Atelier HIRES-France

White paper: Maiolino 2013 arXiv/1310.3163

WG Galaxies & IGM

Led by V. D'odorico

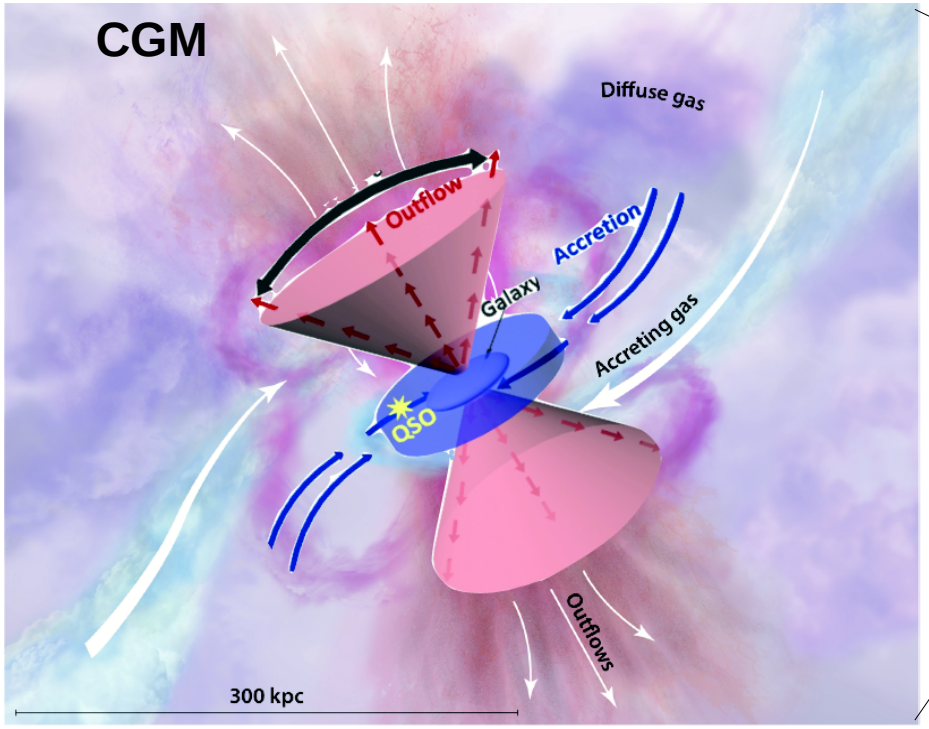
TLRs and IGM

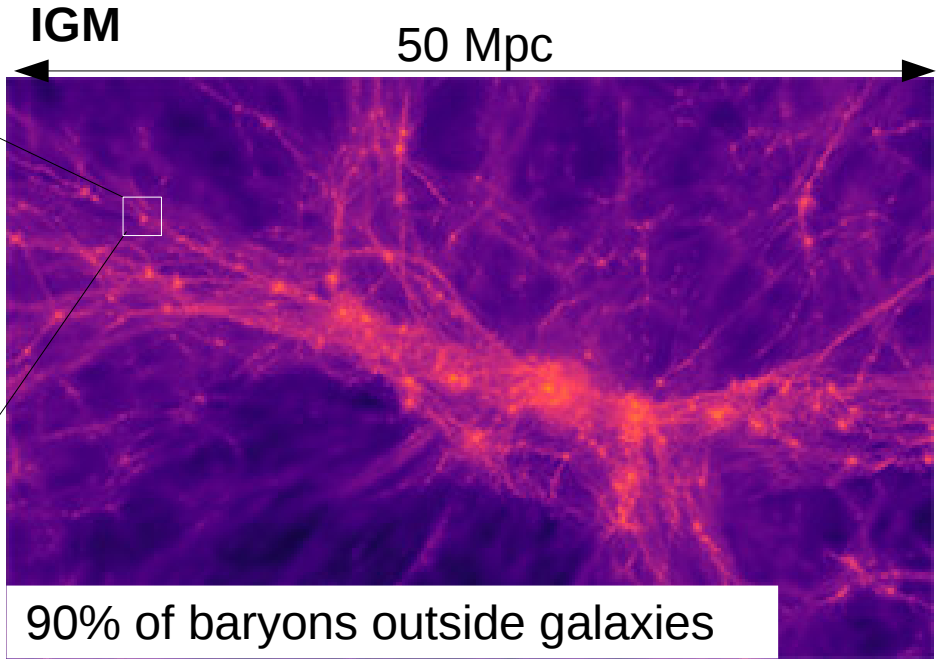
	TLRs		UVES
Resolution	R=100,000		Up to 110,000 (3km/s)
coverage	0.37-2.5 microns		0.3-1.1 microns
Polarimetry	~~Yes~~		
stability	2 cm/s 10 cm/s (exoplanet) 1 m/s		?
IFU	4”		No
multi-plexing	No		No

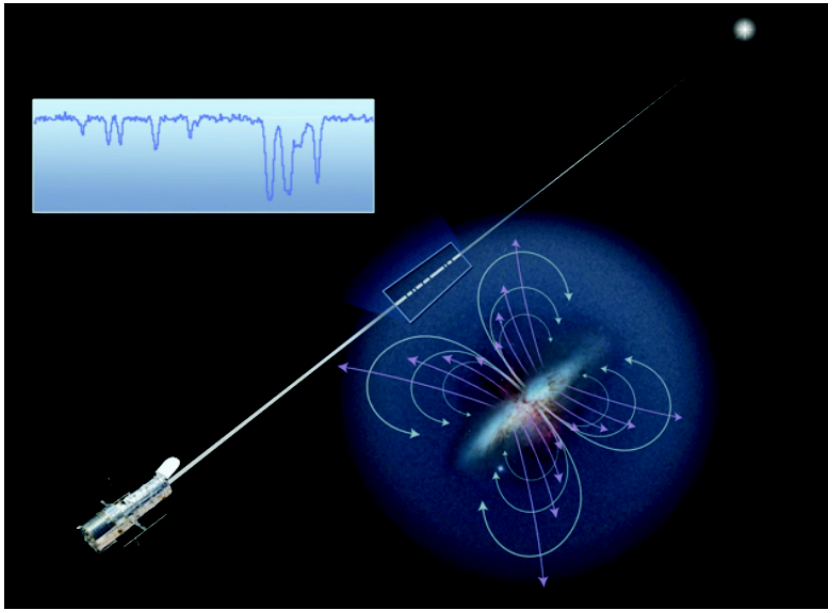
Ch4) Evolution of galaxies and cosmic structures

1) IGM / Ly Forest
2) Pristine / very metal poor DLAs
3) Cosmic Reionization
4) 3D Reconstruction
5) Galaxy evolution (passive ETG)
6) “Low”-Mass (1e5) BH

#1 IGM with quasars





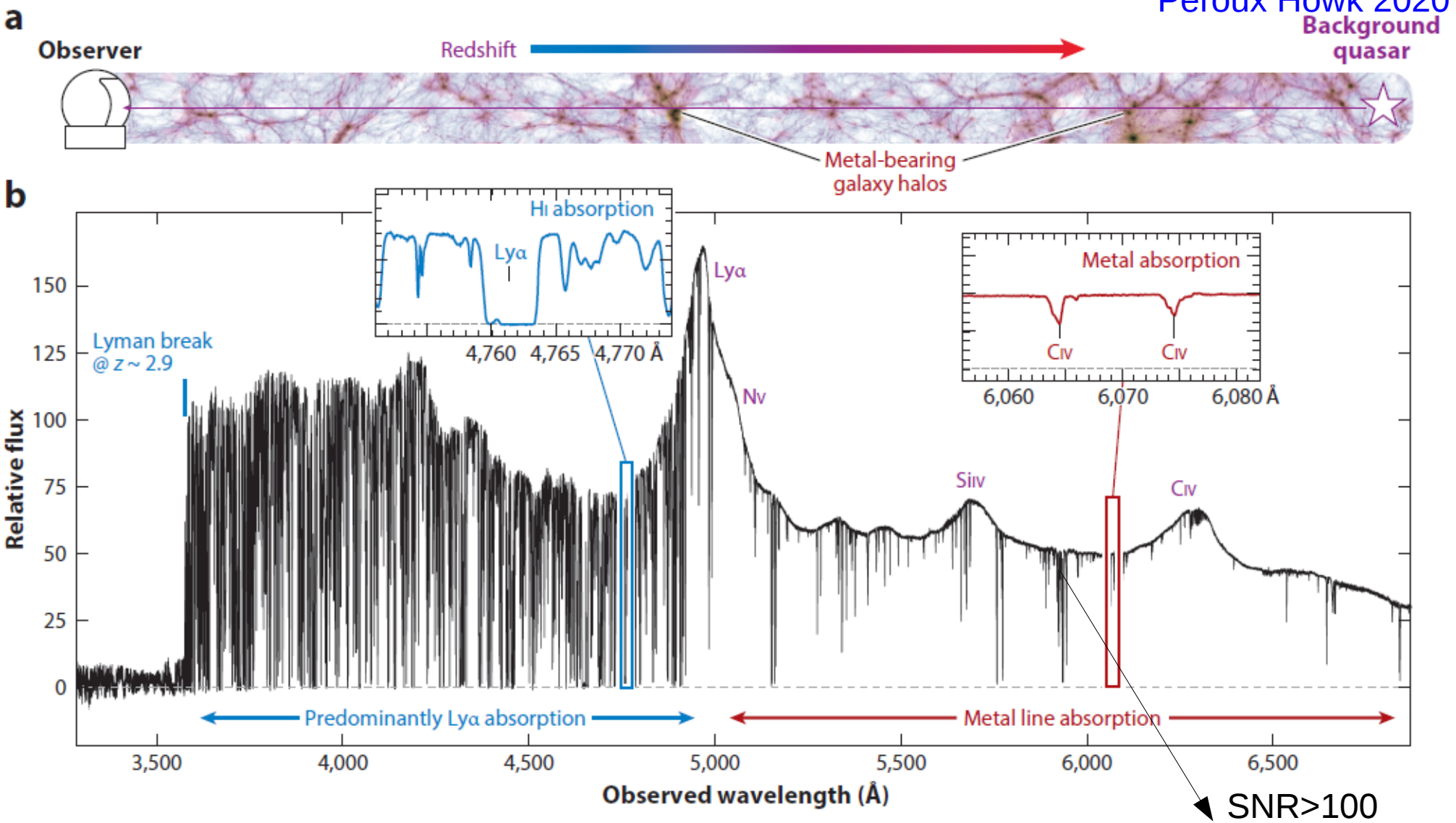


Science questions:
– How much gas (H: DLA, LLS)?
– How many metals?
([C/Fe]; H_2)
popIII ?

