NUCLEAR SCIENCE CENTRE

PAST, PRESENT & FUTURE

A PERSPECTIVE

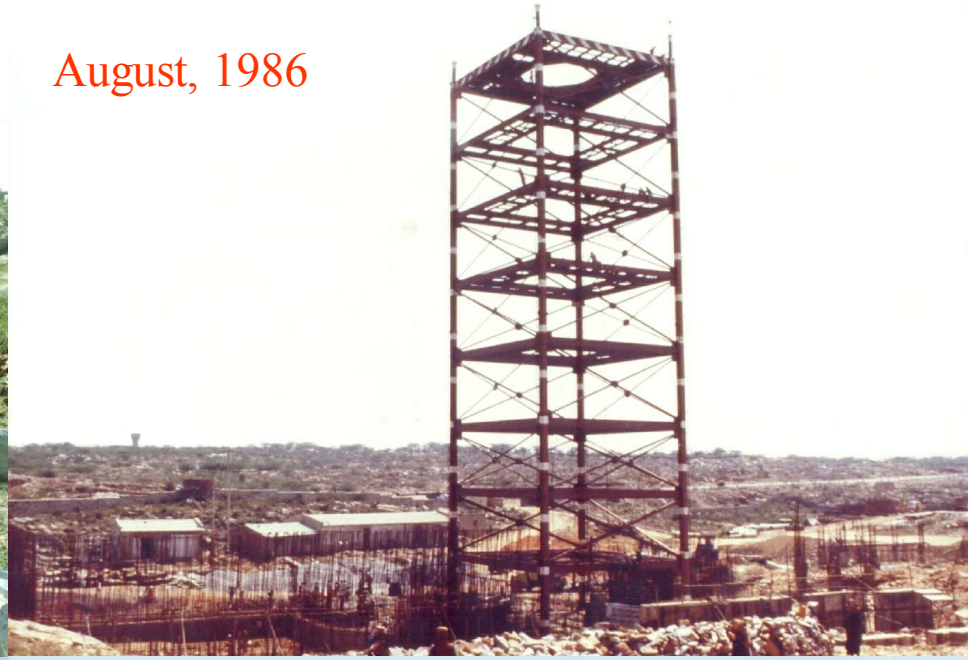
First Inter-University Centre -The GENESIS

Research Centres in the Universities were emphasised in the national policy on education in 1968. The proposal for accelerator centres within the family of teaching institutions was considered by UGC in early 80's and the concept of Inter-University-Centres were accepted by the Govt in 1984. The first such Centre, NSC, came up the same year.

The construction of the building started in 1986 and completed in 1989. The commissioning of the Pelletron Accelerator started in August,1989 and completed on Dec, 1990.

