

# Science Performance: Preliminary Results

Neil J. Cornish  
&

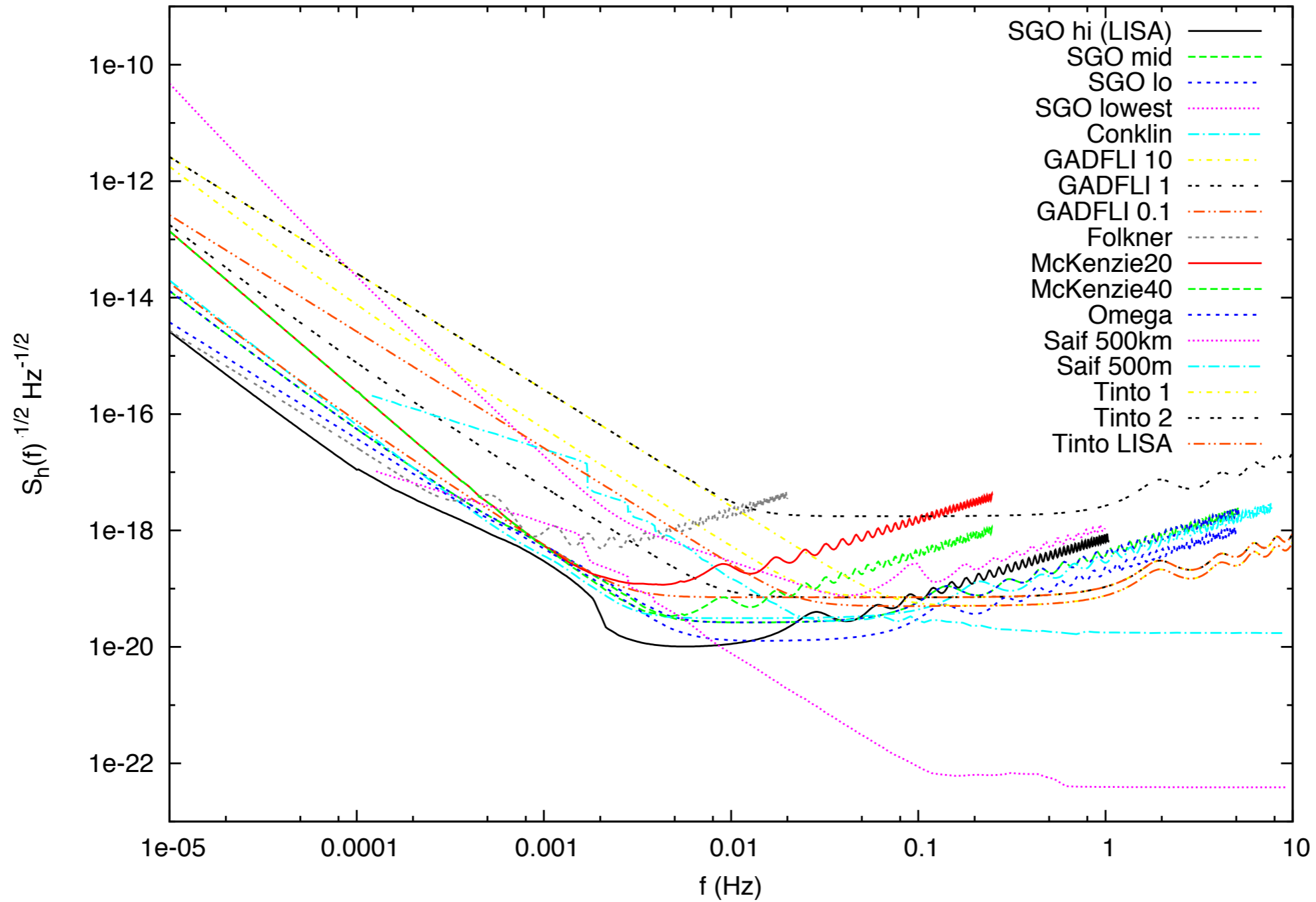
The science performance taskforce

Shane Larson, Tyson Littenberg, Antoine Klein, Michele Vallisneri, Curt Cutler, Jon Gair,  
Ryan Lang, Emanuele Berti, Sean McWilliams, Matt Benacquista, John Baker, Ira Thorpe

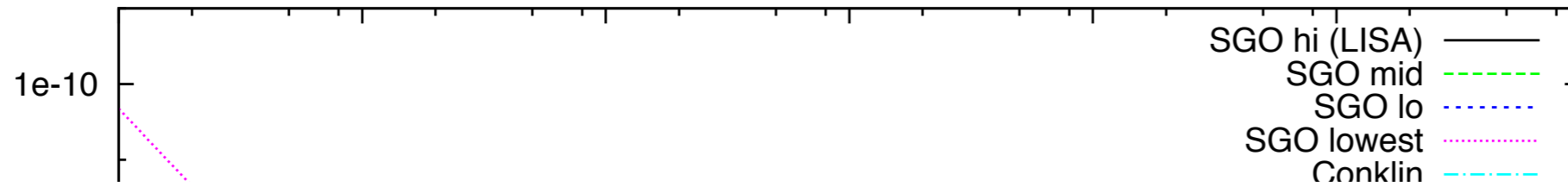
# Science Metrics

- Volume of the Universe explored
- Detection numbers for source populations  
(Massive BHs, EMRIs, Galactic Binaries)
- Discovery Space
- Parameter resolution

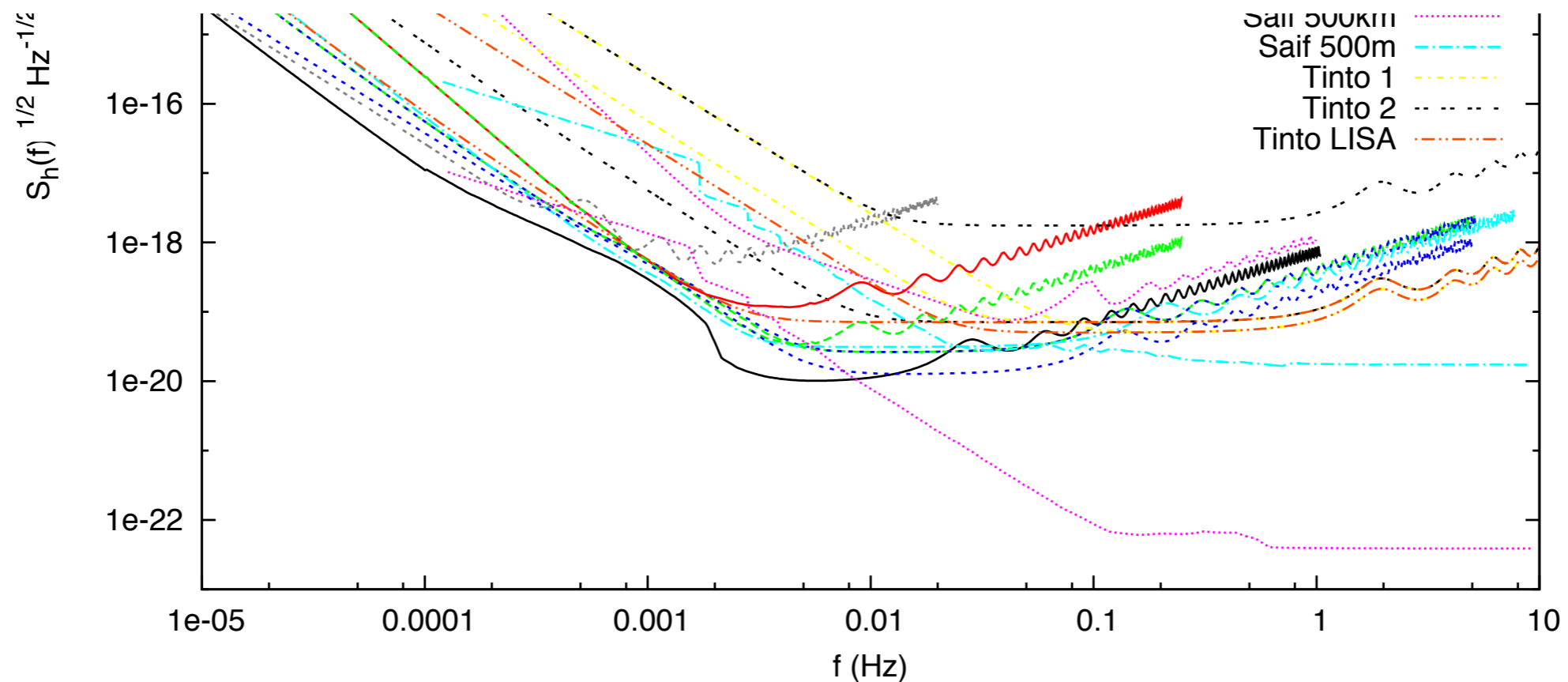
# 17 Sensitivity Curves



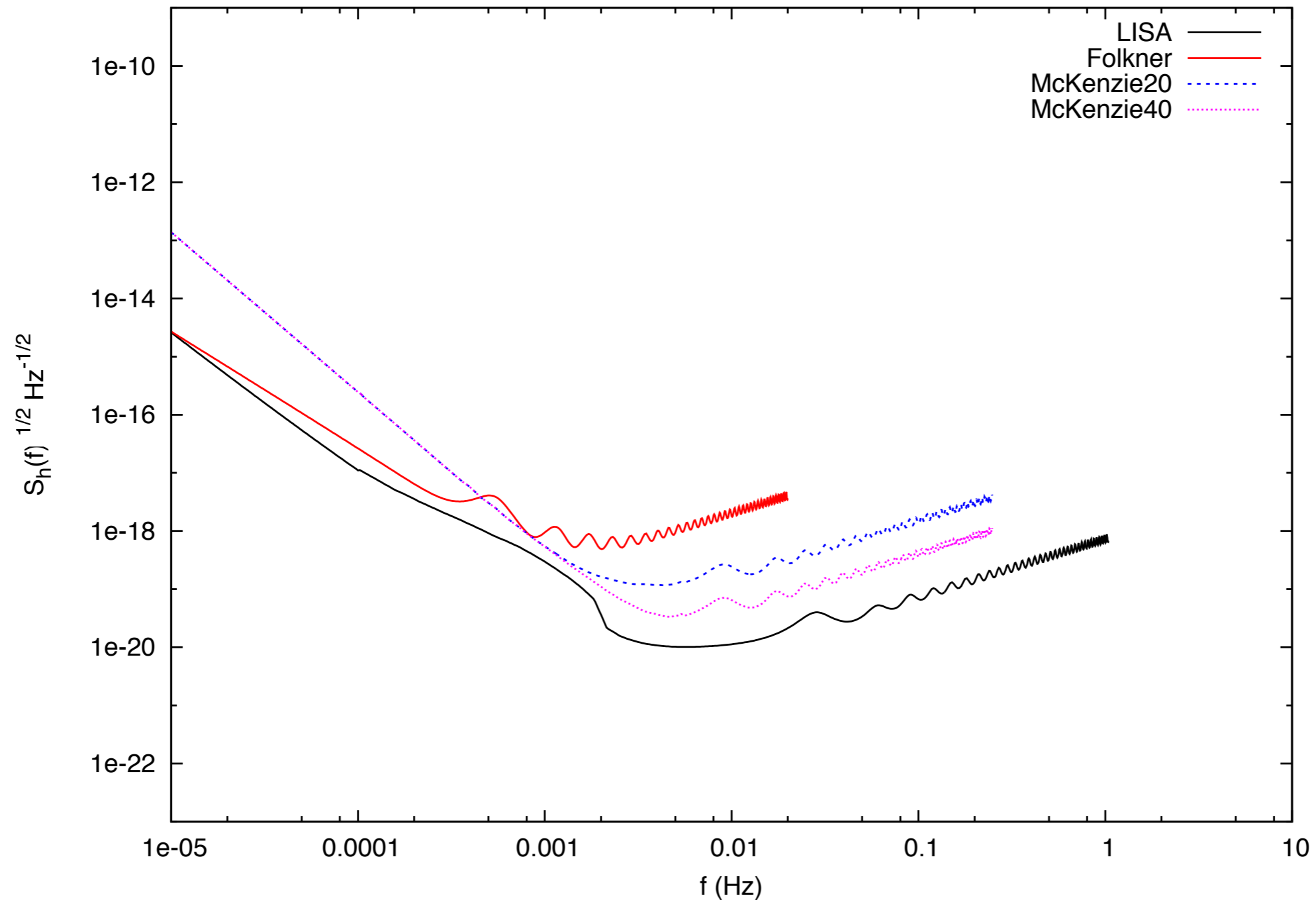
# 17 Sensitivity Curves



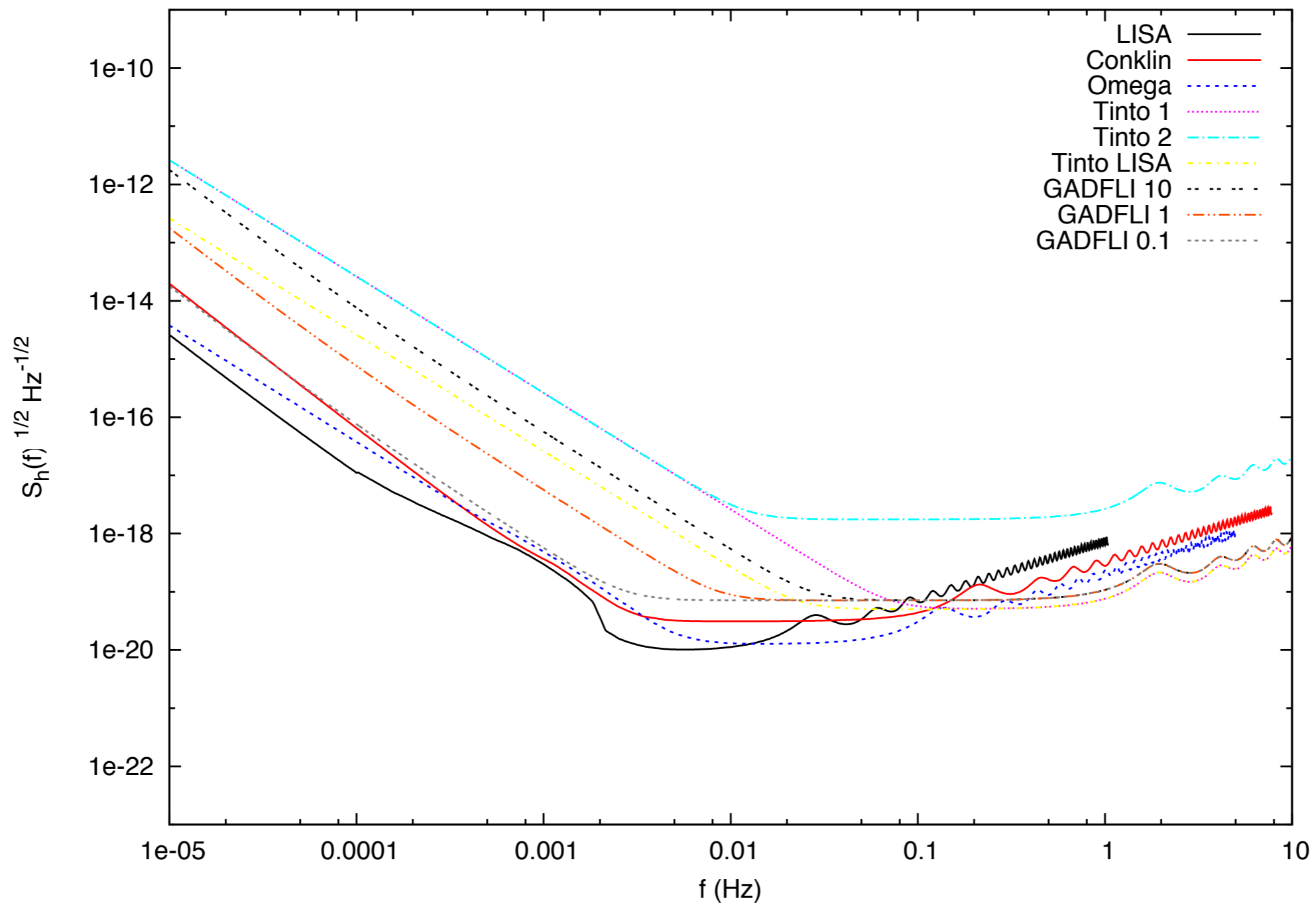
**Note:** These are taken directly from the RFIs,  
and in some instances have proved impossible to reproduce.



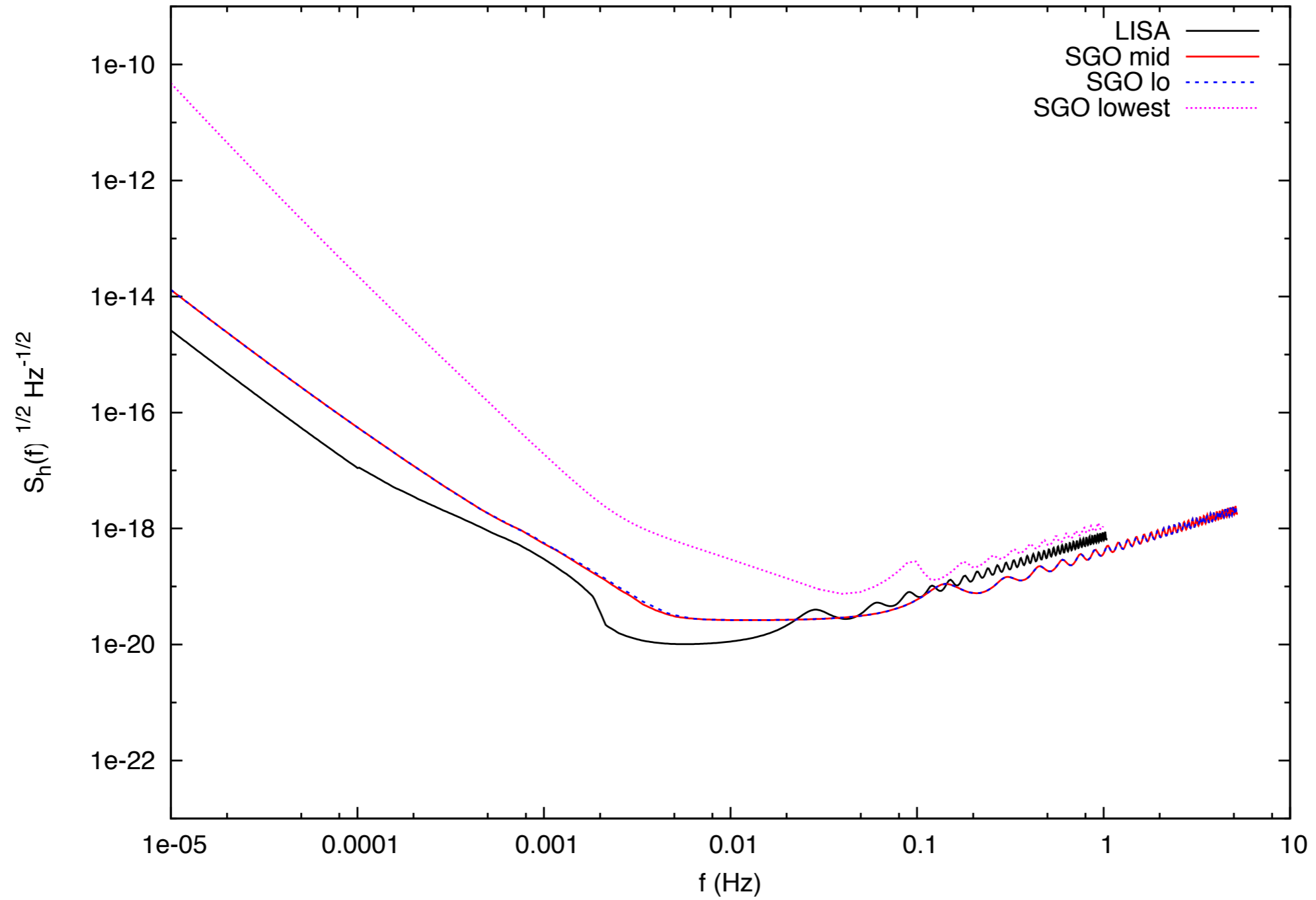
# Group I: No drag free (Long Arm)



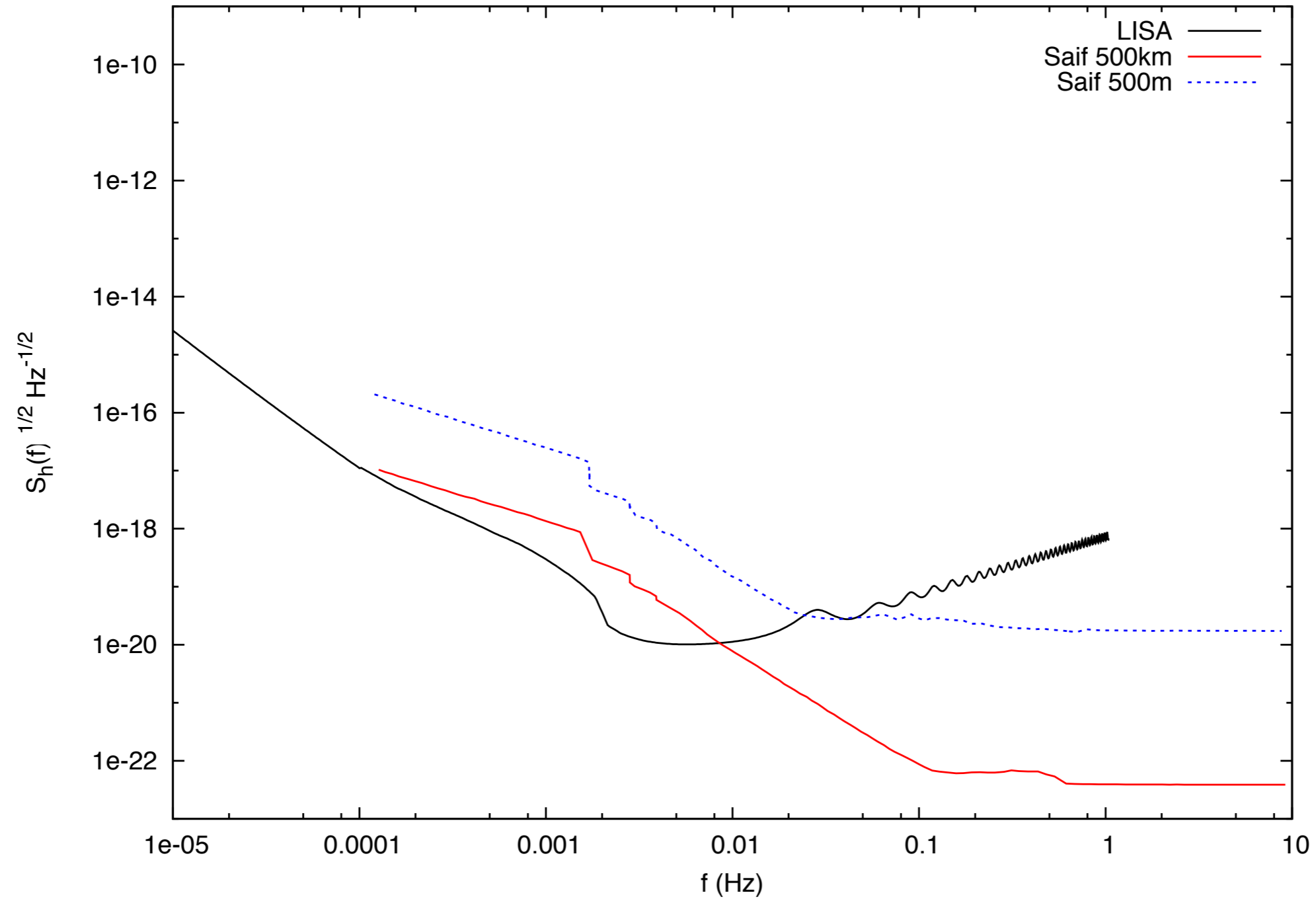
# Group 2: Geocentric (Short Arm)



# Group 3: LISA variants

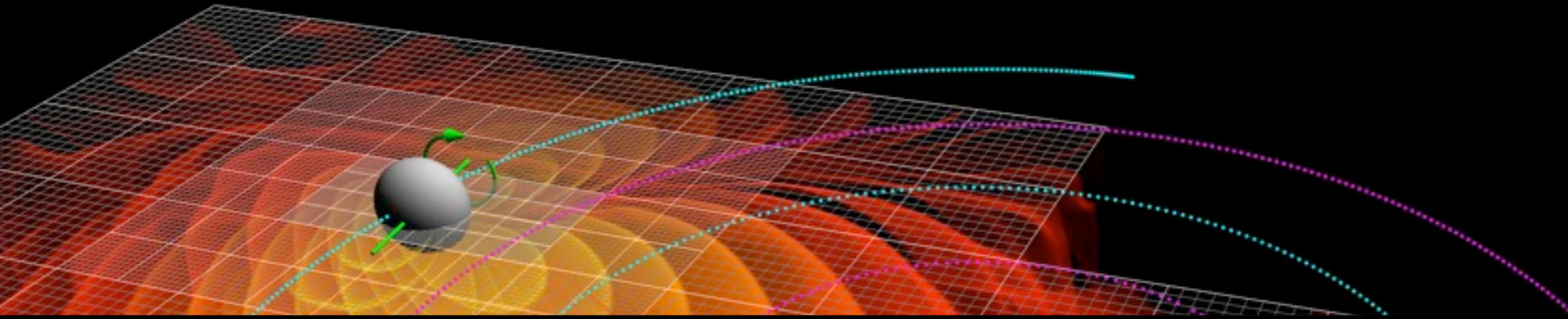


# Group 4: Atom Interferometry (very Short Arm)

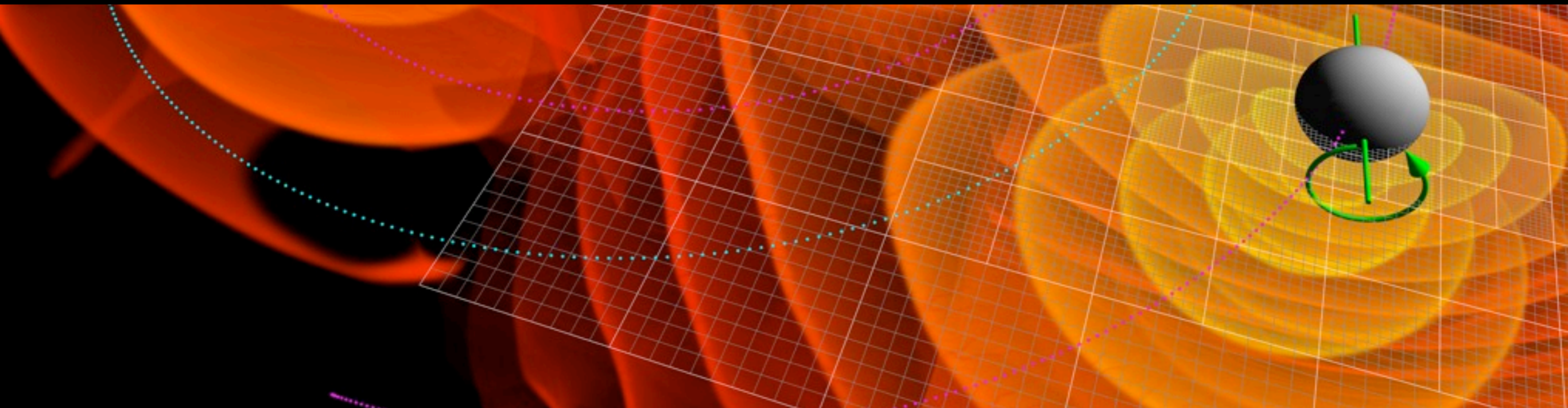




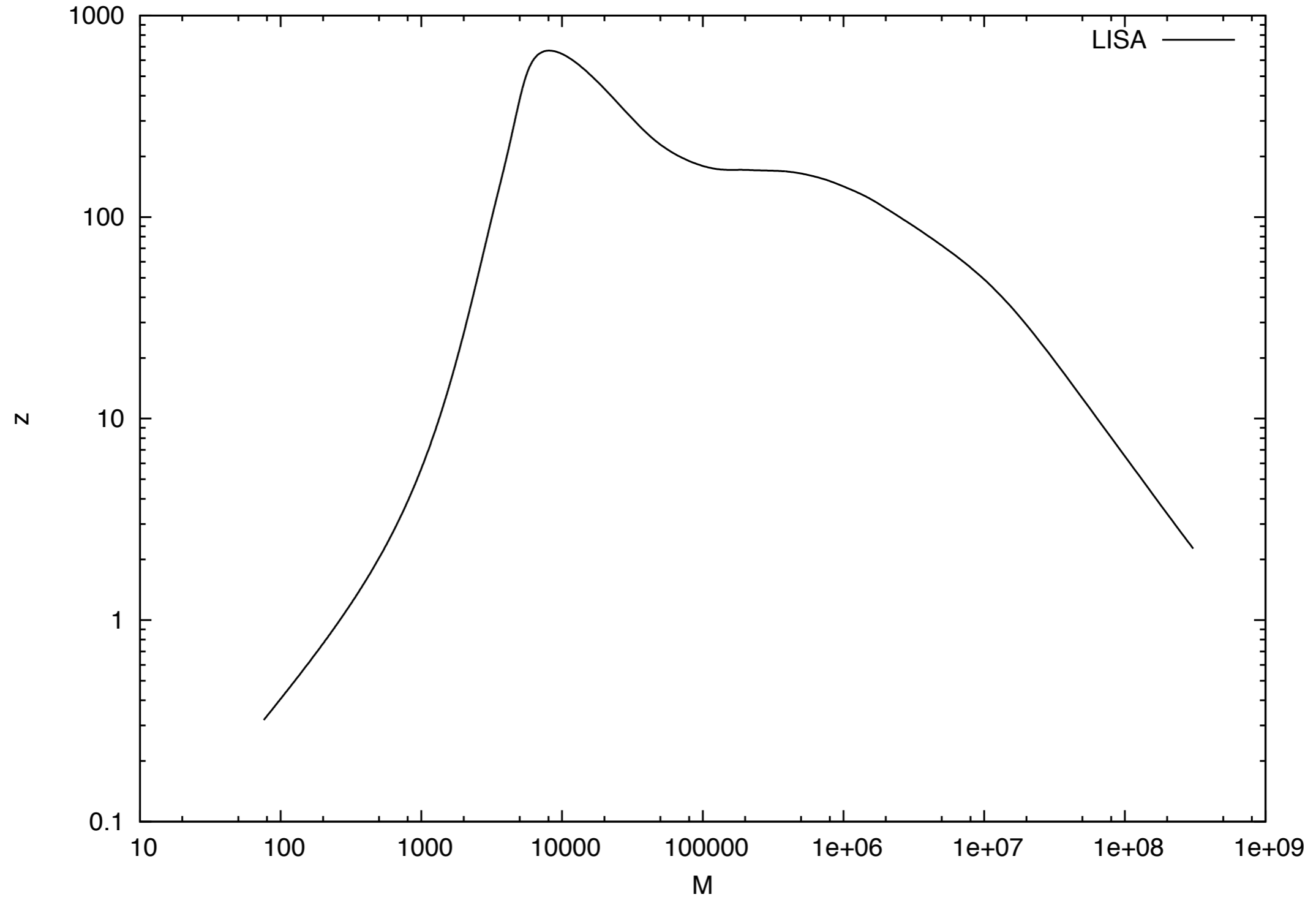
# Massive BH Horizons



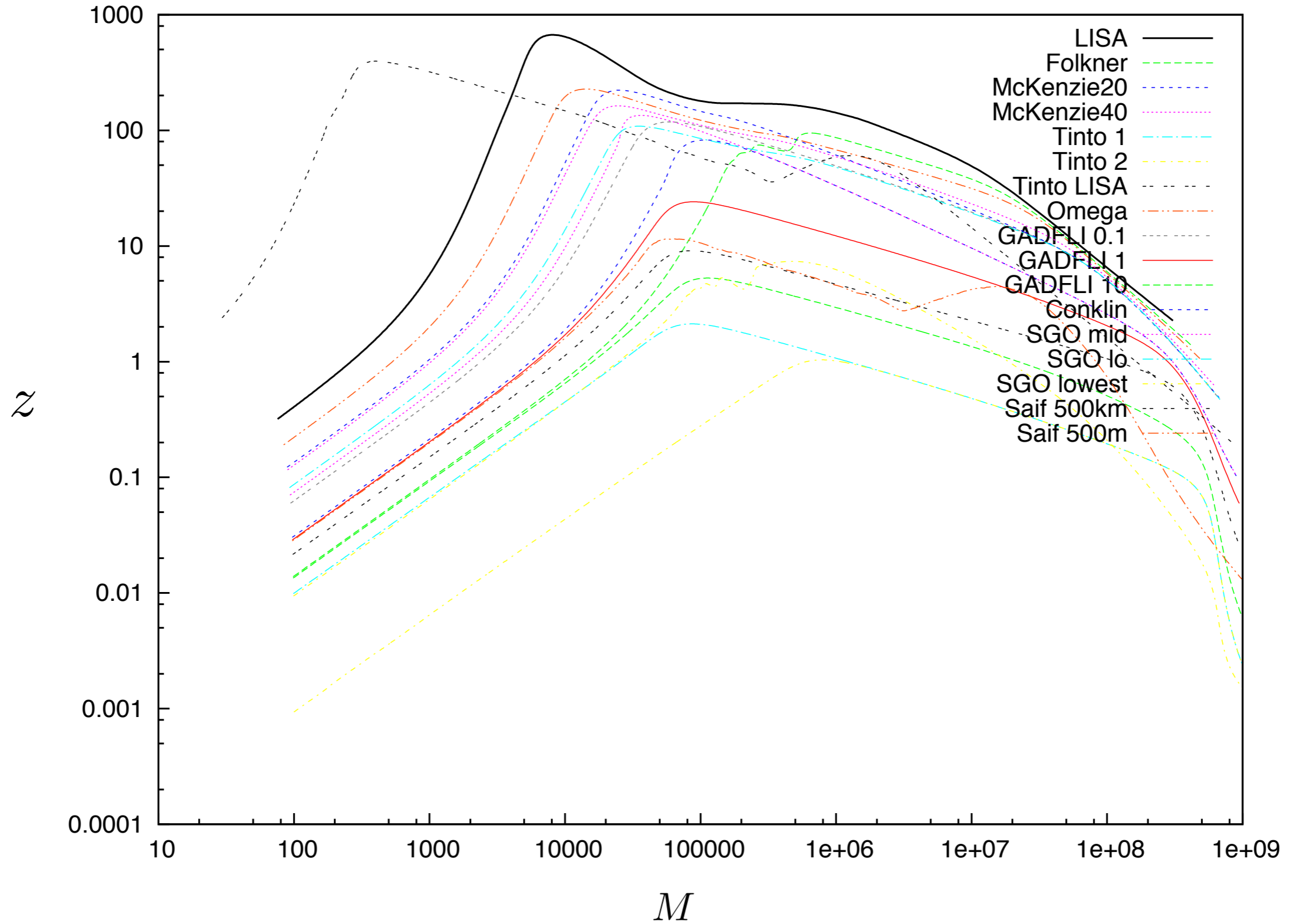
Fiducial System: Mass Ratio 3:1, Spin 0.5, 0.5  
Inspiral-Merger-Ringdown Waveforms. SNR 10 Threshold



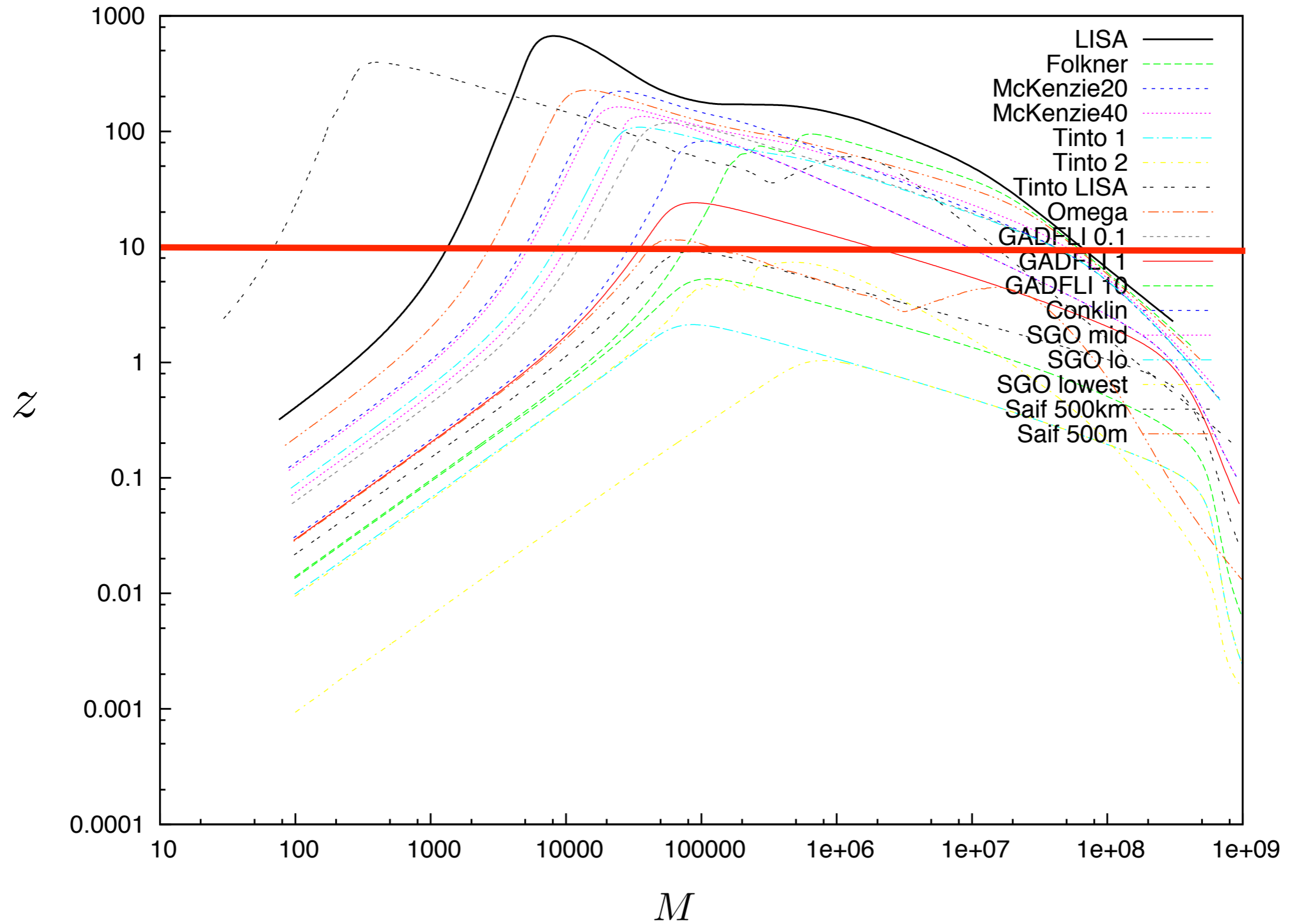
# Massive BH Horizons



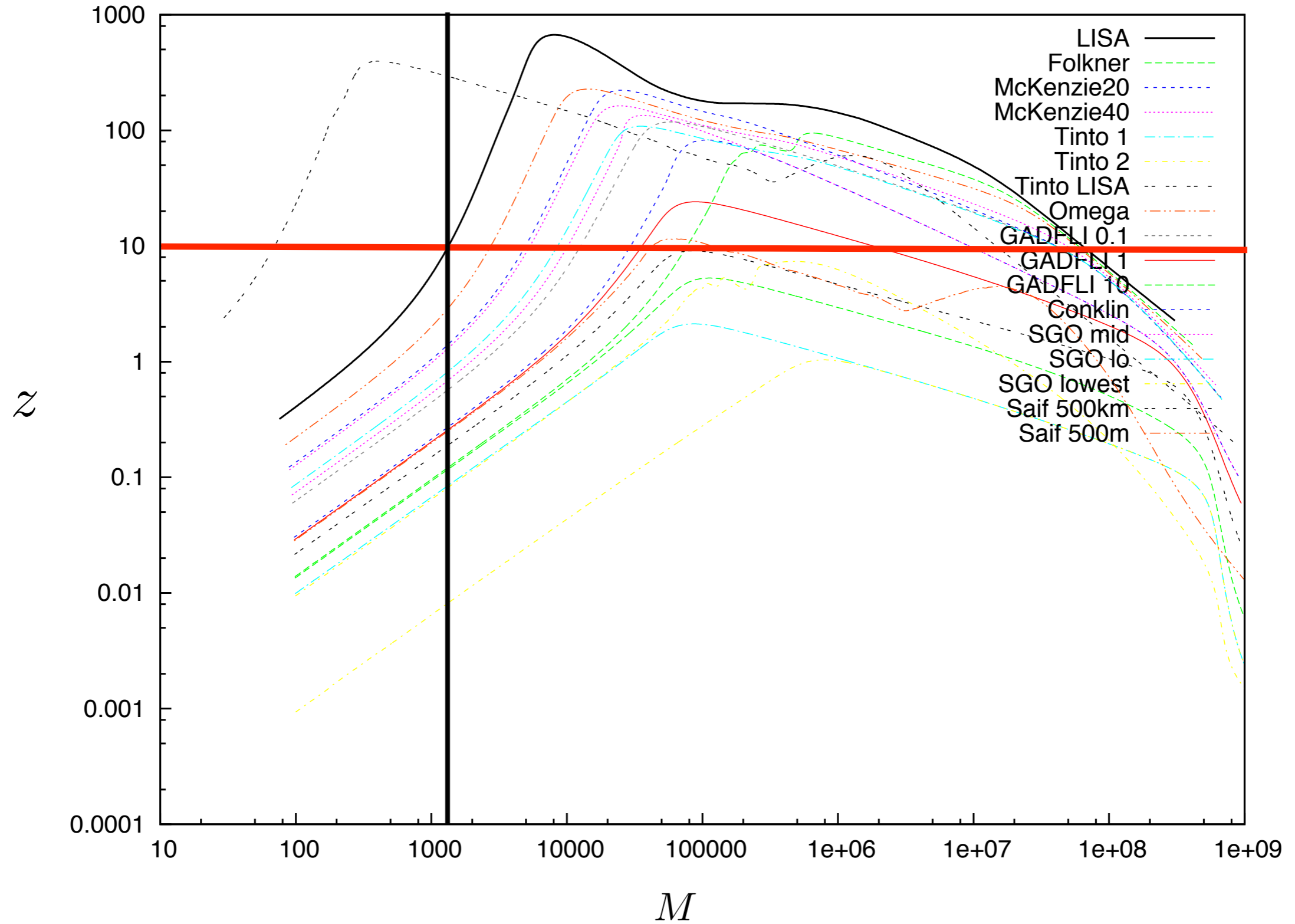
# Massive BH Horizons



# Massive BH Horizons

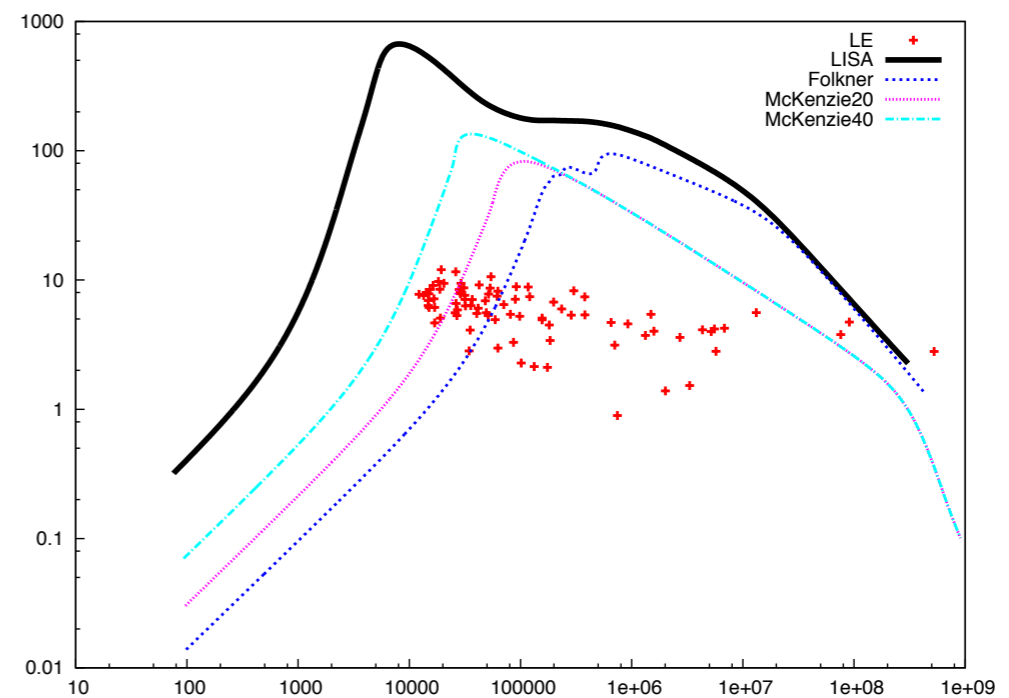
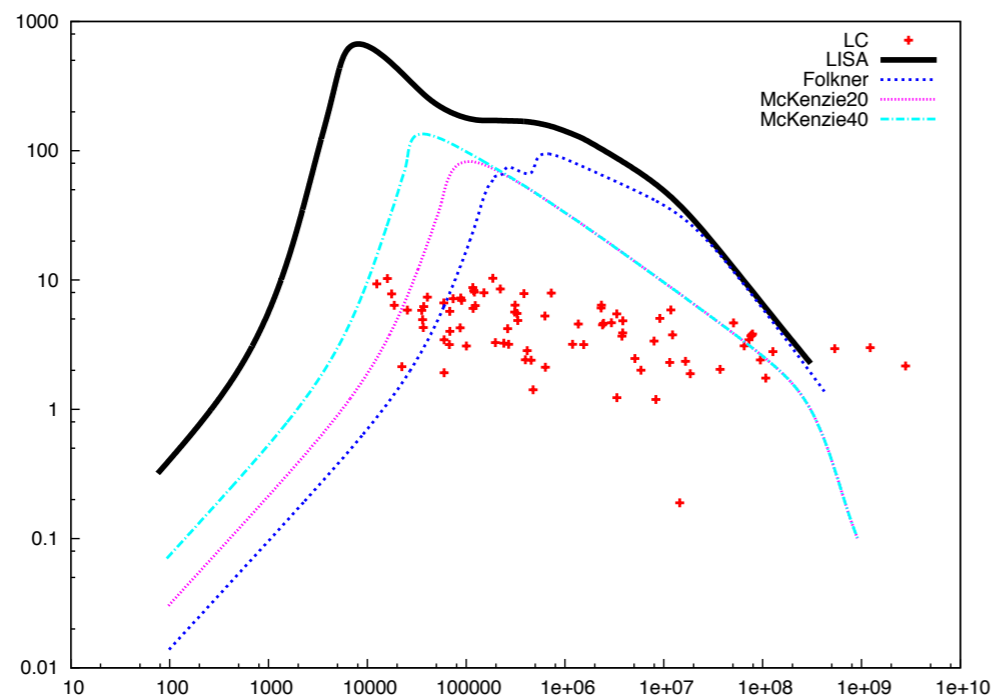
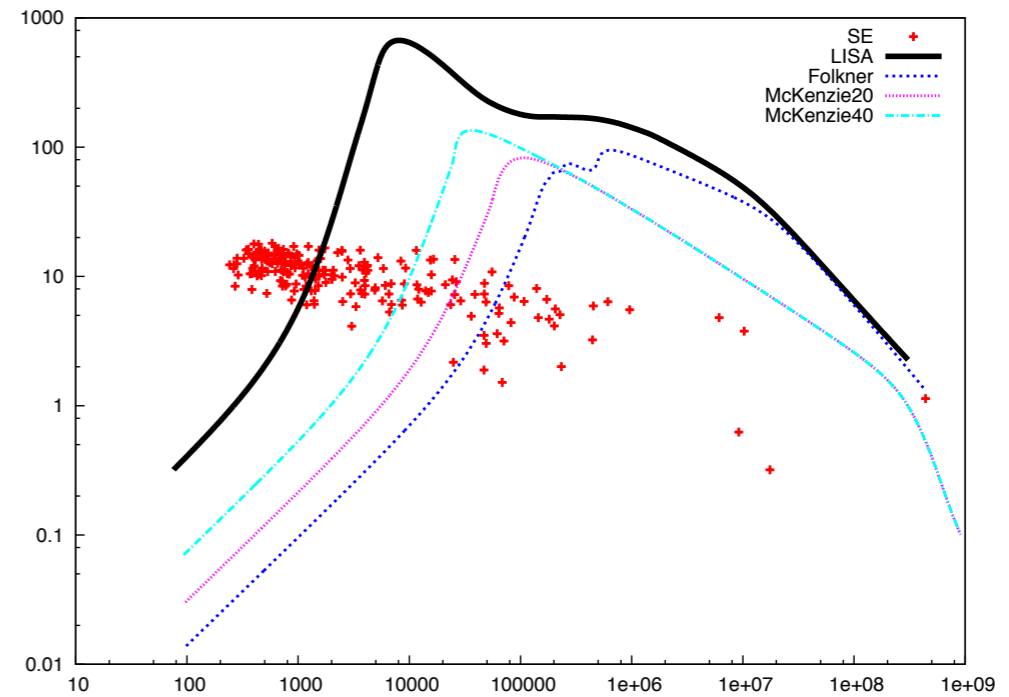
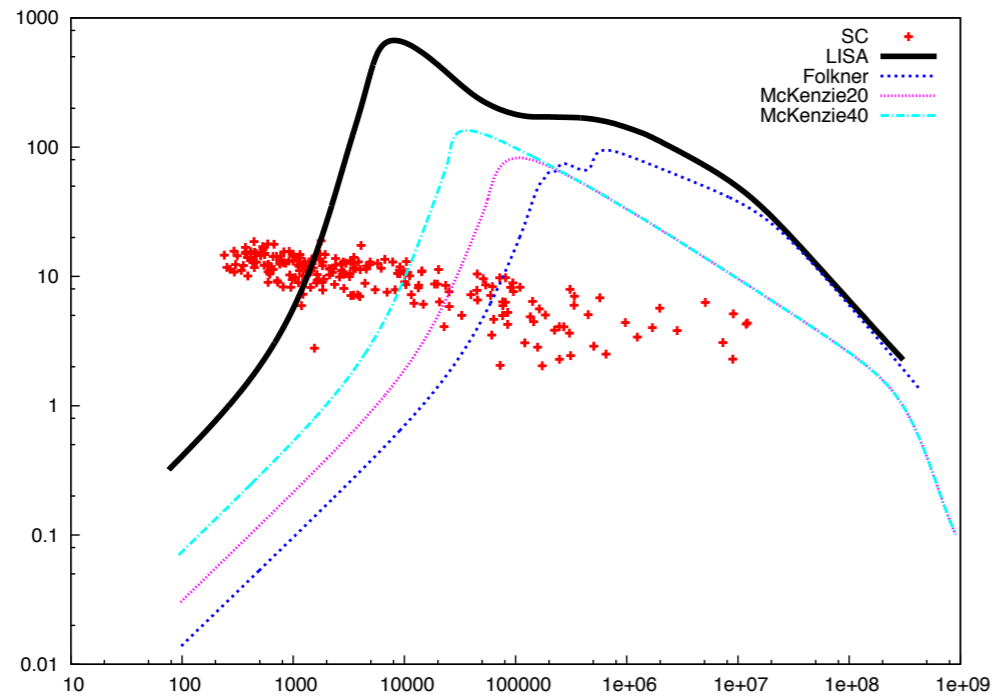


