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FINAL REPORT

to
The National Aeronautics and Space Administration

for

CELESTIAL GAMMA RAY STUDY
Grant No. NAG 5 1605
for the period: June 1, 1991 - August 31, 1995

Principal Investigator: Peter F. Michelson

November 21, 1995

INTRODUCTION

This report documents the research activities performed by Stanford University investigators as part of the data reduction effort and overall support of the Energetic Gamma-Ray Experiment Telescope (EGRET) on the Compton Observatory. This report is arranged chronologically, with each sub-section detailing activities during roughly a one year period of time, beginning in June 1991.

The Stanford investigators are members of the EGRET Science Team along with scientists from Goddard Space Flight Center, the Max Planck Institut für Extraterristrische Physik, Hampdon-Sydney College, and Grumman Aerospace Corporation. The EGRET instrument, designed to detect gamma-rays from about 20 MeV to more than 30 GeV, was successfully put in orbit aboard the Compton Gamma-Ray Observatory in April 1991.

II. REPORT FOR THE PERIOD 6/1/91 - 3/31/92.

The period June 1, 1991 to March 31, 1992 corresponds approximately to Phase I of the Compton Observatory mission. The principal objective during Phase I was to carry-out an all-sky survey for sources of gamma radiation. This initial sky survey was successfully completed and the principal results were published as the First EGRET catalog of High-Energy Gamma-ray Sources by Fichtel, et al. *in Astrophysical Journal Supplement*, **94**, 581 (1994).

Personnel: During this period of the project, the Stanford group consisted of Professor Peter F. Michelson (principal investigator and EGRET co-investigator), Dr. Patrick Nolan (EGRET co-investigator), Dr. Y.C. Lin, and several graduate students that included Mr. Joseph Fierro, Mr. James Chiang and Mr. Marc Shapiro. In addition to these scientific personnel we made use of the technical services of Mr. Joseph Lepetich on a part time basis and also made use of the services of a professional programmer on a consulting basis. One Stanford undergraduate student also worked part time on the project.

Activities: The principal activity of the Stanford group was to support the EGRET team effort. A major activity was the development and refining of software products that are part of the EGRET scientific data analysis package. The software includes

(i) ENERGY: this software utilizes data from the EGRET instrument, including the spark chamber and the TASC, to estimate the energy of each detected photon. This

software was the principal responsibility of the Stanford team. During the initial in-flight calibration this software required some modification.

(ii) SPECTRAL: this software utilizes calibration data files and the scientific data base that contains information about gamma-ray arrival time, energy, etc., to obtain an estimate of the energy spectrum of a particular point source. The pre-flight version of this software was designed only to obtain the pulsed emission spectrum from gamma-ray emitting pulsars such as the Crab pulsar or the Vela pulsar. Modifications were made to incorporate maximum likelihood estimation of the source flux in a particular phase interval. This allows background models to be incorporated into the analysis.

(iii) POINT EXPOSE: this software was derived from software originally developed at Goddard Space Flight Center. It provides the exposure in a specified energy band for a specified time period. It is used in the analysis of variability, both aperiodic and periodic, of point sources.

(iv) SEARCH: this software was develped to carry-out a nearly optimal search for pulse period in a source suspected of being a pulsar and for which no timing ephemeris is available from either radio or optical observations.

(v) We also developed a modified version of the program PULSAR that uses a known radio ephemeris to search for gamma-ray pulsations from a pulsar. The modified version calculates light curves from a specified energy band and also calculates several test statistics (chi-square, Z test and H test) useful in evaluating the significance of any suspected detection.

The group also collaborated on the analysis of scientific data that resulted in several papers, either published or submitted by the EGRET Science team during this period. In addition, a graduate student supported by this grant, James Chiang, collaborated with Prof. Roger Romani on a theoretical analysis of gamma-ray emission from pulsars.

During the period 6/1/91 - 3/31/92, members of the Stanford team attended several EGRET team meetings. These meetings were as follows: June 11-12 (at Stanford), July 24-25 (Goddard), September 26-27 (Goddard), November 21-22 (Goddard).

Presentations at professional meetings or invited seminars: The following papers were delivered by members of the Stanford team on behalf of the EGRET collaboration.

(i) AAS Meeting, Atlanta, GA, January 12-16, 1992
P. Nolan, "EGRET Observations of the Crab and Vela Pulsars: Preliminary Pulsed Spectra above 100 MeV".
J. Chiang, "Pulsar Gamma Rays from Polar Cap Regions".

