

# ET

# EINSTEIN TELESCOPE

## Notes on ET

M. Martinez

(ET steering committee)



ICREA

IFAE



EXCELENCIA  
SEVERO  
OCHOA

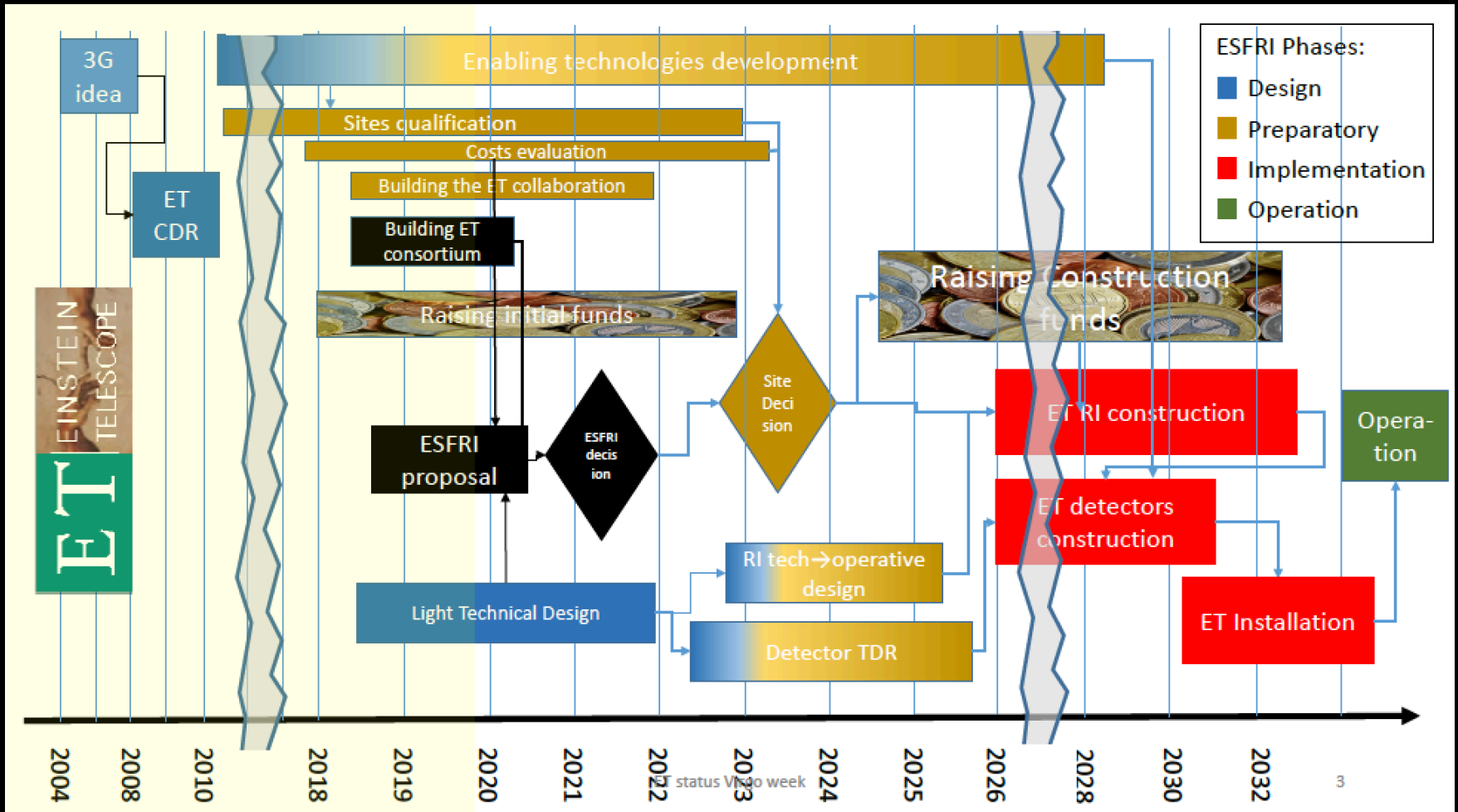


Spanish Meeting on ET  
8<sup>th</sup> April 2021

# Goals of this (short) meeting

- Inform you about the developments and latest news on the ET project and ESFRI process
- Inform you about the discussions with I. Figueroa (from Spanish Ministry) as vice-Chair of ESFRI
- To calibrate the need for a satellite meeting on ET in time for the Iberian meeting in June
- Allow for discussion

