Cosmic Explorer Status

David Shoemaker
for the CE Project

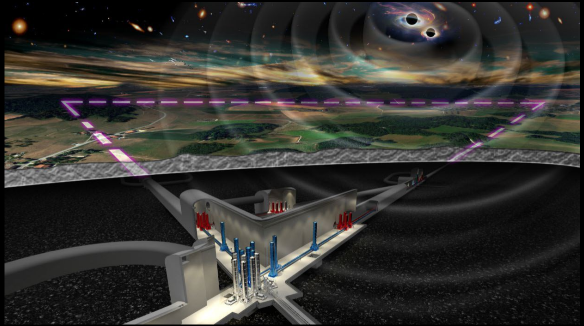
CE-G2500050

Artists: Edward Anaya, Virginia Kitchen, and Angela Nguyen (Cal State Fullerton)

High-Level View

Cosmic Explorer is the US concept for a next-gen gravitational-wave observatory

- 40 km and 20 km L-shaped surface observatories
- 1064 nm @ room temperature
- roughly 10x sensitivity of today's observatories
- Element of global network with ET, LIGO-India, and MMA



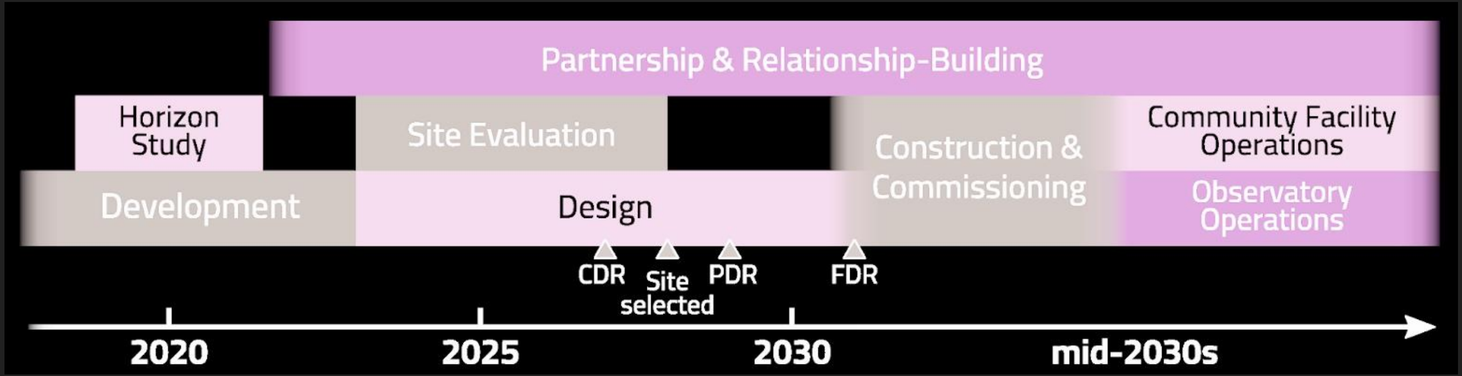
CE is based on, and an evolution from, LIGO

- LIGO-Like observatory and initial detector
- NSF Supported Conceptual Design underway
  - vacuum technology research, site evaluation and responsible siting, detector optical design, mode sensing and control, project management/systems engineering

