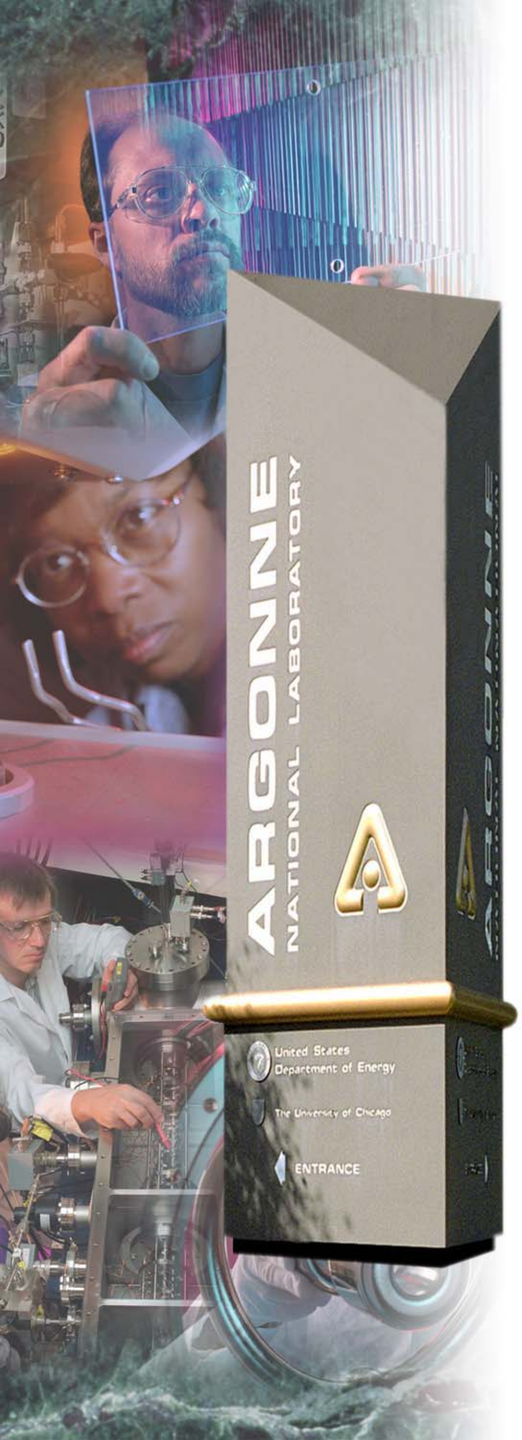

RNB Facilities in North America

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Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

Current Facilities

➢ TRIUMF/ISAC	ISOL (accelerated)
➢ ORNL/HRIBF	ISOL (accelerated)
➢ LBNL/88”	Batch
➢ ANL/ATLAS	Batch & In-flight
➢ UND/TWINSOL (UND/UofM)	In-flight
➢ TAMU/K500-MARS	In-flight
➢ SUNY/Stony Brook	HI fusion/traps
➢ MSU/NSCL/K500⊗K1200	Fragmentation

Upgrades and Proposals

The Canadian ISAC-2 Project

- In the current 5-year plan of TRIUMF
- Construction in progress

The U.S. Rare Isotope Accelerator Facility

- R&D in progress
- Critical Decision 0 expected in FY2004

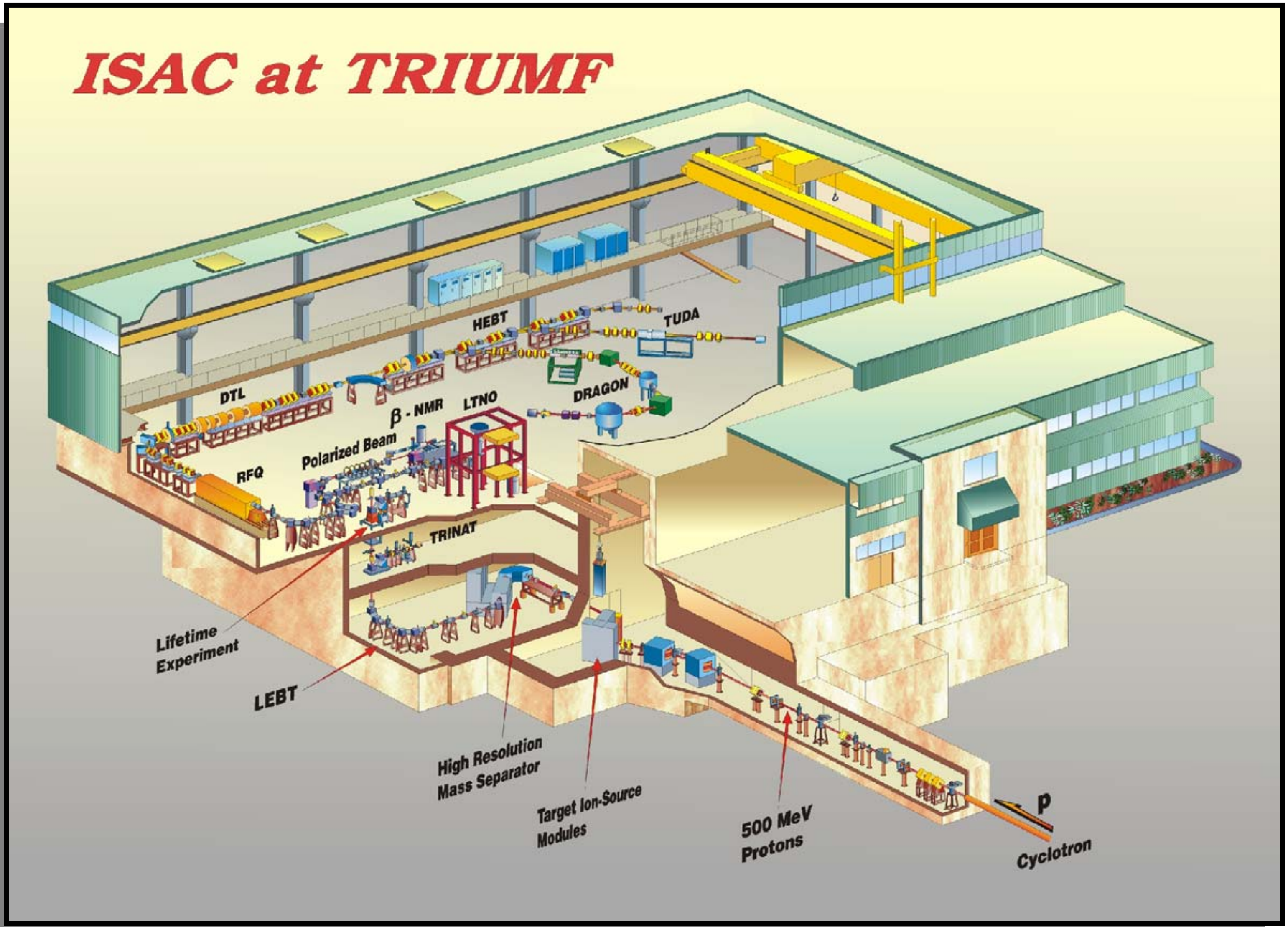
TRIUMF/ISAC-1

A Current ISOL Facility

- **Production:** 500-MeV protons, 100 μA, CW beam
- **Acceleration:** CW RFQ + IH-Linac to 1.5 MeV/u, m/q≤30
- **Beams:** ^{8,11}Li, ^{21,32}Na, … up to 10^{11} /s
- **Experiments:** DRAGON, TUDA, polarized Li, Na

See talk by M. Dombsky this afternoon, & abstracts 128, 132, 157, 174, 180, 200, & 205

