List of 4/06/89

LIGO: RATIONALE FOR A TWO-SITE OBSERVATORY UNDER ONE MANAGEMENT

I. SITE CRITERIA

Flatness (construction cost!) for 4 km × 4 km L-shaped facility ($\hat{=}$ single polarization).

Note: 4 km length comes from:
a) requirement for strain sensitivity adequate to detect the theoretically best understood sources, i.e., coalescing neutron star binaries (we don't want to miss by a little)
b) geometric limitations (< 5 km) of identified site candidates
c) length-independent and length-dependent costs comparable

II. TWO-SITE REQUIREMENT

1) Need two widely separated sites with interferometers in coincidence (correlation) to discriminate against pseudo-events.

Note 1: Even in this case, non-gaussian noise may be frequent enough to give false event coincidences. (For $n = 20/hr$, $t_1 = 14$ ms : $N_1 = 2\, t_1 n^2 \approx 27/yr$). Using full-length/half-length interferometer coincidence requirement will further reduce false coincidences, except for correlated false events with small amplitudes.

Note 2: Periodic sources can be detected with a single site.

2) Payoff from two-site observatory alone is significant, producing interesting physics and astrophysics, e.g.:

Physics:

a. Confirmation of existence of gravity waves
b. Limits on graviton mass (if also optical event)
c. Verification of graviton spin (if at least one site has full polarization, i.e., 2 L's at 45°)
d. Discovery of Black Hole (from gravity wave signal shape)

Astrophysics:

a. Wave shapes establish types of sources
b. "Sky Survey" gives statistics of types of sources (burst, periodic, ...)
c. Source located on cone defined by times of arrival

III. FULL EVENT SPECIFICATION

The determination of $h_+, h_\times, \Theta, \phi$ for general events and reasonable sky coverage requires at least three sites.

Generally, the larger the number of sites, the higher the sensitivity and the smaller the location error boxes (given long baselines).

IV. SINGLE-MANAGEMENT REQUIREMENT

The design, construction and gravity-wave search phases of a 2-site LIGO must be conducted under a single management, as opposed to a consortium, steering committee or board of directors.

> *Note: The early days of the Caltech/MIT collaboration under a steering committee represent convincing proof that effective decision making and executive functions on a "pioneering" type of project like LIGO cannot be performed by a committee, even under the relatively favorable conditions of the Caltech/MIT relationship (one country, one funding agency, ...).*

1) Single management during construction.
   LIGO technology is not "mature". Design and development decisions allow considerable latitude, someone must have the power to decide.

   > *Note: For example, there is no way to objectively decide today whether the Michelson or the Fabry-Perot approach will be best in the long run, but resource limitations demanded a decision today!*

   Single management is needed, among others, for:
   - optimization of design tradeoffs
   - simultaneous start-up
   - maximum observatory "live-time" (other teams may not provide for guaranteed round the clock observations plus opportunity for detector development)
   - commonality of sensitivity (you cannot achieve maximum sensitivity by "agreement" or "orders," only by skill!)

     Note: It is the least sensitive detector that sets the threshold for discrimination against spurious events and thus for successful detection.

   Since periodic sources may not be the most easily detected ones, it is of no use to have one interferometer on standby while waiting for the second to come on line years later. The cost implications are horrendous! Also, the ages of the senior investigators on the U.S. team do not allow significant delays without jeopardy to the LIGO project.

2) Single management during start-up of operations (pre-discovery phase).

The LIGO start-up phase requires controlled and continuing interplay between observing, testing, data analysis, and development. It will be particularly crucial to conduct a systematic investigation of random noise sources at the separate sites, both in the single and the coincidence modes. These difficult diagnostics require absolute control under a single management. One needs correlation with another facility whose characteristics one fully understands and which one has the power to modify.

> *Note: Discovery of gravity waves will be vastly more difficult and challenging than many believe. Gravity wave signals have uncertain strengths, waveforms, and frequency of occurrence. Events have unknown signature (at least at the beginning). LIGO technology is new and needs shakedown.*

V. PHASE II OPERATIONS (international n-interferometer ($n \geq 3$) observing mode).

Once one knows how to measure gravity waves, one can schedule international network runs along the successful VLBI example of radio astronomy.

> Operations scenario: The 2-station LIGO observatory will be used by itself for detector development and for observations aiding in the definition of problems which will then be pursued at higher definition via scheduled runs of the international network.

RV/bb
4/3/89