Cosmic Explorer: A next-generation gravitational-wave observatory in the United States

Joshua Smith (on behalf of the CE Project)
The Nicholas and Lee Begovich Center
for Gravitational-Wave Physics and Astronomy
California State University Fullerton

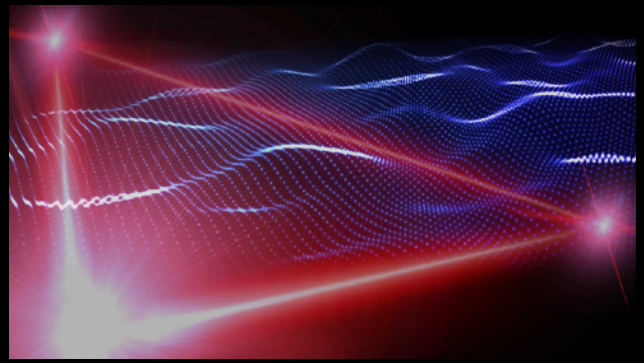
Credit: Edward Anaya, Virginia Kitchen, and Angela Nguyen (Cal State Fullerton)

APS2025 APR-R20
CE-G2500014

Next-generation gravitational-wave observatories

Images courtesy Einstein Telescope, LISA, Cosmic Explorer

Next-generation gravitational-wave observatories

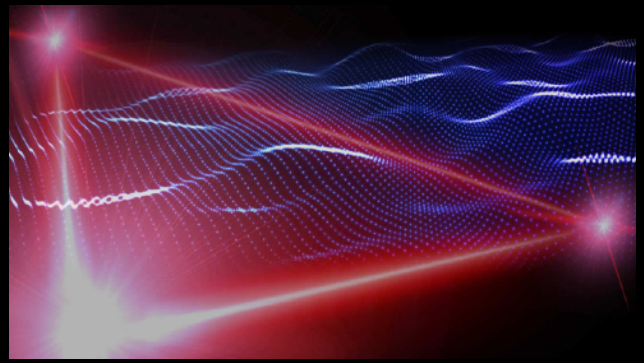


LISA

- 2.5 million km triangular interferometer in space
- GW frequencies 0.1mHz—1Hz

Images courtesy Einstein Telescope, LISA, Cosmic Explorer

Next-generation gravitational-wave observatories



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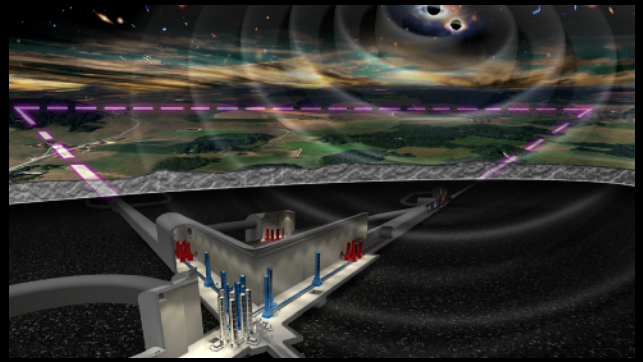

Einstein Telescope (ET)

- 10 km underground triangle
- 6 interferometers in “xylophone” configuration:
    - Cryogenic low frequency
    - High power high frequency
- GW frequencies 7Hz—2kHz

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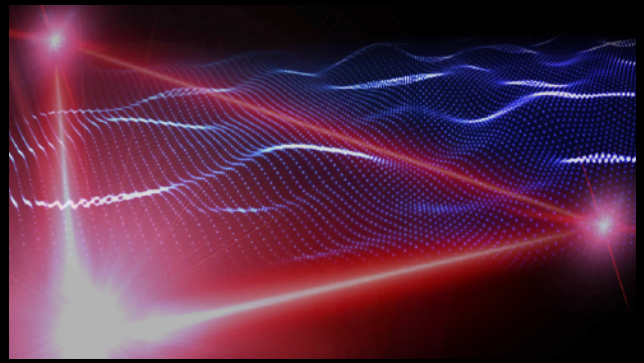

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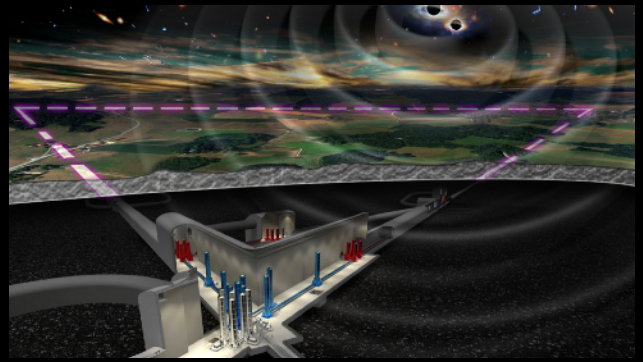

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Cosmic Explorer (CE)

- 20 km and 40 km L-shaped surface observatories
- scaled up LIGO technology & enhancements
- GW frequencies 10Hz—2kHz

Images courtesy Einstein Telescope, LISA, Cosmic Explorer

Next-Generation Gravitational-Wave (ngGW) Subcommittee of MPS Advisory Committee (MPSAC)

https://nsf-gov-resources.nsf.gov/files/mpsac-nggw-subcommittee-repor-2024-03-23-r.pdf?VersionId=uhdtblJUPYsavII5EUuSNQJcFdRr92q_

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  - Else: one 40km and one 20km Cosmic Explorer

