Dear x y

We are writing to you about joining a workshop sponsored by the NSF on vacuum technology for future instruments in physics and astronomy. The three day workshop will be held at the Livingston Louisiana LIGO (Laser Interferometer Gravitational-wave Observatory) site in January or February 2019 (see possible dates below). The purpose of the workshop is to explore ideas in vacuum technology to significantly reduce the costs of proposed new large vacuum facilities being considered for 3rd generation ground based gravitational wave detectors. The ideas and concepts discussed may well also have application to new particle accelerators and plasma physics facilities. The attached file provides the motivation for the workshop as well some concepts that might result in useful ideas. The intent of the workshop is to explore new and possibly unconventional ideas and result in recommendations for future study. A review report of the workshop will be written for dissemination by the NSF.

The workshop will reimburse your travel and per diem expenses.
If you are interested in taking part in the workshop indicate all the weeks you are able to attend in the list below. We will choose the week with largest attendance.

January 28 -> February 1
February 4 -> February 8
February 25 -> March 1

Please return email to weiss3@ligo.mit.edu if you are interested in joining the workshop and also tell us if you have some ideas you would like to present to the workshop.

Fred Dylla (***dylla@aip.org)***
Rainer Weiss (weiss@ligo.mit.edu)
Michael Zucker (mike@ligo.mit.edu)

cc:

Terry Anderson tga_guitars@mac.com

Curtis Baffes, cbaffes@fnal.gov

Carlo Bradaschia carlo.bradaschia@pi.infn.it

Alex Chen alexchen@fnal.gov

Paolo Chiggiato Paolo.Chiggiato@cern.ch

Dennis Coyne coyne_d@ligo.caltech.edu

Paul Cruikshank Paul.Cruikshank@cern.ch

Jon Feicht jfeicht@ligo.caltech.edu

Walter Gekelman gekelman@physics.ucla.edu

Daniel Henkel daniel.henkel@yahoo.com

Jay Hendricks jay_hendricks@avs.org

LK Len lk.len@science.doe.gov

Yulin Li, yulin.li@cornell.edu

Yev Lushtak, Yevgeniy_Lushtak@saes-group.com

Michael Mapes mapes@bnl.gov

Dennis Manos dmanos@wm.edu

Scott McCormick smccormick@ligo-la.caltech.edu

Dave Morrissey morrissey@nscl.msu.edu

John Noonan noonan@anl.gov

Antonio Pasqualetti antonio.pasqualetti@ego-gw.it

Matt Poelker poelker@jlab.org

Chandra Romel romel_c@ligo-wa.caltech.edu

Yoshio SAITO" yoshio.saito@kek.jp

Bruce Strauss Bruce.Strauss@science.doe.gov

Ryutaro Takahashi ryu.takahashi@nao.ac.jp

Martin Tellalian Martin.Tellalian@mcdermott.com

Takayuki Tomaru tomaru@post.kek.jp

Workshop to reduce the costs of large ultrahigh vacuum systems for forefront scientific instruments.

Major new scientific instruments are being considered for forefront areas in physics and astronomy which involve new large vacuum facilities. In some areas such as the next generation of interferometric gravitational wave detectors the vacuum system for the interferometer arms becomes the dominant cost. In new particle accelerator concepts and plasma fusion reactors the vacuum system is one of several major cost drivers. The intent of the workshop is to determine whether there have been technical advances as well as new insights and concepts which could lead to major cost reductions in the vacuum systems.

An example occurs in preliminary planning of 3rd generation interferometric gravitational wave detectors now being considered in both the United States and in Europe. It has been established that the science is greatly enhanced if the detectors can be made more sensitive. One effective way to accomplish the sensitivity increase is to make the interferometer arms longer by a factor of 10. Scaling from the initial LIGO construction demonstrates the issues well. The two LIGO detectors have four 4km arms of 1.2m diameter tubing held at 10^{-9} torr The length independent costs for the beamtubes adjusted to 2014 dollars was $ 30M and the length dependent costs was $6.3M/km leading to total beamtube cost of $ 130M . Using the initial LIGO numbers to scale to two of the large detectors one gets $1060M for four 40km arms beamtubes with an additional cost for cut and fill of about $200M. (Cut and fill varies as the arm length cubed and depends critically on the surface contour and composition of the site.) It is interesting to compare this cost to the commercial natural gas lines of equal tube diameter. 160km of 4ft diameter tubing installed in 2014 costs between $160M to $260M depending on terrain and labor costs. It is possible that by being imaginative and willing to carryout some basic engineering research one could realize a significant factor in cost reduction in the beamtubes for the large detectors.

The beamtubes in the gravitational wave detectors are passive components. The power dissipated in the beamtubes from the scattered laser light is a few watts on the average; a considerably easier problem to handle than the radiation and particle induced heating of the surfaces in particle accelerators and plasma containment systems.

The Workshop will begin with presentations by the vacuum engineers and scientists who have been involved in the design, construction and costing of the beamtubes for the current operating large baseline interferometric detectors (VIRGO, LIGO, KAGRA and GEO). These projects have already been innovative in reducing costs without significant compromise in performance. Understanding the cost drivers may well provide further ideas. The workshop will hopefully also bring forward some new ideas and concepts to consider. The list below are some preliminary questions for discussion.

1) Are there economies in using other than stainless steel as the envelope material? What is really known about the vacuum properties of the tubing (cold rolled steel) used by the gas companies? What are the vacuum experience and costs associated with aluminum and coated plastics?

2) Are nested vacuum systems practical and would they offer cost reduction? For example, a system with an outer cylinder designed to take the atmospheric pressure loads but not necessarily of material easy to outgas or make completely leak free – say at a pressure of 10^{-4} torr. An inner cylinder of thin wall UHV compatible material with getters distributed on it. The temperature of the thin wall system adjusted by passing current through it.

3) Is it worth developing techniques to mass produce tubing much as culvert? LIGO did this with spiral welding.

4) Are there mass production surface treatment and cleaning techniques to reduce outgassing? . Is heating the best way, or can one use UV and plasma excitation?

5) (Specifically for gravitational wave detector beamtubes) The development of surface treatment to reduce the reflectivity of the beamtube inner surfaces at 1 to 2 micron wavelengths. Also to assure low levels of particulates that may dislodge and drop into the optical beams.

6) Is it worth investigating optical pressure gauging and leak detection?

7) What are the prospects for new getter materials in maintaining UHV conditions in systems with a low gas load?

8) Are there new ideas for large diameter gate valve designs both to isolate from atmospheric pressure but also to separate regions with UHV from poorer vacuum?

One can imagine this workshop is the first in a sequence intended to set directions for future research in vacuum technology. Other areas which need attention in future workshops is cryogenics and the special problems of high energy particles and radiation causing outgassing at the surfaces..

An interesting article that describes the evolution of ideas for large vacuum systems is *Development of ultrahigh and extreme high vacuum technology for physics research* H.F. Dylla , J.Vac Sci Technol A21(5), Sep/Oct 2003 (doi10.1116/1.1599891)