The primordial ^{4}He abundance from a large sample of low-metallicity HII regions

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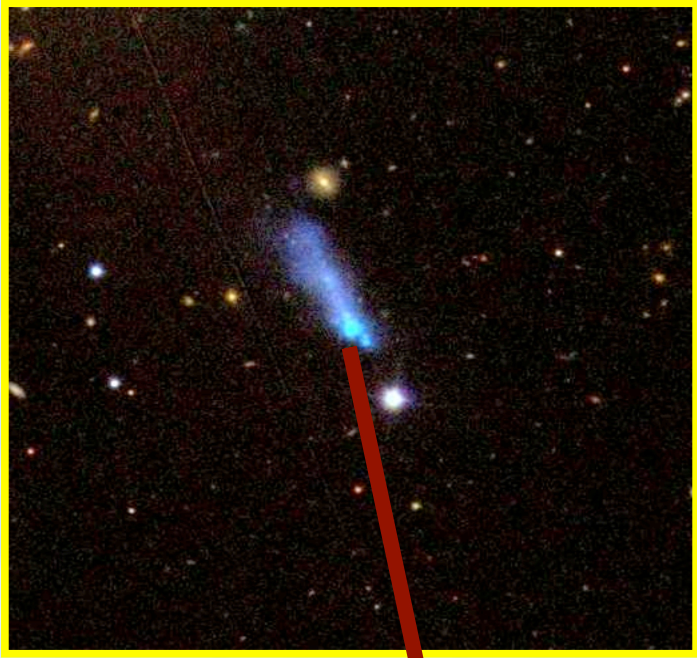
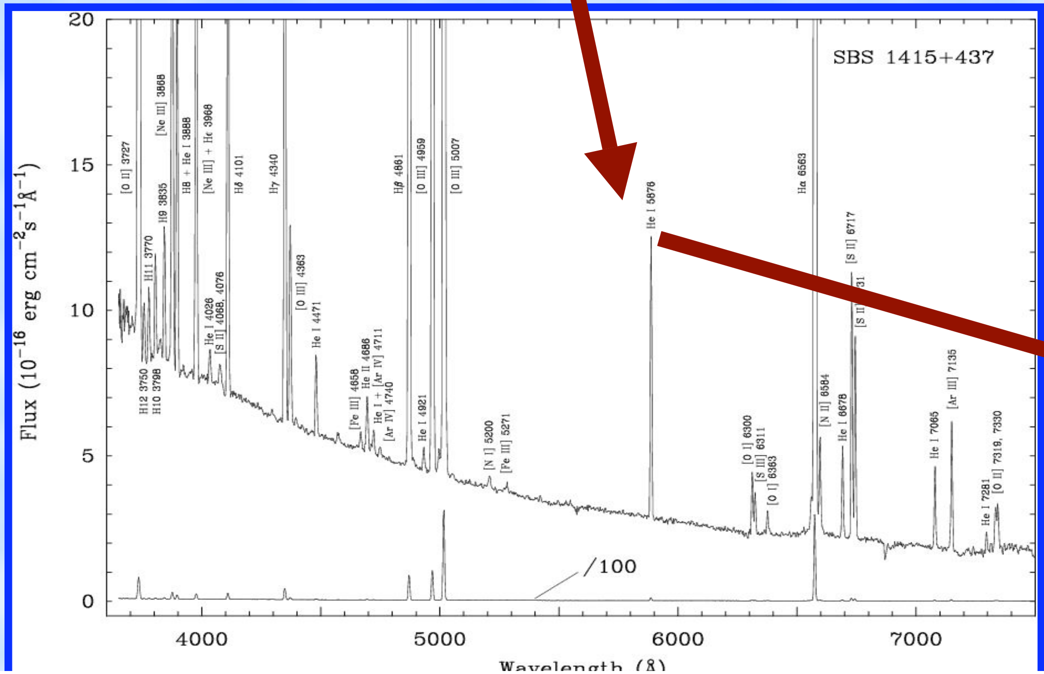
Why large samples?

