4 February 1999

PHYSICS LETTERS B

ELSEVIER

Physics Letters B 447 (1999) 127–133

GALLEX solar neutrino observations: results for GALLEX IV

GALLEX Collaboration

W. Hampel [a], J. Handt [a], G. Heusser [a], J. Kiko [a], T. Kirsten [a], M. Laubenstein [a], E. Pernicka [a], W. Rau [a], M. Wojcik [a,1], Y. Zakharov [a,2], R.v. Ammon [b], K.H. Ebert [b], T. Fritsch [b], D. Heidt [b], E. Henrich [b], L. Stielglitz [b], F. Weirich [b], M. Balata [c], M. Sann [c], F.X. Hartmann [c], E. Bellotti [d], C. Cattadori [d], O. Cremonesi [d], N. Ferrari [d], E. Fiorini [d], L. Zanotti [d], M. Altmann [e], F.v. Feilitzsch [e], R. Mößbauer [e], S. Wänninger [e], G. Berthomieu [f], E. Schatzman [f,3], I. Carmi [g], I. Dostrovsky [g], C. Bacci [h,4], P. Belli [h], R. Bernabei [h], S. d'Angelo [h], L. Paoluzi [h], M. Cribier [i], J. Rich [i], M. Spiro [i], C. Tao [i,5], D. Vignaud [i], J. Boger [j], R.L. Hahn [j], J.K. Rowley [j], R.W. Stoenner [j], J. Weneser [j]

[a] *Max-Planck-Institut für Kernphysik (MPIK), Postfach 103980, D-69029 Heidelberg, Germany* [6]
[b] *Istitut für Technische Chemie, Forschungzentrum Karlsruhe (FZK), Postfach 3640, D-76021 6021 Karlsruhe, Germany*
[c] *Laboratori Nazionali del Gran Sasso (LNGS), S.S. 17 / bis Km 18 + 910, I-67010 L'Aquila, Italy* [7]
[d] *Dipartimento di Fisica, Università di Milano e INFN, Via Celoria 16, I-20133 Milano, Italy* [7]
[e] *Physik Department E15, Technische Universität München (TUM), James-Franck Straße, D-85747 Garching b. München, Germany* [8]
[f] *Observatoire de la Côte d'Azur, Département Cassini, B.P. 229, 06004 Nice Cedex 4, France*
[g] *Department of Environmental and Energy Research, the Weizmann Institute of Science (WI), P.O. Box 26, 76100 Rehovot, Israel*
[h] *Dipartimento di Fisica, II Università di Roma 'Tor Vergata' e INFN, Sezione di Roma 2, Via della Ricerca Scientifica, I-00133 Roma, Italy* [7]
[i] *DAPNIA / Service de Physique des Particules, CEA / Saclay, F-91191 Gif-sur-Yvette Cedex, France* [9]
[j] *Brookhaven National Laboratory (BNL), Upton, NY 11973, USA* [10]

Received 28 October 1998
Editor: K. Winter

[1] Permanent address: Instytut Fizyki, Uniwersytet Jagiellonski, ul. Reymonta 4, PL-30059 Kraków, Poland.
[2] Permanent address: INR, Russian Academy of Sciences, 117312 Moscow, Russia.
[3] Present address: DASGAL, Bâtiment Copernic, Observatoire de Paris, 5 place Jule Janssen, F-92195 Meudon Principal, France.
[4] Permanent address: Dipartimento di Fisica, III Universitá di Roma, Via C. Segre 2, 00100 Roma, Italy.
[5] Permanent address: CPPM, Faculté des Sciences de Luminy, Case 907, 13288 Marseille Cedex 09, France.
[6] This work has been supported by the German Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF). This work has been generously supported by the Alfred Krupp von Bohlen und Halbach-Foundation, Germany.
[7] This work has been supported by Istituto Nazionale di Fisica Nucleare (INFN), Italy.
[8] This work has been supported by the German Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF).
[9] This work has been supported by the Commissariat à l' énergie atomique (CEA), France.
[10] This work has been supported by the Office of High Energy and Nuclear Physics of the US Department of Energy, United States.

