Status & Plans for the TRIUMF ISAC Facility

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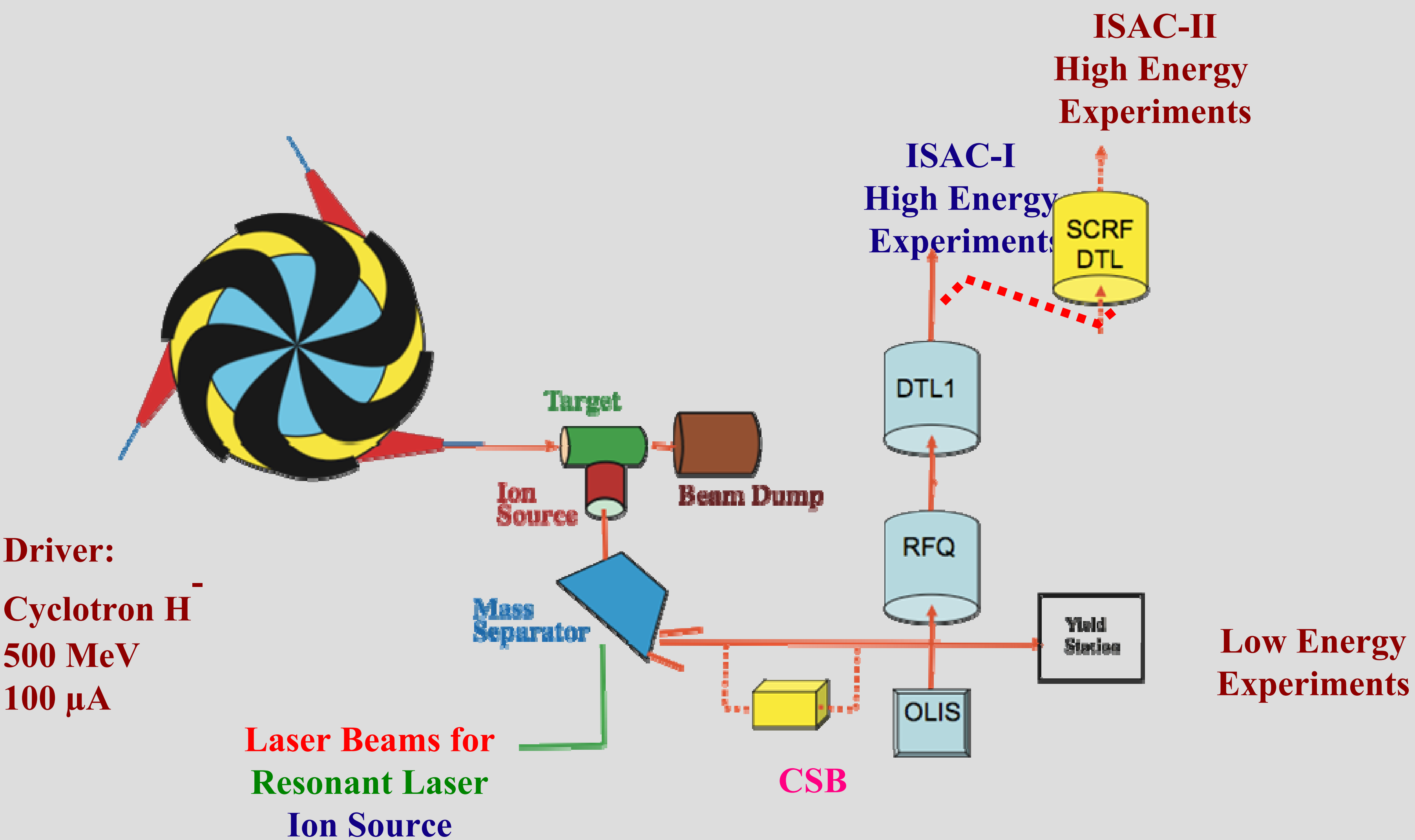
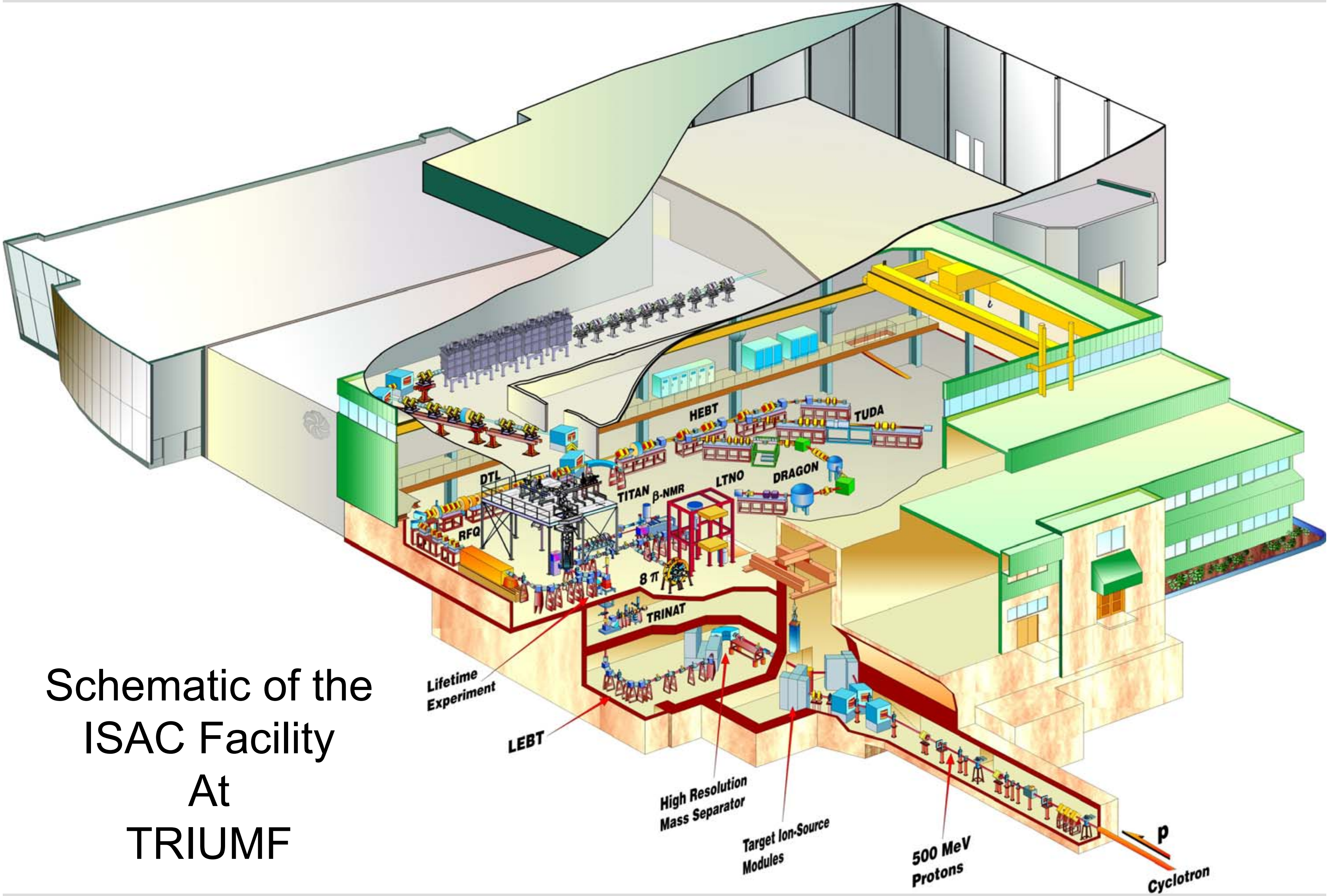
APAC 07, Jan 29-Feb 2
Indore, India


TRIUMF
ISAC

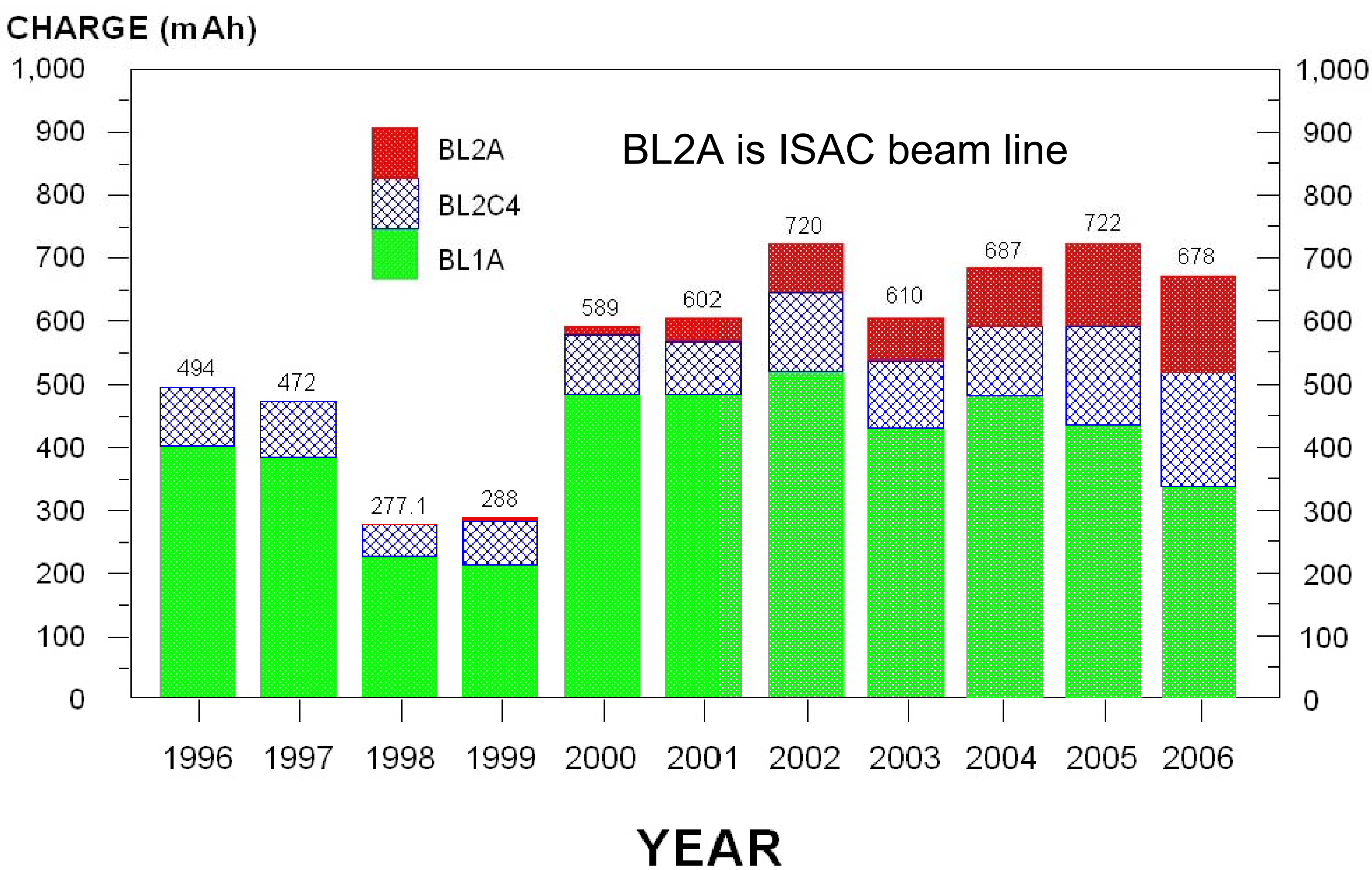
Schematic Layout of TRIUMF/ISAC with H- Driver, ISOL Production & Post Accelerators





Schematic of the
ISAC Facility
At
TRIUMF

ANNUAL TOTAL CHARGE DELIVERY

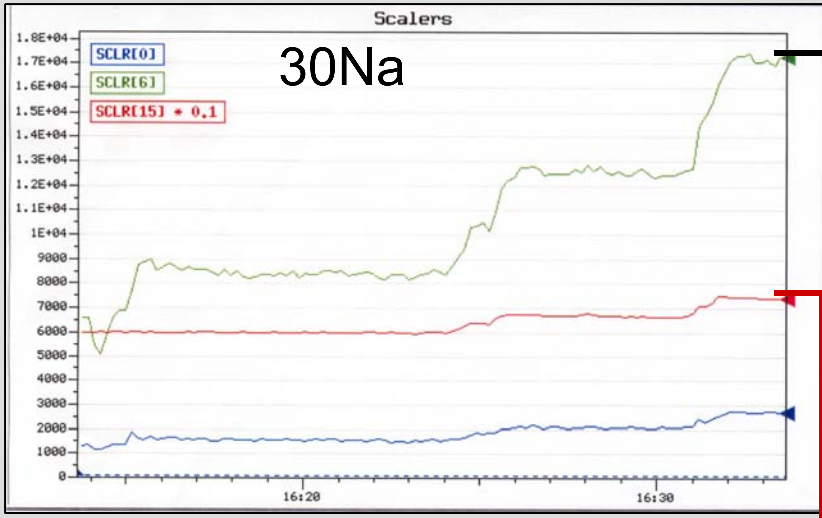


ISOL Method, RIB Yield

- The yield depends on the following parameters:

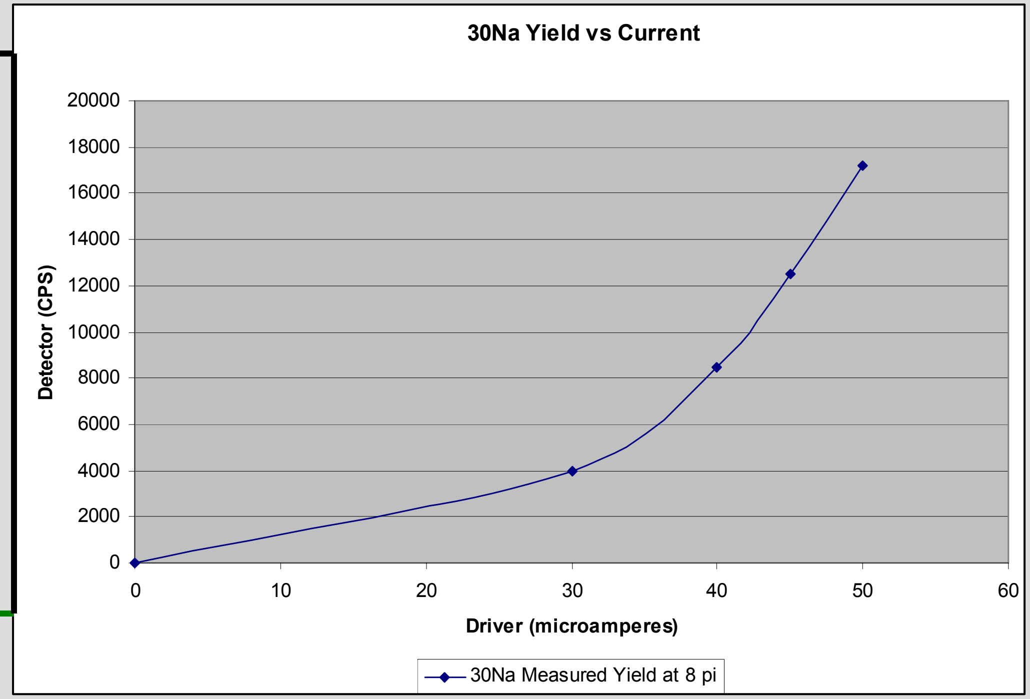
♦ $Y = \Phi \, \sigma \, \chi \, \varepsilon_R \varepsilon_E \varepsilon_i$,

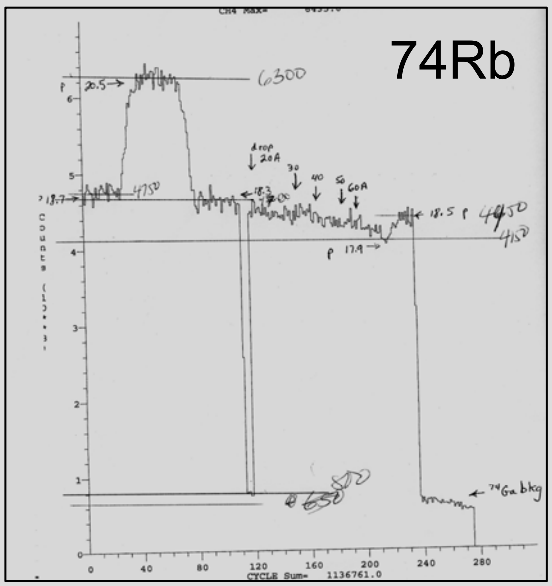
- Φ = Proton beam intensity,
- σ = Cross section,
- χ = Target thickness,
- ε_R = Effusion efficiency,
- ε_E = Diffusion efficiency,
- ε_i = Ionization efficiency.

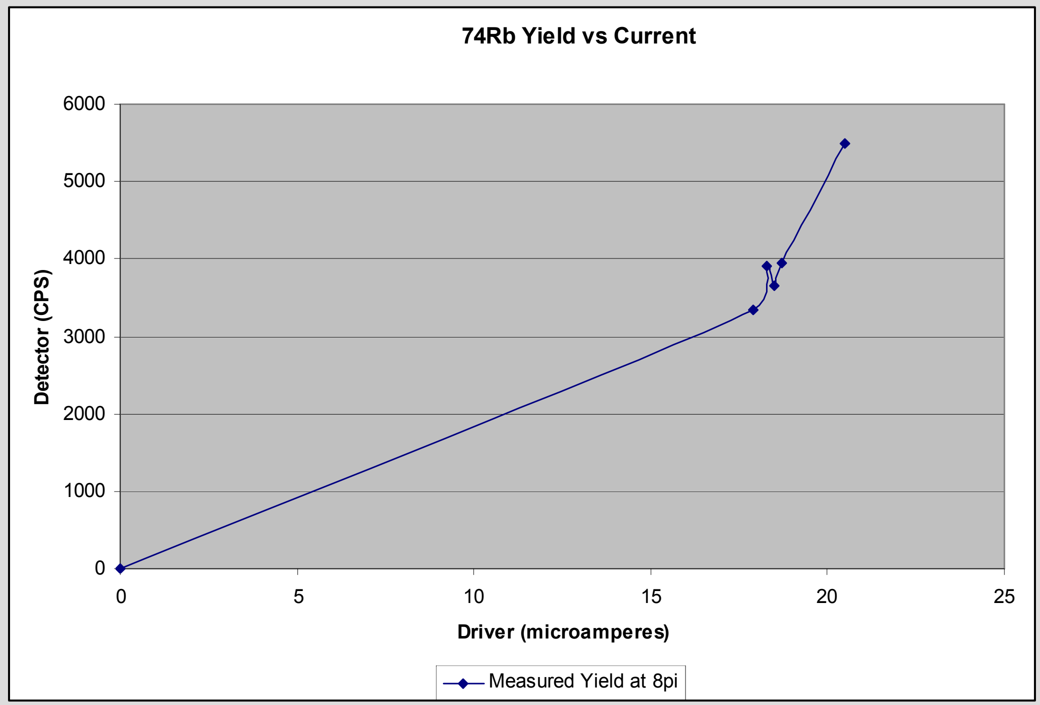


50 μA Protons

Yield Ratemeter



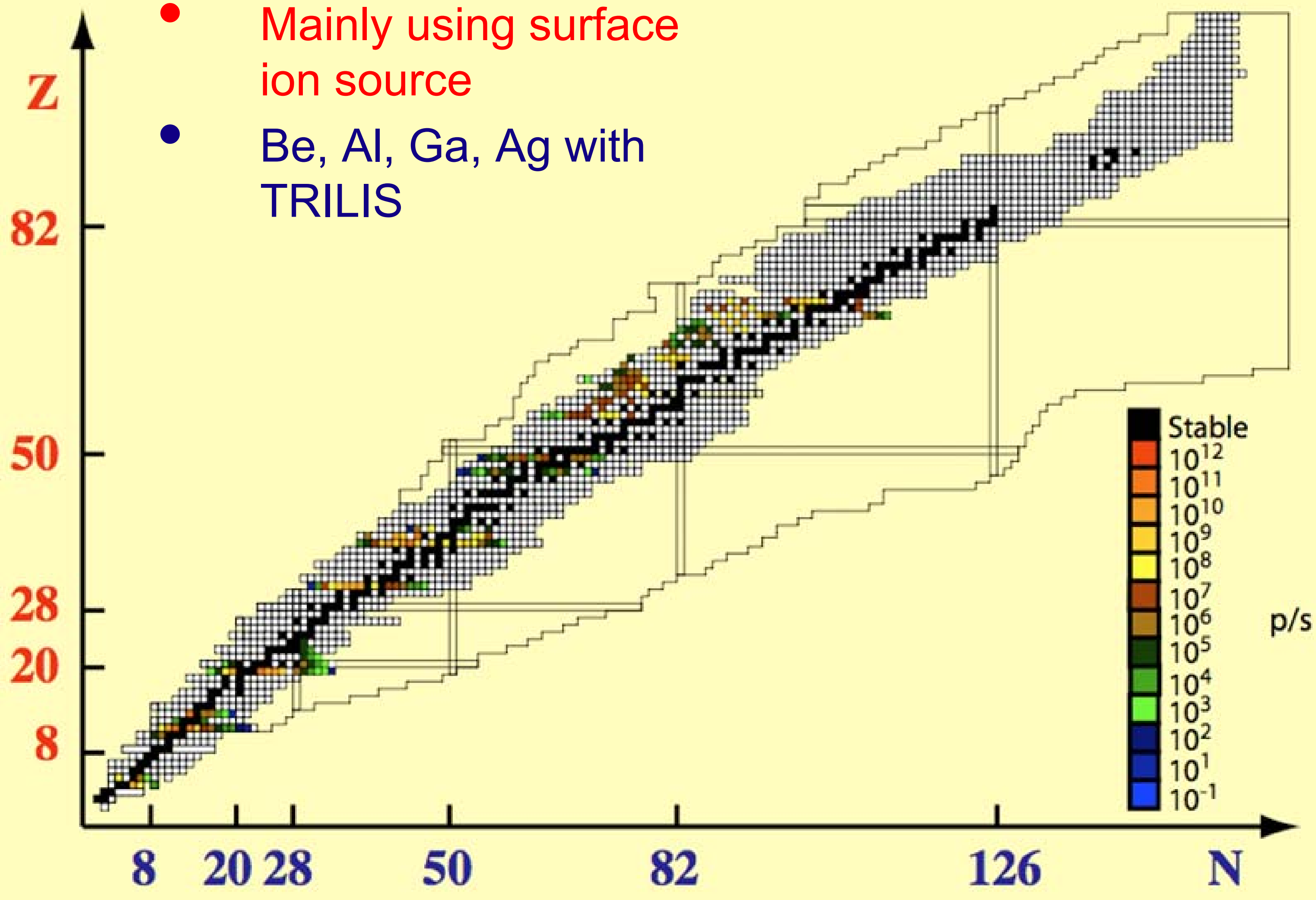




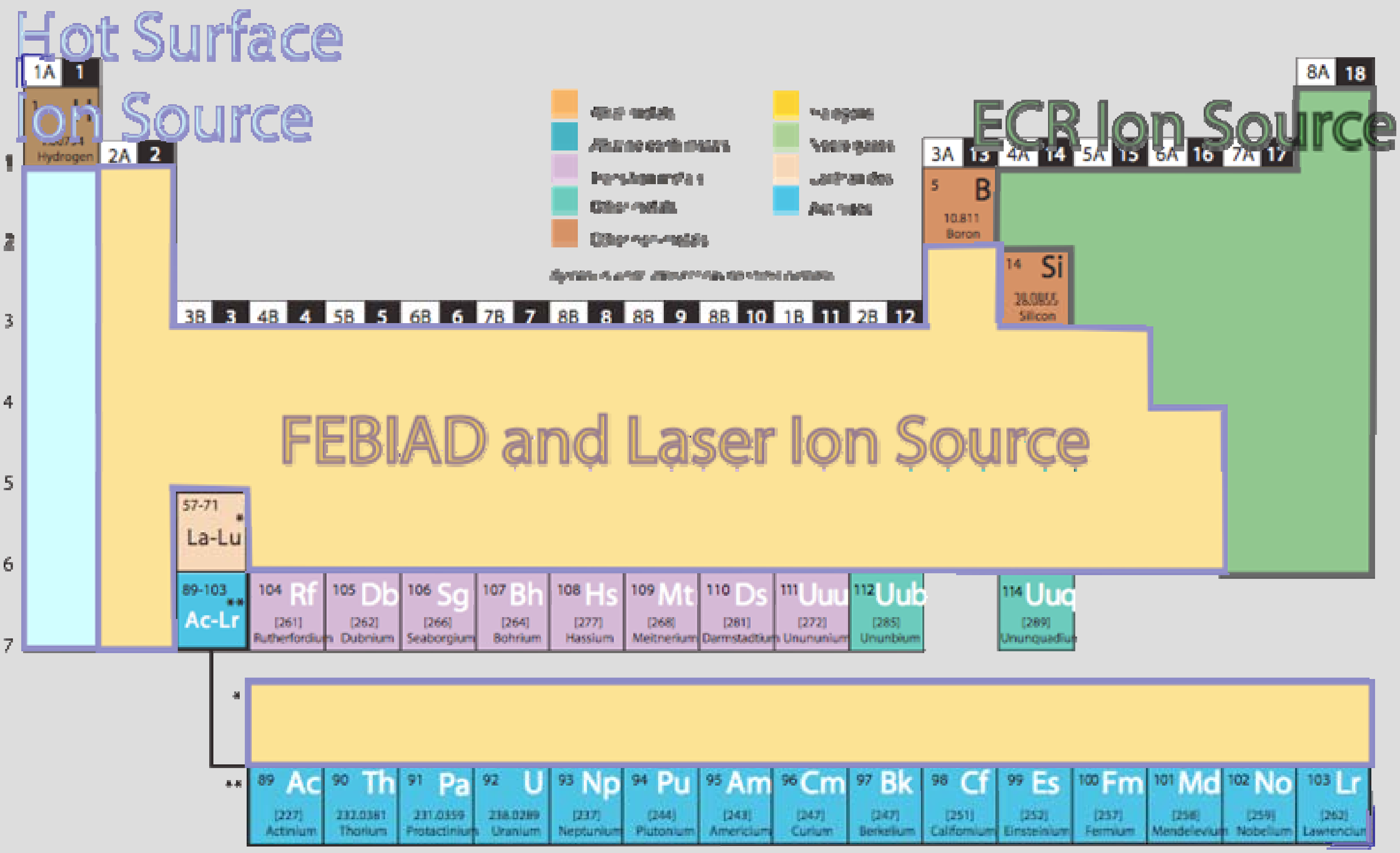
RIB Yields are non linear wrt Driver Current

