



DCC_NUMBER_PENDING

**Report of Activities For LIGO-M050377-00
accomplished by University of Wisconsin at Milwaukee
(UWM)**

**During the Period
August 15, 2008 – August 14, 2009**

This report is organized by the categories proposed under the current MOU and its associated attachments between University of Wisconsin at Milwaukee and the LIGO Laboratory.



**Report of Attachment DAT to the
Memorandum Of Understanding (LIGO-M050377-00)
between the
University of Wisconsin at Milwaukee (UWM)
and the
Laser Interferometer Gravitational Wave Observatory (LIGO)
Submitted August 14, 2009**

Binary Inspiral Search

Brady, Biswas, Clayton, Creighton, Fotopoulos and Vaulin all made contributions to the CBC group activities. In particular:

a) The UWM group (Biswas, Clayton, Goggin, Mercer and Vaulin) continued to help with ihope development, integration and testing as required by the CBC group.

b) The UWM group (Clayton, Biswas, Vaulin, and Brady) analyzed three months of the data during the LIGO-Virgo joint operation for low-mass compact binaries. This effort was coordinated closely with the other group members leading the analysis of various months. In particular, the work was closely coordinated with Marion, Guidi and Gouaty. Part of this effort included investigations of bank-chisq, continuous-chisq, and coherent follow-up within the analysis pipeline. The bank-chisq was investigated as an alternative to the now standard chisq; they were found to have similar response and veto capabilities. It is recommended that the bank-chisq be used at the first stage of the pipeline as it is computationally inexpensive. Despite continued effort to integrate the coherent step, a number of issues continue to plague the integration of this step. The group will continue to work toward this goal. A paper describing this analysis is being written and should be ready for submission later this year.

c) The development of the triggered GRB analysis for inspiral waves has been completed. Nick Fotopoulos and Alex Dietz (Annecy) have coordinated this activity. Brady, Creighton, Burguet-Castell, and Yu also contributed to this activity. The resulting analysis is available (and currently being actively tested) to run on-line in S6 with a goal of providing rapid and timely response to triggers.

d) The UWM group (Creighton, Goggin, Brady) are participating in the search for ringdown waves. Goggin completed and submitted the S4 ringdown analysis paper. The UWM Group has worked with Paul Baker (MSU) to undertake the S5 ringdown search. Features of the analysis which were identified for addition during the S4 search will also be added. Goggin and Yu completed work to allow inspiral and ringdown searches to be run simultaneously with ihope. This infrastructure is being used to study the relative sensitivity of the two searches to various waveforms. The tuning of the analysis is well underway. Goggin has coordinated and provide much of the intellectual leadership in the S5 search. The UWM group supported and mentored Jin Li (UTB) during a visit to UWM. Goggin has also mentored a number of other people in running the search.

e) No progress was made on triggered ringdown searches although it remains on the list of activities the group may attempt in the coming year.

f) The UWM group (Brady, Clayton and Vaulin) worked to integrate the likelihood based ranking statistic into inspiral searches. In particular, Clayton and Vaulin have introduced an effective-likelihood method to rank triggers in the LIGO-Virgo search. They demonstrated that this approach is better than previous ranking statistics in the context of the LV search using standard ROC techniques applied to the full pipeline.

g) Brady and Biswas worked with Sarah Caudill and Gaby Gonzalez to study background estimation techniques that might be used to complement time-slide background estimation. Biswas and Caudill presented an overview of their preliminary results at the LV meeting in Paris and are preparing a technical note, which may result in a paper, on the topic. Codes being developed for this study can be easily integrated into the current search pipelines if they prove robust enough for production.

h) The group did not get significantly involved in parameter estimation studies during the past year.

i) Gridifying the inspiral pipeline took a back seat to S6 preparations for those listed for that task.

j) The UWM group (Vaulin, Goggin, Mercer, Brady) have made preliminary investigations of using inspiral and ringdown searches together to search for gravitational waves from a compact binary coalescence. These investigations will be carried over into the IMR subgroup of CBC. Goggin, Mercer participated in the IMR group to the LSC; Mercer produced sets of simulated signals which were added to S5 data and analyzed using several pipelines including the ringdown pipeline (Goggin). This study is ongoing, with the current focus on comparing pipelines with fixed false alarm rates.

k) Brady, Goggin, Mercer, Vaulin participated in the NINJA project, analysing waveforms produced by numerical relativity studies in Gaussian noise with the inspiral and ringdown pipelines. This resulted in a publication.

l) Brady, Marion, Mours developed a rapid source localization code based on timing from a reference frequency that incorporates the CBCG catalog. This code is available in pylal and is being integrated in the CBC pipeline. In addition, Price is leading a coordinated effort to compare the different methods that are available for sky localization. Some of the others involved in this project are Searle, Hanna, Cannon, Vecchio, Veitch, Mandel, Raymond, van der Sluys, Roever. This is expected to lead to a technical paper.

