

# Cosmic Explorer

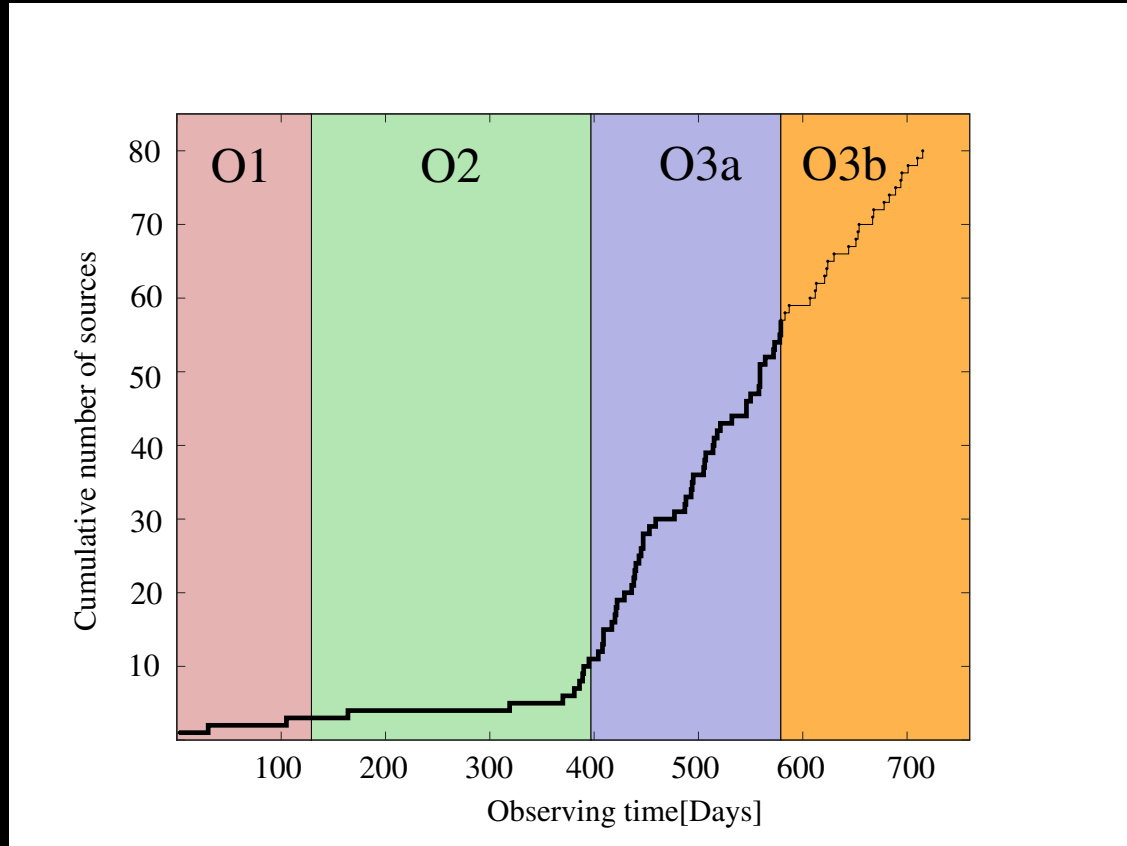
 @CosmicExpGW

Salvatore Vitale on behalf of the Cosmic Explorer Project Team

MIT

GW probes BSM 2021

# Where are we?

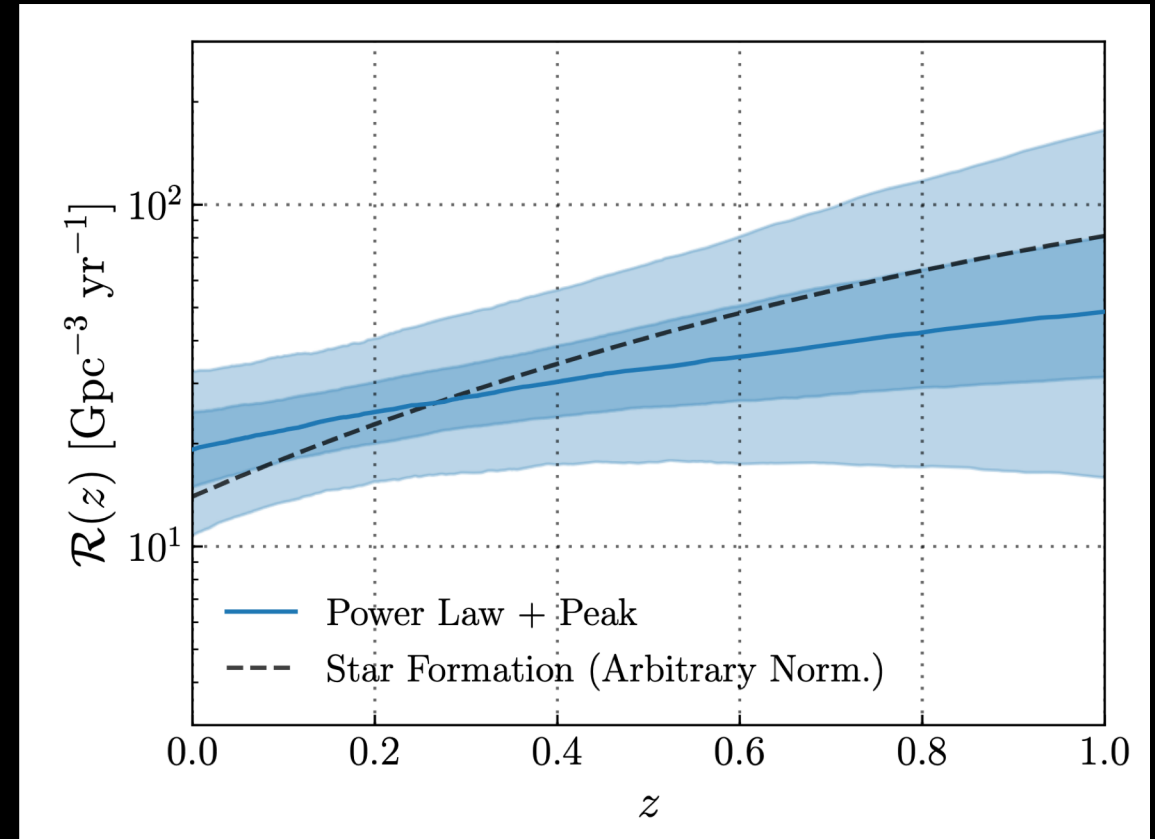


SV 2011.03563, adapted from LVC public document G1901322

- 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

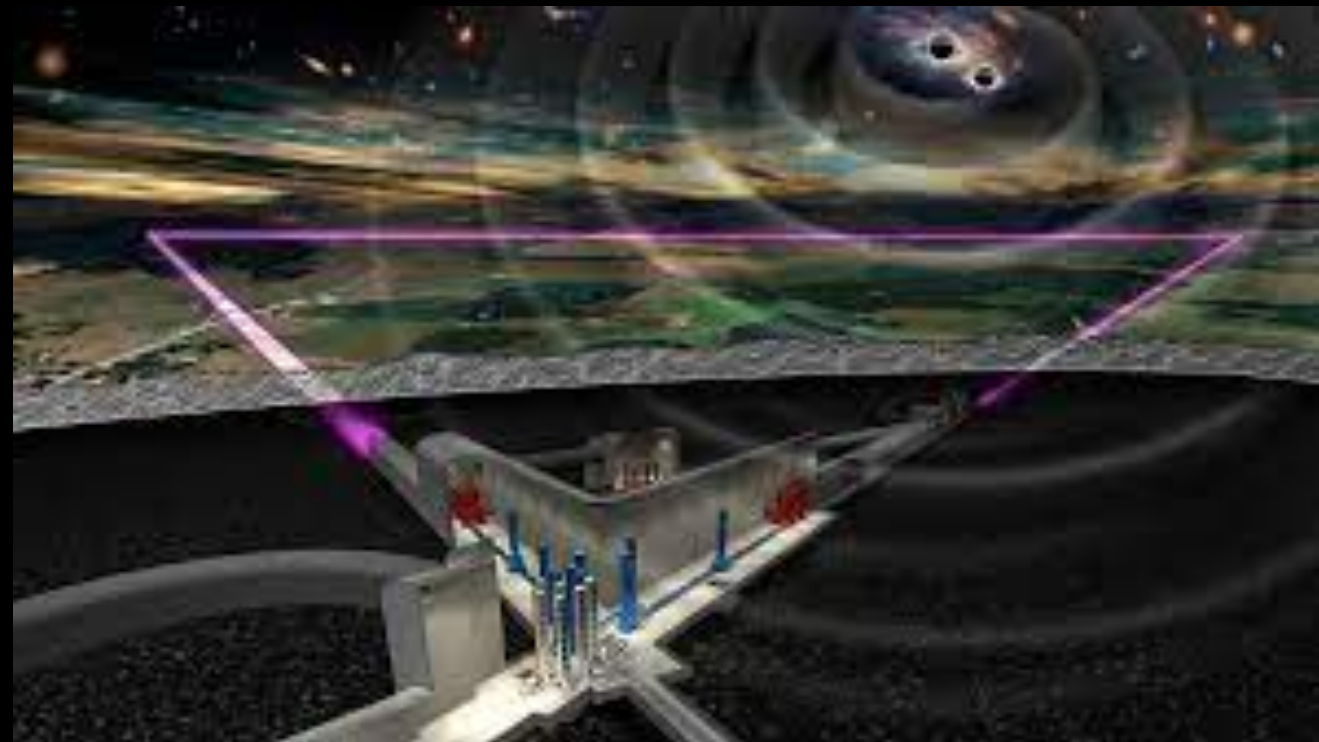
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- To gain access to sources across the universe new facilities are required
- 3G detectors
  - Strain sensitivity 10x better than advanced detectors
  - Detect black hole binaries at large redshifts
  - High signal-to-noise ratios
  - Many 100K sources 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!

