LIGO

Ground-based Gravitational-wave Detectors: Beyond 2030

Dave Reitze
LIGO Laboratory, Caltech

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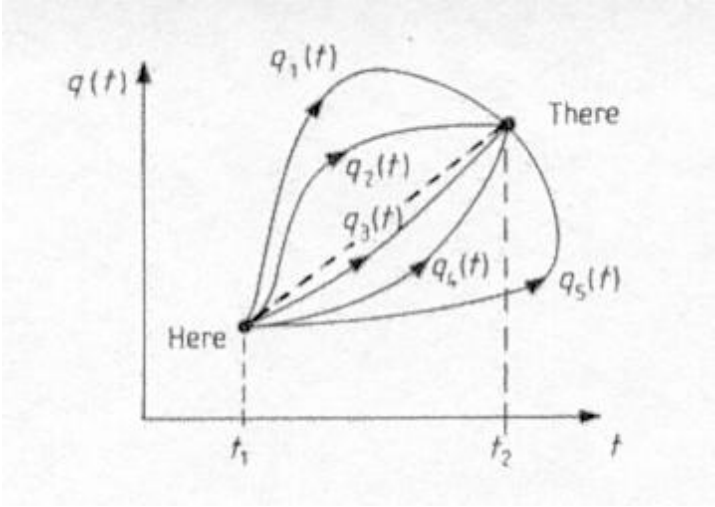
What do we want to be doing 15 – 20 years from now??

How do we get there??



Credit: https://universe-review.ca/I12-03-pathintegral.jpg

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Outline

- *Third Generation Detector Planning: 2007-2017*
- *The Gravitational-wave International Committee*
- *Coordinating the Global Effort*

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Historical Gestation Periods for GW Detectors in the US

- Initial LIGO → 23 years
  - **1983** MIT and Caltech jointly present results of the km-scale interferometer study to NSF. Receive endorsement by NSF committee on new large programs in physics.
  - **1990** The US National Science Board (NSB) approves the LIGO construction proposal, which envisions Initial LIGO followed by Advanced LIGO.
  - **1994-1995** Site construction begins at the Hanford and Livingston locations.
  - **2002** The first coincident operation of Initial LIGO interferometers with the GEO600 interferometer.
  - **2006** Initial LIGO design sensitivity achieved.
- Advanced LIGO → 16 years
  - **1999** The LSC Concept Paper for Advanced LIGO completed.
  - **2003** LIGO Laboratory submits proposal to NSF for Advanced LIGO proposal.
  - **2006** NSF conducts review of Advanced LIGO Construction.
  - **2008** Advanced LIGO Construction is funded by NSF.
  - **2014** Advanced LIGO Construction completed.
  - **2015** Advanced LIGO begins science operations

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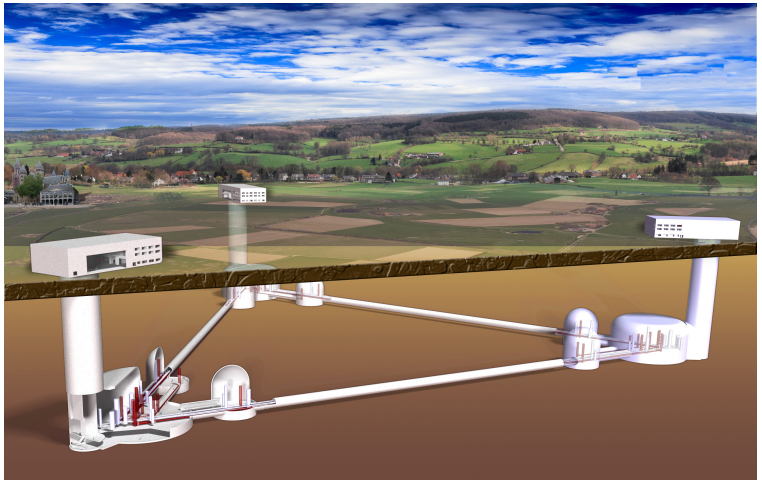
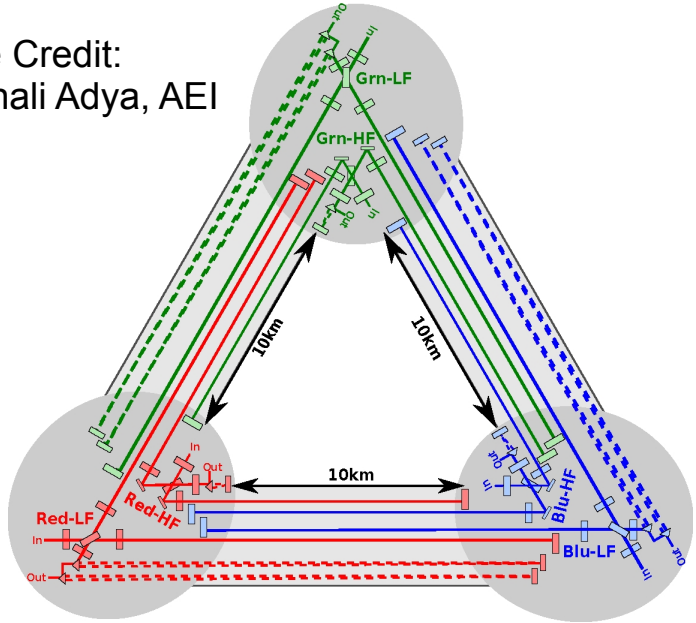
Einstein Telescope (EU)

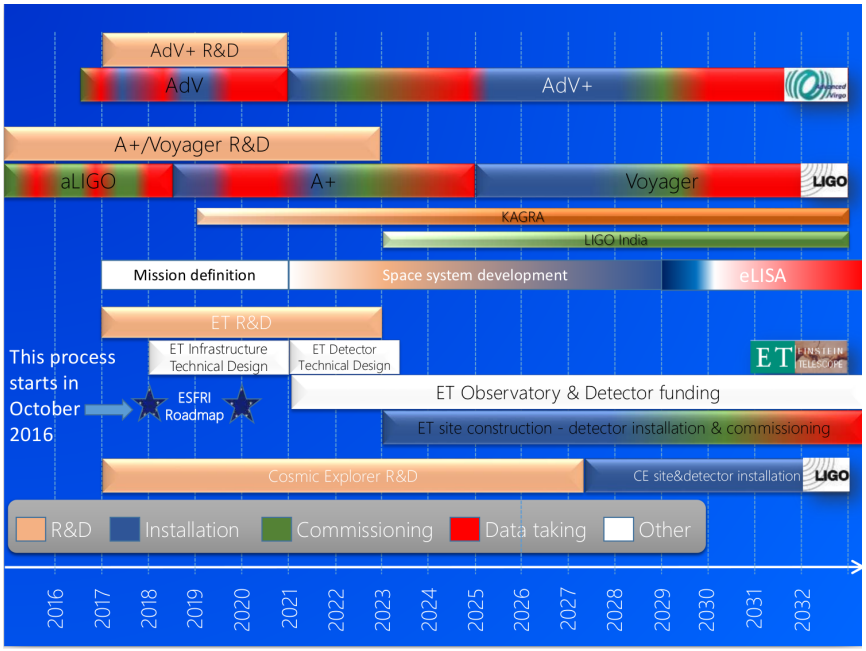


- Third-generation GW observatory
- Target sensitivity for ET a factor of ten improvement in comparison to current advanced detectors
- 10 km long, Underground
- Xylophone configuration, 6 interferometers

