Einstein Telescope Design Study: WG4 Goals

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I. INTRODUCTION

Einstein Telescope is a third generation gravitational wave antenna which is hoped to be a factor 10 better in sensitivity than advanced detectors with a possible wide band sensitivity from 1 to 5 Hz all the way up to 10 kHz. This is a frequency window in which we can expect a wide variety of sources and the sensitivity will be deep enough to address a range of problems in fundamental physics, cosmology and astrophysics.

The goal of ET design study is to identify potentially interesting problems and study them in greater depth in the context of instrument design. The GWIC Road Map will serve as a reference for our study with the goal to make in-depth exploration of what science goals can be met the Einstein Telescope.

II. WORKING GROUP 4

The goal of WG4 is to address ET science and data analysis. The above frequency range and sensitivity pose some serious and unprecedented technological challenges. The design goal is to get the best possible sensitivity in the range $[1, 10^4]$ Hz but compromises might have to be made based on the level of technical challenge, the cost to meet those challenges, site selection, etc. The ultimate design should be based on the scientific merit of the different trade-offs.

WG4 will set forth key *science requirements* to be met by a third generation detector the examples of which include

1. Studying cores of compact objects and general relativistic instabilities.
2. Solving the enigma of gamma-ray bursts and resolving their different classes.
3. Understanding the mass-spectrum of compact stars and their populations (neutron stars, strange stars, etc.).
4. Measuring the cosmological parameters with GW standard sirens.
5. ...

We need to be able to evaluate the science potential of ET for different geometrical and optical configurations, choice of materials and site, etc., each corresponding to a different sensitivity curve.

A detector with such a sensitivity window and span will pose new data analysis challenges. There will be many classes of sources all visible at the same time requiring a paradigm shift in the way data is currently analyzed. Moreover, some of the souces that are considered to be transient will not be so in ET requiring greater computational costs as well as the development of new search algorithms. A careful and comprehensive study of the data analysis challenges and solutions should be carried out along side the science goals.

In the light of this it is envisaged that the participating groups will have two primary responsibilities:

1. Address the science that ET can do which a second generation detector can't. Group the science into one of fundamental physics, cosmology and astrophysics and prioritize the science potentials.
2. Develop tools that can be used to evaluate the performance of different detector configurations in the context of science goals and develop a metric based figure-of-merit to pick an optimal choice for the design of ET.
3. Evaluate the data analysis requirements and study if computational cost is a limiting factor in meeting the science goals.

III. SUB GROUPS OF WG4

The activities of WG4 will be carried out under the following subgroups.

1. Compact binary coalescences (Chris Van Den Broeck)
   (a) Binary neutron stars (TR, JV, AV, BSS, BM, FM, DB)

   (b) Neutron star-black hole binaries (BSS, JV, AV, TR)
   (c) Stellar-mass binary black holes (BSS, JV, AV, TR, BM, FM, DB)
   (d) Intermediate-mass binary black holes (JG)
   (e) Extreme mass ratio inspirals (LB)

2. Neutron stars as continuous wave sources (Badri Krishnan)
   (a) Lower frequency or old pulsars and neutron stars (GW, MP, CP)
   (b) High frequency or new and recycled pulsars (GW, MP, CP)
   (c) Blind searches (GW, MP, CP)
   (d) Low mass X-ray binaries (CP)

3. Multi-messengers:(Patrick Sutton)
   (a) Triggered and follow-up searches (SH)
   (b) Supernovae, hypernovae, gamma-ray bursts, , LMXBs, Magnetars, radio transients (KK, KG, HS, WK, NS, TA, BM, FM, DB)
   (c) Neutrino detectors, cosmic rays
   (d) Timing information needed from known CW sources

4. Transient sources (A.N. Other)
   (a) Black hole mergers and quasi-normal modes (NA, KK, KG, HS, WK, NS, TA)
   (b) Glitches in pulsars and neutron-star normal modes (NA, KK)