# Schedule



- 5 years R&D
- 10 years construction
- Operations 2035

# ESFRI Schedule

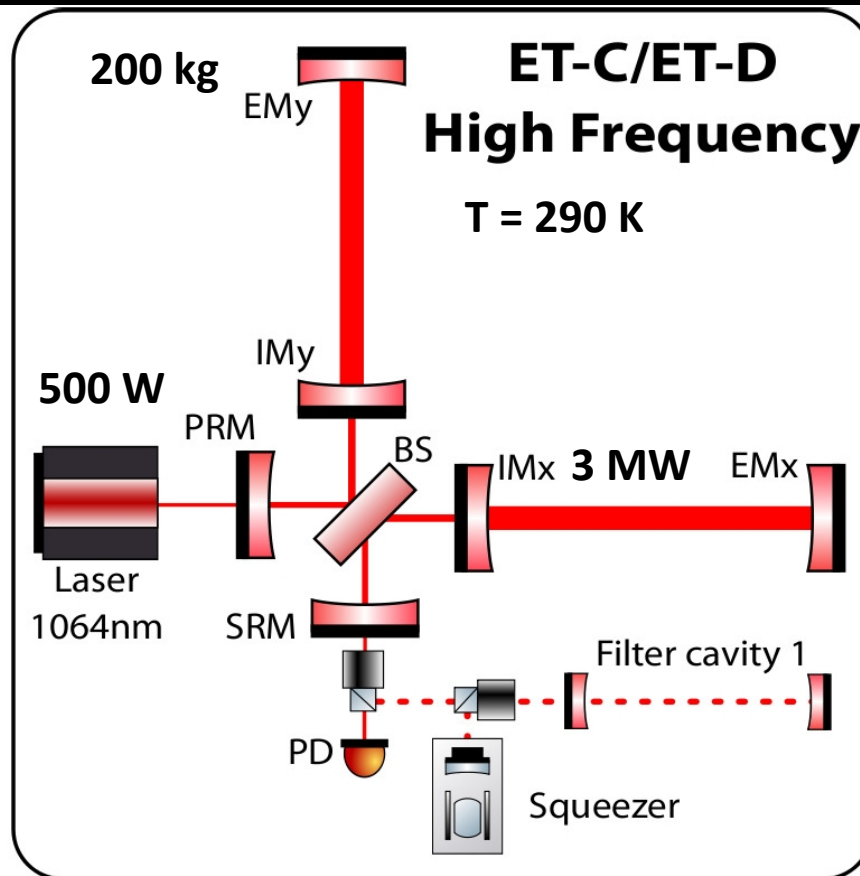
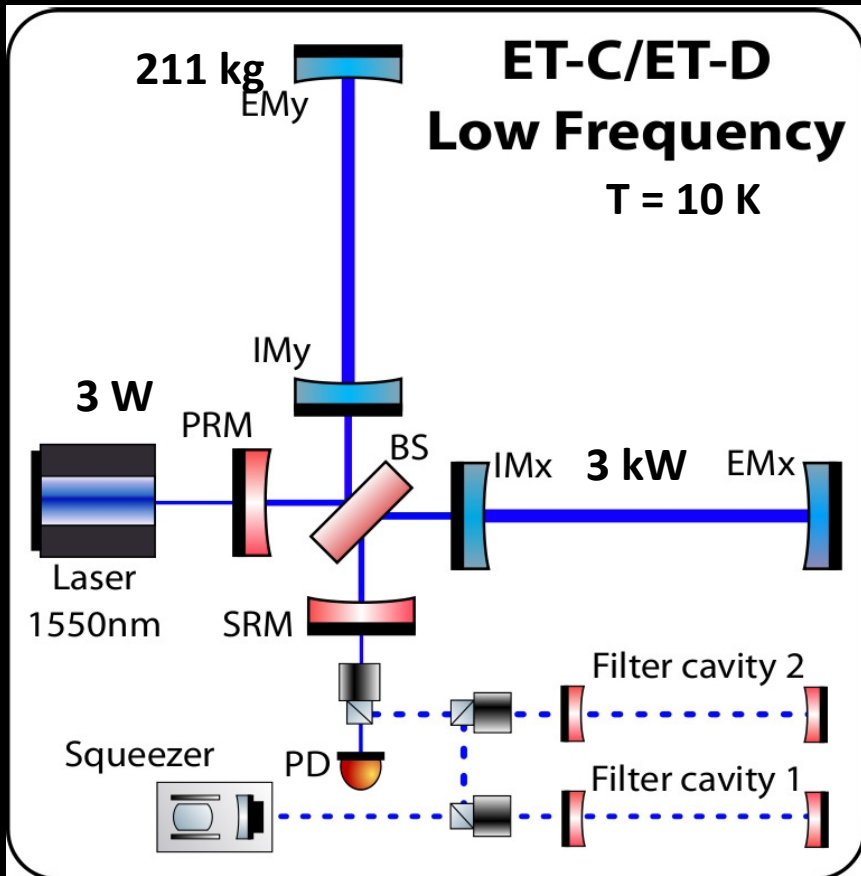
- ESFRI interview on 14th April
  - ESFRI decision by June-September
  - ESFRI new roadmap launch by October – November
  - ET Collaboration will be concretized after ESFRI
- ET Steering committee preparing the interview and answering the questions posted a priori by the panel
- In general the questions are all very reasonable and our understanding is that the ET is being evaluated favorably (no guarantee of success yet)



# Questions (I)

- **Q1. A sizable number of technical challenges exist to reach the required sensitivity by the Einstein Telescope. What are the particularly critical items requiring further R&D effort and the associated risks and their potential impact on the programme? Is there any plan in place to mitigate against the risks?**

