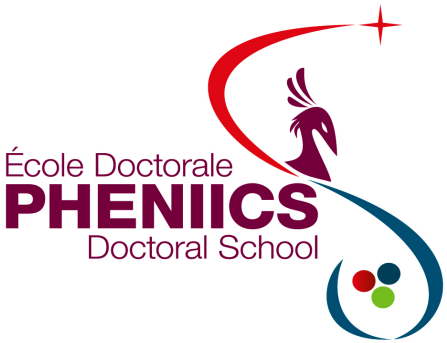
Particules, Hadrons, Energie, Noyaux, Instrumentation, Imagerie, Cosmos et Simulations



Warm Dark Matter Constraints from the Lyman-alpha Forest

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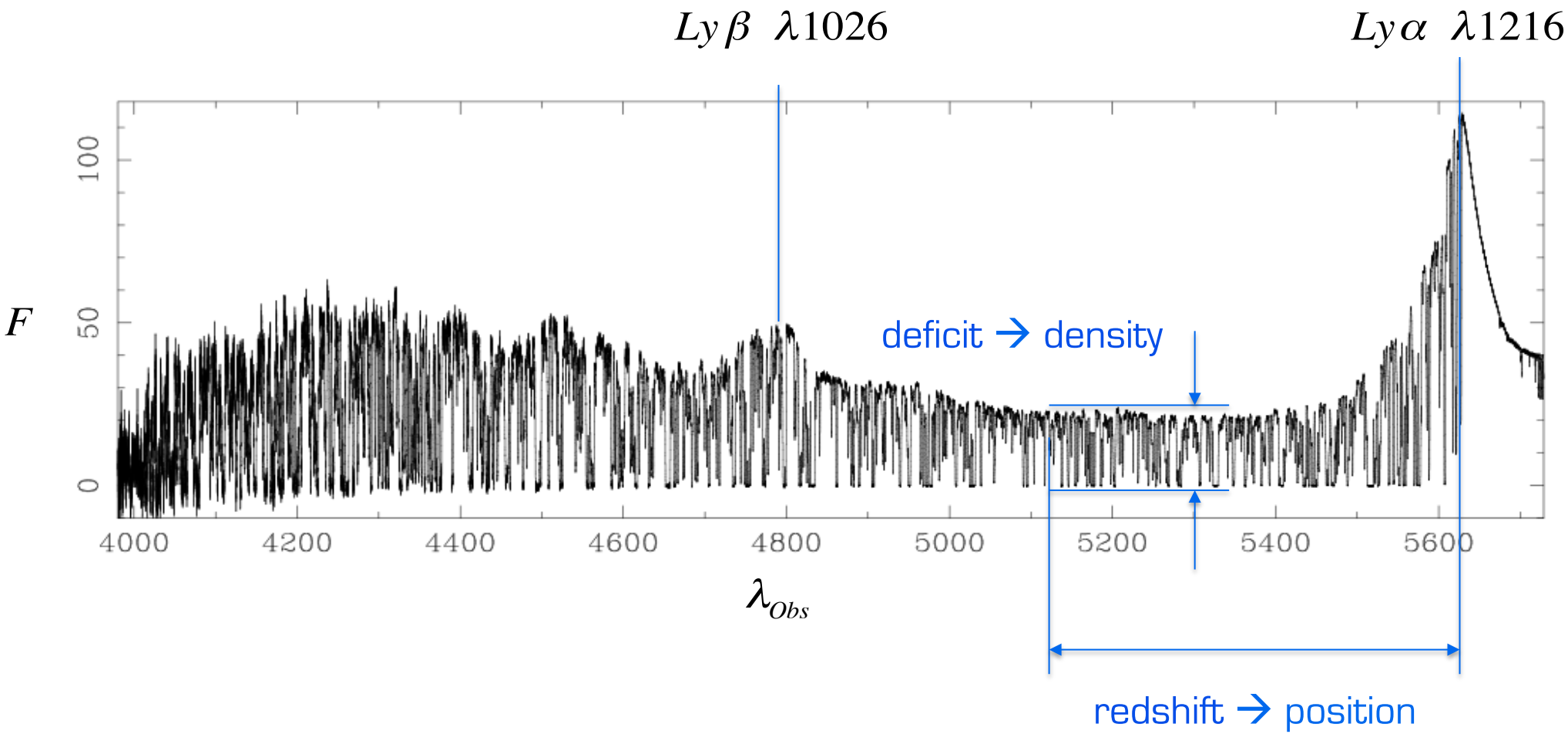
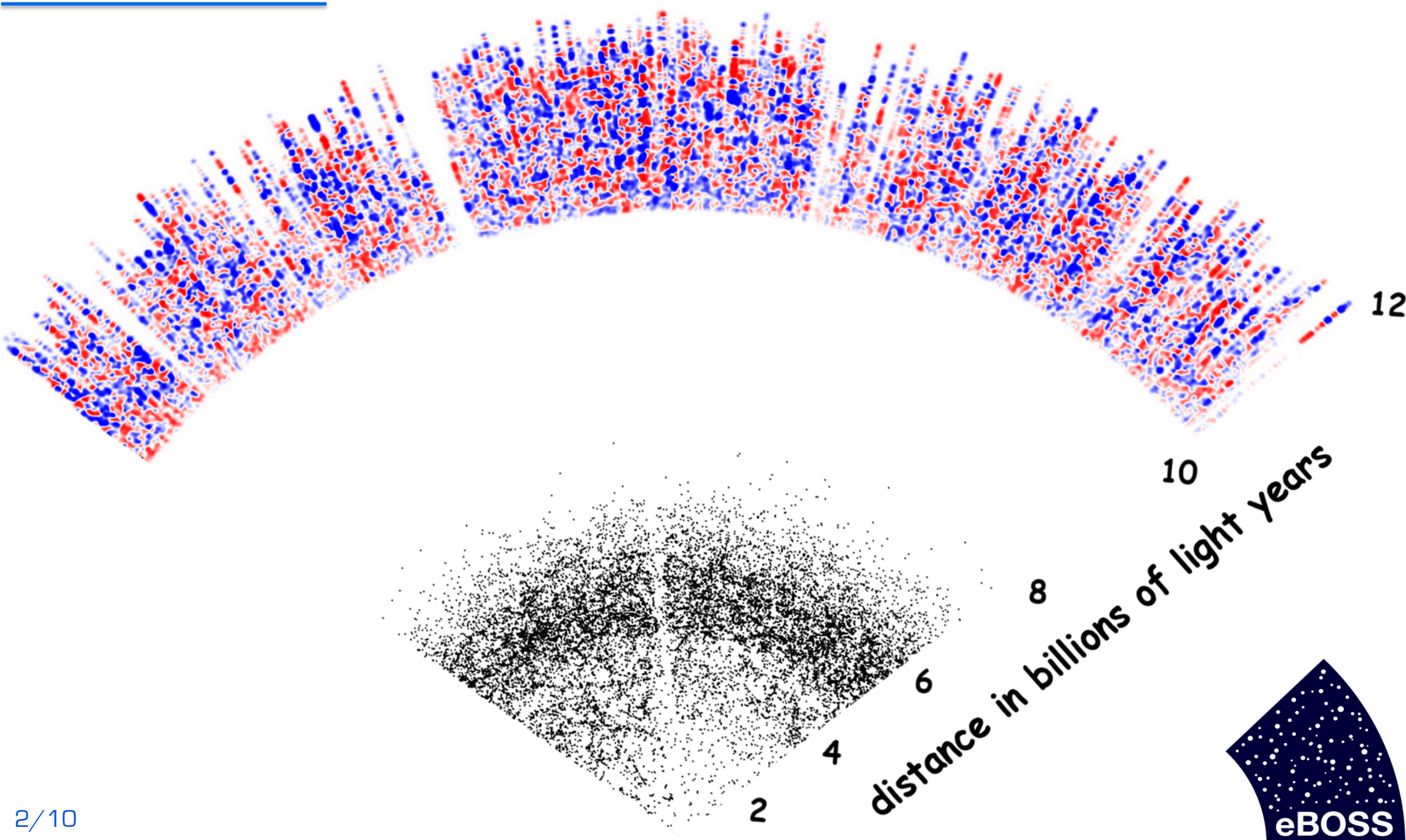
Irfu / SPP – CEA

