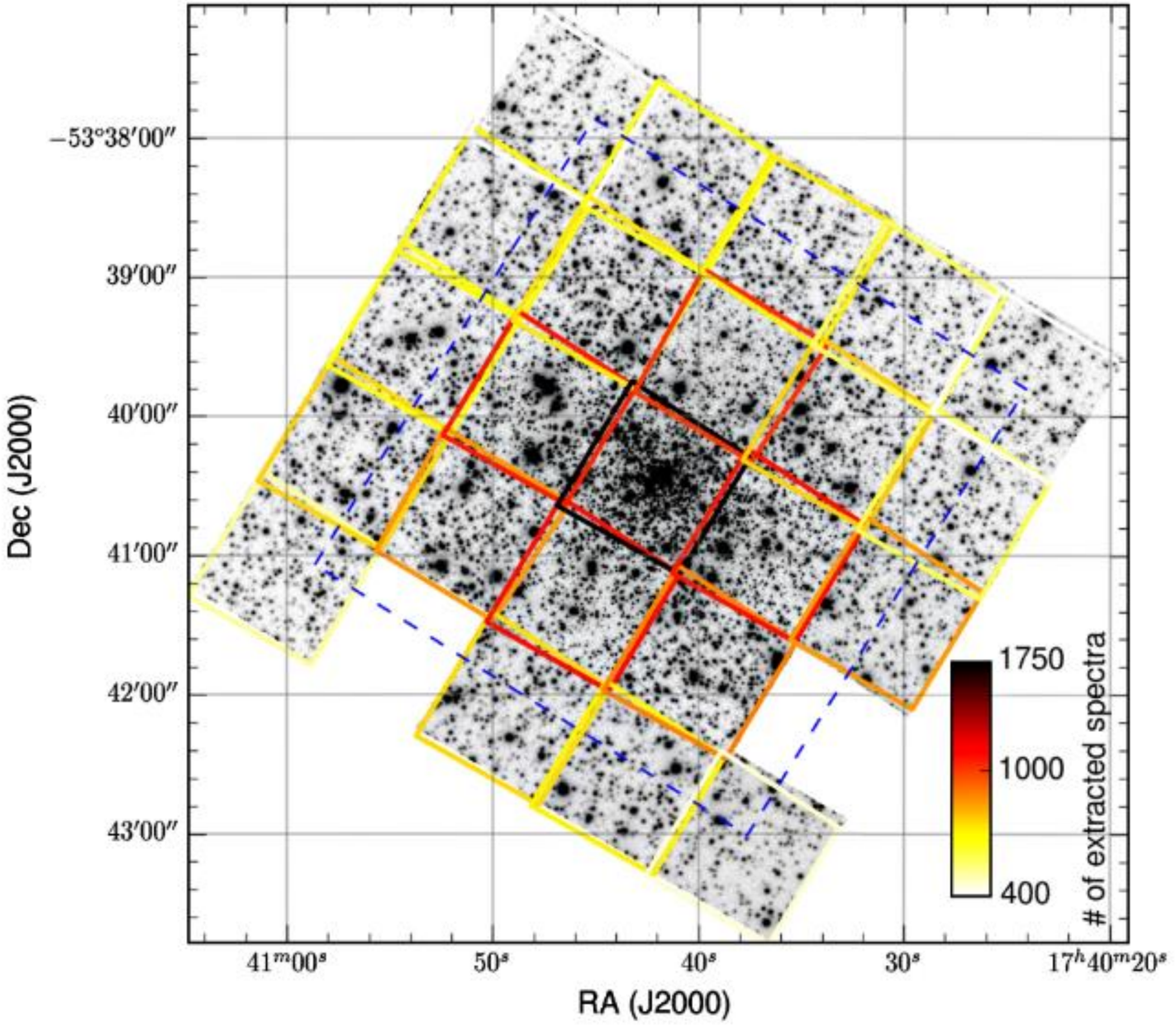
GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN IN PUBLICA COMMODA SEIT 1737

INSTITUT FÜR ASTROPHYSIK & GEOPHYSIK

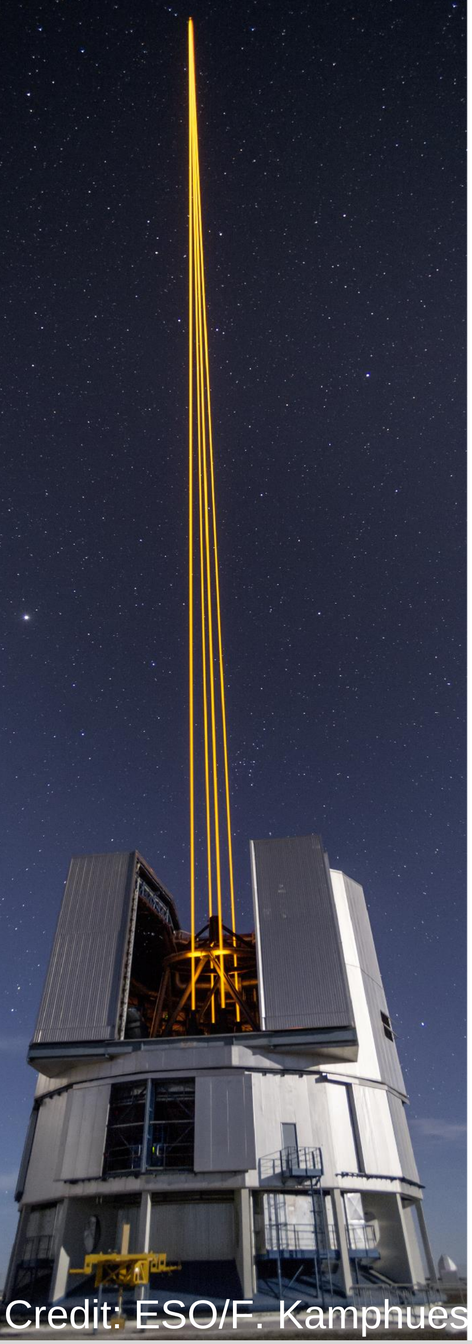
MUSE multi unit spectroscopic explor

A WD Triple in NGC6397

*Fabian Göttgens, **Stefan Dreizler**, Sebastian Kamann, Ulrich Heber, Marily Latour, Sven Martens, Johanna Müller-Horn, Sara Saracino, Tim-Oliver Husser, MUSE-Team*



