathrm{M_{rec}}})$

Fractional deviation: $\max(\frac{M_{rec}}{M_{cat}}, \frac{M_{cat}}{M_{rec}})$

	Fractional deviation			
Method	$\log(M_{Cat.}) \leqslant 13.86$	$13.86 < \log(M_{Cat.}) \leqslant 14.52$	$14.52 < \log(M_{Cat.})$	Rank
PCN	1.67	1.30	1.17	1
NUM	1.57	1.41	1.18	2
PCS	1.79	1.47	1.27	3
PCO	2.30	1.45	1.27	4
CLN	3.27	1.56	1.67	5
PFN	2.48	2.19	1.59	6
MPO	3.09	1.99	1.93	7
RW	3.62	1.89	1.71	8
ESC	4.86	1.81	1.58	9
AvL	3.27	2.44	2.14	10
AS2	5.19	2.23	1.45	11
AS1	5.88	2.13	1.44	12
MVM	3.80	2.66	1.80	13
HBM	3.89	2.79	2.67	14
PFS	4.40	4.30	3.15	15
PFR	3.33	4.41	5.91	16
PFO	5.33	7.32	1.86	17
TAR	4.77	8.20	12.27	18
PCR	28.68	4.06	2.81	19

Fractional deviation: $\max(\frac{M_{rec}}{M_{cat}}, \frac{M_{cat}}{M_{rec}})$

	Fractional deviation			
Method	$\log(M_{Cat.}) \leqslant 13.86$	$13.86 < \log(M_{Cat.}) \leqslant 14.52$	$14.52 < \log(M_{Cat.})$	Rank
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TAR	4.77	8.20	12.27	18
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lower fractional deviation

Fractional deviation: $\max(\frac{M_{rec}}{M_{cat}}, \frac{M_{cat}}{M_{rec}})$

	Fractional deviation			
Method	$\log(M_{Cat.}) \leqslant 13.86$	$13.86 < \log(M_{Cat.}) \leqslant 14.52$	$14.52 < \log(M_{Cat.})$	Rank
PCN	1.67	1.30	1.17	1
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AS1	5.88	2.13	1.44	12
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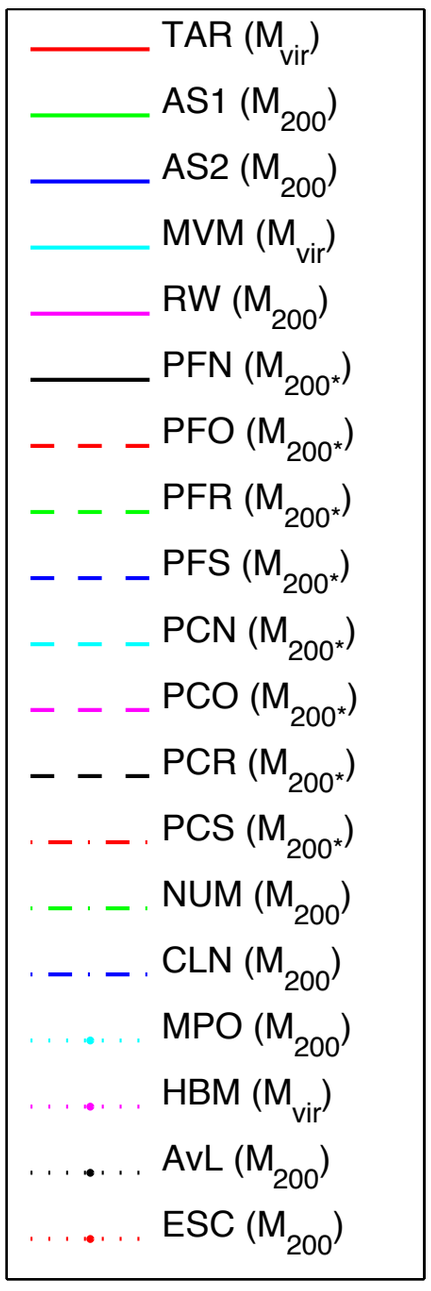
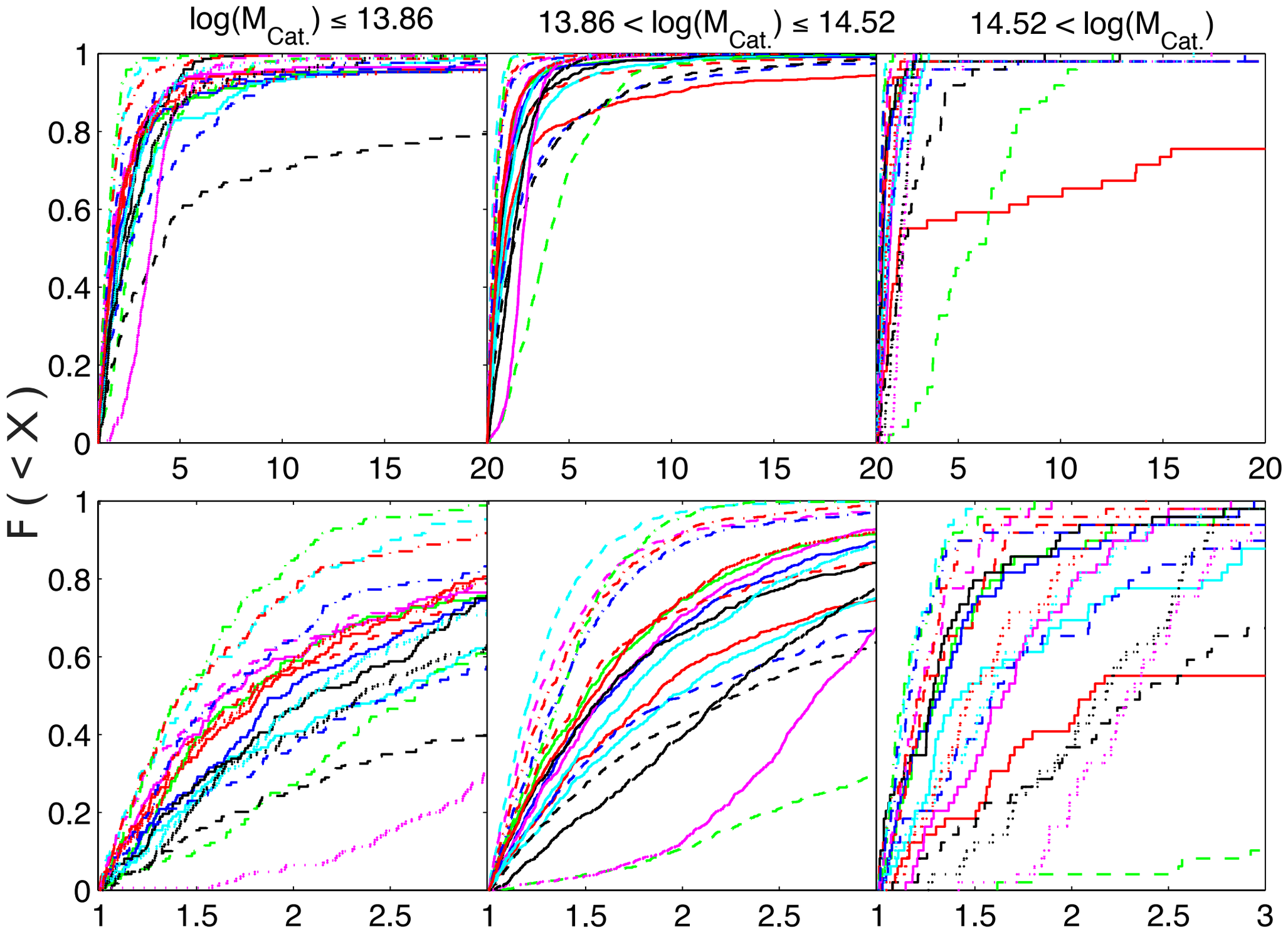
HBM	3.89	2.79	2.67	14
PFS	4.40	4.30	3.15	15
PFR	3.33	4.41	5.91	16
PFO	5.33	7.32	1.86	17
TAR	4.77	8.20	12.27	18
PCR	28.68	4.06	2.81	19