(ii) IEEE Nuclear Science Symposium, Santa Fe, NM, November 5-9, 1991
P. Nolan, "Performance of The EGRET Astronomical Gamma-Ray Telescope".

(iii) Conference on Isolated Pulsars, Taos, NM, February 1992
J. Chiang, "Pulsar Gamma Rays from Polar Cap Regions".

(iv) Physics/Applied Physics Colloquium, Stanford University, February 18, 1992
P. Michelson, "Preliminary Results from the EGRET Telescope on the Compton Observatory".

(v) Physics Colloquium, Naval Postgraduate School, Monterey, Feb 21, 1992
P. Michelson, "Preliminary Results from the EGRET Telescope on the Compton Observatory".

(vi) Seminar, Space Sciences Laboratory, University of California, Berkeley, October, 1991
P. Michelson, "Preliminary Results from the EGRET Telescope on the Compton Observatory".

Publications:
This list includes only papers that were accepted for publication during the period 6/1/91 - 3/31/92.

Hartman, R.C., Bertsch, D.L., Chiang, J., Fichtel, C.E., Hunter, S.D., Kanbach, G., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Michelson, P.F., Von Montigny, C., Nel, H.I., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "Detection of High Energy Gamma Radiation from Quasar 3C279 by The EGRET Telescope on The Compton Gamma Ray Observatory", *Astrophys. J. (Letters)* **385**, L1 (1992).

Schneid, E.J., Bertsch, D.L., Chiang, J., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Michelson, P.F., Von Montigny, C., Nel, H.I., Nolan, P.L., Pinkau, K., Rothermel, H., Sommer, M., Sreekumar, P., and Thompson, D.J., "EGRET Detection of High Energy Gamma Rays from the May 3, 1991 Gamma-ray Burst", accepted for publication in *Astron. Astrophys.*, November 1991.

III. REPORT FOR THE PERIOD 4/1/92 - 11/1/92.

This section covers work performed by Stanford University investigators during the period April 1, 1992 to November 1, 1992.

Personnel: During this period, the Stanford group consisted of Professor Peter F. Michelson (principal investigator and EGRET co-investigator), Dr. Patrick Nolan (EGRET co-investigator), Dr. Y.C. Lin, and several graduate students that included Mr. Joseph Fierro, Mr. James Chiang and Mr. Tom Willis. In addition to these scientific personnel we

contined to make use of the technical services of Mr. Joseph Lepetich on a part time basis and also made use of the services of a professional programmer on a consulting basis. One Stanford undergraduate student (Mr. Robert Heeter) worked part time on the project.

Activities: Major activities were the continued refinement of software products that are part of the EGRET scientific data analysis package, the scientific analysis of flight data, reporting of scientific results at a variety of scientific meetings, and the writing of scientific papers for scholarly journals. The software responsibilities of the Stanford team during this period included

(i) ENERGY: this software utilizes data from the EGRET instrument, including the spark chamber and the TASC, to estimate the energy of each detected photon. This software required additional modification during the report period to account for in-flight calibration changes.

(ii) SPECTRAL: this software utilizes calibration data files and the scientific data base that contains information about gamma-ray arrival time, energy, etc., to obtain an estimate of the energy spectrum of a particular point source. The original version of this software was designed only to obtain the pulsed emission spectrum from gamma-ray emitting pulsars such as the Crab pulsar or the Vela pulsar. Modifications were finally implemented to incorporate maximum likelihood estimation of the source flux in a particular phase interval. This allows background models to be incorporated into the analysis.

(iii) POINT EXPOSE: this software was derived from software originally developed at Goddard Space Flight Center. It provides the exposure in a specified energy band for a specified time period. It is used in the analysis of variability, both aperiodic and periodic, of point sources. The software was completed.

(iv) SEARCH: No modifications were made during 4/1/92 - 11/1/92.

(v) During this time period a version of the PULSAR program was delivered to Goddard Space Flight Center.

During 4/1/92 - 11/1/92 the Stanford group collaborated on the analysis of scientific data that has resulted in several papers, either published or submitted by the EGRET Science team. Several IAU telegrams were also published. Publications and submitted papers during this period are listed below.

Members of the Stanford team contined to attend EGRET team meetings. These meetings were as follows: April 22 (Goddard), June 25-26 (Garching), August 18-20 (Stanford), September 22-24 (Goddard).

Presentations at professional meetings or invited seminars: The following papers were delivered by members of the Stanford team on behalf of the EGRET collaboration.

