

Development Activities at BARC-TIFR Pelletron Accelerator Facility



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BARC-TIFR PAF

Outline

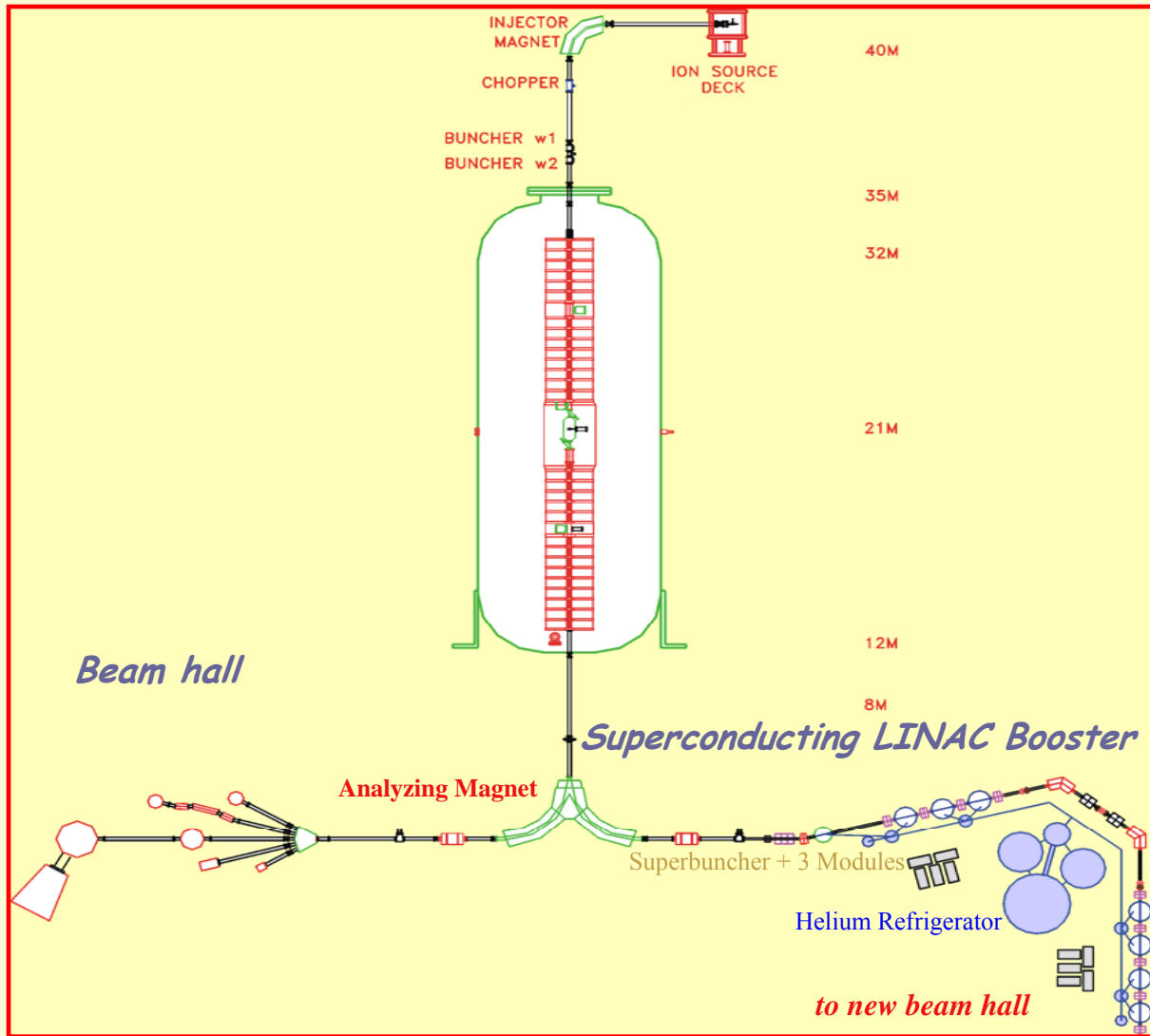
- **Accelerator Performance**
- **Developmental Activities**
 - **Associated Applications**
- **Future Programme**





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BARC - TIFR Pelletron Accelerator Facility





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Specifications of Pelletron



- **Model** 14 UD from NEC, USA
- Column voltage rating 15 MV
- Tube voltage rating 14 MV
- Voltage stability ± 2 kV
- Proton energy range 8 to 28 MeV
- Heavy ion energy range $4(n+1)$ to $14(n+1)$ MeV
- **Test current values**
 - Protons 3-5 μ amps.
 - Alphas 2 μ amps.
 - Heavy ions 100 nA particle





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Pelletron

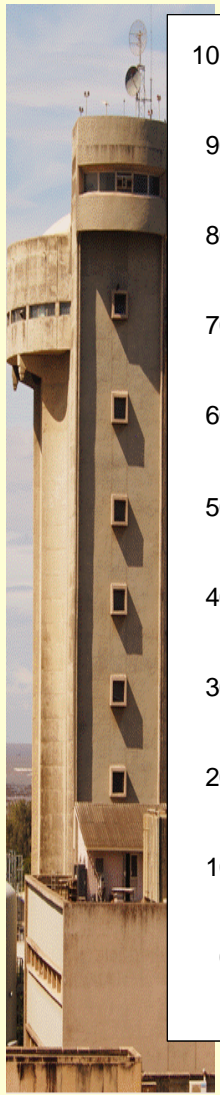
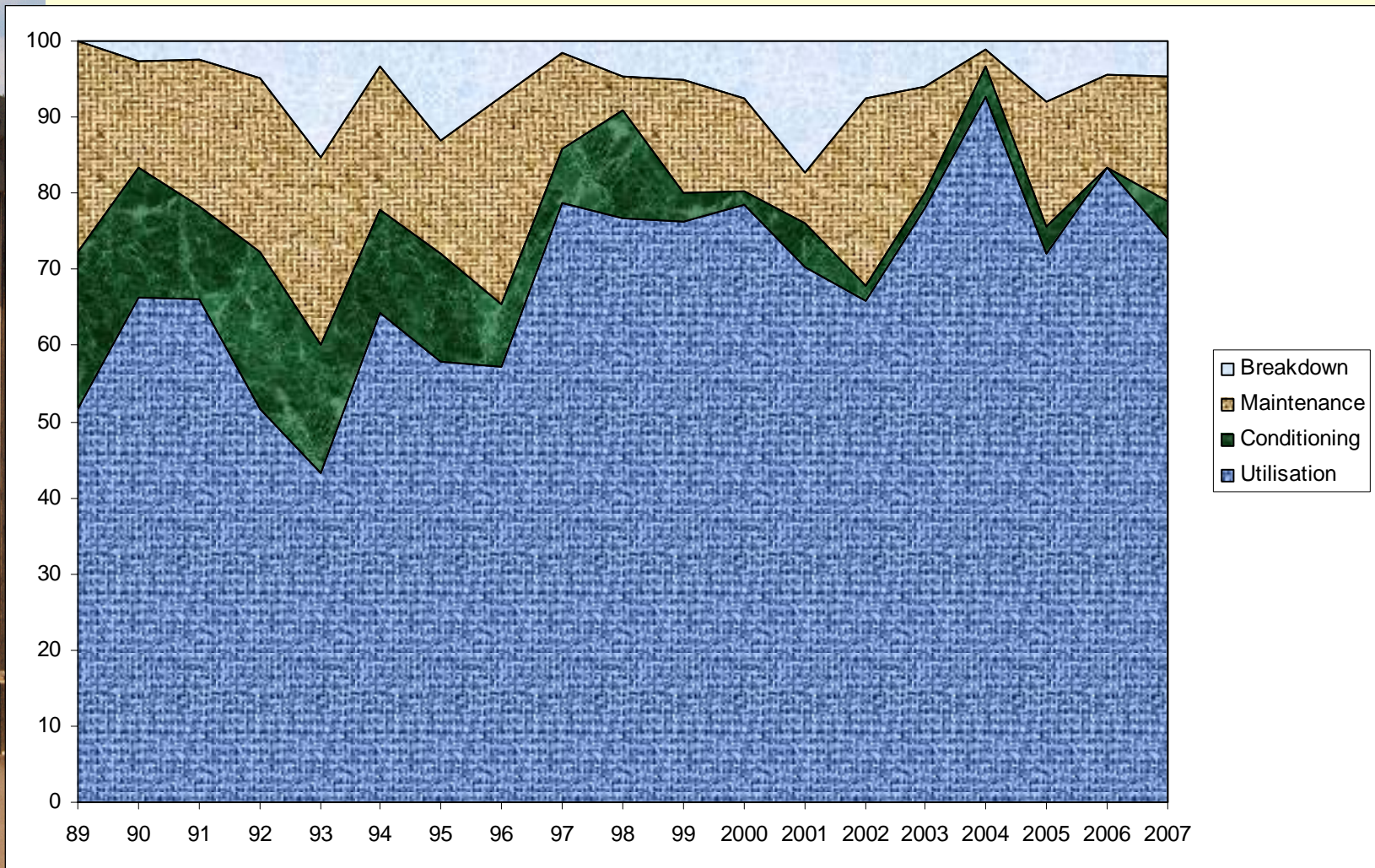
- Experimental facilities for
 - ❖ Nuclear physics
 - ❖ Atomic physics
 - ❖ Interdisciplinary areas
- Users
 - ❖ BARC
 - ❖ TIFR
 - ❖ SINP & VECC
 - ❖ DRDO, ISRO and other educational institutions
- Publications
 - ❖ *International Journals: 400*
 - ❖ *Physical Review Letters: 12*
 - ❖ *Ph.D. theses: 75*