MUSE Mosaic of NGC6397, Husser et al. 2016


Credit: ESO/F. Kamphues

Galactic Globular Clusters and MUSE

GCs old, massive star clusters in the halo

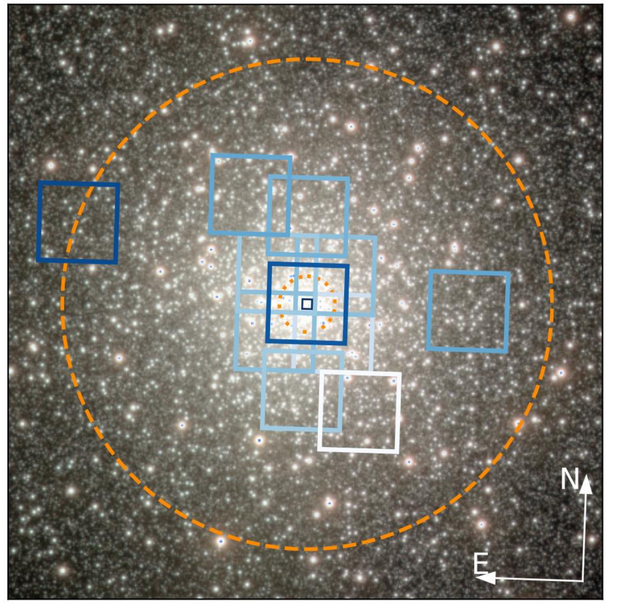
~10^5 to 10^6 $M_\odot$ within a few pc

MUSE GTO + GO

~ a decade of MUSE observations

reliable spectra of > 400,000 stars *(1)*

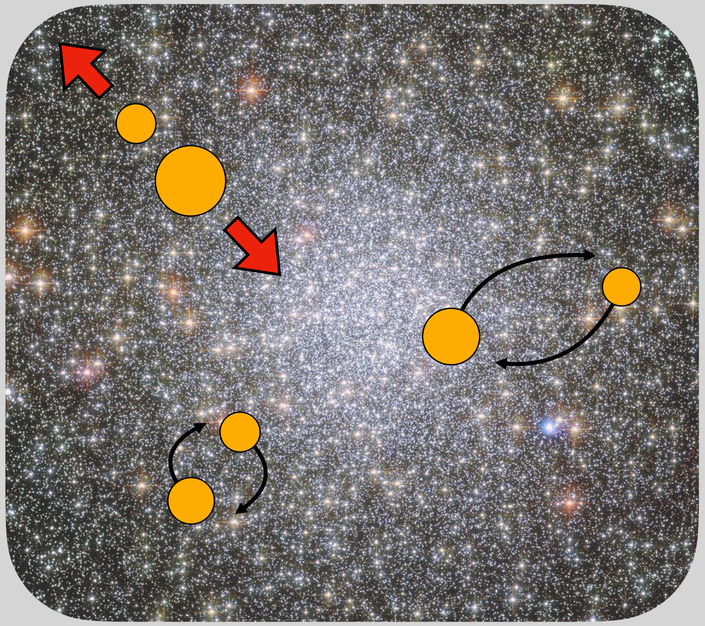
Multiple epochs per star



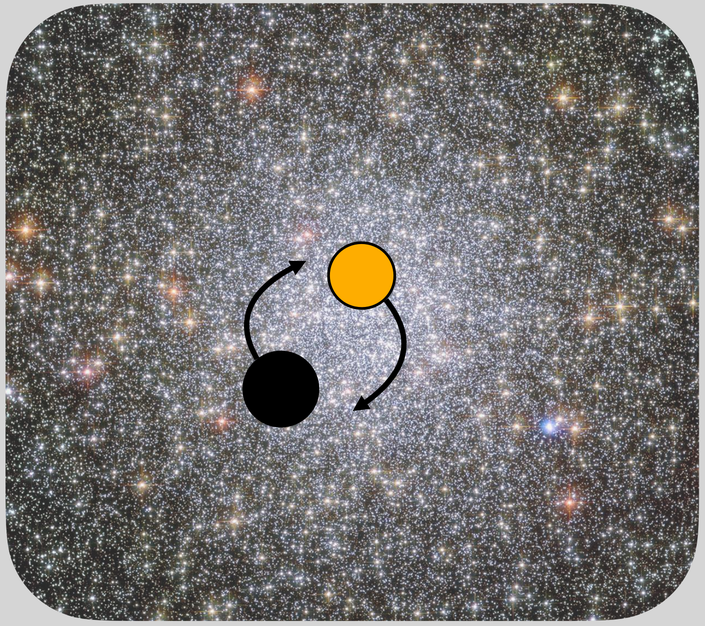
MUSE FoV of 47 Tuc,
image taken from VMC survey

(1) Kamann et al. (2013)

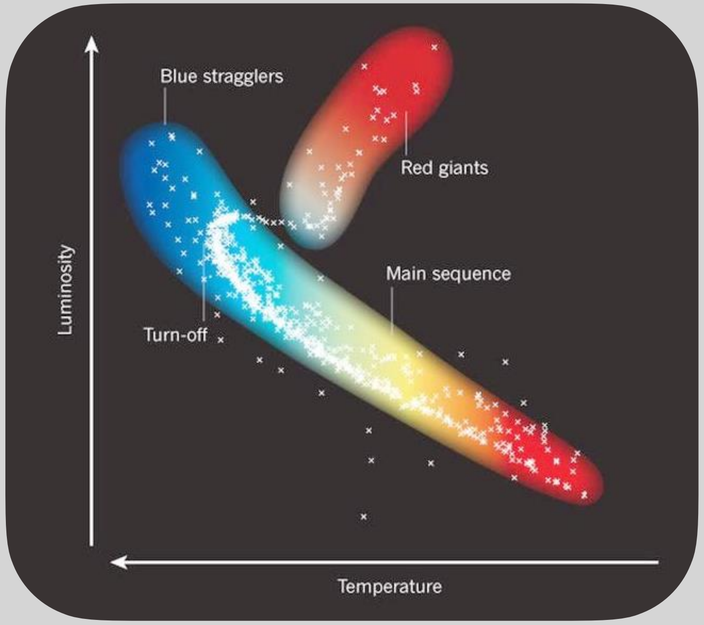
Binaries in Globular Clusters



Binary fraction, mass segregation and cluster dynamics



Stellar and intermediate mass **Black Holes, GW sources**



High stellar density favors formation of exotic binaries: **Blue stragglers**, **ms pulsars**, …

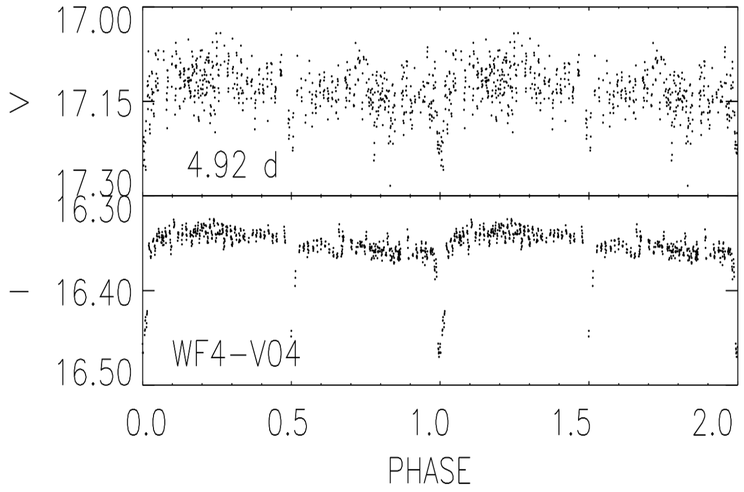
47 Tuc, Credits: NASA, ESA

Previous observations

eclipsing binaries

Albrow & Gilliland (2001),
Weldrake & Sackett (2004),
Kaluzny et al. (2013),
Nardiello et al. (2019)

