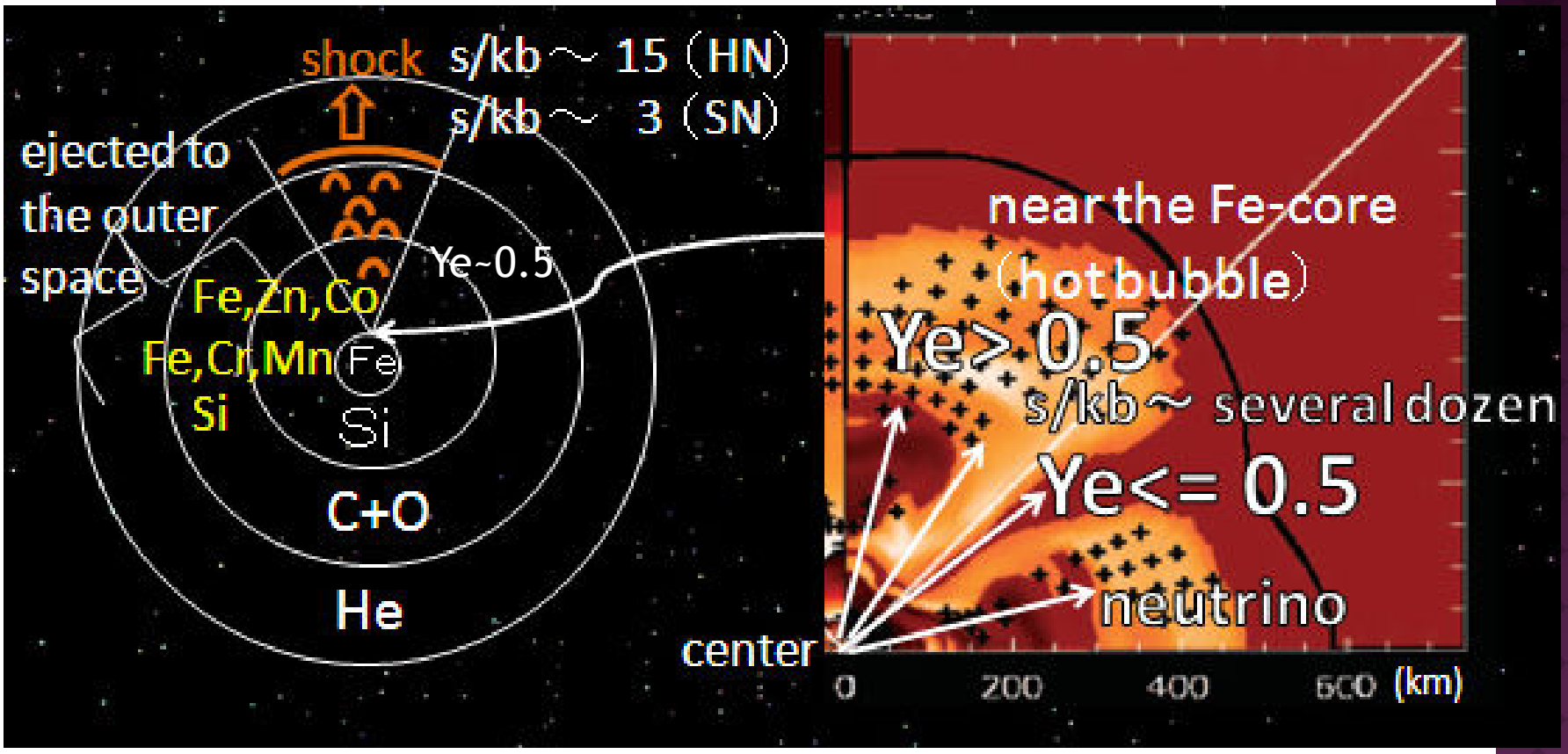
NUCLEOSYNTHESIS IN HIGH-ENTROPY HOT-BUBBLES OF SNE AND ABUNDANCE PATTERNS OF EMP STARS (IZUTANI & UMEDA, ACCEPTED TO APJL)

Natsuko Izutani
Univ. of Tokyo

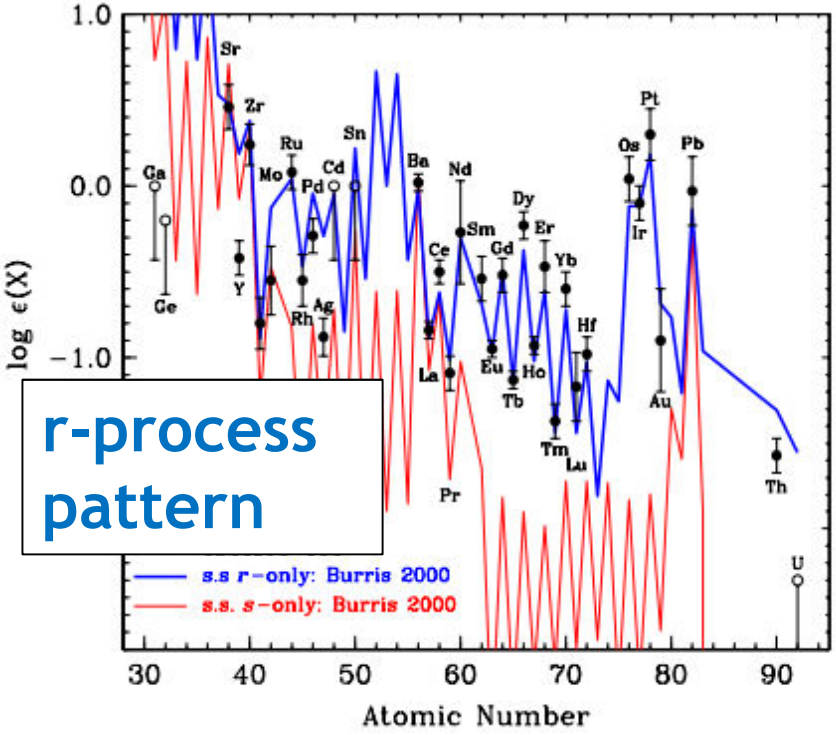
WHAT IS HOT-BUBBLE ?

