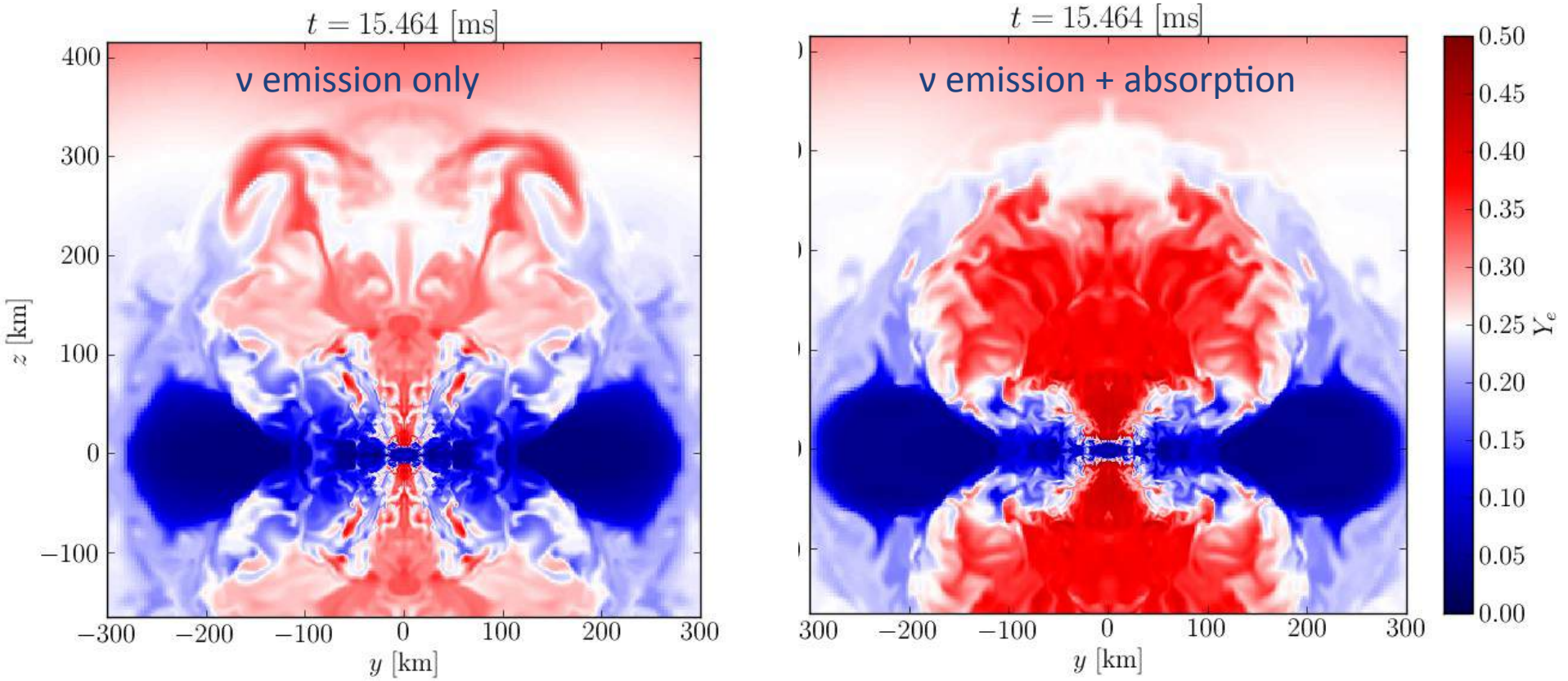
Summary so far

- A large fraction of the ejecta from BNS mergers is launched by secular winds
  - Spiral-wave/MHD winds from long-lived remnants (blue kilonova?)
  - Disk recombination winds from BH+disk systems (red kilonova?!?)
- Dynamical ejecta also plays a key role as screen for kilonova emission [Perego+ 2017, Kawaguchi+ 2018, ...]
- Different scenarios imply very different nucleosynthesis yields, but current models and observations cannot distinguish them yet
- What else are we missing?

Neutrino effects on the eiecta

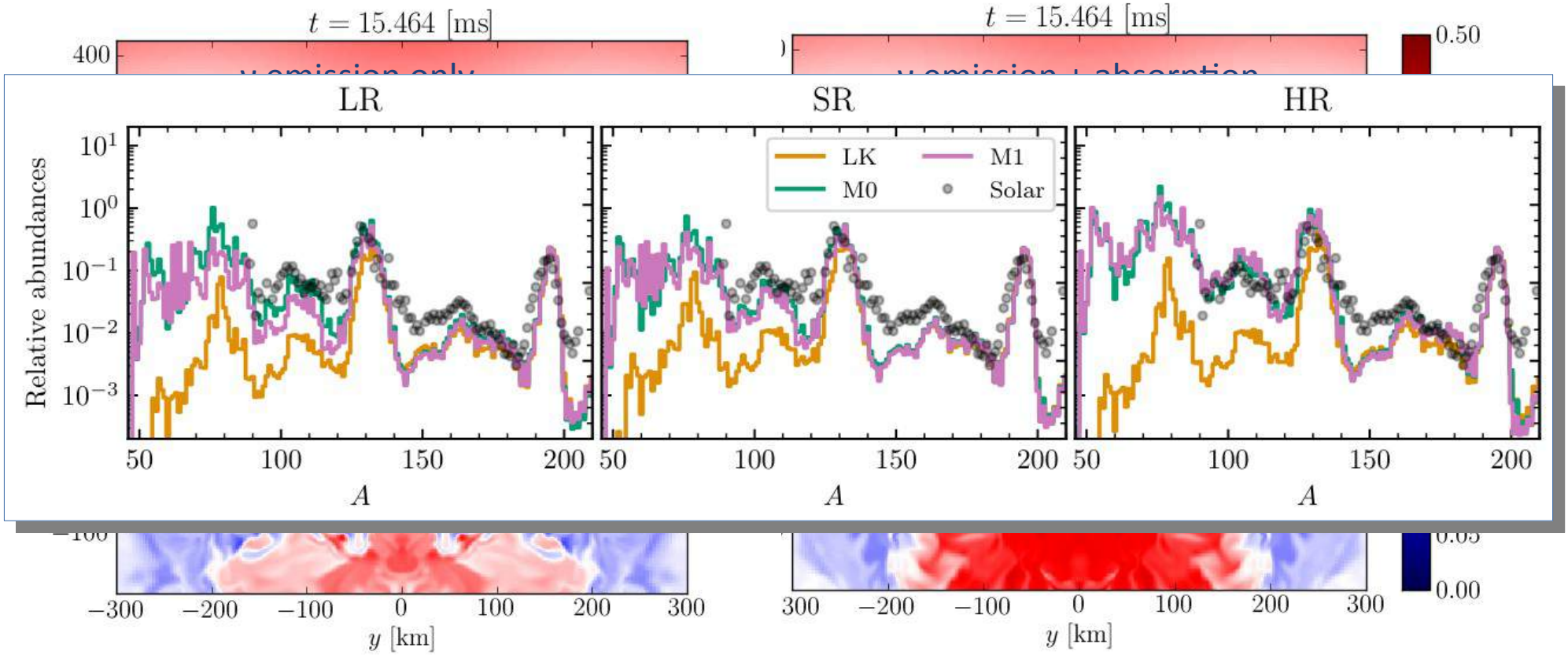


See also Sekiguchi+ 2015; Foucart+ 2016; Combi+ 2023; Foucart+ 2024; ...

Gabriel's talk later

Radice+, MNRAS 460:3255 (2016)
Zappa+, MNRAS 520:1481 (2023)

Neutrino effects on the eiecta

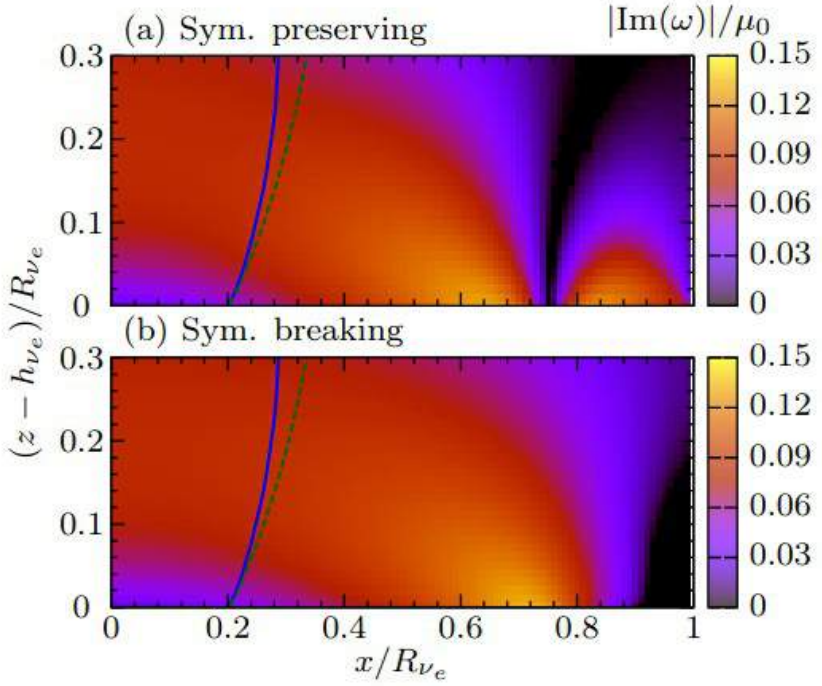


See also Sekiguchi+ 2015; Foucart+ 2016; Combi+ 2023; Foucart+ 2024; ...