# Q1: 2G → ET



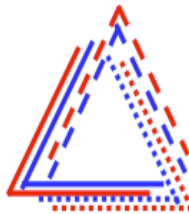
Optical element,  
Fused Silica,  
room temperature

Optical element,  
Silicon,  
cryogenic

— Laser beam 1550nm  
— Laser beam 1064nm  
- - - squeezed light beam

Challenging  
engineeringNew  
technology in  
cryo-coolingNew  
technology in  
opticsNew laser  
technologyHigh precision  
mechanics and  
low noise  
controlsHigh quality  
opto-  
electronics and  
new controls

- The multi-interferometer approach asks for two parallel technology developments:



- **ET-LF:**

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

- **ET-HF:**

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

Evolved laser  
technologyEvolved  
technology in  
opticsHighly  
innovative  
adaptive opticsHigh quality  
opto-  
electronics and  
new controls

## • High power circulating in the ET-HF detector

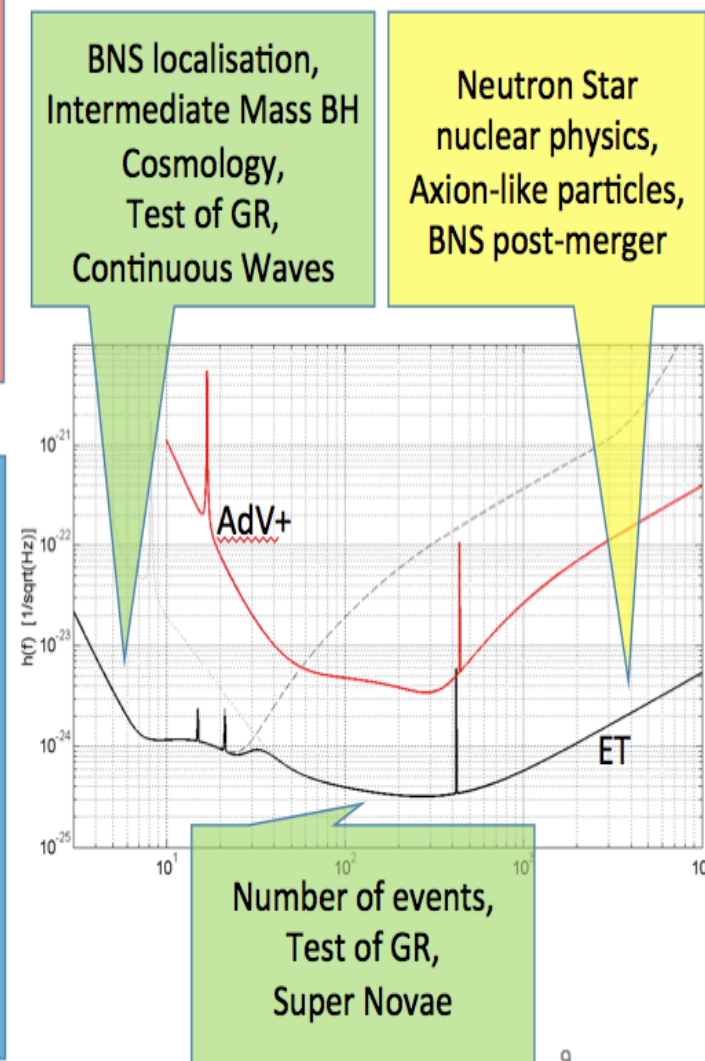
- The management of this power ( $\sim 3\text{MW}$ ) and the control of thermally induced aberrations of the ET-HF optics are still under investigation

Potential impact on sensitivity at High Frequency

## • The low-frequency motion requirements for ET-LF

- Achieving low frequency performance is a challenge in 2G and 3G detectors.
- **Cryogenics in ET-LF**
  - The impact of cryogenic infrastructure on ET-LF's low-frequency sensitivity and the choice of materials for ET-LF's optics are still under investigation

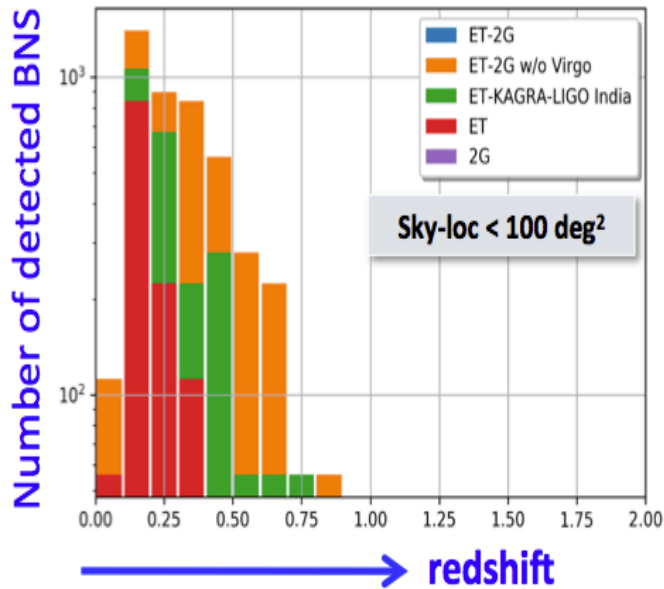
Potential impact on sensitivity at Low Frequency



