Closter look at...

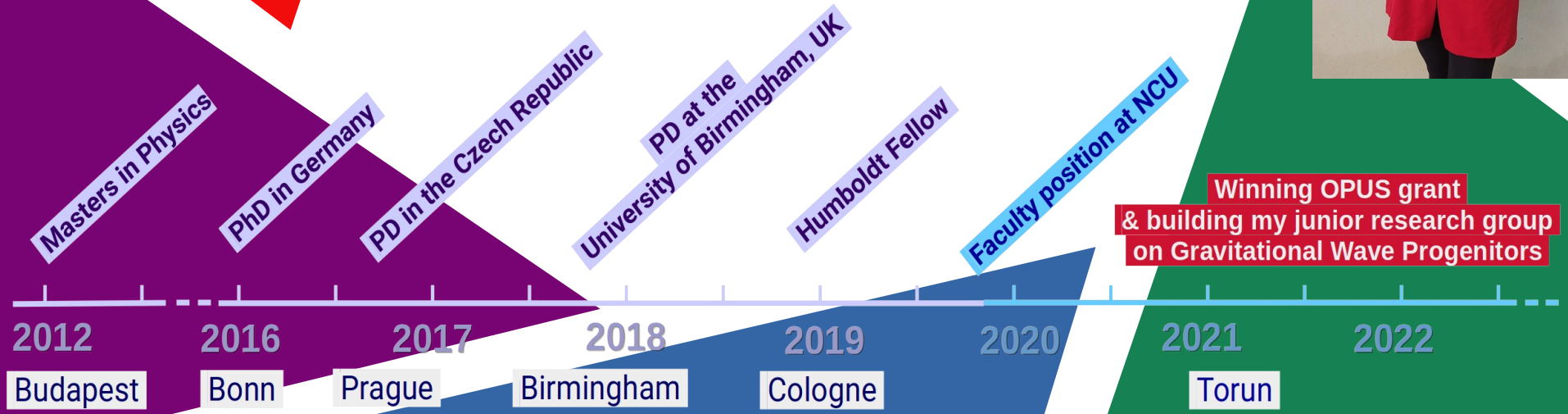
Massive Stars at low metallicities

dr. hab. Dorottya Szécsi
(Nicolaus Copernicus University)

Splinter Meeting ‘LowMet’
AG 13/09/2024, Uni of Cologne

dr. hab. Dorottya Szécsi
Nicolaus Copernicus University

Who am I?



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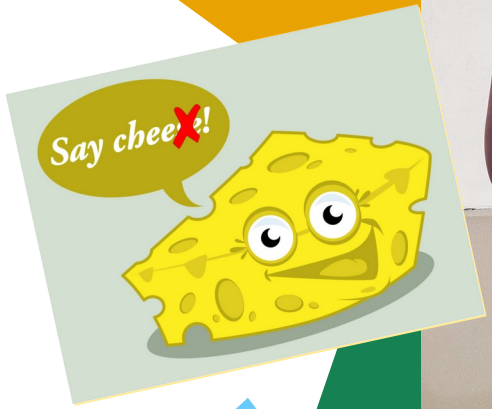


Masters in Physics — 2012 — Budapest

PhD in Germany — 2016 — Bonn

PD in the Czech Republic — 2017 — Prague

PD at the University of Birmingham, UK — 2018 — Birmingham

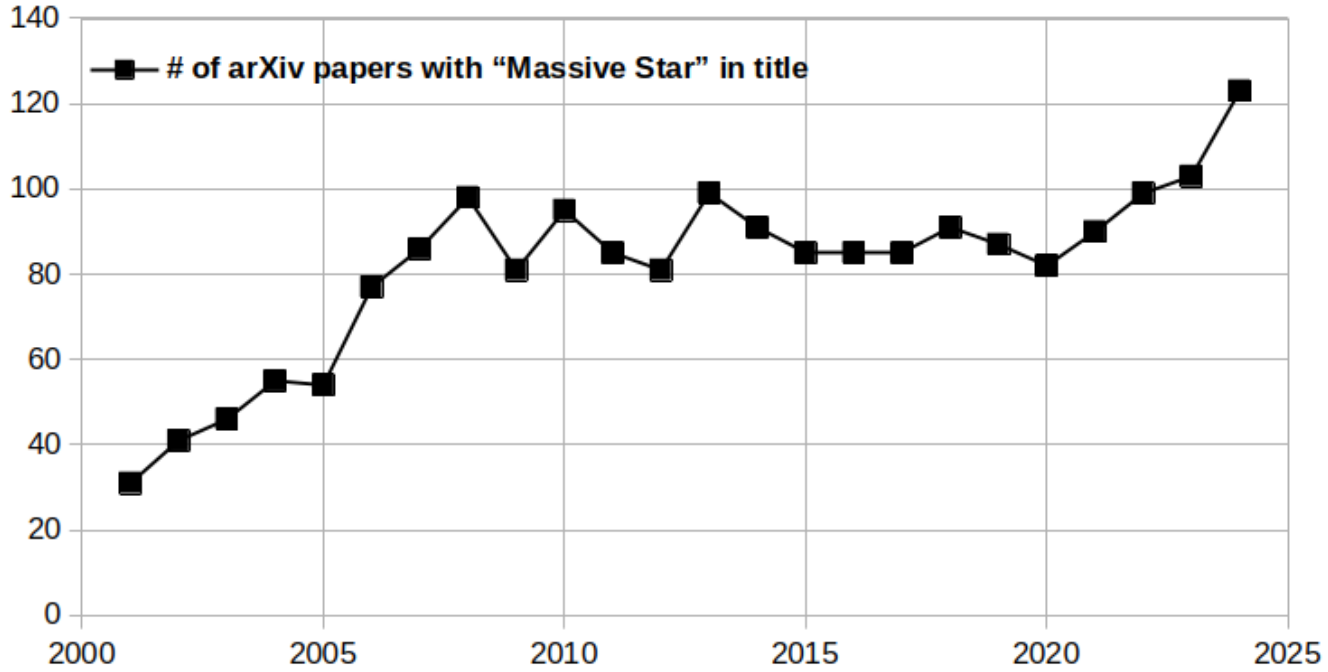
Humboldt Fellow — 2019 — Cologne

Faculty position at NCU — 2020

Winning OPUS grant & building my junior research group on Gravitational Wave Progenitors — 2021 — Torun

