Notes on ET ESFRI document

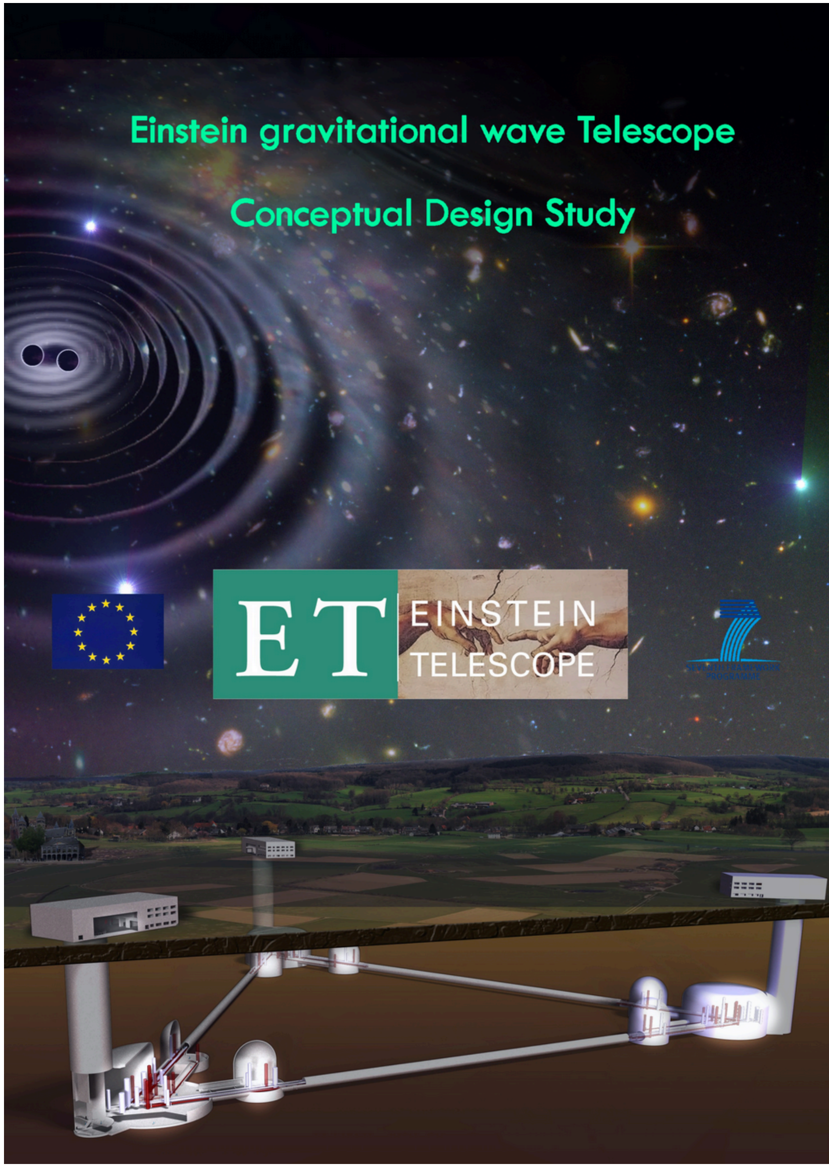
M. Martinez
(ET steering committee)

