

# Research and citation impact of publications of the Nuclear Physics Division at Bhabha Atomic Research Centre

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## ABSTRACT

*The paper analyses the citations to 257 publications published during 2003-2008 by the Nuclear Physics Division at Bhabha Atomic Research Centre, using Web of Science database as the source data. The extent of citations received, in terms of the number of citations per paper, year-wise break up of citations, citation time-lag, domain-wise citations, citing authors, subject analysis of citations, categories of citing documents, citing journals, keyword analysis of citations, citing institutions, and the distribution of citations are determined. During 2003-31<sup>st</sup> August 2010, Nuclear Physics Division publications received a total of 5627 citations. The average number of citations per year was 703.38 and the average number of citations per publication was 21.89. The highest number of citations received was 1155 in 2007. Citation time-lag was zero for 76 (29.57%) papers, one year for 92 (35.80%) papers and two years for 19 (7.39%) papers. High Energy Physics and Quark Gluon Plasma domain received the highest percentage (75.5%) of citations. The core citing authors were: A. Lebedev (449) followed by D. D'Enterria (396), S. Mioduszewski (392), M.J. Tannenbaum (378), H. Masui (378), R. Averbeck (377), Y. Akiba (377), R. Lacey (375), G. David (374), T.C. Awes (374). The core journals citing Nuclear Physics Division publications were: Physical Review - C (1148 citations), Journal of Physics - G (663 citations), Nuclear Physics - A (618 citations), Physical Review Letters (347 citations), European Physical Journal - C (332 citations), Physics Letters - B (263 citations), Physical Review - D (214 citations), International Journal of Modern Physics - E (169 citations), European Physical Journal - A (121 citations).*

Keywords: Citation analysis; Scientometrics; Bibliometrics; Research productivity; Research evaluation

## INTRODUCTION

Evaluation is a very important component of any research and development activity in a research institution. Evaluating science has become a major aim for those dealing with decision making for the management of science. Martin and Irvin (1983) have thoroughly reviewed the basic research inputs and outputs and various possible assessment methods. They also considered the count of scientific publications and citations, and peer evaluation methods providing characteristic indicators. Publication and citation counting techniques have been used in the assessment of scientific activity for at least fifty years (Narin 1976). Laharia and Singh (1987) have discussed the various approaches used to measure the

scientific productivity and Lancaster (1991) has suggested bibliometric measures of productivity and impact in research.

Citation brings out the connection between two documents; the one which cites and the other which is cited. The act of citing in general, an expression of the importance of the material cited, as authors often refer to previous material to support, illustrate or elaborate on a particular point (Garfield 1978; 1994). A highly cited work, naturally, is the one that has been found to be useful by relatively large number of authors, or in relatively large number of experiments. Citation count is, therefore, a measure of scientific activity, utility and impact of scientific work. However, citation counts do not say anything about the nature, utility or impact of the work (Garfield 1979a).

Citation analysis constitutes an important tool in qualitative and quantitative studies of science and technology. To assess the quality of a given publication, the number of times it has been cited in the literature can be counted. Similarly, the number of times a person has been cited in the literature can be taken as a measure of the quality of that person's work (Garfield 1979b; Lawani 1977; Moravcsik, Murugesan and Shearer 1976; Narin, Carpenter and Woolf 1983; Smith 1981; Wallmark and Sedig 1986). Citation analysis is a more complex task than is often recognised in the sense that it requires careful identification of exactly what is being analysed. Every citation represents a decision of the author to draw attention to the work of another as being relevant to his theme at a particular point in the document he is writing (Sandison 1989). Citation counts help a research administrator to assess the quality of, not only each individual scientist, but also that of his organisation as a whole. A few studies of this sort on individual institutions / departments have been conducted all over the world (Salisbury 1980; Cohen 1981; Schubert and Braun 1981; Yankevich 1982; Carpenter et al. 1988; Garg and Rao 1988; Vinkler 1990; Kalyane and Kalyane 1991; Minor and Dostatni 1991; Dizon and Sadorra 1995; Ugolini, Parodi and Santi 1997; King 1998; Gupta, Suresh Kumar and Khanna 1999; Zacho 1991; Frohlich and Resler, 2001; Koganurmth, Angadi and Kademani 2002; Lee 2003; Schloegl et al. 2003). Kademani et al. (2005a; 2005b; 2006, 2007a) have carried out scientometric analysis to understand publication productivity of various divisions of Bhabha Atomic Research Centre such as Bio-organic Division, Chemistry Division, Analytical Chemistry Division, and Radiochemistry Division. Adopting similar method, Girap et. al. (2009) have also carried out the analysis for publication productivity of Technical Physics and Prototype Engineering Divisions of Bhabha Atomic Research Centre. Kademani et. al. (2007b) have studied the impact of 1733 publications published during 1970–1999 by the Chemistry Division of Bhabha Atomic Research Centre, by analysing the citations received to the publications using Science Citation Index for the period 1982–2003.

The unit of study in citation analysis can be any form of written communication or an author, an organisation or a nation (Small and Greenlee 1979). However, citation counts cannot be taken as the sole measure of quality, because numerous other factors affect scientists' work and the impact of their publications is only a measure of their overall influence. For instance, a scientist who spends most of his time on teaching may contribute in an indirect way to the future achievements of his institution. Sometimes a scientist may require years of background work to prepare a paper and that single paper itself would be a vital contribution having more value than that of publications of other prolific authors. Nevertheless, scientists themselves are almost invariably keen to see this kind of information (Martyn 1975; Cronin 1984; Mac Roberts and Mac Roberts 1989; Brown 1993; Mahajan 1993). One should be very careful while collecting and carrying out citation analysis as it may contain some discrepancies (Garfield 1977; Moed and Vriens 1989) and

that citation analysis as a subject remains controversial (Taube 1993). Liu (1993) reviewed on the citation studies that have dealt with citation functions, citation quality, citation concept and citation motivation. Rousseau (1995) proposed a framework within which citations can be used for evaluation purposes.

