



# Development and Operation of SCRF Resonators at IUAC Delhi

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***IUAC, New Delhi 110067***



**TTC Meeting**  
**New Delhi**  
**Oct. 22-23, 2008**

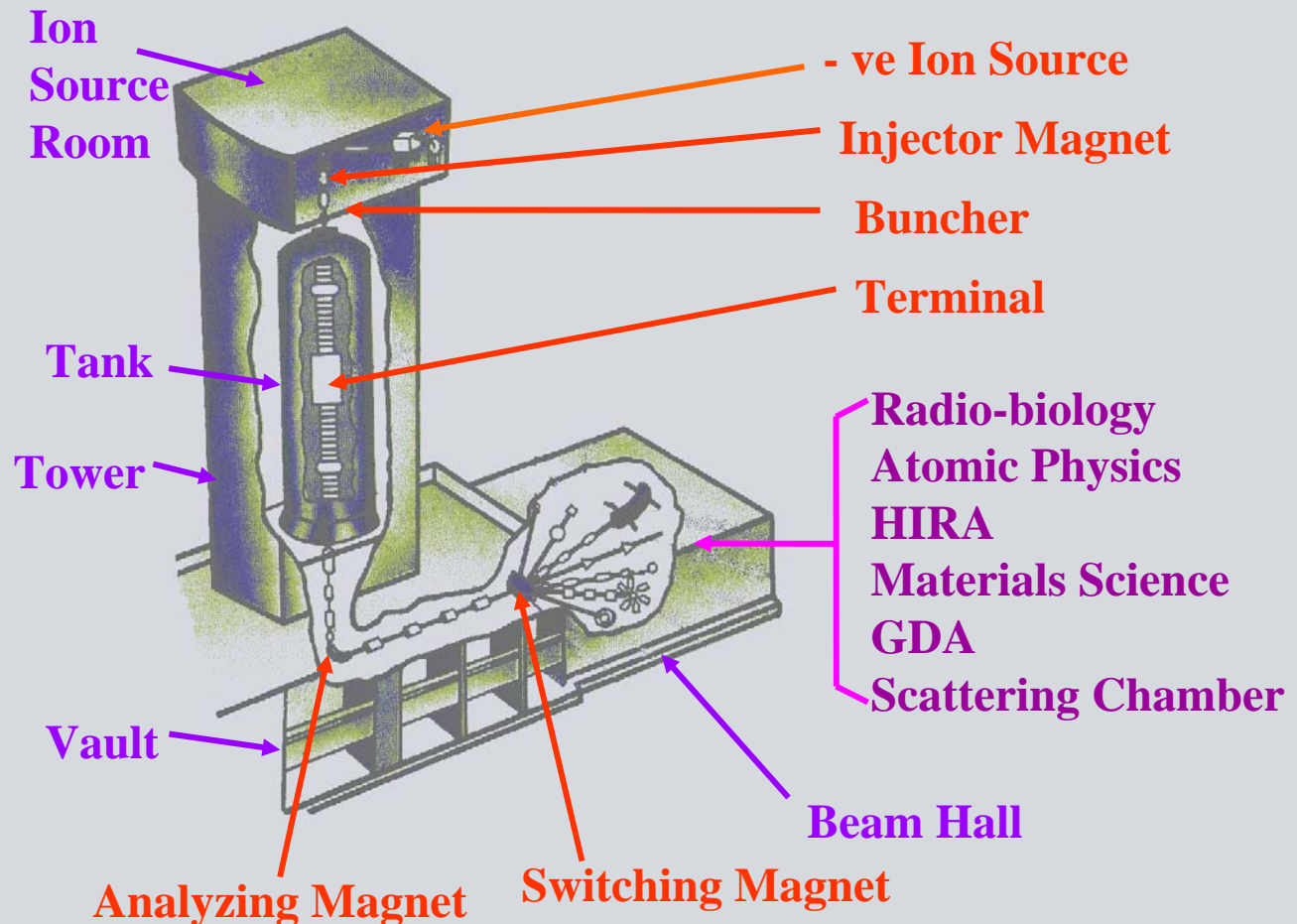
# 15UD Pelletron Accelerator at IUAC

Tank ht: 26.5 m  
Diameter: 5.5 m  
Pressure: 86 PSI  
of SF<sub>6</sub> gas

Ions accelerated:  
H to Au beams

Ion Currents:  
Typically  
5 - 50 pA

Energy : 30 - 250  
MeV



# IUAC SC LINAC schematic

**INJECTOR  
MAGNET**

**MC SNICS**

**MULTIHARMONIC  
BUNCHER**

**15 UD  
PELLETRON**

**SWITCHING  
MAGNET,  
Beam Hall I**

**ANALYSING  
MAGNET**

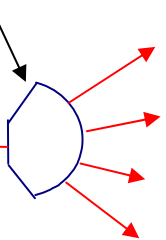
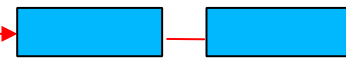
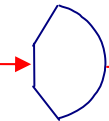
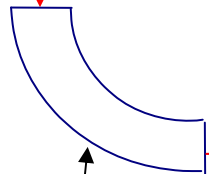
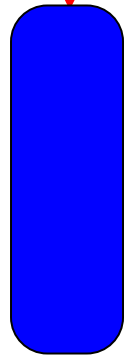
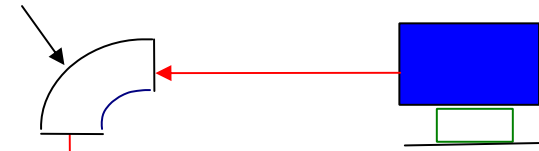
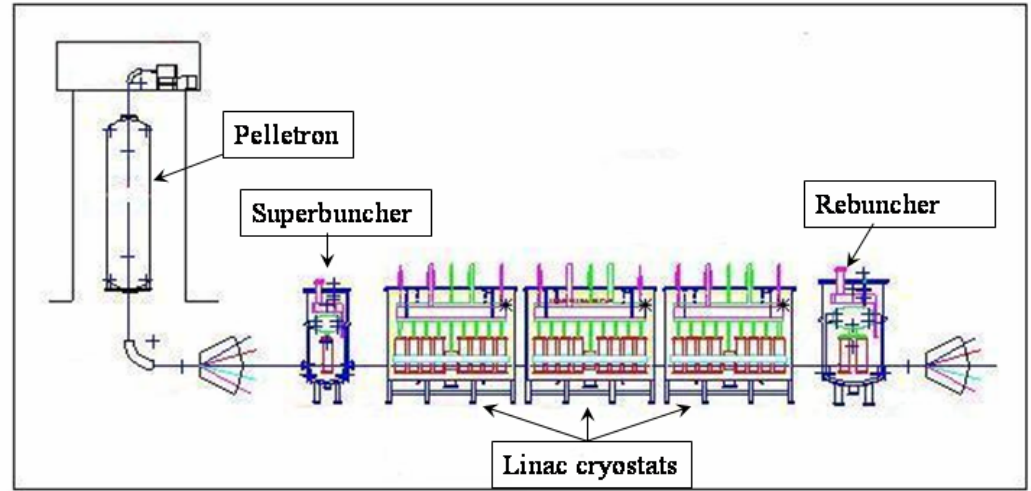
**SWEEPER**

