OPTIMOS-EVE at E-ELT
& lessons from starbursts from z=0 to 3

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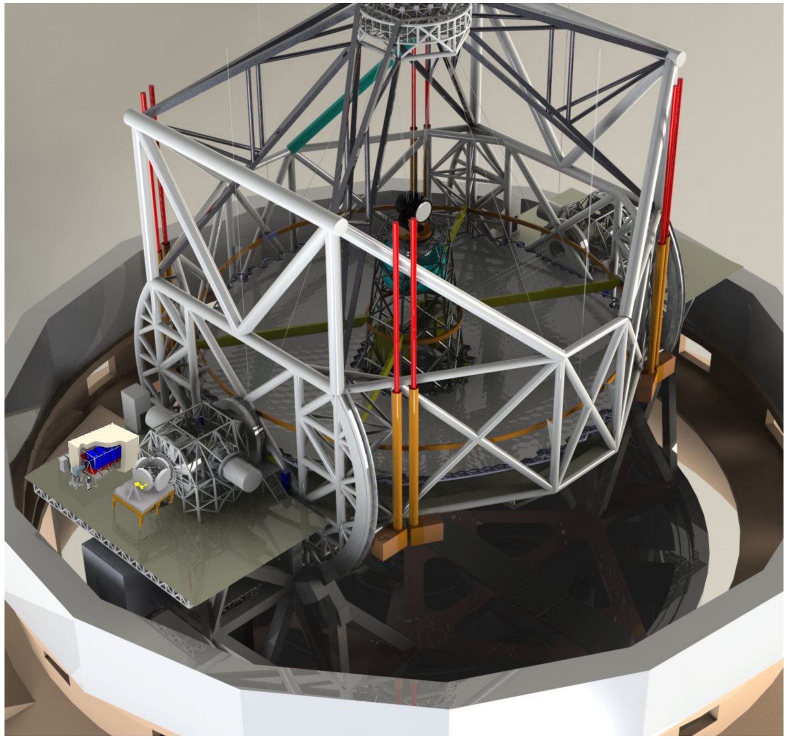
XXVth IAP Colloquium: The Lyman alpha Universe

Baseline (1)

Phase - A study for E-ELT, completion in March 2010

- Relies mainly on proven technology;
- Design for simplicity & robustness
- Flexibility of the system only on the fibers for maintenance/risks reasons;
- Keeps the possibility to implement new modes (AO)

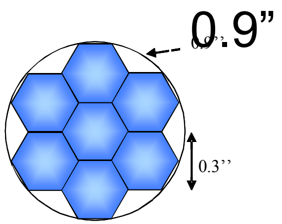


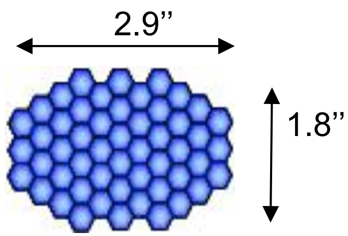
OPTIMOS-EVE is proposed as a first light instrument for the E-ELT

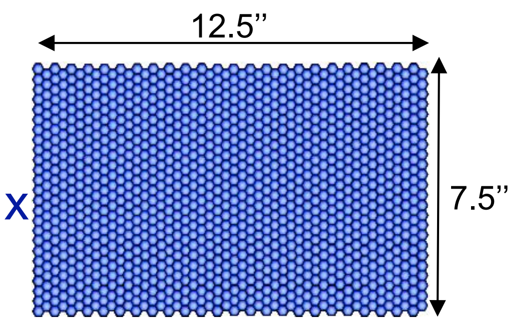
Baseline (2)

A fibre-fed UV-to NIR (0.35-1.7μm) multi-object spectrograph

- ★ High resolution: R=5000-40000
- ★ Multiplex: up to 300 point sources
- ★ Simultaneous observations in visible & NIR arms
- ★ Field of View: 7' diameter or more (goal)
- ★ Can operate in seeing limited mode or GLAO
- ★ Several deployable IFUs of different sizes up to 7"x12"

150-300 x 

25-45 x 

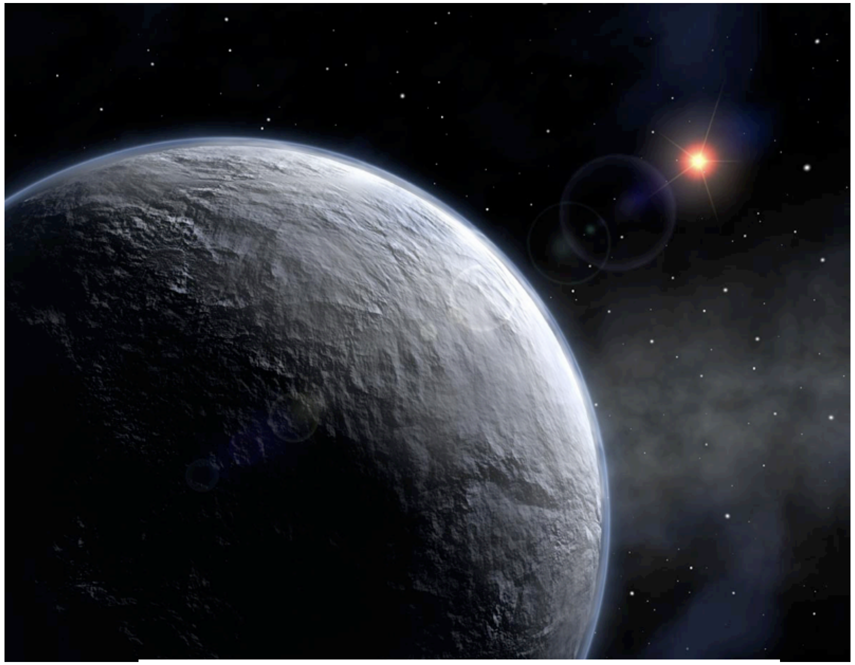
1-2 x 

To address a large diversity of science cases

EVE Science team

The OPTIMOS-EVE Science Team lead by **Piercarlo Bonifacio** (Observatoire de Paris – GEPI) : Alvarez Alvaro (Observatoire de Paris – LESIA), Andersen Michael (Astrophysikalisches InstitutPotsdam), Balkowski Chantal (Observatoire de Paris – GEPI), Barucci Antonella (Observatoire de Paris – LESIA), Battaglia Giuseppina (ESO), BockeléeMorvan Dominique (Observatoire de Paris – LESIA), Bouchy Francois (Institut d'Astrophysique de Paris), **Bunker Andrew** (University of Oxford), Dalton Gavin (Project Board – Science&Technology Facilities Council, Oxford), **de Bergh Catherine** (Observatoire de Paris – LESIA), FernandezSoto Alberto (Observatori Astronomic, Universitado de Valencia), Flores Hector (Observatoire de Paris – GEPI), Fynbo Johan (Dark Cosmology Center, University of Copenhagen), Gavignaud Isabelle (Astrophysikalisches Institut Potsdam), Groot Paul (Radboud University Nijmegen), Guenther Eike (Thueringer Landessternwarte Tautenburg), **Hammer François** (PI Observatoire de Paris – GEPI), Hatzes Artie (Thueringer Landessternwarte Tautenburg), Hill Vanessa (Observatoire de la Côte d'Azur), Hjorth Jens (Dark Cosmology Center, University ofCopenhagen), Hook Isobel (University of Oxford), Ibata Rodrigo (Observatoire astronomique de Strasbourg), James Gael (ESO), Jehin Emmanuel (Université de Liége), Kaper Lex (CoPI – Universiteit van Amsterdam), Koopmans Leon (University of Groningen), **Ludwig Hans-G.** (Observatoire de Paris – GEPI), Martayan Christophe (ESO), Mei Simona (Observatoire de Paris – GEPI), Peirani Sebastien (Institut d'Astrophysique de Paris), **Petitjean Patrick** (Institut d'Astrophysique de Paris), Puech Mathieu (Observatoire de Paris – GEPI), Quirrenbach Andreas (Director – Zentrum fur Astronomie, University of Heidelberg), Rodrigues Myriam (Observatoire de Paris – GEPI), Rollinde de Beaumont Emmanuel (Institut d'Astrophysique de Paris), Royer Frederic (Observatoire de Paris – GEPI), Sbordone Luca (Observatoire de Paris – GEPI), **Schaerer Daniel** (Observatoire de Genève), Stam Daphne (Netherlands Institute for Space Research), Steinmetz Matthias (Director Astrophysikalisches Institut Potsdam), Testi Leonardo (ESO), Tolstoy Eline (University of Groningen), Waltham Nick (Science&Technology Facilities Council, Oxford), Weiler Michael (Observatoire de Paris - GEPI), Whalley Martin (Science&Technology Facilities Council, Oxford), Woodhouse Guy (Science&Technology Facilities Council, Oxford), Yang Yanbin (Observatoire de Paris – GEPI)

