Cosmic Explorer

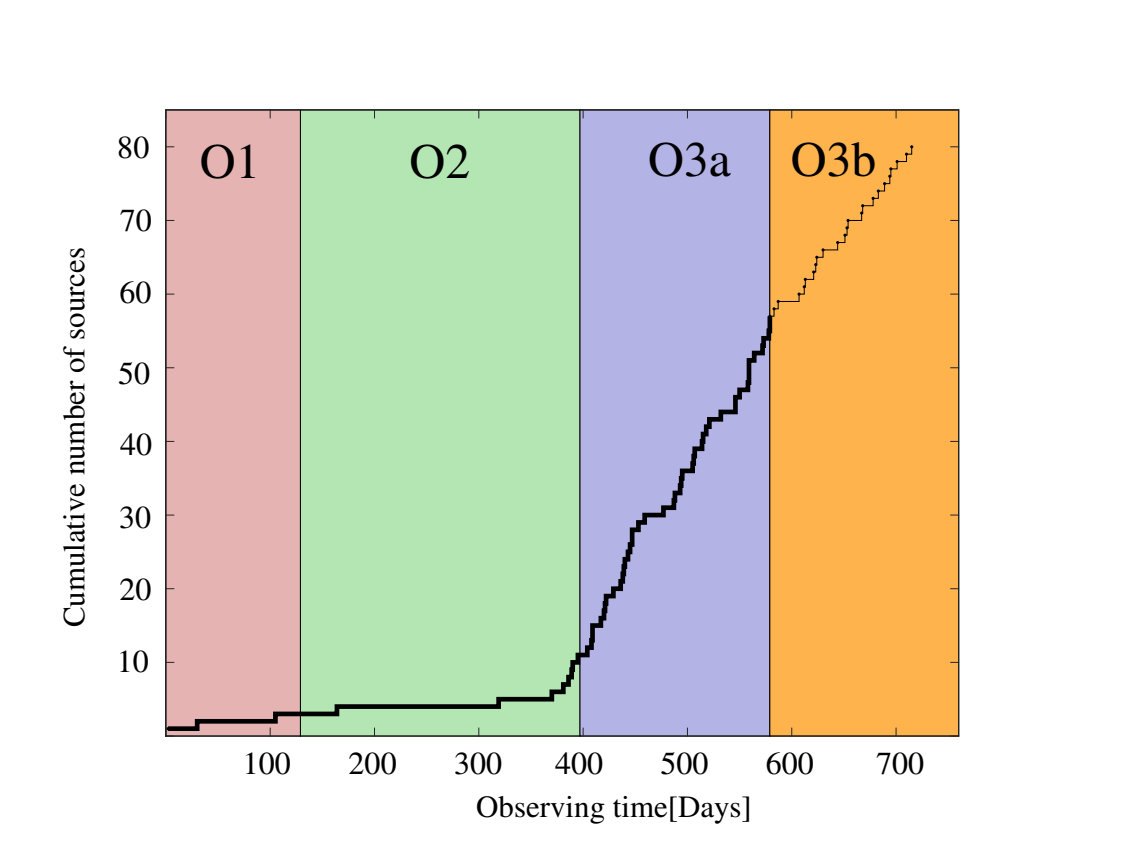
@CosmicExpGW

Salvatore Vitale on behalf of the Cosmic Explorer Project Team

MIT

GW probes BSM 2021

Where are we?

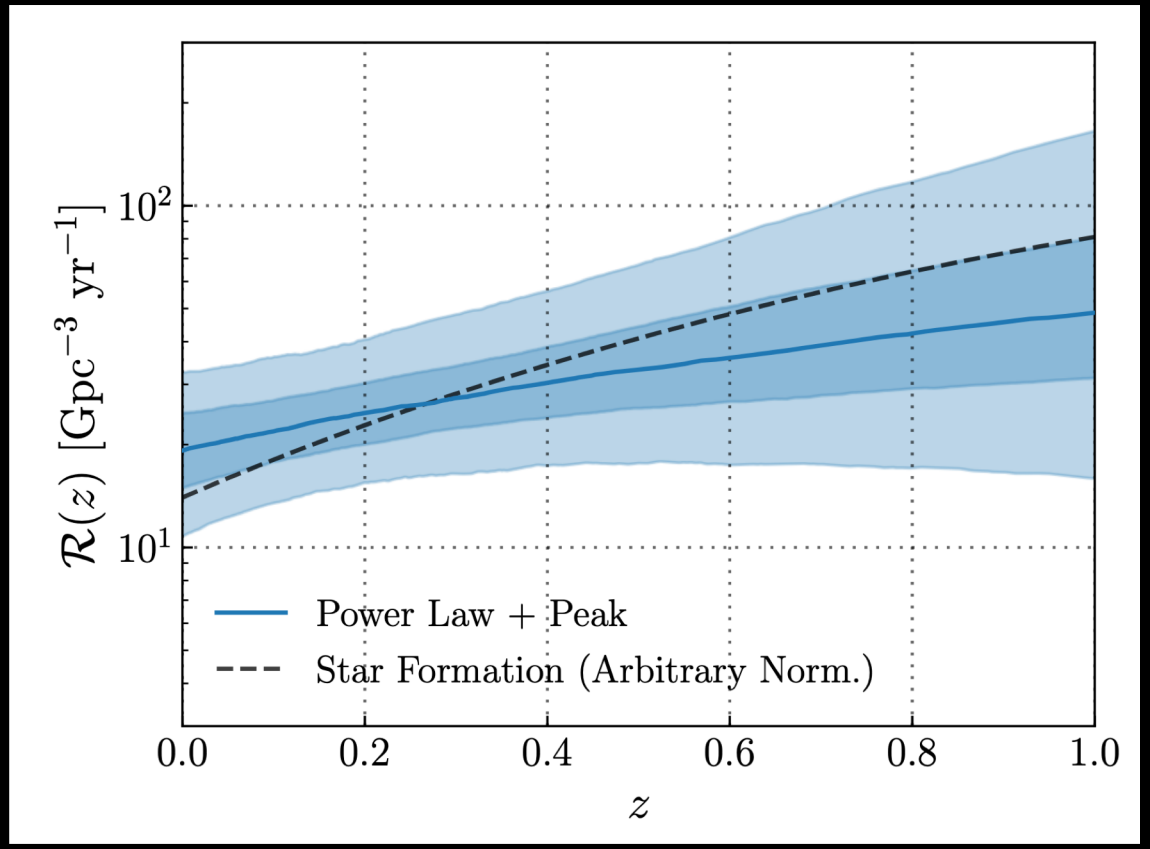


SV 2011.03563, adapted from LVC public document G1901322

- Advanced LIGO detectors have run since 2015 (with Virgo since 2017)
- Three observing runs
- The third observing run lasted roughly one year
  - 56 candidate events made public (one per week!)
  - Two neutron star black hole mergers (LVK 2106.15163)
  - A few odd balls
  - LVC catalogs paper online: 2010.14527, 2010.14529, 2010.14533

Where are we?

- Even at design sensitivity, current detectors will be limited to
  - Local universe
  - ~100-200 sources (mostly BBH) per year
  - Low to moderate signal-to-noise ratio
  - Limited number of sources with EM counterparts