ISAC RIB since 1998

- Mainly using surface ion source
- Be, Al, Ga, Ag with TRILIS



Ion Source Operation



ISAC Target & Thermal Ion Source

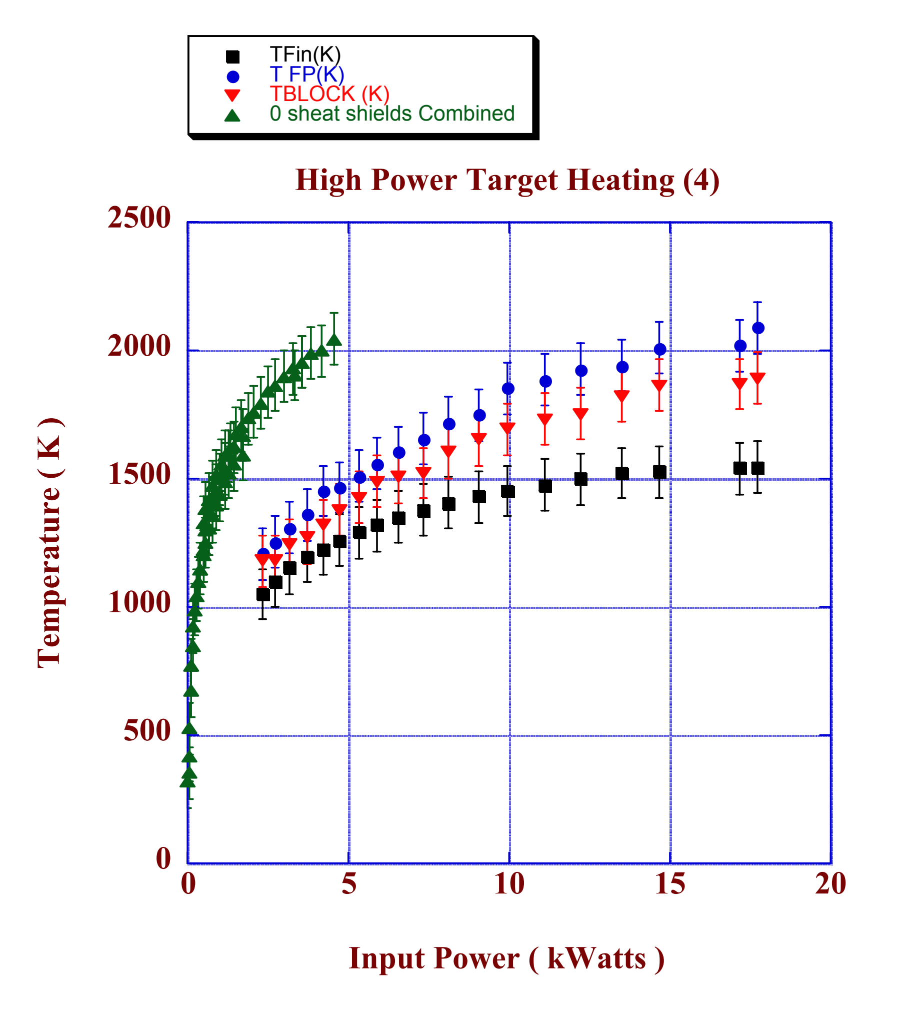
Target is made of a 19 mm diameter Ta tube 20 cm long.

The transfer tube is EB welded perpen-dicular to the oven tube.

The target material is stacked into the Ta tube.

The transfer tube is used for the SIS and LIS.

High Power Target



P. Bricault et al., EMIS XIV, Nucl. Instr. Meth.

Normal target design with fins on the target container.

Target Materials

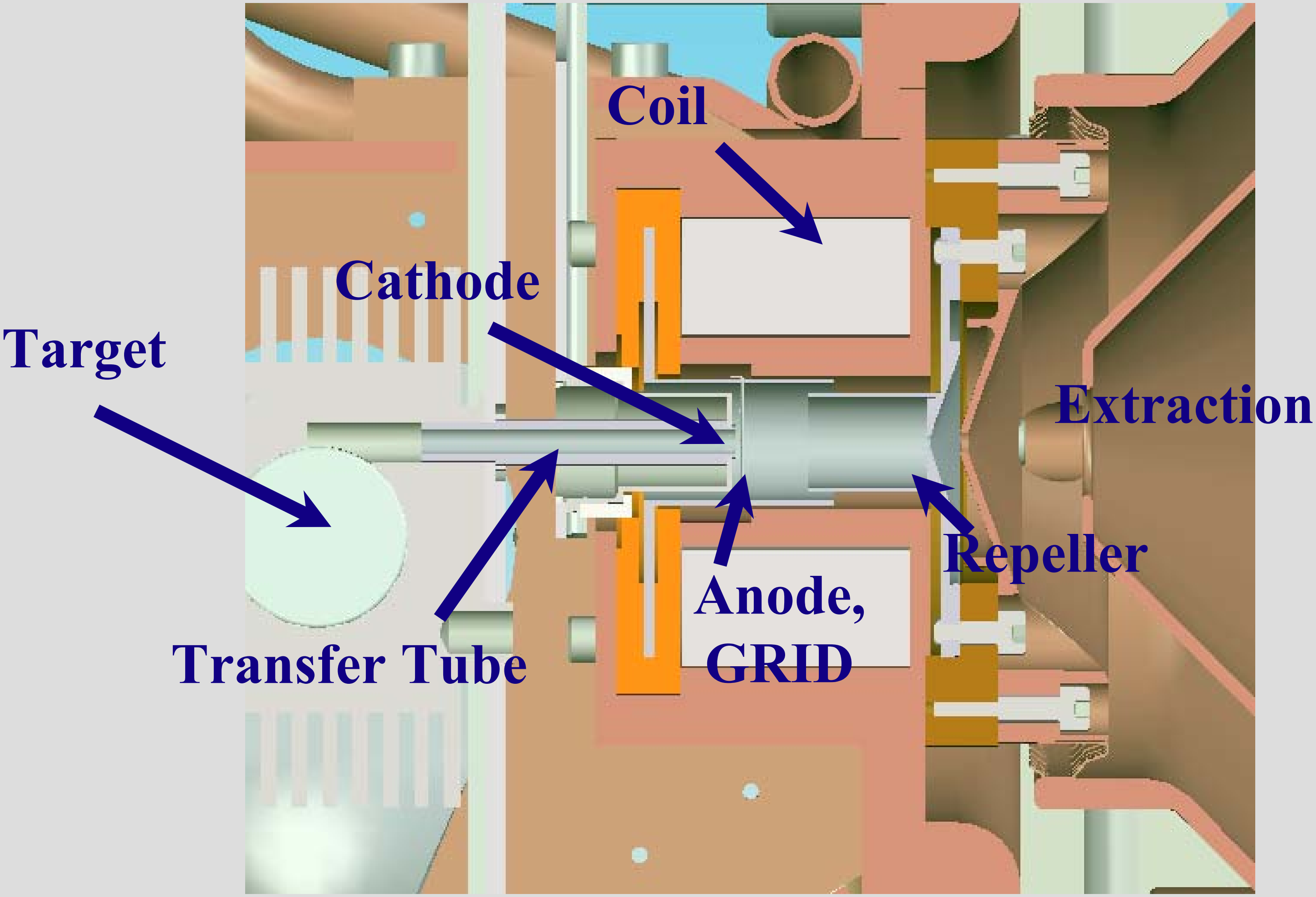
- Initially pressed pellets of oxide material and refractory metal foils were used.
- The oxides have very low thermal conductivity and the proton beam intensity was restricted to about 5 µA.
- With carbide compounds higher currents were possible. We were limited to 20 µA on SiC.
- Currently the carbides are bound onto a graphite foil to remove the heat load more effectively & 70 µA is possible.
- The same technique with Nb_5Si_3 on Nb foils is being tested.
- Refractory foils operated at 50 kW

Ta Foils

SiC on Graphite foil

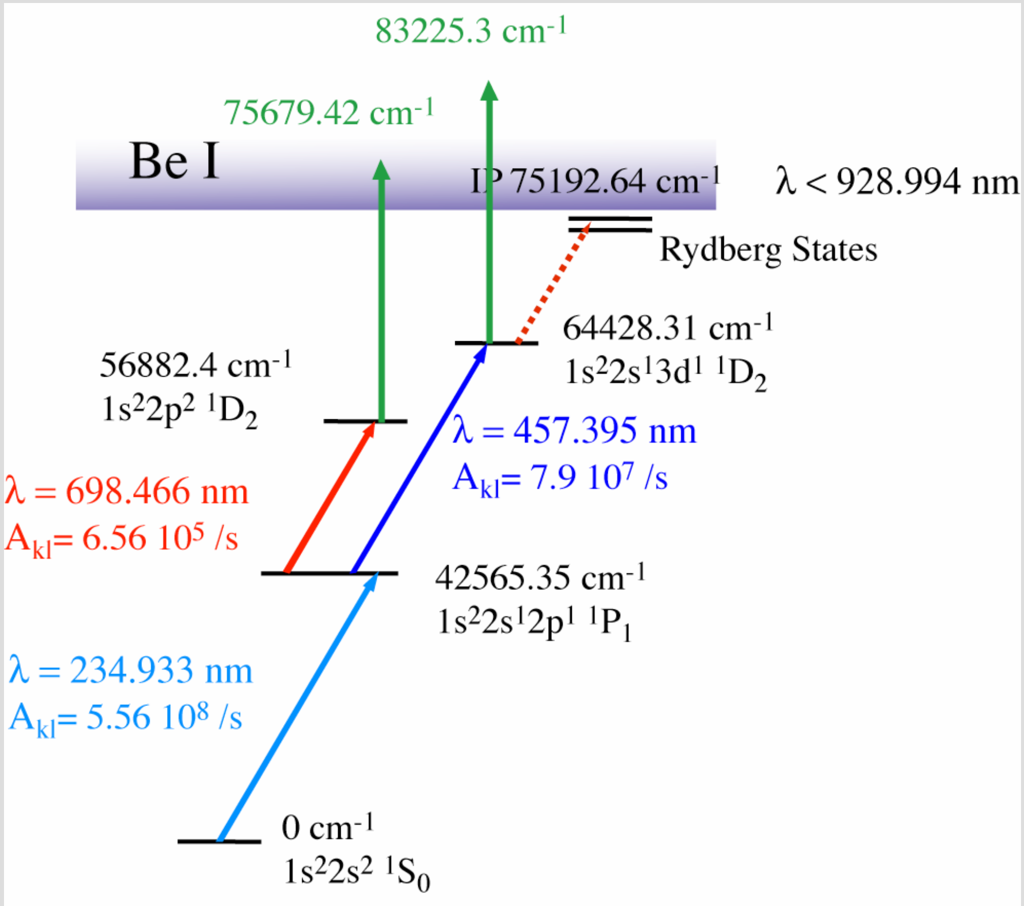
FEBIAD

Operational for 6 weeks at high power

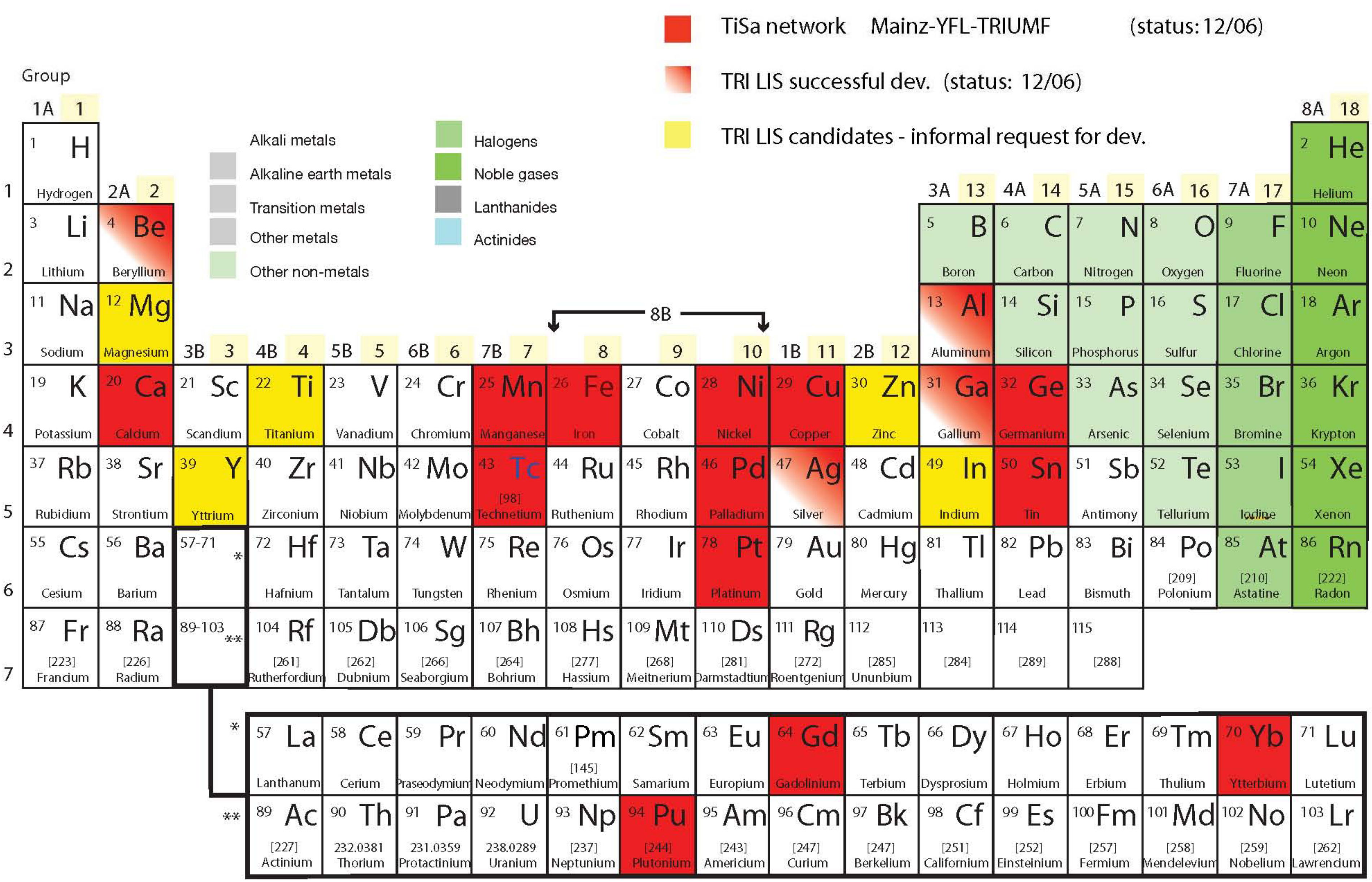


Resonant Laser ionization

$^{9-14}$Be 35µA p^+ on Ta target
on-line dev / yield run (05/2006)



