Einstein Telescope:

A 3rd Generation Gravitational Wave Detector

2024. 11. 30.

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Korea Astronomy & Space Science Institute

Einstein Telescope

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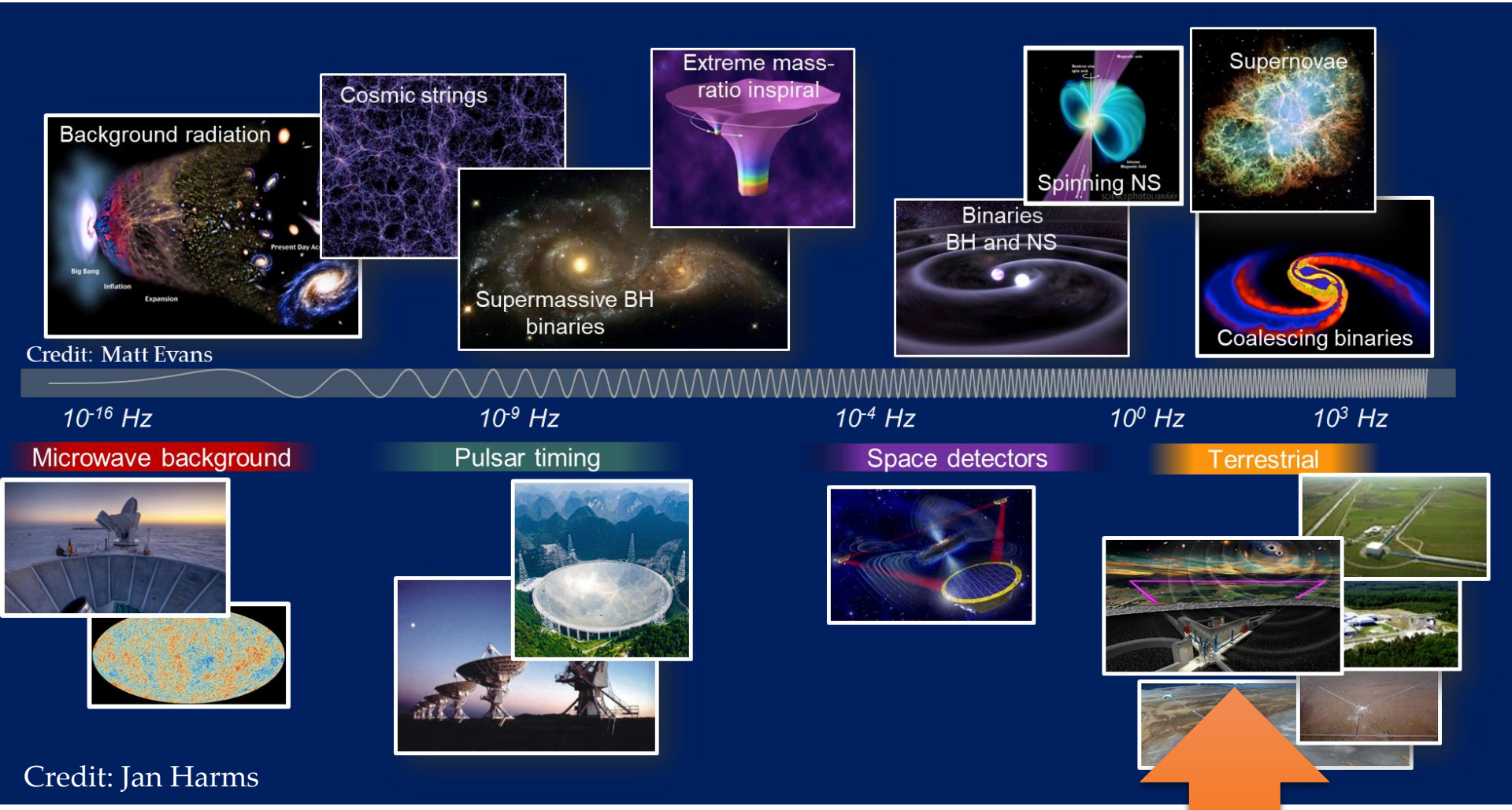
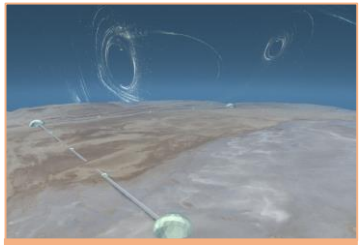
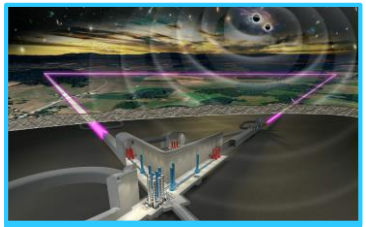


