Ion Accelerators IUAC Delhi

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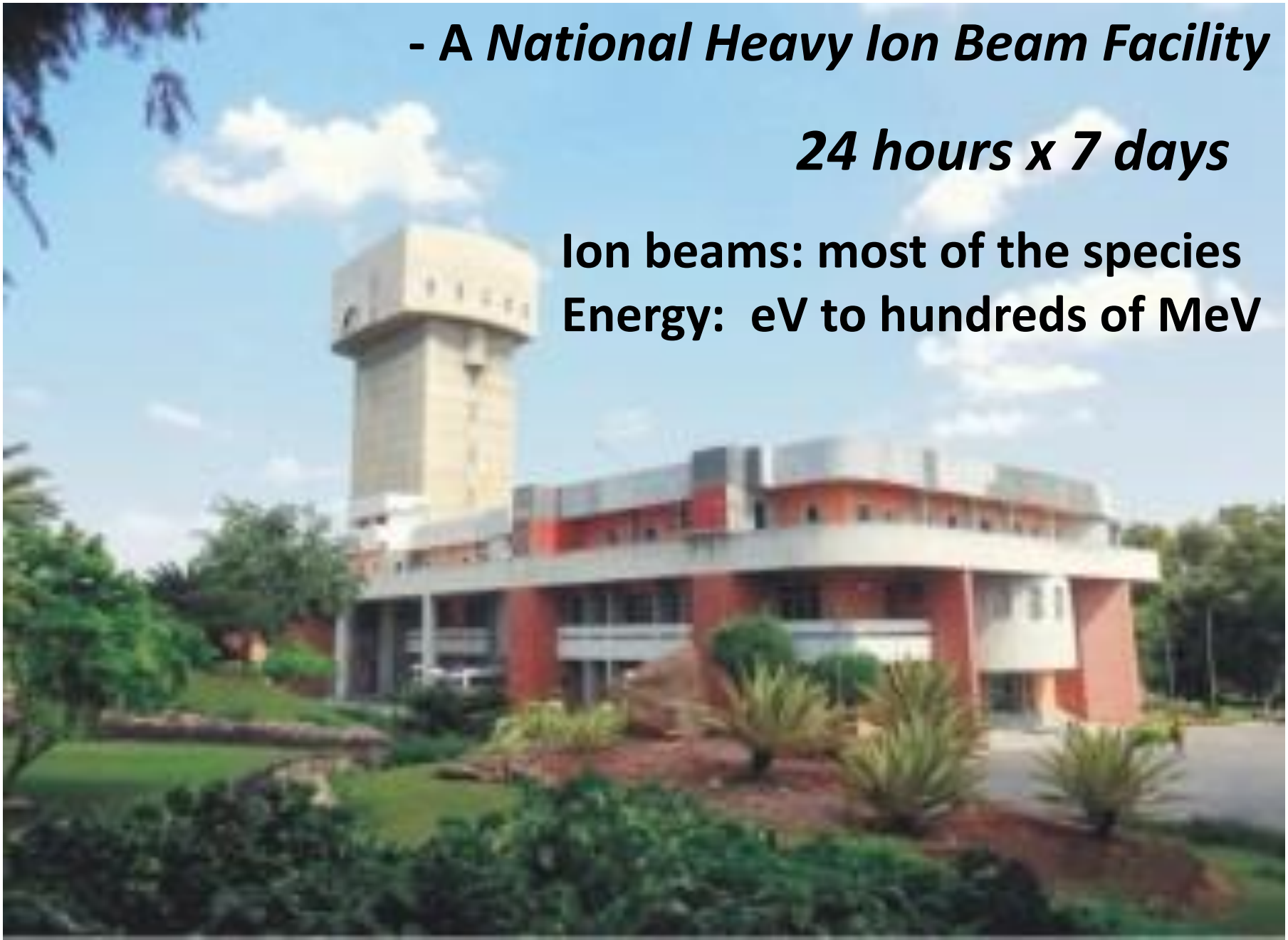
Inter-University Accelerator Centre (IUAC)



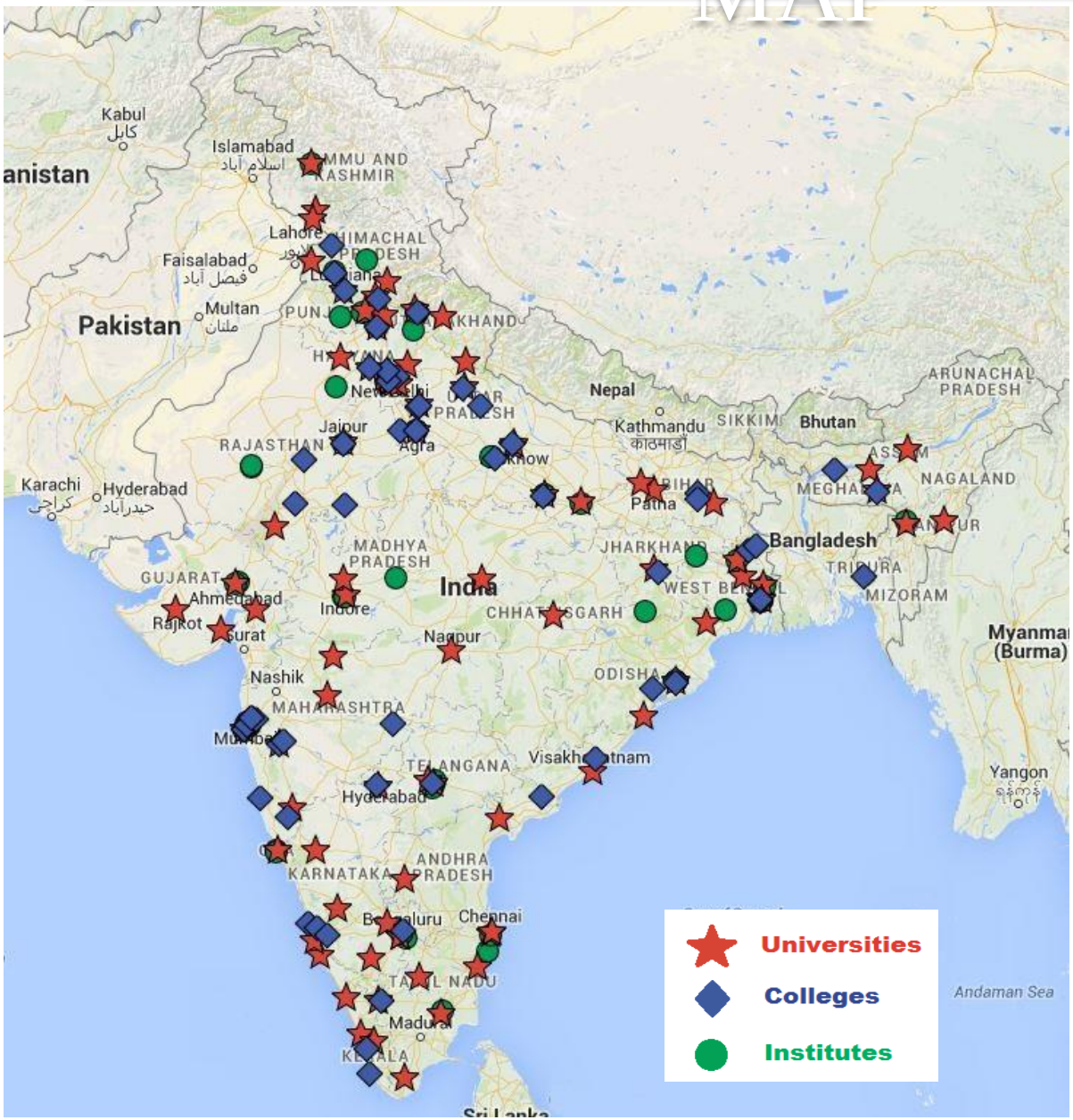
- A National Heavy Ion Beam Facility

24 hours x 7 days

Ion beams: most of the species

Energy: eV to hundreds of MeV

MAP


Kabul
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India
Ahmedabad
Indore
Rajkot
Surat
Nagpur
Nashik
Mumbai
Hyderabad
Visakhapatnam
Bengaluru
Chennai
Madurai
Yangon
Myanmar (Burma)
Andaman Sea
Sri Lanka
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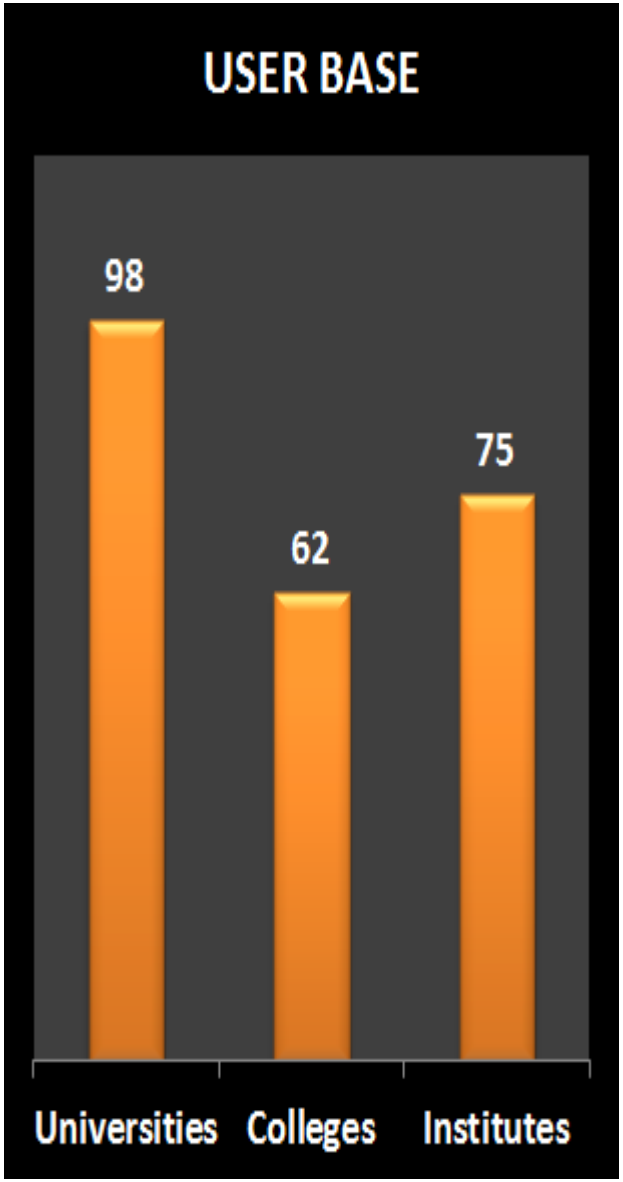
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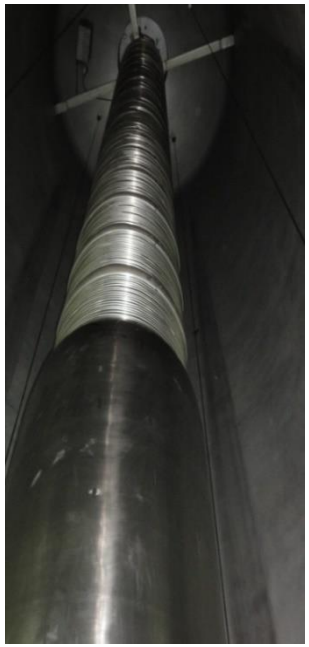
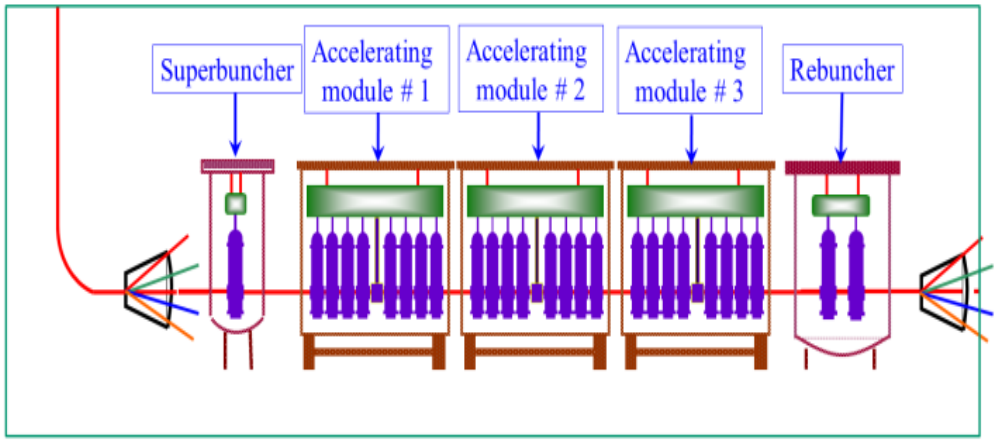
ION ACCELERATORS AT IUAC



