Facilities for Nuclear Physics in India

Amit Roy
Inter-University Accelerator Centre
New Delhi- 110 067

ACCELERATORS FOR NUCLEAR PHYSICS

Inter University Accelerator Centre, New Delhi

(15 MV Pelletron & SC Nb QWR based Linac Modules for energy augmentation, High Current Injector)

Tata Institute of Fundamental Research, Mumbai

(14 MV Pelletron, SC Pb plated Cu QWR based Linac Booster for energy gain)

Variable Energy Cyclotron Centre, Kolkata

(224 cm Variable Energy Cyclotron, K-500 SC Cyclotron Accelerator, RIB facility etc.)

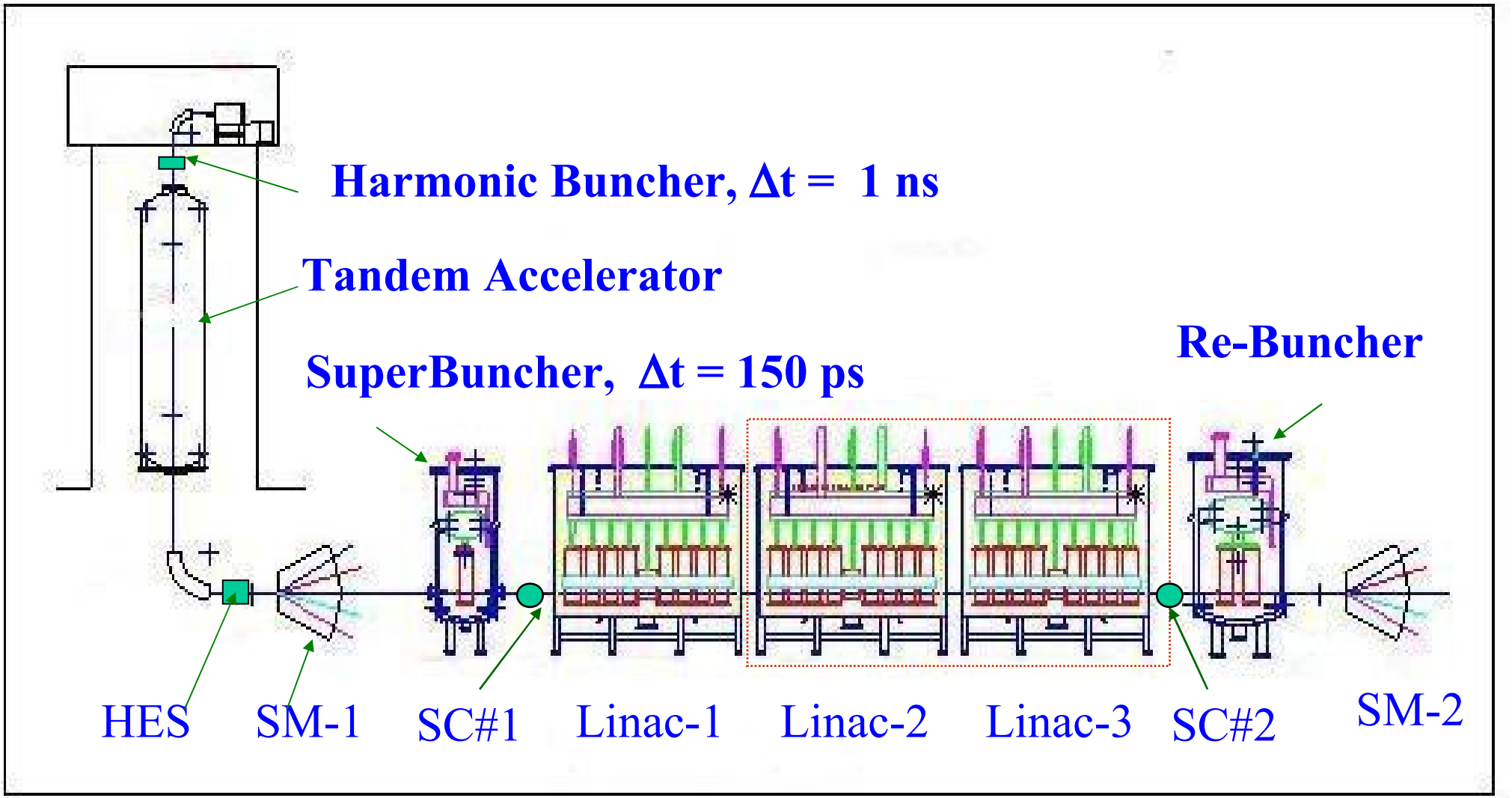
Saha Institute of Nuclear Physics, Kolkata

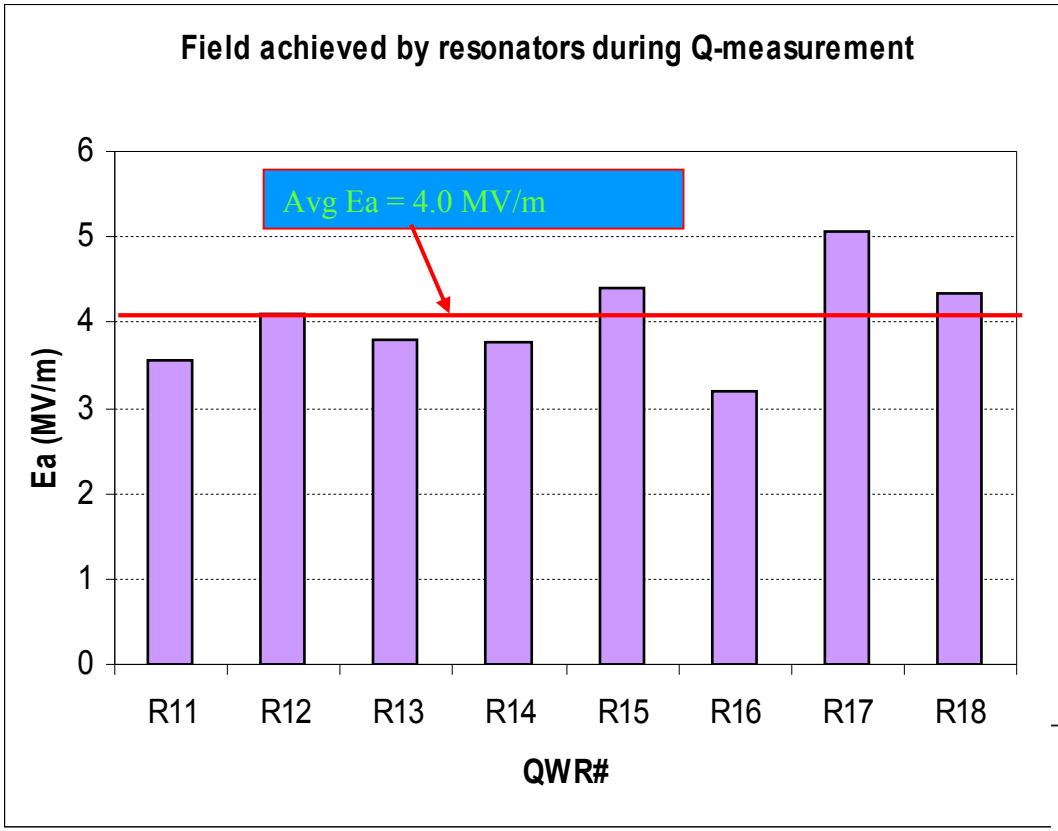
(3 MV Tandetron, to be installed)

Other Major Accelerators: **Electron Synchrotrons INDUS-I, INDUS-II at Raja Ramanna Centre for Advanced Technology, Indore.**

FOTIA at Bhabha Atomic Research Centre, Mumbai

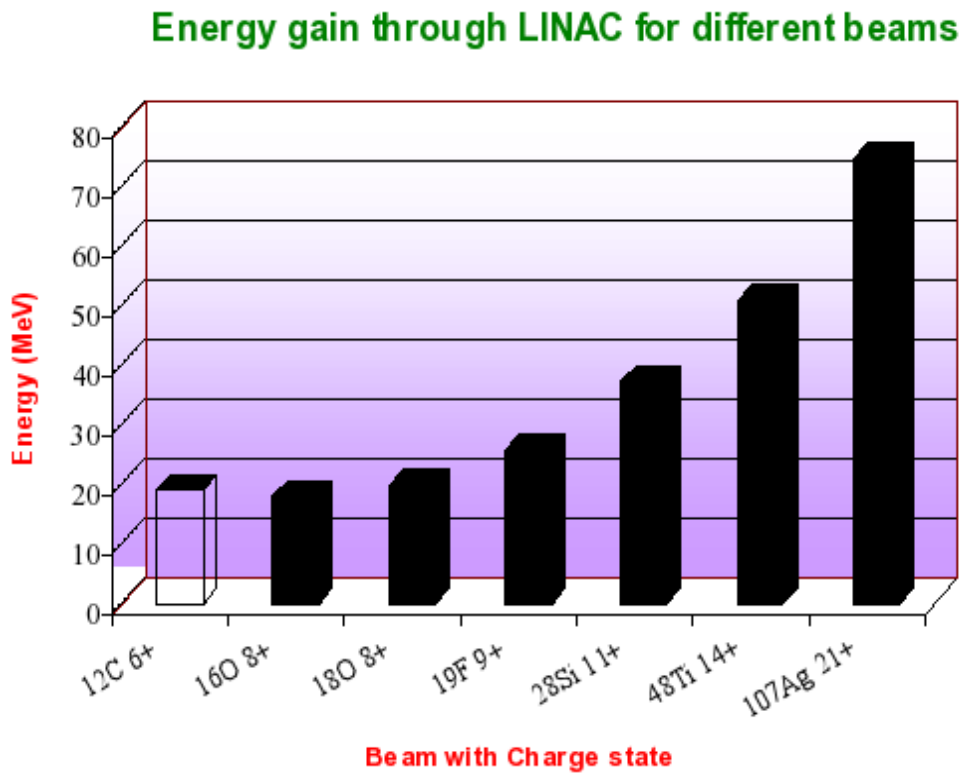
Layout of the Accelerator system, IUAC, New Delhi



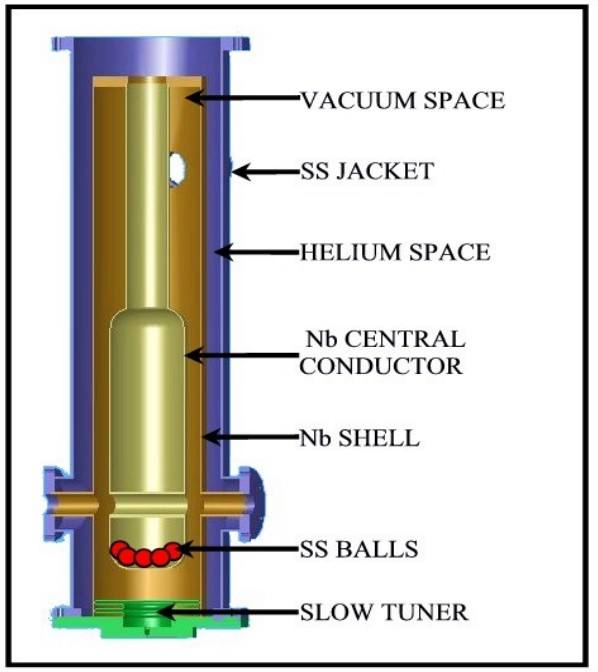


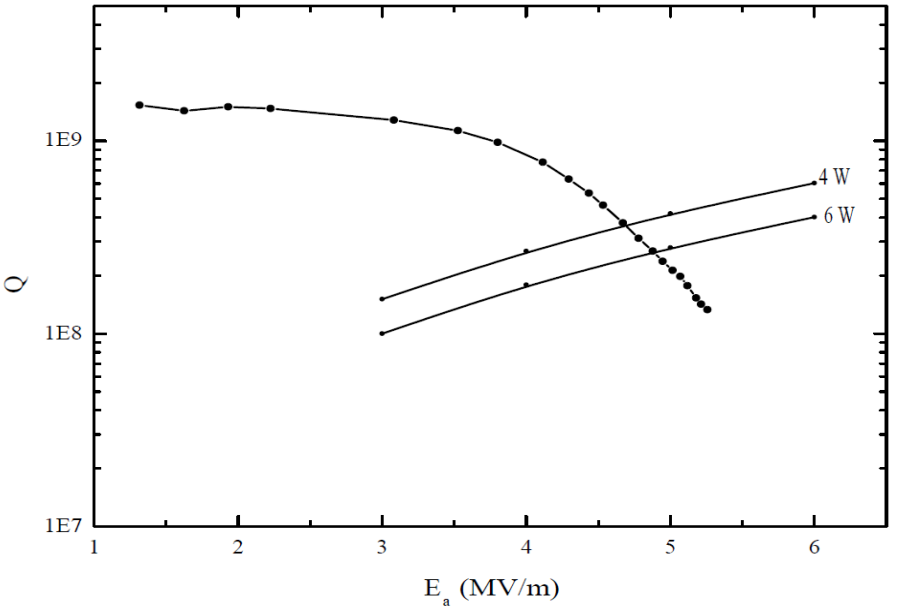
Linac Operation with Buncher, Linac Module 1 and Rebuncher