ISAC-1: An existing 50-kW ISOL facility



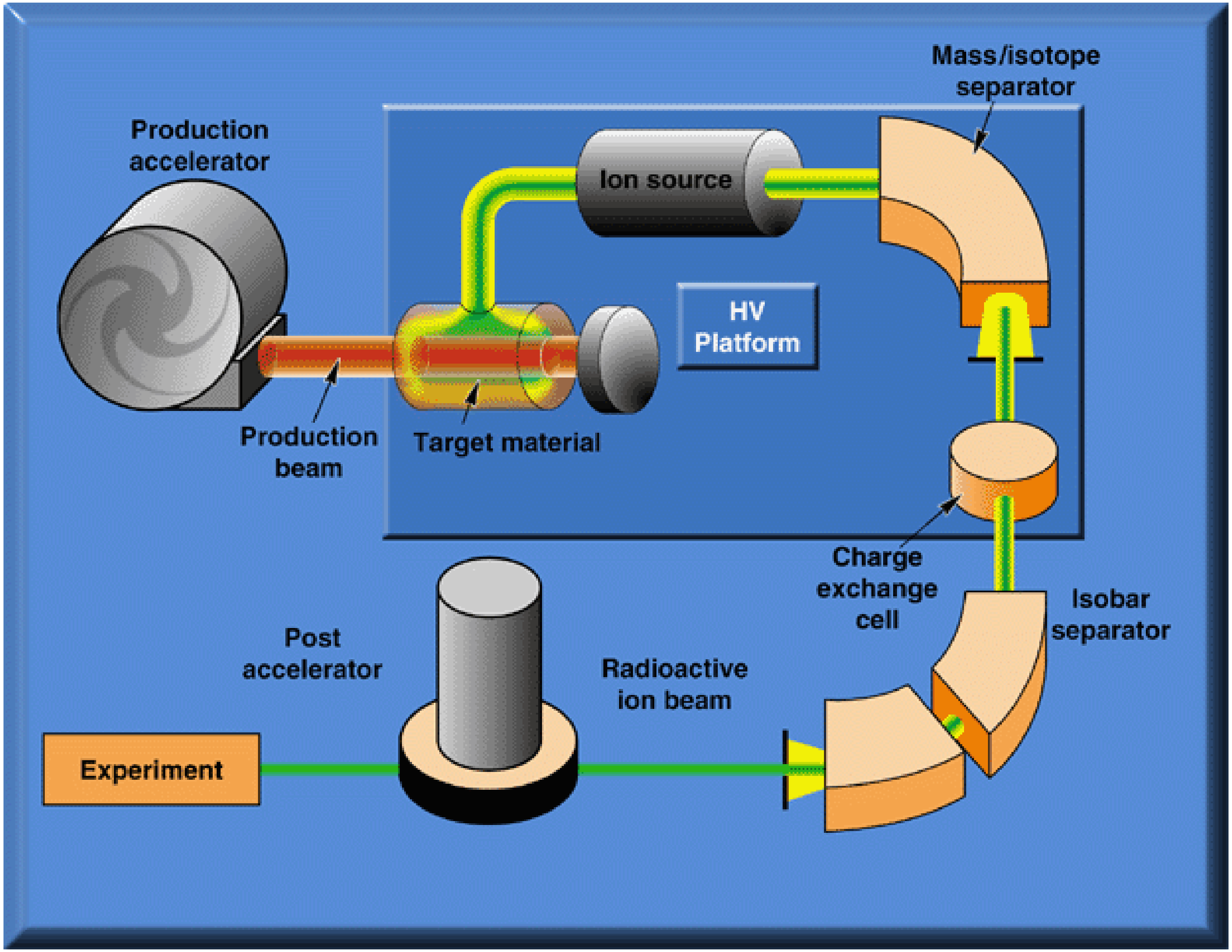
ORNL/HRIBF

A Current ISOL Facility

- **Production:** ORIC cyclotron, p, d, α; ~50 MeV; ~10 μA CW
- **Acceleration:** 25 MV Tandem, DC beams, negative ions
- **Radioactive beams:** ^{69,70}As on target ~10^5 /s
  ^{17,18}F, ^{56}Ni ~10^5-10^8/s
  ^{132}Sn, etc.
- **Experiments:** DRS (Daresbury Recoil Separator)
  RMS (Recoil Mass Separator)

See talks by Stracener, Radford, Liang, & Blackmon, & abstracts: 89, 91, 95, 101, 108, 120, 133, 153, 159, 160, & 169.

Schematic Layout of HRIBF



HRIBF Research Highlights

➢ Recent experimental highlights

- ^{18}F(d,p) experiment, first to use DRS with RIB
- Coulex with ^{132}Sn-region nuclei
  - *^{128}Sn, ^{130}Sn, ^{132}Sn, ^{134}Sn*
  - *Coulex with ^{80}Ge, ^{82}Ge*
- Fusion of ^{132}Sn + ^{64}Ni
  - *Excitation function down to a few mb (~.9V_b to ~1.2V_b)*
  - *Surprising enhancement below barrier*
- ^{82}Ge(d,p) transfer study
  - *Beautiful results at 10k pps Ge*
- Mass measurements: $^{83-86}$Ge, $^{77-79}$Cu

LBNL 88" Cyclotron: BEARS & "Recyclotron"

- **BEARS Production:** LBNL PET cyclotron; 10 MeV p; 40 μA CW
- **Recyclotron Production:** 88" cyclotron
- **Acceleration:** 88" cyclotron, 1-20 MeV/u
- **Radioactive beams:** BEARS: ^{11}C, ^{14}O ~10^5-10^8/s
  Recyclotron: ^{76}Kr ~10^9/s
  Traps: ^{21}Na (MOT)
- **Experiments:** Silicon Detector Arrays; 8π array; BGS (Berkeley Gas-filled Separator); Traps