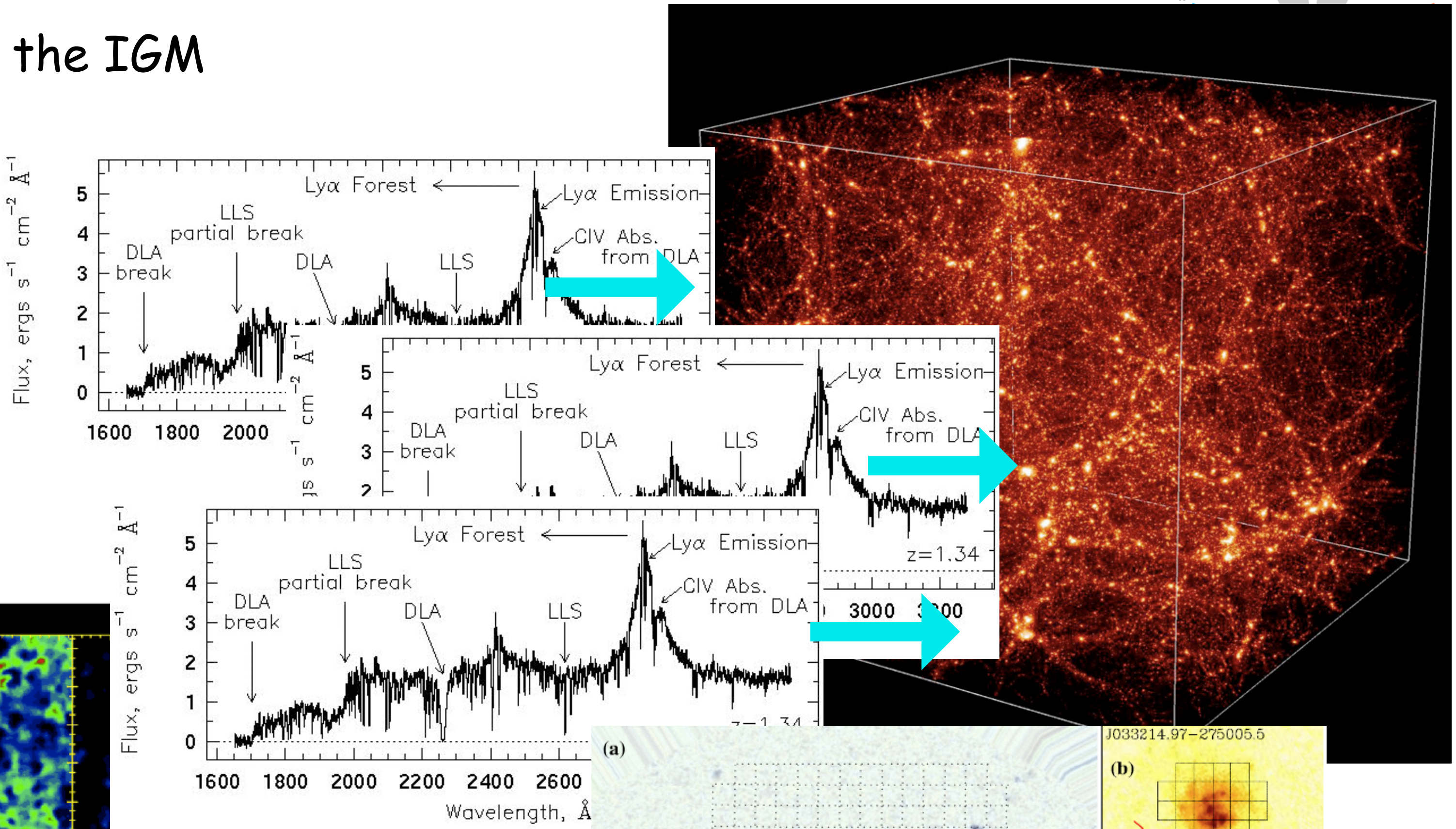
With a radial velocity precision of 10 m/s we may search for exo-planets in external galaxies



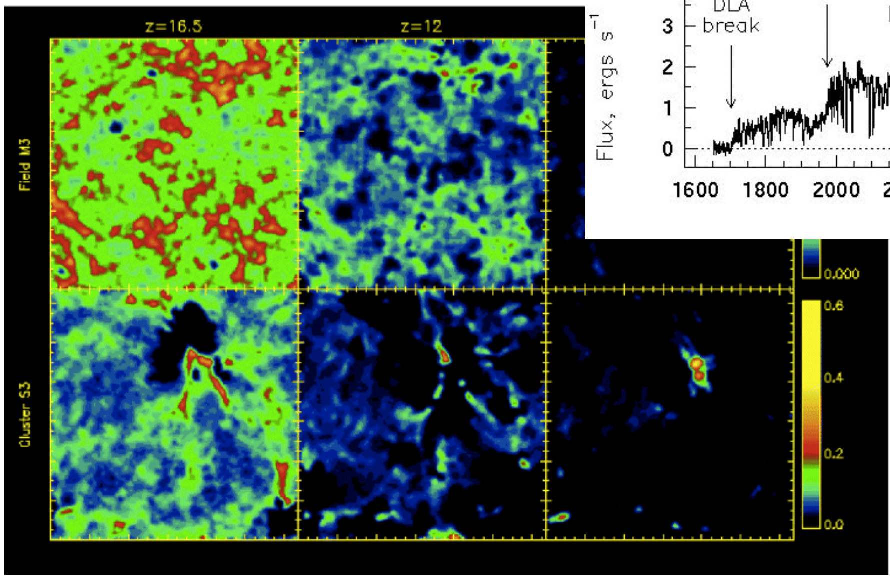
What	m_V [mag]
Galactic Bulge, giant	≈ 16
GC NGC 6397, turn-off	16.5
47 Tuc, turn-off	17.6
ω Cen, turn-off	18.1
Sagittarius, red clump	18.2
Sagittarius, turn-off	(21.5)
LMC, giant	≈ 18.5
SMC, giant	≈ 19.0

With R=5000 down to I=25 we shall be able to measure kinematics and chemical composition of the stellar populations in the giant elliptical Cen A and of other galaxies of that group