Resonators fabricated at ANL and IUAC used for beam acceleration

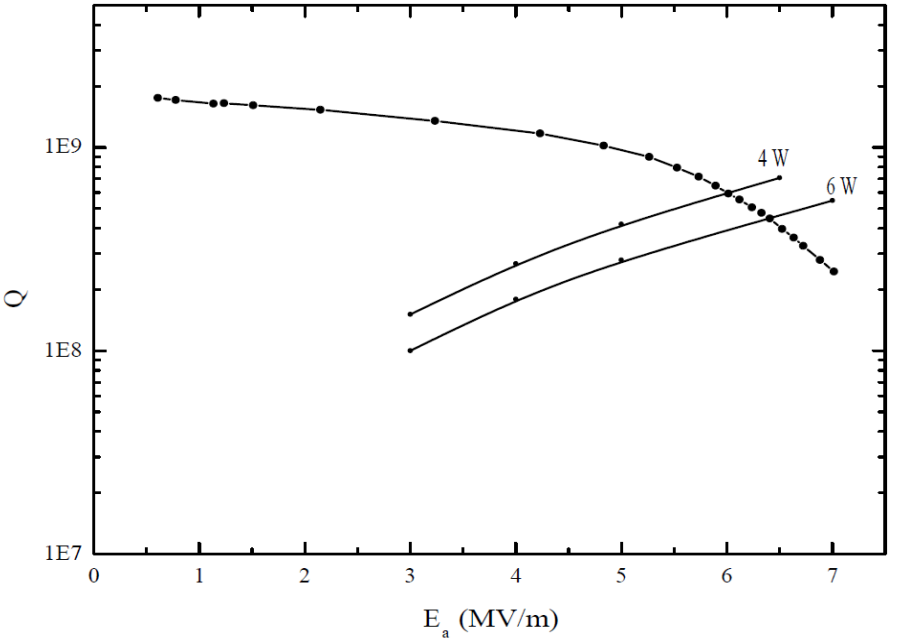


Development of QWR for Module 2 & 3

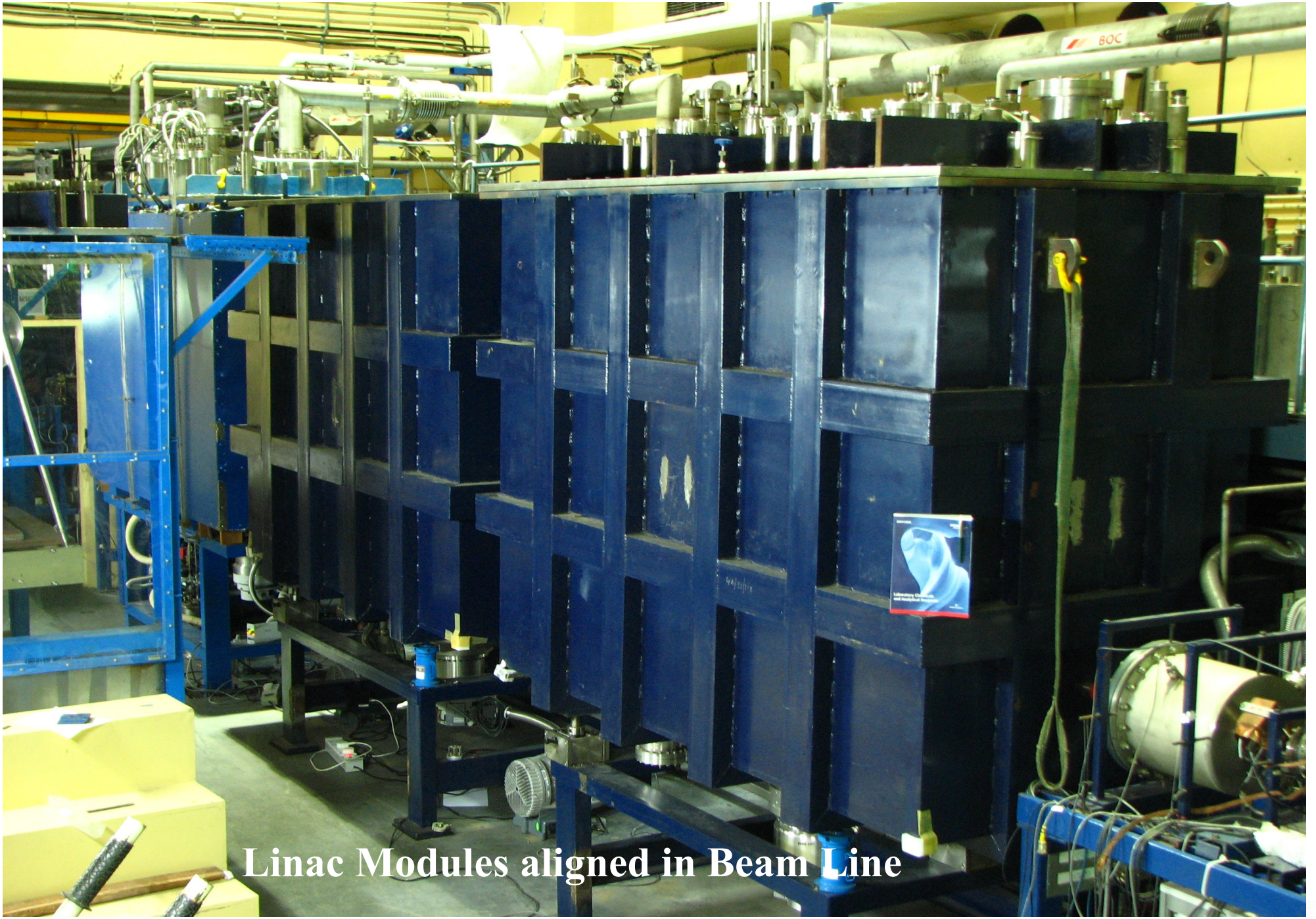




Nb Quarter Wave Resonators

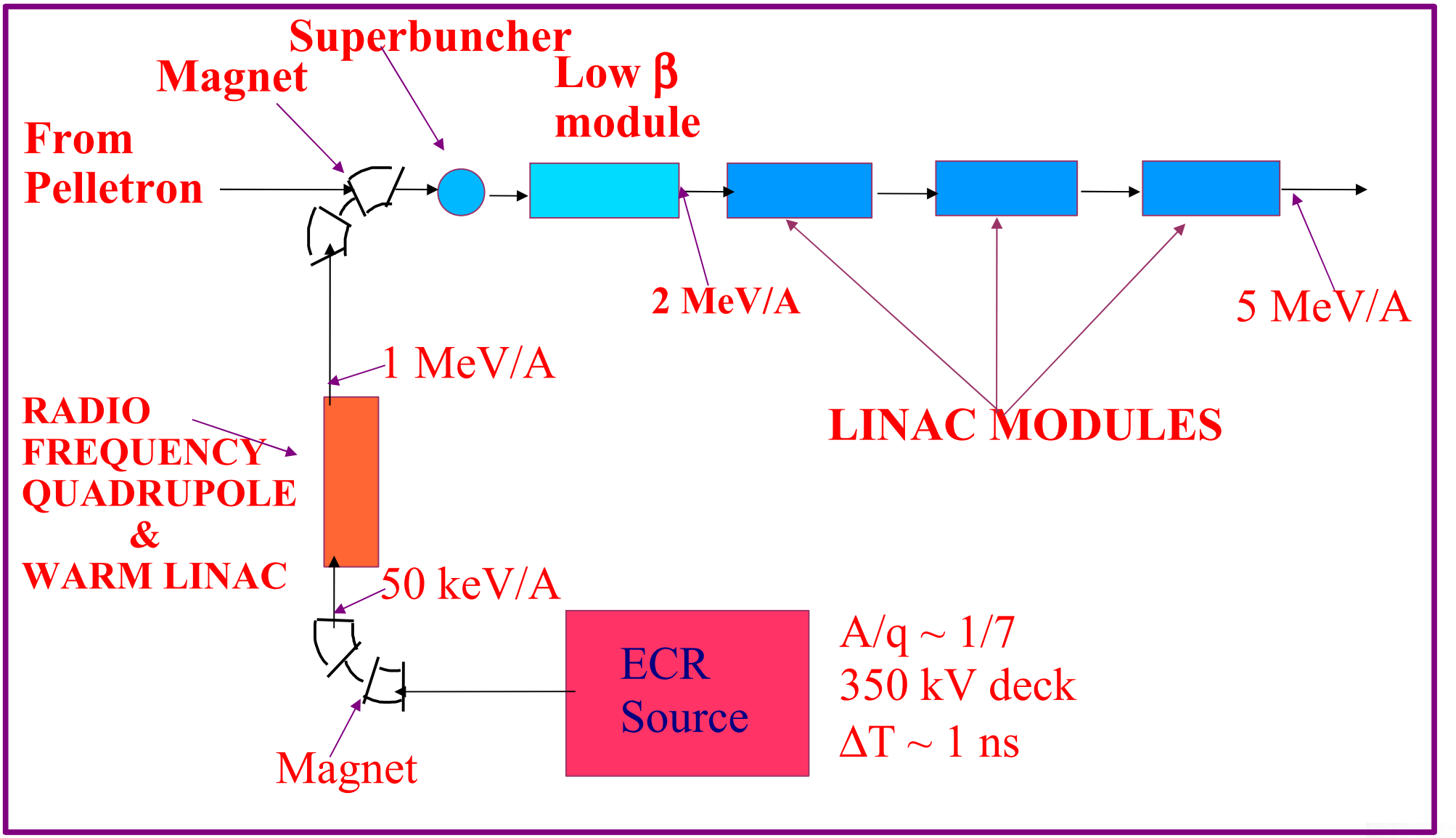


Peak Electric fields ~ 4. Ea

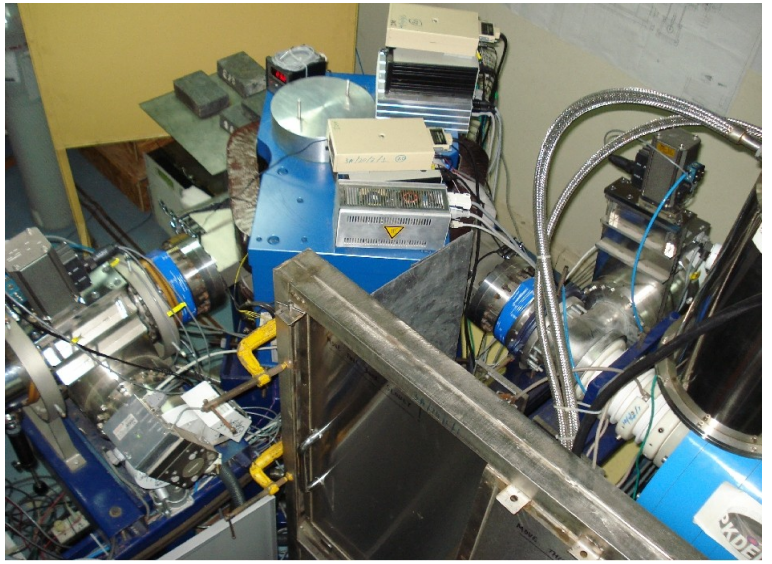


Linac Modules aligned in Beam Line

ECR based High Current Injector for LINAC



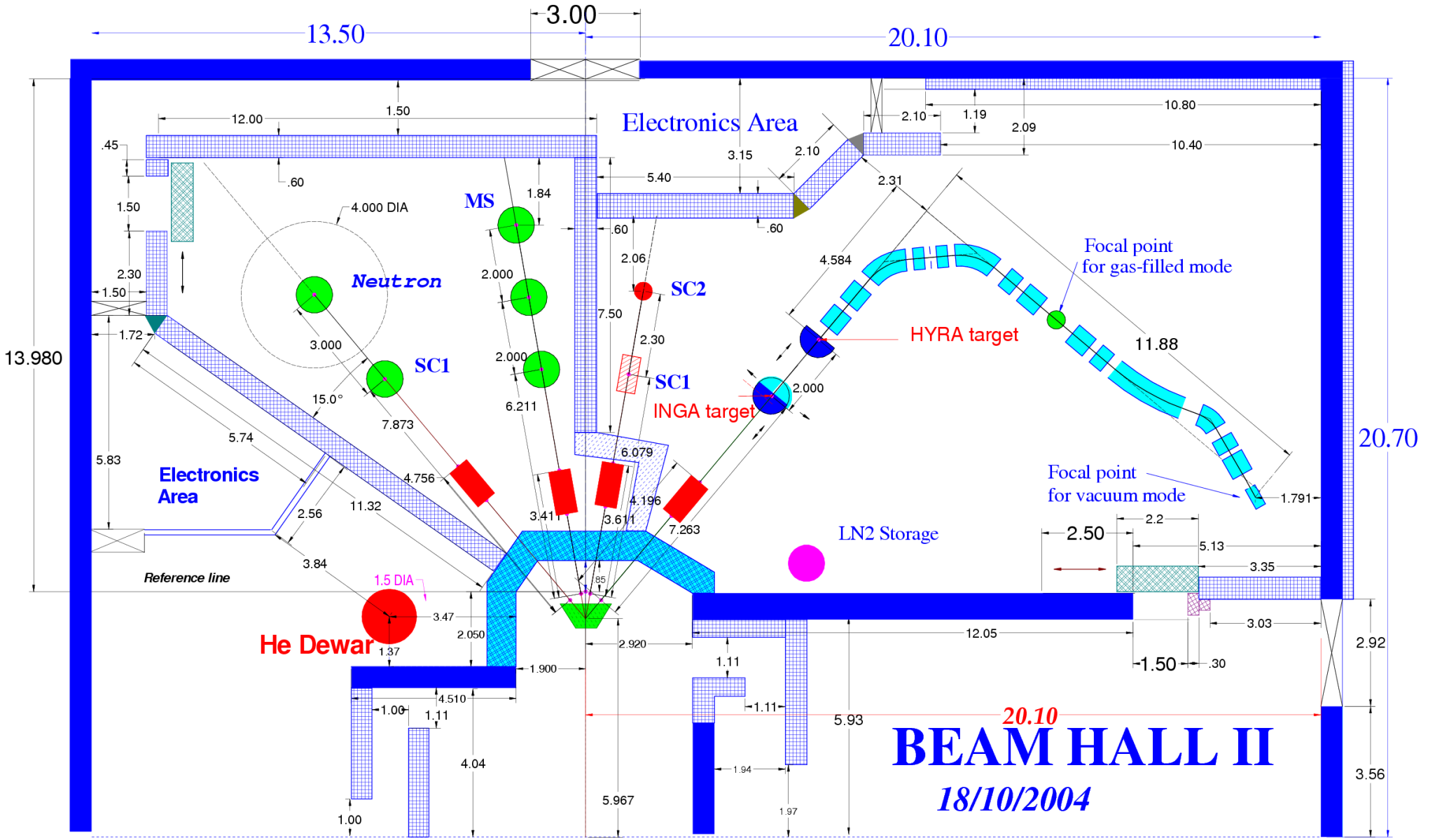
High Current Injector Components

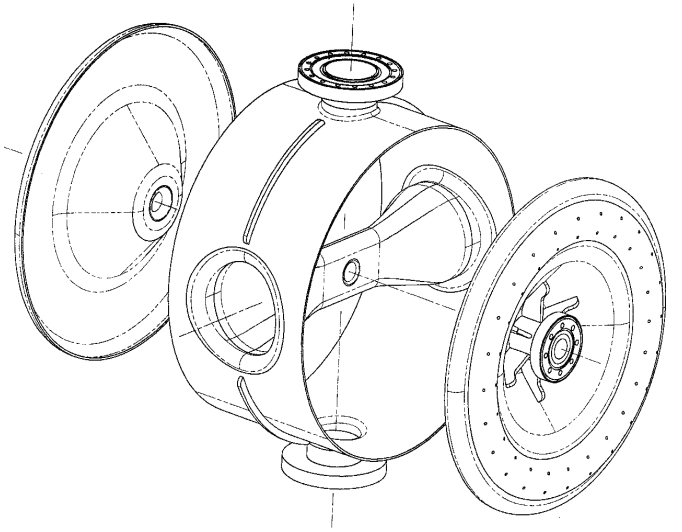


PKDELIS, world's first High Tc superconductor based ECR ion source

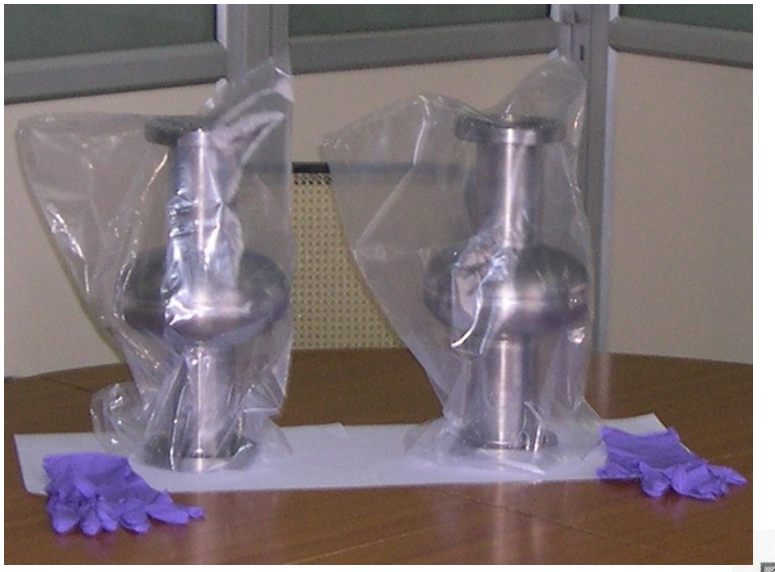
Prototype Radiofrequency Quadrupole accelerator

Drift Tube Linac prototype


3.00
13.50
20.10
Electronics Area
12.00
1.50
.45
.60
1.50
4.000 DIA
MS
1.84
Neutron
2.30
1.50
1.72
3.000
SC1
15.0°
7.873
5.74
5.83
Electronics Area
