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THE *ULYSSES* SUPPLEMENT TO THE BATSE 4Br CATALOG OF COSMIC GAMMA-RAY BURSTS

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ABSTRACT

We present Interplanetary Network localization information for 147 gamma-ray bursts observed by the Burst and Transient Source Experiment between the end of the Third BATSE catalog and the end of the Fourth BATSE catalog, obtained by analyzing the arrival times of these bursts at the *Ulysses* and *Compton Gamma-Ray Observatory* (*CGRO*) spacecraft. For any given burst observed by these two spacecraft, arrival time analysis (or "triangulation") results in an annulus of possible arrival directions whose half-width varies between 7′ and 2°.3, depending on the intensity and time history of the burst, and the distance of the *Ulysses* spacecraft from Earth. This annulus generally intersects the BATSE error circle, which results in an average reduction of the error box area of a factor of 25.

Subject headings: gamma rays: bursts — catalogs

1. INTRODUCTION

In a previous paper (Hurley et al. 1999) we have presented the *Ulysses* supplement to the BATSE 3B Catalog of Cosmic Gamma-Ray Bursts (hereafter referred to as the 3B supplement). This catalog contained improved positions for 218 bursts in the Third BATSE catalog (Meegan et al. 1996), obtained by arrival time analysis, or "triangulation" between the *Compton Gamma-Ray Observatory* and *Ulysses* spacecraft. The last BATSE burst in the 3B supplement is 3168, on 1994 September 15. In the present catalog, we update the 3B supplement with the addition of data on 147 bursts that occurred between 1994 September 15 and 1996 August 15 (BATSE 5575), the last burst in the BATSE 4Br catalog (Paciesas et al. 1999) observed by *Ulysses*. As none of the information in the 3B supplement has changed, we do not include any of the detailed data on the bursts in that catalog.

2. INSTRUMENTATION, SEARCH PROCEDURE, DERIVATION OF ANNULI, AND BURST SELECTION CRITERIA

None of these has changed from the 3B supplement. We review each briefly but refer the reader to Hurley et al. (1999) for a more detailed description.

The *Ulysses* GRB detector (Hurley et al. 1992) consists of two 3 mm thick hemispherical CsI scintillators with a projected area of about 20 cm^2 in any direction. The detector is mounted on a magnetometer boom far from the body of the spacecraft and has a practically unobstructed view of the full sky. BATSE consists of eight detector modules situated at the corners of the *Compton Gamma-Ray Observatory* spacecraft. Each contains a Large Area Detector (LAD), a 50.8 cm diameter by 1.27 cm thick NaI scintillator (Meegan et al. 1996).

Every cosmic burst detected by BATSE is systematically searched for in the *Ulysses* data as soon as the BATSE data are available for it. This is done by using the approximate arrival direction from BATSE and the position of the *Ulysses* spacecraft to calculate a range of possible arrival times at *Ulysses*. Typical window lengths are 300–500 s.

When a GRB arrives at two spacecraft with a delay δT, it may be localized to an annulus whose half-angle θ with respect to the vector joining the two spacecraft is given by

$$\cos\theta = \frac{c\delta T}{D}\,, \tag{1}$$

where c is the speed of light and D is the distance between the two spacecraft. (This assumes that the burst is a plane wave, i.e., that its distance is much greater than D.) The annulus width $d\theta$, and thus one dimension of the resulting error box, is $c\sigma(\delta T)/D \sin\theta$, where $\sigma(\delta T)$ is the uncertainty in the time delay. The radius of each annulus and its right ascension and declination are calculated in a heliocentric (i.e., aberration-corrected) frame.

The main selection criterion for a burst in this catalog is that it must have been detected by *Ulysses* and BATSE. We also utilize several other criteria, based on the correlation coefficient between the two light curves, a χ^2 statistic, and the ratio of the observed *Ulysses* counts to the BATSE counts. A final criterion for inclusion in the 3B supplement, namely that the burst must not have been observed by a third interplanetary spacecraft, is automatically satisfied for the present catalog, since no interplanetary spacecraft with burst detectors were in operation, other than *Ulysses*.

