The updated mean fluxes of the known 1AGL and 1AGLR AGILE-GRID bright ɣ-ray source list on 2.3 years dataset

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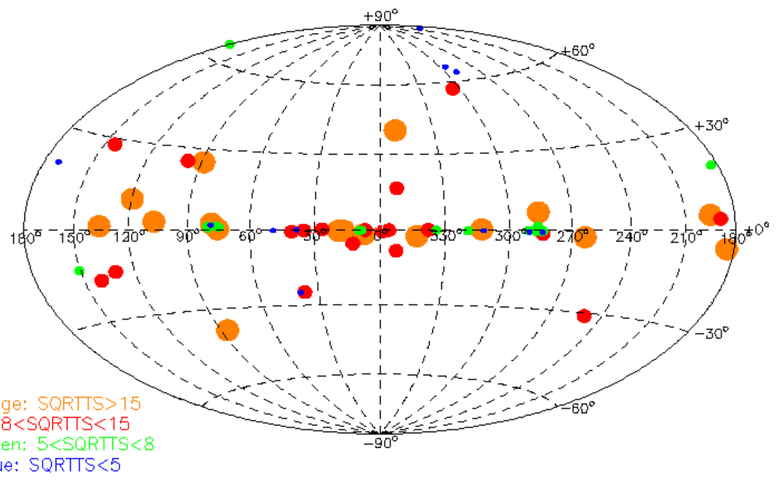

Figure 1: the Aitoff plot of 65 distinct known source positions, whose list is composed of the distinct1AGL and the revised 1AGLR sources. The source analysis has been obtained from the processing on all the pointed observations data from July 2007 to October 2009 (colors and symbol sizes are proportional to significance, blue the lowest and orange the highest).

Abstract:

The first AGILE-GRID source catalog (Pittori et al 2009; 1AGL) was obtained on the first year of pointed observations dataset , while the more recent "updated AGILE-GRID bright ɣ-ray source list" (Verrecchia et al. 2013; 1AGLR) was obtained with a 1AGL source position revision on the complete pointed observations dataset performed from July 9, 2007 to October 30, 2009, and a data processing on single "Observation Blocks", in the 100 MeV -- 50 GeV energy range. The 1AGL catalog included a sample of 47 sources and reported the mean first year flux for each, while 1AGLR included 54 sources among which 15 new and 20 repositioned 1AGL, reporting for each the flux detected in each single OB. No updated mean flux of 1AGLR was was published.
As one of the ADC responsability we developed a new processing procedure to support future catalogs, to be realized in collaboration with the AGILE Team. We decided to execute a preliminary reprocessing of all the known 1AGL +1AGLR sources on the complete (about 27.5 months) observation dataset obtained using more recent calibration with respect of both the catalogs. We report here the results source list with the updated fluxes.

Introduction

AGILE (Astrorivelatore Gamma ad Immagini LEggero) ([2], [3]) is an Italian Space Agency mission dedicated to ɣ-ray astrophysics in the 30 MeV -- 50 GeV and hard X-ray in 18 -- 60 keV energy ranges, in orbit since April 23 2007. AGILE has been the first instrument of a new generation of high-energy space missions based on solid-state silicon technology, permitting us to substantially advance our knowledge on many source classes such as active galactic nuclei, ɣ-ray bursts, pulsars (PSRs), unidentified ɣ-ray sources, Galactic compact objects and supernova remnants. The AGILE spacecraft operated in "fixed-pointing" mode until October 2009 (completing 101 pointings or "Observation Blocks", OBs), when the attitude control system had to be reconfigurated and the scientific operations changed into "spinning mode". Currently the instrument pointing direction scans the sky with an angular velocity of about 1deg/s, accessing about 80% of it each day. The significance-limited (4 sigma) sample of 47 1AGL sources were detected in the E >100 MeV band with a conservative analysis of the inhomogeneous first-year sky coverage dataset. An updated list of bright ɣ-ray was published in [4], mainly based on a preliminary position revision of bright 1AGL on the galactic plane using the complete "pointed observations", presented a variability study of the sample of 54 distinct sources analysing each OB separatedly, without publishing mean fluxes.