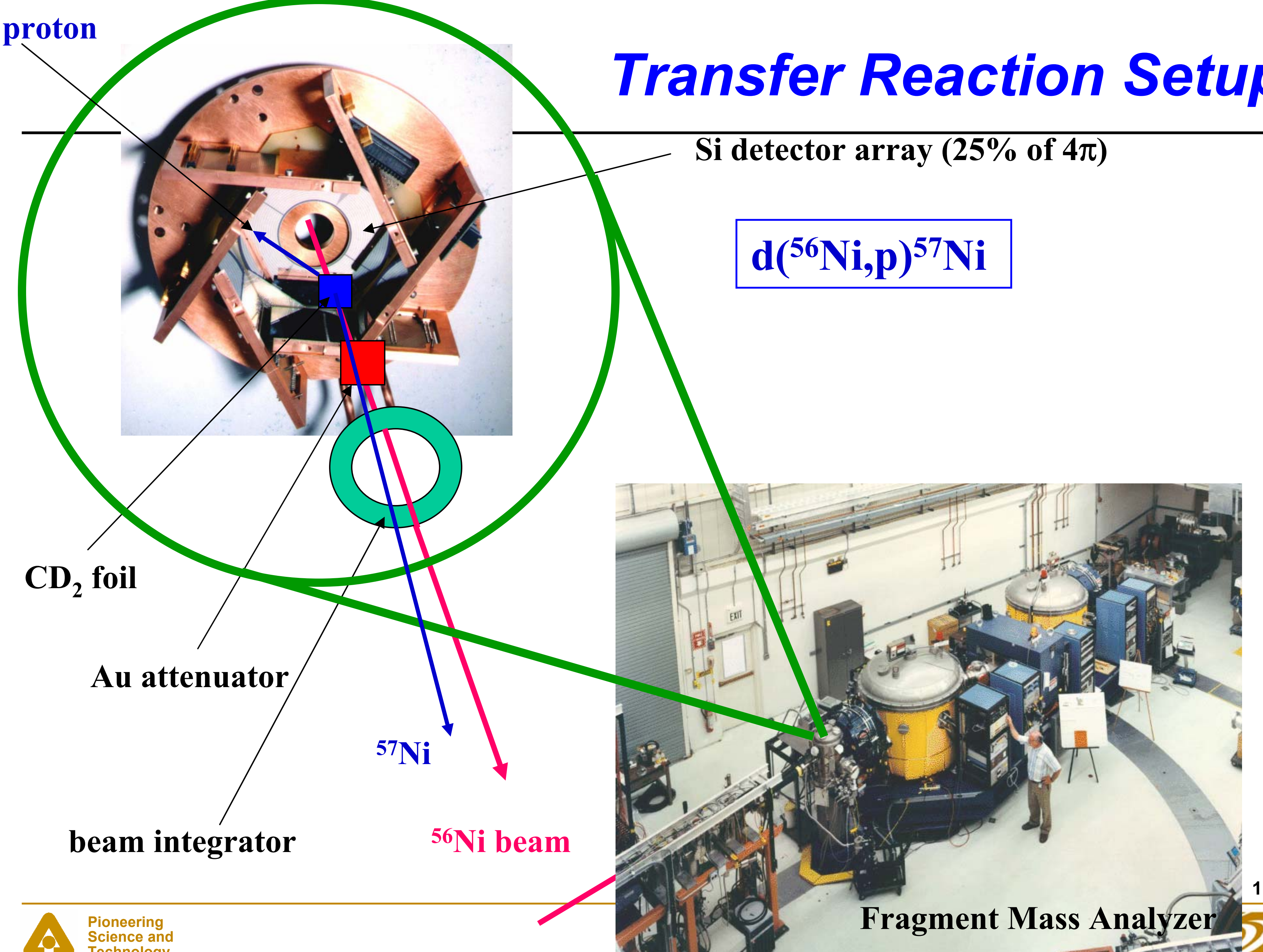
See abstracts 74, 82, 135, 147, & 202

ANL/ATLAS: Batch Mode

- **Production:** ^{18}F: U. Wisc. PET Cyclotron, ~10 MeV p, ≥100 μA
  ^{56}Ni: ANL IPNS, 50 MeV p, ~15 μA
- **Acceleration:** FN Tandem + SC Linac, 0.5-5 MeV/u
- **Radioactive beams:** ^{18}F, ^{56}Co, ^{56}Ni 10^5-10^7/s
- **Experiments:** Gas-filled split-pole spectrograph
  FMA + Silicon detector array

See abstracts 125 & 177.

Transfer Reaction Setup

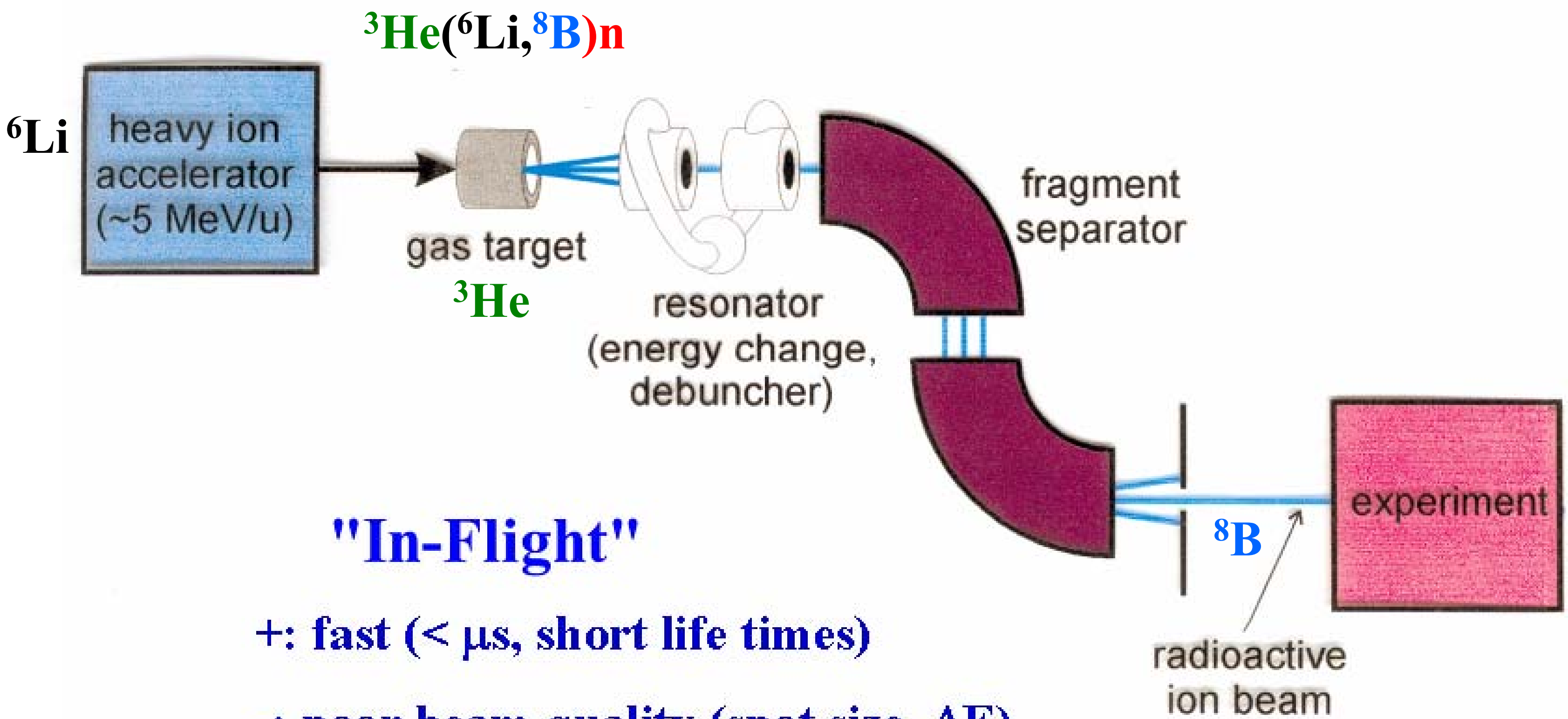


ANL/ATLAS: In-Flight Production

- **Accelerator:** Superconducting linac; ~5-10 MeV/u; ~400 pnA CW
- **Reactions:** e.g. $^{2}H(^{16}O,\ ^{17}F)n$, gas cell
- **Radioactive beams:** ^{6}He, ^{8}B, ^{17}F, ^{21}Na, 10^{3}-10^{6} /s on target
- **Experiments:** Traps, Implantation, Fusion/fission, transfer reactions (split-pole & FMA)

See talks by Winter, Clark, & Rehm, & abstracts 140, 158, 176, 178, 179, & 195.

In-Flight Production at ATLAS



"In-Flight"

+: fast (< μs, short life times)

-: poor beam quality (spot size, ΔE)

^{17}F, ^{21}Na, ^{25}Al, ^{37}K, ^{8}B, ^{6}He, ^{8}Li, ^{11}C ..

TWINSOL (Notre Dame/UofM)

- **Accelerator:** **FN Tandem, 10 MV, ~ μA, DC beam**
- **Reactions:** **e.g. $^{9}Be(^{7}Li, ^{6}He)\,^{10}B$, $^{3}He(^{6}Li, ^{8}B)n$**
- **Radioactive beams:** **^{6}He, ^{8}Li, ^{7}Be, ^{8}B… 10^{4}-10^{8} /s**
- **Experiments:** **Elastic scattering, sub-barrier fusion/fission**

See abstracts 111 & 138.

MARS & Big Sol @ Texas A&M

- **Accelerator:** K500 superconducting cyclotron
  100-200 pnA, CW beams
- **Reactions:** Inverse (p,n), (d,n) in gas cells;
  ~10-50 MeV/u
- **Radioactive beams:** ^{7}Be, ^{20}Na, ^{20}F, ^{57}Cu, ^{62}Ga
  10^{5}-10^{6}/s
- **Experiments:** MARS (Momentum Achromat Recoil Separator); Big Sol (superconducting solenoid); Decay studies; scattering experiments, (^{7}Be,^{8}B), ANC, etc.

See talks by Tribble, & abstracts: 118, 145, 161, & 182.