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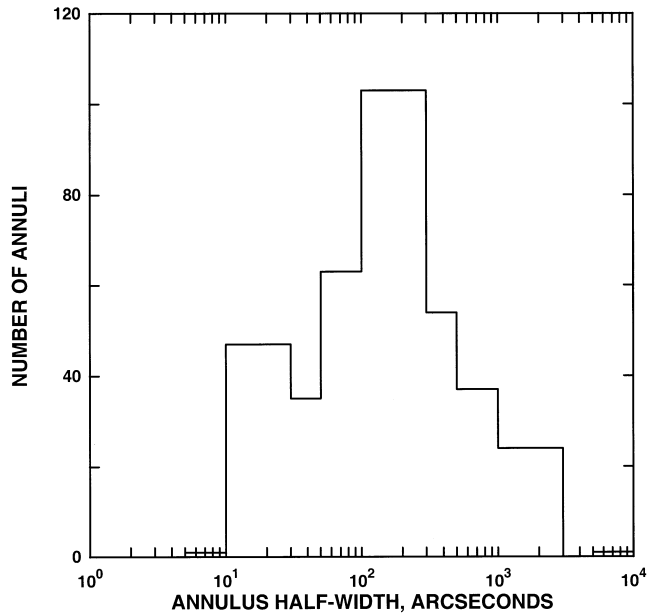

FIG. 1.—Distribution of 365 *Ulysses*/BATSE annulus half-widths

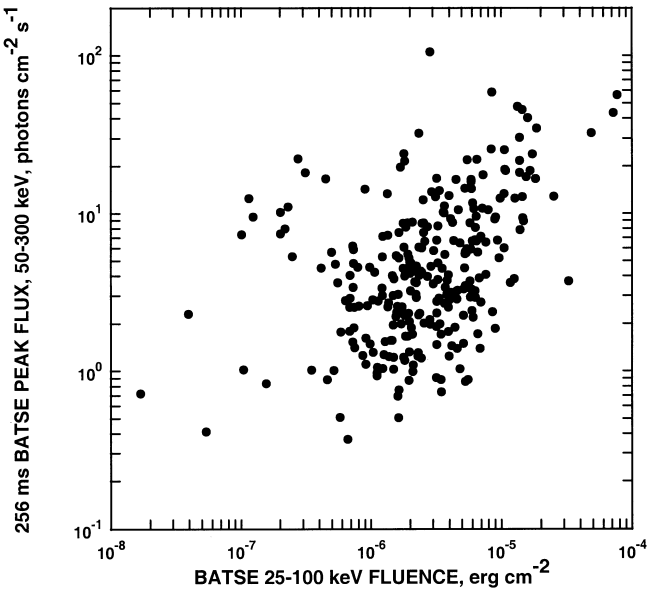

FIG. 3.—Peak fluxes (measured over 256 ms, 50–300 keV) and 25–100 keV fluences of 285 of the bursts in this catalog. No entries are given in the 4Br catalog for 80 of the bursts.

3. A FEW STATISTICS

There are 1637 bursts in the 4Br catalog (Paciesas et al. 1999). Of these, 428 were observed by *Ulysses* and BATSE and in some cases, other spacecraft as well.[2] Thus *Ulysses* observed approximately one out of every 3.8 BATSE bursts over this period. The combination of the 3B supplement and the present catalog contains 365 bursts.

