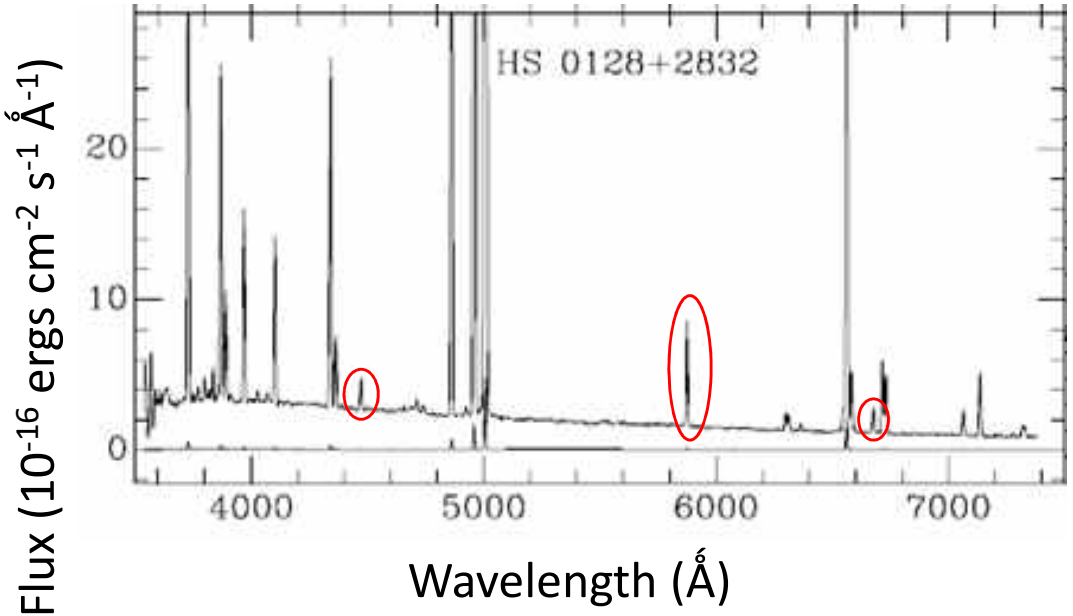
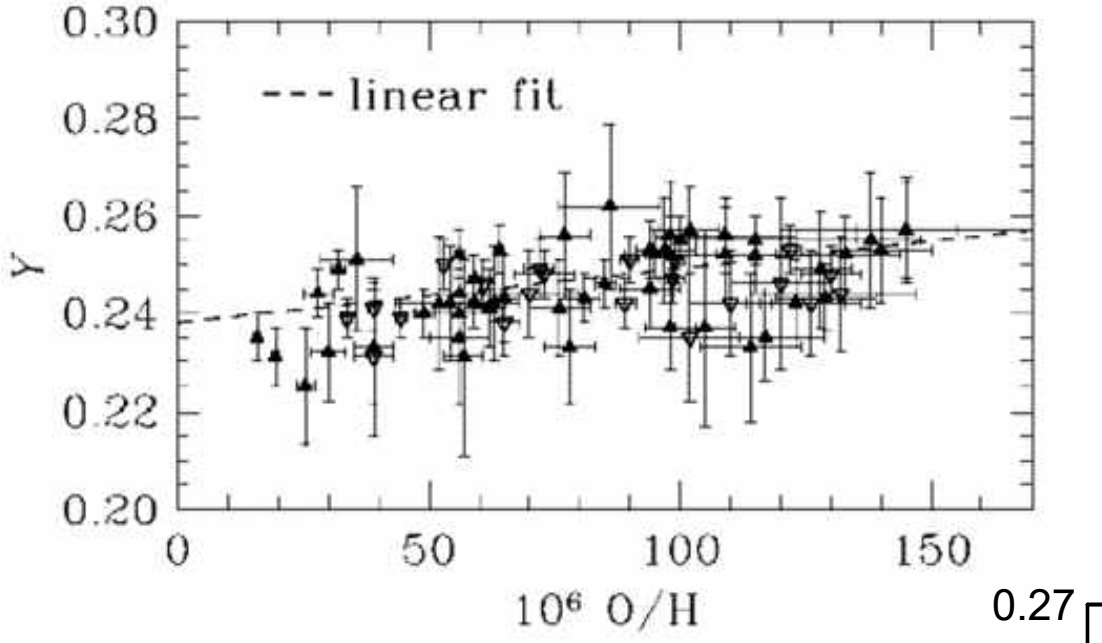
Determination of Y_p (primordial mass fraction of ^4He)

Blue-Compact Dwarf Galaxies

--- is a small galaxy containing clusters of young, hot, massive stars.

