

Attachment Number A
to the
Memorandum of Understanding (LIGO-M950061-00-M)
between the
University of Wisconsin - Milwaukee Relativity Group (UWMRG)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory
August 15, 2003

This Attachment to the Memorandum of Understanding LIGO-M950061-00-M covers the role of UWMRG as a Charter Member of the LIGO Scientific Collaboration (LSC) and a member of the LIGO I Development Group (LIDG). The period of performance for the activities in this Attachment is from August 15, 2003 to February 15, 2004. This period may be modified by agreement to a revision of this Attachment.

1. LIGO Scientific Collaboration - The LIGO Scientific Collaboration is organized as a separate organization from the LIGO Laboratory. It includes scientists from the LIGO Laboratory, and those from collaborating institutions, and has its own leadership and governance. The Collaboration will ensure equal scientific opportunity for individual participants and institutions. It will organize the research, publications, and all other scientific activities. The Collaboration will report to the Laboratory Directorate for final approval of its research program, technical work, observational physics publications, and talks announcing new observations and physics results. This will be done through regular reports to the Directorate and its PAC.
2. Charter Membership - An initial period for formation of the Charter group of institutions in the LIGO Scientific Collaboration commenced on March 1, 1997 and ended following the first full meeting of the Collaboration at which the Collaboration Council assumed its role.

Following the charter period proposals will be evaluated through the Collaboration Council. With Collaboration approval, an MOU with the LIGO Laboratory, including Attachments defining specific work will be required for any participating institutions.

3. This document is an agreement between the University of Wisconsin - Milwaukee Relativity Group (UWMRG) and the LIGO Laboratory concerning the activities of UWMRG as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (LIDG), and as indicated in Items No.8, No. 9 and No. 10.
4. LIGO I Development Group - The LIGO I Development Group is the scientific collaboration

for implementing and exploiting the initial LIGO detector and physics through the initial science data run. Only groups who establish a specific Attachment approved by the LIGO Laboratory, which defines a sufficient contribution and participation in LIGO I development, implementation or data analysis will be part of this initial LIGO data run and science. Participation in future data runs and science that follow LIGO I will be possible for other groups, with guidelines to be determined by the LIGO Scientific Collaboration. It is anticipated that LIGO I data will only be made available through formal collaboration within the LIGO I Development Group during the first two years following its collection.

The general guideline for institutional membership in the LIGO I Development Group is that the contribution per collaborator of any new group to the design, construction, and implementation of the initial LIGO detector and to the first data run be comparable to that of the LIGO Laboratory scientists.

5. Report of Progress - UWMRG will provide a status report on its activities in support of LIGO every six months. The report will consist of: a) a summary status on research by topic as indicated in Item No. 10 including progress against the milestones if any, significant accomplishments such as new insights/discoveries or publications, issues of concern if any, and an indication of invested time, b) updated List of Collaborators, and c) a plan of activities for the succeeding six-monthly period. The report will be due one month before the close of the period of performance under the Attachment in question.
6. Term of Membership - The Membership will be renewed every six months upon evidence of satisfactory performance of agreed upon duties.

The coordinates of UWMRG members are included in the Attachment Z to the Memorandum of Understanding LIGO-M950061-00-M.

7. Intellectual Property Rights - The rights to intellectual property developed under this Attachment will be subject to the National Science Foundation Grant Policy as indicated in Section 730, Intellectual Property.
8. Software Deliverables for LIGO I

Note A: It is necessary that any delivered code conforms to the LAL style as laid out in the LAL specification T990030. This includes; 1) coding style, headers, etc; 2) use of function calls, etc; 3) organization of software in the directory structures indicated in the document; 4) inclusion of test codes and validation tests to enable users to very successful installation of implementing; and 5) documentation to enable users to understand and adopt code.

9. LSC Service Functions - Participation in LIGO I brings with it responsibility for service functions to support the overall effort in achieving high detector sensitivity and high data quality. In particular, each LIGO I group is expected to assist in the staffing of scientific monitoring shifts during organized data runs. The staffing of these shifts is notable for both its importance and the travel burden it places on scientists. This burden makes an equitable shift allocation mechanism necessary.

