Cosmic Explorer and the US Astro2020 Decadal Survey

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What is the Decadal Survey?

The National Academies of Sciences, Engineering, and Medicine shall convene an ad hoc survey committee and supporting study panels to carry out a decadal survey in astronomy and astrophysics.

The study will generate consensus recommendations to implement a comprehensive strategy and vision for a decade of transformative science at the frontiers of astronomy and astrophysics.

http://www.nas.edu/astro2020

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The astrophysics community takes the recommendations seriously.

The Decadal Survey ranks projects

...and appraises their construction and operating costs, and their technical risk.

TABLE ES.3 Ground: Recommended Activities—Large Scale (Priority Order)

(example: 2010 Decadal Survey)

Recommendation[b]	Science	Technical Risk[c]	Appraisal of Costs Through Construction[a] (U.S. Federal Share, 2012-2021)	Appraisal of Annual Operations Costs[d] (U.S. Federal Share)
1. LSST —Science late 2010s —NSF/DOE	Dark energy, dark matter, time-variable phenomena, supernovae, Kuiper belt and near-Earth objects	Medium low	$465M ($421M)	$42M ($28M)
2. Mid-Scale Innovations Program —Science mid-to-late 2010s	Broad science; peer-reviewed program for projects that fall between the NSF MRI and MREFC limits	N/A	$93M to $200M	
3. GSMT —Science mid-2020s —Immediate partner choice for ~25% federal share	Studies of the earliest galaxies and galactic evolution; detection and characterization of planetary systems	Medium to medium high	$1.1B to $1.4B ($257M to $350M)	$36M to $55M ($9M to $14M)

We are **not** asking the Survey to rank Cosmic Explorer

The Cosmic Explorer effort is not mature enough right now:

- We don't have a singular design
- We don't have an engineering study
- We don't have detailed cost estimates.

Then what are we asking for?

If the committee feels it is appropriate, the report may comment on areas of technology investment in ground-based gravitational-wave observations that would give the best scientific returns.

https://sites.nationalacademies.org/SSB/SSB_190177

LIGO Lab science whitepaper (March 2019)

The US Program in Ground-Based Gravitational Wave Science: Contribution from the LIGO Laboratory https://arxiv.org/abs/1903.04615

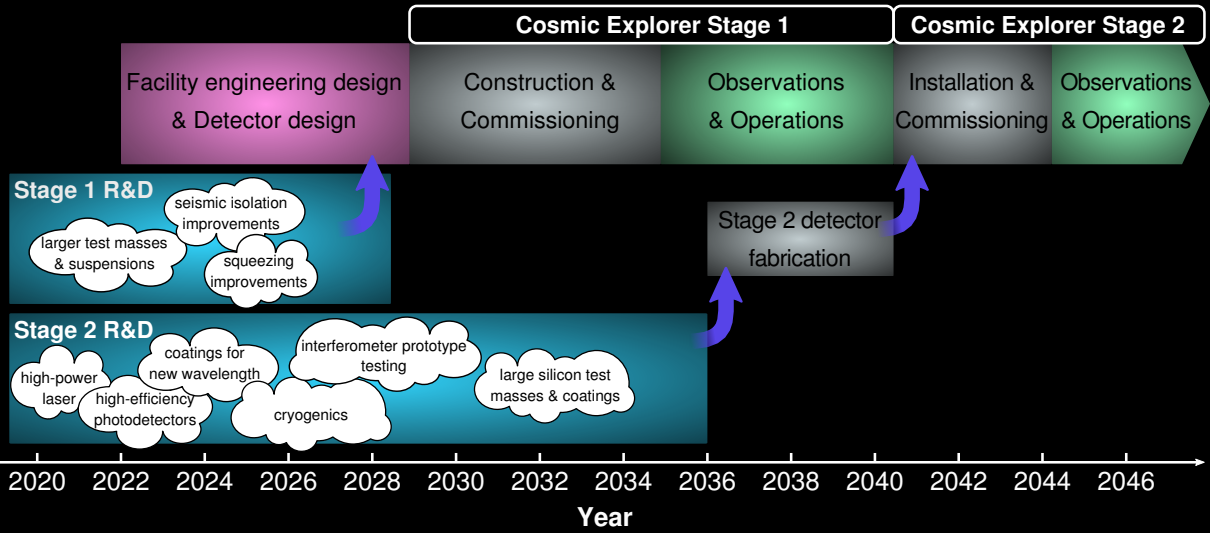
Describes the science case for collecting CBCs

- at high redshift
- with high SNR
- in large numbers

Outlines the two-stage CE timeline

Mentions the need for engineering and costing studies

No mention of dollar values



LIGO Laboratory, (2019), arXiv:1903.04615

Complemented by GWIC 3G whitepapers

Cosmology and early Universe arXiv:1903.09260

Extreme gravity and fundamental physics arXiv:1903.09221

Black hole binaries arXiv:1903.09220

Multimessenger observations of neutron star binaries arXiv:1903.09277

Multimessenger observations of supernovae and isolated neutron stars (magnetars, pulsars, ...) arXiv:1903.09224

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Hinges on several unknowns:

- When will Voyager technology be ready?
- Which detectors will be online after 2025, and with what sensitivity?
- How many facilities would be upgraded to Voyager?
- Under what conditions would the astro community tolerate a multiyear shutdown of 4 km facilities?
- How long would the community tolerate a static detector network?

Technological activity whitepaper („APC") (July 2019)

The Astro 2020 Decadal Survey requests that teams that would like to have an activity, project, or state of the profession consideration evaluated by the Survey submit a 5–10 page document that includes

- Science goals
- Technical overview
- Any new technologies and their expected maturation timescales
- Organization and parterships
- Schedule
- Cost estimates

https://sites.nationalacademies.org/cs/groups/depssite/documents/webpage/deps_193135.pdf

Technological activity whitepaper (July 2019)

Our whitepaper will propose

- an engineering study for Cosmic Explorer (especially of the vacuum and site infrastructure);
- a set of upgrades to laboratory R&D facilities (likely to include, e.g., a cryogenic 2 μm upgrade of the Caltech 40 m prototype);
- a program for site selection;
- a program to establish an international collaboration for constructing and operating Cosmic Explorer; and

and will provide an estimate of costs for the above.

Technological activity whitepaper (July 2019)

We think the total cost of these activities is $\mathcal{O}(10\,\text{M\$})$, but we want a credible number.

Over the next ~month we will engage engineering consultants to refine the estimated cost.

We will submit as a mid-scale ground-based activity—no independent costing evaluation required.

Next steps

The technical activity whitepaper is due July 10.

Longest lead-time item: a credible cost estimate for an engineering study.

We are hoping the Survey will give

- a strong endorsement of ground-based gravitational-wave science generally, and
- a favorable review of the Lab's proposed activities: an engineering study, prototype upgrades, a site selection process, and a program to establish an international collaboration.