15 UD Pelletron



Nb QWR based LINAC

1.7 MV RBS/C Facility

Dedicated ^{14}C AMS Facility

LEIBF-1: ECR
Positive Ion Facility

LEIBF-2: MC-SNICS
Negative Ion Facility

50 kV Acceleration system

Nuclear Physics Research at IUAC

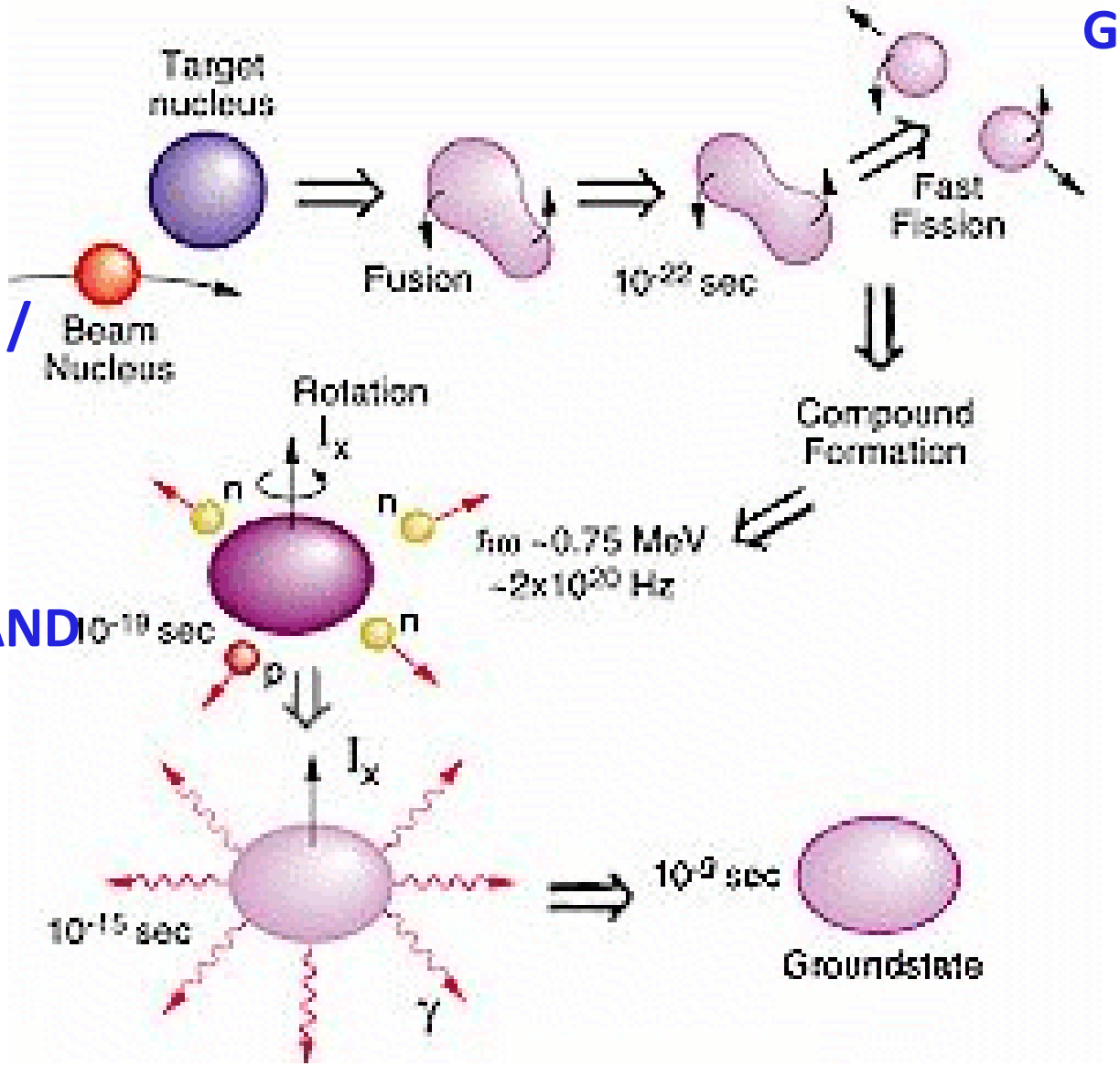
GPSC

PELLETRON / LINAC

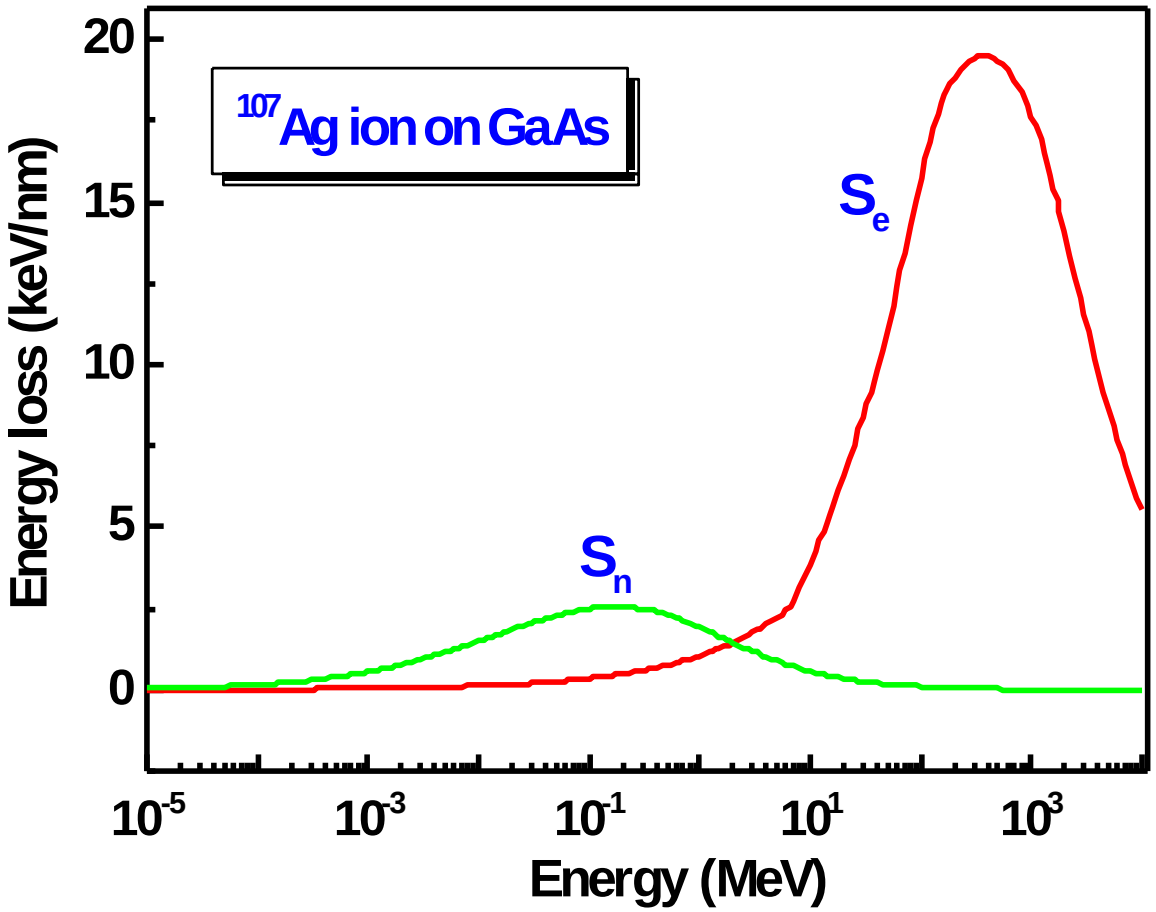
CPDA / NAND

HIRA / HYRA

GDA / INGA

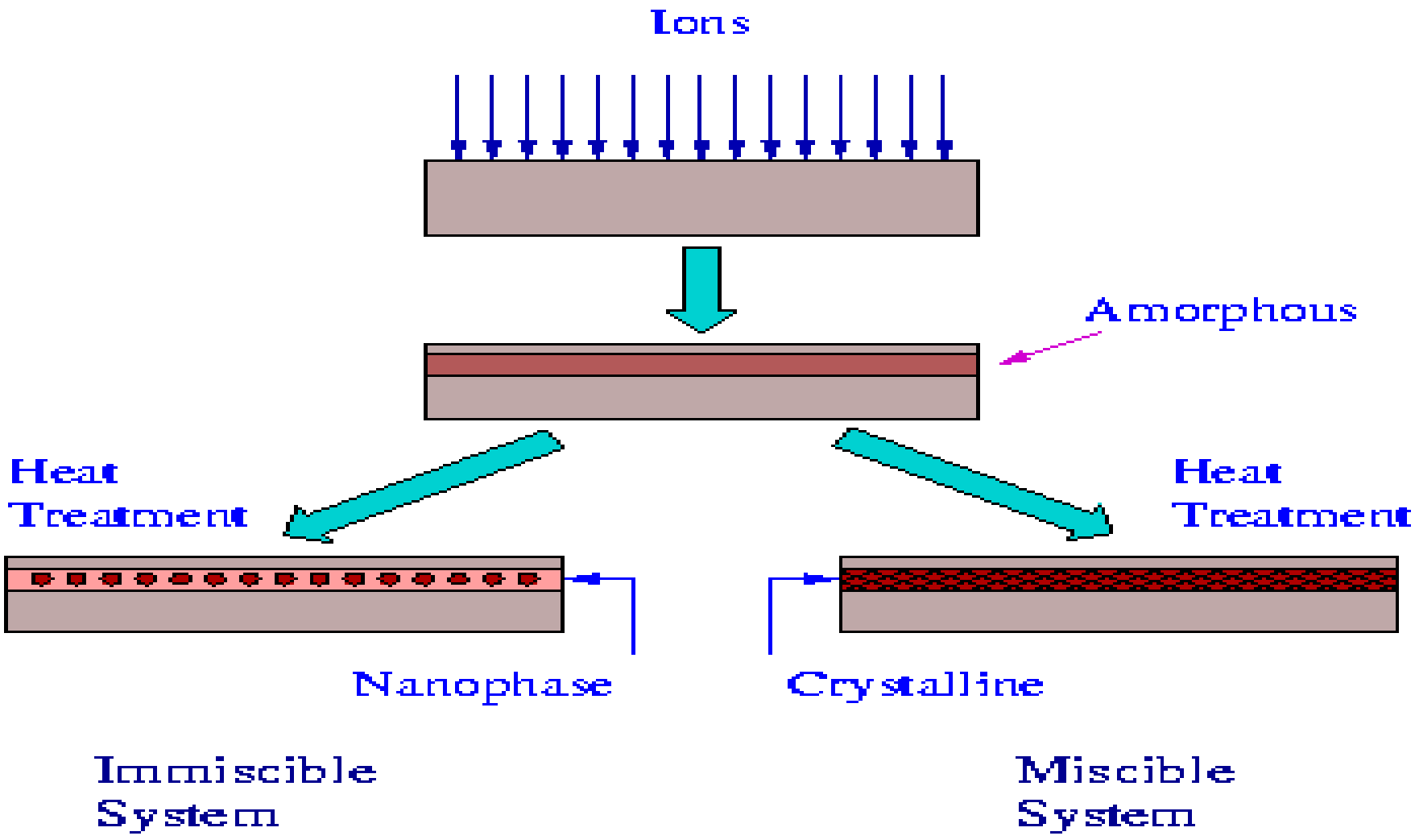


Stopping and Ranges of Ions in Matter (SRIM) simulations:



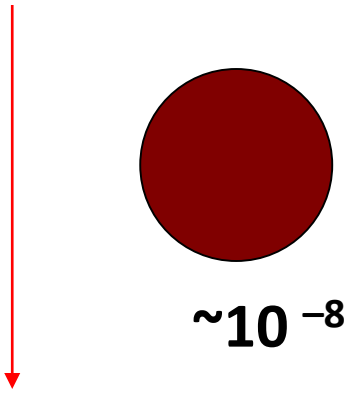
The deposited energy depends on mass and energy of projectile and on mass of target

Phase formation using Ion beams



Interaction Processes

- **Swift Heavy Ions(SHI) Energy ≥ 1MeV/u**
  - **Velocity ~ Bohr electron velocity**
  - **$S_e >> S_n$**



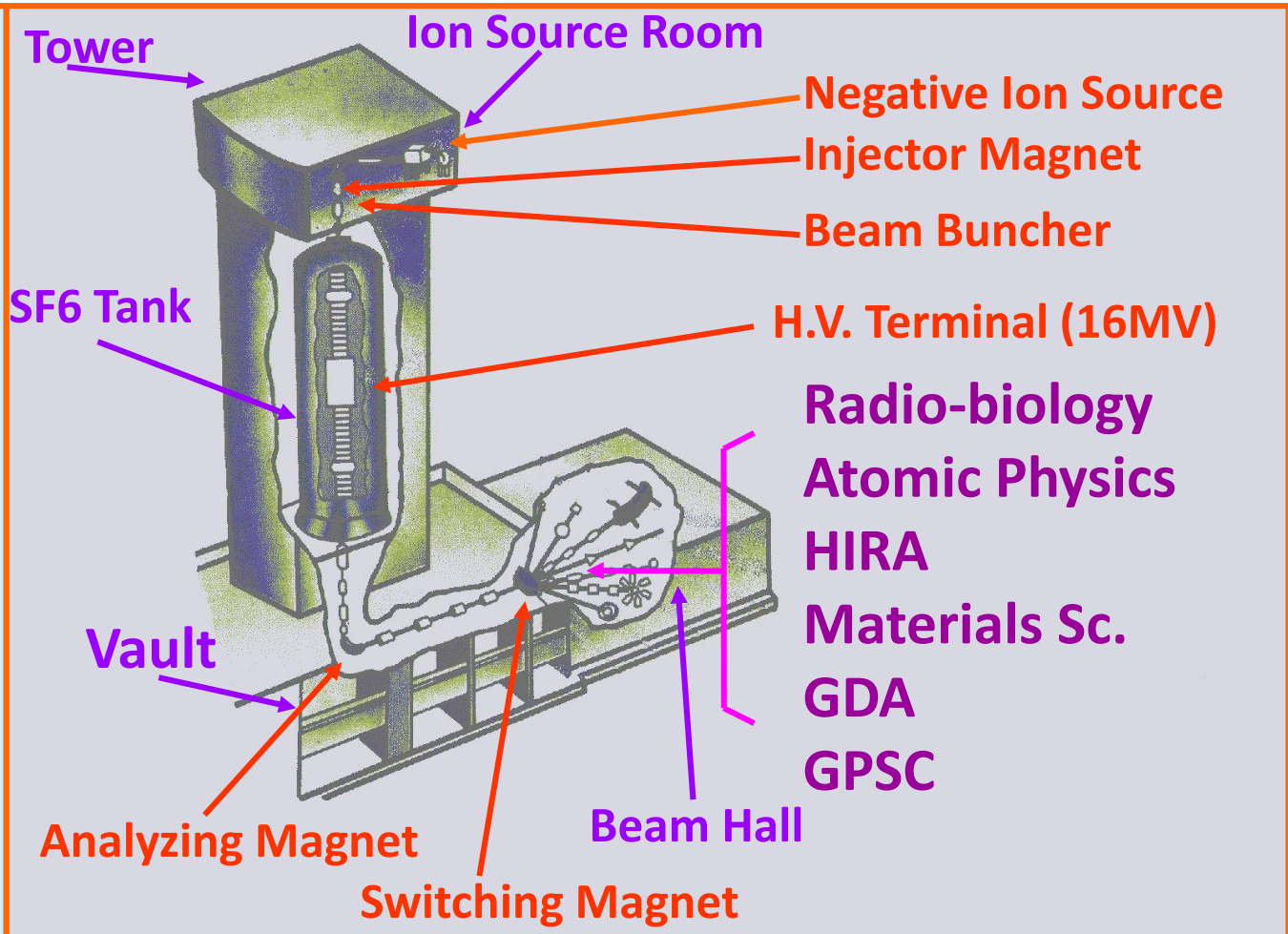
- **Passage of ion through material causes excitation or ionization of atoms ($t \leq 10^{-17}$ sec, v ~ 1cm/ns)**

