Montana Stellar Dynamics Group

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Who we are:

- **The Team: M. Benacquista**
  - Over 10 years experience in source modeling for space-based gravitational wave detection
- **The Institution: Montana State University-Billings**
  - Primarily Undergraduate
  - No physics degree
- **What we offer:**
  - Interest in gravitational wave astronomy
  - Understanding of relativistic binaries in dense stellar systems
  - Connections to other groups outside of the LSC

Interest in Gravitational Wave Astronomy

Some Astrophysical Sources in the LIGO/Advanced LIGO Band

- Intermediate mass black hole ringdown
- Compact object "fly-by's"
- Neutron stars in mass transferring systems
- Stellar mass black hole and/or neutron star binary coalescence

- These can be produced in dense stellar systems

Understanding of Relativistic Binaries in Dense Stellar Systems

- Formation channels for relativistic binaries in globular clusters and other dense stellar clusters
- Astrophysical uncertainties in the evolution of dense stellar systems
- How gravitational wave observations can be used to constrain population models

Connections to Groups Outside of the LSC

- Member of the *Experimental Stellar Dynamics Group* of the VESF
  - Expertise in modeling dense stellar systems
  - Expertise in developing post-Newtonian waveforms for eccentric binaries
  - Access to GRACE at University of Heidelberg
- KITP Scholar (2005-2007)
  - Opportunity to study dynamics of neutron stars
  - Opportunity to study black holes in galactic nuclei

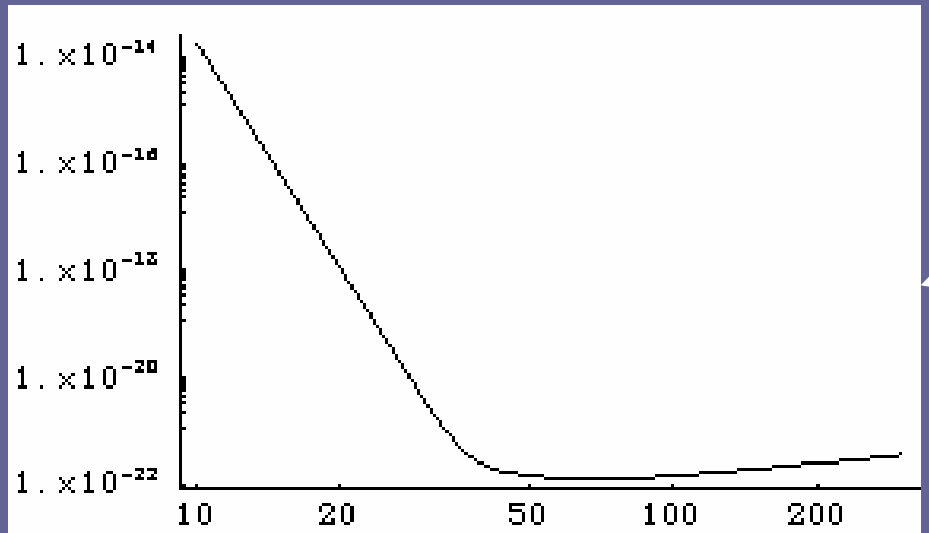
Initial research interest

- The ringdown of intermediate mass black holes (IMBH) at birth or following merger with a stellar mass object is at the low frequency end of the LIGO band.
- Astrophysically interesting as they provide insight into the dynamics of young dense stellar clusters.
  - If the IMBH grows through runaway collisions of MS stars, there is a competition between mass loss through winds and mass gain through collisions.
  - Detection of ringdown would reveal final mass and angular momentum, and likelihood of this scenario.

