

Multiplicity at sub-solar metallicity

A multi-epoch 4MOST Community
Survey towards the Magellanic
Clouds

by Hugues Sana & Tomer Shenar



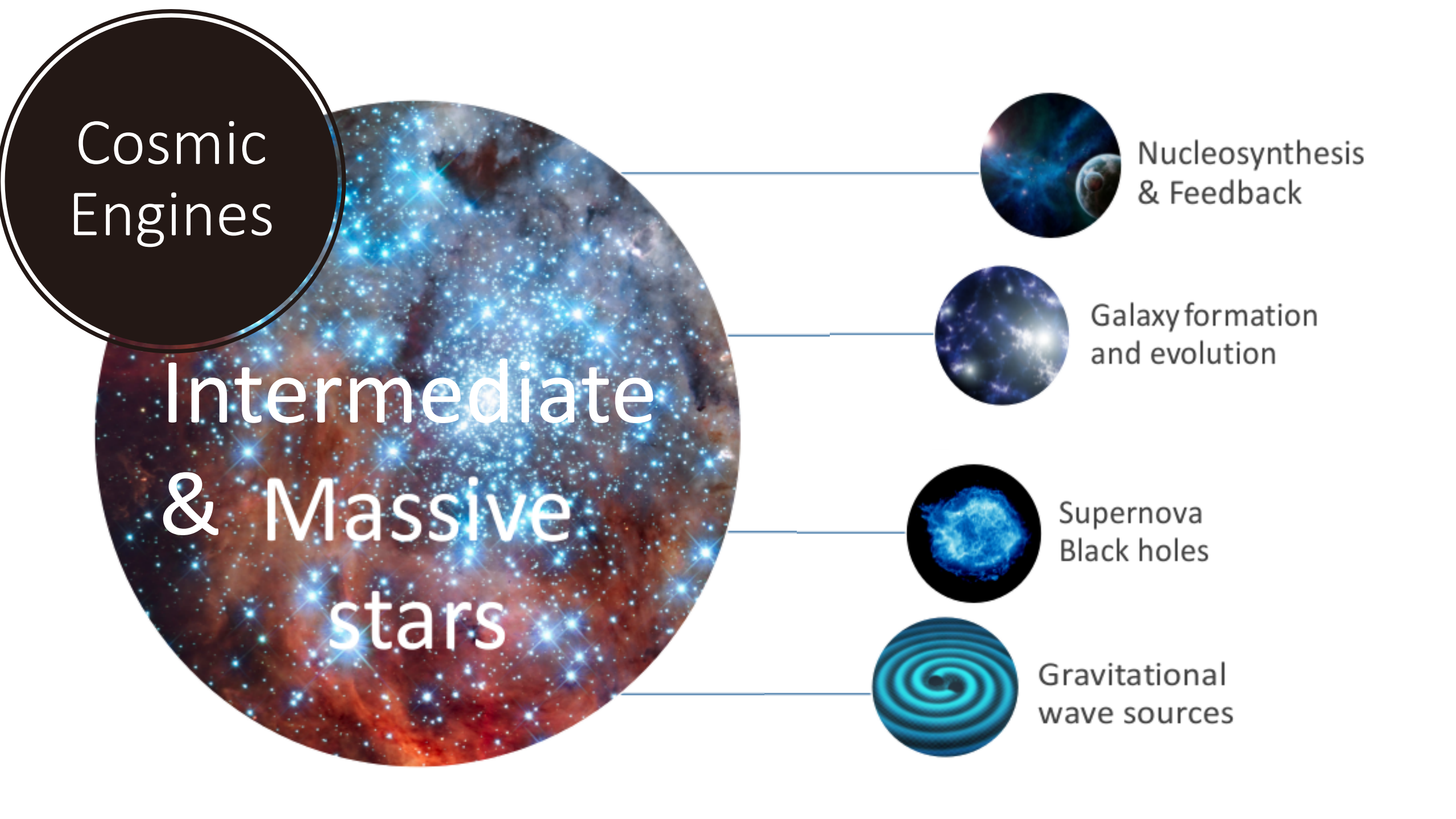
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Legacy-value data set

- To unravel binary evolution of intermediate- and high-mass stars
- To challenge (binary) evolution models of compact object and GW progenitors
- First step towards impact of binarity on the early-Universe and its observations



