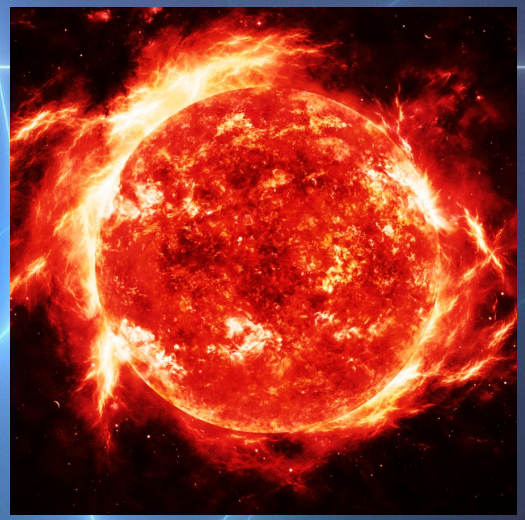
Role of supergiants in the formation of globular clusters

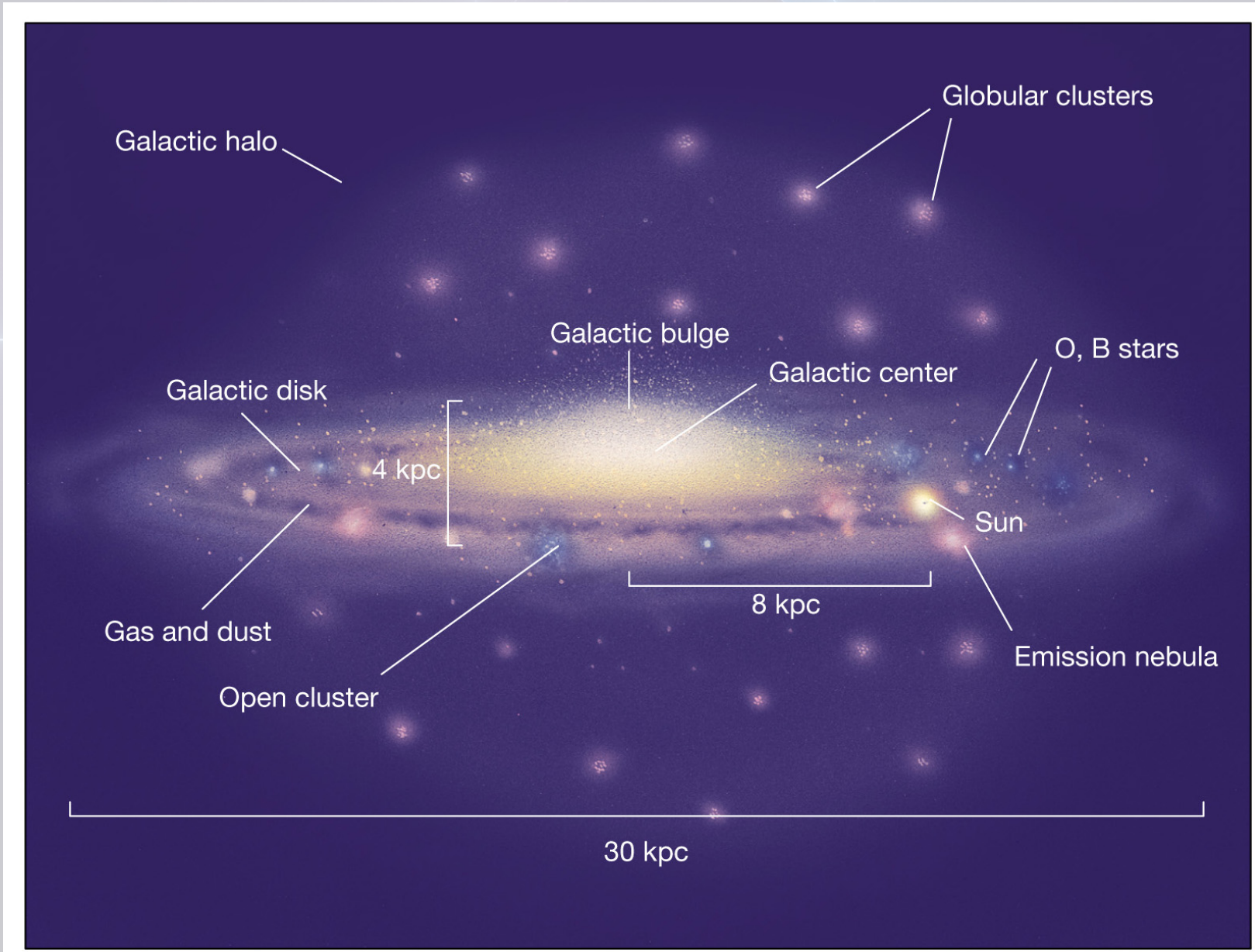
Dorottya Szécsi

University of Birmingham



Royal Observatory Edinburgh
10th October 2018

The problem with globular clusters



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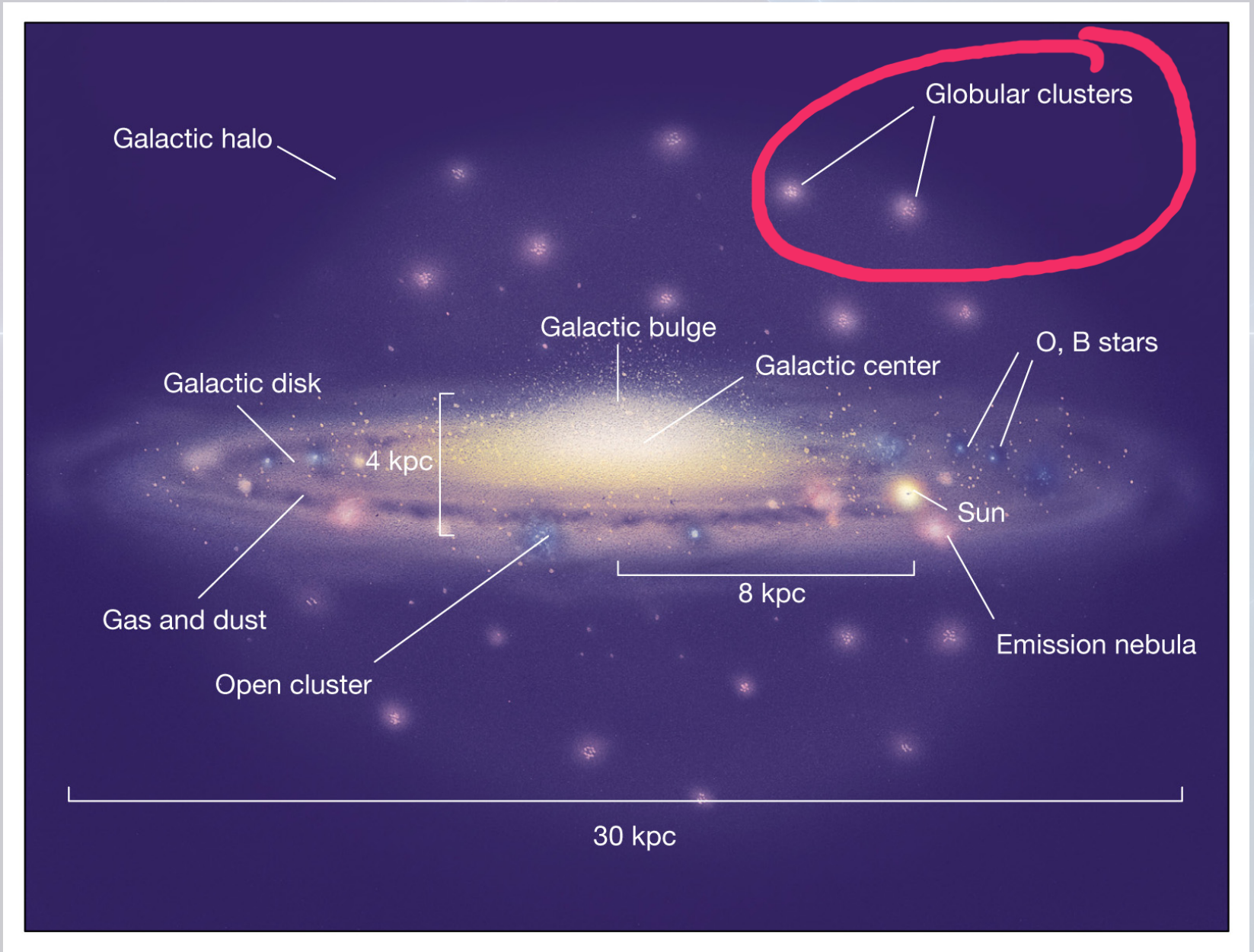

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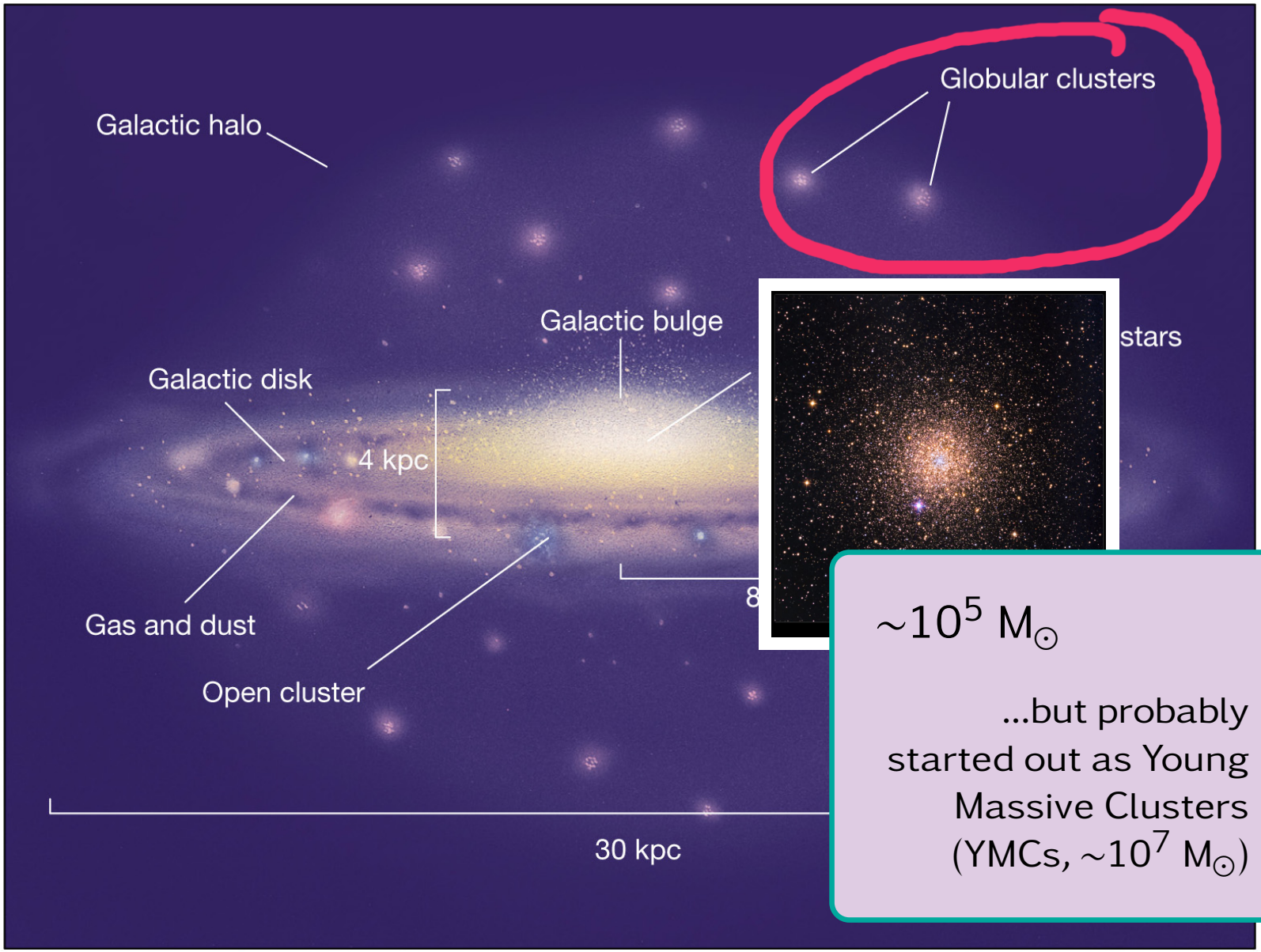
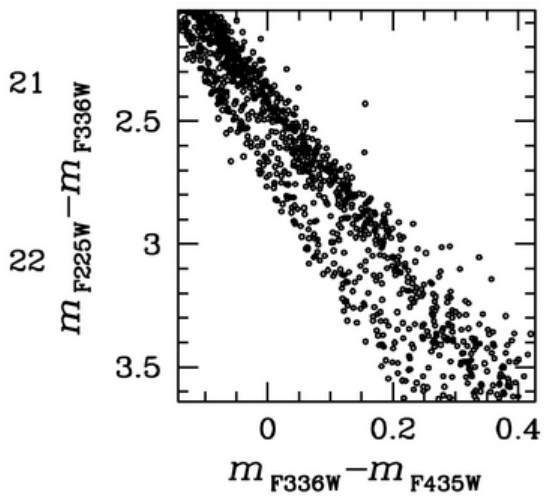