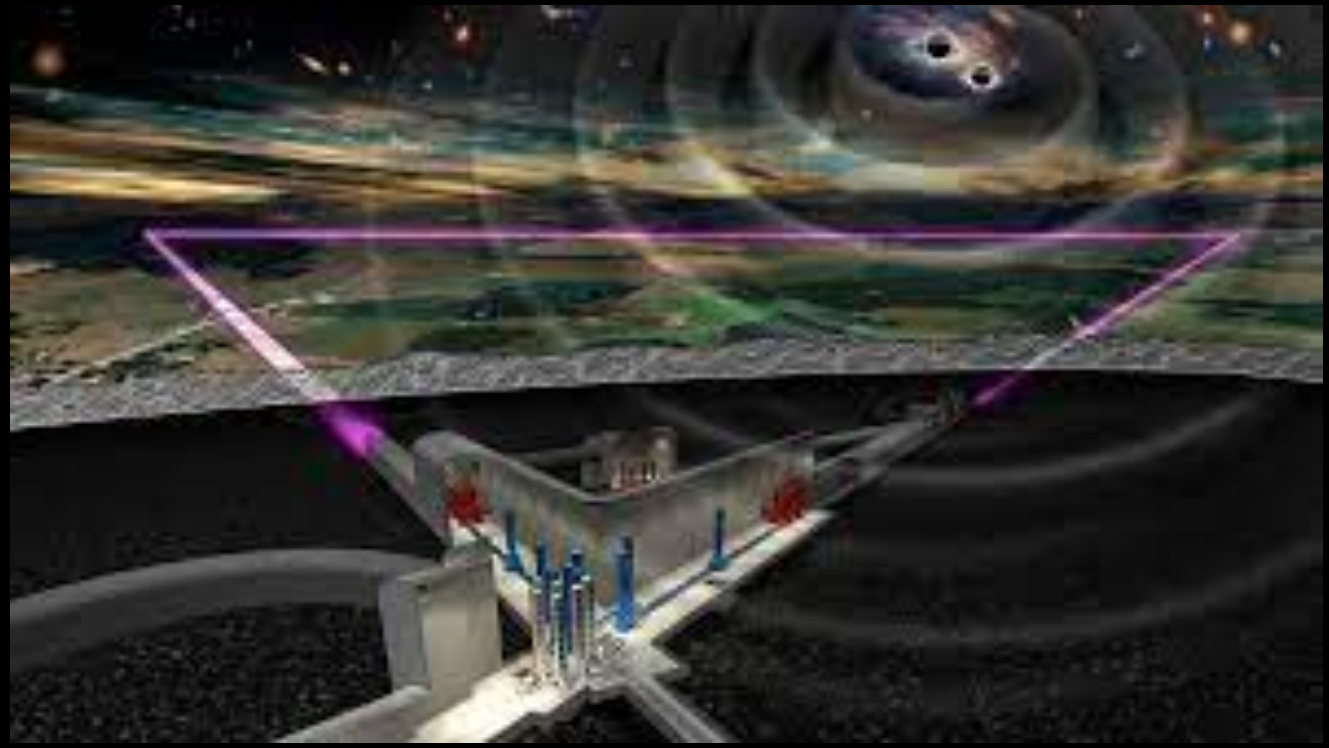
LVK 2010.14533

Third-generation (3G) detectors

- To gain access to sources across the universe new facilities are required
- 3G detectors
  - Strain sensitivity 10x better than advanced detectors
  - Detect black hole binaries at large redshifts
  - High signal-to-noise ratios
  - Many 100K sources per year
- Targeting operation in the second half of 2030s

Einstein Telescope

- A proposed next-generation ground-based gravitational-wave detector
- Triangular-shaped, 10 Km arms
- Underground to access low (Hz) frequency
- Mature design, design report published in 2011
- Recently included in the European Strategic Forum for Research Infrastructures (ESFRI) roadmap!

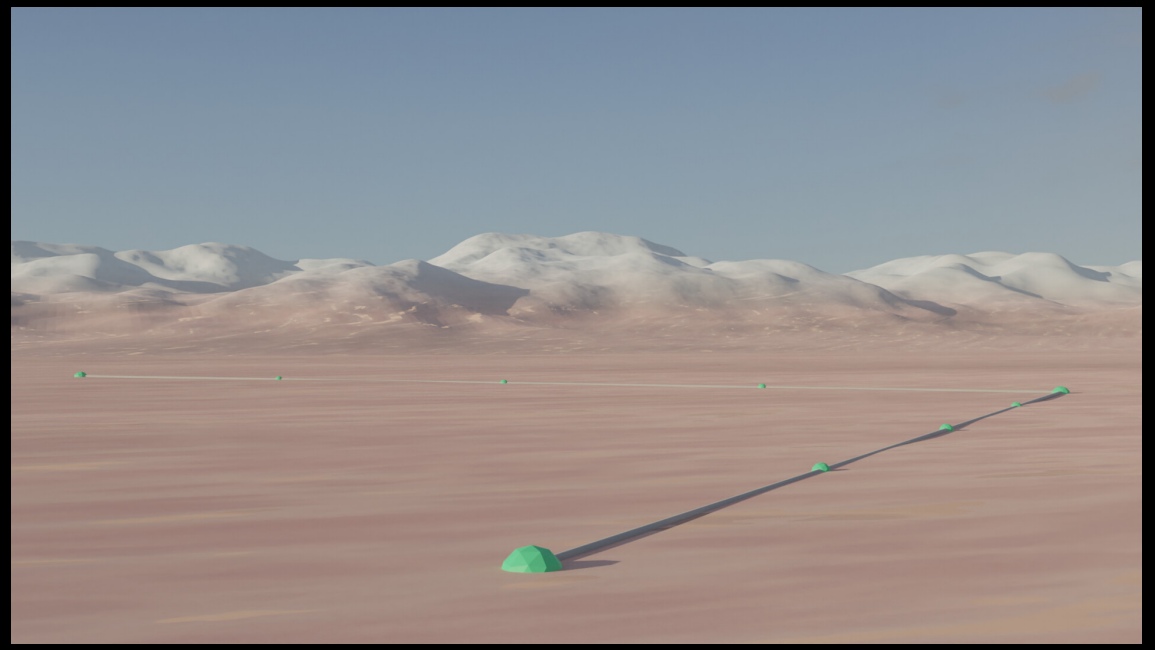


Credit: NIKHEF

Cosmic Explorer

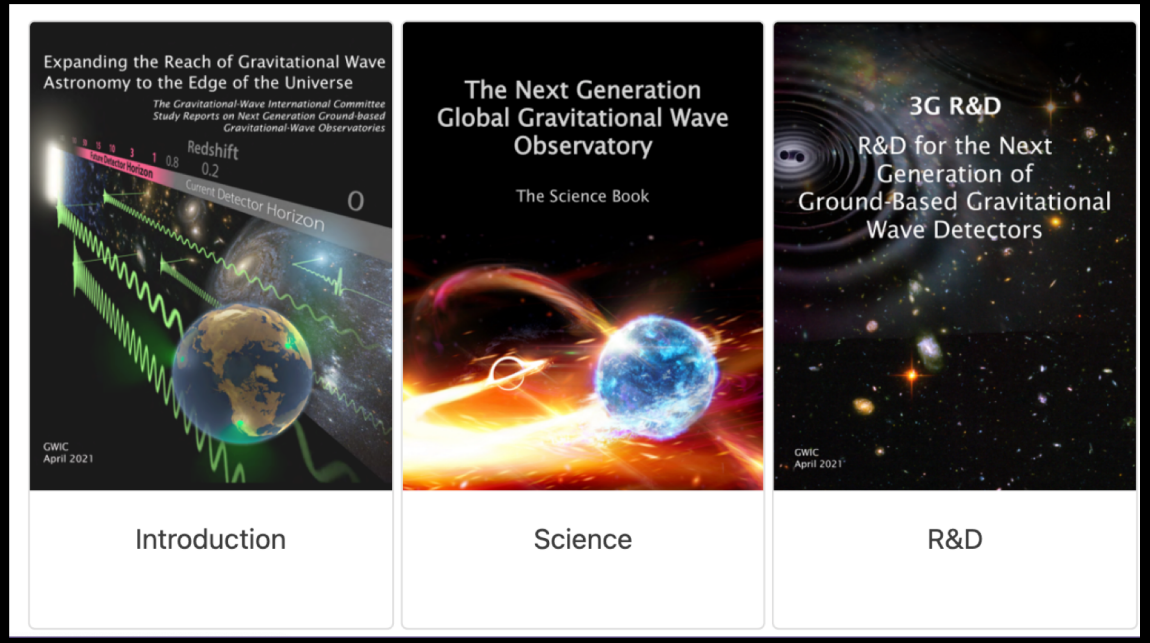
- A proposed next-generation ground-based gravitational-wave detector
- L-shaped like current detectors, but 40Km
- On the ground
- Can be optimized to target high-frequency (KHz) or medium-frequency (100s Hz) sources