Spanish Meeting on ET ESFRI Proposal
Barcelona, 3rd February 2020

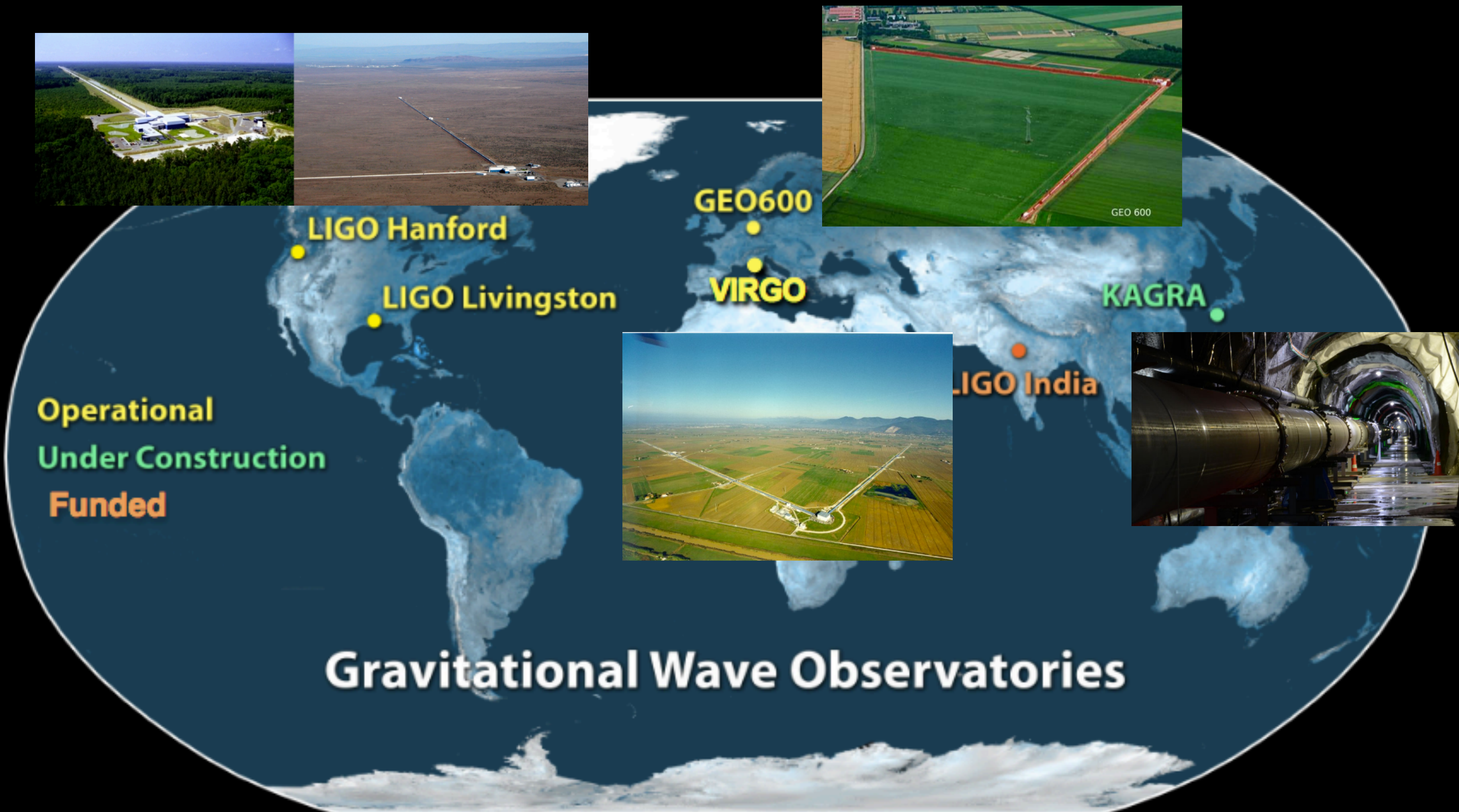
Outline

http://www.et-gw.eu/

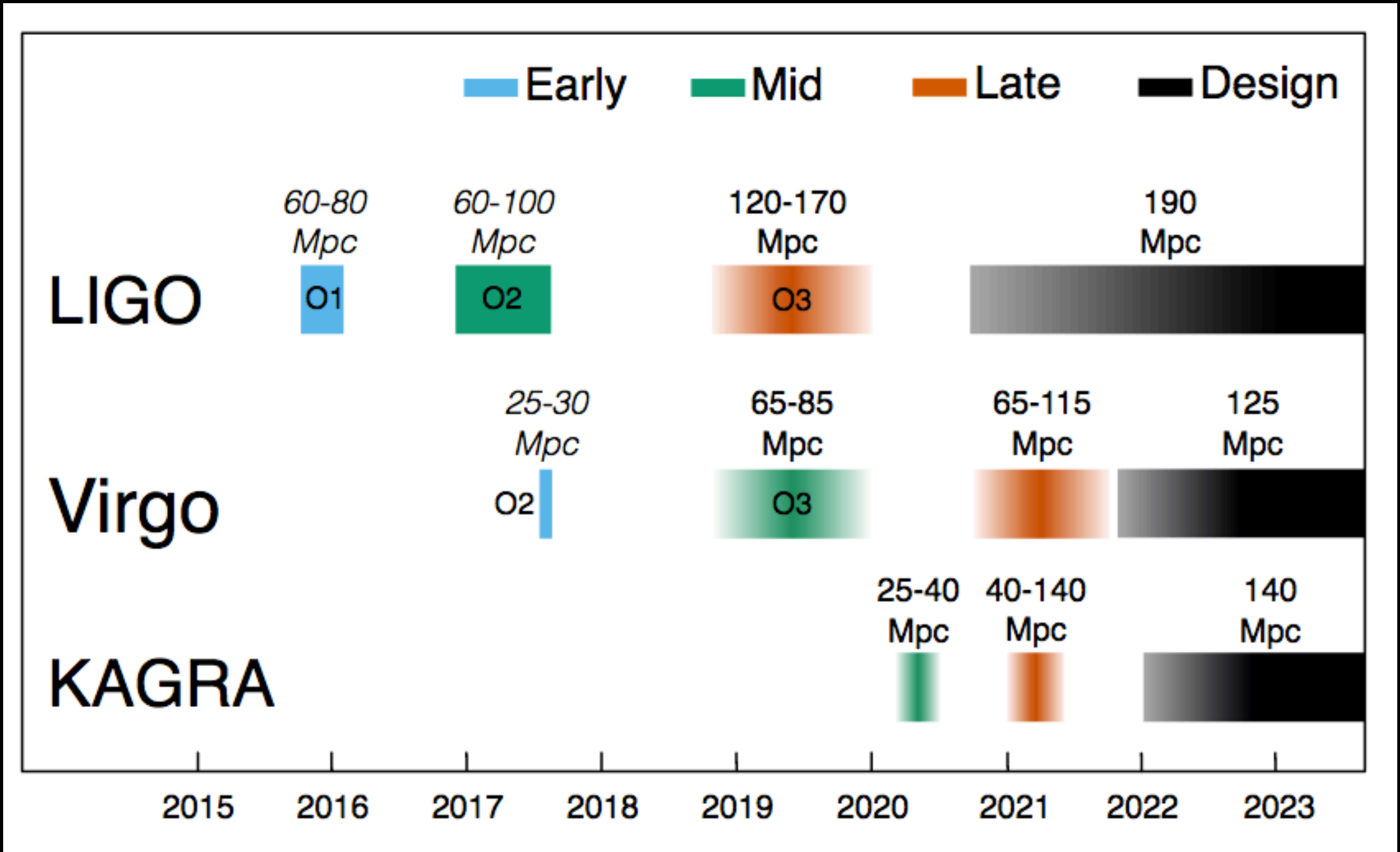
- Short Introduction to ET project
  - Timeline
  - Size of the project
  - Sensitivity
  - Technologies
  - Estimated cost
  - Location(s)
  - Computing
  - Relation with CERN
- Details on ESFRI document (Spanish part)
- Immediate deadlines



