HIAT09
Venezia, June 8-12, 2009

DEVELOPMENT OF HEAVY ION ACCELERATOR AND ASSOCIATED SYSTEMS

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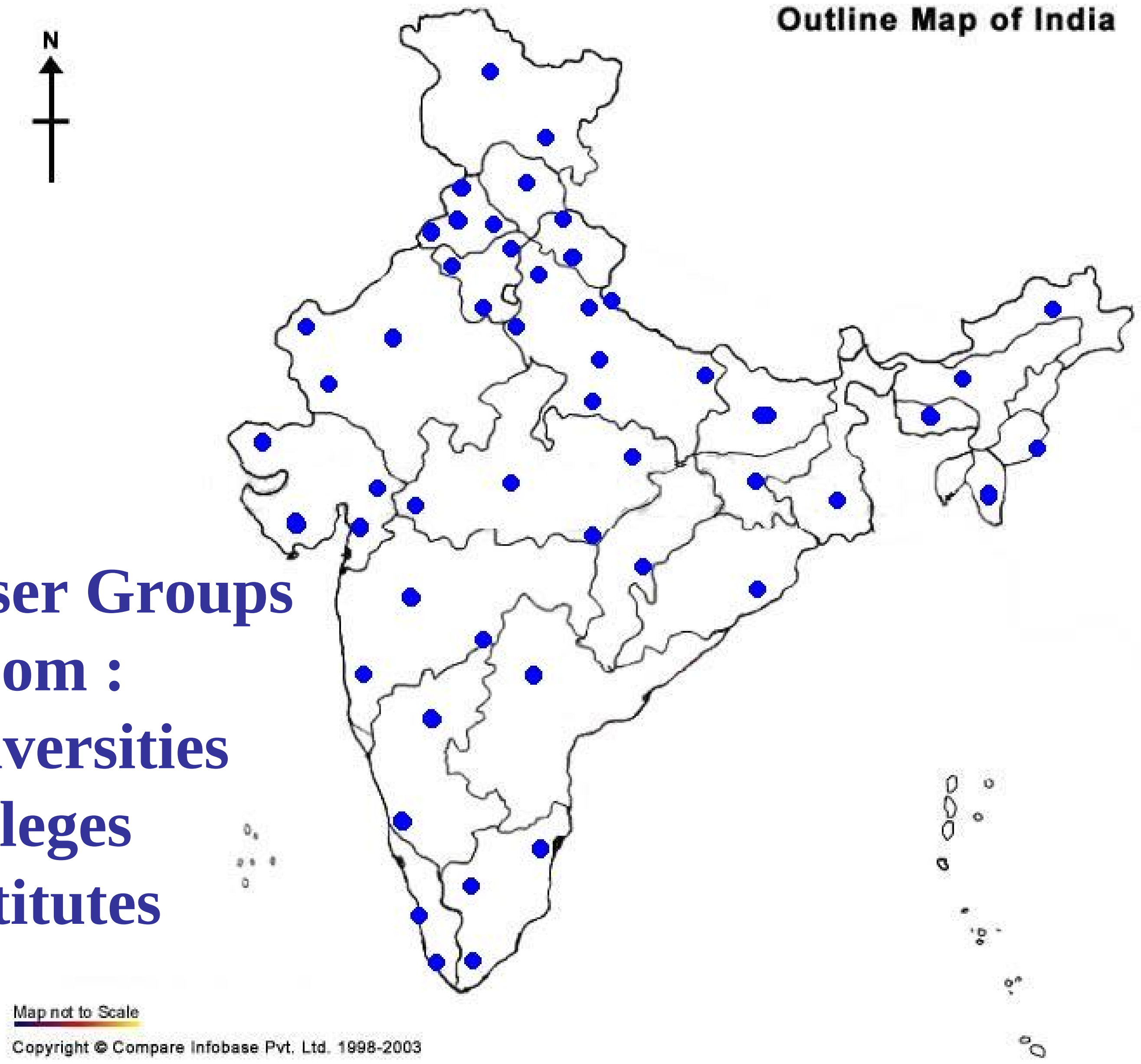
New Delhi 110067

User Community of IUAC



> 300 User Groups from :

76 Universities

44 Colleges

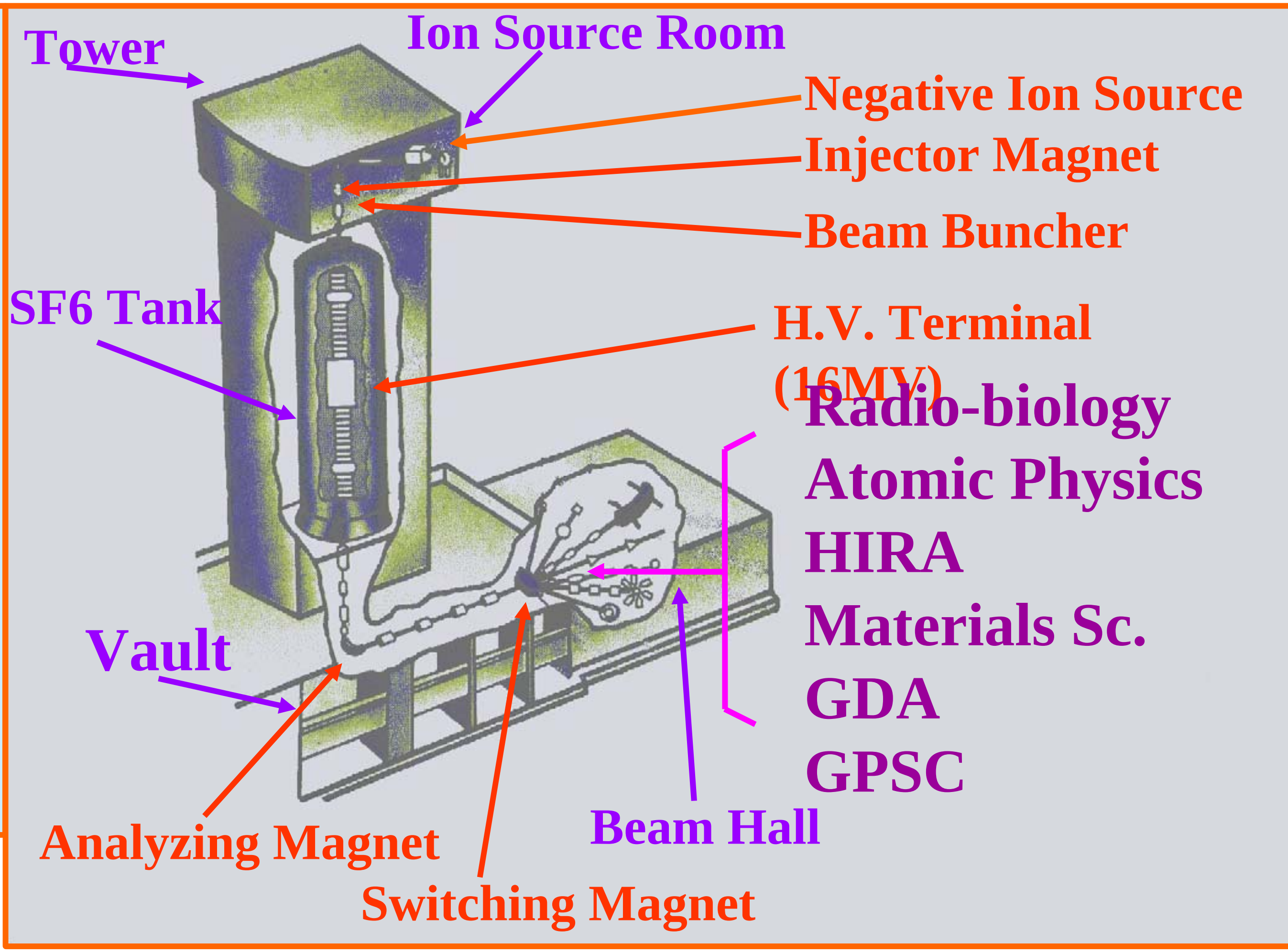
45 Institutes

15UD Pelletron Accelerator at IUAC

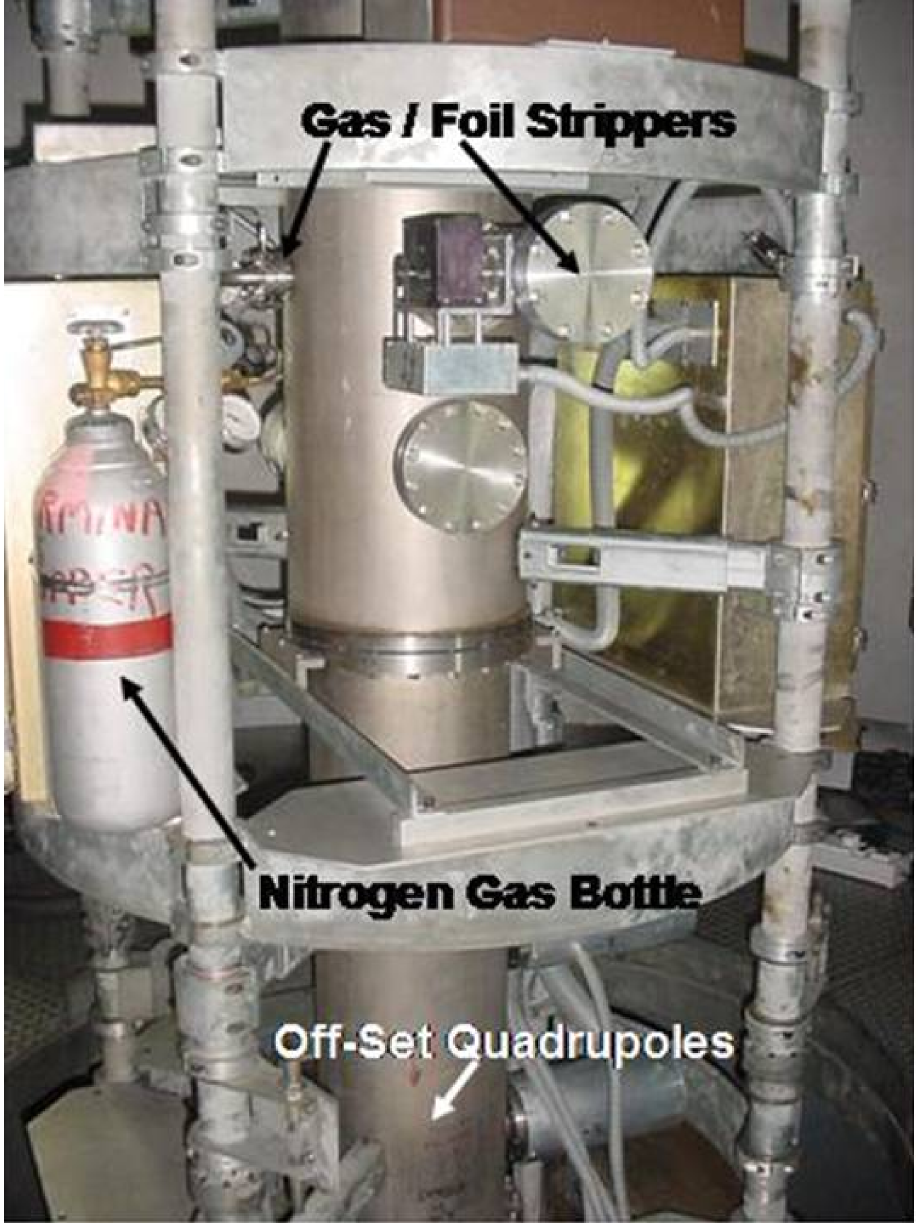
Tank height: 26.5 m
Diameter: 5.5 m
Pressure: 86 PSI
SF_6 gas

Ions accelerated:
H to Au beams

Currents: ~ 1 -50 pnA
Energy : 30 – 270 MeV



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



Off-set quadrupoles after strippers in terminal

D.Kanjilal et al, Nucl. Instr. Meth. A 328 (1993) 97

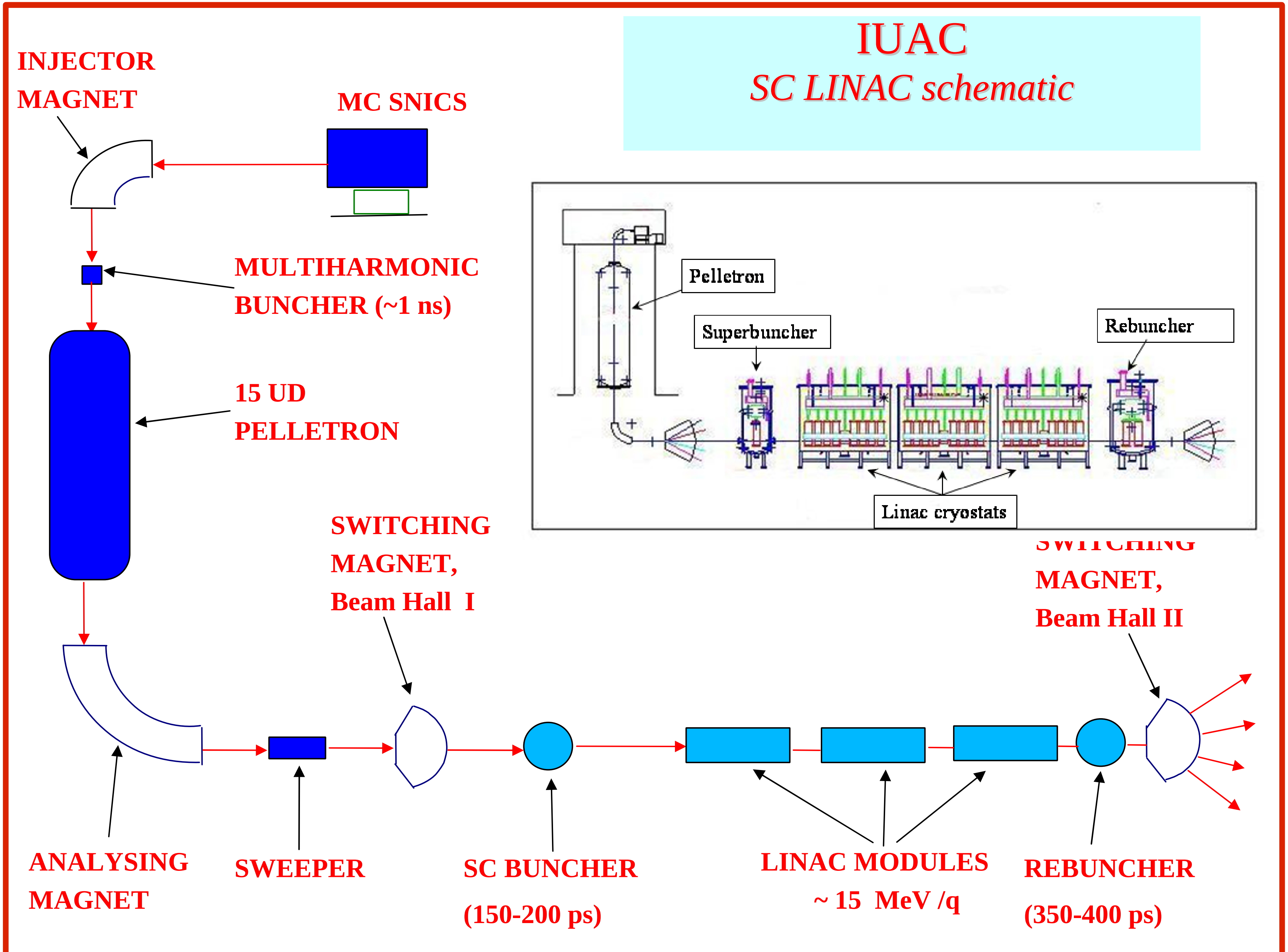
NEW SF_6 CHILLER FOR ACCELERATOR :

- The SF_6 chiller, installed inside Pelletron tank, is meant for cooling SF_6 gas inside the tank during recirculation.

- A new Chiller has been designed, fabricated, tested and installed to replace.

- Water circulates inside tubes with 8 passes .

- The new heat exchanger is installed outside Pelletron tank.