Recoil production: 10^{-17} s
Modification in lattice: ~ 10^{-12} s

15UD Pelletron Accelerator at IUAC

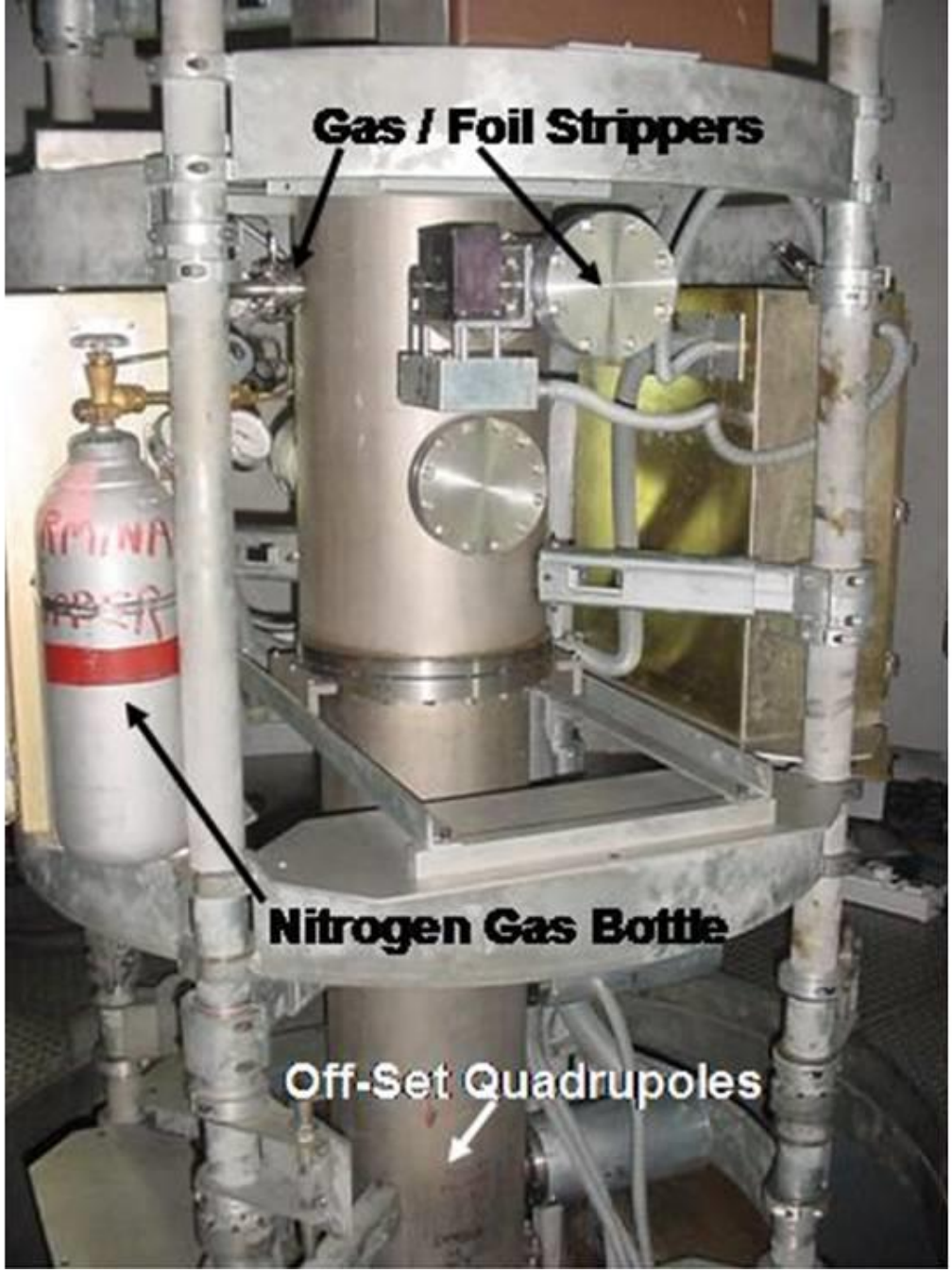
Modifications:

1. Resistor Grading
2. MC-SNICS
3. Terminal Turbos
4. MH Buncher
5. Off=set-FC, Wien Filter etc for AMS



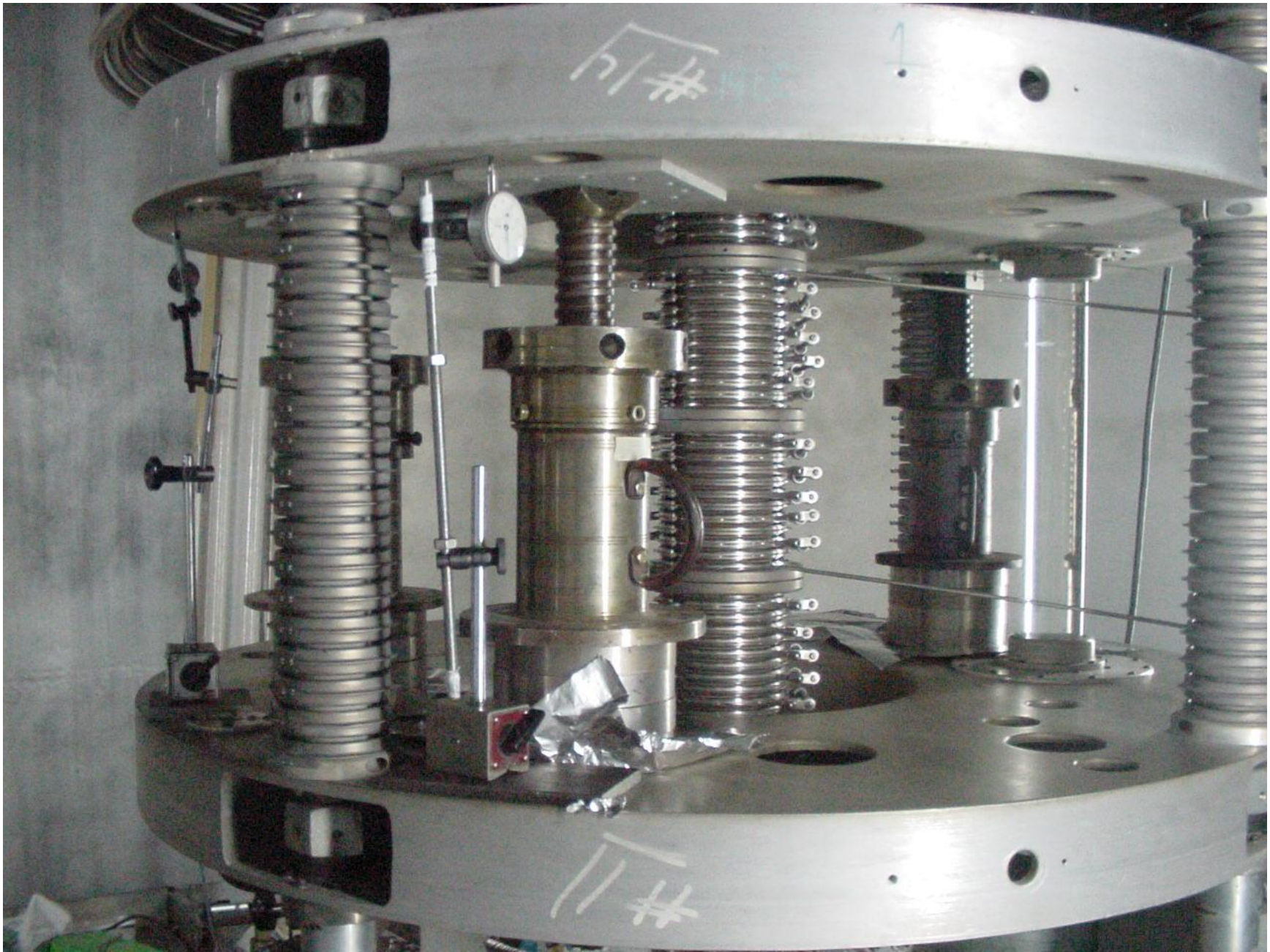
Special Features:

1. Off-set QP in Terminal
2. Earthquake Protection
3. Compressed Geometry Tubes

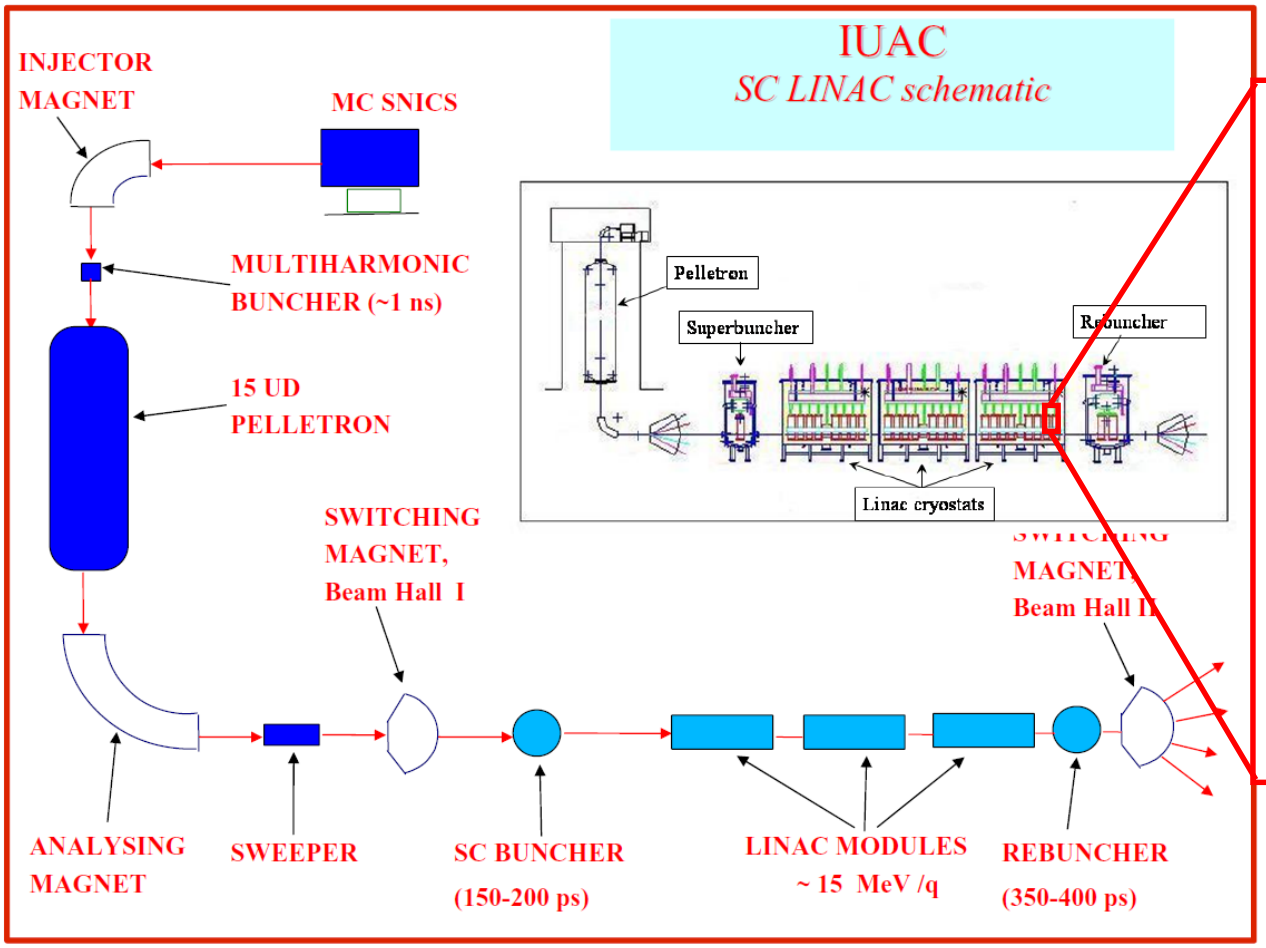


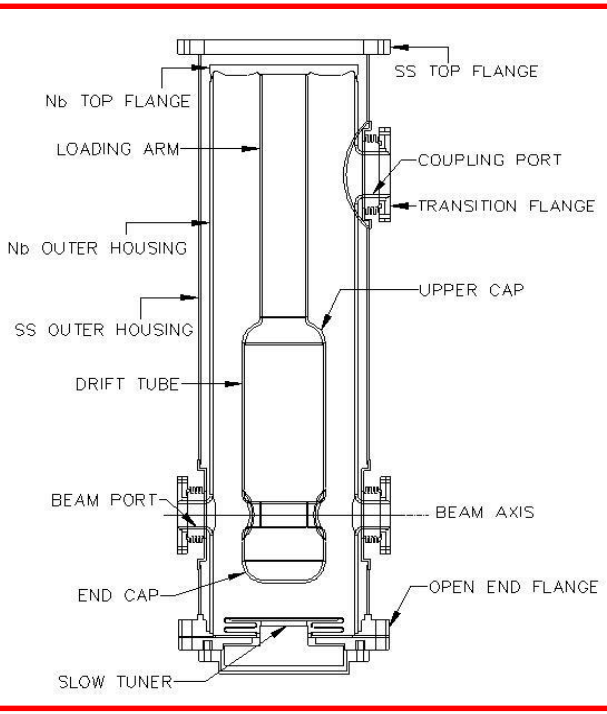
Off-set quadrupoles after strippers in terminal