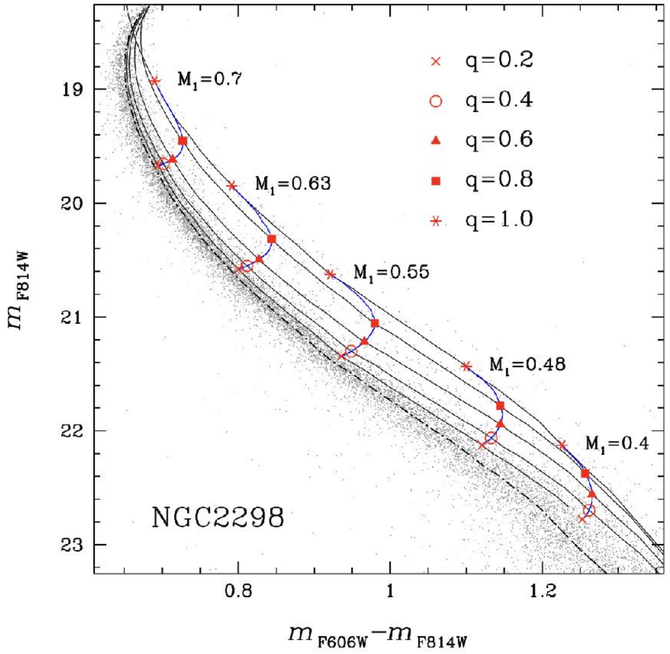
Albrow & Gilliland (2001)



binary main sequence

Milone et al. (2012),
Ji & Bregmann (2015)

Milone et al. (2012)



radio & X-ray sources

Heinke et al. (2005)
Bahramian et al. (2017),
Miller-Jones et al. (2015)
Rivera Sandoval et al. (2018)

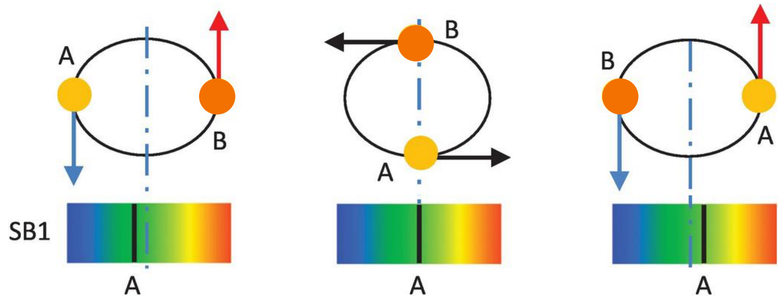
„tip of the iceberg“

- ➡ limited information on companion masses and period distribution
- ➡ low overall binary fraction

Search for SB1 binaries

data $t, v_{\mathrm{rad}}, \sigma_{v_{\mathrm{rad}}}$

model $v_{\mathrm{rad}} = v_{\mathrm{z}} + K(\cos(\omega + f) + e\cos(\omega))$



Walker (2017)

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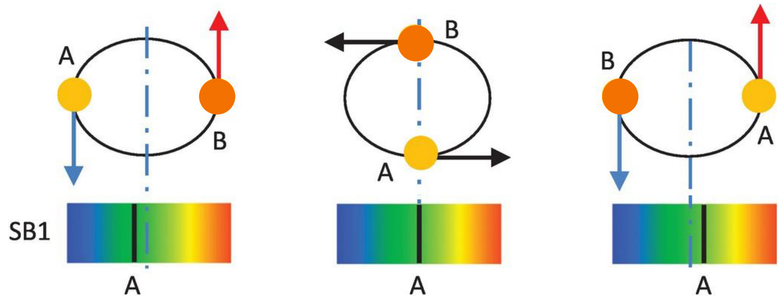
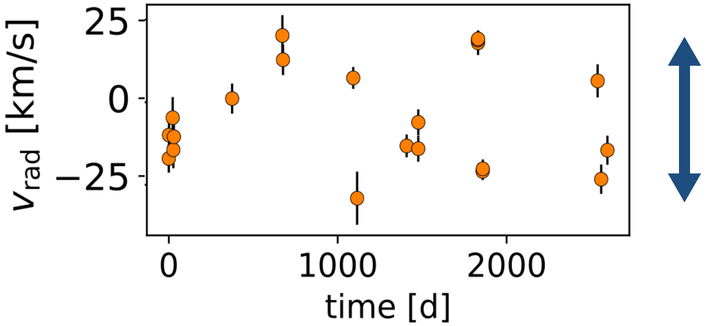


Walker (2017)

A. identify binaries in a statistical approach *(Giesers et al. 2019)*



larger RV scatter ⇔
higher binary probability

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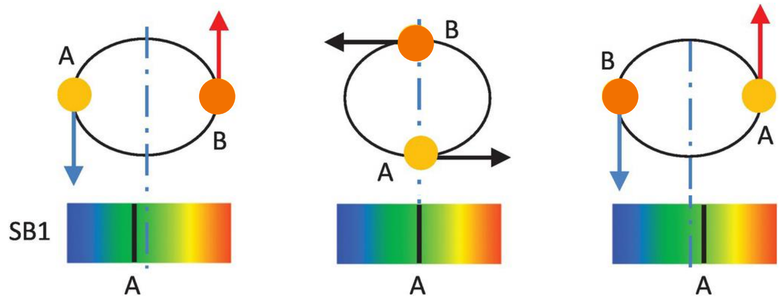

