ROLE OF INDIA IN BUILDING THE FACILITY FOR ANTIPROTON AND ION RESEARCH

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Theme Meeting on FAIR Science : Panjab University, Chandigarh

FAIR

विज्ञान एवं प्रौद्योगिकी विभाग
DEPARTMENT OF
SCIENCE & TECHNOLOGY

राष्ट्र की सेवा में परमाणु
परमाणु ऊर्जा विभाग
DAE
ATOMS IN THE SERVICE OF THE NATION

Beginning of Indo-German Cooperation

It all started in 1990-91

Large detectors built at CERN

In collaboration with

GSI, Germany

Journey begins for India at FAIR

Signing of joint ministerial declaration on Indian participation in construction and operation of Facility for Antiproton and Ion Research (FAIR)

7th February 2007

New Delhi, India

FAIR Convention signed : FAIR GmbH formed

4th October 2010

Wisbaden, Germany

Country	
Germany (Federal Gov. and Hessen)	
Russia	
Finland	
France	
India	
Poland	
Romania	
Slovenia	
Sweden	

Bose Institute (Kolkata) is Indian shareholder

DST-DAE Mega Science project

India's contributions: 3% of the total cost of FAIR construction (in-kind)

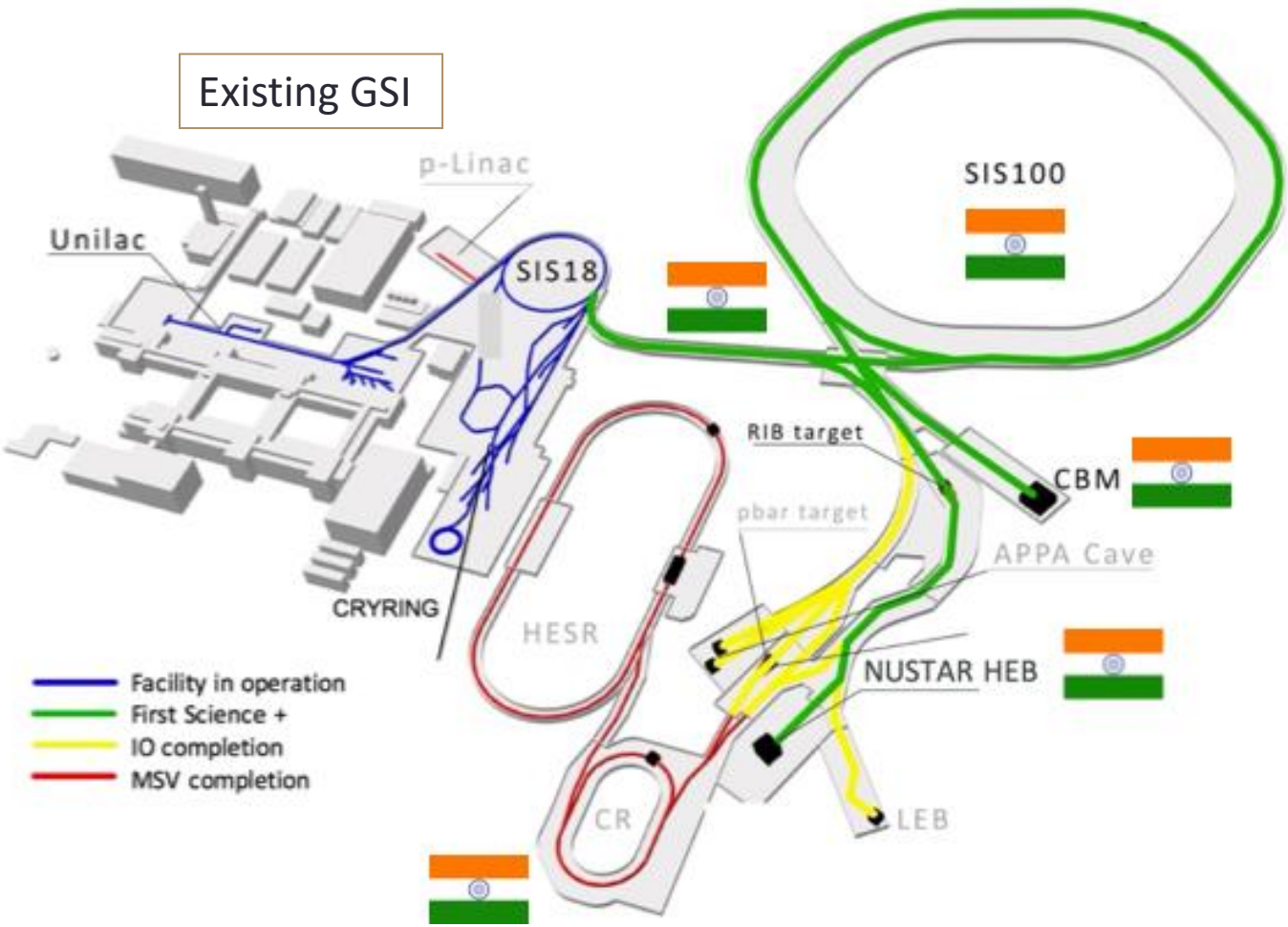
FAIR at a glance

High Intensity beams:
1000 x
For primary HI beam
10 000 x
For radioactive ion beams
10 0 x
For antiproton beams

Primary beams:
10^{12} /s $^{238}U^{28+}$ 1-2 AGeV
$4 \cdot 10^{13}$/s Protons 90 GeV
10^{10}/s U 35 AGeV (Ni 45 AGeV)

Secondary beams:
rare isotopes 1-2 AGeV
antiprotons up to 30 GeV

- Highest Beam Intensities
- Brilliant Beam Quality
- Higher Beam Energies
- Highest Beam Power
- 4 parallel operations



Realizing FAIR in steps

- **Early Science (ES):** FAIR pre-cursor programme at the Super-Fragment-Separator (S-FRS) and NUSTAR High-Energy Branch (HEB) served by beams from SIS18.