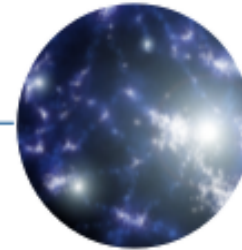


Cosmic
Engines

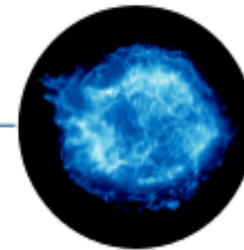
Intermediate
& Massive
stars



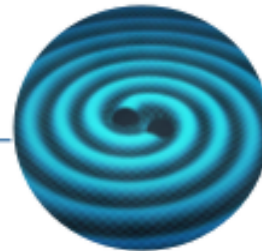
Nucleosynthesis
& Feedback



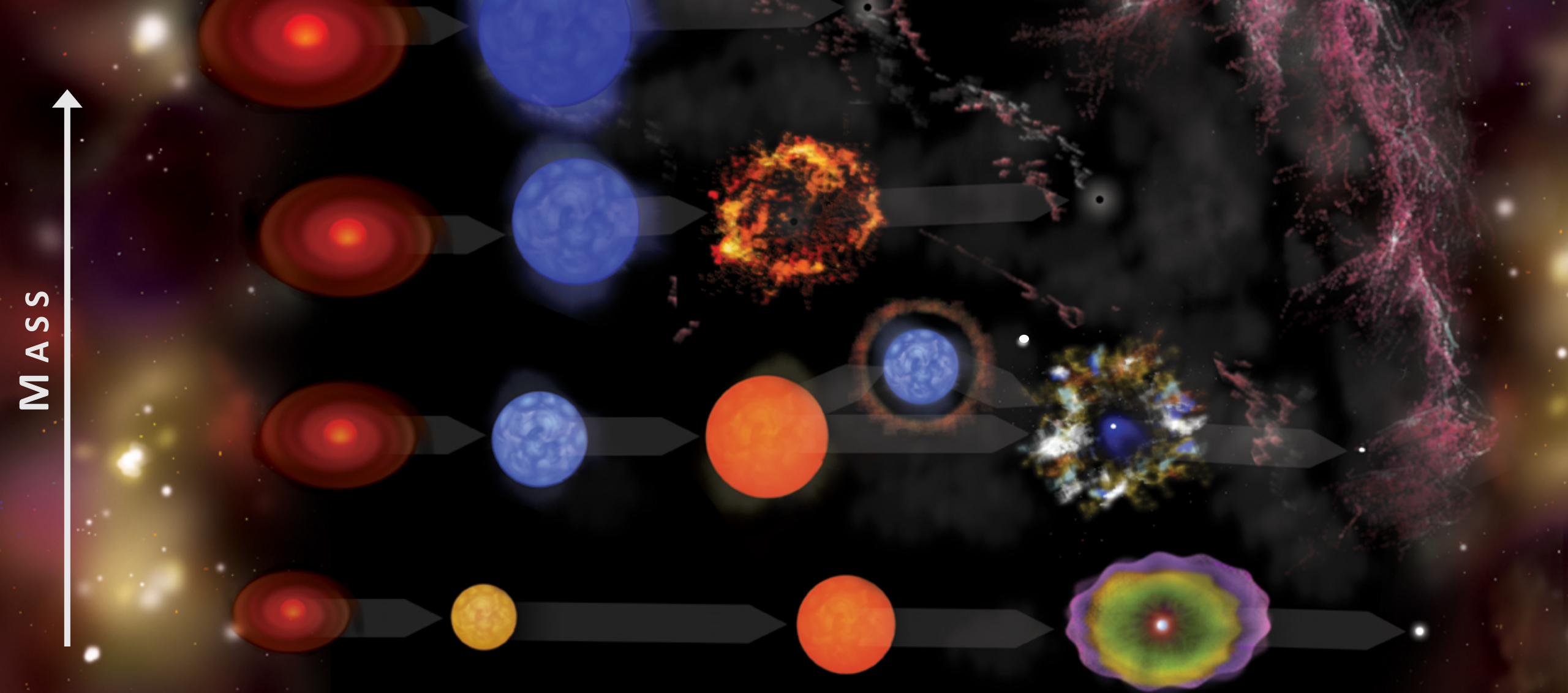
Galaxy formation
and evolution



Supernova
Black holes

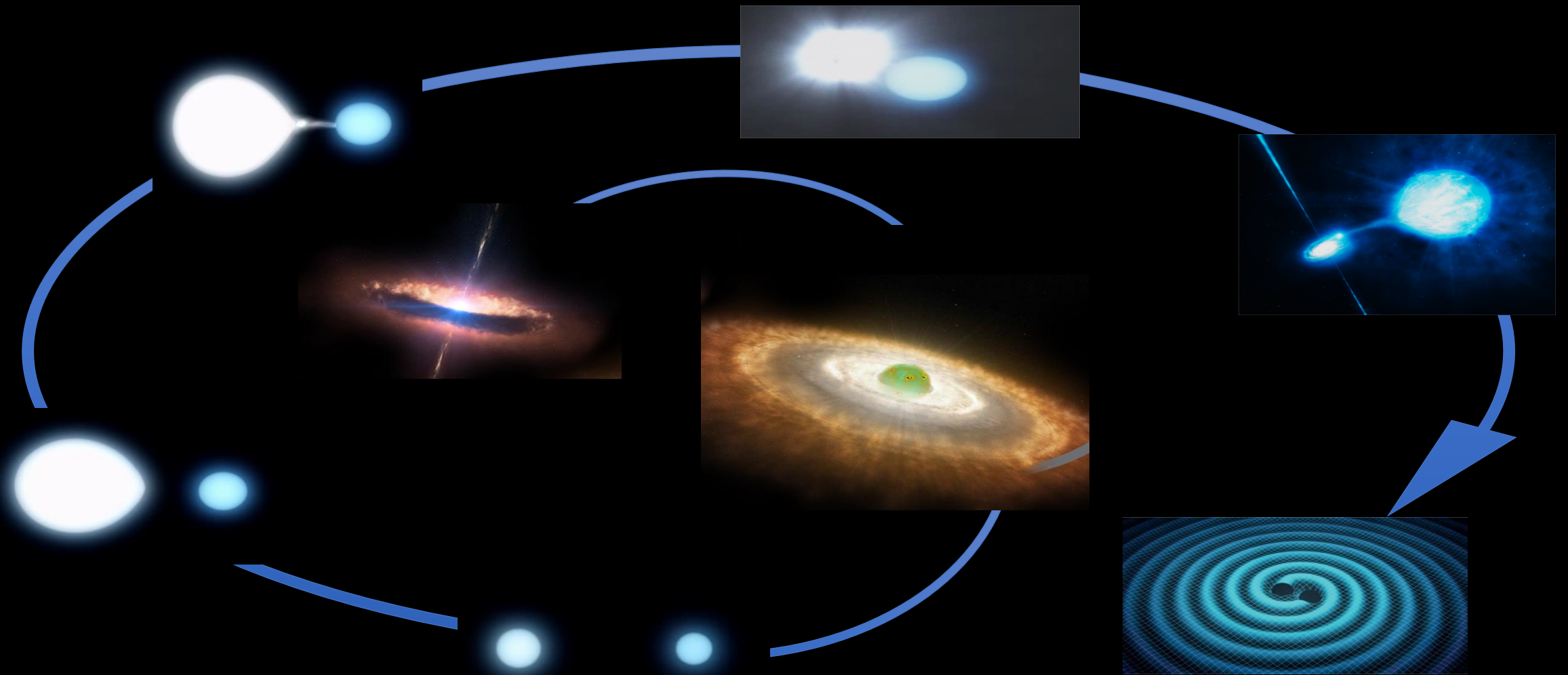


Gravitational
wave sources



A (SINGLE) STAR'S LIFE CYCLE

MASS - ROTATION - INTERNAL STRUCTURE - WINDS



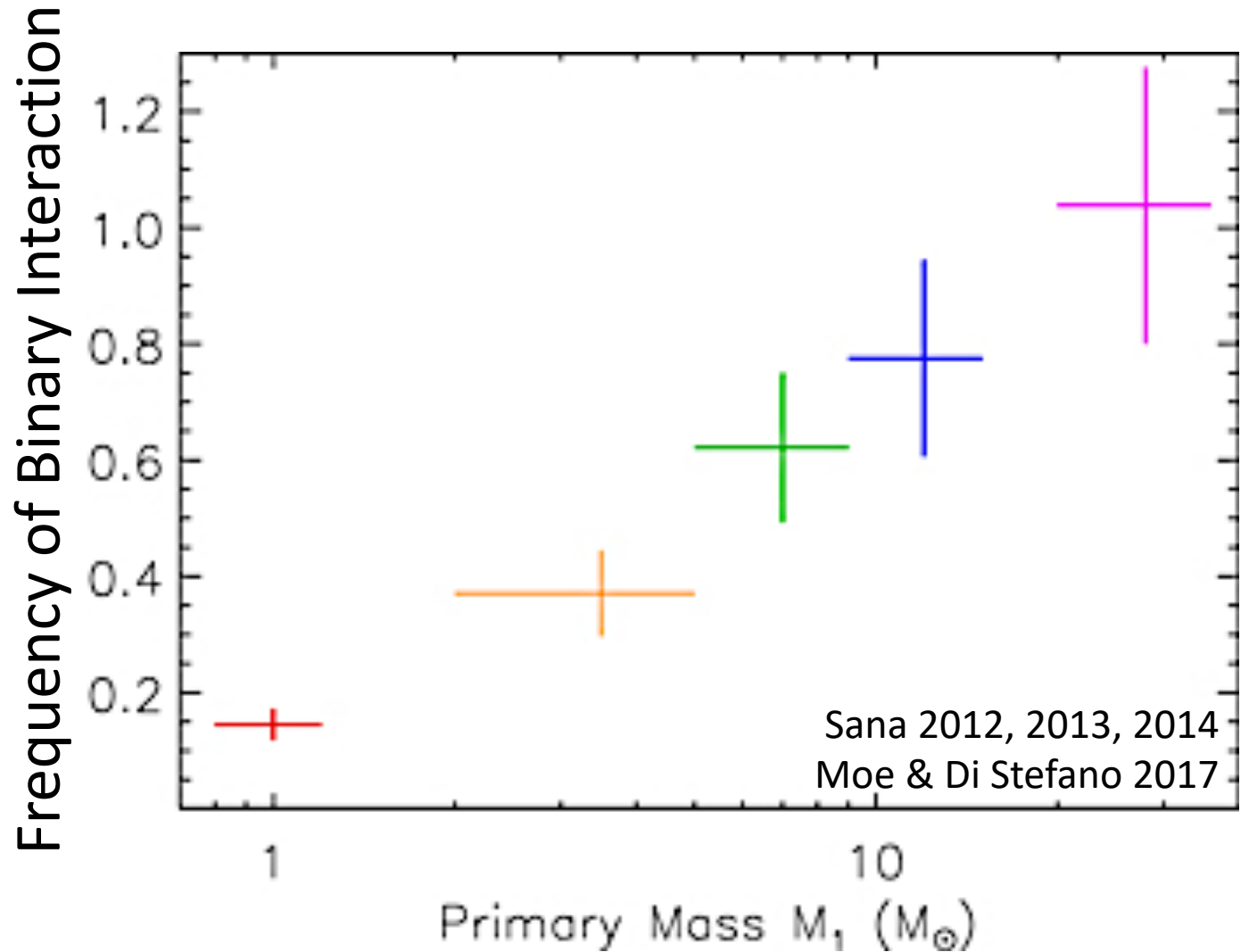