**SC BUNCHER**

**LINAC MODULES  
~ 15 MV /q**

**REBUNCHER**

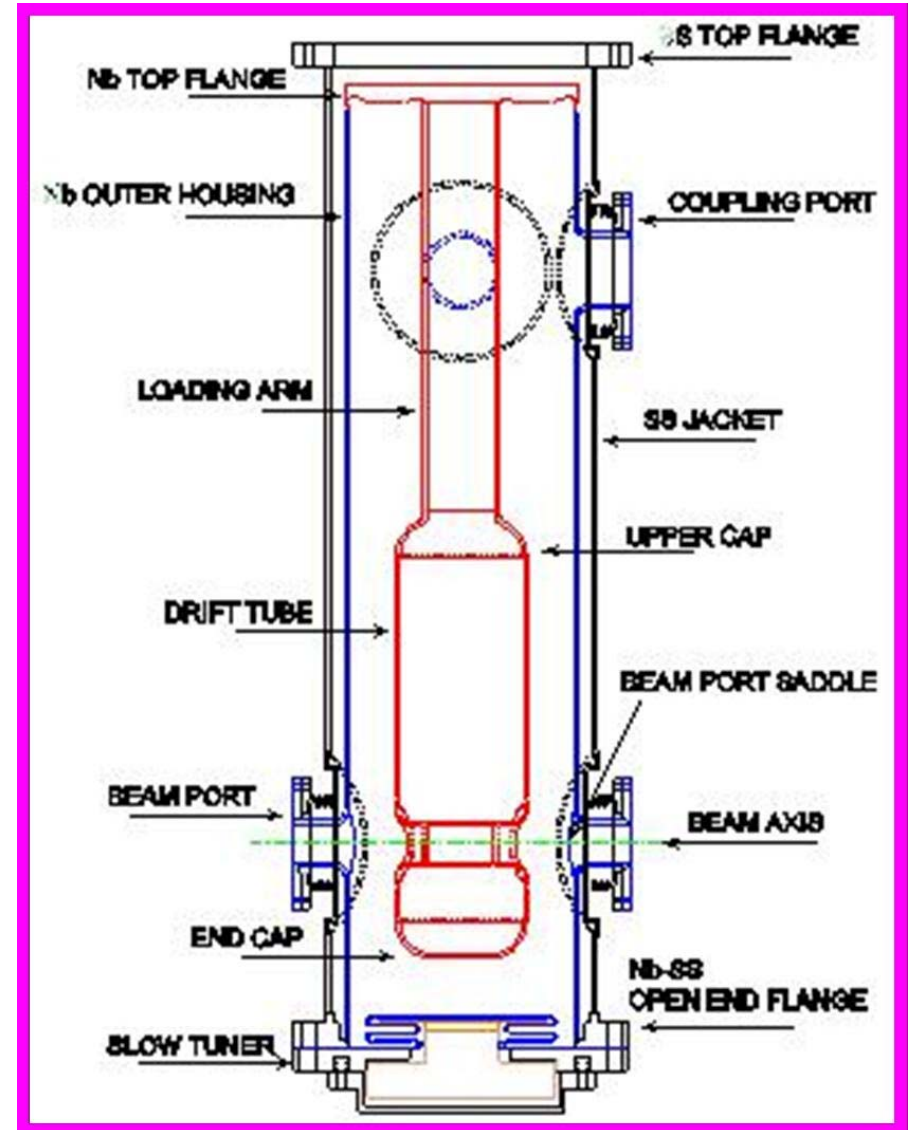
**SWITCHING  
MAGNET,  
Beam Hall II**

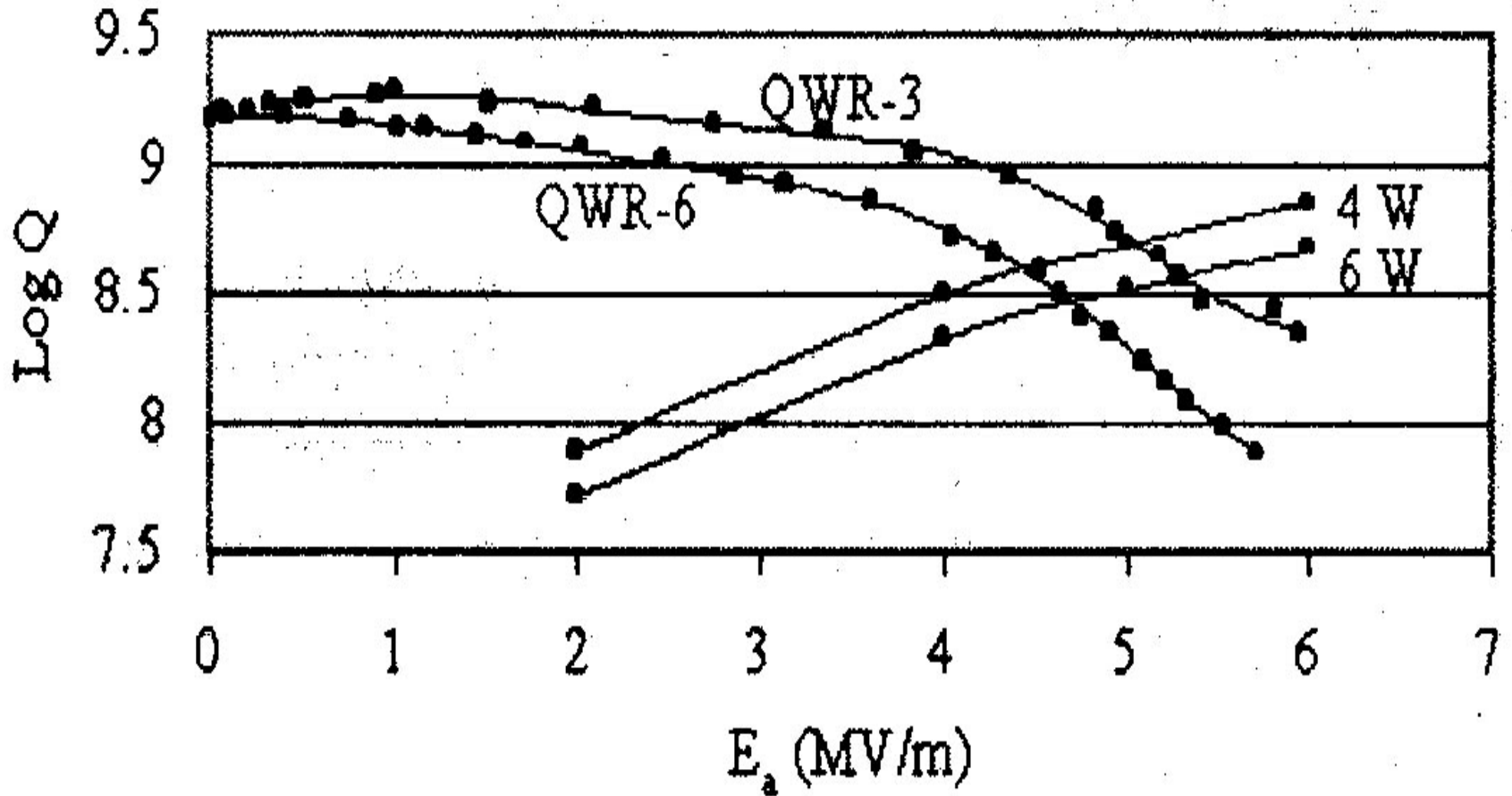


# Capacitance-loaded QWR resonator of IUAC (Initially developed in Collaboration with ANL, USA)



IUAC Quarter Wave Resonator (QWR)

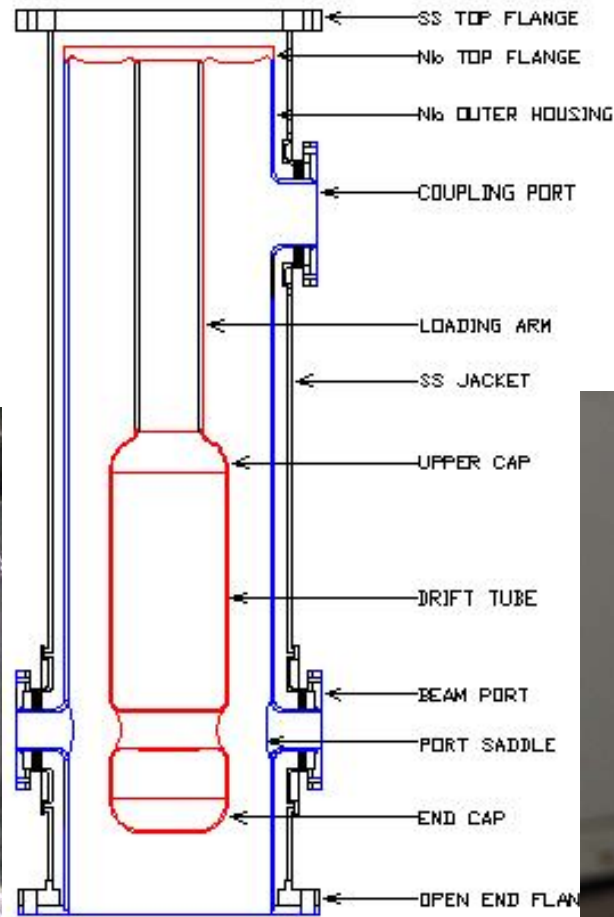




Measured values of Q of the resonator as a function of accelerating electric field  $E_a$

First indigenous Nb QWR ( $E_a \sim 4.2\text{MV/m}$  at 4W),  $v/c=0.08$





Q.W. RESONATOR



Transition Flanges: Welded bellows replaced by formed bellows

# Electron Beam welding facility



60 kV, 15 kW, CNC controlled. Chamber size: 2.5 m x 1.0 m x 1.0 m





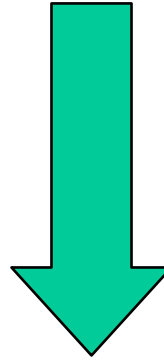
Electron Beam Welding of Nb Central Conductor

