l'Observatoire de Paris | GEPI
Galaxies Étoiles Physique et Instrumentation

ZAH
ARI ITA LSW

The extremely metal-poor stars in external galaxies

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cnrs dépasser les frontières

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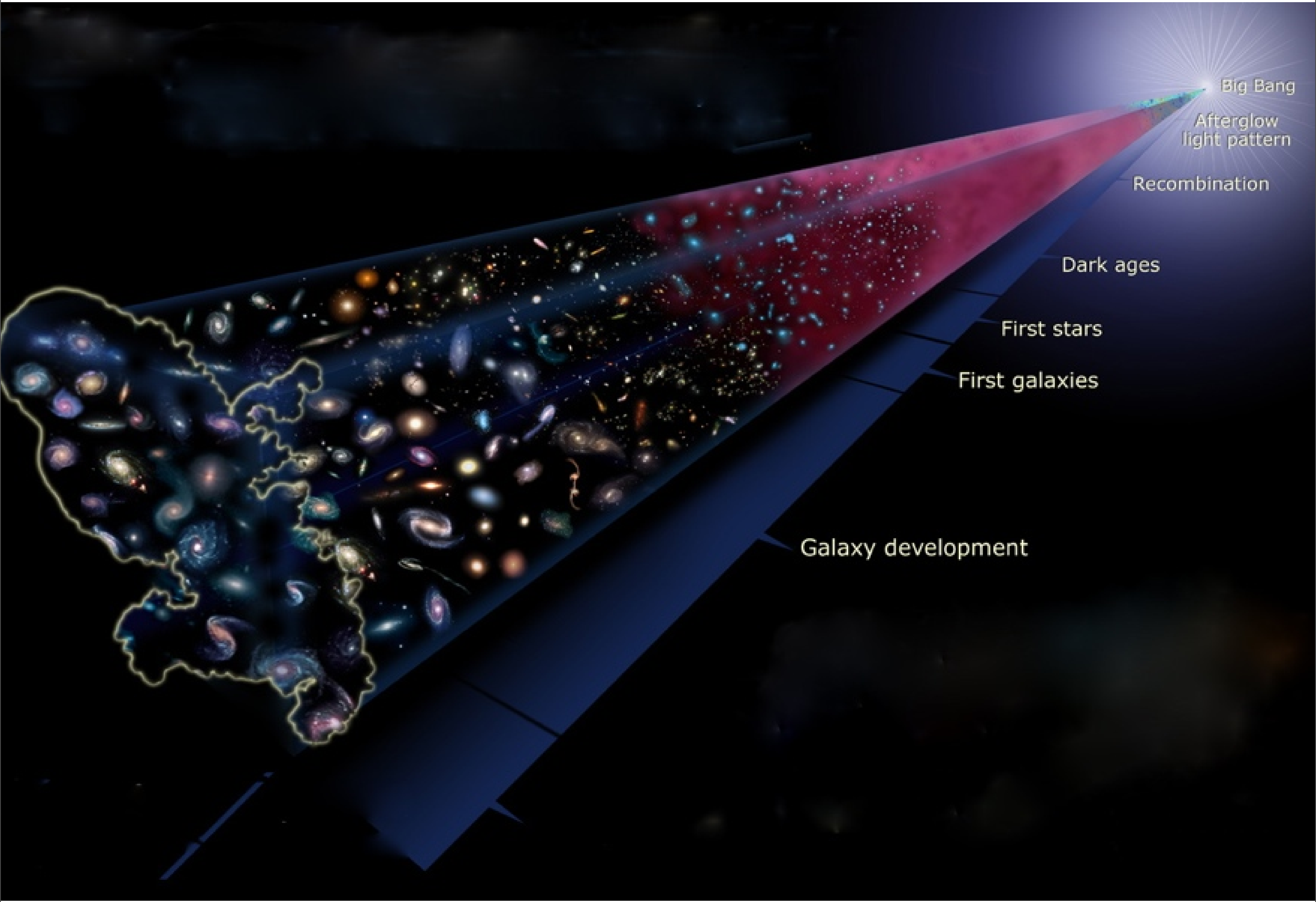
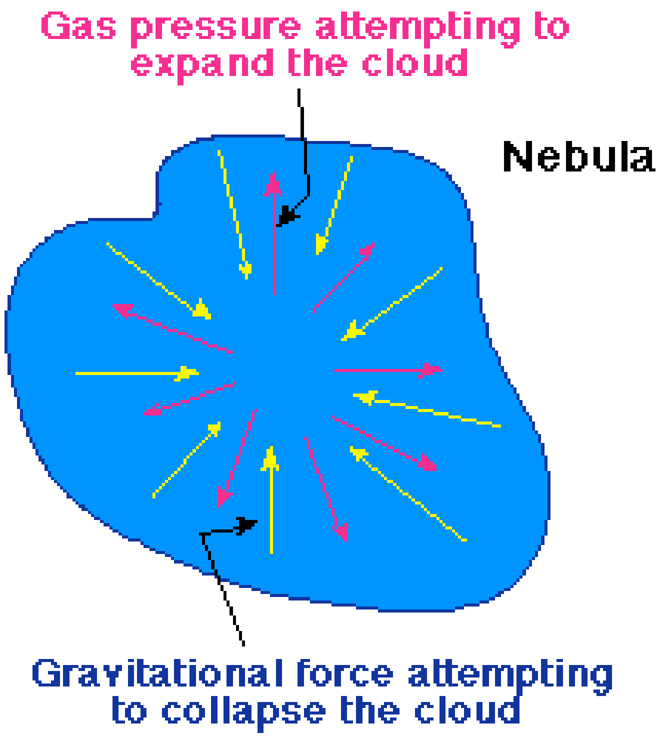
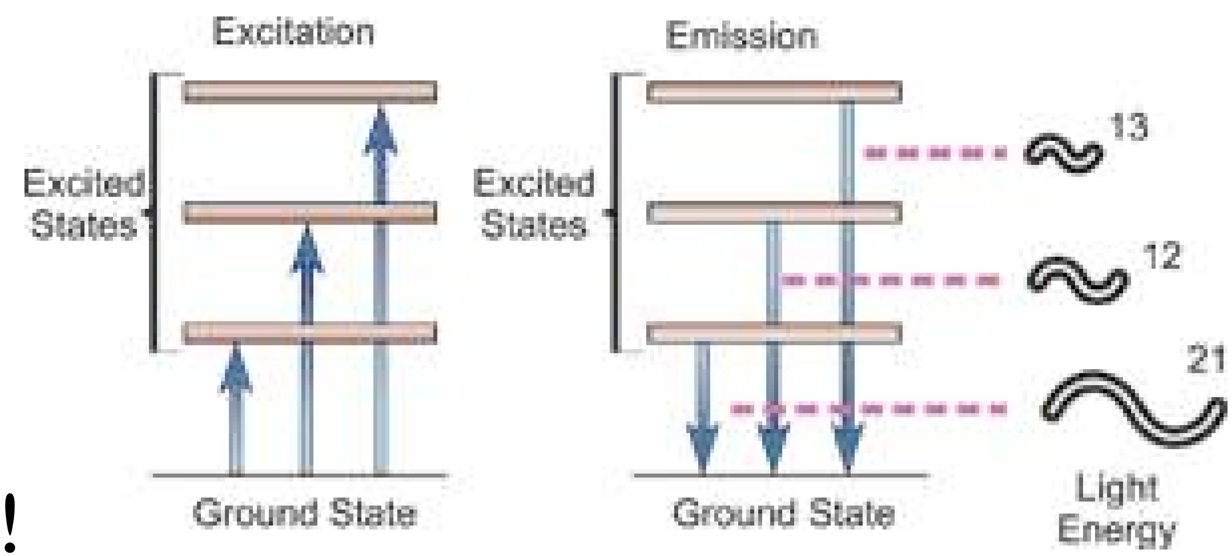

Big Bang
Afterglow light pattern
Recombination
Dark ages
First stars
First galaxies
Galaxy development

- What were the properties of the first stars ?
- Did they have a role on re-ionization ?
- What was their mechanism of formation ?
- What was their role in shaping the galaxy ?



