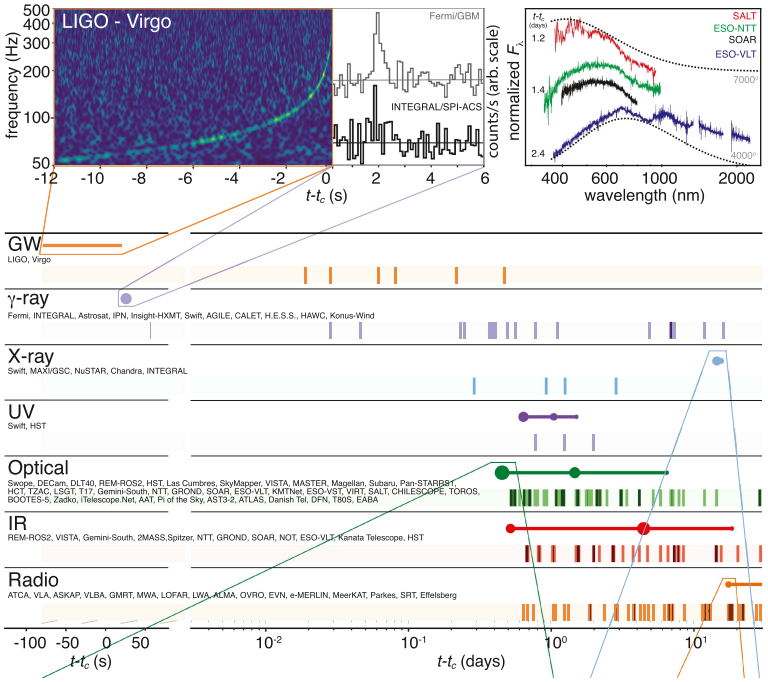
# GRAND in the gravitational wave astronomy era

LIGO: GW170817+EM170817 (including GRB 170817A )

multi-messenger astrophysics w. GWs has started!!!

By ~2030

- GW detector network is available (A+/Voyager, LIGO-I, aVirgo, KAGRA)
- LSST and powerful EM networks
- Even 3rd generation detectors (e.g., Einstein Telescope)




ET sensitivity is better by ~10

-> NS-NS can be detected up to ~2 Gpc

-> detection rate increases by ~1000

Good news for GRAND-like detectors

e.g., GW alerted EM & neutrino searches

GW-driven stacking analyses

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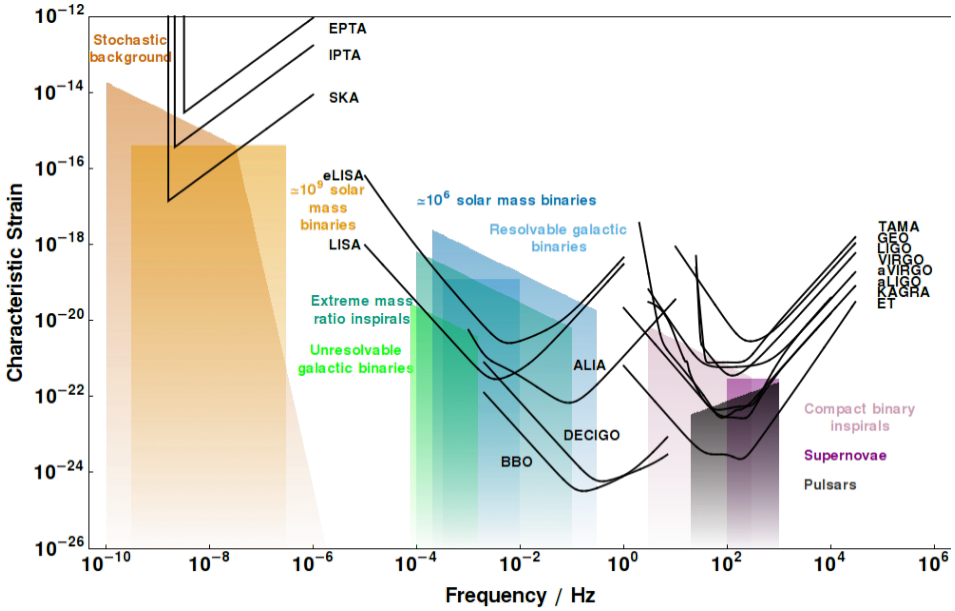