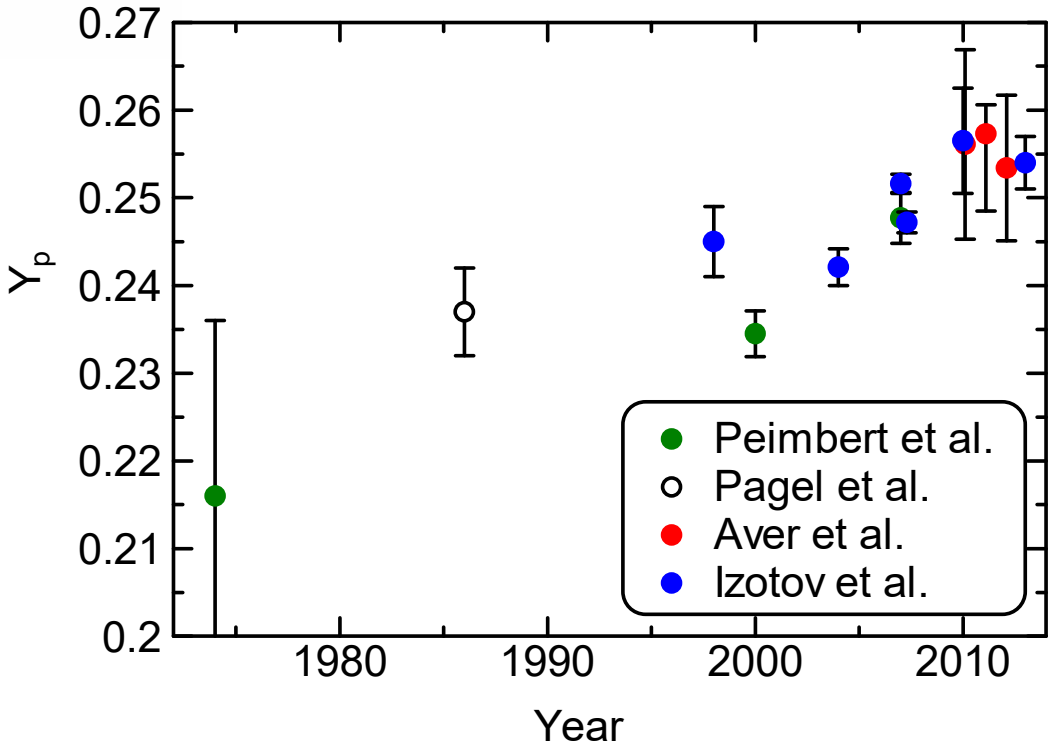
It is known to be less chemically evolved, and therefore it is expected to show chemical abundances close to the primordial ones.





Y_p (primordial Y) is obtained as the limit of zero-metallicity.

- Increased number of samples; ~80 → 1442
- Improved model for He-I photo-emissivity



Note. "Metallicity"

