Searches for the highest redshift galaxies

Poster 32

SuprimeCam LAE Survey at Redshift 7.3 : A progress report

M.Iye, T.Shibuya, N.Kashikawa, H.Furusawa, K.Ota, M.Ouchi, & K.Shimasaku

Survey field: Subaru Deep Field (~800 arcmin^2)

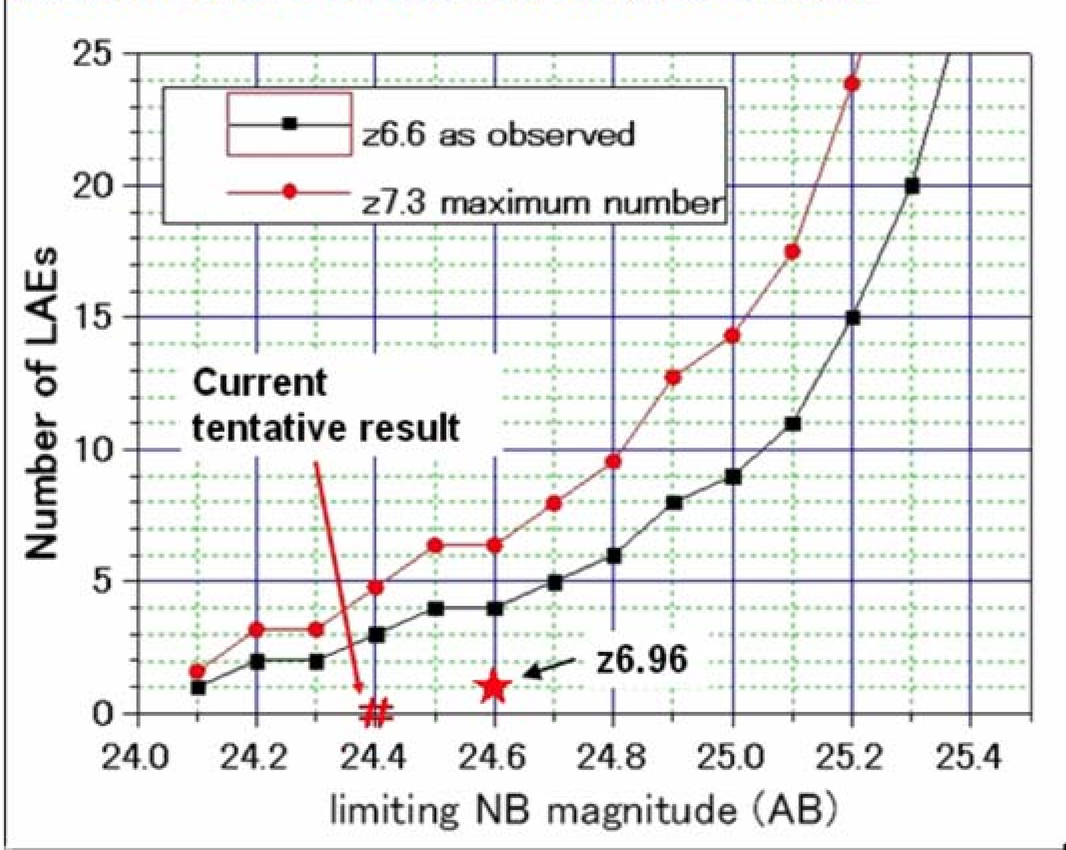
Exposure time: 22 hours (so far analyzed 17 hours data)

Limiting Magnitude (Tentative): NB1006=24.4 mag (5σ, 2" ϕ)

=> As yet no significant photometric candidate is identified.

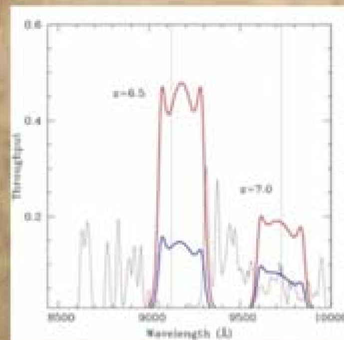
Whether the present survey provides another constraint on cosmic re-ionization or not is not yet clear.

Need more analysis and check on photometric zero-point.



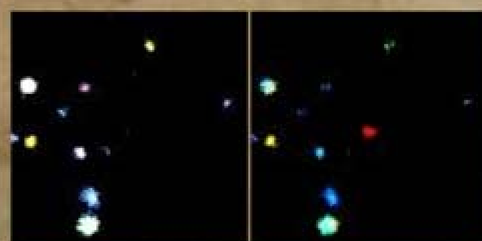
Magellan Very High-z Lya-Emitter Survey

Haojing Yan *(Ohio State University)*

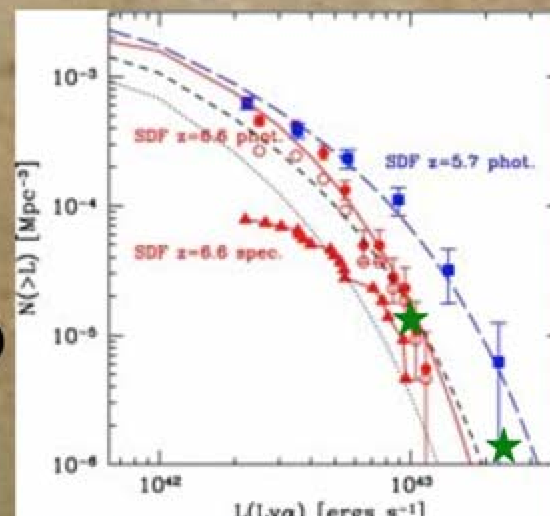


CFHTLS-D2 CFHTLS-D4

- Narrow-band imaging at 6.5-m Magellan IMACS (D=27' FOV) at z=6.5 & 7.0
- <u>Aim:</u> bright-end of the LF; cosmic variance



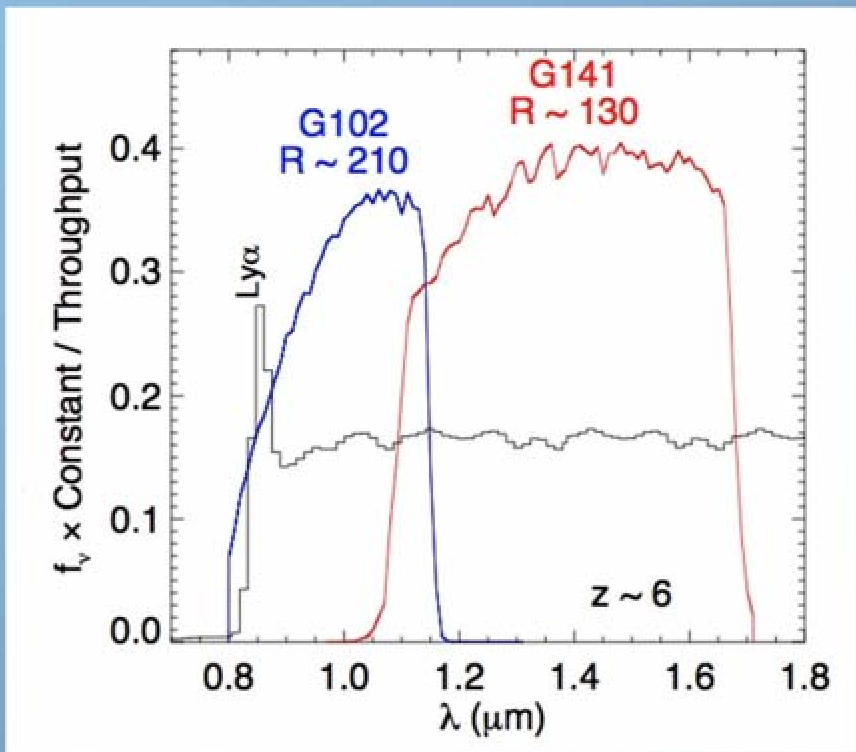
- Two pointings finished at z=6.5 (~20hr exp. each)
- Bright candidates found in both fields
- N(>1.0e43 erg/s) ≥ 1.2e-5 Mpc^{-3}
  N(>2.5e43 erg/s) = 1.5e-6 Mpc^{-3}