SUNY/Stony Brook: In-Flight Fusion

- **Accelerator:** Tandem + Superconducting linac
- **Reactions:** e.g. $^{197}Au(^{18}O, ^{210}Fr)5n$
- **Radioactive beams:** ^{210}Fr, 10^6 -10^7/s, also $^{208,209,211,212}Fr$
- **Experiments:** Optical Traps, Laser Spectroscopy

See abstract 102.

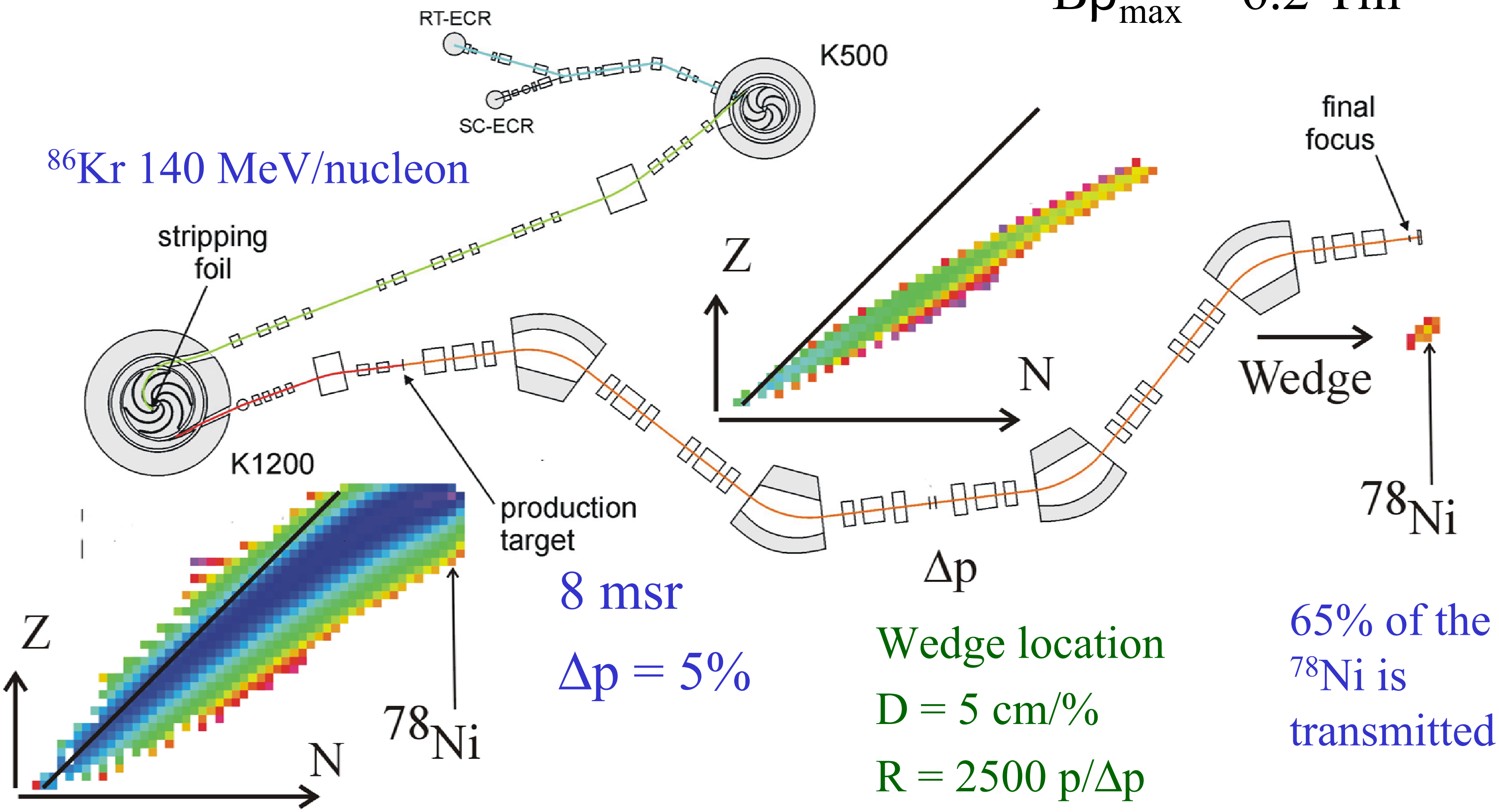
MSU/NSCL: Coupled Cyclotron Project

- **Accelerator:** K500⊗K1200 Coupled Superconducting Cyclotrons; up to 1 pμA CW (4-kW beams)
- **Primary beams:** 200 MeV/u ^{16}O, 85 MeV/u ^{238}U, etc.
- **Radioactive beams:** ^{11}Li, ^{26}P, ^{40}S, ^{120}Rh, etc.
- **Experiments:** A1900, S800, 4π array, n wall, sweeper magnet, etc.

See talks by Stolz, Bazin, & Schatz & abstracts 86, 88, 119, 148, 149, 152, 172, 194, & 196.

The A1900 at the NSCL

$B\rho_{max} = 6.2$ Tm



8 msr

Δp = 5%

Wedge location

D = 5 cm/%

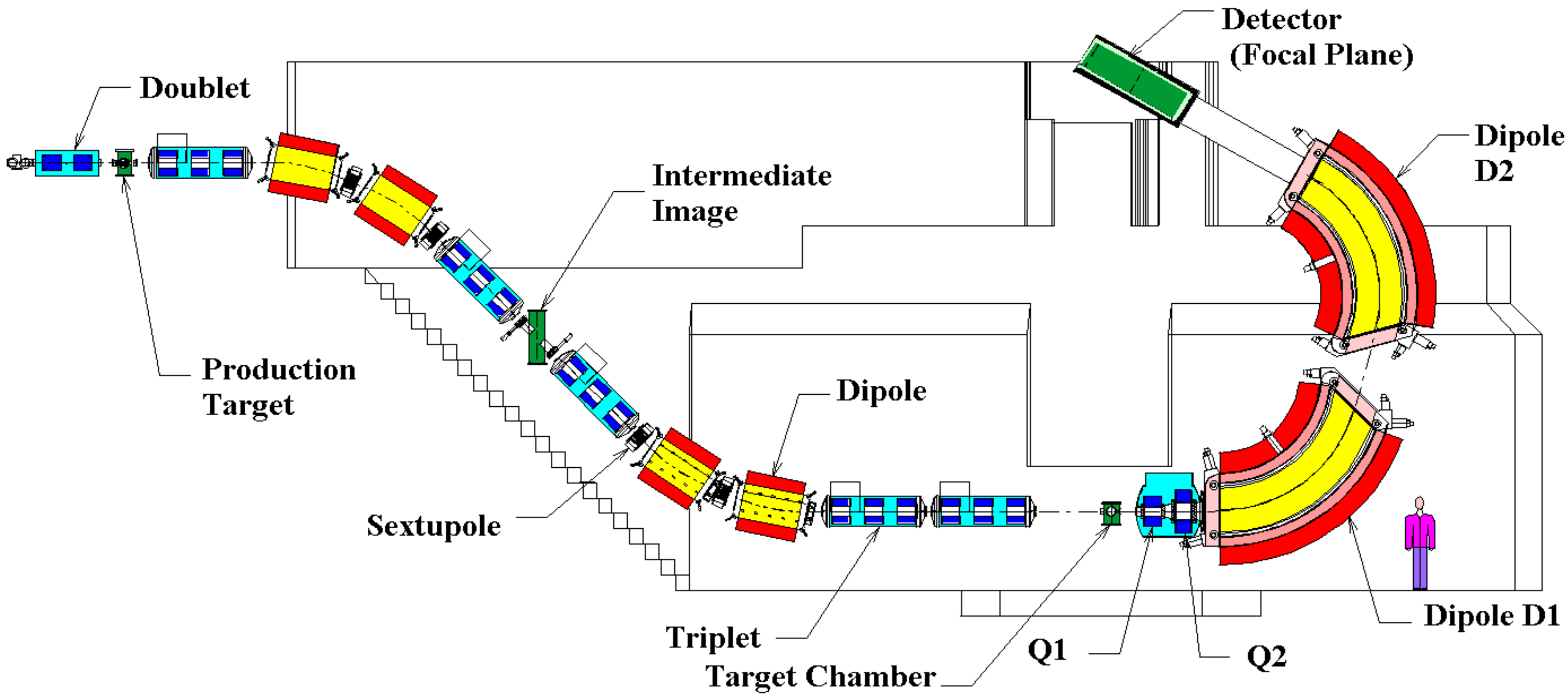
R = 2500 p/Δp

65% of the ^{78}Ni is transmitted

S800 Superconducting Magnetic Spectrograph

NSCL design and construction (completed in 1996)

