Superconducting LINAC at Mumbai: an overview

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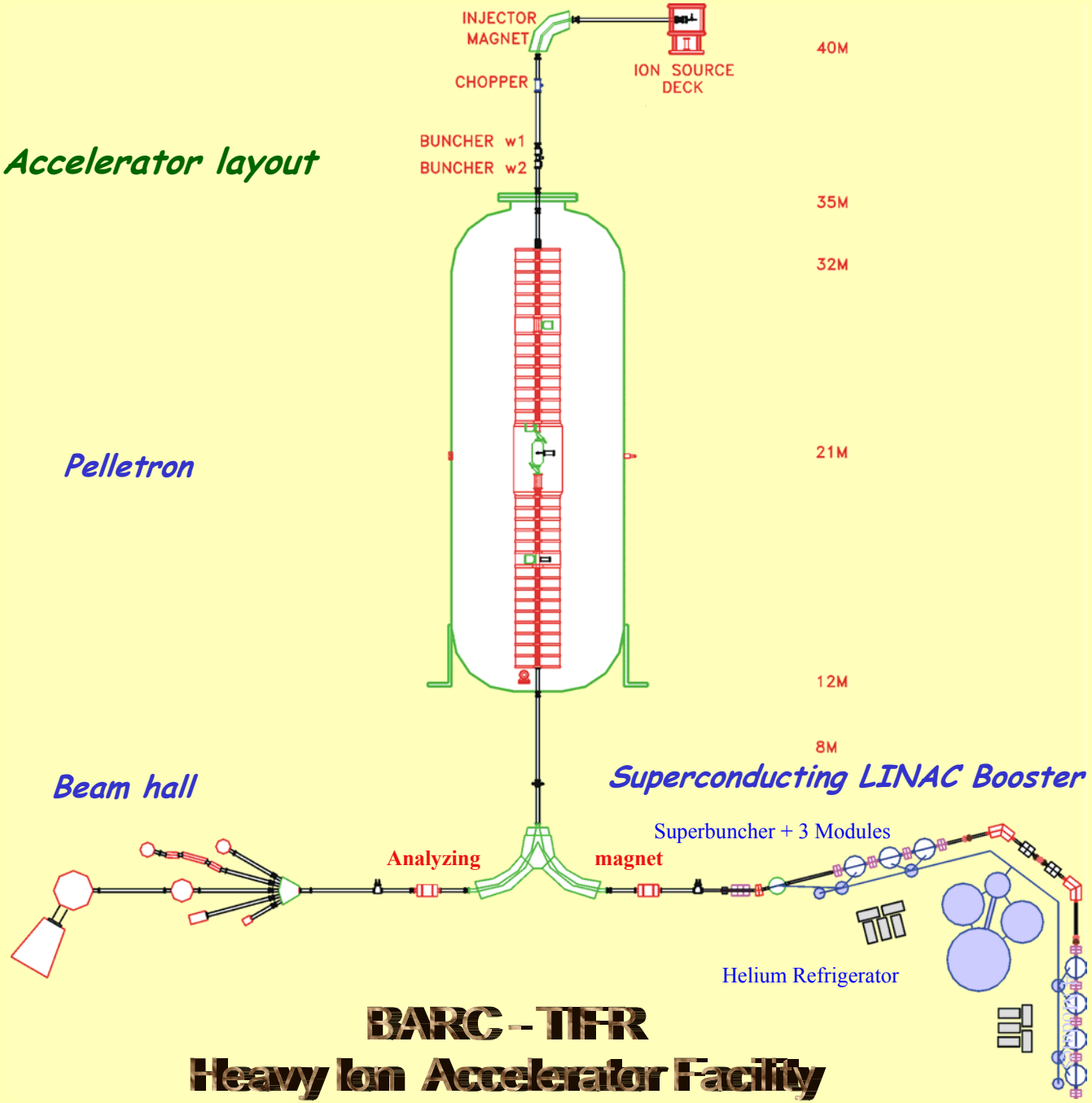

Accelerator layout
INJECTOR MAGNET
ION SOURCE DECK
CHOPPER
BUNCHER w1
BUNCHER w2
40M
35M
32M
Pelletron
21M
12M
8M
Beam hall
Superconducting LINAC Booster
Superbuncher + 3 Modules
Analyzing
magnet
Helium Refrigerator
BARC - TIFR
Heavy Ion Accelerator Facility
to new beam hall

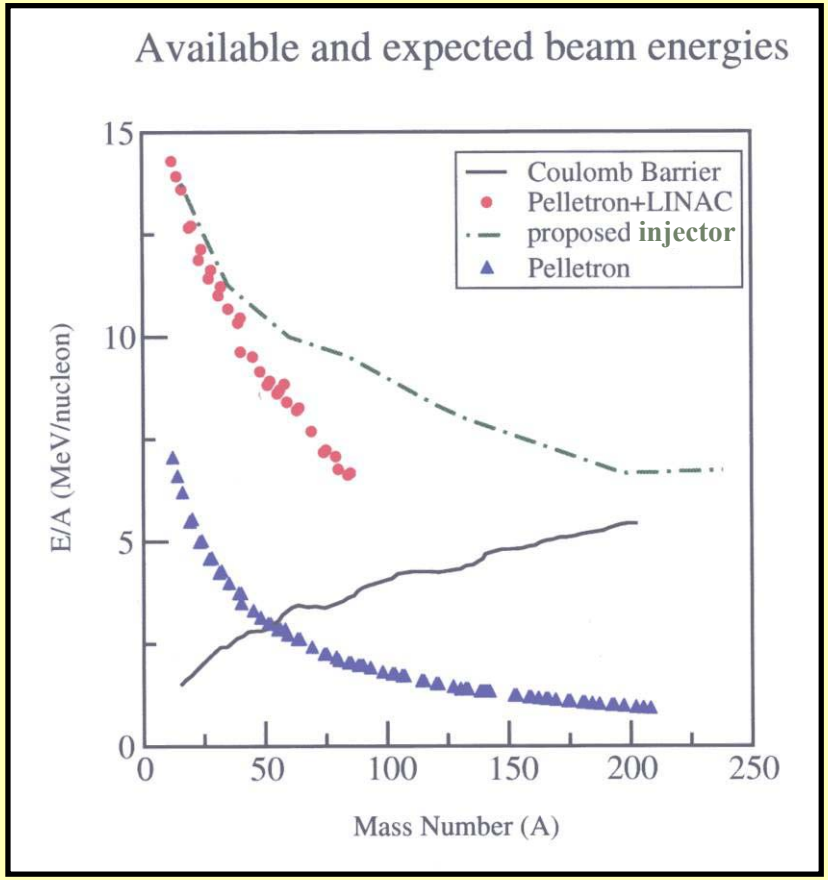
TIFR-BARC Accelerator Facility

Pelletron accelerator

- E/A ~ 3-7 MeV, β ~ 0.08-0.12
- Heavy ions reactions upto A ~ 40

Superconducting Linac booster

- E/A ~ 5-12 MeV, β ~ 0.10-0.16
- Heavy ions reactions upto A ~ 80
  (limited by pre-accelerator)
- Beam intensity: 0.1-10 pnA (10^{9-11} p/s)
  (limited by ion source)