Replacement of column support posts



IUAC superconducting LINAC

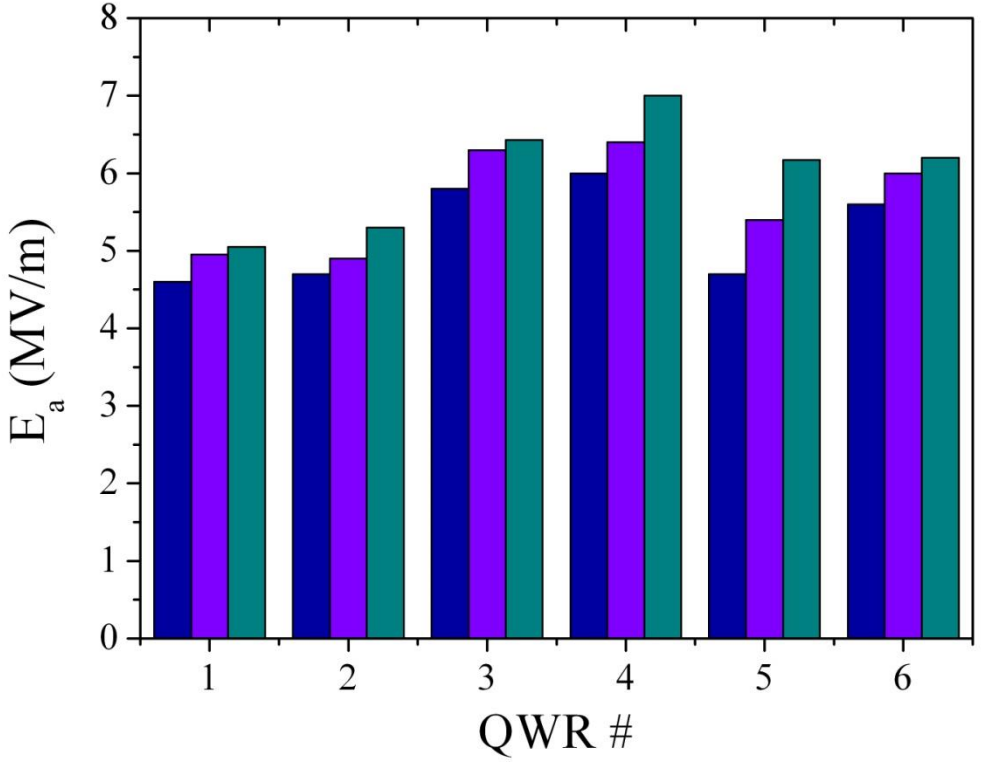




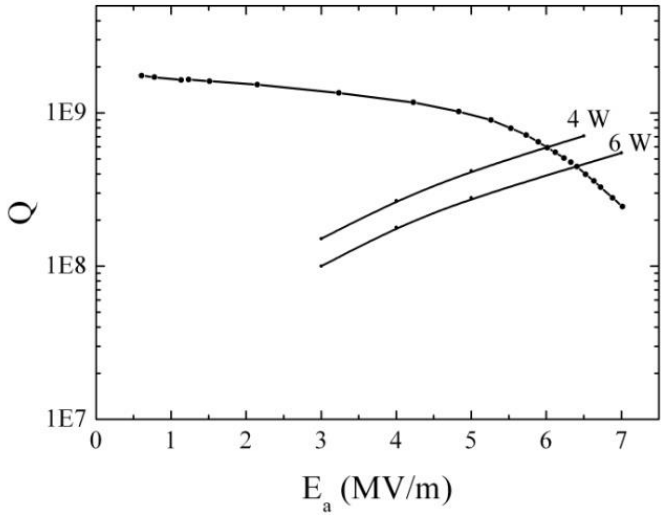
Nb Quarter Wave Resonator.

Indigenous QW Resonator of IUAC (v/c=0.08)

Performance of some of the Indigenously built Nb QWRs



Accelerating gradient E_a achieved in different QWRs indigenously built at IUAC, for the Superconducting Linac.



Resonator Q as a function of the accelerating gradient E_a at 4.2 K (QWR # 4).

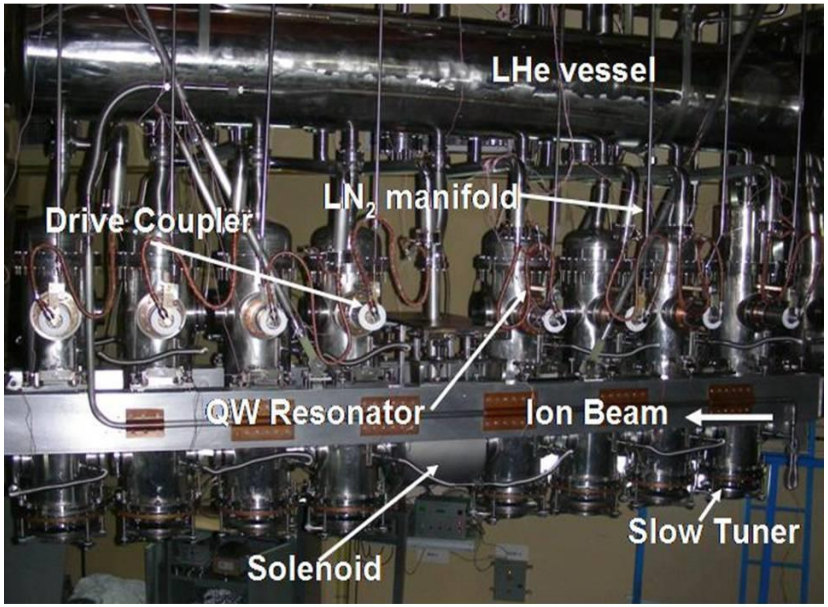
Latest Linac Run

A. All 5 cryostats (SB, 3 linac and RB) are operational

B. First and second linac cryostats have all 8 QWRs each

C. Third linac cryostats has 6 QWRs.

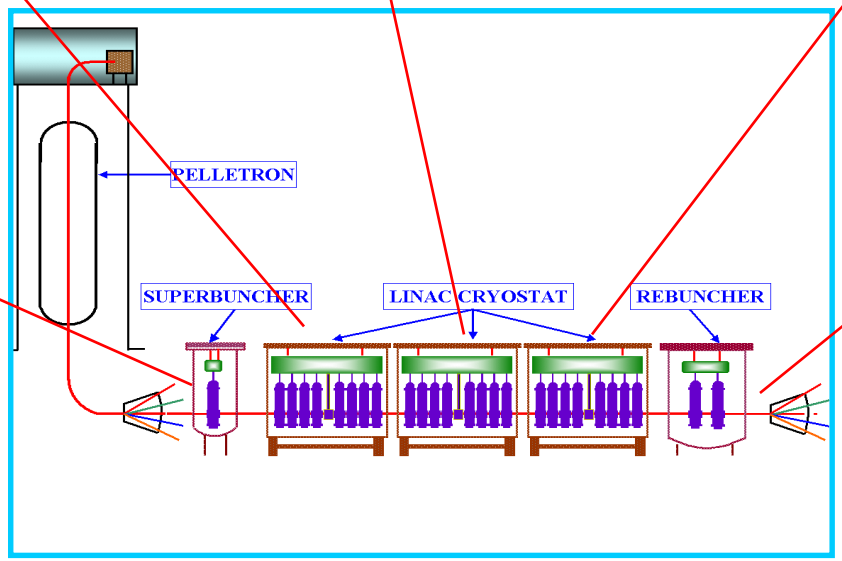
D. Cold test and beam acceleration with all five cryostats are performed



PIEZO Controlled Slow Tuner

All three LINAC Modules

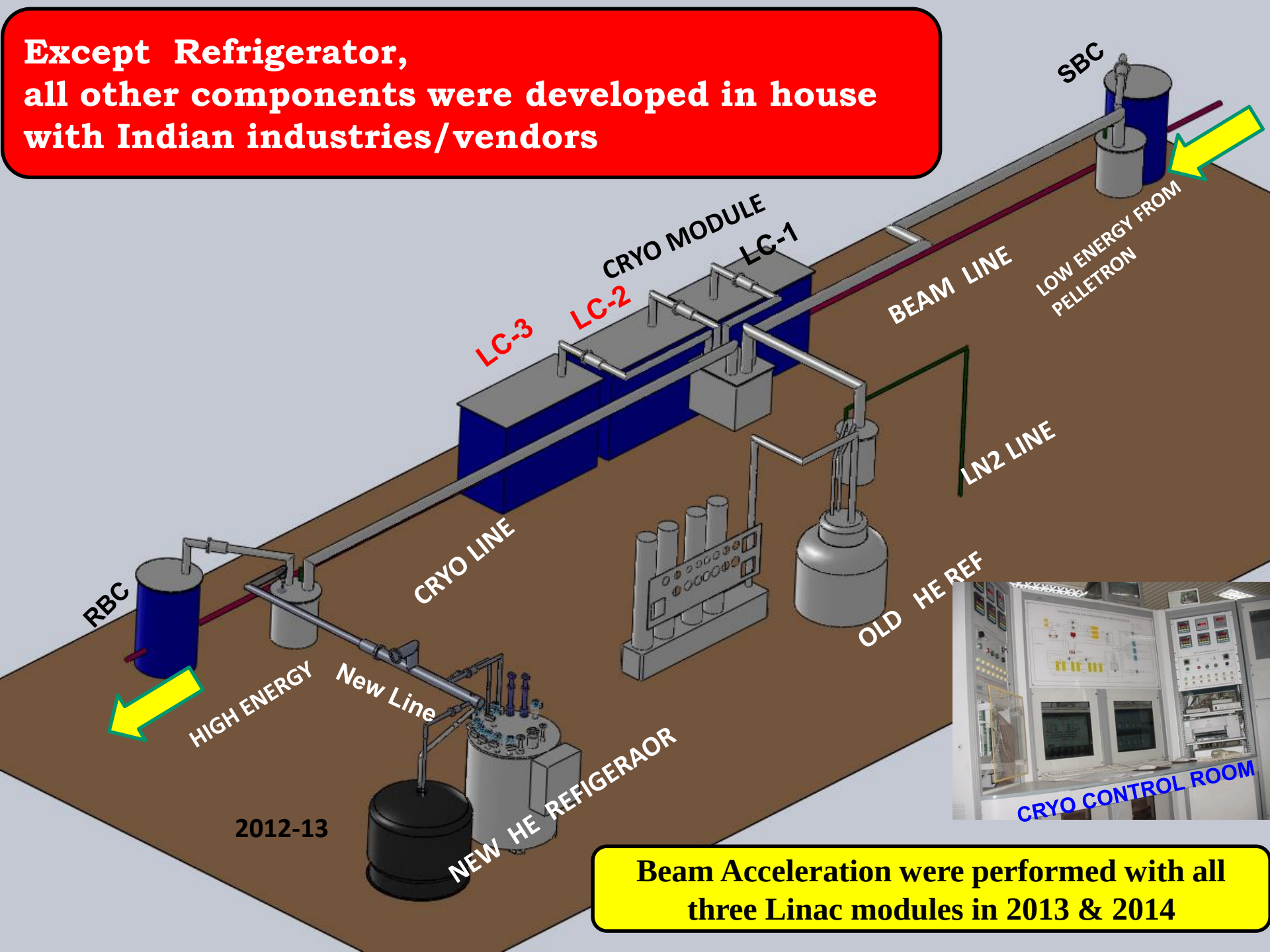
Linear accelerator system of IUAC



Consists of 27 identical Quarter Wave resonators, $\beta_0 = 0.08$, $f_0 = 97$ MHz

One kW Helium Refrigerator at IUAC

Except Refrigerator,
all other components were developed in house with Indian industries/vendors



Beam Acceleration were performed with all three Linac modules in 2013 & 2014

Indigenous Production of QWRs

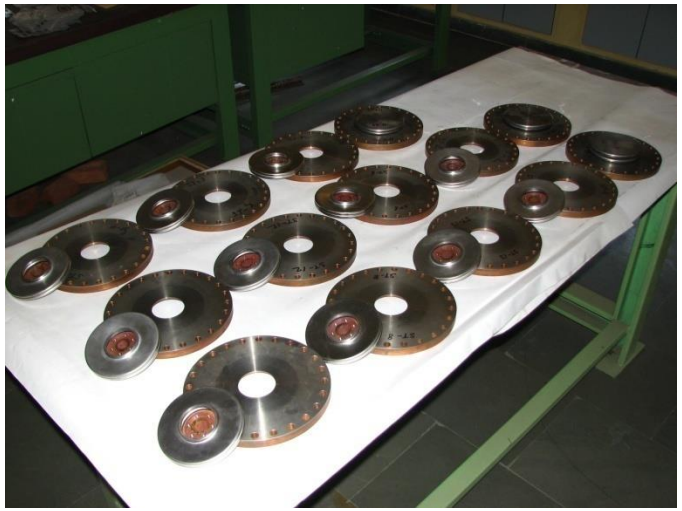
Niobium Central Conductor assemblies.

