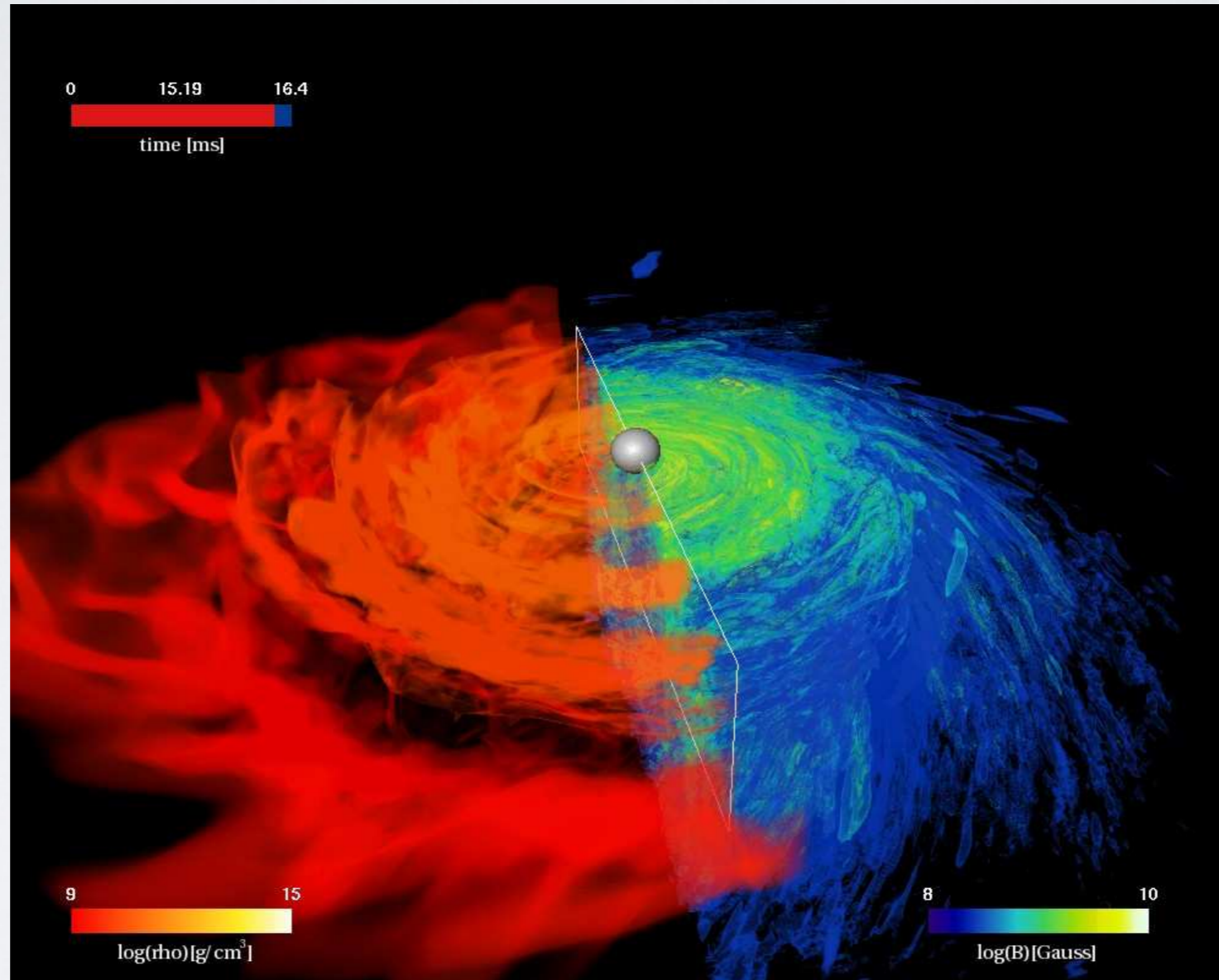


MAGNETAR FORMATION FROM THE MERGER OF BNS



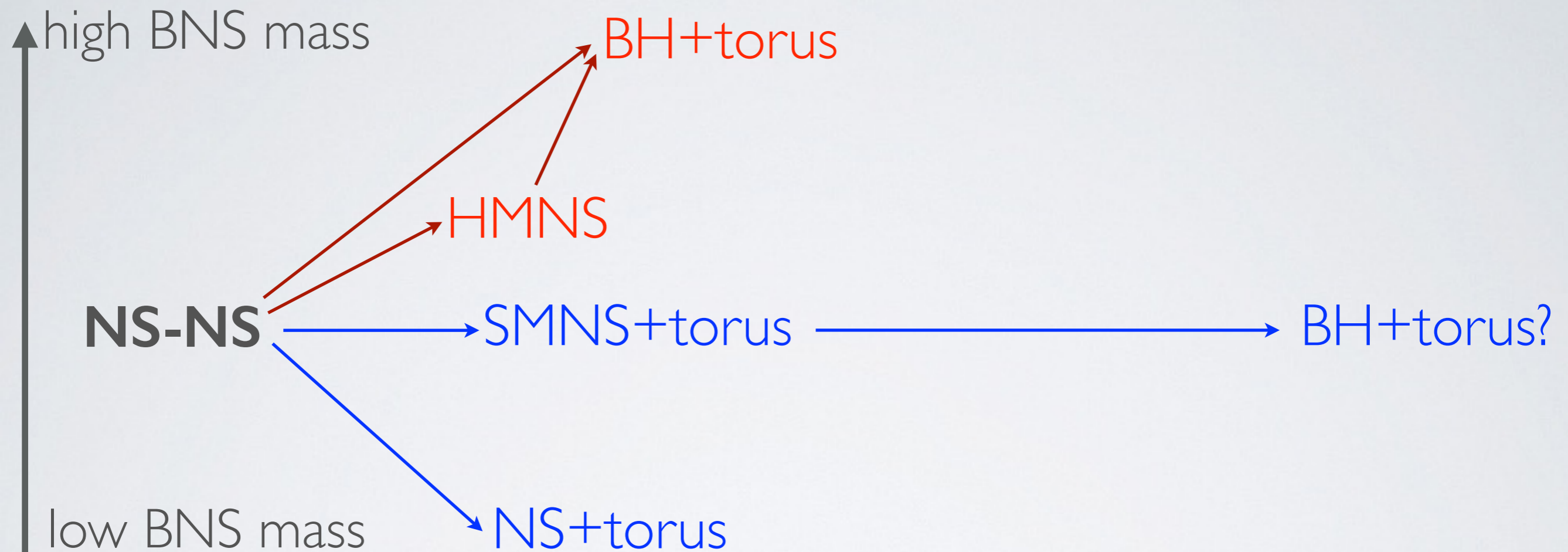
Bruno Giacomazzo

University of Trento and INFN-TIFPA, Italy



BNS POST-MERGER EVOLUTION

Depending on mass and EOS several post-merger scenarios:



Magnetic fields play fundamental role in post-merger dynamics
(jets from BH/NS+torus, NS collapse to BH, ...)