2022

Massive Stars is an active field



Developements since 2000

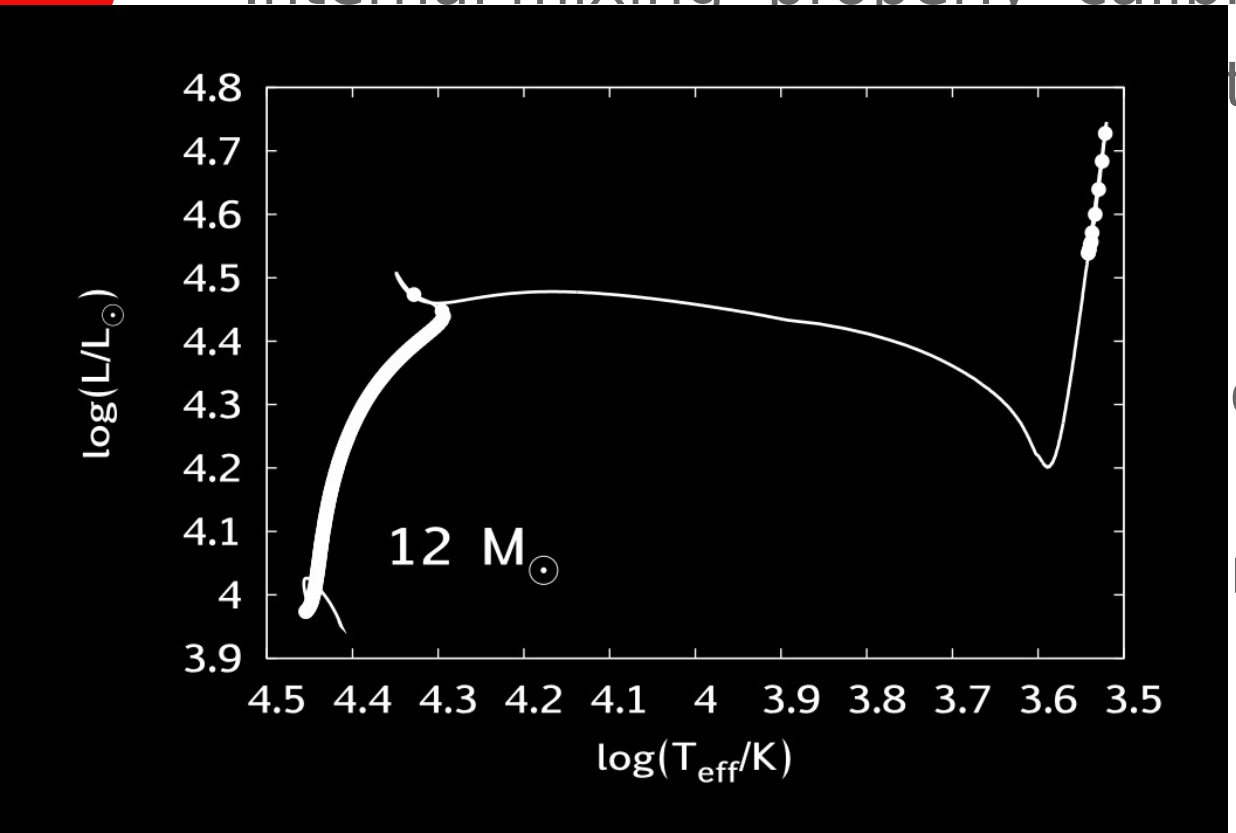
Not a full list!

- Internal mixing ‘properly’ calibrated
- Rotation included → new evolutionary pathways!
- Mass loss rates refined
- Binarity is SUPER important
- MESA = open-source stellar evolution code (blackbox?)
- Stellar atmospheres, envelope inflation (?!), convective overshoot, nuclear reaction rates…

Developements since 2000

Not a full list!

- Internal mixing ‘properly’ calibrated



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inflation (?!),
reaction rates...