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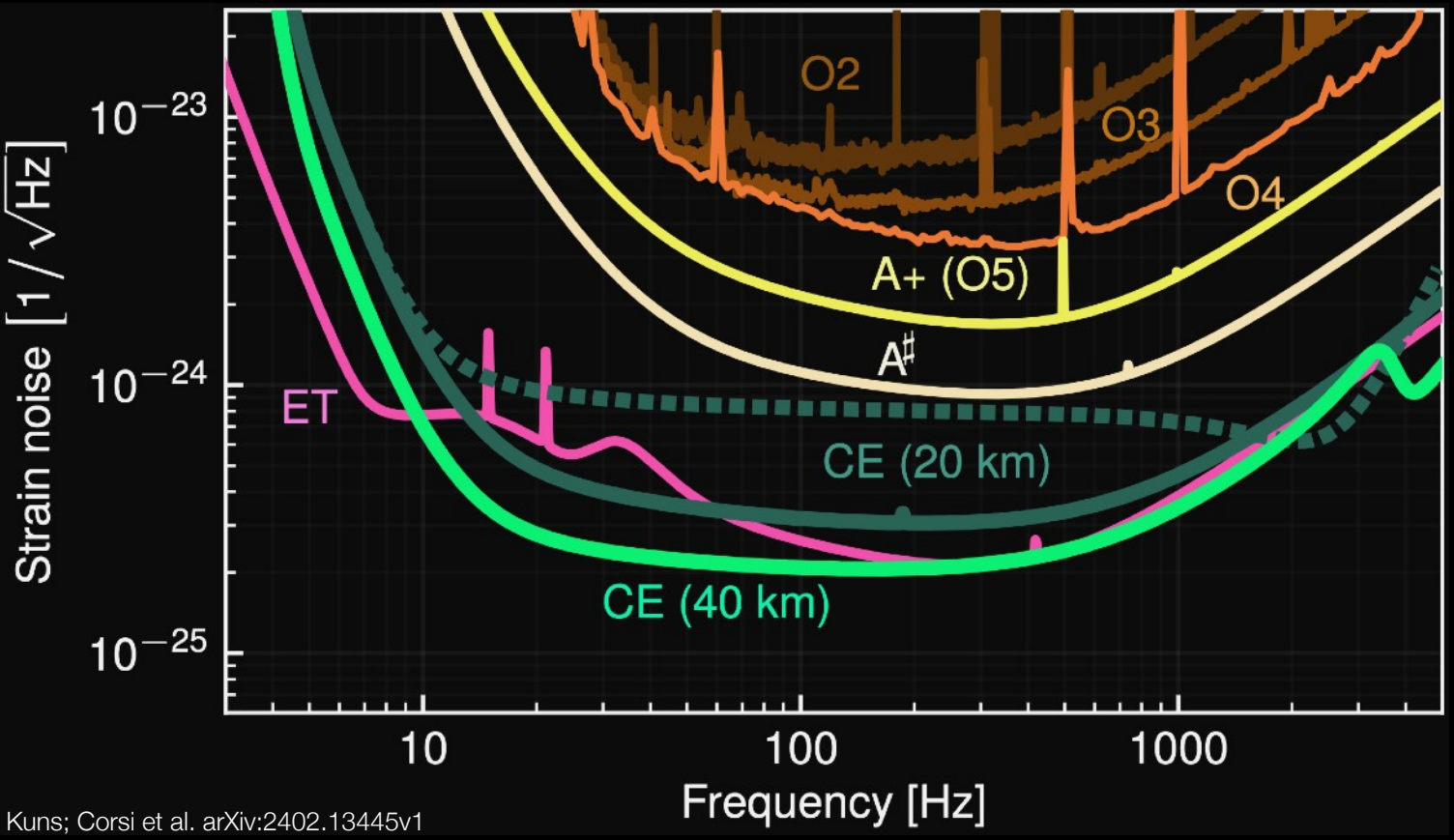
From LIGO-Virgo-KAGRA to the next generation



2023

LIGO VIRGO KAGRA

COSMIC EXPLORER

Next-generation (~2035)

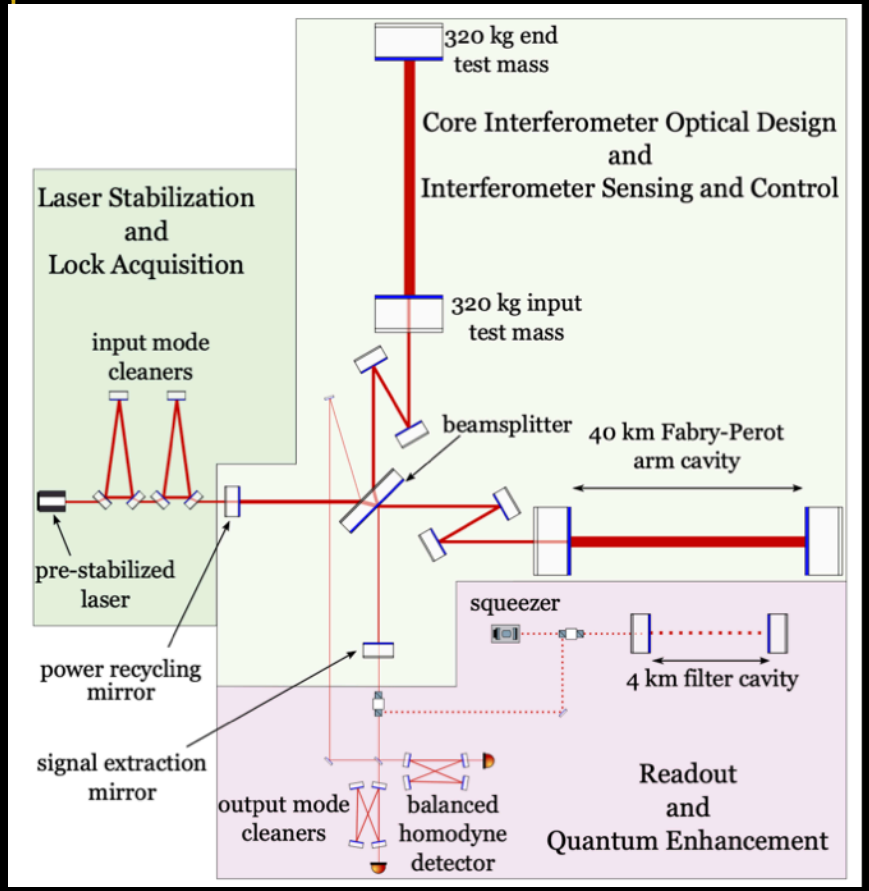
Kuns; Corsi et al. arXiv:2402.13445v1

Cosmic Explorer design basics

Frequency-dependent squeezing-enhanced dual-recycled Fabry-Perot Michelson interferometers (like LIGO A+)

↑ Historical layout, for better, see later slides, talks, ask our session chair Paul Fulda, U Florida

Cosmic Explorer design basics



Frequency-dependent squeezing-enhanced dual-recycled Fabry-Perot Michelson interferometers (like LIGO A+)

Quantity	A+ (O5)	A# (O6)	CE
Arm length (km)	4	4	**40**
Wavelength (nm)	1064	1064	**1064**
Mirror mass (kg)	40	**100**	**320**
Mirror diameter (cm)	34	**46**	**70**
Arm power (MW)	0.8	**1.5**	**1.5**
Squeezing (dB)	6	**10**	**10**

