Cosmic Web and Large scale stuctures

Journées PNCG 2016

P. Noterdaeme, M. Douspis

PNCG 2016

Programme National de Cosmologie et Galaxies

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Warning 1

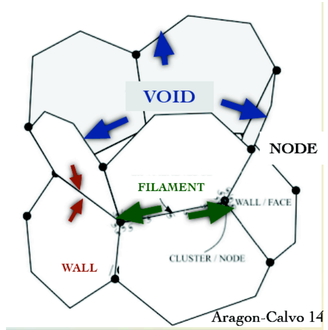
Warning 2

PNCG 2016

PROGRAMME NATIONAL DE COSMOLOGIE ET GALAXIES

Large scale structures

- Cosmic web is the assembly of **filaments**, superstructures (super clusters and **voids**) and ***clusters*** at the node (*see Monique's Talk*). If not directly detected it can be observed as **backgrounds/foregrounds** in multi wavelenght surveys.



- Last years: LSS
  - Huge progress in Optical/NIR with SDSS (and more to come, *see Nicolas' Talk*)
  - Huge progress in microwave with Planck
  - Soon in radio with LOFAR puis PAON, SKA-pre, SKA

Flash talk Ferrari

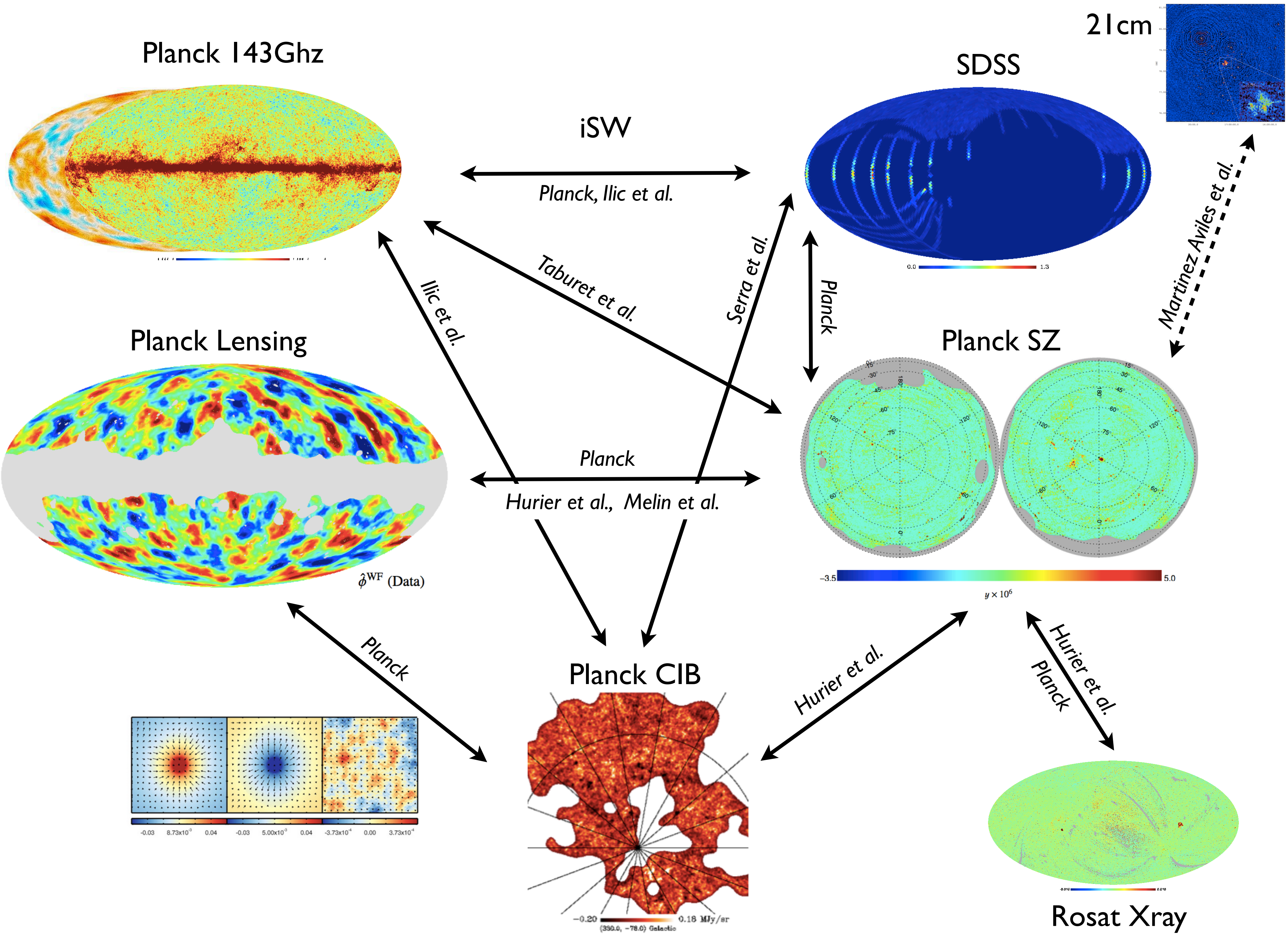
- In addition to CMB, Planck provided the first all-sky maps of hot gas (SZ), dust and cold gas (CIB) and mass (CMB lensing). Allow to probe each of these contributions individualy and their role in the CW but also their **cross correlations**

- Progress in **simulations** and reconstruction methods

- **Voids** are now cosmological probes

- View of larges scales (CMB) and deep obs. (HST) allow to shed light on **Reionisation**

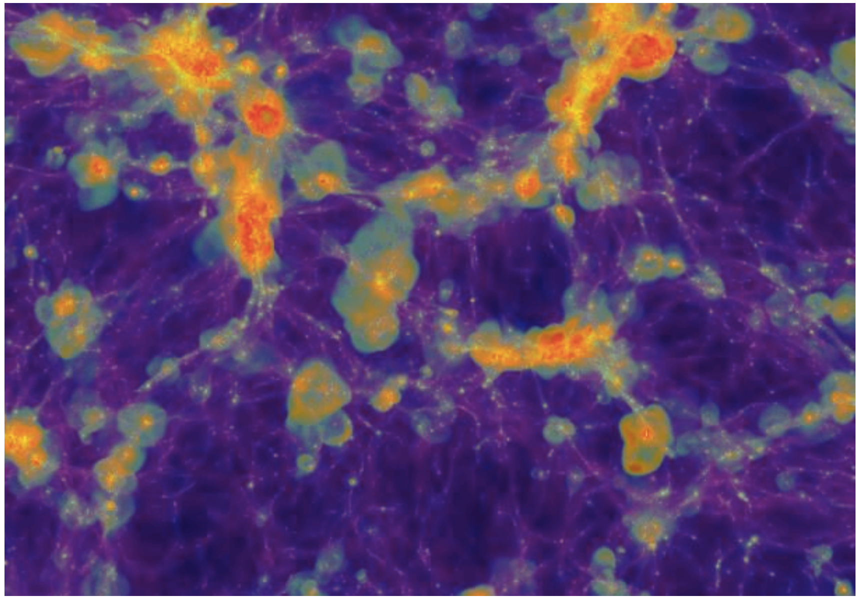
- Going to smaller scales: **environmental effects, IGM distribution**