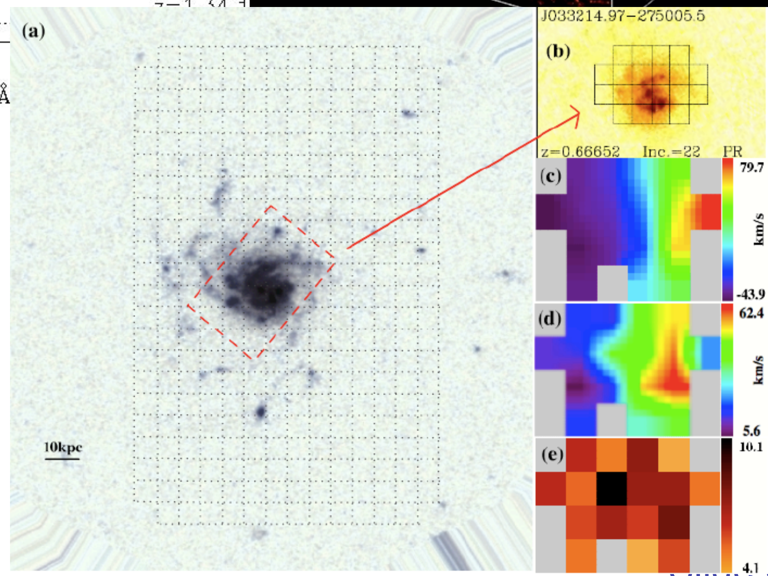
Tomography of the IGM



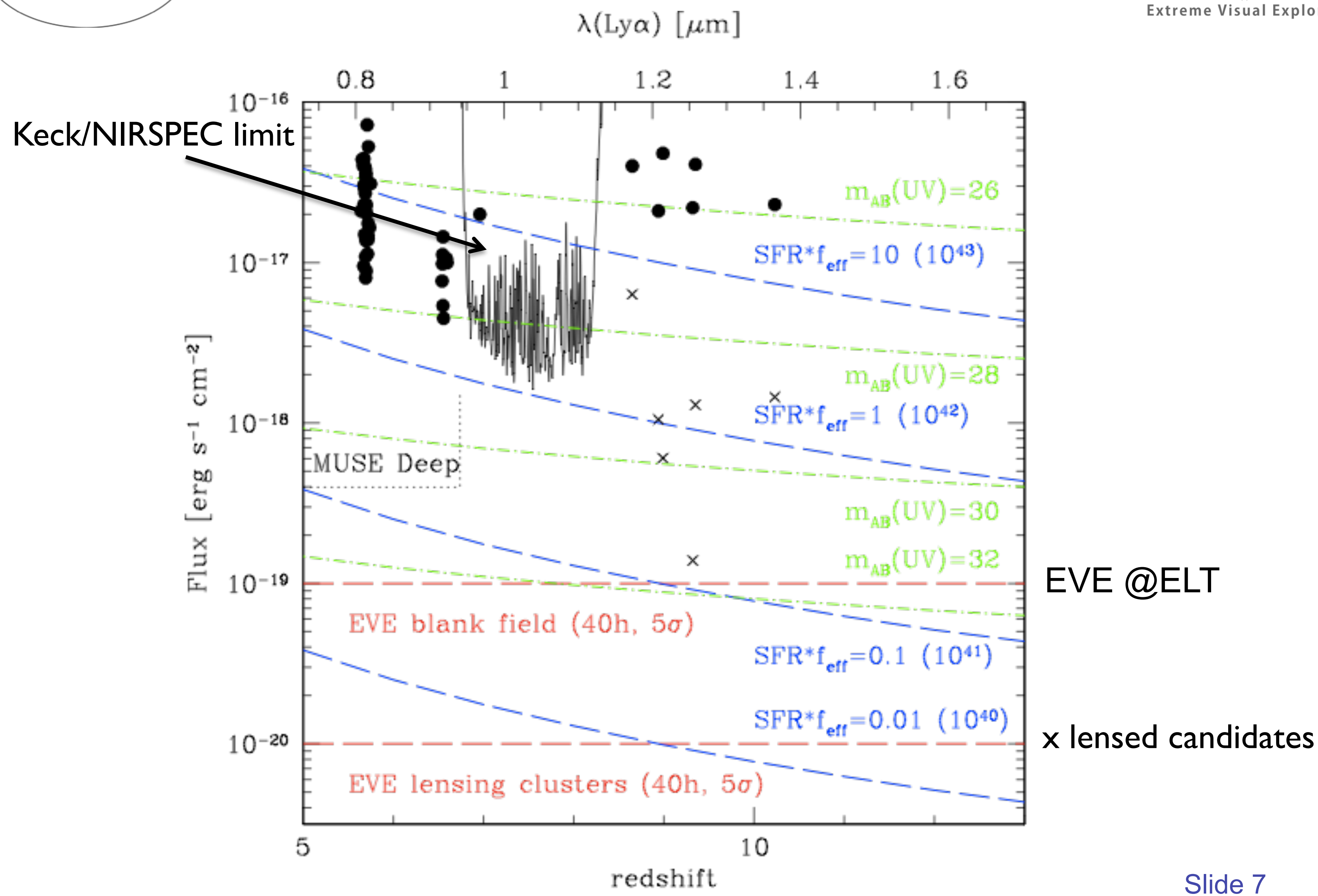
Tracing reionization



Kinematics of galactic haloes

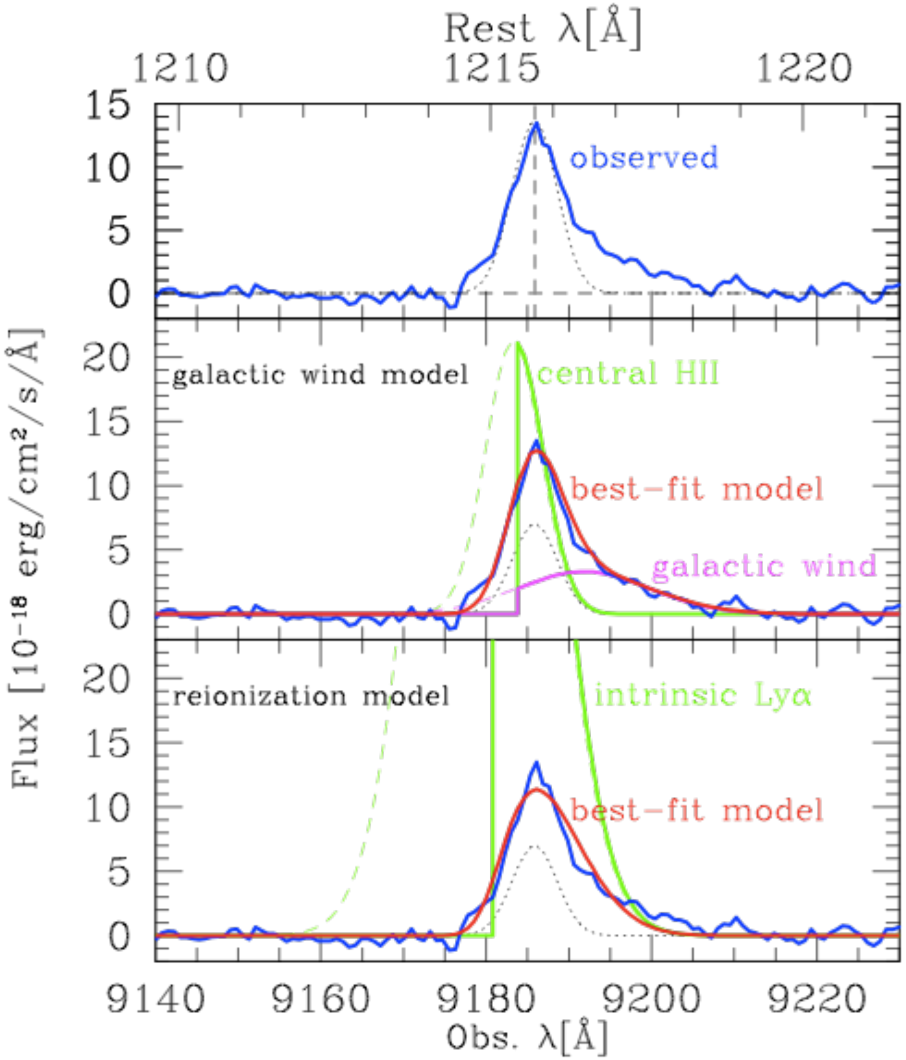


Search for very distant sources



Spectral resolution

To better remove sky lines (especially in NIR) and also to study line profile



Excerpt from EVE Science Case (Schaerer & Bunker)

Fairly high resolution spectra are required to separate the effects of the IGM transparency from radiation transfer effects in the host galaxy and its close environment.