Formal Design Study completed in 2011:
http://www.et-gw.eu/etdsdocument

Slide Credit:
Vaishali Adya, AEI





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Cosmic Explorer (US)

- Third-generation GW observatory
- Target sensitivity a factor of > 10 improvement in comparison to current advanced detectors
- Above ground, 40 km arm length, L configuration

Formal Design Study: not yet, but proposal under development (M. Evans, MIT, PI

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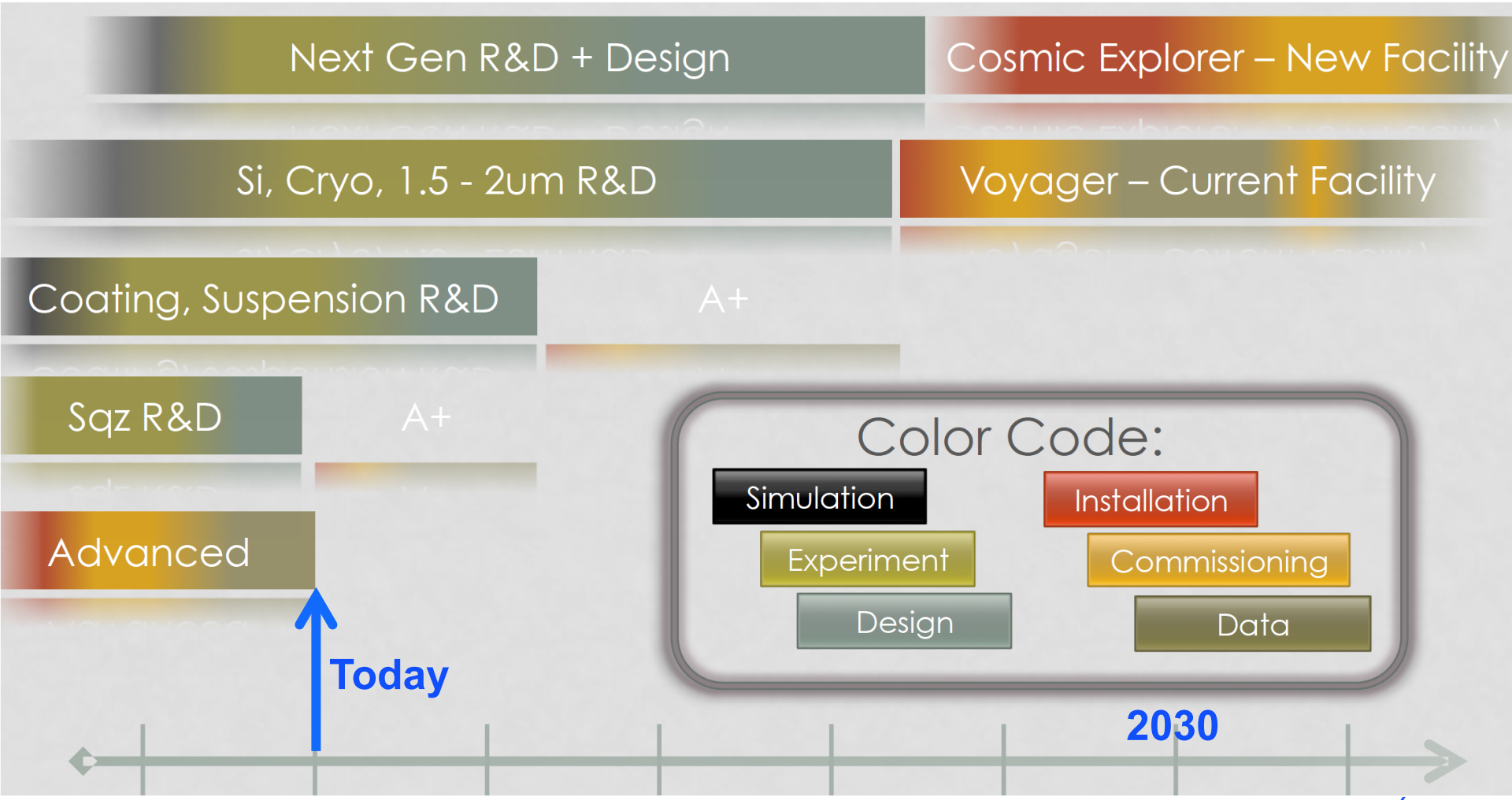
(Very) Conceptual Timeline for CE