0370-2693/99/$ - see front matter © 1999 Published by Elsevier Science B.V. All rights reserved.
PII: S0370-2693(98)01579-2

Abstract

We report the GALLEX solar neutrino results for the measuring period GALLEX IV, from 14 February 1996 until 23 January 1997. Counting for the GALLEX IV runs was completed on 19 June 1997. The GALLEX IV result from 12 solar runs is [118.4 $\pm$ 17.8 (stat.) $\pm$ 6.6 (sys.)] SNU (1σ). The combined result for GALLEX I + II + III + IV, which comprises 65 solar runs, is 77.5 $\pm$ $6.2\,^{+4.3}_{-4.7}(1\sigma)$ SNU. The GALLEX experimental program to register solar neutrinos has now been completed. In April 1998, GALLEX was succeeded by a new project, the Gallium Neutrino Observatory (GNO), with newly defined motives and goals. © 1999 Published by Elsevier Science B.V. All rights reserved.

1. Introduction

The GALLEX detector at the Gran Sasso Underground Laboratories monitors solar neutrinos with energies above 233 keV via the inverse beta decay reaction $^{71}\text{Ga}(\nu_e,e)^{71}\text{Ge}$ in a 100-ton gallium chloride target solution. We apply ultra-low-level counting techniques to detect the ^{71}Ge after its extraction from the target solution at the end of each exposure period of typically 3–4 weeks (defined as a run). Descriptions of the project, the experimental procedures, the results, and discussions of their significance have been reported on a regular basis [1–11].

We present here the results from the 12 solar runs which were performed between 14 February 1996 and 23 January 1997 (GALLEX IV). Preliminary results were presented in Ref. [12]. GALLEX IV was preceded by the GALLEX I, GALLEX II, and GALLEX III solar run series (Table 1), with solar runs being done on a schedule of approximately one per month until January 1997. In total, 65 solar runs were done, comprising 1594 net days of exposure. Table 2 presents a matrix of all GALLEX runs and of their respective publication dates. The GALLEX periods were separated by a scheduled change of the target tanks (after GALLEX I) and by two Cr-source exposure periods (after GALLEX II and GALLEX III, respectively).

The proper operation of the GALLEX detector was demonstrated with the two ^{51}Cr neutrino source experiments [13]. Another performance demonstration was done from February to June 1997, by spiking the gallium detector with ^{71}As [14].

In this paper we first describe some experimental aspects concerning the GALLEX IV runs (Section

Table 1
Time schedule of the GALLEX operations

Time period	Operations	Data set
May 91 – May 92	solar ν observations	GALLEX I
May 92 – Aug 92	change of the target tank	
Aug 92 – Jun 94	solar ν observations	GALLEX II
Jun 94 – Oct94	1st source experiment	
Oct 94 – Sep 95	solar ν observations	GALLEX III
Sep 95 – Feb 96	2nd source experiment	
Feb 96 – Jan 97	solar ν observations	GALLEX IV
Feb 97 – Apr 97	^{71}As tests	

Table 2
Summary of GALLEX runs performed

Date of data release	Ref.	Solar runs					Blanks total
		GX I	GX II	GXIII	GXIV	total	
May 1992	[1]	14				14	5
June 1993	[2]	15	6			21	11
Feb. 1994	[3]	15	15			30	19
June 1995	[5]	15	24			39	27
July 1996	[6]	15	24	14		53	31
October 1998	this work	15	24	14	12	65	36

