How to Manage a Large International Gravitational Wave Collaboration

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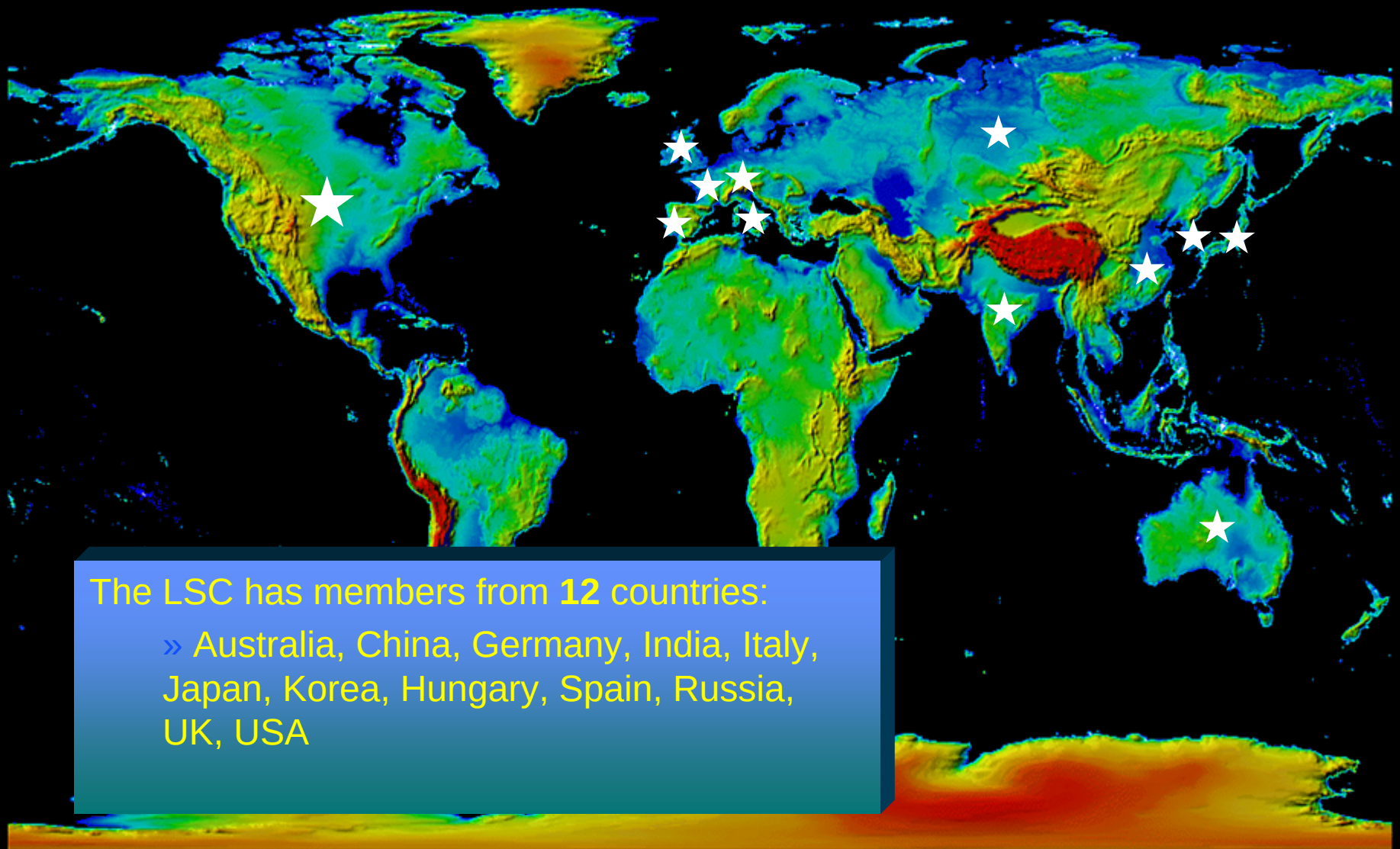
LIGO Scientific Collaboration

Outline

- The LIGO Scientific Collaboration
- The structure of the LSC
- International partnerships
- Challenges and lessons in managing large collaborations

Geographic distribution of the LIGO Scientific Collaboration



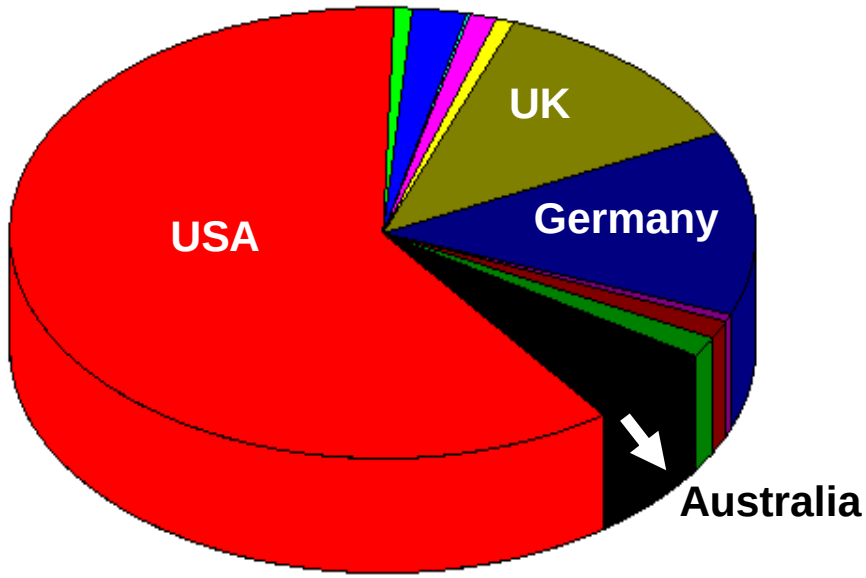
The LSC has members from **12** countries:

» Australia, China, Germany, India, Italy, Japan, Korea, Hungary, Spain, Russia, UK, USA

