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Amaldi 12 Town Hall Meeting: 3G Ground-based GW Detectors

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Outline

- *Some Opening Remarks*
- *Open Discussion Framed By a Few Questions*

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The Terrain in the Next Few Years

- Ground-based detectors have made the first detections of gravitational waves

→ *The window of GW astronomy has opened, moving us into the arenas of frontier strong field physics, high energy astrophysics, multi-messenger astronomy*

The case for proposing a 3G detector will never be as good as it is in the next few years!

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Science Case for 3G detectors

The case for a 3G detector begins with science:

- **What capability can you achieve? What science can you do with that capability? What will it cost?**
- **These questions are all linked, and have to be iterated right up until the construction proposal is submitted**

- ET Design Study provides a good basis for a 3G science case, but must be refined as we now know more

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Steps to funding a US 3G detector

- Advanced LIGO must reach its design sensitivity
  - #1 -- because it provides proof that we understand and can tame the noises in 2G interferometers
  - #2 -- it will demonstrate to funding agencies that we can deliver on our design goals
- The science case for 3G detectors must be extremely well developed given what we know at the time of the proposal
- The community will have to prepare their respective funding agencies that big projects are being planned
  - It can take 5 years to get a project 'queued up' into the NSF Major Research Equipment and Facilities Construction budget
- ***(in the US)*** An external evaluation must be conducted by a panel of experts
  - Is the science case sufficiently strong for a 3G detector?
  - Is the technology development mature?
  - Is their preliminary costing and project planning, or is there a path to those?
  - ….
- International planning and coordination
- Support and advocacy from an outside community
  - They support GW science because it adds to their science
  - For the GW community, it's the astronomers, perhaps nuclear physicists

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Funding Agency Coordination

- In the US, agencies (NSF) will follow scientific community desires …
- … subject to boundary conditions
  - Boundary Condition #1: available agency budgets and budget projections (dictated by US Congress)
  - Boundary Condition #2: agency priorities (eg, applied vs fundamental science)

- NSF has established the Gravitational Wave Agency Correspondents group to lay the groundwork for establishing coordination among agencies that support ground-based GW research
  - Current membership: ARC (Australia), CFI (Canada), CNRS (France), CONACYT (Mexico), DFG (Germany), INFN (Italy), NASA (US), NSF (US), STFC (UK), Indian DAE membership pending
  - A working group, ie, no Directors, Presidents, Chiefs

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External Evaluation by Blue Ribbon Panels

- In the US, blue ribbon panels play a critical role in informing agencies on science priorities and road mapping how a specific field will develop
- Two primary routes: 1) field-specific NRC studies & 2) Decadal Surveys

1. **Field-Specific National Research Council Studies**
   - NRC is formally part of the US National Academies of Science, Engineering, and Medicine
   - Studies are both comprehensive and intensive
     - 10-15 members, membership is a mix of scientists from within the community and objective outsiders
   - Agencies must request and fund them (cost: up to $500k)
2. **Decadal Surveys → Astro2020 Decadal Survey**
   - Astronomy and various fields of Physics conduct Decadal Surveys
     - Initial LIGO was endorsed in a 1986 physics decadal survey
   - Decadal Surveys carry different weights in Physics & Astronomy
     - In Astronomy, they are treated with *biblical reverence* (although they aren't always followed by agencies due to funding constraints)
     - In Physics, they are useful as inputs to physics funding priorities

- **A large US 3G detector construction project will almost certainly have to go through one of these two routes**

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A few considerations in formulating the Global 3G Network

- First generation GW interferometers were independently designed and constructed.
  - LIGO, Virgo (joint French, Italian), GEO (joint German, UK)
  - We were competitors at the time
- Second generation GW detectors had some elements of coordination …
  - Advanced LIGO had US, UK, German, Australian contributions
- … but by and large were independently designed and built
- We now collaborate on the analysis of GW data
  - LIGO-Virgo agreement (2007), LV pre-agreement with KAGRA (2013)

For 3G, the GW community intends to 'go big'

- The scale of the project (at least two 10+ km class interferometers) may require coordination across collaborations/projects to take advantage of 'economies of scale'
- Advantages of coordination
  - (At least partial) homogeneity in design and construction
  - Coordinated site selection for optimal network design
  - Makes best use of distributed expertise
- Disadvantages of (or challenges in) coordination
  - Requires establishment of robust management structure, necessitating giving up some control by partners
  - Requires robust system engineering, establishment of standards, interface control, quality assurance program, …

1. Science Case Subcommittee

Mission: Commission a study of ground-based gravitational wave science from the global scientific community, investigating potential science vs architecture vs. network configuration vs. cost trade-offs, recognizing and taking into account existing studies for 3G projects (such as ET) as well as science overlap with the larger gravitational-wave spectrum.

Vicky Kalogera	**(NU, co-chair)**	Stefan Hild	(Glasgow, UK)
B. Sathyaprakash	**(Penn State, co-chair)**	Mansi Kasliwal	(Caltech, USA)
Matthew Bailes	(Swinburne, Aus)	Luis Lehner	(Perimeter, Canada)
Marie Anne Bizouard	(CNRS, France)	Ilya Mandel	(Birmingham, UK)
Alessandra Buonanno	(AEI, Germany)	Vuk Mandic	(Minnesota, USA)
Adam Burrows	(Princeton, USA)	Maria Alessandra Papa	(AEI, Germany)
Monica Colpi	(INFN, Italy)	Sanjay Reddy	(INP, USA)
Matt Evans	(MIT, USA)	Stephan Rosswog	(Oskar Klein, Sweden)
Steve Fairhurst	(Cardiff, UK)	Chris Van Den Broeck	(Nikhef, Netherlands)

2. R&D Coordination Subcommittee

Mission: Develop and facilitate coordination mechanisms among the current and future planned and anticipated ground-based GW projects, including identification of common technologies and R&D activities as well as comparison of the specific technical approaches to 3G detectors. Possible support for coordination of 2G observing and 3G construction schedules.

