A SURVEY ON PUBLICATIONS IN FUSION RESEARCH AND TECHNOLOGY SCIENCE AND TECHNOLOGY INDICATORS IN FUSION R&T

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Abstract

Scientific publications disseminate research results and are therefore an interesting subject for science and technology analysis. Bibliographic databases contain scientific publications which are indexed and structured. The paper considers Fusion Research and Technology records*) which are stored in the International Nuclear Information System (INIS) bibliographic database. For the first time, all scientometric and bibliometric information specific to a selected field of science and technology contained in a bibliographic database, using INIS records, is analysed and quantified. A variety of new science and technology indicators which can be used for assessing research and development activities are also presented.

Introduction

Fusion Research and Technology (R&T) publications are stored in bibliographic databases such as the International Nuclear Information System (INIS). The objective of this study is to quantify and analyse bibliographic records on Fusion R&T in INIS*) to offer an overview of the developments in this research field. For the first time a scientometric study has been performed to investigate a selected field of science and technology and the INIS database has been used as a source of data. A variety of science and technology indicators are retrieved. Possible applications of this study are outlined.

Fusion R&T is within the INIS scope and represents about 7% of the whole INIS database (more than 130 000 Fusion R&T relevant records were entered in the period from 1970 to mid-1998). In this field, there is an input of 5500-7000 records every year (Fig.1). The number of records per publication year is kept constant, approximately 6000 records in the last 10 years. The input for the last 2-3 years is still continuing as the input preparation of each publication represents an extra step. The projection of input for the last years is indicated by the dashed lines. Fourteen Member States provide about 95% of the INIS input in Fusion R&T. More than 86% of the input comes from the ITER Parties (including Canada and Kazakhstan, participating in the ITER EDA through the European Union and the Russian Federation, respectively, and Switzerland) and from the IAEA. Fusion R&T records come from 64 different input centres, Fig. 2. The number of countries and international organizations with Fusion activities is 49 and the number of institutions is 309, according to the World Survey of the Journal ``Nuclear Fusion", IAEA, Vienna, 1997. It is to be noted that the number of publications per country reflects the concentration of scientific publishing houses in those countries rather than research activities.

Language

About 80% of all documents related to fusion are published in English (Fig.3). This includes translated publications. These are mainly published in the United States of America and, the records of them are therefore provided by the INIS centre in the USA. Translated records represent almost one tenth of the input from the USA. Out of all authors listed in the Fusion R&T records, roughly 66% are from non-English-speaking countries. Altogether there are Fusion R&T records in 32 different languages.

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*) This paper is a summary of the ``Science and Technology Indicators in Fusion R&T" part of a study entitled: ``Fusion Research and Technology in the INIS Bibliographic Database". A survey on publications in Fusion Research and Technology. Science and Technology Indicators in Fusion R&T. by Claus-D. Hillebrand, Division of Scientific and Technical Information, IAEA, Vienna, 1998.

Categories

INIS records are categorized according to the INIS subject categories and scope descriptions arranged in conformity with the International Classification System for Physics developed by the International Council for Scientific and Technical Information (Table I). The main subject categories of interest are Fusion Research and Fusion Technology with their subfields such as (shortened names) plasma (-confinement; -diagnostics; -transport and -impurities;
-waves,-oscillations and -instabilities; -production, -heating; -reactions; -fluid and MHD properties); elementary processes in plasma for Fusion Research and specific fusion devices; inertial confinement; magnetic confinement; plasma-facing components; magnet coils and fields; power supplies; blankets and cooling systems; heating and fueling systems; power conversion systems; component development and materials studies for Fusion Technology.

The subject fields with the highest number of records are plasma waves, oscillations and instabilities; plasma (-production, -heating, -transport, -diagnostics) under Fusion Research; and components (-development, -materials, -study), inertial confinement and plasma-facing components under Fusion Technology (Fig.4).