Nuclear Physics Division (NPD) is one of the important divisions of Bhabha Atomic Research Centre established in the early stages of Department of Atomic Energy to carry out research and developmental activities relevant to atomic energy programmes. It carries out basic research in low, intermediate and high energy nuclear physics and accelerator based applied research. It also looks after operation, maintenance and development of ion accelerators and development of instrumentation for Nuclear Physics Research. Upadhye et al. (2010) have carried out the publication productivity of the Nuclear Physics Division of Bhabha Atomic Research Centre for the period 2003 - 2008. The present study attempts to carry out citation analysis of NPD publications published during 2003-2008 reported in Chatterjee, Suresh Kumar and Choudhury (2008).

## **OBJECTIVES, MATERIALS AND METHODS**

The main objective of the study is to highlight the citation impact of publications by the Nuclear Physics Division (NPD) at Bhabha Atomic Research Centre (BARC), specifically to highlight the following:

- a) the extent of citations received to the publications of NPD at BARC;
- b) year-wise growth of citations to NPD publications;
- c) domain-wise distribution of citations;
- d) the time-lag between publication of a paper and its getting first citation;
- e) core authors citing NPD publications;
- f) subject category-wise analysis of journal citations;
- g) types of documents citing NPD publications;
- h) the scattering of citations among journals;
- i) the institutions citing NPD publications;
- j) the country-wise distribution of publications citing NPD publications; and
- k) the keywords of citing documents to assess the influence of NPD publications on other areas of research

NPD of BARC has published a total of 257 publications during 2003-2008. The present citation analysis covered the period from 2003 to August 2010. All the 257 publications published during 2003-2008 were considered for the analysis. Citations were collected for each publication from the *Web of Science*. All the data elements were transferred to a spreadsheet application and after data validation, scientometrics analysis was carried out as per objectives of the study.

## **RESULTS AND DISCUSSION**

The 257 papers sampled in this study are categorised in various domains: High Energy Physics and Quark Gluon Plasma, Nuclear Reactions and Spectroscopy, Intermediate Energy Reactions, Theoretical Research, Nuclear Fission, Interdisciplinary Research and Applications, Detectors and Nuclear Instrumentation, and Accelerators and Instrumentation. During 2003-31<sup>st</sup> August 2010 these 257 publications have received a total of 5627 citations. The average number of citations per year was 703.38. The average

number of citations per publication was 21.89. Table 1 details the distribution of NPD publications on the basis of citations received.

Table 1: Distribution of Citations Received for NPD’s Publication Output

| Number of citations | Number of publications | Total number of citations | Cumulative | Number of citations | Number of publications | Total number of citations | Cumulative |
|---------------------|------------------------|---------------------------|------------|---------------------|------------------------|---------------------------|------------|
| 0                   | 50                     | 0                         | 0          | 36                  | 1                      | 36                        | 1489       |
| 1                   | 29                     | 29                        | 29         | 37                  | 1                      | 37                        | 1526       |
| 2                   | 30                     | 60                        | 89         | 38                  | 1                      | 38                        | 1564       |
| 3                   | 13                     | 39                        | 128        | 39                  | 1                      | 39                        | 1603       |
| 4                   | 14                     | 56                        | 184        | 41                  | 1                      | 41                        | 1644       |
| 5                   | 5                      | 25                        | 209        | 42                  | 2                      | 84                        | 1728       |
| 6                   | 4                      | 24                        | 233        | 44                  | 1                      | 44                        | 1772       |
| 7                   | 10                     | 70                        | 303        | 46                  | 1                      | 46                        | 1818       |
| 8                   | 11                     | 88                        | 391        | 47                  | 1                      | 47                        | 1865       |
| 9                   | 3                      | 27                        | 418        | 48                  | 2                      | 96                        | 1961       |
| 10                  | 4                      | 40                        | 458        | 50                  | 1                      | 50                        | 2011       |
| 11                  | 4                      | 44                        | 502        | 51                  | 1                      | 51                        | 2062       |
| 12                  | 5                      | 60                        | 562        | 59                  | 1                      | 59                        | 2121       |
| 13                  | 2                      | 26                        | 588        | 60                  | 1                      | 60                        | 2181       |
| 14                  | 2                      | 28                        | 616        | 62                  | 2                      | 124                       | 2305       |
| 15                  | 3                      | 45                        | 661        | 64                  | 1                      | 64                        | 2369       |
| 16                  | 3                      | 48                        | 709        | 67                  | 1                      | 67                        | 2436       |
| 17                  | 1                      | 17                        | 726        | 77                  | 2                      | 154                       | 2590       |
| 18                  | 2                      | 36                        | 762        | 84                  | 1                      | 84                        | 2674       |
| 20                  | 2                      | 40                        | 802        | 85                  | 1                      | 85                        | 2759       |
| 21                  | 3                      | 63                        | 865        | 101                 | 1                      | 101                       | 2860       |
| 22                  | 1                      | 22                        | 887        | 120                 | 1                      | 120                       | 2980       |
| 23                  | 2                      | 46                        | 933        | 122                 | 1                      | 122                       | 3102       |
| 24                  | 1                      | 24                        | 957        | 125                 | 1                      | 125                       | 3227       |
| 25                  | 4                      | 100                       | 1057       | 134                 | 1                      | 134                       | 3361       |
| 26                  | 1                      | 26                        | 1083       | 157                 | 1                      | 157                       | 3518       |
| 27                  | 3                      | 81                        | 1164       | 179                 | 1                      | 179                       | 3697       |
| 28                  | 1                      | 28                        | 1192       | 263                 | 1                      | 263                       | 3960       |
| 30                  | 2                      | 60                        | 1252       | 306                 | 1                      | 306                       | 4266       |
| 31                  | 1                      | 31                        | 1283       | 316                 | 1                      | 316                       | 4582       |
| 32                  | 1                      | 32                        | 1315       | 334                 | 1                      | 334                       | 4916       |
| 34                  | 2                      | 68                        | 1383       | 711                 | 1                      | 711                       | 5627       |
| 35                  | 2                      | 70                        | 1453       | <b>Total</b>        | <b>257</b>             | <b>5627</b>               | -          |

**Year-wise Growth of Citations**

Figure 1 presents year-wise growth of citations of NPD publications. The continuous growth of citations was found throughout except in the year 2008 and 2010. The citation rate peaked during 2006-2009 as the maximum 4055 (72.36%) citations were received during the period. The highest numbers of citations received were 1155 in the year 2007. Citations received in 2009 and 2010 are exclusively of the publications published during 2003-2008, since 2009 and 2010 publications are not included in this study. It is interesting to note that NPD publications continue to garner citations.

