# Cosmic Explorer Beamtube EXperiment (CEBEX)

## *First steps*

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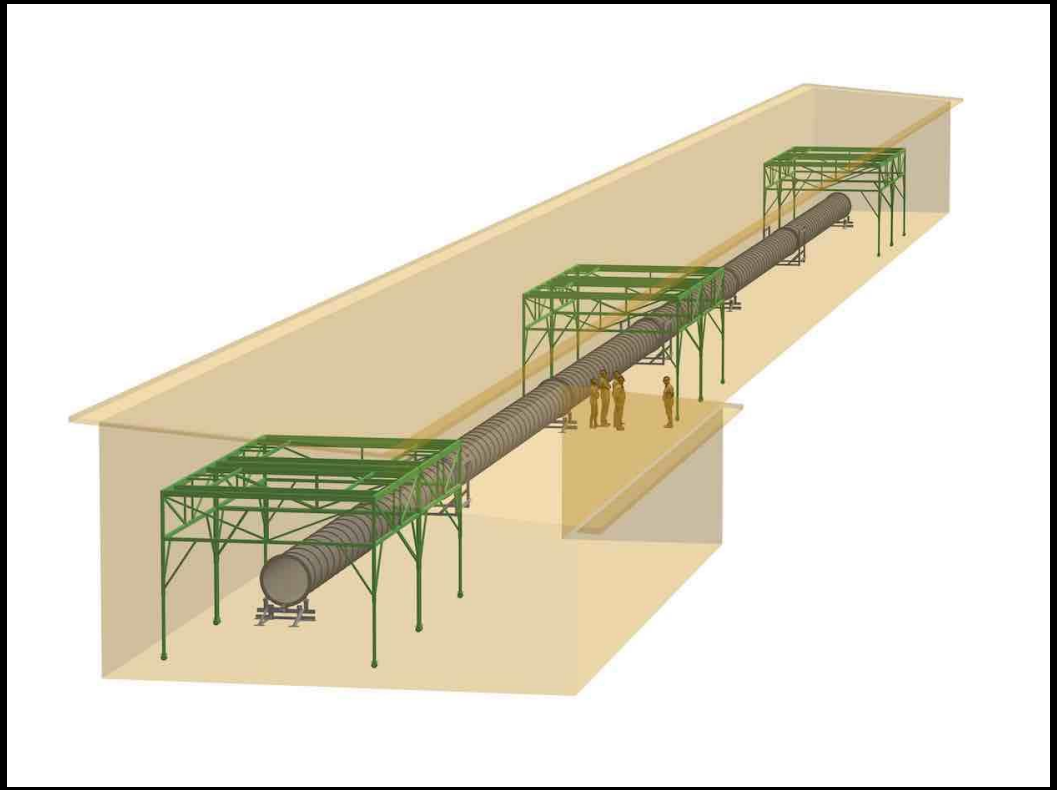
*LIGO Laboratory and Cosmic Explorer Consortium*