LIGO Scientific Collaboration

LSC facts and figures

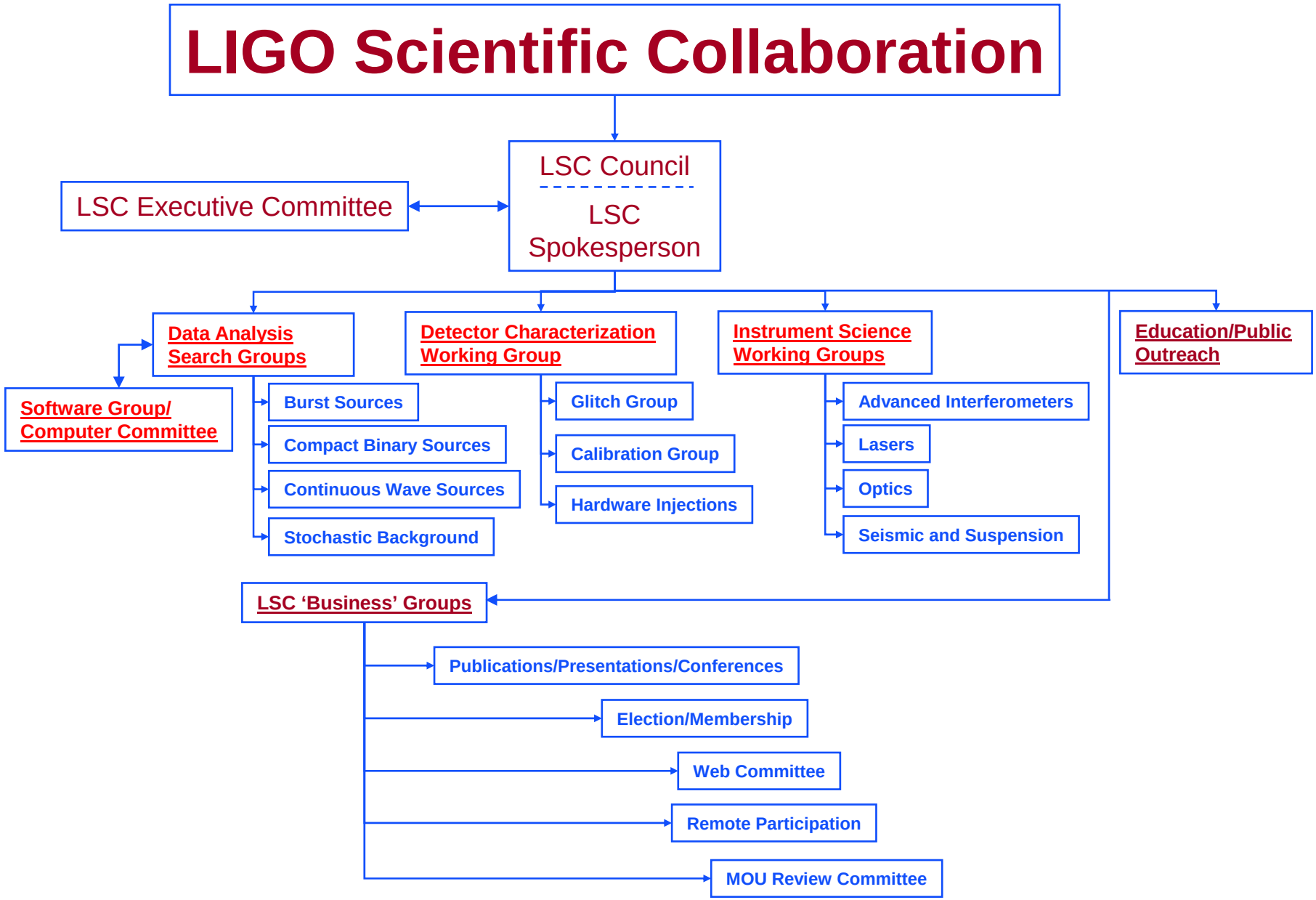
- LSC began in 1997
  - » 24 institutions, 250 members
- The LSC in 2009:
  - » 763 people, 60 institutions
    - – Australia (44), USA (462), Hungary (6), Russia (18), India (1), Japan (9), China (6), UK (91), Germany (10), Spain (4), Italy (10), Korea (11)
  - » 467 'full time equivalents'
  - » Historically, growing at a rate of 10% per year
- The GEO600 collaboration (Germany, UK, Spain) and ACIGA (Australia) are members of the LSC
- Many members of the LIGO Laboratory are members of the LSC



- *The LSC is an open collaboration! Any institution may join if they are willing to work on research areas of interest to the LSC*

What is the LSC?