Burst Search

a) No development of a signal-based veto for the ringdown code or extending the frequency range of the ringdown search was attempted for S5 due to technical difficulties. We may pursue this for an S6 ringdown search.

b) No activity on the development of a new approach to determine upper limits on unmodeled sources of gravitational wave bursts was done in the past year.

c) The S5 search for cosmic string cusp radiation bursts was delayed by the review of the S4

search. We plan to perform a search of the S5 data this year. Siemens finished the S4 cosmic string search in collaboration with Kipp Cannon (Caltech). The review team (chaired by Papa) began April 2008 and concluded March 2009. A paper was submitted for publication in March 2009.

d) Creighton served as chair of the Burst Review Committee until 20 July, 2009. During his time as Review Chair, the following searches were reviewed and published/submitted:

S5 GRB search with X-Pipeline

S5y1 All-sky Burst Search with Coherent WaveBurst S5y1 LIGO All-sky Burst Search with the Q-Pipeline S5y1 All-sky Burst Search with BlockNormal+CorrPower

S5y1 LIGO High-frequency All-sky Burst Search

S5y1 Search for GWs Associated with SGR Flares

Stack-a-flare SGR 1900+14 Storm Search

GRB 070201 Search

S4 Cosmic String Search

S4 LIGO-GEO Burst Search

S4 All-sky LIGO-only Burst Search

LIGO-AURIGA Joint Search

S2, S3, S4 GRB GWB Search

Analysis of the SGR 1806-20 Hyperflare of Dec. 27, 2004

In addition, Siemens and Creighton served on the X-Pipeline Review Team, and Papa served on the cosmic string review team.

Pulsar Search

a) Papa, Allen, Siemens, and Hammer continued to participate in the work of the CW group.

b) Papa worked on the post-processing of the Einstein@Home results, in particular concentrating on the S5 R3 run.

c) Allen continued to lead the E@H effort. The S4 results paper was published in PRD, and the S5 R1 results paper has been accepted to PRD and is now in proof.

d) The group attempted to recruit a system administrator for Einstein@Home. No suitable candidates were found and Hammer performed the system administrator duties. The hiring effort will continue.

e) Hammer continued to administer the Einstein@Home data servers and database and helped with the data preparation.

f) Siemens continued to develop and implement the re-sampling technique for pulsar searches in collaboration with Pinkesh Patel (Caltech).

g) Siemens generated the data for the analysis for the second half of the E@H S5 run and helped with the optimization of the S5 search design.

h) Allen and Papa participated in the review process for the search codes used in E@H.

i) Allen helped to develop a new and faster incoherent search method (called the Global Correlation Transform) to use in future E@H searches.

Stochastic Background Search

- a) The group is no longer actively engaged in the H1-H2 project, but Fotopoulos continued to support the coherence code.
- b) Anderson served as chair of the Stochastic Review Committee.
- c) Siemens continued to work with the stochastic group to understand the bounds that the S5 LIGO stochastic search places on cosmic string parameter space in collaboration with LVC member Mandic.
- d) Siemens worked on non-Gaussian stochastic background detection methods in collaboration with LVC members Regimbau, Drasco, Robinson, and Birindelli.

LIGO Data Grid services and software

a) Hardware resources and services

i) Nemo is a 780-node beowulf-class parallel computer, built and operated by the LSC group at the University of Wisconsin - Milwaukee (UWM). Nemo remained accessible to members of the LIGO Scientific Collaboration (LSC) by request through the LAMS. Wiseman continued to maintain the physical facilities for the cluster.

ii) Servers are provided and maintained to host the following services for the LSC: web sites and wikis for numerous working groups and committees; version control system access for LSCSOFT, ligovirgo, lscdocs, etc; e-mail lists for a number of working groups and committees; bug tracking for software and hardware resources of the LIGO Data Grid; data related to these services was backed up nightly.

iii) All the S5 and S6 LIGO RDS

C0X, RDS

L1andRDS

L3dataishostedatUWMonfileserverrunningRAID6,alongwithcalibratedstrainVSR1andVSR2Virgodata.

b) System Administration

i) Two full-time system administrators (Oldenburg, Skelton) maintained and enhanced the hardware resources and services over the period of this MOU.

ii) System administrators worked with their counterparts at other institutions to insure proper integration of the resources and services described above into the LIGO Data Grid.

iii) System administrators at UWM provided help desk support to all users.

c) Grid Services

i) Warren Anderson continued to serve on the Security and Certificate Authority task force (SCAT) and continued to serve as a point of contact between the LDG and the DOEGrids Certificate Authority (CAT) for the purposes of communicating and addressing LIGO needs in this area.

iii) Brian Moe continued to maintain the LDG available data service which provides one-stop shopping for the location of data around the LDG. T

iv) Authentication and Authorization: Anderson and Koranda continued to serve on the AuthComm sub-committee of the Computing Committee. Both made significant contributions to the design and gradual deployment of the new authentication infrastructure.

