Notes on ET

M. Martinez
(ET steering committee)

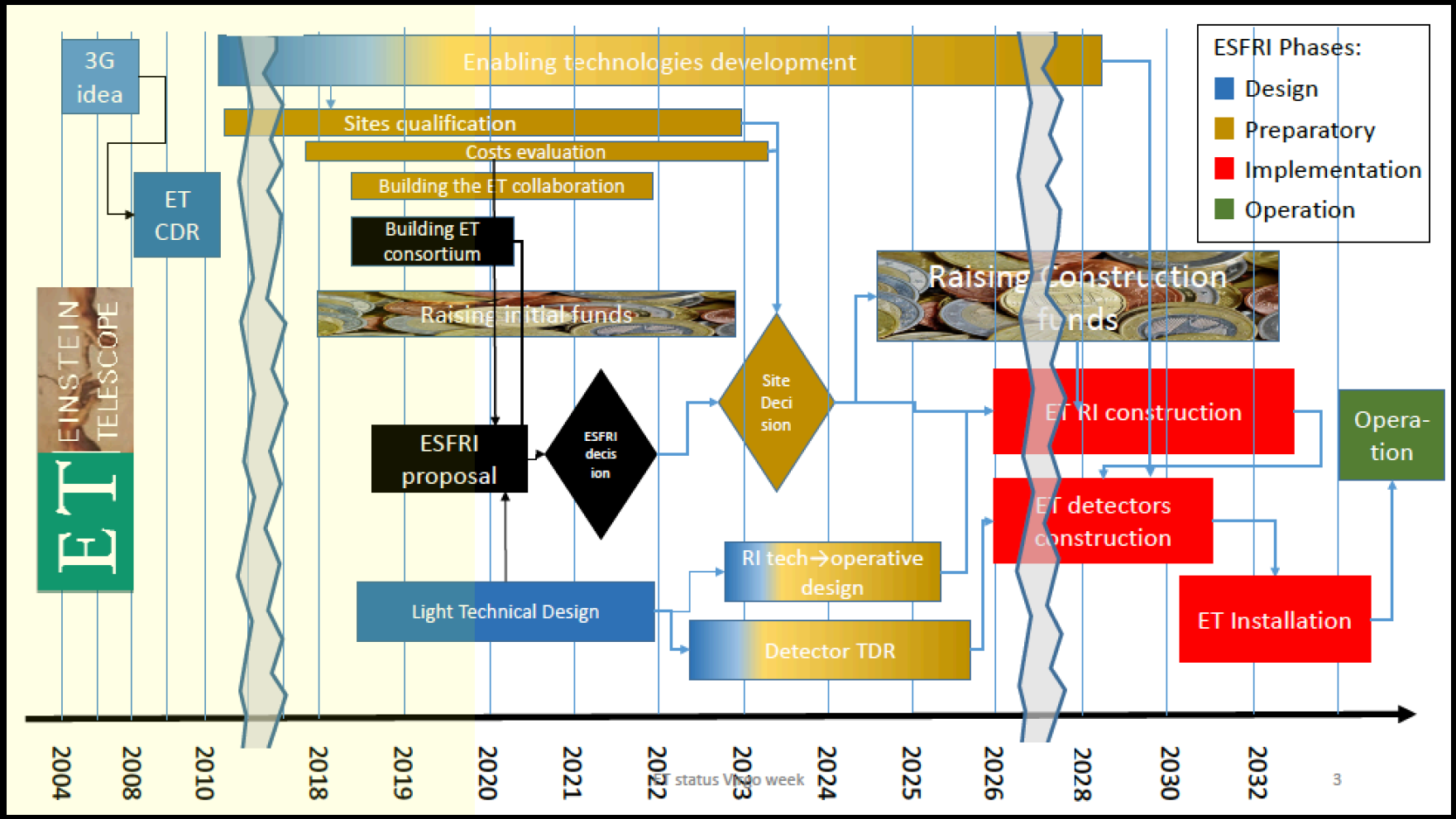
ICREA IFAE EXCELENCIA SEVERO OCHOA BIST

Spanish Meeting on ET
8th 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 concretized after ESFRI