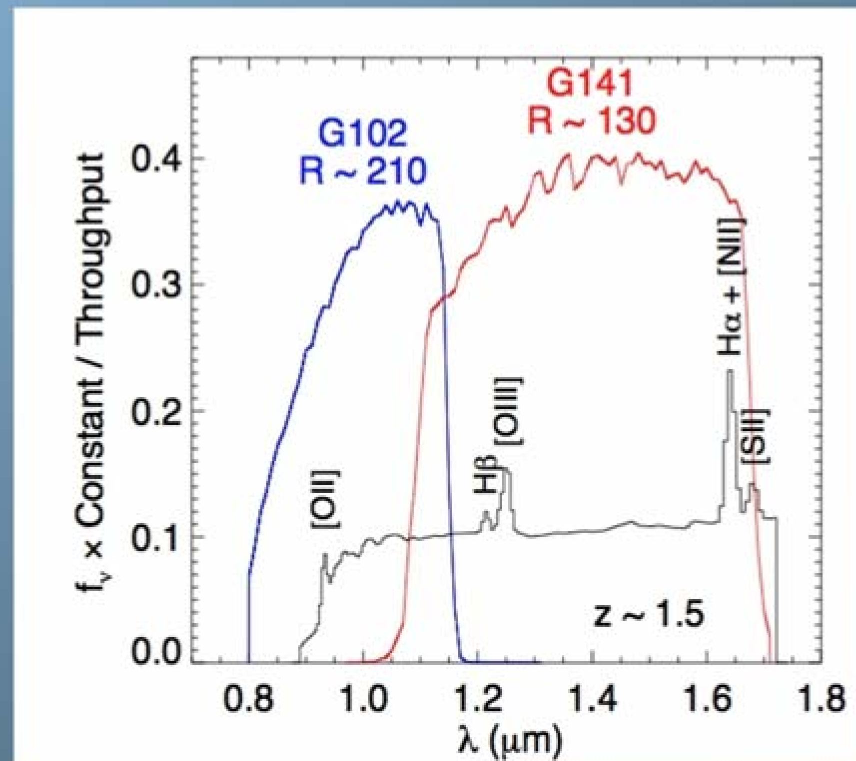


A WFC3/IR Grism Survey of the z~1-8 Universe

Alaina Henry (UCSB)

- ~ 40 parallels (190 arcmin^2) x 5 orbits of G102 and G141





- Expect 10-100 LAEs at z~6-7
- Hundreds of galaxies at z ~1-3

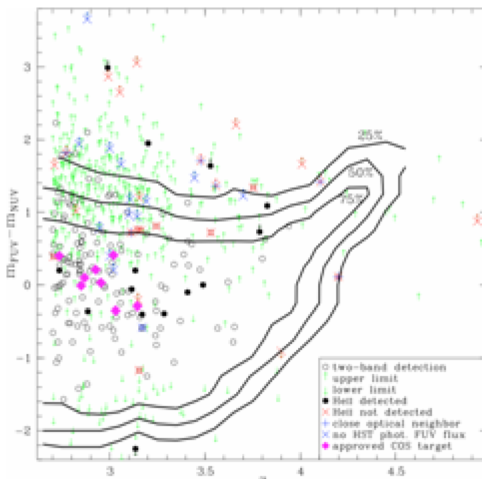
Results will test claims of Lyα evolution at z~6

HeII reionization

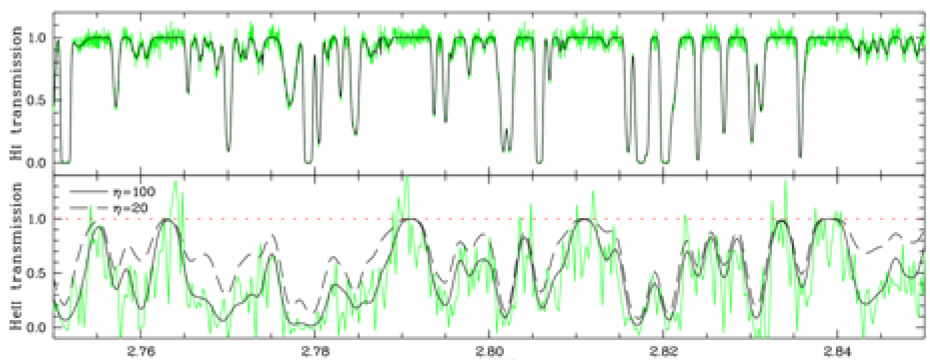
Probing HeII reionization with GALEX-selected quasar sightlines

G. Worseck, J. X. Prochaska, L. Wisotzki, A. Dall'Aglio, C. Fechner, P. Richter, J. F. Hennawi & D. Reimers

- detection of He II Lyα forest traditionally difficult (far UV transition, most sightlines blocked due to intervening H I Lyman limit systems)
- our approach: find likely transparent sightlines by requiring the quasars to show a *blue* GALEX UV color $m_{\rm FUV} - m_{\rm NUV}$
- 8 UV-bright $2.73 < z < 3.14$ quasars selected for confirmation with HST/COS (21 orbits awarded in Cycle 17)
- optical H I spectra of all targets from VLT/UVES (38.2h awarded) and Keck/HIRES (1 night but clouds)
- **Science goals:**
  1. Confirm He II absorption (> 50% detection probability for each target)
  2. Characterize He II absorption at $z \sim 3$ near He II reionization epoch
  3. Probe He III zones near QSOs
  4. Constrain evolving spectral energy distribution of the UV background via $\eta =$He II/H I
  5. Constrain ionizing source population at $z \sim 3$



GALEX UV color $m_{\rm FUV} - m_{\rm NUV}$ of $z > 2.7$ QSOs vs. redshift. All known sightlines with detected He II absorption are rediscovered by GALEX and most of them have a blue UV color as expected. Our 8 COS targets have similar blue UV colors. Monte Carlo simulations yield a high probability that a QSO sightline with a blue GALEX UV color will be transparent at the He II Lyα 304Å break (contours).



Mock H I Lyα forest (*top*) and corresponding He II absorption spectrum (*bottom*) illustrating the expected quality of our UV/optical dataset (green). The optical H I spectra are will have S/N=20 at $R \sim 40000$, whereas the HST/COS spectra are expected to yield S/N~ 6 at $R \sim 2400$. The fitted H I forest is used to infer the correct column density ratio $\eta =$He II/H I$\simeq 100$ in the He II spectrum (black lines).

Lyman continuum escape

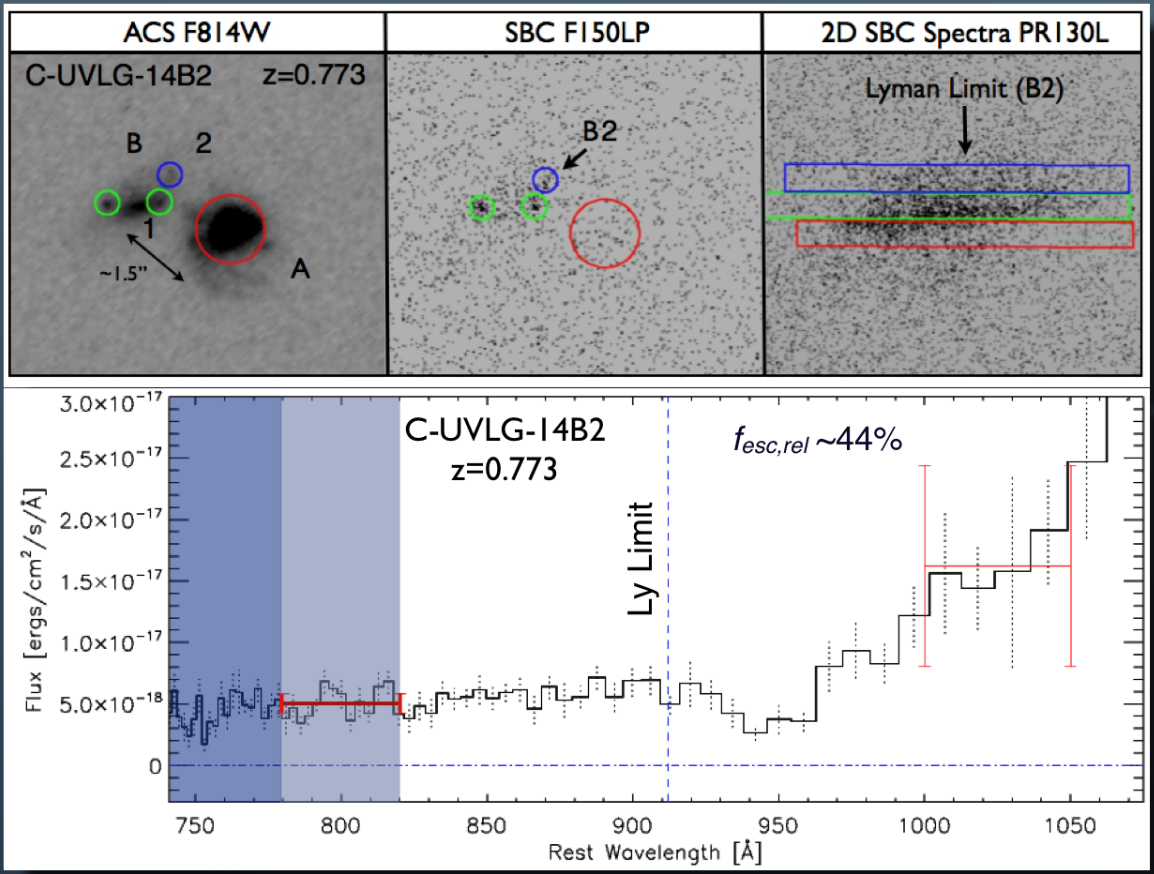
The Escape Fraction at z~0.7: First Detection?

Carrie R. Bridge, Caltech /SSC

Poster 37

HST Survey

We use Solar Blind Channel (SBC) slitless UV spectra of 32 Lyman Break Galaxy Analogs (LBGA) to measured the LyC relative escape fraction at z~0.7.



Bridge et al. 2009 in prep

Results

- First direct detection of LyC leakage in a starburst galaxy at z≲2.5

  $f_{esc,rel}$ =44%±6% or

  $f_{\nu(1500Å)}/f_{\nu(830Å)}$=9.2

- Stacked 3σ upper limits of $f_{esc,rel}$ <2% (for non-detections)

The analysis presented uses 17 LBGAs.

Implications

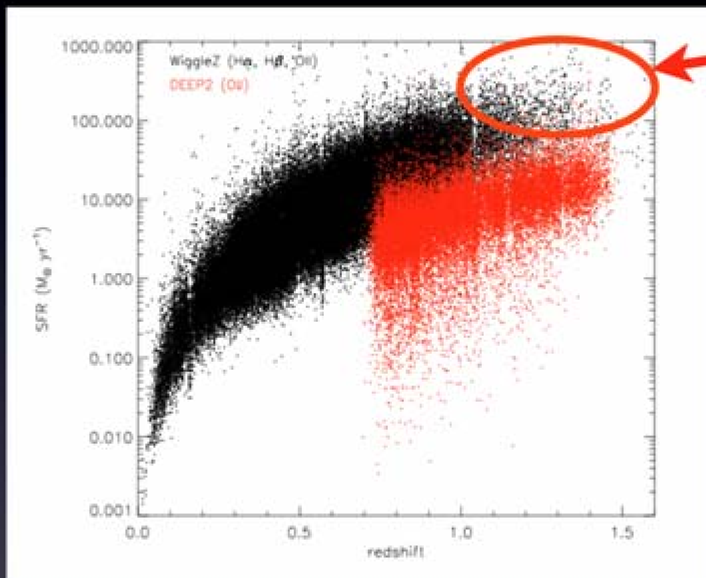
- The fraction of galaxies with large $f_{esc,rel}$ is smaller at z<1 (<5%) compare to z~3 (10-15%).
- Mergers may be an important dynamical mechanism allowing LyC radiation to escape.

Team Members: H. Teplitz, B. Siana, C. Scarlata, P. Capak, J. Melbourne, T. Brown, R.-R. Chary, J. Colbert, C. Conselice, M. Dickinson, H. Ferguson, J. Gardner, M. Giavalisco, D. De Mello, M. Salvato

Leaking Lyman Continuum at z=1.4

The Nature of Super-Starbursts in WiggleZ Dark Energy Survey

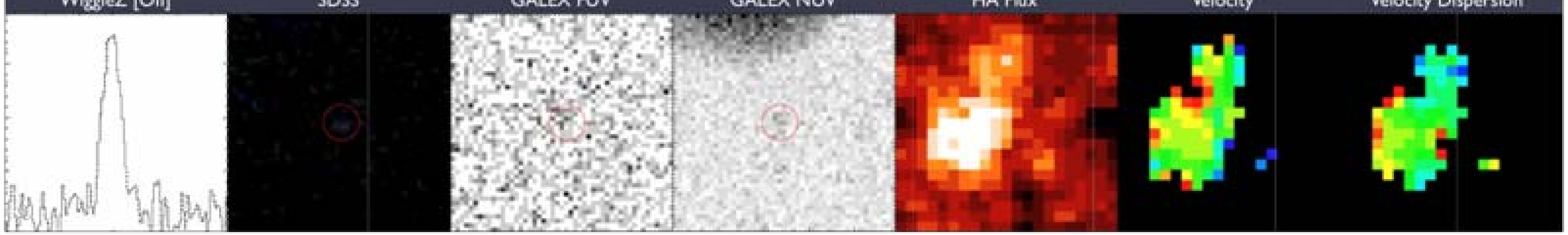
Emily Wisnioski[1], & the WiggleZ team[2] 1. Swinburne University of Technology, 2. University of Queensland, University of Sydney, Anglo Australian Observatory, California Institute of Technology, University of British Colombia



The WiggleZ Dark Energy Survey in partnership with UV GALEX imaging has identified a population of rare super-starburst galaxies at z=1.0-1.5 with star formation rates of 100-1000M(solar)/yr.

