Nuclear Fission in r-Process Nucleosynthesis

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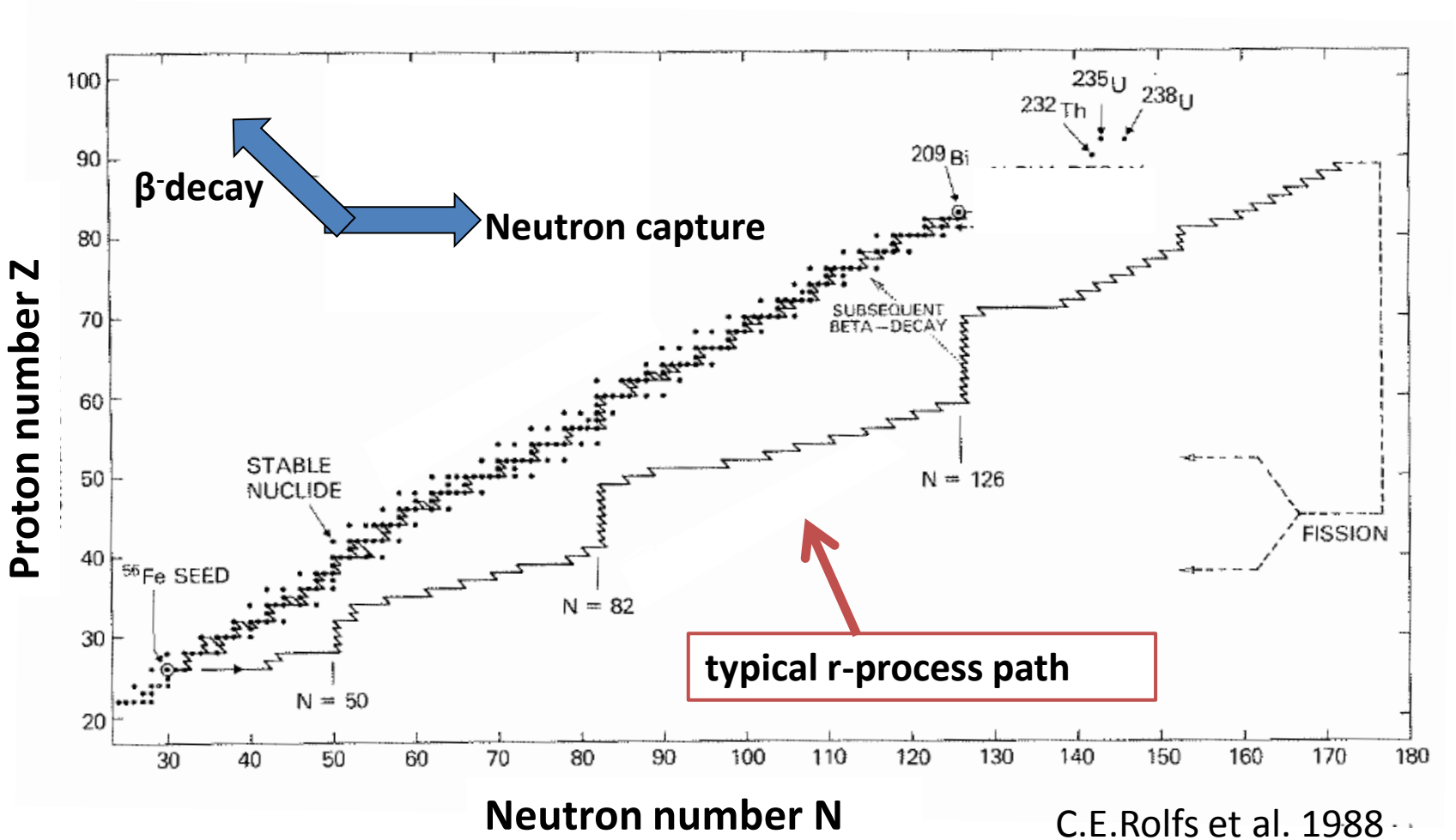
Introduction