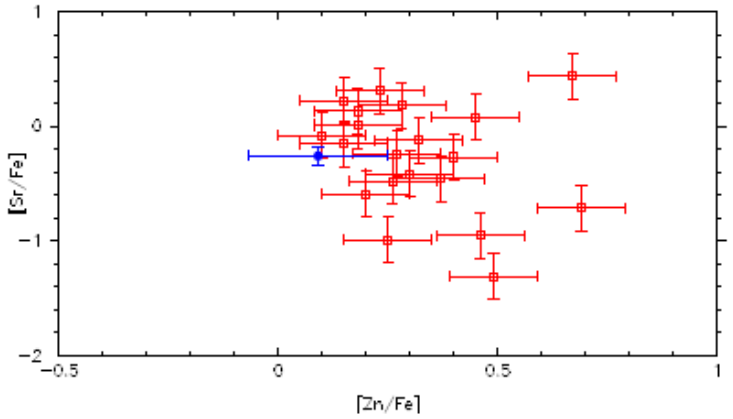


(Pruet+ 2005)

Various Ye & High-Entropy
→ Possible Origin of Various Elements

HEAVY ELEMENTS



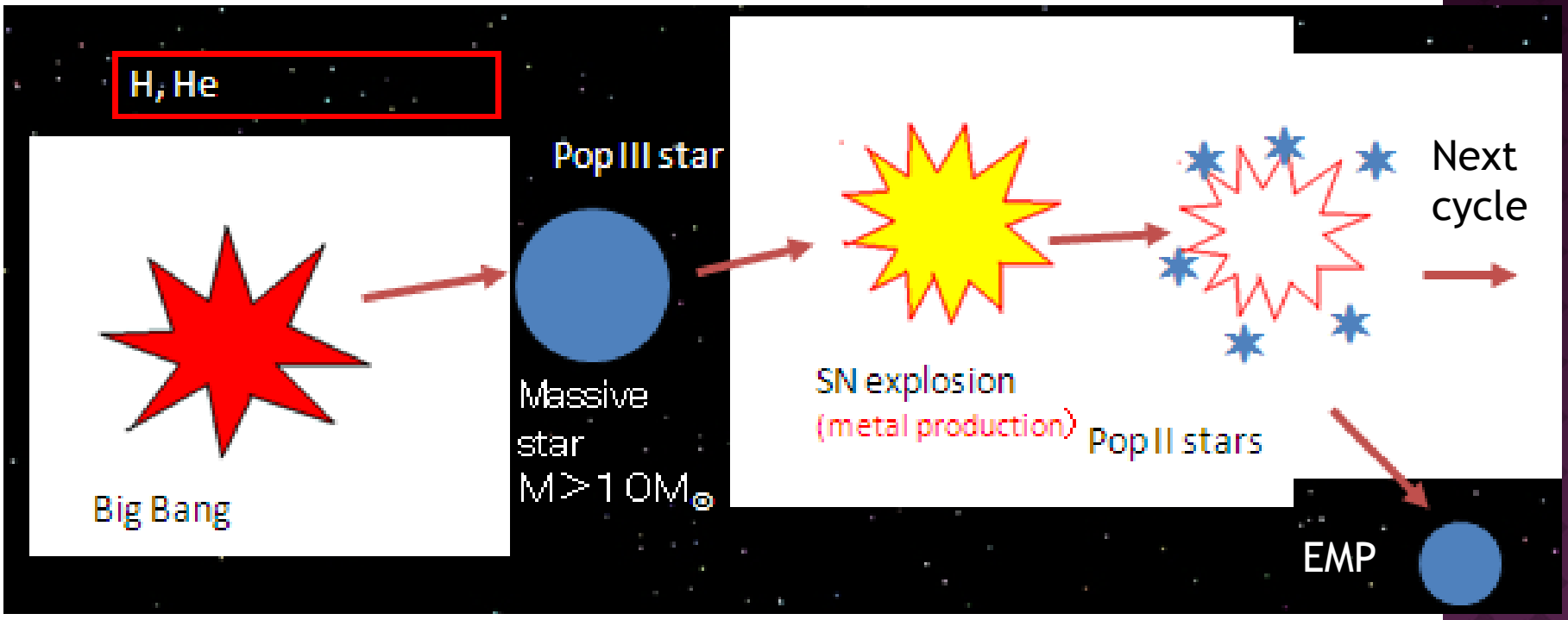


Heavy elements (above Zn):

The most heavier elements(Ba, Eu, etc.)
… their origin is unknown yet.

