“Widowed” stars probe BH kicks

Mathieu Renzo
PhD in Amsterdam

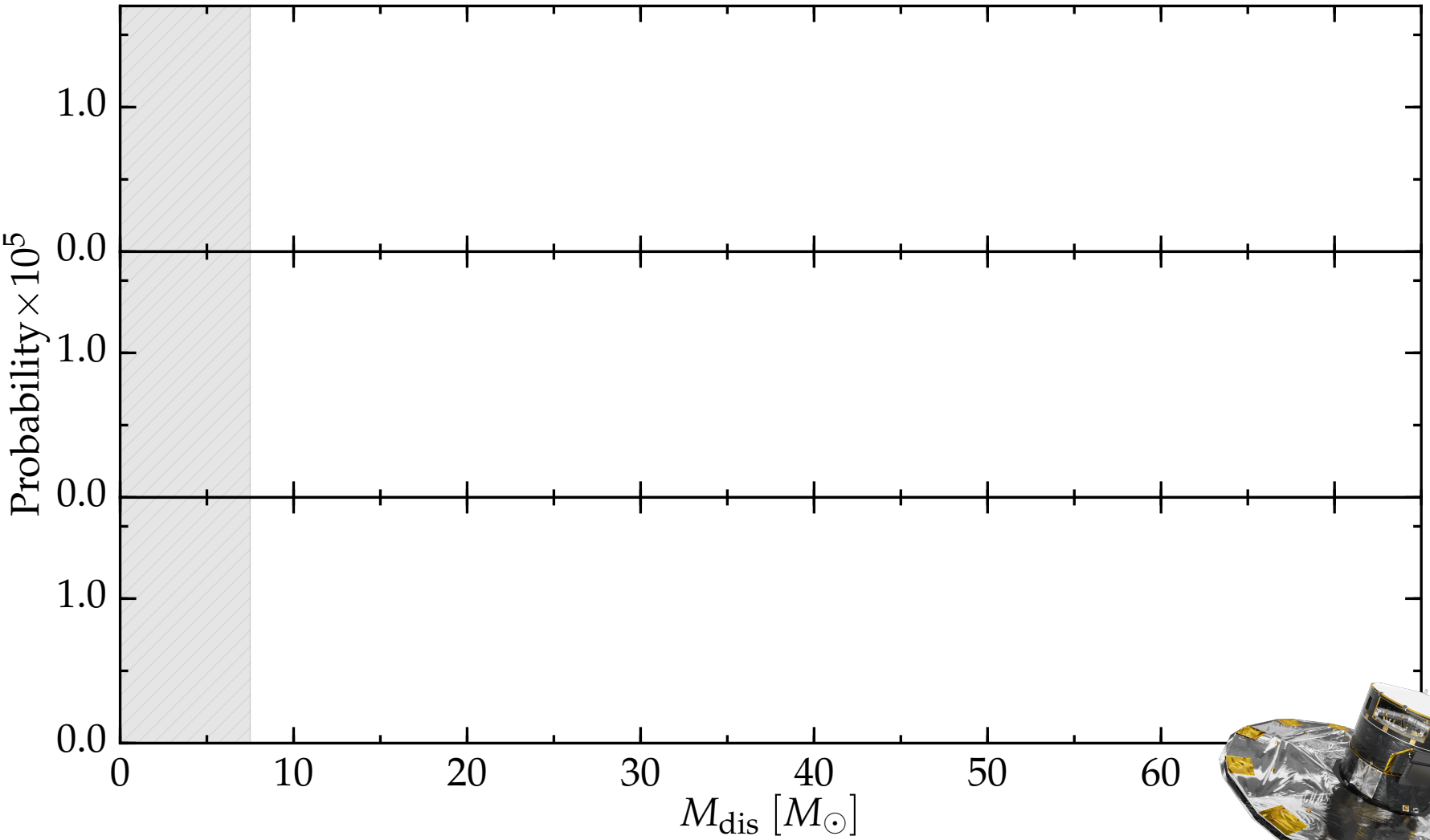
Collaborators: S. E. de Mink, E. Zapartas, Y. Götberg, E. Laplace, R. J. Farmer, S. Toonen, S. Justham, R. G. Izzard, D. J. Lennon, H. Sana, S. N. Shore

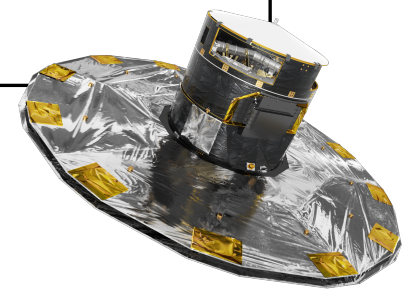
NASA, JPL-Caltech, Spitzer Space Telescope

A way to constrain BH kicks with *Gaia*

ANTON PANNEKOEK INSTITUTE

Massive runaways mass function ($v \geq 30\,\mathrm{km\ s^{-1}}$, $M \geq 7.5\,M_\odot$)





