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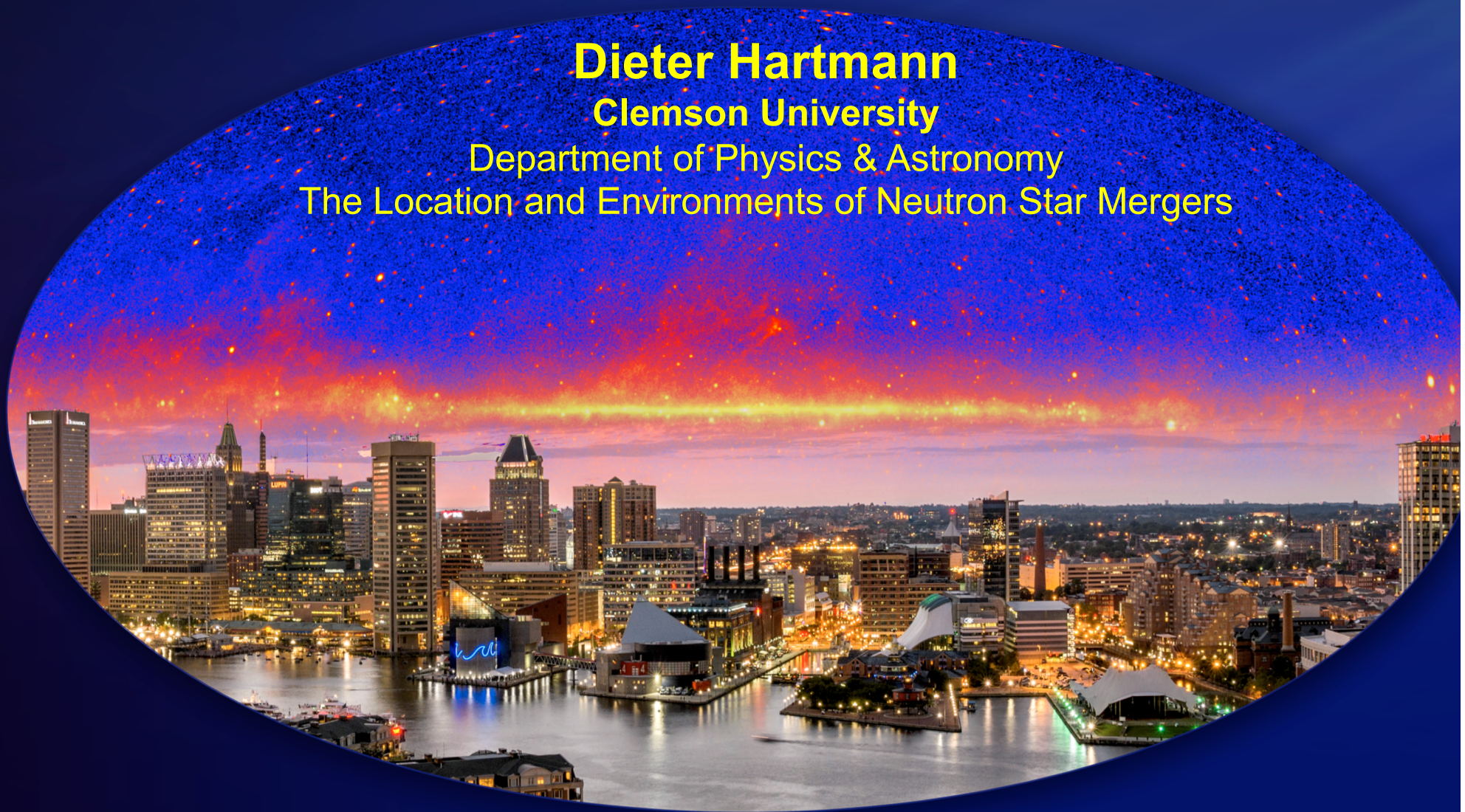
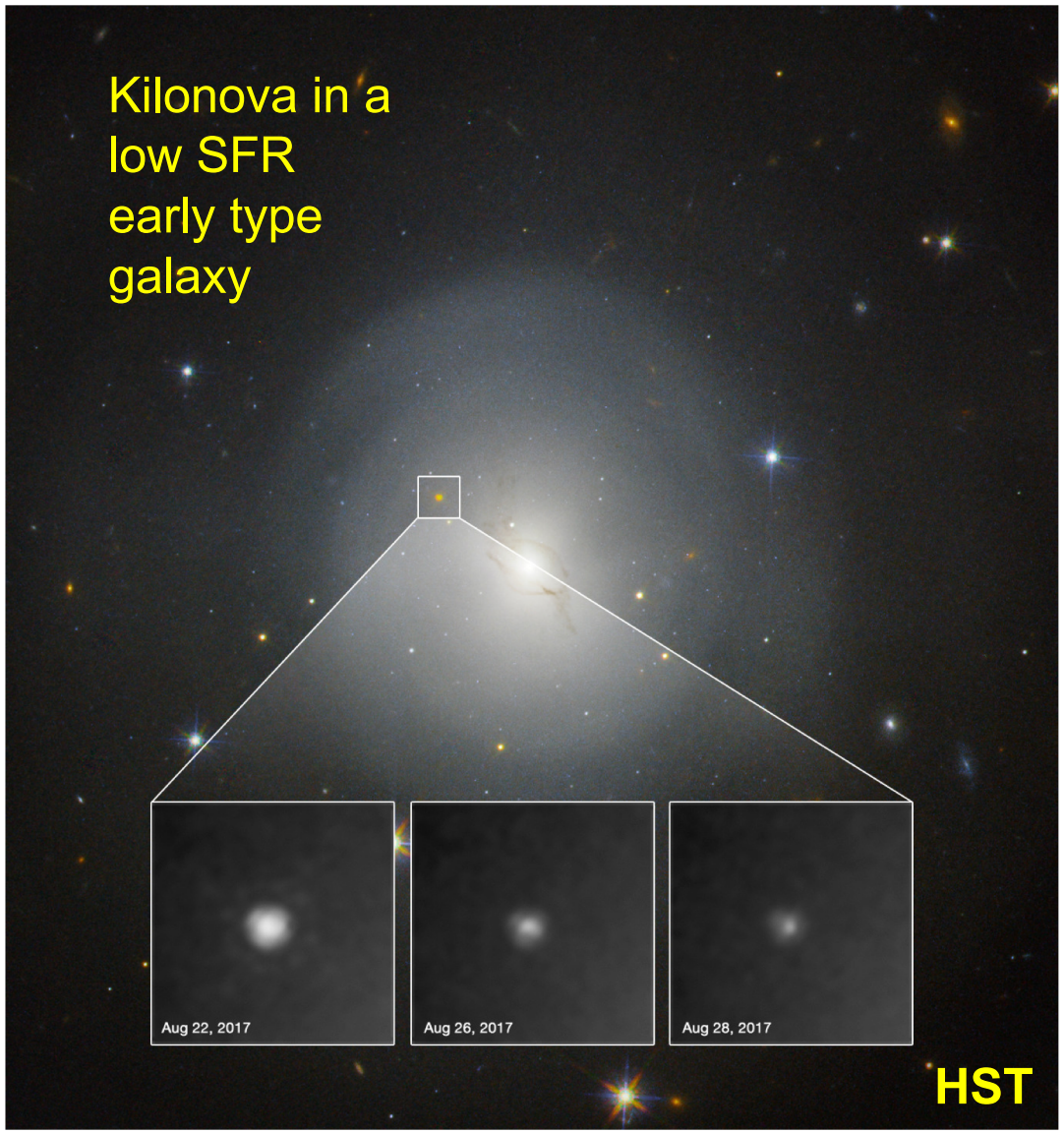
The Location and Environments of Neutron Star Mergers



The Location and Environments of Neutron Star Mergers in an Evolving Universe

ApJ, 865, 27, 2018, 9/20

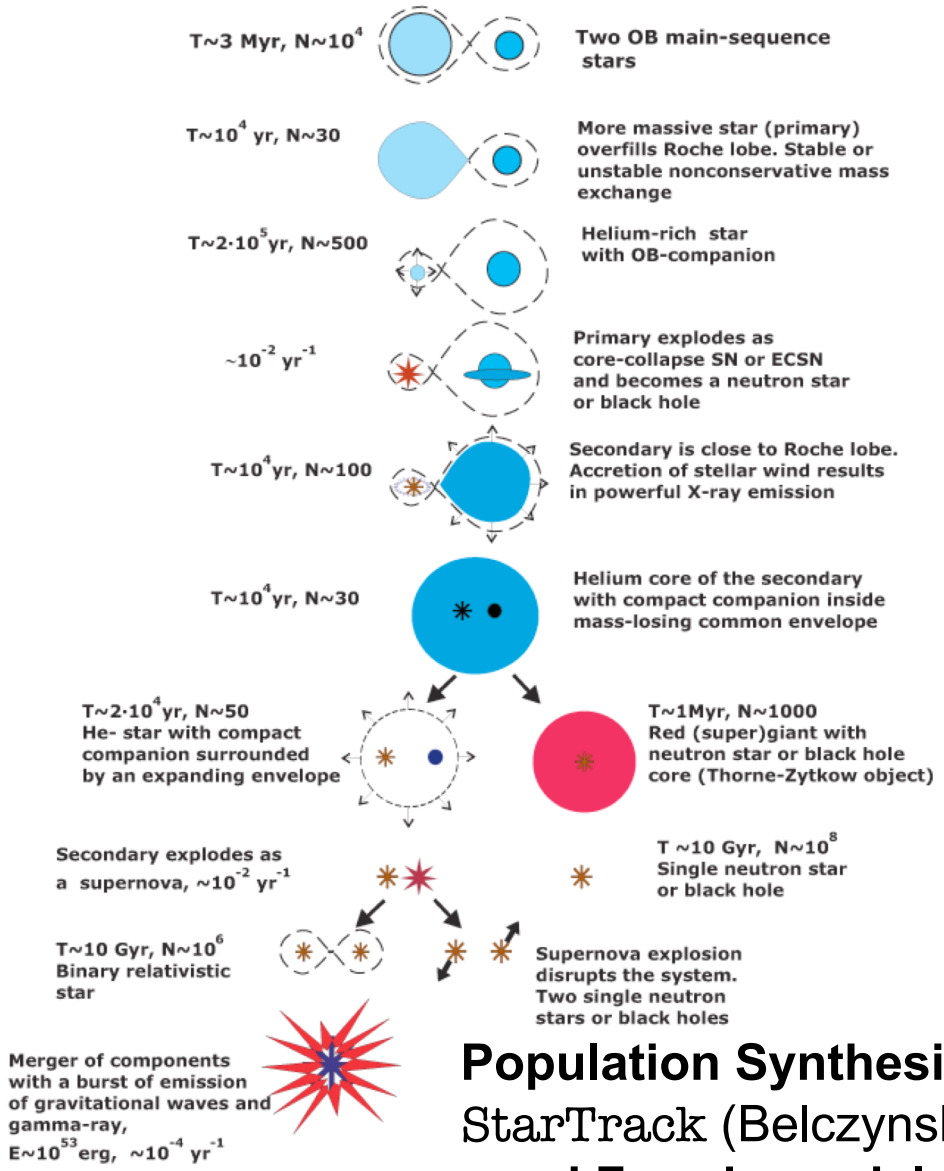
Brandon K. Wiggins
Christopher L. Fryer
Joseph M. Smidt
Dieter Hartmann
Nicole Lloyd-Ronning
Chris Belcynski



GW170917 proved the GW – SHB – BNS merger paradigm

Afterglow properties depend on the merger environment
which depends on merger location in an evolving baryonic environment

