"India's Participation in the construction of Facility for Antiproton and Ion Research (FAIR) at Darmstadt, Germany"

Status & Future

Sanjay K. Ghosh
Bose Institute

A Joint Project of DST and DAE

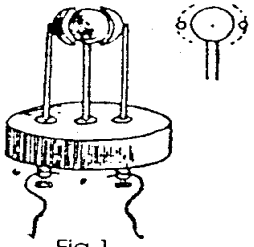


Fig.1
J. C. Bose's Spark transmitter

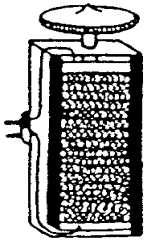


Fig.2
spiral spring detector

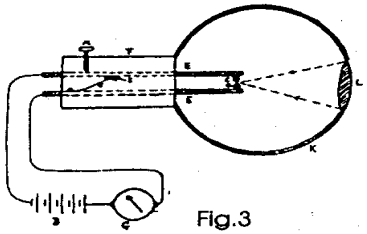
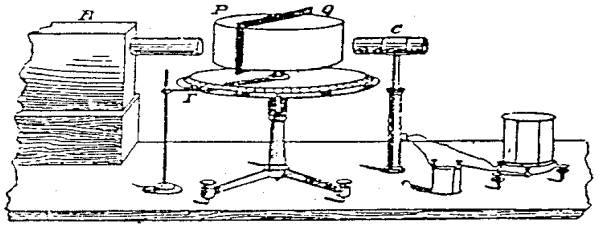


Fig.3
Bose's Galena detector used as a "Universal Radiometer" of "Tejometer"

November 1895 at a public demonstration at the Town Hall of Kolkata



—Electric Refractometer
R. the Radiator. C. the Receiver.
Fig.4
Focal points of Bose's hemispherical dielectric lens pair

Fig.5
wire grid poloriser

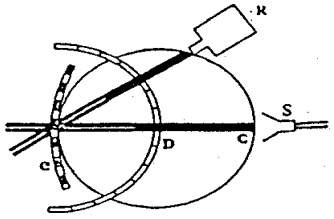


Fig.6
Bose's cylindrical grating showing transmitter and receiver positions along focal curve

In 1897, J C Bose described to the Royal Society in London his research carried out in Kolkata at millimetre wavelengths

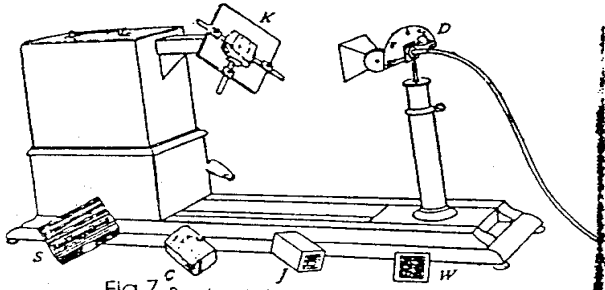


Fig.7 Bose's polarisation apparatus
(K, the Crystal Holder. S, a piece of Stratified Rock. C, a Crystal. J, the Jute Polariser. W, the Wire Grating Polariser. D, the Vertical Graduated Disc by which the Rotation is measured.)

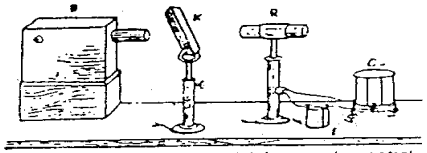


Fig.8 Bose's millimeter wave link for remote control
B, Metallic box enclosing the Ruhmkorff coil and Radiator
K, The crystal to be examined. E, Voltaic Cell.
G, The Galvanometer R, Tube enclosing sensitive receiver

