

Structure of the Observational Science Board

(updated September 2021)

1 Mandate

The Observational Science Board (OSB) envisages to develop the Einstein Telescope science case, to start building the scientific community around it, and to bring it to a scientific maturity to exploit the data taken when ET will start operation. The OSB main goals, for an estimated timeline of the next four years, can be summarized as follow:

- Develop the ET science case to help the instrument technical development and implementation, and later to fully exploit the specific capabilities of the ET detector;
- Stimulate the interest of the scientists going beyond the gravitational wave community, for example involving cosmologists, nuclear physicists, high-energy physicists, astronomers and astrophysicists;
- Build the synergy, collaboration and coordination with other gravitational-wave, electromagnetic, neutrino observatories which will operate together with ET or observatories able to give complementary insights into the ET science;
- Identify the specific data analysis and computing needs for ET and begin the development of data analysis tools and algorithms.
- Involve students, post-doc and early career researchers, and contribute to training the young community which will lead the ET data analysis and scientific interpretation when it will be operative;
- Contribute to generate broad public interest in the ET science.

In order to achieve the above goals the OSB stimulates and coordinates activities related to ET in the domain of theoretical physics/cosmology, astrophysics, gravitational-wave data analysis, and synergies with multi-messenger observations; provides and develops theoretical motivations for the ET Science Case, develops ET-related codes and tools and make them available to the community, starts exploratory work toward data analysis, and provides a pool of competences on the theoretical side that can address questions arising from the ET design studies.

Below we discuss specific activities for the OSB to develop the ET science case, build the ET science community, and stimulate the public interest. In order to carry out such activities, the OSB will be supervised and coordinated by three Chairpersons, and will be organized in Divisions (Divs). Division coordinators might further organized their division into Work Packages, if they consider this appropriate.

For the first four year period, the ET Steering Committee has appointed as OSB chairs: Michele Maggiore (Fundamental Science, Blue Book coordination), Marica Branchesi (Astrophysics, relations with the astronomical community) and Ed Porter (computing, data analysis). Division coordinators are in principle appointed for a two-year period. They can be removed earlier in case of lack of progress, or renewed if appropriate.

2 Blue Book

The development of the Science Case will be structured around a ‘Blue Book’, meant as a living document that summarizes and updates original work related to ET. This can be in the form of summary of relevant parts of papers in the literature, as well as original work performed specifically for the Blue Book. The timeline for a first version of the Blue Book is (tentatively) two years from the beginning of the structuring of the OSB. Taking Summer 2021 as a starting date for the activities, this leads (approximately) to Summer 2023.

The Blue Book will be organized in a series of chapters, corresponding to the different Divisions, under the responsibility of the corresponding division coordinators. The division coordinators have the task of organizing the work of the corresponding Division, of contacting and involving in the project the most appropriate persons, and managing the team that will be created through broad calls to the scientific community. The overall coordination of the Blue Book will be ensured by the Chairpersons of the OSB. The proposed structure, possibly subject to evolution in time in response to emerging needs, is as follows.

Div1: *Fundamental Physics*. Physics near BH horizon, tests of GR, exotic compact objects.

Coordinators:

Paolo Pani (Italy, Università di Roma ‘La Sapienza’)

Rafael Porto (DESY, Germany)

Chris van den Broeck (Utrecht, the Netherlands)

Div2: *Cosmology*. Dark energy, dark matter, estimation of cosmological parameters, modifications of gravity at cosmological scales; stochastic backgrounds of cosmological origin.

Coordinators:

Mairi Sakellariadou (King’s College, London, UK)

Angelo Ricciardone (Padova University, Italy)

Archisman Ghosh (Ghent University, Belgium)

Div3: *Population studies*. Predictions for population of astrophysical origins. Predictions for primordial BHs. Stochastic backgrounds of astrophysical origin.

Coordinators:

Michela Mapelli (Padova University, Italy)

Antonio Riotto (Geneva University, Switzerland)

Giulia Cusin (Geneva University, Switzerland and IAP, Paris, France)

Div4: *Multimessenger observations*. MMO with electromagnetic and neutrino facilities. High-energy, UV-optical-nIR, mm-radio, neutrinos.

Coordinators:

Susanna Vergani (Observatoire de Paris, France)

Giancarlo Ghirlanda (INAF, Italy)

Stephen Smartt (Queen's University Belfast, UK)

Div5: *Synergies with other GW observatories*. Synergies with 2G detectors, CE, LISA. Studies of the ET capabilities in various ground-based network configurations, such as ET+2G, ET+CE. In collaboration with Div1-Div4, Div6, Div7, work to identify the science case benefits of using a network of ground-based detectors. Studies of the potential of multi-band observations with LISA. Together with Div9, work in collaboration with the CE researchers toward the realization of mock data challenges and to solve common problems for data analysis with 3G detectors.

Coordinators:

Bangalore Sathyaprakash (Penn State, USA, and Cardiff, UK)

Nelson Christensen (ARTEMIS, Nice, France)

Samaya Nissanke (University of Amsterdam and Nikhef, the Netherlands)

Div6: *Nuclear Physics*. EoS of neutron stars in isolated and binary systems, nucleosynthesis in BNS merger.

Coordinators:

Tanja Hinderer (Utrecht, the Netherlands)

Michaela Oertel (Meudon, France)

Tim Dietrich (AEI and Potsdam University, Germany)

Div7: *Transient GW sources*. Predictions for Supernovae, magnetars, cosmic string bursts, other non CBC transients.

