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**Abschlußbericht zum Projekt  
Nr.97/5000/8207**

**„Biologische Wirkungen im cm/mm-  
Wellenlängenbereich  
Phase I: Literaturrecherche“**

**(Final Report to Project  
Nr.97/5000/8207  
„Biological Effects of cm/mm Waves  
I: Literature Survey“)**

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## **1 Introduction**

This inquiry was designed to gain an overview over published studies, dealing with „Biological Effects of cm/mm-Waves“. Therefore, it was necessary to identify the research articles from adequate literature databases, books, reports and other grey literature and to evaluate their contents. The criteria for inclusion in this investigation were, that the applied electromagnetic fields were in the frequency range of interest and that the studies reached a certain completeness in experimental descriptions and therefore allowed an appropriate comparability of the used methods. The publications selected this way were obtained from libraries and in case of matching the topic added to the database LEEMFO.

## **2 References to the literature survey**

As references were chosen:

- 1) EMF Database
- 2) MedLine
- 3) BioMedNet
- 4) Telekom Database
- 5) IMST Database
- 6) Books and other printed material

EMF Database, Telekom Database and IMST Database are especially build up to collect information about publications on research of biological effects due to electromagnetic field exposure. Medline and BioMedNet are databases which deal with medical issues, but in consequence, they enclose publications in the field of interest. Therefore, the results of the literature searches was redundant with same information given by the different databases. This was done to hopefully reach a vast completeness of information on the existing literature in the desired frequency range.

### **3 Retrieval**

The search for relevant literature in the different databases is not trivial. Each database requires a specific search routine which has to be developed individually to obtain the relevant information out of the huge amount of data in the respective pool. A fundamental disadvantage of all database systems is the lacking of a possibility to search for a frequency range (as provided by LEEMFO). This is due to the compound search string consisting of numbers and text strings which had necessarily to be chosen to fulfil the requirements for the survey. This lack made it necessary to pull out an immense quantity of surplus data from the databases which had to be reduced to a reasonable number by hand, by software macros, and by self-made software. This was of course time-consuming. The common basis for the revision of the data was the database software VCH BIBLO which is used at the IMST. The self-made software mentioned above based on export and import routines of this public purchase software. This method enabled a semi-automatical selection of publications in the desired frequency range and was therefore a helpful tool to reduce the several thousands of publications accumulated by the different searching methods to a workable number.

### **4 Procurement**

Purchasing the selected publications was done by order slip at the universities of Duisburg and Bonn. Therefore, each article had to be entered into the ordering system of the universities and the limits of ordering (5 articles per day per person) had to be kept in. The ordered publications were delivered in most cases after 4 to 10 weeks. It turned out that some of the publications could not be achieved this way and had to be checked on the spot in the respective library and copied personally if relevant. This procedure which took us to different universities was very time consuming and hindered a faster evaluation of the publications. In addition and not to be procured were used the publications already held by the IMST.

## 5 Selection of relevant publications

The number of the initially selected titles could be reduced by several „filtering steps“ as shown in Fig. 1. They were used to expel those articles, which contained at least one of the search parameters in the title, the abstract or the keywords but in the end did not fit the topic of the survey. Included were only articles in the exposure range from 3 GHz to 100 GHz. It turned out that studies older than about 20 years fulfilled not the present standard demands for experimental description and it was not possible to gain sufficient knowledge about the used exposure. The survey was therefore concentrated on the latest articles with most accurate methods and descriptions.

Excluded were

- articles which had nothing to do with the topic (e.g. optimising of exposure, dielectric parameters of different materials, calculations of SAR-values etc.)
- review articles and other secondary literature
- solely published abstracts
- articles in Russian, Chinese, Hungarian, etc. language
- publications which followed one original publication and were published in different journals with almost the same contents.

About 14.000 quotations were the result of the database searches plus the ASCII-text file from Deutsche Telekom. They were processed according to their origin. Those which were not in the form of VCH BIBLIO software had to be prepared for import filters of this software. This was done iteratively with routines in macro language of MICROSOFT WORD, manual corrections, and following import trials. After importing the data, the included macro language of VCH BIBLIO and also manual corrections were used to put the entries on an equal footing.

It was now possible to search the data pool from Medline, Telekom, and IMST databases with the search implemented in VCH BIBLIO. The resulting 4190 entries were examined for twofold or higher occurrence of single publications which is a unique feature of the VCH BIBLIO software compared to the others. This led to a number of 3800 titles.

An ASCII-text based self-made software helped us to a limited extent to translate frequencies given in the title, keywords or abstract to an equal form and to append them to the respective article data. This led to a chance to search for the desired frequency range and it was therefore