The time development of records within the subfields shows in general a smaller fluctuation in yearly number of records in Fusion Research than in Fusion Technology within the time period considered (1991-1996). The number of records within the inertial confinement fusion subfield is steadily increasing. The number of records within the materials studies and magnetic confinement fusion subfields varies from year to year but has increased over the time period considered and the number of records correlates with the number of records in the three subfields components development, materials study and plasma-facing components. This probably reflects the number of biennial conferences on Fusion Research and Technology. The increase in the number of records in the materials studies, components development and plasma-facing components indicates a shift in recent research activities.

The multidisciplinary nature of the INIS database allows the study of the correlation between scientific disciplines. For each record, up to three categories can be assigned, if the record covers more than one subject field. The Fusion R&T records with second and third categories have the following subject fields assigned (listed in order of importance): materials science, other physics fields, and instrument and reactor engineering and technology, Fig.5.

Publication types

The record type (e.g. journal articles, reports, books, miscellaneous, patents) and literary type (e.g. short communications, conferences, numerical data, progress reports) of each record entry is indicated in the database. This allows the publishing format to be characterized.

Journal articles represent about 50% of all records, reports 31%, books 13%, miscellaneous 5% and patents 1%, Fig.6. The percentage of report records seems high when compared with other physics disciplines. This may be due to the location of fusion devices in research centres in which many device specific reports are published, as the readership of these reports is small and the reports are not suitable for publication in journals because of their length, technical content, etc. The ``report" type is often used for progress reports, listing of numerical data and dissertations. The high number of book records results from the publication format of some conference proceedings, in which each contribution counts as a book record. Also, under journal articles one can find a high number of conference contributions, numerical data and short communications. The input of patents has been somewhat erratic over the years covered by INIS database. This has to do with the change of patent records copyright in some countries and the difficulty of converting records from patent to bibliographic databases. The number of patent records has increased in recent

years. This can probably be linked to the increased effort to commercialize research and technological results.

The number of journal records is higher in the field of Fusion Research than in the field of Fusion Technology, whereas in the latter field the number of report and patent records is higher.

The time development of publication types gives an indication of research activities. The number of journal articles varies about 10-15% from year to year. The number of journal records per publication year entered in the INIS database averages around 3000. The number of records has fluctuated around this level over the last 20 years. The number of report records has decreased since 1989. It has to be noted that the number of reports made available on the Internet has increased and some research centres have changed their research programme. The frequency of book records over the publication years is very irregular, the reason probably being the irregular choice of formats in publishing conference proceedings.

The literary indicator contains additional information. The numerical data contained in the records increased tremendously between 1983 and 1992, but thereafter decreased steadily. No logical explanation for this has yet been found. Dissertations have two prominent peaks, in 1972 and 1986, both numbering 140 each as compared with an average 80 records per year in the other years. An analysis of the records, e.g. title and keywords in the first year, does not point to any specific explanation. In 1972, the topics of the theses submitted covered all fields of the Fusion R&T categories. In 1986, about one third of the theses contained the keyword or free text (see the explanation below) Alcator Tokamak.

The publication type, sorted by input country, gives some additional information on the publishing activities in these countries and, with further analysis, also gives some indications on research activities. Eight countries (all participating in the ITER EDA) and the IAEA constitute the largest input centres with about 93% of all journal records. About 94% of the report records are derived from 10 countries and about 98% of all books on fusion R&T are published in 9 countries; again all participants to the ITER EDA.

Authors

The country tag in the author field indicates, better than the country in which the document has been published, the actual national research activities. More than 86% of the authors come from the “ITER countries” (Fig.7, considered period: 1970-mid-1998). The distribution of authors according to country somewhat resembles the distribution of the world gross national product (GNP) and is different from the distribution of input countries because in some of these there is a high concentration of science publishing houses.

Journal statistics

Journal articles are published in more than 1500 different journals and represent about 50% of all Fusion R&T records in INIS. Whereas the 15 journals (1%) with the highest number of fusion relevant journal article records (more than 1000 records per journal) represent 57% of all journal records, a further 63 journals (4.2%) with more than 100 and less than 1000 records represent about 29% of all journal records. Journals with more than 10 but less than 100 records represent about 10% of all journal records. Journal articles with 4 pages are the most frequent, although the average is 7.3 pages.