# Surface Preparation Laboratory

Acid Fume Hood



High Pressure rinsing system



- EP
- High pres. rinsing
- Assembly

# In-House Fabrication of Resonator

## High Vacuum Furnace



Max Temp. 1200 C  
@  $5.0 \times 10^{-7}$  torr

Hot Zone –  
 $\phi$  0.6 m  $\times$  1 m



# Indigenous Resonator Fabrication



Parts of central conductor



Central conductor and housing



Resonator inside Nb getter box before annealing



Resonator & SS-jacket  
Before welding



Niobium Top Flanges and Central Conductor assemblies



Niobium Outer Housings



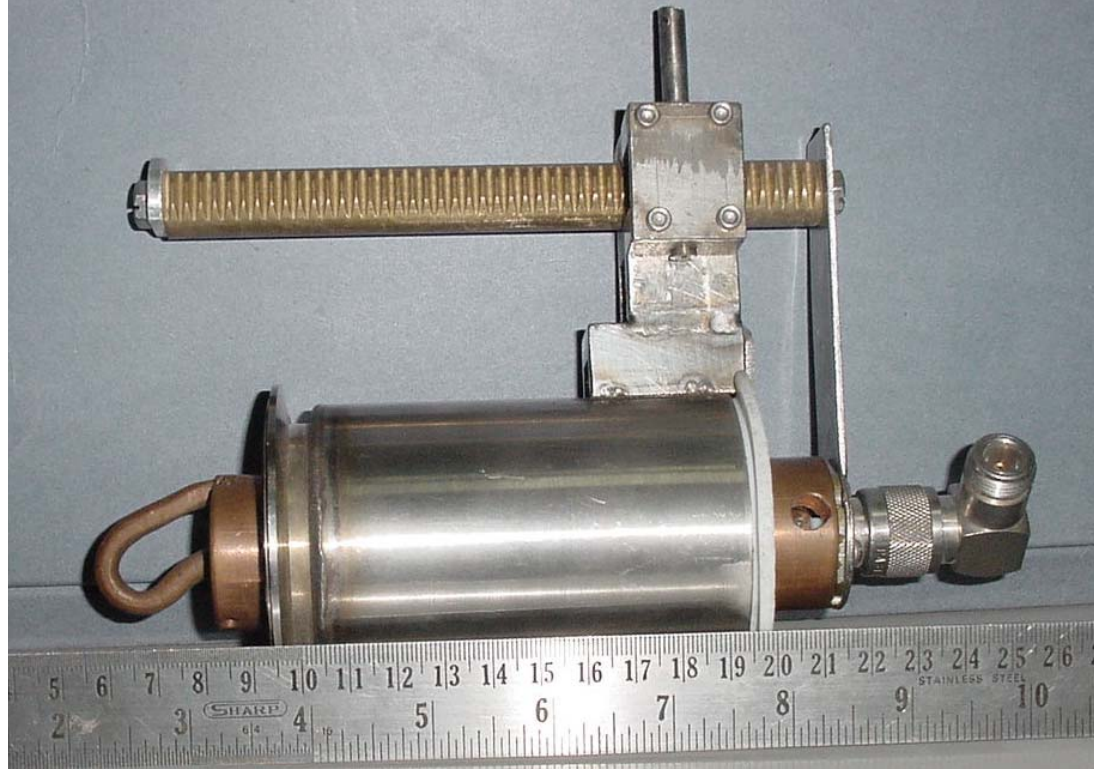
Loading Arm & Drift Tube cylinders

Indigenous Fabrication of 15 QWRs

# Old and new Coupler

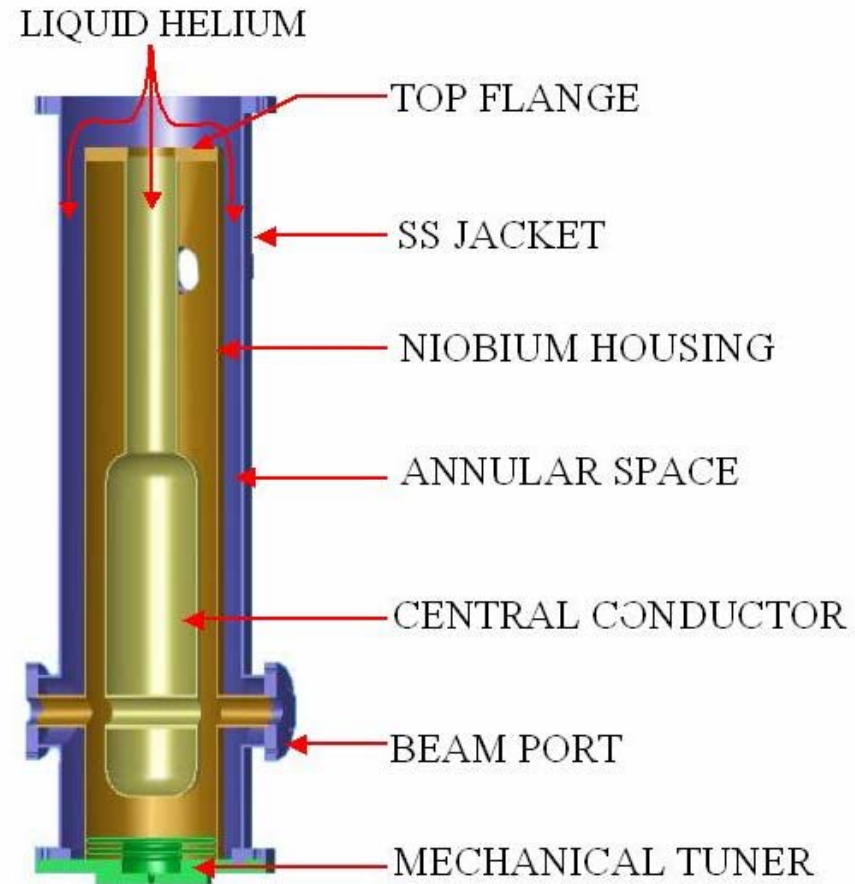
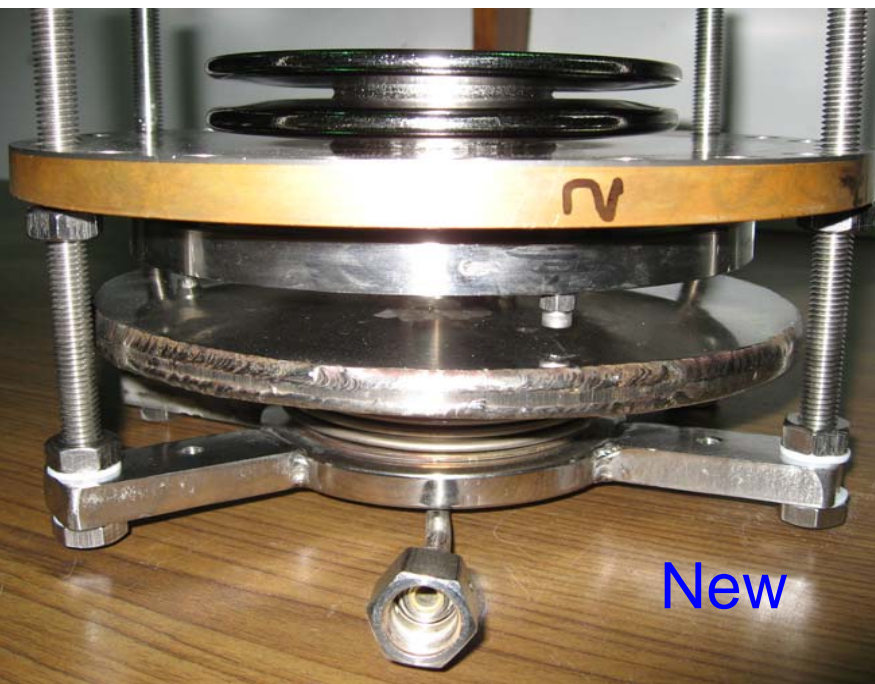