In order to form a star you need to cool the gas during the collapse, to avoid the pressure to halt the collapse. This becomes critical for low-mass star formation

Collisional excitation and radiative recombination is a very effective mechanism to cool, but you need metals !



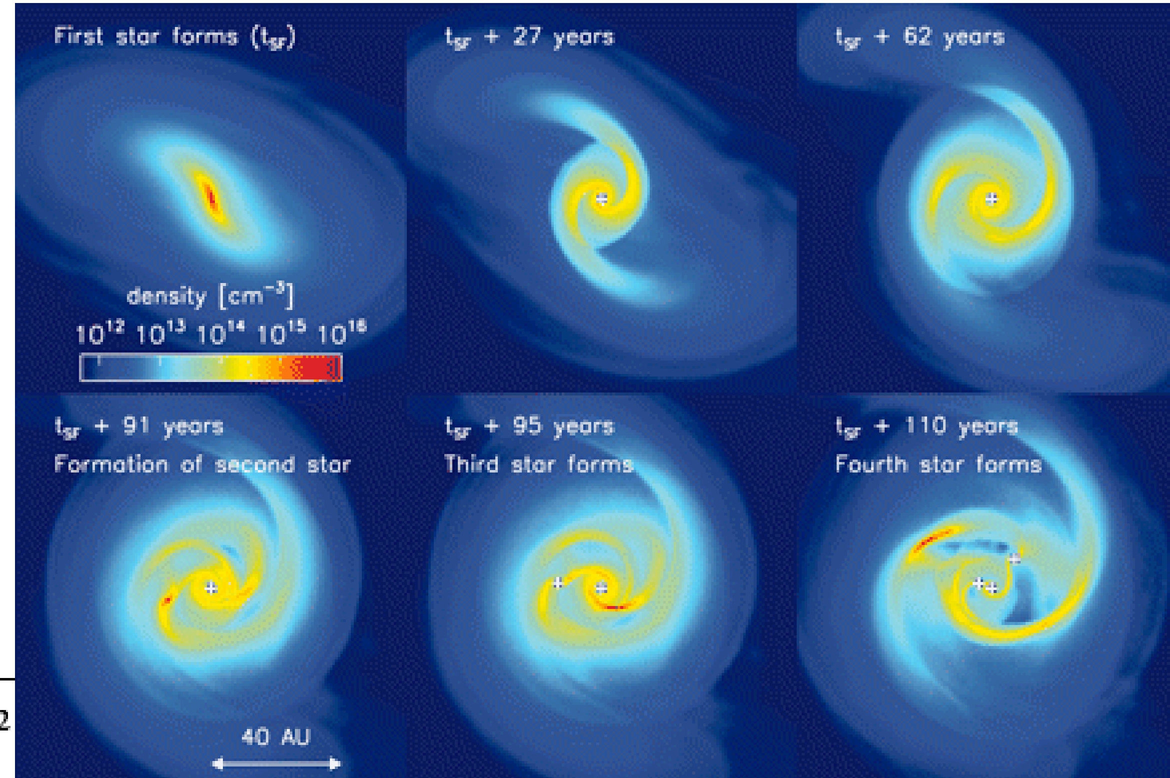
- The first generation of stars could have been formed exclusively by massive stars that quickly exploded as SNe

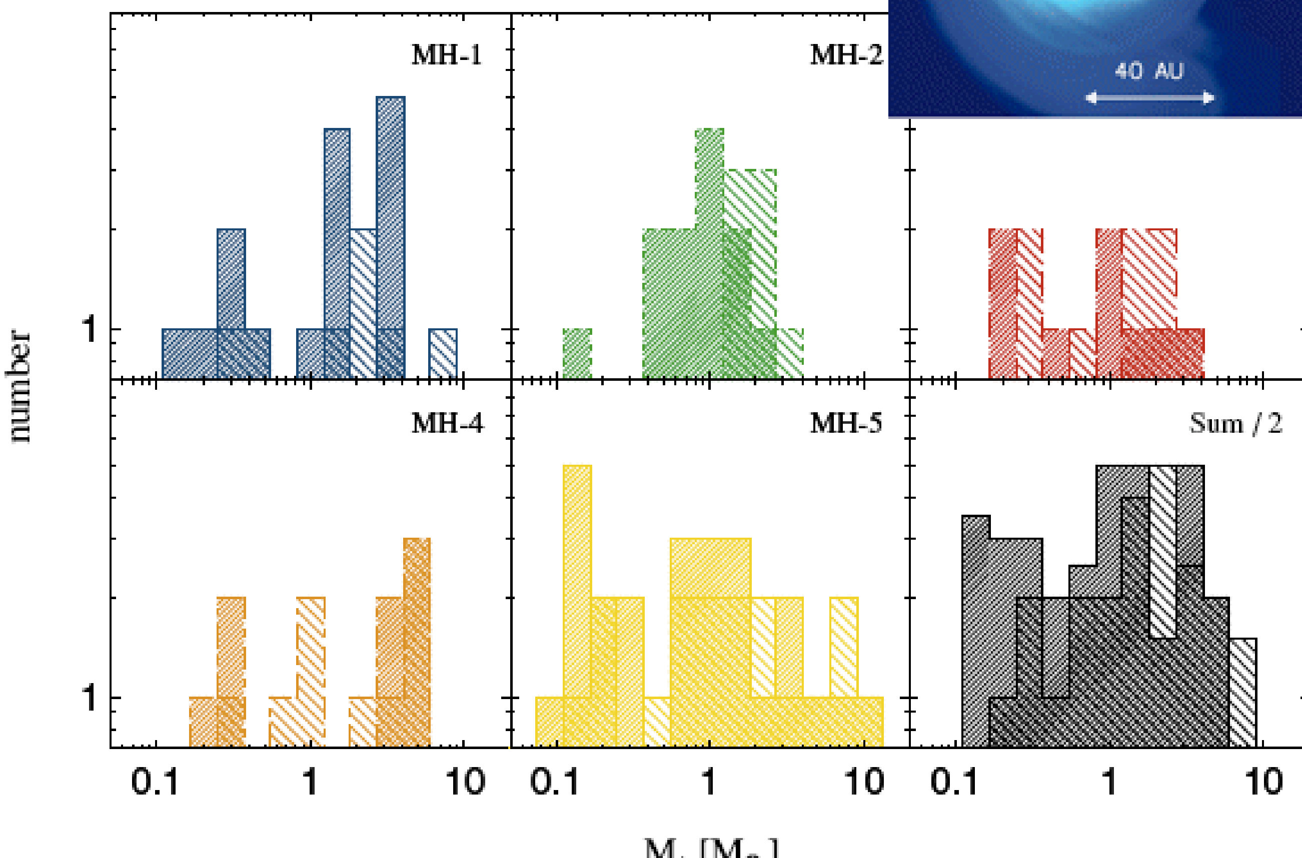
- However:

1. low mass stars could have been formed by fragmentation [with (Schneider et al. 2012) or without (Clark et al. 2011) dust]

2. What is the metallicity above which star formation proceeds normally (critical metallicity) ?

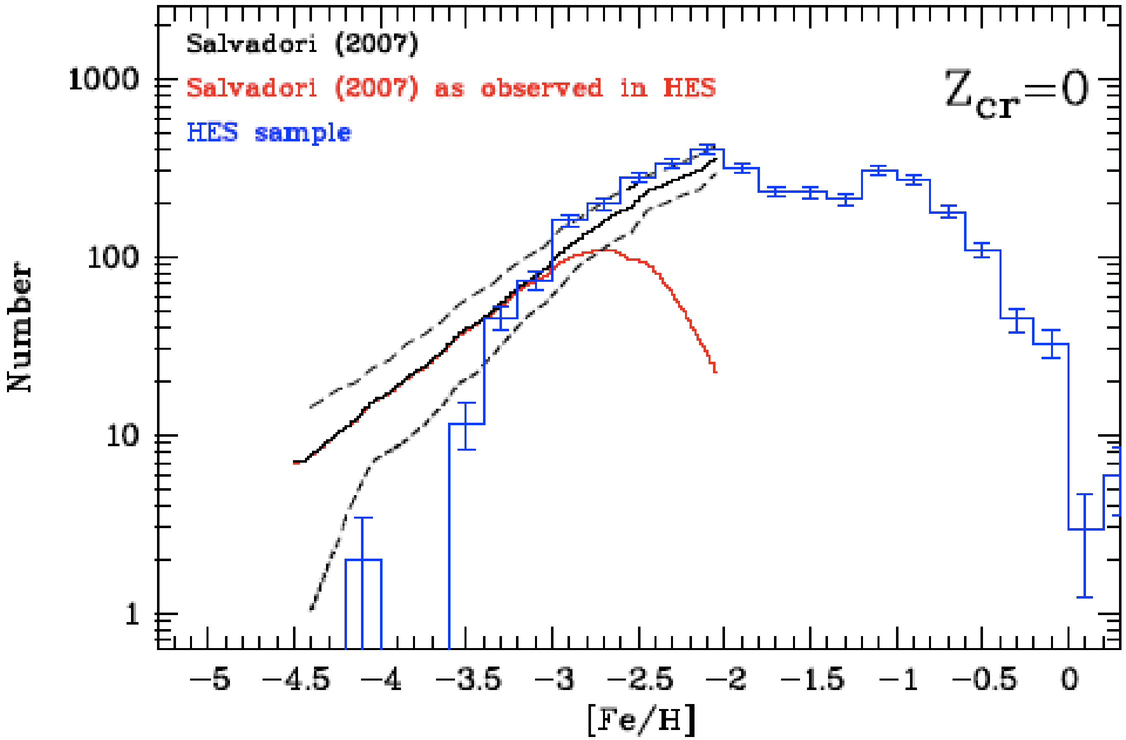
Clark et al. 2011





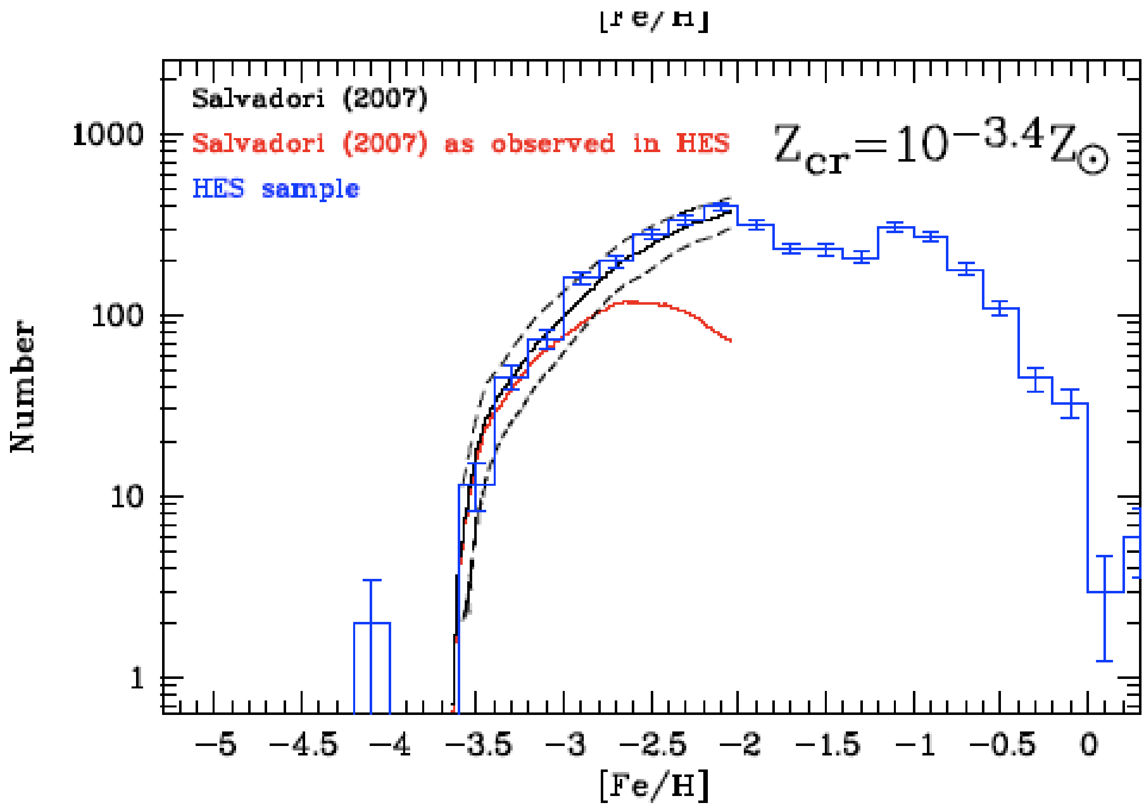
Greif et al. 2011

The Metallicity Distribution Function: an important diagnostic