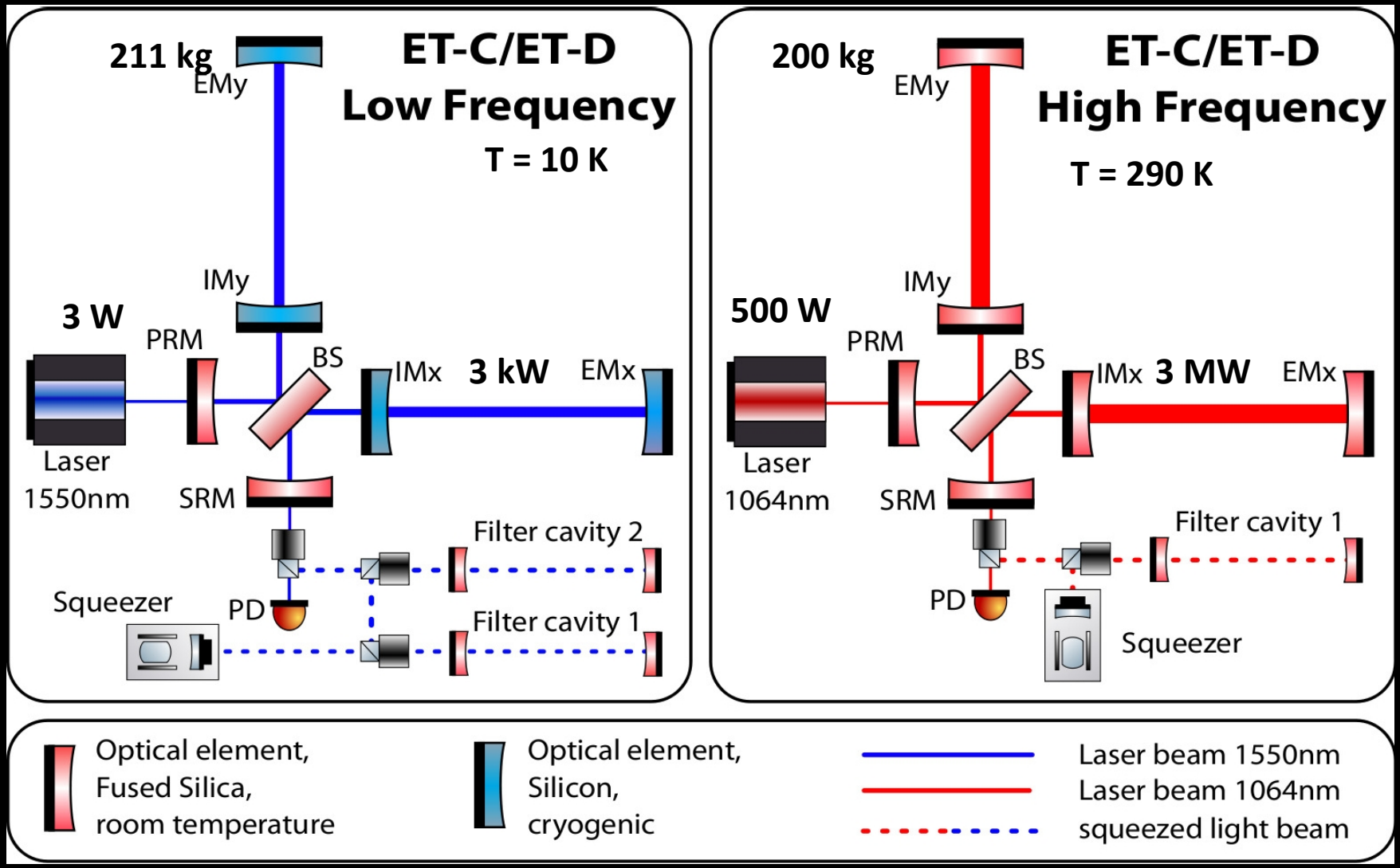
→ET Steering committee preparing the interview and answering the questions posted a priori by the panel

→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


211 kg
EMy
ET-C/ET-D
Low Frequency
T = 10 K
IMy
3 W
PRM
BS
IMx
3 kW
EMx
Laser
1550nm
SRM
Filter cavity 2
Squeezer
PD
Filter cavity 1
200 kg
EMy
ET-C/ET-D
High Frequency
T = 290 K
IMy
500 W
PRM
BS
IMx
3 MW
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

