BUILDING NEXT-GENERATION GRAVITATIONAL WAVE SEARCHES

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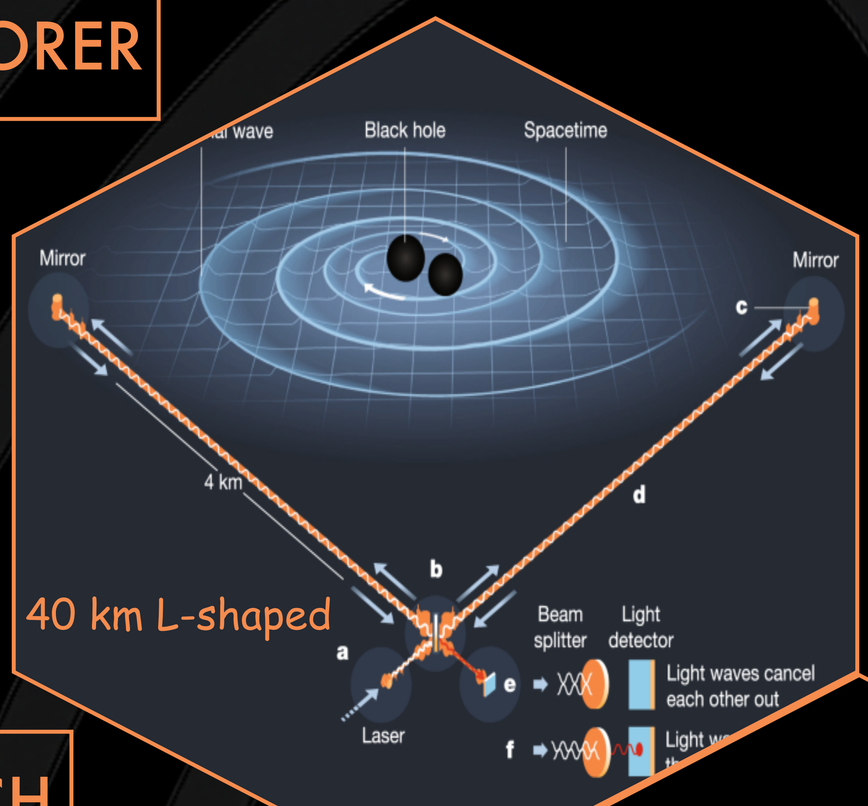
COSMIC EXPLORER



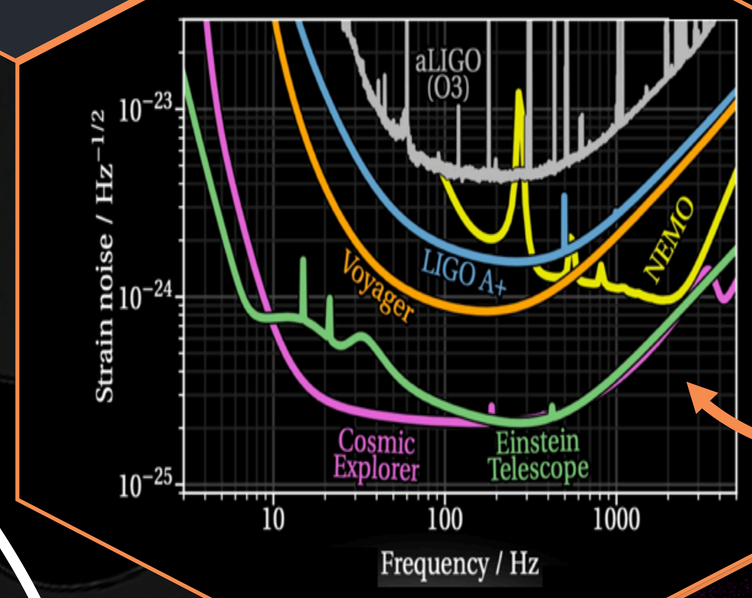
CHALLENGES

- Signals may last minutes to hours in the detector band
- Enhanced low-frequency sensitivity could detect precessing and eccentric binary systems
- Signals will be detected 1 per minute
- Long signals will increase computational cost for detection and Bayesian inference
- High sensitivity will demand improved noise vetoing
- Efficient analysis is crucial for extracting source properties

