Hubble Frontier Fields:
''A New Era for Gravitational Lensing''

SF2A :
Science with the James Webb Space Telescope
2nd June 2015

Durham University

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THE *HST FRONTIER FIELDS* INITIATIVE

WHY THE *HUBBLE FRONTIER FIELDS* ?

(http://www.stsci.edu/hst/campaigns/frontier-fields)

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THE MOST POWERFUL TELESCOPE TO OBSERVE THE DISTANT UNIVERSE

1. Highly-constrained Gravitational Lensing mass models

2. Highly-precise Magnification estimates

1. THE DISTANT UNIVERSE
2. CLUSTER PHYSICS : STUDYING THE COSMIC WEB
3. GALAXY EVOLUTION, …

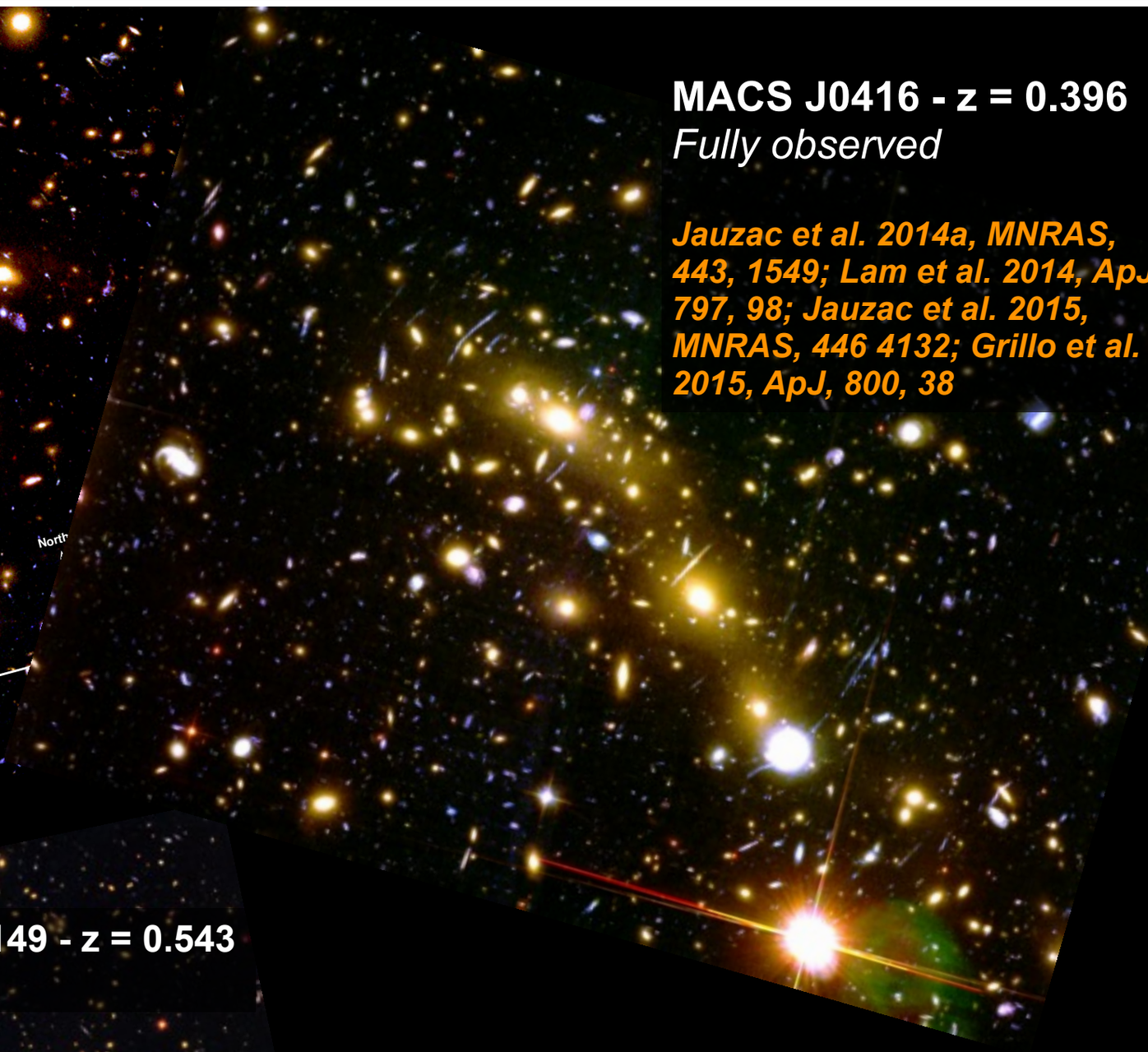
THE *HST FRONTIER FIELDS* TARGETS

Abell 2744 - z = 0.308
Fully observed

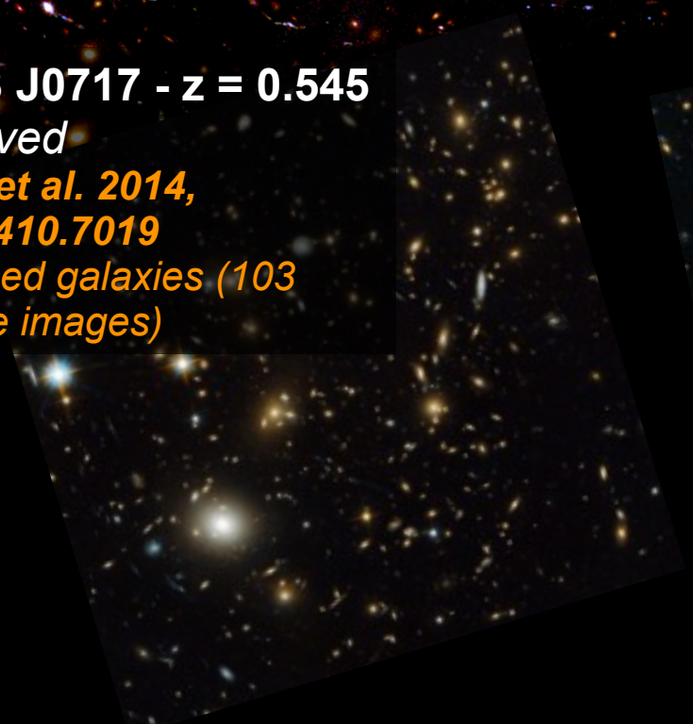
Atek et al. 2014a, ApJ, 786, 60 ; Laporte et al. 2014, A&A, 562, 8; Zitrin et al. 2014, ApJ, 793, 12; Ishigaki et al. 2015, ApJ, 799, 12; Atek et al. 2015, ApJ, 800, 18; Jauzac et al. 2014b, arXiv 1409.8663