The histogram of Figure 1 shows the distribution of annulus half-widths (i.e., $\delta R_{\rm IPN}$ in Table 1) for the 365 bursts localized. The smallest is about 7″, the largest 2°.3, and the average is 5′.4. A total of 265 of the annuli, or 73%, intersect the BATSE 1 σ error circles, whose radii are defined by $r_{1\,\sigma} = (\sigma_{\rm stat}^2 + \sigma_{\rm sys}^2)^{1/2}$, where $\sigma_{\rm sys}$ is the systematic error, 1°.6, and $\sigma_{\rm stat}$ is the statistical error. This is less than the number that would be predicted (87%). An analysis of a preliminary version of the IPN catalog describes several more complicated BATSE error models that are consistent with the BATSE-IPN separations (Briggs et al. 1998). A more extensive analysis, utilizing the data in the present paper, appears in Briggs et al. (1999). One quantity of interest is how close the annulus passes to the center of the error circle. Let α_1, δ_1 be the right ascension and declination of the center of a BATSE error circle, and let α_2, δ_2, θ_2 be the right ascension, declination, and radius of an annulus. Then the minimum distance between the error circle and the annulus is given by

$$d = |\theta_2 - \cos^{-1}[\sin(\delta_1)\sin(\delta_2) + \cos(\delta_1)\cos(\delta_2)\sin(\alpha_1 - \alpha_2)]| . \quad (2)$$

A histogram of the distribution of minimum distances between the annuli and the centers of the BATSE error circles is given in Figure 2.

In general, the annuli obtained by triangulations are small circles on the celestial sphere, so their curvature, even across a relatively small BATSE error circle, is not always negligible, and a simple, four-sided error box cannot be defined. For this reason, we do not cite the intersection points of the annulus with the error circle.

Figure 3 shows the BATSE peak fluxes and fluences for 285 of the 365 bursts with flux and fluence entries in the 4Br catalog.

[2] A list of all cosmic bursts and the spacecraft which detected them may be found at http://ssl.berkeley.edu/ipn3/index.html.

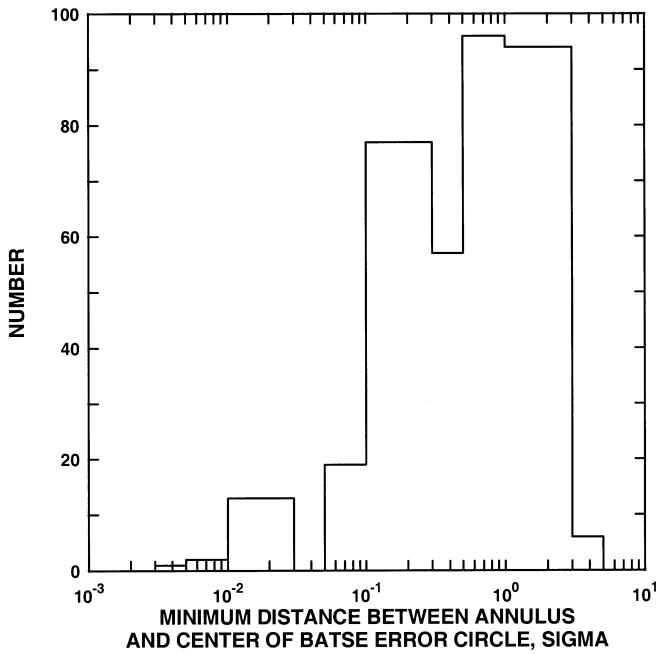

FIG. 2.—Distribution of minimum angular distances between the 365 annuli and the centers of the BATSE error circles. The angular distances are expressed in number of σ for the BATSE error circle radii, i.e., $d/r_{1\,\sigma}$.

4. TABLE OF ANNULI

The ten columns in Table 1 contain the following information: column (1): the date of the burst, in ddmmyy format; column (2): the universal time of the burst at Earth; column (3): the BATSE number for the burst; column (4):