The survey study entitled ``Fusion Research and Technology in the INIS bibliographic database” contains a list of journal profiles in which for larger journals the number of records are plotted against the Fusion R&T subfields. The profiles allow comparison of the scope of each journal. The list of fusion journals in the survey contains a ranking of journals by the number of records (which is a function of publication years, input years, articles published per year and scope) and is compared with the list of the Science

Citation Index (SCI) of the Institute of Scientific Information in Philadelphia, USA. The comparison shows that, for instance, the scope of the SCI list in Fluids and Plasmas (not controlled fusion itself) is broad but does not cover certain fields such as material studies, etc. Furthermore, the Fusion Technology journals are not separated from fusion Research Journals in the SCI list.

Keywords and Free Text

A common feature of a bibliographic database is the subject indexing of records by assignment of keywords. As the subject index is used in books, each database record is complemented by a list of ``controlled terms'' (keywords, or in INIS terminology - descriptors) which are chosen to describe better the content, concepts, methods and models. These controlled terms are scientific and technical words listed in the INIS Thesaurus which also defines relationships (e.g. hierarchical or affinitive) to other controlled terms. The descriptors are used for the retrieval of documents. Descriptors are assigned to each input record by indexers working in each INIS centre. About 8000 different descriptors are relevant to Fusion R&T and, on average 9-10, descriptors per record are used. The most frequently used descriptors are plasma, tokamak devices, magnetic fields, plasma diagnostics and thermonuclear reactors. These descriptors indicate that the main emphasis in Fusion R&T of the INIS database is on fusion reactors and on controlled fusion experiments.

An alternative retrieval tool is the search by “free text” (that is, natural language words and phrases occurring in all textual fields, including titles and abstracts). The free text can be a scientific term which appears in the title or abstract and is not necessarily a descriptor, but, nevertheless can be used for retrieval. In addition to the use of descriptors, “non-standard keywords” (in INIS terminology - free text terms) are permitted to be input in another indexing field and allow flexibility of indexing and searching. Newly proposed descriptors are usually accepted with a delay of several months. The free text “ITER” has been in use since March 1987, when it was agreed by the four ITER Parties, in the light of the international nature of the proposed design activity, to use the name ITER for international thermonuclear experimental reactor, instead of ETR, which was in use until then (Fig.8). The usage of this term has increased steadily, year by year, since that time, with the exception of 1993. This may be due to the termination of the ITER Conceptional Design Activities in December 1990, and the ITER Engineering Design Activities actually starting in late 1992.

Outlook

The survey study “Fusion Research and Technology in the INIS bibliographic database” contains many tables and graphs, which form the basis of this summary, and provides more detailed information. A basic analysis was performed aimed at different interest groups, such as the scientific and technology community, science publishers and editors, librarians and science managers.

In the study, additional information on science and technology indicators and trends is also shown, as well as information on Fusion R&T related publications and their formats. The study will be published by the IAEA.

Further, more advanced and focused analyses and evaluation of the data for some of these interest groups are also possible. The survey opens the possibility of further studies, e.g. the co-operation between different institutions and countries, mapping publication patterns, highlighting scientific co-operation, development of human resources, etc.

Scientometric studies can assist in analysis and formulation of science and technology policy by mapping changes in research activities, providing thematic and strategic

analysis of the relative position of research communities, sketching profiles of activities, and the performance of countries and institutions.

Annex

Table I

Nuclear Physics Subject Categories in INIS

--G5000 PLASMA-PHYSICS-AND-FUSION
---G5100 Plasma-Physics-and-Fusion-Research
-- G5110 Plasma-confinement
-- G5120 Plasma-diagnostic-techniques-and-instrumentation
-- G5130 Plasma-kinetics,-transport,-and-impurities
-- G5140 Plasma-waves,-oscillations,-and-instabilities