(Binary) Stellar Evolution -> BNS

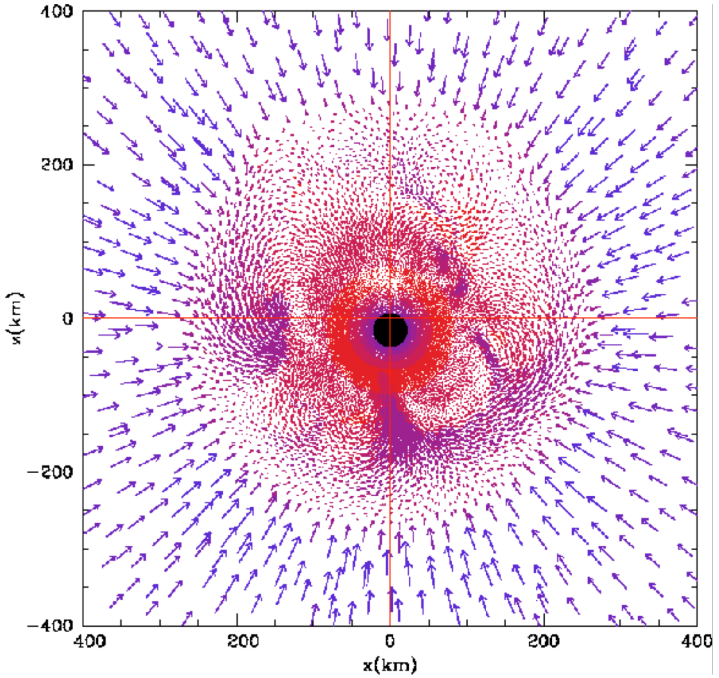


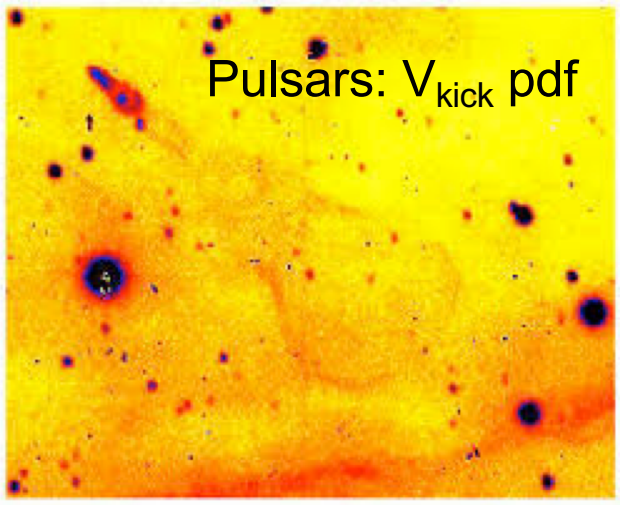
Population Synthesis

StarTrack (Belczynski)