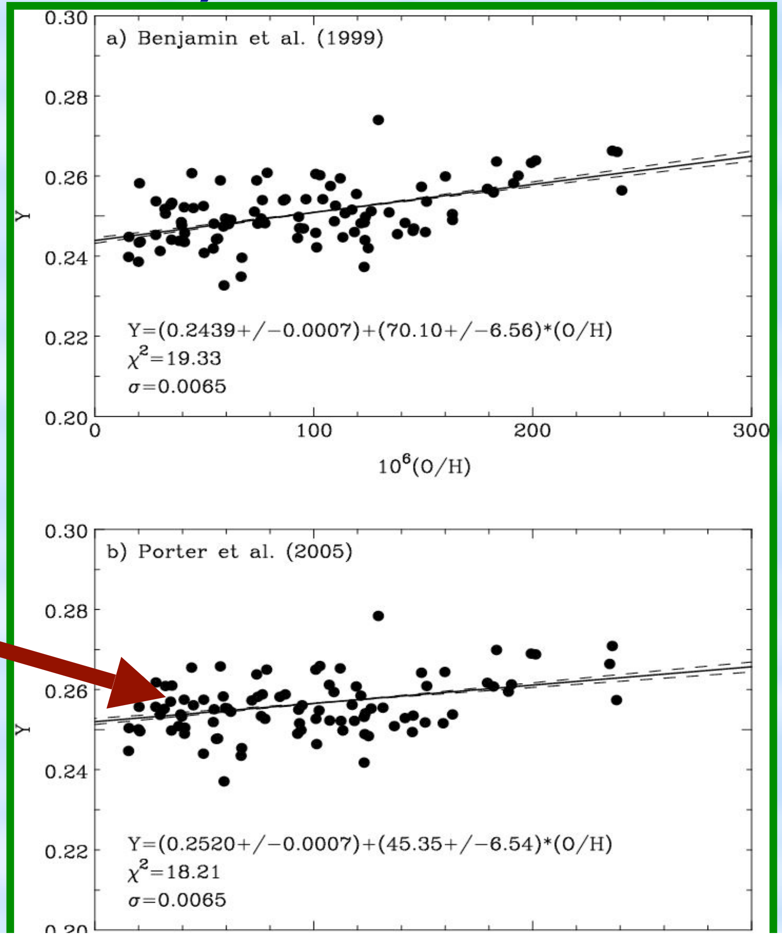
The typical flux errors of strong HeI lines are greater than 2-3% and are more than 10% for the weak HeI lines. Increasing of the sample will greatly reduce the effect of statistical errors in the determination of Y_p by a factor of up to ~10.

The method

- -Low-metallicity HII regions with strong emission lines (12+logO/H = 7.0 – 8.3)
- -Linear regression Y-O/H (Peimbert, Torres-Peimbert 1974,1976)







Sources of uncertainties:

1. Statistical errors

Peimbert & Torres-Peimbert (1974,1976)	- 5 HII regions
Pagel et al. (1992)	- 36
Izotov et al. (1994)	- 10
Olive & Steigman (1995)	- 49
Izotov et al. (1997)	- 27
Fukugita & Kawasaki (2006)	- 31
Peimbert et al. (2007)	- 5
Izotov et al. (2007)	- 350
This study	-1700

(Our previous observations + SDSS + ESO archival data)

2. Systematic errors

- HeI recombination emissivities ↑
- ionization structure of the HII region ↓
- temperature structure ↓
- collisional excitation in the hydrogen ↑ and helium ↓ lines
- fluorescence in the hydrogen ↑ and helium ↓ lines
- underlying stellar HeI absorption lines ↑

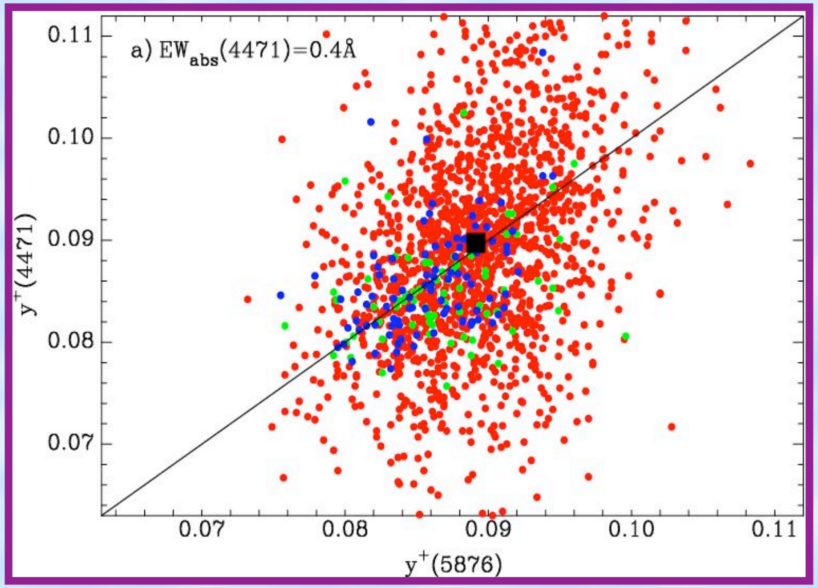
HeI 3889, 4471, 5876, 6678, 7065 emission lines are used.
Y's are derived as a weighted mean of Y from 4471, 5876, 6678 lines.