Cosmic Explorer Horizon Study (CEHS) 2021



The Gravitational Wave International Committee and 3G

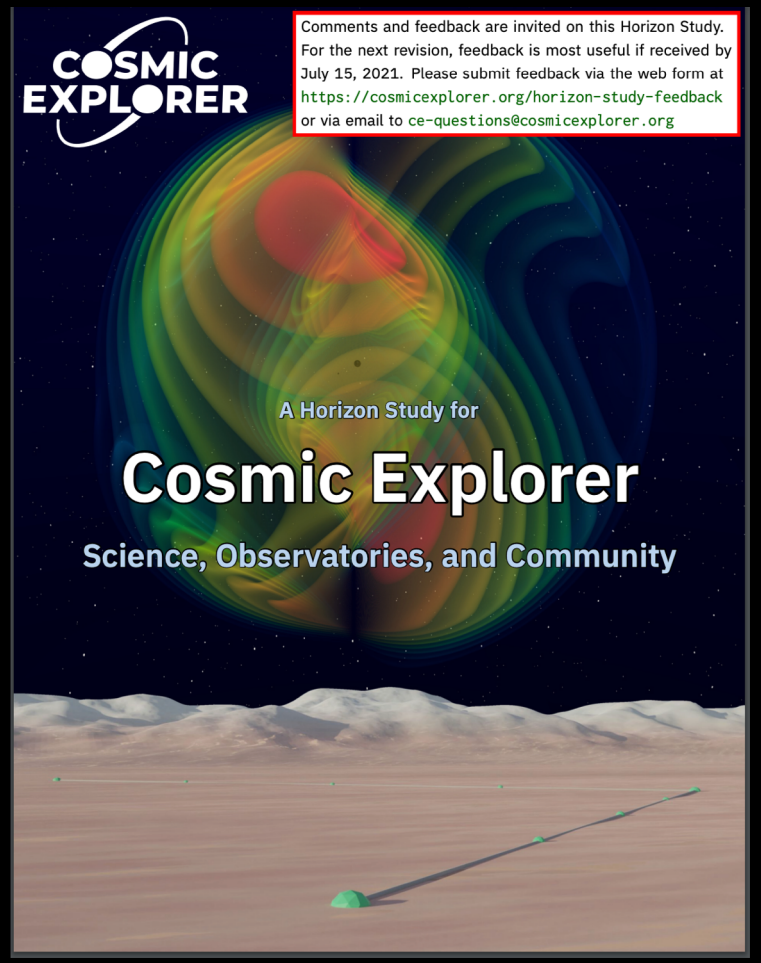
- To get the most out of 3G detectors, a network is required
- The GWIC has formed a committees focusing on 3G R&D, science, and global coordination
- Read more here: gwic.ligo.org/3Gsubcomm/
- Dozens of useful documents and links !



Cosmic Explorer Horizon Study

- NSF funded an Horizon Study (CEHS) to explore design options and scientific potential of ground-based next-generation detectors in the US
- A mature draft can be read at