As one of the AGILE Data Center (ADC) responsibility we support the creation of new catalogs, so we executed a preliminary reprocessing of the 1AGL + 1AGLR known source sample, 65 distinct sources, on maps created from the whole "pointing mode" dataset ("deep" maps from now on) with the latest calibrations (I0023).

The AGILE satellite raw data, down-linked about every 100 minutes, are transmitted from the Mission Control Center at Telespazio, Fucino, to the AGILE Data Center (ADC), part of the ASI Science Data Center (ASDC) located in Rome (Italy). The ADC has the duties of data reduction, scientific processing and archiving and finally to distribute standard Level-2 data to Guest Observers (GOs) or, when data become public, to all the scientific community (see ADC web page http://agile.asdc.asi.it).

The OB data archive and source detection procedure

The OB data archive is created with the execution of the "standard analysis" OB pipeline at the ADC at the end of an OB, to remove data corresponding to slews and occasional losses of fine-pointing attitude and build the official OB data archive. Moreover scientific maps, counts, exposure and the diffuse emission one, were created selecting confirmed events and excluding albedo contaminated time intervals or those at off-axis angles > 60°. The ``pointing mode" OB archive is composed of 101 OB covering a wide timespan with non uniform exposures (ranging from 1d to 45dd). All the OB were recently reprocessed with the last software release (calibration I0023).
An ADC procedure has been developed to create scientific maps from the complete pointing mode dataset and also in the future from the complete AGILE-GRID dataset up to now, including the data acquired in Spinning mode. Scientific maps of 50°x50° size were created centered on 12 centers to allow analysis of all the source. The procedure developed for the scientific analysis in the E > 100 MeV band is based on source detection at fixed preselected positions using the AGILE Maximum Likelihood (ML). It consists of two main steps: I) preliminary ML multi-source analysis to evaluate all the source fluxes together, to allow fluxes comparison; II) execution of a further ML task run of each source separately after fixing the nearby source flux and the Gal/Iso diffuse emission parameter to estimate the sqrt(TS) parameter for each of them, so that it represents the significance (see below).

Source detection method

The detection method used is the ML. The significance of a source detection is given by the "test statistic" TS, defined as -2 times the log of the likelihood ratio, which according to the Wilks' theorem follows the χ^2 distribution ([12], [13]).
We express this source significance as a number of standard deviations "n" of a Gaussian distribution. Likelihood ratio is built considering for the background only hypothesis the AGILE diffuse ɣ-ray model ([14], [15]). We used the task "AG_multi4" included in the AGILE software for the ML "multi-source" analysis.

The AGILE Instrument

The AGILE Payload detector consists of the silicon tracker (ST; [6], [7]), the X-ray detector SuperAGILE ([8]), the CsI(Tl) Mini-Calorimeter (MCAL; [9], [10]), and an anti-coincidence system (ACS; [11]). The combination of ST, MCAL, and ACS forms the Gamma-Ray Imaging Detector (GRID). GRID, sensitive to photon energies in 30 MeV-50 GeV band, has a wide FOV(~2.5 sr in pointing) and accurate timing (a few μs), positional and attitude information (15' location accuracy for > 10σ detection).

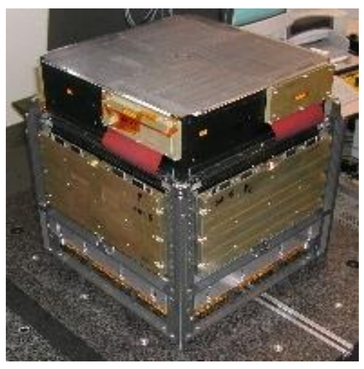

Figure 2: the AGILE-GRID 2.3 years all-sky exposure map in Aitoff projection obtained with the "FM" event filter on all the pointed-observations data (101 OBs) and recent calibrations (I0023).