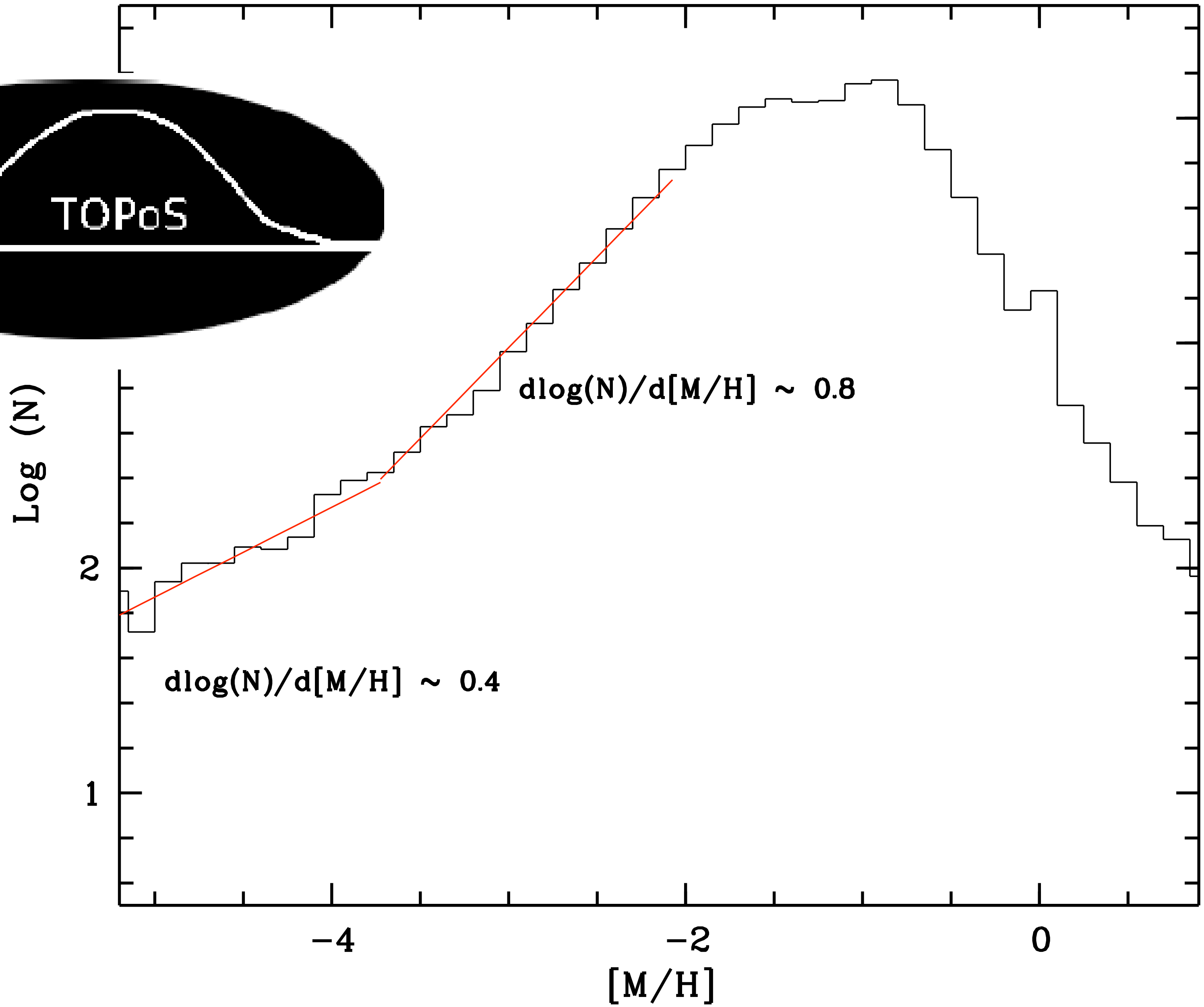


MDF from Hamburg-ESO Survey (~1600 stars) Schörck et al. 2009

Compared to different models of primordial star formation, with dust cooling (Salvadori et al. 2007)



Large Programme VLT (PI E. Caffau, 150 h VLT), X-Shooter GTO spin-off



146848 stars with TO colour from SDSS

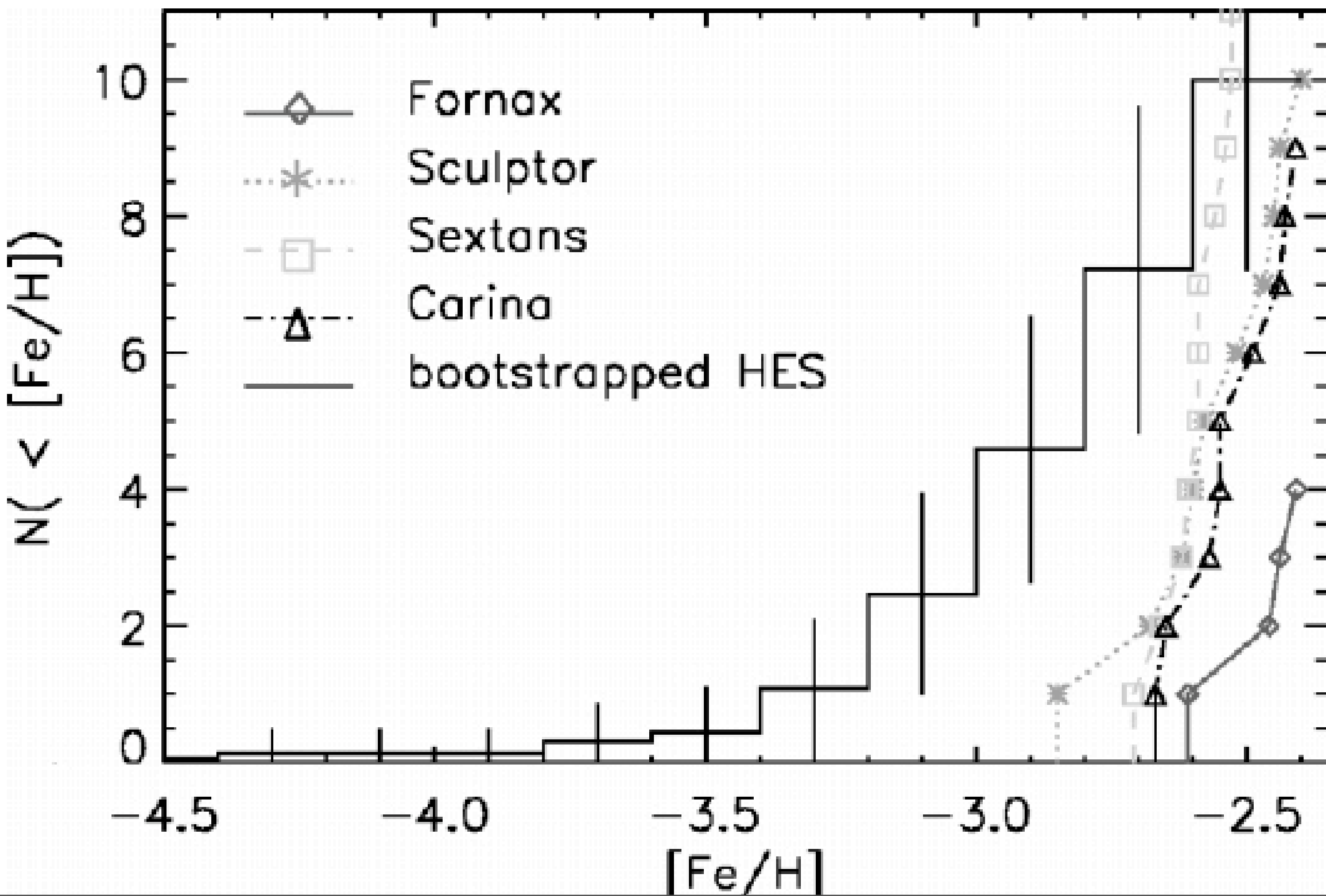
$0.18 \leq (g\text{-}z)_0 \leq 0.7$ AND $(u\text{-}g)_0 \geq 0.7$