# Questions (II)

- **Q2. It is proposed to upgrade the current 2nd generation gravitational wave antennas and to continue operating them in parallel with the ET operation, which will require substantial resources. What are the compelling scientific justifications for this?**

## ET+ 2G detector network (Virgo, LIGO-Hanford, LIGO-Livingston, LIGO-India, KAGRA)



Number of BNS events with sky-loc < 20 deg <sup>2</sup> < 100 deg <sup>2</sup>		
ET	125	1230
ET+KI	233	2640
ET+HLKI	435	4420
ET+HLKIV	437	4420

Kagra and LIGO-India improve the sky localization

Due to its close proximity to ET, Virgo **does not improve** sky localization

Operating with 2G detector network improves the ET sky-localization capability up to a redshift of about 0.6 (3.5 Gpc)



**Multi-messenger science, cosmology, nuclear physics**

# Questions (III)

- **Q3.** The number of gravitational wave detections by the ET will be significantly larger than that by the 2G network, which may be an issue for the other observatories to make follow-up measurements. Has the possible impact for those observatories and their capacity to respond to alerts been evaluated?
  - Only a fraction of events will have EM counterparts  $O(100/\text{year})$
  - 10% observation period in places like Vera Rubin telescope
  - For some of them on survey mode no interruption needed
- **Q4.** Question on data volume and computing needs and the use of HPC
  - Few PBs per year.. Moderate bandwidth, use of HPCs
  - Room for improvement in the software
  - Will be equivalent to an LHC experiment in Run 4
  - Affordable already now
- **Q5.** Question on open data/tools policy to be followed
  - Already happening now in 2G experiments
- **Q6.** What is the “secondment programme” referenced in the proposal and how will it be granted?
  - The ET site will host an excellence centre in GW research
  - ET site will be an attractor for scientists in Europe and worldwide



# Multi-messenger observatories

ET will operate in synergy with a new generation of innovative observatories



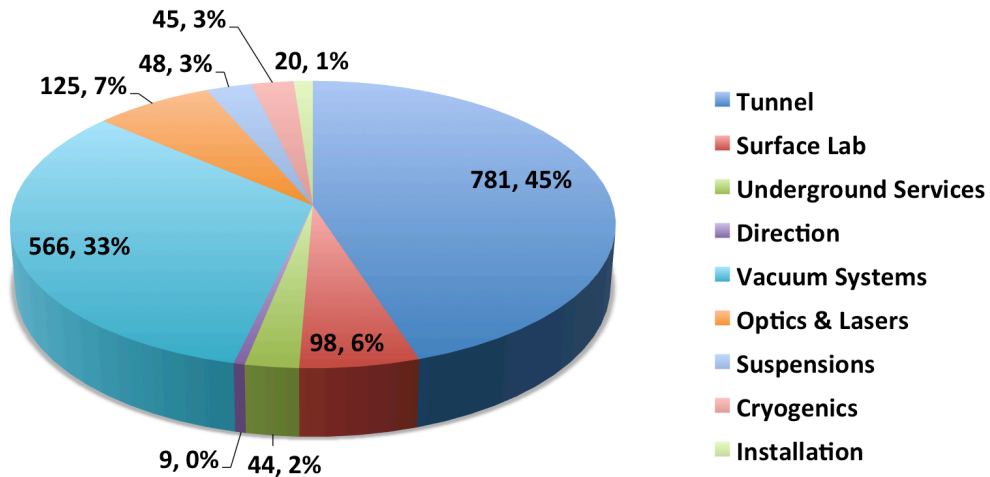


# Questions (IV)

- **Q7.** Please provide details of the strategy for funding the preparatory and implementation (construction) phases and further clarification on the procedures and timeline associated with the decision for final location of the ET.
- **Q8.** What approaches will be taken to increase the number of participating countries and ultimately broaden the membership over the coming years?
- **Q9.** Please provide further details on the business plan and on the project timeline for the ET. Include in your response the agreed steps for their final approval and sign-off by the consortium and Board.

# Q7. Estimated cost

ET Estimated Costs (M€)



Preparatory phase (170M€)

1. Site qualification (funded)
2. Site preparation (50 – 60 M€)  
Covered by host country
3. R&D on technology (95 M€)  
(how much Spain can contribute ?)

