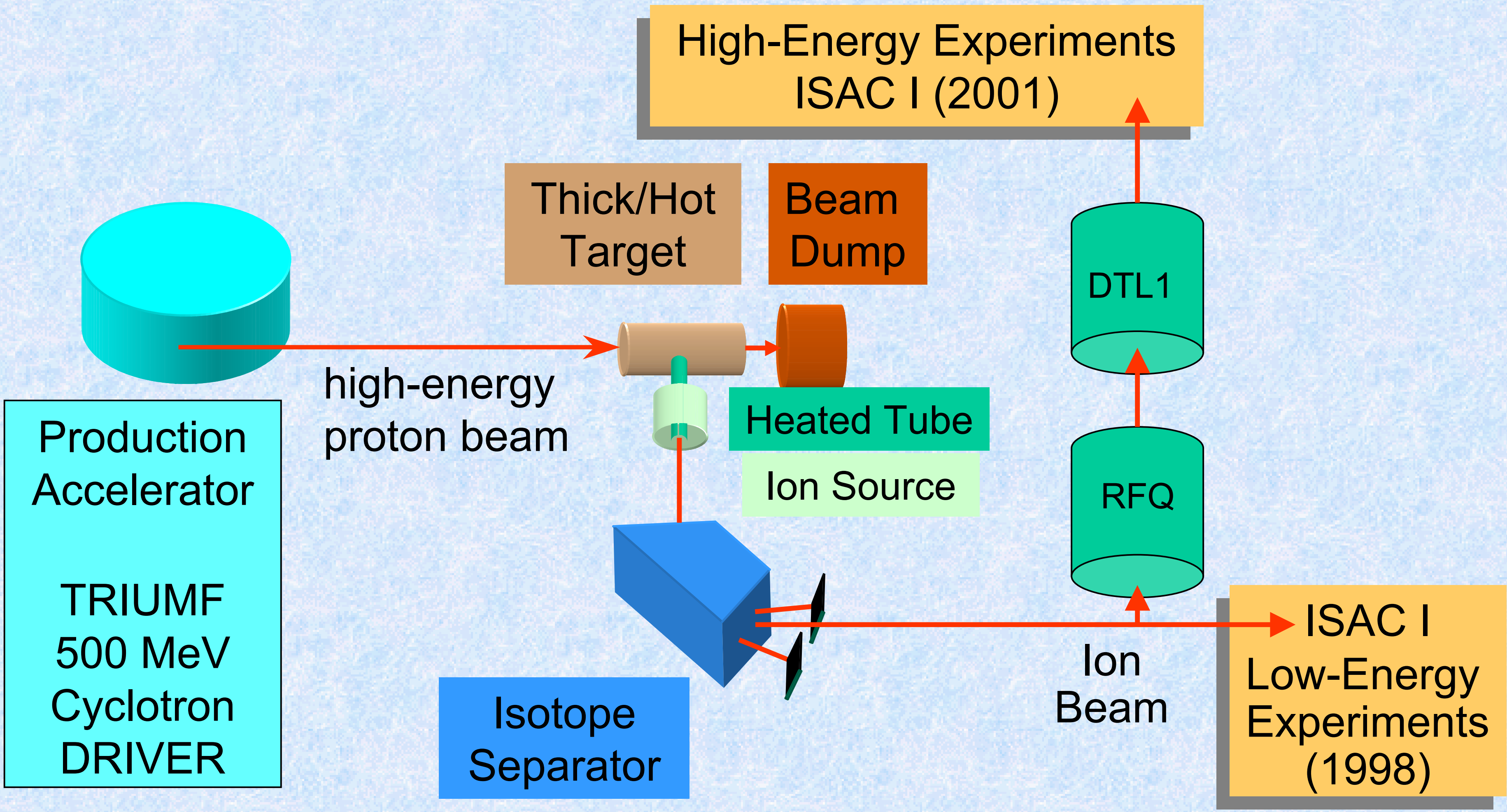
ISAC STATUS

P. W. Schmor
ISAC/TRIUMF

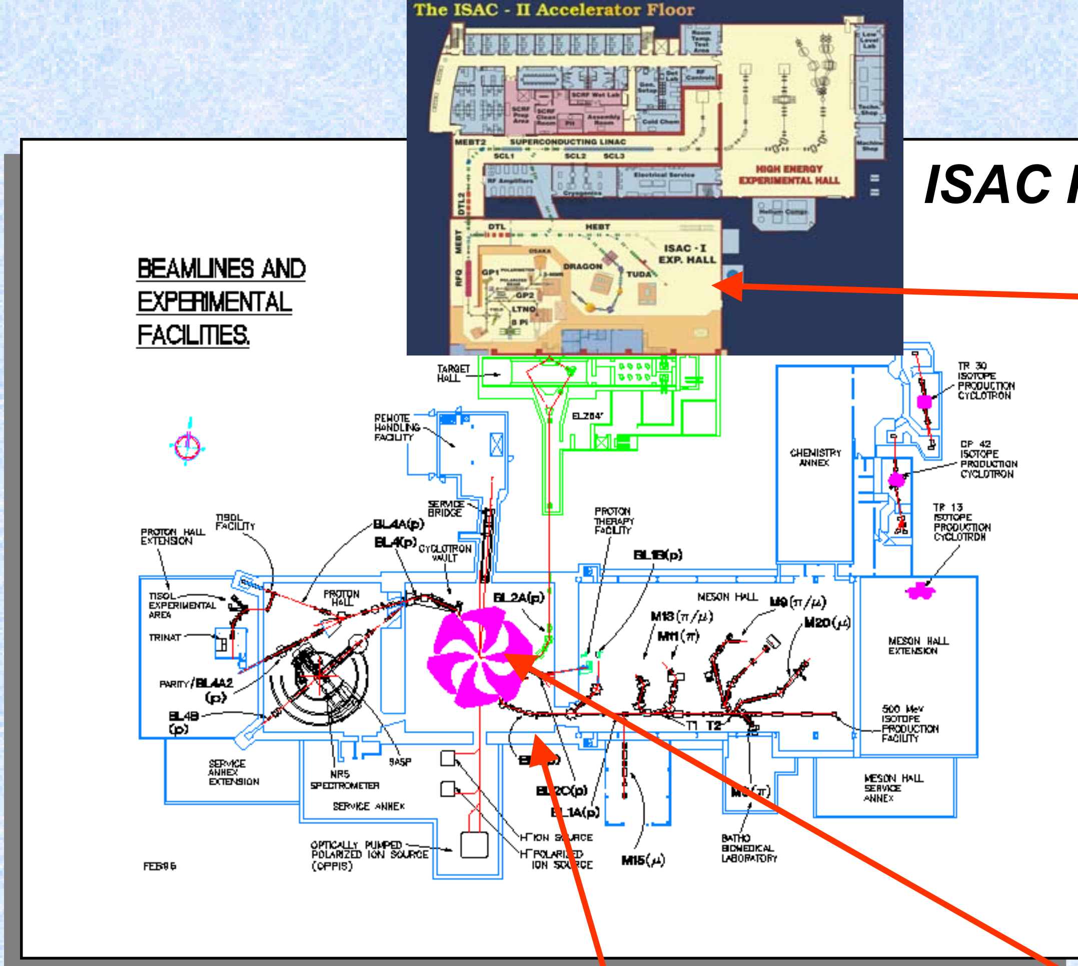
RIA WORKSHOP

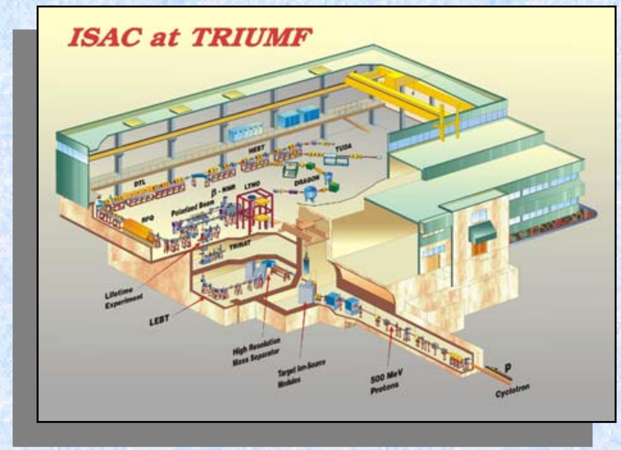
August 2003

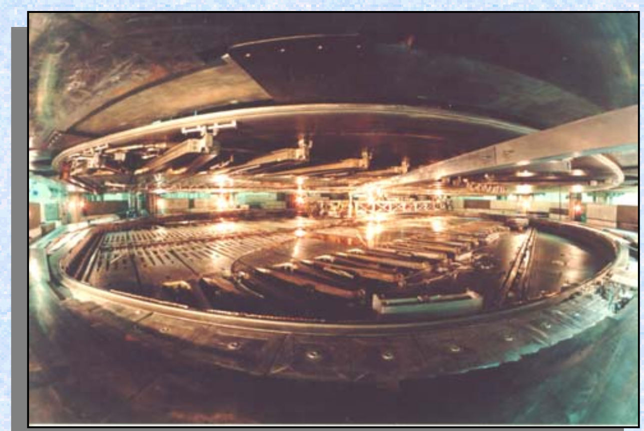
ISAC I = ISOL & POST-ACCELERATORS



ISAC I


The ISAC - II Accelerator Floor
SUPERCONDUCTING LINAC
HIGH ENERGY EXPERIMENTAL HALL
ISAC - I EXP. HALL
DRAGON
TUDA
BEAMLINES AND EXPERIMENTAL FACILITIES.
TARGET HALL
REMOTE HANDLING FACILITY
CHEMISTRY ANNEX
TR 30 ISOTOPE PRODUCTION CYCLOTRON
CP 42 ISOTOPE PRODUCTION CYCLOTRON
TR 13 ISOTOPE PRODUCTION CYCLOTRON
PROTON HALL EXTENSION
TISOL FACILITY
SERVICE BRIDGE
BL4A(p)
BL4(p)
CYCLOTRON VAULT
PROTON THERAPY FACILITY
BL1B(p)
TISOL EXPERIMENTAL AREA
PROTON HALL
BL2A(p)
MESON HALL
M9 (π/μ)
M13 (π/μ)
M20 (μ)
M11 (π)
MESON HALL EXTENSION
TRINAT
PARITY/BL4A2 (p)
BL4B (p)
500 MeV ISOTOPE PRODUCTION FACILITY
T1
T2
SERVICE ANNEX EXTENSION
NRS SPECTROMETER
SASP
BL2C(p)
BL1A(p)
MESON HALL SERVICE ANNEX
SERVICE ANNEX
H⁻ ION SOURCE
H⁻ POLARIZED ION SOURCE
OPTICALLY PUMPED POLARIZED ION SOURCE (OPPIS)
M15 (μ)
BATHO BIOMEDICAL LABORATORY
FEB96


ISAC at TRIUMF
Lifetime Experiment
LEBT
High Resolution Mass Separator
Target Ion Source Modules
500 MeV Protons
Cyclotron
p



ISAC DRIVER

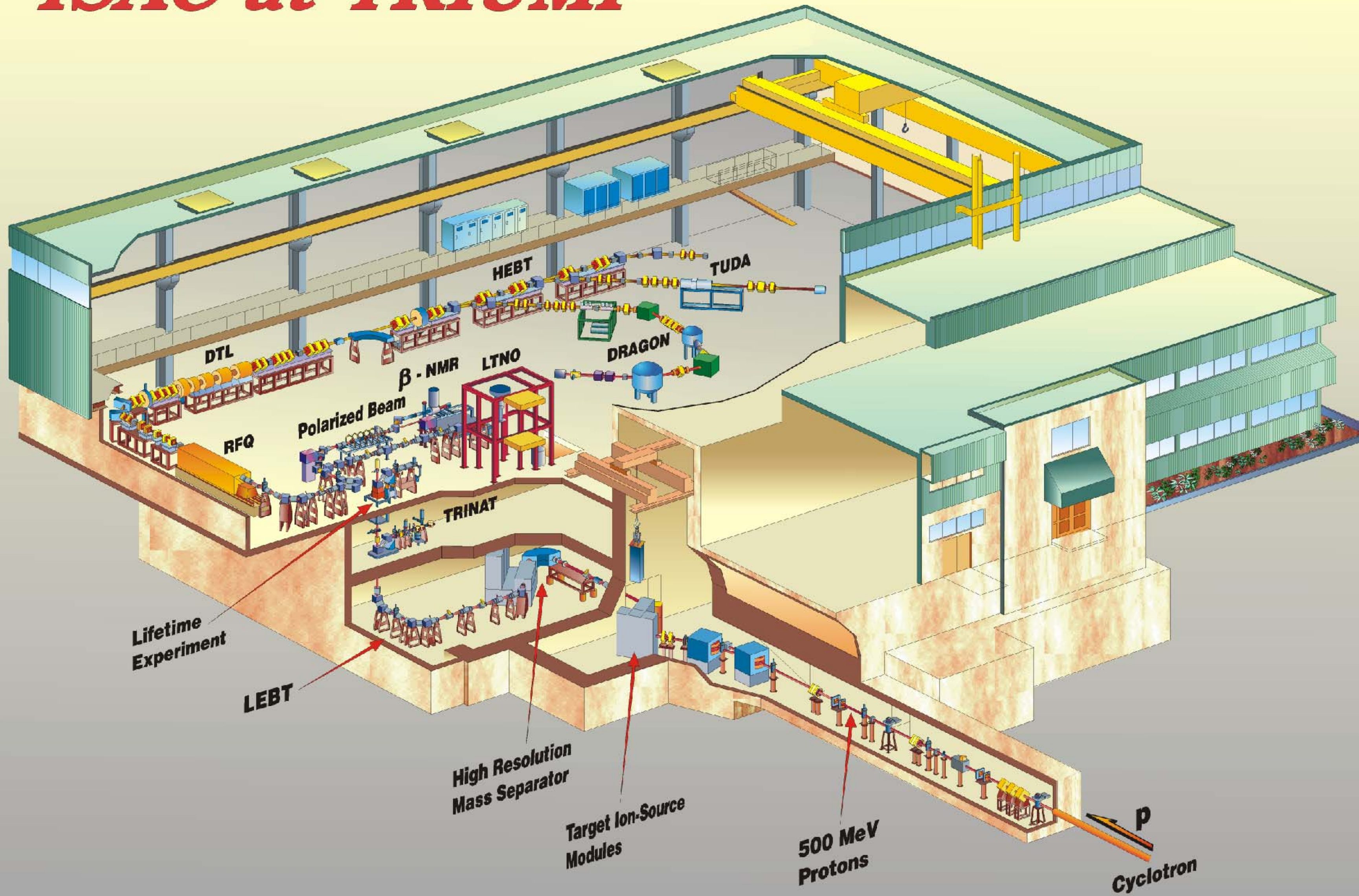
- 500 MeV H- Cyclotron
  - Operates ≈ 5000 h/y with ≈ 90% availability
  - In 2002 the delivered charge was 700 mAh
  - Extracted Protons
    - 275 μA cw
      - Limiting factor was Beam Dumps & Targets
    - 300 μA with 90% duty cycle
    - 400 μA with 25% duty cycle
      - Upgrading of Certain Cylotron Components Required for 100% duty cycle
        - » Budgeted for 2005 - 2010