One of the high-SFR WiggleZ z~1.4 targets has been identified as having a reliable FUV detection using a 12 ksec follow-up exposure with the GALEX satellite and has a redshift confirmed with Keck. This is a surprise as this redshift puts the observed FUV band blueward of the Lyman limit making it a candidate for keeping the intergalactic medium ionized at z < 4. Our z~1.4 object could be the first discovery of a star-forming galaxy with high escape fractions possibly solving a significant cosmological problem.

WiggleZ [OII] | SDSS | GALEX FUV | GALEX NUV | HA Flux | Velocity | Velocity Dispersion



Cosmological modelling of Lya emission

Semi-analytical models of high redshift Lyman-α Emitters★

Saumyadip Samui, Raghunathan Srianand, Kandaswamy Subramanian

Simultaneous fit of UV and Lyman-α LF of Lyman-α emitters and UV LF of LBGs at $3 \le z \le 6.5$

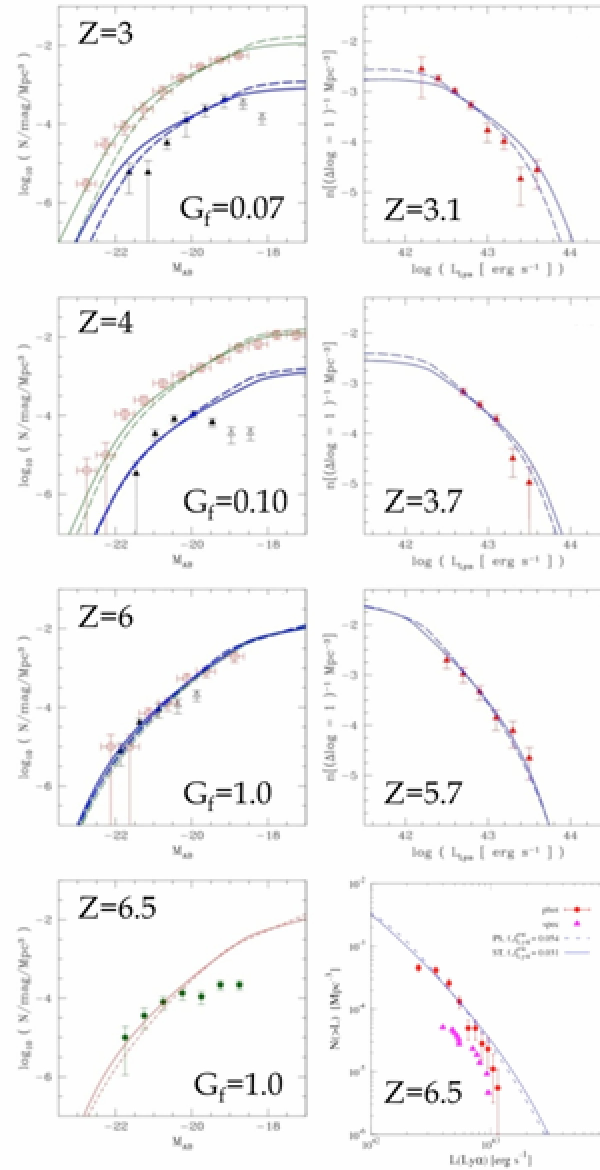
Model

- Press-Schecter / Sheth-Tormen mass function in a LCDM cosmology
- Star formation in a galaxy : $M_{SF}(\dot{M}, z, z_c) = f_* \left(M \frac{\Omega_b}{\Omega_m} \right) \frac{t(z)-t(z_c)}{\kappa^2 t^2_{dyn}(z_c)} \exp\left[-\frac{t(z)-t(z_c)}{\kappa t_{dyn}(z_c)} \right]$
- A subset (G_f) of all LBGs are Lyman-α emitters
- Lyman-α luminosity (case B recombination) :

$$L^{obs}_{Ly\alpha} = f^{Ly\alpha}_{esc} L_{Ly\alpha} = f^{Ly\alpha}_{esc} \left[0.068 h \nu_\alpha (1 - f_{esc}) N_\gamma \dot{M}_{SF} \right]$$

Results

- ✓ At $z \le 4$ only 10% of LBGs are LAEs
- ✓ At $z = 5.7$ almost 100% of LBGs are LAEs
- ✓ Redshift evolution of the escape fraction of Lyman-α photons is less than 3σ between z=3 to z=6.5
- ✓ For $z > 6$ LF of LAEs are consistent with evolution in mass function
- ✓ Average EW of LAEs decreases with redshift



★ Accepted for publication in MNRAS

Study of Re-ionization using Lyman-Alpha Emitters

Akila Jeeson Daniel, MPA, Garching
22/06/09

- **Abstract:** This poster shows the work in progress of an attempt to study re-ionization using simulated Lyman-Alpha Emitters (LAEs) in a cosmological setup.

- **Background:** It was proposed by Haiman and Spaans (1999) that a class of high-redshift galaxies, LAEs can be used to constrain the neutral hydrogen fraction in the Universe. LAEs can be unambiguously detected using the Lyman break and the strength, width and asymmetry of the observed Lyman-alpha line (Dayal et. al 2008). Lyα photons are highly sensitive to even small amounts of neutral hydrogen (e.g. neutral fraction of 10e-4) in the Inter Galactic Medium (IGM). Therefore, the observed luminosity function at different redshifts can be used to constrain the re-ionization history. In addition to this method, the Lyα line skewness and equivalent width give constraints on the neutral fraction in the IGM. Also, clustering properties of sources can shed light on the re-ionization stage. But to constrain the re-ionization history, we need to compare observations to models which include structure formation along with its radiative, chemical and mechanical feedback effects.