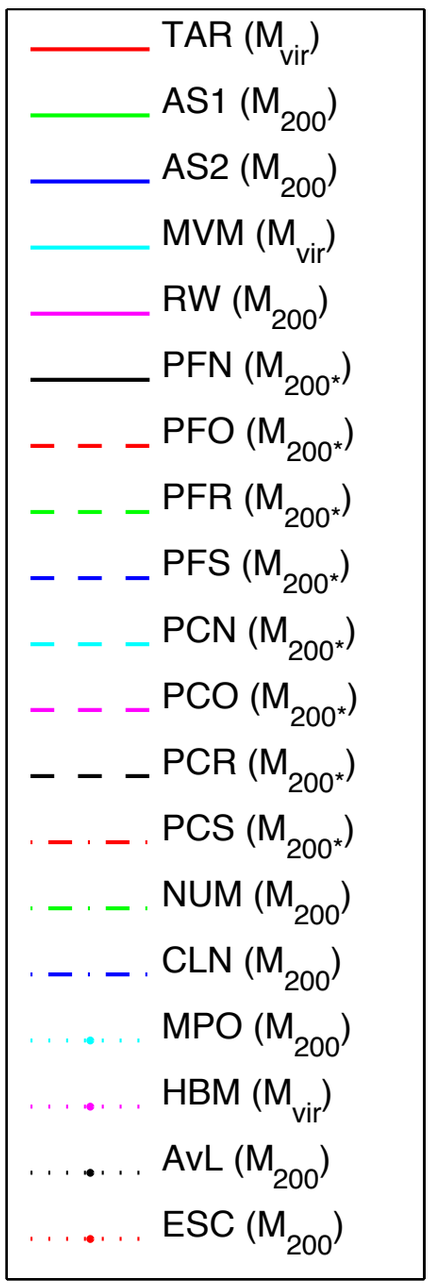
lower fractional deviation →

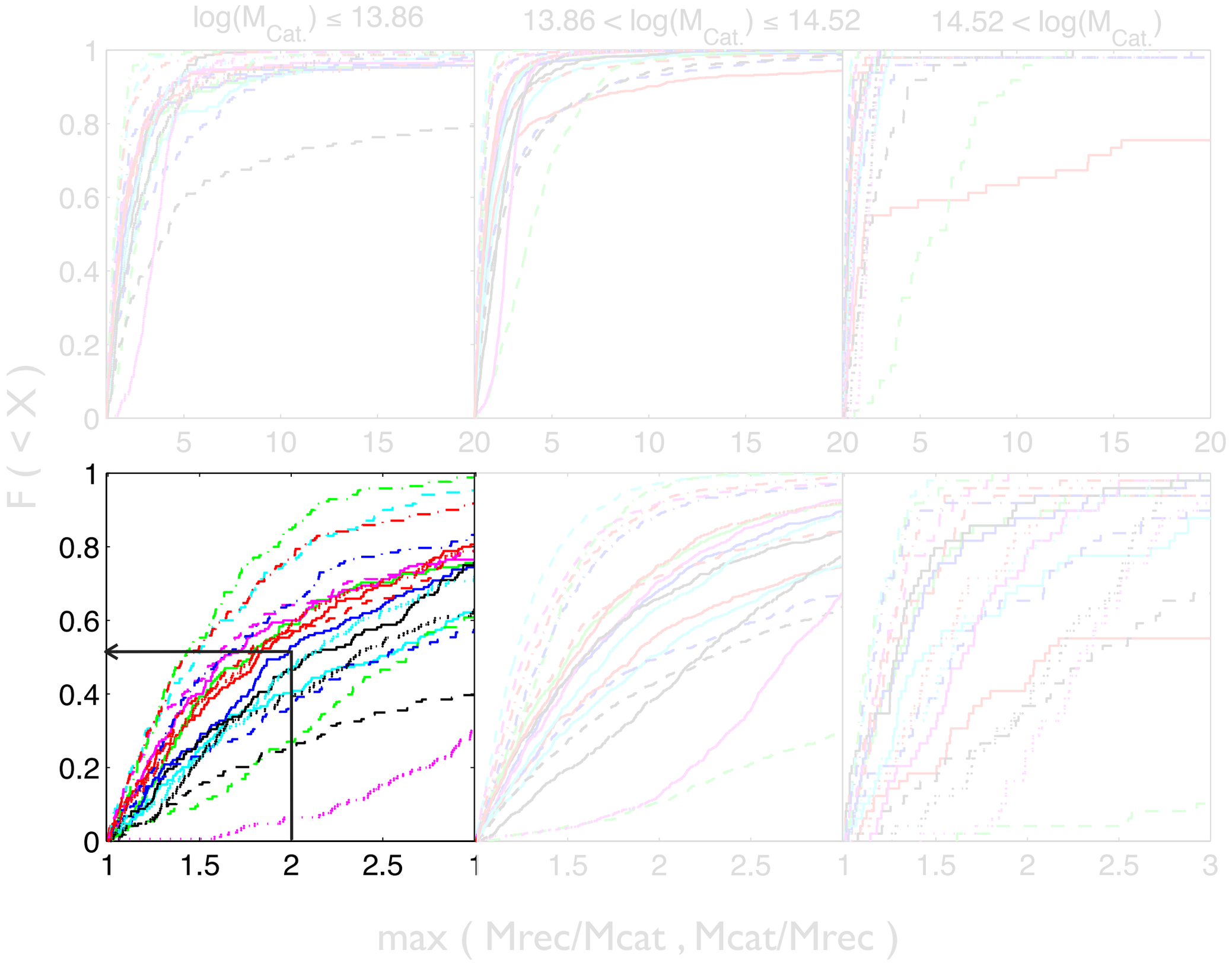
Fractional deviation



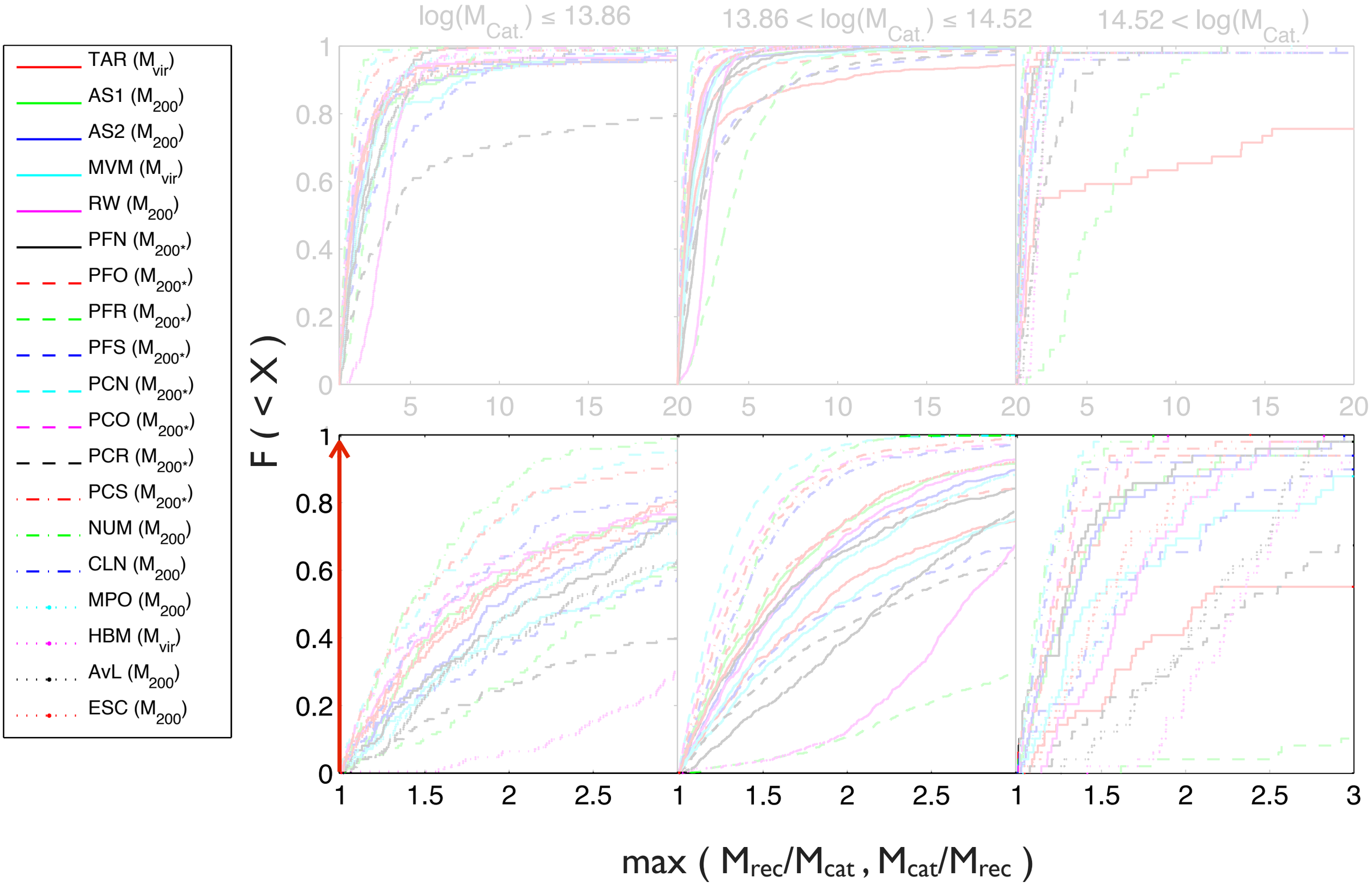


Fractional deviation

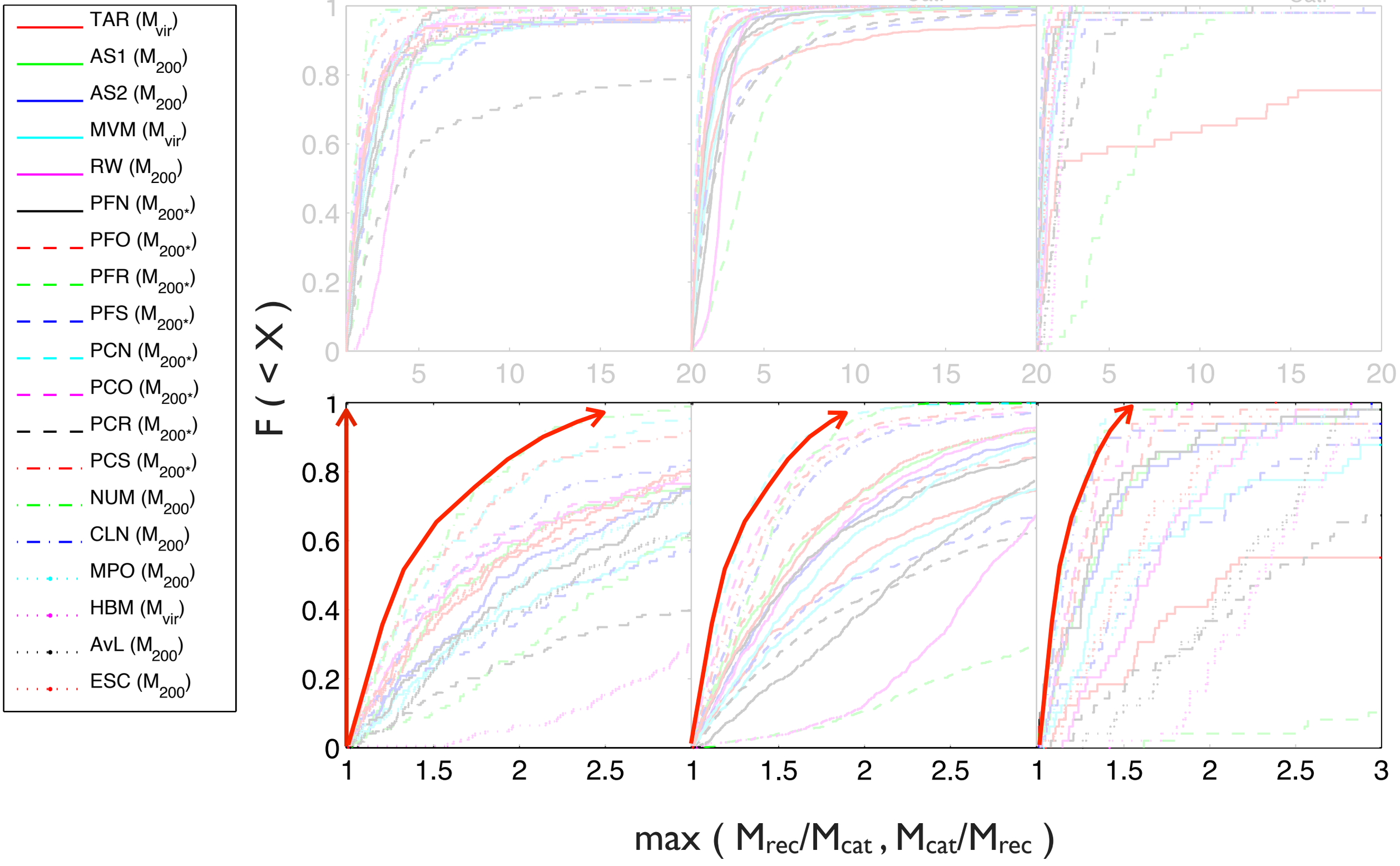