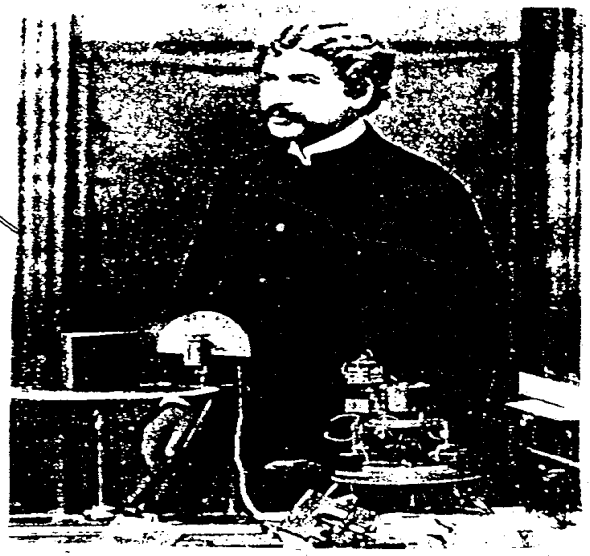
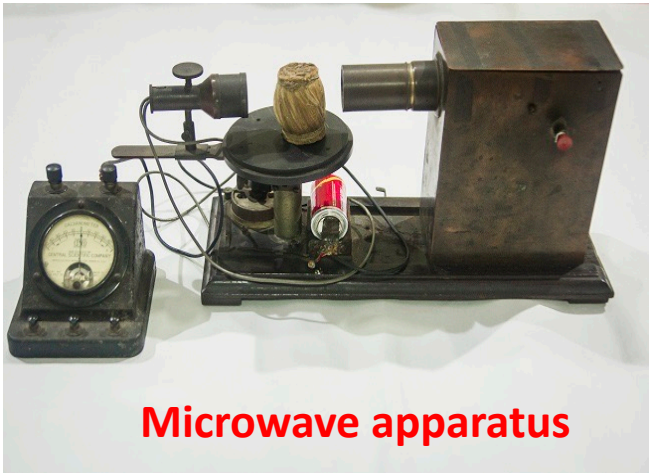


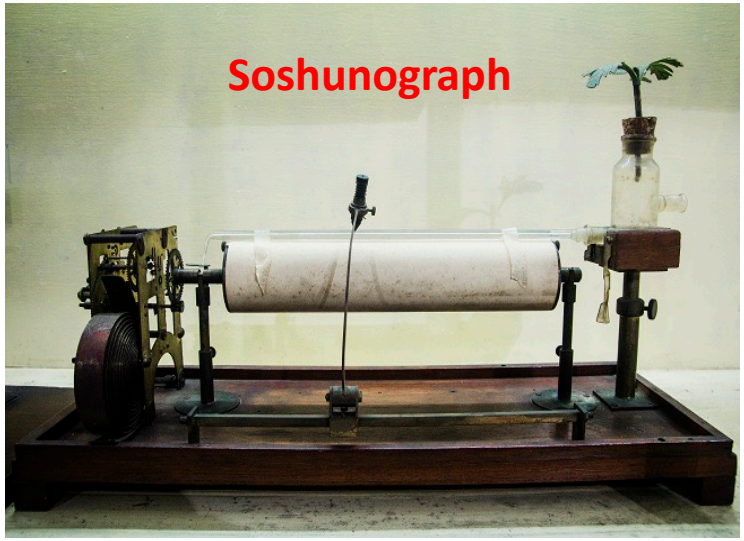
Fig.9 Photograph of bose's millimeter wave instruments

Nevill Mott, Nobel Laureate in 1977 for contributions to solid-state electronics, remarked - "J.C. Bose was at least 60 years ahead of his time. In fact, he had anticipated the existence of P-type and N-type semiconductors.

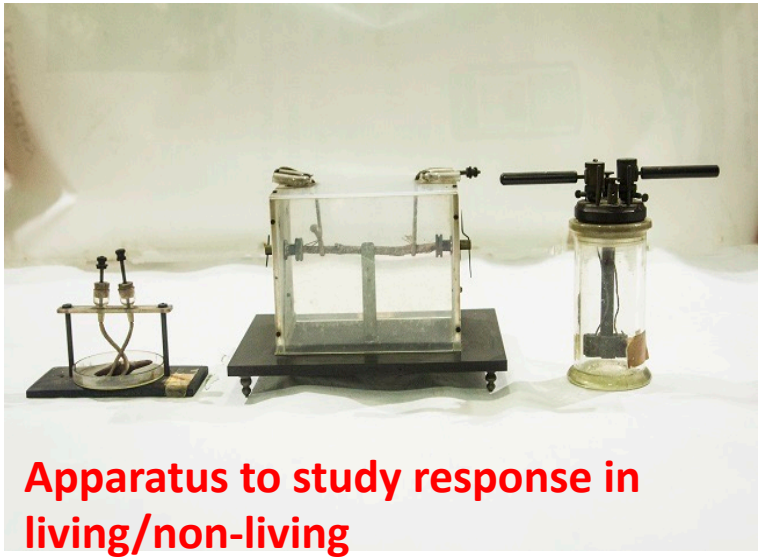
In-house technology innovation & development



