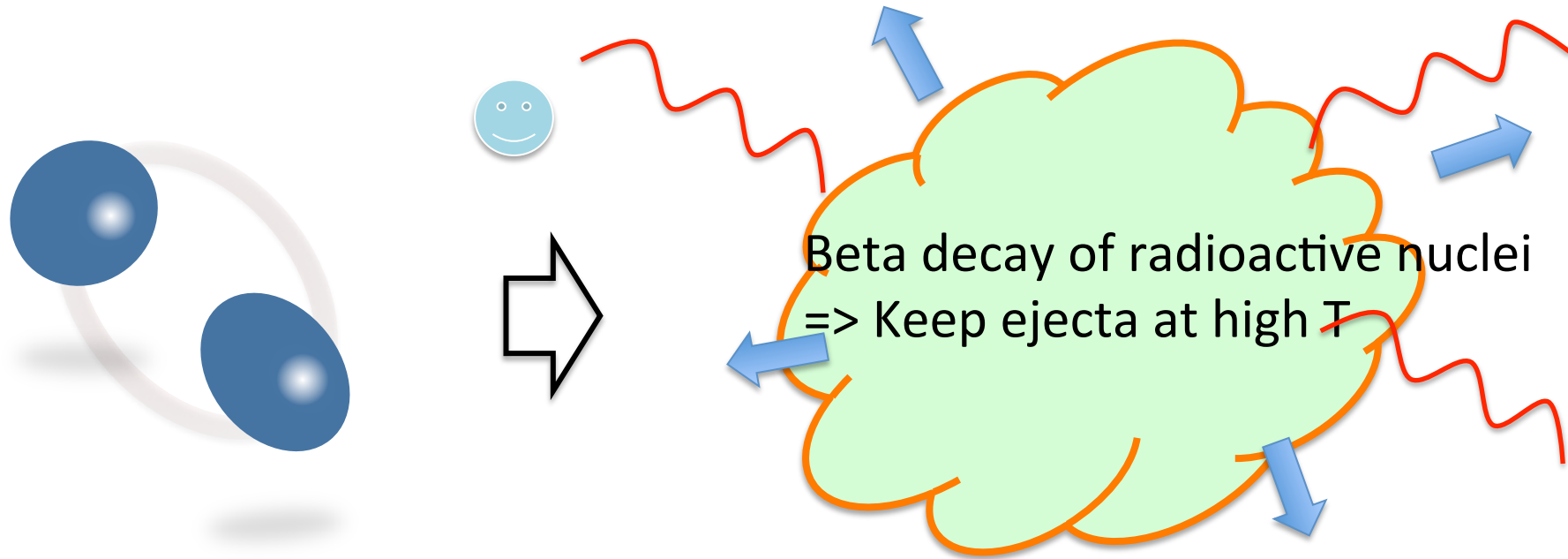


# Short GRB – Macronova Connection

Kenta Hotokezaka

(Hebrew University of Jerusalem)

# What is “macronova”?



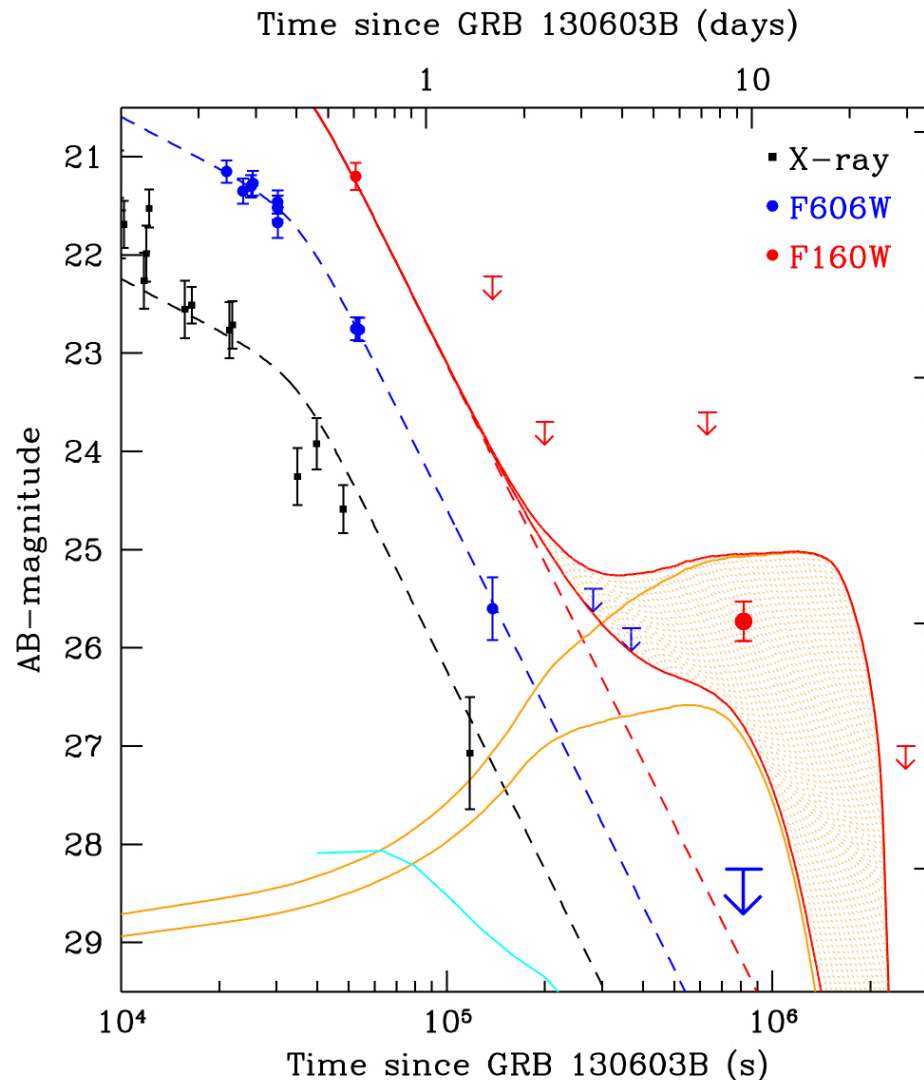
A kilonova/macrovova was proposed by Li & Paczynski in 1998 as an observable consequence of NS-NS mergers.