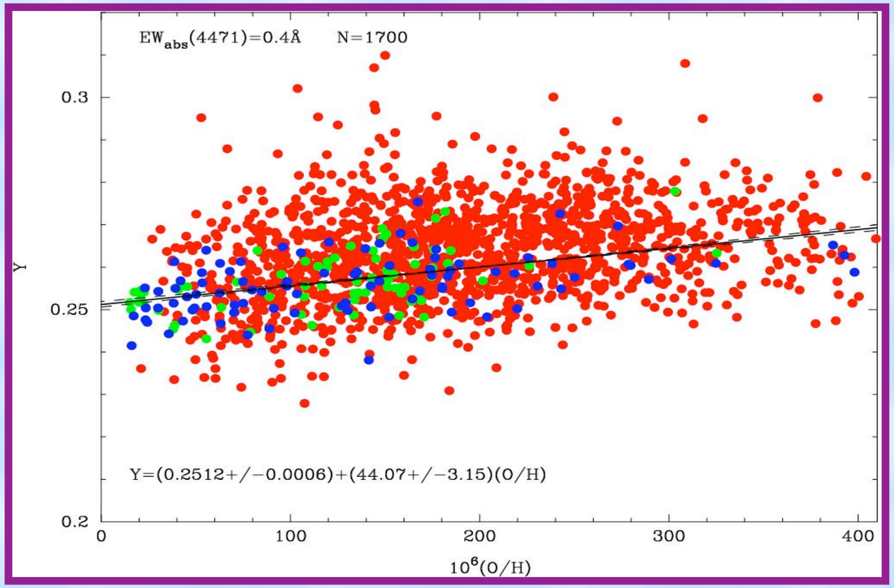
Monte Carlo simulations for every HII region – the best solution is that with the minimum χ^2 for He abundances derived from all 5 lines.

Basic set of parameters (Izotov et al. 2007):

- the reddening law by Whitford (1958) is adopted.
- the electron temperature of the He^+ zone is varied in the range (0.95 – 1.0)T_e(OIII).
- oxygen abundances are calculated adopting $T_e(He^+)$ and T_e(OIII).
- $N_e(He^+)$ and τ(3889) are varied in the ranges 10-450 cm^{-3} and 0-5.
- the fraction of Hα emission due to collisional excitation is varied in the range 0% - 5%.
- the equivalent width of the HeI 4471 absorption line is fixed to EW_{abs}(4471)=0.4Å, 3889/4471=1.0, 5876/4471=0.3, 6678/4471=0.1, 7065/4471=0.1.
- HeI emissivities of Porter et al. (2005) are adopted.
- the He ionization correction factors ICF(He^++He^{++}) from Izotov et al. (2007) are adopted.

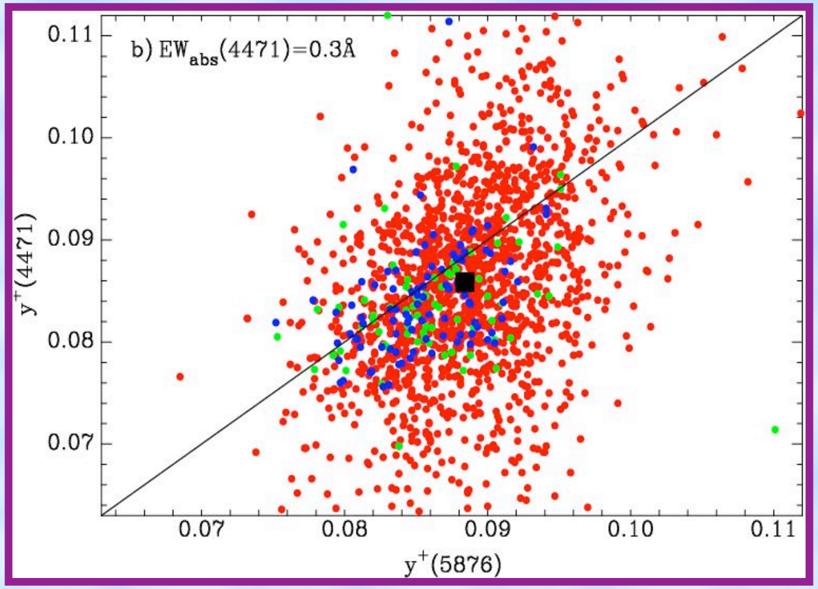
Underlying stellar HeI line absorption.

