Researcher Career Opportunities in India

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The Cockcroft Institute
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UNIVERSITY OF LIVERPOOL

Plan of Presentation

- *Journey of a Researcher in India*
- *Accelerator Facilities in India : Existing and Upcoming*
- *Medical Accelerator Program in India*
- *Research Funding and Exchange program in India*
- *Industrial work for Accelerators in India*

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- Starting point for Researcher (Physics)
  1. B.Sc. & M.Sc. (5years)/B. Tech. (4 years)/B. Tech. & M. Tech. (5/6 years) after completing 15 years of School Education
  2. National level exams for qualifying for Research (NET-JRF, GATE, JEST, etc…)
  3. Institutional/ University written exam along with personal Interview
  4. 6-12 months of Pre-Ph.D. course work
  5. Supervisor

- Journey of Research
  1. Literature Survey, Problem defining and registration (by defending problem in presence of external reviewer)
  2. Research begins (minimum time period of your regular degree: 24 months (continue/Part time)
  3. Usually Grants are available for (4+1 years)
  4. Research Publications (Minimum 2 Publications)
  5. Pre-Thesis defence (open, Internal committee)
  6. Thesis writing and submission (with certain minimum conditions to be full filled)
  7. Review of thesis by minimum 2 external examiners
  8. Thesis defence (open, in presence of external examiners) and finally if everything goes fine, degree.

- Jobs in Academic/Govt. Research Labs

1. M.Sc./B. Tech./M. Tech. → Scientific Officers, Research Assistants (after training of one year)
2. M.Sc + National exam/ M. Tech. → Teaching Job at Colleges level/University entry level
3. Ph.D. → Teaching Job at Colleges level/University entry level and Scientific officers
4. Ph.D. plus experience (minimum 3 years) → Minimum eligibility for Academic jobs in Top Institutes.

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- *Bhabha Atomic Research Centre (BARC)*
- *Raja Ramanna Centre for Advanced Technology (RRCAT)*
- *Variable Energy Cyclotron Centre (VECC)*
- *Inter University Accelerator Centre (IUAC)*
- *Institute of Physics (IOP)*
- *Indian Institute of Technology, Kanpur (IITK)*
- *Guru Ghasidas Vishwavidyalya*
- *Indira Gandhi Centre for Atomic Research (IGCAR)*
- *Mangalore University*
- *National Centre for Compositional Characterization of Materials (CCCM)*
- *Punjab University*
- *S P Pune University*
- *Tata Institute of Fundamental Research (TIFR)*
- *Institute for Plasma Research (IPR)*
- *Saha Institute of Nuclear Physics (SINP)*
- *Kurukshetra University, Kurukshetra*
- *Central University of Punjab, Bathinda*
- *Society for Applied Microwave Electronics Engineering & Research (SAMEER), Mumbai*
- *University of Allahabad, Allahabad*