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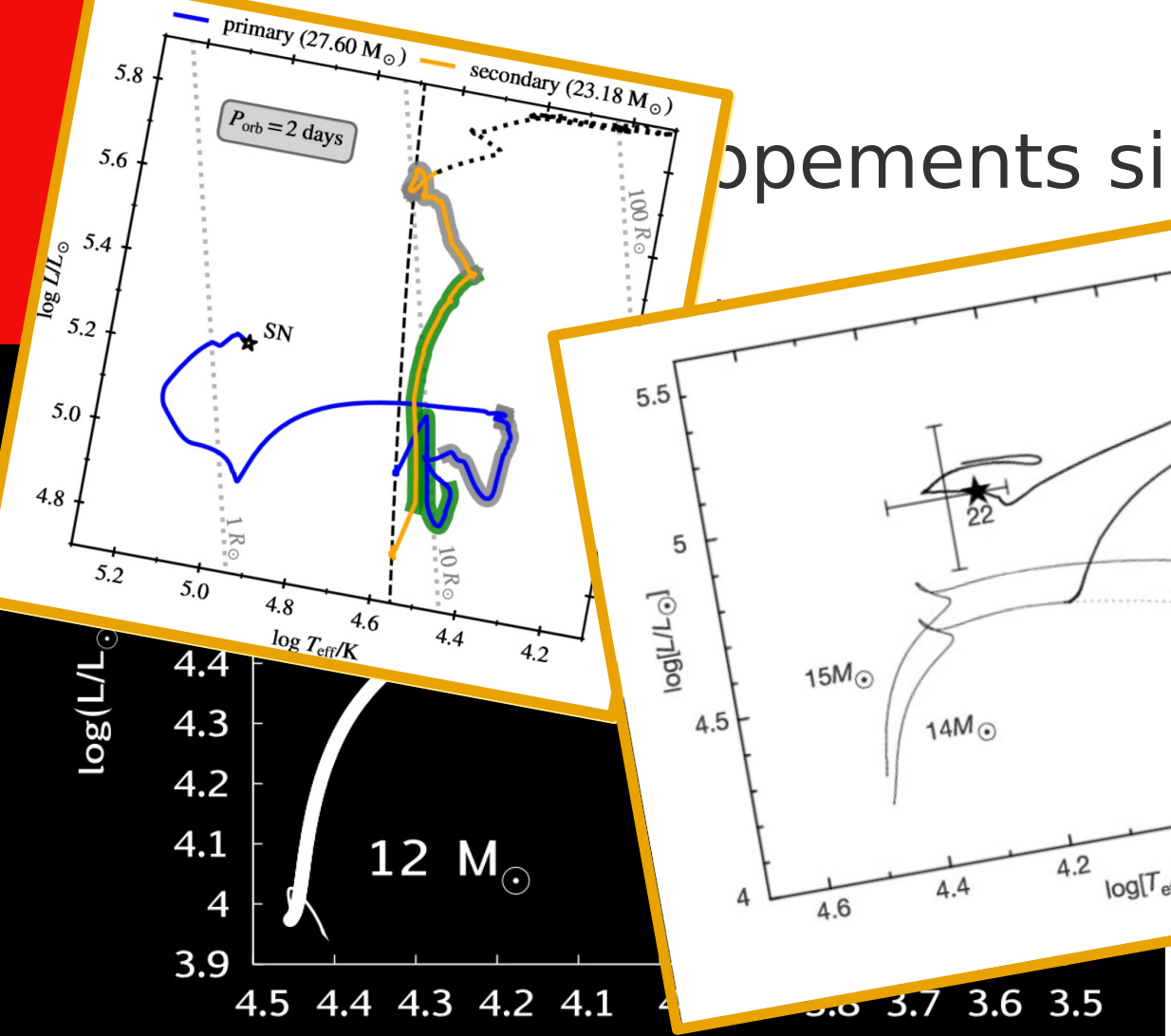
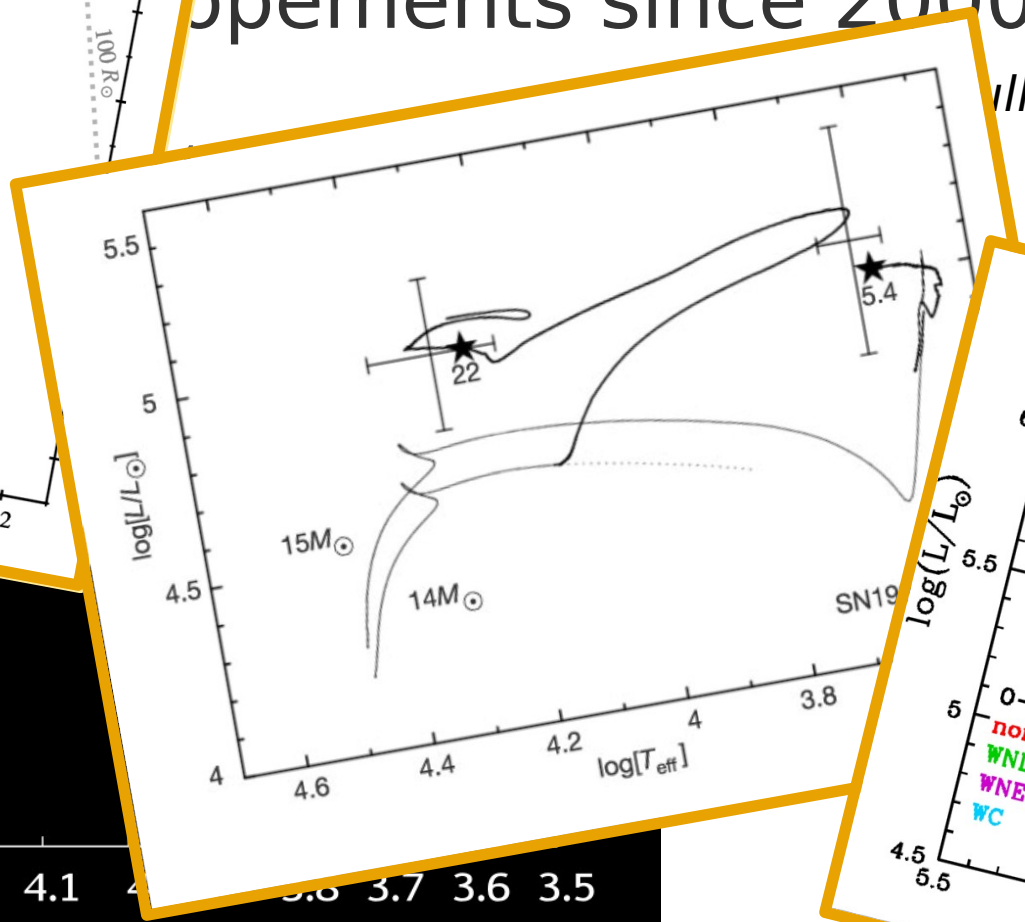
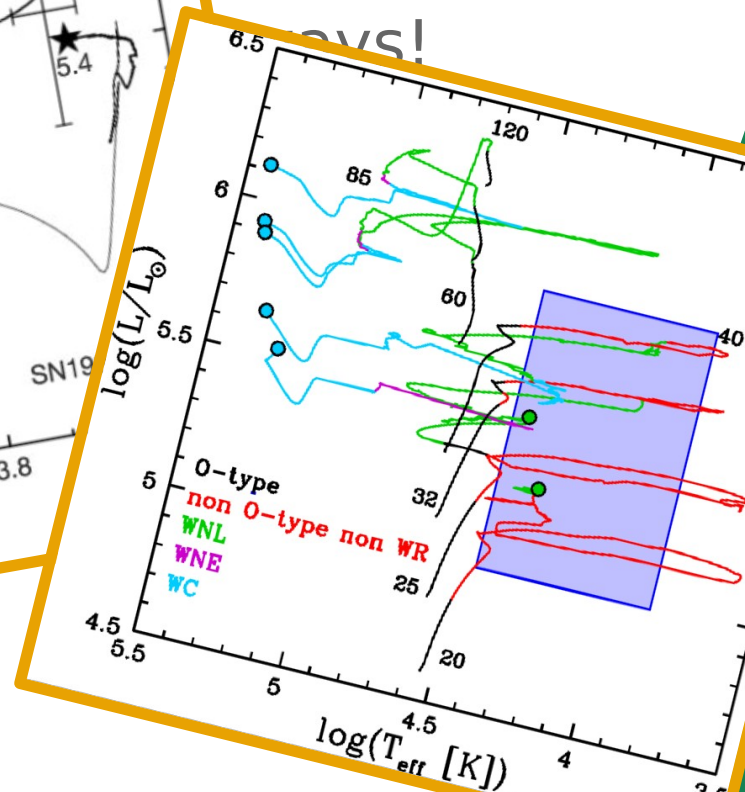
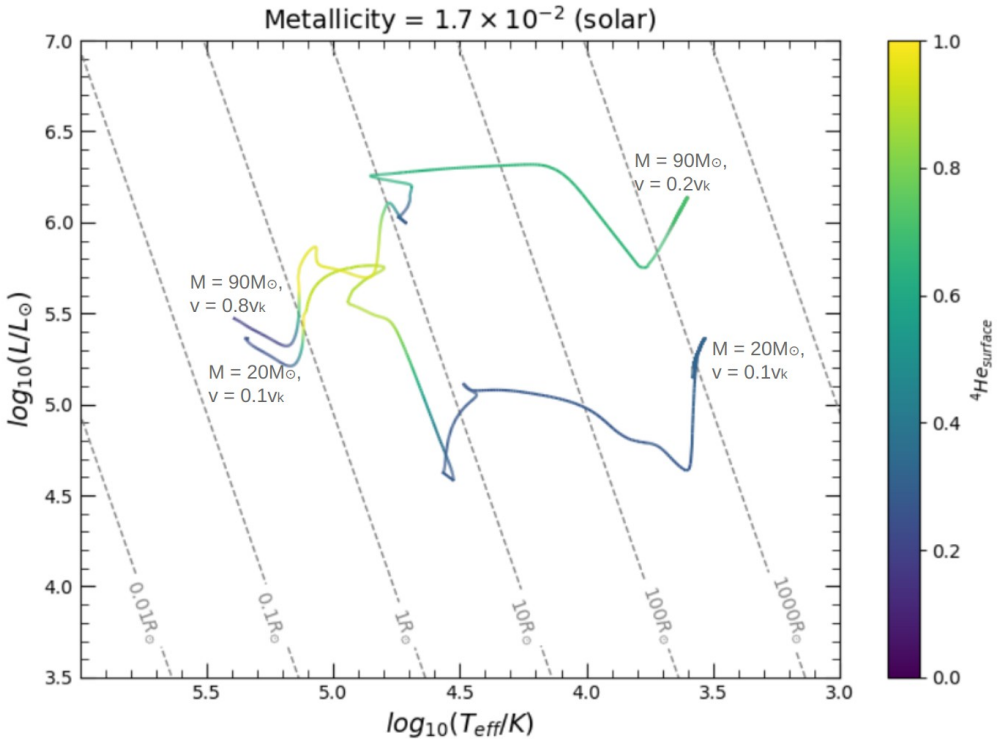
ull list!