(i) Stanford Linear Accelerator Center Colloquium, November 2, 1992
Peter F. Michelson, "Results from EGRET"

(ii) Compton Observatory Symposium, Washington University at St. Louis, October 15-17, 1992
Peter F. Michelson, "AGNs detected by EGRET", poster paper
Patrick Nolan, "EGRET Observations of QSO 2230+114", poster paper

(iii) April 1992 Meeting of the American Physical Society, Washington, D.C.
Patrick Nolan, "EGRET Observations of High-Energy Gamma Rays from the Crab and Vela Pulsars"

(iv) EGRET/COMPTEL Workshop, Ising, Germany, June 22, 1992
Patrick Nolan, "EGRET Observations of Pulsars"
Y.C. Lin, "EGRET Observations of Bl Lac Objects"

(v) International Symposium on Fluid Mechanics and Theoretical Physics, Beijing, China, June 6-8, 1992
Peter F. Michelson, "Results from the First Year of Observations with EGRET", invited talk

Publications:

This list includes only papers that were published or submitted for publication during the period 4/1/92 - 11/1/92.

Michelson, P.F., Bertsch, D.L., Chiang, J., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Von Montigny, C., Nel, H.I., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "Search for Periodic Gamma-ray Emission from Cygnus X-3 by The EGRET Telescope on The Compton Gamma Ray Observatory", *Ap. J. Lett.*, December 20, 1992.

Thompson, D.J., Arzoumanian, Bertsch, D.L., Brazier, K.T.S., D'Amico, N., Fichtel, C.E., Fierro, J.M., Hartman, R.C., Hunter, S.D., Johnston, S., Kanbach, G., Kaspi, V.M., Kniffen, D.A., Lin, Y.C., Lyne, A.G., Manchester, R.N., Mattox, J.R., Mayer-Hasselwander, H.A., Von Montigny, C., Michelson, P.F., Nel, H.I., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Taylor, J.H., "Pulsed High Energy Gamma Radiation from PSR 1706-44 (2CG342-02)", *Nature*, in press, October 1992.

Kanbach, G., Bertsch, D.L., Chiang, J., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Michelson, P.F., Von Montigny, C., Nel, H.I., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "Detection of Long-Duration Gamma Ray Emission from the Solar Flare on June 11, 1991 by the EGRET Telescope on CGRO", to be published in *Astr. & Astrophys. (Suppl.)* 1993.

von Montigny, C., Bertsch, D.L., Chiang, J., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Michelson, P.F., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "EGRET Observations of 3C 273", to be published in *Astr. & Astrophys. (Suppl.)* 1993.

Lin, Y.C., Bertsch, D.L., Chiang, J., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Kwok. P.W., Mattox, J.R., Mayer-Hasselwander, H.A., Michelson, P.F., Von Montigny, C., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "Detection of High-Energy Gamma-Ray Emission from the Bl Lac Object Mkn 421 by the EGRET Telescope on the Compton Observatory", accepted for publication in *Ap.J. Lett.*, October, 1992.

Nolan, P.L., Lin, Y.C., Bertsch, D.L., Chiang, J., Fichtel, C.E., Hartman, R.C., Hofstadter, R., Hughes, E.B., Hunter, S.D., Kanbach, G., Kniffen, D.A., Mattox, J.R., Mayer-Hasselwander, H.A., Michelson, P.F., Von Montigny, C., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "Performance of the EGRET Astronomical Gamma-Ray Telescope", *IEEE Trans. Nuc. Sci.* **39**, 993 (1992).

Mattox, J.R., Bertsch, D.L., Chiang, J., Dingus, B.L., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mayer-Hasselwander, H.A., Von Montigny, C., Michelson, P.F., Nolan, P.L., Pinkau, K., Schneid, E., Sreekumar, P., and Thompson, D.J., "The EGRET Detection of OVV Quasar 1633+382", to be published in *Ap.J. Lett.*, 1993.

Bertsch, D.L., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Von Montigny, C., Michelson, P.F., Nolan, P.L., Pinkau, K., Rothermel, H., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "Pulsed high-energy gamma-radiation from Geminga (!E0630+178)", *Nature* **357**, 306 (1992).

Papers Submitted:

Bertsch, D.L., Dingus, B.L., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Von Montigny, C., Michelson, P.F., Nolan, P.L., Pinkau, K., Schneid, E., Sreekumar, P., and Thompson, D.J., "Detection of Gamma-Ray Emission from the Quasar PKS 0208-512", submitted to Ap.J. Lett., September, 1992.