A nominal guideline is that each LIGO I group should staff a fraction of the shifts comparable to its FTE fraction devoted to LIGO I activities. An eight-hour shift is assumed. The current count of FTE in the Collaboration is 127 (not including GEO FTE). The University of Wisconsin-Milwaukee Relativity Group (UWMRG) has 9.4 FTE's associated with LIGO I and is expected to staff 7.4 % of the scientific monitoring shifts during this MOU period.

Bruce Allen will be responsible for interaction with the designated LSC Shift Organizer (currently Keith Riles of Michigan Univ.) with respect to UWMRG's Service Function commitments.

Groups making extensive contributions to the LSC in other service efforts that involve a substantial travel burden may request a reduction in their nominal share of shift staffing. Those efforts can include:

- 1) Commissioning and instrument improvement
- 2) Participation in on-site detector characterization investigations
- 3) Development/operation of analysis software/hardware infrastructure and validation of analysis software that requires travel away from the home institution.

10. During the period August 15, 2003 to February 15, 2004, UWMRG will carry out the projects as indicated below. The projects are rated in order of priority from 1 to 3, the rating of 1 being assigned to LIGO I completion tasks, and the ratings of 2 and 3 being assigned to best efforts commitments

LSC Data Analysis Software Working Group / Rating 1

a) Brady will continue to chair this working group of the LSC which is charged to coordinate software development activities for data analysis in the LSC.

Development of grid computing applications for LIGO data analysis are now in full swing within this group and will continue following the plan circulated to the LSC Spokesperson and Lab Director. The first stage of that plan is well in hand, i.e. prototype search codes exist and are being used for S2 data analysis, the next stage will run for the period of this MOU is assessment of grid application guidelines and drafting of a white paper. In parallel, the group will continue to add necessary tools to LAL and LALApps to make them more useful for the purpose of application development and deployment.

Toward the end of this MOU period, the group will attempt to migrate the S2 (or S3) search pipelines into the Pegasus infrastructure, which is being developed within the GriPhyN project.

Allen will continue to work with the OS migration team to determine a suitable OS migration path for the LSC's computing infrastructure, now that Redhat 9 support has terminated. Allen will also help to maintain a set of upgrade RPMs for RH9 until a migration path has been determined.

Binary inspiral search code / Rating 1

b) The UWM group (Brown, Brady, Creighton, Fairhurst, Messaritaki and Woods) will use the inspiral search code to analyze the S3 data for NS/NS binaries, BH binaries and MACHO binaries. Detailed verification and efficiency studies will be performed using software and hardware injections (Fairhurst). New template waveforms from Cardiff will be integrated into the code for BH/BH searches in S2 data (Messaritaki & Woods).

Direct measurements of computational cost and comparisons to theoretical expectations will be made using the S3 data.

A hierarchical search algorithm using multi-stage triggered analyses will be explored to save on computational cost.

The S2 binary inspiral search pipeline will serve as a prototype for the deployment into a Grid environment. The development of a Pegasus implementation of the workflow will be undertaken in collaboration with the GriPhyN members at ISI.

The UWM group will also work with both the Cardiff and UTB groups on integration of BBH inspiral searches with burst searches.

CW Sources / Rating 1

c) Siemens and Allen will continue to participate in the work of the Pulsar Analysis Group work. They will proceed with the testing and improvement of the LALDemod() function, and will use the current driver code, ComputeFStatistic, to perform coincident all-sky coherent searches for unknown pulsars using S2 and S3 data. Furthermore they will work on porting all these codes to the grid environment.

Allen will continue to support the hardware pulsar injection infrastructure developed for the S2 and S3 runs, which was used for both pulsar and stochastic background injections during S3. Allen will also continue to develop and support the Short Fourier Transform (SFT) data type as an official LSC archival and exchange data product, and will continue to produce and publish SFTs for forthcoming science runs.