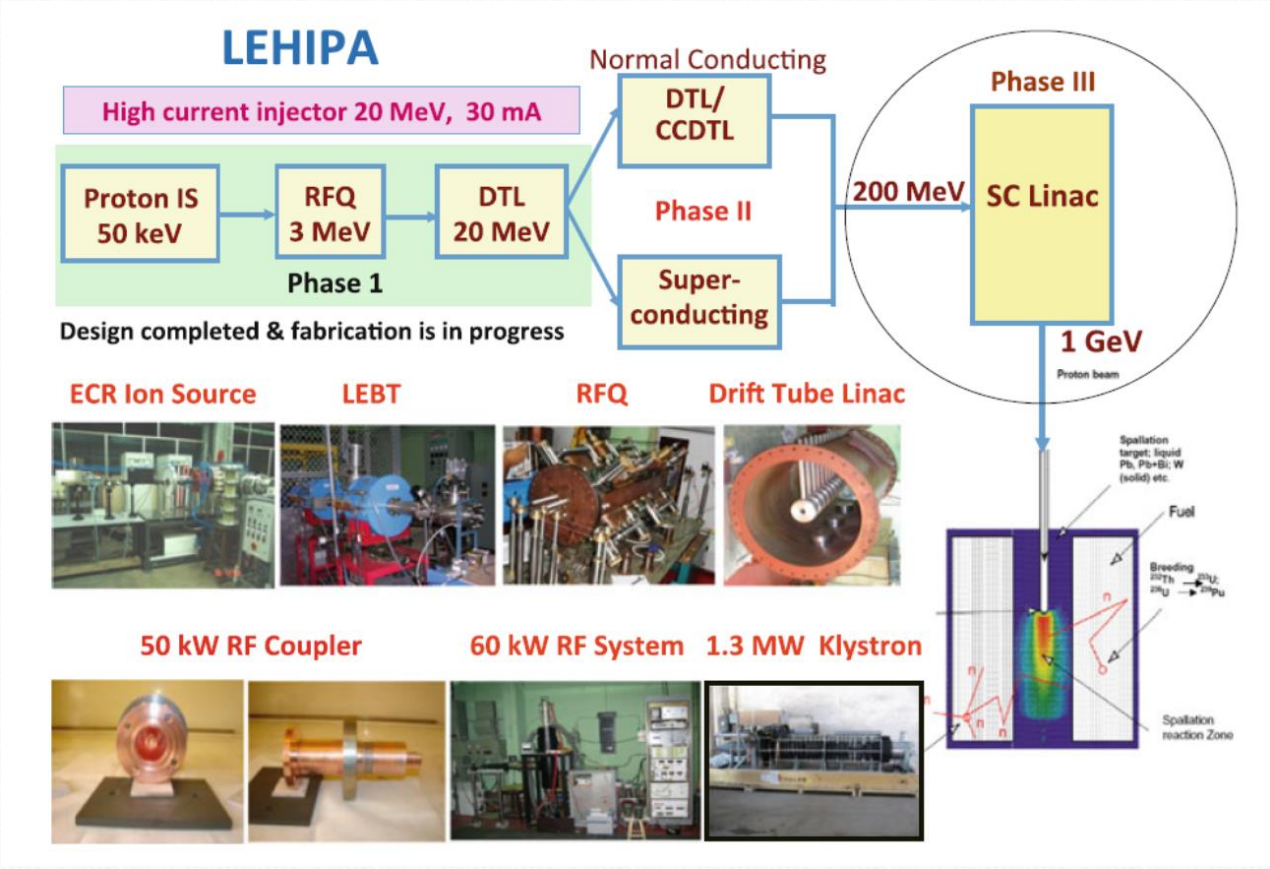
http://www-nds.iaea.org/publications/

Universities and Institutes

- Total number of Universities in the Country as on March 2019 : 907
- Indian Institute of Technology : 23
- Birla Institute of Technology and Science: 3 in India and 1in Dubai
- Indian Institute of Science, Bengaluru, India
- Indian Institute of Science Education and Research: 07
- National applicants: Research Scholar, Research Assistant, Post-Doctoral Fellowship, Research Associate, Scientist (Scientific Officers), Academic Teaching Positions, D S Kothari fellowship, Inspire Faculty fellowship, National Post-Doctoral Fellowship, DST Woman Scientist, UGC Women fellowship, Science and Engineering Research Board (SERB) fellowships…
- International applicants: Mostly Ph.D. and Post-Doctoral positions

- Existing: Folded Tandom Ion Accelerator (FOTIA), 14 MeV Neutron generator (~14.1 MeV using D-T and ~2.45 MeV using D-D), 10 MeV electron RF LINAC, 3 MeV electron accelerator (DC), 16.5 MeV Medical Cyclotron (Proton 16.5 fixed and D+ 4 MeV & Radionuclidies 18F. 11C, 13 N & 15O).

- Upcoming: Low Energy High Intensity Proton Accelerator (LEHIPA) for Accelerator Driven System in India primarily for the purpose of Th Utilization



