

# LIGO Laboratory and LSC Background on Major Collaborative Efforts

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# Overarching Goals and Perspective

- Directly observe gravitational waves
- Publish convincing results
- Maximum exploitation of scientific opportunity, the “best science”

# A Caution and an Opportunity

- Our field has a moment in time and a regrettable past
  - What is the attention span of our patrons?
- What will matter 50 years from now?
  - What should we do now from a standpoint viewed far in the future?

# Observations Are Very Difficult ...

- Example: Rare particle decay community is used to many internal experimental checks on data and detector characterization
  - recording known calibrated reactions
  - hierarchy of triggers
  - target in/out
  - run at different magnet settings
  - independent calibration of resolutions and sensitivities
  - vary detector acceptance
  - verify all of this with comprehensive simulation
  - even use totally blind data cuts before looking at possible signal
  - confirmation by other experiments

# ... Observations Are Very Difficult

- Gravitational wave community is a very long way from this maturity
  - growing appreciation of the need for detector characterization and comprehensive modeling
  - support for networked analysis growing under pressure from Virgo and LIGO
    - early suggestion from Virgo to use common data format finessed more complex issues
- Even if all of the internal checks are done by each experiment, it is understood that the best science will be done by joint running and joint analysis in a global network!

# History of LIGO Actions on Collaboration

- Barish and Sanders supported broad collaboration upon assuming leadership of LIGO in 1994
  - particle physics and astroparticle physics provides positive example
- January 1995 Aspen Meeting was used by Sanders to raise “LIGO User’s Group” model for discussion
  - discussions were heated and vigorous
  - Virgo present at meeting, comments were received from Virgo members
- January 1996 Aspen Meeting led to LRC formation
  - more vigorous discussion on “small” science vs “big” science
- Barish described vision for LIGO Laboratory and LSC with NSF Panel on Long Term Use of LIGO in 1997
  - his ideas were recommended
- LSC was formed

# Gravitational Wave International Committee (GWIC)

- Joins leadership of all gravitational wave projects
- Provides “face time” for leadership members
- Provides mutual support forum
- Sponsors international meetings
- Provides framework for internationalization of the research
- Too infrequent to substitute for project-to-project interactions

# LIGO Scientific Collaboration (LSC) Structure

- Equal scientific opportunity to all scientific groups who earn membership by pledging a collaborative contribution to the LIGO scientific program
- LIGO science is proposed and carried out and realized through the LSC, not the LIGO Laboratory
  - LIGO Laboratory scientists are about 1/3 of the LSC
- The Laboratory can speak to the LSC and vice-versa
- The “L” is important to the Laboratory and the NSF
- But real bilateral collaboration beyond LIGO is part of the program



# LSC Roles

- For the LIGO I subgroup, contribute to realization of the initial LIGO (LIGO I) and join in authorship of LIGO I physics publications
- Contribute to R&D of technologies for future LIGO interferometers
- Contribute to development of the tools and analysis of the data on all LIGO data
  - including detector characterization and astrophysics analysis through an internal LSC proposal and team process
- Participate in collaborative development in all of these areas with non-LSC groups from Virgo, GEO, TAMA and ACIGA and other non-LSC groups

# Some of the History of LIGO - Virgo Collaboration

- Long history of individual lab-to-lab collaboration in detector measurements and R&D
  - optics, lasers, isolation systems, materials, baffles, beam tube technology, noise calculations, modeling, data format, algorithms, ...
- Recent lab-to-lab discussions on modeling, data analysis, cryogenics, isolation, ...
- Formal CNRS-NSF reciprocal sponsorship of visitors
- Discussions of networked data analysis
- ...

# Limits to LIGO - Virgo Collaboration in the Past...

- At 1995 Aspen meeting, and in communication afterwards, Virgo members described different views of Virgo as a single experiment or as a long term capability
- LIGO leadership has frequently been confused by different views within Virgo
- We have tried to promptly inform Virgo management of any possibilities and issues
  - we have always found these discussions with Virgo open and helpful

# ...Limits to LIGO - Virgo Collaboration in the Past

- Many Virgo member Laboratories also act outside Virgo framework
  - we encourage action through Virgo but this is not always accepted
- For Virgo - LIGO collaboration to advance to a more intimate relationship, we must develop a way to have unified and clear communication between the LIGO Lab/LSC/NSF on one side and Virgo/EGO/CNRS/INFN on the other side to eliminate confusion

# LIGO - GEO Collaboration

- GEO joined the LSC as a project, in a unified way
  - they took several roles
    - suspension technology
    - materials technology
    - lasers
    - interferometer configurations
    - data analysis tools development
    - members of data analysis teams
    - modeling collaboration
    - leadership roles within the LSC management
    - proposed capital partnership in LIGO II
- The GEO Project and their funding agencies have presented a single, unified view of this collaboration

# LIGO - TAMA Collaboration

- TAMA has not joined the LSC as a Project, but they do have an MOU with the LIGO Laboratory outside the LSC (as does Virgo)
- The NAOJ-TAMA group has joined the LSC with the concurrence of the TAMA management
  - collaboration in the RSE and Thermal Noise Interferometer experiments at Caltech
- Coincident TAMA-40 Meter run carried out
- LIGO SAS isolation research now being applied to TAMA R&D in a collaborative program
  - as closeout of LIGO SAS development
- Joint cryogenics R&D being discussed

# LIGO - ACIGA Collaboration

- LIGO and ACIGA have exchanged visitors
- Collaborative R&D on sapphire, isolation, lasers, configurations
- LIGO members have joined internal Australian R&D proposals as collaborators and capital partners
- ACIGA and LIGO/LSC are discussing a role in LIGO II

# The GEO Model

- GEO joins LIGO
- LIGO does not join GEO
- GEO contributes suspension design and R&D, signal recycling R&D, high power laser R&D, data analysis algorithm development
- GEO gains access to the data and authorship of publications
- GEO role is a unified commitment of GEO, supported by both funding agencies for GEO.
- GEO is proposing a capital partnership in LIGO II ( about \$6 million each for UK and Germany)
  - funding agencies encourage these activities
- Is this model one-sided? GEO is attracted to access to the large LIGO system for a modest entry.



# Issues for LIGO - Virgo Collaboration

- LIGO is open to arranging more intimate collaboration.
- Could Virgo join in LIGO?
- Could LIGO join in Virgo?
- Current detectors or future detectors?
- GEO model is a starting point.
- Virgo - LIGO arrangement can be different
- LSC is part of any LIGO - Virgo collaboration

# Possible Next Steps - Suggestions Only

- Exchange visitors/observers at designated open collaboration meeting and commissioning activities
- Joint R&D should increase
- Define interests in
  - LIGO I from Virgo
  - LIGO II from Virgo
  - Virgo from LIGO
  - future European detectors from LIGO
- Base possible agreement to collaborate on these 4 definitions
- Agreements with Virgo must have unanimous enthusiasm from Virgo/EGO/CNRS/INFN/member institutes and from LIGO/LSC/NSF.