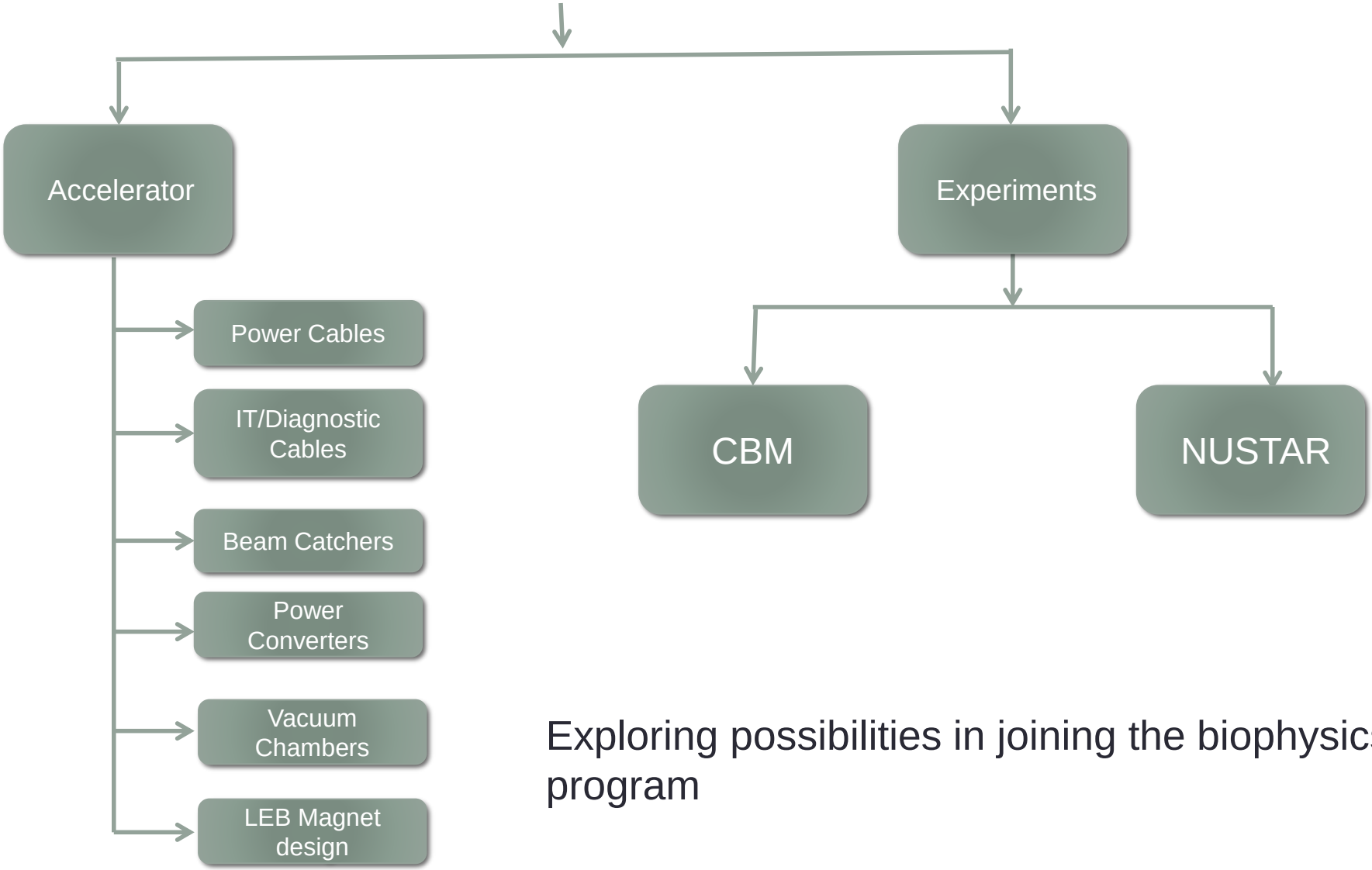
- **First Science (FS):** first science at the Super-Fragment-Separator (S-FRS) and NUSTAR High-Energy Branch (HEB) served by beams from SIS100.

- **First Science + (FS+):** in addition to FS the CBM branch served by beams from SIS100.

- **First Science ++ (FS++):** in addition to FS+:
  - the branch into the APPA cave, and
  - the NUSTAR Low-Energy Branch (LEB)

India @ FAIR

3% share in FAIR GmbH

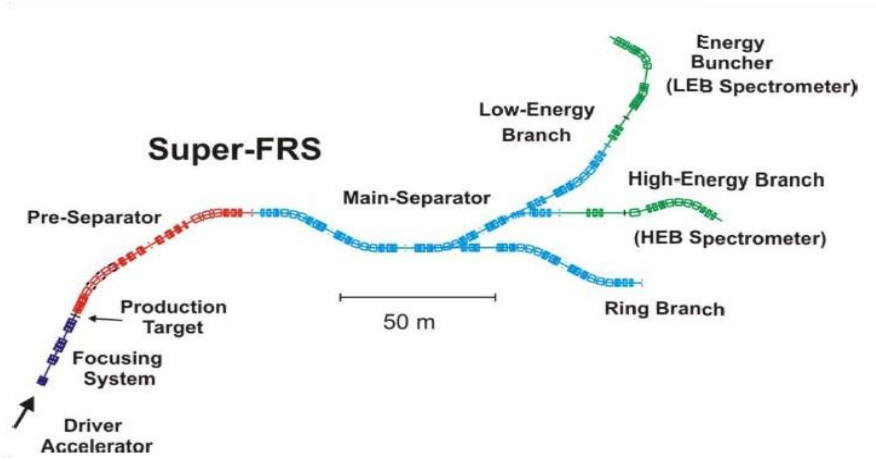


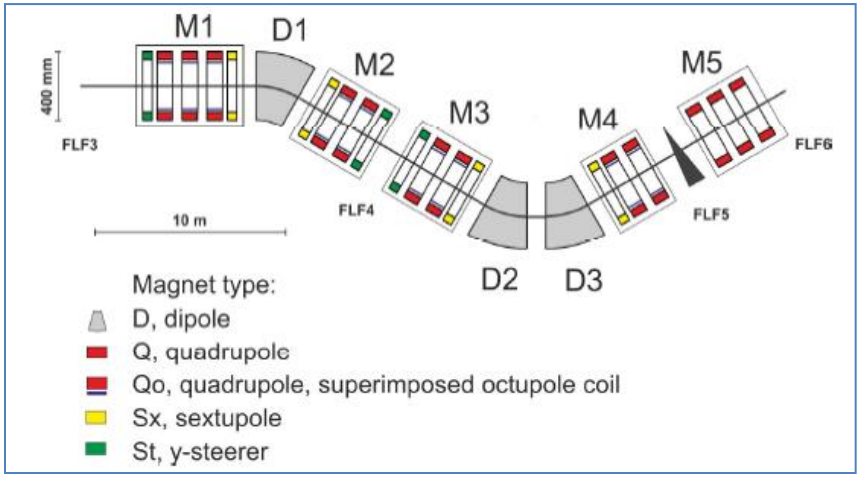
Exploring possibilities in joining the biophysics program