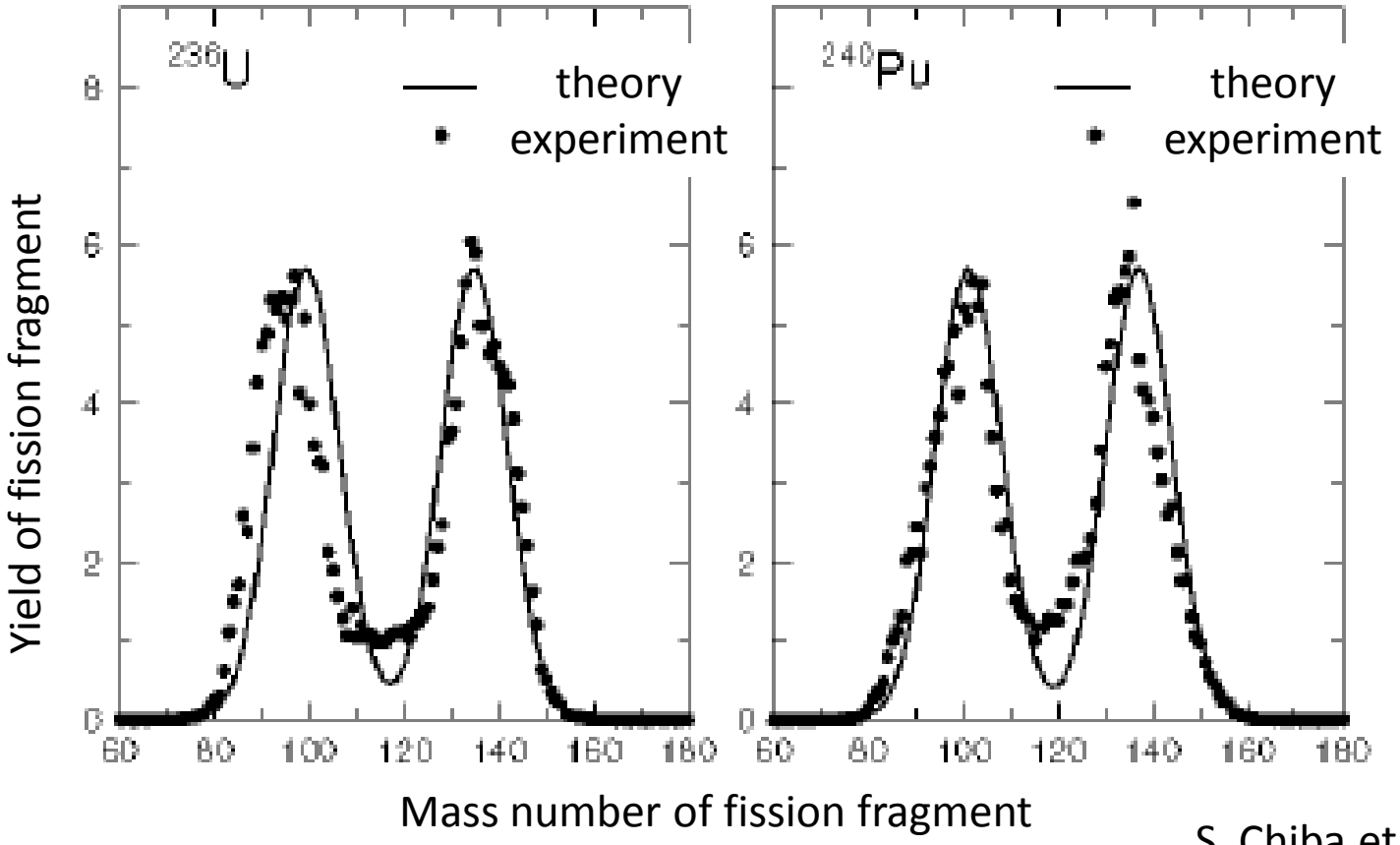
C.E.Rolfs et al. 1988

Motivation

- We don’t know where the r-process occurs.

  Supernova? Neutron star merger? Gamma-ray burst?
- If the fission occurs, we can expect that the elemental abundance pattern ejected from the site significantly changes.