MACS J0416 - z = 0.396
Fully observed

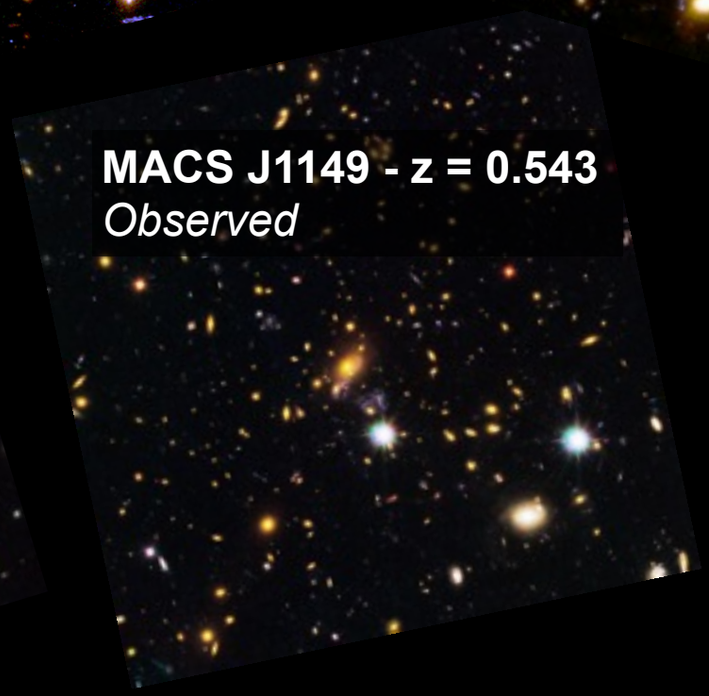
Jauzac et al. 2014a, MNRAS, 443, 1549; Lam et al. 2014, ApJ, 797, 98; Jauzac et al. 2015, MNRAS, 446 4132; Grillo et al. 2015, ApJ, 800, 38



MACS J0717 - z = 0.545
Observed
Diego et al. 2014, arXiv1410.7019
50 lensed galaxies (103 multiple images)



MACS J1149 - z = 0.543
Observed



Abell 370
z = 0.375

Abell S1063
z = 0.348

THE *HST FRONTIER FIELDS* TARGETS

Abell 2744 - z = 0.308
Fully observed

MACS J0416 - z = 0.396
Fully observed

PRE-HFF & HFF MASS INITIATIVE :

Public mass models

http://archive.stsci.edu/prepds/frontier/lensmodels/

PARAMETRIC

GLAFIC
Oguri10

LTM
Zitrin+09,13

Lenstool
Jullo+07

NON-PARAMETRIC

WSLAP+
Diego+07

SaWLens
Merten+09,14

SWUnited
Bradac+05

GRALE
Liesenborgs+06

hybrid-Lenstool
Jullo+09

1. *MACSJ0416* : BEFORE HFF …

Past Lensing History

2013

Zitrin et al. 2013, *ApJ, 762, 30*

34 SL multiple images
no WL data

2014 : PreHFF GL analysis

Johnson et al. 2014, *ApJ*, 797, 48
Coe et al. 2015, *ApJ*, 800, 84
Richard et al. 2014, MNRAS, 444, 268

47 SL multiple images
~50 WL gal.arcmin^{-2}

1. *MACSJ0416* : … AFTER HFF !!!

TODAY Lensing Picture

2014 : HFF GL analysis

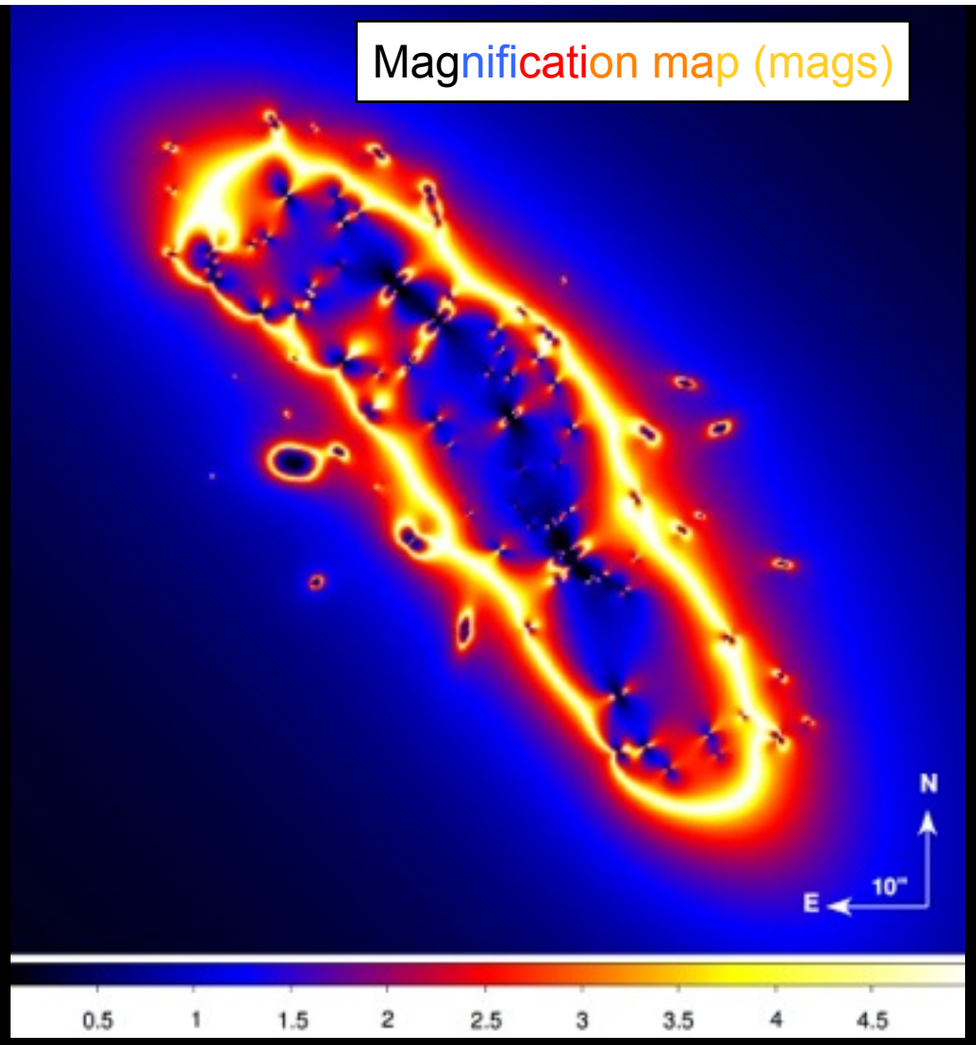
Jauzac et al. 2014a, *MNRAS, 443, 1549*
Jauzac et al. 2015, *MNRAS, 446, 4132*

194 SL multiple images

~100 WL gal.arcmin^{-2}

The MOST constrained galaxy cluster to date !!!