ISAC I & II

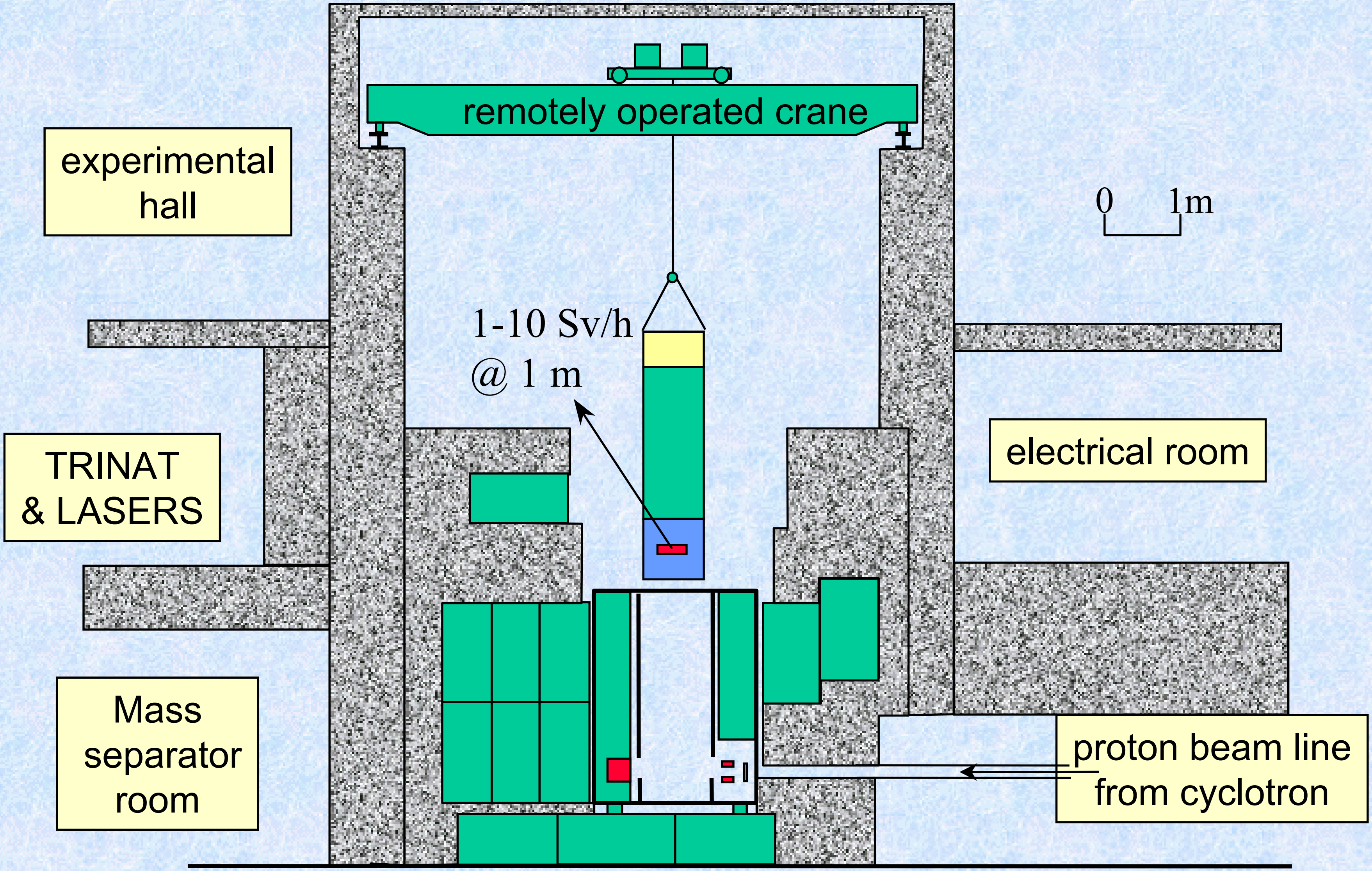
- **ISAC** (ISOL + ACCELERATORS)
  - **ISAC-I**
    - Funded in 1995
    - Low Energy
      - **E ≤ 60 keV & A_{max} ≈ 240**
        - First RIB Experiment in November 1998
    - High Energy (Accelerated)
      - **Variable Energy from 0.15 to 1.5 MeV/u for q/A ≥ 1/30**
        - First Beam in December 2000
  - **ISAC II**
    - Funded in April 2000
    - Civil Funded April 2001
      - **Variable Energy from 1.5 to 6.5 MeV/u for A ≤ 150**
        - First Beam Scheduled for Mid 2005 (4.3 MeV/u)
  - **ISOL Target Area**
      - **Shielded for 100 μA of 500 MeV Protons on Uranium**

ISAC I   STATUS

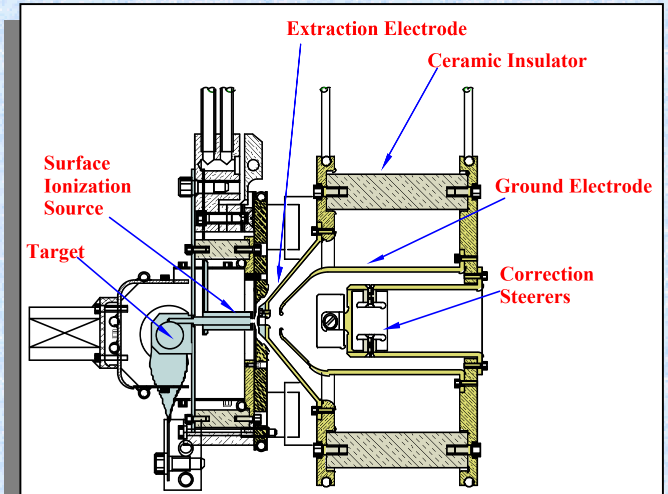
ISAC at TRIUMF



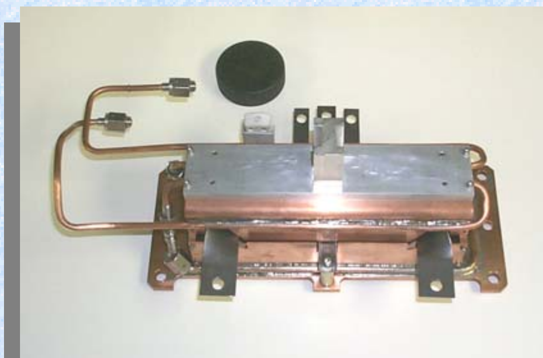
ISAC TARGET SERVICING



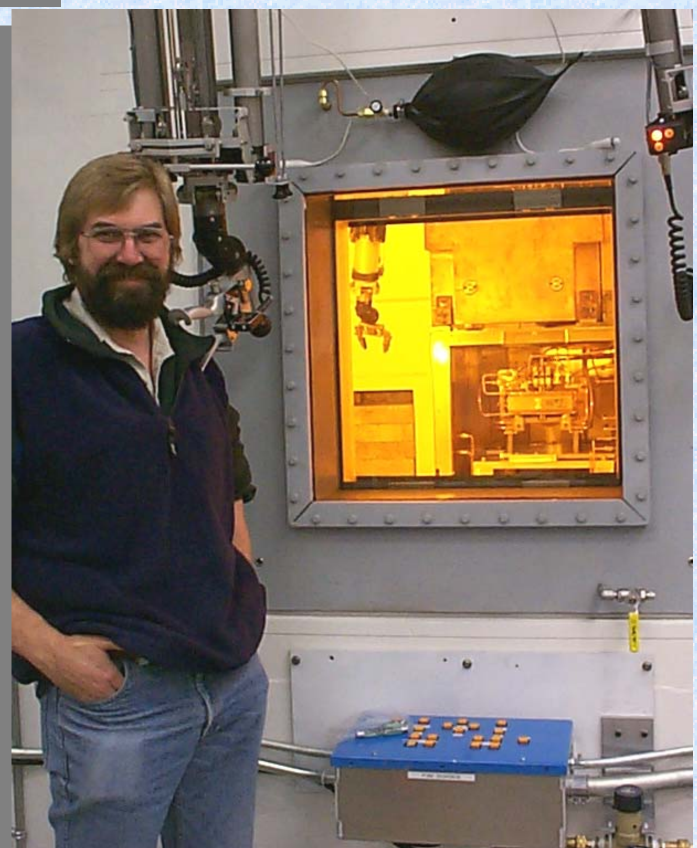
REMOTE HANDLING for ISAC TARGETS, ION SOURCES & MODULE COMPONENTS



HOT CELL AND REMOTE CRANE FOR MODULE & TARGET SERVICING



THERMAL ION SOURCE



ISAC I TARGET DEVELOPMENT

- ISOL Target Area
  - **Shielded for 100 μA of 500 MeV Protons on Uranium**
  - **Dec 17, 1999 – 100 μA on Mo Target**
  - **May 25, 2001 - 40 μA on Nb Target**
  - **July 23, 2001 - 40 μA on Ta Target**
  - **Oct 18, 2001 – 15 μA on SiC Target**
  - **Sept 9, 2002 – 40 μA on TiC Target**
  - **Nov 11, 2002 – 45 μA on SiC Target**

SiC TARGETS

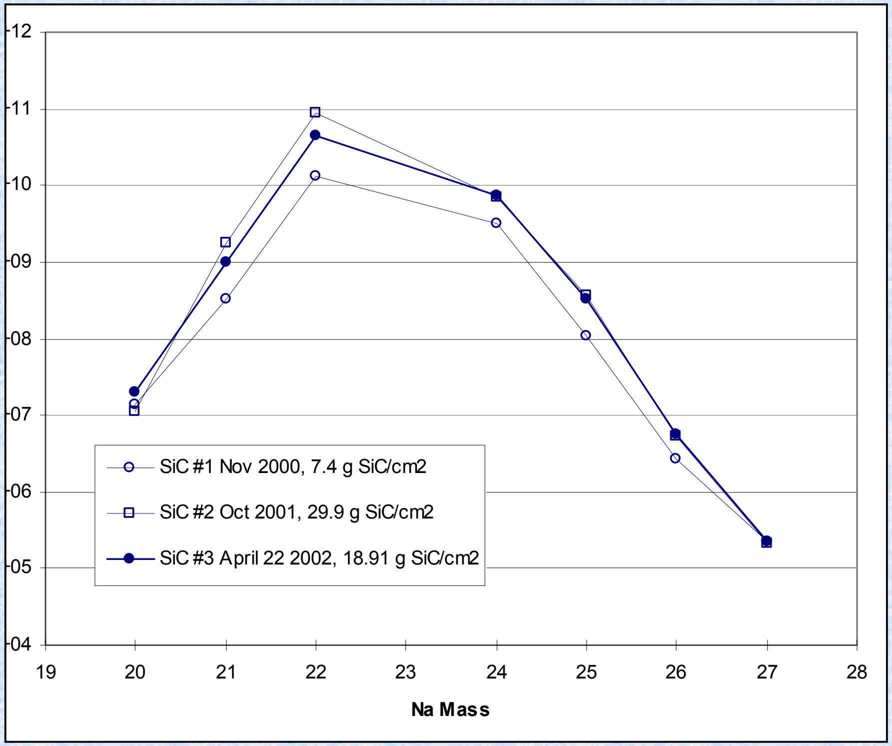
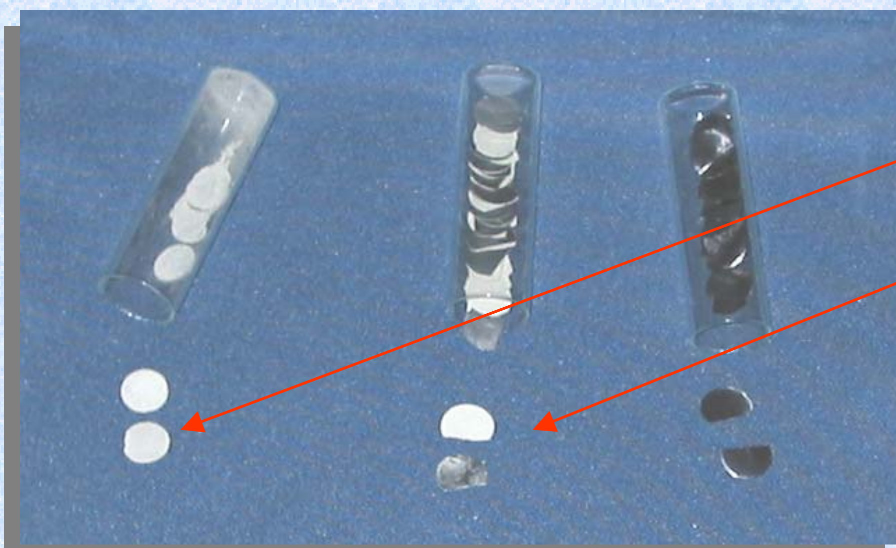


Table 1: Comparison of 10 μA p+ yields from ISAC SiC targets

Nuclide	SiC #1 Yield (/s)	SiC #2 Yield (/s)	SiC #3 Yield (/s)
	7.4g SiC/cm^2	29.9g SiC/cm^2	18.9g SiC/cm^2 & 5.5g C/cm^2
^{20}Na	1.4×10^7	1.1×10^7	2.0×10^7
^{21}Na	3.3×10^8	1.8×10^9	1.0×10^9
^{22}Na	9.1×10^9	8.8×10^{10}	4.4×10^{10}
^{24g}Na	3.6×10^9	7.0×10^9	7.3×10^9
^{24m}Na	1.2×10^7	3.8×10^6	3.1×10^6
^{25}Na	1.1×10^8	3.7×10^8	3.3×10^8
^{26}Na	2.7×10^6	5.2×10^6	5.7×10^6
^{27}Na	2.3×10^5	2.1×10^5	2.2×10^5

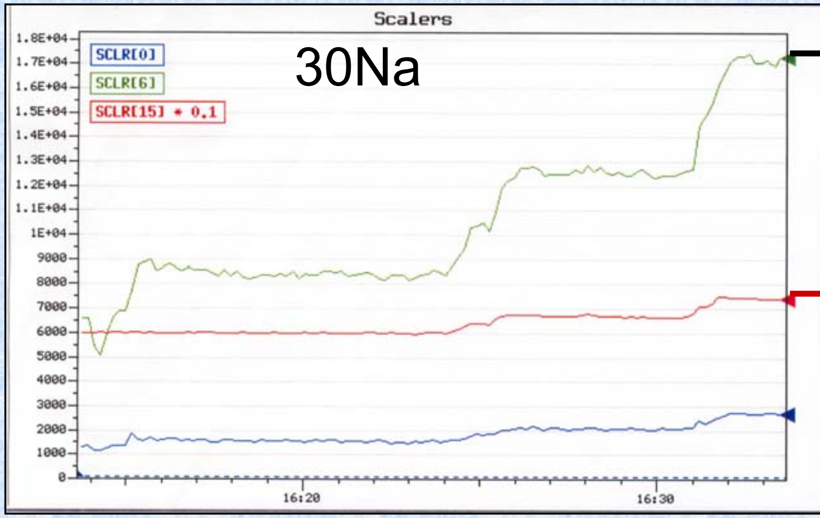


SiC #3

SiC Deposited on 0.1 mm Thick Sheet of Exfoliated Graphite Capable of 45 μA of Protons