LSC Instrument Science White Paper 2017-2018, LIGO-T1700231–v2



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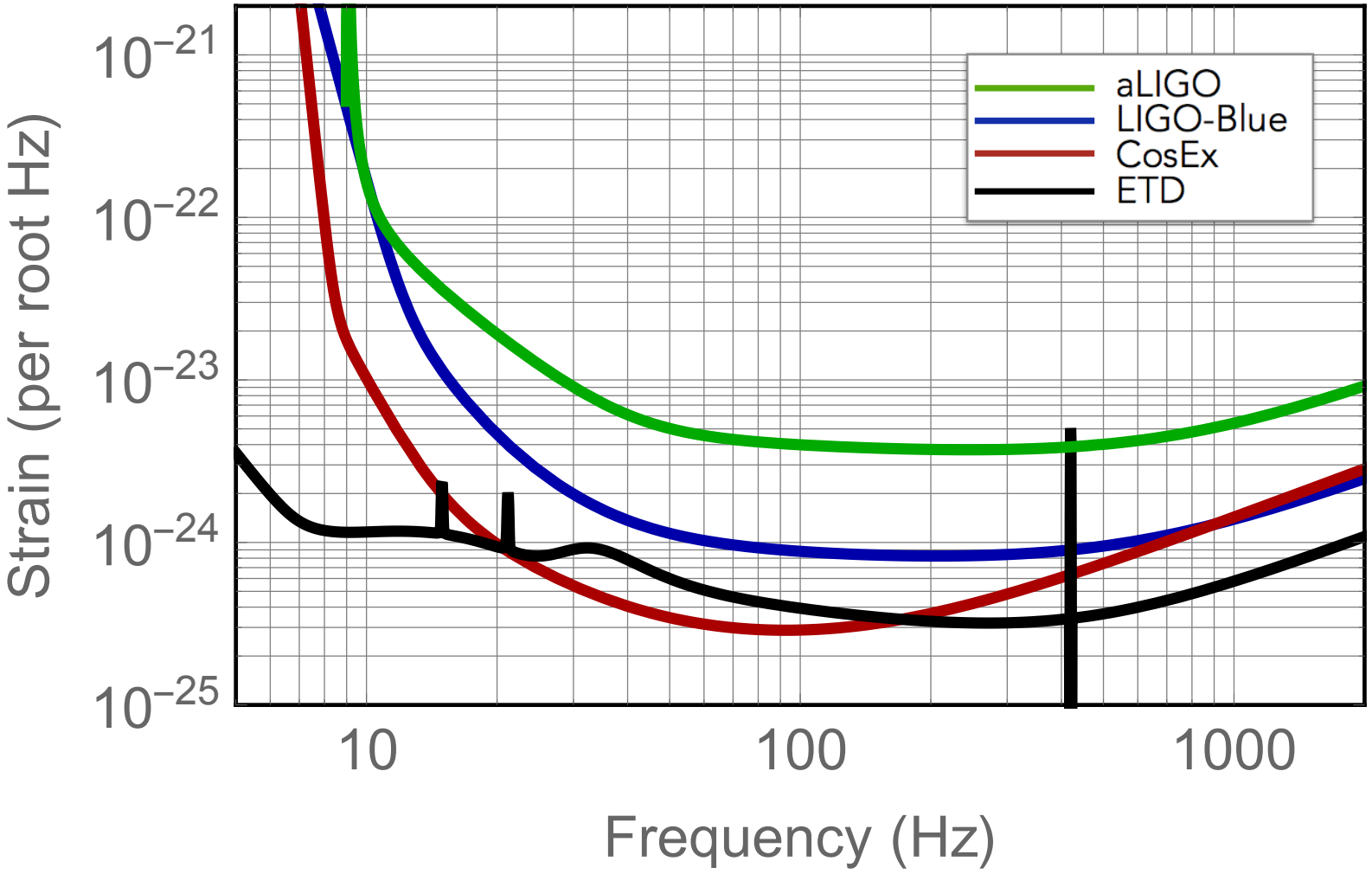
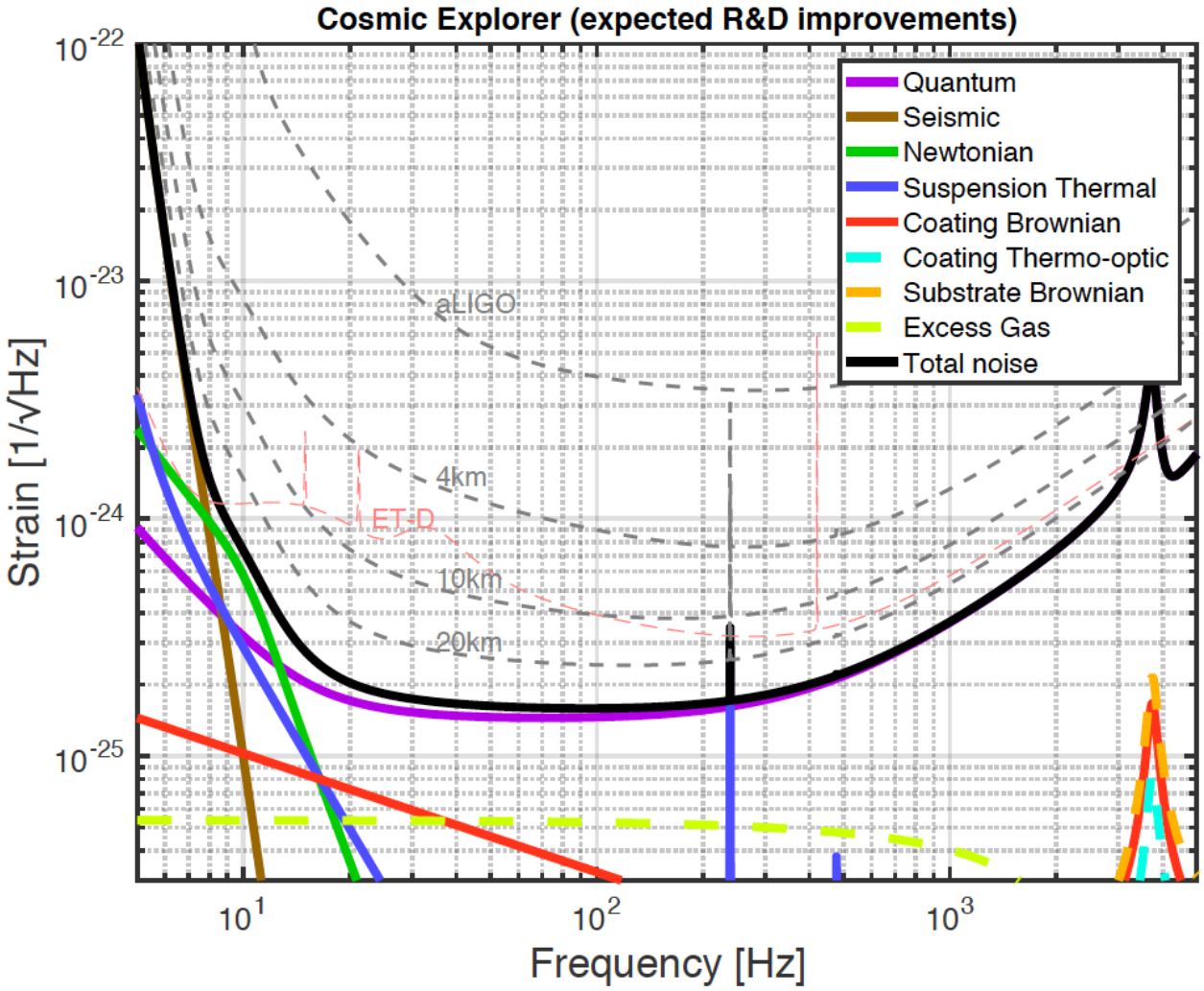
The 3G Sensitivity Horizon (circa 2015)



LIGO

The 3G Sensitivity Horizon (circa 2017)