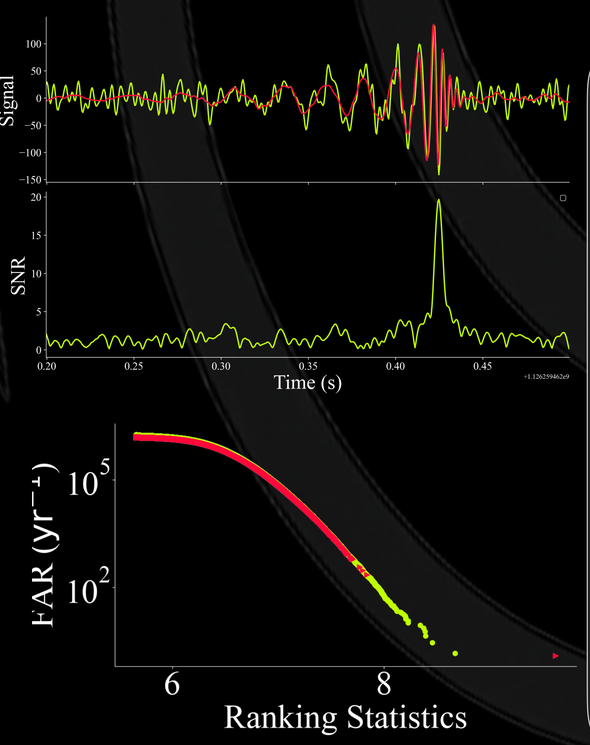
NOVEL SEARCH METHOD

Fully Coherent Bayesian Search Pipeline

- **Develop** a fully coherent Bayesian pipeline for gravitational-wave detection
- **Integrate** with the open-source **PyCBC** GW analysis toolkit
- **Enable** reproducible results for current and future LIGO–Virgo–KAGRA observing runs

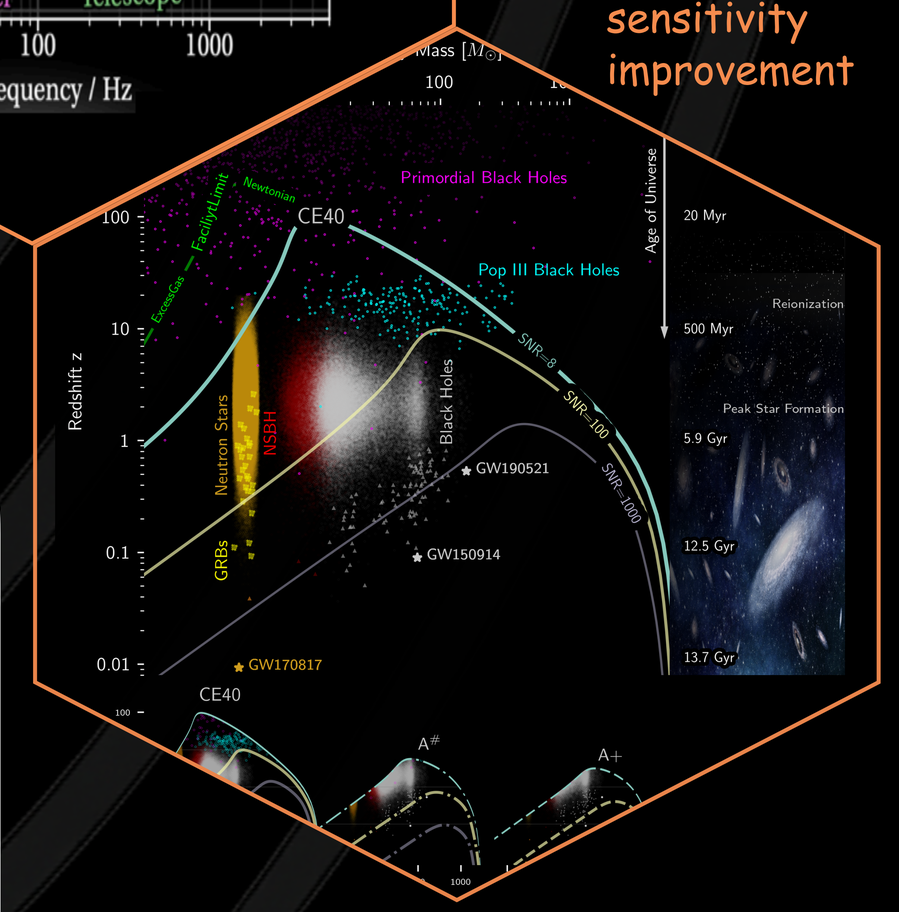


Order of magnitude sensitivity improvement



Stage 1: Candidate Identification

- Multi-detector matched-filter **coarse** search– efficiently maximizing likelihood over intrinsic parameters
- Coherent marginalization over sky location & orientation– use of highly optimized Python or machine learning libraries



Observations of new populations like Population III black holes, primordial black holes

Stage 2: Rapid evidence computation

- Follow up potential candidates from the first stage
- Compute bayesian evidence for the candidate

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NSF U.S. National Science Foundation

References:

- B. P. Abbott et al., Phys Revs Lett., 116, 061102 (2016)
- Evans et al., arXiv:2109.09882 (2021)
- www.ligo.caltech.edu/images
- Reitze et al., arXiv:1907.04833 (2019)
- Soni et al., PhysRevD., 105, 064005 (2022), 109, 024046 (2024)
- Soni & Nitz ApJ **978** 69 (2025)