Peroux; Noterdaeme P; Petitjean P.

#1 IGM with quasars

Péroux Howk 2020



SNR>100
D'odorico 2017

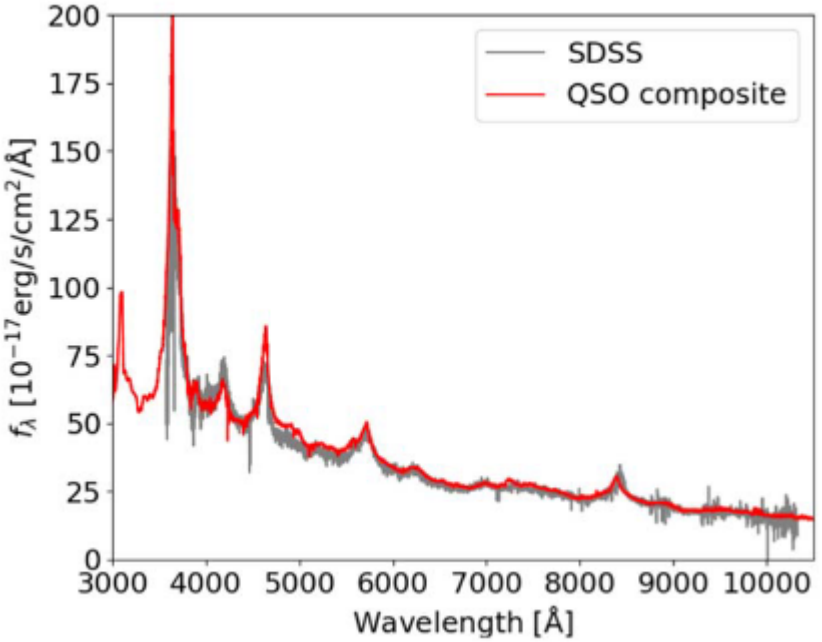
#1 IGM with quasars

A Carbon-enhanced Lyman Limit System: Signature of the First Generation of Stars?

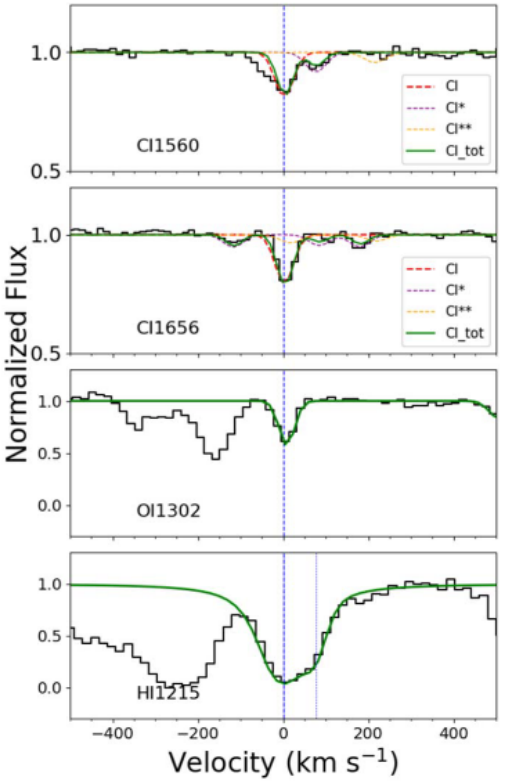
Siwei Zou[1,2], Patrick Petitjean[2], Pasquier Noterdaeme[2], Cédric Ledoux[3], Raghunathan Srianand[4], Linhua Jiang[1], and Jens-Kristian Krogager[2]

Zou, Petitjean+ 2020

- Prestine gas (CEMP)
  - popIII → [C/Fe]