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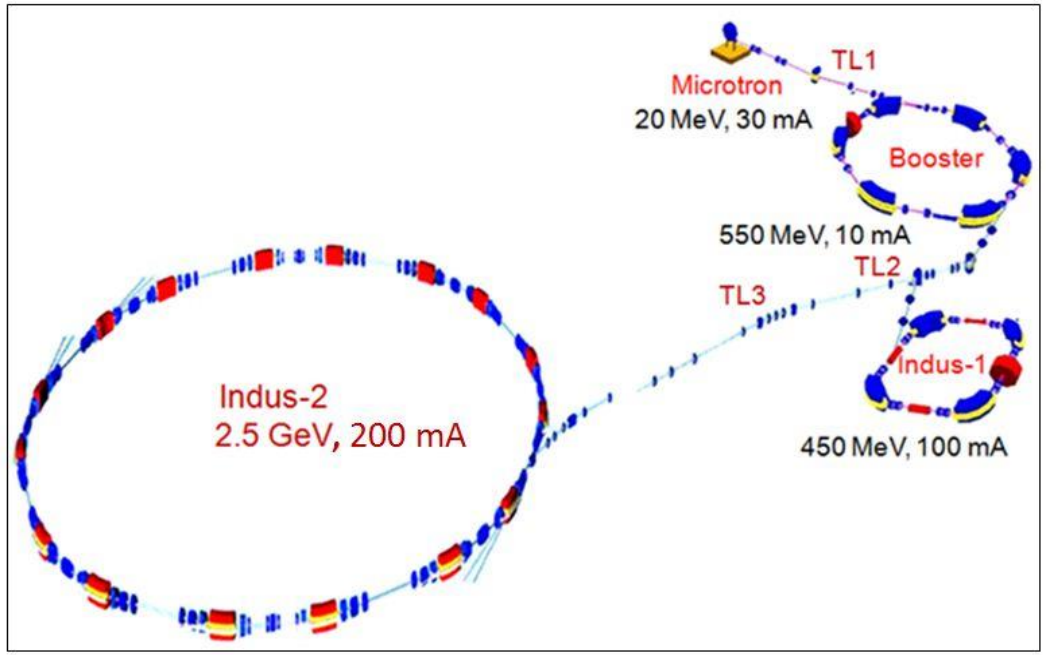
Raja Ramanna Centre for Advanced Technology

- Two Syncrotron Radiation namely Indus-1 (450 MeV electron Storage ring) and Indus-2 (2.5 GeV electron storage ring) with beam current of ~200 mA.
- Superconducting RF Cavity development: 1.3 GHz (Single Cell & Multi-cell) & 650 MHz (Single Cell & Multi-Cell) and Tuner development for SRF cavity
- Free Electron Laser facility, Tera-Hertz – Infra-Red Spectroscopy
- H^- ion sources, low energy beam transport system, Radio frequency quadrupole, medium energy beam transport systems, drift tube linac (up to 100 MeV).



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Variable Energy Cyclotron Centre

- K130 cyclotron and K500 Superconducting cyclotron
- Electron Cyclotron Resonance Ion Source, RF ion source and Focused Ion beam systems
- 30 MeV Medical Accelerator (Max. current 500 μA). It will produce, in addition to F-18 (FDG), other SPECT isotopes such as Ga-67, In-111, Th-201, I-123 etc. for medical diagnostics.
- ANURIB- Advanced National facility for Unstable Rare Isotope Beams
- This facility will produce & accelerate rare, beta-stable and beta-unstable (radioactive) ion beams with beam energy 1.5 keV/u which will be suitable for nuclear spectroscopy, materials science and radio-biology studies.
- **Upcoming:** 30 MeV Superconducting electron LINAC, Superconducting LINAC for heavy ions. High frequency Superconducting ECR ion source

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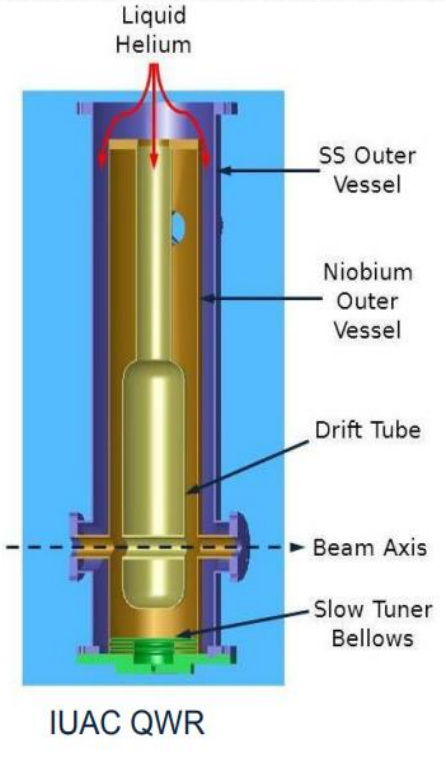
Inter University Accelerator Centre (IUAC)