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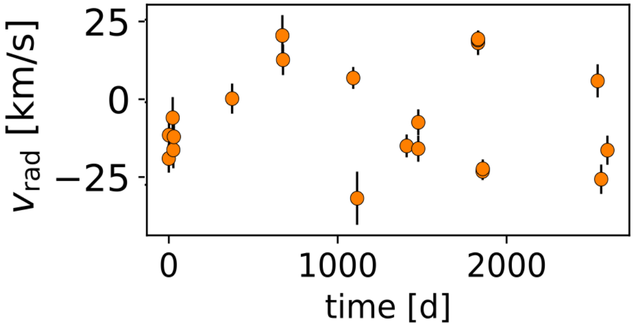
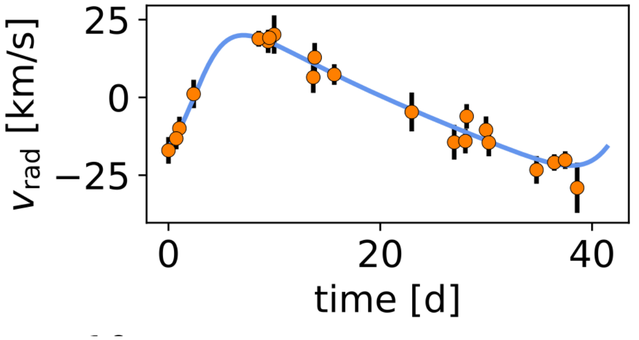
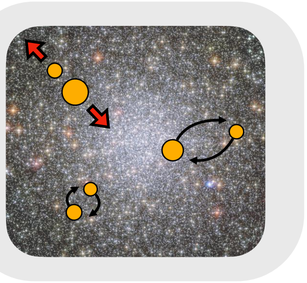


larger RV scatter ⇔ higher binary probability

B. determine orbital parameters using nested sampling *(Buchner 2021)*



nested sampling works well for multi-modal solutions



Binary demographics

Binary fraction

Discovery binary fraction

↓

account for limited discovery probability ← depends on CMC/MOCCA binary parameters

↓

correct for limited sensitivity and FoV ← depends on CMC/MOCCA radial and q profiles