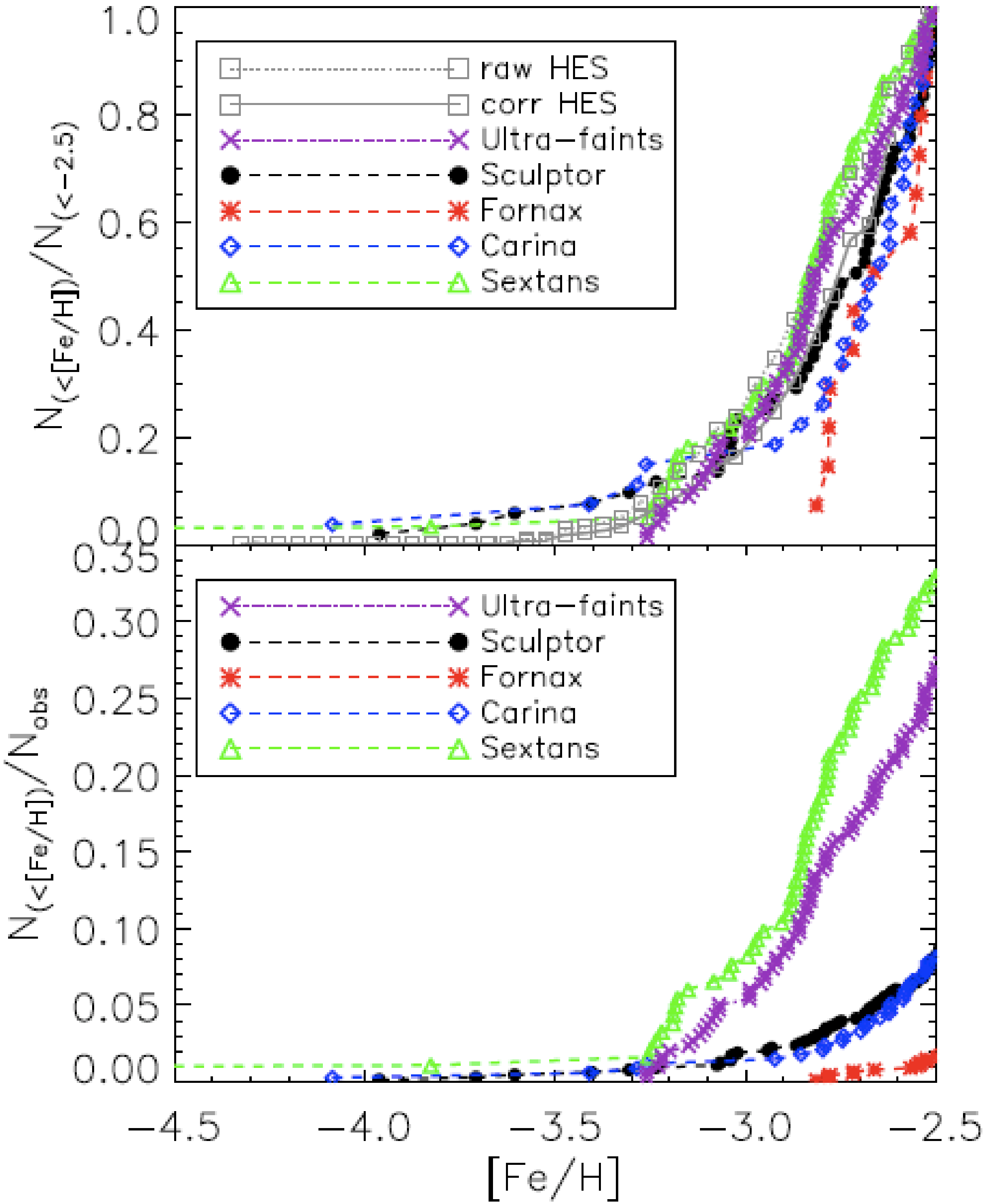
What do we know about other galaxies ?

A NEW VIEW OF THE DWARF SPHEROIDAL SATELLITES OF THE MILKY WAY FROM VLT FLAMES: I

WHERE ARE THE VERY METAL-POOR STARS?

Helmi et al. 2006





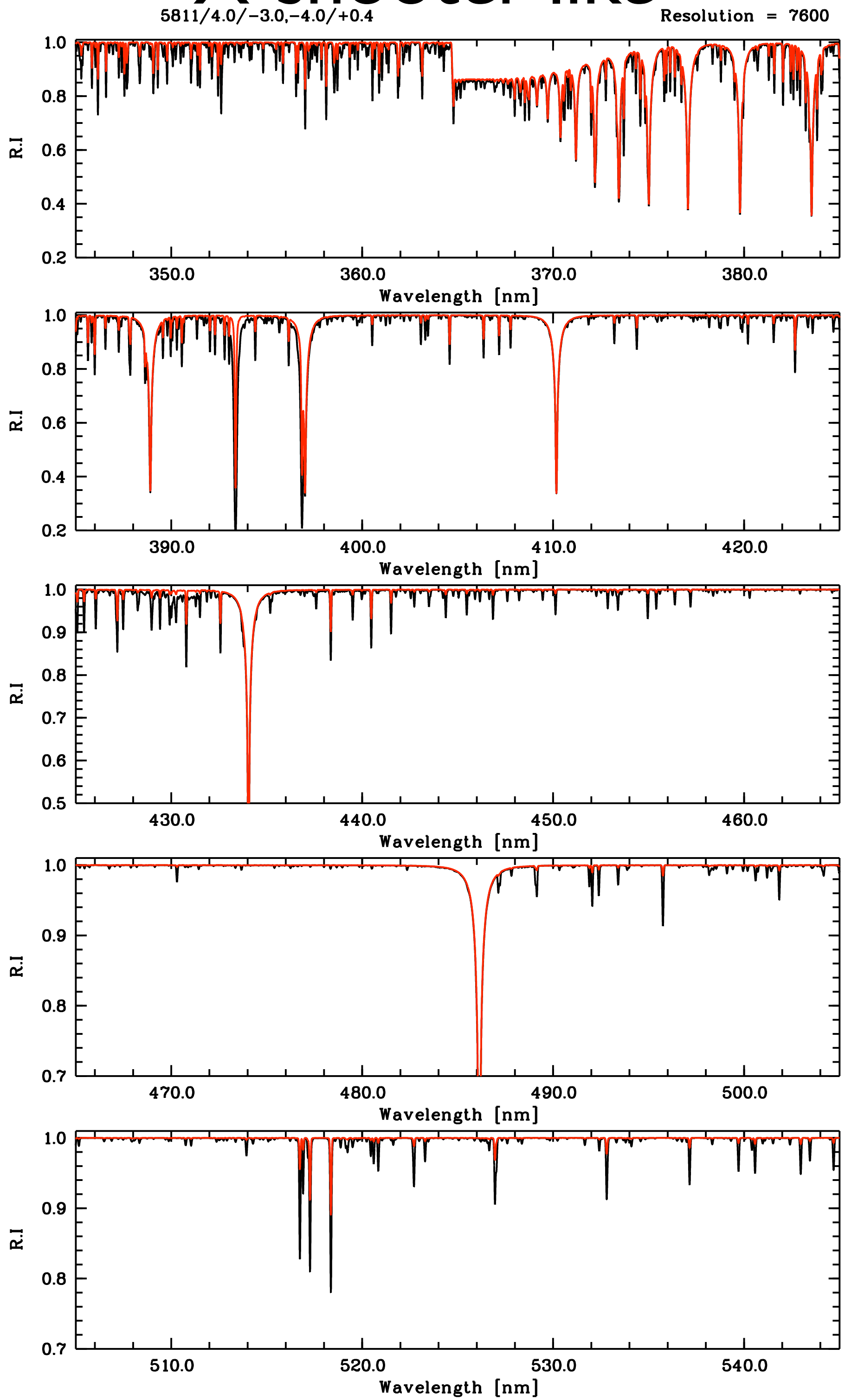
Starkenburg et al. 2010 re-calibration of Ca II triplet metallicities, NLTE effects etc...