LEB Magnets

❖ Low Energy Buncher (LEB) of the Superconducting Fragment Separator (Super-FRS) - device for particle identification after secondary reactions

❖ Dipole, quadrupole and sextupole magnets forming the Energy Buncher have to accept fragment beams requiring large usable apertures with stringent magnetic field quality





- Physics and engineering design and CAD modelling realized
- CDR and FDR cleared
- Production withdrawn due to higher cost
- 0.5 mEuro (2005 price) credited to India
- Indian engineers offered to be consultants for dipoles

Ultra-stable Power Converters

- These are required for powering superconducting and room temperature magnets
- ppm stability in voltage and current
- Both single and dual power supplies
- **Most of the power converters for HEBT quadrupole- and steering magnets are being built by the Indian company ECIL** (Electronics Corporation of India Limited).

- ***Design:*** ***VECC, RRCAT, BARC, ECIL, BI***
- ***Provider:*** ***ECIL, Hyderabad***
- ***Shipped:*** ***454***

Power Converters: built and delivered

Ultra-high Vacuum Chambers

- Thin-walled chambers to house the beam diagnostic equipment.
- To maintain a vacuum level of 10^{-9} millibar pressure.
- Challenging features: special quality of steel was to be used as material
- Welding and other manufacturing processes required special handling, multistep cleaning was required to ensure vacuum quality etc.
- A major challenge is to weld up to 7 cylindrical ports on a barrel, which, when completed, should maintain mechanical tolerances at the level of tens of microns. The technology demanded extremes of care and quality control.

UHV Chambers: built and delivered

- ***Design:*** ***VTPL, IUAC, VECC, BI***
- ***Provider:*** ***Vacuum Techniques Pvt. Ltd., Bengaluru***
- ***All 58 chambers have been supplied and accepted by FAIR***

FAIR
Facility for Antiproton and Ion Research in

Certificate of Completion

The components mentioned in Council Decision IV.15.5 was delivered, successfully tested and accepted. Thus a value of 452,400.00 € (@2005 Indian Shareholder Bose Institute).

Council Decision IV.15.5:
The Council assigns the components specified in the Expressions of Interest from India, for contributing in kind to the FAIR Accelerator Facility, to the Indian Shareholder Bose Institute as in-kind contribution.
A detailed in-kind contract including all annexes and complete technical specifications, according to FAIR Council Resolution III.10.1 is to be signed.

The corresponding PSP-Codes are: 2.3.6.3.1.2.1; 2.3.6.5.1.2.1; 2.3.6.5.2.2; 2.3.6.5.3.2.1, HEBT Vacuum Chambers for the Commons subproject.

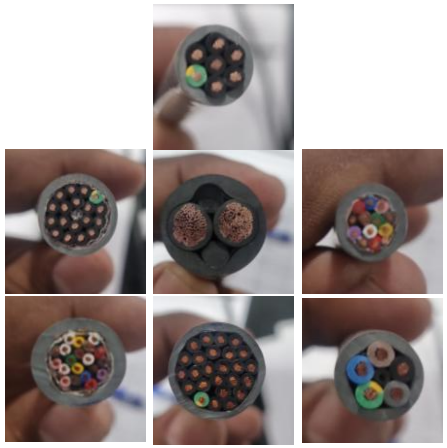
For information: The cost-book value of these items amounts to 452,400.00€. This project comprises several other PSP-codes with a total cost-book value of 14,614,290.50 €.

Scientific Managing Director	Technical Managing Director	Deputy Administrative Director
Prof. Paolo Giubellino	Jörg Blaurock	Markus Jaeger

Facility for Antiproton and Ion Research in Europe GmbH · Planckstraße 1 · 64291 Darmstadt · www.fair-center.eu

IT and Diagnostic Cables (52 types, 930 km)

- Required for signal/data transfer for diagnostic purpose.
- Not so complex otherwise but needs radiation hard insulation.
- EBXL-XLPE insulation with halogen free sheath used as per user requirement

