International cooperation for Particle Physics & Technology in India

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Funding for High Energy & Astroparticle Research In India

Main Funding Agencies:

- Department of Science & Technology, Govt. of India (DST)
  - Main funding agency for Universities and institutes under DST. It is also the nodal agency to coordinate international agreement for cooperation in science research with other countries.

- Department of Atomic Energy, Govt. of India (DAE)
  - Main funding agency for autonomous institutes under DAE like TIFR, SINP, VECC etc.

- Department of Space
  - Mostly for astronomy & astrophysics : e.g. ASTROSAT project.
Funding Procedure

- Small University groups can apply for funding any time to DST.
  - PAC appointed by DST recommends funding after reviewing proposals.

- Large funding are usually linked to India’s 5 yearly plan period. Project can start at the beginning of a plan period - can span over several plan periods. Prior discussions and approval by Mega Science Committee needed.

- DAE and DST jointly support participation of Indian institutes and universities in mega science experiments and abroad. in the country (started with LHC)
HEP in India

- **Reasonable size groups in all areas of HEP.**
  - **Formal theory.**
  - **Phenomenology.**
  - **Experiment.**

- **First dedicated HEP Centre. Inter-Institutional Centre for High Energy Physics coming up in South India (INO centre)**
Levels of International participation/collaboration

There are three levels at which participation and collaboration in the field of particle physics is happening for India.

- Involvement of Indian Scientists as users in major international facilities:
- Involvement and partnerships in International programs and facilities:
- Developing Indian facilities and participation of International community in Indian facilities and experiments.
Involvement of Indian Scientists as users in major international facilities

In the pre-LEP era, there has been participation in experiments at CERN, ANL & Fermilab fixed target facilities.

Participation mostly limited to the analysis of data.

- Emulsion based data
- Bubble Chamber data
Involvement and partnerships in International programs and facilities:

- Designing and building parts of detectors and software system for the L3 experiment at CERN, D0 experiment at Fermilab, LHC experiments ALICE and CMS.

- Participation in making the LHC machine.

- Building beam lines at existing synchrotron facilities oriented towards the Indian science interests.
Participation in International programs - current

- Participation in the CMS and ALICE experiments continues.
- Participation has started in the upgrade of these experiments.
- Participation in the Belle experiment at KEK continues.
- Beam line is setup at KEK photon factory for material science research.
- Collaboration with CERN results in the development of GRID middleware and two Tier II centers are set up for LHC experiments.
- Participation in neutrino experiments at Fermilab.
Participation in International programs- Future

- Cooperation with CERN will continue beyond the LHC: ISOLDE, CLIC, novel accelerator technologies....
- Associate membership to CERN has progressed and some approvals have already been obtained.
- Cooperation with Fermilab started with participation in the accelerator research, in neutrino experiments and indetector developments.
- Cooperation with KEK will continue for participation in the super-Belle experiment and material science research.
- Signed MOU with DESY for research with the photon factory.
- India is a participant in the FAIR consortium from the beginning along with Germany, Russia, Poland, Romania, Slovenia and Sweden. Experiments will start in 2016.
- India is a partner in the ITER project.
Indian facilities
Always open for International participation

Kolar Gold Field Underground Laboratory

DETECTION OF MUONS PRODUCED BY COSMIC RAY NEUTRINO DEEP UNDERGROUND

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Received 12 July 1965
Existing Indian Facilities

Giant Meter Wave Radio Telescope

- Fully operational since 2002, to study astrophysical phenomena at low frequencies 50 to 1540 MHZ.
- Largest in the world to operate at these frequencies.
- Contains 30 antennas.
- 50% of the users are international. Groups bid for telescope time and proposals are chosen. No charges are levied for using the facility.
Up coming facilities in India

- **India-based Neutrino Observatory (INO):** Funding included in Government’s planning document. Pre-project activities started.

- **MACE Gamma Ray Telescope in Himalayas.**

- **LIGO (Laser Interferometry Gravitational wave detector):** India is going to be one of the sites (in collaboration with NSF, USA).

- **Astrosat Project- Indian astronomy satellite with International collaboration.**
Atmospheric Cherenkov Experiment at Hanle (altitude - 4.3 km)

Higher Cherenkov photon density at higher altitude

Lower atmospheric attenuation of Cherenkov photons

Lower energy threshold at higher altitudes

Interesting physics issues:
more sources can be observed, cutoffs in spectra of Active Galactic Nuclei, pulsars

Phase 1: HAGAR (IIA+TIFR+SINP) 7 element WS array; Now operating
Phase 2: 21 m Dia MACE (BARC) imaging Tel. Expected in 2014
Phase 3: MACE-II Stereo imaging; 2015+
MACE Gamma-Ray Telescope

- **MACE (Major Atmospheric Cherenkov Experiment).**
- **Location:** Hanle, North India.
  - *(32.8 N, 78.9E, 4200m asl).*
- **Trigger threshold:** ~20 GeV.
- **Light collector:** 356 sq.m.
- **Pixel size:** 0.1 d.
- **Number of pixels:** 1408.
- **Cost:** 10m USD. (fully funded).
- **Status:** Construction of the telescope is in advance stage at ECIL, Hyderabad.
- **Installation:** 2014.
INO Project

- Construction of an underground laboratory & surface facilities near Madurai, Tamil Nadu.
  - Construction of a massive 50 kton detector (ICAL) for neutrino physics.

- Setting up INO Centre at Madurai to act as hub for all INO related activities (Inter-Institutional Centre for High Energy Physics).
  - Base station for INO physicists & Engineers.
  - Development of various particle detectors.
  - INO Graduate School for Human Resource Development.
  - Industry Interface.
  - INO visitors from India & Abroad.

- Possible Future experiments
  - Neutrinoless double beta decay (R & D ongoing)
  - Ton scale dark matter detector (R & D started)
Formation of a consortium of about 30 researchers from 10 institutes/univ., in gravitational, optical and vacuum physics, to lead and implement the Indian Initiative in Gravitational wave Observations (IndIGO).

Discussions are on to setup the 3rd LIGO detector in India.

A 3-m scale advanced prototype interferometer with ultra-fine displacement sensitivity is fully funded for completion by 2015, at TIFR, Mumbai.

LIGO-India proposal is being discussed in the Mega Science Committee setup by planning commission.
ASTROSAT: Satellite based Experiment:

- Scheduled for launch in 2014. Indian Space mission with participation from Canada & UK.

- Will carry five astronomy payloads covering UV, soft X ray, and hard X-ray bands, in near equatorial orbit.
Summary

- India is participating meaningfully in mega science facilities outside India.

- **India has built its own mega science projects and welcomes international participation in their explorations.**

- **India is bidding for partnerships in many of the mega projects of the near future and will be a stake holder.**
Concluding remarks

- India has a strong presence in various High Energy Physics laboratories around the world.

- Two Indian funding agencies DAE & DST are now acting synergistically to raise India’s research capabilities in several frontline areas of research including High Energy Physics. Several small & large projects are at various stages of approval.

- Because of the collaborative nature of these projects, it allows us to develop networking of research and higher education with institutions in the country and abroad. Such networking are encouraged by our funding agencies.

- We should look for synergies in various projects, operational or under consideration in different regions of the world and whenever possible should find ways for common R & Ds for various sub areas connected to these projects.