Q1: Enabling Technologies

ESFRI

ET EINSTEIN TELESCOPE

Challenging engineering

New technology in cryo-cooling

New technology in optics

New laser technology

High precision mechanics and low noise controls

High 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 technology

Evolved technology in optics

Highly innovative adaptive optics

High quality opto-electronics and new controls

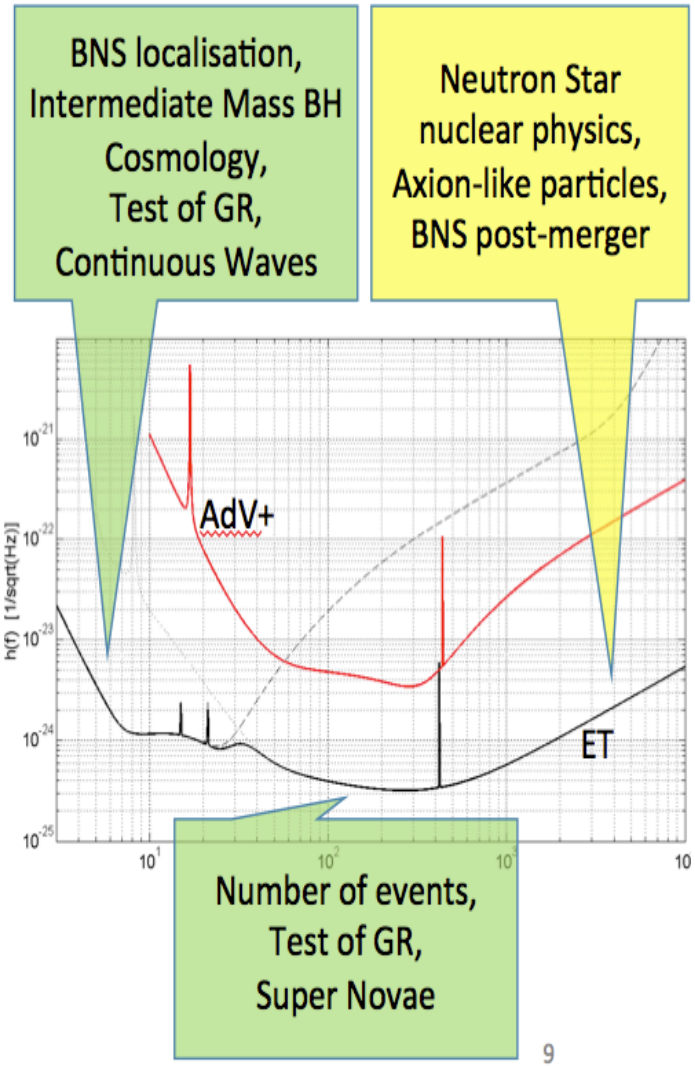
Q1: Critical technological aspects

- **High power circulating in the ET-HF detector**
  - The management of this power (~3MW) 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**

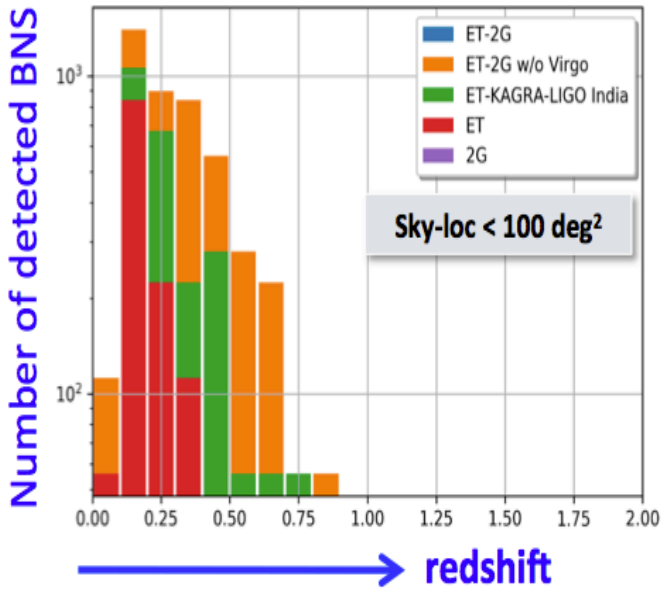


Questions (II)

- **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?**

Q2: The global GWD network

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



Number of BNS events with sky-loc	< 20 deg²	< 100 deg²
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/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

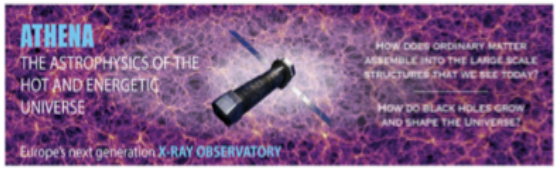
- **Q6**. What is the "secondment programme" referenced in the proposal and how will it be granted?

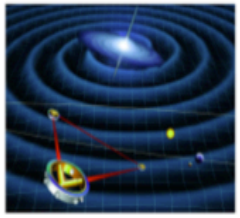
→ The ET site will host an excellence centre in GW research

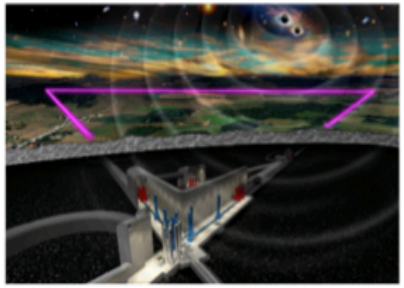
→ ET site will be an attractor for scientists in Europe and worldwide

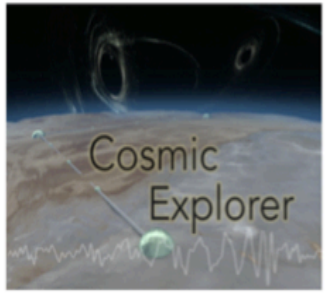
Multi-messenger observatories

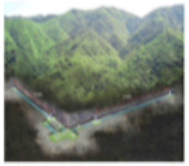
ET will operate in synergy with a new generation of innovative observatories











Advanced GW detectors+

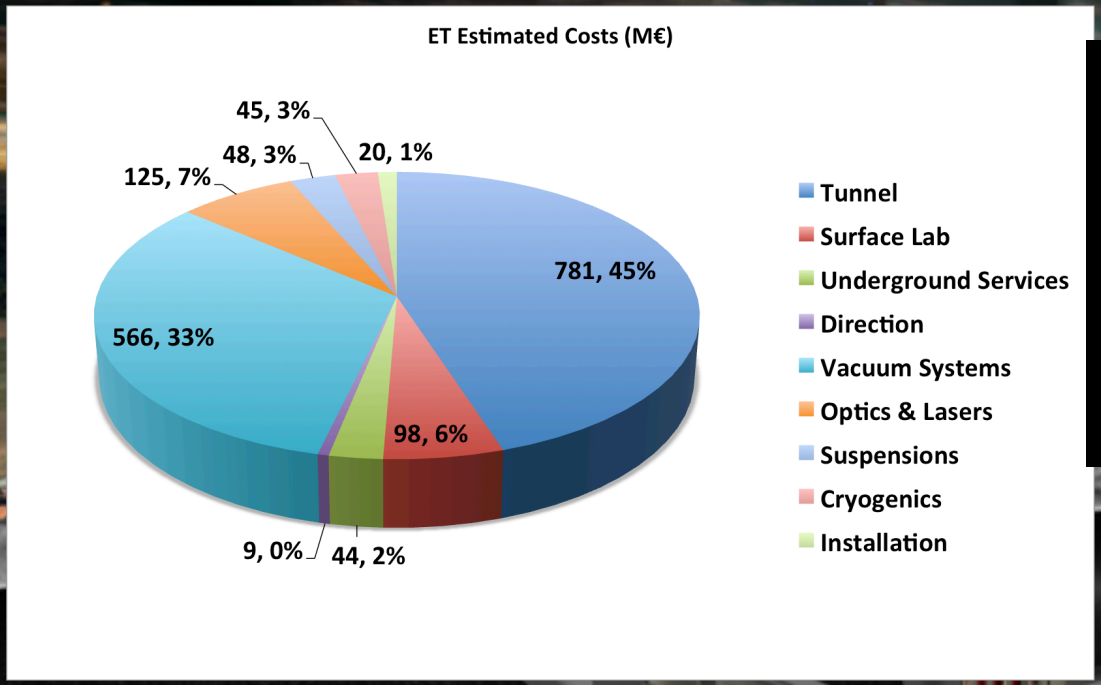
Questions (IV)

- **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



Preparatory phase (170M€)

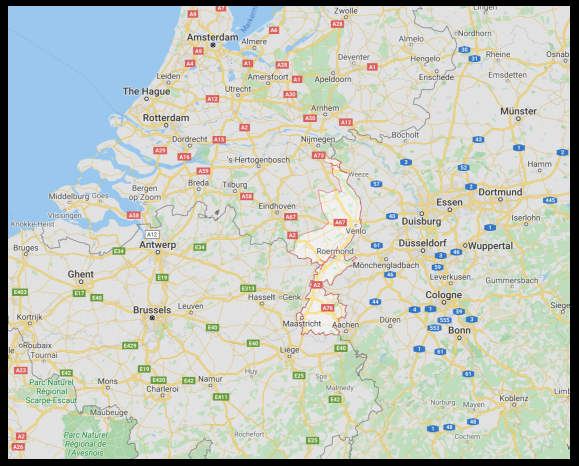
1. Site qualification (funded)
2. Site preparation (50 – 60 M€)
   Covered by host country
3. R&D on technology (95 M€)
   (how much Spain can contribute ?)

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

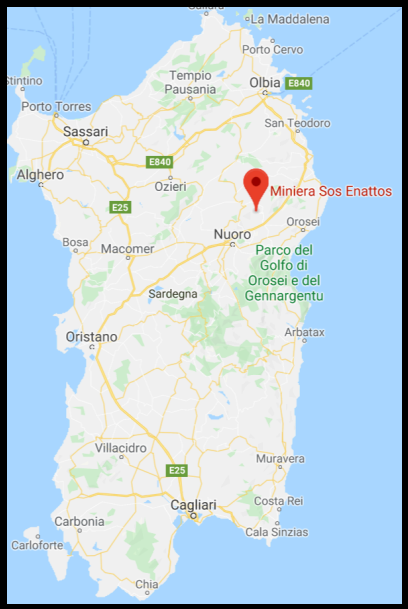
Construction : 1900 M€ (in 10 years)
M&O : 37M€ /year