At NS-NS merger

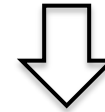
- ✓ A fraction of material is ejected as radioactive nuclei.
- ✓ Ejecta can be bright object due to radioactive heating.
- ✓ Luminosity: Nova < NS-NS merger < Supernova.

# “Macronova” candidate was discovered 2013

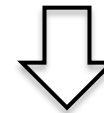
$$\text{Magnitude} = -2.5 \times \log(\text{Flux}) + M(\text{zero})$$



- ✓ R-band upper limits and H-band observed point are consistent with macronova (kilonova, Li-Paczynski nova, r-process nova).



- ✓ NSNS or BHNS produce short GRBs.
- ✓ The estimated mass of ejected r-process elements  $> \sim 0.02 M_{\text{sun}}$



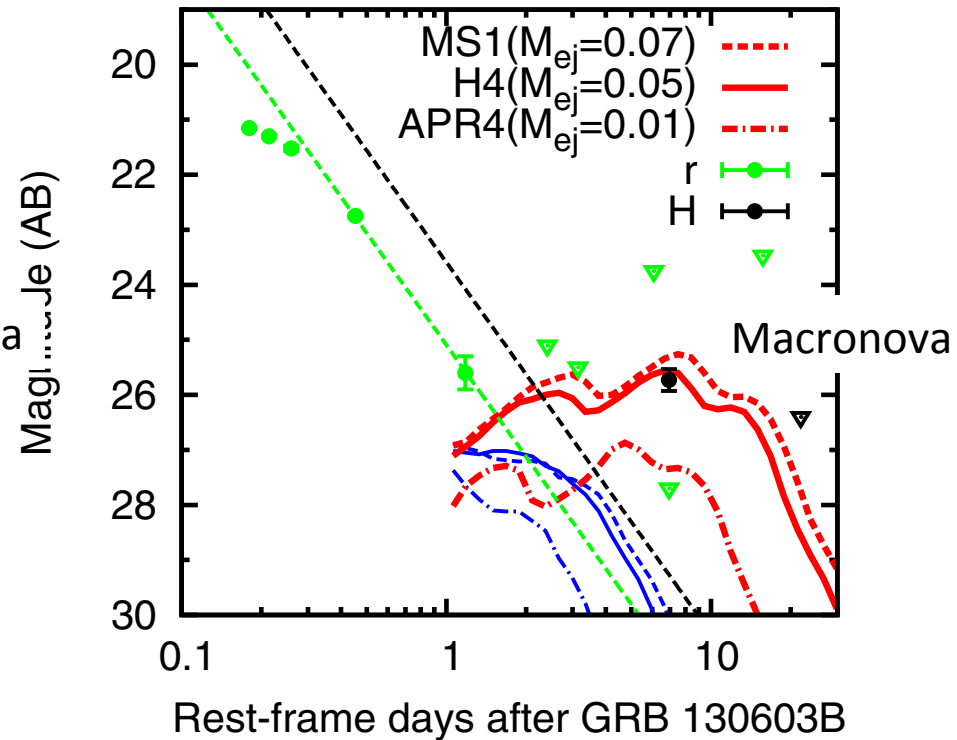
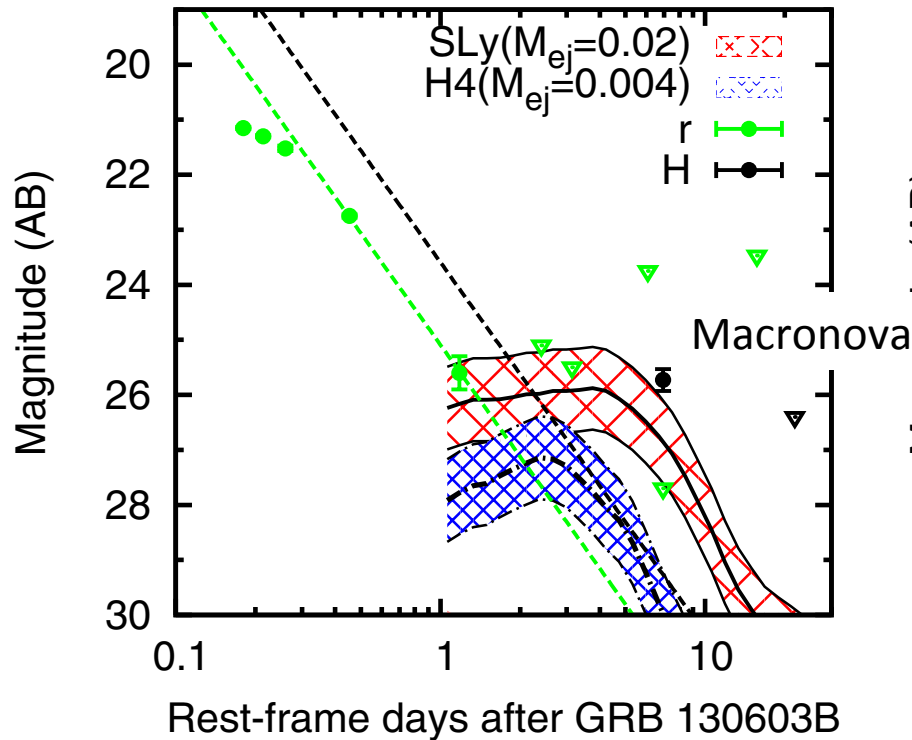
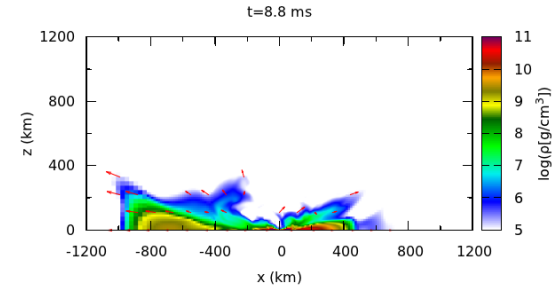
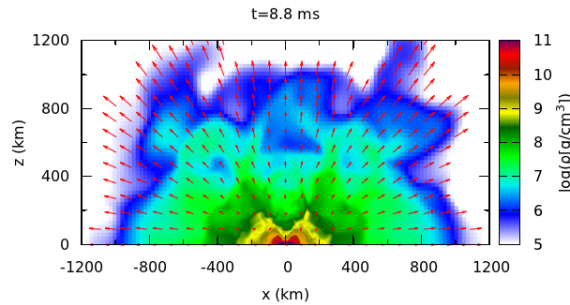
- ✓ What is the progenitor?  
NS-NS or BH-NS ?  
dynamical ejecta or wind?
- ✓ How about other short GRBs?