Table 3
Characteristics of the GALLEX IV runs A146-A168

Type [a]	Run#	Time period	Duration (days)	Carrier [b]	Yield		Pos. [e]	Counter			End of counting	Counting on-time (days)
					yield [c]	MS corr. [d]		label [f]	eff L (%)	eff K (%)		
SR54	A146	14.02.96 06.03.96	20.9	70	98.8	97.8	a	(Fe)118	28.0	33.2	17.09.96	194.5
SR55	A148	07.03.96 29.03.96	22.0	72	106.4	96.7	p	(Fe)112	27.2 [h]	34.4	17.09.96	171.6
SR56	A149	29.03.96 17.04.96	19.0	74	98.2	95.0	p	(Si)114	29.2	31.3	08.11.96	204.9
BL32	A150	17.04.97 18.04.97	1.0	70	103.9	99.5	p	(Si)108	22.5 [h]	32.3	08.11.96	203.8
SR57	A151	18.04.96 08.05.96	20.0	76	94.6	94.0	p	(Fe)103	24.2 [h]	34.4	10.12.96	215.8
	A153 [g]	09.05.96 05.06.96	27.0	74					Ge lost			
	A155 [g]	06.06.96 26.06.96	20.0	76	95.2	94.8		(SC)138	HV unstable		08.01.97	195.7
BL33	A156	26.06.96 27.06.96	1.0	72	100.8	96.1	p	(SC)136	33.0	38.3	08.01.97	194.6
SR58	A157	27.06.96 17.07.96	20.0	74	97.5	95.8	a	(SC)130	33.0	38.3	10.02.97	207.5
SR59	A158	17.07.96 07.08.96	21.0	70	97.7	96.1	p	(Si)119	24.9 [h]	31.1	10.02.97	186.5
	A159 [g]	07.08.96 28.08.96	21.0	76	94.2	93.5		(SC)135	HV unstable		03.03.97	186.4
BL34	A160	28.08.96 29.08.96	1.0	72	100.0	95.5	p	(Si)106	29.1 [h]	32.0	03.03.97	185.4
SR60	A161	29.08.96 18.09.96	20.0	74	96.2	95.0	a	(Si)113	27.9 [h]	32.4	31.03.97	193.6
SR61	A162	18.09.96 10.10.96	22.0	70	98.9	98.4	p	(Fe)039	28.9	34.3	31.03.97	171.5
SR62	A163	10.10.96 20.11.96	41.0	76	94.0	93.4	p	(FC)093	33.0	38.1	14.05.97	174.5
BL35	A164	20.11.96 21.11.96	1.0	72	100.4	95.5	p	(Fe)118	28.0	33.2	27.04.97	156.7
SR63	A165	21.11.96 11.12.96	20.0	74	96.5	94.7	p	(Fe)112	24.9 [h]	34.4	19.06.97	189.5
SR64	A166	11.12.96 09.01.97	29.0	70	98.1	96.9	p	(Si)114	29.2	31.3	19.06.97	160.5
SR65	A167	09.01.97 22.01.97	13.0	76	94.2	94.0	p	(Si)108	30.2	32.3	19.06.97	147.6
BL36	A168	22.01.97 23.01.97	1.0	72	102.5	96.7	p	(SC)138	31.6 [h]	38.2	19.06.97	146.6

2), and then report the new GALLEX IV solar neutrino data (Section 3). In the discussion (Section 4), we address the internal consistency of GALLEX data.

2. Experimental

GALLEX IV, the last GALLEX exposure period, began on 14 February 1996 and lasted till 23 January 1997, including runs from A146 to A168. During this time 12 solar runs (SR54 to SR65) and 5 blank runs (BL32 to BL36) were successfully performed. Blank runs were made after every third solar run. Table 3 lists the characteristics of these runs.

The basic experimental procedures for the germanium extraction and the counting conditions in GALLEX IV were the same as in the previous GALLEX I-III solar runs.

Three runs were unsuccessful and did not provide useful data (A153, A155, A159), one run because of a malfunction in the germanium sample preparation, and the other two because of counting-system failures.

The total GALLEX IV exposure time (without the 3 lost runs and the 5 days for blank exposures) is 268 days.