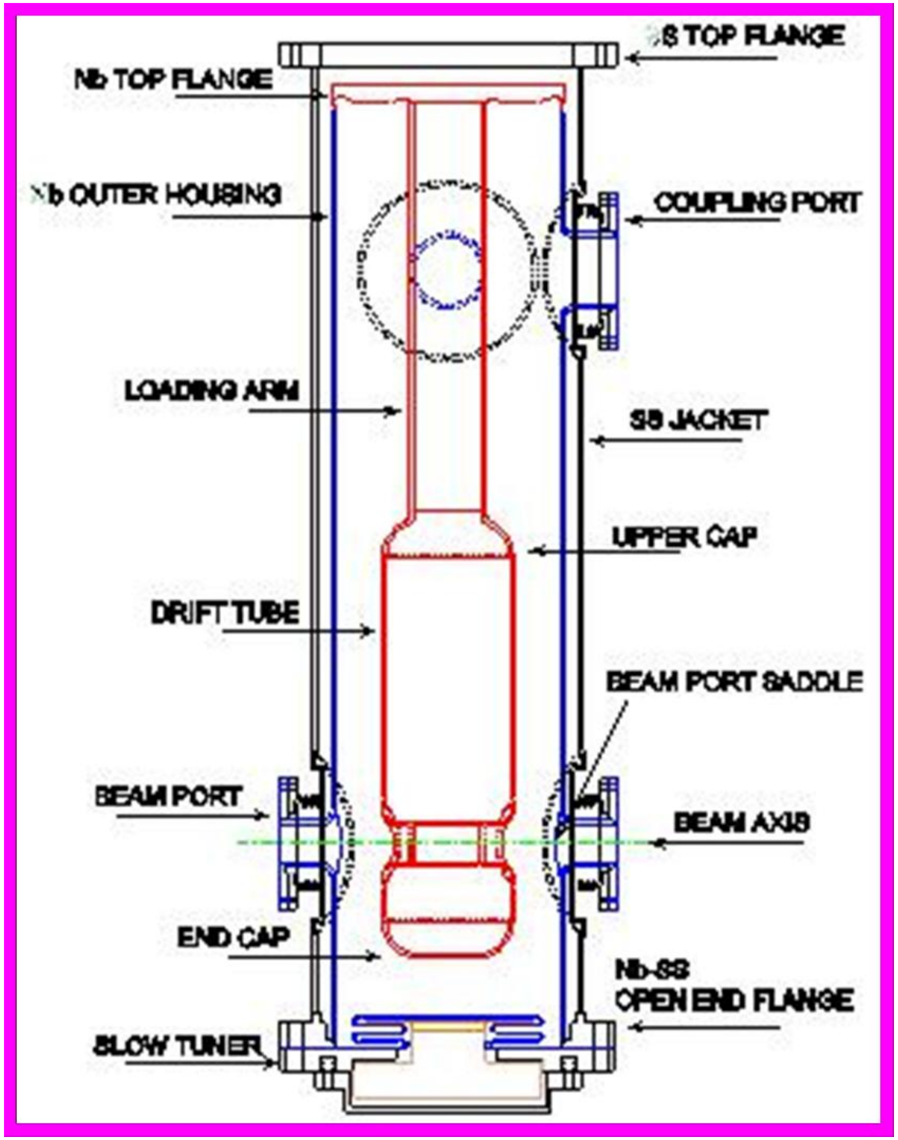

IUAC
SC LINAC schematic
INJECTOR MAGNET
MC SNICS
MULTIHARMONIC BUNCHER (~1 ns)
15 UD PELLETRON
Pelletron
Superbuncher
Rebuncher
Linac cryostats
SWITCHING MAGNET, Beam Hall I
MAGNET, Beam Hall II
ANALYSING MAGNET
SWEEPER
SC BUNCHER (150-200 ps)
LINAC MODULES ~ 15 MeV /q
REBUNCHER (350-400 ps)

IUAC

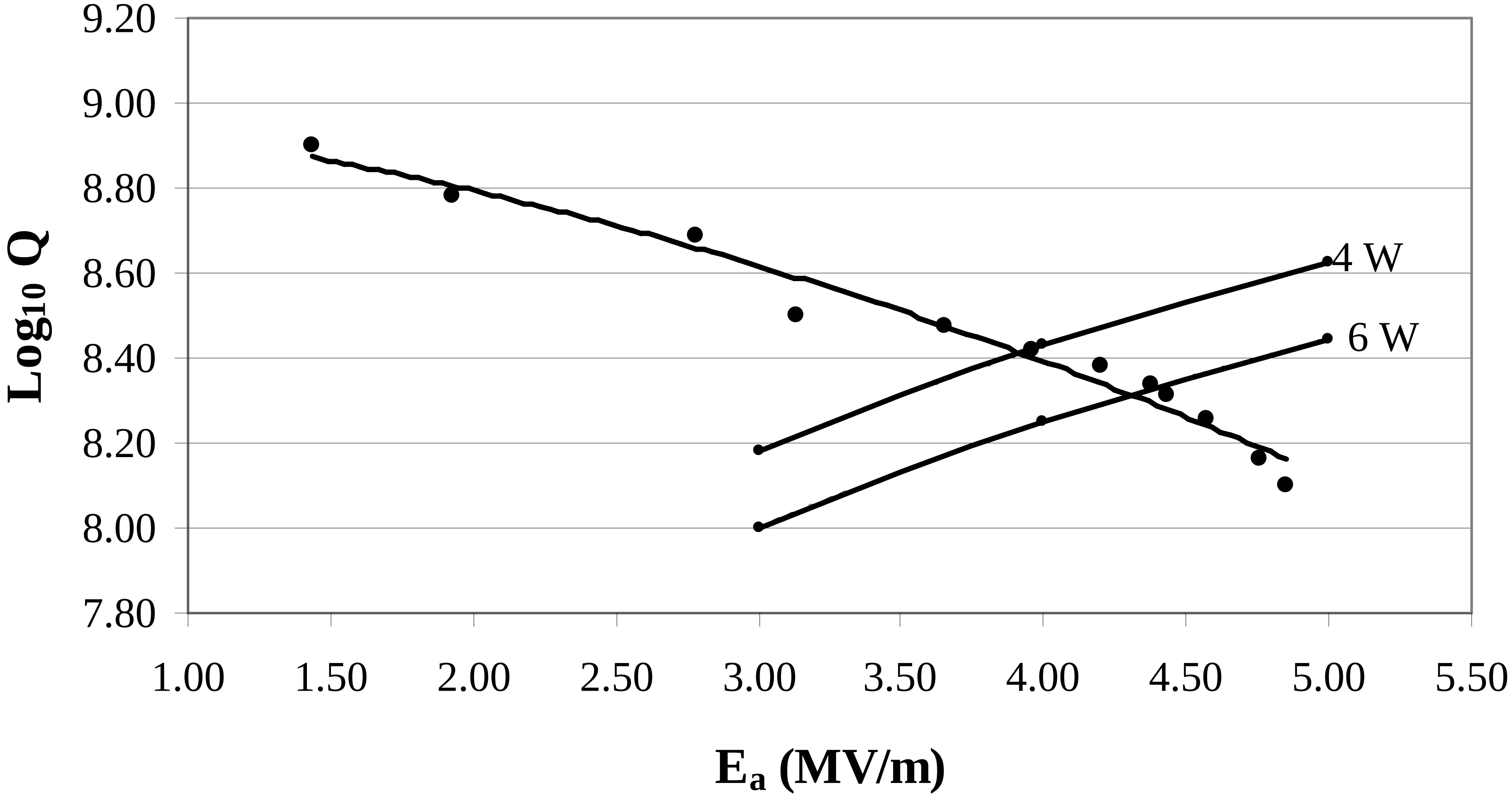
Proposed capacitance-loaded QWR resonator

Work started in early 90s. ANL Collaboration started in 1992.

IUAC Quarter Wave Resonator (QWR)



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



Performance of one of the indigenously built QWRs at 4.5 K

Electron Beam welding facility

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

Before welding using EBW

Surface Preparation Laboratory

Acid Fume Hood

High Pressure rinsing system

- EP
- High pres. rinsing
- Assembly in a clean room

In-House Fabrication of Resonator

High Vacuum Furnace

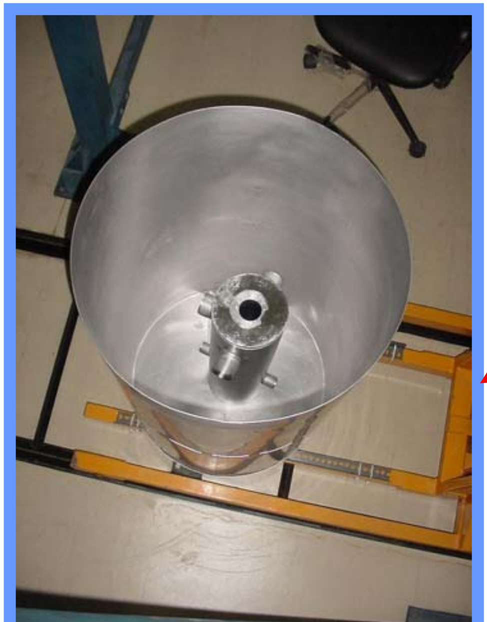
Max Temp. 1200 C
@ 5.0 x 10^{-7} torr

Hot Zone –
ϕ600mm x 1000mm

Indigenous Resonator Fabrication

Parts of central conductor

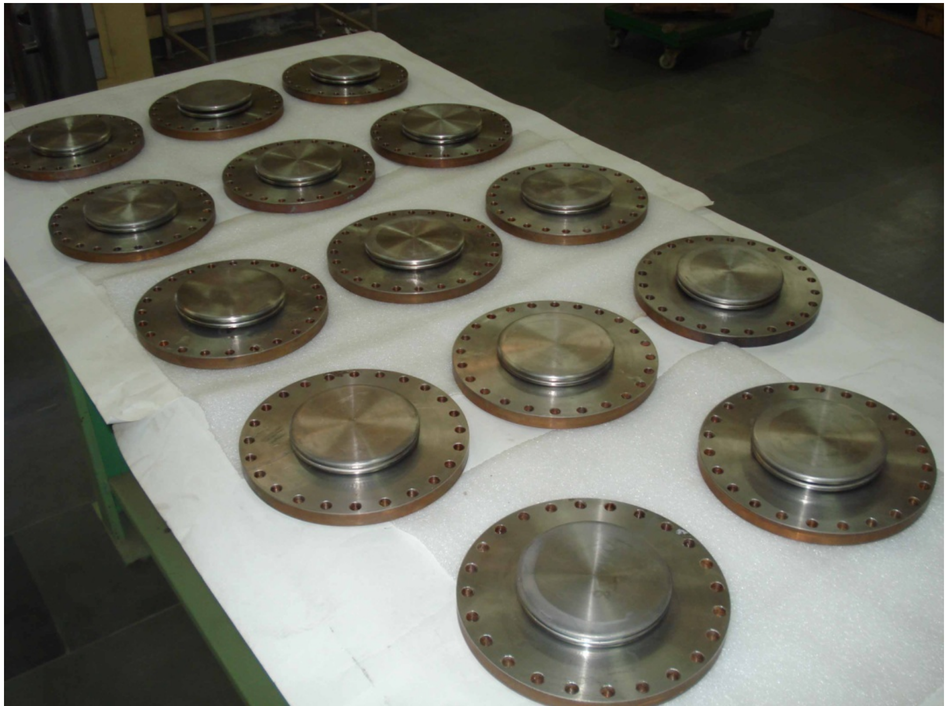
Central conductor and housing



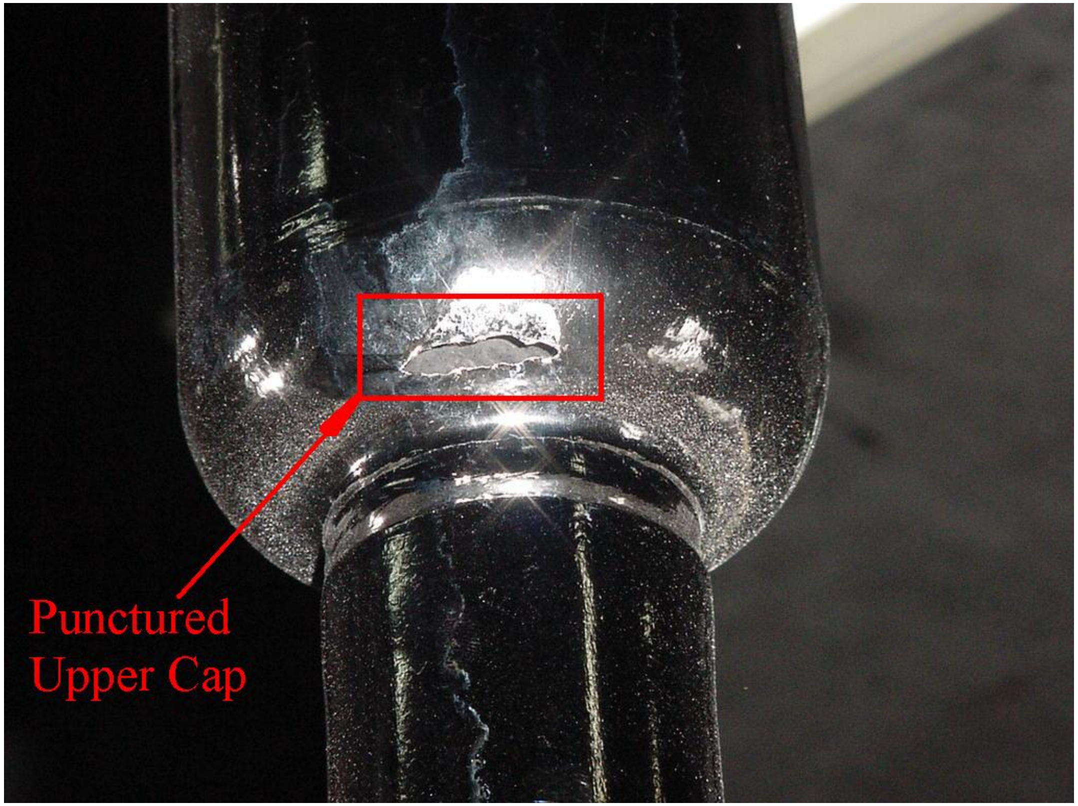
Resonator inside Nb getter box before annealing

Resonator & SS-jacket Before welding

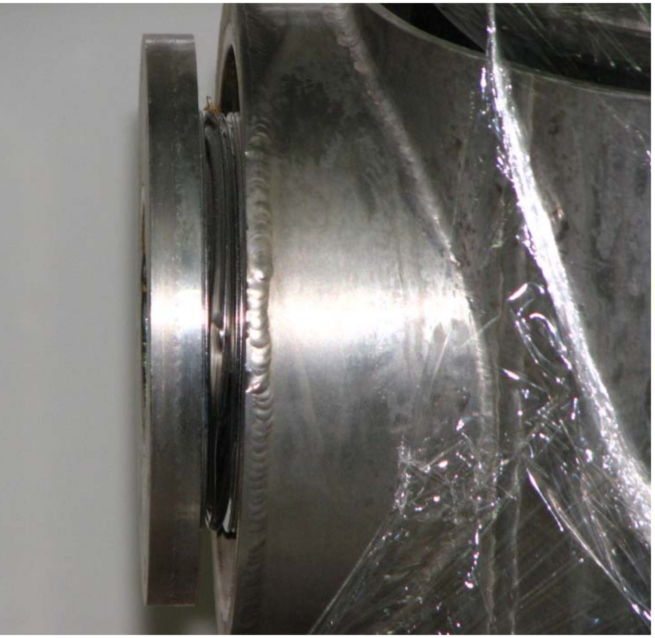
Bare niobium QWRs ready for the outer stainless steel jacketing

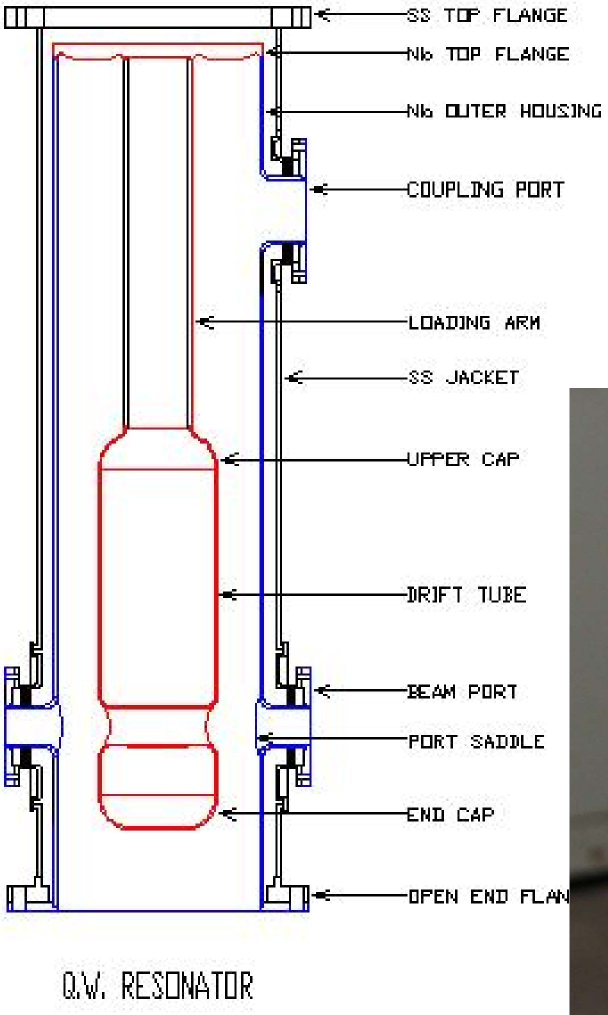


Niobium Slow tuner bellows



Punctured upper cap on the central conductor of the coaxial line.