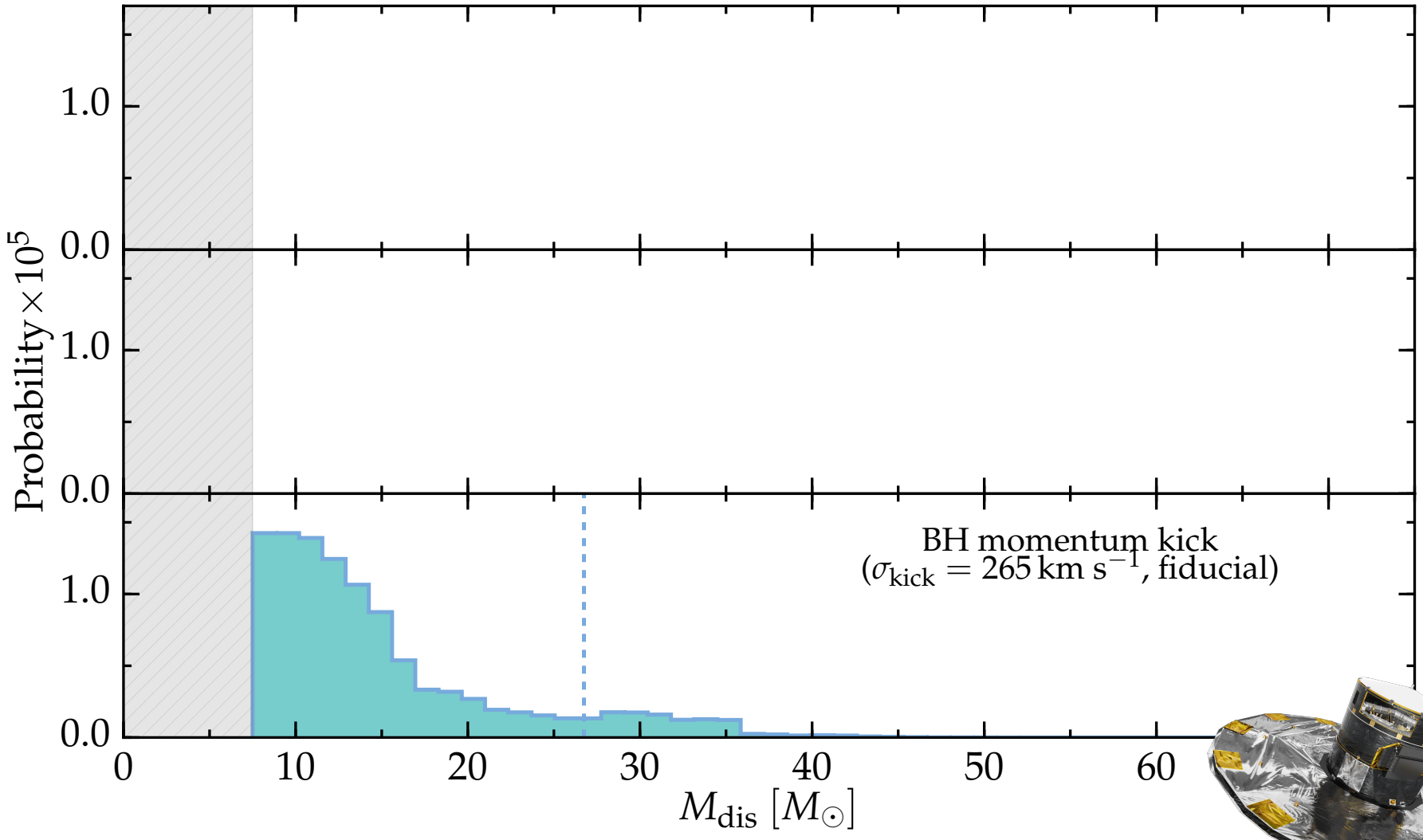
gaia

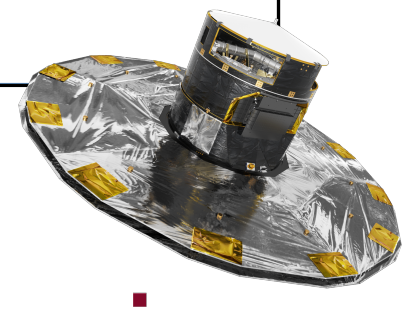
Renzo *et al.*, submitted, arXiv:1804.09164

A way to constrain BH kicks with *Gaia*

ANTON PANNEKOEK INSTITUTE

Massive runaways mass function ($v \geq 30\,\mathrm{km\ s^{-1}}$, $M \geq 7.5\,M_\odot$)