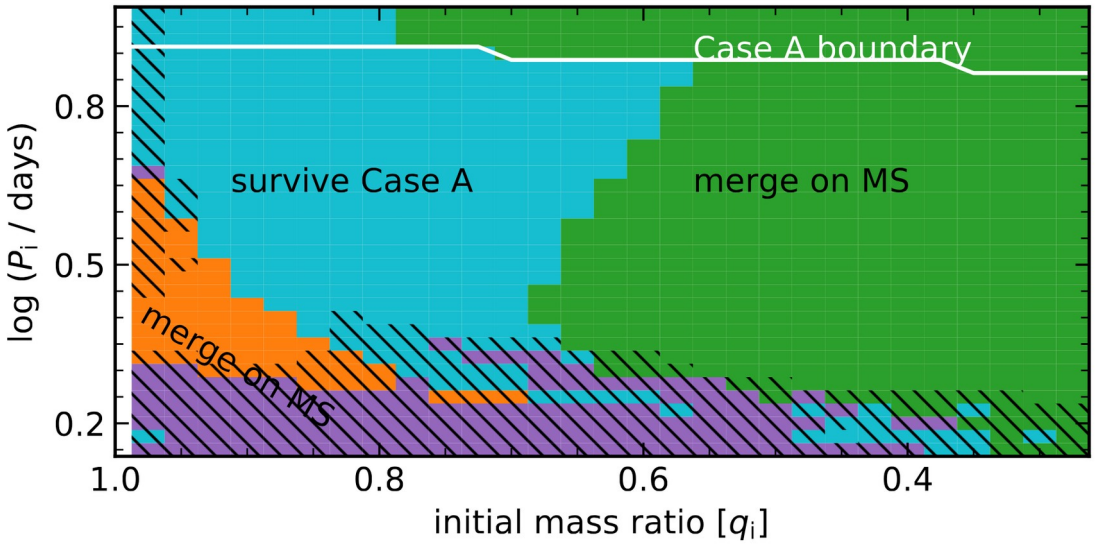


My own PhD student...