Lyman-alpha Forest



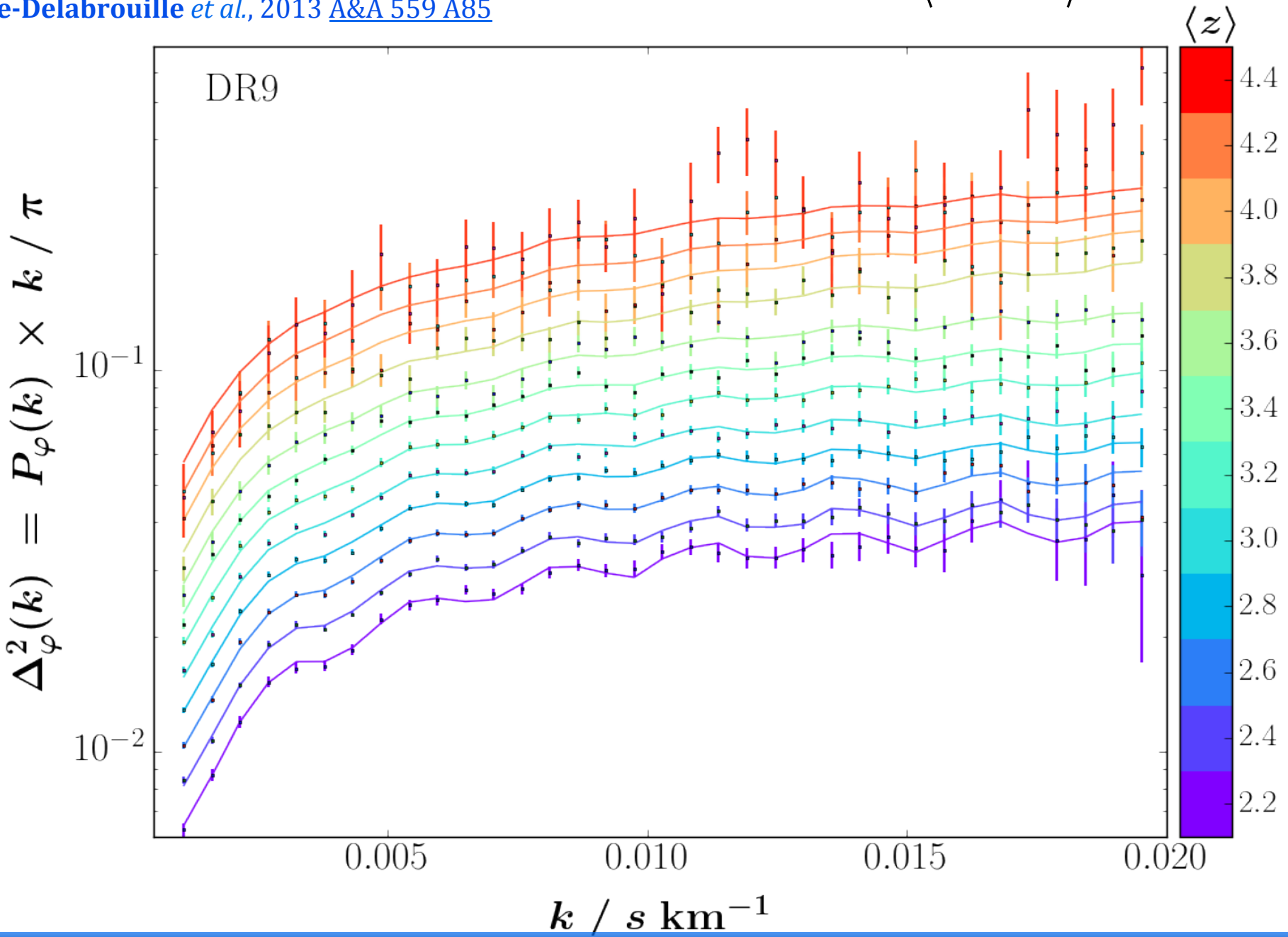
SDSS-BOSS



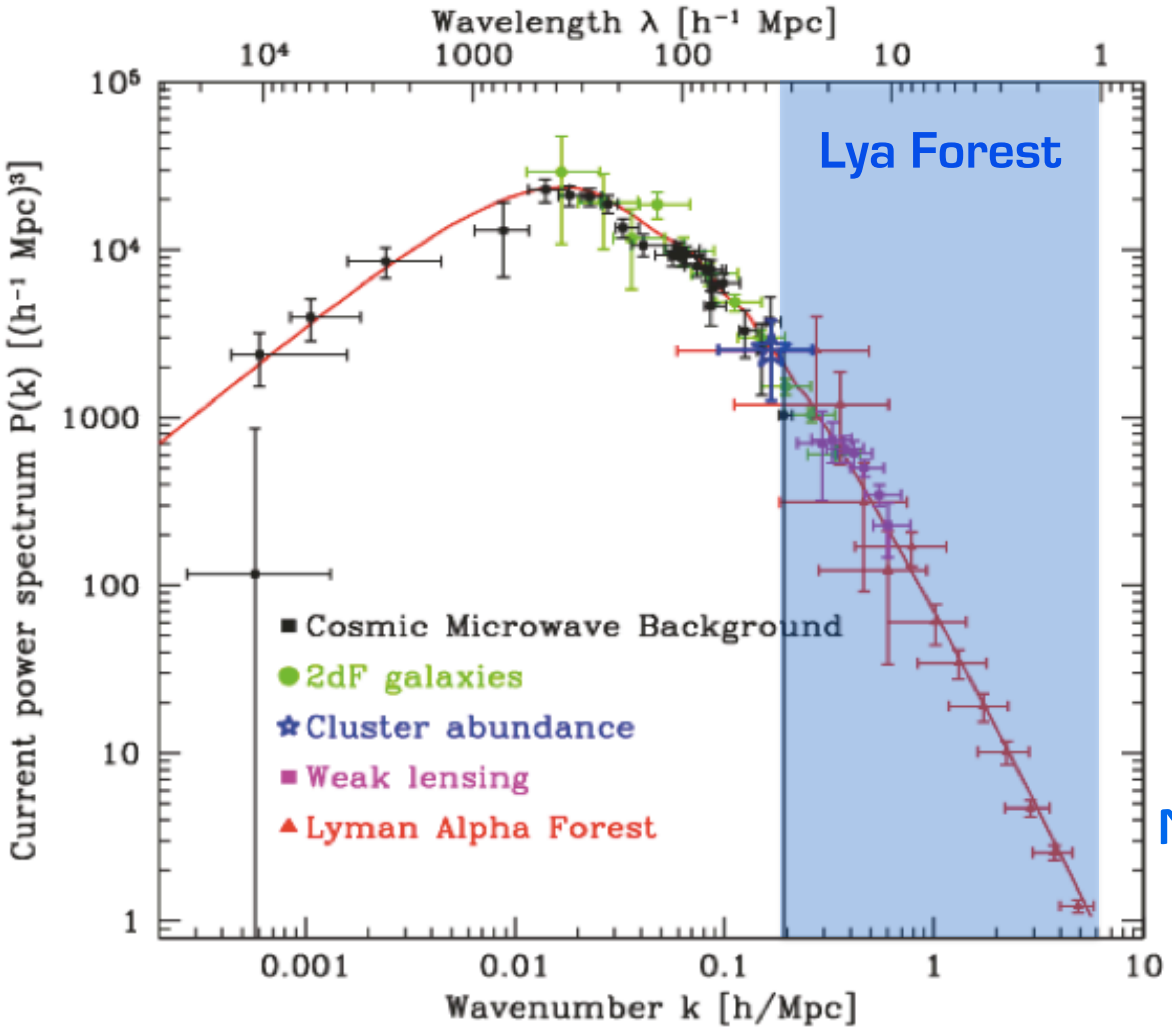
Flux Power Spectrum

$$P_\phi(k) = \left\langle \left| \tilde{\delta}_\phi(k) \right|^2 \right\rangle$$

Palanque-Delabrouille *et al.*, 2013 A&A 559 A85



from Flux PS to Matter PS



Tegmark & Zaldarriaga, 2002

$$P_{1D}(k_{\parallel}) = \frac{1}{2\pi}\int_{k_{\parallel}}^{\infty} k P_{3D}(k)\mathrm{d}k$$

- unidimensional probe
- non-linear regime

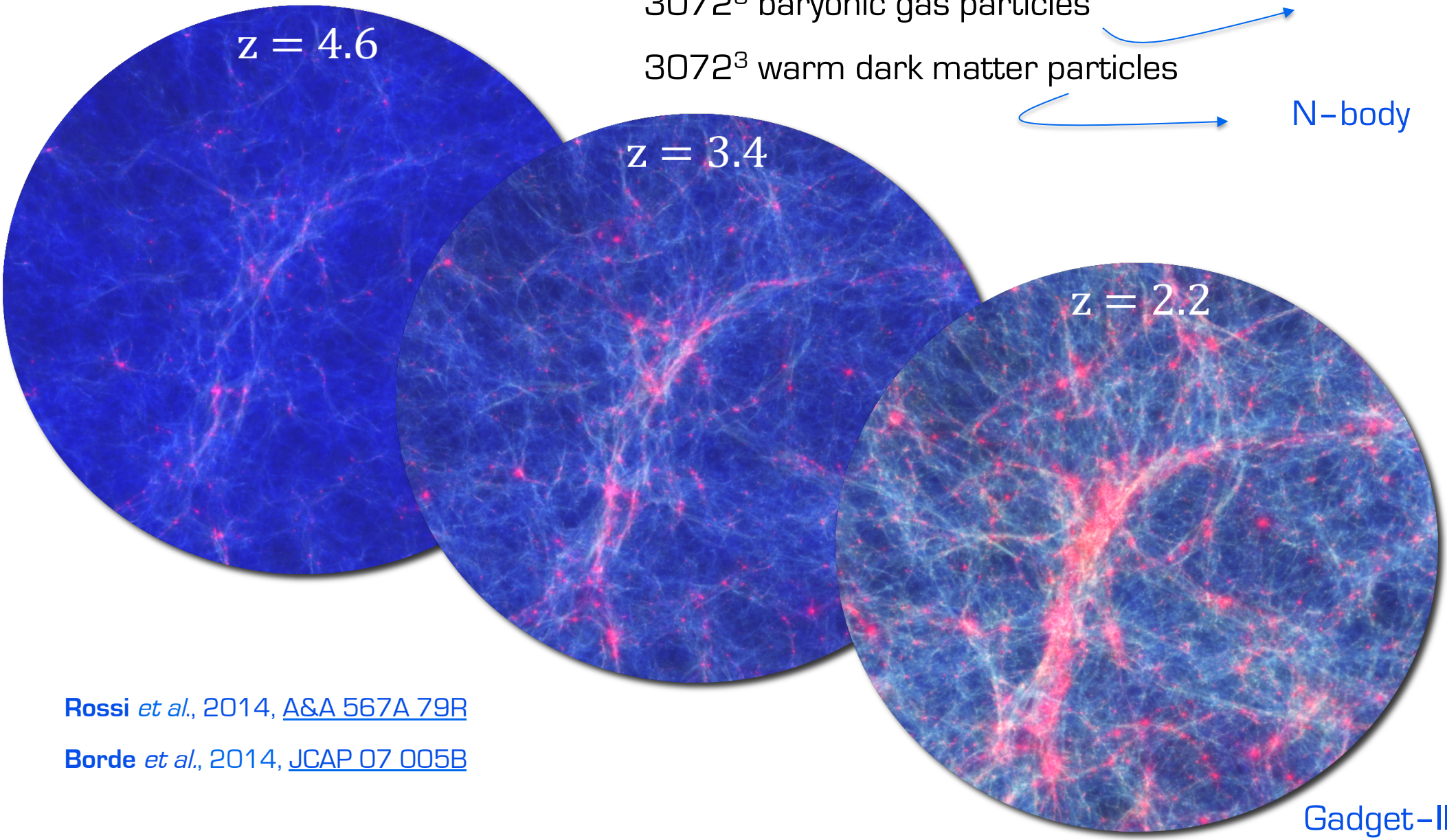
Numerical Approach Required

Simulations

$(100\ h^{-1}.\mathrm{Mpc})^3$ cube containing:

3072^3 baryonic gas particles — Hydrodynamics

3072^3 warm dark matter particles — N-body

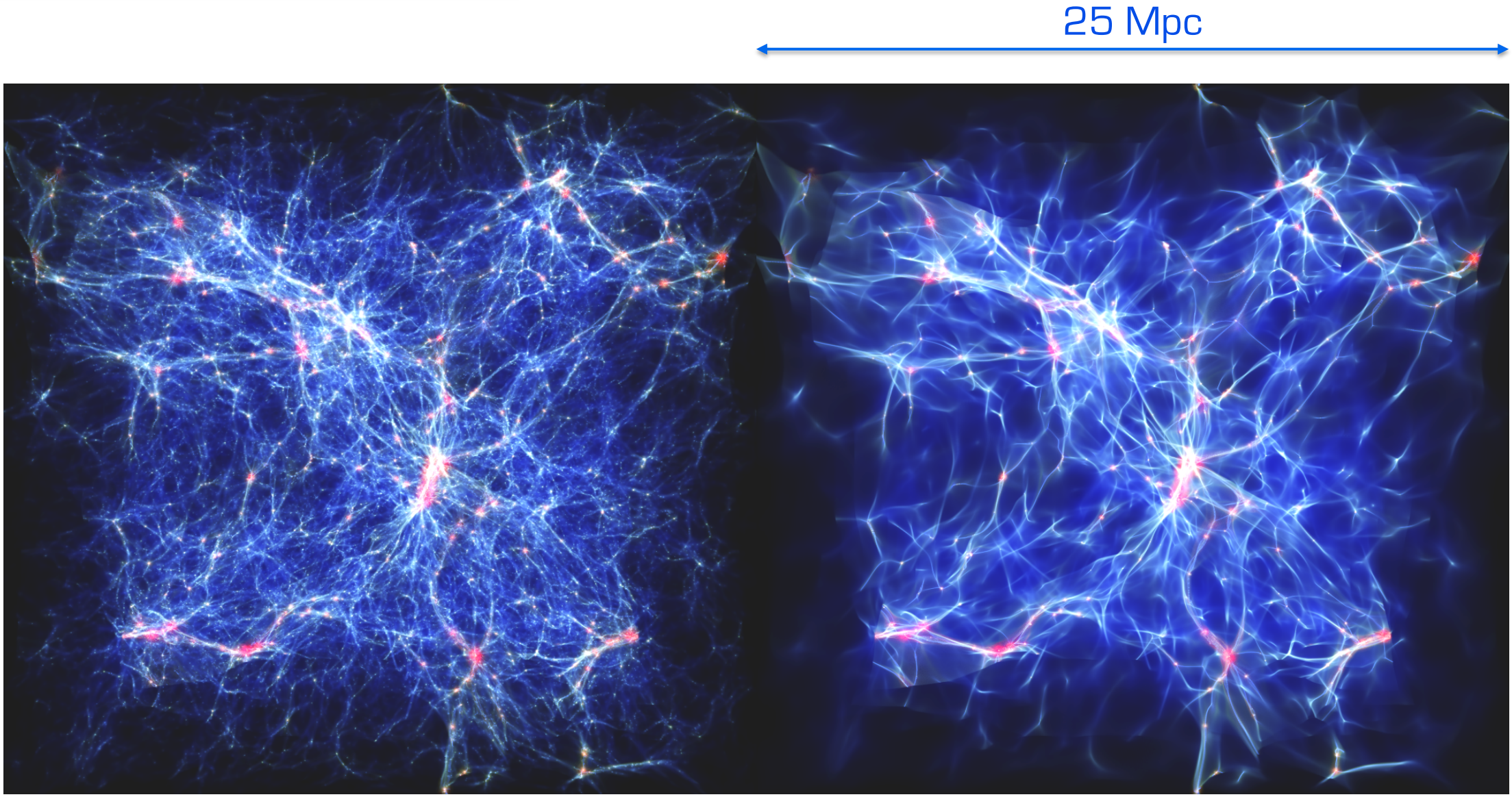


Gadget-III

Rossi *et al.*, 2014, A&A 567A 79R

Borde *et al.*, 2014, JCAP 07 005B

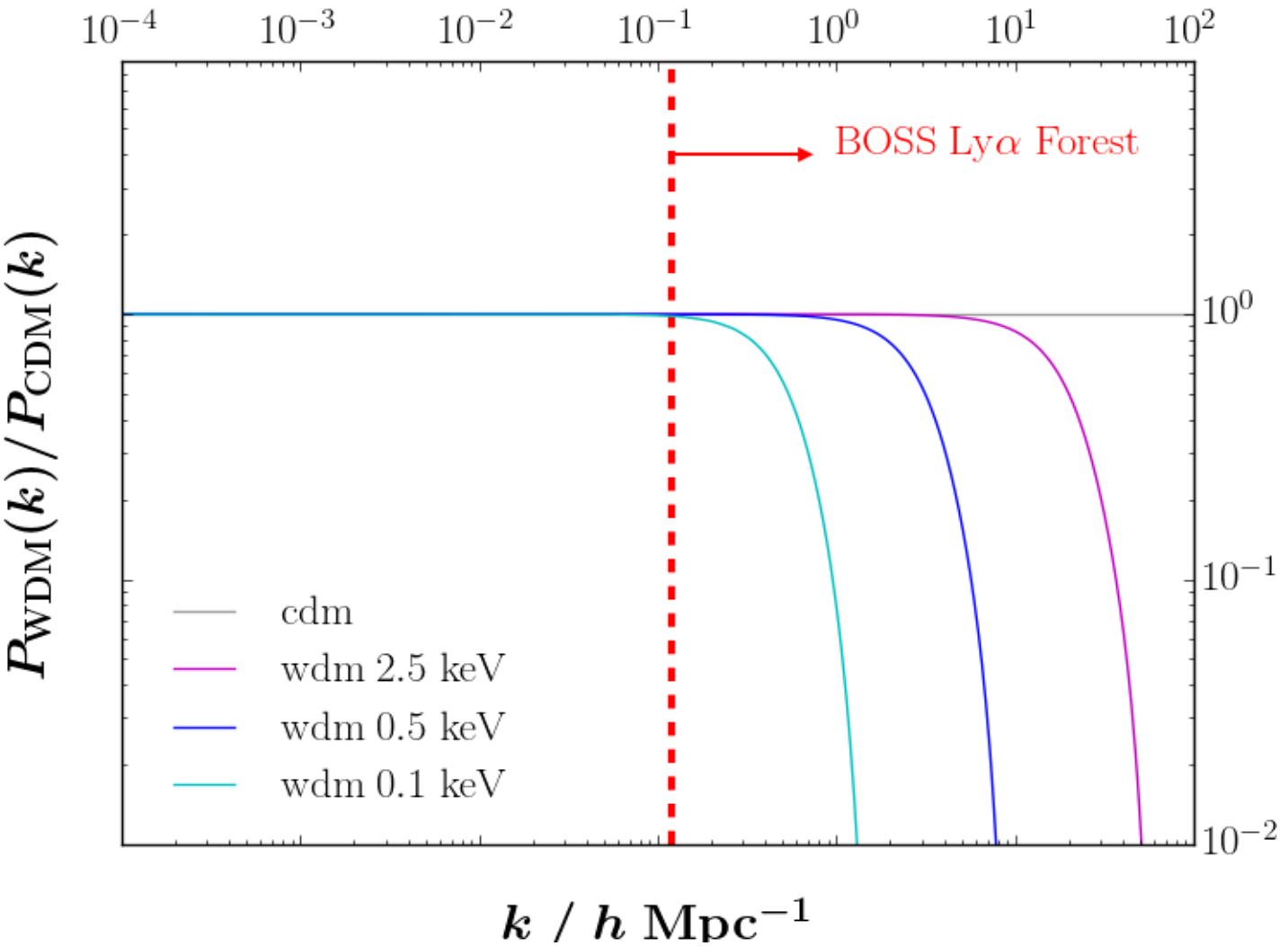