Hunter, S.D., Bertsch, D.L., Fichtel, C.E., Hartman, R.C., Kanbach, G., Kniffen, D.A., Kwok, P.W., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Von Montigny, C., Michelson, P.F., Möller, P., Nolan, P.L., Pinkau, K., Radecke, H.-D., Shaver, P., Schneid, E., Sommer, M., Sreekumar, P., and Thompson, D.J., "Detection of High Energy Gamma Rays from Quasar PKS 0528+134 by the EGRET Telescope on the Compton Gamma Ray Observatory", submitted to *Ap.J.*, September 1992.

Sreekumar, P., Bertsch, D.L., Dingus, B.L., Fichtel, C.E., Hartman, R.C., Hunter, S.D., Kanbach, G., Kniffen, D.A., Lin, Y.C., Mattox, J.R., Mayer-Hasselwander, H.A., Michelson, P.F., Von Montigny, C., Nolan, P.L., Pinkau, K., Schneid, E., and Thompson, D.J., "Observations of the Large Magellanic Cloud in High Energy Gamma Rays", submitted to *Ap.J. Lett.*, August 1992.

IAU Circulars

S. Hunter, et al., "New High Latitude Gamma-Ray Sources", #5594
J. R. Mattox, et al., "Geminga", #5583
R. L. Hartman, et al., "PKS 0202+149, PKS 0235+164, PKS 0420-014", #5519
D. Kniffen, et al., "PSR 1706-44", #5485
R. L. Hartman, et al., "3C 454.3 and CTA 102", #5477

IV. REPORT FOR THE PERIOD 11/2/92 - 11/20/93.

This section covers work performed by Stanford University investigators during the period November 2, 1992 to November 20, 1993. During this period, analysis of Phase I observations was completed and Phase II observations were completed. Analysis of Phase II observations was a principal activity during this time period. Phase III observations that were part of successful key projects proposals that the team was involved withwere also performed.

Personnel: The Stanford group consisted of Professor Peter F. Michelson (principal investigator and EGRET co-investigator), Dr. Patrick Nolan (EGRET co-investigator), Dr. Y.C. Lin, and several graduate students that included Mr. Joseph Fierro, Mr. Tom Willis, and Mr. L. Marhenke. We contined to make use of the technical services of Mr. Joseph Lepetich on a part time basis. One Stanford unmatriculated graduate student (Mr. Scott Schriver) worked part time on the project.

Activities: Major activities have been the continued refinement of software products that are part of the EGRET scientific data analysis package, the scientific analysis of flight data, reporting of scientific results at a variety of scientific meetings, and the writing of scientific papers for scholarly journals. Several papers were published or submitted by the EGRET Science team during this period. Several IAU telegrams were also published during the report period. Publications and submitted papers are listed below.

During the period covered by this report, members of the Stanford team attended several EGRET team meetings. These meetings were as follows: December 8-11, 1992 (Goddard), Feb 8-11, 1993 (Goddard), May 25, 1993 (Goddard), June 23-25, 1993 (Goddard), August 17-19, 1993 (Stanford).

Presentations at professional meetings or invited seminars: The following papers were delivered by members of the Stanford team on behalf of the EGRET collaboration.

(i) American Physical Society Meeting, Washington, D.C., April 14, 1993
Peter F. Michelson, "Results from from the EGRET All-sky Survey: A High ENergy View of the Universe", invited talk

(ii) 1st Mt. Stromlo Symposium on the Physics of Active Galaxies, Canberra, Australia, June 29, 1993
Peter F. Michelson, "EGRET Observations of AGNs", invited talk

(iii) 23rd Yamada Symposium, The Universe and Its Observational Quest, Tokyo, Japan, June 1993
Peter F. Michelson, "The Compton Observatory/EGRET All-Sky Survey: A High Energy Gamma-ray View of the Universe", invited talk

(iv) Compton Observatory Symposium, University of Maryland, September 22, 1993
Peter F. Michelson, "Variability of EGRET-detected Active Galaxies and Acceleration Mechanisms", invited talk
Y.C. Lin, "EGRET Observations of Mkn 421 in Phase I and Phase II of the Compton Observatory's Viewing Program - A Summary", poster paper

(v) The 2nd Buckingham Lecture, University of Western Australia, Perth, Australia, October 30, 1993
Peter F. Michelson, "From X-ray to Gamma-Rays: Observing Neutron Stars and Black Holes", invited lecture

(vi) AAS Meeting, Phoenix, AZ, January 4-7, 1993
Y.C. Lin, "EGRET Observations in High ENergy Gamma-rays of Seyfert Galaxies Selected According to X-ray Fluxes", oral contributed paper

(vii) AAS Meeting, Berkeley, CA, June 6-10, 1993
Y.C. Lin, "Possible Time Variations in the High Energy Gamma-ray Fluxes of 0235+164, 0716+714, and Mkn 421", oral paper
P.F. Michelson, "Variability of Hard Gamma-ray Emission from Active Galaxies Observed by EGRET", poster paper
P.L. Nolan, "EGRET Observations of A Mid-latitude Region: $10^o < b < 45^o$, $-90^o < l , 90^o$", poster paper
J. Fierro, "EGRET Observations of High Energy Gamma-ray Pulsars", oral presentation

Publications:

This list includes papers that were published during 11/2/92 - 11/20/93 that members of the Stanford EGRET team are co-authors on. It also includes IAU Circulars.