R=5000 is perfect

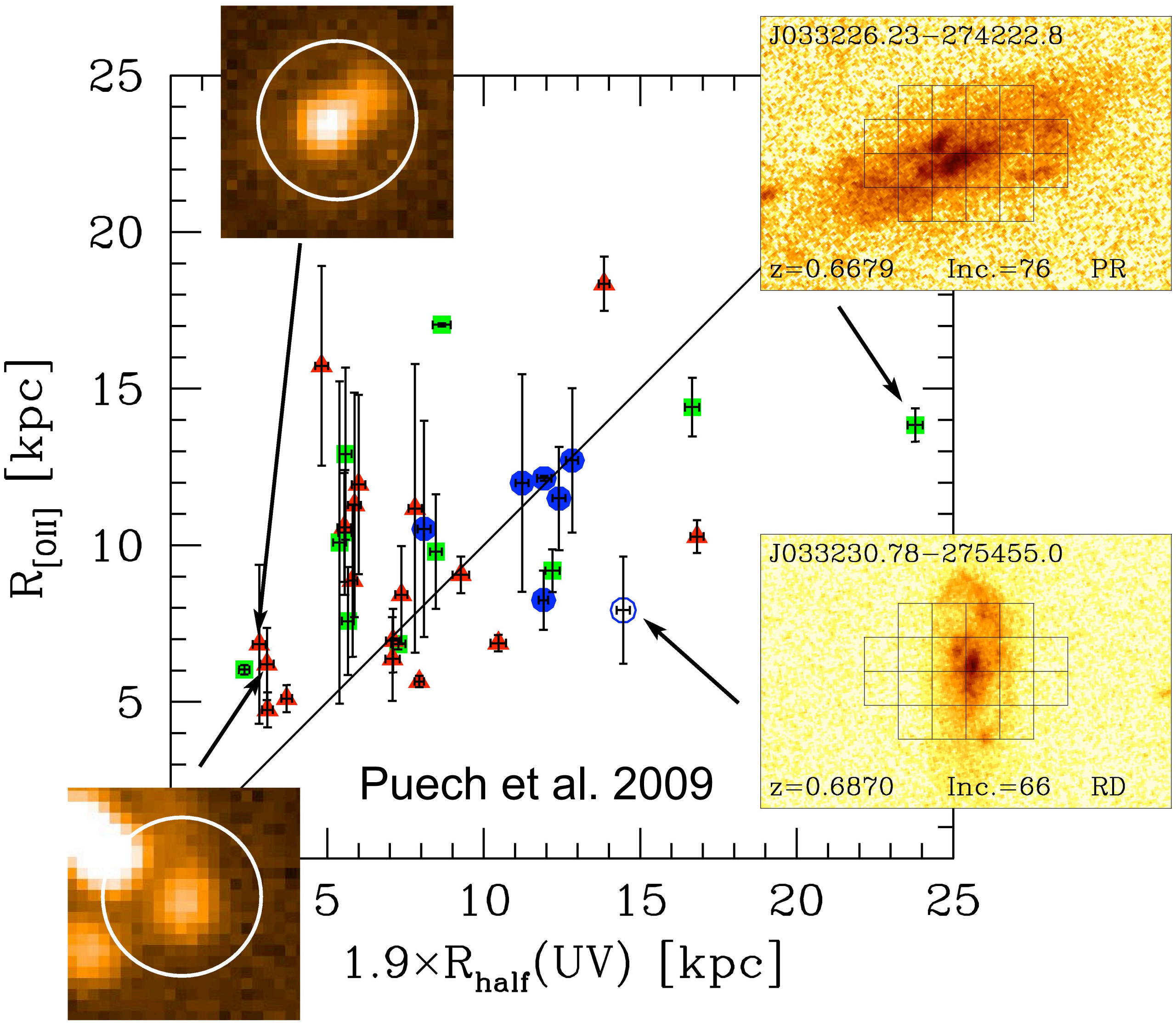
Spatial extent

At z = 0.65

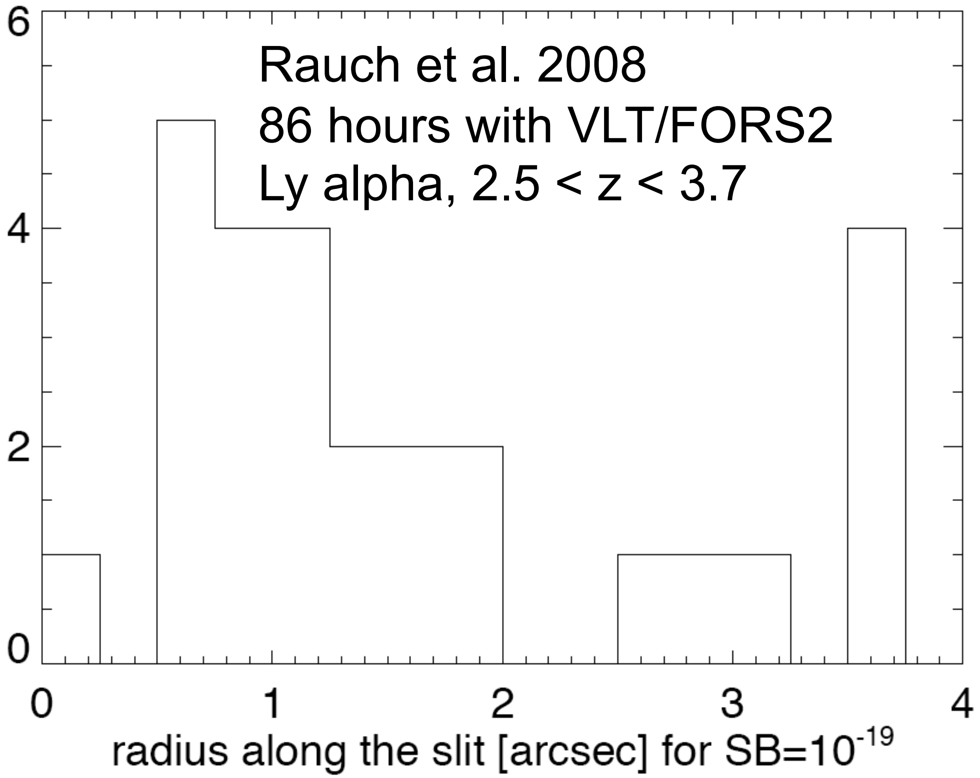
R_{gas} from GIRAFFE [OII] maps

Deconvolved from IFU pixel grid & seeing using Monte-Carlo simulations

In z= 0.65 compact galaxies: gas extents much farther thanUV light



Spatial extent and diffuse emission of Lyα

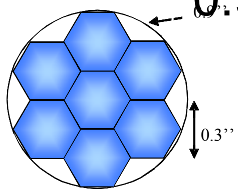


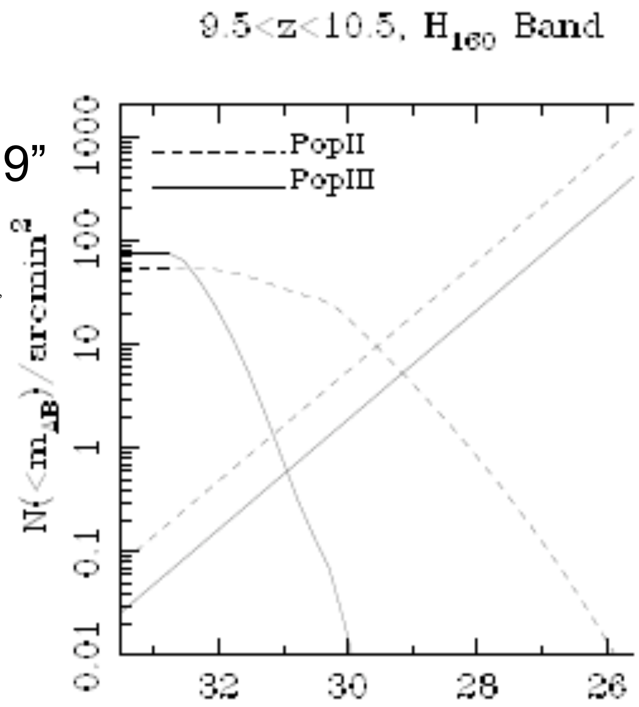
Galaxie	f_{esc} (%)	$f_{diffuse}$ (%)
Haro 11	2.6	74
ESO 338-IG04	8	70
SBS 0335-052	0.25	∼ 100
NGC 6090	0.56	73
IRAS 08+65	7	65
Tololo 65	1.7	∼ 100

