MULTI-MESSENGER ASTROPHYSICS WITH 2+ AND 3G DETECTORS

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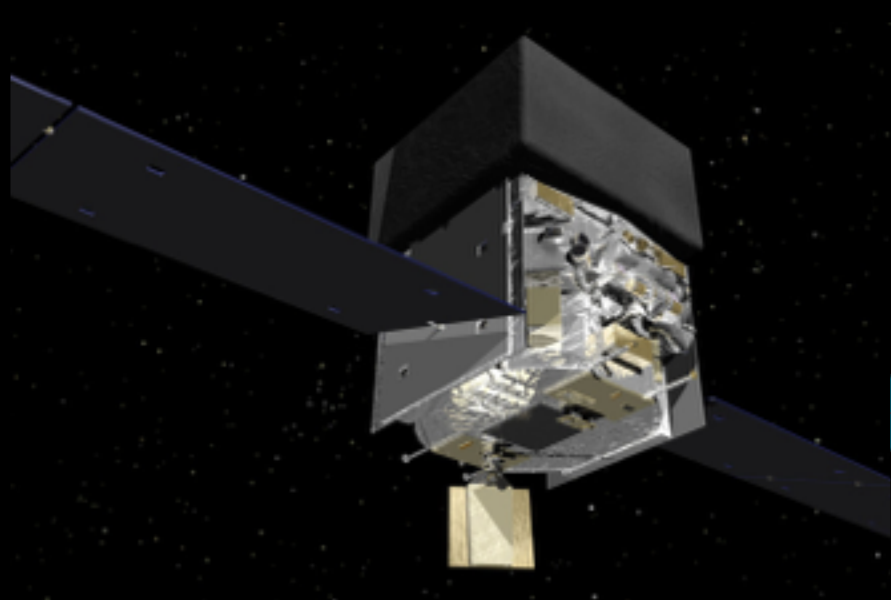
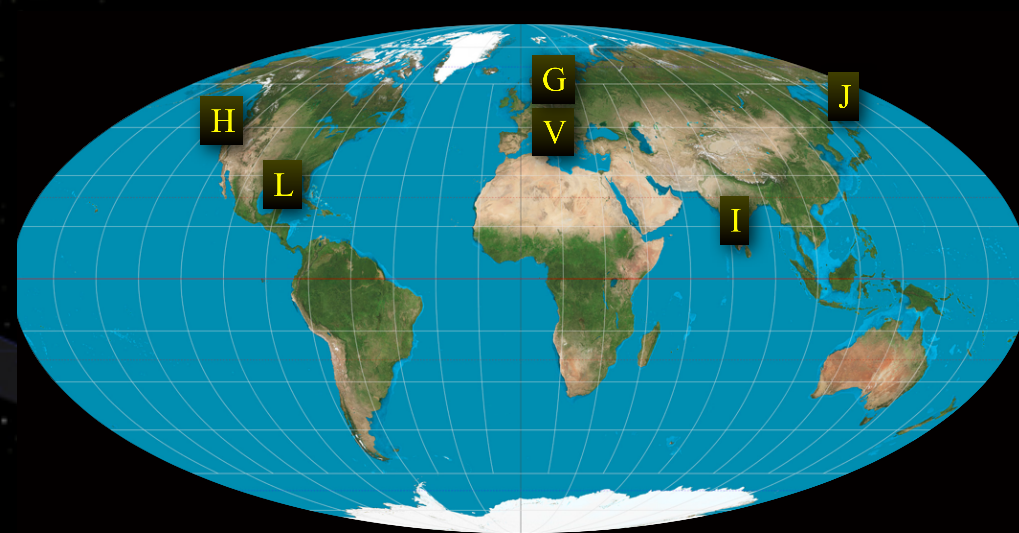
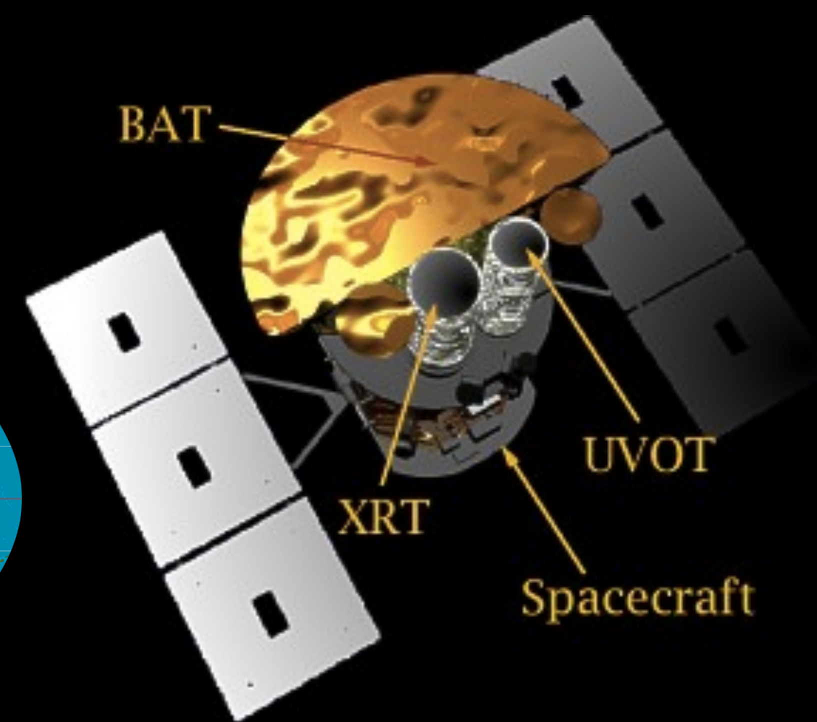
SWIFT - BAT: WIDE FIELD DETECTOR THAT PRODUCES SUB-ARC SECOND RESOLUTION WITHIN MINUTES