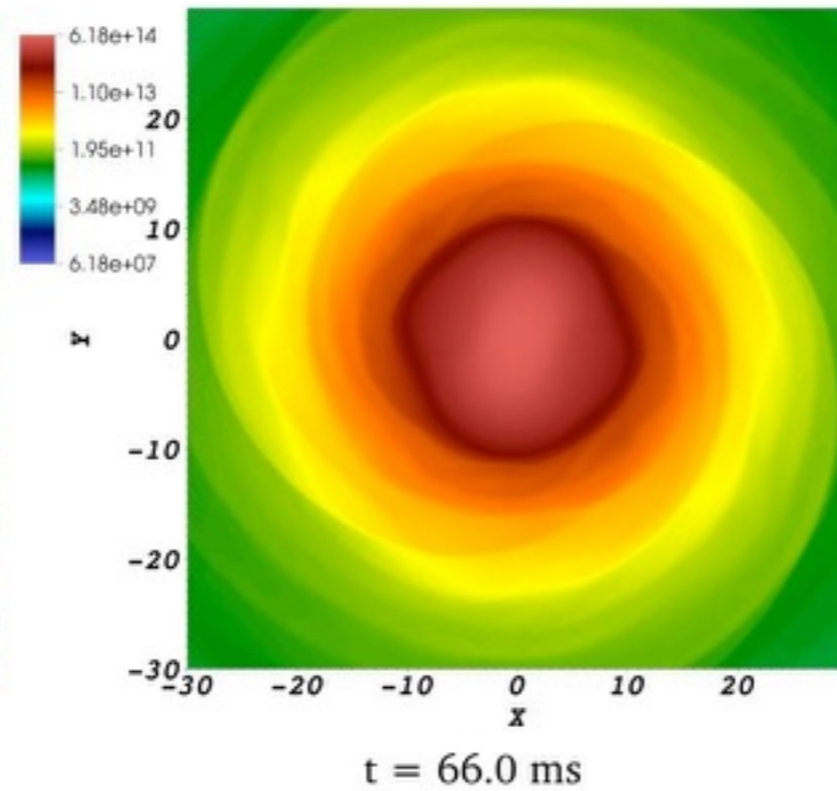
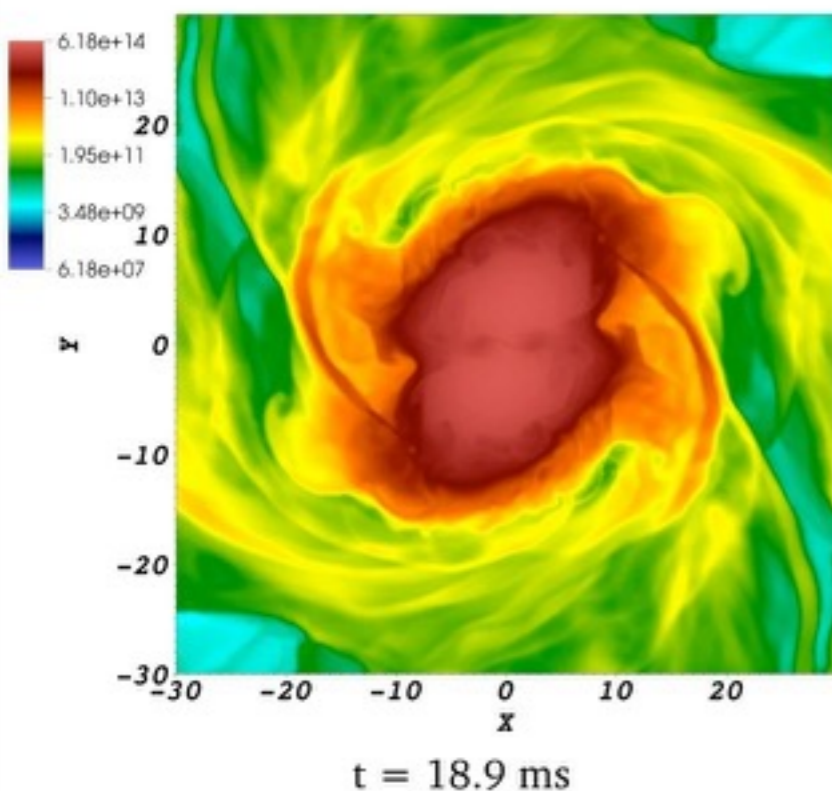
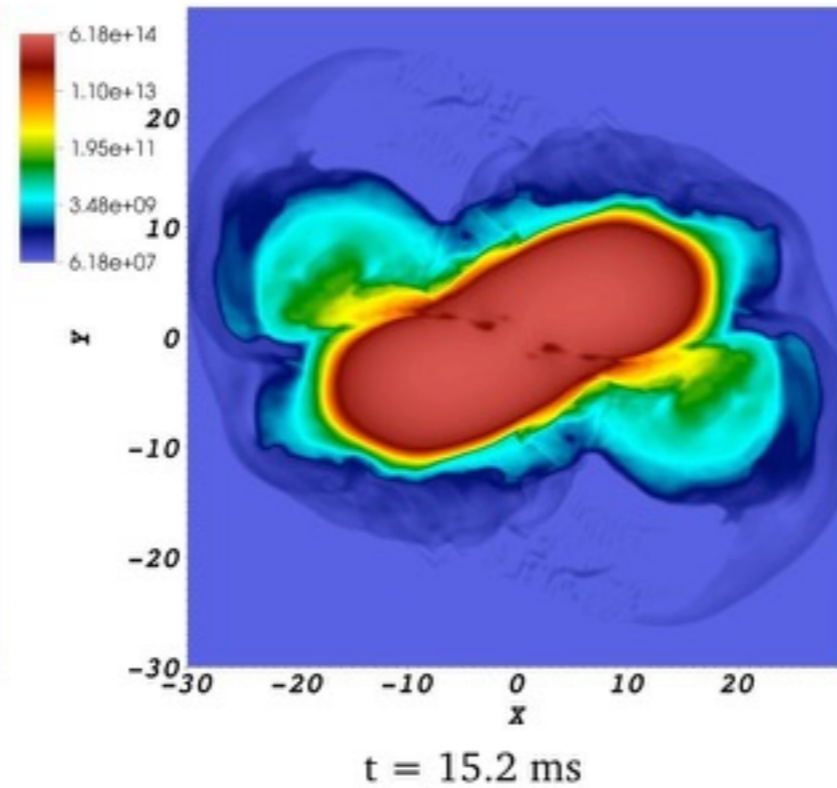
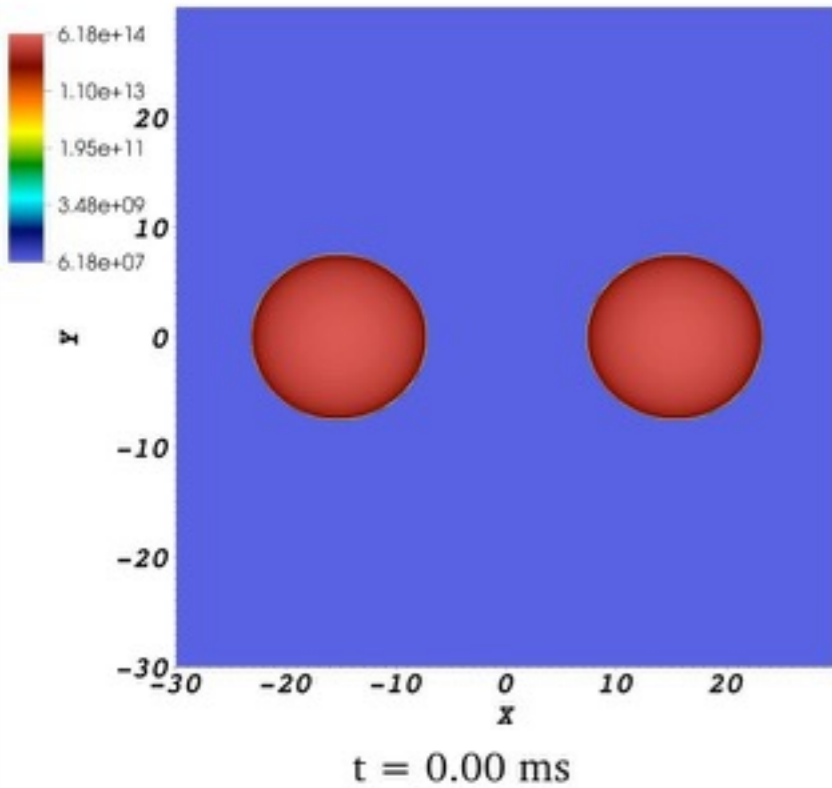
All these scenarios may lead to SGRBs with different properties