Fractional deviation

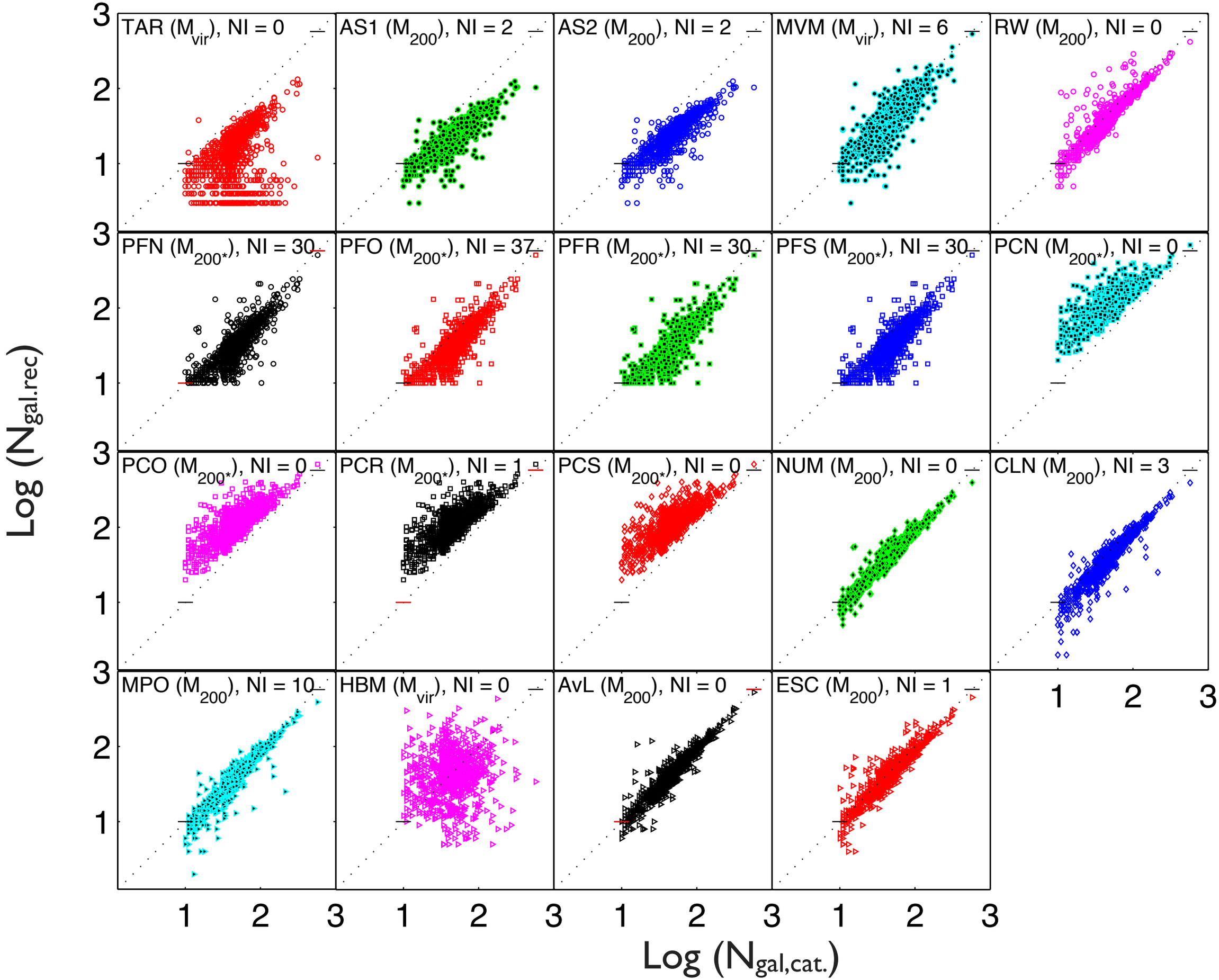


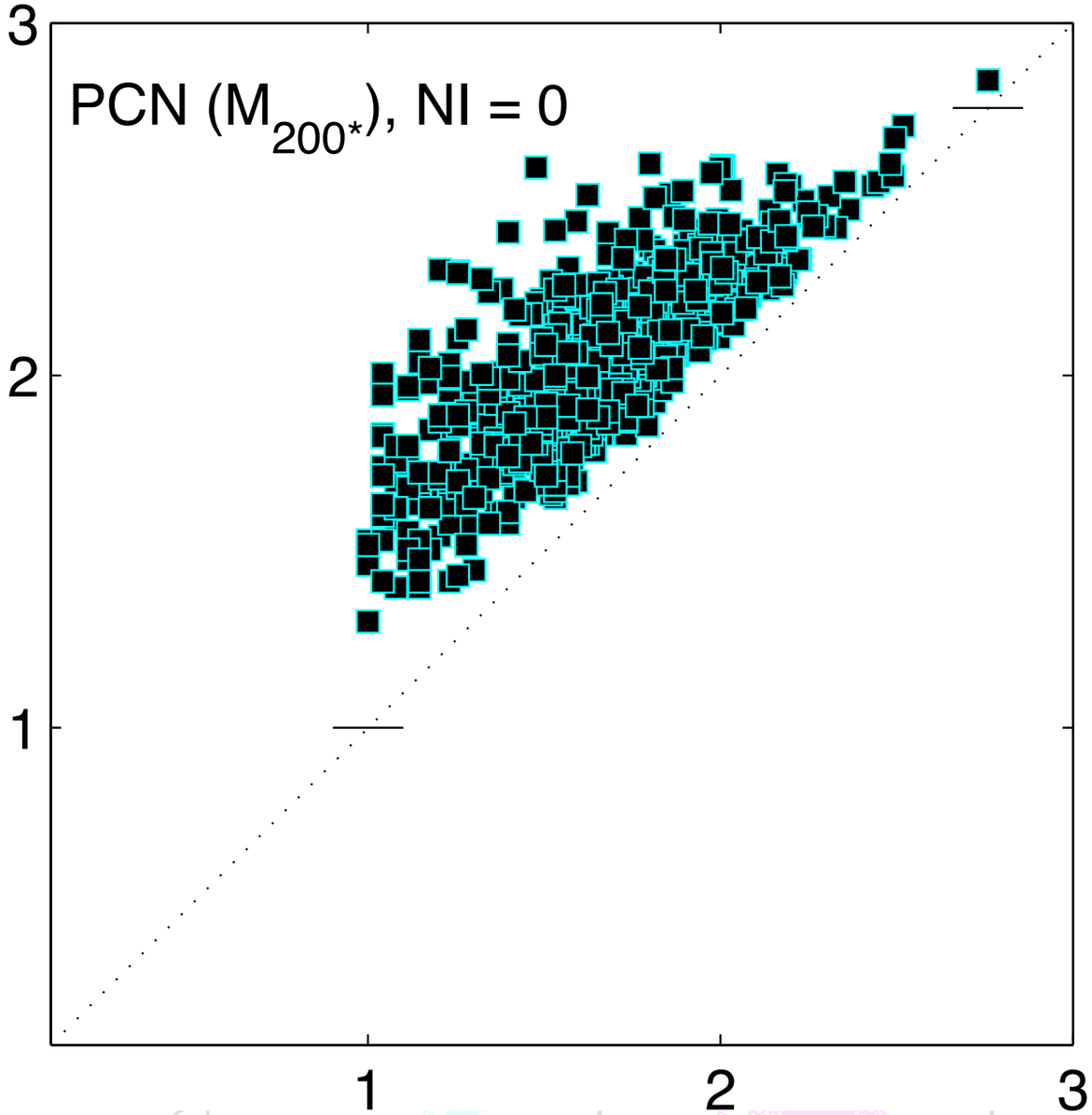
Fractional deviation

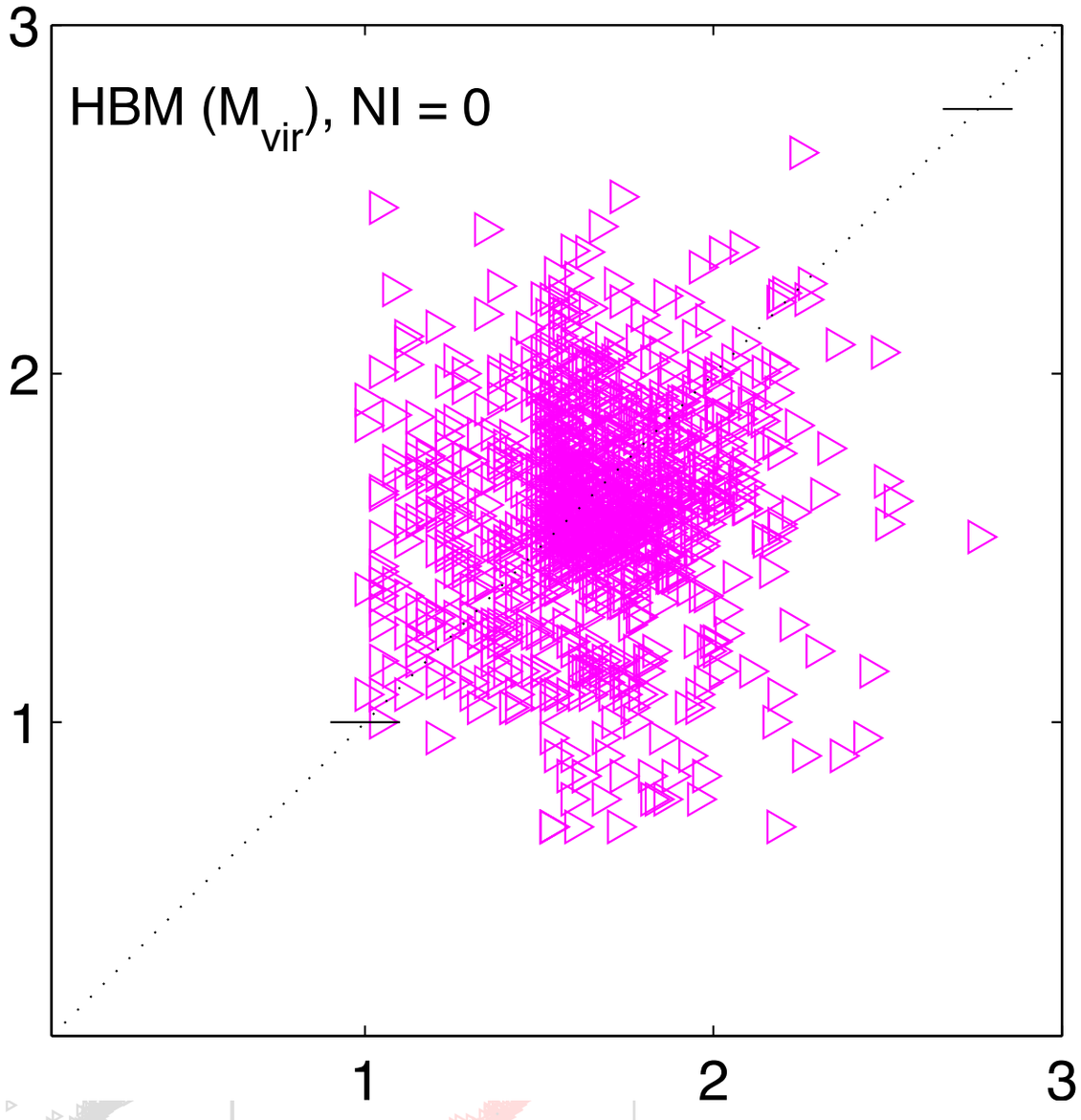


Results

IV: 'True' N_{gal} vs. recovered N_{gal}


TAR (M_{vir}), NI = 0
AS1 (M_{200}), NI = 2
AS2 (M_{200}), NI = 2
MVM (M_{vir}), NI = 6
RW (M_{200}), NI = 0
PFN (M_{200*}), NI = 30
PFO (M_{200*}), NI = 37
PFR (M_{200*}), NI = 30
PFS (M_{200*}), NI = 30
PCN (M_{200*}), NI = 0
PCO (M_{200*}), NI = 0
PCR (M_{200*}), NI = 1
PCS (M_{200*}), NI = 0
NUM (M_{200}), NI = 0
CLN (M_{200}), NI = 3
MPO (M_{200}), NI = 10
HBM (M_{vir}), NI = 0
AvL (M_{200}), NI = 0
ESC (M_{200}), NI = 1
Log ($N_{gal.rec}$)
Log ($N_{gal,cat.}$)
1
2
3

