# Nucleosynthesis processes

"regular burning"

pp / CNO → He

α - process → abundant nuclei
"α" nuclei
up to $^{56}Fe$ [$^{56}Ni$]

S - process → "weak" in massive stars
≤ low
"main" in AGB stars

"strong" in low-Z stars

$^{56}Fe$ → S-process path
→ n-rich nuclei along line of stable nuclei
assume: n-capture time ≈ $\beta^-$ decay time
~ time-scale of stellar evolution

r-process  rapid neutron capture

We do not know origin

. may be
  - hot wind from proto-neutron star
  - nucleosynthesis in vicinity of NS
  - NS-NS mergers

need: short time scale ($\lesssim$10-100s)
high entropy
n-excess?
make seed, but not too many

p-process  really: $\gamma$-process
$(\gamma, x)$

→ p-rich nuclei

[historically (p,$\gamma$) similar to (n,$\gamma$-)

+ $\nu$-process
$(\nu, x)$  neutral current

$(\nu_e, [x]e^-)$
$(\bar{\nu}_e, [x]e^+)$

νp process → some p-process
made p-rich environment
by $n(\nu_e, e^-)p$

α-rich freezout from NSE

→ some nuclei above $^{56}Ni$
Cu, Zn

XRB: [Hot CNO cycle]

αp-process really fast, up to ~$^{56}Ni$
(p,γ) + (α,p)
α-capture catalyzed by protons

rp-process up to A ~ 106
Sn-Te-Sb cycle
delayed by $\beta^+$ decays
@ proton drip line

# s-proc — Branching Points

T-dep decay

long-lived nuclei

→ $\tau_{STAR} \sim \tau_{\beta^-}$

Seeds for s-proc: start @ $^{56}Fe$!

Sources of neutrons:

Massive stars: $^{22}Ne(\alpha, n)^{25}Mg$

He-burn, C-burn

$^{12}C + {}^{12}C \rightarrow {}^{23}Na + p$

$^{23}Mg + n \longrightarrow$

p-capture, $\beta^+$, $(\alpha, n)$

low-M stars

$^{13}C$ pocket

$^{13}C$ from $^{12}C(p,\gamma)$

$^{13}C(\alpha, n)^{16}O$