Input data(1)
Fission Fragment Mass Distribution



S. Chiba et al. 2008

Our using data of the fluid

- neutrino-driven supernova(Woosley et al.1994)

  initial ye=0.43, initial density~10^6[g/cm^3]

- magnetohydrodynamic jet explosion of supernova(Nishimura et al.2006)

  initial ye=0.16, initial density~10^7[g/cm^3]

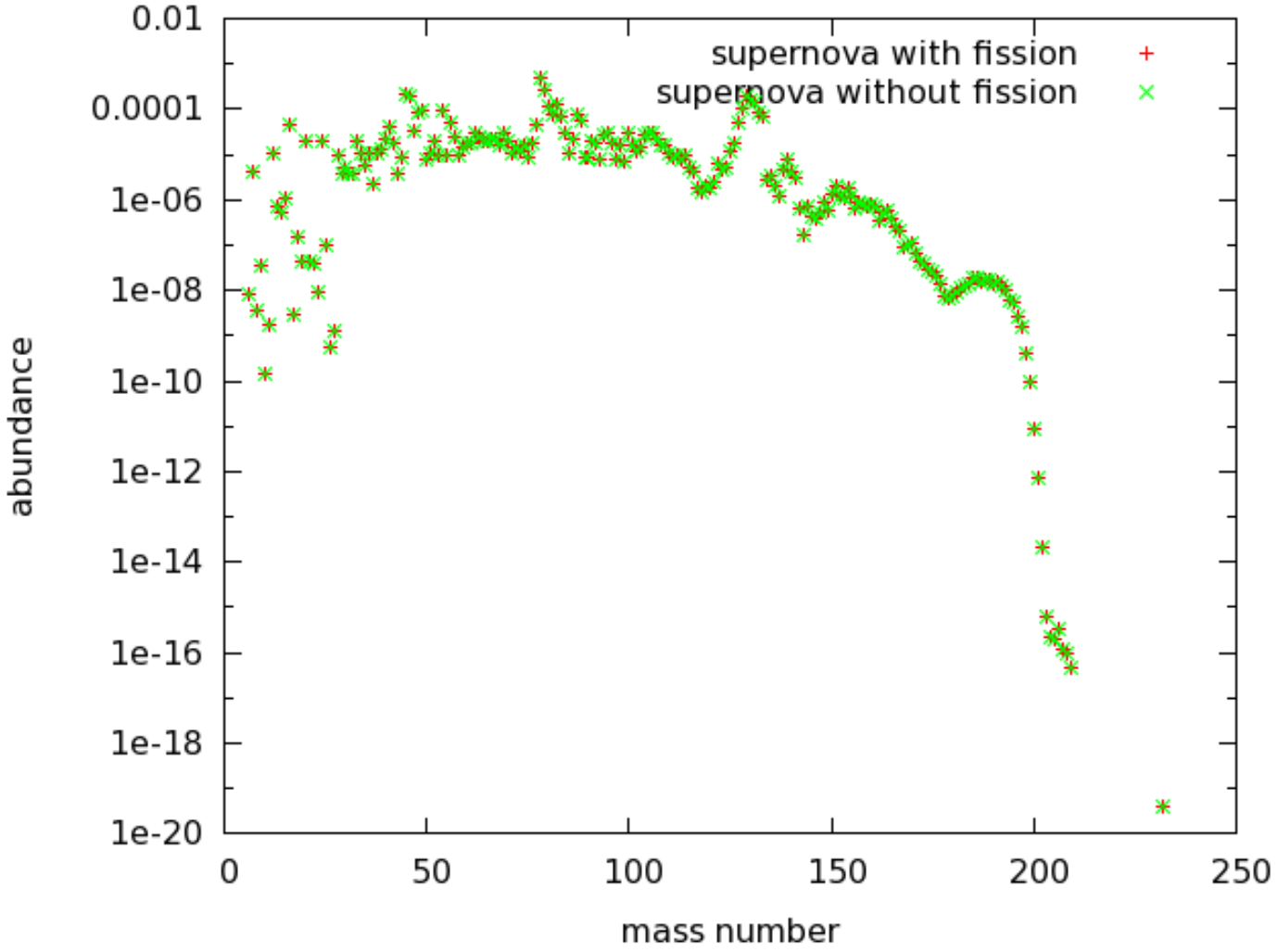
- neutron star merger (Freiburghaus et al.1999)

  initial ye=0.10, initial density~10^{11}[g/cm^3]