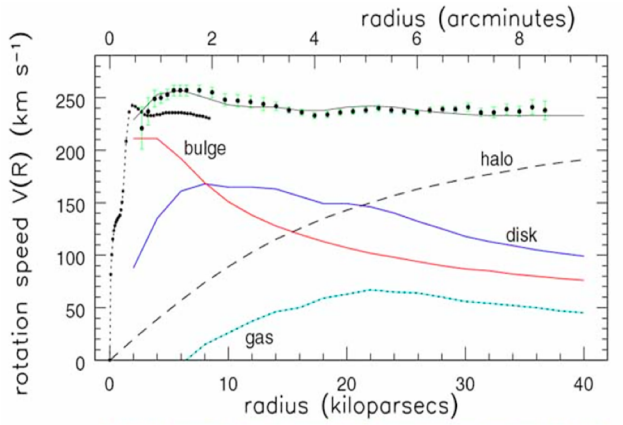
- and Fryer's model -

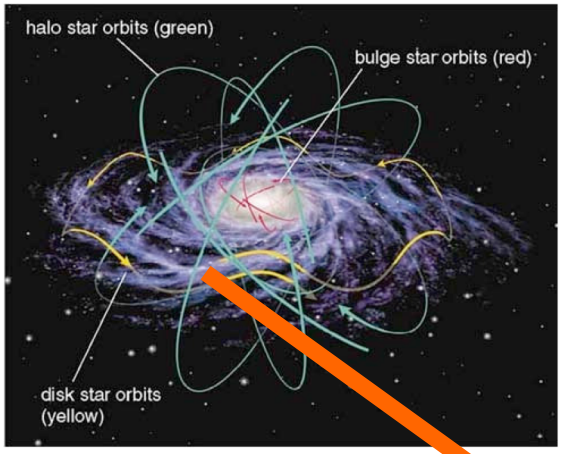
Neutron star kicks (~ few 100 km s^{-1}





Escaping the host

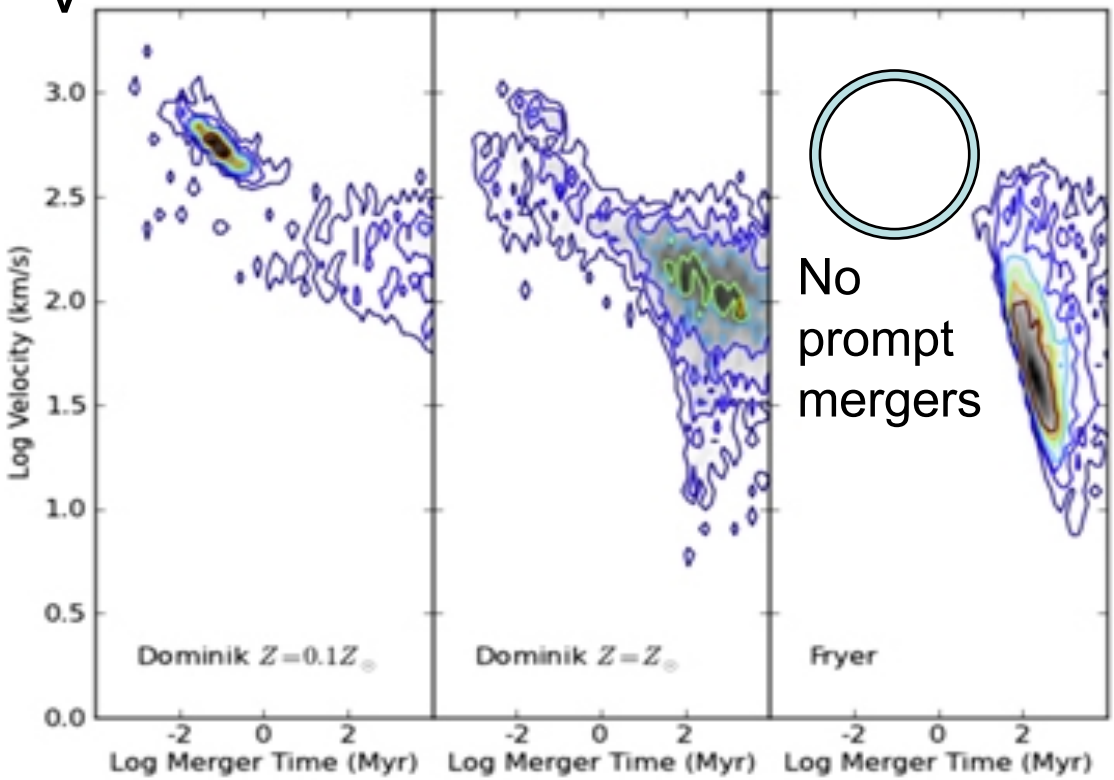




Other channels:
Dynamic formation in globular clusters and galaxy cores

Offset ~ Merger time * system velocity

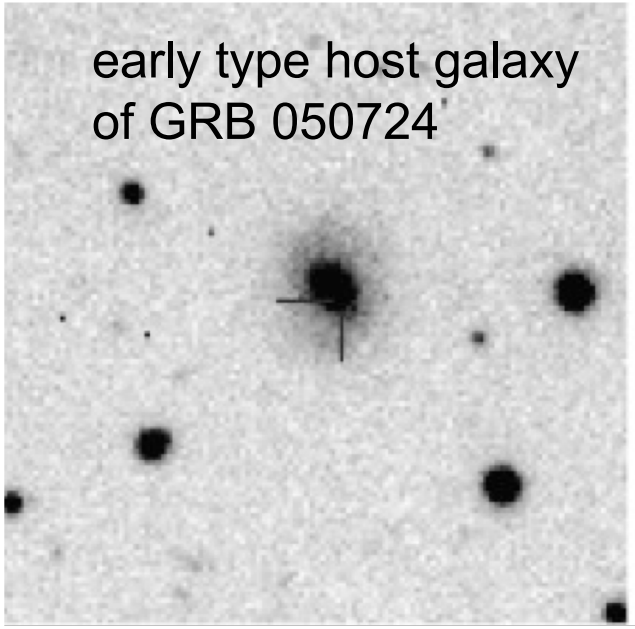
V

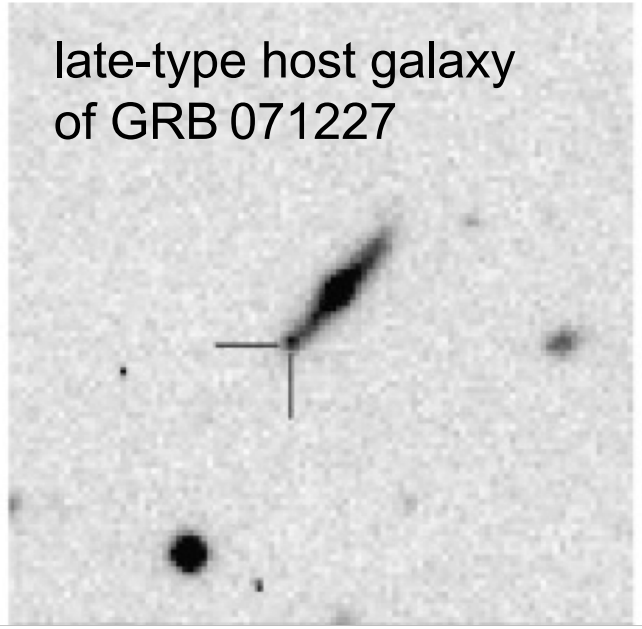


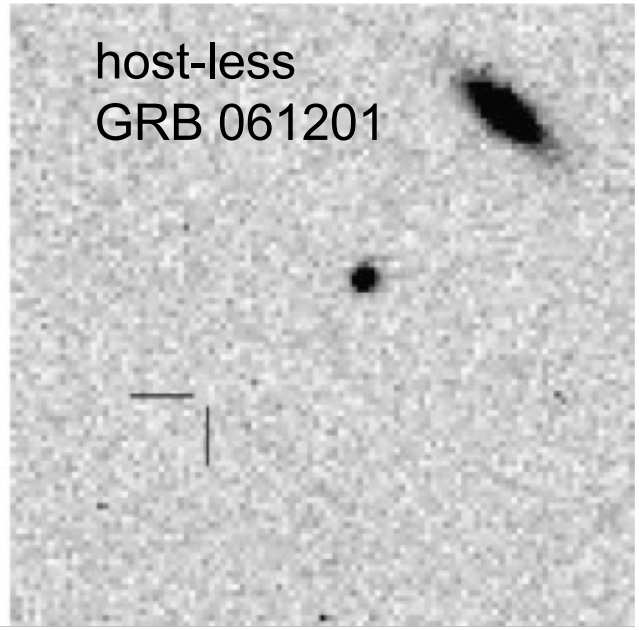
No prompt mergers

T_{merge}

Galactic ISM & IGM are f(z)



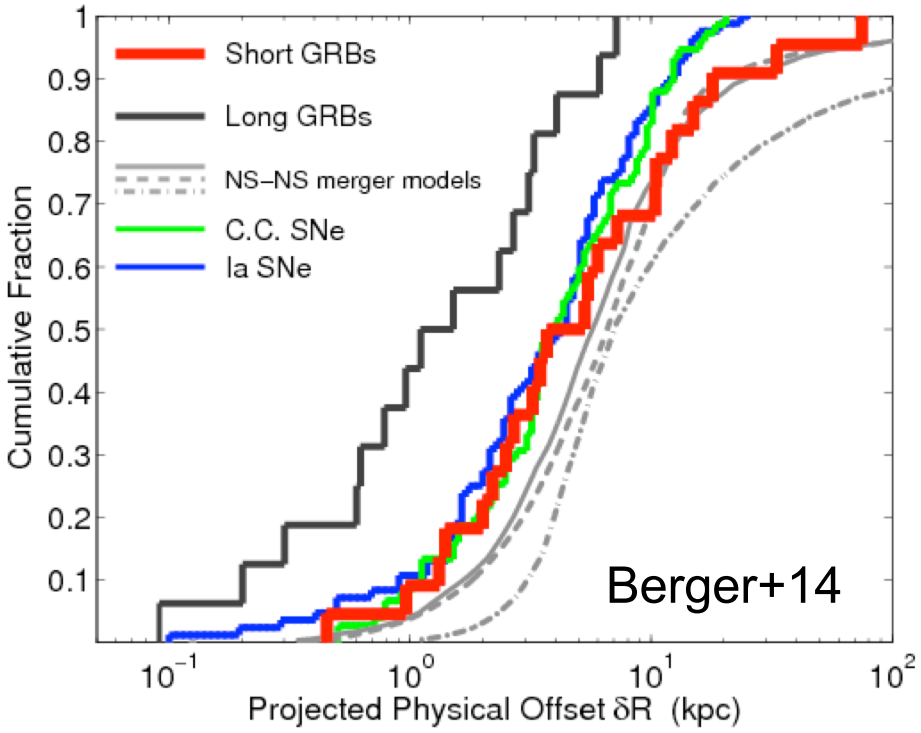




P. D'Avanzo 2015: All images in *R*-band with ESO-VLT / FORS.

The offset distribution was one of the key arguments in support of the sGRB – BNS paradigm