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Performance

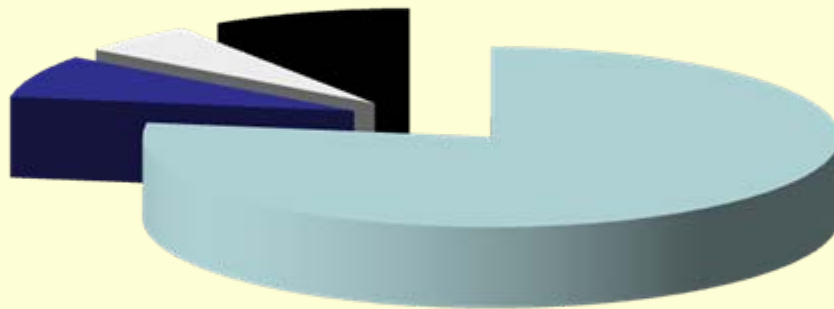




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Performance 2008



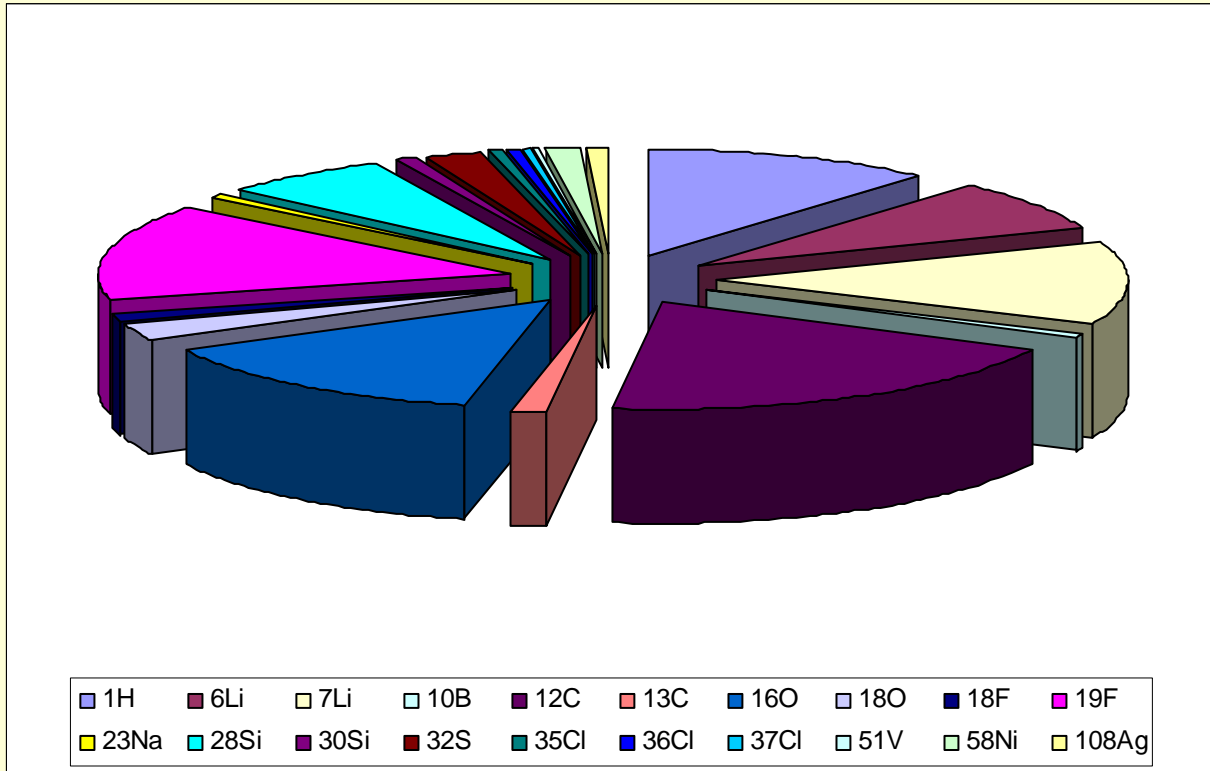
- Accelerator Operation (6792 hrs)
- Scheduled Maintenance (672 hrs)
- Unscheduled Maintenance (480 hrs)
- Conditioning (816 hrs)





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Accelerated Ion Beam





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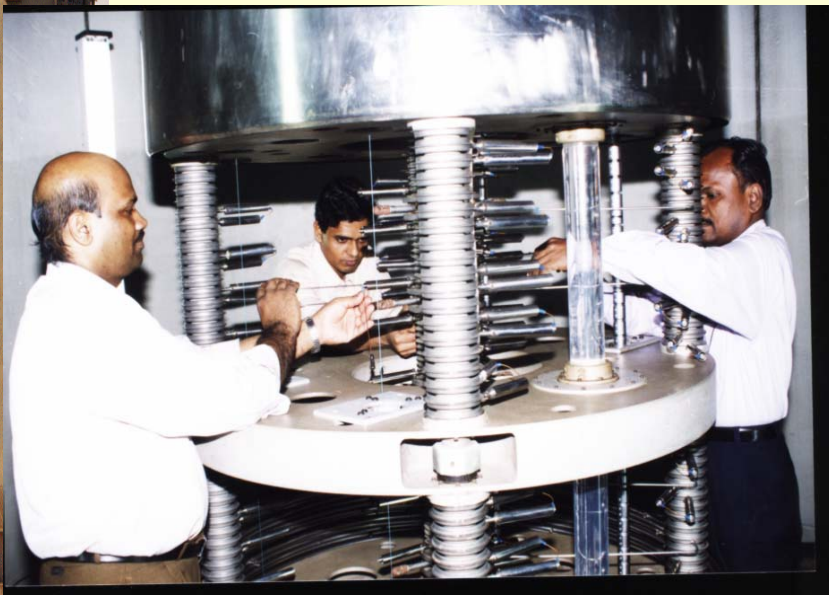
Corona to Resistor Grading New Terminal Potential Stabilizer