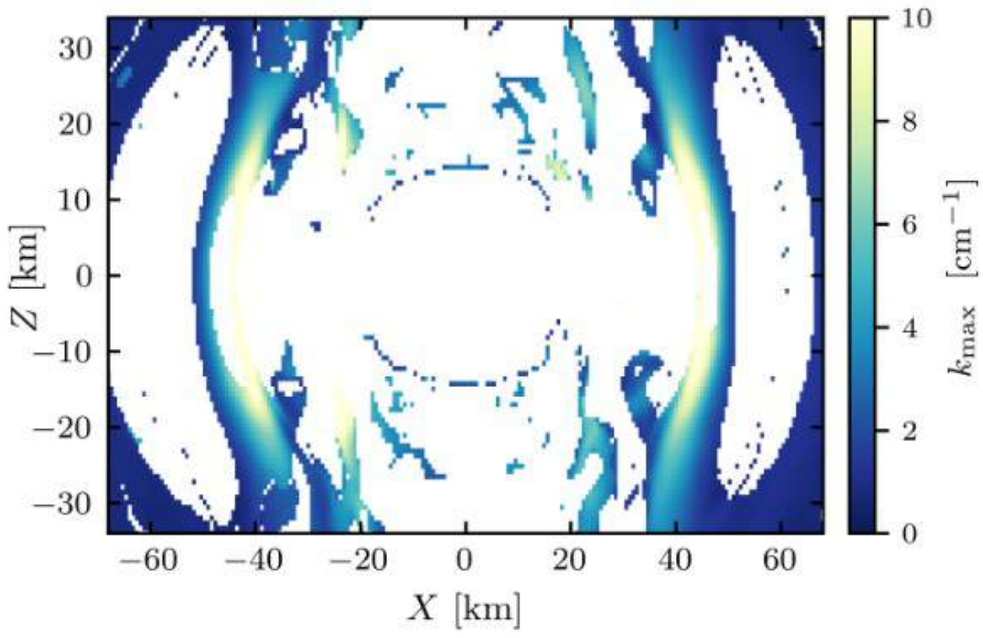
Gabriel's talk later

Radice+, MNRAS 460:3255 (2016)
Zappa+, MNRAS 520:1481 (2023)

Fast-flavor instability



From Wu & Tamborra 2017



From Froustey+ 2025

See Nagakura+ 2023; Martin+ 2023; Johns 2024; Ehring+ 2024;
Larib & Richers 2025; Lund+ 2025; Qiu+ 2025a,b; ...

Quantum neutrino effects

Quantum kinetic equation: $\frac{Df}{D\lambda} = -i[H, f] + \mathbb{C}[f]$

We consider a flavor transformation scenario that can be solved exactly

BGK approximation

$$-i[H, f] \to \frac{1}{\tau(\rho)}(f^a - f)$$

Detailed balance

$$\nu_x \overline{\nu}_x \leftrightarrows \nu_y \overline{\nu}_y$$

See Nagakura+ 2023; Martin+ 2023; Johns 2024; Ehring+ 2024; Larib & Richers 2025; Lund+ 2025; Qiu+ 2025a,b; ...

See Yi Qiu's talk!

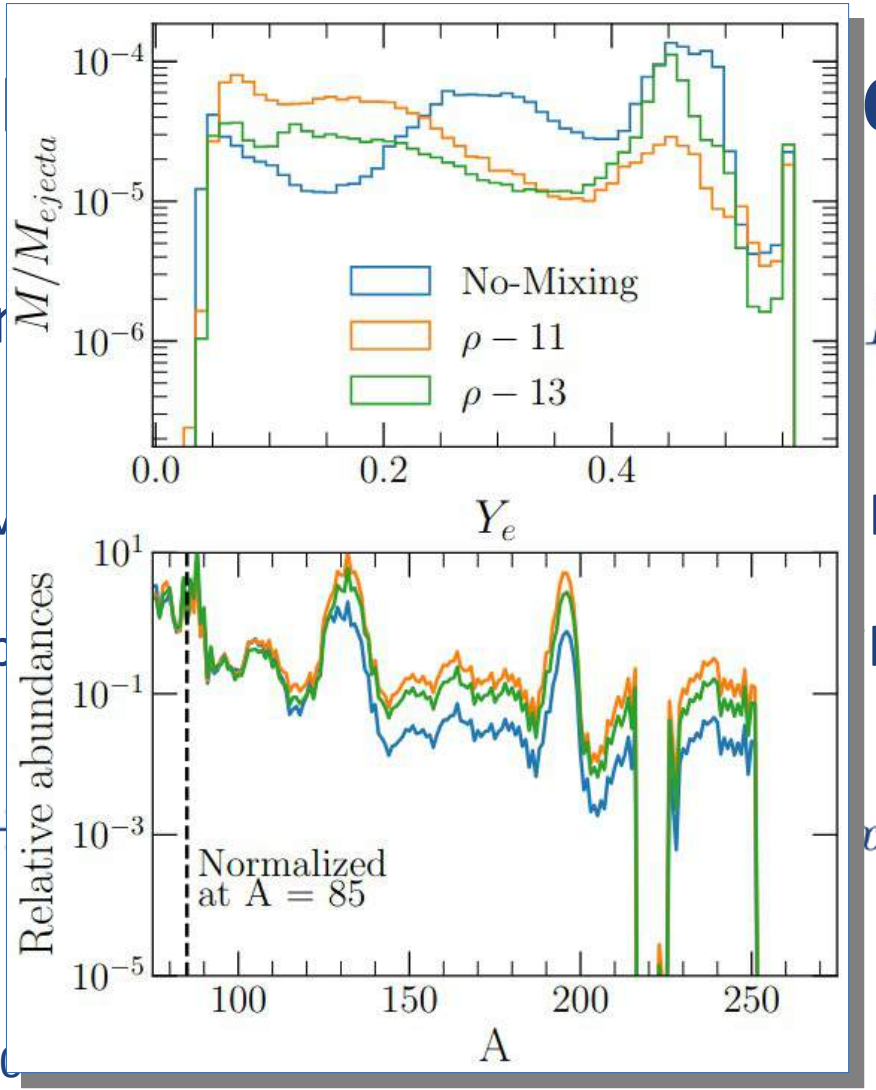
Qua ects

Quantum kin $H, f] + \mathbb{C}[f]$

We consider a flav be solved exactly

BGK app led balance

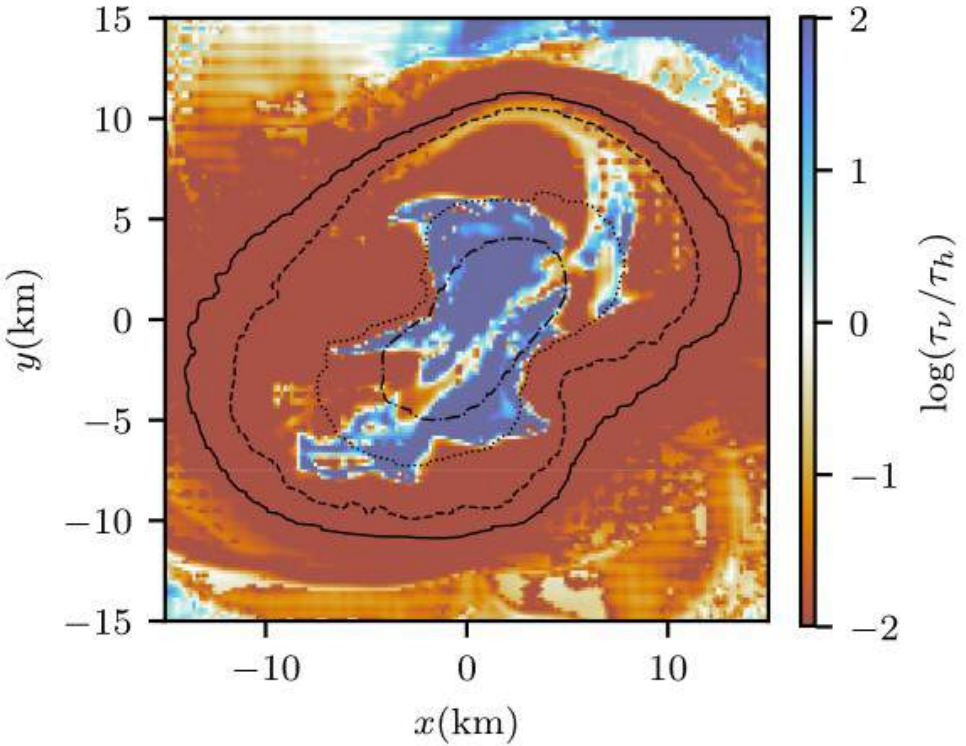
$-i[H, f] -$ $x \leftrightarrows \nu_y \overline{\nu}_y$

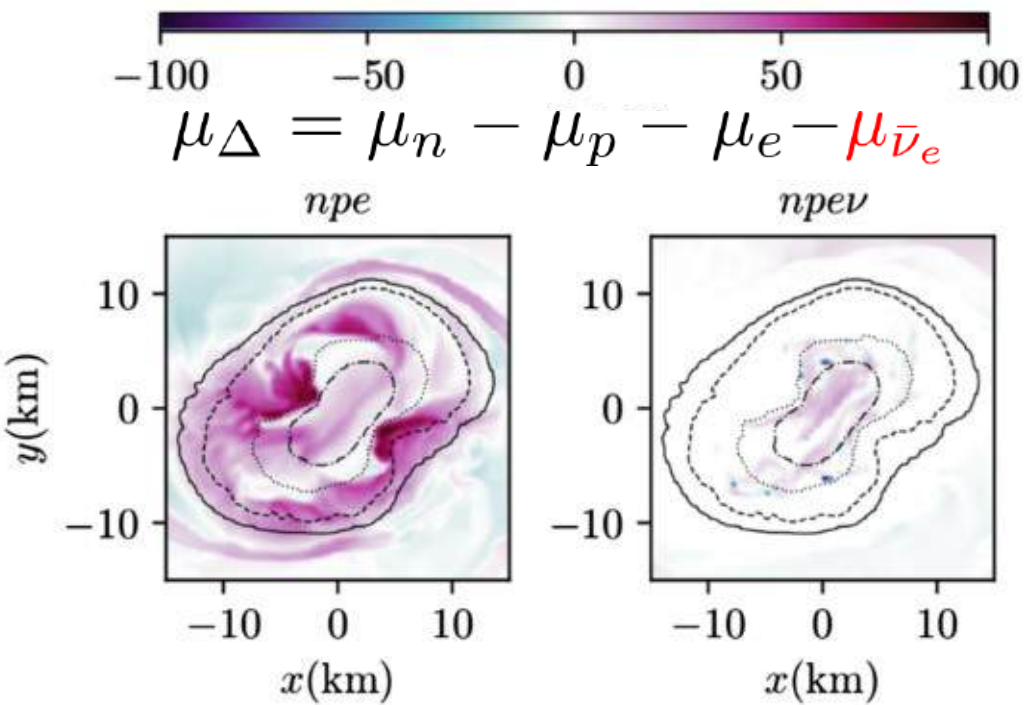


See Nagakura+ 2023; Martin+ 2
Larib & Richers 2025; Lund+ 2025; Qiu+ 2025a,b; ...

See Yi Qiu's talk!