2. *MACSJ0416* : MASS & MAGNIFICATION



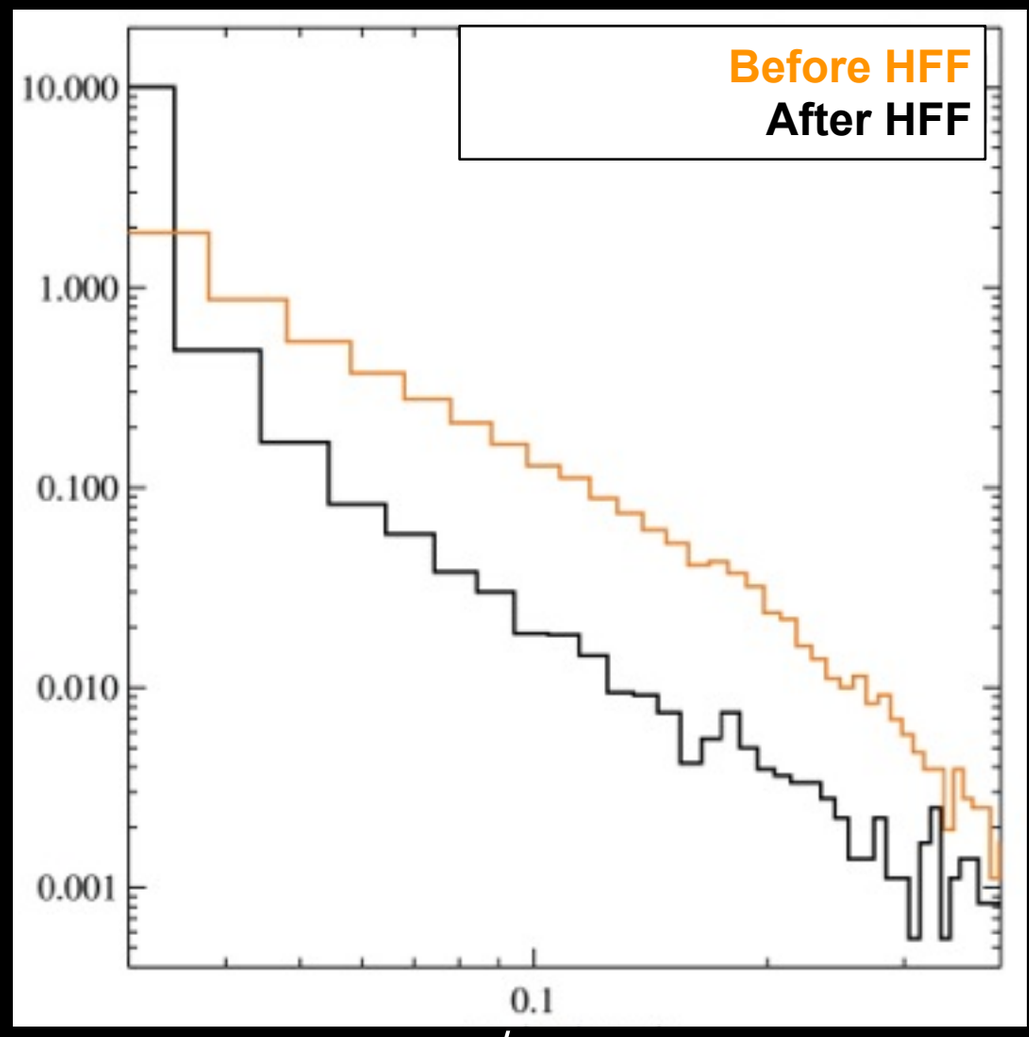
Mass estimation to ***the 1% level :***

M(R<200kpc) = 1.60 ± 0.01 (stat) 10^{14} M_{sun}

Magnification to ***the 4% level :***

μ = 3.88 ± 0.15 (stat)

Highest precision ever obtained for mass & magnification measurements



4. *ABELL 2744* : BEFORE HFF ...

Past Lensing History

Smail et al. 1997, *APJ, 479, 70*
Allen 1998, *MNRAS, 296, 392*

2011

Merten et al. 2011, *MNRAS, 417, 333*

34 SL multiple images
no WL data

2014 : PreHFF GL analysis

Johnson et al. 2014, *ApJ*, 797, 48
Coe et al. 2015, *ApJ*, 800, 84
Richard et al. 2014, MNRAS, 444, 268

55 SL multiple images
~50 WL gal.arcmin^{-2}

HST/ACS imaging - Merten et al. 2011

4. *Abell 2744* : … After HFF !!!

TODAY Lensing Picture

2014 - 2015 : HFF GL analysis

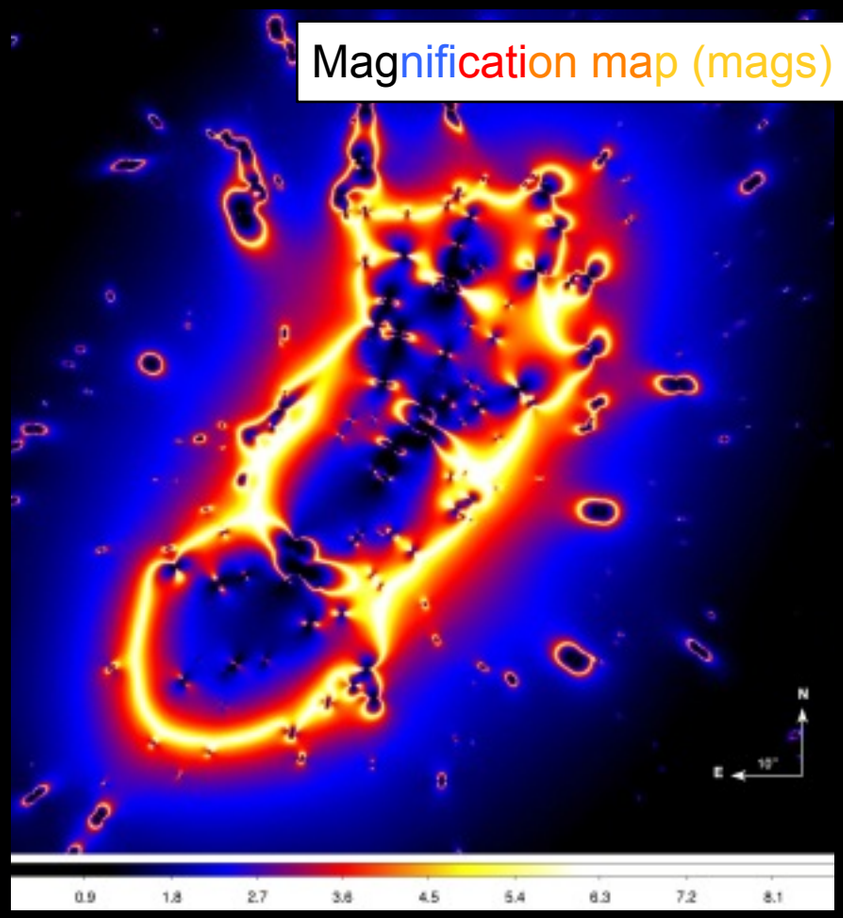
Jauzac et al. 2014b, *arXiv1409.8663*
Lam et al. 2014, ApJ, 797, 98
Wang et al. 2015, arXiv1504.0240
Jauzac et al. 2015, *in prep.* - Medezinski et al. *2015, in prep.* - Merten et al. 2015, *in prep.*

183 SL multiple images

~100 WL gal.arcmin^{-2}

The 2nd MOST constrained cluster to date !!!

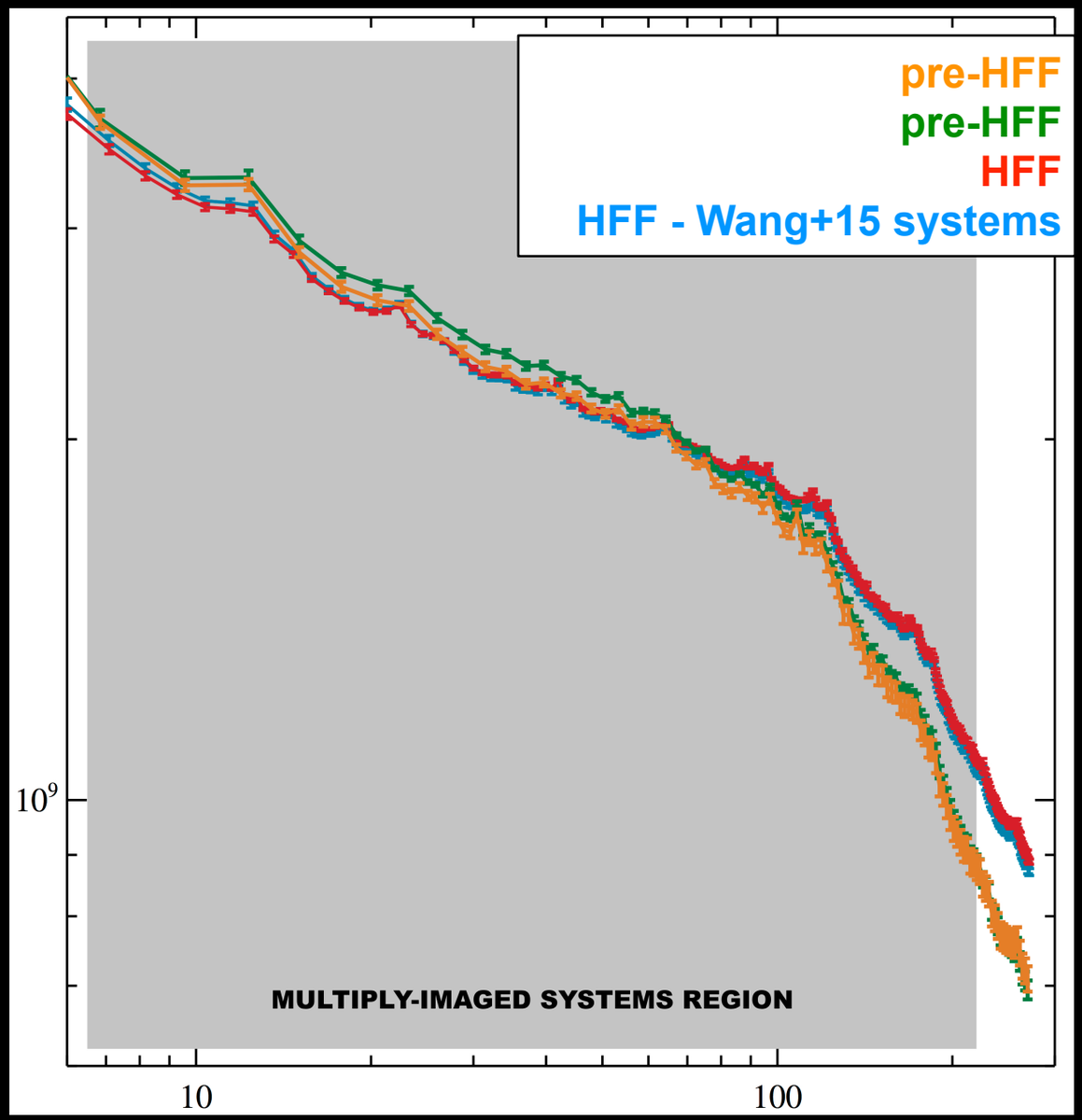
5. *ABELL 2744* : MASS & MAGNIFICATION

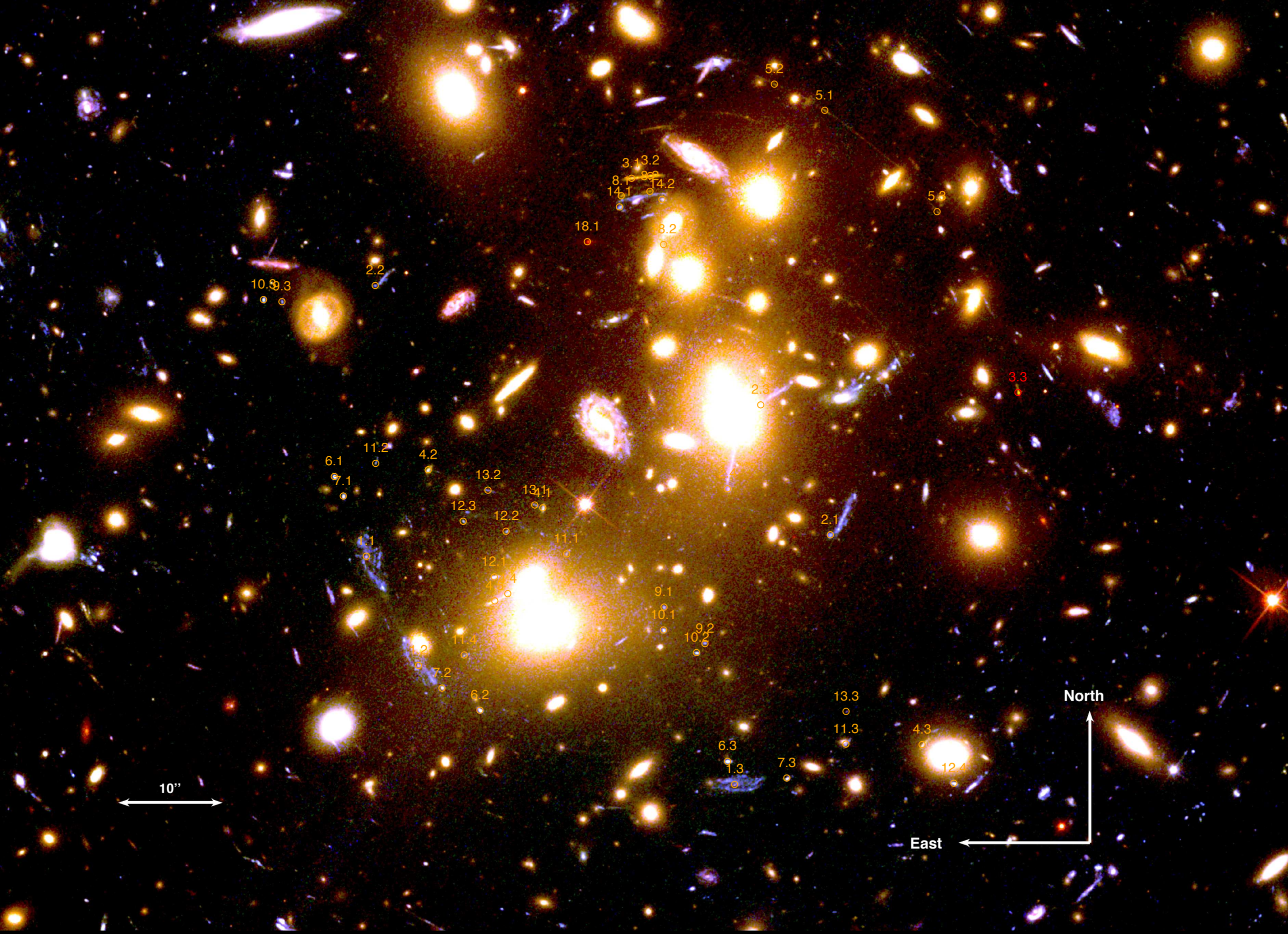


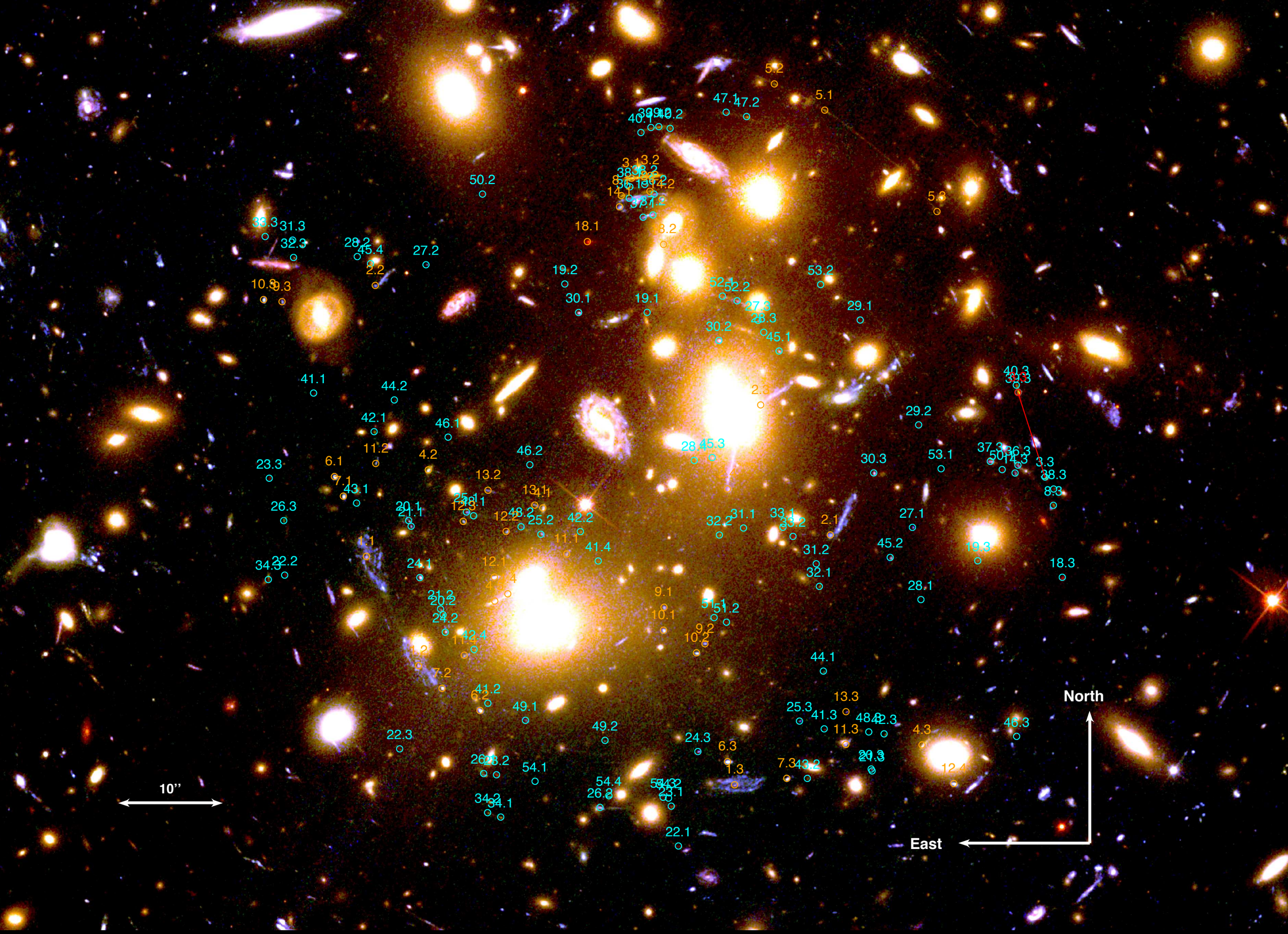
Mass estimation to ***the <1% level :***
M(R<200kpc) = 2.162 ± 0.005 (stat) 10^{14} M_{sun}

Magnification to ***the % level :***
μ = 5.61 ± 0.10 (stat)