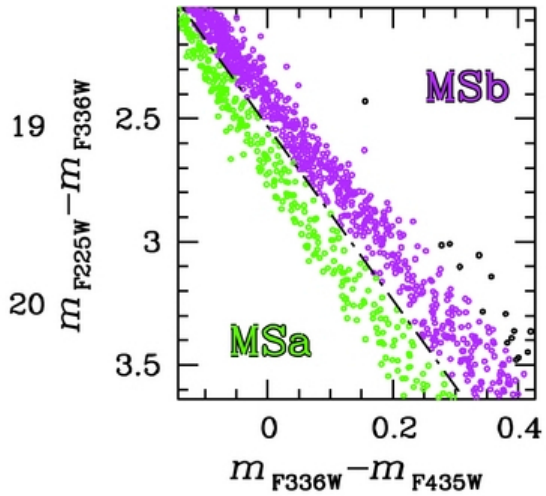
$\sim 10^5\ M_\odot$

...but probably started out as Young Massive Clusters (YMCs, $\sim 10^7\ M_\odot$)

The problem with globular clusters

Main-sequence split





(Credit: Milone+11)

Globular clusters

stars

30 kpc

ut probably
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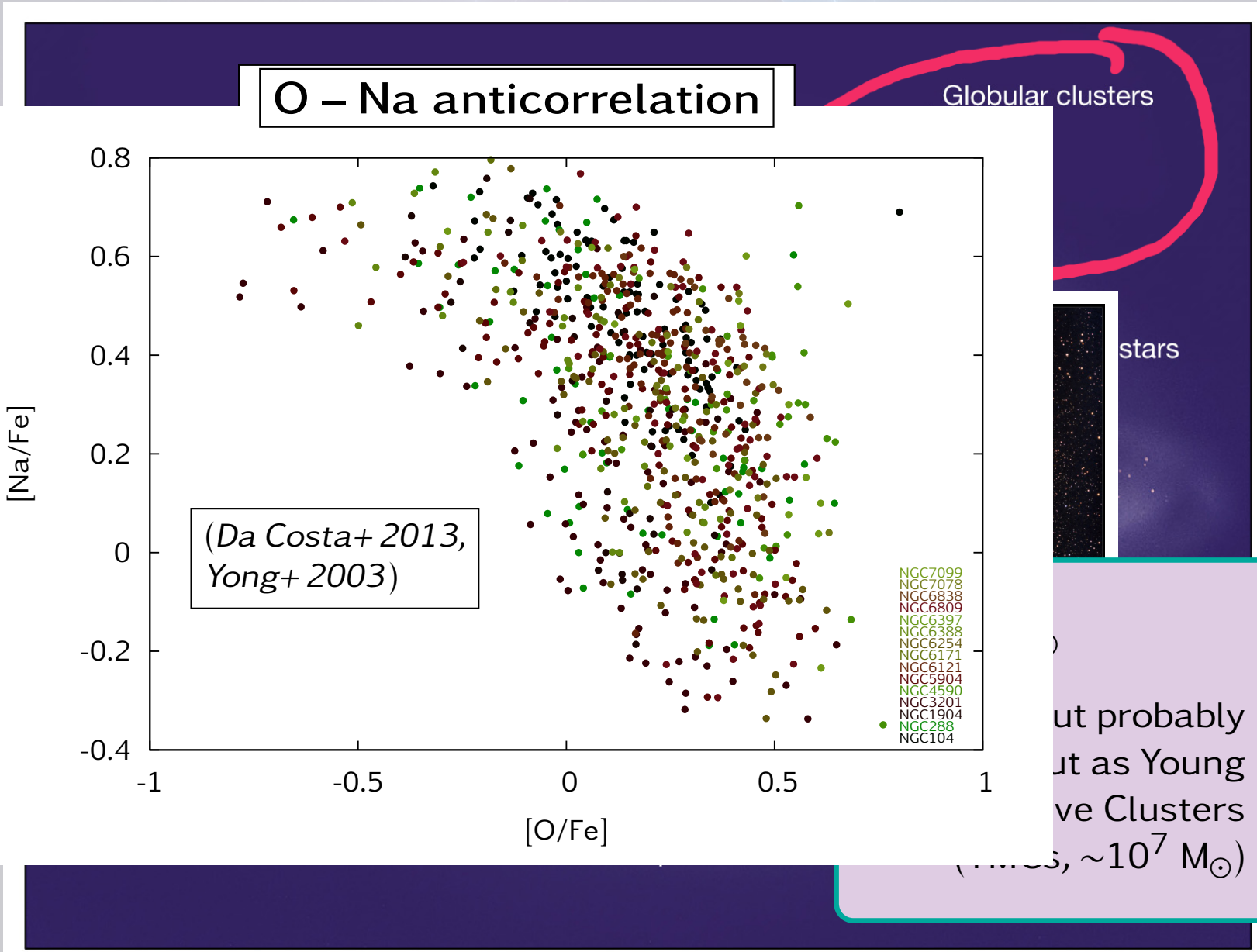
(YMCs, ~10^7 $M_\odot$)

The problem with globular clusters



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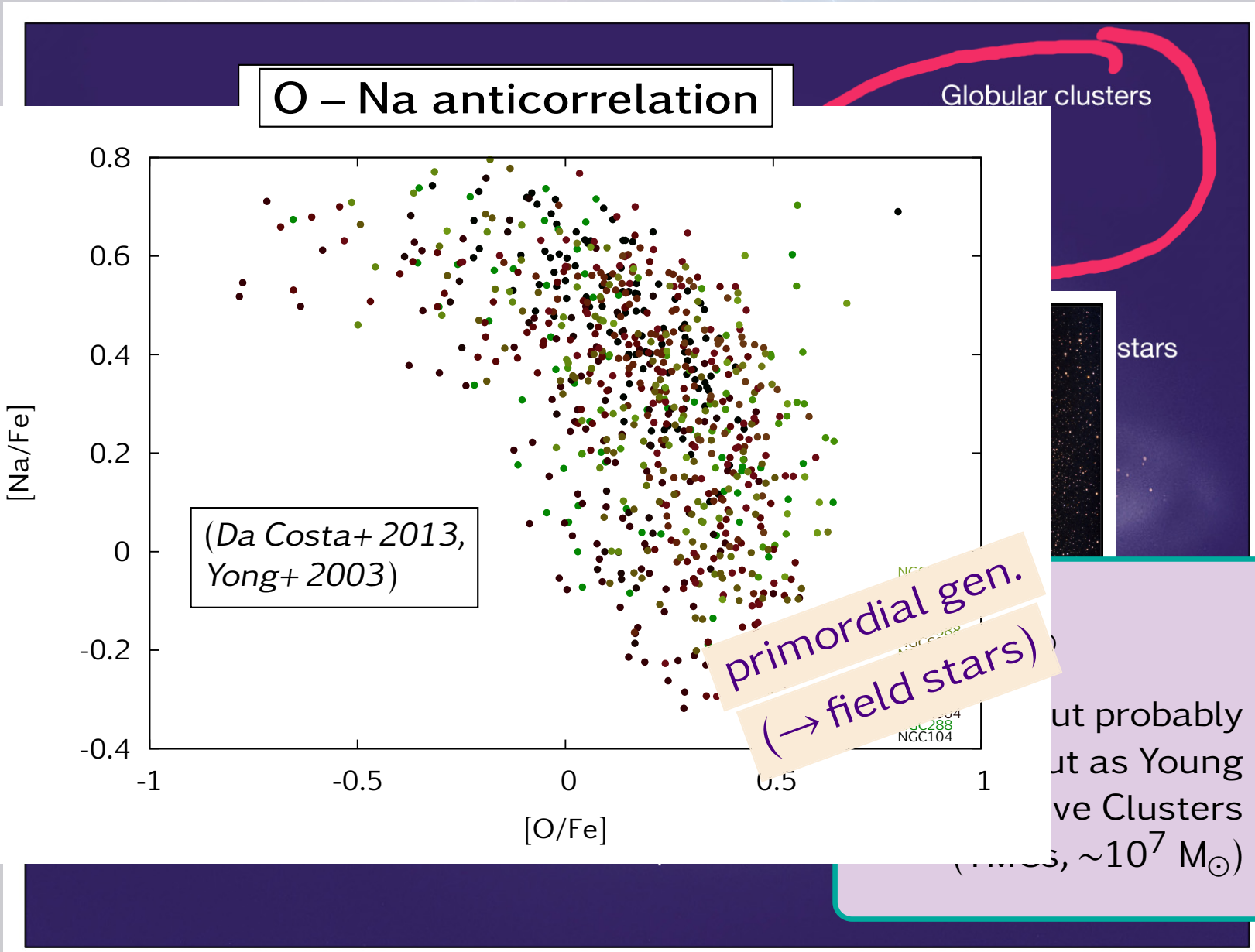