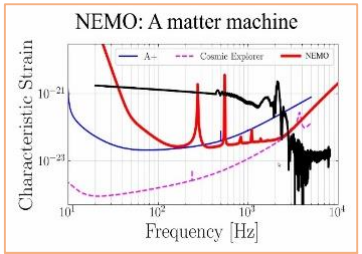
Ground-based GW Detectors



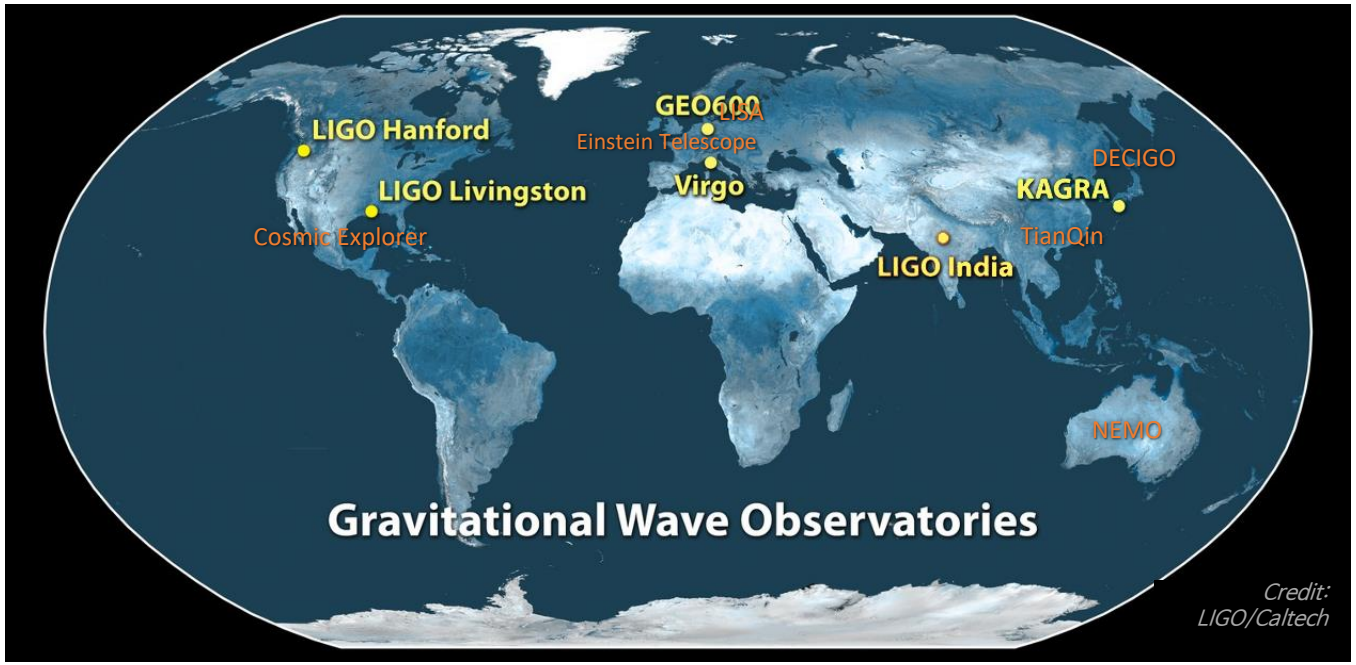
Cosmic Explorer



Einstein Telescope



NEMO



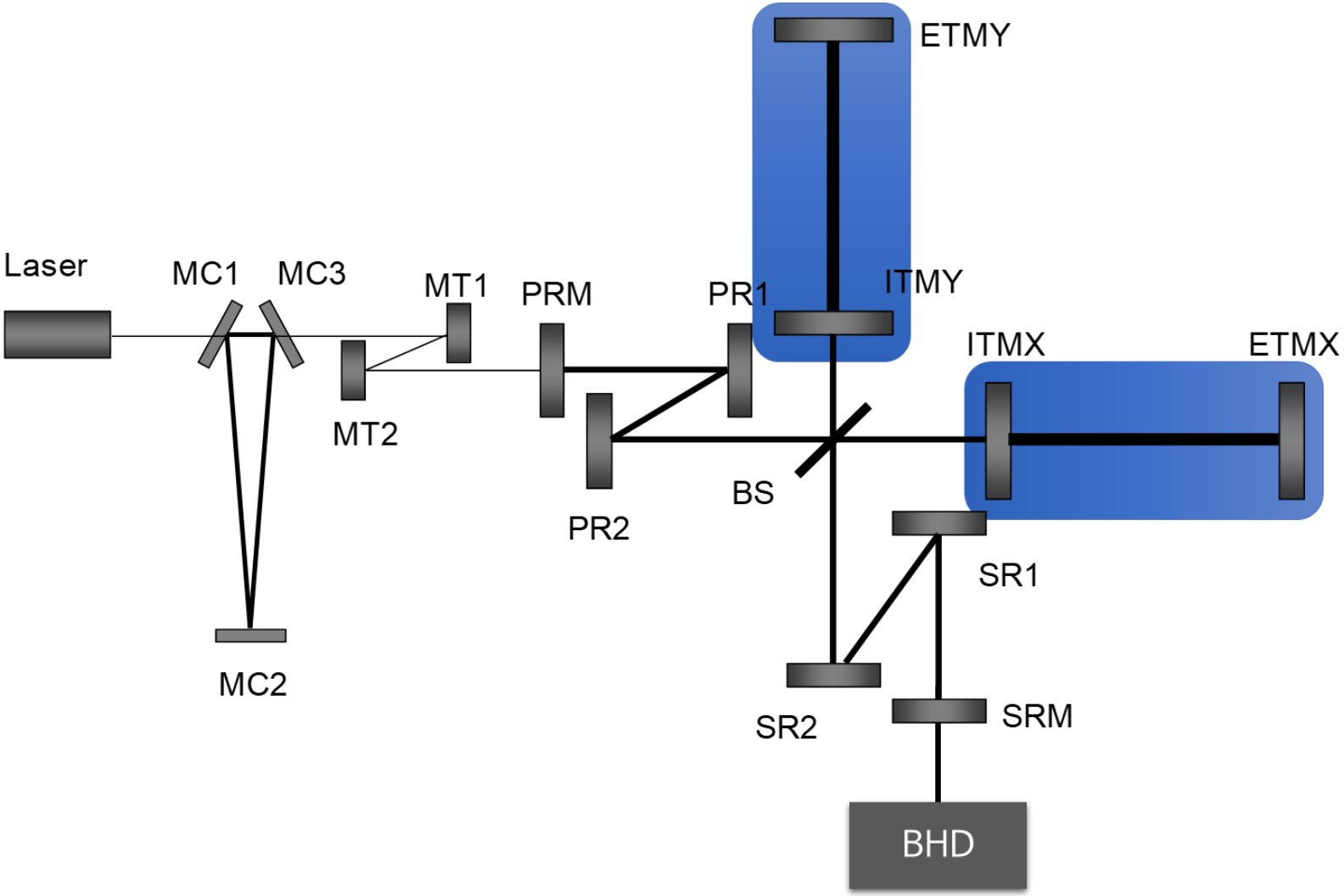
LIGO

Virgo

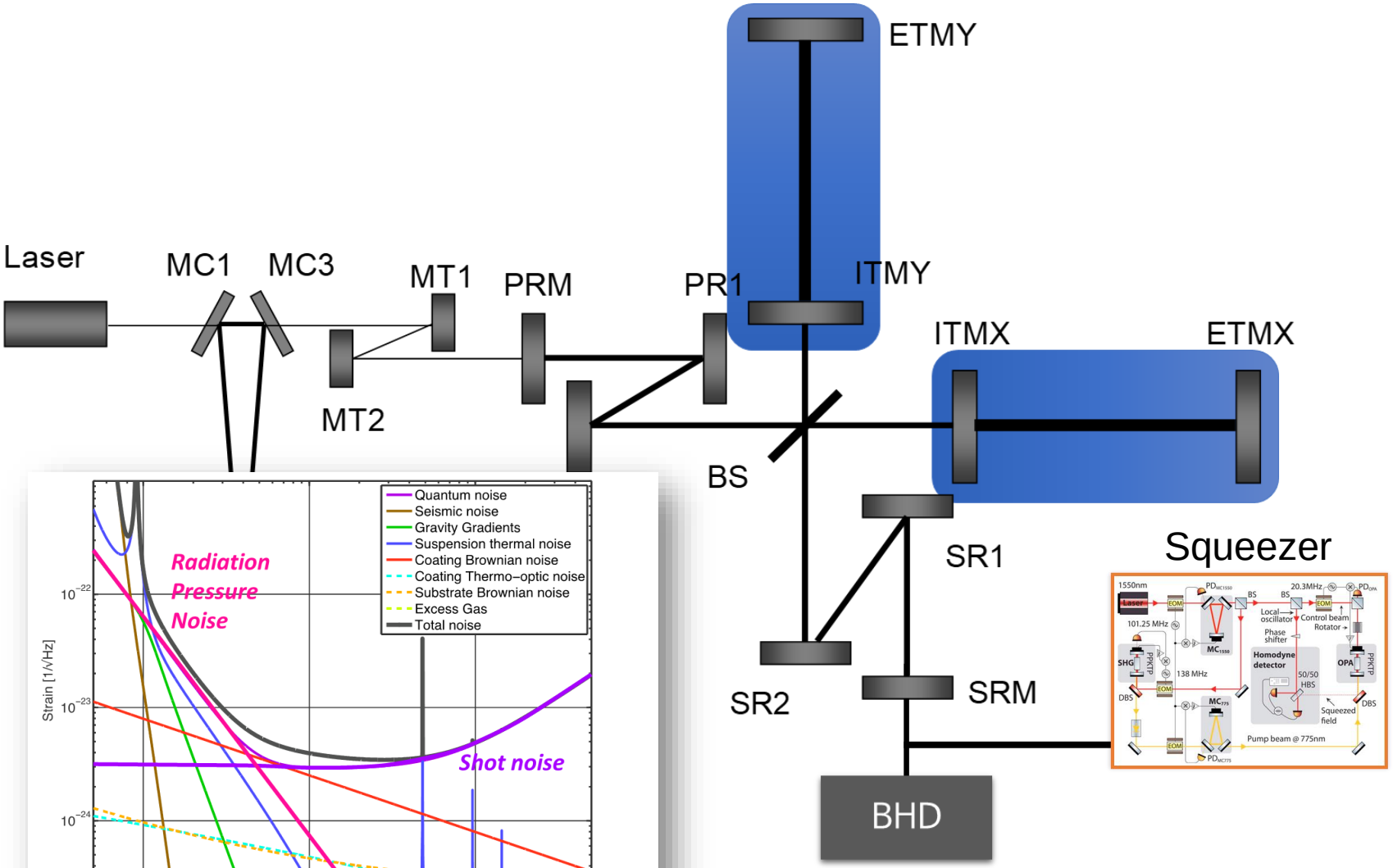
KAGRA

LIGO-India

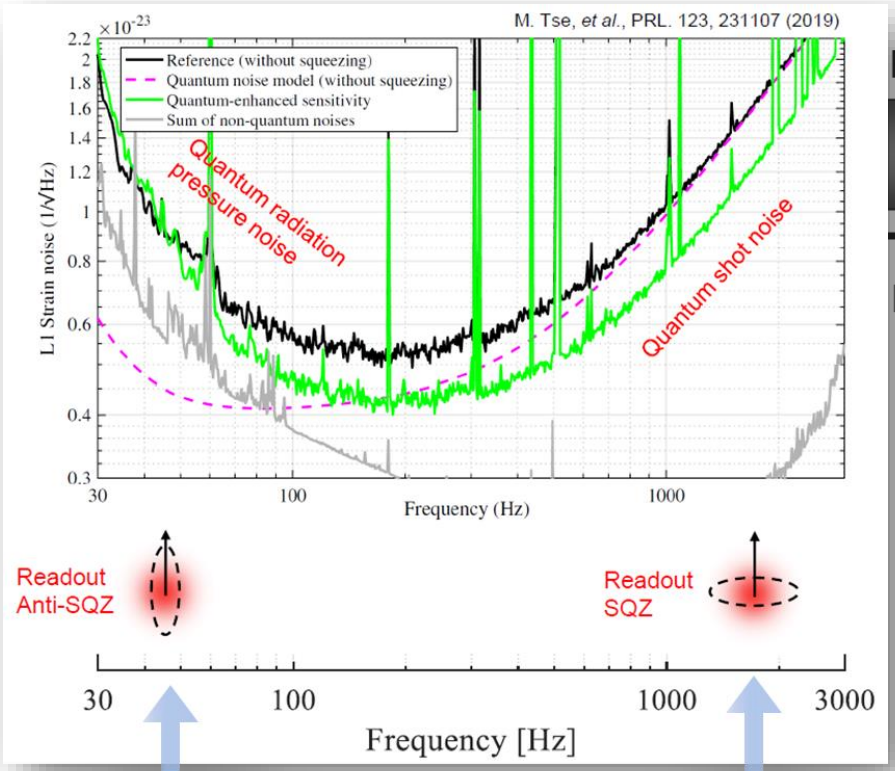
Ground-based GW Detectors – DRFPMI

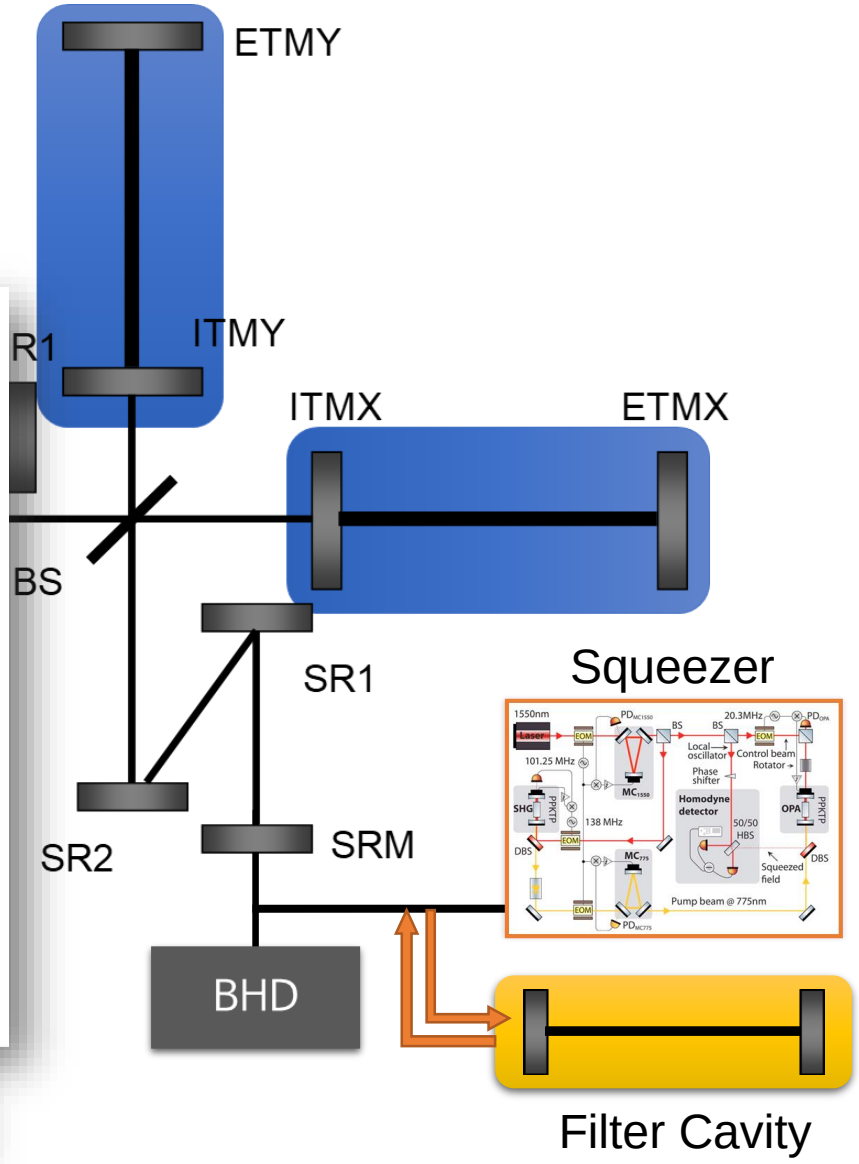


Ground-based GW Detectors – DRFPMI + SQZ

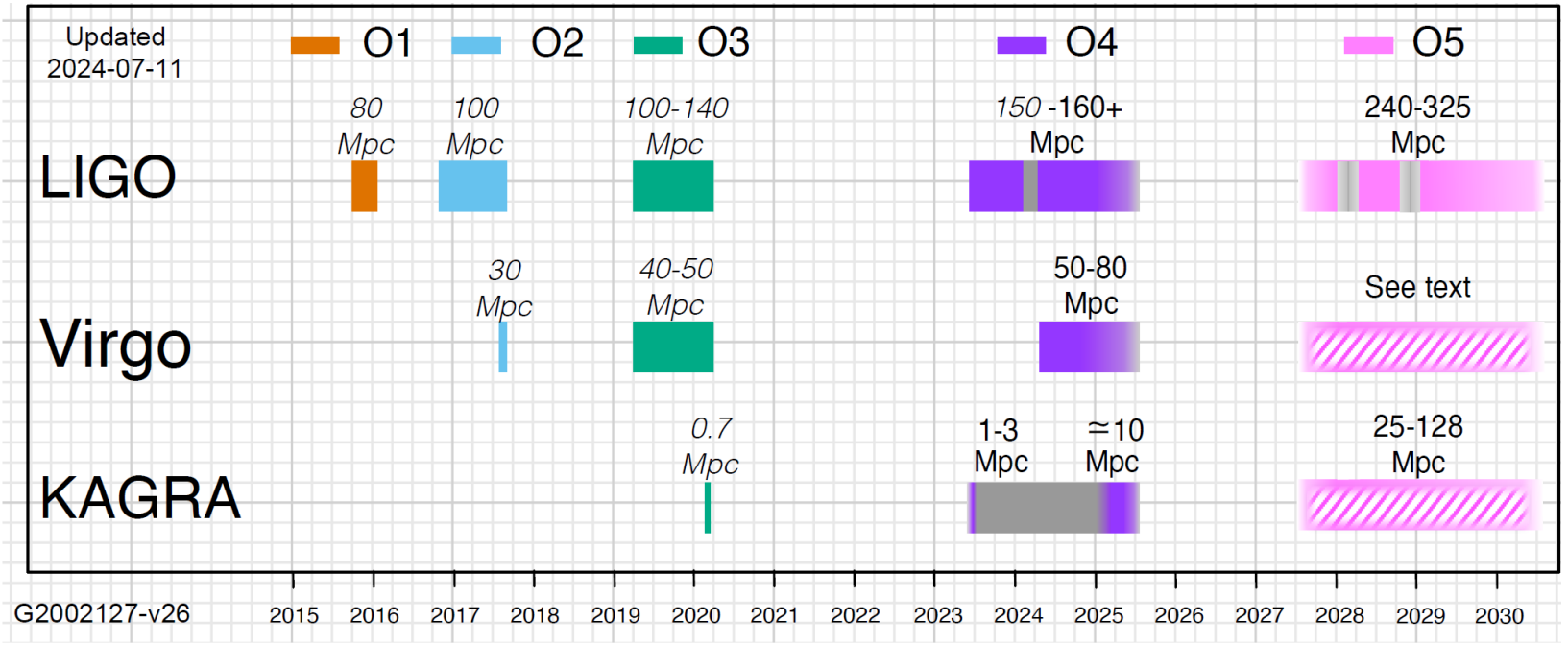


Ground-based GW Detectors – DRFPMI + SQZ + FC

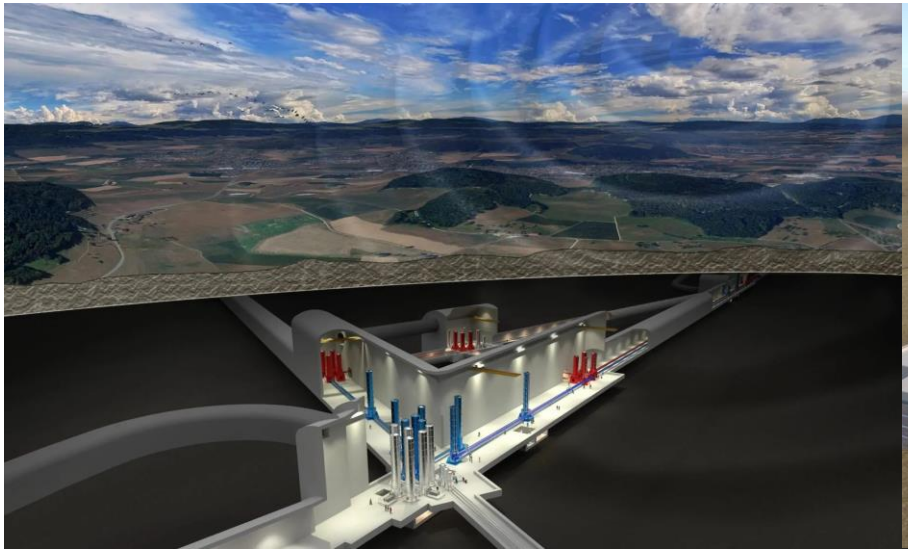




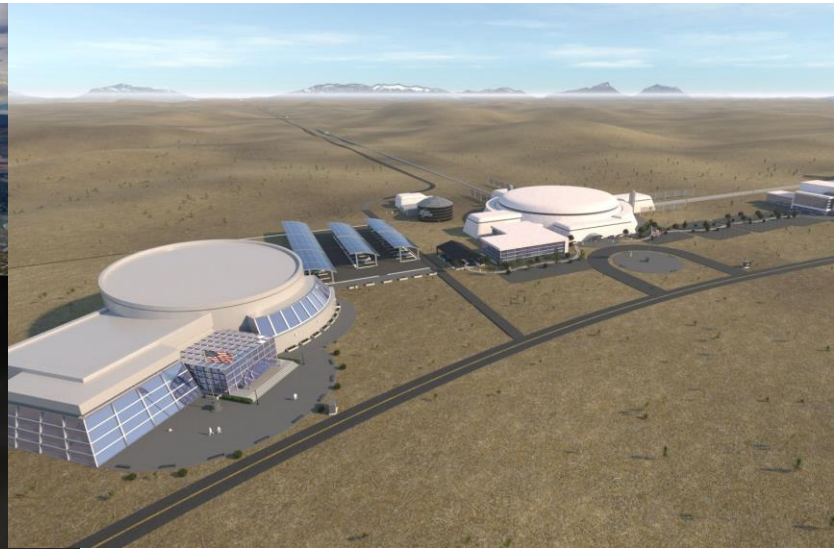
2nd Generation GW Detectors



3rd Generation GW Detectors



Einstein Telescope



Cosmic Explorer

COSMIC EXPLORER

neXt-Generation Collaborative Design (XGCD)

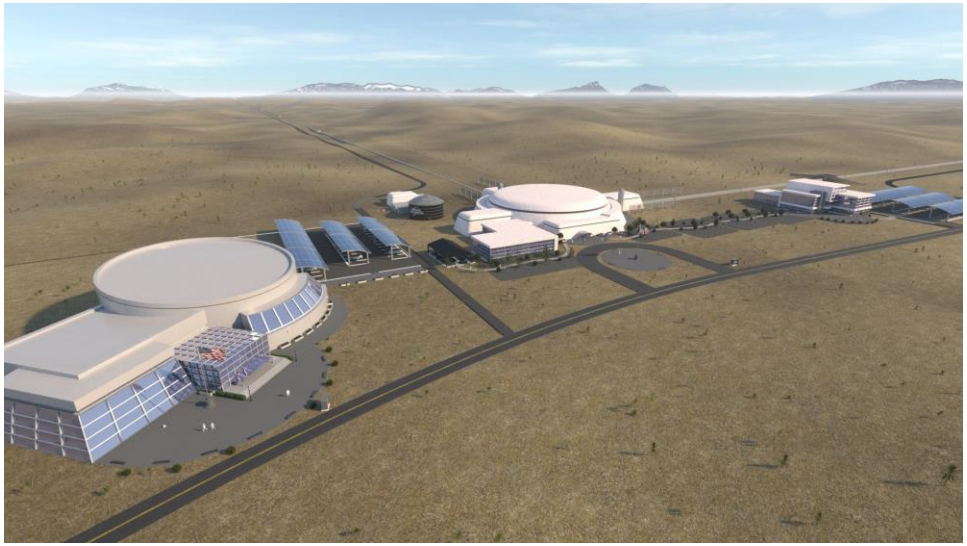
NSF

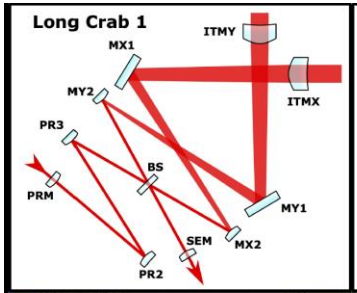
https://indico.gssi.it/e/xgcd

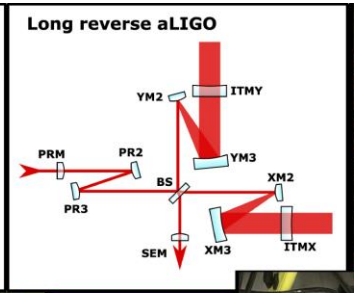
- ET-CE technical discussion on topics of common interest
- Optical Design and Straylight mitigation discussed so far