Excerpt from H. Atik PhD thesis
(see also Kunth et al. 2003)

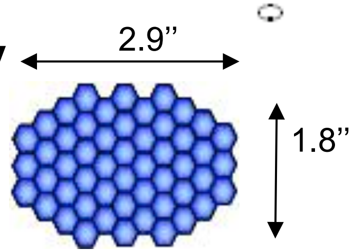
An observational strategy?

1- Observe the numerous Lyα candidates with $m_{AB}<32$ with ~300 mono-object bundles (R=5000 to avoid sky lines)





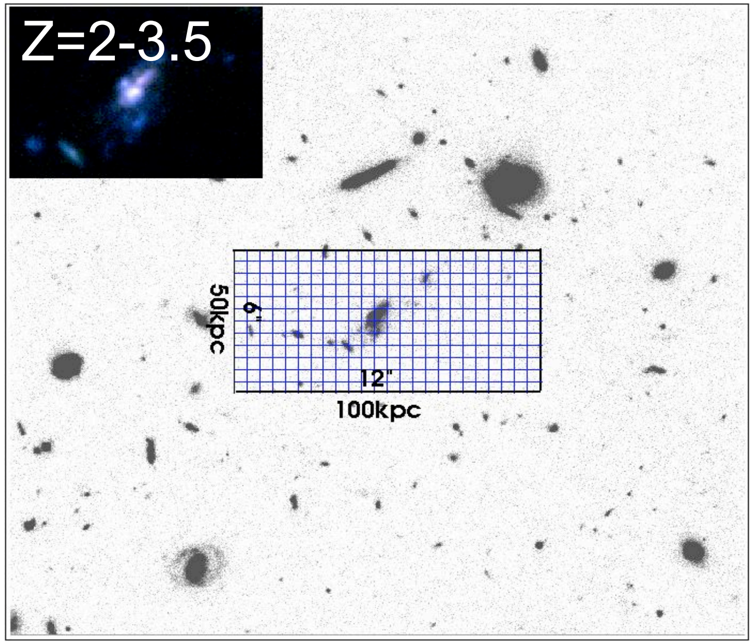
2- Re-observe the sample of z=9.5-10.5 galaxies with ~ 40 larger IFUs to properly remove sky and to detect diffuse/total emission as well as study galaxy physics (large scale motions)



3- A full census of Lyα emission at z>10, also with complimentary observations with JWST (Balmer emission lines to get f_{esc})

Emissions at larger scales

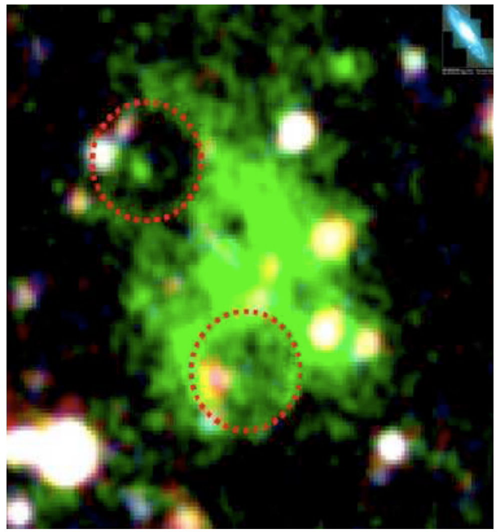
EVE @ELT



1- Detecting halo kinematics up to z=3.5

- f([OII] 372.7nm)=10^{19} ergs/s/cm^2 may detect down to SFR= 0.03 Mo/yr, the debris and satellites of massive galaxies at z=2.5.
- Such fluxes (per individual channel) can be reachable in 8 hrs.
- OII is observable up to z=3.5 in the H band.

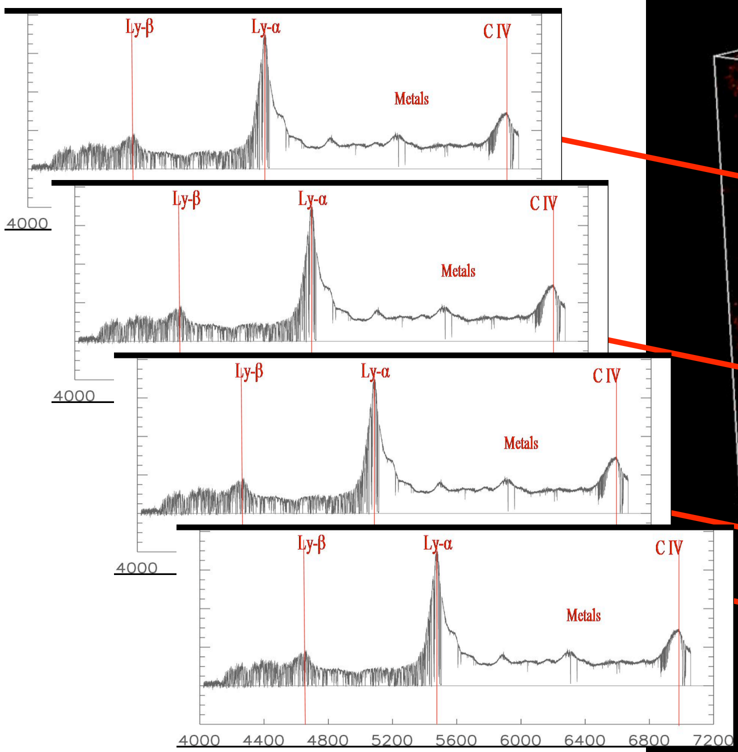
2- Detecting (cluster) background lenses up to z=13