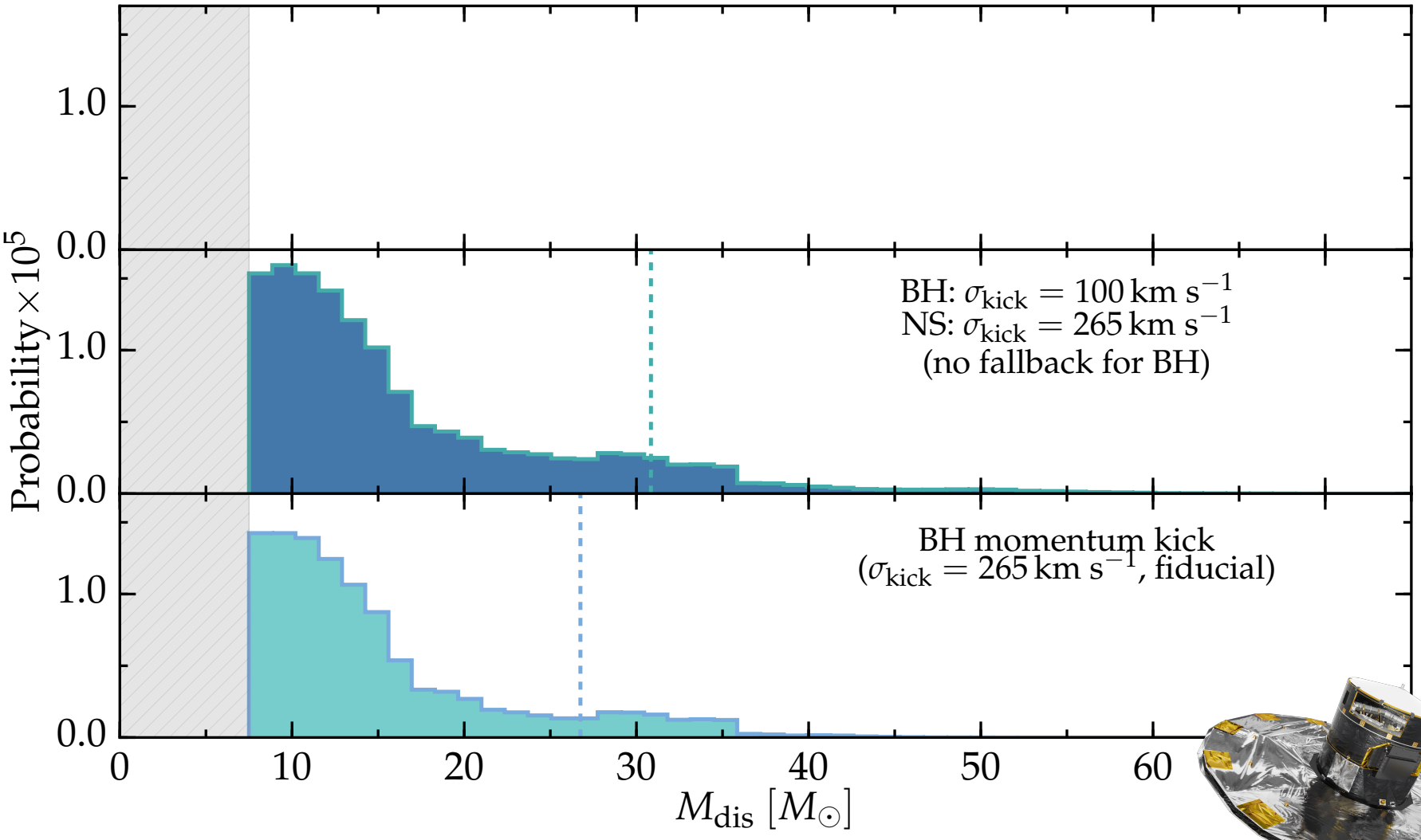
gaia

Renzo *et al.*, submitted, arXiv:1804.09164

A way to constrain BH kicks with *Gaia*

ANTON PANNEKOEK INSTITUTE

Massive runaways mass function ($v \geq 30\,\mathrm{km\ s^{-1}}$, $M \geq 7.5\,M_\odot$)

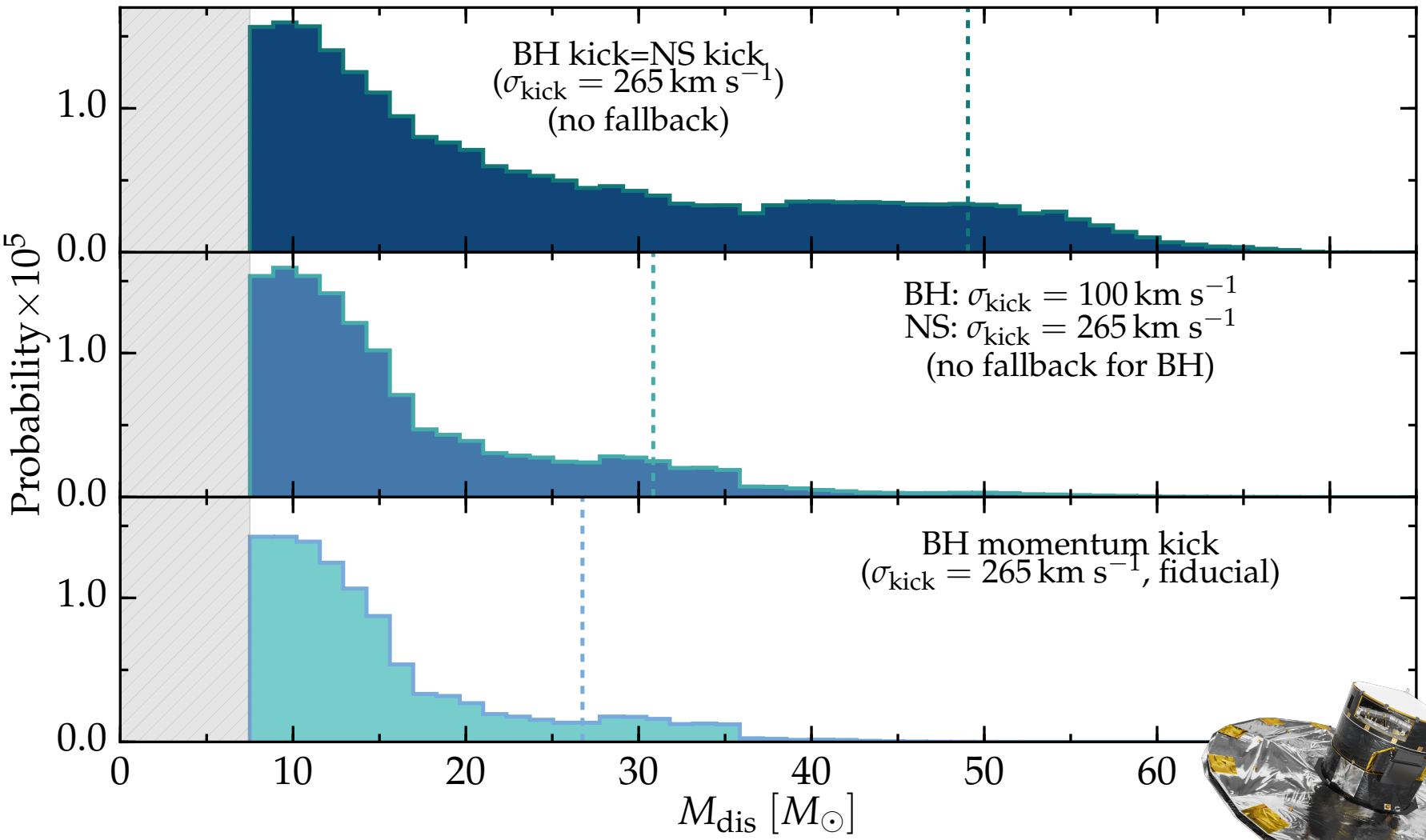


Renzo *et al.*, submitted, arXiv:1804.09164

A way to constrain BH kicks with *Gaia*

ANTON PANNEKOEK INSTITUTE

Massive runaways mass function ($v \geq 30\,\mathrm{km\ s^{-1}}$, $M \geq 7.5\,M_\odot$)