↓

Total binary fraction

47 Tuc 2.4 ± 0.9

Müller-Horn et al. 2024, under review

ω Cen 2.1 ± 0.4

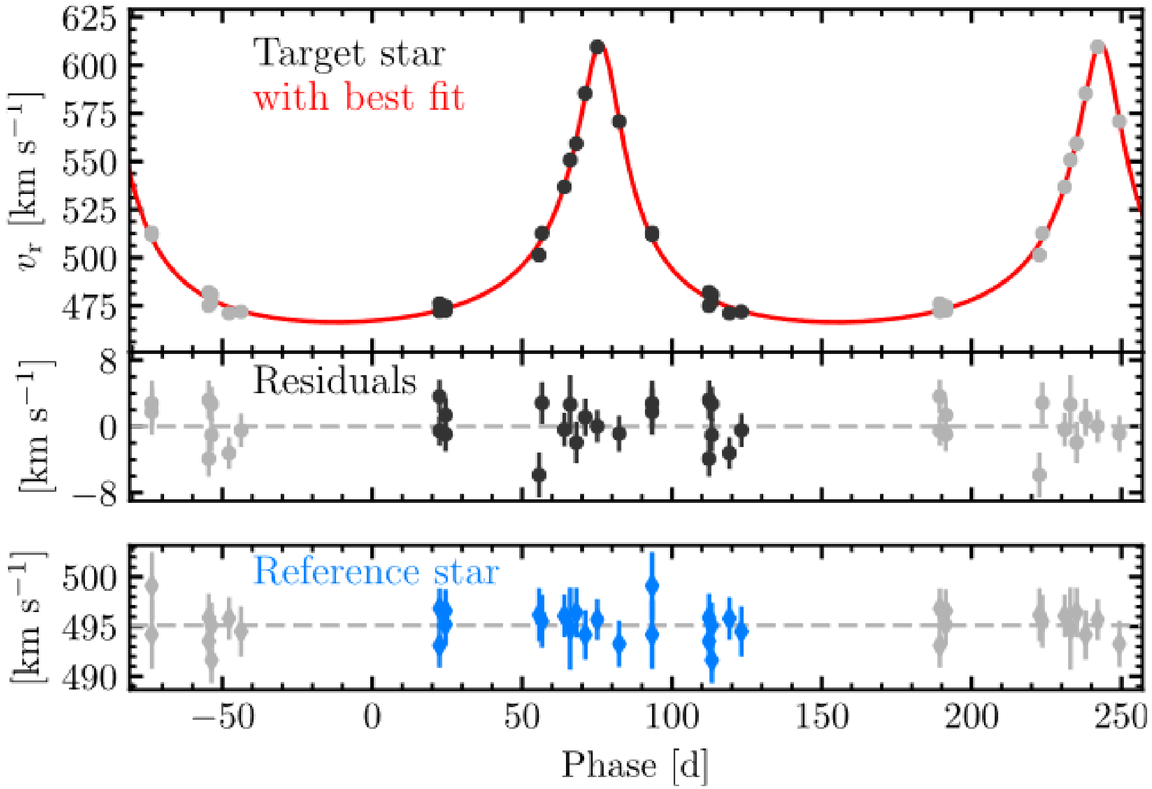
Wragg et al. 2024, arXiv

NGC 3201 6.75 ± 0.72
P1 > P2

Giesers et al. 2019, A&A
Kamann et al. 2020, A&A

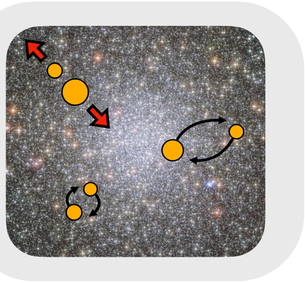
Black hole(s) in NGC 3201

Dark remnant companions



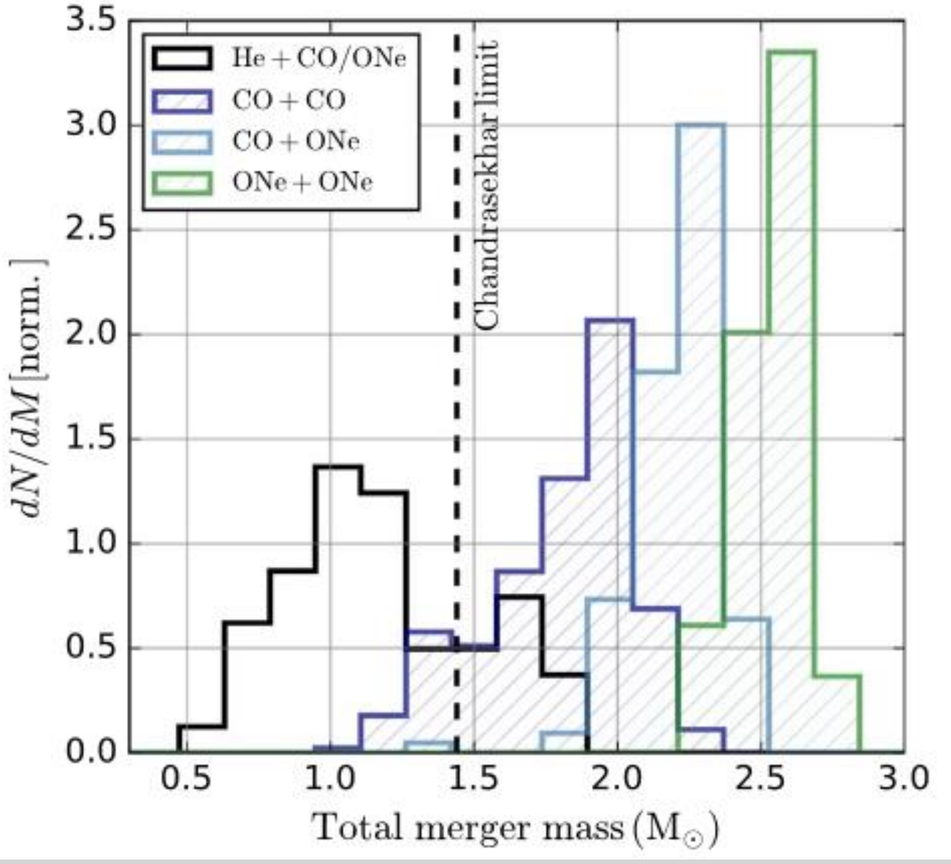
BH + MS	3
NS + MS	1
WD + MS	25

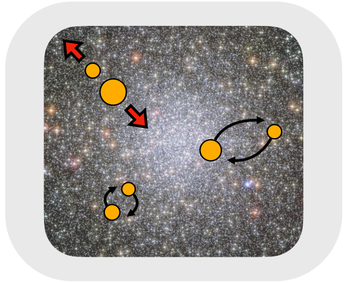
Giesers et al. 2018, A&A, Giesers et al. 2019, A&A