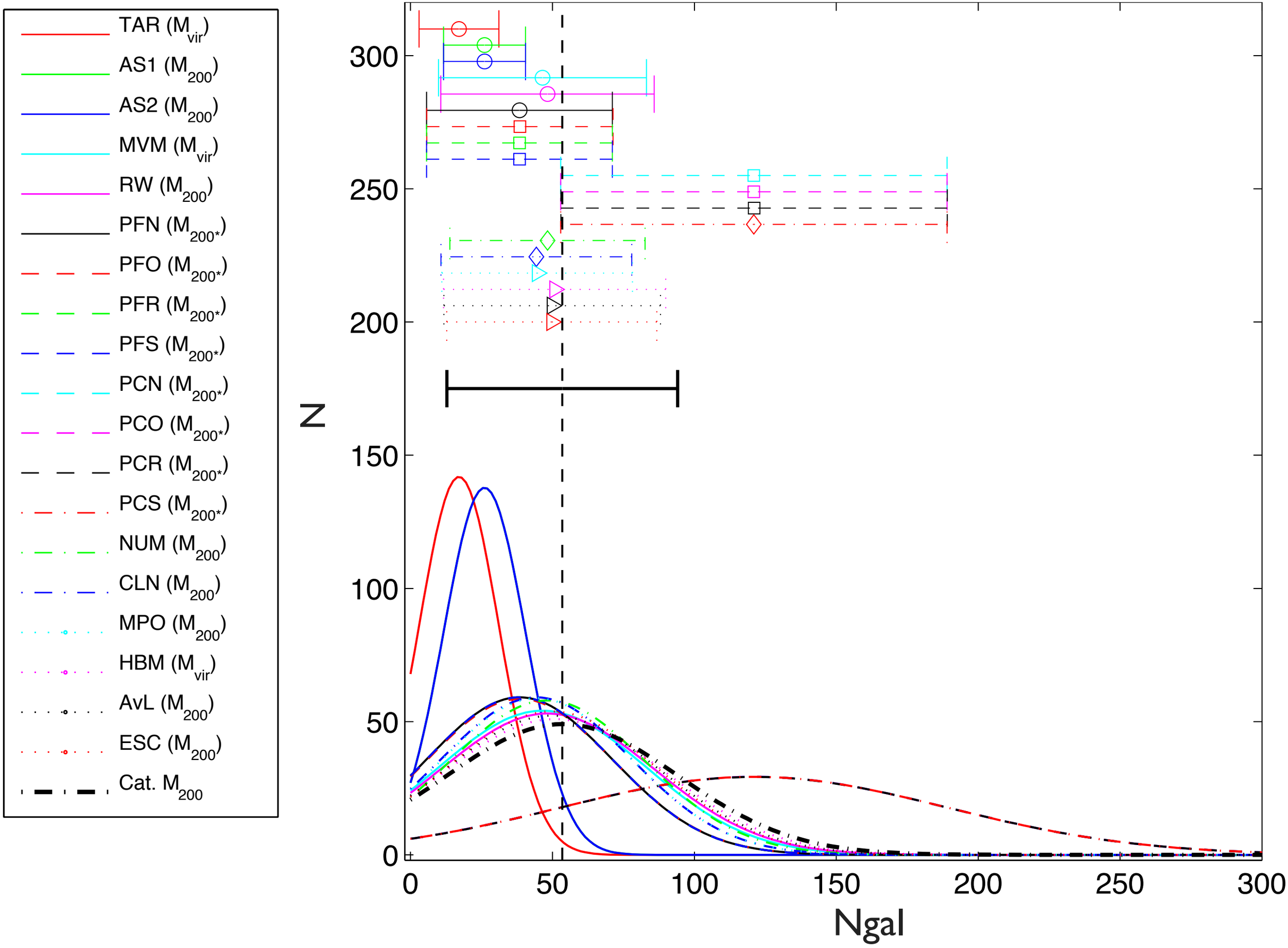

PCN (M_{200*}), NI = 0
3
2
1
1
2
3

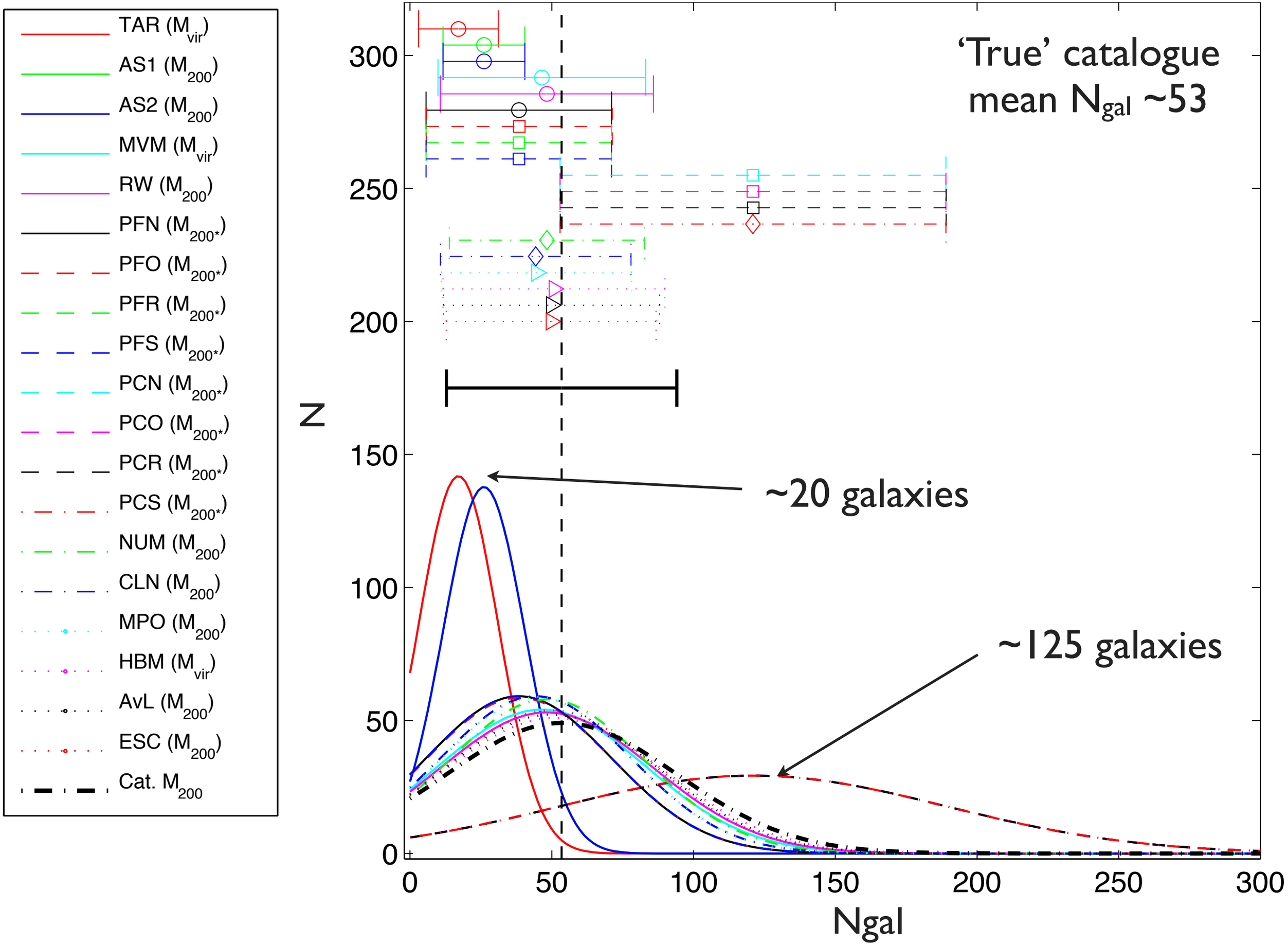

HBM (M_{vir}), NI = 0
3
2
1
1
2
3

TAR (M_{vir}), NI = 0
AS1 (M_{200}), NI = 2
AS2 (M_{200}), NI = 2
MVM (M_{vir}), NI = 6
RW (M_{200}), NI = 0
Log ($N_{Gal,cat.}$)