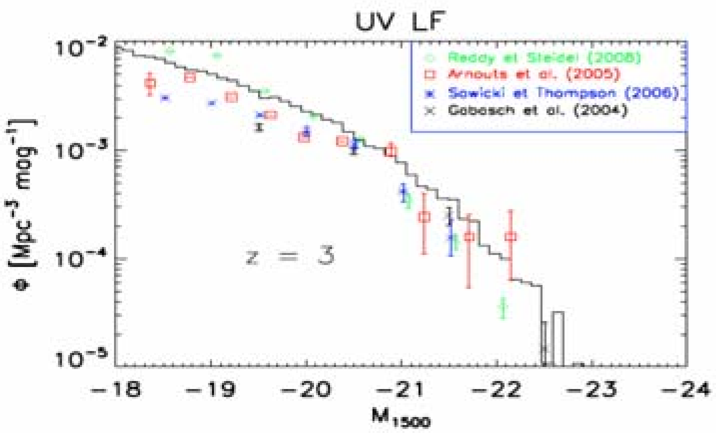
- **Aim:** To do a statistical parameter study of simulated LAEs to constrain re-ionization history.

- **Method:** Take cosmological simulations (Gadget simulations; Maio et al.,2007, 2008 & 2009) at high redshift (z=6-12) with primordial and metal chemistry, star formation and supernova feedback included. Extract density, temperature, ionization structure, velocity profile and source properties like stellar mass & metallicity from the simulation box and run radiative transfer using CRASHα (Pierleoni et al., 2009). The source luminosity is calculated using STARBURST99 (Leitherer et al., 1999; Vazquez & Leitherer,2005) . Repeat this for all sources in the simulation box to get a statistically significant sample. Compare the luminosity functions and line profiles to observations.

- **Planned examples of parameter study:** Halo properties, environment, clustering, effects of IMF, redshift, feedback, chemistry, dust, IGM inhomogeneities, escape fraction.

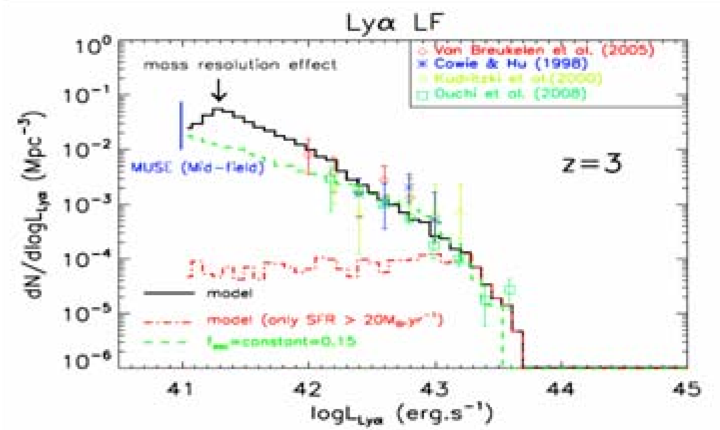
Semi-analytical modelling of Lyman-Alpha Emitters

(T. Garel, J. Blaizot, B. Guiderdoni, D. Schaerer, A. Verhamme)

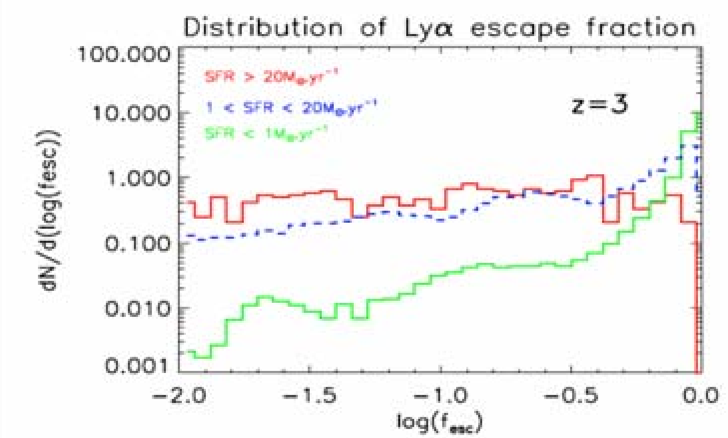


1- Forthcoming instruments, such as VLT/MUSE, require predictions for Lyα emitting galaxies at low luminosities.
The GalICS hybrid model (Hatton et al.,2003) predicts physical properties of galaxies at high redshift. For instance, UV LF are well reproduced at z=3 (and 6, cf poster).

2- To evaluate the Lyα emission, we use a grid of models made with the RT code MCLya (Verhamme et al., 2006).
We develop a simple wind model which provides us with the values of the input parameters of the MCLya grid.
This model is applied to GalICS galaxies.



3- Our model fits the Lyα LF at z = 3 (and 6, cf poster).
Intensely star forming galaxies (SFR > 20M_{sun}) are responsible for the LF's bright end.
They contribute equally to all luminosities, because of the flat distribution of their escape fractions.
The faint end (to be uncovered by MUSE) is dominated by low-SFR galaxies, which tend to have higher escape fractions on average.



Modeling Lyman Alpha Emitters Around the End of Reionization

Zheng Zheng (Institute for Advanced Study), **Renyue Cen** (Princeton University), **Hy Trac** (Center for Astrophysics), and **Jordi Miralda-Escudé** (Institut de Ciències de l'Espai)

We model $z = 5.7$ Lyman Alpha Emitters (LAEs) by combining a state-of-the-art cosmological reionization simulations (Trac, Cen, & Loeb 2008) in a box of $(100h^{-1}\mathrm{Mpc})^3$ and a Monte Carlo Lyα radiative transfer code (Zheng & Miralda-Escudé 2002). The volume is three times that of the Subaru/XMM-Newton Deep Survey for $z = 5.7$ LAEs (Ouchi et al. 2008).

Model setups:

Each LAE is located at the center of a halo.
Lyα photons are initially emitted from a point source.
Lyα luminosity is proportional to star formation rate.
The initial Lyα spectrum follows a Gaussian profile with width determined by halo virial temperature.

Model outputs:

Lyα (narrow-band) image and spectra
LAEs are identified from the image following typical observational procedures.

Summary of Main Results:

Detailed radiative transfer calculation of Lyα photons shows that the spatial and frequency diffusions of Lyα photons are important in determining the observability of high-z LAEs. Because of resonant scatterings, Lyα sources become extended and only the central part can be detected as LAEs.

At a given intrinsic Lyα luminosity (or host halo mass), the observed (apparent) luminosity shows a broad distribution because of the dependence of propagation of Lyα photons on the environment around LAE sources. The observed (apparent) Lyα luminosity depends on the density and peculiar velocity of the matter around sources, and their gradient along the line of sight.

Lyα radiative transfer effect can explain an array of observational properties of LAEs.

The dependence of the observability of LAEs on environment, a consequence of Lyα radiative transfer, introduces new features in LAE clustering. We predict that the large-scale two-point correlation function of LAEs shows an elongated pattern along the line of sight (opposite to redshift distortion) and has a scale-dependent bias.