Renzo *et al.*, submitted, arXiv:1804.09164

Backup slides

Most common massive binary evolution

Credits: ESO, L. Calçada, M. Kornmesser, S.E. de Mink

ANTON PANNEKOEK INSTITUTE

Spin up, pollution, and rejuvenation

The binary disruption shoots out the accretor

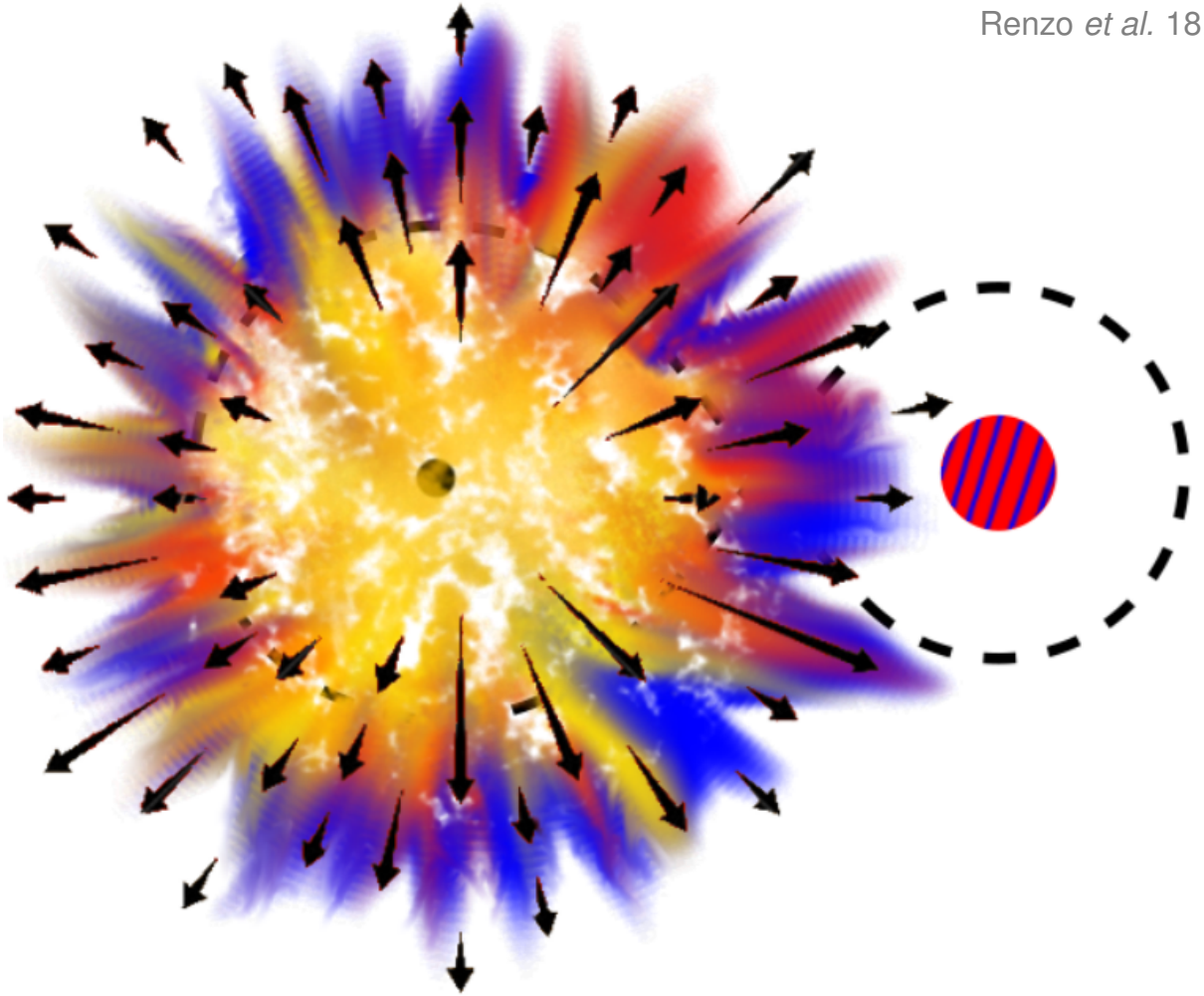
Spin up: Packet ’81, Cantiello *et al.* ’07, de Mink *et al.* ’13
Pollution: Blaauw ’93
Rejuvenation: Hellings ’83, Schneider *et al.* ’15

What exactly disrupts the binary?