- Existing: 15 UD pelletron, Superconducting Linear Accelerator, Pelletron Accelerator RBS-AMS systems, Accelerator Mass Spectroscopy, Low Energy Ion Beam Facilities

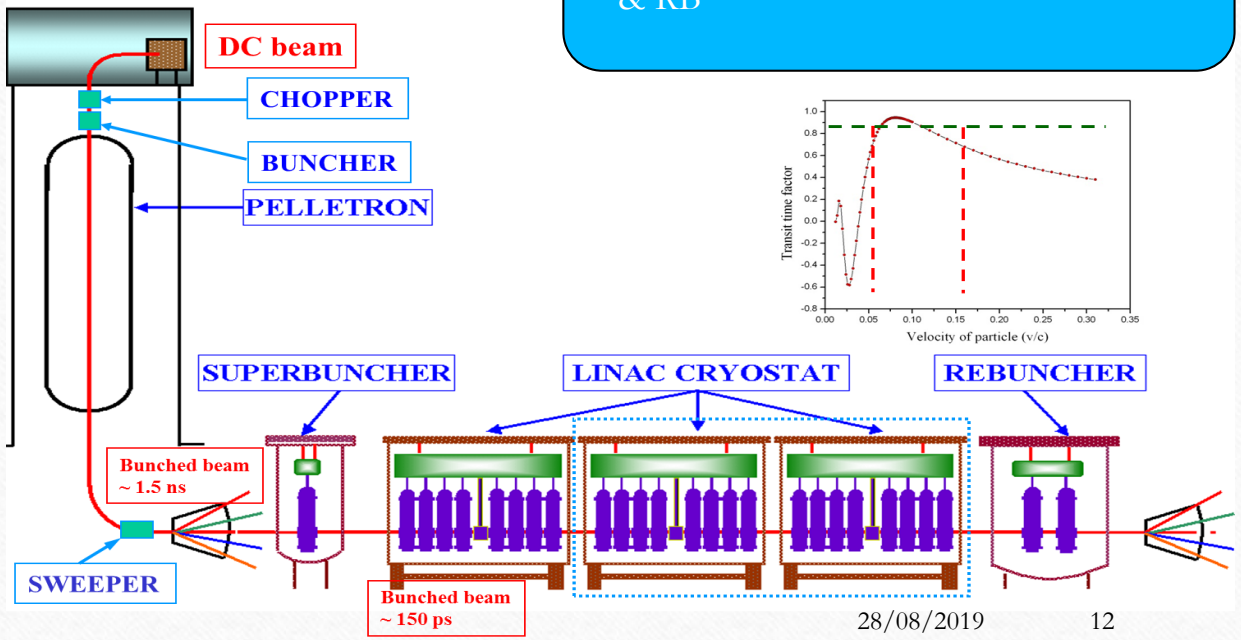
- **Ongoing** : High Current Injector, Delhi Light Source based on FEL system



IUAC QWR

Pelletron accelerator and Superconducting Linac

- Accelerate from C to Ag
- 8.8 MeV/q obtained so far
- All 3 accelerating modules along with SB & RB



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- Guru Ghasidas Vishwavidyalaya: 3 MV Tandom Acclerator (high neutron flux production)
- Indian Institute of Technology, Kanpur: 1.7 MV Tandom Accelerator
- Indira Gandhi Centre for Atomic Research: 1.7 MV Tandom Accelerator
- Institute of Physics, Bhubhaeswar: 3 MV Pelletron Accelerator
- Mangalore University: Variable Energy Microtron (8/12 MeV, 50 mA)
- National Centre for Compositional Characterization of Materials (CCCM), Hyderabad: 3 MV Tandetron Accelerator
- Panjab University: low Energy Cyclotron (2-3 MeV Proton)

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- Savitribai Phule Pune University: 14 MeV Neutron Generator, 6.5 MeV Electron Accelerator: Race-Track Microtron
- Institute for Plasma Research: High Intensity 14 MeV Neutron Generator
- Saha Institute of Nuclear Physics: 3 MV Tandetron Accelerator
- University of Allahabad: High Fluence Ion Beam Facility
- Tata Institute of Fundamental Research (TIFR): 14 UD Pelletron Accelerator
- Institute of Plasma Physics: High Intensity 14 MeV Neutron generator
- Saha Institute of Nuclear Physics: FRENA (3 MV Tandem Accelerator)
- Kurukshetra University: 200kV positive heavy ion accelerator
- Central University of Punjab: 50 keV Ion implantation facility

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- The Cancer Group at Apollo Hospitals - 125 Surgical and Radiation Cancer specialists & expert diagnostic consultants.