# Massive BH Horizons



# Group I: Massive BH Horizons

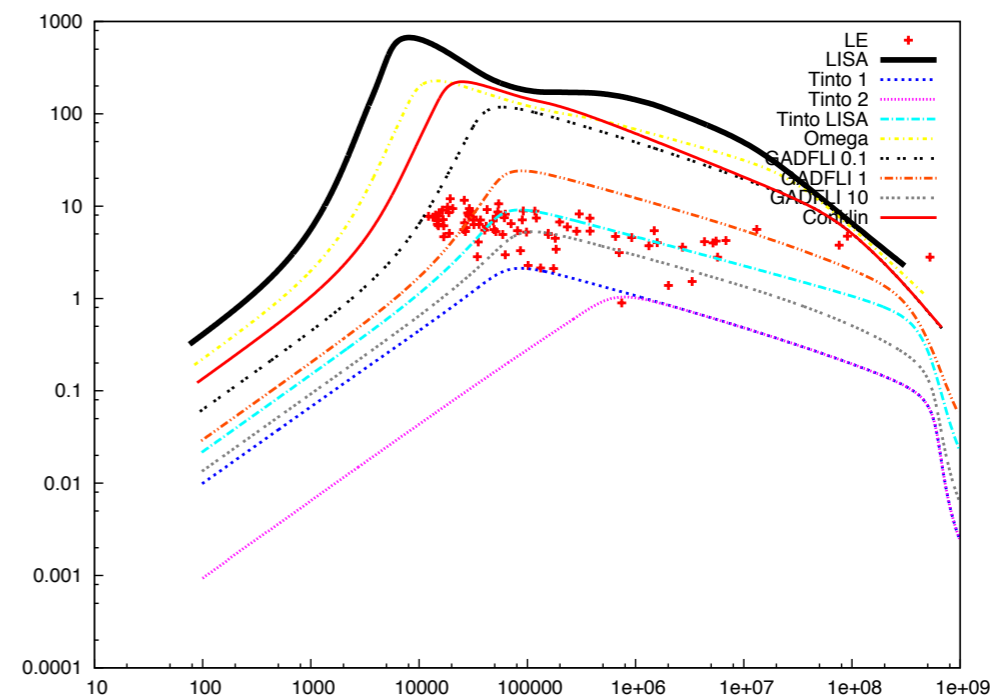
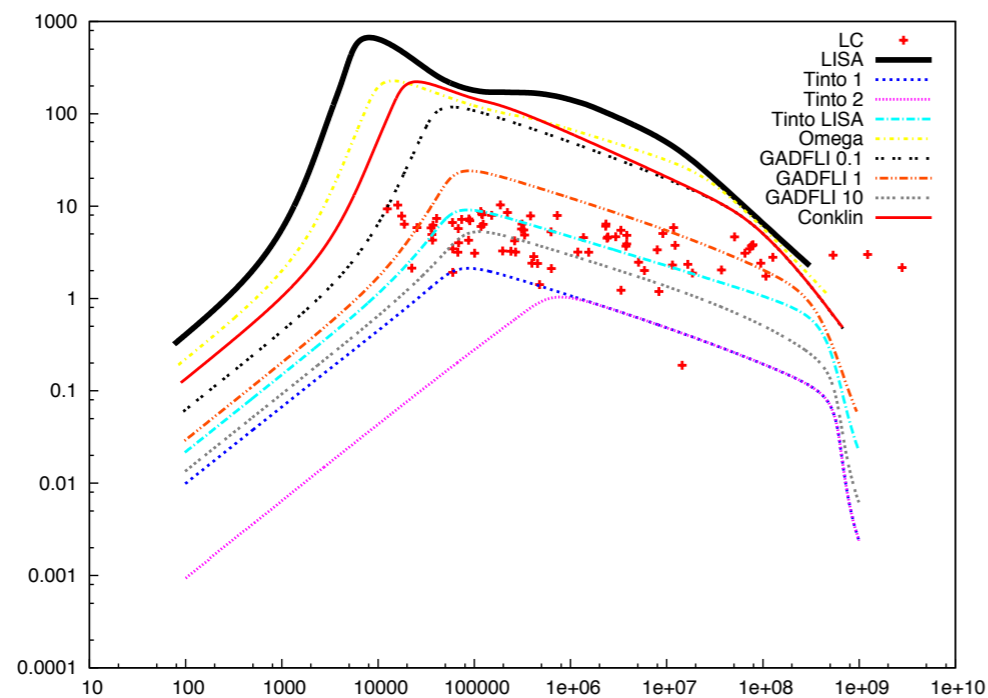
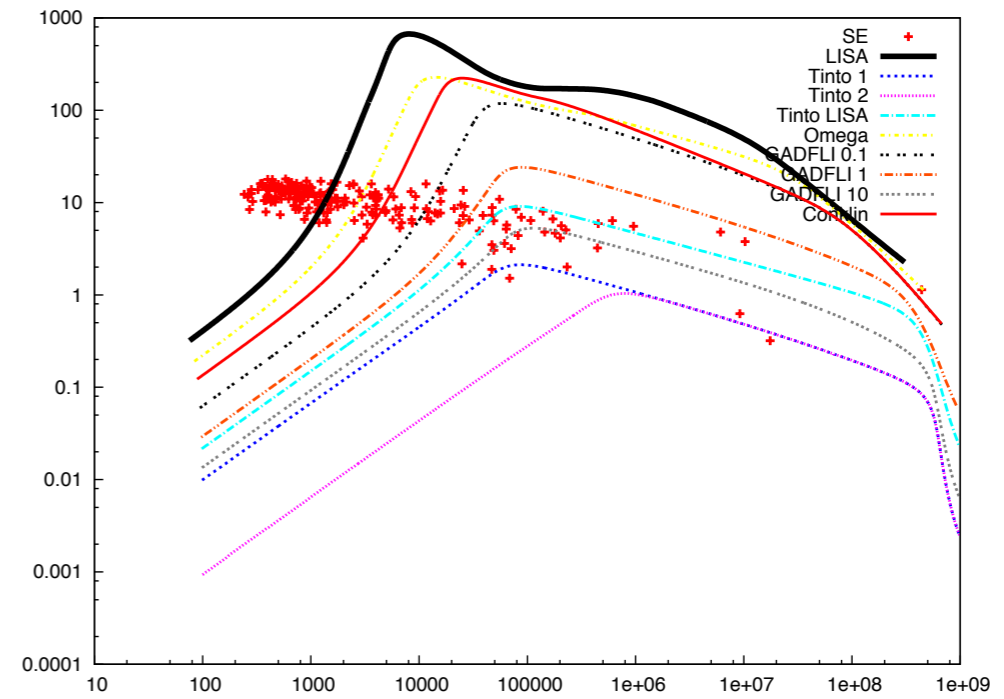
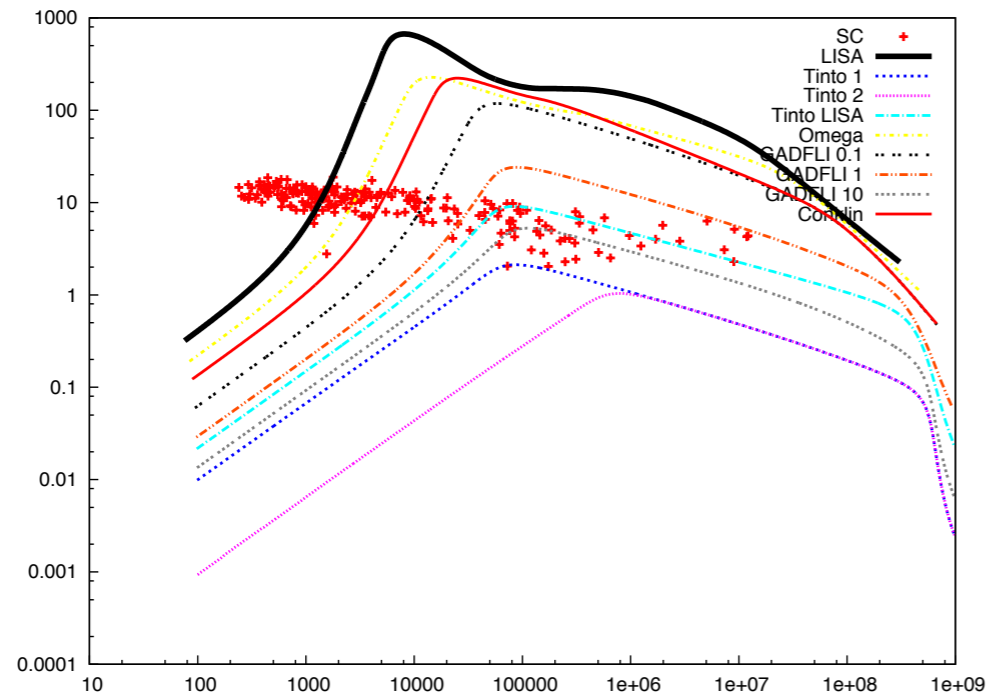
$\mathcal{Z}$



$M$

# Group 2: Massive BH Horizons

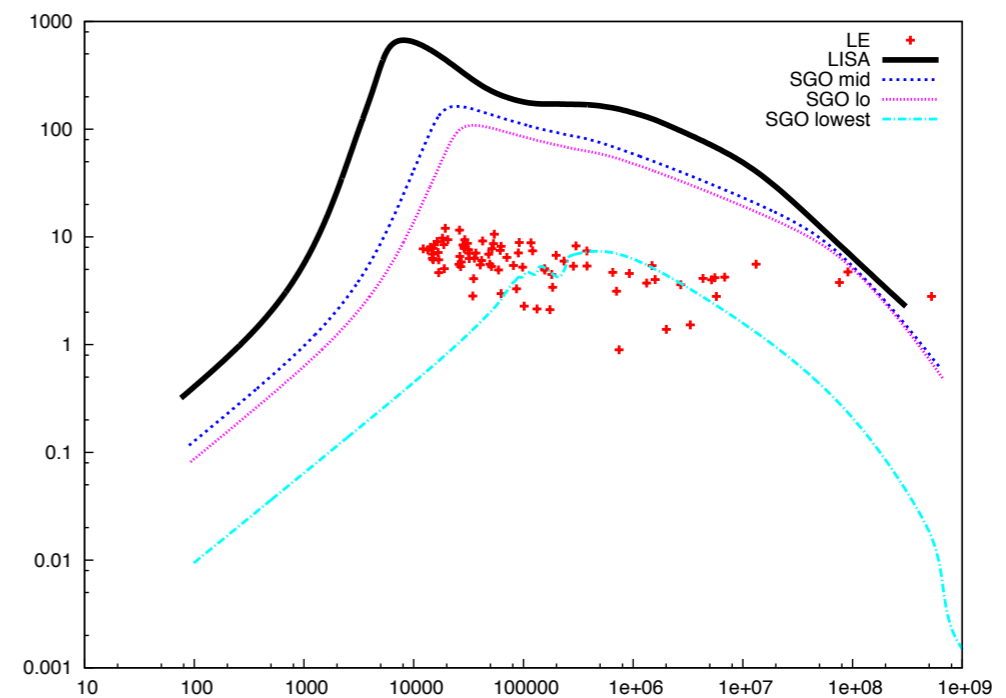
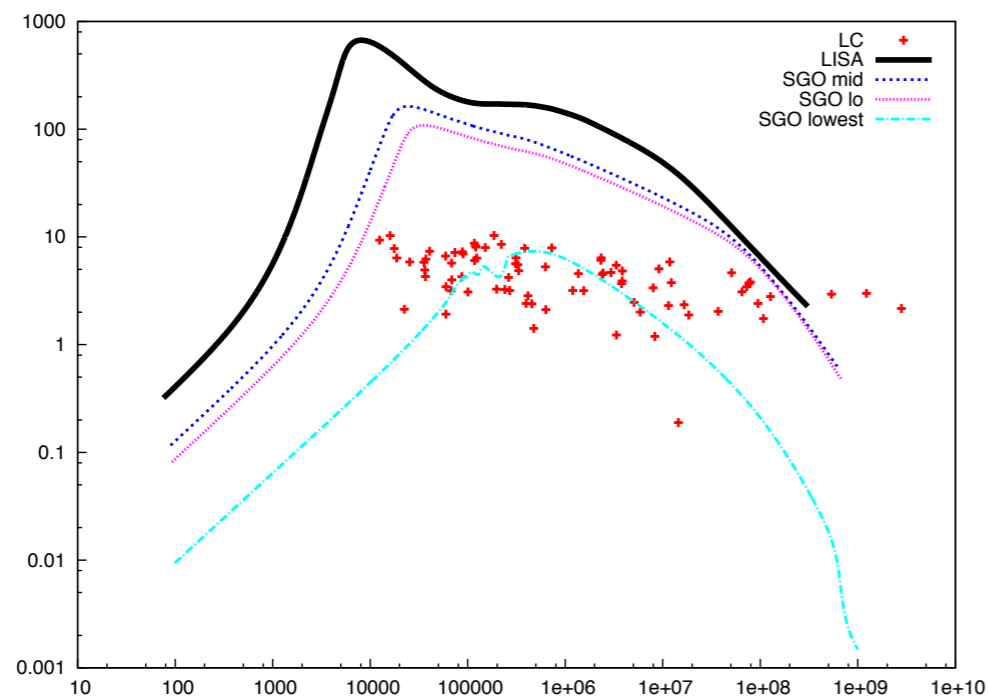
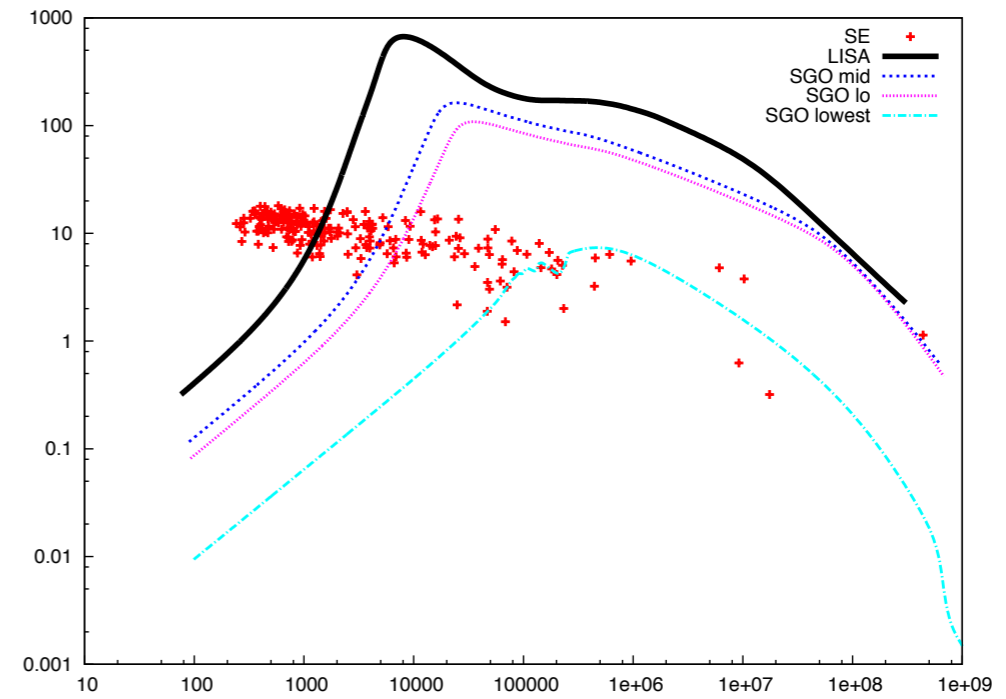
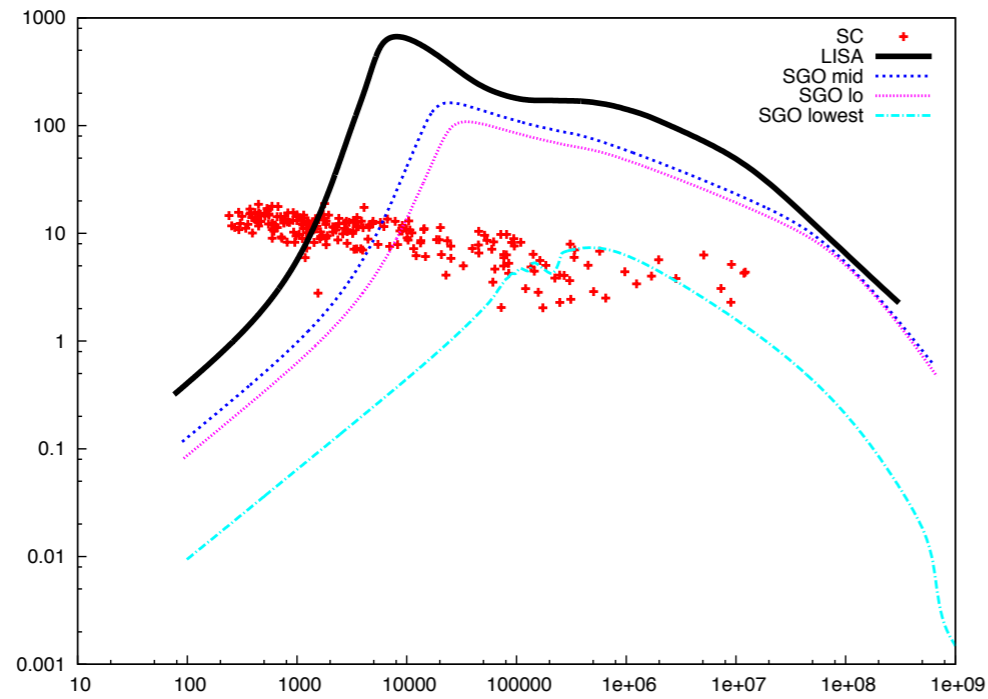
$\mathcal{Z}$