dcc.cosmicexplorer.org/CE-P2100003/public



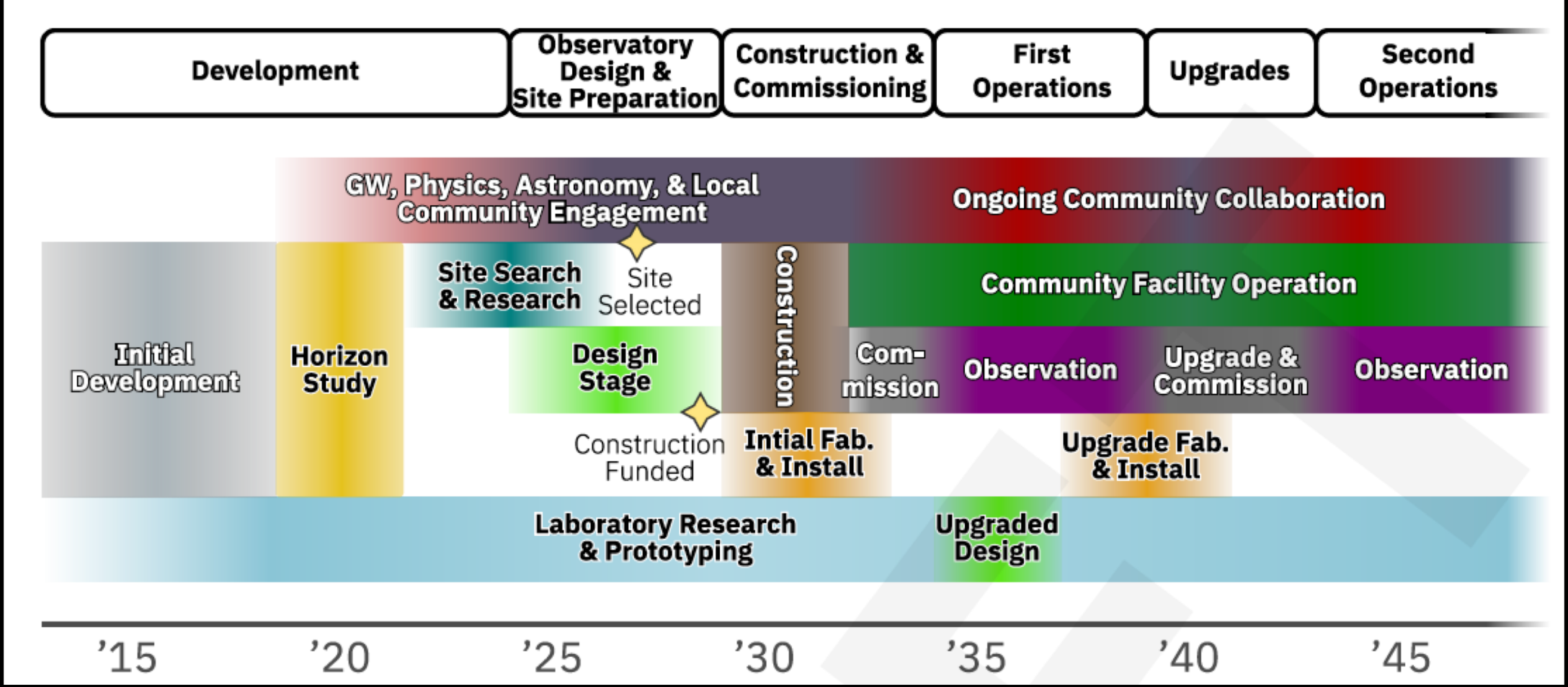
CEHS 2021

Cosmic Explorer Horizon Study

Contents

CEHS 2021

Timeline

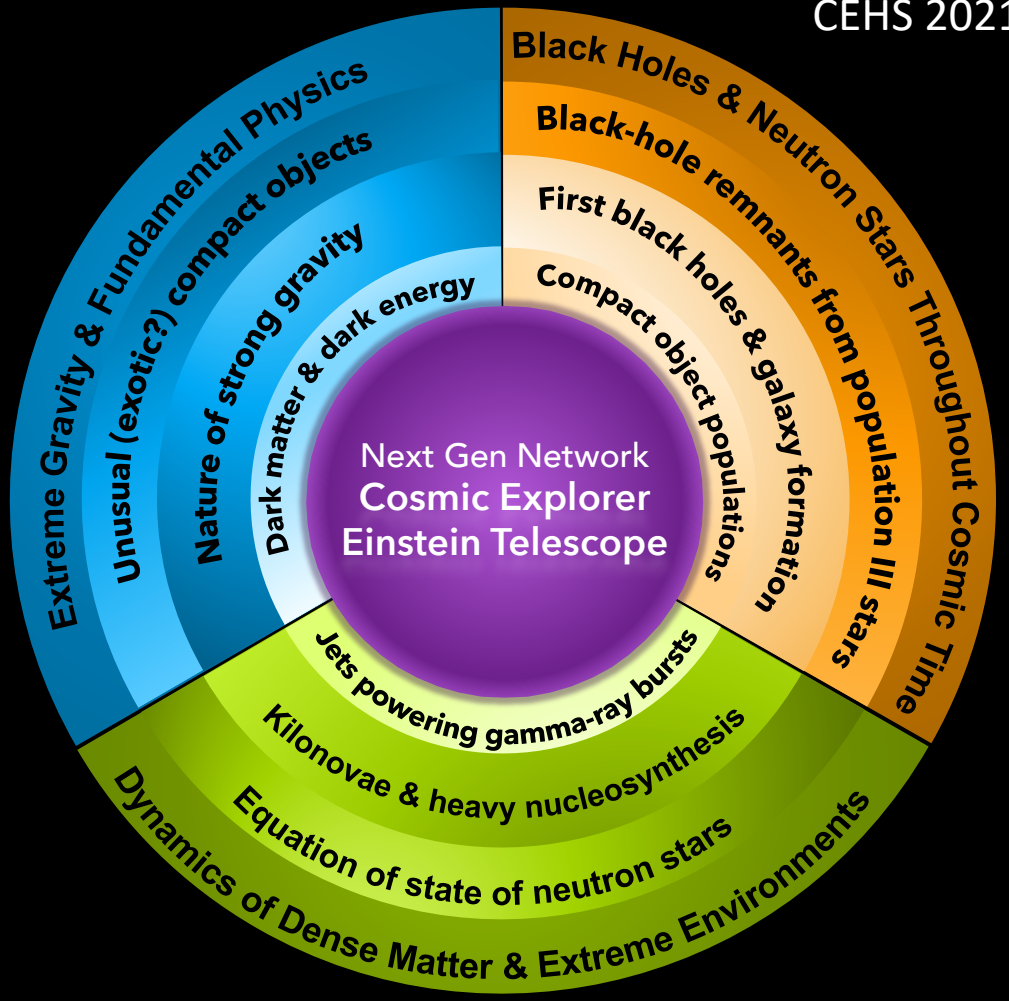


CEHS 2021

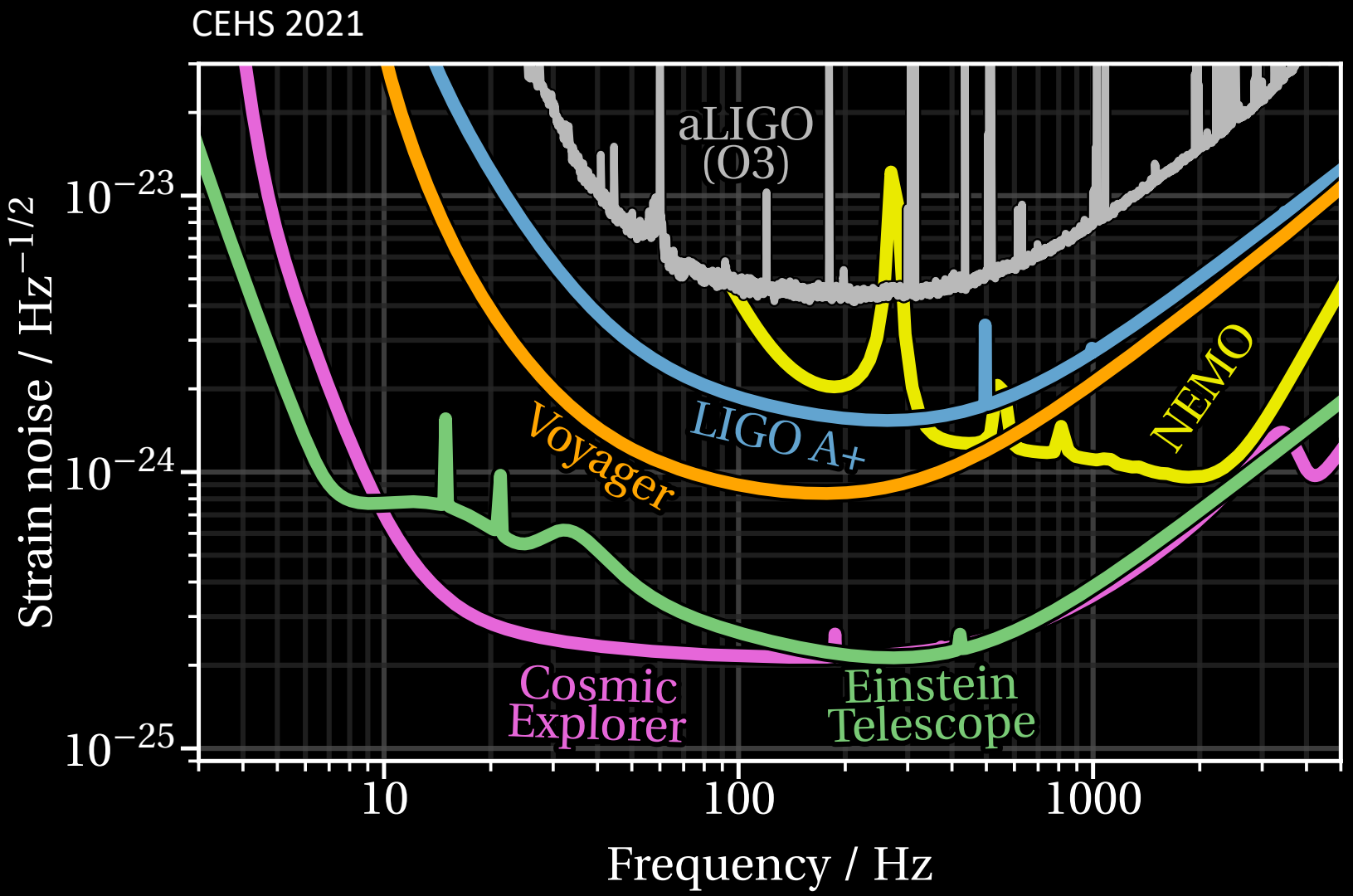
Cosmic Explorer Horizon Study

- The CE HS identifies key science outcomes that can be reached with this type of facility
  - Black holes and neutron stars throughough cosmic time
  - Dynamics of dense matter & extreme environments
  - Extreme gravity & Fundamental Physics