Credit: Rafia Sarwar (NCU)

My own post-doc...



Outcome of binary modelling with 23 $M_\odot$ primary star (Sen et al. 2022)

Credit: Koushik Sen (NCU)

Wait, but...

...why don't ***we*** have this cool new stuff?

star-formation community who need stellar-wind feedback

I hear you...

Not that simple.

- Conceptual excuse
  - consensus needs to be reached first (amongst ourselves) *sorry not sorry*
- Practical excuses
  - resource allocation: discovery vs. “incremental work”
  - lack of awareness?

Lack of awareness

- Personal experience: massive star people aren’t aware of your needs & desires
  - every time I bring it up at internal workshops, I feel like:

- And I’ve been bringing it up.

So: they should hear from ***you***!

For example: it's **fully consensual** by now that binaries are SUPER important. *Yet...*

Grid name	Metallicity	Nuclear network	log M1i	qi	logPi	Location of data	Citation
SMC full grid	SMC	basic2.net, co_burn2.net	0.6-2.15	0.30-1.0	0.0-3.5	hal: /vol/hal/halraid/cwang/MESA_bi	https://ui.adsabs.harvar
SMC full grid	SMC	basic2.net, co_burn2.net	1.0-2.25	0.25-1.0	0.0-3.5	hal: /vol/hal/halraid/cwang/MESA_bi	unpublished
SMC MC grid	SMC	basic2.net, co_burn2.net	0.7-2.00	0.30-1.0	0.0-3.5	hal: /vol/hal/halraid/cwang/MESA_bi	https://ui.adsabs.harvar
SMC MC grid	SMC	basic2.net, co_burn2.net	0.5-2.00	0.10-1.0	contact-3.5	hal: /vol/hal/halraid/xxu/mesa-run/SM	https://ui.adsabs.harvar
SMC MC grid	SMC	basic2.net, co_burn2.net	0.5-2.00	0.10-1.0	contact-3.5	hal: /vol/hal/halraid/xxu/mesa-run/SM	unpublished
LMC lowsc grid	LMC	basic2.net, co_burn2.net	1.0-1.60	0.25-1.0	0.15-3.5	hal: /vol/hal/halraid/pablo/mesa-run	https://ui.adsabs.harvar
LMC grid extend	LMC	basic2.net, co_burn2.net	1.65-1.85	0.25-1.0	0.10-4.0	hal: /vol/hal/halraid/dpauli/GRID	unpublished
LMC WR grid	LMC	basic2.net, co_burn2.net	1.45-2.00	0.25-1.0	0.10-4.0	hal: /vol/hal/halraid/dpauli/Yoon_GRI	https://ui.adsabs.harvar
SMC Case BB	SMC	basic2.net, co_burn2.net	0.90-1.40	0.25-1.0	0.10-4.0	hal: /vol/hal/halraid/cwang/MESA_b	unpublished
SMC high Mdot	SMC	basic2.net, co_burn2.net	1.80-2.00	0.3-0.8	0.90-1.2	hal: /vol/hal/halraid/cwang/MESA_bi	unpublished
Enhanced mixing	~0.00034	basic.net, co_burn.net	1.40-2.00	0.5-1.0	0.5-2.0	hal: /vol/hal/halraid/bhastings/Master	unpublished
POSYDON (v1)	Solar till now					https://zenodo.org/records/6655751	https://ui.adsabs.harvar
POSYDON (v2)	Solar till now (low	metallicity grids [Z⊙,10−1Z⊙,10−2Z⊙,10−3Z⊙,10−4Z⊙] in preparation?)					in prep.
Heidelberg	Solar						unpublished
BBH-PISN-CHE	solar/4 - solar/50	basic.net, co_burn.net	1.40-2.70	1.40-2.70	-0.4-0.6	link to mesa inlists broken, see next	https://ui.adsabs.harvar
BBH-PISN-CHE	-5 < log Z < -2.37	basic.net, co_burn.net	1.40-2.70	1.0 only	-0.4-0.6	https://zenodo.org/record/3667546	https://ui.adsabs.harvar
ULXs	-6 < log Z < -2	basic.net, co_burn.net	1.40-2.70	0.05-0.6	-0.3-0.5	https://zenodo.org/record/3431313	https://ui.adsabs.harvar
Contact Binaries	LMC, SMC	approx21.net	Mtot = 20-80	0.6 - 1.0	0.6-2.0 days	not public, not in hal	https://ui.adsabs.harvar

Credit: K. Sen, R. Sarwar

ple: it's **fully consensu**
aries are SUPER importa

Limited nuclear networks (usually 6-8 basic elements)