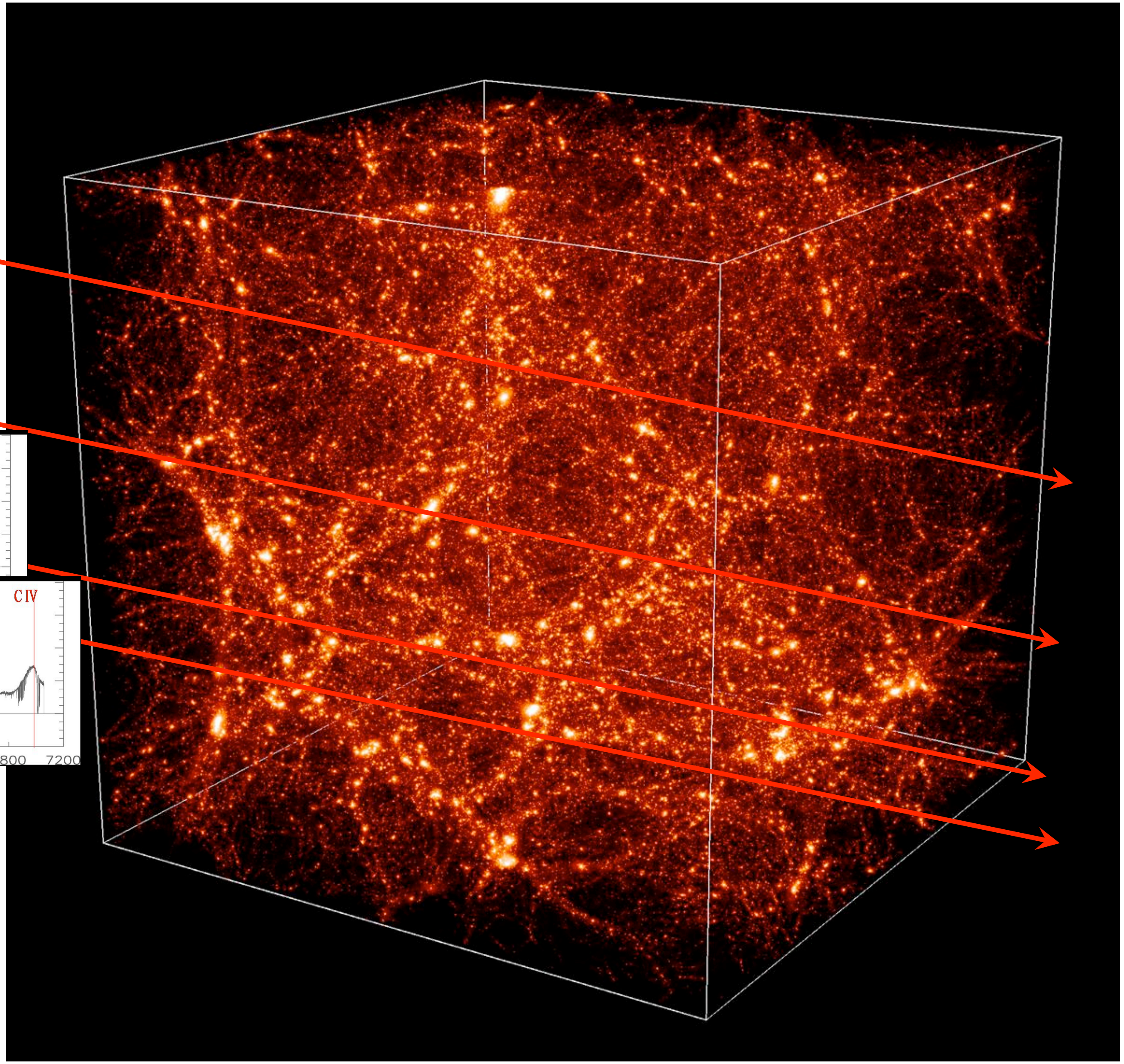


3- Detecting extended Lya emission (blobs) at z> 10

Direct 3D reconstruction of the IGM
(excerpt from P. Petitjean)

No QSOs but LBGs





Correlation of HI Lyman-α

Z=2.5-3 => 4500A

+ metals and galaxies

✦ LBGs of r~24.8 have the desired surface density (900/square degree)

✦ Resolution R=5000 (minimum ! to get rid of metallic lines in the Ly α forest)

✦ In a 7' diameter field ~ 9 to 17 sources brighter than r=24.8, fainter sources can be observed total of ~20/field

✦ 75 pointings to cover a square degree

✦ S/N ~ 8 in about 10h/field

This implies a **total of 750h**

A FOV of 10' and multiplex of 40 would achieve the same result in 1/2 of the time.

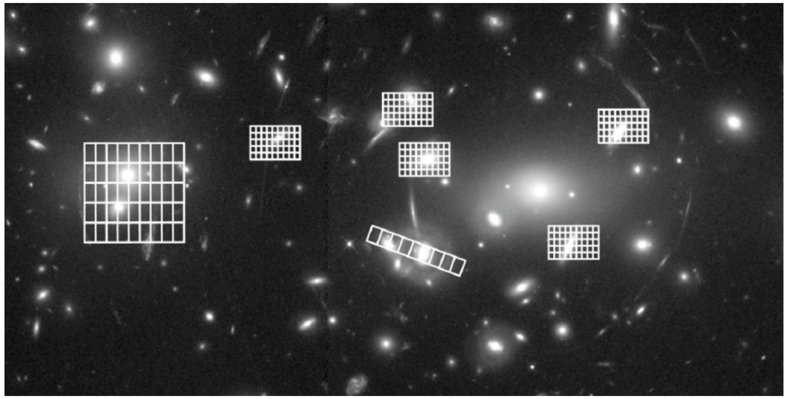
Conclusions

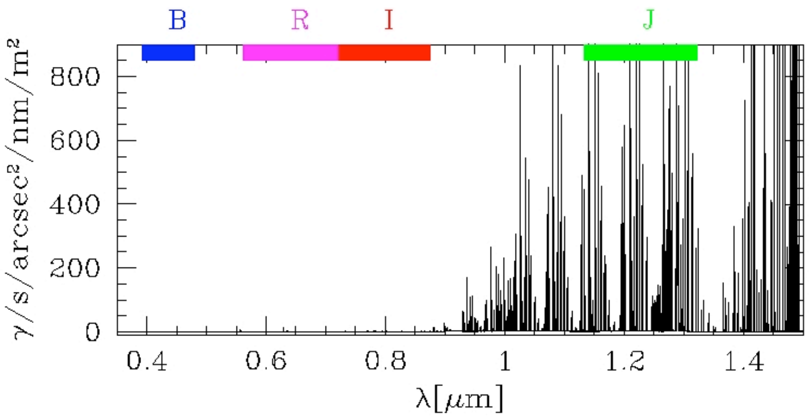
- OPTIMOS-EVE is offering a large number of observing modes at moderate & high resolution;

- It is with a simple design and without complexity (e.g. GIRAFFE) and can be completed with further implementations;

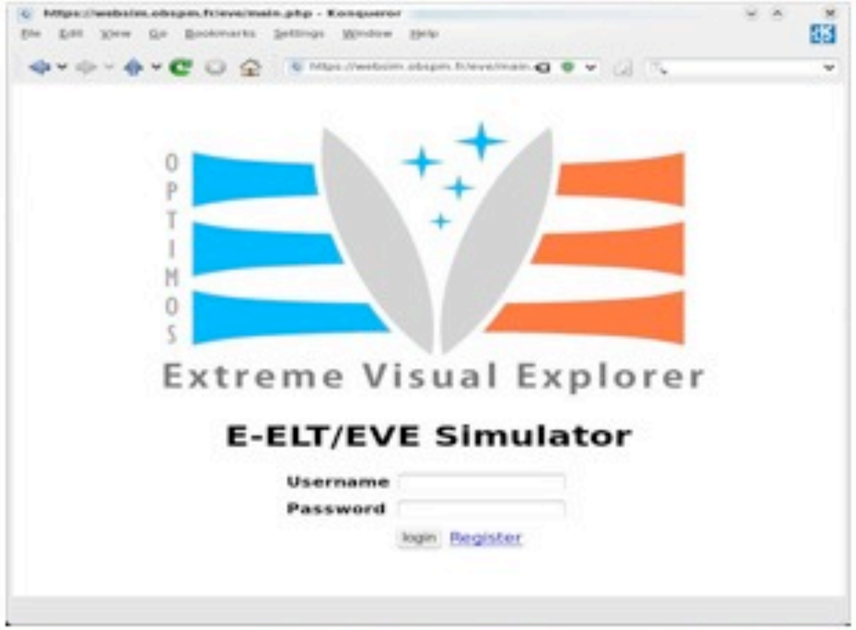
- It can observe from UV, Visible to near-IR;

- Can address a large fraction of the E-ELT science cases at the very beginning of its exploitation.