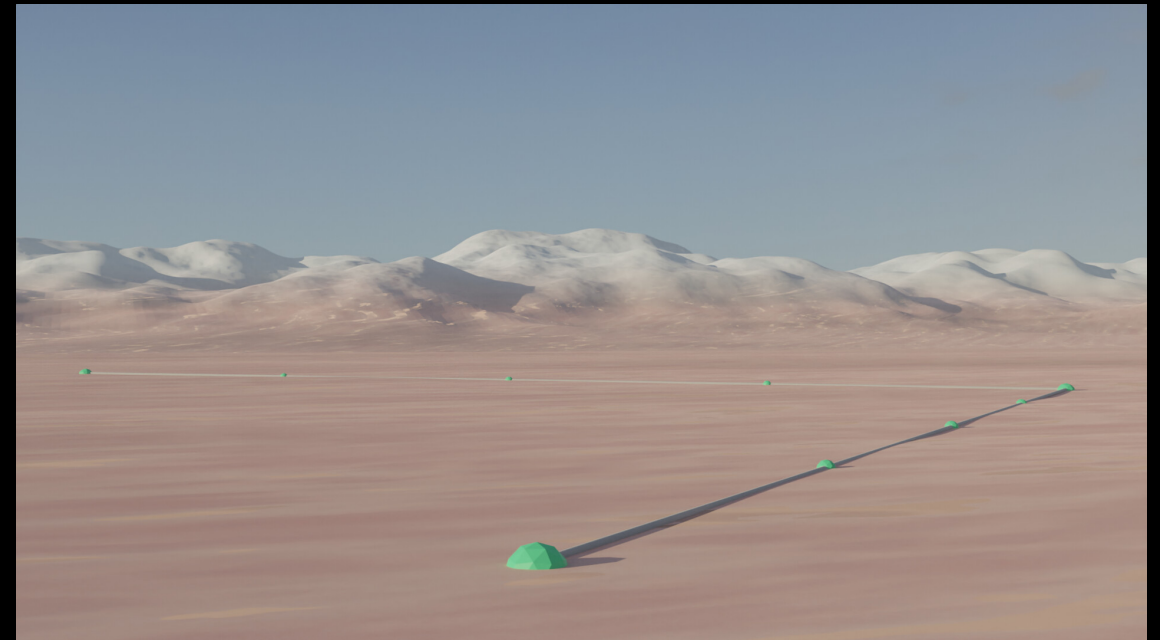


Credit: NIKHEF

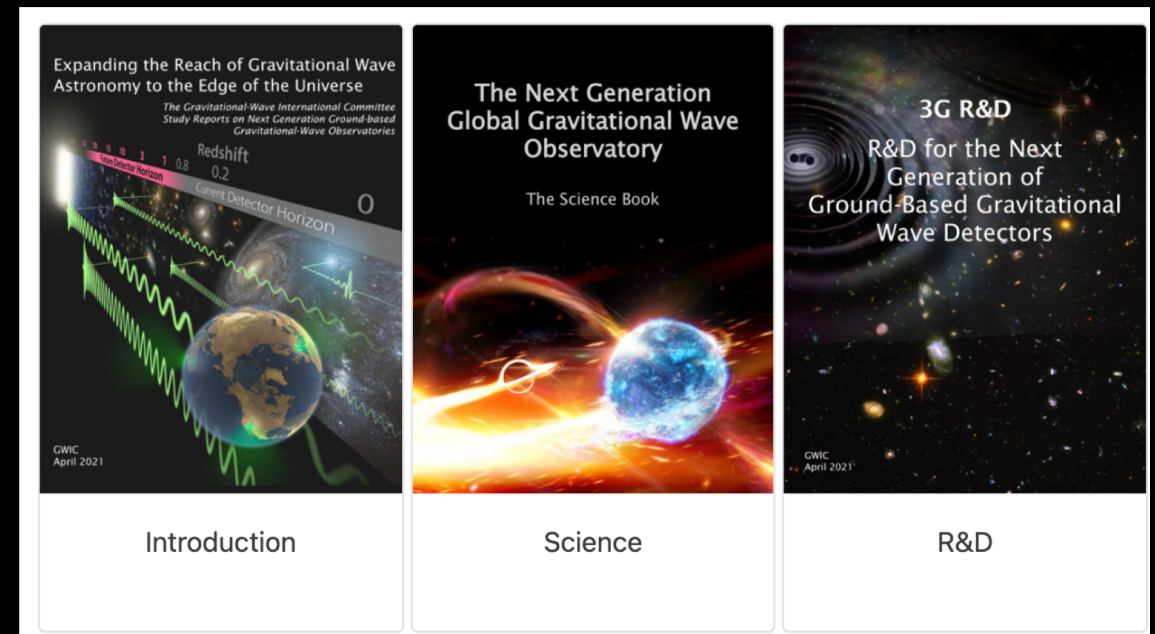
# Cosmic Explorer

- 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



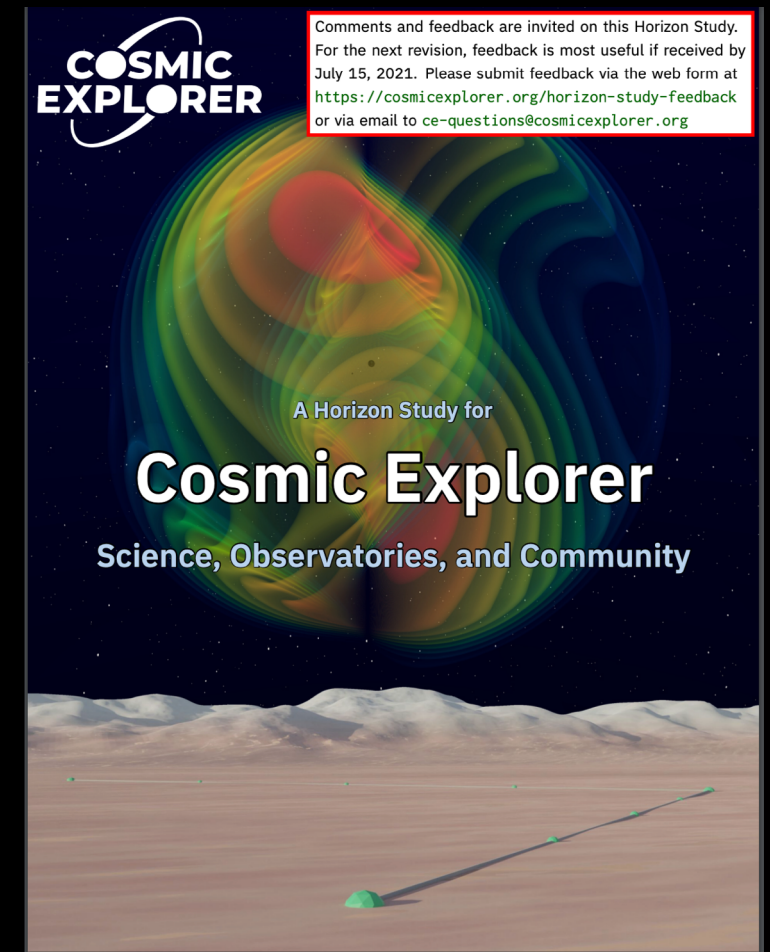
- To get the most out of 3G detectors, a network is required
- The GWIC has formed a committees focusing on 3G R&D, science, and global coordination
- Read more here:  
[gwic.ligo.org/3Gsubcomm/](http://gwic.ligo.org/3Gsubcomm/)