The lighter elements(Sr, Y, Zr, Mo, Ru, Rh)
… hot-bubble
(from the observation, normal SN)

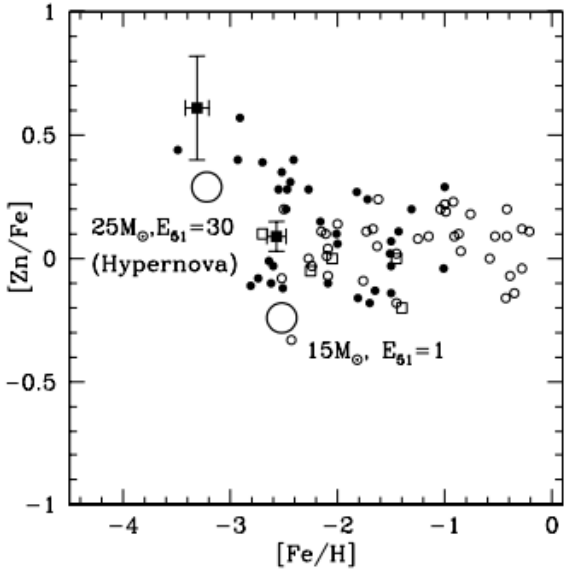
POP III SNE AND EMP STARS

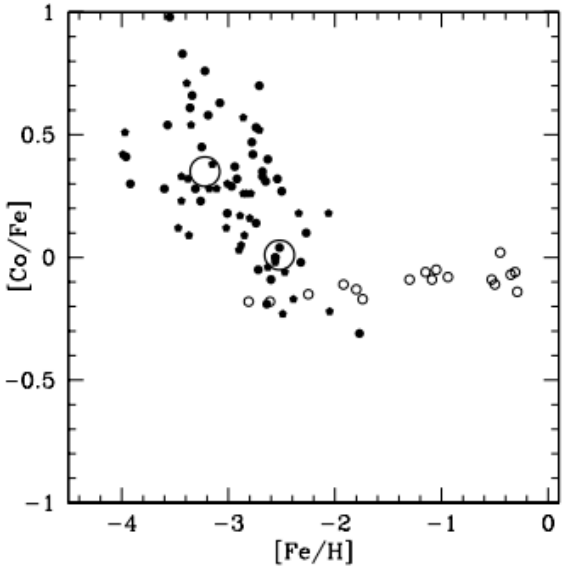


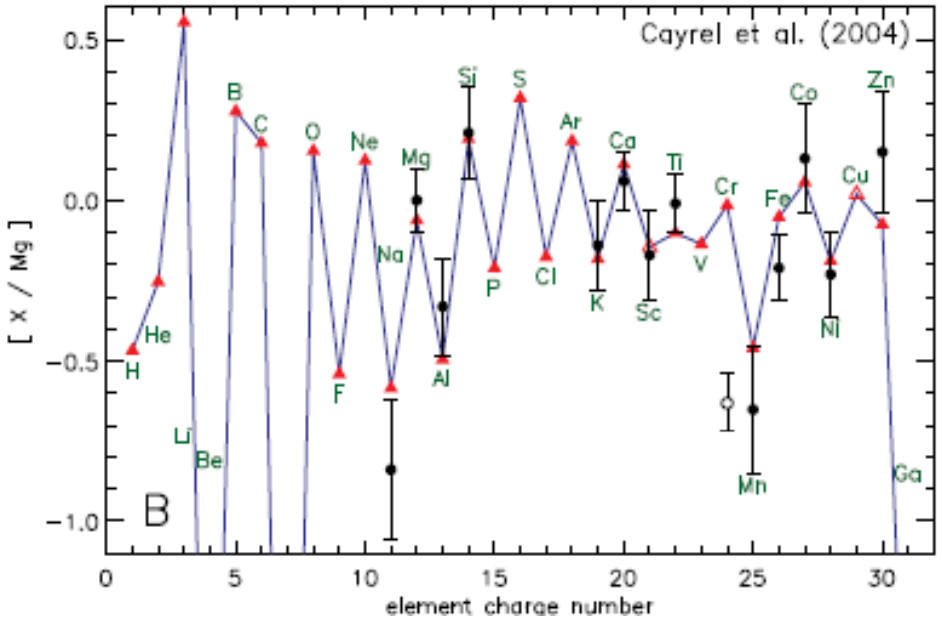
EMP stars ⇔ Pop III SNe

sometimes called “blueprint” of Pop III SNe

ORIGIN OF EMP STARS
- HYPERNOVA OR SUPERNOVA ? -







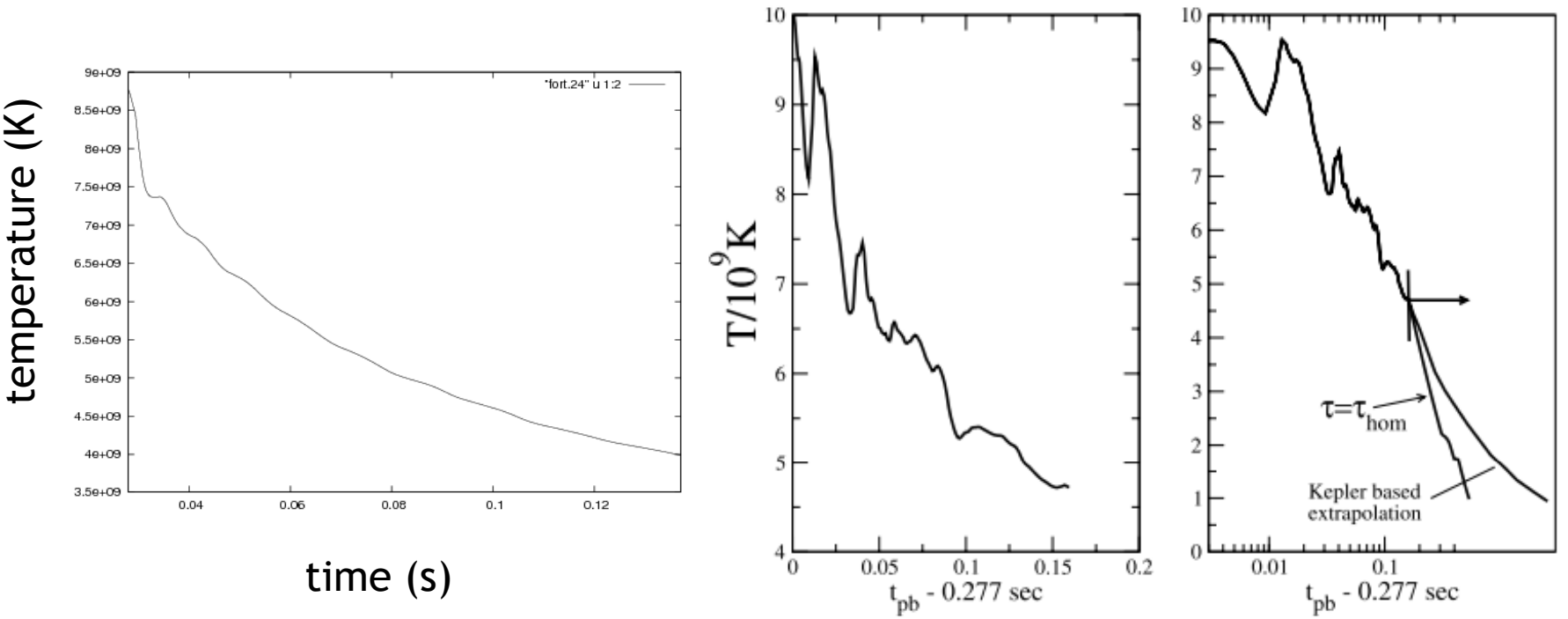
(Heger & Woosley ‘10)