1) Thompson, D.J., et al. "EGRET observations of active galactic nuclei: 0836+710, 0454-234, 0804+499, 0906+430, 1510-089, and 2356+196." ASTROPHYSICAL JOURNAL, LETTERS (20 Sept. 1993) vol.415, no.1, pt.2, p. L13-16. (Journal article - English)
2) Fierro, J.M., et al. "Pulsed high-energy gamma rays from PSR 1055-52."

ASTROPHYSICAL JOURNAL, LETTERS (10 Aug. 1993) vol.413, no.1, pt.2, p. L27-30. (Journal article - English)
3) Nolan, P.L., et al. "Observation of high-energy gamma rays from the quasi-stellar object CTA 102." ASTROPHYSICAL JOURNAL (1 Sept. 1993) vol.414, no.1, pt.1, p. 82-5. (Journal article - English)
4) Mattox, J.R., et al. "The EGRET detection of quasar 1633+382." ASTROPHYSICAL JOURNAL (20 June 1993) vol.410, no.2, pt.1, p. 609-14. (Journal article - English)
5) Kniffen, D.A., et al. "Time variability in the gamma-ray emission of 3C 279." ASTROPHYSICAL JOURNAL (1 July 1993) vol.411, no.1, pt.1, p. 133-6. (Journal article - English)
6) Thompson, D.J., et al. "Gamma radiation from blazar PKS 0537-441." ASTROPHYSICAL JOURNAL (10 June 1993) vol.410, no.1, pt.1, p. 87-9. (Journal article - English)
7) Nolan, P.L., et al. "PKS 0528+134." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (22 May 1993) no.5802, p. 1 pp.. (Journal article - English)
8) Hunter, S.D., et al. "Detection of high energy gamma rays from BL Lac PKS 0235+164 by the EGRET telescope on the Compton Observatory." ASTRONOMY AND ASTROPHYSICS (May 1993) vol.272, no.1, p. 59-62. (Journal article - English)
9) Hunter, S.D., et al. "Detection of high-energy gamma rays from quasar PKS 0528+134 by EGRET on the Compton Gamma Ray Observatory." ASTROPHYSICAL JOURNAL (20 May 1993) vol.409, no.1, pt.1, p. 134-8. (Journal article - English)
10) Nolan, P.L., et al. "Observations of the Crab pulsar and nebula by the EGRET telescope on the Compton Gamma-Ray Observatory." ASTROPHYSICAL JOURNAL (1 June 1993) vol.409, no.2, pt.1, p. 697-704. (Journal article - English)
11) Hartman, R.C., et al. "EGRET detection of high-energy gamma radiation from the OVV quasar 3C 454.3." ASTROPHYSICAL JOURNAL, LETTERS (20 April 1993) vol.407, no.2, pt.2, p. L41-4. (Journal article - English)
12) Sreekumar, P., et al. "PKS 0528+134." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (7 April 1993) no.5754, p. 1 pp.. (Journal article - English)
13) Sreekumar, P., et al. "PKS 0528+134." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (7 April 1993) no.5753, p. 1 pp.. (Journal article - English)
14) Bertsch, D.L., et al. "Detection of gamma-ray emission from the quasar PKS 0208-512." ASTROPHYSICAL JOURNAL, LETTERS (1 March 1993) vol.405, no.1, pt.2, p. L21-4. (Journal article - English)
15) von Montigny, C., et al. "2CG 135+01." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (13 Feb. 1993) no.5708, p. 1 pp.. (Journal article - English)
16) Sommer, M., et al. "GRB 930131." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (5 Feb. 1993) no.5707, p. 1 pp.. (Journal article - English)
17) Sreekumar, P., et al. "Constraints on the cosmic rays in the Small Magellanic Cloud." PHYSICAL REVIEW LETTERS (11 Jan. 1993) vol.70, no.2, p. 127-9. (Journal article - English)
18) Michelson, P.F., et al. "Search for periodic gamma-ray emission from Cygnus X-3 by the EGRET telescope on the Compton Gamma-ray Observatory." ASTROPHYSICAL JOURNAL (20 Dec. 1992) vol.401, no.2, pt.1, p. 724-7. (Journal article - English)
19) Lin, Y.C., et al. "GRO J1837+59." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (16 Dec. 1992) no.5676, p. 1 pp.. (Journal article - English)
20) Lin, Y.C., et al. "Detection of high-energy gamma-ray emission from the BL lacertae object Markarian 421 by the EGRET telescope on the Compton Observatory." ASTROPHYSICAL JOURNAL, LETTERS (20 Dec. 1992) vol.401,