*Joint Bimonthly CE/ET Vacuum Studies Working Group*
*20 November, 2024*

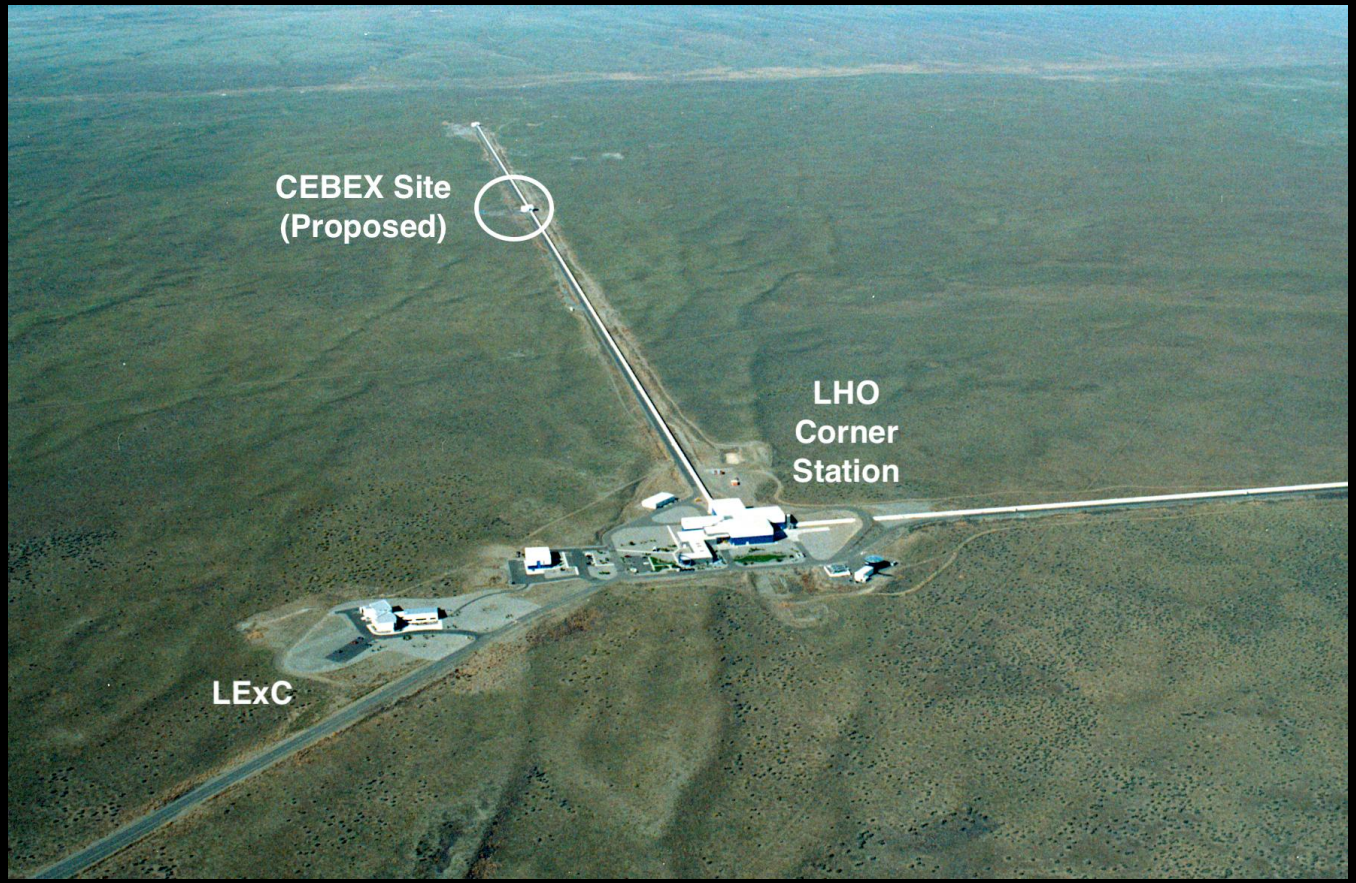
LIGO-G2402406

# CEBEX concept

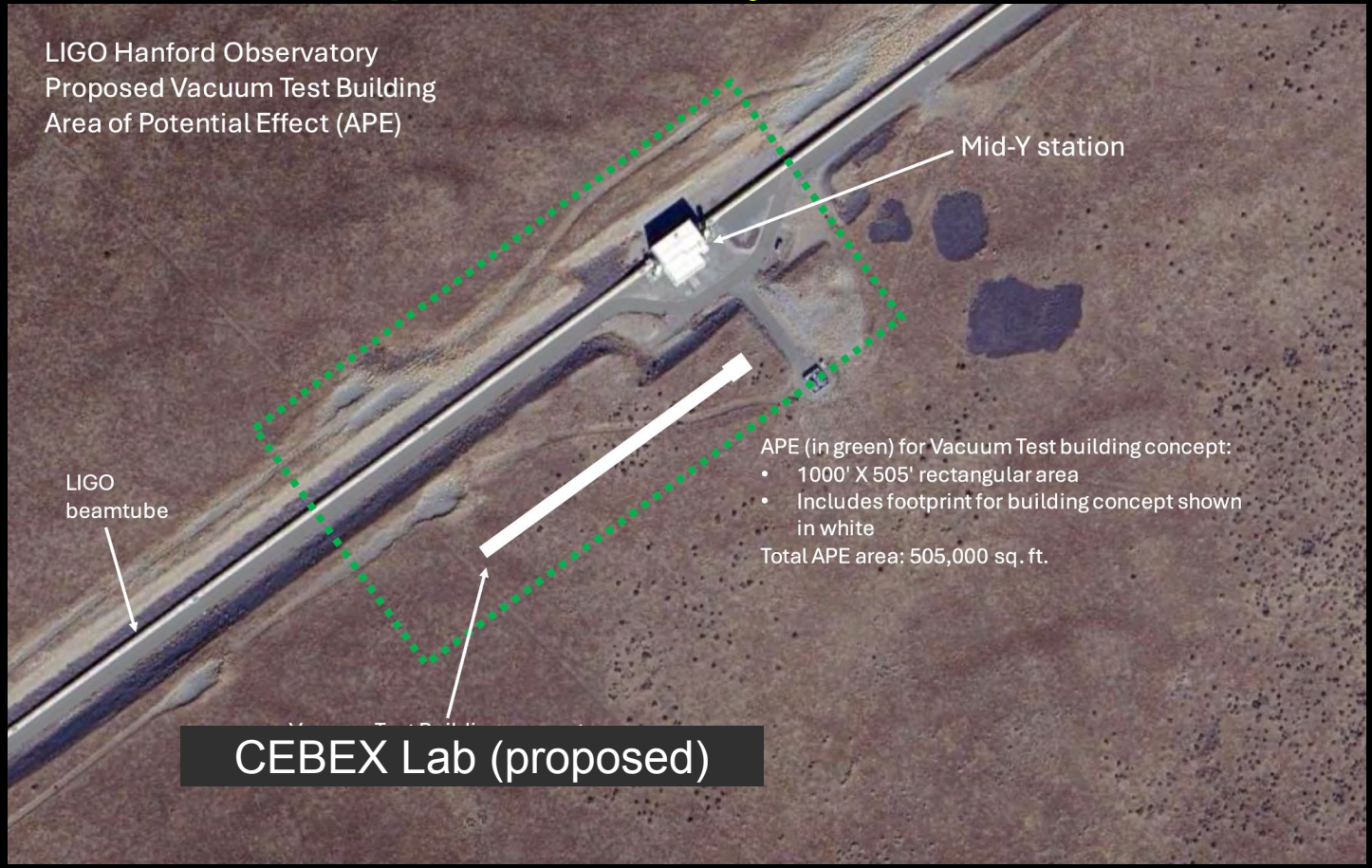


- US NSF award PHY-2422892
  ***CE beamtube technology pathfinder***
- Complementary with CERN's *ET Pilot Sector* program
- 120m (400') x 1.2m (4') prototype UHV beamtube w/ instrumentation & bakeout
- New 140m x 7m x 6m lab to be constructed at LHO
- 4-5 full time staff + 2-4 FTE part-time
- Tube installation target:
  *September 2025*
- To deliver CE conceptual design & parametric cost estimate
- Program authorized through Sept. 2028