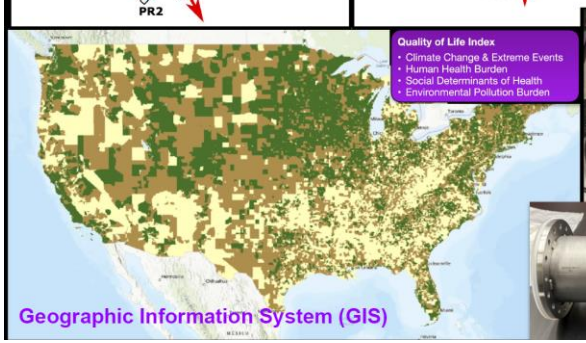
Credit: Lisa Barsotti

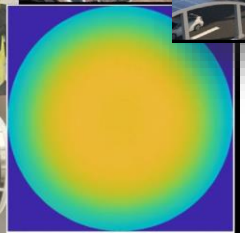
Cosmic Explorer











Credit: L. Barsotti

Cosmic Explorer

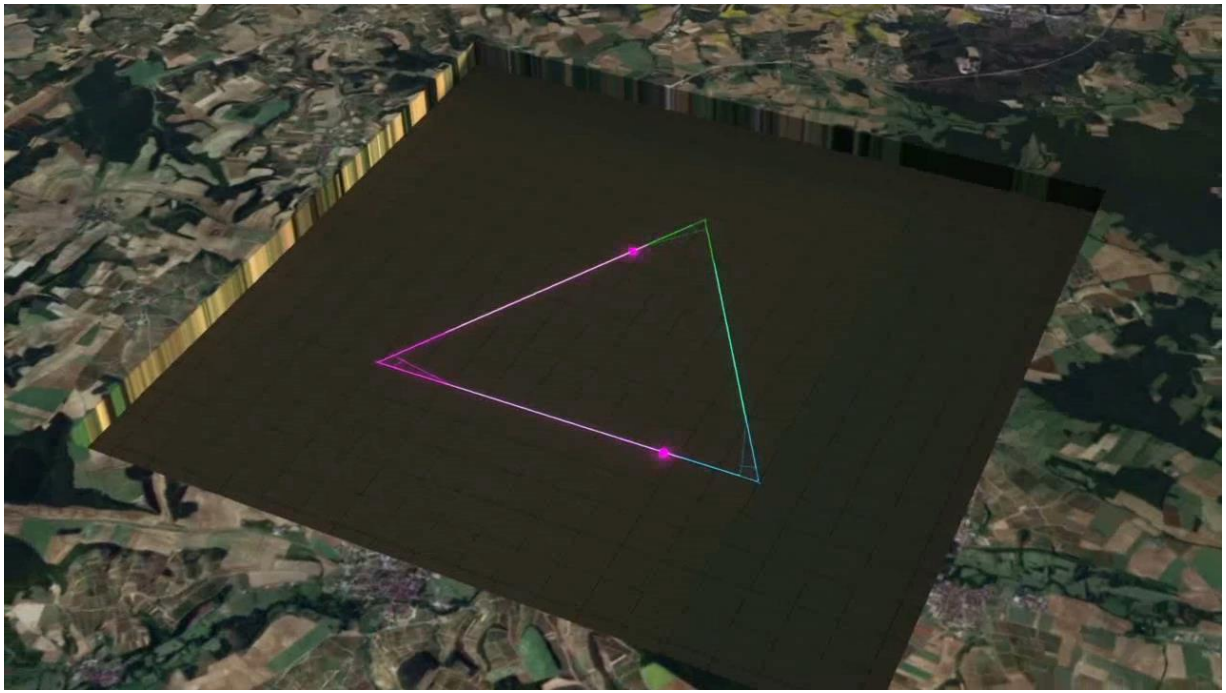
What are the steps for Cosmic Explorer? (Dawn V 2019)

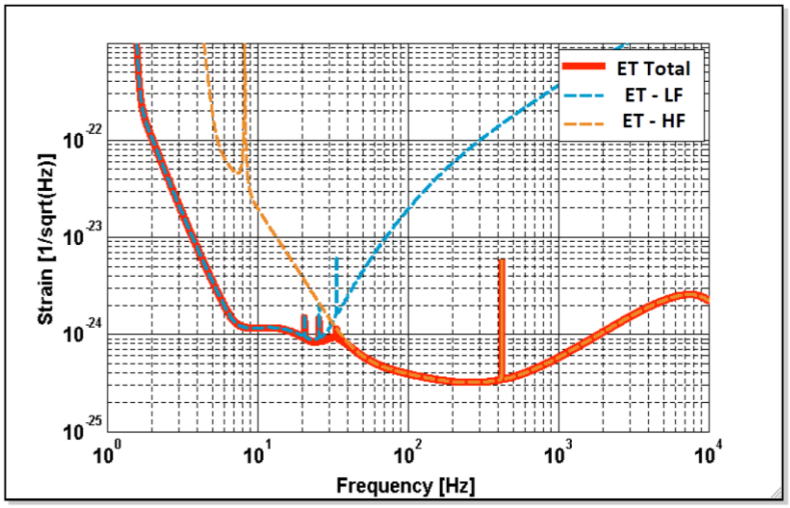
Horizon planning (3G Design NSF award in 2018) Cosmic Explorer White Paper (3G Design award product)	3 years (2021)	CEHS (2021)
Community endorses the WP (through Dawn meeting?)	½ year (2021)	Dawn VI (2021)
NRC report based on CE WP and GWIC reports	1 ½ years? (2023)	Bypassed
MPSAC subcommittee reviews NRC report Physics Division develops a written plan for MPS approval NSF Director decides to authorize CD funding	½ year (2024)	ngGW (2024) In the works In the works
Conceptual Design period	2-3 years (2027)	Support started in 2023 ($8M)
Preliminary Design period award	2-3 years (2030)	
NSF approves submission to NSB	½ year (2030)	
Final Design period NSB prioritization OMB/Congress budget negotiations	2-3 years (2032)	
Congress appropriates MREFC funding (2032-37)	**14 years (2032)**	

Credit: P. Marronetti (NSF gravity program director)