XShooter

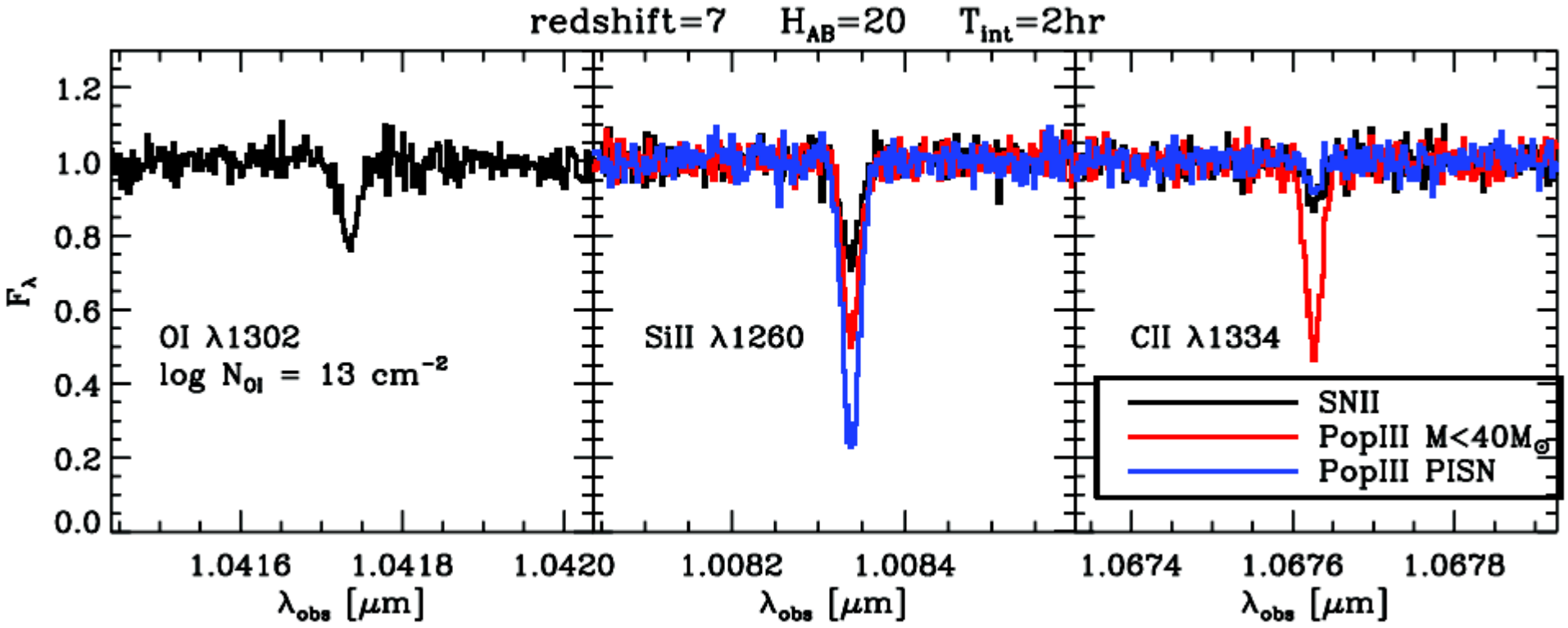


[C/Fe] = +2.2

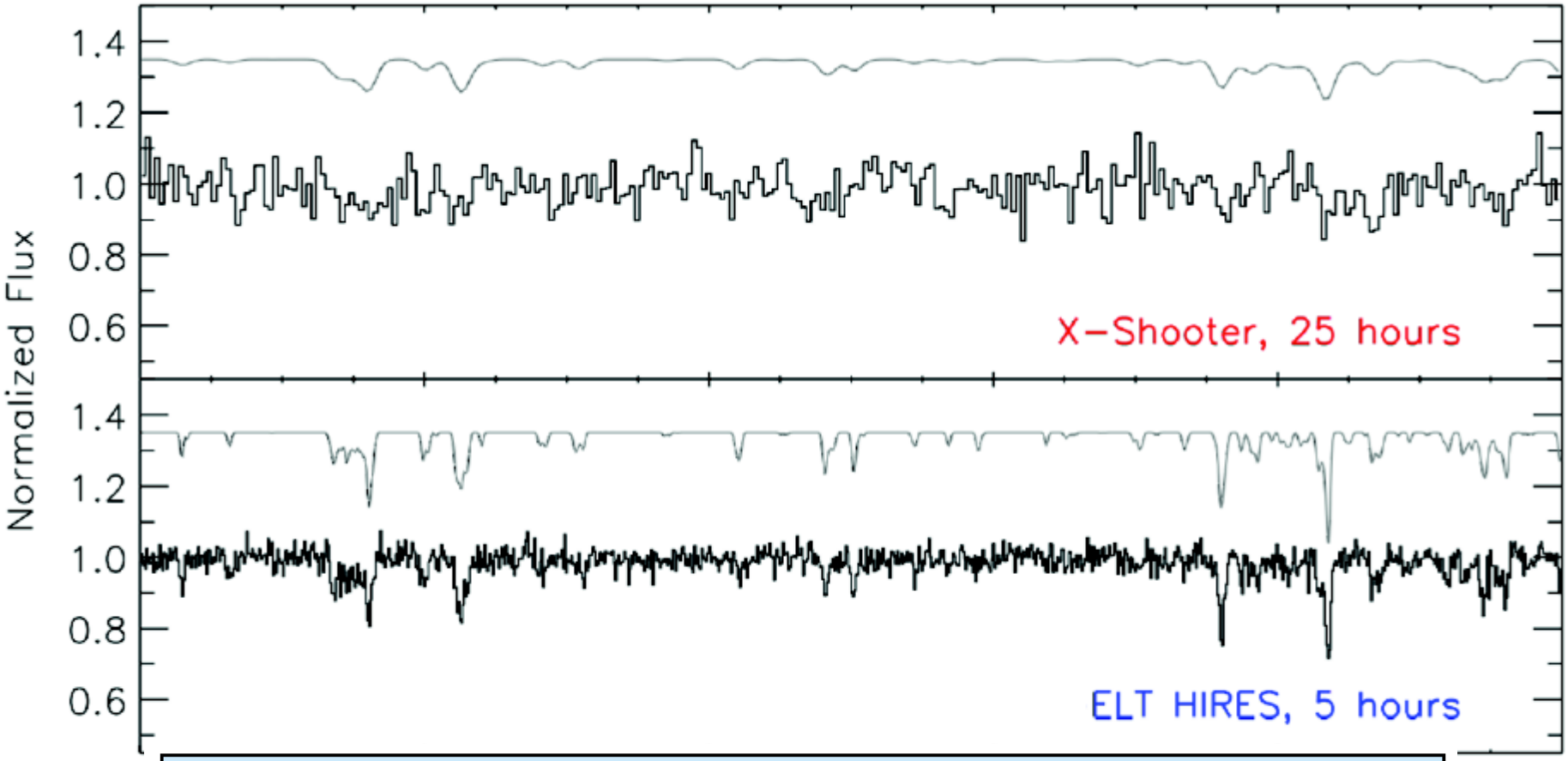
[Fe/H] = -1.6

#2 low-Z gas / PopIII

- At z>5.5



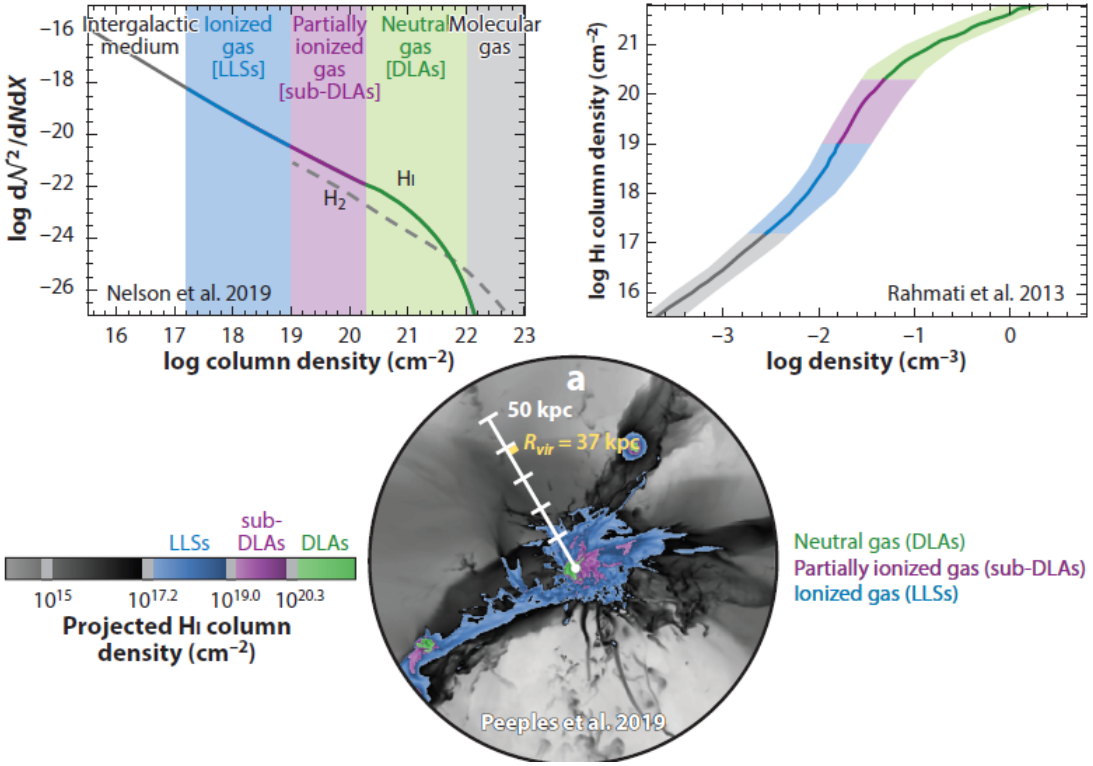
#2 Low-Z gas (O/H=1e-3)



Essential requirements for the investigation of Near-Pristine Gas at High Redshift						
Spectral resolution	Wavel. Range (µm)	Wavel. Accuracy (km/s)	Stability	Multiplex	Backgr. Subtr.	AO/ IFU
50,000	0.4-1.8	0.6	not critical	No	~1 %	no

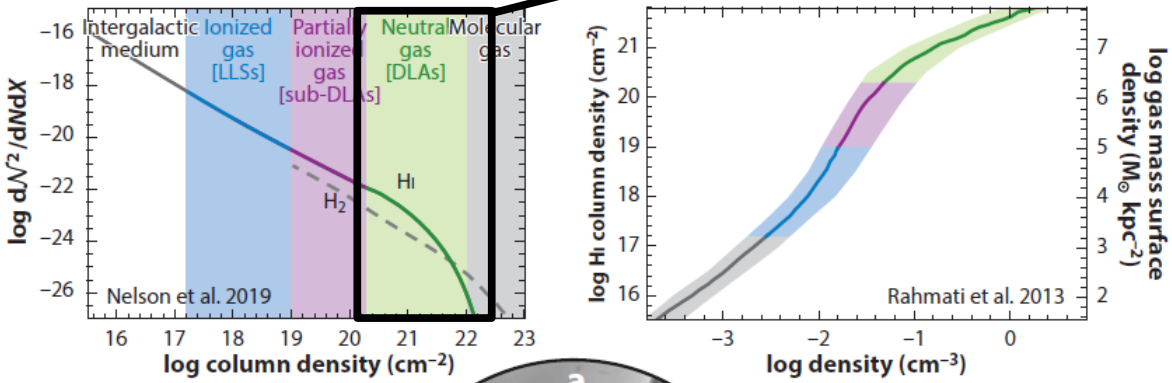
#2 low-Z gas

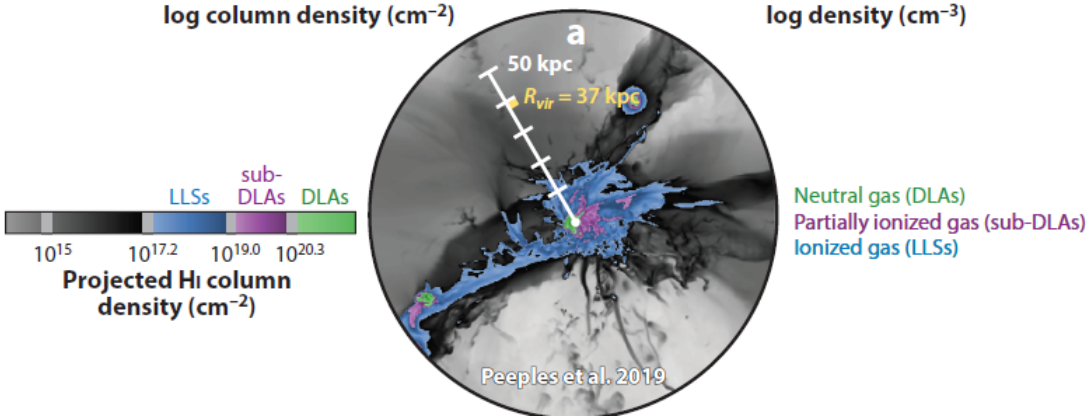
- At z<5.5:



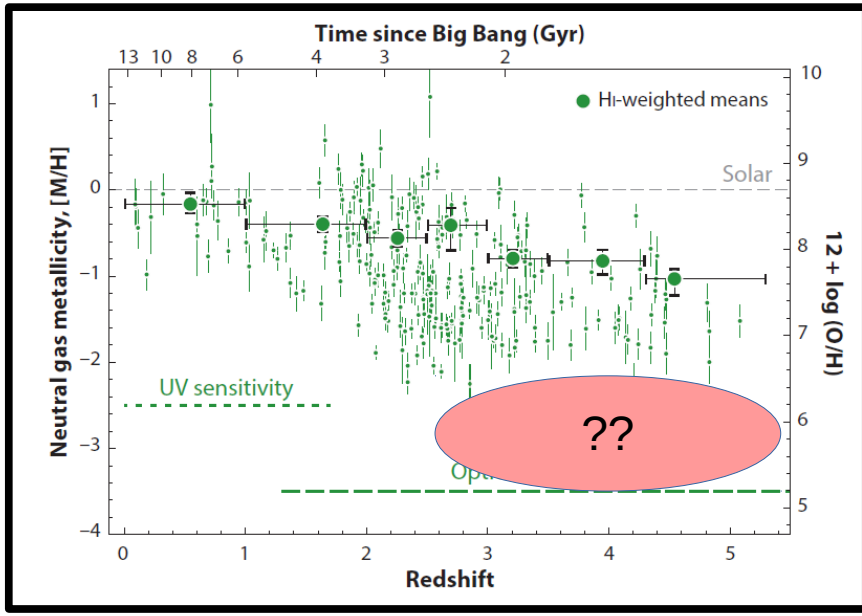
#2 low-Z gas

- At z<5.5:





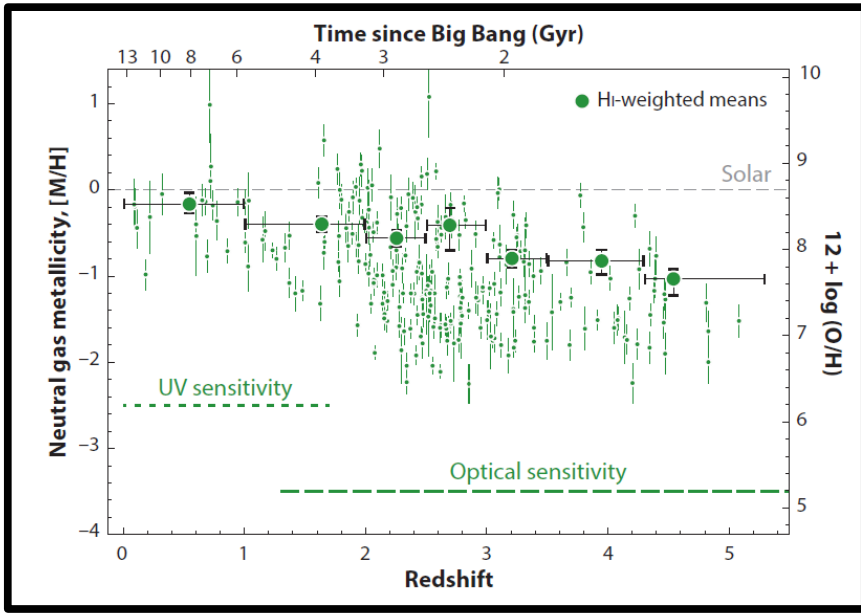
Péroux et al.