Dynamical impact of neutrinos

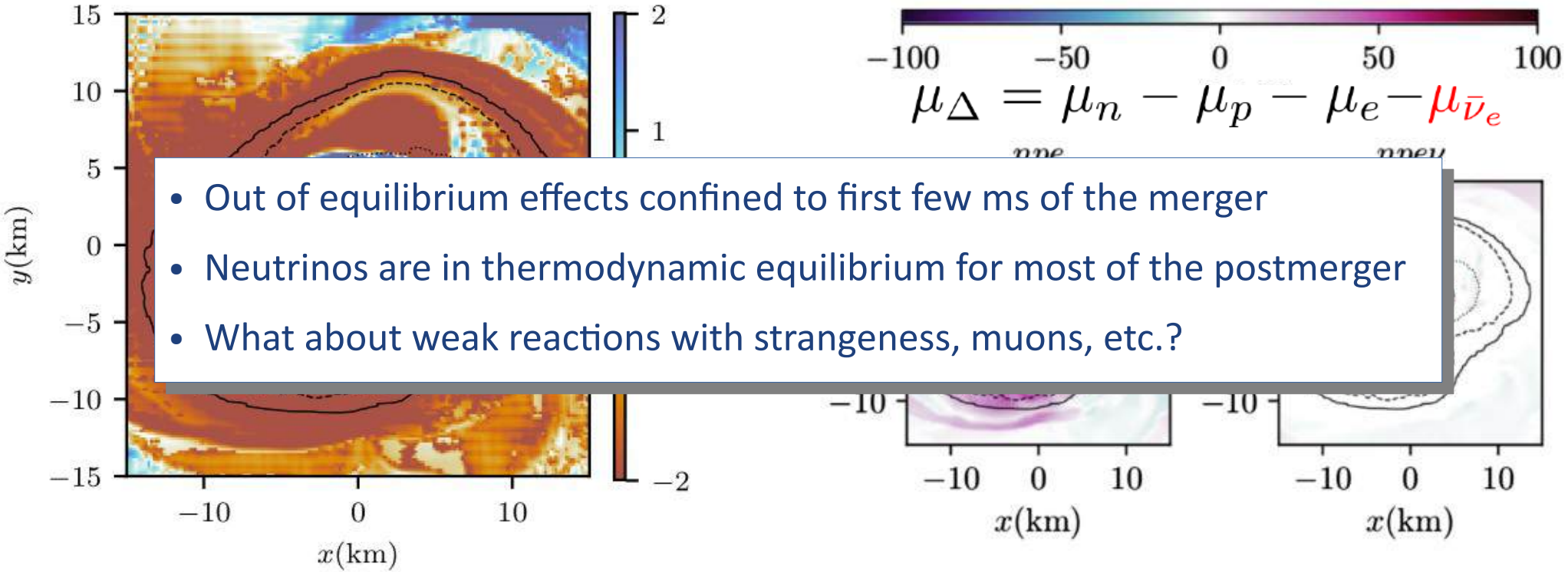




See also Alford+ 2017; Perego+ 2019;
Most+ 2021, 2022, 2024; Hammond+ 2021; ...

From Espino+ PRL 132:211001 (2024)

Dynamical impact of neutrinos

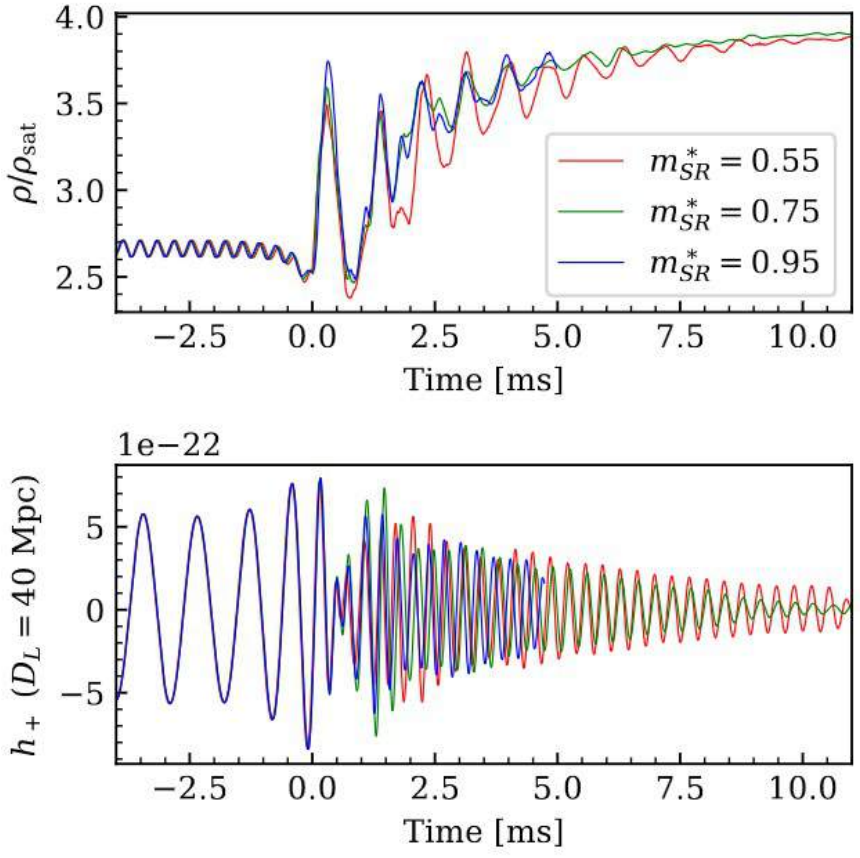


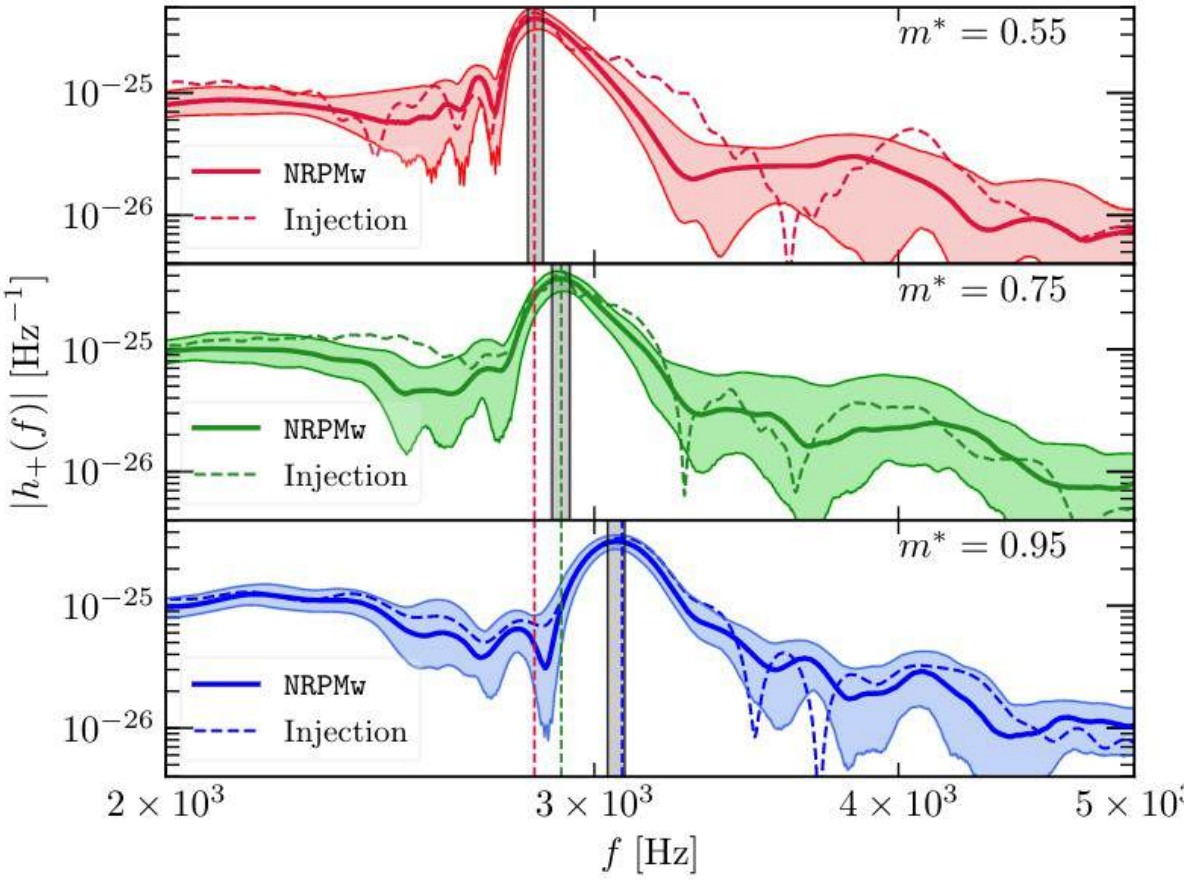
- Out of equilibrium effects confined to first few ms of the merger
- Neutrinos are in thermodynamic equilibrium for most of the postmerger
- What about weak reactions with strangeness, muons, etc.?

See also Alford+ 2017; Perego+ 2019;
Most+ 2021, 2022, 2024; Hammond+ 2021; ...