Microwave apparatus



Soshunograph

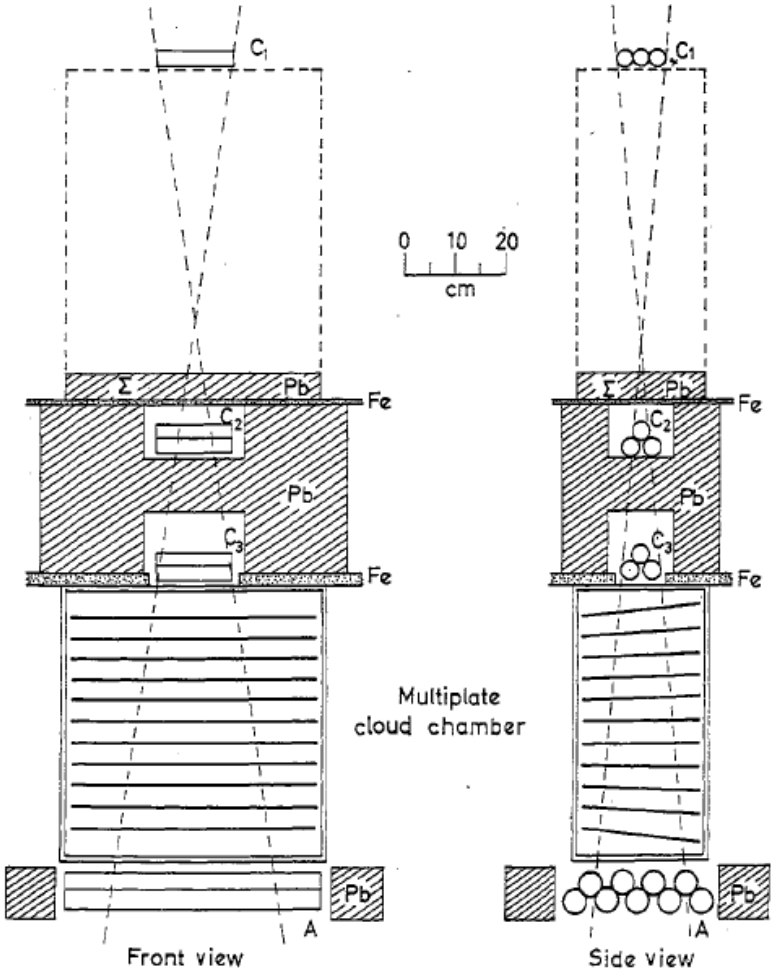


Apparatus to study response in living/non-living

Photosynthetic Bubbler

Cosmic Ray research: Cloud Chamber & Photographic Emulsion – D.M. Bose

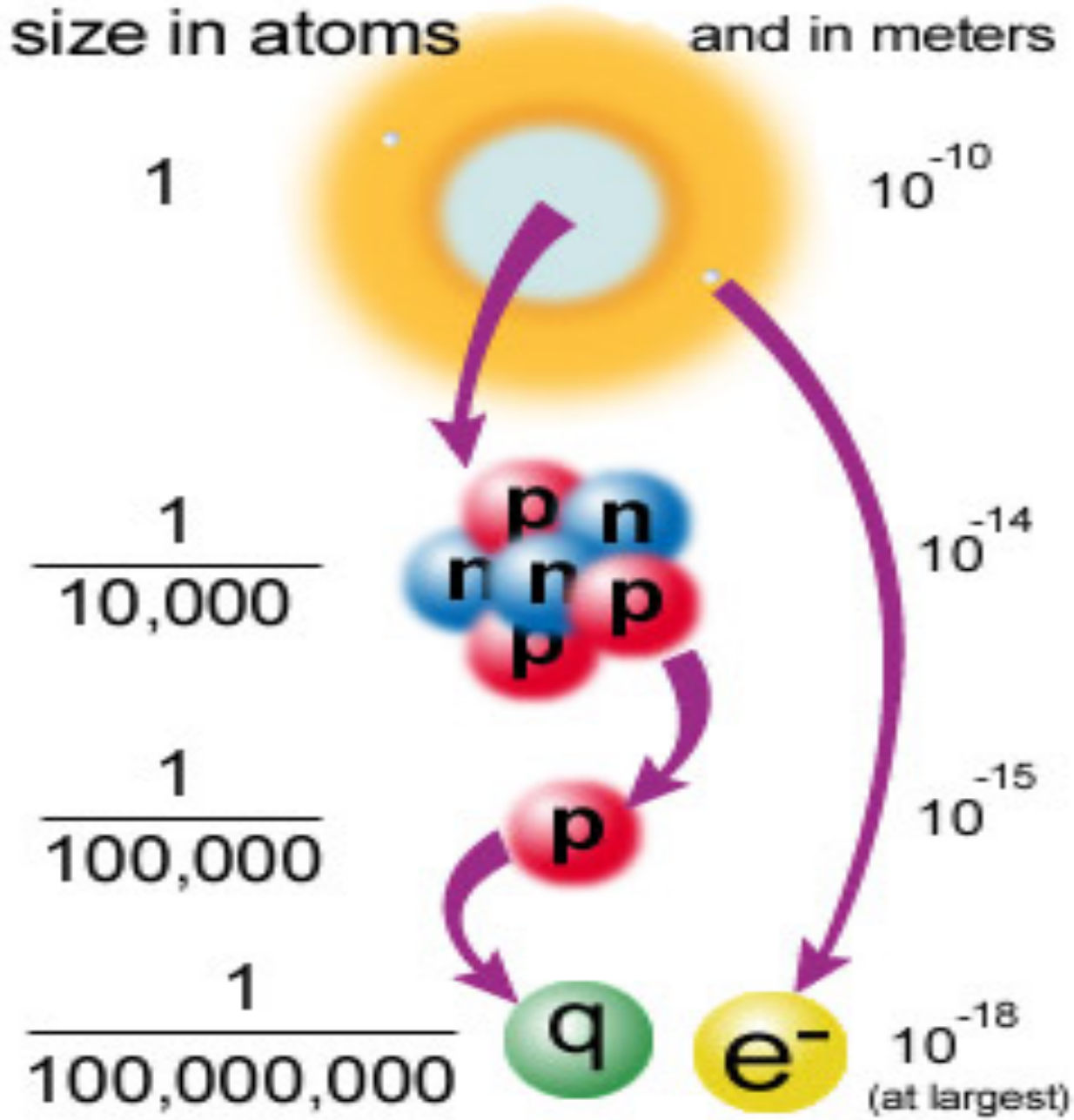
- Photographed the recoil tracks of radioactive nuclei during alpha emission
- Earliest evidence of disintegration of nitrogen nuclei under the bombardment of alpha particle



First cloud chamber in India – During 1920s

S. N. Sengupta and M.S. Sinha
Proc.Phys. Soc. 79,1183 (1962)

The experiment was performed at Darjeeling (altitude 2200 metres, atmospheric depth 800 g cm^{-2}). The method used was to stop cosmic-ray muons in copper plates fitted in a cloud chamber and observe the angular distribution of the electrons resulting from the decay of these muons.


size in atoms
and in meters
1
10^{-10}
1
10,000
p
n
n
n
p
p
10^{-14}
1
100,000
p
10^{-15}
1
100,000,000
q
e^-
10^{-18}
(at largest)

NuPECC summarized Nuclear Physics questions:

- How do the structure of hadrons and their interactions emerge from QCD?
- What is the structure of nuclear matter?
- What are the phases of nuclear matter?
- What is the role of nuclei in shaping the evolution of the Universe?
- What lies beyond the Standard Model?