LSC Instrument Science White Paper 2017-2018, LIGO-T1700231–v2

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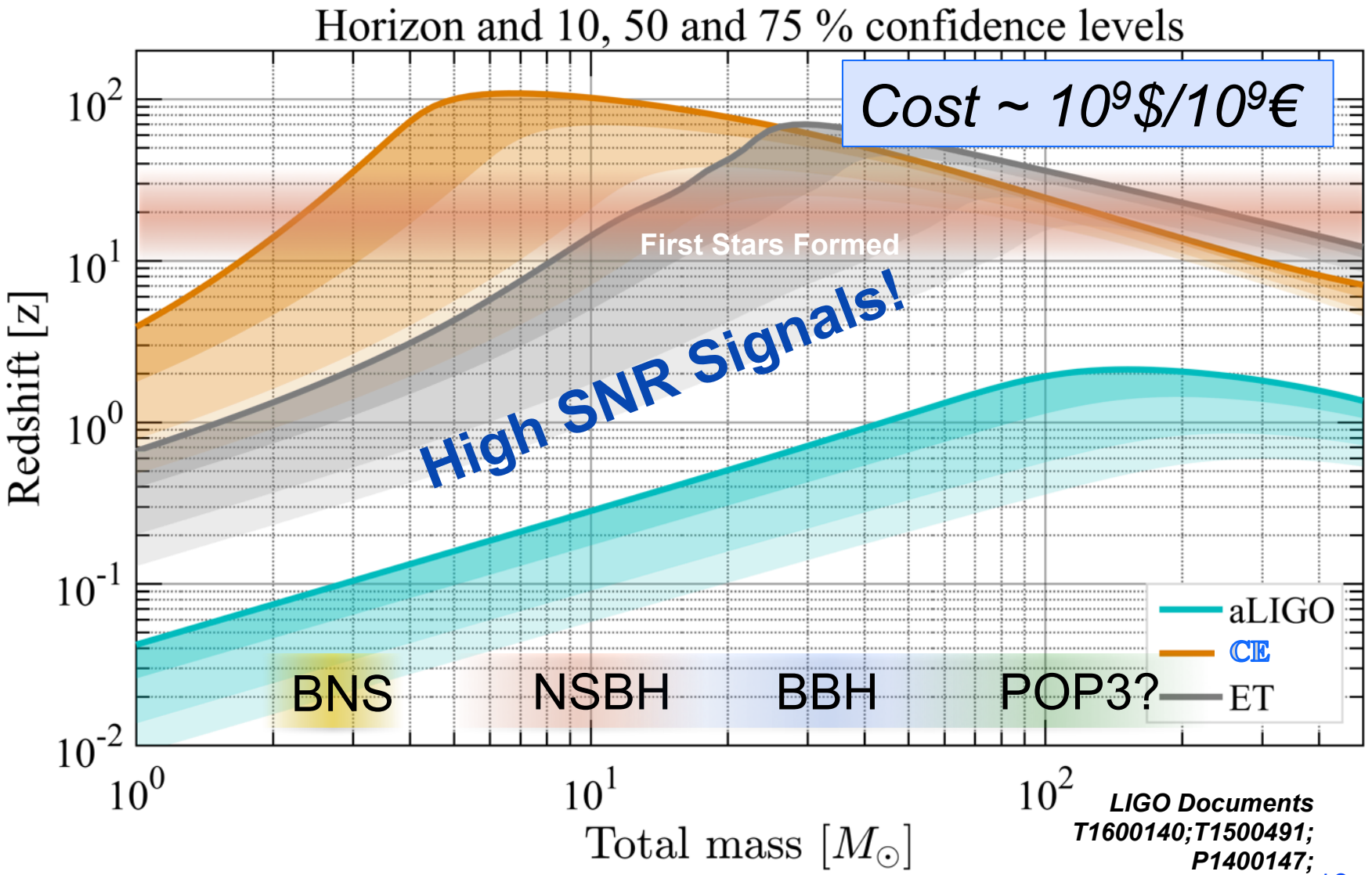
ET and CE Have Cosmological Reach!



LIGO Documents T1600140;T1500491; P1400147; ET Document ET-0106C-10

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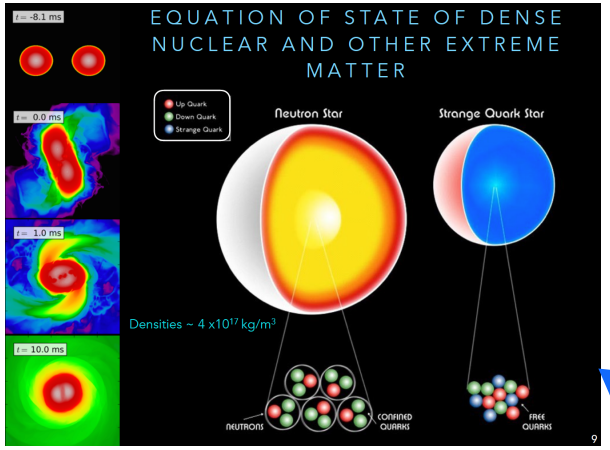
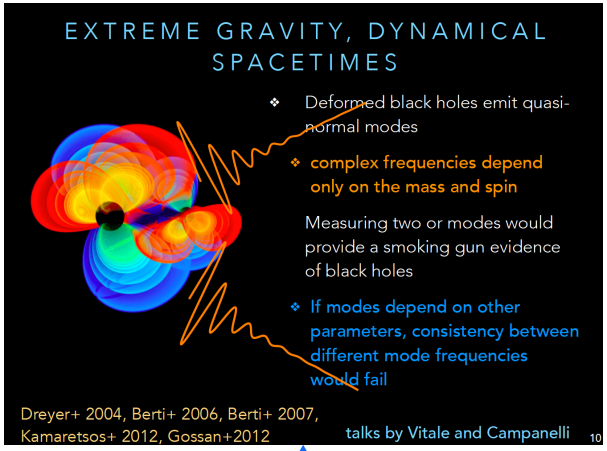
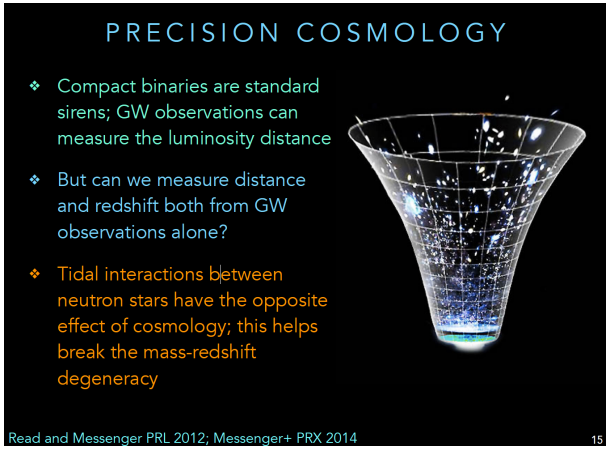
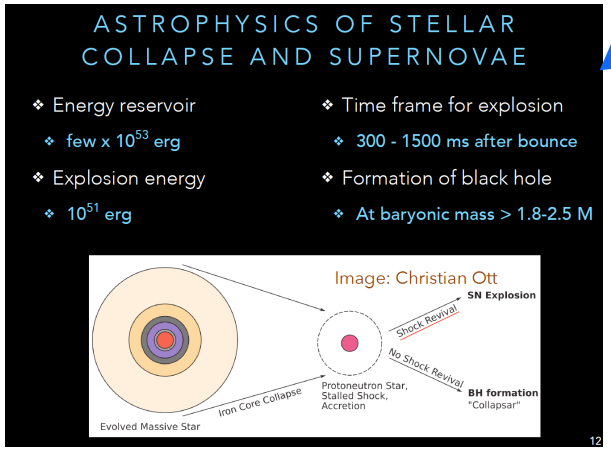
Making the 3G Science Case