Still it is obvious that the low-metallicity populations cannot be properly sampled by these giant-only samples

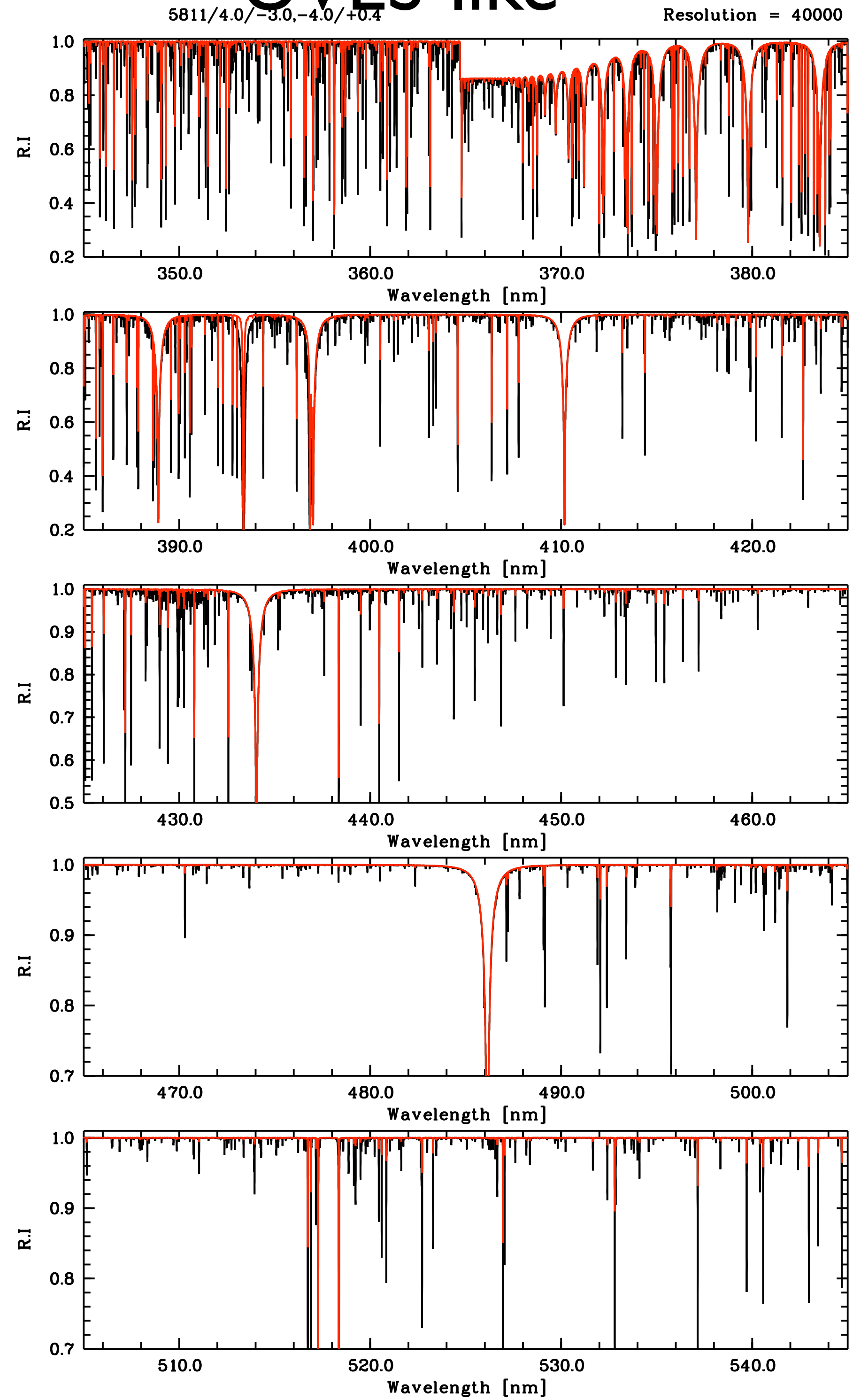
If you want large samples go to the TO !

Name	Alias	TO	α (J2000)	δ	DDO Type	M_V	V_r	D(Mpc)
WLM	DDO 221	29.8	00^h 01^m 57.8	-15 27´ 51	Ir IV-V	-14.4	-120	0.93
IC 10	UGC 192		00 20 24.5	59 17 30	Ir IV:	-16.3	-344	0.66
NGC 147	UGC 326		00 33 11.6	48 30 28	Sph	-15.1	-193	0.66
And III	A0032+36.		00 35 17.0	36 30 30	dSph	-10.2	...	0.76
NGC 185	UGC 396		00 38 58.0	48 20 18	Sph	-15.6	-202	0.66
NGC 205	...		00 40 22.5	41 41 11	Sph	-16.4	-244	0.76
M 32	NGC 221		00 42 41.9	40 51 55	E2	-16.5	-205	0.76
M 31	NGC 224		00 42 44.2	41 16 09	Sb I-II	-21.2†	-301	0.76
And I	A0043+37		00 45 43	38 00 24	dSph	-11.8	...	0.81
SMC	...	23.9	00 52 36	-72 48 00	Ir IV/IV-V	-17.1	148	0.06
Sculptor	...	24.8	01 00 04.3	-33 42 51	dSph	- 9.8	110	0.09
Pisces	LGS 3		01 03 56.5	21 53 41	dIr/dSph	-10.4	-286	0.81
IC 1613	...		01 04 47.3	02 08 14	Ir V	-15.3	-232	0.72
And V	...		01 10 17.1	47 37 41	dSph	-10.2	...	0.81
And II	...		01 16 27	33 25 42	dSph	-11.8	...	0.70
M 33	NGC 598		01 33 50.9	30 29 37	Sc II-III	-18.9	-181	0.79
Phoenix	...		01 51 03.3	-44 27 11	dIr/dSph	- 9.8	...	0.40
Fornax	...	25.7	02 39 53.1	-34 30 16	dSph	-13.1	53	0.14
LMC	...	23.5	05 19 36	-69 27 06	Ir III-IV	-18.5	275	0.05
Carina	...	25.0	06 41 36.7	-50 57 58	dSph	- 9.4	223	0.10
Leo A	DDO 69		09 59 23.0	30 44 44	Ir V	-11.5	24	0.69
Leo I	Regulus		10 08 26.7	12 18 29	dSph	-11.9	287	0.25
Sextans	...	24.8	10 13 02.9	-01 36 52	dSph	- 9.5	226	0.09
Leo II	DDO 93		11 13 27.4	22 09 40	dSph	-10.1	76	0.21
Ursa Min.	DDO 199	23.9	15 08 49.2	67 06 38	dSph	- 8.9	-247	0.06
Draco	DDO 208	24.5	17 20 18.6	57 55 06	dSph	- 8.6	-293	0.08
Milky Way	Galaxy		17 45 39.9	-29 00 28	S(B)bc I-II	-20.9	16	0.01
Sagittarius	...	22.4	18 55 04.3	-30 28 42	dSph(t)	-13.8::	142	0.03
SagDIG *	...		19 29 58.9	-17 40 41	Ir V	-10.7:	- 79	1.40:
NGC 6822	...		19 44 56.0	-14 48 06	Ir IV-V	-16.0	- 56	0.50
Aquarius*	DDO 210		20 46 53	-12 50 58	V	-11.3	-131	1.02
Tucana*	...		22 41 48.9	-64 25 21	dSph	- 9.6	...	0.87
Cassiopeia	And VII		23 26 31	50 41 31	dSph	- 9.5	...	0.69
Pegasus	DDO 216		23 28 34	14 44 48	Ir V	-12.3	-182	0.76
Pegasus II	And VI		23 51 39.0	24 35 42	dSph	-10.6	...	0.83