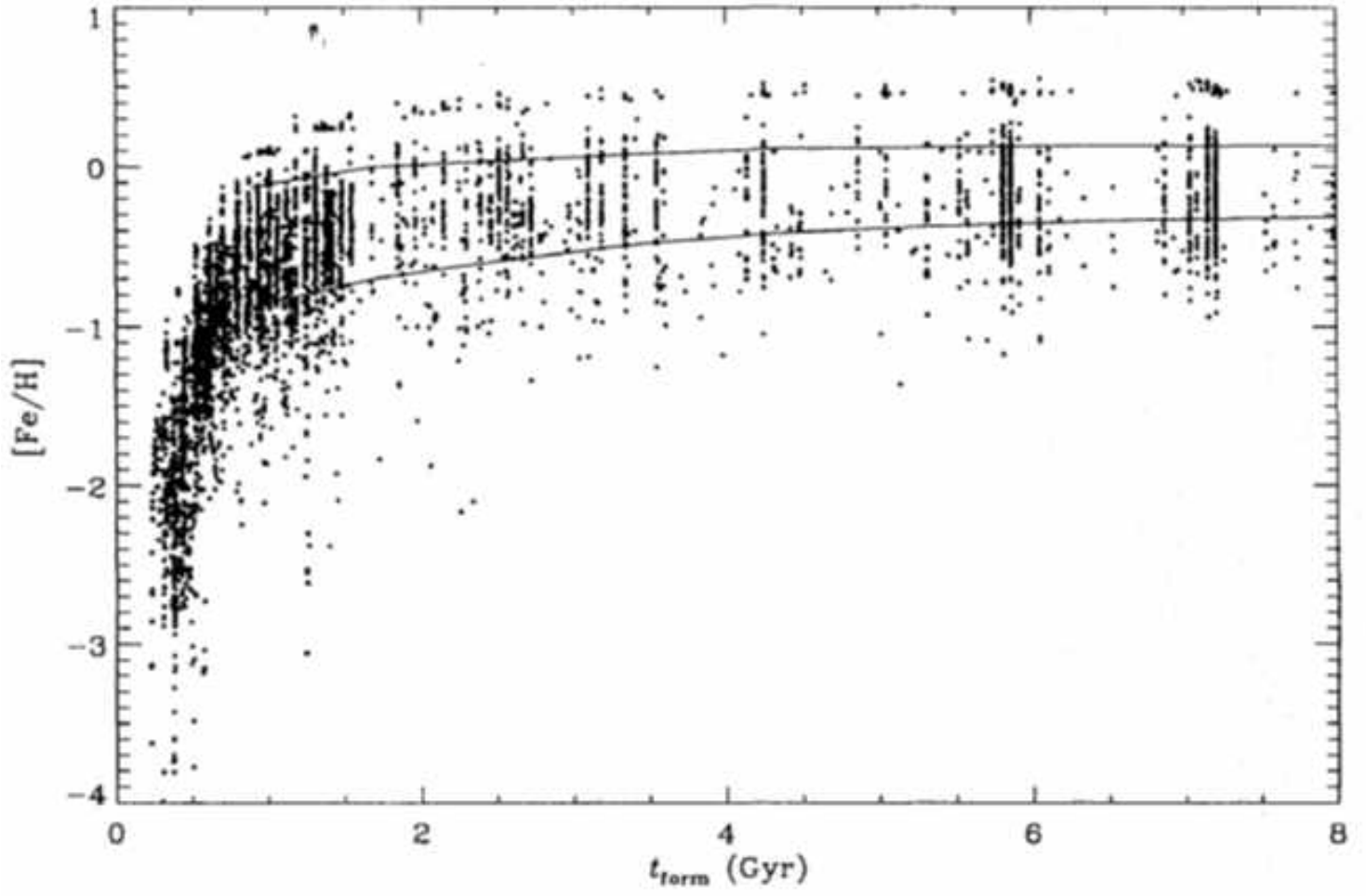
Definition; $$Z = \left[Z/H\right] \equiv \log_{10}\left(\frac{N_Z}{N_H}\right)_{star} - \log_{10}\left(\frac{N_Z}{N_H}\right)_{sun}$$

where N_H and N_Z are the number densities of hydrogen and an element heavier than helium.

Meaning;

Since the elements heavier than He are produced mainly or only in stars, Z is an indicator of how the star is evolved or how the interstellar cloud is polluted by the stellar products, and therefore it can be used as an index of the age of a star.