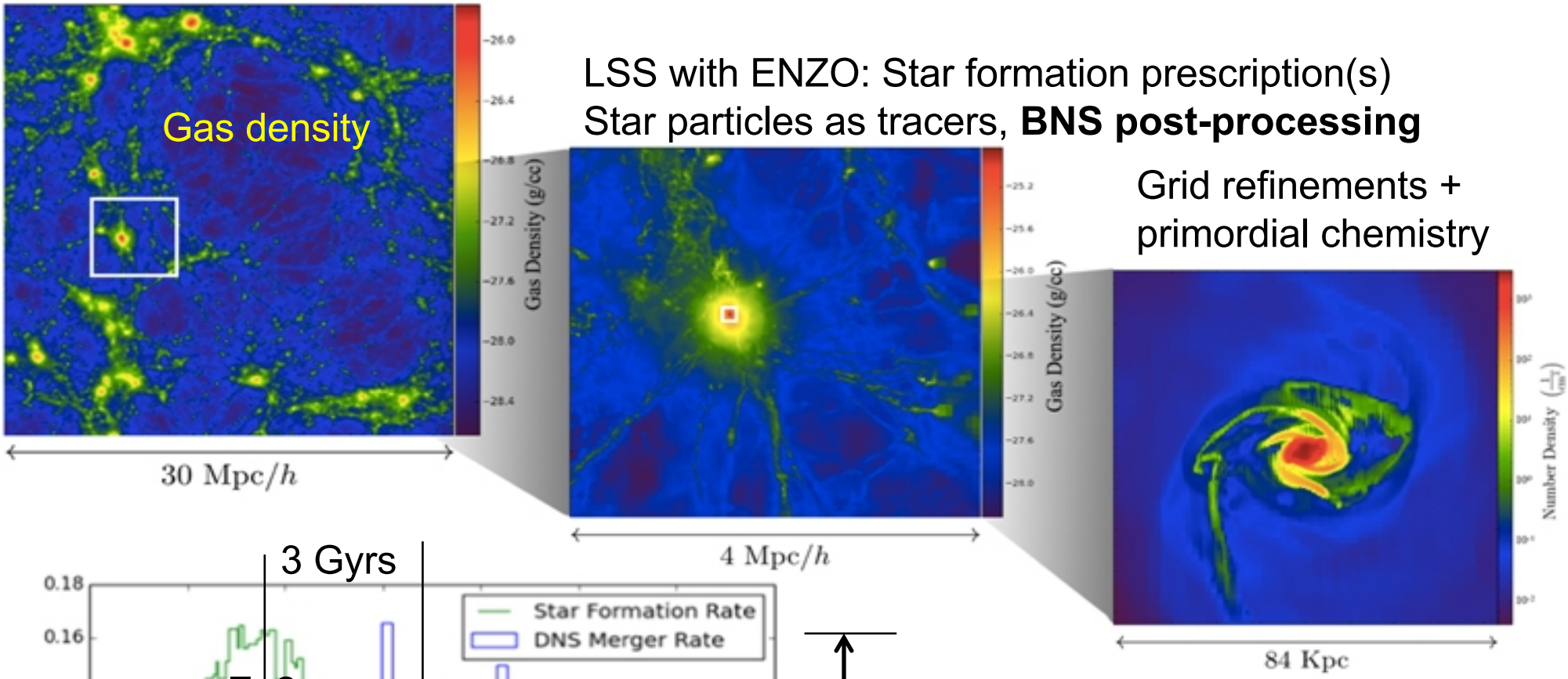
Fryer, Woosley, DH 1999
Several groups:
Simple galactic dynamics

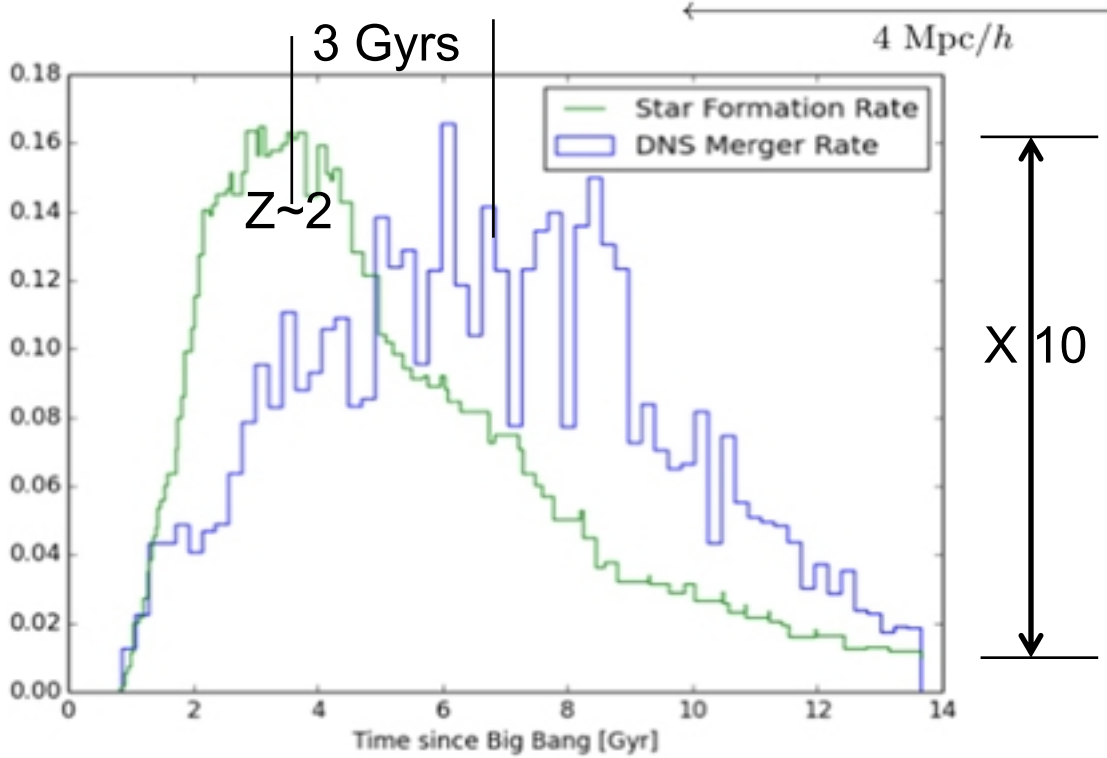


δR (kpc)

LSS with ENZO: Star formation prescription(s)
Star particles as tracers, **BNS post-processing**