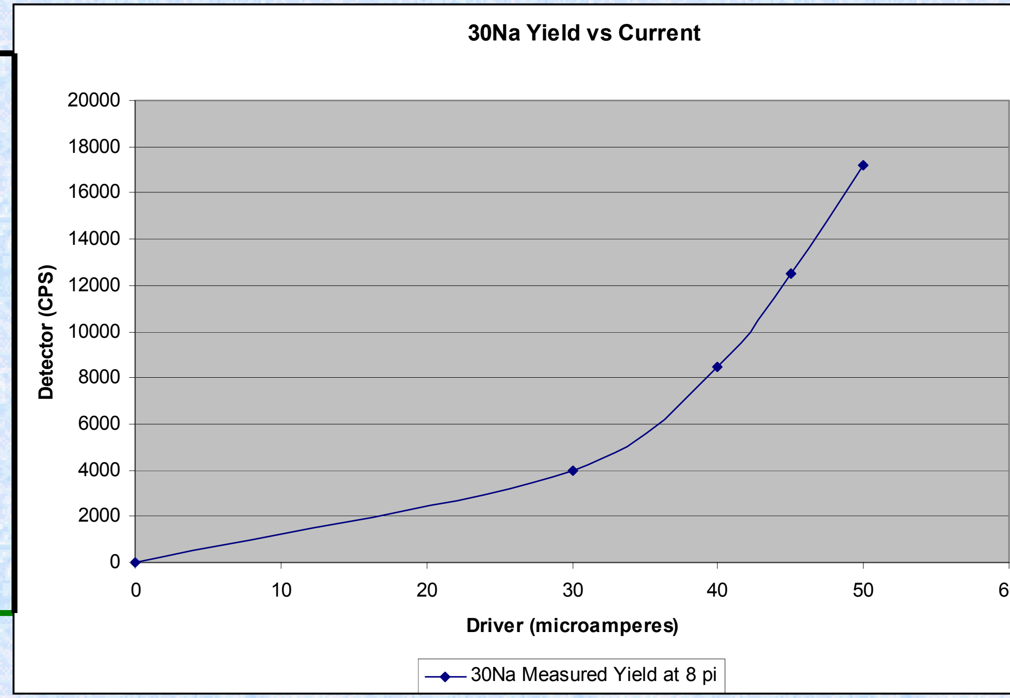
ION SOURCE SUMMARY

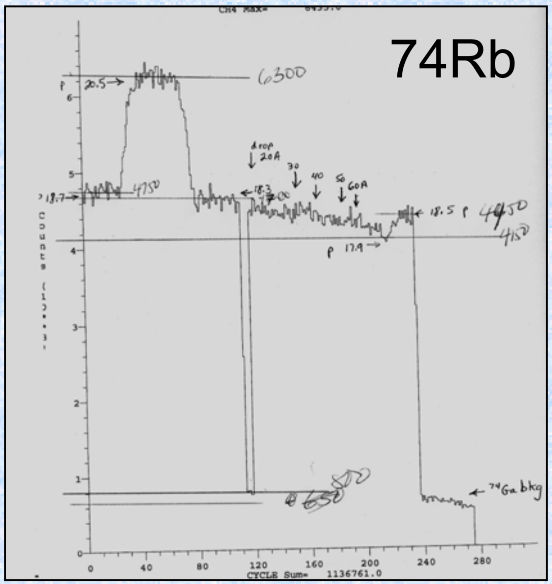
- Surface Ion Source
  - Presently Being Used for RIB Production of Alkalis + ...
  - Both East & West Stations have Modules with SISs
- ECRIS
  - Mainly for Noble Gases & other Volatiles
  - 2.45 GHz ECR for Target Module #3 is Being Commissioned
  - Operation with RIB in May 2003
    - Ionization Efficiency Less than Measured on Test Stand
    - Studies Underway to Determine Discrepancy
- LIS
  - Lasers Use TiS Crystals
    - Compact & Reliable
  - Successful November Test at Conditioning Station
    - Collaboration with Mainz
- OLIS (Off Line Ion Source)
  - Accelerator Commissioning & Stable Beams for Experiments
  - Alkali Source Fabricated & Installed

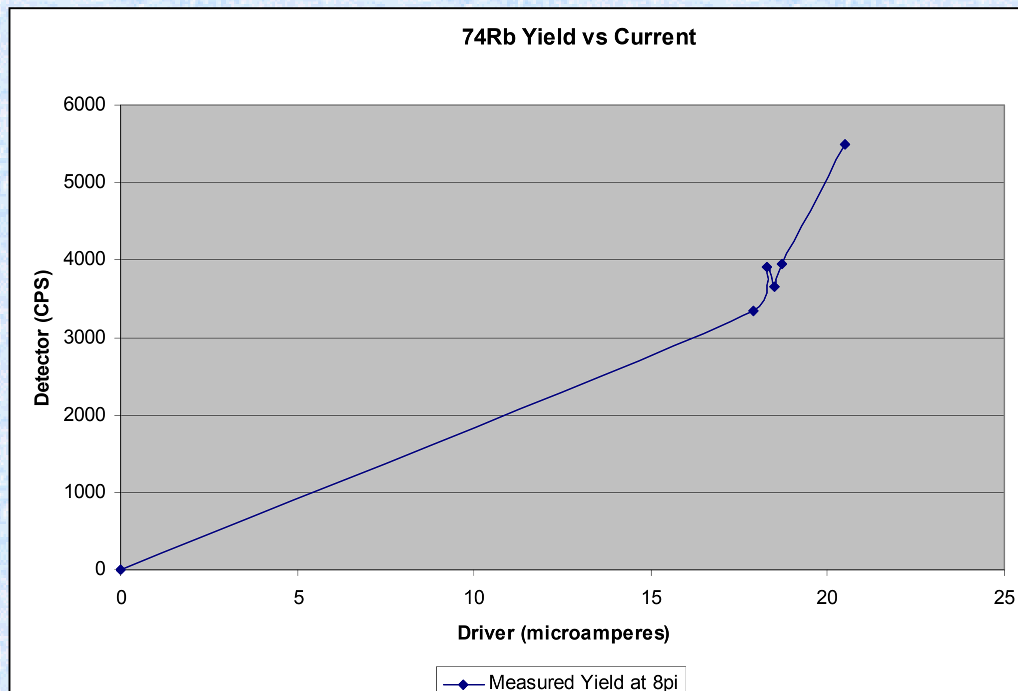


50 μA Protons

Yield Ratemeter



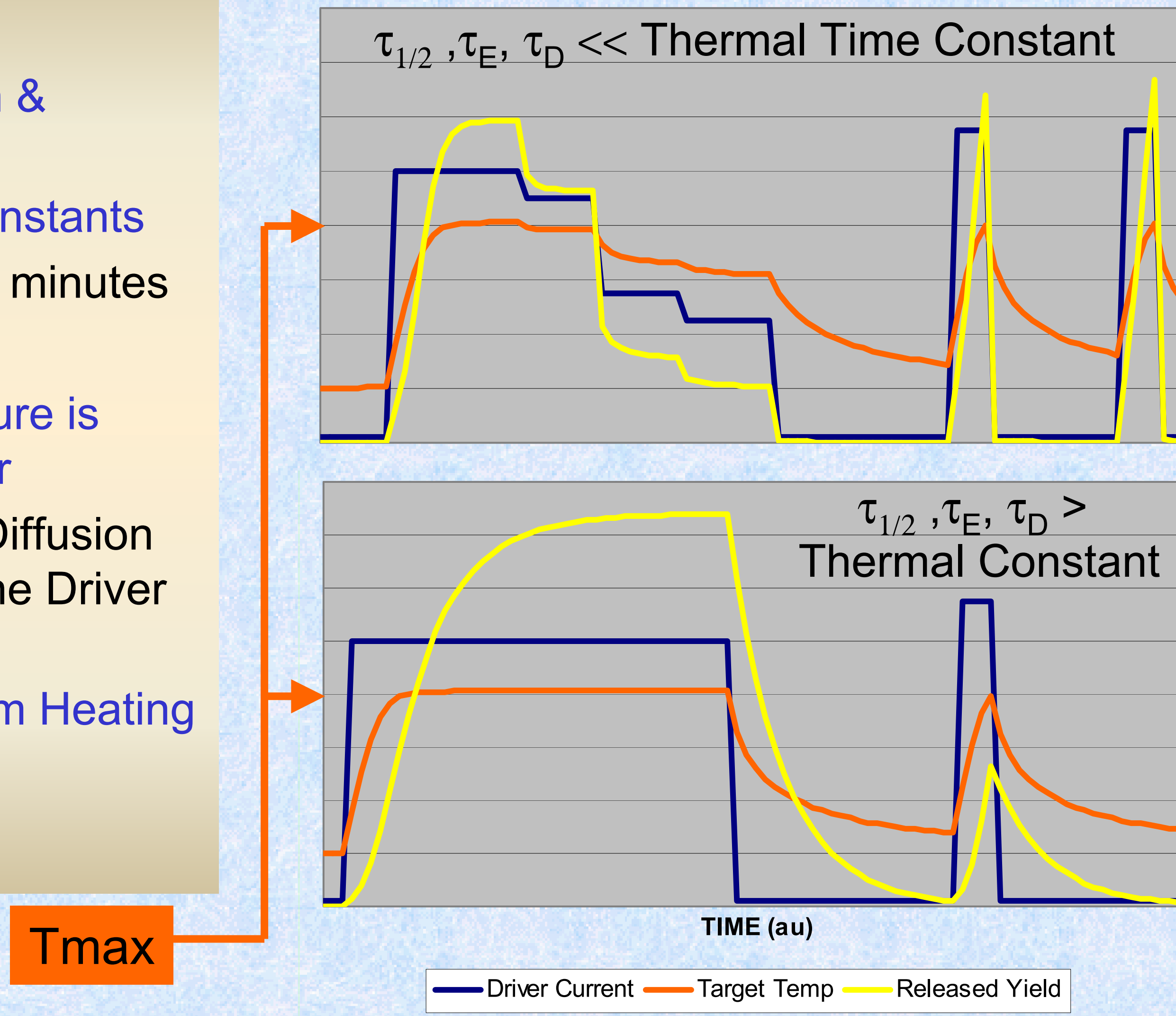




30Na & 74Rb Yield vs Driver Current

SCHEMATIC of TIME DEPENDENCE for DRIVER CURRENT with HIGH POWER, ISOL TARGET TEMP. & RELEASED YIELD

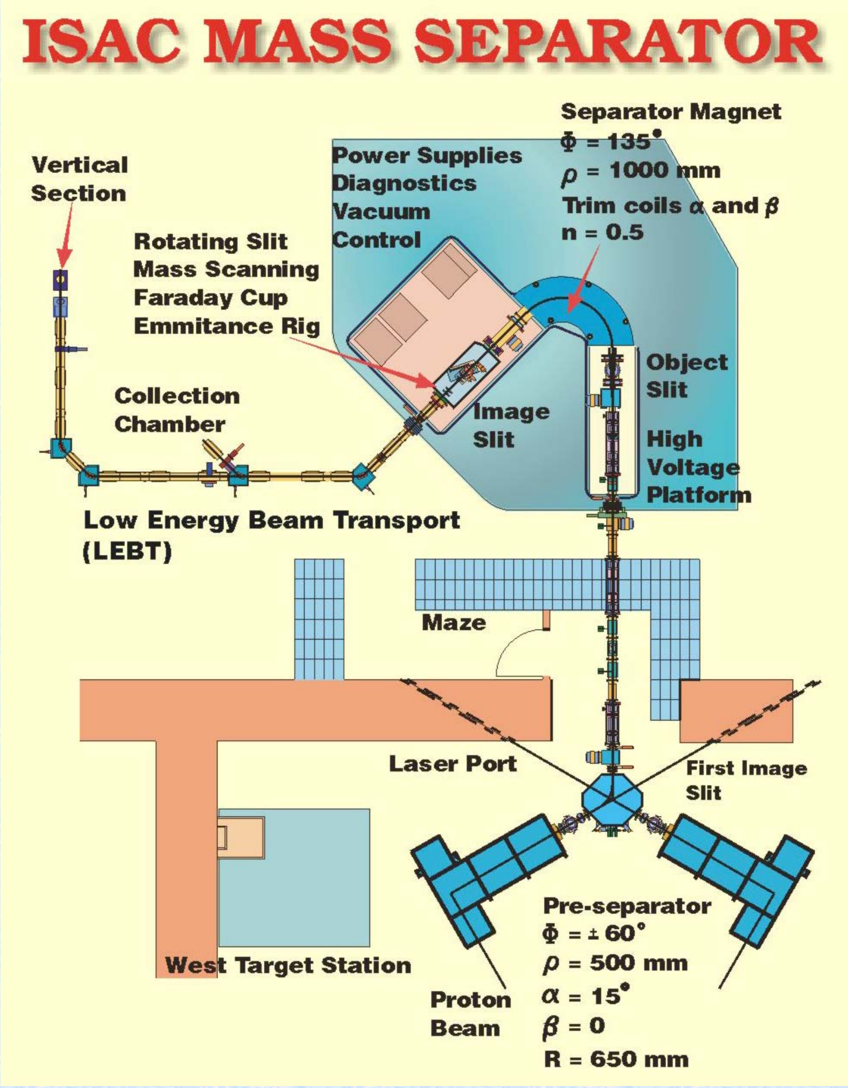
- Optimum Driver Current Pulse Lengths
  - >> Half-life, Diffusion & Effusion Times
  - >> Thermal Time Constants
    - Typically several minutes
- Driver Current Stability
  - Operating Temperature is Determined by Driver
    - Yield, Effusion, Diffusion Determined by the Driver Current
  - With Significant Beam Heating
    - ΔRIB/RIB > ΔI/I

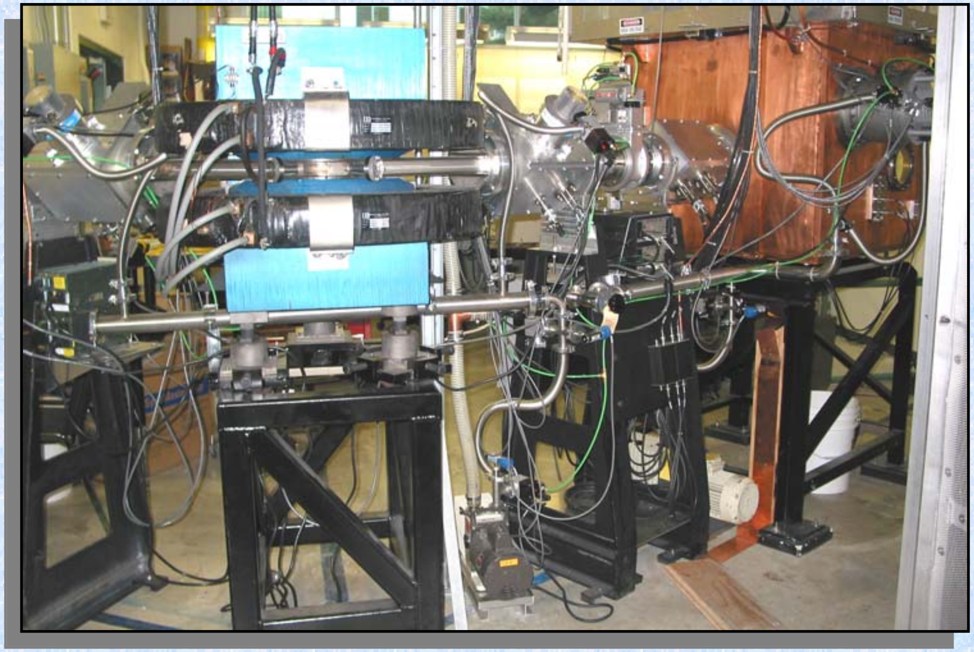


DRIVER RELIABILITY IS IMPORTANT

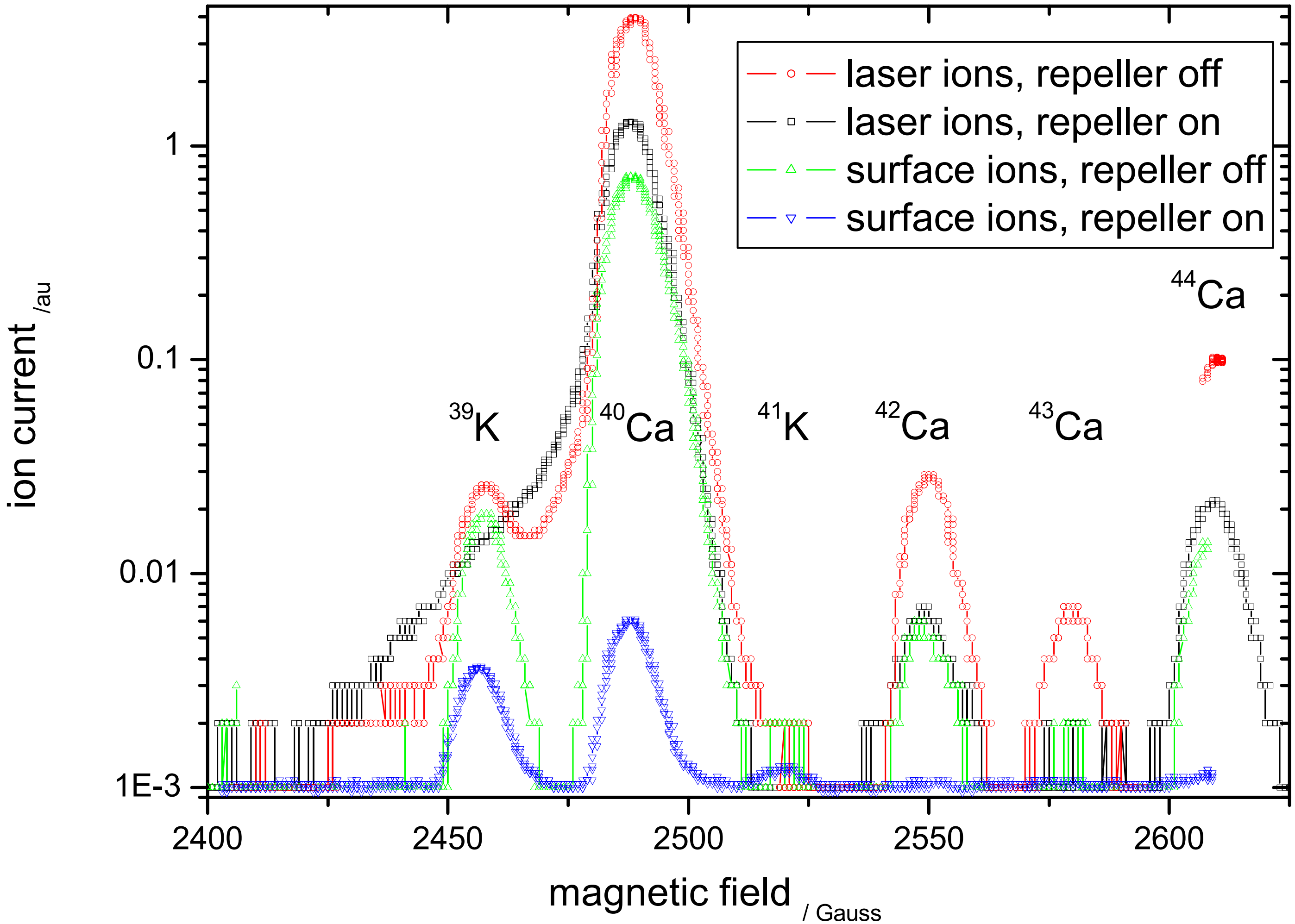
- ISOL OPERATION AT HIGH POWER
  - ♦ TARGET HEATING DOMINATED BY BEAM HEATING
    - Current Stability is Important
      - * Small Variations in Current Produce Larger Variations in RIB Yields
    - Accelerator Reliability is Important
      - * RIB returns slower than Driver Beam rise time when Driver Beam pulses on
      - * RIB (short lived exotic) disappears quickly when Driver Beam pulses off