Special care was required for the pulse shape analysis of the L pulses of 8 runs (A148, A150, A151, A158, A160, A161, A165, A168). In these runs, due to electronic noise problems, it was not possible to perform our standard pulse shape analysis on the portion of the L pulses that occurred at very low energies ($<$ 0.7 keV). In such cases the lower edge of the L energy window has been slightly raised compared to the standard one, with correction made for the reduction in counting efficiency. This procedure allowed us to use the usual pulse shape analysis method, at the expense of a small reduction of the counting efficiency (a few percent on the average).

Table 4
Results for individual solar neutrino runs in GALLEX IV. The results are obtained by applying the GALLEX standard rise-time cut, as discussed in Section 2. All SNU-values shown are net solar production rates of ^{71}Ge after subtractions for side reactions, and Rn-cut inefficiency (6.5 $\pm$ 2.1 SNU, see Table 5). Errors are statistical only

Run number		K + L result (SNU)
SR54	A146	140^{+75}_{-63}
SR55	A148	57^{+54}_{-40}
SR56	A149	118^{+71}_{-56}
SR57	A151	155^{+73}_{-59}
SR58	A157	108^{+74}_{-61}
SR59	A158	151^{+73}_{-59}
SR60	A161	-78^{+62}_{-52}
SR61	A162	106^{+57}_{-46}
SR62	A163	186^{+63}_{-54}
SR63	A165	70^{+54}_{-41}
SR64	A166	184^{+71}_{-60}
SR65	A167	101^{+72}_{-54}
GALLEX IV		118.4 ± 17.8

3. Results from GALLEX IV

The individual run results for the net solar production rates of ^{71}Ge (based on the counts in the K and L energy and rise time windows [1,2]) are given in Table 4, after subtraction for side reactions and Rn background effects [7]. Data are evaluated using our standard energy - rise-time and Rn cuts, followed by our maximum likelihood analysis.

The net result of GALLEX IV is [118.4 $\pm$ 17.8 (stat.) $\pm$ 6.6 (sys.)] SNU (1σ) or 118.4 $\pm$ 19 SNU (1σ) with error combined. This is after subtraction of 6.5 $\pm$ 2.1 SNU (Table 5), attributed to contribu-

Note to Table 3:
[a] SR = solar neutrino run, BL = short exposure, blank run. [b] 70,72,74,76 indicate the use of carrier solutions enriched in ^{70}Ge, ^{72}Ge, ^{74}Ge, ^{76}Ge respectively. [c] Integral tank-to-counter yield of Ge carriers, errors are $\pm$1.7%. [d] See [5,6] for a detailed explanation. [e] a = active (NaI) counting position; p = passive counting position [2]. [f] Counters have either iron (Fe) or silicon (Si) cathode. SC = counter with silicon shaped cathode. FC = counter with iron shaped cathode. [g] Unsuccessfull runs in which counting data were not obtained. [h] Special data treatment for L pulses (see text).

Table 5
Side reaction subtractions (in SNU) to be applied to solar neutrino runs (for details see [2])

	GALLEX IV	GALLEX(I–IV)
muon induced background [16]	2.8 ± 0.6	2.8 ± 0.6
fast neutrons [17]	0.15 ± 0.1	0.15 ± 0.1
^{69}Ge produced by muons and ^{8}B-neutrinos falsely attributed to ^{71}Ge [2]	1.0 ± 1.0	1.0 ± 1.0
Rn outside the counters [2]	0.3 ± 0.3	0.3 ± 0.3
subtotal	4.3 ± 1.2	4.3 ± 1.2
Rn-cut inefficiency	2.2 ± 1.7	2.2 ± 1.2
total to subtract	6.5 ± 2.1	6.5 ± 1.7

tions from side reactions (4.3 ± 1.2) SNU and to the Rn-cut inefficiency (2.2 ± 1.7 SNU). The total number of observed decays of ^{71}Ge due to solar neutrinos in GALLEX IV is 77 (6.4 per run). The systematic errors are specified in Table 6 (see [2] for more details).