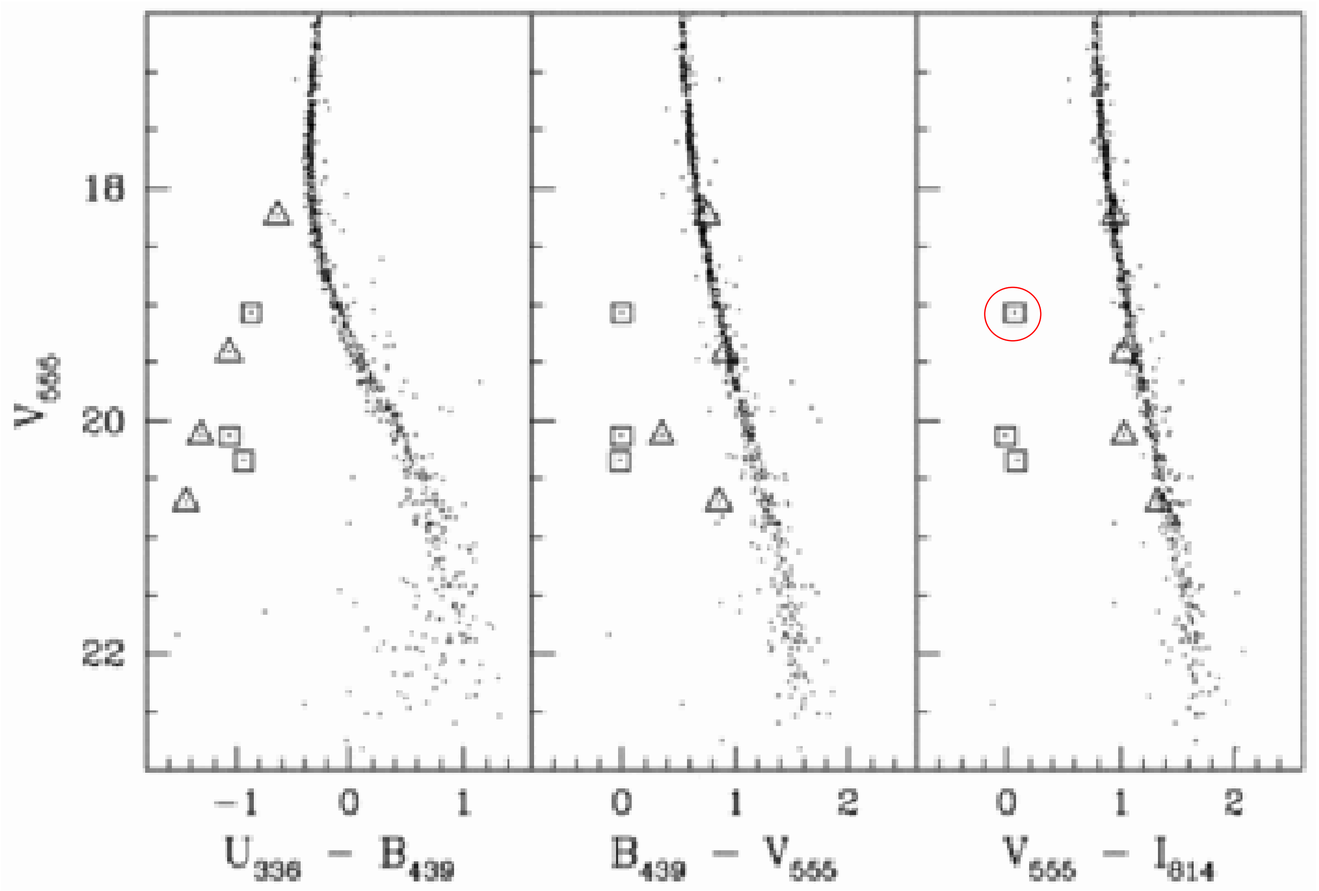
NGC 6397 central dynamics

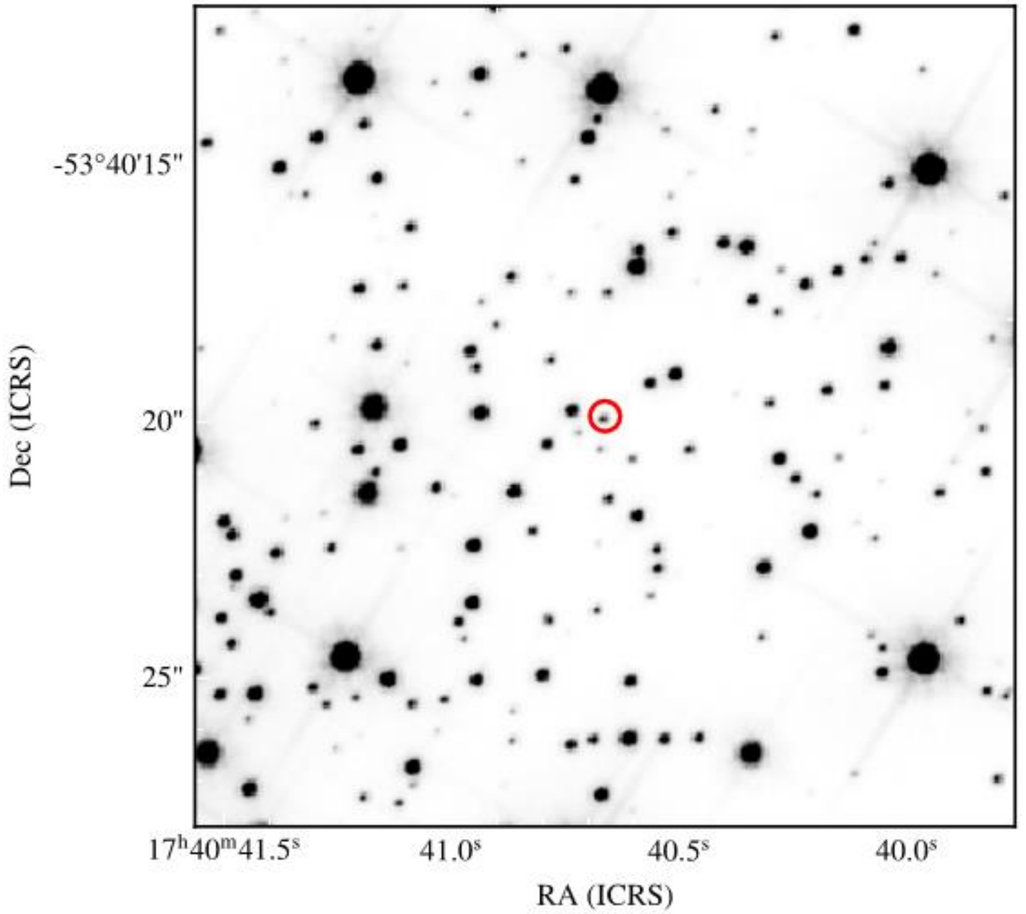
- Kamann et al 2016: MUSE RV dispersion: IMBH or dark sub-cluster ~600 $M_\odot$
- Eduardo & Gray 2021: HST+GAIA astrometry: 1000-2000 $M_\odot$ BH sub-cluster
- Kremer et al. 2021: CMC simulations: WD sub-cluster
  - MUSE proposal for binary detection
  - No WD-MS binary detected
  - But …

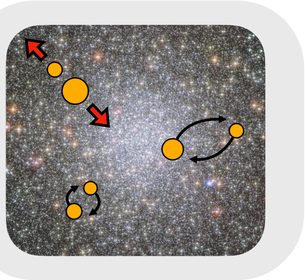




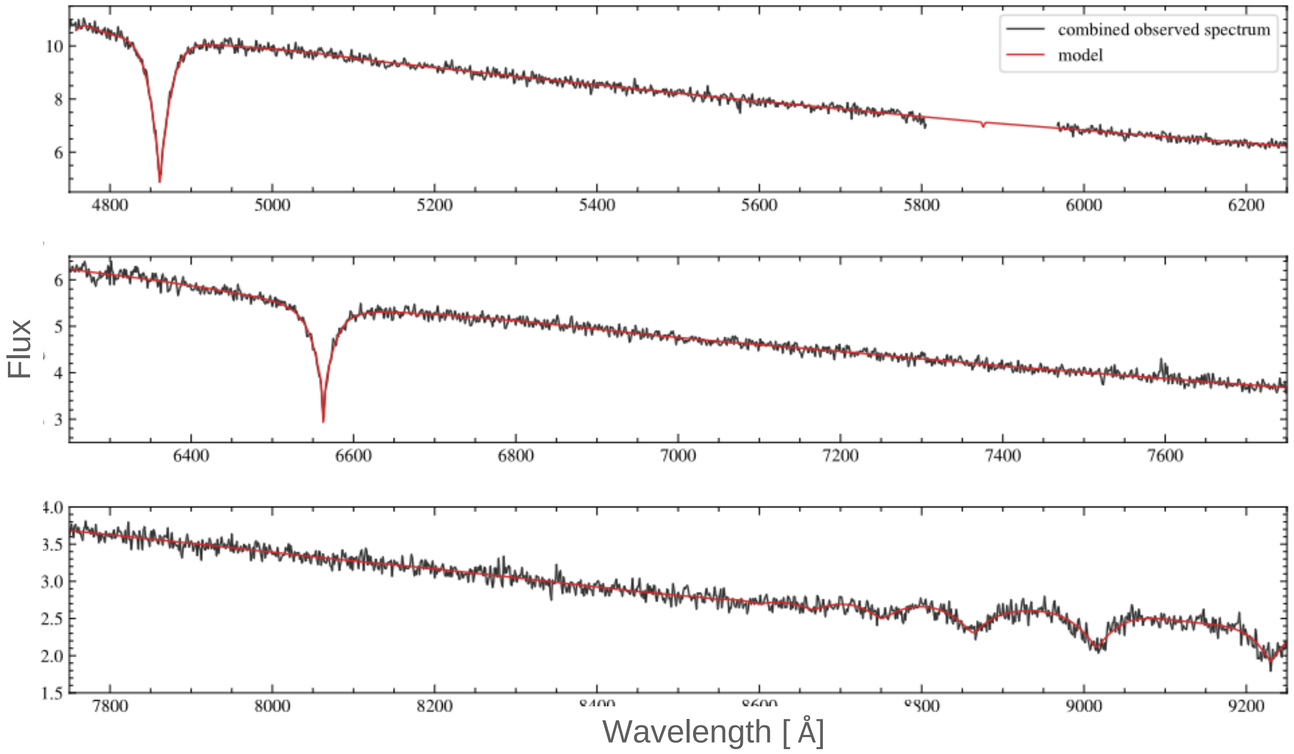
CV search in NGC6397 (Cool et al. 1998)