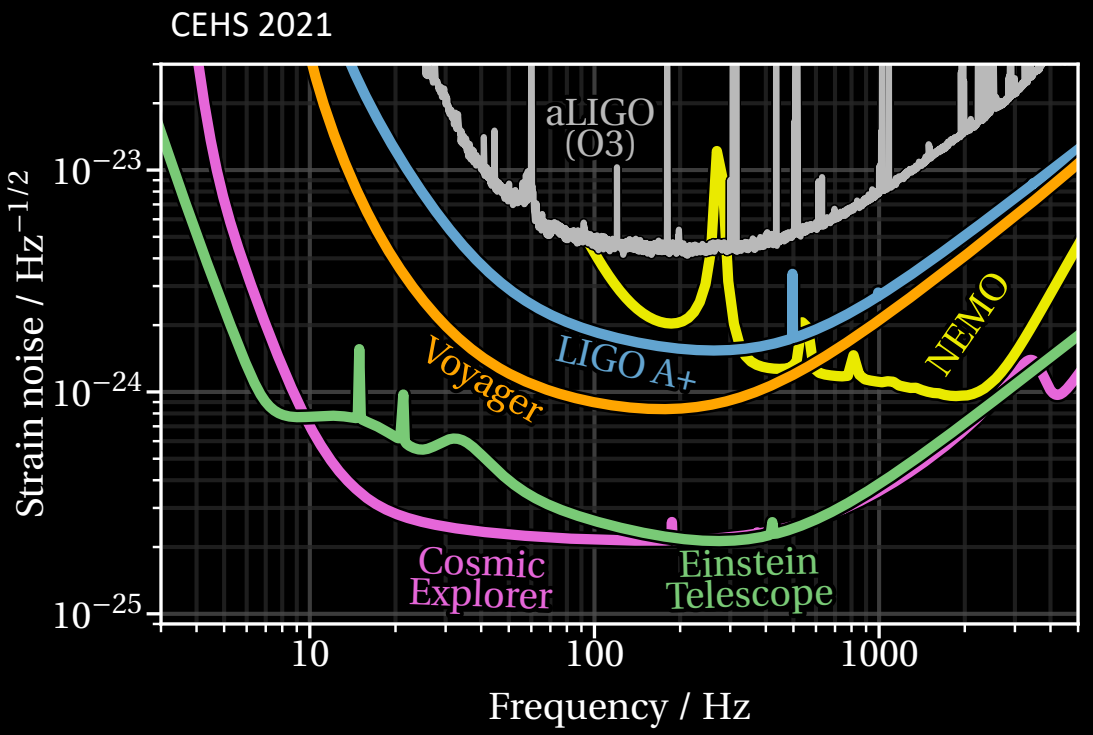
CEHS 2021



Detector sensitivity



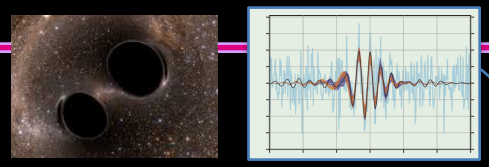
Detector sensitivity

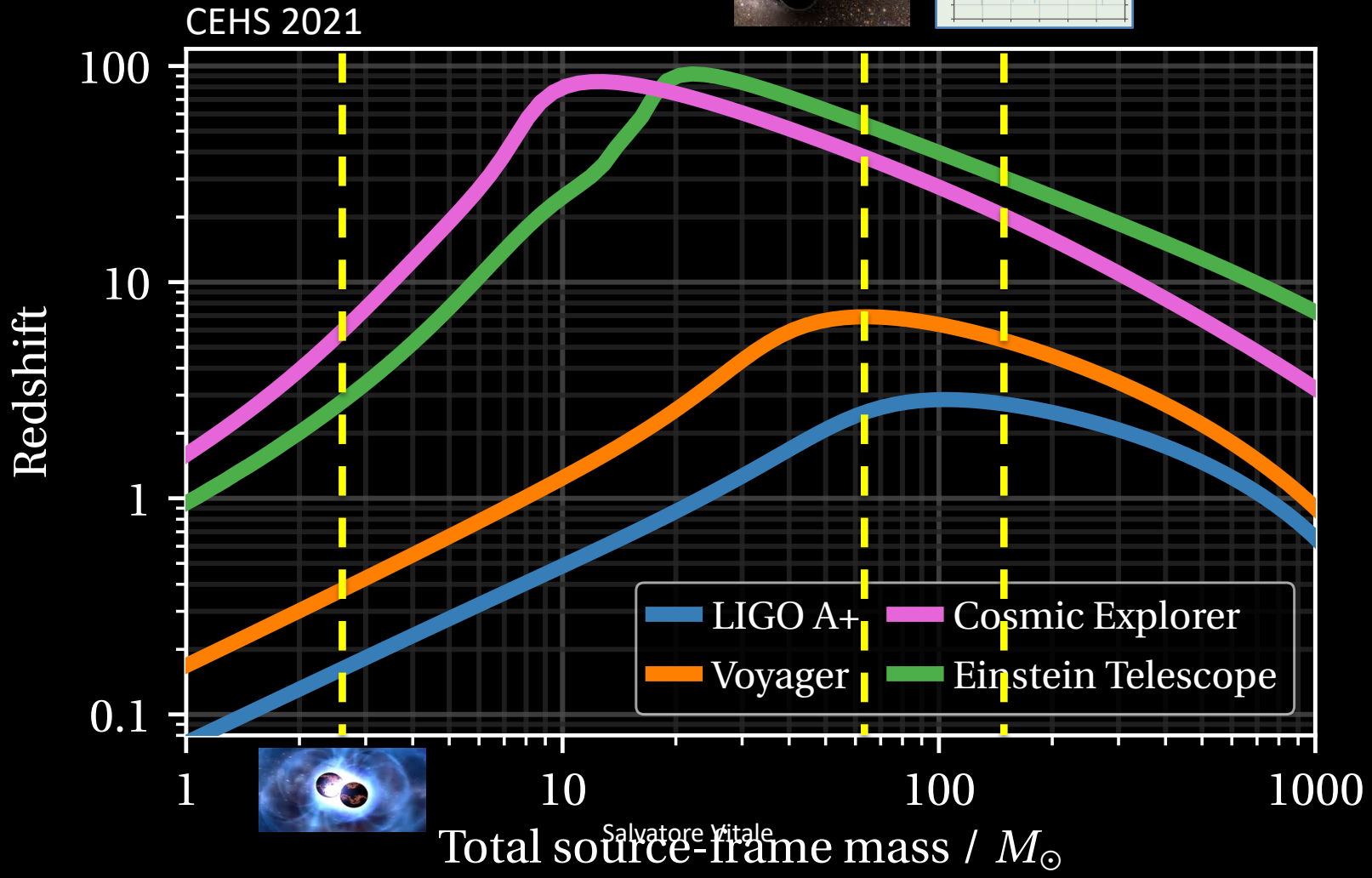


- You can use the Cosmic Explorer sensitivity curves in your projects!

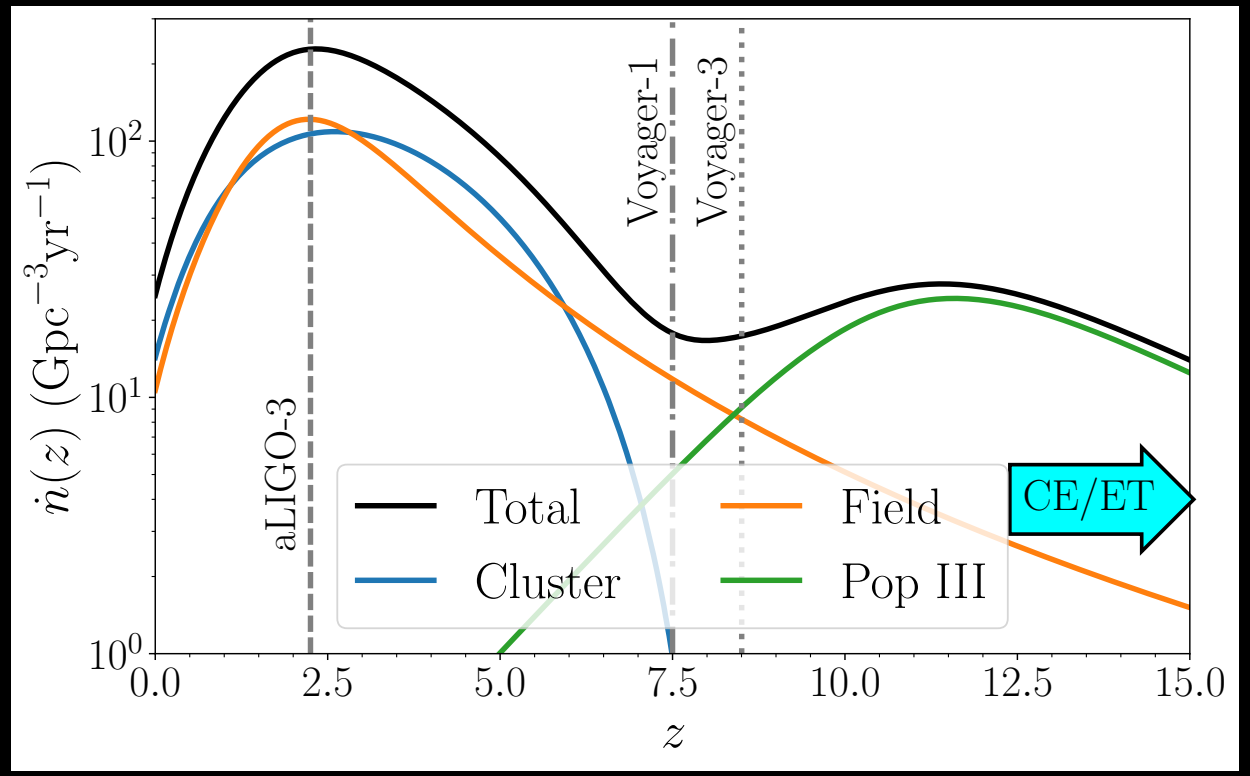
dcc.cosmicexplorer.org/CE-T2000017/public