Rarely publically available → whatevs, build a collab. ✓

Grid name	Metallicity	Nuclear network	log M1i	qi	logPi	Location of data	Citation
SMC full grid	SMC	basic2.net, co_burn2.net	0.6-2.15	0.30-1.0	0.0-3.5	hal: /vol/hal/halrai wang/MESA_bi	https://ui.adsabs.harvar
SMC full grid	SMC	basic2.net, co_burn2.net	1.0-2.25	0.25-1.0	0.0-3.5	hal: /vol/hal/ha aid/cwang/MESA_bi	unpublished
SMC MC grid	SMC	basic2.net, co_burn2.net	0.7-2.00	0.30-1.0	0.0-3.5	hal: /vol/hal/halraid/cwang/MESA_bi	https://ui.adsabs.harvar
SMC MC grid	SMC	basic2.net, co_burn2.net	0.5-2.00	0.10-1.0	contact-3.5	hal: /vol/hal/halraid/xxu/mesa-run/SM	https://ui.adsabs.harvar
SMC MC grid	SMC	basic2.net, co_burn2.net	0.5-2.00	0.10-1.0	contact-3.5	hal: /vol/hal/halraid/xxu/mesa-run/SM	unpublished
LMC lowsc grid	LMC	basic2.net, co_burn2.net	1.0-1.60	0.25-1.0	0.15-3.5	hal: /vol/hal/halraid/pablo/mesa-run	https://ui.adsabs.harvar
LMC grid extend	LMC	basic2.net, co_burn2.net	1.65-1	0.25-1.0	0.10-4.0	hal: /vol/hal/halraid/dpauli/GRID	unpublished
LMC WR grid	LMC	basic2.net, co_burn2.net	0	0.25-1.0	0.10-4.0	hal: /vol/hal/halraid/dpauli/Yoon_GRI	https://ui.adsabs.harvar
SMC Case BB	SMC	b	.40	0.25-1.0	0.10-4.0	hal: /vol/hal/halraid/cwang/MESA_b	unpublished
SMC high Mdot	SMC			0.3-0.8	0.90-1.2	hal: /vol/hal/halraid/cwang/MESA_bi	unpublished
Enhanced mixing	~0.00			0.5-1.0	0.5-2.0	hal: /vol/hal/halraid/bhastings/Master	unpublished
POSYDON (v1)	So					https://zenodo.org/records/6655751	https://ui.adsabs.harvar
POSYDON (v2)	S		⊙,10−3Z⊙,10−4Z⊙] in preparation?)				in prep.
Heidelberg	Sc						unpublished
BBH-PISN-CHE	sc			1.40-2.70	-0.4-0.6	link to mesa inlists broken, see next	https://ui.adsabs.harvar
BBH-PISN-CHE	-5		2.70	1.0 only	-0.4-0.6	https://zenodo.org/record/3667546	https://ui.adsabs.harvar
ULXs	-6 < log Z		0-2.70	0.05-0.6	-0.3-0.5	https://zenodo.org/record/3431313	https://ui.adsabs.harvar
Contact Binaries	LMC, SMC	appr	Mtot = 20-80	0.6 - 1.0	0.6-2.0 days	not public, not in hal	https://ui.adsabs.harvar

None of them are complete in time… (num.crushes, MS/pMS mergers…)

Credit: K. Sen, R. Sarwar

They weren't created with you in mind. 😇😭

So when you meet your next massive-star person, tell them…

- What you need EXACTLY and why
  - List of elements (list them all!) *you can ask me for my list ;)*
  - Any other stellar property like surface temp., luminosity, wind kinetic energy…
  - *YOU NEED TIME COMPLETION, RIGHT? Tell them!*
- Not all application need time-completed populations.
  - e.g. mass of final remnant can be estimated by He-core
  - e.g. compact object merger rates can be estimated without pushing *stellar* mergers to evolve further
- But for proper stellar-wind feedback, time-completed populations are essential. This should be a **goal** in the massive star community. Be white crows with me? ;)