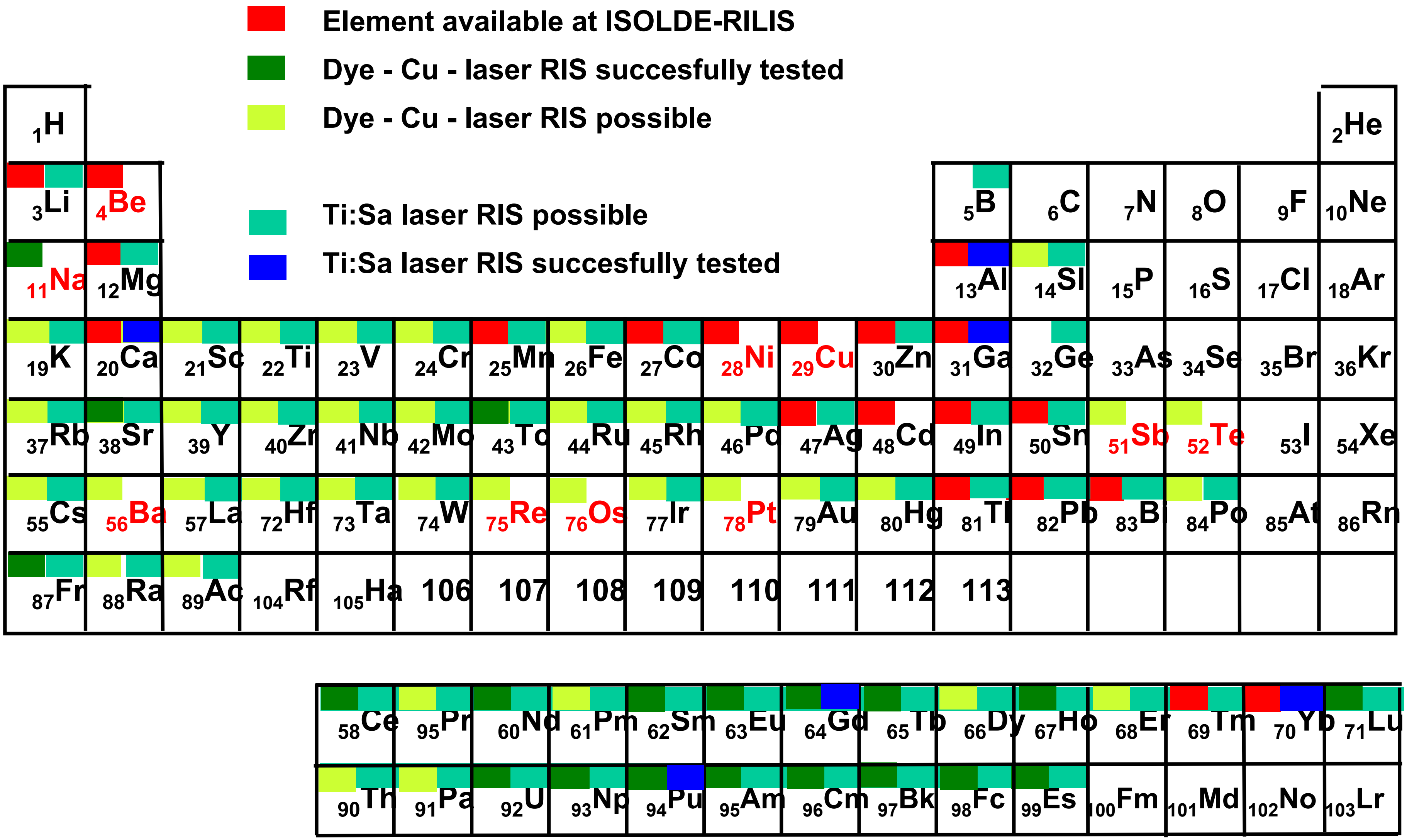
LASER ION SOURCE & CONDITIONING STATION

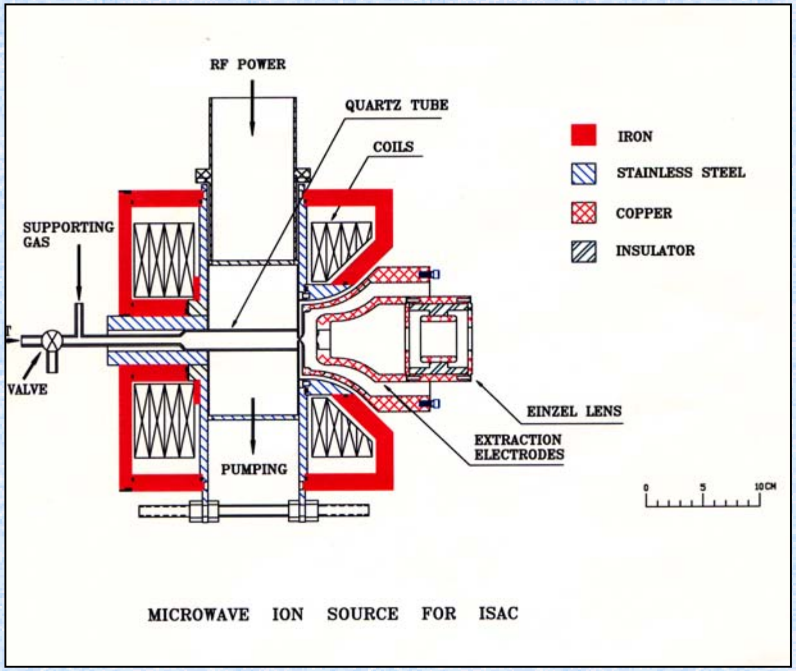




first mass scans with laser and surface ions




Element available at ISOLDE-RILIS
Dye - Cu - laser RIS succesfully tested
Dye - Cu - laser RIS possible
Ti:Sa laser RIS possible
Ti:Sa laser RIS succesfully tested
1H 2He
3Li 4Be 5B 6C 7N 8O 9F 10Ne
11Na 12Mg 13Al 14Si 15P 16S 17Cl 18Ar
19K 20Ca 21Sc 22Ti 23V 24Cr 25Mn 26Fe 27Co 28Ni 29Cu 30Zn 31Ga 32Ge 33As 34Se 35Br 36Kr
37Rb 38Sr 39Y 40Zr 41Nb 42Mo 43Tc 44Ru 45Rh 46Pd 47Ag 48Cd 49In 50Sn 51Sb 52Te 53I 54Xe
55Cs 56Ba 57La 72Hf 73Ta 74W 75Re 76Os 77Ir 78Pt 79Au 80Hg 81Tl 82Pb 83Bi 84Po 85At 86Rn
87Fr 88Ra 89Ac 104Rf 105Ha 106 107 108 109 110 111 112 113
58Ce 95Pr 60Nd 61Pm 62Sm 63Eu 64Gd 65Tb 66Dy 67Ho 68Er 69Tm 70Yb 71Lu
90Th 91Pa 92U 93Np 94Pu 95Am 96Cm 97Bk 98Fc 99Es 100Fm 101Md 102No 103Lr