The source table

The source table obtained after the processing of the source list on the recent "deep maps", reporting the updated fluxes, the previous 1AGL one, the confirmed association and the possible association with 5BZCAT and 3FGL catalogs, is shown below:

AGILE Name	(R.A. DEC) (J2000)	LII	BII	sqrt(TS)	Flux+/-Err	Other name	CLASS	3FGLAssociat.	BZCAT Association
1AGLRJ0007+7307	00 07 01.8 73 06 35.6	119.670	10.520	22.5	26.1+/-1 6.9	CTA1	Pulsar	3FGL J0007.0+7302	5BZQJ0019+7327
1AGLRJ0135+4759	01 35 01.7 47 58 39.6	130.435	-14.258	9.7	14.7+/-1 16.3	S40133+47	FSRQ	3FGL J0137.0+4752	5BZQJ0136+4751
1AGLRJ0222+4305	02 22 13.1 43 04 26.2	140.050	-16.760	8.3	14.0+/-1 6.7	3C 66A	BL Lac	3FGL J0222.6+4301	5BZBJ0222+4302
1AGLRJ0240+6115	02 40 10.6 61 14 44.9	135.630	1.084	28.4	72.4+/-3 11.0	LSI+61303	HMXRB	3FGL J0240.5+6113	------
1AGLRJ0321+4137	03 20 37.4 41 37 11.8	150.646	-13.086	5.9	10.9+/-2 7.0	NGC1275	AGN	3FGL J0319.8+4130	5BZUJ0319+4130
1AGLJ0535+2205	05 35 06.0 22 05 41.7	184.560	-5.630	56.2	281.1+/-7 9.4	Crab	Pulsar	3FGL J0534.5+2201	------
1AGLRJ0539-4358	05 38 32.2 -43 58 14.3	249.940	-31.125	9.8	28.9+/-3 2.5	PKS0537-441	BL Lac	3FGL J0538.8-4405	5BZBJ0538-4405
1AGLJ0617+2236	06 17 21.8 22 36 14.3	189.040	3.070	13.4	46.1+/-4 3.6	IC443	SNR	3FGL J0617.2+2234	
1AGLJ0634+1748	06 34 15.9 17 48 27.8	195.140	4.360	82.0	323.1+/-7 5.2	GEMINGA	Pulsar	3FGL J0633.9+1746	------
1AGLJ0657+4554	06 57 29.2 45 54 14.5	170.730	20.110	3.4	8.1+/-2 1.6	---	AGN unclassified	---	5BZQJ0654+4514
1AGLRJ0713+3340	07 12 44.2 33 23 54.1	184.260	18.660	6.1	15.7+/-3 7.1	---	AGN unclassified	---	5BZQJ0719+3307
1AGLRJ0723+7121	07 22 40.2 71 20 47.9	143.980	28.080	14.4	25.6+/-2 8.1	S50716+714	BL Lac	3FGL J0721.9+7120	5BZBJ0721+7120
1AGLJ0835-4509	08 35 13.4 -45 09 09.0	263.520	-2.790	179.5	725.7+/-7 18.3	VelaPSR	Pulsar	3FGL J0835.3-4510	------
1AGLRJ1018-5852	10 17 36.1 -58 51 24.9	284.160	-1.710	11.7	38.4+/-3 3.1	---	unidentified	3FGL J1018.9-5856	
1AGLRJ1022-5751	10 21 33.3 -57 50 44.5	284.040	-0.580	6.7	23.4+/-3 2.5	---	unidentified	3FGL J1023.1-5745	
1AGLRJ1022-5825	10 21 37.4 -58 25 21.0	284.360	-1.060	3.1	11.1+/-3 2.9	---	unidentified	3FGL J1021.9-5815	------
AGLJ1029-5836	10 29 24.1 -58 36 29.0	285.320	-0.680	7.0	22.9+/-3 3.8	0FGLJ1028.6-5817	Pulsar	3FGL J1030.0-5809	
1AGLRJ1044-5944	10 44 25.9 -59 44 01.4	287.550	-0.710	6.3	19.5+/-3 6.0	EtaCar	CWB	3FGL J1043.6-5930	
AGLJ1045-5736	10 45 00.7 -57 36 06.1	286.620	1.210	5.6	15.6+/-3 5.2	---	unidentified	3FGL J1044.5-5737	------