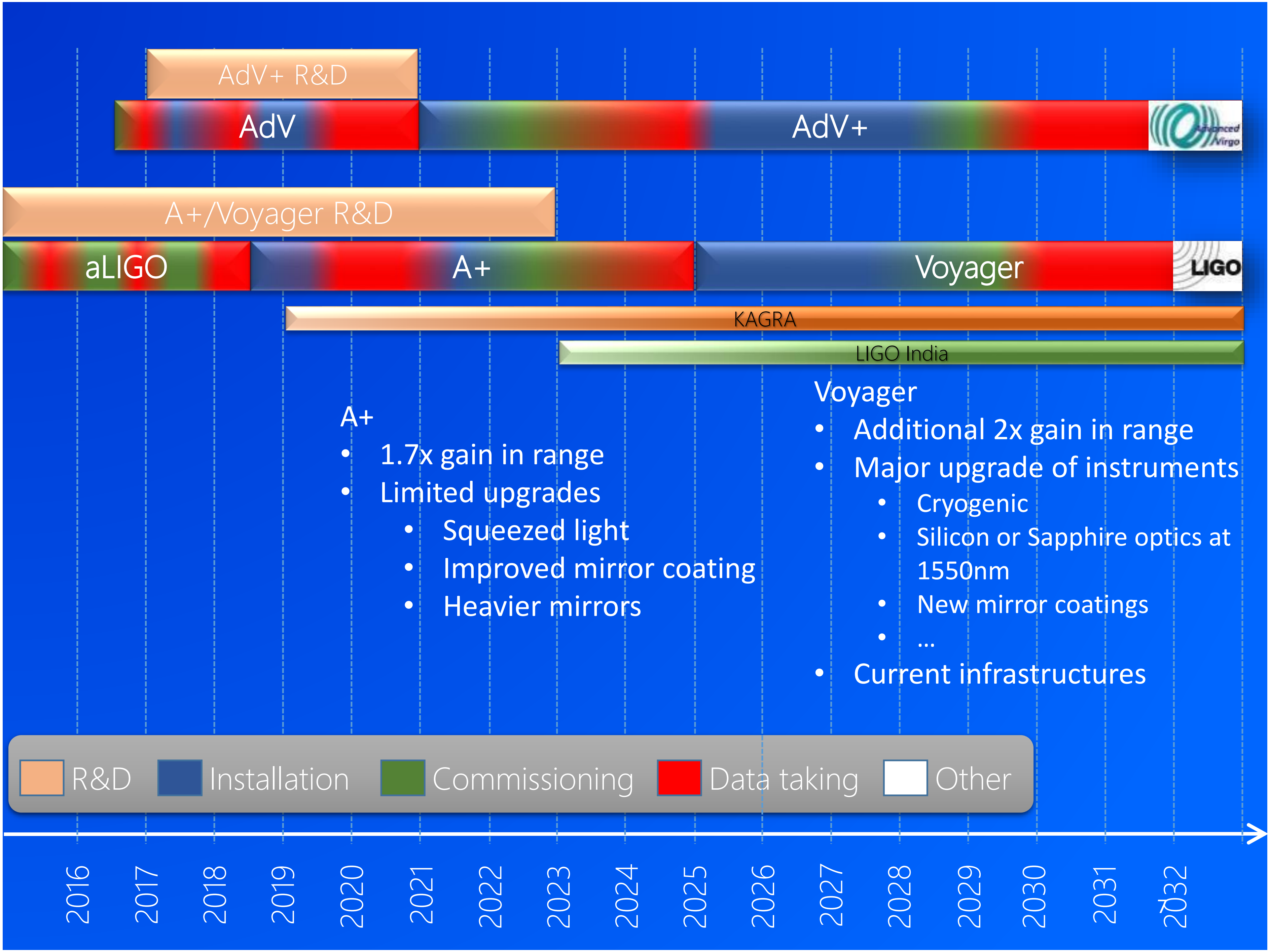
Interferometers



Observation Schedule



Observation periods 06 - O7 (TBC) will extend the program towards 2030s


AdV+ R&D
AdV
AdV+
A+/Voyager R&D
aLIGO
A+
Voyager
KAGRA
LIGO India
A+
• 1.7x gain in range
• Limited upgrades
• Squeezed light
• Improved mirror coating
• Heavier mirrors
Voyager
• Additional 2x gain in range
• Major upgrade of instruments
• Cryogenic
• Silicon or Sapphire optics at 1550nm
• New mirror coatings
• …
• Current infrastructures
R&D
Installation
Commissioning
Data taking
Other
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032