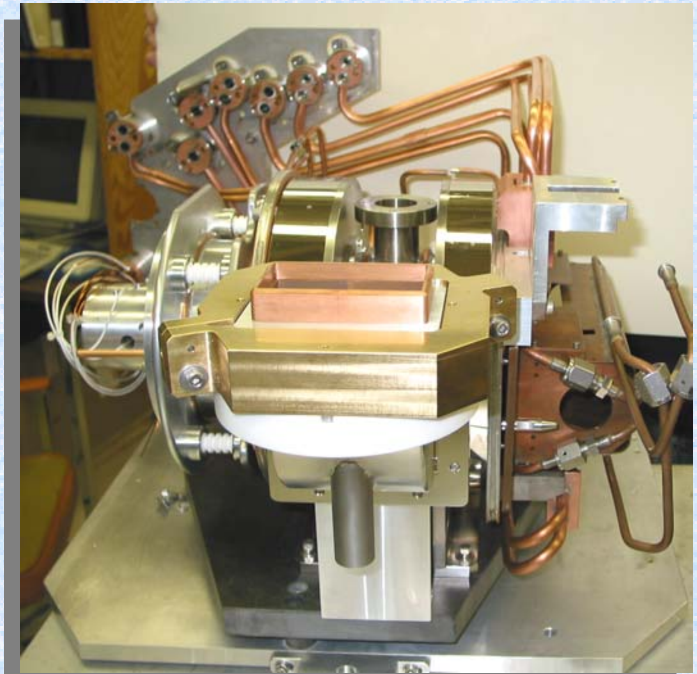


ISAC ECR ION SOURCE

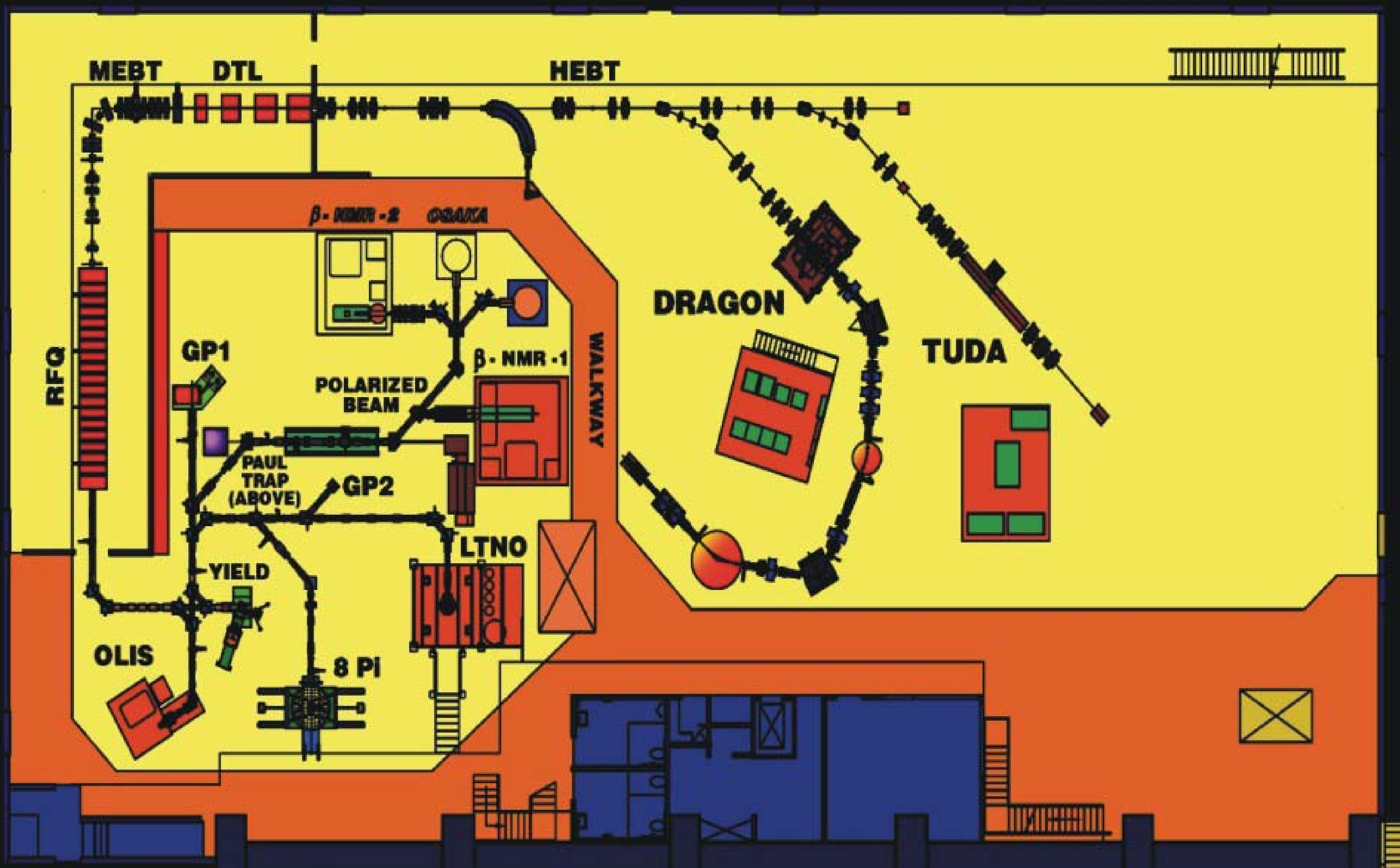
2.45 GHz

COMMISSIONING IN FALL 2002

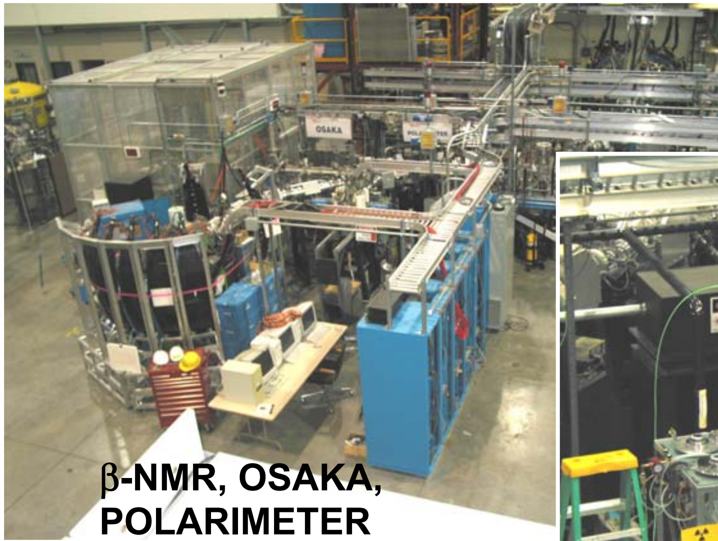
TARGET MODULE #3

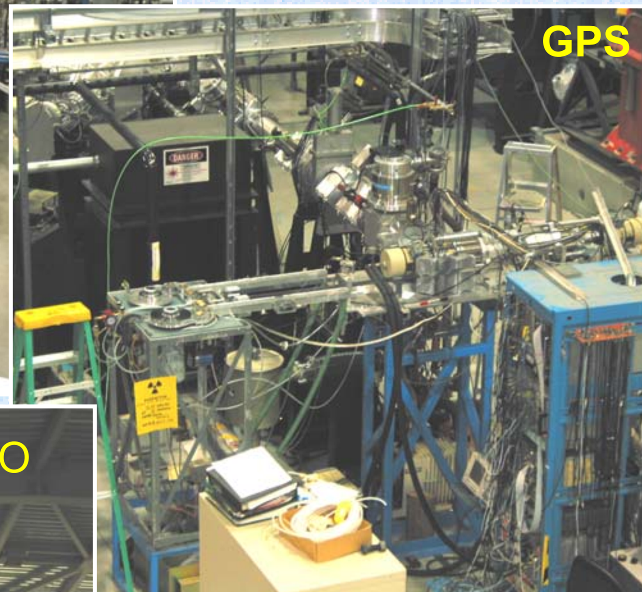


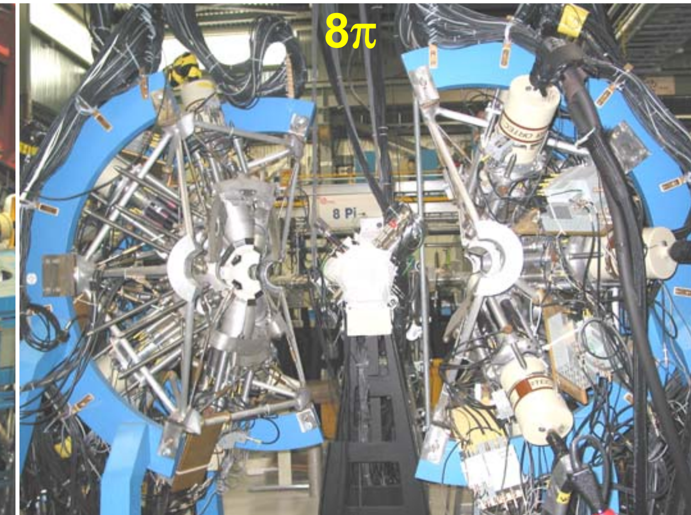
ISAC EXPERIMENTAL HALL

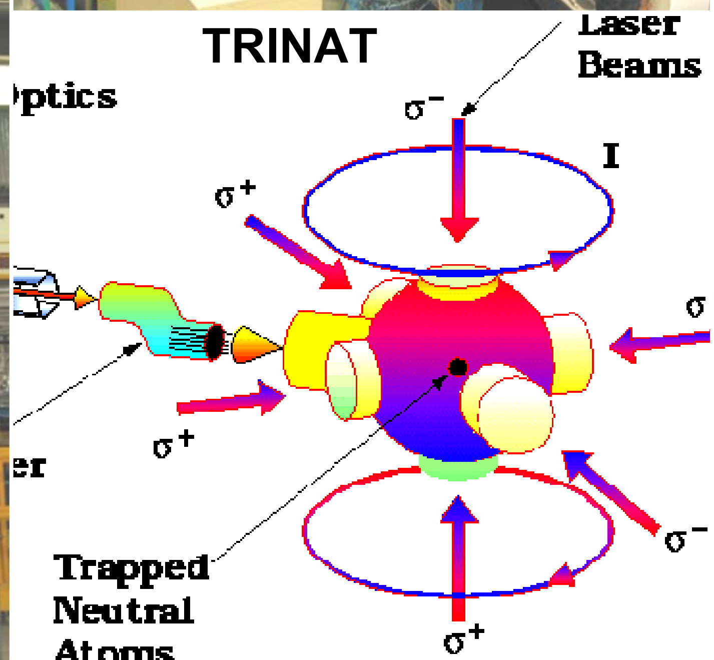


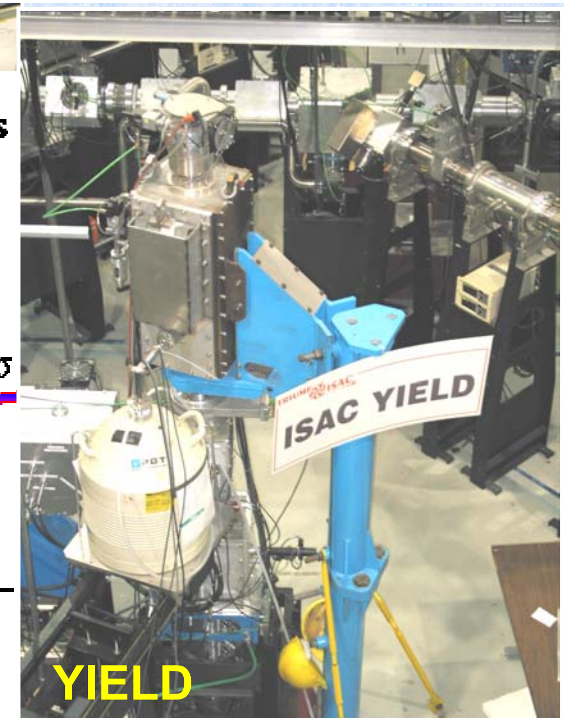
LOW ENERGY STATIONS





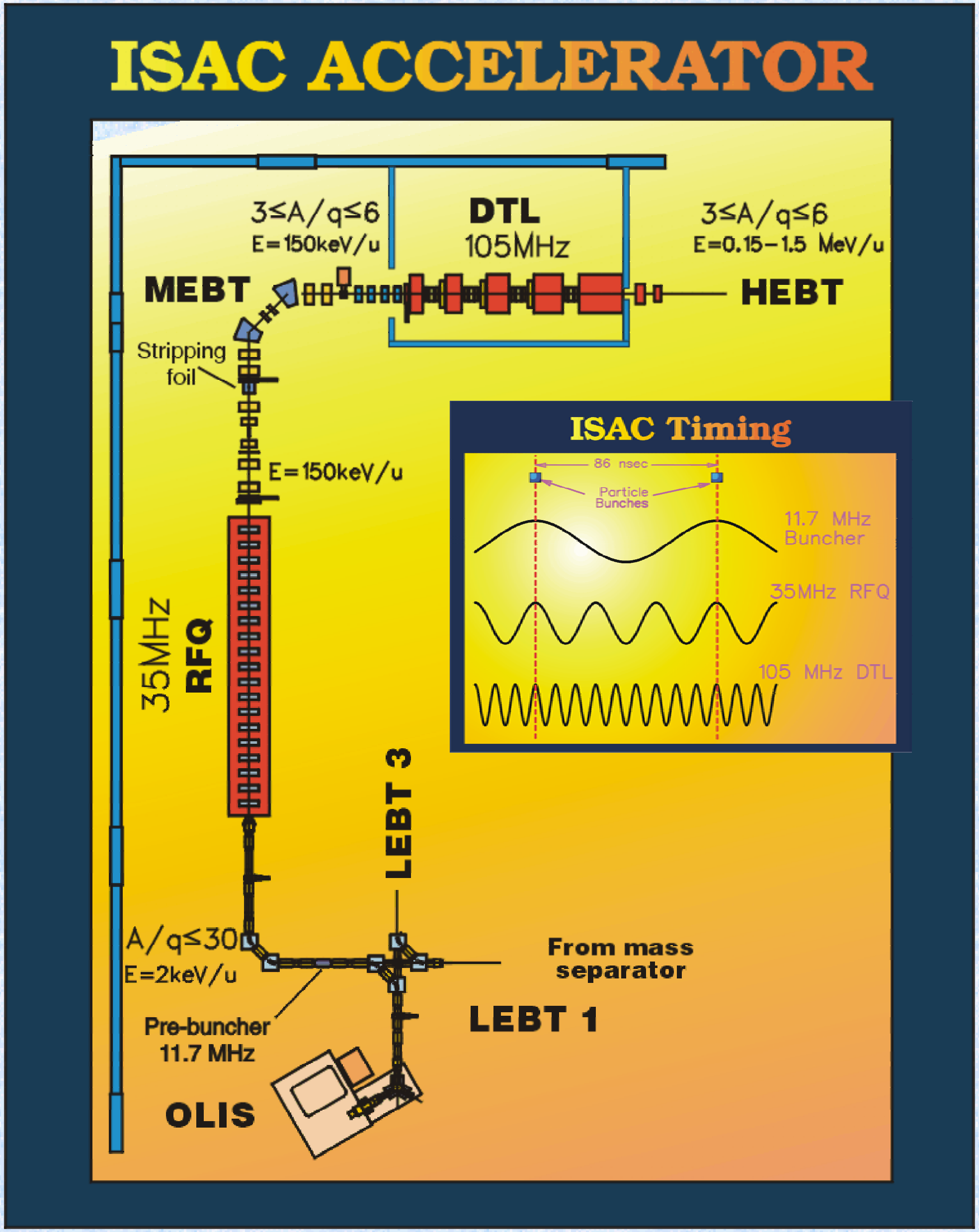






ISAC-I Accelerator

- 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=0.15-1.53 MeV/u
  - A/Q<=6
- HEBT
  - Diagnostic section
  - 11.8/35 MHz rebunchers

