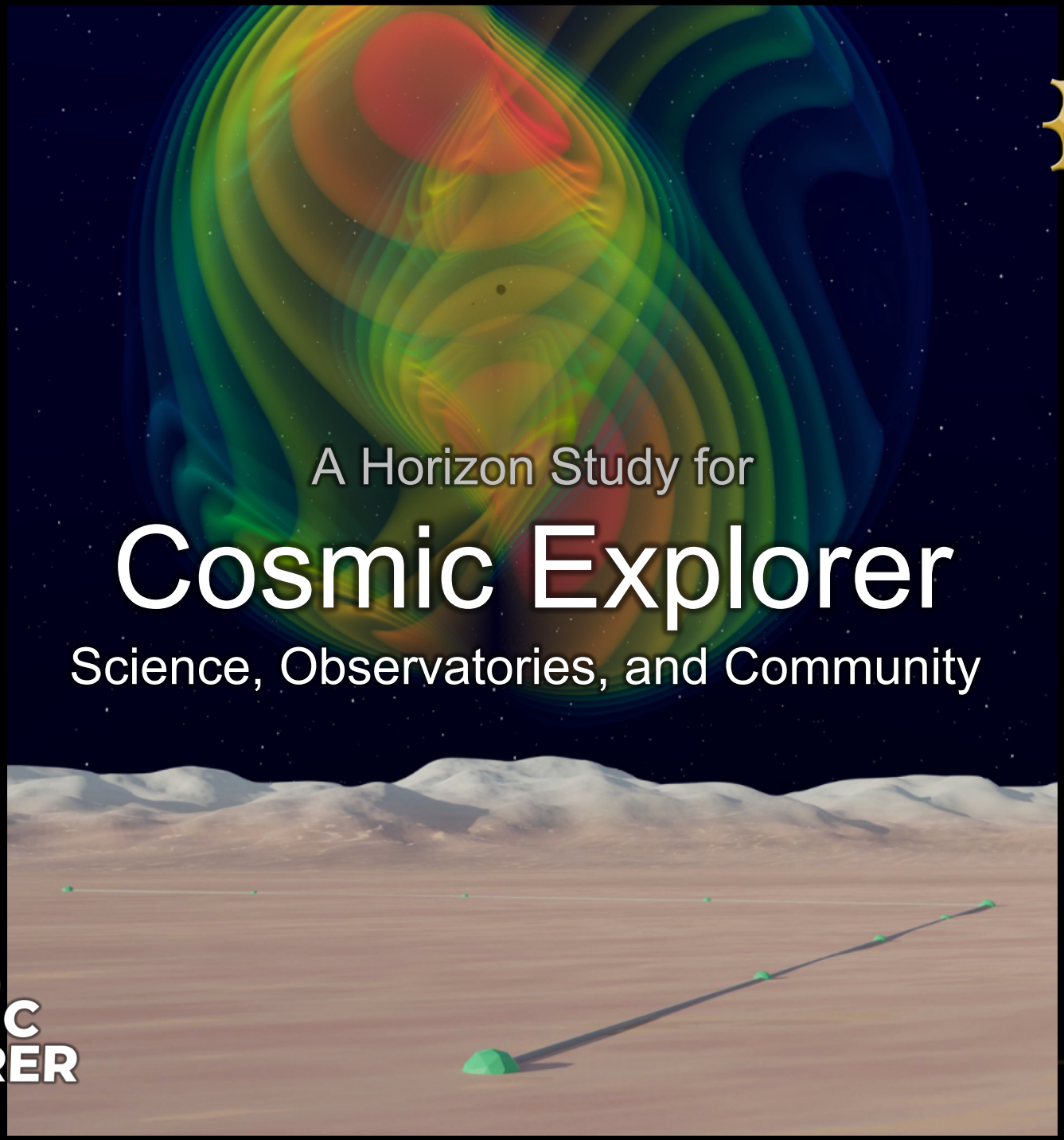
Cosmic Explorer Horizon Study

Matthew Evans, on behalf of the Cosmic Explorer Team



A Horizon Study for

Cosmic Explorer

Science, Observatories, and Community

COSMIC EXPLORER

CEHS: the current draft

Contents

COSMIC EXPLORER

Timeline for finishing the CE Horizon Study

- June 9: Draft ready for wide circulation (to CE Consortium, LVK, Astro/DGrav/DOE communities, others)
- July 15-30: Incorporate input in final round of editing
- Aug 1: Deliver polished draft to NSF
- October 5-7: Present at DAWN meeting for community for input and endorsement

2) Purpose and Scope

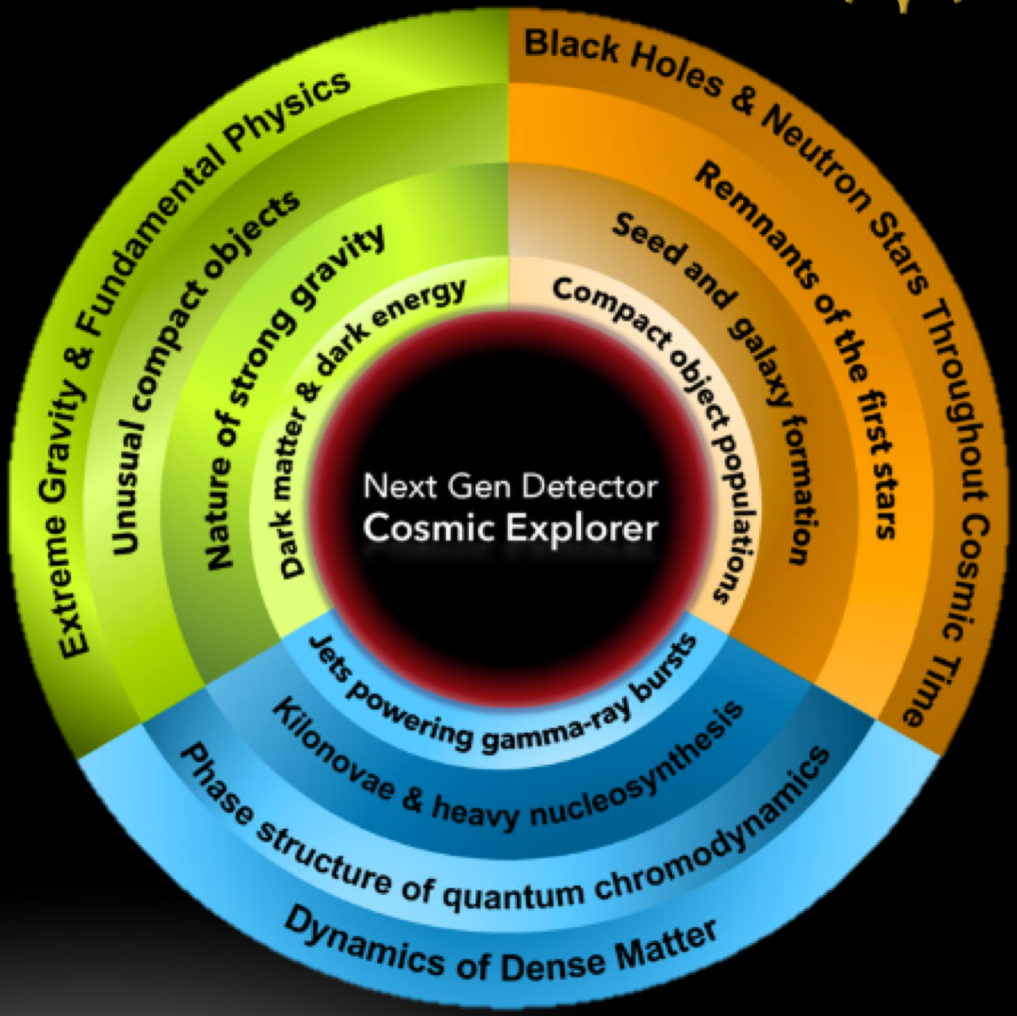
- The CE Horizon Study includes
  - A vision of the science enabled by CE
  - A reference design for the CE instrument and its evolution
  - An analysis of design options and their impact on the scientific output of CE
  - A parametric cost estimate for CE construction

- It is intended to inform the **scientific community**, and the agencies which fund that community, with the goal of providing a **foundation for further development of CE** in those communities while spurring action toward CE's construction.