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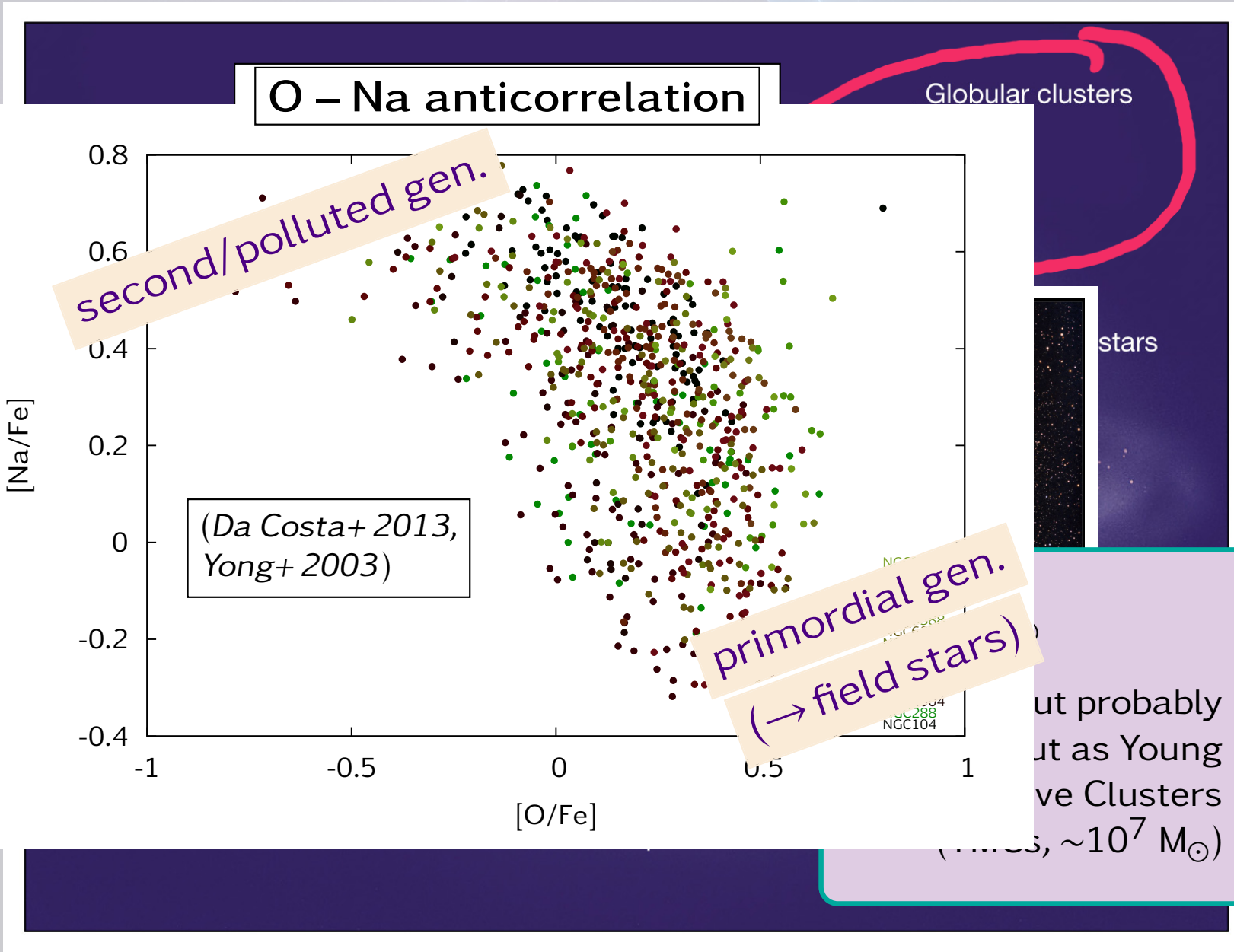

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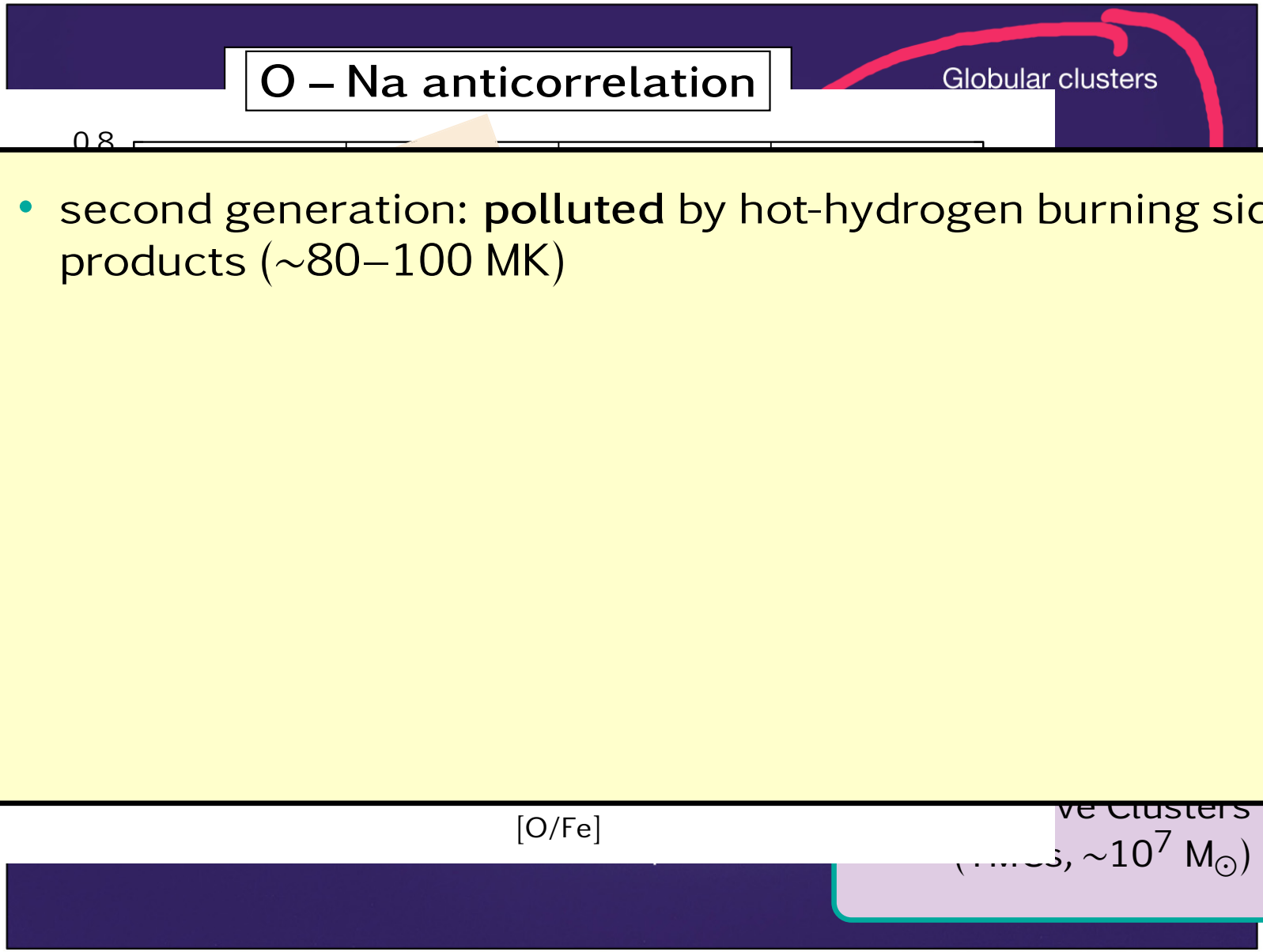

- second generation: **polluted** by hot-hydrogen burning side products (~80–100 MK)

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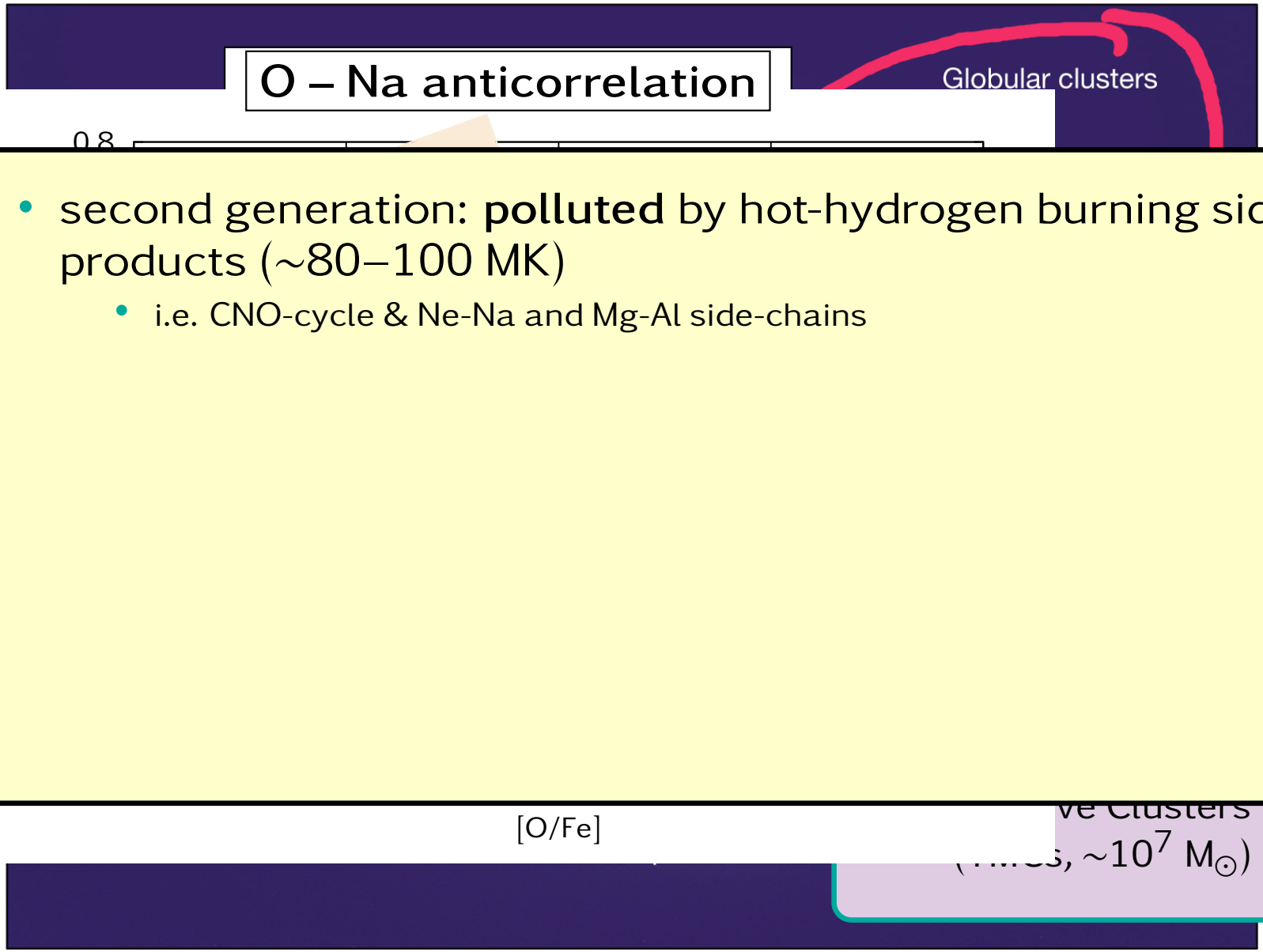

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  - i.e. CNO-cycle & Ne-Na and Mg-Al side-chains