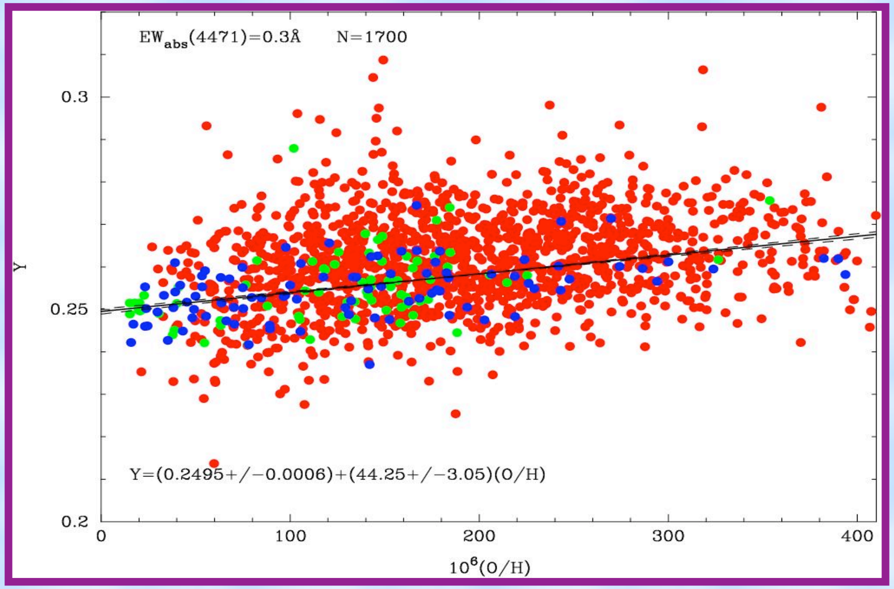




HeI 4471

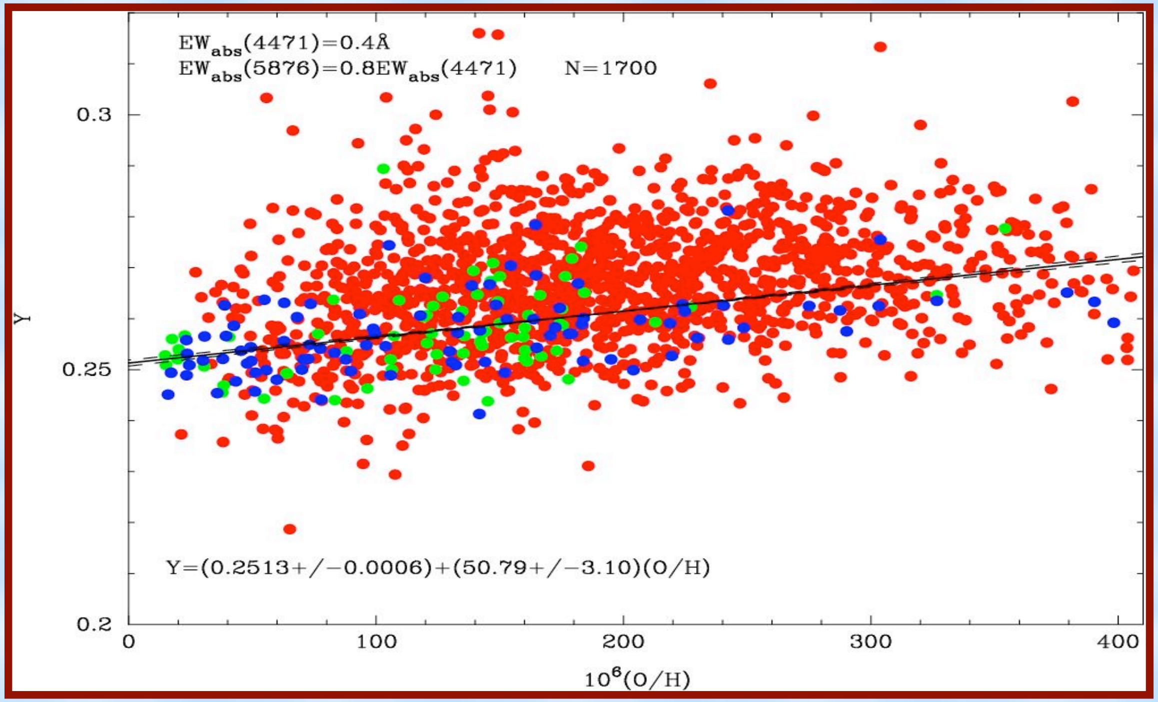
EW=0.4Å
Y_p=0.2512



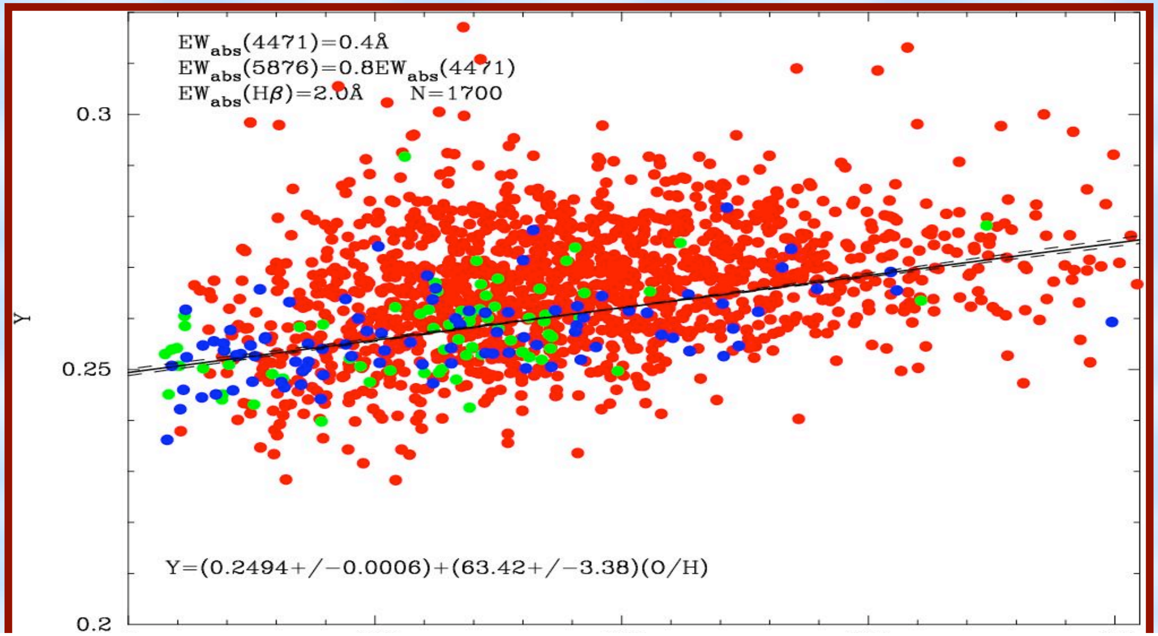


EW=0.3Å
Y_p=0.2495

Underlying stellar hydrogen line absorption



$EW_{abs}(H\beta)$ together with the extinction coefficient is calculated from the observed hydrogen Balmer decrement.
$Y_p=0.2513$