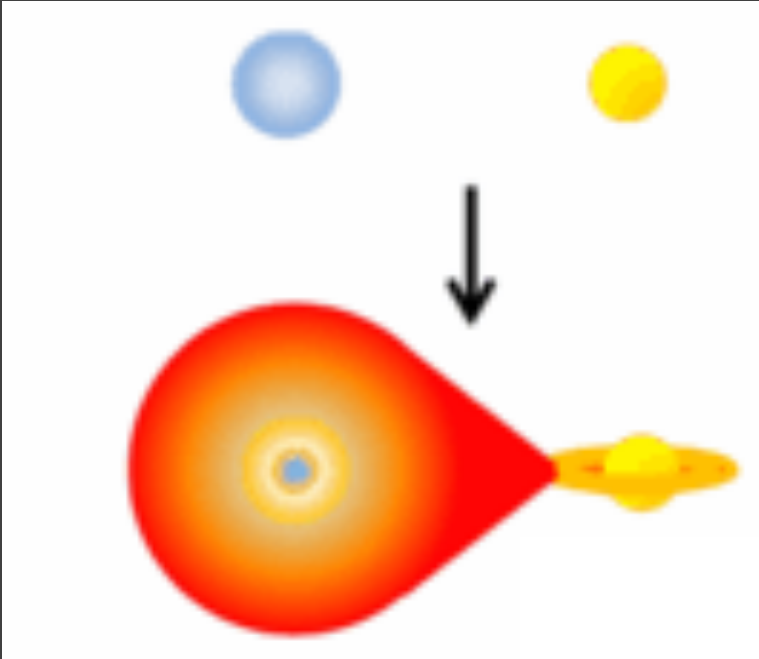
A (BINARY) STAR'S LIFE CYCLE

BINARY STATUS – ORBITAL PERIOD – MASS-RATIO

MASS – ROTATION – INTERNAL STRUCTURE – WINDS

How often do stars interact ?

Interaction driven by the secular expansion of stars





Challenges

Formation of tight binaries

Initial P , e , q distributions
and Z dependence

Uncertain physics

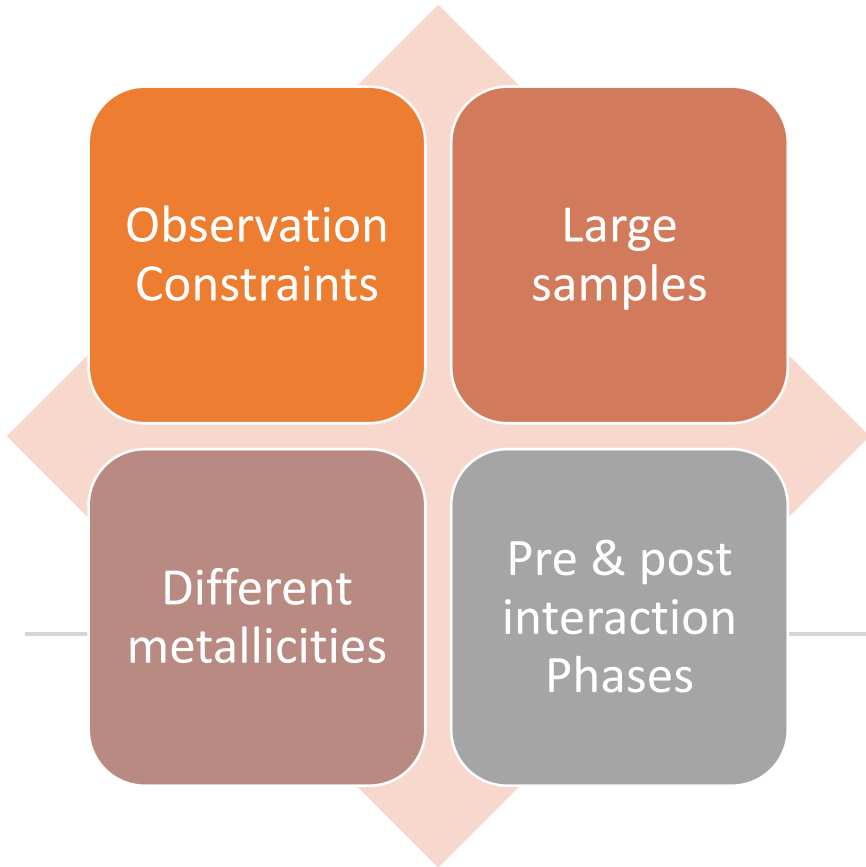
Tides, efficiency of M & L transfer,
merger, B field, ...