COSMIC EXPLORER

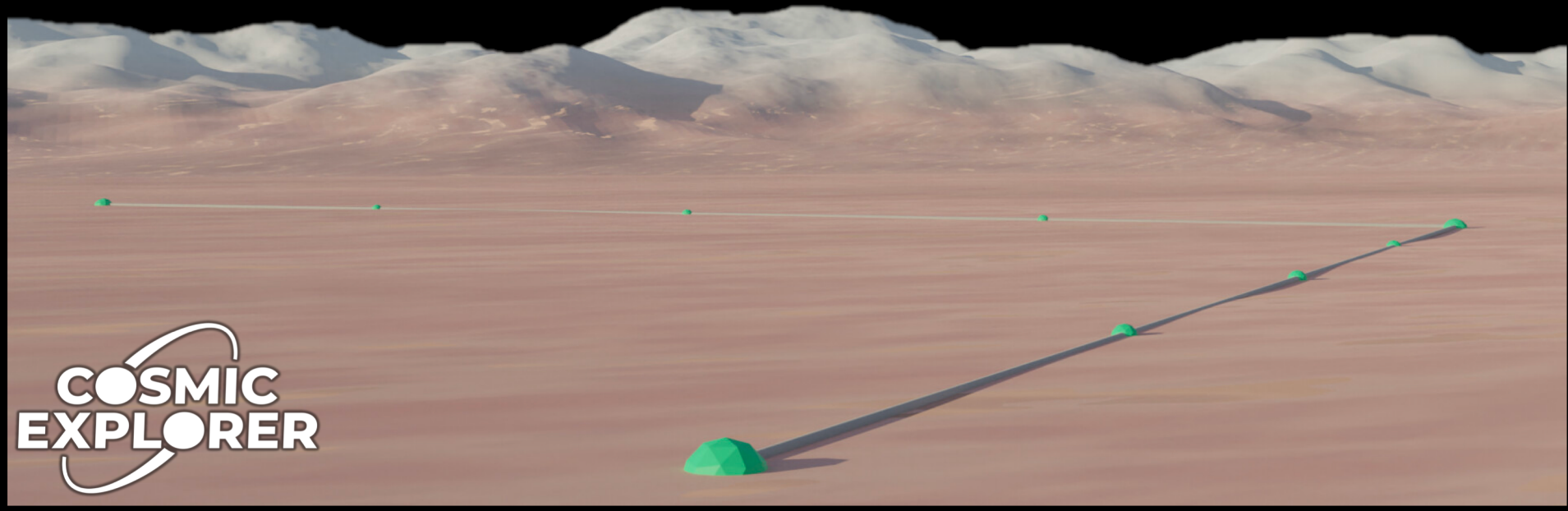
5) Key Science Questions

- 3 main categories of science goals
- Discussed in terms of what CE can do as a function number of observatories and global GW network



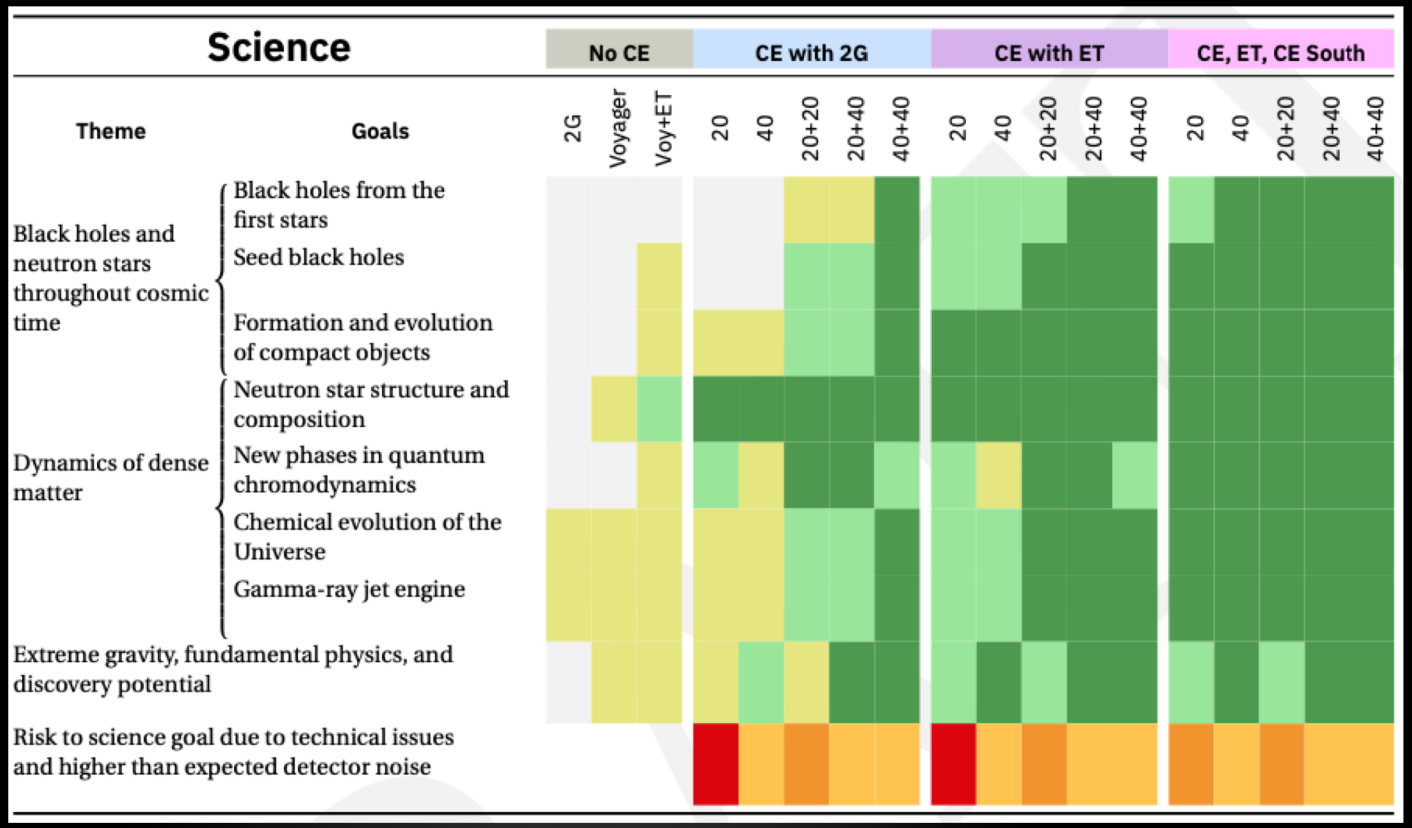
6) A Science-Driven Design for CE

- This section provides a high-level discussion of the design concept for CE
  - Why is ground-based laser interferometry the best way to achieve our science goals?
  - Why are we considering large L-shaped above-ground facilities?
    - What are the fundamental drivers behind arm length?
    - What are the advantages of 1 vs. 2 or more facilities?