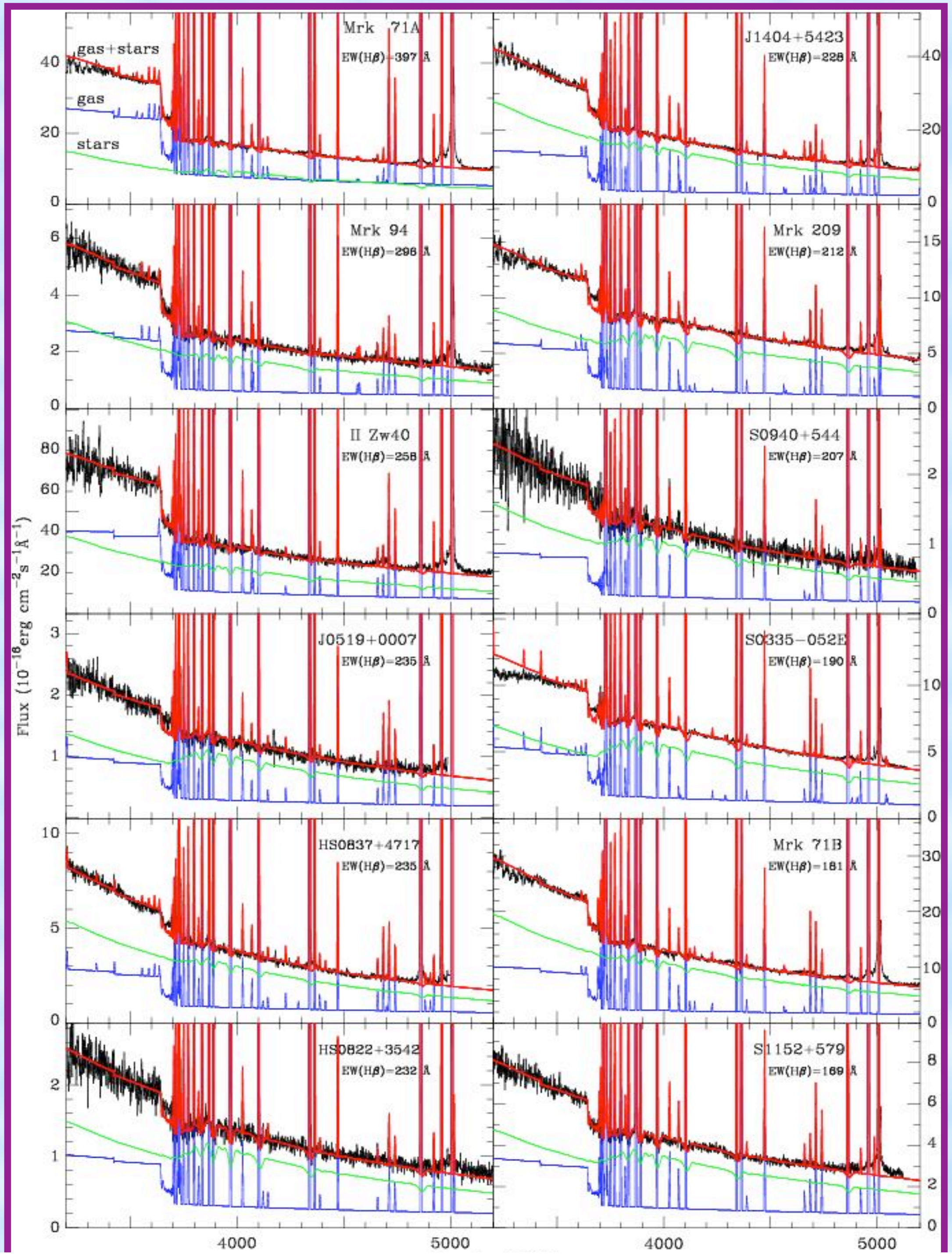


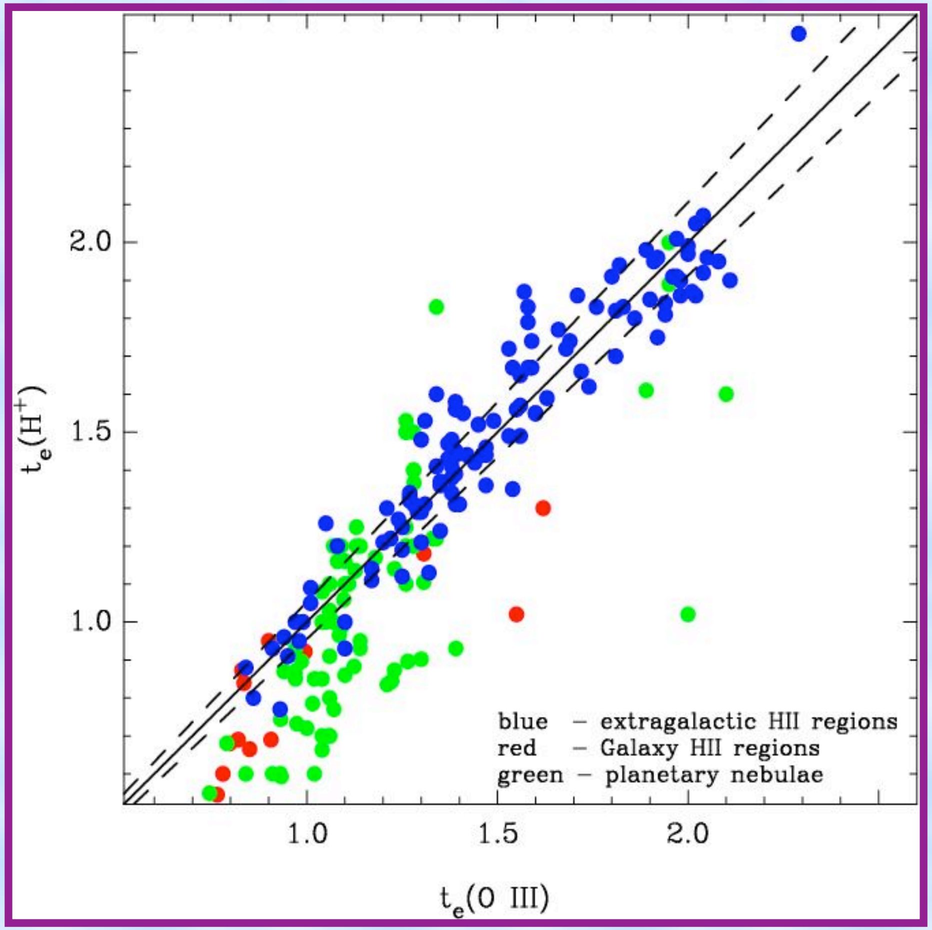
$EW_{abs}(H\beta)=2Å$