Harald Lueck	**(AEI, co-chair)**	Jan Harms	(Urbino, Italy)
David McClelland	**(ANU, co-chair)**	Giovanni Losurdo	(Caltech, USA)
Rana Adhikari	(Caltech, USA)	Anil Prabkahar	(IIT Madras, India)
Masaki Ando	(NAOJ, Japan)	Fulvio Ricci	(INFN Rome, Italy)
Marty Fejer	(Stanford, USA)	Norna Robertson	(Caltech, USA)
Andreas Freise	(Birmingham, UK)	Benno Willke	(AEI, Germany)
Gabriela Gonzalez	(LSU, USA)	Mike Zucker	(MIT, USA)

5. Governance Structures Subcommittee

Mission: By applying knowledge of the diverse structures of the global GW community, propose a sustainable governance model for the management of detector construction and joint working, to support planning of 3rd generation observatories.

Federico Ferrini	**(Italy, EGO, co-chair)**
Jay Marx	**(USA, LIGO, co-chair)**
Beverly Berger	(USA, LIGO)
Gabriela Gonzalez	(USA, LIGO)
Jim Hough	(UK, GEO)
Stavros Katsanevas	(France, CNRS)
Ajit Kembhavi	(India, LIGO-India)
Frank Linde	(Netherlands, Nikhef)
David McClelland	(Australia, ANU)
Masatake Ohashi	(Japan, KAGRA)
Fulvio Ricci	(Italy, Virgo)
Gary Sanders	(USA, TMT)
Stan Whitcomb	(USA, LIGO)

Time Scales

- GWIC will work over the next 12 months to assemble a preliminary report and set of recommendations to the community by next summary
- Preliminary report will be broadly circulated for comment and input among the relevant communities.
- Interim report not later than December 2018 delivered to relevant communities and Agencies
- Expect to have a final report sometime in 2019

- The GWIC report/recommendations should serve to focus and align the community, leading to next steps

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An Open Call to Get Involved with Developing the Science Case for the 3G Detector Network

Invitation for Expression of Interest:

Open call to engage with the GWIC International 3G Science Case Team and contribute to the development of the science case for the next generation of ground-based gravitational-wave detectors by expressing interest in joining relevant working groups.

The detection of gravitational waves in 2015 has ushered in a new era of discovery. Gravitational waves will advance our exploration of extreme astrophysics and gravity and address open questions in fundamental physics and astronomy. Judging by the revolution in our understanding of the cosmos brought about by multi-wavelength astronomy (radio, infrared, ultraviolet, x-ray and gamma-ray beyond the optical band), gravitational waves observations are likely to reveal objects and physical phenomena never imagined before, provide crucial new insights into some of the most fascinating and powerful events in the universe, while boosting the impact multi-messenger astronomy.

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The 3G Science Case Team will carry out its work in part by engaging the whole physics and astronomy community through the formation of a number of working groups (WGs). These WGs will be led by members of the 3G SCT, potentially with deputy chairs selected from the scientists expressing interest. The WG topics will center around key questions in fundamental physics, astrophysics and cosmology. Examples include but are not limited to:

- extreme gravity, dynamical spacetimes, tests of general relativity and its alternatives
- equation of state of matter at extreme density and internal structure of neutron stars
- formation and evolution of compact binaries in different physical conditions
- formation & evolution of light seed black holes and their growth
- astrophysics of stellar collapse and supernovae
- astrophysical and primordial stochastic backgrounds
- cosmology and cosmography
- numerical relativity simulations and analytical relativity theory

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An Open Call to Get Involved with Developing the Science Case for the 3G Detector Network

With this letter, we invite all interested individuals to join the *3G Science Team* and contribute to developing the science case for the next generation of detectors. The invitation is open to anyone who would like to contribute to this effort, regardless of seniority. If you are interested in joining the science team please send the co-chairs of the Science Case Team (Vicky Kalogera <vicky@northwestern.edu> and B.S. Sathyaprakash <bss25@psu.edu>) a short, 1-page CV (which will be used as your bio on 3G web site), a brief summary of your current research interests (0.5 page) and science topics (from the list above or other) to which you would like to contribute; this will help us gauge the interest of the community in various topics and in formulating the working groups. The deadline for the receipt of letters of intent is 31 July 2017. Working groups are expected to begin their work no later than the end of August 2017, with the goal of producing the 3G Science Case document by the end of 2018. For any questions, please contact co-chairs or any member of the Science Team.

OR: gwic-3g@sympa.ligo.org

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Very Open Questions

- What should the 3G network look like?
  - How many? Where? What topology? homogeneous or mixed?
- How to map science case onto detector design?
  - Eg, 40 km arm length put FSR at 3.75 KHz, in the range of signals produced by BNS mergers
- How much coordination is needed among the builders of 3G detectors?

  One detector replicated N times

  ←....→

  Heterogeneous detectors with common technologies
- What is the role of the 2nd gen detectors in the 3G eras
- How should we be reaching out to other communities to make them aware and, then, advocate?
  - Transient and high energy astronomy; numerical GR, nuclear physics; atomic, molecular, optical physics, high energy physics
- How should the ground-based GW community interact with the Astro2020 Decadal survey (US) and APPEC Roadmap (EU)

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The Floor is Open!!