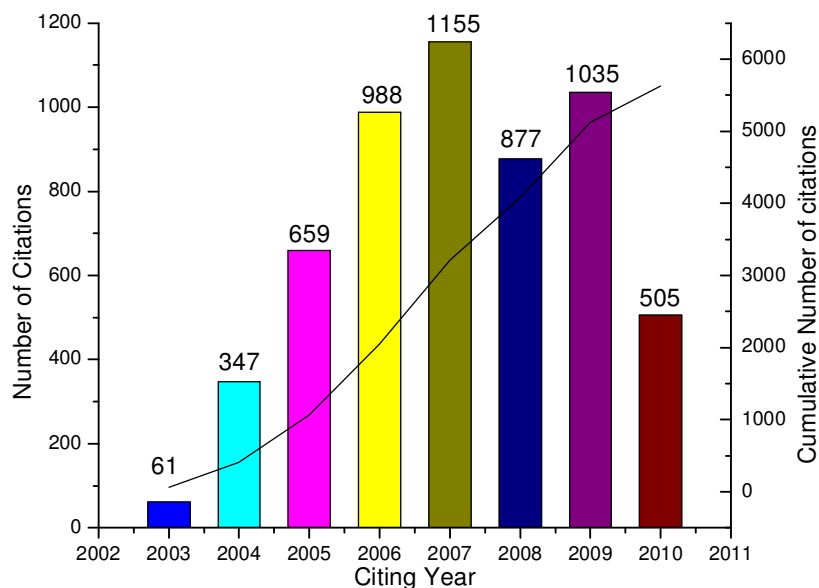


Figure 1: Year-wise Growth of Citations Received by NPD Publications

### Domain-wise Distribution of Citations

Table 2 shows the number of publications and the citations received in each domain of NPD research areas. NPD has contributed significantly to eight main domains: High Energy Physics and Quark Gluon Plasma with 58 publications, Nuclear Reactions and Spectroscopy (78), Intermediate Energy Reactions (27), Theoretical Research (23), Nuclear Fission (22), Interdisciplinary Research and Applications (29), Detectors and Nuclear Instrumentation (14), and Accelerators and Instrumentation (6) during 2003-2008.

Table 2: Domain-wise Publications of NPD and the Citations Received

| Domain                                      | No. of Publications | No. of citations | % of Citations | Cumulative % Citations |
|---|---------------------|------------------|----------------|------------------------|
| High Energy Physics and Quark Gluon Plasma  | 58                  | 4248             | 75.5           | 75.5                   |
| Nuclear Reactions and Spectroscopy          | 78                  | 677              | 12.0           | 87.5                   |
| Intermediate Energy Reactions               | 27                  | 272              | 4.8            | 92.3                   |
| Theoretical Research                        | 23                  | 170              | 3.0            | 95.3                   |
| Nuclear Fission                             | 22                  | 128              | 2.3            | 97.6                   |
| Interdisciplinary Research and Applications | 29                  | 78               | 1.4            | 99.0                   |
| Detectors and Nuclear Instrumentation       | 14                  | 48               | 0.9            | 99.9                   |
| Accelerators and Instrumentation            | 6                   | 6                | 0.1            | 100.0                  |
| <b>Total</b>                                | <b>257</b>          | <b>5627</b>      | -              | -                      |

In terms of citations garnered, 'High Energy Physics and Quark Gluon Plasma' has received 4248 (75.5%) citations followed by, 'Nuclear Reactions and Spectroscopy' with 677 (12%) citations, 'Intermediate Energy Reactions' (272, 4.8%), 'Theoretical Research' (170, 3%), 'Nuclear Fission' (128, 2.3%), 'Interdisciplinary Research and Applications' (78, 1.4%), 'Detectors and Nuclear Instrumentation' (48, 0.9%) citations, and 'Accelerators and Instrumentation' with 6 (0.1%) citations. The citation rate depends on a variety of factors such as the number of people working, number of papers published, type of publications, and the area of research (highly specialised or broad).

Year-wise citations received by NPD for their publications in various domains are presented in Figures 2a - 2h. It was observed that citations peaked in 2009 for the domains Nuclear Reactions and spectroscopy, Nuclear Fission, Theoretical Research, Detectors and Nuclear Instrumentation, and Accelerators and Instrumentation while citations peaked during 2007-2008 for the domain Intermediate Energy, High Energy Physics and Quark Gluon Plasma in 2007 and Interdisciplinary Research Applications in 2008.