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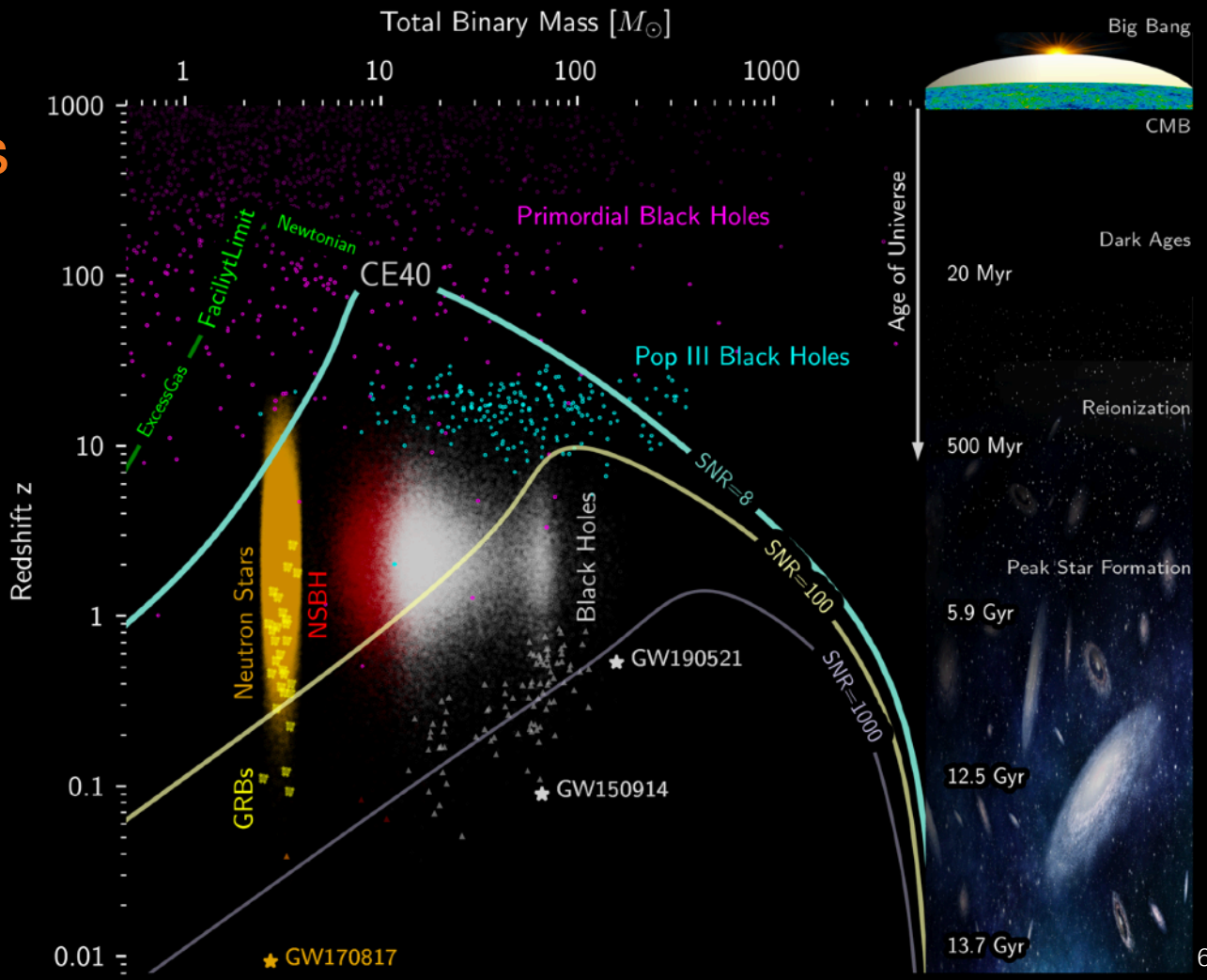
Cosmic Explorer's view into the universe



CE White Paper
for NSF MSCAC ngGW,
arXiv:2109.09882

Cosmic Explorer Timeline

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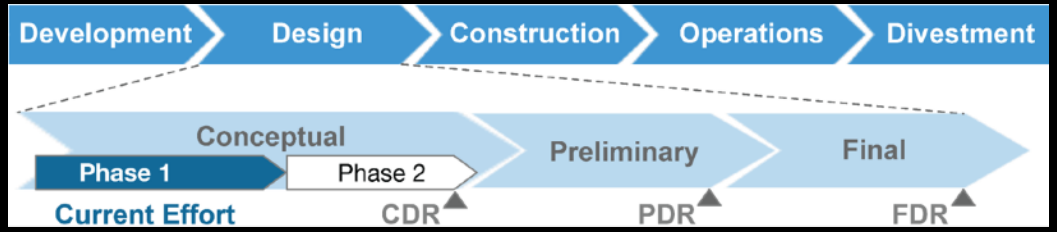
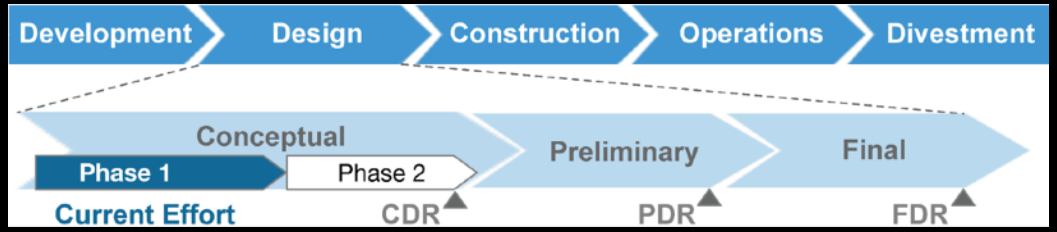


Infrastructure Lifecycle from NSF's [Research Infrastructure Guide]

Cosmic Explorer Timeline



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Project phases

- Conceptual Design (3+years)
- Preliminary Design (2-3 years)
- Final Design (2 years)
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- Operations (25 - 50 years)
- Decommissioning/Divestment

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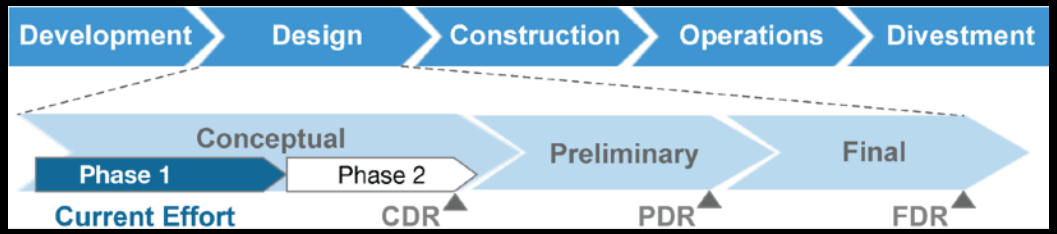

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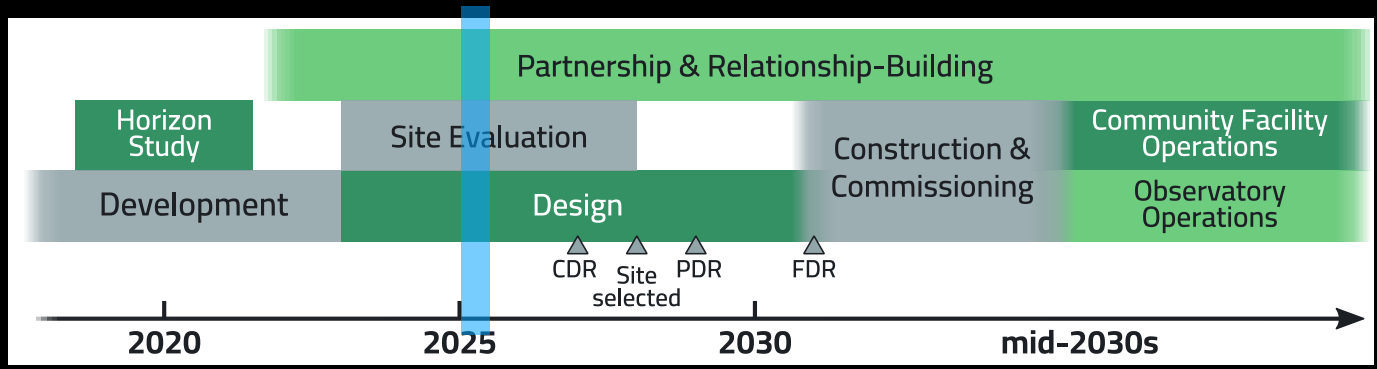