Key highlights of Apollo Cancer Care are.

- ✓ Proton Rooms
- ✓ High End Diagnostics Imaging Centre
- ✓ High End Day Care Chemo Wards
- ✓ Operating Rooms
- ✓ Linear Accelerators
- ✓ Comprehensive Cancer Care
- ✓ Beds Inpatient Facility
- ✓ Organ-Specific Cancer Care

4/661, Dr Vikram Sarabai Instronic Estate 7th St, Dr. Vasi Estate, Phase II, Taramani, Chennai, Tamil Nadu 600096

- Started In January 2019, Cyclotron delivering ~230 MeV Protons and having 2-3 gantries in addition to a fixed beamline.

https://proton.apollohospitals.com/about-us

National Hadron Beam Facility

TATA Memorial Centre (TMC) Mumbai, India

- Similar to Apollo Hospital facility
- Operational in a couple of years.
- An academic centre to provide advanced radiation therapy for service, research & education.
- Benefit patients in both paying & non-paying categories (40:60).
- Both are Turnkey facilities for cancer therapy and supplied by M/s. IBA Belgium
- One similar facility to be set up at Bengaluru

https://tmc.gov.in/index.php/national-hadron-beam-facility

- SAMEER has developed two units of 6 MV Medical LINAC under National Jai Vigyan project and installed them at Chennai and Vardha. In the second phase four units of 6 MV Medical LINAC are being made and deployed in the identified hospitals for treating the cancer patients.

- **Dual photon and multiple electron energy integrated oncology system**

✓ Medical Linear accelerator system will have 2 photon energies and 5 electron energies for the treatment.
✓ An advanced version of Linear accelerator used for cancer therapy.
✓ DIT sponsored project - design and developmental work in critical areas - beam bending system, triode guns, electron dosimetry, asymmetric collimator, etc.

SIDDHARTH

- An Indigenous 6 MV LINAC named SIDDHARTH has been approved by the Atomic Energy Regulatory Board (AERB) of India and is functional at two centres.
- BARC has designed an indigenous telecobalt unit named "Bhabhatron". The prototype was installed at Advanced Centre for Treatment Research and Education in Cancer at Mumbai.
- In collaboration with Panacea Medical Technology Pvt. Ltd, BARC has developed Bhabhatron-II, an integrated image guided radiotherapy unit and a flat panel radiotrherapy simulator (IMAGIN).
- Medical cyclotrons for Fluorine 18 based FDG production as FDG with PET-CT camera - a powerful tool for Cancer diagnostics. Almost 20 such facilities are operational all over India at different places. Most of them deliver protons of 10-20 MeV energy - all commercial and many of them are in private domain.
- About 250, medical electron LINAC's are operational in India - used for cancer therapy via x-ray irradiation - normally, 6-15 MeV electron LINAC's housed in a gantry.
- SAMEER, Mumbai have developed such systems and transferred technology to a private company.
- But, so far, almost all the medical electron LINAC's system have be imported by the hospitals.