TABLE 1

Ulysses/BATSE ANNULI

Date (1)	UT (2)	N_B (3)	$\alpha_{2000,B}$ (4)	$\delta_{2000,B}$ (5)	$\sigma_{\mathrm{stat},B}$ (6)	$\alpha_{2000,\mathrm{IPN}}$ (7)	$\delta_{2000,\mathrm{IPN}}$ (8)	R_{IPN} (9)	δR_{IPN} (10)
210994.....	05:08:13	3178	204.90	−17.77	5.29	155.521	−55.212	54.343	0.014
031094.....	05:17:17	3212	186.90	35.04	1.29	343.275	60.048	79.473	0.094
081094.....	13:32:52	3227	305.62	−52.18	0.87	167.522	−62.363	58.853	0.011
141094.....	09:20:08	3241	31.66	7.43	1.14	352.973	64.966	64.035	0.007
141094.....	23:15:16	3242	164.78	19.74	1.31	173.571	−65.225	84.182	0.027
171094.....	10:19:33	3245	301.55	9.81	0.19	356.264	66.336	65.561	0.013
201094.....	18:20:00	3251	158.99	−2.72	2.33	180.319	−67.826	69.752	0.157
201094.....	20:05:27	3253	49.99	−24.74	1.03	180.416	−67.860	82.022	0.015
231094.....	04:34:32	3255	212.28	−82.35	0.42	183.608	−68.895	15.870	0.031
261094.....	02:52:35	3257	205.96	−6.53	0.47	188.047	−70.152	64.991	0.220
261094.....	22:10:50	3259	109.06	33.56	0.85	9.376	70.489	62.802	0.225
311094.....	11:21:58	3269	217.27	−24.16	1.13	197.728	−72.274	49.713	0.266
191194.....	19:30:50	3287	182.50	21.98	0.42	70.723	74.969	73.825	0.018
211194.....	17:24:57	3290	35.45	−66.37	1.98	256.325	−74.588	34.074	0.032
251194.....	22:04:30	3295	240.92	−18.48	0.70	267.701	−73.352	55.459	0.077
261194.....	12:22:01	3298	264.74	−61.30	0.23	269.192	−73.135	14.236	0.054
271194.....	14:30:17	3303	69.17	44.97	1.29	91.859	72.712	30.076	0.085
281194.....	18:41:26	3306	19.57	−33.95	1.06	274.576	−72.231	63.385	0.030
281294.....	07:39:41	3330	353.78	−49.23	1.64	313.638	−54.491	24.995	0.141
291294.....	22:50:58	3334	255.18	39.99	1.16	134.838	53.382	76.440	0.069
040195.....	07:18:39	3345	303.26	−15.63	0.47	318.438	−49.769	36.621	0.046
080195.....	02:04:20	3349	17.71	−12.94	3.58	320.718	−47.219	57.551	0.015
110195.....	04:47:43	3351	336.24	−64.78	1.26	322.465	−45.130	21.569	0.071
110195.....	12:18:30	3352	19.57	−10.22	0.32	322.636	−44.919	61.714	0.215
310195.....	11:35:35	3385	17.89	19.54	1.61	331.814	−31.836	67.978	0.109
080295.....	02:10:24	3408	336.96	54.19	0.33	334.717	−27.012	83.394	0.007
100295.....	02:20:21	3410	154.55	−27.48	1.15	155.444	25.748	53.632	0.008
110295.....	02:24:57	3412	9.51	52.65	1.08	335.804	−25.124	85.830	0.006
110295.....	20:07:48	3415	64.35	−55.02	1.16	336.065	−24.664	67.625	0.016
210295.....	20:45:05	3436	294.31	−32.15	0.60	339.467	−18.452	42.614	0.220
260295.....	14:48:56	3442	158.99	−13.90	0.60	160.996	15.516	29.579	0.100
020395.....	23:52:54	3449	206.65	60.22	2.80	162.370	12.830	62.763	0.111
050395.....	15:05:04	3458	197.20	−11.12	0.29	163.182	11.209	40.913	0.042
250395.....	07:10:44	3480	52.81	50.50	0.58	349.026	1.021	71.668	0.011
250395.....	17:36:31	3481	66.22	−11.56	0.33	349.154	1.299	79.595	0.006
270395.....	07:19:07	3485	54.12	38.01	1.32	349.610	2.296	70.902	0.374
270395.....	23:47:51	3486	274.40	20.46	2.57	349.812	2.735	76.492	0.519
010495.....	11:50:42	3488	197.93	56.95	1.22	171.120	−5.632	66.998	0.014
010495.....	20:43:54	3489	86.06	43.75	0.29	171.229	−5.870	89.812	0.041
030495.....	13:19:47	3491	36.39	10.71	0.43	351.723	6.965	43.887	0.013
030495.....	23:33:46	3492	184.64	56.55	1.67	171.848	−7.251	62.959	0.007
180495.....	23:16:35	3512	92.40	3.26	0.65	176.274	−17.317	81.419	0.106
210495.....	12:29:49	3516	72.01	−63.06	0.79	177.047	−19.094	81.042	0.054
250495.....	00:15:19	3523	163.16	−35.25	0.35	178.117	−21.561	16.998	0.037
030595.....	18:36:10	3537	159.16	−7.19	0.54	180.893	−27.907	32.533	0.010
100595.....	07:47:59	3569	188.57	−65.48	0.80	183.070	−32.803	31.251	0.064
130595.....	22:41:43	3571	271.60	−72.91	0.73	184.322	−35.558	57.903	0.033
210595.....	06:59:17	3588	22.21	−26.86	1.75	7.005	41.245	67.579	0.456
220595.....	23:41:23	3593	109.56	19.28	0.86	7.656	42.576	89.976	0.034
230595.....	05:39:29	3594	85.63	43.08	1.81	7.754	42.769	54.744	0.138
080695.....	22:34:32	3634	57.56	−53.60	0.76	195.210	−56.006	66.277	0.140
100695.....	01:54:09	3637	100.10	−17.65	0.83	195.810	−56.903	79.794	0.464
190695.....	05:28:39	3643	290.94	−13.39	12.98	201.402	−64.026	81.112	0.287
200695.....	00:44:33	3644	45.72	6.13	1.49	21.969	64.638	61.737	0.019
240695.....	23:21:24	3648	165.37	14.99	0.59	205.921	−68.350	89.790	0.039
250695.....	04:03:21	3649	271.64	−21.15	0.57	206.097	−68.497	61.270	0.058
300695.....	21:10:37	3655	174.28	21.48	2.61	32.000	72.602	81.349	0.169
010795.....	03:32:38	3657	320.14	−20.82	0.26	212.326	−72.789	75.052	0.007
010795.....	06:35:37	3658	346.27	37.74	0.36	32.474	72.874	39.854	0.022
060795.....	11:52:15	3662	28.61	31.52	0.81	40.076	76.364	45.942	0.385
110795.....	03:49:49	3663	85.81	−24.01	1.03	229.867	−79.179	73.994	0.113
130795.....	08:56:16	3664	286.67	30.04	2.14	56.024	80.361	63.327	0.303
260795.....	14:19:38	3709	12.54	−40.72	1.81	300.441	−83.254	47.559	0.021
040895.....	01:58:54	3734	287.45	56.26	0.32	154.235	80.709	40.979	0.010