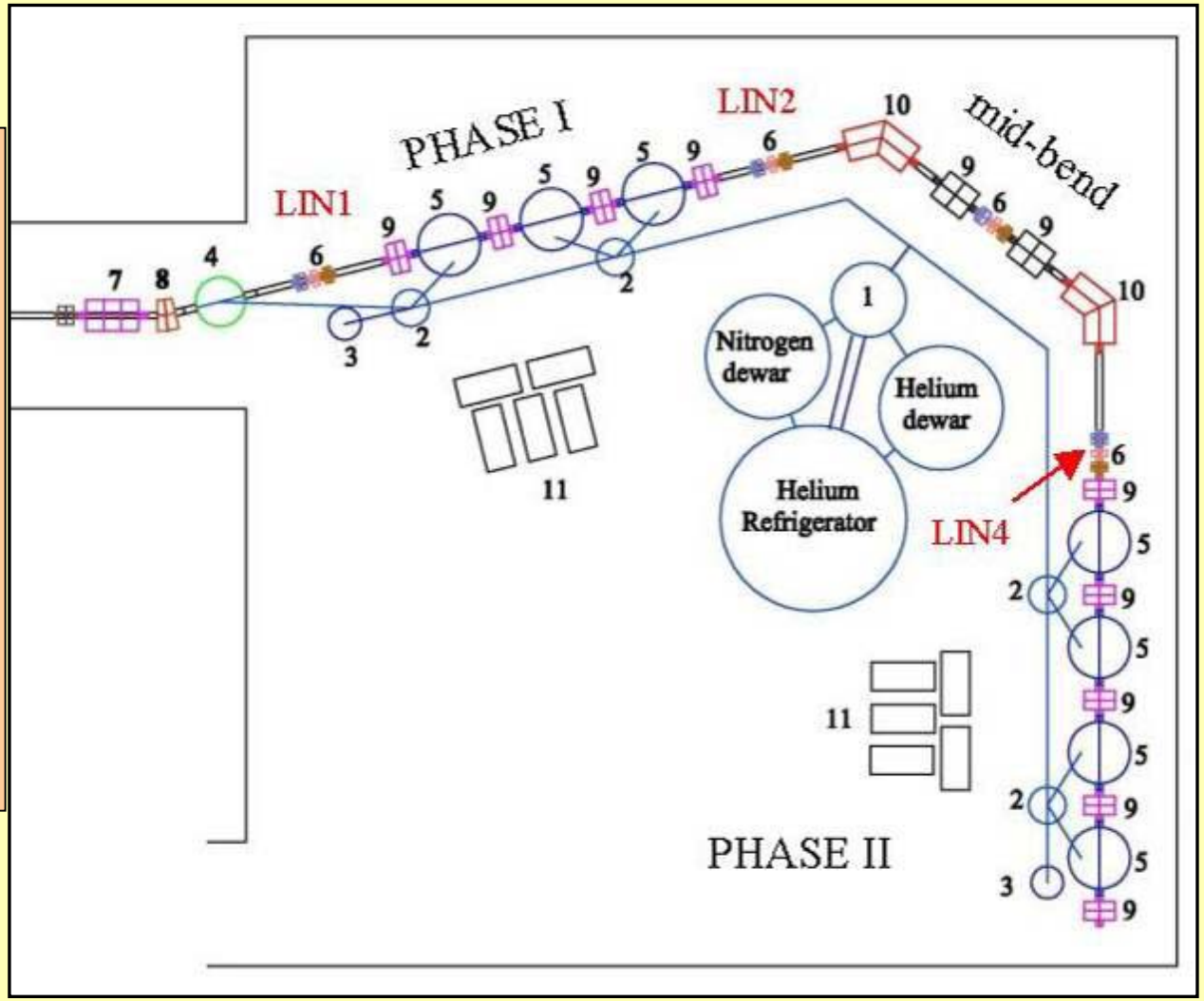
Joint TIFR – BARC Project

Specifications

Heavy ions upto A~80
E/A~5-12 MeV

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

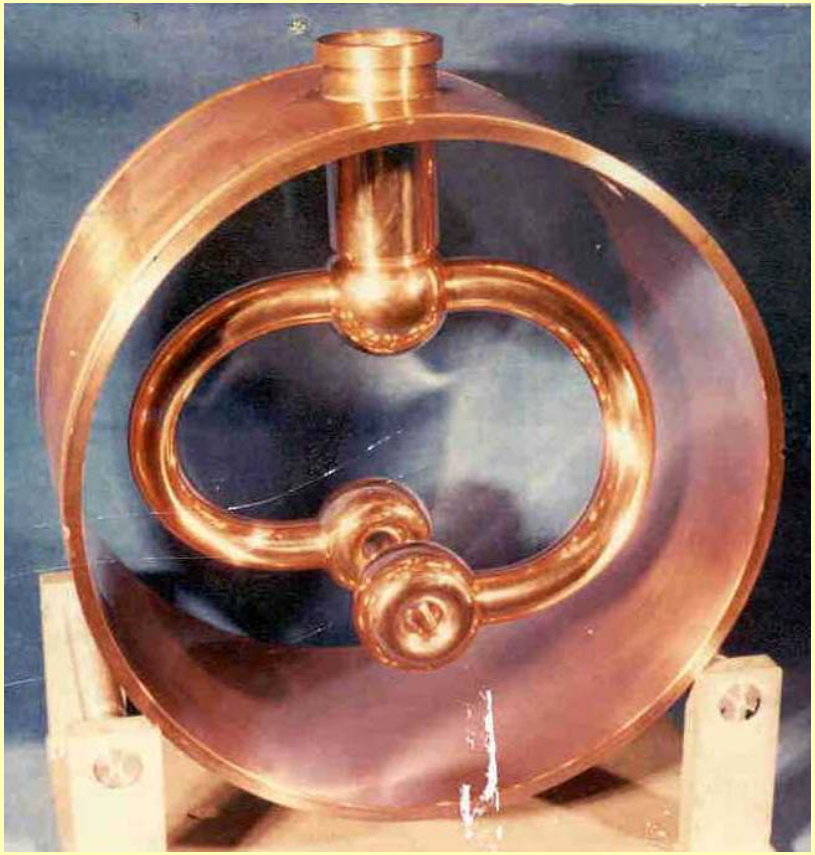
Bunch width ~200 ps
Beam Intensity 0.1-10 pnA



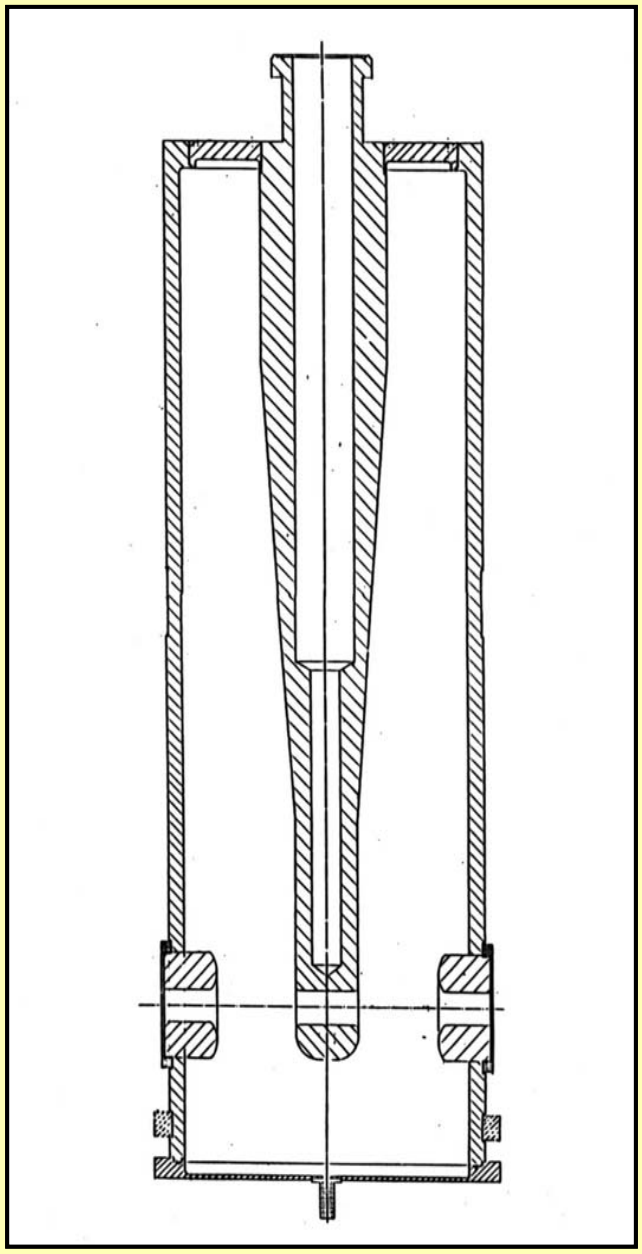
Phase I commissioned on September 22nd, 2002
Phase II commissioned on July 9th, 2007
LINAC dedicated to users on Nov. 28th, 2007