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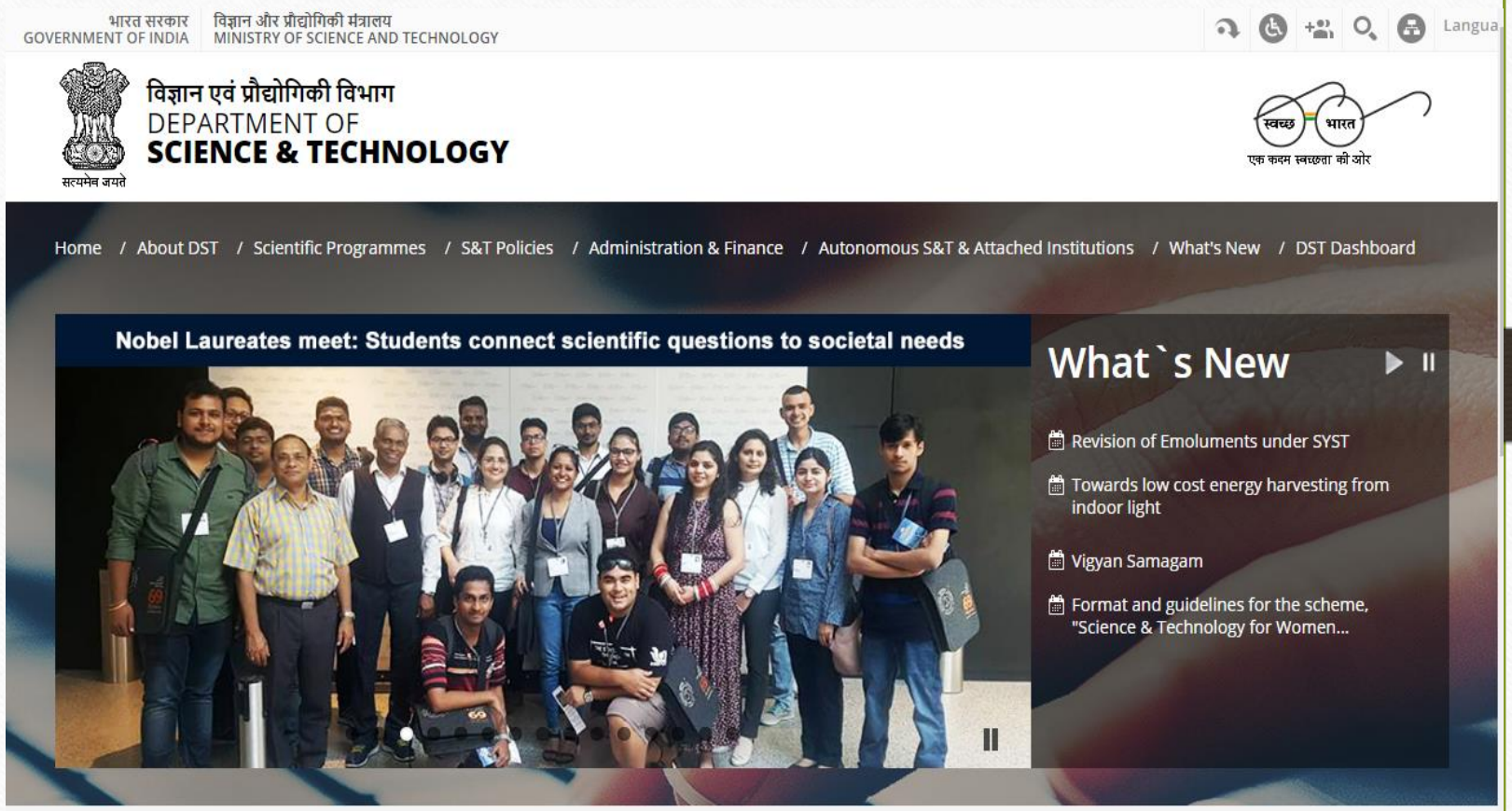
Department of Science & Technology

Proposals can be submitted to DST with a joint application. This application must include one Indian Principal Investigator and one Principal Investigator from the country with whom this joint proposal is called.