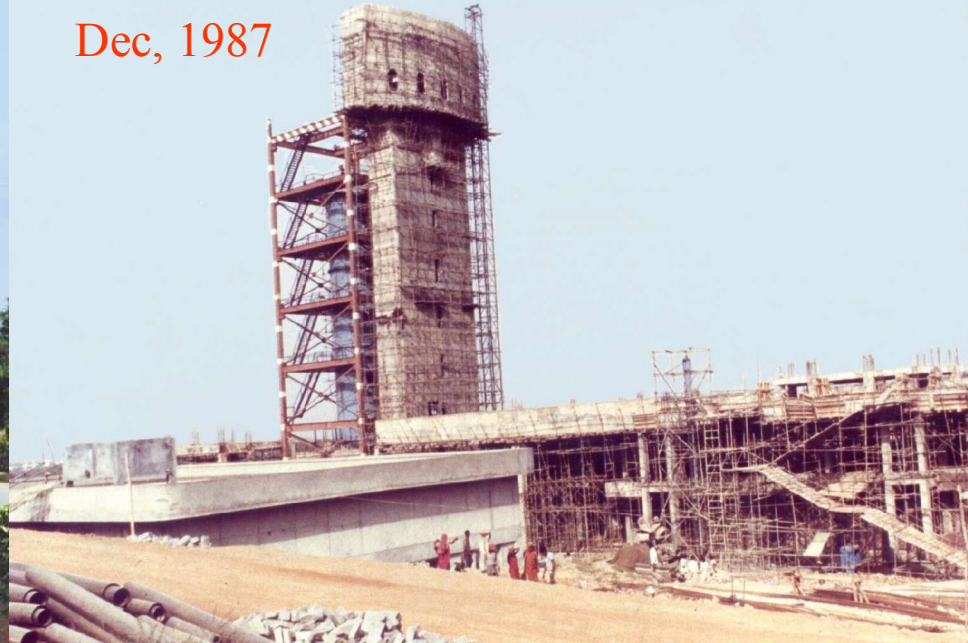
Before July, 1986

August, 1986



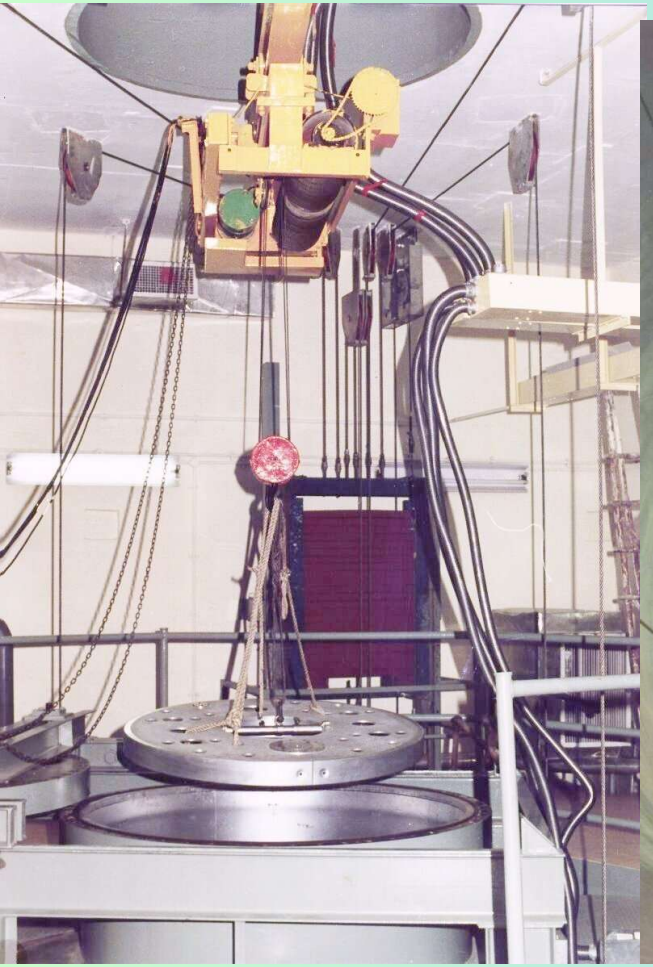
Nov, 1989

Dec, 1987

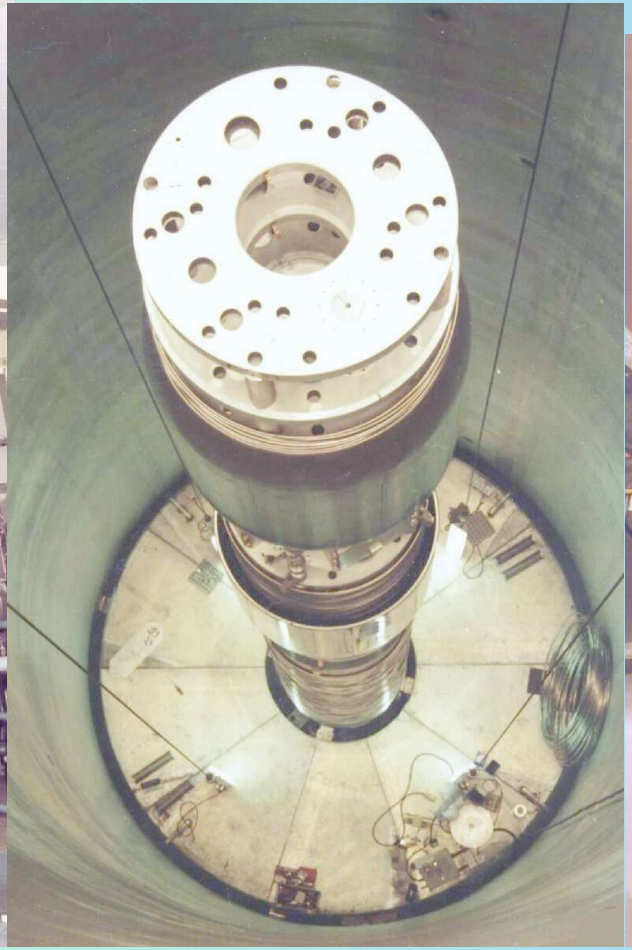


COMMISSIONING OF THE ACCELERATOR

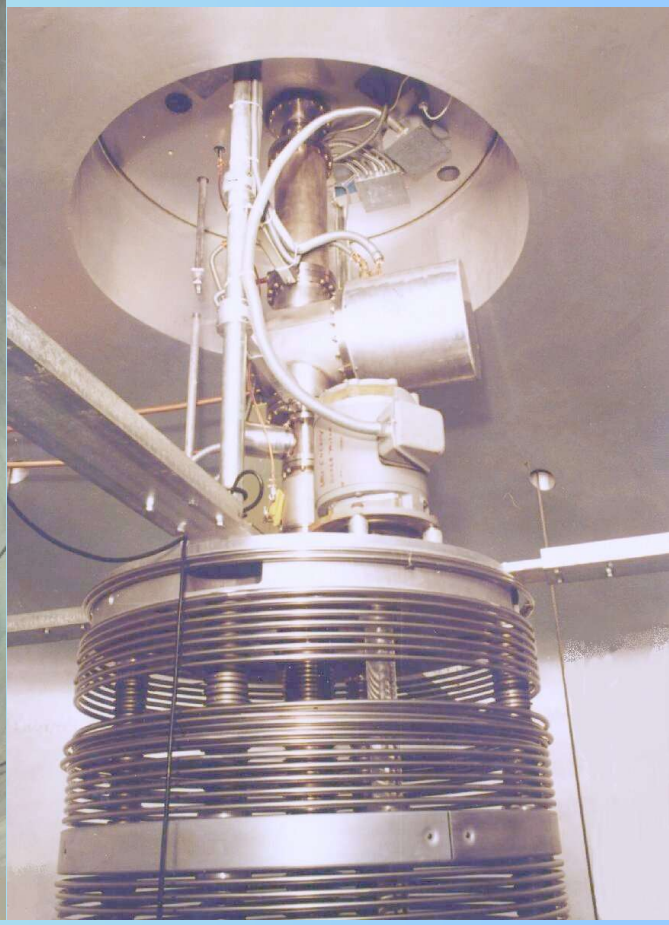
Top of Accelerator tank



View from top during assembly



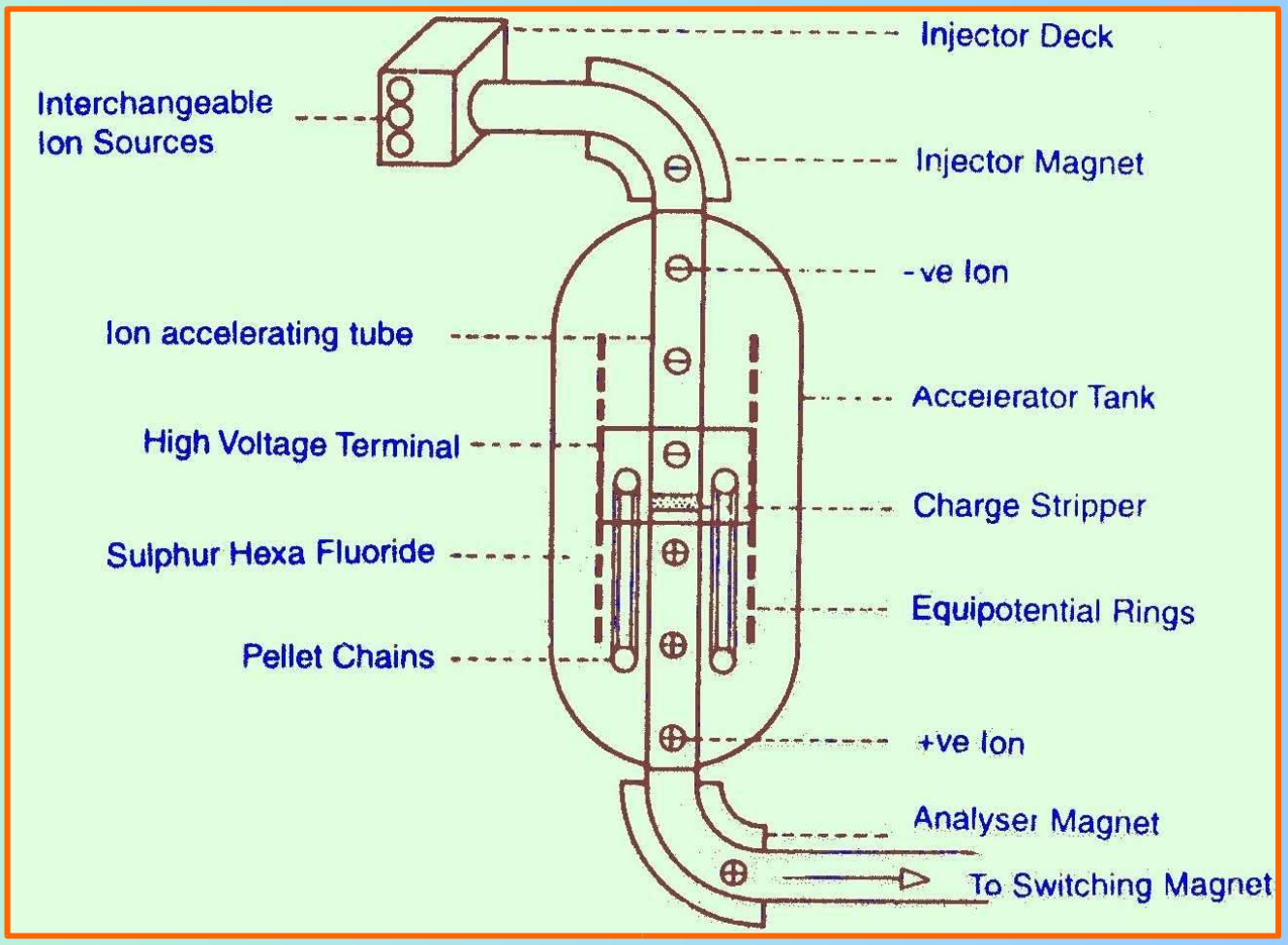
Accelerator tubes and equi-potential rings installed



Acceleration of ions in a tandem

Total energy of the ion = (q+1)V where V is the terminal voltage and q is charge state after stripping at the terminal.

The charge stage and the beam energy can be enhanced by inserting a second striper downstream to the terminal.



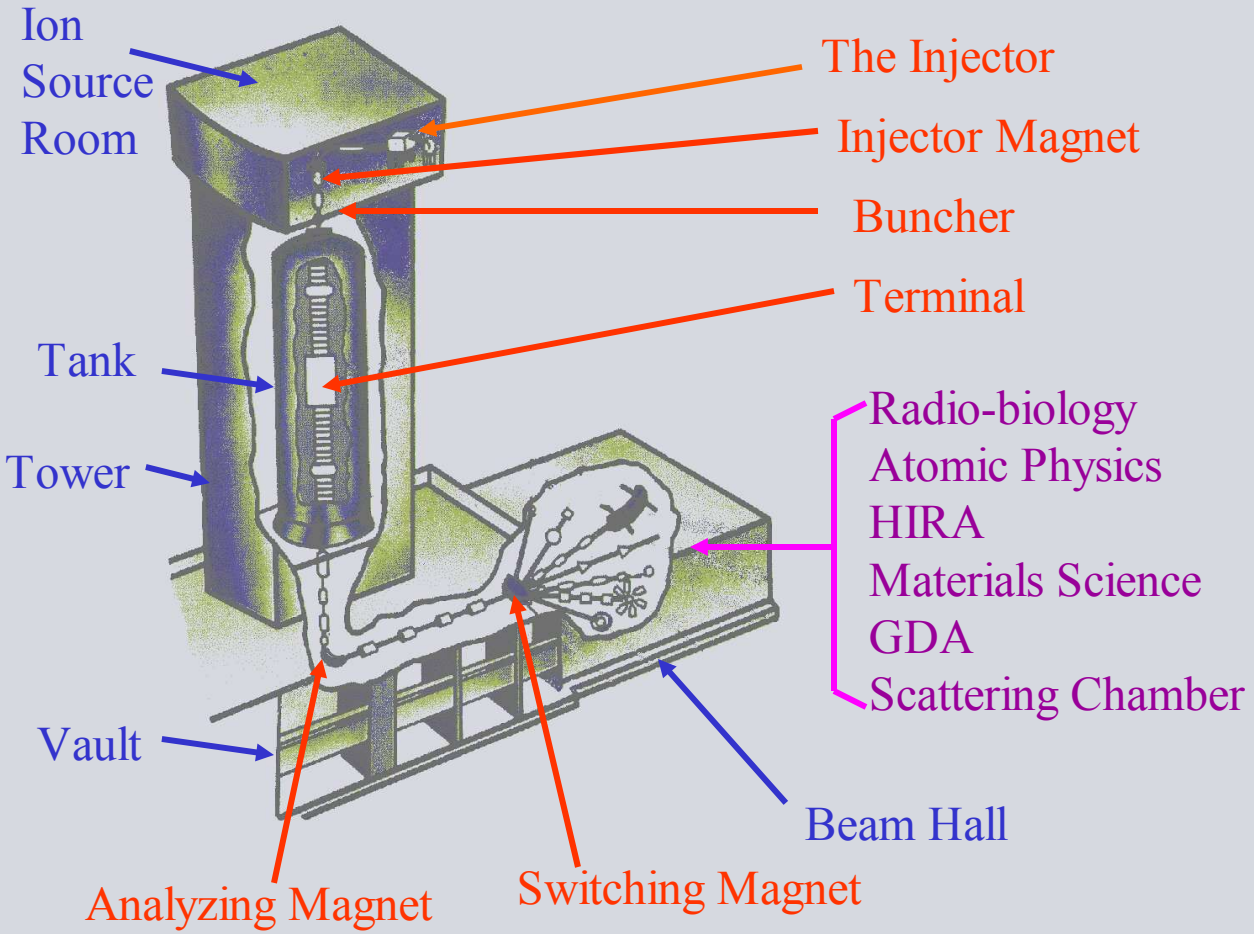
The Pelletron Accelerator

Tank ht: 26.5 m
Diameter: 5.5 m
Pressure: 86 PSI of SF_6 gas

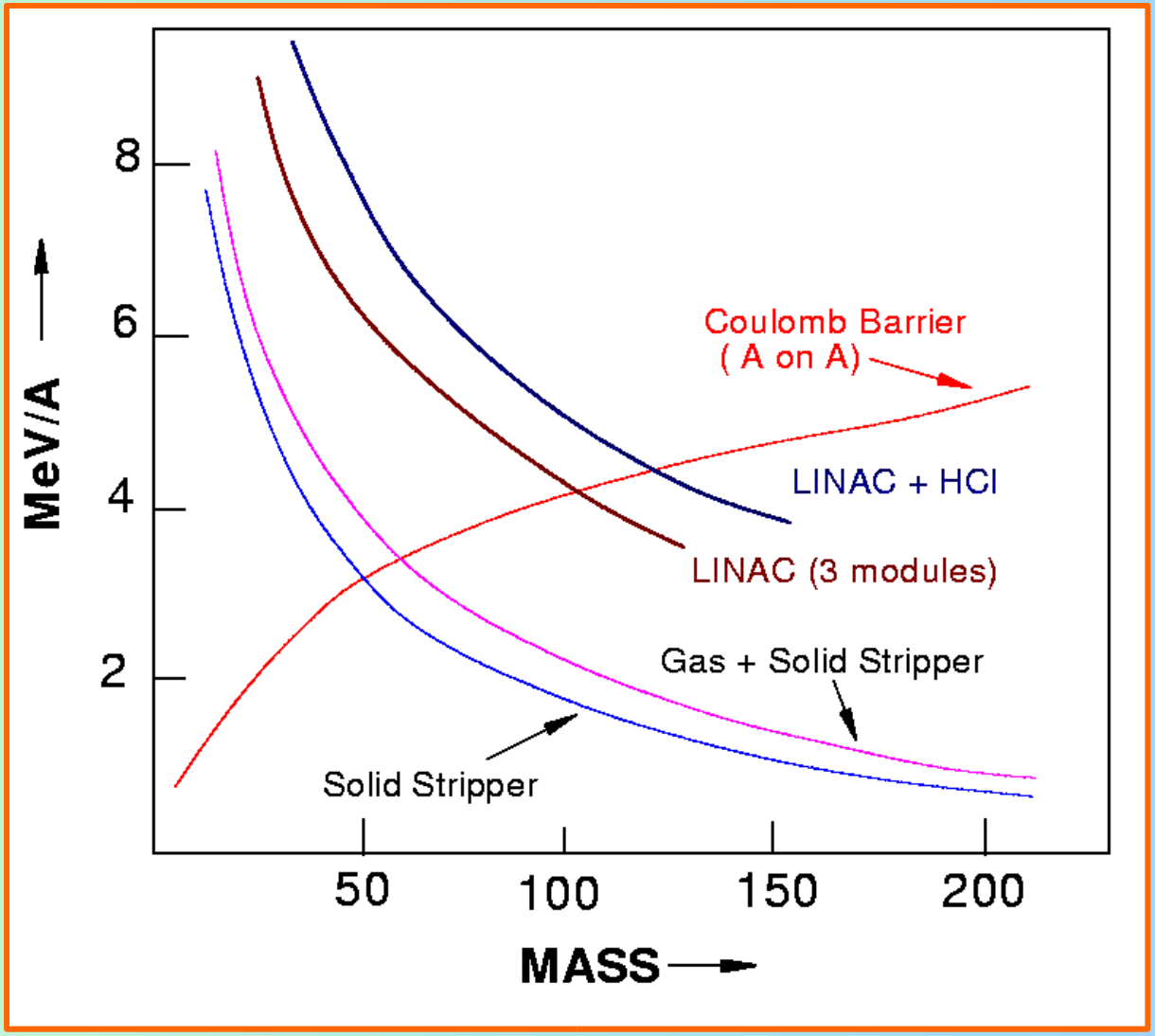
Ions accelerated:
H to Au beams

Ion Currents:
Typically
5 - 50 pnA

Energy : 30 - 250 MeV



Ion Energies from the Accelerator



RESEARCH PROGRAM AT NSC

Basic sciences

Nuclear reactions near Coulomb barrier

High spin spectroscopy

Spectroscopy of highly charged ions

Interaction of swift heavy ions with materials

Applied Research

Materials characterization

Materials Modification

Device fabrication

Interdisciplinary areas

Radiation Chemistry

Radiation Biology

Accelerator Mass spectroscopy

Archeology, Geology, Oceanography e.t.c

EXPERIMENTAL FACILITIES FOR NUCLEAR PHYSICS

GAMMA DETECTOR ARRAY (GDA)