Related to Q7-Q9



30 M€ investment
ETparthfinder

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



22 M€ investment
Lab in construction

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

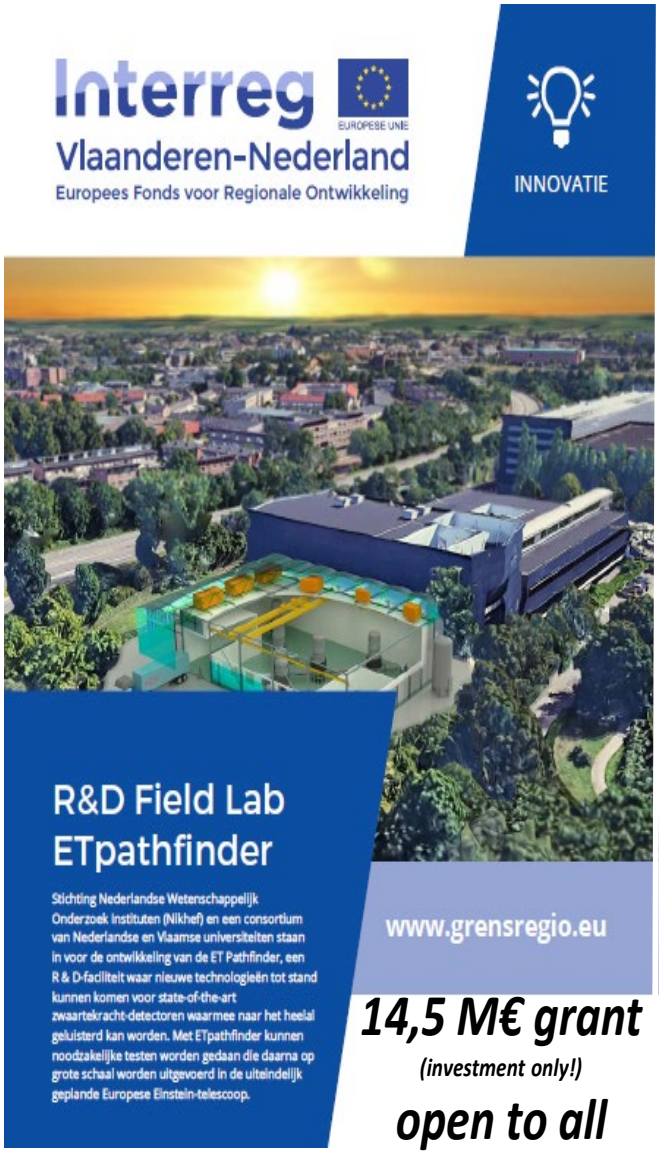
→ This might become a game changer

@ Sardinia
→ Promoted by INFN

?

Discussions taking place with other countries like France and UK

New technologies: *ETpathfinder R&D lab*



14,5 M€ grant

(investment only!)

open to all

1st phase: 2019-2022 (funded)

envisaged for many more decades

see: https://www.etpathfinder.eu/

Focus:

- *cryogenic silicon mirrors*
- *controls*

Projectleader:

S. Hild, Maastricht University

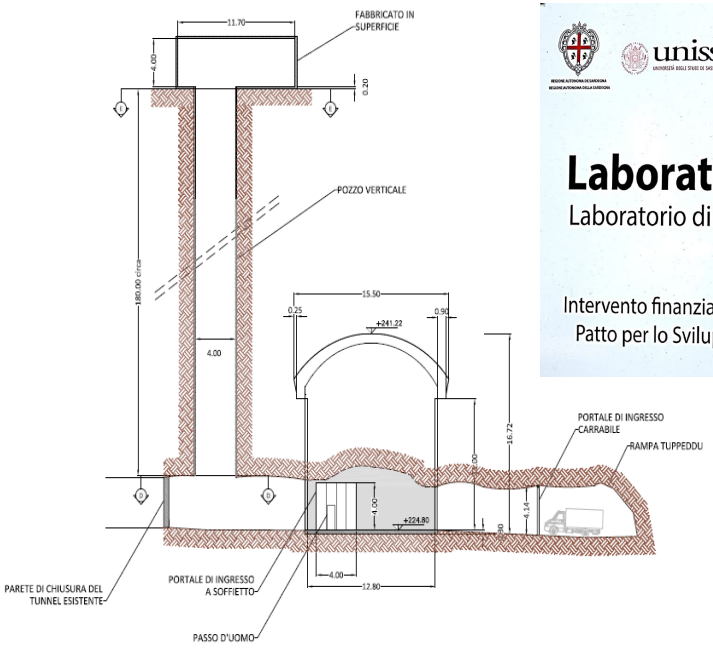
Sar-Grav Laboratory in Sos Enattos

Funded by Regione Sardegna (4M€)

- A 200m^2 **surface Laboratory** with annexed control room;
- 120m^2 **underground Laboratory** under construction

Focus:

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



ET symposium

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

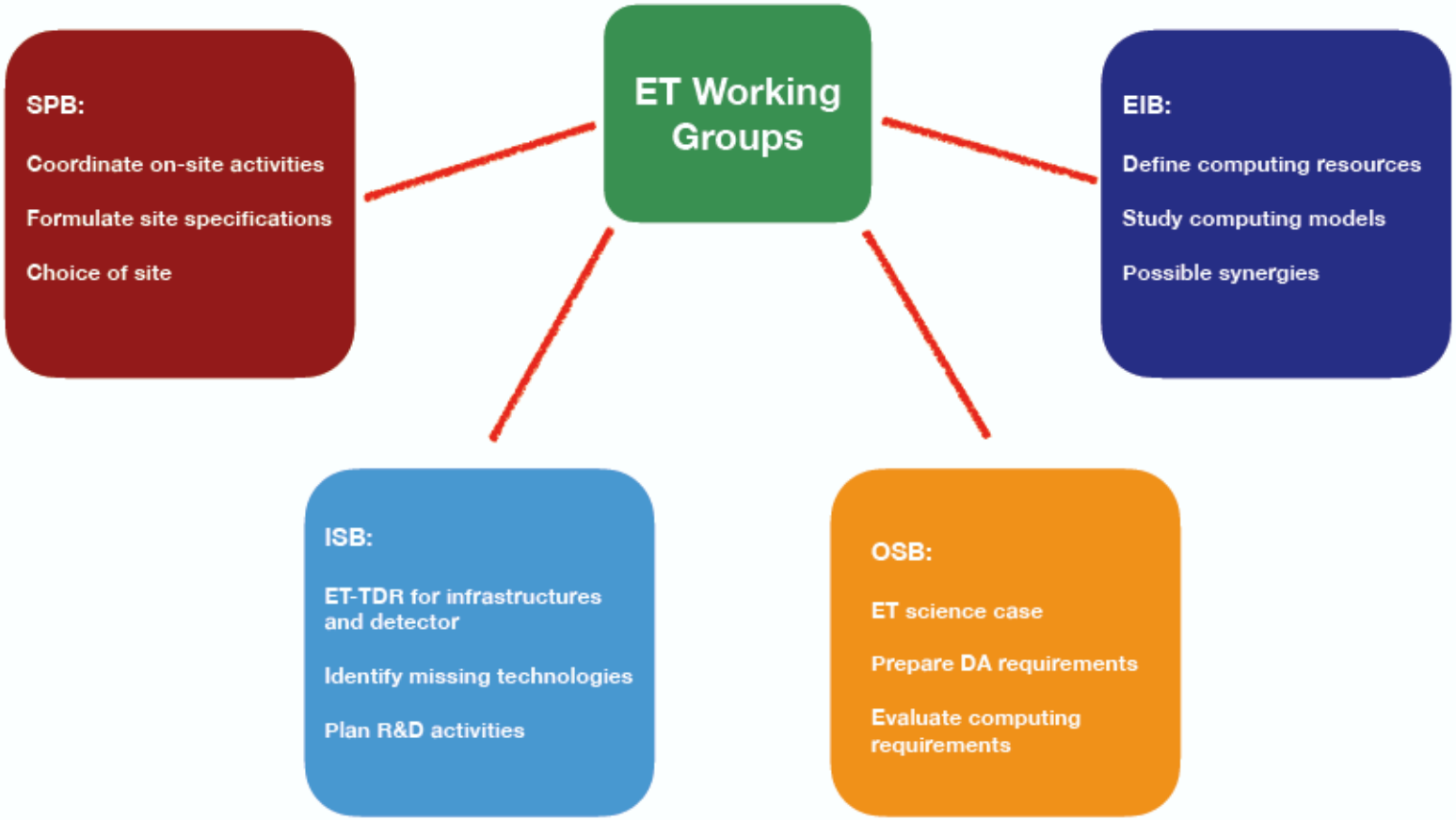
Questions V

- **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

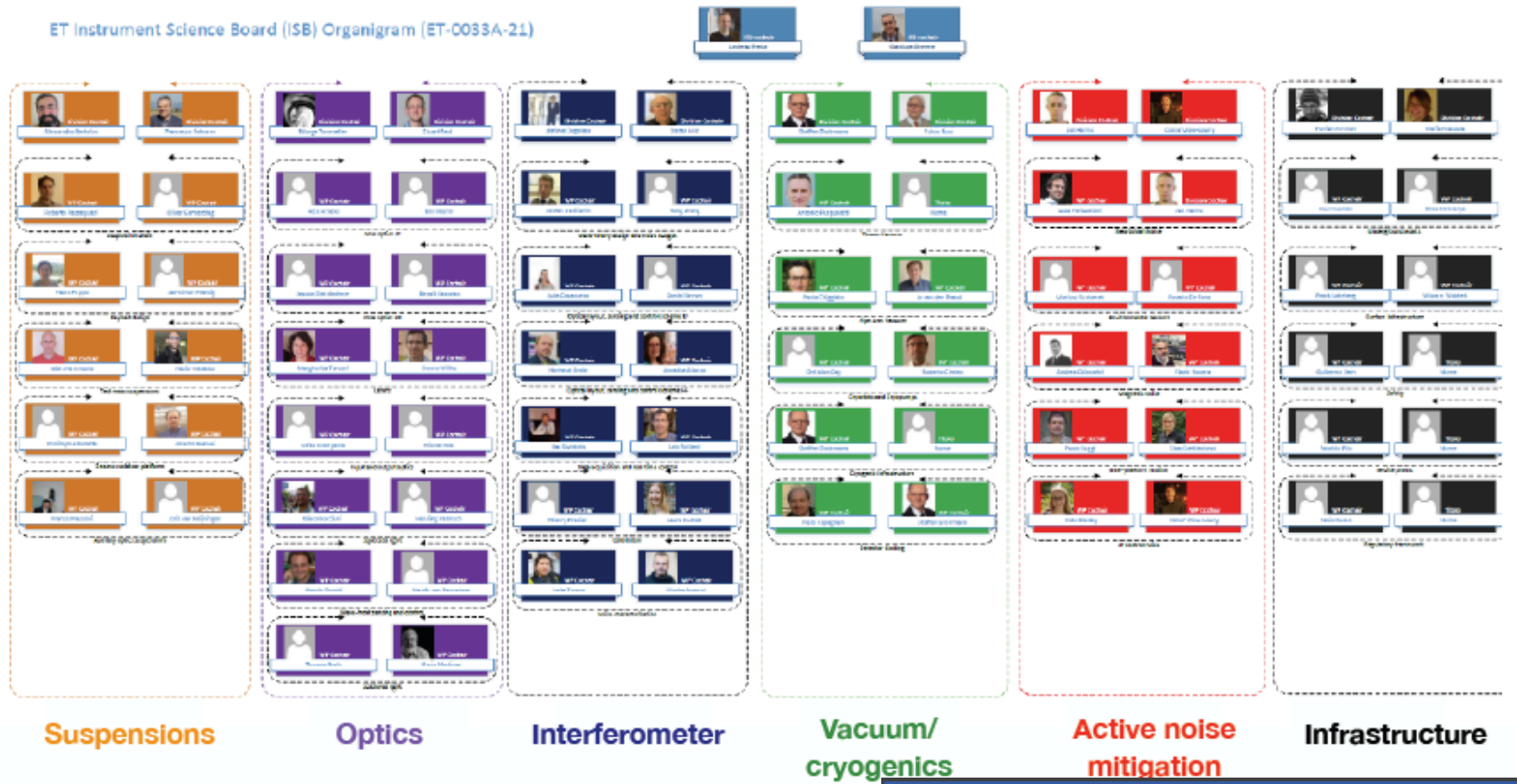
→Having a Strong Project Office with a Large Research Entity behind it would help (CERN, DESY, etc…)