Warm Dark Matter



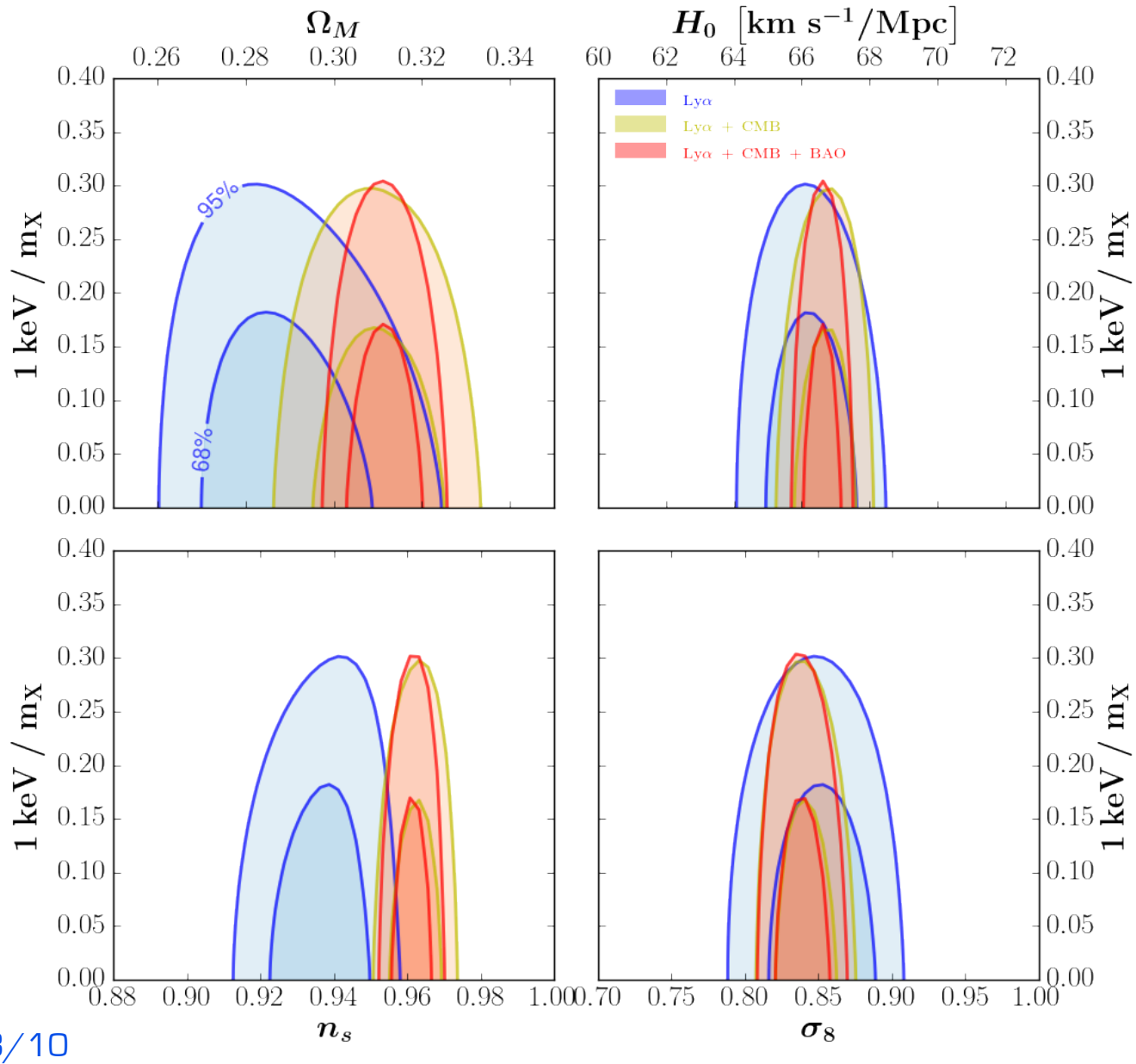
Cold Dark Matter

Warm Dark Matter

Impact on Power Spectrum



Degeneracies



Other Parameters

Cosmological

Spectral index	2
Expansion Rate	1
Fluctuations Amplitude	1
Matter Density	1