Grid refinements +
primordial chemistry





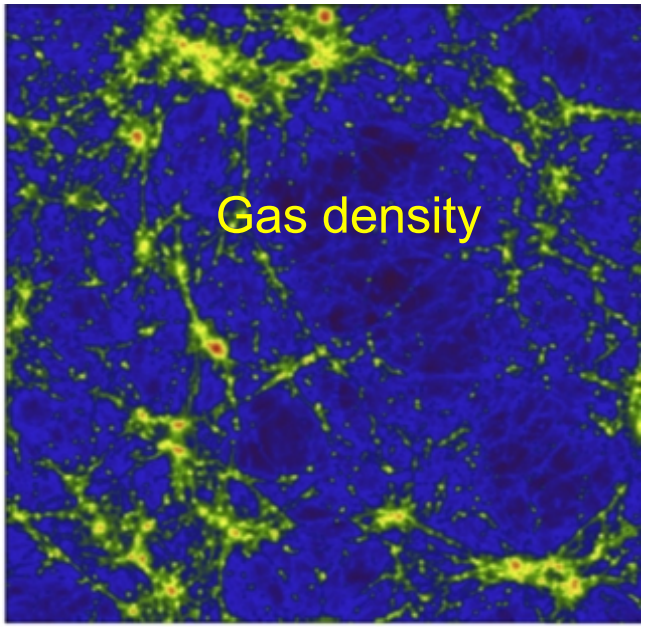
X 10

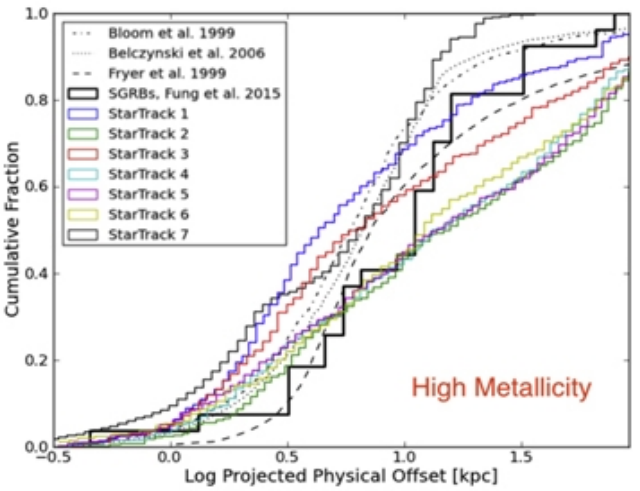
SFR ~ SNR
... but
SFR ≠ DNS MergerR

Z ~ 2 – 3.5 , 10-12 Gyrs ago

30 Mpc scale (comoving)

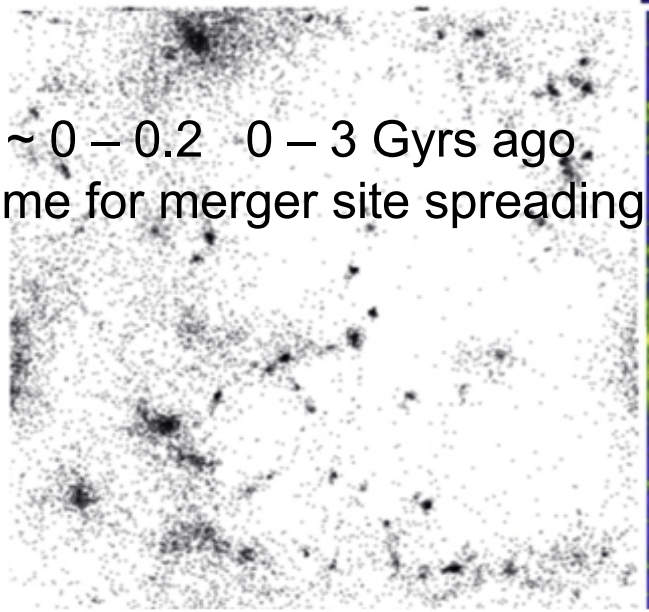
Offset Distributions

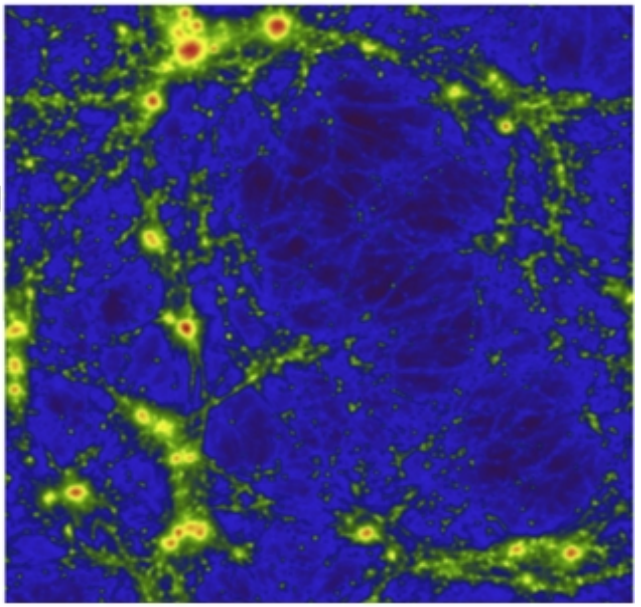


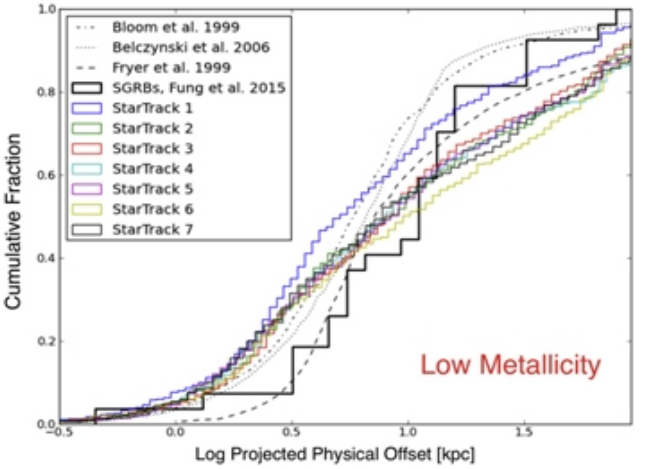