Listening to the Universe





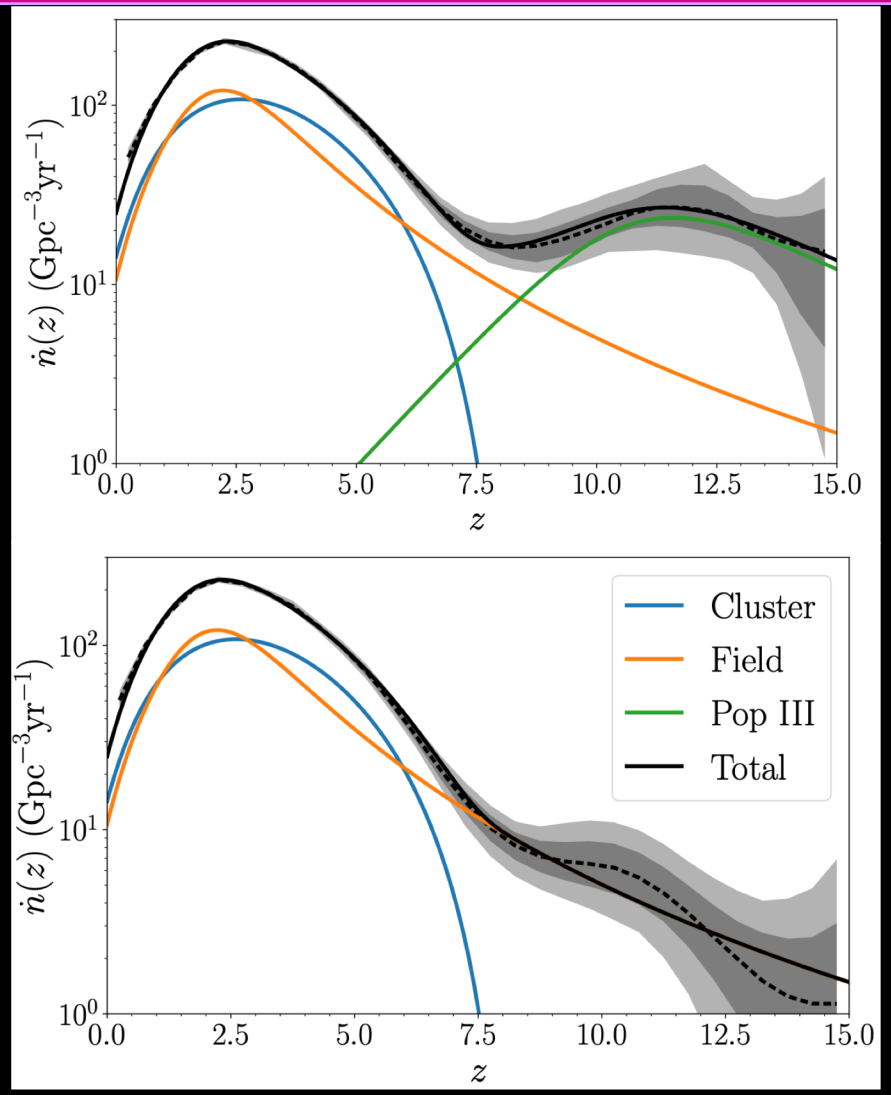
Populations of binaries



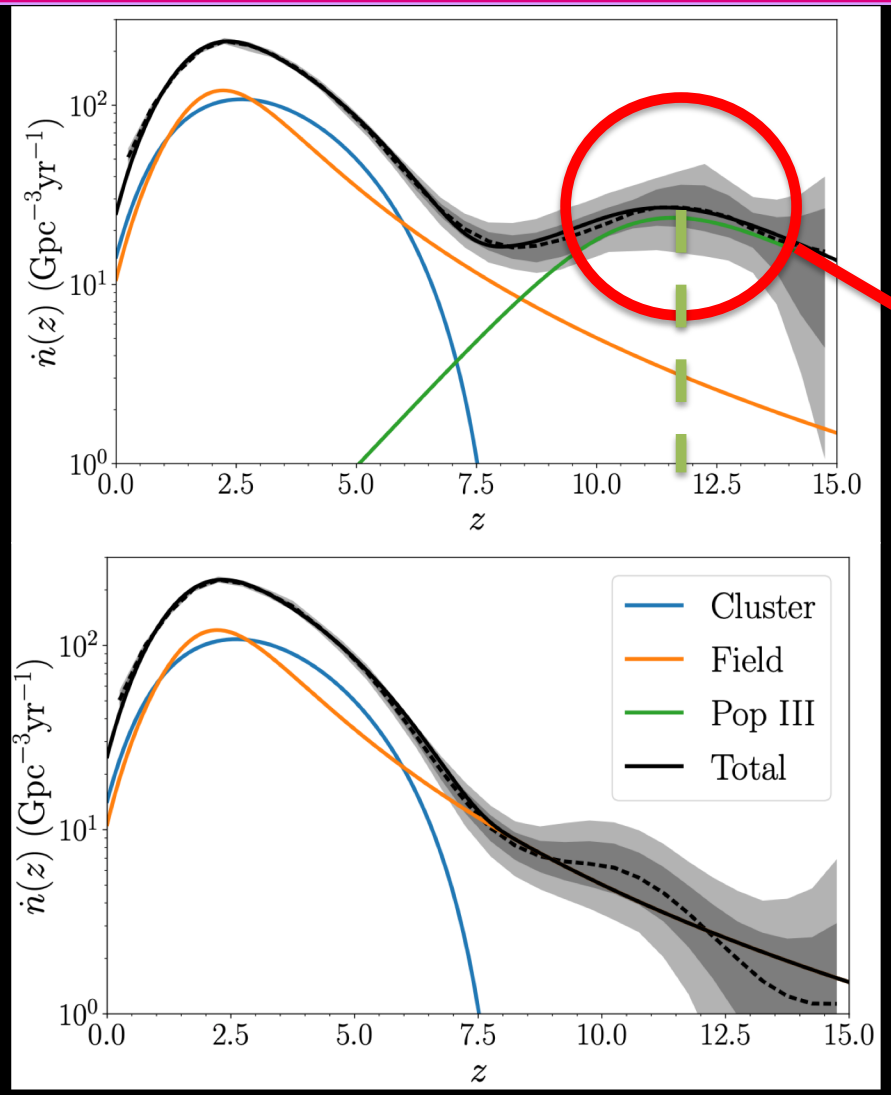
Ng+ 2012.09876

- Can detect black holes from populations which are currently unaccessible
- It is important to have a network, to measure distance well, and hence source-frame mass