Four Pillars of FAIR

- APPA Physics (Atomic, Plasma Physics and Applications)
- CBM – Compressed Baryonic Matter
- NUSTAR Physics (Nuclear Structure, Astrophysics and Reactions)
- PANDA – Antiproton Annihilation at Darmstadt

Prominent features of FAIR accelerator

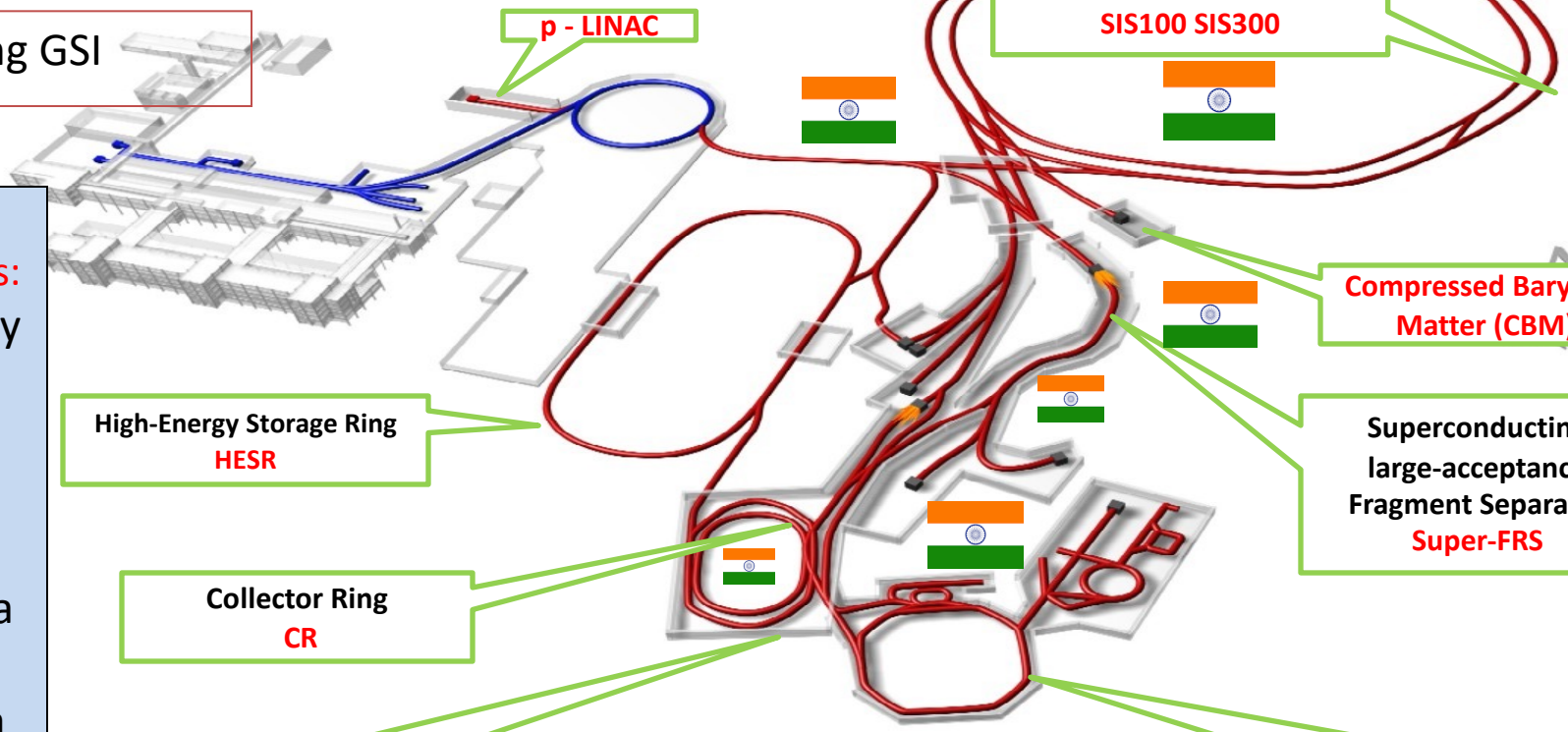
High Intensity beams:
1000 x
For primary HI beam
10 000 x
For radioactive ion beams
10 0 x
For antiproton beams

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

Existing GSI



Member Countries:
Germany
Russia
India
France
Poland
Romania
Finland
Slovenia
Spain
Sweden
UK

Unique Aspect

An important aspect in the design of the facility is a high degree of truly parallel operation of the different research programs.