# Both NS-NS and BH-NS can produce the observed signature of GRB 130603B

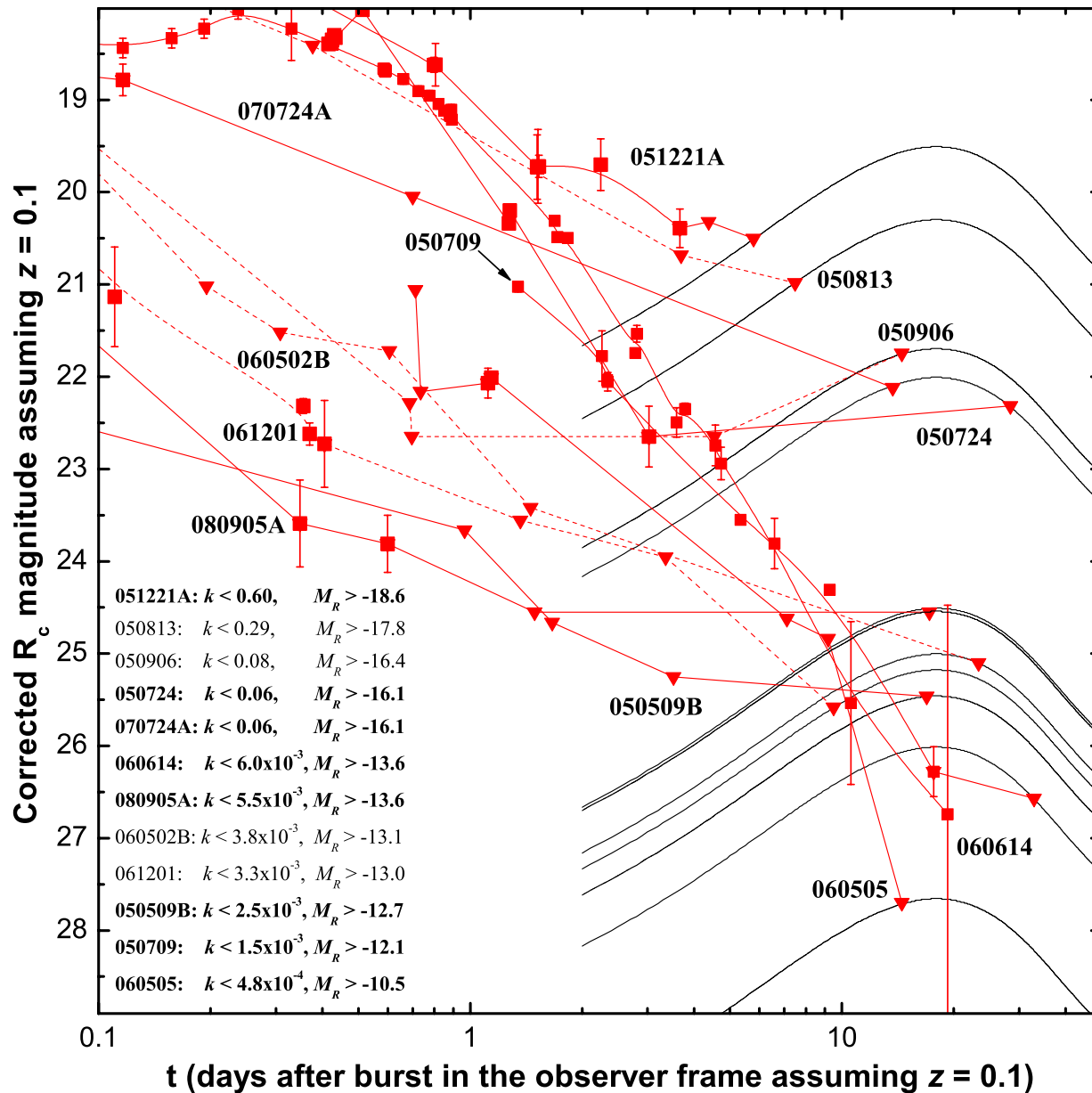
NS-NS merger

BH-NS merger

Ejecta  
x-z plane

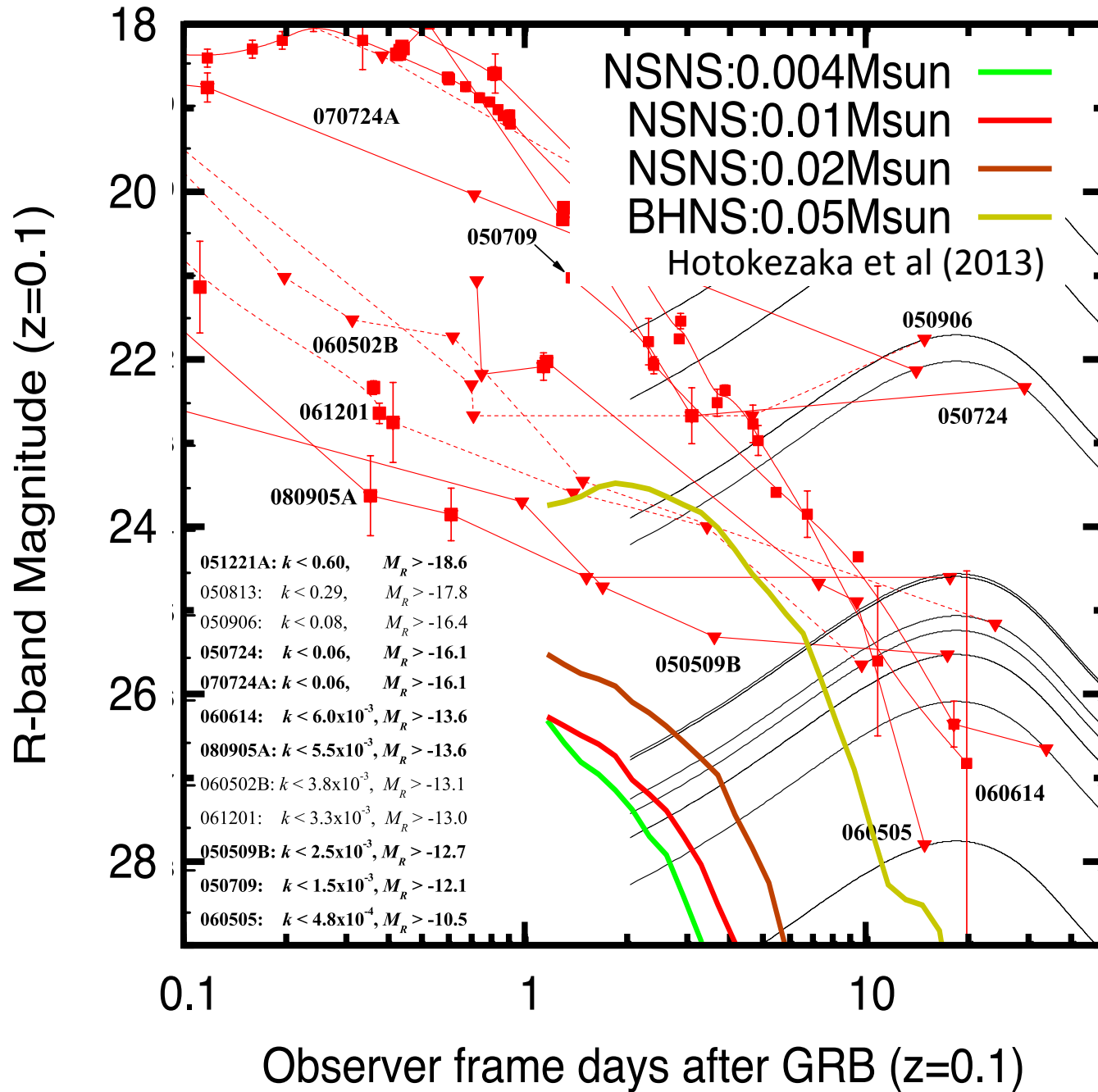