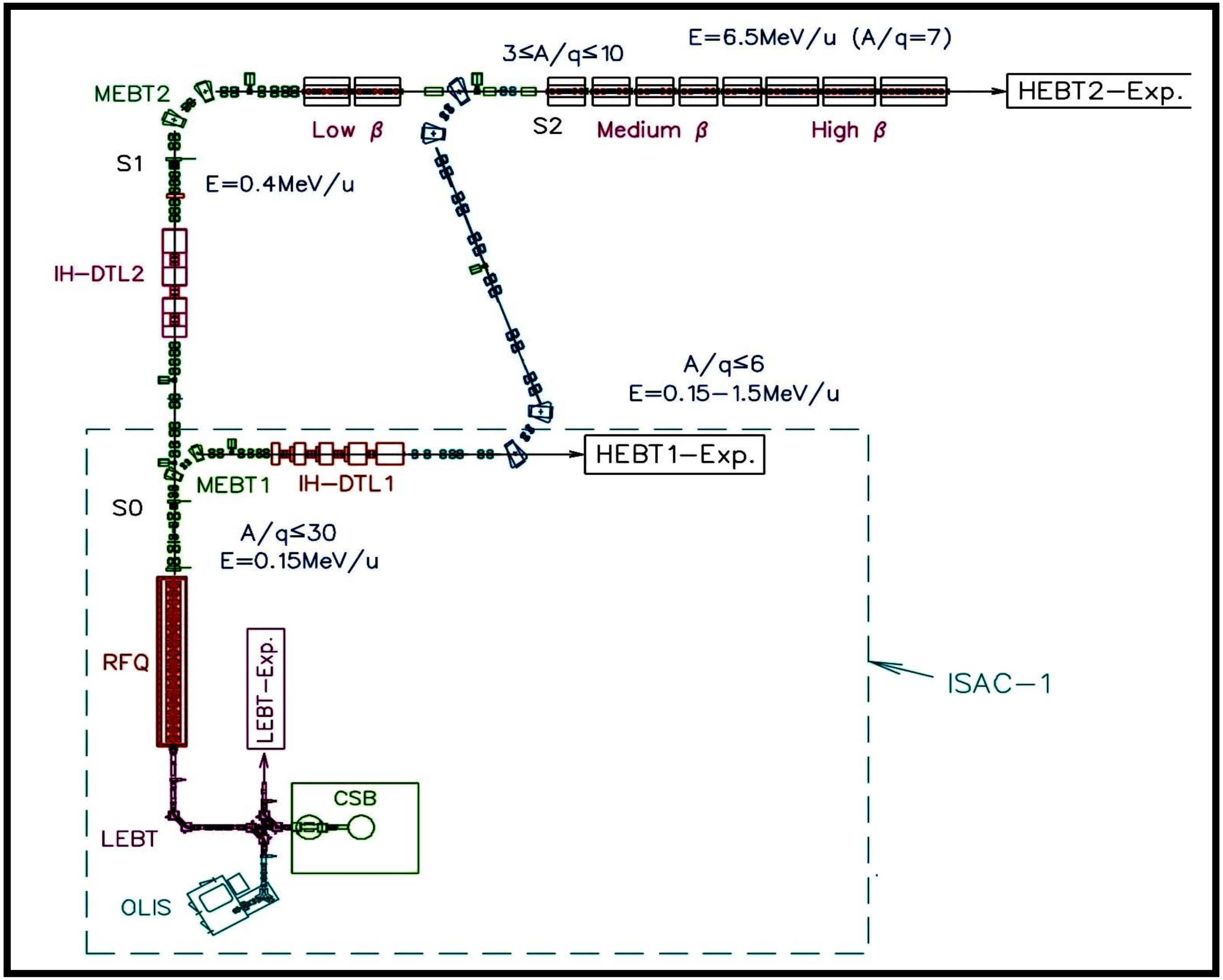
- Maximum Rigidity: 1.2 GeV/c
- Large energy range: 10%.
- Large solid angle: $\Delta\Omega$ = 15-20 msr, $\Delta\theta = 10°$, $\Delta\phi = 7°$.
- Resolution: $E/\Delta E$ = 10,000; $p/\Delta p$ = 20,000; $\delta\theta < 2$ mr.



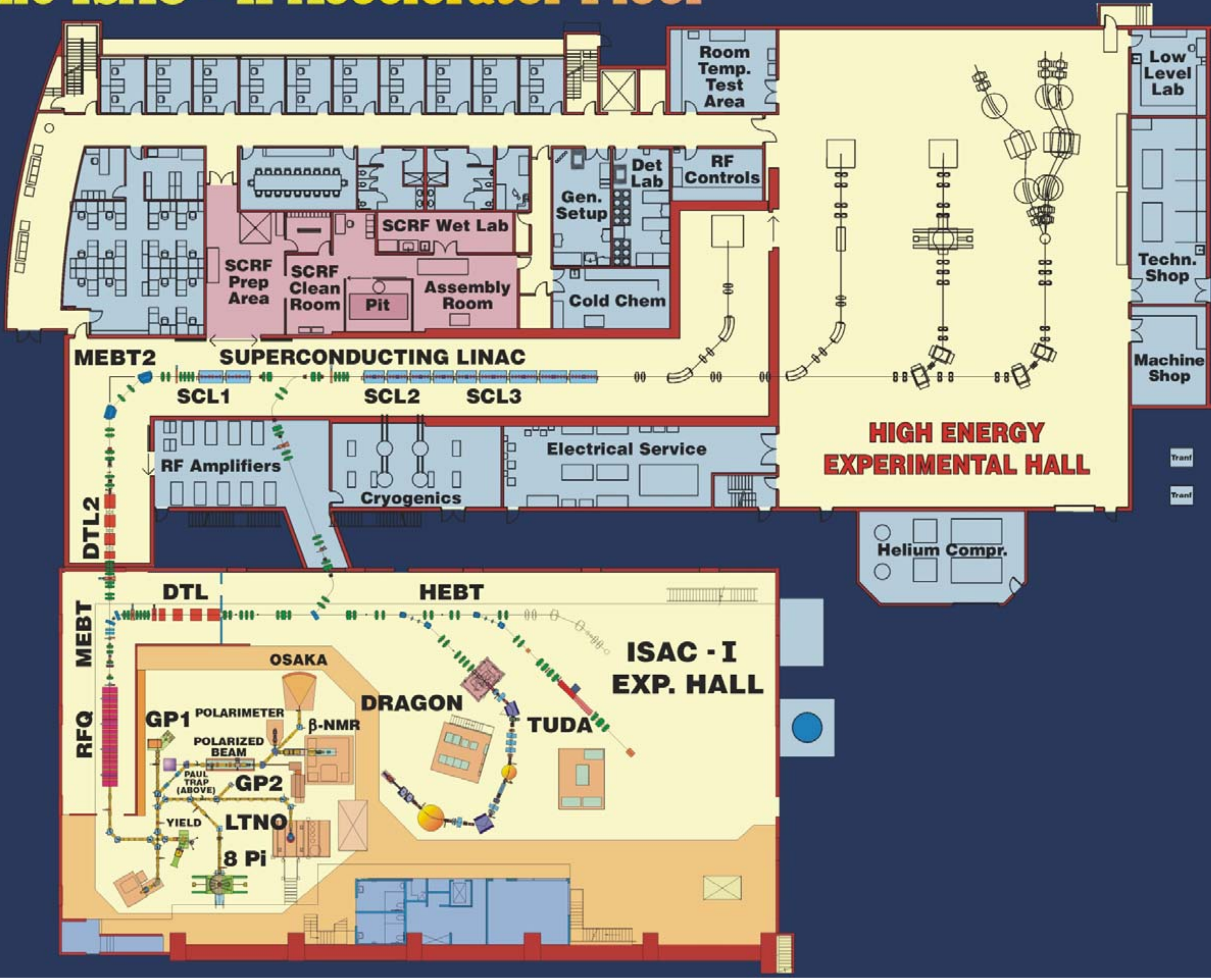
ISAC-2

- **Upgraded post-accelerator and expanded facilities**
  - Extended mass range to A=150
  - Extended energy range to 6.5 MeV/u
  - New building (completed) and expanded experimental hall