- *Improved Voltage stability*
- *Ease of operation at lower terminal*

- *smoother control of the terminal potential in the generating voltmeter (GVM) mode*

➤ *³⁶Cl Accelerator Mass Spectrometry*

- *Estimated detection limit is $\sim 7 \times 10^{-14}$ (blank sample, Prime Lab)*
- (Nucl. Inst. & Meth. Phys. Res. B 267 (2009) 1171)**
- **Extend this programme for ¹²⁹I**

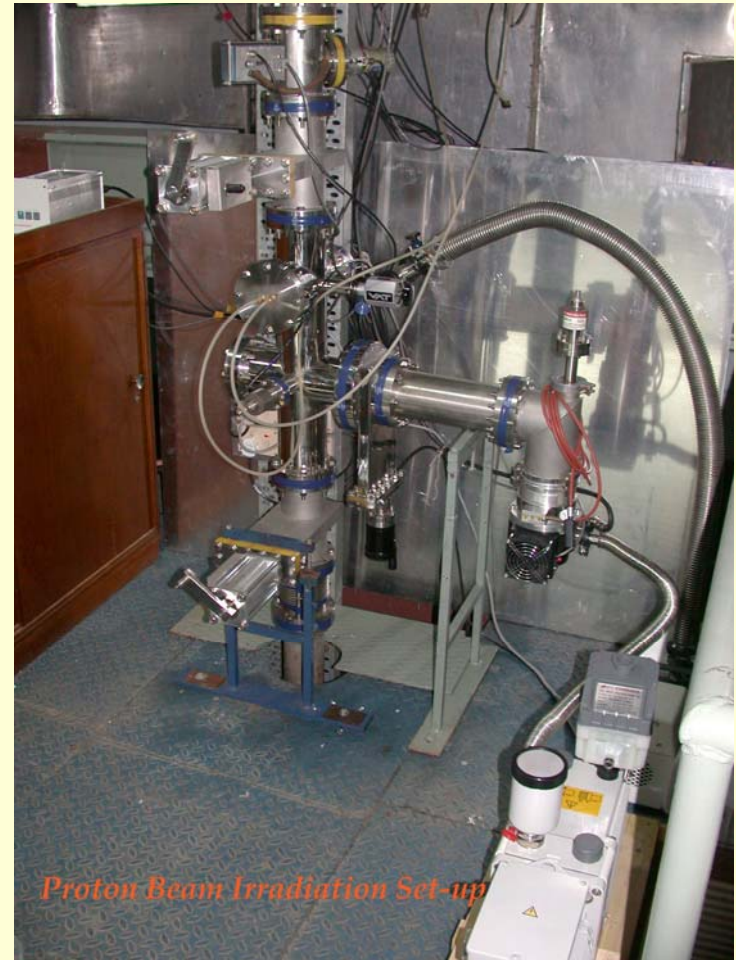




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Proton Irradiation Facility

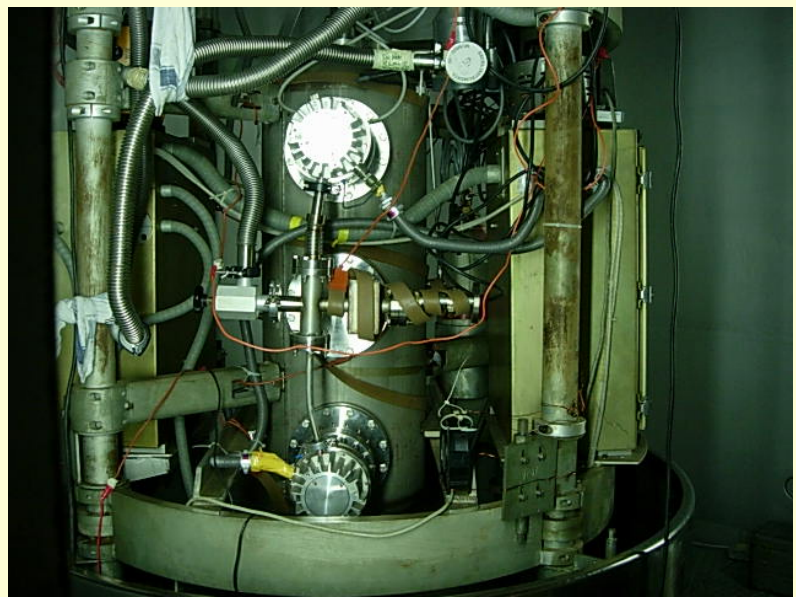
- Irradiation facility above analyzing magnet (6 m level)
- Provides proton beam from 4 - 26 MeV of up to μA current.
- Used for Production of neutrons and for radiopharmaceutical applications. (“Tracer Packet Technique”)
- Production of ^{236}Pu as a tracer.
- Accurate monitoring of plutonium inhalation by radiation workers and of the environmental materials; convenient half-life of 2.85 Years and alpha particle energies (5.73, 5.76 MeV) well separated from those of reactor grade plutonium isotopes.
- production of ^{236}Pu by proton irradiation of ^{237}Np .





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Recirculating Terminal Gas-stripper



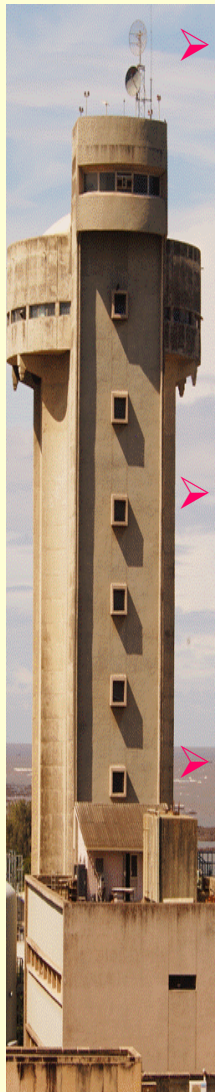
Terminal Gas Stripper System

	Beam Current with Foil Stripper	Beam Current with Gas & Foil Stripper
Tank Top BeO ⁻ yield	220 nA	220nA
Tank Bottom Be ⁺ⁿ , O ⁺ⁿ total yield	400 nA	610 nA
Be ⁺³ analyzed yield	10nA	35 nA
<p>@ Terminal Voltage – 10 MV, Beam Energy- 33.6 MeV ; Gas stripper Pressure 240 Micron</p>		



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Schematic of Ion Source Test Set Up



➤ Beam Development

Composite Cathode

Gas-feed Cathode

Rare earth Cathode

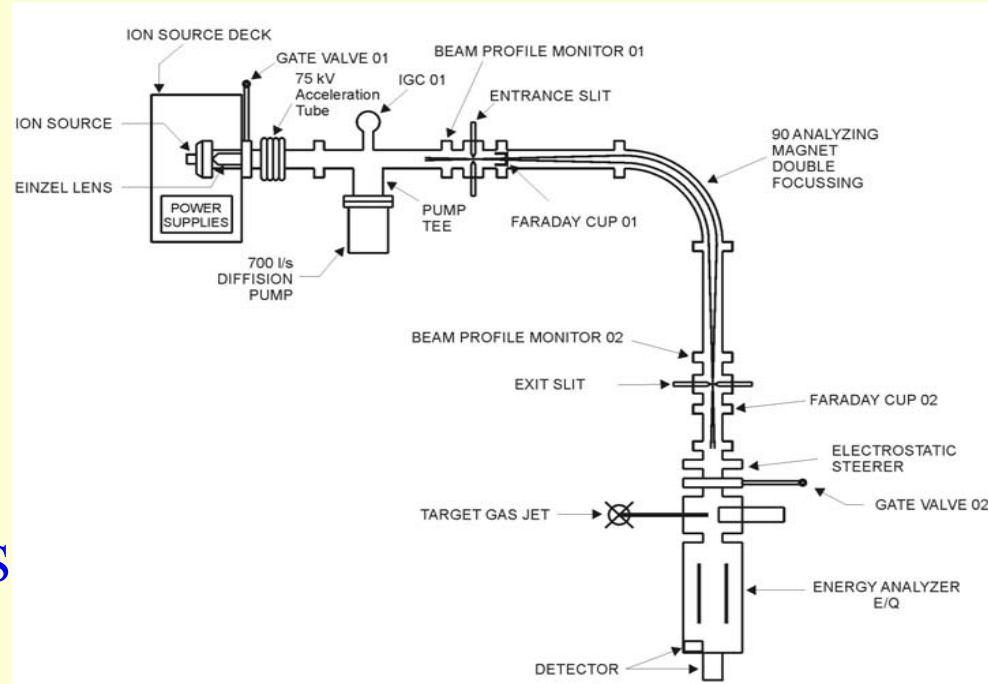
➤ Sputter-source Development

SNICS, GF-SNICS, MC-SNICS

➤ Applications using Test Bench

Set Up

- Production and Characterization of molecular and Cluster Negative Ions
- Search for Doubly Charged Negative Ions
- Negative Ion Implantation
- Isotopic Ratio Measurements

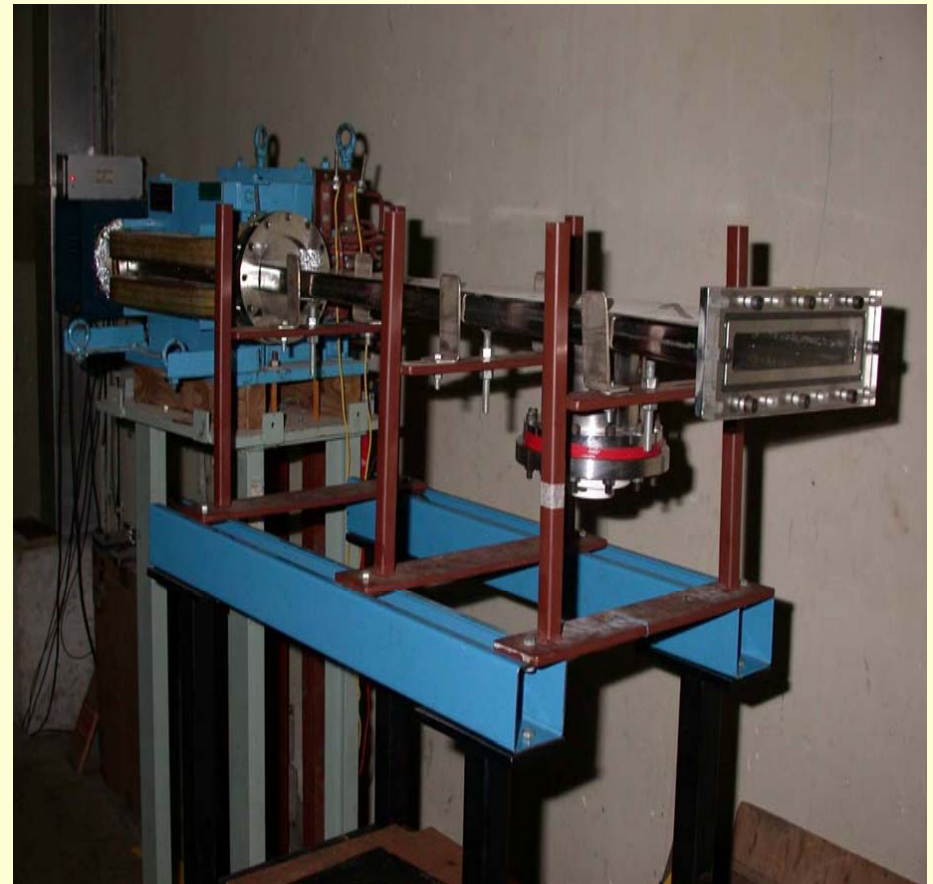
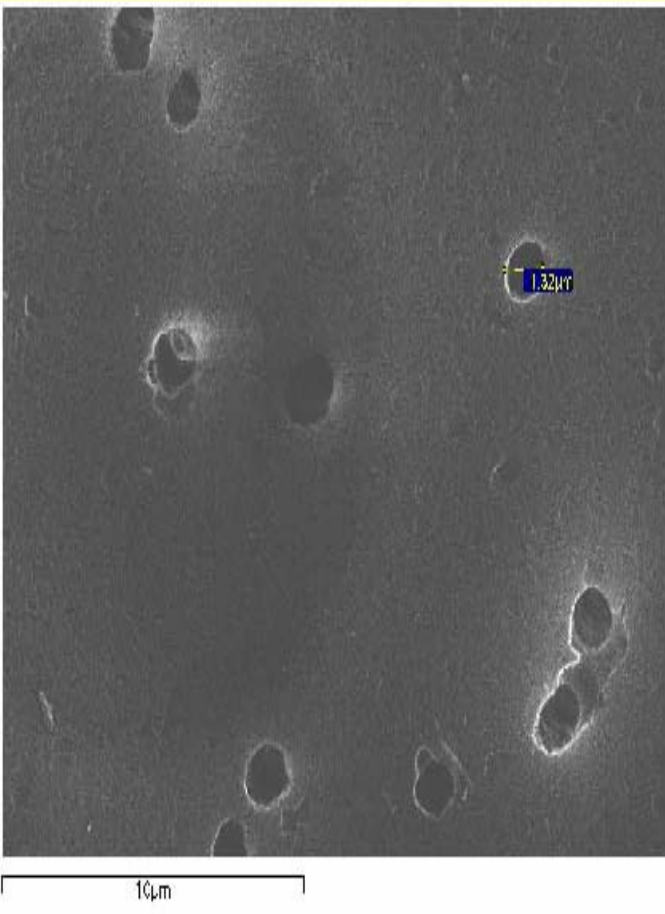




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Track Membrane Set Up

- Membranes produced being used in medical science, analytical science and micro-filtration.