Planck 143Ghz
21cm
SDSS
0.0
1.3
iSW
Planck, Ilic et al.
Taburet et al.
Ilic et al.
Serra et al.
Planck
Martinez Aviles et al.
Planck Lensing
$\hat{\phi}^{WF}$ (Data)
Planck SZ
-3.5
5.0
$y \times 10^6$
Planck
Hurier et al., Melin et al.
Planck
Planck CIB
-0.20
0.18 MJy/sr
(330.0, -78.0) Galactic
Hurier et al.
Hurier et al.
Planck
-0.03
8.73x10⁻³
0.04
-0.03
5.00x10⁻³
0.04
-3.73x10⁻⁴
0.00
3.73x10⁻⁴
Rosat Xray

Simulations

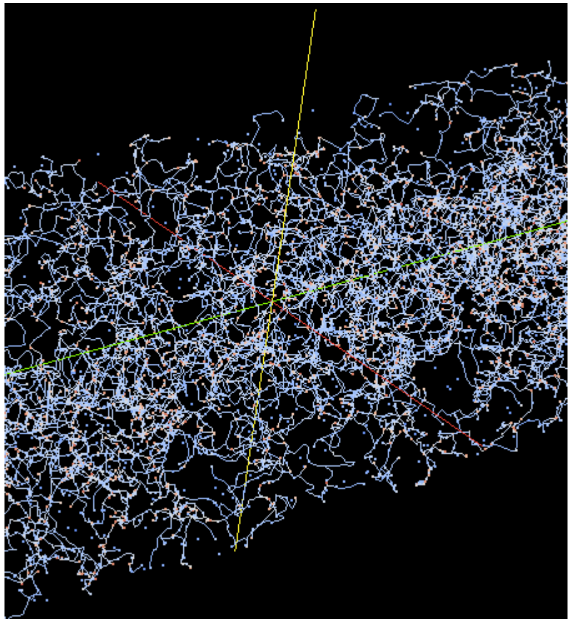
- Horizon AGN
  - 1000 Mpc comoving
  - 1024^3 DM particules
  - Planck Cosmology
  - Hydro+Gas dynamics & cooling/heating, star formation, feedback from stars and AGN



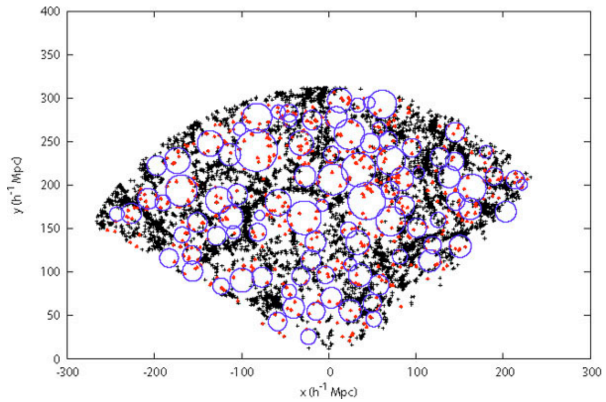
- Ridge extractor to identify filaments

- Possible applications
  - preparing deep and large surveys
  - formation/physics of galaxies

- see also later (environment, reionisation)



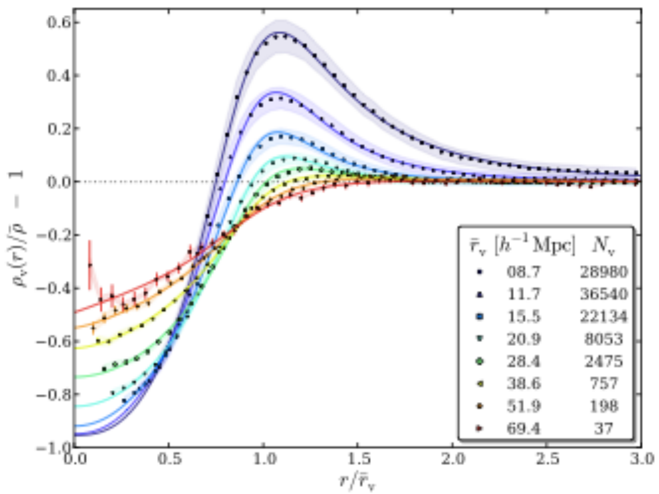
Voids as a new cosmological probe



Pan 2011

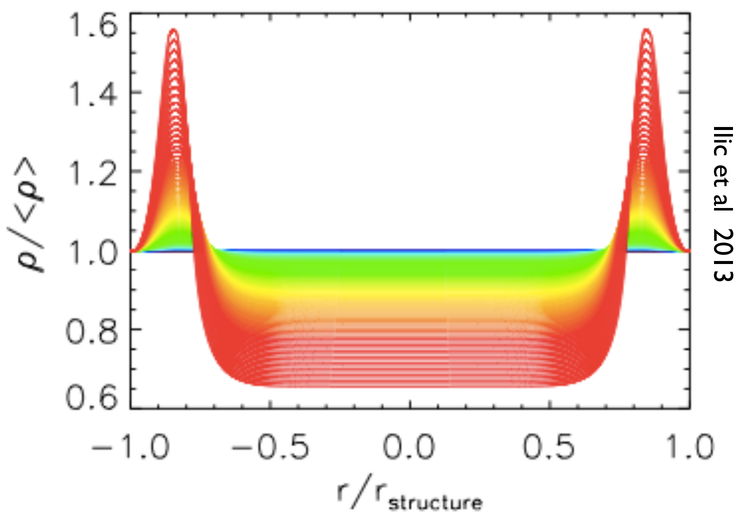
- Detection possible with new surveys (SDSS+)
  - Different techniques and catalogues:
    (Granett, Sutter, Pan, Cai, Hamaus)
    - Voronoi, Delaunay, watershed