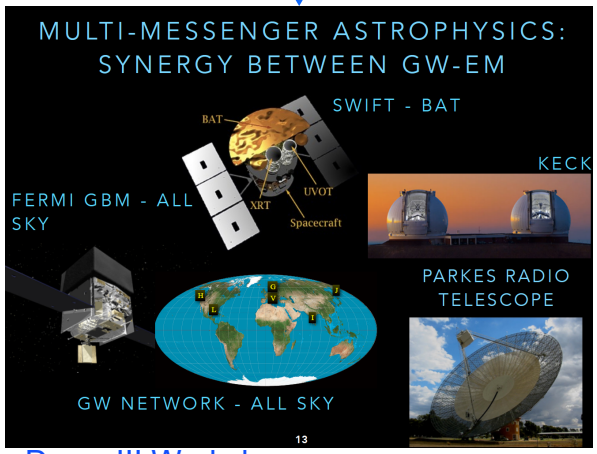


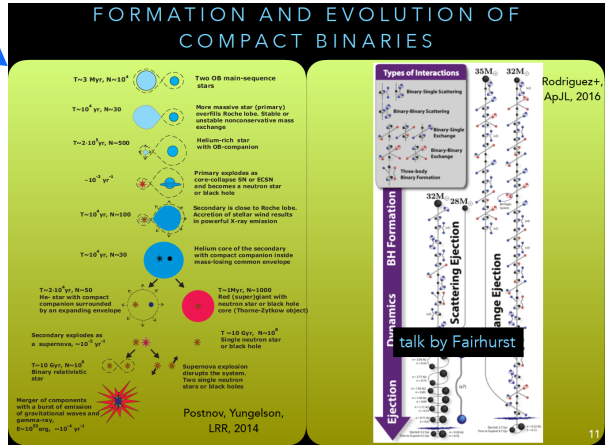




The 3G Gravitational Wave Ground-based Network







Credit: B. Sathyaprakash, Dawn III Workshop, https://wiki.ligo.org/LSC/LIGOworkshop2017/WebHome

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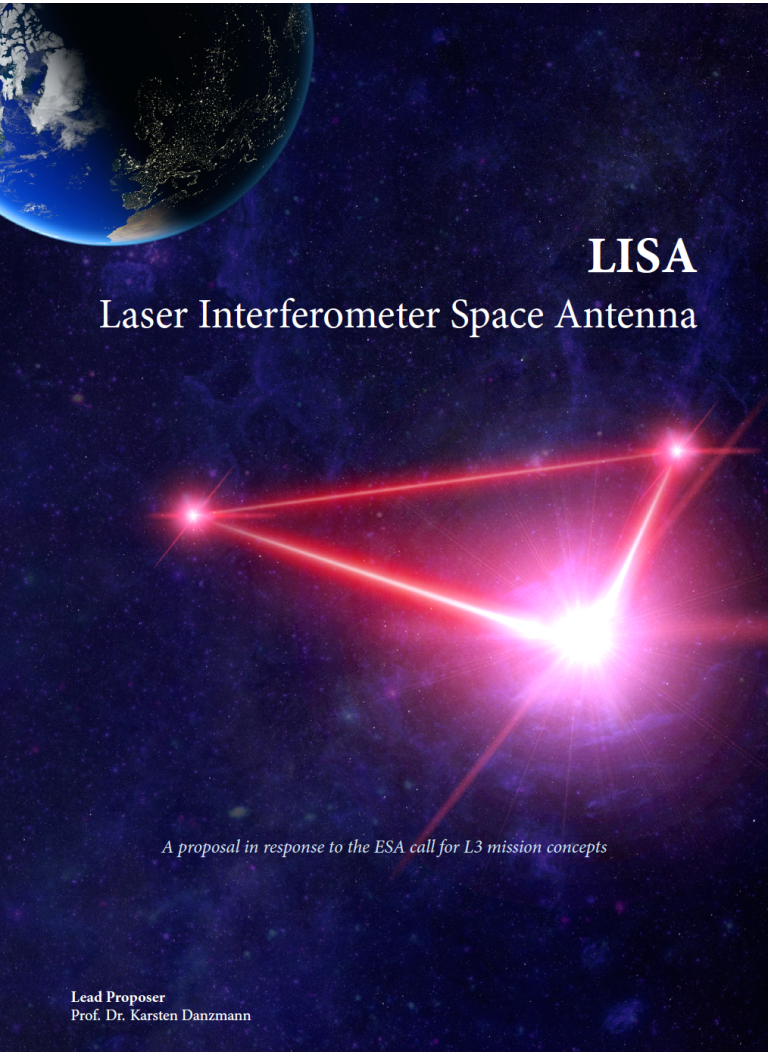
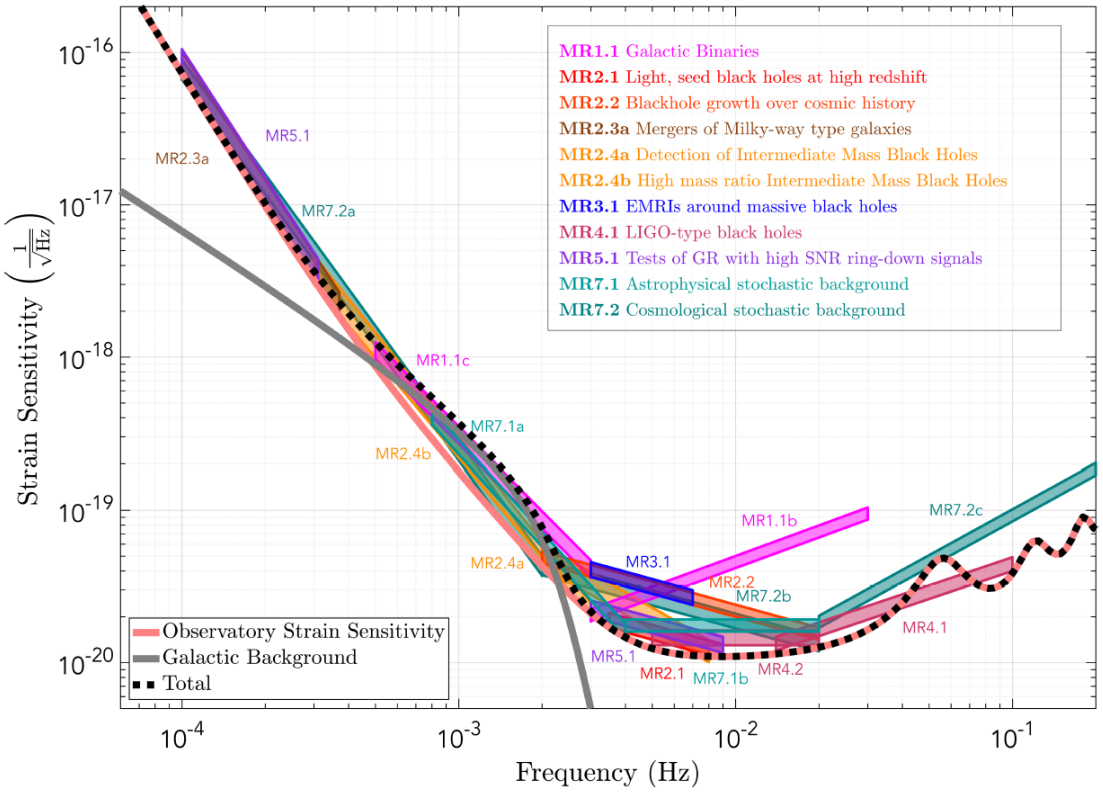
An Excellent Case Study: The LISA Science Case