NSF processes define the possible CE funding path and project timeline

Cosmic Explorer Timeline

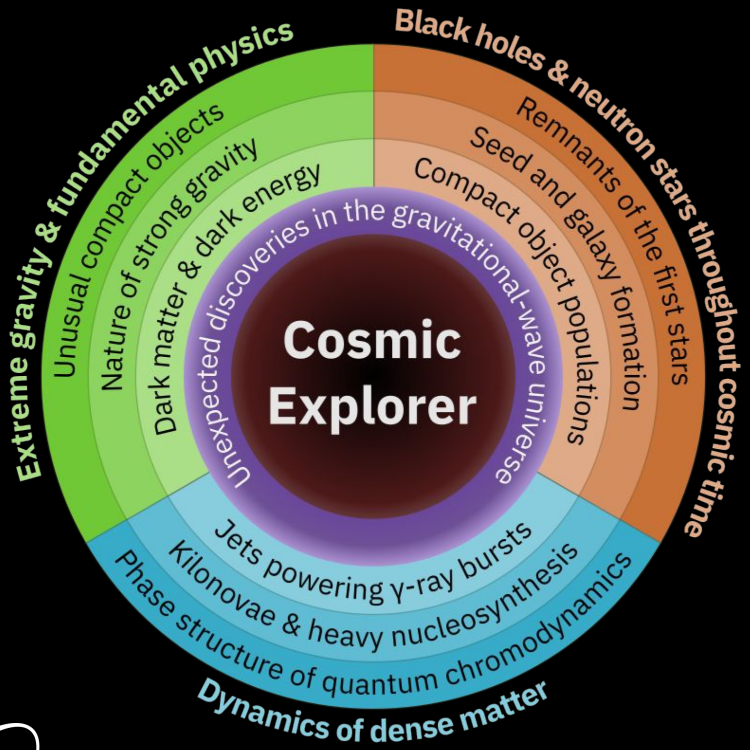
- Plan for Project evolution
  - Conceptual Design (3+years)
  - Preliminary Design ~$75M (2-3 years)
  - Final Design ~$100M (2 years)
  - Construction ~$1-2B (5 years)
  - Operations ~$60M / year (50 years?)
  - Decommissioning/Divestment

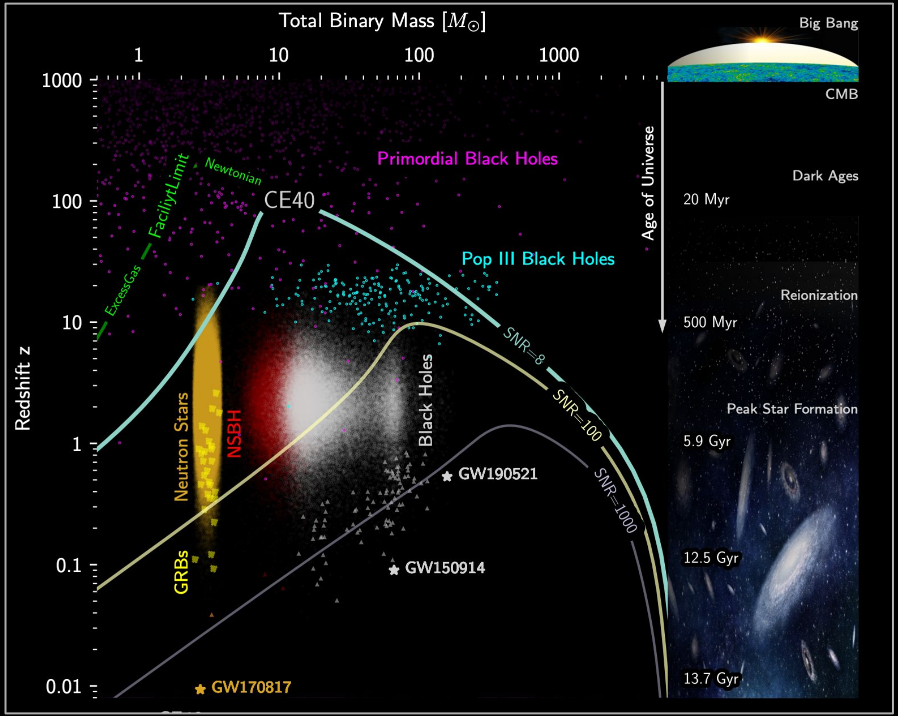


https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf21107

Observational Science

Talk by Alessandra Corsi on Thursday morning 10:45





https://arxiv.org/abs/2109.09882

https://arxiv.org/abs/2306.13745

Cosmic Explorer Design Philosophy

LIGO – Initial, and then Advanced – established an excellent paradigm for Observatory and Instrument design. CE is an evolutionary step forward:

- Design of Observatory and Detector motivated by astrophysics
  - Initial/Advanced LIGO were designed at the limit of technology
  - CE has some degrees of freedom to focus on Astrophysics Goals
  - Enables a true ‘‘Science flowdown’
- Low risk for observatory configuration
  - Huge capital investment required for the Observatory
  - → Scale up LIGO
- Low risk for the initial detector
  - Must have high confidence in quick success with Initial detector
  - 50 year lifetime will allow new ideas for later detectors – Quantum/AI/Cryogenics/etc.