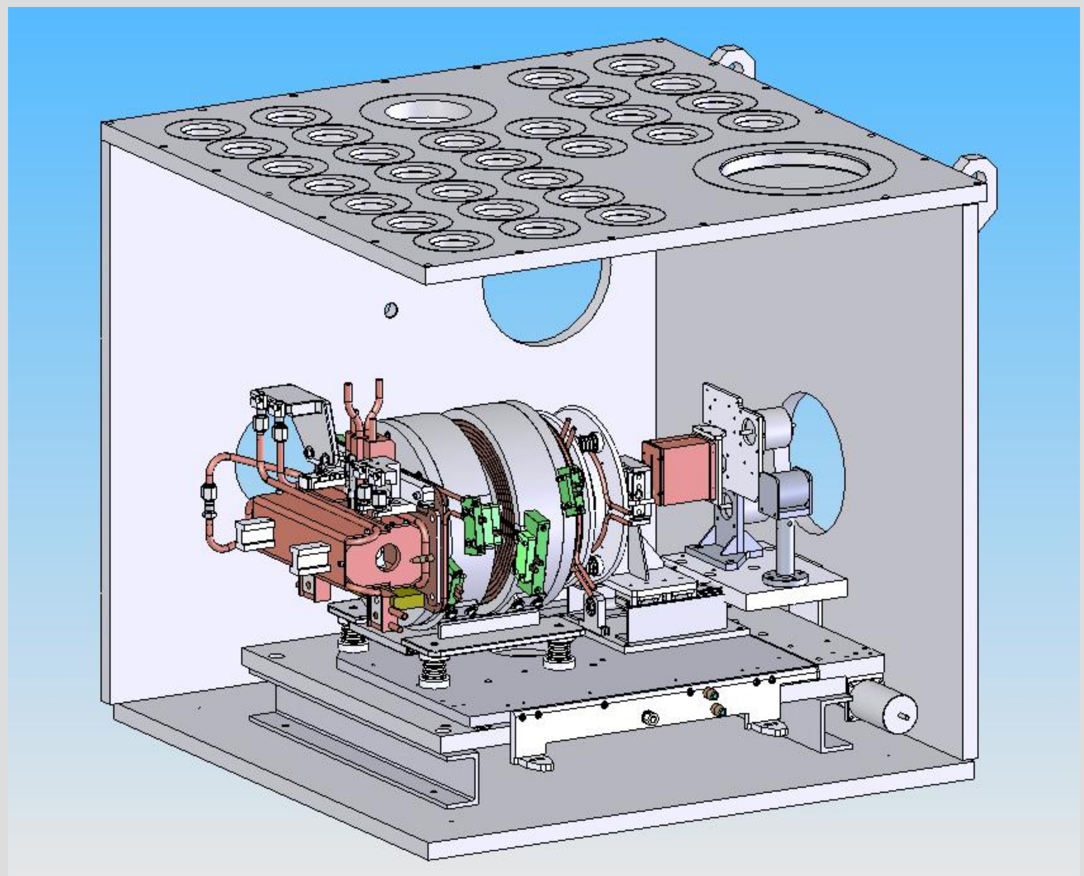
- Each element has specific atomic levels,
- The beam purity depends on the number of resonant step one uses,
- Rydberg or auto-ionization level probed to improve the Li ioniziation efficiency from a thermal surface ionization source



TiSa network Mainz-YFL-TRIUMF (status: 12/06)
TRI LIS successful dev. (status: 12/06)
TRI LIS candidates - informal request for dev.
Group
Alkali metals
Alkaline earth metals
Transition metals
Other metals
Other non-metals
Halogens
Noble gases
Lanthanides
Actinides
1A 1
2A 2
3A 13
4A 14
5A 15
6A 16
7A 17
8A 18
3B 3
4B 4
5B 5
6B 6
7B 7
8B
8
9
10
1B 11
2B 12
1
2
3
4
5
6
7
1 H Hydrogen
2 He Helium
3 Li Lithium
4 Be Beryllium
5 B Boron
6 C Carbon
7 N Nitrogen
8 O Oxygen
9 F Fluorine
10 Ne Neon
11 Na Sodium
12 Mg Magnesium
13 Al Aluminum
14 Si Silicon
15 P Phosphorus
16 S Sulfur
17 Cl Chlorine
18 Ar Argon
19 K Potassium
20 Ca Calcium
21 Sc Scandium
22 Ti Titanium
23 V Vanadium
24 Cr Chromium
25 Mn Manganese
26 Fe Iron
27 Co Cobalt
28 Ni Nickel
29 Cu Copper
30 Zn Zinc
31 Ga Gallium
32 Ge Germanium
33 As Arsenic
34 Se Selenium
35 Br Bromine
36 Kr Krypton
37 Rb Rubidium
38 Sr Strontium
39 Y Yttrium
40 Zr Zirconium
41 Nb Niobium
42 Mo Molybdenum
43 Tc [98] Technetium
44 Ru Ruthenium
45 Rh Rhodium
46 Pd Palladium
47 Ag Silver
48 Cd Cadmium
49 In Indium
50 Sn Tin
51 Sb Antimony
52 Te Tellurium
53 I Iodine
54 Xe Xenon
55 Cs Cesium
56 Ba Barium
57-71 *
72 Hf Hafnium
73 Ta Tantalum
74 W Tungsten
75 Re Rhenium
76 Os Osmium
77 Ir Iridium
78 Pt Platinum
79 Au Gold
80 Hg Mercury
81 Tl Thallium
82 Pb Lead
83 Bi Bismuth
84 Po [209] Polonium
85 At [210] Astatine
86 Rn [222] Radon
87 Fr [223] Francium
88 Ra [226] Radium
89-103 **
104 Rf [261] Rutherfordium
105 Db [262] Dubnium
106 Sg [266] Seaborgium
107 Bh [264] Bohrium
108 Hs [277] Hassium
109 Mt [268] Meitnerium
110 Ds [281] Darmstadtium
111 Rg [272] Roentgenium
112 [285] Ununbium
113 [284]
114 [289]
115 [288]
*
57 La Lanthanum
58 Ce Cerium
59 Pr Praseodymium
60 Nd Neodymium
61 Pm [145] Promethium
62 Sm Samarium
63 Eu Europium
64 Gd Gadolinium
65 Tb Terbium
66 Dy Dysprosium
67 Ho Holmium
68 Er Erbium
69 Tm Thulium
70 Yb Ytterbium
71 Lu Lutetium
**
89 Ac [227] Actinium
90 Th 232.0381 Thorium
91 Pa 231.0359 Protactinium
92 U 238.0289 Uranium
93 Np [237] Neptunium
94 Pu [244] Plutonium
95 Am [243] Americium
96 Cm [247] Curium
97 Bk [247] Berkelium
98 Cf [251] Californium
99 Es [252] Einsteinium
100 Fm [257] Fermium
101 Md [258] Mendelevium
102 No [259] Nobelium
103 Lr [262] Lawrencium

MISTIC-ECR Ion Source

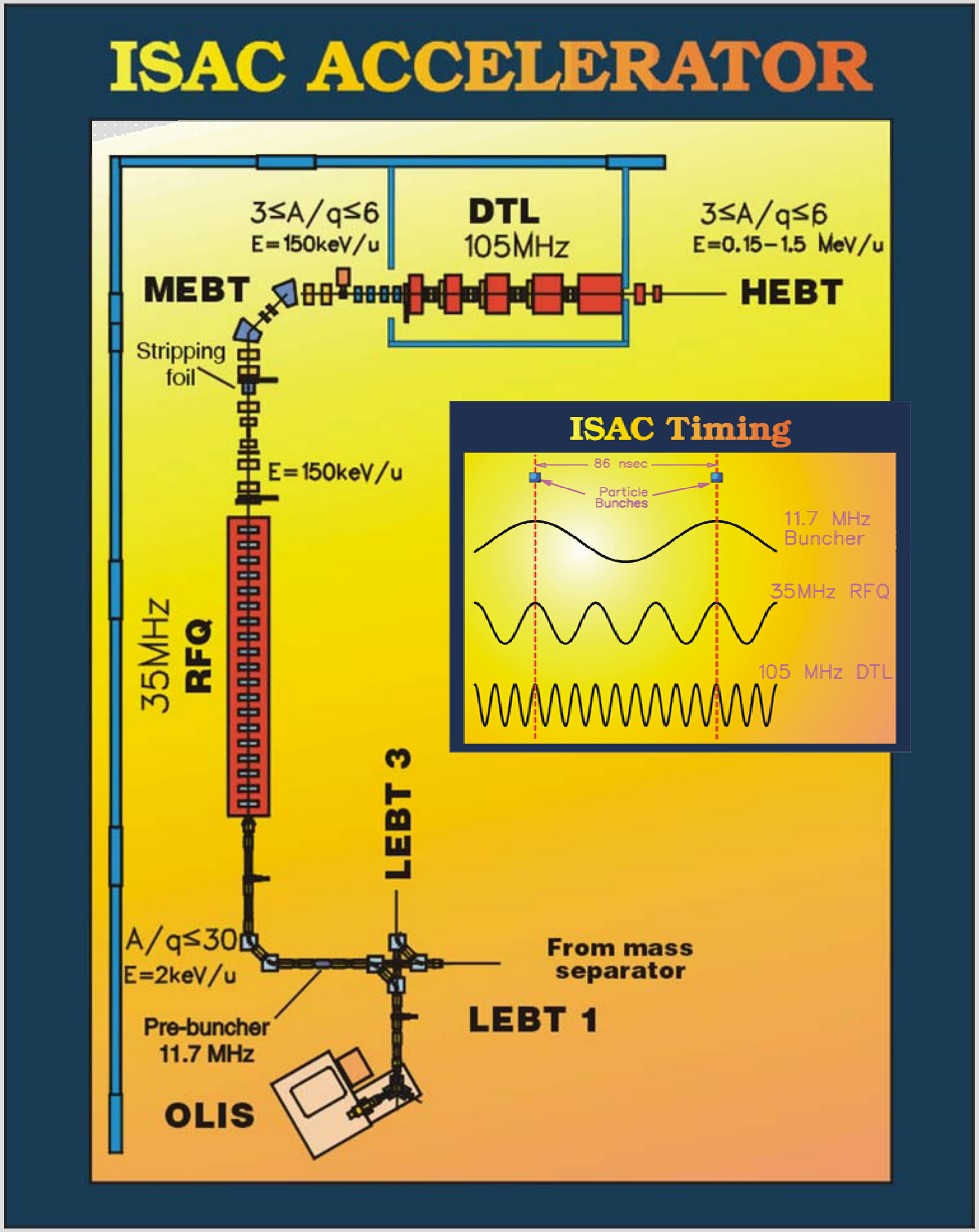
Operational on Ion Source
Test Stand

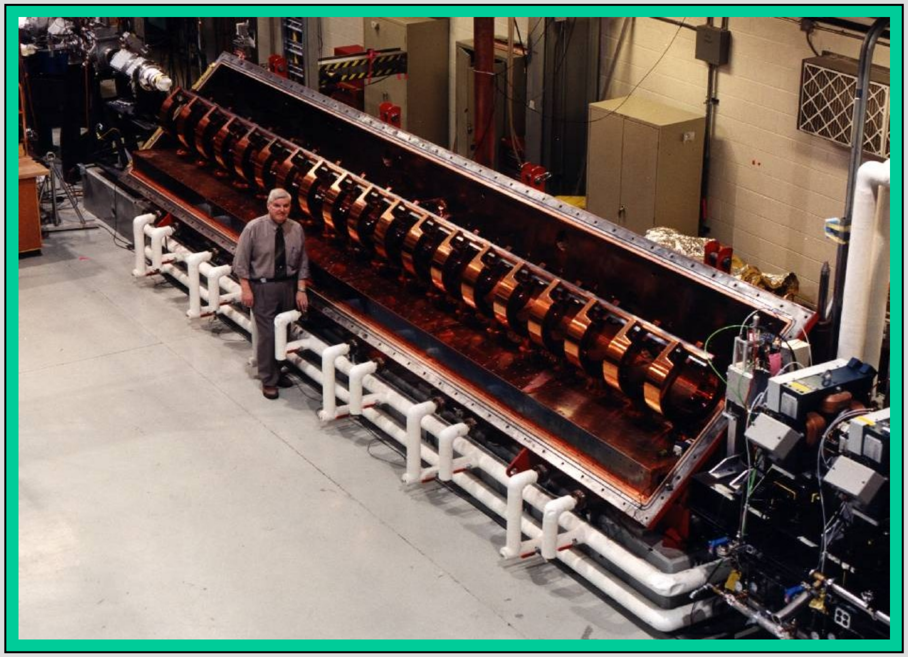


ISAC Accelerators

ISAC-I Accelerator

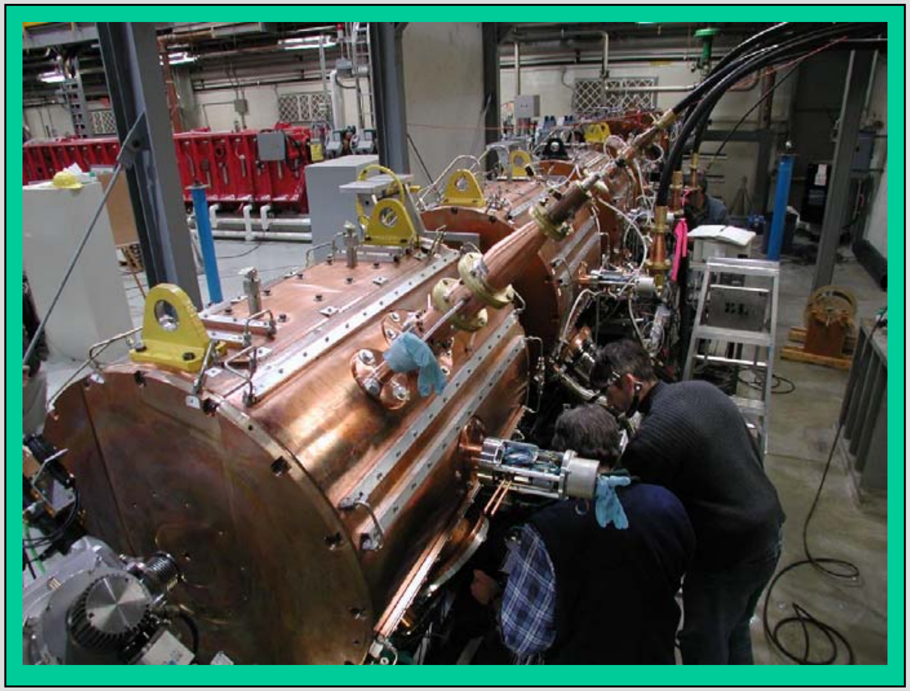
- OLIS
  - Stable beams
- LEBT
  - All-electrostatic (2 keV/u)
  - 11.8 MHz multi-harmonic pre-buncher
- 35 MHz cw RFQ
  - E=2→153 keV/u
  - A/q<=30
- MEBT
  - Stripping foil
  - 35 MHz rebuncher
- 105 MHz cw Variable Energy DTL
  - E=0.15-1.8 MeV/u
  - A/Q<=6
- HEBT
  - Diagnostic section
  - 11.8/35 MHz rebunchers