MAGNETAR FORMATION

Giacomazzo & Perna 2013, ApJ Letters, 771, L26

Investigated merger of two $1.2 M_{\odot}$ NSs

Used Ideal Fluid, $\Gamma=2.75$, $k=30000$ (Oechslin et al 2007)



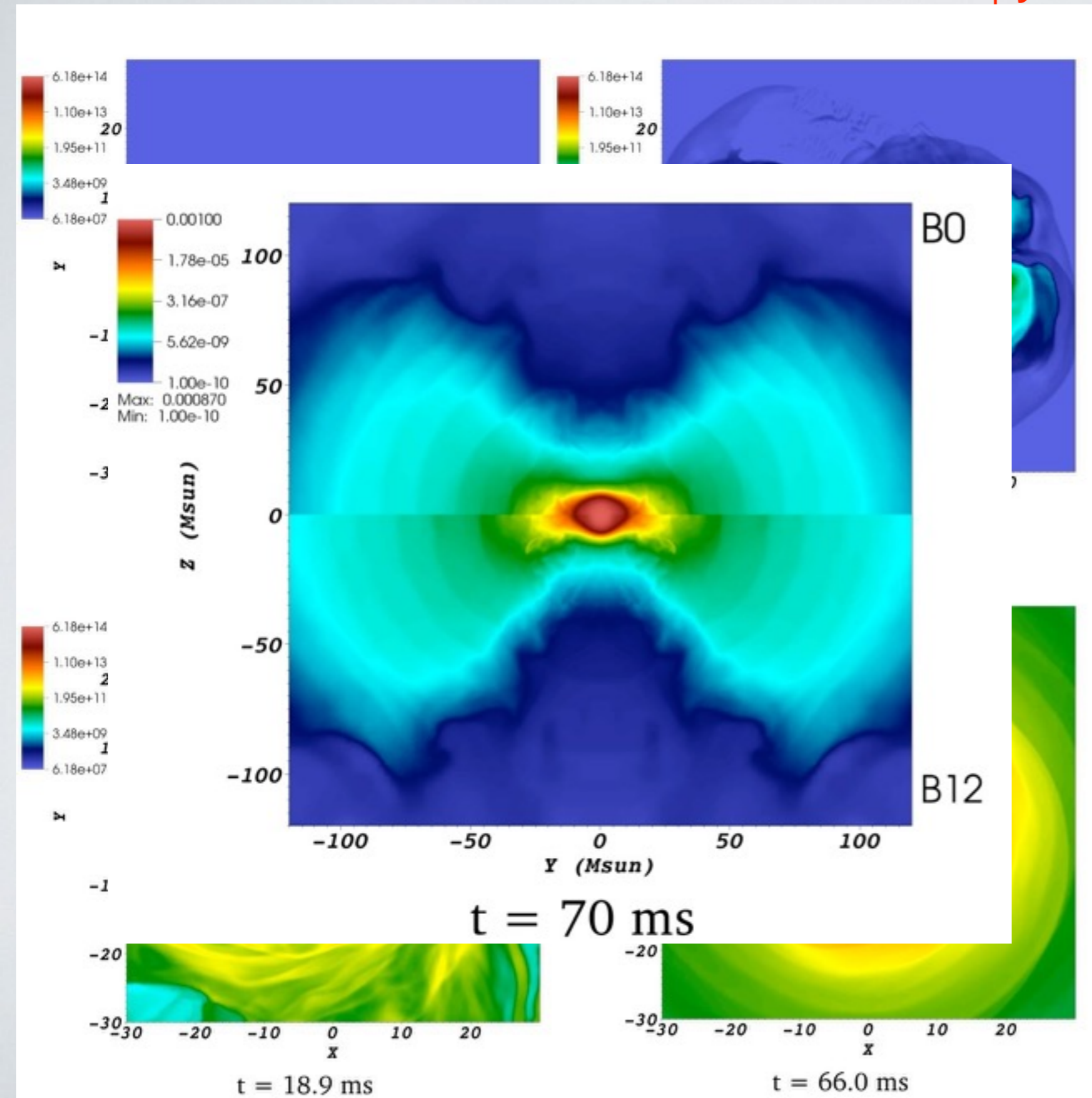
MAGNETAR FORMATION

Giacomazzo & Perna 2013, ApJ Letters, 771, L26

Investigated merger of two $1.2 M_{\odot}$ NSs

Used Ideal Fluid, $\Gamma=2.75$, $k=300000$ (Oechslin et al 2007)