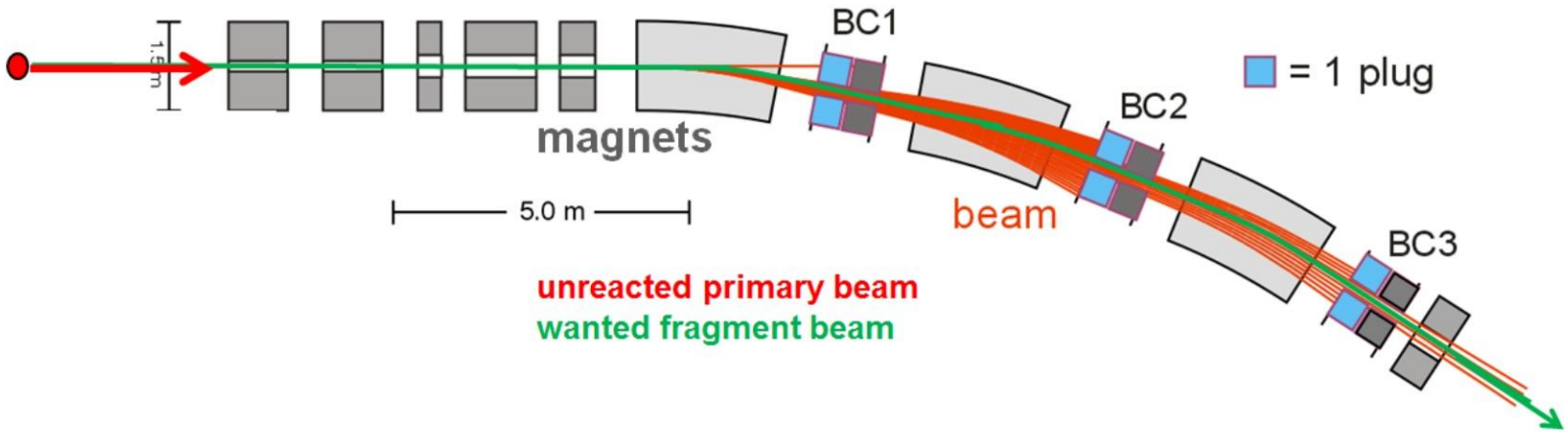


FAT at M/s. Siechem, Pondicherry

Cables ready to be shipped

- All cables delivered in 3 lots
- Site Acceptance Test (SAT) successful

Beam Catchers

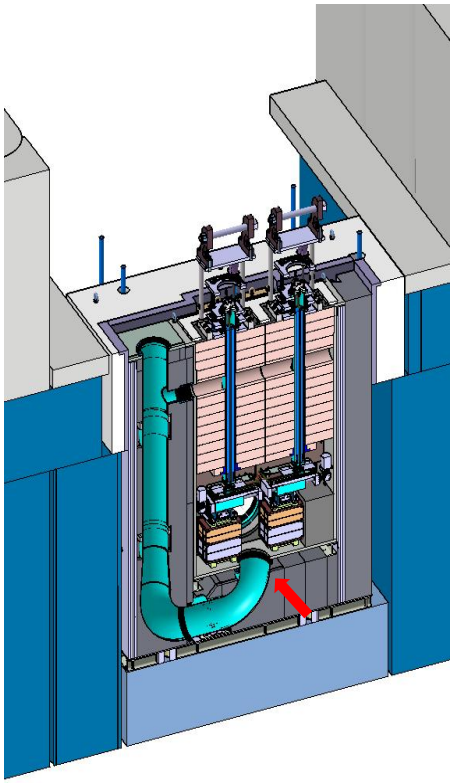


Required to safely catch the unreacted primary beams and a large share of unwanted fragments after the target in Super-FRS.

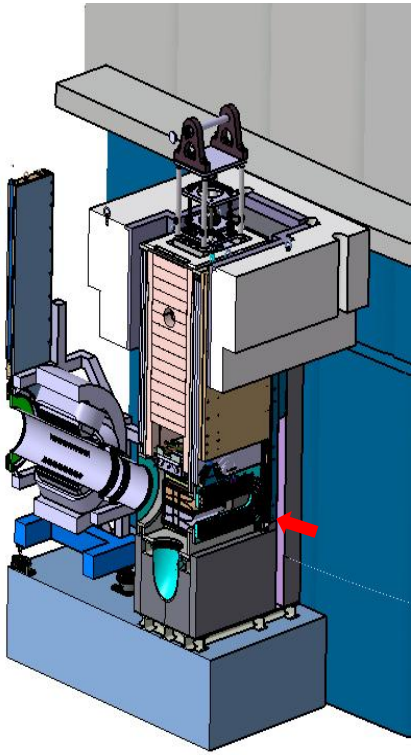
Challenges:

- Must be integrated directly into the separator
- Huge average power (23KW) dumps in very short time (100 nsec)
- Both fast and slow extraction method needs to be incorporated
- Absorber is needed to be built suitable for remote handling

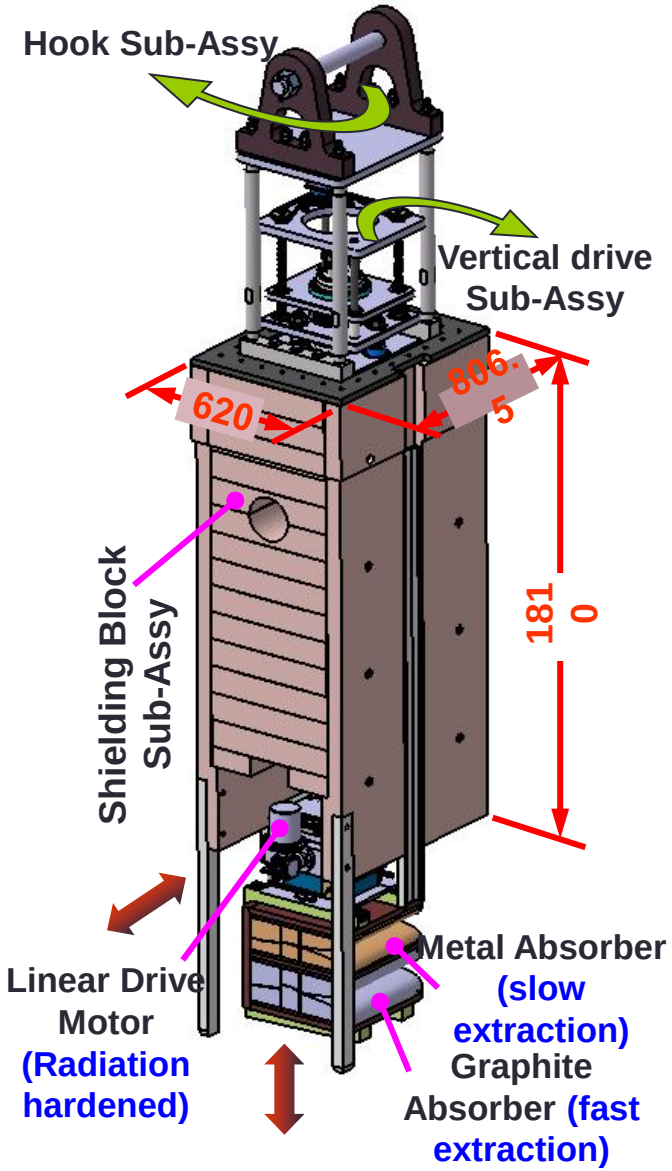
Beam Catchers: Unique interplay of vacuum technology, heavy engineering and precision movements