TABLE 1—*Continued*

Date (1)	UT (2)	N_B (3)	$\alpha_{2000,B}$ (4)	$\delta_{2000,B}$ (5)	$\sigma_{\mathrm{stat},B}$ (6)	$\alpha_{2000,\mathrm{IPN}}$ (7)	$\delta_{2000,\mathrm{IPN}}$ (8)	R_{IPN} (9)	δR_{IPN} (10)
050895.....	03:44:14	3736	79.86	−39.38	1.75	337.035	−80.272	48.132	0.020
090895.....	23:52:25	3750	51.09	14.06	0.63	166.942	78.209	79.289	0.060
180895.....	01:23:22	3765	278.65	33.87	0.35	177.565	74.696	61.035	0.015
040995.....	14:38:08	3776	258.86	47.48	0.47	190.635	67.770	40.016	0.071
090995.....	23:44:12	3788	216.36	−0.11	0.37	193.474	65.934	65.317	0.037
021095.....	21:33:06	3843	46.05	−1.88	0.63	23.193	−59.716	59.919	0.146
101095.....	21:12:23	3857	126.55	39.35	3.18	206.055	58.154	49.436	0.274
141095.....	12:06:04	3866	167.85	−20.64	1.15	207.291	57.546	84.406	0.031
161095.....	00:41:21	3870	35.82	−24.36	0.35	27.801	−57.306	33.071	0.010
161095.....	19:53:28	3871	118.99	−49.09	2.27	28.067	−57.187	49.121	0.218
191095.....	13:24:04	3875	161.51	−87.81	1.80	28.962	−56.801	33.350	0.602
021195.....	05:52:55	3891	138.57	46.99	0.53	213.224	55.399	43.599	0.029
041195.....	01:37:42	3893	40.39	27.26	0.42	33.757	−55.279	80.709	0.053
071195.....	17:32:37	3900	11.99	29.34	5.26	214.811	55.089	87.309	0.101
121195.....	18:27:59	3905	132.52	49.08	2.94	216.218	54.931	52.665	0.025
131195.....	23:25:55	3906	355.11	−44.76	1.12	36.540	−54.909	30.208	0.120
171195.....	02:48:38	3909	285.79	37.05	1.96	217.381	54.892	50.236	0.052
191195.....	08:17:12	3912	306.46	−40.71	0.42	37.957	−54.907	59.571	0.047
241195.....	05:54:18	3918	73.32	51.68	1.15	219.187	55.028	69.352	0.215
021295.....	10:51:40	3929	328.06	−35.76	0.62	41.082	−55.493	51.555	0.051
031295.....	01:06:27	3930	279.84	−19.25	0.19	221.213	55.539	89.971	0.016
081295.....	05:26:56	3936	353.00	70.15	0.60	222.287	56.016	48.493	0.016
081295.....	11:47:23	3937	57.66	−28.15	4.59	42.331	−56.043	25.744	0.112
081295.....	23:24:13	3938	72.65	−68.48	1.98	42.428	−56.095	19.484	0.489
131295.....	04:57:32	3954	283.98	−6.82	0.60	223.214	56.597	82.982	0.024
191295.....	16:51:19	4039	240.79	60.51	0.66	224.261	57.531	11.292	2.297
201295.....	08:51:21	4048	104.53	23.20	0.48	224.353	57.639	85.179	0.031
271295.....	22:00:00	4146	68.61	1.59	1.85	45.226	−58.994	64.010	0.136
281295.....	15:47:26	4157	93.13	28.22	0.81	225.298	59.142	85.093	0.045
110196.....	12:55:23	4312	138.07	48.17	0.53	225.658	62.292	46.594	0.010
140196.....	12:15:04	4368	216.19	−29.73	0.09	225.469	63.054	89.387	0.041
190196.....	09:37:55	4462	86.33	54.65	0.77	224.911	64.359	55.420	0.050