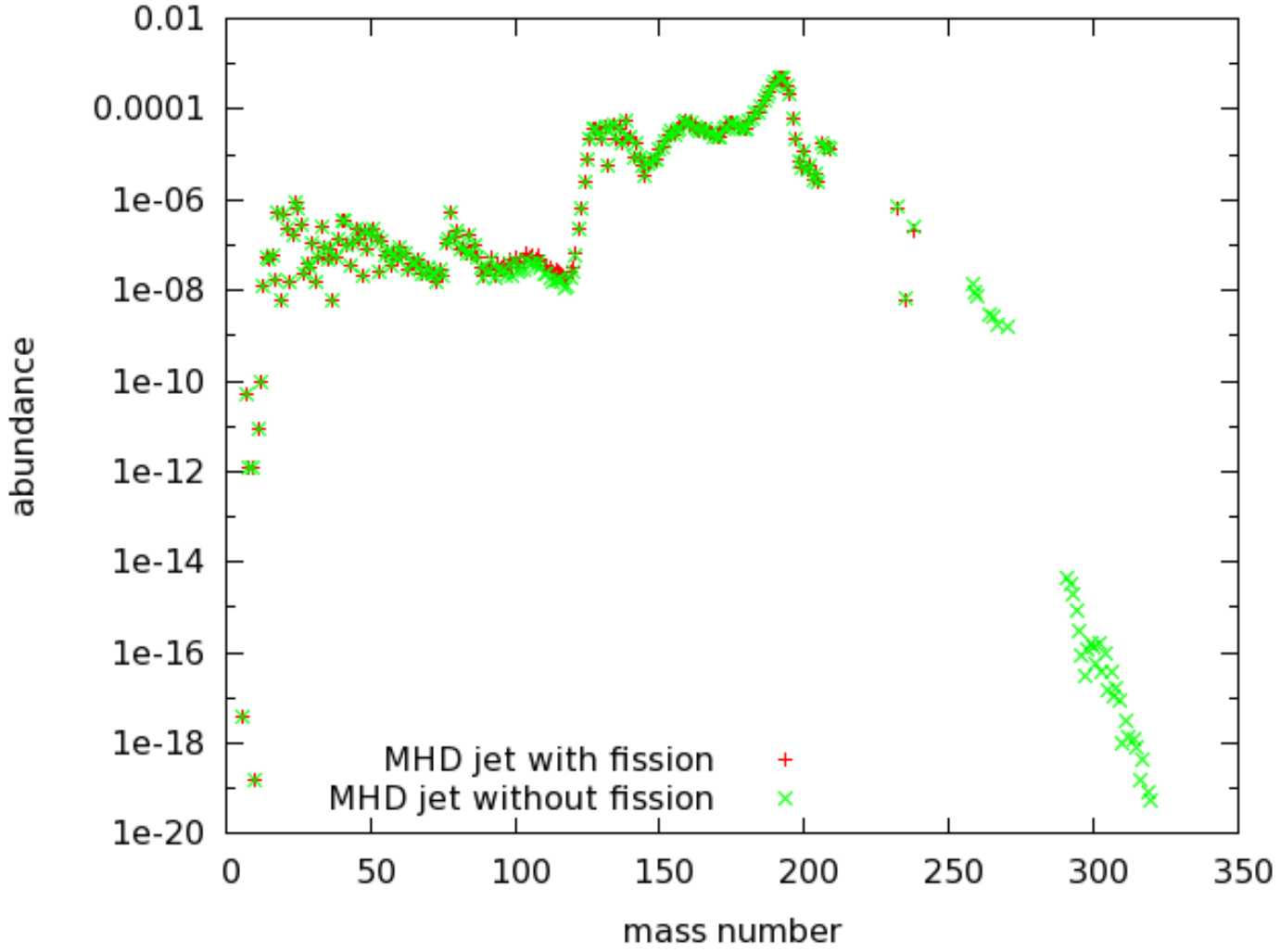
topic

1. How dose the fission affect the final abundance pattern for each r-process candidate site using new fission data?
2. How many fission cycles occur.