FERMI GBM - ALL SKY







GW NETWORK - ALL SKY

ENABLING MULTIMESSENGER ASTROPHYSICS

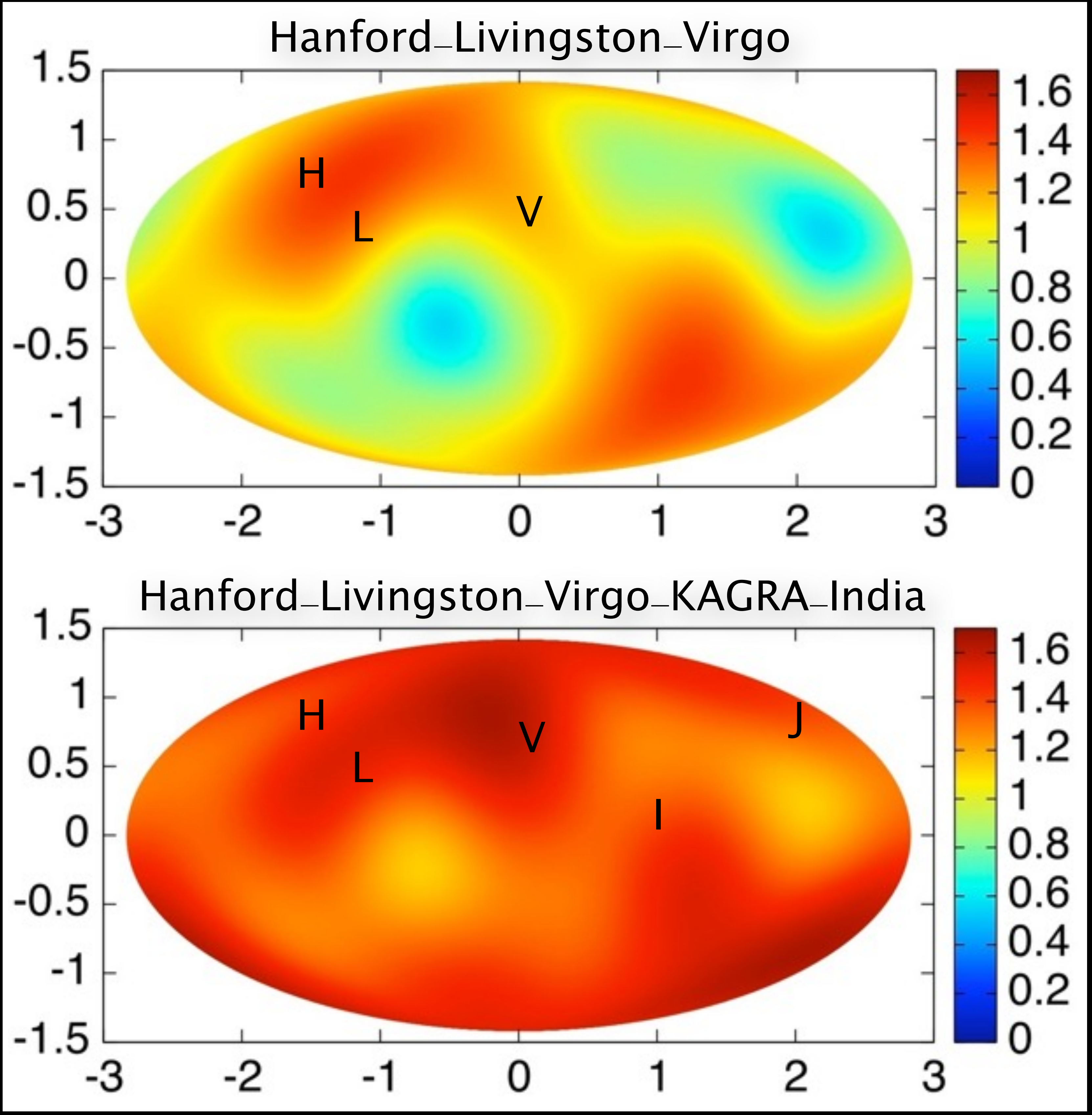
- EM FOLLOW-UP TRIGGERED BY GW SEARCHES
- GW SEARCHES TRIGGERED BY EM TRANSIENTS
- CORRELATION BETWEEN GW-EM TRANSIENTS
- QUITE A BIT IN PROGRESS ON THE FIRST TWO METHODS, NOT A LOT ON THE THIRD
- THIS TALK WILL FOCUS ON: AN EARLY WARNING SYSTEM FOR GAMMA-RAY BURSTS

ENABLING MULTI MESSENGER ASTROPHYSICS WITH AN EARLY WARNING SYSTEM

- We normally search GW data triggered by GRB but not the opposite, i.e. we don't search for GRBs triggered by a GW event
  - Not referring to EM afterglows but specifically to prompt gamma-ray emission that follows merger
- No one knows how promptly after merger gamma-rays are emitted, but …
  - Metzger et al (arXiv:0712.1233) argue that shGRBs could have extended emission lasting for up to 100 s
- Is there a scientific case for "early warning" and swift follow-up
  - Briefly the answer is "yes"

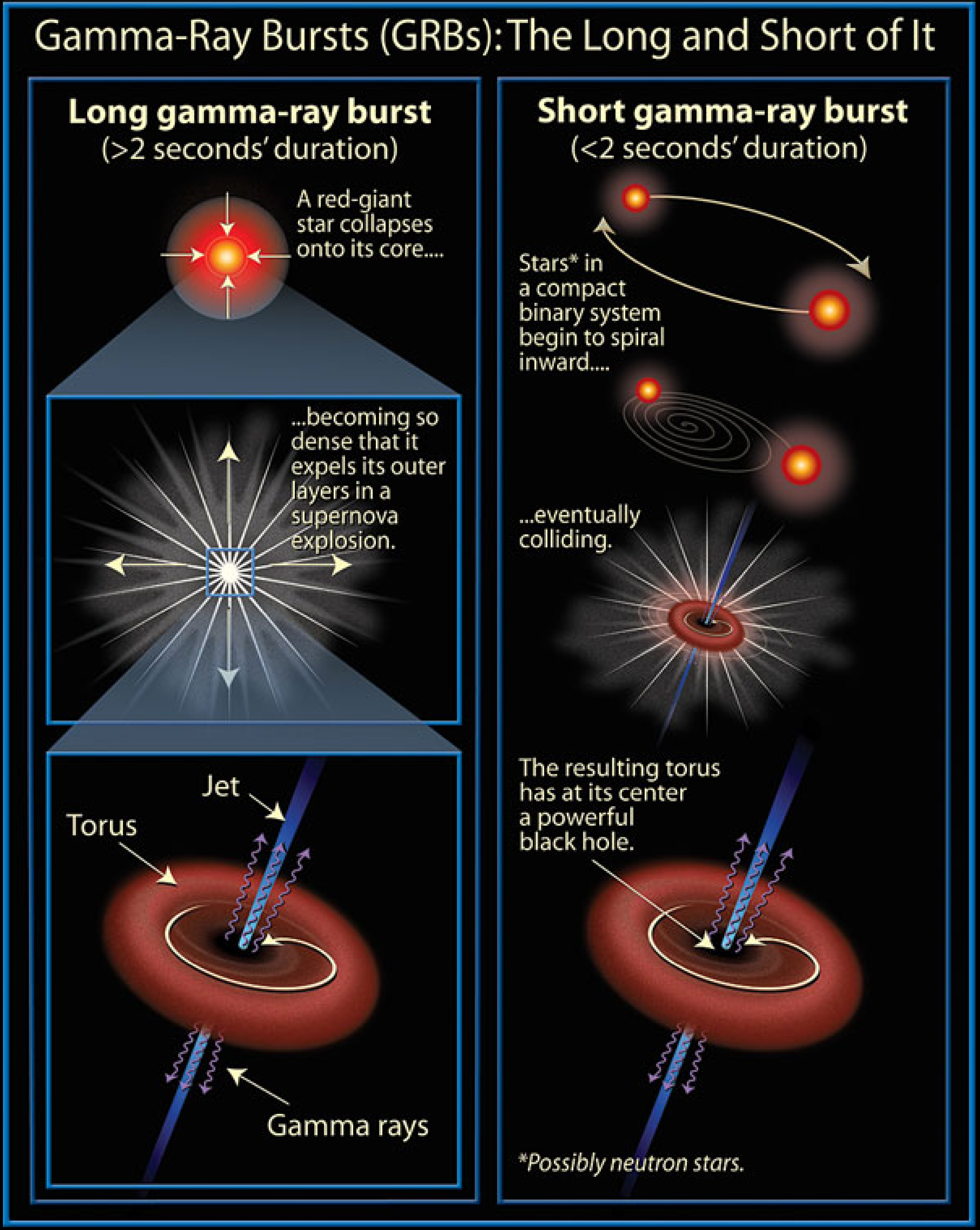
GRAVITATIONAL WAVE DETECTOR NETWORK

- A network of gravitational wave detectors is always on and sensitive to most of the sky
- Signals can be milliseconds long or last for years
- Multiple signals could be in band but with different amplitudes
- We can integrate and build SNR by coherently tracking signals in phase