X-shooter-like



UVES-like



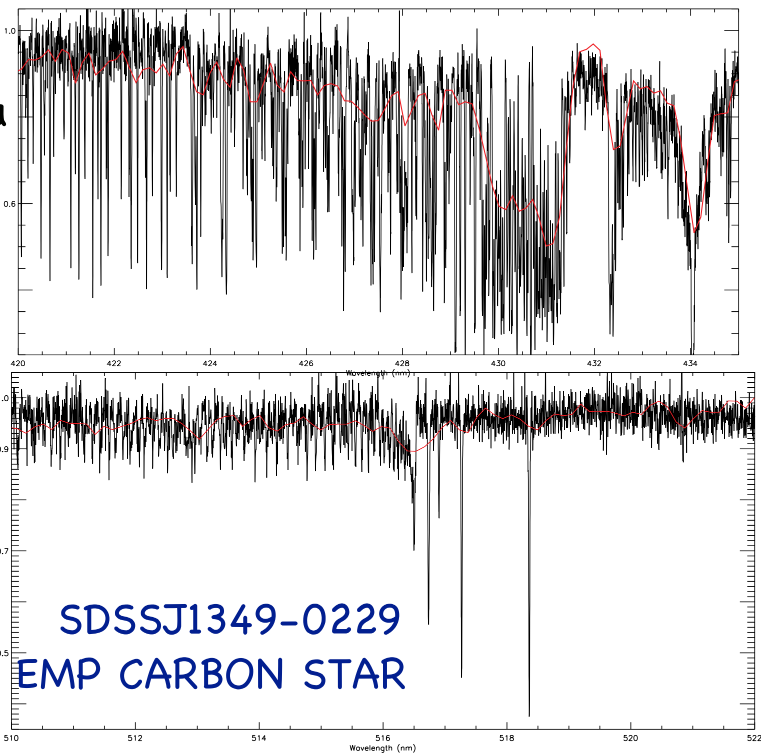
Instrument Requirements
Wavelength range

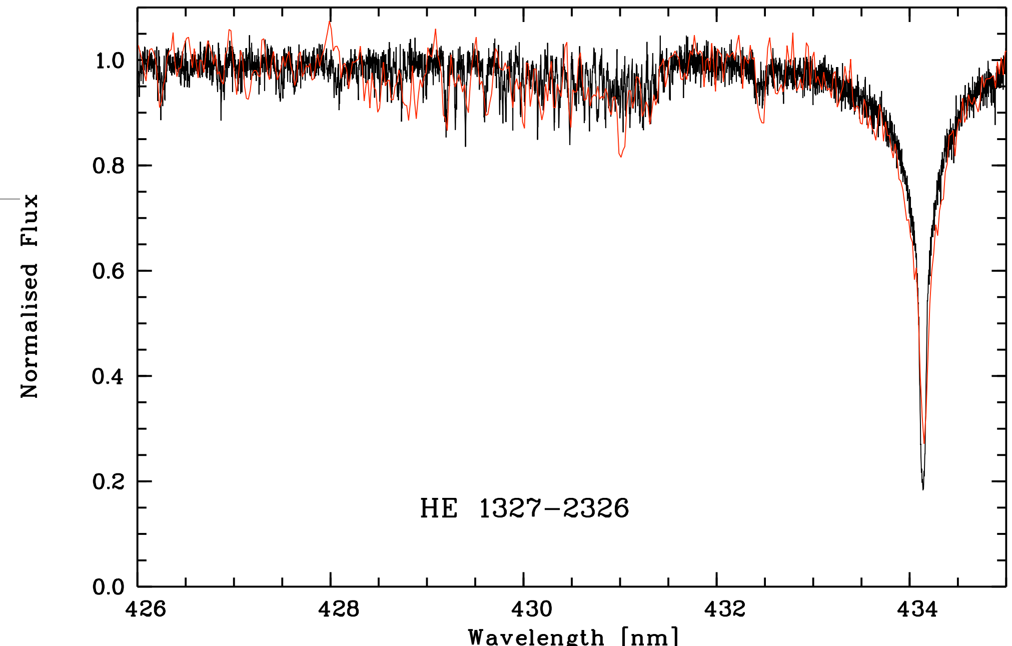
- blue: [380-520] nm
- red: [640-672] nm for EMP
- red (goal) [640-676] S I Mult. 8

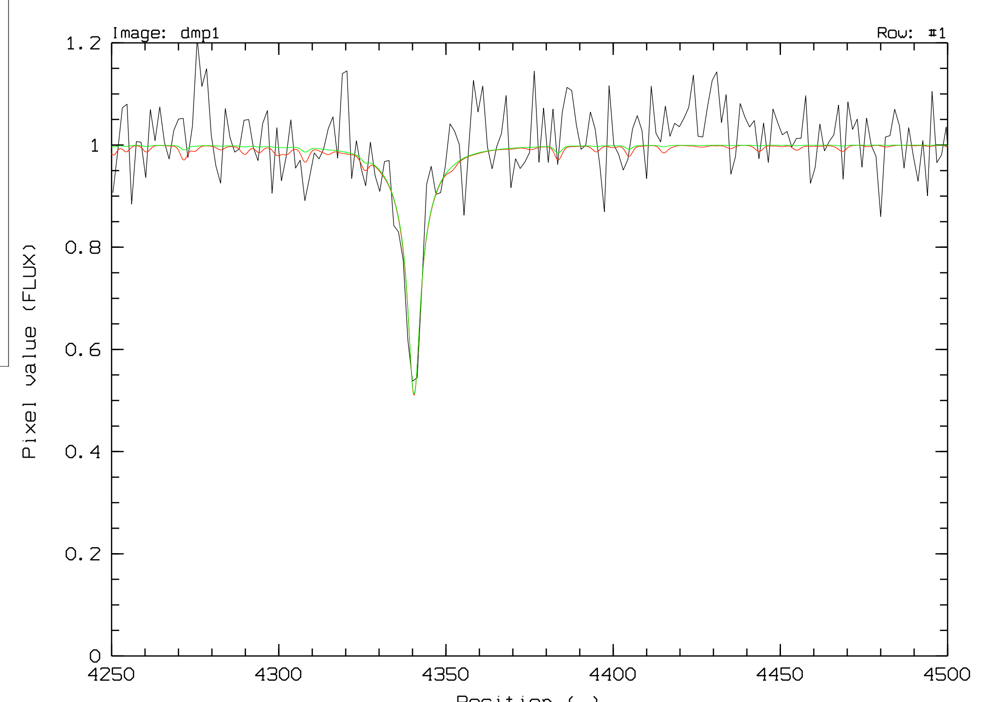
- Hα, Li I 670.7 nm
- Ca II K, G-band 430nm
- CN band 388nm
- Ba II 4554 nm
- Eu II 644 nm and 664 nm
- enough Ca, Mg, Fe II lines