ANTON PANNEKOEK INSTITUTE

86^{+11}_{-9}% of massive binaries are disrupted

Renzo *et al.* 18, arXiv:1804.09164



- Unbinding Matter

  (e.g., Blaauw '61)
- Ejecta Impact

  (e.g., Wheeler *et al.* '75,

  Tauris & Takens '98, Liu *et al.* '15)
- SN Natal Kick

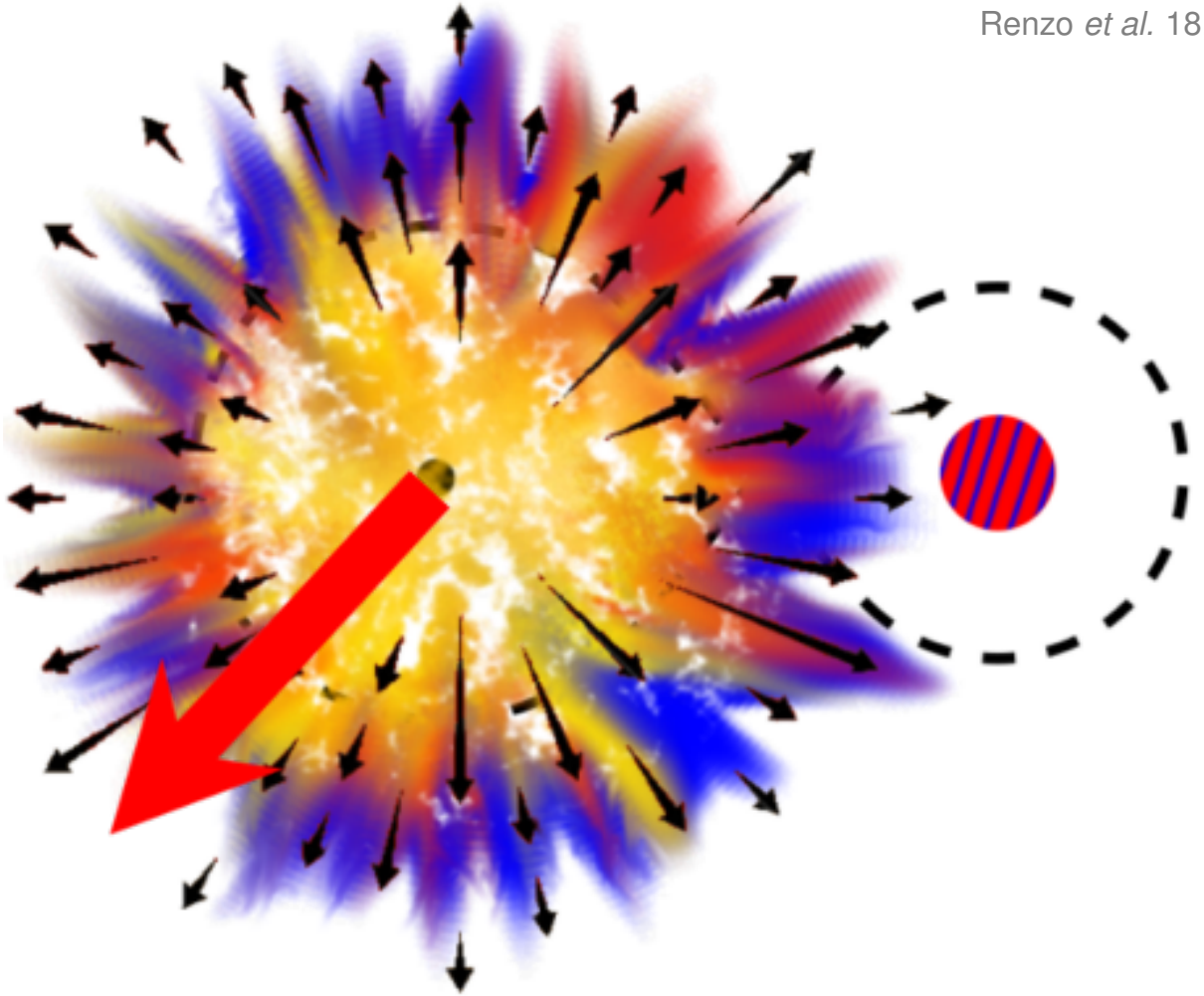
  (e.g., Shklovskii '70, Janka '16)

What exactly disrupts the binary?

ANTON PANNEKOEK INSTITUTE

86^{+11}_{-9}% of massive binaries are disrupted

Renzo *et al.* 18, arXiv:1804.09164



- Unbinding Matter

  (e.g., Blaauw '61)

- Ejecta Impact

  (e.g., Wheeler *et al.* '75,

  Tauris & Takens '98, Liu *et al.* '15)

- SN Natal Kick

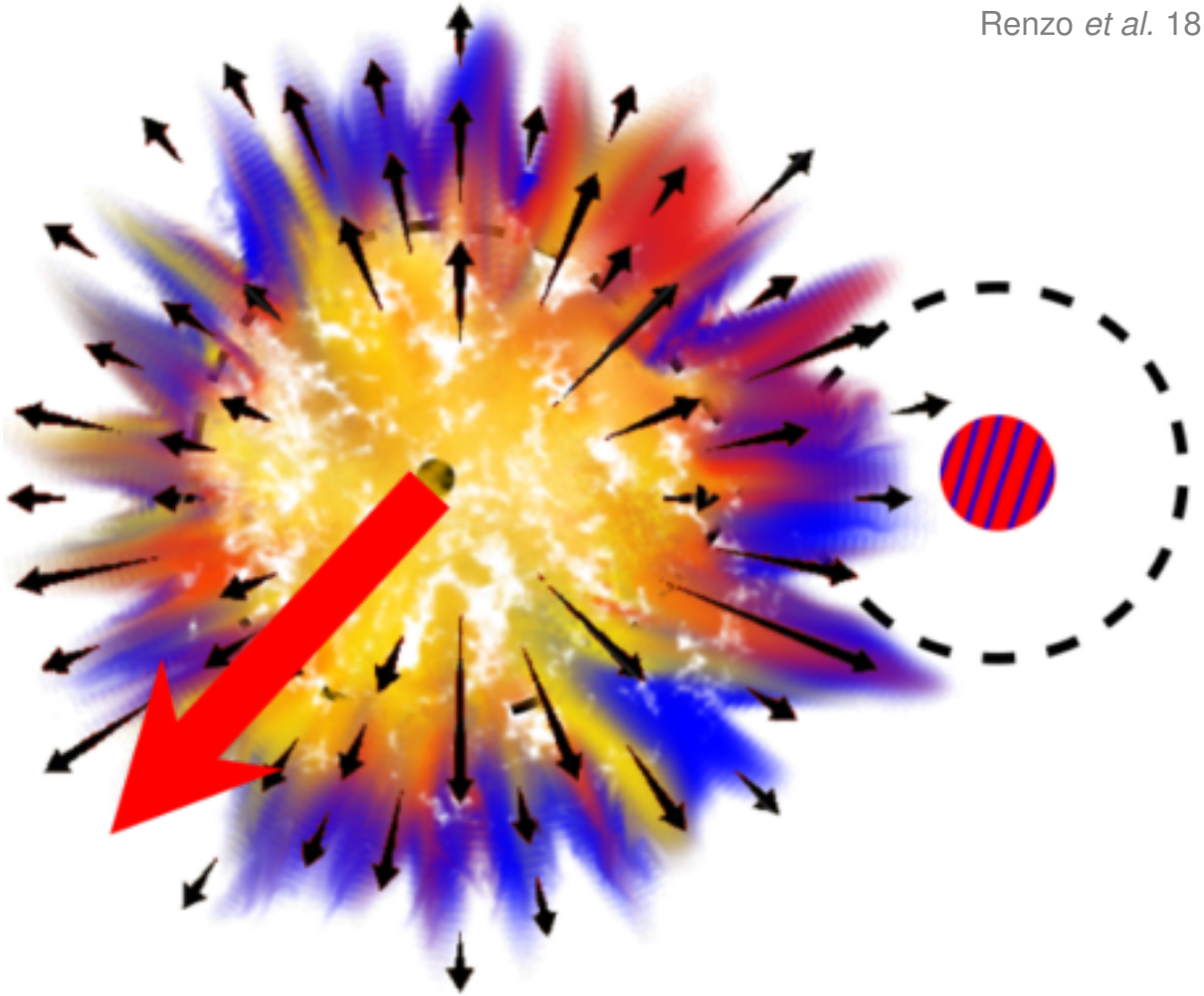
  (e.g., Shklovskii '70, Janka '16)

What exactly disrupts the binary?