PROGENITORS OF GRBS

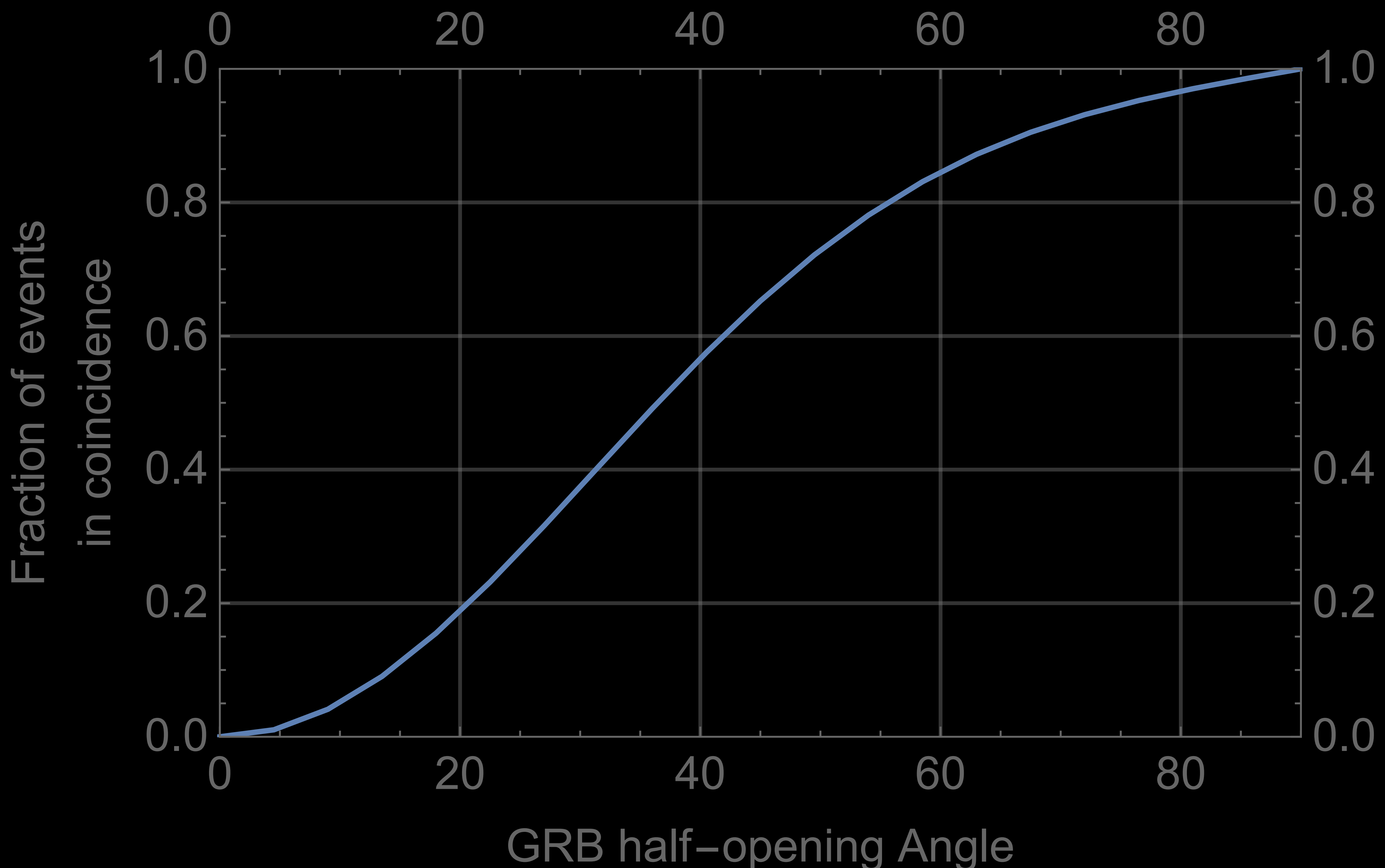
- What causes these giant explosions?
- What are the different classes of GRBs?
- Synergy between EM and GW Astronomy
  - Distances measured with GW
  - Redshift measured with EM
  - Could potentially be very useful for cosmography



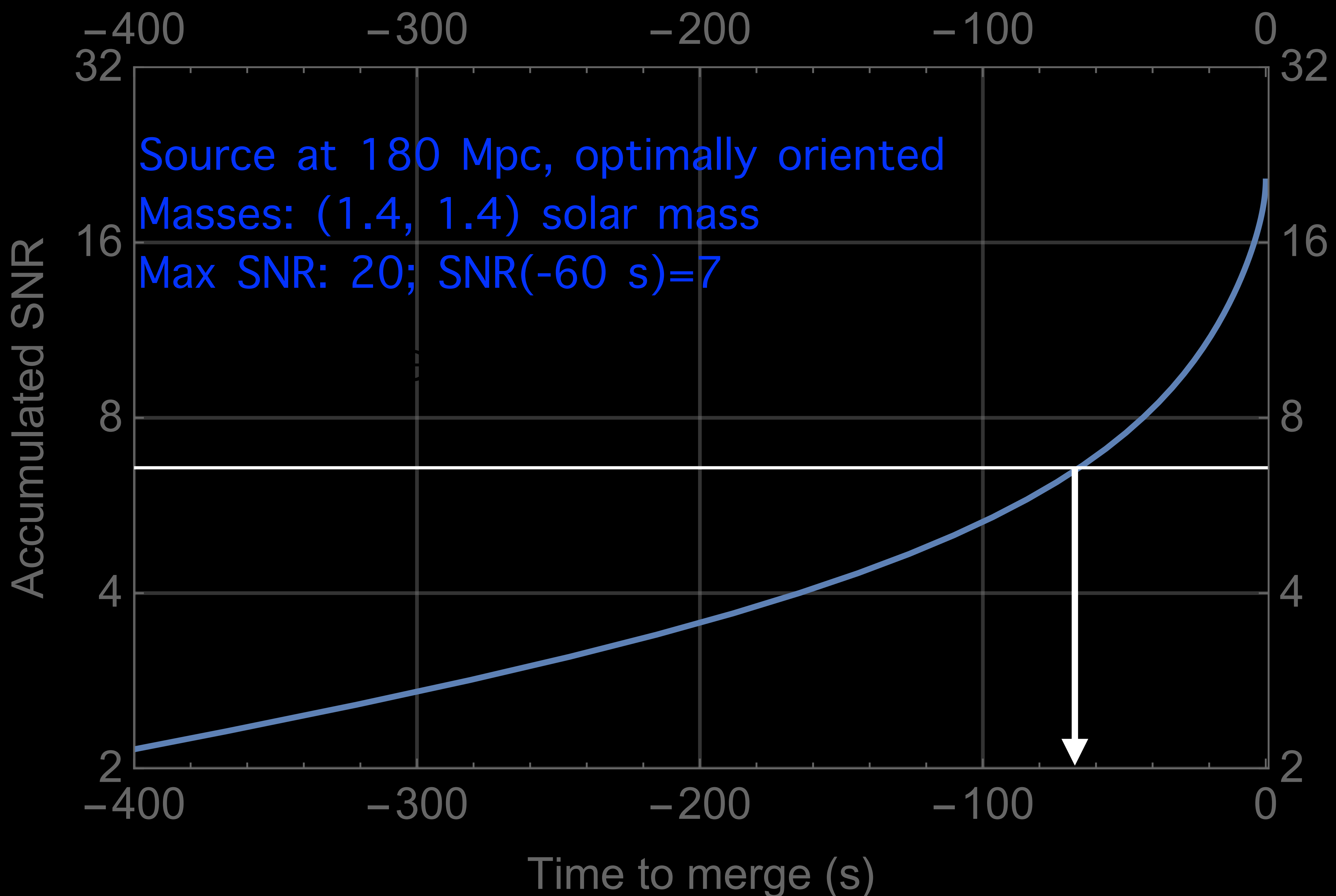
SO WHAT IS THE MOTIVATION?