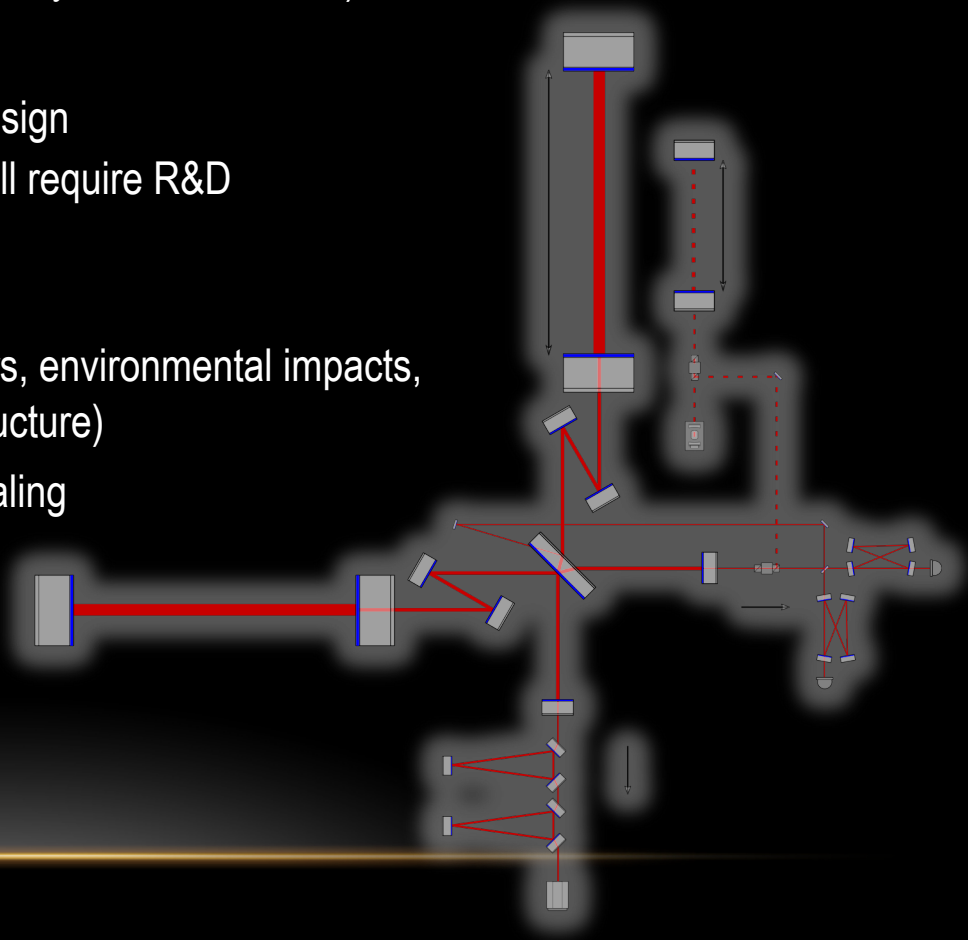
7) Optimizing Design Performance

A study of how design choices impact the key science goals, in the context of a global network with ET and CE South



8) Technical Overview and Design Choices

- This section provides a technical overview of the Cosmic Explorer Observatory including
  - technical siting considerations (seismicity, infrasound, etc.)
  - required infrastructure
  - vacuum system requirements and design
- It also outlines the key technologies that will require R&D to enable the CE science goals.
- Finally, other key considerations including
  - Choice of site (esp. local stakeholders, environmental impacts, natural hazards, surrounding infrastructure)
  - Cost vs. Arm length – not a linear scaling
  - Beamtube material and diameter



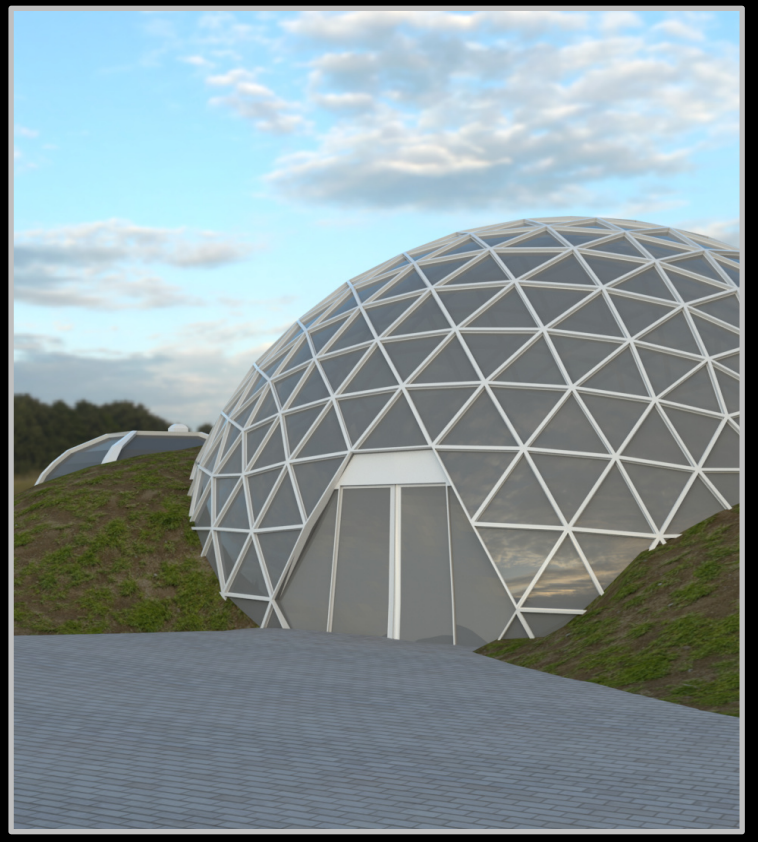
9) Data Management, Analysis, and Computing

- Here we present a vision for providing CE data to the scientific community
- Describe plans for Open Data and dissemination of
  - Production of clean, calibrated data set for science community
  - Dissemination of alerts for multi-messenger science
- Estimate the computing and human resources needed to deliver these goals
- Discuss needs for operations analysis and computing
- Discuss areas where support is needed for community's analysis and computing

COSMIC EXPLORER

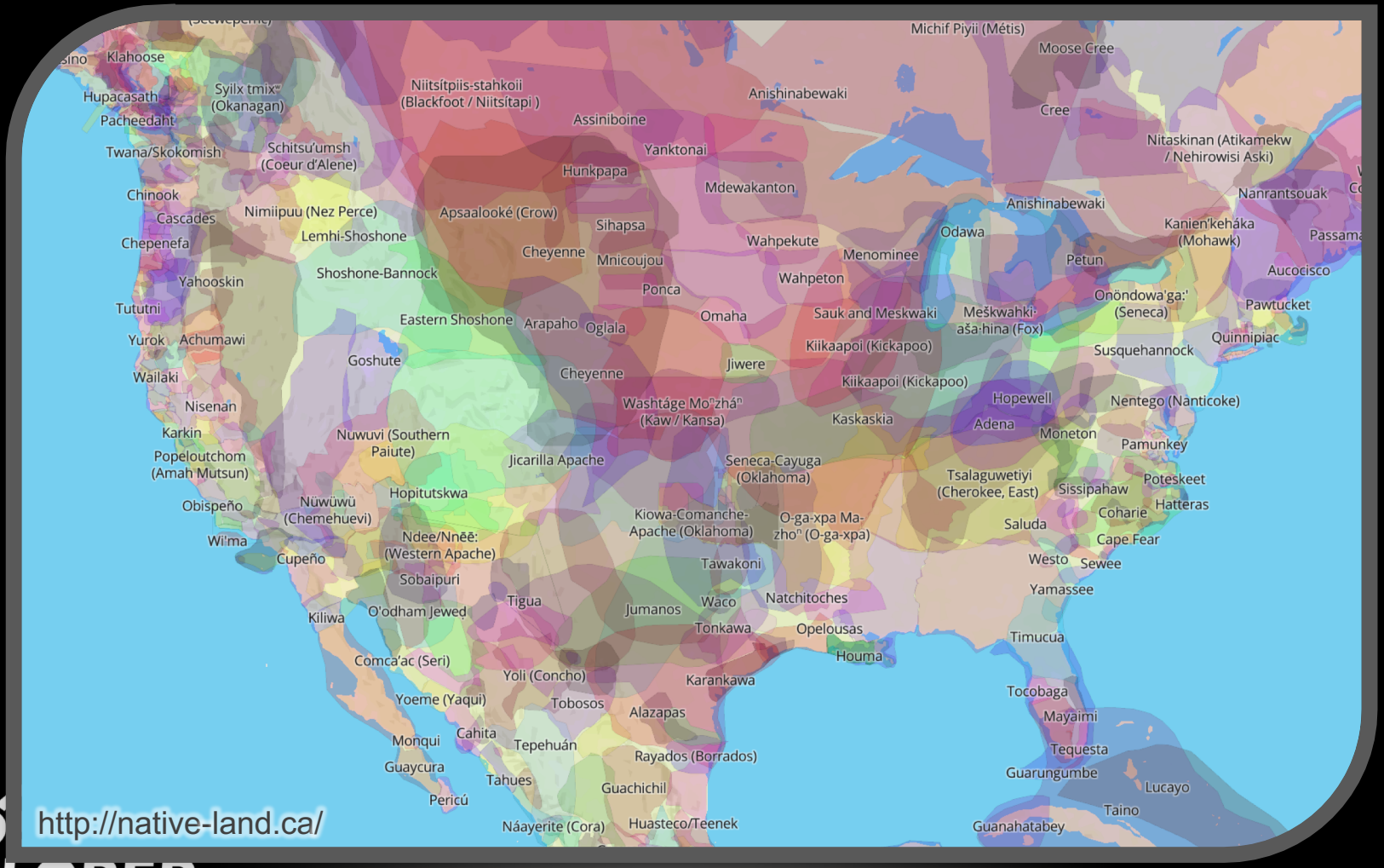
10) Cosmic Explorer at the Local and Global Scales

The Cosmic Explorer project will develop observatory designs with a **multi-dimensional approach that creates synergy with its respective local, scientific, and global communities**. This includes designing the physical and virtual infrastructure to serve Cosmic Explorer's broad community integration and engagement goals, and developing interpersonal relationships among members of these communities. **Early and ongoing engagement with communities connected with Cosmic Explorer, from local to global, will be crucial to the project's success**.