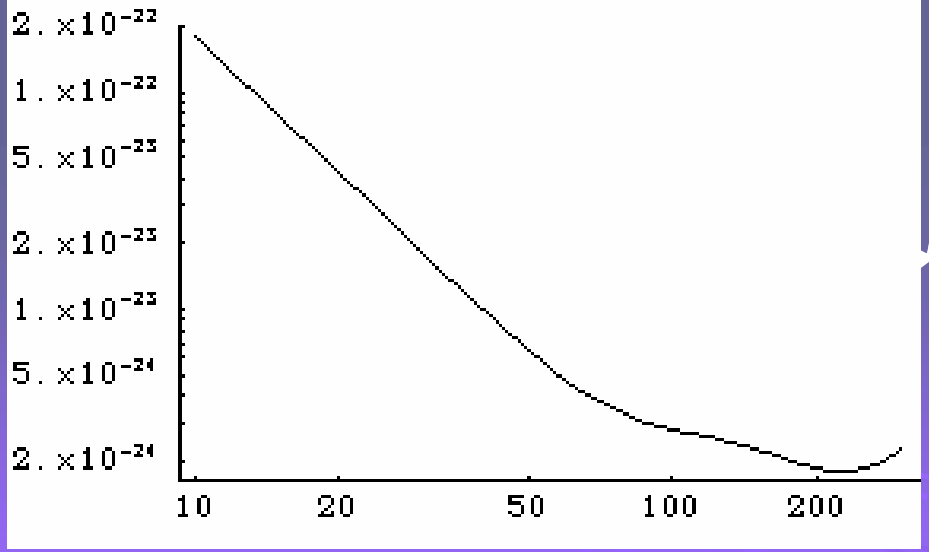
- Use connections with the Experimental Stellar Dynamics Group to explore parameter space for IMBH production scenarios.
  - Cluster potential
  - Stellar density
- Determine the event rate for IMBH ringdowns and the properties of likely host galaxies.
  - Metallicity
  - Merger history
  - etc.

- Use understanding of the current LIGO capabilities to determine detection rates and possible selection effects.
  - Software injections
  - Tune data analysis code
  - Tune coincidence codes
- Determine if LIGO can provide interesting limits on IMBH production scenarios
- Determine if Advanced LIGO can provide more interesting limits on these scenarios