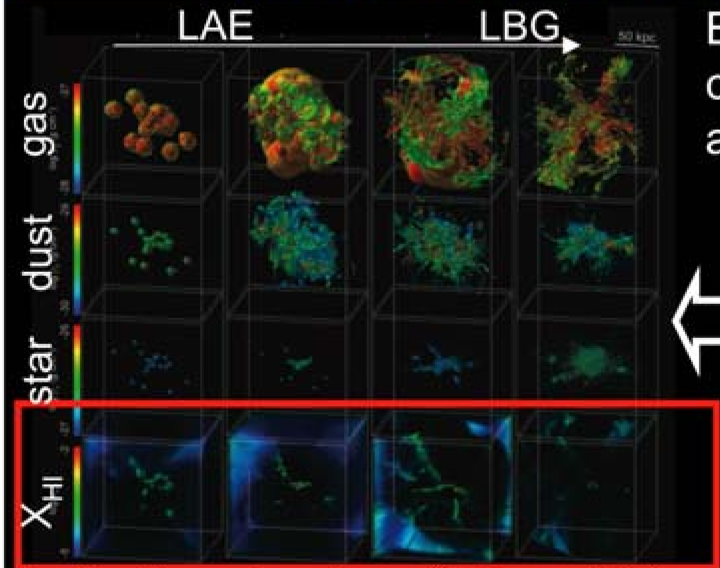
On one hand, the new features in LAE clustering are valuable for studying the late stage of reionization. On the other hand, they add complications in using LAE clustering to constrain cosmological parameters (e.g., through BAO measurements).

References:

Ouchi, M., et al. 2008, ApJS, 176, 301
Trac, H., Cen, R., & Loeb, A. 2008, ApJ, 689, L81
Zheng, Z., & Miralda-Escud, J. 2002, ApJ, 578, 33

The escape of ionizing photons from high-z Lyman alpha emitters

★H. Yajima, M. Umemura, M. Mori, J. -W. Choi, K. Nagamine



Ionization structure (Yajima+09a)

Escape fraction of ionizing photons can control UV background intensity and Lyman alpha luminosity!

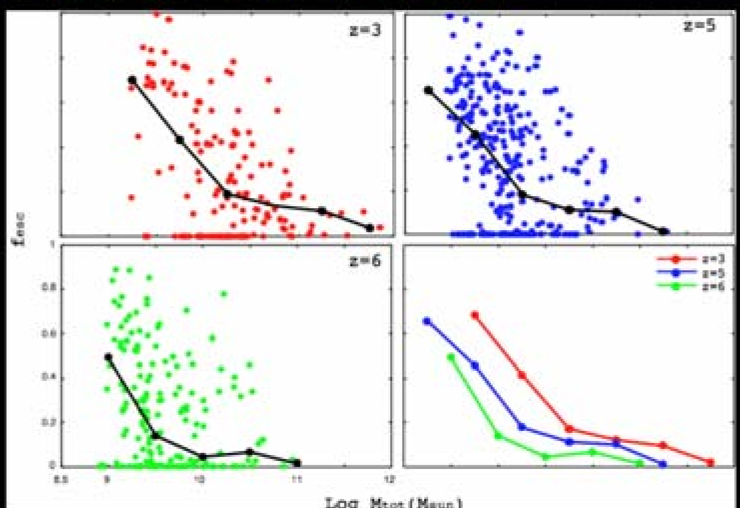
Result 1(A LAE evolution cal. +Radiation Transfer cal.)

High-z LAEs and LBGs have a large escape fraction (17-47%) and therefore can ionize the IGM at z=3-5.

Result 2 (Cosmological SPH cal. +Radiation Transfer cal.)

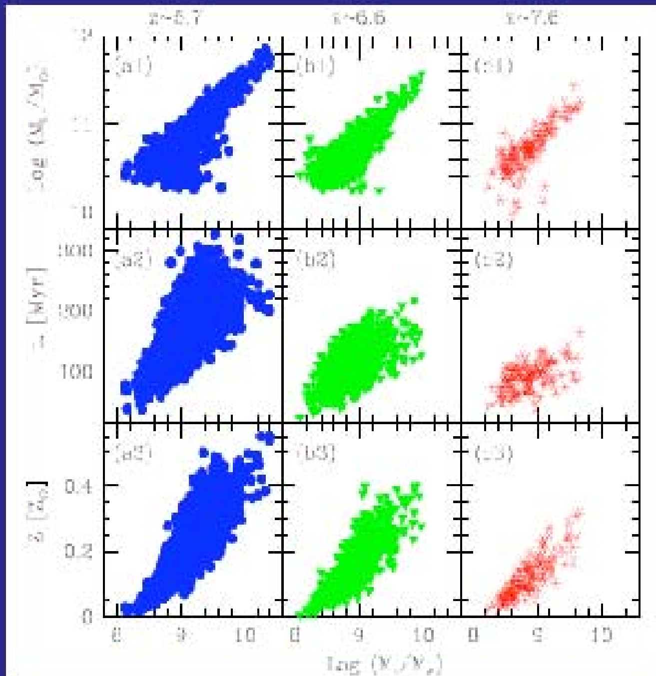
The escape fraction of high-z galaxies increase as the halo mass decrease.

(Yajima+09b in prep.)

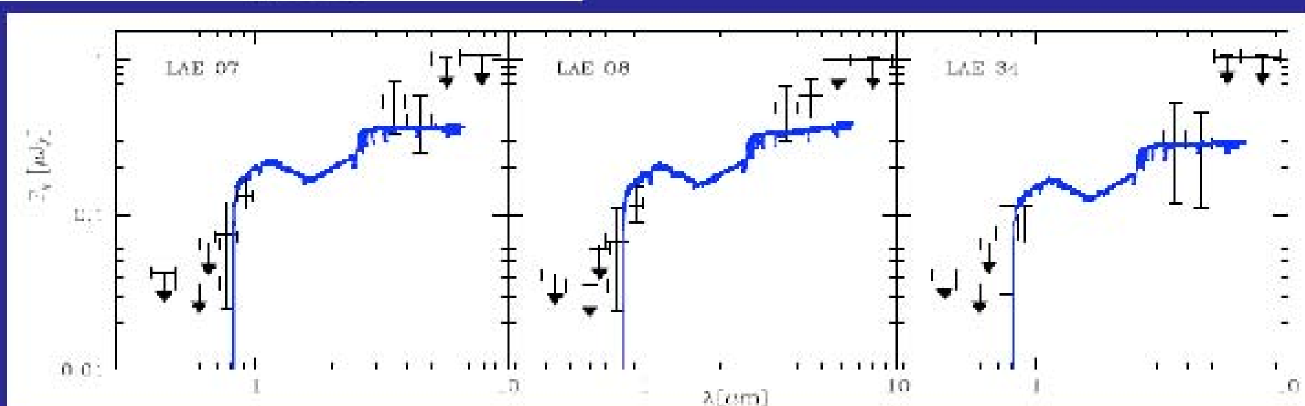


Unveiling the nature of Lyman Alpha Emitters (arXiv:0907.0337)

Pratika Dayal (SISSA/ ISAS)