Host country is expected to contribute with > 50% of the total cost

Chicken/Egg dynamics  
Agencies will only talk about big money after ESFRI stamp

Construction : 1900 M€ (in 10 years)  
M&O : 37M€ /year

# Related to Q7-Q9



30 M€ investment  
ETparthfinder

@ Limburg area (border NL-B-D)  
→ Promoted by Nikhef



22 M€ investment  
Lab in construction

@ Sardinia  
→ Promoted by INFN



@ Germany is very present in ET and Etpathfinder  
They foresee a large investment in the following years

→ This might become a game changer

Discussions taking place with other countries like France and UK

# New technologies: *ETpathfinder R&D lab*

**Interreg**   
 EUROPESE UNIE  
**Vlaanderen-Nederland**  
 Europees Fonds voor Regionale Ontwikkeling



**R&D Field Lab  
 ETpathfinder**

Stichting Nederlandse Wetenschappelijk Onderzoek Instutien (Nikhef) en een consortium van Nederlandse en Vlaamse universiteiten staan in voor de ontwikkeling van de ET Pathfinder, een R & D-faciliteit waar nieuwe technologieën tot stand kunnen komen voor state-of-the-art zwaartekracht-detectoren waarmee naar het heelal geluisterd kan worden. Met ETpathfinder kunnen noodzakelijke testen worden gedaan die daarna op grote schaal worden uitgevoerd in de uiteindelijk geplande Europese Einstein-telescoop.

[www.grensregio.eu](http://www.grensregio.eu)

**14,5 M€ grant**  
*(investment only!)*  
**open to all**



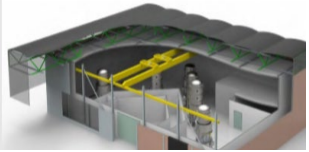
1<sup>st</sup> phase: 2019-2022 (funded)  
 envisaged for many more decades  
 see: <https://www.etpathfinder.eu/>



**ETpathfinder**  
 DESIGN REPORT

The ETpathfinder Team\*

\*Maastricht University, University of Antwerp, Ghent University, Katholieke Universiteit Leuven, Universit  Catholique de Louvain, Kassel University, Vrije Universiteit Brussel, Fraunhofer Institute for Laser Technology, E.ON Energy Research Center, University of Twente, Eindhoven University of Technology, Liège University, VITO, INO.



**Focus:**

- *cryogenic silicon mirrors*
- *controls*

**Projectleader:**

*S. Hild, Maastricht University*



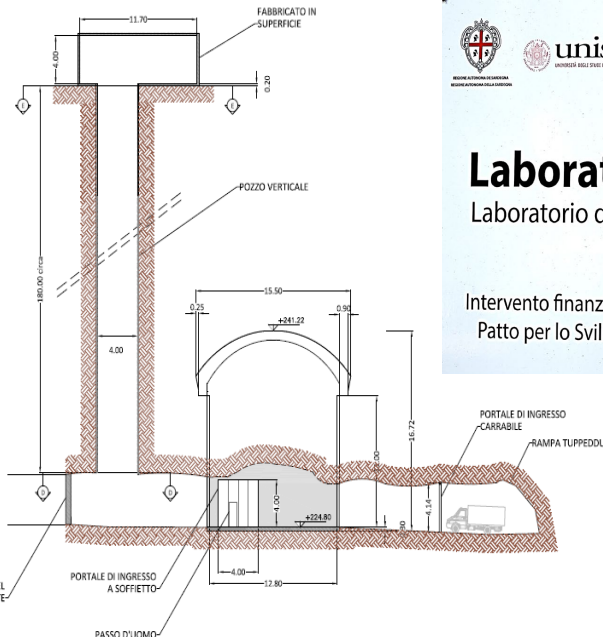
# Sar-Grav Laboratory in Sos Enattos

Funded by Regione Sardegna (4M€)

- ❑ A 200m<sup>2</sup> **surface Laboratory** with annexed control room;
- ❑ 120m<sup>2</sup> **underground Laboratory** under construction

*Focus:*

Low seismic noise experiments (e.g. Archimedes O(600k€)) Cryogenic Payloads, low frequency and Cryogenic sensors development



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INFN  
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## Laboratorio Sar-Grav

Laboratorio di Fisica della Gravitazione

Intervento finanziato con risorse FSC 2014-2020  
Patto per lo Sviluppo della Regione Sardegna