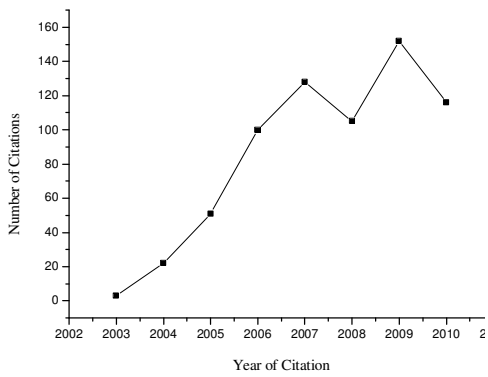


Figure 2a: Year-wise Growth of Citations in Nuclear Reactions and Spectroscopy

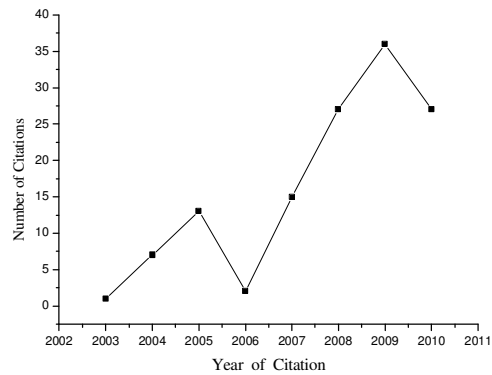


Figure 2b: Year-wise Growth of Citations in Nuclear Fission

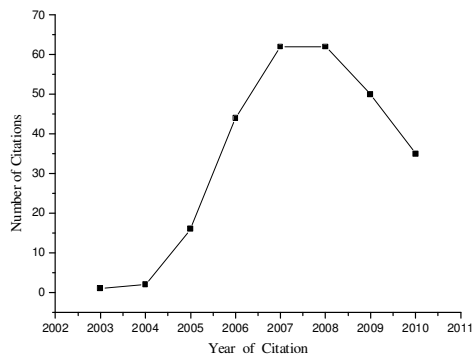


Figure 2c: Year-wise Growth of Citations in Intermediate Energy Reactions

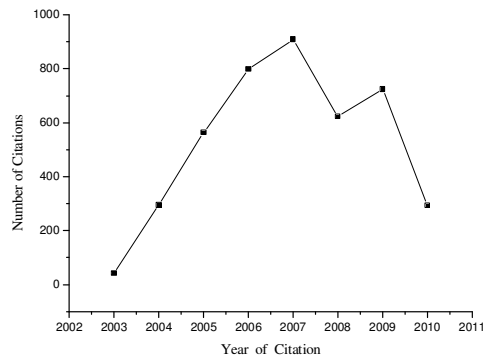


Figure 2d: Year-wise Growth of Citations in High Energy Physics and Quark Gluon Plasma

**Research and Citation Impact of Publications of the Nuclear Physics Division at BARC**

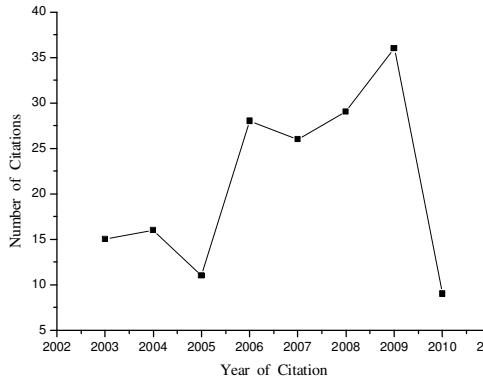


Figure 2e: Year-wise Growth of Citations in Theoretical Research

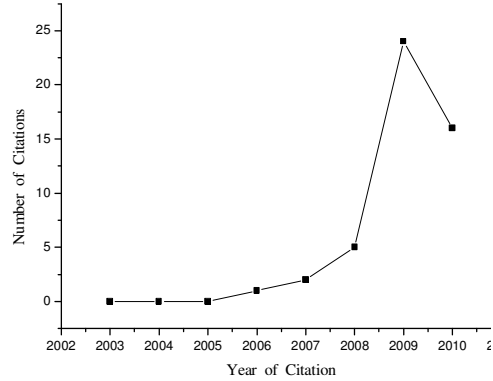


Figure 2f: Year-wise Growth of Citations in Detectors and Nuclear Instrumentation

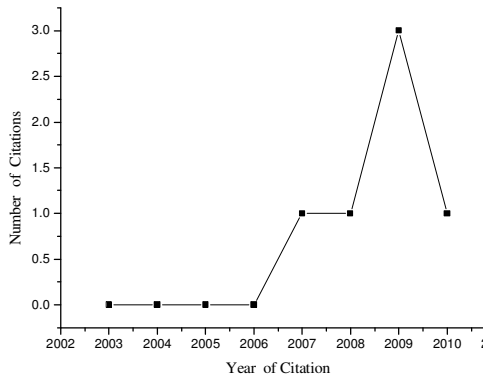


Figure 2g: Year-wise Growth of Citations in Accelerators and Instrumentation

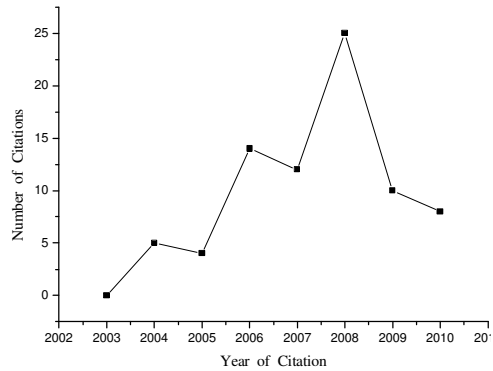


Figure 2h: Year-wise Growth of Citations in Interdisciplinary Research and Applications

**Citation Time-Lag**

Citation time-lag is one of the indicators which may throw light on independence of research programmes or individual scientists. The average value of time-lag within a particular citing publications or series of publications reflects how modern the publication is or how integrated it is in the evolving research front. In rapidly evolving 'hot' areas, time-lag will be small and in many cases zero. If time-lag is large, say ten years, it usually indicates that the publication or series of publications belongs to a stagnating research area or is out of contact with main stream of research.

For calculating the time-lag, 257 publications published during 2003-2008 have been considered. Out of 257 publications, 50 (19.46%) publications remain un-cited. Hence only 207 publications were considered for calculating the time-lag. Time-lag between publications of an article and its receiving first citation in the case of NPD publications is in the range of 0 to 5 years. It was revealed that 76 (29.57%) publications received citations in the same year of publication, followed by 92 (35.80%) publications received citations after one year of publication, 19 (7.39%) publications received citations after two years of publication, 14 (5.45%) publications received citations after three years of publication, 5

(1.95 %) publications received citations after four years of publication, and 1 (0.39 %) publication received citations after five years of publication. It is found that 65.37 percent of the publications have received their first citations within two years of their publication indicates that NPD publications were noticed instantly and had immediate direct impact among the fellow researchers working all over the world in the field of nuclear physics. This also indicates that domain related to these cited publications are rapidly evolving “hot” areas. Figure 3 depicts the number of publications and the citation time-lag.