ISAC 35MHz Split-ring RFQ

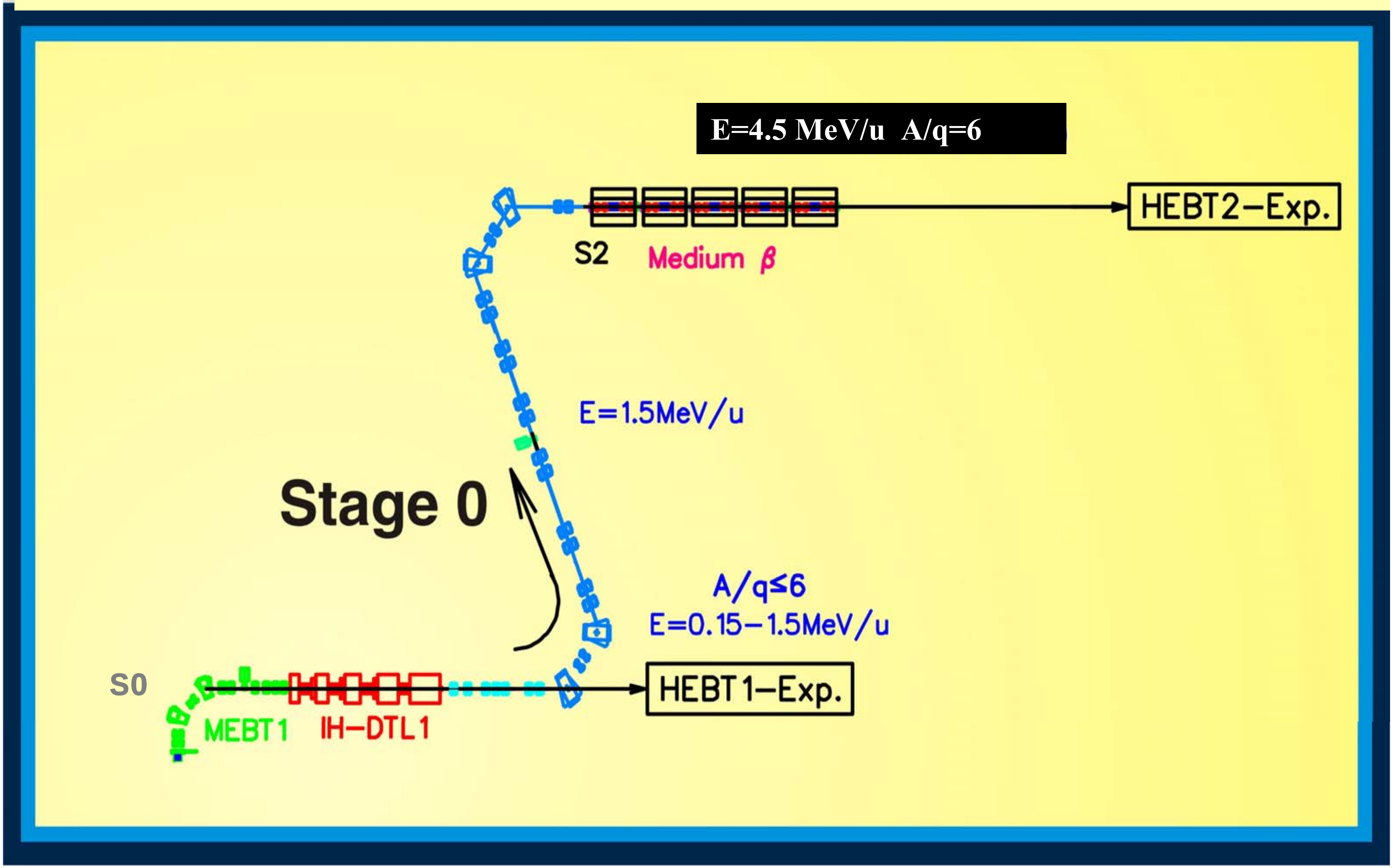
Accelerates ions with A/q<=30 from 2 keV/u to 150 keV/u



ISAC 106MHz Separated Function DTL

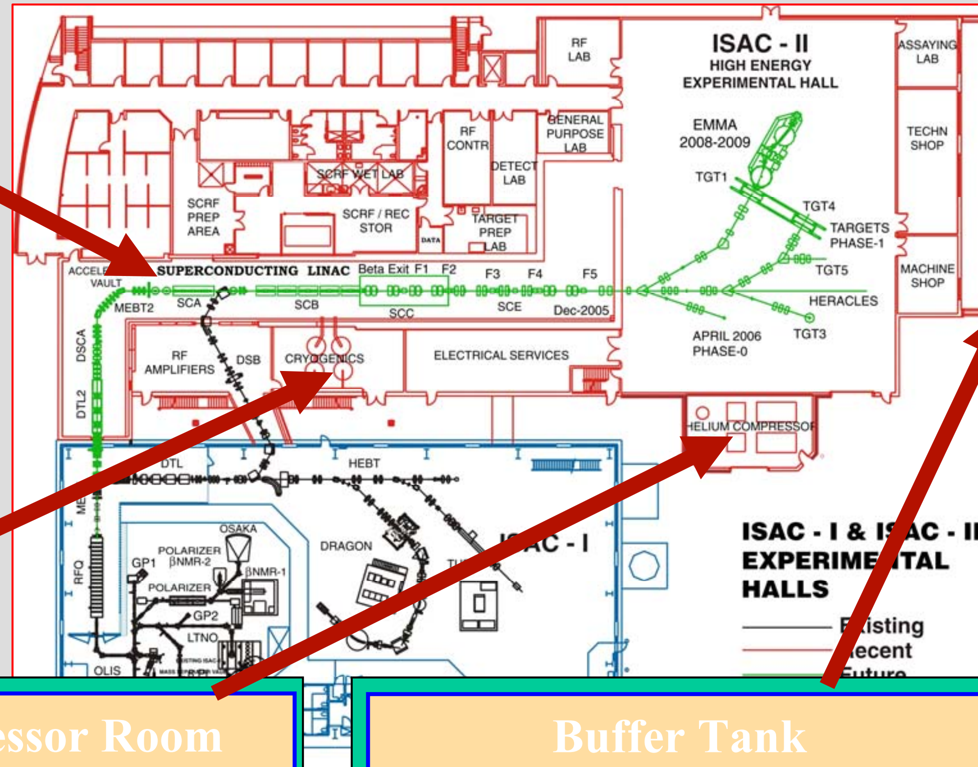
Accelerates ions with A/q<=6 to final energies fully variable from 0.15<E<1.8 MeV/u