-- G5150 Plasma-production,-heating,-current-drive,-and-interactions
-- G5160 Fusion-reactions
-- G5170 Plasma-fluid-and-MHD-properties
-- G5180 Elementary-and-classical-processes-in-plasmas
-- G5190 Other-plasma-physics-studies
-- G5200 Fusion-Technology
-- G5210 Specific-fusion-devices-and-experiments
-- G5211 Inertial-confinement-devices
-- G5212 Magnetic-confinement-devices
-- G5220 Plasma-facing-components

-- G5230 Magnet-coils-and-fields
-- G5240 Power-supplies,-energy-storage
-- G5250 Blankets-and-cooling-systems
-- G5260 Heating-and-fueling-systems;-fuels
-- G5270 Power-conversion-systems
-- G5280 Component-development;-materials-studies

ANNEX

About INIS Database

The decentralized multidisciplinary bibliographic database of the IAEA is a part of **INIS** which was created in 1970 and is administered by the INIS Section of the IAEA with the purpose of collecting and disseminating information on science and technology through its Member States.

INIS has 120 Members including 18 International Organizations which provide records on science and technology documents published in the states where the 120 INIS members are located. Records of documents are provided to INIS in English, along with the titles in the language of origin. All countries and international organizations participating in the Nuclear Reaction Data Centre network are also INIS Members. (United States of America, Japan, Russia, China, Germany, Hungary, Ukraine, NEA / DB - OECD, NDS-IAEA

The main INIS fields of scope are: (i) chemistry, materials and earth sciences; (ii) life and environmental sciences; (iii) isotopes, isotope and radiation applications; (iv) engineering and technology; (v) other aspects of nuclear and non-nuclear energy; (vi) physics.

The largest subject category is physics with about one third of all records, followed by engineering and technology with one fourth. Chemistry, material and earth sciences as well as life and environmental sciences represent about one fifth each.

ANNEX

Definition of Scientometrics and Bibliometrics

The terms bibliometrics and scientometrics were introduced almost simultaneously by Pritchard and by Nalimov and Mulchenko in 1969. While Pritchard explained the term bibliometrics as "the application of mathematical and statistical methods to books and other media of communication, Nalimov and Mulchenko defined scientometrics as "the application of those quantitative methods which deal with the analysis of science viewed as an information process. According to these interpretations, scientometrics is restricted to the measurement of science communication, whereas bibliometrics is designed to deal with more general information processes. The at best fuzzy distinction between the two has virtually disappeared over the course of the last three decades and, today, the terms are more or less synonymous. Meanwhile, the term infometrics has come to replace the originally broader specialty of bibliometrics.

(Source: 2nd European Report on Science and Technology Indicators, Dec. 1997, page 111, EC-Luxembourg, EUR17639)

Table II Publication Types

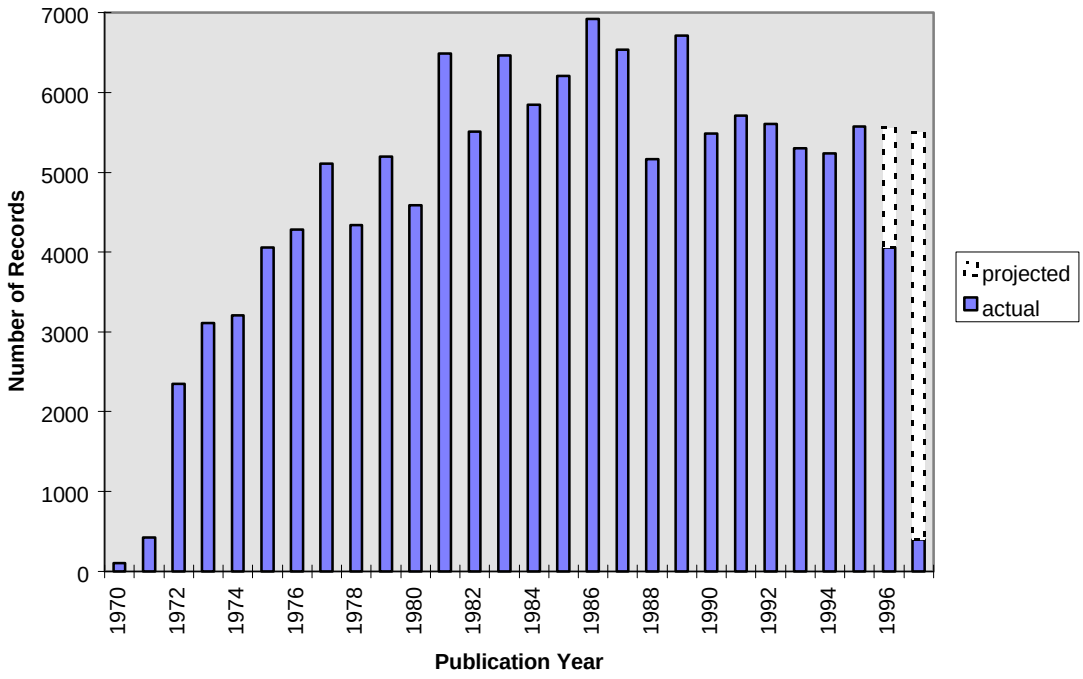
Records Types:

J	Journals
R	Reports
B	Books
I	Miscellaneous
P	Patents

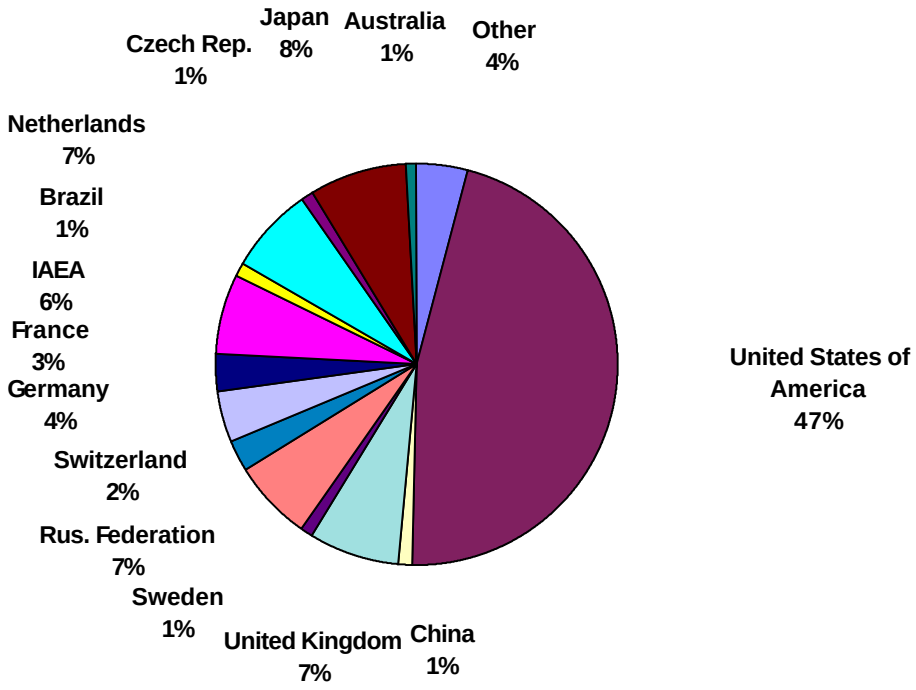
Literary Types

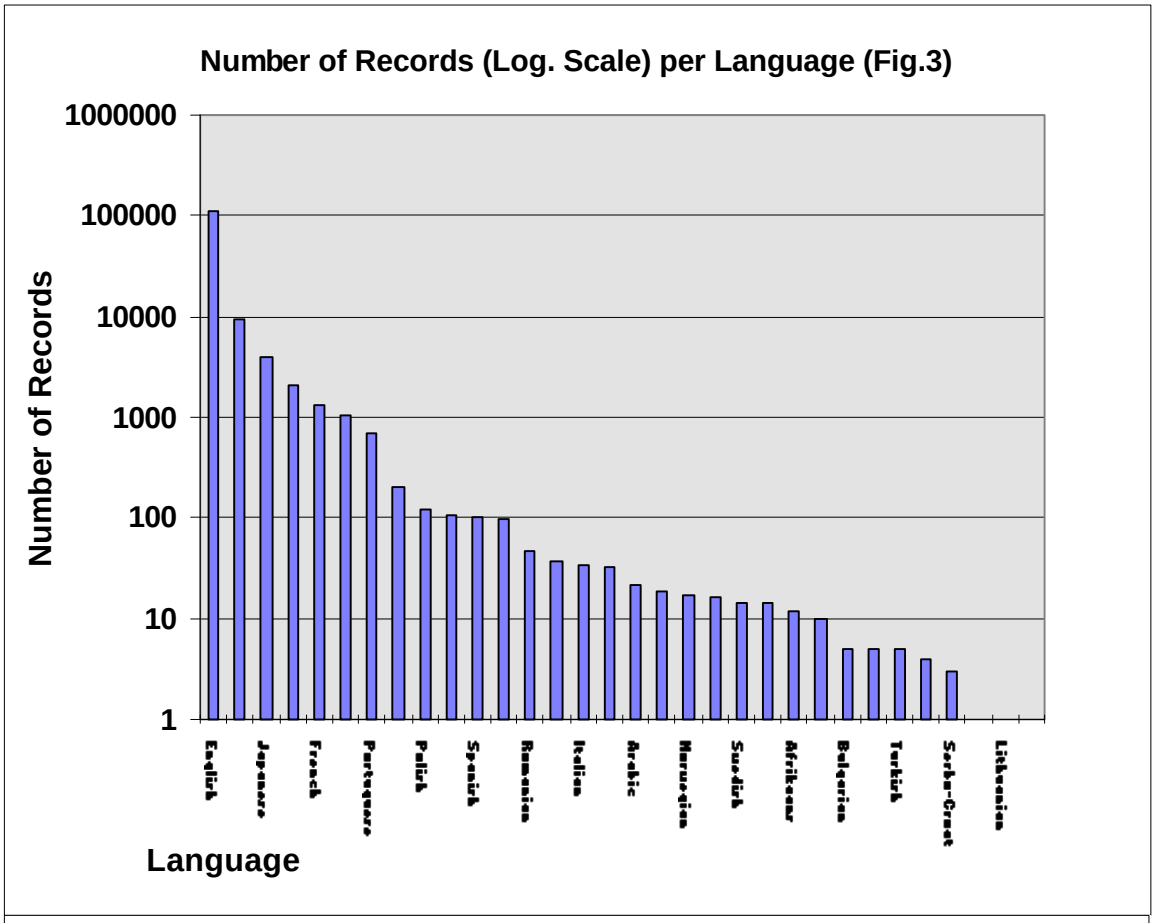
E	Short Communication
N	Numerical Data
V	Computer Program Description
X	Nonconventional Literature
Y	Progress Reports
U	Dissertations
K	Conference
Z	Bibliography