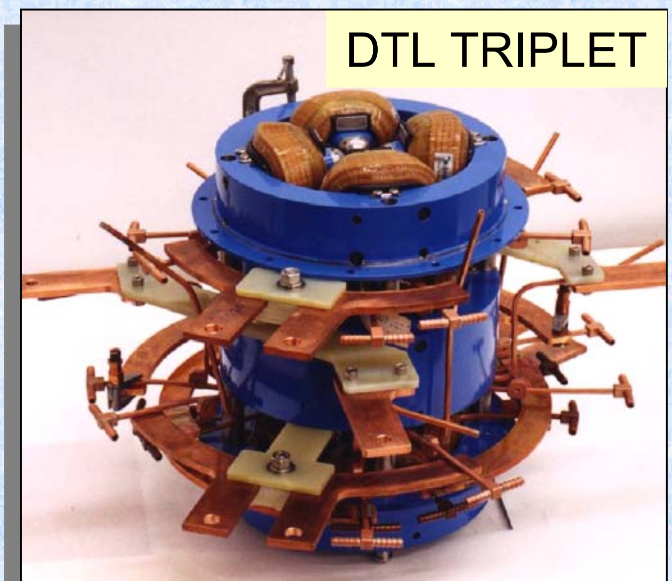


ACCELERATOR TECHNOLOGY

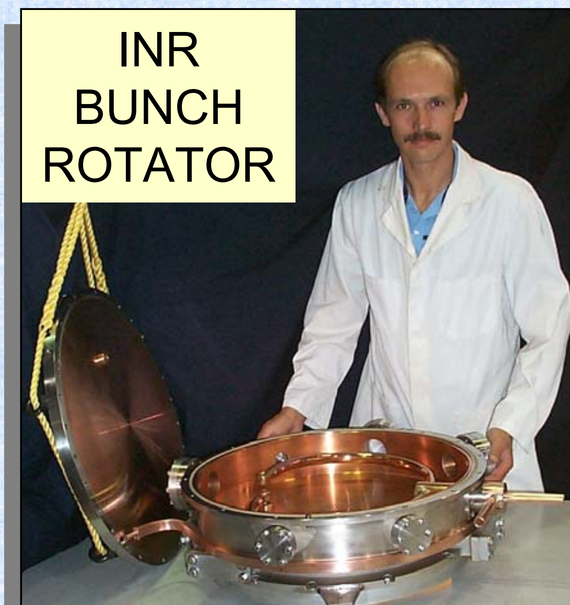
DTL TANK 2

RFQ

MEBT REBUNCHER

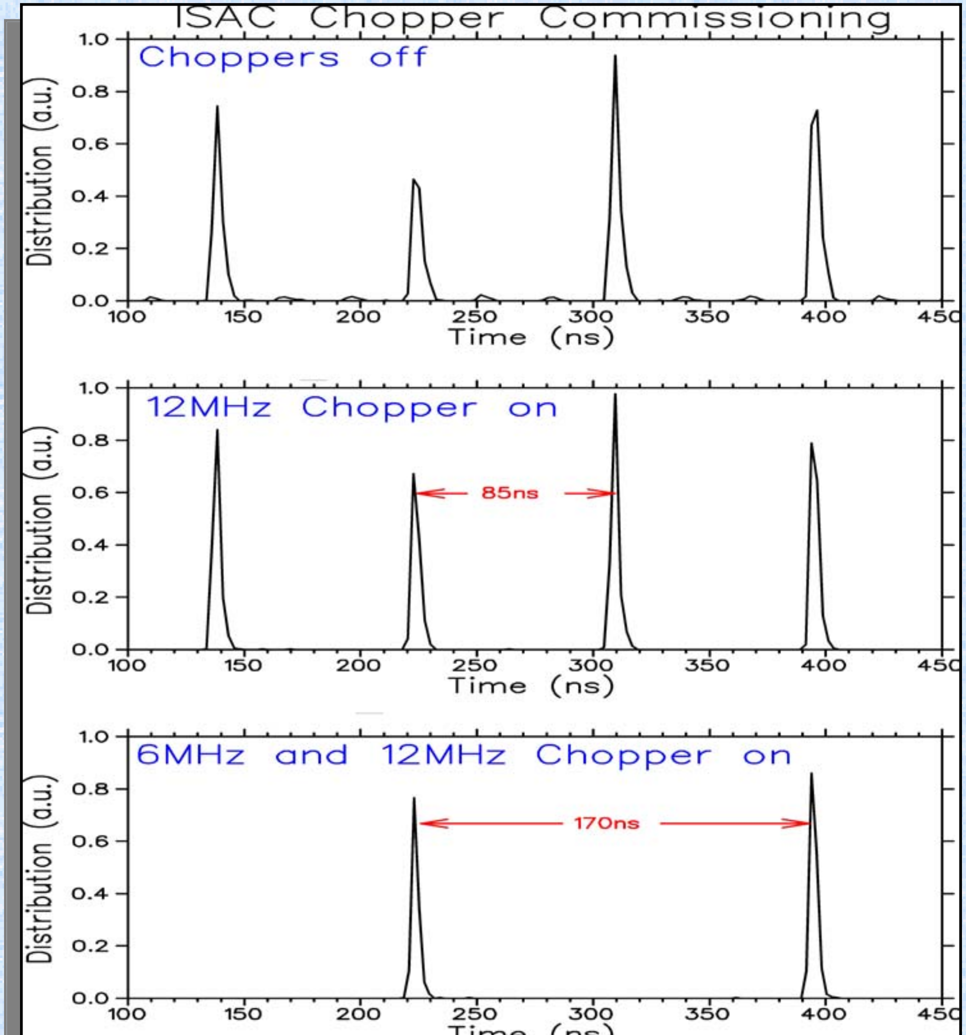


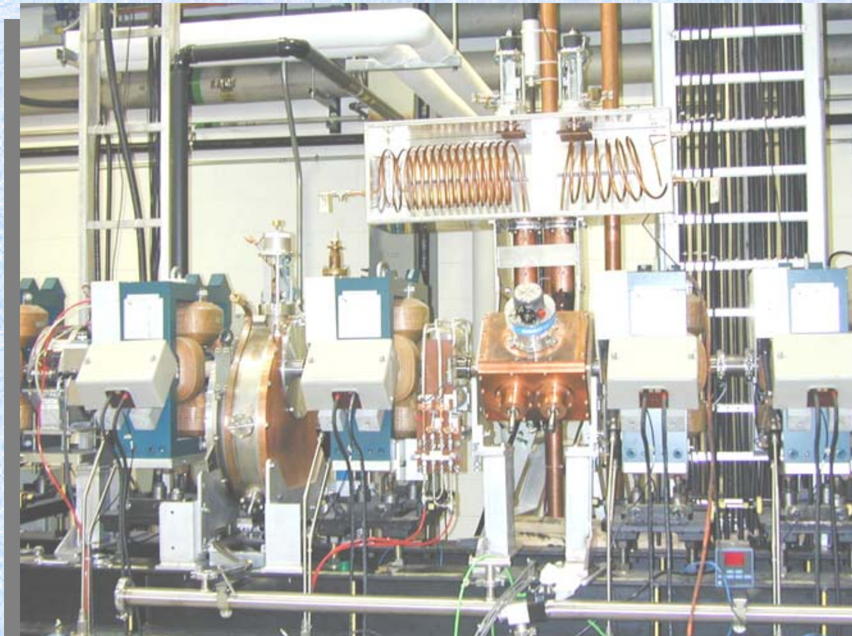
DTL TRIPLET

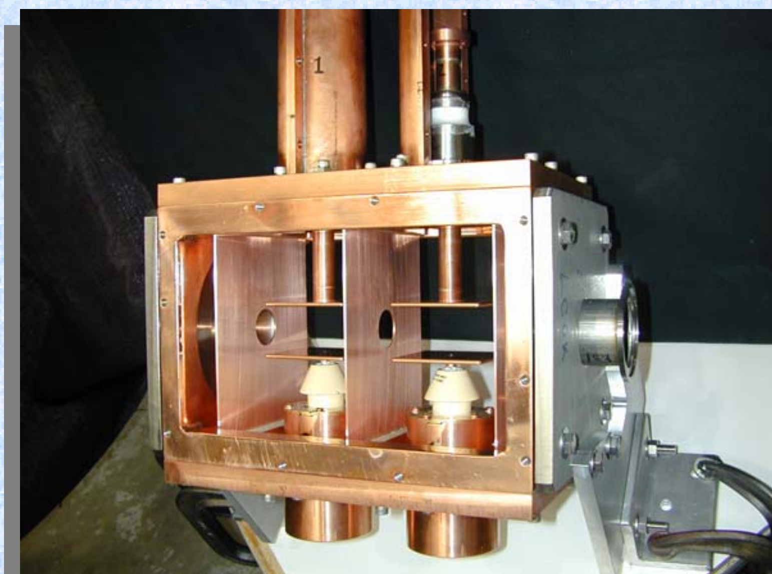


INR BUNCH ROTATOR

DUAL FREQUENCY MEBT CHOPPER
MAY 2, 2001

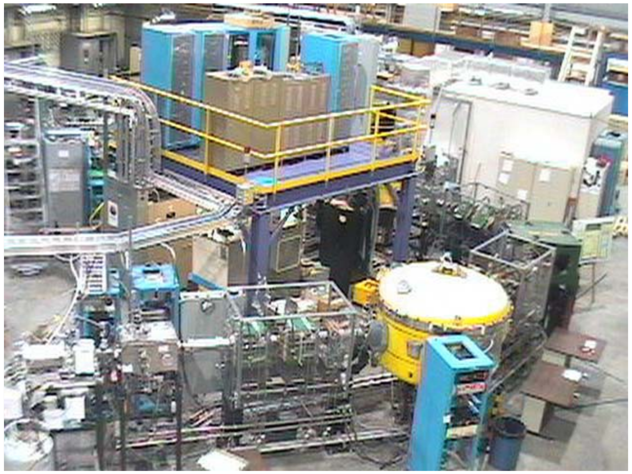


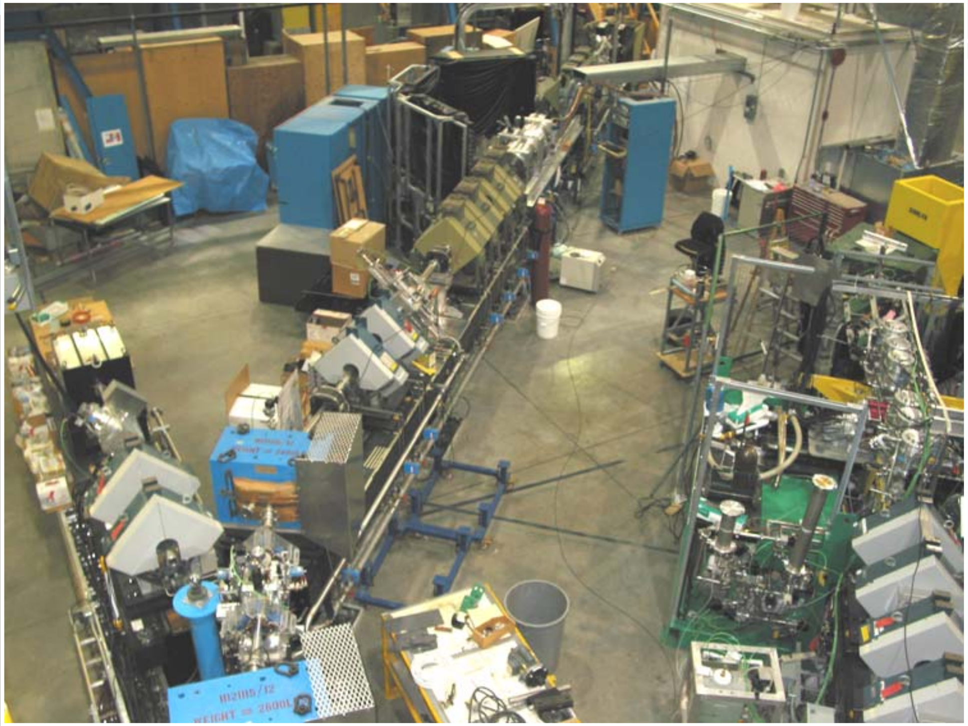


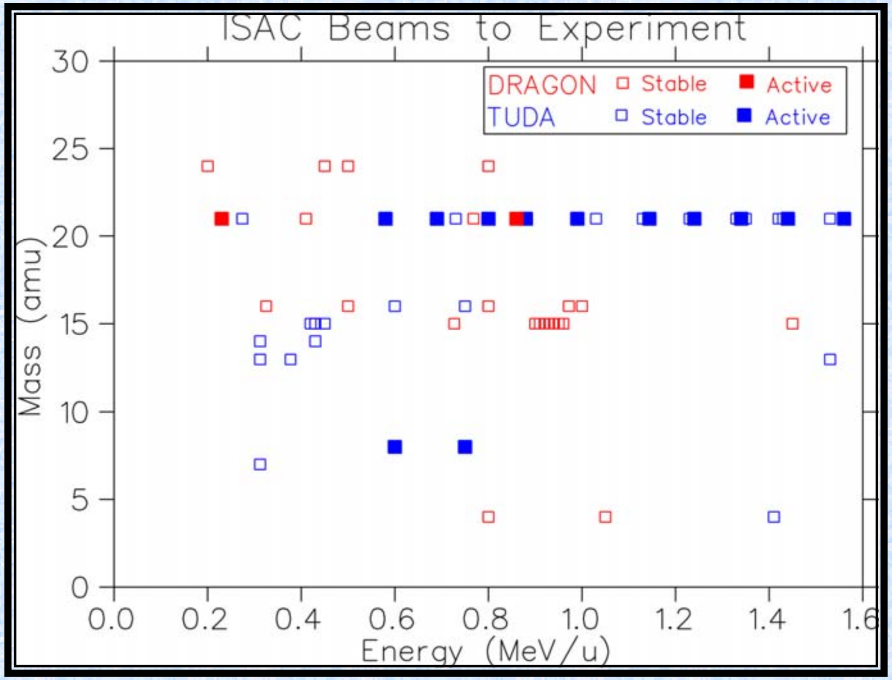


ACCELERATED BEAMS at ISAC

TUDA
&
DRAGON



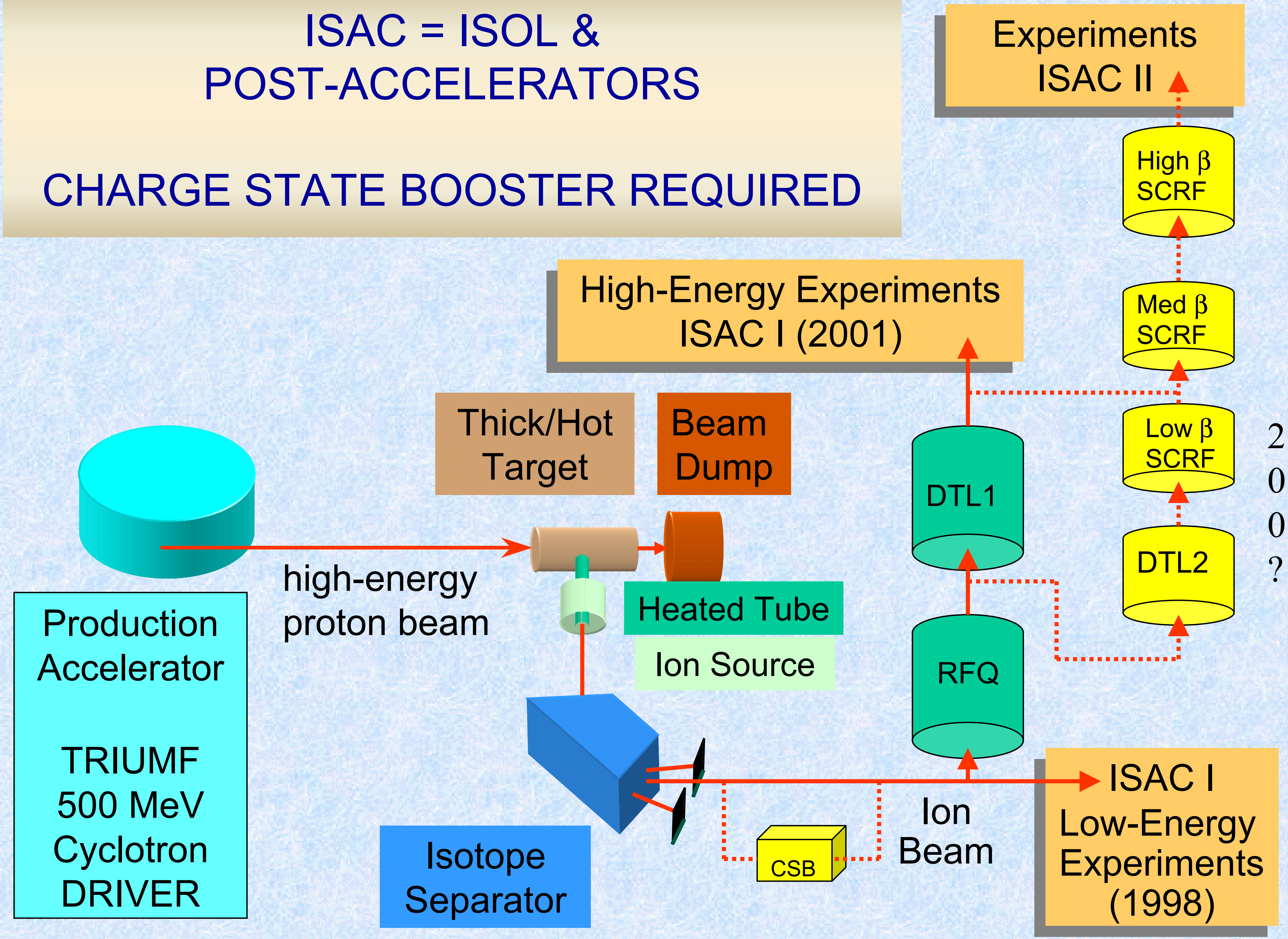




ISAC II   STATUS

ISAC = ISOL & POST-ACCELERATORS

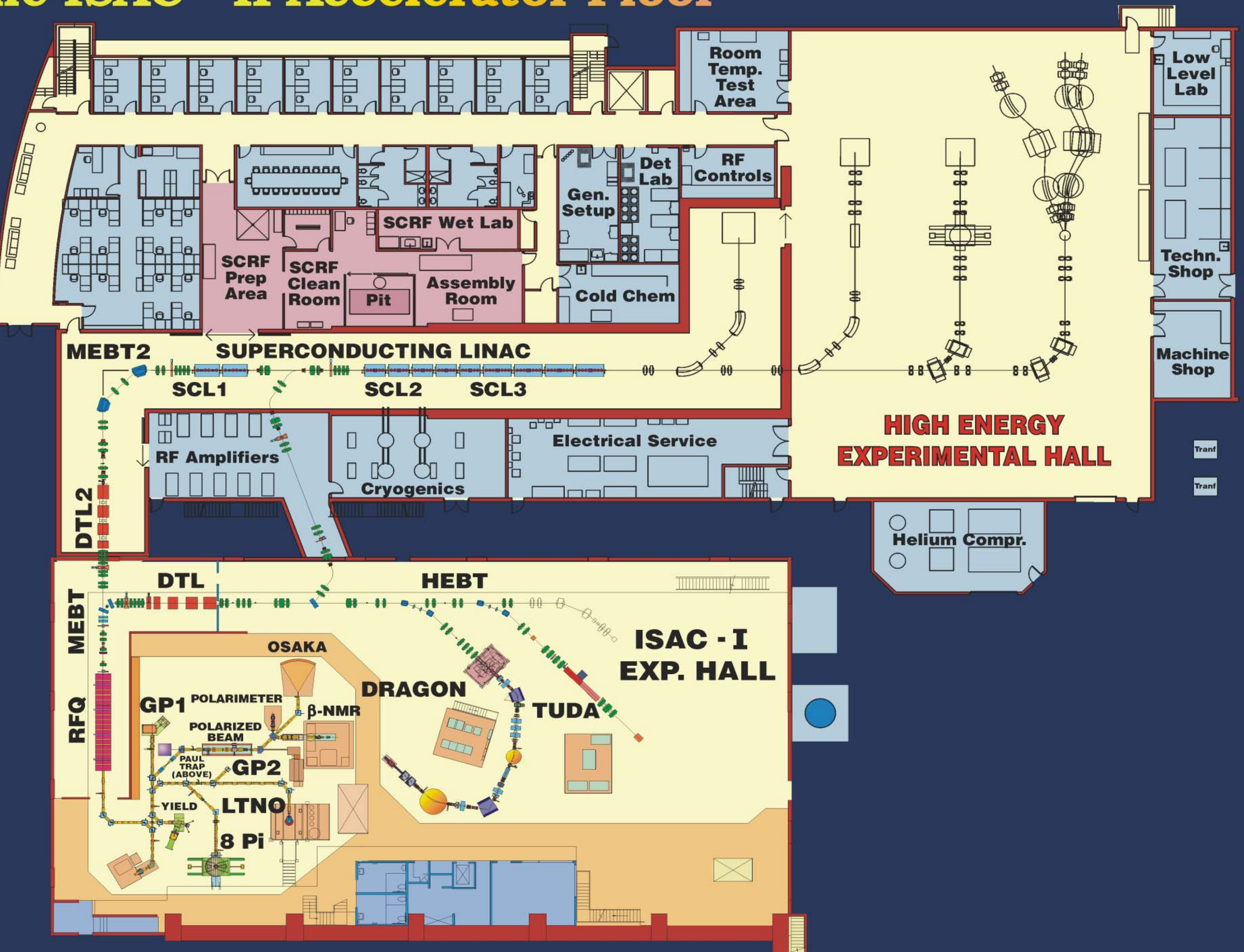
CHARGE STATE BOOSTER REQUIRED



ISAC II EXTERIOR FROM SW

Front Entrance & Accelerator Hall

The ISAC - II Accelerator Floor



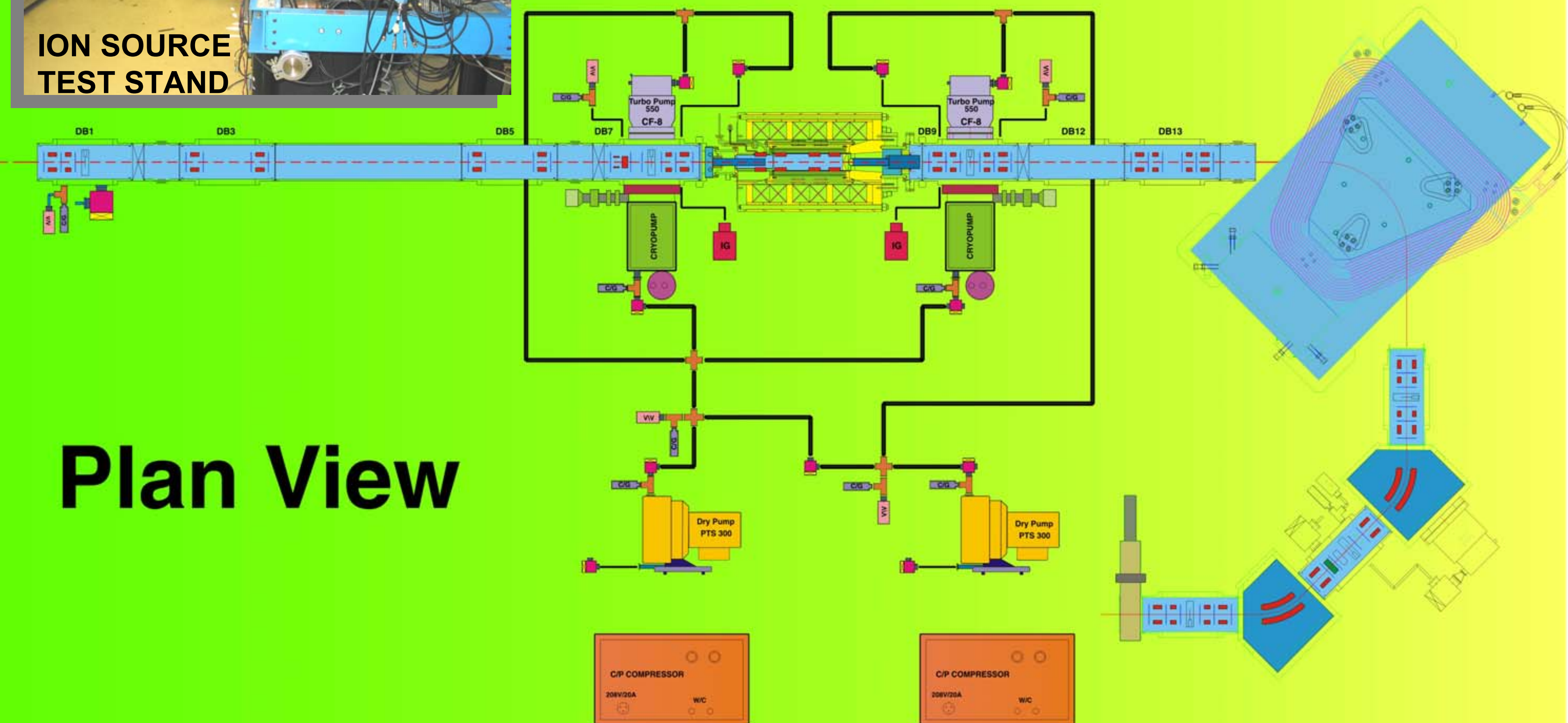
ISAC II

CHARGE STATE BOOSTER

CSB

ECR CHARGE STATE BOOSTER on TRIUMF IS TEST STAND

CSB Section



Plan View

MEASURED CHARGE STATE BOOSTER IONIZATION EFFICIENCY & CHARGE BOOSTING TIME

for