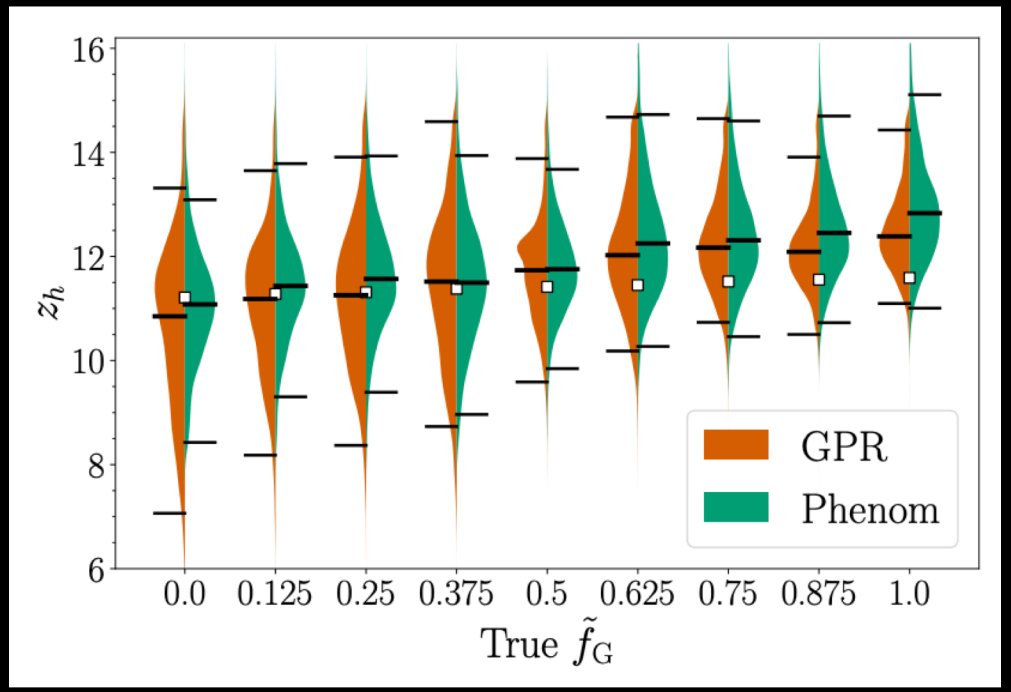
Detecting of Pop III BH mergers



Detecting of Pop III BH mergers



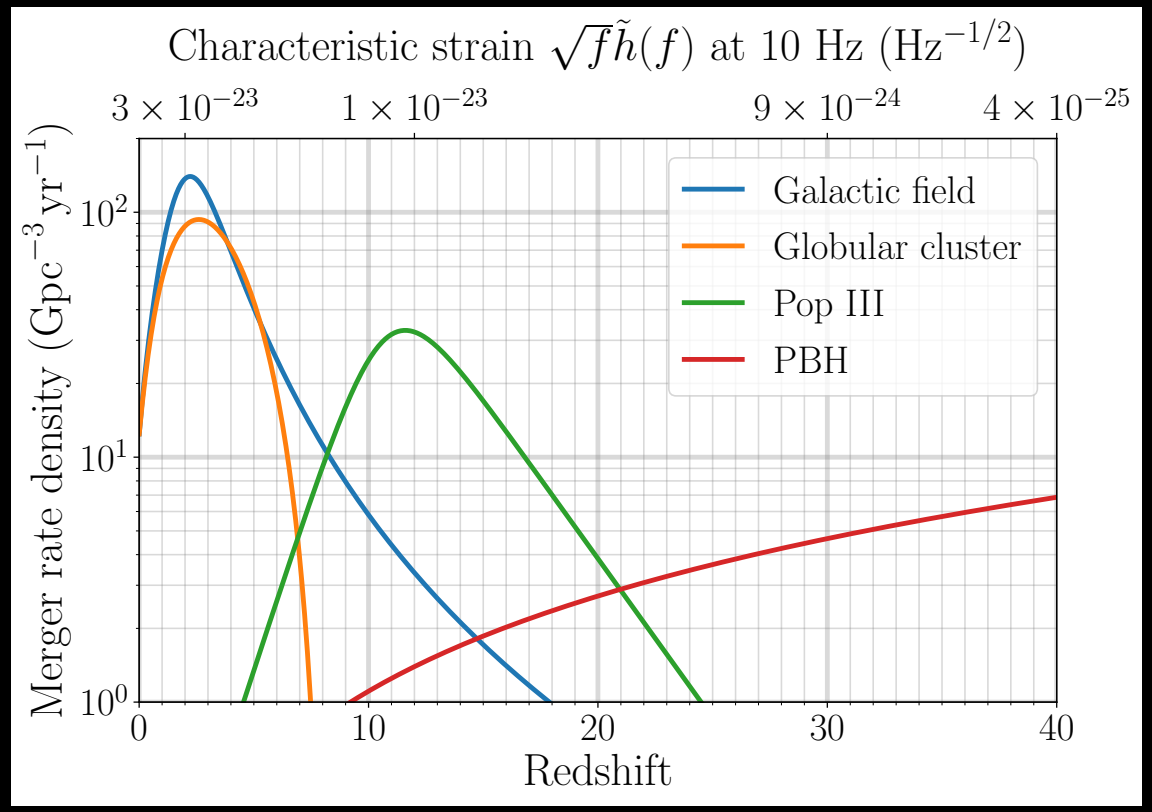
Can measure the location of high-z peak with a few months worth of data and no modeling!



Ng+ 2012.09876

Detecting PBHs mergers

- Primordial black holes mergers might be recognizable because of
  - Mass and spins spectrum
  - Eccentricity at merger
  - Extemely high redshift
- Of these, the high redshift seems like the most uncontroversial tracer



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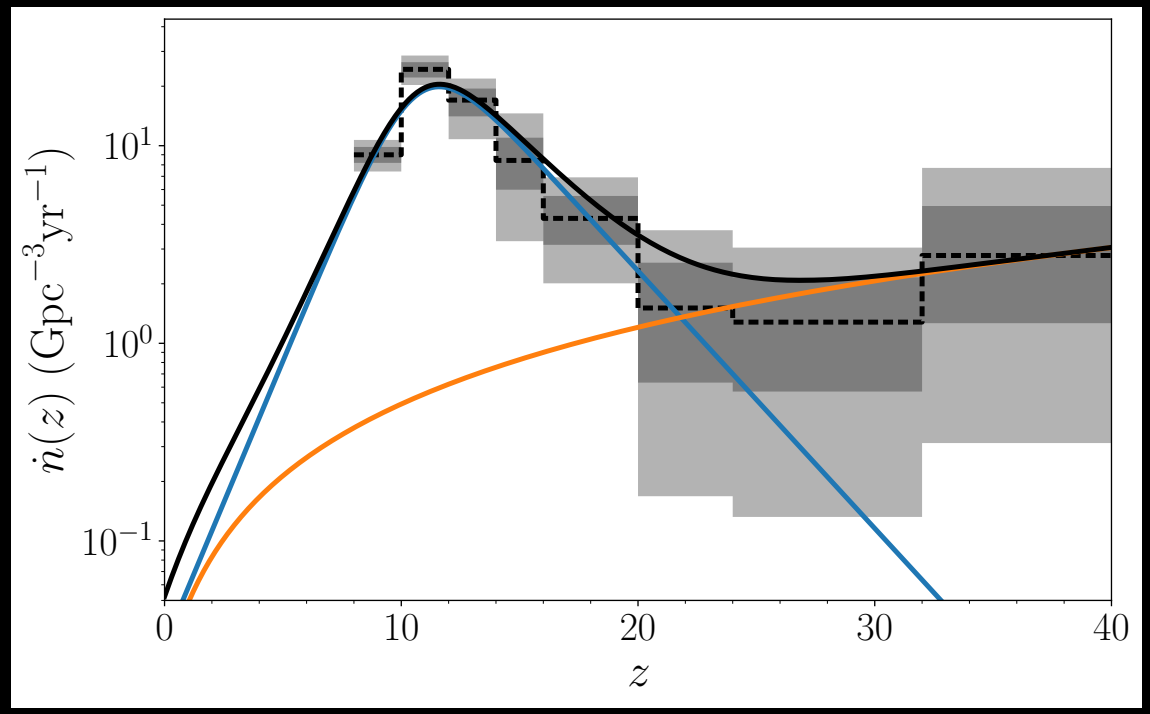
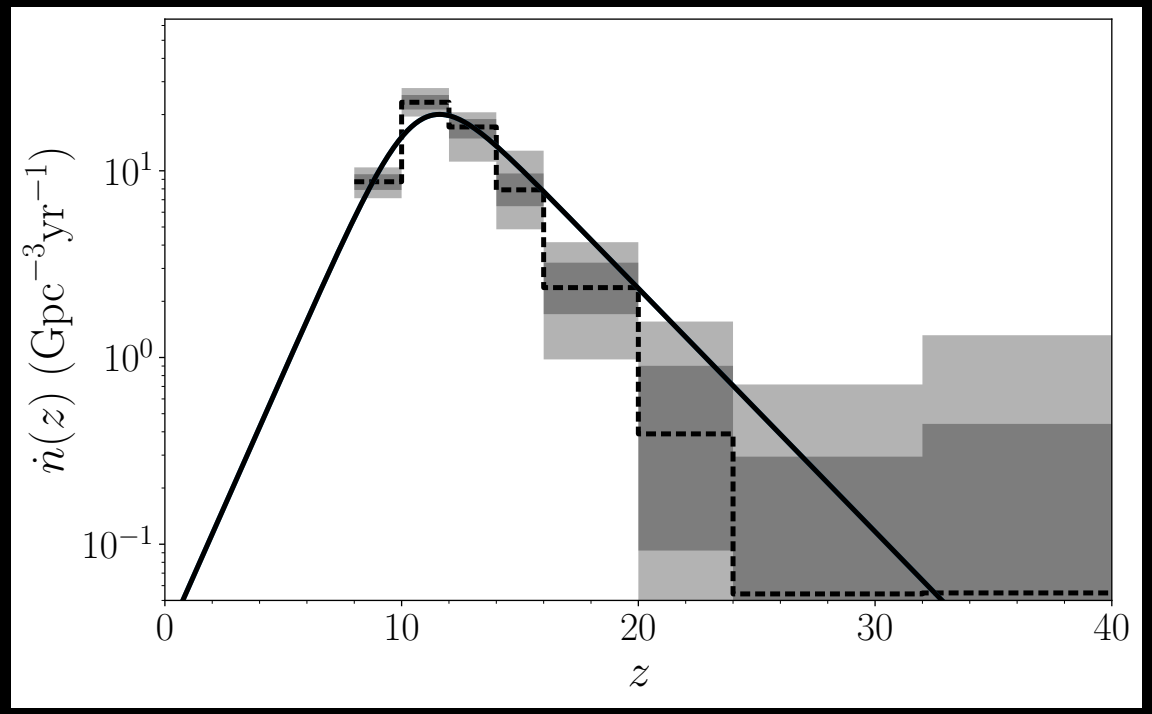
Detecting PBHs mergers