Age-metallicity relation C.M. Raiteri et al., A&A 315, 105-115 (1996)



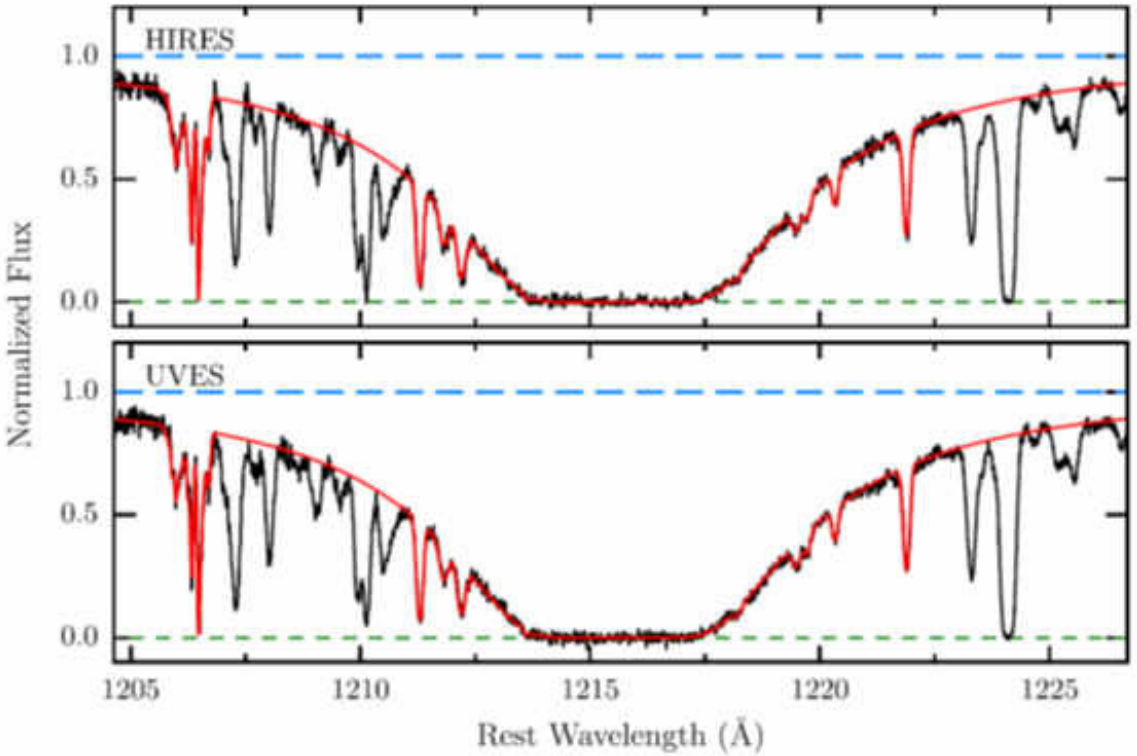
Abundance of Deuterium

Interstellar clouds

Quasar (light source)

Absorption !!