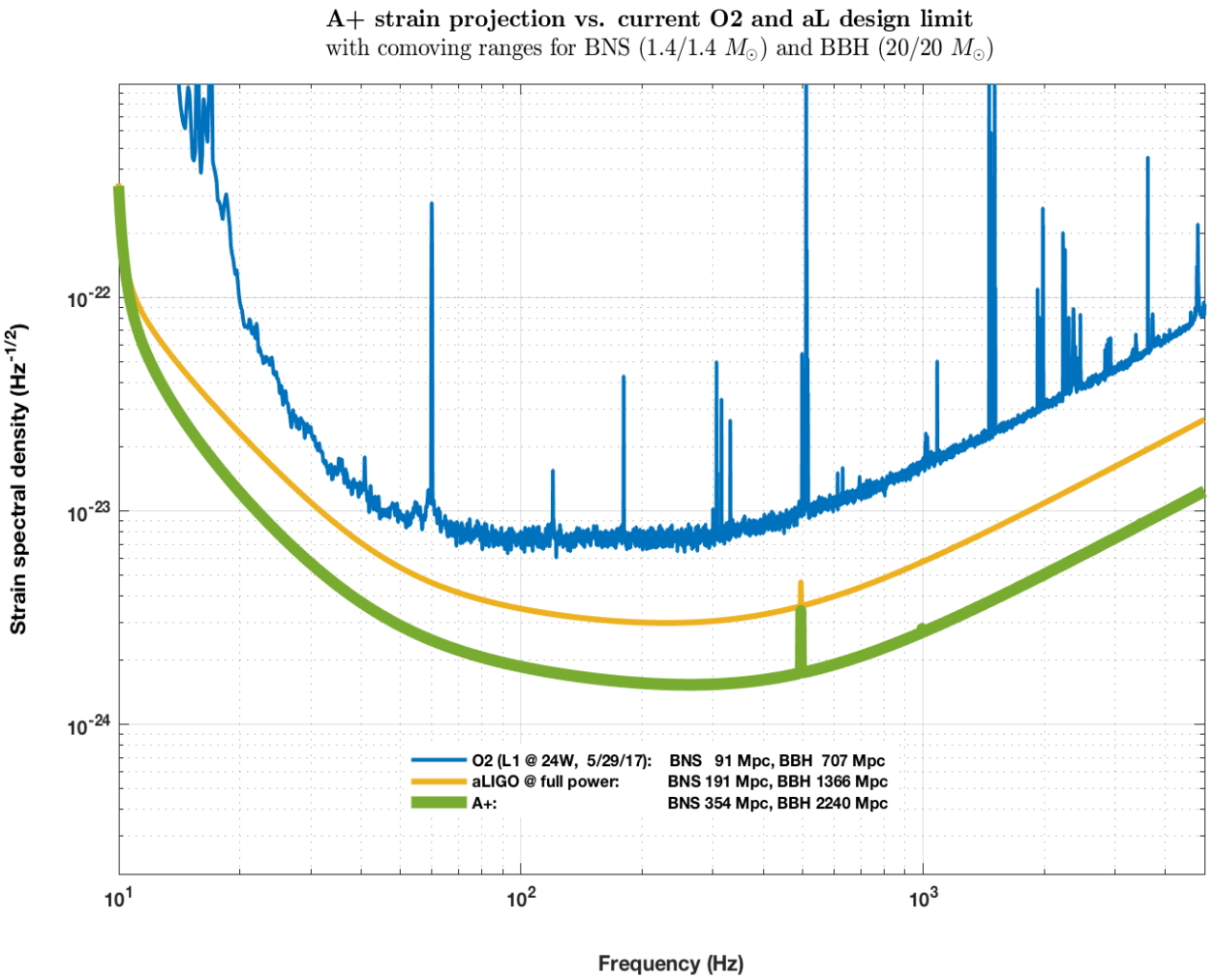




https://www.elisascience.org/files/publications/LISA_L3_20170120.pdf

A+: a Mid-Life Enhancement for Advanced LIGO

- Near term: 'A+', a mid-scale upgrade of Advanced LIGO
  - » Improvements across all bands
- Projected time scale for A+ operation: 2023 - 2025



