Il progetto ETIC nella Sezione INFN di Bologna

Progetto D877661E denominato Einstein Telescope Infrastructure Consortium (ETIC)

Missione 4, “Istruzione e Ricerca” - Componente 2, “Dalla ricerca all’impresa” - Linea di investimento 3.1, “Fondo per la realizzazione di un sistema integrato di infrastrutture di ricerca e innovazione”, del PNRR

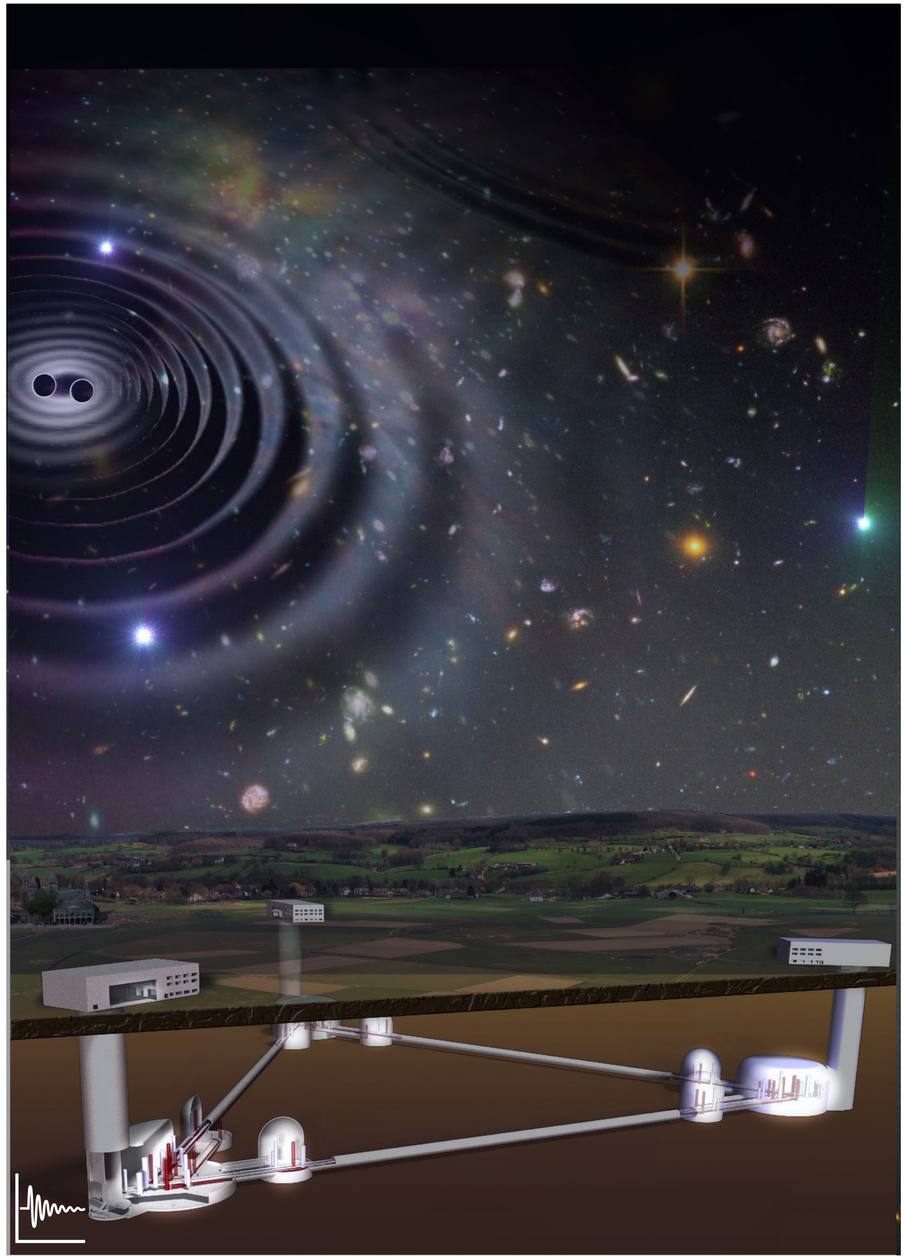
Riccardo Travaglini - Assemblea di Sezione di Fine Anno - 23/12/2022

The Einstein Telescope

A 3rd generation, gravitational-wave observatory

A proposed underground infrastructure with increased arm length and new technologies

- Cryogenics for optics
- Enhanced infrastructural and active noise-mitigation measures
- New quantum technologies to reduce the fluctuations of the light



Credits: R. Williams (STScI)