# Afterglow (R-band) of the previous Short GRBs



# Observed limits vs Simulated Macronova

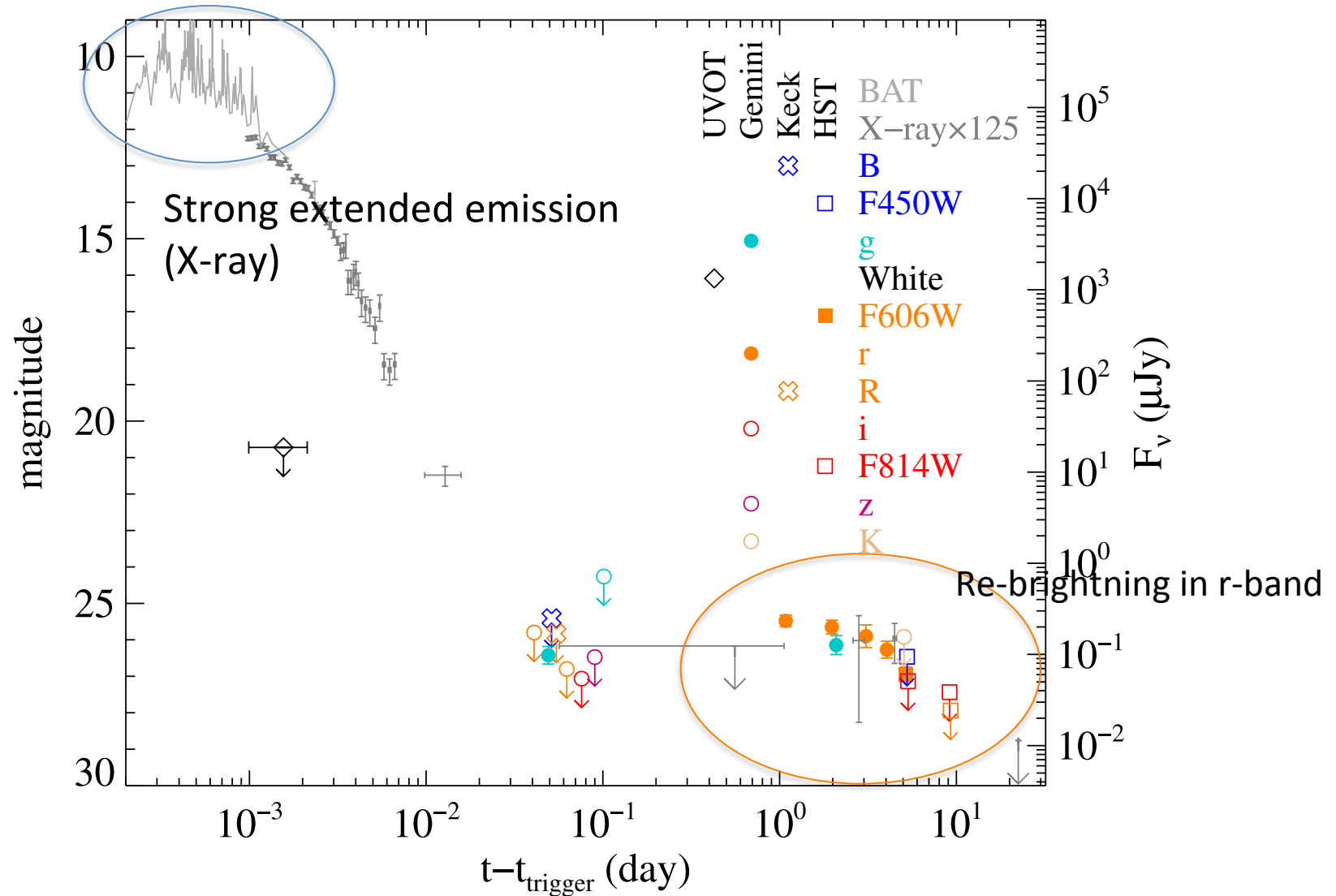
Kann et al, ApJ, 734 (2011)



# Suspected object : short GRB 080503

Redshift is unknown.