COSMIC EXPLORER

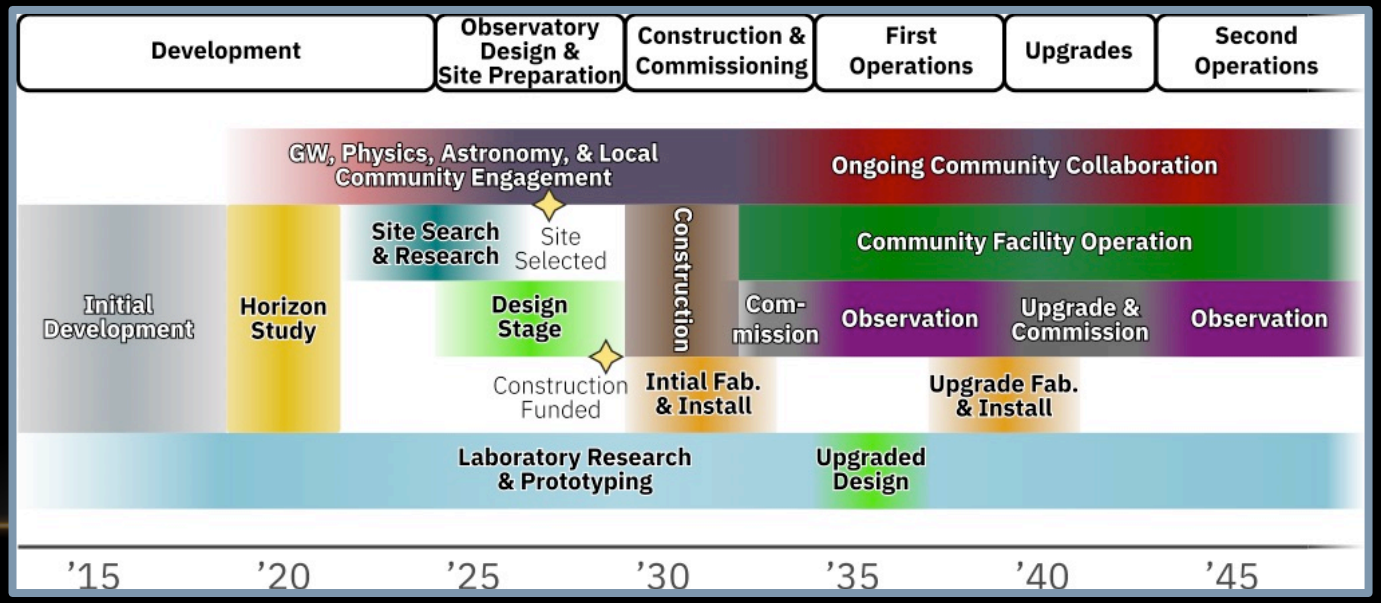
No matter where we build Cosmic Explorer, the history of the land will play a **pivotal role** in this project. We will have the **opportunity**, and obligation, to work with Indigenous Peoples to build synergistic relationships and to ensure that we respect their land, their culture and their sovereignty.



If you are not aware of issues surrounding TMT, please read arXiv:2001.00970 .

11) Cosmic Explorer Project

Top-Level Costs	$(M) USD 2021	Percent
Civil Engineering	358.2	28
Vacuum System	482.1	37
Detector	306.2	24
Management, Design, Project	146.2	11
Grand Total (2 Observatories)	**1292.7**	100



COSMIC EXPLORER

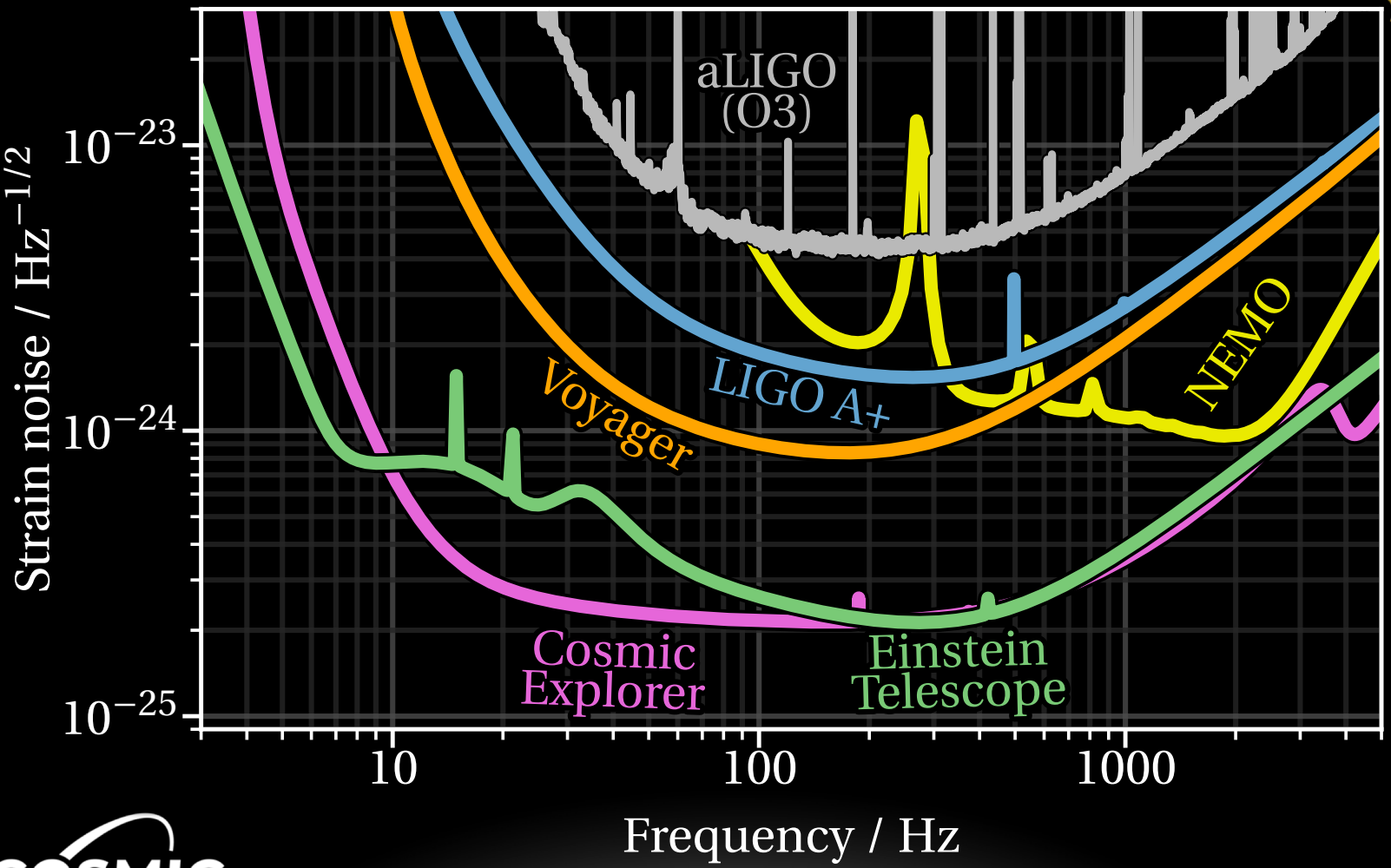
The Message

- Over the next few months, we (i.e. including you!) will be
  - setting the stage for future GW observatories in the US
  - delivering the CE Horizon Study to the NSF
  - following through by expanding the CE support base