G-Band

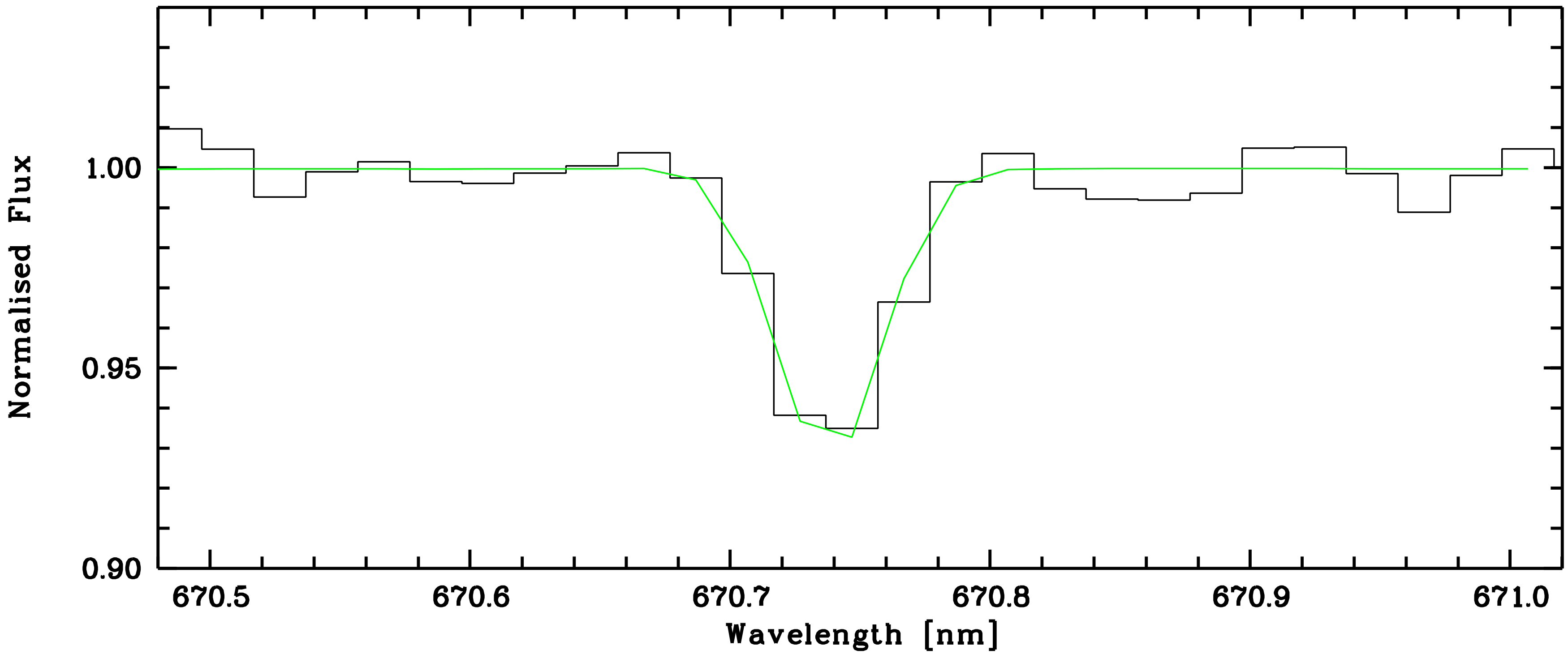
Behara et al. 2010 A&A 513, A72







Lithium



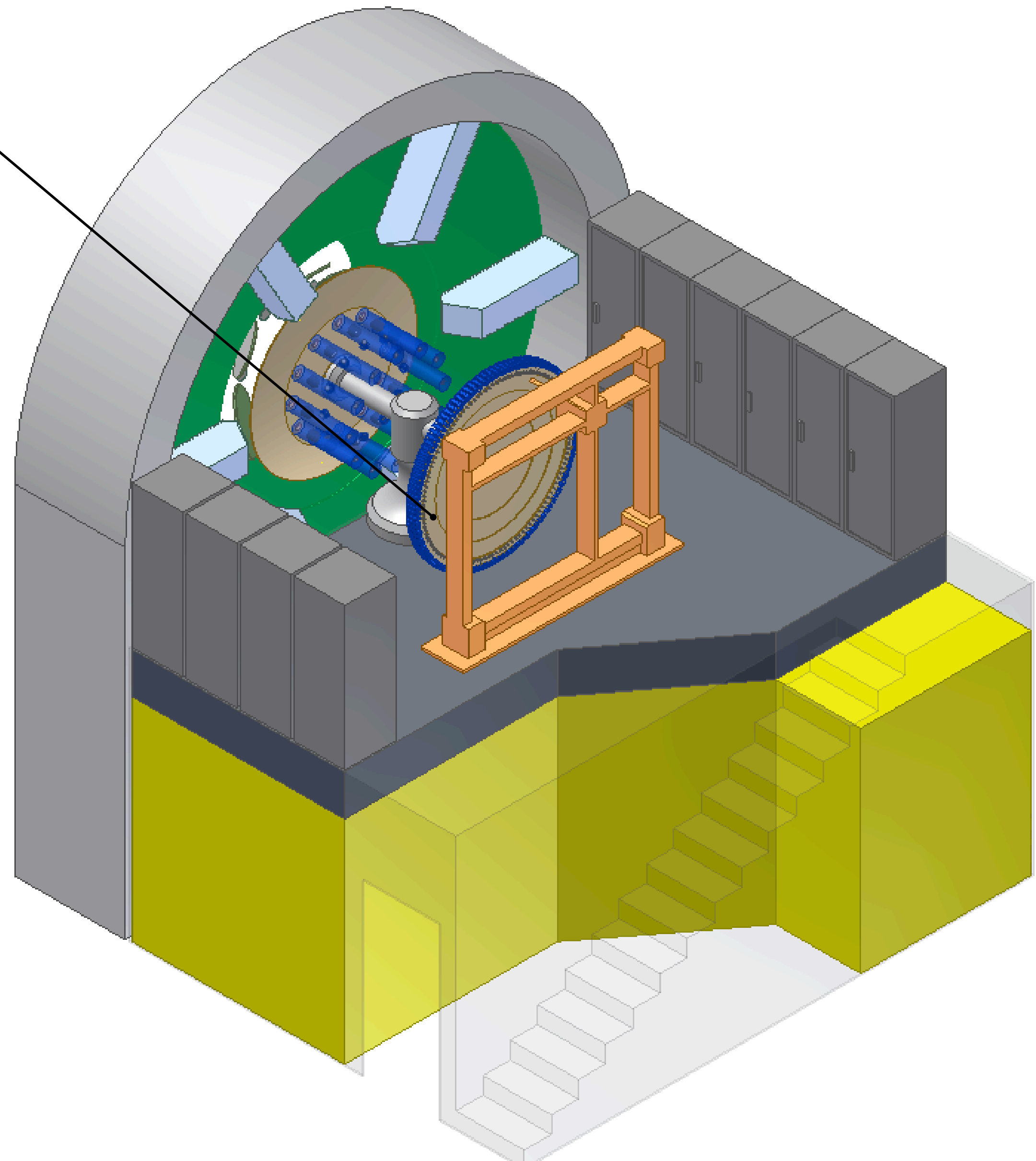
X-Shooter spectrum R= 12400

Instrument Requirements
Resolution

- R = 10 000 (X-Shooter-like)
- R = 20 000 (Giraffe-like)
- R = 40 000 (UVES-like)

- R > 10 000 (baseline)
- R > 12 000 (goal)

Fibre Only Option: High Multiplex Mode



Assumptions
120 science channels
Buttons with fibre retraction scheme
Stepped focal plate
In-plane rotation >180deg

Known issues
Change in field curvature causes difficulty in fibre alignment and focus.
Synchronisation of plate rotation with LGS system.

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SEE POSTER Jagourel et al.