no.2, pt.2, p. L61-4. (Journal article - English)
21) Dingus, B.L., et al. "PKS 1406-076." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (7 Jan. 1993) no.5690, p. 1 pp.. (Journal article - English)
22) Sreekumar, P., et al. "Observations of the Large Magellanic Cloud in high-energy gamma rays." ASTROPHYSICAL JOURNAL, LETTERS (1 Dec. 1992) vol.400, no.2, pt.2, p. L67-70. (Journal article - English)
23) Mayer-Hasselwander, H.A., et al. "Geminga." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (6 Nov. 1992) no.5649, p. 1 pp.. (Journal article - English)

V. REPORT FOR THE PERIOD 11/2/93 - 12/15/94.

This section covers work performed by Stanford University investigators during the period November 2, 1993 to December 20, 1994. The principal activity during this period was the continuing analysis of data obtained during Phases I, II, and III for sources of high-energy gamma radiation. This work resulted in a number of team publications in cooperation with team members at Goddard Space Flight Center, MPE, Hampden-Sydney College, and Grumman Aerospace. Preparation of several summary papers on particular regions of the sky were also begun. Preparation of a 2nd EGRET Source Catalog was begun as well. Phase II and III observations were completed. The Stanford team also contributed substantial effort to the on-going Viewing Period analysis and to a re-analysis of the all-sky survey data.

Personnel: The Stanford group duirng this period consisted of Professor Peter F. Michelson (principal investigator and EGRET co-investigator), Dr. Patrick Nolan (EGRET co-investigator), Dr. Y.C. Lin, and graduate students (Mr. Joseph Fierro, Mr. Thomas Willis, Mr. Scott Schriver, Mr. Brian Jones and Mr. L. Marhenke).

Activities: Major activities included the continued refinement of software products that are part of the EGRET scientific data analysis package, the scientific analysis of flight data, assistance in the analysis of in-flight instrument performance (particularly of the TASC), reporting of scientific results at a variety of scientific meetings, and the writing of scientific papers for scholarly journals. During the period 11/2/93 - 12/15/94, the POINT EXPOSE software was substantially improved and the program PULSAR was streamlined for efficient use in conjunction with LIKE and SPECTRAL for the detailed analysis of the phase-dependent spectral properties of pulsar emission.

The Stanford group also collaborated on the analysis of scientific data that resulted in several papers, either published or submitted by the EGRET Science team. Several IAU telegramswere published as well. Publications and submitted papers are listed below.

Members of the Stanford team also attended several EGRET team meetings. These meetings were as follows: December 8-11, 1993 (Goddard), March 1994 (Goddard), June 7-9, 1994 (MPE, Munich), August 8-11, 1993 (Stanford).

Presentations at professional meetings: The following papers were delivered by members of the Stanford team on behalf of the EGRET collaboration.

(i) Towards A Major Atmospheric Cherenkov Detector, Institute for Cosmic Ray Research, University of Tokyo, May 27, 1994
Peter F. Michelson, "Recent Results from EGRET" (invited talk)

(ii) The First Edoardo Amaldi Conference on Gravitational Radiation, Frascati, Italy, June 14-16, 1994
Peter F. Michelson, "High-energy Gamma-ray Bursts" (invited talk)

(iii) The Gamma-ray Sky with CGRO and Sigma, Les Houches France, January 21-30, 1994
Peter F. Michelson, "EGRET Observations of High-Energy Diffuse Radiation" (invited talk)

(iv) American Astronomical Society Meeting, Washington, D.C., January 11, 1994
Patrick L. Nolan, "Point Sources Detected by EGRET with $b > 10^o$"
Y.C. Lin, "EGRET Observations of the Region with Galactic Latitudes South of $b = -30^o$"

(v) High-Energy Astrophysics Division Meeting, American Astronomical Society, Napa, California, November 2-5, 1994
Patrick L. Nolan, "Review of EGRET Pulsar Observations"

Publications:

This list includes papers, published during 11/2/93 - 12/15/94, that members of the Stanford EGRET team are co-authors on. It also includes IAU Circulars.