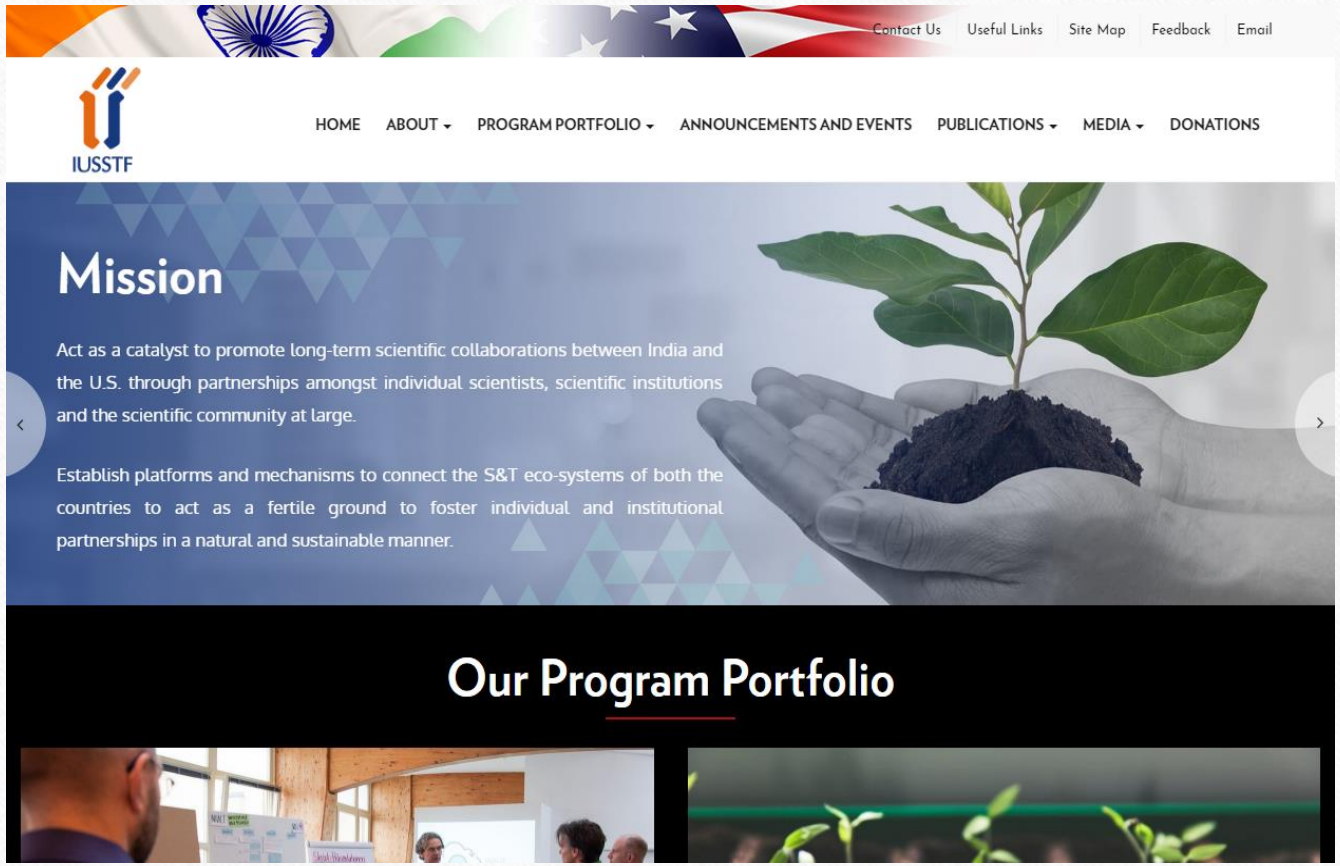


http://www.dst.gov.in/

Indo-U.S. Science and Technology Forum (IUSSTF)

The Indo-U.S. Science and Technology Forum (IUSSTF) is an autonomous bilateral organization jointly funded by both the governments that promotes Science, technology, Engineering and Innovation through substantive interaction among government, academia and industry.

For more details: https://www.iusstf.org/



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Excel Instruments (Palghar, Maharashtra, India)

- PLD system, Sputtering system, PECVD and HFCVD systems, Evaporation systems, Arc melting systems, Customized system (having clients all over the world)

Indo German Tool Room Ahmedabad and Aurangabad

- Development Commissioner (MSME) Ministry of Micro, Small & Medium Enterpries (All type of Engineering drawing testing, designing and manufacturing along with training program)

FOURVAC Technologies, Pune, India

- HV and UHV chambers, CF, KF and ISO flanges and fittings, feedthroughs, valves, motion and manipulation, customized products, etc…

SMP Enterprises, Pune, India

Vacuum Technologies Pvt. Ltd., Bangalore, India

Things I have learnt through my Journey

- *Share ideas and pay attention to ideas from others*
- *Consult with mentors/seniors*
- *Gain experience from many places (Work with different teams in different environments)*


Thank You!