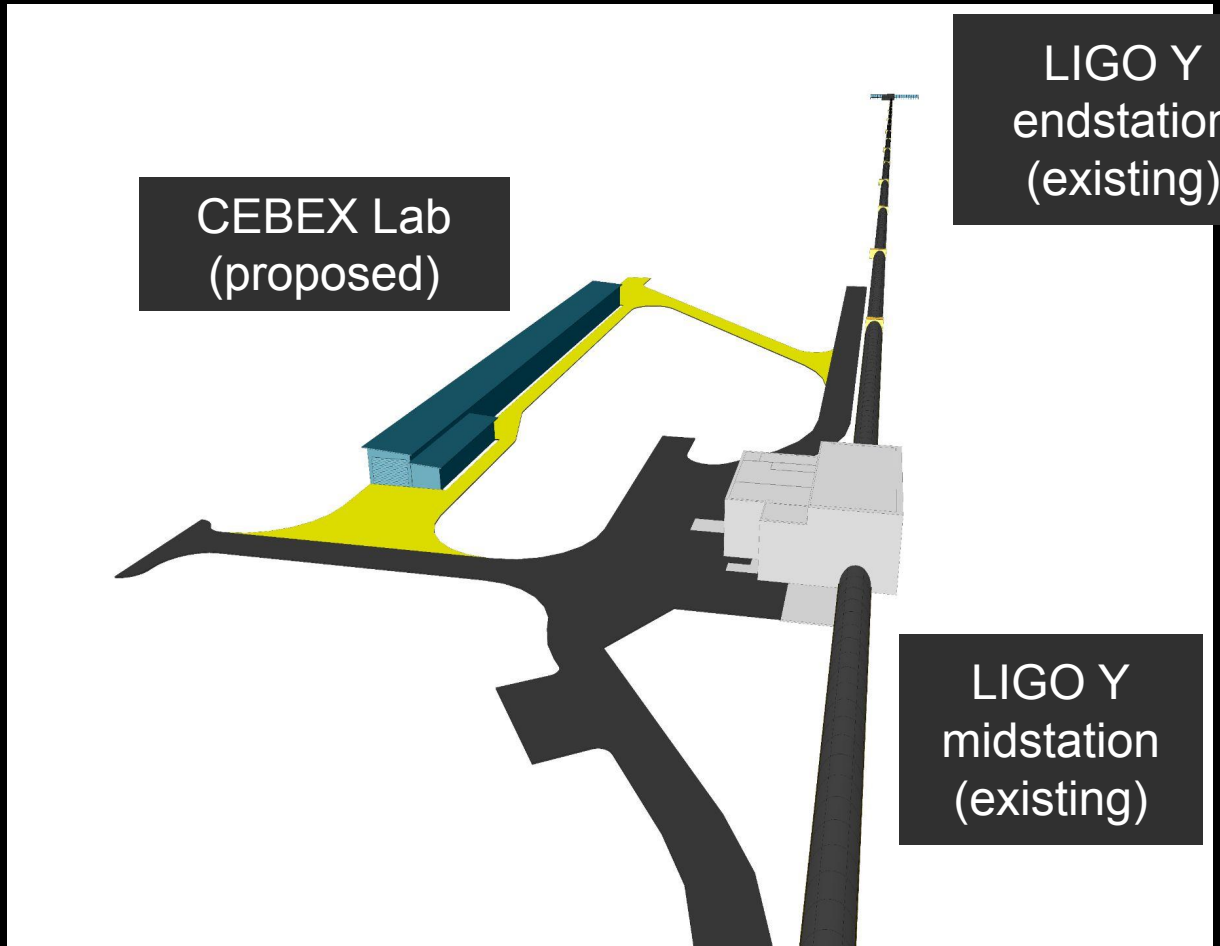
# Proposed location



# Proposed site layout and APE



# Concept ISO view (looking SW)



# ɔn so far

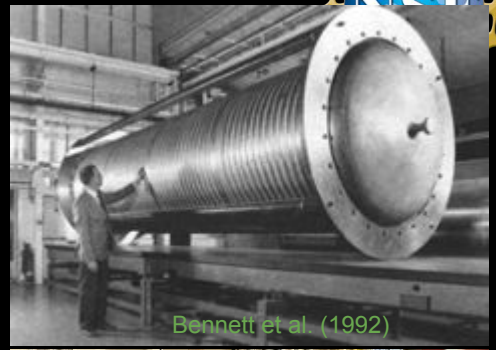
- Lab construction
  - NSF pursuing DOE and Tribal Nations site approval (req'd for LHO construction)
  - A&E specification, commercial "Design & Build" RFP on track for December release
- Team construction
  - Core team (Lead, PM, Chief Eng., Chief Sci., Sr. Sci.) on p/t loan from LIGO Operations
  - External p/t Sr. Mech. Eng., p/t Sr. Facilities Eng. (appointment pending)
  - Actively recruiting 4 fulltime CEBEX engineers,  (3) Vacuum and (1) Mechanical
- Tube construction
  - Under discussion- see next page
- Tube Material
  - Under discussion- see next page
- Bakeout
  - Depends on tube design
  - Currently pursuing 2 options:
    - DC $I^2R$ Joule heating (valve-isolated sectors) ← *baseline*
    - Traveling induction heat w/ viscous entrainment (no explicit valve isolation)