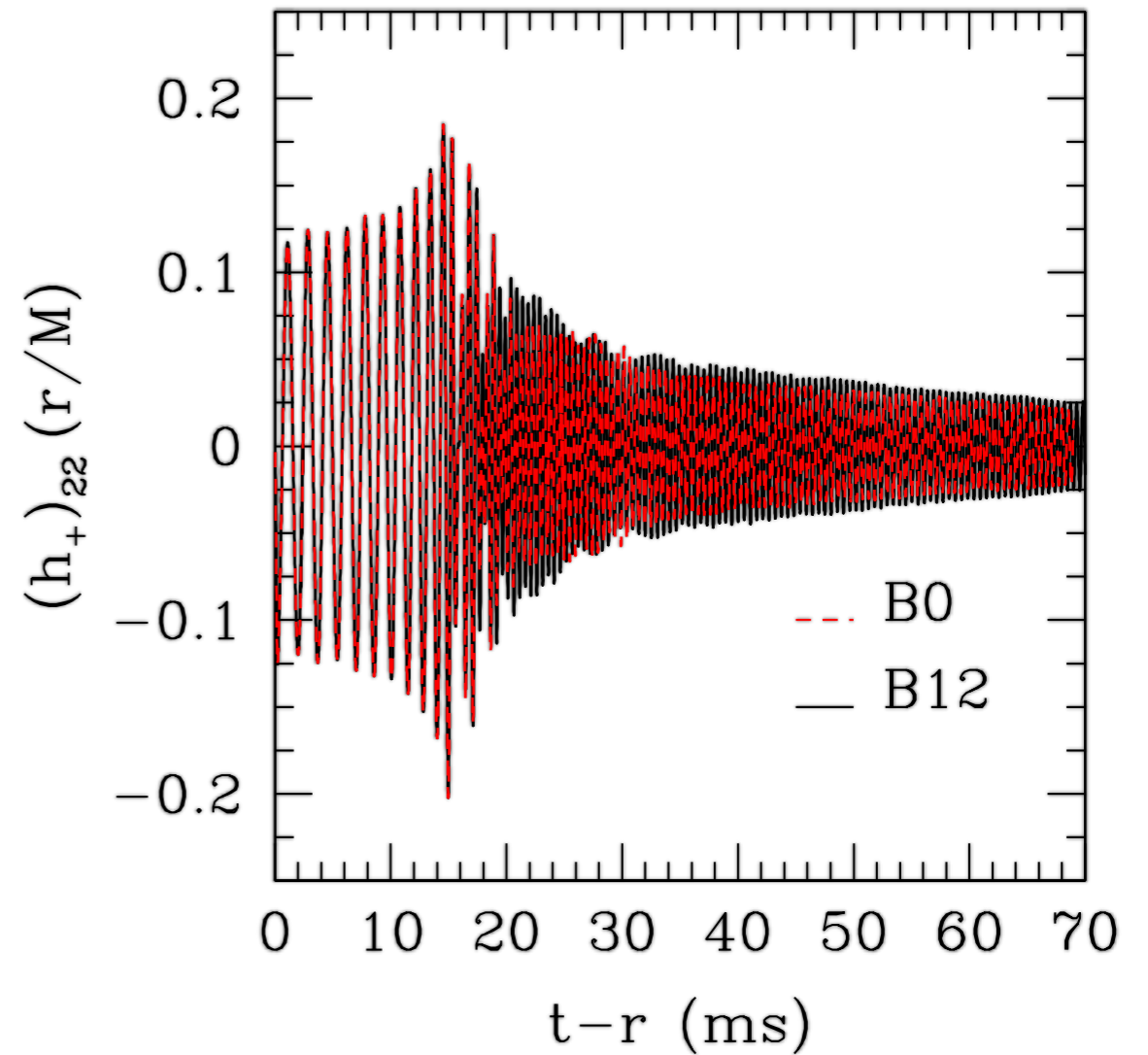
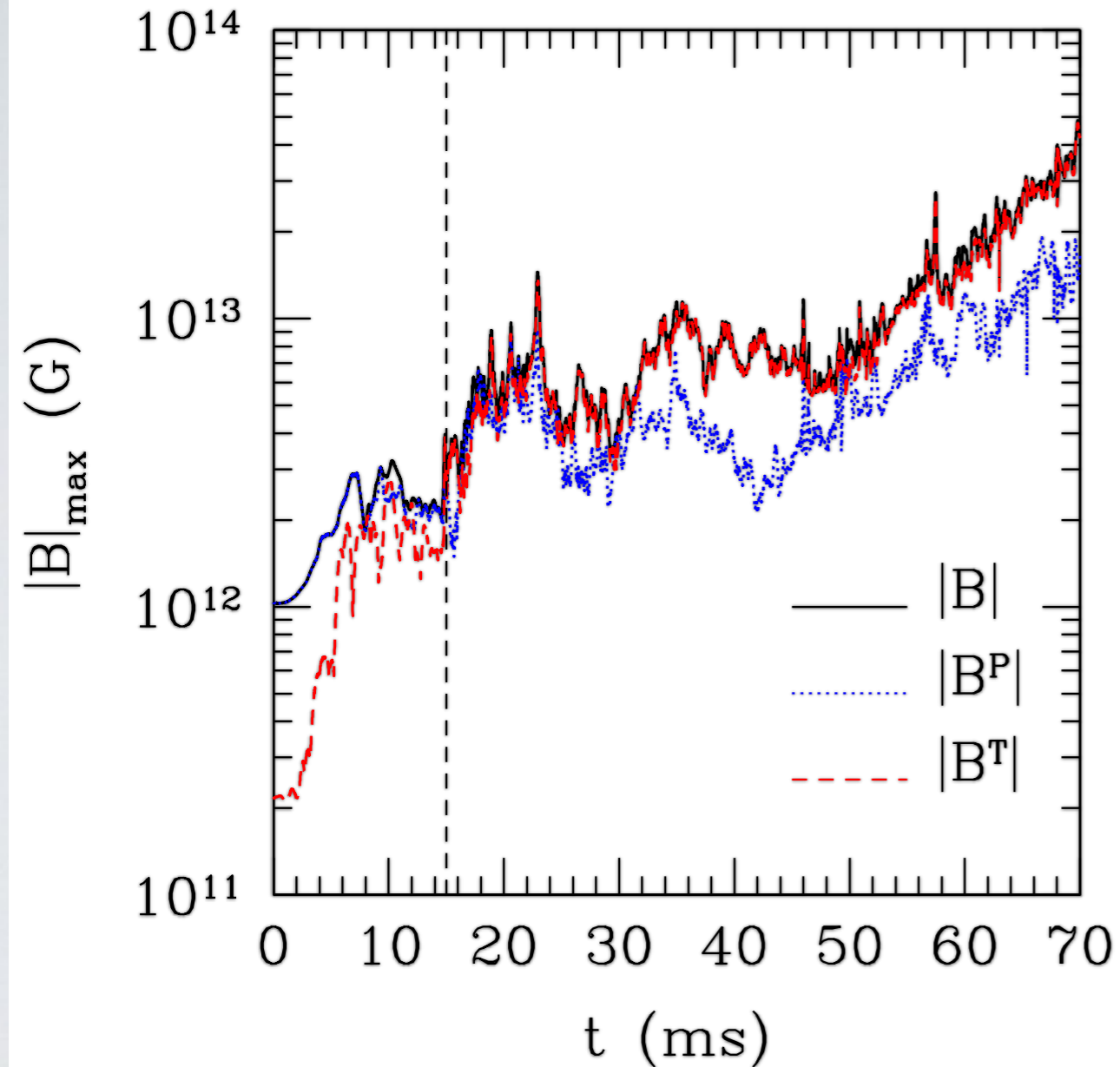
Produced a stable “ultraspinning” NS ($J/M^2 \sim 0.9$) surrounded by a magnetized disk of $\sim 0.1 M_{\odot}$.