E=0.9×10^51erg×（M/20Msolar)^(-1)

no contribution
from the hot-bubble

(Umeda & Nomoto ’05)

OUR MODEL VS. SIMULATION



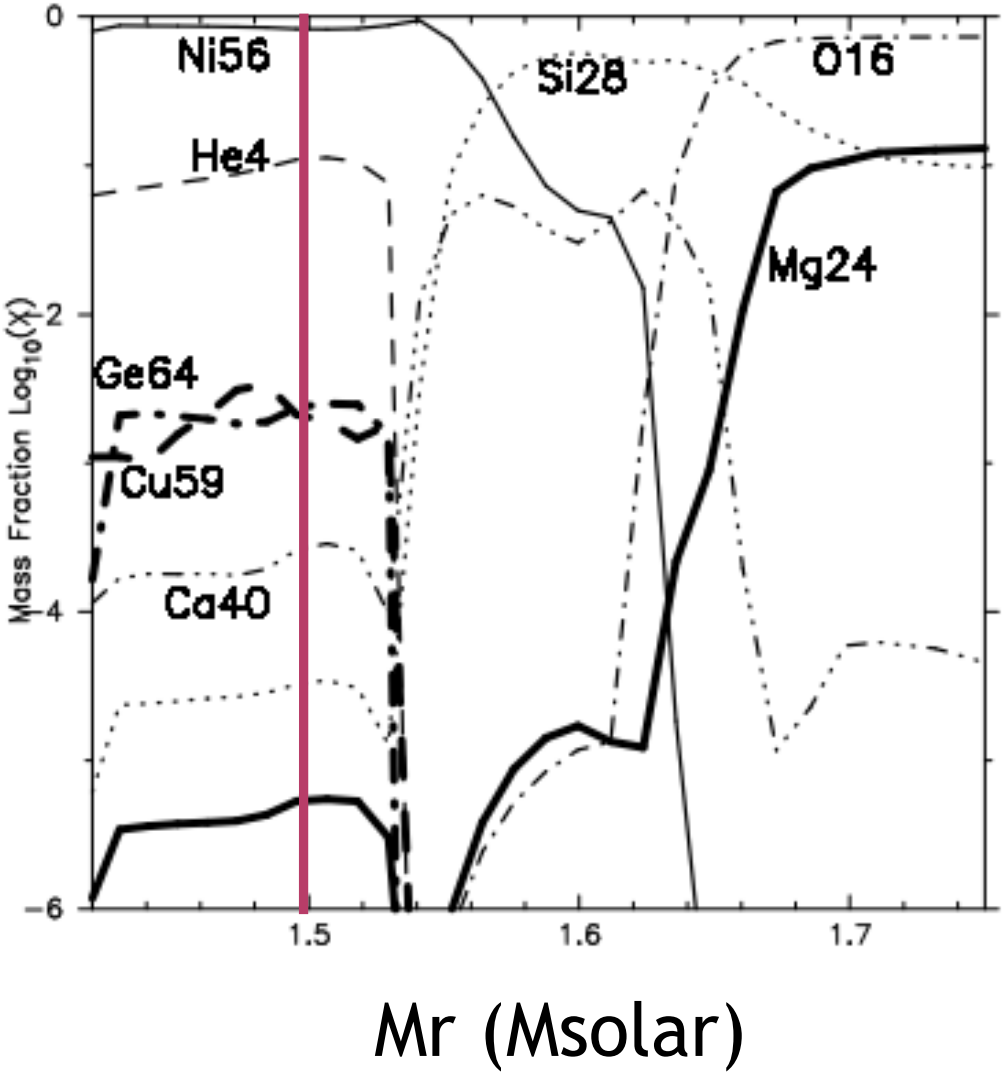
(Pruet+ 2005)

Ye (0.45-0.55), Entropy (s/kb = 5-150)

Important timescale: τhom(T9>4) & time(T9= 2-1)

	our model	Pruet+ 2005
τhom	0.04 (s)	0.02-0.1 (s)
time(T9=2-1)	1 (s)	1 (s) or 0.1-0.2 (s)

OUR MODEL (MASS-CUT)