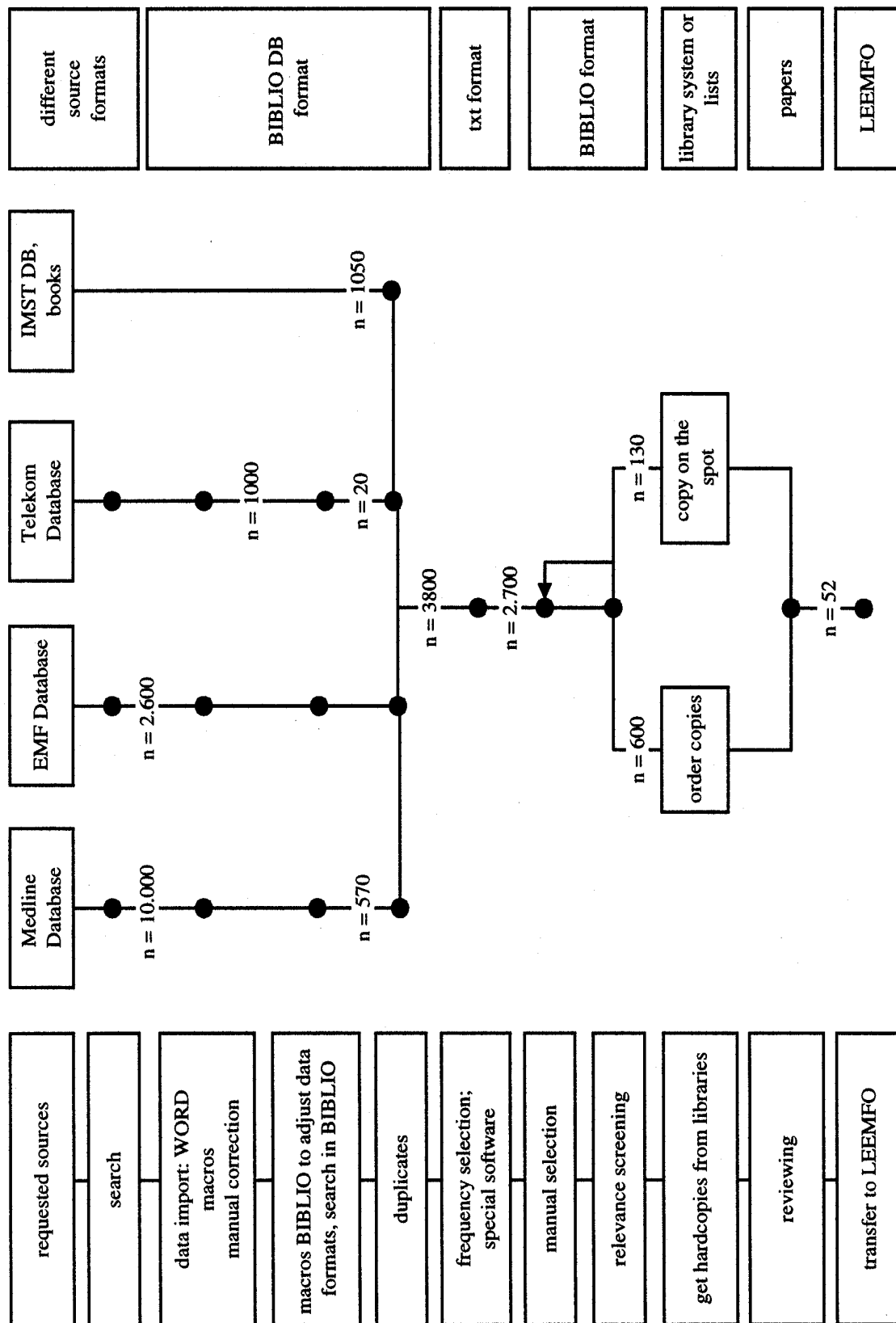


Fig. 1: Scheme of the sequence of the survey

necessary to export the data from VCH BIBLIO, process them as described, prepare them again for import and import them afterwards into VCH BIBLIO again. Following searches with help of Boolean conjunctions and successive inspection of the results and again manual selections took us to 2700 publication titles.

A purely manual evaluation of the titles, keywords and abstracts of these quotations with respect to their matching the given topic brought up a number of 730 articles which contained possibly the experiments aimed at.

Approximately 600 publications were ordered at different university libraries. If it was not possible to order a copy of a certain article, copies were made on the spot by one of the co-workers (ca. 30 articles). 130 publications were at hand in the IMST.

After procuring the articles, they had to be evaluated for the final criteria mentioned above. All papers had to be read through thoroughly. The best matching 52 publications were chosen and form the basis of the Figs. 2 to 10.

## **6 Information transfer to LEEMFO database**

Entering experimental data from the publications into LEEMFO database turned out to be difficult in the sense of sorting the given information to the appropriate fields and category. This step was often questionable and therefore time consuming. As the different publications varied widely in their subject, it was debatable to classify the single publications into given categories and to implement the information in a standard mask. It was, e.g. not possible to correctly describe experiments on animal behaviour because there was no mask for that kind of experiments. Thus, an indirect way of encoding the data of these studies had to be developed. This problem raised often, especially when experimental details had to be added. The exact rationale in some experiments was very intricate to imply into the database and is (other way round) even hard to understand from the database when the scientists performed complex assays including several contributing parameters. An example:

Behavioural experiments on panic reactions of rats were performed to determine electromagnetic field effects on the efficiency of administered tranquillisers. At the moment, there is no reasonable way to fit these data into the database to make the reader understand the sense of the whole experiment and to check the validity of the results. This might be explained

by the present stage of development of the database but has absolutely to be improved in the future.

During the work on the LEEMFO database, everything noticeable, all problems, errors and mistakes made by misunderstandings were noted and forwarded to the company maintaining the database.

## **7 Topics of selected publications**

Following summary is based on the selection of publications for evaluation in LEEMFO database. The chosen articles were classified in orders and suborders according to their belonging to different fields of biological research:

- molecular biology
- experiments with bacteria and fungi
  - genetics
  - proliferation
  - physiology
- experiments in cell biology
  - genetics
  - proliferation
  - cell structure
  - membrane
- experiments on animals
  - central nervous system and nerves
  - behaviour
  - physiology
  - immune system
  - wound healing, teratology, genetics
- human sciences
  - central nervous system

## 8 Results

Fig. 2 and Fig. 3 show the number of studies using continuous wave or modulated electromagnetic fields respectively and the carrier frequency (rounded) of the applied fields. There are apparently very few studies in the frequency ranges from 10 to 34 GHz and from 78 to 100 GHz, and none of them fitted (as described) into the survey. Most studies were made with exposure around 41/42 GHz and 52/53 GHz and often with Russian broad-band applicators. Only one study was done with frequency modulated fields at 5.6 GHz (200 MHz band). All other experiments dealt with rectangular (pulse duration = interpulse pause duration) or pulse modulated fields with pulse duration in the range of up to several microseconds and repetition rates of 100 to 937 pulses/s.

Fig. 4 presents the distribution of research articles over experimental objects. The main focus lies on rat studies, followed by bacterial and biochemical investigations. This may be due to distinct reasons, the closer relationship of rats to humans and therefore a better transferable result and experiments which bring closer to the basis of electromagnetic field effects respectively.

The biological systems which were studied cover the entire range from biochemical reactions to complex animal behaviour. There is no main emphasis on a special biological function. The most frequent research area deals with genetic topics such as mutations and chromosome defects (9 studies). There are four studies in vivo which describe changes on physiological parameters under the control of the autonomous nervous system (circulatory system and temperature regulation) with rats. These were done with sufficient high intensities to cause thermal effects. There are no similar studies with lower intensities to detect the same effects under athermal conditions.