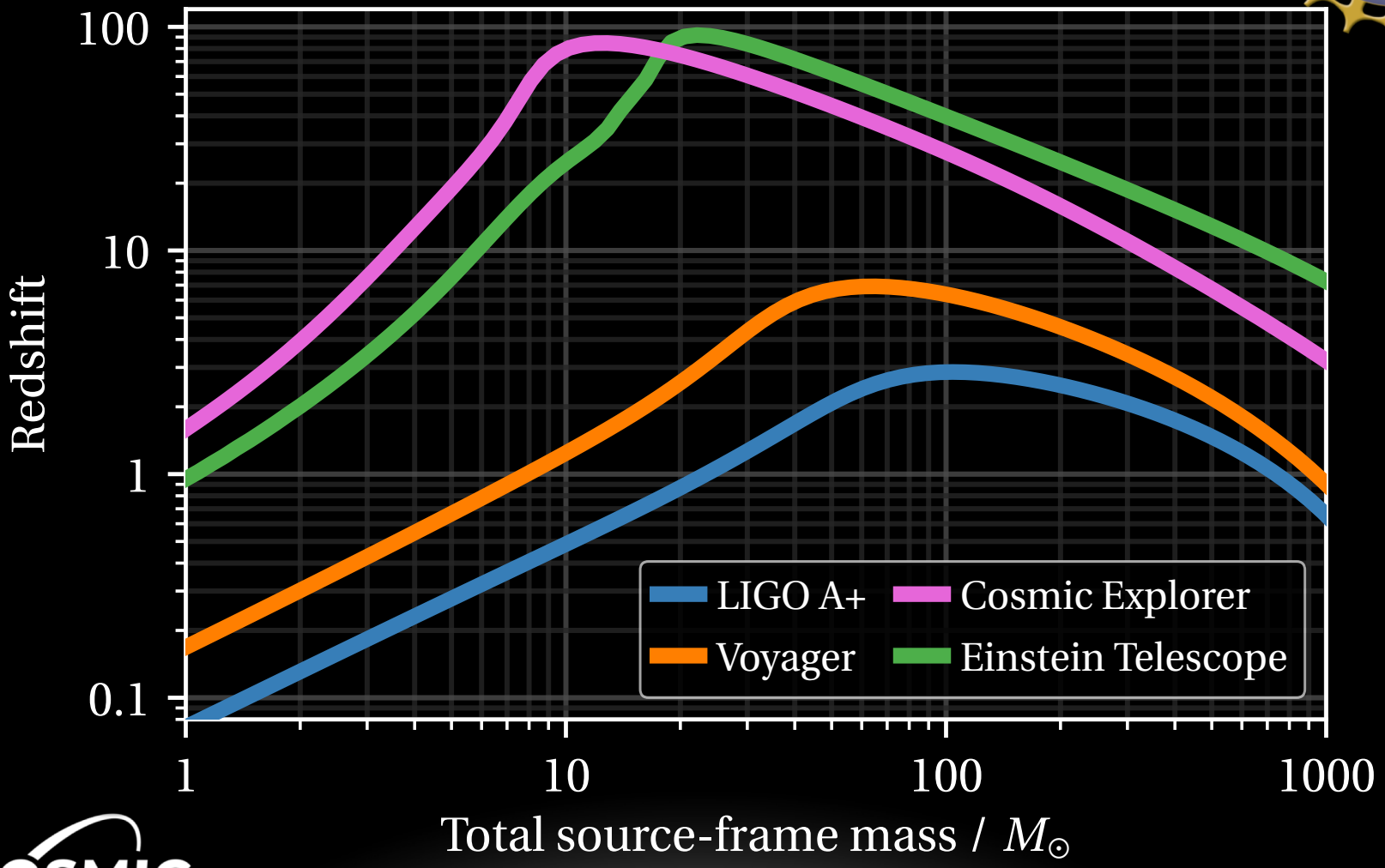
- We need you to be involved!
  - google form for feed-back: **tinyurl.com/CEHSform**
  - **CE will be built by this community.**

cosmicexplorer.org/consortium.html

Extra material


aLIGO
(O3)
LIGO A+
Voyager
NEMO
Cosmic
Explorer
Einstein
Telescope
10^{-23}
10^{-24}
10^{-25}
Strain noise / $\mathrm{Hz}^{-1/2}$
10
100
1000
Frequency / Hz

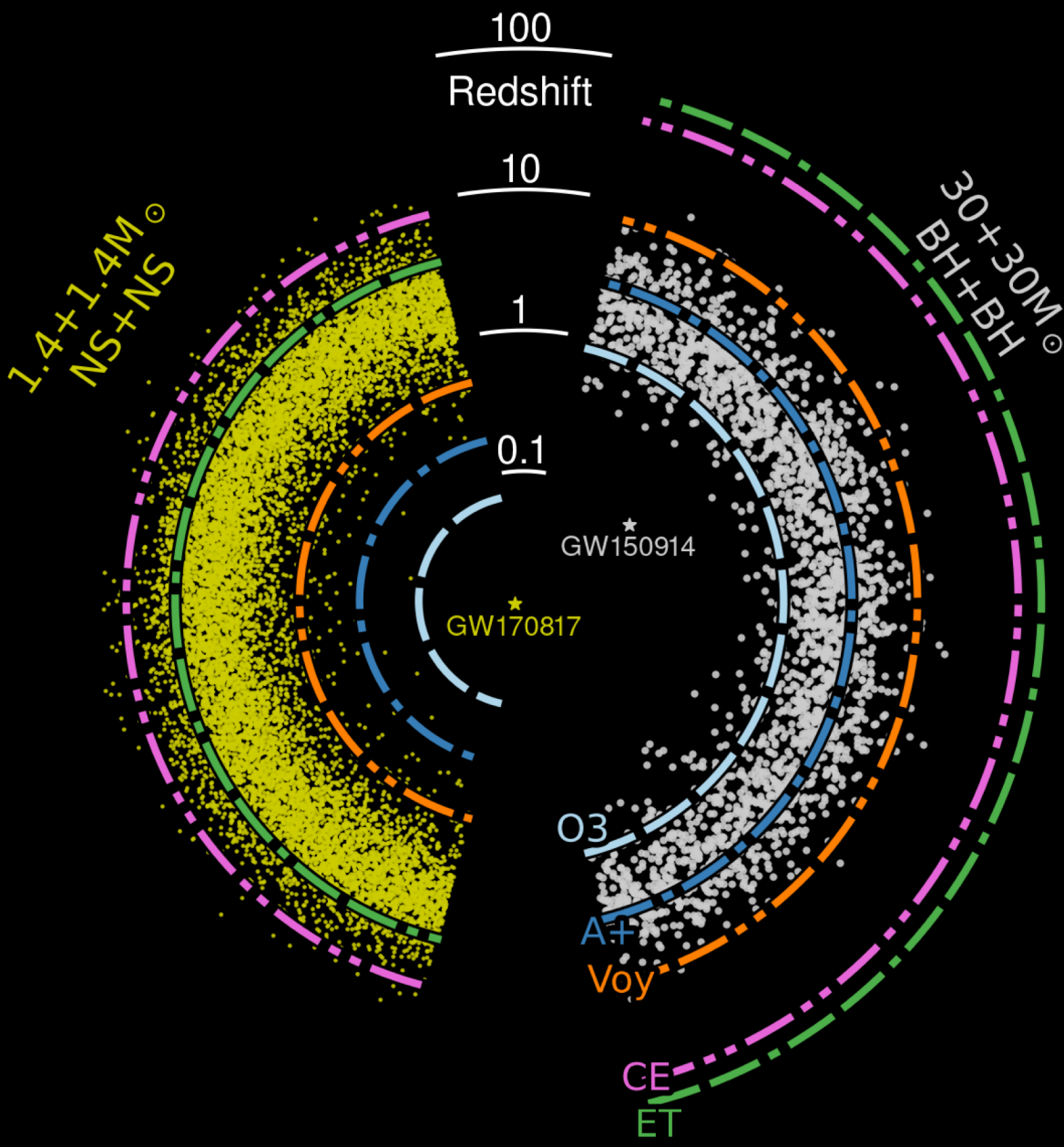
Black Holes & Neutron Stars Throughout Cosmic Time