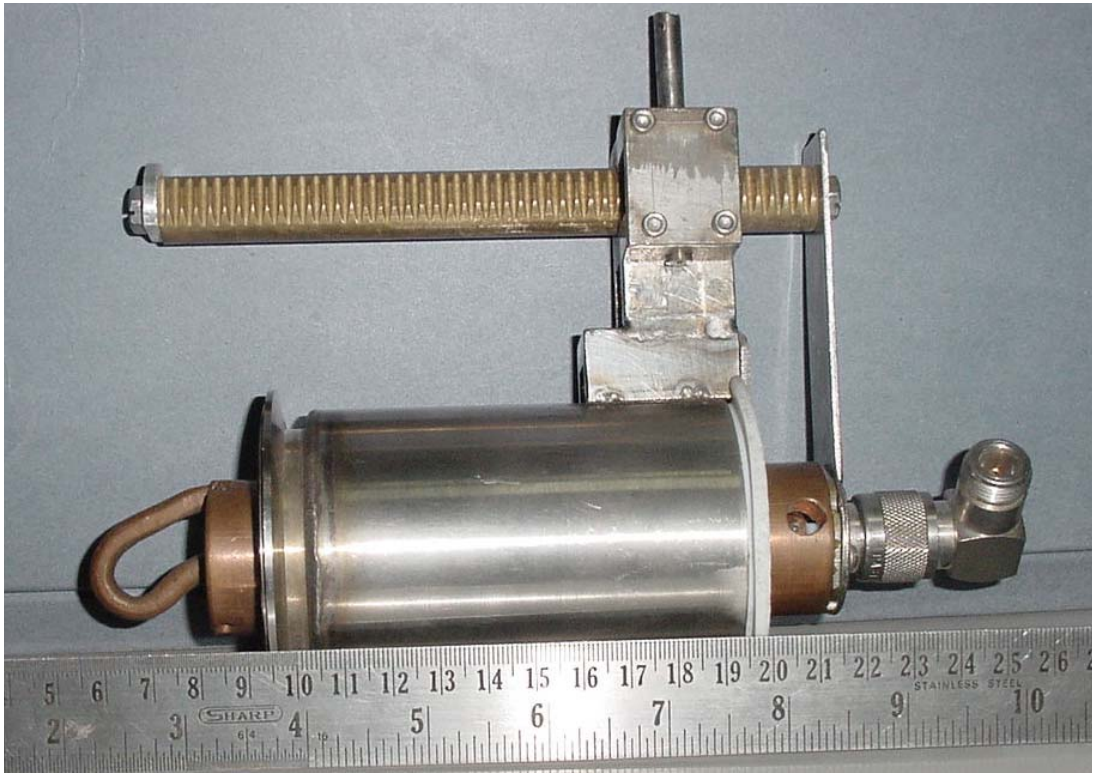




Transition Flanges: Welded bellows replaced by formed bellows

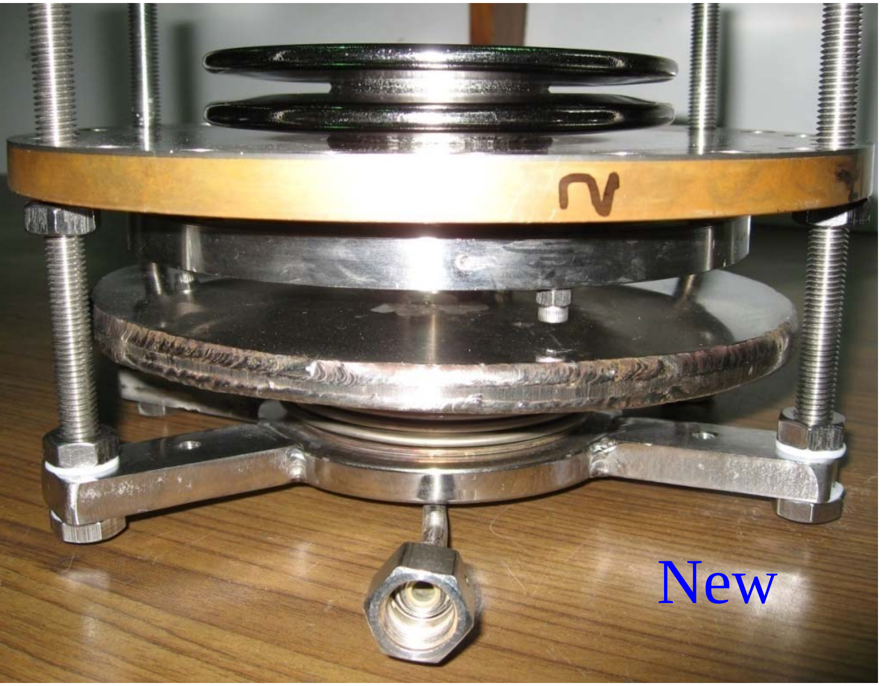
Old and new Coupler

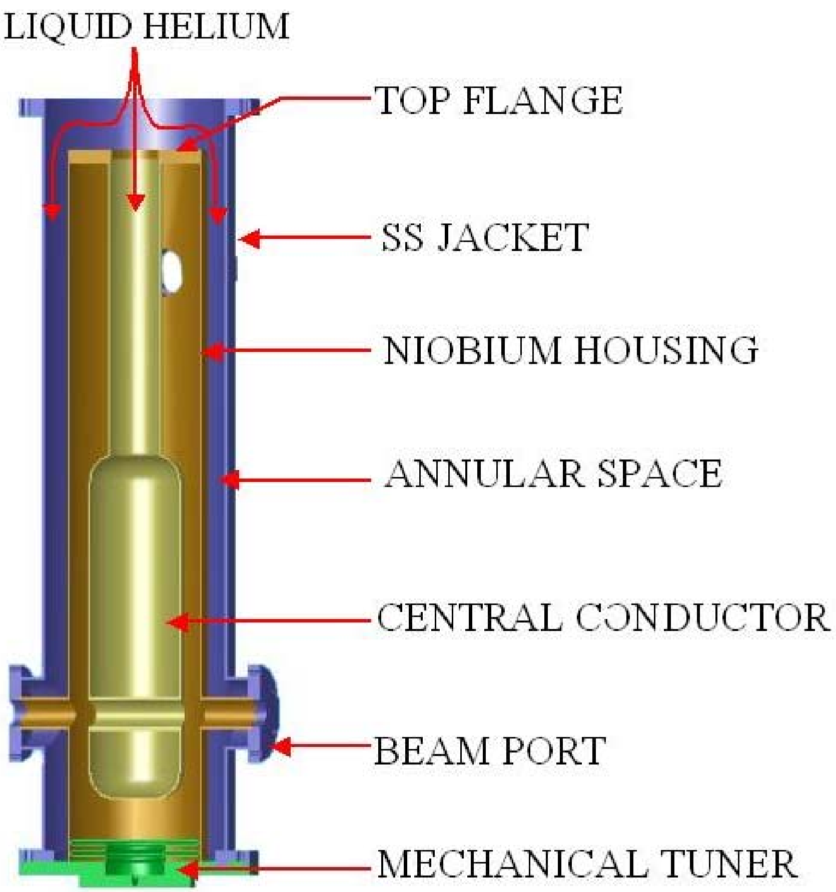
Old



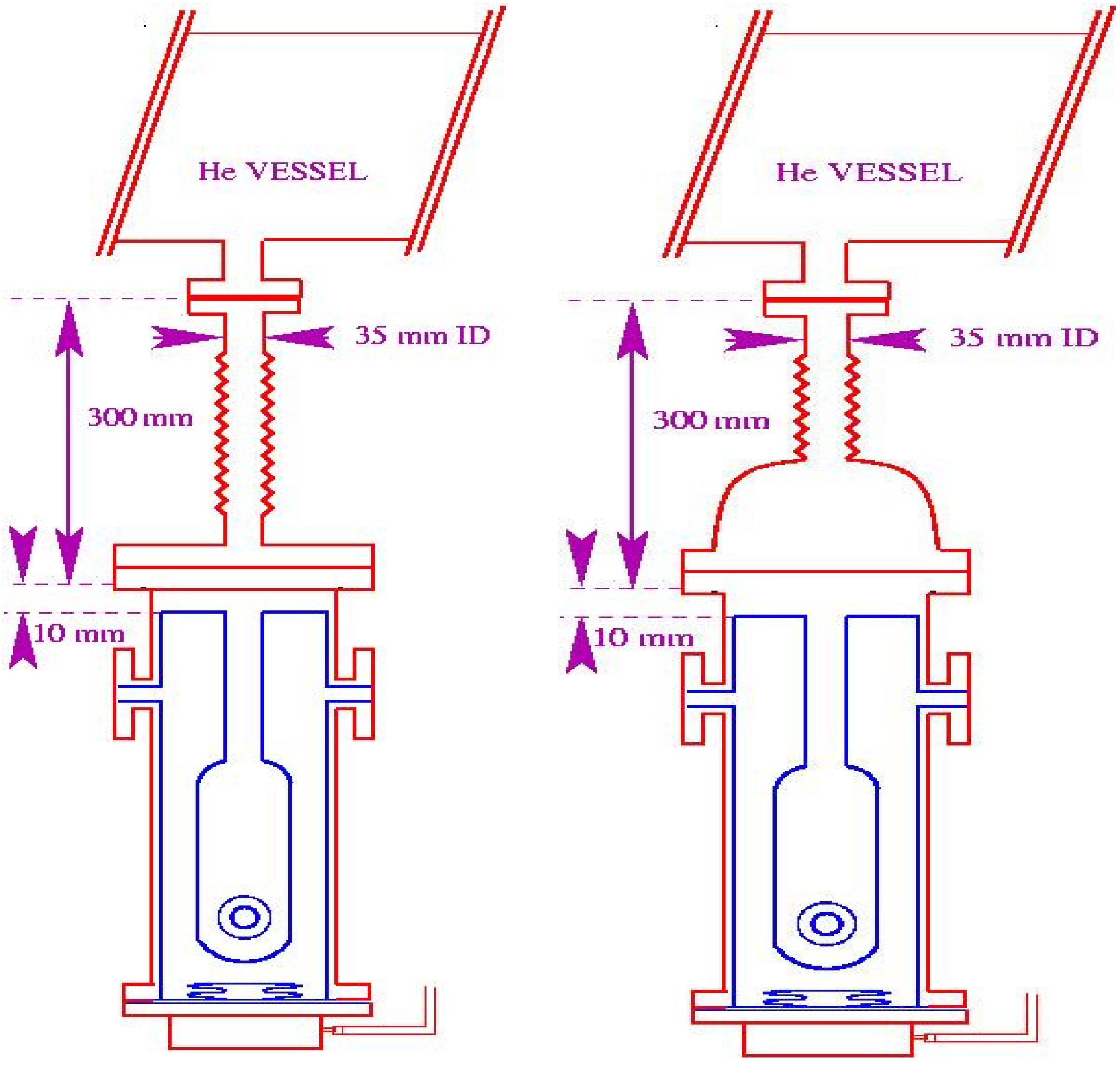
New

Old and new slow tuners

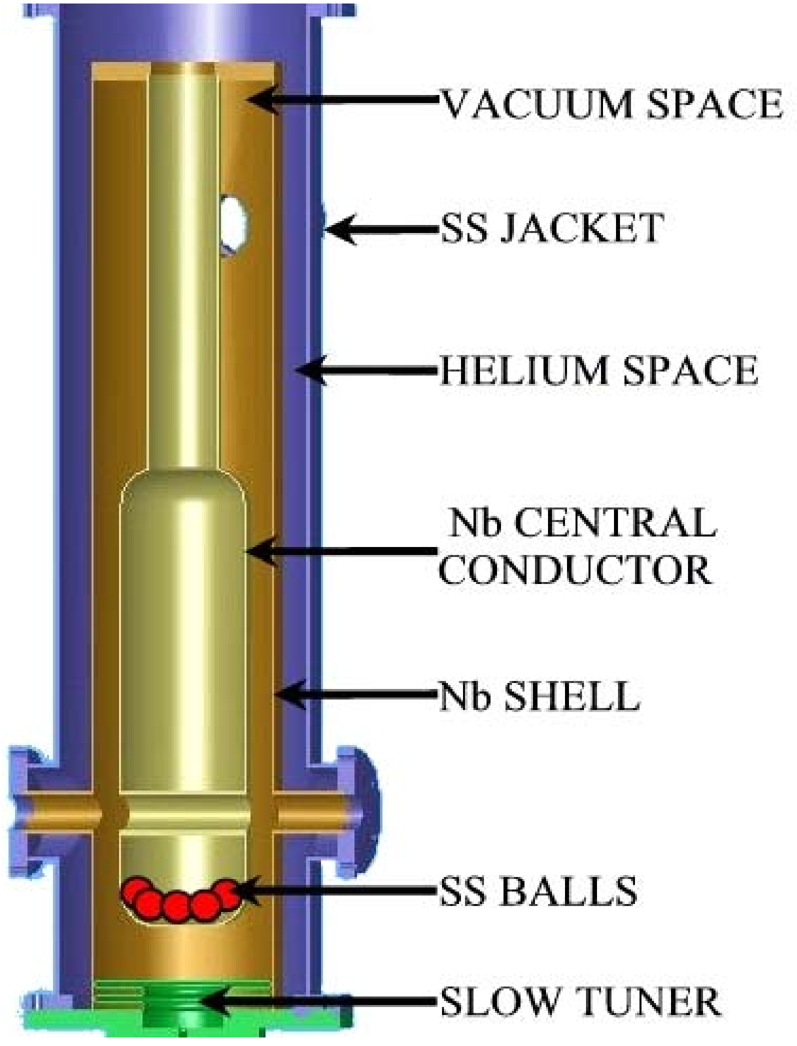




Schematic of old top flange & new dome (HAT) on top of QWR

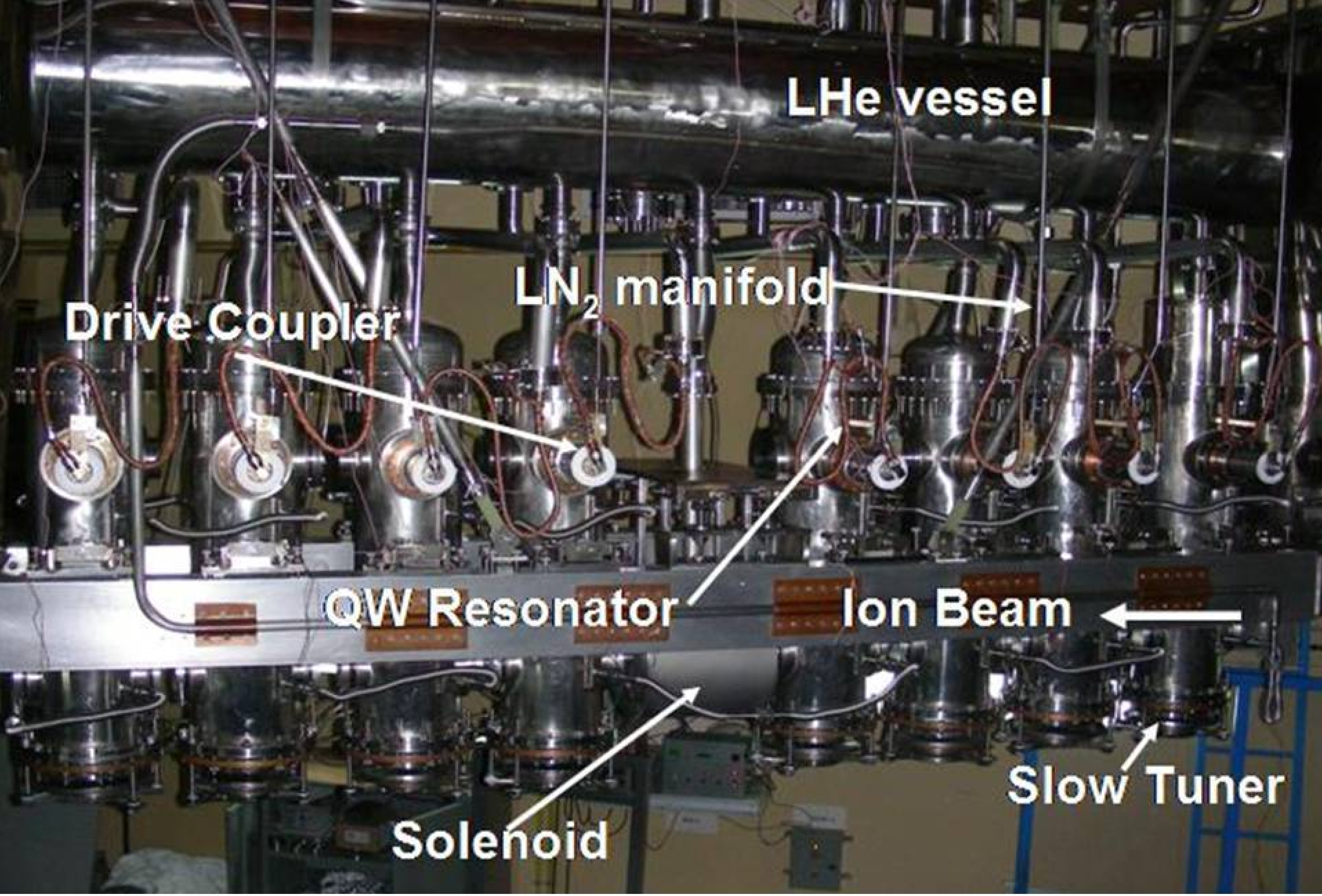


Damping of Micro-harmonics

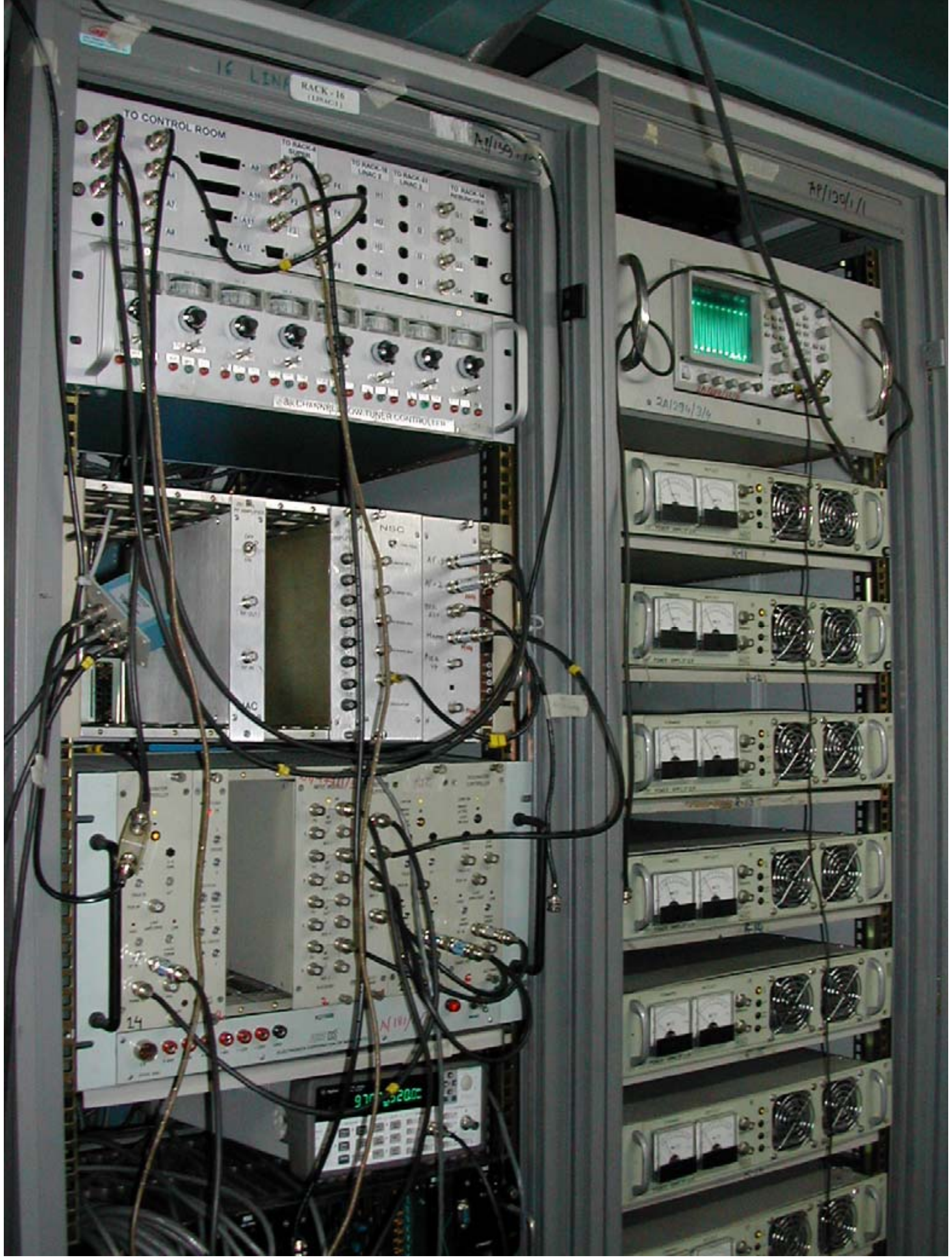