ISAC-II (Phase I - Medium Beta Section) Commissioned in 2006

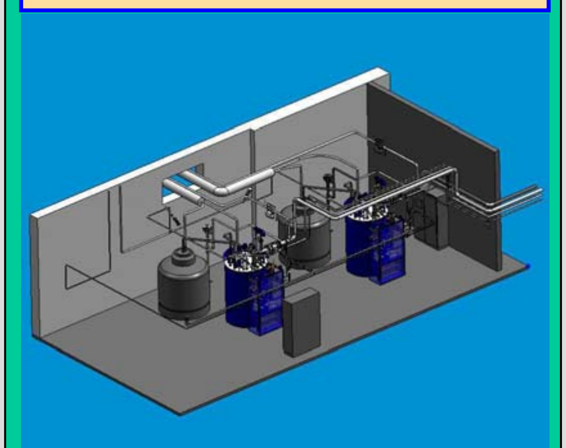


ISAC-II Cryogenics

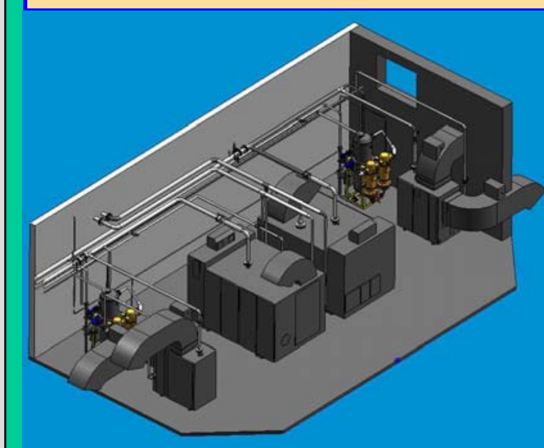
Accelerator Vault



Refrigerator Room



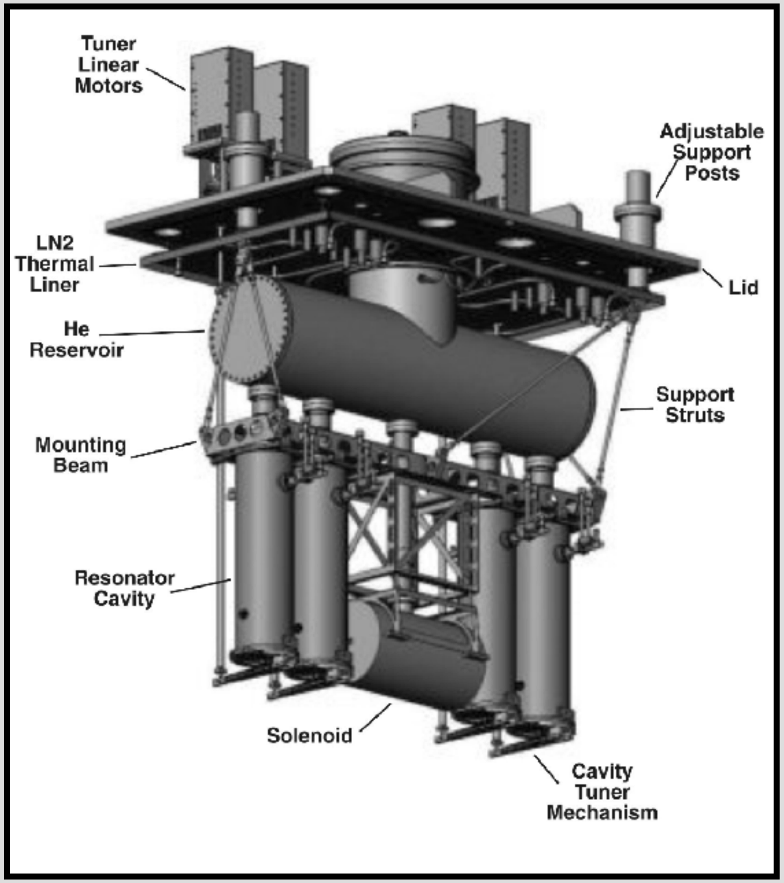
Compressor Room



Buffer Tank

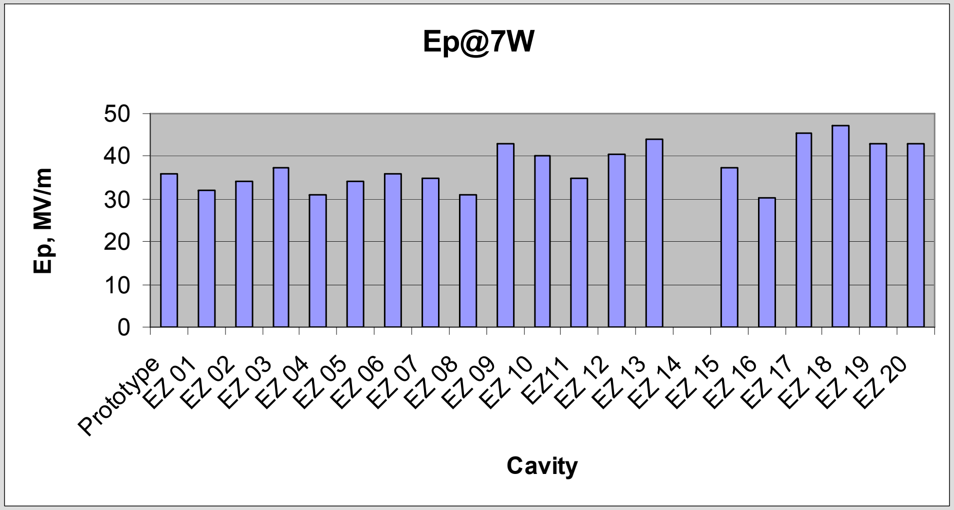
Medium Beta Cryomodule

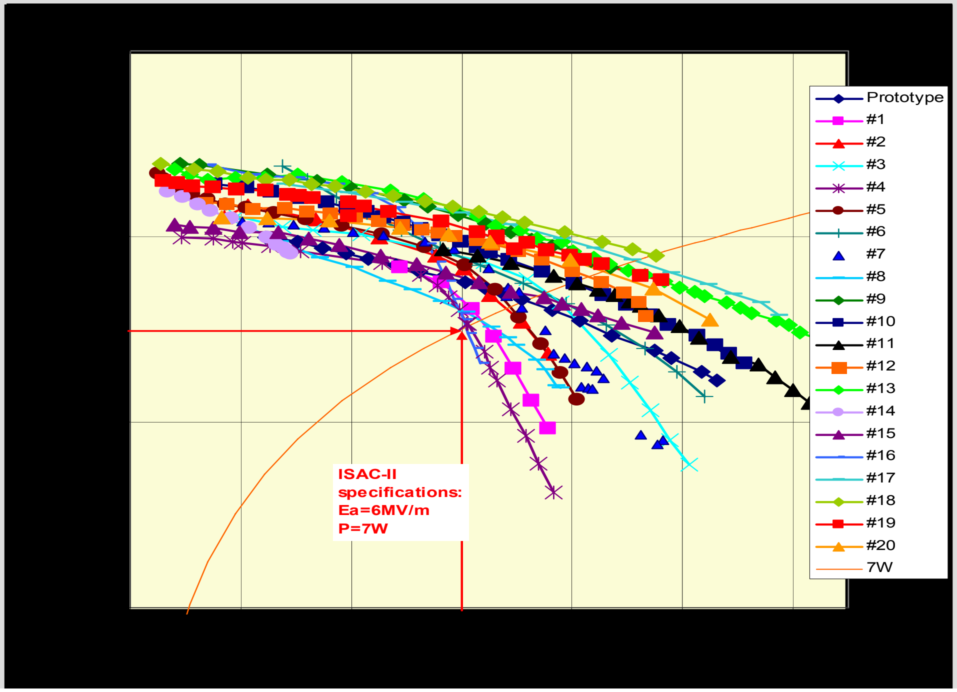
- ❑ 2x2x1m stainless steel box vacuum vessel
- ❑LN2 cooled copper sheet used as thermal shield
- ❑Mu metal between vacuum tank and LN2 shield
- ❑Cold mass suspended from lid on three adjustable support pillars
- ❑Four cavities Ep=30MV/m
- ❑One SC solenoid @ 9T
- ❑V_{eff}=4.3MV
- ❑Single vacuum for thermal insulation and rf



Lid Assembly in Assembly Frame

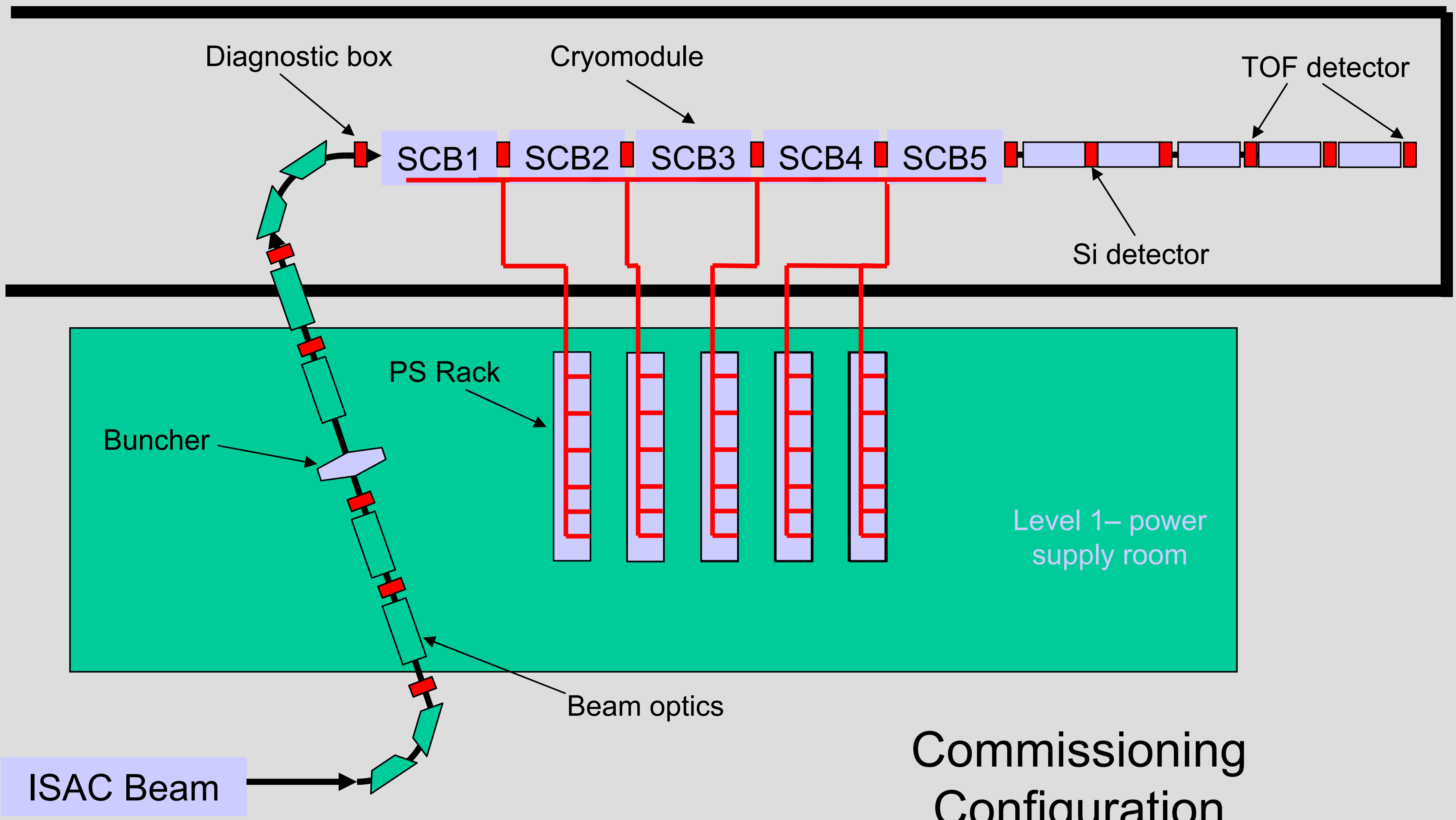
Single Cavity Performance Summary



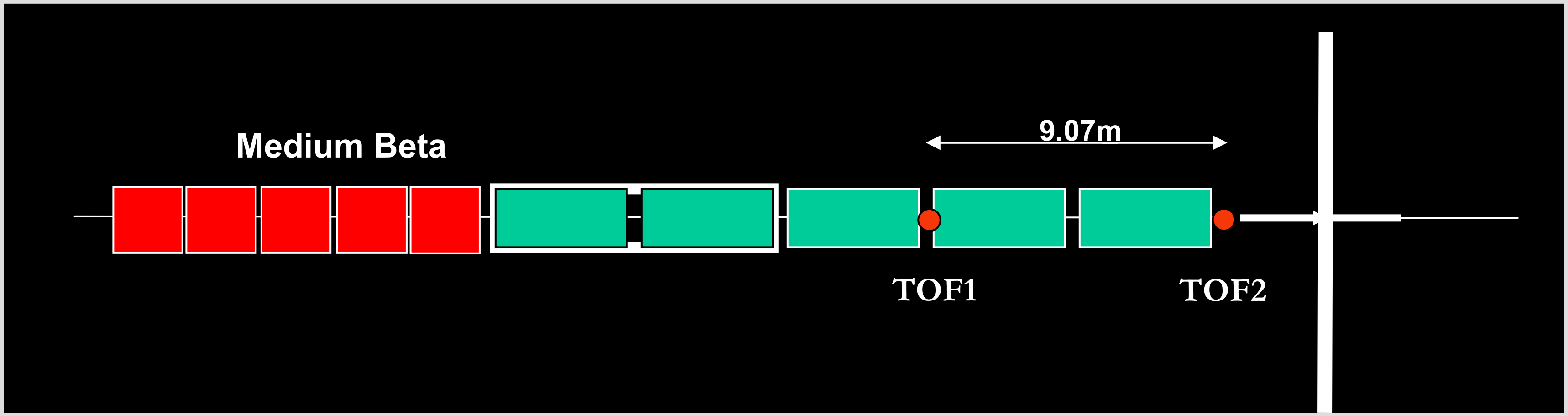


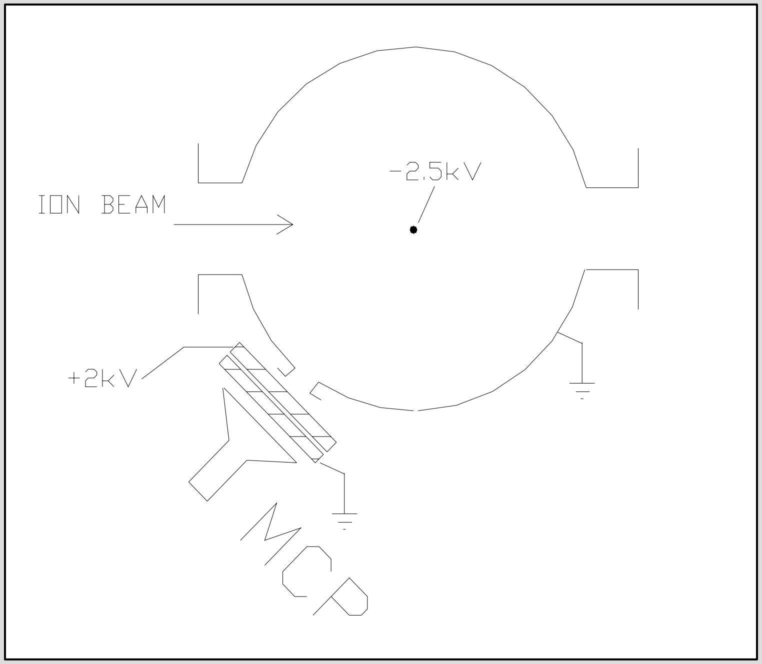
- •Cavities tested initially in single cavity cryostat
- •Average peak surface field at operating power of 7W is now Ep=38MV/m corresponding to a voltage gain of 1.4MV/cavity and a magnetic field of Bp=75mT and a gradient Ea=7.5MV/m