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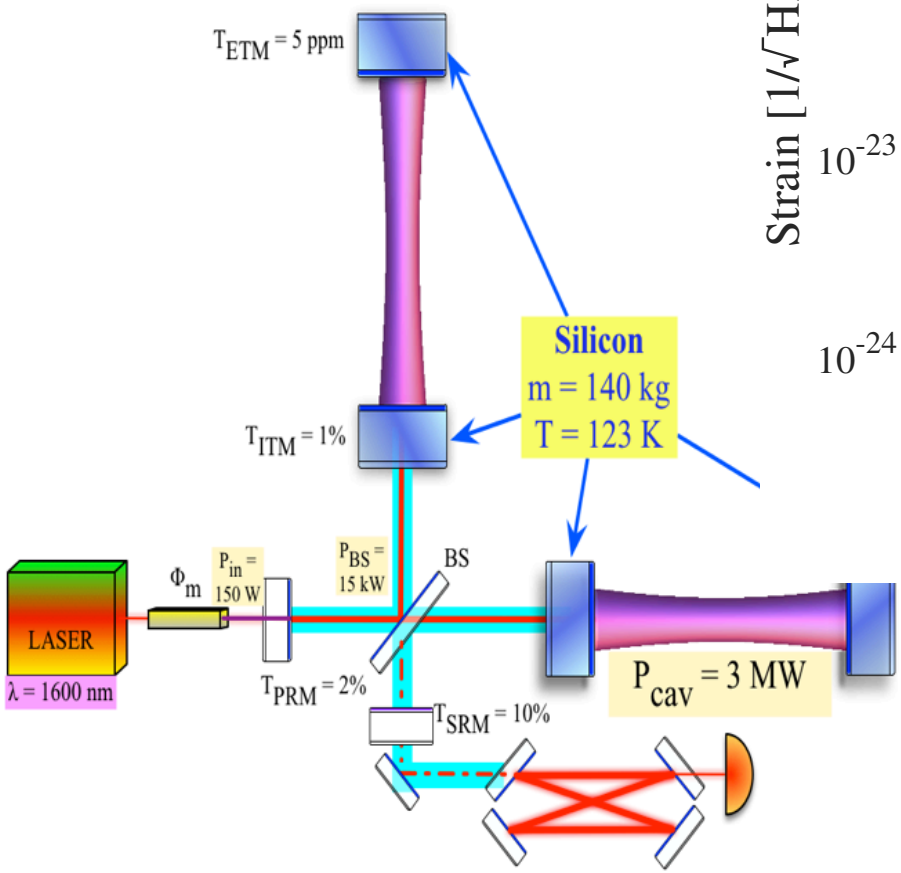
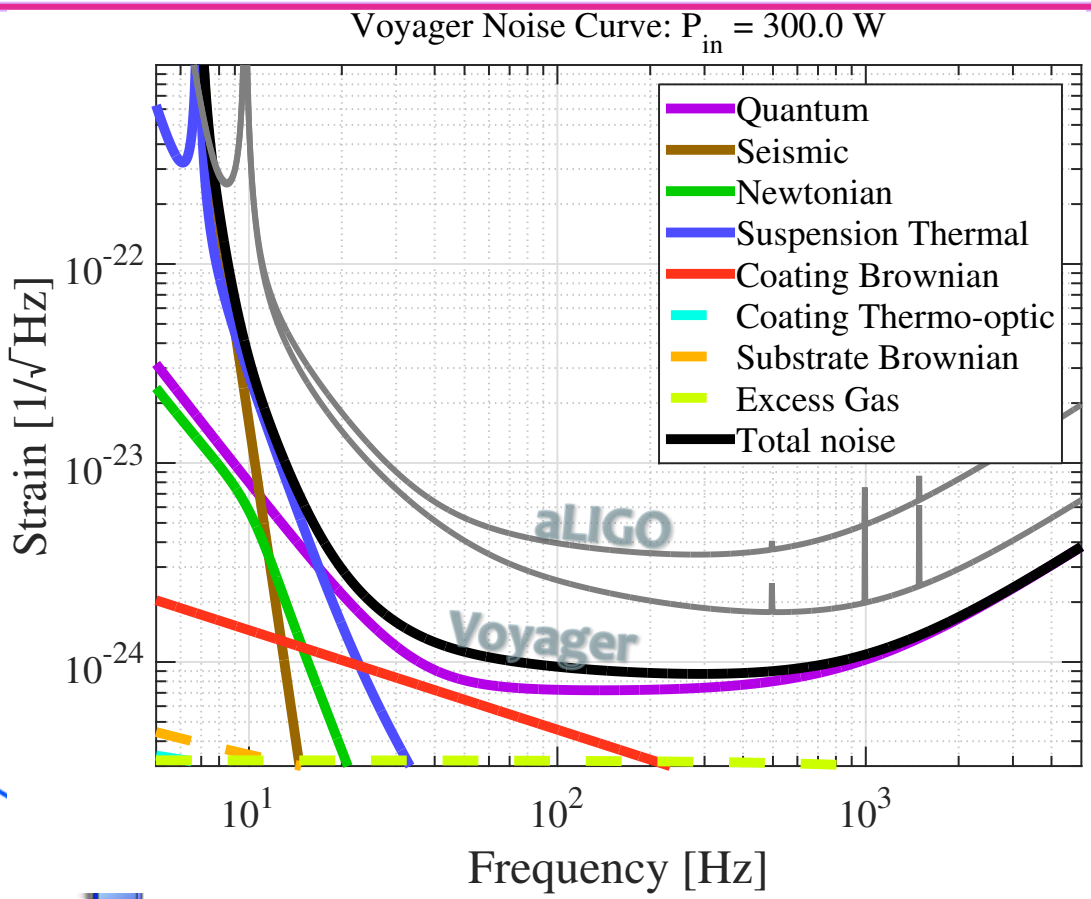
LIGO Voyager: Fully Exploiting the Current LIGO Facilities

Si optics, > 100 kg
Si or AlGaAs coatings
(Mildly) Cryogenic
λ~2 μm, 300 W





BNS *R* < 800 Mpc
BBH *z* < 5 (@10 $M_\odot$)
Cost ~10^8 M$

https://dcc.ligo.org/LIGO-T1400226,
https://dcc.ligo.org/LIGO-T1200031,
https://dcc.ligo.org/LIGO-T1200099
https://dcc.ligo.org/LIGO-T1600140

GWIC
Gravitational Wave International Committee

How to Get From Here to There?

GWIC (Gravitational Wave International Committee)

Body formed in 1997 to facilitate international collaboration and cooperation in the construction, operation and use of the major gravitational wave detection facilities world-wide

- Affiliated with the International Union of Pure and Applied Physics
  - From 1999 until 2011, GWIC was recognized as a subpanel of PaNAGIC (IUPAP WG.4).
  - In 2011, GWIC was accepted by IUPAP as a separate Working Group (WG.11).

Links to the:
International Astronomical Union (IAU)
International Society for General Relativity and Gravitation (ISGRG)

GWIC
Gravitational Wave International Committee

Who is GWIC?

The membership of GWIC represents all of the world's active gravitational wave projects*, as well as other relevant communities, covering gravitational wave frequencies from nanohertz to kilohertz. Each project has either one, two, or four members on GWIC depending on size.