Niobium Top Flanges.

Niobium Outer Housings.

Production of QWRs

Bare niobium QWRs.



Slow Tuner components.

One dozen Production QWRs.

Niobium Slow Tuner bellows.

Control Room for 15UD Pelletron and SC Linac Booster

Recoil Mass Spectrometers (Nuclear reaction studies, aids spectroscopic studies)

Heavy Ion Reaction Analyzer (HIRA)

One of four operating in the world

8.8 metres long, rotation possibility

Good mass separation of products

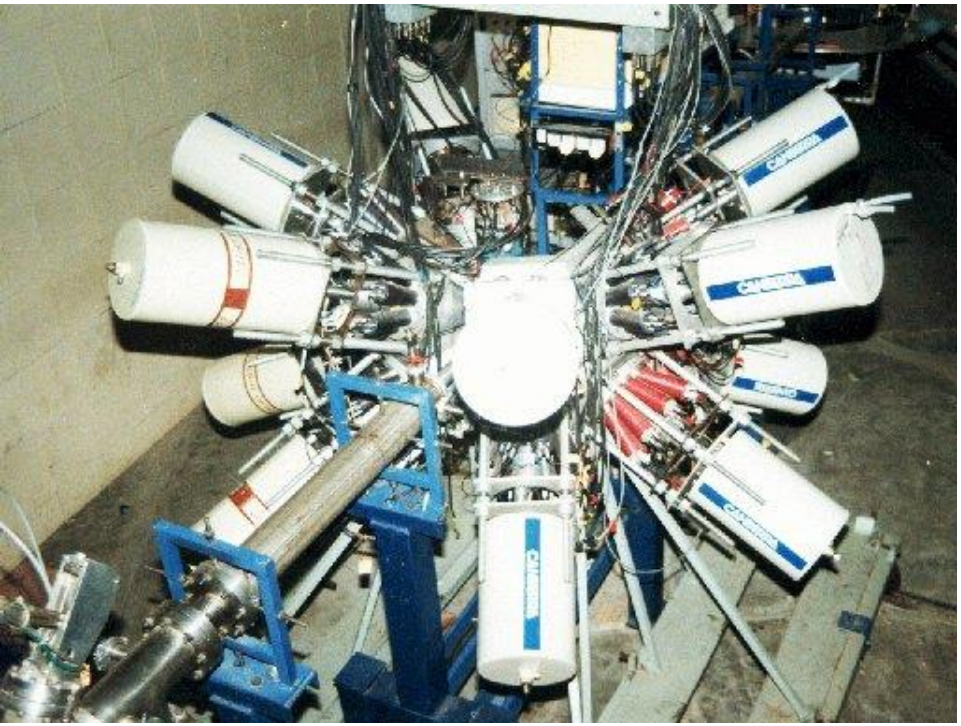
Hybrid Recoil mass Analyzer (HYRA)

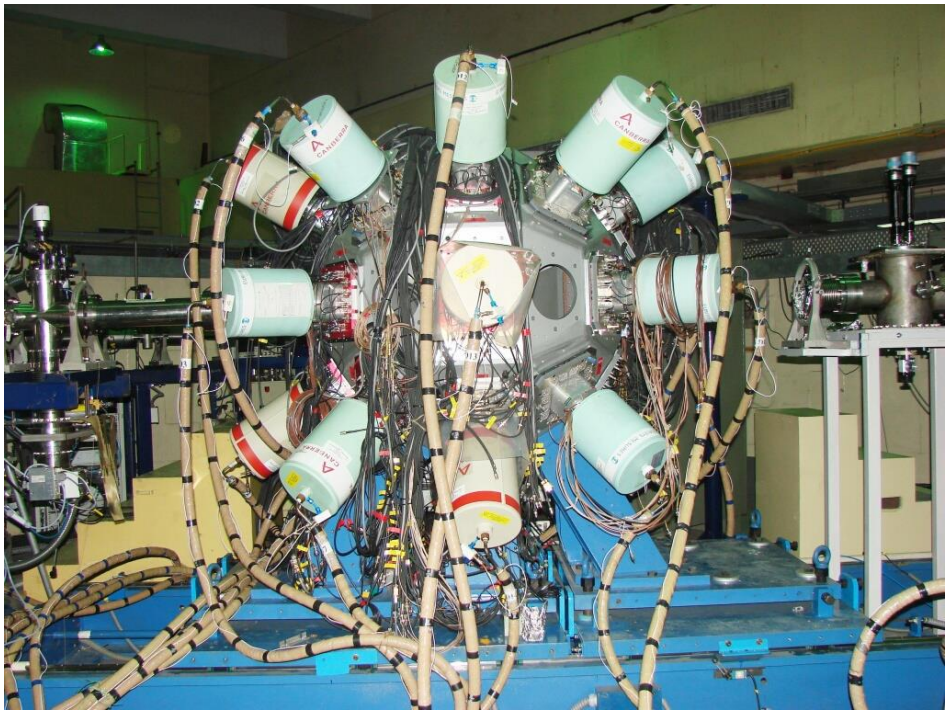
Dual stage, dual mode spectrometer

First stage

14.5 (= 7.5 + 7.0) metres long

Gamma Detector Arrays (Spectroscopic studies, Lifetime - excited states, Shape of nuclei)





Gamma Detector Array (GDA)

12 High Purity Germanium (HPGe) detectors

Add-on facilities to improve the resolving power

Indian National Gamma Array (INGA)

24 HPGe based clover detectors

Pooled from various Indian institutes
IUAC/TIFR/VECC/SINP/BARC/UGCDAECSR

Facilities for fission studies:

General Purpose Scattering Chamber (GPSC)

Scattering and fission experiments

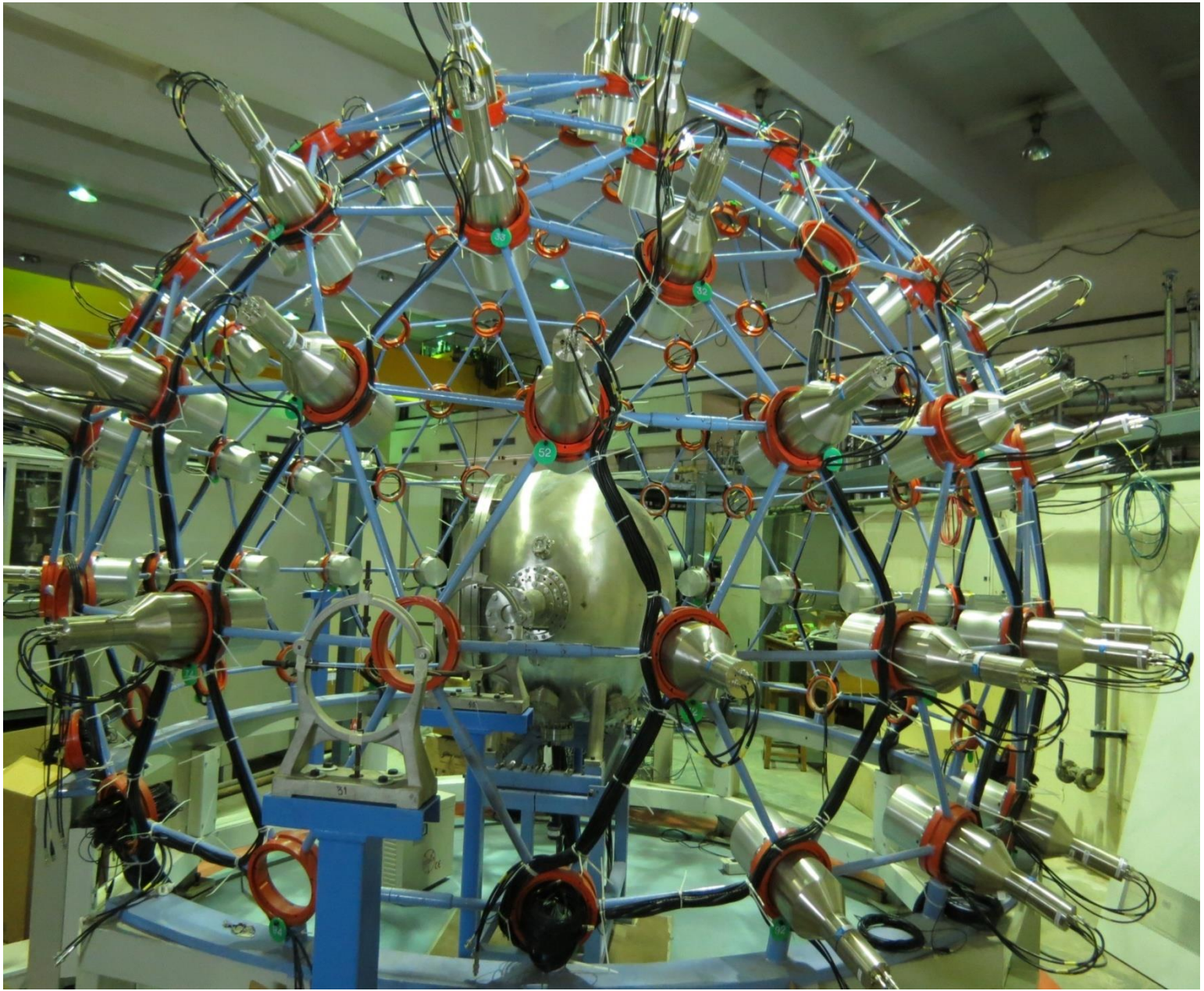
1.5 m diameter chamber

National Array of Neutron Detectors (NAND)

100 neutron detectors each at 1.75 m
(one of a few in the world)

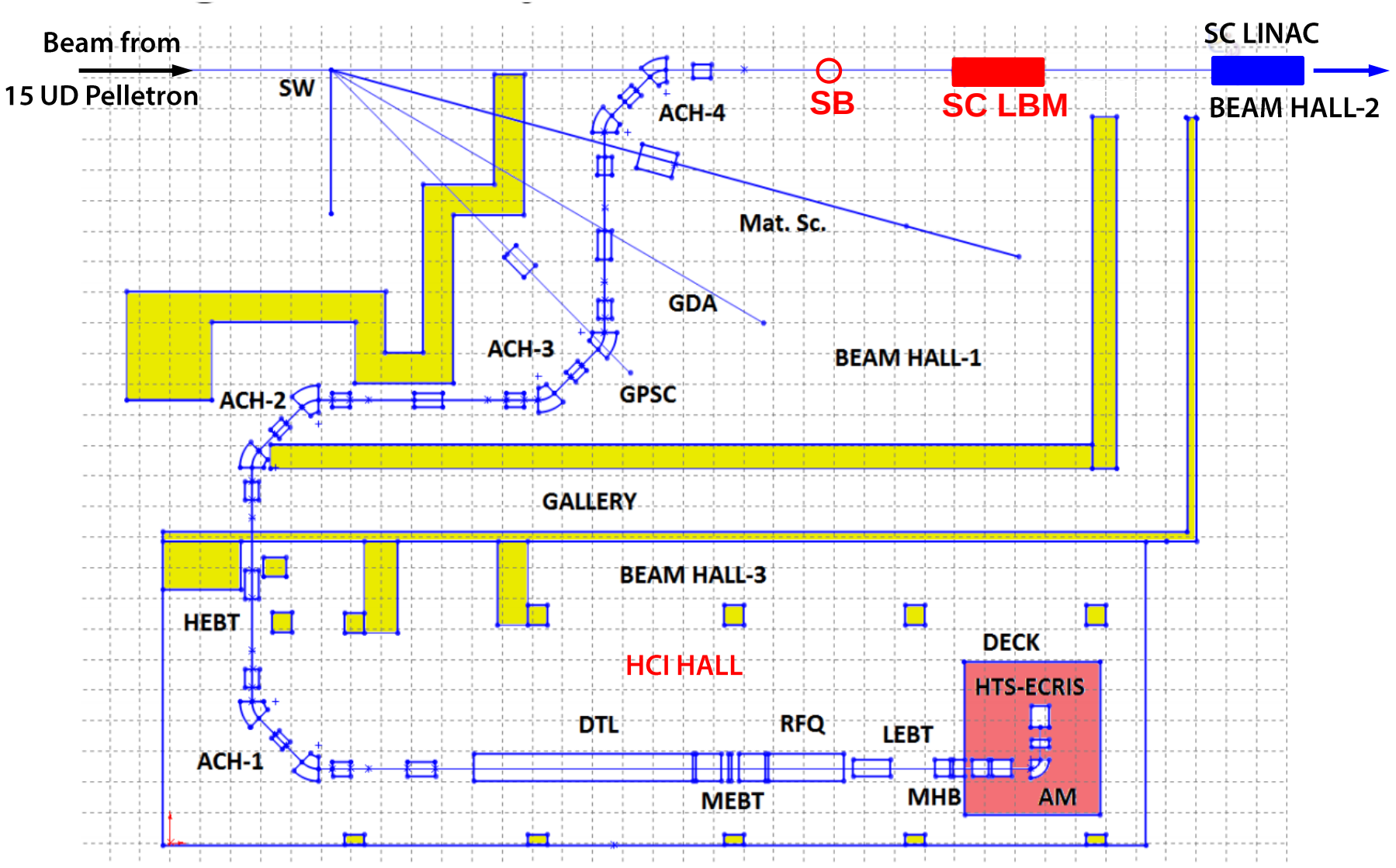
Fission fragments in coincidence with neutrons

Neutron Detector Array – 100 detectors



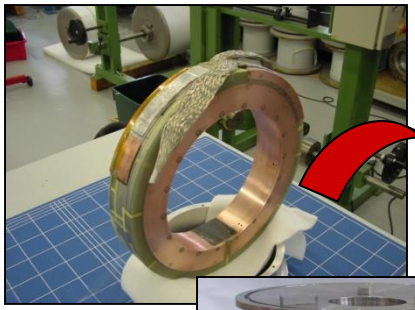
Materials Science Beam Line: Experimental Facilities

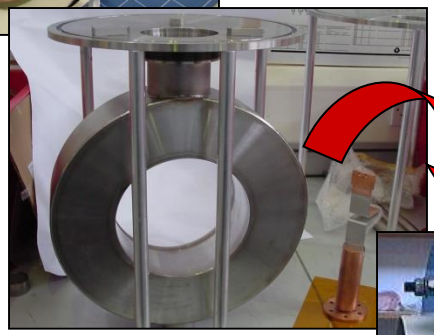
High Current Injector (HCI)



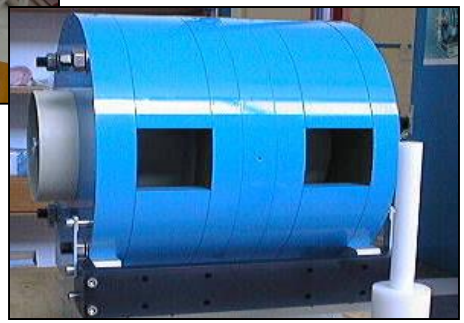
Various Stages of Development of HTS-ECRIS

HTS coil

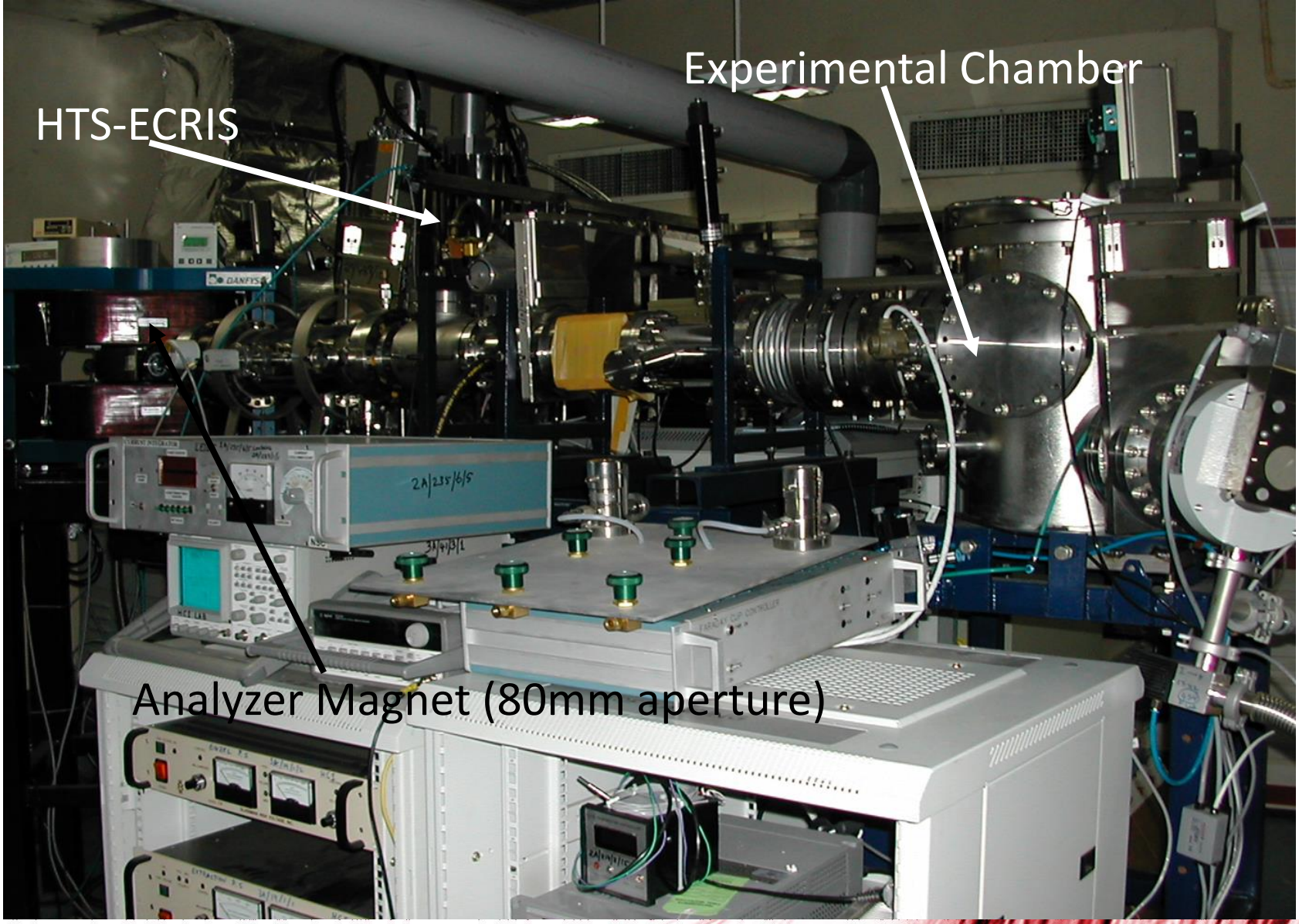




Coil cryostat



Iron yoke

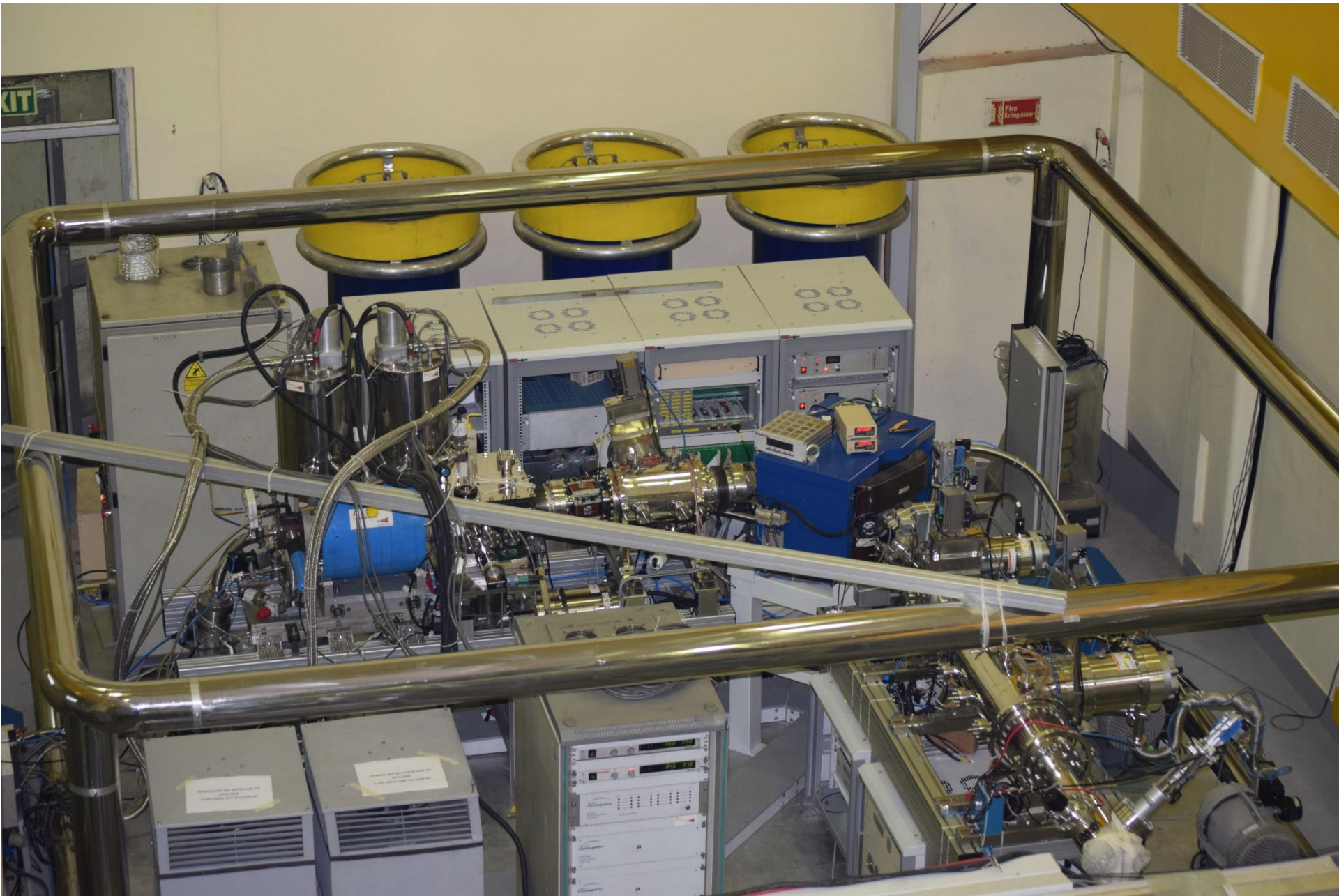


AIP | Review of Scientific Instruments

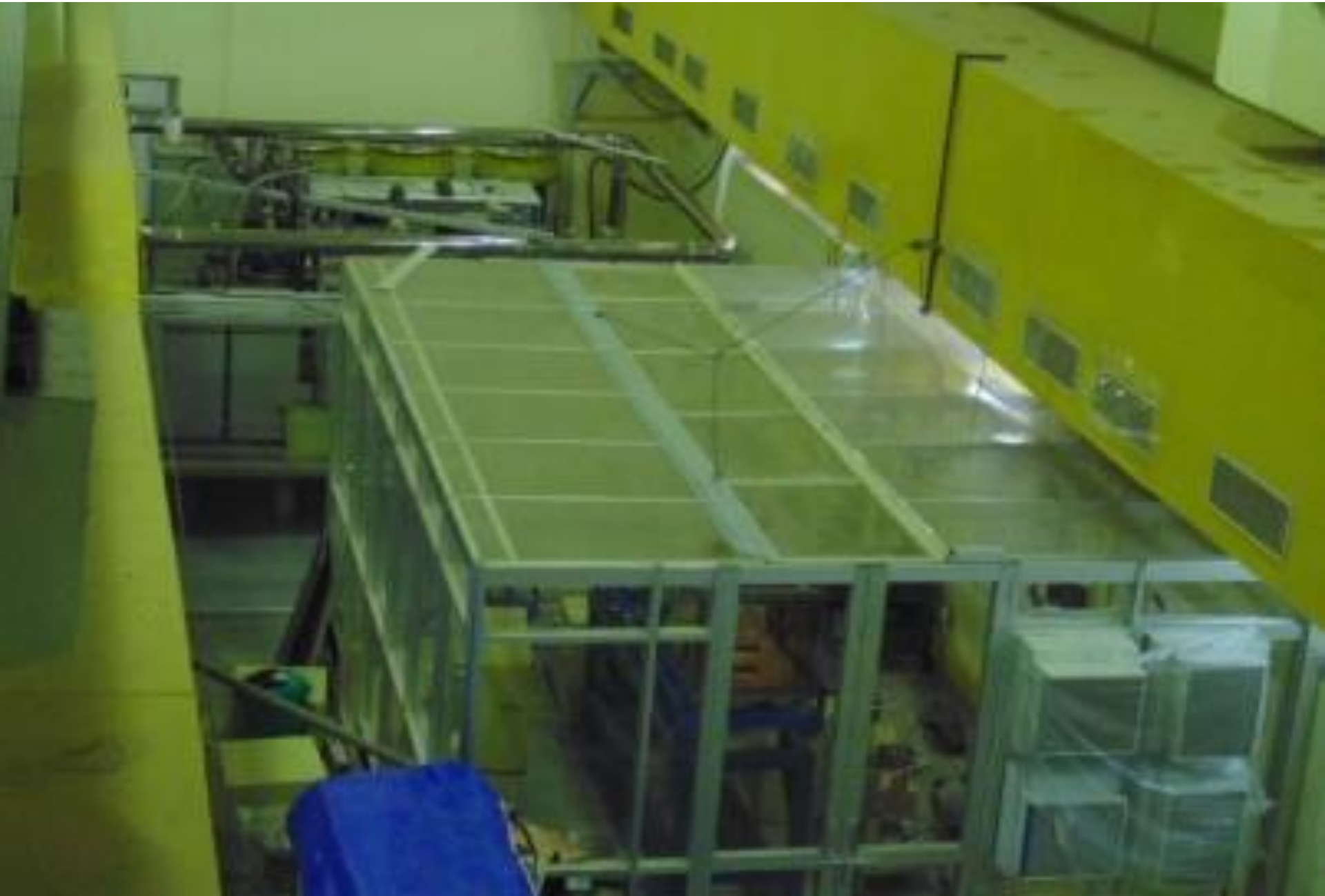
Performance of first high temperature superconducting ECRIS

D. Kanjilal et al., Rev. Sci. Instrum. 77, 03A317 (2006)

HTS-ECRIS on HV Platform



HTS-ECRIS on HV Platfom



Drift Tube Linac

Energy: 180 KeV/u to 1.8 MeV/u
A/q = 6, 97 MHz, 6 RF Resonators

Tank #	Length (cm)	No. Of Cells	Eout (MeV/u)
1	38.5	11	0.32
2	73.4	13	0.55
3	94.4	13	0.85
4	86.5	11	1.15
5	92.2	11	1.46
6	81.6	9	1.80

DTL Stems being aligned

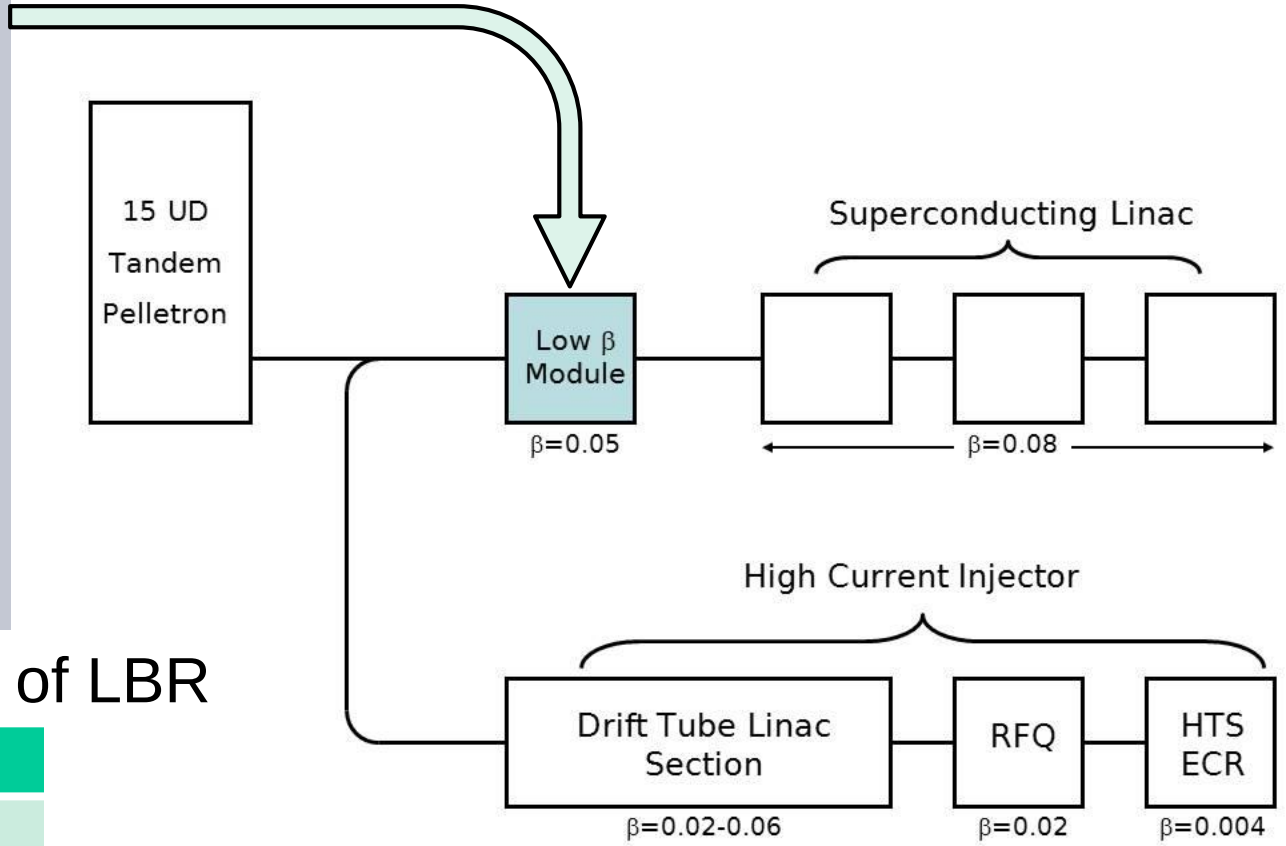
Design validation has been done on full scale prototype resonator

Test of DTL high power teat at IUAC Delhi

Low Beta Resonator - LBR

Cut away 3D view of LBR

Parameter	Value
β	0.05
f	97 MHz
L_{eff}	~11 cm
U_0	26 mJ
B_{peak}	64 G

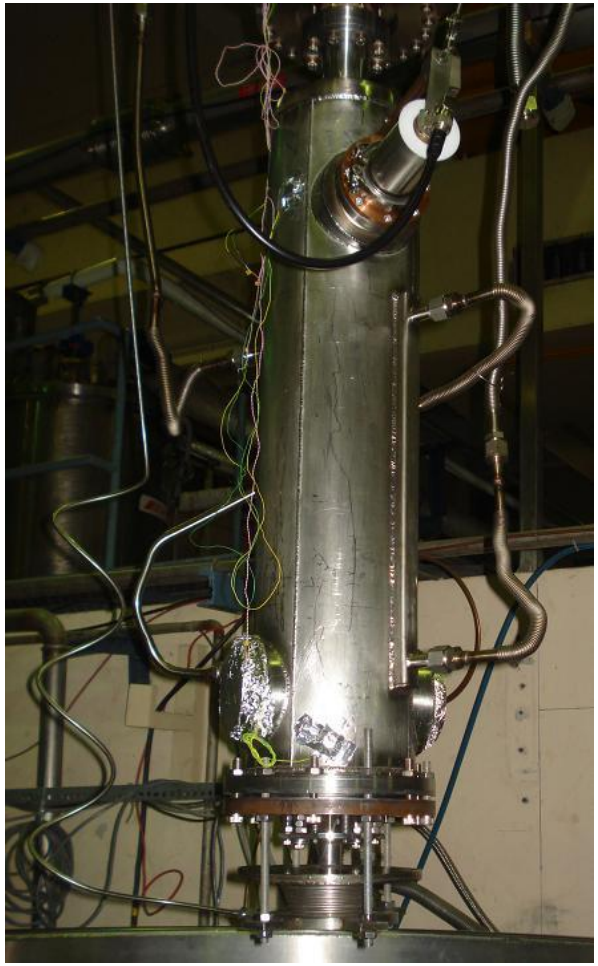


Proposed High Current Injector (HCI) at IUAC

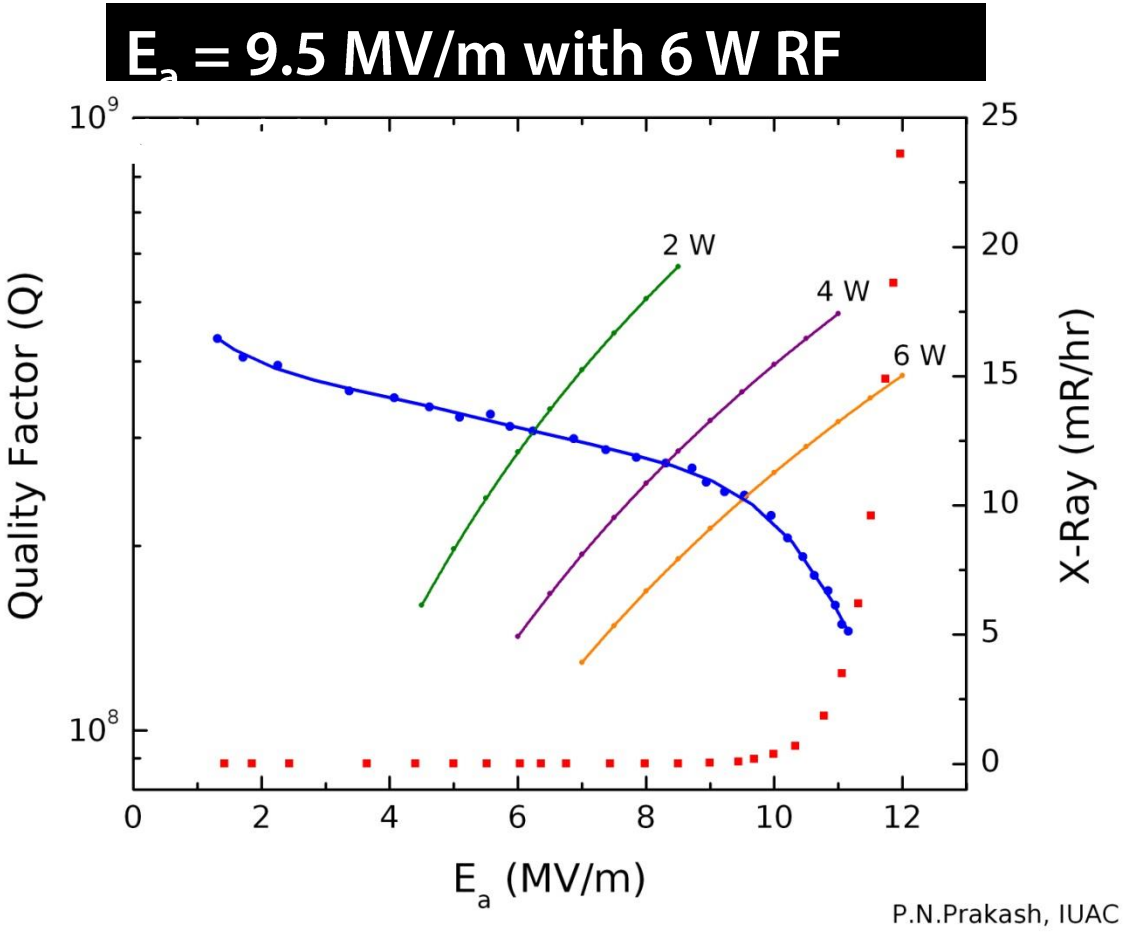
Low Beta Resonator

Major niobium assemblies of the Low Beta Resonator (left). Low Beta Resonator complete with the outer helium vessel (right).

Prototype Low Beta Resonator



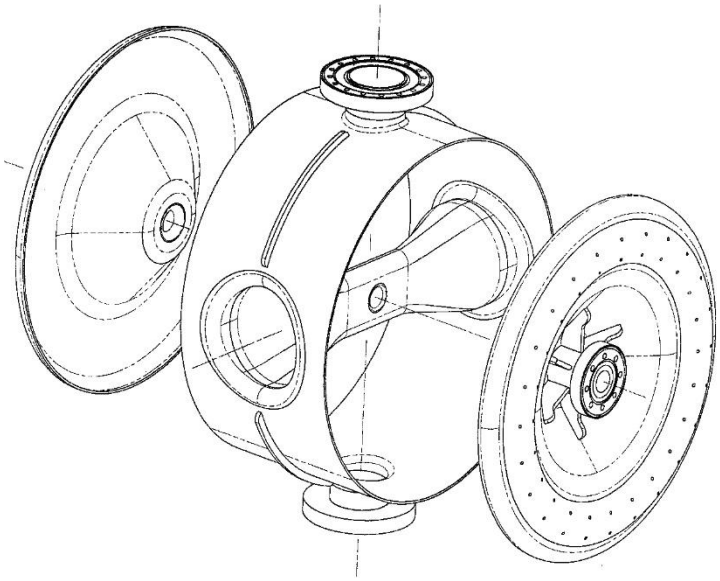
Prototype Low Beta Resonator being lowered in the Test Cryostat for 4.2 K tests.



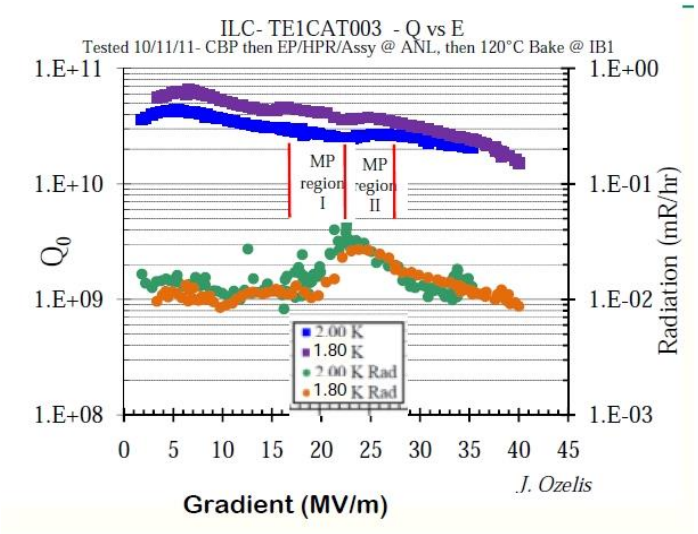
Quality factor (Q) of the prototype low beta resonator as a function of accelerating gradient (E_a), at 4.2 K.