ISAC-2 Final Configuration - 2009



The ISAC - II Accelerator Floor

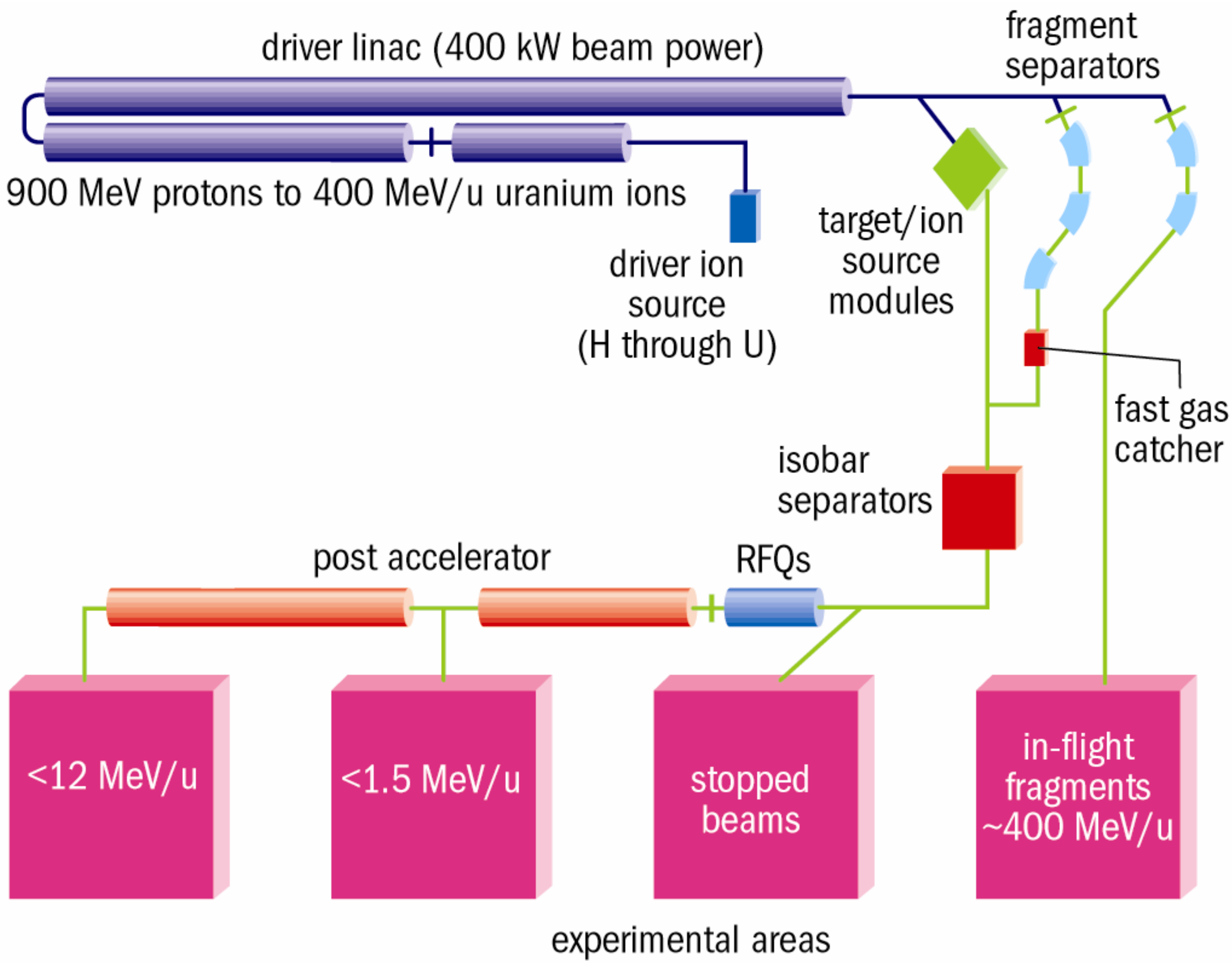


RIA Technical Features

- **High power CW SC Linac Driver (1.4 GV, 400 kW)**
  - Advanced ECR Ion Source
  - Accelerate 2 charge states of U from ECR
  - All beams: protons-uranium
  - Superconducting over extended velocity range: 0.2 – 900 MeV/u
  - Multiple-charge-state acceleration after strippers
  - Adapted design to use both SNS cryomodules
  - RF switching to multiple targets
- **Large acceptance fragment separators**
  - 1) "Range Bunching" + Fast gas catcher for ISOL
  - 2) High resolution and high purity for in-flight
- **High power density ISOL and fragmentation targets**
  - Liquid lithium as target for fragmentation and cooling for n-generator
- **Efficient post-acceleration from 1+ ion sources**
- **Next-generation instruments for research with rare isotopes**

See talk by Loveland & abstracts 92, 93, 96, 98, 100, 191, & 201.

Schematic of the RIA Facility

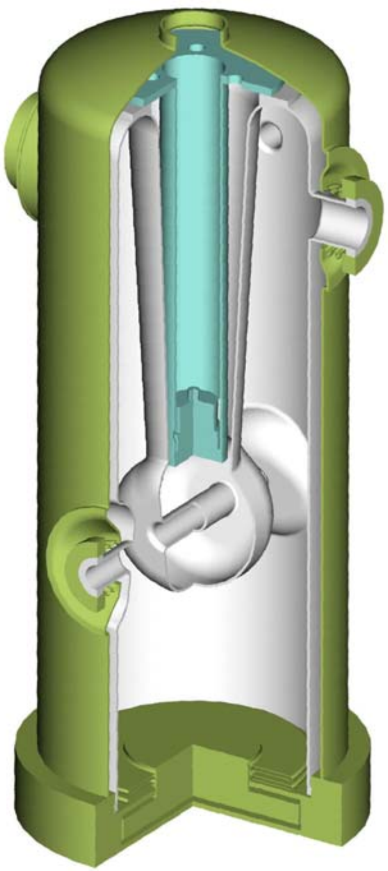


Partial Beam list for the RIA Driver Linac

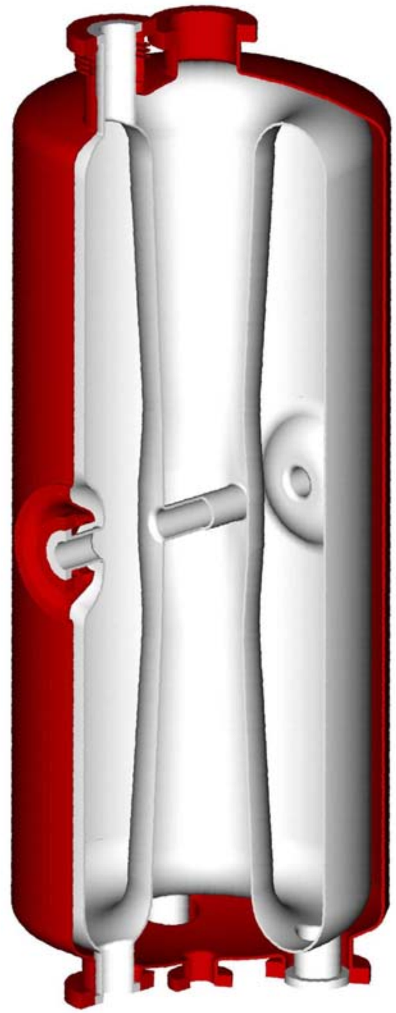
A	I source	Qinj	Qstrip	Qout	I out	Energy out
	pμA				pμA	MeV/u
1	556	1	-	1	445	899
3	232	2	-	2	186	717
2	416	1	-	1	333	600
18	54	6	8	8	40.3	551
40	29	8	18	18	18.0	554
86	15	14	33-34	36	8.8	515
136	12	18	46-48	53-54	6.2	476
238	8	28-29	69-73	87-90	4	403