The combined result for GALLEX I–IV (65 solar runs) is [77.5 ± 6.2 (stat.)$^{+4.3}_{-4.7}$ (syst.)] SNU (1σ) [11].

The result from the 5 GALLEX IV blanks, after subtraction of the expected production rate from solar neutrinos and from side reactions, is 2.7 ± 13.3 SNU (stat) ± 1.8 (sys) (1σ). The result from the total of 36 blanks done in GALLEX I–IV is -4.1 ± 4.3 (stat) ± 1.3 (sys) (1σ) SNU, consistent with a null result.

4. Discussion

4.1. Consistency of the GALLEX results

The individual run results for GALLEX IV (from Table 4) are plotted in Fig. 1 together with the respective data for GALLEX I, II and III. The scatter of single run results is compatible with a Monte Carlo generated distribution of single run results for a constant production rate of 77.5 SNU under the conditions of normal single runs, using the actual conditions of the different runs in appropriate proportions (Fig. 2).

We compare now the GALLEX overall result with the partial results for the runs grouped in the four exposure periods GALLEX I, II III, and IV (Table 7). The results for the four measuring periods show appreciable scatter. We note that GALLEX III is 2.2 σ below, and GALLEX IV 2.2 σ above the mean value. The χ^2-test, for the result of the four data-taking periods to be compatible with the mean, yields only a 1.5% probability ($\chi^2 = 10.4$ with 3 D.O.F.), which is quite low, but nevertheless compatible with a normal distribution. However there is nothing special in grouping the runs in this way. For example, if we divide all 65 solar runs into four equal quarters (subsequent run numbers 1–17, 18–33, 34–49, 50–65), the respective probability is 26.7% ($\chi^2 = 3.9$ with 3 D.O.F.). Other groupings tend also

Table 6
Main factors contributing to the systematic error in GALLEX

	GALLEX IV	GALLEX(I–IV)
counting efficiency including energy and risetime cuts	±4.7%	±4.5%
target size and chemical yield	±2.2%	±2.2%
^{68}Ge correction error	$^{+0.0}_{-0.1}$%	$^{+0.9}_{-2.6}$%
side reaction subtraction error	±1.8%	±2.2%
total systematic error	±5.5%	$^{+5.6}_{-6.1}$%

[11] If we apply instead the alternative pulse shape fit analysis described in [15] the result of GALLEX IV is 99.4 ± 15.5 (stat.) SNU, and the combined result for GALLEX I–IV is 74.9 ± 5.9 (stat.) SNU. The explanation of the fact that this is consistent with our standard pulse shape analysis requires elaborations which will be included in our forthcoming final GALLEX summary paper (see Section 4.3).

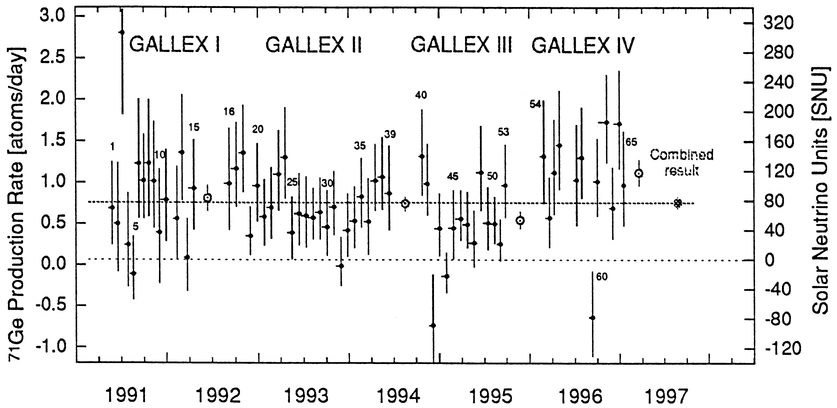

Fig. 1. Summary of the results of GALLEX individual solar runs (closed points). The left hand scale is the measured ^{71}Ge production rate; the right hand scale, the net solar neutrino production rate (SNU) after subtraction of side reaction contributions. Error bars are $\pm 1\sigma$ statistical only. Open circles are the combined results for each of the measuring periods, GALLEX I, II, III and IV (see Table 1). The label 'combined' applies to the mean global value for the total of all 65 runs. Horizontal bars represent run duration; their asymmetry reflects the 'mean age' of the ^{71}Ge produced.

to give probabilities $> 10\%$; in this sense it is just the GALLEX grouping of measuring periods (I–IV) which exhibits this extreme behavior.