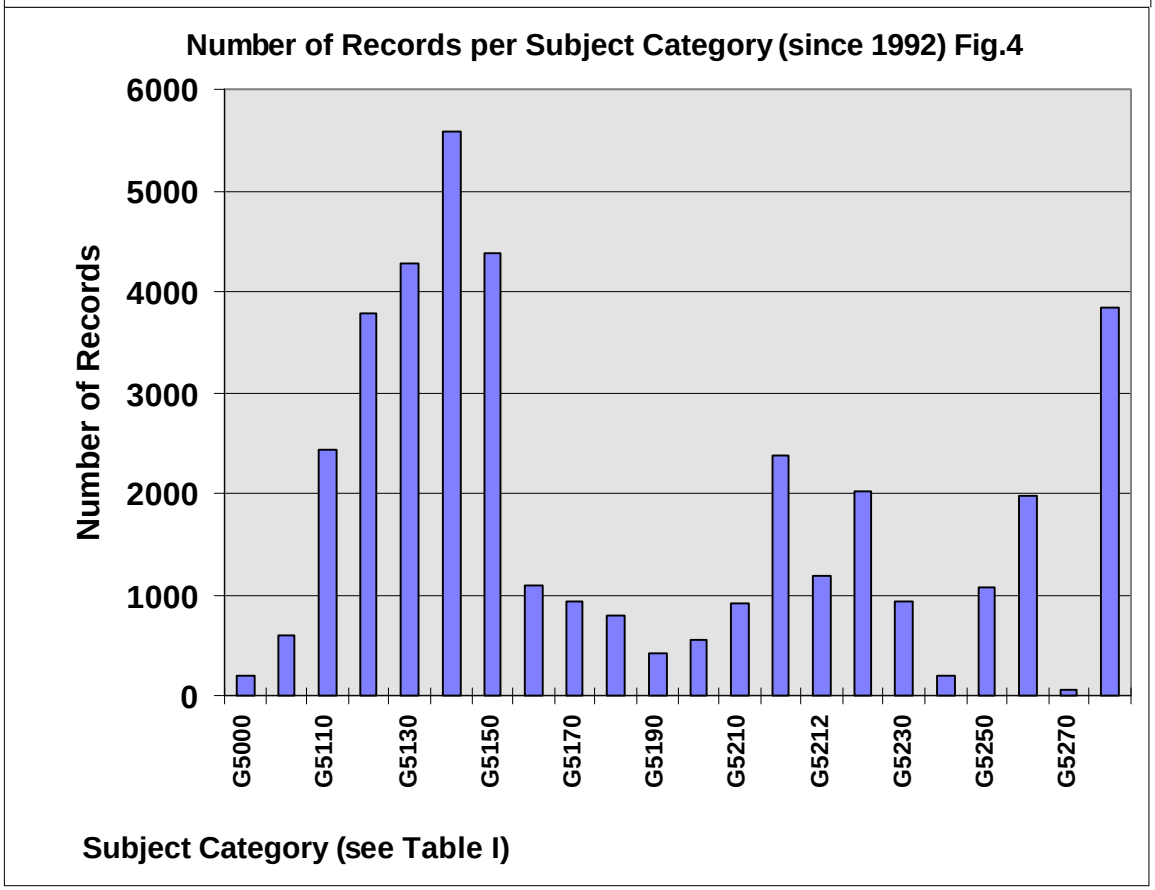
Number of Fusion R&T Records per Publication Year Fig.1



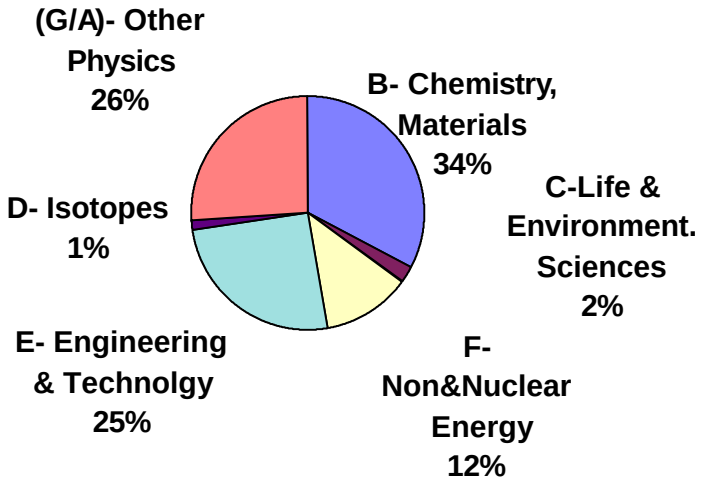
Number of Records (%) per Input Country (Fig.2)