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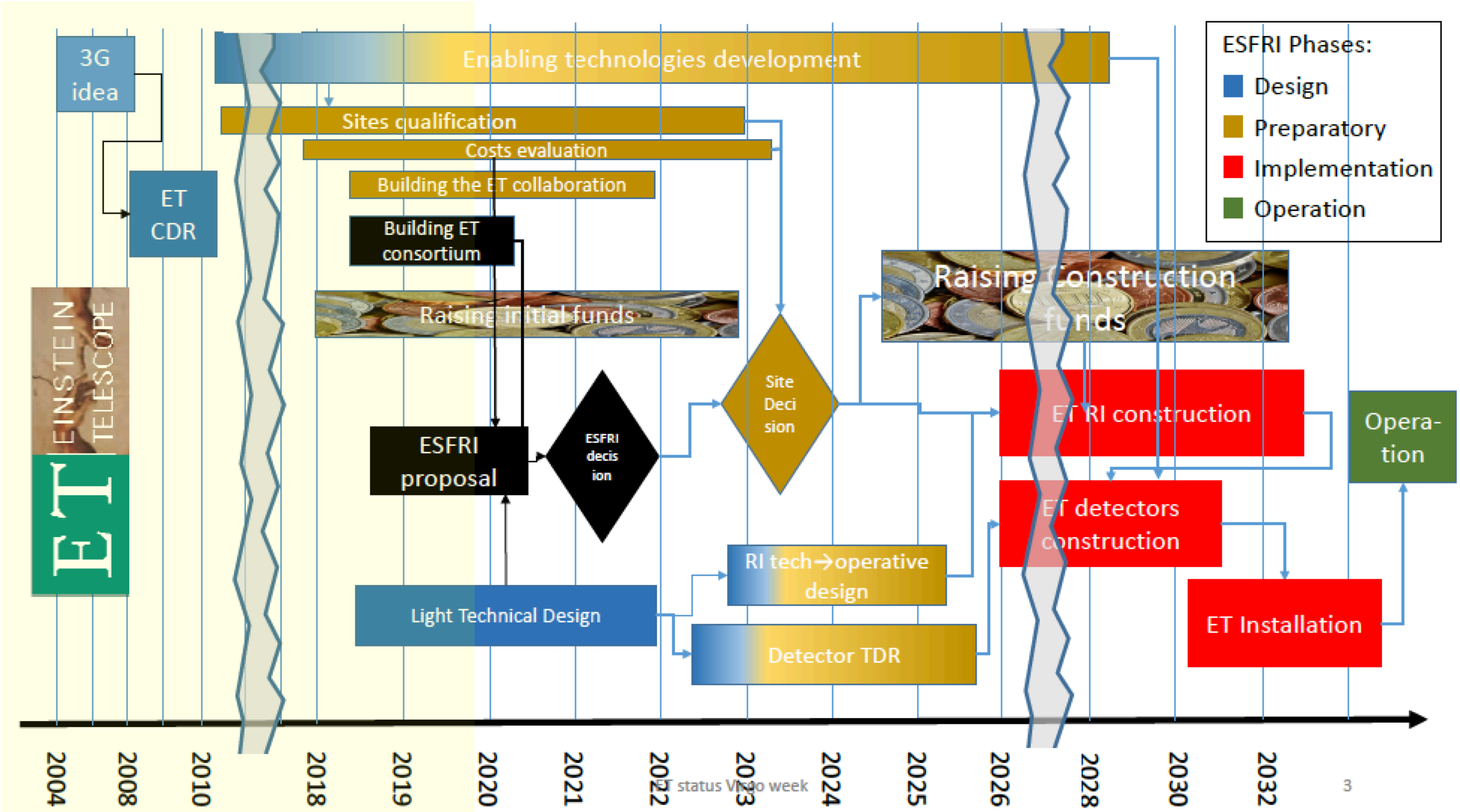
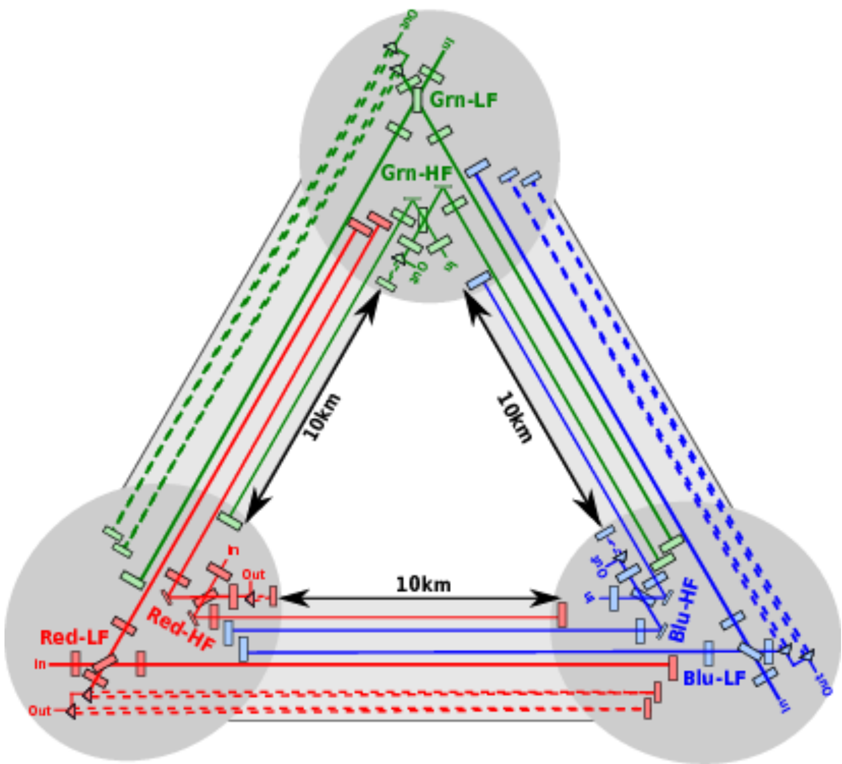
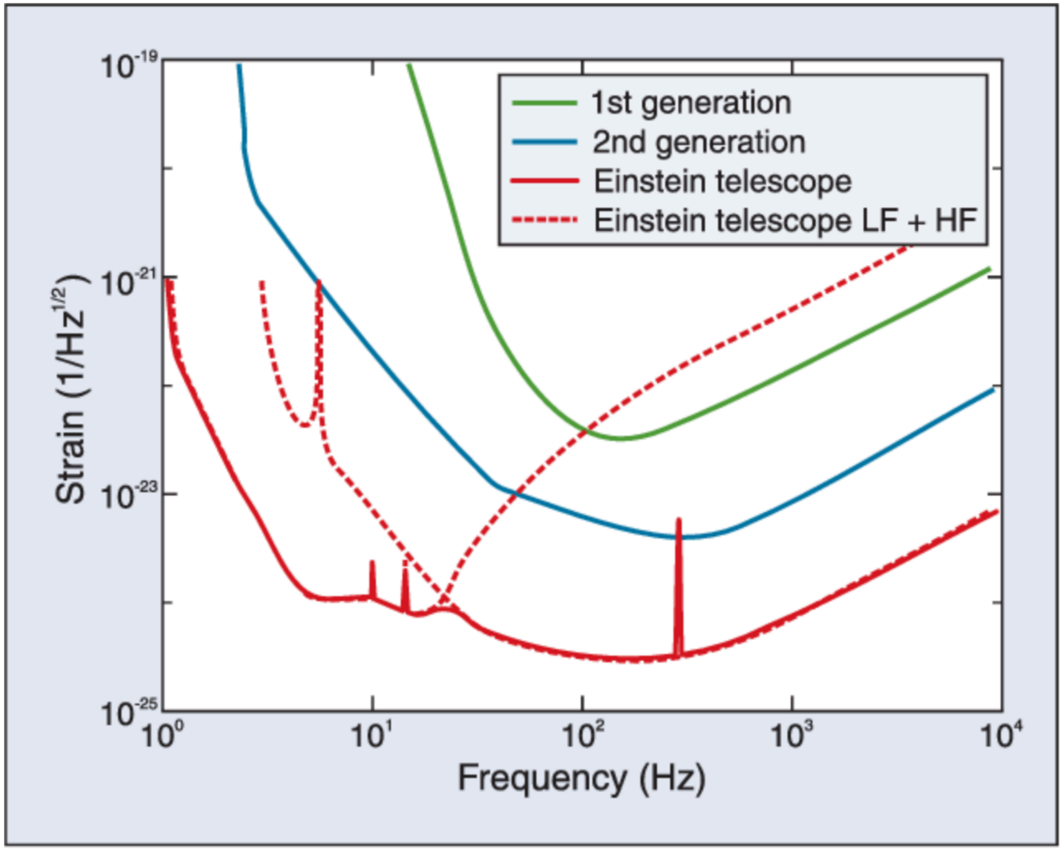
Timeline for ET