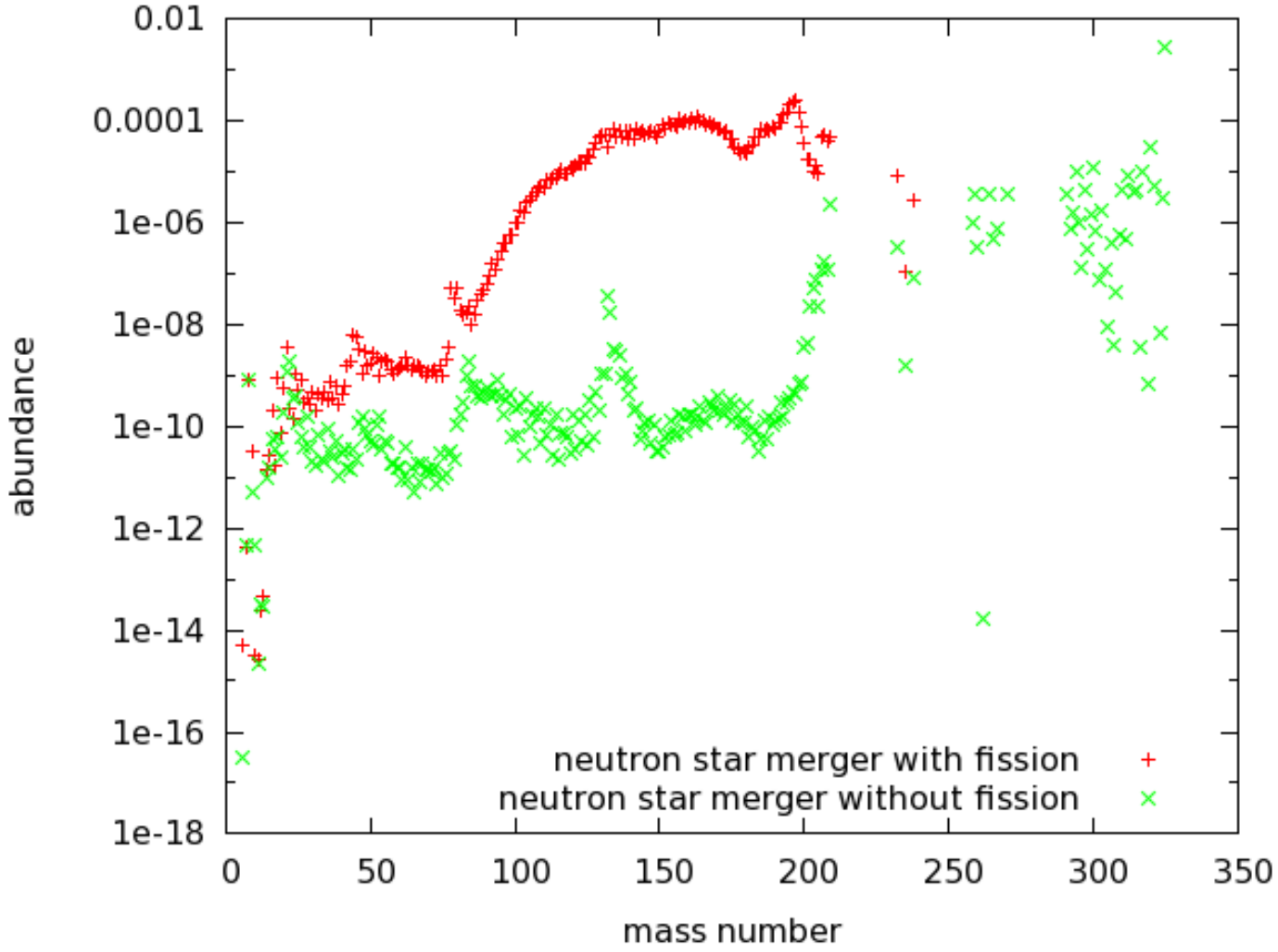
Neutrino Driven Wind



MHD Jet


0.01
0.0001
1e-06
1e-08
1e-10
1e-12
1e-14
1e-16
1e-18
1e-20
abundance
0
50
100
150
200
250
300
350
mass number
MHD jet with fission
MHD jet without fission