400 kW beam power

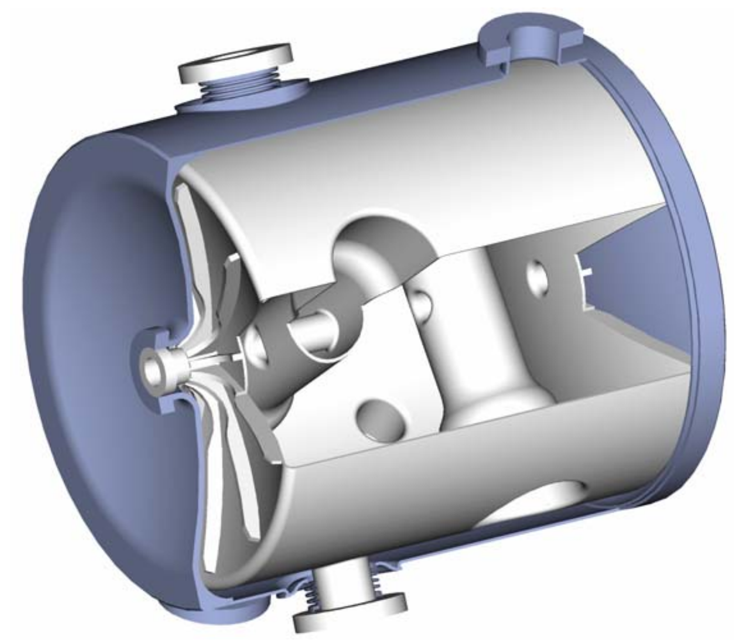
Intermediate-velocity SC Drift-tube Cavities