1) McGlynn, T.A., et al. " gamma -ray flare from direction of NRAO 190." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (26 Aug. 1994) no.6061, p. 1 pp.. (Journal article - English)
2) Fichtel, C.E., et al. "EGRET data reduction and analysis." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 721-5. (Conference paper - English)
3) Chiang, J., et al. "The luminosity function of EGRET-detected gamma-ray loud active galactic nuclei." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 654-8. (Conference paper - English)
4) Michelson, P.F., et al. "Variability of EGRET-detected active galaxies and acceleration mechanisms." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 602-10. (Conference paper - English)
5) Lin, Y.C., et al. "EGRET observations of Mrk 421 in phase 1 and phase 2 of

the Compton Observatory's viewing program-a summary." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 582-6. (Conference paper - English)
6) Hartman, R.C., et al. "EGRET observations of active galactic nuclei." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 563-71. (Conference paper - English)
7) Nolan, P.L., et al. "The unidentified gamma ray source GRO J1837+59." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 360-4. (Conference paper - English)
8) De Jager, O.C., et al. "The Crab unpulsed spectrum: new results and interpretation." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 72-6. (Conference paper - English)
9) Mattox, J.R., et al. "Timing the Geminga pulsar with high-energy gamma rays." Second Compton Symposium. Held: College Park, MD, USA, 20-22 Sept. 1993. AIP CONFERENCE PROCEEDINGS (1994) no.304, p. 77-81. (Conference paper - English)
10) Brazier, K.T.S., et al. "Upper limits on the high-energy gamma-ray fluxes from PSR 1951+32 and 1509-58." MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY (15 May 1994) vol.268, no.2, p. 517-20. (Journal article - English)
11) Sreekumar, P., et al. "A study of M31, M87, NGC 253, and M82 in high energy gamma rays." ASTROPHYSICAL JOURNAL (1 May 1994) vol.426, no.1, pt.1, p. 105-8. (Journal article - English)
12) Sommer, M., et al. "High-energy gamma rays from the intense 1993 January 31 gamma-ray burst." ASTROPHYSICAL JOURNAL, LETTERS (20 Feb. 1994) vol.422, no.2, pt.2, p. L63-6. (Journal article - English)
13) Mayer-Hasselwander, H.A., et al. "High-energy gamma radiation from Geminga observed by EGRET." ASTROPHYSICAL JOURNAL (20 Jan. 1994) vol.421, no.1, pt.1, p. 276-83. (Journal article - English)
14) De Jager, O.C., et al. "Crab Nebula." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (10 Nov. 1993) no.5887, p. 1 pp.. (Journal article - English)
15) Lin, Y.C., et al. "EGRET limits on high-energy gamma-ray emission from X-ray- and low-energy gamma-ray-selected Seyfert galaxies." ASTROPHYSICAL JOURNAL, LETTERS (20 Oct. 1993) vol.416, no.2, pt.2, p. L53-6. (Journal article - English)

VI. REPORT FOR THE PERIOD 12/16/94 - 8/31/95.

This section covers work performed by Stanford University investigators during the period 12/16/94 - 8/31/95. The principal activity during this period was continuing analysis of data in support of the EGRET team effort and in support of the CGRO Guest Investigator program. The 2nd EGRET Source Catalog wascompleted and submitted for publication during this time.

Personnel: The Stanford group duimg this period consisted of Professor Peter F. Michelson (principal investigator and EGRET co-investigator), Dr. Patrick Nolan (EGRET co-investigator), Dr. Y.C. Lin, and graduate students (Mr. Joseph Fierro, Mr. Thomas

Willis, Mr. Brian Jones and Mr.Bill Tompkins). During this period, Fierro successfully passed his thesis defense. His written thesis on High-Energy Emission from Pulsars will be completed in December 1995.

Activities: Major activities included the continued refinement of software products that are part of the EGRET scientific data analysis package, the scientific analysis of flight data, assistance in the analysis of in-flight instrument performance (particularly of the TASC), reporting of scientific results at a variety of scientific meetings, and the writing of scientific papers for scholarly journals. During the period 12/16/94 - 8/31/95, new capabilities were added to the SPECTRAL analysis software and substantial effort was also put into detailed analysis of the phase-dependent spectral properties of pulsar emission. The latter was a major part of the thesis of J. Fierro.

The Stanford group also collaborated on the analysis of scientific data that resulted in several papers, either published or submitted by the EGRET Science team. Several IAU telegramswere published as well. Publications and submitted papers are listed below.