240196.....	00:56:25	4556	51.04	54.05	0.30	224.023	65.642	60.001	0.012
010296.....	21:48:43	4701	358.05	14.46	0.31	41.148	−68.141	89.132	0.014
020296.....	14:05:51	4710	215.04	−64.63	1.54	40.852	−68.331	47.716	0.116
060296.....	04:58:17	4757	195.53	−9.07	0.40	219.081	69.332	81.557	0.033
100296.....	09:46:37	4814	232.30	77.01	1.63	216.549	70.451	6.653	0.268
160296.....	16:03:16	4898	355.45	16.75	0.52	211.691	71.973	82.540	0.020
290296.....	23:56:04	5080	358.22	12.40	2.55	16.953	−74.180	78.054	0.040
160396.....	18:34:44	5255	223.00	−70.17	1.40	355.865	−74.031	31.819	0.250
190396.....	14:26:33	5277	94.84	−47.72	2.01	352.443	−73.674	48.164	0.050
210396.....	21:11:20	5299	7.56	67.05	0.25	169.850	73.326	41.277	0.007
220396.....	05:27:21	5304	96.98	−54.61	0.26	349.471	−73.264	44.180	0.025
310396.....	05:53:26	5389	111.86	−20.39	0.85	341.046	−71.409	80.424	0.047
080496.....	22:12:27	5413	85.04	1.88	1.10	155.435	69.173	83.270	0.173
090496.....	19:56:17	5416	15.52	42.42	1.37	154.975	68.924	63.480	0.077
090496.....	21:25:44	5417	42.54	41.92	1.34	154.944	68.907	58.168	0.016
150496.....	21:41:28	5427	2.64	15.12	2.06	332.405	−67.200	86.464	0.117
160496.....	04:08:59	5428	66.85	73.60	2.06	152.315	67.127	25.706	0.199
180496.....	01:41:44	5433	170.50	0.42	1.46	151.681	66.572	69.690	0.042
180496.....	18:33:15	5436	110.32	−16.15	0.70	151.469	66.367	88.460	0.008
220496.....	16:39:35	5443	134.80	27.20	1.50	150.446	65.217	40.657	0.100
250496.....	23:59:50	5447	9.80	56.51	1.46	149.780	64.243	55.057	0.021
280496.....	13:12:32	5450	304.24	35.13	1.01	149.374	63.491	77.240	0.065
300496.....	13:51:26	5451	11.80	−51.49	1.11	329.116	−62.893	28.853	0.137
160596.....	23:24:08	5464	62.28	−18.07	1.82	328.560	−58.205	77.589	0.150
230596.....	16:32:01	5470	46.75	−63.32	1.85	328.920	−56.373	38.872	0.035
240596.....	09:05:26	5472	160.82	2.60	2.83	148.969	56.192	54.514	0.349
240596.....	20:09:09	5473	358.52	−24.77	0.72	329.006	−56.066	38.585	0.032
280596.....	02:14:22	5476	291.86	22.03	1.49	329.287	−55.209	84.466	0.025
290596.....	12:07:45	5477	14.40	48.89	0.36	149.423	54.842	71.176	0.004
310596.....	01:54:35	5479	34.21	−28.50	1.32	329.587	−54.434	53.620	0.031
050696.....	08:09:52	5486	154.26	−1.98	0.23	150.195	53.106	52.945	0.034
070696.....	21:41:15	5489	48.43	75.10	0.36	150.528	52.471	41.496	0.015
100696.....	21:23:02	5492	328.24	−29.35	2.63	330.940	−51.742	23.798	0.667
230696.....	01:18:48	5512	180.78	7.59	0.74	152.847	48.923	46.048	0.046