- Dozens of useful documents and links !



# 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](https://dcc.cosmicexplorer.org/CE-P2100003/public)



CEHS 2021



# Cosmic Explorer Horizon Study

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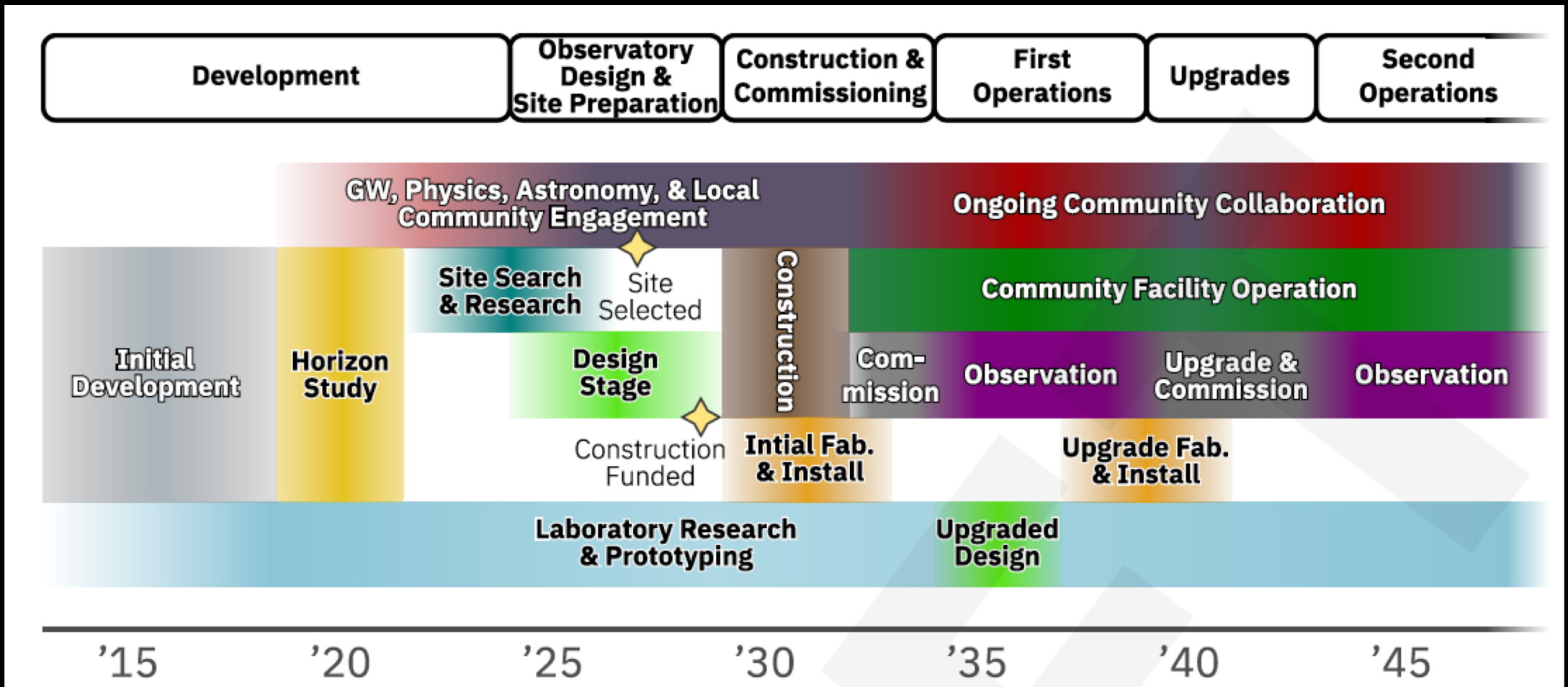
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# Timeline

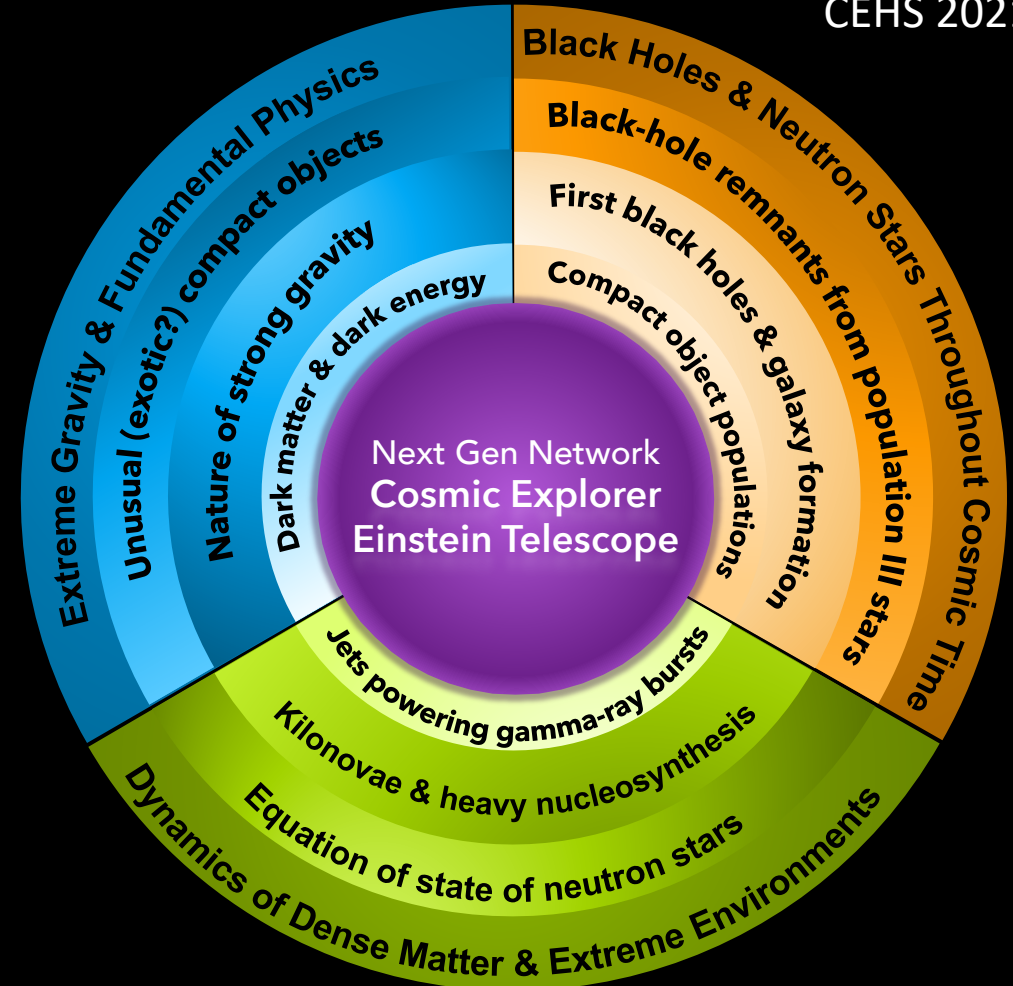


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# Cosmic Explorer Horizon Study