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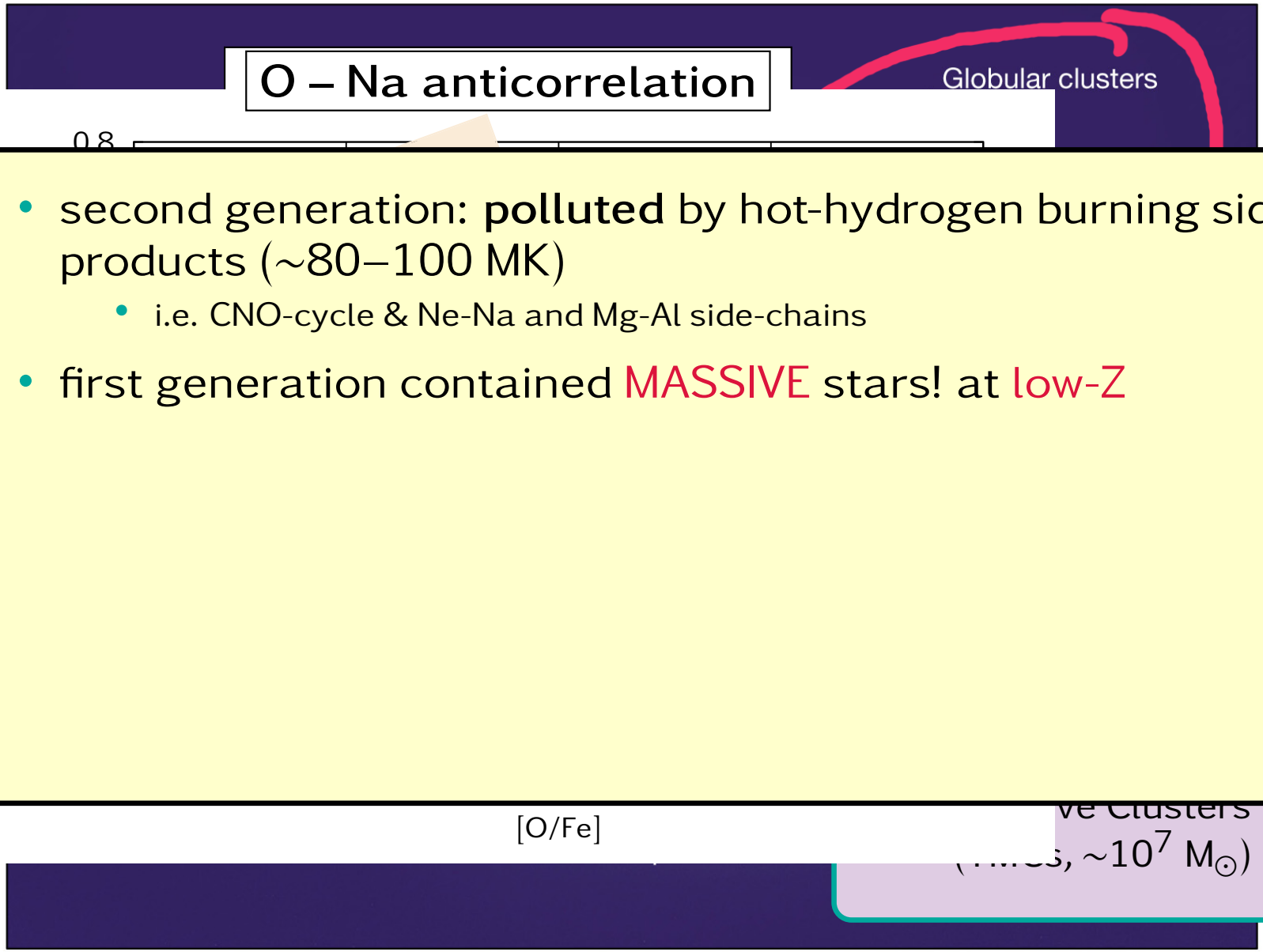

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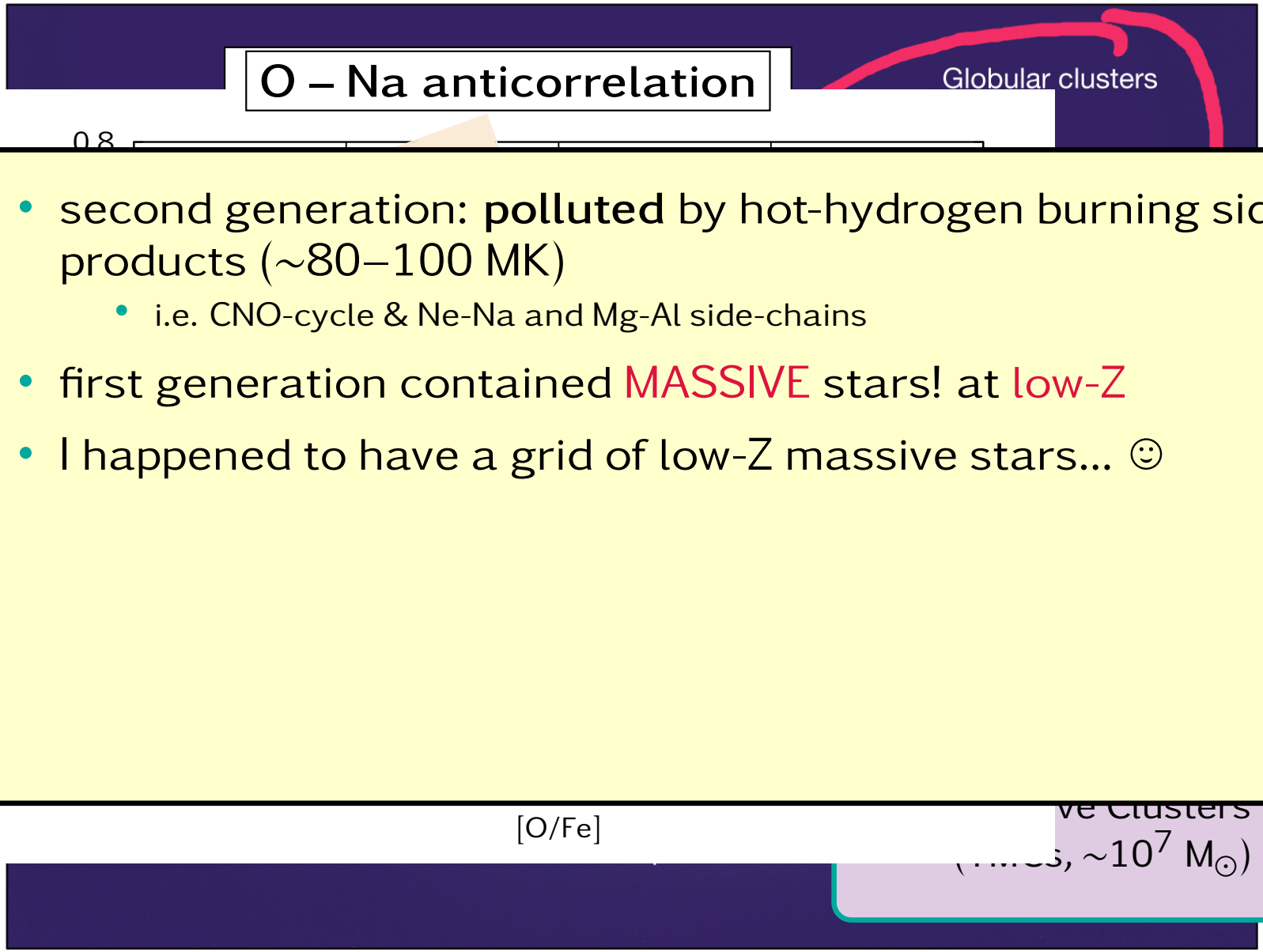

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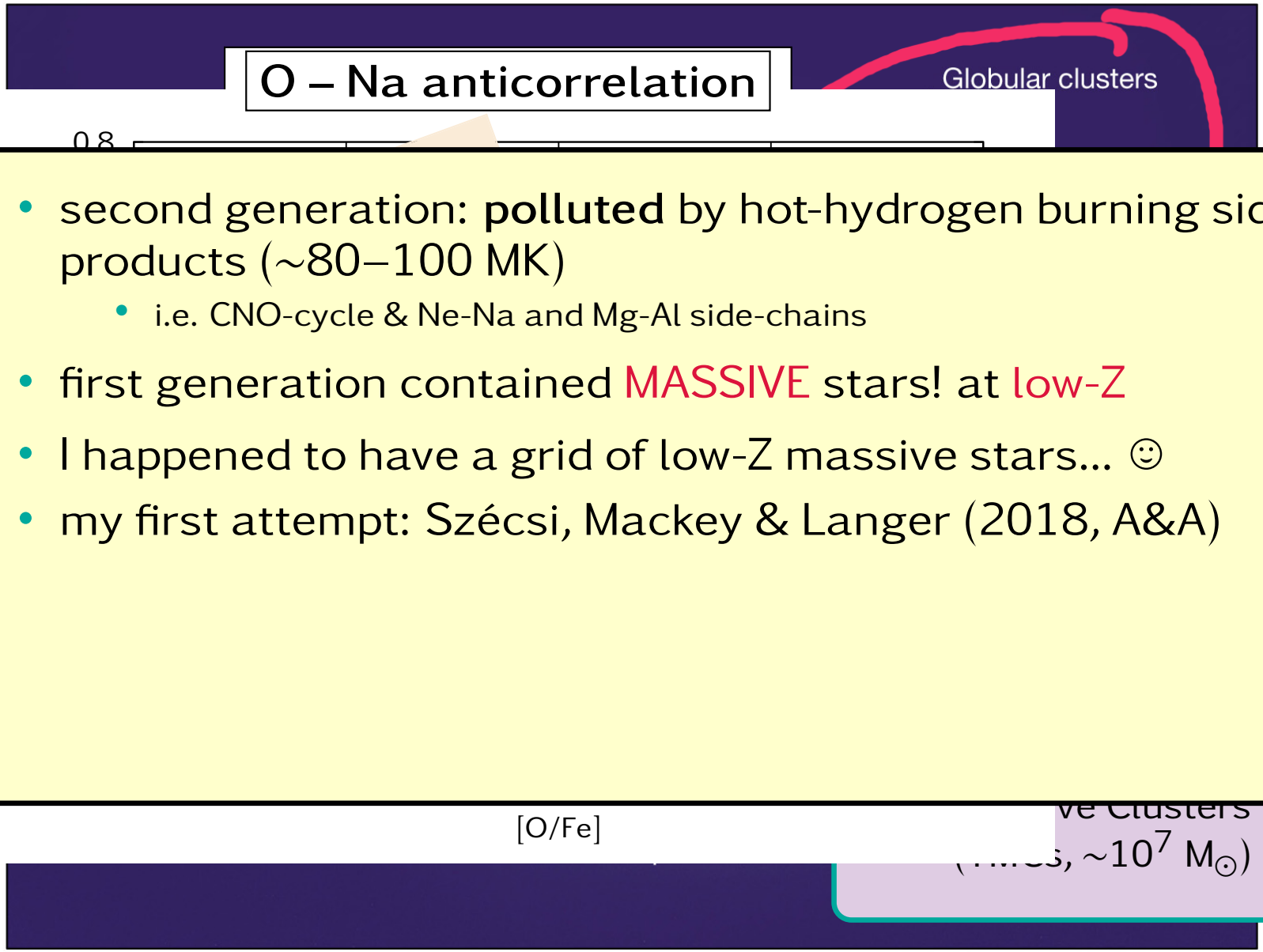