As can be seen in Fig. 5, the main emphasis of this survey lies on the work published in the 1990s. This is because of the indeed rising number of publications on bioelectromagnetics in this period. It turned out, that the very early publications lack a lot of information and were therefore rejected from closer evaluation.

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The following figures (Fig. 6 to Fig. 10 ) show the utilised intensities (in form of power densities and/or SAR) over the respective frequencies. When the experiments were performed in a range of frequencies or intensities, these data were represented by a bar or column resp. covering the whole range. These exposure data were sorted according to occurrence of an effect and classified into thermal and athermal exposure if stated by the authors or otherwise classified as athermal if close to the standards. This judgement may in several cases be disputable because some authors use rather high energy levels and their statements are not always conclusive in that their results are of a thermal or non-thermal nature. The graph also presents the IRPA and CENELEC standards to ease orientation in the field levels.

The lack of studies dealing with influences of weak (athermal) electromagnetic fields on basic physiological functions of humans in this frequency range implicates a need for corresponding research when introducing highest frequency emitters to the market. It has to be shown, that there is not the risk to provoke similar effects with low-level fields in humans as found with higher intensities in rats.

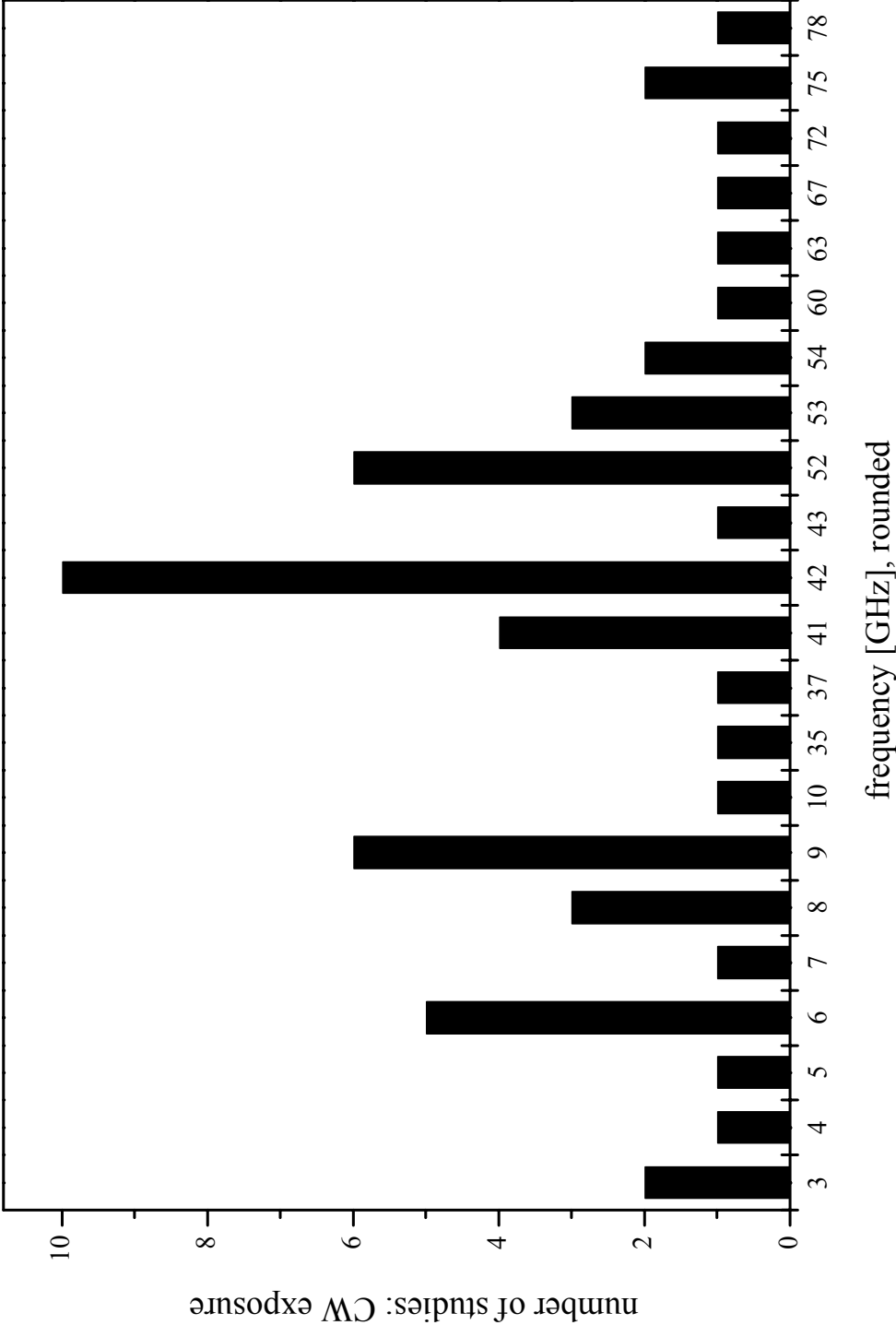


Fig. 2: see description on page 9

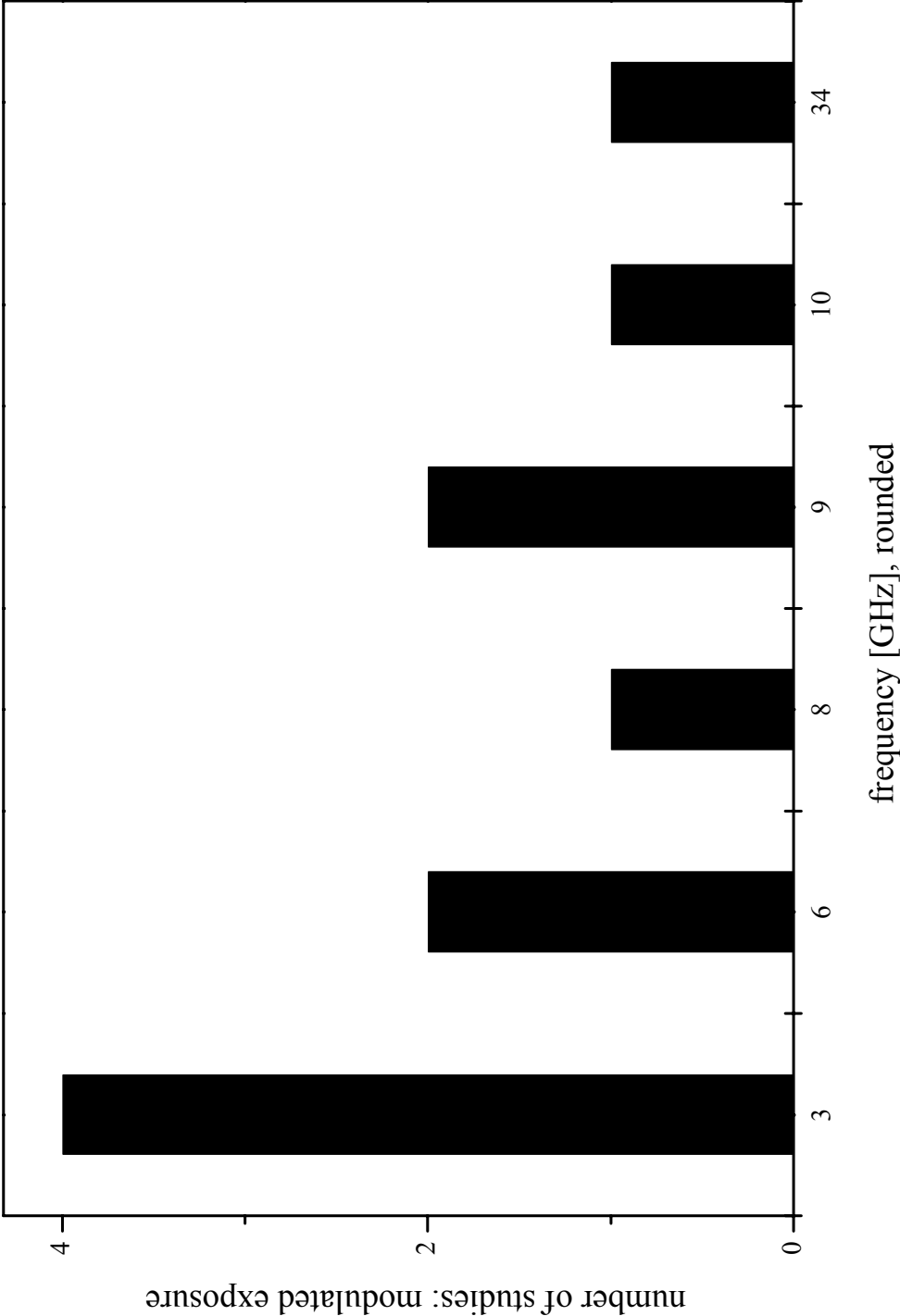


Fig. 3: see description on page 9

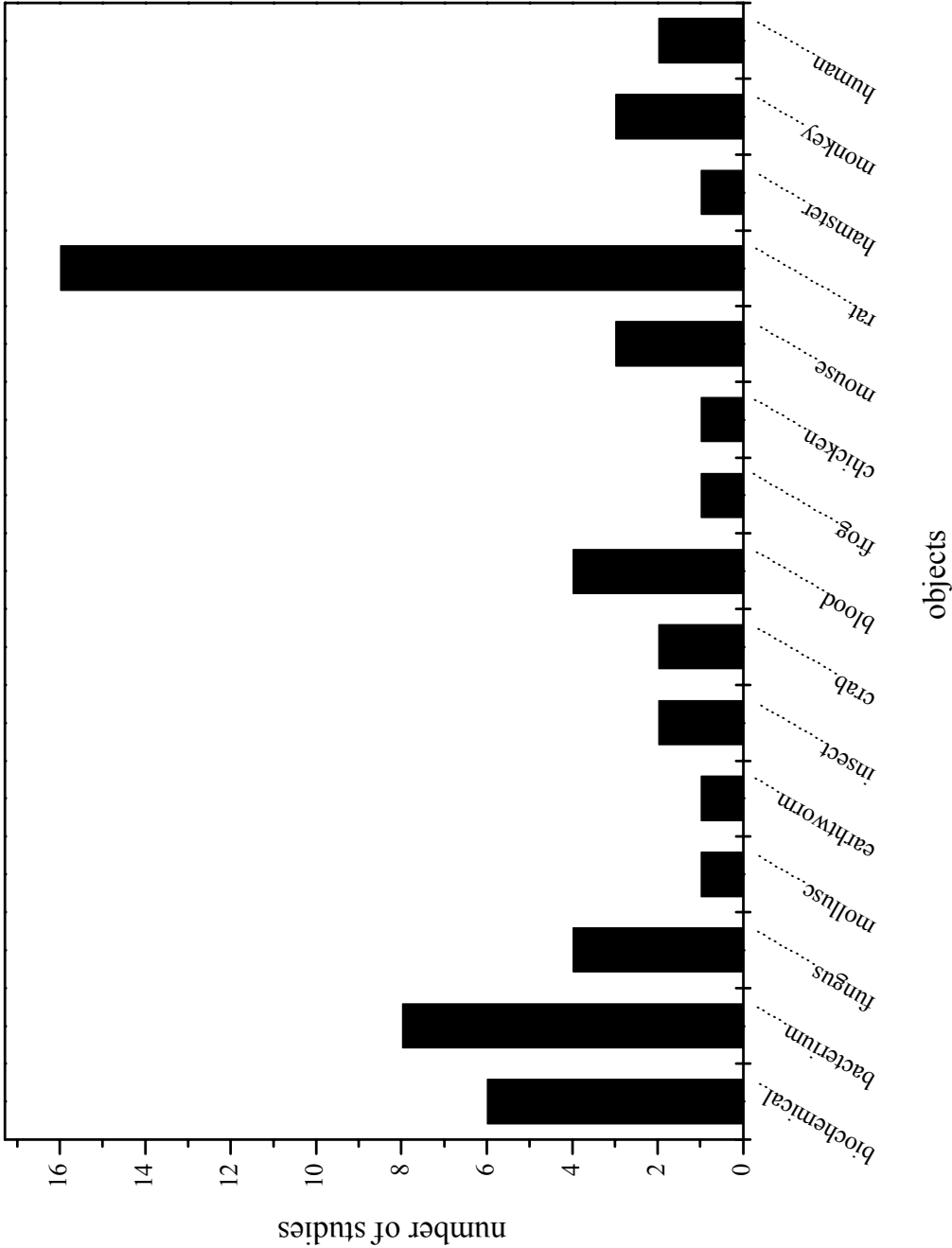


Fig. 4: see description on page 9

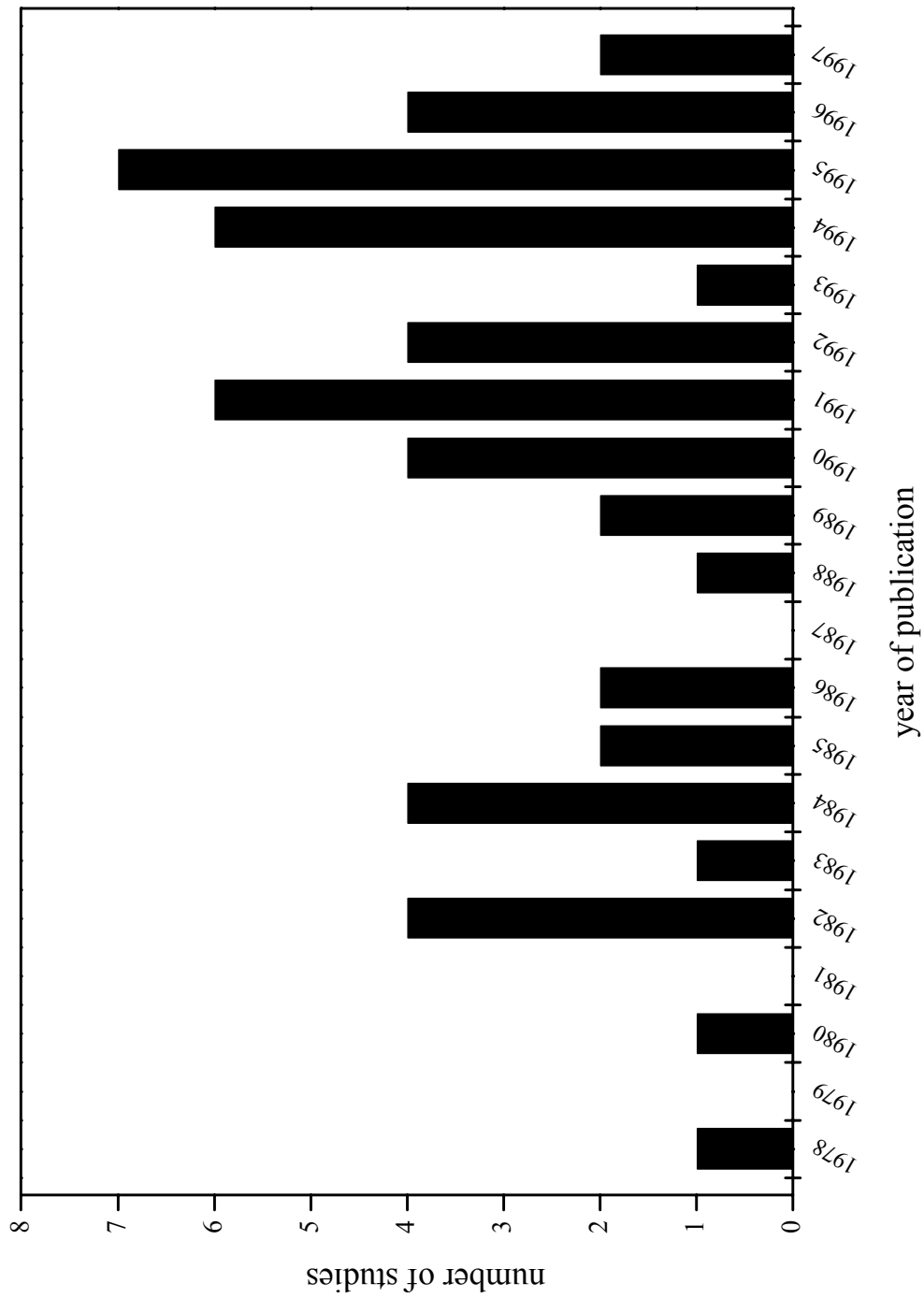


Fig. 5: see description on page 9

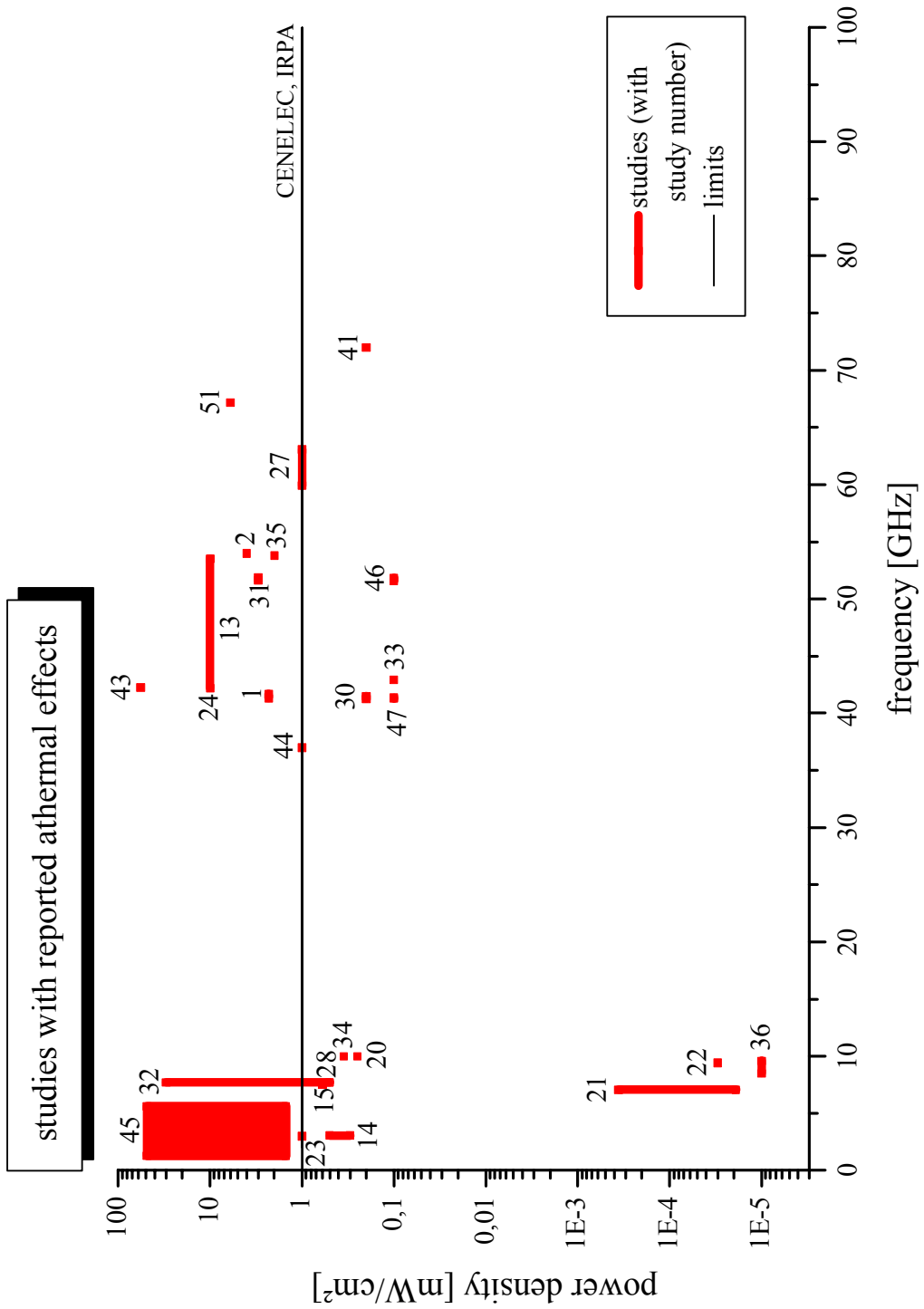


Fig. 6: see description on page 10

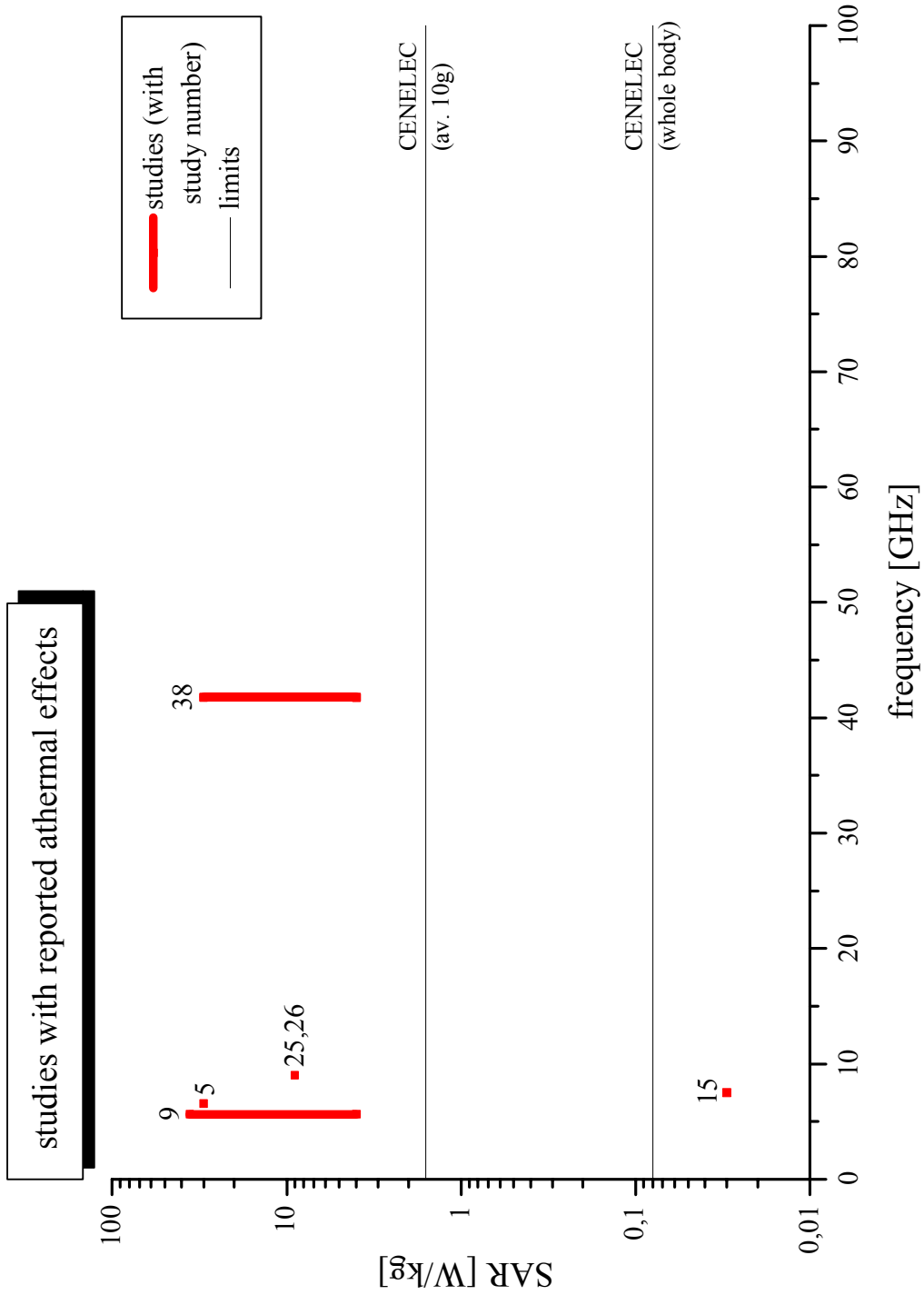


Fig. 7: see description on page 10