MAGNETAR FORMATION

Giacomazzo & Perna 2013, ApJ Letters, 771, L26

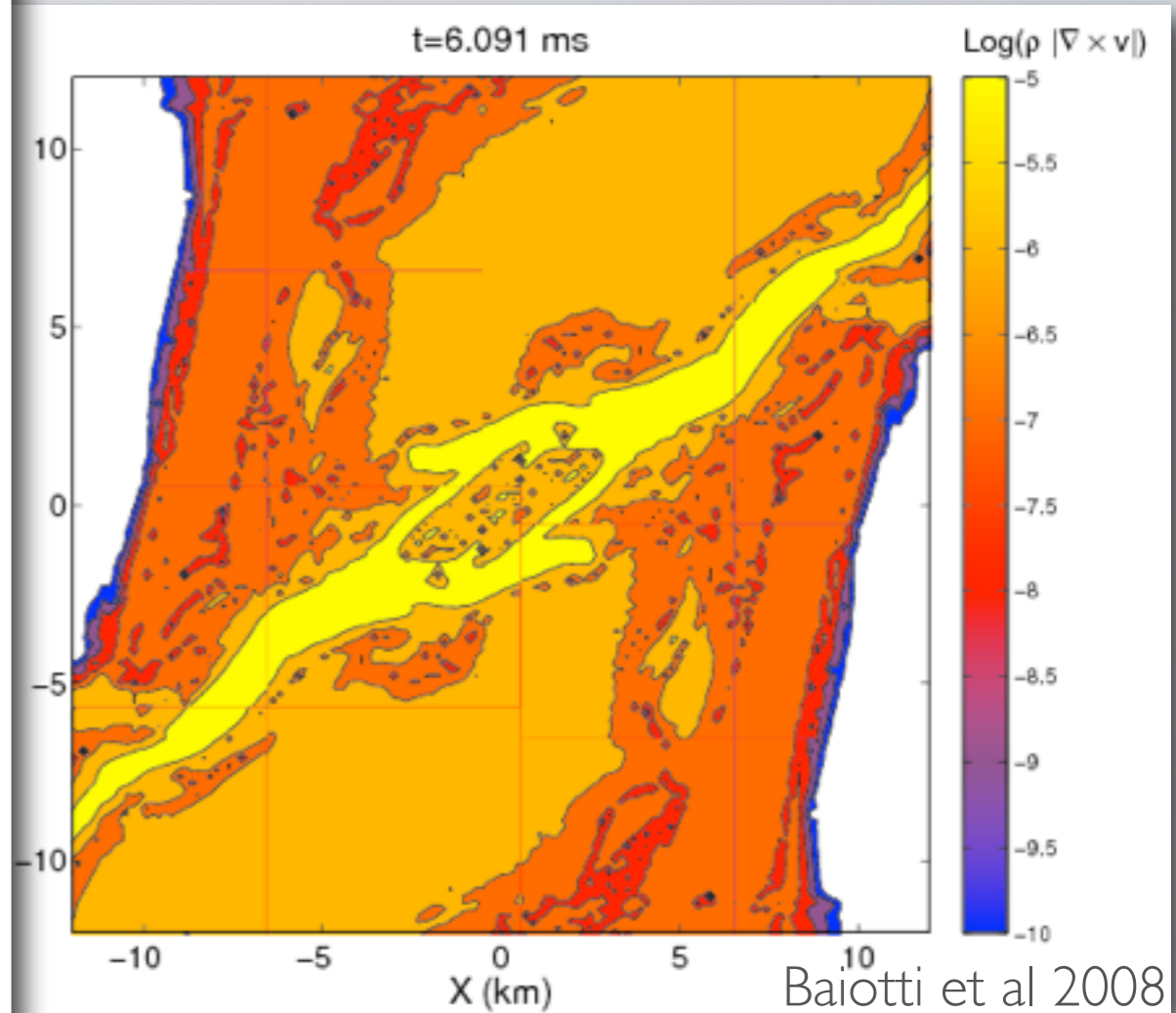
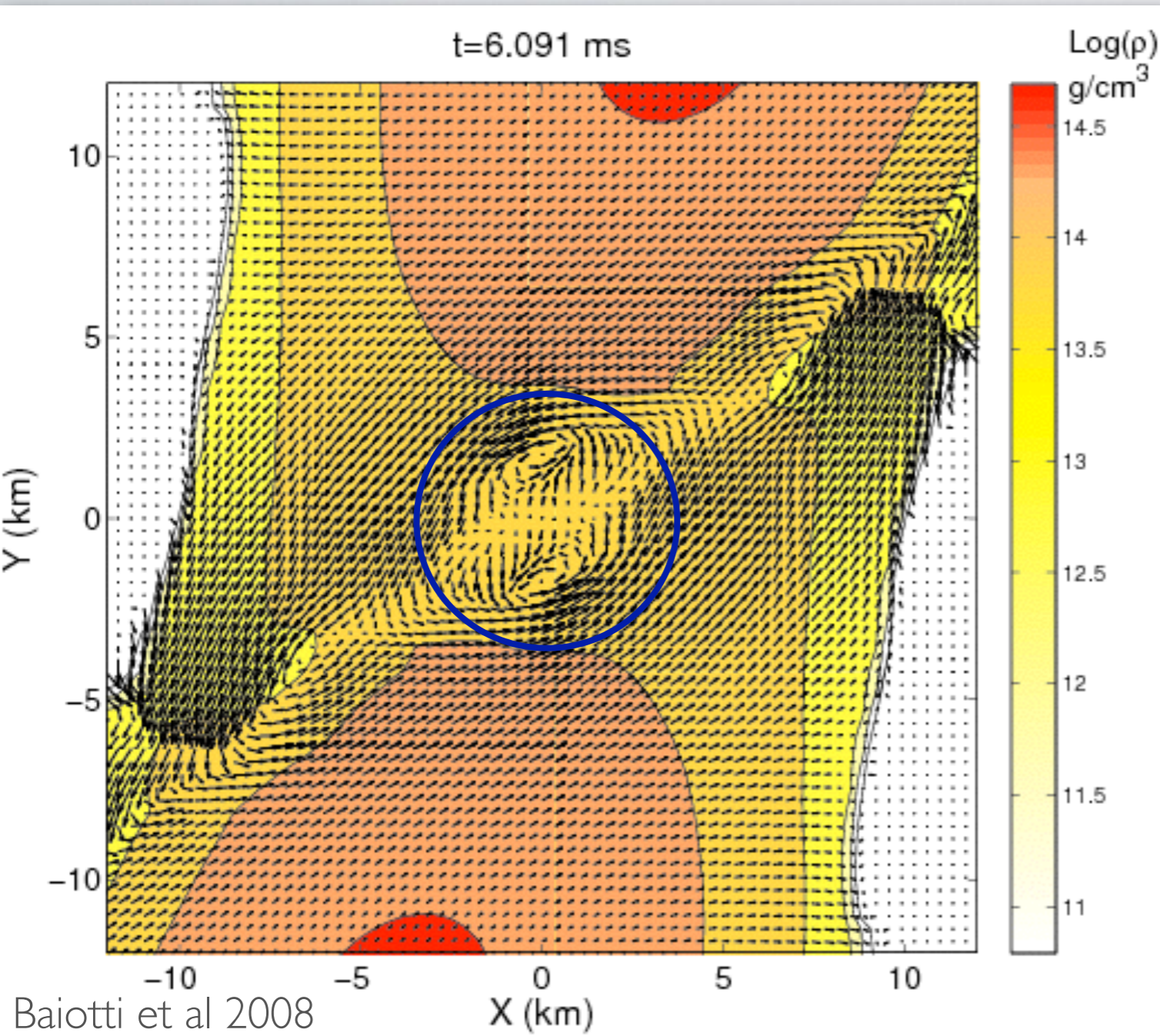
GWs publicly available for download at www.brunogiacomazzo.org/data.html



Magnetic field amplified of ~ 2 orders of magnitude. Difference in the GW signal are small and present only in the post-merger phase.