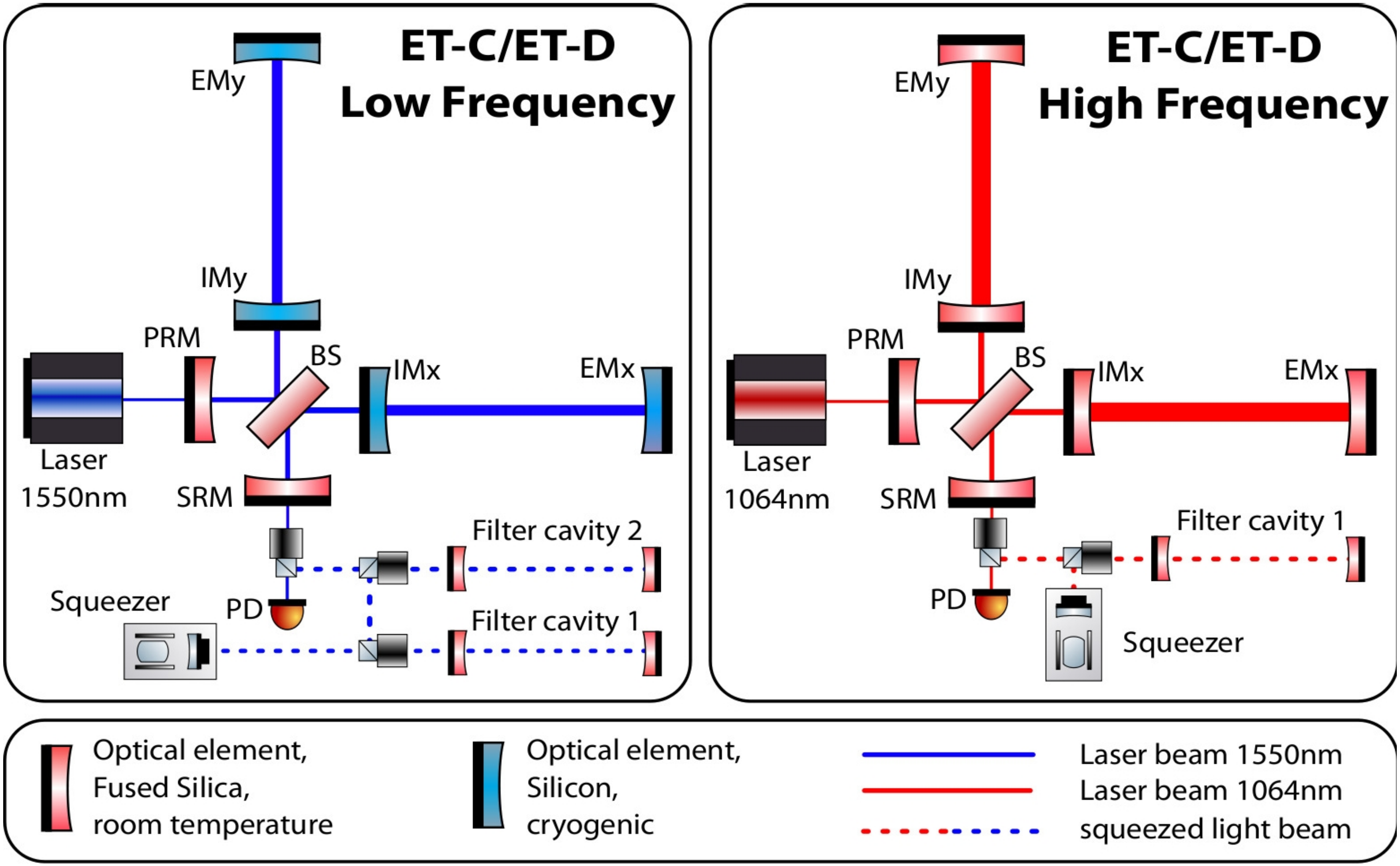
Operations by 2035

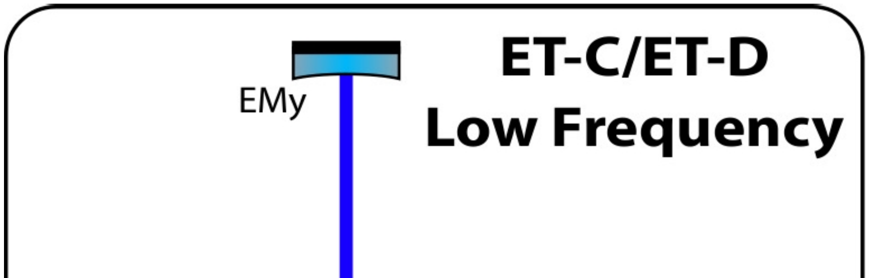
Einstein Telescope (6 in 1) Xylophone

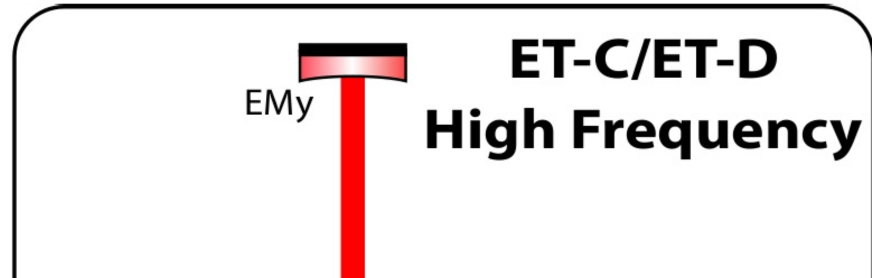




- Underground to bit seismic/newtonian noise
- Longer arms of 10km instead of 3 km in Virgo (4 km in LIGO)
- Triangle configuration of 3 ITFs for measuring polarization and for vetoing on glitches
- Each decoupled in 2 devices for low and high frequency best performance


ET-C/ET-D
Low Frequency
EMy
IMy
PRM
BS
IMx
EMx
Laser
1550nm
SRM
Filter cavity 2
Squeezer
PD
Filter cavity 1
ET-C/ET-D
High Frequency
EMy
IMy
PRM
BS
IMx
EMx
Laser
1064nm
SRM
Filter cavity 1
PD
Squeezer
Optical element,
Fused Silica,
room temperature
Optical element,
Silicon,
cryogenic
Laser beam 1550nm
Laser beam 1064nm
squeezed light beam



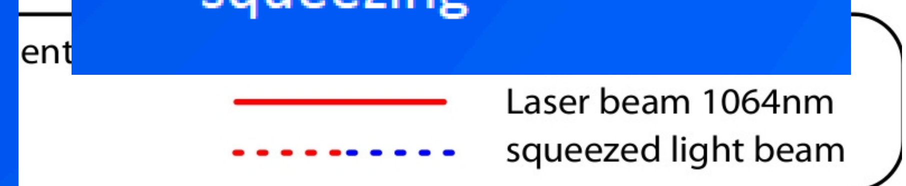


ET-Low Frequency:

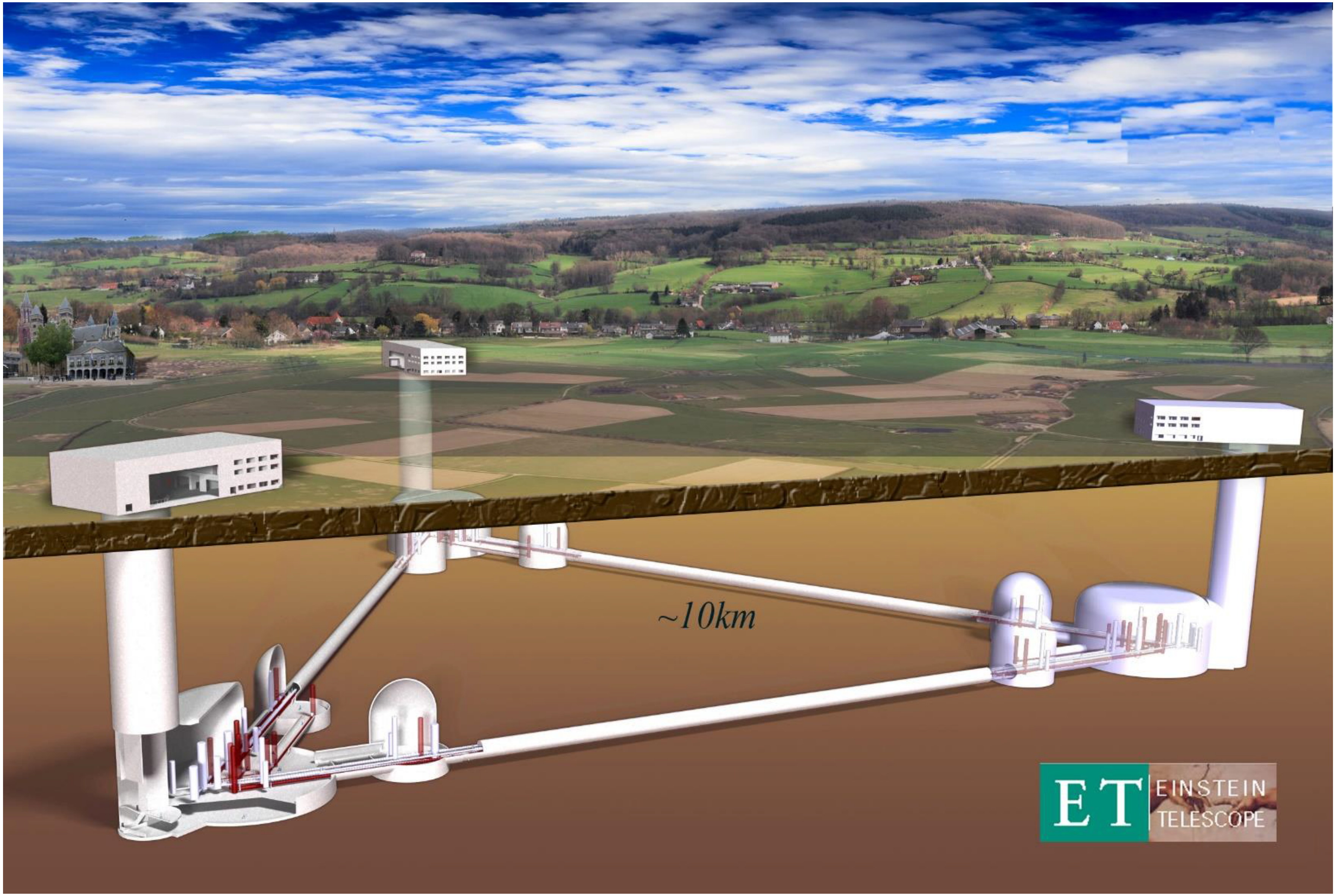
- Underground
- Cryogenics
- Silicon (Sapphire) test masses
- Large test masses
- New coatings
- New laser wavelength
- Seismic suspensions
- Frequency dependent squeezing

ET-High Frequency:

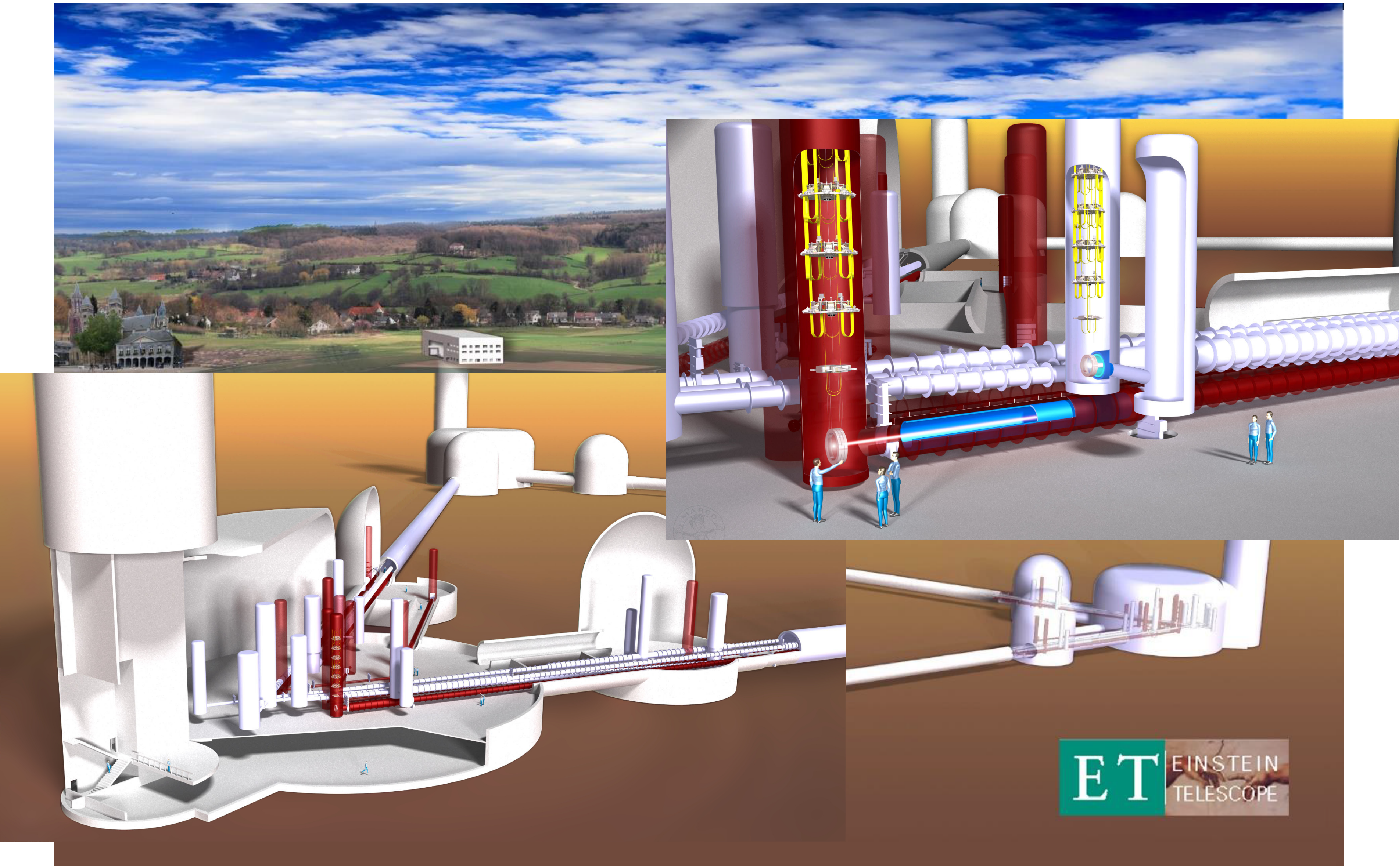
- High power laser
- Large test masses
- New coatings
- Thermal compensation
- Frequency dependent squeezing