From Espino+ PRL 132:211001 (2024)

Thermal effects

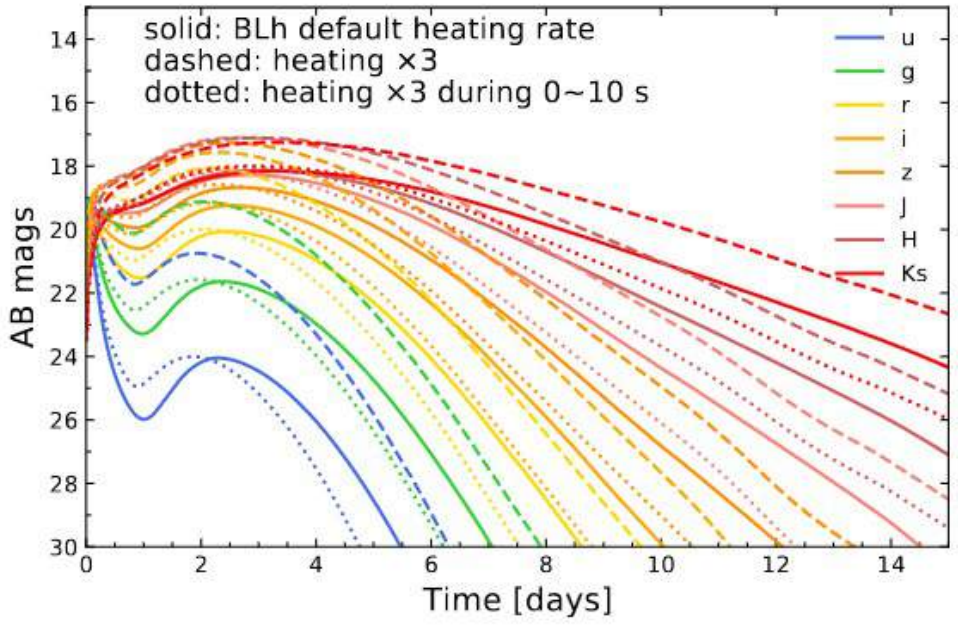




See also Raithel+ 2021, 2022

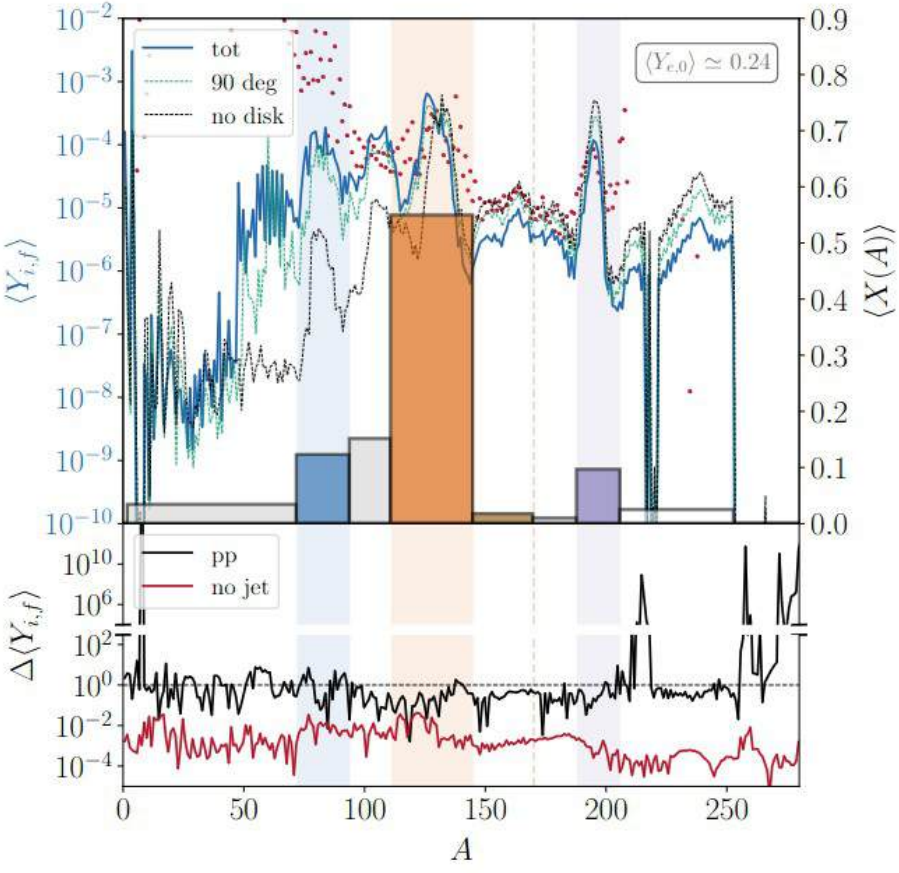
From Fields+ ApJL, 952:L36 (2023)

Rad-hydro modeling of kilonovae



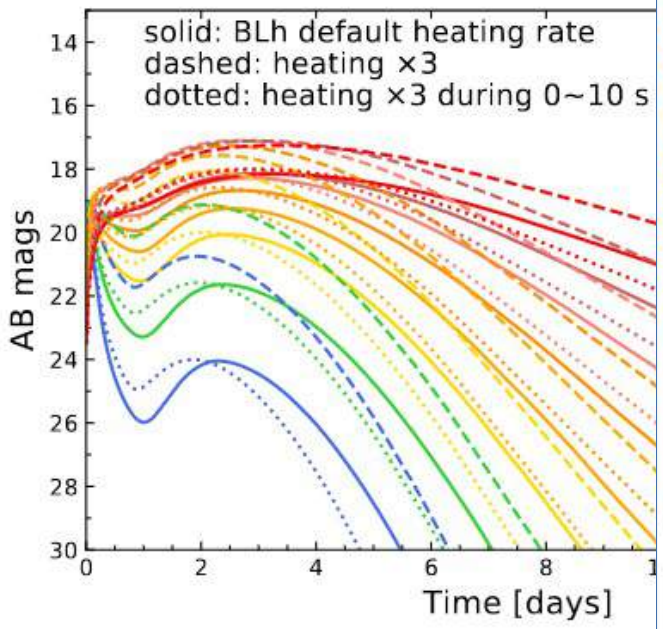
From Wu+ MNRAS 512:328 (2022)

The radiation-hydrodynamics in the first few seconds
Impacts both light-curves and nucleosynthesis yields



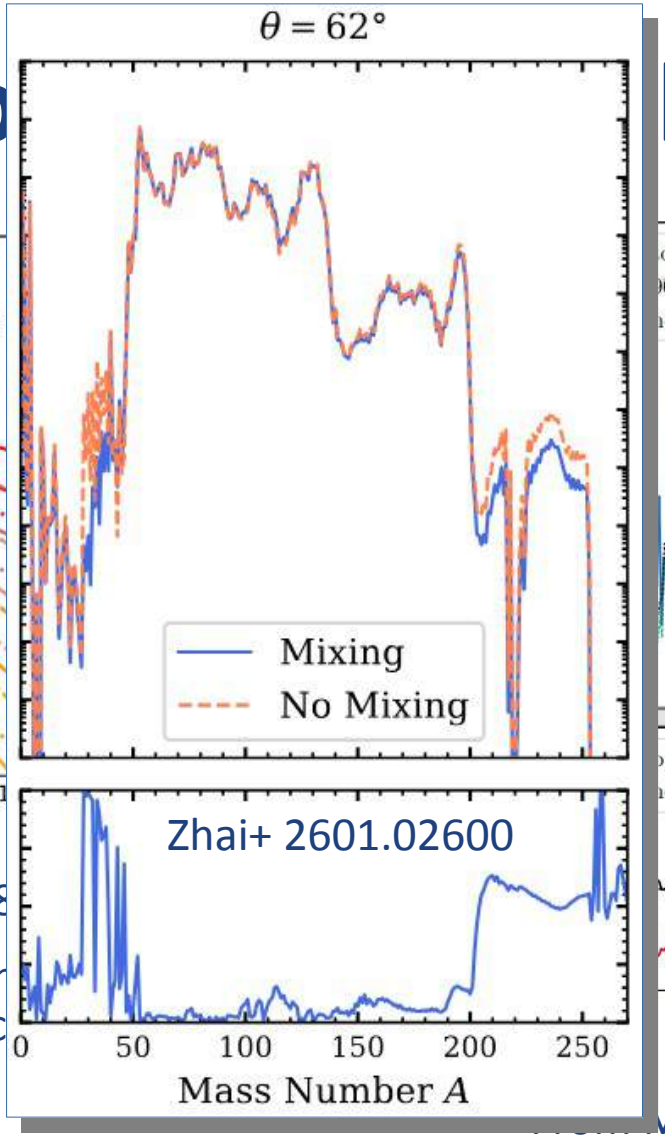
From Magistrelli+ ApJL 974 L5 (2024)

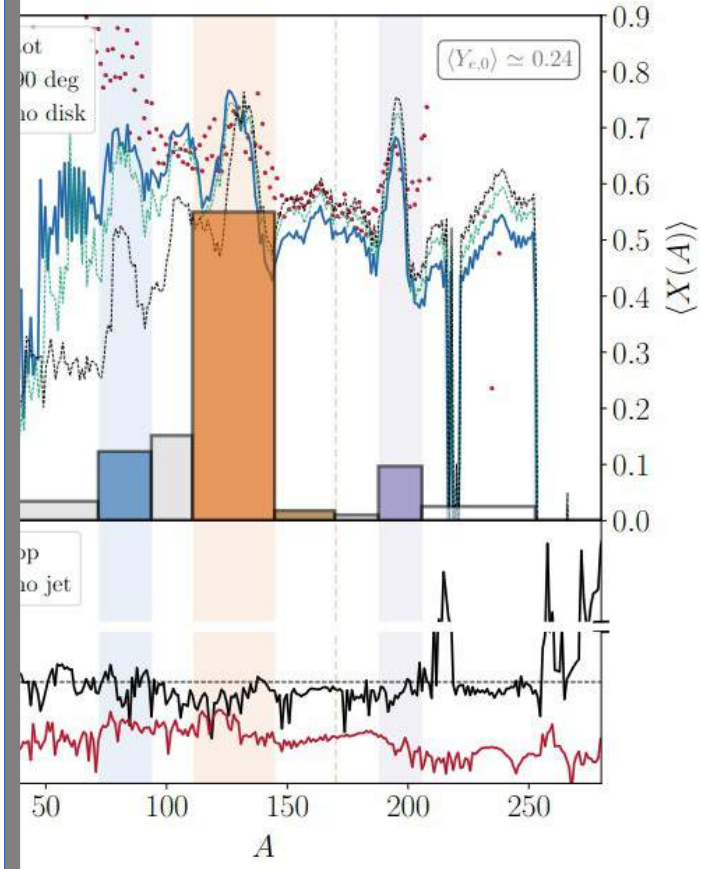
Rad-hydro kilonovae



From Wu+ MNRAS 512:328

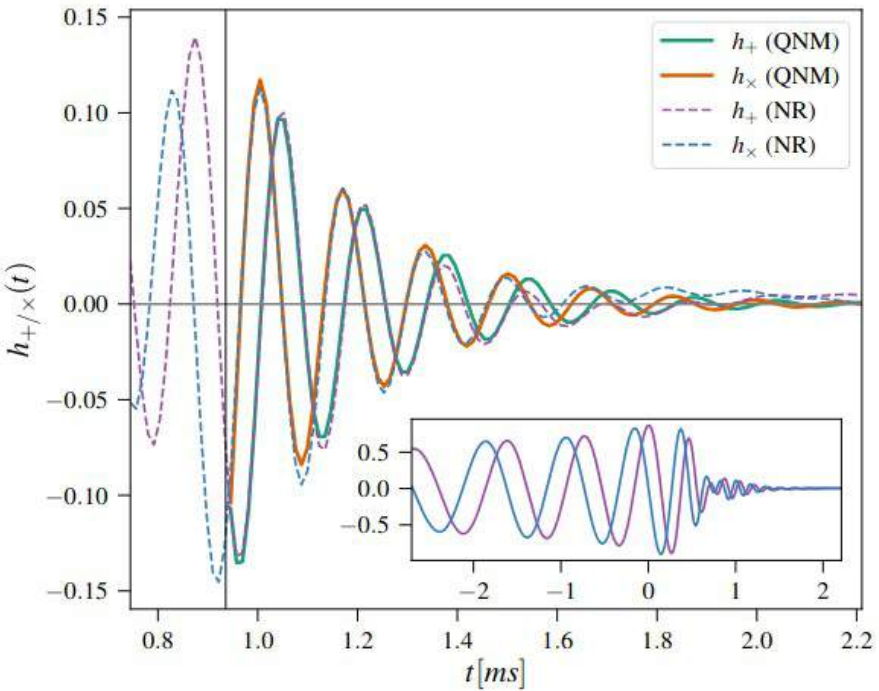
The radiation-hydrodynamics in th
Impacts both light-curves and nuc