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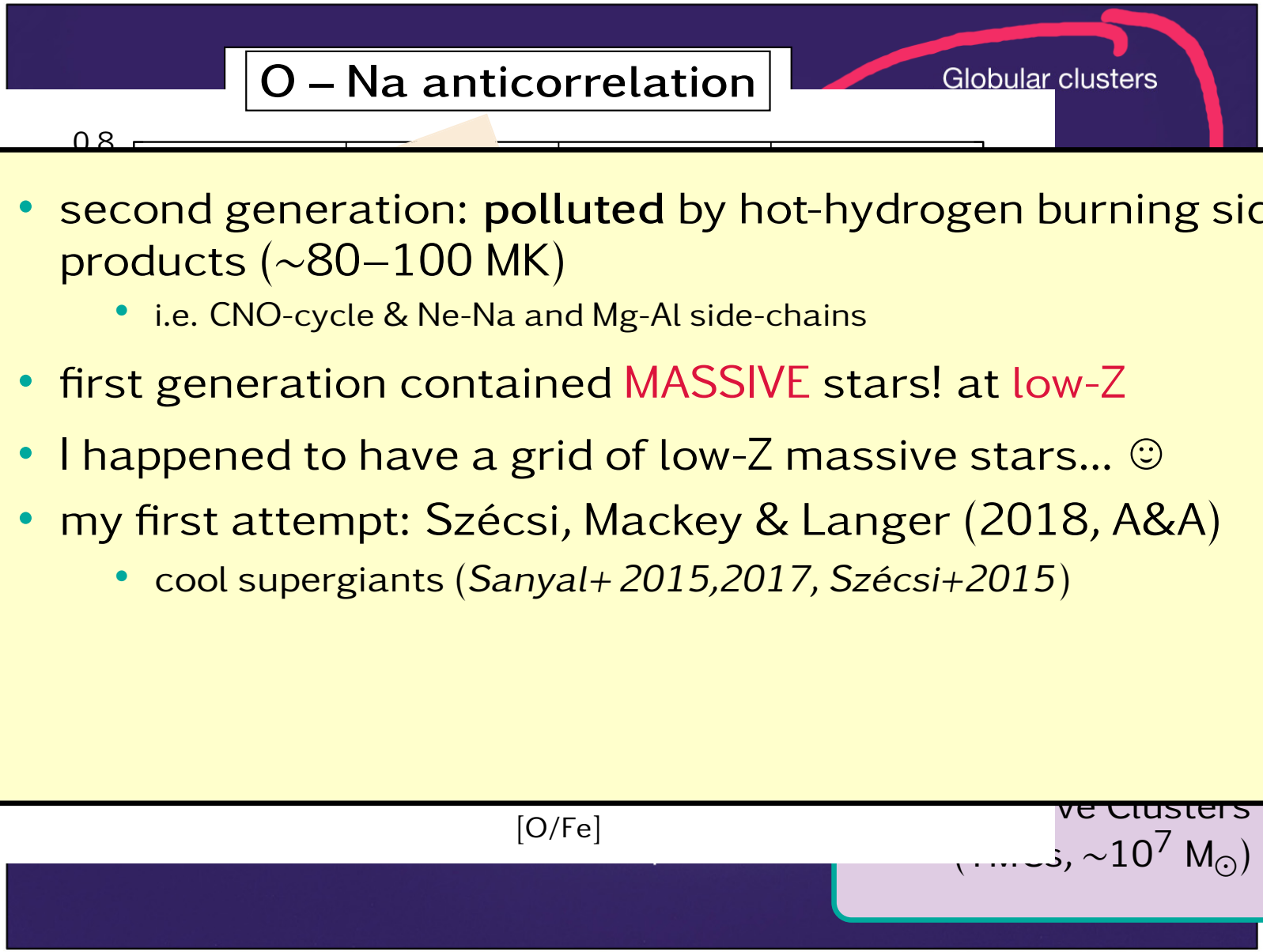

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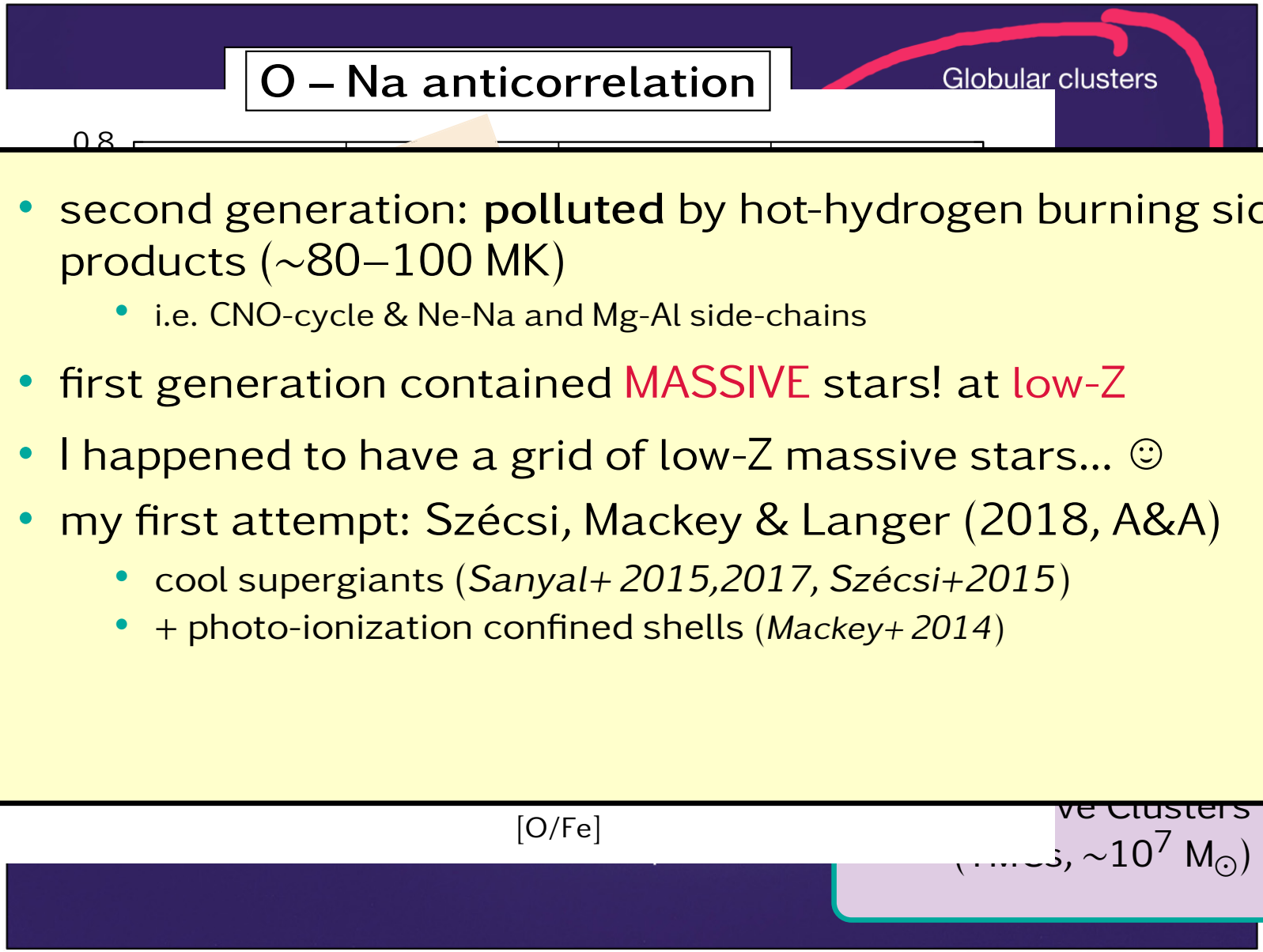

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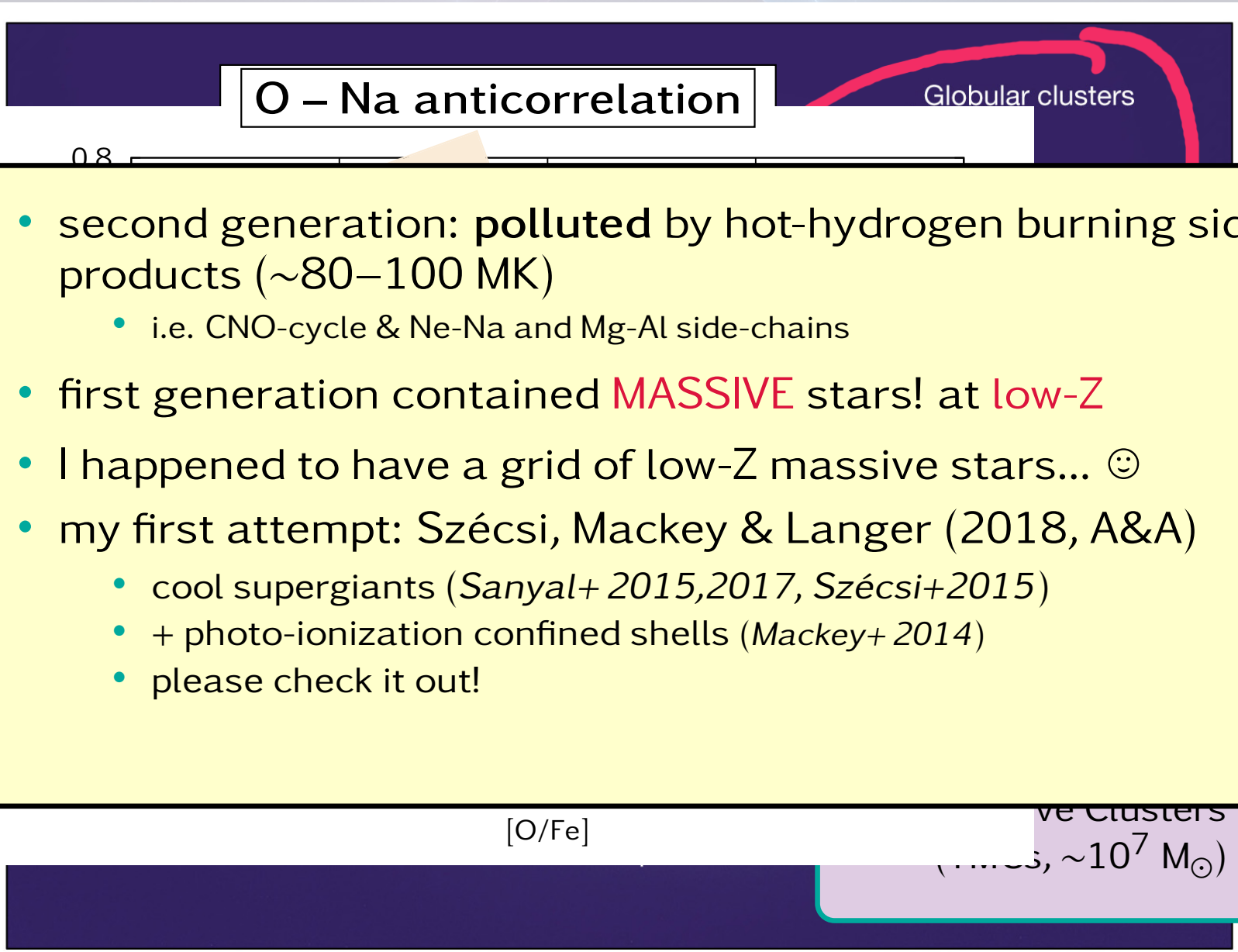

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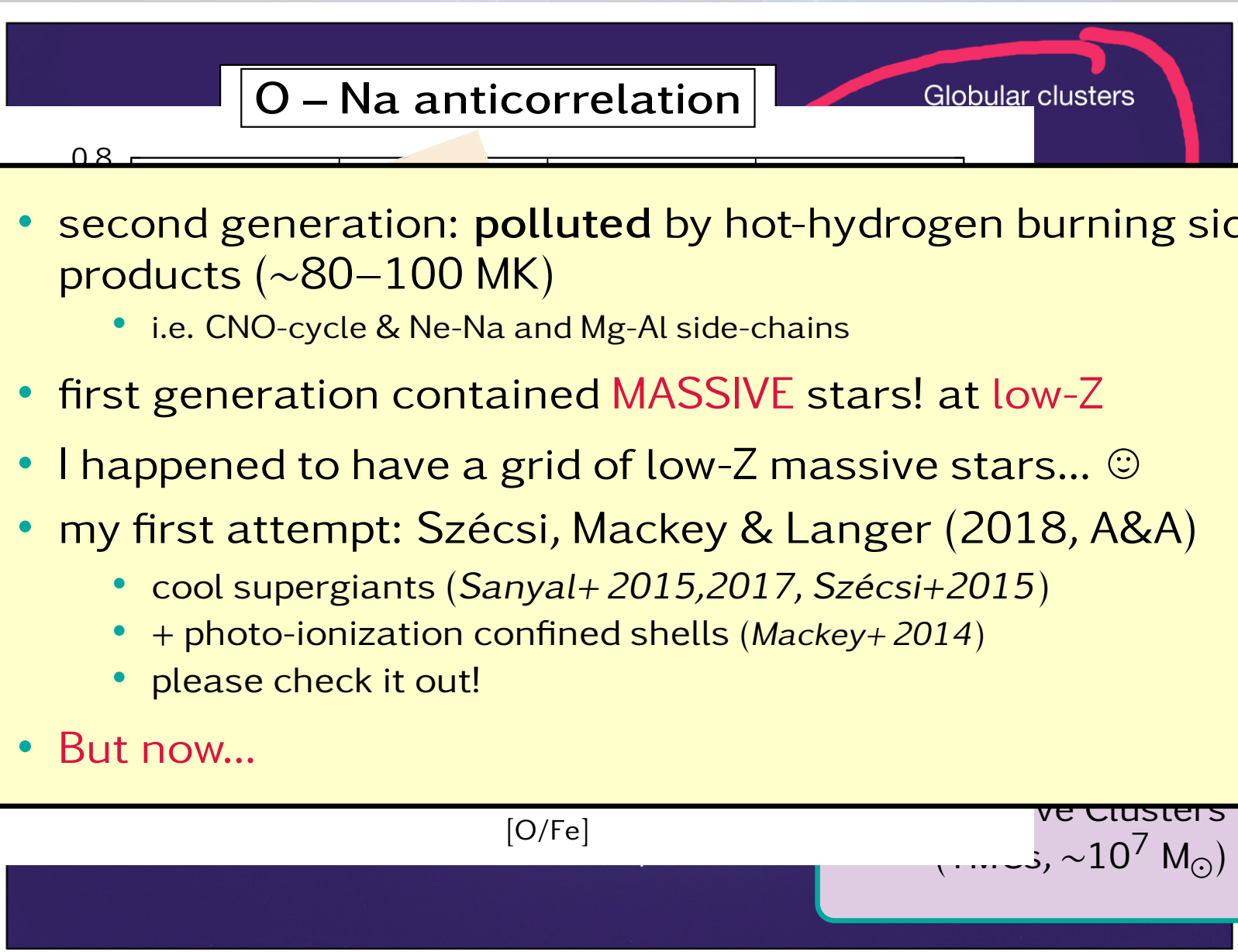