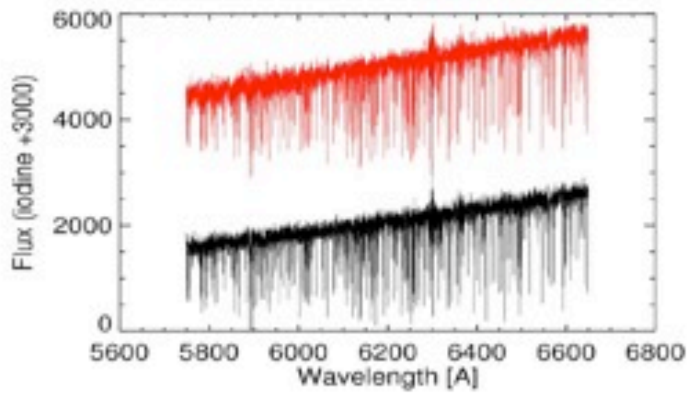




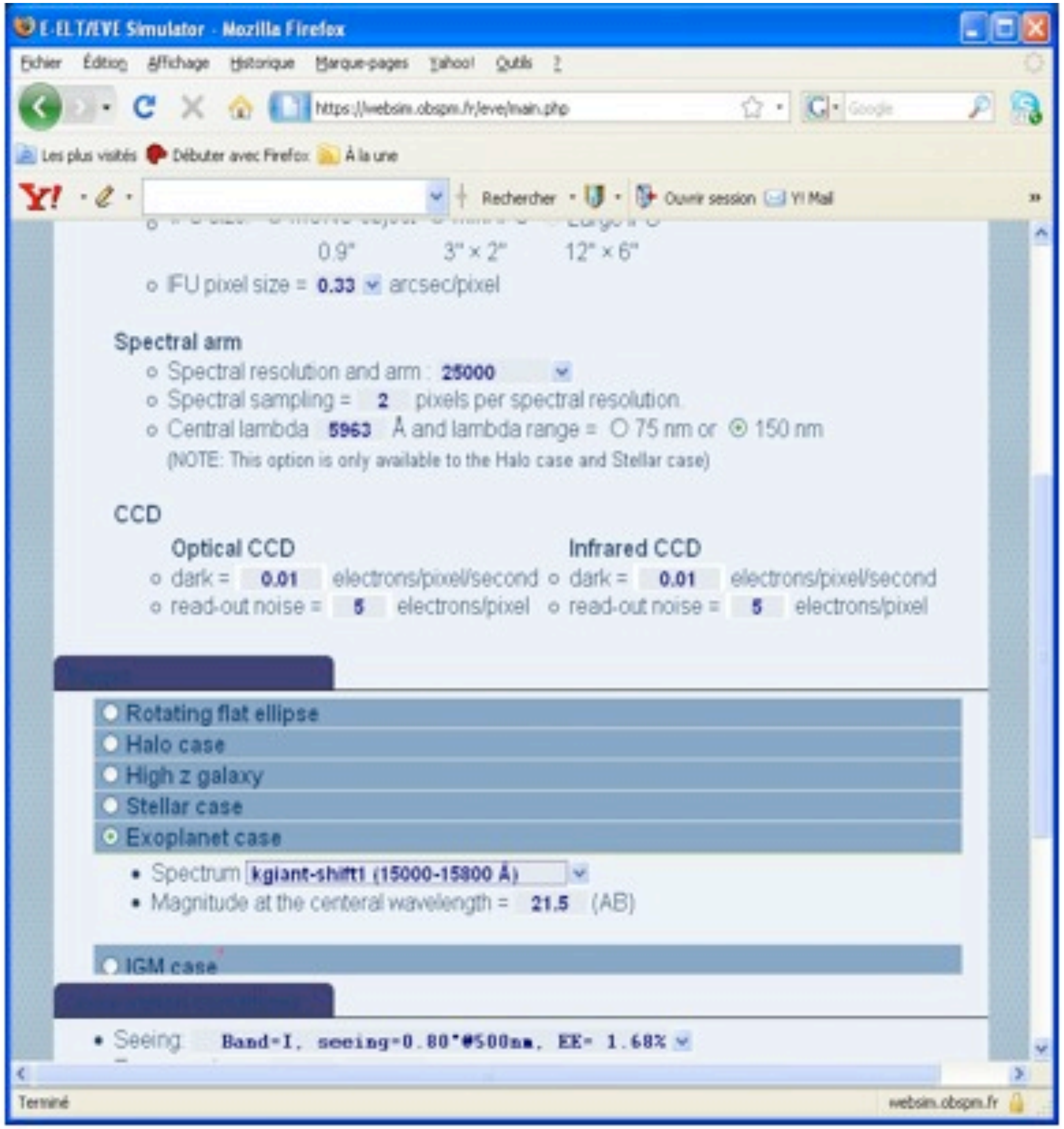
simulator



Simulated spectra of K-giant, T_{eff}=4700 K, $\log g$=2.0, [M/H]=0

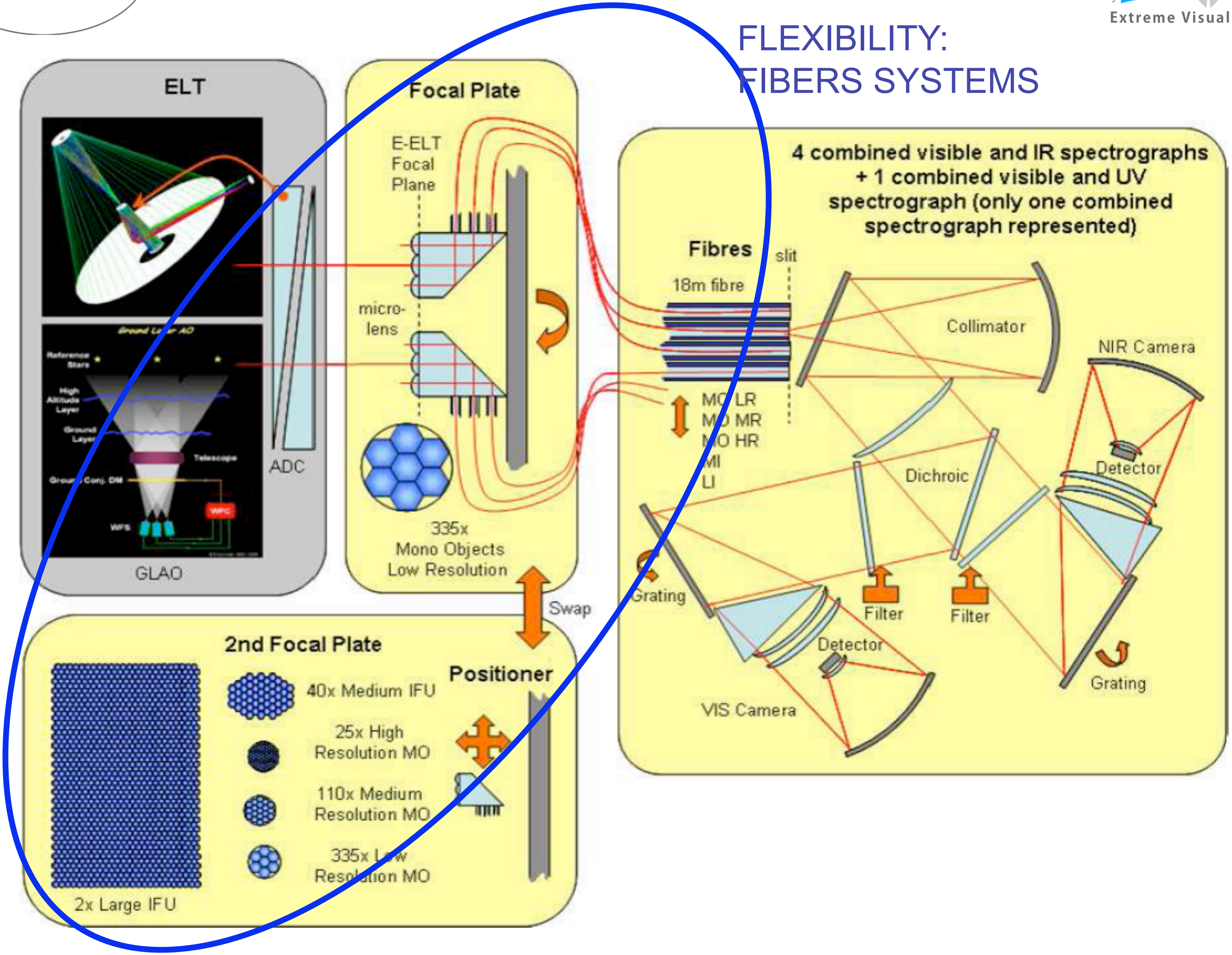


- 2x2 IFU pixels, 0.7" seeing, sky emission, S/N 50, R=20 000, perfect λ-calibration, 900 Å wavelength interval, without and with iodine cell