Cross-sectional view of a resonator along with SS-balls used for damping

S. Ghosh et al, Phys. Rev. ST Accel. Beams 10, (2007) 42002

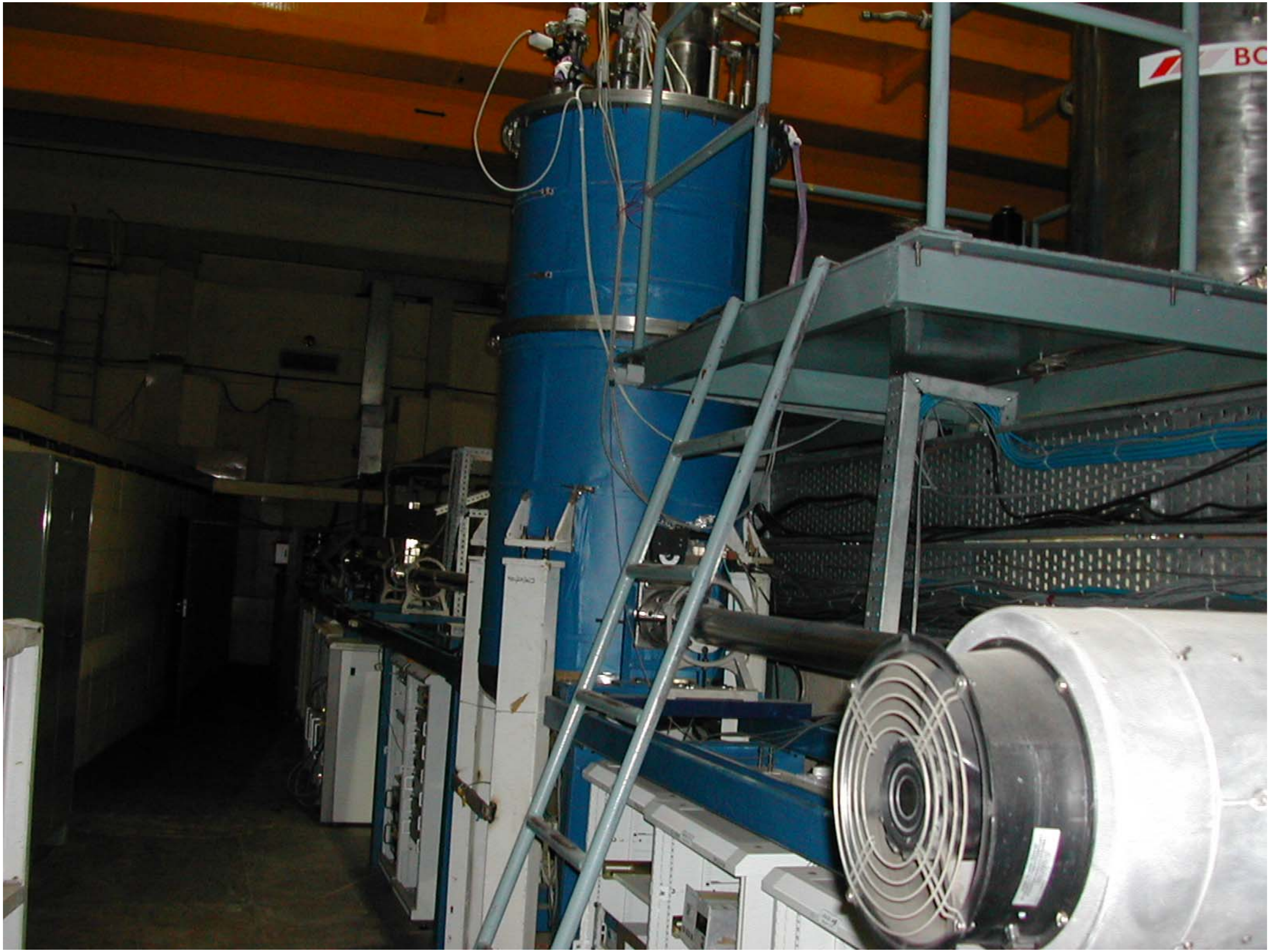


Eight QWRs, SC Solenoid, etc of the first Linac module



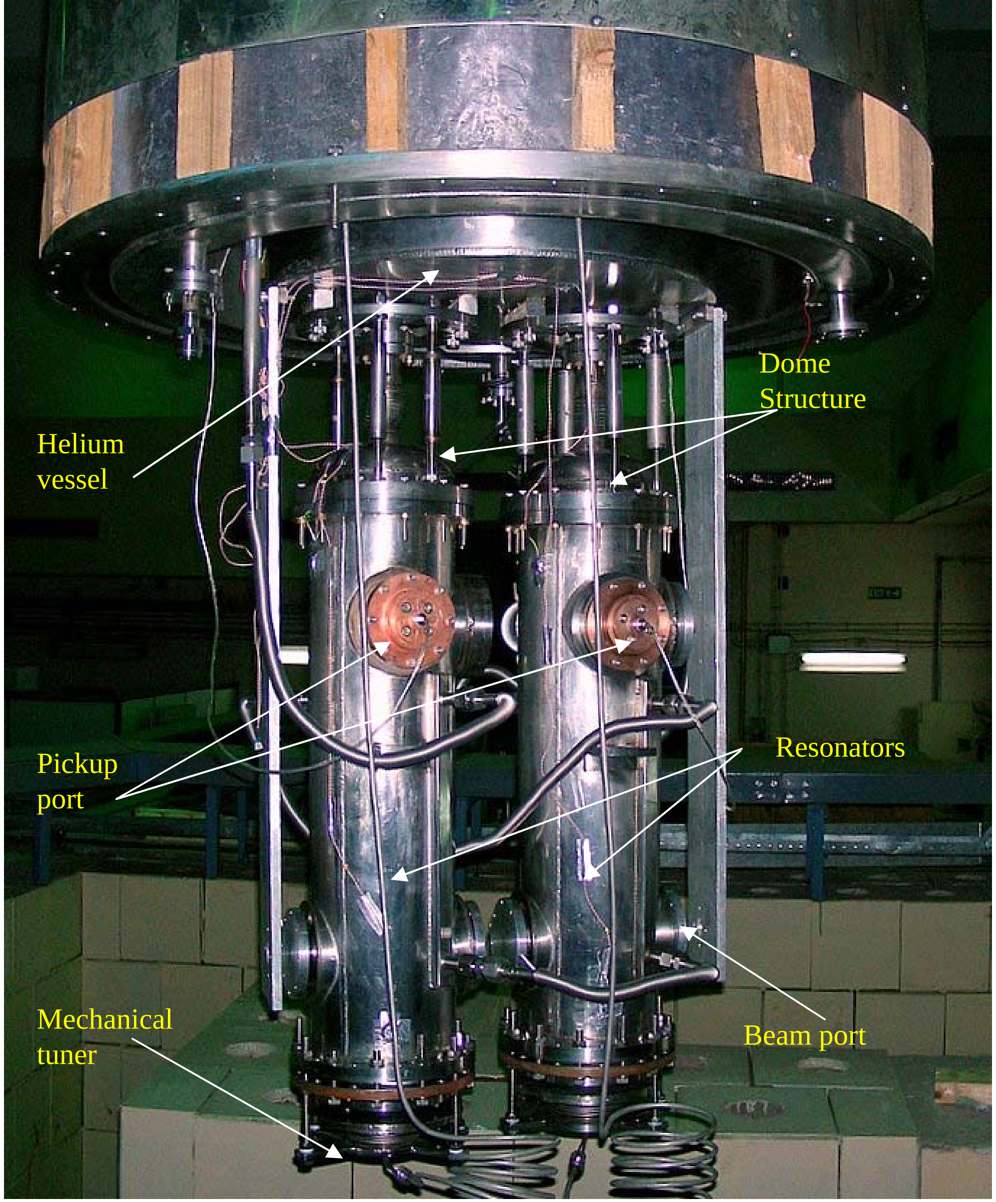
RF Amplifier and Control system

Power supplies for beam transport systems



Superbuncher in the beam line (FWHM~170 ps)

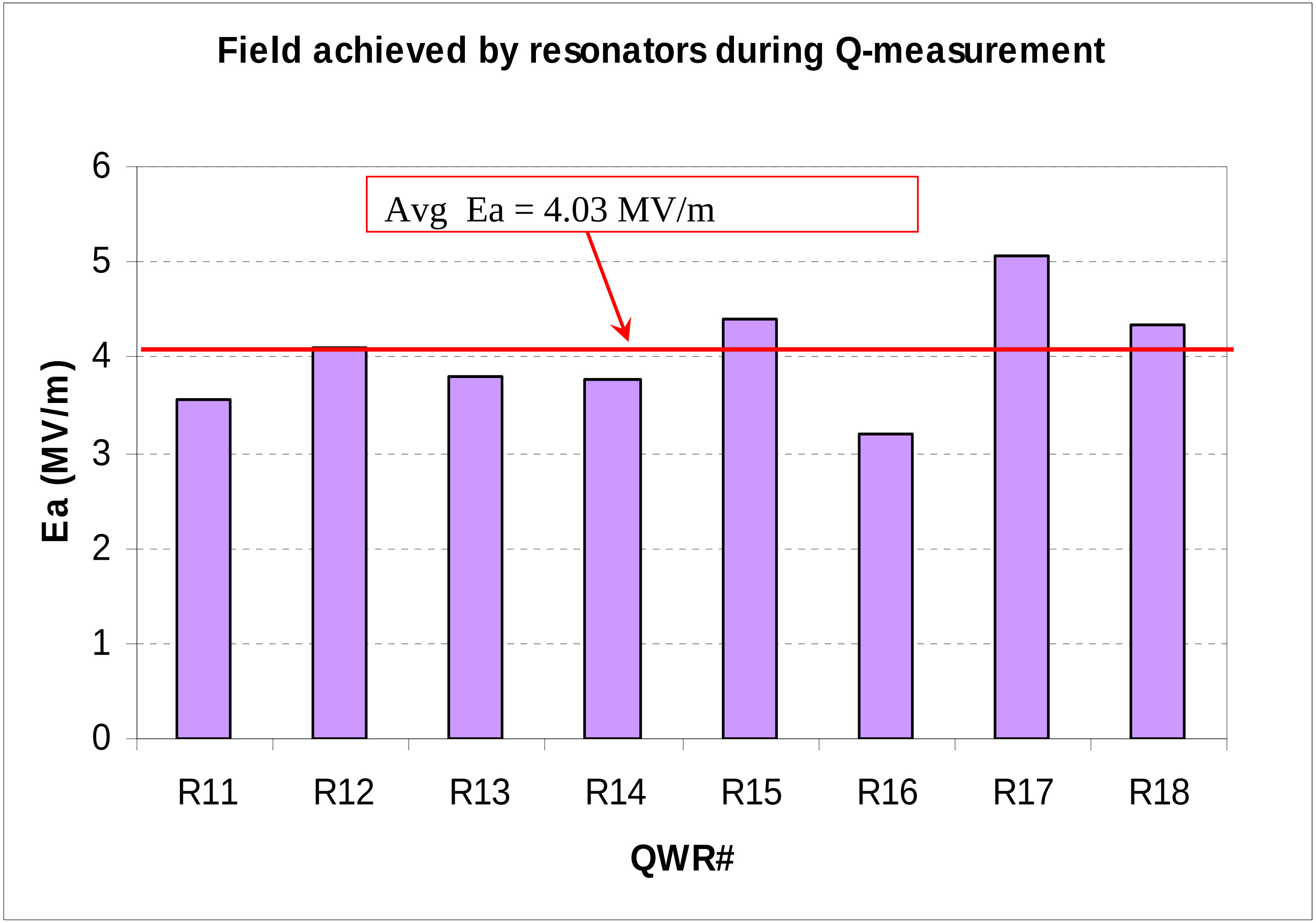
LINAC Module ready for delivering beams



Rebuncher having two QWRs (350-400 ps)