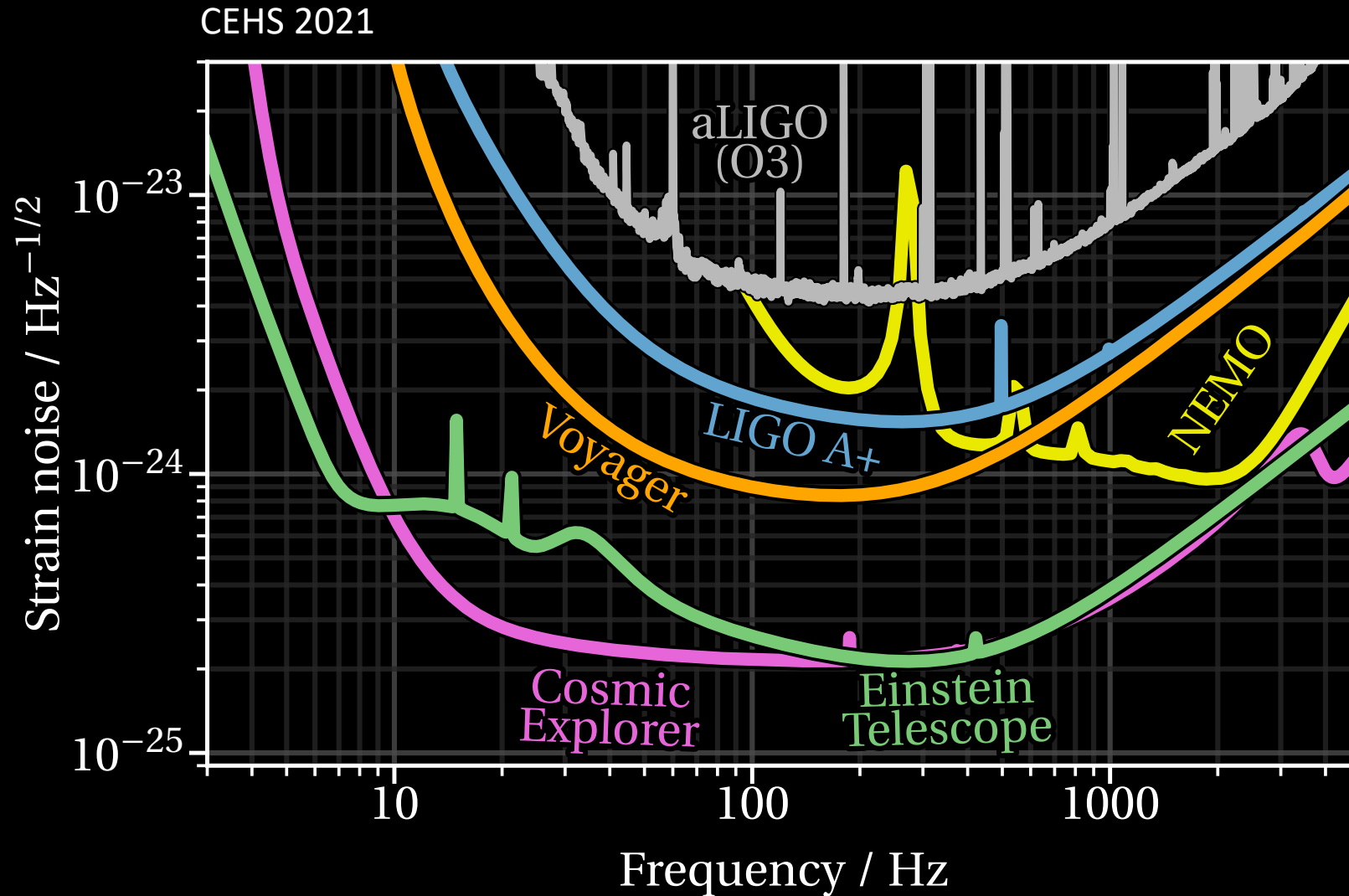
- The CE HS identifies key science outcomes that can be reached with this type of facility
  - Black holes and neutron stars throughout cosmic time
  - Dynamics of dense matter & extreme environments
  - Extreme gravity & Fundamental Physics

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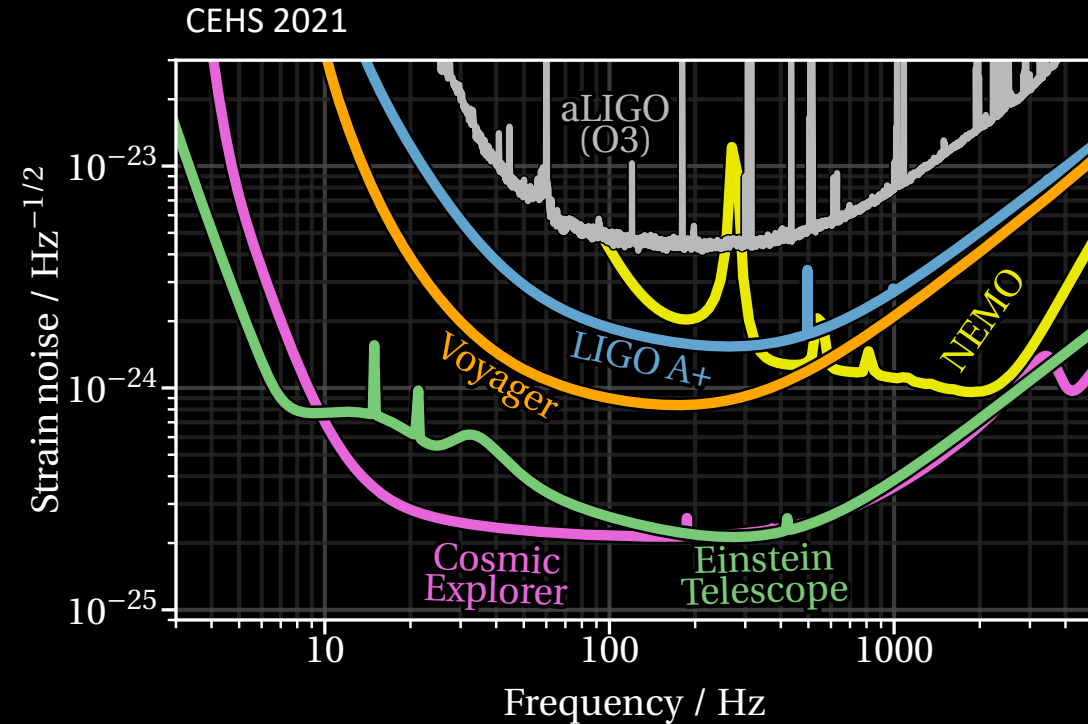