setup by Delhi,Punjab, Andhra, BHU, Bombay and MS(Baroda) University

High Spin spectroscopy

Life-time measurements

HEAVY ION RECOIL ANALYSER (HIRA)

setup by Calicut, Bangalore,Andhra,MSU , Punjab, NEHU, BHU, AMU, Bombay, Delhi, Saurastra and MadrasU

Heavy Ion Fusion near Coulomb Barrier

Production of low energy RIB

GENERAL PURPOSE SCATTERING CHAMBER

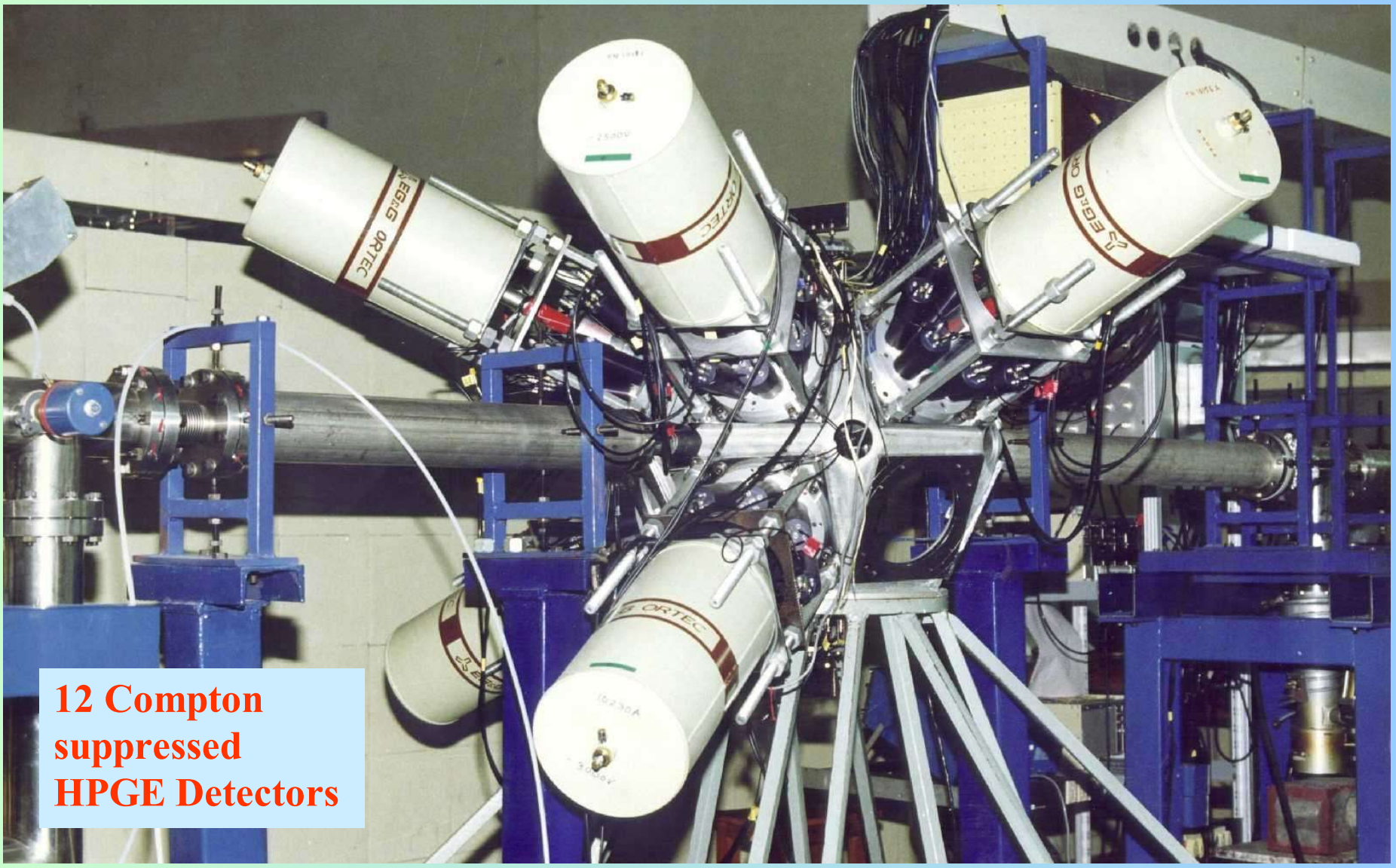
setup by Bangalore, Gulbarga & Mysore U

Heavy Ion Scattering and transfer reactions

Projectile Breakup

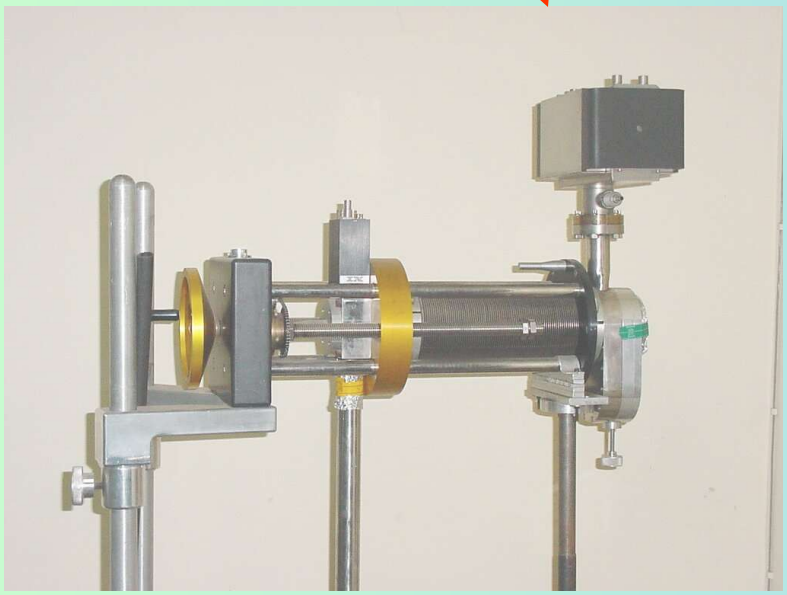
Materials Science

GAMMA DETECTOR ARRAY (GDA)