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Beam Profile Monitor

- **A PCI based FPGA compatible BPM digitizer along with the associated GUI is Developed.**
- **Digitizer can display two BPM waveforms simultaneously.**
- **Waveforms can also be filtered and archived.**
- **Helps in beam tuning.**
- **Can also function as a general purpose PCI interface card.**



BPM digitizer

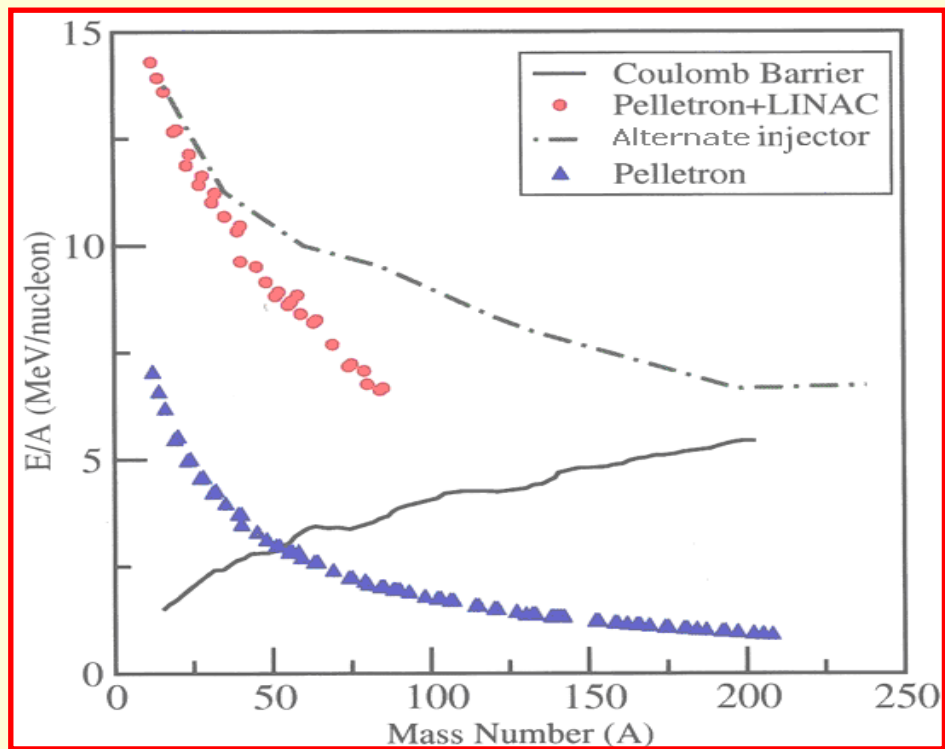




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Available Energy Range

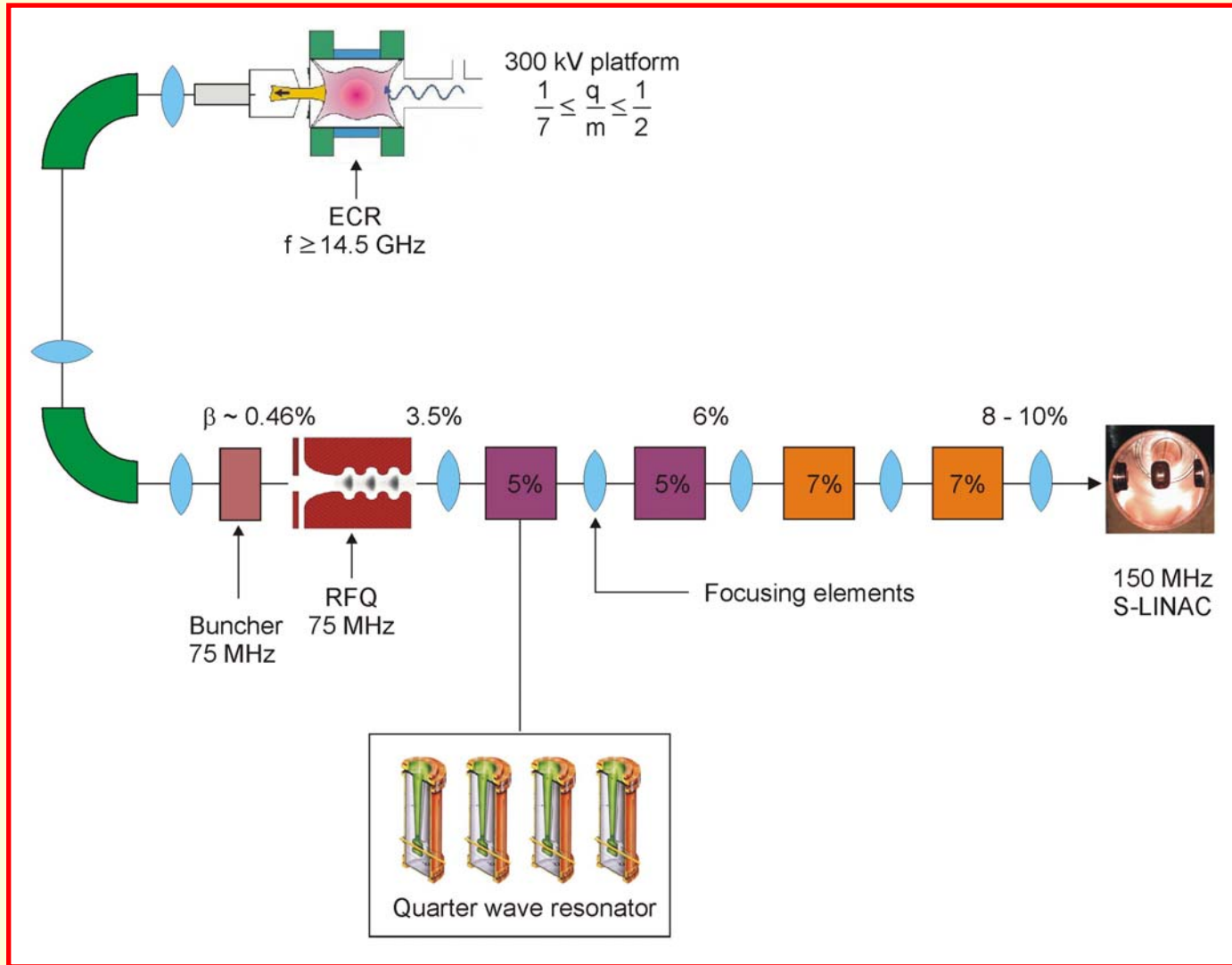
Ion	Pelletron		Pelletron +LINAC E(MeV)	Proposed Injector +LINAC		
	A/Q	E(MeV)		A/Q	E(MeV)	I_{target} (pnA)
O	2.5	90	210	2.5	220	>1000
Cl	4.0	126	360	4.0	400	60
Ar	--	--	--	3.5	460	60
Co	6.0	145	470	4.5	600	100
Kr	--	--	--	4.5	800	70
Xe	--	--	--	5.0	1150	3
Au	16.0	180	--	7.0	1300	8
U	20.0	180	--	6.5	1600	5