Observation



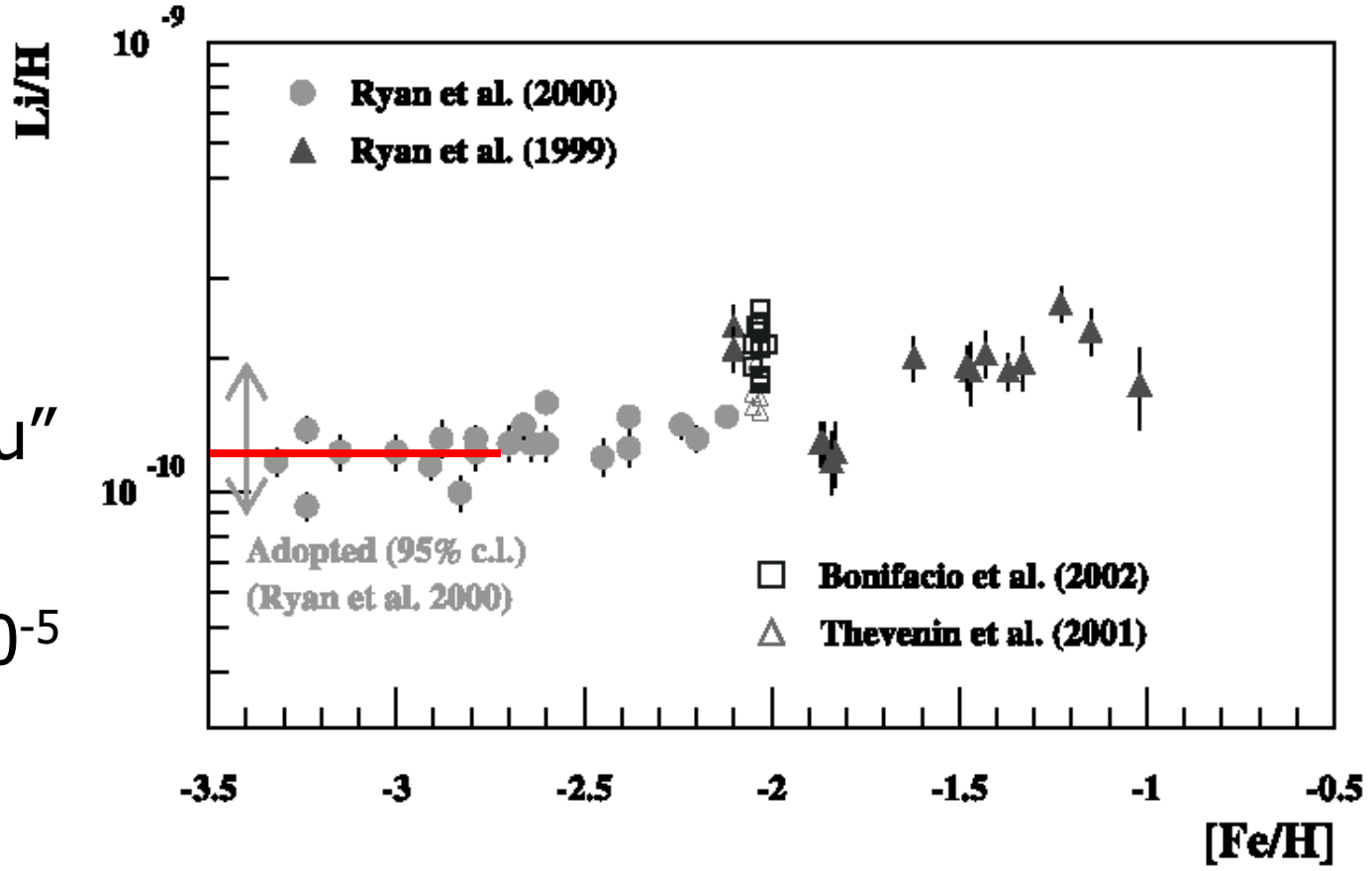
R.J. Cooke et al., Astrophys. J. 830, 148 (2016)

