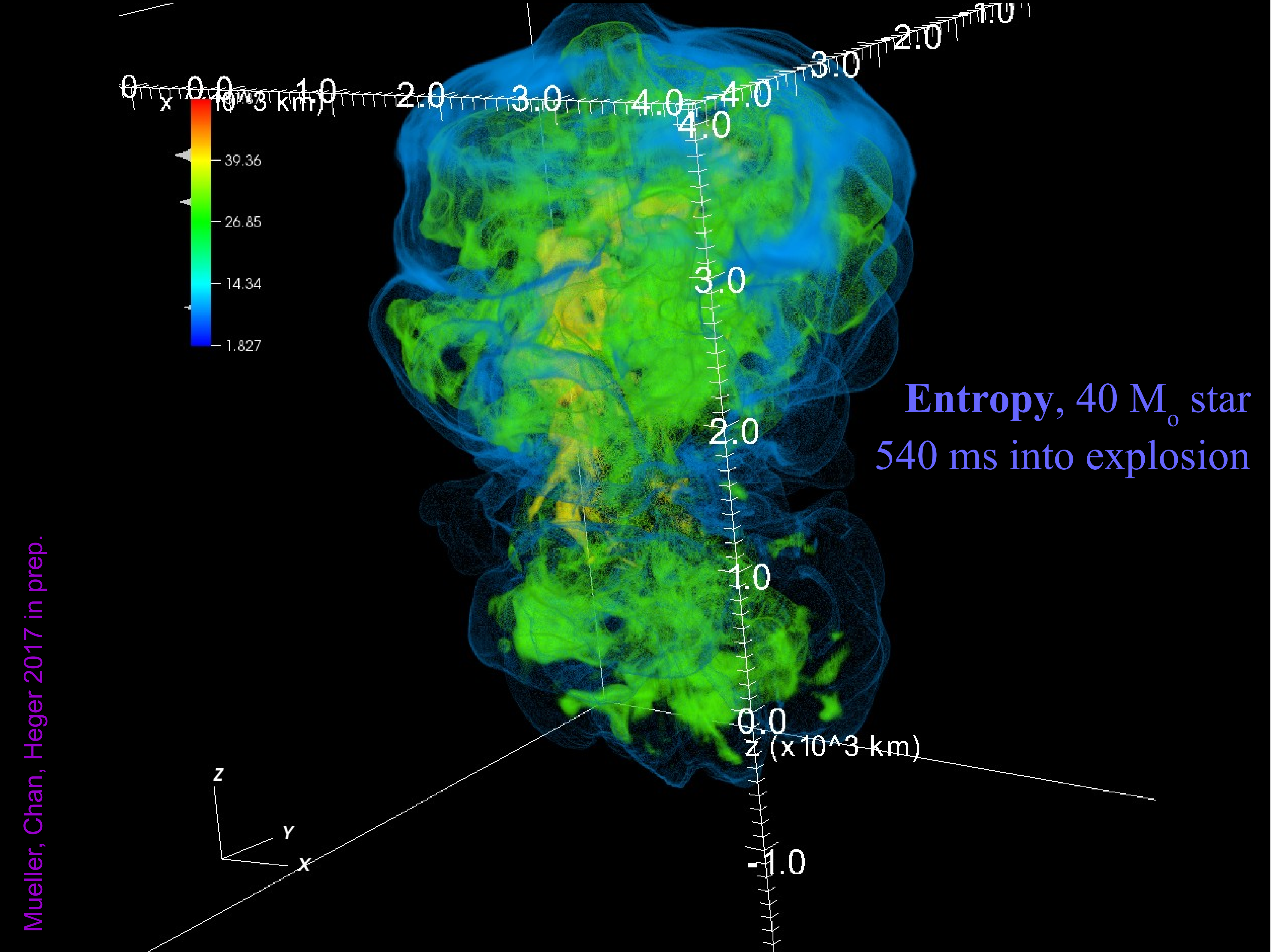


Entropy, 40 M$_o$ star
540 ms into explosion
Mueller, Chan, Heger 2017 in prep.
39.36
26.85
14.34
1.827
z (x 10^3 km)