Transverse section



Longitudinal section



BC1, BC2, BC3 Cavity Dimensions

Structural Frame

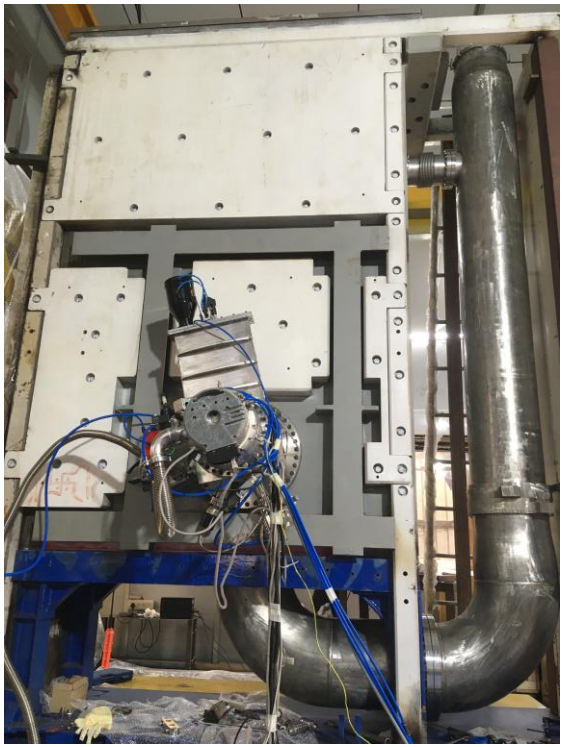
- Dimensions (LxBxH): 2838mm x 860mm x 3350mm
- **BC1, BC2 and BC3 frames are identical**

Vacuum Cavity

- Dimensions (LxBxH): 1600mm x 600mm x 2520mm

BC3 Top Plug Assy (≈7.0t)

Beam Catcher: Prototype BC3



- ***Design:*** **CSIR-CMERI, VECC, BI**
- ***Provider:*** **M/s. Trident Auto Components Pvt. Ltd., Kanpur**

At the last leg of testing the prototype (BC3) at Factory

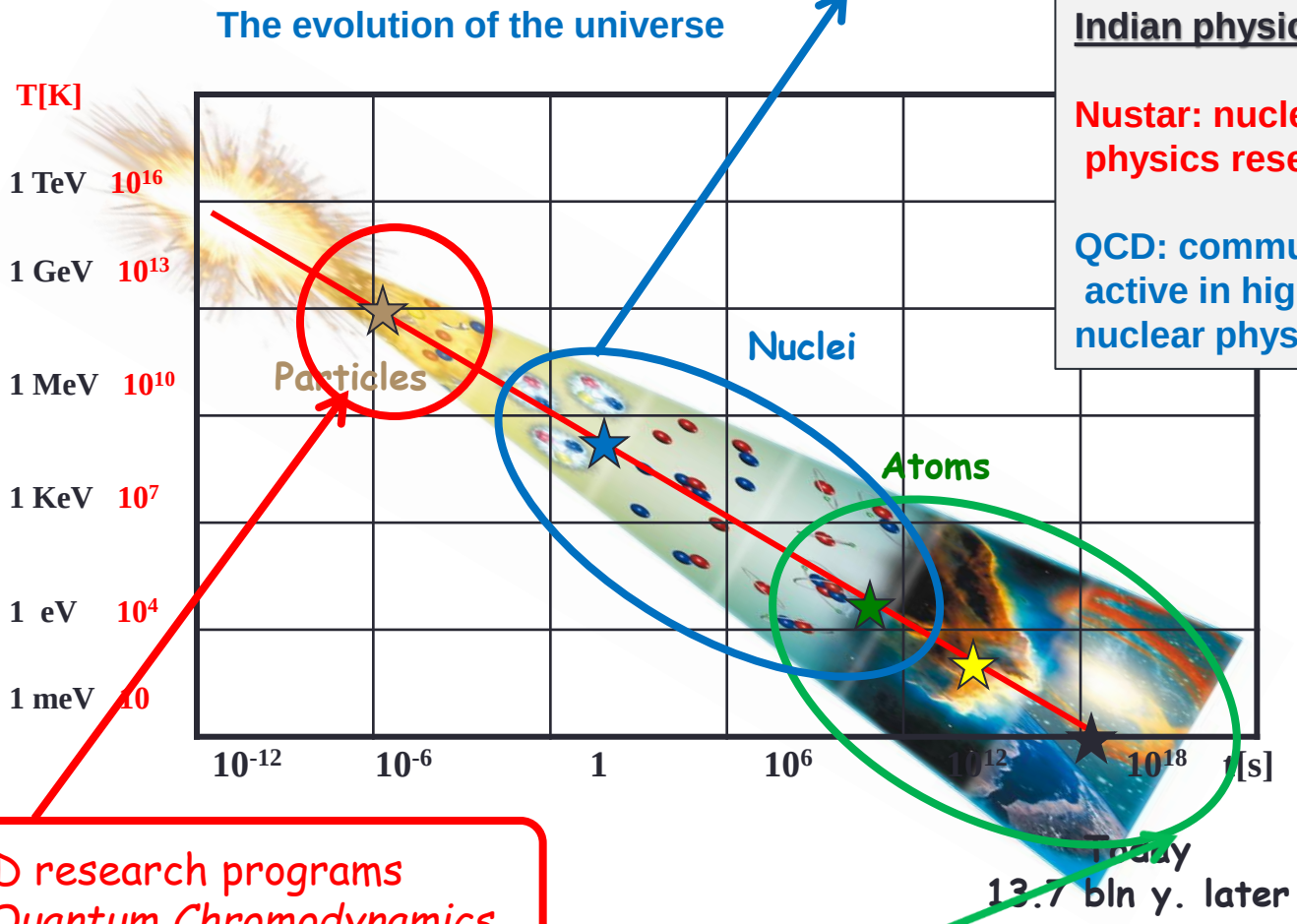
Physics @ FAIR

FAIR – NUSTAR research programs (*Nuclear Structure, Astrophysics and Reactions*

Indian physics connection

Nustar: nuclear physics research

QCD: community active in high energy nuclear physics



FAIR – QCD research programs (*Quantum Chromodynamics*

_FAIR – APPA research programs (*Atomic ,Plasma Physics and Applications*)