ANTON PANNEKOEK INSTITUTE

86^{+11}_{-9}% of massive binaries are disrupted

Renzo *et al.* 18, arXiv:1804.09164



- Unbinding Matter

  (e.g., Blaauw '61)

- Ejecta Impact

  (e.g., Wheeler *et al.* '75,

  Tauris & Takens '98, Liu *et al.* '15)

- SN Natal Kick

  (e.g., Shklovskii '70, Janka '16)

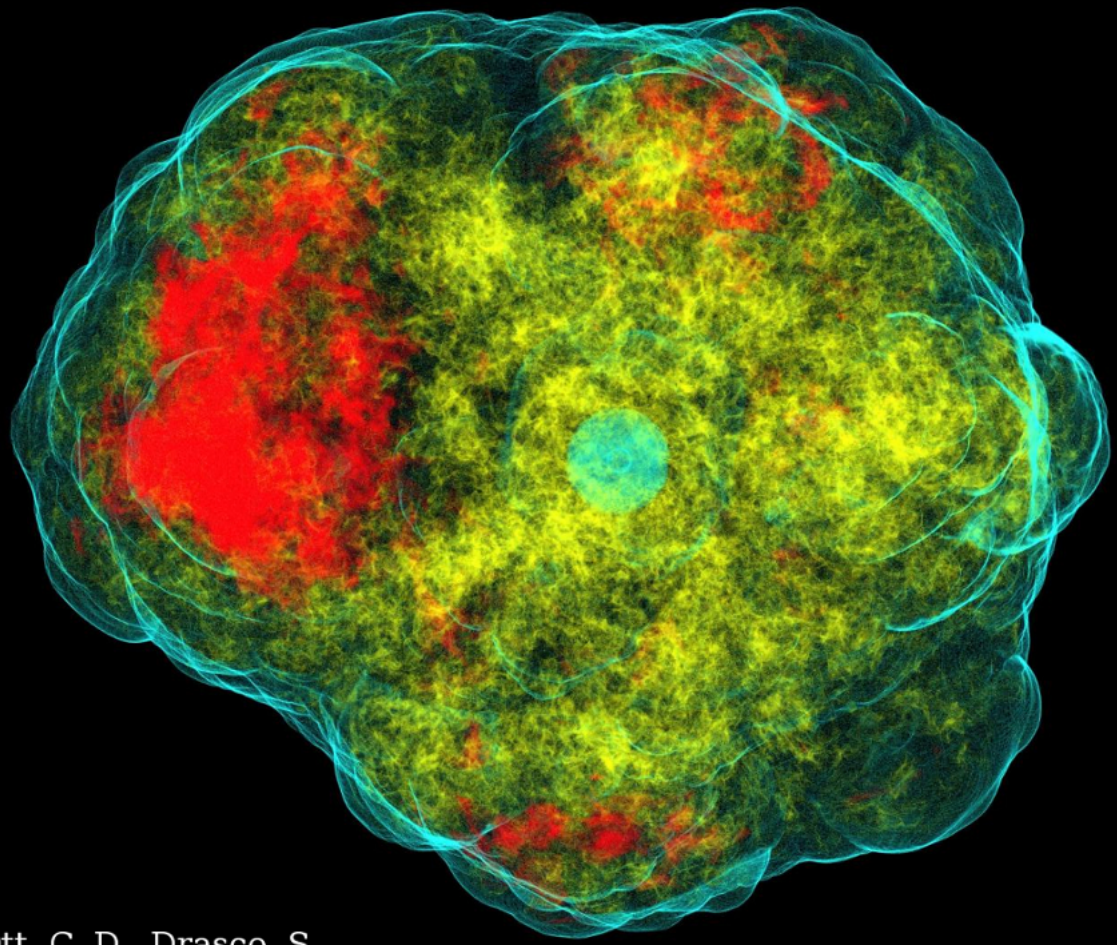
$$v_{\rm dis} \simeq v_{2,\rm orb}^{\rm pre-SN} = \frac{M_1}{M_1+M2}\sqrt{\frac{G(M_1+M2)}{a}}$$