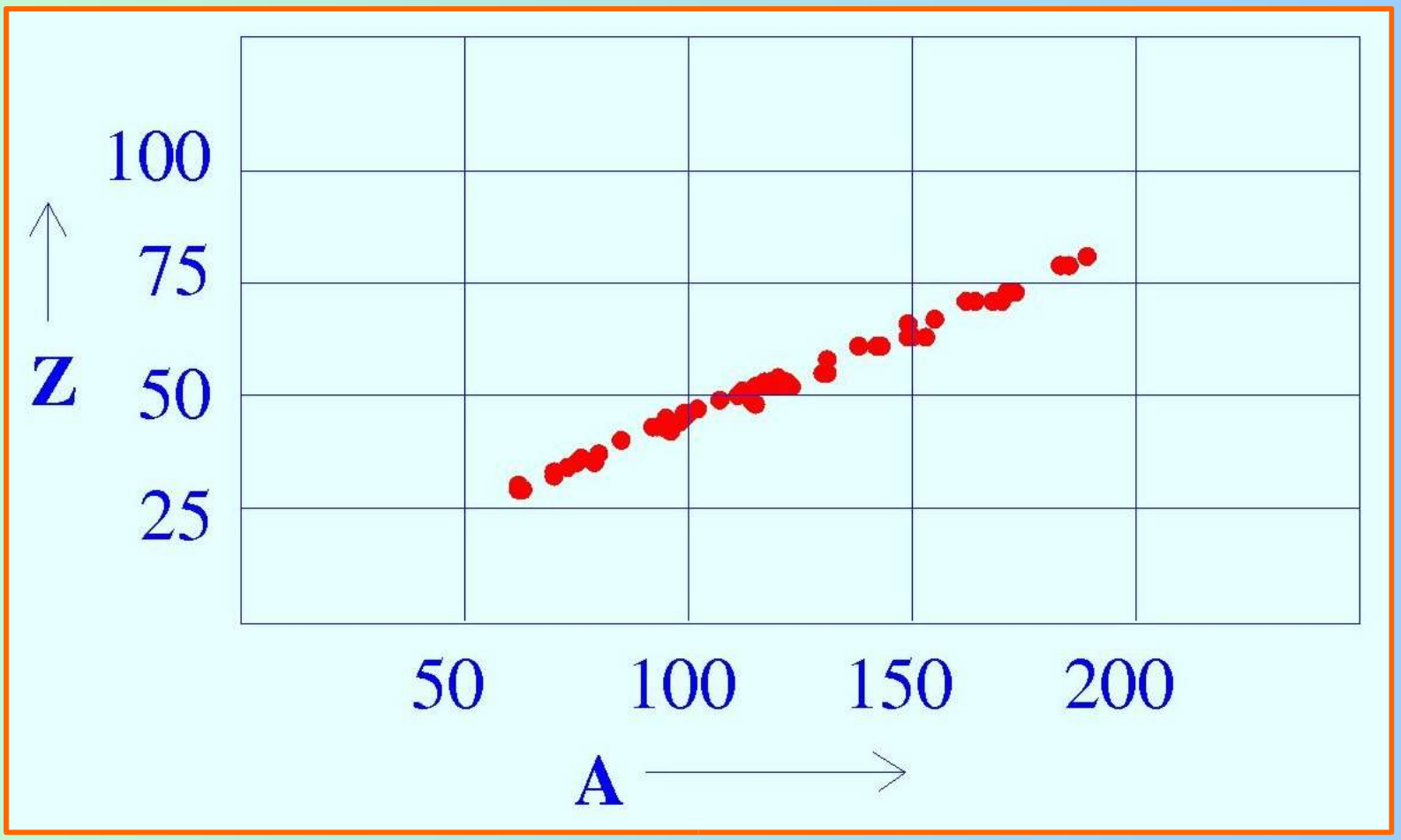


ANCILLARY FACILITIES WITH GDA

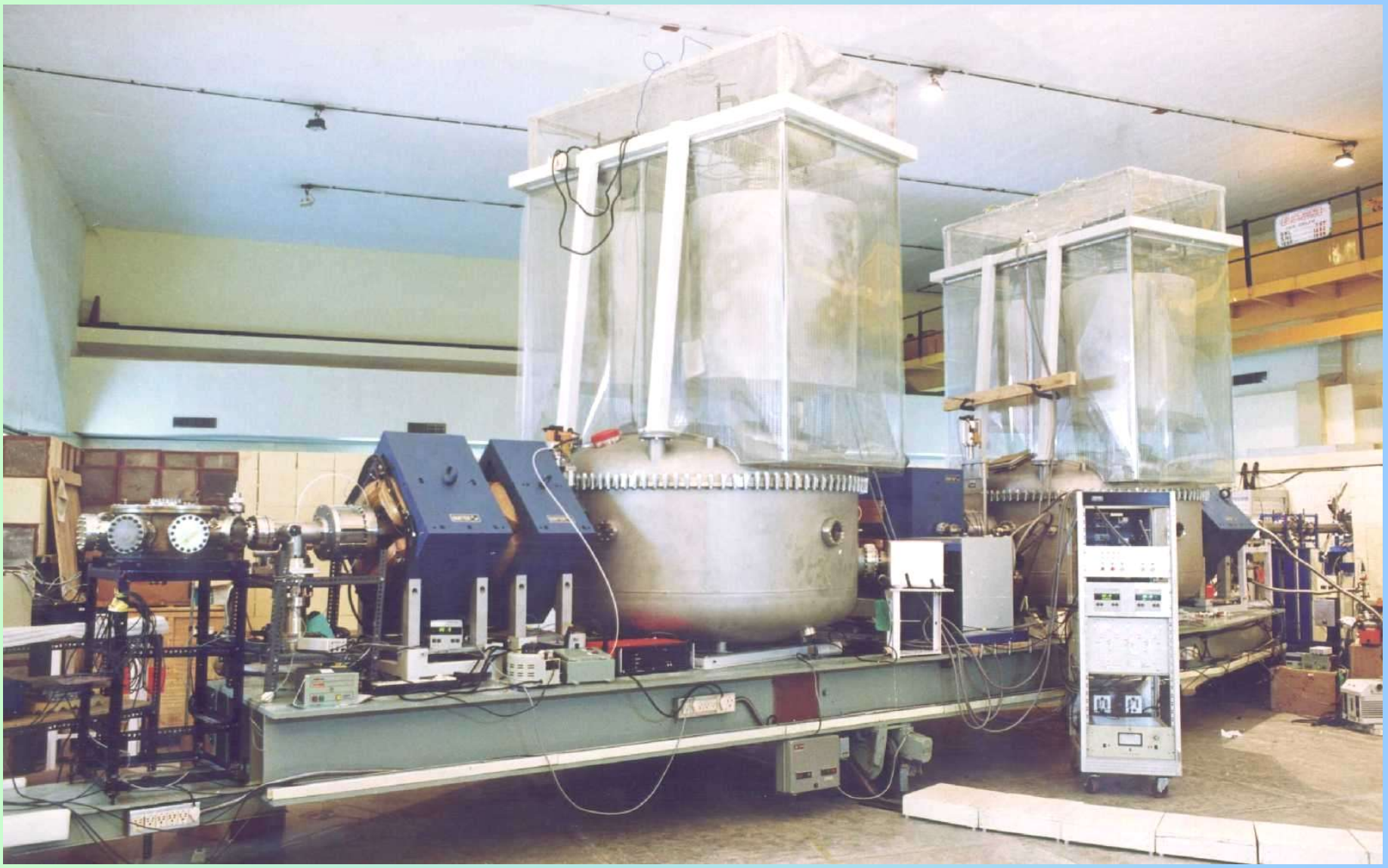
BGO Multiplicity Filter	*MS(Baroda)*
Charged Particle Detector Array	*Delhi, Bombay*
Electromagnet for PAC studies	*Panjab U*
RDM Setup for lifetime measurements	*Delhi U*
Electron Spectrometer	*Panjab U*



List of nuclei studied using GDA facility



HEAVY ION REACTION ANALYSER (HIRA)



Research Programs with HIRA

- Nuclear Reactions around the Barrier region
- Recoil tagged gamma spectroscopy
- Focal Plane Radioactivity
- Studies with secondary beams from HIRA

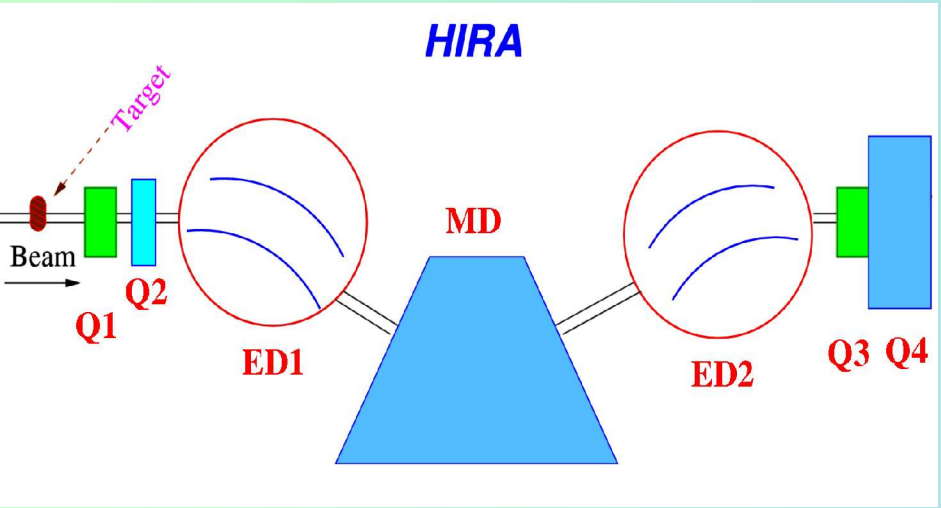
Systems studied

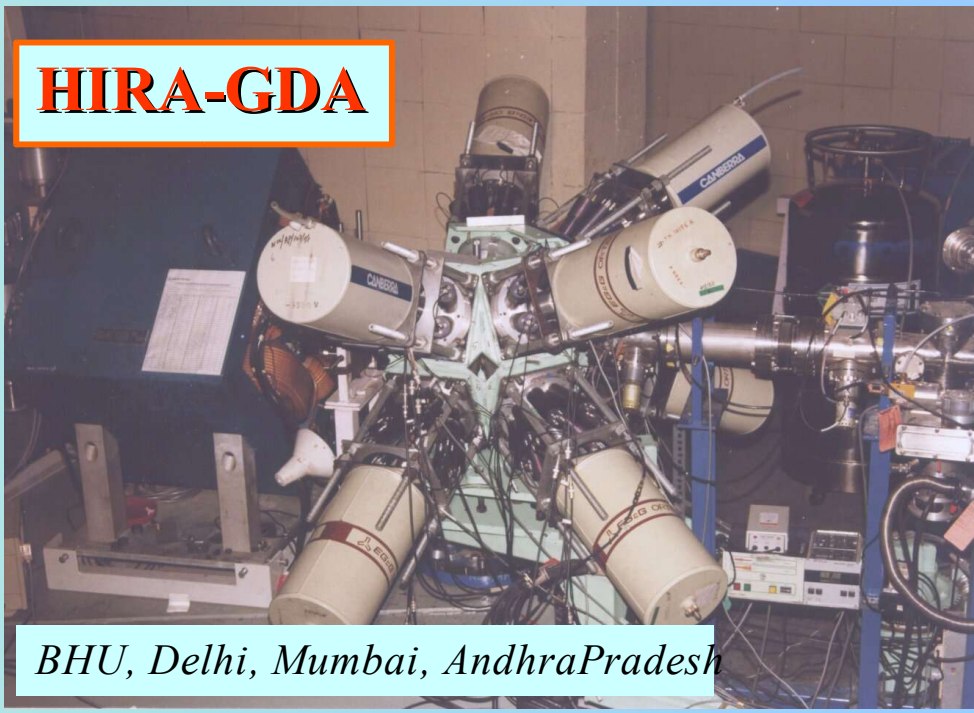
$^{28}Si + {}^{64}Ni$ $^{32}Si + {}^{64}Ni$

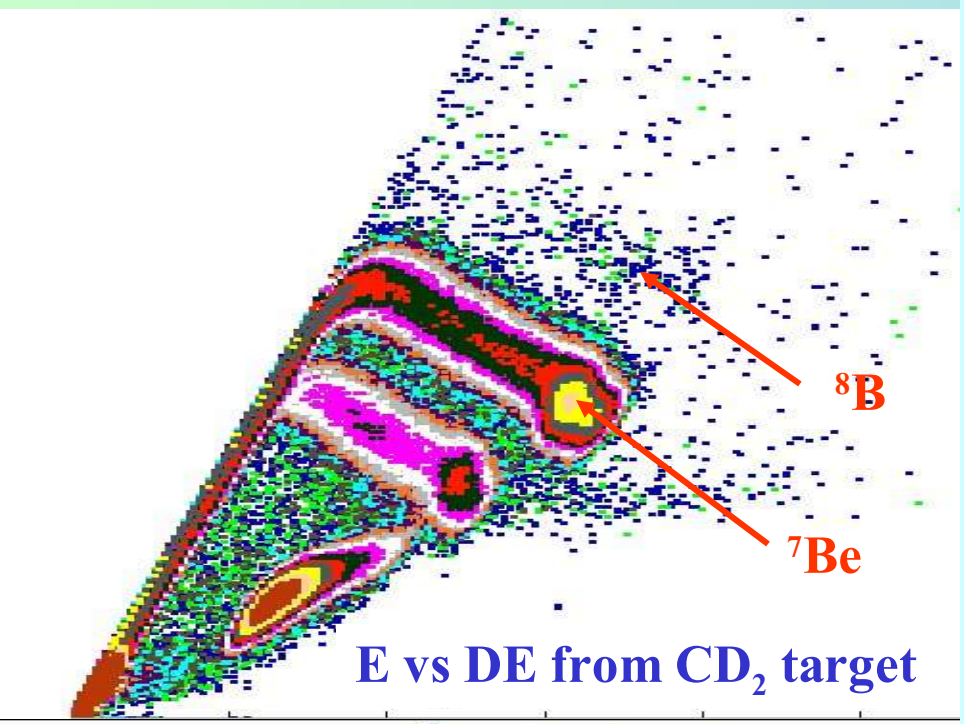
$^{28}Si + {}^{144}Nd$ $^{46}Ti + {}^{64}Ni$