Superbuncher cavity

Before Plating

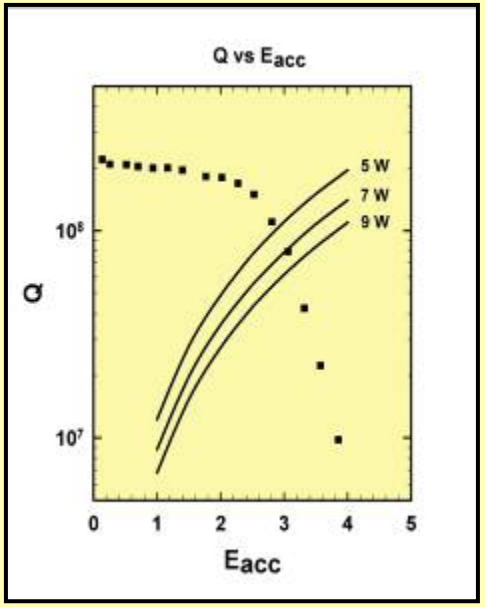


After Lead Plating

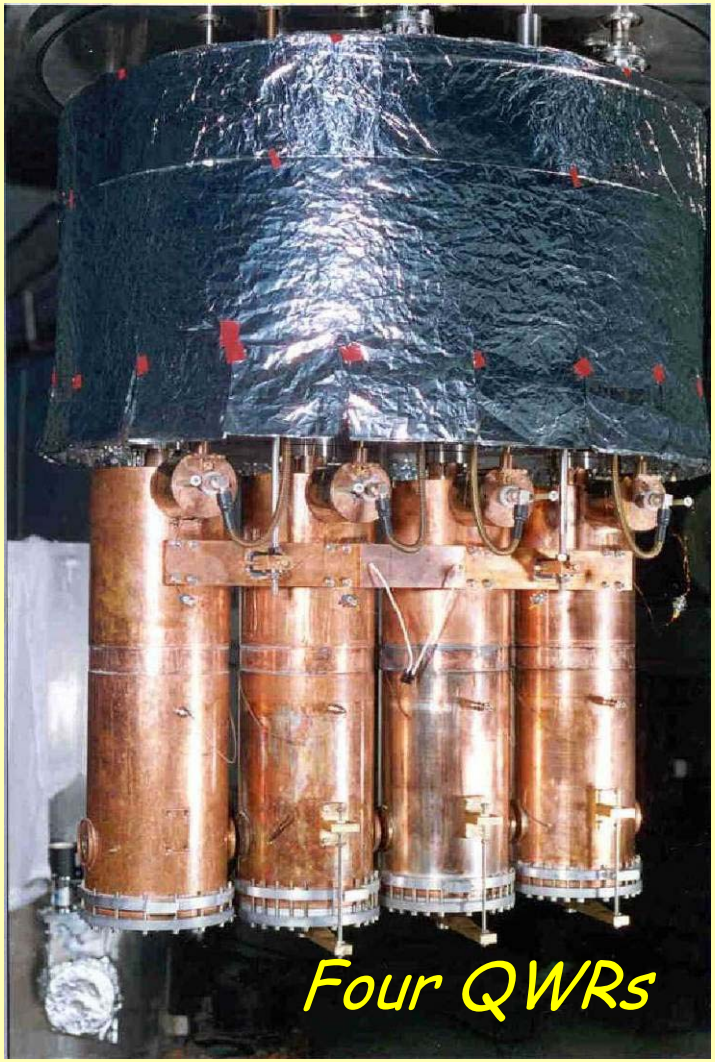


Quarter Wave Resonators

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

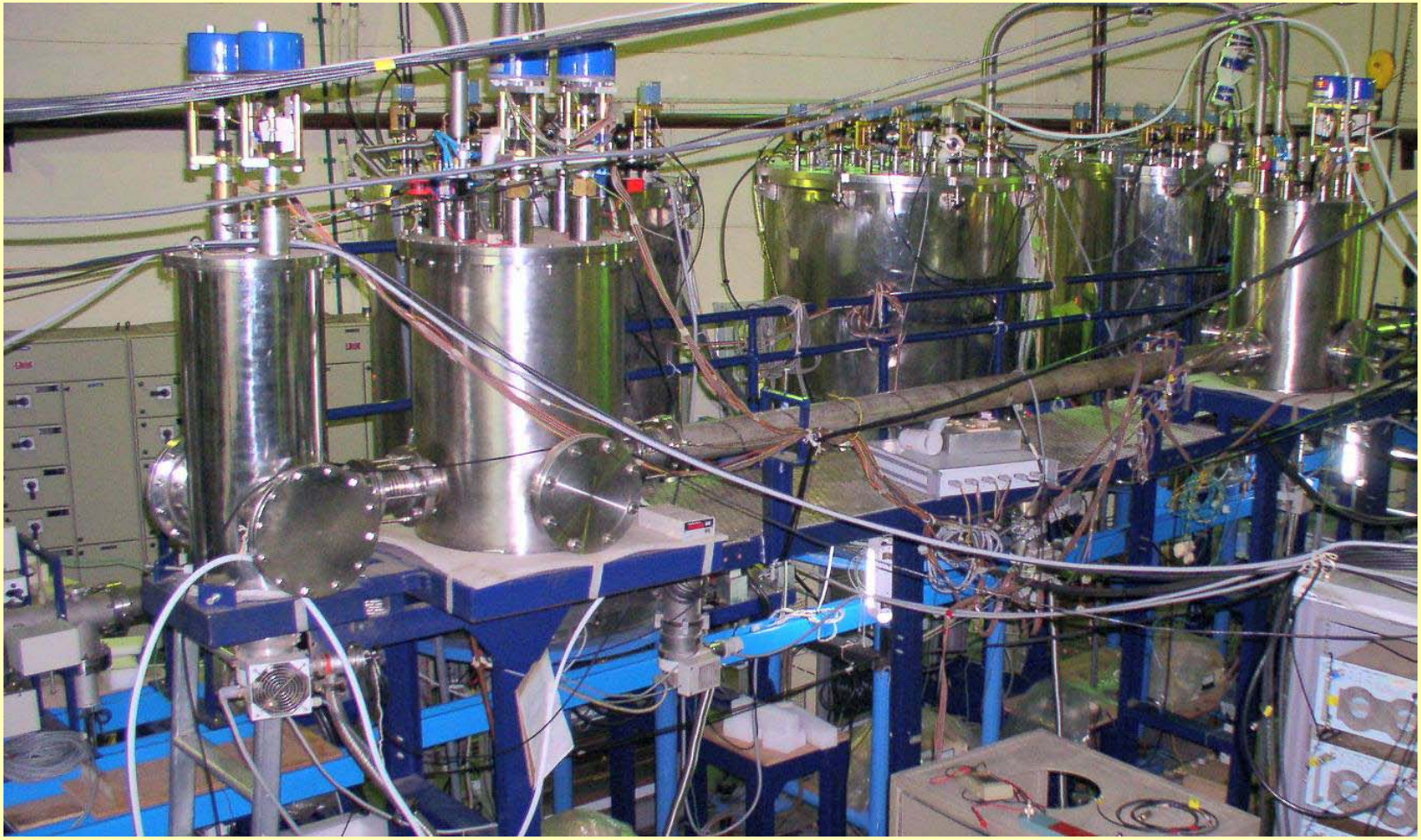


Module Cryostat



Top view of the module

He vessel and QWRS



Cryostat modules housing the resonators with liquid He distribution box

Cryogenics system for the Linac

Helium Refrigerator	Linde TCF-50S
Al Plate Fin Heat Exchangers	
Two stage Turbine Expansion	Engines
Two stage JT Expansion	
250 KW Screw Compressor	62 g/s

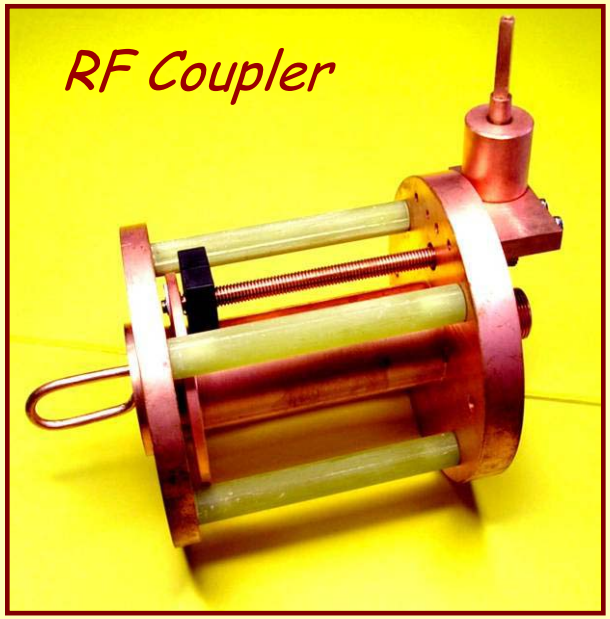
Refrigeration at 4.5 K/Liquification

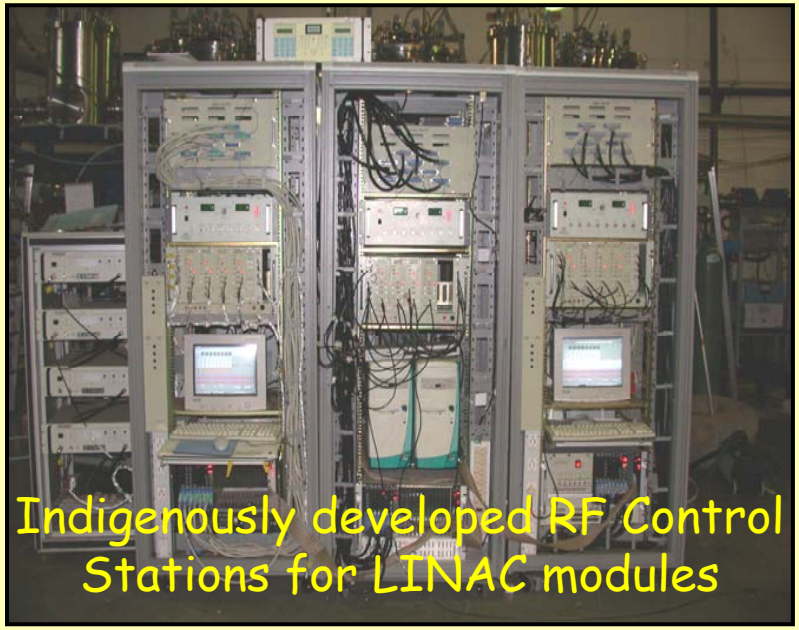
Without LN_2	300 W, 50 l/hr
With LN_2pre-cooling	380 W, 120 l/hr

The entire cryogenic distribution was fabricated and assembled on-site and has performed as per design.

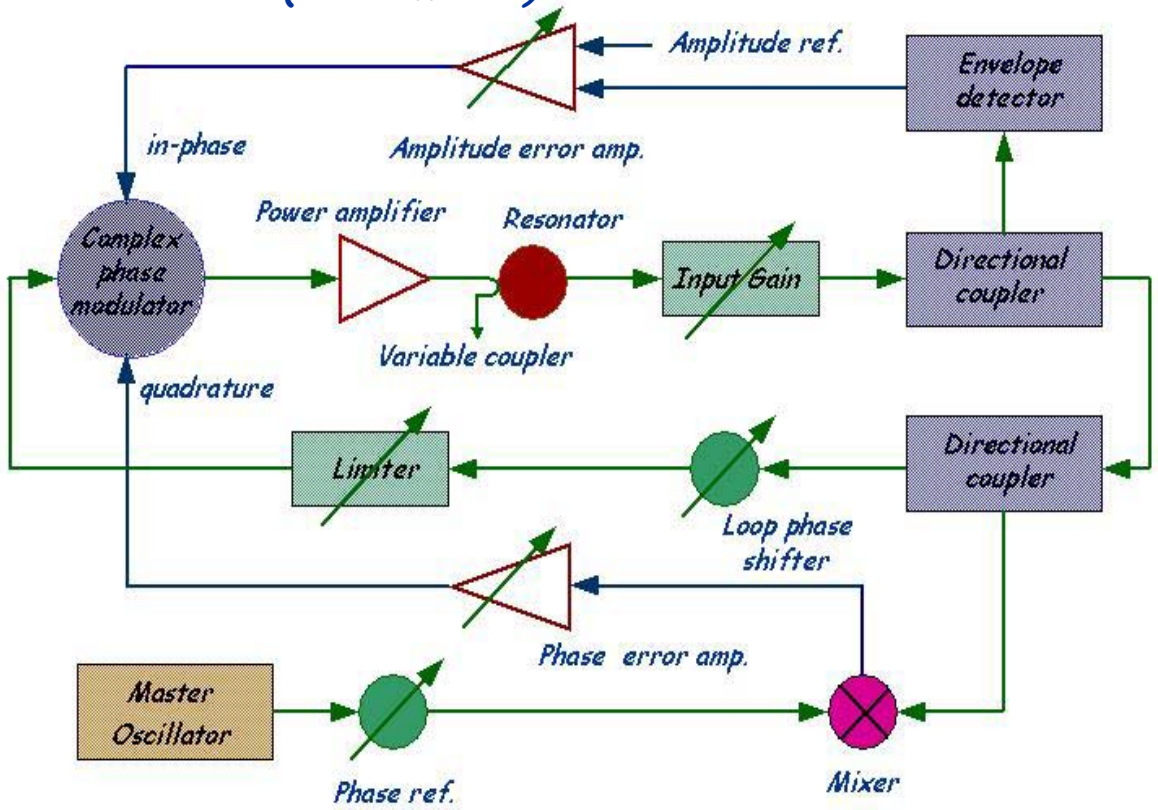
RF ELECTRONICS FOR SUPERCONDUCTING RESONATORS

- **RESONATOR CONTROLLER AND CAMAC SYSTEM:**
  - *IN HOUSE DEVELOPMENT USES EITHER INDIGENOUS OR EASILY AVAILABLE RF MODULES.*
  - *HIGH PERFORMANCE AND LOW COST.*
  - *ALSO USED AT IUAC & ANU (CANBERRA).*
- **RF POWER AMPLIFIER:**
  - *COLLABORATIVE EFFORT OF BEL, BARC-TIFR and NSC*