# Detector sensitivity



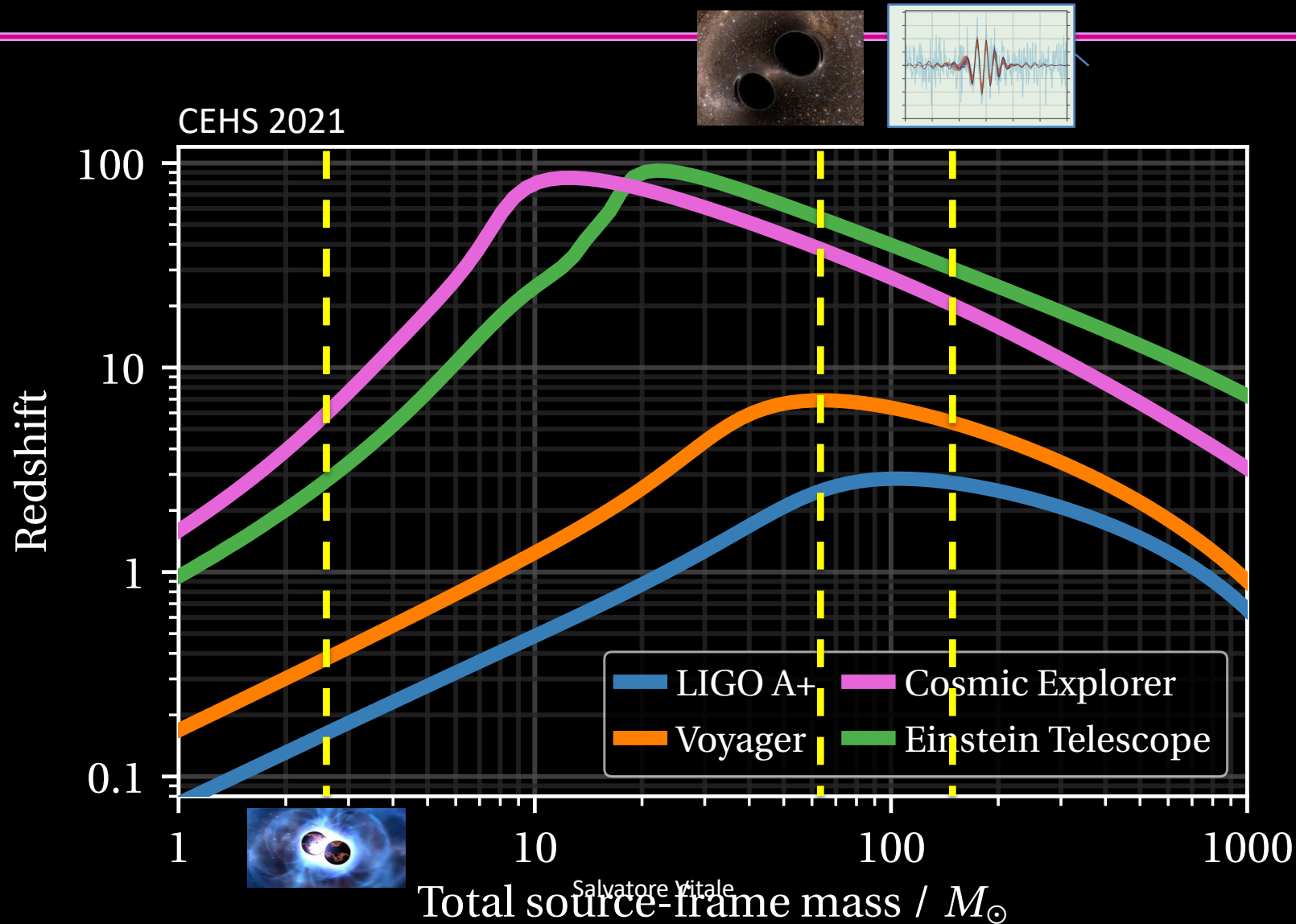
# Detector sensitivity



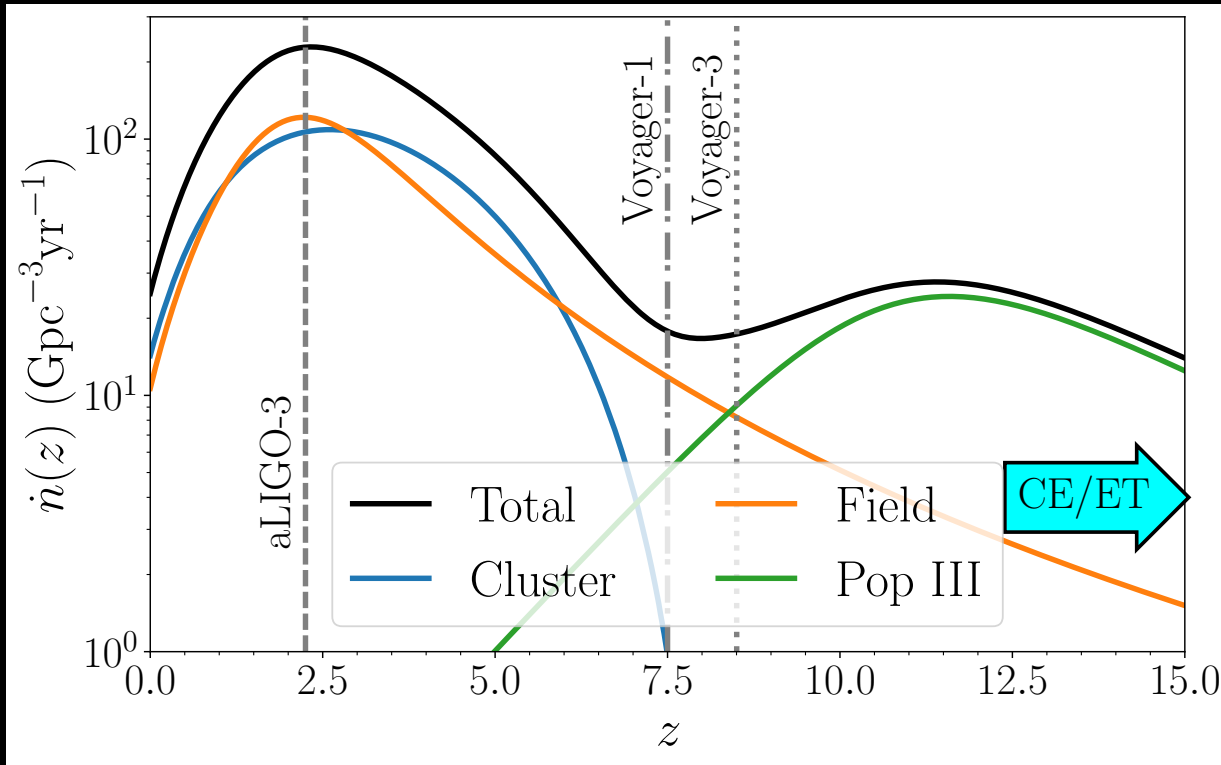
- You can use the Cosmic Explorer sensitivity curves in your projects!

[dcc.cosmicexplorer.org/CE-T2000017/public](https://dcc.cosmicexplorer.org/CE-T2000017/public)