Diversity of Channels

Case A, B, C, stable/unstable
→ diversity of outcome

(Some) rapid interaction phases

Stars out of dynamical & thermal equilibrium



Formation of tight binaries

and its Z dependence

Uncertain physics

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merger, B field, ...

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4
MOST

is the only facility able to
deliver the needed data

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2 sub-solar metallicity environments
(time machine: $Z_{\text{Sun}}/2$, $Z_{\text{Sun}}/5$)

24 000 stars

Main sequence
& Post main sequence

5 years time base

30 epochs

~ 360h

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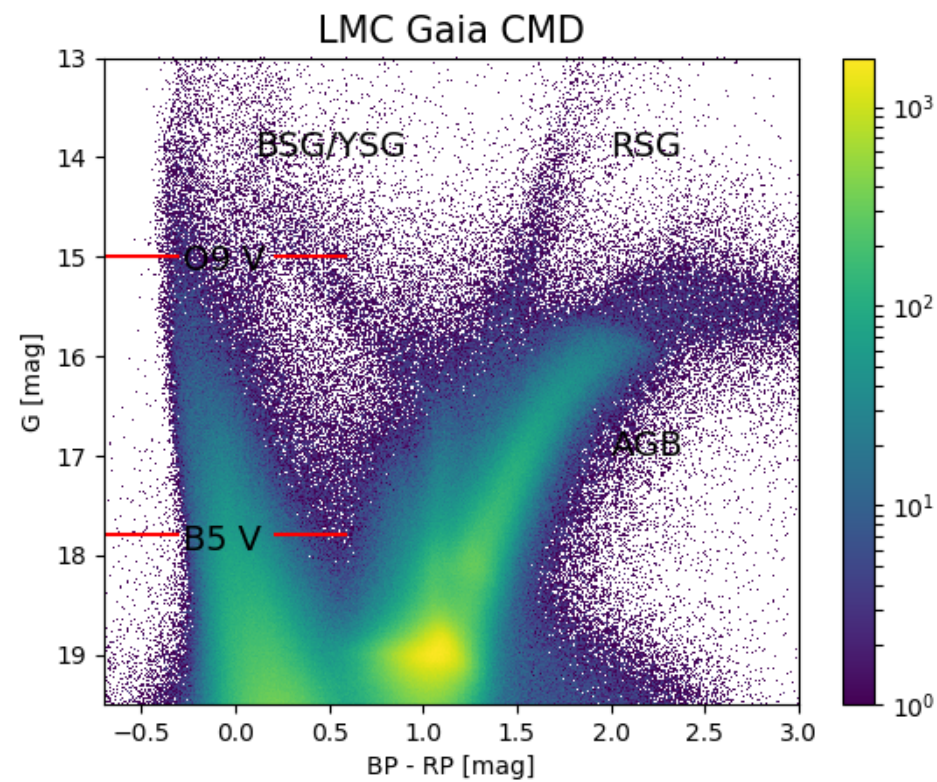
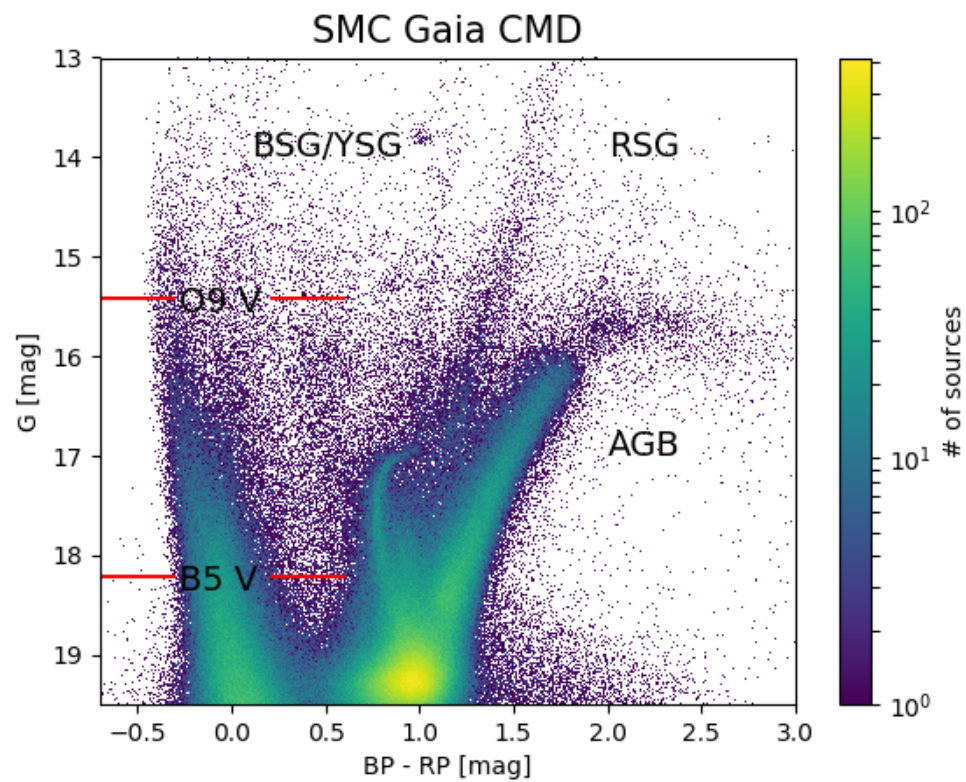
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GAIA CMD