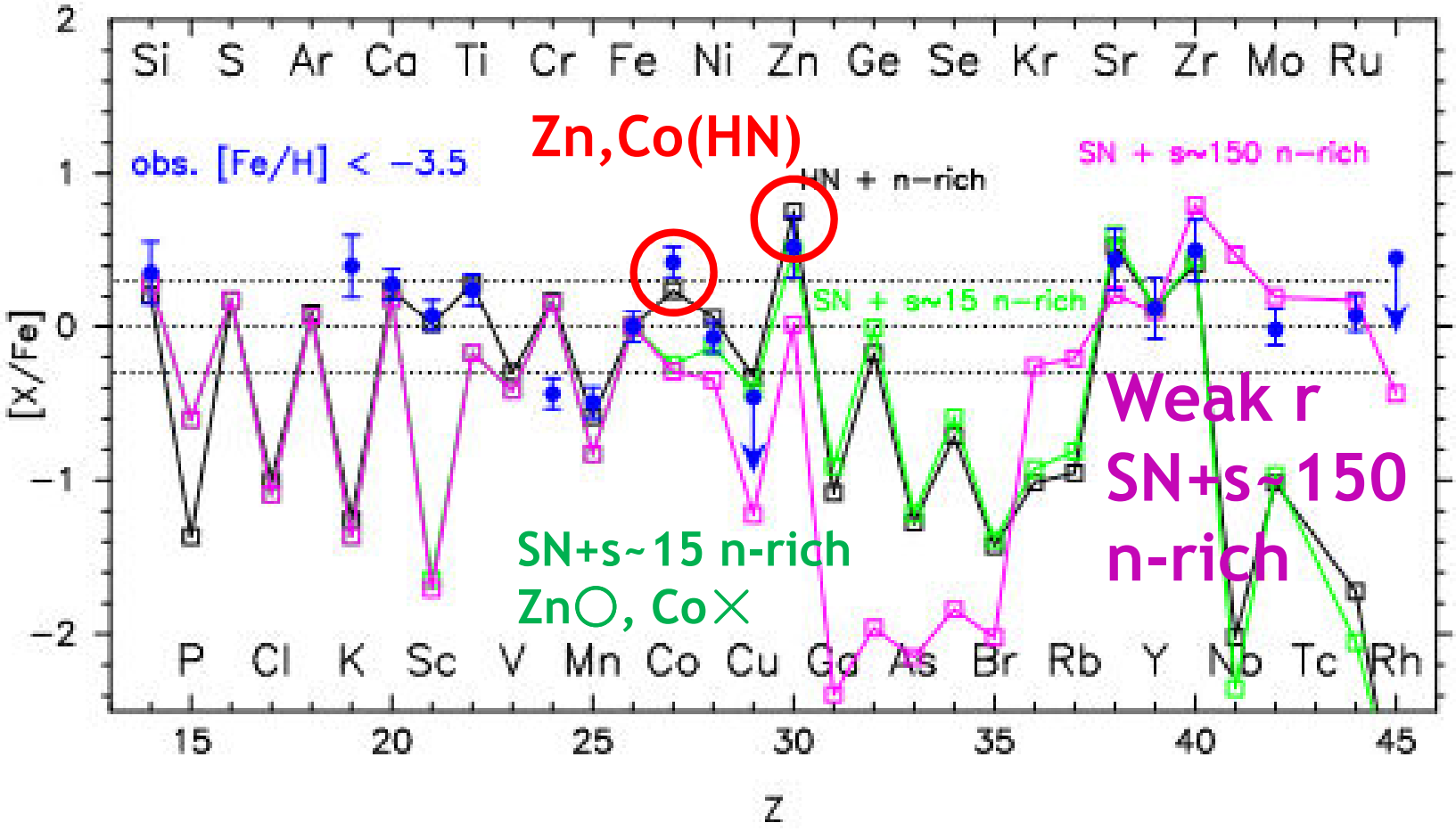
◆15 Msolar, E = 1 foe (SN)

Total ejecta
= matter above mass-cut
+ hot-bubble matter (ΔM)

◆25 Msolar, E = 20 foe (HN)