- Modeling and simulations
  - Profiles from sims



Hamaus et al 2015

  - Profiles from LTB metrics



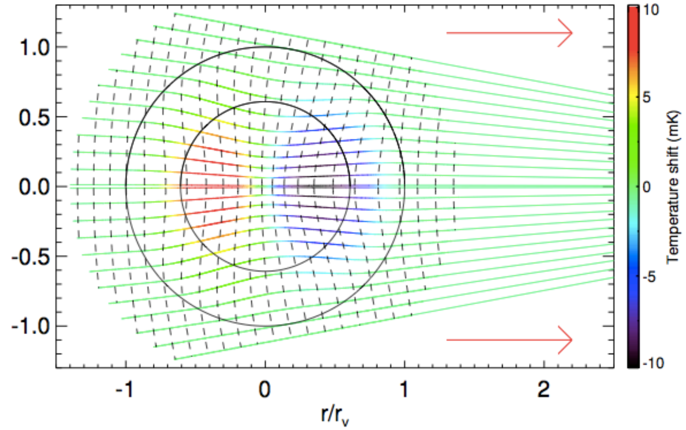
Ilic et al 2013

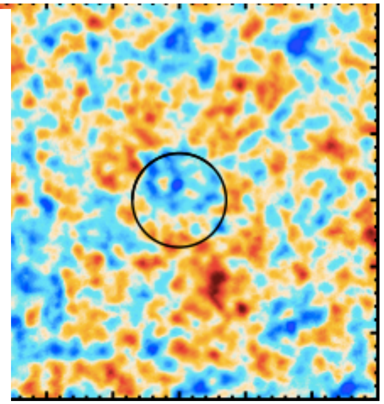
Flash talk : DeFromont

Voids as a new cosmological probe

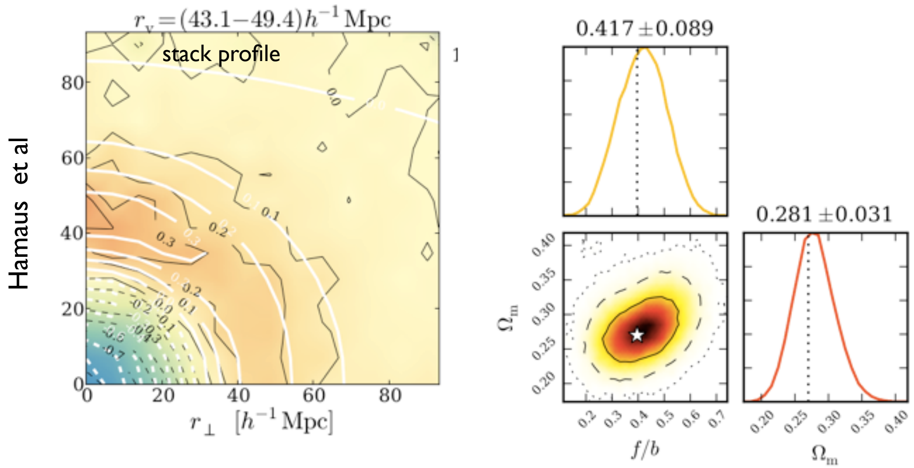
- Imprint of voids in CMB
  - ISW, Cold spot

Flash talk : Ilic

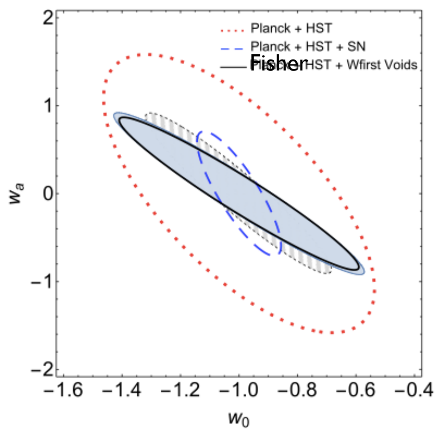




Ilic et al. 2013 & Planck 2014



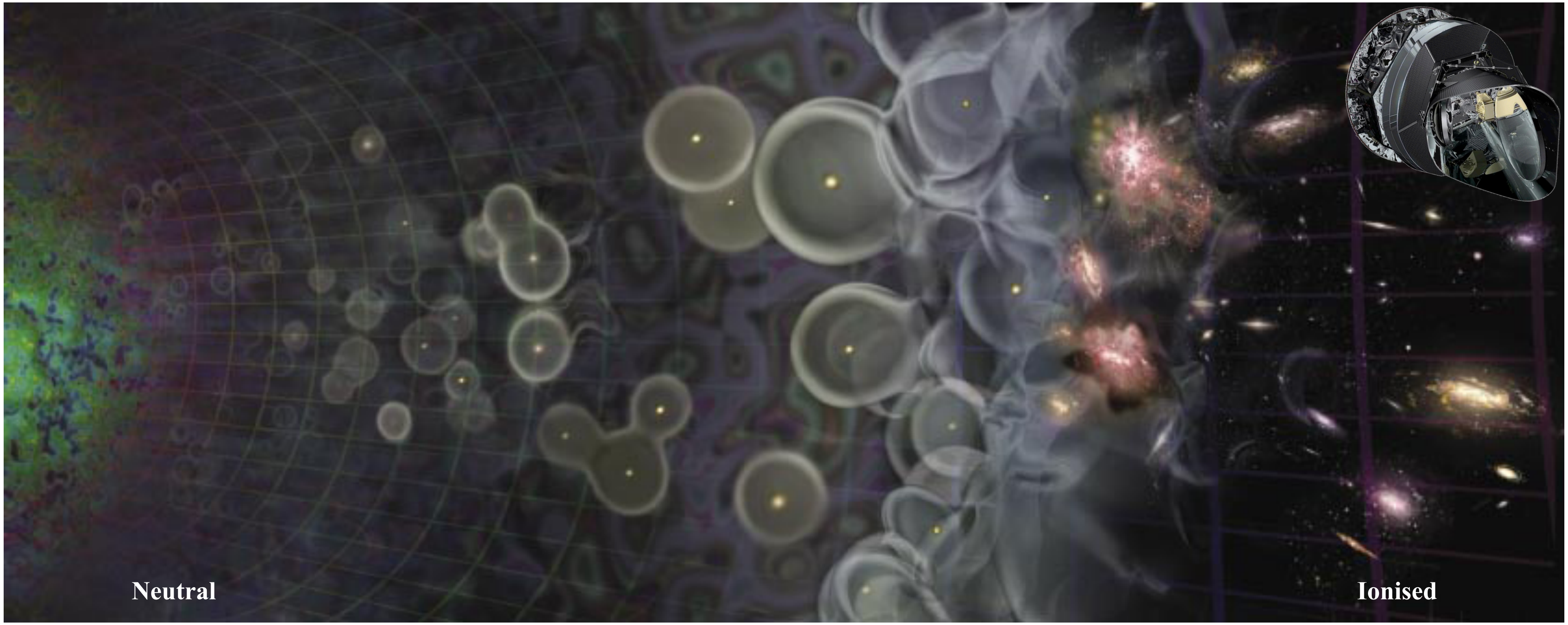
Alcock-Paczyński test in SDSS DR12



Pisani et al. 2015

- next: Counting voids
  - Euclid, WFIRST, LSST

How and when did it occur?



Adapted from :Sci. Am. & A. Loeb, 2006

CMB
372 000 years

First stars
100 Myrs ?

First galaxies?

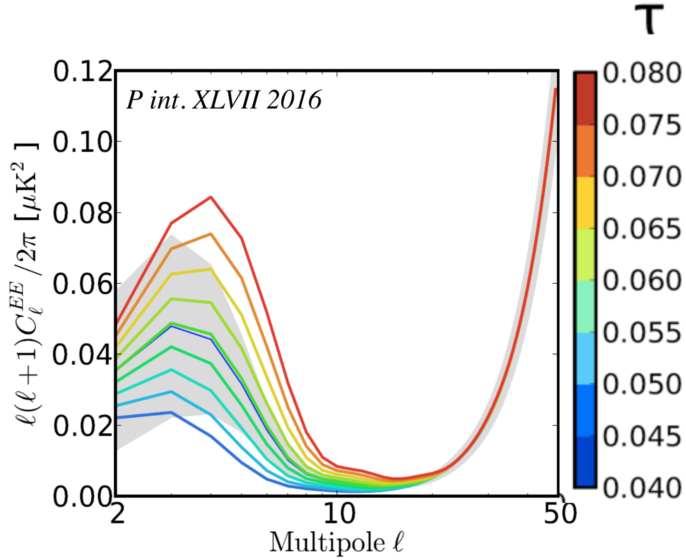
First quasars?

Reionisation
Complete at 1Gyr (?)