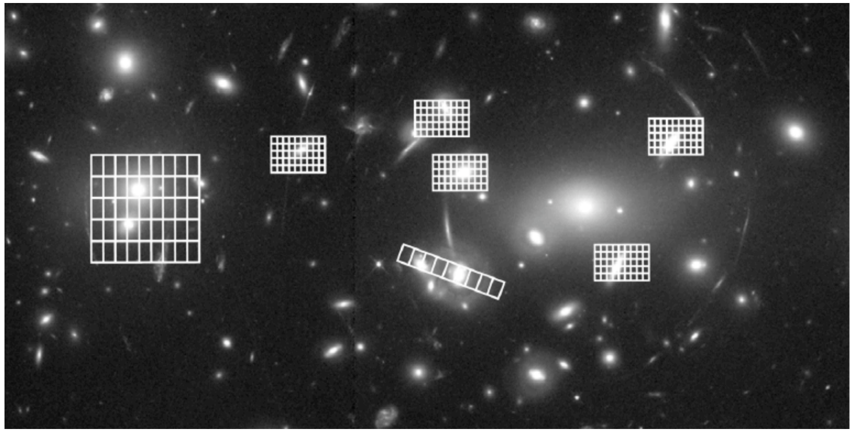


Functional Concept

FLEXIBILITY:
FIBERS SYSTEMS



Why fibers ?

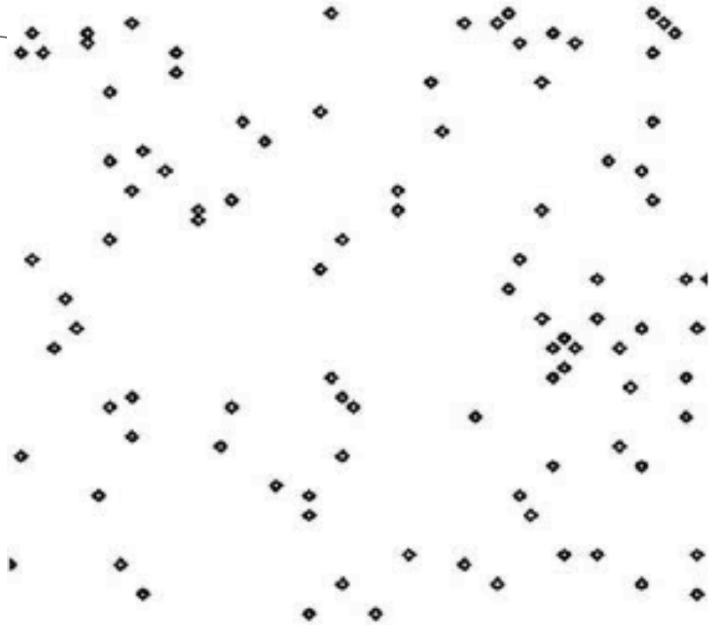


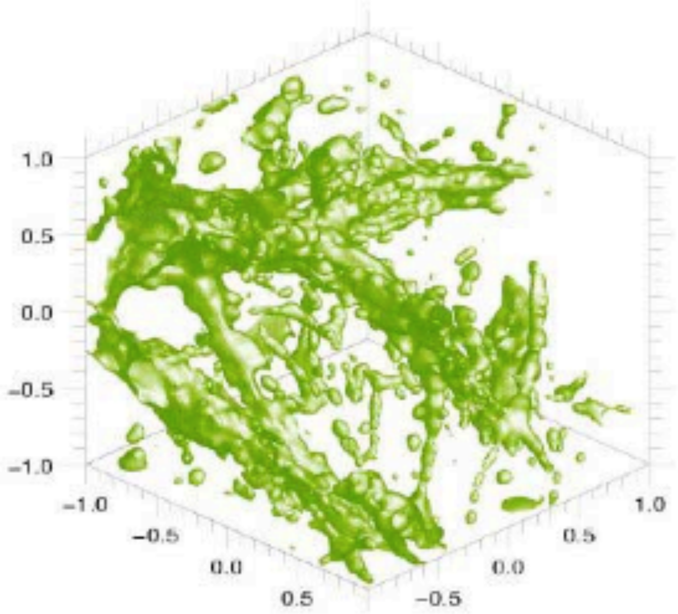
- Modern astrophysics requires IFUs
  & is demanding of spectral resolution;
- adapting several fiber diameters (here 3 diameters) allow to enhance spectral resolution while keeping spectral coverage & efficiency;
- R> 5000 to warrant to be background limited for λ > 720 nm;
- allow focus-injection (extra-solar planets) & as large as possible IFUs (high-z haloes);
- Possible applications of multi-fibers bundles with AO:

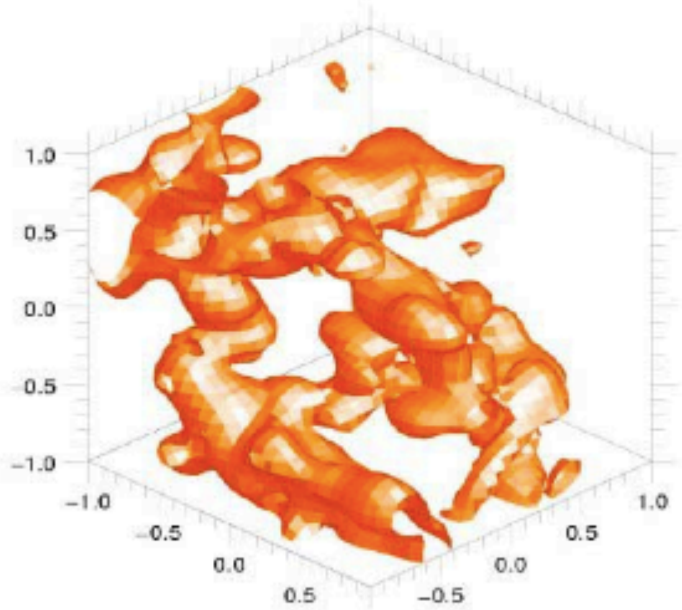
- facilitate sky substraction in NIR for improved spatial resolution
- possibility to study a « large » IFU, on axis adapted to LTAO

Main drawback: transmission of fiber system (72%), BUT…

Caucci et al. 2008







Inversion methods tested : density of sources:

LBGs: about 900 sources/sq degree at r=24.8

QSOs: only 100 sources/sq degree

Topology of the IGM (cosmological parameters; growth of structures)

Correlation IGM-galaxies: winds; metal enrichment; infall

Why fibers ?

Main drawback: transmission of fiber system (72%), BUT…

1. Small aperture losses at average seeing (0''.7 FWHM in V-band)

0''.5

85% the efficie
for catching th
galaxy with an

- Similar ratio even with GLAO in J-band
- Worse for not good seeing conditions wl

2. No flexure expected for a positionner-f

3. Efficiency is also related
   to spectral resolution
   (removing sky lines at $\lambda > 720$nm)