TABLE 1—*Continued*

Date (1)	UT (2)	N_B (3)	$\alpha_{2000,B}$ (4)	$\delta_{2000,B}$ (5)	$\sigma_{\mathrm{stat},B}$ (6)	$\alpha_{2000,\mathrm{IPN}}$ (7)	$\delta_{2000,\mathrm{IPN}}$ (8)	R_{IPN} (9)	δR_{IPN} (10)
230696.....	09:11:43	5514	163.70	−59.73	5.98	332.903	−48.848	74.746	0.026
240696.....	03:26:13	5517	98.96	32.05	1.83	153.032	48.680	43.631	0.221
250696.....	04:42:26	5518	110.59	−8.21	0.89	153.213	48.448	68.138	0.109
280696.....	05:20:22	5523	326.98	48.28	1.22	153.745	47.787	83.868	0.030
020796.....	15:11:26	5525	36.78	−15.53	0.47	334.542	−46.848	58.984	0.110
030796.....	13:42:53	5526	4.62	−7.75	0.96	334.713	−46.652	46.702	0.136
070796.....	10:16:40	5530	320.95	82.51	1.07	155.435	45.862	50.112	0.027
070796.....	12:24:53	5531	189.27	−1.78	1.23	155.451	45.843	53.860	0.121
080796.....	20:09:32	5534	307.03	9.80	0.51	335.703	−45.574	61.292	0.018
150796.....	00:48:26	5539	3.43	35.50	1.69	336.899	−44.355	85.016	0.096
220796.....	07:05:06	5548	29.64	31.67	0.91	338.339	−42.989	88.901	0.012
310796.....	05:46:01	5557	43.93	12.51	0.89	340.144	−41.403	83.839	0.012
030896.....	18:45:22	5561	338.02	−50.13	1.93	340.865	−40.801	12.019	0.014
040896.....	23:28:55	5563	218.67	68.20	0.39	161.109	40.606	41.491	0.004
070896.....	19:49:26	5567	157.53	32.13	0.21	161.690	40.139	10.156	0.025
080896.....	16:42:03	5568	85.25	37.02	0.44	161.869	39.998	57.917	0.009
150896.....	10:00:27	5575	265.33	−58.01	0.98	343.241	−38.943	56.214	0.008