Indian groups in FAIR experiments

CBM

- VECC, Kolkata
- Bose Institute, Kolkata
- University of Calcutta, Kolkata
- IOP, Bhubaneswar
- NISER, Bhubaneswar
- University of Jammu, Jammu
- Panjab University, Chandigarh
- IIT-Bombay
- IIT-Indore
- Gauhati University, Guwahati
- AMU, Aligarh
- University of Kashmir, Srinagar
- North Bengal University, Siliguri
- IIT-Patna
- IIT-Madras
- IISER-Tirupati

NUSTAR-DEGAS

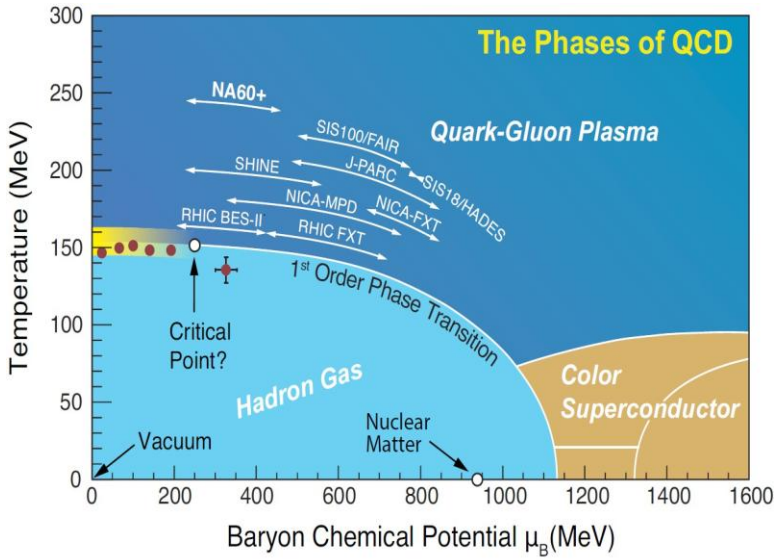
- TIFR, Mumbai
- DU, Delhi
- IUAC, New Delhi
- VECC, Kolkata
- IIT-Ropar
- IIT-Roorkee
- PU, Chandigarh

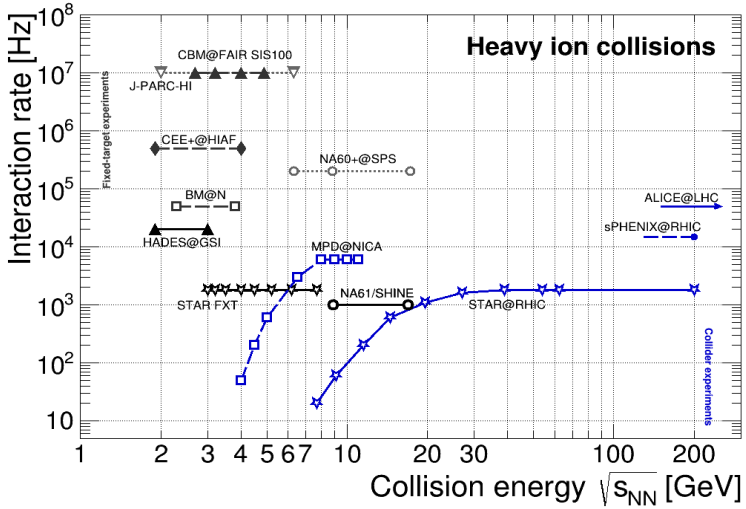
NUSTAR-MONSTER

- VECC, Kolkata
- BARC, Mumbai
- PU, Chandigarh

Compressed Baryonic Matter (CBM)

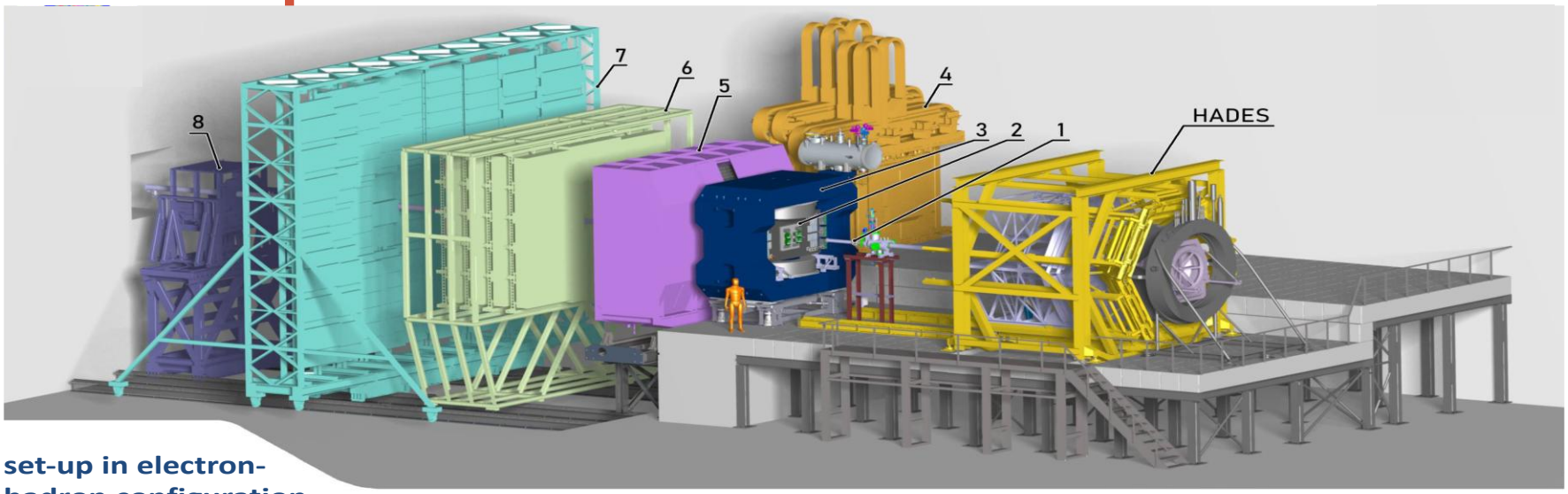
- **Systematic exploration of the QCD phase diagram**
  - Low baryon density regime (LHC, RHIC ...)
  - High baryon density regime (RHIC, CERN-SPS, CBM ...)
- **Precise measurement of the physics observables of interest**
  - High luminosity
- **Detectors with high rate handling capabilities**
  - Micro Pattern Gas Detectors (MPGD)
  - Resistive Plate Chamber (RPC) / Straw Tubes ?
- **Innovative technologies for data acquisition**