White Paper for NSF MSCAC ngGW
https://arxiv.org/abs/2306.13745

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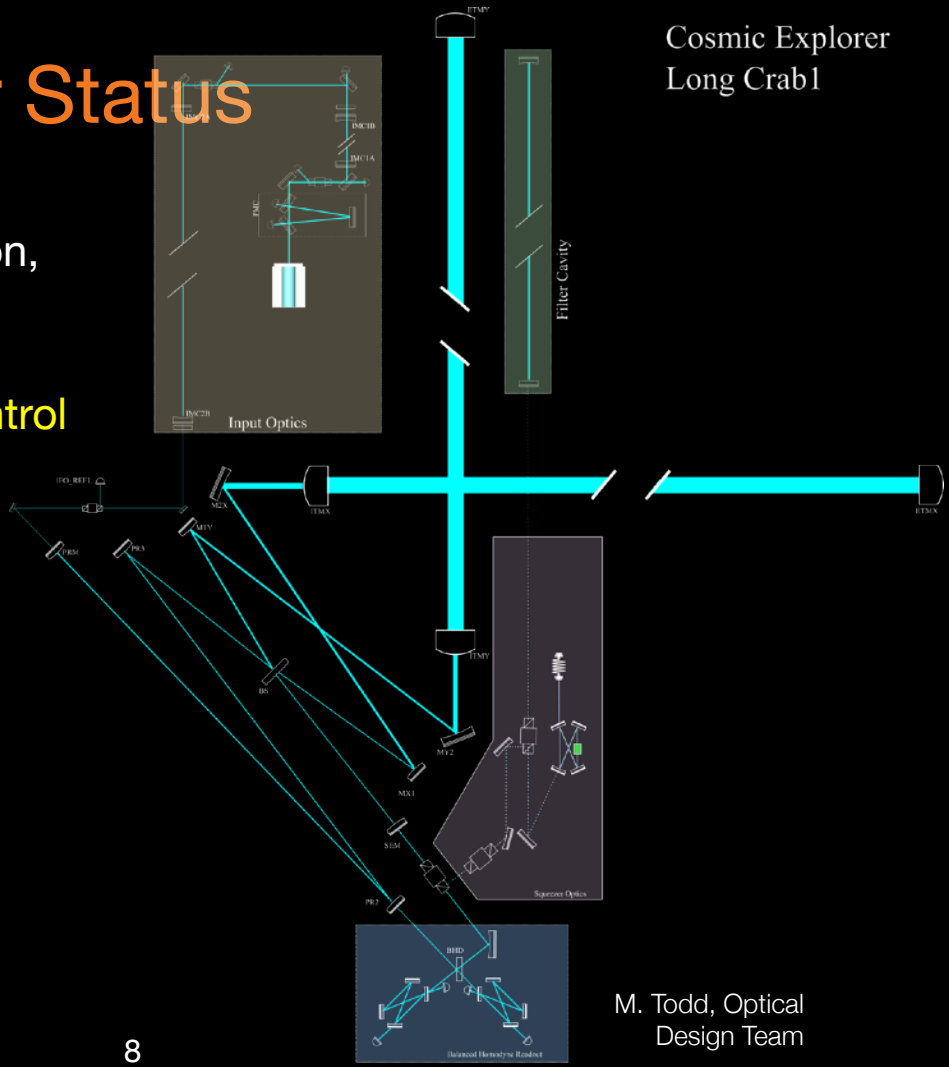

M. Todd, Optical Design Team

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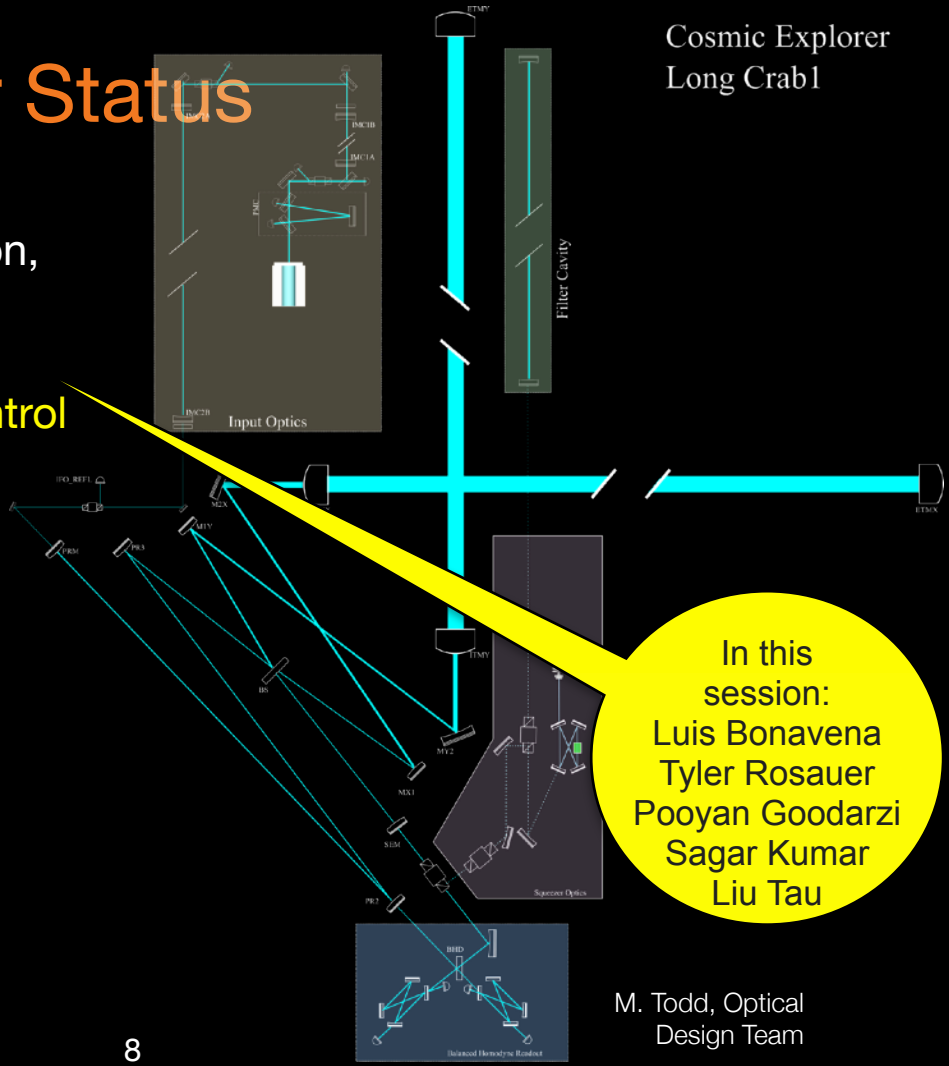