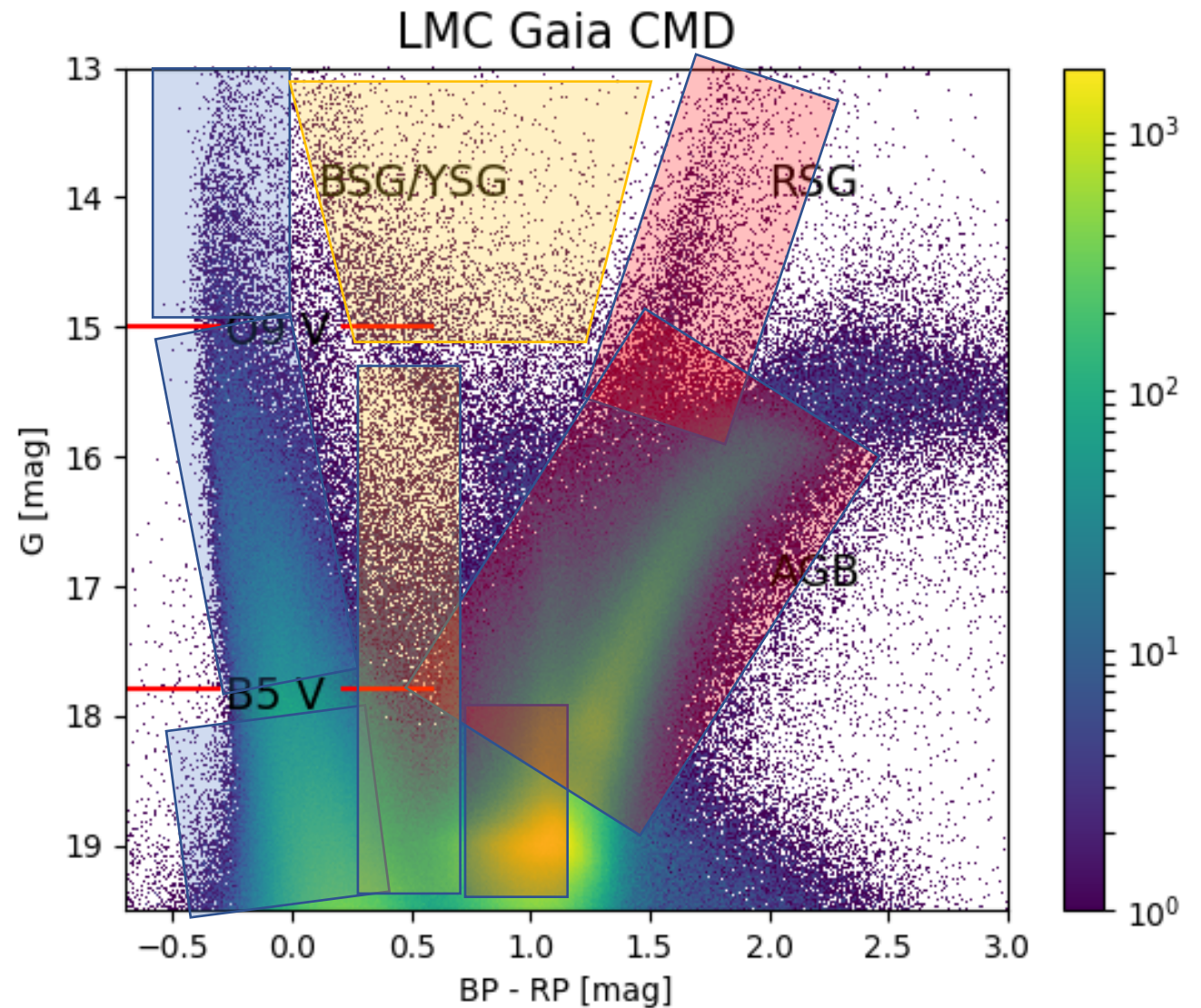
Observational Sample & Target selection

Main-sequence

- O stars
- Early-B stars
- Late-B /Early A stars

Post-main sequence

- Blue/Yellow Supergiants (Hertzsprung gap)
- A giants & supergiants
- Red supergiants
- AGB & post-AGBs
- Red clump stars