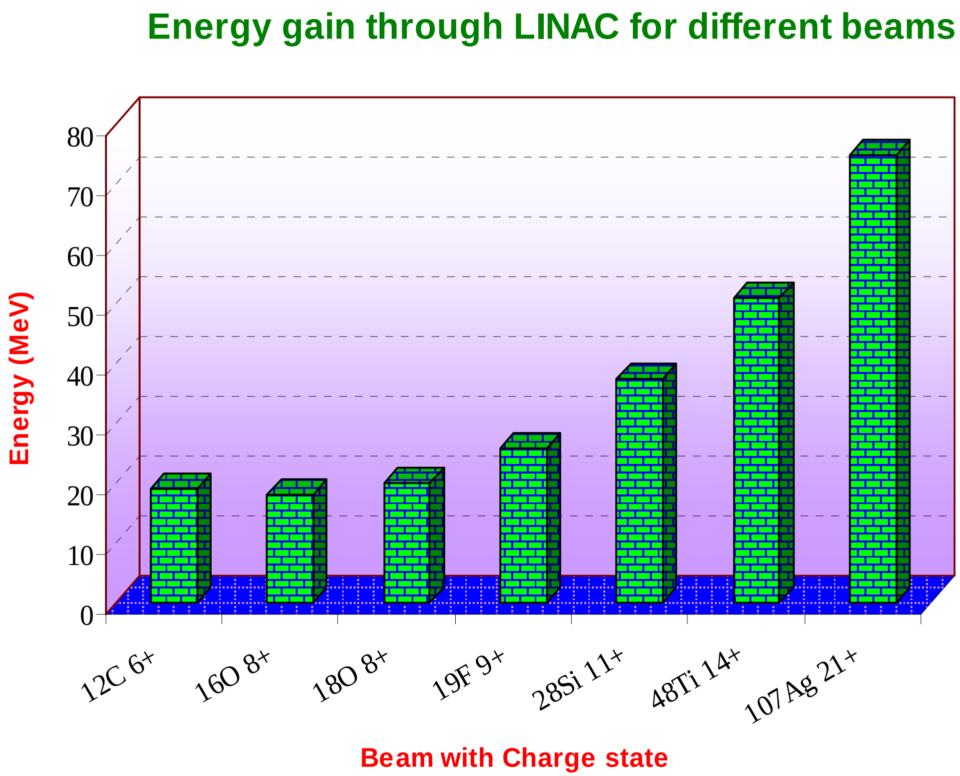
S. Ghosh et al, Phys. Rev. ST Accel. Beams,12, Phys. Rev. ST Accel. Beams **12**, (2009) 40101

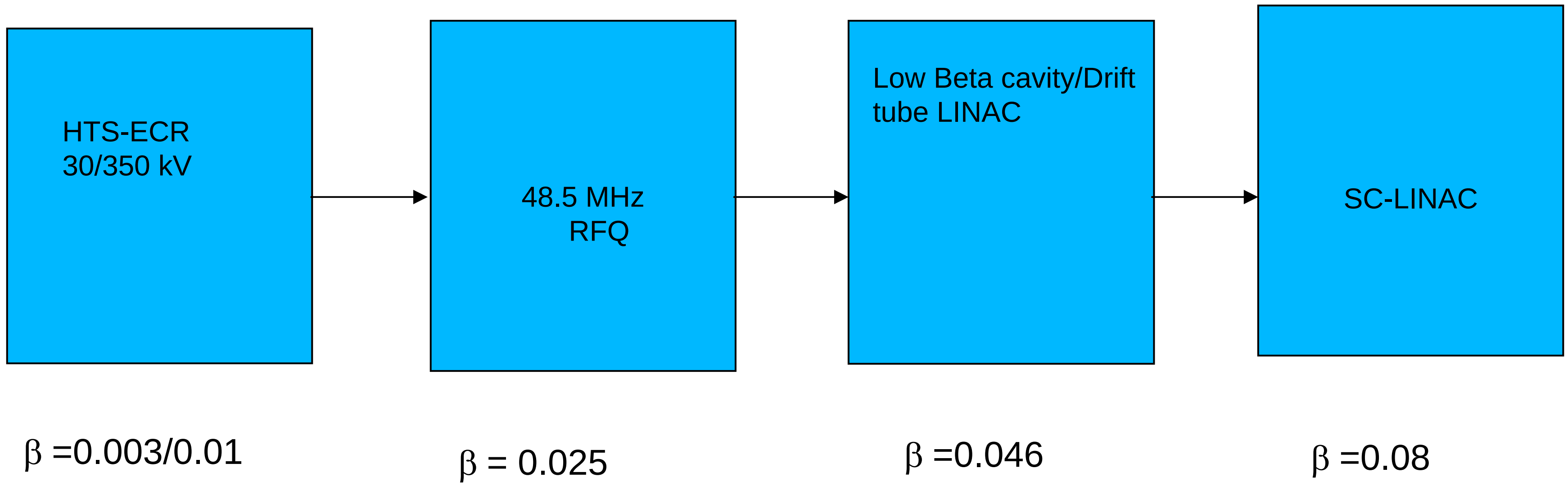
LINAC Beam Run, April-May '09



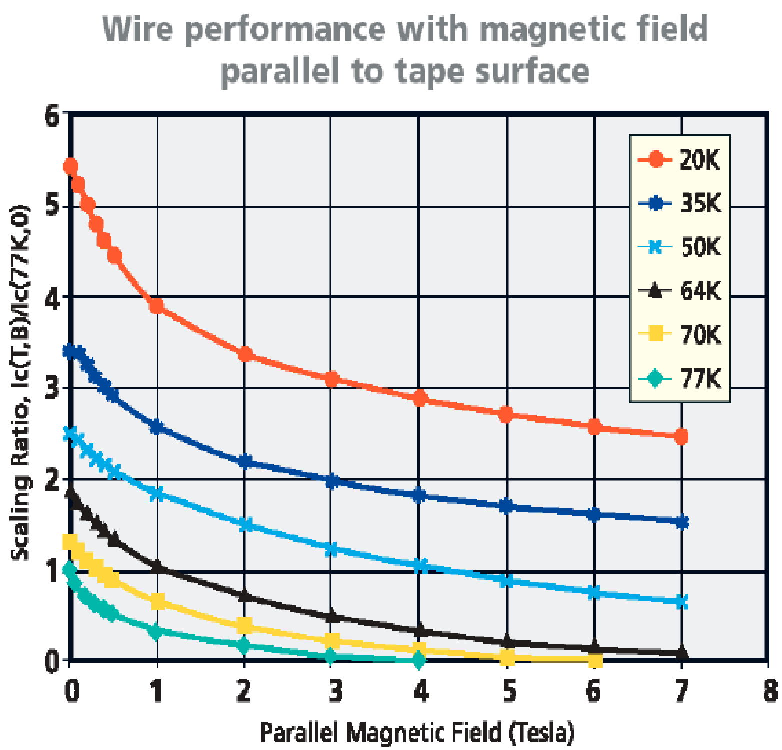
LINAC Beam Run, April-May '09

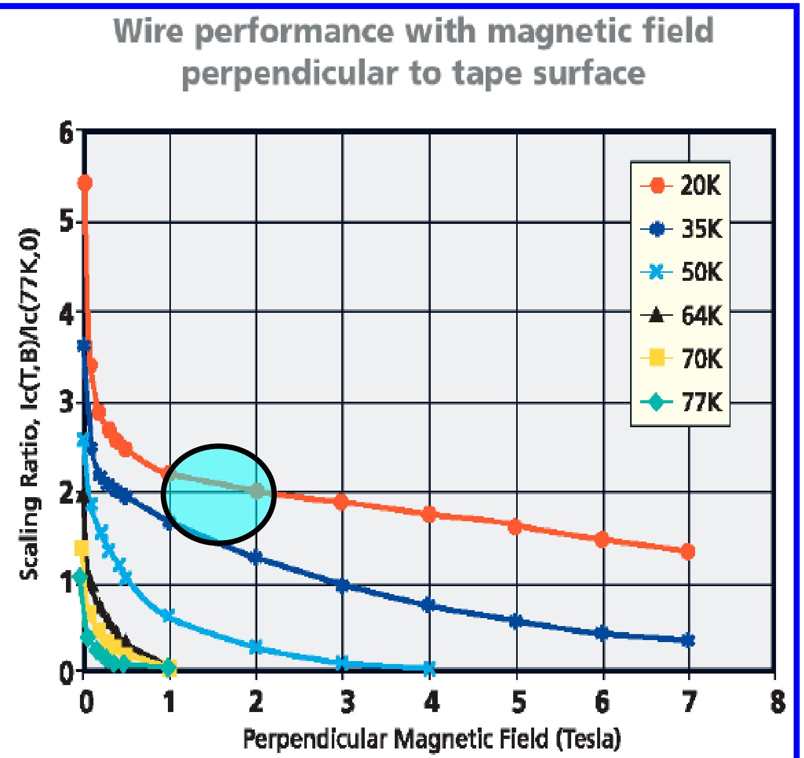
Beam	Energy from Pelletron (MeV)	Energy from LINAC(MeV)	Total Energy (MeV)
12 C, 6+	87	19.2	106.2
16 O, 8+	100	20.02	120
		18	118
		10.25	110.25
18 O, 8+	100	20.026	120
		16	116
		12.25	112.25
		8	108
19 F, 9+	115	25.8	140.8
		22.2	137.8
28 Si, 11+	130	37.5	167.5
48 Ti, 14+	162	51	213
		36	198
107 Ag, 21+	225	75	300





Schematic of the proposed high current injector





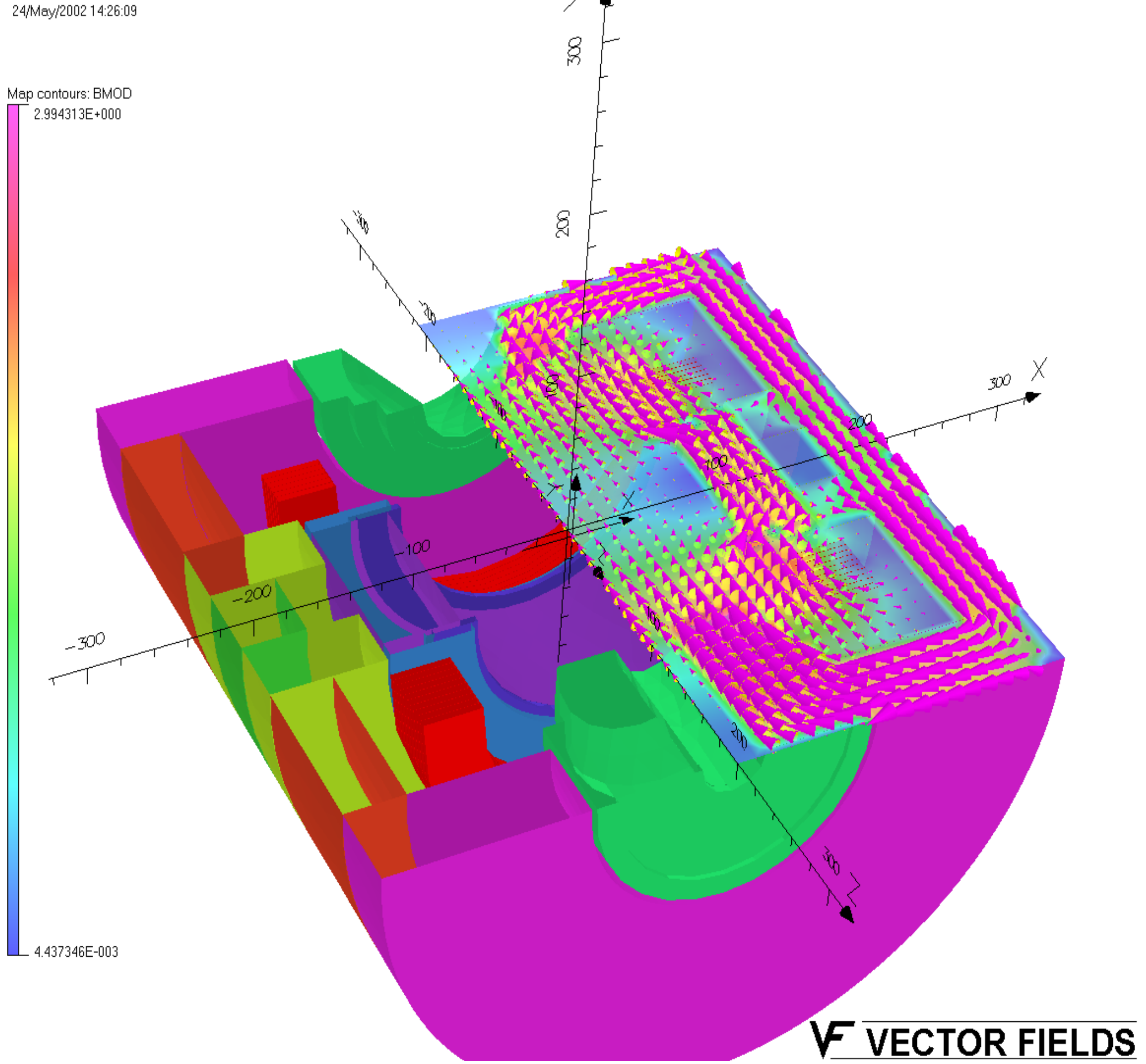
American Superconductor
REVOLUTIONIZING THE WAY THE WORLD USES ELECTRICITY

Current carrying capacity of HTS depends on:

- Temperature
- Magnitude of the field

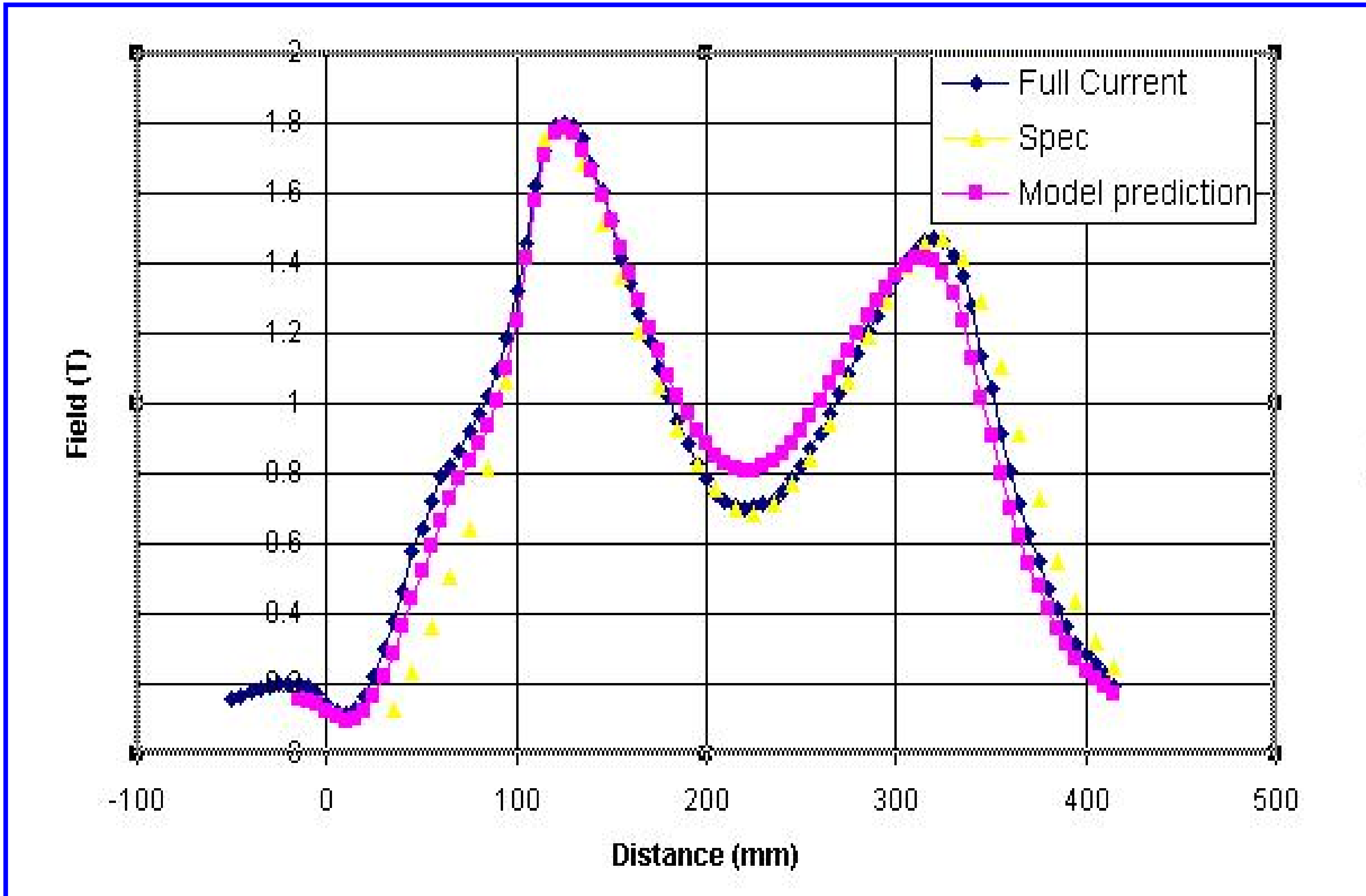
and also on the direction of the field

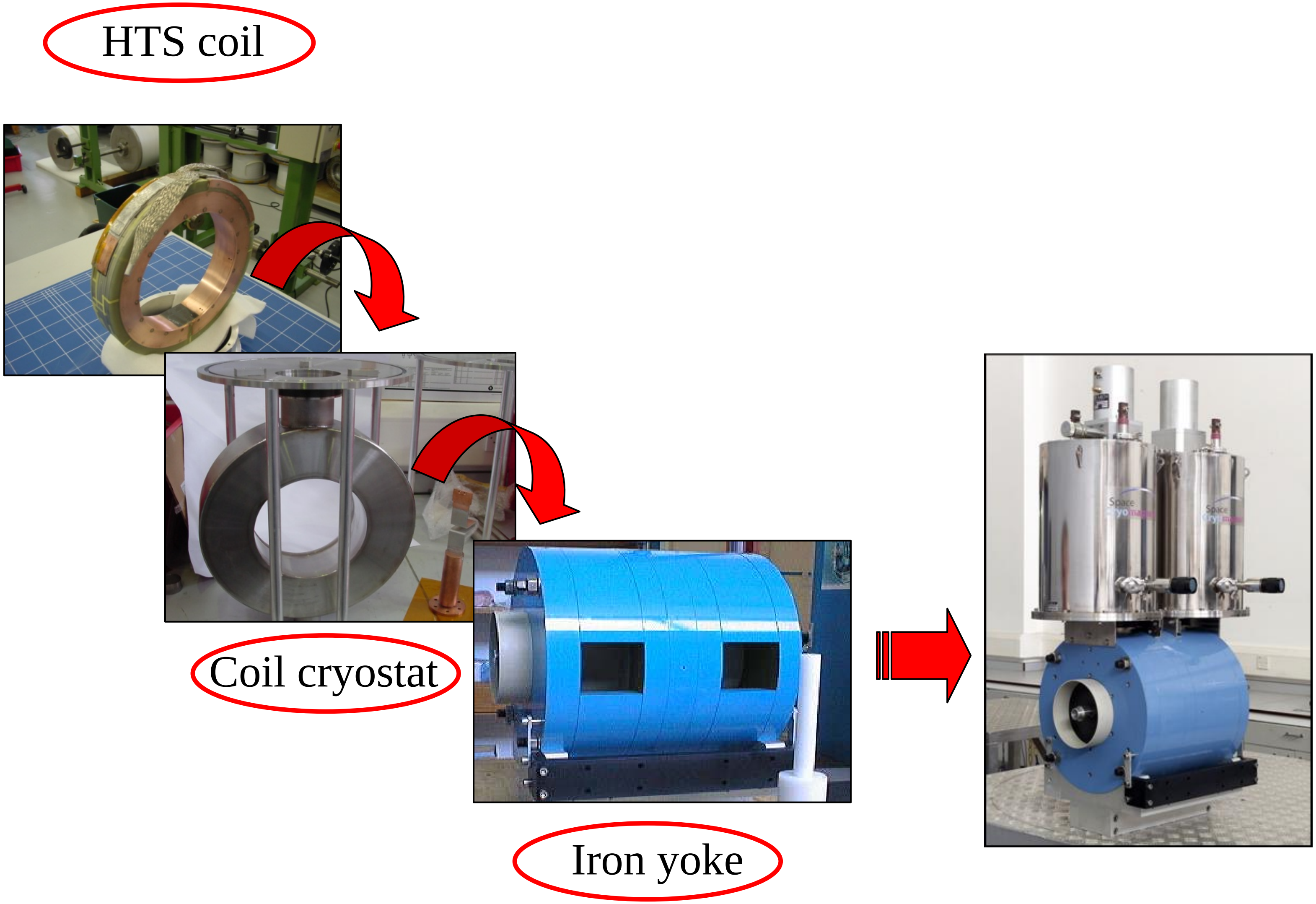
Maximum operating current	181 A
Maximum radial field	1.4 T
I_c @ 77 K,0B	110 A



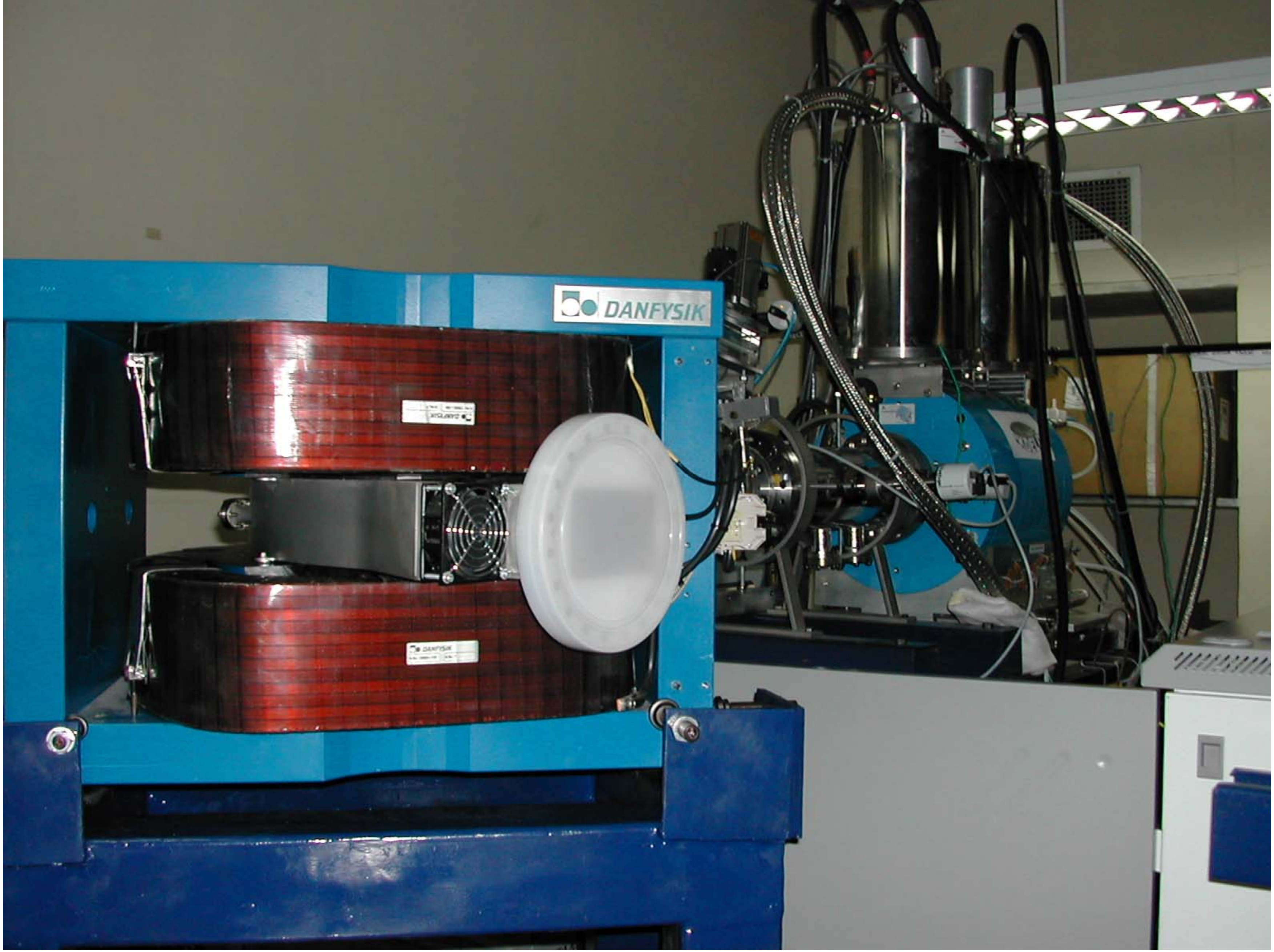
Field vectors on the yoke cross section

Axial field measurements





D. Kanjilal et al, Rev. Sci. Instr. 77 (2005)1



HTS- ECRIS PKDELIS with large pole-gap (80mm) Analyzing magnet (air-cooled)

Beam	Q	Quoted Current	Obtained Current
12 C	2	2 mA	2.280 mA
16 O	2	2 mA	2.006 mA
20 Ne	2	2 mA	2.111 mA
20 Ne	3	1 mA	1.533 mA
40 Ar	4	1 mA	1.023 mA
40 Ar	8	600 μA	725 μA
129 Xe	14	150 μA	157 μA
129 Xe	21	20 μA	27 μA
180 Ta	20	30μA	65 μA
180 Ta	25	25 μA	26 μA
197 Au	21	15 μA	28 μA
197 Au	28	10 μA	19 μA
208 Pb	21	15 μA	66 μA
208 Pb	28	12 μA	18 μA