- GOAL: Observe as many GRBs as possible aided by early triggers provided by GW searches
- Let us assume the rate of binary neutron star mergers observed by a detector network is X per year
- GRB-GW coincidences are likely to be ~ X/100 per year
  - 20% of GW events will be potentially seen as GRBs but SWIFT observes only ~10% of the sky
- If we have a GRB satellite that can slew to a desired direction within ~30 s we can improve the coincidence by a factor of 3 (with swift slewing) to 10
  - Could acquire same statistic in 10 yrs as opposed to 30-100 years

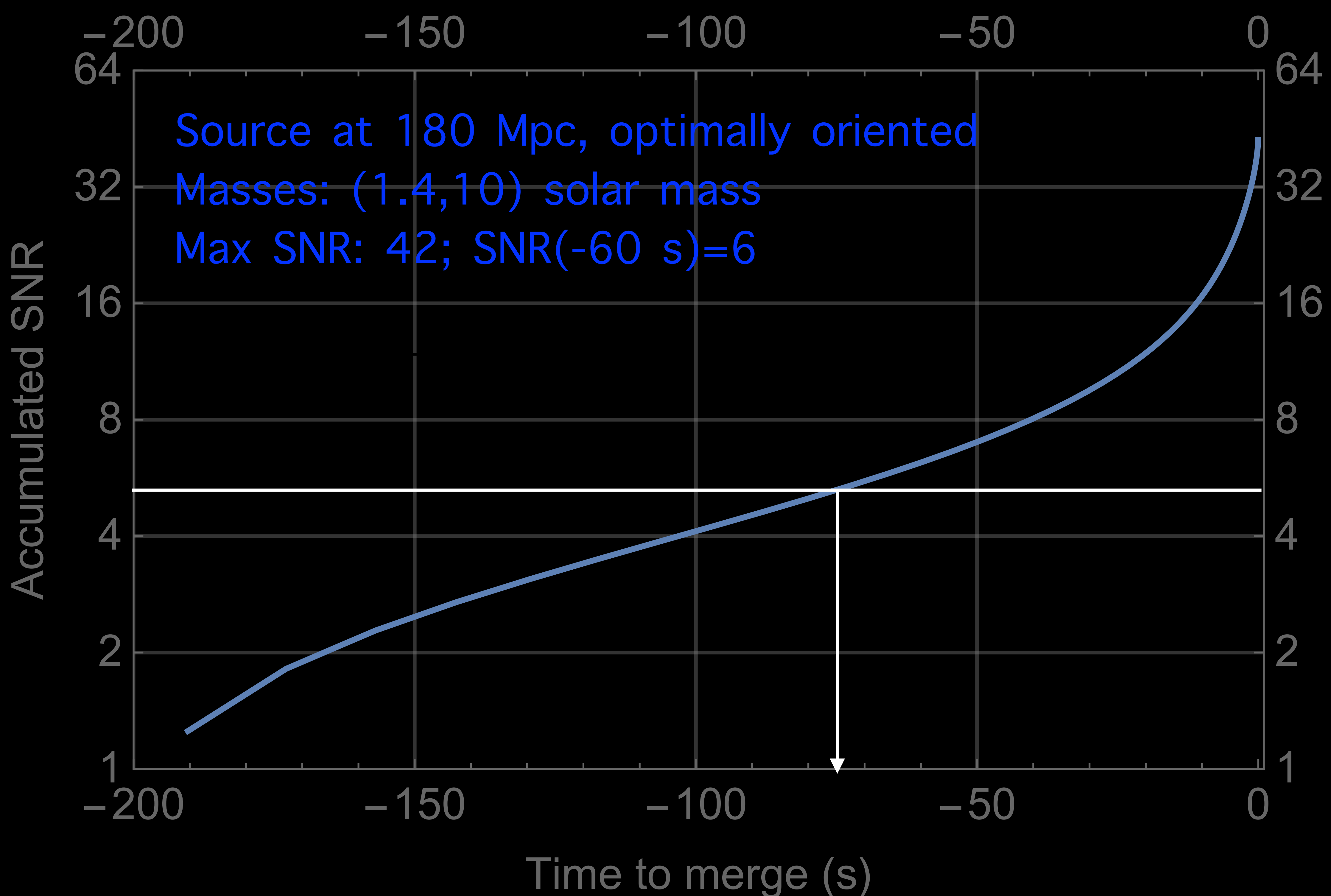
FRACTION OF GW-GRB COINCIDENCES



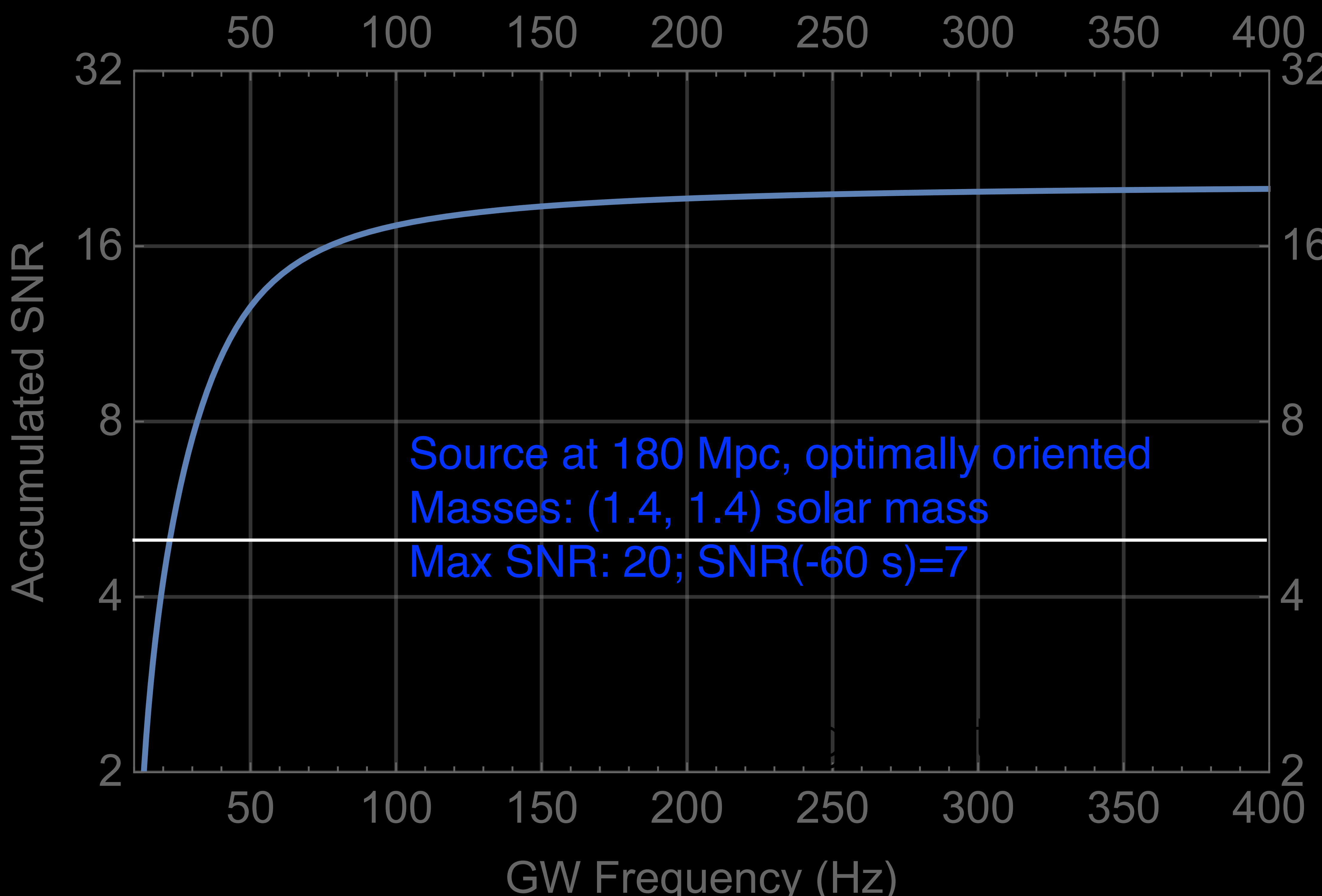
SIGNAL-TO-NOISE RATIO BUILD UP IN TIME FOR BINARY NEUTRON STARS: ADVANCED DETECTORS