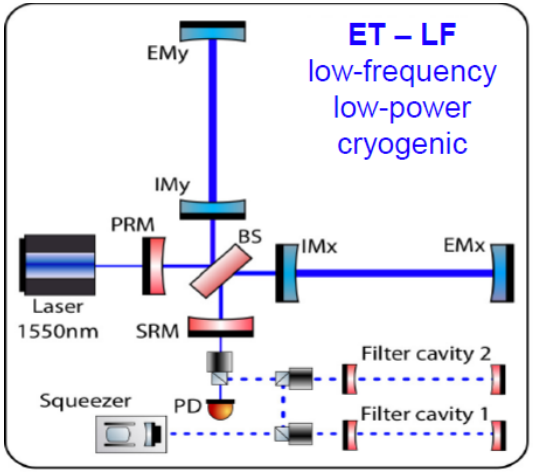
Einstein Telescope

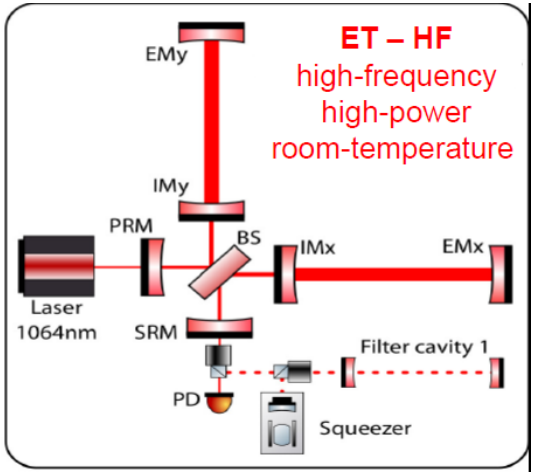
Einstein Telescope – Concept

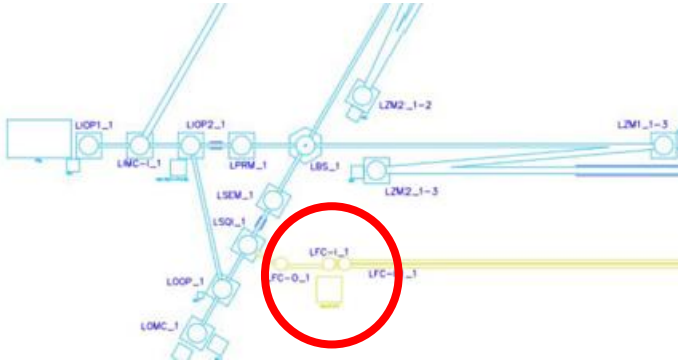


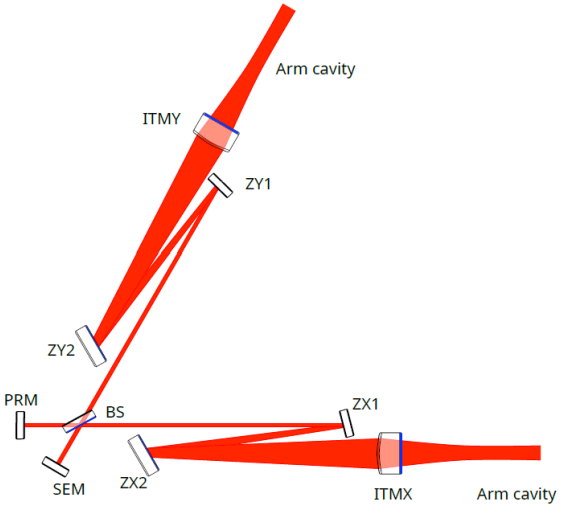


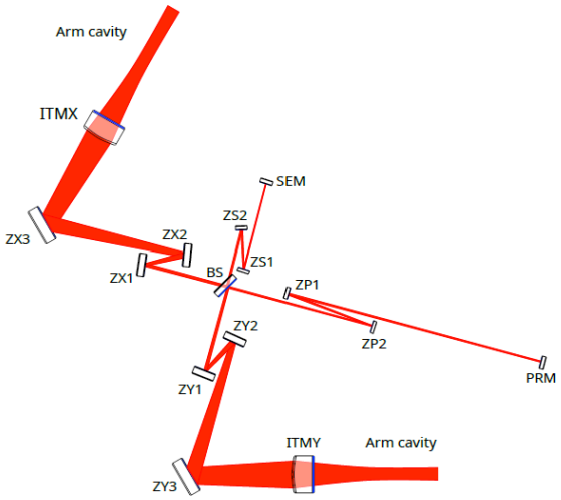
Einstein Telescope – Design

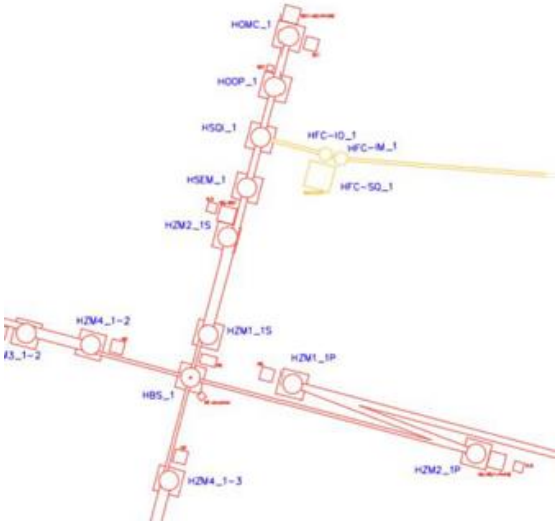




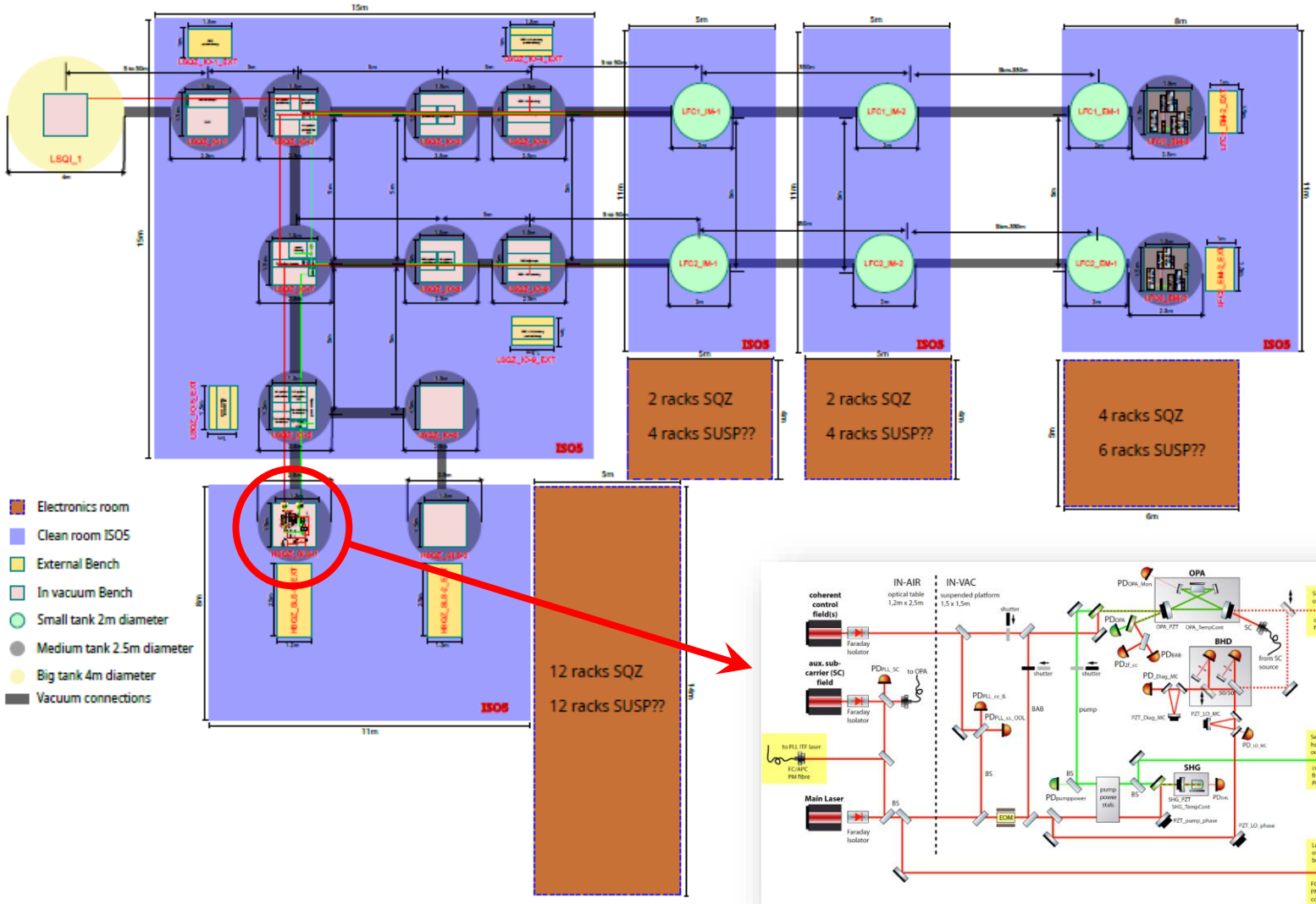








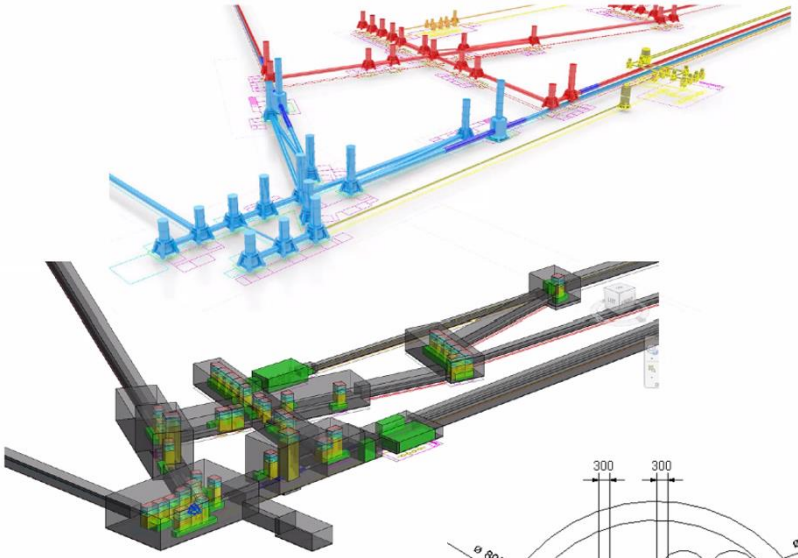
Einstein Telescope – Design



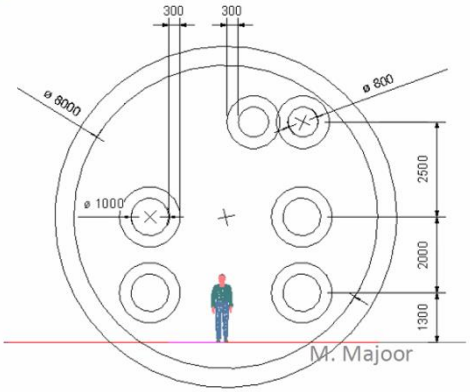
Einstein Telescope – Design Trades

Various Alternative Layouts are Being Studied

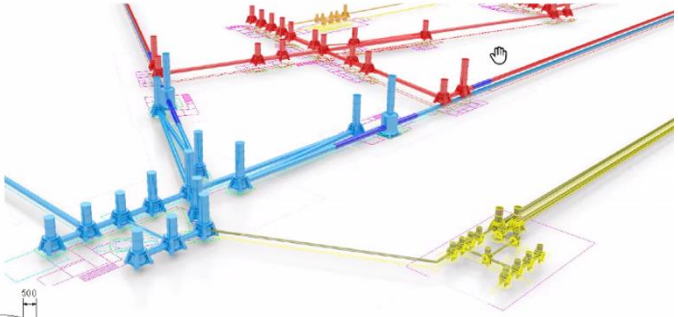
Lateral access cleanrooms to aid with flexibility,
LF filter cavity in a combined arm tunnel

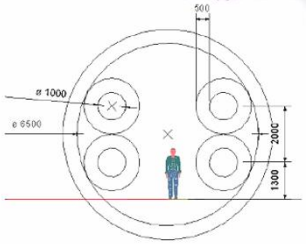


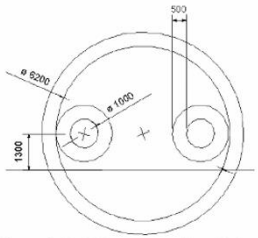
Working towards the detector layout block model with all of the space claims



Various bottom access cleanrooms in current design,
LF filter cavity in a separate 5km tunnel

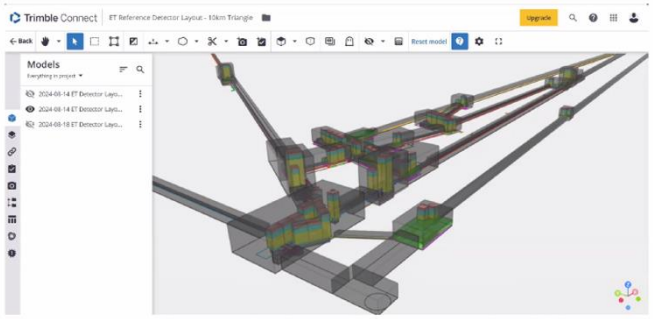






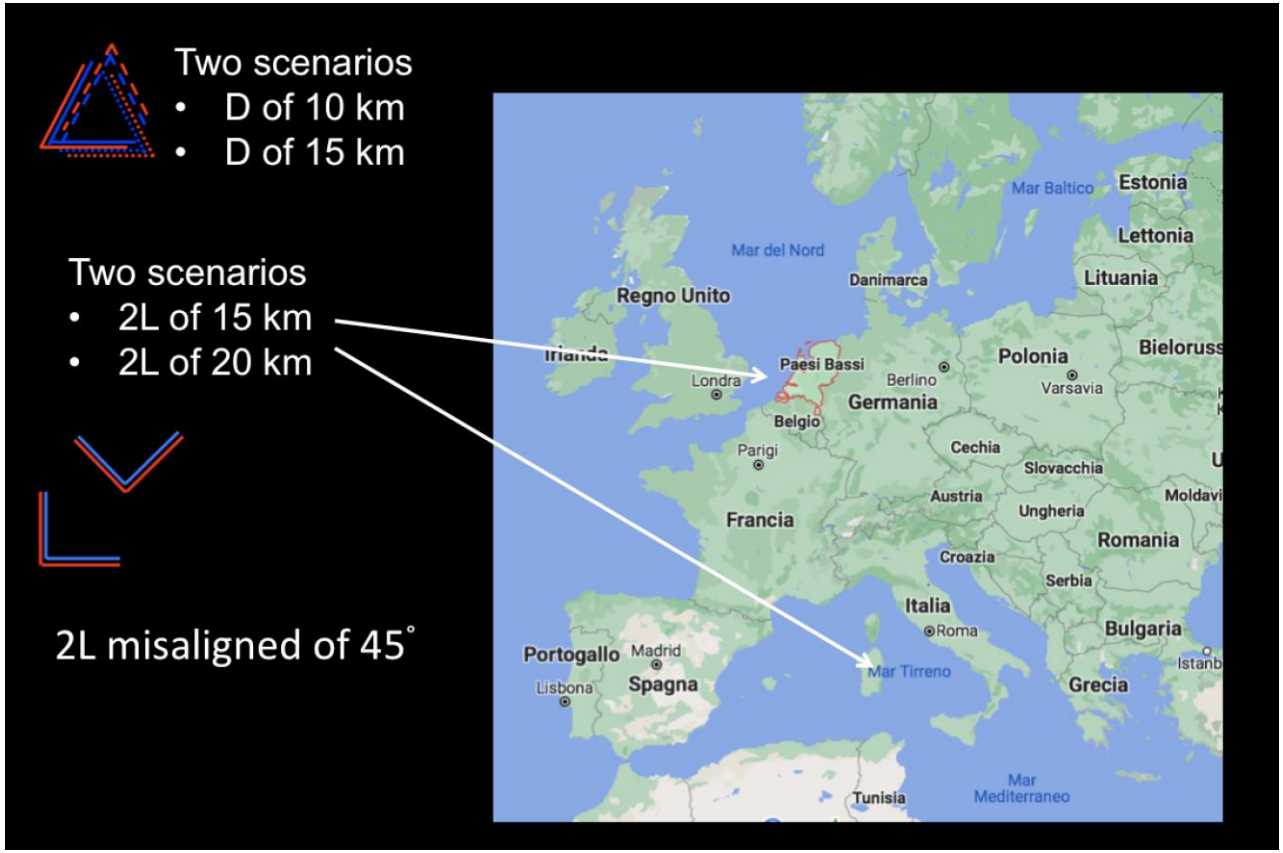
An additional 5km tunnel for the LF-FC has high implications for the cost.

Main arm cavity ⌀6.5m 5km LF-FC tunnel ⌀6.2m



Platform for easily sharing models and collaborative working between various parties is still in-progress