Old



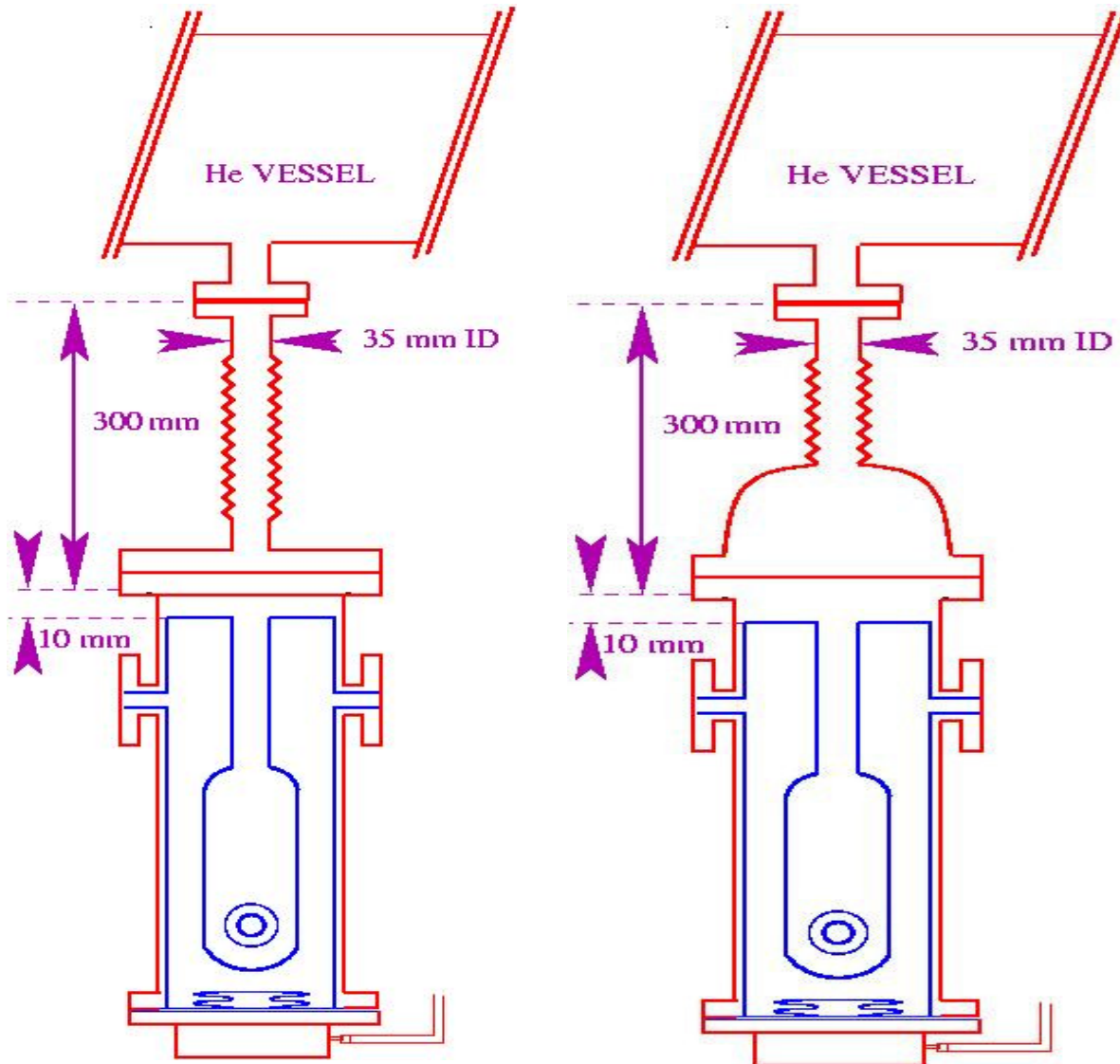
New

# Old and new slow tuner fixtures

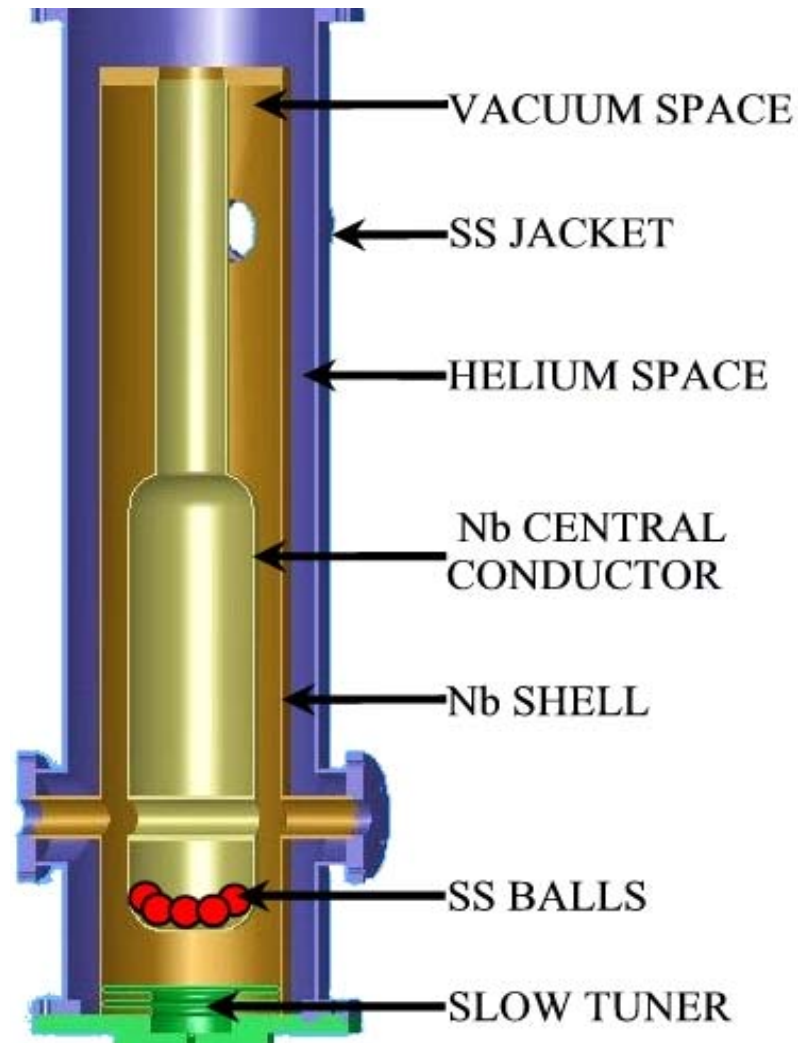




# Schematic of old top flange & new dome (HAT) on top of QWR

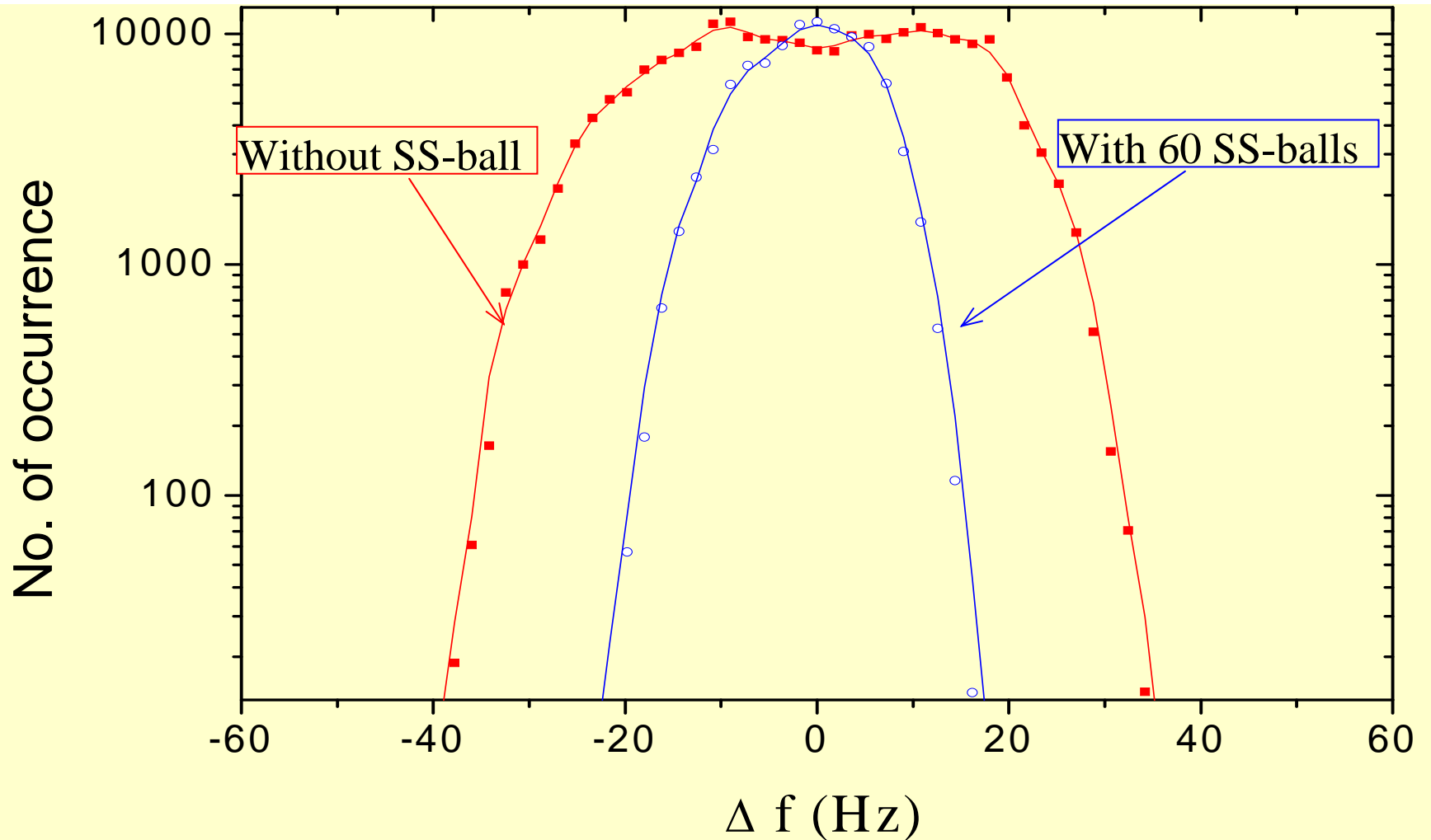


# Damping of Micro-harmonics



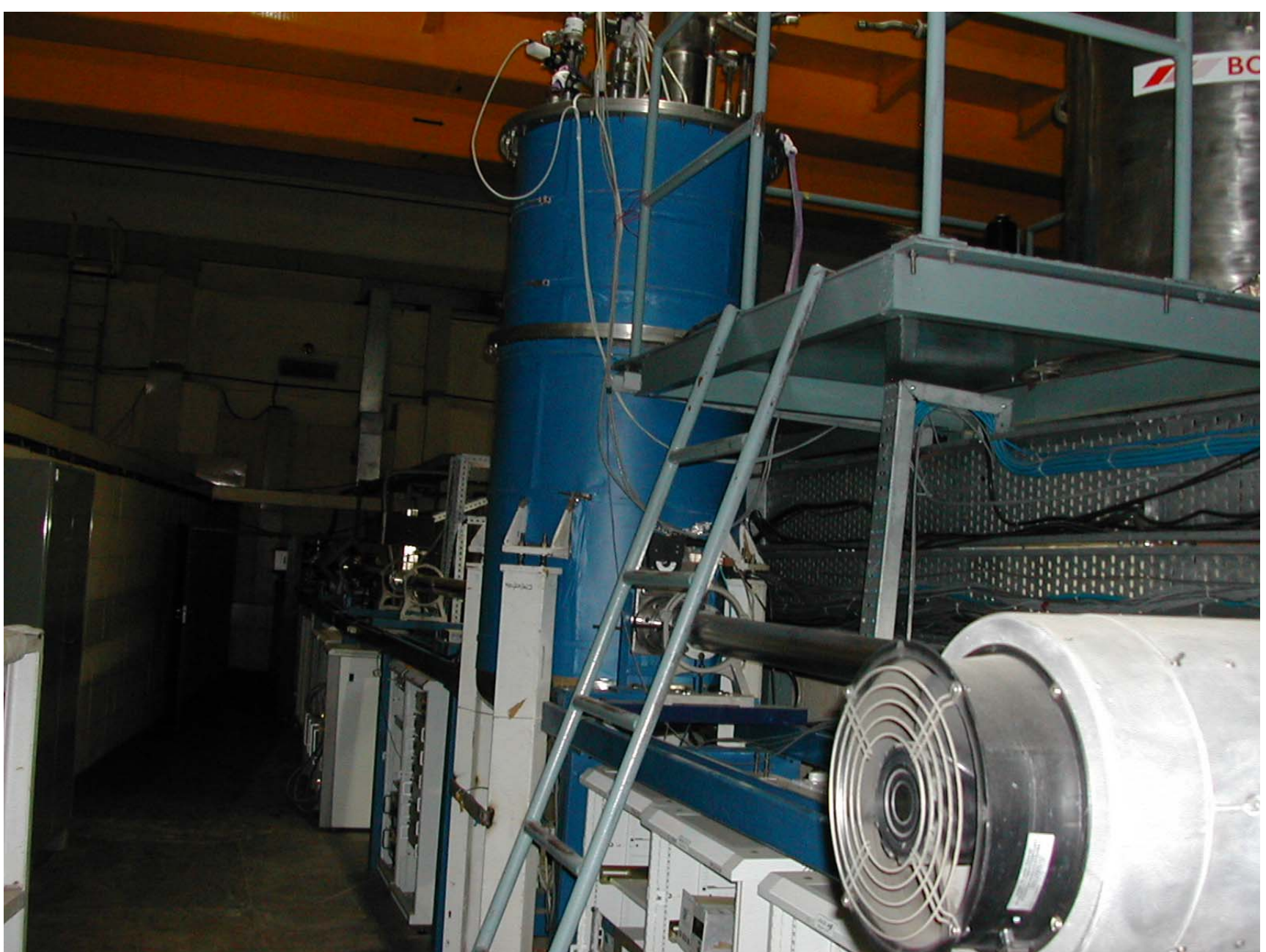
Cross-sectional view of a resonator along with SS-balls used for damping