Neutron Star Merger



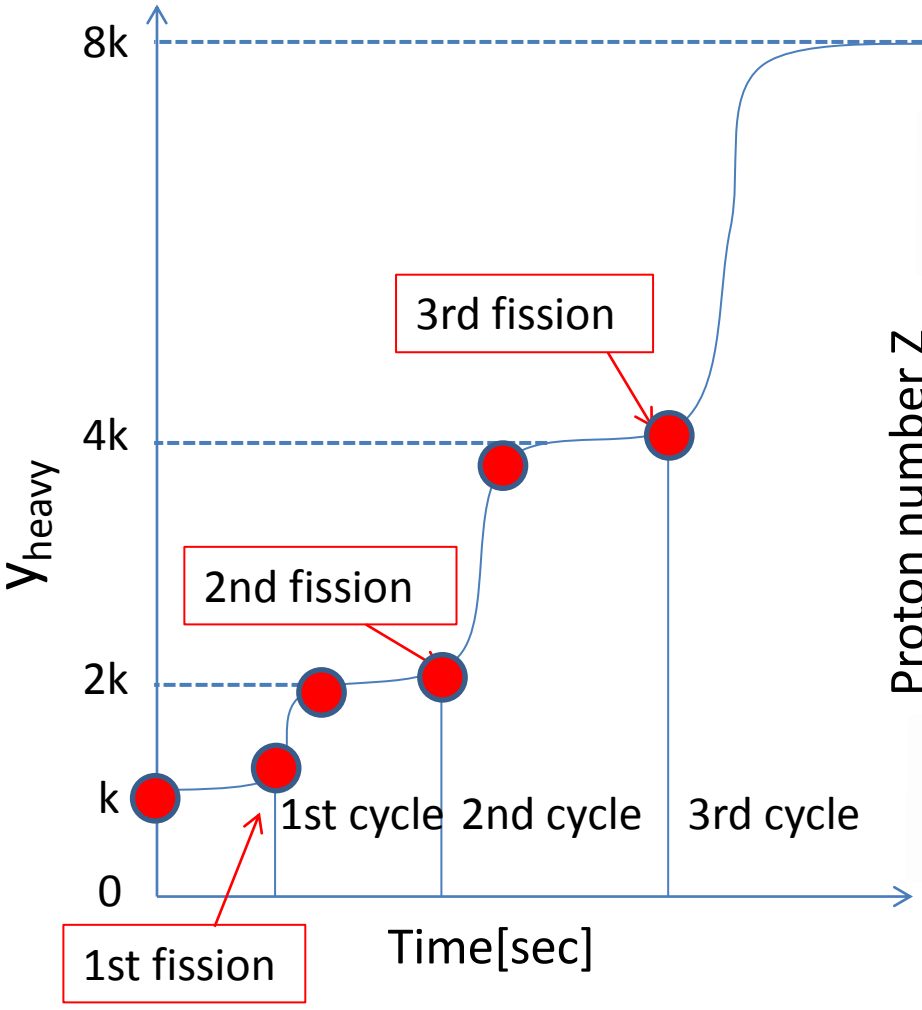
Result

- The final abundance patterns of the neutrino-driven wind and the MHD jet are not affected by the nuclear fission, while the neutron star merger is largely affected by it.
- Therefore, we consider only the neutron star merger to investigate how many fission cycles occur.