Einstein Telescope – Δ vs. 2L

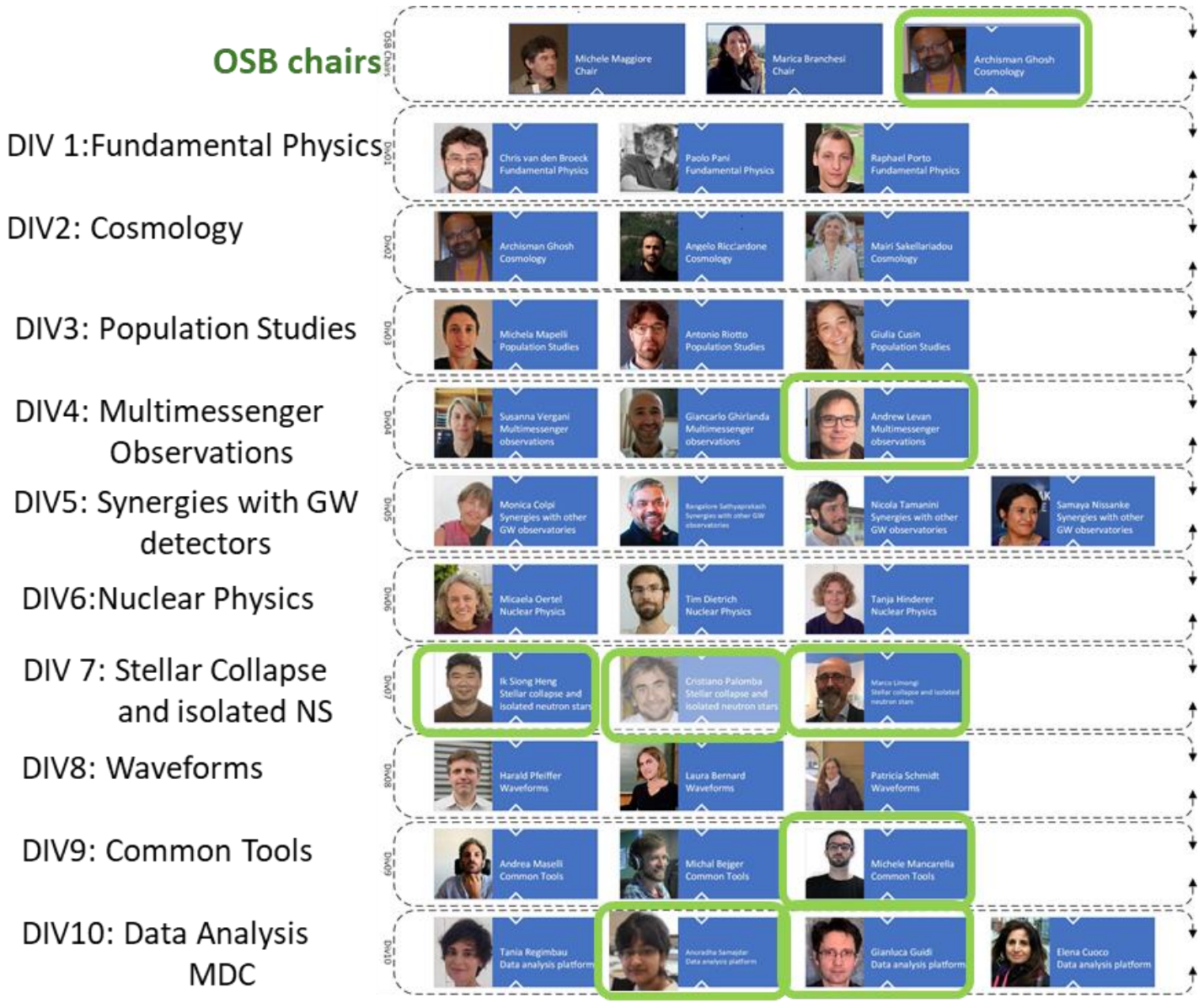


Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

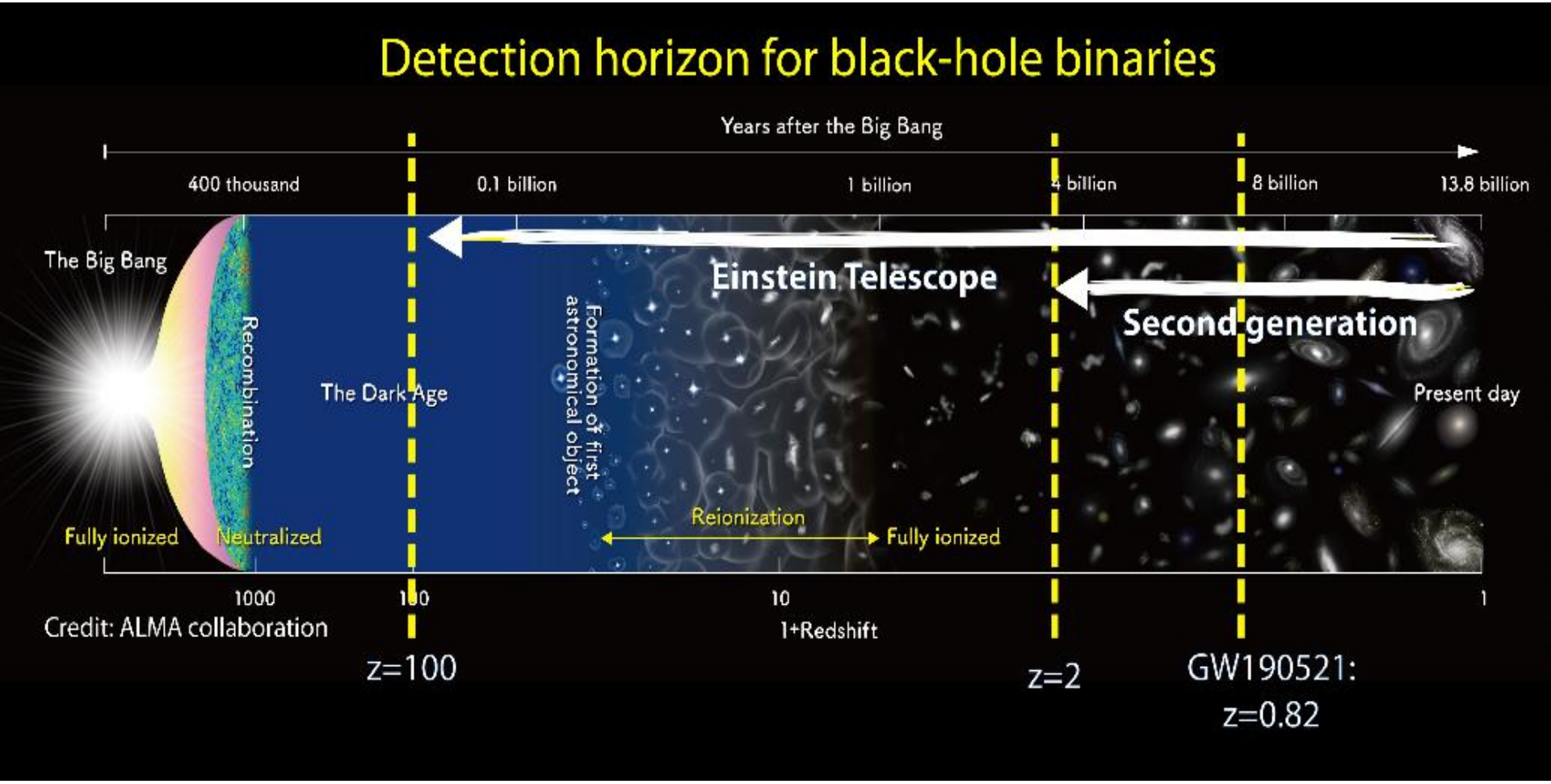
Science with the Einstein Telescope: a comparison of different designs

- Triangle 10-km arms (1 site)
- 2L 15-km arms at 45 ˚ (2 sites)

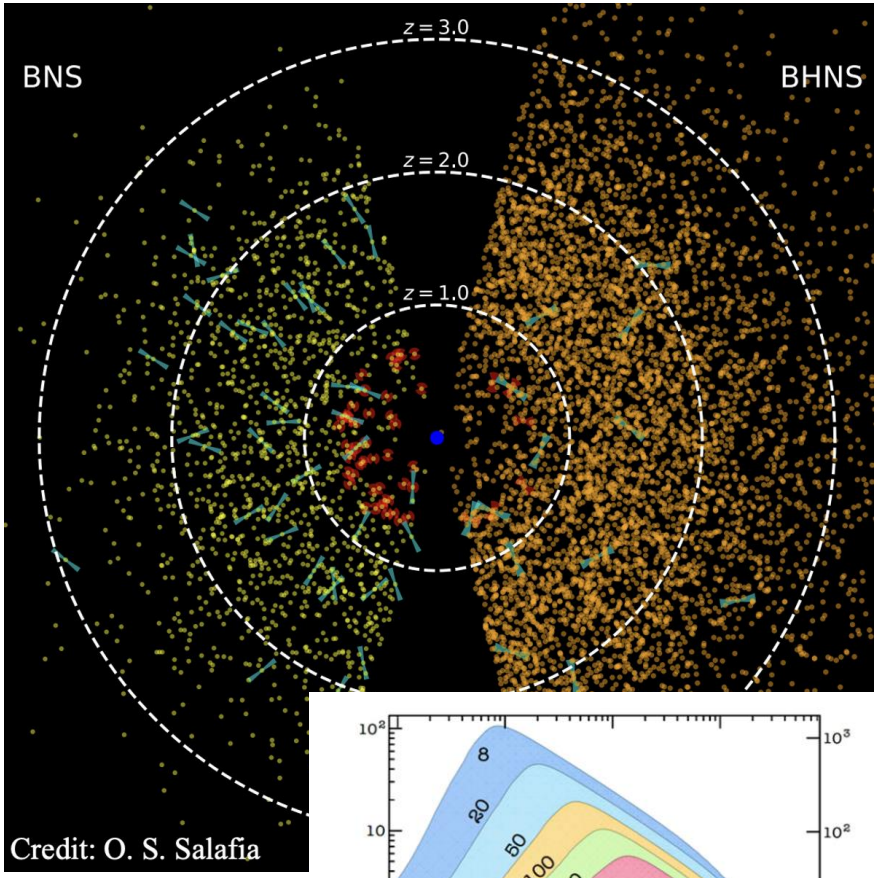
Einstein Telescope – Science

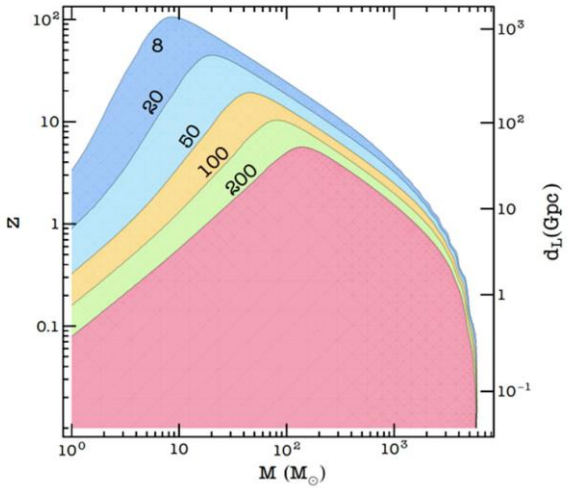


Einstein Telescope – Science Impacts



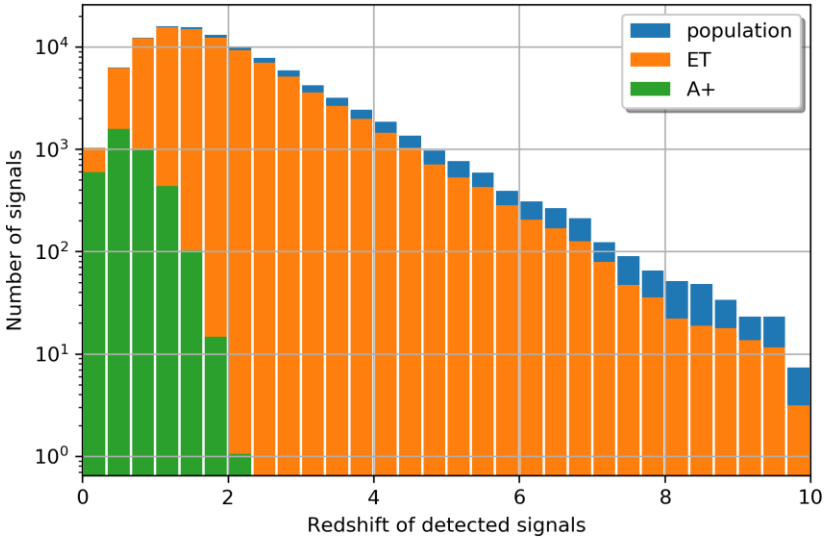
Einstein Telescope – Science Impacts



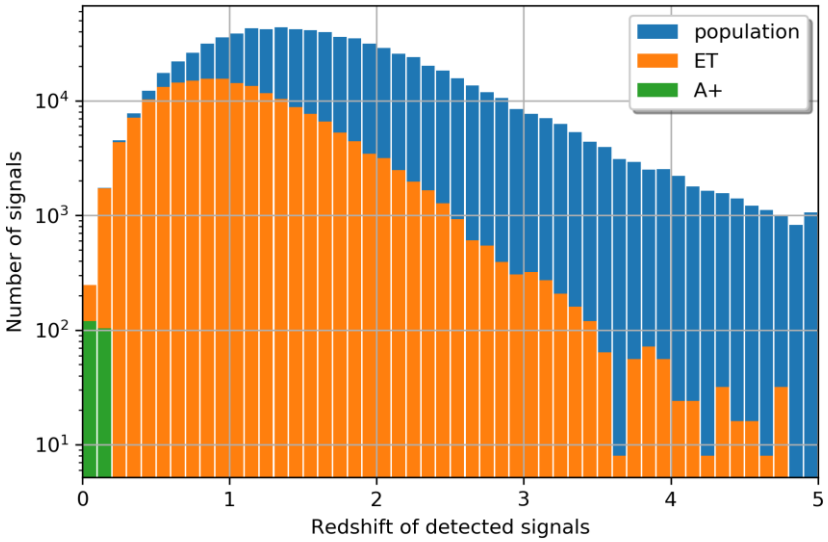


Credit: M. Branchesi

BINARY BLACK-HOLE MERGERS



BINARY NEUTRON-STAR MERGERS

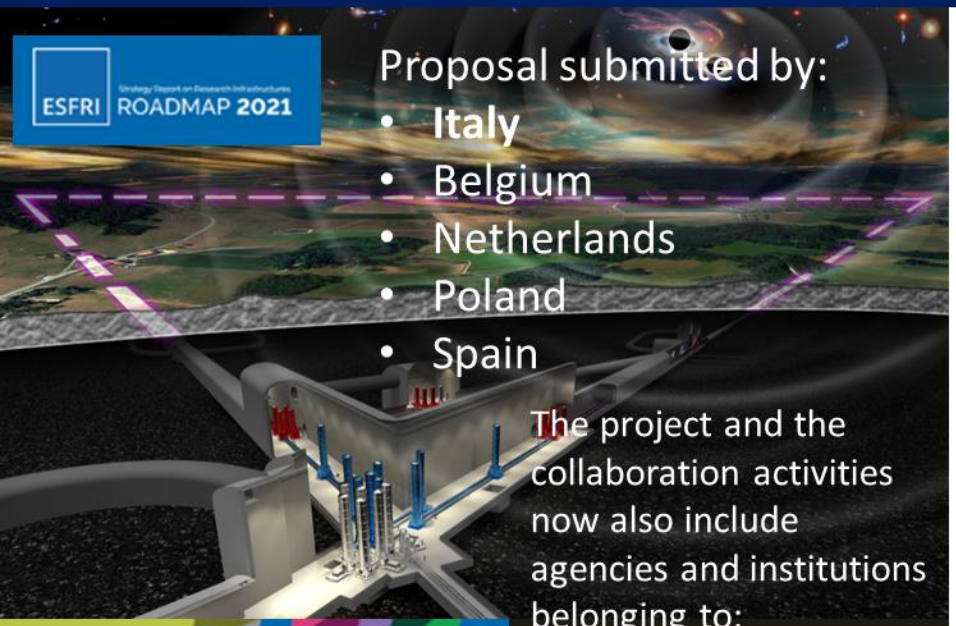


Einstein Telescope – Milestone

European Strategy Forum on Research Infrastructures

ET in the ESFRI Roadmap

ET EINSTEIN TELESCOPE



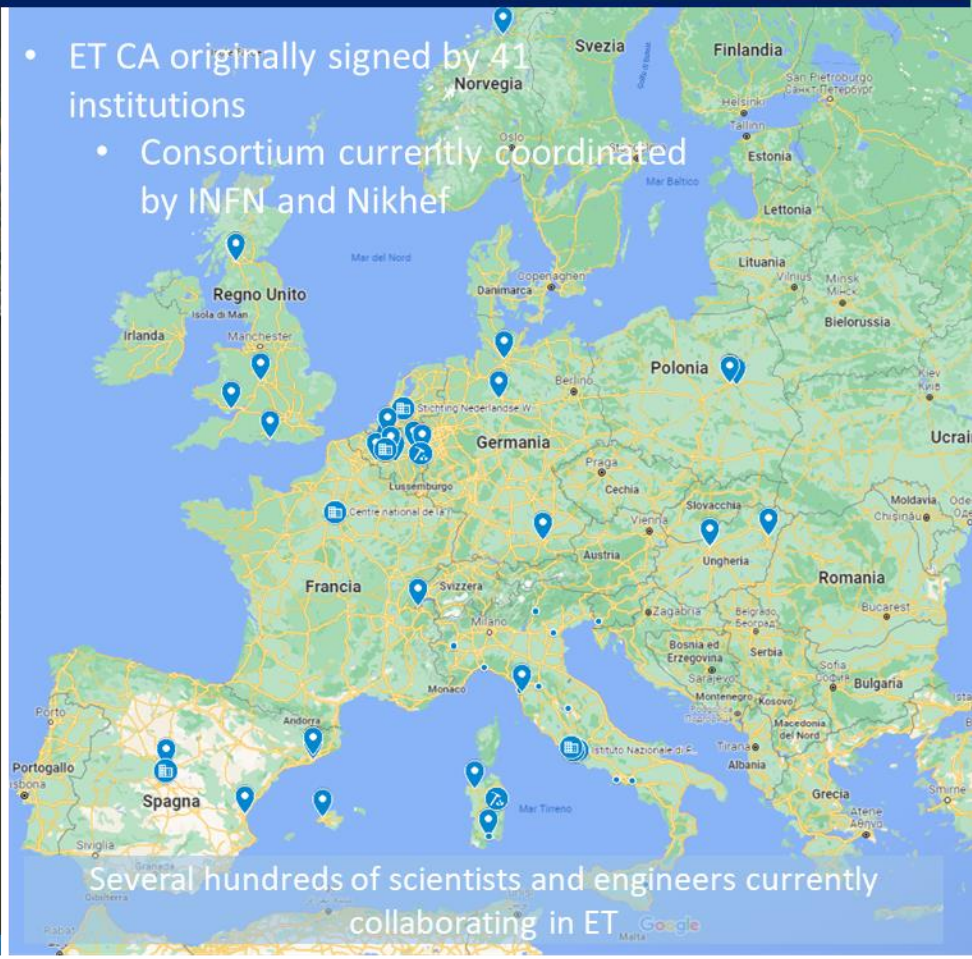
Proposal submitted by:

- **Italy**
- Belgium
- Netherlands
- Poland
- Spain

The project and the collaboration activities now also include agencies and institutions belonging to:

- **Austria**
- **France**
- **Germany**
- **Hungary**
- **Switzerland**
- **UK**