# Comparison of frequency jitter with and without damping balls



## Comparison of power requirement with and without damping balls

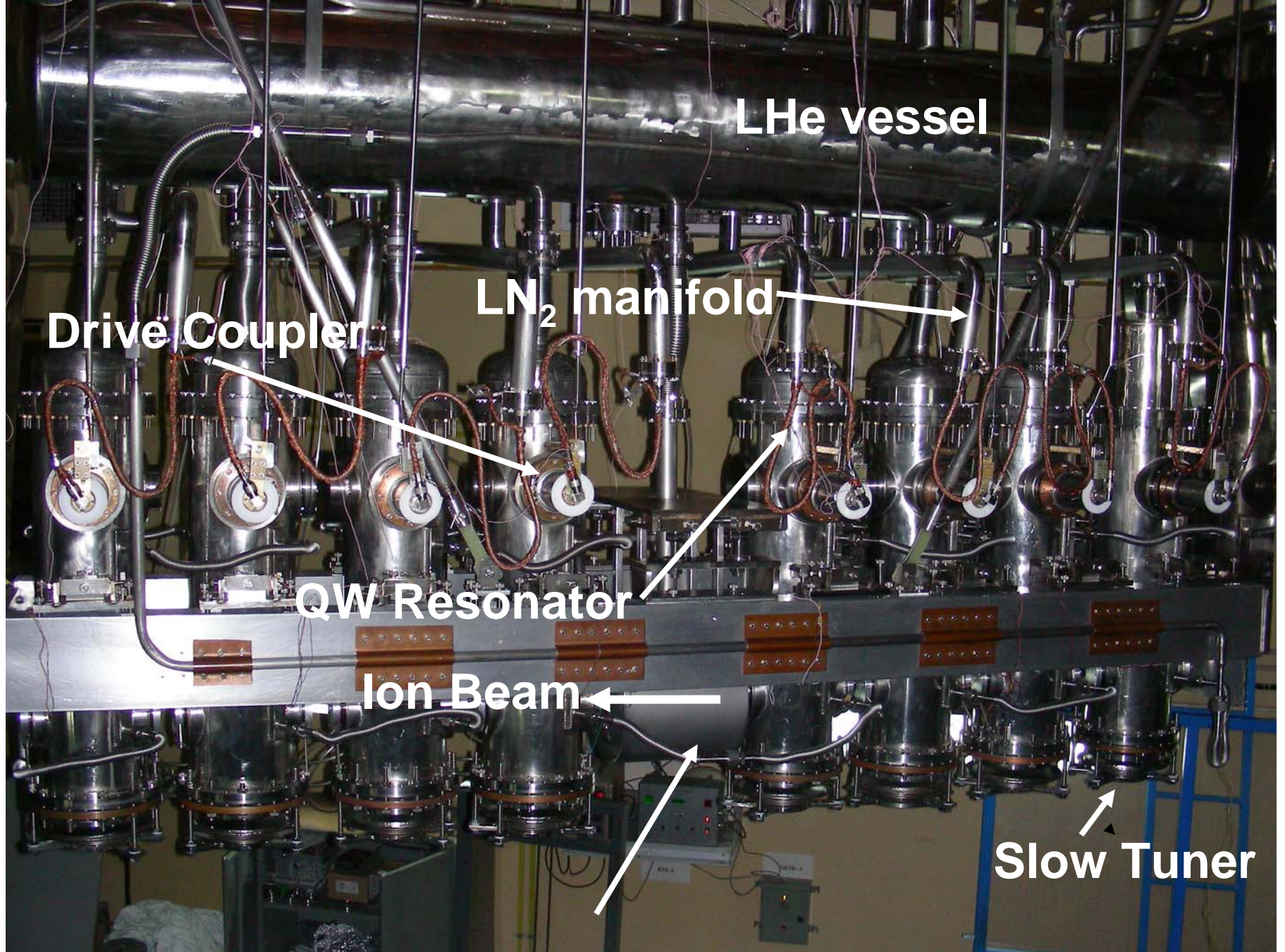
Cryostat	QWR	$Q_0$ @ 6 Watts	$E_{acc}$ (MV/m) @ 6 watt	$E_{acc}$ (MV/m) during phase lock	Required power (W) without damping	Required power (W) with damping
Test	1	$1.6 \times 10^8$	3.5	3.5	60	28
	2	$4.7 \times 10^8$	6.0	5.0	80	35
Linac	3	$2.1 \times 10^8$	4.0	3.1	218	90
	4	$2.1 \times 10^8$	4.0	2.5	280	100