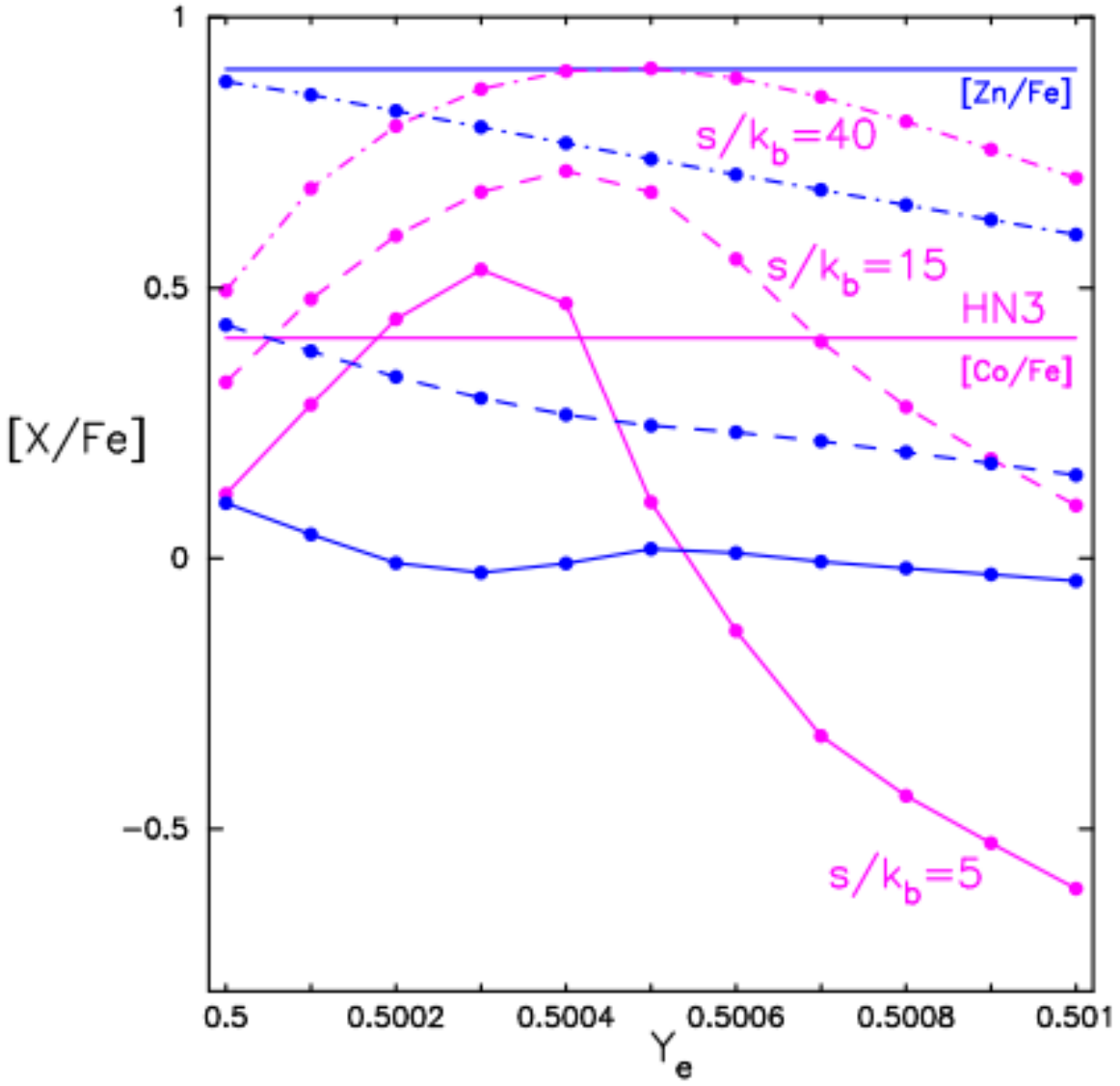
Total ejecta
= matter above mass-cut

WHAT IS NEEDED FOR WEAK-R ELEMENTS ?

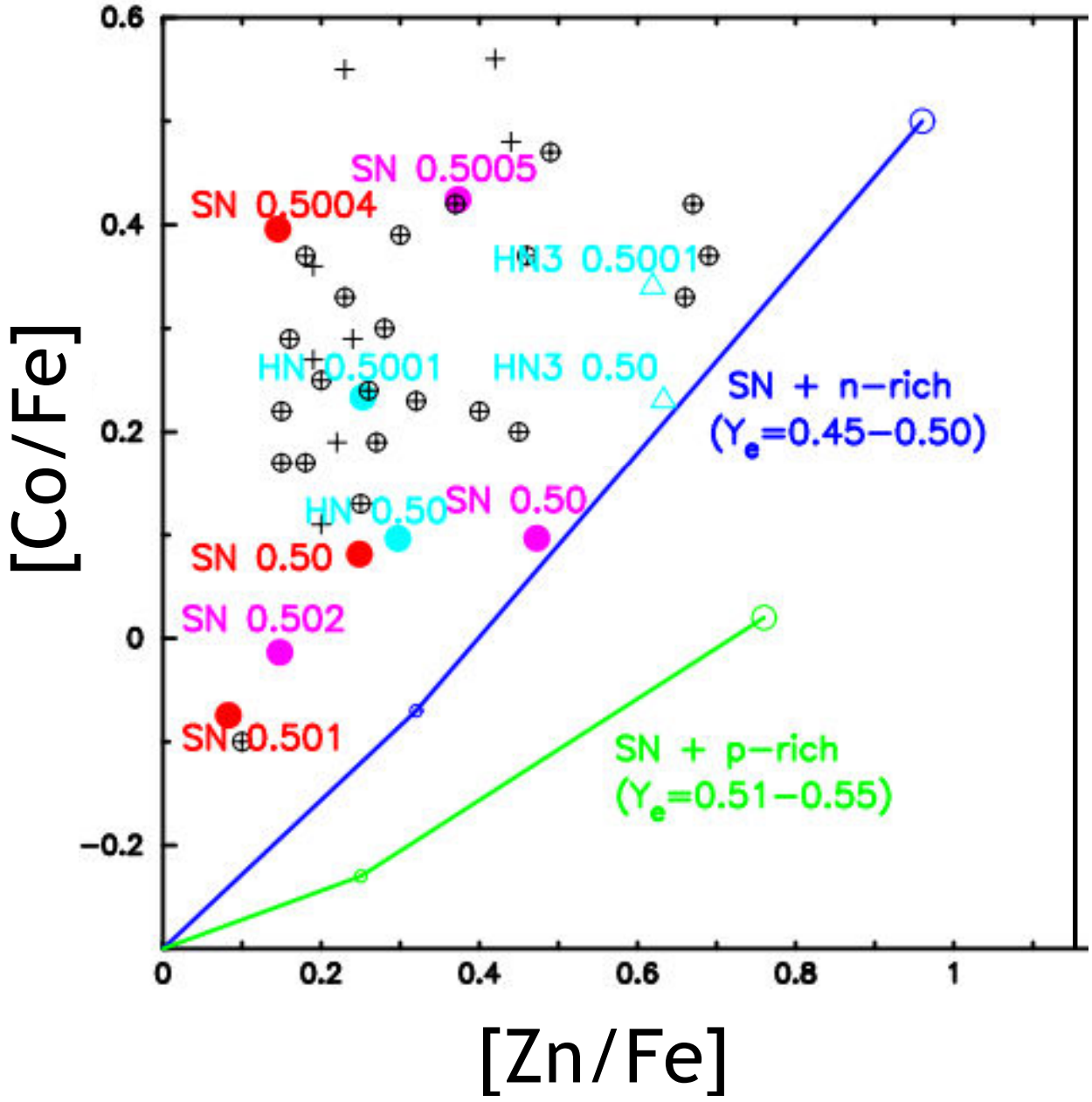


Neutron-rich matter with s ~150 is needed for weak r-process elements!