Z ~ 0 – 0.2 0 – 3 Gyrs ago

Time for merger site spreading





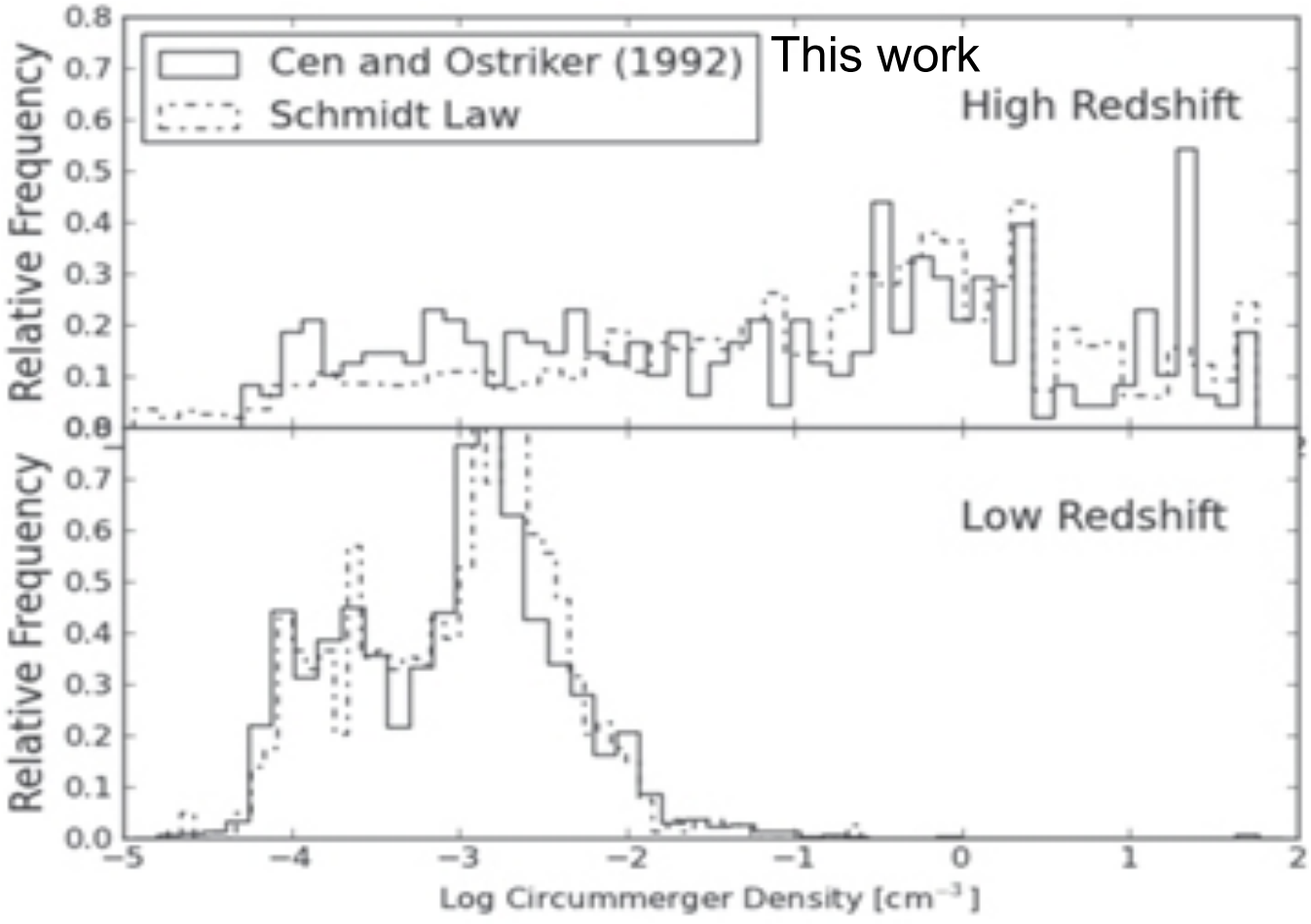


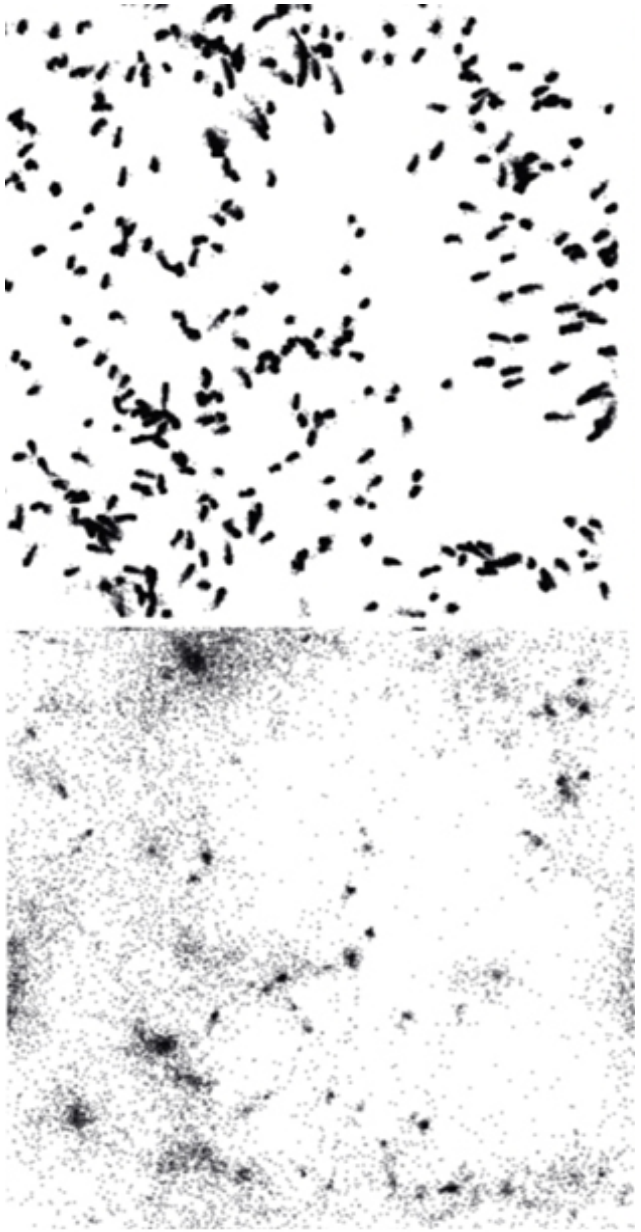
Message: future observations will constrain popsyn

Figure 5 & 6 from The Location and Environments of Neutron Star Mergers in an Evolving Universe
Brandon K. Wiggins et al. 2018 ApJ 865 27 doi:10.3847/1538-4357/aad2d4