Physics

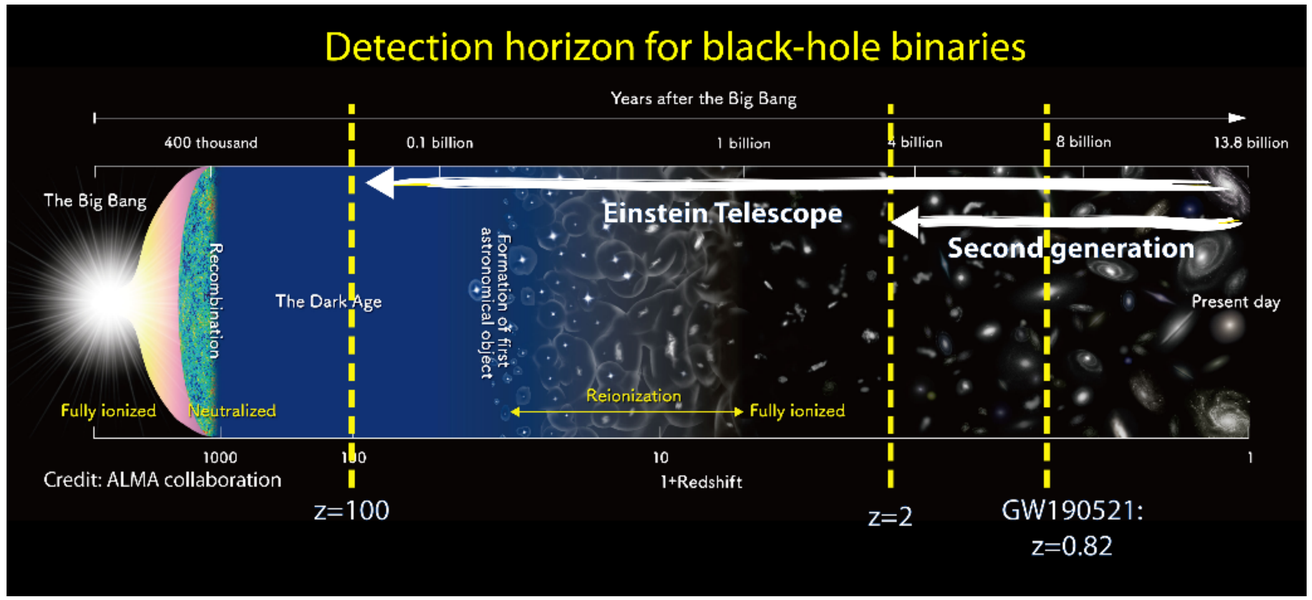
Up to the cosmological dark ages

ASTROPHYSICS

- Black hole properties
- Neutron star properties
- Multi-band and -messenger astronomy
- Detection of new astrophysical sources

FUNDAMENTAL PHYSICS AND COSMOLOGY

- The nature of compact objects
- Tests of General Relativity
- Dark matter
- Dark energy and modifications of gravity on cosmological scales
- Stochastic backgrounds of cosmological origin



See T. Chiarusi slides at the March ’22 Assemblea di Sezione
https://agenda.infn.it/event/30749/

ET Timeline

Foundation

XII ET Symposium in Budapest (Hungary)
The Birth of the ET Collaboration

M.Punturo (INFN-PG)
nominated as Interim Spokeperson

7 Jul 2022

1st ET Annual meeting (EGO)