pre-HFF (Richard et al. 2014, MNRAS, 444, 268) :
μ = 4.69 ± 0.32 (stat)



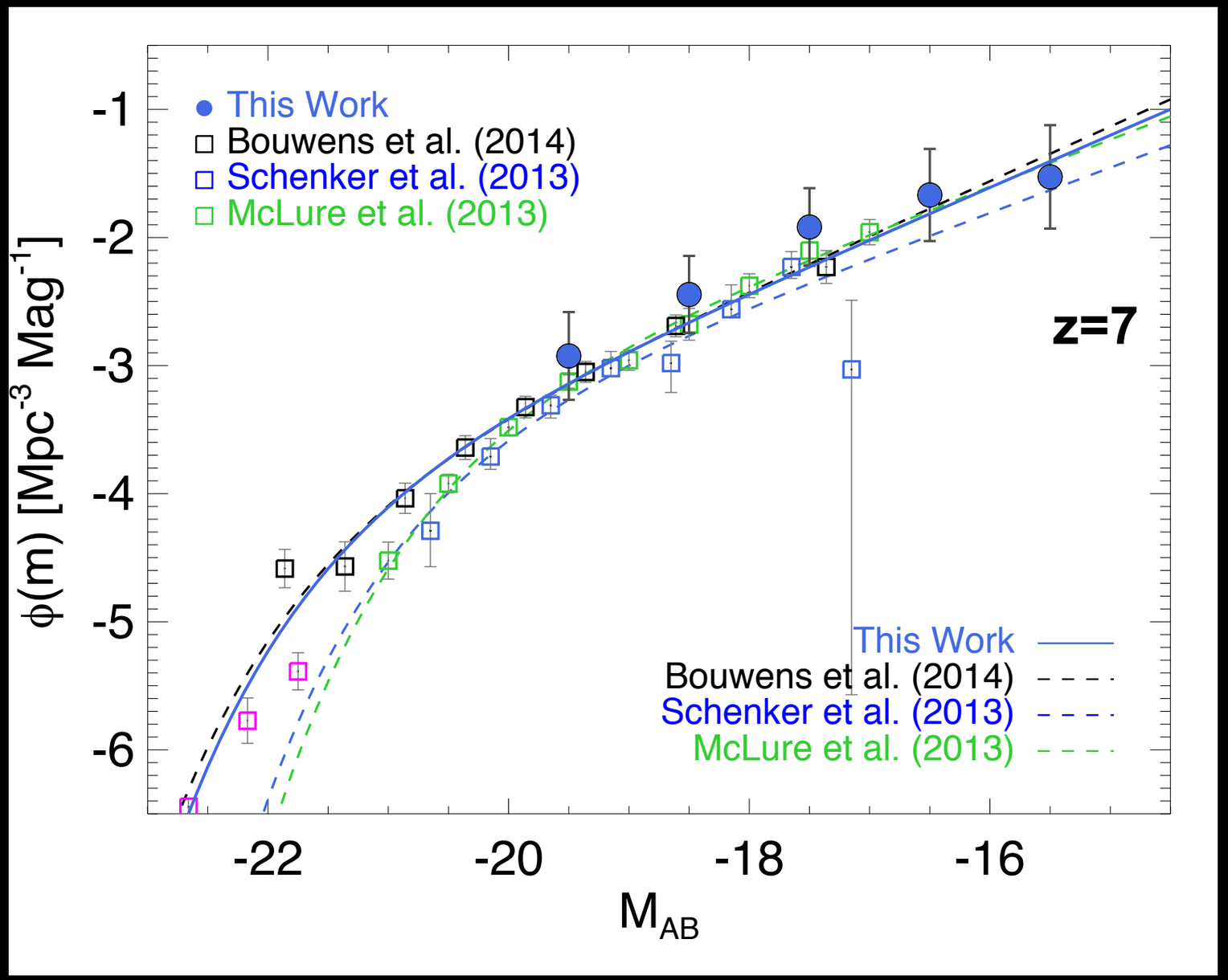

5.2
5.1
3.1
3.2
8.1
14.1
14.2
5.3
18.1
8.2
2.2
10.3
9.3
3.3
2.3
11.2
4.2
6.1
7.1
13.2
13.1
4.1
12.3
12.2
2.1
11.1
12.1
4
9.1
10.1
9.2
10.2
11.4
7.2
6.2
13.3
11.3
4.3
6.3
7.3
1.3
12.4
10”
North
East