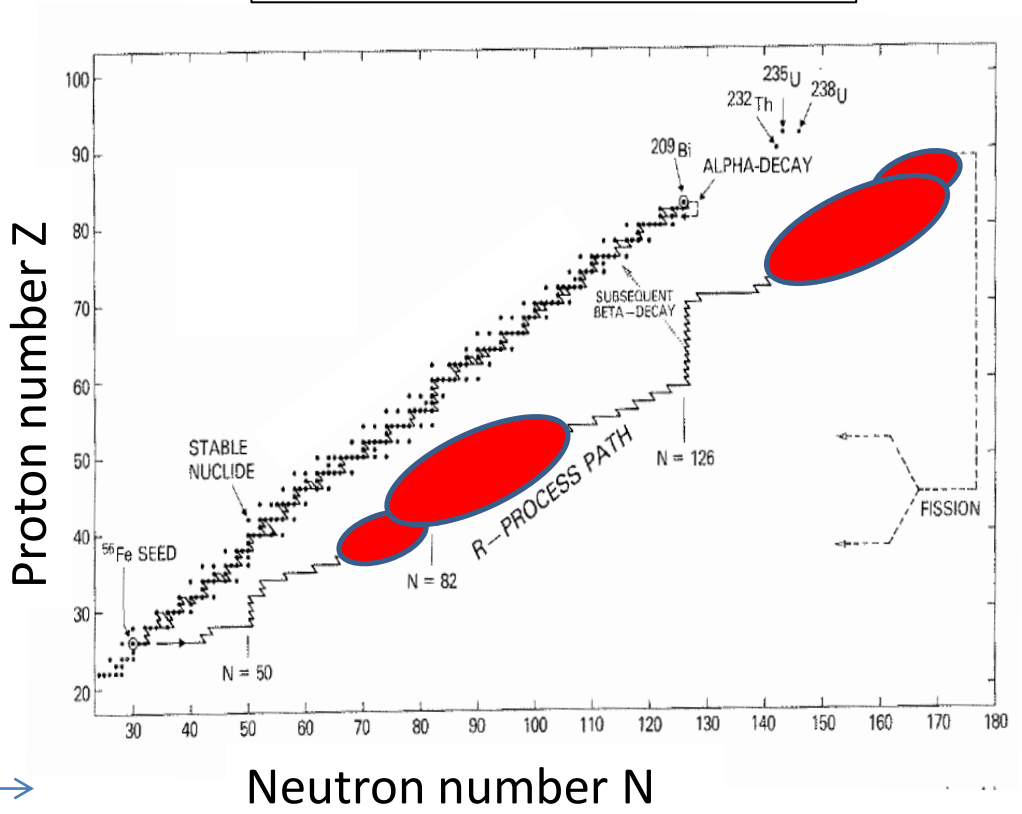
topic

- How does the fission affect the final abundance pattern for each r-process candidate site using new fission data?
- How many fission cycles occur?