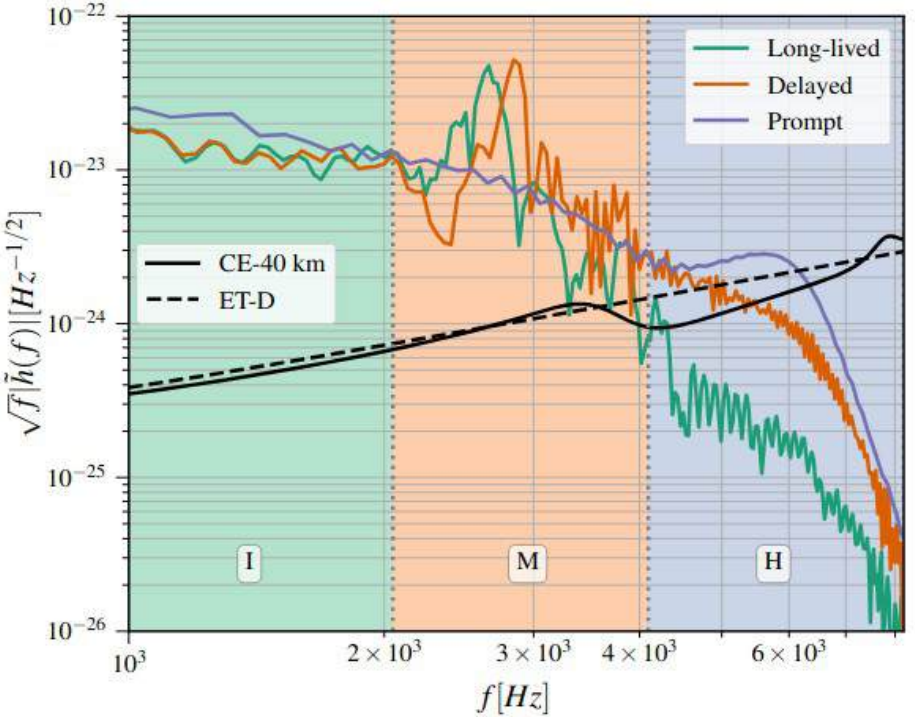




Magistrelli+ ApJL 974 L5 (2024)

GWs from BH formation

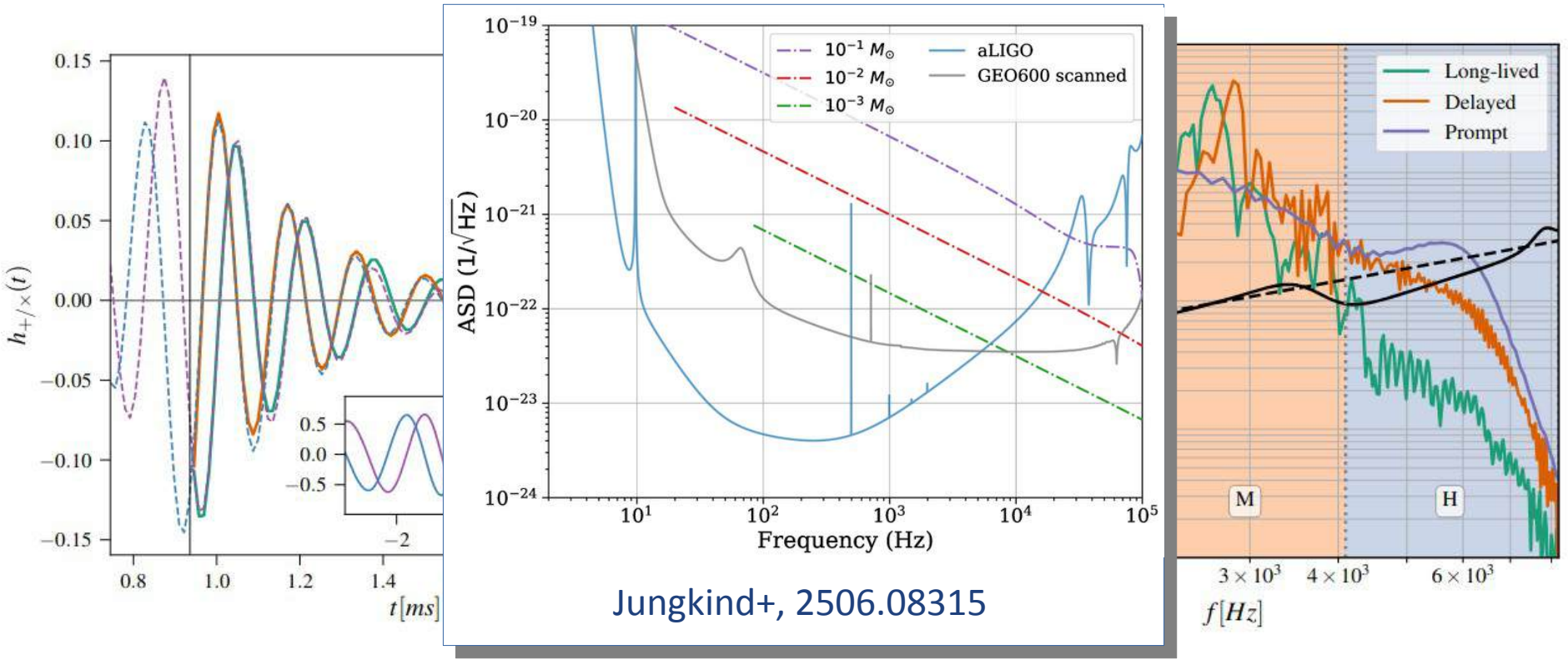




See also Shibata 2005; Zhang+ 2021

From Dhani, DR+, PRD 109:044071 (2024)

GWs from BH formation

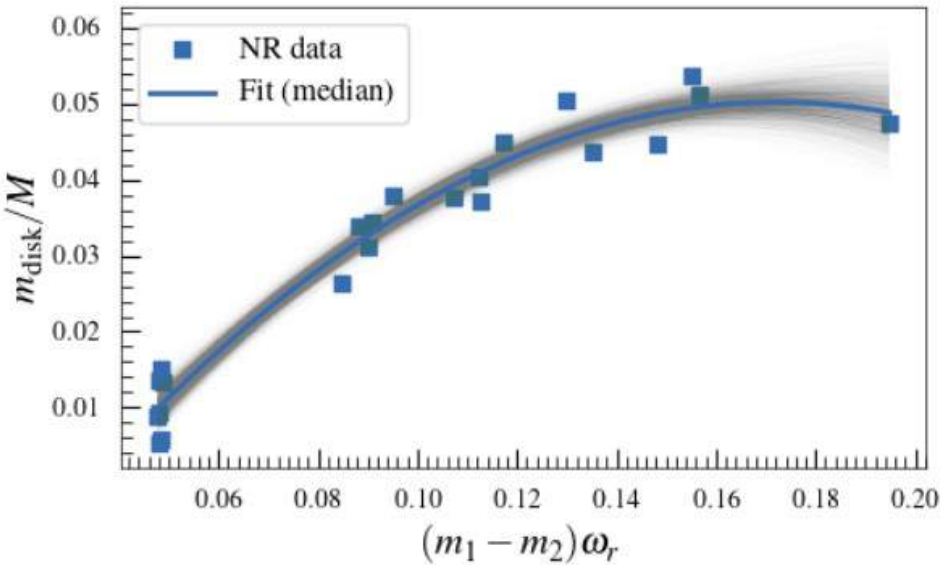


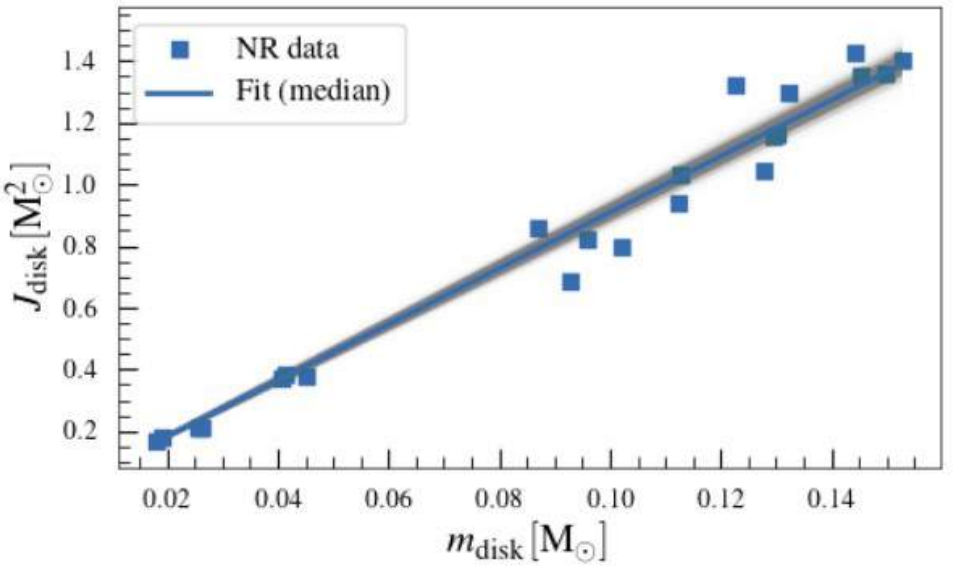
Jungkind+, 2506.08315

See also Shibata 2005; Zhang+ 2021

From Dhani, DR+, PRD 109:044071 (2024)