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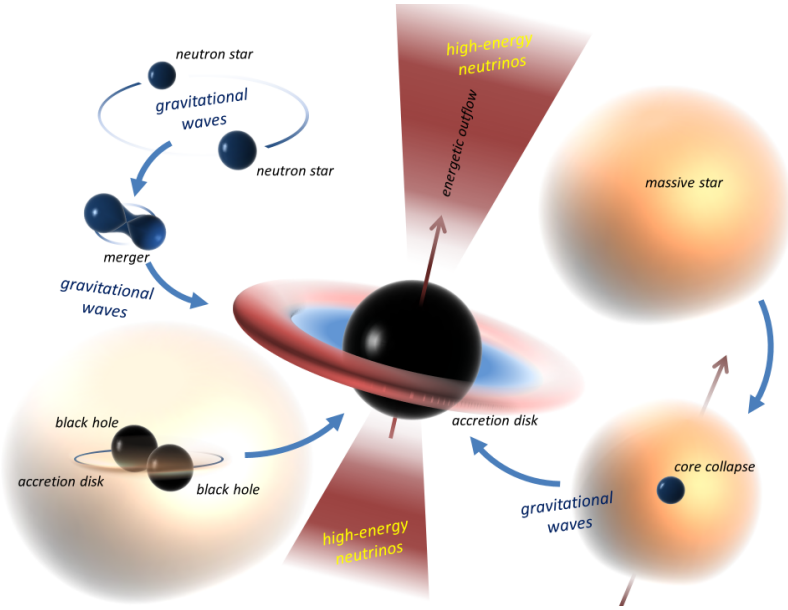
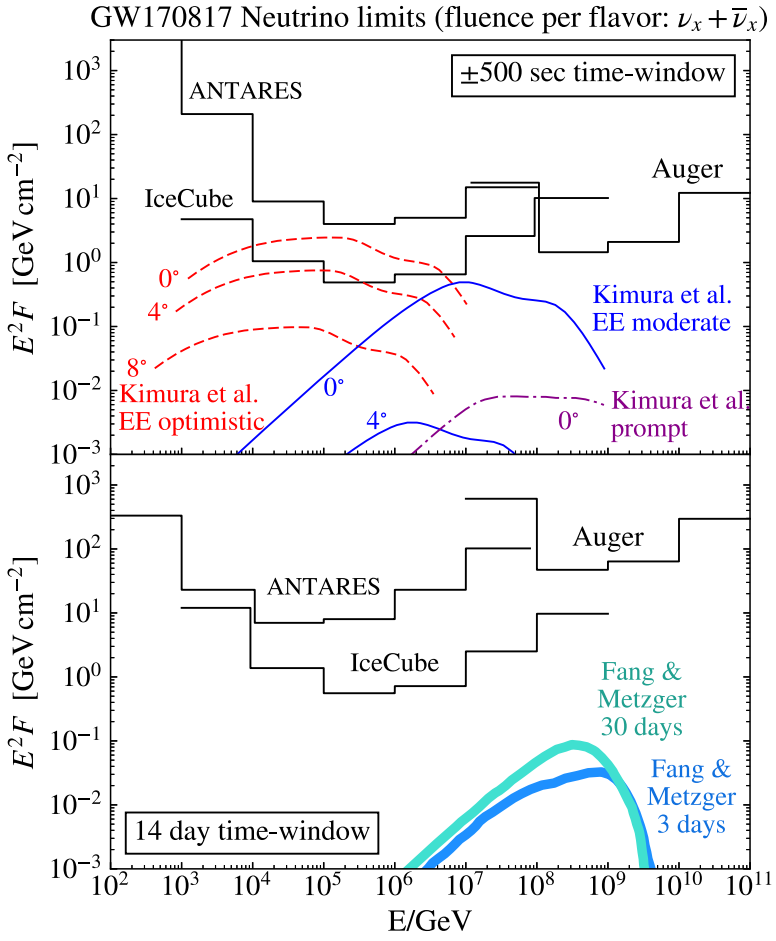


## Example 2: High-Energy Neutrino and Gamma-Ray Transients from Compact Mergers




Short GRBs (face-on)
- GRBs detectable at cosmological distances
  local rate: ~10 Gpc$^{-3}$ yr$^{-1}$
- Coincident GW detection is promising
  (~300 Mpc by aLIGO designed, ~3 Gpc by ET)
- 1/4-1/3 have long-lasting X-ray emission
  promising high-energy neutrino sources (~0.1-1 d)
  (~30-80 Mpc by GRAND if right direction)