Indicator of fission

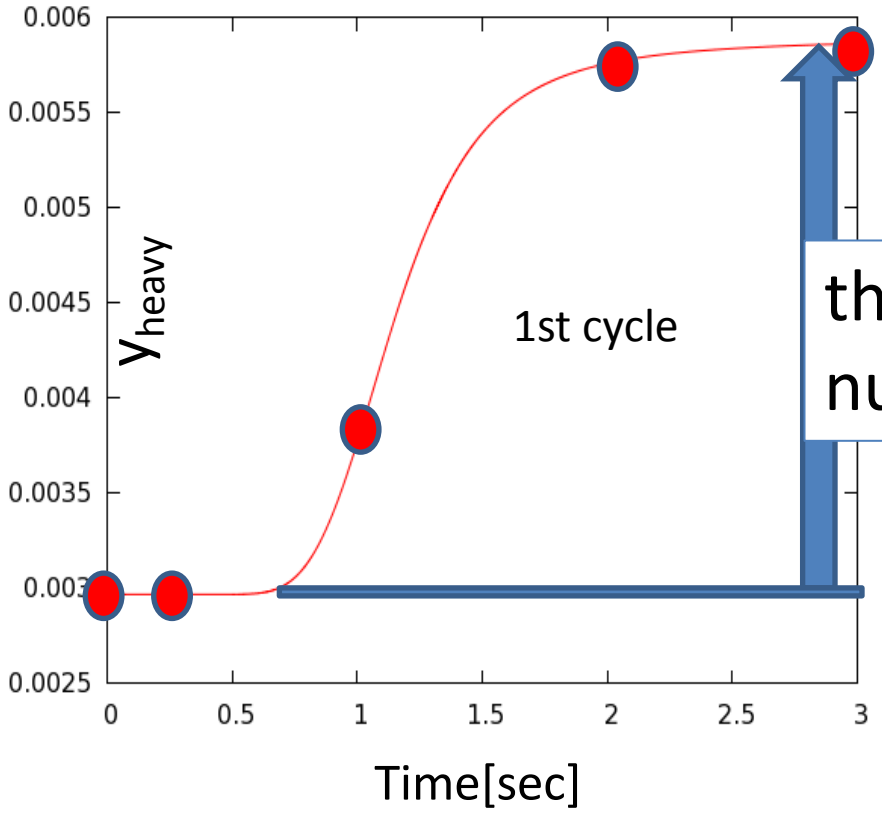


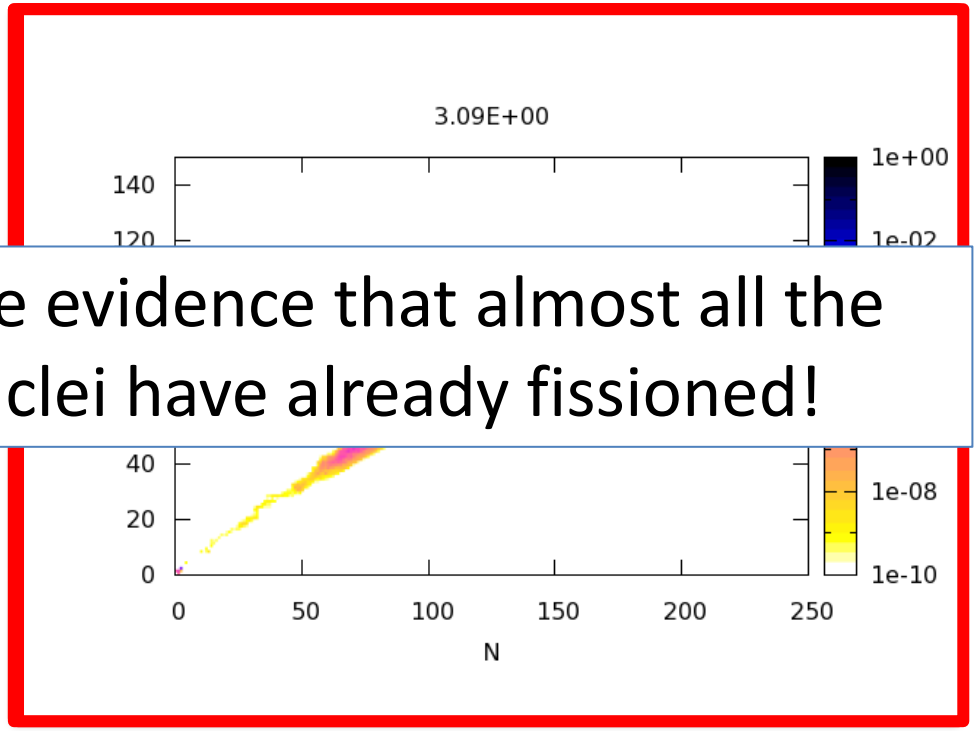
$$y_{heavy}=\sum_{Z>2,N} y(Z,N)$$



C.E.Rolfs et al. 1988

Indicator of fission





the evidence that almost all the nuclei have already fissioned!

Result

- Almost all the nuclei fissioned.
- Fission cycle started but neutron capture stopped before one cycle is finished.

Summary

- We calculated r-process nucleosynthesis for three candidate site(Supernova ,MHD jet ,Neutron star merger) with new fission data.
- We could find that there is the effect of fission for Neutron star merger only.
- We formed the quantity to count fission cycles and there are no fission cycles even for neutron star merger.

Future Work

- We will apply our network code to modern numerical simulation of neutron star merger(Korobkin et al. 2012).