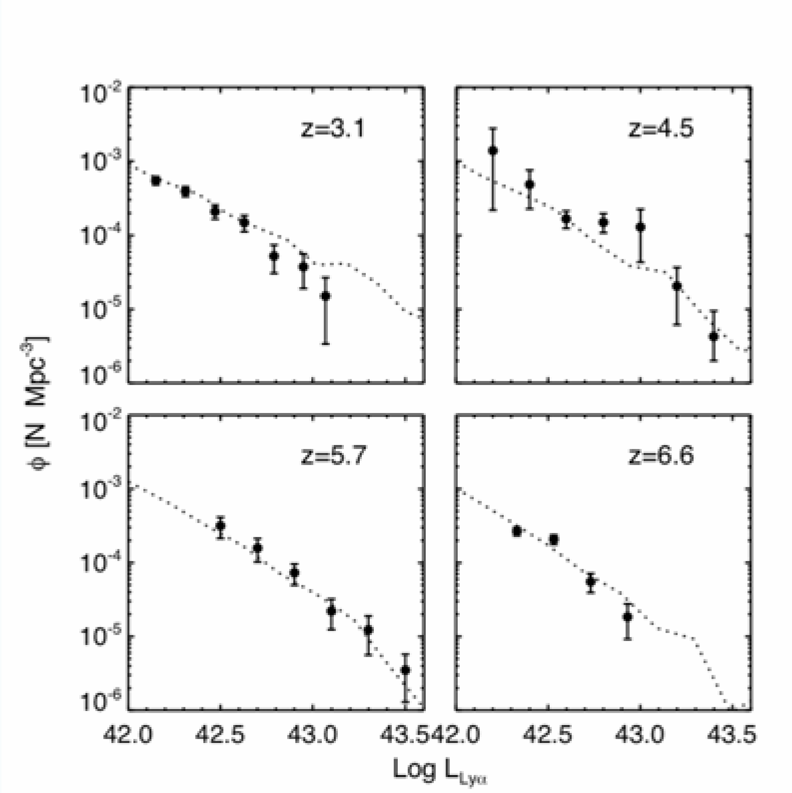
1. Halo masses are between 10^10.5-12 solar mass.
2. LAEs are intermediate age objects.
3. They can be highly metal enriched, with mean stellar metallicity ~ 22% solar at z~5.7.
4. SEDs well reproduced by E(B-V)=0.15 and no free parameters once the escape fractions are fixed from the Lya and UV LFs.



A Physical Model of Lyman-Alpha Emitters

Vithal Tilvi, Sangeeta Malhotra, James Rhoads,
Evan Scannapieco, Rob Thacker, Ilian T. Iliev, Garrelt Mellema

- We populate dark matter halos by LAEs, in a cosmological simulation (GADGET2).
- LAEs are powered by the accretion of new material which drives the star-formation.
- The star-formation efficiency (SFE) is the only free parameter in our model.
- Our model yields a constant SFE at $z \approx 3$-7, and reproduces observed Lyα luminosity functions at these redshifts.
- Reproduces observed stellar ages (< 30 Myrs), stellar masses ~10^7-10^8 $M_\odot$, SFRs≈1-10 $M_\odot yr^{-1}$ and clustering lengths of LAEs, $r_o \approx 3$-6 h^{-1}.
- Our model naturally produces the duty cycle of LAEs.



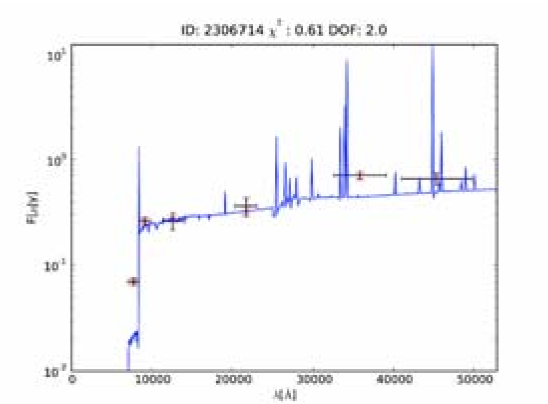
Model & observed Lyα LFs at z≈3 - 7

Properties of Star Forming Galaxies and LAE's at different redshift

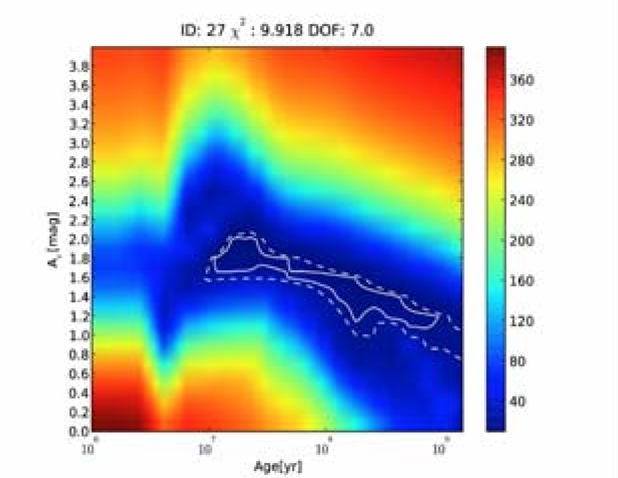
(S. de Barros, D. Schaerer)

We include in HyperZ photometric redshift code(Bolzonella, Miralles & Pello 2000) emission lines and different metallicities to fit SEDs. Furthermore, we have created tools to explore parameters space(SFR, stellar mass, age, extinction, equivalent width) to check the agreement with other SEDs fitting.
We reanalyze two samples of galaxies: 10 z~6 galaxies studied earlier by Eyles et al(2007) and 14 z~4.5 LAEs studied by Finkelstein et al(2009).

Our analysis of the Eyles sample shows that the nebular emission can mimic the Balmer break, with the consequence that some galaxies may have an overestimate age.
This can be an argument to generalize the including of nebular emission on the SEDs fitting.



Best SED fit for 23_6714 object(Eyles et al 2007)



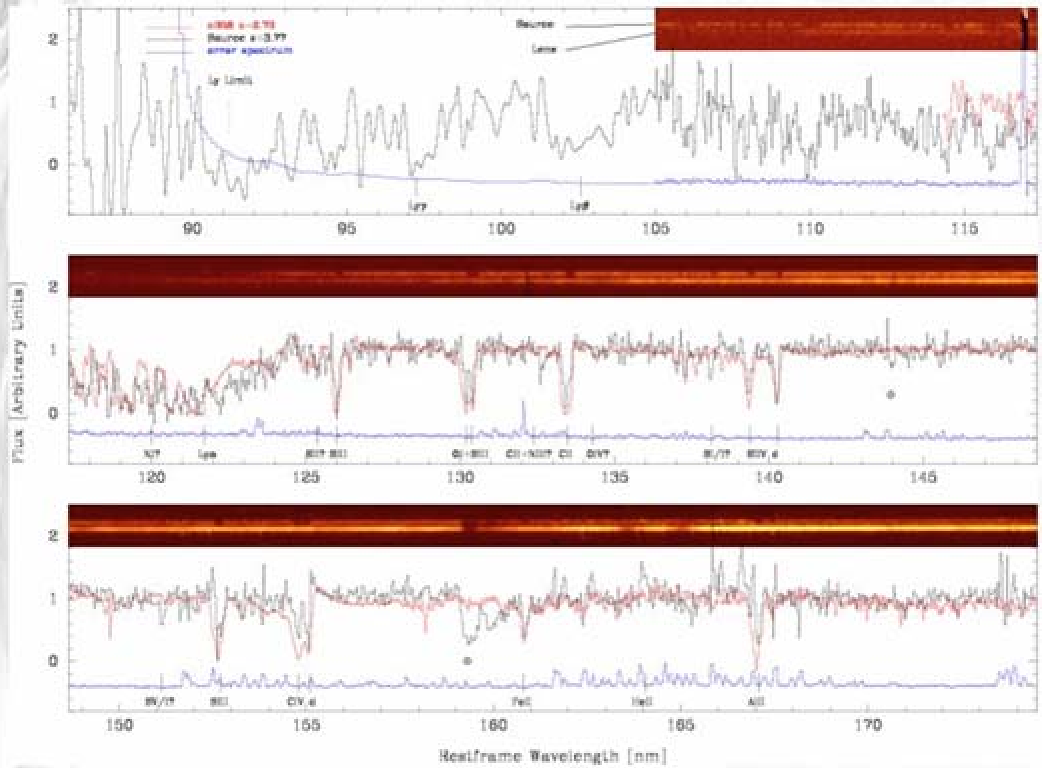
X^2 distribution for object CS2-7(Finkelstein et al 2009). The overlaid contour indicate 68% limit(solid line) and 95% limit(dashed line).