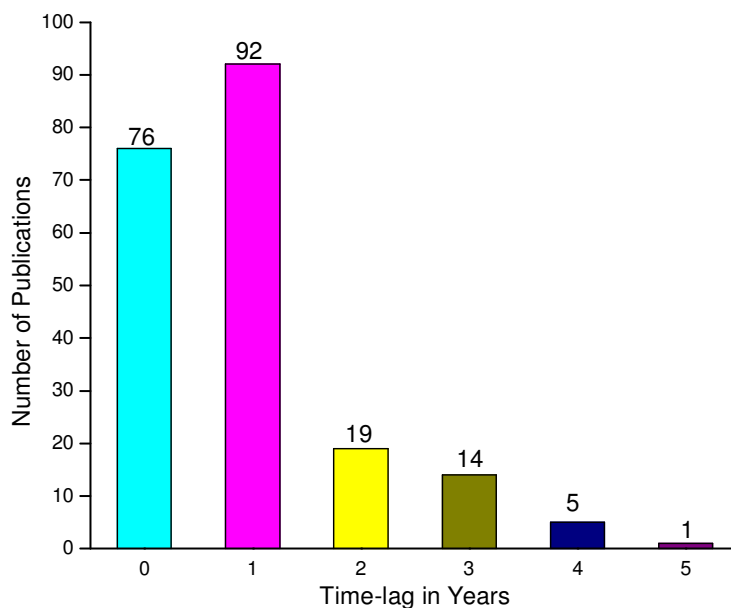


Figure 3: Citation Time-lag for NPD Publications

### Subject Category-wise Analysis of Journal Citations

All the citing journals of NPD were classified as per the Web of Science subject categories. Table 3 shows that the distribution of journal citations of NPD was not only from nuclear physics category but also cover many multidisciplinary areas of research. This indicates the influence and impact of NPD publications over many allied areas of research.

### Extent of Citations and Categories of Citing Documents

In order to gain visibility, it is important to know what is published and what communication channel is chosen for publication. A high quality paper published in an internationally well-known journal attracts the attention of the scientists instantly and receives many citations whereas an important paper published in an unknown journal may remain dormant and uncited for years. Table 4 indicates the types of documents citing NPD publications. Among the citations received, 4696 (83.45%) were from journal articles, followed by 476 (8.46%) conference papers, 431 (7.66%) reviews, 8 (0.14%) corrections, 8 (0.14%) letters, 4 (0.07%) chapters in books, 3 (0.05 %) editorials and 1 (0.02%) reprint.



Table 3: Distribution of Citing Journals and Citations of Nuclear Physics Division Publications as per Web of Science Subject Categories

| Sl. No. | Subject Category                                 | Number of Journals | No. of Citations |
|---------|--|--------------------|------------------|
| 1       | Nuclear Physics                                  | 10                 | 2924             |
| 2       | Physics - Multidisciplinary                      | 43                 | 1215             |
| 3       | Particles and Fields Physics                     | 8                  | 740              |
| 4       | Nuclear Science and Technology                   | 9                  | 87               |
| 5       | Mathematical Physics                             | 4                  | 66               |
| 6       | Atomic Physics and Molecular Chemistry           | 8                  | 40               |
| 7       | Astronomy and Astrophysics                       | 5                  | 15               |
| 8       | Fluids and Plasma Physics                        | 1                  | 11               |
| 9       | Multidisciplinary Science                        | 4                  | 8                |
| 10      | Chemical Engineering                             | 3                  | 4                |
| 11      | Geochemistry and Geophysics                      | 2                  | 4                |
| 12      | Condensed Matter Physics                         | 4                  | 4                |
| 13      | Polymer Science                                  | 1                  | 4                |
| 14      | Chemistry - Multidisciplinary                    | 2                  | 3                |
| 15      | Physical Chemistry                               | 3                  | 3                |
| 16      | Materials Science Composites - Multidisciplinary | 3                  | 3                |
| 17      | Biochemistry and Molecular Biology               | 1                  | 2                |
| 18      | Analytical Chemistry                             | 2                  | 2                |
| 19      | Computer Science - Interdisciplinary             | 1                  | 2                |
| 20      | Engineering - Multidisciplinary                  | 1                  | 2                |
| 21      | Materials Science Ceramics                       | 2                  | 2                |
| 22      | Optics   | 2                  | 2                |
| 23      | Chemistry Inorganic and Nuclear                  | 1                  | 1                |
| 24      | Energy and Fuels                                 | 1                  | 1                |
| 25      | Materials Science Coatings and Films             | 1                  | 1                |
| 26      | Applied Physics                                  | 1                  | 1                |
|         |  | 123                | 5147             |

Table 4: Types of Documents Citing NPD Publications

| Types of Documents  | Number of Citations | Citations % | Cumulative Citations % |
|---------------------|---------------------|-------------|------------------------|
| Journal articles    | 4696                | 83.45       | 83.45                  |
| Conference Papers   | 476                 | 8.46        | 91.91                  |
| Reviews             | 431                 | 7.66        | 99.57                  |
| Corrections         | 8                   | 0.14        | 99.72                  |
| Letters             | 8                   | 0.14        | 99.86                  |
| Chapters in Books   | 4                   | 0.07        | 99.93                  |
| Editorial Materials | 3                   | 0.05        | 99.98                  |
| Reprint             | 1                   | 0.02        | 100.00                 |
| Total               | 5627                | 100.00      | -                      |

### Citing Journals and their Distribution

This section discusses the journals that are citing NPD publications and the quality of the citing documents. Basically, one of the important factors by which the quality of a journal is ascertained, is by its impact factor. Analysis indicates that, out of 5087 journal citations, 5022 (98.72%) citations were from 119 international journals, and only 65 (1.28%) citations were from four Indian journals. Table 5 presents the journal-wise scattering of citations along with their impact factor. The leading citing journals were: *Physical Review- C* with 1148 citations, *Journal of Physics - G* (663 citations), *Nuclear Physics - A* (618 citations), *Physical Review Letters* (347 citations), *European Physical Journal - C* (332 citations), *Physics Letters - B* (263 citations) and *Physical Review - D* with 214 citations. It is observed that most of the NPD publications are cited in prestigious journals having high impact factor.

Table 5: Journals Citing NPD Publications Receiving  $\geq 10$  Citations

| Sl. No. | Citing Journals   | IF 2009 | Number of Citations | % of Citations |
|---------|---|---------|---------------------|----------------|
| 1       | Physical Review - C   | 3.477   | 1148                | 22.57          |
| 2       | Journal of Physics - G  | 2.124   | 663                 | 13.03          |
| 3       | Nuclear Physics - A   | 1.706   | 618                 | 12.15          |
| 4       | Physical Review Letters                                       | 7.328   | 347                 | 6.82           |
| 5       | European Physical Journal - C                                 | 2.746   | 332                 | 6.53           |
| 6       | Physics Letters - B   | 5.083   | 263                 | 5.17           |
| 7       | Physical Review - D   | 4.922   | 214                 | 4.21           |
| 8       | International Journal of Modern Physics - E                   | 0.643   | 169                 | 3.32           |
| 9       | European Physical Journal - A                                 | 1.968   | 121                 | 2.38           |
| 10      | Acta Physica Polonica - B                                     | 0.648   | 89                  | 1.75           |
| 11      | International Journal of Modern Physics - A                   | 0.941   | 80                  | 1.57           |
| 12      | Journal of High Energy Physics                                | 6.019   | 63                  | 1.24           |
| 13      | Physics of Atomic Nuclei                                      | 0.539   | 63                  | 1.24           |
| 14      | Pramana-Journal of Physics                                    | 0.349   | 60                  | 1.18           |
| 15      | Chinese Physics - C   | 0.251   | 49                  | 0.96           |
| 16      | Modern Physics Letters - A                                    | 1.075   | 44                  | 0.86           |
| 17      | Acta Physica Hungarica - A                                    | -       | 40                  | 0.79           |
| 18      | Nuclear Instruments & Methods in Physics Research Section - A | 1.317   | 38                  | 0.75           |
| 19      | Journal of Physics A - Mathematical and General               | -       | 33                  | 0.65           |
| 20      | Czechoslovak Journal of Physics                               | -       | 31                  | 0.61           |
| 21      | Annual Review of Nuclear and Particle Science                 | -       | 29                  | 0.57           |
| 22      | Chinese Physics Letters                                       | 0.972   | 28                  | 0.55           |
| 23      | Progress of Theoretical Physics Supplement                    | 0.547   | 28                  | 0.55           |
| 24      | Brazilian Journal of Physics                                  | 0.575   | 27                  | 0.53           |
| 25      | Nuclear Physics - B   | -       | 27                  | 0.53           |
| 26      | Reports on Progress in Physics                                | 11.444  | 26                  | 0.51           |
| 27      | European Physical Journal-Special Topics                      | 0.84    | 25                  | 0.49           |
| 28      | Journal of Physics A-Mathematical and Theoretical             | 1.577   | 23                  | 0.45           |
| 29      | Progress of Theoretical Physics                               | 2.368   | 22                  | 0.43           |
| 30      | High Energy Physics and Nuclear Physics - Chinese Edition     | 0.233   | 20                  | 0.39           |
| 31      | Physics Letters - A   | 2.009   | 18                  | 0.35           |
| 32      | Physics Reports - Review Section of Physics Letters           | 17.752  | 18                  | 0.35           |
| 33      | Nuclear Instruments & Methods in Physics Research Section - B | 1.156   | 17                  | 0.33           |
| 34      | Rivista Del Nuovo Cimento                                     | 3.5     | 17                  | 0.33           |
| 35      | Physics of Particles and Nuclei                               | 0.935   | 13                  | 0.26           |
| 36      | Journal of the Korean Physical Society                        | -       | 12                  | 0.24           |
| 37      | Nuclear Data Sheets   | 1.145   | 12                  | 0.24           |
| 38      | Communications in Theoretical Physics                         | 0.579   | 11                  | 0.22           |
| 39      | Nuclear Physics B   | 4.341   | 11                  | 0.22           |
| 40      | Physical Review E   | 2.4     | 11                  | 0.22           |
| 41      | Physical Review A   | 2.866   | 10                  | 0.2            |

### Top Institutions Citing Nuclear Physics Division Publications

In all, there were 1093 institutions which have appeared in the citing papers. Table 6 gives the core citing institutions based on their frequency of appearance in the citing papers. Top ten citing institutions were Brookhaven National Laboratory, USA with 1377 citations, SUNY Stony Brook, USA (932 citations), Joint Institute of Nuclear Research, Dubna, Russia (622 citations), Columbia University, USA (507 citations), University of Sao Paulo, Brazil (482 citations), University of Tokyo, Japan (474 citations), Bhabha Atomic Research Centre, Mumbai, (467 citations), CE Saclay, Gif Sur Yvette, France (443 citations), Los Alamos National Laboratory, USA (439 citations) and Oak Ridge National Laboratory, USA with 427 citations.

**Publications from Top Countries Citing Nuclear Physics Division Publications**

All the countries which have appeared in the affiliation field in the citing papers were counted. In all, there were 71 countries citing NPD publications. The most frequently occurred countries in the citing papers were: USA with 2783 citations followed by Germany with 1106 citations, India (944 citations), Peoples Republic of China (891 citations), France (848 citations), Russia (774 citations), Japan (770 citations) and Brazil with 540 citations. Figure 4 shows the top citing countries having citations greater than or equal to 400 citations.

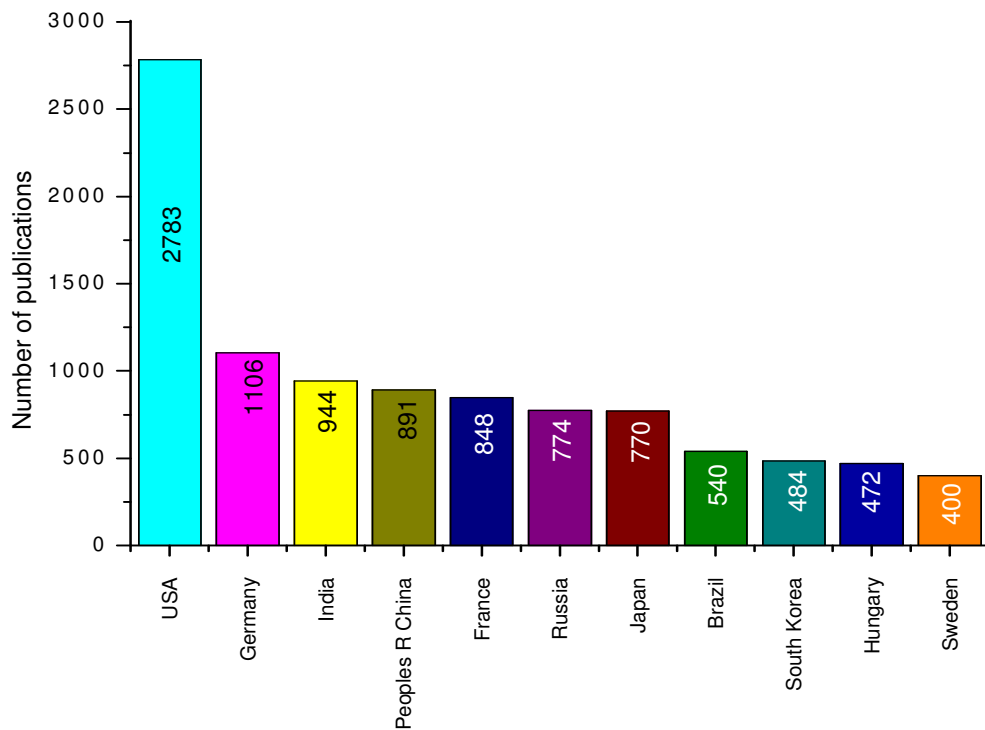


Figure 4: Top Countries citing Nuclear Physics Division publications

Table 6: Core Institutions Citing NPD Publications

| Rank | Citing Institutions                                   | No. of citations | %    |
|------|---|------------------|------|
| 1    | Brookhaven Natl. Lab., USA                            | 1377             | 3.67 |
| 2    | SUNY Stony Brook, USA                                 | 932              | 2.49 |
| 3    | Joint Inst. Nucl. Res., Dubna, Russia                 | 622              | 1.66 |
| 4    | Columbia Univ., USA                                   | 507              | 1.35 |
| 5    | Univ. Sao Paulo, Brazil                               | 482              | 1.29 |
| 6    | Univ. Tokyo, Japan                                    | 474              | 1.26 |
| 7    | Bhabha Atomic Research Centre, Mumbai, India          | 467              | 1.25 |
| 8    | CE Saclay, Gif Sur Yvette, France                     | 443              | 1.18 |
| 9    | Los Alamos Natl. Lab., USA                            | 439              | 1.17 |
| 10   | Oak Ridge Natl. Lab., USA                             | 427              | 1.14 |
| 11   | Kyoto Univ., Japan                                    | 418              | 1.12 |
| 12   | Petersburg Nucl. Phys. Inst., Russia                  | 413              | 1.1  |
| 13   | Univ. Paris, Paris, France                            | 412              | 1.1  |
| 14   | Univ. Tsukuba, Japan                                  | 412              | 1.1  |
| 15   | Univ. Nantes, Nantes, France                          | 407              | 1.09 |
| 16   | Iowa State Univ., USA                                 | 406              | 1.08 |
| 17   | Lawrence Livermore Natl. Lab., USA                    | 391              | 1.04 |
| 18   | Univ. Tennessee, USA                                  | 386              | 1.03 |
| 19   | Vanderbilt Univ., USA                                 | 386              | 1.03 |
| 20   | Florida State Univ., USA                              | 384              | 1.02 |
| 21   | Russian Res. Ctr., Kurchatov Inst., Moscow, Russia    | 377              | 1.01 |
| 22   | Tokyo Inst. Technol., Japan                           | 376              | 1    |
| 23   | Univ. Illinois, USA                                   | 374              | 1    |
| 24   | Univ. Munster, Munster, Germany                       | 370              | 0.99 |
| 25   | Univ. Calif. Riverside, USA                           | 368              | 0.98 |
| 26   | Weizmann Inst. Sci., Israel                           | 367              | 0.98 |
| 27   | Korea Univ., South Korea                              | 366              | 0.98 |
| 28   | Ecole Polytech, France                                | 365              | 0.97 |
| 29   | Yonsei Univ., South Korea                             | 363              | 0.97 |
| 30   | Lund Univ., Dept. Phys., SLund, Sweden                | 358              | 0.96 |
| 31   | KEK, Ibaraki, Japan                                   | 358              | 0.96 |
| 32   | Seoul Natl. Univ., South Korea                        | 357              | 0.95 |
| 33   | RIKEN, Inst. Phys. & Chem. Res., Wako, Saitama, Japan | 357              | 0.95 |
| 34   | Hiroshima Univ., Higashihiroshima, Japan              | 356              | 0.95 |
| 35   | Univ. New Mexico, USA                                 | 355              | 0.95 |
| 36   | Texas A&M Univ., USA                                  | 353              | 0.94 |
| 37   | Univ. Clermont Ferrand, Clermont Ferrand, France      | 353              | 0.94 |
| 38   | Waseda Univ., Japan                                   | 349              | 0.93 |
| 39   | Banaras Hindu Univ., India                            | 346              | 0.92 |
| 40   | New Mexico State Univ, USA                            | 344              | 0.92 |
| 41   | Debrecen Univ., Hungary                               | 342              | 0.91 |
| 42   | Abilene Christian Univ., USA                          | 341              | 0.91 |
| 43   | Georgia State Univ., USA                              | 340              | 0.91 |
| 44   | Nagasaki Inst. Appl. Sci., Nagasaki, Japan            | 340              | 0.91 |
| 45   | Nevis Labs., USA                                      | 340              | 0.91 |
| 46   | China Inst. Atom Energy, Peoples R China              | 334              | 0.89 |
| 47   | Myongii Univ., South Korea                            | 315              | 0.84 |
| 48   | St. Petersburg State Polytech Univ, Russia            | 314              | 0.84 |
| 49   | Univ. Colorado, USA                                   | 300              | 0.8  |
| 50   | Inst High Energy Phys., Protvino, Russia              | 300              | 0.8  |

### Distribution of Keywords in the Citing Publications

Keywords are one of the best scientometrics indicators to understand and grasp instantaneously the thought content of the papers and to find out the growth of the subject field. Analysing the keywords appeared either in the title or assigned by the indexer or the author himself will help in knowing in which direction the knowledge grows. The high frequency keywords will enable us to understand the aspects of Nuclear Physics that have been studied. The keywords appeared in the “Keywords” and “Keywords Plus” fields in Web of Science of citing papers were analysed to assess the impact of the NPD publications to the wide ranging domains of Nuclear Physics. The high frequency keywords were Quark-Gluon Plasma (1166), Heavy-Ion Collisions (987), Collisions (762), Nucleus-Nucleus Collisions (711), QCD (644), Matter (569), Elliptic Flow (532). Table 7 gives a list of high frequency keywords appeared  $\geq 50$  times.

Table 7: Keywords Appearing  $\geq 50$  Times in Citing Publications

| Keywords                   | Frequency |
|----------------------------|-----------|
| QUARK-GLUON PLASMA         | 1166      |
| HEAVY-ION COLLISIONS       | 987       |
| COLLISIONS                 | 762       |
| NUCLEUS-NUCLEUS COLLISIONS | 711       |
| QCD                        | 644       |
| MATTER                     | 569       |
| ELLIPTIC FLOW              | 532       |
| TRANSVERSE-MOMENTUM        | 325       |
| SCATTERING                 | 291       |
| COLOR GLASS CONDENSATE     | 271       |
| ENERGY-LOSS                | 252       |
| NUCLEAR COLLISIONS         | 244       |
| RADIATIVE ENERGY-LOSS      | 230       |
| GLUON PLASMA               | 205       |
| ENERGY                     | 191       |
| PB-PB COLLISIONS           | 188       |
| SPS                        | 186       |
| HADRON-PRODUCTION          | 177       |
| AU+AU COLLISIONS           | 174       |
| NUCLEI                     | 173       |
| PLUS AU COLLISIONS         | 172       |
| SPECTRA                    | 172       |
| LARGE TRANSVERSE-MOMENTUM  | 169       |
| PARTON DISTRIBUTIONS       | 168       |
| PHENIX                     | 167       |
| ROOT-S                     | 156       |
| FINITE-TEMPERATURE         | 149       |
| CENTRALITY DEPENDENCE      | 135       |
| HADRON SPECTRA             | 135       |
| DEEP-INELASTIC SCATTERING  | 130       |
| PHASE-TRANSITION           | 122       |
| AU COLLISIONS              | 121       |
| PROTON                     | 121       |
| DETECTOR                   | 120       |
| ENERGIES                   | 119       |
| STAR                       | 119       |
| CHARGED-PARTICLE           | 116       |
| GLUON DISTRIBUTION         | 116       |
| J / PSI SUPPRESSION        | 109       |

| Keywords                        | Frequency |
|---------------------------------|-----------|
| JETS                            | 85        |
| PION INTERFEROMETRY             | 85        |
| THERMODYNAMICS                  | 79        |
| NUCLEAR-MATTER                  | 78        |
| D+AU                            | 76        |
| EMISSION                        | 75        |
| COULOMB BARRIER                 | 74        |
| NUCLEUS COLLISIONS              | 74        |
| MULTIPLICITY                    | 72        |
| DRELL-YAN                       | 70        |
| FLUCTUATIONS                    | 69        |
| OPACITY                         | 69        |
| PHOTOPRODUCTION                 | 68        |
| TEMPERATURE                     | 68        |
| PROTON-PROTON                   | 67        |
| ION COLLISIONS                  | 66        |
| RELATIVISTIC NUCLEAR COLLISIONS | 66        |
| FUSION                          | 65        |
| FINAL-STATE INTERACTIONS        | 63        |
| BOSE-EINSTEIN CORRELATIONS      | 62        |
| DECAY                           | 61        |
| PARTON ENERGY-LOSS              | 61        |
| ABELIAN ENERGY-LOSS             | 60        |
| PROMPT PHOTON PRODUCTION        | 60        |
| PARTONS                         | 59        |
| TOMOGRAPHY                      | 59        |
| VECTOR-MESONS                   | 59        |
| CHIRAL-SYMMETRY                 | 57        |
| ANISOTROPIC FLOW                | 56        |
| HYDRODYNAMICS                   | 56        |
| ANISOTROPY                      | 55        |
| COLLECTIVE FLOW                 | 55        |
| E+E-ANNIHILATION                | 55        |
| EQUILIBRATION                   | 55        |
| FREEZE-OUT                      | 55        |
| SMALL X                         | 55        |
| SYMMETRY                        | 55        |
| TRANSITION                      | 54        |
| AU-AU COLLISIONS                | 53        |

|                         |     |
|-------------------------|-----|
| HADRONS                 | 105 |
| TO-LEADING ORDER        | 105 |
| SIGNATURE               | 104 |
| FRAGMENTATION FUNCTIONS | 100 |
| ELASTIC-SCATTERING      | 96  |
| HIGH-DENSITY QCD        | 96  |
| QUARK                   | 96  |
| MESON                   | 92  |
| RESONANCE               | 92  |
| PARTICLES               | 86  |
| PLASMA                  | 86  |

|                            |    |
|----------------------------|----|
| LEADING ORDER              | 53 |
| PHOTONS                    | 53 |
| PSEUDO-HERMITICITY         | 53 |
| NON-HERMITIAN HAMILTONIANS | 52 |
| PARTON                     | 52 |
| FIELD-THEORY               | 51 |
| INELASTIC ALPHA-SCATTERING | 51 |
| LHC                        | 51 |
| TRANSPORT                  | 51 |
| INTERFEROMETRY             | 50 |
| PARTICLE-PRODUCTION        | 50 |

## CONCLUSION

This paper has attempted to highlight the impact of research carried out by the scientists of NPD at BARC during 2003-2008. The Division has published 257 publications during this period in diverse domains. The citation analysis of these publications is carried out covering the period 2003-31<sup>st</sup> August 2010 using Web of Science. During this period, NPD has received a total of 5627 citations. The results indicate that 80.16 percent of the cited papers have received their first citations within five years of their publication indicating that NPD publications were noticed immediately by the researchers working all over the world in this field and well integrated in the evolving research front. The highest number of citations received were 1155 in 2007. The average number of citations per year was 703.38 and the average number of citations per publication was 21.89. As many as twelve highly cited publications could be identified based on the number of citations they have received. High Energy Physics and Quark Gluon Plasma domain received the highest percentage (75.5%) of citations. NPD publications received the highest number of citations from the United States of America with 2783 citations, followed by Germany with 1106 citations and India with 944 citations. Brookhaven National Laboratory, U.S.A. cited 1377 times the NPD publications followed by SUNY Stony Brook, U.S.A. with 932 citations and Joint Institute of Nuclear Research, Dubna, Russia with 622 citations. It will be quite interesting, if one attempts to study the motivations, for which Nuclear Physics Division publications received citations.

## ACKNOWLEDGEMENT

Authors are highly indebted to Dr. R. K. Choudhury, Head Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai, for his encouragement and support in taking up this study and offering valuable suggestions to improve the paper.

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