1AGLRJ1048-5843	10 47 32.8 -58 42 43.6	287.430	0.380	7.1	21.2+/-3 5.8	J1048-5832	Pulsar	3FGL J1048.2-5832	
1AGLJ1058-5239	10 58 31.1 -52 39 47.4	286.150	6.490	16.2	34.2+/-2 8.0	---	unidentified	3FGL J1057.9-5227	------
1AGLRJ1105+3818	11 04 46.5 38 18 00.6	179.579	65.062	5.4	16.2+/-3 9.7	Mkn421	BL Lac	3FGL J1104.4+3812	5BZGJ1105+3946
1AGLRJ1107-6115	11 06 31.5 -61 15 24.5	290.660	-0.910	4.0	12.0+/-3 9.1	---	unidentified	3FGL J1105.2-6113	------
1AGLRJ1112-6104	11 12 22.0 -61 04 21.3	291.240	-0.470	7.7	23.0+/-3 9.7	---	unidentified	3FGL J1111.9-6038	------
1AGLJ1222+2851	12 22 39.8 28 51 02.3	196.090	83.420	2.5	15.2+/-0 6.6	WComae(ON+231)	BL Lac	---	5BZBJ1221+3010
1AGLJ1228+0142	12 28 59.5 01 42 41.4	290.040	64.020	4.9	18.8+/-4 2.8	3C273	FSRQ	3FG L J1229.1+0202	5BZQJ1229+0203
1AGLJ1238+0406	12 38 31.0 04 06 14.3	294.740	66.770	2.2	16.4+/-0 0.6	---	FSRQ	---	5BZQJ1239+0443
1AGLJ1256-0549	12 56 33.2 -05 49 42.6	305.270	57.020	11.8	46.8+/-5 10.6	3C279	FSRQ	3FGL J1256.1-0547	5BZBJ1258-0447
1AGLJ1412-6149	14 12 06.1 -61 49 32.6	312.300	-0.430	2.4	16.2+/-0 14.3	---	unidentified	3FGL J1409.7-6132	
1AGLRJ1417-6108	14 17 28.6 -61 07 35.7	313.130	0.030	17.1	62.2+/-4 13.5	---	unidentified	3FGL J1420.0-6048	------
1AGLJ1506-5859	15 06 01.5 -58 59 13.7	319.520	-0.520	6.2	19.3+/-3 7.1	---	unidentified	3FGL J1509.4-5850	------
1AGLRJ1513-0906	15 13 09.8 -09 05 31.3	351.373	40.091	25.1	80.6+/-4 2.0	PKS1510-089	FSRQ	3FGL J1512.8-0906	5BZQJ1512-0905
1AGLJ1624-4946	16 24 26.9 -49 46 52.0	334.090	-0.250	7.1	27.4+/-4 7.5	---	unidentified	3FGL J1622.9-5004	------
1AGLRJ1625-2531	16 25 19.9 -25 30 43.5	352.030	16.360	11.4	28.1+/-2 3.7	OS-237.8	AGN	3FGL J1625.7-2527	5BZUJ1625-2527
1AGLJ1639-4702	16 39 05.5 -47 02 28.2	337.750	-0.150	14.6	59.0+/-4 11.2	---	unidentified	3FGL J1638.6-4654	------
1AGLJ1709-4428	17 09 24.7 -44 28 50.9	343.070	-2.640	42.3	110.7+/-3 16.6	PSRJ1709-4429	Pulsar	3FGL J1709.7-4429	------
1AGLJ1736-3235	17 36 20.0 -32 35 00.8	355.850	-0.240	12.3	54.4+/-4 15.8	---	unidentified	3FGL J1737.3-3214	------
1AGLJ1746-3017	17 46 01.5 -30 17 23.7	358.890	-0.780	9.2	43.1+/-4 12.7	---	unidentified	3FGL J1747.2-2958	------
1AGLJ1801-2317	18 01 22.7 -23 17 20.0	6.660	-0.180	12.7	42.6+/-3 5.0	W28	SNR	3FGL J1801.3-2326	------
1AGLRJ1803-3941	18 02 46.5 -39 40 36.5	352.450	-8.440	10.4	22.7+/-2 20.6	---	unidentified	3FGL J1802.6-3940	5BZQJ1802-3940
1AGLRJ1805-2149	18 05 25.6 -21 49 06.6	8.400	-0.270	6.2	28.0+/-4 3.2	---	unidentified	3FGL J1805.6-2136	
1AGLRJ1807-2103	18 07 30.1 -21 03 26.2	9.300	-0.320	7.4	33.1+/-4 2.3	AGLJ1807-2104	unidentified	---	