# Tube options

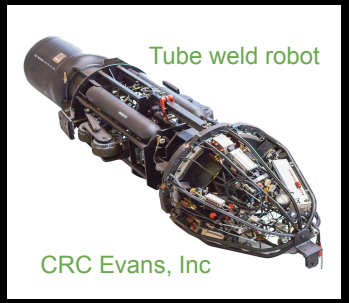
- Material downselect: *still agnostic* (at least for a little while)
  - This group's work establishes carbon, ferritic options in addition to austenitic (a triumph !!)
  - CERN test vessels and ET Pilot Sector providing definitive baseline for ferritic SS
  - To 1st order, all three mat'ls compatible with "thin" (< 5 mm, convoluted or stiffened) fabs
    - Thick wall ( > 9 mm, unstiffened) fab *appears restricted to carbon steel*
- Fab & field assembly: *still brainstorming*
  - Thick wall options depend on unknowns that will take time to resolve, e.g.,
    - Viscous-flow bakeout ($I^2R$ incompatible)
    - CS corrosion protection & surface morphology
    - M/L impact on logistics, supports, vibration isolation, expansion joints
  - We therefore evidently need to maintain a thin-wall option, as baseline or at least in parallel
  - Pursuing 2 options (or more) is possible, up to budget constraint
    - Laboratory will accommodate parallel beamlines, or subdivided sector length
- Expect material and fab downselect review in spring of '25 (TBR)

# Things we're looking at…

- Inspired and influenced by CERN Pilot Sector design (reviewed 22 January, 2024)
  - Axisymmetric corrugations (RAL, GEO, CERN)
  - Spiral corrugations (CERN)
    - possible structural issues (torsion) during bakeout?
- Short (< 3m) vs. long (~ 20m) unit segments
  - LIGO has field joints every 20m, ~ 16 h each w/ leak test
  - CE could use < 2.5 m subunits if each field joint takes < 1h
    - Robotic pipeline welding?
  - Could open new fabrication & logistic options
- Cost, frequency, and function (isolation?) of tube supports