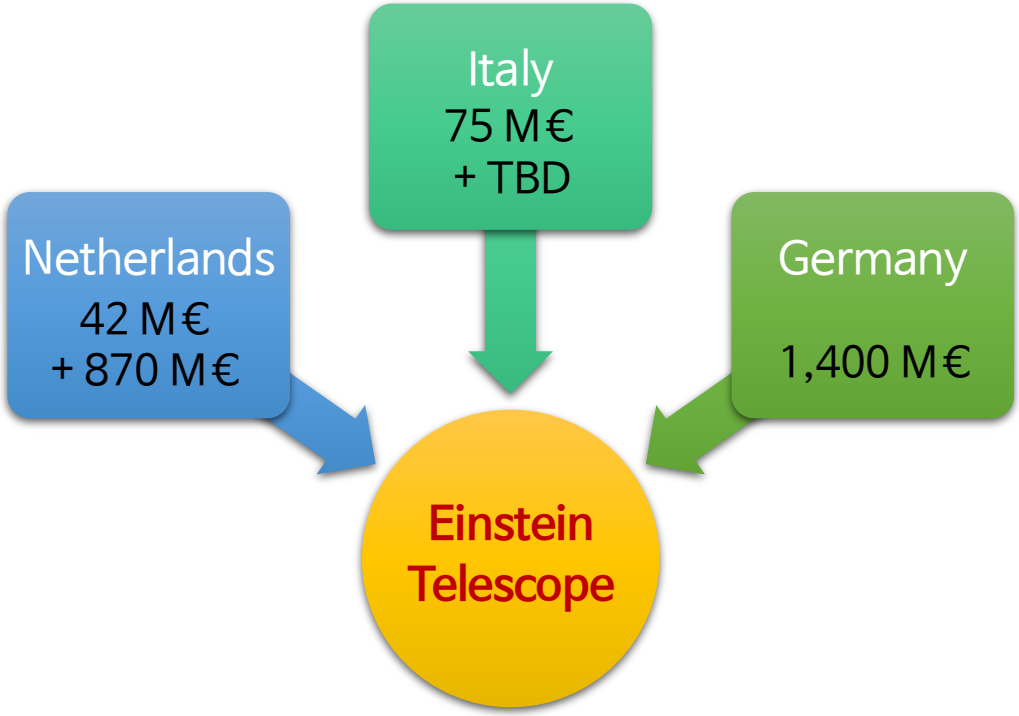
Large preparatory funds available in some country (IT, NL, …), an EU INFRA-DEV proposal just approved with a grant of 3.45M€ and an EU INFRA-TECH proposal has been just submitted



- ET CA originally signed by 41 institutions
  - Consortium currently coordinated by INFN and Nikhef

Several hundreds of scientists and engineers currently collaborating in ET

Einstein Telescope – Site Candidates



Presentazione della candidatura italiana per Einstein Telescope

Palazzo Chigi
구독자 20.6만명
구독

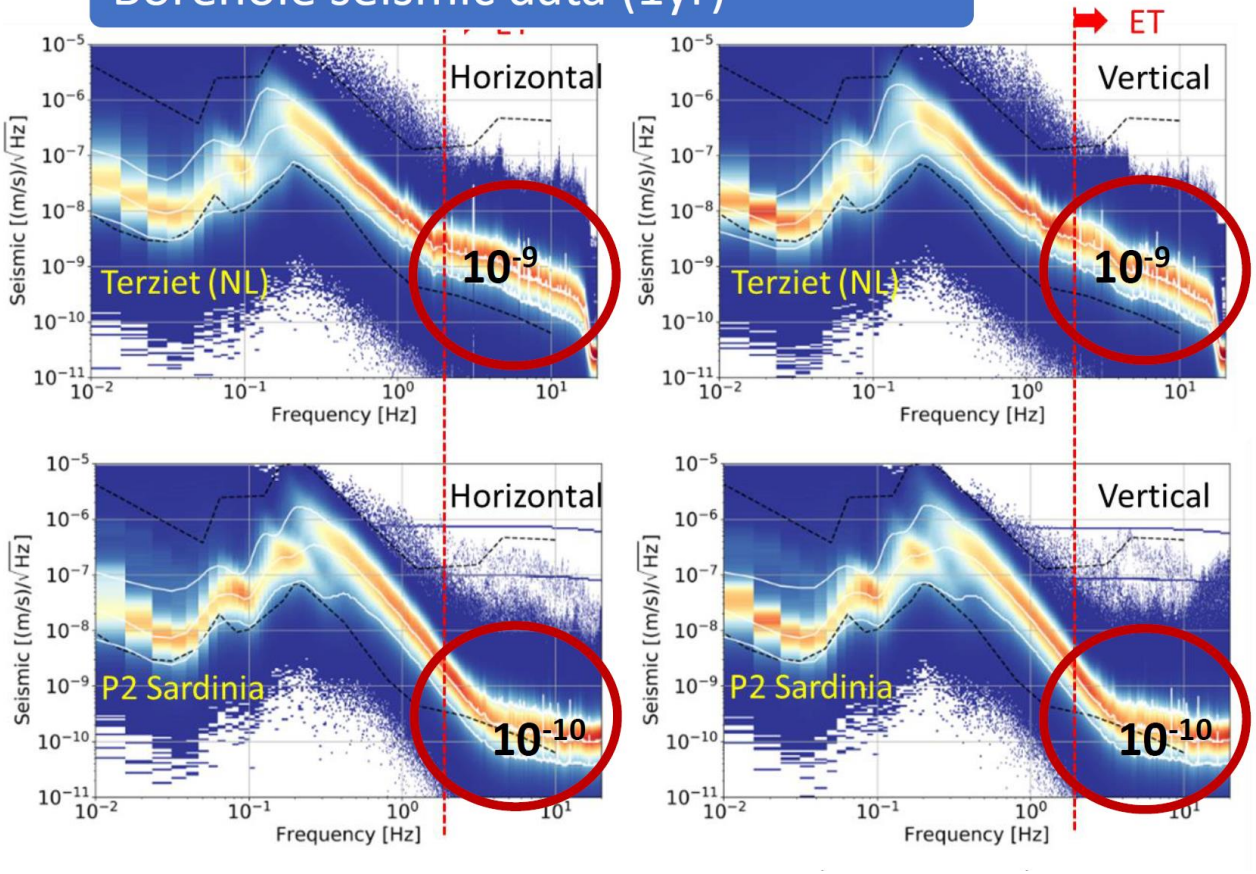
334 공유 오프라인 저장 저장

조회수 9.3천회 스트리밍 시간: 1개월 전 **INAF - ISTITUTO NAZIONALE DI ASTROFISICA - OSSERVATORIO ASTRONOMICO DI ROMA**

Roma, 06/06/2023 - Il Presidente del Consiglio, Giorgia Meloni, interviene alla presentazione della candidatura italiana per Einstein Telescope, la futura grande infrastruttura di ricerca per la rivelazione delle onde gravitazionali. L'evento si tiene nella sede dell'INAF Istituto Nazionale di Astrofisica.
https://www.governo.it/it/articolo/pr... 더보기

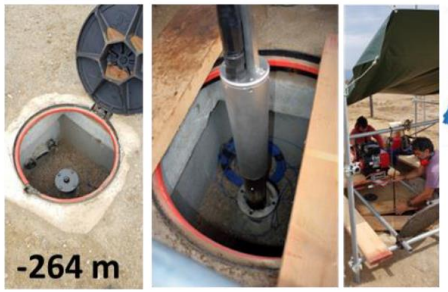
Einstein Telescope – Site Candidates

Borehole seismic data (1yr)