- *Large collaborations need a charter and governance structure*
- Charter: 'The LIGO Scientific Collaboration (LSC) is a self-governing collaboration seeking to detect gravitational waves, use them to explore the fundamental physics of gravity, and develop gravitational wave observations as a tool of astronomical discovery.'
  - » The LSC is the face of LIGO to the outside scientific community
  - » The LSC is responsible for defining the scientific direction of LIGO
- The main roles of the LSC:
  - » establish overall data analysis strategy, goals, timelines, carry out data analysis program
  - » identify priorities for R&D, and carry out the R&D program
  - » disseminate the results of the data analysis program and the R&D program
    - – Stringent internal reviews of LSC scientific results before publication/presentation
  - » participate in the scientific operations of the LIGO detectors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LSC Spokesperson
LSC Executive Committee
Data Analysis Search Groups
Software Group/ Computer Committee
Burst Sources
Compact Binary Sources
Continuous Wave Sources
Stochastic Background
Detector Characterization Working Group
Glitch Group
Calibration Group
Hardware Injections
Instrument Science Working Groups
Advanced Interferometers
Lasers
Optics
Seismic and Suspension
Education/Public Outreach
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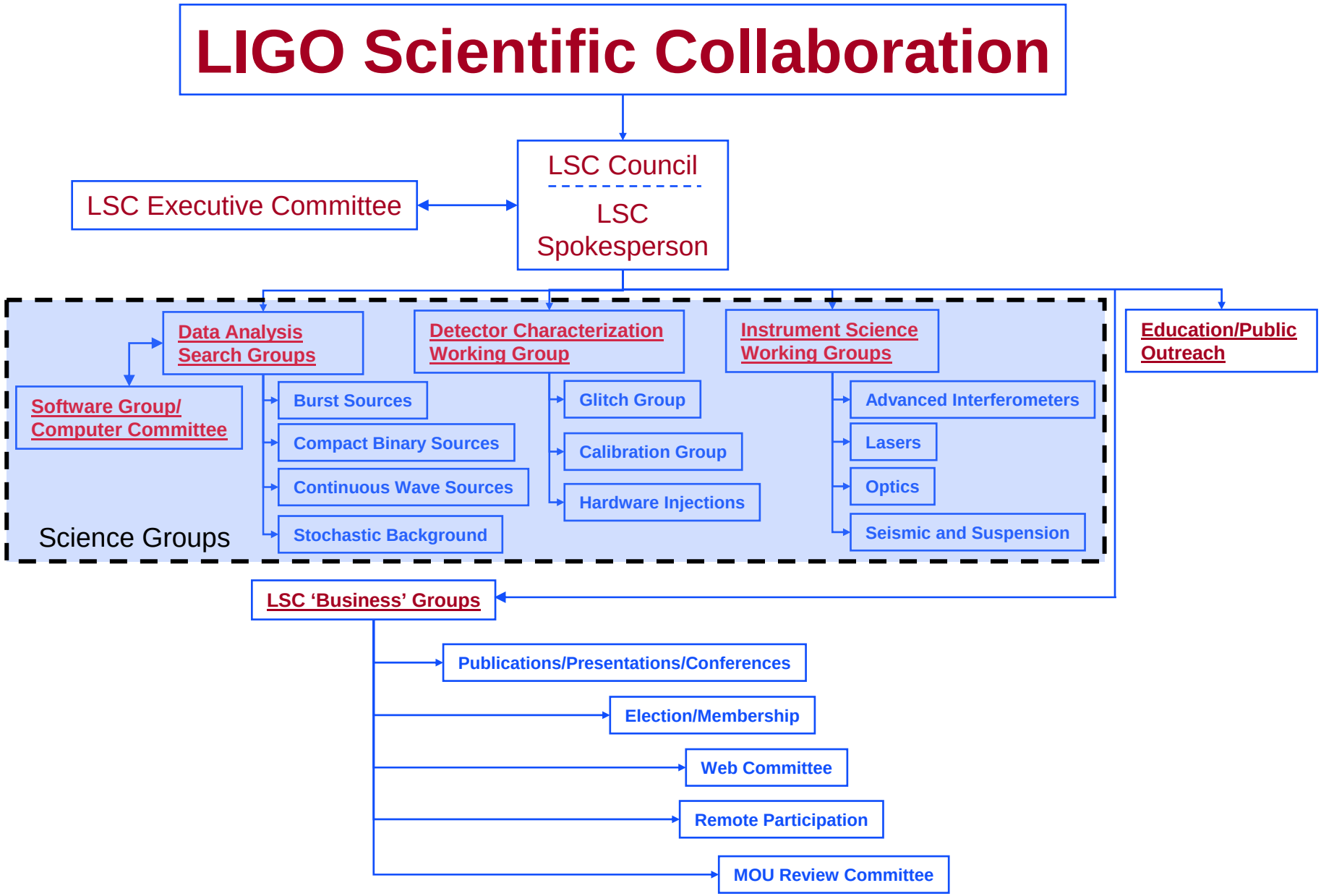
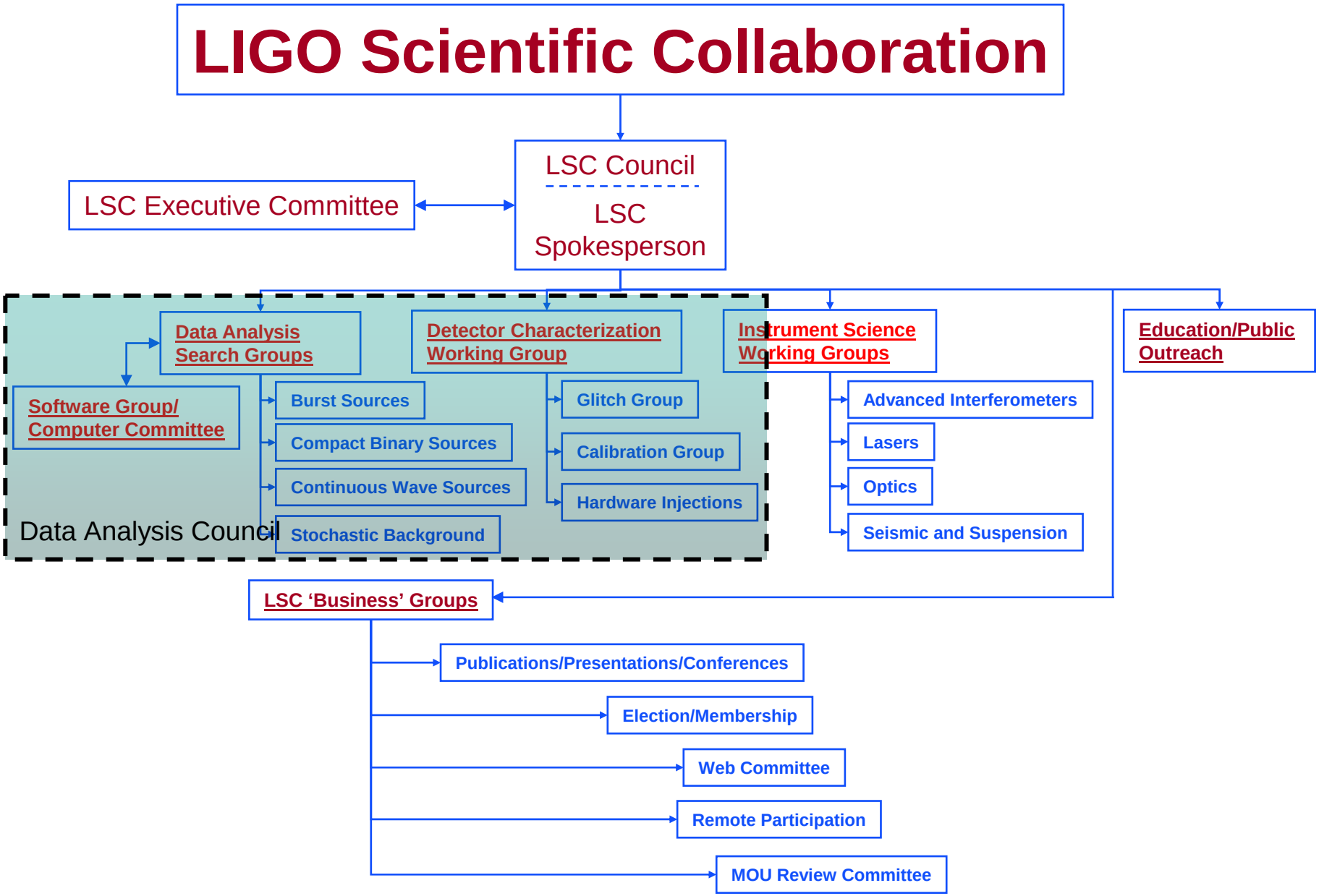
Publications/Presentations/Conferences
Election/Membership
Web Committee
Remote Participation
MOU Review Committee