Indigenously developed RF Control Stations for LINAC modules

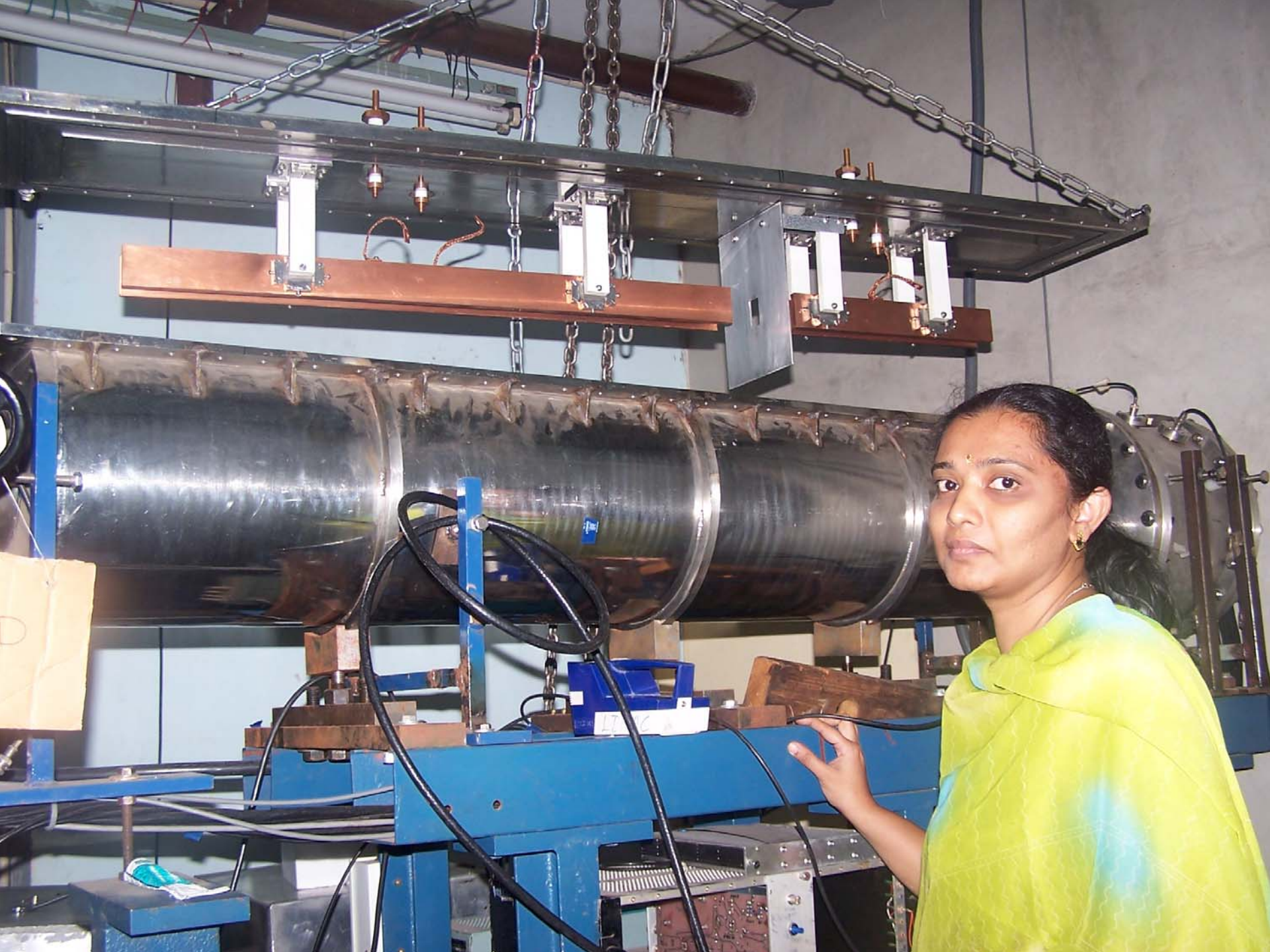
RF Controller (schematic)



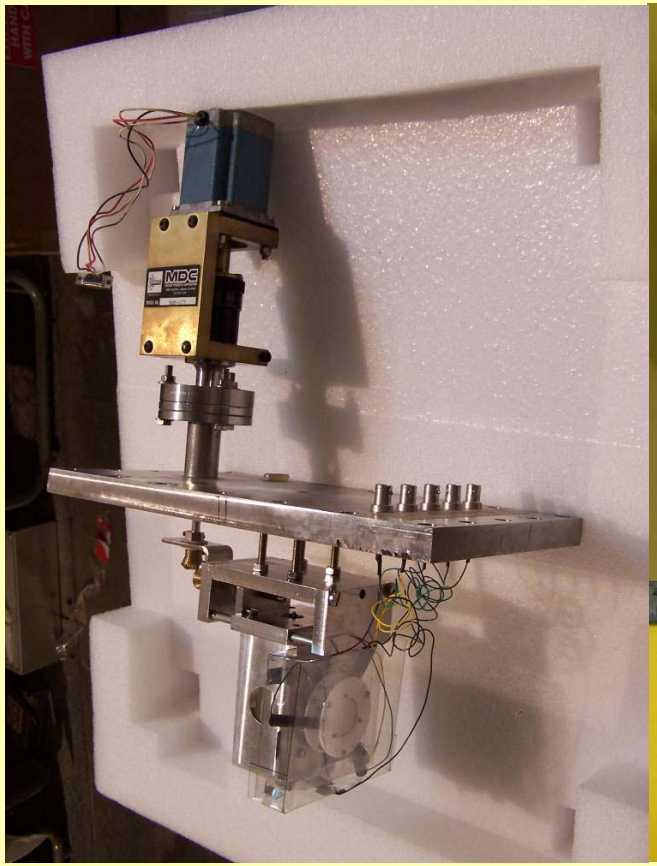
- RF controller cards based on self excited loop based on phase and amplitude feedback.
- 150 Watts, 150 MHz RF power amplifiers.
- CAMAC based control system.
- Control software on LINUX with Java (master + local stations).

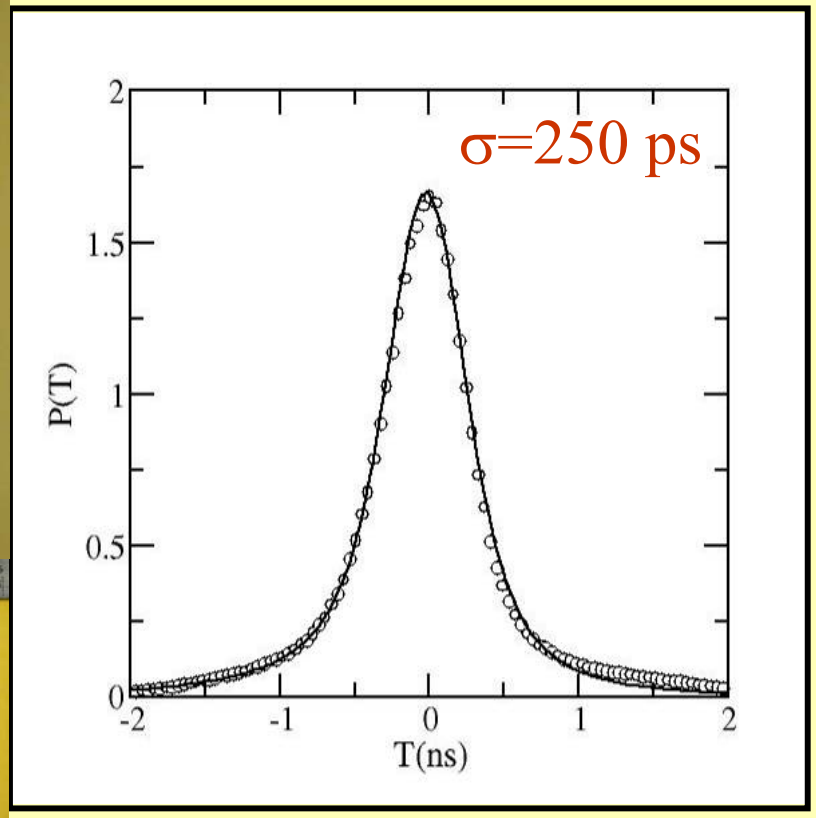
LINAC Control & information System

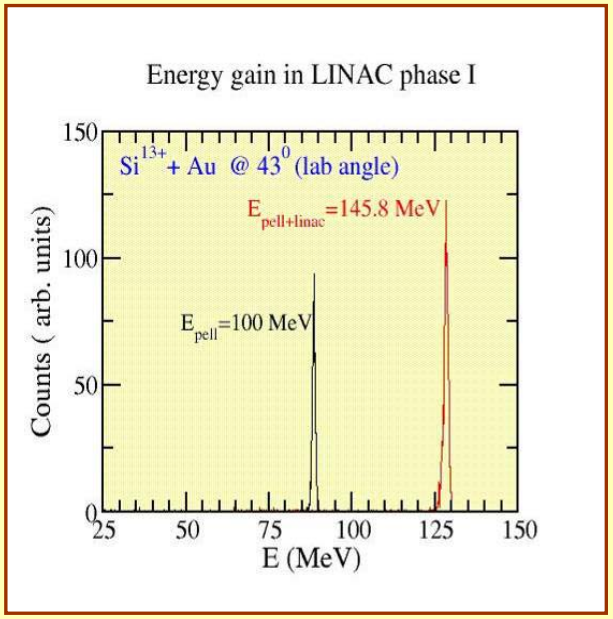
- **USES LINUX OPERATING SYSTEM**
  - *Open source, freely available quite popular among physics community, stable and most secure.*
- **WEB BASED DISTRIBUTED CONTROL SYSTEM**
  - *Can access from intranet using a browser for monitor/control.*
  - *Uses JAVA as programming language.*