ACIGA Bram Slagmolen

AURIGA (retiring in 2017) Massimo Cerdonio

Einstein Telescope Michele Punturo

European Pulsar Timing Array Michael Kramer

GEO 600 Karsten Danzmann, *Sheila Rowan (Chair)*

IndIGO Bala Iyer

KAGRA Yoshio Saito, Takaaki Kajita

LIGO Dave Reitze, David Shoemaker

LISA Neil Cornish, Bernard Schutz, Ira Thorpe, Stefano Vitale

NANOGrav Xavier Siemens

NAUTILUS (retiring in 2017) Eugenio Coccia

Parkes Pulsar Timing Array George Hobbs

Spherical Acoustic detectors Odylio Aguiar

Theory Community Clifford Will

Virgo Jo Van den Brand, Fulvio Ricci

IUPAP AC2 (ISGRG) Beverly Berger

IAU D1 Marica Branchesi

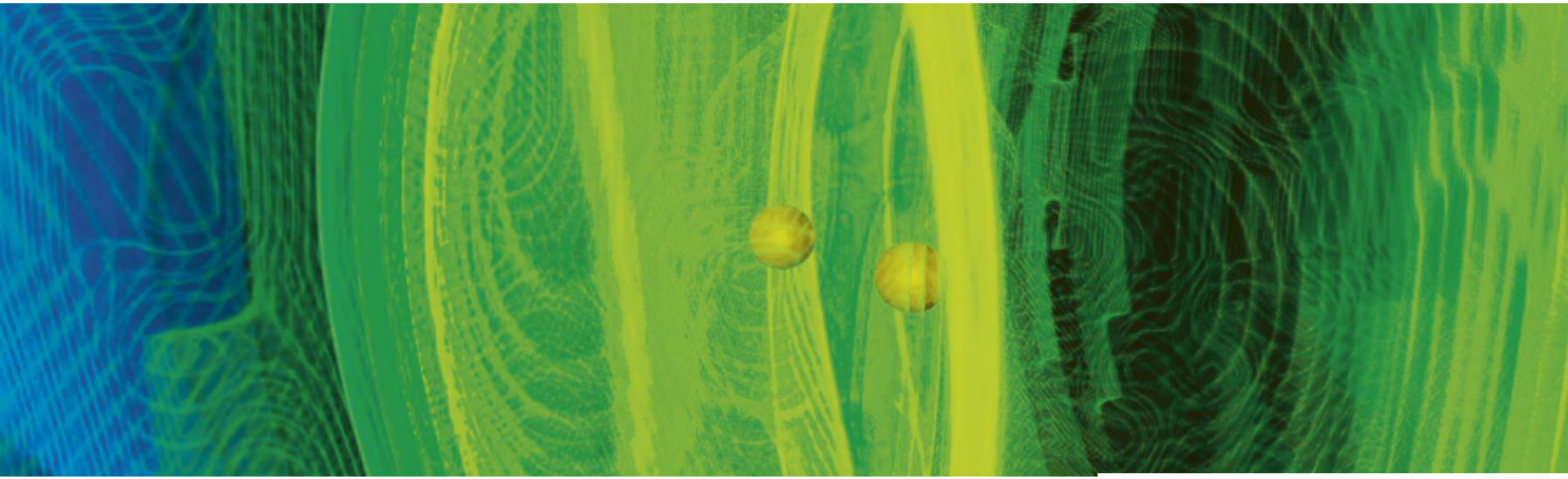
Executive secretary : David Shoemaker
Co- secretary: Stan Whitcomb

***no CMB community membership**

THE GRAVITATIONAL WAVES INTERNATIONAL COMMITTEE ROADMAP

The future of gravitational wave astronomy

GWIC



A global plan

Recognizing that the field is approaching this historic moment, in July 2007 the Gravitational Wave International Committee (GWIC)[1] initiated the development of a strategic roadmap for the field of gravitational wave science with a 30-year horizon.

The goal of this roadmap is to serve the international gravitational wave community and its stakeholders as a tool for the development of capabilities and facilities needed to address the exciting scientific opportunities on the intermediate and long-term horizons.

https://gwic.ligo.org/roadmap/Roadmap_110726_WEB.pdf

GWIC
Gravitational Wave International Committee

GWIC's role in coordinating 3G detector development

GWIC Subcommittee on Third Generation Ground-based Detectors

GWIC subcommittee purpose and charge:

With the recent first detections of gravitational waves by LIGO and Virgo, it is both timely and appropriate to begin seriously planning for a network of future gravitational-wave observatories, capable of extending the reach of detections well beyond that currently achievable with second generation instruments.

The GWIC Subcommittee on Third Generation Ground-based Detectors is tasked with examining the path to a future network of observatories/facilities

Membership of GWIC 3G Committee

Co-Chairs:
Michele Punturo – Einstein Telescope
David Reitze - LIGO

Federico Ferrini – European Gravitational Observatory
Takaaki Kajita - KAGRA
Vicky Kalogera – Northwestern (co-opted)
Harald Lueck, AEI (co-opted)
Jay Marx, LIGO (co-opted)
David McClelland, ACIGA (co-opted)
Sheila Rowan - GWIC Chair
Bangalore Sathyaprakash – Penn State (co-opted)
David Shoemaker – Executive Secretary

Goals

1) Science Drivers for 3G detectors

(Kalogera, Sathyaprakash + subcommittee)

"Commission a study of ground-based gravitational wave science from the global scientific community, investigating potential science vs architecture vs. network configuration vs. cost trade-offs, recognizing and taking into account existing studies for 3G projects (such as ET) as well as science overlap with the larger gravitational-wave spectrum."

Goals

2) *Coordination of the Ground-based GW Community:*

(Lueck, McClelland + subcommittee)

"Develop and facilitate coordination mechanisms among the current and future planned and anticipated ground-based GW projects, including identification of common technologies and R&D activities as well as comparison of the specific technical approaches to 3G detectors. Possible support for coordination of 2G observing and 3G construction schedules."

Goals

3) *Networking among Ground-based GW Community:*

(Punturo, Reitze)

"Organize and facilitate links between planned global 3G projects and other relevant scientific communities, including organizing:

- town hall meetings to survey the community
- dedicated sessions in scientific conferences dedicated to GW physics and astronomy
- focused topical workshops within the relevant communities"

Goals

4) *Agency interfacing and advocacy:*

(Rowan)

"Identify and establish a communication channel with funding agencies who currently or may in the future support ground-based GW detectors; communicate as needed to those agencies officially through GWIC on the scientific needs, desires, and constraints from the communities and 3G projects (collected via 1) – 3) above) structured in a coherent framework; serve as an advocacy group for the communities and 3G projects with the funding agencies."

Goals

5) *Investigate 3G detector governance schemes*

(Ferrini, Marx + subcommittee)

"By applying knowledge of the diverse structures of the global GW community, propose a sustainable governance model for the management of detector construction and joint working, to support planning of 3rd generation observatories."

GWIC
Gravitational Wave International Committee

Upcoming Near Term Meetings of Interest

6-7 July, 2017	What's Next for Gravitational Wave Astronomy?
Syracuse, NY	Marriott Syracuse Downtown, 100 E Onondaga St, Syracuse, NY 13202
9-14 July, 2017	12th Edoardo Amaldi Conference on Gravitational Waves
Pasadena, CA	Hilton Pasadena, 168 S Los Robles Ave, Pasadena, CA 91101
28 Aug-1 Sep, 2017	LIGO-Virgo Collaboration Meeting
Geneva, Switzerland	CERN, Geneva, Switzerland

The committee will need your input and help to develop the proper path forward!

gwic-3g@sympa.ligo.org

GWIC

Gravitational Wave International Committee

What Next?
A Town Hall Meeting

This afternoon 2:00 – 3:30 pm, Hilton Ballroom

The committee will need your input and help to develop the proper path forward!

gwic-3g@sympa.ligo.org