# ET symposium

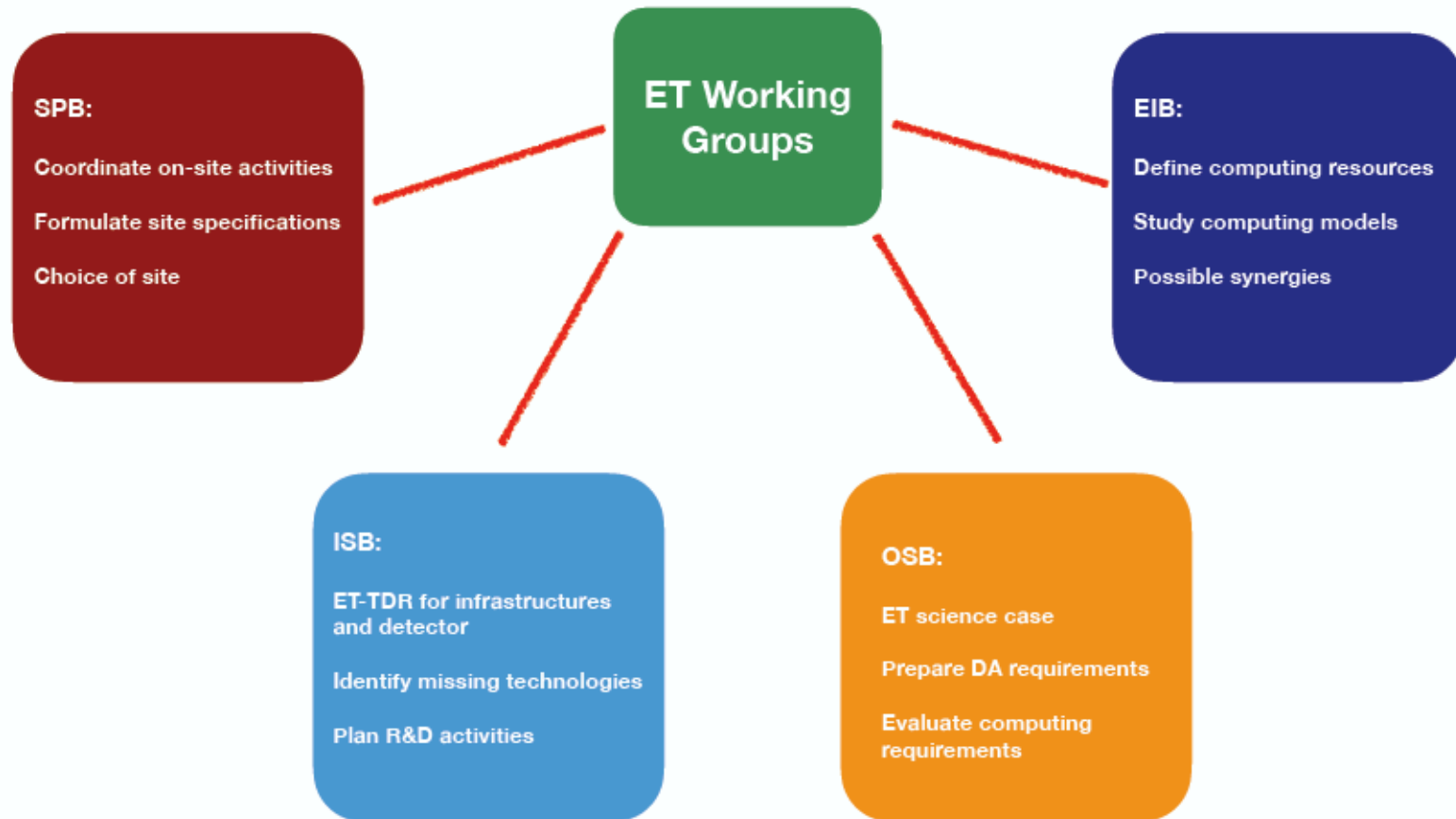


<https://indico.in2p3.fr/event/20576/timetable/#all.detailed>

# Questions V

- **Q10.** ESFRI considers that insufficient plans at this stage have been put in place to address governance related matters. Please provide further information to satisfactorily address the necessary minimal key requirements related to governance.
  - ESFRI referees are worried about this because of the very bad CTA experience and the size of the project
  - Having a Strong Project Office with a Large Research Entity behind it would help (CERN, DESY, etc...)

# ET Organisation

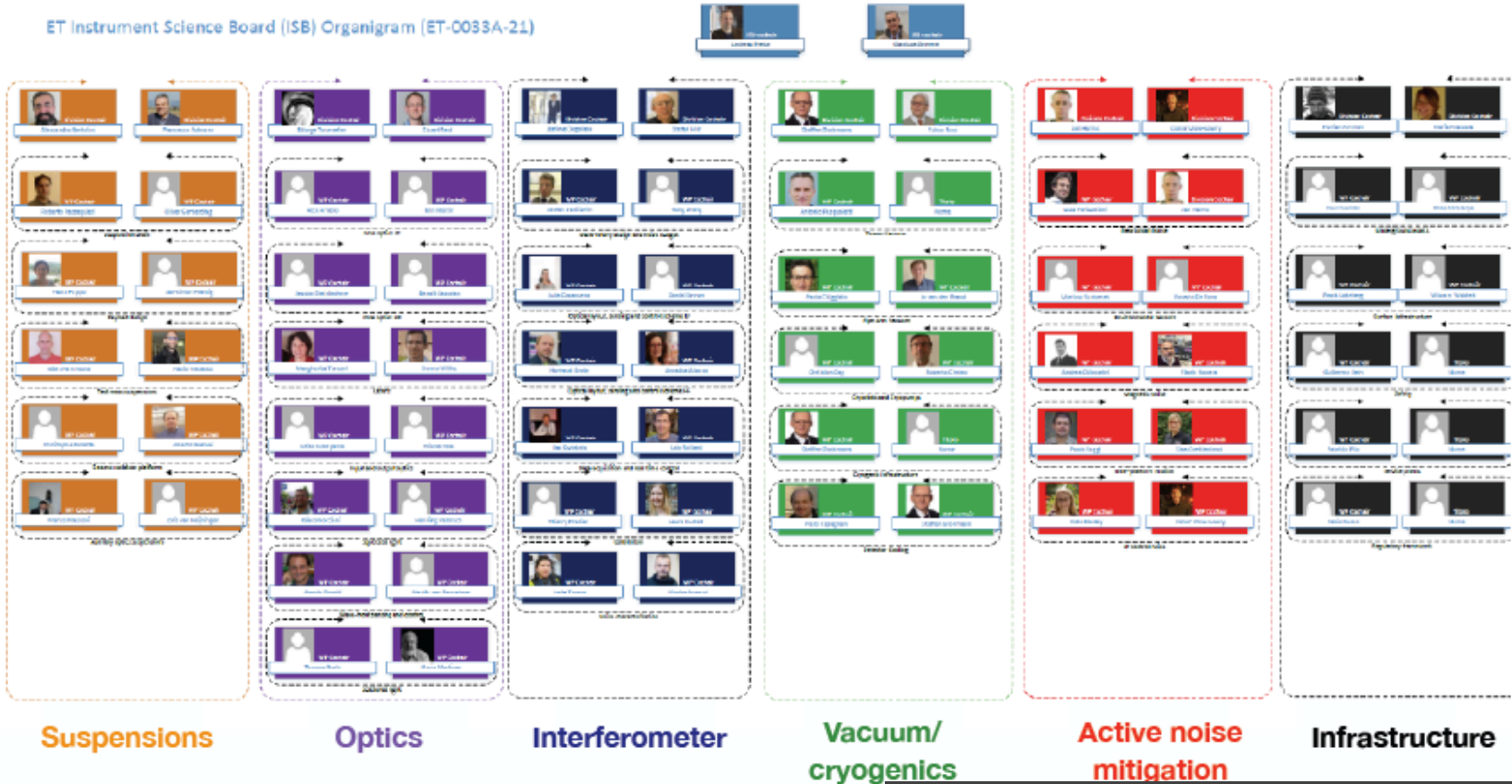




# Instrument science board (ISB)

<https://wiki.et-gw.eu/ISB/WebHome>

ET Instrument Science Board (ISB) Organigram (ET-0033A-2.1)



A first workshop took place on 29<sup>th</sup> – 31<sup>st</sup> March  
<https://indico.ego-gw.it/event/173/>

**ET-ISB workshop (day 1)**  
 Monday 29 Mar 2021, 09:00 → 13:00 Europe/Rome  
 Andreas Freise (VU Amsterdam), Gianluca Gemme (INPN)

**Description:** We are aiming at a hands-on workshop in which we start by discussing together, but then also have times for small groups to work on a specific task. That will happen during the days of the workshop but also on March 30th.

We will work on the following topics:

- Optimal mirror temperature for LF
- Low frequency noise strategy
- What are the facility limits?

The workshop will be held online on Zoom. Instructions for connecting are at [this link](#).

A working area where useful info will be stored is available at [this link](#).

# Observational science board (OSB)

Marica Branchesi - Michele Maggiore - Ed Porter

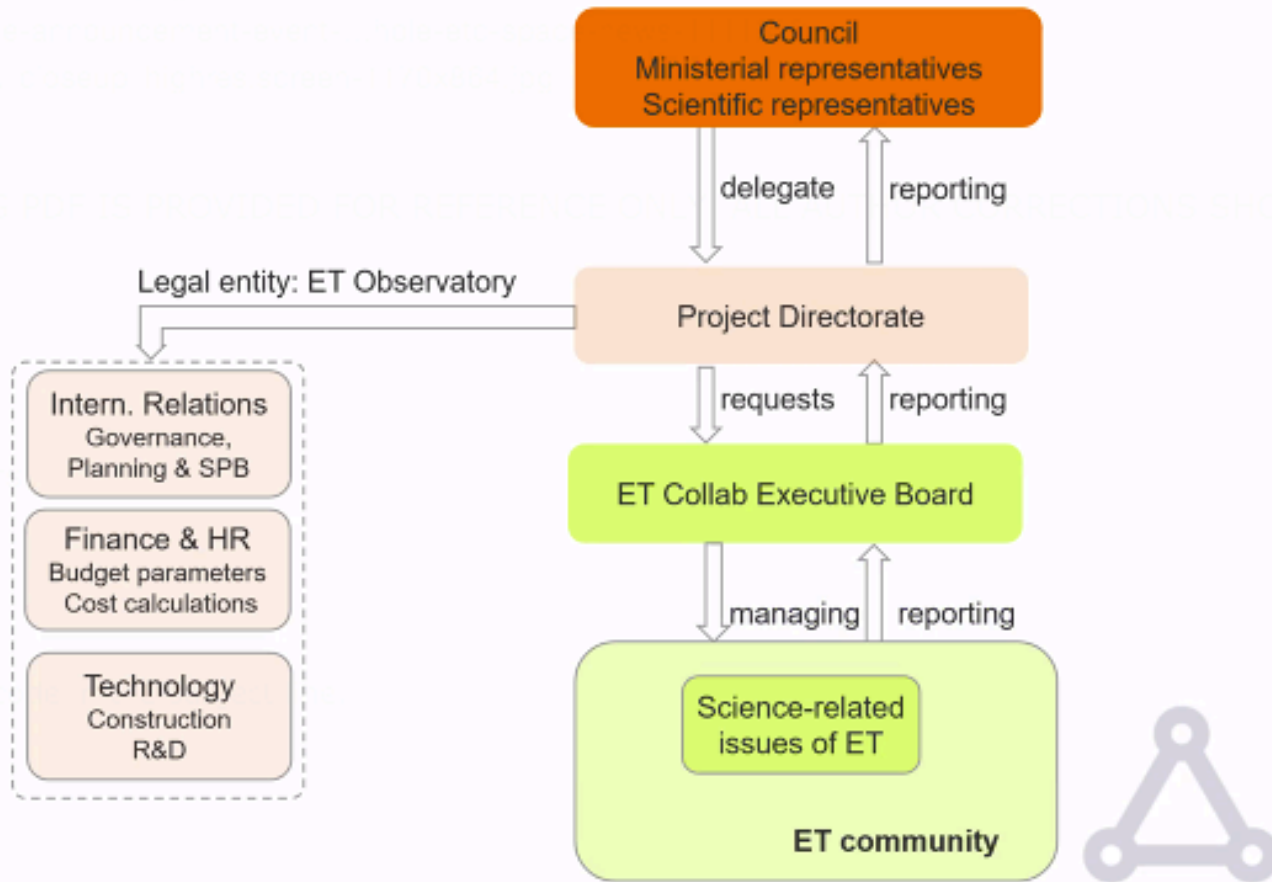
Fundamental physics	Cosmology	Population Studies	MM observations	Synergies w. other GW observ.	Nuclear physics	Transient GW Sources	Waveforms	Science Potential	DA platform
Physics near BH horizons	Dark Energy	Predictions of population of astrophysical origin	ET / high-energy	Synergies with 2G+ detector	EoS of NSs in isolated systems	Predictions for Supernovae	Waveforms relevant for ET	Science potential for various detector configurations	DA platform
Tests of GR	Dark matter	Predictions of primordial BHs	ET / optical	Synergies with CE, 3G	EoS in NSs in binary systems	Predictions for magnetars	Improvement of waveforms for BBH	Common tools	
Exotic compact objects	Estimation of cosmological parameters	Stochastic backgrounds of astrophysical origin	ET / radio	Synergies with LISA	Nucleo-synthesis in BNS mergers	Predictions for cosmic string bursts	Improvement of waveforms for NSBH		
	Modifications of gravity at cosmological scales		ET / neutrinos				Improvement of waveforms for BNS		
	Stochastic background of cosmological origin								

## Construction phase

# Governance

### Structure during construction phase

PD may evolve into ET Observatory which will be a legal entity and will have significant staff



High-level negotiations taking place now in Italy and The Netherlands to establish a model for governance → definition of Project Directorate above the ET Collaboration → In internal, informal discussions DESY has been suggested by some people as project office

# Meeting @ Madrid (I)

- Meeting of 1.5h with Inmaculada Figueroa in Madrid for an informal discussion about the ESFRI process
  - Triggered by the fact she was not attending the last meeting with the funding agencies supporting ET
  - She confirm Spain will maintain its political support
  - She also insisted in the message that there is no financial commitment to date.
- As vice-chair of ESFRI she shared some information about the ranking of the proposal
  - Physics case got the best possible evaluation
  - There are no candidatures at the level of ET (in size/cost)
  - In general the evaluations are coming well
  - The timeline of ET is good since other infrastructures will be built by them so there is no big conflict with other investments
  - She made also some questions and expressed some mild concerns (see next slide)

# Meeting @ Madrid (II)

- The proposal would be stronger if more countries would be politically supporting it
  - France, Germany, etc..
  - I mentioned to her the situation in Germany
  - France has a wait-and-see approach while supporting 2G
- Concern that other ESFRI infrastructure are running all into over-costs
- ET-Spain needs to get (formally) organized (Ministry should see it from outside)
  - in ESFRI goes ahead there will be 4M€ for preparatory work and Spain needs to be there getting part of the money
- A list of areas of impact/interest from Spanish institutions should be listed
- ET should be part of the discussions about e-Science taking place at the Ministry level if computing is going to be a big player
- My message was that ESFRI stamp is needed to motivate a phase transition in the internal discussions in Spain but also in other countries (France is a good example)
- My message was that groups contributing to large experiments will be in the position to contribute and compete (electronics, sensors, cryo ... etc..) & Computing
- Clearly we cannot compete on the R&D on mirrors and coating (French area)
- I put also in value the fact that theory predictions of waveforms is crucial

# My conclusions

- The meeting @ Madrid went well and was useful to reconnect Spain to the ESFRI process
- We should sent information to I. Figueroa before the 14th of April on the project and the view of the Spanish Institutions (I have the impression she will appreciate it)
- We need to increase the list of institutions with concrete plans on the hardware R&D and explore centers on Optics and not only on GWs
- **Spanish groups should actively participate in ISB and OSB ET boards**
- **Spanish groups should get involved in ETpathfinder initiatives**
- A ½ day dedicated meeting in June would be a very good opportunity to define/coordinate ideas and to bring other parties to the effort.
  - Maybe we could even invite Ministry Representatives to it
  - In time with the ESFRI decision making

Lets discuss