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- But now…

So I went to do my 1st postdoc in Prague...

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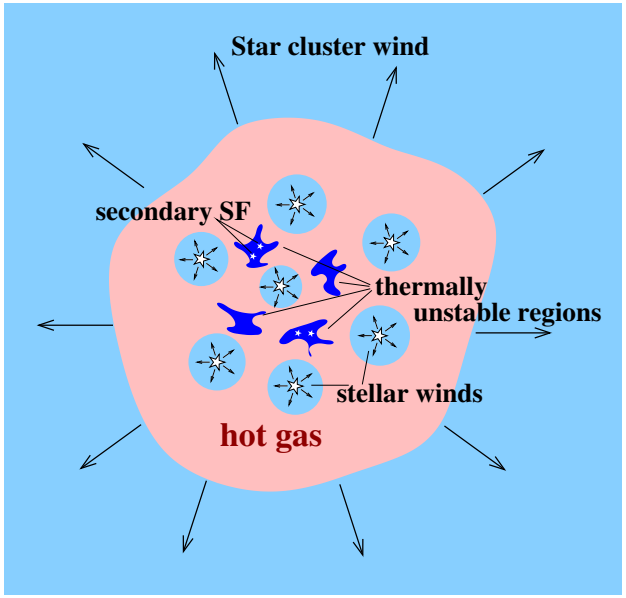
Rapidly cooling shocked stellar winds model

- young massive clusters have winds
  stellar winds → collisions → shocked wind → outflow
- thermal instability, rapid cooling
  if the cluster is massive and compact enough
- dense warm/cold clumps are formed
  cluster gravity ⇒ clumps fall to the centre;
  accumulation ⇒ self-shielding against EUV radiation
- 2nd generation (2G) stars formed
  enriched by products of massive stars chem. evolution



Basic parameters:

- L_{SC}, $\dot{M}_{SC} \leftarrow M_{1G}$, stellar evolution tracks
- R_{SC} + eventually radial profile (R_c, β)

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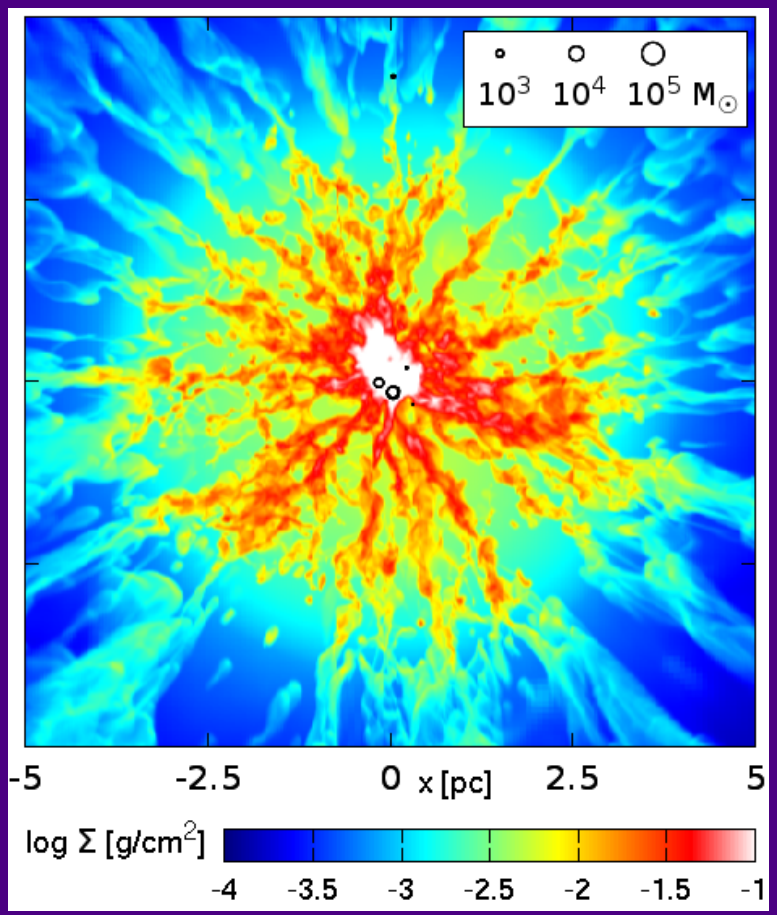
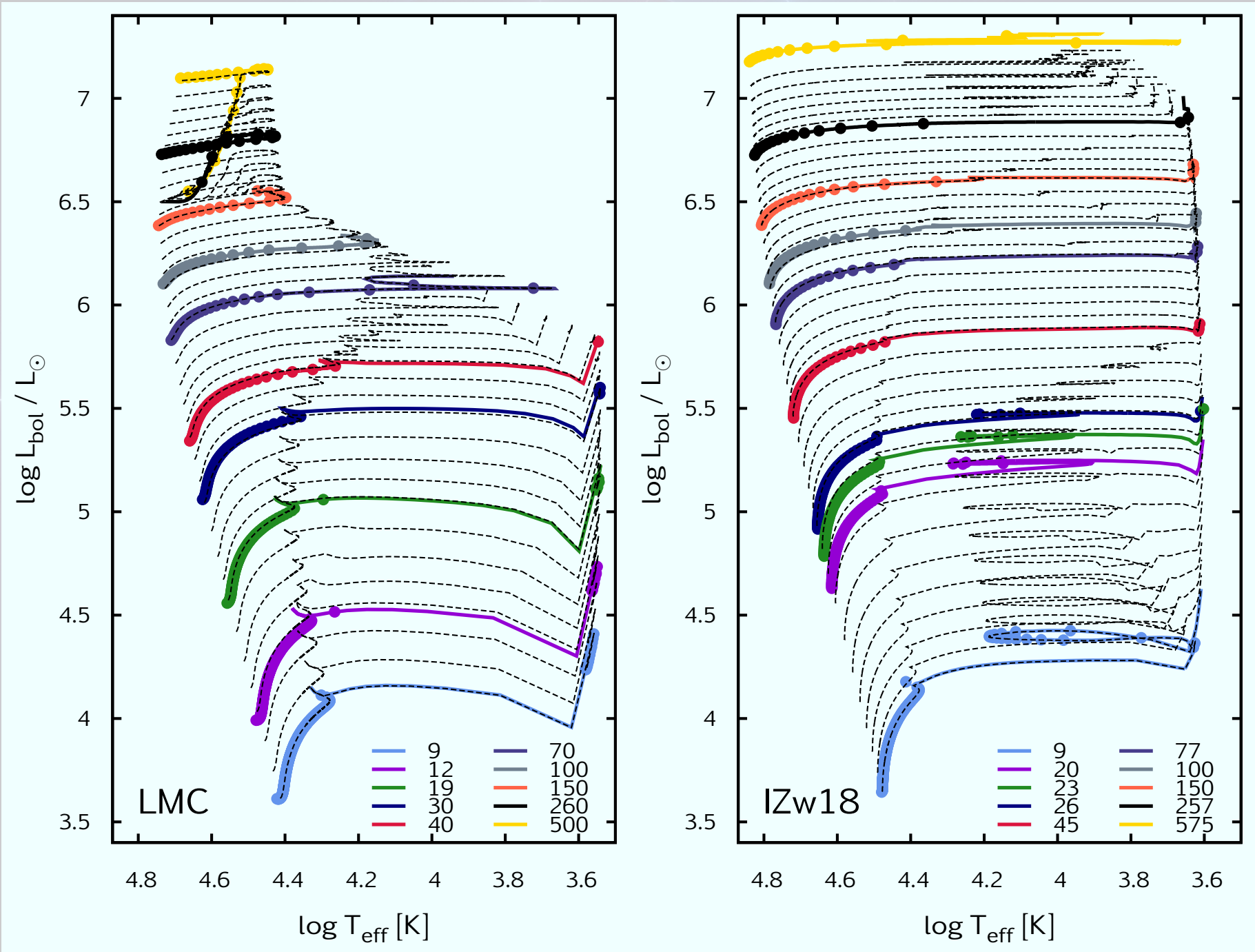
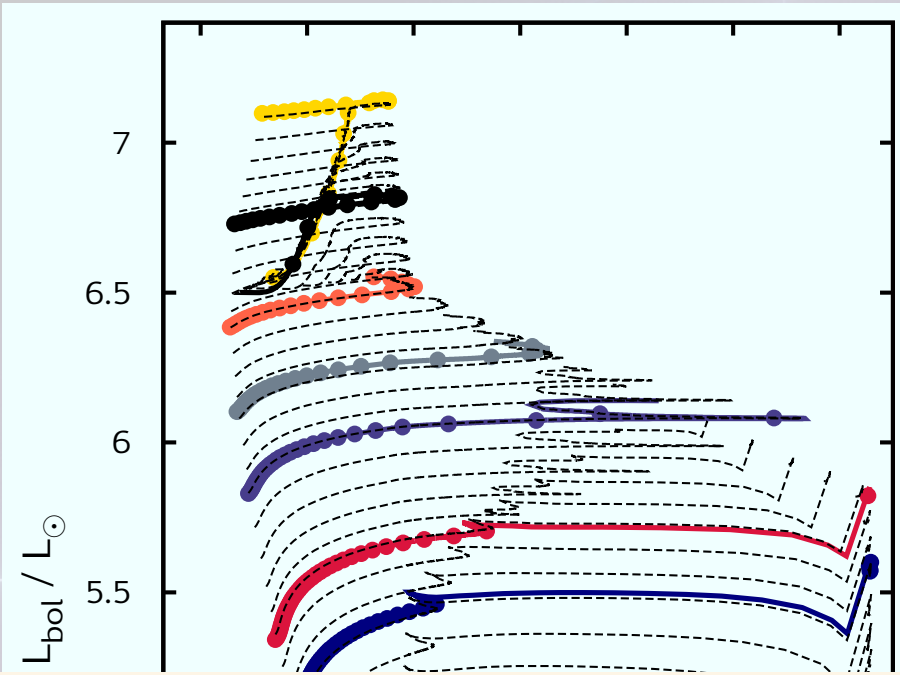
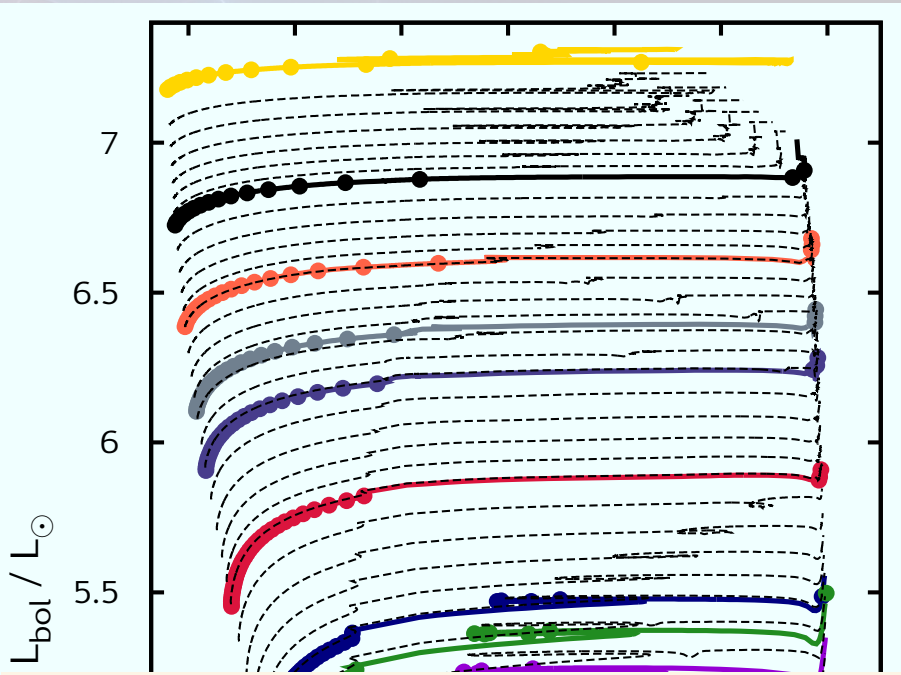
Rapidly cooling shocked stellar winds model