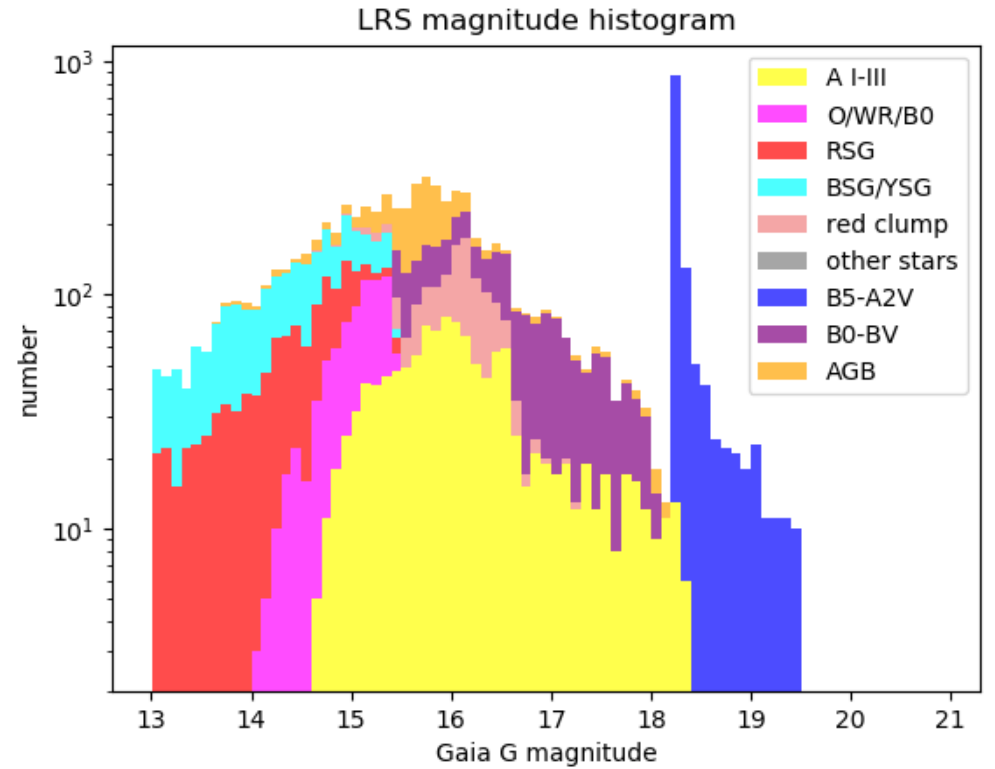
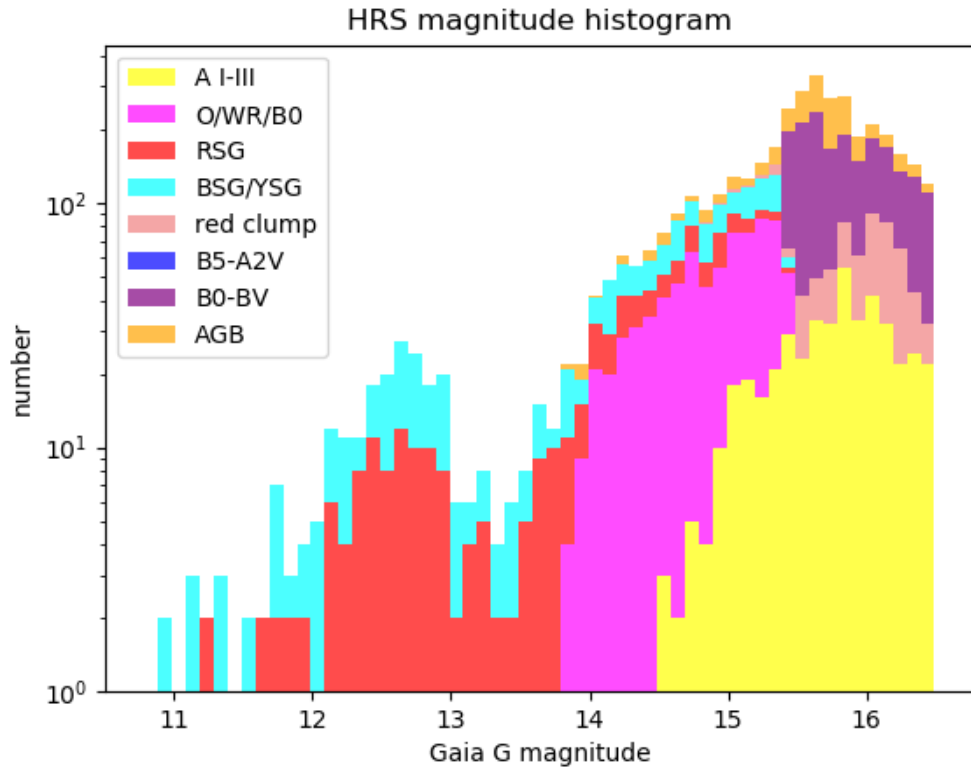
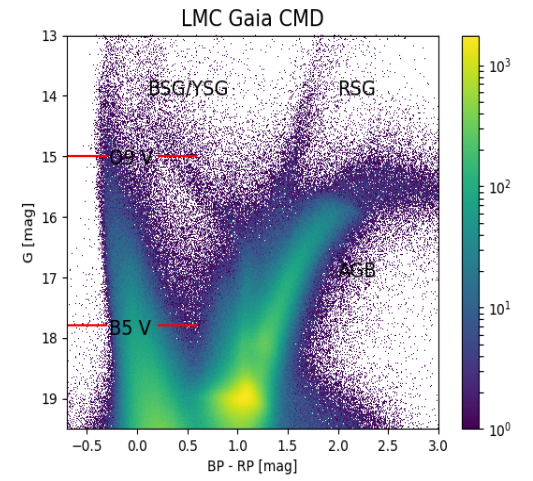


~1500 objects per category in each of the Clouds

→ Binary fraction to better than 5% at the 99.7 confidence level

→ Mapping 3-main axis of orbital parameter distributions (P,q,e)

4 MOST LARGE MAGELLANIC CLOUD



MAIN SEQUENCE

POST MAIN SEQUENCE

	Early- type: O-B0V	Early B: B0-B5V	Late B: B5V or later	A III-I	Blue & Yellow Supergiants	Red Supergiants	AGB/ post- AGB	Red clump stars	total
HRS, SMC	650	1220	0	450	460	310	650	320	4060
LRS, SMC	520	1220	1220	1220	1220	860	1220	640	8120
HRS, LMC	1090	1220	0	10	890	300	540	10	4060
LRS, LMC	660	1100	1100	1100	1100	1100	1100	860	8120
total	2920	4760	2320	2780	3670	2570	3510	1830	24360

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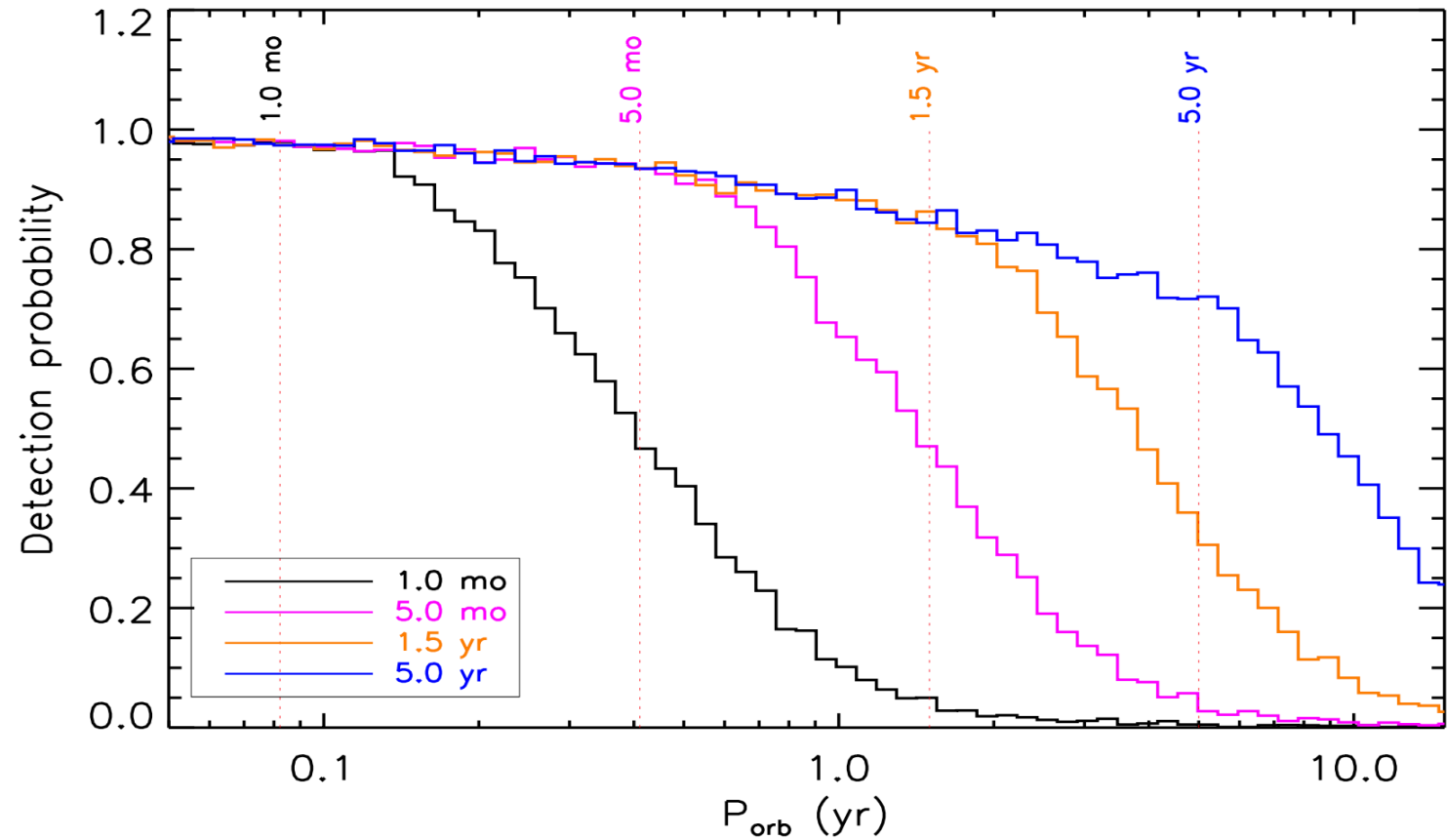
Main sequence
& Post main sequence