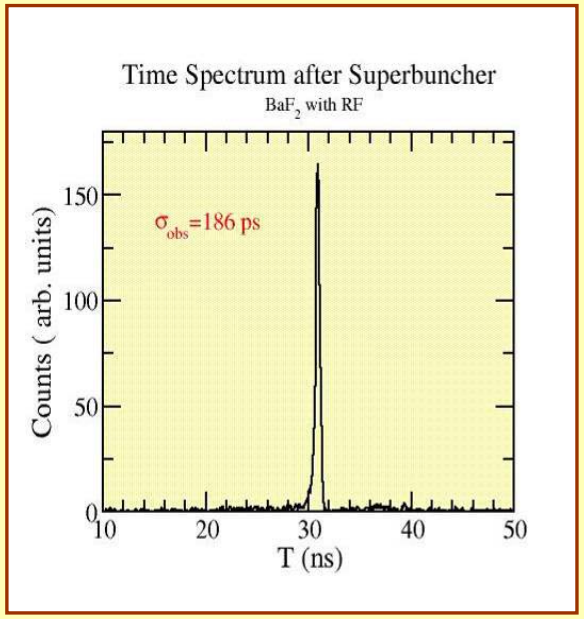


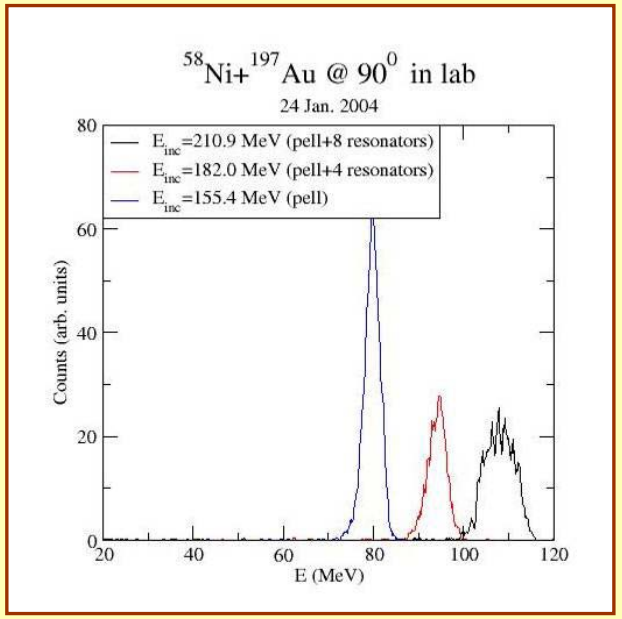
Micro-sphere Plate detector for timing







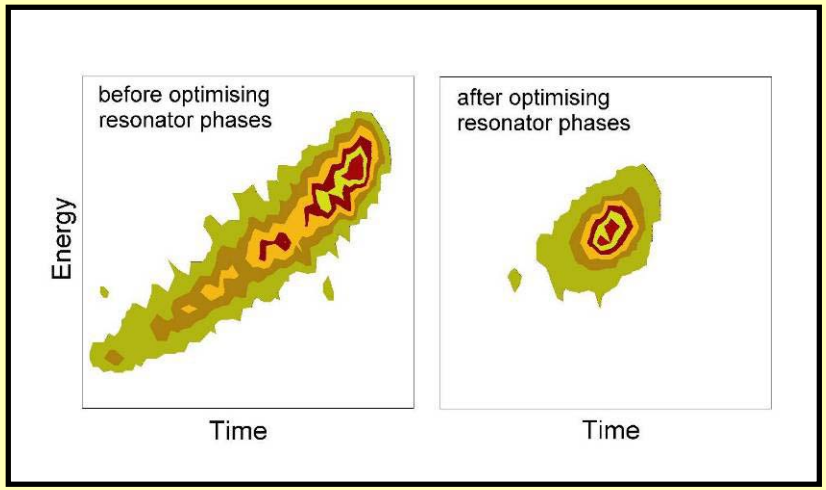




The first beam was accelerated through the phase I of LINAC Booster on 22nd Sept. 2002.

Ni Beam acceleration Jan 2004.

Longitudinal phase space after mid-bend



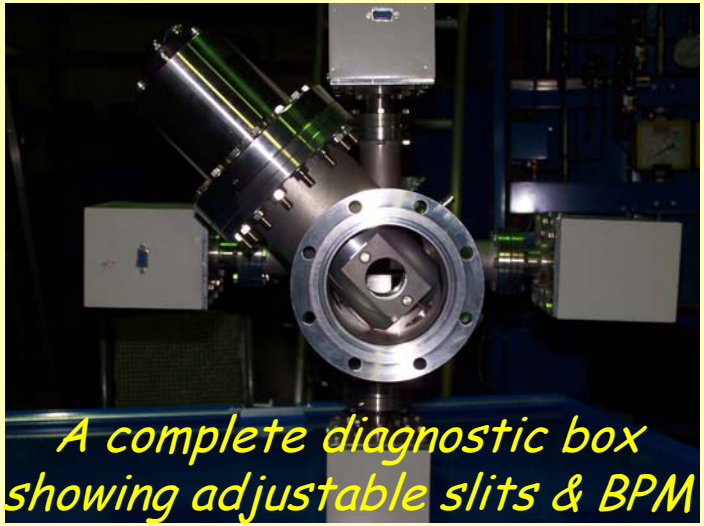
Beam Diagnostic tests: Feb-March '03.
The first beam cycle: April-May '03.