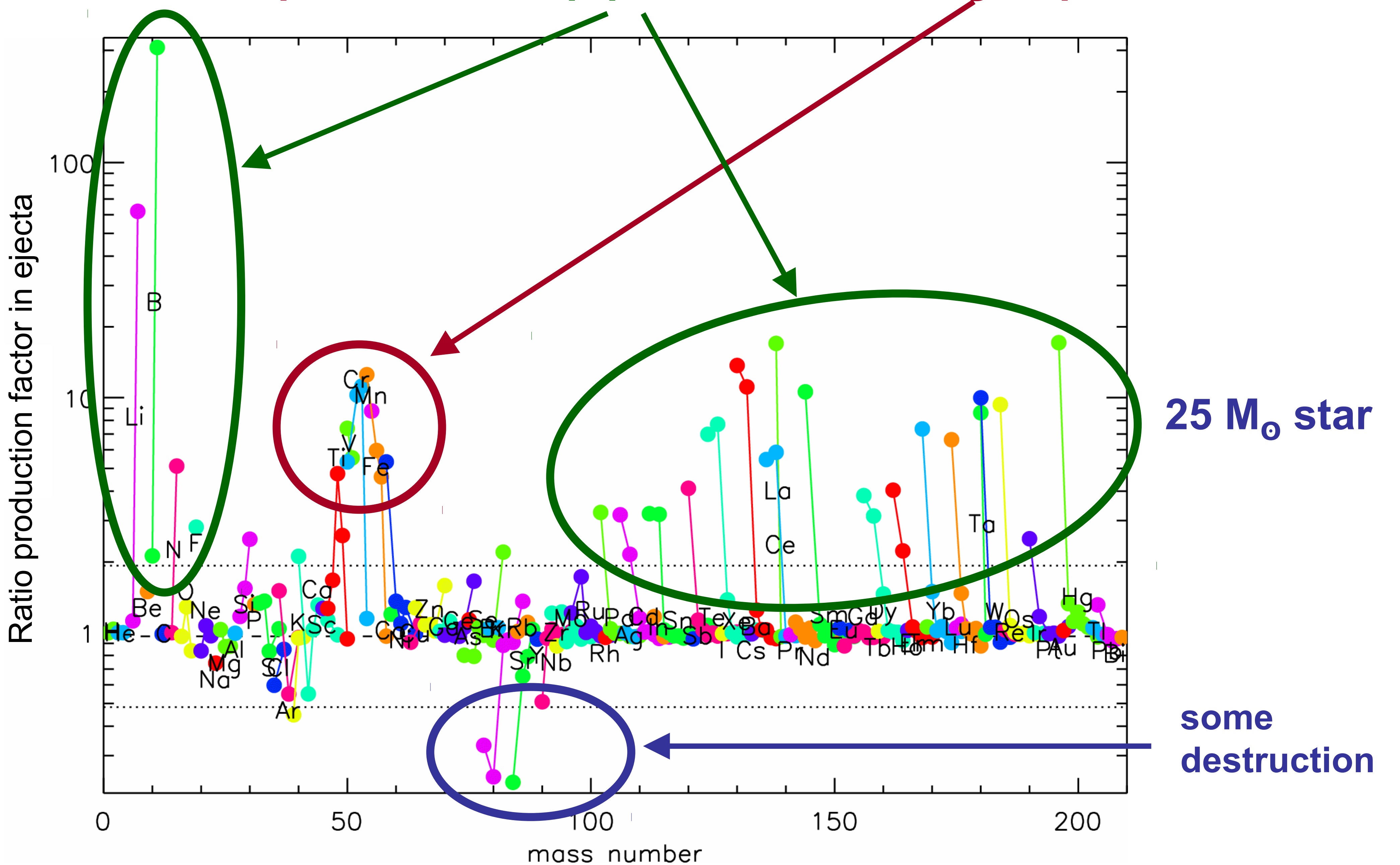
Explosive Nucleosynthesis

in supernovae from massive stars

Fuel	Main Product	Secondary Product	T (10^9 K)	Time (s)	Main Reaction
Innermost ejecta	***r*-process?** **νp-process**	-	**>10?**	**1**	(n,γ), β^-
Si, O	^{56}**Ni**	**iron group**	**>4**	**0.1**	(α,γ)
O	**Si, S**	**Cl, Ar,** **K, Ca**	**3 - 4**	**1**	$^{16}O + ^{16}O$
O, Ne	**O, Mg, Ne**	**Na, Al, P**	**2 - 3**	**5**	(γ,α)
		***p*-process** ^{11}**B**, ^{19}**F**, ^{138}**La**, ^{180}**Ta**	**2 - 3**	**5**	(γ,n)
		ν-process		**5**	(ν, ν'), (ν, e^-)

Explosive Nucleosynthesis contribution

→production of p-process and iron group



Overview:

Scales

"Beers Scale"

[Fe/H] ("metallicity")	Name
$\lesssim -1$	metal-poor stars
$\lesssim -2$	very metal-poor stars
$\lesssim -3$	extremely metal-poor stars
$\lesssim -4$	ultra metal-poor stars
$\lesssim -5$	hyper metal-poor stars
$\lesssim -6$	mega metal-poor stars
zero metallicity	primordial stars (Population III stars)

adopted from Beers and Christlieb

Stellar Mass Scale

Mass Range ($M_\odot$)	Name
10 – 100	massive stars
100 – 1,000	very massive stars
1,000 – 10,000	extremely massive stars
10,000 – 100,000	ultra massive stars
100,000 – 1,000,000	hyper massive stars
1,000,000 – 10,000,000	mega massive stars
$\gtrsim 150,000$	supermassive stars[†]

[+] stars that do not enter hydrostatic burning

20170327-1-

Supernovae - Outline

$1 B = 10^{51}$ erg

↑

"Bethe"

= 1 foe

- after central Si burn
  or off-centre Si burn
  → core above critical mass
  → collapse initiated by electron capture (EC)
  → followed by photo-desintegration
    Fe → α → p, n
  → core bounce as nuclear density is reached
  → outward shock loses E due to
    - ν loss
    - photo-desintegration
  → shock "stalls"

SN energies

$1\,M_\odot c^2 \simeq 2\times10^{54}$ erg

- SN total ~ 15 % of NS rest mass

→ SN (ν) ~ $3\text{-}5\times10^{53}$ erg total (99% ν's)

- observed SN 1987A: total kinetic Energy

$1\text{-}2\times10^{51}$ erg → $\lesssim 1\%$ of E

(measurement of mass and velocity)

- SN photons / visible: typical 10^{49} erg

($\lesssim 0.01\%$ of total E !)

[Q: why?

! gas cools due to adiabatic expansion

while optically thick

Despite initially a radiation bubble

E converted to E_{KIN} by PdV work