COSMIC EXPLORER

CE-G2000035 - Evan Hall

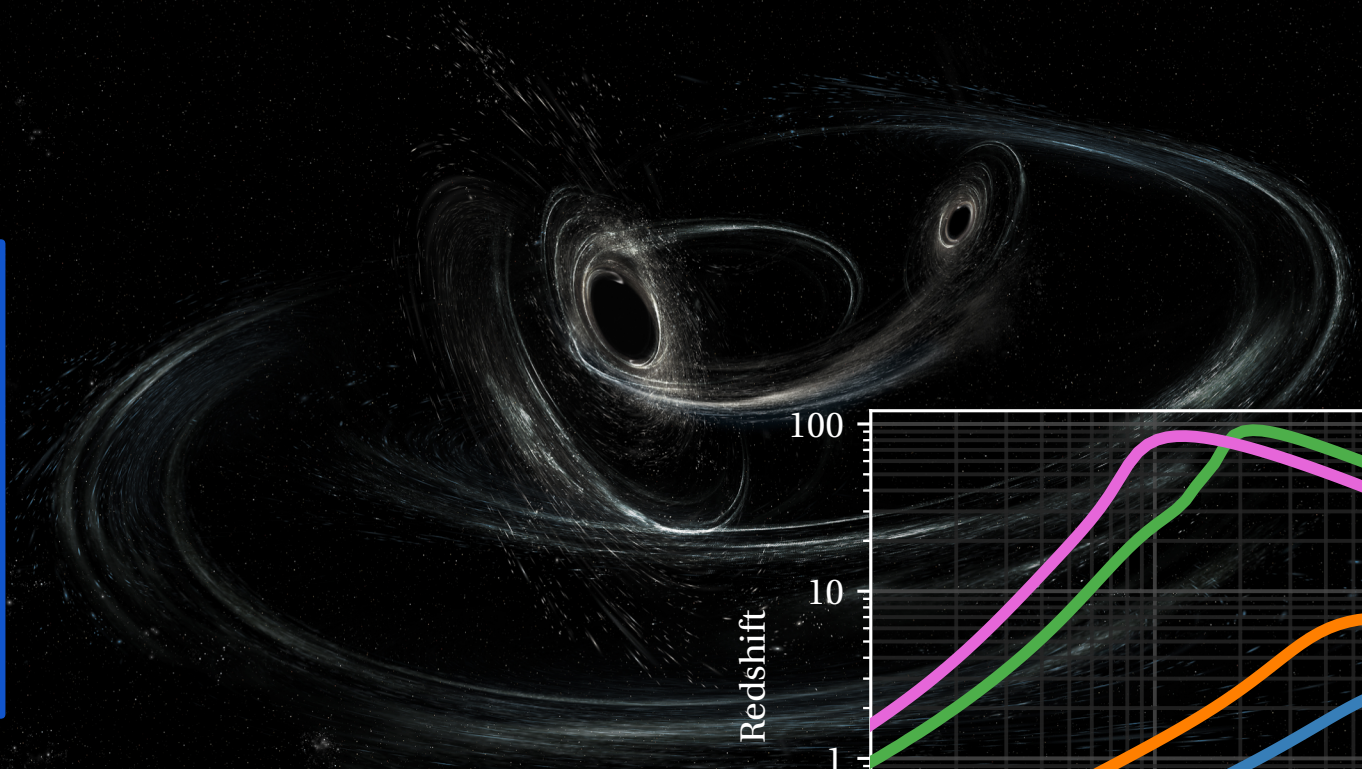
Black Holes & Neutron Stars
Throughout Cosmic Time

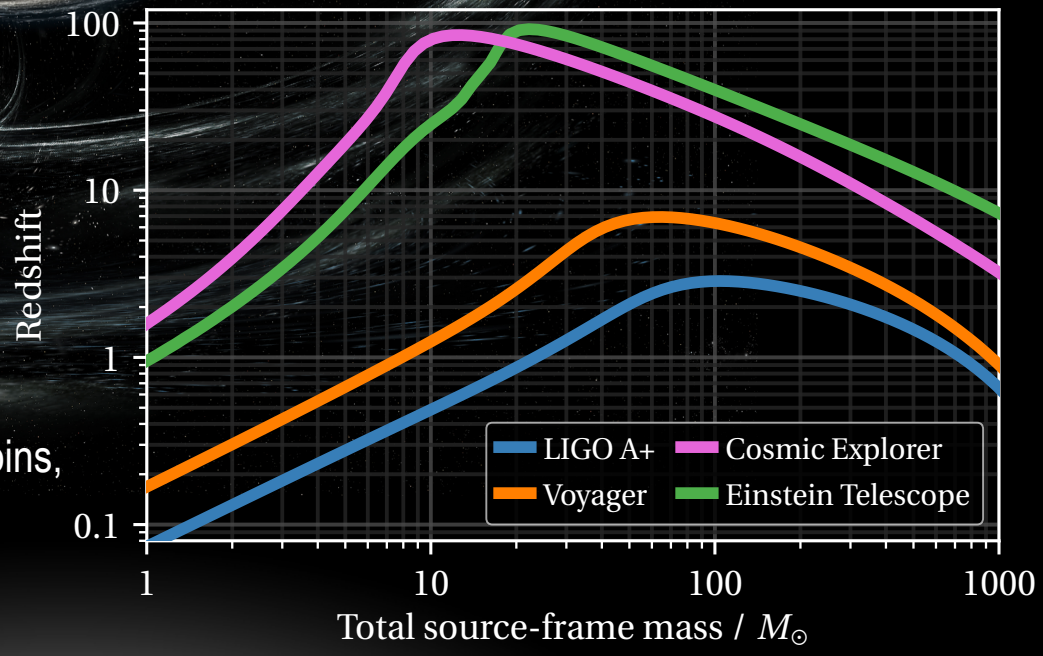


COSMIC EXPLORER

Precision tests will be enabled by black hole mergers like those seen now (~30 solar mass, at z ~ 0.3), which will have an SNR ~ 1000 in CE.