Long-lived magnetars from low-mass NS-NS
- Can be edge-on but ruled out for GW170817
- Possible ~0.1 EeV neutrino sources (~1-30 d)
  (~30-80 Mpc by GRAND)

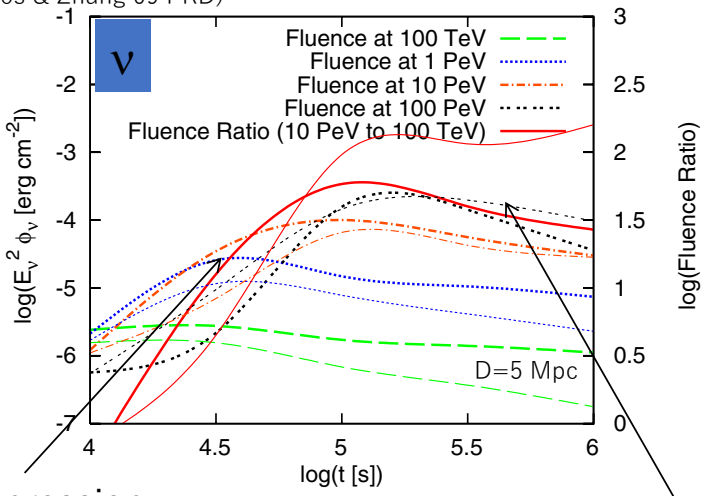
NS-NS mergers? NS-BH mergers? BH-BH mergers?
- Theory predictions have large uncertainties
- Experimental searches should be done anyway

Horizon distances of neutrino detectors are shorter than those of 2nd and 3rd GW detectors

## Example 2: High-Energy Neutrino and Gamma-Ray Transients from Luminous Supernovae

- Superluminous supernovae/gamma-ray bursts could be driven by fast-spinning neutron stars
- Fast-spinning neutron stars are promising gravitational waves though model-dependent (e.g., ~10-20 Mpc by aLIGO designed, ~100-200 Mpc by ET; rotational instabilities/distortion)
- Newborn pulsar are suggested as the origin of UHECRs (Fang, Kotera & Olinto 12, Fang, Kotera, KM & Olinto 14)
- Possible ~0.1 EeV neutrino sources (~1-10 d; ~30-80 Mpc by GRAND) (KM, Meszaros & Zhang 09 PRD)
- EM counterparts should exist and LSST, ZTF etc. will give us information on supernovae types

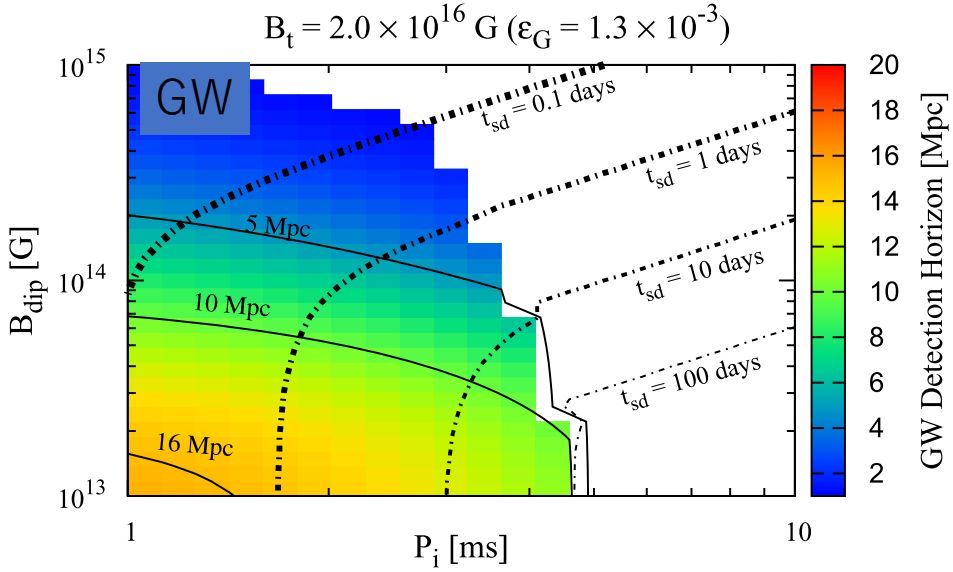
(KM, Meszaros & Zhang 09 PRD)




flux suppression due to hadronic cooling of mesons

ν earlier!

day-to-year ν transients




(Kashiyama, KM et al. 16 ApJ)