E.Coccia (GSSI)
Elected as CB chair

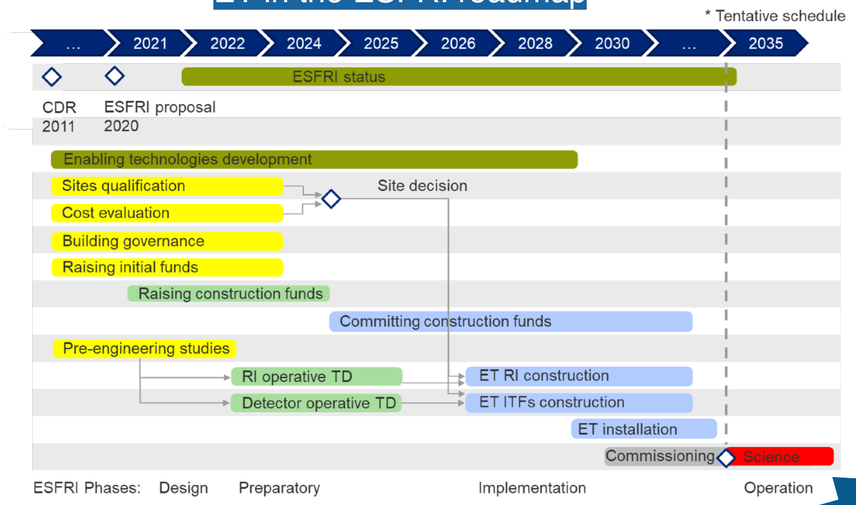
15–17 Nov 2022

ETIC project
Kickoff Meeting

https://l.infn.it/qx

19 Dec 2022

ET in the ESFRI roadmap



2026: start infrastructure construction

2030: installation

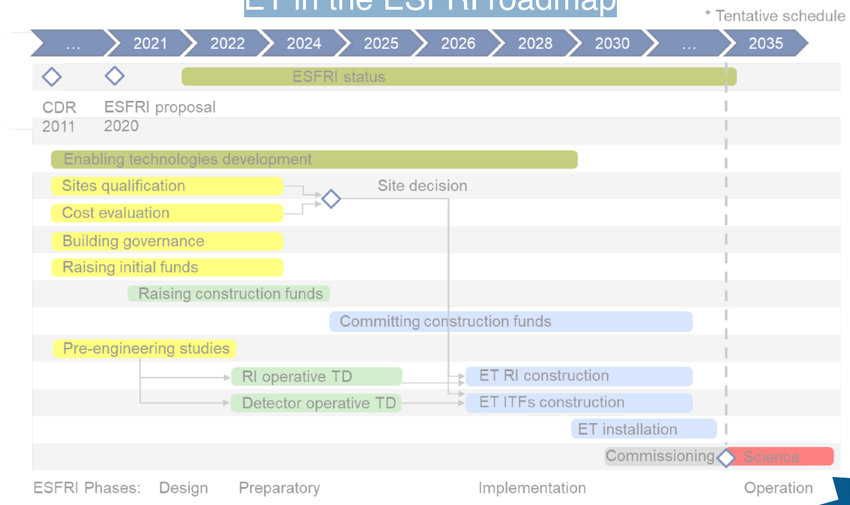
2024: site decision

2035: science

INFN-Bologna and ET

Foundation and Empire

ET in the ESFRI roadmap



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2026: start infrastructure construction

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2030: installation

2024: site decision

19 Dec 2022

15–17 Nov 2022

28 Oct 2022

Meeting with INFN CSN2 referees

Meeting or 2023 Bologna group budget
Leaded by Tommaso Chiarusi (DIFA)
25 participants, 3.05 FTE
DIFA INFN-BO INAF_OAS

23 Sept 2022

RU BoET Kickoff

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
INFN
INAF OAS BOLOGNA

BoET
kick-off meeting

ET EINSTEIN TELESCOPE

Michele Moresco
Dipartimento di Fisica e Astronomia "Augusto Righi", Università di Bologna
23 september 2022

14 Jul 2022

Assemblea di Sezione

Richieste Servizi Sezione			
Servizio	Attività/competenze	M. U.	Intervallo temporale
Elettronica	Supporto FPGA per attività data processing/ accelerazione algoritmi	3	distribuito su tutto l'anno
Calcolo e Reti	Supporto gestione sistemi informatici per apparati con FPGA e White Rabbit	2	Distribuito tutto l'anno
Officina Meccanica	Supporti meccanici per schede elettroniche/ adattamento crate	1	Seconda parte 2023
Progettazione	Progettazione strutture/supporto per interfacce tra detector e sistema DAQ	1	Seconda parte 2023

https://agenda.infn.it/event/29625/

7 Jul 2022

Bologna Research Unit joined the ET collaboration
Leaded by M.Moresco (DIFA)
50 participants, 6.8 FRTE
DIFA INFN-BO INAF_OAS

INFN-BO

ETIC

Progetto D877661E - Einstein Telescope Infrastructure Consortium

Scopo

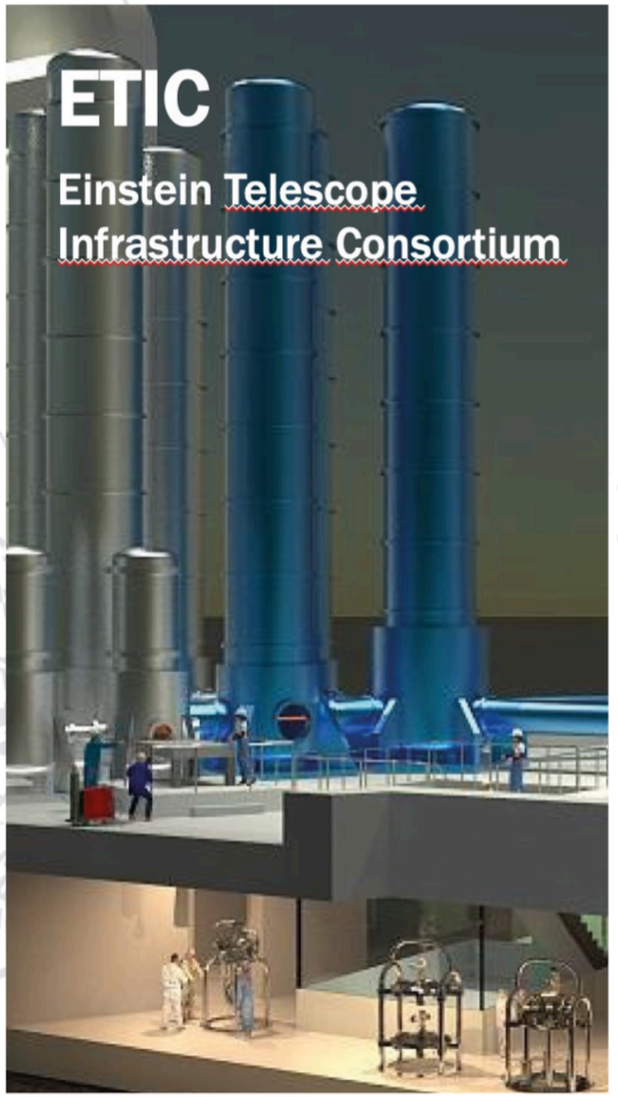
- Potenziare le sedi INFN dove si svolge R&D per E.T.
- Sviluppare tecnologie per E.T.
- Realizzare la progettazione preliminare e parte di quella esecutiva per il sito in Sardegna

Proponente: INFN - Budget complessivo approvato: 50 M€

- 30 M€ R&D tecnologico, 20 M€ studio di fattibilità sito

Unità operative:

- 11 strutture INFN: Bologna, Cagliari, Genova, LNGS, LNS, Napoli, Padova, Perugia, Pisa, Roma 1, Roma Tor Vergata, Torino
- 11 UNIVERSITÀ Co-proponenti: UniBO, UniCA, UniGE, Federico II, Vanvitelli, UniPD, UniPG, UniPI, Roma Sapienza, Roma ToV
- 2 ENTI Co-proponenti: INAF, ASI



Piano Nazionale di Ripresa e Resilienza

MUR

INFN
Istituto Nazionale di Fisica Nucleare

Credits: M.Pallavicini (INFN)
presented at "Giornate di Studio sul Piano Triennale INFN 2023"
https://agenda.infn.it/event/32125/

BETIF

Bologna Einstein Telescope Infrastructure

Applications/Use cases

Enabling Technologies	Computing acceleration	AI algorithms	Detector Sync	Detector control	Multi-messenger astronomy	Data acquisition	Low latency analysis
FPGA	X	X	X	X		X	X
White Rabbit			X		X	X	
GPUs	X	X				X	X

Products

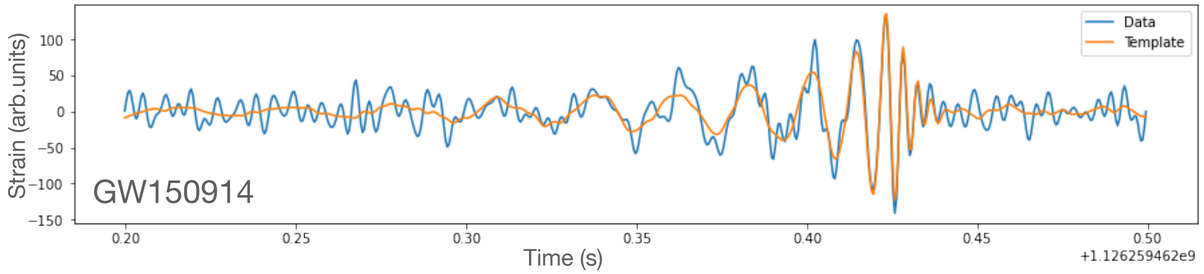
Equipped Laboratory for electronics development with integrated hw facilities

- Server with FPGA accelerator cards
- FPGA cards for detector interface
- WR server farm
- WR network
- High-speed standard network
- Server with GPUs

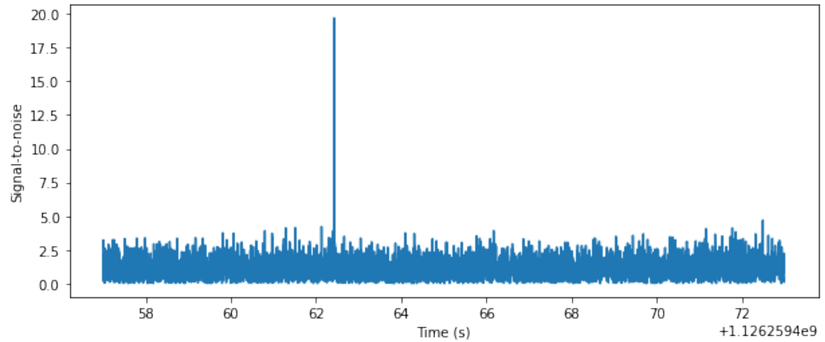
Proposal: contributions from T. Chiarusi, D. Bonacorsi e R. Travaglini; advice from E. Scapparone e G. Sirri

Example of application #1

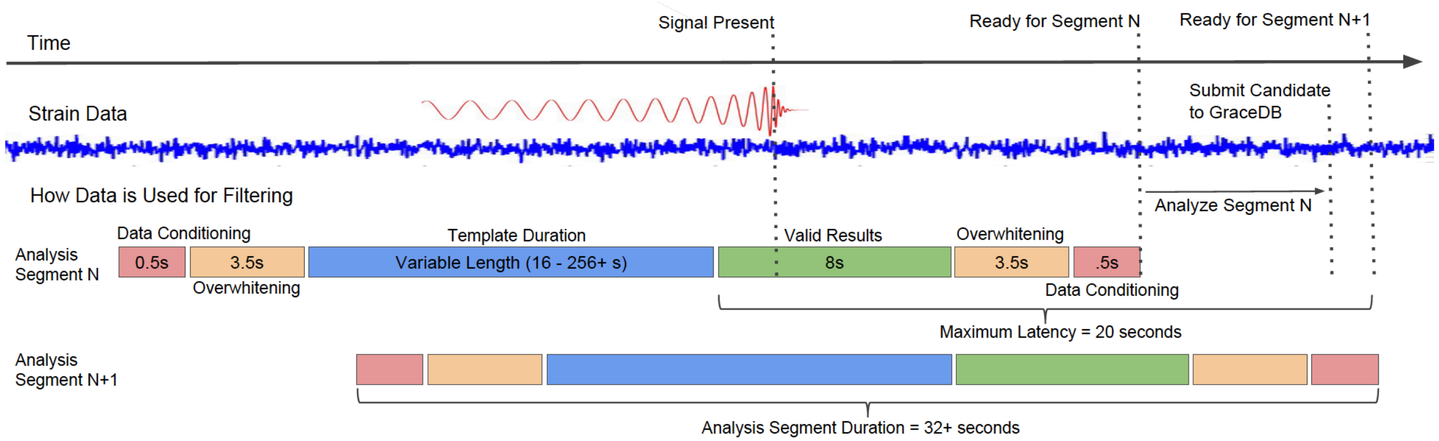
Matched filter for rapid GW detection



Matched filter
with a signal template



- Apply to the Data a filter template bank to explore a wide range of parameter space for merger masses
- Processing pipeline requires low latency (~1m) to alert partner detectors
- GPUs are used for LIGO/VIRGO
- FPGA and High-Speed data networks can speed up latency
- FPGA can provide a lower power consumption at a performance tradeoff
- ET would cope with “negative latency alerts”