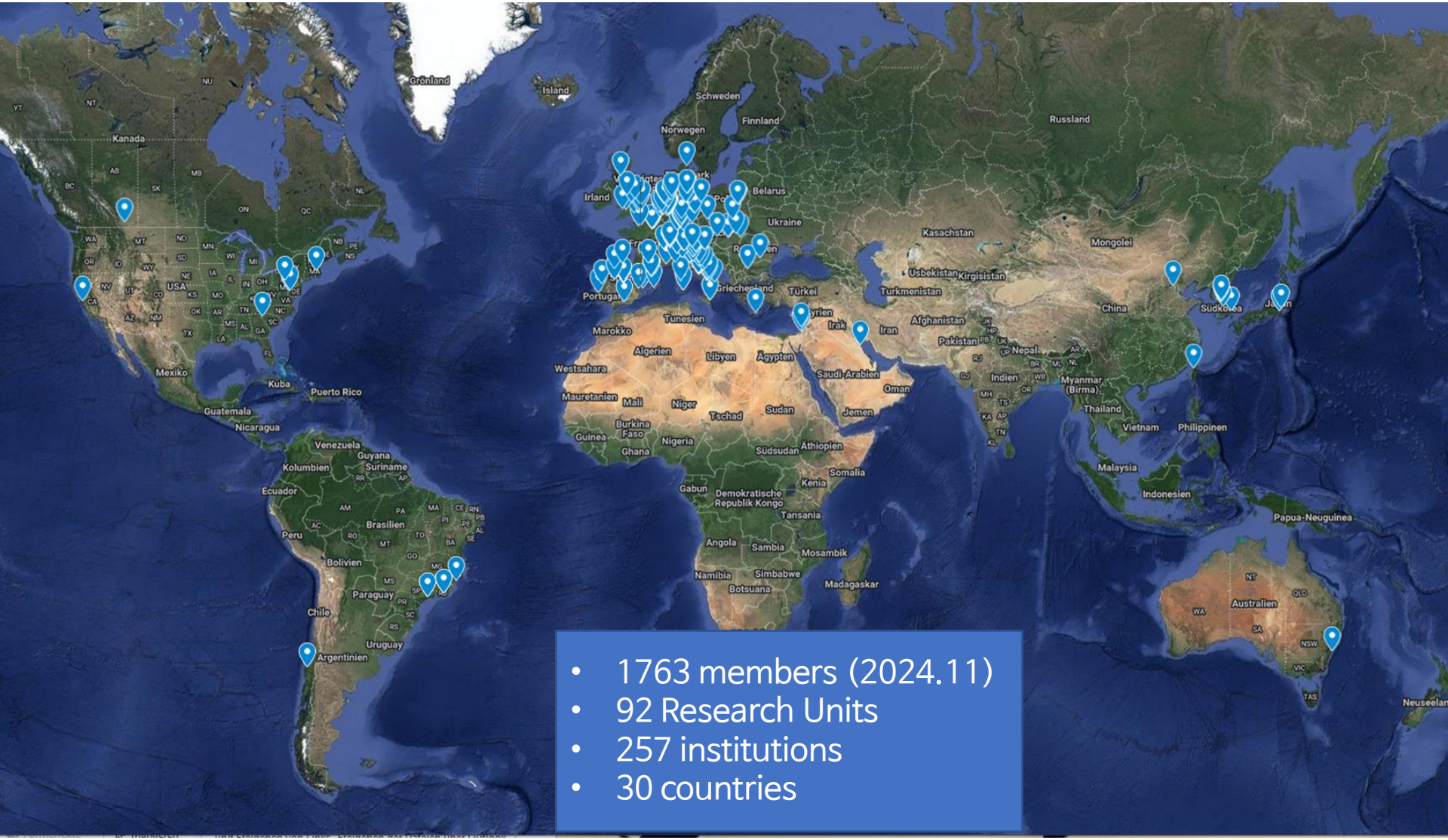
EMR Terziet (NL) borehole

Sardinia P2 borehole



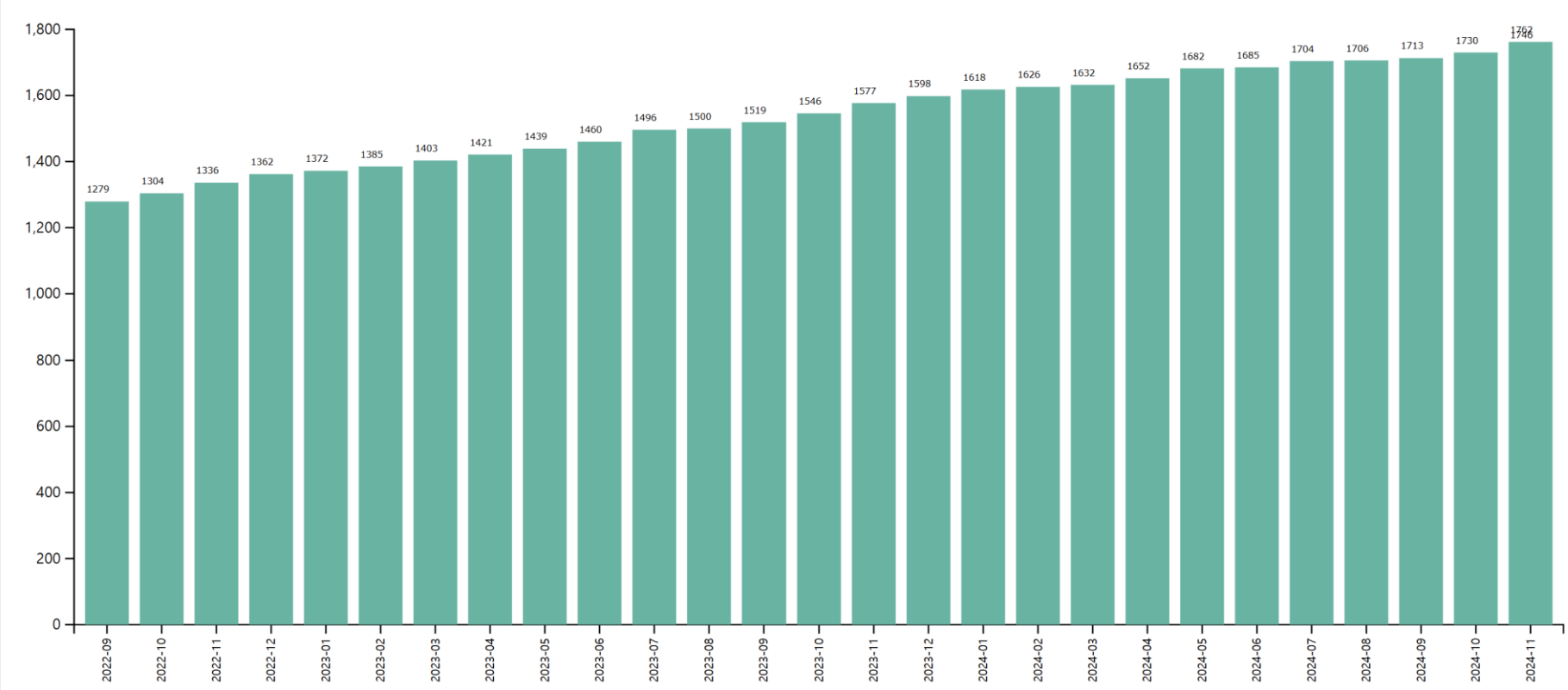
Credit: L. Naticchioni

Einstein Telescope – Collaboration

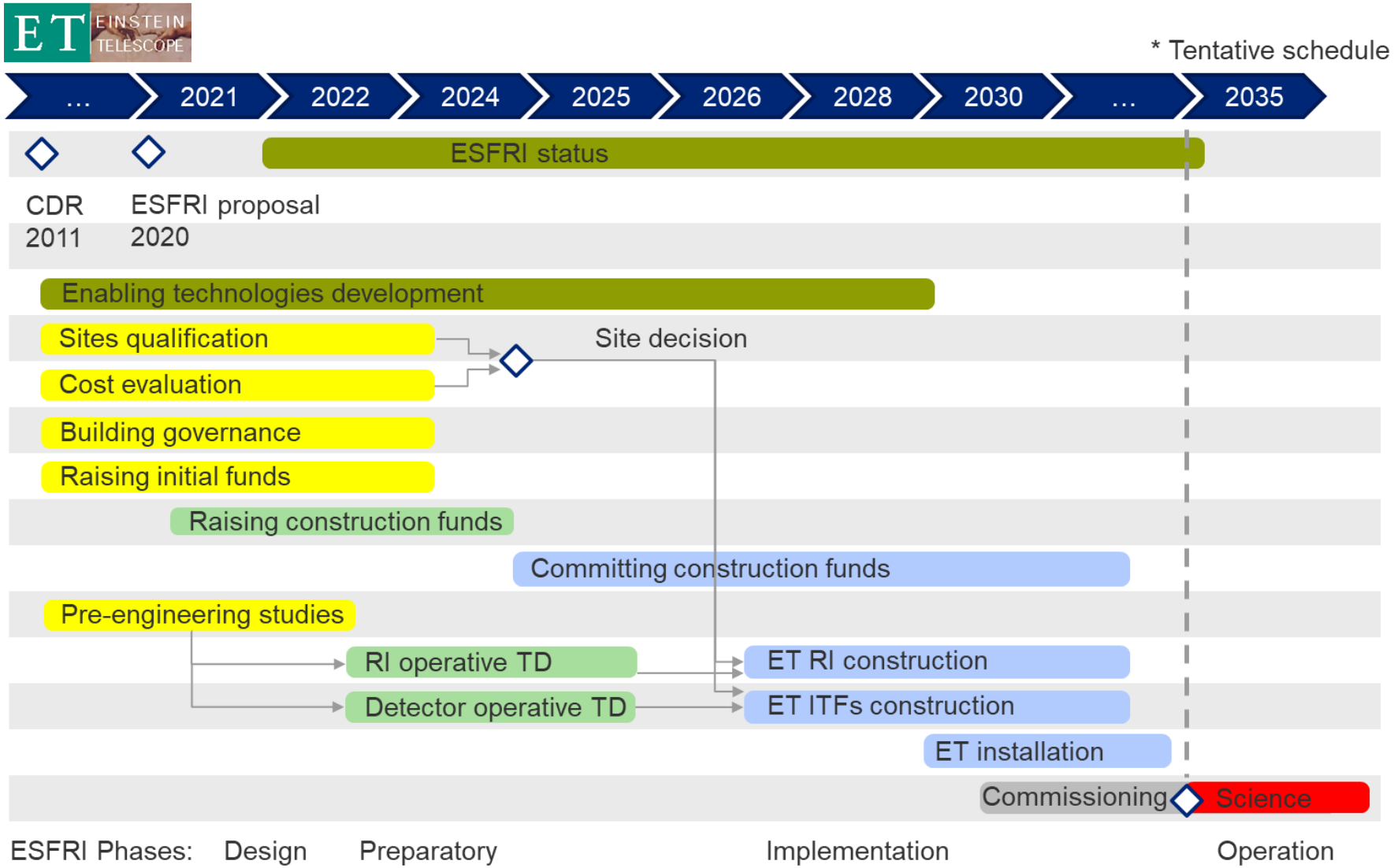


- 1763 members (2024.11)
- 92 Research Units
- 257 institutions
- 30 countries

Einstein Telescope – Collaboration



Einstein Telescope – Timeline



Einstein Telescope – R&D

ET-PATHFINDER

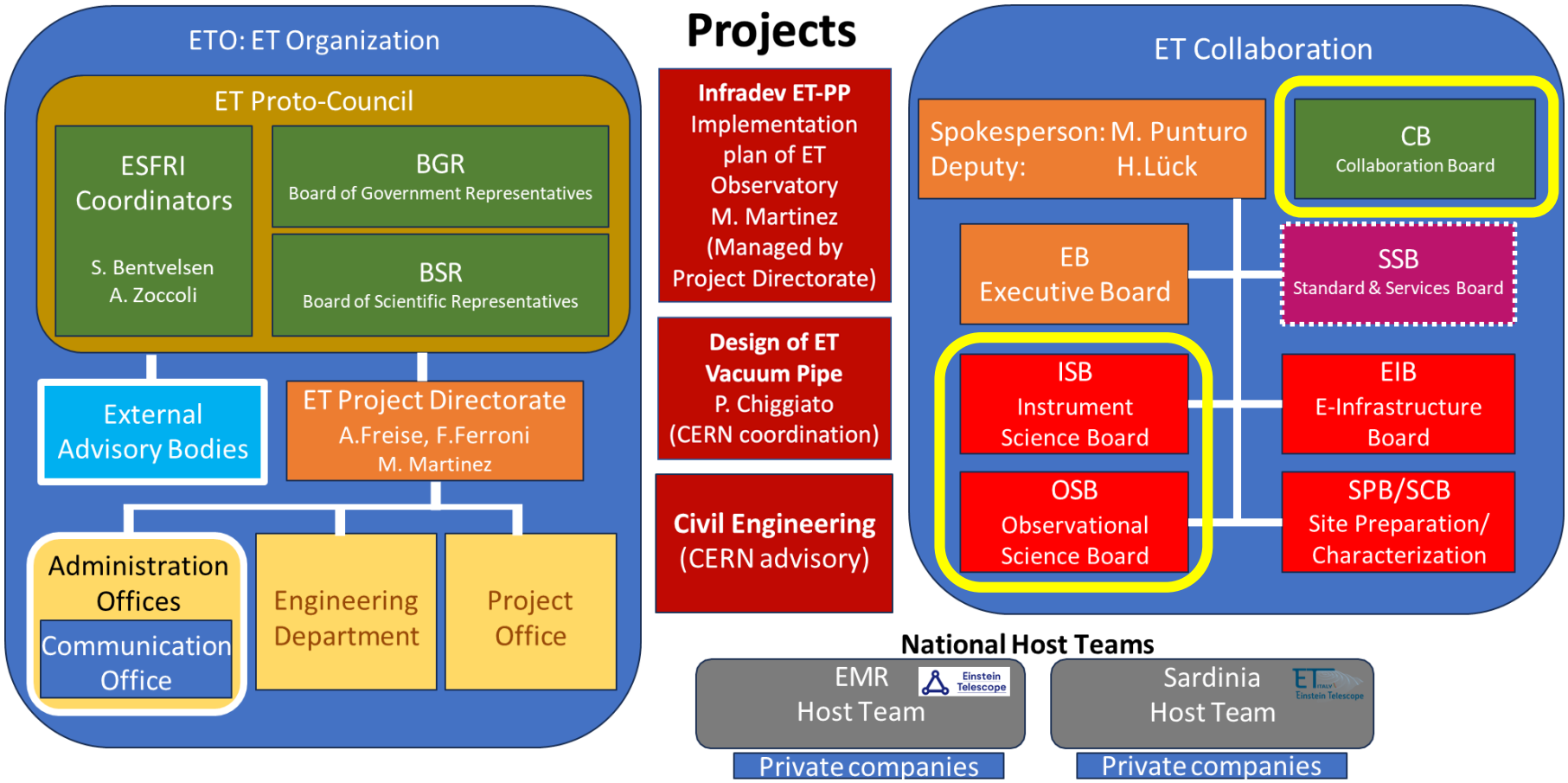
- New facility for testing ET-LF technology in a low-noise, full-interferometer setup
- Key aspects: Silicon mirrors (3 to 100+kg), cryogenics cryogenic liquids and sorption coolers, water/ice management), "new" wavelengths (1550 and 2090nm), coatings etc
- Start with 2 FPMI, one initially at 120K and one 15K (2022+)
- >20 partners from NL/B/G/FR/SP/UK
- Initial capital funding of 14.5 MEuro
- Detailed Design Report available at apps.et-gw.eu/tds/?content=3&r=17177
- **Open for everyone interested to join**
- For more information please see: www.etpathfinder.eu

CREDIT: S. Hild

Einstein Telescope – R&D

III Korean Group in ET

ET Structure

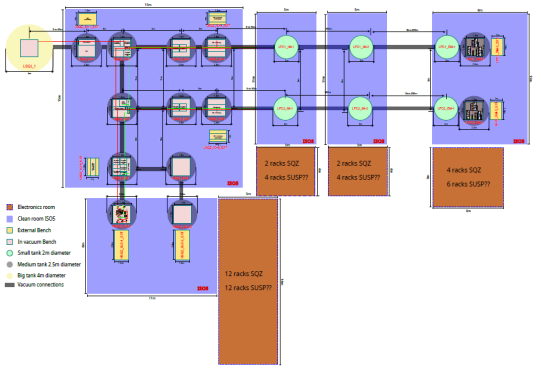


Instrument Science Board (ISB)

ISB > Optics > Squeezed Light Working Group

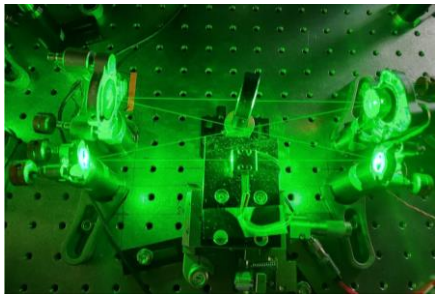
Sungho Lee, Chang Hee Kim, Kyungmin Kim, Byeongjun Park

- Global design subgroup
- EPR simulation subgroup



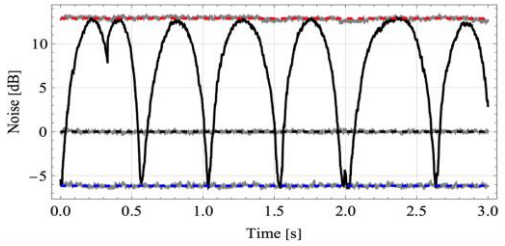
Young-Sik Ra, Geunhee Gwak, Byeong-Yoon Go

- Squeezed light source (1550 nm) subgroup



June Gyu Park

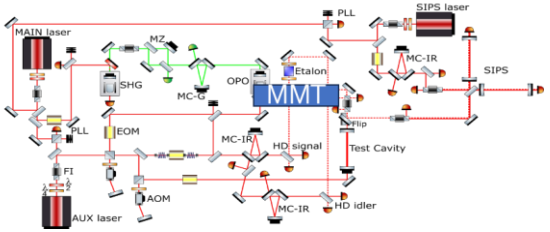
- Global design subgroup
- PyGWINC simulation subgroup



Soojong Pak, Hojae Ahn, Sumin Lee

- Global design subgroup

EPR-SIPS Experiment



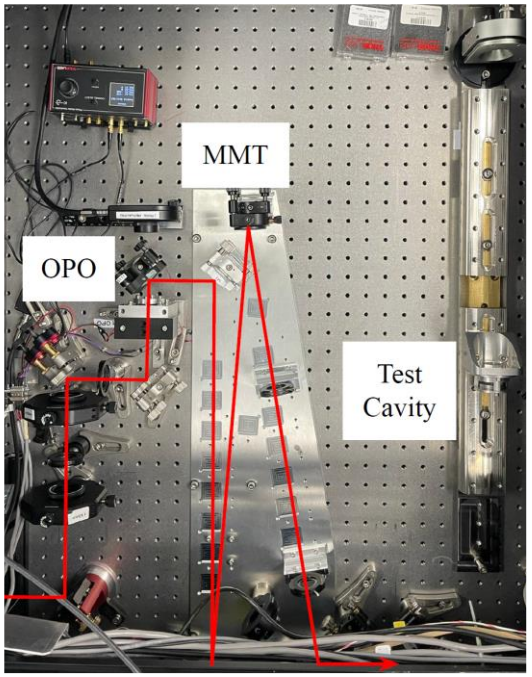
ISB > Optics >
Input Output Optics / Wavefront Sensing & Control

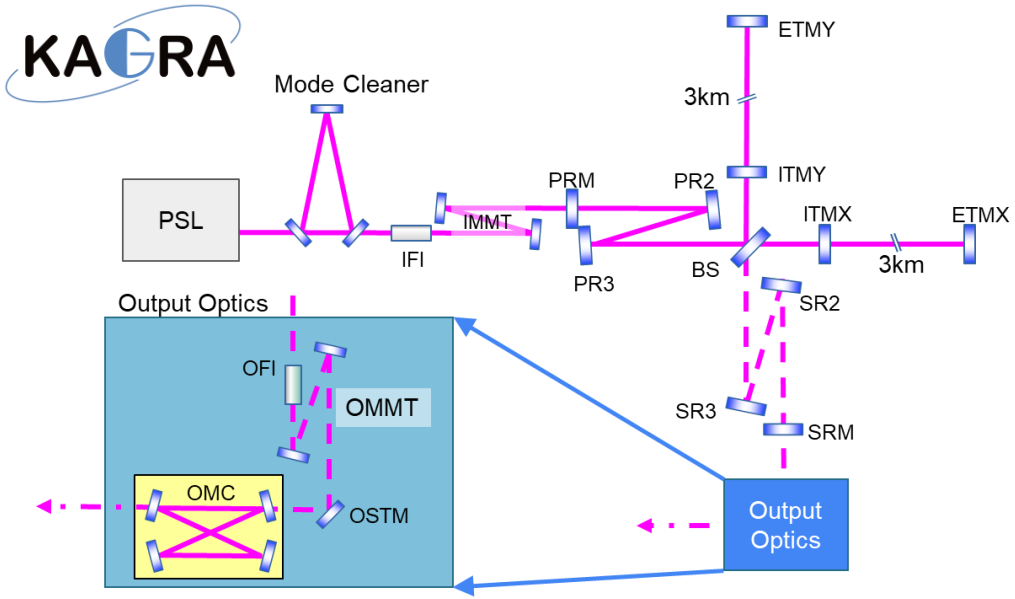
Soojong Pak, Hojae Ahn, Sumin Lee

- Input Output Optics working group
- Wavefront Sensing and Control working group