5 years time base

30 epochs

~ 360h

Detection probability
for different observing
time base



Binary interaction up to $P_{orb} \sim 5-15$ yr

Binary products $P_{orb} \sim 1-3$ yr

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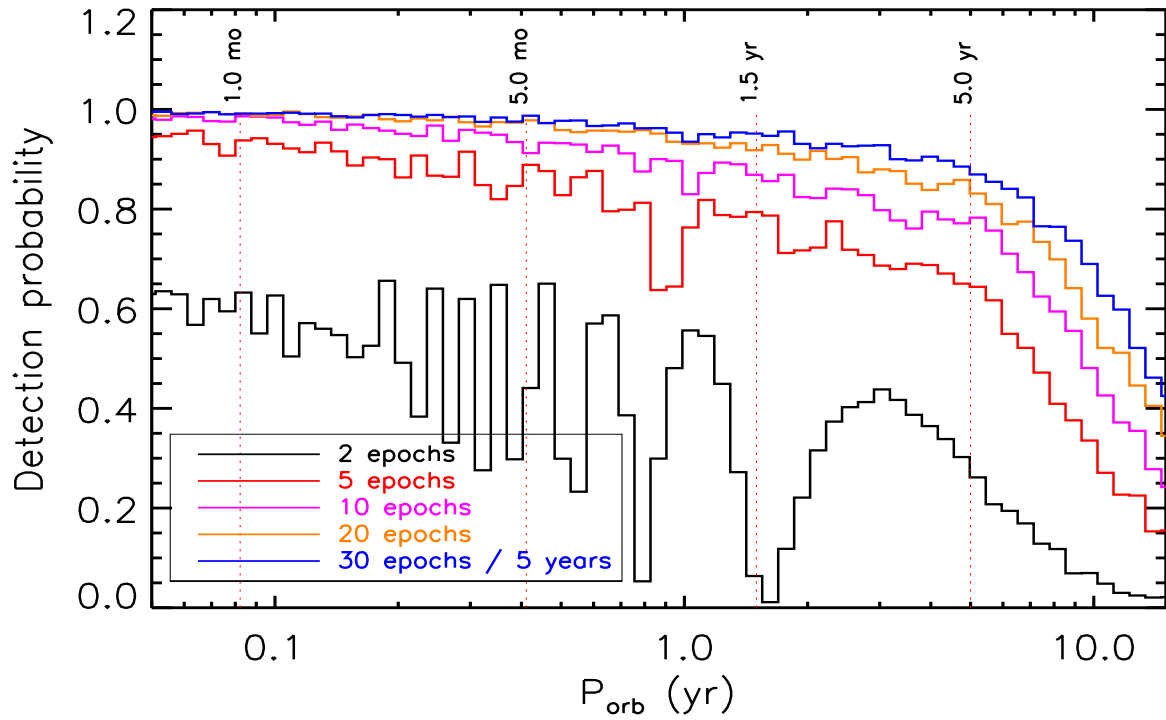
Main sequence
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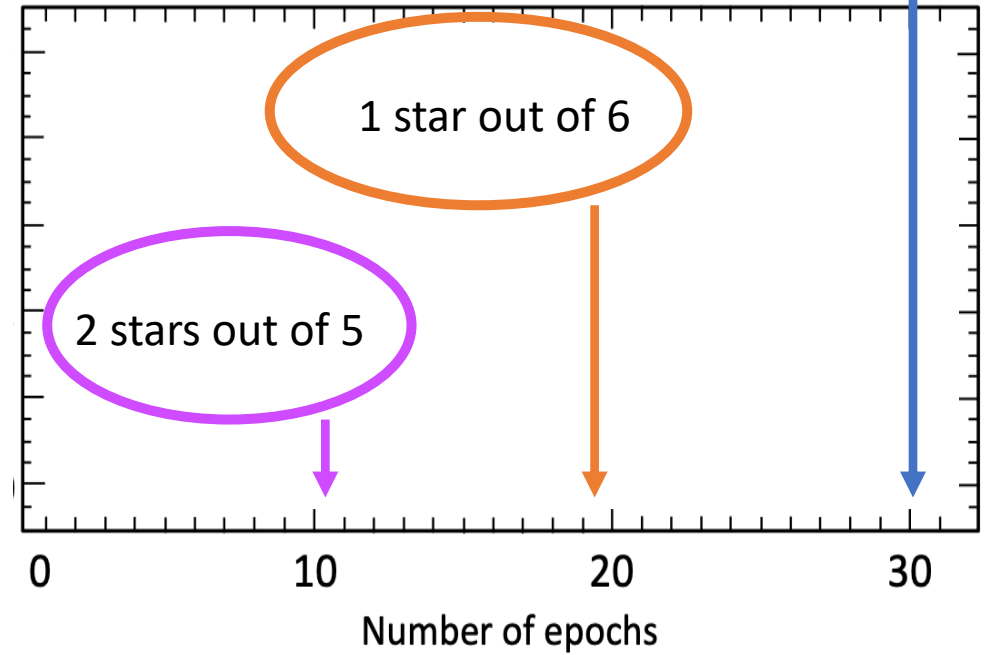
Binary detection probability