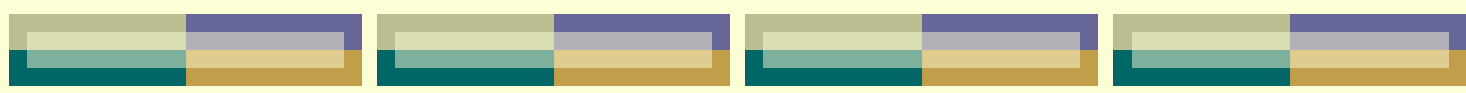




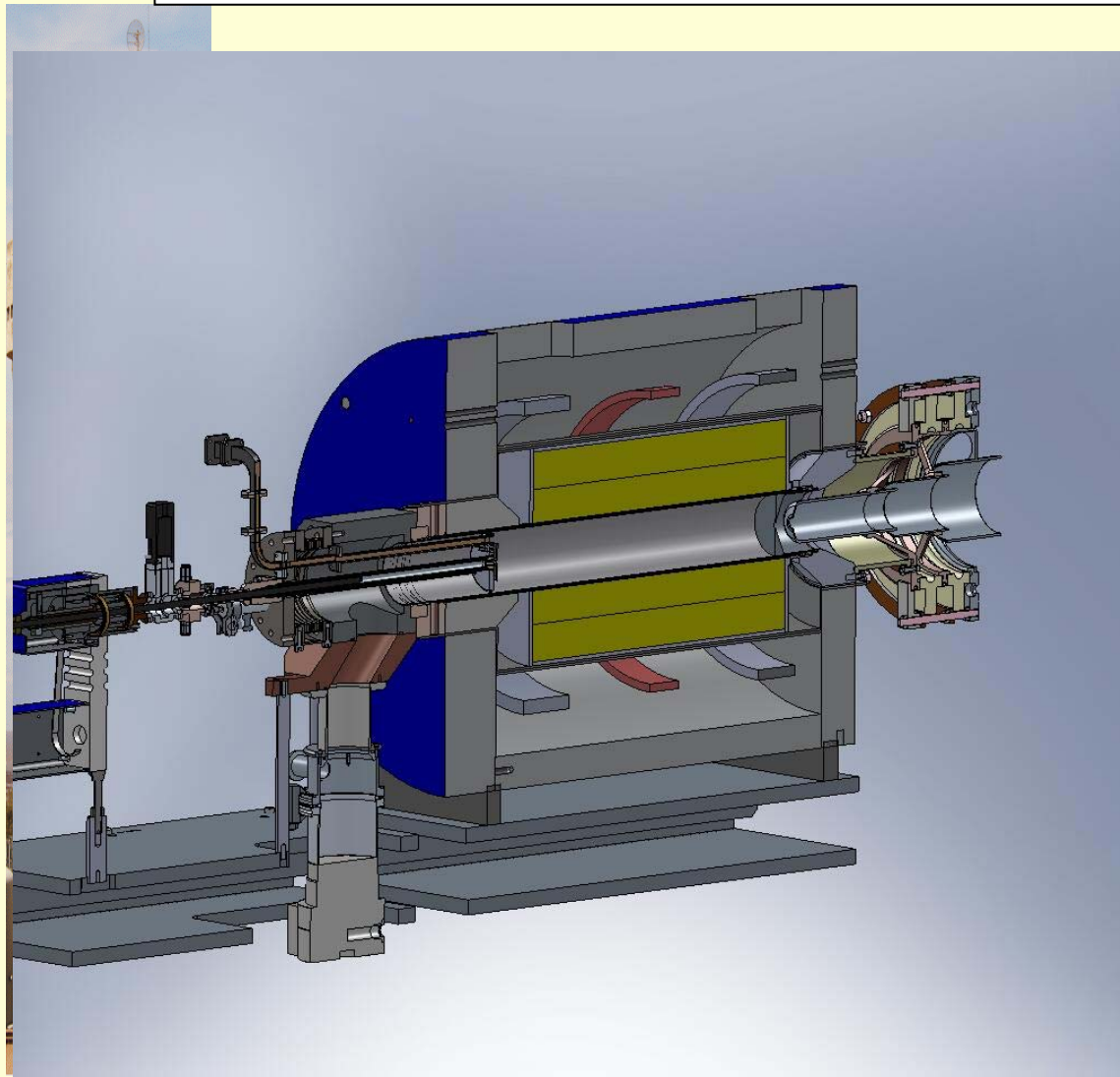
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Positive Ion Injector Schematic





ECR Source (PK-ISIS)



Specifications

Operating Frequency: 18 GHz

Maximum Axial Field at injection: 1.8 T

Maximum Axial Field at extraction: 1.37 T

Minimum Axial Field: 0.4-0.5 T

Radial magnetic Field: 1.25 T

Maximum Extraction Voltage: 30 KV

RF Power: 1.7 KW





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Distinctive Features of PK-ISIS Source

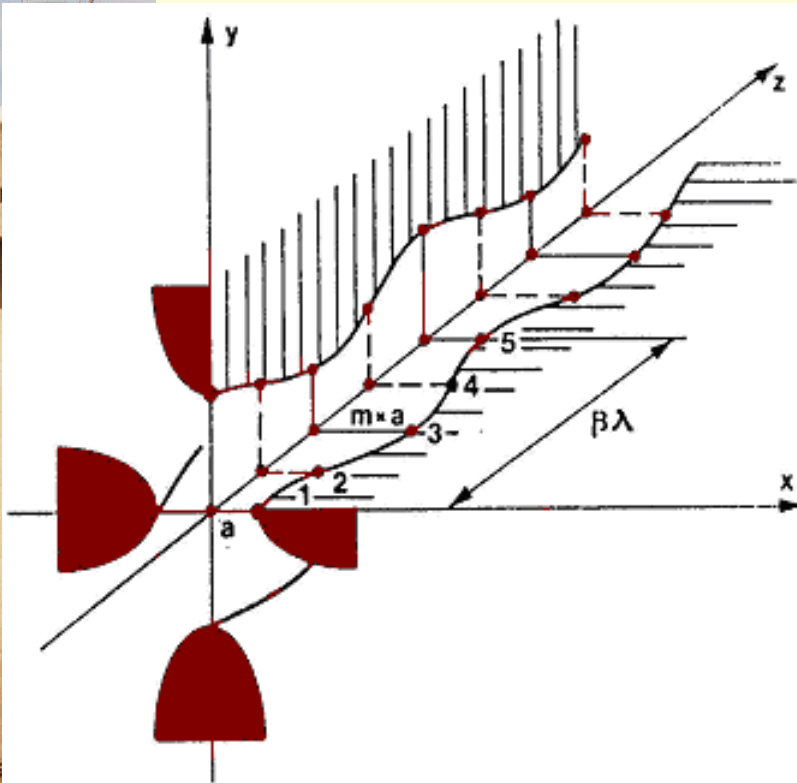
- Expected to deliver 5 to 10 times higher beam intensity than existing commercial sources and/or shifting the charge state distribution to higher ($+^{34}\text{U}^{238} \sim 3 \text{ e}\mu\text{A}$).
- Variable B_{min} via an independent third coil.
- Low Temperature Superconducting wire Technology and no He cryogen.
- Reduced coils power consumption to 15 kW (200 kW for room temperature).
- Can be mounted on a high voltage platform.
- Have mass selection feature on high voltage platform.
- Integrates modern design concepts like RF direct injection, DC-bias moving disk, out-of-axis oven and axial sputtering facility for metallic beams.