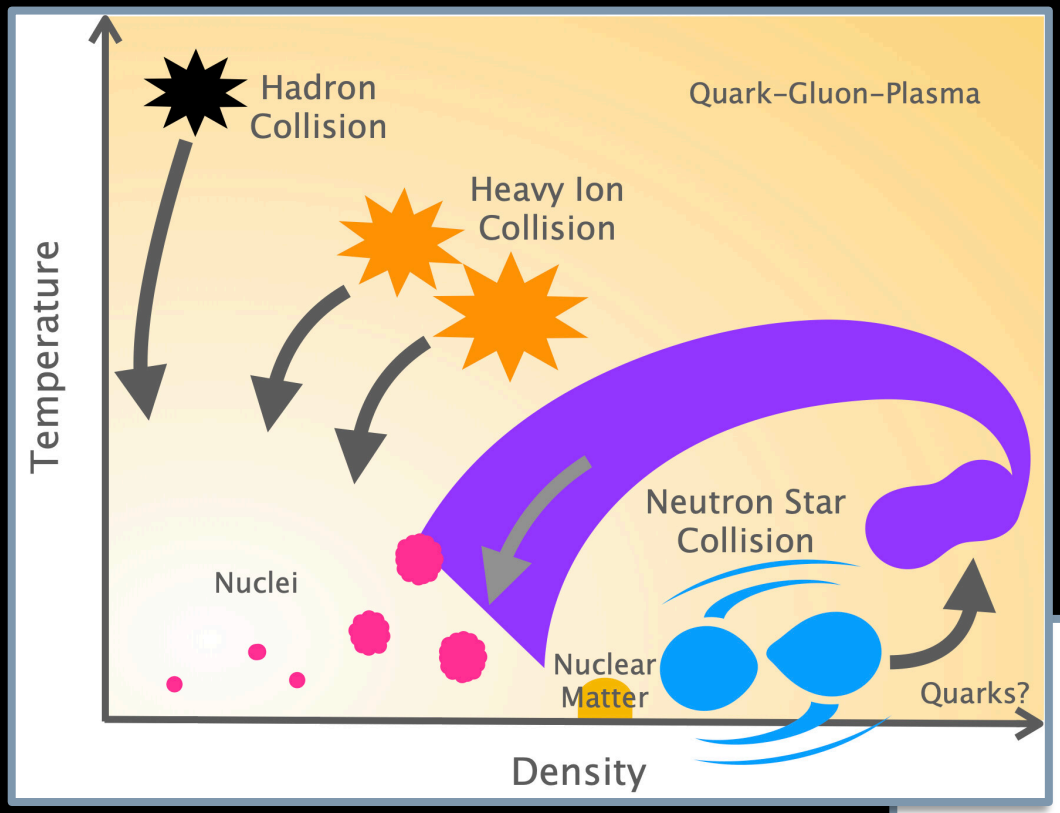
Extreme Gravity & Fundamental Physics

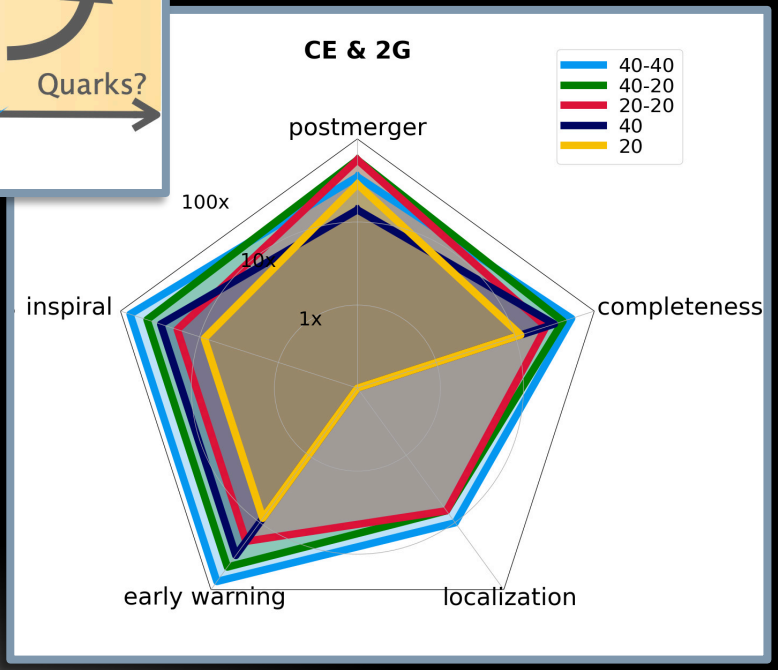




With thousands of BBH events per day, we will be able to cherry pick the most telling events (high spins, large kicks, edge-on, high ellipticity, etc.).