SIGNAL TO NOISE RATIO BUILD-UP IN TIME: NEUTRON STAR-BLACK HOLE: ADVANCED DETECTORS



SIGNAL-TO-NOISE RATIO BUILD UP IN FREQUENCY: BINARY NEUTRON STARS IN ADVANCED DETECTORS



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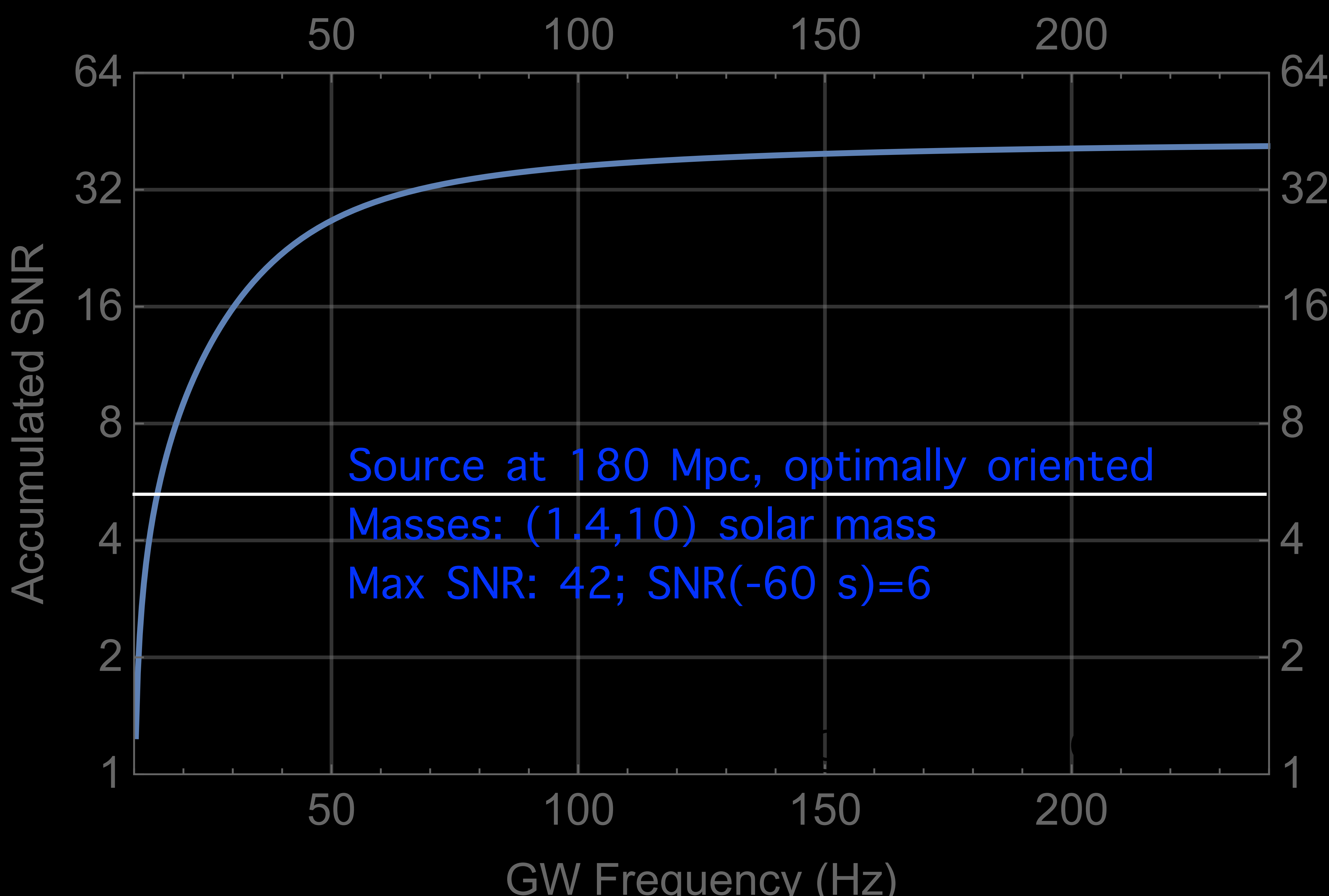
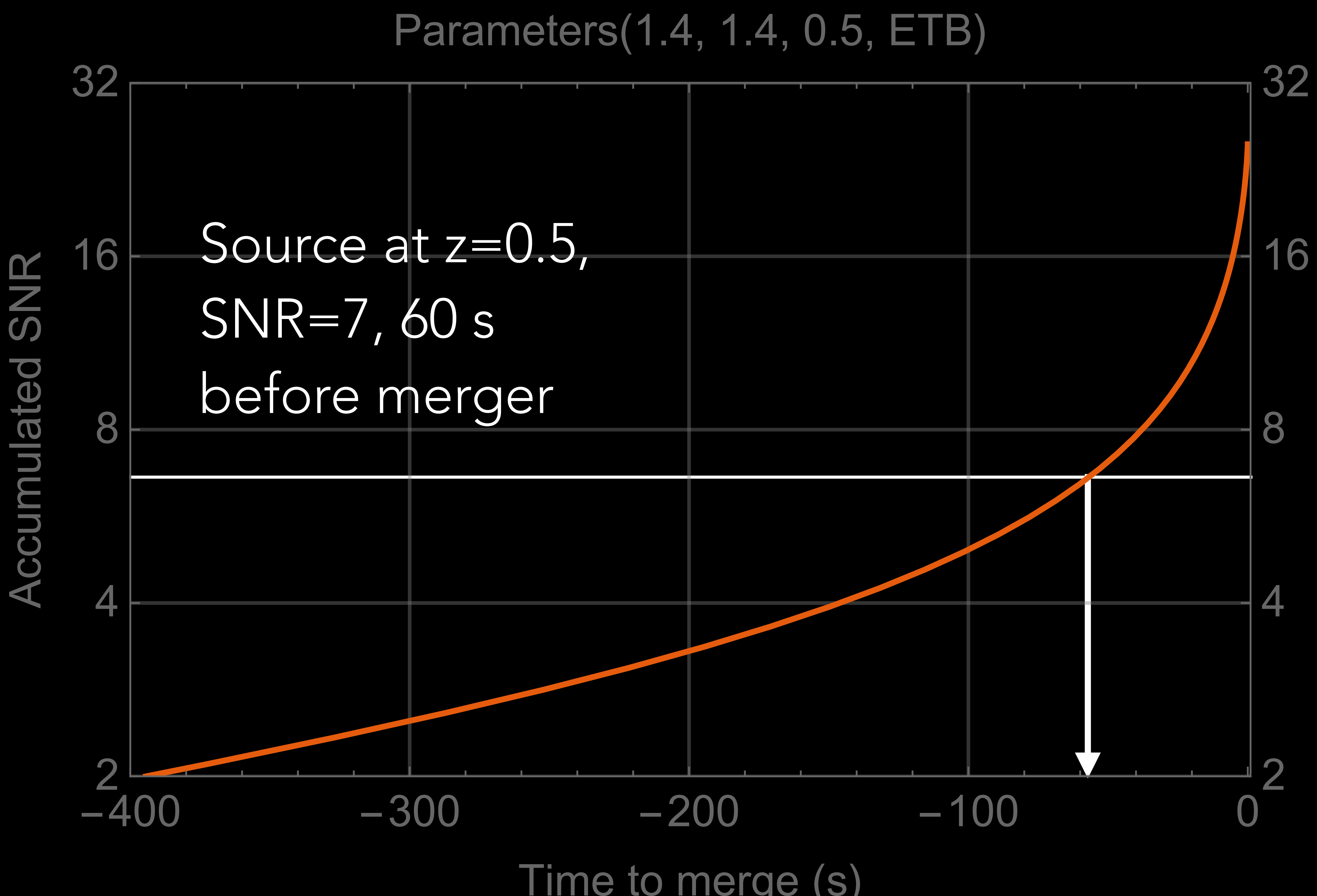