LIGO

LSC

LIGO Scientific Collaboration

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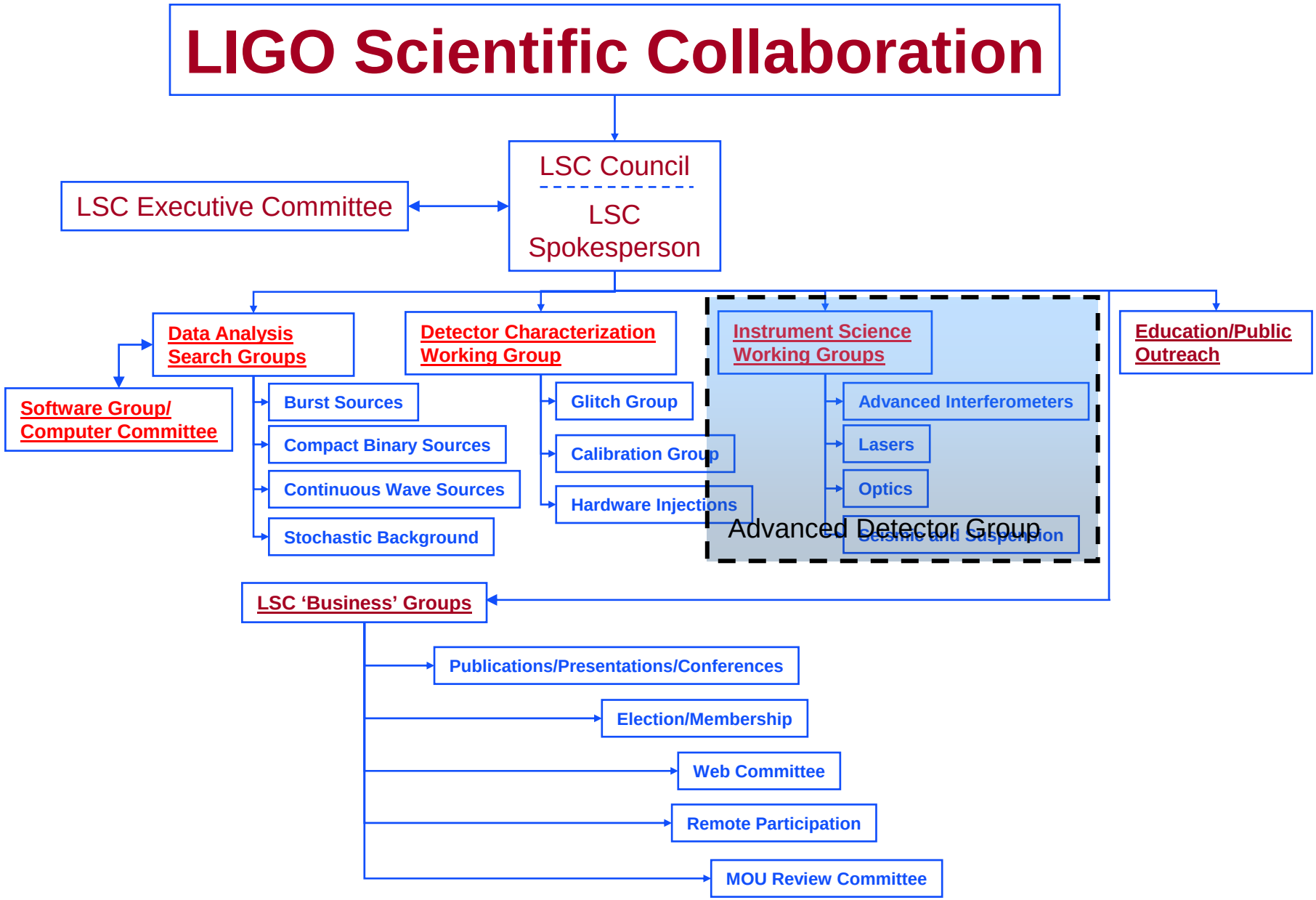
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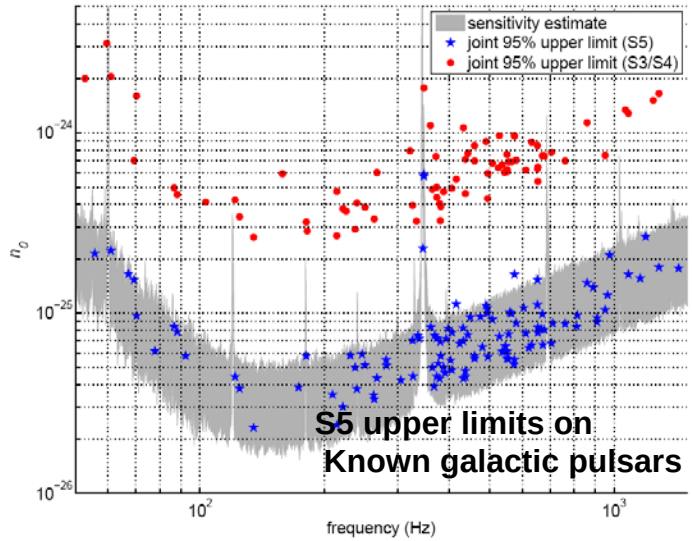
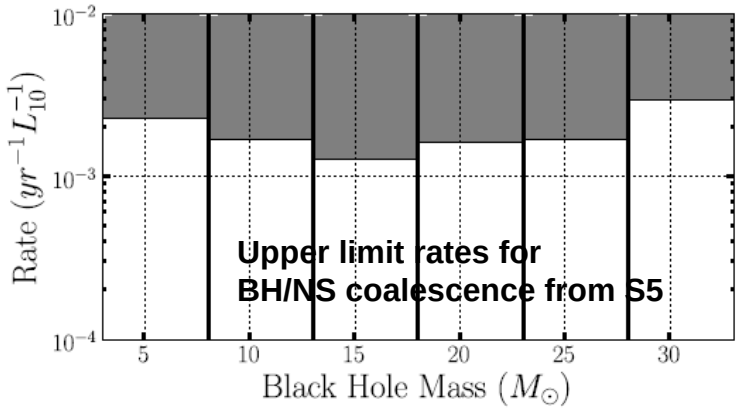
Data analysis (search) groups