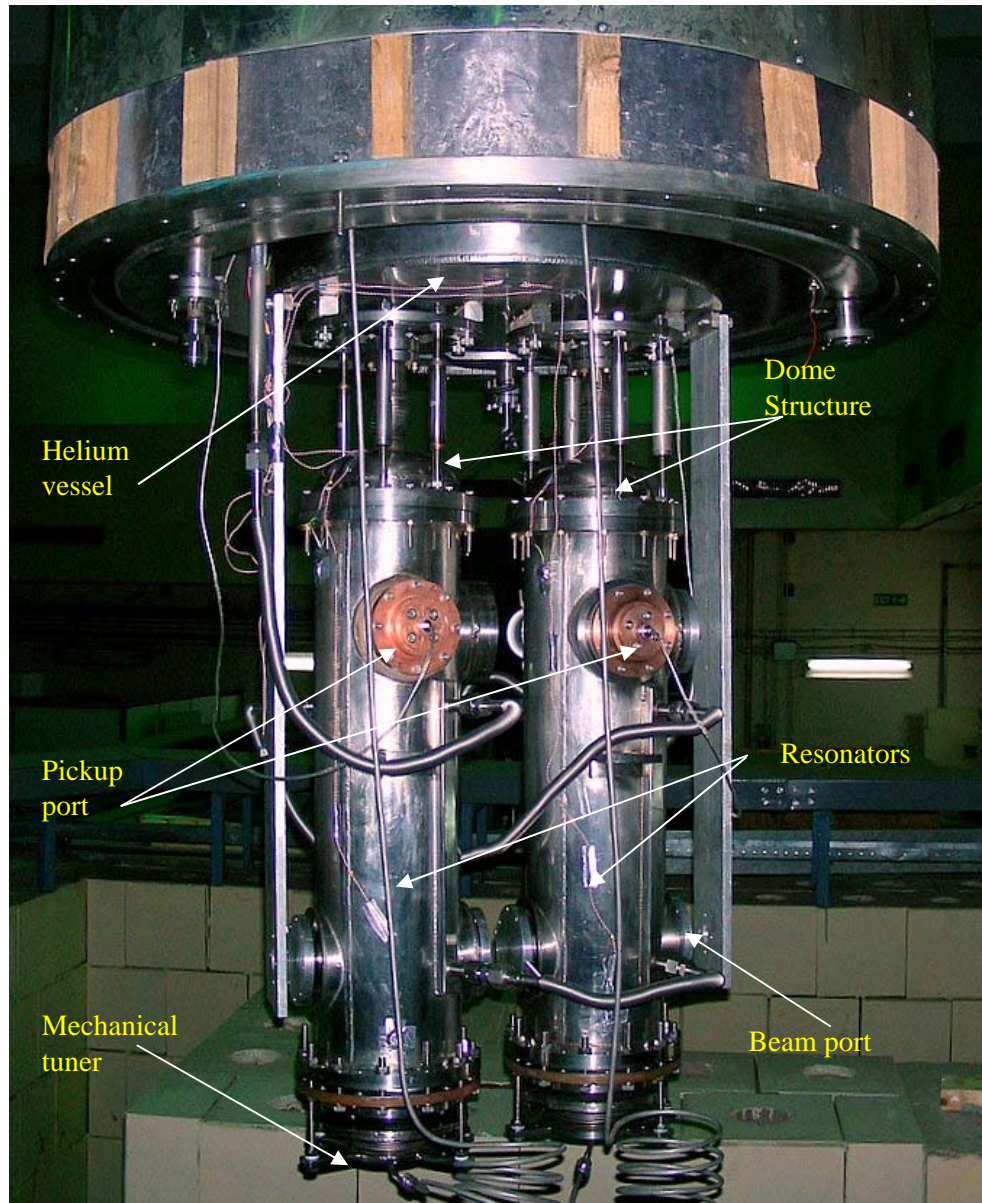
**Superbuncher in the beam line (FWHM~170 ps)**



**First LINAC Module having 8 QWRs**

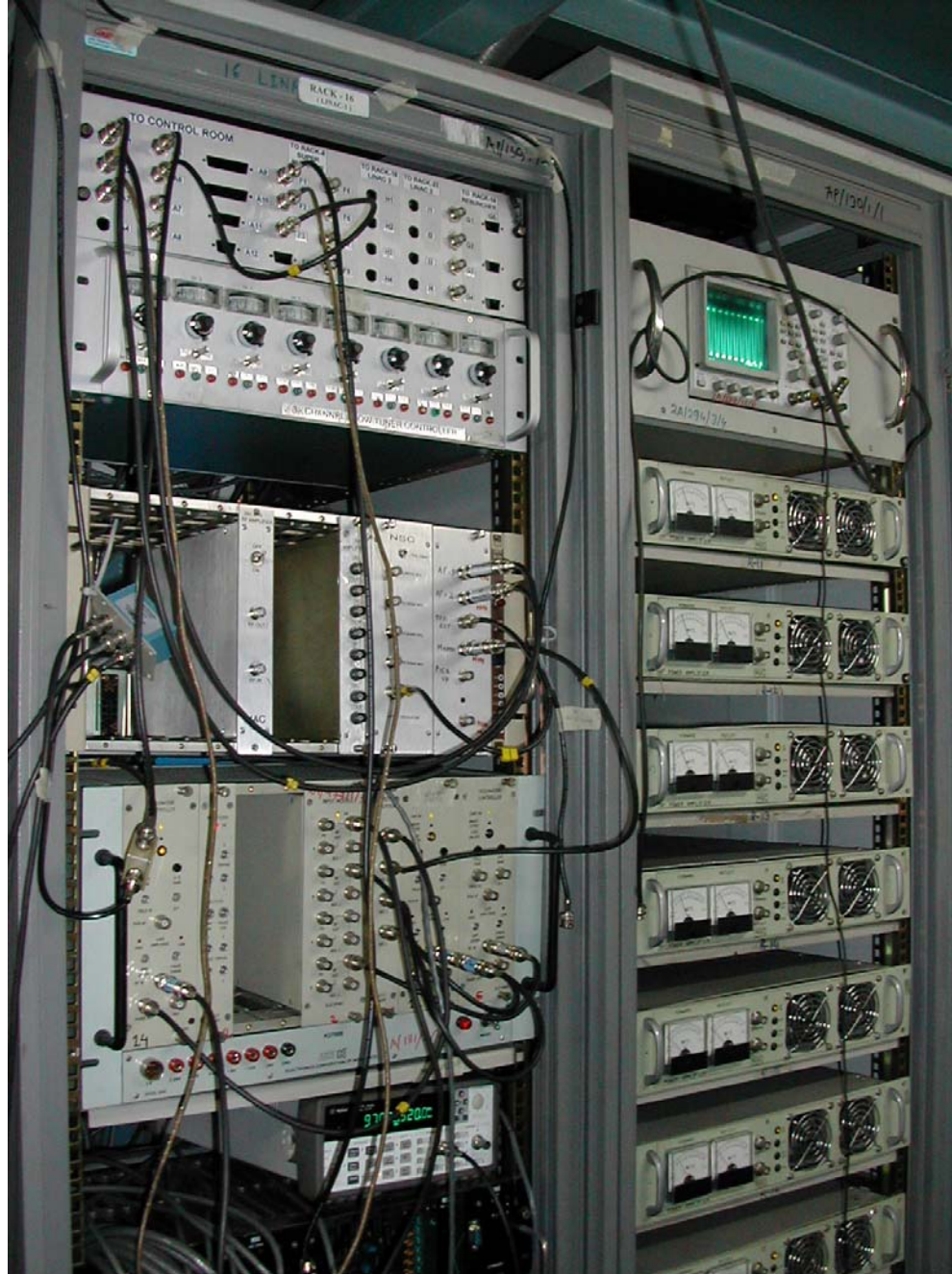


Resonators of the first Linac module ( $E_{av} \sim 3.6$  MV/Resonator)