Abundance of Lithium

Li/H in atmosphere of metal-poor dwarfs

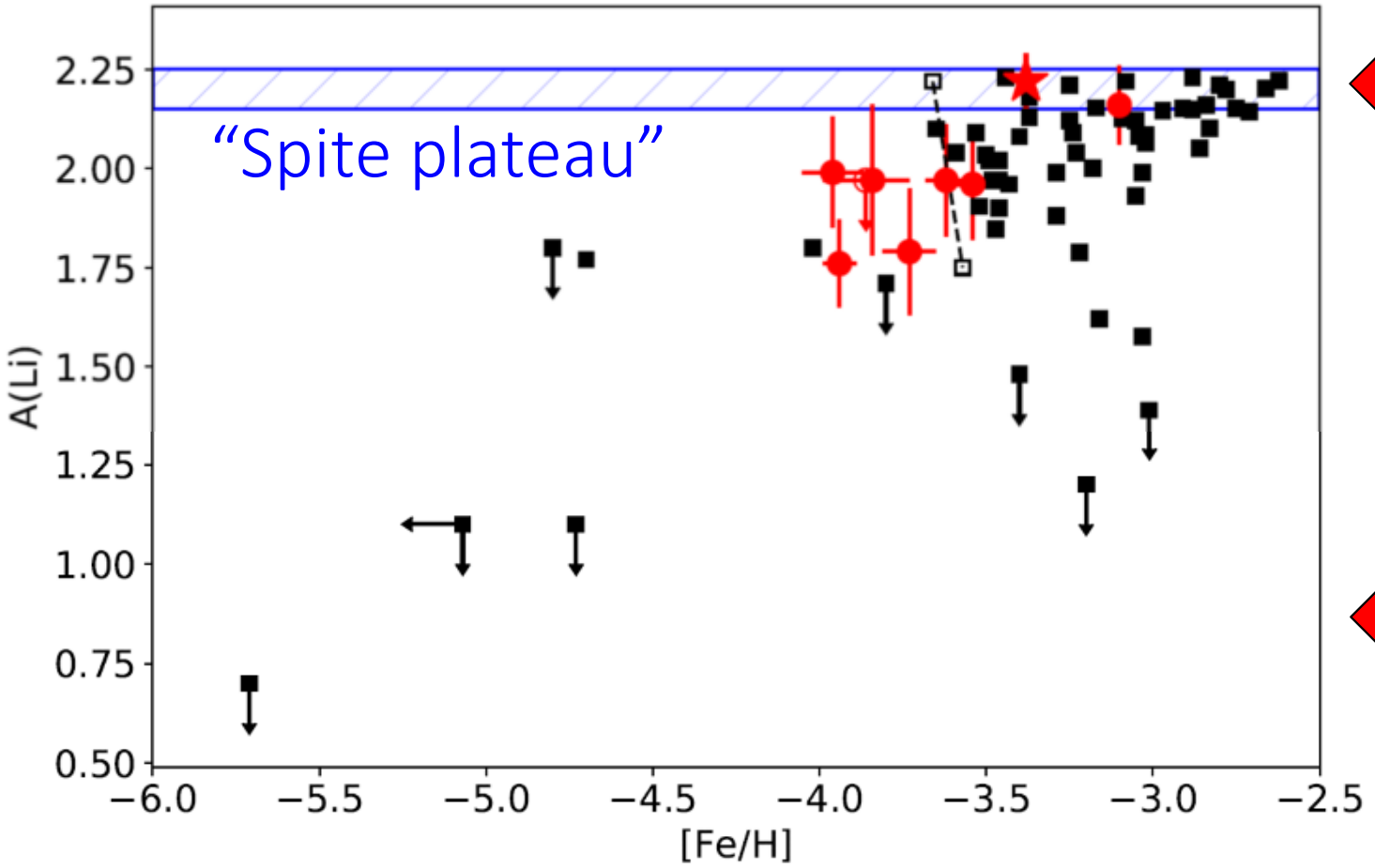
"Spite Plateau"

$^{7}Li/H = 1.23^{+0.68}_{-0.32} \times 10^{-5}$



^{7}Li problem

Matsuno, Aoki, Beers, Lee, Honda,
ApJ 154:52 (2017)



1/3 of BBN

1/8 of BBN !

- The constant value has not yet been observed.
- The upper limit has already been < ~1/8 of BBN.

Sensitivity to thermonuclear reaction rates

$$\frac{\Delta A}{A} = \left.\frac{\partial \ln(A)}{\partial \ln\left(N_A \langle \sigma v \rangle\right)}\right|_{\eta(WMAP)} \times \frac{\Delta \langle \sigma v \rangle}{\langle \sigma v \rangle}$$

Coc & Vangioni 2010

at WMAP baryonic density

Reaction	D	^{3}He	^{7}Li
^{1}H(n,γ)^{2}H	-0.20	0.08	1.33
^{2}H(p,γ)^{3}He	-0.32	0.37	0.57
^{2}H(d,n)^{3}He	-0.54	0.21	0.69
^{2}H(d,p)^{3}H	-0.46	-0.26	0.05
^{3}He(n,p)^{3}H	0.02	-0.17	-0.27
^{3}He(d,p)^{4}He	0.01	-0.75	-0.75
^{3}He(α,γ)^{7}Be	0	0	0.97
^{7}Li(p,α)^{4}He	0	0	-0.05
^{7}Be(n,p)^{7}Li	0	0	-0.71