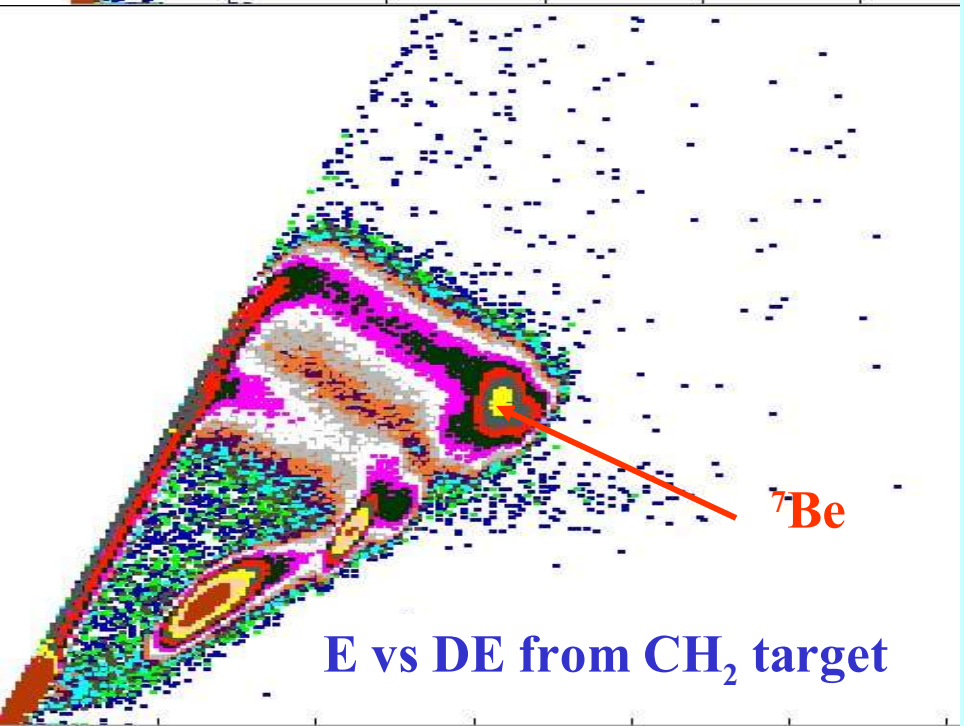
$^{50}Ti + {}^{60}Ni$ $^{48}Ti + {}^{58,60,64}Ni$

$^{19}F + {}^{93}Nb$ $^{19}F + {}^{175}Lu$









LOW ENERGY RIB FACILITY AT NSC

HIRA facility has been used to separate out the reaction products from the direct beam using the excellent momentum resolution offered by the magnetic dipole element of HIRA. The reaction p(^{7}Li,^{7}Be)n has been used to produce a low energy (11-22 MeV) beam of ^{7}Be with better than 99.99% purity and 3 mm diameter spot size (5x 10^{4} ions/sec intensity).

The angular distribution of the transfer reaction d(^{7}Be,^{8}B)n at E_{cm} = 4.5 MeV, has been measured for the extraction of S17.

Other Radioactive Ion Beams (^{6}He,^{8}Li,^{11}C & ^{17}F) are planned in future.

EXPERIMENTAL FACILITIES FOR MATERIALS SCIENCE

HIGH VACUUM CHAMBER

setup by Kurukshetra, Hyderabad, JNU, Poona Universities, IIT (Delhi) and IISC, Bangalore

Iono/photo luminescence

Elastic Recoil Detection Analysis

Electrical Transport

Conduction Noise

UHV CHAMBER

Scanning Tunneling Microscopy (STM)

Residual Gas Analysis

GONIOMETER CHAMBER

Ion Channeling facility

X-ray Reflectivity

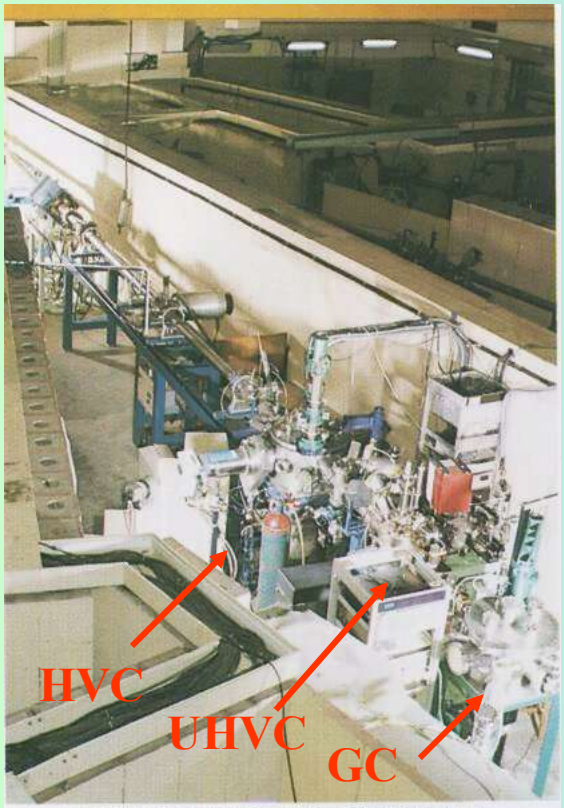
Blocking ERDA

General Purpose Scattering Chamber

in situ Hall Measurement

TOF for Desorption Mass Spectrometer

GONIOMETER CHAMBER



MATERIALS SCIENCE BEAM LINE

ULTRA HIGH VACUUM CHAMBER

HIGH VACUUM CHAMBER

MATERIALS SCIENCE RESEARCH - AN OVERVIEW

Engineering of Electronic Materials & Devices: ion beam induced modifications in amorphous/ crystalline semiconductors

High Tc Superconducting Materials: Flux pinning

Colossal Magnetic Resistance Materials: change of R and T_p in $La_xCa_xMnO_3$

Modifications of surfaces & interfaces: Ion beam mixing of Ti/Si & Fe/Si , Cr on SS-304 steel

Diamond Like Carbon Films: hydrogen loss

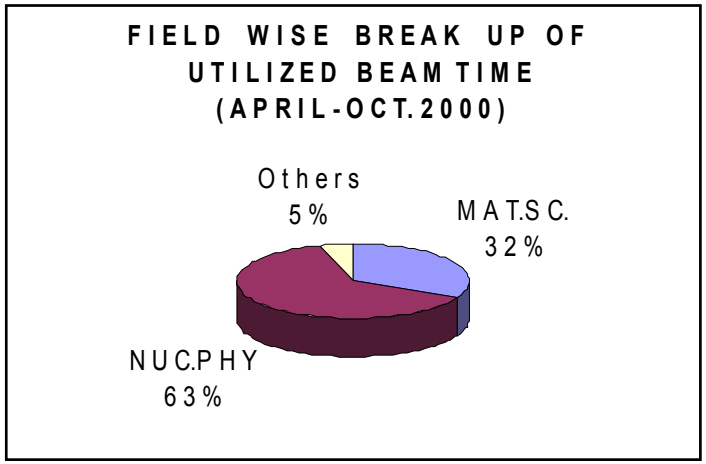
Swift Heavy Ions in Polymers: Generation of micropores

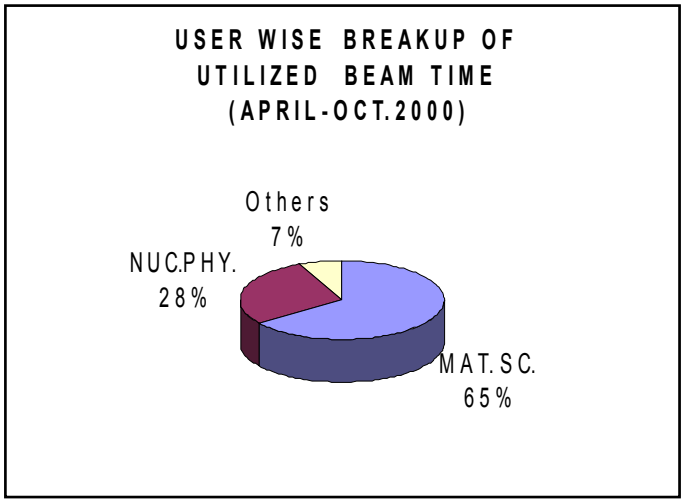
Dynamic Studies during irradiation: online resistivity measurements in superconductors

Optical Waveguide formation in Organic Crystals: irradiation by 100 MeV Ag ions

Noise Measurements : ion induced defects in semiconductors, HTC and CMR materials