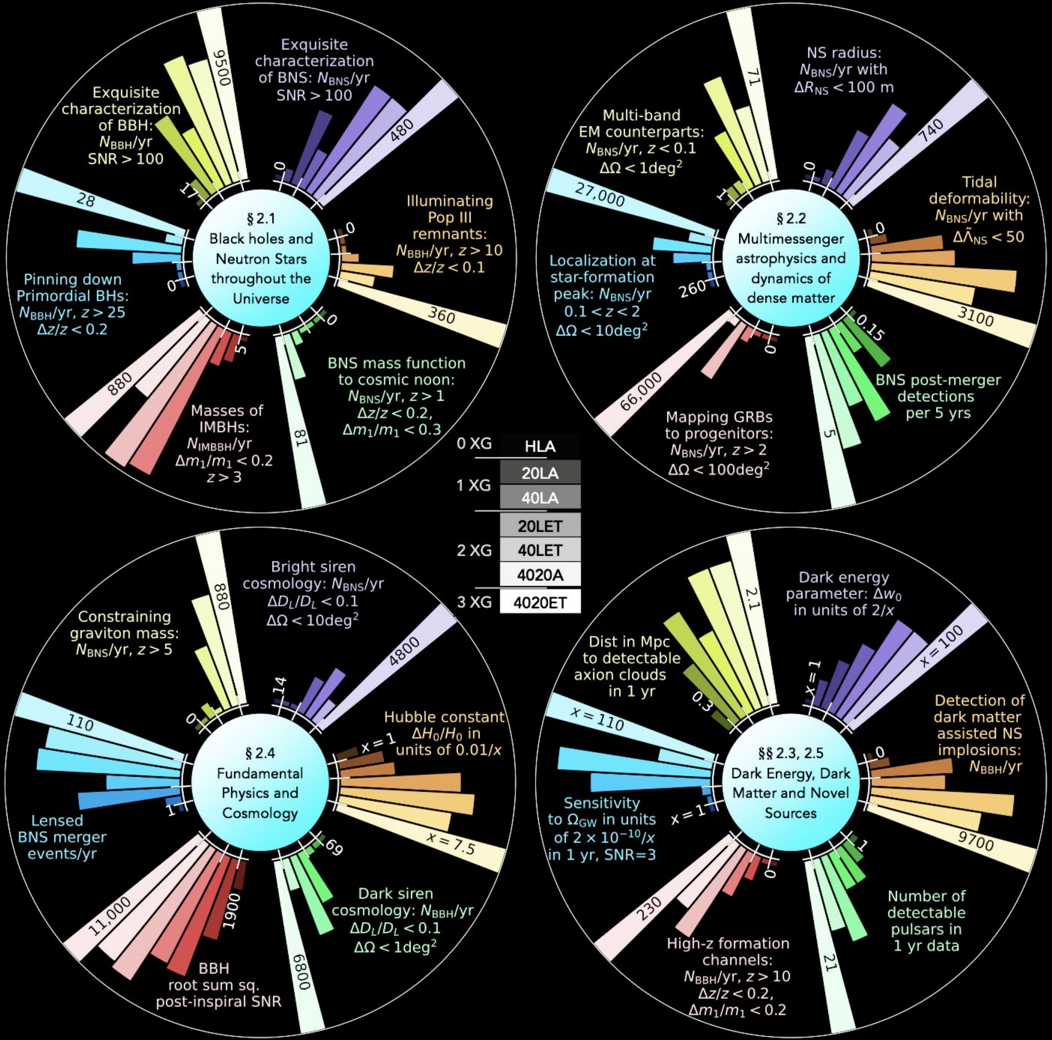
Science Traceability Matrix

Objective: Justify monetary requests with strategic, clearly stated/credible, science goals

- **Science Goals**: From high-level strategy/vision documents.
- **Science Objectives**: The specific science questions we need to answer.
- **Measurement Objectives**: The specific measurements required.
- **Measurement Requirements**: What a measurement must include in terms of content, precision and quality in order to accomplish the measurement objectives.
- **Instrument Technology Requirements**: Identify technology critical for accomplishing the measurement requirements (including detector networks).
- **Data Products**: Define the output of each measurement, including likelihood, Bayesian evidence, Bayes factor, etc.