Measuring the disk mass with GWs

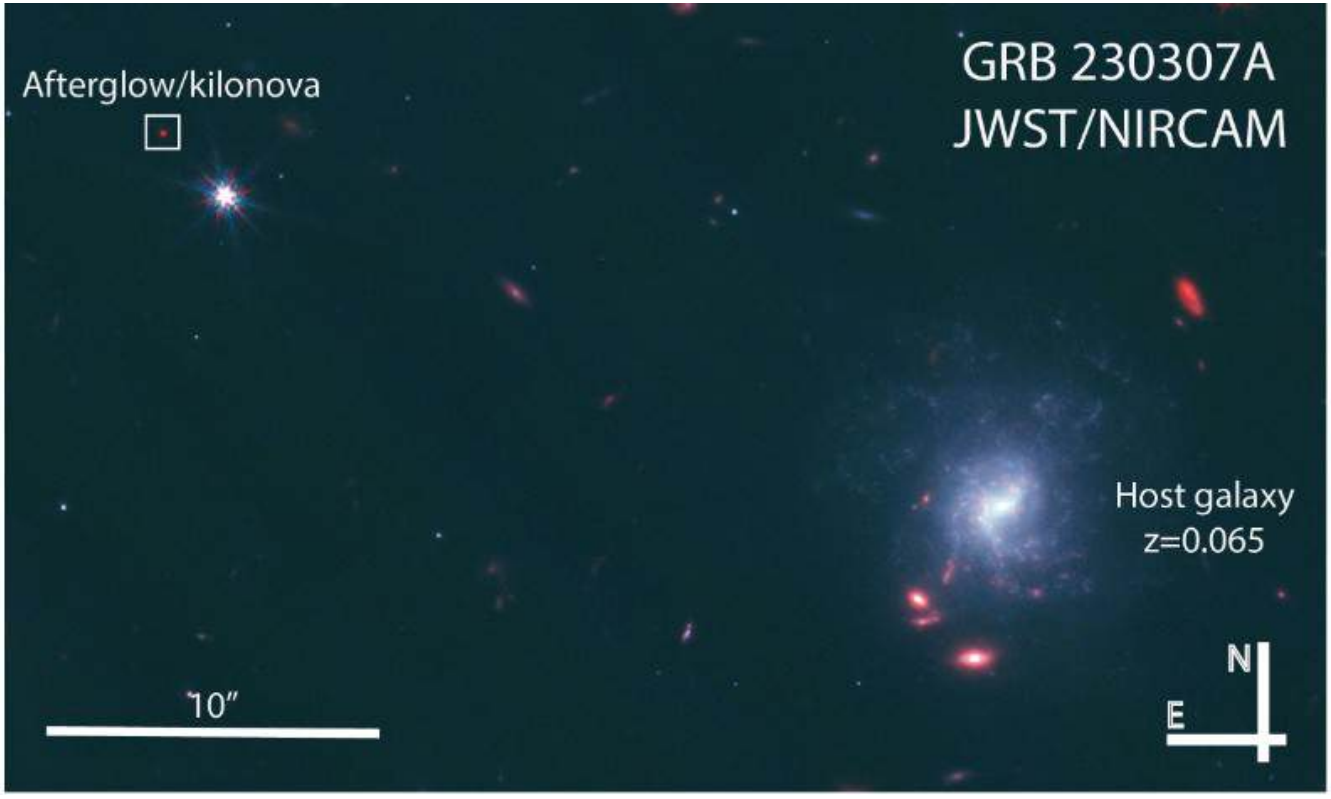




We could measure the disk mass with a precision of ~10% at SNR of 5!

From Dhani, arXiv:2507.14071

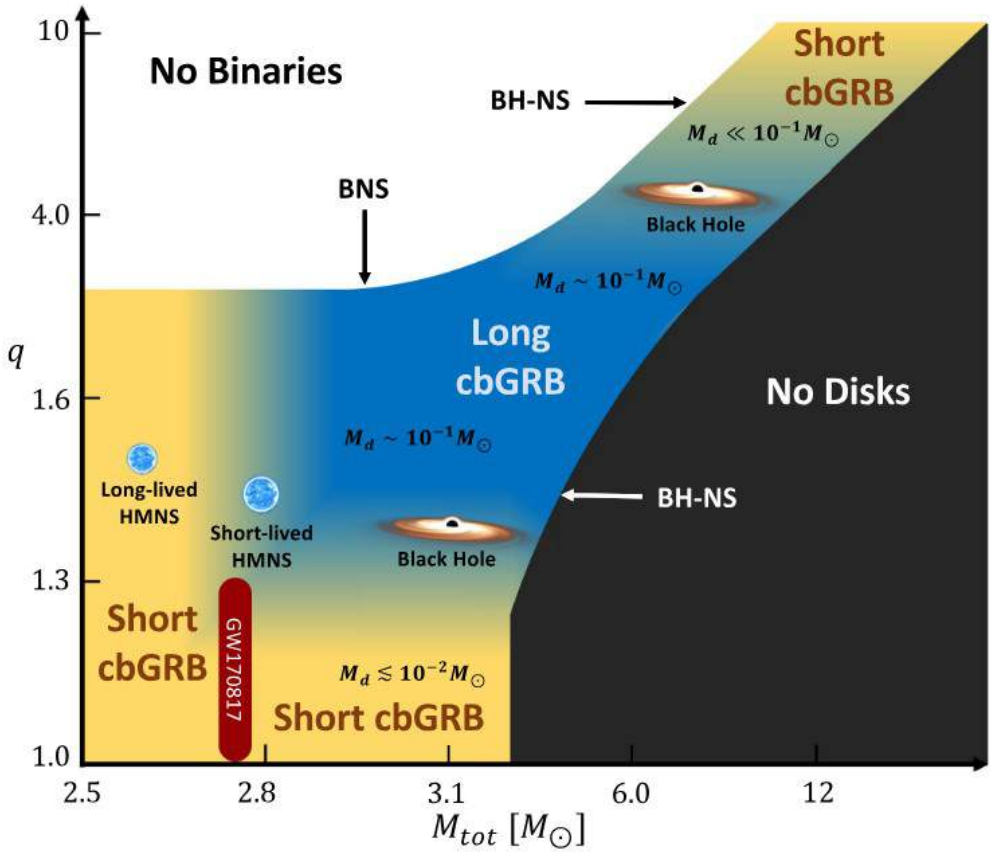
Kilonovae from long-GRBs?!?



See also Mei+ 2022; Rastinejad+ 2022; Troja+2022; Yang+ et al. 2022; ...

From Levan+, Nature (2023)

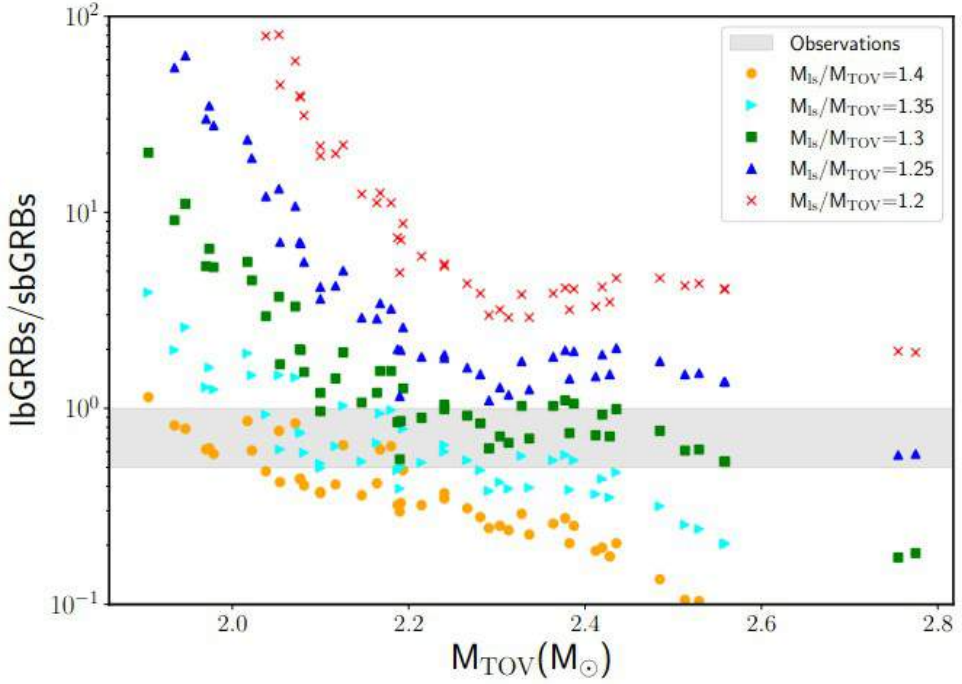
Long vs short bursts from mergers

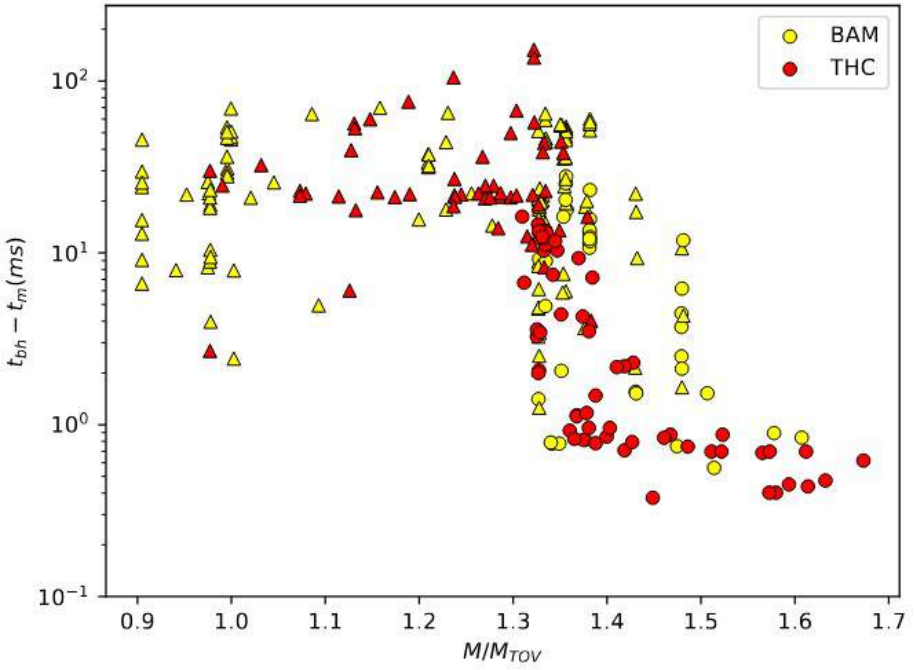


From Gottlieb+, ApJL 2023

- Mergers forming small disks power short-GRBs
- Mergers producing large disks power long-GRBs
- Ration of long to short merger GRBs can tell us about ratio of long to short lived remnants