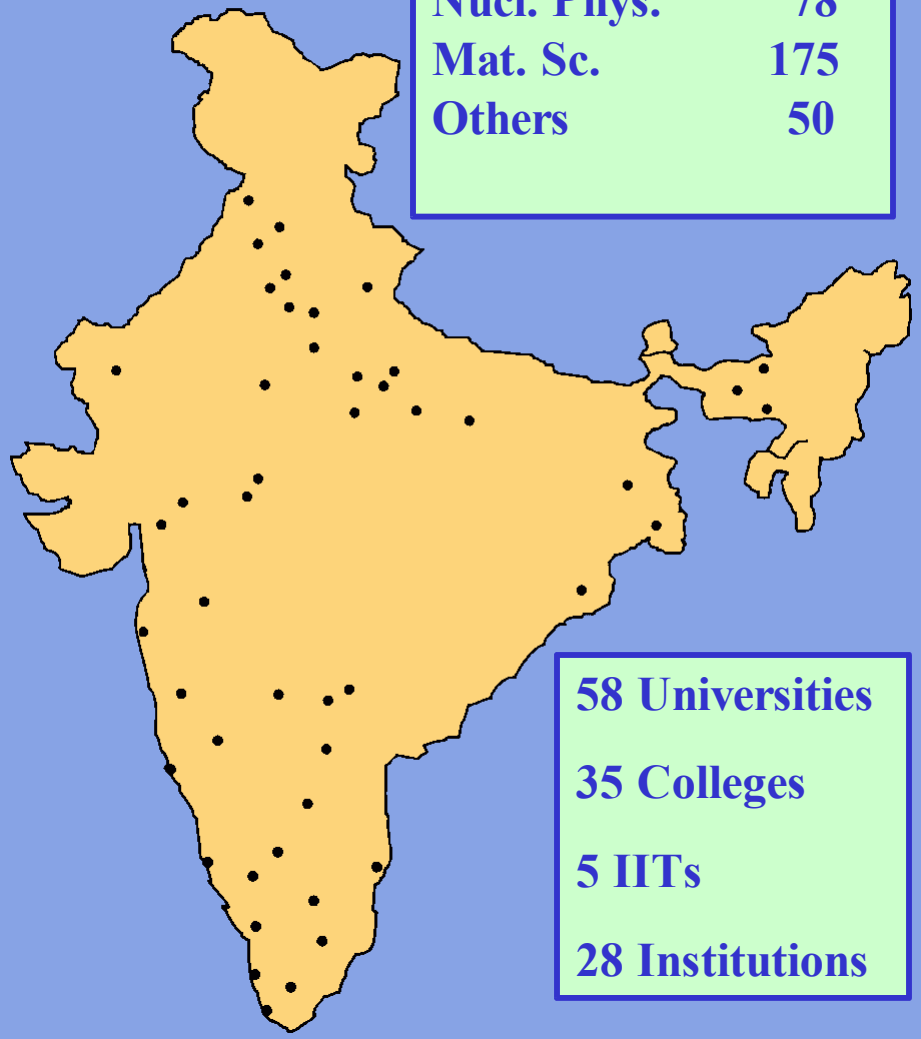
USER COMMUNITY OF NSC





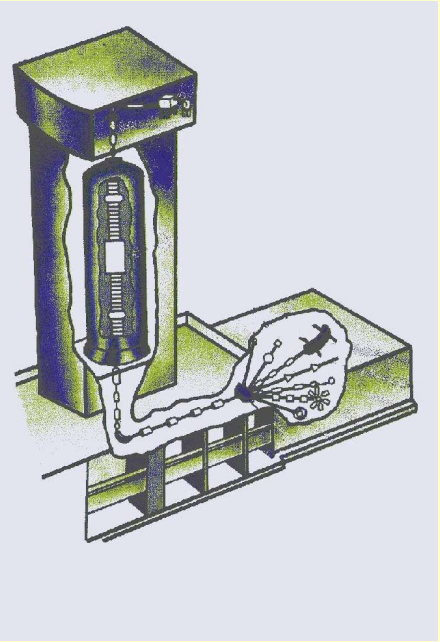
250 users

Publications	(-2000)
Nucl. Phys.	78
Mat. Sc.	175
Others	50



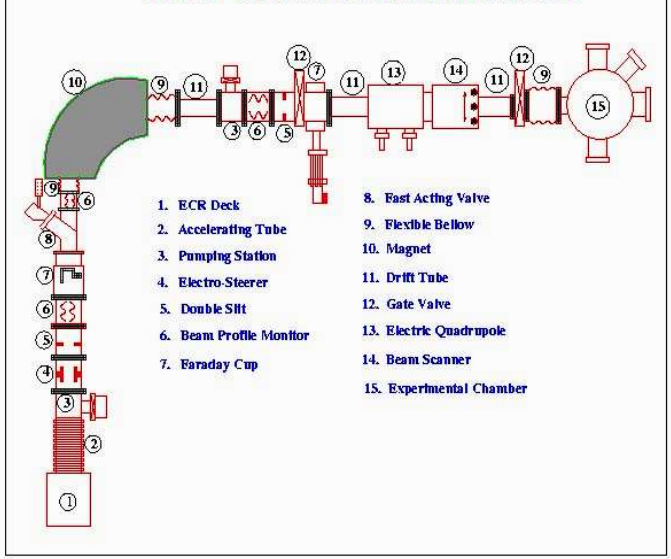
- 58 Universities
- 35 Colleges
- 5 IITs
- 28 Institutions

ACCELERATOR UPGRADATION



- UPGRADATION OF BUNCHER ELECTRONICS
- MODIFICATION IN TRAVELLING WAVE DEFLECTOR
- SINGLE GAP MULTIHARMONIC BUNCHER
- PASE LOCKING OF PELLETRON BEAM
- INDEGINEOUSLY DEVELOPED DATA ACQUISITION & CONTROL
- FARADAY CUP AT POST ACCELERATION STAGE
- CAPACITIVE PICK UP LOOPS FOR THE CHAINS
- CHARGING SYSTEM FOR ON LINE MONITORING
- RESISTANCE BASED VOLTAGE GRADIENT
- RECIRCULATING GAS STRIPPER SYSTEM
- CONVERSION OF DOUBLET TO SINGLET UNITS
- STRIPPER POSITION READBACK
- INDIGENOUSLY DEVELOPED 16 CORE FIBER OPTIC CABLE CONNECTOR
- INDIGENOUS DEVELOPMENT OF ACCELERATOR COMPONENTS

LEIBF Program



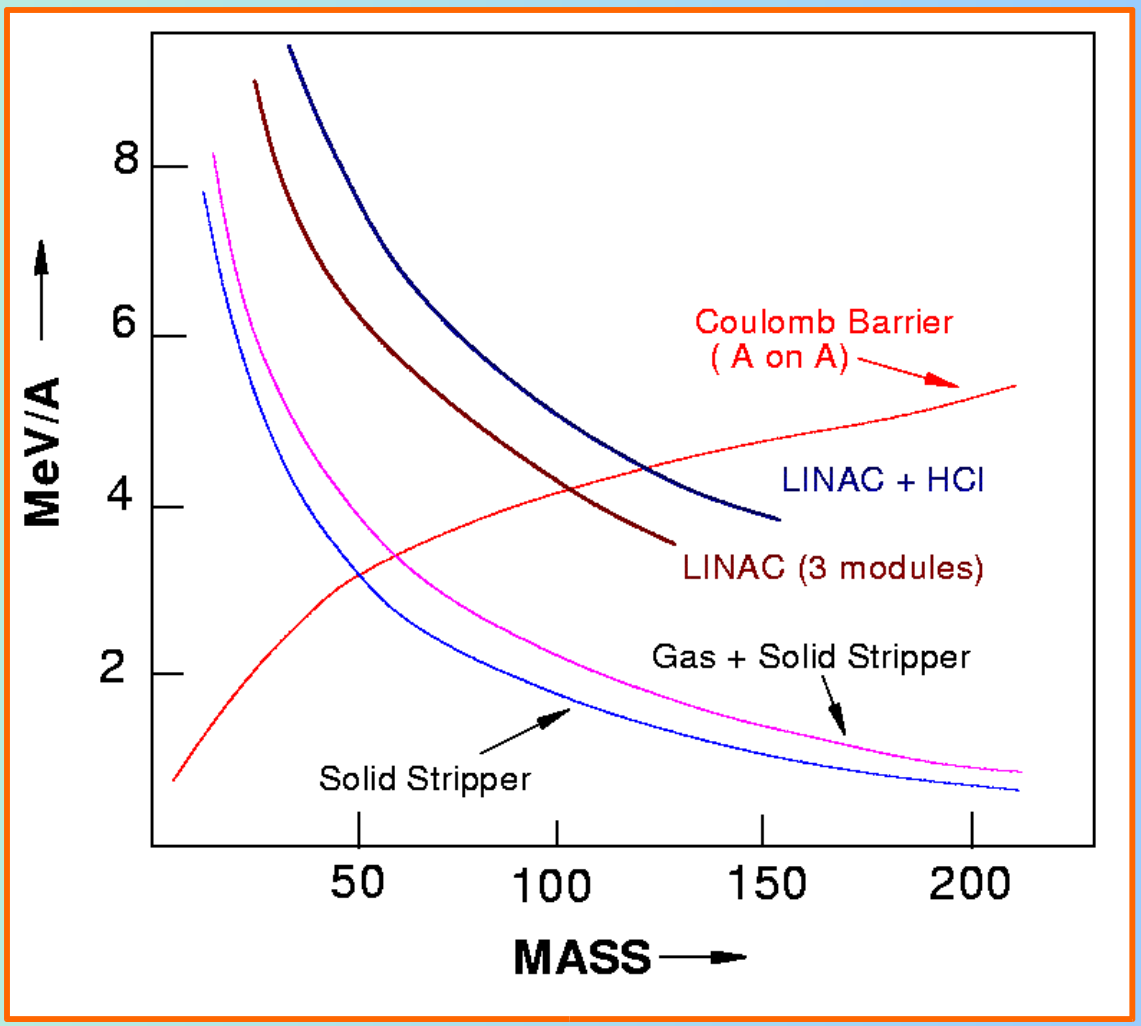
Unique ECRIS based multiply charged ion beam facility having energy in the range of a few tens of keV to a few MeV

Low Energy Ion beam synthesis of SiC and formation of Nano-crystals, Ion Implantation, Ion Beam Induced epitaxial recrystallisation; atomic physics with highly charged ions