5. Stochastic sources (Tania Regimbau)
   (a) Primordial backgrounds
   (b) Astrophysical backgrounds

6. Data analysis requirements (Leone Bozzi)
   (a) Computational resources for prioritized list of science goals (LB, BA)
   (b) Dedicated resources (LB, BA)
   (c) Distributed E@H-type resources (LB, BA)

IV. DELIVERABLES AND ORGANIZATION OF THE WORK

WG4 deliverables are a set of documents on aspects mentioned in Section II in respect of the sources in Section III and any additional issues that come up as the project progresses. People who work on different aspects of the project are strongly encouraged to publish results on their own to strengthen and corroborate the choices made during the design study. However, I do expect one final publication on ET Science (possibly an initial short one too) with everyone involved on ET Science. This could either be a review or a (longish) conference proceedings.

I expect to organize monthly telecons and quarterly f2f meetings where different groups report on problems and progress. We will use a wiki and a cvs/svn archive for recording and reporting the work carried out by the Study Team.

Participation in the Study could be either as a member of an institution that led the FP7 proposal or via the ET Science Team.

1. The ET web pages and resources are at: `http://www.et-gw.eu/`
2. To register for WG4 mailing list go to: `https://mail.virgo.infn.it/mailman/listinfo/wg4-et`. The e-mail address for the group is `WG4-et AT ego-gw.it`
3. WG4 working area is at: `https://workarea.et-gw.eu/et/WG4-Astrophysics`
4. To register for the ET Science Team go to: `https://mail.virgo.infn.it/mailman/listinfo/science-team-et`. The e-mail address for the Science Team is: `science-team-et AT ego-gw.it`

V. PARTICIPANTS

Table I lists the ET-funded organizations and the person-months they have committed (not necessarily funded by FP7). Here is a list of people who have agreed to take part in the project.

1. Sathyaprakash, B.S. (Cardiff, WG4 Coordinator, 0.3)
2. Allen, Bruce (Hannover)
3. Andersson, Nils (Southampton)
4. Apostolatos, Theoharis (Thessaloniki/Athens)
5. Arun, K.G. (Paris)
6. Barack, Leor (Southampton)
7. Birindelli, Simona (Pisa)
8. Bose, Sukanta (Pullman)
9. Bosi, Leone (Perugia, 0.5)
10. Bozzi, Antonella (Cascina)
11. Buskulic, Damir (Annecy)
12. Cuoco, Elena (Pisa, 0.2)
13. Fairhurst, Stephen (Cardiff)
14. Ferrari, Valeria (Rome)
15. Freise, Andreas (Birmingham)
16. Gair, Jon (Cambridge)
17. Glampedakis, Kostas (Tuebingen)
18. Hendry, Martin (Glasgow)
19. Heng, Siong (Glasgow)
20. Hild, Steffan (Birmingham)
21. Iyer, Bala (Paris)
22. Kastaun, Wolfgang (Tuebingen)
23. Kokkotas, Kostas (Tuebingen)
24. Krishnan, Badri (Golm)
25. Leuck, Harald (Hannover)
26. Marion, Frederique (Annecy)
27. Misra, Chandrakant (Bangalore)
28. Mottin, Eric-Chassande (Paris)
29. Mours, Benoit (Annecy)
30. Palomba, Cristiano (Rome)
31. Pitkin, Matthew (Glasgow)
32. Regimbau, Tania (Nice)

TABLE I: Resources committed to WG4 by the ET participating institutions

Participant	EGO	INFN	AEI	CNRS	B'ham	Glasgow	NIKHF	Cardiff
Per-months yr^{-1}	7	16	10	22	8	8	18	47

33. Parameswaran, Ajith (Caltech)
34. Regimbau, Tania (Nice)
35. Sopuerta, Carlos (Barcelona)
36. Sotani, Hajime (Tuebingen)
37. Stergioulas, Nick (Thessaloniki/Athens)
38. Sutton, Patrick (Cardiff)
39. Van Den Brand, Jo (Amsterdam)
40. Van Den Broeck, Chris (Cardiff, 0.5)
41. Vecchio, Alberto (Birmingham)
42. Veith, John (Birmingham)
43. Vinet, Jean-Yves (Nice)
44. Woan, Graham (Glasgow)