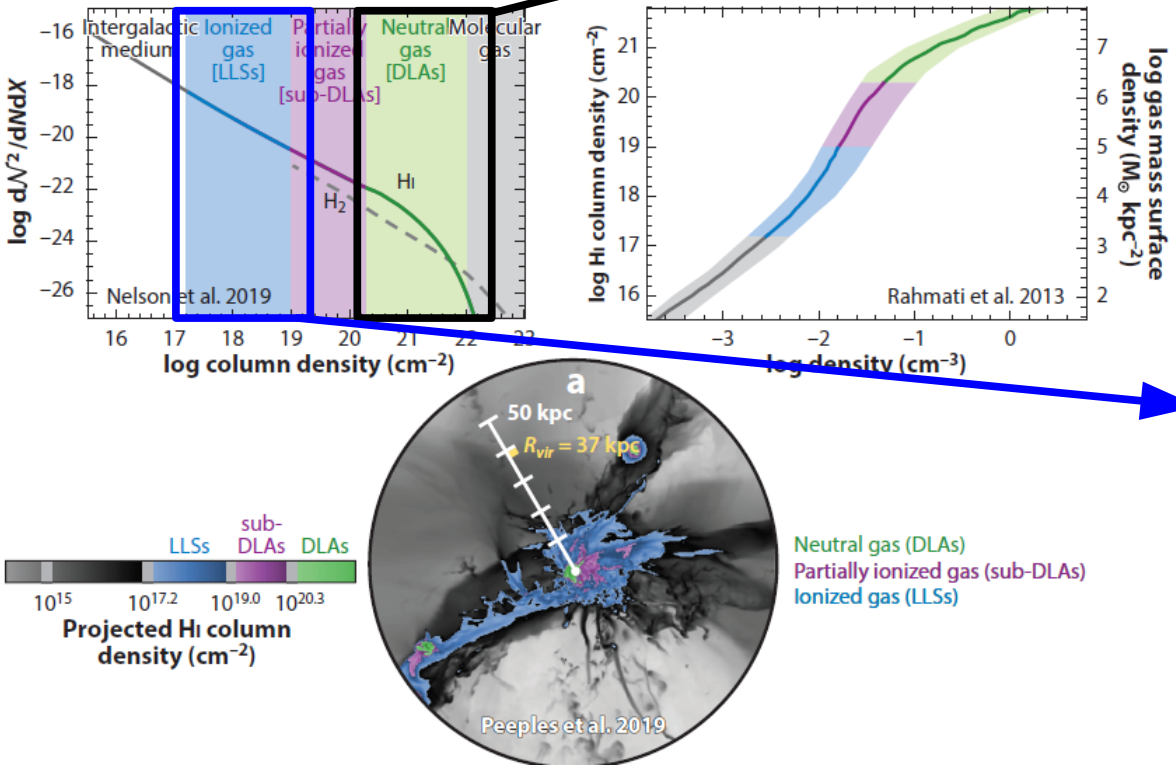


#2 low-Z gas

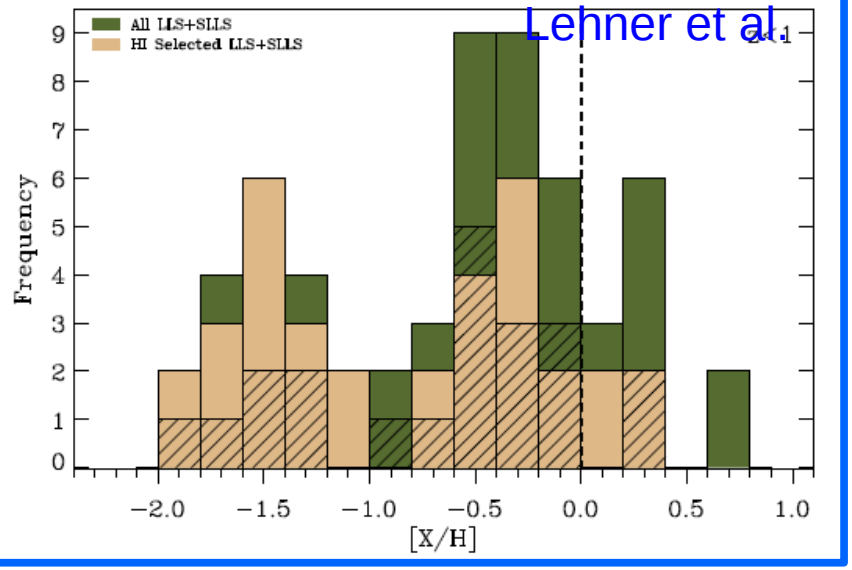
- At z<5.5:

Péroux et al.





Lehner et al.



#3 Reionization with QSOs

Becker+ 2019

- Frequency OI:
  - Down from z=6
  - Expectation:

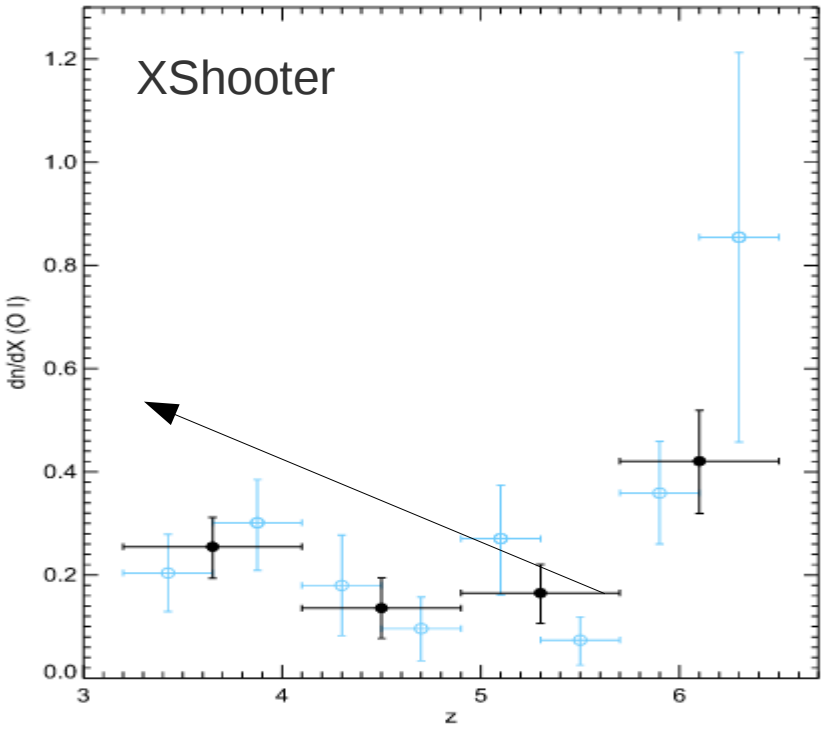
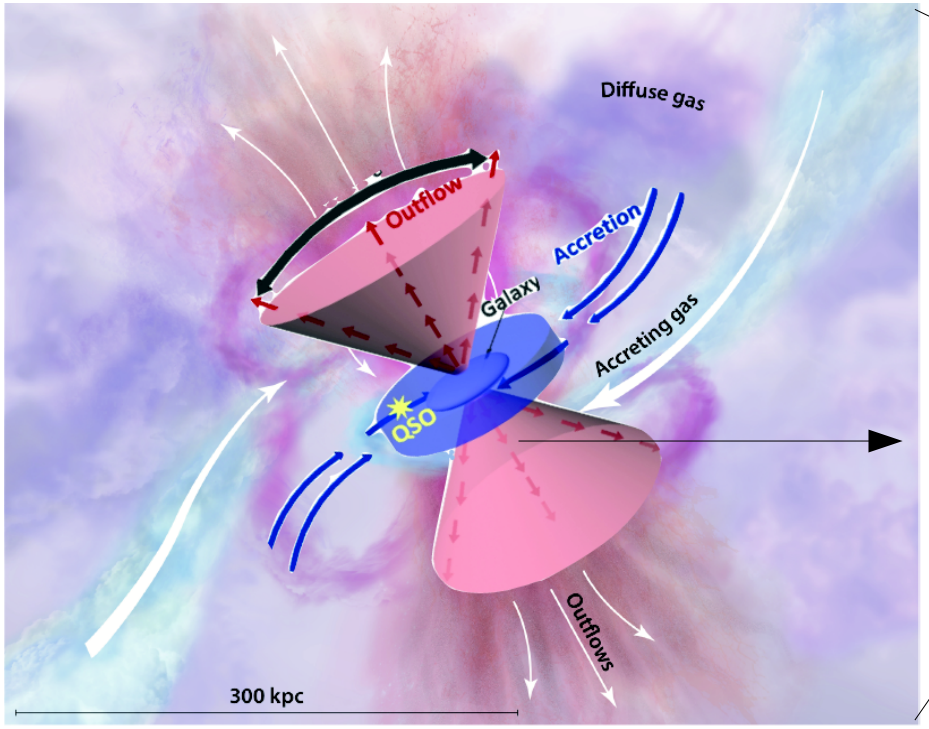


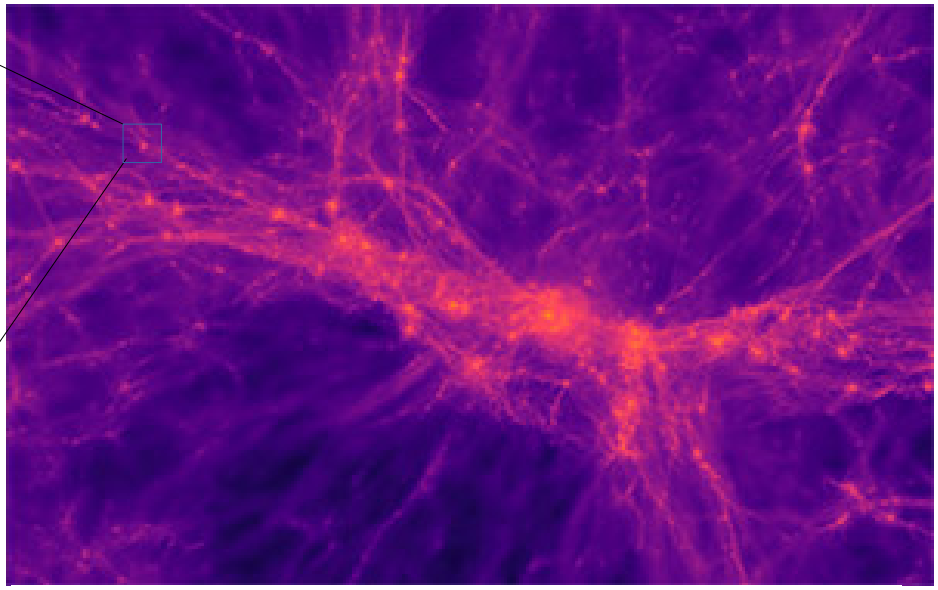
Figure 10. Comoving number density of O I systems with $W_{1302} > 0.05$ Å as a function of redshift. Filled circles are the same as in Figure 6 and use bin sizes $\Delta z = 0.8$–0.9. Open circles use redshift bins $\Delta z = 0.4$–0.45.