LMC
IZw18
log L_bol / L_⊙
log T_eff [K]
7
6.5
6
5.5
5
4.5
4
3.5
4.8
4.6
4.4
4.2
4
3.8
3.6
9
12
19
30
40
70
100
150
260
500
9
20
23
26
45
77
100
150
257
575


7
6.5
6
5.5
L_{bol} / $L_\odot$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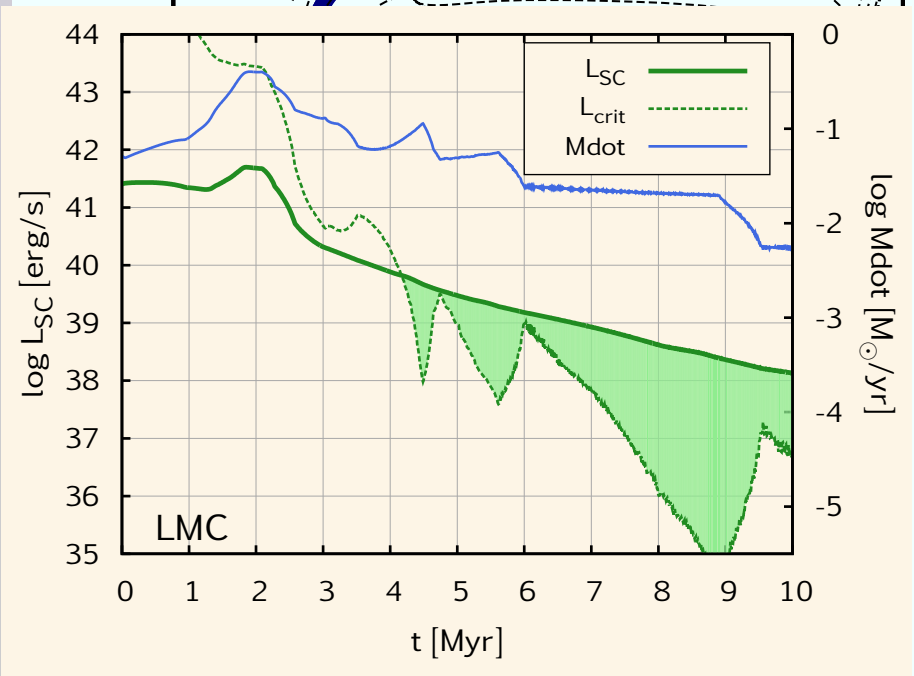
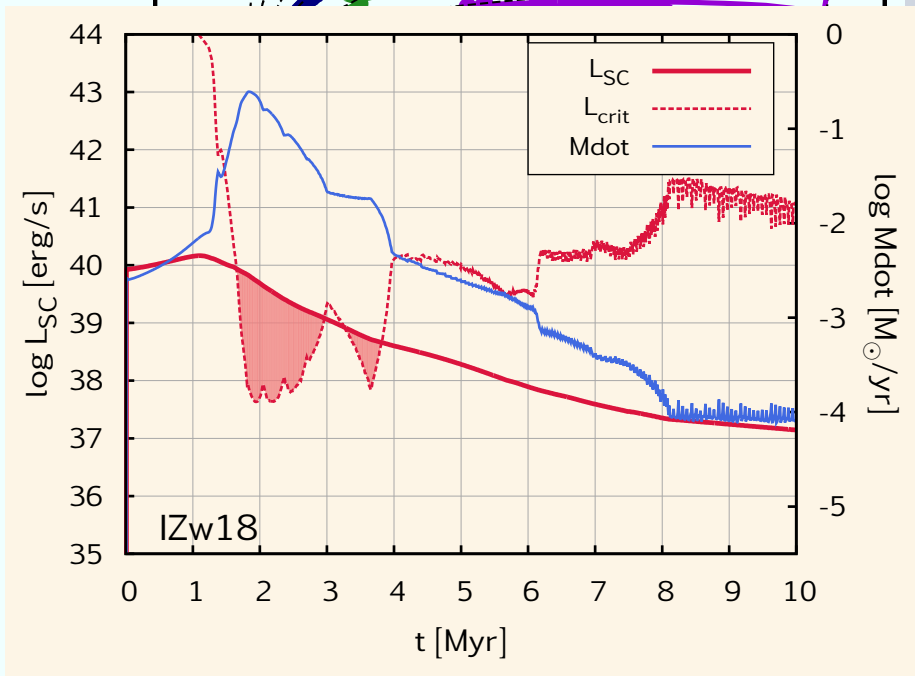
L_{bol} / $L_\odot$


L_{SC}
L_{crit}
Mdot
LMC
log L_{SC} [erg/s]
log Mdot [$M_\odot$/yr]
t [Myr]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IZw18
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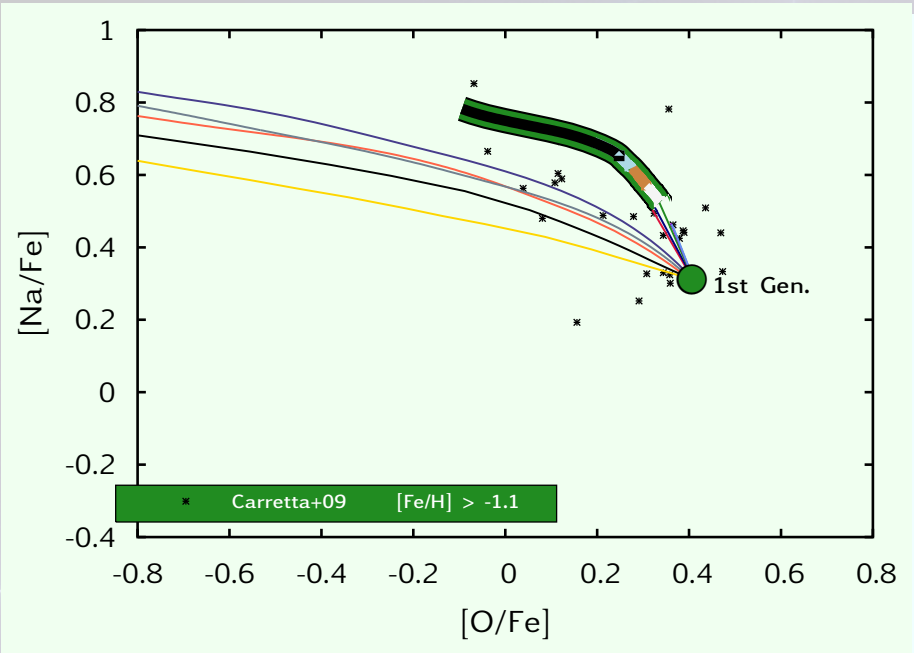
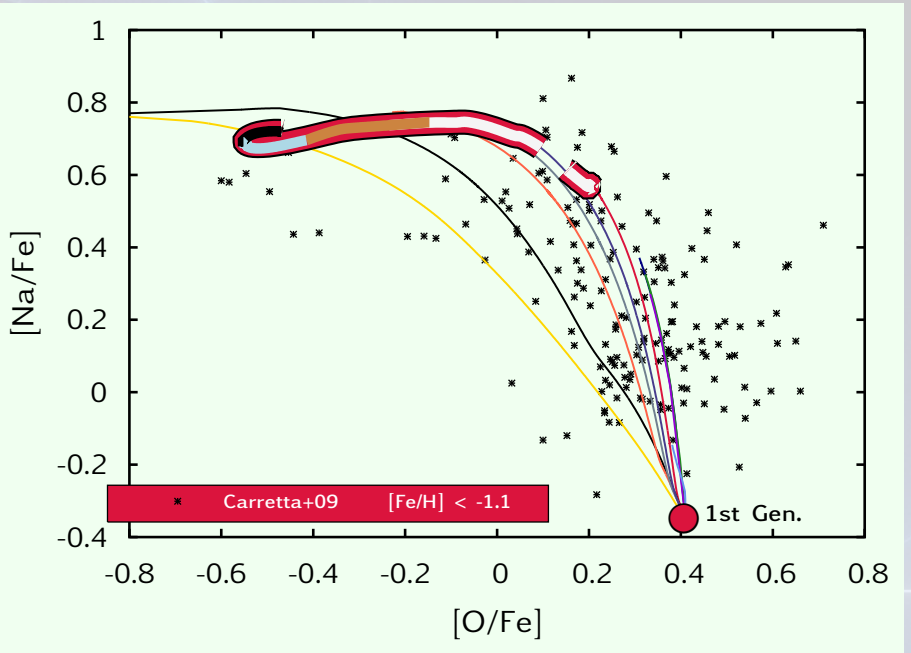