Most binaries produce a slow "walkaway" star

SN natal kick

Observationally: $v_{\mathrm{pulsar}} \gg v_{\mathrm{OB-stars}}$

Physically: ν emission and/or ejecta anisotropies

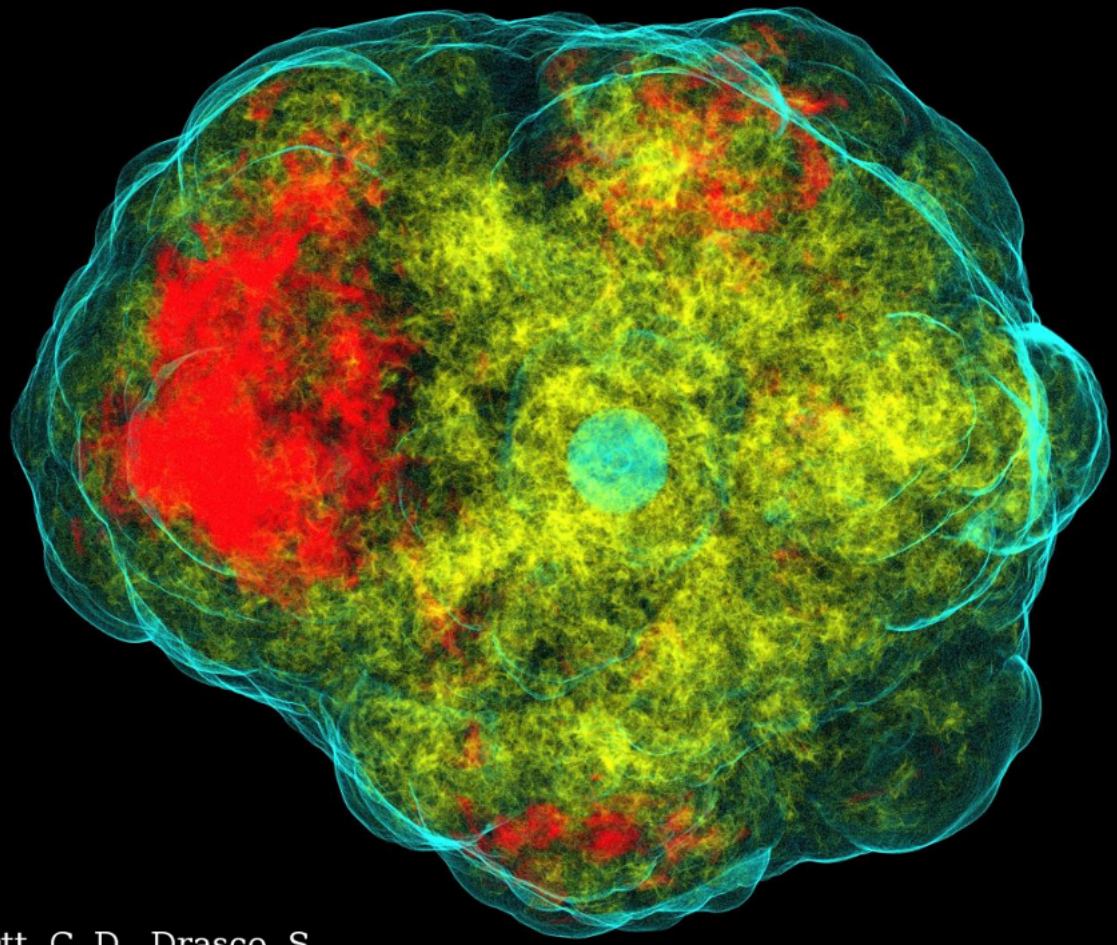


Credits: Ott, C. D., Drasco, S.

SN natal kick

Observationally: $v_{\mathrm{pulsar}} \gg v_{\mathrm{OB-stars}}$

Physically: ν emission and/or ejecta anisotropies

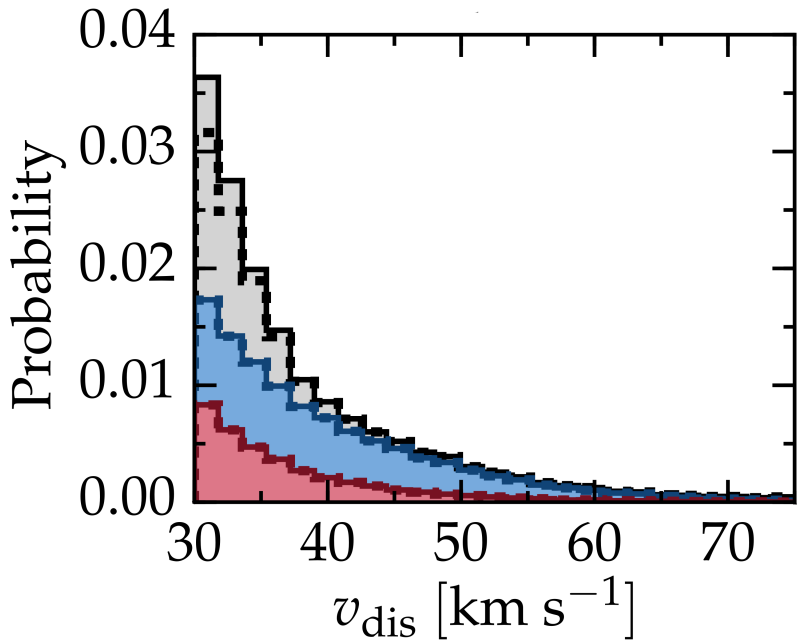


Credits: Ott, C. D., Drasco, S.

BH kicks?