Implication for NS mergers

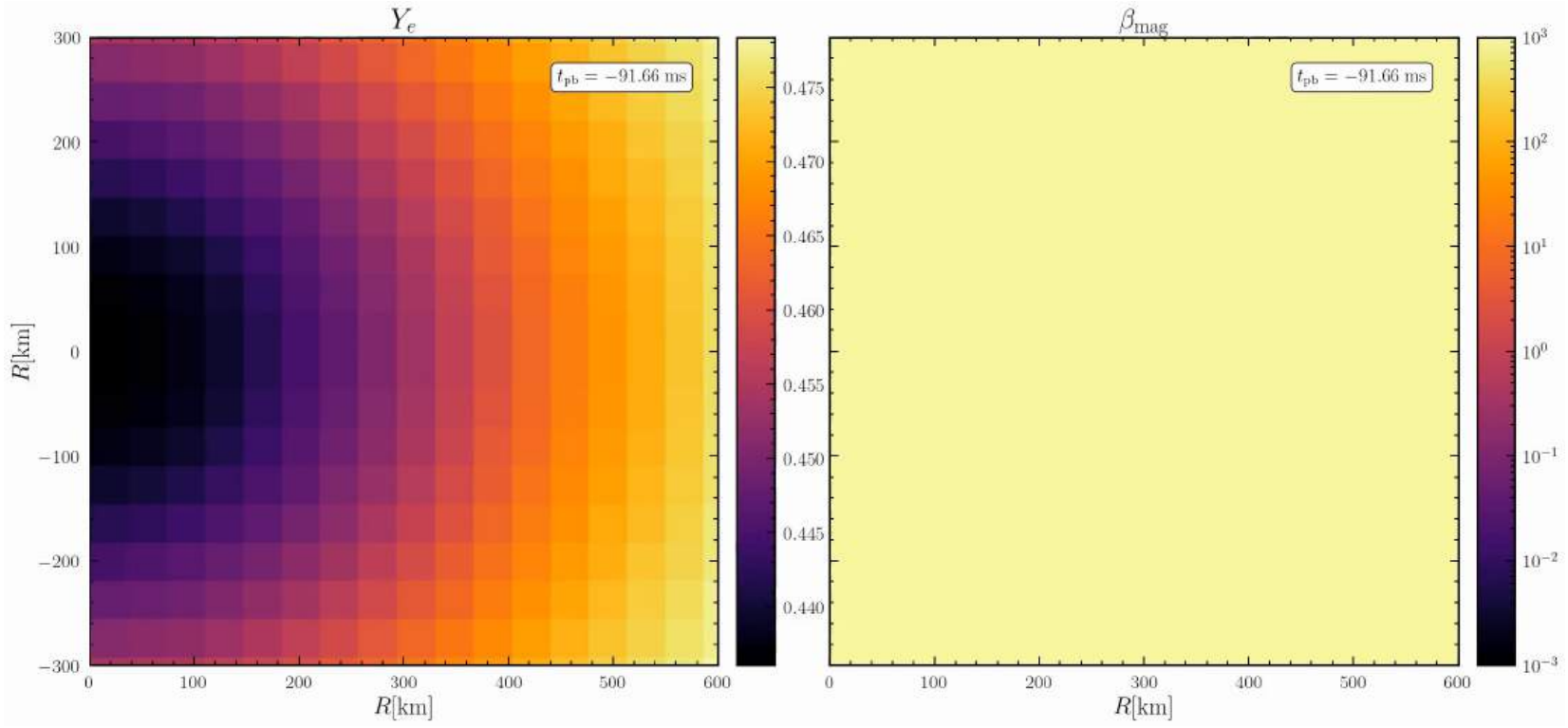




The ratio of long to short compact-binary GRBs could constrain k_{long}

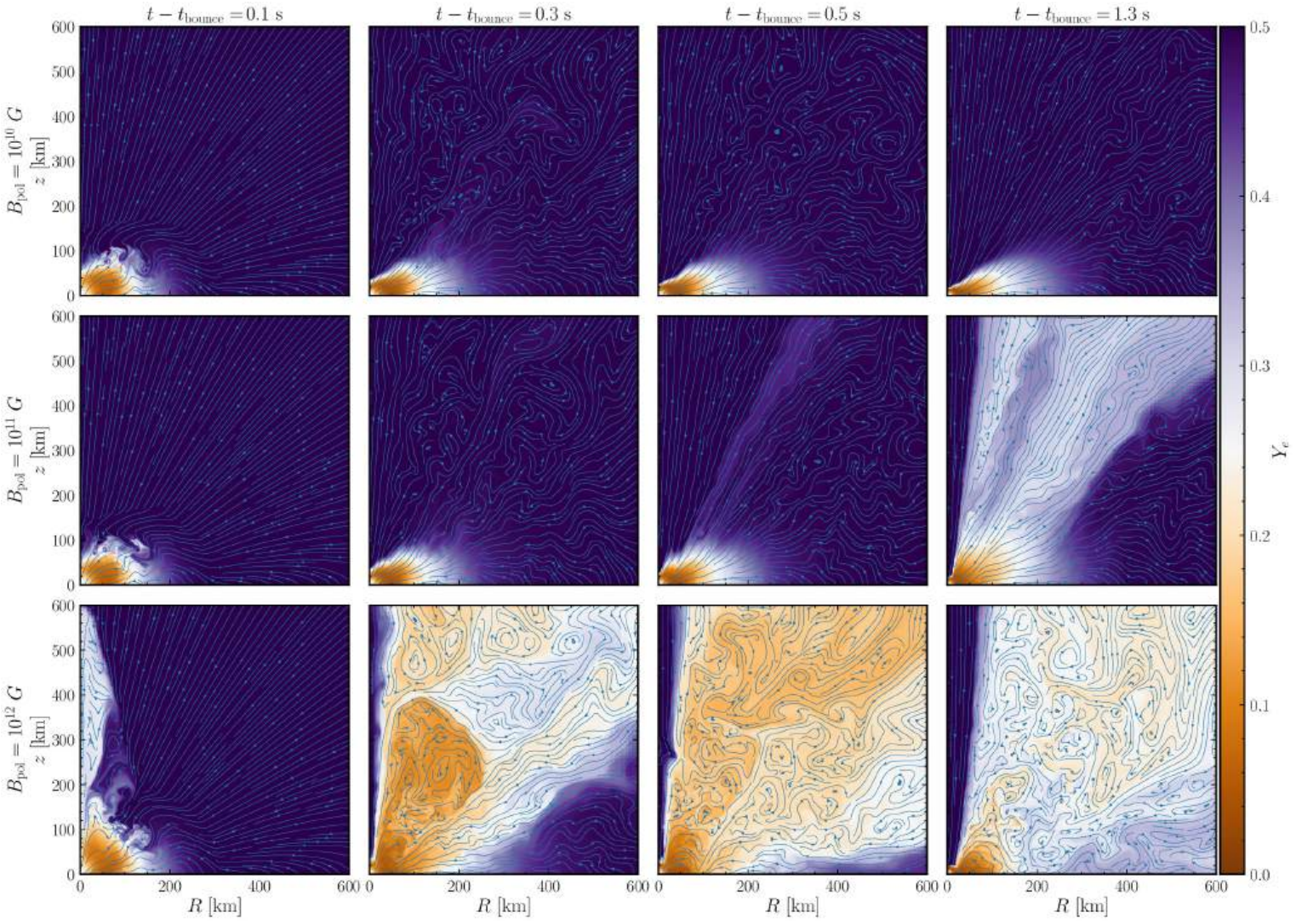
From Perna+ PRD 111:063015 (2025)

An alternative progenitor: AIC



Simulation and visualization: Tetyana Pitik

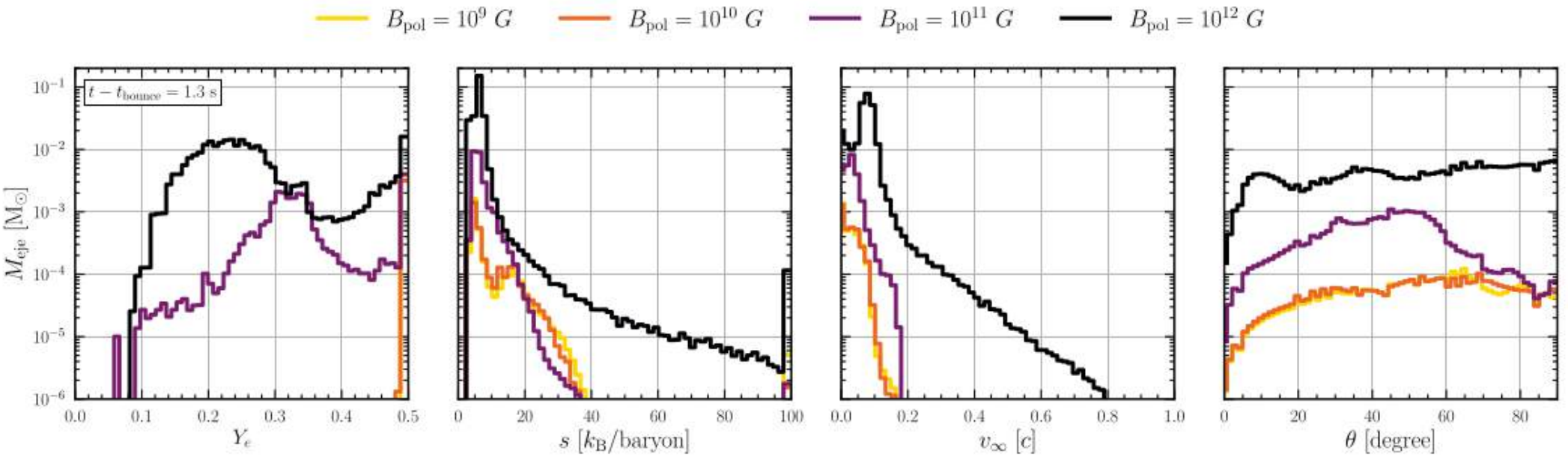
From Cheong+ ApJL 978 (2025)



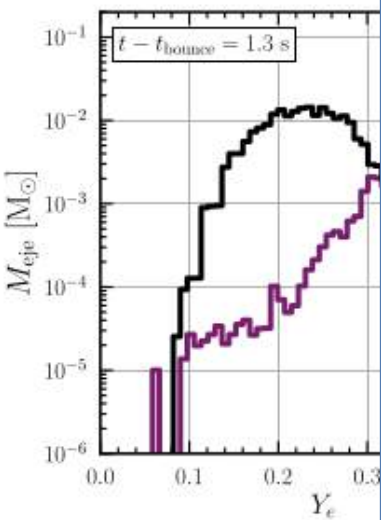
See also Batziou+ 2024; Chan+ 2025; Kuroda+ 2025; Combi+ 2025; ...