Nitz, A. H., Dal Canton, T., Davis, D., and Reyes, S., “Rapid detection of gravitational waves from compact binary mergers with PyCBC Live”, Physical Review D, vol. 98, no. 2, 2018. doi:10.1103/PhysRevD.98.024050.

Example application #2

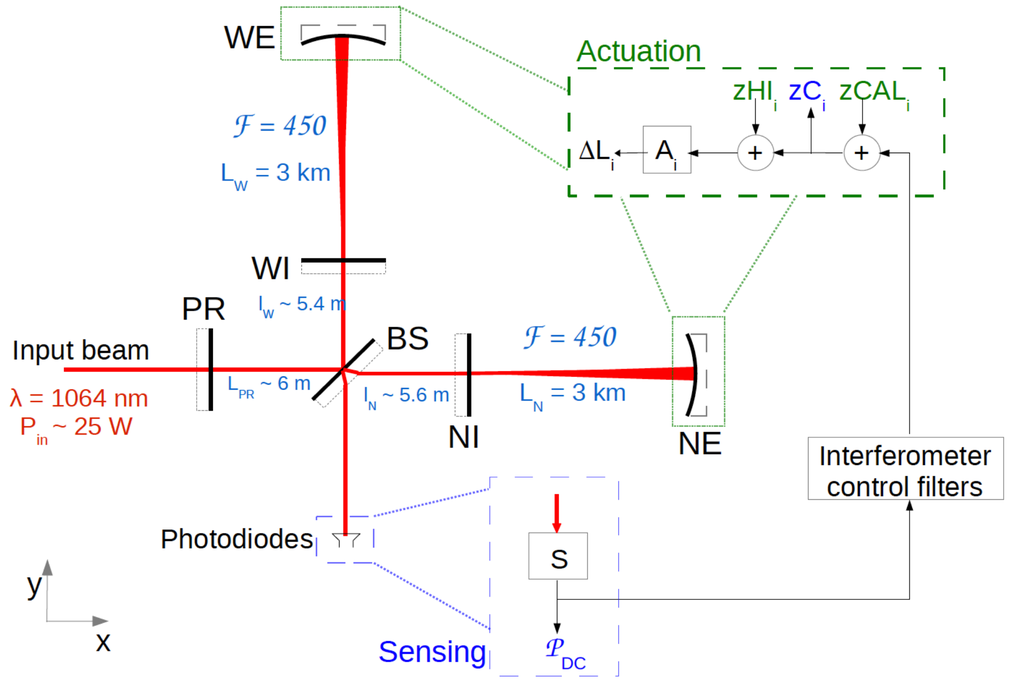
Interferometer calibration and control loops

Requirements

- Calibration: ror Advanced VIRGO the absolute timing precision must be of the order of 0.01 ms or less; ET is expected to be better than 1 us
- Control: relative timing between the fast ADCs distributed over the entire experiment with a timing jitter at the level of 1 ps

White Rabbit is an attractive technology:

- sub-nanosecond accuracy and picoseconds precision of synchronization
- typical distances of 10 km between network elements
- Gigabit rate of data transfer (data and synch use the same network)
- Strong expertise in Bologna



F Acernese *et al*, Calibration of Advanced Virgo and Reconstruction of the detector strain h(t) during the Observing Run O3 , 2022 *Class. Quantum Grav.* **39** 045006
DOI *10.1088/1361-6382/ac3c8e*