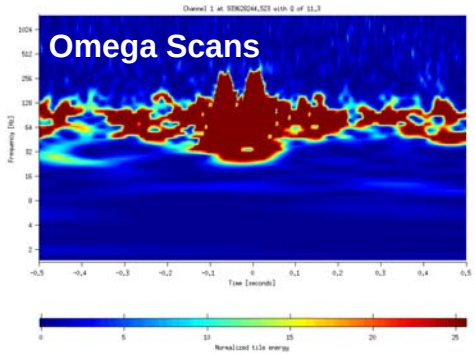
- Have the difficult job of taking the detector noise and searching for signals
- Organized along the lines of particular GW sources
  - » Burst Group – search for unmodelled transient sources
  - » Compact Binary Coalescence Group – search for binary NS/NS, NS/BH, BH/BH sources
  - » Continuous Wave (Pulsar) Group – search for monochromatic GW emissions from spinning neutron stars - known pulsars and unknown
  - » Stochastic Group – search for incoherent GW noise from the primordial universe and from unresolved sources
- Approximately 200 people work in these groups
- Heard much about this from Maria Alessandra Papa yesterday

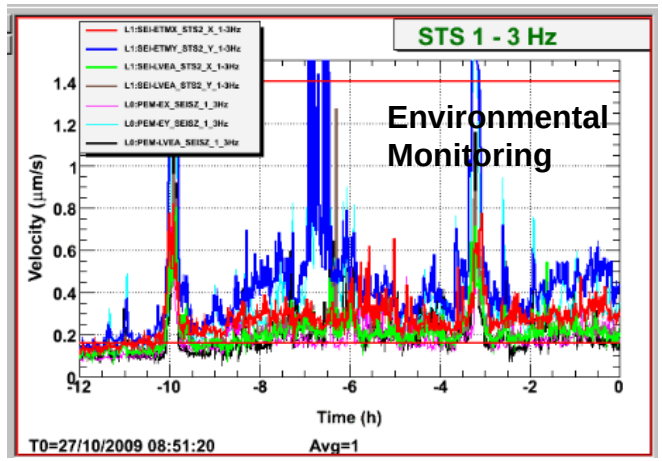


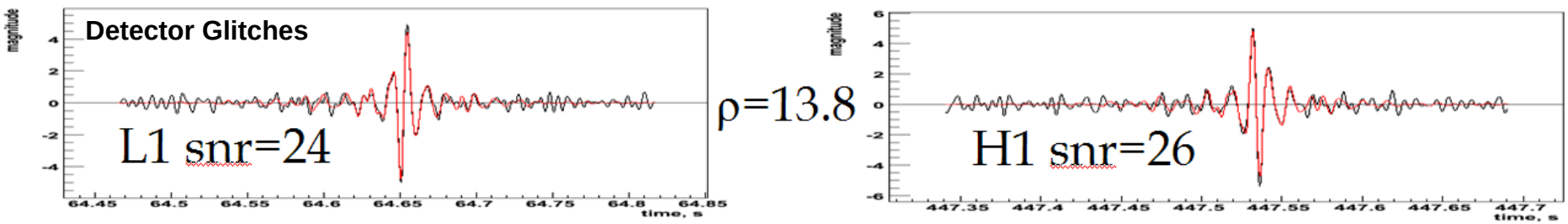


Detector characterization group

- Performs a crucial role in characterizing the performance of the interferometers and maintaining the quality of science data
  - » Develop data quality monitoring tools
    - – Instrumental and environmental
  - » Establish LIGO control room operational protocols
  - » Provide detector calibration
  - » Develop ways to characterize and eliminate spurious transient signals ('glitches') in the data
- Roughly 50-75 people work in this area