We also note that there is no significant dependence of the GALLEX result on wether we evaluate K-pulses or L-pulses. This is shown in Table 7 where we compare the results obtained selecting only L events, only K events, and both L and K events.

4.2. The overall GALLEX result

The results of the two Cr source experiments [13] and of the Arsenic experiments [14] validate the GALLEX solar neutrino experiment, and limit any systematic biases to less than a few percent. After 65 solar runs, the total number of measured ^{71}Ge events in GALLEX is 300, and the neutrino interaction rate is [77.5 $\pm$ 7.7] SNU (1σ). It is substantially below the predictions of the various standard solar models (about 130 SNU [18]). The latest update for the result of the SAGE experiment [67 $\pm$ 7] SNU (1σ) [19] agrees well with our result.

Given that the solar luminosity is provided by the pp-fusion reaction in the core of the Sun, and the ^{8}B solar neutrino flux is as measured by Superkamiokande, one can conclude from our result alone that the ^{7}Be solar neutrino flux is much below what is expected from the standard solar model. This has been already extensively discussed by us [5,10], and by others [20]. Our final result, with its reduced errors, reinforces this conclusion and makes it almost inescapable to invoke neutrino mass.

4.3. Outlook

The end of the GALLEX observations in early 1997 was followed by a break until the spring of 1998. During this period, a major overhaul and modernisation of the experimental set-up (which had

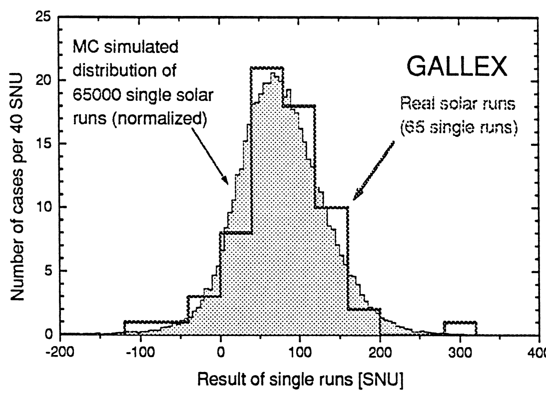

Fig. 2. Monte Carlo distribution deduced from 65000 single run simulations using the actual conditions of the 65 runs in appropriate proportions (thin line). Superimposed is the histogram for the real 65 GALLEX single run results (thick line).

Table 7
Results from solar exposure periods

	Time period	Net exp. days	Runs	L only (SNU) [a]	K only (SNU) [a]	L + K (SNU) [b]	L + K (SNU) [c]
GALLEX I	14.05.91 – 29.04.92	324	15	111 ± 28	64 ± 21	$83.4 \pm 17.2 {}^{+6.8}_{-9.0}$	$83.4^{+18.5}_{-19.5}$
GALLEX II	19.08.92 – 22.06.94	649	24	68 ± 14	82 ± 13	$75.9 \pm 9.7 {}^{+4.2}_{-4.6}$	$75.9^{+10.5}_{-10.7}$
GALLEX III	12.10.94 – 04.10.95	353	14	41 ± 17	61 ± 14	$53.9 \pm 10.6 \pm 3.1$	53.9 ± 11.0
GALLEX IV	14.02.96 – 23.01.97	268	12	116 ± 28	120 ± 23	$118.4 \pm 17.8 \pm 6.6$	118.4 ± 19
GALLEX I–IV	14.05.91 – 23.01.97	1594	65	74.4 ± 10.0	79.5 ± 8.2	$77.5 \pm 6.2 {}^{+4.3}_{-4.7}$	$77.5^{+7.6}_{-7.8}$