10''
North
East

5. *ABELL 2744* : MASS & MAGNIFICATION

IMPACT OF MODEL UNCERTAINTIES ON THE UV LF :

Comparison between **HFF** and **pre-HFF** based model of A2744



Atek et al. 2014, 2015
Jauzac et al. 2014b
Richard et al. 2014a

5. *ABELL 2744* : MASS & MAGNIFICATION

IMPACT OF MODEL UNCERTAINTIES ON THE UV LF :

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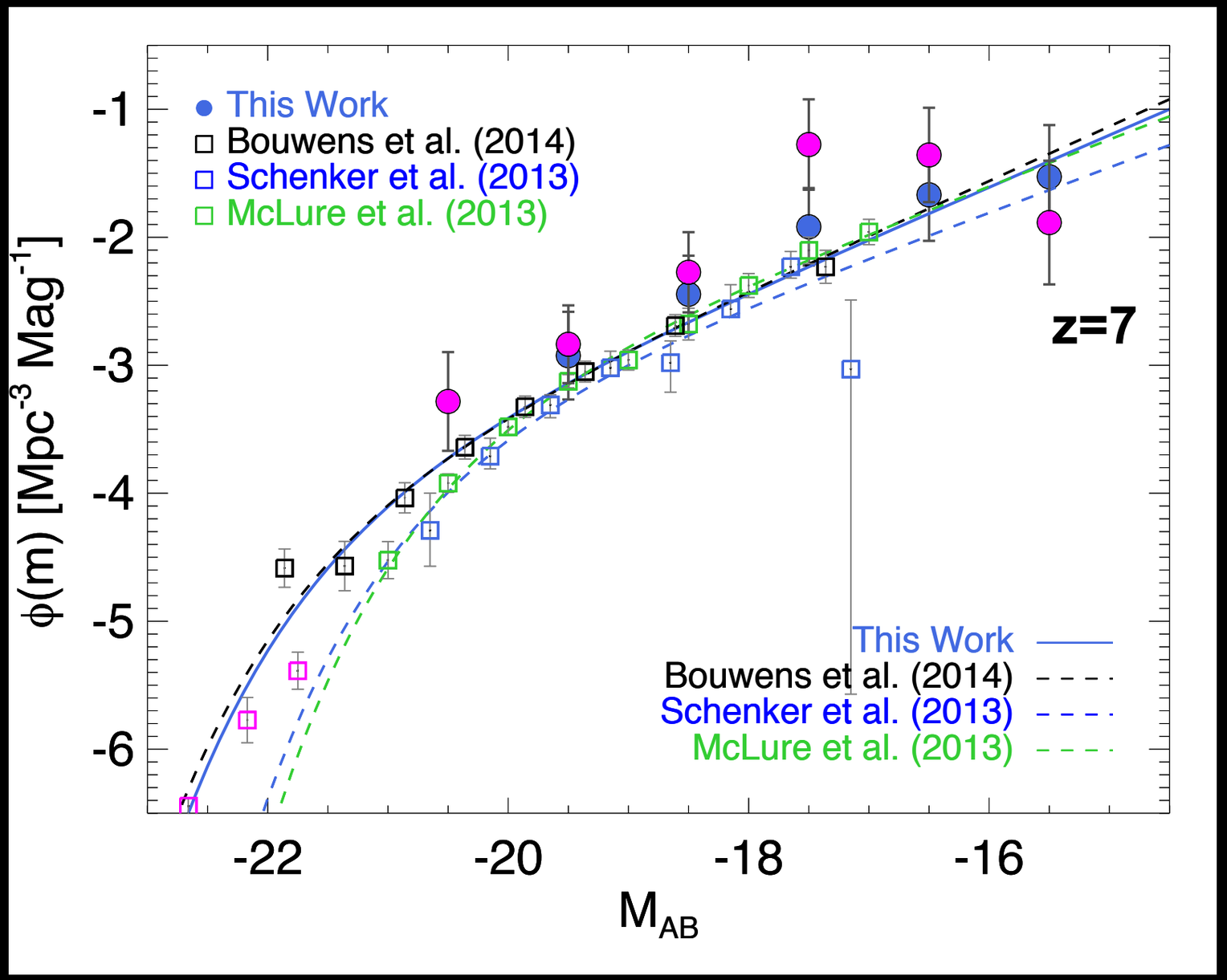


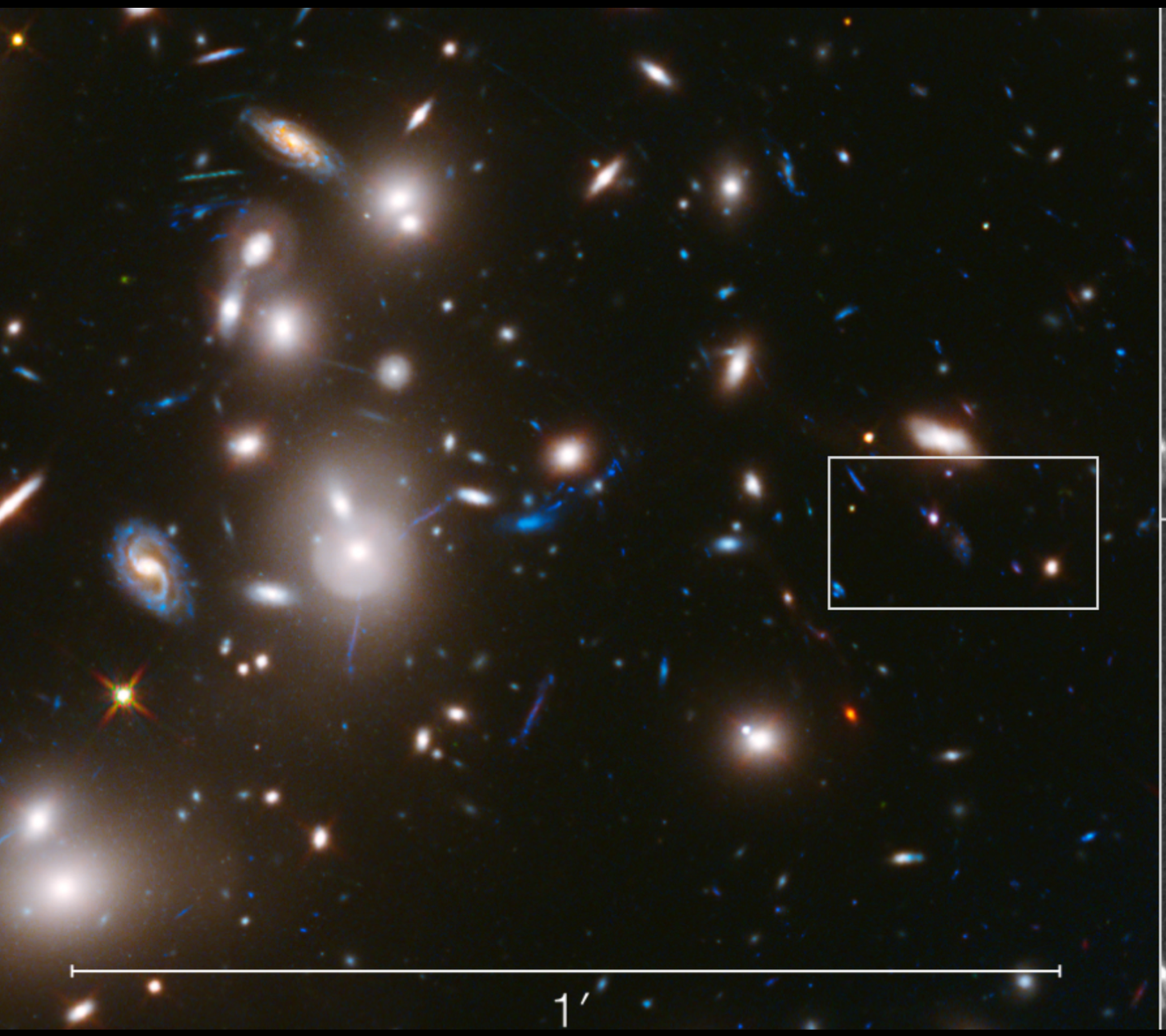
Atek et al. 2014, 2015
Jauzac et al. 2014b
Richard et al. 2014a