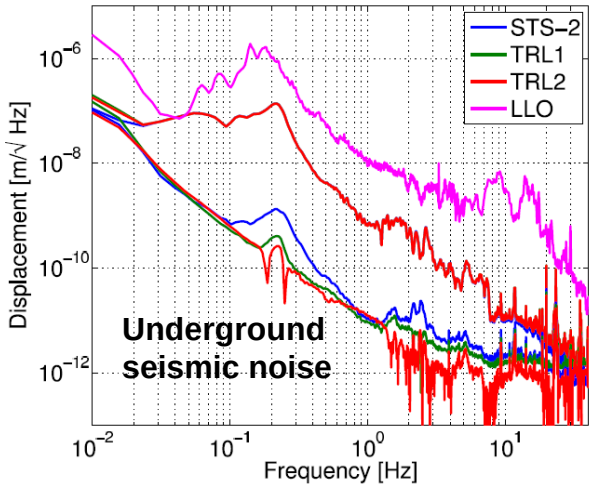


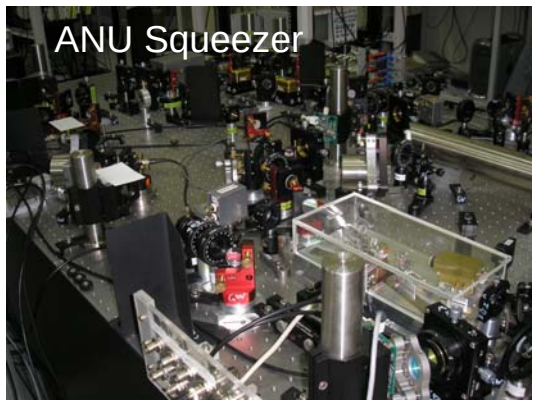




Instrument science groups

- The LSC instrument science groups work on the current LIGO and GEO detectors as well as future detector development
  - » Experimentalists (for the most part)
    - – practical and otherwise
  - » You've heard many talks at this meeting about the work of this group
- Organized along relevant instrumental themes
  - » Advanced interferometer configurations
  - » Lasers and Light Sources
  - » Optics
  - » Seismic isolation (including suspensions)
- Before AdvLIGO was a $210M project, it was a concept developed by the LSC!
- Approximately 400 people work in this group





Advanced LIGO Design:

LSC White Paper on Detector Research and Development

E. Gustafson, D. Shoemaker, K. Strain, R. Weiss

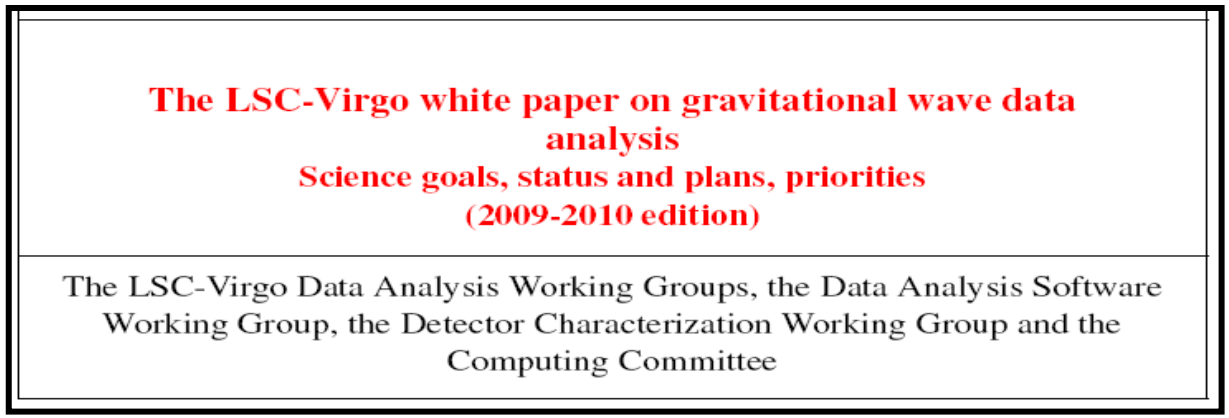
11 September 1999 - LIGO T990080-00-D

Collaboration scientific planning

- *Large collaborations need to think ahead to understand emerging research trends and plan and communicate accordingly*
- The LSC produces yearly white papers which present the plans for research and development over the next ~ 2-3 years
  - » WP sections are developed within LSC working groups
- Primary functions of the white papers
  1. LSC internal planning – survey R&D efforts through out the LSC and identify emerging areas, R&D needs
  2. NSF – a white paper helps reviewers judge proposals based on needs of LSC ('intrinsic merit')
  3. Existing and prospective LSC members
     - identifies places where R&D is needed
     - Define transition of grants as they evolve from Advanced LIGO to beyond Advanced LIGO

LSC research white papers

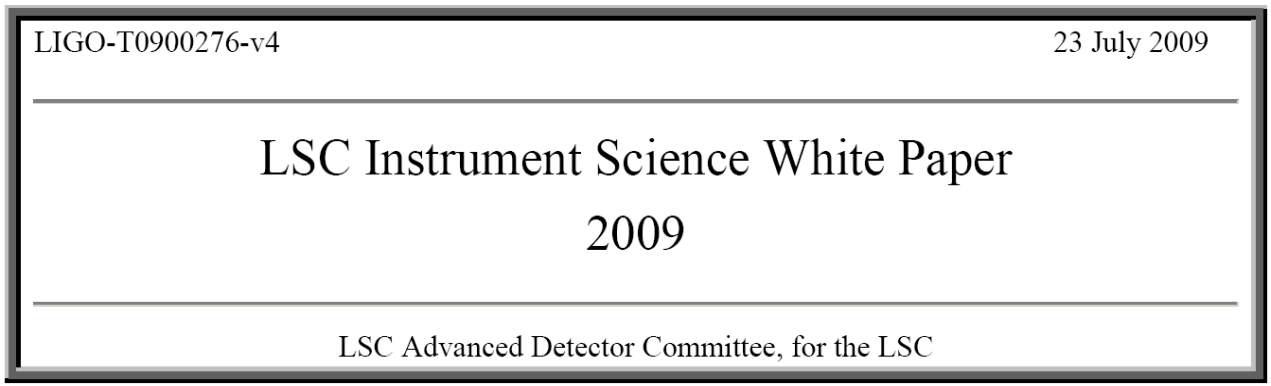
- Data analysis / detector characterization white paper, 118 pages