PARAMETER DEPENDENCE OF ZN AND CO IN HOT-BUBBLES



TOTAL EJECTA (ZN AND CO)

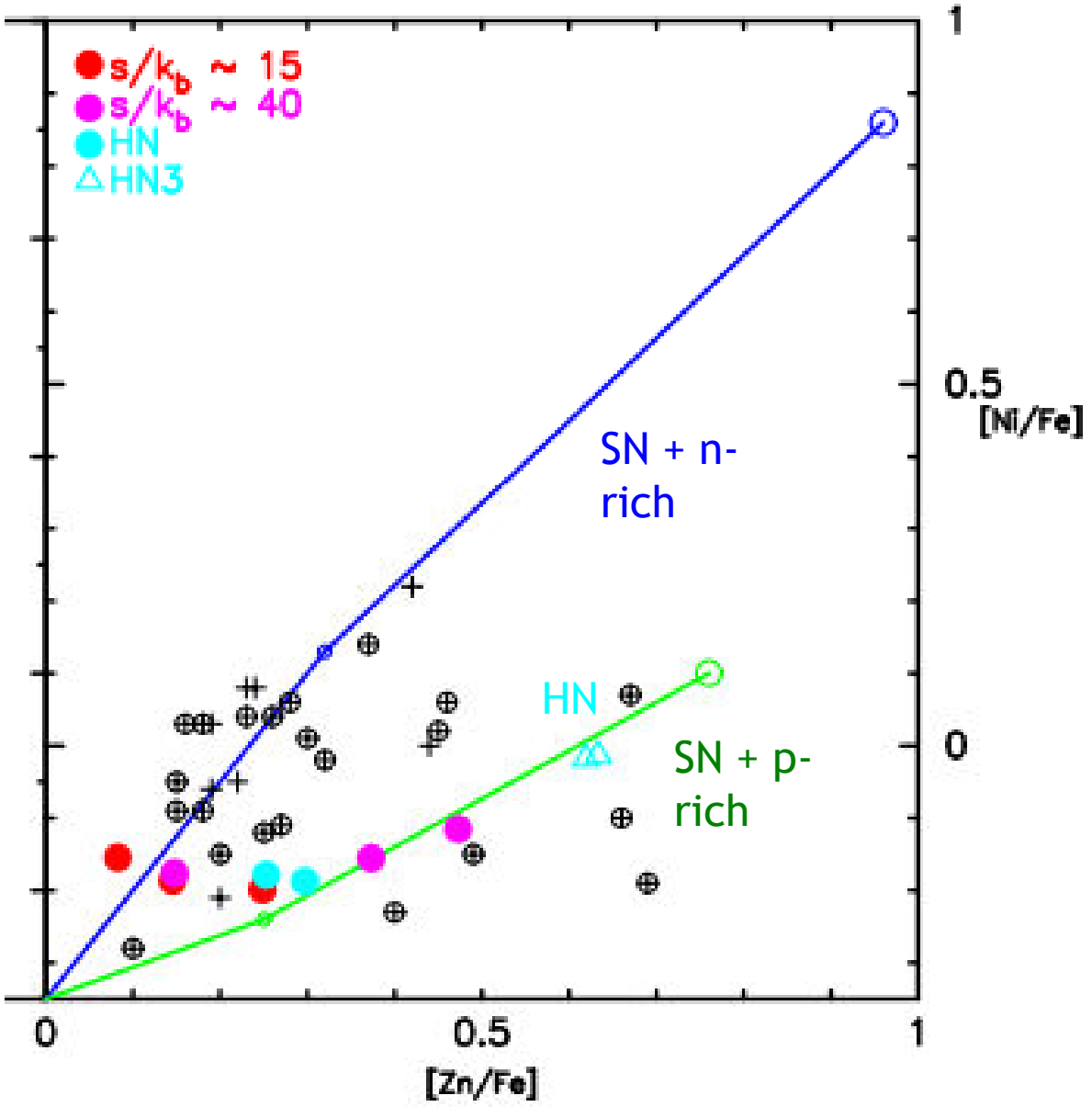


0.50<=Ye<0.501
s/kb=15-40
ΔM~0.06Msolar
is needed

s/kb~15

s/kb~40

TOTAL EJECTA (ZN AND NI)



BRIEF SUMMARY OF THE RESULTS

◆HN
or
◆normal SN added matter with
0.50<Ye<0.501 and s~15-40
as much as 0.06Msolar

can reproduce Co and Zn in EMP stars.

DISCUSSION (TIMESCALE)

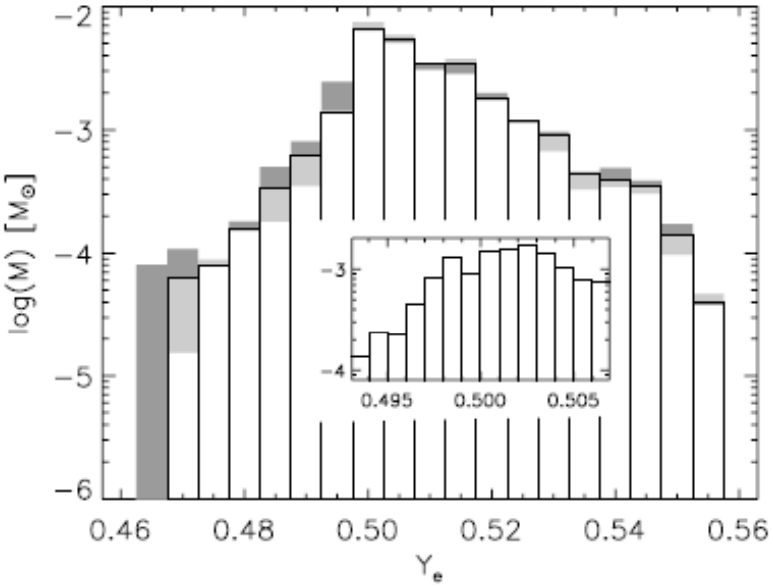
- [Co/Fe] is changed by the timescale below T9 = 4