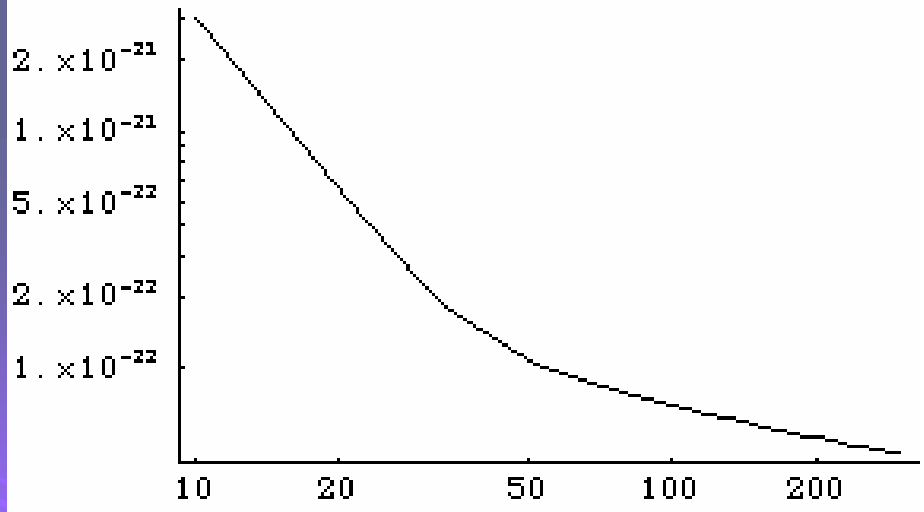
Initial Work with Sensitivity Curves



- LIGO
- Advanced LIGO

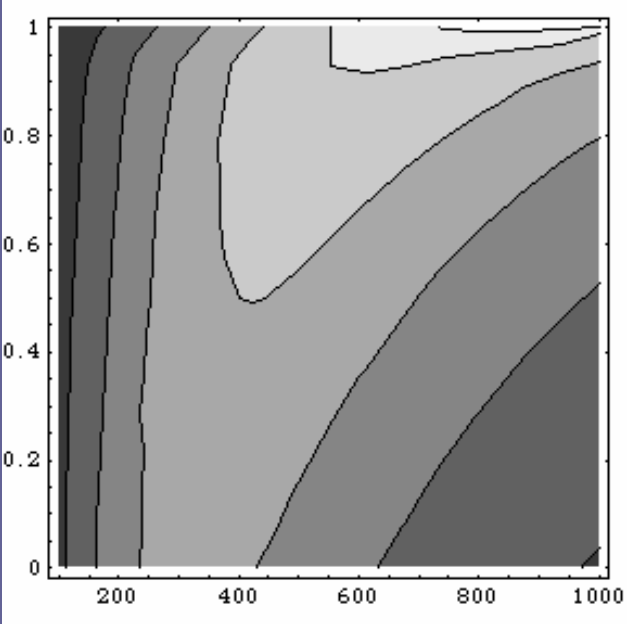


- Virgo

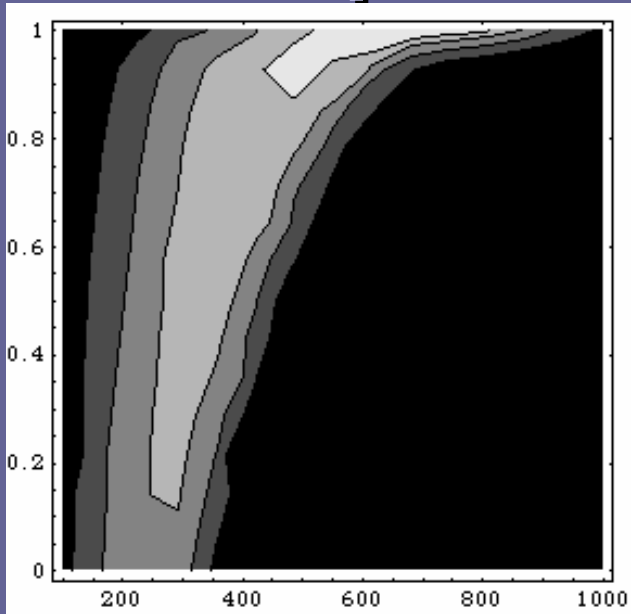


Signal-to-noise at 15 Mpc

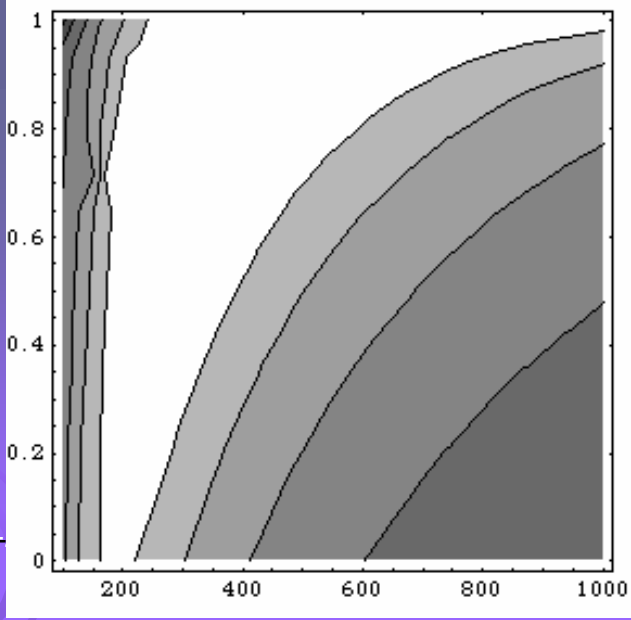
Virgo



LIGO



Advanced LIGO



- Assume efficiency $\varepsilon = 10^{-4}$
- Virgo and LIGO I signal-to-noise contours 2 – 14.
- Adv. LIGO contours $\times$ 10

Summary

The Montana Stellar Dynamics Group has:

- Experience in gravitational wave astronomy
- Connections with other theory groups
- Preliminary work with publicly available sensitivity curves
- A desire to explore detection efficiency using real LSC data and data analysis tools