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Radio Frequency Quadrupole



a: minimum distance from axis
 $m \times a$: maximum distance from axis
m: modulation factor
 $\beta\lambda$: modulation period

- Quadrupole configuration provides focusing
- Vane modulations generate electric field for bunching and acceleration



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RFQ Design Parameters

- ❖ Frequency 75 MHz
- ❖ E_{in} 10 keV/u (0.46 %)
- ❖ E_{out} 575 keV/u (3.5 %)
- ❖ Current 100 μ A
- ❖ q/m $> 1/7$
- ❖ Acceptance $> 1 \pi$ mm mrad





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RFQ Design with pre-buncher



Mean Aperture (r_0)

8mm

Channel parameters

Kilpatrick Factor

1.4

Intervane Voltage

112 kV

Synchronous Phase

-90° -20°

Modulation(m)

1.0 - 2.3

No.of Cells

167

Length

4.69 m

Output Characteristics

Transmission

87.2 %

Momentum spread

$\pm 0.35\%$

Phase Width

$\pm 9^{\circ}$



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RFQ Fabrication at IGTR



RFQ Assembly

Vacuum Chamber





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View of Tower and Lab-Block

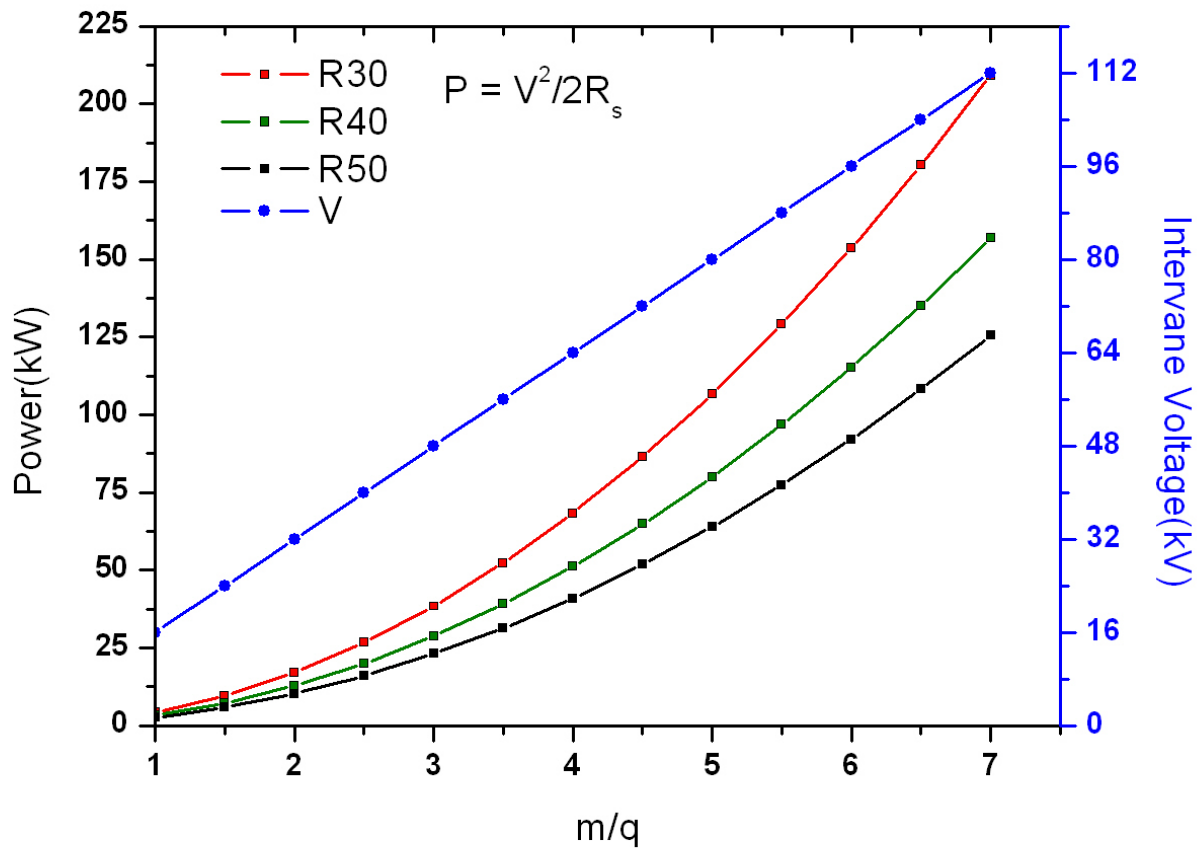


Thank You



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Power Dissipation

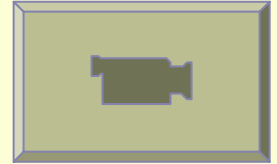




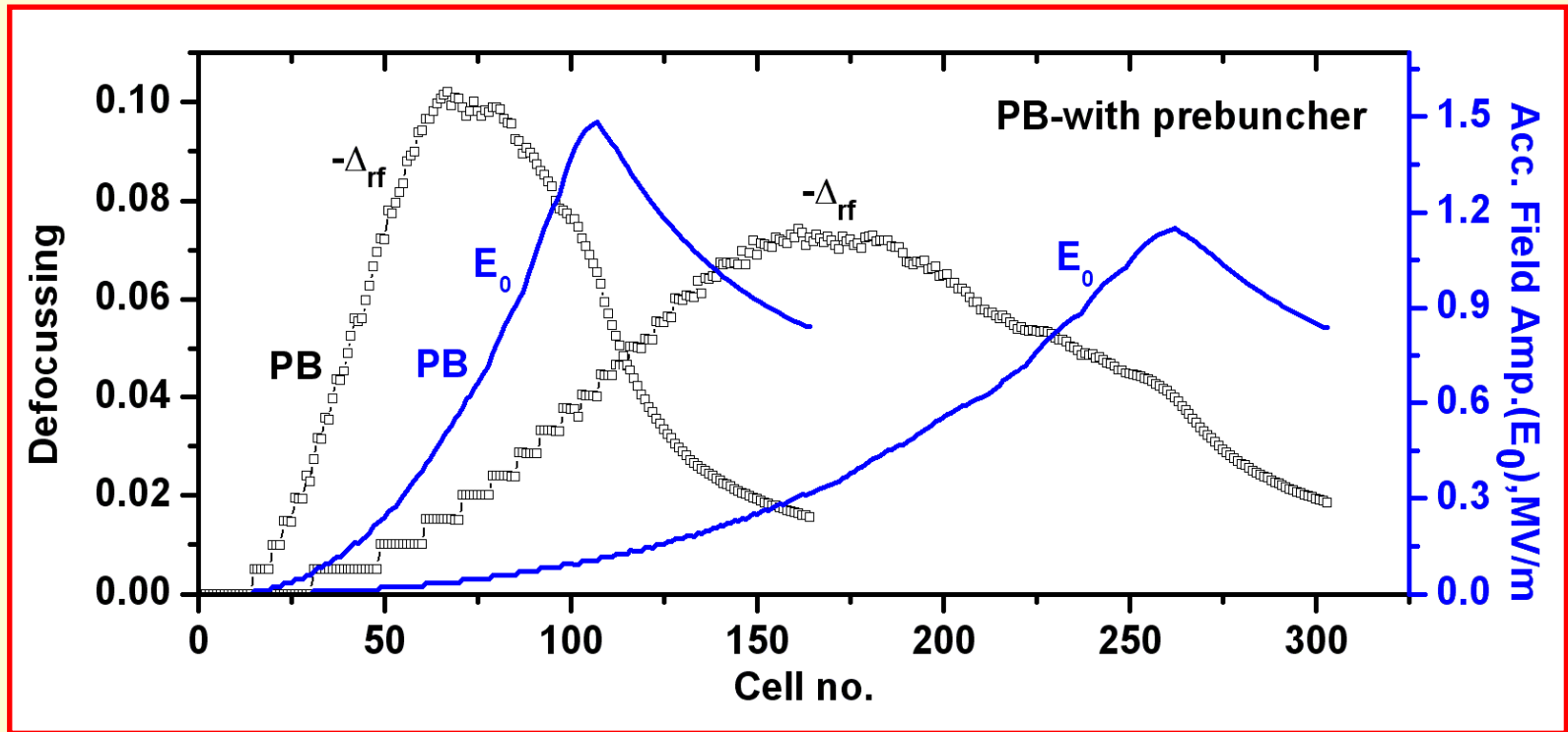
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Electric Field (with & without prebuncher)