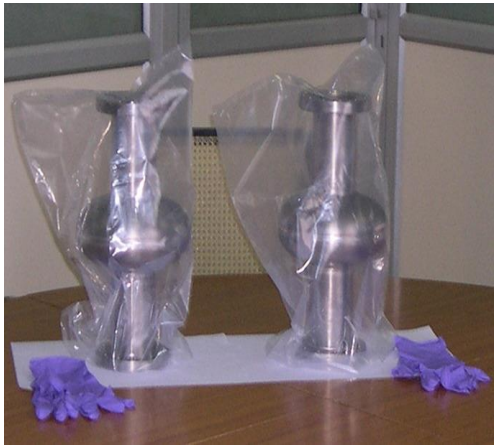
Collaborations

Spoke Cavity for Fermilab Project X



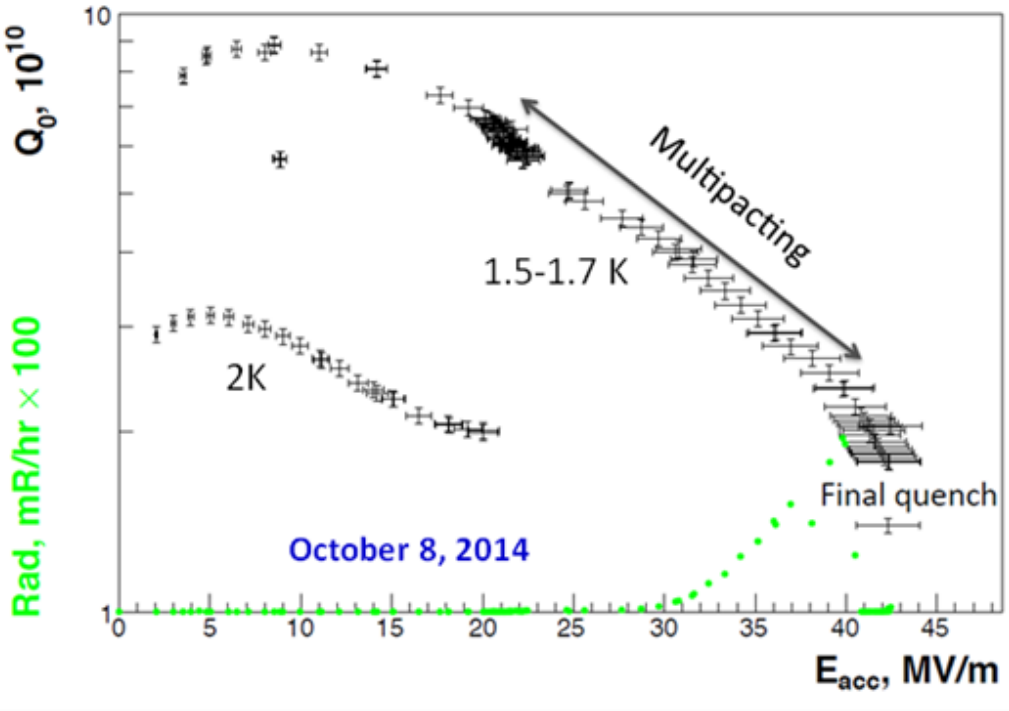
β =0.22, 325 MHz





1.3 GHz TESLA type Cavity with RRCAT

First multi-cell niobium cavity built in India.



Recent result of the cold test done at Fermi Lab. The cavity reached 20.3 MV/m accelerating gradient @ 2 K, and 42 MV/m @ 1.5-1.7

Single Spoke Resonator SSR1 for Fermi Lab

Niobium Single Spoke Resonator SSR1 being readied for attaching the End Walls.

Both the resonators have been completed.

1.7 MV Tandem Pelletron Accelerator with Experimental Facilities

Dedicated AMS Facility using 0.5MV Pelletron

^{14}C sample Preparation Laboratory

Automated Graphitization unit in collaboration ETH, Zurich .

AMS: ^{10}Be and ^{26}Al Sample Preparation Lab

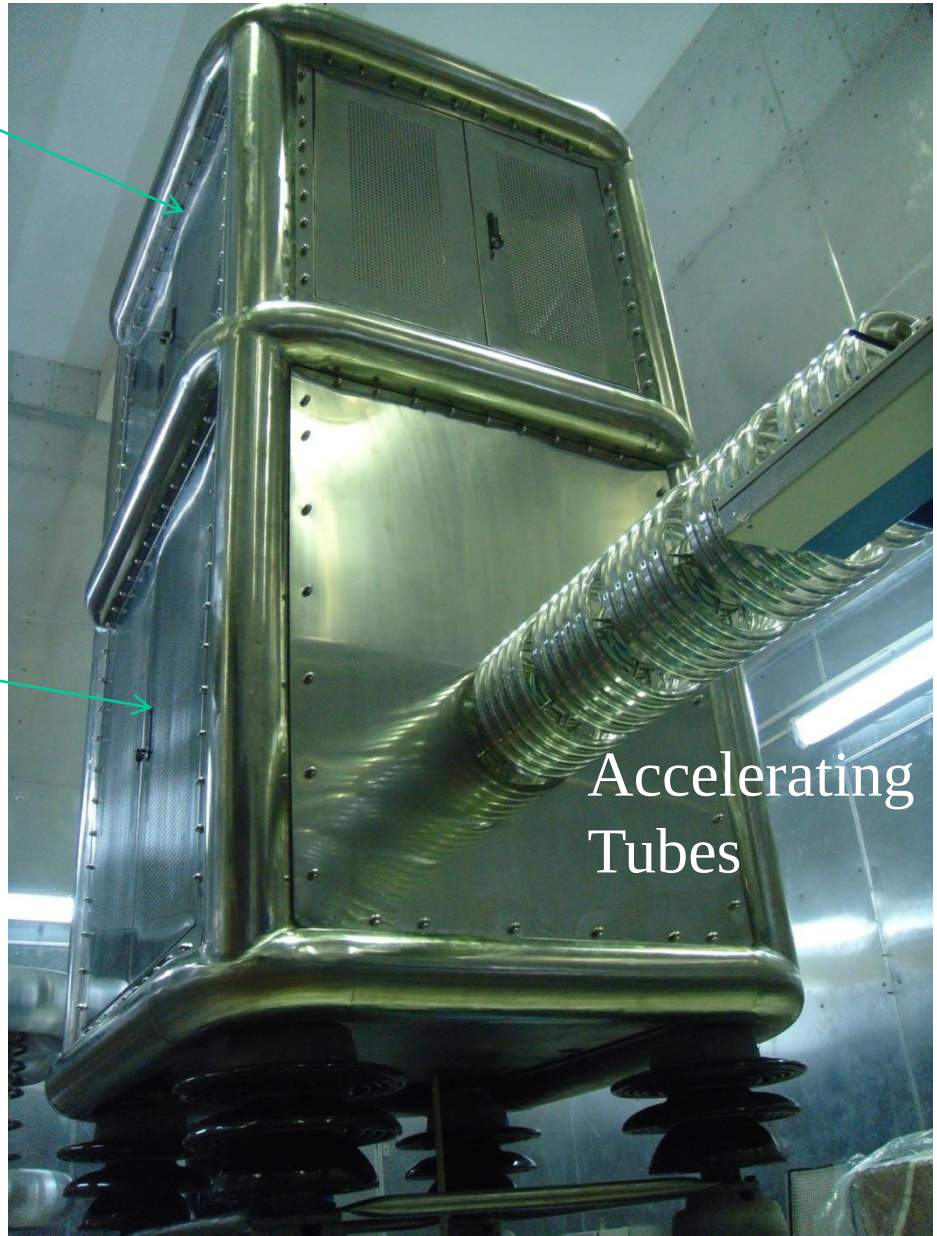
^{10}Be and ^{26}Al isotopes for geological and climatological studies

Clean Chemistry Laboratory:

400 kv HV Platform with Accelerating Tubes

Electronics and Control

ECRIS



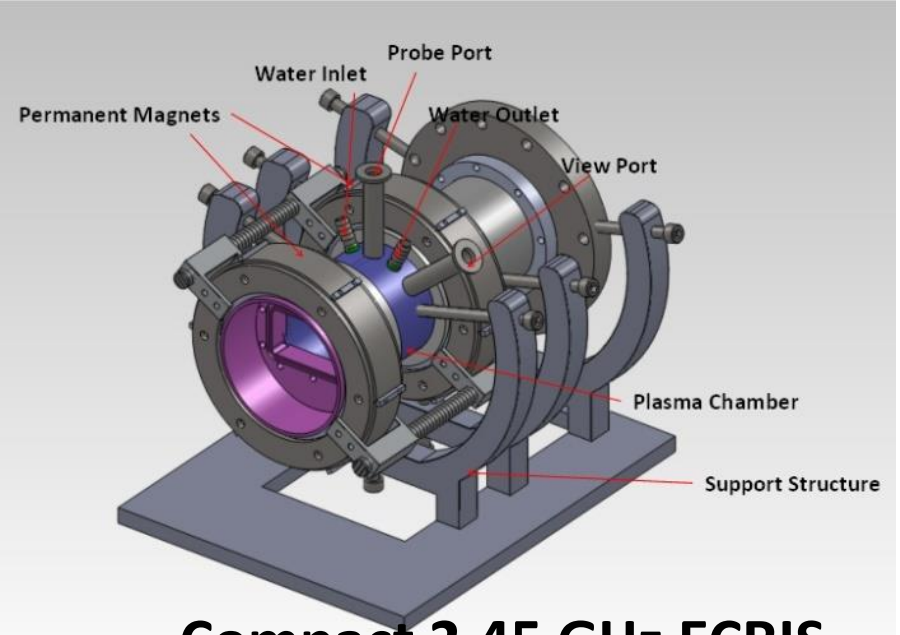
ECR Ion Source with associated components on 400 kV HV Platform

Low Energy Experimental Facilities: ECRIS of High Voltage Platform

Soft Landing of ions after deceleration

HV Platform of Negative Ion Implanter

Beam Line of Negative Ion Implanter

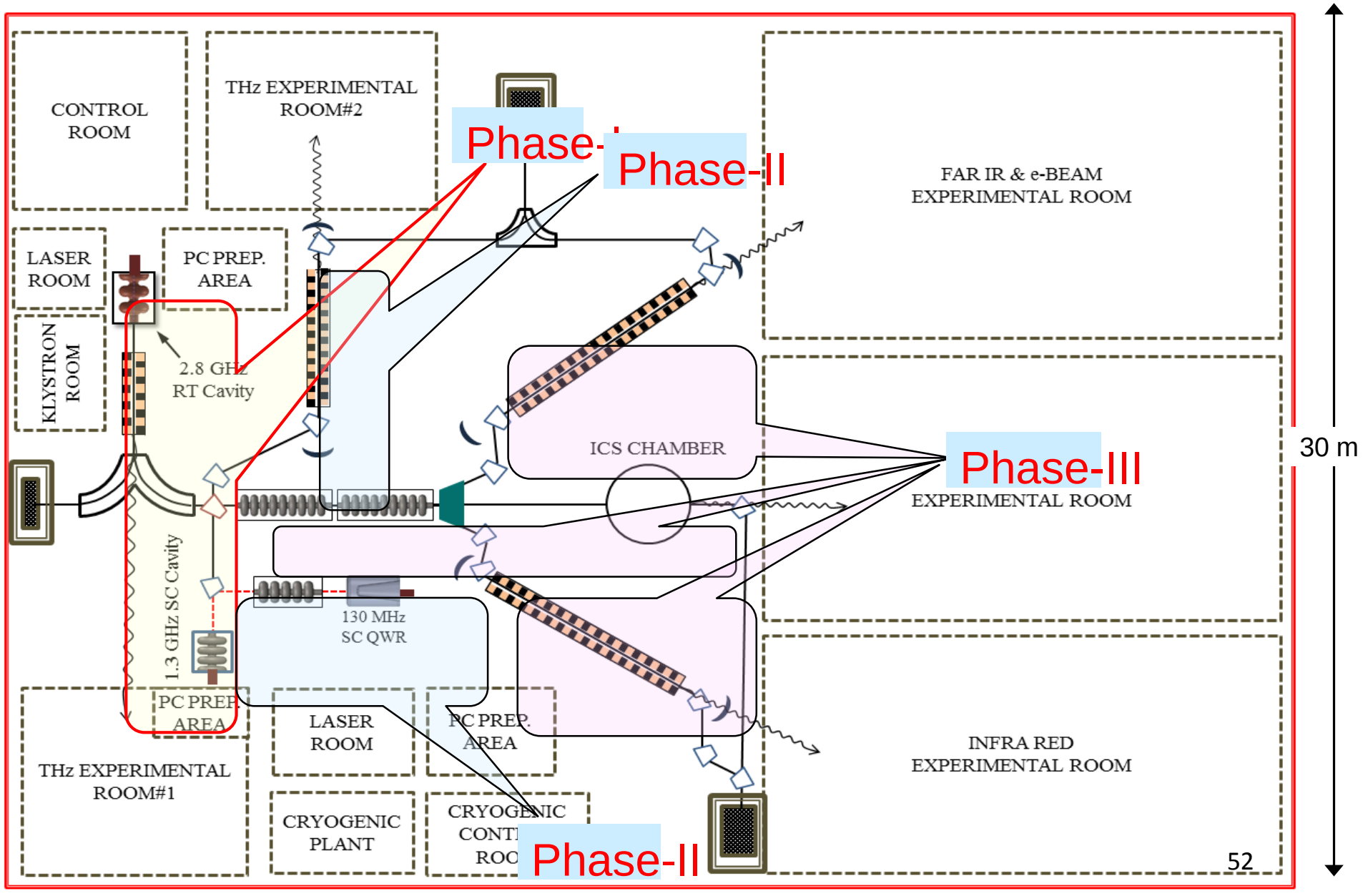


Compact 2.45 GHz ECRIS

50 kV Acceleration system

Compact Medium Lab Scale Ion Beam Systems

Layout of Future FEL Facility at IUAC



Conclusion

Expertise and infrastructures for development of various accelerating systems and associated research activities have been developed at IUAC.

Technology related to niobium resonators for Heavy Ion Accelerator has been established in the country.

HTS-ECR ion source on elevated (kV) platform followed by RFQ, DTL and Low Beta Cavities will be an alternate injector for higher current and energy.

Modern ^{14}C Accelerator Mass Spectrometry (AMS) facility is being established having sensitivity comparable to the best in the world.

Long term road map for future accelerators for free electron laser as well as up-gradation / addition of accelerators and related research facilities at IUAC are planned.

Acknowledgements

Colleagues *whose sincere and hard works help us developing modern Accelerators, associated Technology and Research Activities.*

Thank You for your kind attention