Ar^{+8} @ 14.5 GHz = 540 μA
Ar^{+8} @ 18 GHz = 725 μA

&

Ar^{+8} (405 μA) @ 765 W
Ar^{+8} (317 μA) @ 331W

D. Kanjilal et al, Rev. Sci. Instr. 77

HYPERNANOGAN → PKDELIS

B_{axial}= 1.3 T

B_{radial} = 1.2 T

Max required power = **200 kW**

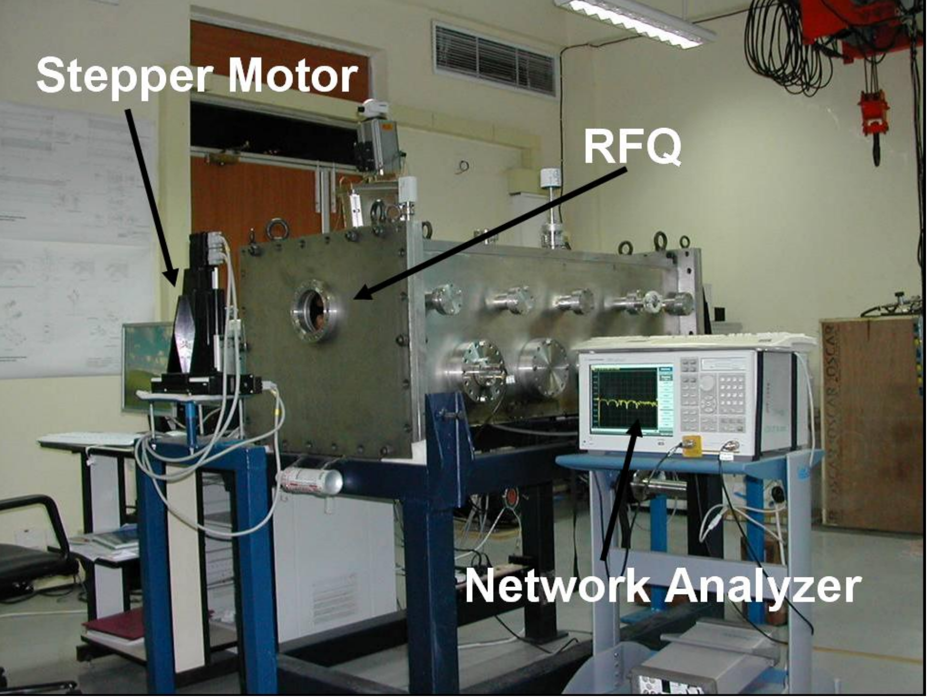
Water cooling = **6800 l/h**

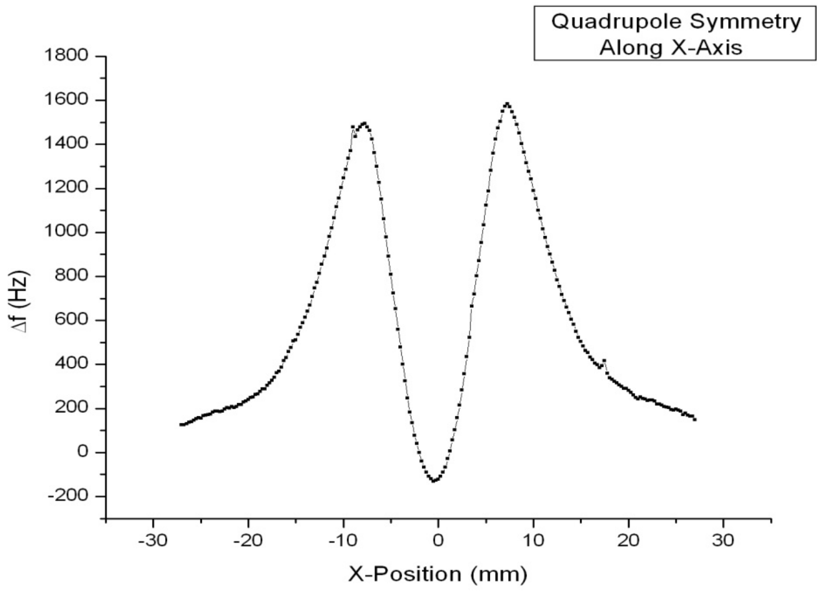
B_{axial}= 1.8 T

B_{radial} = 1.37 T

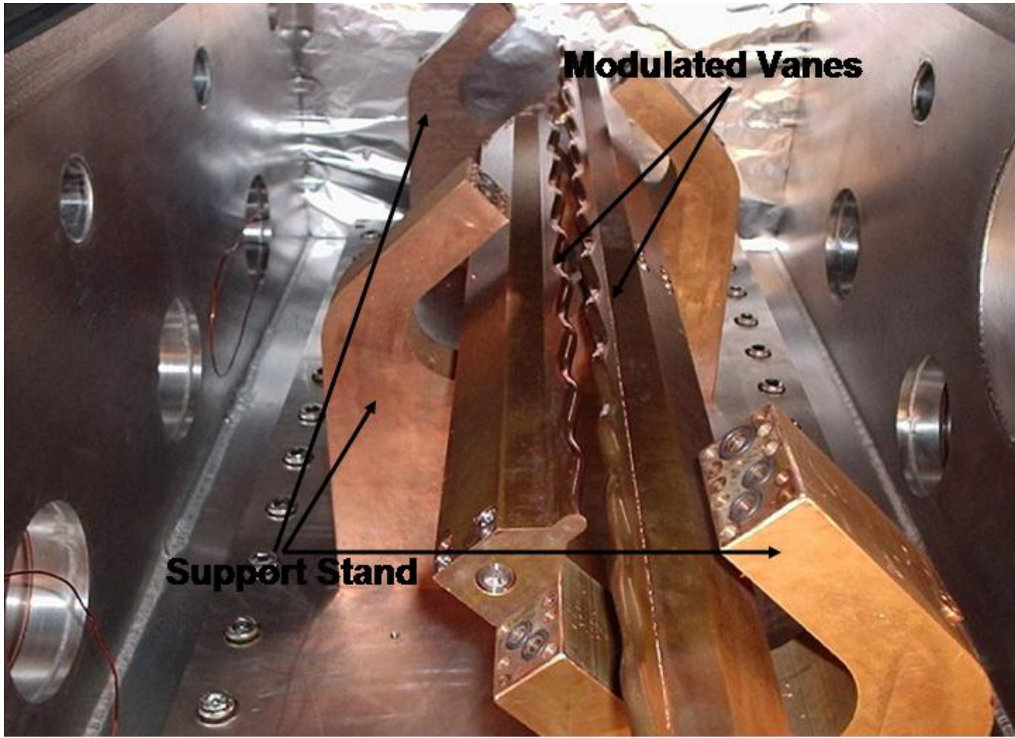
Max required power = **20 kW !**

Water cooling **200 l/h !**



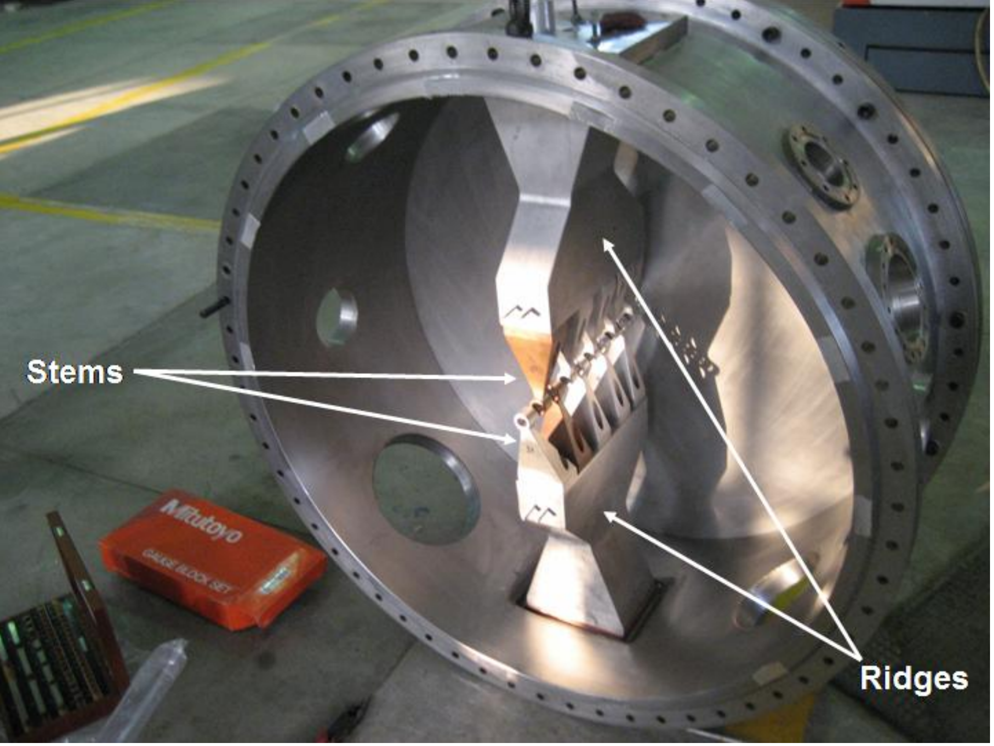


Bead pull test of RFQ

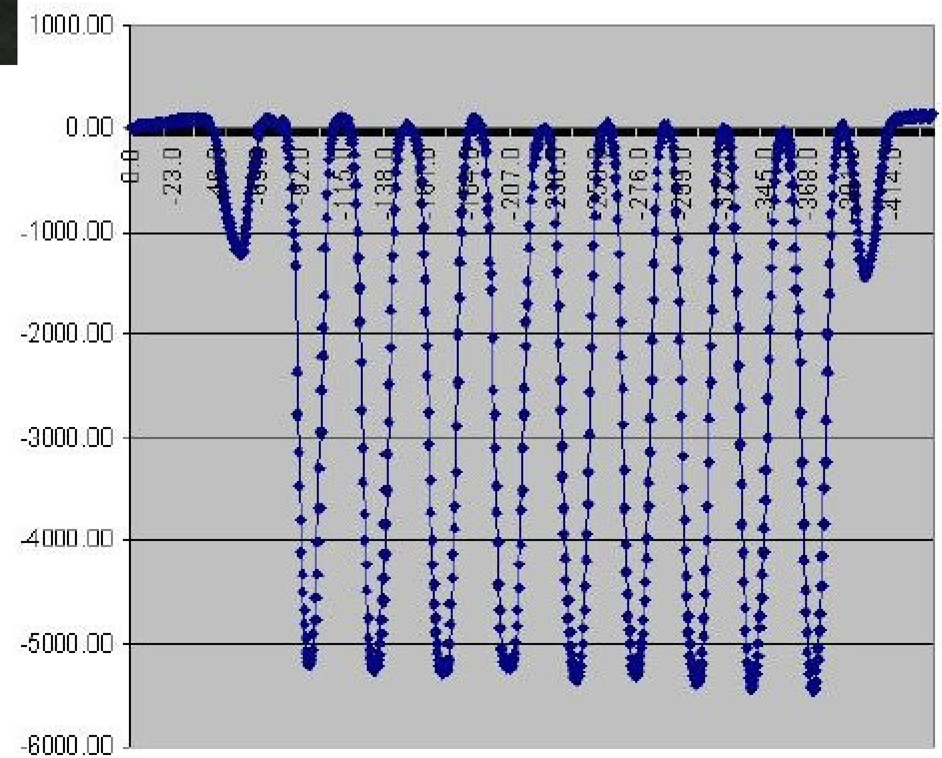


Modulated vanes of RFQ

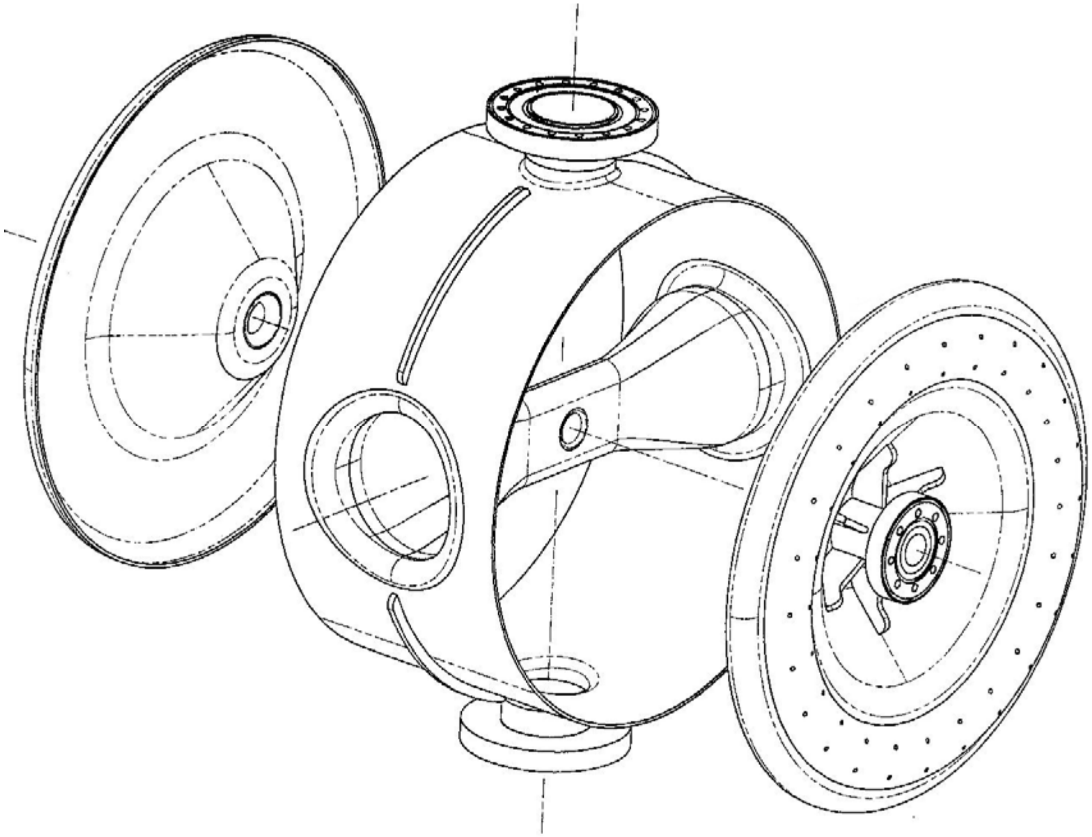
Prototype DTL cavity (dia = 85 cm, length =38 cm).



Bead pull test plot



Collaboration

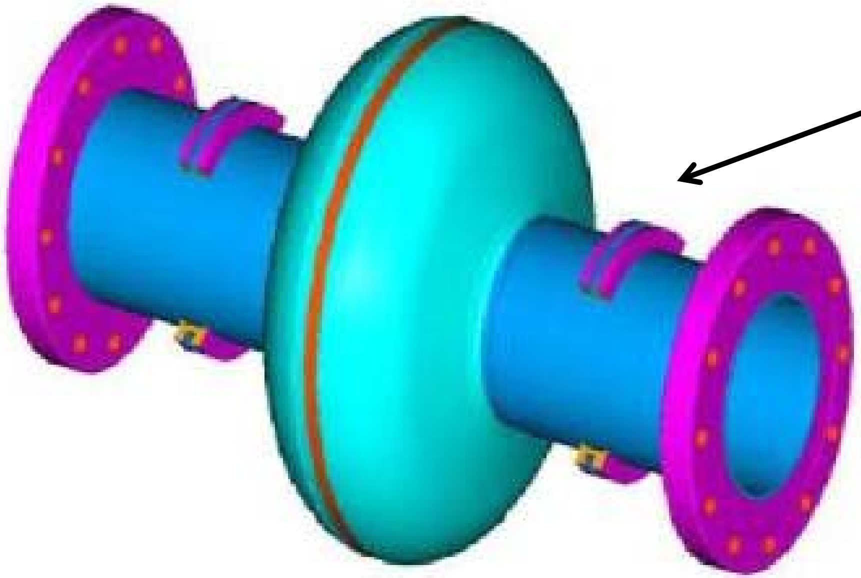


Niobium Single Spoke Resonators (The diameter ~ 500 mm.) operating at 325 MHz, β=0.22, for the Proton Driver Linac of High Intensity Neutrino Source at FNAL, USA .

Collaboration

Dies and Fabrication of Half Spoke and End Wall

Collaboration



Tesla-type Single Cell cavity
(Length = 392 mm)

Half cell of the Tesla-type single cell cavity

Control Room for 15UD Pelletron and Linac

Conclusion

Required infra-structures and facilities for indigenous development, fabrication and tests of various ion accelerators and associated components are developed.

HTS-ECR ion source on elevated (kV) platform followed by RFQ and DTL will be alternate injector of linac. HTS ECRIS has been operational for more than 27000 hours.

Technology of niobium QWR has been developed successfully.

The first LINAC module has been completed and used to deliver beam for scheduled experiments.

Thank you

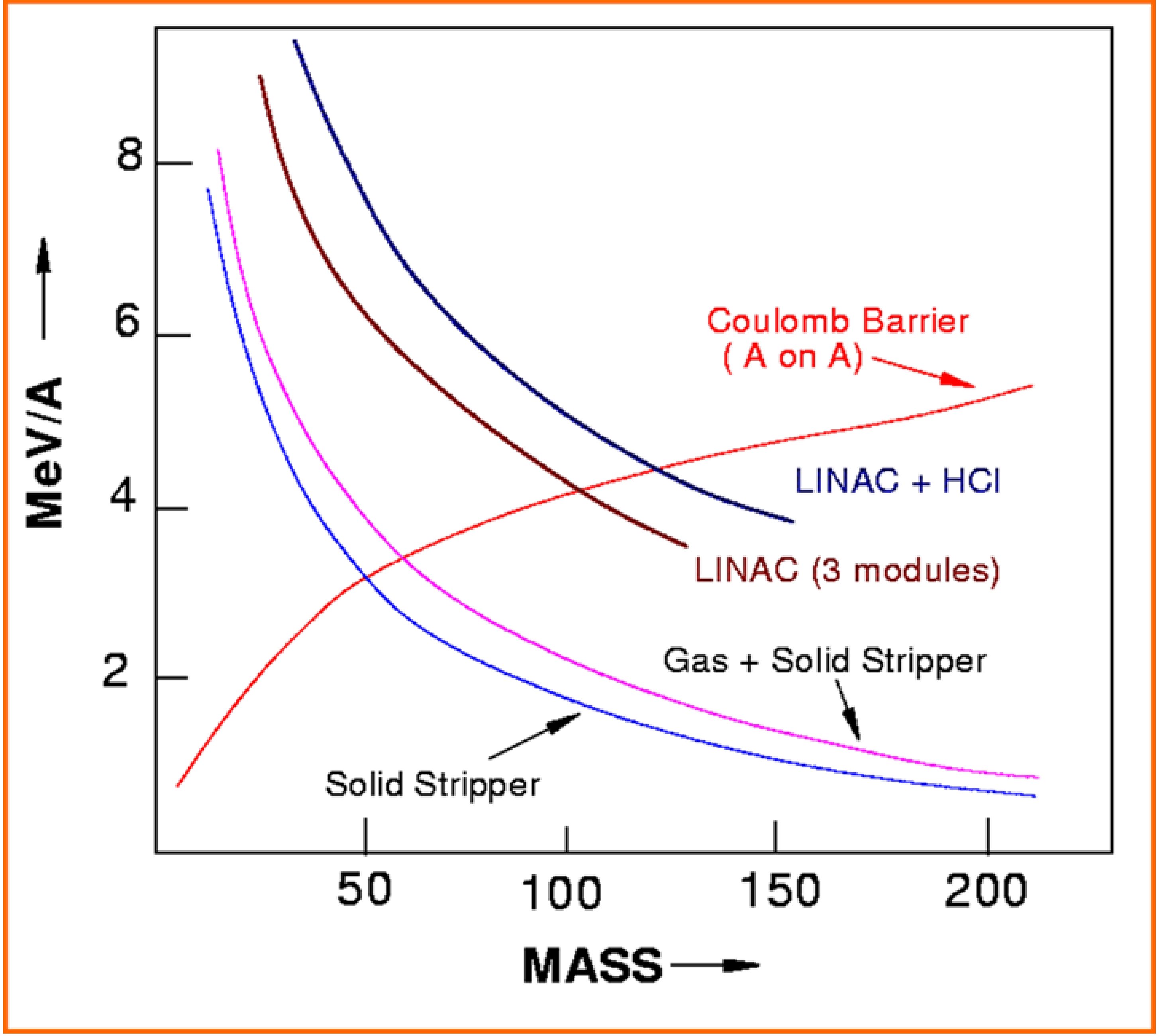
LHe: Based on Expansion engine. 150 l/h, 600W at 4.5K
From CCI, USA.
(LN2 for shield, distribution line pre-cooling of He refrigerator: 5000W @80K)

BEAMS extracted from PKDELIS

Ion	RF power (Watts)	Beam current
20Ne 2+	391	2 mA
40Ar 8+	521	732 mA
129Xe 14+	615	158 mA
129Xe 21+	600	44 mA
181Ta 20+	426	65 mA
181Ta 25+	476	27 mA
197Au 21+	786	38 mA
197Au 27+	873	20 mA
208Pb 21+	1200	99 mA
208Pb 28+	776	20 mA

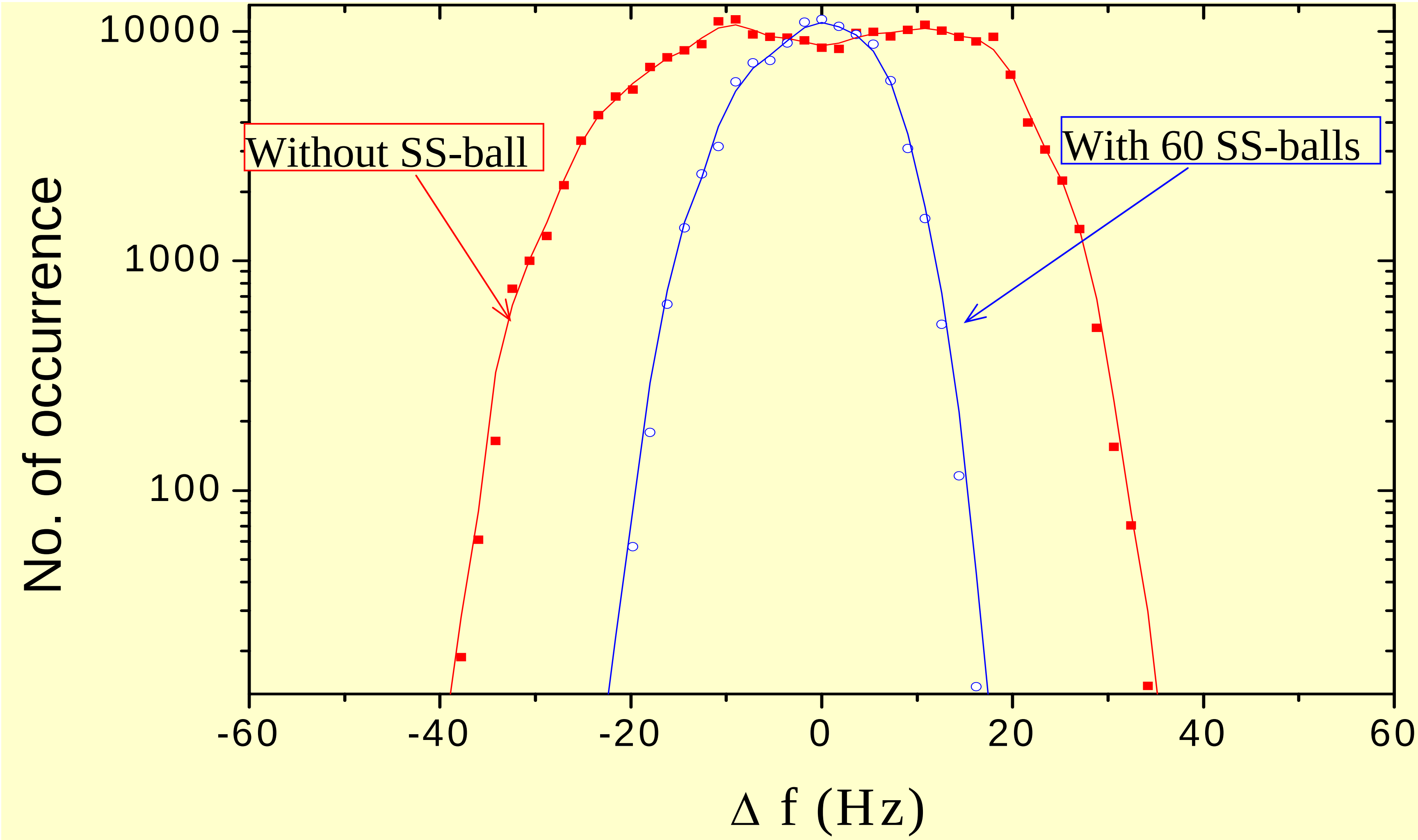
QWR#, ST#	Decay time (c.c.) at low field	Max Field achieved HPP-conditioning (Volts with 50 ohm term at scope)	No. of breakdowns observed	Duration of HPP conditioning	V_{in}^0/ V_{sig}^0	Electric field (MV/m) achieved @ 6 W
R11(11,13)	0.48	1.18	2-3	~ 1 hour	3.804/ -6.668	2.8 @ 3.6 W
R12(8,_)	0.550	4.1	7	~ 1 hour	3.865/ 3.368	3.4
R13(10,10)	1.4	2.016	Nil	~ 1 hour	3.759/ -4.539	4.2
R14(2,7)	0.846	2.166	Nil	1 hour 10 mins	3.868/ -2.723	3.5
R15(empty)						
R16(1,_)	0.520	2.15	Nil	1 hour 30 mins	3.858/ -1.704	3.015 @ 4 W
R17(12,2)	0.450	2.1	Nil	~ 1 hour	3.653/ -2.644	3.7
R18(3,4)	0.750	4.93	10-12	1 hour 30 mins.	3.755/ 2.586	4.1
SB (4,_)	X	0.946	4-2	½ hour	3.192/ -4.944	Not measured
RB1(IFR1,_)	0.95	2.033	Nil	2 hours	3.687/ -2.81	3.6
RB2(IFR2,_)	0.61	2.433	Nil	1 hour	3.731/ -1.420	3.73