the BATSE right ascension of the center of the error circle (J2000), in degrees; column (5): the BATSE declination of the center of the error circle (J2000), in degrees; column (6): the total 1 σ statistical BATSE error circle radius, in degrees (the approximate total 1σ radius is obtained by adding 1°.6 in quadrature, but see Briggs et al. 1998, 1999 for an improved error model); column (7): the right ascension of the center of the IPN (BATSE/*Ulysses*) annulus, epoch J2000, in the heliocentric frame, in degrees; column (8): the declination of the center of the IPN (BATSE/*Ulysses*) annulus, epoch J2000, in the heliocentric frame, in degrees; column (9): the angular radius of the IPN (BATSE/*Ulysses*) annulus, in the heliocentric frame, in degrees; and column (10): the half-width of the IPN (BATSE/*Ulysses*) annulus, in degrees; the 3 σ confidence annulus is given by $R_{\mathrm{IPN}} \pm \delta R_{\mathrm{IPN}}$.

Entries are given only for the 147 bursts that occurred between the end of the 3B and the end of the 4Br catalog. The BATSE data have been taken from the latest on-line catalog and are given here for convenience only; the catalog[3] should be considered to be the ultimate source of the most up-to-date BATSE data. Table 1 is also available electronically.[4]

Figure 4 compares the BATSE error circles with the IPN annulus/error circle intersections for the bursts in this catalog. To generate the plot, it was assumed that all annuli pass through the centers of their corresponding BATSE error circles.

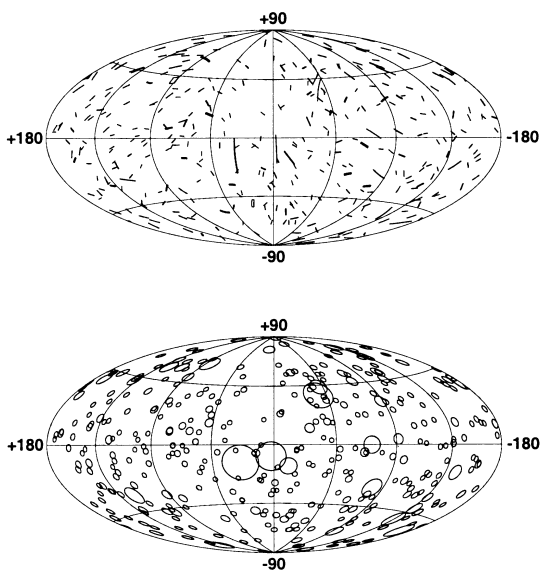

FIG. 4.—*Top*: Distribution of 365 *Ulysses*/BATSE error circle/annulus intersections. *Bottom*: distribution of 365 BATSE 4Br error circles in Galactic coordinates.

5. CONCLUSION

The *Ulysses* GRB experiment continues to operate. As of 1998 April, it has detected about 560 BATSE gamma-ray bursts. Data on these events may be found at the IPN web site.[5]

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[3] Available at http://www.batse.msfc.nasa.gov/data/grb/4bcatalog/.
[4] At http://ssl.berkeley.edu/ipn3/index.html.
[5] http://ssl.berkeley.edu/ipn3/index.html.

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