Coordinators:

Marie-Anne Bizouard (ARTEMIS, Nice, France)

Pablo Cerda-Duran (Valencia, Spain)

Enrico Cappellaro (INAF, Italy)

Div8: *Waveforms*. Study of waveform relevant for ET. Improvement of the waveforms for BBH, NSBH, BNS. Development of waveforms for IMBHs and IMRIs.

Coordinators:

Harald Pfeiffer (MPI, Germany)
Patricia Schmidt (Birmingham, UK)
Laura Bernard (Meudon, France)

Div9: *Scientific potentials of different detector configurations, and common tools*. This Division provides a bridge with the Instrument Science Board (ISB) and works in strong collaboration with it. Given the strain sensitivities in different detector configurations provided by the ISB, Div8 develops publicly available tools to calculate the ET capabilities for astrophysical predictions (e.g. horizon, range and detection efficiency for different systems of compact object binary and other gravitational-wave sources). It also provides freely available software to calculate standardized and official figures of merits for different detector configuration and for different detector networks. Div8 is also responsible for ‘quickly’ responding to needs of the collaboration for presenting plots and results to funding agencies, conferences, etc.

Coordinators:

Ik Siong Heng (Glasgow, UK)
Michal Bejger (Warsaw, Poland)
Andrea Maselli (GSSI, Italy)

Div10: *Data analysis platform*. Div10 will have the role of building a common data analysis platform, identifying the best option for computing resources (eg shared resources, cloud, etc.), developing solutions to ET data-analysis problems, and harmonizing the data analysis work tuned toward different WPs, ensuring the compatibility of the tools used and avoiding duplication of the work. In order to ensure connection and coordination between the development of data analysis and the physics/astrophysics studies, each researcher working on the data analysis for specific science cases or gravitational-wave sources will be asked to be member of both Div10 and the relevant(s) physics/astrophysics Divisions (Div1 to Div8). Activities toward mock data challenges should also be started. It is advisable to have a strong connection with similar activities in CE (in collaboration with Div5), given the similarity of the data analysis problems for 3G detectors. The study of the computing need will be performed in strong connection with the Infrastructure Board.

Div10 could possibly evolve into a separate Data Analysis Board, after the four-year timeline covered by this document.

Coordinators:

Tania Regimbau (Annecy, France)
John Veitch (Glasgow, UK)
Elena Cuoco (EGO, Italy)
Chris van den Broeck (Utrecht, the Netherlands)

The work will start by identifying the main open questions that ET is expected to answer and which is not possible to address with the current detectors.

No publication policy will be enforced at the current stage of development of the OSB, since this would not be attractive to enlarge the community and involve students. The participating groups will be free to publish separately their original results in the usual forms (journals, etc.) The only requirement asked is that, about a week before posting a paper of relevance to ET to the arxiv/journal, the authors will circulate the draft to the OSB. The OSB chairs and DIV coordinators have the responsibility to check that no wrong or confusing statements concerning ET are made, to verify that there is the right recognition of work done by others within the divisions, and to prevent potentially conflictual situations with other ET members. In order to encourage collaboration and the development of the ET community, the DIV coordinators should encourage people to share on-going projects well in advance with respect to the paper circulation and create an environment where the members of the OSB feel protected on sharing ideas without being scooped by others. All the members are strictly requested to follow the right code of conduct under penalty of exclusion from the collaboration, and the DIV coordinators are requested to monitor on correct behaviour. In case of conflicts or incorrect behaviour, the members of the OSB are encouraged to contact the DIV coordinators and/or the OSB chairs.

The Divisions organized for the writing of the Blue Book are expected to naturally evolve and widen into operative Divisions to be ready for the ET observations. The OSB will monitor and drive this transition.

3 Div-S: Synergies with future electromagnetic and neutrino observatories

In order to maximize the ET science results, it is of strategic importance that there will be electromagnetic/neutrino facilities optimized to work in synergy with ET. This requires to involve the world-wide astrophysical/neutrino communities in the ET multi-messenger science development and be sure that they will undertake all the steps to prepare their communities. The OSB needs to work in tight contact with scientists from other observatories to provide instrument scientific requirements in terms of technical development, implementation and operations based on multi-messenger science cases.

While the development of the multi-messenger ET science case is domain of Div4, the synergies with other observatories require external activities:

- to identify the best instruments to work in synergy with ET, to identify the possible missing synergies and the possible plan to establish a connection;
- to keep updated information about external experiments, and be sure that other experiments have the correct information about ET;
- to discuss challenges (e.g. missing instruments, optimization of operation) and define a plan to tackle them;
- to stimulate discussion on the development of networking and communication infrastructures, and on how tackling technical issues (e.g. how to deal with billions of

alerts, and how to make data accessible and usable to a larger and larger community following the FAIR principle, common platform);

- to be updated about synergy fund opportunities, or European project synergy activities.
- to stimulate the interest of observers on the ET science, e.g by proposing dedicated workshops on synergies(e.g. “ET in the era of ELT”, “ET and CTA synergy”).

These activities are organized in a separate Division, Div-S, which is intended as a forum and not as an operational division as the ones described above. The Div-S includes the OBS chairpersons, the Div4 coordinators, and reference people from the external experiments (who are not expected to become ET OSB members). All the activities of the Div-S need to be developed in tight contact and coordination with the ET Executive Board.