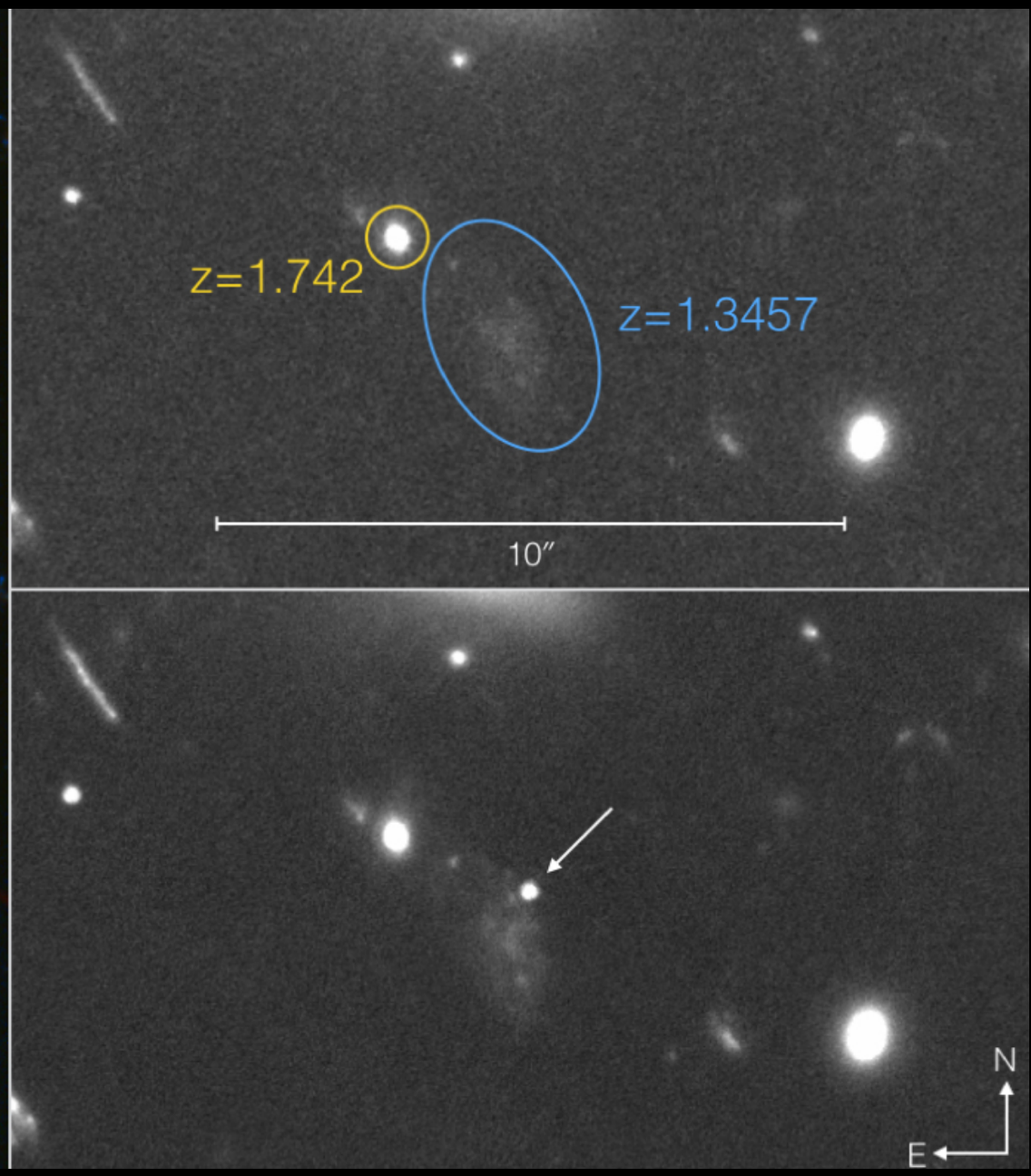
5. *Abell 2744* : Mass & Magnification

SN HFF14Tom :