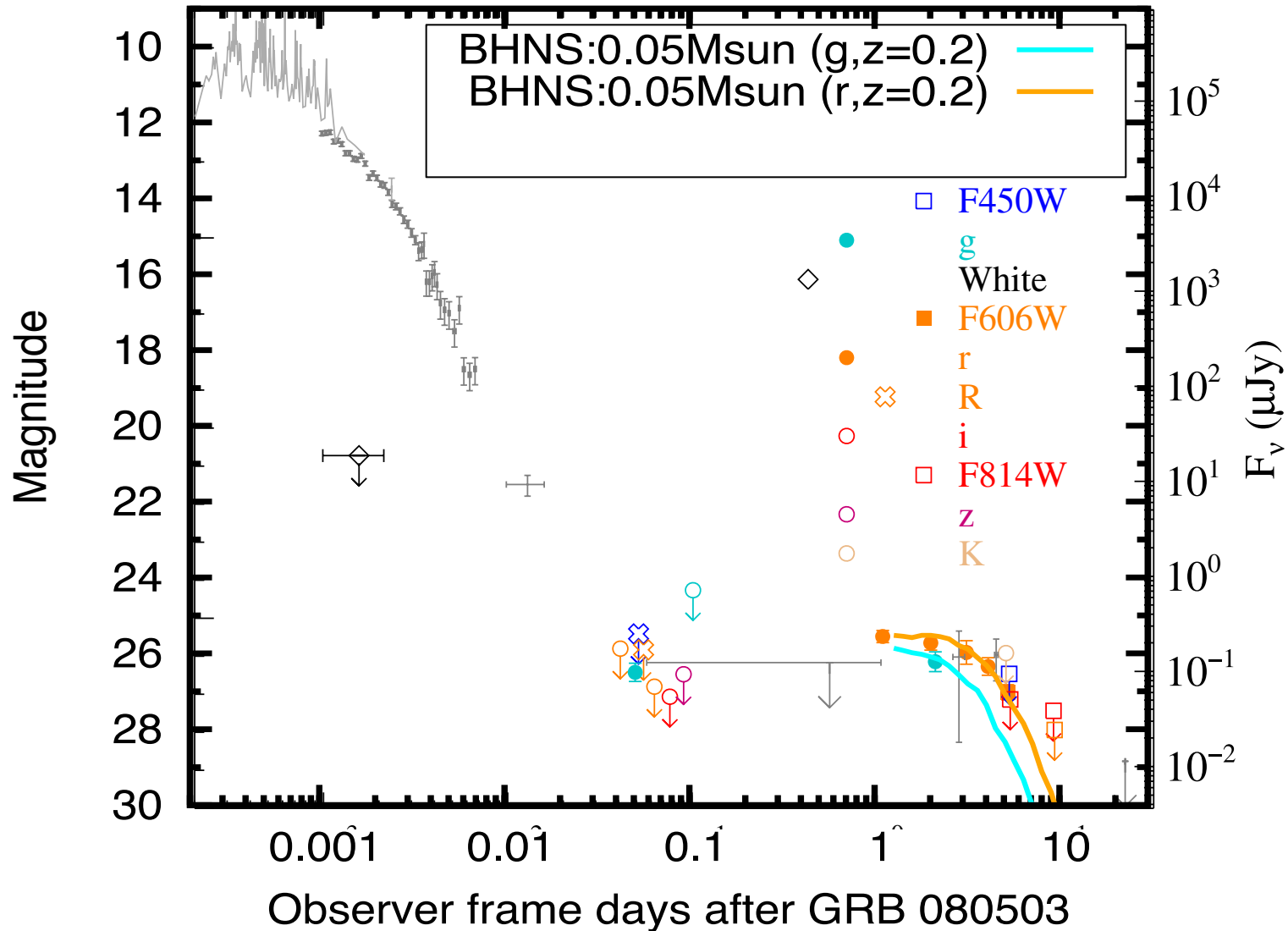
Perley et al, ApJ 696 (2009)



# Suspected object : short GRB 080503

Redshift is unknown.

Perley et al, ApJ 696 (2009)