Sungho Lee

- Input Output Optics working group

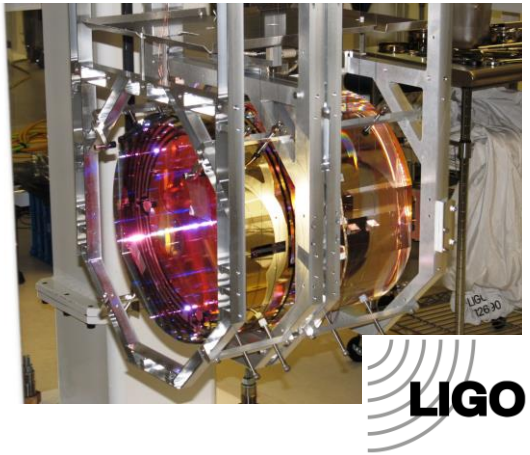




ISB – Optics– Core Optics Working Group (HF/LF)

Kyung-ha Lee

- Atomic structure characterization research for RT and cryogenic coating potential candidates



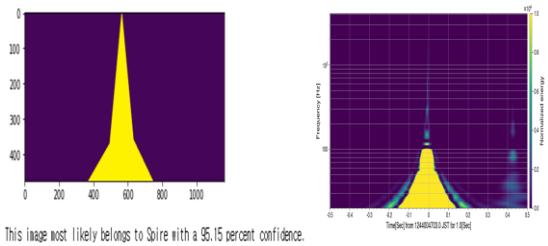
- **Atomic structure characterization via TEM**
  - Adapting the approach we have established in past 3 years to find the optimal coating candidates for ET-HF which will operate in room temperature condition and ET-LF which will operate in cryogenic condition

- **Interface study**
  - Investigate the fundamental reason for the discrepancy between single layer loss and multi-layer loss
  - Potential diffusion of particular elements across the interface between each layer

ISB – Interferometer – Noise Characterization

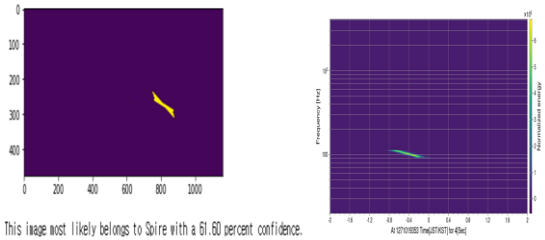
Kujin Kwak, Kihyun Jung, Woojin Lee

- Experienced with KAGRA Detector Char.
- Glitch finding, classification, elimination

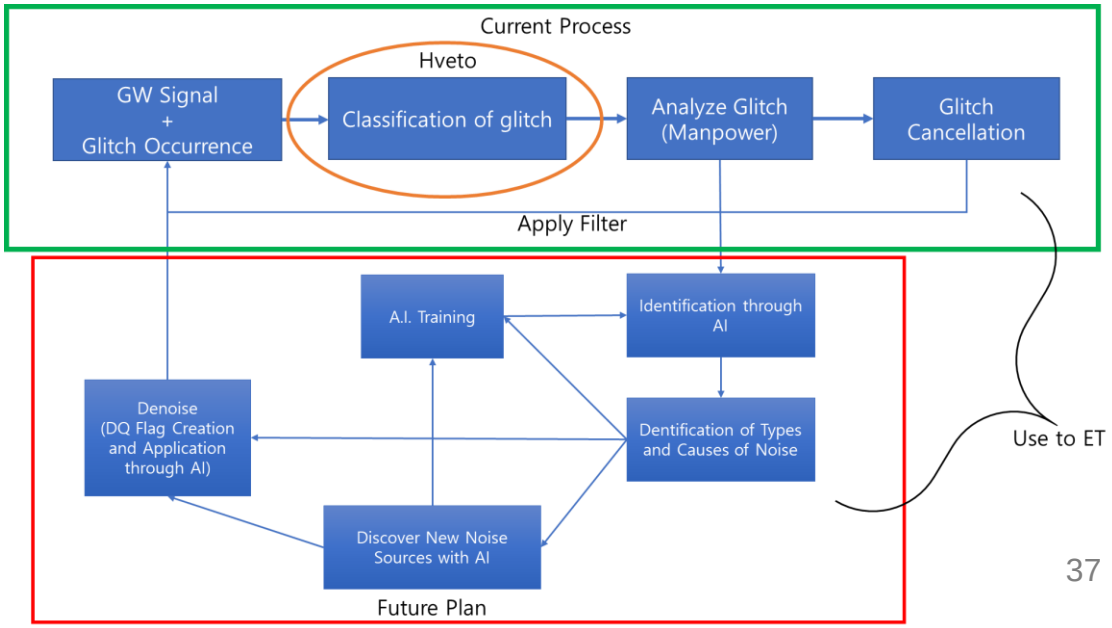


Young-Min Kim

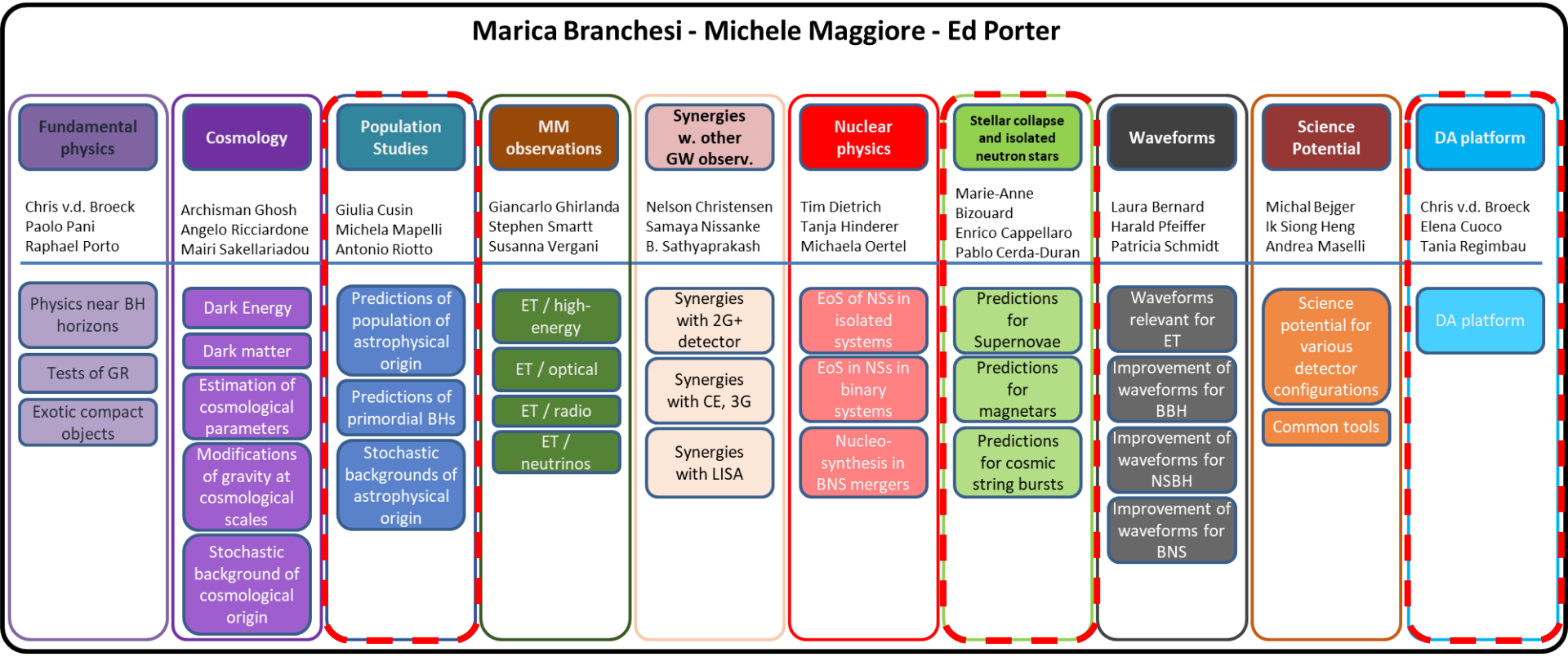
- Experienced with LIGO/KAGRA Detector Char.
- Collaboration with the UNIST group



- Trying to introduce AI in the glitch classification
- In the future, it is possible to contribute to the detector characterization for ET that will be built similar to the KAGRA environment.



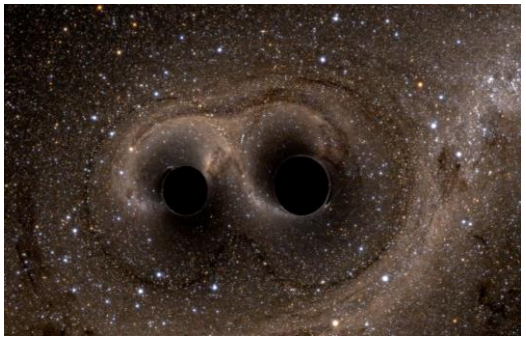
Observational Science Board (OSB)



OSB – Division 3 – Population Studies

Chunglee Kim, Sumi Lee, Seohyun Park

- BBH populations of astrophysical origin
- BH mass spectrum and BBH formation

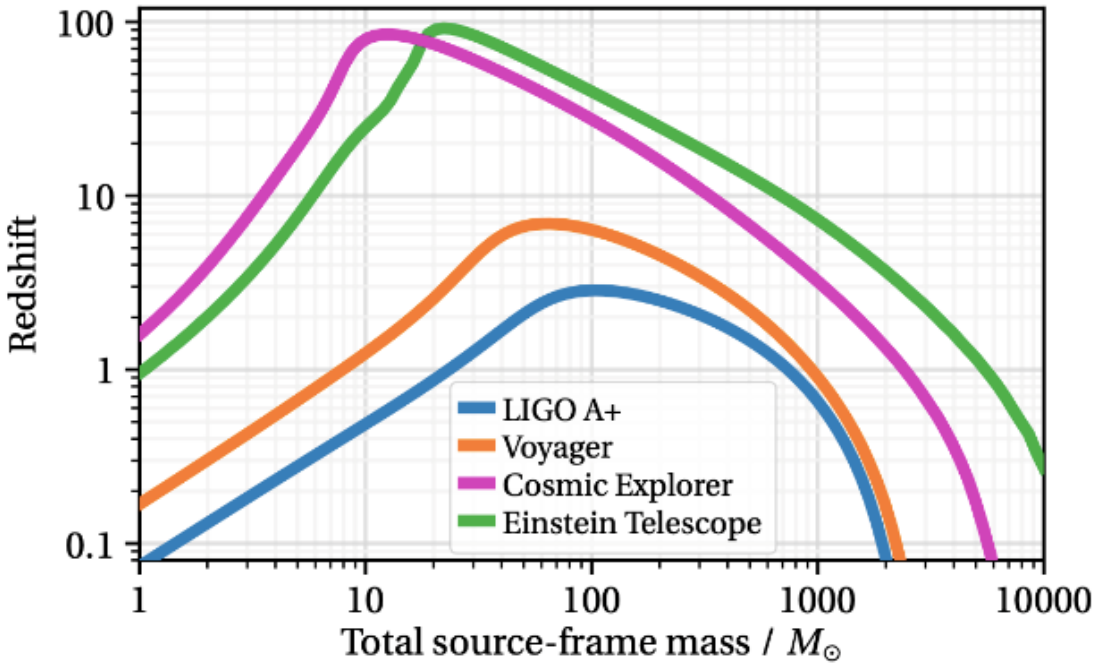


ET will be sensitive to observe massive BBHs than those detectable by LIGO-Virgo-KAGRA detectors

- Mass of ET sources: O(1) ~ O(10,000) of Msun
- Redshift : up to O(10)~O(100)

→ Participating in the ET Blue Book (science cases)

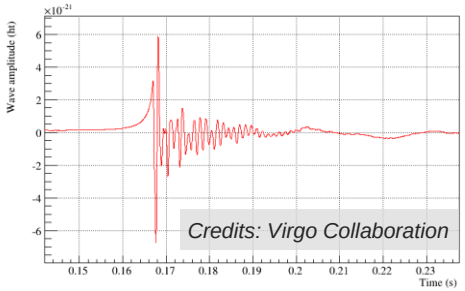
→ ET mock data challenge



OSB – Division 7 – Stellar Collapse and Isolated Neutron Stars

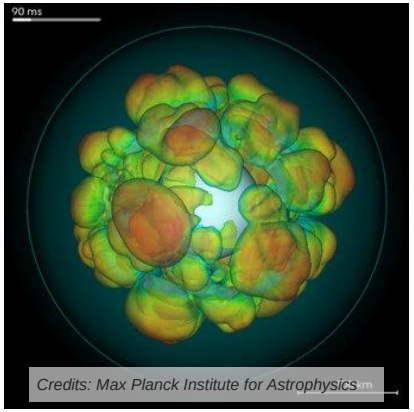
Kujin Kwak, Kihyun Jung

- Numerical method developed for the relativistic photon radiative transfer → Neutrino transfer during the core collapse



Young-Min Kim, Jinho Kim

- Numerical simulation for EOS of neutron stars
- Collaboration with the UNIST group



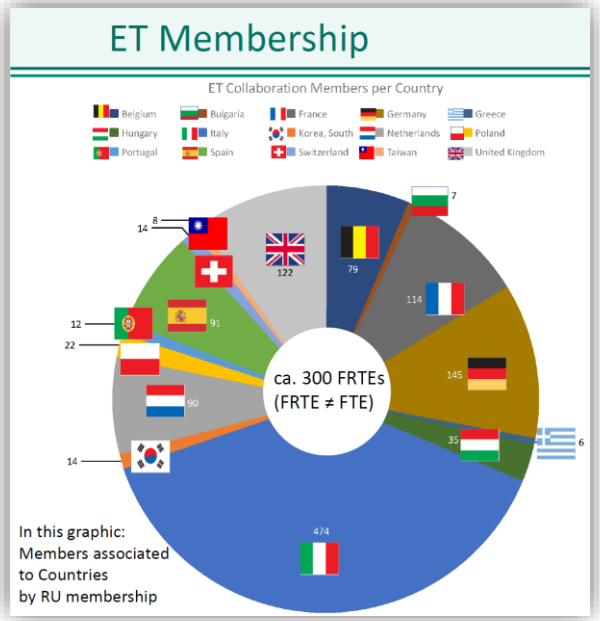
- LMXBs (Low Mass X-ray Binaries):
  - XRBs (X-ray Bursts), Superbursts, Evolution and population studies in collaboration with Ewha and IBS/CENS
- Stellar evolution (SE) of massive stars with MESA (public SE code)
- Pre-supernova models with different conditions
- Predicting neutrino fluxes as well as GW signals

Korean Group in the ET Collaboration

Korean Research Unit

- ✓ 20 members from 7 institutions
  (KASI, KAIST, KHU, UNIST, EWU, SKKU, Yonsei)

- ✓ KGWG: 68 members (2024-09-19)
- ✓ 14 members in 2022, at the start of the ET Collaboration
- ✓ NIMS group will join soon!




Thank you for your attention!
ET
EINSTEIN
TELESCOPE