Simple beam splitting and switching to different target locations is of course generally possible at any accelerator with relatively small effort. But this in general does affect the integrated luminosity of a single experiment.

Truly parallel operation, with the constraints of accelerator cycles, is considerably more difficult, this implies that the facility operates for the different programs more or less like a dedicated facility.

Indian in-kind items identified so far

Accelerator components

- SC magnets for LEB
- Power converters
- Ultra-high Vacuum chambers
- Power cables
- Beam stoppers
- IT Cable
- Roof Shielding
- He Tank

Detectors and Electronics

- Spectrometer for nuclear physics
- Neutron detector for nuclear physics
- Ion-trap for nuclear physics
- Muon chambers for high energy expts.

Experiments:

1. ***NUSTAR***
2. ***CBM***

I. LEB Magnets Status

- Physics design: complete
- Basic engineering design: complete
- Based on Engineering design CAD modeling: complete.
- *CDR cleared by FAIR*
- Production withdrawn due to much higher cost
- **0.5 M Euro credited to India (2005 price)**
- Indian engineers have been offered to be consultant for dipoles

II. Power Converter

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

Design by VECC+ RRCAT

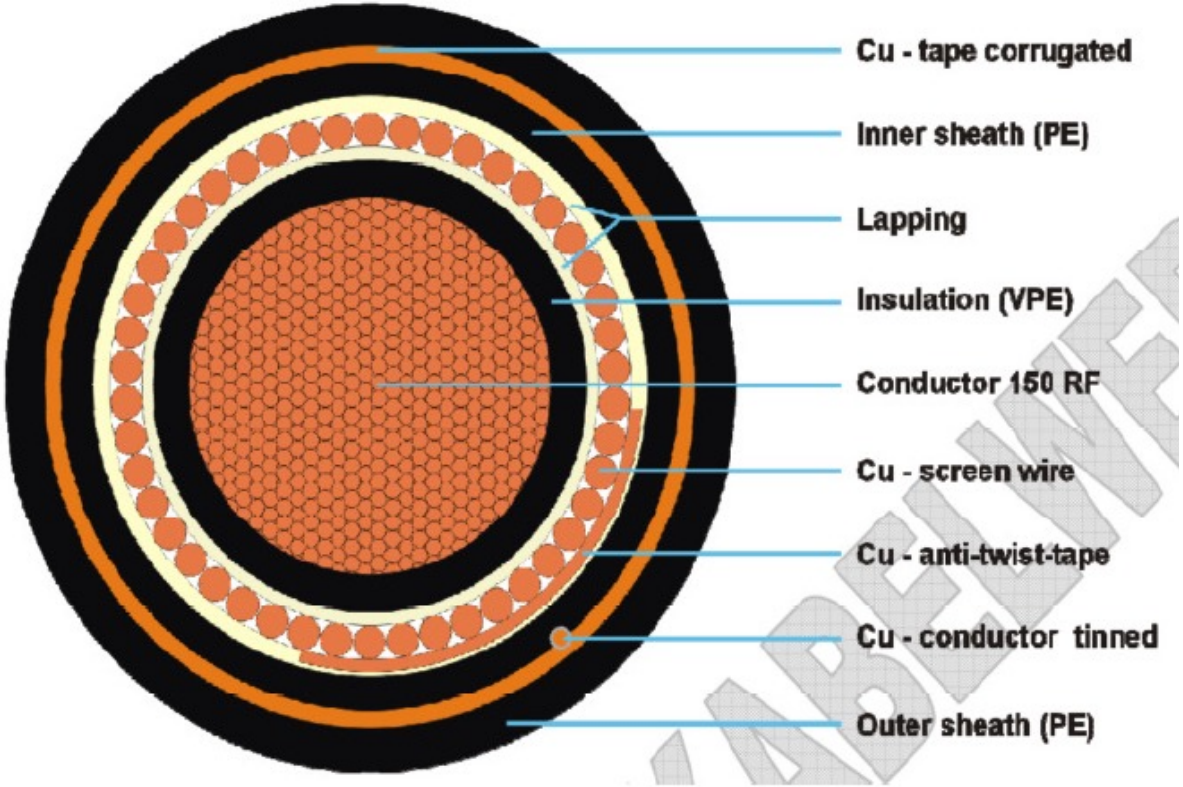
Power converters: 302 shipped (ECIL-Hyd)