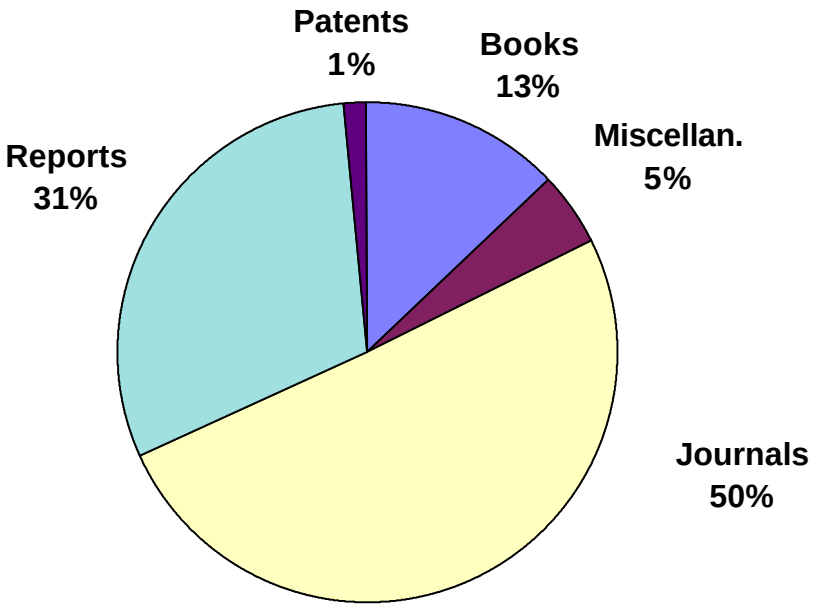



Number of Records (Log. Scale) per Language (Fig.3)
1000000
100000
10000
1000
100
10
1
Number of Records
Language


Number of Records per Subject Category (since 1992) Fig.4
6000
5000
4000
3000
2000
1000
0
Number of Records
G5000
G5110
G5130
G5150
G5170
G5190
G5210
G5212
G5230
G5250
G5270
Subject Category (see Table I)

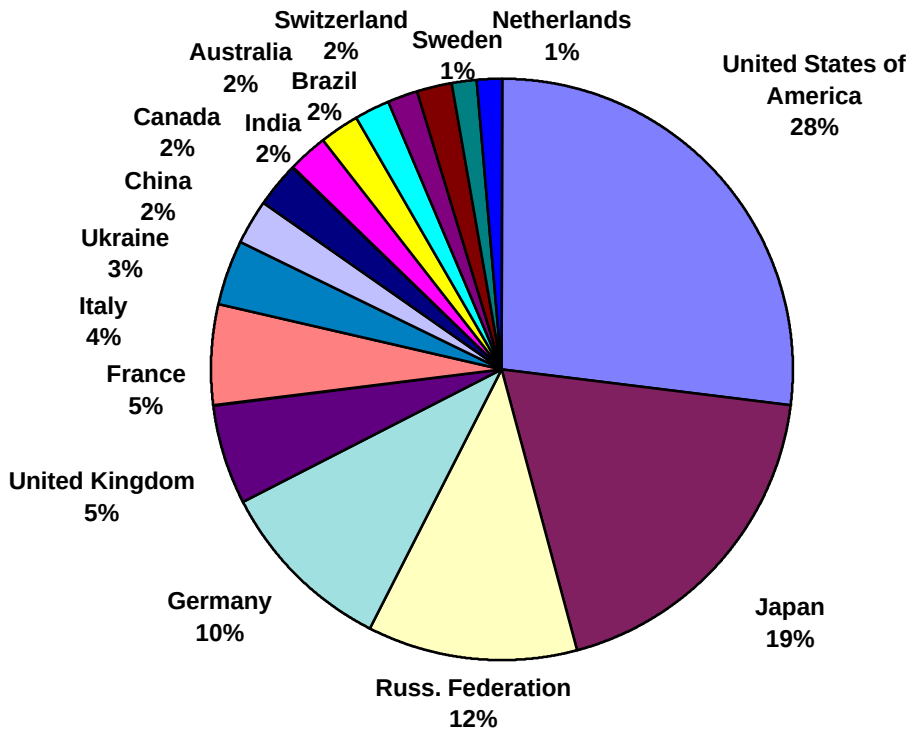
Number of Records (%) with Fusion R&T in Primary Category and other Categories in Secondary Category Level (Fig.5)





Number of Records (%) per Record Type (Fig.6)

Number of Records (%) with an Author Associated with a Country



Number of Records with Free Text 'ITER' per Publ. Year Fig.8