Science Performance: Preliminary Results

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Science Metrics

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

![Sensitivity Curves Diagram](image-url)
17 Sensitivity Curves

Note: These are taken directly from the RFIs, and in some instances have proved impossible to reproduce.
Group 1:
No drag free (Long Arm)
Group 2: Geocentric (Short Arm)
Group 3: LISA variants

\[ S_h(f) \propto f^{-1/2} \text{Hz}^{-1/2} \]

where \( S_h(f) \) is the power spectral density.
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
Group 1: Massive BH Horizons
Group 2: Massive BH Horizons

$M$

$z$
Group 3: Massive BH Horizons

\[ \begin{align*}
M &\quad 10 & 100 & 1000 & 10000 & 100000 & 1e+06 & 1e+07 & 1e+08 \\
S &\quad 0.001 & 0.01 & 0.1 & 1 & 10 & 100 & 1000 \\
G &\quad 0.001 & 0.01 & 0.1 & 1 & 10 & 100 & 1000 \\
L &\quad 0.001 & 0.01 & 0.1 & 1 & 10 & 100 & 1000 \\
A &\quad 0.001 & 0.01 & 0.1 & 1 & 10 & 100 & 1000 \\
H &\quad 0.001 & 0.01 & 0.1 & 1 & 10 & 100 & 1000 \\
\end{align*} \]
Group 4: Massive BH Horizons
Massive BH Detection #'s

Large Seed Models

BH Detections per year

SGO hi 22
Conklin Omega 20
SGO mid McKenzie 40
SGO lo McKenzie 40
GADFLI 0.1 Saif 500km
GADFLI 1.1 McKenzie 20
GADFLI 2.0 Saif 500m
Folkner Tinto LISA
Tinto SGO lowest
Tinto 1 GADFLI 10
Tinto 2
Massive BH Detection #’s

Small Seed Models

BH Detections per year
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

![Graph showing various curves representing different models and parameters related to EMRI horizons. The x-axis represents mass (M Solar), and the y-axis represents redshift (z). Different models are indicated by distinct line styles and colors.]
EMRI Detections

Population model a variant of
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

The graph illustrates the relationship between distance (D, in kpc) and frequency (f, in Hz) for various models. The models include:

- SGO hi
- SGO mid
- SGO lo
- SGO lowest
- Conklin
- GADFLI 10
- GADFLI 1
- GADFLI 0.1
- Folkner
- McKenzie 20
- McKenzie 40
- Omega
- Saif 500 km
- Saif 500 m
- Tinto 1
- Tinto 2
- Tinto LISA
WD-WD Horizons

The diagram shows a range of models, each labeled with different colors and line styles to represent various sources or configurations. The x-axis represents frequency (f Hz) ranging from 0.0001 to 0.1, and the y-axis represents distance (D kpc) from 0.0001 to 100000.

Lines and symbols indicate different models such as SGO hi, SGO mid, SGO lo, SGO lowest, Conklin, GADFLI 10, GADFLI 1, GADFLI 0.1, Folkner, McKenzie20, McKenzie40, Omega, Saif 500km, Saif 500m, Tinto 1, Tinto 2, Tinto LISA, and others.
WD-WD Detection #'s

White Dwarf Detections

SGO hi, Conklin, Omega, SGO mid, McKenzie 40, SGO lo, GADFLI 0.1, Salf 500km, McKenzie 20, GADFLI 1, Folkner, Salf 100m, Tinto LISA, SGO lowest, GADFLI 10, Tinto 1, Tinto 2
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: \[ \text{DS}^2 = \int \frac{d \ln f}{f S_n(f)} \]
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/WDs ok if detected at all.
Parameter Estimation

Quality versus Quantity
Parameter Estimation
Parameter Estimation
Parameter Estimation

Massive BHs, LISA-like missions

Similar detection numbers, but each descope × 3-10 loss in resolution