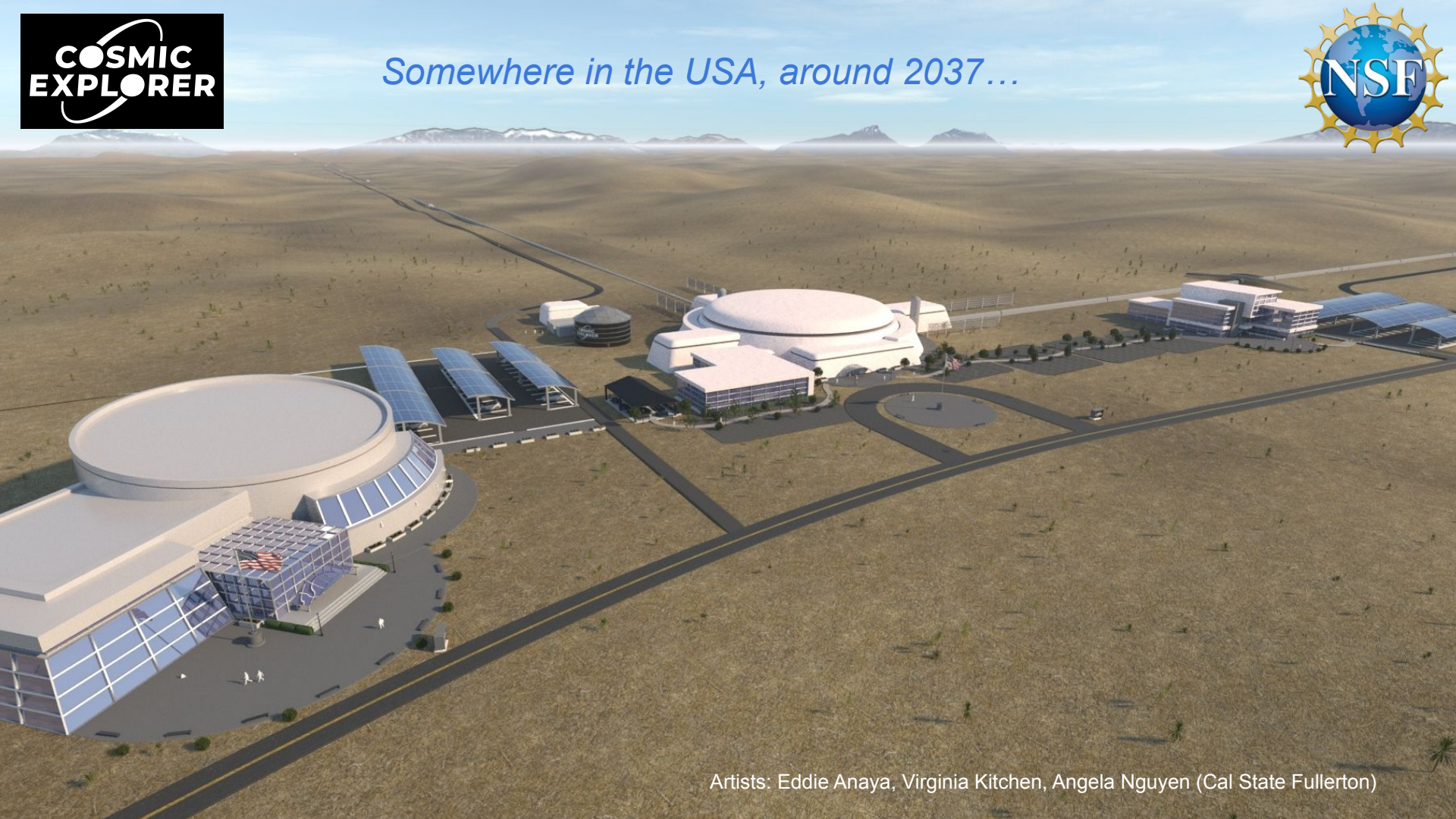





# Onward

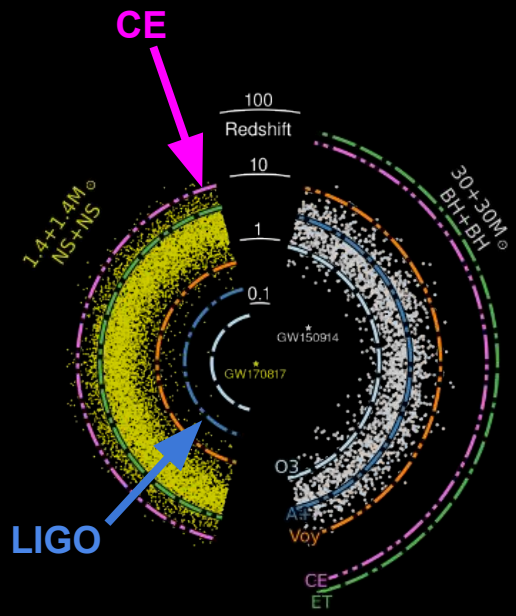
- We're following at least a year behind the Pilot Sector program
  - This is a huge advantage (and great motivation!)
  - Building on ET team's extensive groundwork
  - Hope to cover additional new ground that's mutually beneficial
- Building on outstanding work by this working group; may it continue!
- We appreciate your input as CEBEX program takes shape
- 3G GW Beamtube Workshop III @ LHO: **6-9 May 2025**


COSMIC EXPLORER
Somewhere in the USA, around 2037…
NSF
Artists: Eddie Anaya, Virginia Kitchen, Angela Nguyen (Cal State Fullerton)

# Cosmic Explorer

**Cosmic Explorer** (CE) is NSF's program to build the world's ***next-generation gravitational-wave observatory***

- 40 km L-shaped laser interferometer (10x LIGO)
- About 10x sensitivity of LIGO
  - → will find black holes and neutron stars ***to the edge of the observable universe***