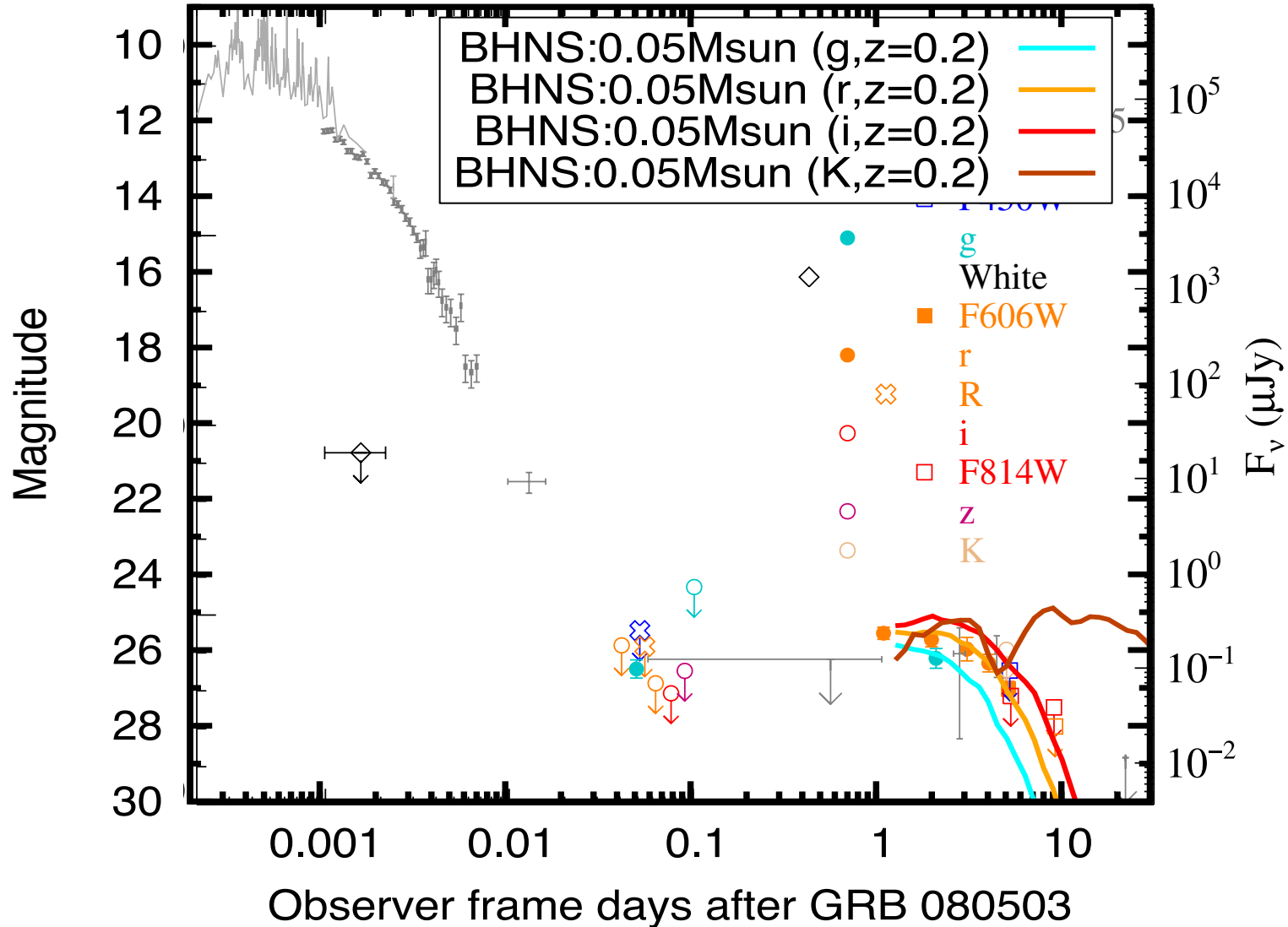




# Suspected object : short GRB 080503

Redshift is unknown.

Perley et al, ApJ 696 (2009)



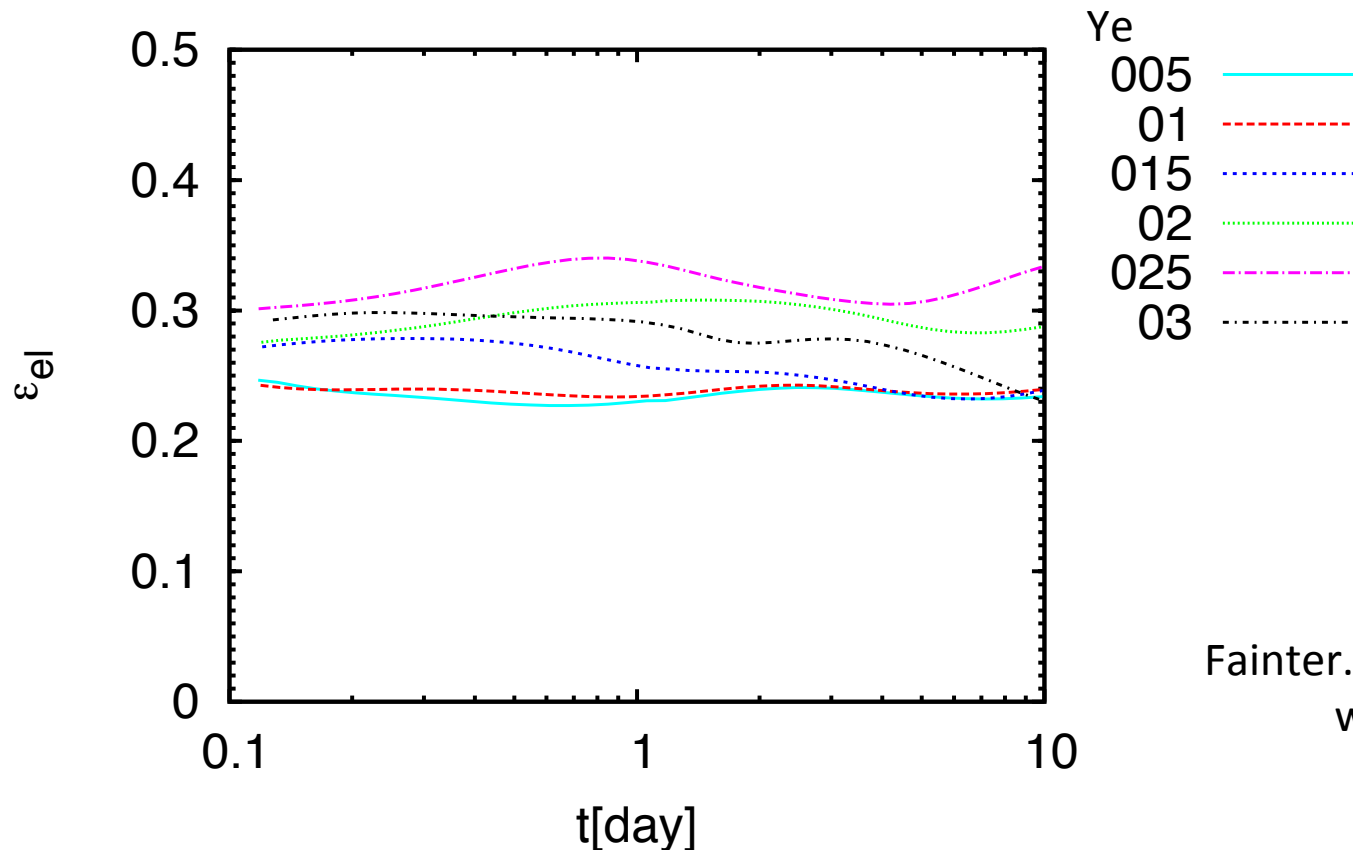
# Ejected r-process mass and Energy fraction goes to electrons

- ✓ Beta decay => electron, gamma ray, neutrino



- ✓ Luminosity  $\propto e_{\{el\}} \times M_{ej} / t_{peak}$

This is assumed to be 0.5 in previous works.