# Listening to the Universe



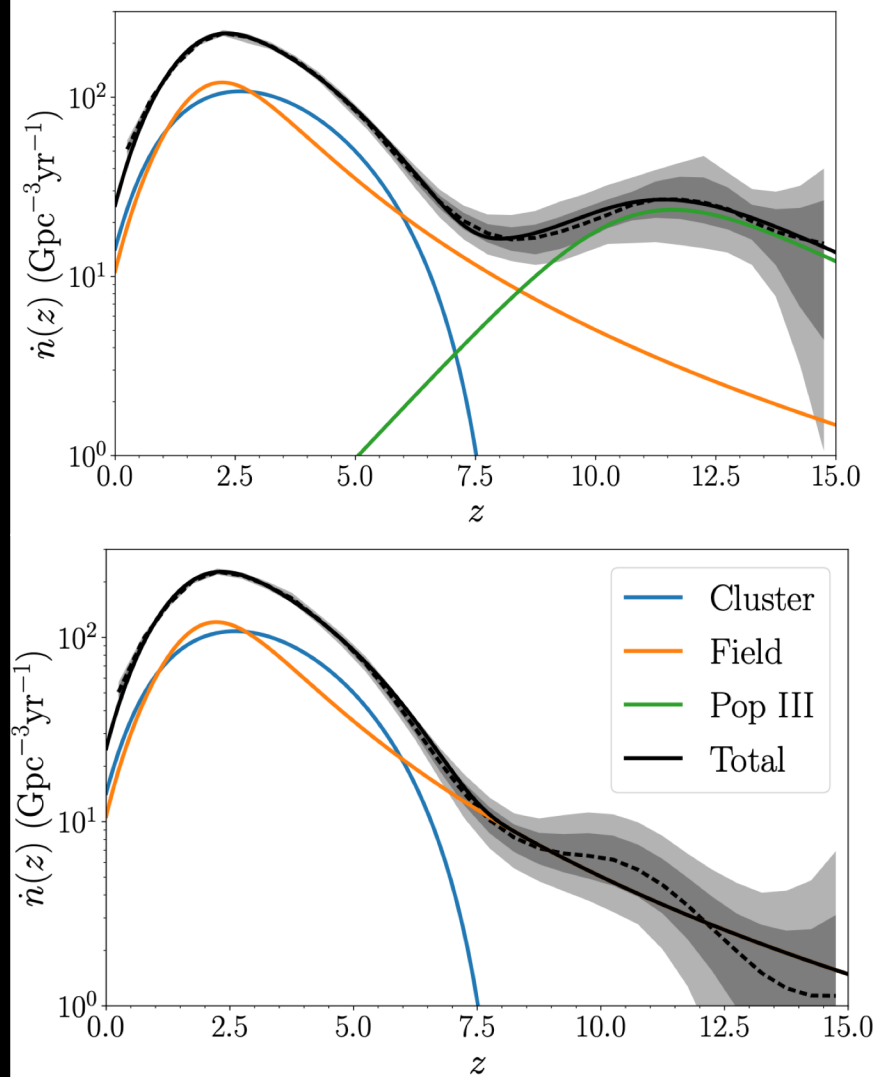
# Populations of binaries



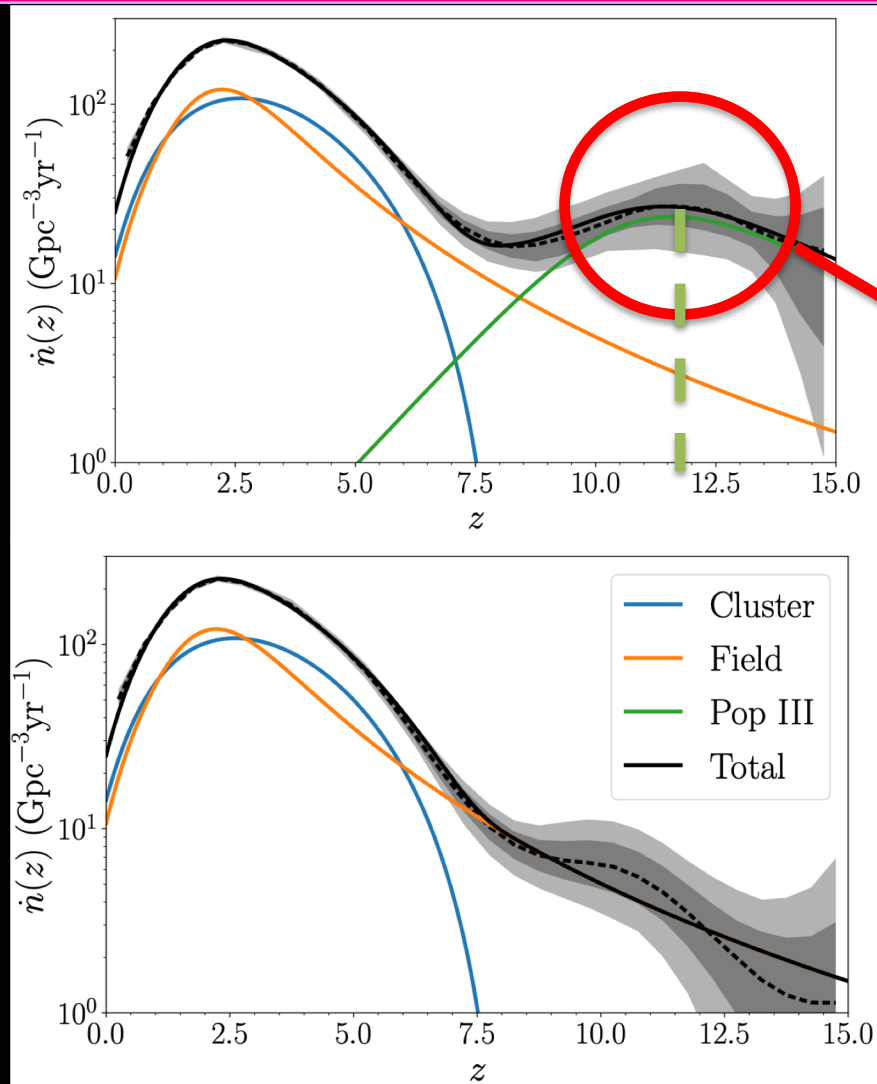
- Can detect black holes from populations which are currently inaccessible
- It is important to have a **network**, to measure distance well, and hence source-frame mass