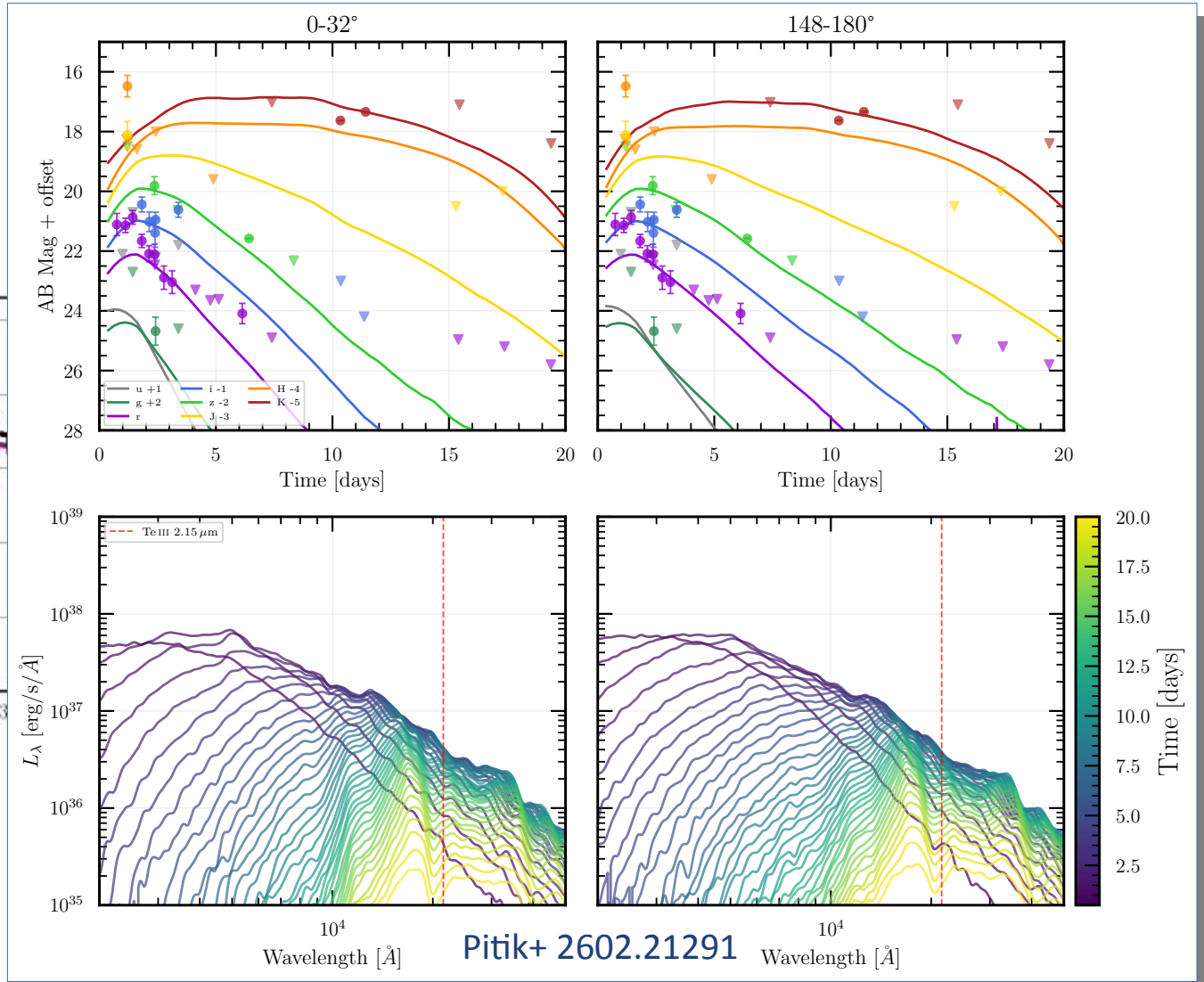
From Cheong+ ApJL 978 (2025)

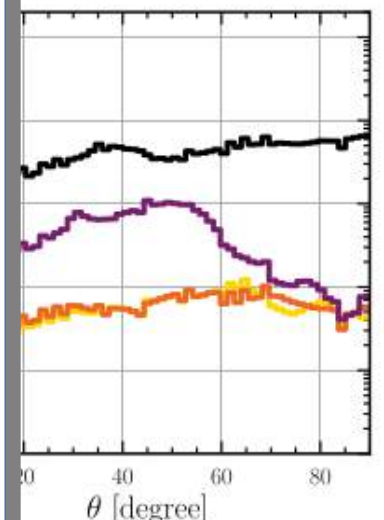
Kilonova from AIC



From Cheong+ ApJL 978 (2025)



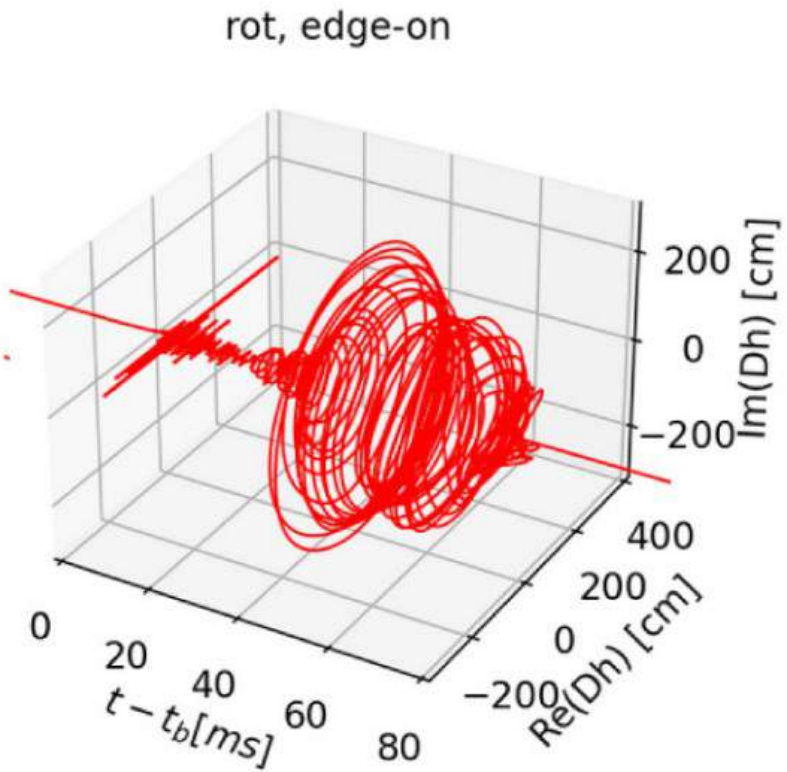


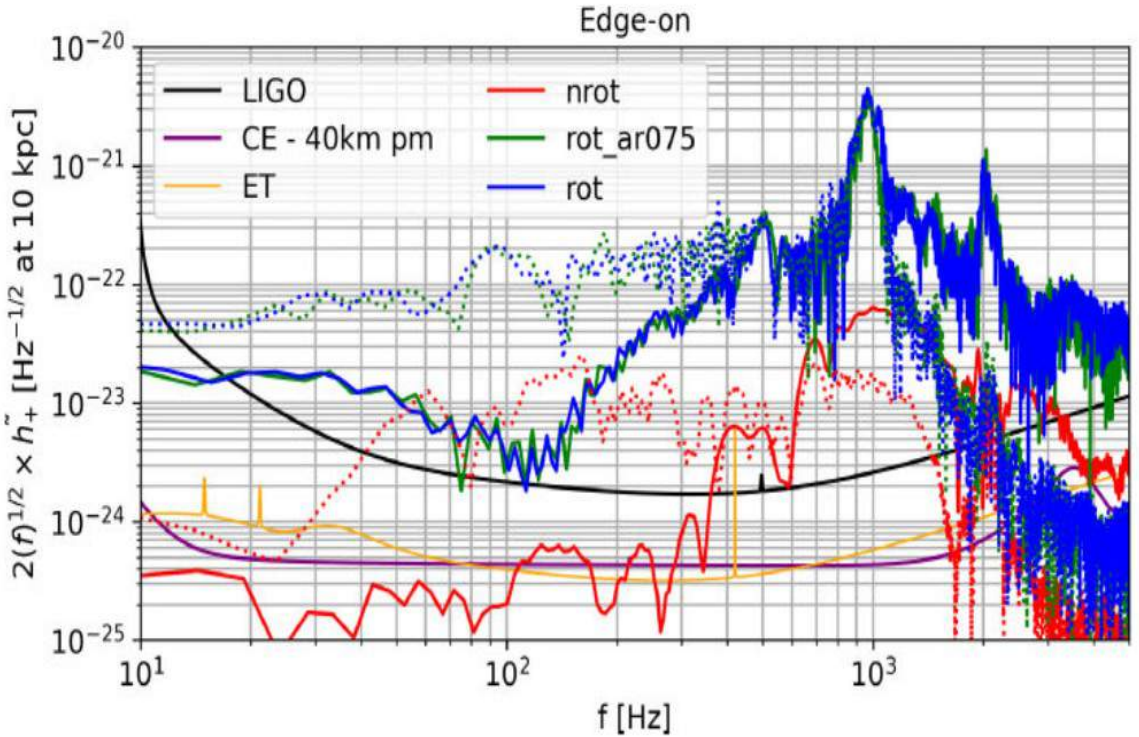


Pitik+ 2602.21291

+ ApJL 978 (2025)

Gravitational-waves from AICs





See also Shibagaki+ 2020, 2021, 2023; Shibata 2026

From Longo+, MNRAS 525:6359 (2023)

Conclusions

- We appear to be on the verge of solving the r-process puzzle
- However, cracks are starting to form in the picture we built in 2017
- On the theory side, uncertainties in the long-term dynamics, MHD effects, and neutrinos are a limiting factor, but we are making rapid progress!
- LGRBs with kilonovae are a new piece of the puzzle. Do they rescue binaries or do they confirm that there are other sources?