Science Traceability Matrix

Assessing the Science Objectives



Observatory Design Status

- 10x longer than LIGO
  - 40km baseline (+20km for BNS)
  - Boosts sensitivity x10
- Surface construction
  - Sacrifice some low-frequency sensitivity (Newtonian Noise)
  - Gain length, moderate the cost, maximize future flexibility
- Vacuum system in study
  - Significant NSF funding
  - Collaboration with CERN, ET

Geographical and Sociological aspects: Talks by Joey Key, Warren Bristol, and Laurence Datrier

Artist: Andrew Jenkins, Cal State Fullerton

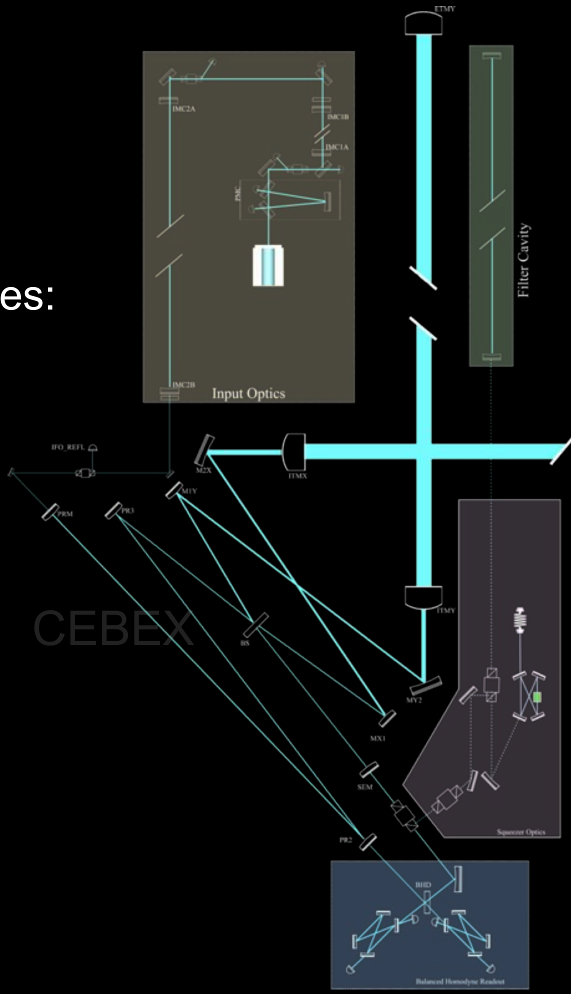
Instrument design

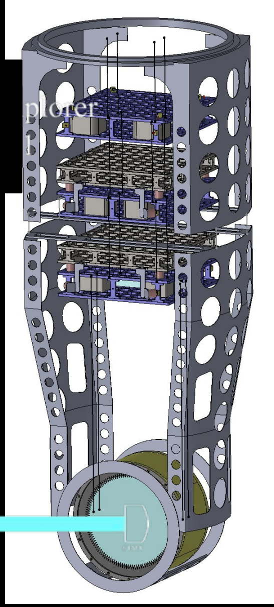
LIGO as ‘prototype’ for CE –
A# upgrade very directly relevant

Current Funded Conceptual Design activities:

- Optical/interferometer design
- Thermal compensation
- Stray light mitigation
- Improved optical coatings
- Lasers and squeezers
- Vibration isolation
- Gravity gradient noise mitigation
- Suspension design
- Digital Architecture