Essential requirements to investigate the Cosmic Reionization						
Spectral resolution	Wavel. Range (µm)	Wavel. Accuracy (km/s)	Stability	Multiplex	Backgr. Subtr.	AO/ IFU
50,000	0.8-1.8	0.6	not critical	No	~1 %	no

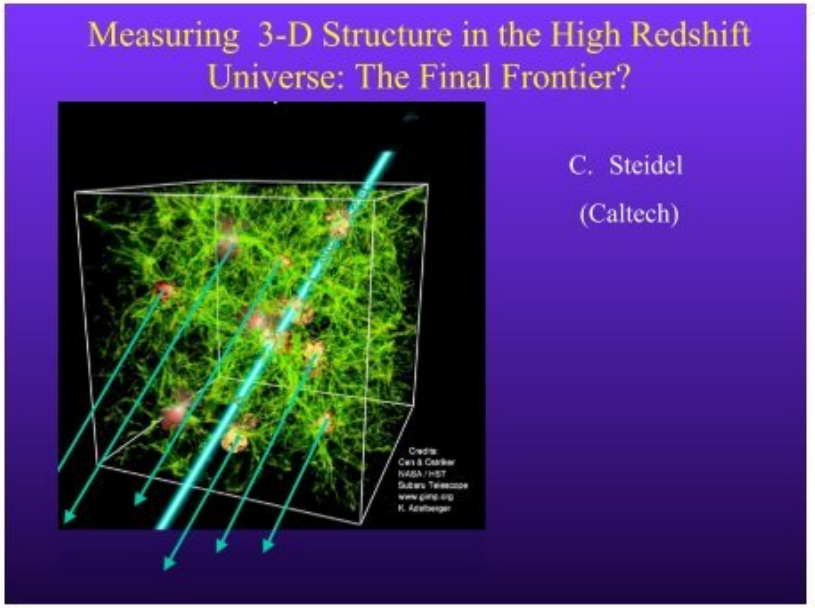
#4 Cosmic web tomography



90% of baryons outside galaxies



- Need dense sampling !!



#4 Cosmic web tomography

w/UVES snr5-10 limit to r=18

ELT: up to r=21
10 per sq.deg.

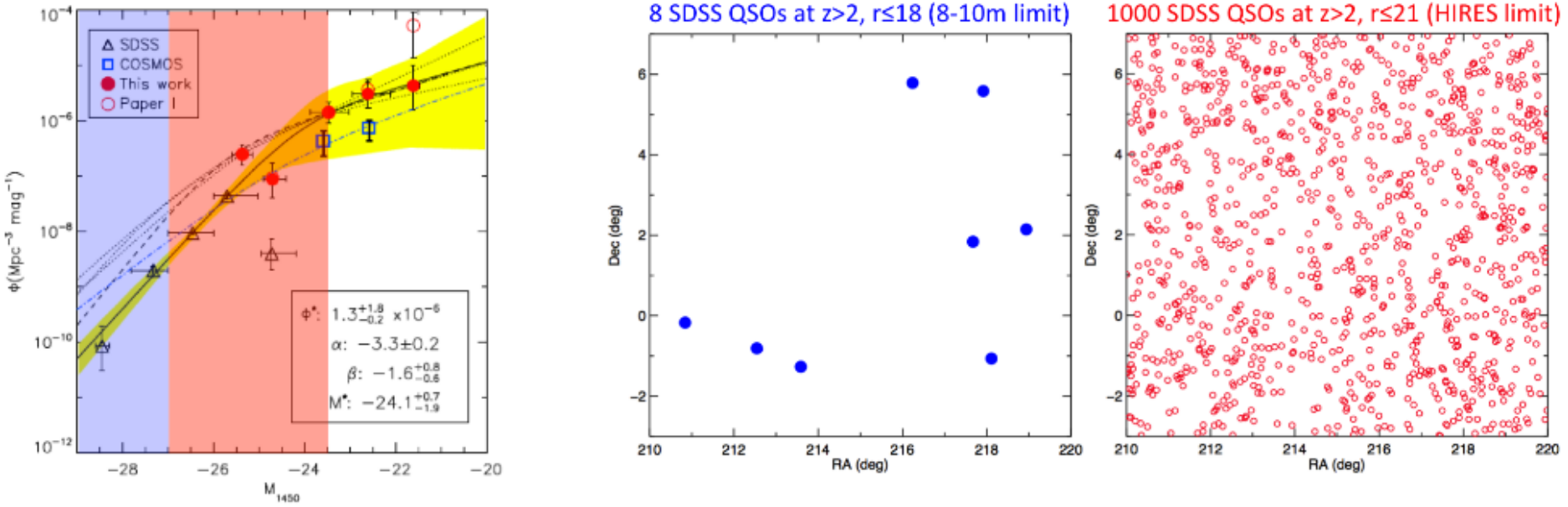
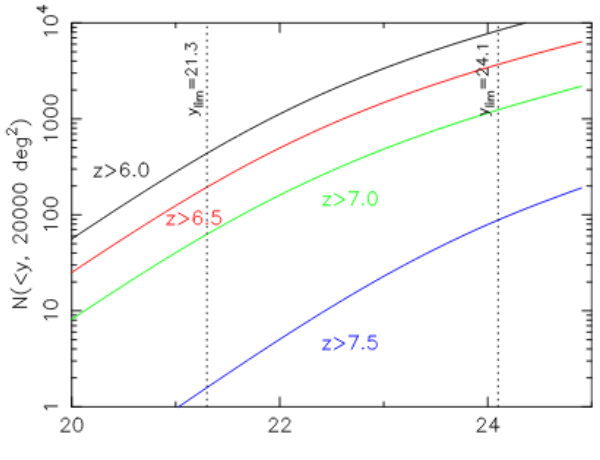
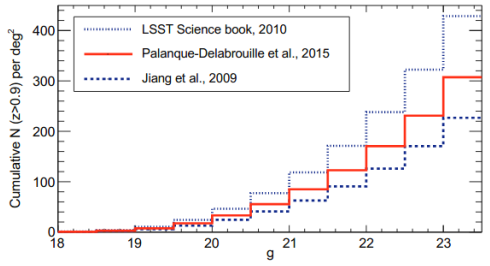


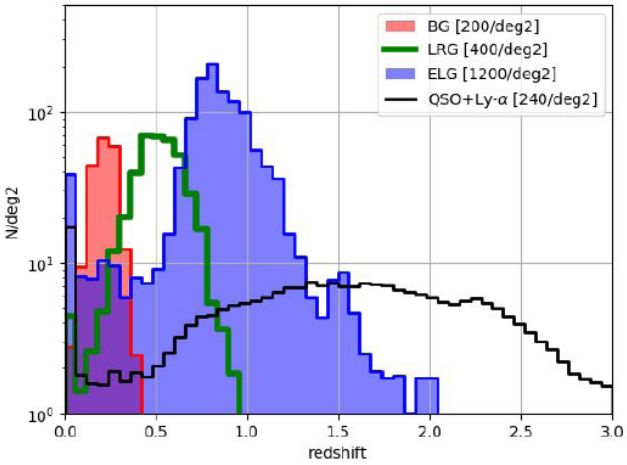
Fig.6. *Left:* Luminosity function of quasars at z~4. The blue shaded region shows the limit of high-resolution spectrographs at 8-10m telescopes, while the red shaded region shows the sensitivity extension enabled by HIRES at the E-ELT. Right: distribution and number of SDSS quasars at z>2 within reach of high-resolution spectrometers at 8-10m telescopes and of HIRES at the E-ELT, in an area of 10x10 deg^2.

#4 Cosmic web tomography

- Pletora of QSO surveys
  - SDSS; eBOSS
  - Panstars
  - LSST (100/deg2 z>6)
  - 4MOST / CRS (200/deg2)
  - DES / DESI