$M$

# Group 3: Massive BH Horizons

$\mathcal{Z}$

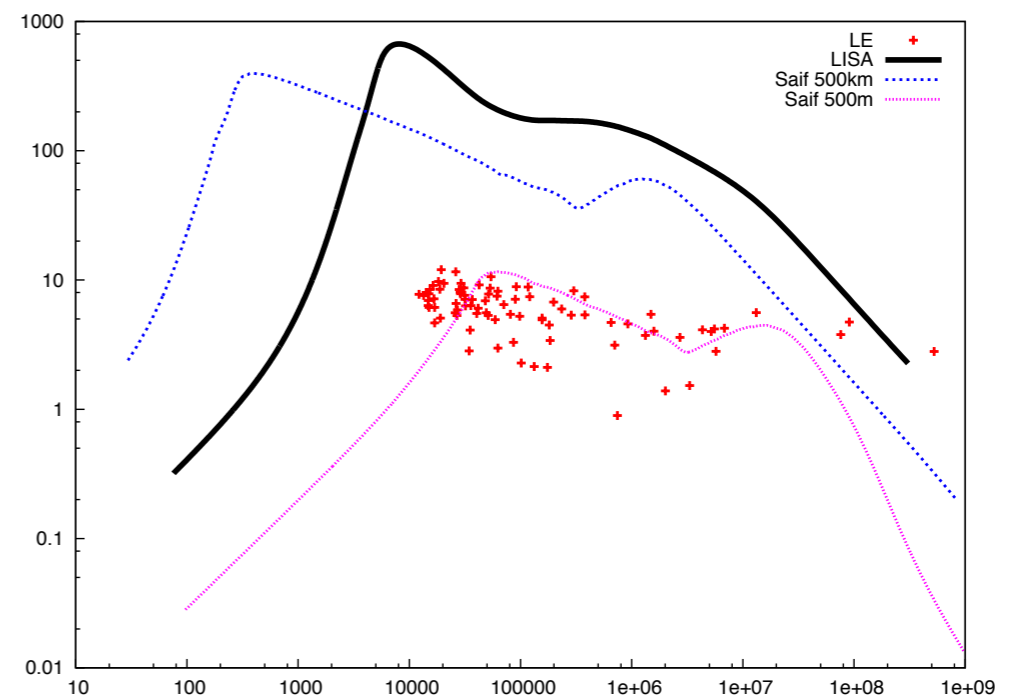
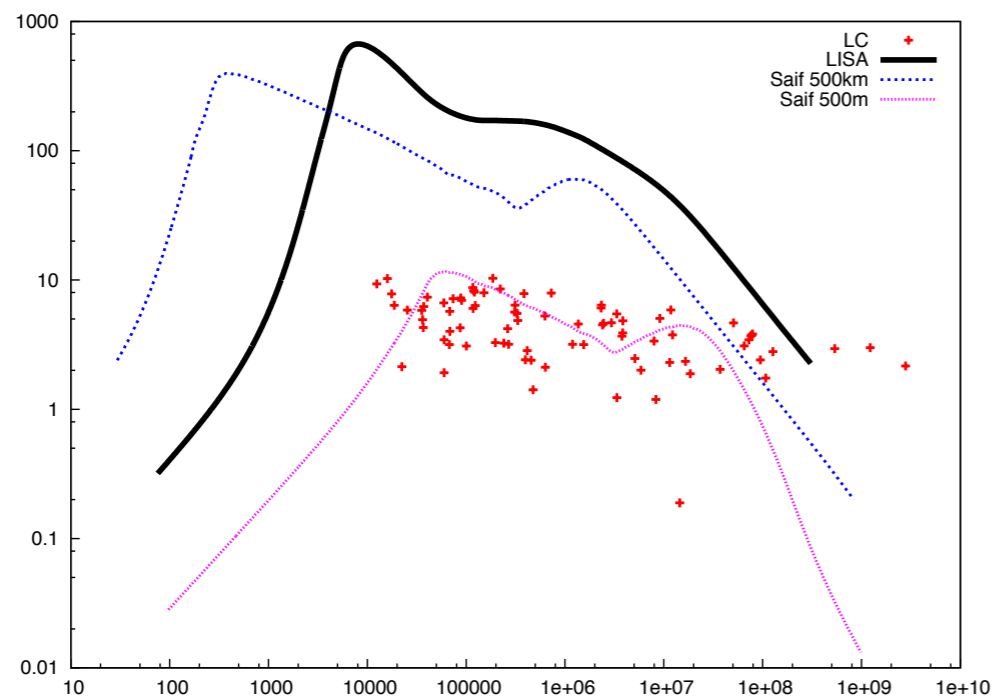
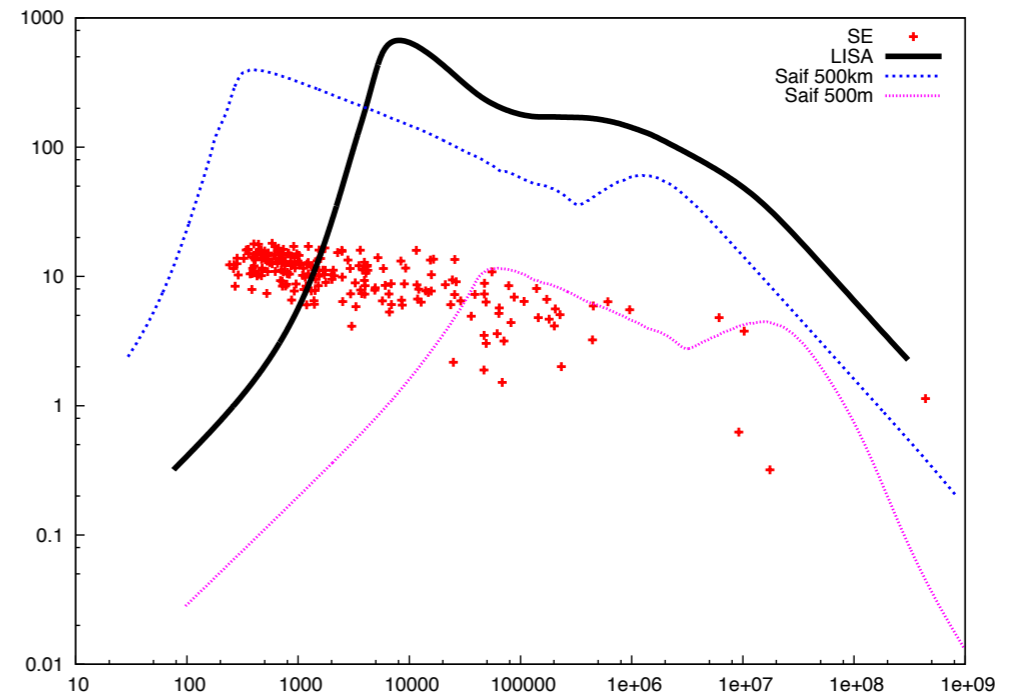
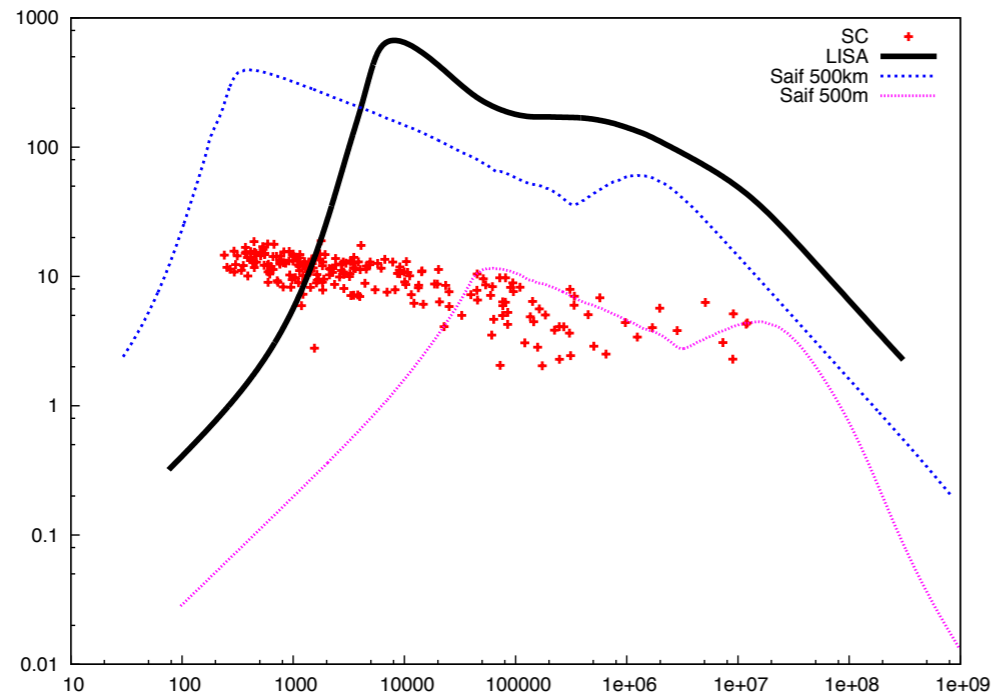