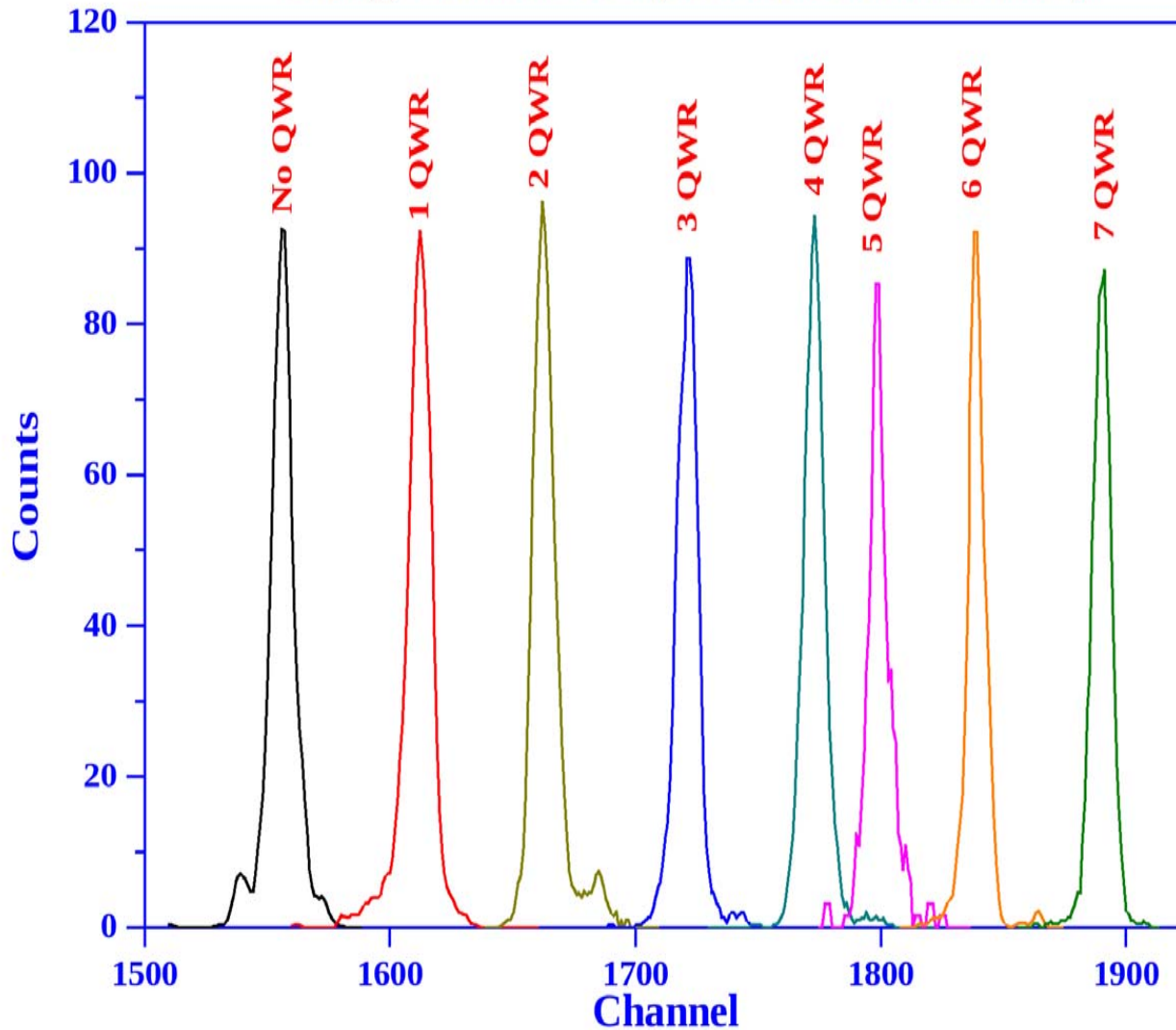
**Two Quarter Wave Resonators (QWRs) installed in the Rebuncher cryostat**





Indigenous RF Amplifier and Control system

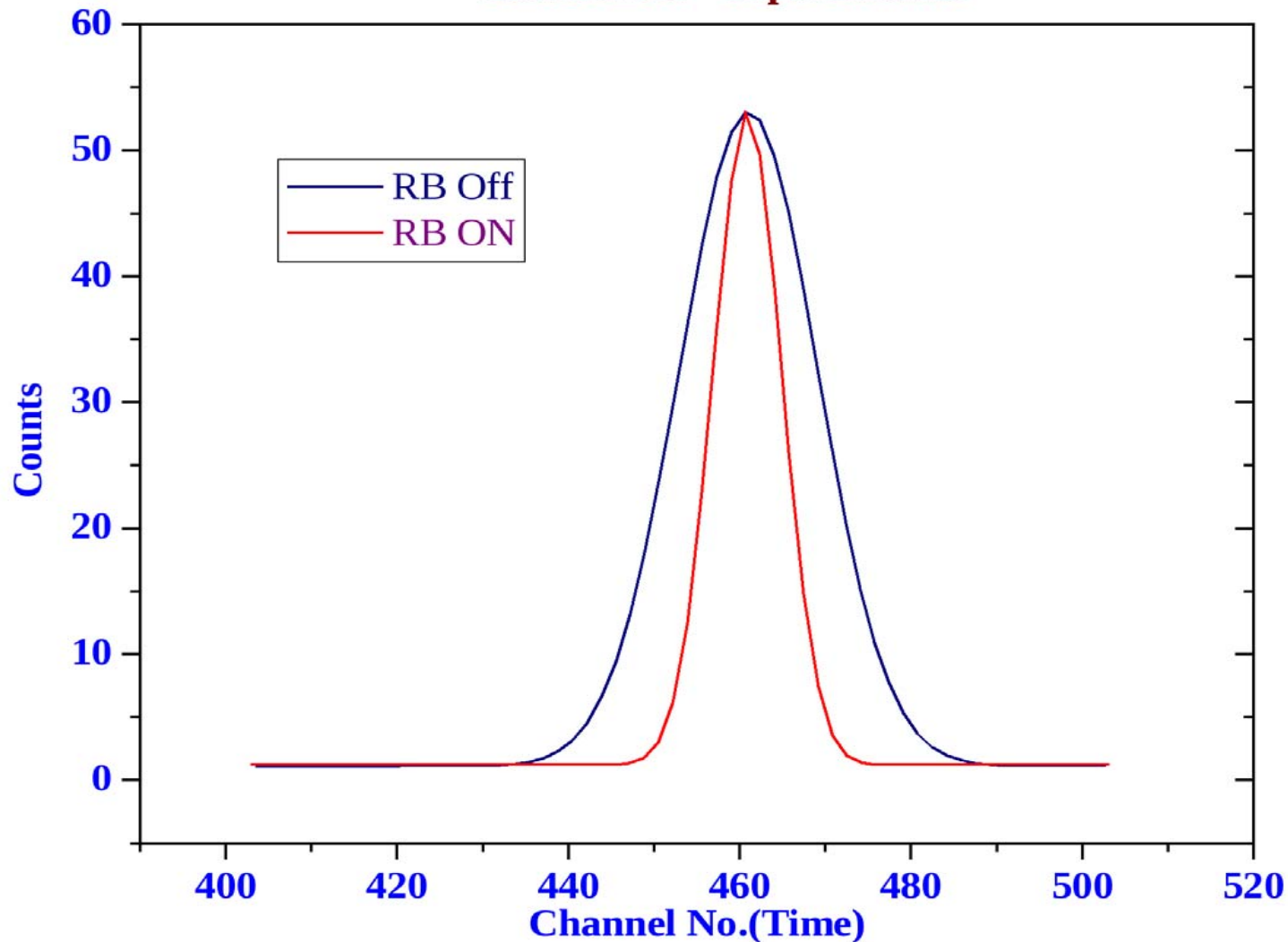
### Energy Gain 28 MeV (Cal. 83.55 keV/Channel)