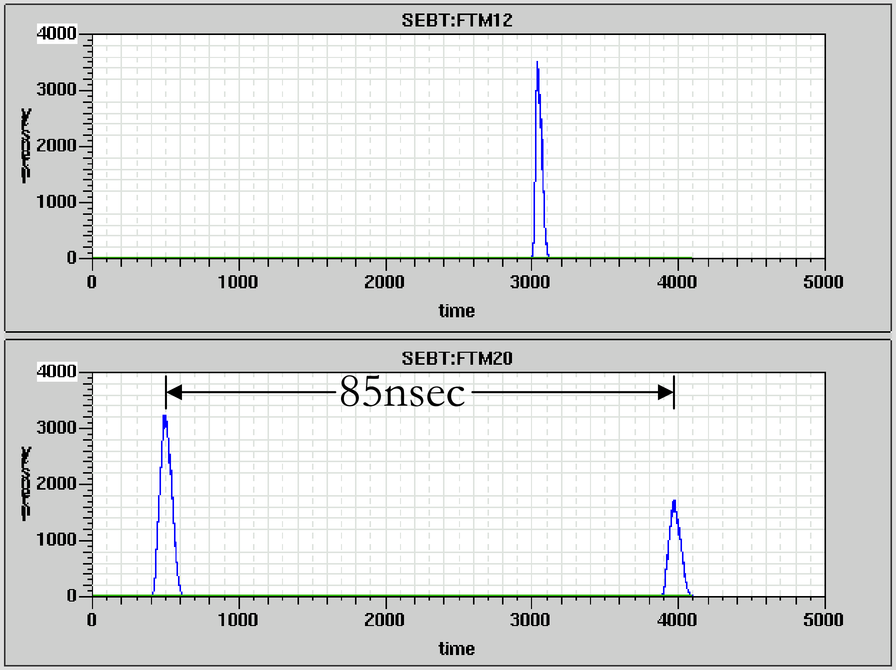
LINAC Commissioning Floor Layout



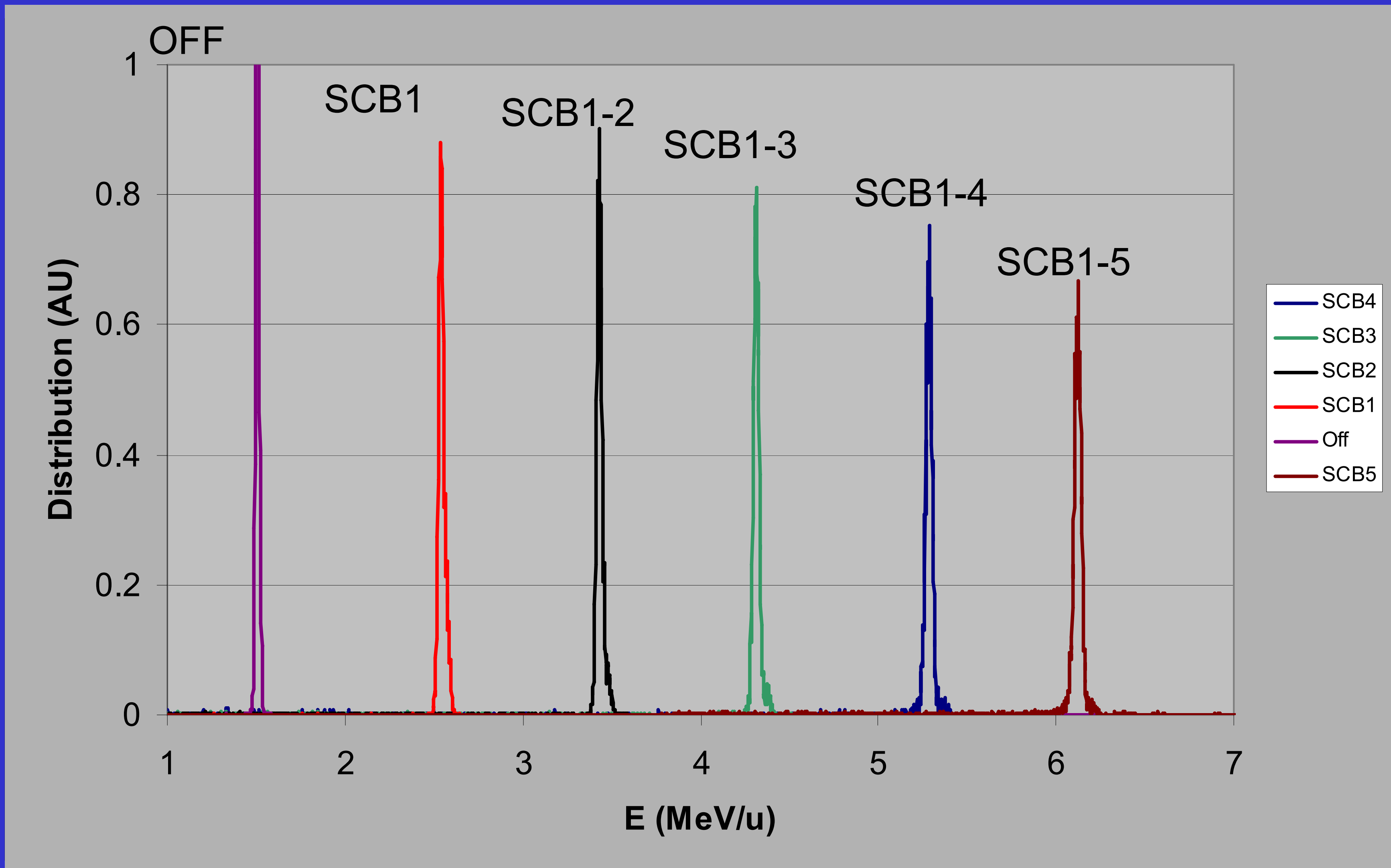
Energy Measurement – Time of Flight (TOF)





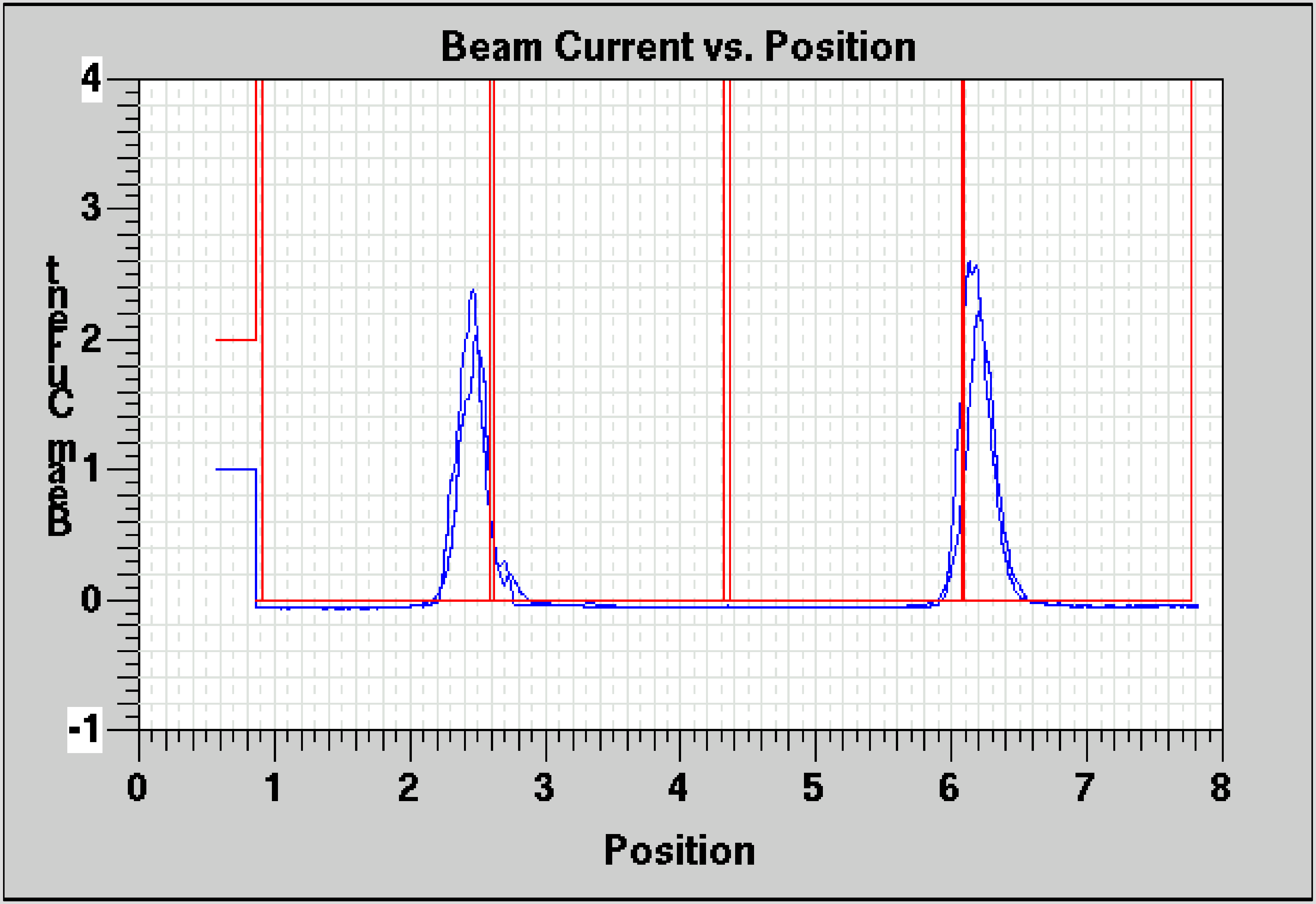


Milestone: Acceleration April 8, 2006

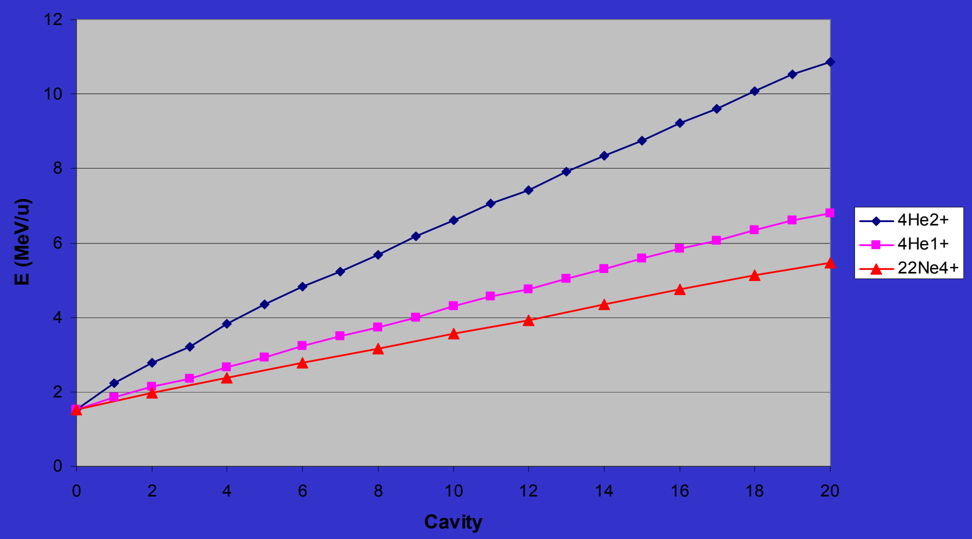


Energy after each cryomodule for C12(3+) with an injection energy of 1.5Mev/U.

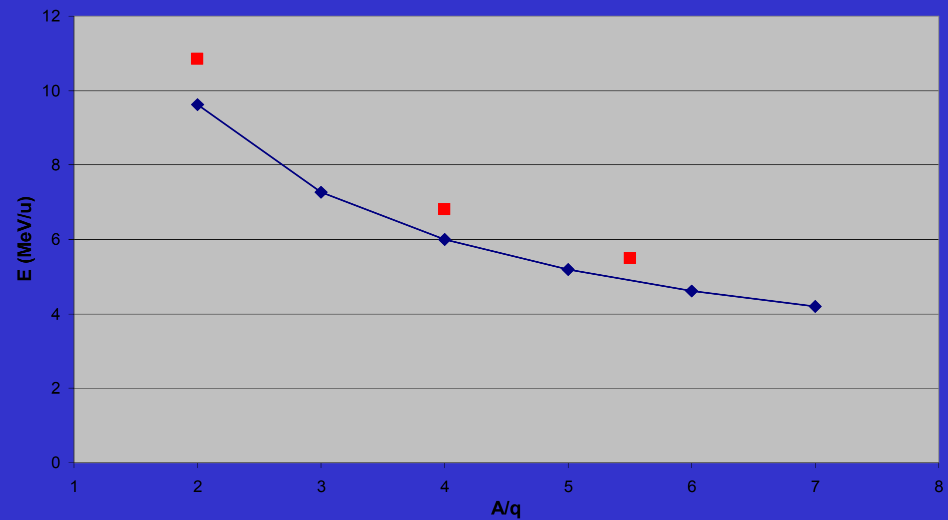
Beam Profile of full energy beam



Acceleration Summary



Energy history during acceleration.



Expected E_{final} for 6MV/m and actual E_{final}

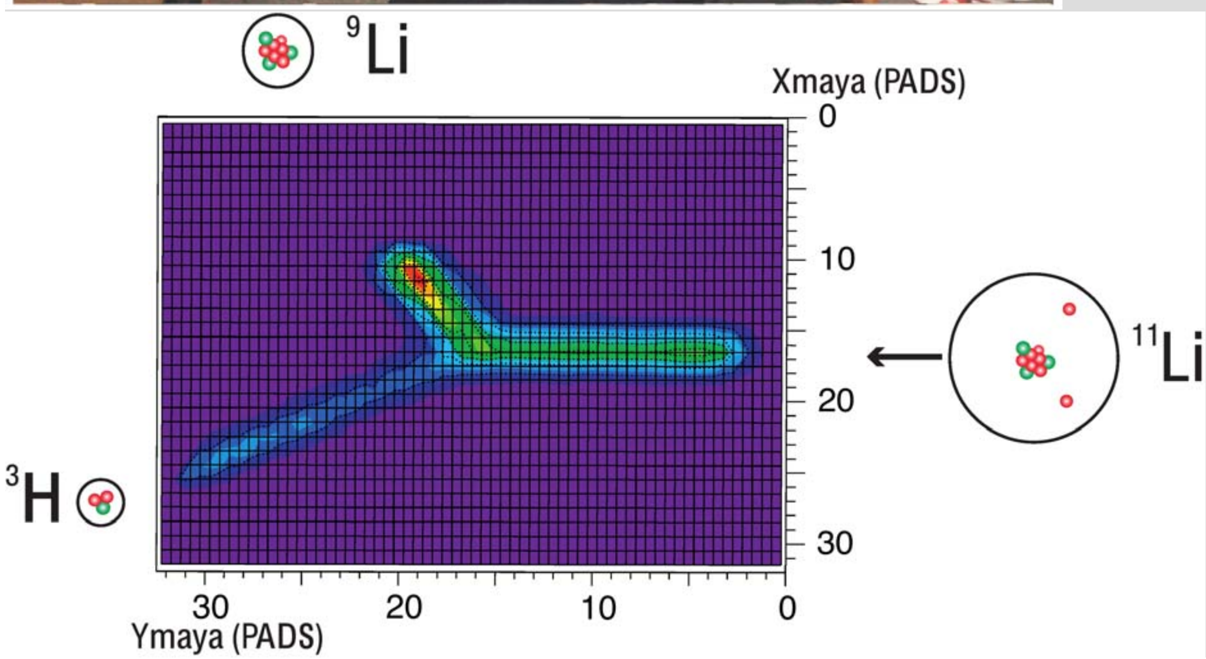
Commissioning beams

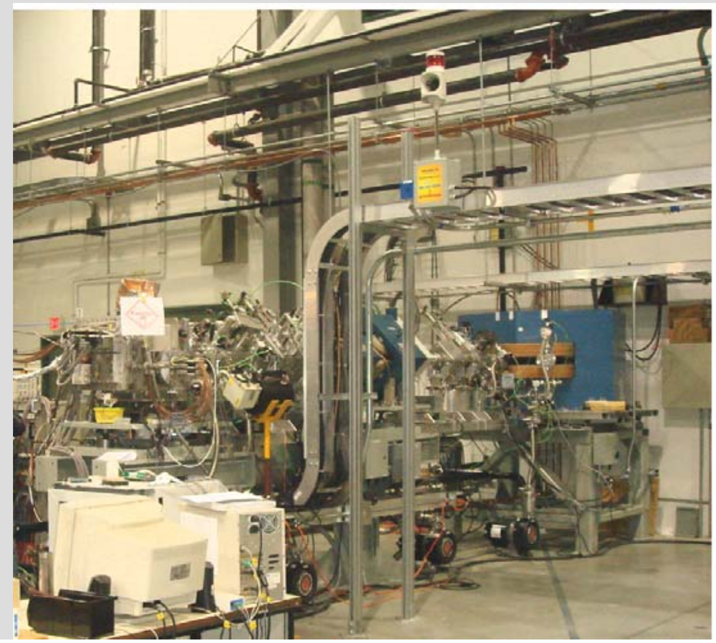
- A/q=5.5 (22Ne4+)
- A/q=4 (40Ca10+, 20Ne5+, 12C3+, 4He1+)
- A/q=2 (4He2+)