$Y_p=0.2494$

Temperature structure.I.

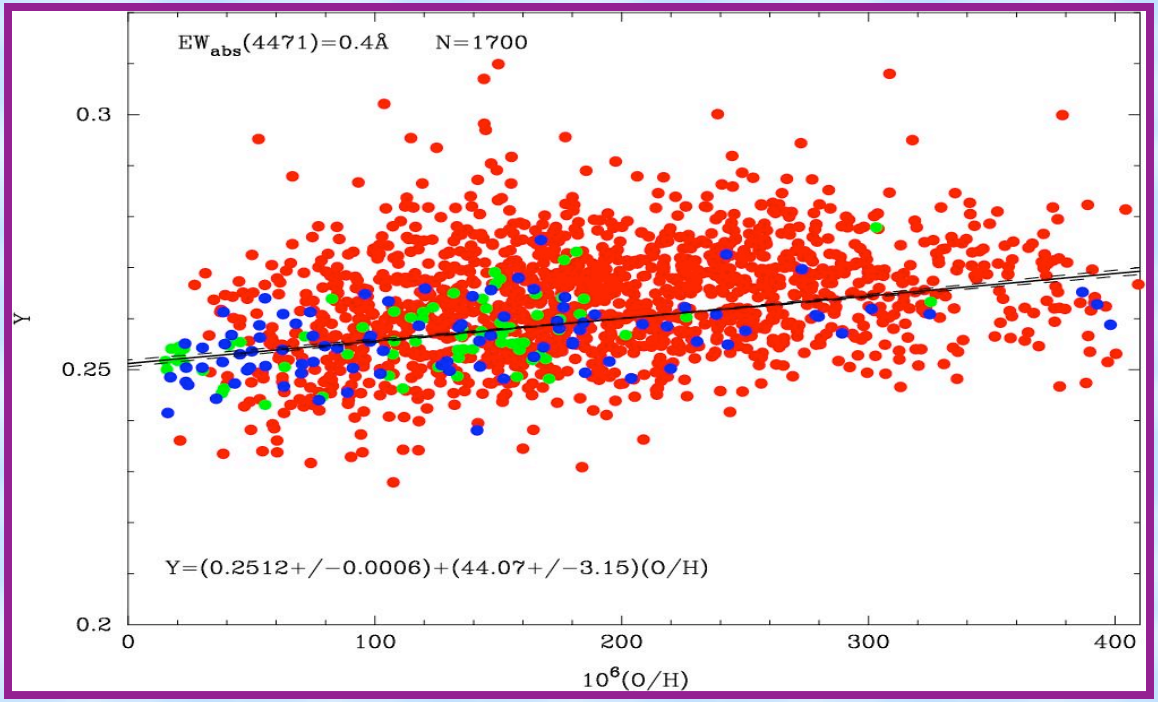
T_e(OIII), $T_e(H^+)$, $T_e(He^+)$.