$M$



# Group 4: Massive BH Horizons

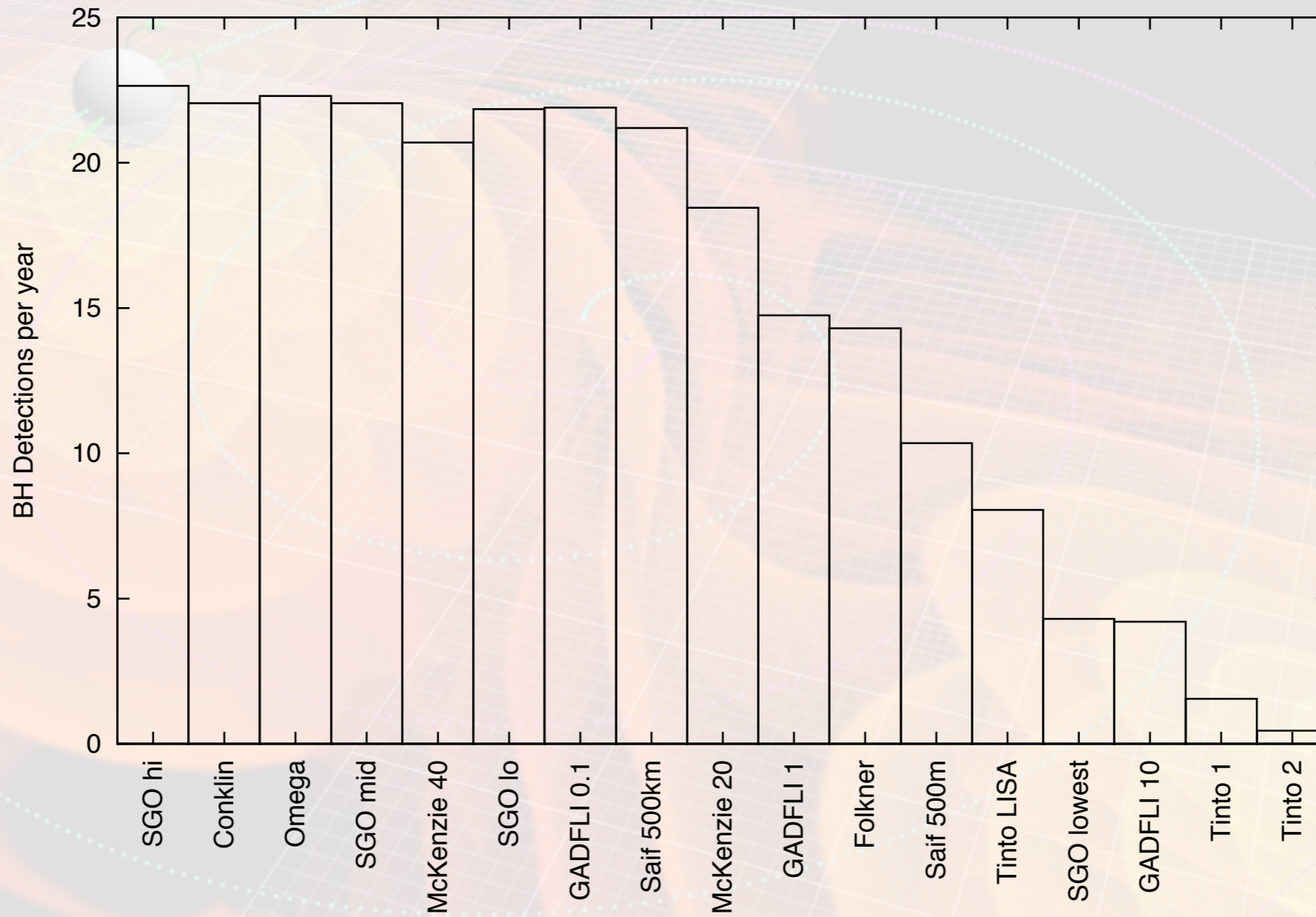
$\mathcal{Z}$



$M$

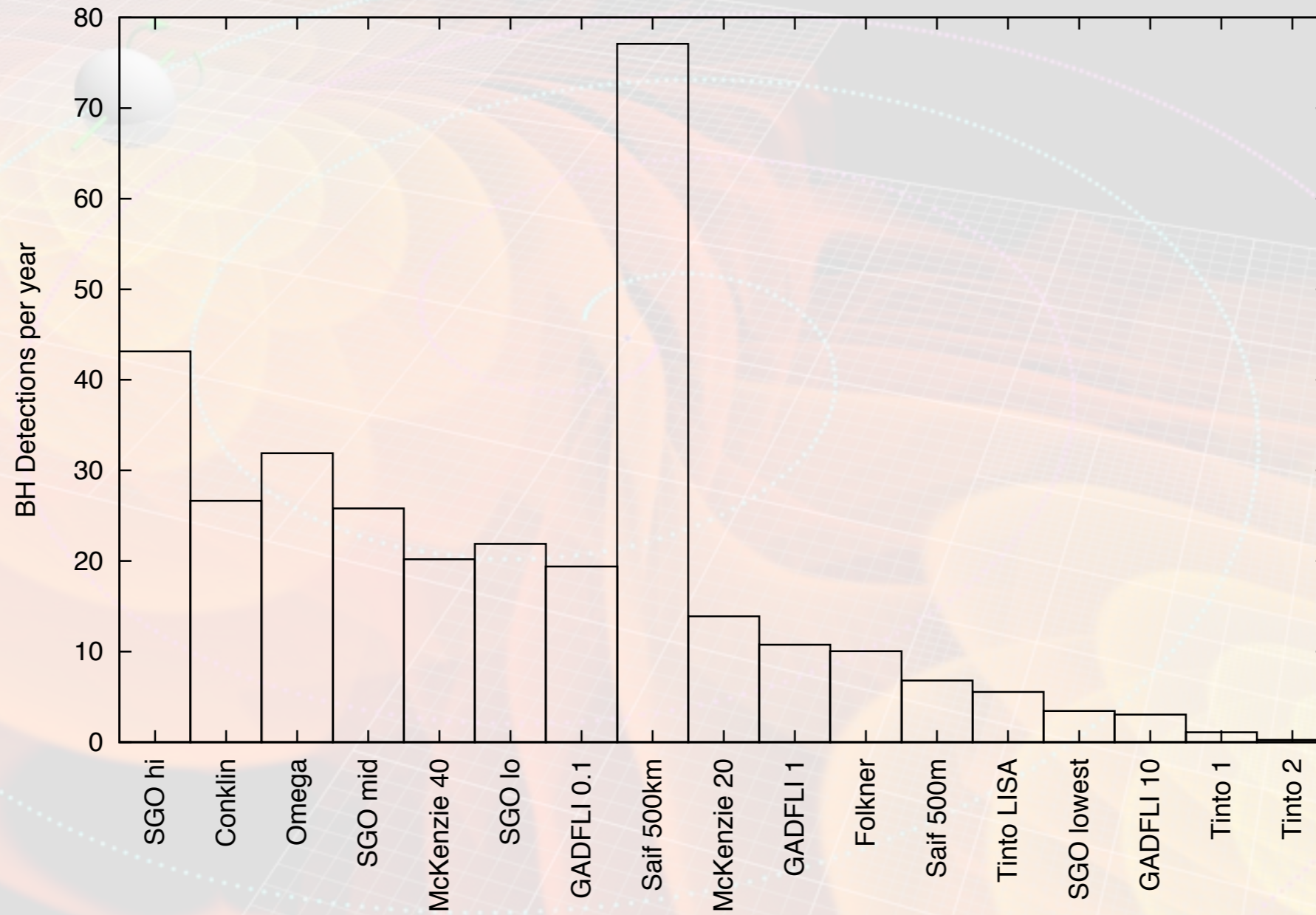
# Massive BH Detection #'s

## Large Seed Models

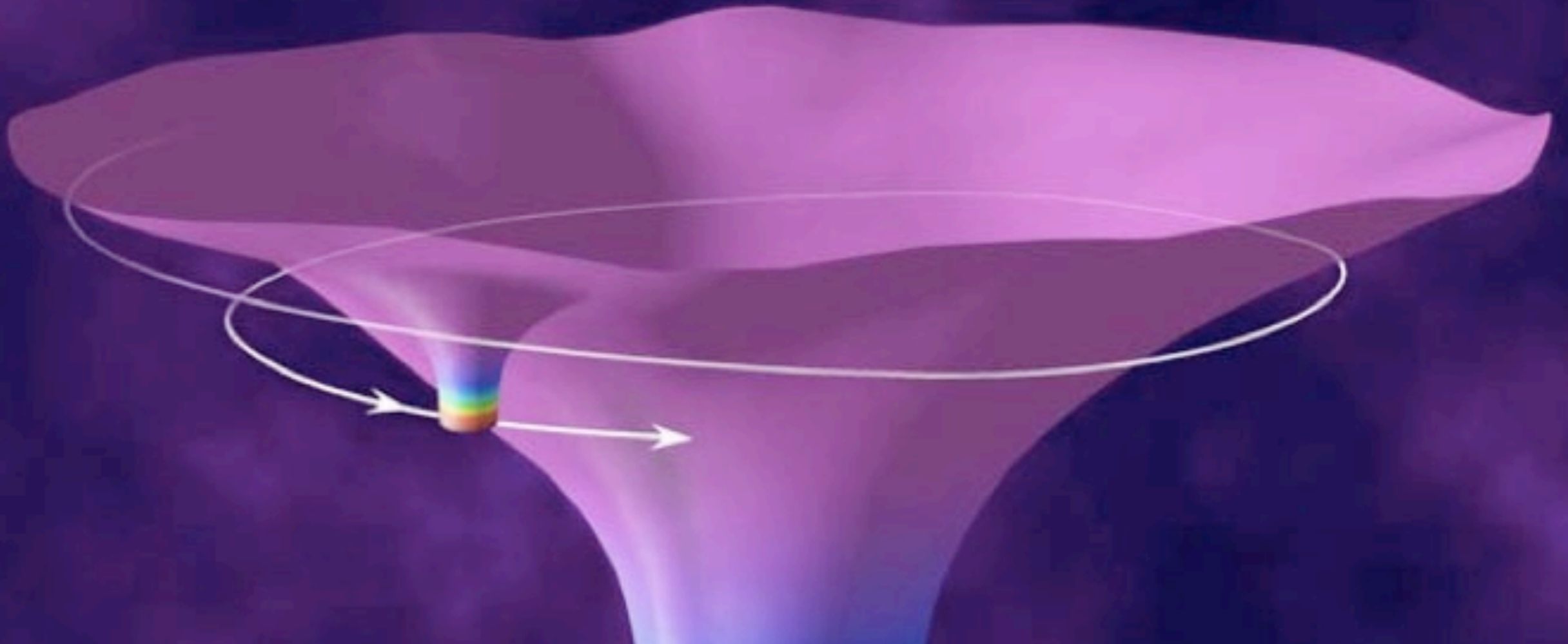


# Massive BH Detection #'s

## Small Seed Models

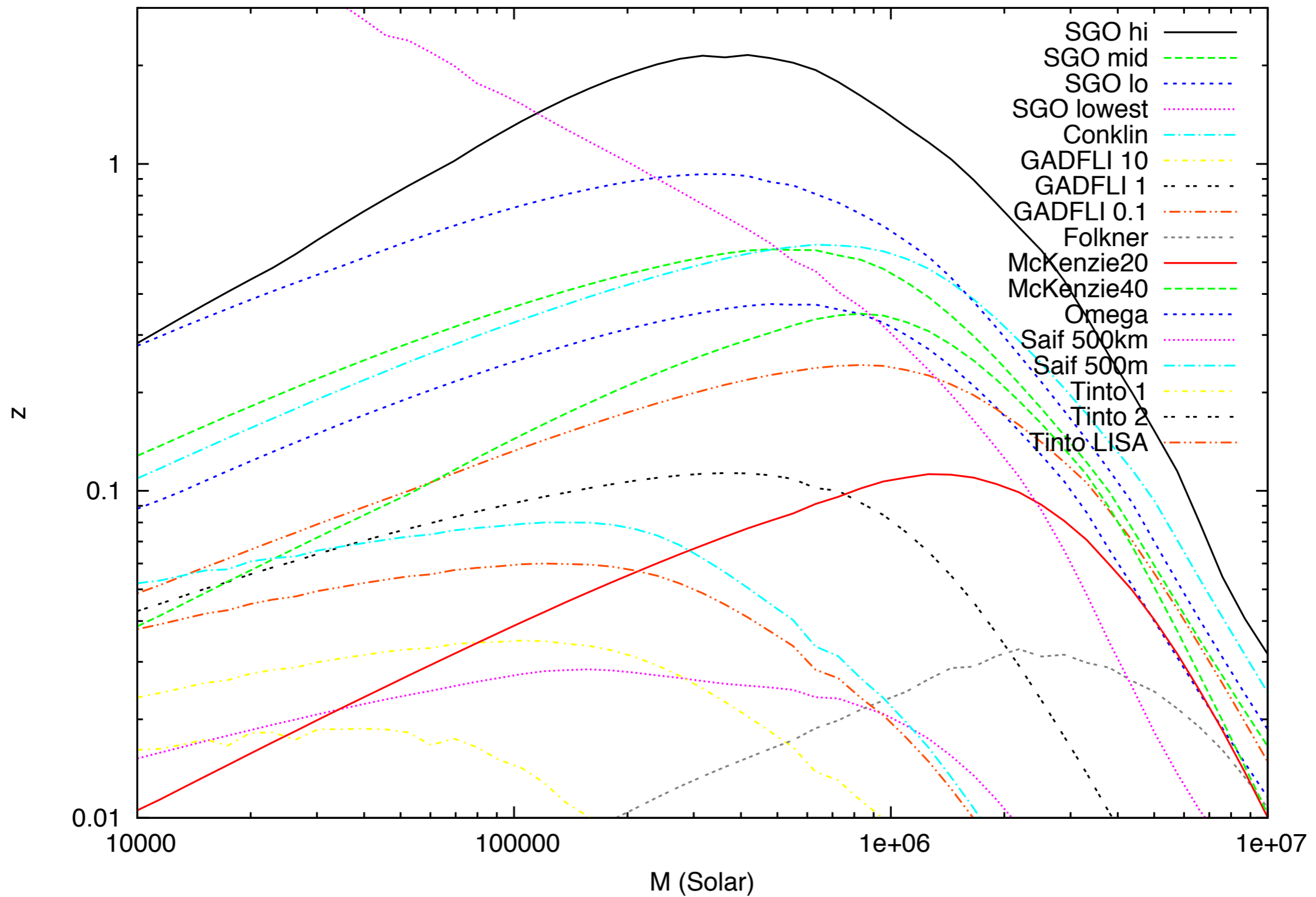


# EMRI Horizons

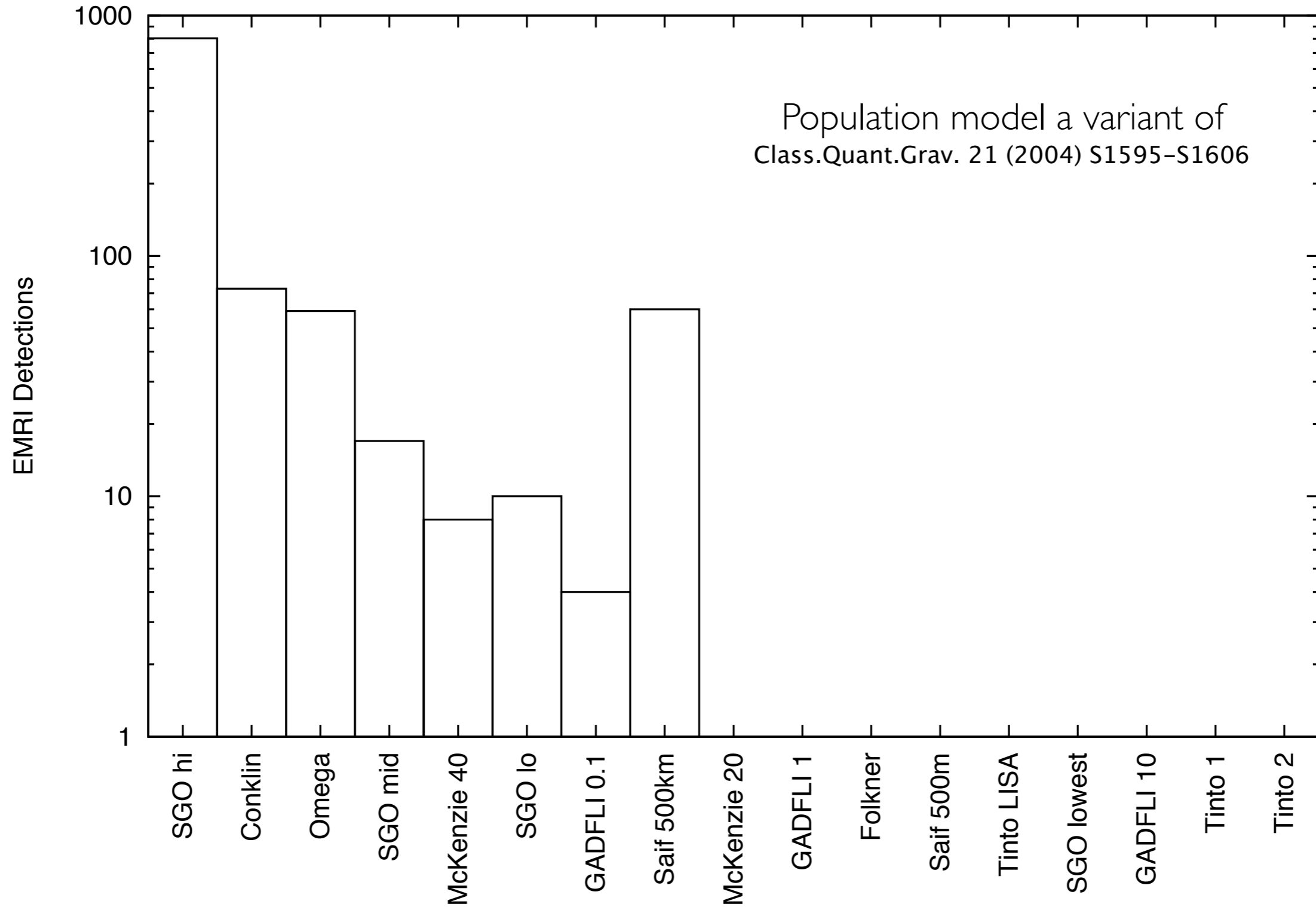


Fiducial System:  $10 M_{\odot}$  compact object, eccentricity 0.5 at 2 years before plunge. Spin 0.5 central BH. Barack-Cutler waveforms. SNR = 15 Threshold.