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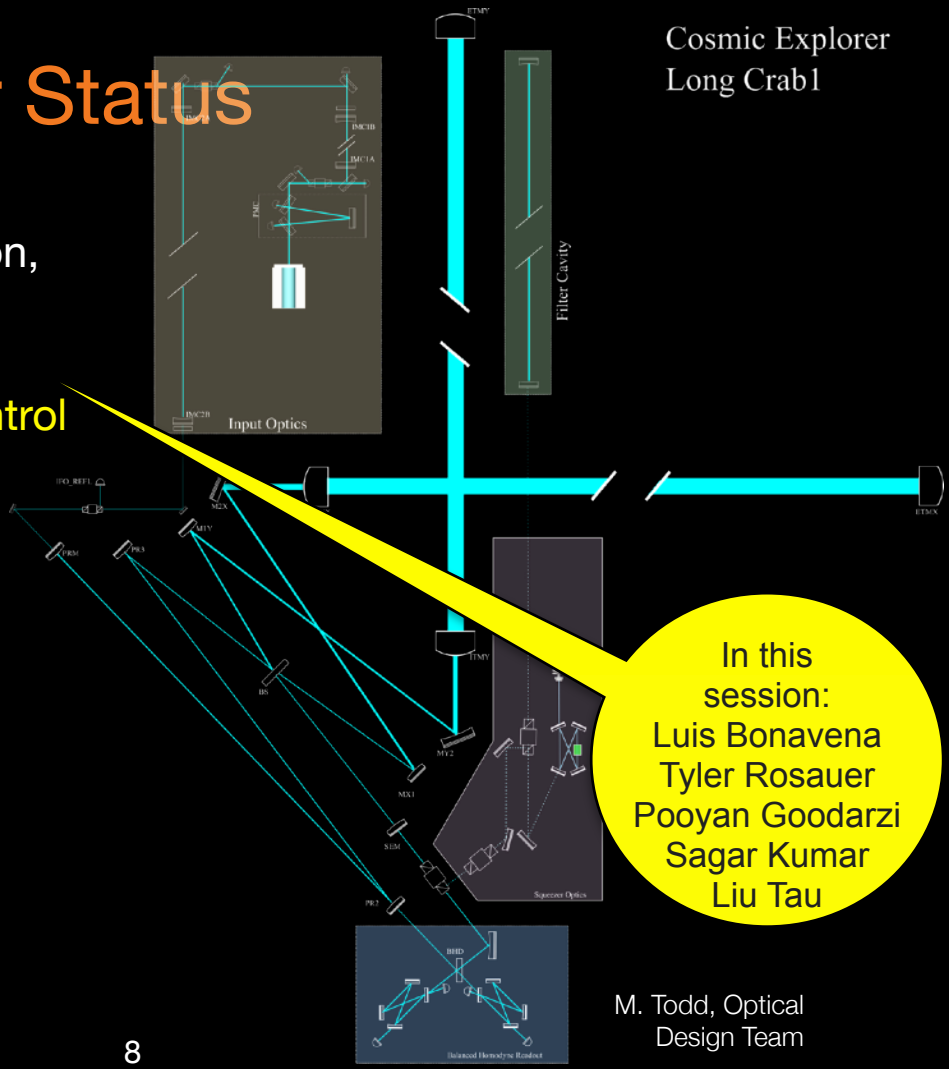

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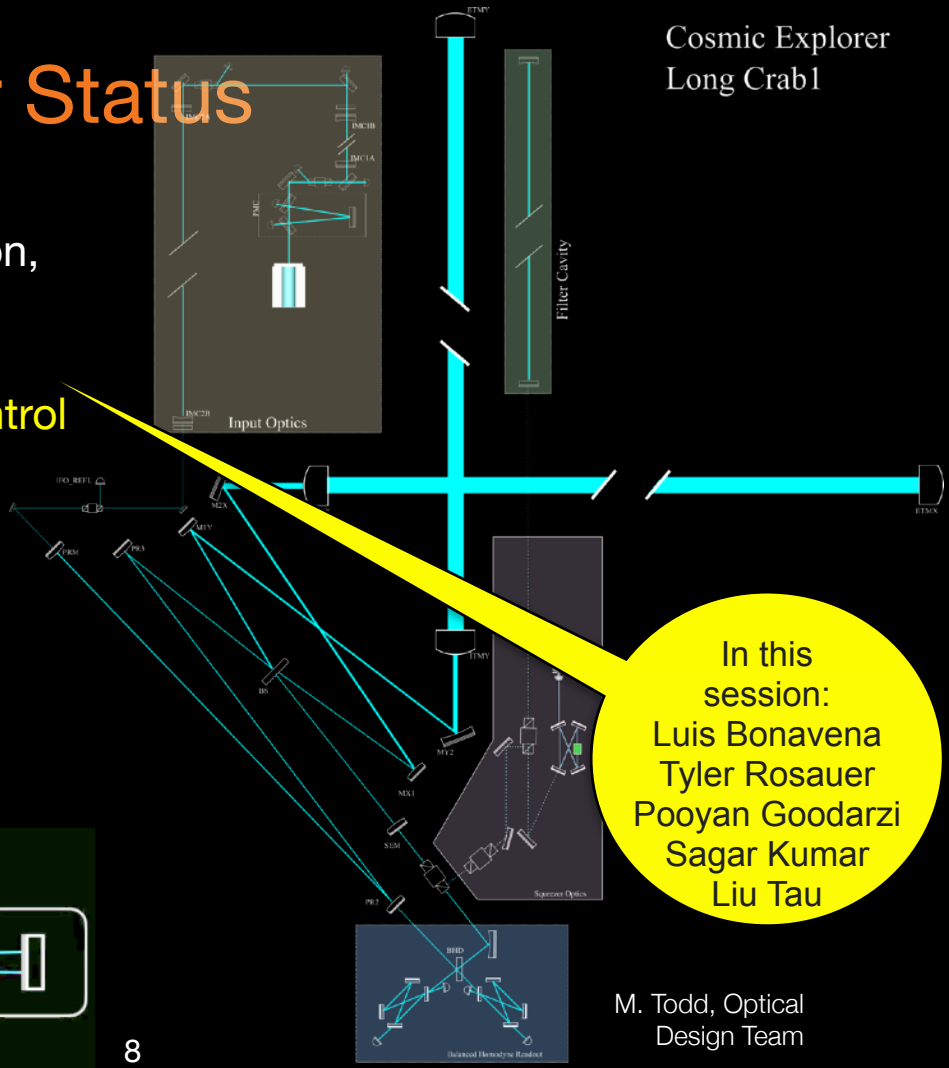

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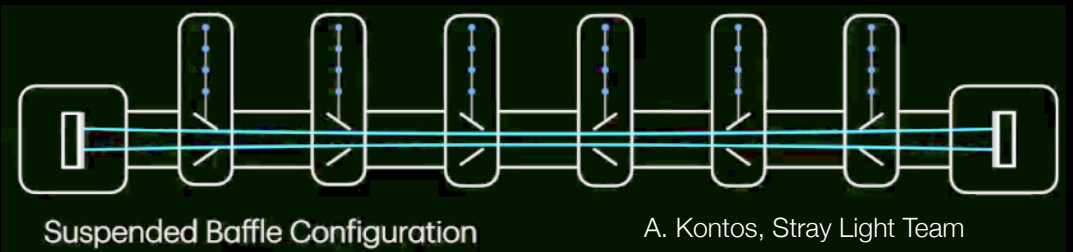