Guseva et al. (2005)- relation between T_e(OIII) and $T_e(H^+)$.



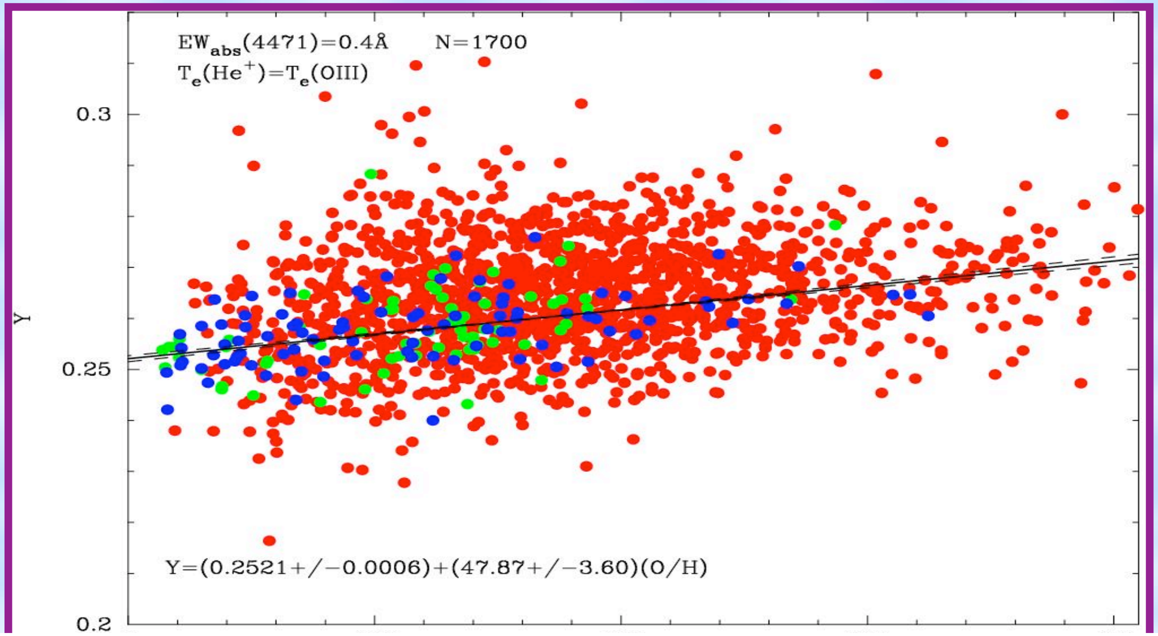


Temperature structure.II.



$T_e(He^+)$ is derived from Monte Carlo simulations varying it in the range $(0.95\text{-}1.00)T_e(OIII)$