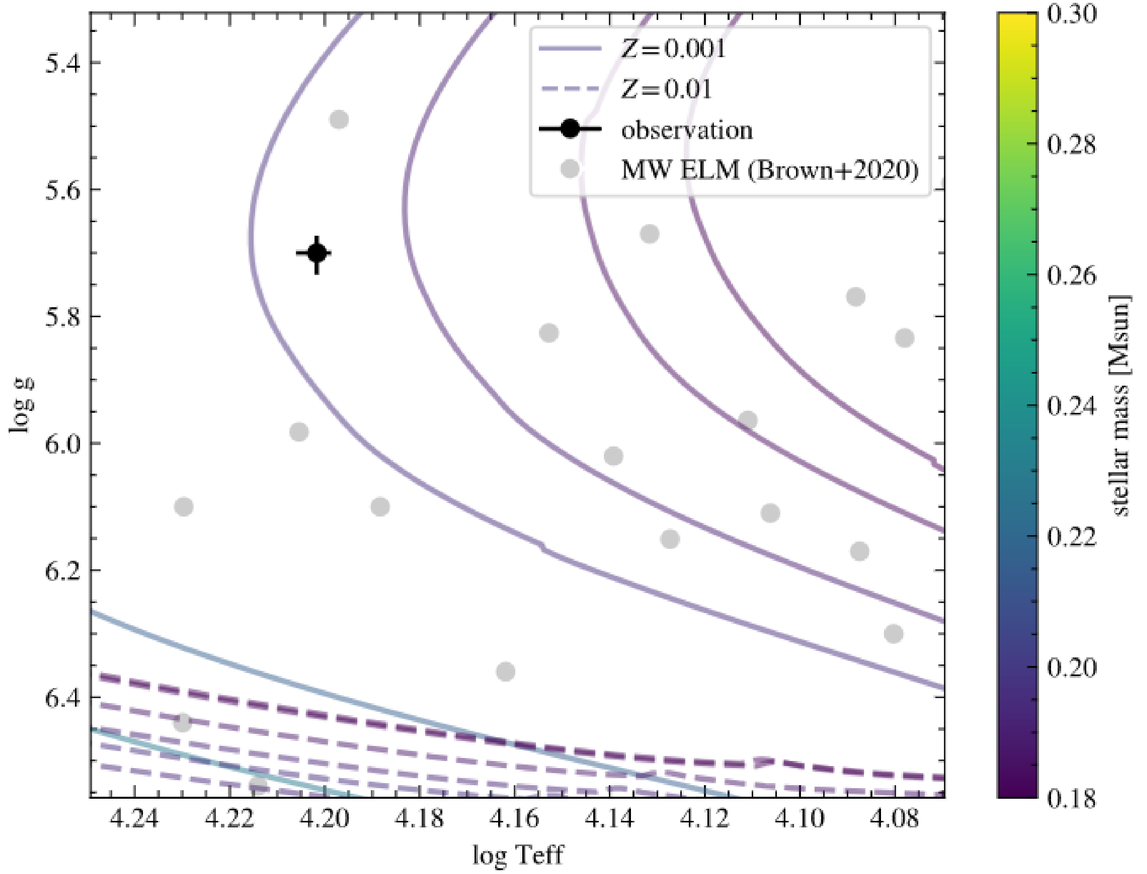




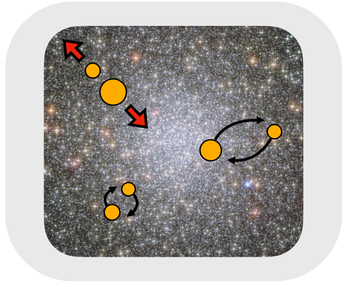


Spectroscopic analysis
(Göttgenes et al. In prep)

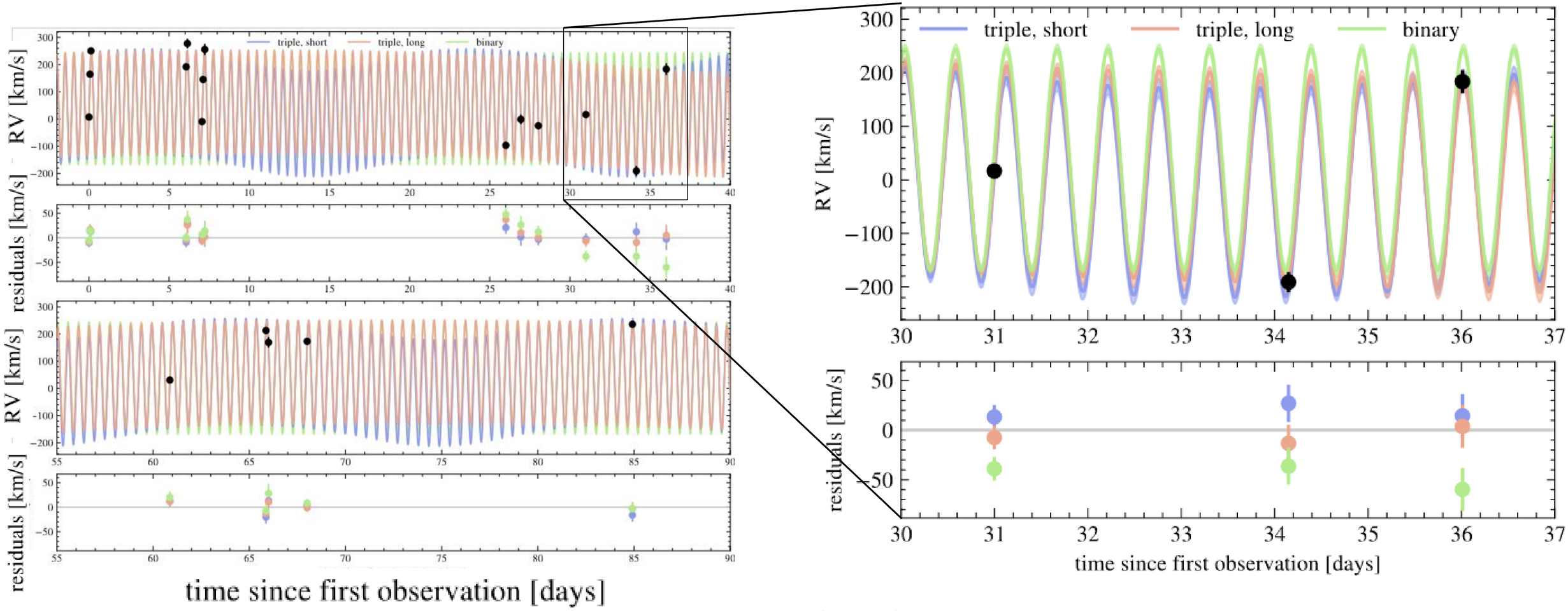




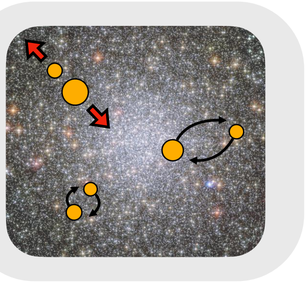
He WD with 0.23 $M_\odot$



Possible Triple in NGC 6397 (WD+WD+NS?)