Size of Project

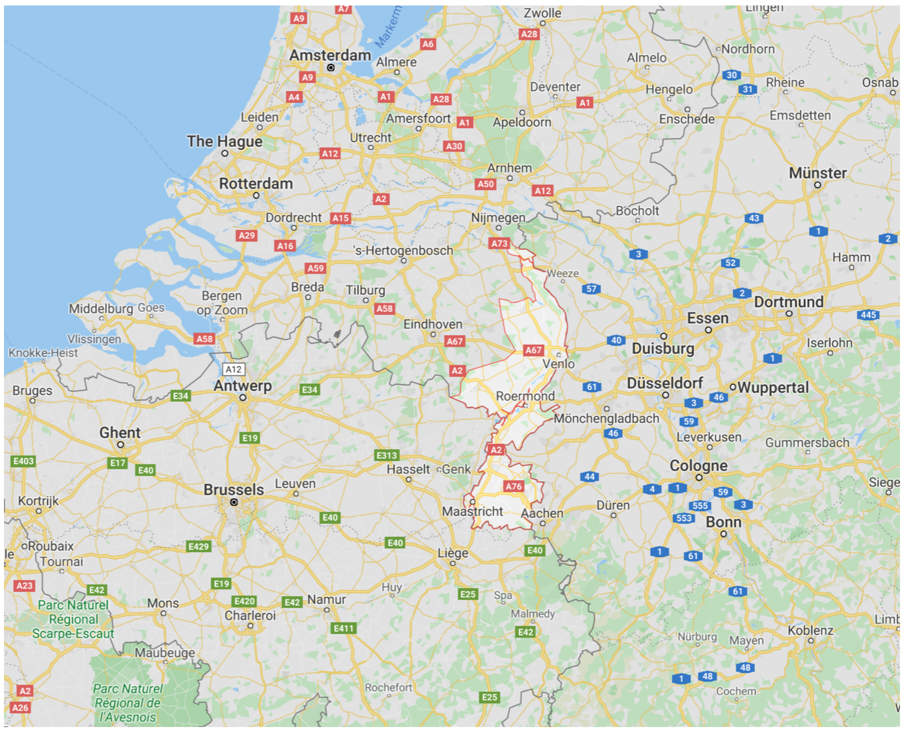


Size of Project



Locations

Two “competing” sites



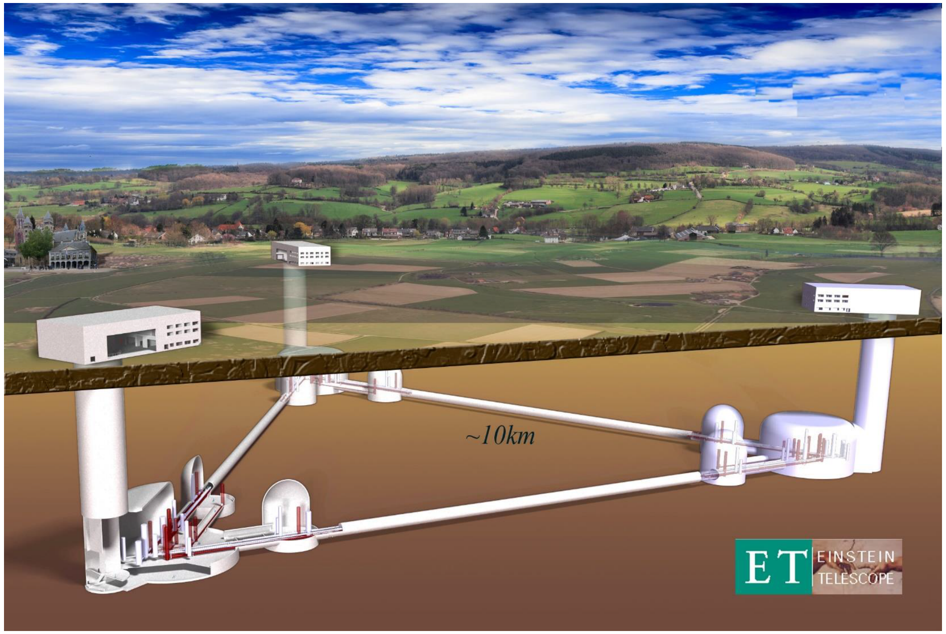
@ Limburg area (in the NL-B-D border)
→ Sponsored by Nikhef

@ Sardinia
→ Sponsored by INFN

Estimated Cost

At the moment it is assumed ~1900 M€

Concept development and design phase (~5M€)
→ already covered



Preparation phase (~170M€)
→ Includes also decision of site
→ Technology development
→ 25% covered by some countries

Implementation phase (~1730M€)
→ 780M€ for civil work
→ 565M€ for vacuum system
→ 220M€ experiment
→ 144M€ for infrastructure and services

Operational phase (~37M€/year)

Decommissioning phase (~40M€)