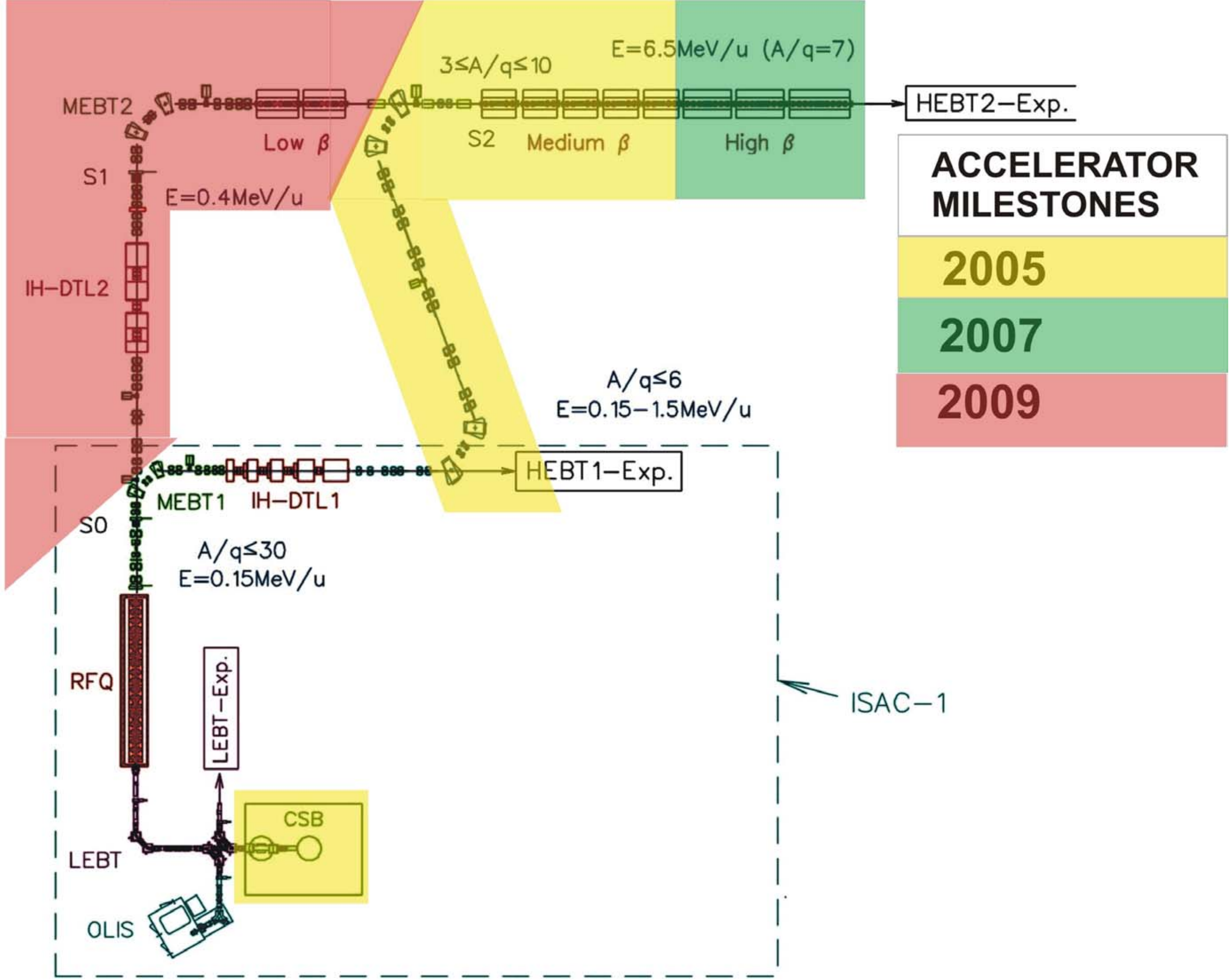
RATIOS REQUIRING NO ADDITIONAL STRIPPING

ISOTOPE	η(%)	τ(ms)	a/q
$^{23}Na^{1+\to 8+}$	5	100	2.9
$^{39}K^{1+\to 9+}$	4.6	120	4.3
$^{40}Ar^{1+\to 6+}$	3	75	6.7
$^{59}Co^{1+\to 9+}$	2.8	50	6.5
$^{64}Zn^{1+\to 10+}$	4.1	150	6.4
$^{69}Ga^{1+\to 11+}$	3.6	125	6.3
$^{85}Rb^{1+\to 13+}$	2	80	6.5
$^{88}Sr^{1+\to 14+}$	2	100	6.3
$^{109}Ag^{1+\to 17+}$	5	100	6.4
$^{115}In^{1+\to 18+}$	7.9	70	6.4
$^{120}Sn^{1+\to 19+}$	1.8	?	6.3

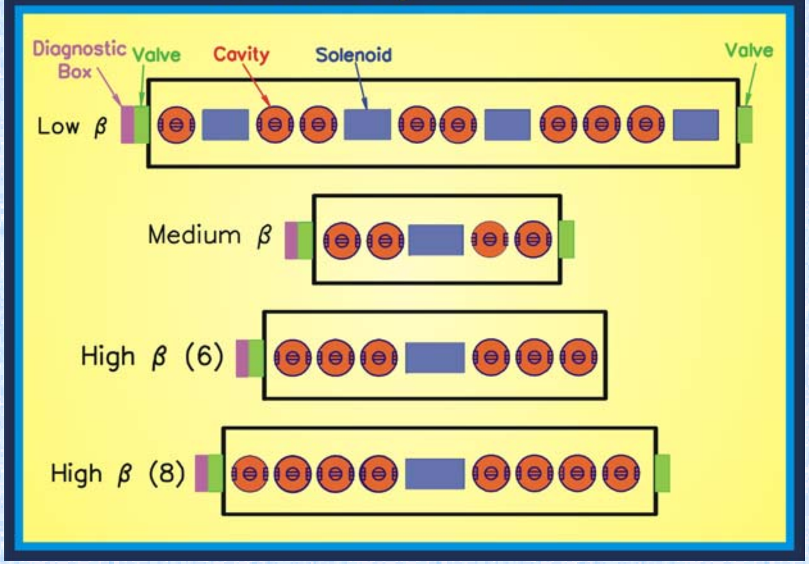
ISAC II

ACCELERATOR

STATUS

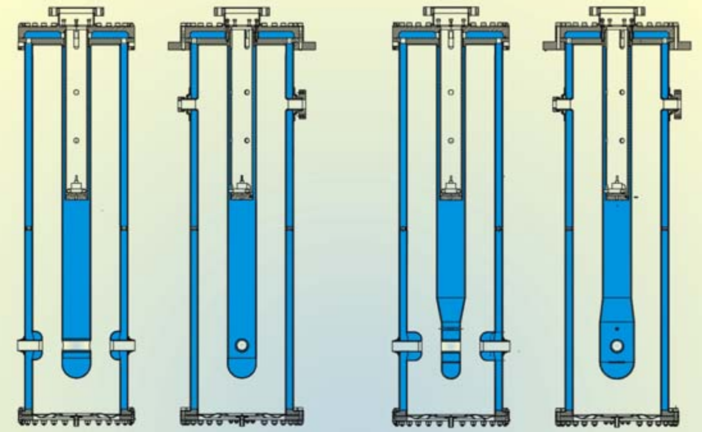

E=6.5MeV/u (A/q=7)
3≤A/q≤10
MEBT2
HEBT2–Exp.
Low β
S2
Medium β
High β
ACCELERATOR MILESTONES
2005
2007
2009
S1
E=0.4MeV/u
IH–DTL2
A/q≤6
E=0.15–1.5MeV/u
HEBT1–Exp.
MEBT1
IH–DTL1
S0
A/q≤30
E=0.15MeV/u
RFQ
LEBT–Exp.
ISAC–1
CSB
LEBT
OLIS

ISAC-II SC Linac



Section	β_0 (%)	f_{RF} (MHz)	No.	E_a (MV/m)
Low β	4.2	70.7	8	5
Med β	5.7	106	8	6
	7.1	106	12	6
High β	10.4	141	20	6

Medium Beta Cavities



(a) Nominal (β=7.1%) (b) Flat (β=5.7%)