Ng+ 2012.09876

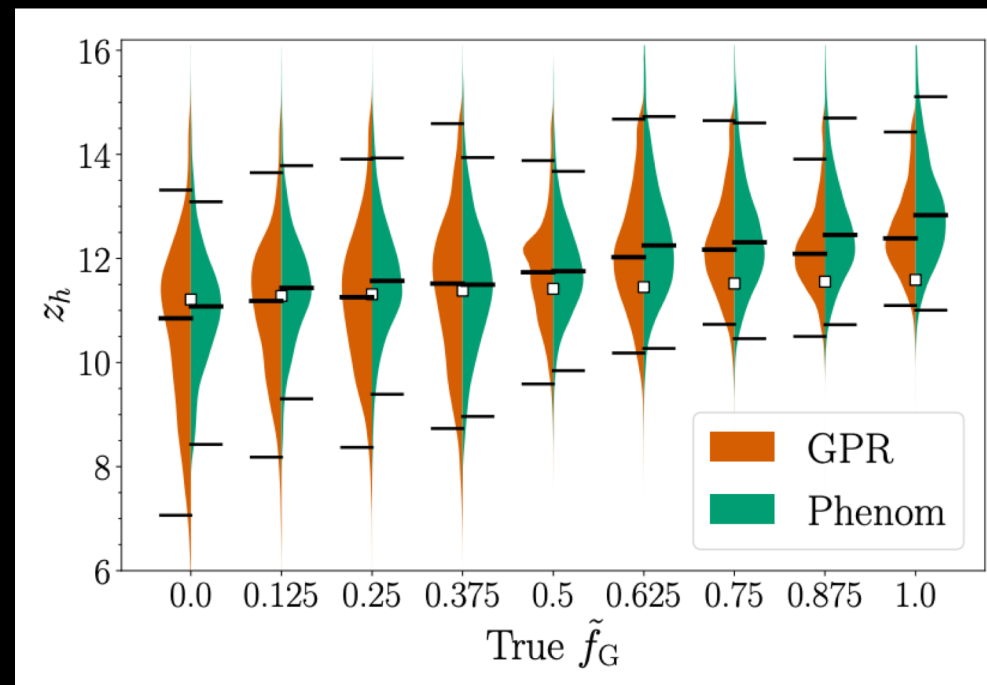
# Detecting of Pop III BH mergers



# Detecting of Pop III BH mergers



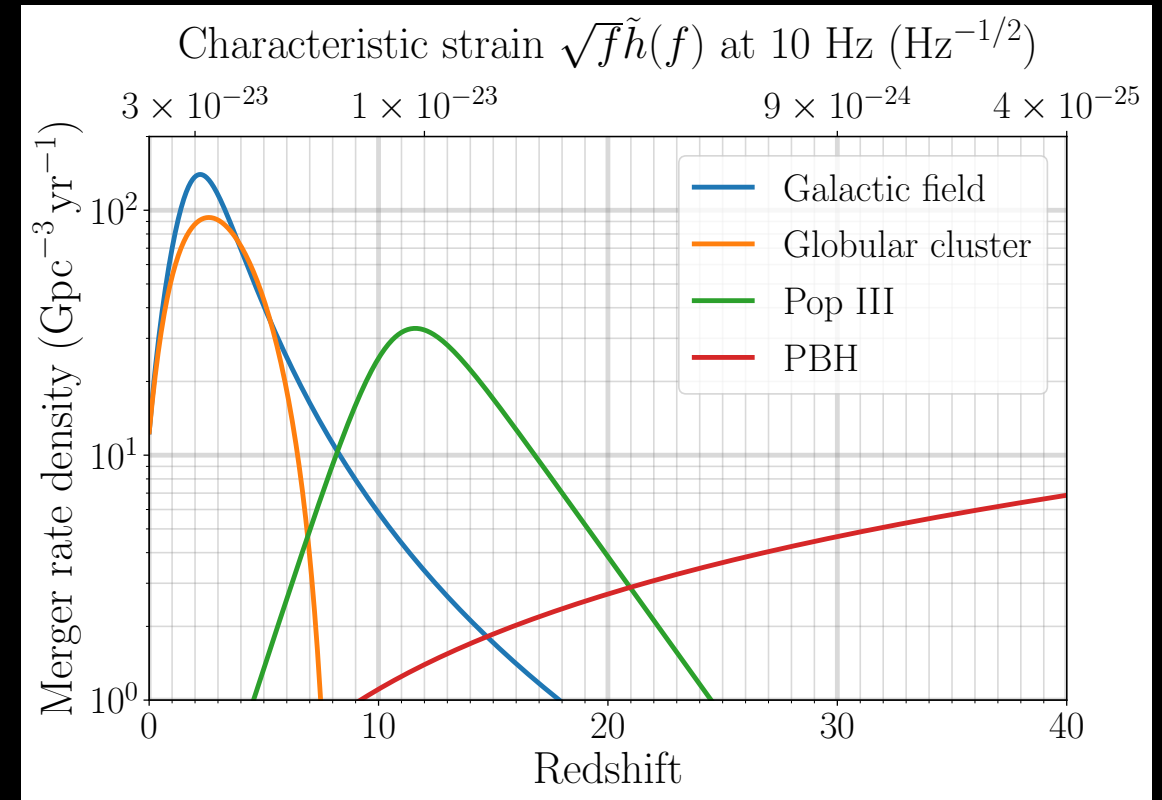
Can measure the location of high- $z$  peak with a few months worth of data and no modeling!



Ng+ 2012.09876

# Detecting PBHs mergers

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

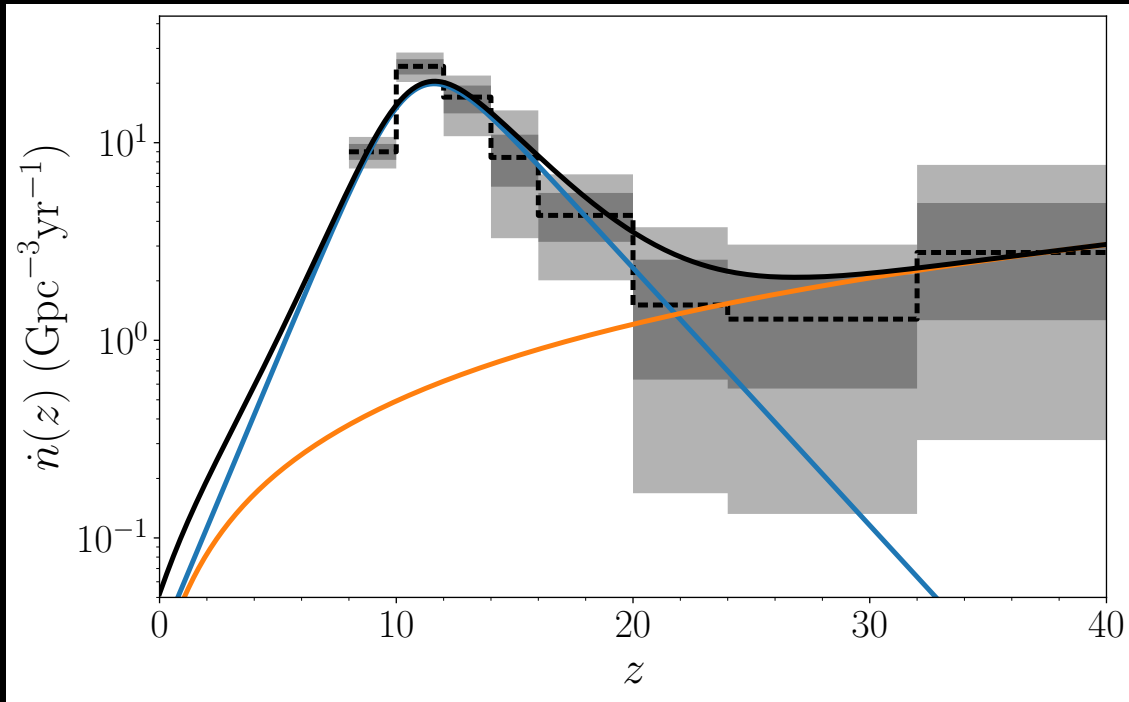


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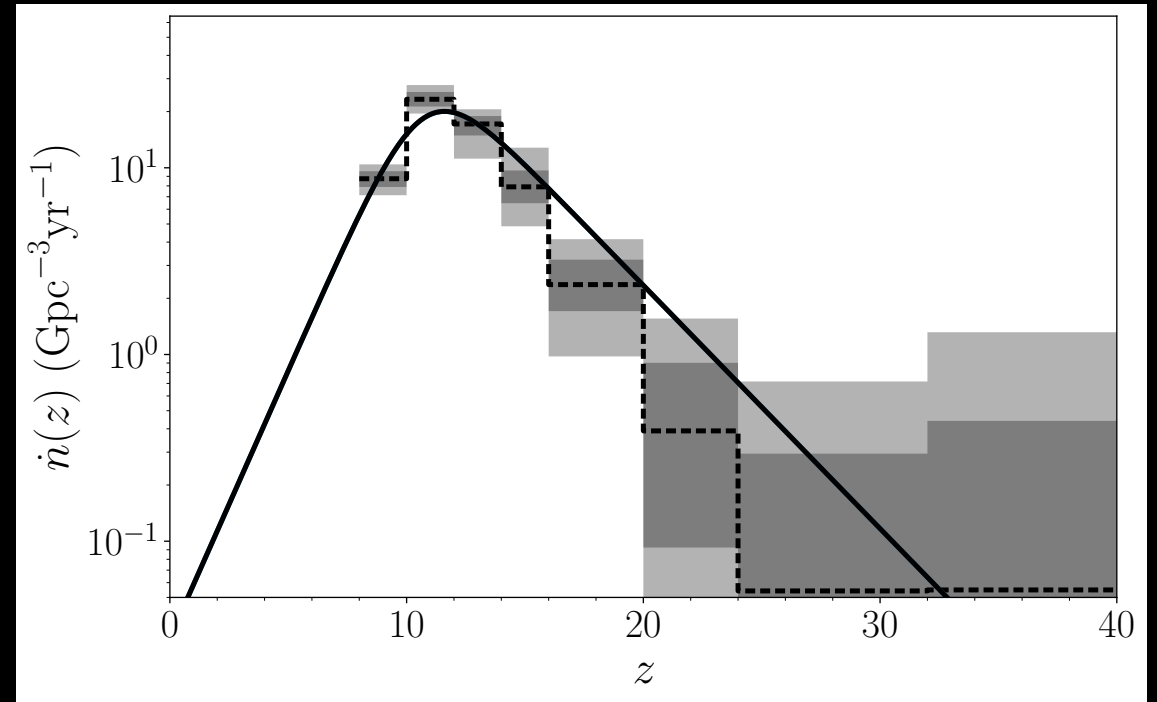