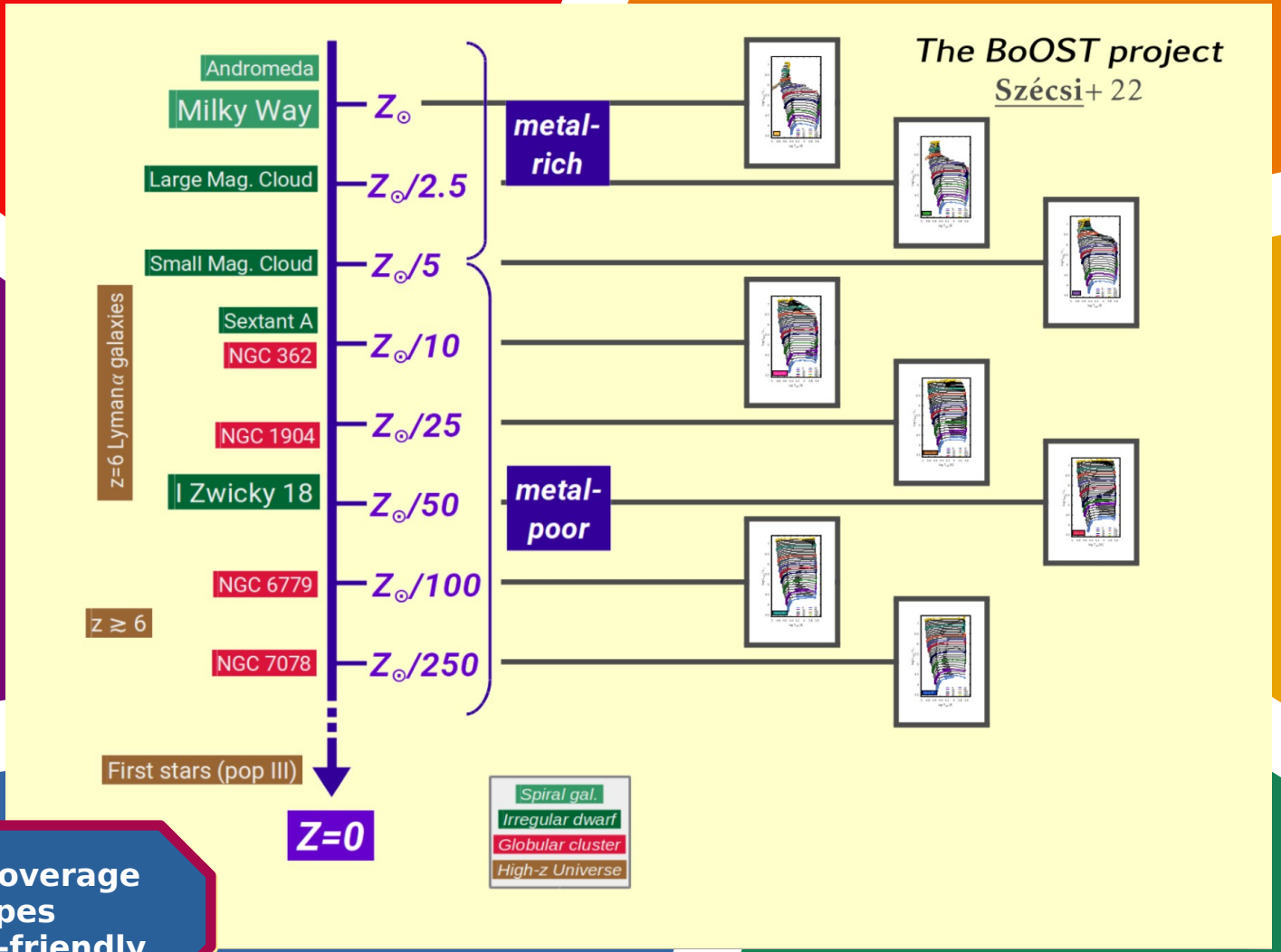
Need you to speak up. 😄😄

I’m already offering...

The BoOST project

The BoOST project

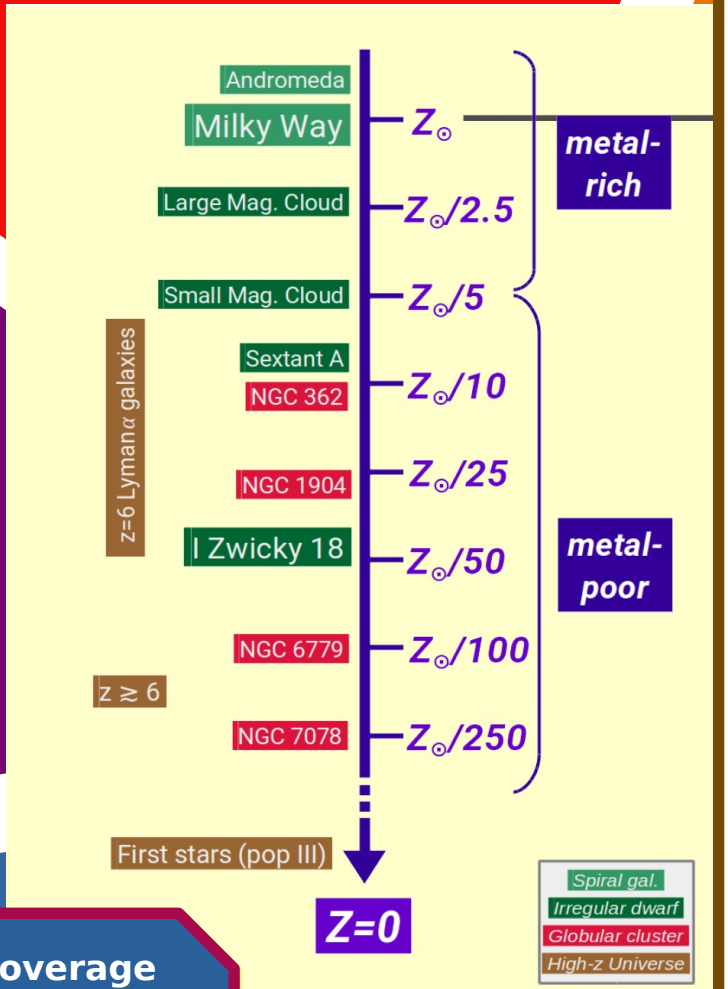
Computed with the Bonn evolution code → excellent for massive stars