1AGLRJ1809-2333	18 09 23.0 -23 33 02.9	7.330	-1.910	16.3	60.7+/-4 4.5	---	unidentified	3FGL J1809.8-2332	------
1AGLJ1815-1732	18 15 29.7 -17 32 27.1	13.290	-0.280	2.0	17.9+/-0 1.7	---	unidentified	3FGL J1814.1-1734	
1AGLRJ1822-1456	18 22 30.1 -14 56 11.8	16.380	-0.530	15.9	73.1+/-5 4.8	---	unidentified	3FGL J1821.6-1436	
1AGLJ1827-1247	18 26 57.7 -12 46 58.6	18.790	-0.480	17.1	78.5+/-5 7.2	---	unidentified	3FGL J1826.1-1256	
1AGLRJ1833-2057	18 33 22.9 -20 56 40.8	12.240	-5.600	11.7	30.9+/-3 5.0	PKSB1830-210	FSRQ	3FGL J1833.6-2103	5BZQJ1833-2103
1AGLJ1836+5923	18 36 16.7 59 23 44.2	88.845	24.987	37.1	38.7+/-1 5.1	---	unidentified	3FGL J1836.2+5925	5BZBJ1841+5906
1AGLRJ1839-0550	18 39 00.8 -05 50 25.9	26.320	0.090	10.9	43.7+/-4 14.7	J1838-0549	Pulsar	3FGL J1838.9-0537	
1AGLRJ1848+6709	18 48 22.6 67 09 21.8	97.540	25.140	13.4	18.0+/-1 8.2	---	FSRQ	3FGL J1849.2+6705	5BZQJ1842+6809
1AGLJ1856+0122	18 55 57.7 01 22 24.4	34.670	-0.380	12.0	38.7+/-3 19.6	W44	SNR	3FGL J1857.8+0129	
1AGLJ1901+0429	19 01 20.7 04 29 38.5	38.060	-0.150	3.7	13.3+/-3 18.5	---	unidentified	3FGL J1900.3+0411	------
1AGLJ1908+0614	19 08 08.4 06 14 34.5	40.390	-0.850	9.9	32.8+/-3 16.2	---	unidentified	3FGL J1907.9+0602	------
1AGLJ1923+1404	19 22 53.7 14 03 45.2	49.000	-0.420	4.7	13.8+/-3 7.6	---	unidentified	3FGL J1923.2+1408	------
1AGLRJ2016+3644	20 16 20.6 36 44 03.2	74.590	0.830	8.0	20.3+/-2 18.0	G74.9+1.2	SNR	3FGL J2015.6+3709	5BZUJ2015+3710
AGLJ2019+3816	20 19 43.4 38 16 23.7	76.240	1.140	6.3	16.4+/-2 19.7	---	unclassified	---	5BZUJ215+3710
1AGLRJ2021+3653	20 21 01.3 36 52 57.6	75.240	0.140	19.3	40.6+/-2 18.6	PSRJ2021+3651	Pulsar	3FGL J2021.1+3651	5BZUJ2015+3710
1AGLRJ2021+4030	20 21 14.1 40 29 54.5	78.240	2.160	41.2	116.6+/-3 21.8	---	unidentified	3FGL J2021.0+4031	------
AGLJ2024+4027	20 24 29.0 40 27 28.7	78.560	1.630	4.0	12.9+/-3 22.1	---	unidentified	---	------
1AGLRJ2027-0747	20 26 46.2 -07 47 29.5	36.839	-24.716	9.2	16.7+/-2 5.3	---	FSRQ	3FGL J2025.6-0736	5BZQJ2025-0735
1AGLRJ2030-0617	20 30 21.5 -06 17 23.5	38.757	-24.837	4.3	7.4+/-1 6.4	2FGLJ2030.3-0622	AGN	3FGL J2030.2-0622	5BZUJ2030-0622
1AGLRJ2031+4130	20 30 54.1 41 29 46.5	80.110	1.250	8.0	17.1+/-2 21.5	0FGLJ2032.2+4122	Pulsar	3FGL J2032.2+4126	
1AGLRJ2033+4057	20 33 10.5 40 56 46.9	79.920	0.580	8.0	20.2+/-2 21.7	---	unidentified	3FGL J2032.5+4032	------
1AGLJ2231+6109	22 31 07.2 61 09 46.8	106.820	2.760	16.2	30.5+/-2 5.9	PSRJ2229+6114	Pulsar	3FGL J2229.0+6114	------
1AGLRJ2254+1602	22 53 56.1 16 09 03.0	86.106	-38.178	56.6	122.6+/-3 6.3	3C454.3	FSRQ	3FGL J2254.0+1608	5BZQJ2253+1608