*Nuclear physics A**770**, 126 (2006)*
*Phys.Rev. C**73**, 064609 (2006)*

Development of Beamline components & Diagnostic elements

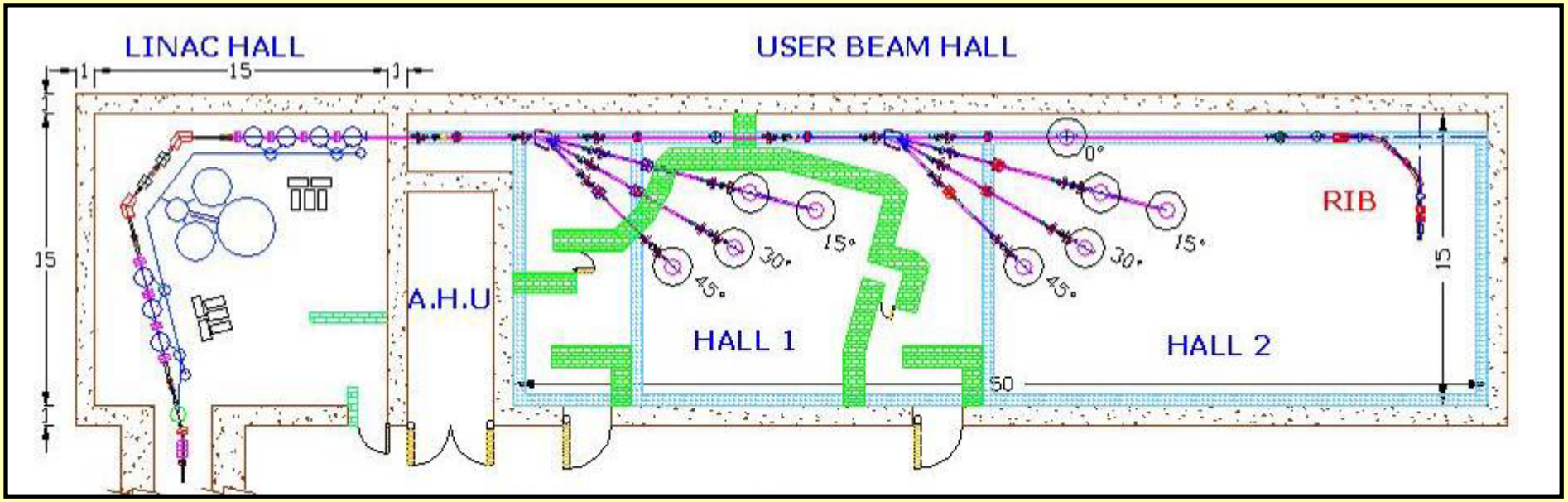
Ion pump and Sublimator pump

BPM & Faraday Cup



A complete diagnostic box showing adjustable slits & BPM

LINAC & Experimental Beam Halls



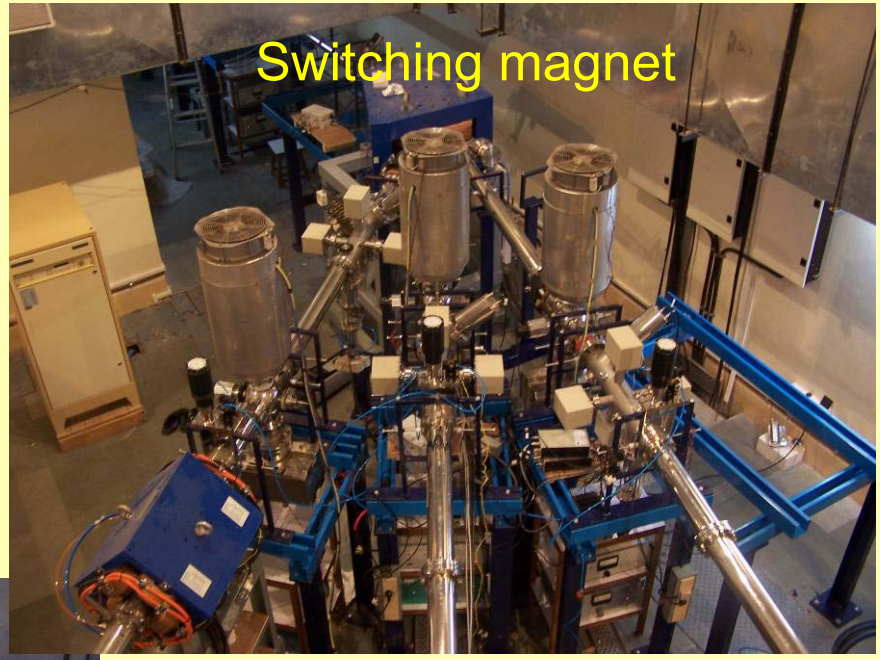
Hall 1

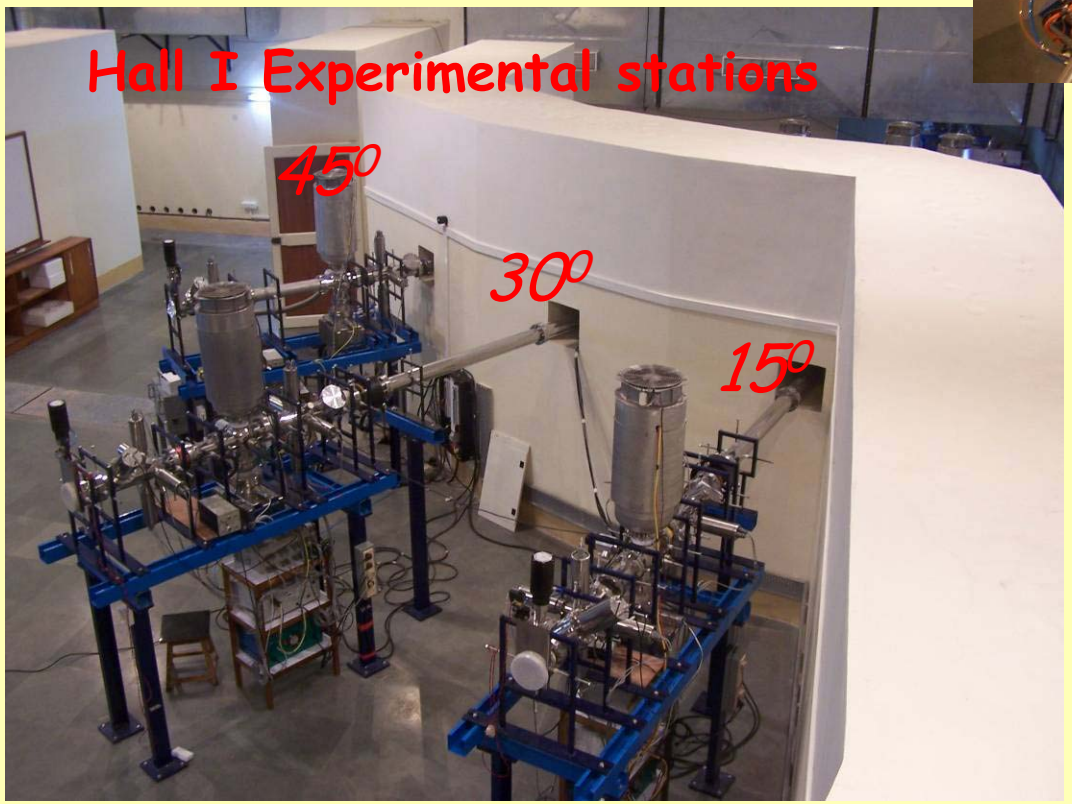
- Condensed Matter Physics (7 T Magnet) & Atomic, Molecular & Cluster Physics
- General purpose / Irradiation line
- High energy gamma ray & neutron wall

Hall 2

- General Purpose Scattering Chamber
- HP Ge Spectrometer (INGA)
- Charged particle ball
- Magnetic separator for light RIBs

User beam Hall I





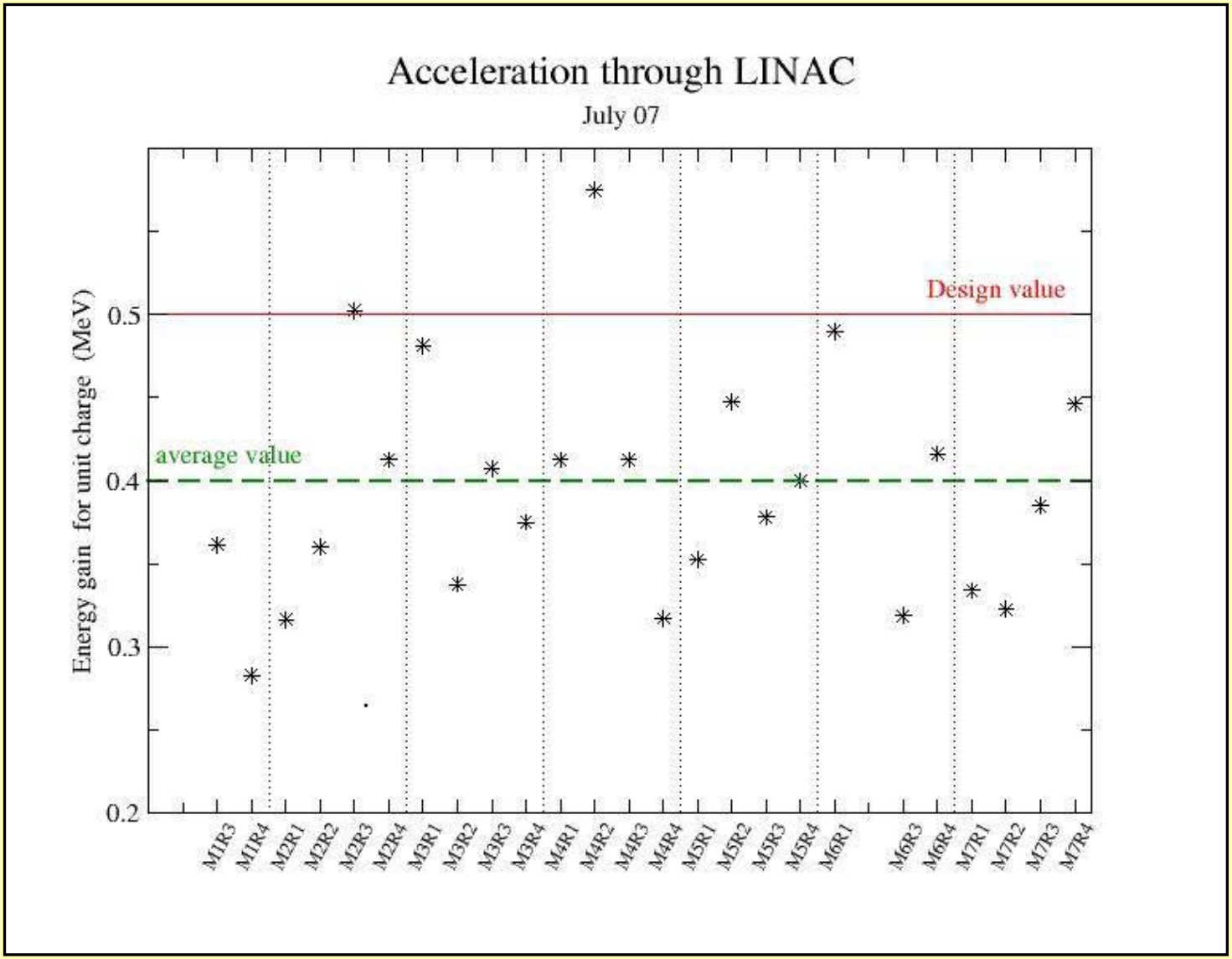
Exclusive Measurements of GDR in $^{28}Si + ^{124}Sn$ @ 188 MeV