SIGNAL-TO-NOISE RATIO BUILD UP IN TIME FOR BINARY NEUTRON STARS: ETB



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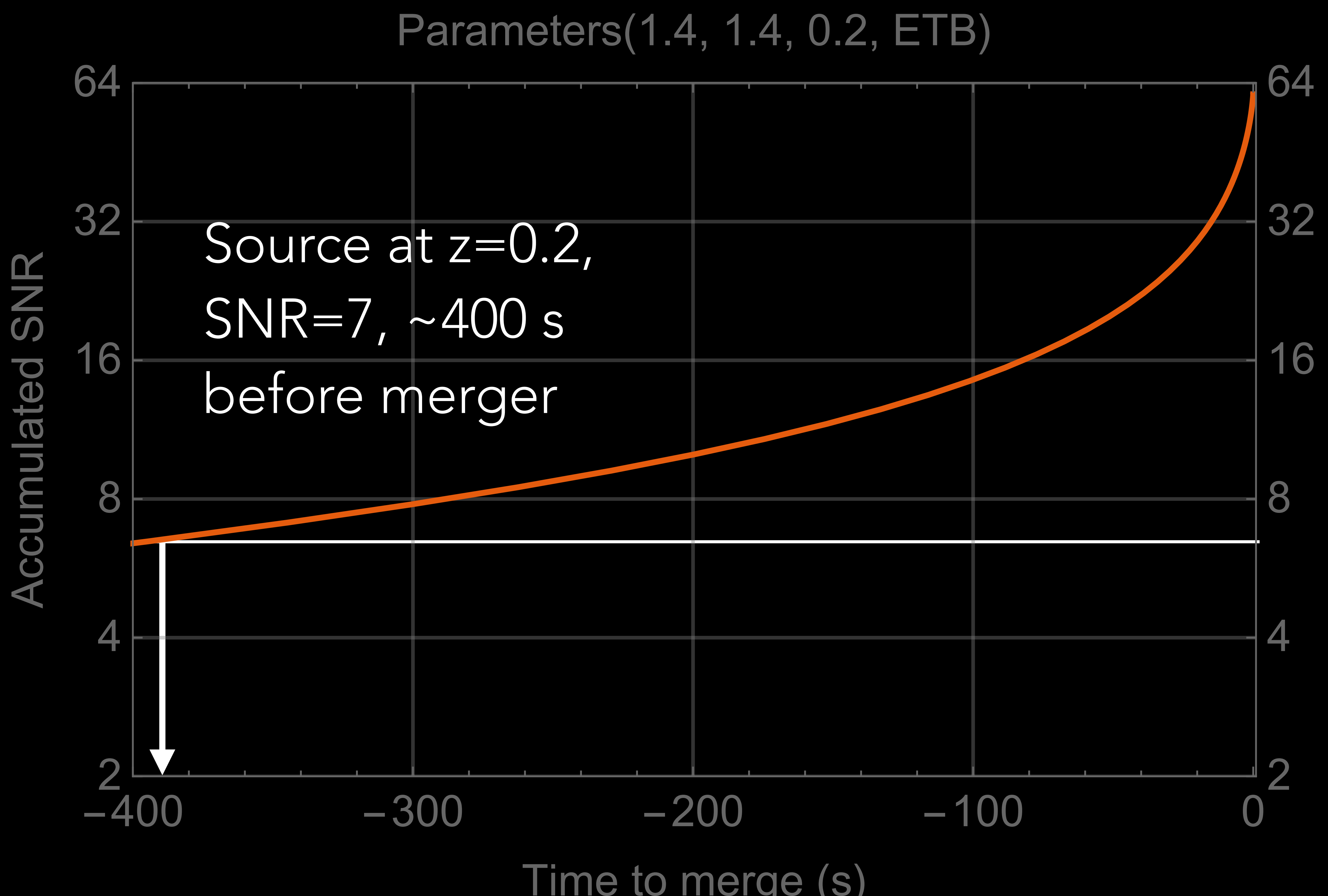
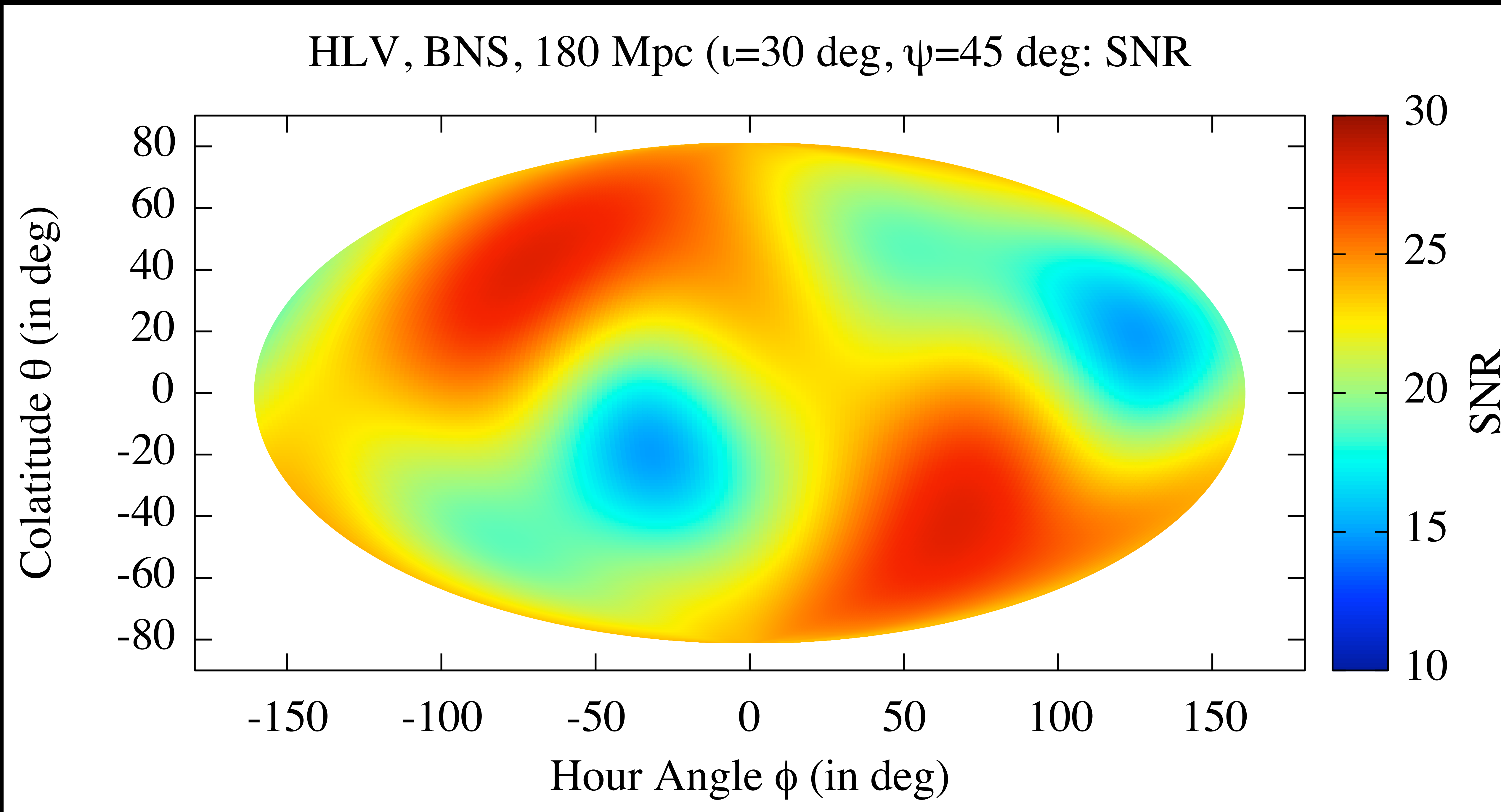
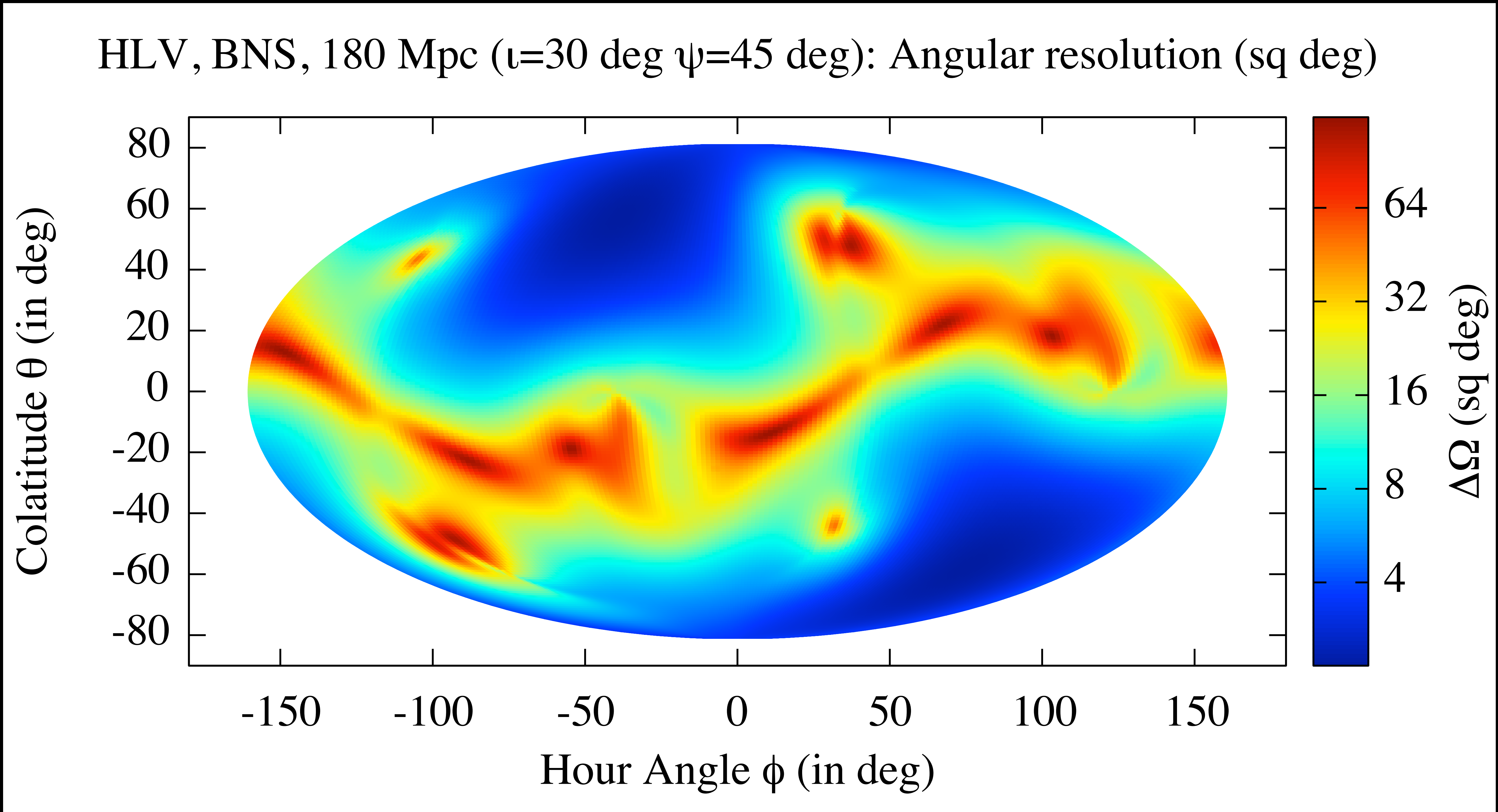