Performance

- Power @ 7W/cavity
- Design gradient is 6MV/m
- Average gradient is 7.2MV/m
- Final energy is 10.8, 6.8 and 5.5MeV/u for A/q=2, 4, 5.5 respectively
- Transmission >90%

January 05, 2007
First RIB in ISAC II

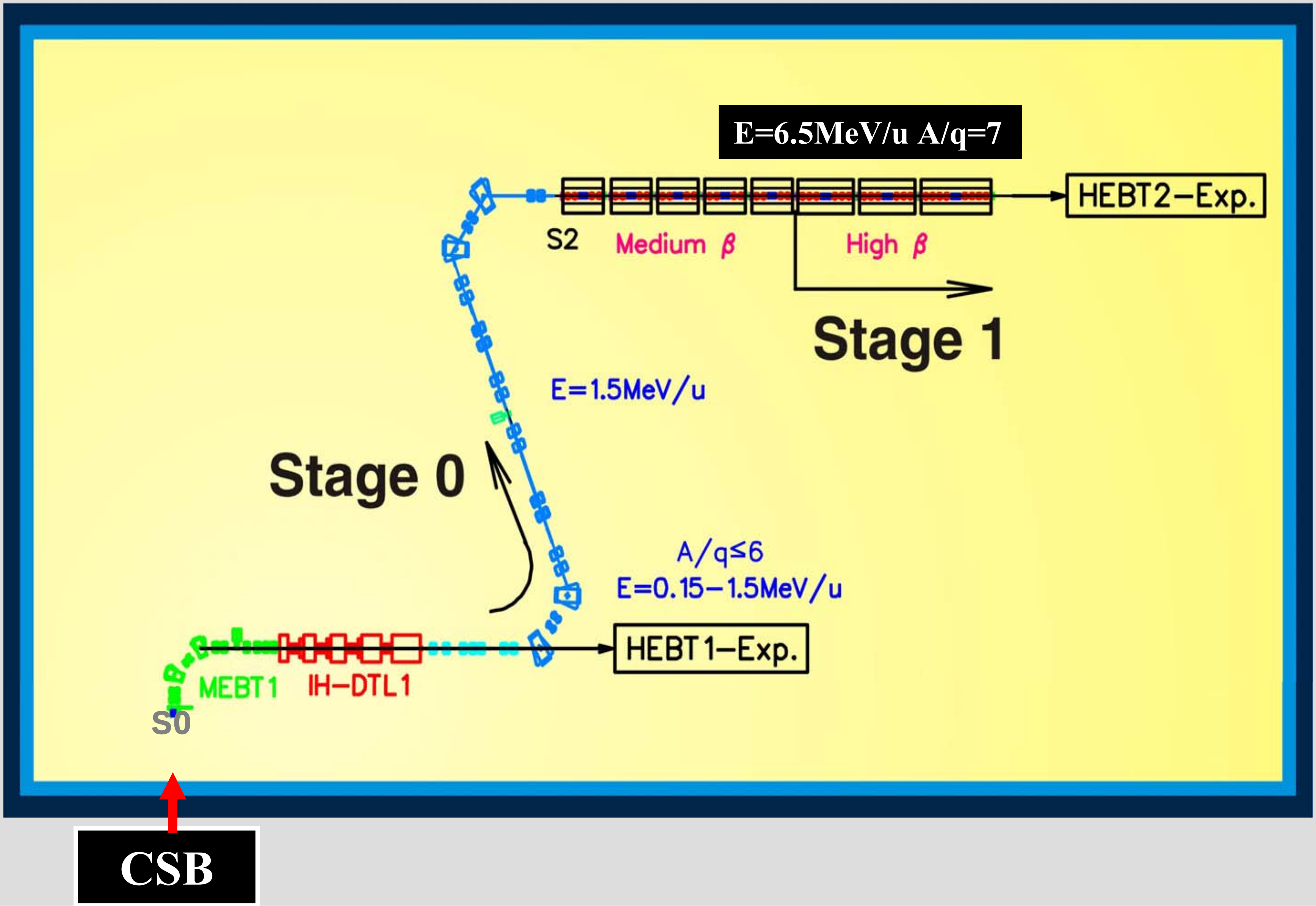




Near Term Plans for ISAC I & II

- Install ISAC II experimental stations & Beamlines
  - TIGRESS, EMMA, Heracles, ..
- Operation with Actinide Targets
  - Initial tests in 2007
  - Obtain fission produced neutron rich isotopes
- Completion of ISAC II Accelerators
  - High Beta cavities planned for 2009
  - To reach design energy of 6.5 MeV/u for all masses
- Installation of Charge State Booster in 2008
  - Heavier masses can be accelerated

Stage 1 - 2009



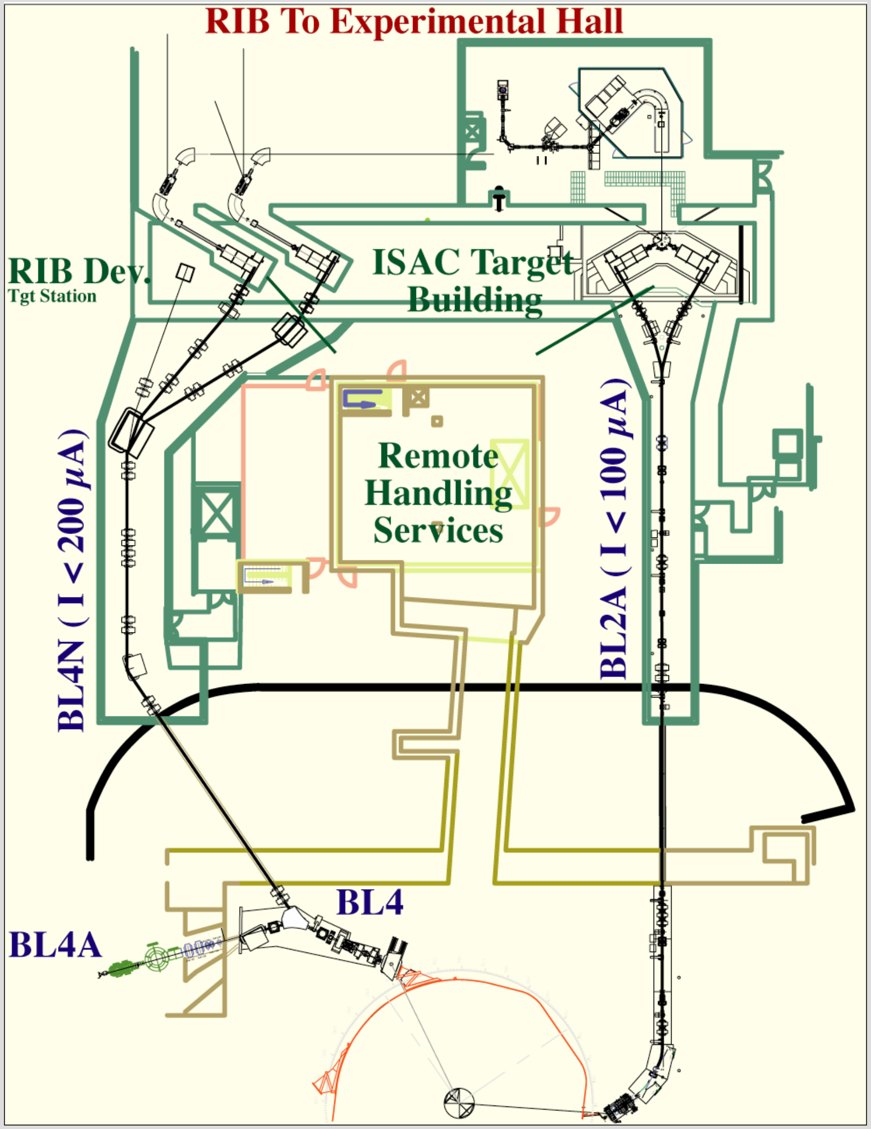
E=6.5MeV/u A/q=7
HEBT2–Exp.
S2
Medium β
High β
Stage 1
E=1.5MeV/u
Stage 0
A/q≤6
E=0.15–1.5MeV/u
HEBT1–Exp.
MEBT1
IH–DTL1
S0
CSB

ISAC Future Plans

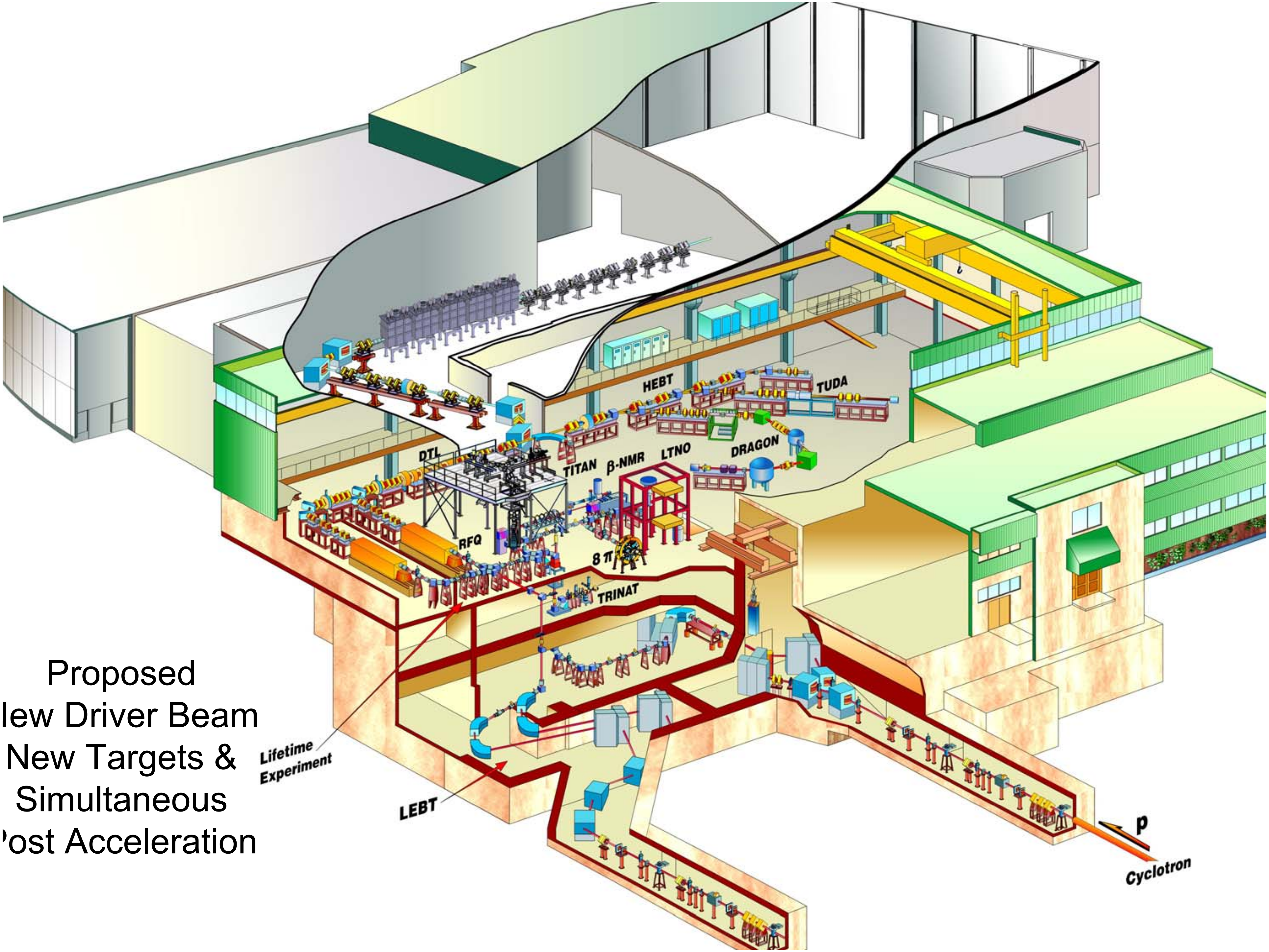
Beyond ISAC II

ISAC Future Plan

- The TRIUMF cyclotron driver could provide another proton beam (~ 200 - 400 μA) from a presently unused beam line (BL4AN) to new target stations,
- These target stations would then provide a place to perform systematic development of exotic beams,
  - Ion Source development,
  - Characterization of new targets
- An additional Radioactive Nuclear Beam could be simultaneously accelerated from these new target stations for experiment



Proposed
lew Driver Beam
New Targets &
Simultaneous
'ost Acceleration



Summary

- Target & Ion Sources
  - ISAC operates at 100 μA (50 kW)
  - Composite carbide targets on graphite foils operate at the same powers as refractory foils
  - Surface, FEBIAD & resonant laser ion sources are in operation
  - ECR ion source is in testing stage
  - Actinide target capability is planned
- ISAC II
  - Stage 0 of ISAC II accelerators (medium beta) has operated with RIB
  - ♦ First experiment took data in Jan. 2007 (MAYA) using ^{11}Li
  - ♦ A further 20MV of acceleration being prepared for 2009
- Concepts are being developed for a dedicated target testing facility & for simultaneous multi user capability