Today
13.8 Gyrs

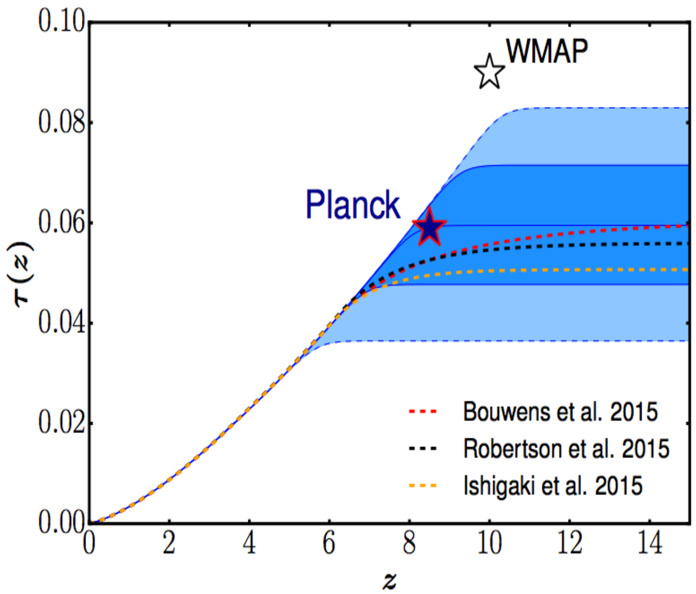
Reionisation in CMB studies

- Reionisation leave imprints in CMB observations:
  - Damping Temperature and Polarisation power spectra
  - Bump large scale polarisation
  - Kinetic SZ effect at small scales
    - good probe of tau not detailed history



- Planck HFI provides best signal at large scale:
  - Reionisation is late and short
  - tau~0.06, zreio~8, Delta_z~4
  - Observed high z galaxies are enough to reionise Universe
    - What happend before with first stars ?

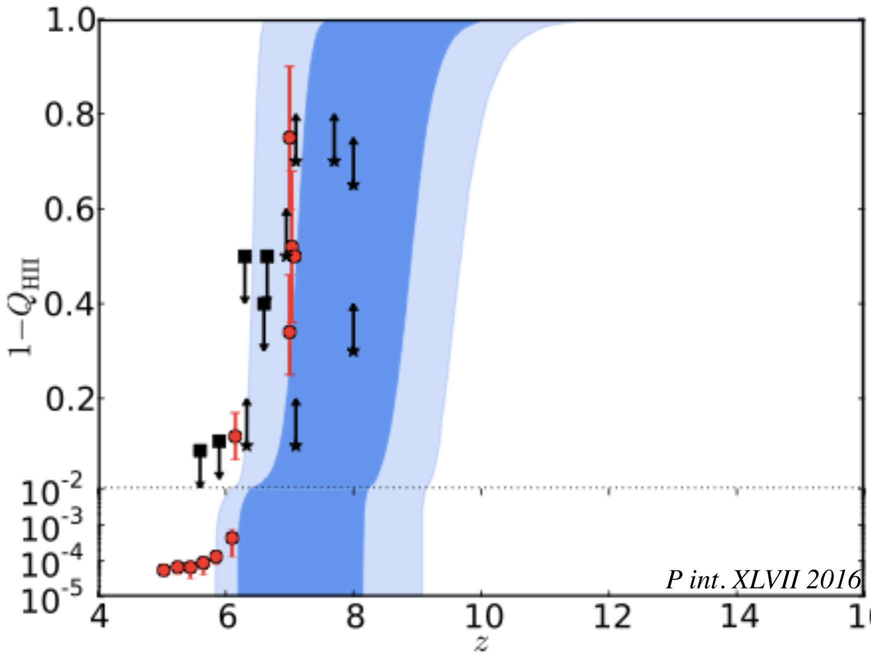
- Next HFI2017, PIXIE, Core



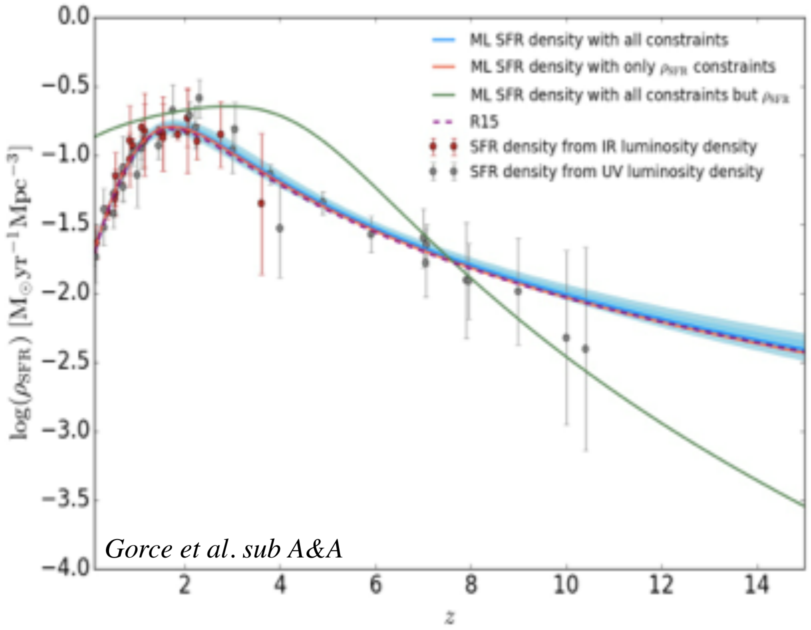
Langer&Douspis SF2A 2016 adapted from P int XLVII 2016

CMB measure agrees with other probes

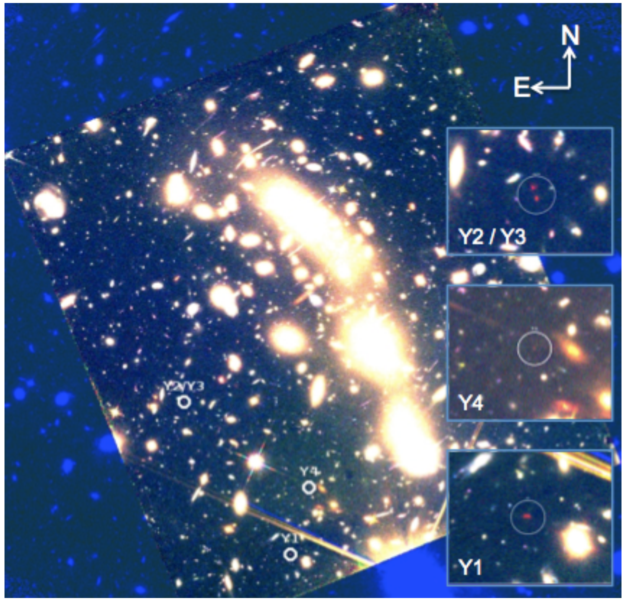
Direct measure of ionisation fraction



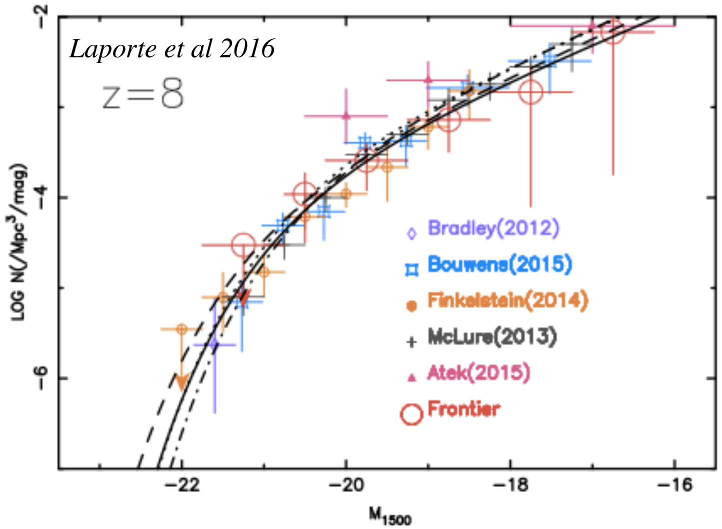
SFR density from IR&UV luminosity functions of high z galaxies