Allen will continue to lead the LSC's Einstein@home effort, to develop a LIGO data analysis screensaver using the Berkeley Open Infrastructure for Network Computing (BOINC). This will be publicized by the APS as part of the 2004 World Year of Physics (WYP2004). An initial test release of the BOINC client for windows and linux should take place around the end of the summer 2004.

These activities will be coordinated within the pulsar search group.

Burst Sources / Rating 1

d) Brady, Cannon and Ray-Majumder will search for bursts in the S3 data set using the standalone power code which has been developed at UWM. The group is responsible for tuning the ETG to be used in the burst group's searches of the S2 data and the LIGO-TAMA effort. In the process of this work, the group will develop an automated way to run the pipeline under the Condor system with a goal of incorporating the method into the Pegasus infrastructure in the early part of 2005.

Brady and Majumdar will complete their studies of using of trial astrophysical waveforms (such as Zwerger-Muller) to provide guidance for developing burst searches for astrophysical source identification.

Creighton and Siemens will develop a search code to detect gravitational waves from cosmic string cusps and kinks. This activity will be coordinated with the burst analysis group.

Creighton will continue development of the ringdown search code.

Inspiral Upper Limit working group / Rating 1

e) Brady will co-chair this working group of the LSC with Gabriela Gonzalez. The UWM group will contribute to this group in the following ways: (i) enhancement of templated inspiral search code; (ii) development of statistical methods needed for inspiral searches; (iii) development of black-hole search templates; (iv) detector characterization activities. The work on S1 and S2 data performed by Duncan Brown is intended for use in his PhD dissertation (summer 2004, approximately). The UWM group will also improve the feedback from the inspiral code to the control rooms at LHO and LLO.

DMT/Data Conditioning API development / Rating 1

f) Ottewill will continue to work on the DMT monitors for correlation monitoring (CorrMon) and line tracking (MTLineMon). He will also continue to work with Christensen on inter-site and environmental correlation studies.

Siemens will continue to work on the generation of the strain $h(t)$ for S3 and will develop an on-line system to be placed at the sites for S4.

ASIS

g) Members of the Milwaukee LSC group will continue to coordinate the work of the LSC Astrophysical Source Identification and Signature (ASIS) working group. Allen will chair the group, Brady will serve as webmaster, and Wiseman will serve as the meeting organizer.

Since the focus of work within the LSC has shifted to the four astrophysical source search groups, the ASIS working group has been dormant. The main efforts in this period will be helping to organize and coordinate the parallel group sessions at the LSC meeting, and to serve as a forum for issues that do not conveniently fall under the purview of the existing four search groups.

Grid Computing

h) Allen and Koranda will continue working in the GriPhyN collaboration. In particular they will continue to help design, construct, and deploy the LIGO-GriPhyN prototype for data analysis. Koranda will continue design, development, and deployment of the LIGO Data Replicator (LDR), a package for high-speed, robust replication of LIGO data products to UWM and other LIGO/LSC Tier-2/3 sites.

Allen, Brady, Koranda, and Wiseman will continue collaboration in the international Virtual-Data Grid Laboratory (iVDGL) project, the iVDGL Facilities Working Group, and the iVDGL Operations Working Group. Koranda will represent iVDGL as a Registration Authority with the Department of Energy Certificate Authority (CA), including representation on the CA's Policy Management Board.

Software & Computing Committees

i) Brady will serve on the LSC Computing Committee in his role as LSC Software Coordinator; Creighton will serve on the LSC Computing Committee as the UWM representative; Koranda will participate in LSC Computing Committee meetings as an ex-officio expert on Grid Computing.

Creighton continues to serve as the LAL Librarian and as a member of the Software Change Control Board. Much of the scientific search code is nearing completion, and it will be his responsibility to ensure that the software adheres to standards.

LAL Development Coordination / Rating 1

j) Creighton will continue to serve as the LAL software librarian. The librarian will maintain LAL, incorporate packages added by groups in the LSC, and publish releases of LAL at timely intervals. The librarian will also participate in the integration of LAL with other software through the DASWG.