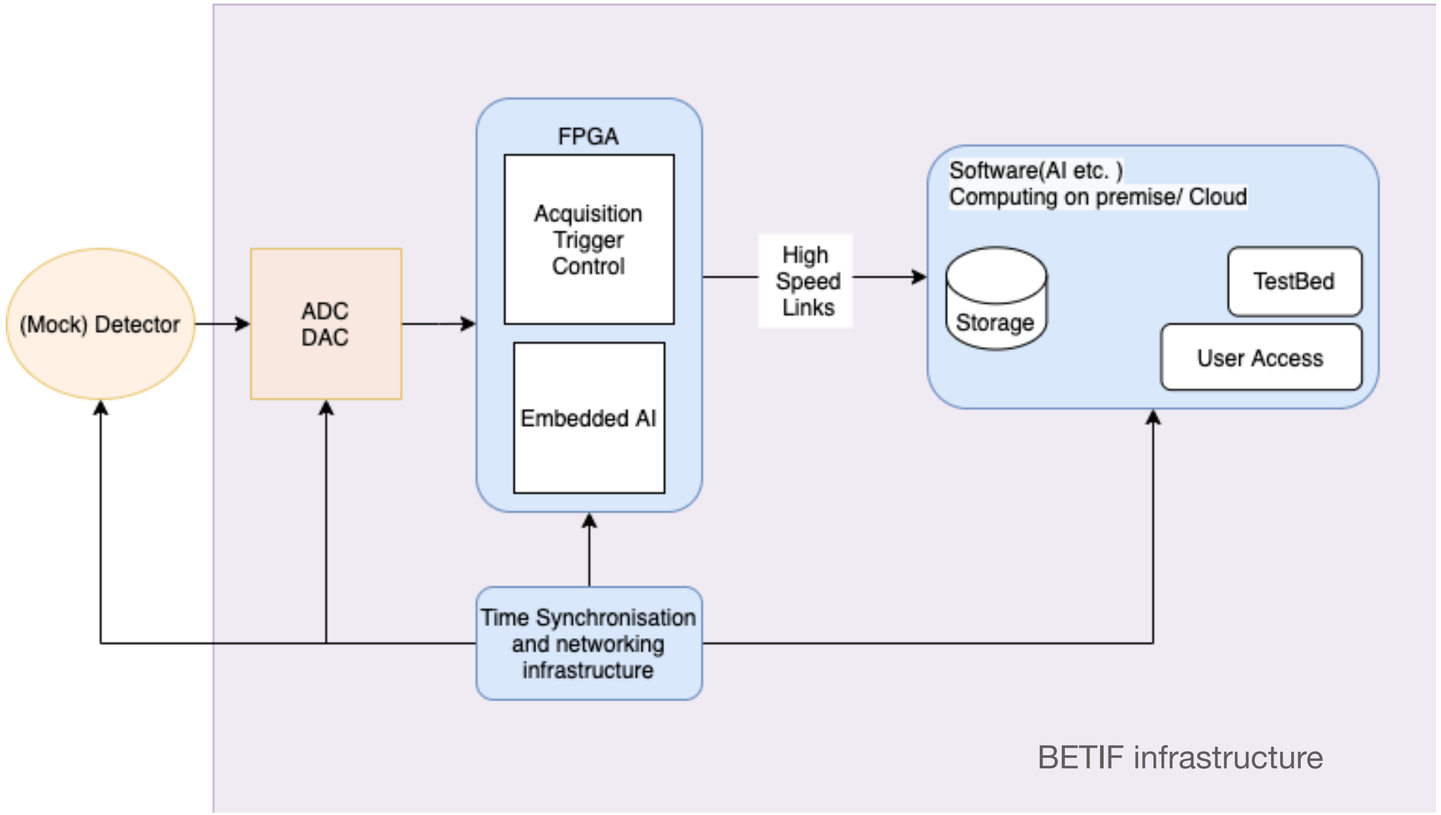
Example application #3

Mock data challenges

From ET design report update 2020 ("long ESFRI document"), ET-0007A-20, 2020 (https://apps.et-gw.eu/tds/?content=3&r=17245):

Mock Data Challenges will be planned to leverage the adoption of new technologies and solutions in computing:

- Novel algorithms
- Hardware acceleration
- AI and Deep Learning (https://indico.ego-gw.it/event/464/)



BETIF

Budget and Personnel

- WP5 - Computing and DAQ

- Contact Person: R.Travaglini
- Backup Contact Person: T.Chiarusi

- Budget for Instruments: 300k€
  - FPGA (~20%)
  - White Rabbit infrastructure (~20%)
  - GPU (~20%)
  - Laboratory and furnitures (~40%)

- TD Personnel
  - 1 tecnologo III livello
  - 1 CTER

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA | INFN

Istituto Nazionale di Fisica Nucleare

CODICE PROGETTO

IR0000004

Einstein Telescope Infrastructure Consortium (ETIC)

18 Technologist* positions in INFN for ET

INFN Unit	Activity/Requirements
Bologna[2]	Design, development and testing of systems based on programmable logic. FPGAs and embedded systems.
Cagliari[1]	Light and ionising radiation detectors, integrated electronics for detector read-out.
Cagliari[2]	Optics, laser technologies, data acquisition systems
Genova[2]	Design, simulation, operation and maintenance of optical and opto-electronic equipment.
LNS-Catania[4]	Experience in the BIM environment and in public construction
Napoli[3]	Simulation, fine-tuning, sensing and control of seismic isolation systems for suspended optics
Napoli[3]	Ultra high vacuum systems, surface contamination assessment
Padova[3]	Skills in vacuum system design; experience in deposition techniques and/or materials science.
Perugia[1]	Project management assistant. Office automation for project management.
Perugia[3]	Mechanical and mechatronic design.
Perugia[3]	Implementation of seismic filtering and vacuum systems
Pisa[3]	Mechanical and FEM design for complex seismic filters in High Vacuum.
Pisa[2]	Electronic design, development of low-noise sensors and actuators.
Pisa[1]	Electronics and software development for feedback control systems, machine learning.
Roma1[3]	Design of mechanical, vacuum and cryogenic systems.
Roma2[2]	Design, simulation, deployment and maintenance of advanced adaptive optics systems. 2 positions
Torino[1]	Design, development and testing of hardware and software systems for high-performance scientific computing (HPC, GPU).

6 Technician** positions in INFN for ET

INFN Unit	Activity/Requirements
Bologna[6]	Installation, testing and use of electronic devices in the laboratory.
Cagliari[7]	Fabrication of mechanical and micromechanical components in the workshop
LNS-Catania[7]	Maintenance, assembly and design support of technological, vacuum and cryogenic plants
Perugia[7]	Production of components in the mechanical workshop. Use of numerical control machines
Roma1[7]	CAD drawing and fabrication of mechanical components in the workshop
Torino[5]	Installation and management of scientific computing and cloud resources in a Linux environment

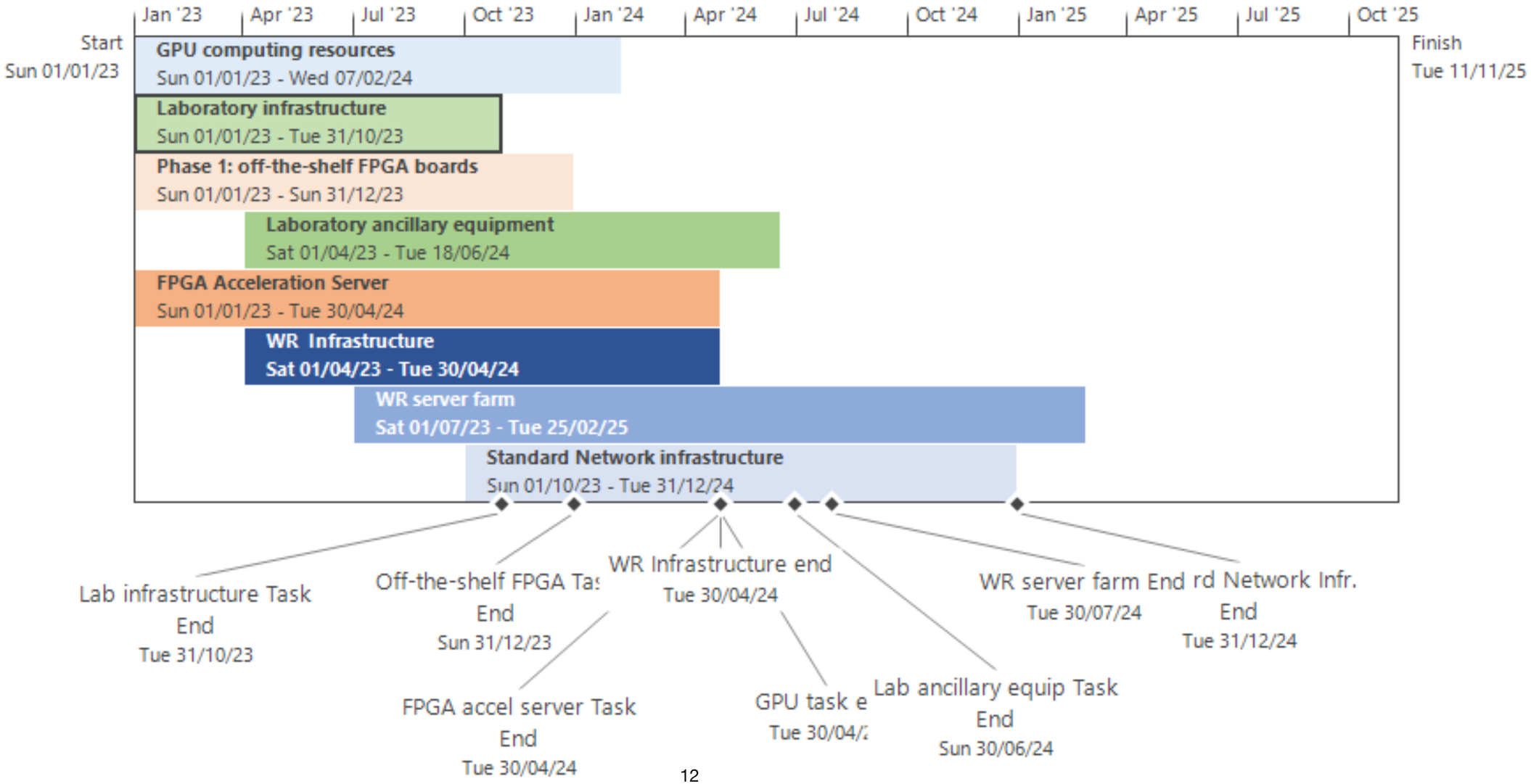
1) https://l.infn.it/cmp
2) https://l.infn.it/ele
3) https://l.infn.it/cri
4) https://l.infn.it/edi
5) https://l.infn.it/tcm
6) https://l.infn.it/tel
7) https://l.infn.it/tme

ET EINSTEIN TELESCOPE

- *2 years positions. For access to the profile of Technologist, a degree in Physics, Engineering (all classes), Computer Science, Mathematics, Biotechnology (all classes), Materials Science and Engineering, Universe Sciences, Natural Sciences, Statistical Sciences, Computer Security, Biology, Chemical Sciences (see call for details)
- ** High school diploma, 2 years contract (see call for details)

BETIF

Tasks and Timeline (draft)



BETIF and friends

Synergies with other ETIC infrastructures and more

- UniBO - DIFA facility in ETIC (*DIFAET*)
  - Operative Unit responsible: Prof. A. Cimatti
  - WP5 Computing & DAQ - WP2 Optics, Electronics and Photonics
  - WP5 deliverable: heterogenous computing platform with major aim on providing (in two phases) high profile, high performance multi-core servers with large storage capability