ET Organisation

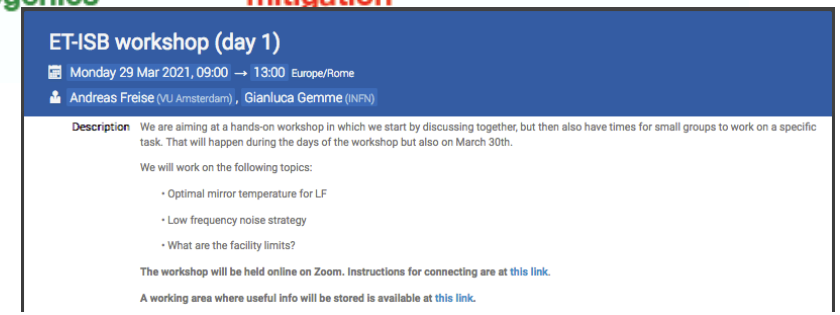


Instrument science board (ISB)

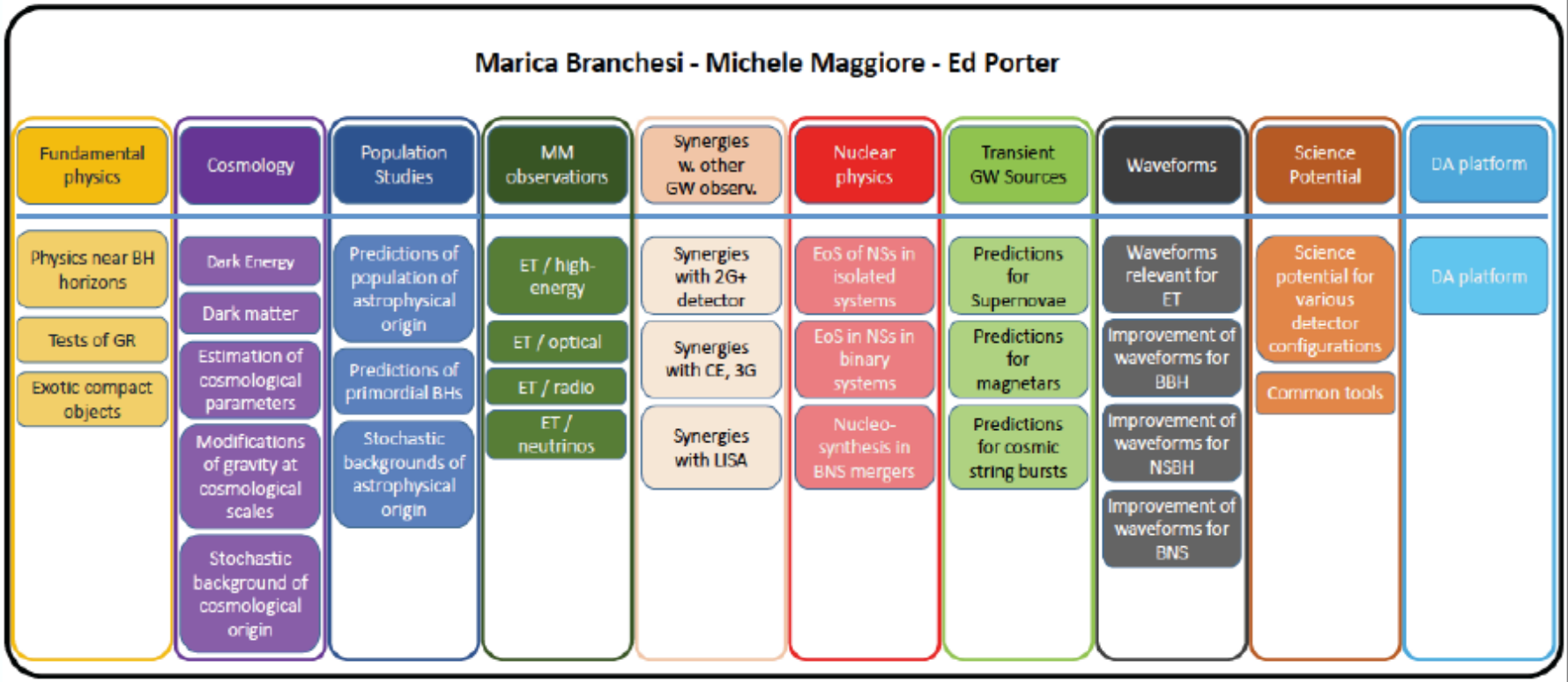
https://wiki.et-gw.eu/ISB/WebHome



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