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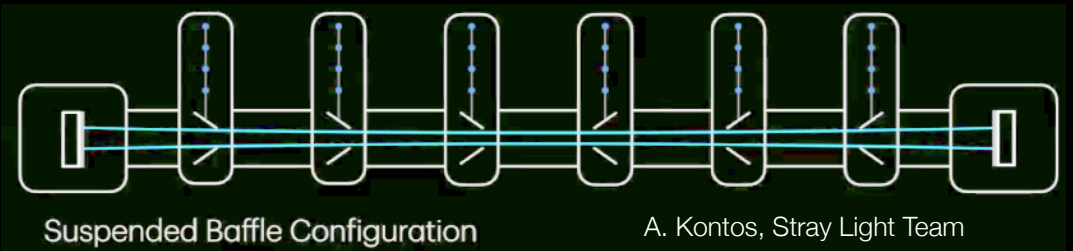

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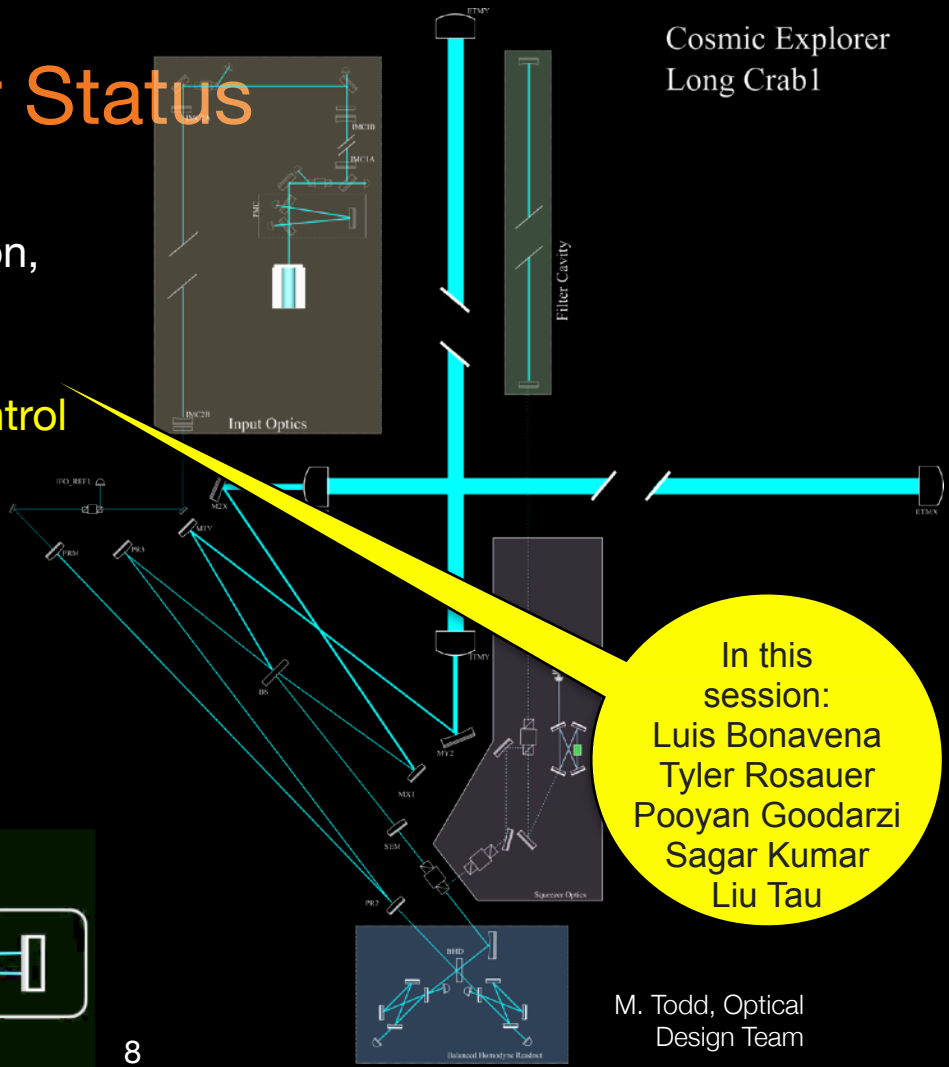

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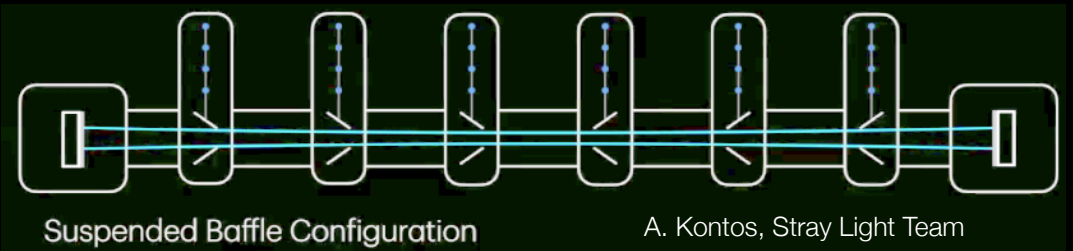