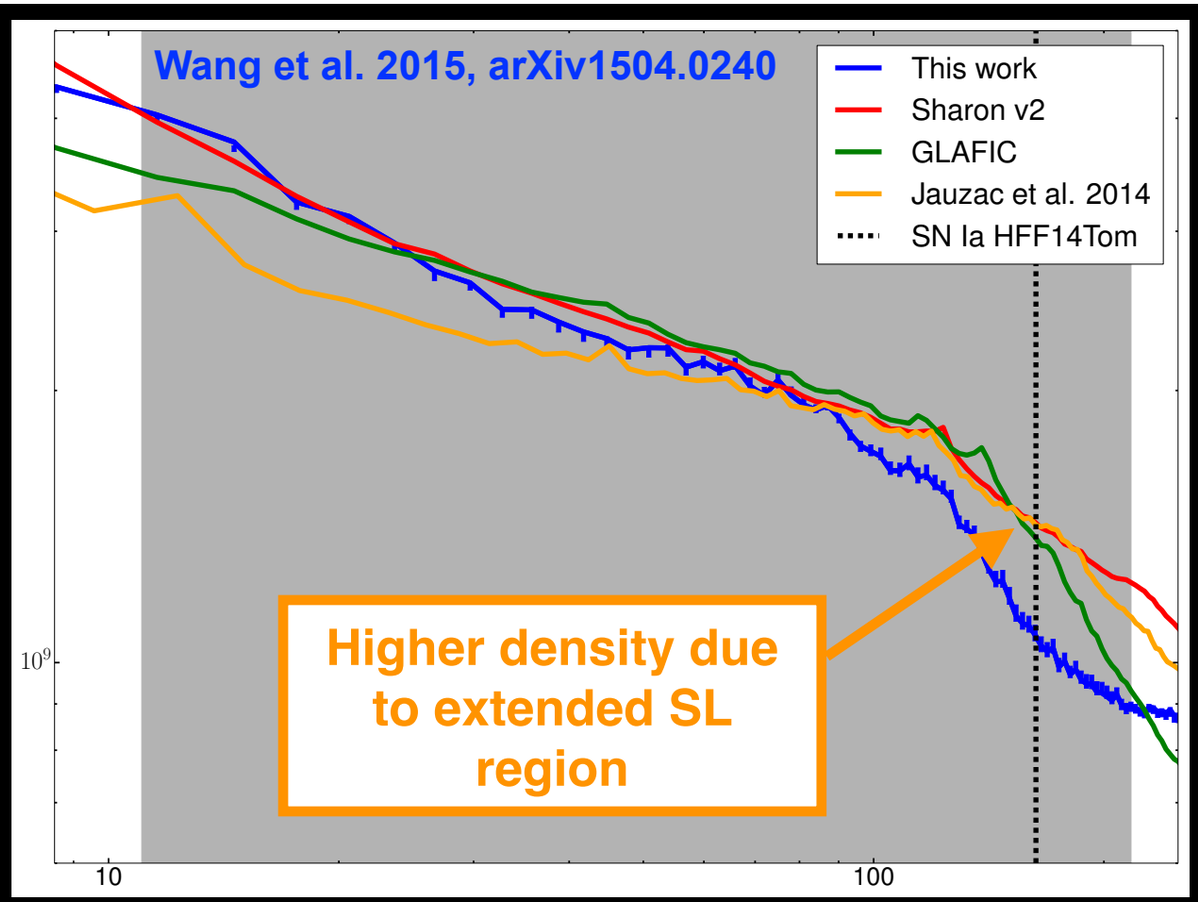
Rodney et al. 2015 - z = 1.35

μ_{SN} = 2.03 ± 0.29 & μ_{HFF} = 3.06 ± 0.14





5. *ABELL 2744* : MASS & MAGNIFICATION



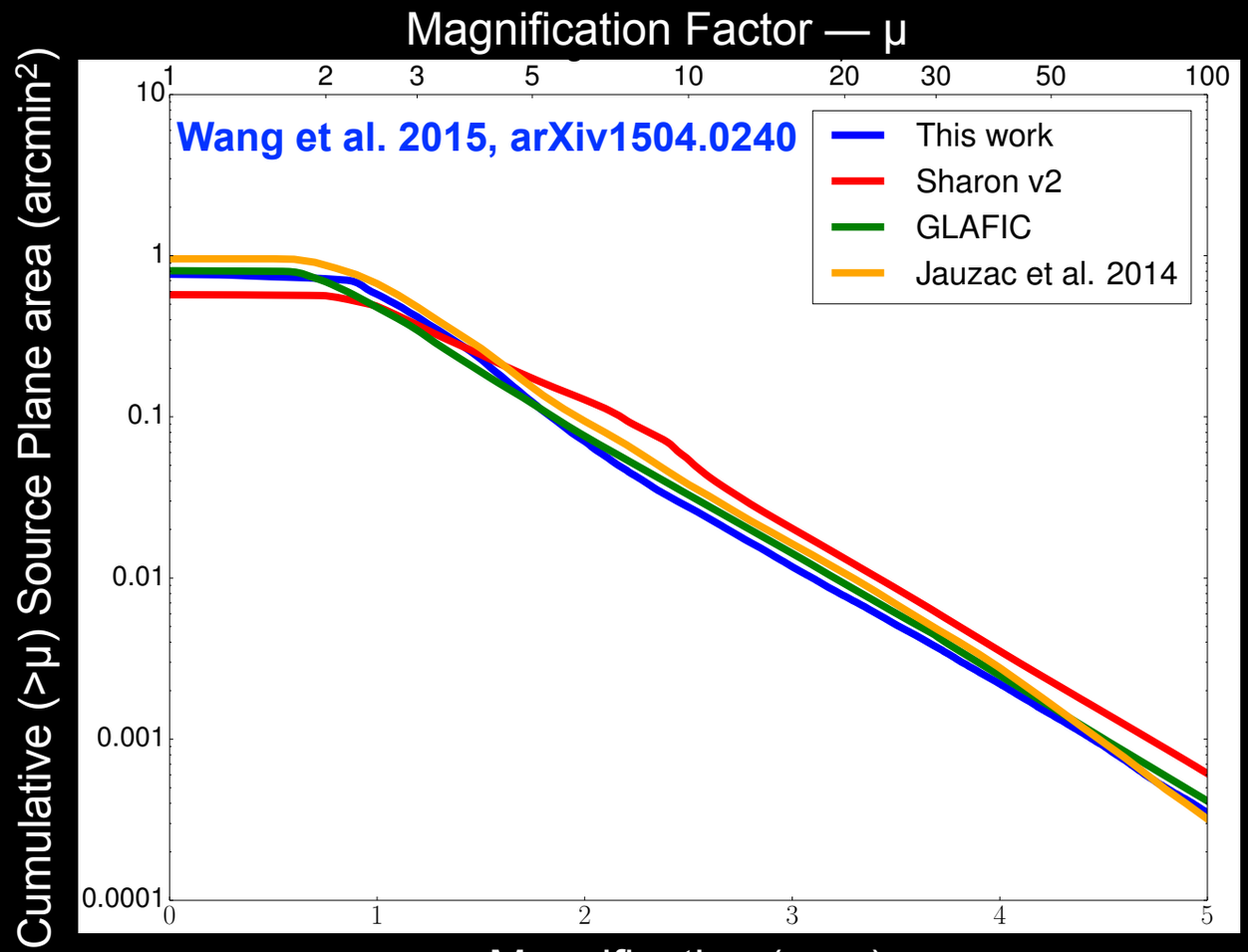
HFF COMPARISON :

Wang et al. (2015), Sharon v2, GLAFIC & Jauzac et al. (2014b)

DENSITY PROFILES

- More SL constraints
- Correction of pre-HFF model

MORE MULTIPLE IMAGES = HIGHER DENSITY ?



GLOBAL MAGNIFICATION

- **GOOD AGREEMENT BETWEEN MODELS**
- Better estimation of the magnification
- Better constraints on high-z luminosity function

  Zitrin et al. 2014, *arXiv 1407.3769,* Ishigaki et al. 2014, arXiv 1408.6903, Atek et al. 2014d, *arXiv 1409.0512*

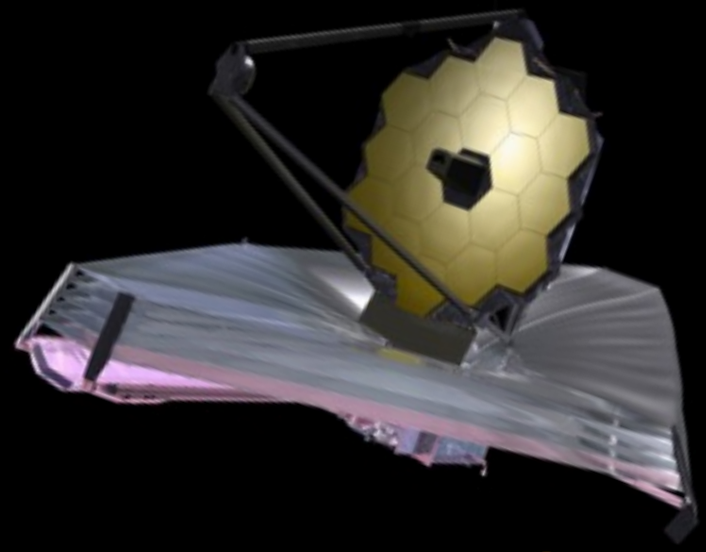
CONCLUSIONS & PERSPECTIVES

Magnification Measurements

- **UNDERSTANDING OF SYSTEMATICS : More investigations on simulated clusters**
  - **SN HFFTom : Discrepancy between all mass models**

- **HIGH-Z UNIVERSE : Already >100 high-z candidates with z > 6**

What's next ?



- **HFF = FIRST STEPS TO WHAT'S GONA BE POSSIBLE WITH JWST !**
  - **Imaging : with JWST *+ 1.8 mag for same exposure time* with HST**
    Spectroscopy : with JWST *~3.5 mag for same exposure time*
  - **HFF-type campaigns much quicker**

My last safari :)

Thank you for your attention