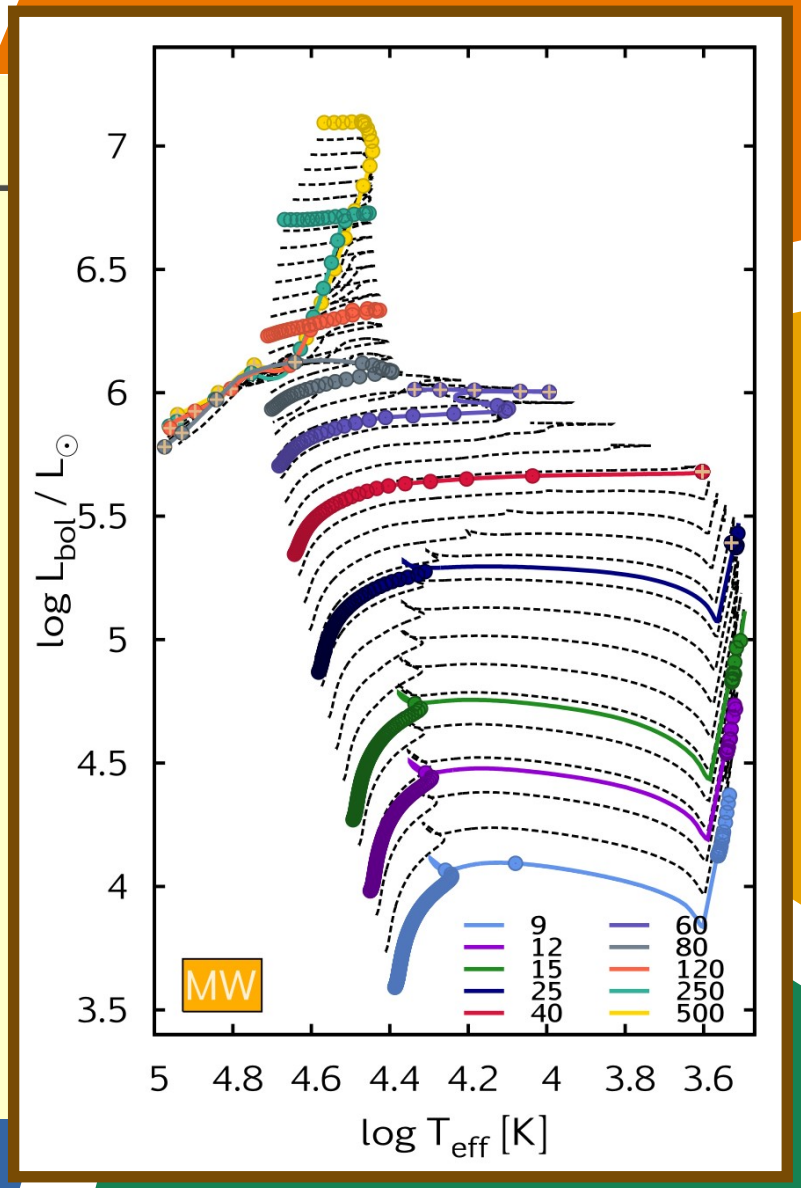


Proper time-coverage
32 isotopes
Public & user-friendly

The BoOST project

Computed with the Bonn evolution code → excellent for massive stars

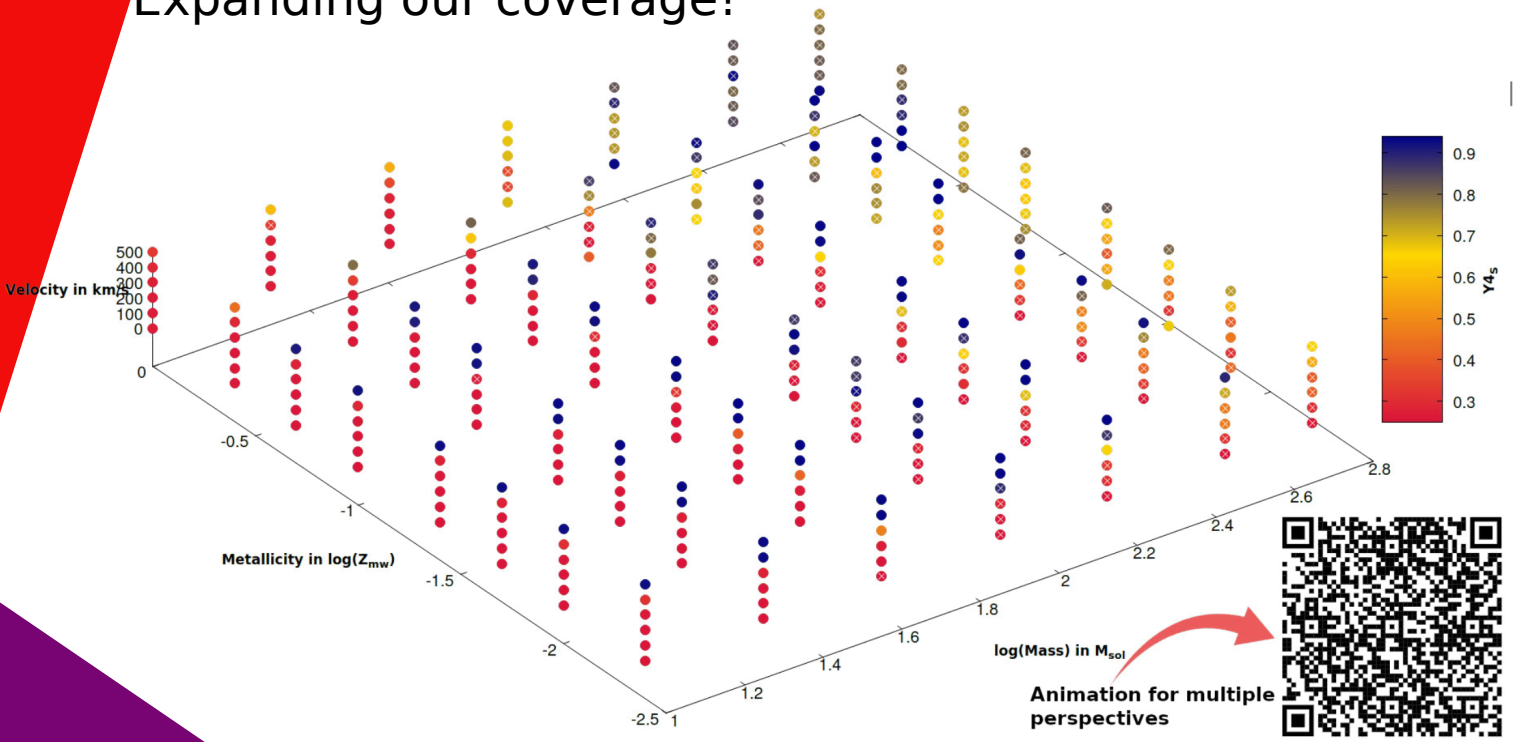




Proper time-coverage
32 isotopes
Public & user-friendly

My other PhD student...

Expanding our coverage!



Credit: Hanno Stinshoff

Thoughts on MESA

- MESA is cool. Love it.
- ***But it's a black box for (most of) you.***
- Don't publish anything without consulting with one of us! *(Employ us? ;))*

massive star people

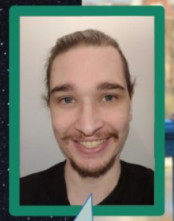
My people :D

Dr Poojan Agrawal
(post-doc at Chapel Hill, NC)

Agrawal & Szécsi et al. (2022, MNRAS)

In Toruń, Poland:

Dr. Koushik Sen
(post-doc)



Hanno Stinshoff
(PhD student)

Rafia Sarwar
(PhD student)

maybe you?
hiring soon for 2025/26

Thank you!

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at low
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