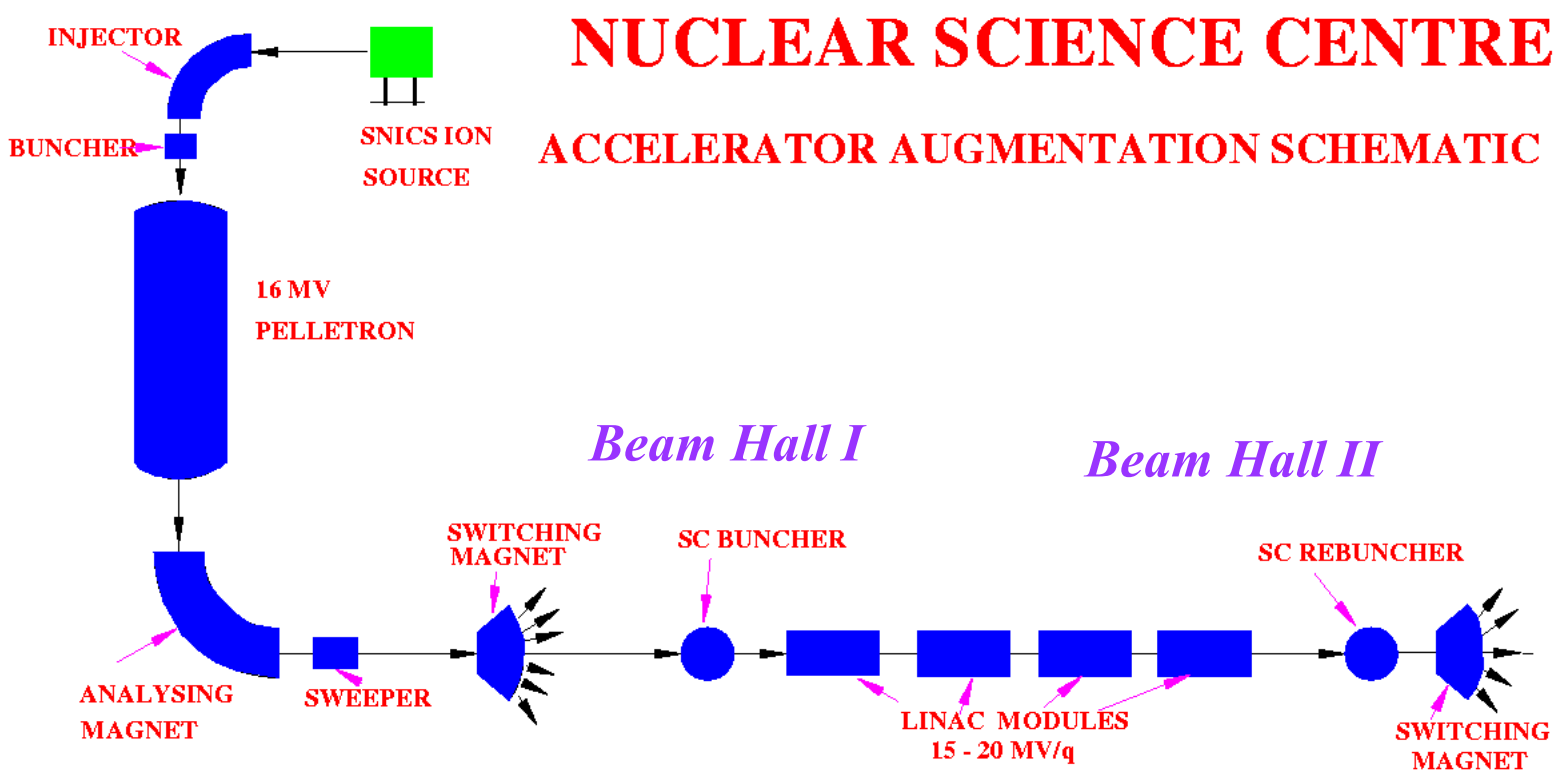
ENERGY AUGMENTATION PROGRAM

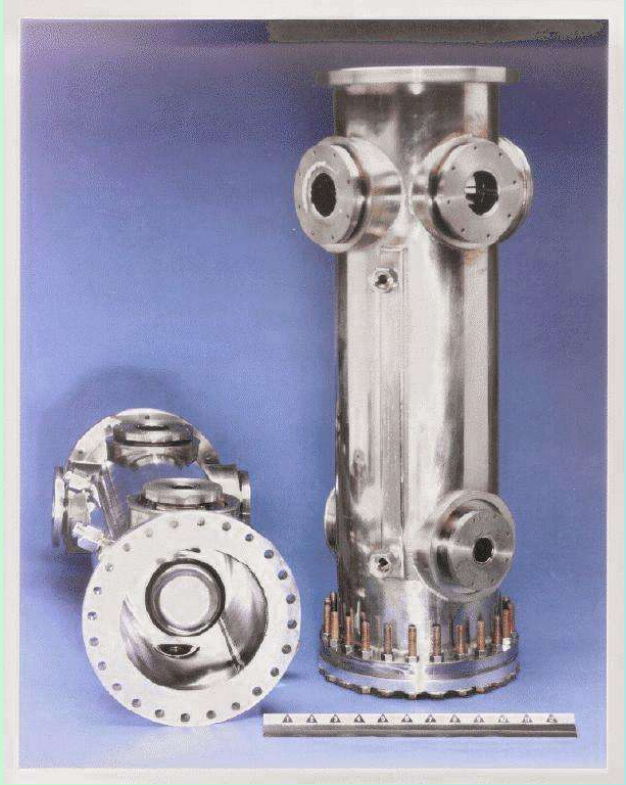
The maximum energy of ions from the Pelletron (~ 200-250 MeV) limits the research program for both nuclear physics and materials science. A superconducting LINAC booster was planned in early 90's for future augmentation of the Pelletron.

The ion energies from the LINAC can be further enhanced by replacing the Pelletron by a high intensity high charged state ion source like ECR.

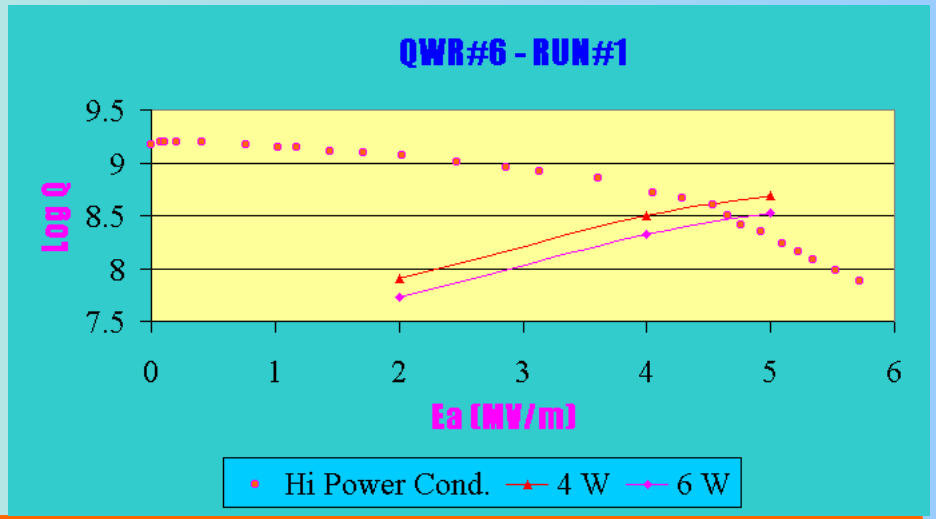


ENERGY BOOSTER LINAC FOR NSC PELLETRON



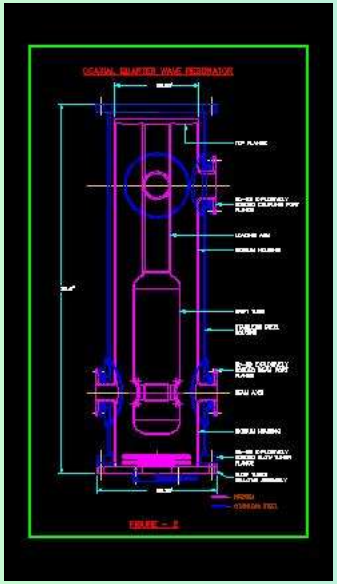


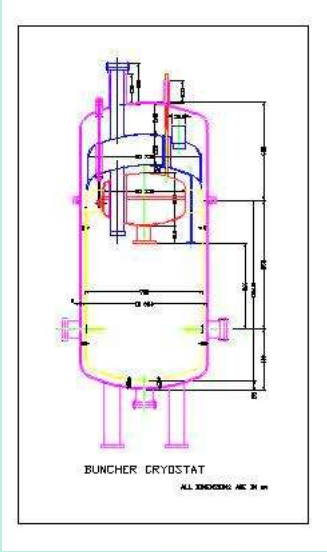
SUPERCONDUCTING LINAC PROJECT

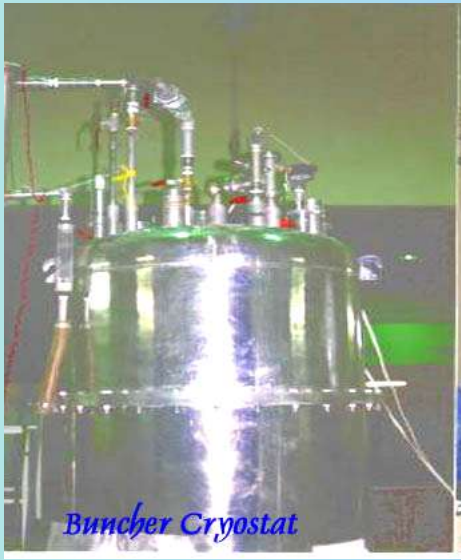


Nuclear Science Centre in collaboration with Argonne National Laboratory, U.S.A., has developed RF superconducting Niobium quarter wave coaxial line resonators for accelerating ions from our Pelletron accelerator up to mass A=100. The resonators will operate at 97 MHz and are optimized for particle velocity (v/c)=0.08 . Resonators are formed entirely of niobium and are jacketed in stainless steel vessels which contain the liquid helium. A stainless steel to Niobium explosively bonded flange provides the welding transition between niobium and stainless steel. A novel pneumatic slow tuner in the form of a niobium bellow provides a tuning range of approximately 100 kHz, substantially larger than any working QWCL resonator. First beam test of the cavity to be used as Superbuncher is planned in March, 2001.

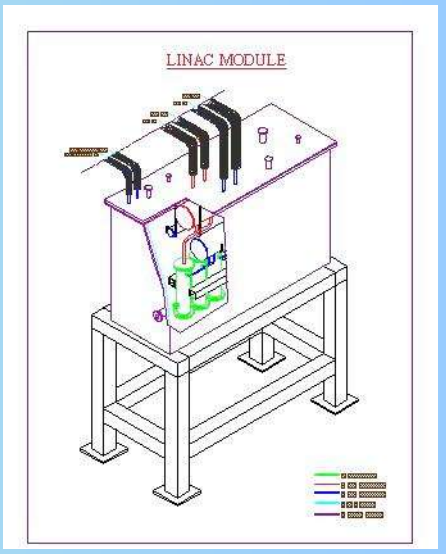
Cryogenics Facility



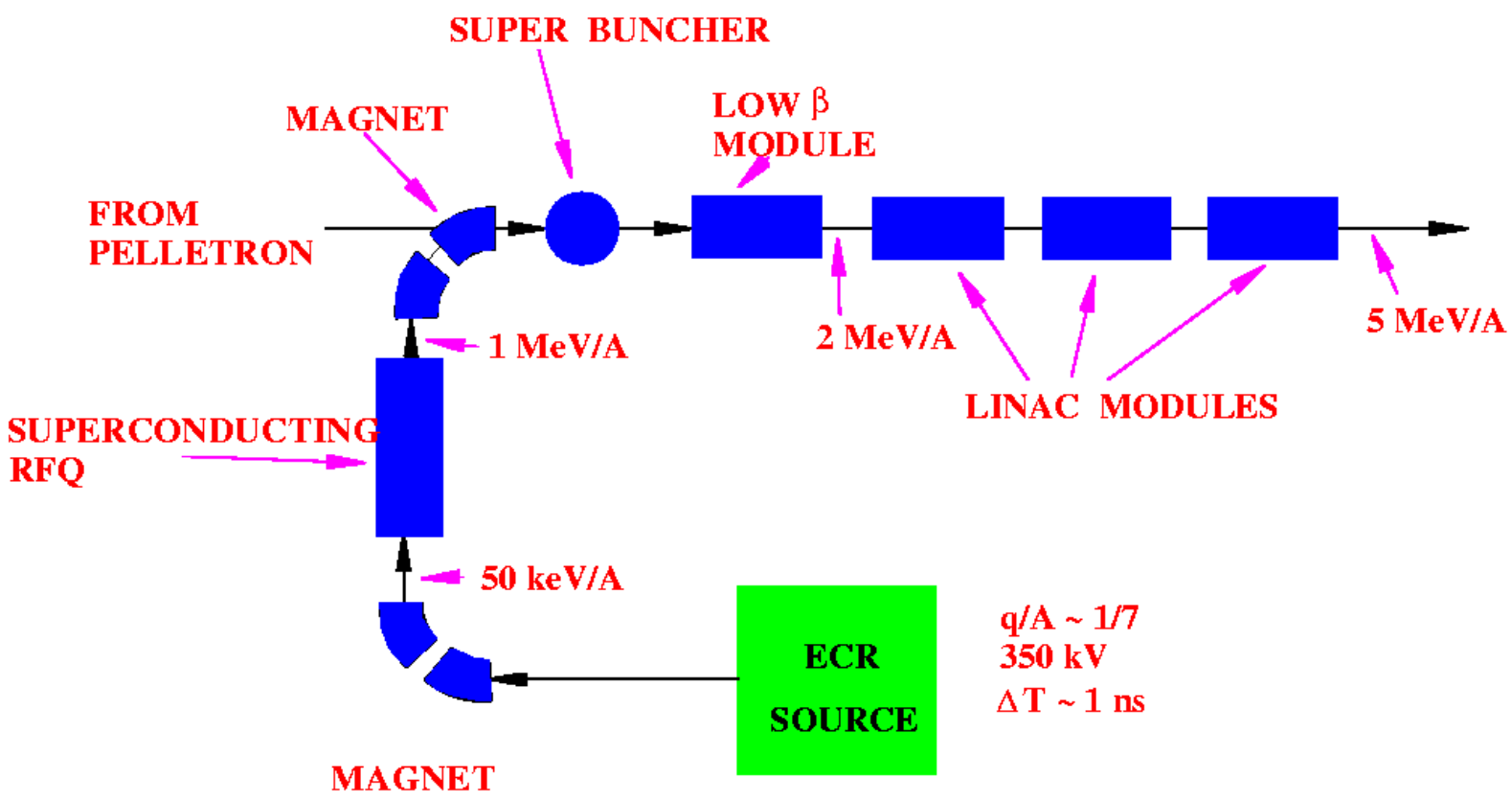




The Cryogenic distribution system for LINAC is one of the largest such facilities in India. It has a Helium refrigeration system with 600 W capacity and a closed loop liquid Nitrogen plant of capacity 5000 W.