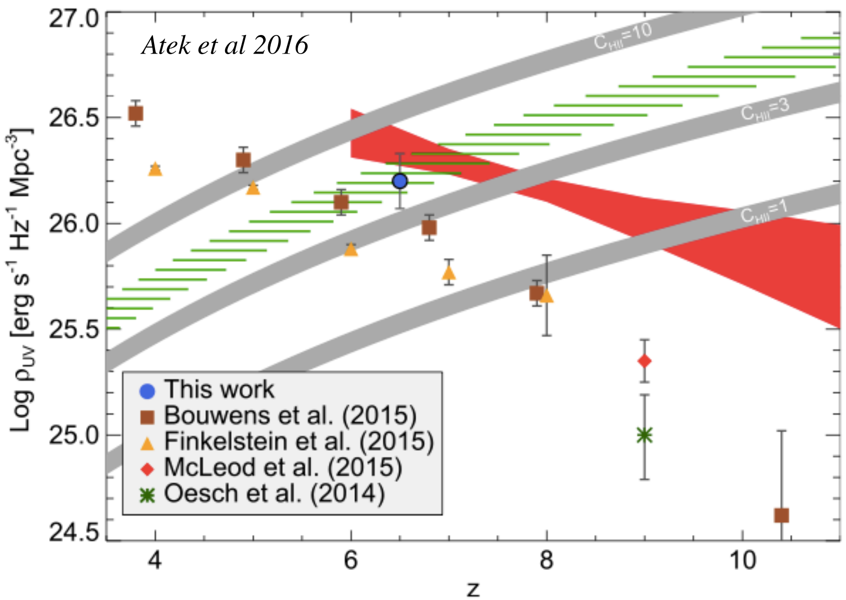
More constraints from high z galaxies



Laporte et al 2015

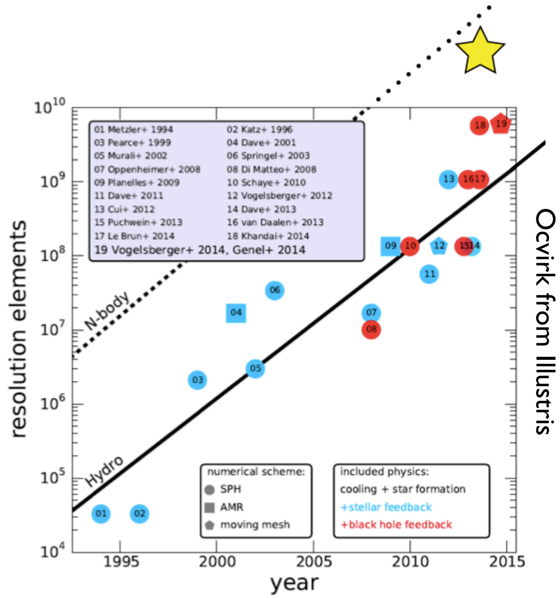


- Using Clusters as lenses to detect low luminosity high z galaxies (clash&HFF)
- Measure luminosity function down to M=-15 and z=10
- UV luminosity density at z~7 is sufficient to keep the universe reionized assuming "standard" conditions
- At z≳8, the faint end of the UV LF is not enough constrained to determine the contribution to the ionization budget
  - Next MUSE, JWST

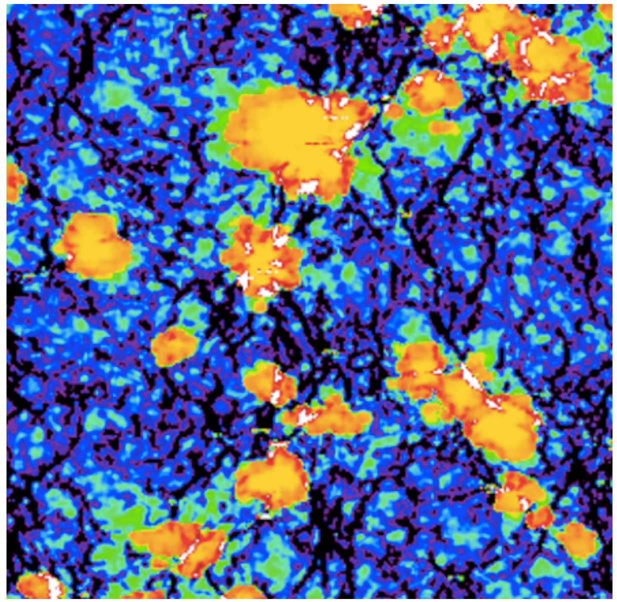


Simulations Reionisation

- Able now to couple gravity, hydro, radiation, on large scale with high resolution RAMSES-cuda EMMA, ...
- Reproduce tau, end of reionisation, luminosity function
  - Show inside out reionisation preferred
  - Show high mass dominate SFR and ramp up late (in agreement with reio history from Planck)
  - Radiative FB suppresses SF in M<10^9 Msol haloes, possibly missing circumventing satellite problem
  - Allow prediction for 21cm data analysis, eg. LICORICE
    - next dvpt GPU, larger, Licorice realease



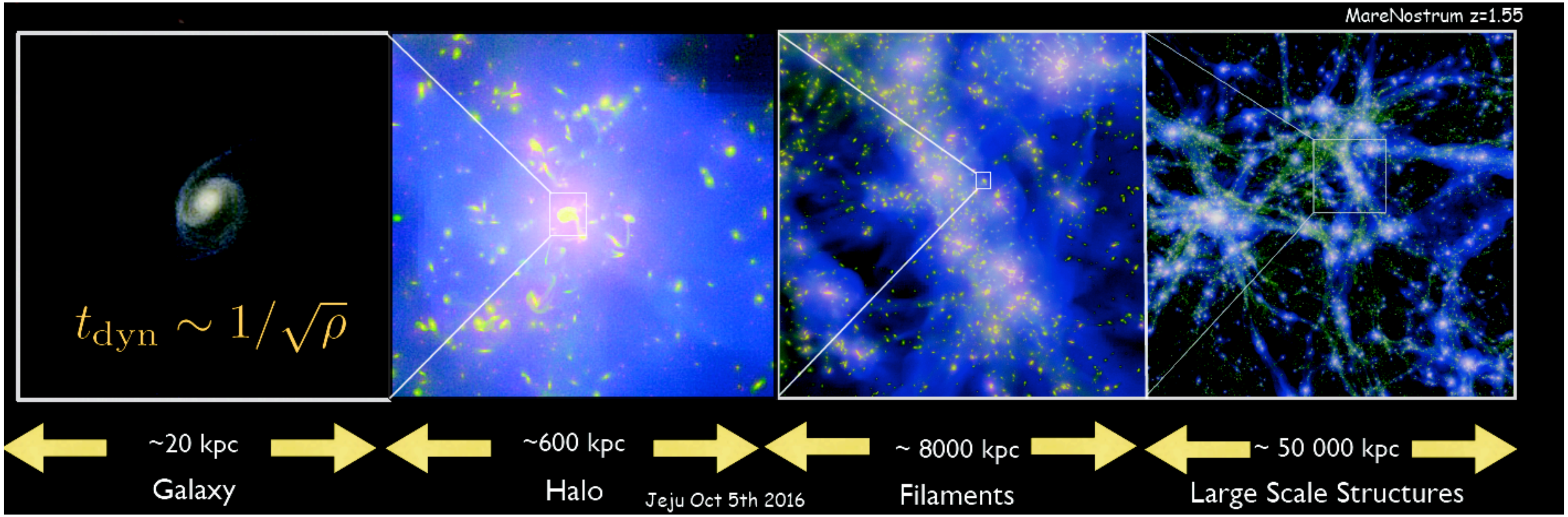
Ocvirk from Illustris



Semelin sf2a 2016

Environmental effects

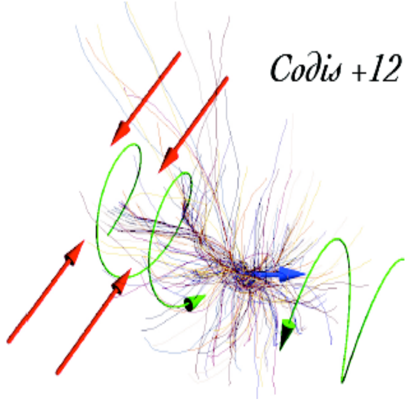
Connecting large-scale structures to galaxy morphology



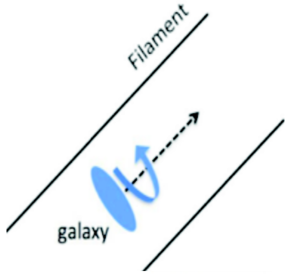
- Large scale structure are much underdense and appear steady
- Galaxy morphology is driven by angular momentum acquisition through anisotropic infall

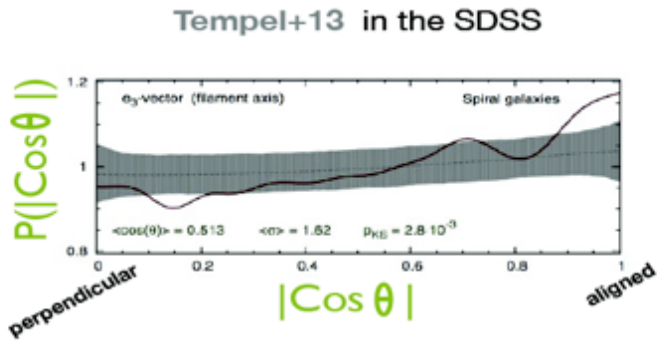
Environmental effects

- Dark Matter swirls along the filaments
  - Transfer of angular momentum to halos and galaxies

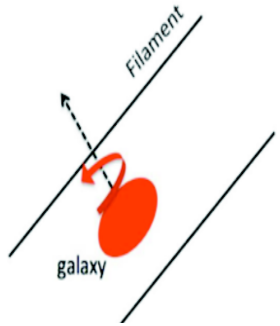


- Low-mass halos/galaxies : spins aligned with filaments





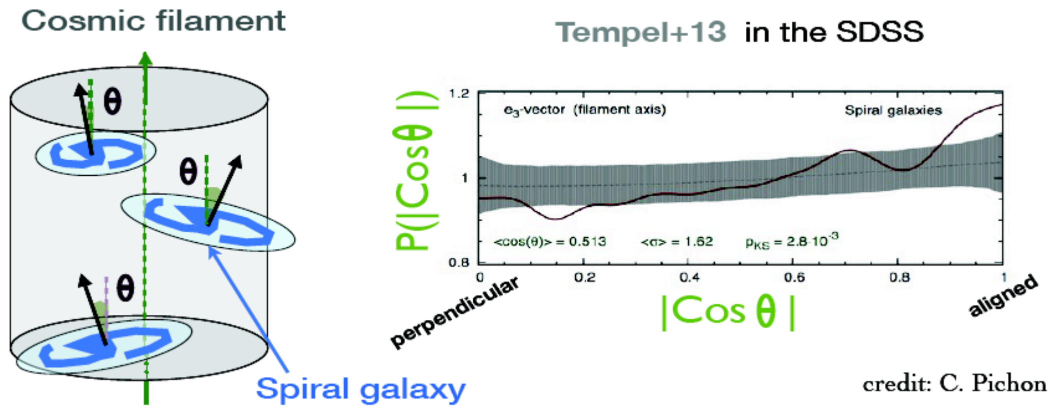
- High-mass halos/galaxies : spins perpendicular to filaments



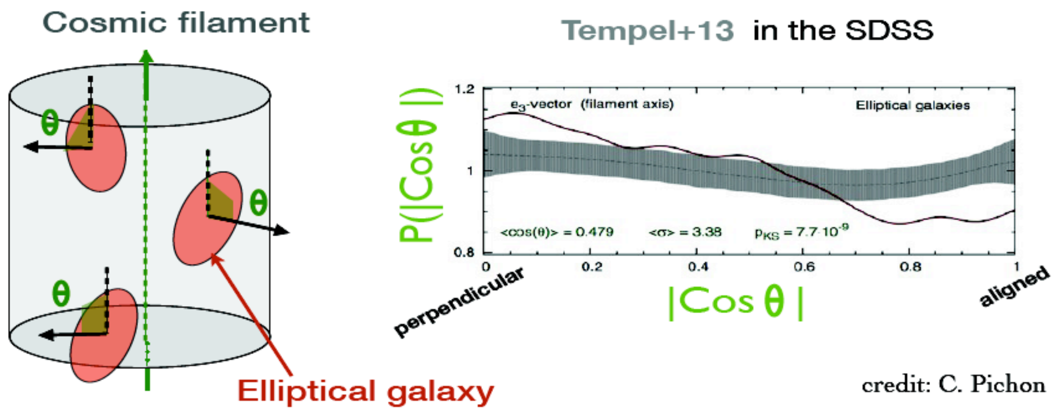
e.g. Dubois+14

Environmental effects

- Low mass and star-forming galaxies rather found at the edges of filaments, which are vorticity rich regions and dominated by smooth accretion (Laigle, Welker)

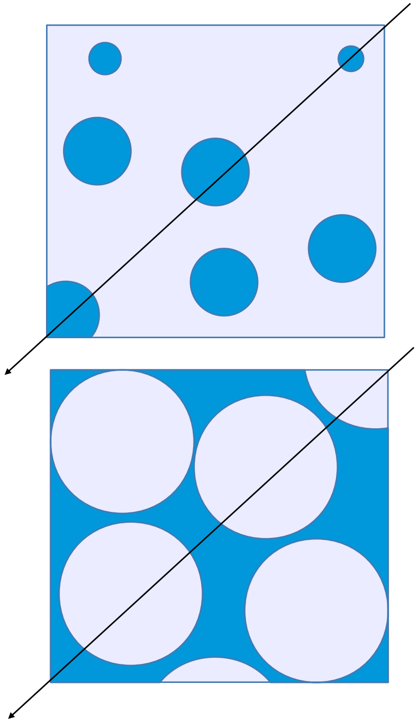


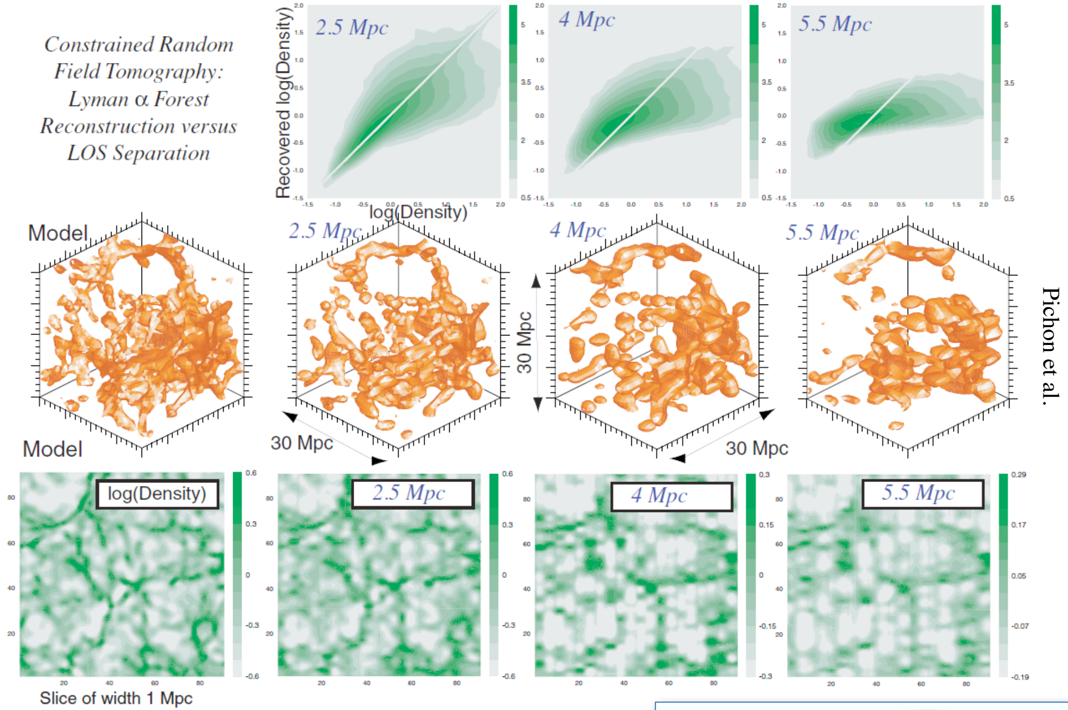
- Most massive and quiescent galaxies lie in the core of filaments: They end up their stellar mass assembly via merging while migrating toward nodes (Codis)



See also: **Aragon-Calvo+07**, **Hahn+07**, **Sousbie+08**, **Paz+08**, **Zhang+09**, **Codis+12**, **Libeskind+13**, **Aragon-Calvo 13**, **Dubois+14**

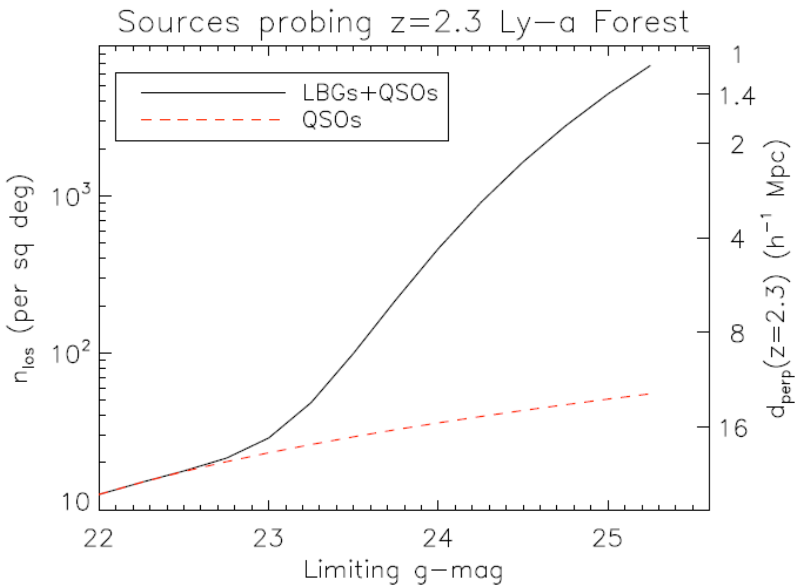
Tomography of the Inter-Galactic Medium

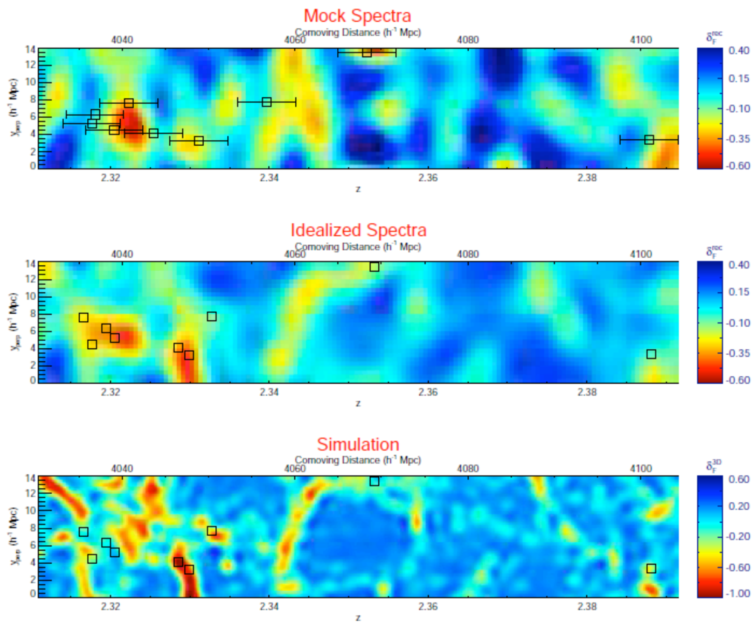




- Mpc resolution requires 1000 los/deg^2
  - BOSS : ~ 17 quasars/deg^2

Tomography of the Inter-Galactic Medium





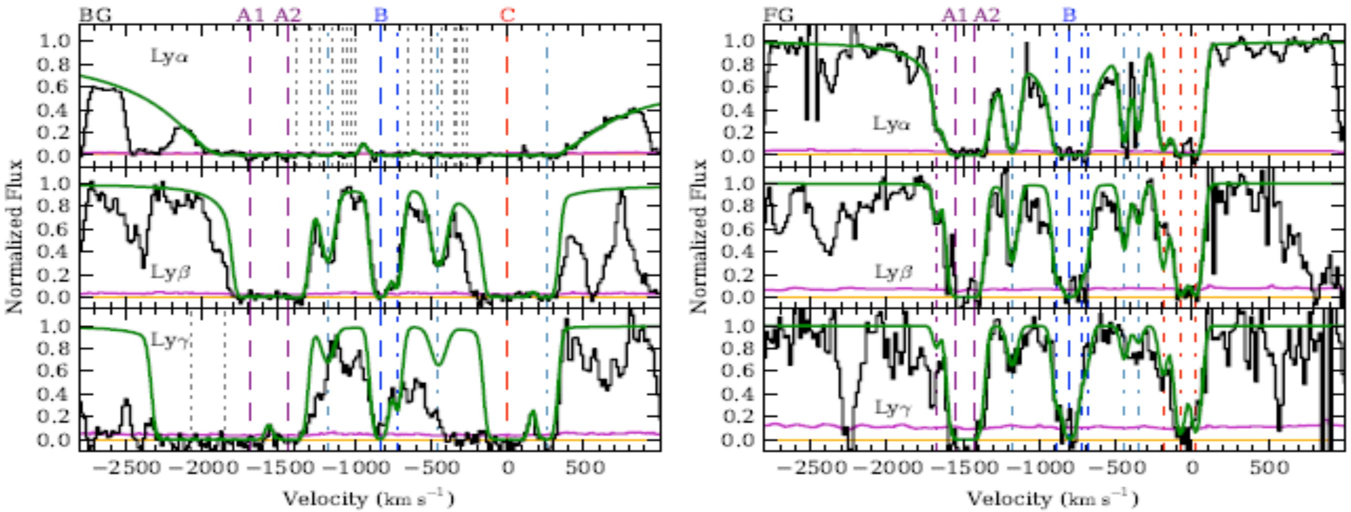
- Steidel et al. 2009: S/N=30 per pixel @ R=5000 for r=24.5
- Evans et al. 2012: S/N>8 per resolution element @ R=5000 for r=24.8