[a] Statistical error only (1σ). [b] Statistical and systematic error (1σ). [c] Statistical and systematic error combined in quadrature.

been continuously in operation since 1990) has taken place. This lengthy period also allowed all the ^{71}Ge activity imported into Gran Sasso for the arsenic experiments to decay completely away. Then in April 1998 solar neutrino observations resumed within the framework of the Gallium Neutrino Observatory (GNO), the successor project to GALLEX, with newly defined motives and goals, and a revised list of collaboration members [21]. The GALLEX collaboration plans to prepare an extensive account of all of its experimental and theoretical activities throughout the project, in a concluding publication forthcoming in early 1999.

Acknowledgements

We wish to acknowledge the competent and skillful technical staffs in the participating institutes.

References

[1] GALLEX Collaboration, P. Anselmann, Phys. Lett. B 285 (1992) 376.
[2] GALLEX Collaboration, P. Anselmann, Phys. Lett. B 314 (1993) 445.
[3] GALLEX Collaboration, P. Anselmann, Phys. Lett. B 327 (1994) 377.
[4] GALLEX Collaboration, P. Anselmann, Phys. Lett. B 342 (1995) 440.
[5] GALLEX Collaboration, P. Anselmann, Phys. Lett. B 357 (1995) 237.
[6] GALLEX Collaboration, W. Hampel, Phys. Lett. B 388 (1996) 384.
[7] P. Anselmann, F.X. Hartmann, Prog. Part. Nucl. Phys. 32 (1994) 35.
[8] T. Kirsten et al., Nucl. Phys. B (Proc. Suppl.) 35 (1994) 418.
[9] E. Henrich, K.H. Ebert, Angew. Chemie Int. Ed. (Engl.) 31 (1992) 1283.
[10] GALLEX Collaboration, P. Anselmann, Phys. Lett. B 285 (1992) 390.
[11] T. Kirsten, Ann. N.Y. Acad. Sci. 759 (1995) 1.
[12] M. Cribier, Nucl. Phys. B (Proc. Suppl.) 70 (1998) 284.
[13] GALLEX Collaboration, W. Hampel, Phys. Lett. B 420 (1998) 114.
[14] GALLEX Collaboration, W. Hampel, Phys. Lett. B 436 (1998) 158.
[15] M. Altmann, F.v. Feilitzsch, U. Schanda, Nucl. Instr. Meth. A 381 (1996) 398; M. Altmann, GALLEX internal note GX-124a (August 1998).
[16] M. Cribier, Astroparticle Physics 6 (1997) 129.
[17] M. Cribier, Astroparticle Physics 4 (1995) 23.
[18] J.N. Bahcall, S. Basu, M.H. Pinsonneault, Phys. Lett. B 433 (1998) 1, V. Castellani et al. Phys. Rep. 281 (1997) 309; V. Castellani et al., astro-ph/9712174, A.S. Brun, S. Turck Chiéze, P. Morel, astro-ph/9806272.
[19] Sage Collaboration, J.N. Abdurashitov et al., to appear in Nucl. Phys. B (Proceed. Suppl.) (Neutrino 98, XVIIIth International Conf. on Neutrino Physics and Astrophysics, Takayama (Japan), June 1998.
[20] J.N. Bahcall, Phys. Lett. B 338 (1994) 276; X. Shi, D. Schramm, D. Dearborn, Phys. Rev. D 50 (1994) 2414; T. Kirsten, Nuovo Cimento C 19 (1996) 821.
[21] E. Bellotti et al., GNO-Proposal, Gran Sasso Lab. (LNGS) report INFN/AE-96/27, also available at http://kosmopc.mpi-hd.mpg.de/gallex.html.