Sampling the merger environments

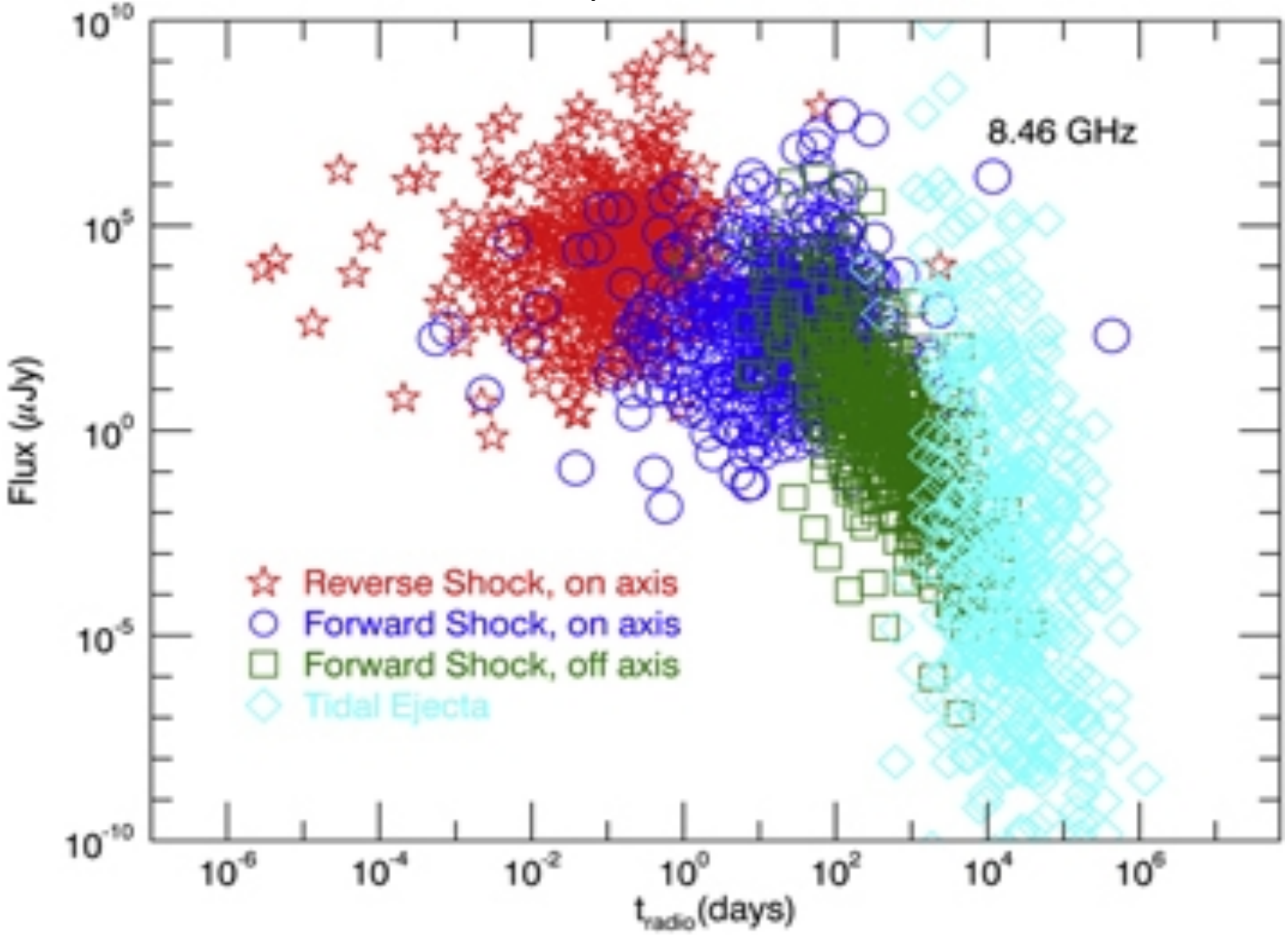
(CCE not yet consistently treated)

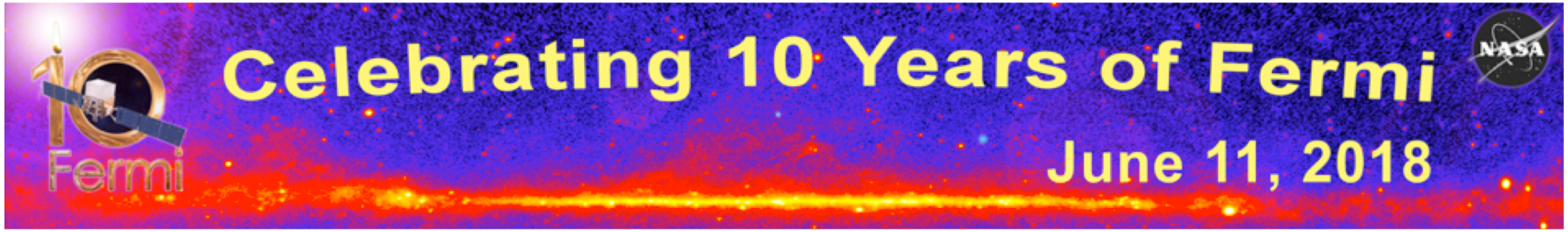




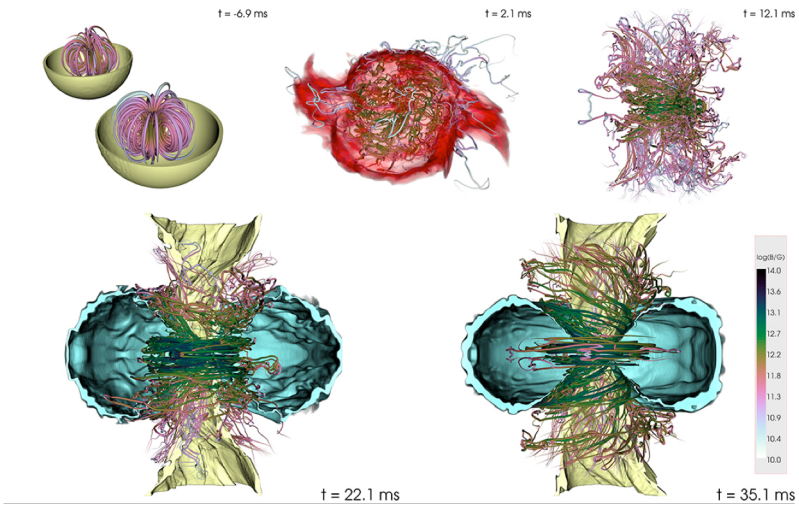
Prediction: Afterglows of high-z sGRBs should be stronger than those at low-z.

We also discuss expected radio emission
All models have F_{peak} >1 mJy out to 100 Mpc





The era of MMA



Kawamura et al., 2016, PRD 94, 064012

GW170917 implies a BNS merger rate density ~ 1.5 yr^{-1} / $(100\ Mpc)^3$ (Abbott et al. 2017)
ONE EVENT

Population Synthesis models can not yield such high rates – by a factor of ~ 100 !!!
(Belczynski et al. 2018) – **BBH rates OK**

Models may need to be revised/extended or new BNS formation channels may be needed.

MESSAGE

More sGRB observations
and further refined LSS/CCE simulations plus BNS post processing are needed to yield pdfs $\phi(z)$, $\phi(R_{offset})$, etc., to refine popsyn models