Retrieving the correct orbital period:

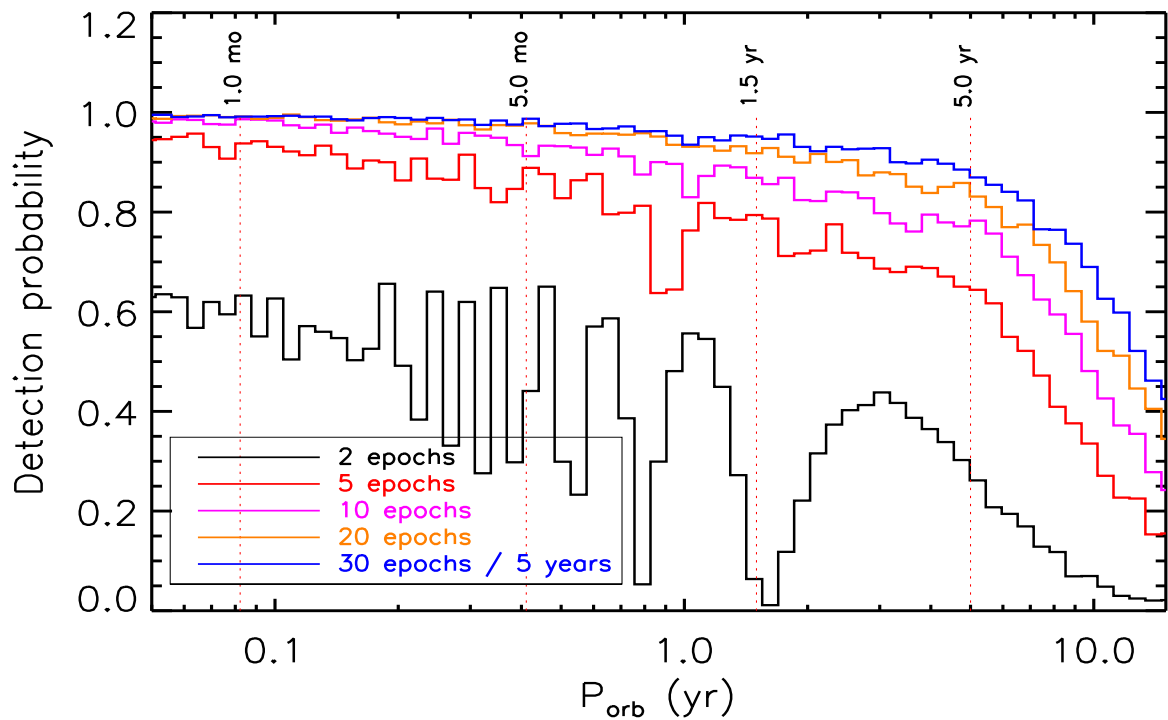
NOT for

1 star out of 30

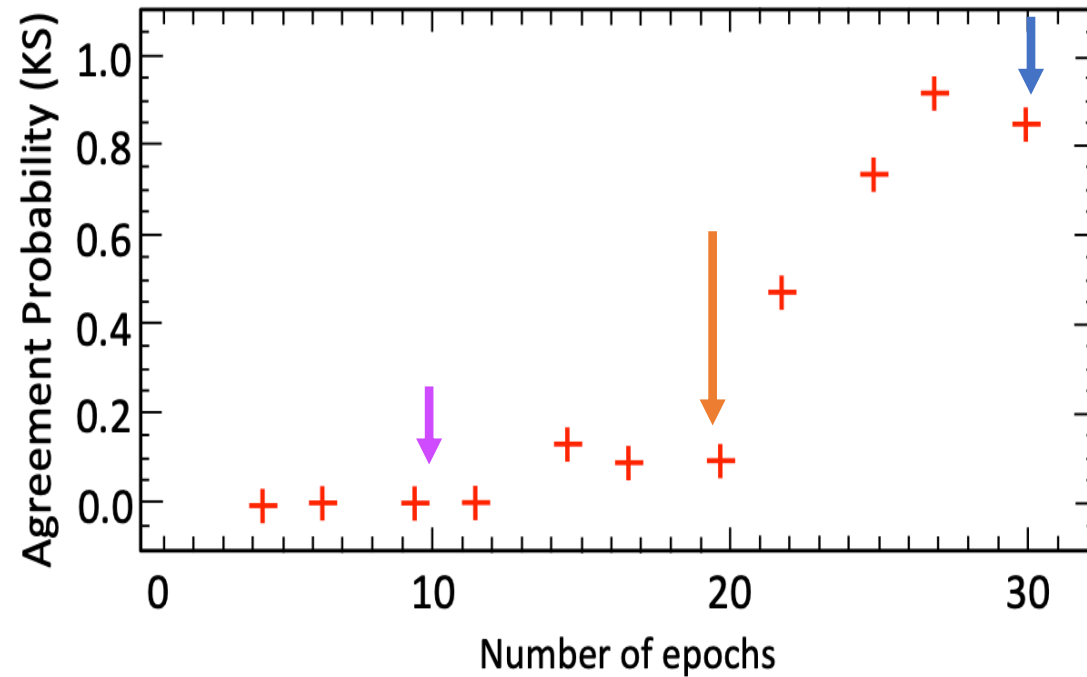


Number of epochs

Binary detection probability



Retrieving the correct period distribution



Number of epochs

Mapping outcome of binary formation

- Birth binary statistics of close binaries
 - Mass transition region (test for protobinary fragmentation, accretion, and orbital migration)
 - Binary initial-mass function, initial conditions of binary evolution
-

Mapping tidal interaction

- $(P-e)$ and $(P-vsini)$ diagrams $f(M, age)$
 - Circularisation and synchronisation in binary systems
 - Angular momentum transport
-

Mapping binary evolution

- Mass conservation parameter $\beta(q,P,M)$ for Case A mass transfer (Algols)
- Complete picture of the surviving MS+RG/RSG common-envelope (CE) binaries
- Plethora of Case B products to map outcome of disk accretion and spin-up

We will observe all the steps from the outcome of binary formation to stages immediately preceding the formation of double compact

→ Stringent test of GW progenitors evolution in a representative metallicity environment

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Project team

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