4.756
2.56
11.32
3.84
Reference line
1.5 DIA
3.47
He Dewar
1.37
2.050
1.900
4.510
1.00
1.11
4.04
1.00
2.000
2.000
6.211
6.079
3.411
3.611
4.196
7.263
.85
2.920
5.967
2.06
SC2
7.50
2.30
SC1
INGA target
5.40
3.15
2.10
.60
.60
2.31
4.584
HYRA target
2.000
11.88
Focal point
for gas-filled mode
Focal point
for vacuum mode
1.791
LN2 Storage
2.10
1.19
2.09
10.80
10.40
2.2
2.50
5.13
3.35
3.03
12.05
1.50
.30
1.11
1.11
1.94
1.97
5.93
20.10
13.980
20.70
2.92
3.56
BEAM HALL II
18/10/2004

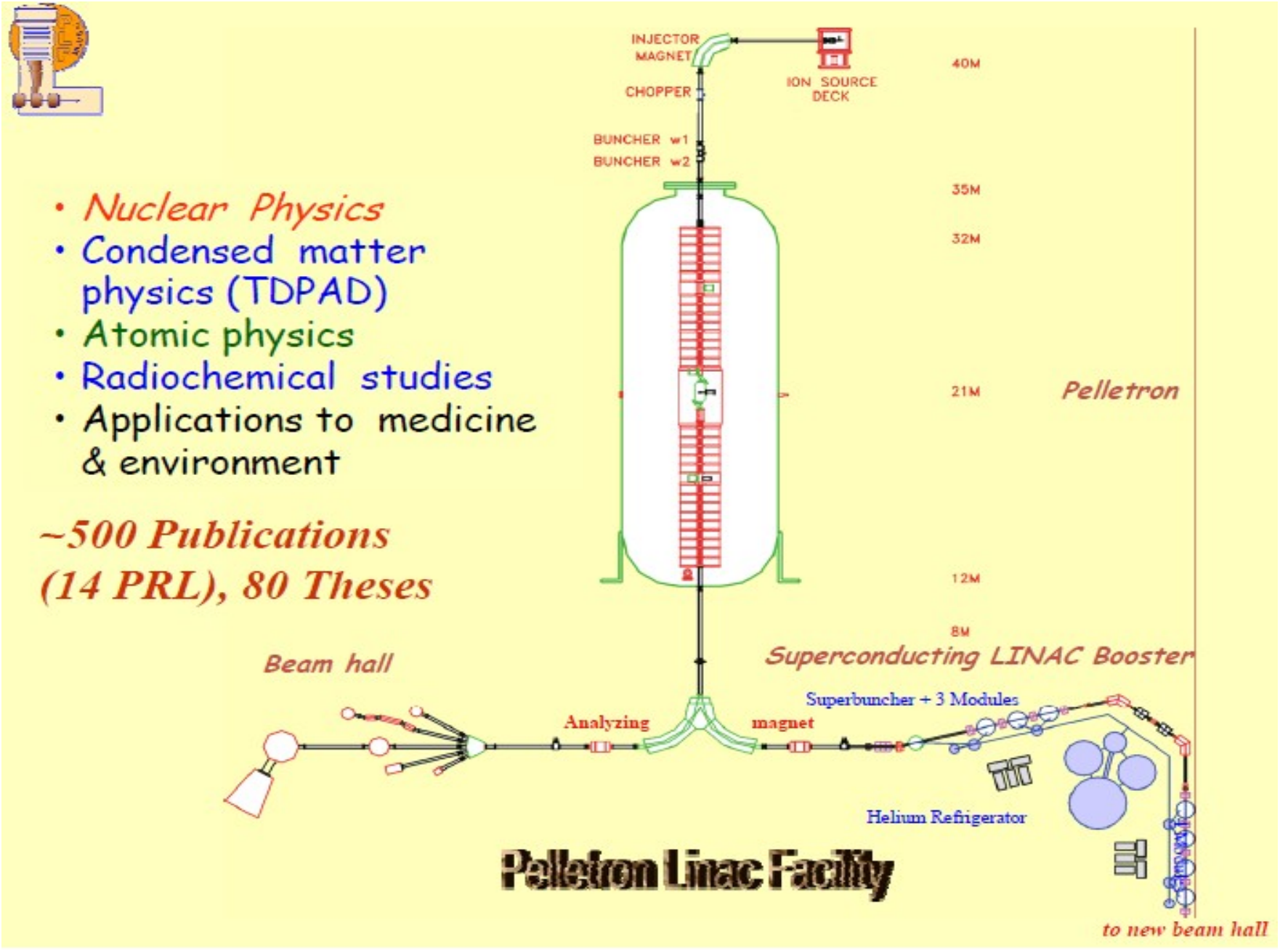


Fabrication of single spoke cavity for Project X, Fermilab



TESLA type 1.3 GHz Single Cell cavities, RRCAT-IUAC collaboration

TATA INSTITUTE OF FUNDAMENTAL RESEARCH, Mumbai

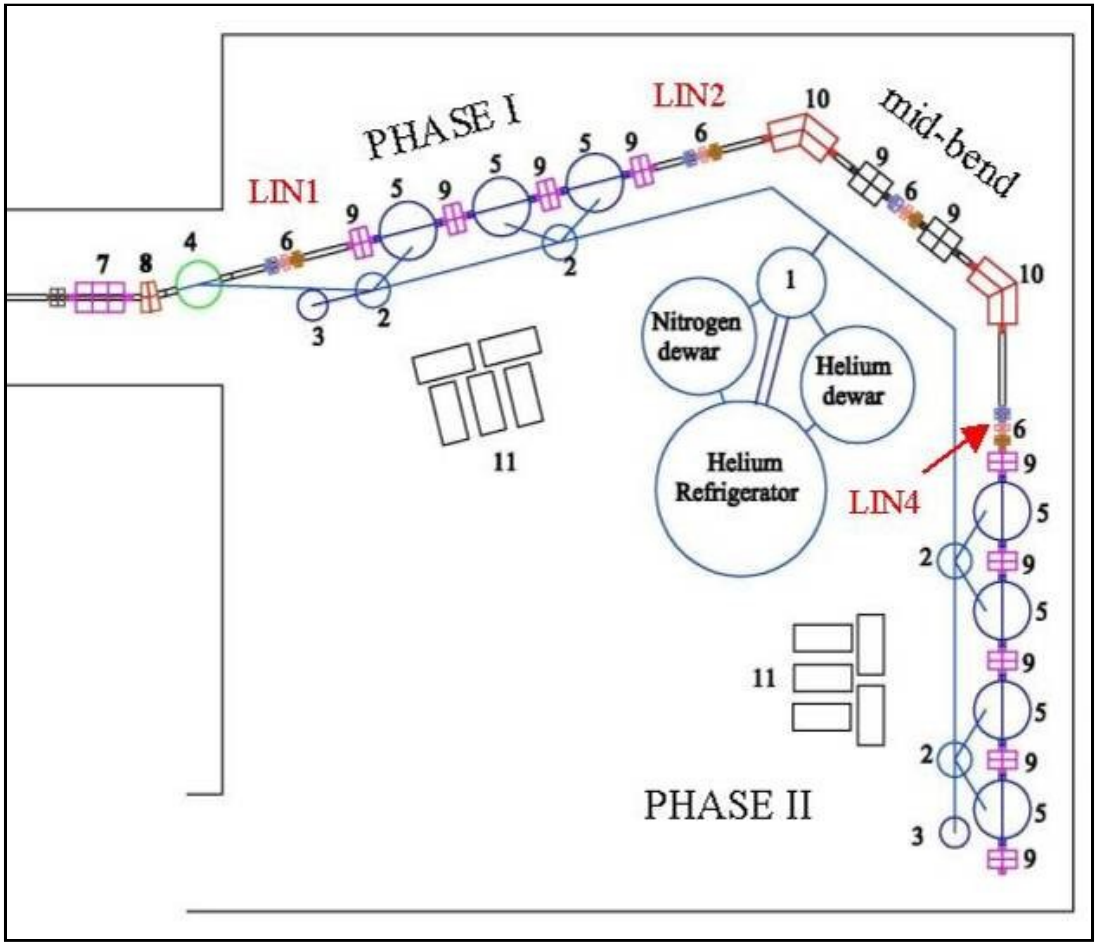


LINAC Booster

Specifications

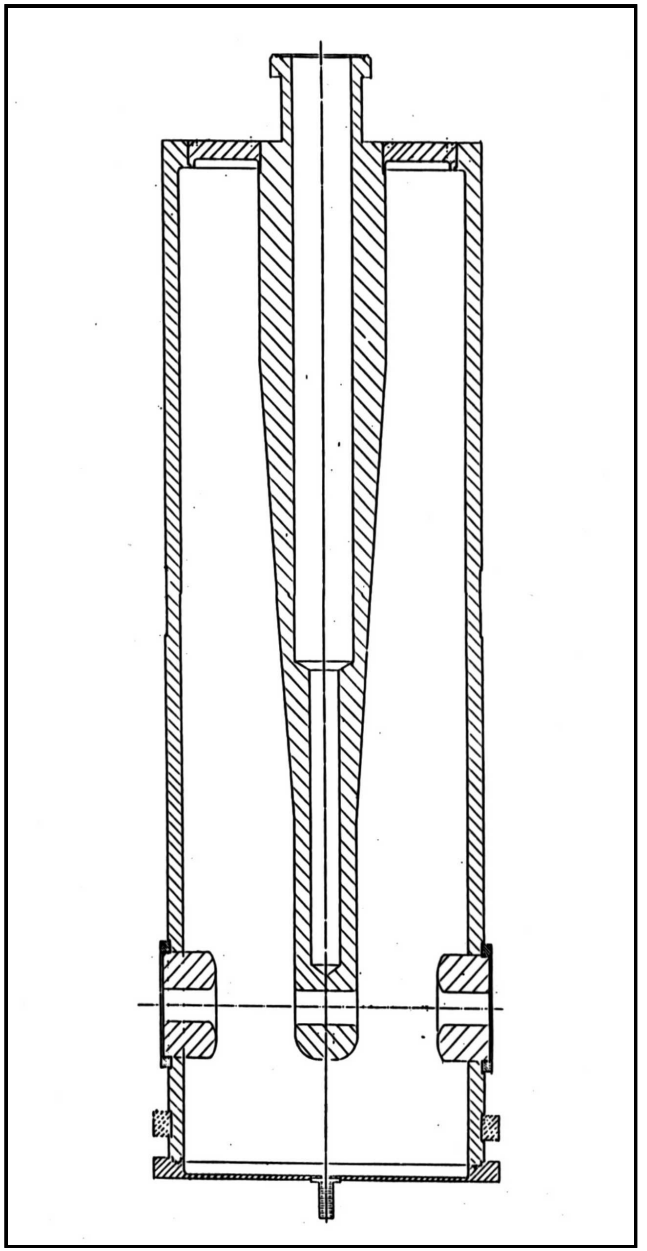
Energy gain 14MV/q
Module 7 nos
Resonators 28 nos

Bunch width ~200 ps
Beam Intensity 0.1-10 pnA



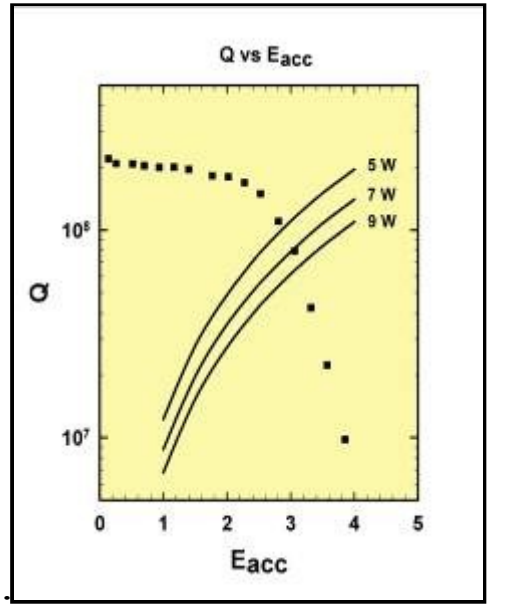
Phase I commissioned on September 22nd, 2002
Phase II commissioned on July 9th, 2007
LINAC dedicated to users on Nov. 28 , 2007

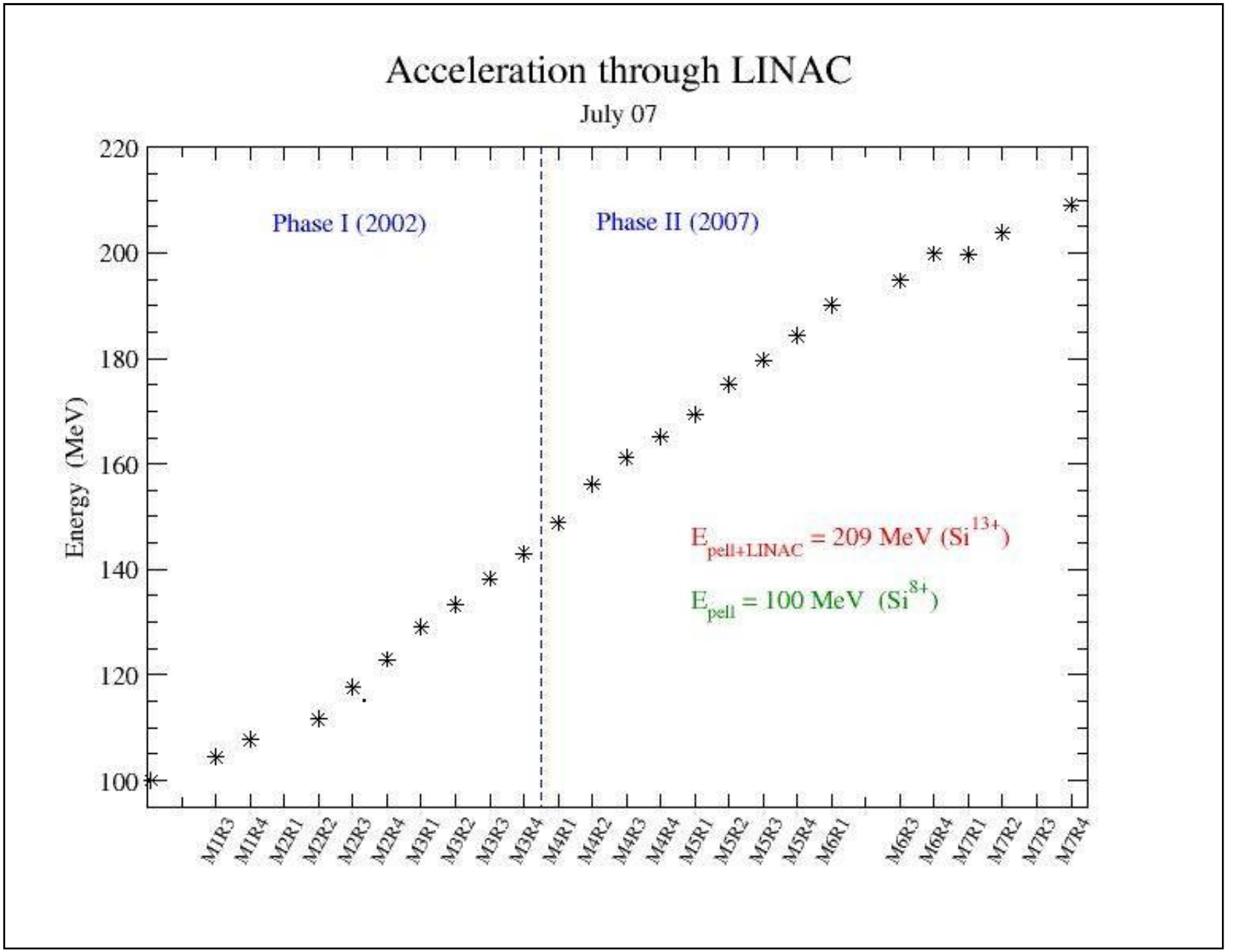
Critical components of LINAC booster have been designed, developed and fabricated indigenously.

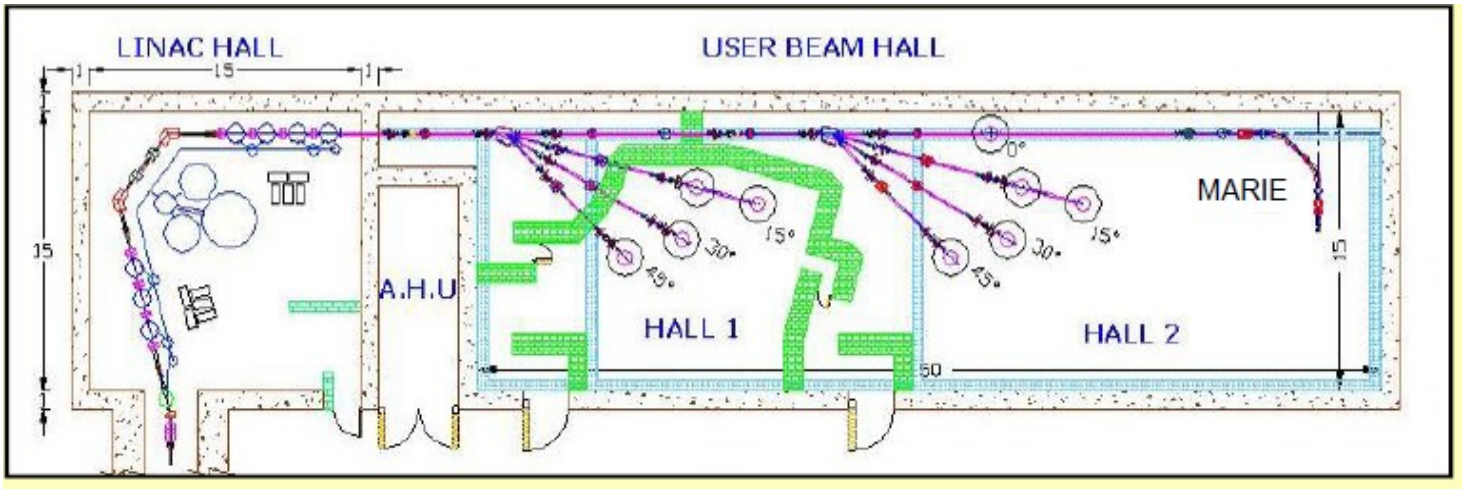


Quarter Wave Resonators

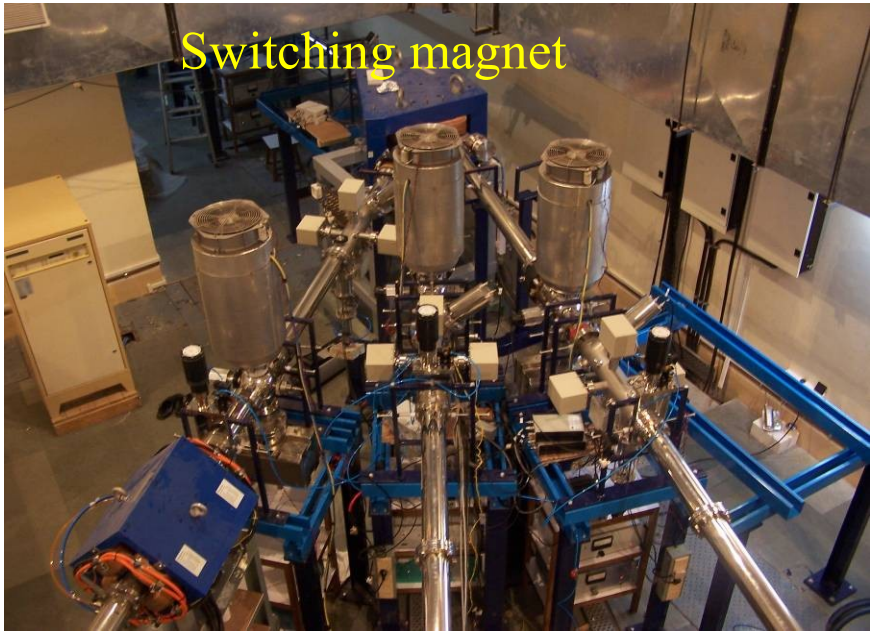
Material	OFHC Cu
Superconducting surface	2 □m thick. Pb
Frequency	150 MHz
Cavity Length	64 cm
Cavity Diameter	20 cm
Optimum velocity	□=0.1
Design goal	2.5 to 3 MV/m @ 6 to 9 Watts



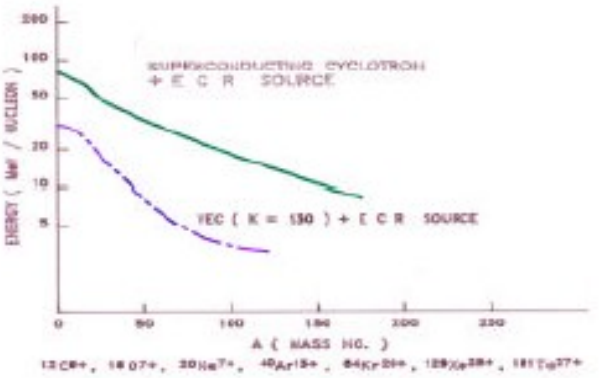

Acceleration through LINAC
July 07
Energy (MeV)
220
200
180
160
140
120
100
Phase I (2002)
Phase II (2007)
E pell+LINAC = 209 MeV (Si 13+)
E pell = 100 MeV (Si 8+)
M1R3
M1R4
M2R1
M2R2
M2R3
M2R4
M3R1
M3R2
M3R3
M3R4
M4R1
M4R2
M4R3
M4R4
M5R1
M5R2
M5R3
M5R4
M6R1
M6R3
M6R4
M7R1
M7R2
M7R3
M7R4