freq=106.08MHz

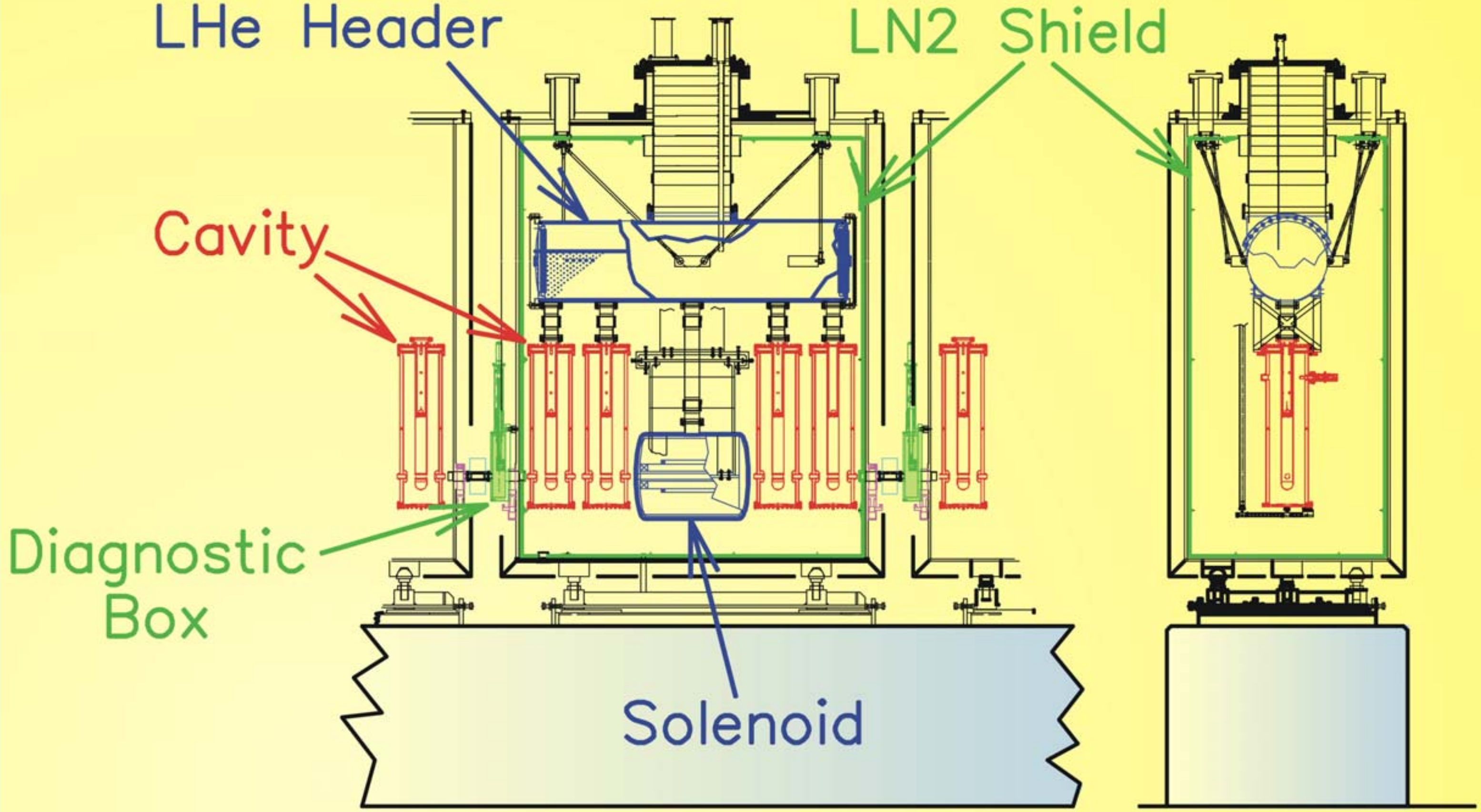
$E_p/E_a \simeq 5$

$H_p/E_a \simeq 100\ G/(MV/m)$

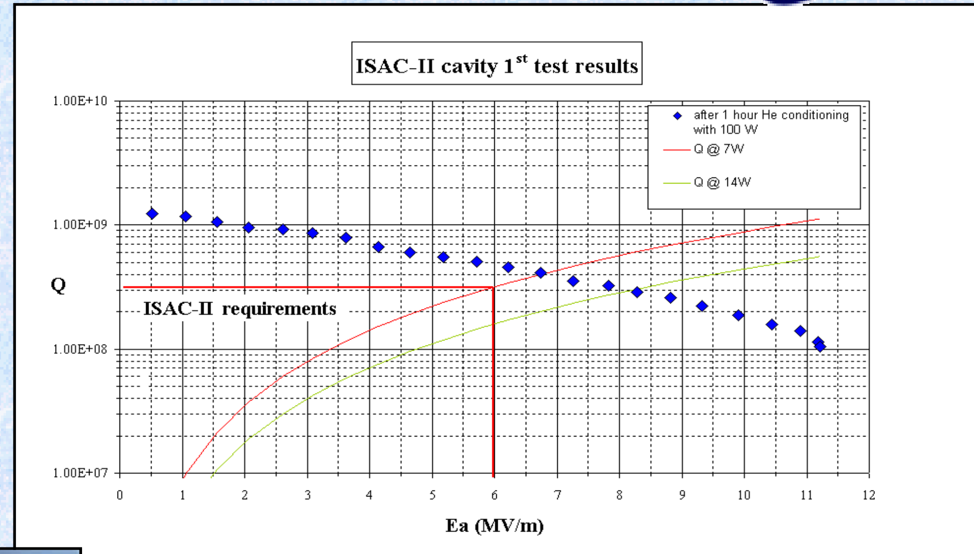
$U/E_a \simeq 0.09 J/(MV/m)^2$

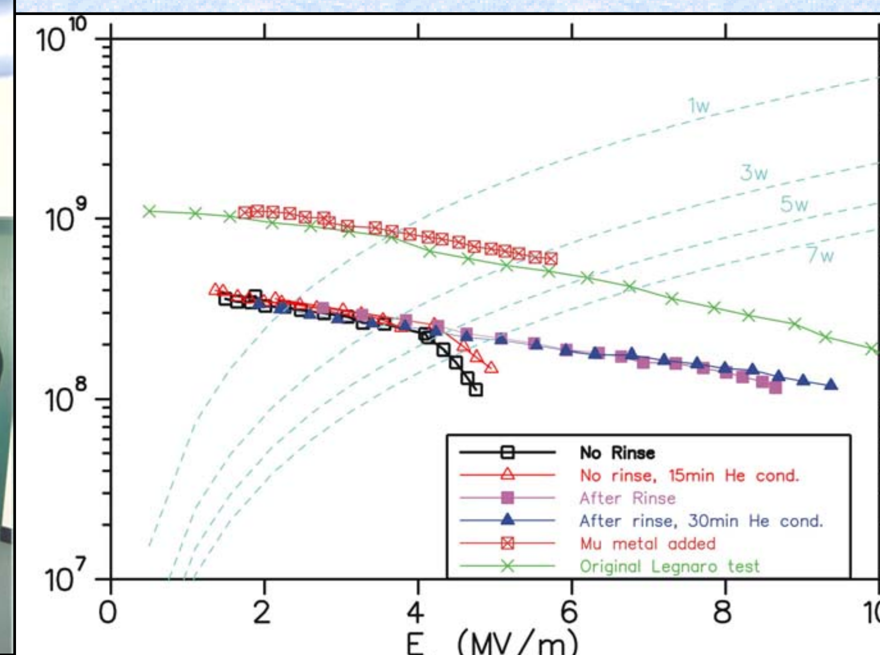
$\Gamma \simeq 19\Omega$

Medium Beta Cryomodule



106 MHz Prototype Cavity





NEXT FIVE YEAR PLAN

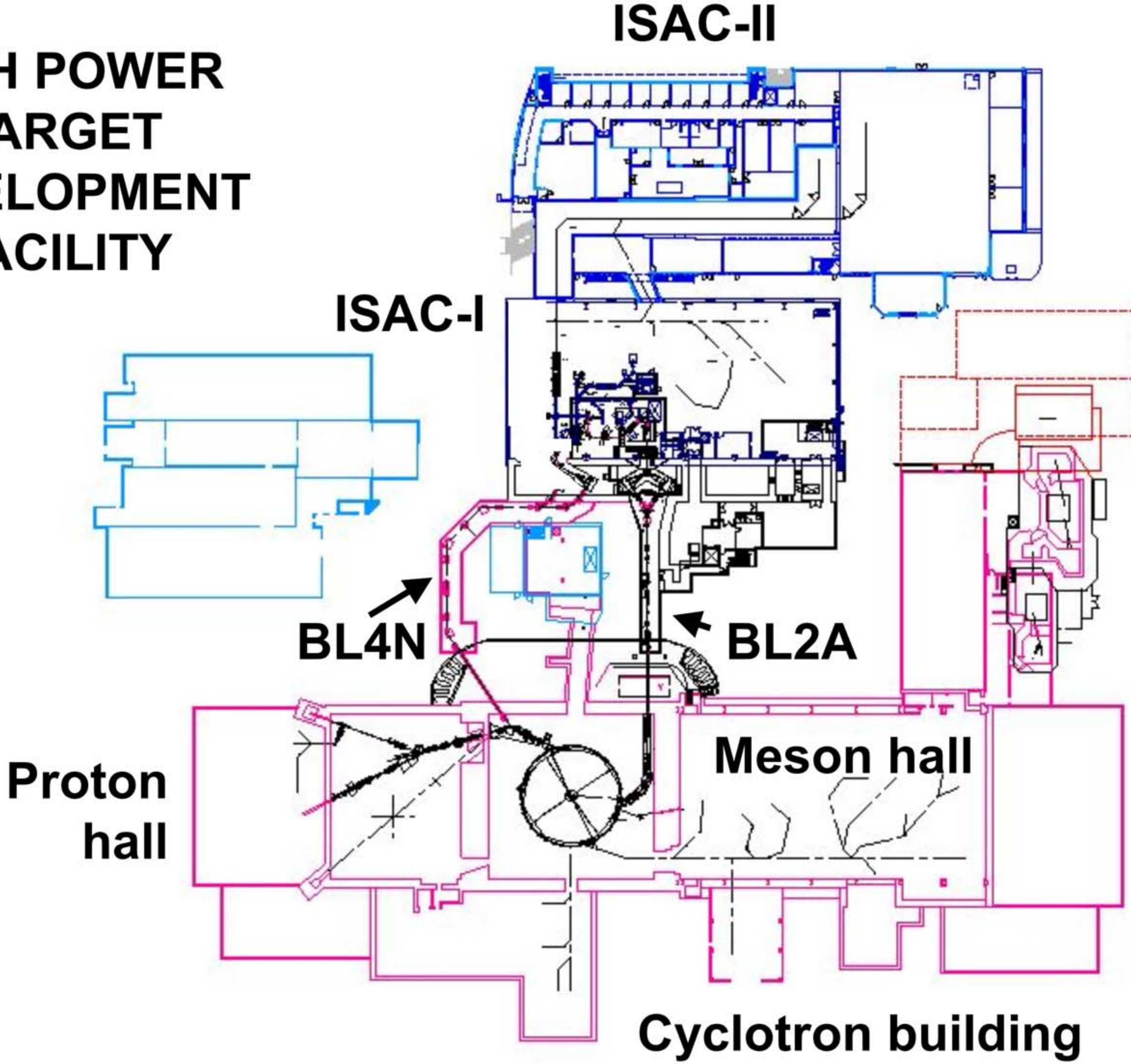
for

ISAC

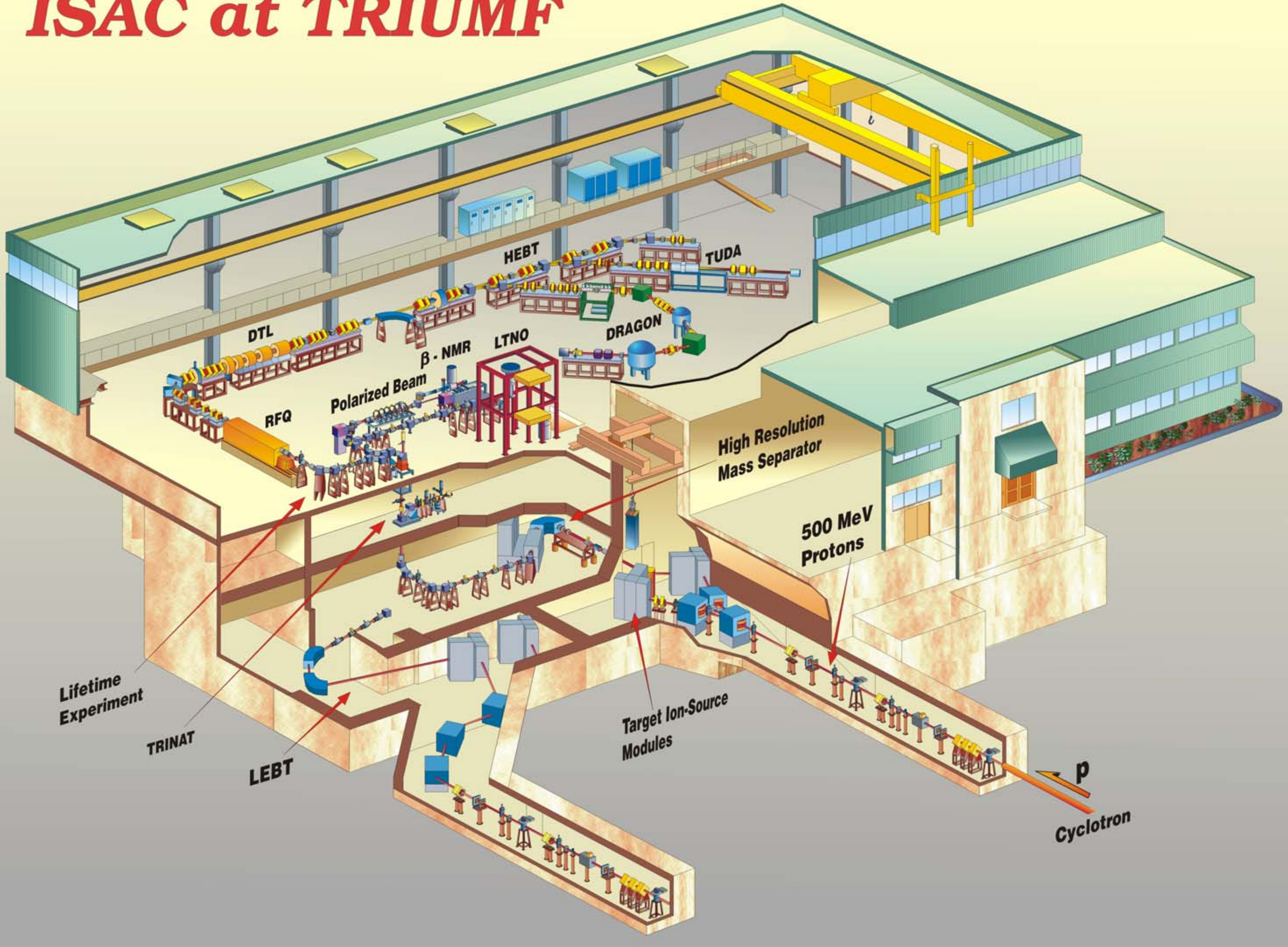
ISAC PROPOSAL FOR NEXT 5 YEAR PLAN

- OPERATE ISAC I & II
- DEVELOP NEW TARGETS, BEAMS & ION SOURCES
- COMPLETE ISAC II
  - ♦ ACHIEVE DESIGN SPECIFICATIONS
    - Medium Beta Section Completed in Mid 2005
      - ⁎ 4.3 MeV/u (Initial Experiments Begin)
    - CSB Commission by End of 2005
      - ⁎ Extends Mass Range for Isotopes with q/a = 1/7
    - High Beta Section Completed in 2007
      - ⁎ 6.5 Mev/u (3 Operating Experimental Stations & Beam Lines)
    - Low Beta & DTL2 Completed in 2009
      - ⁎ CSB only required to provide q/a = 1/30
      - ⁎ Provides full Mass Range & Multiple Charge Acceleration
- 2nd DRIVER BEAM & TARGET STATIONS
  - ♦ INSTALL TARGET/ION SOURCE DEVELOPMENT STATION
  - ♦ PERMITS FUTURE MULTIPLE SIMULTANEOUS EXOTIC BEAMS
- MULTIPLE SEPARATOR STATION CAPABILITY
  - ♦ SEPARATED RIBs TO MULTIPLE SIMULTANEOUS EXPERIMENTS
- ALLOW FOR FUTURE DOUBLE ACCELERATOR CHAIN

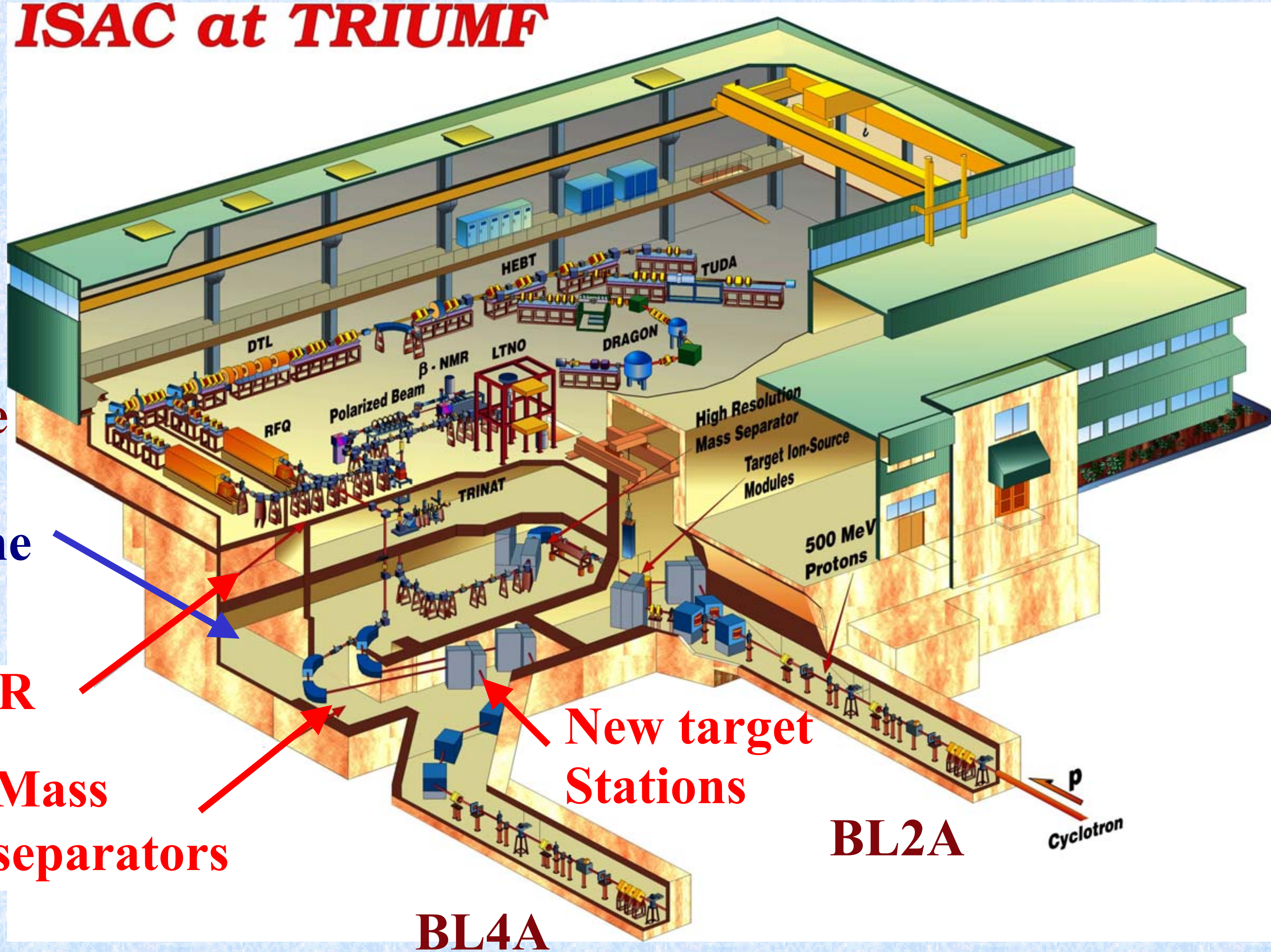
HIGH POWER TARGET DEVELOPMENT FACILITY



ISAC at TRIUMF



ISAC-III building



RIA CONSIDERATIONS

ISAC ISOL EXPERIENCES

- Beam Availability
  - Depends on Simultaneous Availability of
    - Driver, Ion Source &Target, Several Accelerators & Experimental Station
  - First Week of New Target tends to have Lower Availabity
  - Target Yields Tend to Decrease with Useage (Delivered Charge)
    - Adjusting Driver Current to Accommodate Demand Enhances Lifetime
  - Driver Pulses Should be Long wrt Thermal Time Constants
    - [High current pulses expected to result in shorter target life & less RIB/couloumb]
  - Precondtioning of Target & Ion Source off line Shortens Target Turn-Around Times
    - HV, Bakeout, & Stable Beam Production
- Effective Utilization of RIBs Requires Backup Users on Standby
- Driver Current Stability is Important at High Powers
  - When Driver Power Dominates Target Heating
- Target Yields can be Significantly Enhanced by Radiation Enhanced Diffusion
- Target/IS Development is Unavoidable
  - Optimally Target/IS Development should be independant of Operation
  - Requires Significant use of Driver Beam Time
- Acceptable Isotopes\Users of Parasitic Beams are Limited
  - Each Isotope has a Preferred Target Material & Target Geometry
  - Each Isotope has a Preferred Ion Source
    - Elemental Ionization Efficiencies Can Vary Significantly

RIA RELEVANT ISAC PROJECTS

- Target Development
  - High Power
  - Actinide Targets
  - Target Chemistry
- Ion Sources
  - Ion Source Test Stand
  - ECR
  - CSB
  - LIS
- Post Accelerators
  - Beam Dynamics
  - SCRF Cavities & Controls
  - Cryomodules, …
- Remote Handling
  - Tools, Connectors, Techniques, …
- Experimental Program
  - Equipment, Techniques, …
- Operations, Radiation Safety, Scheduling, …
- Experimental
  - TITAN & TIGRESS have been recently funded