CE IFO





CE SUS

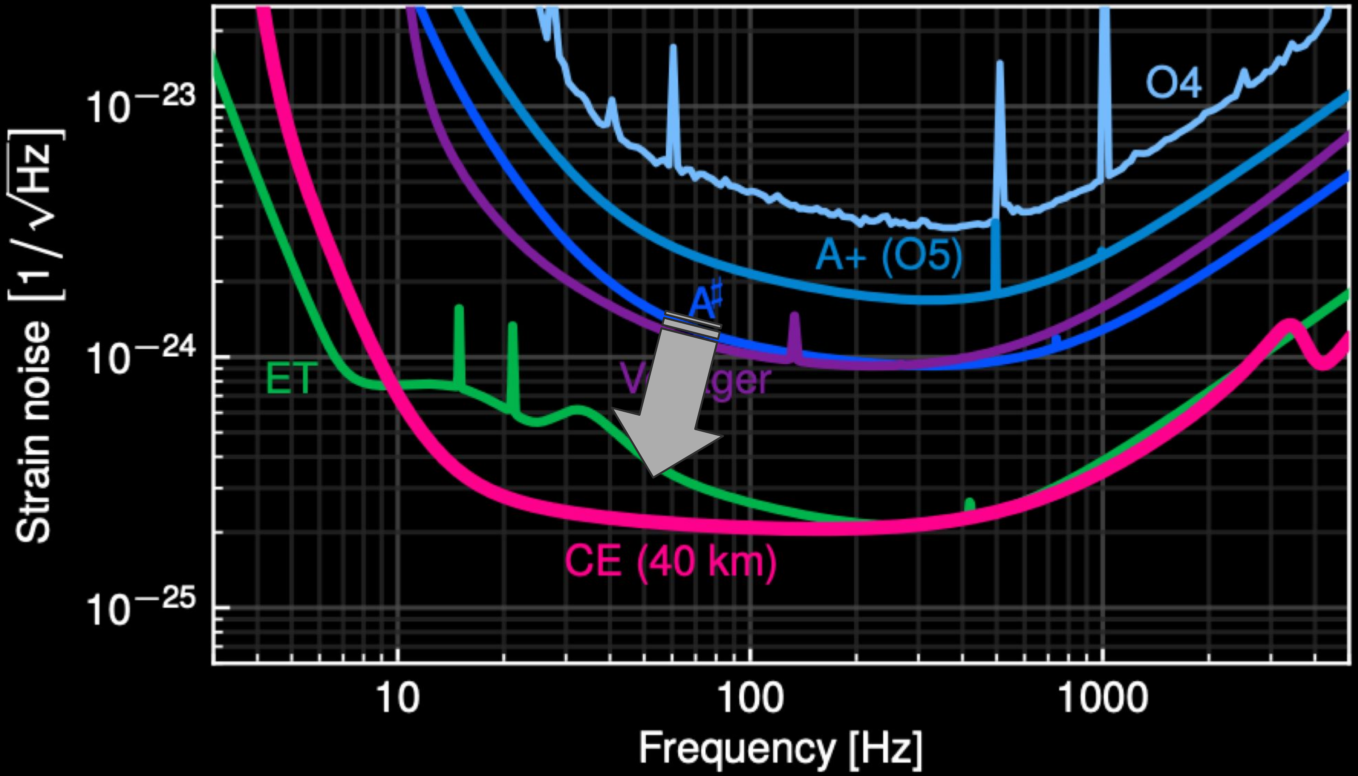
M. Todd, Optical Design Team

A♯ as a pathfinder for Cosmic Explorer

LIGO A♯	Cosmic Explorer
4 km long arms	40 km and maybe 20 km long arms
1.5 MW arm power	1.5 MW arm power
10 dB frequency dependent SQZ	10 dB frequency dependent SQZ
100 kg fused silica test mass	440 kg fused silica test mass
Redesigned QUADs, 160 cm total length, 400 kg total mass, 1.6 GPa fiber stress	Nominally QUADs, 4 m total length, ~2000 kg total mass, 1.6 GPa fiber stress
2× reduction in CTN over A+ coating goal	A+ coating goal
Improved seismic isolation	Improved seismic isolation
2× suppression of Rayleigh wave Newtonian noise	10× suppression of Rayleigh wave Newtonian noise

Detector Sensitivity

Evolution from LIGO to A♯ and Cosmic Explorer



COSMIC EXPLORER

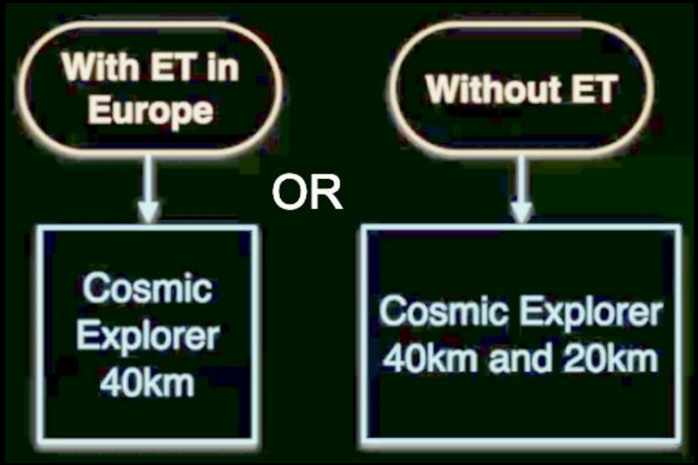
Blue-Ribbon Panel recommendation for CE

Two scenarios:

- With ET in Europe → CE40 only recommended
- Without ET in Europe → CE40+CE20 recommended
- LIGO India an important element of the Network
  - LIGO A# assumed
- *All recommendations include CE!*

What does this mean for CE?

- Continued support and planning by the NSF
- Design work will continue for CE 40km + 20km
- We are working with NSF solicit a full design proposal



credit : Kalogera et al.

NSF MPSAC ngGW report

How can you get involved?

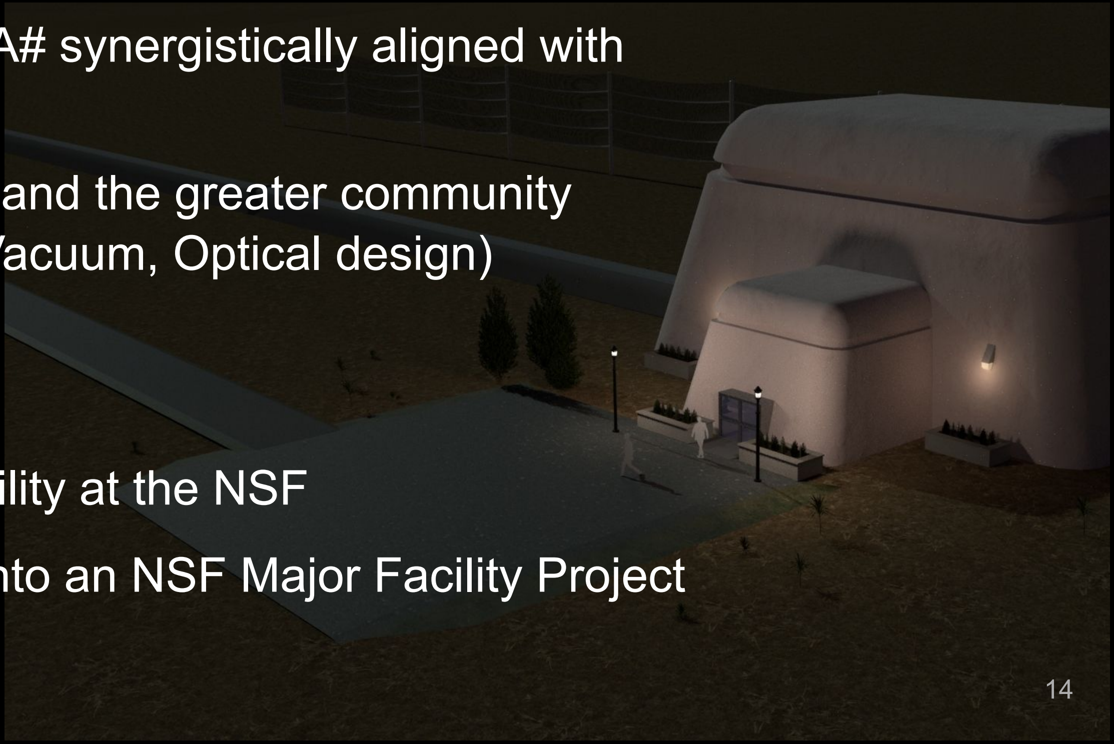
- Join the CE Consortium!
  https://cosmicexplorer.org/consortium.html

- Participate in the CE Science Calls (~monthly)
  https://cosmicexplorer.org/sciencecalls.html

- Join the CE Project… the next round of proposals is in the works!

In Closing…

- We have the basis for a design that delivers great science with low risk
- Technology development for A# synergistically aligned with Cosmic Explorer needs
- We are collaborating with ET and the greater community on multiple topics (Science, Vacuum, Optical design)



- We're looking forward to stability at the NSF

…And for CE to evolve into an NSF Major Facility Project

COSMIC EXPLORER