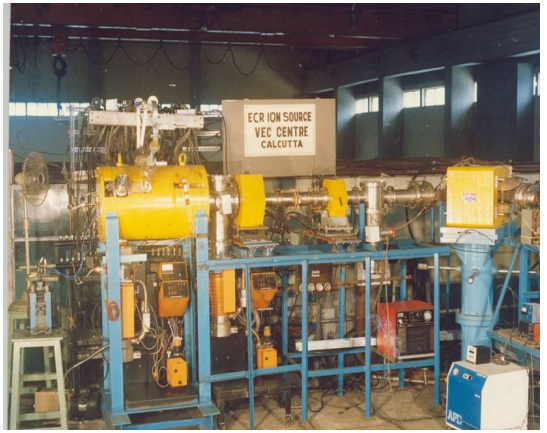

LINAC HALL
USER BEAM HALL
15
1
1
15
A.H.U
HALL 1
HALL 2
MARIE
0°
15°
30°
45°
15°
30°
45°
50
15

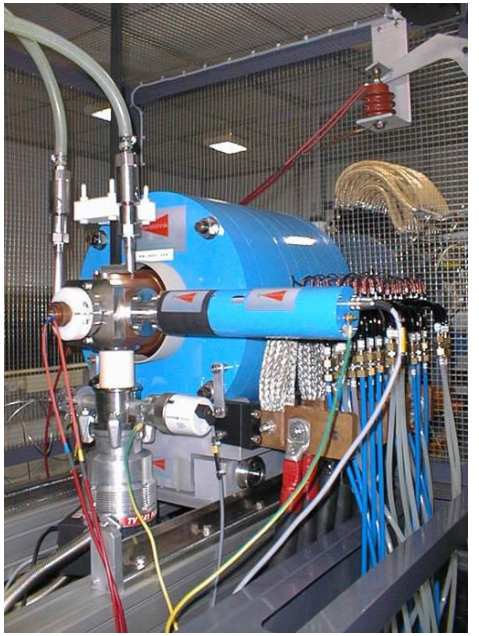

Hall I Experimental stations

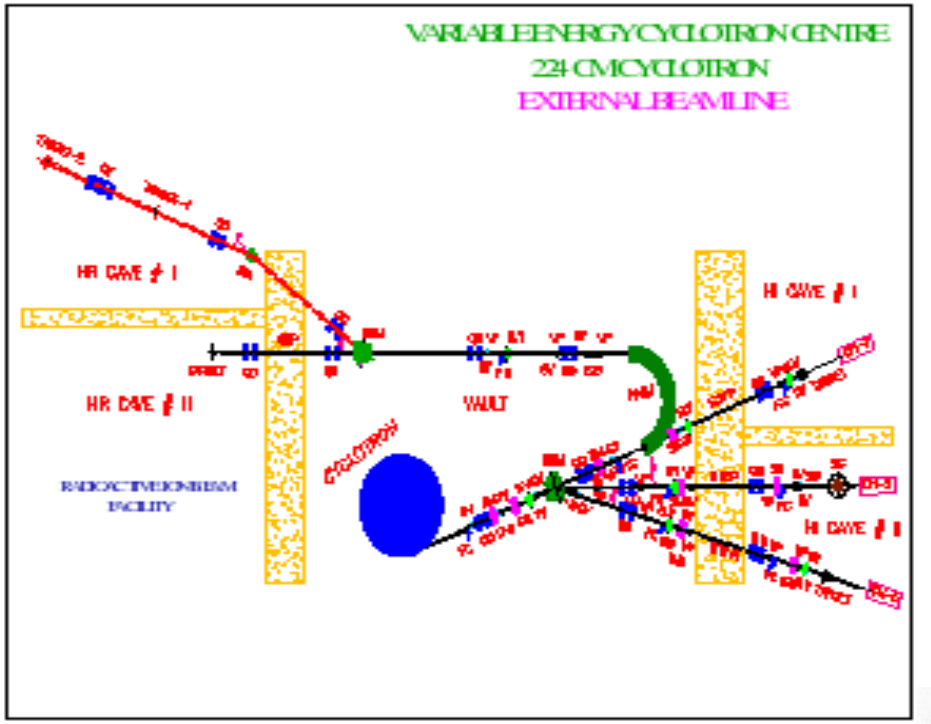

Switching magnet

Variable Energy Cyclotron Centre, Kolkata









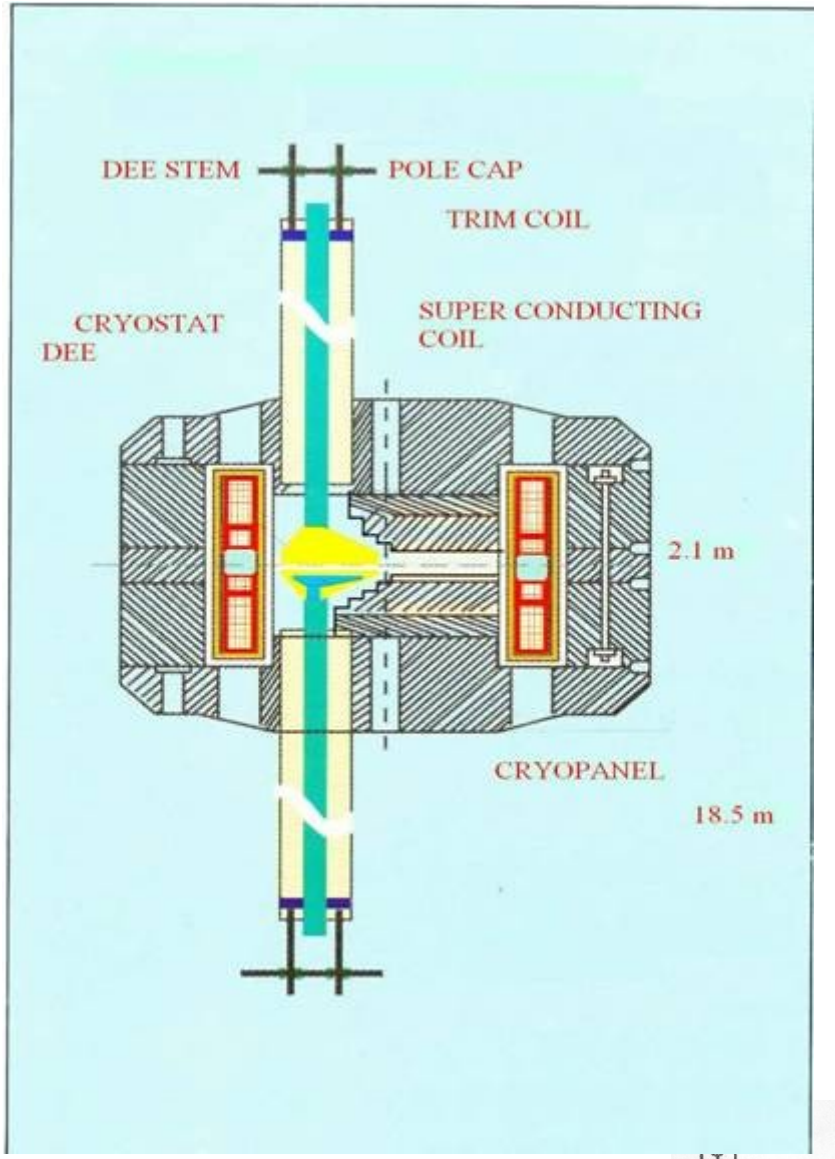
Superconducting Cyclotron

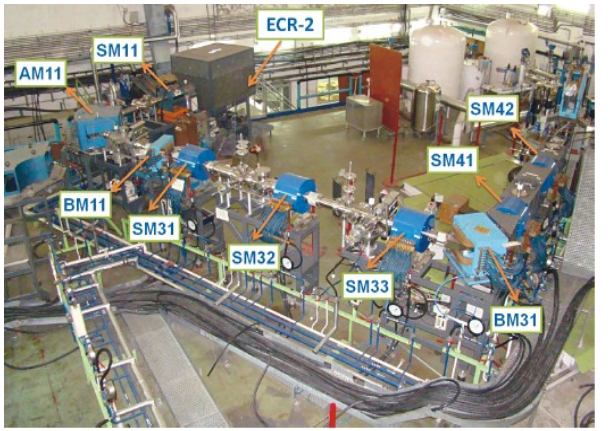
PARTICLE ENERGY:

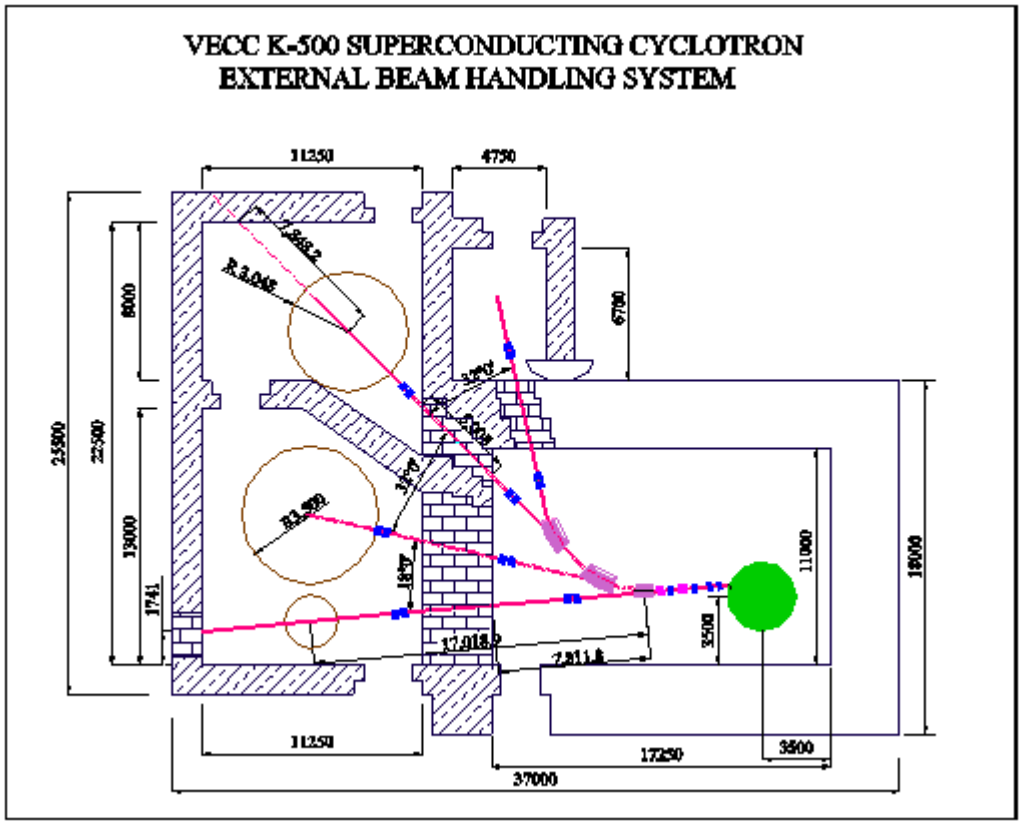
- **Heavy Ions : 520 Q /A MeV/A**
- **Fully stripped light ions : 80 MeV/A**

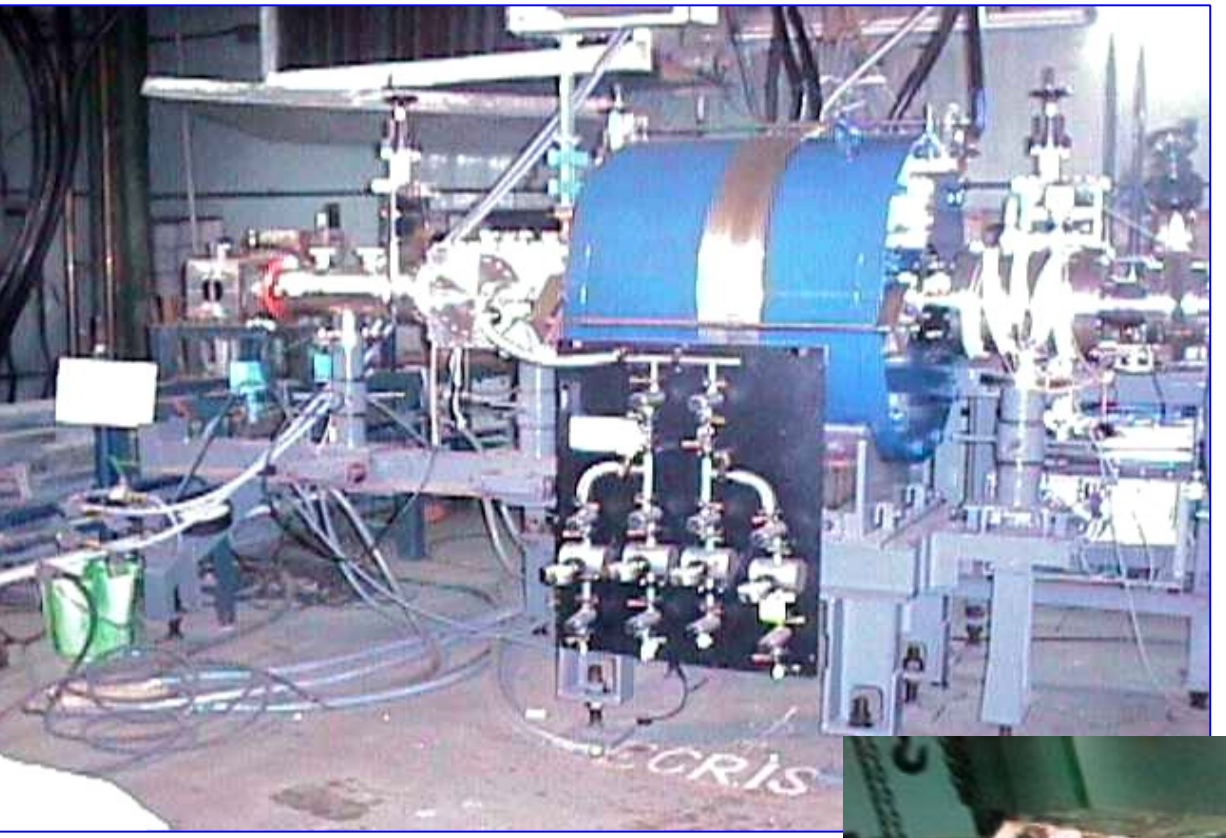
MAGNETIC FILED : ~ 6 T (Max.)