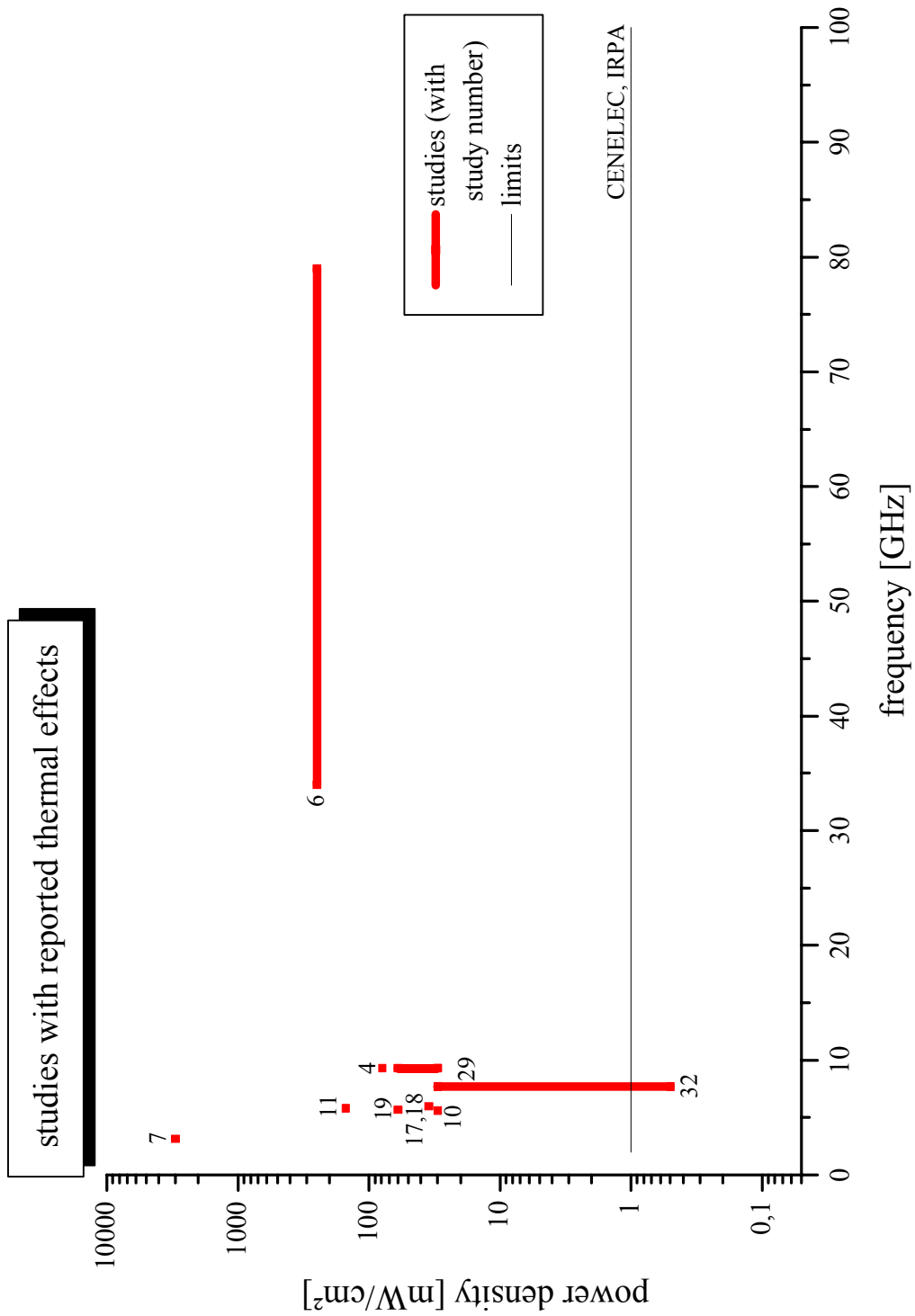


Fig. 8: see description on page 10

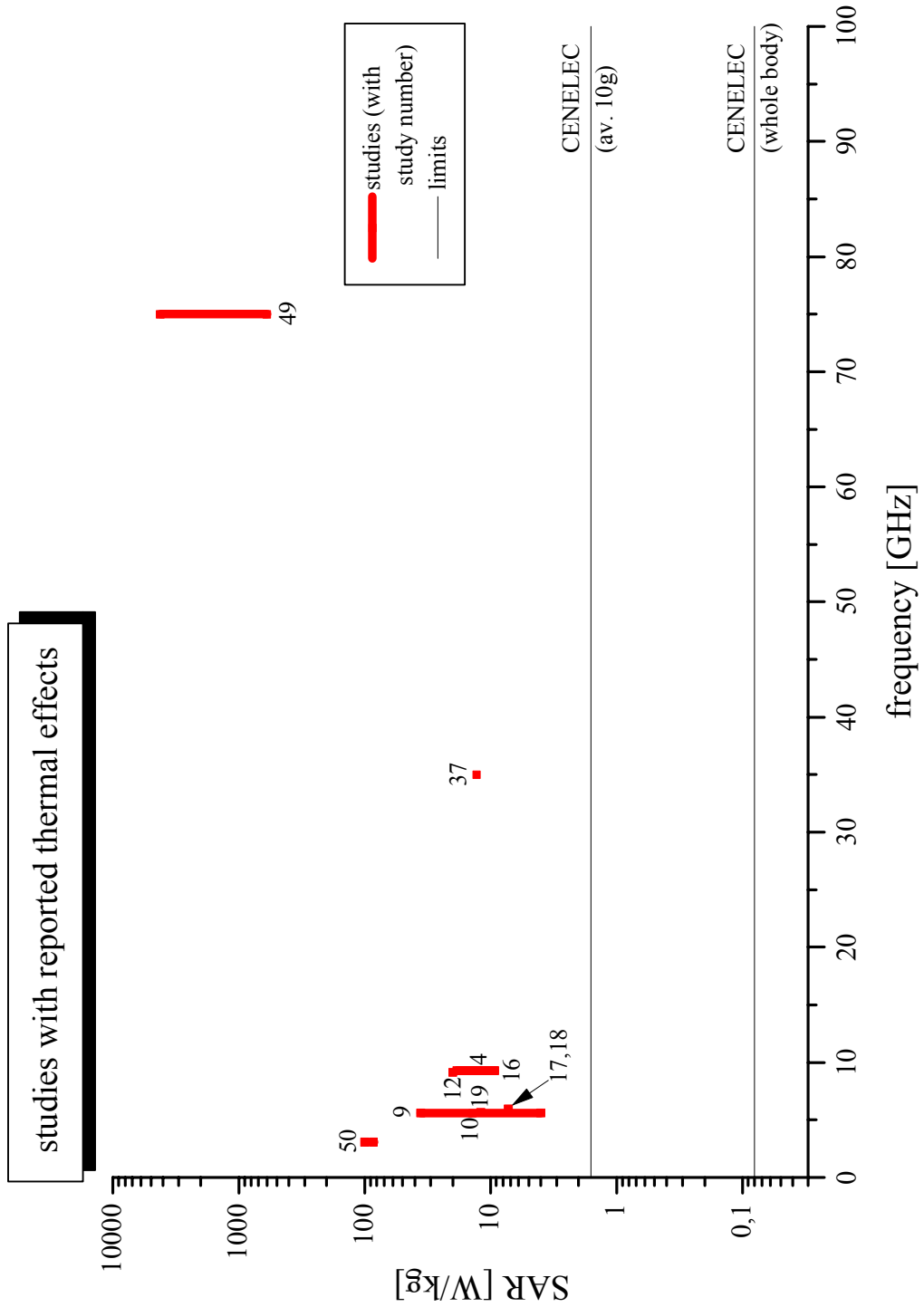


Fig. 9: see description on page 10

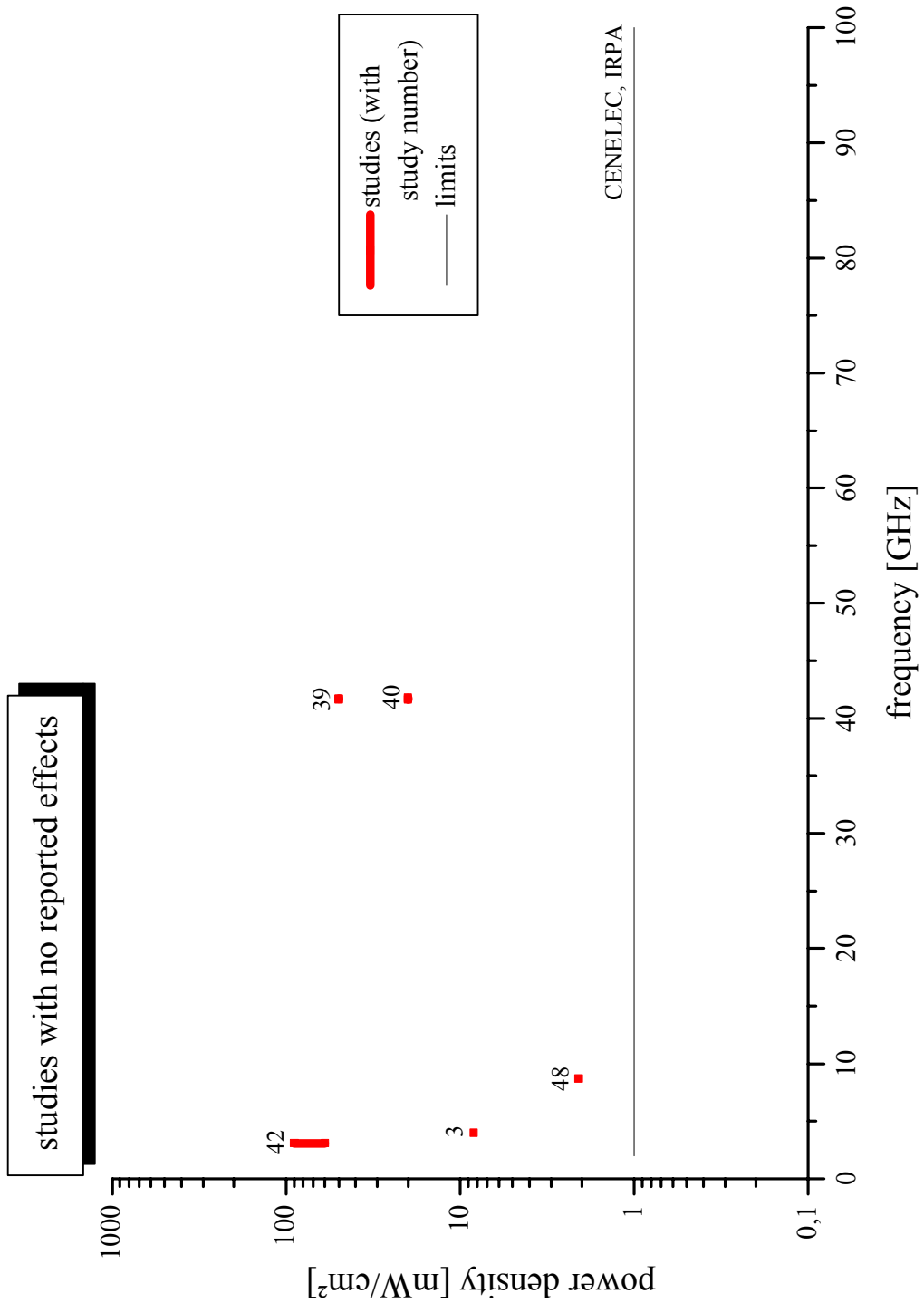


Fig. 10: see description on page 10

## **9 Summary**

For the frequencies from 3 GHz to 100 GHz a bibliographical inquiry was performed. Out of a preliminary number of 14.000 publications on electromagnetic field effects on biological and medical objects, 52 articles were extracted. These were selected according to the criteria mentioned above. The publications were in the fields of molecular biology, biology of bacteria and fungi, cell biology, animal experiments and human sciences. The contents of these articles and an individual judgement of the experimental accomplishment was as far as possible and reasonable incorporated into the LEEMFO database.

## 10 Literature

The sequence and numbering of articles is identical to the sequence and numbering in this report and LEEMFO database.

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