Results and future developments:

The processing of the known ɣ-ray source sample allowed to obtained 61/65 significant sources (in Fig. 1 we show the Aitoff plot of the complete sample) where 4 sources detected by AGILE-GRID during flares of timescale of weeks, were not significant on the 2.3 yrs maps. Sources not detected are:
- 1AGL J1222+2851/WComae, observed with a dedicated ToO; sqrt(TS)=2.5, Flux_UL(E>100MeV)=1.6e-07 ph/cm^2/s;
- 1AGL J1238+0406, transient source of Pacciani et al. 2011, detected in flare during 3C 273 observation; sqrt(TS)=2.2, Flux_UL(E>100MeV)=1.6e-07 ph/cm^2/s;
- 1AGL J1412-6149, near PSRJ1410-6132/G312.4-0.4; sqrt(TS)=2.4, Flux_UL(E>100MeV)=1.6e-07 ph/cm^2/s;
- 1AGLJ1815-1732, near PSRJ1815-1738/HESSJ1813-178; sqrt(TS)=2.0, Flux_UL (E > 100 MeV)=1.8e-07 ph/cm^2/s.

The procedure developed will be used for the processing of all the sources in the new catalogue on the same scientific maps.

References

[1] Pittori, C., Verrecchia, F., Chen, A., et al. 2009, A&A, 506, 1563
[2] Tavani, M., Barbiellini, G., Argan, A., et al. 2008, for the AGILE Collaboration, NIM A, 588, 52 [arXiv:0807.4254]
[3] Tavani, M., Barbiellini, G., Argan, A., et al. 2009a, for the AGILE Collaboration, A&A, 502, 1015
[4] Verrecchia, F., Pittori, C., Chen, A., et al., 2013, A&A, 538, A137
[5] Atwood, W. B., Abdo, A. A., Ackermann, M., et al. 2009, ApJ, 697, 1071
[6] Barbiellini, G., Bordignon, G., Fedel, G., et al. 2001, AIP Conf. Proc., 587, 754
[7] Prest, M., Barbiellini, G., Bordignon, G., et al. 2003, NIM A, 501, 280
[8] Feroci, M., Costa, E., Soffitta, P., et al. 2007, NIM A, 581, 728
[9] Labanti, C., Marisaldi, M., Fuschino, F., et al. 2006, SPIE, 6266, 62663
[10] Labanti, C., Marisaldi, M., Fuschino, F., et al. 2009, NIM A, 598, 470
[11] Perotti, F., Fiorini, M., Incorvaia, S., Mattaini, E., & Sant'Ambrogio, E. 2006, NIM A, 556, 228
[12] Chen, A.W., et al. 2011, in preparation
[13] Mattox, J. R., Bertsch, D. L., Chiang, J., et al. 1996, ApJ, 461, 396
[14] Giuliani, A., Chen, A., Mereghetti, S., et al. 2004, Mem. SAIt Suppl., 5, 135
[15] Giuliani, A., et al. 2011, in preparation
[16] Giuliani, A., Cocco, V., Mereghetti, S., Pittori, C., & Tavani, M. 2006, NIM A, 568, 692
[17] Tavani, M., Sabatini, S., Pian, E., Bulgarelli, A., et al. 2009a, ApJL, 698, L142
[18] Tavani, M., Bulgarelli, A., Piano, G., et al. 2009b, Natur, 462, 620
[19] Sabatini, S., et al. 2010, ApJL, 712, L10
[20] Giuliani, A., et al. 2010, accepted by A&A, [arXiv:1005.0784]
[21] Bulgarelli, A., et al. 2010, submitted to A&A
[22] McLaughlin, M. A., Mattox, J. R., Cordes, J. M., Thompson, D. J., 1996, ApJ, 473, 763
[23] Chen, A.W., et al. 2010, submitted to A&A
[24] Abdo, A.A., et al. 2009, ApJS, 183, 46
[25] Abdo, A.A., et al. 2010, ApJ, 715, 429
[26] Tavani, et al. 2011, Science, 331, 736
[27] Abdo, A.A., et al. 2011, Science, 331, 739