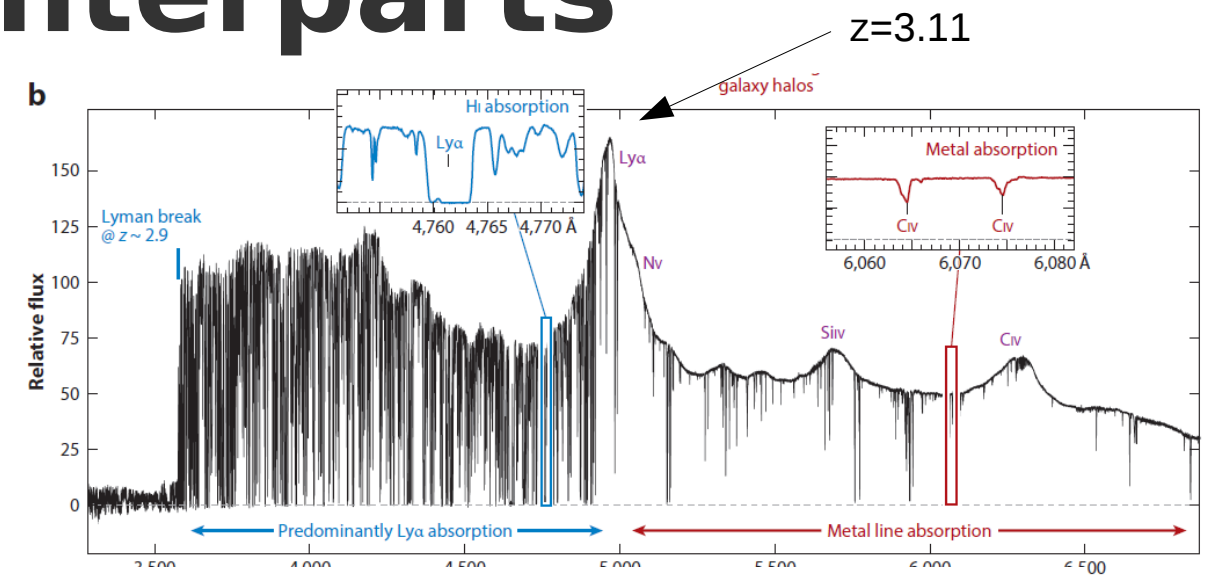


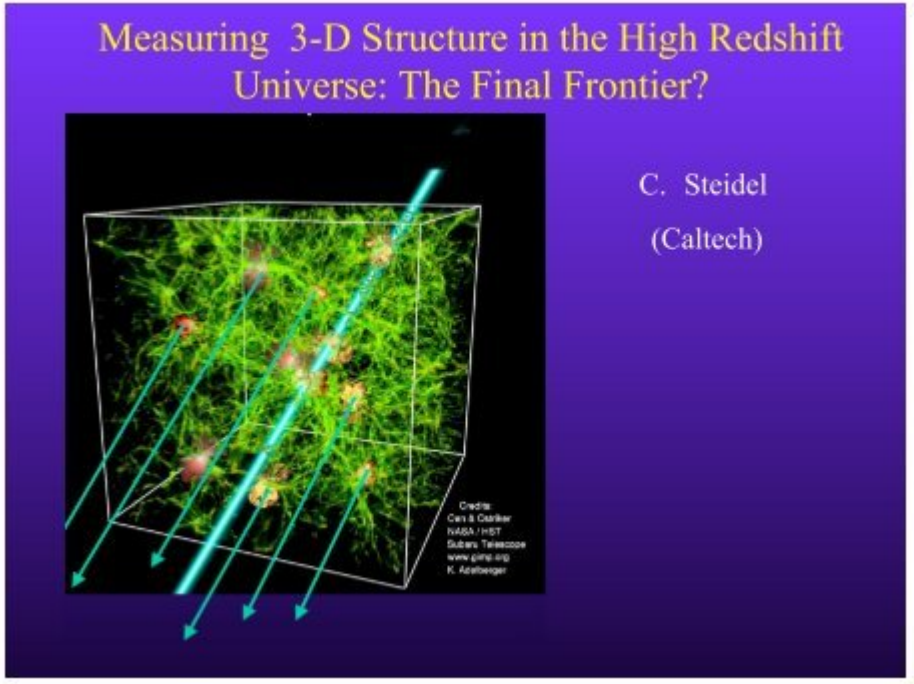


Essential requirements for the 3D reconstruction of the circumgalactic medium						
Spectral resolution	Wavel. Range (µm)	Wavel. Accuracy (km/s)	Stability	Multiplex	Backgr. Subtr.	AO/ IFU
20,000	0.4-1.8	not critical	not critical	5	<1 %	no

#4 Web tomography: Galaxy counterparts

1) <z> QSO=2

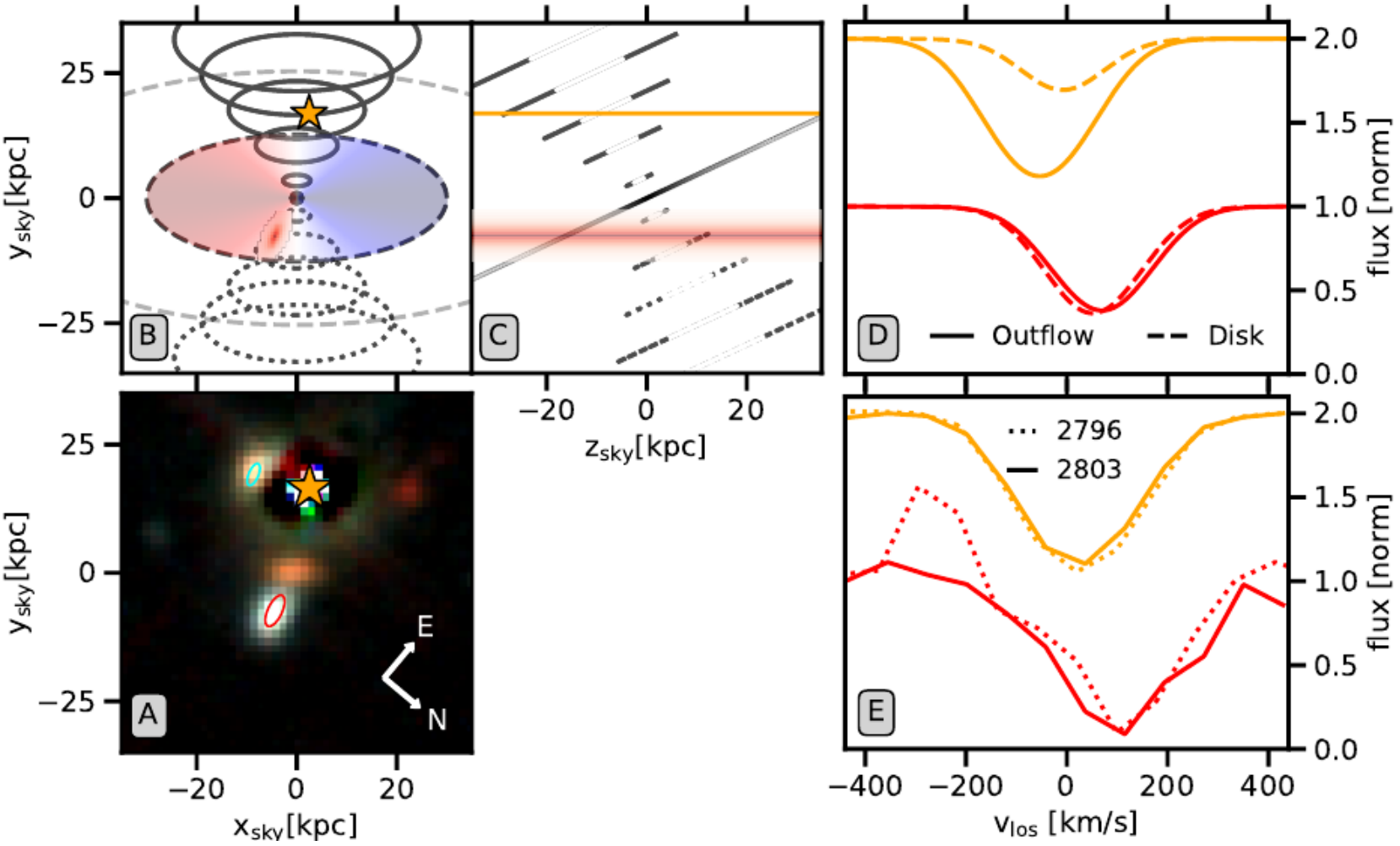




Multi-plexing
(5-10x)