LALApps Development Coordination / Rating 1

k) Brown will serve as the LALApps software librarian. The librarian will maintain LALApps, incorporate packages added by groups in the LSC, and publish releases of LALApps at timely intervals. The librarian will also participate in the integration of LALApps with other software through the DASWG.

Cluster Computing Systems / Rating 1

l) The UWM group will continue to maintain and operate the UWM/LSC Data Analysis Facility (296 node Medusa cluster). We will continue to provide a timely response to user requests, and to support all interested LSC and LDAS users. We will continue to support LDAS, Condor, and DMT access methods to LIGO Data based on user demand.

The goal is to operate Medusa on a 24x7 basis, apart from a weekly scheduled maintenance period lasting approximately 3 hours. During the coming six months we will continue to support analyses of the burst, inspiral, pulsar and stochastic analysis groups.

As part of our commitment to iVDGL, the UWM group will maintain an on-line copy of all LIGO-I reduced data sets (RDS's) (including trend and other processed data) on spinning media at UWM. This data will be made available quickly, via Internet, to any authorized member of the LSC. The UWM group will commit to delivering LIGO data over the Internet at an aggregate rate, which is not less than 15% the speed of the UWM network connection to the outside world. [With the current UWM OC-12 connection, 622 Mb/sec, this would correspond to about 10 MB/sec.] The latency will be less than 15 seconds, unless hardware failures require that data first be retrieved from the Caltech archive, in which case the response time of that archive will determine the latency. The data will be available for use on the UWM computing facilities by authorized members of the LSC.

Allen, Brady, Creighton, Koranda and Wiseman will seek funding to create a new high performance cluster at UWM. We have proposed a 420 dual-cpu node cluster with approximately 400 TB of distributed RAID data storage to the NSF. If this proposal is funded, we will build a new data analysis facility at UWM, for general LSC use, with a commissioning completion target date of January 17, 2005. This facility will include approximately 250kW of power and 200kW (60 tons) of cooling, and should accommodate some additional future growth if desired.

Analysis Group Chairs

m) The collaboration has established several "Analysis Groups" to analyze engineering and science data. These groups have common software, hardware, and logistical needs. Wiseman will continue to coordinate these efforts as the Chair of the Analysis Group Chairs. In particular, he will coordinate the review process for upcoming publications.

LIGO-TAMA Coincidence analysis

n) Brady and Ray-Majumder will participate in the LIGO-TAMA burst coincidence analysis effort. These efforts will be coordinated through the LIGO-TAMA working group.

Brady and Fairhurst will participate in the LIGO-TAMA inspiral analysis effort. These efforts will be coordinated through the LIGO-TAMA working group and the inspiral analysis working group.

LIGO-VIRGO Coincidence analysis

o) Brady and Fairhurst will participate in the LIGO-VIRGO join analysis effort. This will involve a white paper to be written by August detailing further activities. These efforts will be coordinated through the LIGO-VIRGO working group and the inspiral analysis working group.

Upper Limits Reviews

p) Allen and Creighton will serve as LSC reviewers (respectively) of the Stochastic Background Analysis and of the Burst Analysis.

Other Committees

q) Creighton will serve on the LSC detection committee on behalf of the inspiral group. In his capacity of coordinating analysis efforts, Wiseman also participates in the efforts of the LSC detection committee. Allen will serve on the LSC/LIGO restructuring committee. Allen, Brady, and Wiseman will all serve on the LSC Executive Committee.

10. During the period August 15, 2003 to February 15, 2004, the LIGO Laboratory will share, as requested and appropriate, LIGO data of relevance to the research topics in Item No. 10.
11. The research effort pursuant to this Attachment A will be coordinated by Bruce Allen and Albert Lazzarini on behalf of UWMRG and the LIGO Laboratory, respectively.
12. Resource Sharing: The LIGO Laboratory will contribute resources including allocation of appropriate scientific and engineering personnel, research facilities and funding in support of the effort in Item No. 10, as indicated below.
 - a) Accommodations for UWMRG investigators while on LIGO research assignment at Caltech, and/or LIGO sites.

Approved:

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27 July 2004

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