

## **High energy physics R&D productivity of Bhabha Atomic Research Centre as reflected in the e-Print Archives holdings of SLAC**

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### **Abstract**

*Contribution of the Bhabha Atomic Research Centre (BARC) to the e-Print Archive services of Stanford Linear Accelerator Center in the field of High Energy Physics (HEP) on Internet is the main focus of the study. E-Print Archives where BARC is at least one of the affiliation of authors are downloaded from the site 'http://www.slac.stanford.edu/spires/hep/' (297 records as on November 2002) and analysed based on some bibliometric parameters. The study lead to some of the results like most productive high energy physicists, author collaboration pattern, institutional collaboration pattern both international and national, preference of publication types by HEP scientists, core journals in which scientists preferred to publish their articles, inclusion of the records in two well known databases INIS and INSPEC where high energy physics related publications are likely to occur, citations received in Science Citation Index (SCI) of ISI and the HEP database itself and key areas of research through keyword analysis. In addition to that highlight the e-print archive services are additional bibliographic sources for HEP scientists.*

## 1 Introduction

High Energy Physics (HEP) deals with the Fundamental Forces and Matter in the Universe<sup>1</sup>. In recent times, it has emerged as a front line area of research because of its importance in various areas of research like Astrophysics, Cosmology etc. Due to its multi-disciplinary nature, many institutions around the world have established laboratories and are pursuing collaborative research.

Pre-prints of research works were circulated for a peer review among research workers so that a refinement on the paper is possible. But the distribution of pre-prints is inevitably limited and many times all concerns are not addressed due to paucity of time. EPrint Archives were designed to solve these problems. It clearly establishes priority by date stamping contributions. The e-Print Archives also widen access. Some have seen the e-Print Archives as 'democratizing' the scholarly communication process<sup>2</sup>. E-Print Archives are therefore becoming very popular with time.

The HEP Project at SPIRES-SLAC is a joint project of the Stanford Linear Accelerator Center (SLAC) and DESY Physics Labs for the high energy physicists. Founded in 1974, this project includes searchable database of e-Print Archives of almost 4,00,000 bibliographic records, which includes preprints, e-prints, journal articles, technical reports, conference papers, theses, etc. Full texts of more than 1,50,000 are available free of charge. The SLAC HEP database, in which about 150 items are added every week, now gives Electronic Bulletin Board addresses in case of about half of them<sup>3</sup>. Selection of items for inclusion, addition of specialized keywords, and maintenance of the system are carried out by a group of subject specialists<sup>4</sup>.

This freely available bibliographic database of e-Print Archives covers all areas of high-energy physics and its related fields. Separate files for different subfields [Appendix 1] of high-energy physics are maintained for accessing e-Print Archives. Links to the citations received in the HEP database itself for each and every e-Print Archive is a unique feature of this database.

There are 6696 institutions specializing in high-energy physics and astrophysics, which contribute to this database. Links are given from names of Institutions to: (a) full address and phone/fax/url of the institution; (b) papers of the concerned institution in HEP database; (c) people in HEPNAMES directory; and (d) the concerned departmental home pages, where ever known.

As on December 2002, almost 320 institutions in India are participating in HEP Programme [Appendix 2]. High energy physicists, especially scientists from developing countries are getting significant opportunities in the collaborative experiments like PHENIX, GEM, ISOLDE of high energy collisions of heavy ions and protons. Bhabha Atomic Research Centre (BARC) scientists are active participants of these programmes especially PHENIX Collaboration. This article deals with the analysis of bibliographic productivity of BARC high energy physicists with respect to the HEP database of e-Print Archives.

## 2 Objectives

The productivity of a research laboratory can be bibliometrically measured by its literature outputs; participation in international projects and the recognition of research outputs in specialized international databases. All records in HEP database where at least one author's affiliation was BARC were analysed with the following objectives:

1. to highlight HEP database as an additional bibliographic information source for high energy physics scientists;
2. to identify the most productive high energy physicists;
3. to show the authorship pattern;
4. to elucidate the institutional collaboration pattern of BARC high energy physics scientists both international and national;
5. to analyse the choice of publication types BARC high energy physics scientists preferred to publish their articles;
6. to find out the key journals publishing HEP e-Print Archives;
7. to check the inclusion of the records in well known bibliographic databases INIS and INSPEC;
8. to study the citations pattern of the e-Print Archives in Science Citation Index (SCI) of ISI, Philadelphia and the HEP database itself.; and
9. to identify the core areas of research through keyword analysis.

## 3 Materials and Methods

Stanford Linear Accelerator Center web site '<http://www.slac.stanford.edu/spires/hep/>' was accessed to retrieve e-Print Archives where at least one author's affiliation was BARC. As on November 2002, 297 publications were included in this database. MS-Access was used for the analysis of the data. Some clarifications on the database were made from the SLAC database managers through personal communication. CD-ROM version of Science Citation Index (SCI) of ISI, Philadelphia, was used to retrieve citations received to the e-Print Archives studied. CD-ROM version of INIS and INSPEC were also used to see the extensiveness/coverage of these e-Print Archives.

## 4 Author productivity

Among the 422 distinct authors and co-authors (except PHENIX, GEM, ISOLDE collaborated papers) contributing 297 items, 187 (44.31 %) were from foreign institutions 173 (41 %) were from BARC and 62 (14.69 %) were from other Indian institutions. Rank-wise publication productivity of high-energy physicists who have contributed at least 5 papers is given in Table 1.

Table 1: Rank-wise productivity of high energy Physicists  
in the HEP database

<b>Sr. No.</b>	<b>Author</b>	<b>No. of e-Prints</b>	<b>Rank</b>
1	B.K. Jain	56	1
2	A. Mitra	19	2
3	C.L. Bhat	19	2
4	A. Chatterjee	17	3
5	A.B. Santra	17	3
6	A.K. Mohanty	17	3
7	N.G. Kelkar	16	4
8	PHENIX Collaboration	16	4
9	S. Kailas	14	5
10	S.K. Gupta	14	5
11	GEM Collaboration	12	6
12	R.K. Choudhury	12	6
13	A.K. Tickoo	10	7
14	A.K. Pati	9	8
15	D.C. Khandekar	9	8
16	K. Mahata	9	8
17	M. Azam	9	8
18	N. Sarma	9	8
19	P. Shukla	9	8
20	R.C. Rannot	9	8
21	S.V. Lawande	9	8
22	A. Saxena	8	9
23	A. Shrivastava	7	10
24	B.K. Nayak	7	10
25	M.L. Sapru	7	10
26	P. Singh	7	10
27	A.K. Jain	6	11
28	B. Sinha	6	11
29	D. Dutta	6	11
30	S. Bhattacharya	6	11
31	S.C. Phatak	6	11
32	A.S. Divatia	5	12
33	B. Kundu	5	12
34	H. Rebel	5	12
35	K. Kumar	5	12
36	R. Koul	5	12
37	R.N. Aiyer	5	12
38	S. Santra	5	12
39	S.R. Jain	5	12
40	S.V.S. Sastry	5	12
41	V.M. Datar	5	12

(truncated)

## 5 Author Collaboration pattern

Out of 297 e-Print Archives studied, 215 (72.39 %) had multiple authorships (Collaborated papers like PHENIX, GEM, ISOLDE have been counted as multi-authored papers). Among them 149 (around 70 %) publications have been published during the period 1991-2002 (Table 2). From the observation in Figure 1, it can be seen that the number of single authored publications are always less than multi-authored papers and there is a notable difference in numbers in recent years.

Table 2: Multi- vs. single-authored e-Print Archives

Publication Year	Multi-authored e-Prints		Single - Authored e-Prints		I.
	Number	% of Total	Number	% of Total	
1971-1974	6	2.79	1	1.22	85.71
1975-1978	12	5.58	6	7.32	66.67
1979-1982	15	6.98	7	8.54	68.18
1983-1986	13	6.05	11	13.41	54.17
1987-1990	20	9.30	8	9.76	71.43
1991-1994	32	14.88	7	8.54	82.05
1995-1998	32	14.88	14	17.07	69.57
1999-2002	85	39.53	28	34.15	75.22
<b>Average</b>	<b>26.88</b>	<b>12.50</b>	<b>10.25</b>	<b>12.50</b>	<b>71.62</b>

\* CC = Collaboration Coefficient

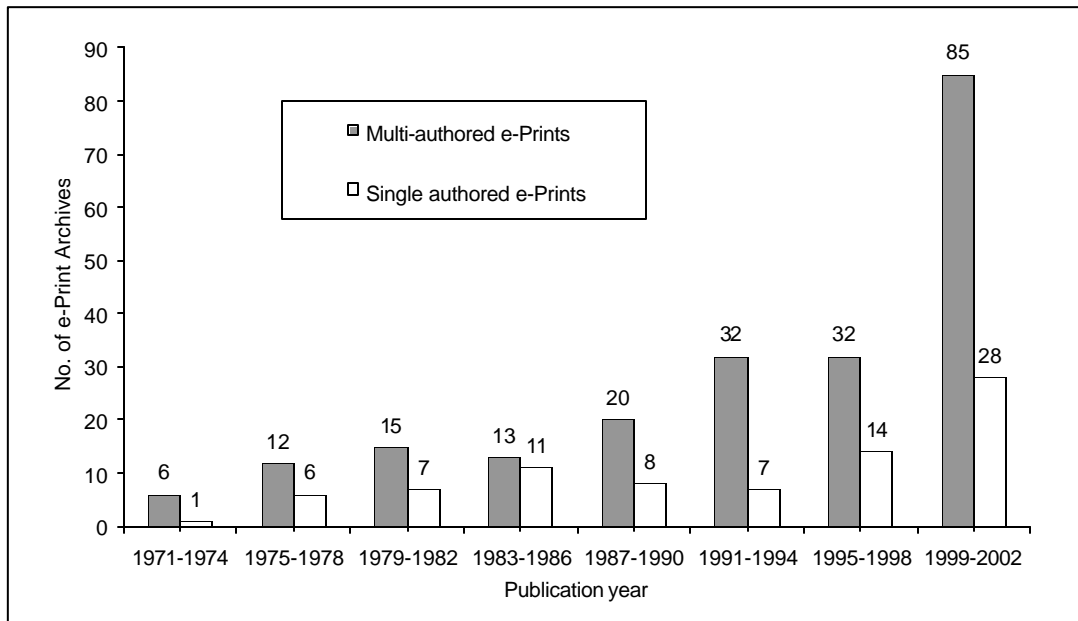


Figure 1: Multiple- vs. single-authored e-Print Archives

The ease of collaboration using e-mail and groupware technologies, the number of multi-authored articles has risen in recent years at a more rapid rate than the number of single-authored articles<sup>5</sup>. Total number of internationally co-authored scientific and technical articles in Institute of Scientific Information (ISI) databases<sup>6</sup> during 1986-88 has increased by 115% during 1995-1997. According to Katz and Hicks<sup>7</sup> collaborative papers have more impact than non-collaborative papers. HEP scientists of BARC have authored a growing number of archives in collaboration with foreign researchers. Internationally and nationally collaborated e-Print Archives accounted for around 17.51 % and 12.12 % respectively. A graphical representation of the growth of HEP publications of collaborative nature is given in Figure 2. Latest 50 % of the internationally collaborated archives have taken only 5 years to publish as against 18 years to publish rest of the 50 per cent.

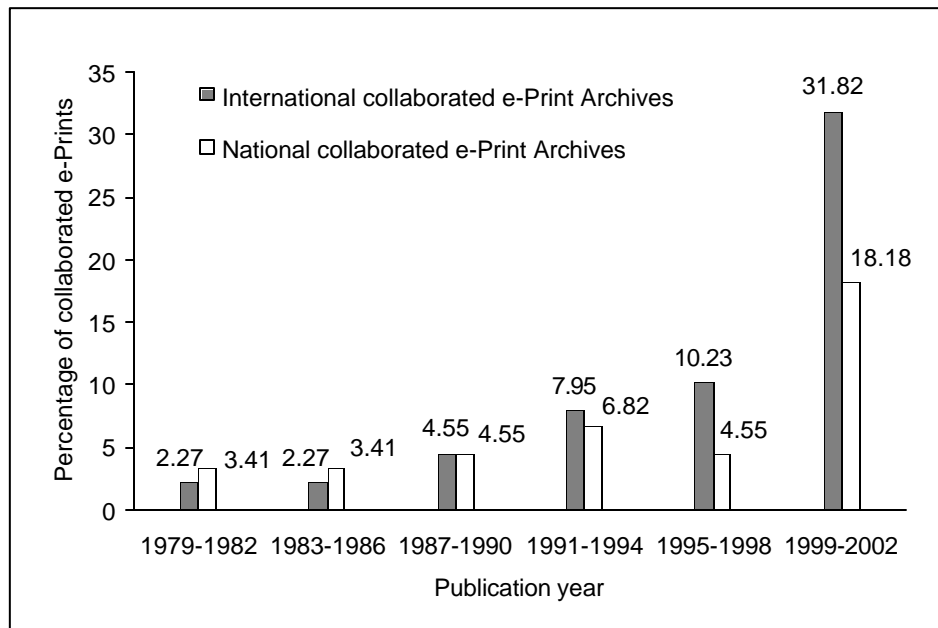


Figure 2: Growth of international and national collaborated e-Print Archives

## 6 Forms of publications

The publication forms in which scientists or technologists publish their research results are some bibliographic indicators of scientific and technological activities<sup>8</sup>. Figure 3 shows that BARC HEP scientists have preferred to publish 61 percent of their e-Print Archives in journals followed by conference papers (14 percent). In the present study, 13 per cent of the research works were still in the form of e-Print Archives. These works may take some other forms later.

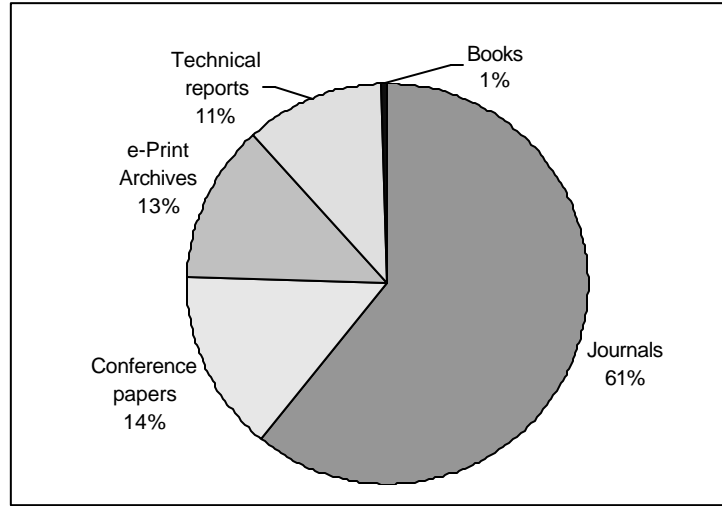


Figure 3: Publication type-wise distribution of BARC e-Print Archives on HEP database

## 7 HEP journals

Table 3 is the list of journals preferred by BARC researchers to publish their e-Print Archives with their origin of publication whether foreign or Indian, frequency of occurrence and impact factor. There are 16 distinct journals used to publish BARC e-prints on HEP database. Three leading journals *Phys. Rev. C*, *Phys. Rev. Lett.* and *Phys. Lett. B* has published around 28 % of the e-prints of BARC. The Indian journal *Pramana* has published only 11 e-prints.

Table 3: List of journals used for publication of BARC e-Print Archives in HEP databases

<b>Journal</b>	<b>Publication</b>	<b>No. of e-Prints</b>	<b>IF* (2000)</b>
<i>Phys.Rev.C</i>	Foreign	58	2.45
<i>Nucl.Phys.A</i>	Foreign	16	2.09
<i>Phys.Rev.Lett.</i>	Foreign	13	6.10
<i>Phys.Lett.B</i>	Foreign	12	3.88
<i>Pramana</i>	Indian	11	0.28
<i>Nucl.Instrum.Meth.A</i>	Foreign	10	0.92
<i>PiN Newslett.</i>	Foreign	5	3.83
<i>Z.Phys.A</i>	Foreign	5	1.74
<i>Phys.Lett.A</i>	Foreign	5	1.11
<i>Phys.Rev.D</i>	Foreign	4	3.70
<i>Nucl.Phys.B</i>	Foreign	4	3.15
<i>Phys.Rev.A</i>	Foreign	3	2.64
<i>Rev.Sci.Instrum.</i>	Foreign	1	1.29
<i>Part.Accel.</i>	Foreign	1	0.42
<i>Nuovo Cim.C</i>	Foreign	1	0.20
<i>Nucl.Tracks</i>	Foreign	1	NA**

\* IF = Impact Factor; and \*\*NA=Not available

## 8 HEP vs. INIS and INSPEC

Figure 4 shows the overlapping of BARC e-Print Archives in these databases where high-energy physics articles are likely to occur. It may be pointed out that 83 (27.95 %) of HEP e-Print Archives were not covered by either INIS or INSPEC. But among them 37 (44.58 %) were e-Print Archives. As soon as these articles get published somewhere they acquire new form and may get added in international databases. HEP database overcomes the timeliness in appearing articles in international databases in a great extent.

## 9 HEP citations vs. SCI citations

HEP database provides the citations received in the HEP database itself for each and every item added to this database. A list of top cited five e-Print Archives of BARC in HEP database itself and SCI is given in Table 4. Among the 297 e-Prints 59 (17.5 %) have received more citations in HEP database than SCI. The average difference of citations received in HEP databases with SCI for the ten top cited publications amount to 49.2.



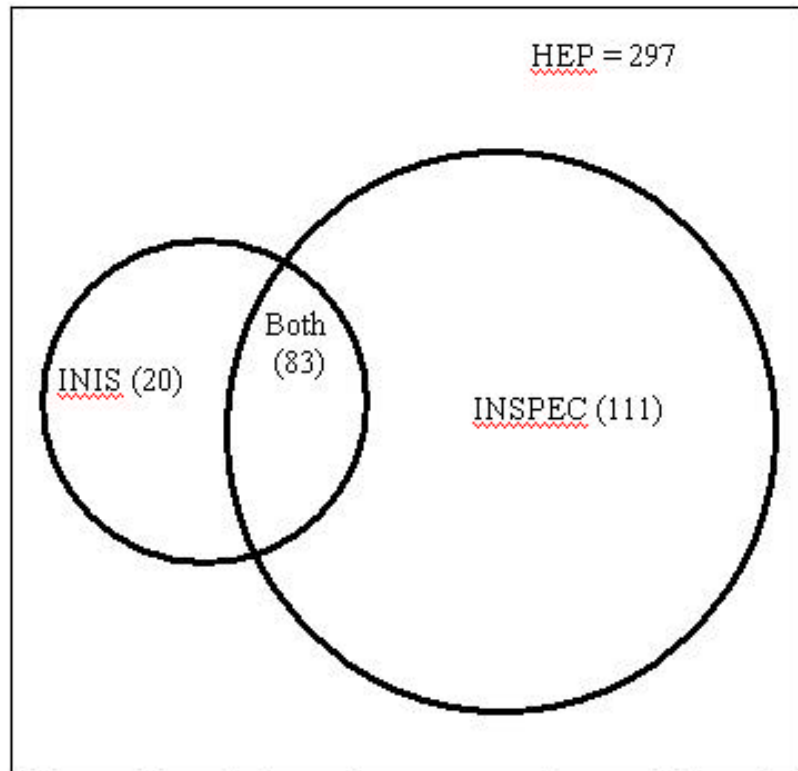


Figure 4: Overlapping and exclusion of BARC e-Print Archives in INIS and INSPEC databases with HEP database

Table 4: Highly cited ten e-Print Archives in HEP database with citations in SCI database.

E-Print Archive	Citations in HEP Database	Citations in SCI
CENTRALITY DEPENDENCE OF CHARGED PARTICLE MULTIPLICITY IN AU - AU COLLISIONS AT $S(NN)^{1/2} = 130$ -GEV, By PHENIX Collaboration (K. Adcox et al.). Dec 2000. 6pp. Published in <b>Phys.Rev.Lett.86:3500-3505,2001</b> e-Print Archive: <b>nucl-ex/0012008</b>	113	72
SUPPRESSION OF HADRONS WITH LARGE TRANSVERSE MOMENTUM IN CENTRAL AU+AU COLLISIONS AT $S(NN)^{1/2} = 130$ -GEV, By PHENIX Collaboration (K. Adcox et al.). Sep 2001. 6pp. Published in <b>Phys.Rev.Lett.88:022301,2002</b> e-Print Archive: <b>nucl-ex/0109003</b>	113	32
<b>FEYNMAN PATH INTEGRALS: SOME EXACT RESULTS AND APPLICATIONS</b> , By D.C. Khandekar, S.V. Lawande (Bhabha Atomic Res. Ctr.). 1986. 115pp. Published in <b>Phys.Rept.137:115-229,1986</b>	95	22
CENTRALITY DEPENDENCE OF $\pi^+$ / $\pi^-$ , $K^+$ / $K^-$ , P AND ANTI-P PRODUCTION FROM $S(NN)^{1/2} = 130$ -GEV AU+AU COLLISIONS AT RHIC, By PHENIX Collaboration (K. Adcox et al.). Dec 2001. 6pp. Published in <b>Phys.Rev.Lett.88:242301,2002</b> e-Print Archive: <b>nucl-ex/0112006</b>	76	19
<b>SEARCH FOR A HEAVY NEUTRINO IN THE BETA DECAY OF S-35</b> , By V.M. Datar (Bhabha Atomic Res. Ctr.), C.V.K. Baba, S.K. Bhattacharjee, C.R. Bhuinya, A. Roy (Tata Inst.). 1986. Published in <b>Nature 318:547-548,1985</b>	66	49
EXACT SOLUTION OF A TIME DEPENDENT QUANTAL HARMONIC OSCILLATOR WITH DAMPING AND A PERTURBATIVE FORCE, By D.C. Khandekar, S.V. Lawande (Bhabha Atomic Res. Ctr.). 1979. Published in <b>J.Math.Phys.20:1870-1877,1979</b>	60	9
MEASUREMENT OF THE MID-RAPIDITY TRANSVERSE ENERGY DISTRIBUTION FROM $S(NN)^{1/2} = 130$ -GEV AU + AU COLLISIONS AT RHIC, By PHENIX Collaboration (K. Adcox et al.). Apr 2001. 6pp. Published in <b>Phys.Rev.Lett.87:052301,2001</b> e-Print Archive: <b>nucl-ex/0104015</b>	56	21
<b>UNIVERSAL SIGNALS OF QUARK - GLUON PLASMA.</b> By B. Sinha (Bhabha Atomic Res. Ctr.). 1983. Published in <b>Phys.Lett.B128:91-94,1983</b>	53	31
TRANSVERSE MASS DEPENDENCE OF TWO PION CORRELATIONS IN AU+AU COLLISIONS AT $S(NN)^{1/2} = 130$ -GEV, By PHENIX Collaboration (K. Adcox et al.). Jan 2002. 6pp. Published in <b>Phys.Rev.Lett.88:192302,2002</b> , e-Print Archive: <b>nucl-ex/0201008</b>	46	5
<b>THE PHENIX EXPERIMENT AT RHIC.</b> By PHENIX Collaboration (D.P. Morrison et al.). BNL-65385, Apr 1998. 5pp. Published in <b>Nucl.Phys.A638:565-570,1998</b> e-Print Archive: <b>hep-ex/9804004</b>	38	19

## 10 Keyword analysis

A list of controlled keywords, which describe the content, concepts, methods, and models of the records<sup>9</sup> complement most of the bibliographic databases. Keywords or descriptors assigned to a record of any bibliographic database together are equivalent to the thought content of the record itself and sometimes they decide what to be or not to be retrieved. Bibliographic databases with web technology especially with hyperlinks are extensively

used to show the relationships between other records through keywords. Number of occurrence of one keyword decides the deemed importance enough to be a sub-field of the main field<sup>10</sup>. Table 5 is a list of keywords (which have at least 5 occurrence) with their respective frequencies in both records with BARC authors and records of whole HEP database along with their ranks. The Rank Correlation test is a distribution free test that determines whether there is a monotonic relation between two variables (x, y). A monotonic relation exists when any increase in one variable is invariably associated with either an *increase* or a *decrease* in the other variable. The monotonic relation is expressed using rank-order numbers instead of the values. This also makes the Rank Correlation a test *distribution free* test. Now, the correlation coefficient can be computed for the given numerical values, which are in the form of ranks. This coefficient of rank correlation is denoted by  $r_{\text{rank}}$  or briefly  $r$  and is calculated by the equation,

$$r_{\text{rank}} = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

Where  $d$  = differences between ranks of corresponding  $x$  and  $y$   
 $n$  = number of pairs of values ( $x, y$ ) in the data

The above equation is called as the Spearman's Formula for Rank Correlation<sup>11-12</sup>. A value of  $r_{\text{rank}}$  near one indicates good agreement, a value near zero, poor agreement. Here  $r_{\text{rank}} = 0.07$ , implies that majority of the keywords taken for representing BARC records are not much going parallel with those in whole HEP database which implies the variety in research activities of BARC in the sub-fields of high energy physics.

Table 5: Related keywords with their respective occurrences (at least 5) in BARC e-Print Archives and the whole HEP database.

Keyword	BARC e-Prints		HEP database	
	Frequency	Rank	Frequency	Rank
numerical-calculations	58	1	128178	2
interpretation-of-experiments	36	2	439969	1
delta(1232)++hadroproduction	22	3	152	44
differential-cross-section-momentum-transfer	18	4	2252	24
carbon	17	5	8366	13
differential-cross-section-angular-dependence	17	5	4718	17
quark-gluon-plasma	17	5	3404	19
differential-cross-section/s	16	6	26103	5
heavy-ion-scattering	16	6	4210	18
p-nucleus-nuclear-reaction	16	6	2922	20
distorted-wave-Born-approximation	16	6	94	47
energy-dependence	13	7	16633	6
nucleus-nucleus-nuclear-reaction	12	8	6114	15
exchange-one-pion	12	8	985	33
rho(770)-exchange	12	8	248	42
channel-cross-section	11	9	14732	7
helium-nuclide	10	10	1940	27
p-p-exclusive-reaction	9	11	421	40
angular-distribution	8	12	13803	9
pi+hadroproduction	8	12	1899	28

Keyword	BARC e-Prints		HEP database	
	Frequency	Rank	Frequency	Rank
potential-optical	8	12	1473	30
proton-proton-interactions	8	12	48	48
quark/s	7	13	45297	4
p-light-nucleus-nuclear-reaction	7	13	704	36
experimental-results	6	14	48962	3
quantum-mechanics	6	14	13866	8
S-matrix	6	14	7796	14
lithium	6	14	1147	31
p-lithium-->helium-6-delta(1232)++	6	14	1	51
scaling	5	15	12576	10
propagator	5	15	10273	12
differential-cross-section-energy-dependence	5	15	2892	21
photon-cosmic-radiation	5	15	2482	23
model-oscillator	5	15	2194	25
model-cluster	5	15	1736	29
field-equations-Korteweg-de-Vries	5	15	544	38
quantum-mechanics-path-integral	5	15	447	39
energy-spectrum-(tritium)	5	15	18	50

## 11 Conclusion

International collaboration pattern among researchers in the era where time or distance is not a matter for communication, is quite interesting. The amounts of collaborated papers have increased drastically in the recent past. Ranking of periodicals helps to finding out the core periodicals in the subject especially for identifying journals<sup>12</sup> relevant to high energy physics, a recently emerged frontier area of research. Bibliographic databases of micro level can cover more relevant records than the databases of macro level. The database under study can be a complementary database of SCI for the HEP scientists as some publications get more citations in the database itself than SCI. Collaborated publications especially PHENIX collaborated papers are highly cited publications. Keyword analysis deciphers the direction of the research field to a certain extent.

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## 13. Appendices

### Appendix 1: General headings of areas covered by HEP Database

- II. Theoretical and Mathematical Physics
  - a. Mathematics for Physics Applications
  - b. Quantum Mechanics
  - c. Quantum Field Theory
  - d. Gravity
  - e. Supersymmetry and Supergravity
  - f. String Theory
  - g. Condensed Matter Physics
  
- III. Elementary Particle Physics – Standard Model
  - a. General Aspects of Elementary Particles
  - b. Quantum Electrodynamics
  - c. Strong Interactions
  - d. Weak Interactions
  - e. CP Violation and Flavor-Changing Weak Interactions
  - f. Neutrino Masses and Mixings
  
- IV. Elementary Particle Physics – Beyond the Standard Model
  - a. Higgs Boson Physics
  - b. Technicolor and Composite Higgs
  - c. Supersymmetry
  - d. Models with Extra Space Dimensions
  - e. Exotic Particles
  - f. Grand Unification
  - g. Experiments in Physics Beyond the Standard Model
  
- V. Astro-Particle Physics
  - a. General Relativity and Gravity
  - b. Normal and Exotic Stars
  - c. Energetic Cosmic Phenomena Dark Matter and Large-Scale Structure
  - d. Early Universe
  - e. Inflation
  - f. The Cosmological Constant Problem
  
- VI. Nuclear and High-Density Strong Interactions
  - a. Nuclear Structure and Reactions
  - b. QCD in Nuclear Physics
  - c. QCD at High Temperature and Density
  - d. Heavy-Ion Reactions
  
- VII. Accelerator Physics
  - a. General Aspects of Accelerator Physics
  - b. Linear Accelerators
  - c. Synchrotrons
  - d. Linear e<sup>+</sup>e<sup>-</sup> Colliders
  - e. Instrumentation and Control of Particle Accelerators

## Appendix 2: Indian institutions participating in the HEP Programme.

A.C. Coll., Jalpaiguri	Calcutta, AASV	Indian Inst. Trop. Met.
Abhedananda Mahavidyalaya	Calcutta, British High Commission	Indian Space Res. Org.
ABTT Coll., Calcutta	Calcutta, Central Drugs Lab	Indian Statistical Inst., Bangalore
Acharya Brajendra Nath Seal Coll.	Calcutta, City Coll.	Indian Statistical Inst., Baranagar
Agra U.	Calcutta, Regional Computing Ctr.	Indian Statistical Inst., Calcutta
Ahmedabad, Phys. Res. Lab	Calcutta, VECC	Indian Statistical Inst., New Delhi
Ajit Foundation, Jaipur	Calicut U.	Indore U.
Aligarh Muslim U.	Chandannagar Coll.	Indore, Ctr. for Advanced Tech.
All India Jat Hero Memorial Coll.	Charuchandra Coll.	Inst. Natl. Phil., India
Allahabad U.	Chhindwara, Gov. Postgraduate Coll.	ISRO, Bangalore
Ananda Mohan Coll.	CMMACS, Bangalore	IUCAA, Pune
Andhra U.	Cochin U.	IUC-DAEF, Kolkata
Anna U.	Cotton Coll., Gauhati	J.K.S. High School, Danrpur
ARIFSAT, Hyderabad	D.A.V. Coll.	Jabalpur, Govt. Eng. Coll.
Arunachal U.	Darjeeling Govt. Coll.	Jadavpur U.
Arya Vidyapith Coll.	Darrang Coll.	Jalandhar Regional Eng. Coll.
Aska Science Coll.	Deen Dayal Upadhyaya Coll.	Jamia Millia Islamia
Assam Sci. Tech. Envir. Council	Dehradun, Inst. Petroleum Explor.	Jammu U.
B.B. Coll.	Delhi U.	Jangipur Coll.
B.E. Coll., Howrah	Delhi, Solid State Physics Lab	Jerusalem Coll. Eng.
B.J.B. Coll.	Devi Ahilya U.	Jhargram Raj Coll.
B.K.C. Coll., Calcutta	Dhanbad, Central Fuel Res. Inst.	Jiwaji U.
Badagara, Govt. Coll	Dhenkanal Coll.	Jodhpur U.
Banaras Hindu U.	Dibrugarh U.	Jogamaya Devi Coll., Kolkata
Bangabasi Coll.	Dinabandhu Andrews Coll.	Jogesh Chandra Chaudhuri Coll.
Bangalore U.	DSN Coll., Unnao	Jorhat, Coll. Sci.
Bangalore, Indian Inst. Astrophys.	Durgapur, Regional Eng. Coll.	Kalimpong Coll.
Bangalore, Indian Inst. Sci.	Fakir Chand Coll.	Kalpakkam Reactor Res. Ctr.
Bangalore, Nehru Ctr	G.C. Coll., Silchar	Kalyani U.
Banki Coll.	Gandhi Faizeam Coll.	Kamala Nehru Inst. Tech., Sultanpur
Barasat Govt. Coll.	Gangadhar Meher Coll.	Kanchrapara Coll.
Baroda U.	Ganjdundwara Coll.	Kanpur, Christ Church Coll.
Barrackpore Rastraguru Surendranath Coll.	Garhwal U.	Karaikkudi, CERI
Basanti Devi Coll., Kolkata	Gauhati Commerce Coll.	Karnatak U.
Basirhat Coll.	Gauhati U.	Kashmir U.
Bejoy Narayan Coll.	Gaya Coll.	Katwa Coll.
Benupalchak High School, Howrah	GGSIU, Delhi	Kendrapara Coll.
Berhampur U.	Gobardanga Hindu Coll.	Kerala U.
Berhampur, Engineering School	Gokhale Coll., Calcutta	KGK Coll., Moradabad
Bethune Coll., Calcutta	Gorakhpur U.	Khallikote Coll., Berhampur
Bhabha Atomic Res. Ctr.	Govt. Coll., Sawai Madhopur	Khanapara, IASST
Bhabha Atomic Res. Ctr., Srinagar	Gujarat U.	Khemundi Coll., Digapahandi
Bhairab Ganguly Coll.	Guru Nanak Dev U.	Kilpauk Medical Coll.
Bharat Petroleum, Mumbai	Gurudas Coll., Kolkata	Kothagudem School of Mines
Bharathidasan U.	Haldia Govt. Coll.	Krishnagar Coll.
Bharatiya Vigyan Sangh, Chennai	Harish Chandra Coll.	Kumaun U.
Bhat, Inst. Plasma Res.	Harish -Chandra Res. Inst.	Kurukshetra U.
Bhavnagar U.	Hazarimal Somani Coll., Mumbai	Lady Brabourne Coll., Calcutta
BHEL, New Delhi	Himachal Pradesh U.	Leather Tech. Coll., Calcutta
Bhima Bhoi Coll., Rairakhol	Hindu Degree Coll.	Loyola Coll., Chennai
Bhubaneswar, Inst. Phys.	Hinjilicut Sci. Coll.	Lucknow U.
Bhubaneswar, Regional Coll. of Educ.	Hislop Coll., Nagpur	M. B. Khalsa Coll., Indore
Bidhannagar Coll.	Hooghly Mohsin Coll.	M.M.M. Engineering Coll., Gorakhpur
Bihar U.	Hyderabad U.	Madras Christian Coll.
Bijay Krishna Girl's Coll.	IACS, Calcutta	Madras Medical Coll.
Birla Inst. Tech. Sci.	IMSc, Chennai	Madras U.
Birla Sci. Ctr., Hyderabad	India Meteorological Dept., Alipore	Madras U., Ramanujan Inst. for Math.
Biswasray Sci. Coll.	Indian Inst. Advanced Study, Simla	Magadh U.
Bolpur Coll.	Indian Inst. Astrophys., Hosakote	Maharaja Manindra Chandra Coll.
Bose Coll., Calcutta	Indian Inst. Tech., Guwahati	Maharshi Dayanand U.
Bose Ctr., Calcutta	Indian Inst. Tech., Kanpur	Mahatma Gandhi U.
Bose Inst., Calcutta	Indian Inst. Tech., Kharagpur	Malda Govt. Teachers Coll.
Burdwan U.	Indian Inst. Tech., Madras	Mangalore U.
Calcutta U.	Indian Inst. Tech., Mumbai	Manipal Inst. Tech.
Calcutta U., Dept. Appl. Math.	Indian Inst. Tech., New Delhi	Manipur U.

Manonmaniam Sundaranar U.
Marathwada U.
Maulana Azad Coll.
Meerut U.
Midnapore Coll.
Mithila U.
Modern School, Calcutta
Mumbai U.
Mysore U.
Mysore, Coll. Education
Nabadwip Vidyasagar Coll.
Nagpur U.
Nagpur, Central Res. Inst.
Nagpur, Inst. Sci.
Nainital Observatory
Nalbari Coll.
Narasingha Dutt Coll.
Natl. Ctr. Radio Astrophys.
Nauni, Univ. Horticulture
Nehru U.
NERIST, Nirjuli
Netaji Mahavidyalaya Coll.
Netaji Nagar Day Coll.
New Alipore Coll.
New Delhi, Natl. Physical Lab
NGM Coll., Pollachi
Nimapara Coll.
Nistarin i Coll.
North Bengal U., Darjeeling
North Lakhimpur Coll.
Northeastern Hill U., Medziphema
Northeastern Hill U., Shillong
Northeastern Res. Inst. Sci. Tech., Itanagar
Nowgong Coll.
Nucl. Sci. Ctr., New Delhi
Orissa U. Agric. Tech.
Osmania U.
P.N. Coll., Khurda
Pandu Coll.
Panjab U.
Patna U.
Pattamundai Coll.
Pilani, CEERI
Port Blair, Govt. Coll.
Pragjyotish Coll.
Prananath Coll.
Presidency Coll., Calcutta
Presidency Coll., Madras
Priyadarshini Coll. Eng.
Pune U.
Punjab Eng. Coll.
Punjabi U.
Raisoni Coll. Eng.
Raja N.L. Khan Coll., Midnapur
Raja Peary Mohan Coll.
Rajasthan U.
Rajendranagar, Advanced Tech. Ctr.
Raman Research Inst., Bangalore
Rammthakar Coll.
Rampurhat Coll.
Ravenshaw Coll.
Ravishankar U.
Rewa, Govt. Science Coll.
Rishra High School
RKMVC Coll.
Roorkee U.

Rourkela, Regional Eng. Coll.
S.C.S. Coll., Puri
S.P. Coll., Srinagar
S.V.M. Coll., Jagatsinghpur
Saha Inst.
Salkia Anglo-Sanskrit H. S., Howrah
Sambalpur U.
Santipur Coll.
Sardar Patel U.
Saurashtra U.
Science Coll., Nagpur
Scottish Church Coll., Calcutta
Seethalakshmi Ramaswamy Coll.
Serampore Coll.
SERC, Bangalore
SGTB Khalsa Coll.
Shanmugha Eng. Coll.
Shivaji U.
Shivalik Coll.
Shree Sharanabasaveshwar Coll. Sci.
Shri Atmanand Jain Coll.
Sir Syed Coll.
SKN Inst., Howrah
SLIET, Longowal
South Gujarat U.
SPIC Science Found., Chennai
Sri Aurobindo Intl. Ctr. Educ.
Sri Guru Gobind Singh Coll.
St. Andrews Coll.
St. Anthony's Coll., India
St. Joseph's Coll., Tiruchirapalli
St. Peter's Eng. Coll.
St. Stephen's Coll.
St. Thomas Coll., India
St. Xavier's Coll., Calcutta
Surendranath Coll.
Taki Govt. Coll.
Tamralipta Coll.
Tata Inst.
TDB Coll., Raniganj
Tech. Sch., Kolkata
Tezpur U.
Tonk, Govt. Coll.
Trivandrum, CDIT
Triv andrum, Ctr. Math. Sci.
Udaipur U.
Uluberia Coll.
Umrao Inst. Fund. Res.
Ururu Dhanalakshmi Coll.
Utkal U.
V.H. Coll.
Vainu Bappu Observatory
Vidyasagar U.
Vijaygarh Jyotish Ray Coll.
Visva Bharati U.
Visvesvaraya Coll. Eng.
Vivekananda Coll.
VSSD Coll., Kanpur
Walchand Eng. Coll.