- The timescale below T9 = 4 multiplied by a factor of ½ and 2 gives [Co/Fe] = 0.5 and 0.2, respectively, while [Co/Fe] ~ 0.4 in the original case

- The upper limit of Ye becomes a little larger ~ 0.502, and ejected mass, a little smaller ~ 0.03 Msolar

DISCUSSION (SIMULATION, VMP)

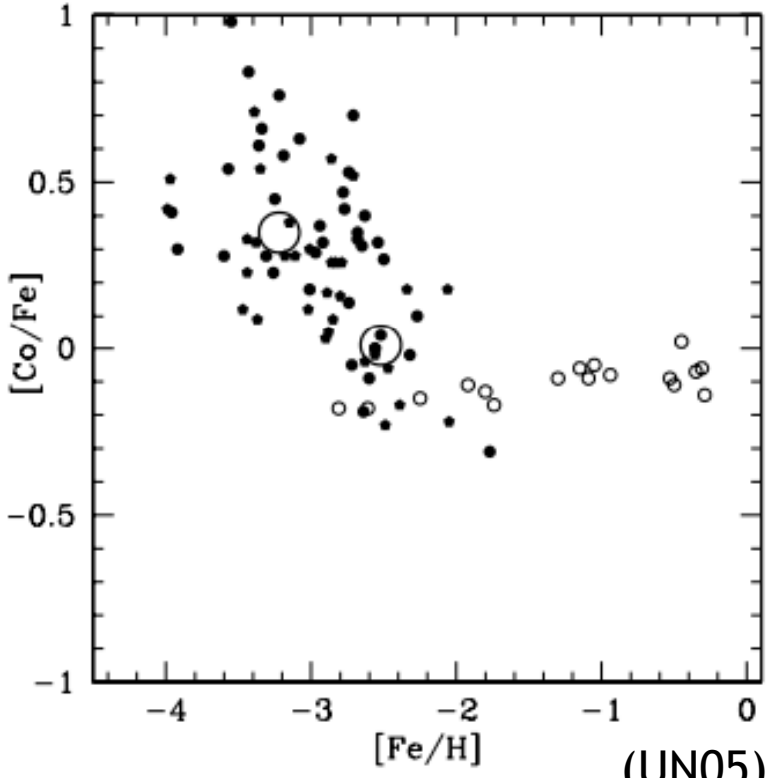
① comparison with simulation



(Janka+ 2003)

Ye < 0.47 1E-4 <Msolar
Ye <= 0.50 6E-3 Msolar
Ye > 0.50 0.03Msolar

② cannot explain VMP stars

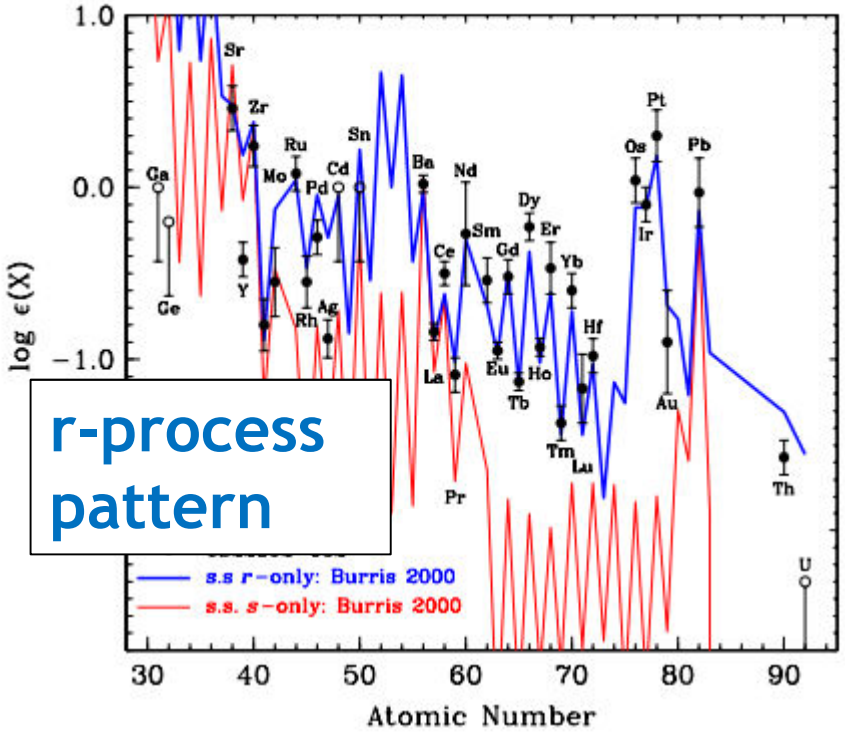


(UN05)

DISCUSSION (WEAK-R)

③ 0.50<=Ye<0.501, s/kb=15-40, ΔM=0.06Msolar
+ neutron-rich, s/kb~150 (weak-r)
Is it possible ?

HEAVY ELEMENTS



＊EMP heavier elements pattern
- s.s.r-process pattern
- enhanced lighter elements (weak r-elements, Sr, Y and Zr)

＊GCE(Travaglio+'04)
Solar Sr 8%, solar Y 18%
cannot be explained by
r-process(main r-process)

→r-process has at least two components
- main r-process (SN ν-driven wind×? , NS-merger ? Disk ?)
- weak r-process (the inner region of SN ?)