v) Koranda continued to design, develop, deploy, and support the LIGO Data Replicator. An improved system was implemented for S6/VSR2. Koranda deployed the service at Cascina and worked with numerous LSC computing centers to deploy the service and get data flowing.

vi) UWM took over maintenance of the Monitoring and Discovery service. Documentation has been provided to enable rollout across the LIGO Data Grid. Xavier Amador is working with Caltech sys admins to get the system deployed there.

vii) Brian Moe continued to serve as the LAMS operator and to process requests for accounts and access to the LDG.

viii) The UWM Nemo cluster was available as an OSG resource provided by LIGO. The UWM group continued to support OSG users on Nemo and provide a level of access to resources for OSG users that is coordinated through the Computing Committee.

ix) The UWM group has continued to develop services to make access to the gravitational-wave data and results easier. The LIGO Archival System (LArS) and the Gravitational-wave candidate event database (GraCEDb) are both prototype projects which will be used in S6/VSR2. A number of members of the group (Clayton, Fotopoulos and Moe) have participated in the architecture, documentation, and testing of these services. Price worked to get MBTA and Omega online triggers into GraCEDb. Have developed a plan for integration with the optical follow-up team. Deployed an LVAlert service which can be used to implement simple trigger based follow-ups easily.

d) Data analysis software toolkits

i) UWM (Brady, Fotopoulos, Mercer, Moe, Price) made contributions to GLUE

ii) LAL Software Suite: UWM (Creighton, Fotopoulos and Mercer) continued to maintain the core infrastructure of LAL, LALApps and PyLAL. LAL/LALApps have been migrated over to the C99 specification, and the LAL Spec adjusted accordingly.

iii) UWM (Amador) continued to release a unified build of the LSCSoft bundle for use by the LSC and other gravitational-wave scientists. Documentation relating to software installation was updated and enhanced where appropriate. Mercer has been packaging LSC software in MacPorts for easy installation on Macs.

e) UWM participated in the planning and development for S6 analysis coordinated jointly by DAC, CompComm, DASWG and DetChar.

f) Brady participated in presentation of a data handling and analysis overview to the PAC.

g) Mercer chaired a DASWG sub-committee on version control systems and managed the transi-

tion to Git for the LALSuite software package.

h) Mercer is a downstream maintainer/packager for the frame library; Fotopoulos developed python interfaces to channels and events in frame format.

Committees and working groups

Brady continued to chair the DASWG committee of the LSC which is charged to coordinate software development activities for data analysis in the LSC. Over the year, the group identified software needs for S6 including low-latency analyses, planned for their implementation, and delivered most of those components by the start of S6. Warren Anderson, Jolien Creighton, Kevin Flasch, Nick Fotopoulos, Scott Koranda, Adam Mercer, Brian Moe, Xavier Amador, and Xavier Siemens all contributed to DASWG.

Creighton served as chair of the burst review committee until 20 July 2009; Anderson served as chair of the stochastic review committee.

Anderson, Brady, Creighton (until 20 July 2009), and Siemens served on the Data Analysis Council. Papa co-chaired this council.

Brady served on the detection committee as one of two representatives for the CBC; the other is Steve Fairhurst.

Anderson, Brady, Creighton and Koranda served on the computing committee; Anderson served on the security subcommittee which provides guidance on cybersecurity issues.

Anderson served as lead on the AuthComm project.

Wiseman continued as scimon shift coordinator.

Brady served as LIGO OSG Council representative.

Siemens continued to serve on the Calibration Team.

Siemens co-chaired the Calibration Team.

Siemens served on the X-Pipeline Review Team.

Siemens continued to serve on the LSC P&P committee.



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Detector Characterization:

- a)** Fotopoulos continued development of the coherence calculator, `pycoh`, which is being used by Christensen and Tomoki to identify cross-correlations between detector readout channels and common linear couplings of the environmental channels with the gravitational wave readout channels.
- b)** Siemens finalized the validation of S5 V4 $h(t)$ data.
- c)** Siemens and Burguet-Castell worked on $h(t)$ production techniques for S6. This work includes digital filter production, a low-latency $h(t)$ DMT-based generator in collaboration with John Zweizig (Caltech) used in on-line analysis and also for DQ flag generation, and the official $h(t)$ generator that uses the RDS system in collaboration with Greg Mendell (LHO). The low-latency data is available for analysis within a minute of acquisition. This is preparatory work for Advanced LIGO.
- c)** Siemens served as co-chair of the calibration team.
- d)** Fotopoulos participated in Astrowatch at LIGO Hanford from January to April 2009.

Signature Pending Approval

Jay Marx
LIGO Laboratory Director

A handwritten signature in black ink, appearing to read "Patrick R Brady". The signature is written in a cursive style with a large, stylized initial "P".

Patrick R Brady
Principal Investigator(s)
UWM

Signature Pending Approval

David Reitze
LSC Spokesperson