#4 CGM tomography

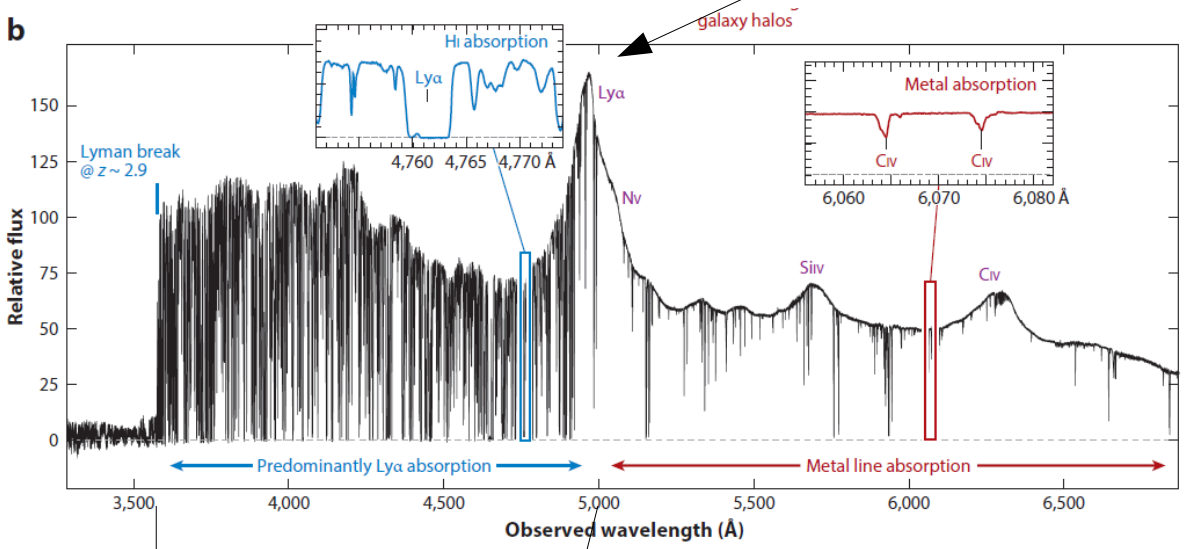
Zabl 2020



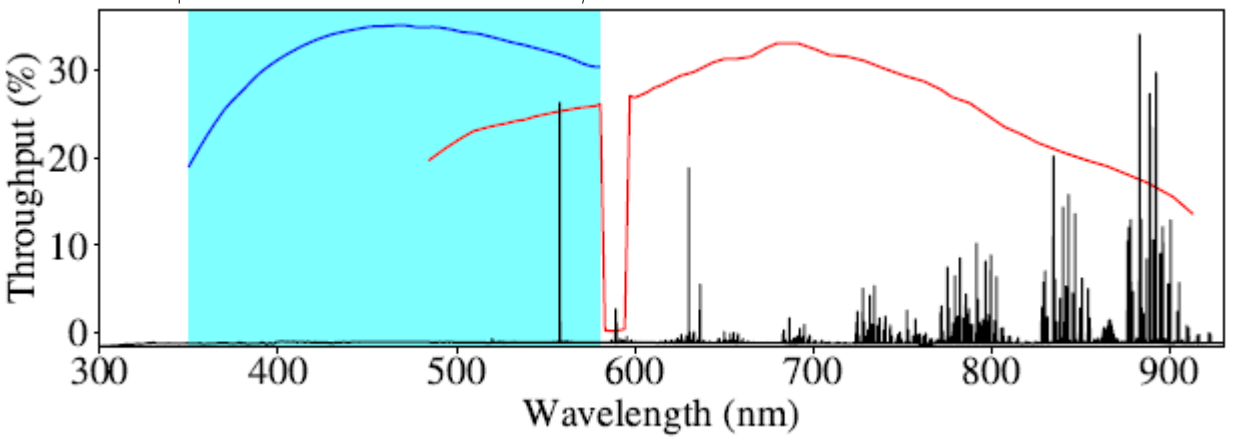
#4 Web tomography: Galaxy counterparts

1) <z> QSO=2

z=3.11

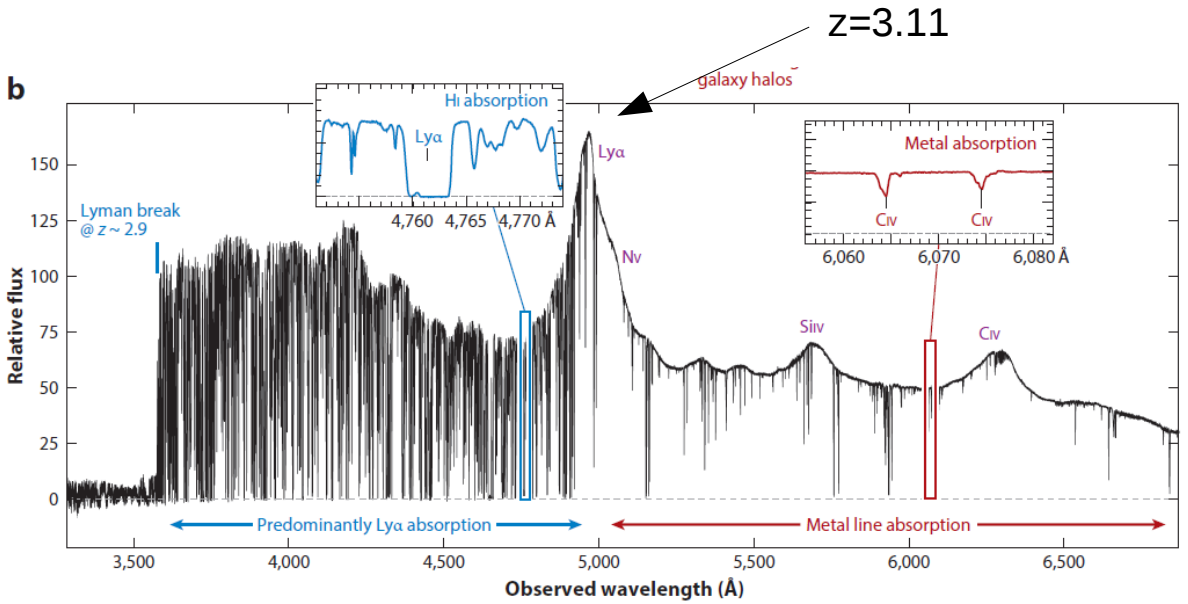


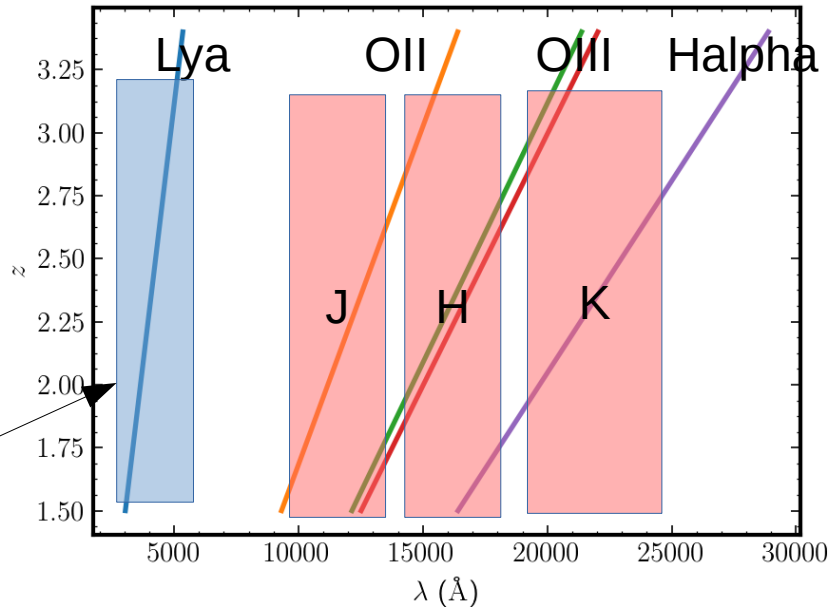
Ly-alpha: → **BlueMUSE**



#4 Web tomography: Galaxy counterparts

1) <z> QSO=2



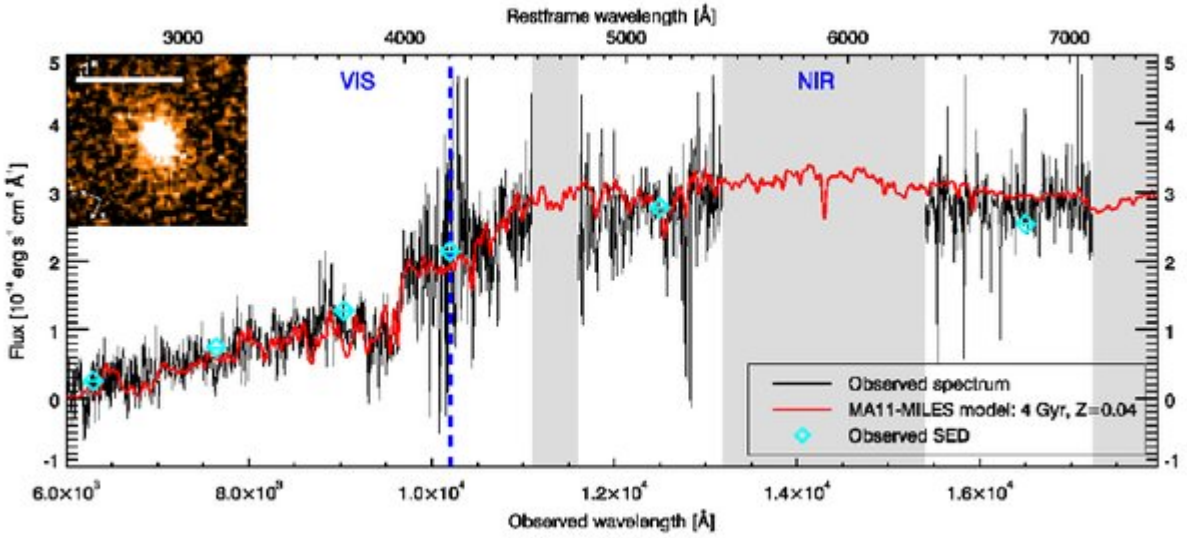


HARMONI

BLUE MUSE
multi unit spectroscopic explorer

#5 Galaxy Evolution

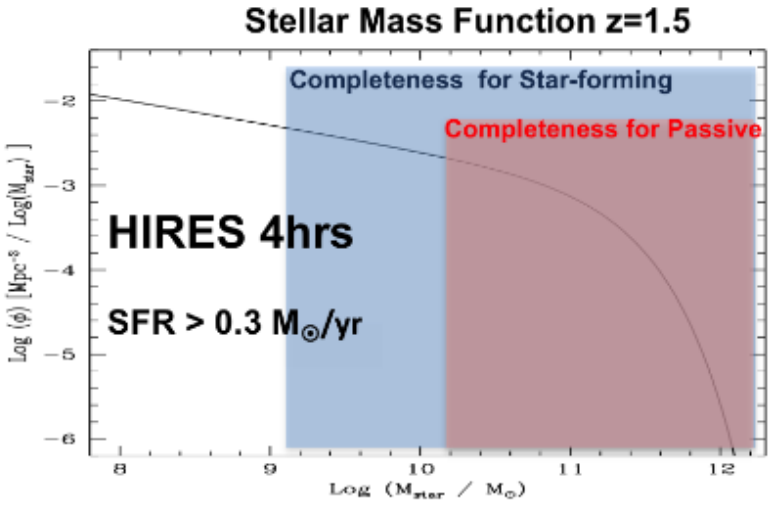
- ETG z>1 are very difficult to study

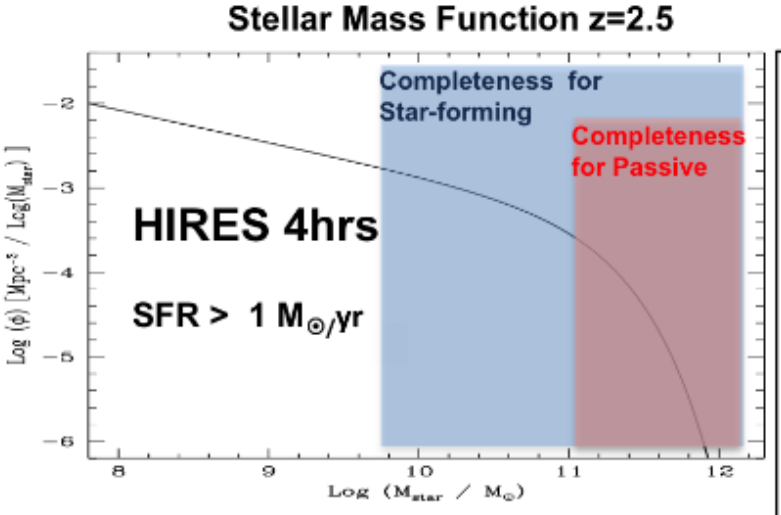


- Open questions:

  Stellar kinematics? Metallicities? Ages, SFHs…?