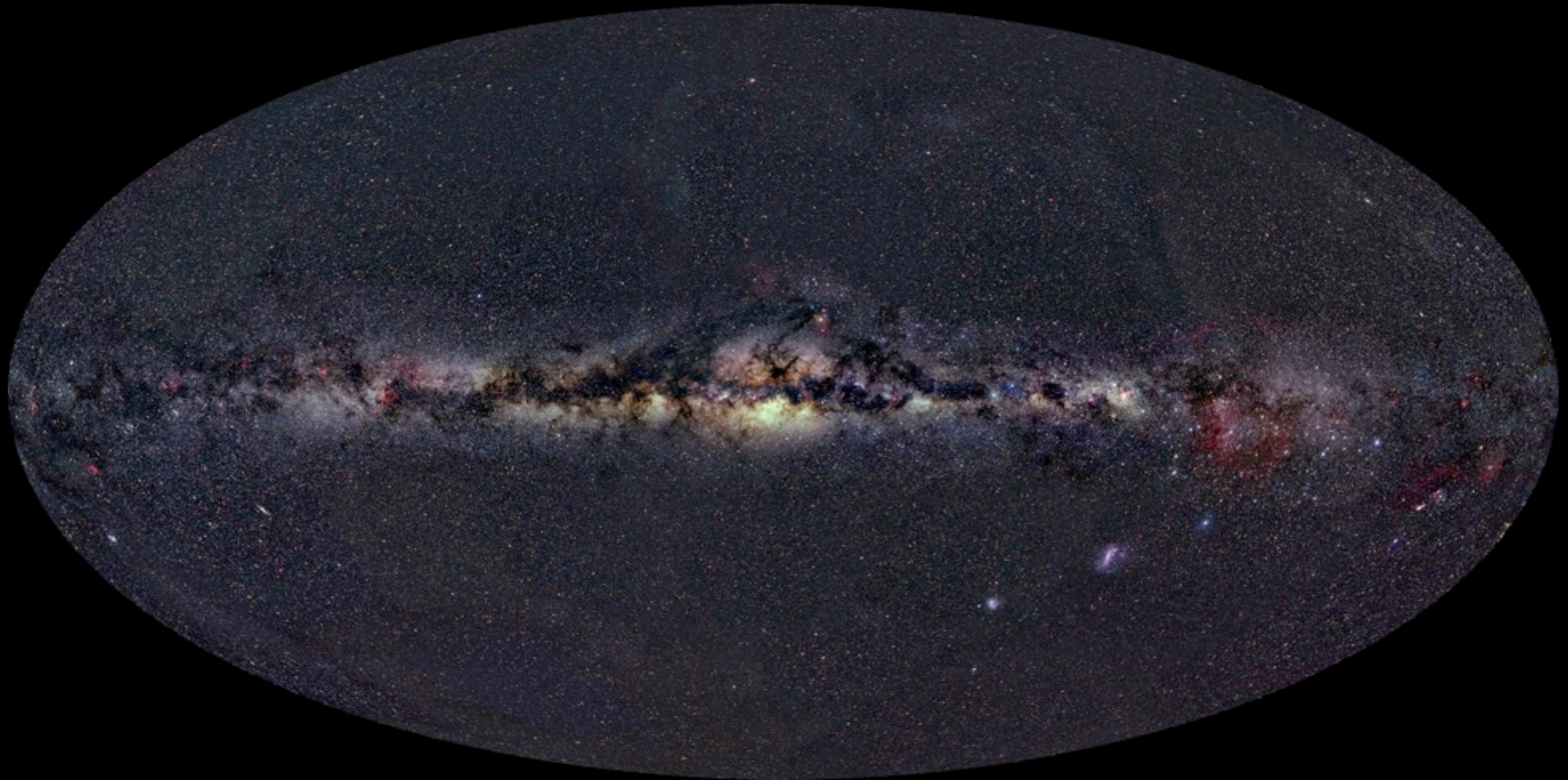
# EMRI Horizons



# EMRI Detections

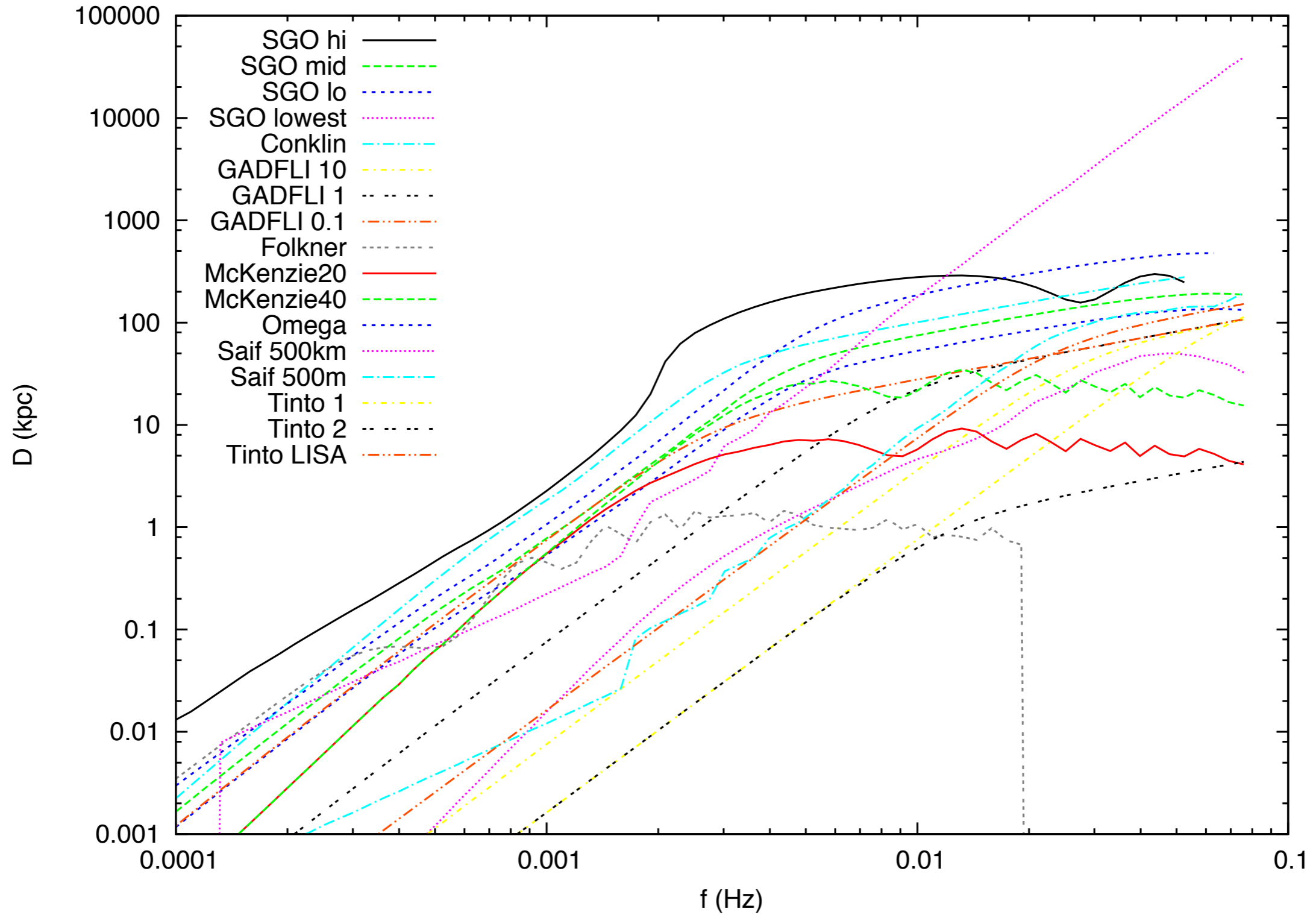


# Galactic Binaries



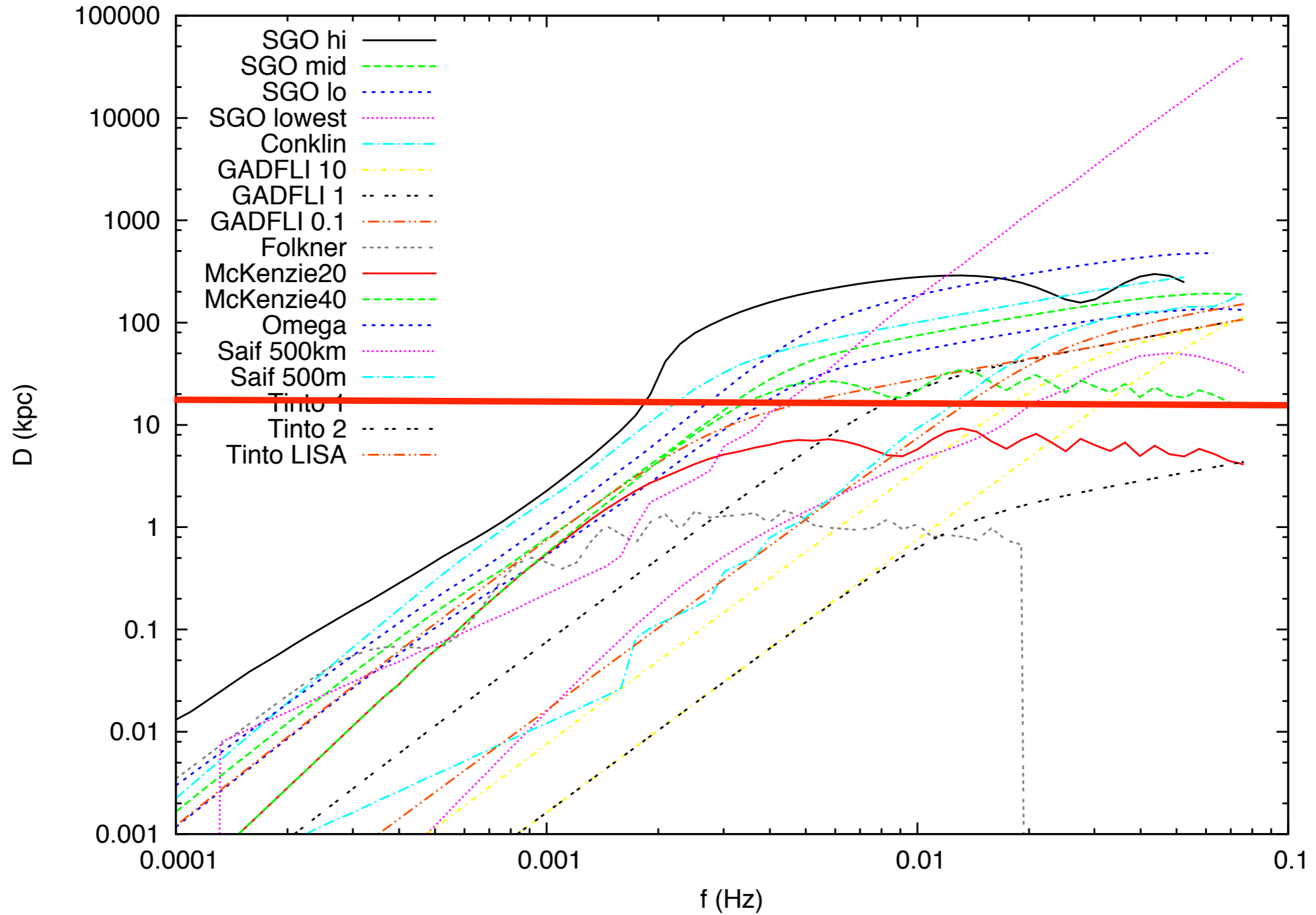
Fiducial Systems: 0.5-0.5  $M_{\odot}$  White Dwarf Binary  
10-10  $M_{\odot}$  Stellar BH Binary  
SNR = 7 Threshold

# WD-WD Horizons

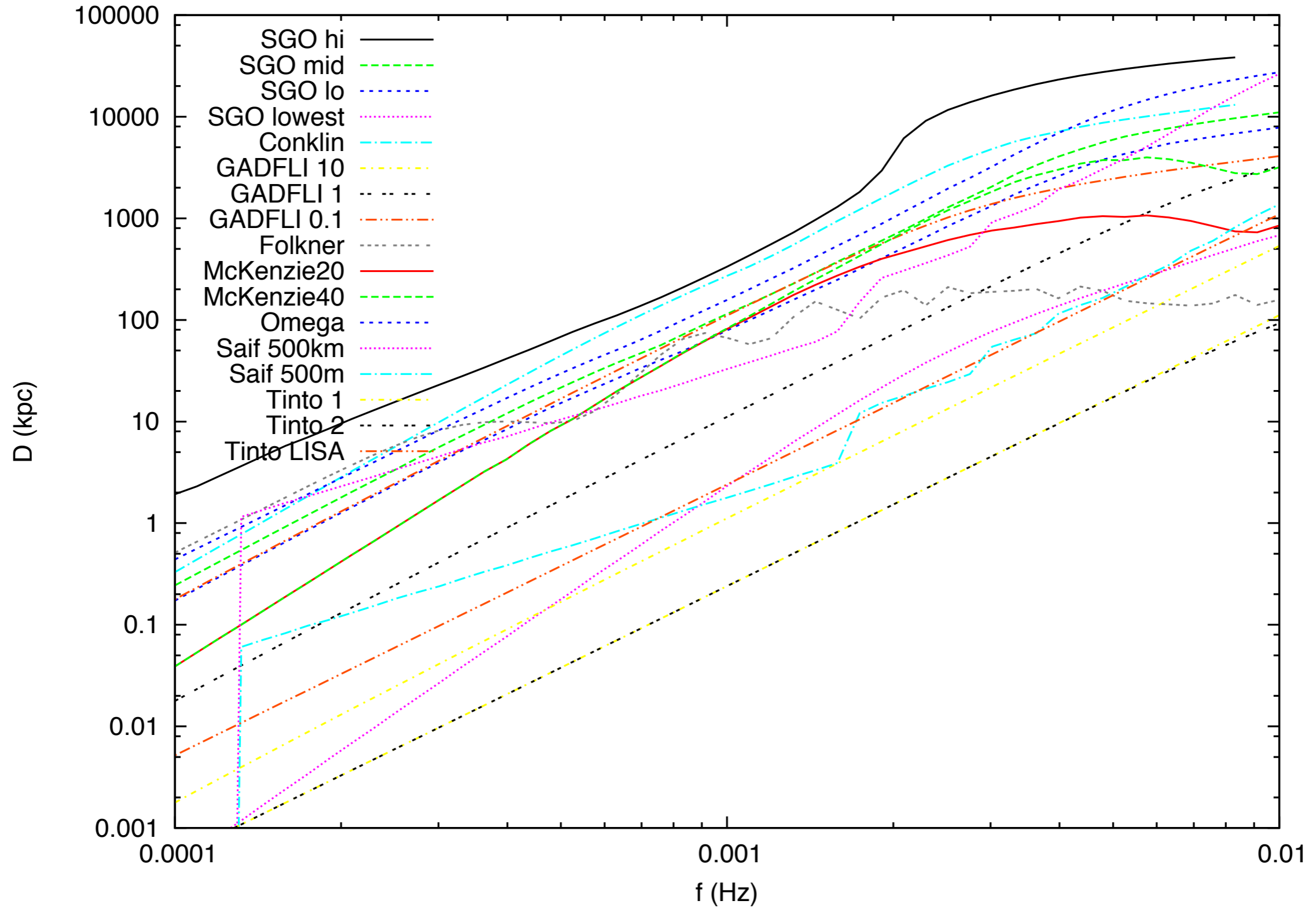




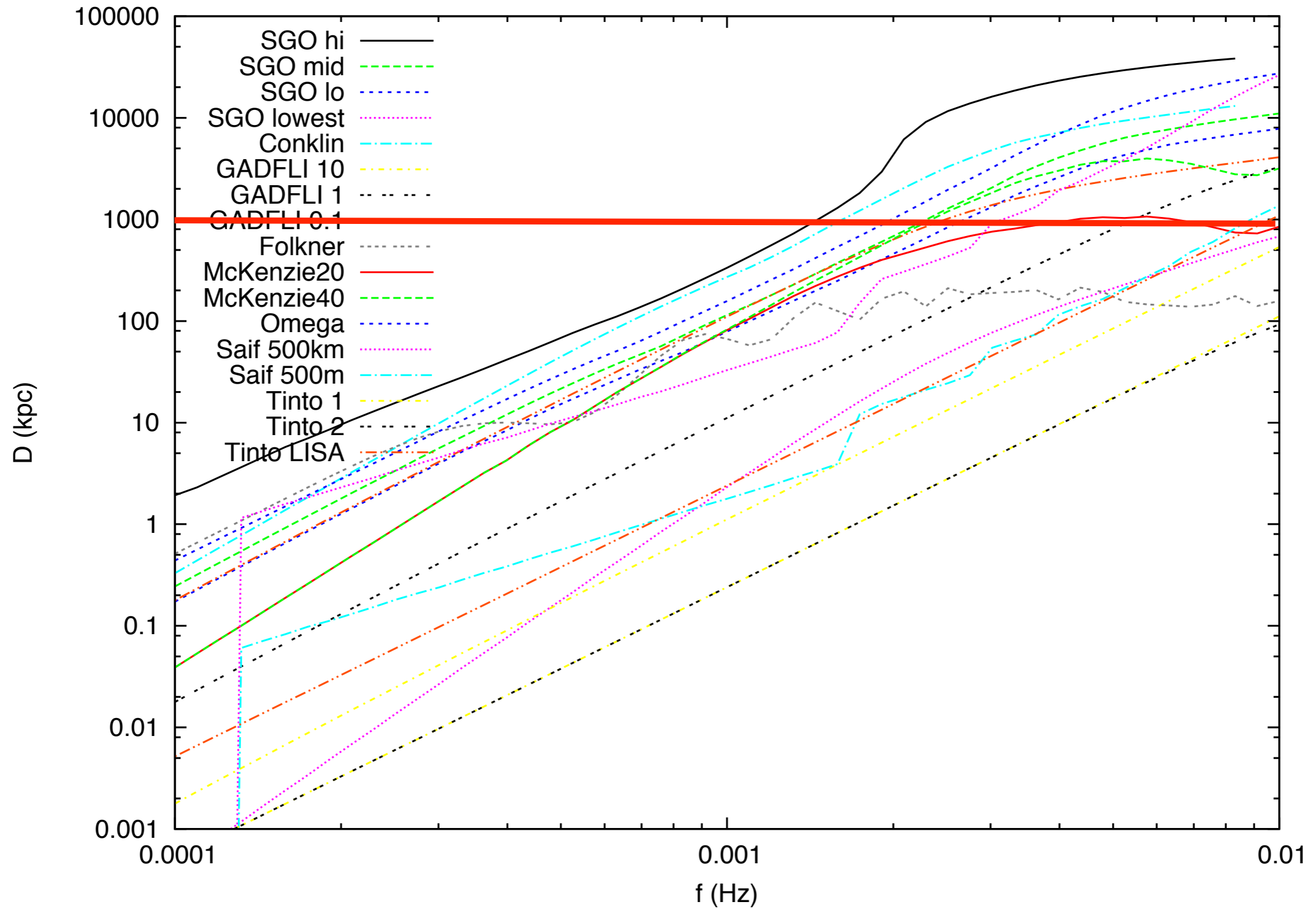
# WD-WD Horizons



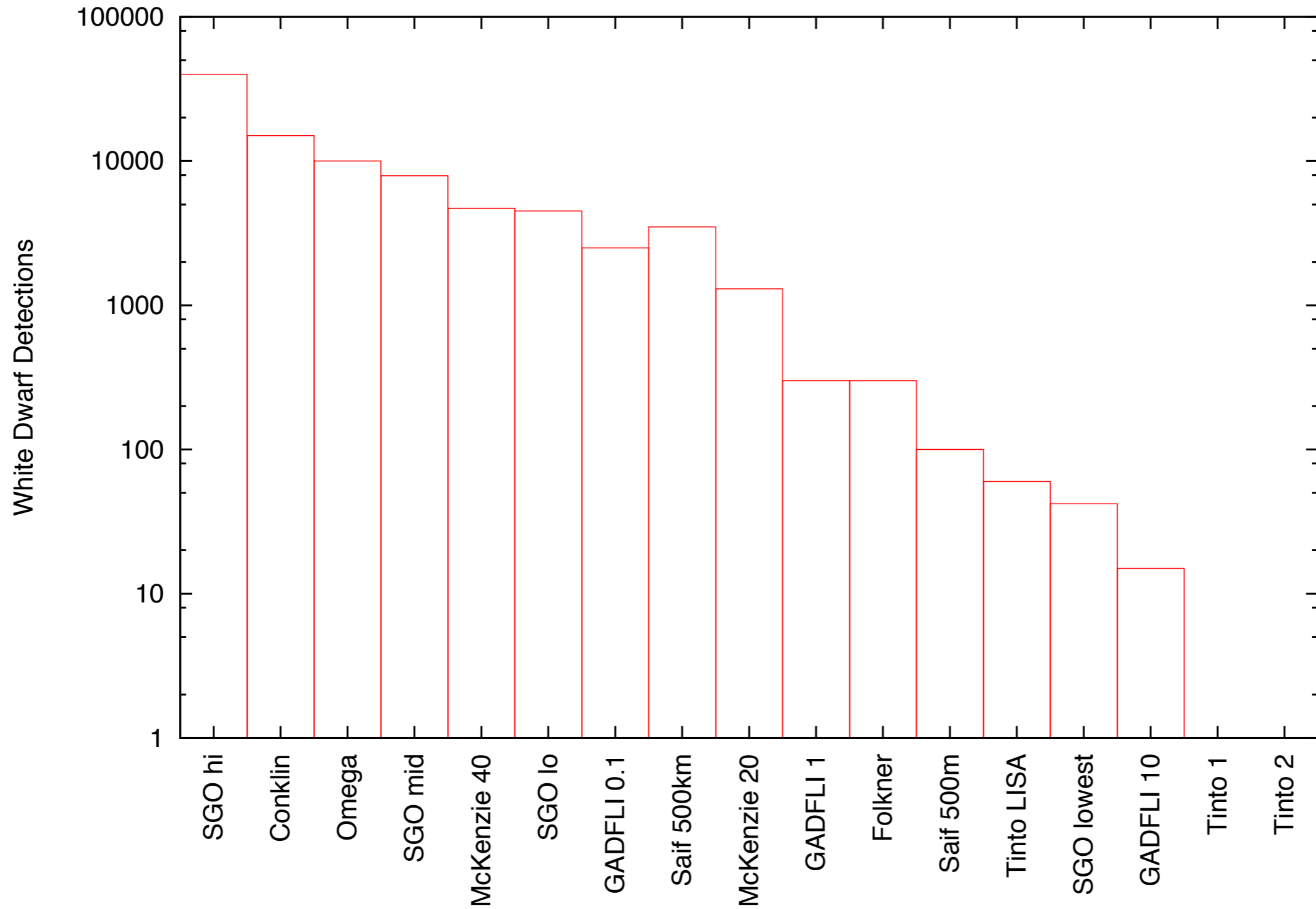
# BH-BH Horizons



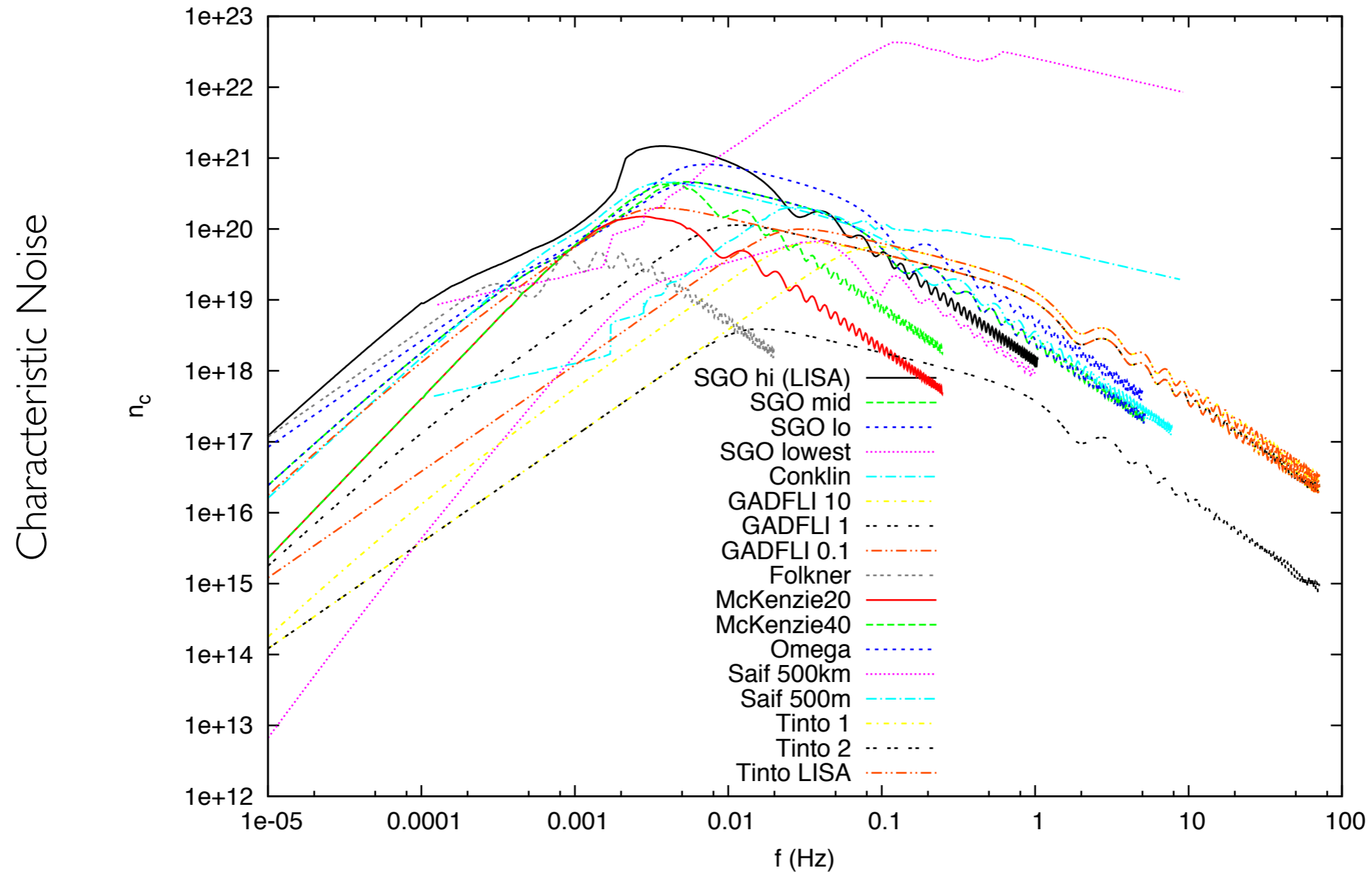
# BH-BH Horizons



# WD-WD Detection #'s



# Discovery Space



How do we measure discovery space?