RF : 9 - 27 MHz., VD : 80 kV




ECR-2
SM11
AM11
SM42
SM41
BM11
SM31
SM32
SM33
BM31

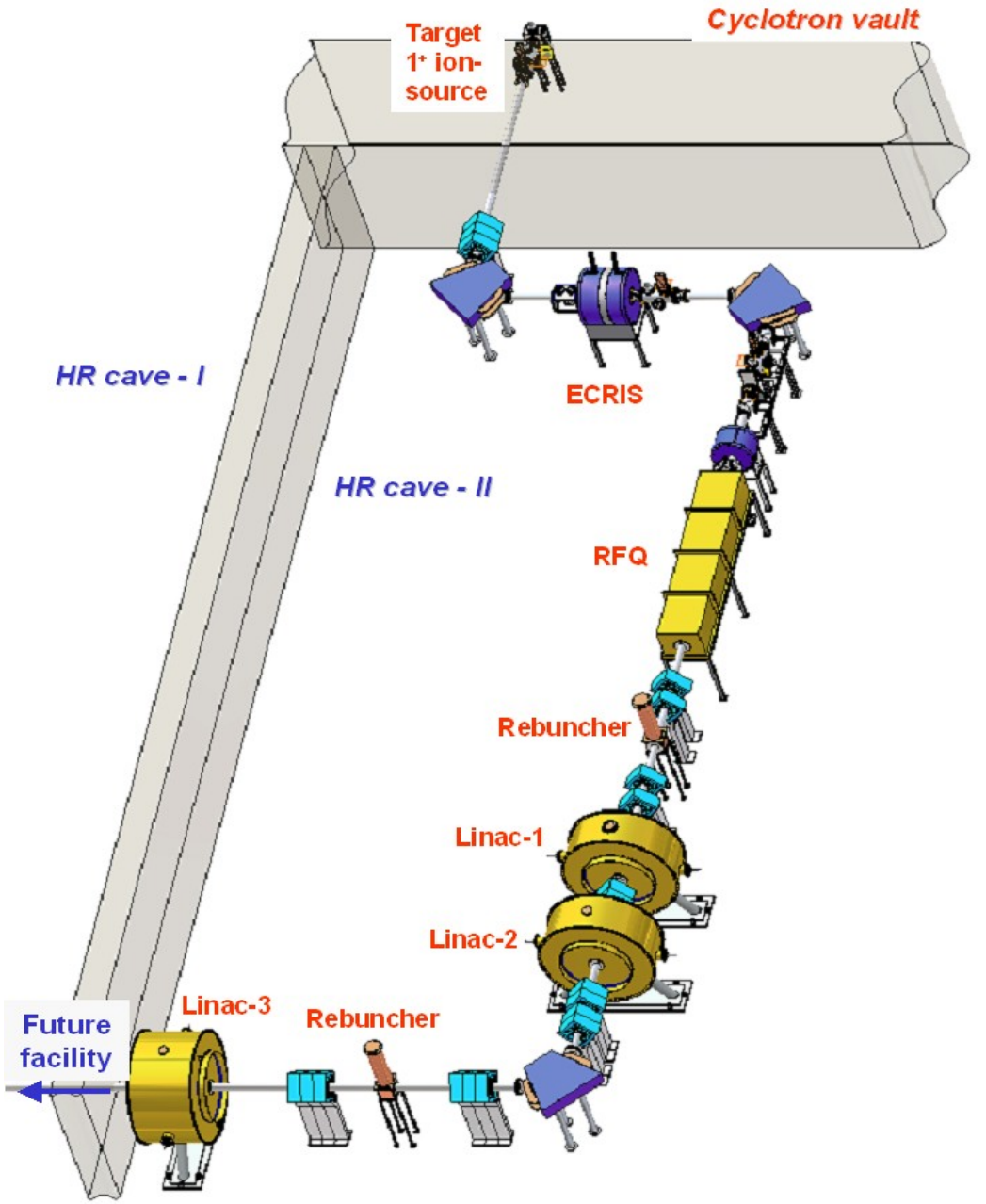

VECC K-500 SUPERCONDUCTING CYCLOTRON
EXTERNAL BEAM HANDLING SYSTEM
11250
4750
8000
6780
25500
22500
18000
1741
11000
18000
3500
11250
17250
3500
37000



On-line ECRIS and 2-IS beam-line

RFQ cold model

Radioactive Ion Beam Facility

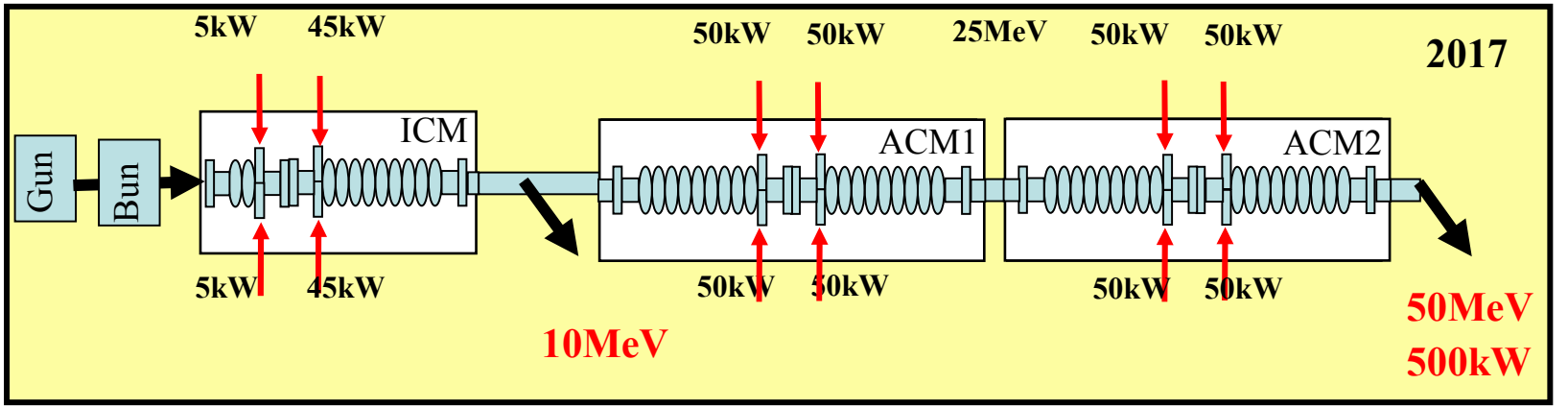


Superconducting Electron Linac

Based on 1.3 GHz SRF technology

2 single-cell capture cavities & 1st multi-cell cavity; 10 MV/m, 1.3 GHz, 2K

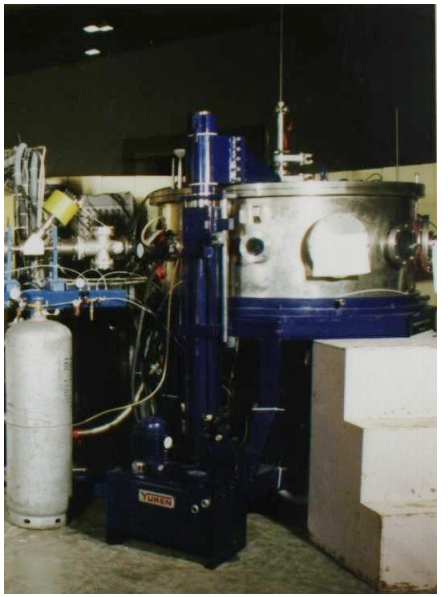
Four 9-cell cavities, 10 MV/m each; 1.3 GHz, 2K



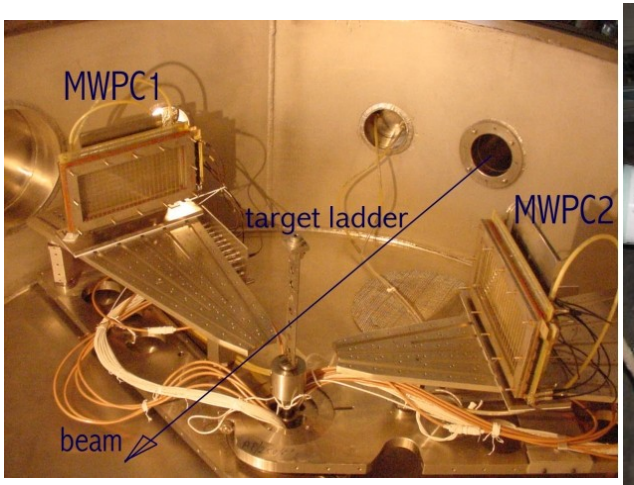
Injector

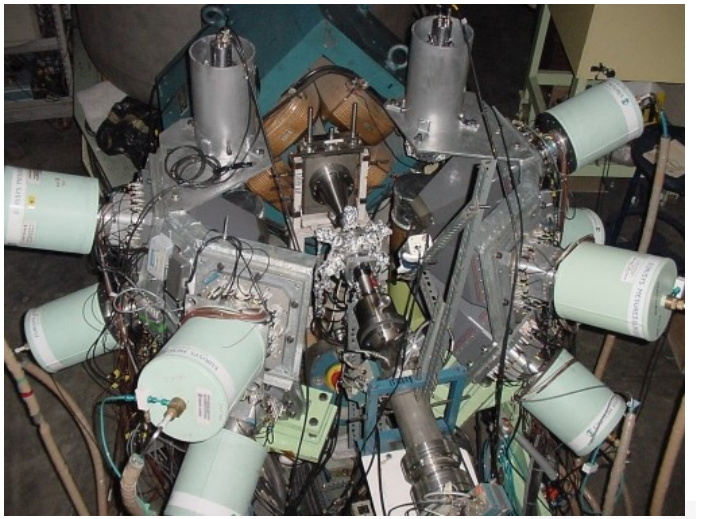
Accelerator

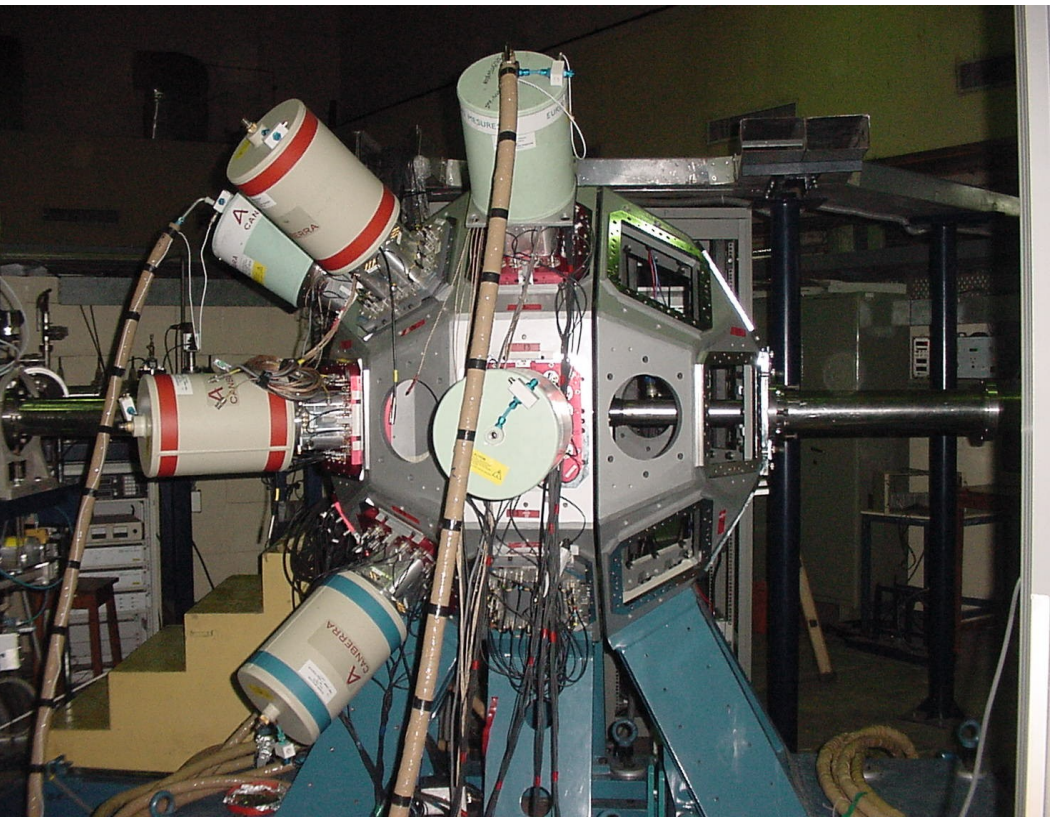
Experimental Facilities

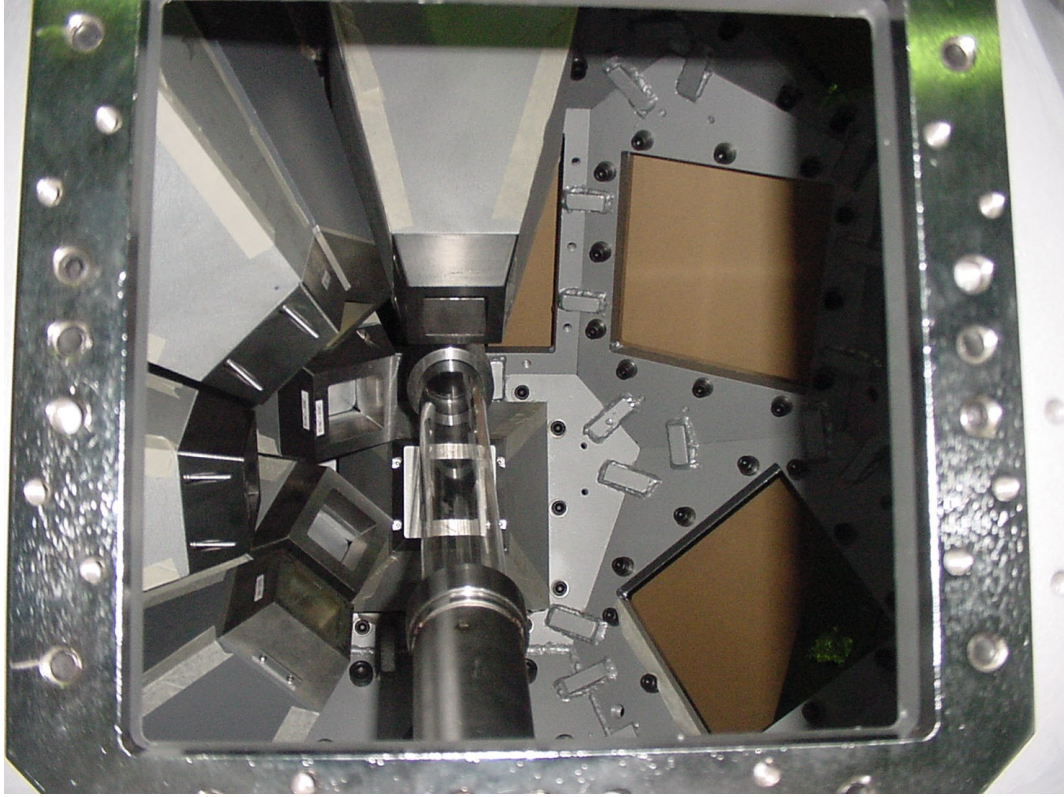


Gamma Detector Array,
Recoil-distance device,
Mini-orange spectrometer,
Charged-particle array,
Neutron Array,
Heavy Ion Reaction Analyser,
Hybrid Recoil Analyser
Indian National Gamma Array, Radioactive Ion Beam.