III. Ultra-high Vacuum Chambers for beam diagnostics

UHV chambers: 58 shipped (VT-Blore)

IV. Co-axial power cables (196 Km, 4 types)

- To connect power converters with the magnets
- Shielded and e-beam curing
- Operating in high radiation environment



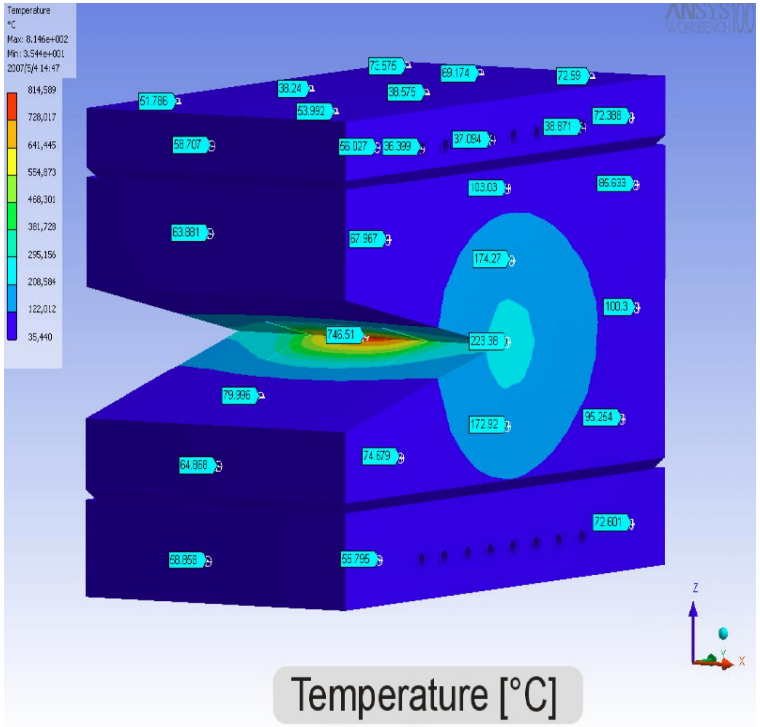
VOLTAGE CLASS = 1.8 / 3 KV (Max. Voltage 3.6KV, as per IEC-60502-1)

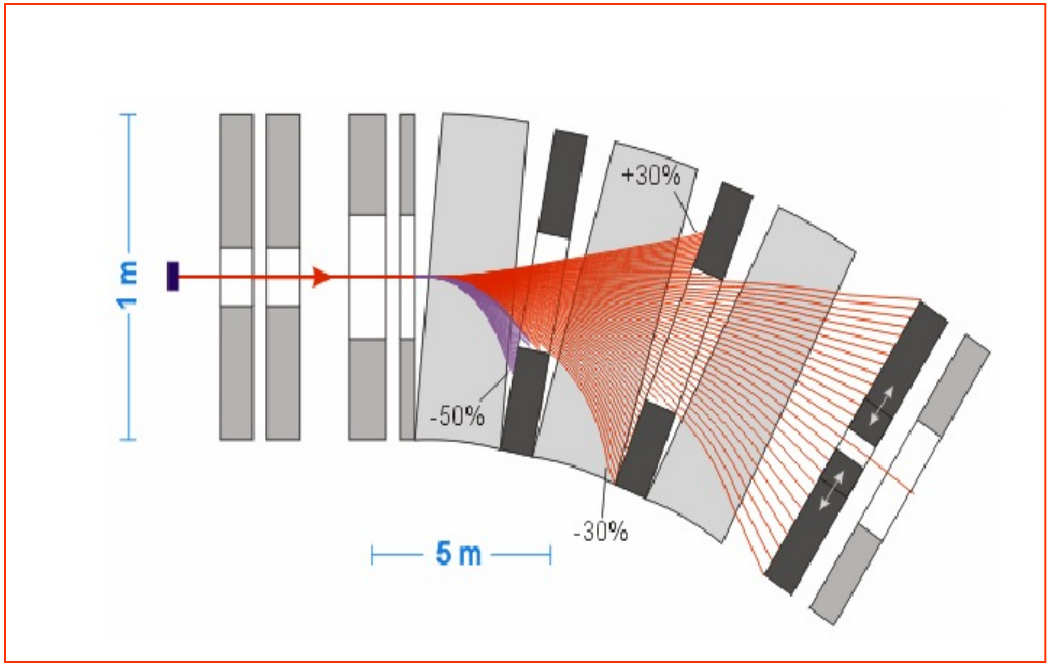
NOT A STANDARD TYPE, SPECIAL CABLE AS PER USER'S REQUIREMENT