MAGNETIC FIELD AMPLIFICATION AT MERGER

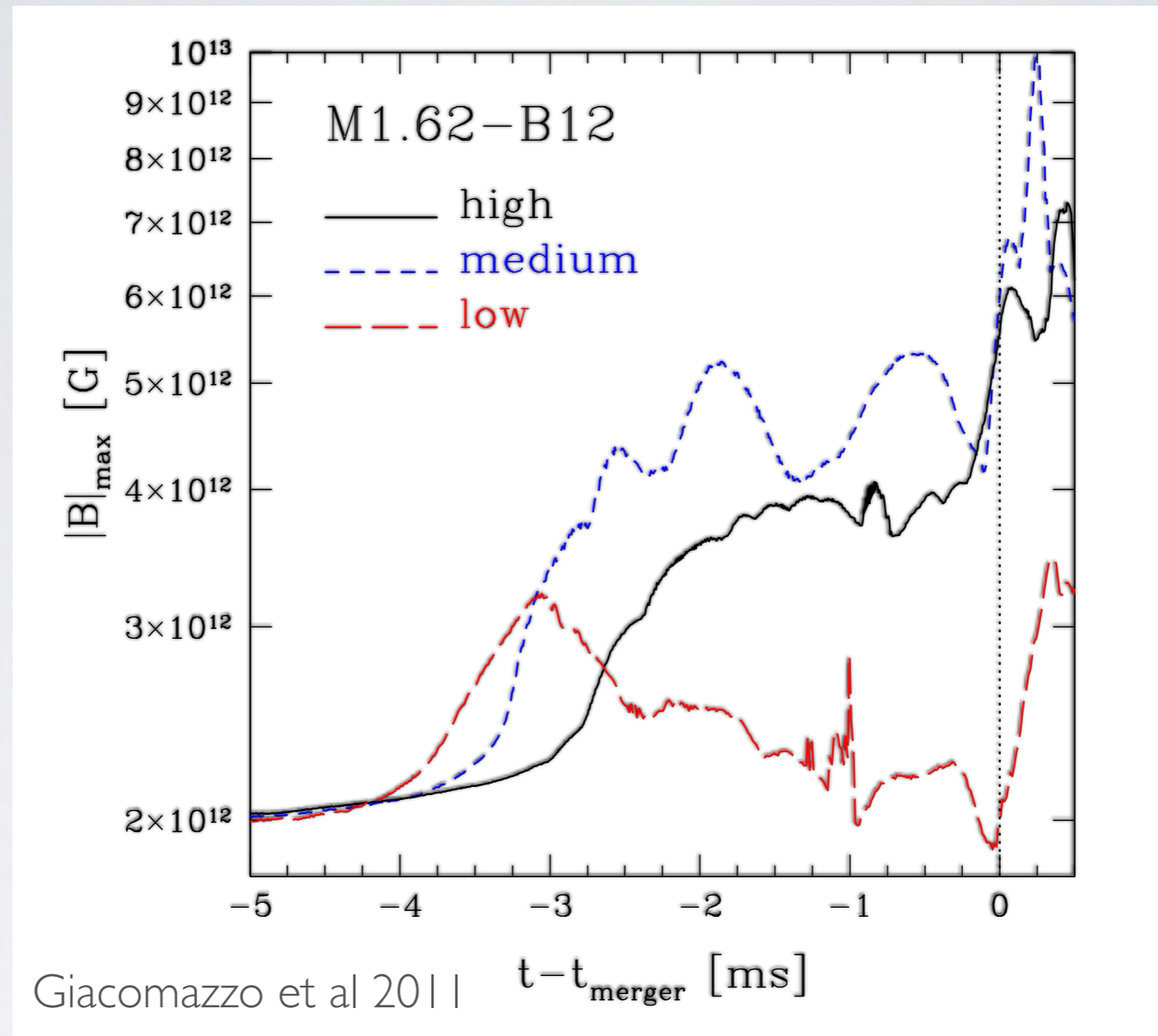
During the merger a shear interface forms and it develops a **Kelvin-Helmholtz instability** which produces a series of vortices.