The LSC-Virgo white paper on gravitational wave data analysis
Science goals, status and plans, priorities
(2009-2010 edition)

The LSC-Virgo Data Analysis Working Groups, the Data Analysis Software Working Group, the Detector Characterization Working Group and the Computing Committee

- Instrument science white paper , 38 pages



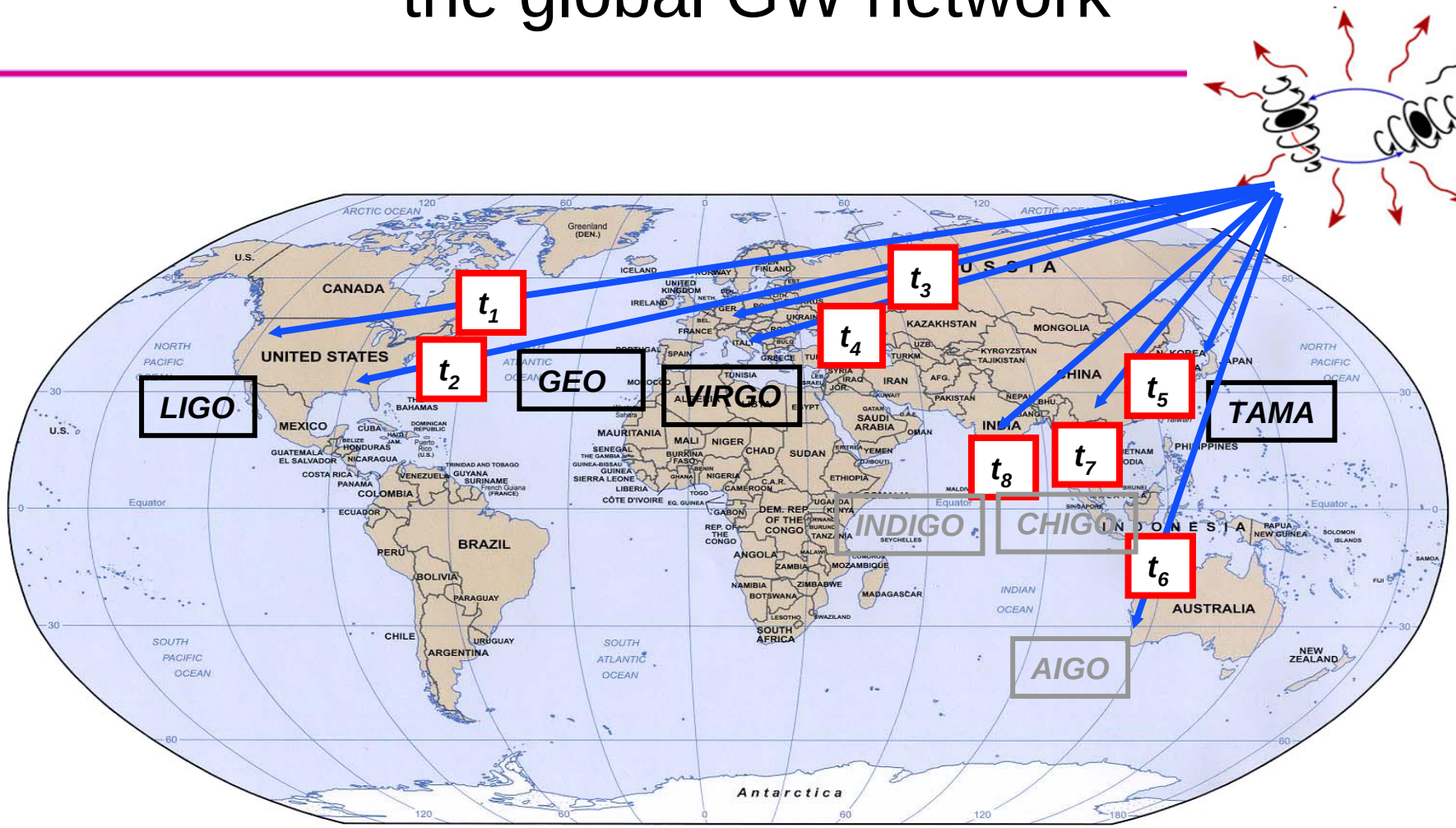
LIGO-T0900276-v4 23 July 2009

LSC Instrument Science White Paper

2009

LSC Advanced Detector Committee, for the LSC

International partnerships I: the global GW network



International partnerships I: the global GW network

- *Doing the best gravitational wave science requires that all of the GW interferometers work together*
  - » Allows for precise source location, optimal network sky coverage, detection confidence, maximum up-time ('always listening'), source parameter estimation
- The LSC has entered into formal partnerships with other major gravitational wave projects
  - » This is the foundation of the global gravitational wave network
- Chief among these are GEO600 and Virgo
  - » GEO600 is a member of the LSC
    - – Approximately 180 members
  - » Virgo is a separate collaboration, but we share data
    - – Approximately 210 members
- GWIC is playing an increasingly important role in the global GW community

LIGO

LSC

Memorandum of Understanding

between

VIRGO

on one side

and the

Laser Interferometer Gravitational Wave Observatory (LIGO)

on the other side

...

We enter into this agreement in order to lay the groundwork for decades of world-wide collaboration. We intend to carry out the search for gravitational waves in a spirit of teamwork, not competition. Furthermore, we remain open to participation of new partners, whenever additional data can add to the scientific value of the search for gravitational waves. All partners in the collaborative search should have a fair share in the scientific governance of the collaborative work.

...