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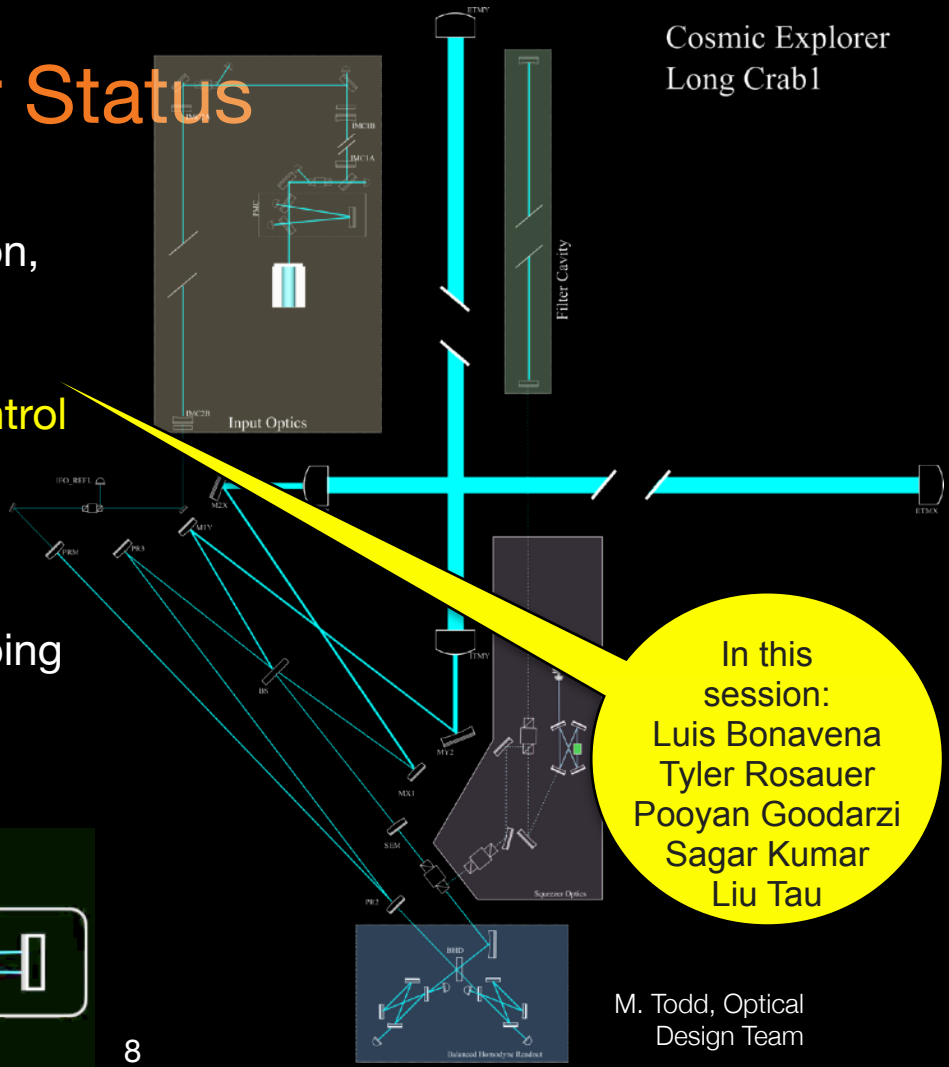

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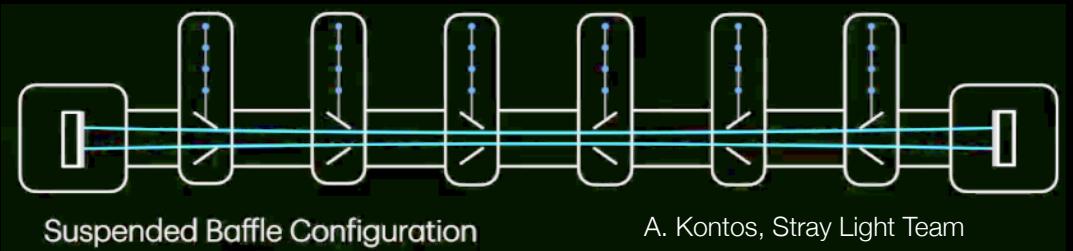

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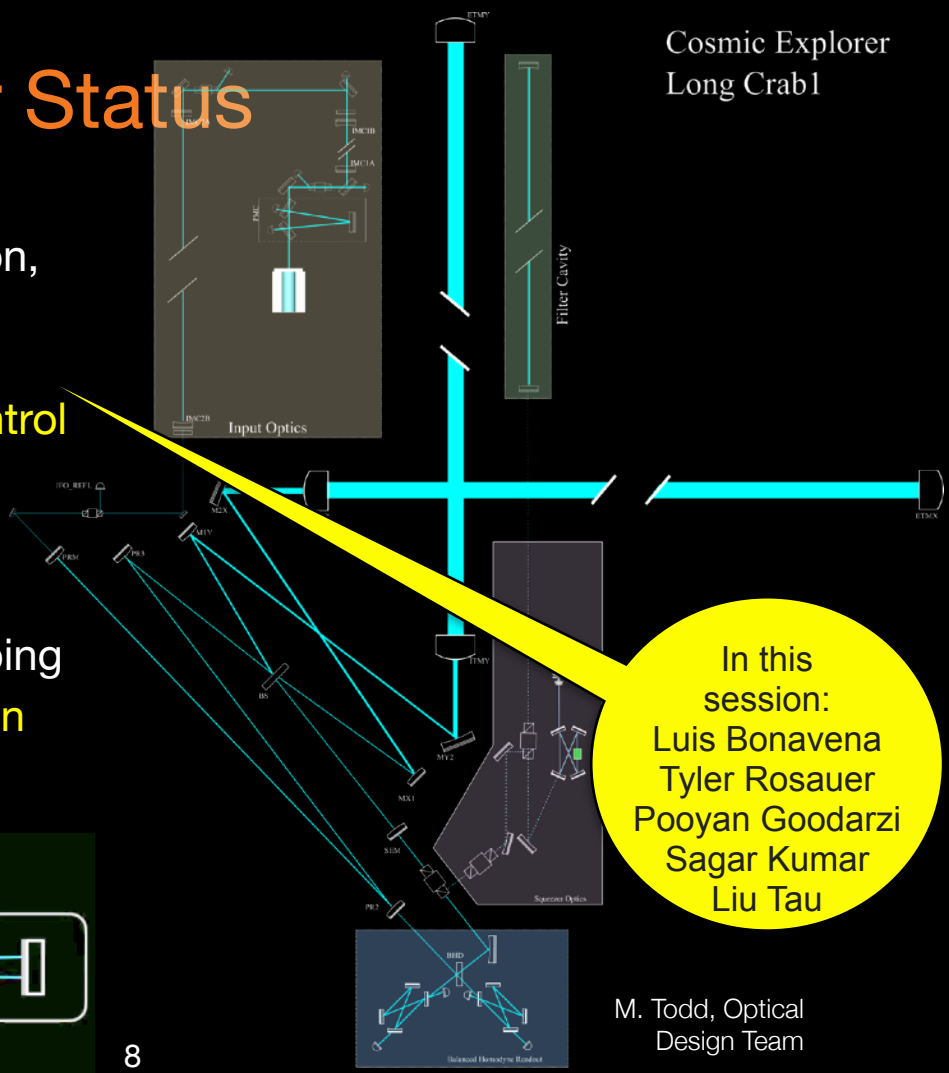

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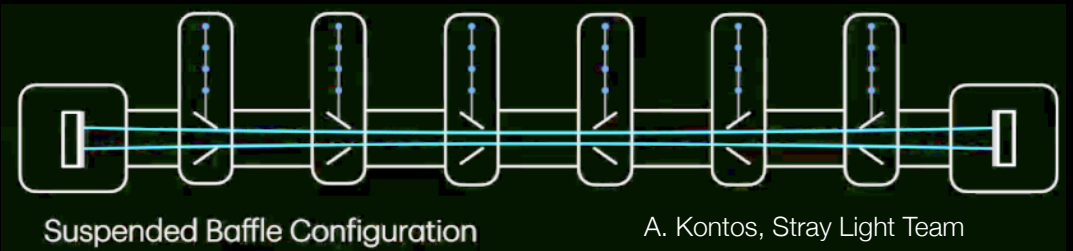