Observational science board (OSB)



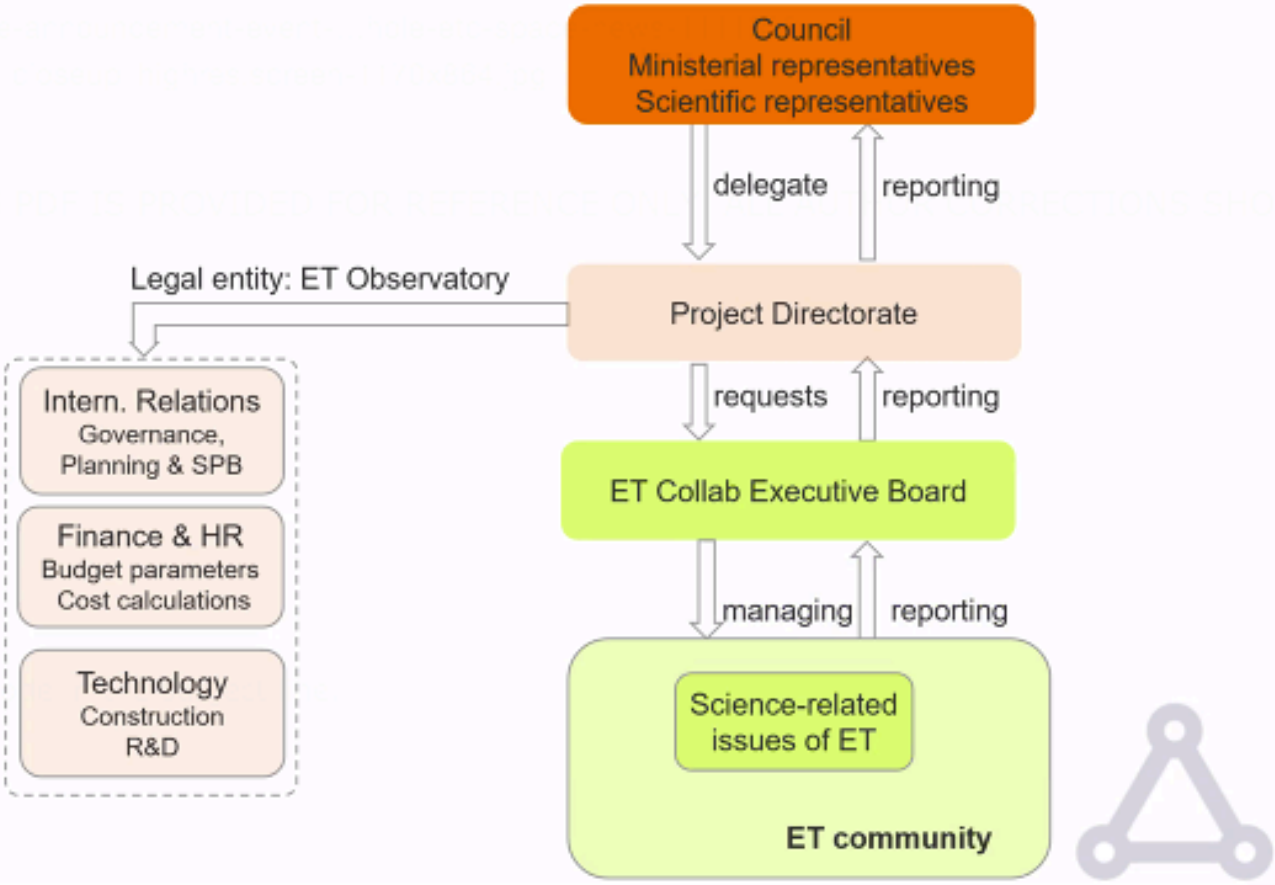
H. Lück, LVK 2021

Governance

Construction phase

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