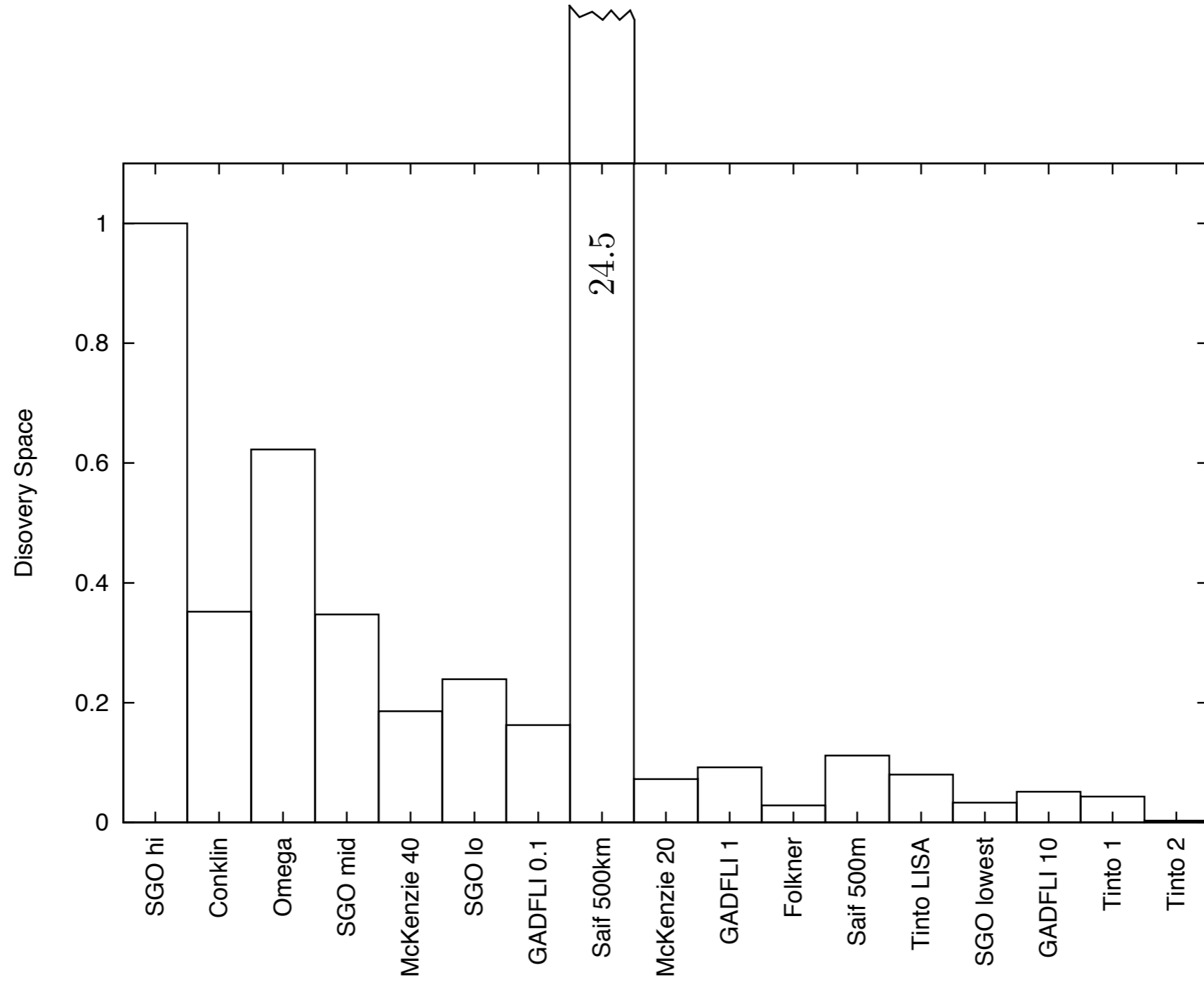
# Discovery Space

How do we measure discovery space?

Recall: 
$$\text{SNR}^2 = \int \frac{h_c^2}{f S_n(f)} d \ln f$$

Define: 
$$\text{DS}^2 = \int \frac{d \ln f}{f S_n(f)}$$

# Discovery Space



# Parameter Estimation

## Quality versus Quantity

Factors that enter:

- Signal to Noise ratio
- Duration of Signal
- Number of interferometers
- Orbital modulation
- Arm length

Big impact on massive BH science.  
EMRIs/WVDs ok if detected at all.

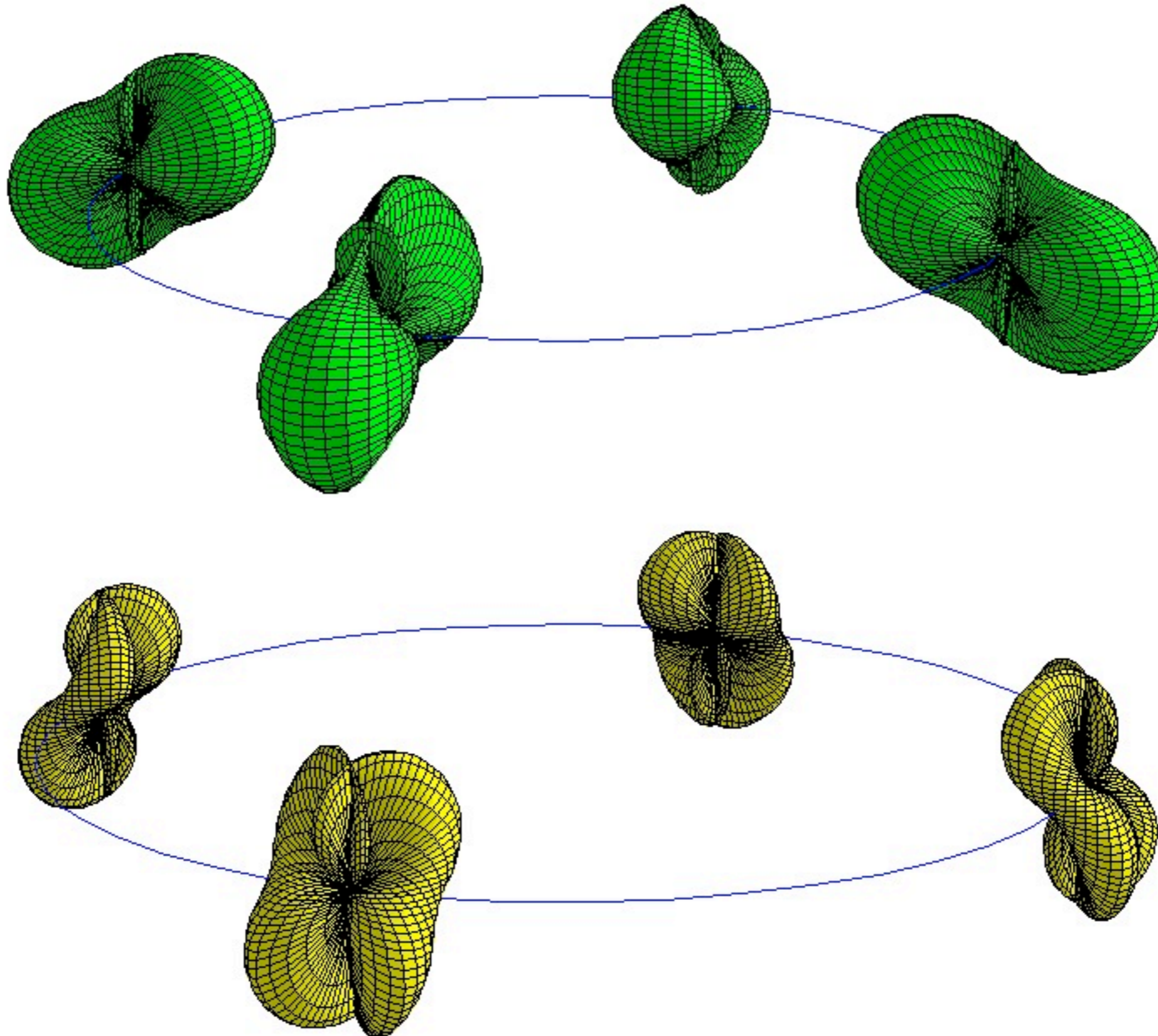


# Parameter Estimation

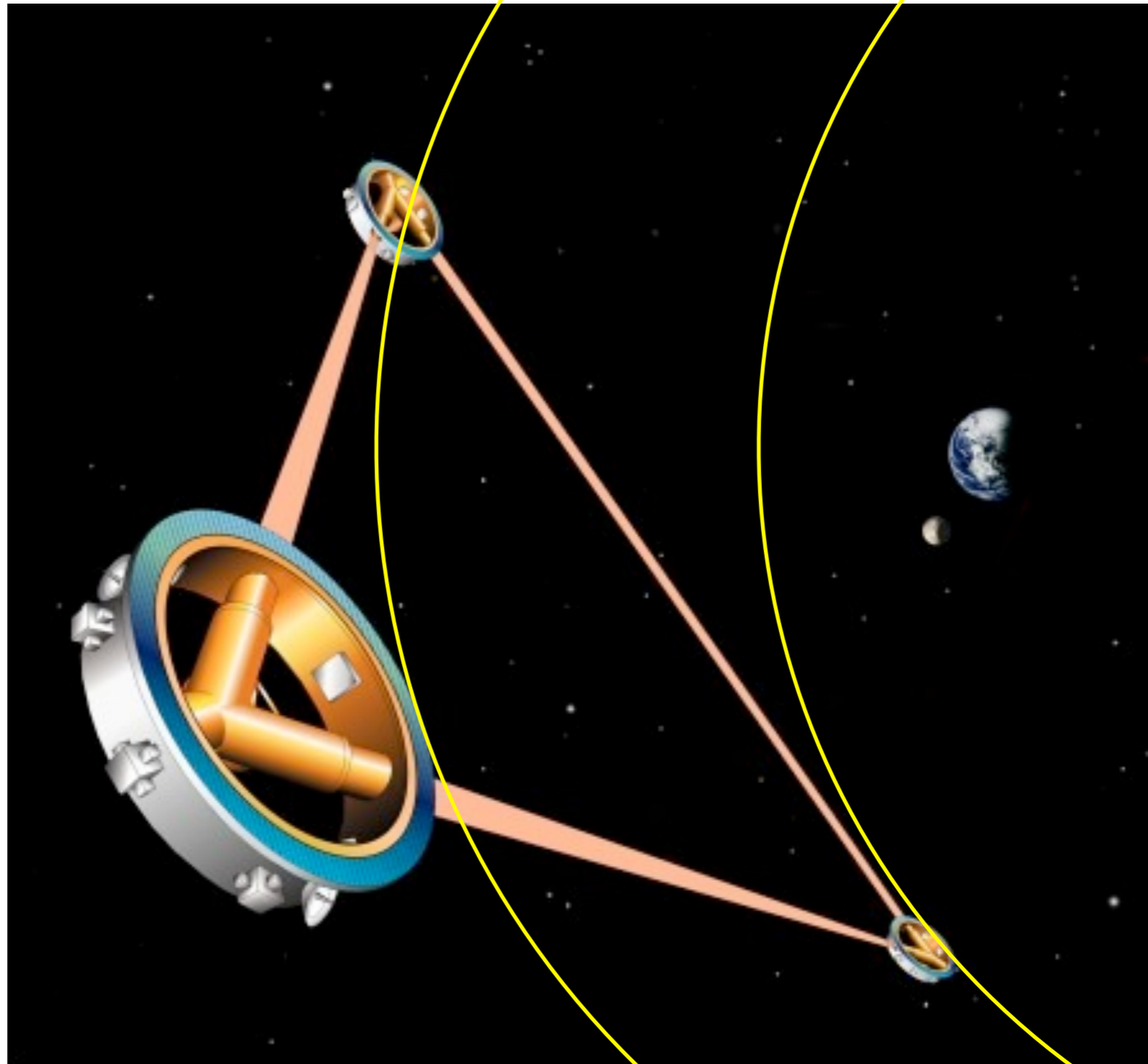
## Quality versus Quantity



# Parameter Estimation

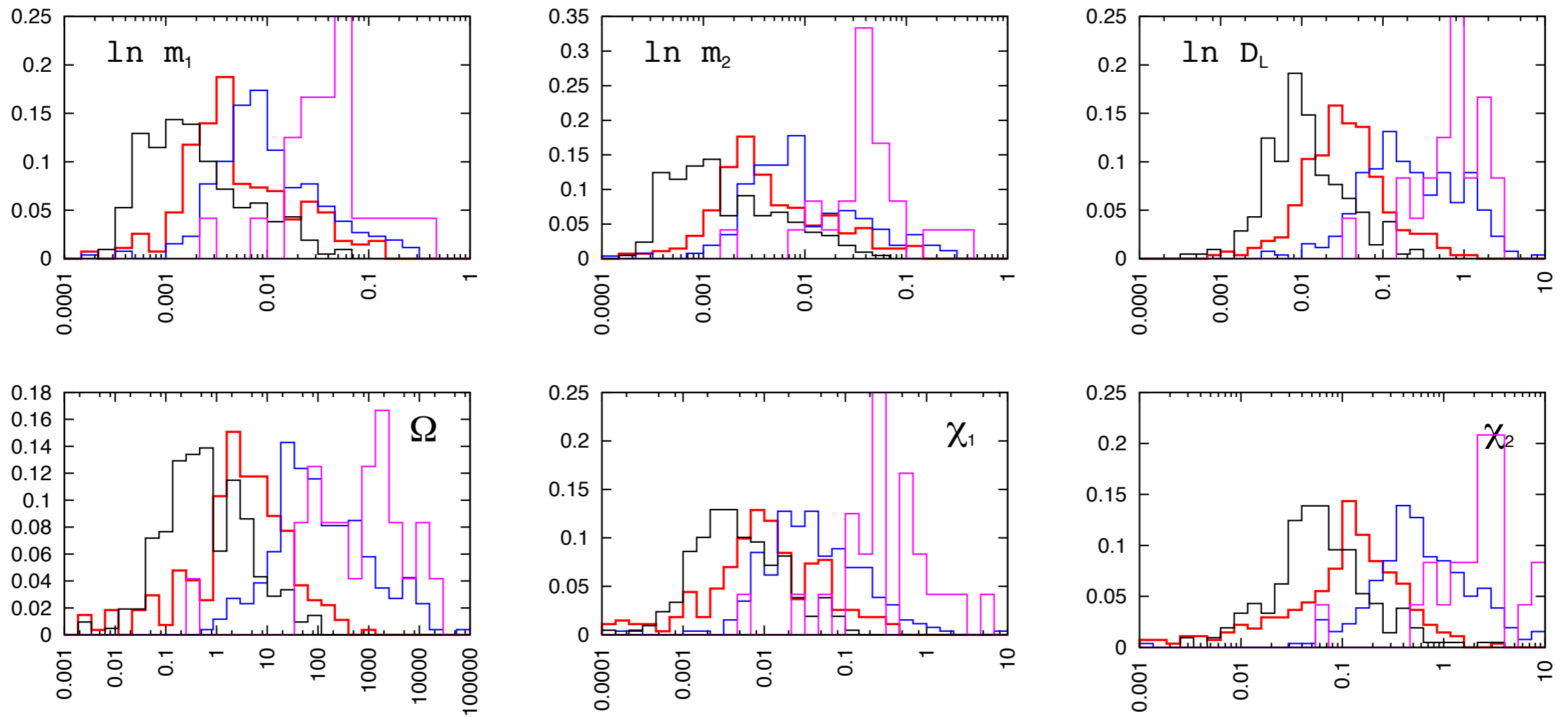


# Parameter Estimation



# Parameter Estimation

## Massive BHs, LISA-like missions



SGO hi   SGO mid   SGO lo   SGO lowest

Similar detection numbers, but each descope  $\times$  3-10 loss in resolution