- ❖ defocusing increased faster and higher to take advantage of already bunched beam



- ❖ $E_{0(PB)}$ 1.48 MV/m E_0 1.15 MV/m



electron Affinity-Ionization Potential Table

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GROUP I A	IONIZATION POTENTIAL						VIII A
	ELECTRON AFFINITY						
1 H 13.595 0.7542	II A	III A	IV A	V A	VIA	VII A	2 He 24.58 0.078 *
3 Li 5.39 0.620	4 Be 9.32 0.19 *	5 B 8.30 0.28	6 C 11.26 1.268	7 N 14.54 < 0	8 O 13.61 1.462	9 F 17.42 3.399	10 Ne 21.56 < 0
11 Na 5.14 0.548	12 Mg 7.64 < 0	13 Al 5.98 0.46	14 Si 8.15 1.385	15 P 10.55 0.743	16 S 10.36 2.0772	17 Cl 13.01 3.615	18 Ar 15.76 < 0
19 K 4.34 0.5012	20 Ca 6.11 0.043	31 Ga 6.00 0.3	32 Ge 7.88 1.2	33 As 9.81 0.80	34 Se 9.75 2.0206	35 Br 11.84 3.364	36 Kr 14.00 < 0
37 Rb 4.18 0.4860	38 Sr 5.69 > 0	49 In 5.78 0.3	50 Sn 7.34 1.25	51 Sb 8.64 1.05	52 Te 9.01 1.9708	53 I 10.45 3.061	54 Xe 12.13 < 0
55 Cs 3.89 0.4715	56 Ba 5.21 > 0	81 Tl 6.11 0.3	82 Pb 7.41 0.36	83 Bi 7.29 1.1	84 Po 8.43 1.9	85 At 9.5 2.8	86 Rn 10.74 < 0

III B	IV B	V B	VI B	VII B	VIII B			IB	II B
21 Sc 6.56 < 0	22 Ti 6.83 0.2	23 V 6.74 0.5	24 Cr 6.76 0.66	25 Mn 7.43 < 0	26 Fe 7.90 0.25	27 Co 7.86 0.7	28 Ni 7.63 1.15	29 Cu 7.72 1.226	30 Zn 9.39 < 0
39 Y 6.5 - 0	40 Zr 6.95 0.5	41 Nb 6.77 1.0	42 Mo 7.18 1.0	43 Tc 7.28 0.7	44 Ru 7.36 1.1	45 Rh 7.46 1.2	46 Pd 8.33 0.6	47 Ag 7.57 1.303	48 Cd 8.99 < 0
57 La 5.61 0.5	72 Hf 7. < 0	73 Ta 7.88 0.6	74 W 7.98 0.6	75 Re 7.87 0.15	76 Os 8.7 1.1	77 Ir 9. 1.6	78 Pt 8.96 2.128	79 Au 9.22 2.3086	80 Hg 10.43 < 0

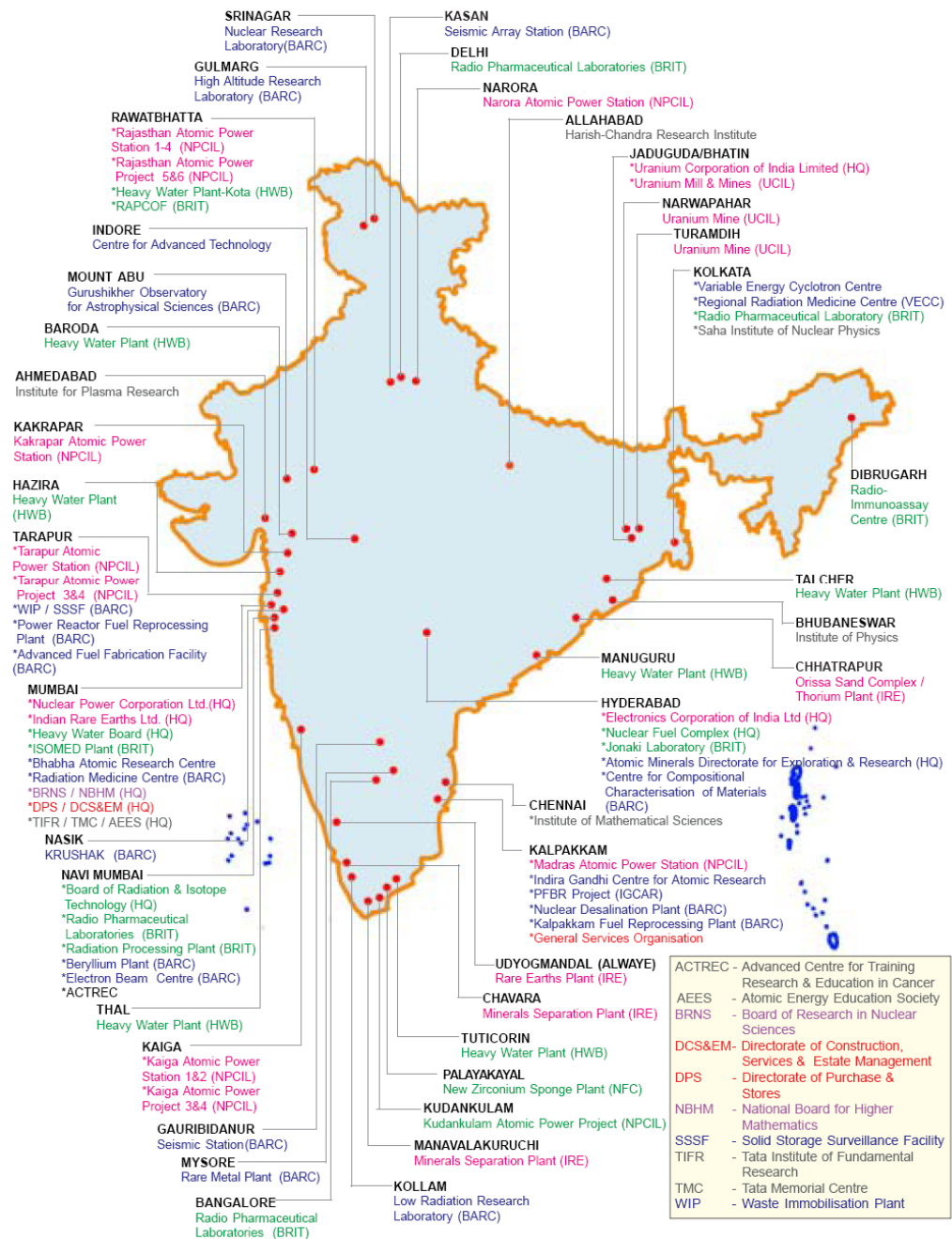
*METASTABLE



Atomic Energy Establishments in India



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