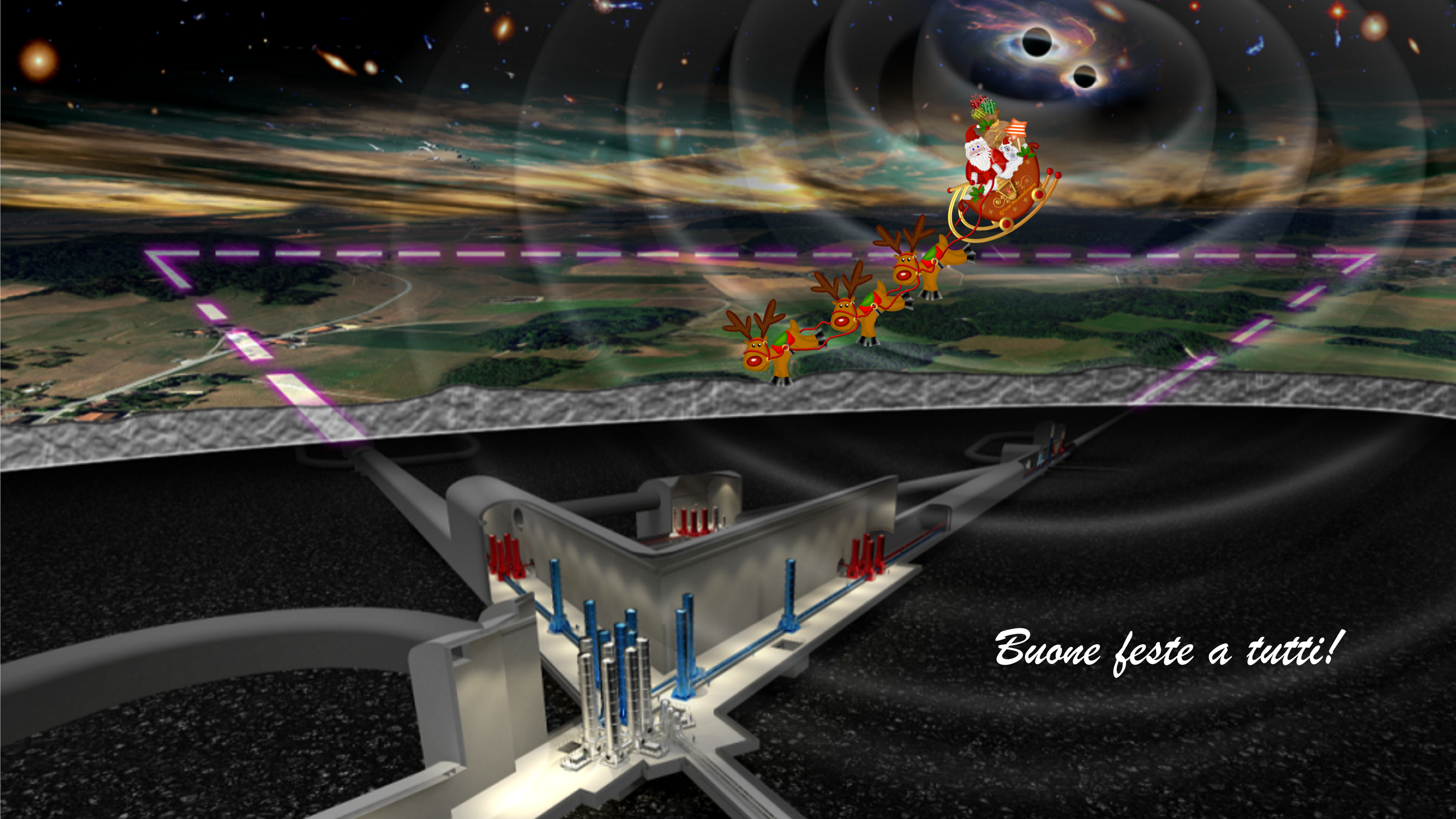
- UniPG - INFN-PG laboratory for ETIC (*CAOS - Centro per Applicazioni sulle Onde gravitazionali e la Sismologia*)
  - International laboratory where to develop the technologies of future GW detectors, hosting a reduced scale prototype of the ET interferometer
  - Project coordinator: Prof. H.Vocca (UniPG)
  - Reference person for the Data Acquisition Task: T.Chiarusi (with my support)

- INFN-Cloud
  - Coordinator: D.Salomoni (CNAF)

- KM3NeT4RR - project “Kilometer Cube Neutrino Telescope for Recovery and Resilience”
  - Operative Unit INFN-BO responsible: T.Chiarusi

Conclusions

- 2022 has been an establishing year for both the ET project and the participation of INFN Bologna
- 2023 will be a crucial year to support the Sardinia site’s candidature
- ETIC project is the natural context where Italian ET efforts (mainly for R&D) will be addressed in the next 2-3 years
- BETIF infrastructure can be the opportunity to strengthen the INFN-BO involvement in ET
- BETIF can be the right place to develop synergies not only with ET-related projects
- Support from the administrative and technical services will be essential!


Buone feste a tutti!