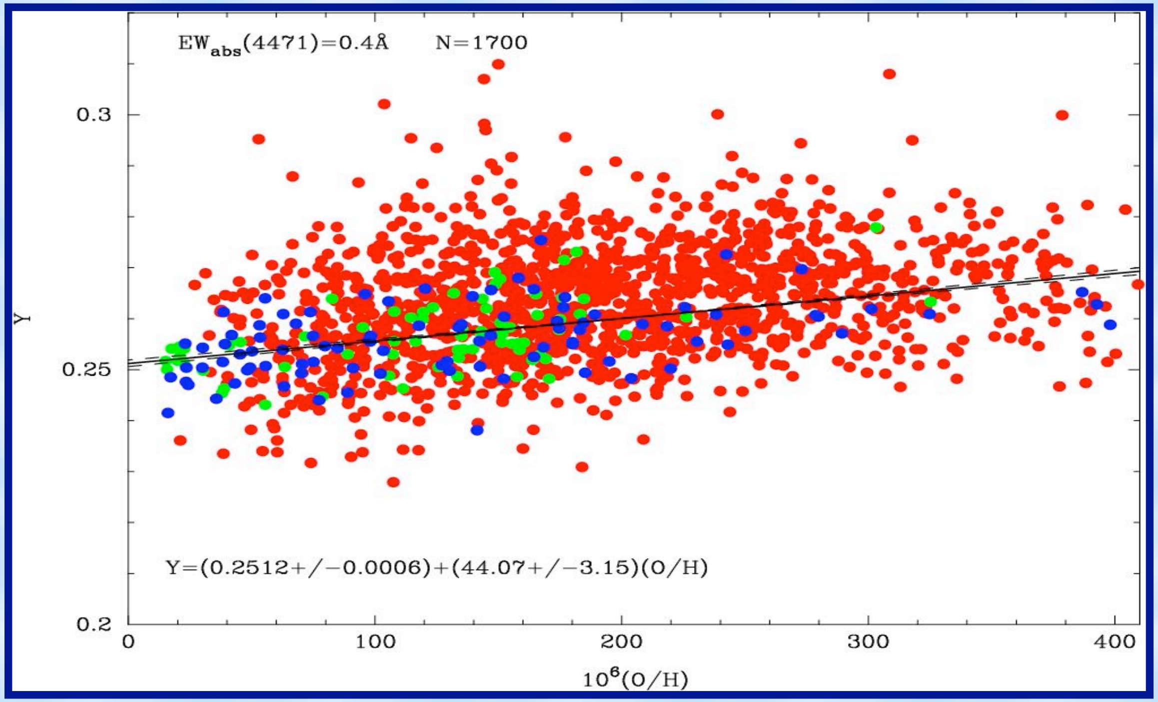
$Y_p=0.2512$



$T_e(He^+)=T_e(OIII)$

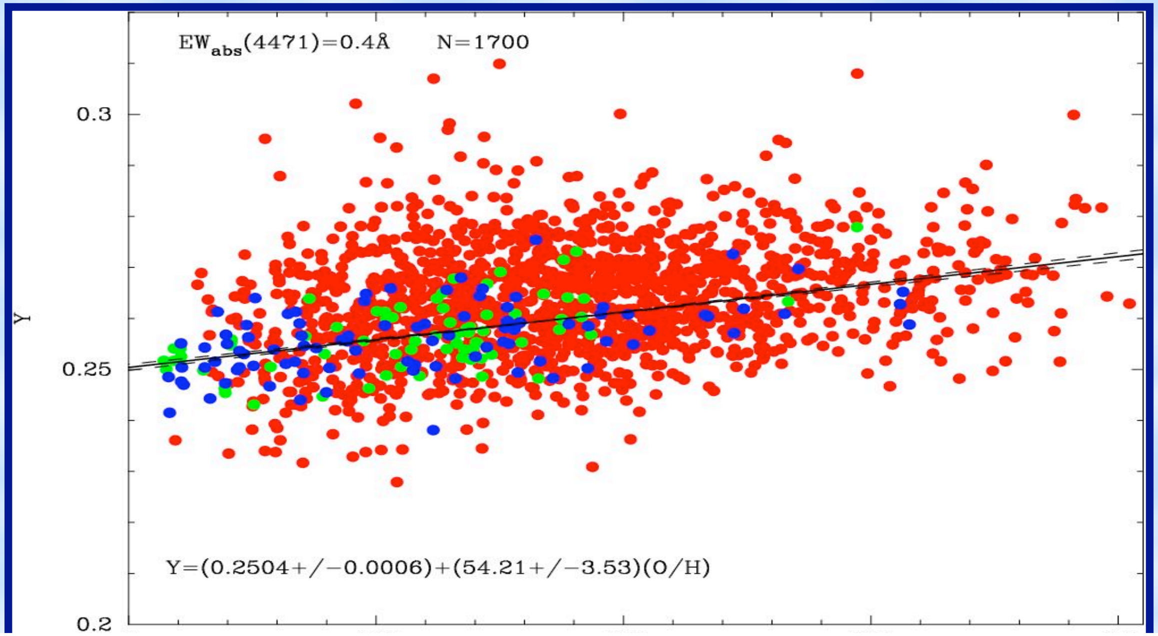
$Y_p=0.2521$

Temperature structure.III.



O/H is calculated with $T_e(He^+)$

Y_p=0.2512



O/H is calculated with $T_e(OIII)$

Y_p=0.2504

Conclusions

1. A large sample of ~1700 low-metallicity HII regions is selected for the determination of the primordial ^{4}He abundance allowing to significantly reduce the effect of statistical errors and to test the effect of systematic errors.
2. The primordial ^{4}He mass fraction Y_p is varied in the range 0.249 - 0.252 depending on the adopted set of parameters to correct for the systematic effects. The reasonable value for Y_p from this study is 0.2512 ± 0.0006(stat.) ± 0.0020(syst.). It is essentially the same as the value derived by Izotov et al. (2007) for 350 HII regions. The effective number of light neutrino N_ν with this Y_p is ~3.3.
3. With improving of our knowledge on the systematic effects a sample of 1700 HII regions could be re-analyzed for improving Y_p.