Fainter...than that  
we expected.

# Discussion (what is the next step?)

Observationally,

- Measurement of the multicolor lightcurves and spectrum is definitely important.

Theoretically,

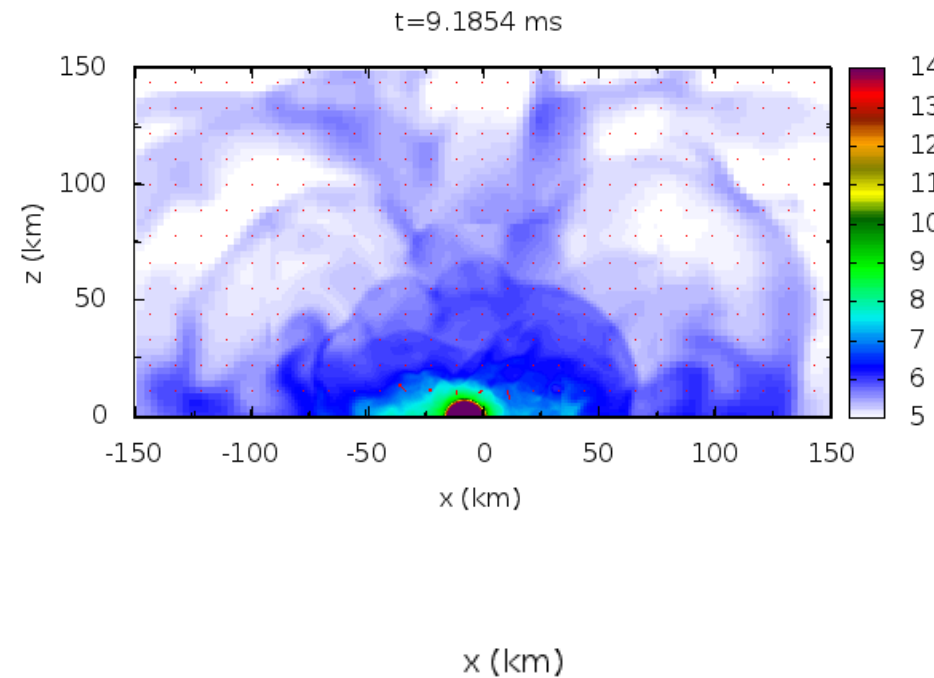
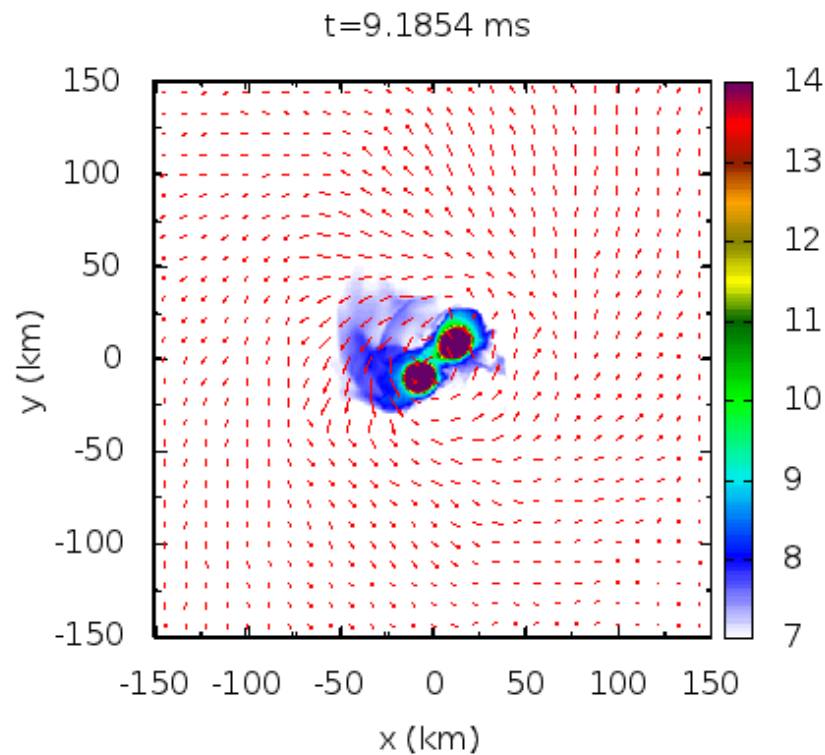
- Can we distinguish NSNS /BHNS and dynamical/wind?
- How accurately do we determine ejected r-process mass?
- Should there be a correlation between GRB energy and macronova energy?
- Short GRB and Short GRB with EE have different type of macronova?
- More discussions are welcome.

# NS-NS Mass ejection on equatorial plane

Binary Neutron Star merger (NS-NS merger)

Numerical relativity computation

Hotokezaka et al (2013)



Mass ejection :  $M_{ej} \sim 0.01 M_{\text{sun}}$ ,  $v \sim 0.2c$

# Dynamical ejecta vs Accretion disk