Astrophysical

IGM temperature-density	5
Optical Depth	2

Nuisance

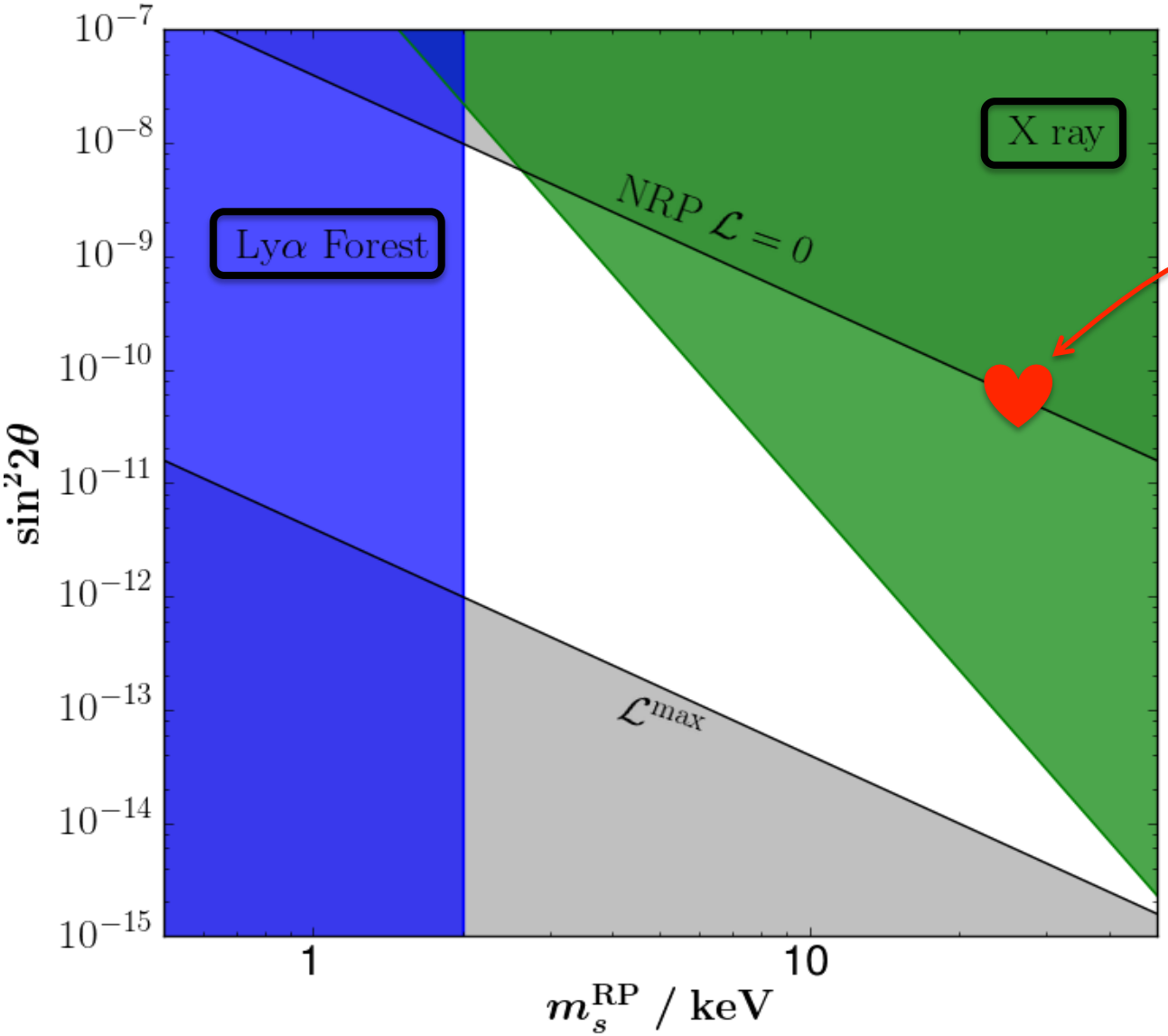
Re-ionization Redshift	3
Ionizing UV background	1
Feedback Processes	5
Spectrograph Resolution	2
Simulations Uncertainty	2
Data Noise	12