Members of the Stanford team also attended several EGRET team meetings. These meetings were as follows: Feb 7-9, 1995 (Goddard), April 19-20, 1995 (Goddard), August 1995 (Stanford).

Presentations at professional meetings: The following papers were delivered by members of the Stanford team on behalf of the EGRET collaboration.

(i) Colloquium, Institute for Space and Astronautical Research, Japan, March 29, 1995
Peter F. Michelson, "Recent Results from the EGRET Experiment on the Compton Gamma-Ray Observatory"

(ii) 3rd Compton Symposium, Munich, 12-14 June 1995
Y.C. Lin, et al., "EGRET Observations of Bl Lacertae Objects with Redshift below 0.2"
P.L. Nolan, et al., "EGRET Observations of Pulsars"
T.D. Willis, et al. "Using Fluctuation Analysis to Constrain the Point Source Contribution to the Isotropic Diffuse Gamma-ray Background"

Publications:

This list includes papers, published during 12/16/94 - 8/31/95, that members of the Stanford EGRET team are co-authors on. It also includes IAU Circulars.

1) von Montigny, C., et al. "Studies of some superluminal blazars and strong flat-spectrum radio quasars, that are not seen in high energy gamma-rays by EGRET." ASTRONOMY AND ASTROPHYSICS (20 July 1995) vol.299, no.3, p. 680-8.

2) Ramanamurthy, P.V., et al. "EGRET detection of pulsed gamma radiation from PSR B1951+32." ASTROPHYSICAL JOURNAL, LETTERS (10 July 1995) vol.447, no.2, pt.2, p. L109-12.
3) Fierro, J.M., et al. "EGRET high-energy gamma -ray pulsar studies. II. Individual millisecond pulsars." ASTROPHYSICAL JOURNAL (10 July 1995) vol.447, no.2, pt.1, p. 807-12
4) Mukherjee, R., et al. "EGRET gamma-ray sources: GRO J0744+54 and GRO J0957+65 (=BL Lacertae object 0954+658)." ASTROPHYSICAL JOURNAL (20 May 1995) vol.445, no.1, pt.1, p. 189-95.
5) Ramanamurthy, P.V., et al. "PSR 1951+32." INTERNATIONAL ASTRONOMICAL UNION CIRCULAR (8 March 1995) no.6147, p. 1 pp.
6) Lin, Y.C., et al. "EGRET observations of the BL Lacertae objects 0716+714 and 0521-365." ASTROPHYSICAL JOURNAL (20 March 1995) vol.442, no.1, pt.1, p. 96-104
7) von Montigny, C., et al. "High-energy gamma-ray emission from active galaxies: EGRET observations and their implications." ASTROPHYSICAL JOURNAL (20 Feb. 1995) vol.440, no.2, pt.1, p. 525-53.
8) Radecke, H.-D., et al. "EGRET detection of the blazar PKS 0420-014." ASTROPHYSICAL JOURNAL (10 Jan. 1995) vol.438, no.2, pt.1, p. 659-62.
9) Fichtel, C.E., et al. "The first Energetic Gamma-Ray Experiment Telescope (EGRET) source catalog." ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES (Oct. 1994) vol.94, no.2, p. 551-81
10) Thompson, D.J., et al. "EGRET high-energy gamma-ray pulsar studies. I. Young spin-powered pulsars." ASTROPHYSICAL JOURNAL (20 Nov. 1994) vol.436, no.1, pt.1, p. 229-38.
11) Michelson, P.F., et al. "EGRET upper limits to the high-energy gamma-ray emission from the millisecond pulsars in nearby globular clusters." ASTROPHYSICAL JOURNAL (1 Nov. 1994) vol.435, no.1, pt.1, p. 218-24.
12) Fichtel, C.E., et al. "Search of the Energetic Gamma-Ray Experiment Telescope (EGRET) data for high-energy gamma-ray microsecond bursts." ASTROPHYSICAL JOURNAL (20 Oct. 1994) vol.434, no.2, pt.1, p. 557-9.
13) Kanbach, G., et al. "EGRET observations of the Vela pulsar, PSR 0833-45." ASTRONOMY AND ASTROPHYSICS (Sept. 1994) vol.289, no.3, p. 855-67.
14) Kanbach, G., et al. "GRO J1629-49", IAU Circular, July 1995.
15) Ulmer, M., et al., "Compton Gamma-ray Observatory Observations of the Crab Pulsar", ASTROPHYSICAL JOURNAL (20 July 1995) vol. 448, no.1, p. 356-364.