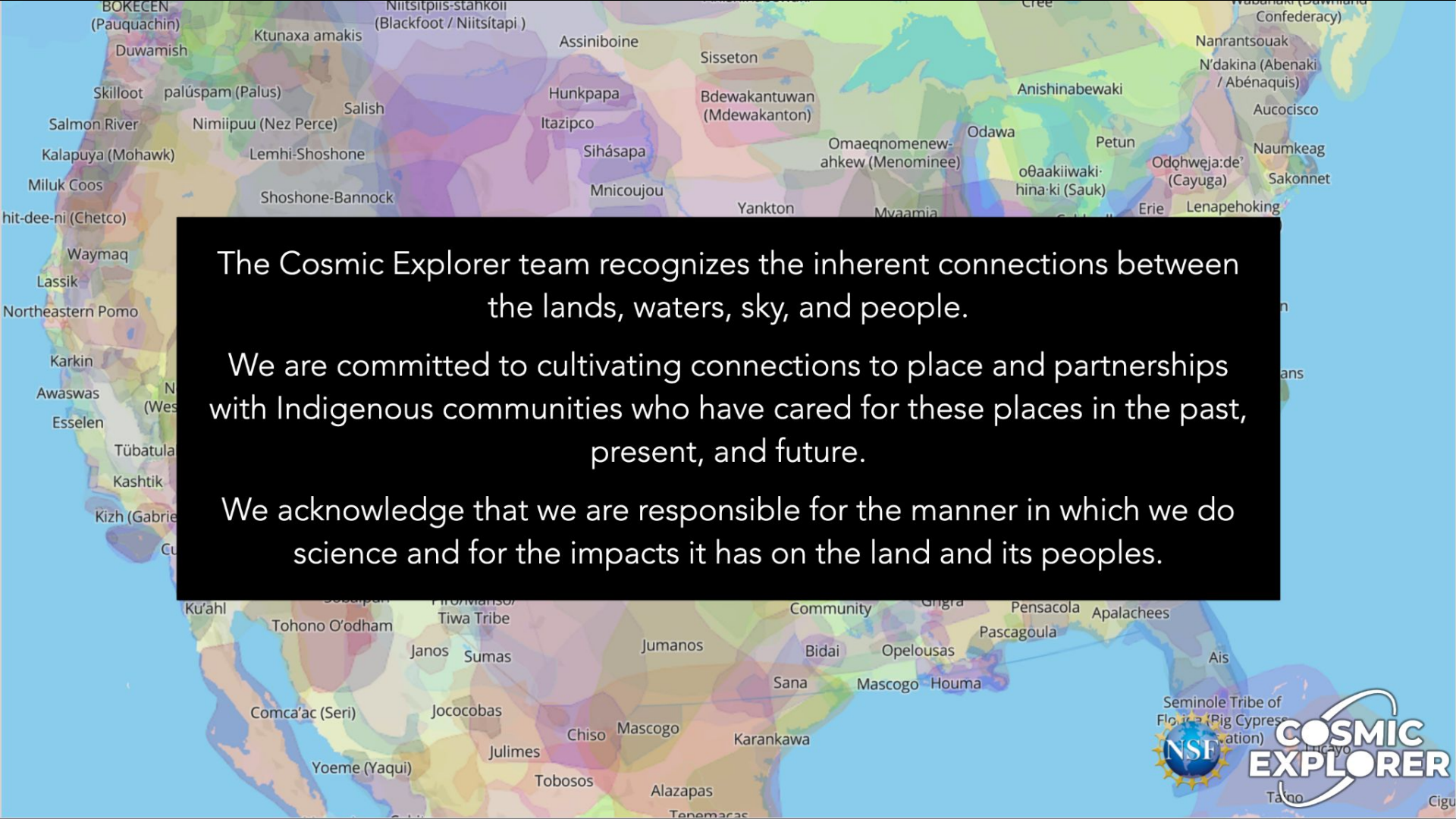



Ultrahigh-vacuum laser beamtubes 10x LIGO – a challenge!

- *LIGO is already the biggest UHV system ever made*
- Simply "scaling up" would be prohibitive in time and $

NSF commissioned **CEBEX** to develop and test new tube technology for CE

- LIGO Hanford is the ideal research site: *expertise, infrastructure, environment & culture*
- A new lab at LHO is needed to support this research program


The Cosmic Explorer team recognizes the inherent connections between the lands, waters, sky, and people.
We are committed to cultivating connections to place and partnerships with Indigenous communities who have cared for these places in the past, present, and future.
We acknowledge that we are responsible for the manner in which we do science and for the impacts it has on the land and its peoples.
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