Talk by T. Galatyuk and P.P. Bhaduri

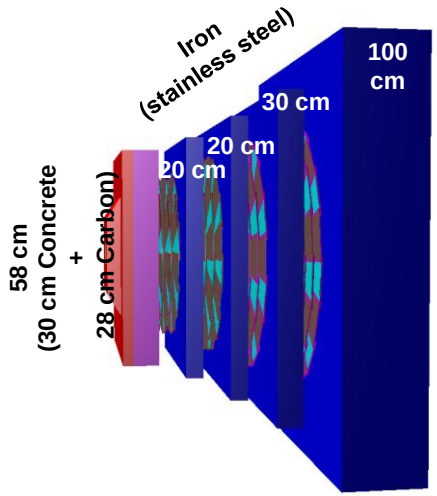
CBM Experiment



set-up in electron-hadron configuration

HADES detector for separate running

1: Time-Zero Detector & Beam Diagnostics
2: Silicon Tracking System / Micro Vertex Detector
3: Superconducting Dipole Magnet
4: Muon Chambers
5: Ring Imaging Cherenkov Detector
6: Transition Radiation Detector
7: Time of Flight Detector
8: Forward Spectator Detector



Muon Chamber (MuCh):

- MuCh Comprises of several detectors & segmented hadron absorbers
- Longitudinal segmentation of absorber and detectors are placed inside absorbers to facilitate tracking
- Angular coverage ~ 5.7º to 25º
- GEM will be used in the first two stations and RPC for the last two stations

Talk by A.K. Dubey

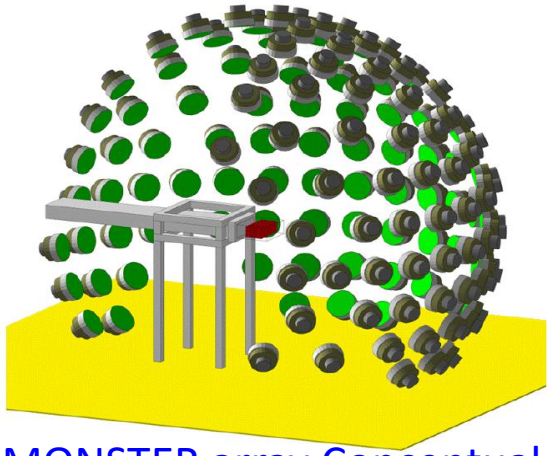
India in NuSTAR

Talk by: S. Mandal

Development and testing of DEGAS detectors @TIFR

First mechanics test, TIFR, Mumbai, India, February 2016

Development and testing of MONSTER detectors @VECC



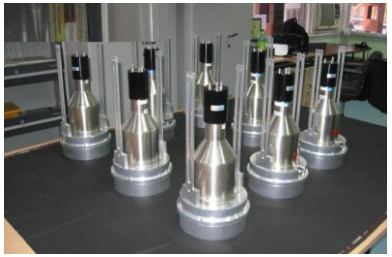
MONSTER array Conceptual design

Organic Liquid Scintillator based

High energy resolution:
4% (1.5 m TOF)

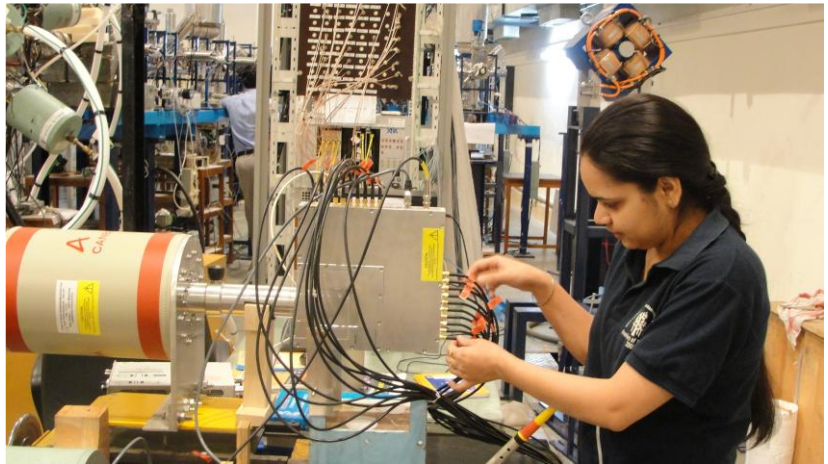
High efficiency:
60% (at 1 MeV)

Fast timing:
1 ns time resolution

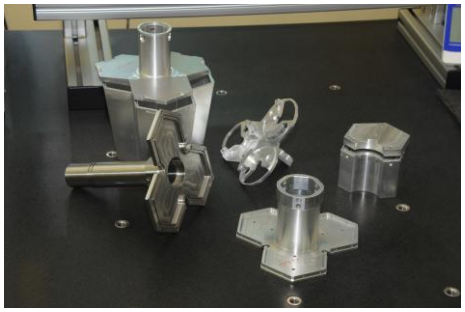


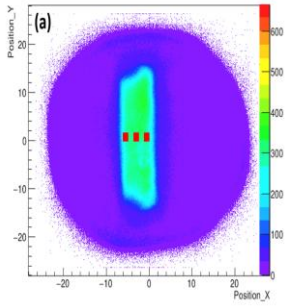
Compact:
Capillary type expansion chamber

