

 PULSAR TIMING CONSORTIUM	Document # LAT-MD-09047-01	Date 7 March 2008
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Gamma-ray Large Area Space Telescope (GLAST)
Large Area Telescope (LAT)
Memo of Understanding for a
Pulsar Timing Consortium

DOCUMENT APPROVAL

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		Scott Ransom, NRAO
		G. Theureau, Nançay
		Patrick Weltevrede, ATNF

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
00	11 February 2008	Initial draft by David Smith
01	12 February 2008	Comments/additions by Dave Thompson
02	19 February 2008	Integrated remarks from the timing community (das,djt)
03	23 February 2008	Add signature page and template of timer's letter of intent, as per LAT PI's request. Define L&EO ; Cycle 1 ; Cycle 2 mission epochs as per timers' request.
04	5-6 March 2008	Revise wording about public release of data; include explicit wording about timing scientist participation in paper preparation; add clause for non-exclusive data use. Change number of pulsars to 225.

1. Purpose

The GLAST Large Area Telescope (LAT) is a long-awaited opportunity to increase the understanding of pulsars significantly. Gamma-ray pulsar studies are enhanced by the availability of contemporaneous timing ephemerides from other wavelengths. Up to hundreds of known pulsars are viable candidates for gamma emission, justifying a large, coordinated timing campaign over several years. LAT data analysis is complex and members of the instrument team provide high quality gamma ray measurements. LAT photon data are available only to team members during Cycle 1.

[The Cycle 1 mission epoch is the approximately one-year period beginning at the end of the 60 day satellite and instrument commissioning period ("L&EO", for Launch & Early Operations). The end of Cycle 1 is when NASA makes the first year photon data public. Cycle 2 is the period following Cycle 1. If the commissioning process goes smoothly then LAT data useful for pulsar searches will be acquired during L&EO.]

We believe that combining our efforts will bring a scientific return whose sum is richer than if we worked apart. This document describes an agreement between radio, X-ray, and gamma astronomers to share expertise and resources, specifically pertaining to issues such as the authorship of articles and the sharing of unpublished data. Those signing this agreement will be referred to as the "timing consortium" in the rest of this document.

2. Overview of the pulsar timing campaign

The timing campaign is described in an article to be submitted to A&A in Spring 2008 and co-authored by many, but not necessarily all, of the members of the timing consortium. It contains a list of 225 pulsars with spindown energy $1 \times 10^{34} < dE/dt < 3 \times 10^{34}$ erg/s considered to be “worthwhile” candidates for GLAST. Those with $dE/dt > 3 \times 10^{34}$ erg/s are called “must-do”. Alternate schemes to select gamma candidates mostly overlap this list – the candidate selection details are beyond the scope of this document. A copy of that list is attached as an appendix.

This MoU concerns only these pulsars. Sharing of timing solutions and LAT results for other known pulsars, or pulsars discovered subsequently, can be arranged outside of the consortium, as described in section 8.

Amongst the justifications for such a long list of gamma candidates is the LAT field-of-view of ~20% of the sky. During Cycle 1 data will be acquired mainly in “survey mode”, where the entire sky will be surveyed every two orbits (3 hours). LAT’s sensitivity is such that the Vela pulsar is detected well enough in 6 hours to consistently determine the pulsar peak position to better than 800 microseconds. For weaker pulsars, however, LAT data will have to be accumulated for an extended time interval – years in some cases – before a gamma-ray signal will emerge.

It is trivial to add additional timing solutions for any pulsar beyond those on the target list. Because the gamma-ray data are being accumulated continuously, the key requirement on any timing solution is that it be phase-locked over a long enough time interval to make a gamma-ray analysis worthwhile.

3. Telescope time allocation

The majority of the high Edot pulsars are being timed with the Parkes, Jodrell, and Nançay telescopes. The Green Bank and Arecibo telescopes are timing a smaller number of radio-faint pulsars. The RXTE X-ray satellite is also timing several radio-faint or radio-quiet pulsars.

Access to these instruments is highly competitive, and there is competition for the funding necessary to analyze and interpret the data. Amongst the criteria valued by time allocation and funding committees is the number and quality of refereed publications produced from resources previously granted. One goal of the consortium is to ensure recognition of results obtained from the timing campaign, in order to assure the continuity of the timing campaign over the life of the GLAST mission. The long-term health of the consortium will enhance the overall scientific return from the LAT instrument.

The efficient use of instrument time requires organization of who-monitors-which pulsar. Patrick Weltevrede (ATNF) will coordinate the timing campaign. He will maintain a table showing which observatories are monitoring the different pulsars, to assure that none are neglected.

4. Pulsar Ephemerides on the Bordeaux and NASA GSFC Data Servers

Timing ephemerides are the product of significant expertise applied to difficult-to-obtain data, and are essential for the study of gamma ray pulsations in most cases. To maximize the scientific

return from the GLAST mission, a balance must be found between the need to sustain repeated timing over several years, and the need to open the data to the broadest scrutiny possible.

Timing solutions provided to the LAT team (“par files” and ancillary files such as templates, when provided) will be stored at the CENBG (Centre d’Etudes Nucléaires de Bordeaux-Gradignan). A web-interface will allow LAT and consortium members to create “D4.fits” files, the file format used by the LAT “Science Tools”. The timing solutions remain the intellectual property of their creators at this step, to be shared outside the LAT collaboration only with the consent of their owners. David Smith is the point-of-contact between the LAT and consortium members. Data portal users will be invited to contact members of the consortium to obtain ephemerides not available on the public servers. Later in the mission, the intent is for the CENBG archive and/or the web functionality to migrate to the GSSC (GLAST Science Support Center) at the Goddard Space Flight Center in Greenbelt, Maryland.