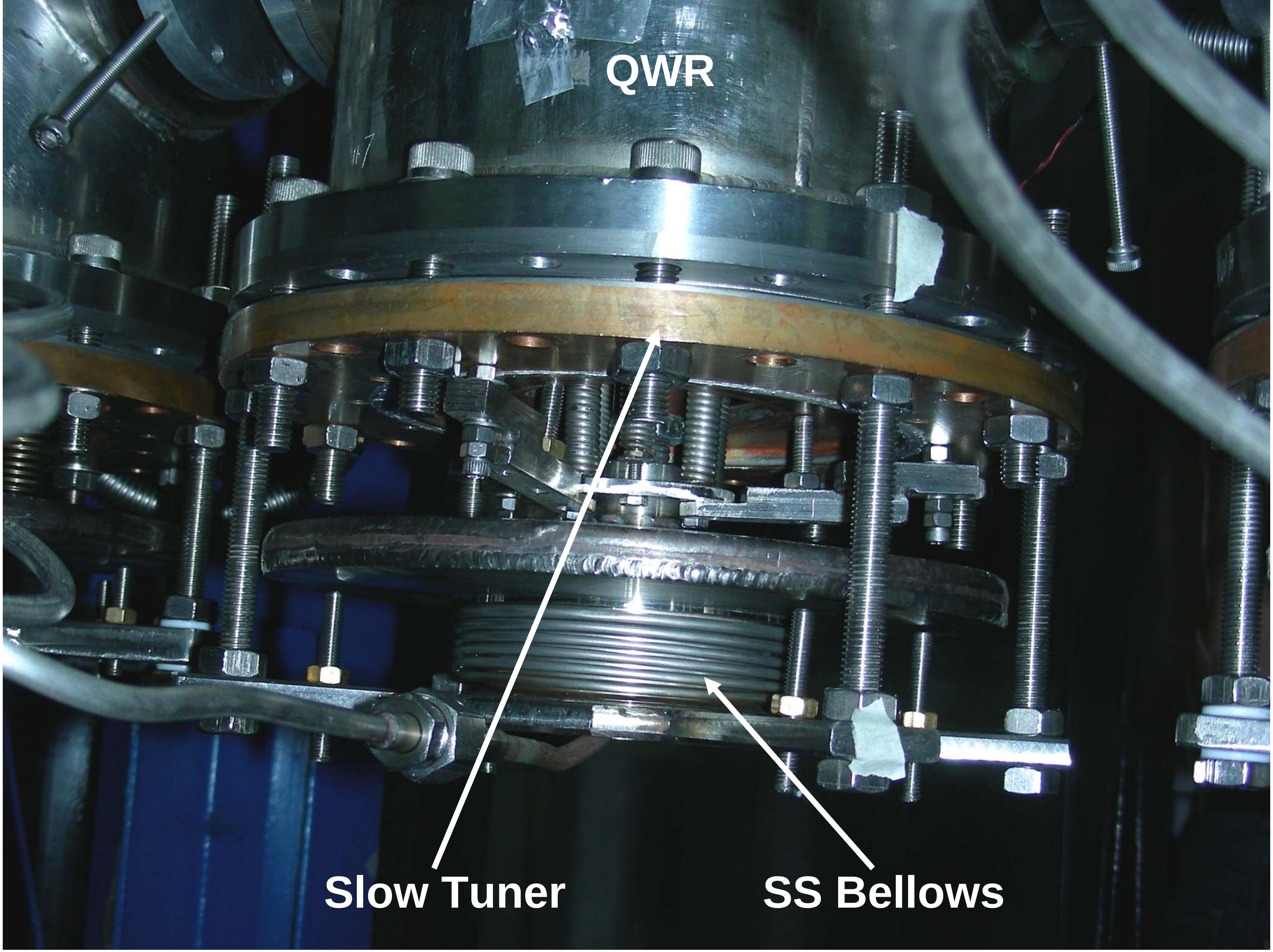
Table 1. Details of HPP conditioning, decay time, calibration values and acceleration fields



Increase in beam energy at various configurations

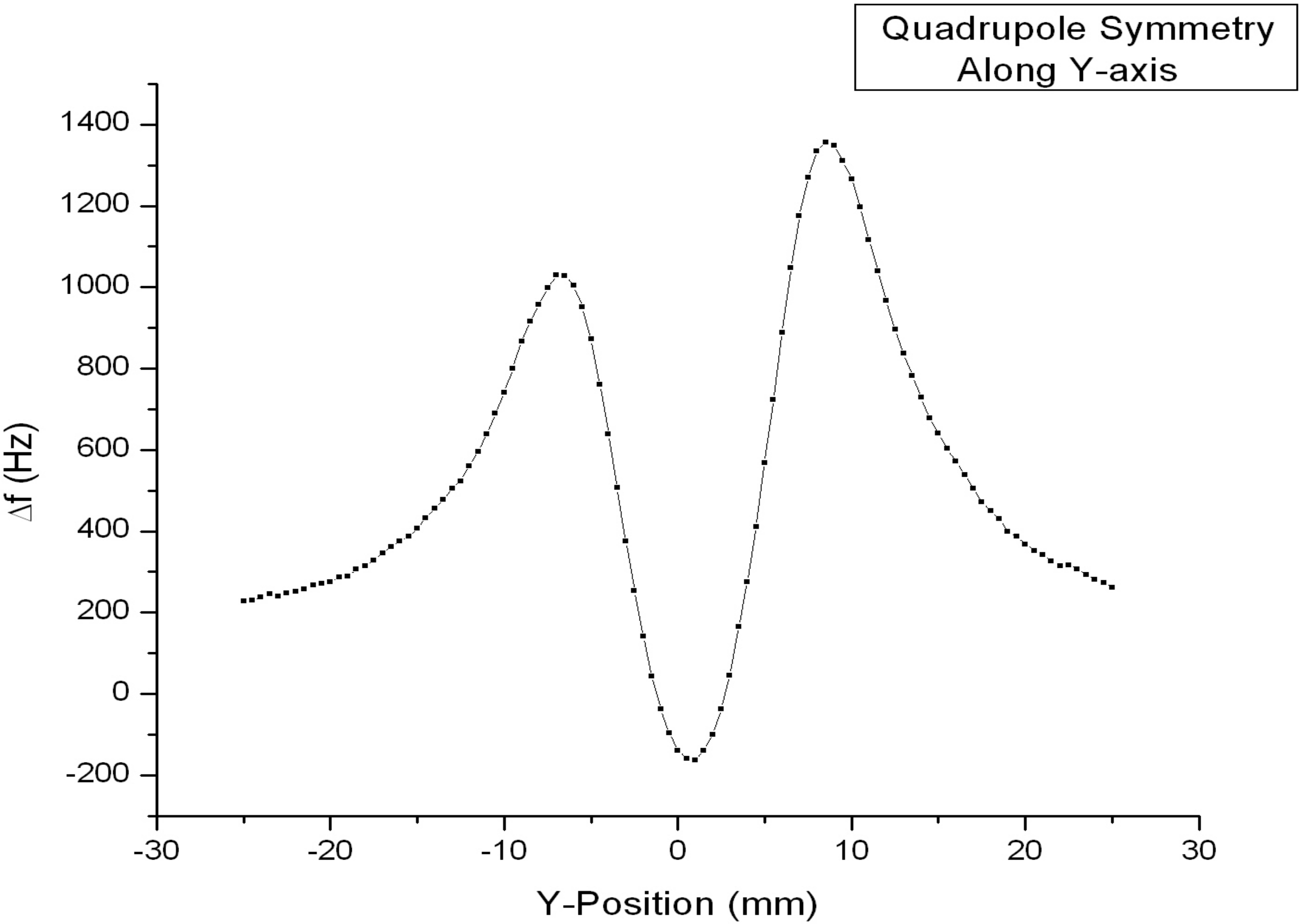
Comparison of frequency jitter with and without damping balls



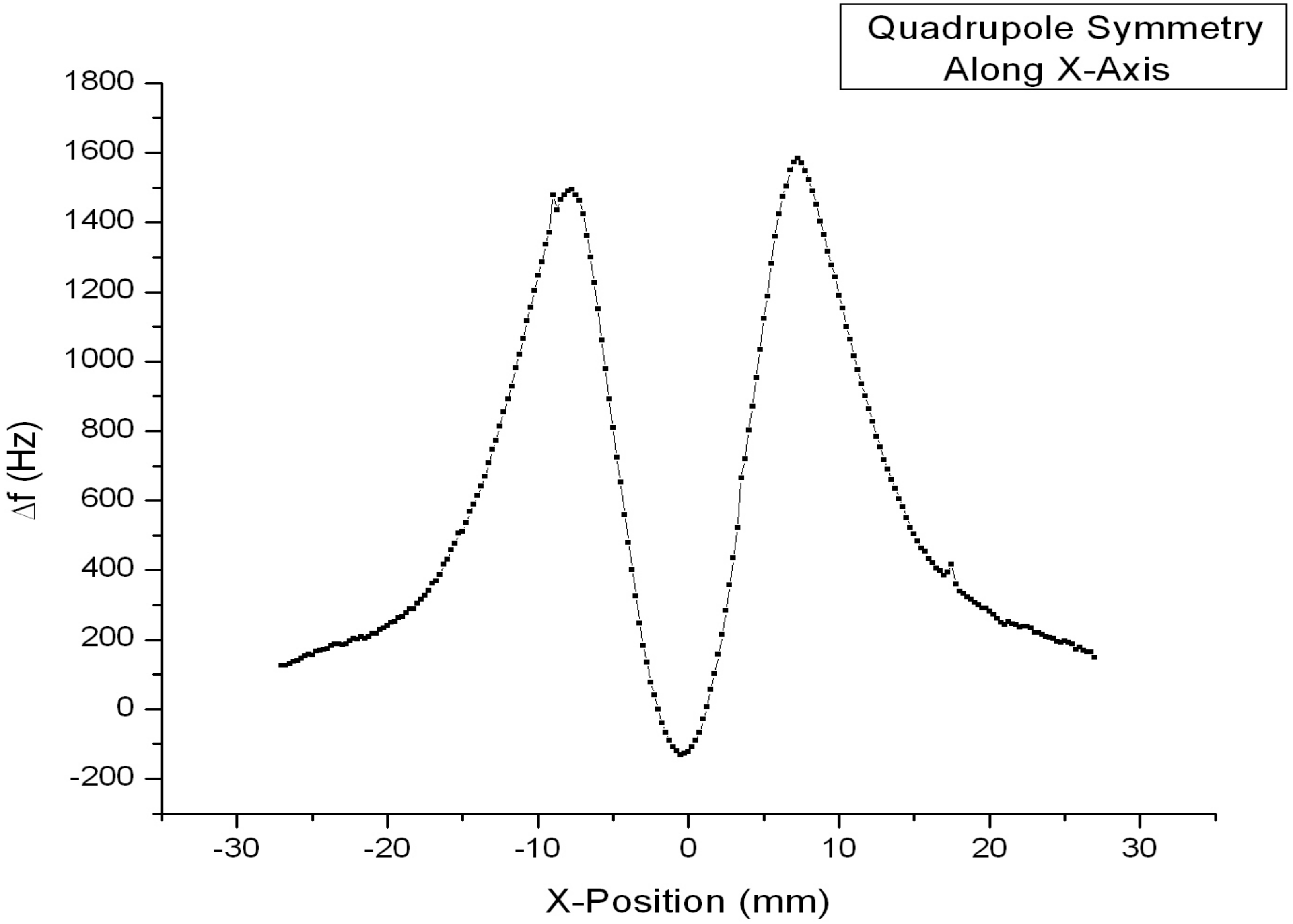


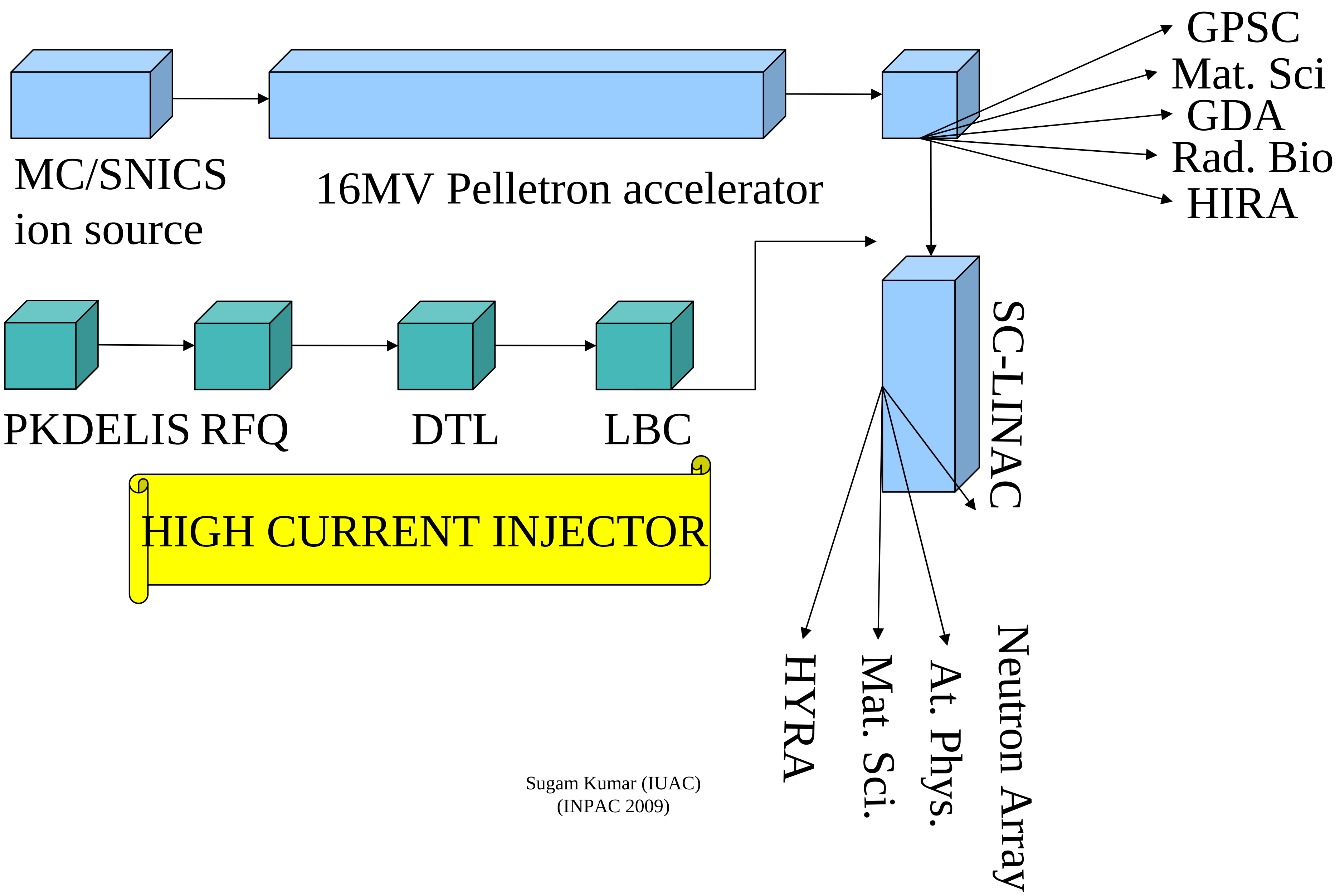
Modified Slow Tuner

Field mapping in horizontal & Vertical Plane



Field mapping in horizontal & Vertical Plane





GPSC
Mat. Sci
GDA
Rad. Bio
HIRA
MC/SNICS
ion source
16MV Pelletron accelerator
SC-LINAC
PKDELIS RFQ
DTL
LBC
HIGH CURRENT INJECTOR
HYRA
Mat. Sci.
At. Phys.
Neutron Array