

Aug 4 13:52 1989 standard input Page 1

List of 5/23/90

From saulson@tristan.mit.edu Fri Aug 4 13:25:02 1989
To: vogt@ligo.caltech.edu
Subject: Full- vs. mid-length interferometers

FROM: Peter Saulson
DATE: August 4, 1989
RE: LIGO Midstations

It is difficult to choose between using the third LIGO port for a mid-length interferometer or a full-length one. Either way, we have lost some capability which we had included in our previous plans. However, my personal preference would be to have the third interferometer have full length.

The feature of a mid-length interferometer that I think we would miss the most is its ability to demonstrate that a real gravitational wave has an effect proportional to length. I can't see any other way to demonstrate this aspect nearly so cleanly.

Much murkier is the question of using a second co-located interferometer, whether full- or mid-length, to reduce the spurious event rate. For those events caused by internal glitches in a single interferometer, any local second interferometer will provide a useful discriminant, with that provided by a full-length one being better because of the better sensitivity.

It is for discerning that an event is spurious due to some external influence that mid-length interferometers should have some advantage. In the simple model that we usually use, we assume that effects acting on masses in the central building will be equal in both interferometers, while effects on an end mass will be present in one interferometer and absent in another. This model should be correct for the "end-mass events". We hope that the "common events" are close enough to the model to distinguish them from gravitational waves. (If we match storage time in the two interferometers, then for a given size signal in the full-length interferometer, a spurious mass motion causes twice the effect in the half-length interferometer compared to a real gravitational wave.)

I am unsure that the external influences will be so cooperative. Forces from seismic noise or acoustic noise typically show variations larger than a factor of two due to standing waves (reflections) in buildings. In general, the larger the variation from the expected equality of influences, the less the mid-length interferometer gives a unique discriminant against externally-driven false events.

Even when there is not a good match in the external influences on two co-located interferometers, there is still utility to looking at the sizes of the events, since a real gravitational wave should give matched signals. It is a model-dependent question whether, in a specific case, the lack of equality of external influences is negligible (in which case the mid-length interferometer helps most), or if instead one may as well use a full-length second interferometer, ruling out all events that don't match the gravitational wave prediction.

For discrimination against external influences, we have an alternative strategy for rejecting them, beyond the benefit we always have of two separated sites. If an external influence can cause a correlated spurious response of two interferometers, it should be susceptible to direct measurement

and vetoing. The trick is, of course, to be sure that we are monitoring the correct physical variable(s).

The conclusion I come to from such arguments is that the mid-length interferometer likely is of some extra help in rejecting spurious events, but is probably not a great deal better than a second full-length interferometer run in coincidence.

The other question to consider is which length is better for the other purposes to which we might put the third LIGO interferometer? For both independent service as a periodic-source detector and as a development port for future interferometer designs, I think that full length gives a clear advantage.

For independent use in a periodic search, longer is better for all of the standard reasons (noise on test masses, recycling, vacuum).

For me, having the best possible development port is the decisive advantage of a second full-length interferometer. I feel this in spite of the fact that we could always do development work in a mid-length space. We will appreciate greatly, I believe, that the test port and the operational port are functionally nearly identical.