Results

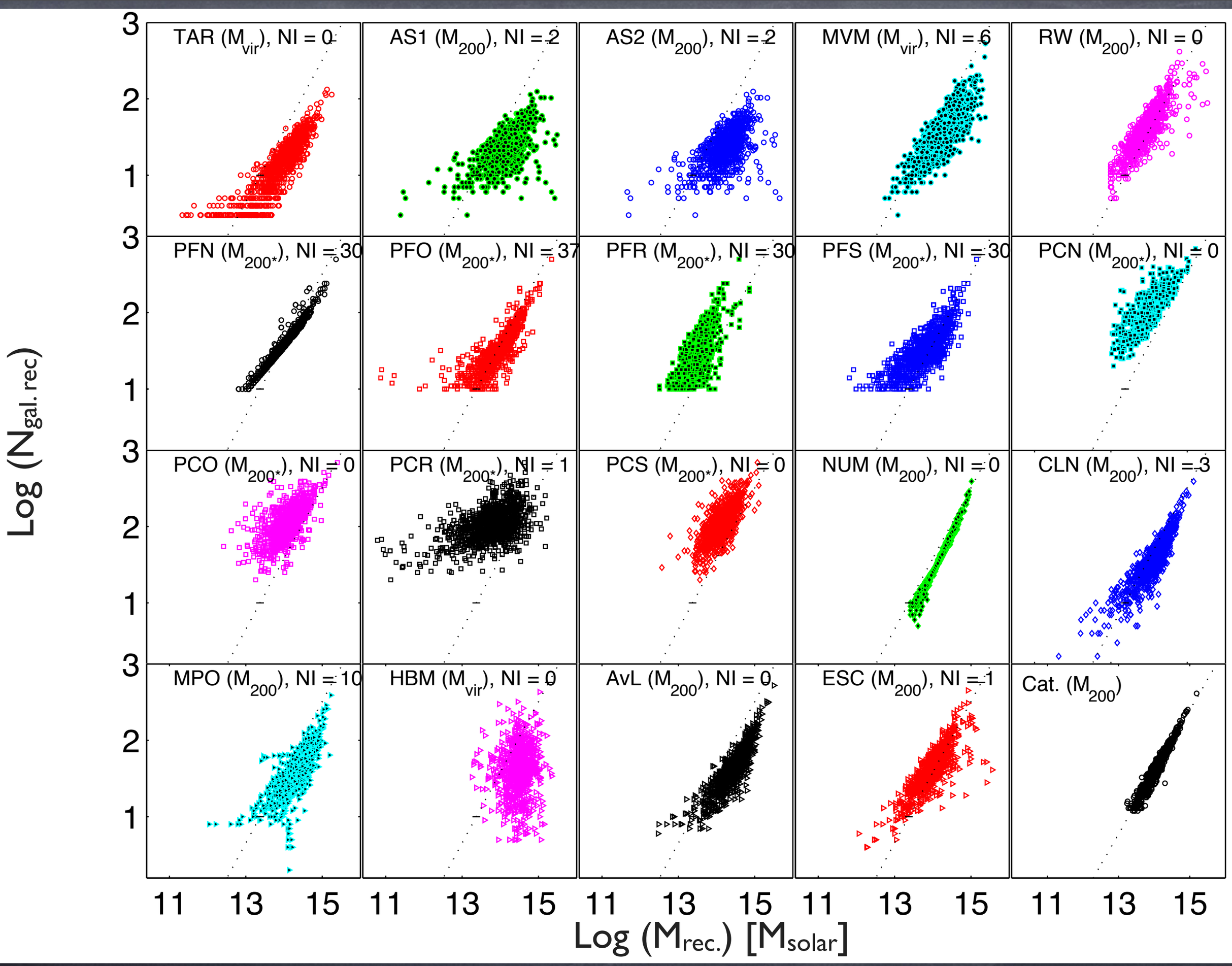
V: Recovered N_{gal} distributions


TAR (M_vir)
AS1 (M_200)
AS2 (M_200)
MVM (M_vir)
RW (M_200)
PFN (M_200*)
PFO (M_200*)
PFR (M_200*)
PFS (M_200*)
PCN (M_200*)
PCO (M_200*)
PCR (M_200*)
PCS (M_200*)
NUM (M_200)
CLN (M_200)
MPO (M_200)
HBM (M_vir)
AvL (M_200)
ESC (M_200)
Cat. M_200
N
Ngal
0
50
100
150
200
250
300


TAR (M_vir)
AS1 (M_200)
AS2 (M_200)
MVM (M_vir)
RW (M_200)
PFN (M_200*)
PFO (M_200*)
PFR (M_200*)
PFS (M_200*)
PCN (M_200*)
PCO (M_200*)
PCR (M_200*)
PCS (M_200*)
NUM (M_200)
CLN (M_200)
MPO (M_200)
HBM (M_vir)
AvL (M_200)
ESC (M_200)
Cat. M_200
'True' catalogue
mean N_gal ~53
~20 galaxies
~125 galaxies
N
Ngal
0
50
100
150
200
250
300

Results

V: Recovered N_{gal} vs recovered mass


TAR (M_{vir}), NI = 0
AS1 (M_{200}), NI = 2
AS2 (M_{200}), NI = 2
MVM (M_{vir}), NI = 6
RW (M_{200}), NI = 0
PFN (M_{200*}), NI = 30
PFO (M_{200*}), NI = 37
PFR (M_{200*}), NI = 30
PFS (M_{200*}), NI = 30
PCN (M_{200*}), NI = 0
PCO (M_{200*}), NI = 0
PCR (M_{200*}), NI = 1
PCS (M_{200*}), NI = 0
NUM (M_{200}), NI = 0
CLN (M_{200}), NI = 3
MPO (M_{200}), NI = 10
HBM (M_{vir}), NI = 0
AvL (M_{200}), NI = 0
ESC (M_{200}), NI = 1
Cat. (M_{200})
Log ($N_{gal. rec}$)
Log ($M_{rec.}$) [M_{solar}]
1
2
3
11
13
15

Summary

- Majority of methods recover halo mass more accurately for higher mass haloes than lower mass haloes.

- Richness based methods within a cylindrical volume appear to recover more accurate masses than FoF based methods.

- Even methods with the lowest fractional deviations, on average, under- or over-estimate halo mass by ~20-70%.

- The number of galaxies associated with each halo also varies substantially, from N_{gal} ~20 to N_{gal} ~125.

Next step: incorporate new methods, R_{200}/σ, phase 2!