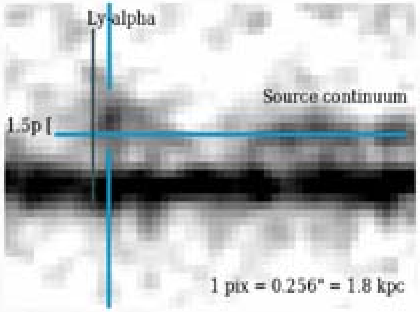
Our analysis of the Finkelstein sample shows that without clumpiness, we can obtain similar values of χ^2 and more compatible values of equivalent width with the observations.

A Lensed Lyman-alpha Galaxies at z=3.77 **(Cabanac, Valls-Gabaud, Schaerer et al.)**

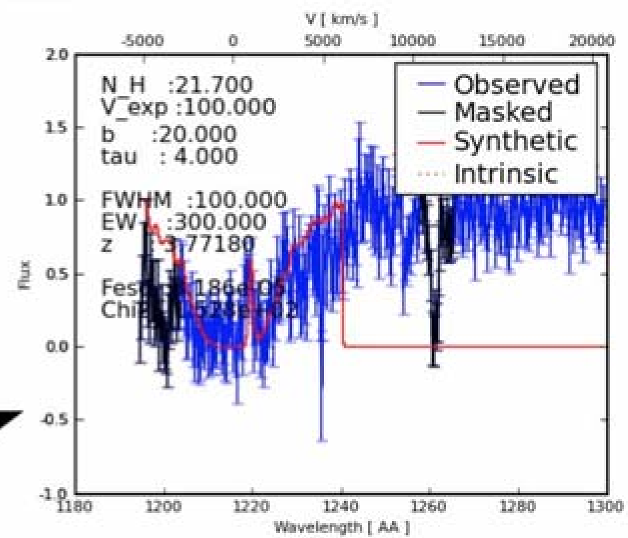
Spectro VLT FORS2 600RI: galactic winds of ~200 km s^{-1} , NH~21.4±0.4 (Voigt)

Age of shell (2.7kpc @ 100-200 km s^{-1}) ~ 10-30Myr





Schaerer et al. (2009) fit of Ly-a with exanding shell model (~100 km s^{-1})



- To fit the profile: high NH + dust is always needed . log(N_H) ~ 21.7 (best fit).

Future instruments & surveys

Fresnel Imager UV Space Mission

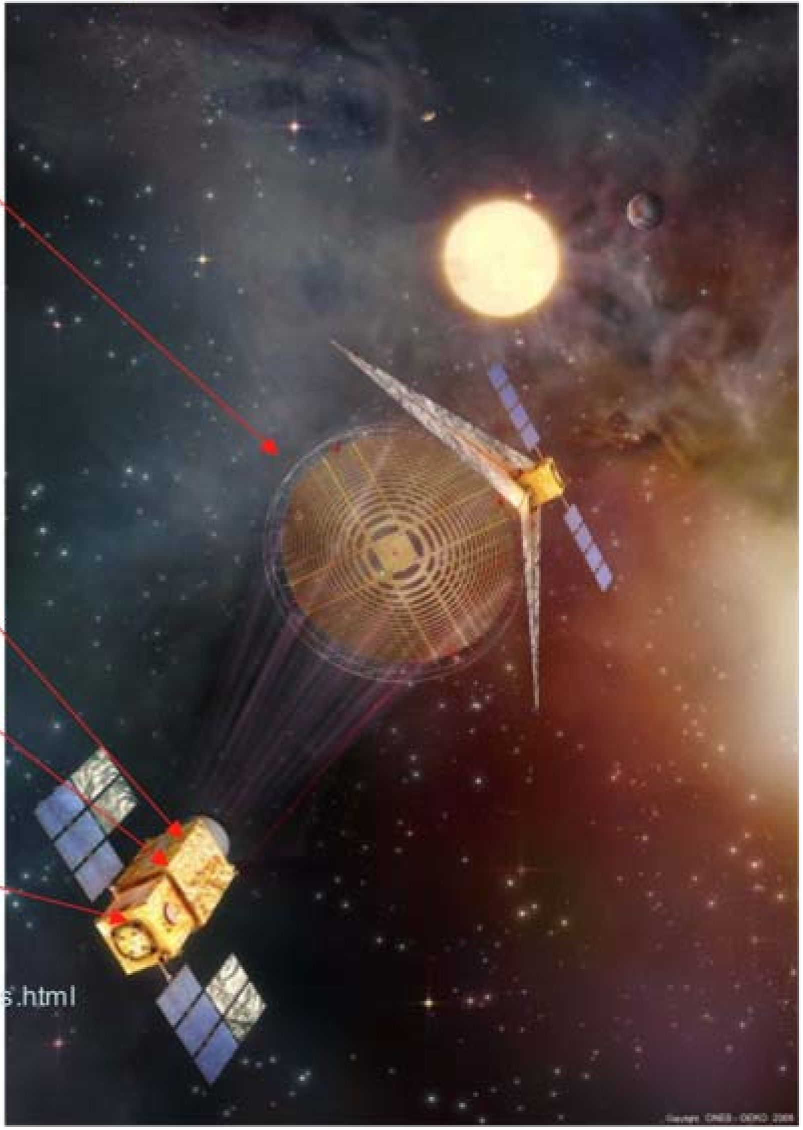
Opening the way to high resolution, high dynamic Imaging in space.

Large "Primary Array" module:
4 to 30 m diameter, or more.

Field optics telescope
$1/10^{th}$ to $1/20^{th}$ the diameter of Primary Array .

Chromatic correction :
Blazed lens or concave grating,
10 to 30 cm diameter

focal Instrumentation:
Spectro-imagers



Meeting in Nice : Sept 23-25, 2009 : check web site
www.
ast.obs-mip.fr/users/lkoechli/w3/space_borne_page/page_congres.html

L.Koechlin, P.Deba, T.Raksasataya , R.Pello.

Lya & UV radiation transfer modelling in galaxies & at cosmolgical scales