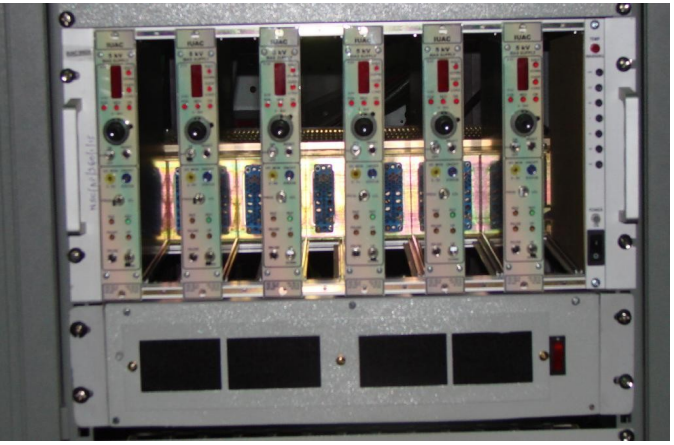


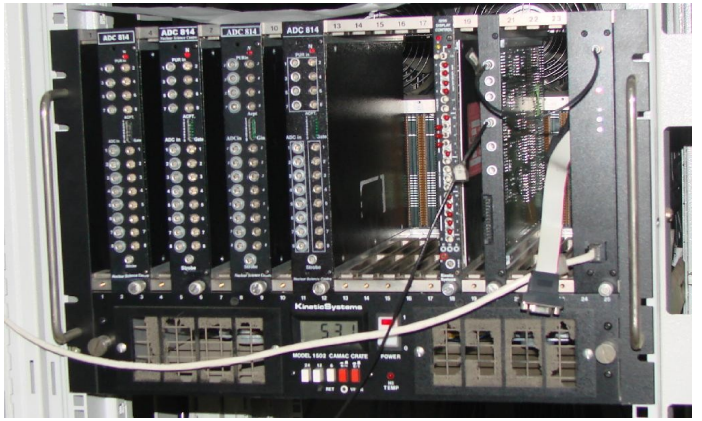


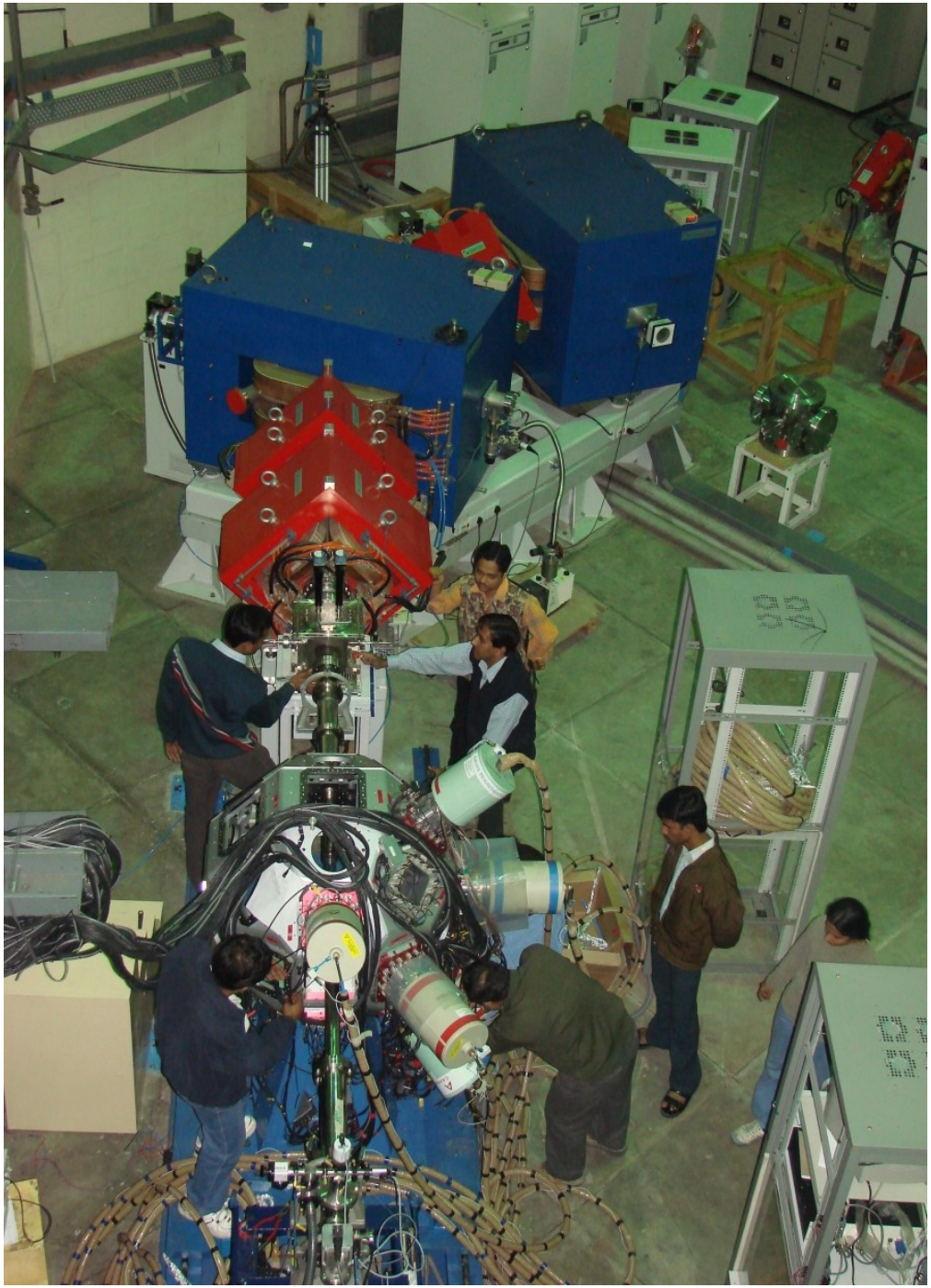


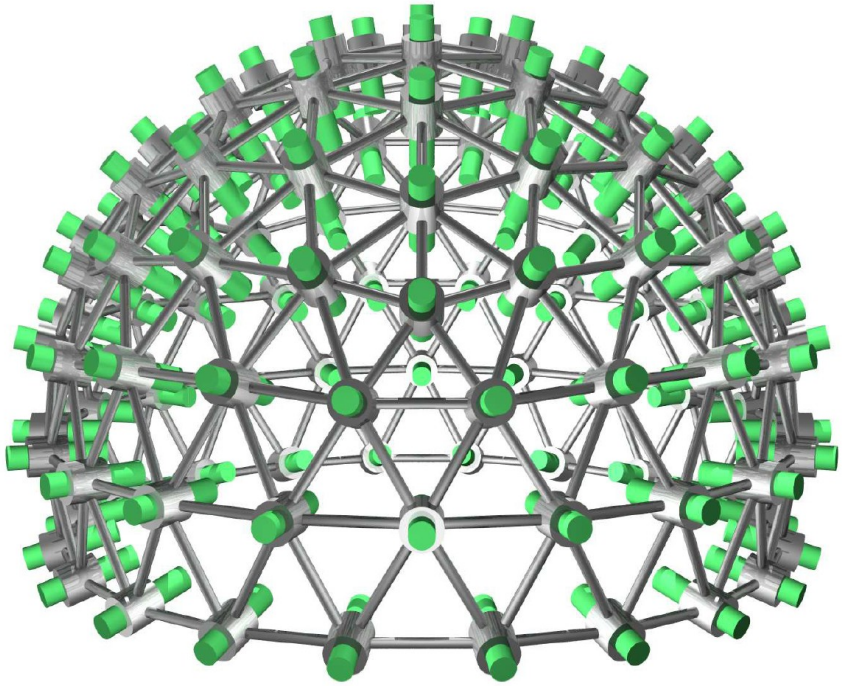
Indian National Gamma Array (INGA)