International Partnerships II: Astronomers

- *Gravitational waves will play a major role in the future of astronomy*
  - » Many GW sources have electromagnetic and/or neutrino counterparts
    - – Leads to multi-messenger astronomy with GWs - connecting different kinds of observations of the same astrophysical event or system
  - » Additional “coincidence” test enables confident detection of weaker GW signals

- The LSC (and Virgo) have begun to develop agreements with a number of astronomical and astrophysicists
  - » Swift X-ray satellite follow ups - target of opportunity observations
  - » GW-high energy neutrino searches - joint offline searches with Ice Cube and ANTARES
  - » Wide-field telescope optical follow-ups – ToOs ROTSE, QUEST, TAROT
  - » GW-supernovae core collapse low energy neutrino searches
  - » Deep, narrow optical target-of-opportunity observations
  - » Radio telescope follow-ups
  - » …

- Each of these collaborations are unique and require different methods for developing collaboration agreements
  - » For example: whether or not to publish, how to list authors, access to data, …

Managing a large international collaboration…

- … is a balance between …

Challenges I

- Size! Bigness! Lots of people! Bureaucracy!
  - » With 763 members, the LSC is a *large* collaboration
  - » And with large organizations comes formal structures and bureaucracies
    - – Balancing formal bureaucracy (necessary, but slow and sometimes painful) against needs for individual creativity (absolutely necessary!) and individual visibility
  - » As LSC grows larger, integrating new groups becomes more difficult
- A collaboration is not a project; it is an affiliation of scientists with a common scientific goal
  - » Run as a democracy, cannot be run like a project or business
    - – The LSC has a miniscule budget ($50K/year)
  - » Still, needs hierarchical organization, lines of authority, and accountability
- Solutions
  - » Collaboration organizational structure
  - » Memoranda of Understanding between the LIGO Lab, the LSC, and the individual groups
    - – Reviewed every year; groups sometimes leave the LSC

Challenges II

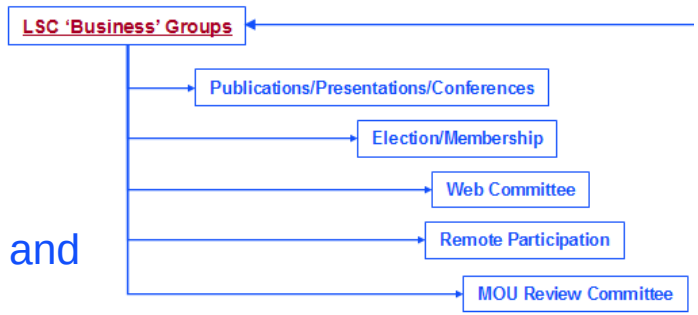
- Time zones!
- Communication among a large and widely distributed group is a challenge
  - » But it absolutely essential, particularly for the data analysis groups
- The LSC has members in 10 time zones
  - » Joint communications between the Pacific Rim, the US, and Europe are essentially impossible
- Solutions:
  - » Meetings – there are currently four collaboration meetings per year
    - – Not everyone attends every one of them
  - » Groups hold weekly (or biweekly or monthly) teleconferences
    - – Some groups hold separate Euro-US and PacRim-US teleconferences
  - » Secure web sites
    - – Accessible to all LSC and Virgo members
  - » LIGO Document control center – centralized repository for all LIGO Lab and LSC documents

Challenges III

- Collaborations are affiliations of scientists and engineers who are all working toward a common goal (or set of goals) but with individual, regional, and national interests
  - » The challenge is to try to balance the overall goals of the collaboration with the those interests
    - – 'herding the cats'
- Solutions:
  - » Sensitivity to institutional, national, and international priorities and constraints
  - » Flexibility in policies
    - – 'not too hard'
    - – 'not too soft'

Challenges IV

- The LSC has many scientific (and non-scientific) jobs that are *absolutely essential* of the proper functioning of the collaboration
  - » And many of the jobs require certain skill sets that scientists are not trained in
- Many of them are not fun, exciting, or scientifically rewarding
  - » Two in particular:
    - – Internal reviews of scientific results
    - – the LSC business functions
  - » Fortunately, most people are willing to step up and take on these jobs
    - – Occasionally, gentle persuasion is needed
    - – Sometimes, arm-twisting is needed



- Solutions
  - » Try to develop incentives and reward systems

Challenges V

- Develop agreements with international partners
  - » Particularly with respect to data sharing
- Different projects and funding agencies have different attitudes toward ‘who owns (and is responsible for) the data”
  - » In the US, the National Science Foundation (with advice from LIGO) is developing plans for making LIGO data publicly available
    - – Not likely to happen until after the first detection of GWs
- Solutions
  - » Careful and sometimes frank discussions among projects and collaborations to develop robust agreements

Yet despite the challenges, the LSC works!

- Five science completed runs to date
  - » S1: August 23 - September 9, 2002
  - » S2: February 14 – April 14, 2003
  - » S3: October 31, 2003 – January 9, 2004
  - » S4: February 22, 2005 – March 23, 2005
  - » S5: November 4, 2005 – September 31, 2007
    - – *Over 1 total year of triple interferometer coincidence data*
  - » S6 currently underway – will last approximately 1 calendar year

- 47 LSC collaboration-wide publications, 56 conference proceedings
  - » Papers that report on astrophysical searches
  - » S1: 5 papers
  - » S2: 10 papers
  - » S3: 4 papers
  - » S4: 13 papers
  - » S5: 15 papers to date, approximately 10-15 more coming

- 325 technical publications
  - » Authored by a subset of LSC members, typically limited in scope to specific technical aspects of gravitational wave detectors, data analysis and astronomy
    - – Publication policies must allow for visibility for individuals

Conclusions

- Large collaborations are necessary to be able to extract the best science out of GW detectors
  - » Analyzing data, building and characterizing GW detectors, and developing future detectors requires a lot of motivated people
- Agreements with other GW projects and collaborations are also necessary to extract best science
  - » The international GW community is growing with possible large detectors in Japan, Australia, and perhaps India and China
  - » All are welcome to join the international network!
- There are challenges in running large collaborations; meeting them is worth it since the science benefits will be great

LIGO Scientific Collaboration