At the end of the Cycle 1 all-sky survey, LAT photon data will be posted on the public data portals at the GSSC. New data will be made public as processed (typically less than a few days after detection). It is the intention of the LAT team to work with the timing consortium to publish primary pulsar results during Cycle 1, so that a public release of timing information will serve primarily to allow other scientists to confirm the gamma-ray pulsar results.

ARTICLE I

Consortium members agree to make a best effort to:

- *publish a large fraction of the timing solutions acquired in this campaign by the end of Cycle 1;*
- *put Cycle 1 timing solutions into the GLAST public database for those pulsars for which LAT detects pulsed emission, with the submission to occur at the time the paper is accepted; and*
- *put the Cycle 1 timing solutions for all 225 pulsars into the public database 6 months after the end of Cycle 1.*

The public database documentation will encourage users to cite the timing parameter authors for published results or to work with the timing scientists directly. Users interested in timing solutions not in the database will be directed to the astronomers monitoring those objects.

A large number of high \dot{E} pulsar rotation ephemerides will be updated regularly in the years following. The timing consortium is not obligated to make such information public, although the benefits to the science may provide a strong incentive to do so.

5. LAT publication policy

LAT guidelines for multi-wavelength work are at

<https://confluence.slac.stanford.edu/display/GLAMCOG/>

The LAT collaboration has defined two publication categories called I and II. The LAT “publication board” assigns papers to categories. Presently, the publication board is Peter Michelson, Steve Ritz, Neil Gehrels, Pat Nolan, and Julie McEnery.

Category I papers are intended to be “major” results. They may be signed by any team member who so desires (over 100 people), as well as by scientists from outside the team contributing to that work. Generally they will be in alphabetical order but the possibility exists that the first authors be the study leaders. During Cycle 1 most papers are likely to be Category I.

Category II papers are signed only by those having contributed directly to that work. The order of authorship is determined by the authors and approved by the publications board.

It should be emphasized that there is no automatic authorship on any LAT paper in either category. This rule applies to LAT team members as well as outside contributors. For each paper, the eligible scientists are invited to participate in the paper preparation and sign the paper, but each individual must actively inform the lead author that he/she wishes to be an author. Timing consortium members will be informed at an early stage of any planned paper and will be encouraged to contribute to the results and the text of the paper. All authors are expected to be able to defend the paper or major portions of it.

6. Authorship for consortium members

The timing campaign resembles other large multi-wavelength efforts for the GLAST mission, such as radio and optical blazar flare monitoring. It is however unique in its duration over the 5 to 10 year mission lifetime, and especially by the need for coordination: *without a coordinated, long-term campaign, a few “popular” pulsars could be monitored more than strictly necessary, by multiple instruments, and a large number of “secondary” pulsars could be neglected. LAT pulsar science would suffer in consequence.* The campaign thus requires some “self-sacrifice” by some pulsar-timers, who will agree to track secondary pulsars instead of “best candidates”. To make this workload sharing acceptable to all timers, the LAT collaboration agrees to the following:

ARTICLE II

Members of the pulsar timing consortium are eligible to participate in the preparation of and to sign any LAT paper using timing data provided by the consortium, whether or not that individual member contributed ephemerides for the pulsars studied in that paper.

In return, the LAT collaboration asks that consortium members share all timing data on the 225 pulsars of interest to the LAT with the LAT team in a timely manner.

The LAT collaboration holds that privileged access to LAT pulsar results and instrument team expertise has high value, justifying a two-year commitment by the consortium, but accepts one year. At that time the consortium members will discuss renewal. The LAT collaboration hopes that radio and X-ray astronomers will find it in their interest to continue to share timing solutions with LAT team members even after the initial commitment ends and LAT data have become public.

ARTICLE III

The agreement is valid until LAT photon data are made public at the end of Cycle 1, but applies to articles-in-preparation for which a significant draft exists at that time.

7. Consortium membership

Here follows the list of radio and pulsar astronomers who agree to abide by the terms of this memo of understanding LIST AS YET UNAPPROVED BY SOME LISTEES!

Parkes S. Johnston, P. Weltevrede, R. Manchester, G. Hobbs

Jodrell M. Kramer, A. Lyne, A. Noutsos, C. Espinoza

Nancay I. Cognard, G. Theureau

GBT and Arecibo F. Camilo, P. Freire, S. Ransom, M. McLaughlin, M. Roberts

RXTE F.E. Marshall, V. Kaspi, E.V. Gotthelf, M. Livingstone,

8. Data & knowledge sharing outside of the consortium

Scientists with timing solutions for pulsars not monitored by the consortium may share those ephemerides with the LAT team at any time, thereby allowing gamma pulsation searches in close coordination with LAT team members. Resulting publications would be co-authored with the LAT team.

Scientists able to contribute significantly to the modeling of specific objects and/or interpretation of LAT and/or multi-wavelength data may also be invited by the LAT team to collaborate on specific studies, in which case they would co-author the resulting publications.

All agreements in this Memorandum are non-exclusive. Timing scientists can share the timing solutions with other observers. LAT scientists can publish results that do not depend on these timing solutions.

Appendix: list of the 225 pulsars, with a first estimate of the timing responsibility: