

GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY (DAE)

BOARD OF RESEARCH IN NUCLEAR SCIENCES (BRNS)

BRNS

Project Proposal Application Form

(The form is available at URL: <http://www.barc.gov.in/webpages/brns>)

BRNS-PPA

The form 'BRNS-PPA' for seeking financial support for research projects is divided into three sections. Information on how to fill the form is provided as 'Instructions'. Please read each section and the instructions before filling the Form.

SECTION-A: Project Details

Part I : Project overview

Part II : Project objectives, Research plan and Deliverables

Part III : Budget details and justifications

Part IV : Other running and previous projects

SECTION-B: Curriculum Vitae of investigators and coordinators.

SECTION-C: Certificates by the authorities

INSTRUCTIONS

1. Applicant must read the instructions given below before filling the form. Do not change the format of the application form & submit it in **MS Word format only**.
2. Applications are accepted throughout the year. The time required for the processing & sanction of the project is typically 4-6 months, depending upon the grant sought.
3. Application, consisting of 3 sections A, B and C, should be prepared as per the prescribed format (**BRNS-PPA**) using Times New Roman format, Font Size: 10 and Line spacing : 1.5. **Two (2) hard copies** of the application form complete, in all respects as per the prescribed format and stapled at the top left corner, should be submitted to: **Programme Officer**
Board of Research in Nuclear Sciences (BRNS)
BRNS Secretariat, Central Complex, 1st Floor
Bhabha Atomic Research Centre (BARC),
Trombay, Mumbai-400085.
The applicant is urged use **both sides of the paper for printing** (except for Section C).
In addition to the hard copy, the soft copy of **Section-A & Section-B** should also be forwarded to :
brns@barc.gov.in. (file size should be restricted to 1.5 MB)
The **acknowledgement** of the application form would be sent via e-mail, only after the hard and soft both the versions of application forms are received at this office.
4. For smooth implementation of the sanctioned project, BRNS insists that a project, in addition to a PI, should have a CI from the same Department/Institution. The CI is expected to ensure that the project work is carried out even when the PI is on leave/deputation. In case of long leave/deputation, PI is expected to inform BRNS sufficiently in advance so that correspondence can be addressed to the CI directly.
5. BRNS can consider projects based on multi-centre studies. For such project proposals, the CIs can be drawn from institutions other than that of the PI. In such cases, funds required by the CIs may be shown separately using the same format. If the project is approved, DAE will sanction funds to PI and CIs separately and send the grants to their respective institutions.
6. Certificate-1 (Section-C) should be from the Head of the Institution of the Principal Investigator (PI), and where applicable that of the Co-Investigator (CI).
7. Projects that have direct relevance to DAE programmes and are carried out in collaboration with a DAE unit will get preference. Such projects will have a Principal Collaborator (PC) from a DAE unit and are expected to have been evolved after discussion between the DAE unit(s) and the PI. The PI and PC will work on complimentary aspects of the problem. For such projects, two copies of Certificate-2 (Section-C) from **Group Director** of the PC must be obtained before submission of the project proposal.

While the projects under collaborative mode are preferred, BRNS also supports independent projects aiming at 'excellence'. For such a project submitted by an investigator, BRNS will nominate a scientist of the Department as a Coordinator (DC).
8. Project Overview (Section-A, Part D): It should reflect the complete information of the project in a concise format, which is normally used by senior management for an overview of the proposal. **It is suggested that it may be filled after completing all other sections of the form.**
9. Advisory Committees (Section-A, Part I, Sr. No. 100): Depending upon the nature of the project, PI may indicate the name of the Advisory Committee to which the proposal should be referred. In brief these Committees and their priority theme areas are given below:

35

Radioisotopes, Radiation Technology and Applications Committee (RTAC): Radiopharmaceuticals, radio-assays, radioisotopes, radiation technologies, tracer techniques, hydrology, nuclear agriculture etc.

36

Nuclear Reactors and Fuel Cycle Committee (NRFC): Structural/ civil/ mechanical/ metallurgical/ chemical engineering, material development, heat transfer, fluid flow, water chemistry, nuclear fuels, nuclear safety, environmental impact of nuclear establishments etc.

37

Basic Sciences Committee (BSC): Basic and applied research in radiochemistry, actinide chemistry, radiation and photo-chemistry, laser induced chemical reactions, unique catalysts, nano materials, cell and molecular biology, mutagenesis, radiation biology, condensed matter physics, laser and plasma physics, nuclear and particle physics, spectroscopy, etc.

10

Strategic Studies Advisory Committee (SSAC): projects of strategic interest not falling within the scope of other committees

10. **Key words** (Section-A, Part I, Sr. No. 102): Maximum 8 key words for indexing the project may be suggested. The first two key words should refer to the major area of research. You may also provide on a separate sheet name & address of three referees who are experts from the research field of your proposed project.
11. **Project Summary** (Section-A, Part I, Sr. No. 103): Summary (about 100 words) should bring out the importance of the project from the point of view of DAE programmes, related work being carried out both within the country and abroad, mode of execution of the project, expected outcome of the project like development of a technology, improved product/process, generation of a data base etc.
12. **Detailed Technical Information** (Section-A, Sr. No.108): Provide 'in-depth' details in this section on as much number of sheets as deemed appropriate. It is recommended to use 2 column layout, single spacing, font size 8 for text and printing on either side of the paper. Please limit the size of the soft copy to 1.5 MB. This information will help us to comprehensively review the project proposal.
13. **Project Objectives** (Section-A, Part II, Sr. No. 200): Enumerate objectives of the proposal. **In-depth details should be provided in Section-B.**
14. **Research Plan and Deliverables** (Section-A, Part II, Sr. No. 210): Describe the work planned during each year of the project and also identify the deliverables at the end of each year. This will facilitate monitoring of the project and to take corrective actions, if any, required from time to time. Normally, the projects are sanctioned for duration of 3 years. The commencement of the project is considered as the date of the joining of the staff sanctioned or 2 months after the date of issue of DAE sanction letter whichever is earlier.
15. **Budget Estimates** (Section-A, Part III, Sr. No. 300): If the project is approved, DAE will provide funds to implement the project only to the non-DAE institution of PI (e.g. University/IIT/IISc etc.). Funds required by the PC for carrying out work in the DAE units will be borne by the respective DAE units. However, funds required for travel and stay of the PC/DC at the PI's institution should be included in the project budget and the PC/DC's travel expenses will be debited to this account. Consolidated amounts need be furnished under Budget Estimates. Budget Details and Budget Justification are to be furnished separately in the relevant columns provided for. **After the financial sanction is issued, transfer of funds from one 'Head of Account' to another is normally not permitted.** Funds are released for one financial year (1st April to 31st March) at a time.
16. **Equipment** (Section-A, Part III, Sr. No. 310): Specifications for the equipment to be procured, names of the suppliers and documents in support of the estimated cost, quotations/ proforma-invoice (not more than 1 month old) in respect of the major equipment should be provided. This will facilitate decision making at our end.
17. **Staff Salary** (Section-A, Part III, Sr. No. 320): The categories of staff who can be employed on a BRNS project and their respective qualifications/experience and salary is as under:

| <u>Category</u> | <u>Qualification/experience</u> | <u>Salary per month*</u> |
|-----------------|---|---|
| JRF | M.Sc/BE/B.Tech/BVSc/B.Pharm & on re-designation as SRF by a committee | Rs.16,000/- for 1 st & 2 nd year Rs.18,000/- from 3 rd year |
| SRF | MTech/ME/MVSc/MPharm/MBBS/BDS or M.Sc/BE/B.Tech/BVSc/B.Pharm with 2 years experience | Rs.18,000/- for 1 st & 2 nd year Rs.20,000/- from 3 rd year |
| RA-I** | Ph.D in Science/ MD or MTech/ME/MVSc/MPharm/MBBS/BDS with 2 years experience | Rs.22,000/- |
| RA-II** | Ph.D in Science/ MD or MTech/ME/MVSc/MPharm/MBBS/BDS with 2 years experience and possessing exceptional academic record | Rs.23,000/- |
| RA-III** | Ph.D in Engineering or same as for RA-II but selected under specific DAE scheme | Rs.24,000/- |

* In addition to the Salary, the staff appointed is also entitled to House Rent Allowance (HRA) and Medical Allowance (MA) as per PI's institute/university rules. HRA can be claimed only after appointment of the staff.

** The slab at which the Salary for RA is to be fixed may be decided by the appointing authority taking into consideration the qualification and experience of the candidate.

If the project proposal is approved, Guidelines/Terms and Conditions for recruitment of Staff are issued along with the Sanction letter. **Wherever an Institute/University has its own norms for recruitment of staff, it may follow them. In such a case please enclose a copy of the norms as issued by the competent authority in the Institute/University along with the project proposal.**

18. **Technical Assistance** (Section-A, Part III, Sr. No. 330): Under this 'Head of Account', the PI can provide overtime/honorarium to existing technical/scientific staff of the institute, engage laboratory attendants/or other help on casual basis subject to the rules of the host institution and get equipment/experimental set-up fabricated by outside agencies. Funds can also be provided under this head for hiring services from outside that are not available in the institute or, if available, has to be paid for. Equipment hire charges, computer hire charges, etc. should be included under this head.
19. **Travel** (Section-A, Part III, Sr. No. 350): The entitlement of mode (Rail/Air) and class of travel will be governed by the rules of the respective institutions to which the PI, CI and PC/DC belong. One visit per year of PC/DC to PI's institution and vice versa during the duration of the project may be taken as a guideline. **PI may use the funds for travelling to attend a conference within India during the second half of the project.** Wherever the project involves fieldwork, the PI may request travel funds accordingly.
20. **Contingency** (Section-A, Part III, Sr. No. 360): The amount that can be sanctioned under this 'Head' will vary depending on the type of project (e.g. experimental project, theoretical project, data collection and survey project, engineering project etc.). 5-10% of the total of equipment and consumable cost may be considered as a guideline. Under the Head 'contingency', the funds can be utilized to meet the expenditure towards advertisement and selection related expenses for the post of JRF/SRF/RA. PI may also utilise this fund towards payment of tuition fee and other expenditure of the staff employed for registering for Ph.D. programme of the university. This can also be used for purchase of urgently required laboratory item or for buying books, but books so purchased should be deposited in the library of the Institute and issued as per the rules of the library.
21. **Overheads** (Section-A, Part III, Sr. No. 370): **BRNS allows 15% of the cost of the project less contingency as 'Overheads'. The limit for this is Rs. 6 lakhs for educational institutions and Rs. 2 lakhs for all other institutions.** This is meant to cover the cost of infrastructure, utilities such as water, electricity, communication and administrative services provided by the university/ institute. Each university/ institute can use its discretion to form regulations to use the funds under this head. Some universities/ institutes follow the practice of depositing all overheads in a common corpus and the interest there from is used for the maintenance of infrastructure/ equipment needed for research projects. **50% of the overheads (i.e. 7.5% of the total yearly grant less contingency) shall be released annually with the grant. The remaining 50% of the overheads**

shall be paid on completion of the project and submission of the final progress report along with the audited statement of accounts (FORM-IV) and utilization certificate (FORM-III).

22. **Projects from other agencies** (Section-A, Part IV, Sr. No. 412 & 415): Please describe each project sanctioned to PI and CI by other agencies in not more than 150 words. The description should clearly bring out any overlap of the areas and objectives & methodology of these projects with the submitted proposal.
23. **Facilities** (Section-A, Part V, Sr. No. 416): Provide details about the infrastructure available in the department and the equipments already available in the group. You may choose to mention difficulties in using the equipments/facilities, if there are any.
24. **Experience** (Section-B, Sr. No. 500, 510 and 520): List the positions held during the last 10 years and the duration for which held. Please highlight the experience that will be useful and relevant to the proposed project. Persons with less than 10 years or no experience are also eligible to apply.
25. **Publications** (Section-B, Sr. No. 500, 510 and 520): List only important publications relevant to the area of the proposed research project.
26. **Processing of Applications:** Applications are refereed by specialists in the field. Based on the comments from the referees, the short listed applicants may be invited to a Technical Programme Discussion Meeting (TPDM) for an oral presentation at Mumbai or at any other convenient place before a panel comprising of the members of the Advisory Committee and the experts. Based on the recommendations of the TPDM and the available budget, the proposal may be recommended for sanction/revision/rejection. This process may take around 3 to 6 months. In certain cases, project proposals may be accepted without presentation in a TPDM.
27. **Release of Funds:** Funds for the first year are released along with the issue of initial sanction. Second year funds shall be released on receipt of a claim from the PI along with technical progress report, SA and UC etc as on 31st March in respect of the funds received in the first year. The grant however would be released after deducting the unutilized amount. For the third/ subsequent years PIs are required to submit progress report and renewal application (**BRNS-PRA**) in the prescribed format. PIs may be called for an oral presentation at a TPDM for monitoring progress of the project. If the progress is found satisfactory, a sanction letter renewing the project for the third/ subsequent years is issued requesting PIs to submit (i) **Claim (Form-II)**, (ii) **Utilization Certificate (Form-III)** and (iii) **Statement of Accounts (Form-IV)** as on 31st March, in respect of the funds received in the second/ previous year.
Forms **II, III & IV** are available on BRNS website.
28. DAE would be transferring the project funds electronically to the Bank Account of the University/Institution. Please furnish the details of the account as indicated in Certificate-1 in order to avoid delays in the receipt of funds, otherwise the amount would be sent by Demand Draft/Cheque to the Head of the Institution.
The sanction of the project is liable for cancellation, in case of suppression of information/fact and/or furnishing false information in the application form

(Sr. Nos. mentioned above refer to the numbers in the Application Form)

NOMENCLATURE

Principal Investigator (PI): A scientist who submits a research proposal to BRNS for a programme to be carried out at a non-DAE institution. (Persons with less than 10 years or no experience are also eligible to apply.)

Co-Investigator (CI): An associate of the PI taking an active part in the project working either in the institution of PI or any other non-DAE institution.

Principal Collaborator (PC): A scientist of the Department Of Atomic Energy (DAE) working in any of its constituent units/ PSUs.

Departmental Coordinator (DC): A scientist of DAE nominated by BRNS.

Constituent units of DAE: Bhabha Atomic Research Centre (BARC), Indira Gandhi Centre for Atomic Research (IGCAR), Variable Energy Cyclotron Centre (VECC), Raja Ramanna Centre for Advanced Technology (RRCAT), Atomic Minerals Directorate for Exploration and Research (AMD), Board of Radiation and Isotope Technology (BRIT), Nuclear Fuel Complex (NFC), Heavy Water Board (HWB).

Public Sector Undertakings: Nuclear Power Corporation of India Limited (NPCIL), Electronics Corporation of India Limited (ECIL), Uranium Corporation of India Limited (UCIL), Indian Rare Earth Limited (IRE).

Non-DAE institutions: All educational & recognized research institutions e.g. Indian Institutes of Technology/ Indian Institute of Science/ Universities/ Colleges/ National Laboratories etc.

BRNS-PPA

(Please Submit only **Two** hard copies & mail the soft copy to brns@barc.gov.in)

SECTION-A

PART I – PROJECT OVERVIEW (Please see Instruction - Sr. No. 8)

100. Advisory Committee Code Number (Please see Instruction - Sr. No. 9): **36**

101. Title: **“Measurements, EXFOR Compilation and theoretical study of nuclear data”**

102. Key Words & Name of 3 Referees (Please see Instruction - Sr. No. 10):

a) Key words: Nuclear data, Measurements, EXFOR Compilations, Nuclear reactions, Theoretical study

b) Name of 3 Referees:

1. Dr. S. Kailas, Director, Physics Group, BARC
2. Dr. V. Gopalakrishnan, IGCAR
3. Dr. A. Chatterjee, Head, NPD, BARC

103. Project Summary (Please see Instruction - Sr. No. 11):

This proposed project work on “Nuclear data measurement, EXFOR database compilation and theoretical study” under the Nuclear Data Physics Centre of India (NDPCI, DAE-BRNS) is a new initiative in the Indian system and is conceived as an important activity.

One of the important databases distributed by IAEA-Nuclear Data Section (IAEA-NDS) through its website mirrored in India at the BARC site (<http://www-nds.indcentre.org.in>), is EXFOR, which is the compilation of published experimental nuclear reaction data for incident neutrons, gammas and charged particles on various targets. Nuclear Data evaluators, applied users and experimentalists use this widely. There is a specific format in which the experimental data is coded into the EXFOR system for ready recovery. The international network of various nuclear reaction data centers at the IAEA, NNDC (USA), NEA (France), RNDC (Russia) etc. are in charge of updating and maintaining EXFOR database. BARC has already initiated this EXFOR activity since 2006 with inputs from BARC (e.g., RPDD, NPD, RCD etc.) and other Indian institutions including universities. The NDPCI formed by Director, BARC within DAE-BRNS as a project has endorsed the recommendations of the International Nuclear Reaction Data Centre network (IAEA-NRDC-2008) and conducted many phenomenally successful training workshops on EXFOR.

Recently, the PI and his collaborators carried out some careful and systematic investigations on sets of experiments and theoretical studies on (n,p) reactions in the mass region 50 to 140, and identified that 16 different (n,p) reaction cross sections needed re-measurement. Experiments and theoretical studies have been performed for these reactions. A systematic study and careful comparison of previously reported measured cross sections with the newly measured data for these reactions reveal that the discrepancies among the previously reported measured data are due to 1) use of inappropriate decay data 2) contributions from the heavier isotopes present in the irradiated

sample 3) contributions from metastable states in the case of unstable ground state formation cross sections. For eg: For the reaction $^{120}\text{Sn}(n,p)^{120}\text{In}^x$. They identified that the ordering of the ^{120}In energy levels are still not known, (one is even missing in energy levels adopted by TALYS-1.2 and EMPIRE-2.19). For this particular reaction, a γ -ray line of energy 1.171 MeV is emitted by ^{120}Sn , through the three levels [3.08 s $1+$, 47.3 s ($8-$), and 46.2 s ($5+$)], undergoing a β decay from ^{120}In . A literature review on the history of these three states in the nuclear decay and structure data library (ENSDF) indicates the following: Until 1976, two levels (3.08 s $1+$ and 44.4 s ($5+$)) were given [1], but the ordering of the two levels was unknown, until 1987, three levels (3.08 s $1+$, 46.2 s ($5+$), and 47.3 s ($8-$)) were given, but the ordering of the three levels was unknown [2]; and until 2002, three levels (3.08 s $1+$, 47.3 s ($8-$), and 46.2 s ($5+$)) were given. The ordering of the two levels ($1+$ and $8-$) was unknown [3]. Therefore, we did not know which one of these three states was the ground state before 2002, and we still do not know which one of the two states ($1+$ and $8-$) is the ground state.

Another important reaction identified is, $^{97}\text{Mo}(n,p)^{97}\text{Nb}^g$ reaction, in which the metastable state contributes to the unstable ground state formation. The same experiment has been repeated with the metastable state contribution taken into account, and the new result explains the discrepancy among previously measured data and theoretical model predictions [4]. Previously reported data never took this contribution into account, and hence the discrepancy is explained by the repeated experiment in which the metastable state contribution has been subtracted. Another example is $^{93}\text{Nb}(n,2n)^{92}\text{Nb}^m$. In the evaluation for ^{93}Nb by JAEA of JENDL-3.3, it was pointed out that the $(n,2n)$ cross-section may be overestimated by about 20 percent for neutron energies $E_n \leq 14\text{MeV}$ [5]. This is really a very high overestimation considering the use of ^{93}Nb in the structural materials of nuclear reactors, superconductor alloys for fusion reactors etc. The evaluators had mentioned that the problem of overestimation of $^{93}\text{Nb}(n,2n)^{92}\text{Nb}^m$ cross sections could not be resolved within their computational framework [6]. In addition, it was suggested that more sophisticated reaction models and parameters might be necessary to match the theoretical value of $^{93}\text{Nb}(n,2n)^{92}\text{Nb}^m$ reaction cross sections over the neutron energy range 9 to 14MeV. Furthermore, few authors also addressed this problem and suggested that the overestimation of $^{93}\text{Nb}(n,2n)^{92}\text{Nb}^m$ reaction cross sections could be resolved by neglecting some of the decay modes of ^{92}Nb from different types of configurations. Moreover, some authors showed that the calculated values of the cross sections of this reaction could be made close to the experimental values if one ignores the contributions from the negative parity doublet consisting of 0.226MeV ($2-$) and 0.390MeV($3-$) energy levels, of ^{92}Nb in the formation of $^{92}\text{Nb}^m$. Furthermore, they claimed that the agreement could be further improved if the contribution of all the negative parity energy levels were neglected. However, the gamma rays emitted by the negative parity energy levels of ^{92}Nb have been experimentally measured, and therefore the contributions of all the energy levels are required to be considered [7]. The same problems have been addressed by the PI and his collaborators, repeated the experiments, performed theoretical study, adjusted some of the statistical model parameters such as the effective imaginary potential, level densities, explained and solved within their computational framework that such blind omissions of contributing negative parity energy levels as suggested by previous workers are not required. But even for the same reaction, a more rigorous study needs to be performed with latest nuclear model codes such as TALYS-1.4 and EMPIRE--3.0.beta1, and inter-comparison between them.

The PI's studies show that many reactions in this mass range need a re-look, both from experimental and theoretical data-physics view-points, motivating further work; hence this proposal. In this proposed project, such

similar reactions important for reactor technology will be identified, and experiments will be proposed with fresh isotopically enriched samples at 14 MeV neutron irradiation facilities at BARC and TIFR Pelletron facility, in collaboration with the PC's from BARC. The identification of important reaction cross sections to be measured, study of measurement techniques to generate reliable and accurate data will also be done with the guidance from BARC PCs and experts from Nuclear Data section, IAEA. For reactions to be studied through this project, focus will also be given on priority list of reactions from the perspectives of immediate nuclear data needs for the reactor technology, [8,9] Table-3 and 4 from the literature published by Forrest. Such measured reaction cross sections will be compiled into EXFOR format and theoretical study will also be performed using TALYS-1.4 and EMPIRE- 3.0 β 1 nuclear model codes, to arrive at appropriate statistical model parameters.

Among the important aims of the project is to help NDPCI in making several new EXFOR entries for the IAEA-EXFOR database. The entries made will be peer-reviewed and put up for acceptance by the IAEA through NDPCI. At least 10 EXFOR entries should be attempted by our team in Mizoram university in a year under the execution of this project.

Apart from that, the PI will act as a co-ordinator for EXFOR compilation with NDPCI and IAEA for pre-screening the new EXFOR entries and through iteration.

Personal Details:

| | | <u>Name</u> | <u>Address</u> | <u>e-mail</u> | <u>Phone</u> | <u>Fax</u> |
|------------|-----------|---------------------------------|--|--|-----------------------------|------------|
| 104 | PI | Dr. B. Lalremruata | Department of Physics Mizoram University (Central University) Tanhri-796004 Aizawl, Mizoram India | marema08@gmail.com | +91-389-2305572 | |
| 105 | CI | Dr. Hranghmingthanga | Department of Physics Mizoram University (Central University) Tanhri-796004 Aizawl, Mizoram India | hthanga@yahoo.com | +91-9436141509 | |
| 106 | PC | PC-1: Dr. S.V. Suryanarayana | NPD, BARC | suryanarayan7@yahoo.com | +91-022-25593662(O) | |
| | | PC-2:Dr. Alok Saxena | NPD, BARC | aloks279@gmail.com | +91-022-25593593 (O) | |
| | | PC-3: Dr. H. Naik | RCD, BARC | naikhbarc@yahoo.com | | |

107. Total Budget : Rs. 25,85,000/- (Twenty Five Lakhs, Eighty Five Thousand Rupees)

108. Detailed Project Proposal Report Enclosed:

Yes/No

(Please see Instruction - Sr. No. 12. This information will help us to comprehensively review the proposal).

PART II - PROJECT OBJECTIVES, RESEARCH PLAN and DELIVERABLES

200. List of Objectives (Please see Instruction - Sr. No. 13):

1. Identification of priority reactions needing new measurements; Nuclear data measurements, EXFOR compilation (from the experiments to be performed in this project and from reports of experiments done across the country), and theoretical study using TALYS-1.4 and EMPIRE-3.0 β 1 nuclear model codes.
2. Coordinating the EXFOR compilation i.e to assist NDPCI and IAEA for pre-screening the EXFOR entries and through iteration.
3. Making about 10 EXFOR entries per year from articles reporting measured nuclear data
4. Initiating for the first time in India, nuclear data evaluation techniques using EMPIRE-GANDR software system.

210. Describe the yearly Research Plan and identify the Deliverables (Please see Instruction - Sr. No. 14):

A. At PI/ CI's Institution

Ist Year: Basic training to JRF and RA in EXFOR format, nuclear model codes TALYS-1.4 and EMPIRE-3.0 beta1, nuclear reactions, experimental techniques, identification of important reactions and measurements to be performed, identification in collaboration with NDPCI and IAEA of scientific papers presenting experimental nuclear reaction cross sections, making IAEA-EXFOR entries, Co-ordinating the EXFOR compilation with NDPCI and IAEA for pre-screening the EXFOR entries and through iteration. 10 new EXFOR entries will be attempted and submitted; isotopically enriched samples will be procured for the reactions identified through this project which will be measured at different incident neutron energies at BARC and TIFR Pelletron. EMPIRE_GANDR system will be installed and studied. Discussion meetings on covariance and error propagations, multivariate error analysis will be attended to.

In the first year, characterization, validation of neutron beam flux and energy at the irradiation facilities at BARC and TIFR Pelletron will also be carried out with the help of PCs from BARC. This will be useful for the experiments to be carried out through this project and also for others who will be doing activation measurements at the facility.

IInd Year: Co-ordinating the EXFOR compilation with NDPCI and IAEA for pre-screening the EXFOR entries and through iteration. Continue making IAEA-EXFOR entries(at least 10 new entries) for experiments performed in India, identification of nuclear data to be compiled, procuring enriched isotopes and natural elemental samples for cross section measurements, performing experiments at BARC and TIFR Pelletron, and theoretical study of reaction cross sections using TALYS-1.4 and EMPIRE-3.0.beta1 nuclear model codes. The GANDR system will also be learnt.

IIIrd Year: Continue making EXFOR entries for experiments performed in India, identification of nuclear data to be compiled, cross section measurements, performing experiments at BARC and TIFR Pelletron facilities,

and theoretical study of reaction cross sections using TALYS-1.4 and EMPIRE-3.0.beta1 nuclear model codes, Coordinating the EXFOR compilation with NDPCI and IAEA for pre-screening the EXFOR entries and through iteration.

We believe that it is very important to get advice from experts in the field of nuclear data physics on which this proposal is based, collaborate with them, so that the aims and objectives of the present proposal is met in a stipulated time, and with a high degree of accuracy and reliability. We plan to involve experts in nuclear data from Nuclear Data section, IAEA, and experts from India as well, to strictly review our work, give suggestions and criticize if necessary, so that the results we get out of this project proposal is accurate, reliable and trusted. In other words, we will interact with other experts in the field throughout the project period towards enhancing the quality of our deliverables.

B. At PC's Institution.

Ist Year: Supervise/Co-ordinate the EXFOR compilation activities, guiding and giving support to implement the project, helping the PI and his team in identifying articles to be compiled and identifying reaction cross sections which requires re-measurement and theoretical interpretation, advice on installation of EMPIRE_GANDR system with help of NDPCI local members.

IInd Year: Supervise/Continue to help PI and his team to identify articles reporting measurements to be compiled, help in getting beam times and performing experiments at BARC facilities for reactions identified through this project, and giving theoretical support. Use of EMPIRE, TALYS will be supported and study with GANDR system will be encouraged.

IIIrd Year: Supervise/Continue to provide help in identifying articles reporting measurements to be compiled into EXFOR format, help and participate in experiments at BARC and TIFR Pelletron facility, and theoretical studies. Continue measurements and theoretical studies with close interactions with NDPCI.

211. Infrastructure facilities related to the project activity available at the PI/CI's Institute:

The facilities (computers, literature, space (separate room for this project), and Internet access) are sufficient to carry out the tasks. The PI has enough experience with the EXFOR compilation, nuclear data measurements and nuclear model codes such as TALYS-1.4, EMPIRE-3.0.beta1.

212. Facilities available at the PC's institution that would be useful to this project:

BARC has adequate and established expertise in data measurements, compilation and evaluation. The project is viable. 14 MeV neutron source at BARC, the FOTIA facility at BARC, and BARC-TIFR Pelletron facility will be used to carry out measurements to complete this project.

PART III - BUDGET ESTIMATES

300. Details of budget requirements (Please see Instruction - Sr. No. 15 to 21)

| Particulars ↓ Amount in Rs. ⇨ | I Year | II Year | III Year | Total |
|---|-----------------------------|----------------------------|----------------------------|------------------|
| 310. Equipment | 1,00,000 | 0.0 | 0.0 | 1,00,000 |
| 1. Computer Notebook – 2(two) | | | | |
| 2. Printer and color scanner(2 in 1) | 15,000 | 0.0 | 0.0 | 15,000 |
| 3. 4x1000GB USB compatible hard-disks | 24,000 | 0.0 | 0.0 | 24,000 |
| 4. Isotopically enriched samples | 1,00,000 | 50,000 | 50,000 | 2,00,000 |
| 320. Staff Salary | | | | |
| JRF: 1(one) or SRF (if available) The budget will be revised accordingly upon availability of SRF. | 1,92,000 | 1,92,000 | 2,16,000 | 6,00,000 |
| SRF: | | | | |
| RA: 1 (one) | 2,64,000 | 2,64,000 | 2,64,000 | 7,92,000 |
| 330. Technical Assistance | | | | |
| 340. Consumables | 20,000 | 12,000 | 12,000 | 44,000 |
| 350. Travel | 1,00,000 | 1,00,000 | 1,00,000 | 3,00,000 |
| PI, CI, JRF and RA: | (30000+30000 +2 x 20000) | (30000+30000+2 x 20000) | (30000+30000+2 x 20000) | |
| 353. Funds required by PI for travel to attend conferences within India. | 50,000 | 50,000 | 50,000 | 1,50,000 |
| 354. Funds for Other visits (please give details) As required by the NDPCI for EXFOR related IAEA-NDPCI work | 50,000 | 50,000 | 50,000 | 1,50,000 |
| PC/DC: | - | - | - | |
| 360. Contingencies | 20,000 | 20,000 | 20,000 | 60,000 |
| 370. Overheads | 50,000 | 50,000 | 50,000 | 1,50,000 |
| 380. Grand Total | 9,85,000 | 7,88,000 | 8,12,000 | 25,85,000 |

BUDGET DETAILS

310. Details of the budget for equipment to be procured by the PI:

| Sl.No. | Item | Ist year | IInd year | IIIrd year | Total |
|---------------|--------------------------|----------|-----------|------------|----------|
| Local: | 1.Computer Notebook – 2x | 1,00,000 | - | - | 1,00,000 |

| | | | | | |
|--|---|-----------------|---------------|---------------|-----------------|
| | 2. Printer and color scanner (two in one) | 15,000 | - | - | 15,000 |
| | 3. 4 x 1 TB usb compatible hard drive | 24,000 | - | - | 24,000 |
| Imported: Mention currency conversion rate used for estimation | Isotopically enriched samples | 1,00,000 | 50,000 | 50,000 | 2,00,000 |
| Total | | 2,39,000 | 50,000 | 50,000 | 3,39,000 |

340. Details of budget for consumables to be procured by the PI (Amount in Rupees):

| Sl. No. | Item | Ist year | IInd year | IIIrd year | Total |
|---------|--|---------------|---------------|---------------|---------------|
| 1. | Stationery, printer cartridges, DVDs, USB pen drives, etc. | 15,000 | 10,000 | 10,000 | 35,000 |
| | Total | 15,000 | 10,000 | 10,000 | 35,000 |

350. Details of travel:

| Amount in Rupees \Rightarrow | Ist year | IInd year | IIIrd year | Total |
|--|----------|-----------|------------|----------|
| 351. Proposed number of visits of PC/DC to PI's Institute | 2 | 2 | 2 | 6 |
| 351A. Duration of stay (no. of days) during each visit | 4 | 4 | 4 | 12 |
| 351B. Total funds required | | | | |
| 352. Proposed number of visits of PI to PC/DC's institute | 2 | 2 | 2 | 6 |
| 352A. Duration of stay (No. of days) during each visit | 7 | 7 | 7 | 21 |
| 352B. Total funds required | 1,00,000 | 1,00,000 | 1,00,000 | 3,00,000 |
| 353. Funds required by PI for travel to attend conferences within India. | 50000 | 50000 | 50000 | 1,50,000 |
| 354. Funds for Other visits (please give details) As required by the NDPCI for EXFOR related IAEA-NDPCI work | 50000 | 50000 | 50000 | 1,50,000 |

BUDGET JUSTIFICATIONS

310. Equipment: Two computer notebooks, one printer and color scanner (2 in 1) and 4 x 1 TB USB compatible hard disks will be essential. Isotopically enriched samples will be procured to be used as target samples for the proposed experiments.

320. Staff: One Junior Research Fellow (JRF, fresh M.Sc candidate) and one Research Assistant (RA, fresh Ph.D candidate) will be recruited as per the salary prescribed by BRNS to assist, carry out and implement the project. Selection will be based on interview through nation wide advertisement for the post.

330. Technical assistance:

340. Consumables: The amount will be used for purchase of required consumables. Cartridges for printer, and data transferring materials such as DVDs and USB pendrives are required since; very often the figures in the articles need to be color scanned for use in digitizing and extracting the experimental data points, and transferring the file from one computer to another.

350. Travel: Workshops on nuclear data measurements, EXFOR compilations and evaluations will be attended. Visits to PI or PC's institute is required to discuss, interact, and carry out experiment and implementing successfully the project in time.

354. PI is being advised to nationally co-ordinate EXFOR compilations at national level for NDPCI and the IAEA. This involves additional trips to be advised by the NDPCI from time to time.

360. Contingencies: As mentioned above.

PART IV - OTHER PROJECTS

410. List all previous projects that are **supported by BRNS or any other funding agency** in which PI is actively participating (either as PI or as CI):

| Sl. No. | Title of the project | Total cost | Agency | Present status |
|---------|----------------------|------------|--------|----------------|
|---------|----------------------|------------|--------|----------------|

411. List all projects submitted **during the current financial year by PI to BRNS or any other agency for funding.** Give details on the present status of the application:

| Sl. No. | Title of the project | Total cost | Agency | Present status |
|---------|----------------------|------------|--------|----------------|
|---------|----------------------|------------|--------|----------------|

412. Brief description of the **project(s) submitted/sanctioned by/to PI by other agencies.** (Please see Instruction - Sr. No.22):

413. List all previous projects **that are supported by BRNS or any other funding agency in which CI** is actively participating (either as PI or as CI):

| Sl. No. | Title of the project | Total cost | Agency | Present status |
|---------|----------------------|------------|--------|----------------|
|---------|----------------------|------------|--------|----------------|

414. List all projects submitted **during the current financial year by CI to BRNS or any other agency for funding.** Give details on the present status of the application:

| Sl. No. | Title of the project | Total cost | Agency | Present status |
|---------|----------------------|------------|--------|----------------|
|---------|----------------------|------------|--------|----------------|

Only this one proposal is being submitted.

415. Brief description of the project(s) submitted/sanctioned by/to CI by other agencies. (Please see Instruction - Sr.No.22):

PART IV - FACILITIES

416. List of **facilities** that will be extended to the investigators by the implementing institution for the project

A. Infrastructure facilities

| Sr. No. | Item Name | Yes/No/ NR* | Sr. No. | Item Name | Yes/No/ NR* |
|-------------------|------------------------------|-------------|---------|--------------------------|-------------|
| 1. | Workshop | Yes | 7. | Telecommunication | Yes |
| 2. | Water & Electricity | Yes | 8. | Transportation | Yes |
| 3. | Standby power supply | Yes | 9. | Administrative I support | Yes |
| 4. | Laboratory space & furniture | Yes | 10. | Library facilities | Yes |
| 5. | AC room for equipment | NR | 11. | Computational facilities | Yes |
| 6. | Refrigerator | Yes | 12. | Animal/Glass house | NR |
| NR*: Not Required | | | | | |

B. Equipment and accessories available within the Investigator's group/Dept. which can be utilized for the project.

| Sr. No. | Name of the Equipment | Model & Make | Year of Purchase |
|---------|--|--------------|------------------|
| 1. | One Desk top computer being used by PI | IBM | 2011 |

SECTION-B

(Please see Instruction - Sr. No.23 & 24)

500. Curriculum vitae (CV) of Principal Investigator (PI),

Name & Designation:

B.Lalremruata,

Assistant Professor,

Department of Physics,

Mizoram University (Central University)

Date & Place of Birth: 12/12/1981, Zawlsei, Champhai District, Mizoram, India

Nationality: Indian

Present post:

Assistant Professor,

Department of Physics,

Mizoram University (Central University),

Tanhril-796004

Mizoram,

India

Institution with address:

Department of Physics,

Mizoram University,

Tanhril-796004

Aizawl, Mizoram

India

Telephone No. (with STD code): 91-9436779952(M) / 0389-2305572(R) Fax No.:

E-mail: marema08@gmail.com

Qualifications: Ph.D(Nuclear Physics)

Experience:

I. Instrumentation

- Experienced in nuclear electronics, Detectors such as HPGe, NaI(Tl), BGO, Silicon surface barrier detectors, GM counters, Liquid Bicorn detectors etc.
- Experienced in handling preamplifiers, amplifiers, PC based MCA with Genie2k, Maestro-32 software, High Voltage power supply (200KV), High Vacuum systems, polarized ³He set up etc.
- Charged particle detection technique, Neutron time of flight(ToF) experimental technique etc,

II. Instrumental handling experience:

1. 14 MeV Neutron Generator

2. 150 keV proton Accelerator
3. Neutron irradiation facility by Li(p,n) neutron source at Pelletron, Mumbai.
4. Polarized ^3He target

III. Softwares Known:

- Nuclear Model calculation and data analysis codes such as EMPIRE-2.19, Talys-1.4, Preco2007, Scat2, Prepro-2004,2010. EXFOR Compilation software etc.
- SRIM/TRIM (Heavy Ion Interaction with materials).
- MS Office, Linux, fortran, C, C++
- Geant4 monte carlo simulation software, ROOT
- COMSOL multiphysics

Awards & Fellowships:

1. Junior Research Fellow Oct'2005 to Sept'2007 BARC-UoP, MoU
2. Senior Research Fellow Oct'2007 to March'2010 BARC-UoP, MoU
3. Postdoctoral Research Associate May'2010 to May'2011 Department of Physics and Triangle University
Nuclear Laboratory(TUNL), Duke University, USA

Membership of Societies National / International:

American Physical Society

List of publications:

International Journals:

1. Systematic study of (n,p) reaction cross sections from the reaction threshold to 20 MeV
B Lalremruata, N Otuka, G J Tambave, V K Mulik, B J Patil, S D Dhole, A Saxena, S Ganesan and V N Bhoraskar.
Physical review C 85, (2012) 024624 .
2. Search for spin-dependent short-range force between nucleons using optically polarized ^3He gas
W. Zheng, H. Gao, **B. Lalremruata**, Y. Zhang, G. Laskaris, W. M. Snow, and C. B. Fu
Physical Review D (Rapid Communications) 85 (2012) 031505.
3. Three-body photodisintegration of ^3He with double polarizations at incident photon energies 12.8 MeV and 14.7 MeV
G Laskaris, Q Ye, H Gao, **B Lalremruata et al.**
Bulletin of the American Physical Society 56, (2011) 9.
4. Double differential cross-sections of (n,α) reactions in aluminium and nickel at 14.77 MeV neutrons.
B.Lalremruata, S.D. Dhole, S. Ganesan, V.N. Bhoraskar
Nuclear Physics A 821(2009) 23-35.
5. 100 keV deuteron induced reactions on natural lithium.
B.Lalremruata, V.Mulik, S.D. Dhole, S. Ganesan, V.N. Bhoraskar.
Physical review C 80, (2009) 044617

6. Excitation function of $^{93}\text{Nb}(n,2n)^{92}\text{Nb}^m$ reaction from threshold to 24MeV

B.Lalremruata, S.D. Dhole, S. Ganesan, V.N. Bhoraskar.

Physical Review C 80, (2009) 014608.

7. Excitation functions and isotopic effects in (n, p) reactions for stable nickel isotopes from reaction threshold to 20 MeV

B.Lalremruata, S. Ganesan, V.N. Bhoraskar, S.D. Dhole

Annals of Nuclear Energy 36 (2009) 458-463

National journals/proceedings

1. Measurement of activation cross sections of (n,p) reactions

M.Bhike, A.Saxena, B.K.Nayak, S.Ganesan, **B. Lalremruata**, R.Palit, R.Tripathi, S.Sodaye, A.V.R.Reddy, S.Kailas and R.K.Choudhury.

DAE-BRNS symposium on nuclear physics, December 11-15,2006, The maharaja Sayajirao University of Baroda, Vadodara

2. Investigation of the neutron induced reaction cross section of various elements in the incident energy range of $E_n = 1 - 4$ MeV

M.Bhike, A.Saxena, B.J.Roy, S.Ganesan, **B. Lalremruata** et.al

DAE Symposium on Nuclear Physics, Vol.-56, (2006) 403

3. Experimental cross-sections of nuclear reactions compiled through the EXFOR

Ranjita Mandal, **B Lalremruata**, V N Bhoraskar, and S Ganesan

DAE-BRNS symposium on nuclear physics , December 22-26,2008, IIT Roorkee.

4. Measurement and estimation of cross- sections of $^{138}\text{Ba}(n,2n)^{137m}\text{Ba}$ and $^{55}\text{Mn}(n, \alpha)^{52}\text{V}$ reactions at 14.8 MeV neutron energy.

V.K. Mulik, **B. Lalremruata**, H.Naik , S.V.Suryanarayan, S.Ganesan, S.D.Dhole and V.N. Bhoraskar.

Proceedings of the DAE Symp.on Nucl. Phys. 55 (2010)360

5. A Systematic Study of (n,p) Reaction Cross Sections in the Mass Region 50 to 140 from Threshold up to 20 MeV

B. Lalremruata, V.Mulik, S.D. Dhole, S. Ganesan, V.N. Bhoraskar.

International Conference on Nuclear Data for Science and Technology, 1073(2010) 209. Jeju Island, South Korea

Signature with date

510. Curriculum vitae (CV) of **Co-Investigator** (CI), if applicable

520. Curriculum vitae (CV) of **Principal Collaborator** (PC):

1. Curriculum Vitae of PC-1:

Name: **Dr. S.V. Suryanarayana**

Designation: Scientific Officer (G)

Present Address:

- (a) **Office:** Nuclear Physics Division
Bhabha Atomic Research Centre
Mumbai-400 085
- (b) **Residence:** Flat 7B GULMARG
ANUSHAKTINAGAR
MUMBAI 400094
- (c) **Email:** suryanarayan7@yahoo.com ; snarayan@barc.gov.in
- (d) **Phone:** +91-022-25593662 (O)
+91-022-25527698 (R)
+91-9819816287 (M)

Educational Qualifications: Ph. D (Physics)

Date of Birth: 04st October 1960

Place of Birth: Hyderabad (A.P), India.

List of Publications:

List of papers during 2005-2011

- I. Publications in Journals,
1. Mass distribution in the 50-, 60-, and 70-MeV bremsstrahlung-induced fission of ^{232}Th
H. Naik, T. N. Nathaniel, A. Goswami, G. N. Kim, M. W. Lee, **S. V. Suryanarayana**, S. Ganesan, E. A. Kim, M.-H. Cho, and K. L. Ramakumar
Physical Review C 85, (2012) 024623.
 2. Total Cross Sections for Neutron Nucleus Scattering
S. V. Suryanarayana, H. Naik, S. Ganesan, S. Kailas, R. K. Choudhury and Guinyun Kim
Journal of the Korean Physical Society 59, (2011) 971.
 3. Measurement of the neutron reaction cross-section of ^{232}Th using the neutron activation technique.

- H. Naik, P.M.Prajapati, **S.V. Suryanarayana**, K.C.Jagadeesan, S.V.Thakare, D.Raj,, V.K. Mulik, B.S.Sivashankar, B.K. Nayak, S.C. Sharma, S. Mukherjee, Sarbjit Singh, A. Goswami, S. Ganesan and V.K. Manchanda,
Eur. Phys. J. A 47 (2011) 51.
4. Photo-neutron cross-section of ^{100}Mo
Rita Crasta, H. Naik, **S. V. Suryanarayana**, P. M. Prajapati, K. C. Jagadisan, S. V. Thakare, S. Ganesh, V. T. Nimje, K. C. Mittal, A. Goswami,
Journal of Radioanalytical and Nuclear Chemistry, 290 (2011) 267.
5. Mass distribution in the bremsstrahlung-induced fission of ^{232}Th , ^{238}U and ^{240}Pu .
H. Naik, V.T. Nimje, D.Raj, **S.V. Suryanarayana**, A.Goswami, Sarbjit Singh, S.N. Acharya, K.C. Mttal, S. Ganesan, P. Chandrachoodan, V.K. Manchanda, V. Venugopal, S. Banarjee,
Nucl. Phys. A 853 (2011) 1.
6. Measurement of photo-neutron cross-sections in ^{208}Pb and ^{209}Bi with 50-70 MeV Bremsstrahlung.
H. Naik, S. Singh, A. Goswami, V.K. Manchanda, G. Kim, K.S. Kim, M. –W. Lee, Md.S. Rahman, D. Raj, **S.V. Suryanarayana**, S. Ganesan, M. –H. Cho, W. Namkng,
Nucl. Instruments Methods in Phys. Research B 269, (2011) 1417.
7. Mass-yield distribution of fission products from photo-fission of $^{\text{nat}}\text{Pb}$ induced by 2.5 GeV bremsstrahlung.
H. Naik, S. Singh, A. Goswami, V.K. Manchanda, **S.V. Suryanarayana**, D. Raj, S. Ganesan, Md. S. Rahman, K.S. Kim, M.W. Lee, G. Kim, M. –H. Cho, I.S. Ko, W. Namkng,
E. Phys. J. A. 47, (2011) 37.
8. Virtual Photon Emission from Quark-Gluon Plasma
S. V. Suryanarayana
arXiv: hep-ph/0704.3676v2, 28 Apr 2007.
Phys. Rev. C.76, (2007) 044903.
9. Generalized emission functions for photon emission from quark-gluon plasma
S. V. Suryanarayana
Phys. Rev. C75, (2007) 021902(R).
10. Jet Quenching in Relativistic Heavy Ion Collisions
S. V. Suryanarayana
Poster presented in International Conf. on Quark Matter,
QM2008, held during 5th -11 Feb 2008, at Jaipur, India
11. Variational method for photon emission from quark gluon plasma
S. V. Suryanarayana
arXiv: hep-ph/0609096, 11 Sep 2006,
12. Adiabatic Heavy ion fusion potentials for Fusion at Deep Sub-barrier Energies
S. V. S. Sastry, S. Kailas, A. K. Mohanty and A. Saxena
Pramana, Indian journal of Physics 64, (2005) 47 ; arXiv:nucl-th/0311041v1
13. Heavy Ion Fusion
S.V. Suryanarayana and S. Kailas

(ci) List of Publications in Symposia

1. Thermal neutron capture cross-section measurement of ^{96}Zr
Paresh Prajapati, H. Naik, **S.V. Suryanarayana**, S. Mukherjee, K.K. Rasheed and S. Ganesan., Nuclear and Radiochemistry Symp. Gitam Institute of Science, Visakhapatnam, vol. I, (2011) 136.
2. Yields of fission products in the 2.5 GeV bremsstrahlung induced fission of ^{238}Pu .
H. Naik, G. Kim, **S.V. Suryanarayana**, D. Raj, Y.D. Oh, M.W. Lee, Sarbjit Singh, A. Goswami, S. Ganesan and V.K. Manchanda. ,
Nuclear and Radiochemistry Symp. Gitam Institute of Science, Visakhapatnam, vol. I, (2011) 455.
3. Medical Isotope ^{33}P production by photo-nuclear reaction of ^{32}S .
S.V. Suryanarayana, K.C. Jagadishan, H. Naik, S.V. Thakare, P.M. Prajapati, M.S. Murali, V.T. Nimje, K. Dixit, P.V. Joshi, A. Goswami, K.C. Mittal, S. Ganesan, M. Venkatesh, V.K. Manchanda, R.K. Choudhury, V. Venugopal and S. Kailas.,
Nuclear and Radiochemistry Symp. Gitam Institute of Science, Visakhapatnam, vol. I, (2011) 138.
4. Measurement of photo-neutron cross-sections in ^{209}Bi with 50-70 MeV bremsstrahlung. ,
H. Naik, G. Kim, D. Raj, **S.V. Suryanarayana**, Sarbjit Singh, A. Goswami, Y.D. Oh, M.W. Lee, S. Ganesan and V.K. Manchanda.,
Nuclear Analytical Chemistry (NAC-IV), Nov. 15-19 (2010) P. 153.
5. Alternative route for the preparation of medical isotope $^{99\text{m}}\text{Tc}$ from $^{238}\text{U}(\gamma, f)$ and $^{100}\text{Mo}(\gamma, n)$ reaction.
H. Naik, K.C. Jagadishan, **S.V. Suryanarayana**, S.V. Thakare, M. Kishore, V.T. Nimje, K. Dixit, P.V. Joshi, A. Goswami, S. Ganesan, K.C. Mittal, M. Venkatesh, V.K. Manchanda and V. Venugopal.,
Nuclear Analytical Chemistry (NAC-IV), Nov. 15-19 (2010) P. 301.
6. Measurement of ^{94}Zr reaction cross-section at $E_n = 0.025$ eV and 2.45 MeV.
Paresh Prajapati, H. Naik, **S.V. Suryanarayana**, S. Mukherjee, S. Bishnoi, T. Patel, K.C. Jagadishan, S.V. Thakare, V.K. Mulik, B.S. Shivashankar, D. Raj, A. Goswami, K.K. Rashee, A. Sinha and S. Ganesan, Nuclear Analytical Chemistry (NAC-IV), Nov. 15-19 (2010) P. 154.
7. Production of medical isotope ^{33}P using $^{37}\text{Cl}(\gamma, \alpha)$ reaction.
S.V. Suryanarayana, K.C. Jagadishan, H. Naik, S.V. Thakare, M.S. Murali, P.M. Prajapati, B.K. Nayak, S. Santra, Srikrishna Gupta, Saroj Bishnoi, T. Patel, B.S. Tomar, P.V. Joshi, A. Goswami, M. Venkatesh, S. Ganesan, R.K. Choudhury, V.K. Manchanda, V. Venugopal and S. Kailas, Nuclear Analytical Chemistry (NAC-IV), Nov. 15-19 (2010) P. 263.
8. Study of ^{33}P medical isotope production using particle accelerators
K.C. Jagadishan, **S.V. Suryanarayana**, S.V. Thakare, H. Naik, P.M. Prajapati, M.S. Murali, V.T. Nimje, K. Dixit, B.S. Tomar, P.V. Joshi, A. Goswami, K.C. Mittal, S. Ganesan, M. Venkatesh, V.K. Manchanda, R.K. Choudhury, V. Venugopal and S. Kailas., Nuclear Analytical Chemistry (NAC-IV), Nov. 15-19 (2010) P. 264.
9. Measurement of Photo-neutron cross section in ^{208}Pb with 50-70 MeV bremsstrahlung
H. Naik, G. Kim, D. Raj, **S.V. Suryanarayana**, Y.D. Oh, M.W. Lee, A. Goswami,
S. Ganesan and V.K. Manchanda., Proceedings of the DAE Symp. on Nucl. Phys. 55, (2010) 356-357.

10. Determination of thermal neutron capture cross-section of ^{94}Zr
P.M. Prajapati, H. Naik, **S.V. Suryanarayana**, S. Mukherjee, K. K. Rasheed and S. Ganesan.,
Proceedings of the DAE Symp. on Nucl. Phys. 55, (2010) p358-359
11. Measurement and estimation of cross-sections of $^{138}\text{Ba}(n,2n)^{137\text{m}}\text{Ba}$ and $^{55}\text{Mn}(n,\alpha)^{52}\text{V}$ reactions at 14.8 MeV neutron energy.
V.K. Mulik, B. Lalremruata, H. Naik, **S.V. Suryanarayana**, S. Ganesan, S.D. Dhole and V. N. Bhraskar.,
Proceedings of the DAE Symp. on Nucl. Phys. 55,(2010) p360-361
12. Measurement $^{232}\text{Th}(n, \gamma)$ reaction cross-section at $E_n= 17.28$ MeV, Sadhana Mukerji, H, Naik, **S V Suryanarayana**, B S Shivashankar, V K Mulik, B K Nayak, A Saxena, S C Sharma, P V Bhagwat, S Ganesan, A Goswami, P D Krishnani
DAE Symp. Nucl. Phys. 56 (2011) 626
13. Measurement of the neutron capture cross-section of ^{238}U using the neutron activation technique,
S V Suryanarayana, H Naik, V K Mulik, P M Prajapati, B S Shivashankar, K C Jagadeesan, S V Thakre, D Raj, S C Sharma, P V Bhagawat, S D Dhole, S Ganesan, V N Bhoraskar
DAE Symp. Nucl. Phys. 56 (2011) 628
14. Measurement of $^{58}\text{Ni}(n, p)$ reaction cross-section at quasi mono-energetic neutron energy of 9.85 MeV,
B S Shivashankar, H Naik, **S V Suryanarayana**, P M Prajapati, V K Mulik, K C Jagadeesan, S V Thakre, S C Sharma, P V Bhagwat, S Ganesan, A Goswami
DAE Symp. Nucl. Phys. 56 (2011) 632
15. Measurements of $^{56}\text{Fe}(n, p)^{56}\text{Mn}$ reaction cross-section at neutron energy of 15.5 MeV,
V K Mulik, B S Shivashankar, P M Prajapati, **S V Suryanarayana**, H Naik, K C Jagadeesan, S V Thakare, S C Sharma, P V Bhagwat, A Goswami, S Ganesan, S D Dhole, V N Bhoraskar
DAE Symp. Nucl. Phys. 56 (2011) 638
16. Fission products yields in photo-fission of ^{232}Th for end-point bremsstrahlung energy of 10 and 50 MeV,
H Naik, G Kim, **S. V. Suryanarayana**, V. T. Nimje, D. Raj, S.N. Acharya, Newton Nathaniel, M.W. Lee, K.S. Kim, K.C. Mittal, A. Goswami, S. Ganesan, M. H Cho, I. S. Ko, W. Namkung, K. L. Ramakumar
2nd Int. Workshop on ADS and Thorium utilization, Dec-11-14, 2011, BARC, Mumbai (2011) E1, 88
17. Measurement of the $^{232}\text{Th}(n, \gamma)$, ^{233}Th and $^{232}\text{Th}(n, 2n)^{231}\text{Th}$ reaction cross-sections at neutron energy of 8.04 MeV,
Rita Crasta, H. Naik, **S. V. Suryanarayana**, Sanjeev Ganesh, B. S. ShivaShankar, V. K. Mulik, P. M. Prajapati, S. C. Sharma, A. K. Mohanty, P. V Bhagwat, S. Ganesan, A. Goswami
2nd Int. Workshop on ADS and Thorium utilization, Dec-11-14, 2011, BARC, Mumbai (2011) C3, 80
18. $^{232}\text{Th}(n, 2n)^{231}\text{Th}$ cross-section measurement at $E_n = 15.5$ MeV,
P. M. Prajapati, H Naik, **S.V. Suryanarayana**, S Mukherjee, K.C. Jagadeesan, S.V Thakre, S Ganesan, A Goswami
2nd Int. Workshop on ADS and Thorium utilization, Dec-11-14, 2011, BARC, Mumbai (2011) C4, 81
19. Gluon emission in quark gluon plasmas
S. V. Suryanarayana
DAE-BRNS Nuclear Physics Symposium Vol. 54 (2009) 592

20. Measurement of $^{90}\text{Zr} (n,p) ^{90}\text{Ym}$ reaction cross-section at 7.3 MeV neutron energy
P.M. Prajapati, V. K. Mulik, B.S. Shivashankar, D. Raj, **S. V. Suryanarayana**, H. Naik, K. C. Jagadeesan, S.V. Thakare, S.K. Mukherjee, Sarbjit Singh, A.Goswami, K.K. Rasheed, S. Ganesan, P.D. Krishanani and C.F. Desai
DAE-BRNS Nuclear Physics Symposium Vol. 54 (2009) 382
21. $^{58}\text{Ni} (n, p) ^{58}\text{Co}$ Reaction cross-section measurement at $E_n=3.7$ MeV
B.S. Shivashankar, P.M. Prajapati, V. K. Mulik, D. Raj, **S. V. Suryanarayana**, H. Naik, K. C. Jagadeesan, S.V. Thakare, S.K. Mukherjee, Sarbjit Singh, A.Goswami, K.K. Rasheed, S. Ganesan, P.D. Krishnani, N. S. Nair and K. M. Prasad
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List of Publications:

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B. REPORTS:

1. A new approach to determine mass-charge yields and kinetic energy distribution.
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C. IAEA PROJECT:

From May 1991 to August 1996 I was involve in IAEA project on measurement of absolute fission yields in the fast neutron fission of actinides (^{238}U , ^{237}Np , ^{238}Pu , ^{240}Pu , ^{243}Am , ^{244}Cm).

D. TEXT BOOK MATERIAL:

My work has been quoted in page 484, 485, 487 of Chapter 9 (i.e. Fission Fragment Angular Momentum by D. De Frenne) of the Book: The Nuclear Fission Process (editor C. Wagmans), CRC Press, Boca Raton Ann Arbor Boston, London (1991).

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