[Na/Fe]
[O/Fe]
1st Gen.
Carretta+09 [Fe/H] > -1.1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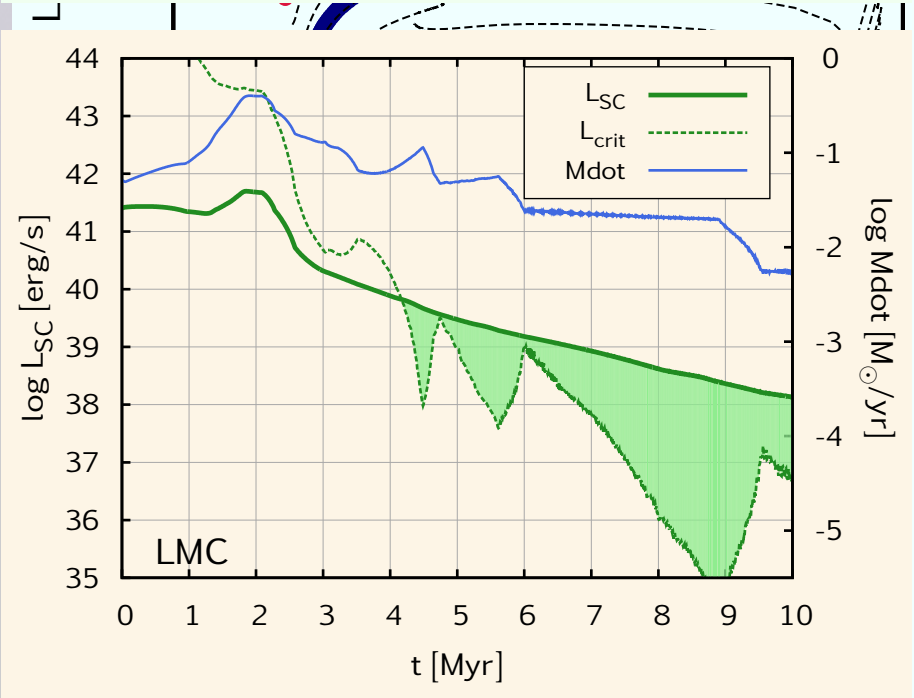
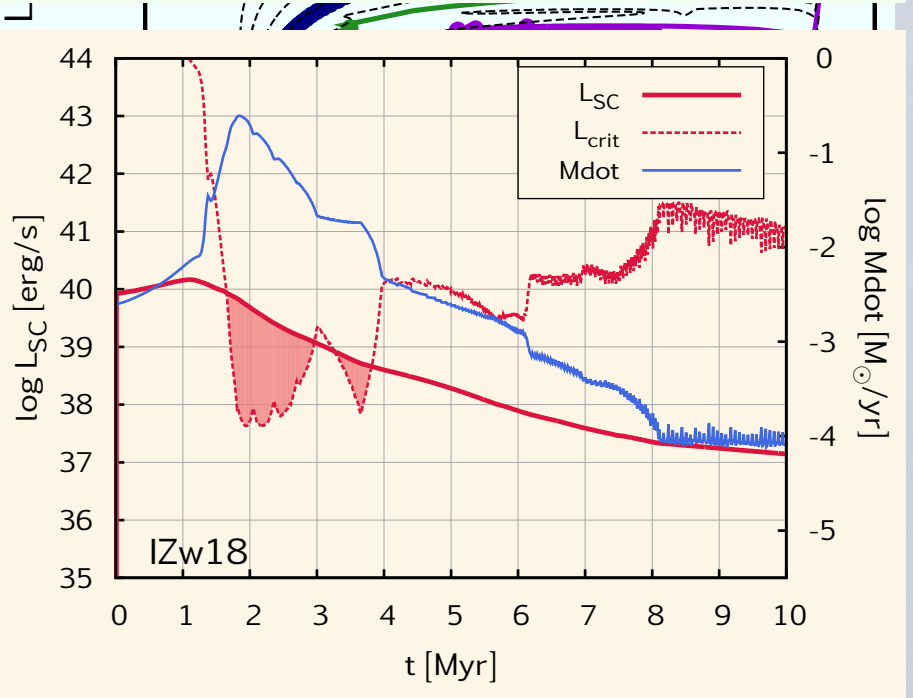
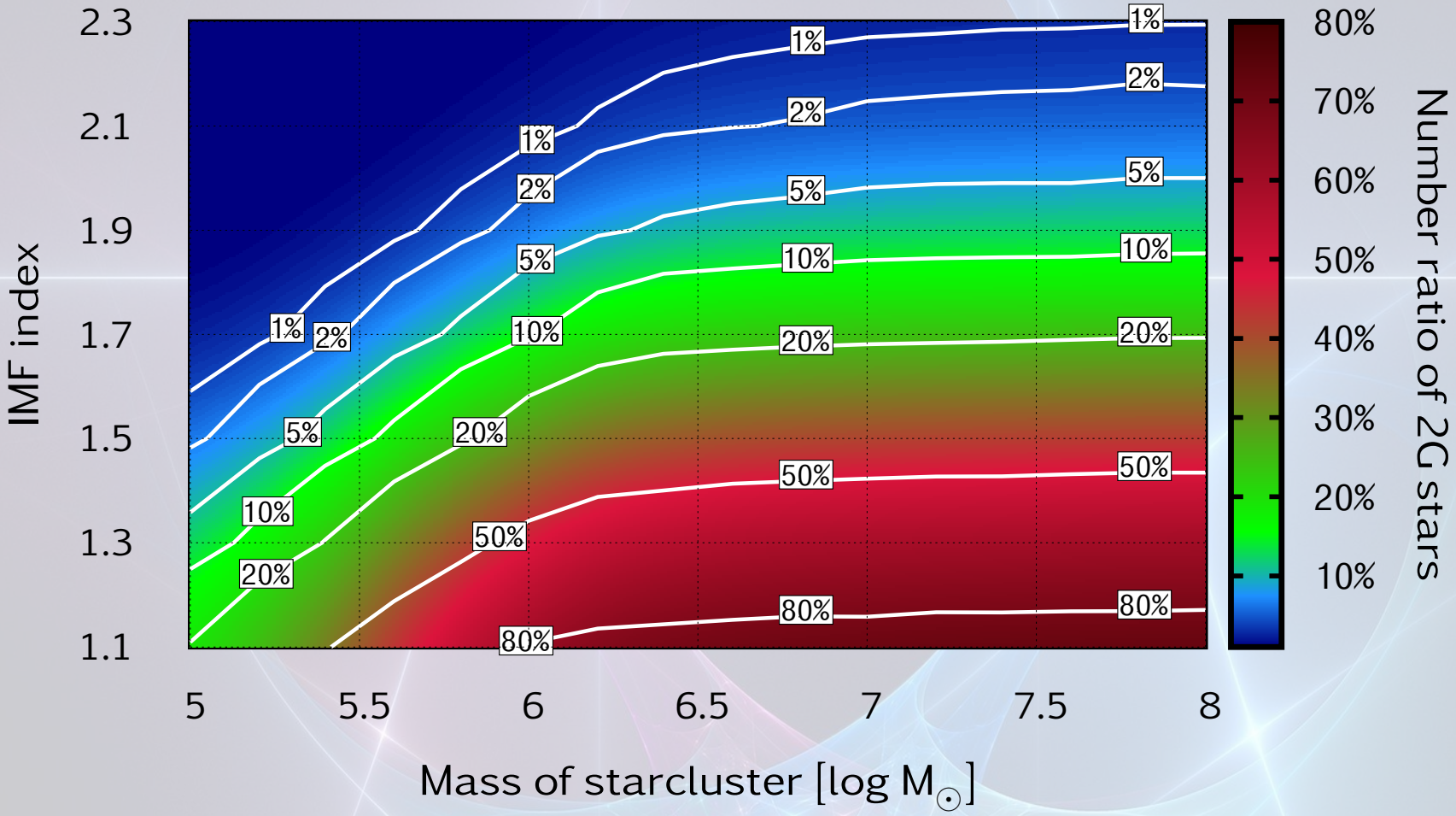

log L_SC [erg/s]
log Mdot [M⊙/yr]
t [Myr]
L_SC
L_crit
Mdot
LMC


log L_SC [erg/s]
log Mdot [M⊙/yr]
t [Myr]
L_SC
L_crit
Mdot
IZw18

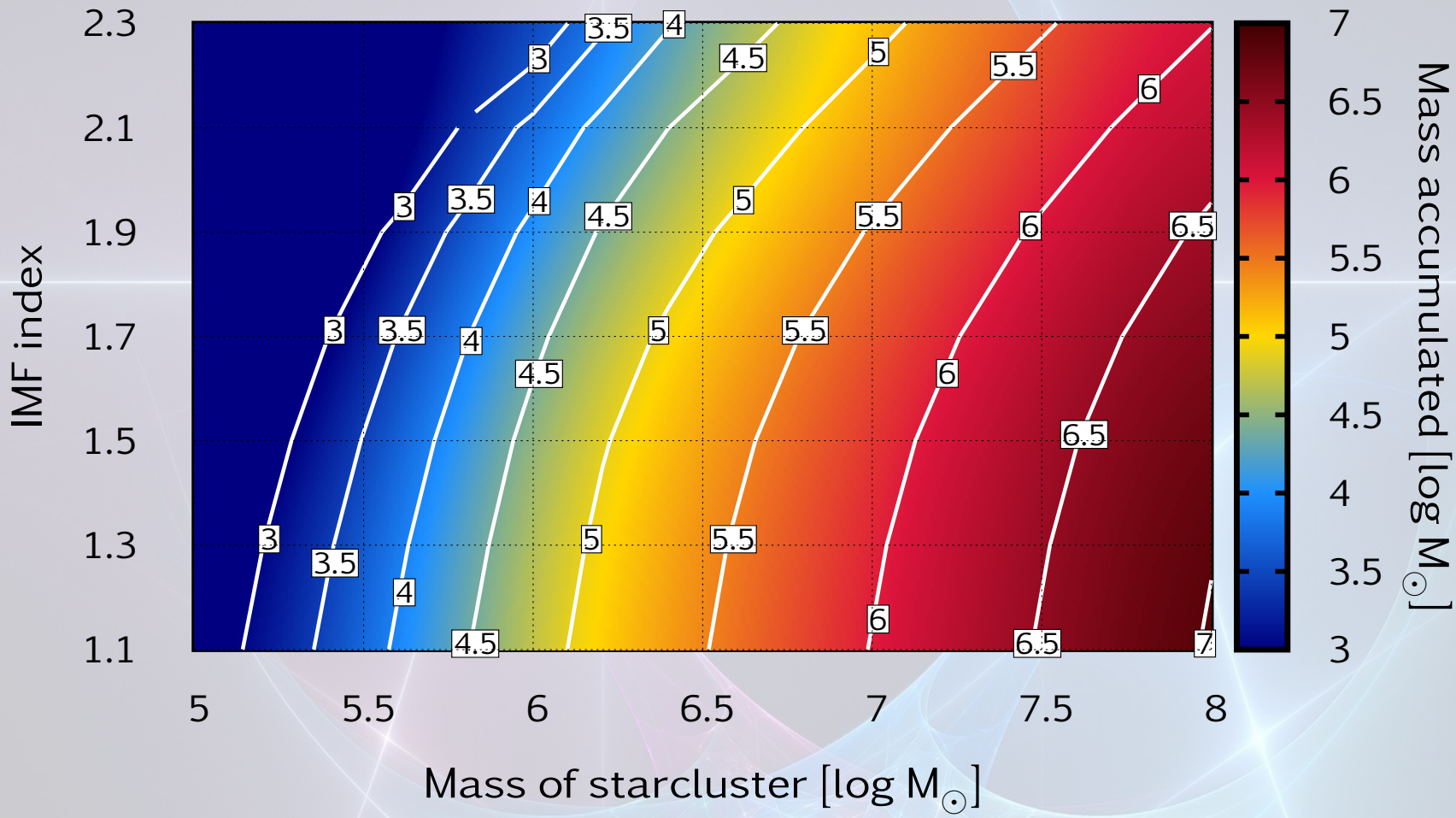
I know you wonder...

- supernovae...
- pair-instability supernovae...
- remnants (GWs ☺)
- cooling time...
- other elements, like Mg&Al, helium
- mass loss uncertainties, existence of low-Z supergiants
- 3D simulations
- binaries... → *COMPAS binary pop.synth. group in Birmingham! ← I work here* ☺
- YMCs → GCs (?)
- mass budget...

Mass budget


IMF index
2.3
2.1
1.9
1.7
1.5
1.3
1.1
5
5.5
6
6.5
7
7.5
8
Mass of starcluster [log M⊙]
Number ratio of 2G stars
80%
70%
60%
50%
40%
30%
20%
10%
1%
2%
5%
10%
20%
50%
80%

Correlation btw. GC mass & size of 2nd gen.



That's all, folks. Thanks.

globular clusters + supergiants

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