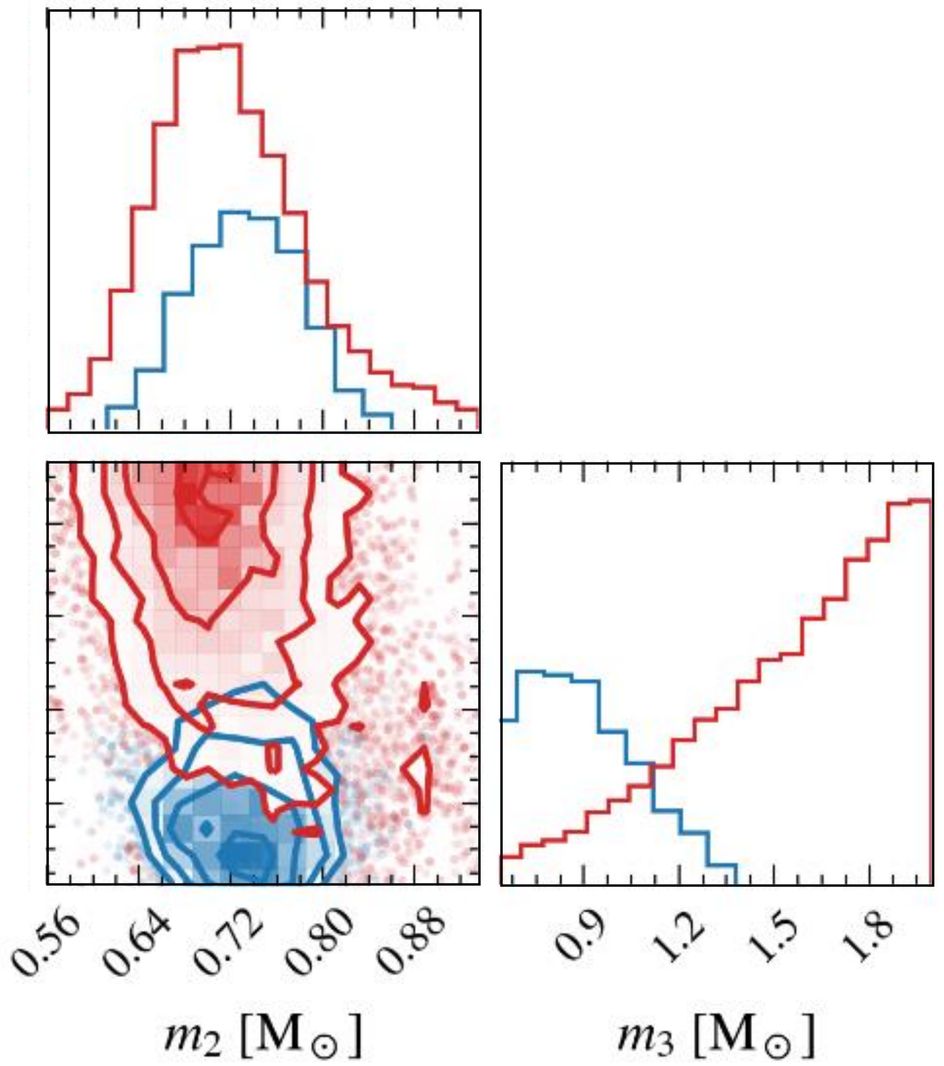


Göttgens et al. 2024, in preparation

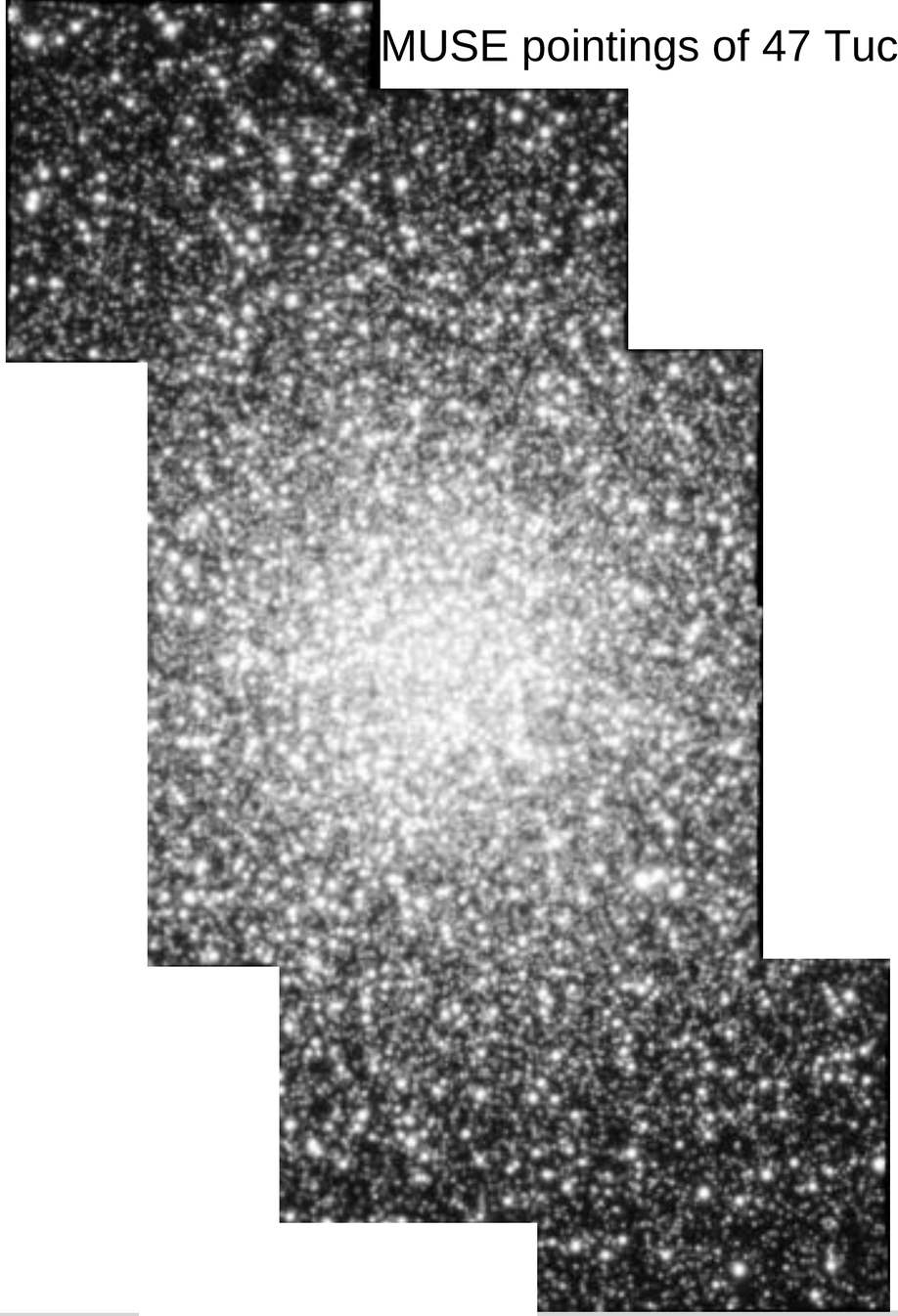


Companion masses

- P_{bin} = 0.52 d, m_1 = 0.23 $M_\odot$
- Two families of solutions: P_3 = (20d, 60d)
  - m_2 = 0.7 $M_\odot$: CO-WD
  - m_3 = 0.9 $M_\odot$: CO-WD
  - m_3 = 0.9…> 2 $M_\odot$: ONeMg-WD NS?



Summary



- He-WD + CO-WD + WD or NS
- Such Triples are predicted by CMC simulations (Kremer, priv. com.)
- Important check for cluster dynamics simulations