$N_{PBH} = 1/8\ N_{Pop\ III}$



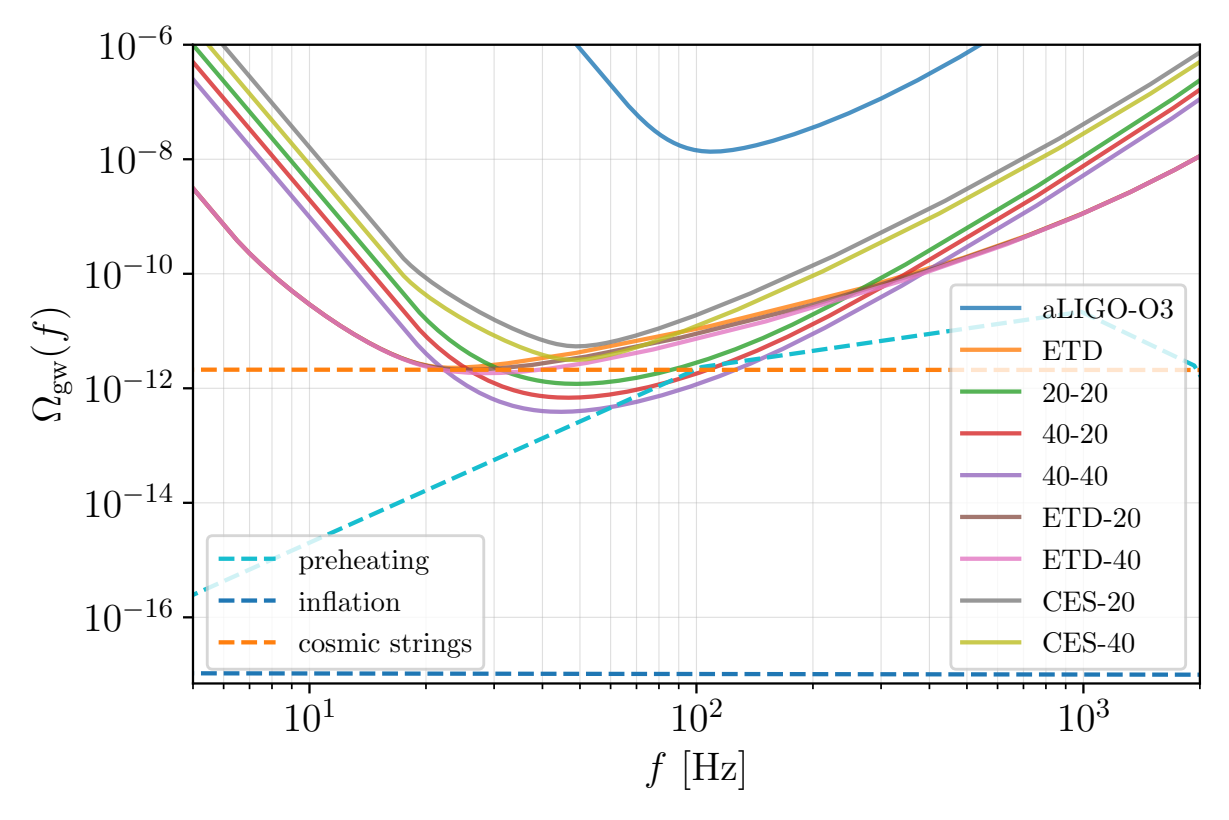
$N_{PBH} = 0$



Ng+ in prep

Stochastic background

CEHS 2021

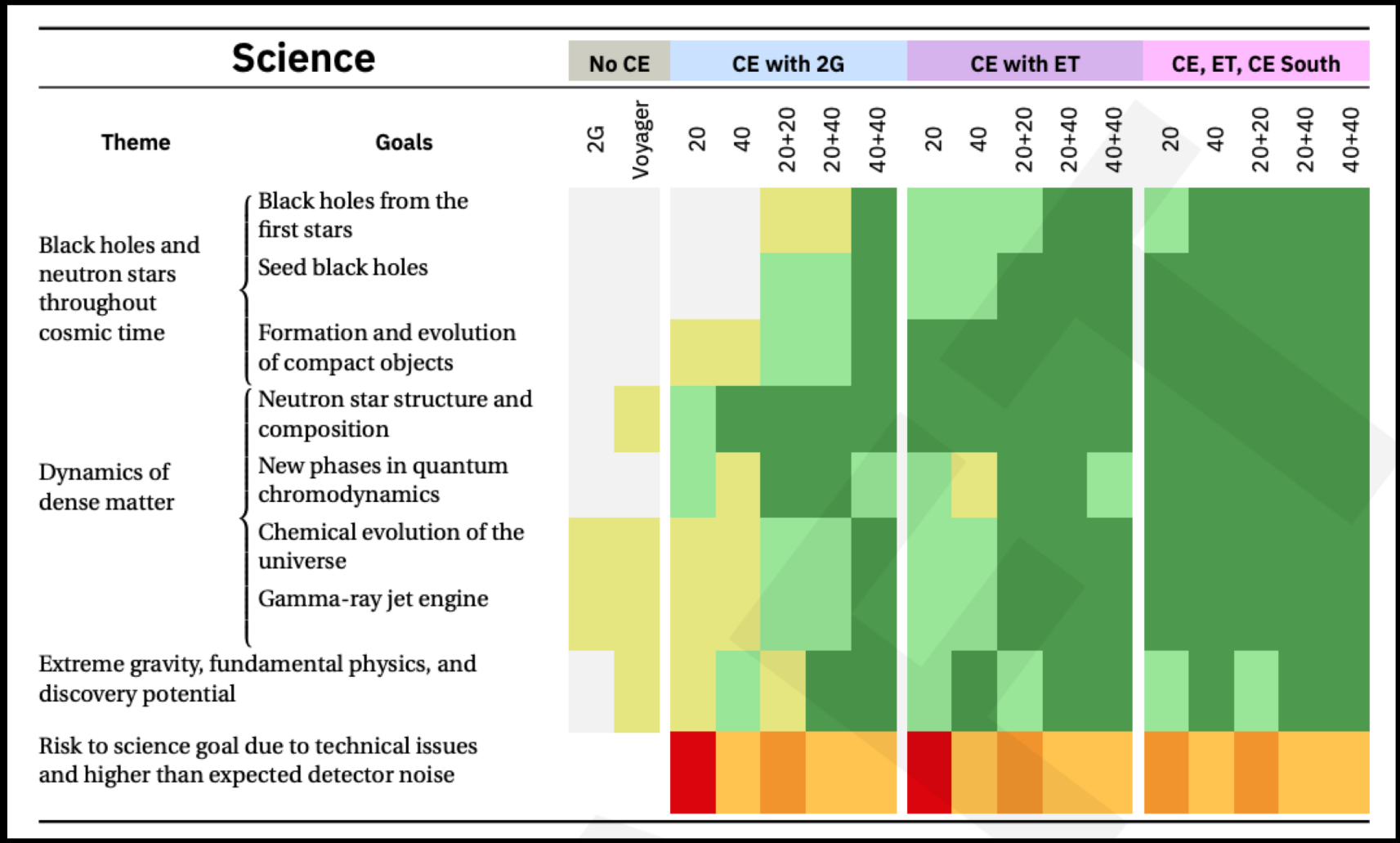


- In a network with ET or with another CE, Cosmic Explorer can contribute to searches for a stochastic background
  - Challenging for slor-roll inflation; cosmic strings and preheating also shown
- You can download these curves at dcc.cosmicexplorer.org/CE-P2100003/public

Trade study

- The composition of the 3G network is not finalized
- The Horizon Study contain an analysis of various configurations and tradeoffs
  - Are 40Km necessary or are 20Km enough?
  - Are two 20Km – 20Km better than one 40Km?
  - Can previous-generation detectors help?
  - What science goals can be pursued with only one detector?

Trade study



CEHS 2021; also Borhanian+ in prep

Much more!

- There is much much more science, I can’t cover in 20 minutes
- Get involved! Numerous opportunities to play role in CE
- Please join the consortium! cosmicexplorer.org/consortium.html
- We have monthly science case calls, contact Sathya bss25@psu.edu if interested
- We have monthly R&D calls, contact Evan evanhall@mit.edu if interested