# Detecting PBHs mergers

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



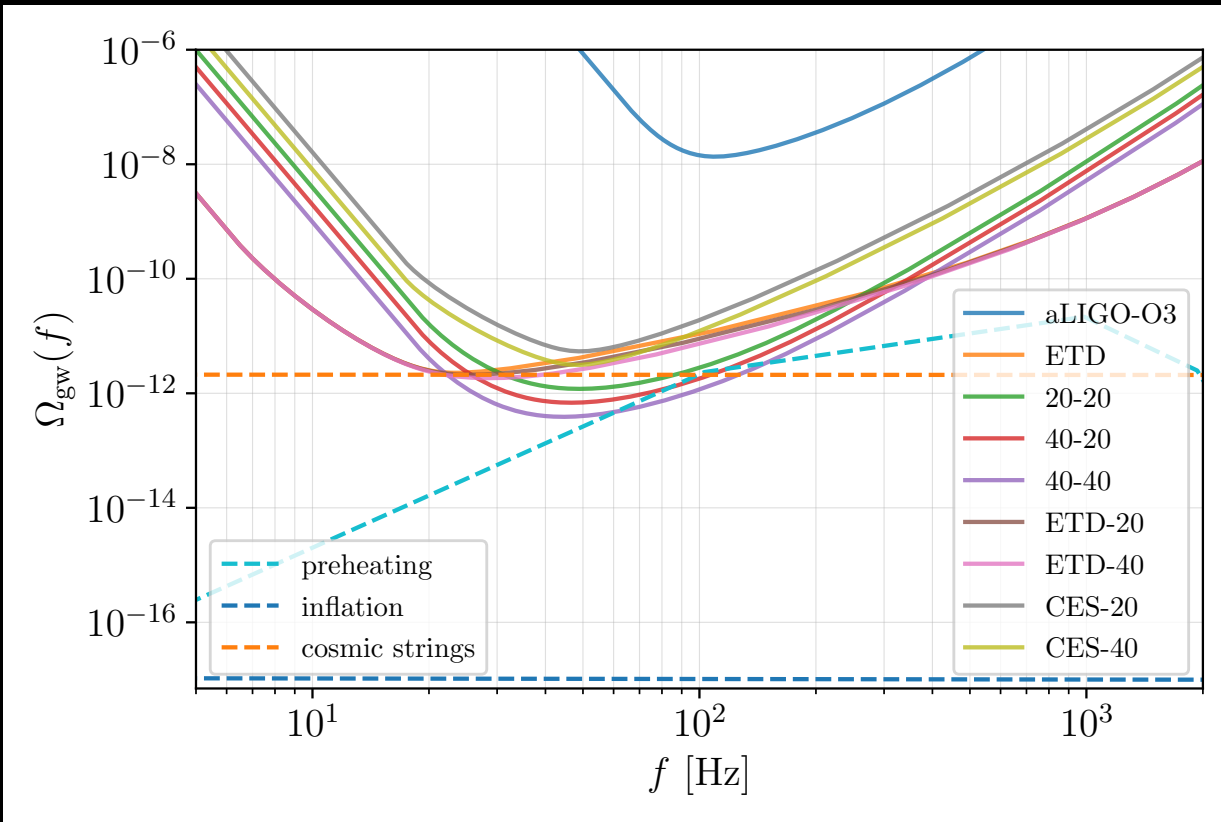
$$N_{\text{PBH}} = 0$$



Ng+ in prep

# Stochastic background

CEHS 2021



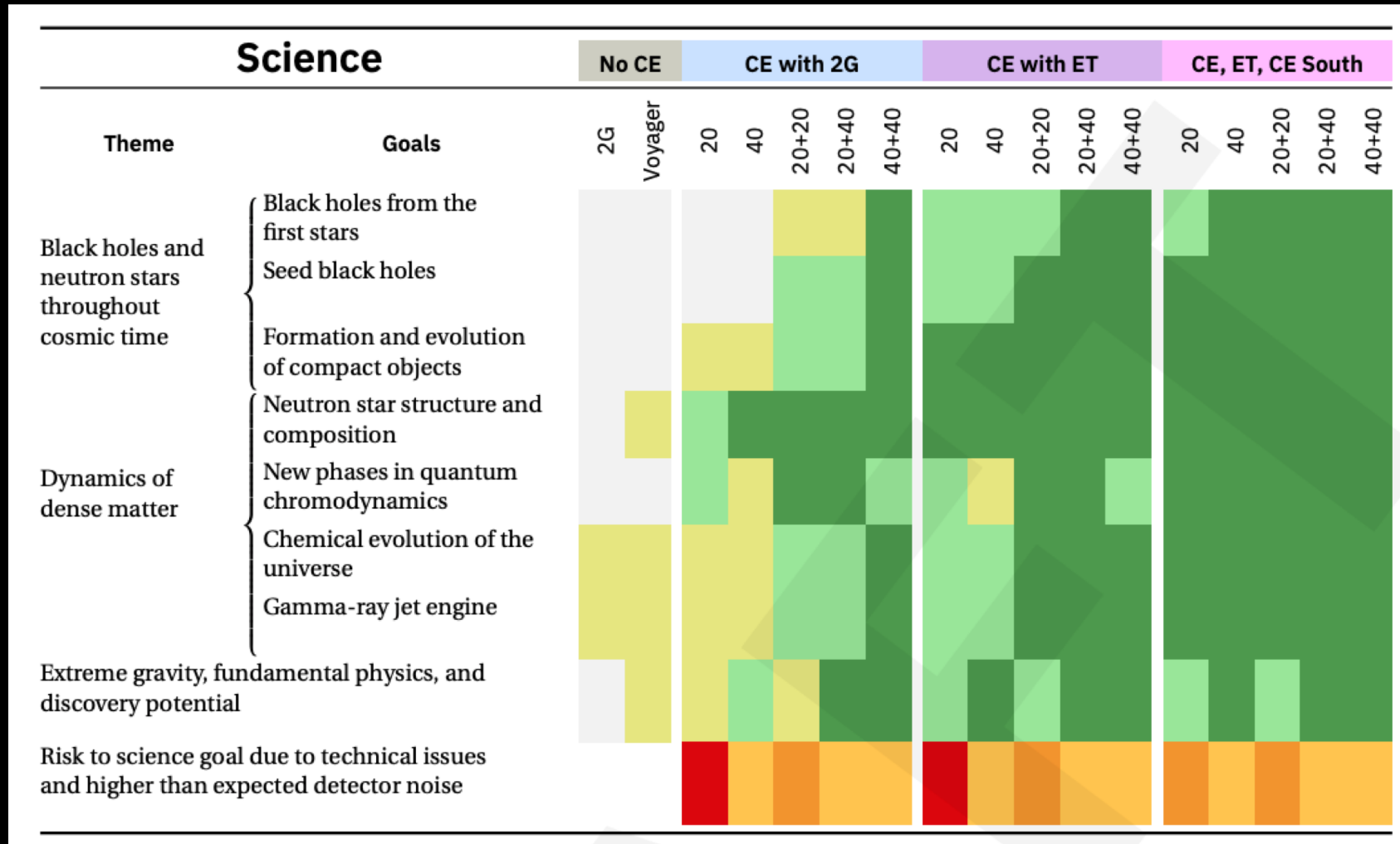
- In a network with ET or with another CE, Cosmic Explorer can contribute to searches for a stochastic background
  - Challenging for slow-roll inflation; cosmic strings and preheating also shown
- You can download these curves at  
[dcc.cosmicexplorer.org/CE-P2100003/public](http://dcc.cosmicexplorer.org/CE-P2100003/public)

# Trade study

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- 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



# 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](https://cosmicexplorer.org/consortium.html)
- We have monthly science case calls, contact Sathya [bss25@psu.edu](mailto:bss25@psu.edu) if interested
- We have monthly R&D calls, contact Evan [evanhall@mit.edu](mailto:evanhall@mit.edu) if interested