Computing now

For the ongoing O3 run LIGO-Virgo estimates:

→ 300 M CPU core-hours per year

→ Most of computing is HTC

→ With the exception of numerical relativity calculations little need for HPC

→ LIGO-Virgo generates about 20TB per ITF of calibrated data and about 1PB of raw data per ITF

→ Using GPUs in computing-intense searches

→ No much use to date of Cloud (more than 90% done in dedicated LIGO-Virgo clusters)

→ Analysis dominated by matched filtering techniques

ET Computing

- Huge increase of rate → from 1/week to about hundreds per day
- Longer events (from seconds/minutes to hours) duration
- Larger parameter space in masses

  (0.1 Mo to 1000 Mo)
- The model of analysis at it is now would need more than three orders of magnitude increase of computing power

→ intense R&D ahead needed

→ Data challenges with injected signals

→ Get inspired by HL-LHC example

→ Collaborate with CERN

Draft 30 July 2019

Gravitational-Wave Data Analysis Computing Challenges in the 3G Era

Ian Bird, Peter Couvares, Ed Porter, Josh Willis

Abstract

Third generation ground-based GW detectors will require not only R&D for new detector technologies. Equally important will be investments in computing infrastructure -- including but not limited to the development of vastly more efficient algorithms to search for transient GW signals and extract their underlying astrophysical parameters, assessments of needed cyberinfrastructure resources, and trade studies of computational 'service provider' models. Here, we describe the major computing challenges facing the GW community in the 3G era and present recommendations for addressing them.

Introduction

To frame and motivate this section of the report, we begin with background on the existing 2G detector scientific collaborations and an overview of the computing models and methods currently employed. The Advanced LIGO/Advanced Virgo collaboration (LVC) is composed of three Gravitational Wave (GW) interferometers located in Hanford (WA), Livingston (LA) and Pisa (Italy). In September 2015, the LVC began a series of advanced era detector runs, with the nomenclature "O#". O1 ran from September 2015 to January 2016, and as well as the first ever detection of GWs, the run ended with the detection of three binary black hole (BBH) mergers. O2 ran from December 2016 until the end of August 2017. As well as the detection of a number of other BBH mergers, O2 saw the first ever detection of a merger of two neutron stars (BNS). O3 began on April 1st 2019, and will run for one year. It is further expected that the Japanese interferometer KAGRA will join the O3 run in late-2019.

From a computing perspective, the biggest challenge in the transition from O1 to O2 was the increased computational power needed for both the search and parameter estimation phases. In the search (detection) phase, the template banks increased in size to accommodate a larger range of masses. In the parameter estimation phase, while the computational cost of each run remained almost the same as in O1, the number of sources, as well as the number of exploratory runs that were needed for the BNS merger, caused the computational cost to explode. In addition, unforeseen and computationally-intensive analyses were needed to measure the Hubble-Lemaitre constant H0, test the validity of GR and to constrain the internal physics of neutron stars.

In its third observing run (O3), the LIGO-Virgo collaboration estimates its data analysis computing requirements at ~300 million CPU core-hours per year, to perform some 80 astrophysical searches, follow-up activities, and detector characterization. The 10 most demanding of these analyses comprise about 90% of the demand, with a long tail of the remaining 70. Most of this computing consists of pleasingly parallel High Throughput

1

Relation with CERN

- CERN just signed an MoA with Nikhef and INFN for the collaboration in aspects relevant for ET
- MoA open to other ET institutions
- Illustrates the strong synergies with CERN technologies

ESFRI Document (I)

- **Participación a nivel nacional**
  - 20. Indicar las instituciones españolas participantes, señalando su papel en la infraestructura europea que se propone.
  - 21. Incluir ficheros con las cartas de apoyo a la propuesta por parte de cada institución nacional implicada en la misma firmada por el representante legal de la misma.
  - 22. ¿Está involucrada alguna ICTS en la propuesta? ¿Cuál(es)?

ESFRI Document (II)

- **Apoyo financiero a la Propuesta**
  - 39. Estimación de la contribución nacional a la Construcción de la infraestructura europea que se propone (Indicar la estimación del valor de la contribución de España a la construcción.)
  - 40. Estimación de la contribución nacional a la Operación de la infraestructura europea que se propone (Indicar la estimación del valor de la contribución de España a la operación.)
  - 41. Indicar el plan previsto para la financiación nacional, mencionar la existencia de recursos y sus posibles orígenes (proveniente de las propias instituciones,, ayudas de gobiernos regionales, nacionales, etc). Describir las posibilidades de uso de fondos adicionales procedentes de los fondos estructurales europeos, fondos de inversión privados u otros

ESFRI Document (III)

- **Misión de la infraestructura**
  - 43. Describa el beneficio que supondría dicha misión para España, en caso de participar en la misma
  - 46. Incluir la relación con infraestructuras nacionales existentes, incluyendo expresamente si forman parte del mapa de ICTS vigente, aprobado el 7 de noviembre de 2018.
- **Impacto socioeconómico**
  - 49. Indique brevemente el impacto esperado de su infraestructura en la actividad de innovación, en la producción de bienes y servicios, por ejemplo, en términos de capacitación de personal, transferencia de conocimiento, programas de acceso y servicios prestados para España:

ESFRI Document (IV)

- **Necesidades electrónicas.**

55. Indicar a nivel nacional qué tipo de servicios de infraestructuras electrónicas necesitará su infraestructura, por ejemplo, recursos para almacenamiento, computación, redes, herramientas para la gestión de datos, seguridad, acceso, análisis remoto, etc, y en su caso si se ha establecido contactos con los proveedores de dichos servicios:

- **Trabajo preparatorio y planificación**

61. Explique brevemente el modelo de negocio de la infraestructura, y su aplicación al caso español expresando el interés de España de participar en la misma

Immediate deadlines

Documento para el Ministerio debería ser mandado antes de finales de Febrero

1. Establecer Editing Team
   – Hoy
2. Version para 14 Feb
   – Cartas de apoyo
3. Circulacion 1 semana
4. Version final 24 Feb
5. → Ministerio 28 Feb

Government	Submission deadline
Poland	31/12/2019
France	10/01/2020
Germany	17/01/2020
Belgium	15/01/2020
Hungary	15/01/2020
UK	10/02/2020
Italy	15/02/2020
Netherlands	18/02/2020
Spain	28/02/2020

En paralelo se está preparando el documento ESFRI Europeo al que tenemos acceso