ECR based High Current Injector for LINAC



LANDMARK DATES

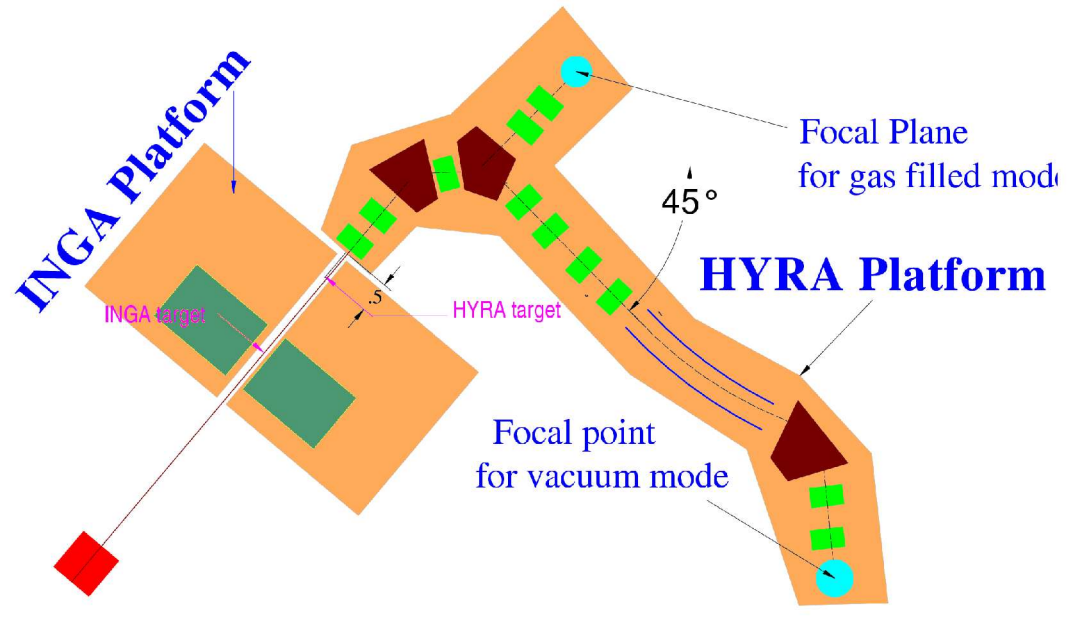
NSC established	Nov, 1984
Construction started	Dec, 1986
Pelletron commissioned	Dec, 1990
GPSC installed	Apr, 1990
1st user beam	July, 1991
GDA commissioned	Aug, 1991
HIRA commissioned	Dec, 1991
ANL project for LINAC	Mar, 1992
Materials Science beam	Mar,1993
LEIBF commissioned	**July,2000**

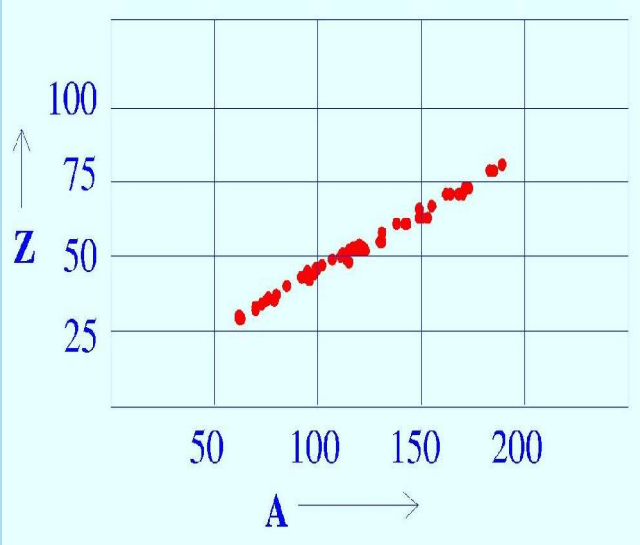
FUTURE PROJECTIONS

Resonators from ANL	Sept,2000
In-beam test of Superbuncher	Mar,2001
1st LINAC Module	Dec, 2001
Beam in Phase II area	July, 2002
3 LINAC modules	July, 2004
High current Injector Project	Dec, 2007

? ? ? ? ?

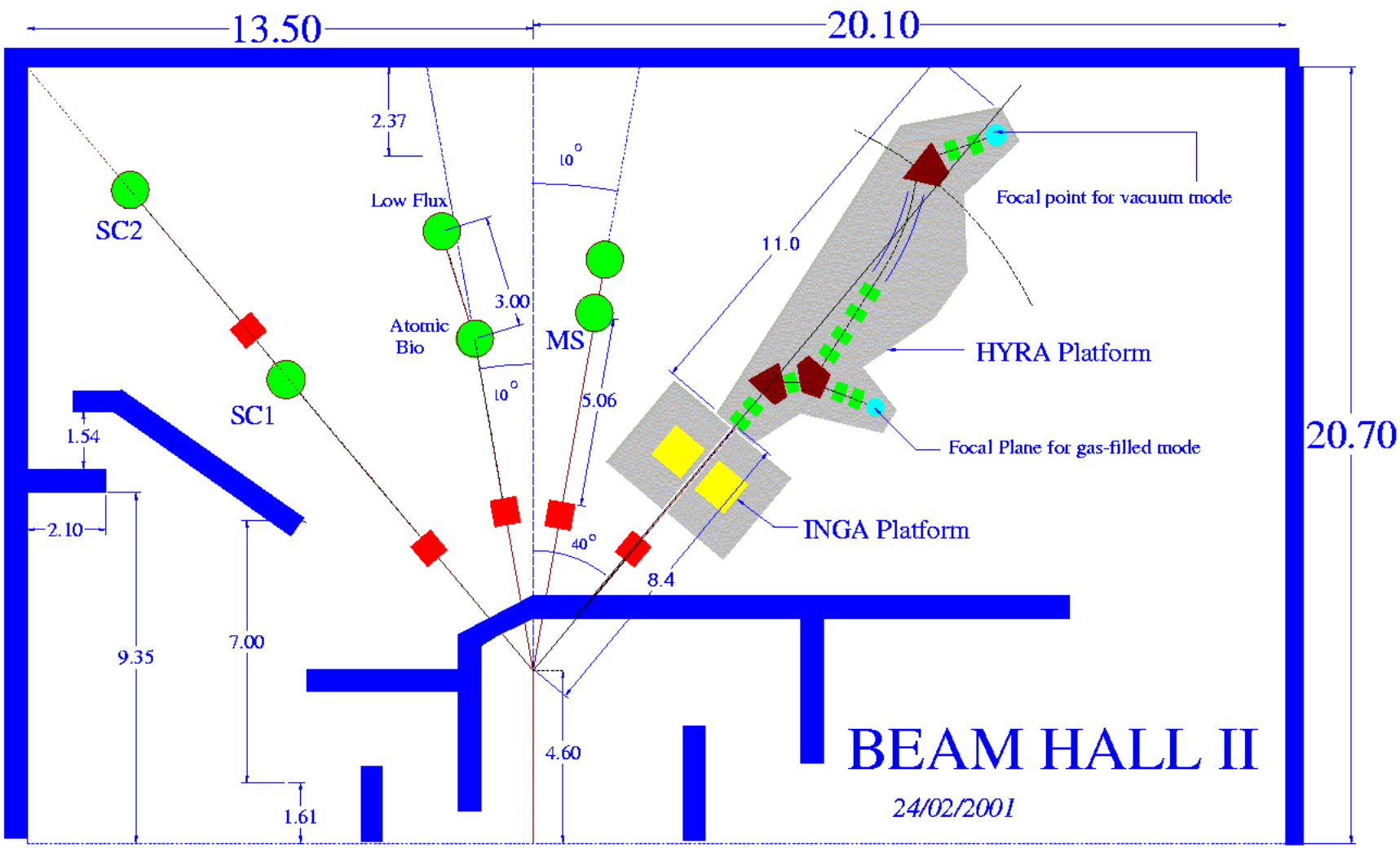
Experimental Program for Beam Hall II





One of the major objectives of increasing the beam energy is to make new areas to be accessible to the user. As can be seen from the accompanying figure,the mass regions A > 200 and A < 60 in inverse kinematics would become available after LINAC installation. Two major projects (LGA & HYRA) for studying these mass regions for nuclear spectroscopy and reaction dynamics were submitted to DST.

We are glad to inform the user community that these two projects have been approved by DST. LGA would now be implemented as part of the Indian National Gamma Array (INGA) composed of 24 Compton-suppressed Clover detectors.DST would initially provide funding for six detectors, and the rest would be obtained by pooling from other research institutions in the country (TIFR, BARC,IUC-DAEF, SINP and VECC.


13.50
20.10
2.37
10°
Low Flux
SC2
3.00
Atomic
Bio
MS
10°
5.06
SC1
11.0
Focal point for vacuum mode
HYRA Platform
Focal Plane for gas-filled mode
INGA Platform
20.70
1.54
2.10
40°
8.4
9.35
7.00
4.60
1.61
BEAM HALL II
24/02/2001

Experimental facilities for Nuclear Physics

All the experimental facilities in Beam hall I were installed in collaboration with various university groups. We plan to use the same modus-operandi for the facilities in Beam hall II area.

The users are requested to come forward and participate in the various workshops planned this year for forming working groups in various facilities.

- June 19 : Workshop on RIB
- June 20 -21: Nucl. Phys. Facilities
- Sept 20-21: Physics with Large Gamma Array coupled with HYRA

THRUST AREAS IN MATERIALS SCIENCE

NSC is augmenting the ion-beam facilities to provide the user community with ions of energies ranging from a few keV to hundreds of MeV and mass ranging from 1 to 200. To exploit the various online/ *in-situ* facilities, the following thrust areas of research in materials science have been identified :

- ☞ Ion beam induced crystallization
- ☞ Transient-enhanced diffusion
- ☞ Ion-beam mixing in multi-layers
- ☞ Electronic sputtering
- ☞ Nano materials :synthesis by ion beam

Users are requested to contact Dr. N.C. Mishra for further details.

FUTURE POSSIBILITIES