PO ISSUED

V Beam stopper

PO ISSUED





Challenges:

- Huge average power (23KW) dumps in very short time (100 nsec)
- Both fast and slow extraction method needs to be incorporated

VI. Signal Cables

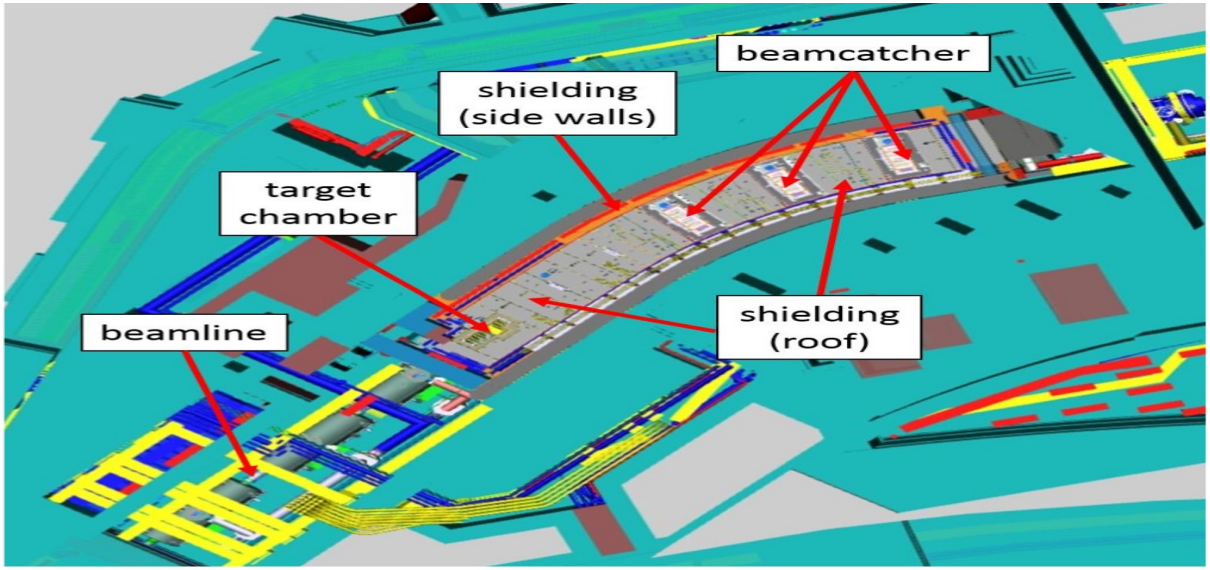
- Total quantity of flexible EBXL wires and cables is **930100 meter** of seven different types
- Radiation Hard

- **PO issued**

VII . Iron roof-shielding (19 blocks, 3 non-magnetic

- S235 grade steel, upto 700 tonne
- Upto 1m thick
- 23 pieces
- A few inside magnetic field
- 20cm thick concrete layer

- PO issued



Target building with the location of the roof shielding (in grey), resting on the iron side walls (orange), surrounded by concrete walls (dark grey and turquoise

Global Complications

- Early 20 COVID Pandemic
- Feb'22: Conflict between Russia and Ukraine started
- An International review committee (Chairs: Prof. R. Heuer, Prof. Trible) formed by the FAIR council for early physics review

Indian in-kind items

Accelerator components

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More to come

Detectors and Electronics

- Spectrometer for nuclear physics
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- Ion-trap for nuclear physics
- Muon chambers for high energy expts.

Experiments:

1. ***NUSTAR***
2. ***CBM***

Difficulties we faced

- *New procedure for procurement - GeM based*
- *Financial power of Institutes*

We must move forward

Academia – Industry hand holding is the future

THANK YOU