Dynamics of Dense Matter & Extreme Environments





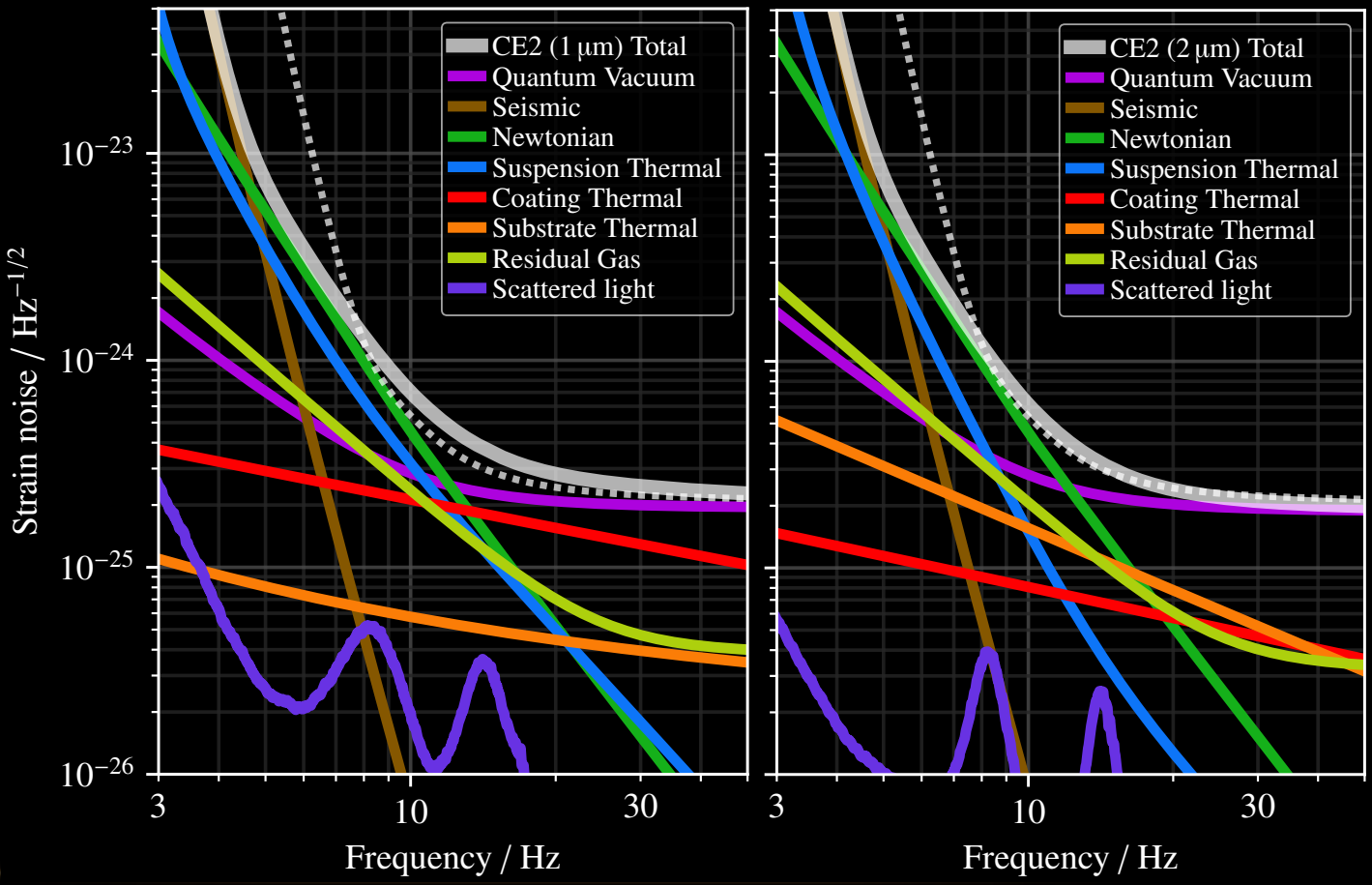
COSMIC EXPLORER

Cosmic Explorer Update

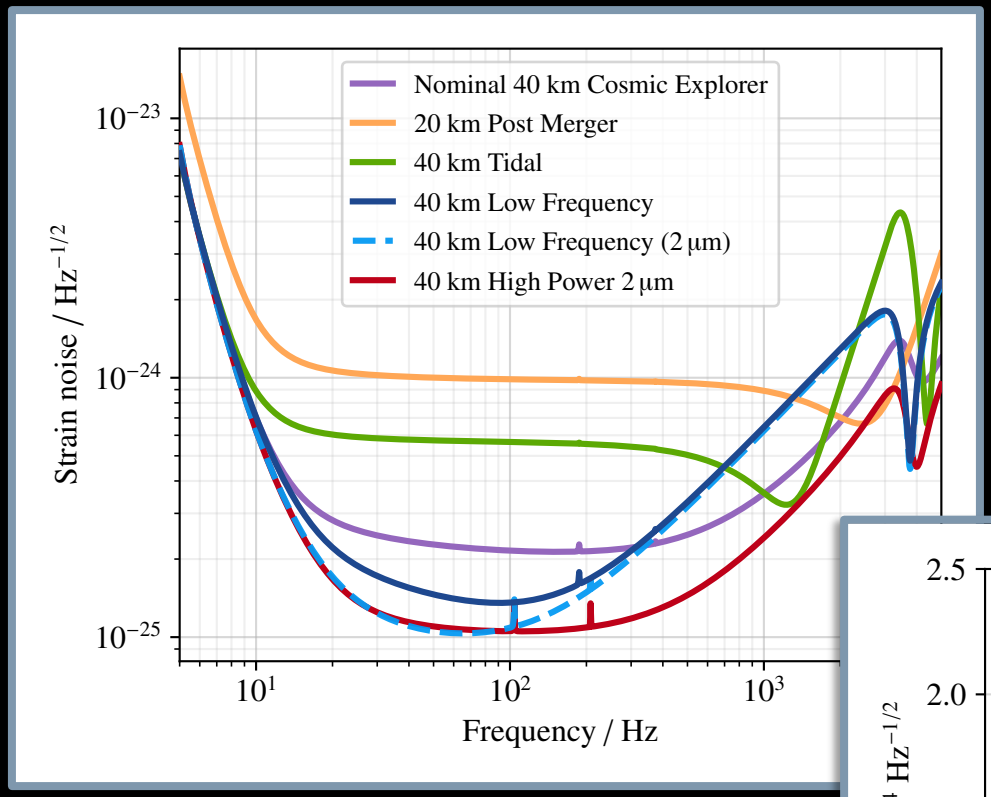
- Incremental improvements on current technology maybe another path to the target CE sensitivity (formerly CE2)

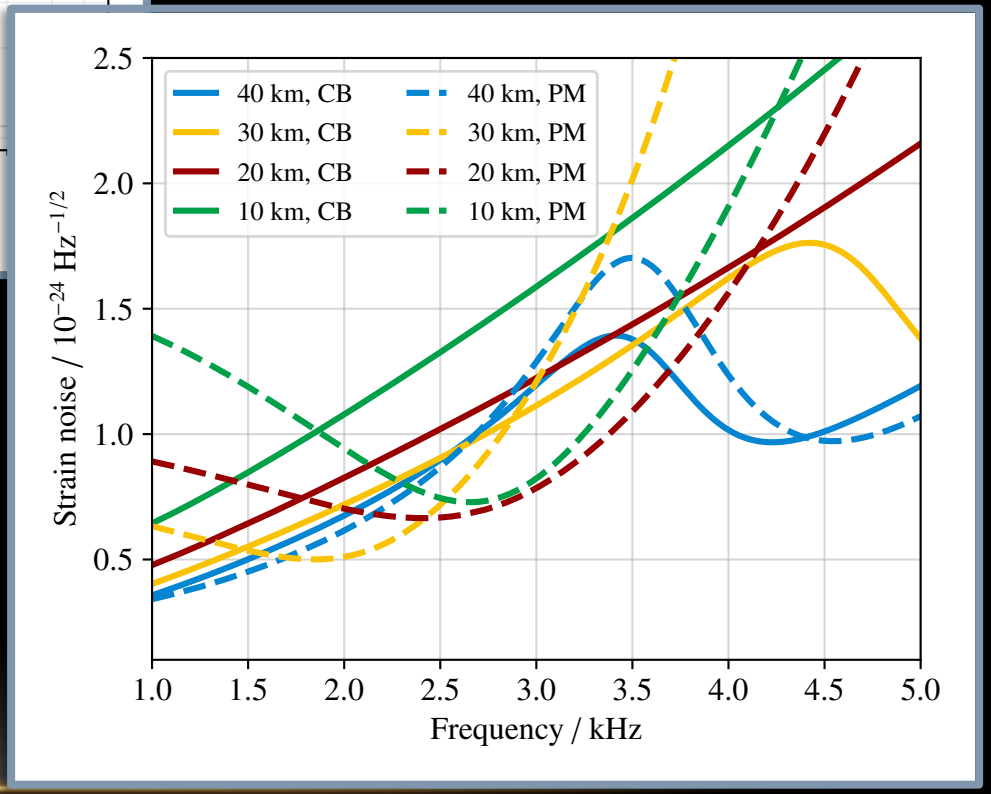
Extreme Gravity & Fundamental Physics

Black Holes & Neutron Stars Throughout Cosmic Time

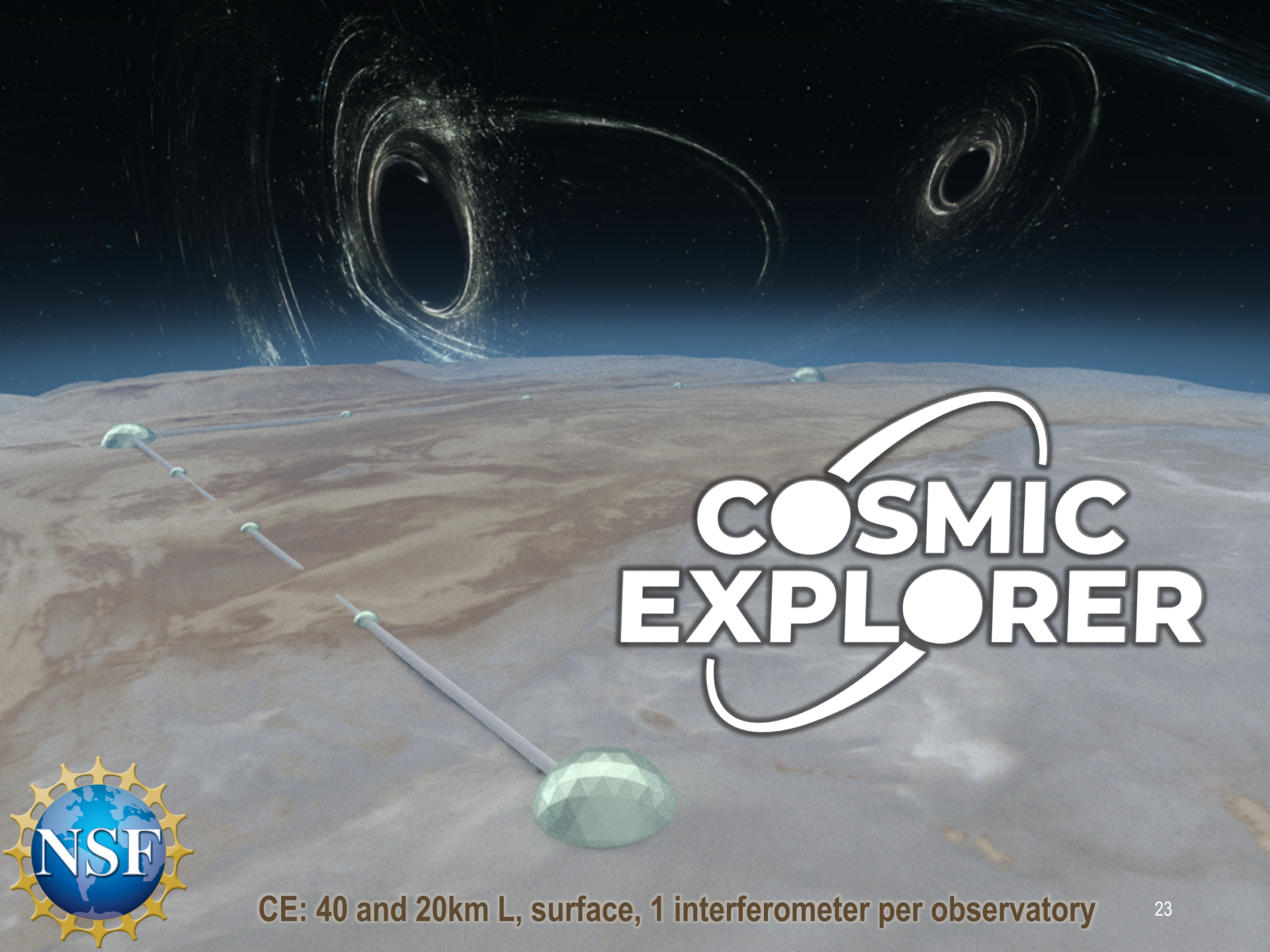


arXiv:2012.03608





COSMIC EXPLORER



CE: 40 and 20km L, surface, 1 interferometer per observatory