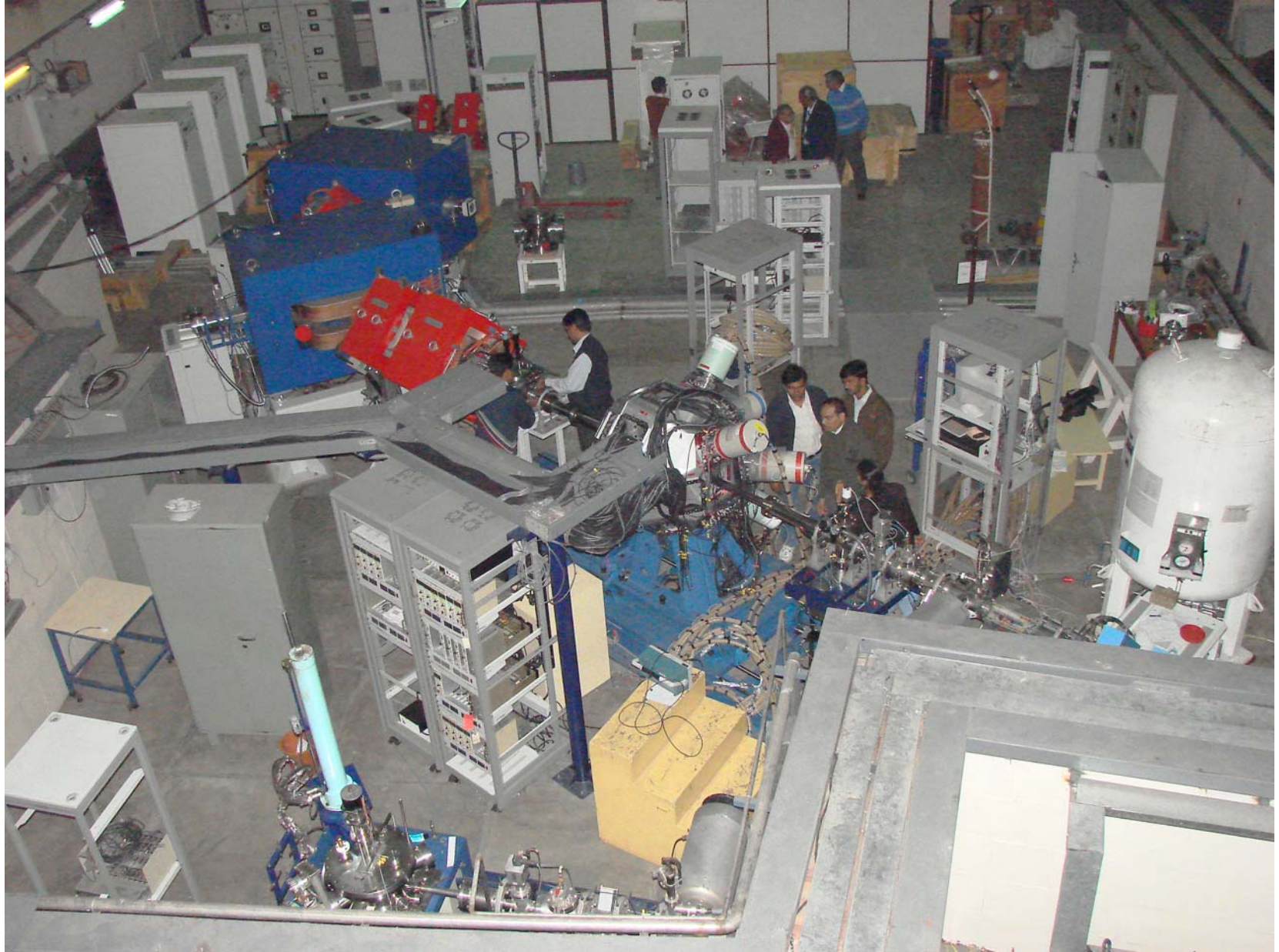
The energy spectrum of the beam accelerated by successive QWRs

# Rebuncher

Calibration = 50ps/Channel



120 MeV  $^{16}\text{O}^{+8}$  beam from Pelletron + LINAC:  
Re-bunched to a time width of  $\sim 500$  ps



**Indian National Gamma Array (INGA) & Hybrid Recoil Analyzer (HYRA) in Beam Hall-2**

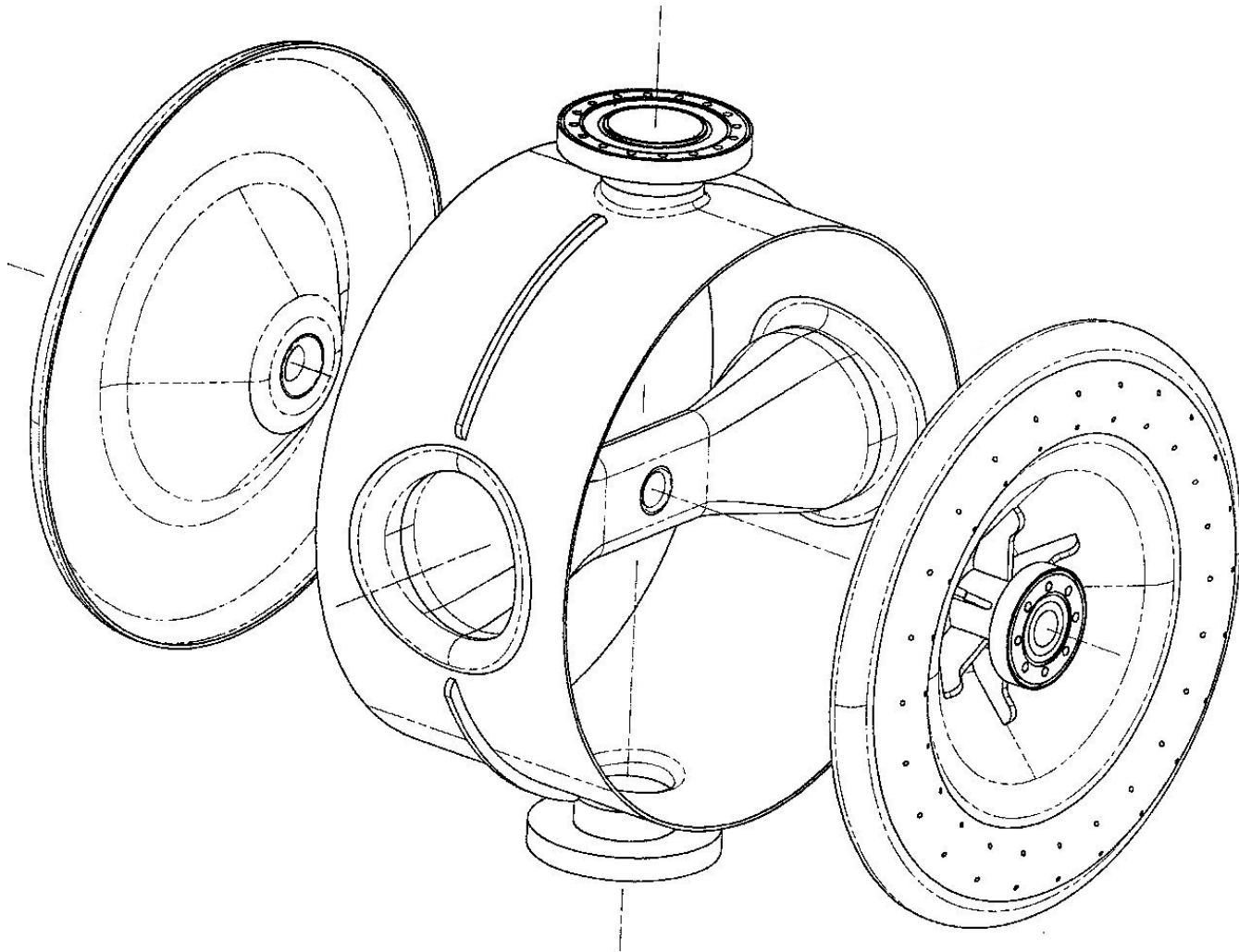


National Array of Neutron Detector (NAND) in Beam Hall-2



Control Room for 15UD Pelletron and Linac

# Niobium Single Spoke Resonator



For Proton Driver Linac of FNAL, USA (325 MHz,  $\beta=0.22$ )



Die & Punch for Half SPOKE



# Conclusion

SCRF Technology has been developed, tested and used for installation of Niobium based Superconducting Heavy Ion LINAC booster accelerator.

Energetic Heavy Ion Beams from 15UD Pelletron are further accelerated by the SC LINAC and delivered for conducting scheduled experiments.

Further developments are undertaken to make the system rugged for round the clock operation with minimum human interaction and for adding two more LINAC modules .

# **Acknowledgements:**

**Colleagues at IUAC**

**involved in**

**Accelerator and associated operational and  
developmental activities**

Thank you



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