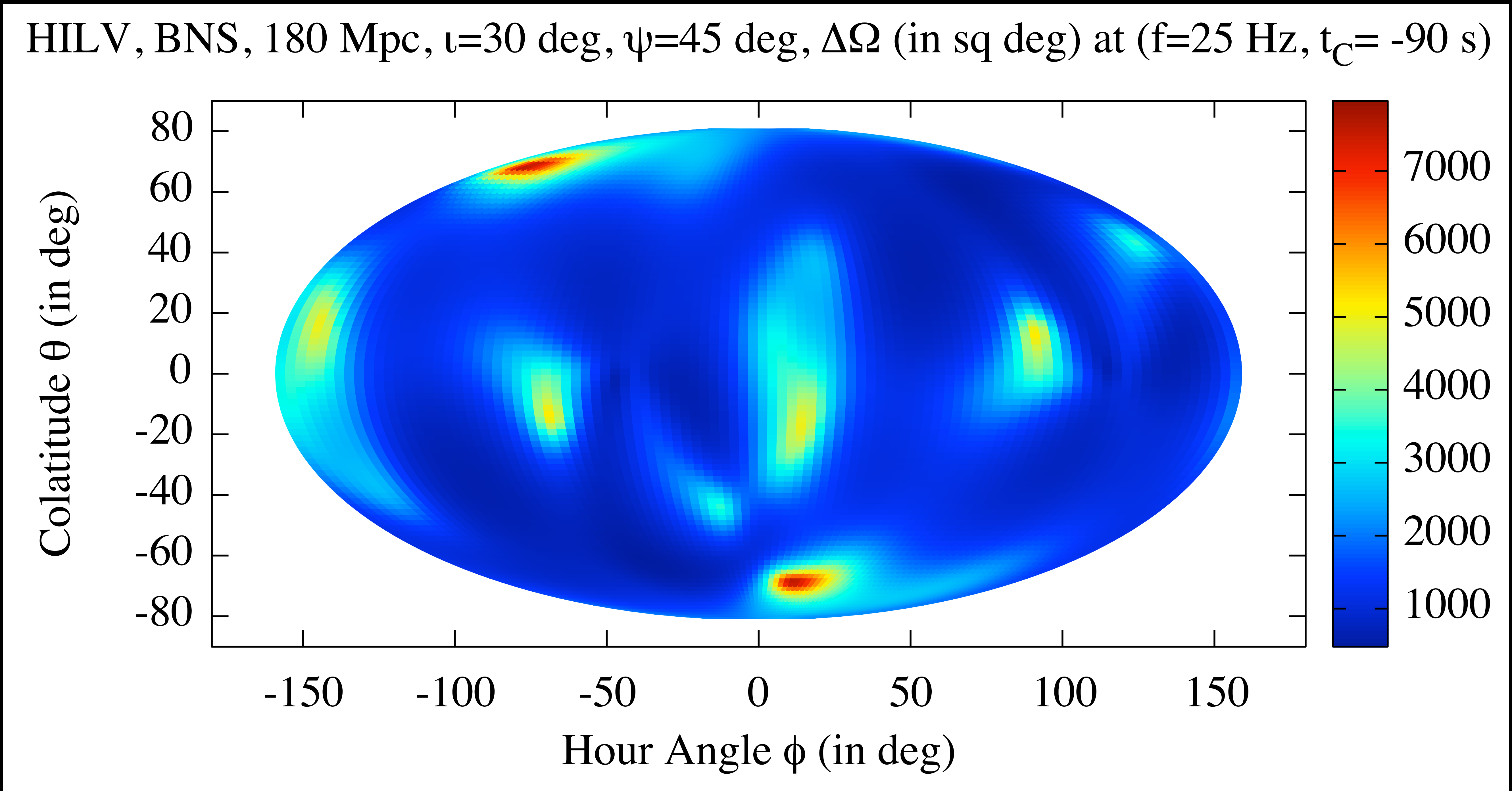
SNR of HLV network



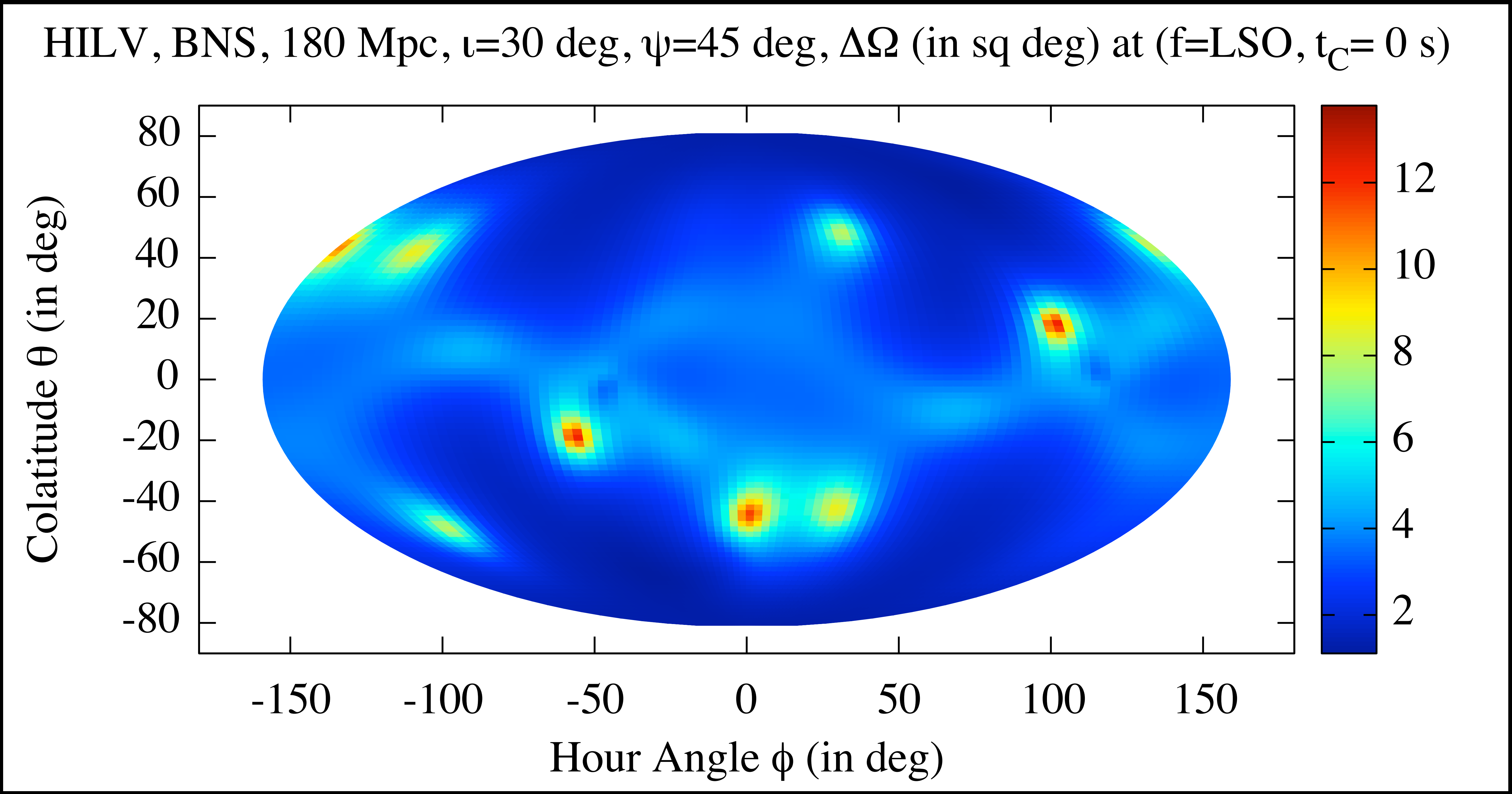
Sky Resolution HLV: after merger



Sky Resolution HILV: 90 seconds before merger



Sky Resolution HILV: after merger



OBSERVING SCENARIO

- Gravitational wave detectors produce a trigger 60 s before merger
- A BAT-like detector is slewed to the sky patch predicted by GW network within 30 s
- BAT observes the prompt GRB emission and fixes the source within a sub-arc second sky patch
- XRT instruments follow-up prompt X-ray emission

HOW QUICK CAN WE TRIGGER?

- Time domain filtering techniques (GSTLAL, SVD/SPIIR) can produce triggers within seconds after the signal reaches ~ 20 Hz
  - Wall clock latency from data transfers, etc. ~ 10 s
  - Telescope slew times could be ~ 30 s
  - So we should be aiming at reporting triggers 60 s before merger
- This gives distance reach of about 250 Mpc for binary neutron stars in aLIGO and AdV
- So event rates are down (450/250)^3 = 6, but can see only 20% of them
- So might see X/30 events in coincidence with GRBs - a factor of 3 improvement

3G detectors could observe every short-hard GRB within z=0.5