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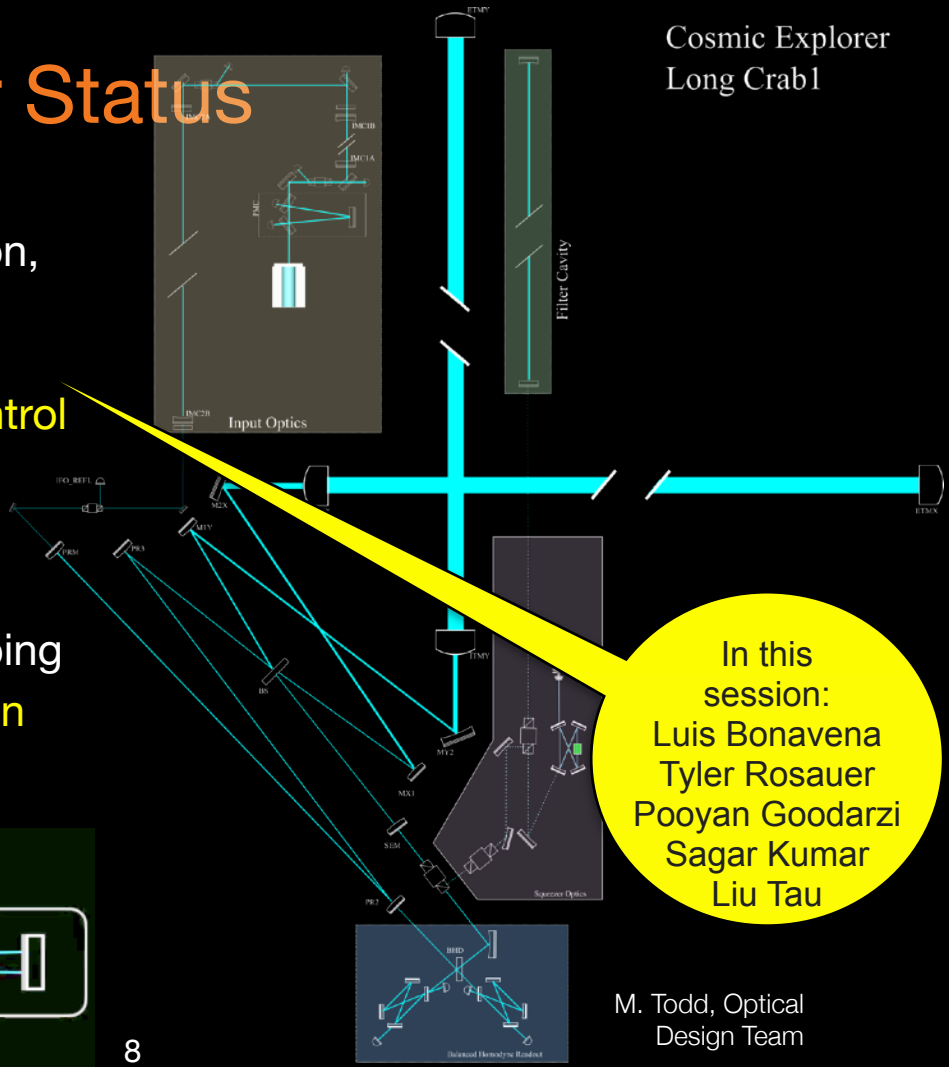

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Physics > Instrumentation and Detectors

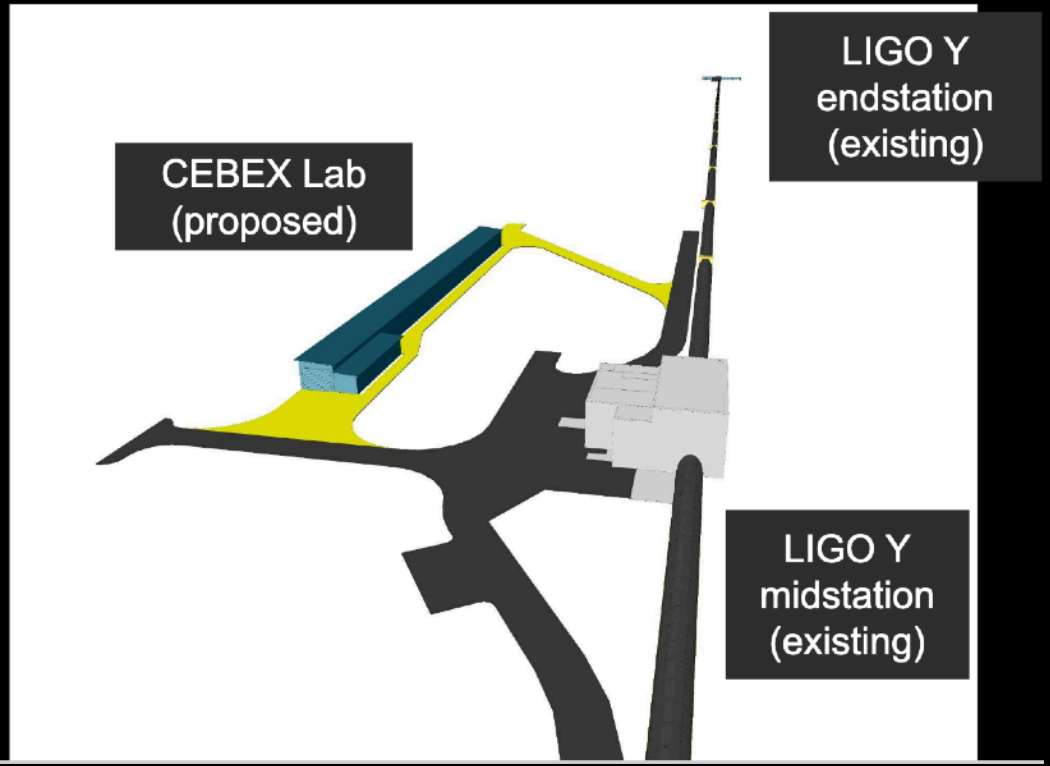
[Submitted on 1 Oct 2024]

Criteria for identifying and evaluating locations that could potentially host the Cosmic Explorer observatories

Kathryne J. Daniel, Joshua R. Smith, Stefan Ballmer, Warren Bristol, Jennifer C. Driggers, Anamaria Effler, Matthew Evans, Joseph Hoover, Kevin Kuns, Michael Landry, Geoffrey Lovelace, Chris Lukinbeal, Vuk Mandic, Kiet Pham, Jocelyn Read, Joshua B. Russell, Francois Schiettekatte, Robert M. S. Schofield, Christopher A. Scholz, David H. Shoemaker, Piper Sledge, Amber Strunk

Cosmic Explorer (CE) is a next-generation ground-based gravitational-wave observatory that is being designed in the 2020s and is envisioned to begin operations in the 2030s together with the Einstein Telescope in Europe. The CE concept currently consists of two widely separated L-shaped

CEBEX Underway at LIGO Hanford



At LIGO Hanford, 120m-long sector test of Cosmic Explorer beam tube vacuum technology, with full instrumentation

Credit: Mike Zucker

https://dcc.cosmicexplorer.org/CE-G2400094

COSMIC EXPLORER

Next Generation Gravitational Wave Observatory

cosmicexplorer.org

See the CE booth at APS!

Contact Info:
josmith@fullerton.edu