Velocity distribution: Runaways

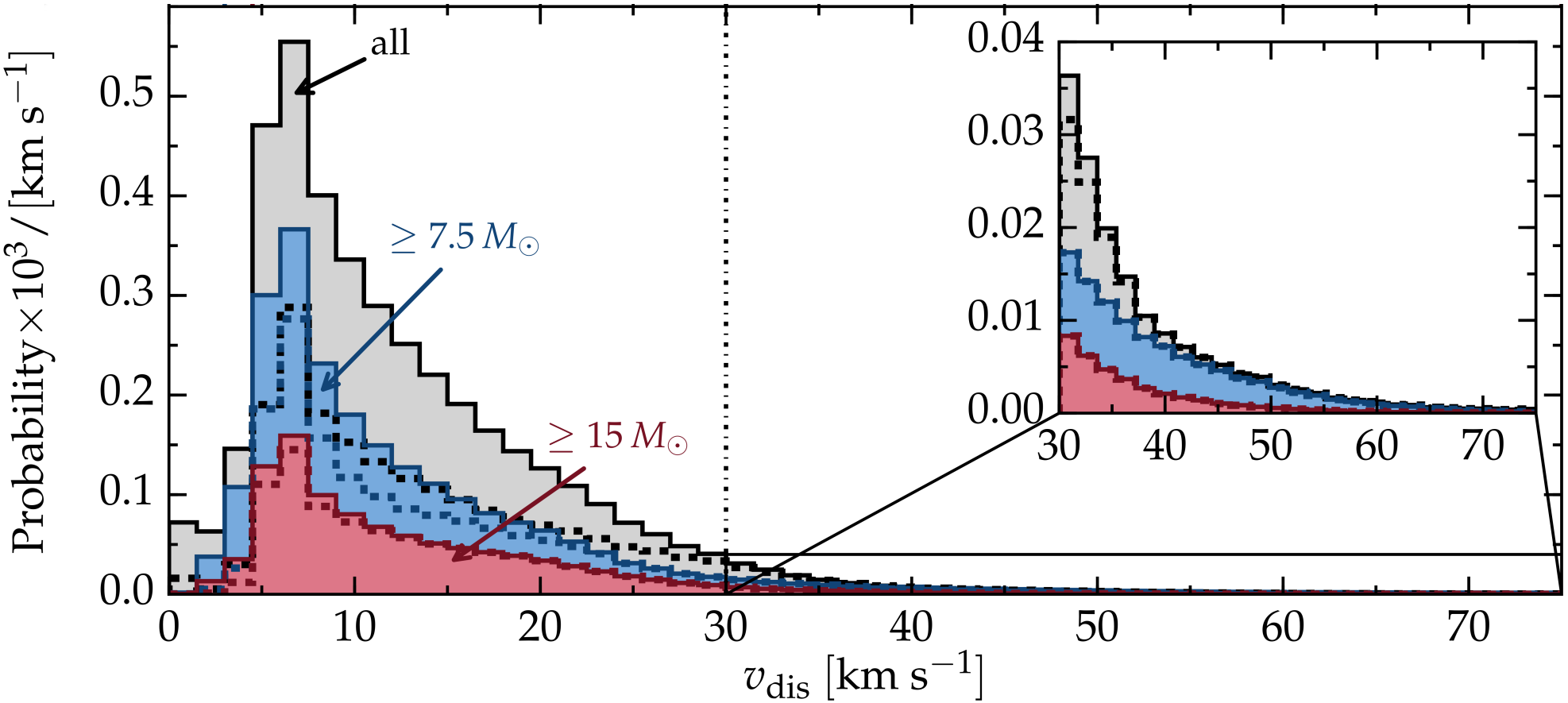
ANTON PANNEKOEK
INSTITUTE



Renzo *et al.*, submitted, arXiv:1804.09164

Velocity distribution: Walkaways

ANTON PANNEKOEK INSTITUTE

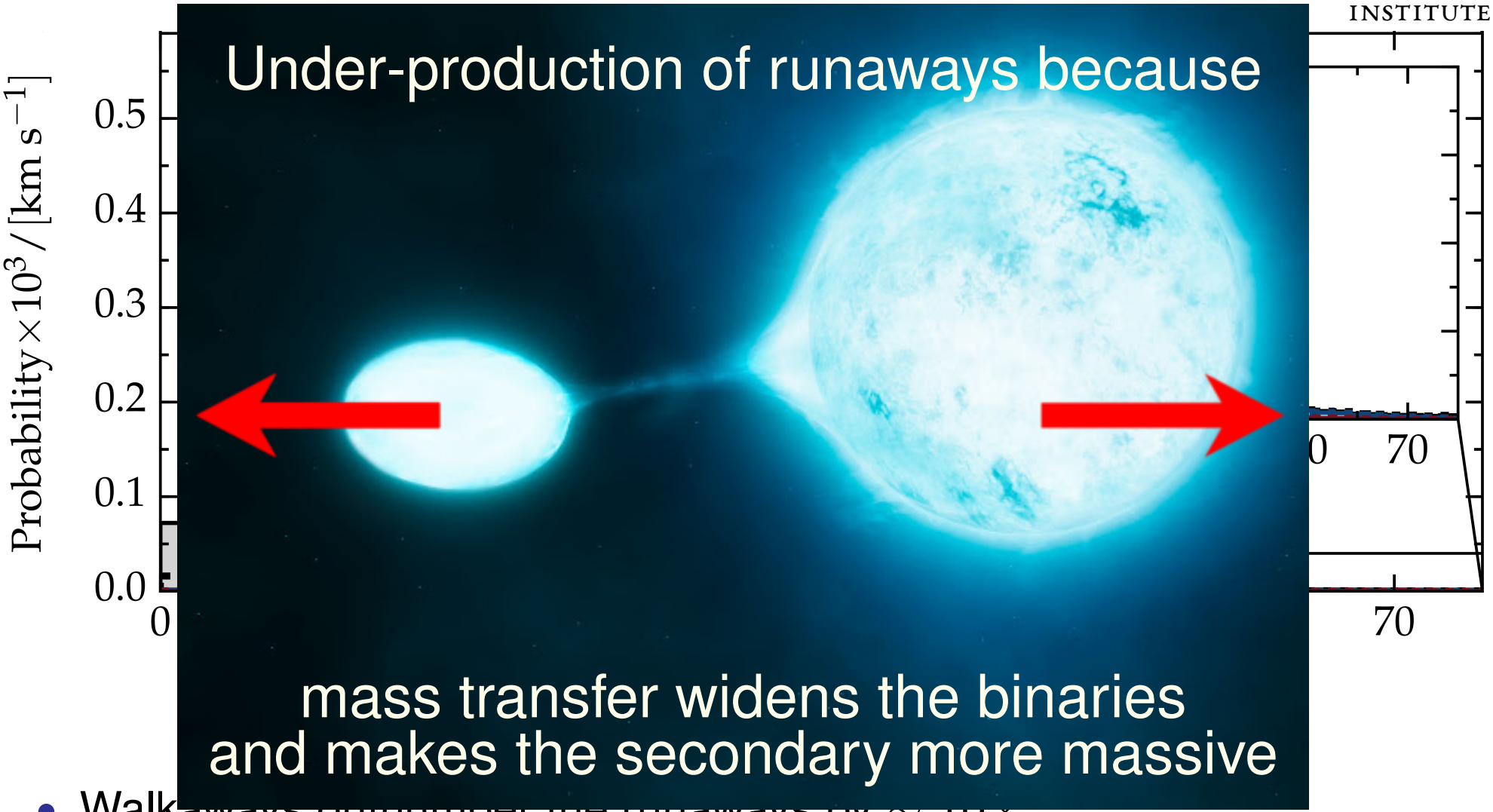


Take home points:

- Walkaways outnumber the runaways by $\sim 10\times$
- Binaries barely produce $v_{\rm dis} \gtrsim 60\,{\rm km\ s^{-1}}$
- All runaways from binaries are post-interaction objects

Renzo *et al.*, submitted, arXiv:1804.09164

Velocity distribution: Walkaways



- Walkaways outnumber the runaways by $\sim 10\times$
- Binaries barely produce $v_{\rm dis} \gtrsim 60\,{\rm km\ s^{-1}}$
- All runaways from binaries are post-interaction objects

Renzo *et al.*, submitted, arXiv:1804.09164