detectors from IUAC, UGC-DAE-CSR. SINP. TIFR

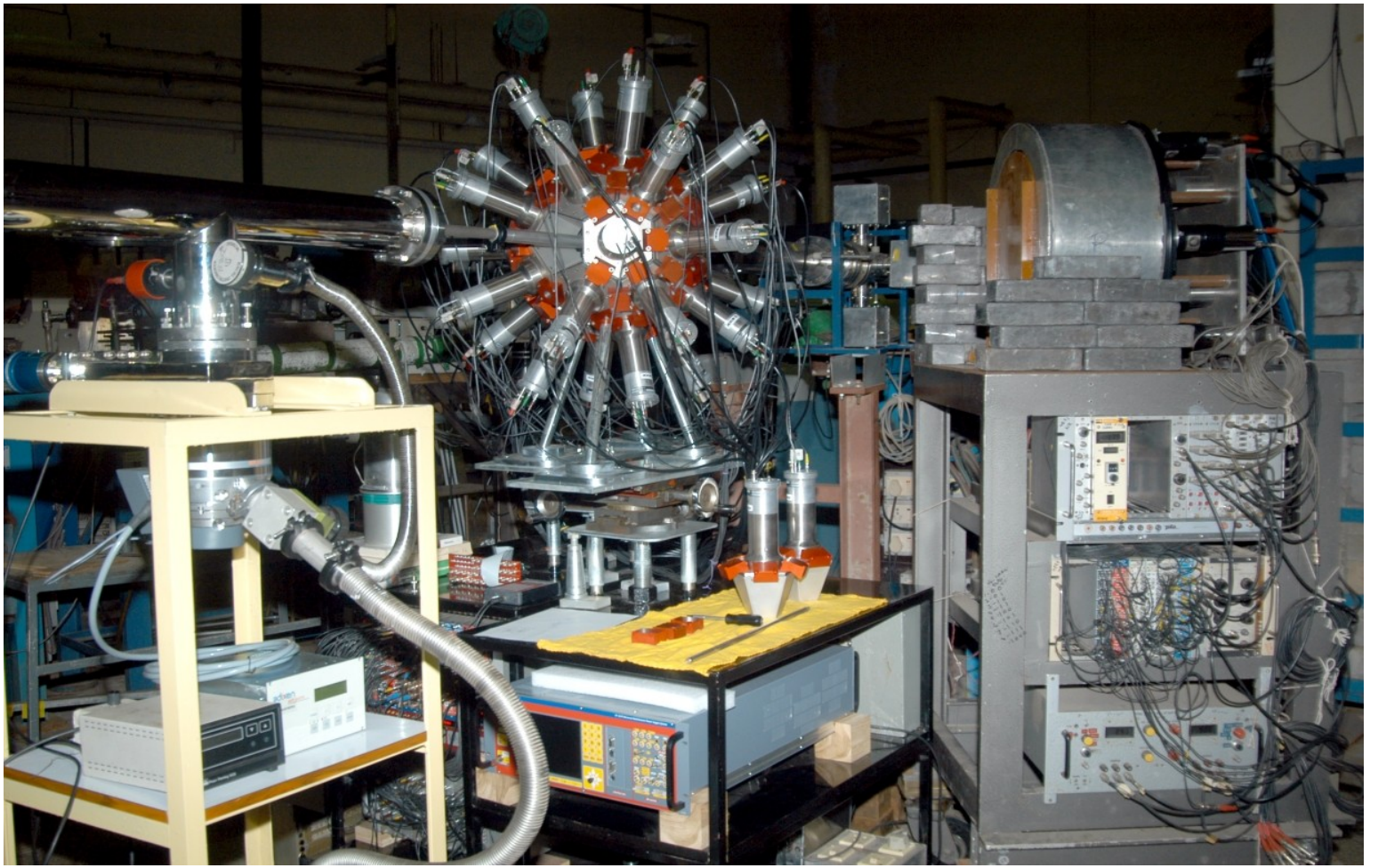








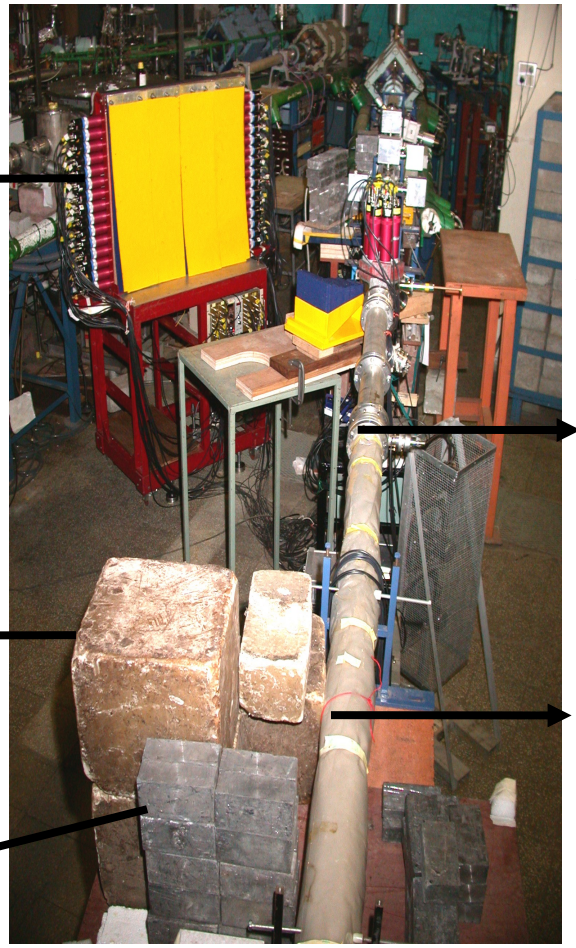
SUM SPIN SPECTROMETER, TIFR

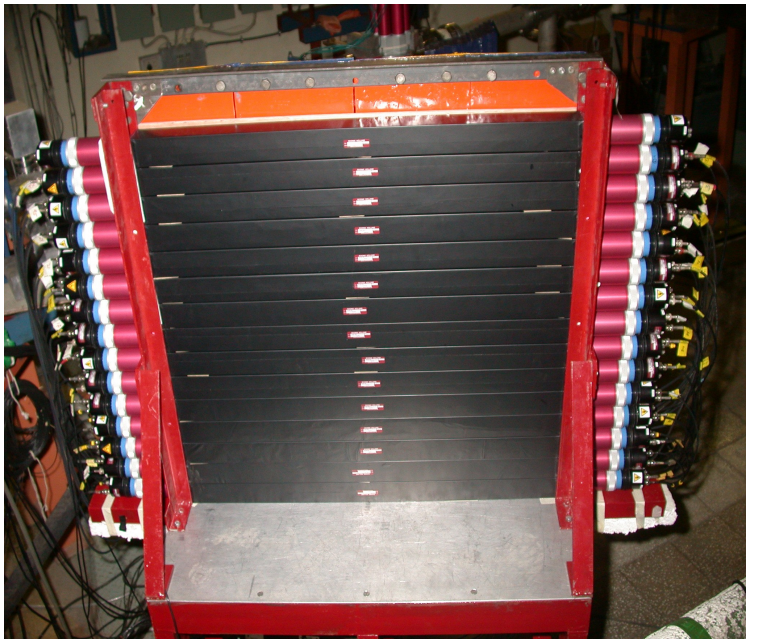


32 x 3”NaI detectors.

Spherical shell inner dia 20 cm.

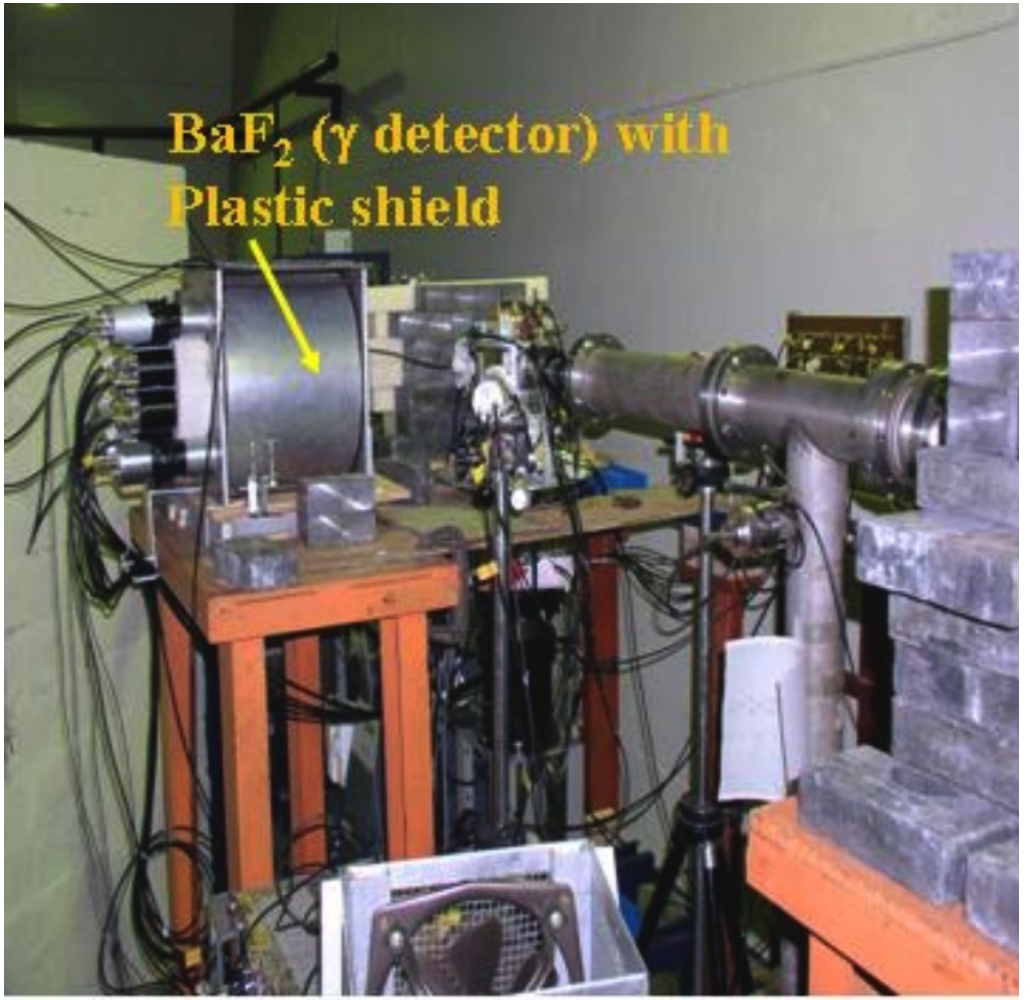
Multiplicity and Sum signals taken.



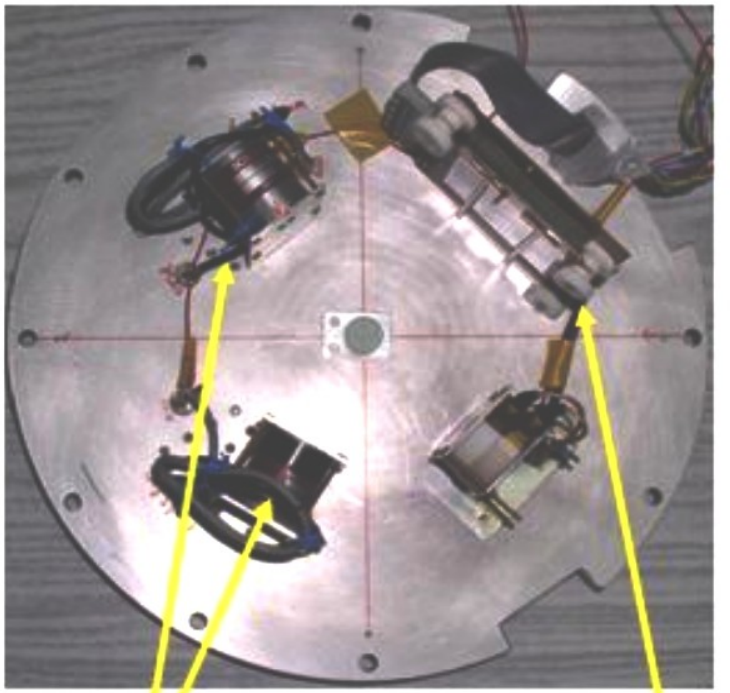


Neutron array at BARC-TIFR

- **16 plastic bars 6 cm x 6 cm x 100 cm with XP2020 PMTs at either end (from SCIONIX)**
- **Mechanical stand (our W/shop) on wheels for arranging plastic detectors in form of a wall (~ 1 x 1 m) centered at beam height**
- **Lead absorber (curtain) for γ-ray attenuation ~ 24 mm thick**
- **Mild steel (~ 30 cm thickness) for neutron attenuation from target**



top flange of the chamber



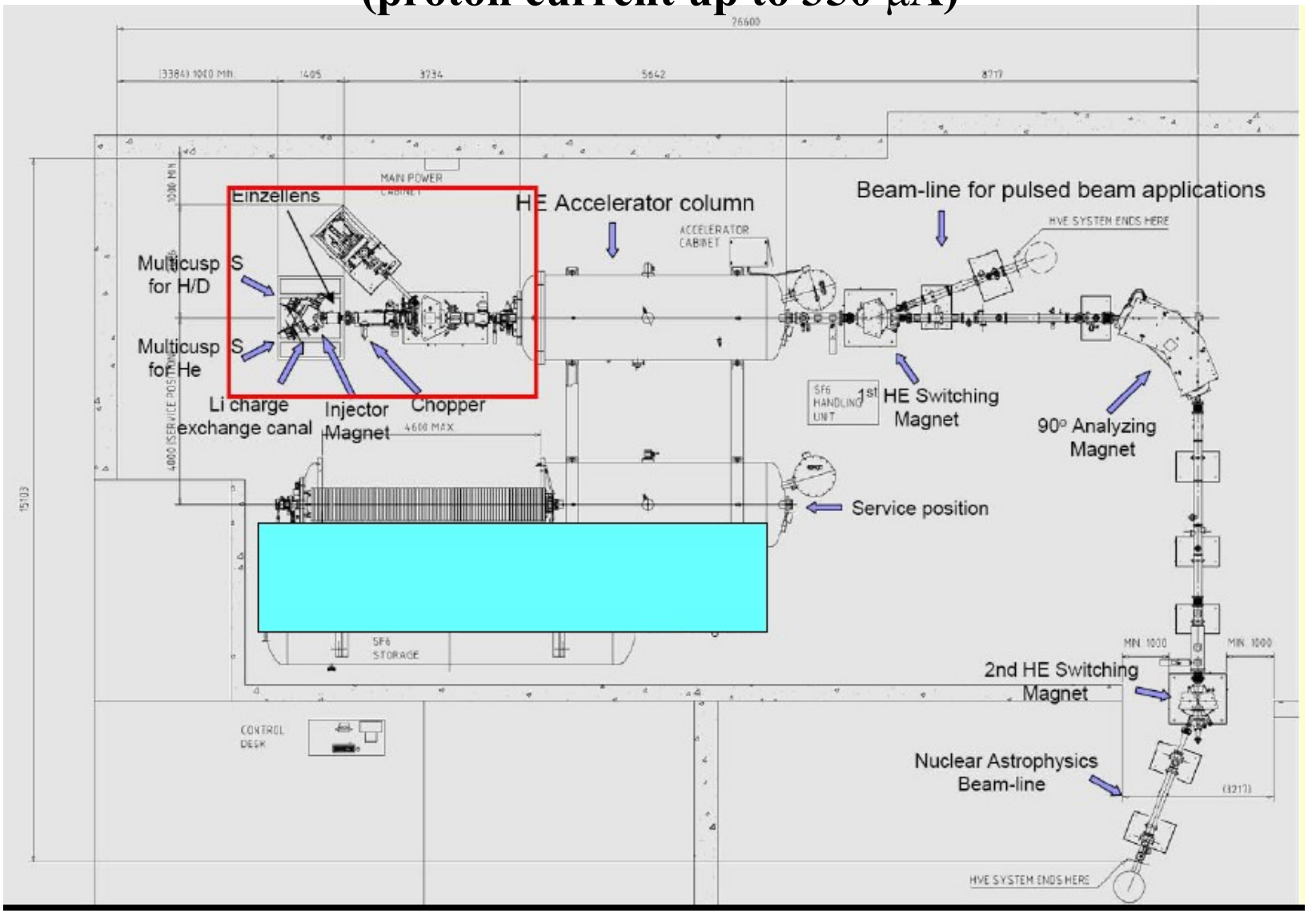
Fission Detector

CsI detectors
for α, p detection

FRENA -Facility for research in Nuclear Astrophysics using a high-current Accelerator over a wide energy range at SINP

0.2-3 MV high-current Tandem Accelerator

(proton current up to 350 μA)



The two Pelletron + Linac combinations at Mumbai and Delhi and the K=140 Cyclotron at Kolkata provide heavy ion beams over a wide mass range near the Coulomb barrier.
The High Current Injector at IUAC would provide higher fluxes of heavy ions for measurement of reactions of lower cross-sections.
The K=500 Superconducting Cyclotron at Kolkata would provide heavy ions in the range of Fermi energies.
FRENA at SINP is a dedicated machine for measuring nuclear cross sections of Astrophysical interest.

The Hybrid Recoil Reaction Analyser and Indian National Gamma Array, High Energy Gamma detectors and the Neutron Array and other add-ons in combination with the accelerator systems constitute front-line facilities for Nuclear Physics research.

The development of Nb SRF technology is a significant achievement and major investments are now made in this area for planning larger accelerators like High power proton accelerator.

Thank You