Results

Reference	95 % limit (keV)		QSO spectra data set	Simulations
	m_X	m_s		(L $[h^{-1}\mathrm{Mpc}]$, N)
VLH05 [18]	0.55	1.8	30 HIRES + 27 UVES + 23 LRIS	(30, 200) hydro
VLH06 [57]	2.0	9.7	3035 SDSS	(20, 256) hydro
BLR09 [22]	2.1	10.4	57 UVES + 3035 SDSS	(60, 400) N-body
SMT06 [58]	2.4	12.2	3035 SDSS	(20, 256 gas 512 DM) hydro
VBH13 [59]	3.3	18.5	14 HIRES + 11 MIKE	(20, 512) hydro
VBH08 [60]	4.0	23.7	55 HIRES + 3035 SDSS	(60, 400) + (20, 256) hydro
This work	4.1	24.5	13,821 SDSS-III	(100, 3072) hydro

Baur *et al.*, 2015 arXiv:1512.01981

Conclusion



Exclusion of NRP mechanisms:

m < 4 keV	NRP
m < 50 keV	RP

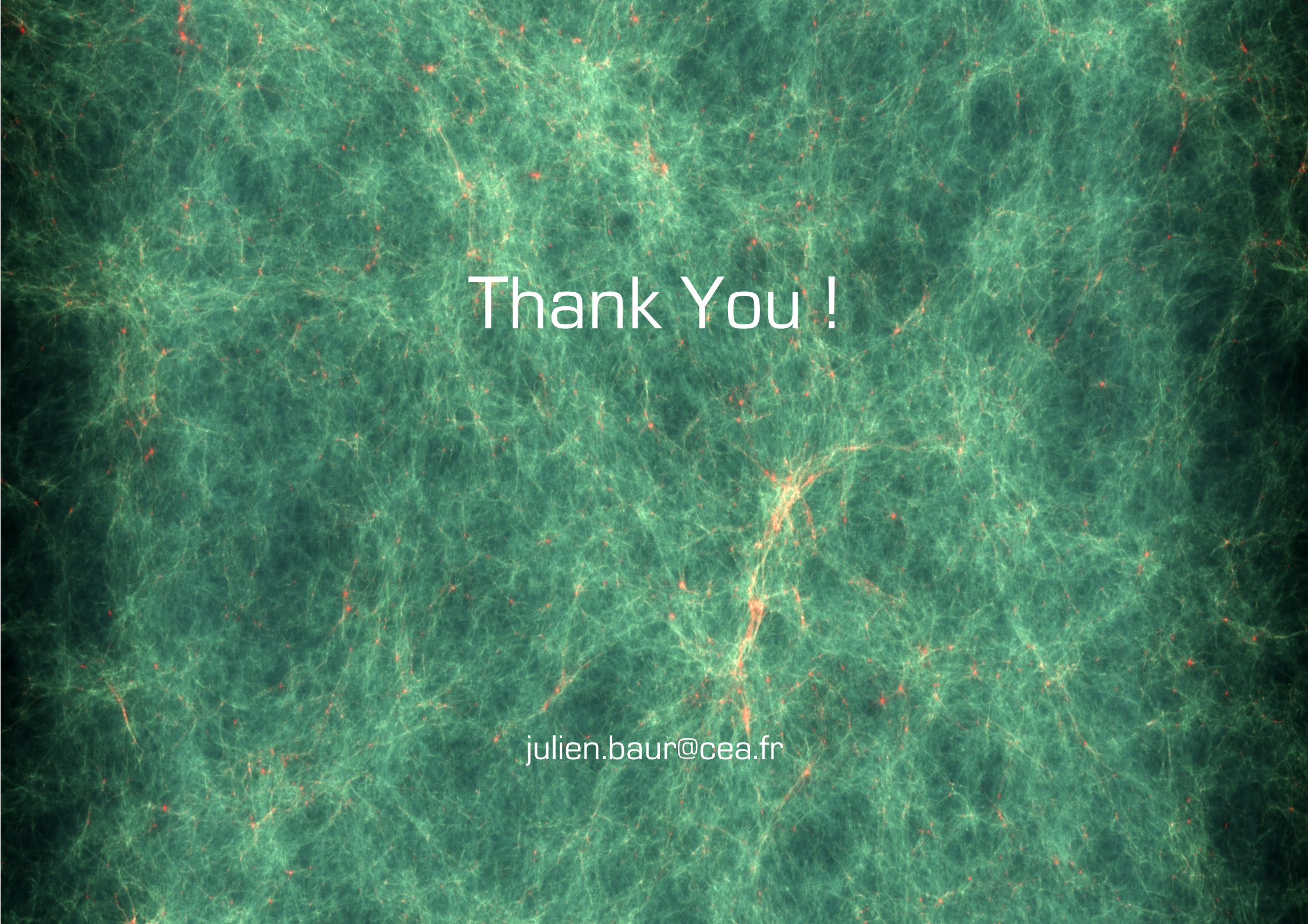
m > 24.5 keV

Most stringent constraint to date !

SDSS I data	(medium res)
Keck data	(high res)

SDSS III data

- sheer sample size
- completeness
- coverage


Thank You !
julien.baur@cea.fr