$$\rho |\nabla \times v|^z$$

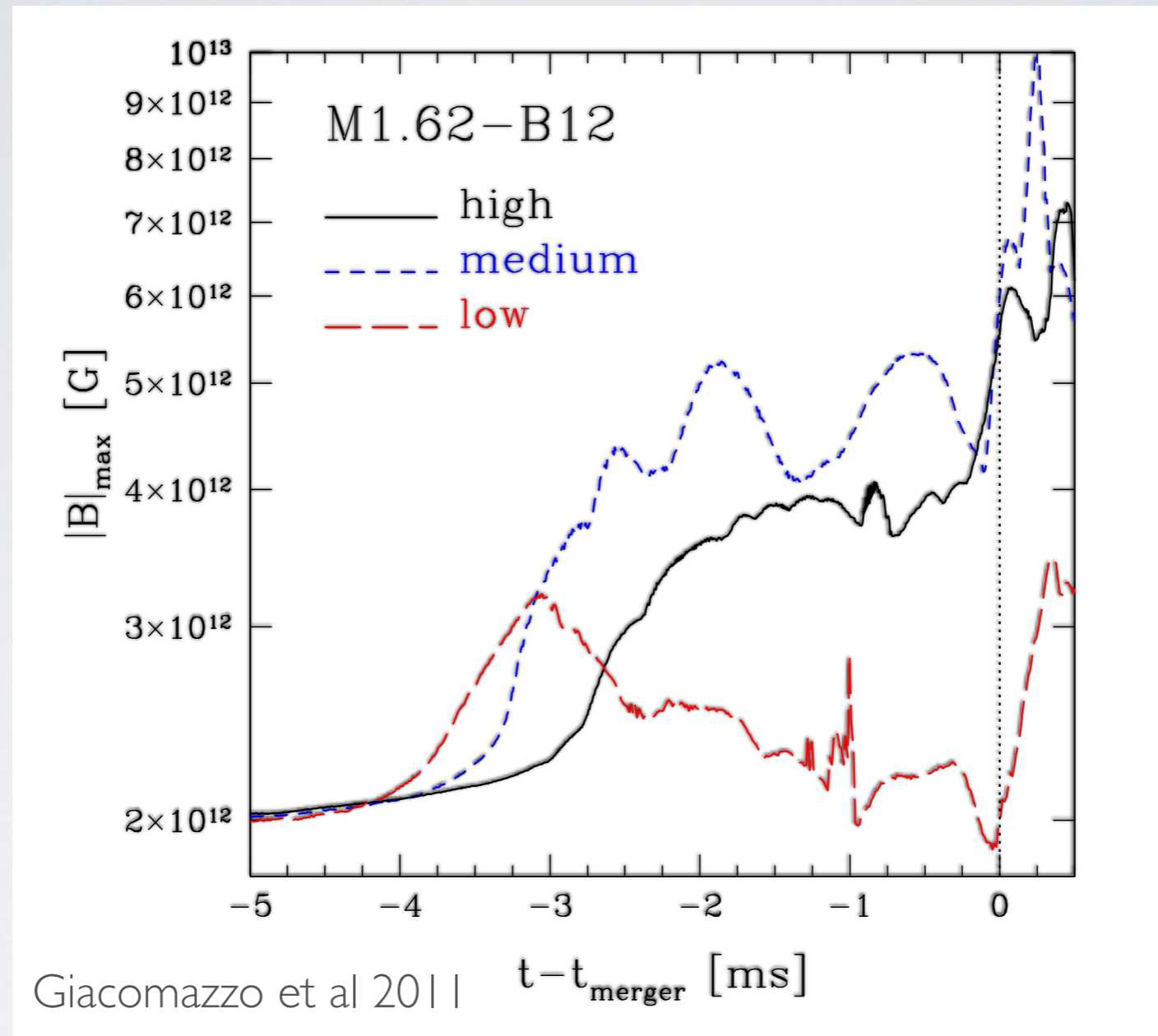
(v^x, v^y) in “corotating” frame

MAGNETIC FIELD AMPLIFICATION AT MERGER



Even with high res we do not observe amplifications of several orders of magnitude (similar results by other GR groups).

MAGNETIC FIELD AMPLIFICATION AT MERGER



Even with high res we do not observe amplifications of several orders of magnitudes (similar results by other GR groups).

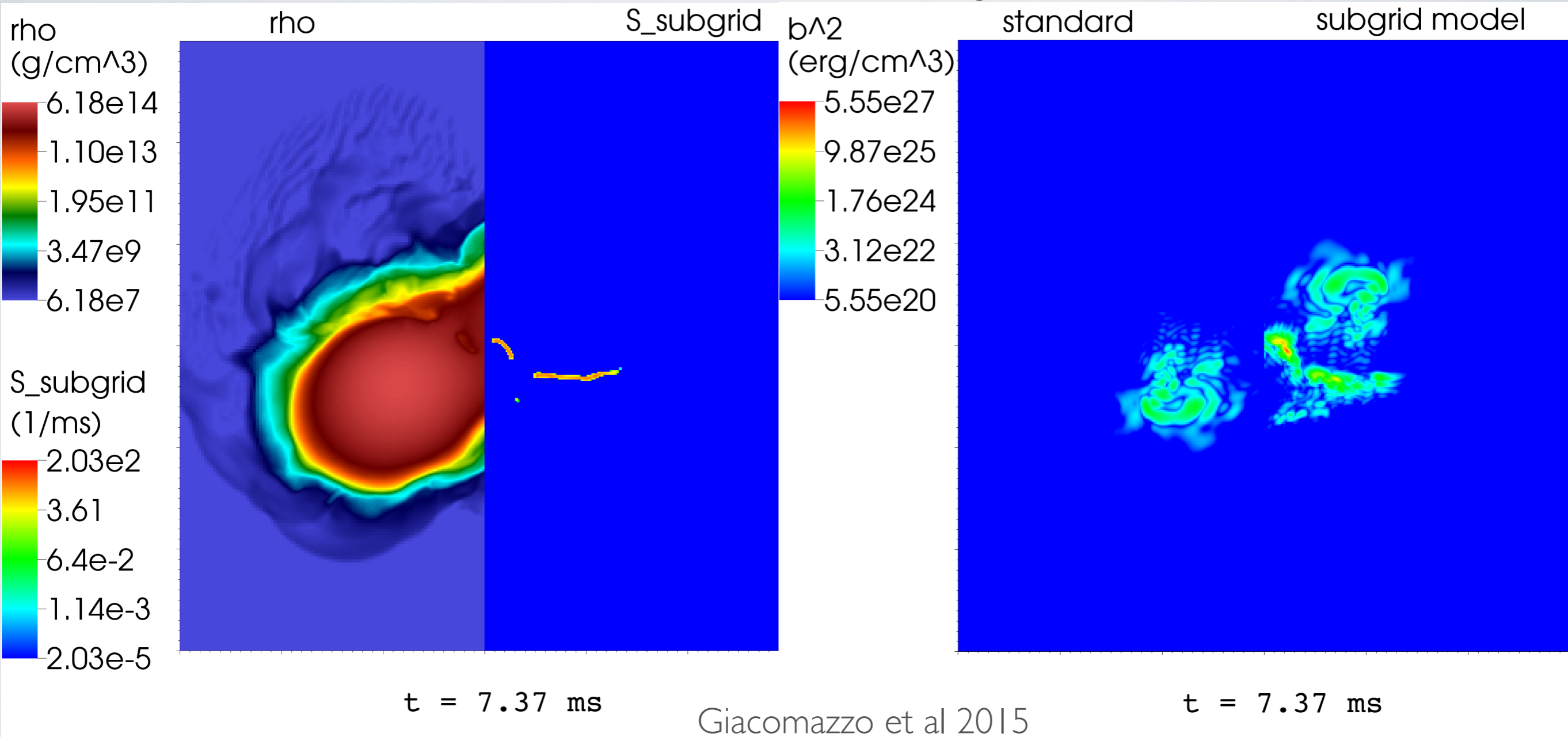
Local very high-res simulations shows that magnetic fields could be strongly amplified (Zrake & MacFadyen 2013), but res unfeasible for global BNS sims!

MAGNETIC FIELD AMPLIFICATION AT MERGER

Giacomazzo, Zrake, Duffell, MacFadyen, Perna 2015, ApJ, 809, 39

We developed a sub-grid model to account for small scale effects:

$$\partial_t A_i = -E_i + S_{\text{subgrid}} A_i$$

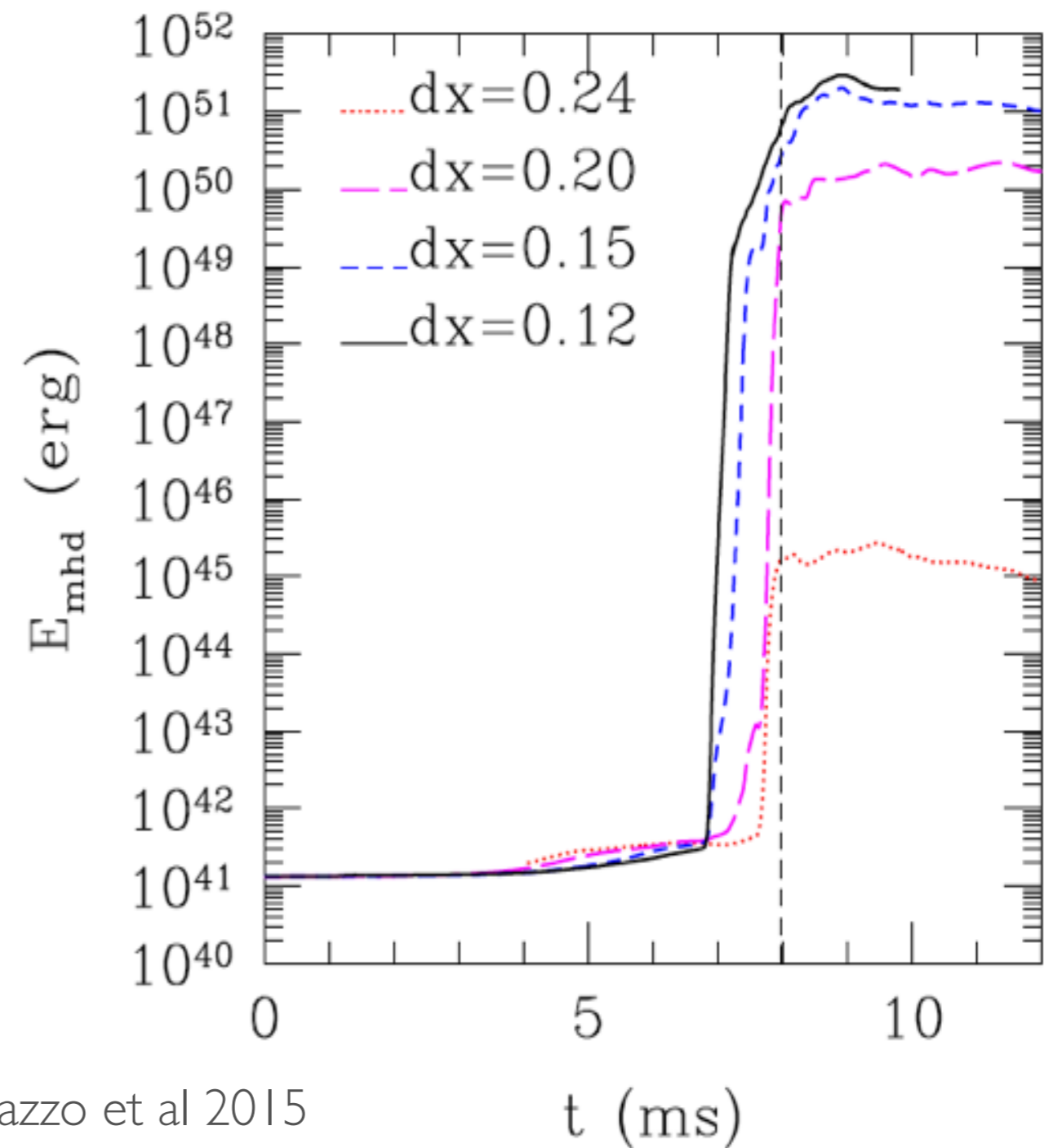
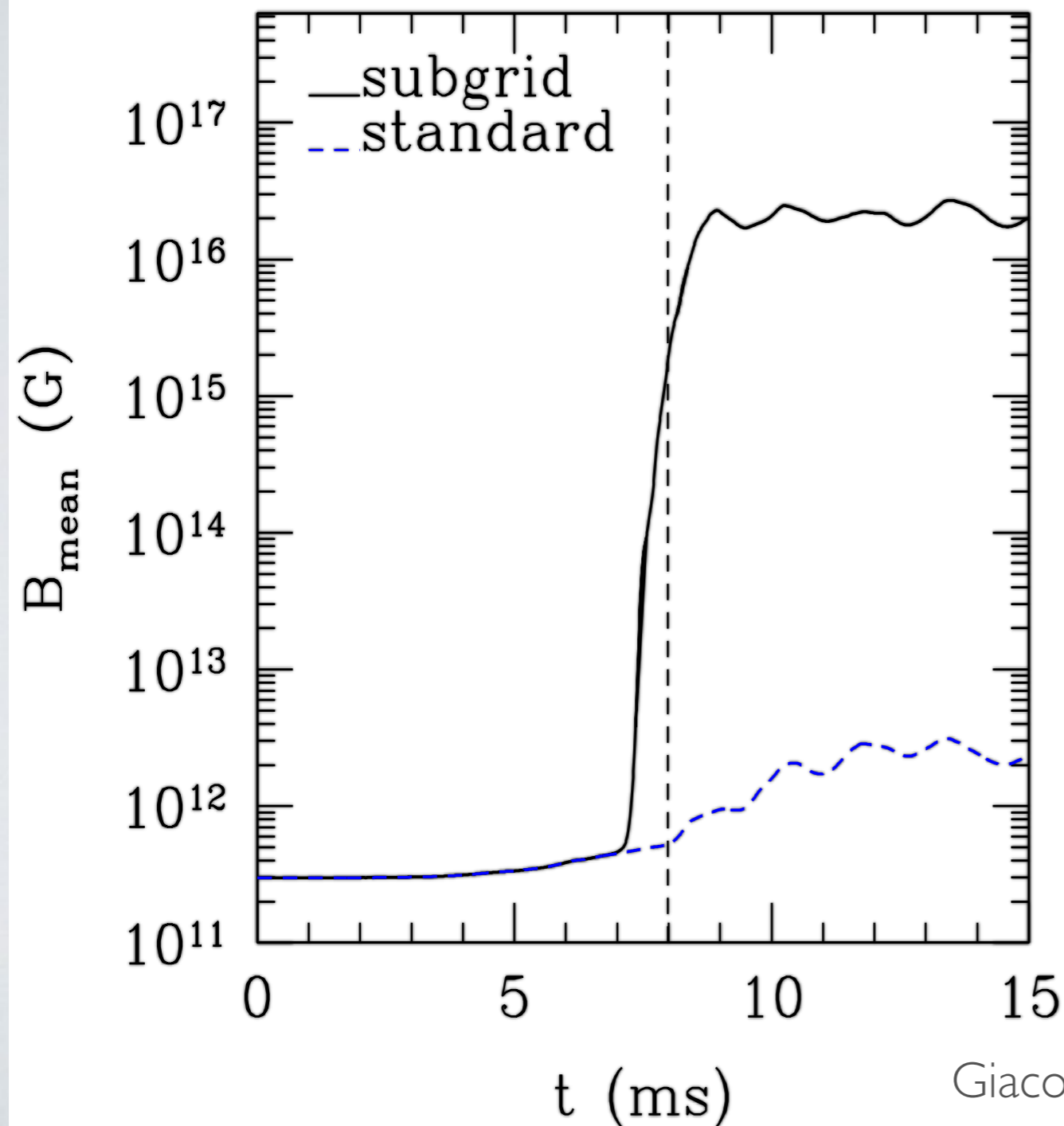


S_{subgrid} is different from zero only in the central turbulent region. Magnetic field amplification is larger in the central vortices.

MAGNETIC FIELD AMPLIFICATION AT MERGER

Giacomazzo, Zrake, Duffell, MacFadyen, Perna 2015, ApJ, 809, 39

We implemented the sub-grid model in our GRMHD code Whisky and run a set of NS-NS simulations.



Giacomazzo et al 2015

CONCLUSIONS

- Stable and Supramassive NSs may be formed after merger
- Magnetic fields can be strongly amplified via small scale turbulence (but still a lot of work to do to get an actual magnetar)
- GW and EM signals may be affected by magnetar formation
- GW detection from long-lived magnetar could also constrain EOS
- Note: magnetar scenario strongly dependent on max NS mass!

References:

Giacomazzo & Perna 2013, ApJ Letters, 771, L26

Dall'Osso, **Giacomazzo**, Perna, Stella 2015, ApJ, 798, 25

Giacomazzo, Zrake, Duffell, MacFadyen, Perna 2015, ApJ, 809, 39