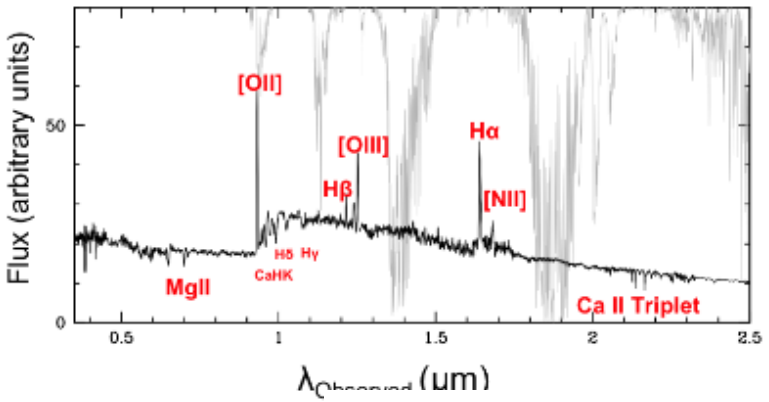
#5 Galaxy Evolution

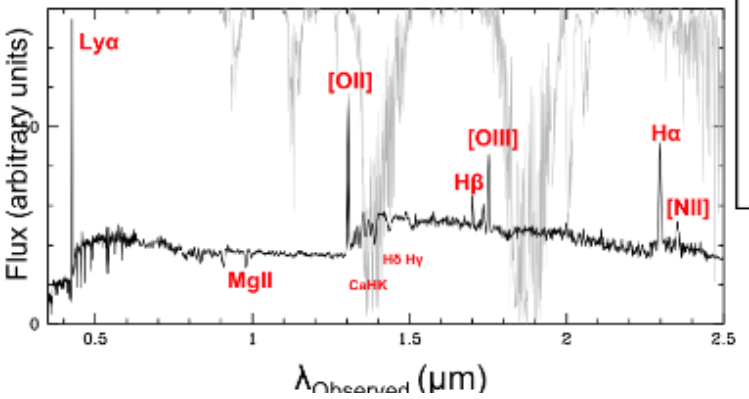




Diagnostics

- *SFR (Hα, Hβ, [OII])*
- *Gas Metallicity (R_{23},N_2)*
- *Stellar metallicity (FeI, MgI)*
- *Stellar ages (Stellar absor.)*
- *IMF (NaI, TiO)*
- *AGN power (BPT)*
- *Dust extinction (Hα/Hβ)*
- *Dynamical mass (σ_v)*
- *BH mass (BLR)*



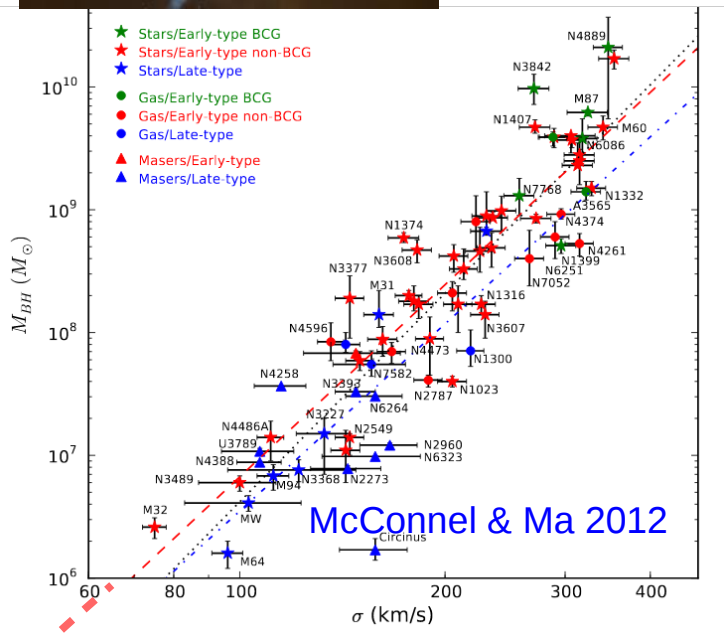


Essential requirements for Passive ETG science case

Spectral resolution	Wavel. Range (μm)	Wavel. Accuracy (km/s)	Stability	Multiplex	Backgr. Subtr.	AO/ IFU
10,000	0.4-2.4	not critical	not critical	5-10	<1 %	no

6# BH formation

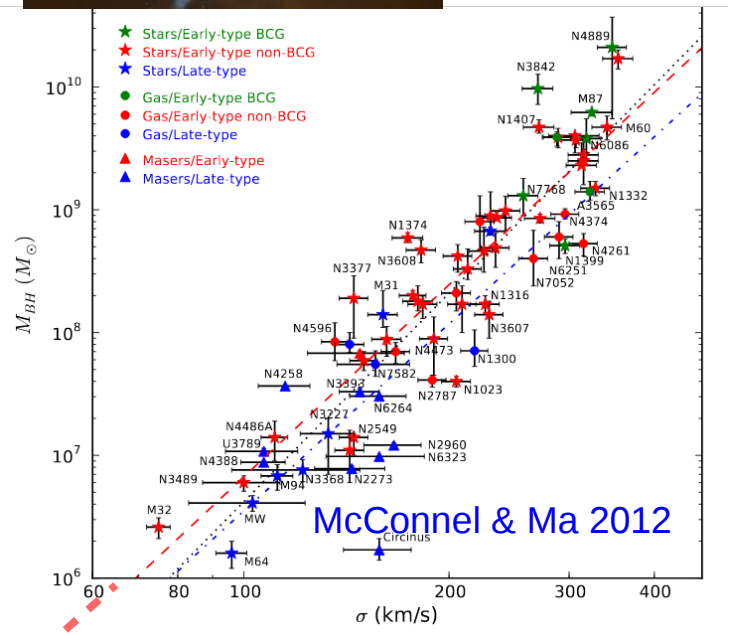
- M-sigma relation to 1e5 Msun?
- Implications:
  - Galaxy evolution
  - BH formation



??

6# BH formation

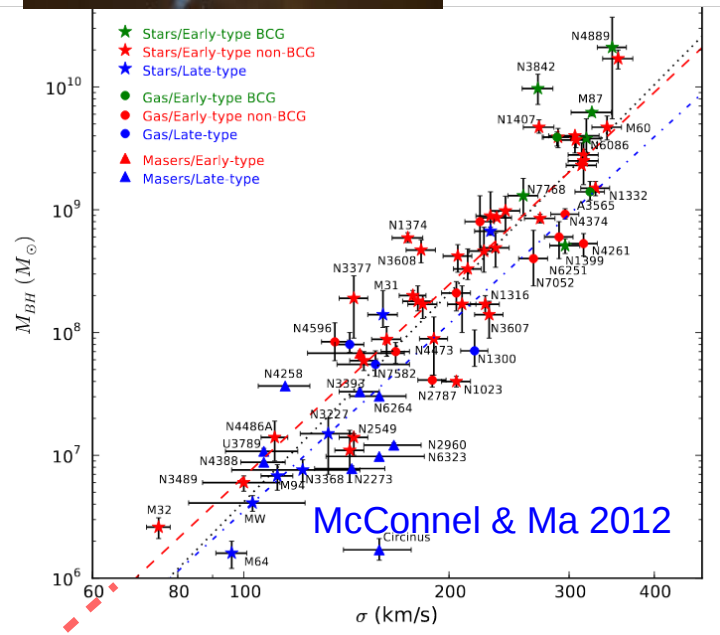
- M-sigma relation to 1e5 Msun?
- BH: 1e5 Msun
  - Rsh~3e5km
  - Rinfluence ~ 80AU or 4mas @Virgo
  - Gas? Stellar? Kinematics ?



??

6# BH formation

- M-sigma relation to 1e5 Msun?
- BH: 1e5 Msun
  - Rsh~3e5km
  - Rinfluence ~ 80AU or 4mas @Virgo
  - Gas? Stellar? Kinematics ?



mass from M(<r) ~ v^2 r

30km/s
R~1e5

Spectro-astrometry;
IFU

Low mass Black Holes	**E**	100,000	1-2.4	not critical	not critical	none	not crit.	AO+ IFU	no
	D	100,000	0.5-2.4	not critical	not critical	none	not crit.	AO+ IFU	no

Requirements Galaxies and IGM

Table.3. Summary of science requirements for the science cases related to **galaxy evolution** and **IGM** (**E**=essential; **D**=desirable)

Science case		Spectral resolution ($\lambda/\Delta\lambda$)	Wavel. range (μm)	Wavel. accuracy ($\lambda/\Delta\lambda$)	Stability	Multi-plex	Backgr. subtr.	AO / IFU	Polarim.
Near pristine gas & reionization	E	50,000	0.6-1.8	50,000	not critical	none	<1%	no	no
	D	100,000	0.6-2.4	100,00	not critical	2[a]	<1%	no	no
3D mapping of the IGM + metallicity	E	5,000	0.4-1.3	5,000	not critical	5	<1%	no	no
	D	20,000	0.37-1.3	20,000	not critical	10	<0.1%	no	no
Galaxy evolution	E	10,000	0.4-2.4	10,000	not critical	5	<1%	no	no
	D	15,000	0.4-2.4	15,000	not critical	10	<1%	no	no
Low mass Black Holes	E	100,000	1-2.4	not critical	not critical	none	not crit.	AO+ IFU	no
	D	100,000	0.5-2.4	not critical	not critical	none	not crit.	AO+ IFU	no

[a] QSO pairs.

Final thoughts

Sc Cases	R	Lambda	Multiplex	IFU	
#1 IGM	50,000	0.4-1.8	no	no	
#2 lowZ	50,000	0.4-1.8	no	no	
#3 Reion	50,000	0.4-1.8	no	no	
#4 Tomo IGM	20,000	0.4-1.3	5-10	no	
#5 ETG	10,000	0.4-2.4	5-10	no	
#6 BH	*100,000*	0.4-2.4	no	Yes	

Final thoughts

Sc Cases	R	Lambda	Multiplex	IFU	
#1 IGM	50,000	0.4-1.8	no	no	
#2 lowZ	50,000	0.4-1.8	no	no	
#3 Reion	50,000	0.4-1.8	no	no	
#4 Tomo IGM	20,000	0.4-1.3	5-10	no	
#5 ETG	10,000	0.4-2.4	5-10	no	
#6 BH	*20,000*	0.4-2.4	no	Yes	Harmoni

Final thoughts

Sc Cases	R	Lambda	Multiplex	IFU	
#1 IGM	50,000	0.4-1.8	no	no	
#2 lowZ	50,000	0.4-1.8	no	no	
#3 Reion	50,000	0.4-1.8	no	no	
#4 Tomo IGM	20,000	0.4-1.3	>5-10(100)	no	*MOSAIC*
#5 ETG	10,000	0.4-2.4	>5-10	no	*MOSAIC*
#6 BH	*20,000*	0.4-2.4	no	Yes	Harmoni

- Multi-object

	VLT	ELT
N=1	– UVES	HIRES
N>10	– FLAMES	MOSAIC
N>100	– *MOONS*	

- Multi-IFU

VLT	ELT
– SINFONI	HARMONI
– KMOS	MOSAIC
– MUSE	...