115 MHz, β =.15



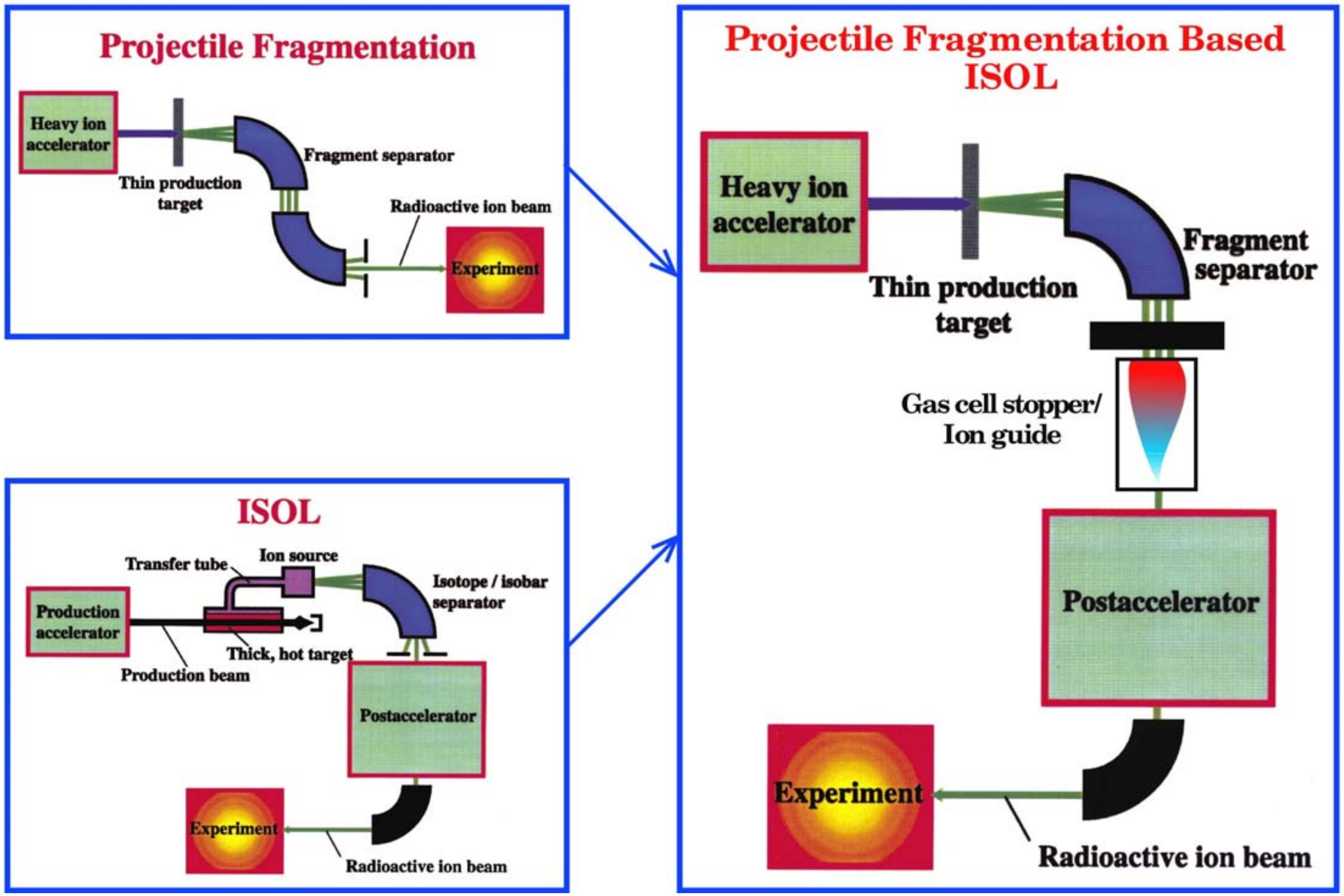
172.5 MHz, β =.25



345 MHz, β =.4

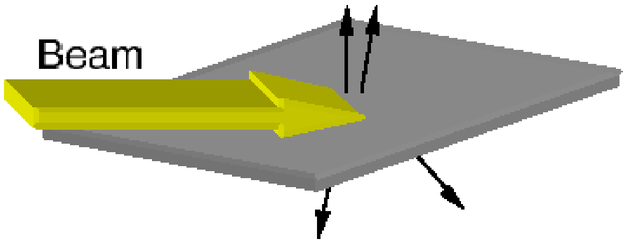
Rare Isotope Production Schemes

- Fast Extraction Times (~msec)
- Chemical independence
- Isobar separation

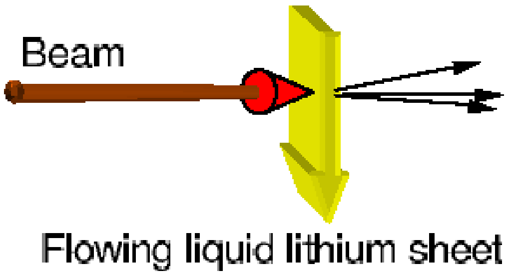


A Variety of Targets and Production Mechanisms

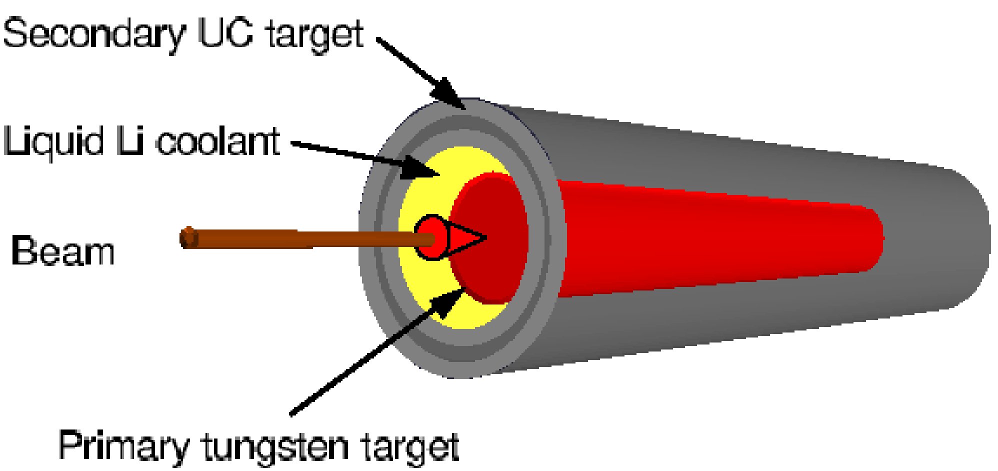
(a) Tilted spallation target



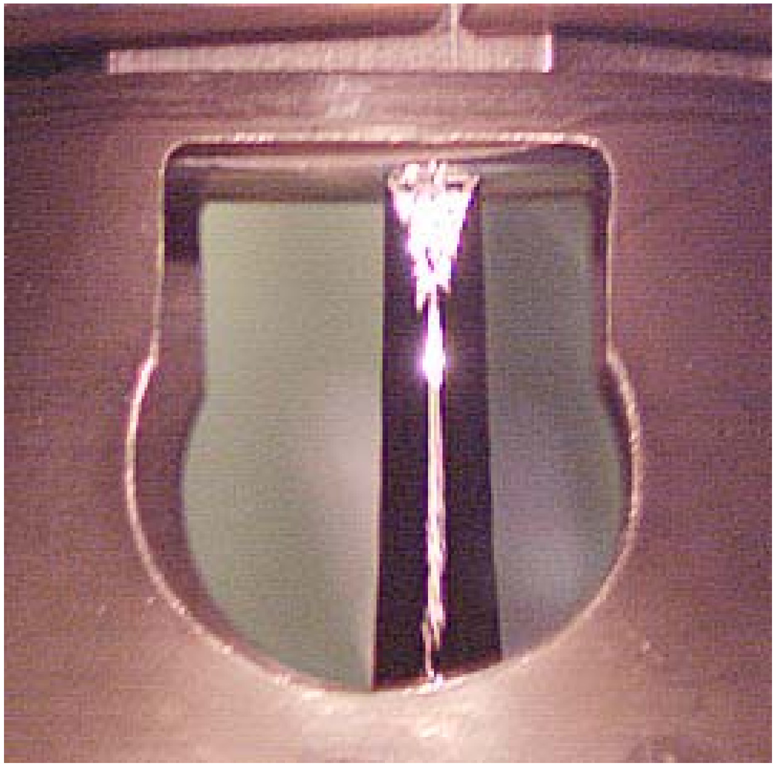
(b) Liquid lithium target



(c) Two-step neutron-induced fission target



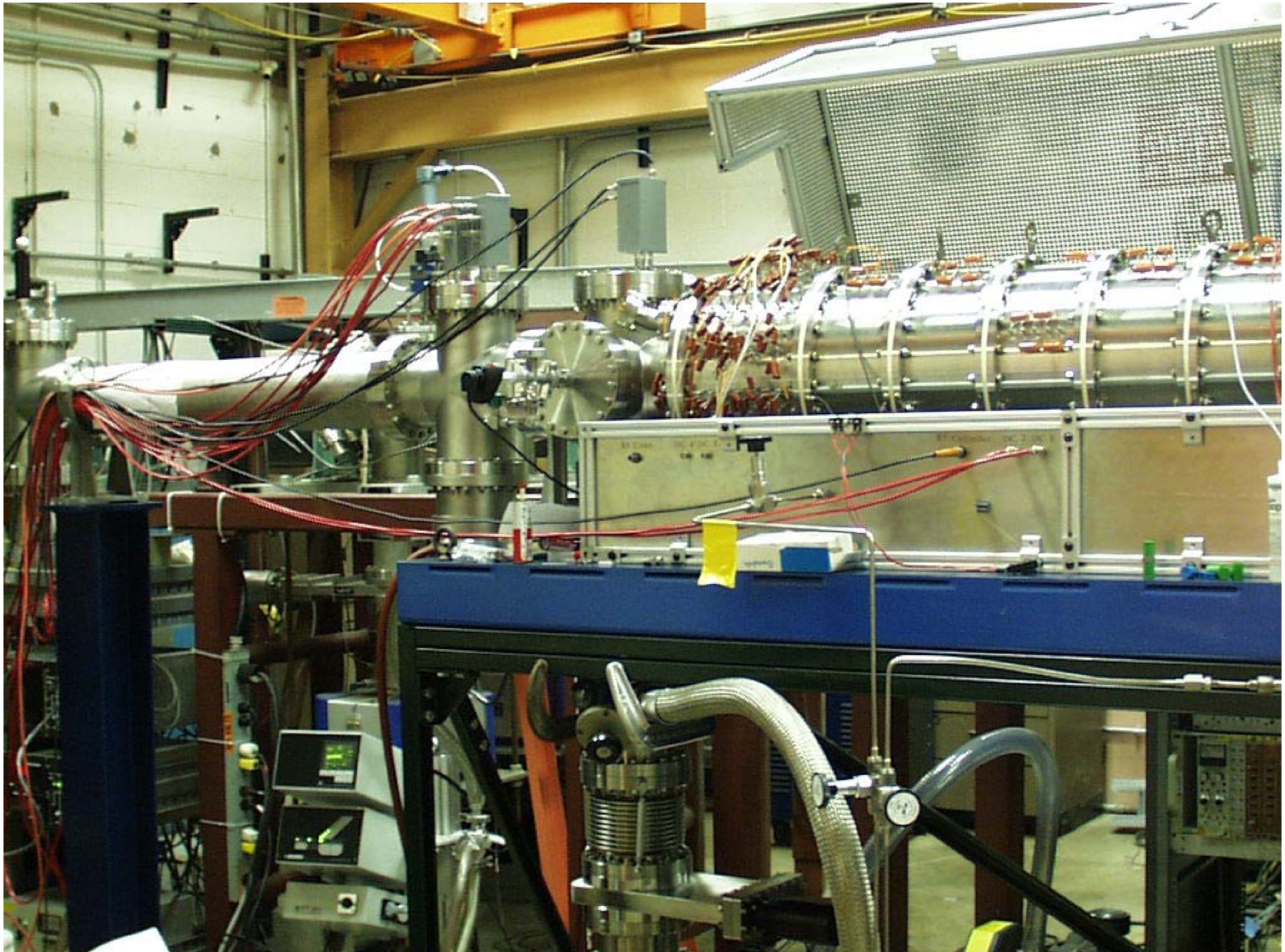
Picture of liquid-lithium jet in vacuum



See talk by C.B. Reed on Windowless Liquid-Lithium Target Tuesday afternoon.

5-mm x 10-mm liquid-lithium jet flowing at 10 m/s in vacuum
(5-mm wide in this view)

RIA gas catcher prototype tested at ATLAS



See abstract 98.

NSAC 2002 Long Range Plan

Recommendation: The Rare Isotope Accelerator (RIA) is our highest priority for major new construction.

R&D: Nine labs in the U.S. are participating in R&D for the RIA project. MSU & ANL are working to develop a cost-effective technical plan. Both institutions would like to be the site of RIA.

Optimistic time line for RIA

DOE Critical Decision 0 in 2004, followed by 3 years of design and 4 years of construction. Commission in 2011.