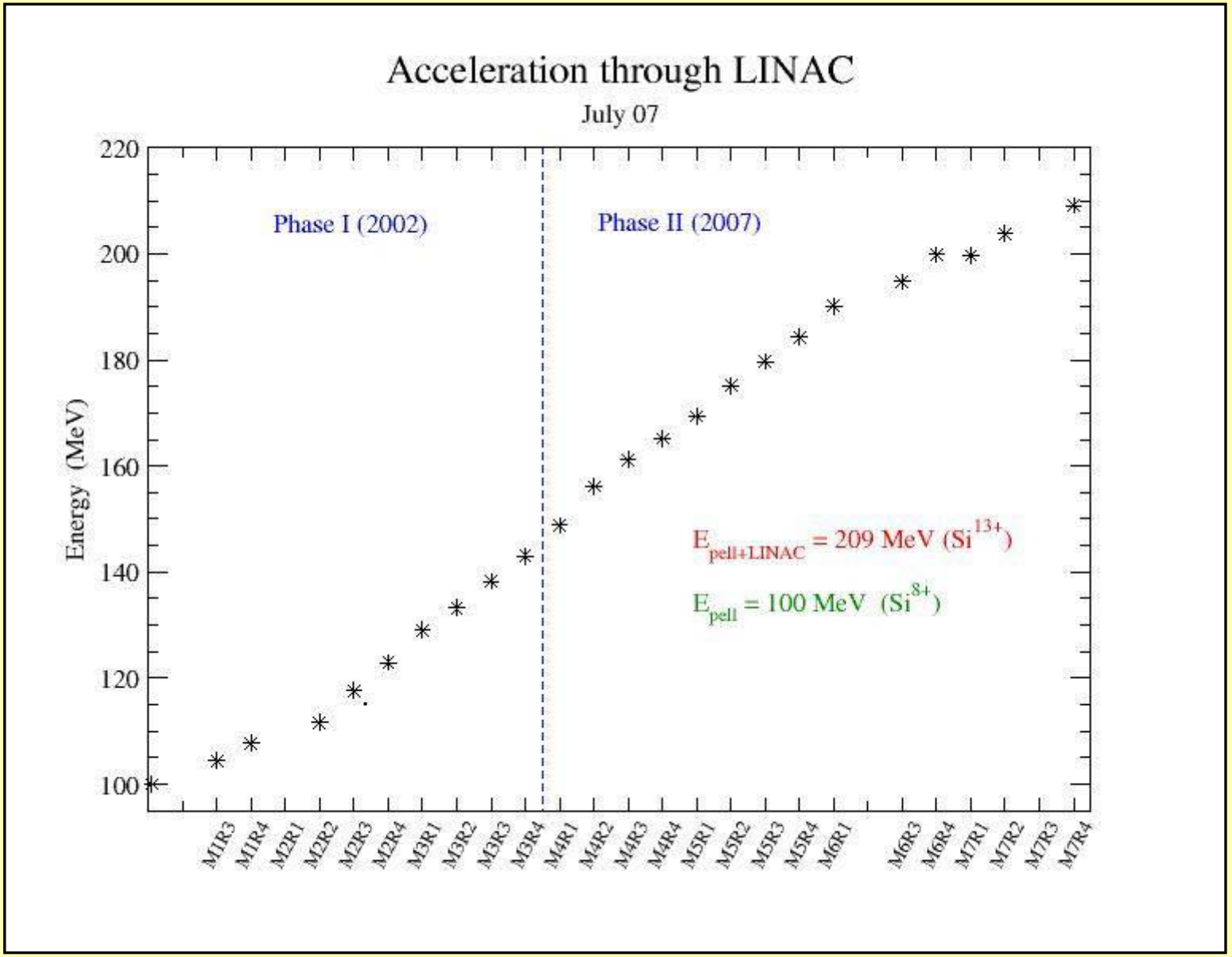
D.R. Chakrabarty et al.

- 7 element BaF_2 detector with plastic anti cosmic shield (for high energy γ rays)
- 38 element BGO multiplicity detector (for angular momentum, ε~70%)
- Annular PPAC detector (for residue gating, ε ~25%)
- HpGe detector (for diagnostic purposes)
- beam ~1 pnA on target, 5 days

$^{28}Si^{13+}$

(July 07)

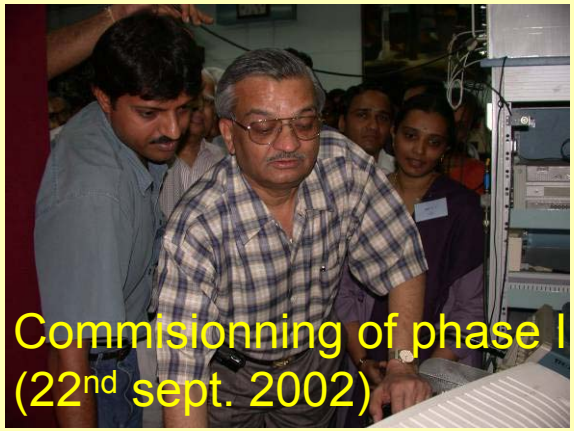



Acceleration through LINAC
July 07
Energy (MeV)
220
200
180
160
140
120
100
Phase I (2002)
Phase II (2007)
E pell+LINAC = 209 MeV (Si 13+)
E pell = 100 MeV (Si 8+)
M1R3
M1R4
M2R1
M2R2
M2R3
M2R4
M3R1
M3R2
M3R3
M3R4
M4R1
M4R2
M4R3
M4R4
M5R1
M5R2
M5R3
M5R4
M6R1
M6R3
M6R4
M7R1
M7R2
M7R3
M7R4

Some Milestones …


First beam acceleration with single module


Installation of mid bend magnets


Commisionning of phase I (22nd sept. 2002)

Accelerator staff and users rejoice
as the
First LINAC experiment begins on
16th April 2003

Dedicated to Users on November 28th, 2007

TIFR & BARC

Team

R.G. Pillay M.B. Kurup B. Srinivasan Vandana Nanal J.N. Karande S. Jangam
P.B. Thakkar K.S. Parab C. D'Costa L.V. Kamble S.M. Powale V.L. Kadam J.Y. Sathe
Sudheer Singh Gopal Joshi C.I. Sujo Shyam Mohan Q.N. Ansari S.K. Sarkar
R.D. Deshpande S.R. Sinha M.S. Pose M.E. Sawant (M.K. Pandey P. Patil)

TIFR

- Dept of Nuclear And Atomic Physics
- Central Workshop
- Central Services
- Low Temperature Facility

BARC

- Nuclear Physics Division
- Electronics Division
- Central Workshop

Vendors

IBP • Vacuum Techniques • Aarti Engineering • Fullinger• SMP Enterprises
Accelerator Consultancy Services• Transact-India/Danfysik • BEL • Sameer
• Kamal Engineering • BOC Edwards • Pfeiffer

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

The superconducting LINAC has been a major milestone in the development of accelerator technology in our country.