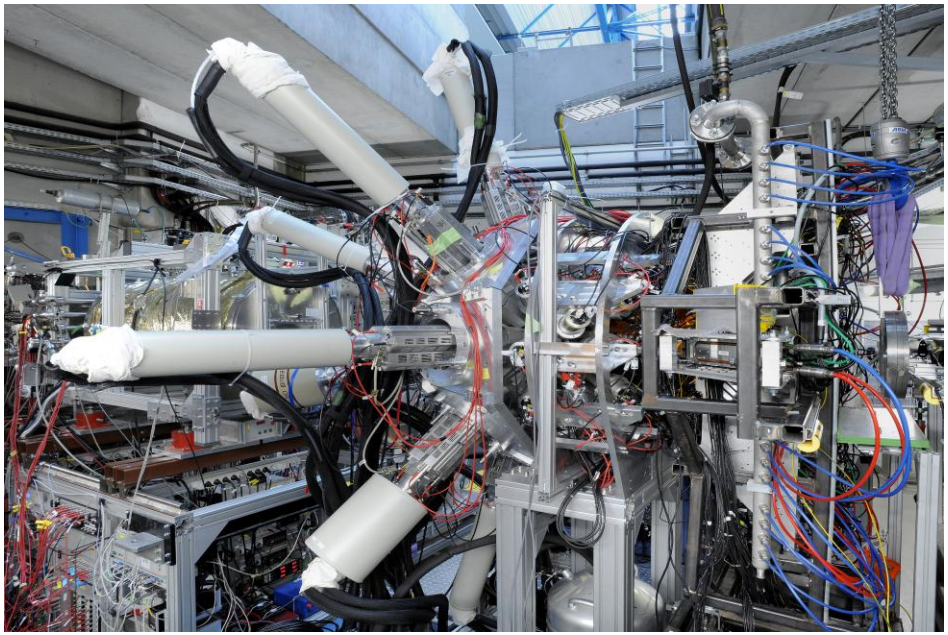
Testing of Planar Ge detector

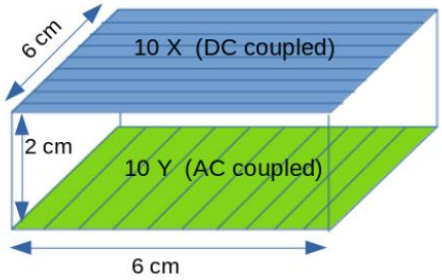


Indian contribution to NuSTAR-DEGAS





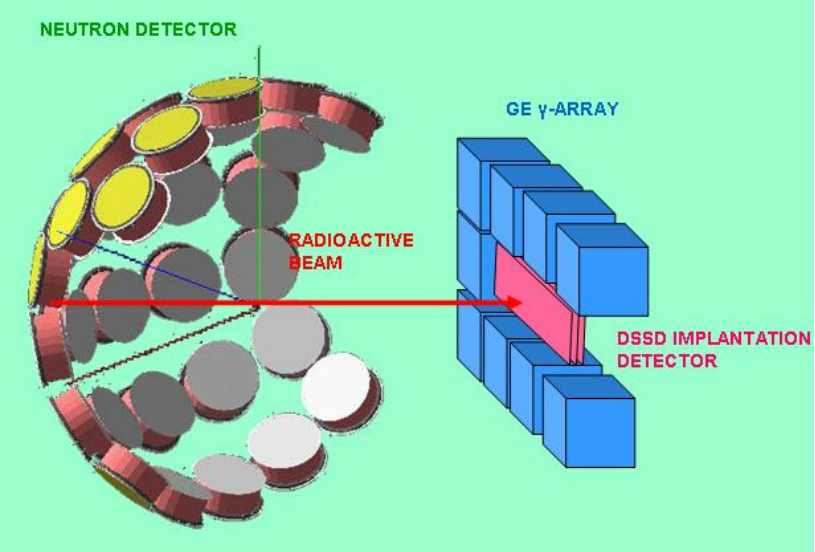




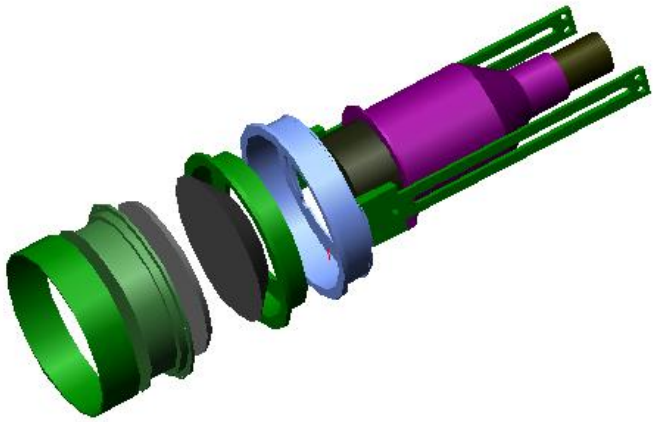
- A prototype of DEGAS mechanics made in TIFR has been approved by FAIR
- DEGAS mechanics fabricated in TIFR are used in the Experiment at FAIR
- An Implant High Purity Germanium Double Sided Strip Detector was used in an experiment at FAIR for low-energy gamma-ray detection (TIFR/IIT Ropar/ DU)
- Geant4 Simulation for DEGAS
- Active contribution in experiments of DESPEC Collaboration

DEGAS is a spectrometer at FAIR which will be used to understand the formation of heavy elements in the Universe

NuSTAR-MONSTER Development in India



- The MONSTER array being developed for DESPEC (DEcay SPECtroscopy) experiments at FAIR, Germany, will consists of 100 (8″×2″) liquid scintillator based fast-neutron detectors.
- The array will be primarily used to investigate the β-decay properties of neutron-rich nuclei.
- As a part of the collaboration, 42 detectors will be developed in India.
- Digital DAQ system being developed; part of the system has been tested at VECC



Schematic of the single detector assembly

Modules and DAQ system developed in India

New opportunity: Biophysics and therapy with ion beams @ FAIR

1st International Biophysics Collaboration meeting at GSI on May 20-22, 2019

- An interdisciplinary collaboration of biologists, physicists, chemists, biochemists and technicians
- Multidisciplinary research on radiobiology, physics, space research and therapy.

Talk by M. Durante

https://www.gsi.de/en/work/research/biophysics

Indo-FAIR Project : the way forward

- India for the first time is participating in an international mega science project from the very early stage of conceptual design of the Facility for Antiproton and Ion Research (FAIR)
- Department of Science and Technology and Department of Atomic Energy, Government of India are committed to engage themselves towards the realization of this project
- Participation in this project has brought new opportunities to Indian industries as they are being tested against challenges to meet the demand of state of the art technology of the most advanced kind for the construction of the facility
- A large number of young researchers are already in the path of training themselves while developing the experiments to be performed using the facility
- Once completed, this facility will be used by a much larger community of scientists from India not only in the area of nuclear and high energy physics but also in other areas such as biophysics and applications