→ **MOS@ELT**

Lee et al. 2014: you don't need to resolve forest. S/N~4 @ R~1000 is enough to g~24

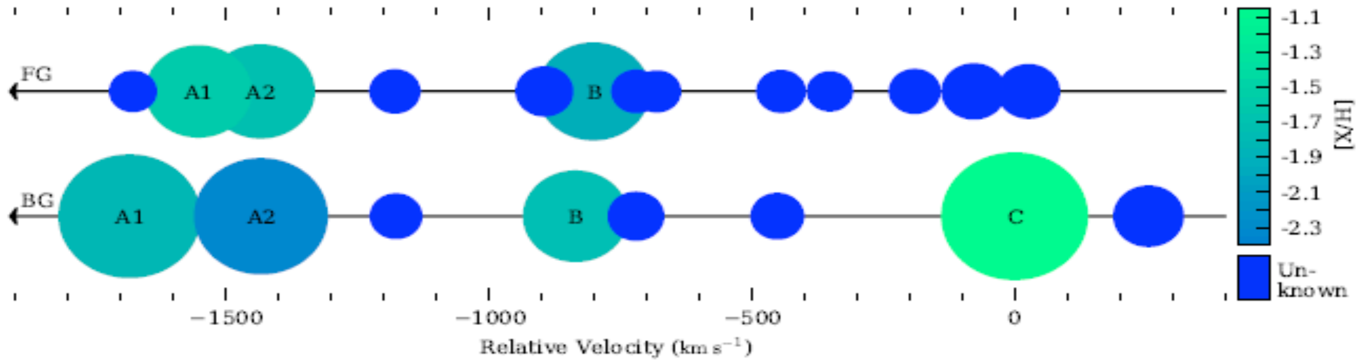
Tomography of the Inter-Galactic Medium

- The knots in absorption



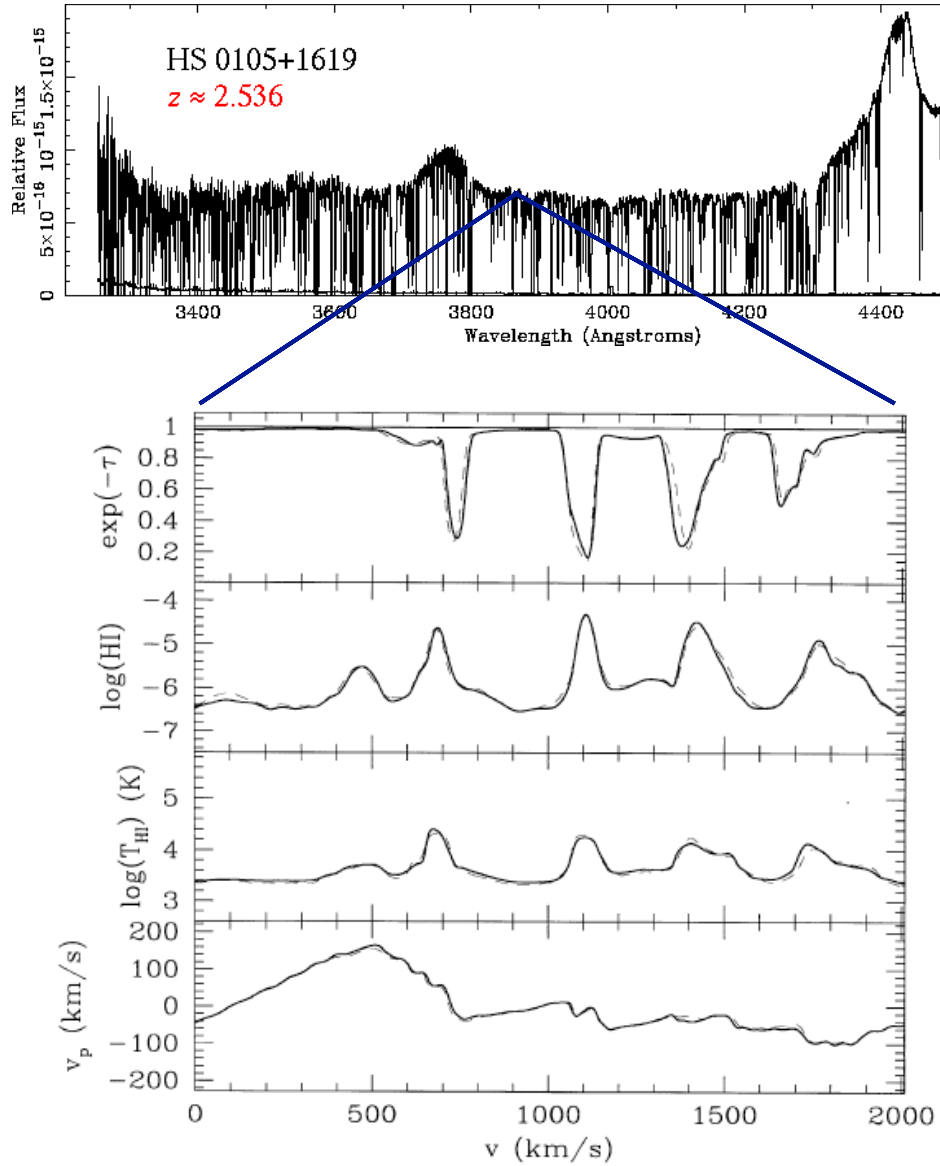
VLT/Xshooter. Finley et al. 2014

Fig. 2. Fits to Lyα (top), Lyβ (middle), and Lyγ (bottom) H I absorptions in the BG (left) and FG (right) spectra. Dashed purple, blue, and red lines mark the log N(H I) > 18.0 components in regions A, B, and C, while dash-dotted purple, blue, and red lines indicate the weaker components within the respective regions. Dash-dotted blue-gray lines signal low column density components between the three main regions that are also part of the absorption structure. Dotted gray lines in the BG-Lyα panel indicate blended components from Si II λ1190 and 1193 absorptions associated with a $z \simeq 2.75$ DLA.



Tomography of the Inter-Galactic Medium

- Overdensity and temperature can be traced along QSO LOS



Prospective

- Cosmic web and LSS
  - Future large surveys : tomography, reconstruction
  - Voids as cosmological probes
  - IGM as tracer of LSS (MOS & LBG)
    - LSST, Euclid, ELT, Athena, SKA
- Correlation with/between current/next surveys
  - Trace relation cold/hot gas and DM
    - Core, S4, PIXIE, NIKA2

Prospective

- Reionisation
    - CMB P & Spectral distorsions (Core, PIXIE)
    - SKA preparation
        - path-finders&precursors, simulation, modelisation
    - Intensity mapping and CII lines (eg. concerto)
    - low luminosity high z galaxies [with gravitational telescope] (JWST, MUSE)
    - IGM, Lya on LOS
- Large scale simulations & HP computing (talk Blaizot)