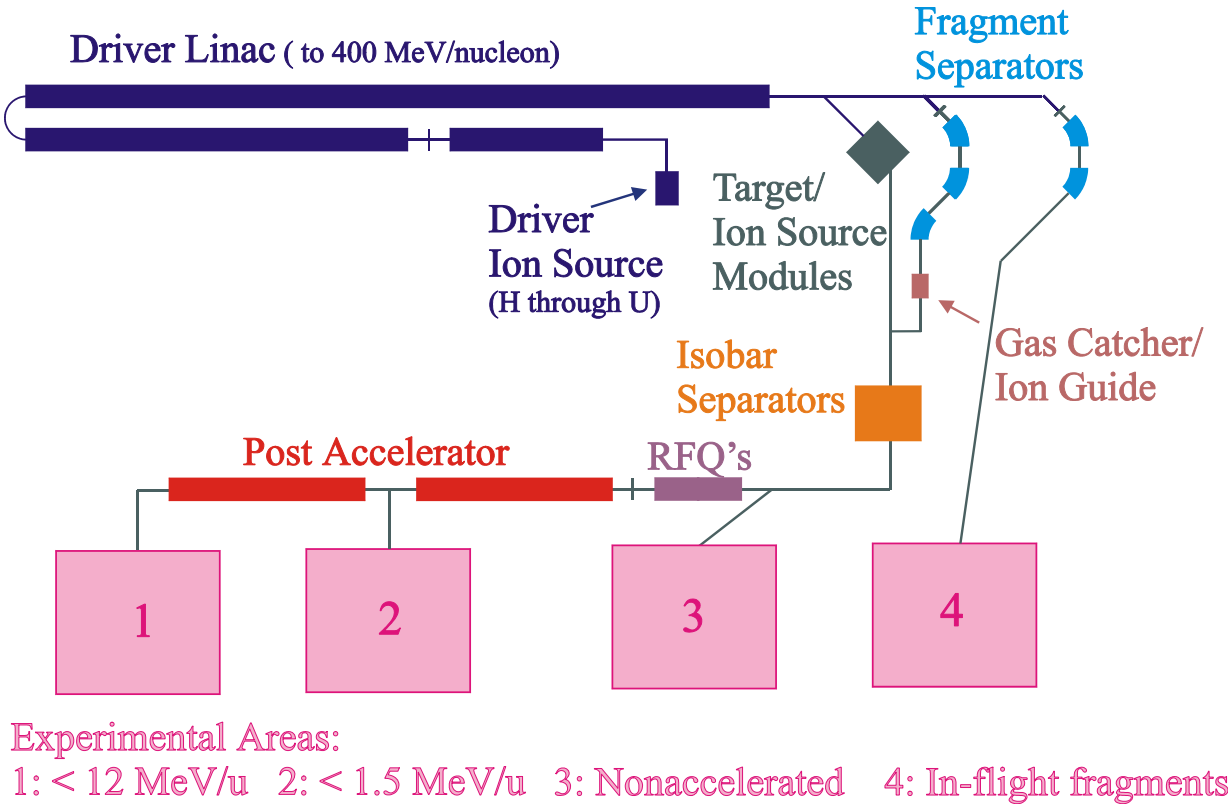
Cost of the ISOL systems

Simplified Schematic Layout of the Rare Isotope Accelerator (RIA) Facility



Experimental Areas:
1: < 12 MeV/u 2: < 1.5 MeV/u 3: Nonaccelerated 4: In-flight fragments

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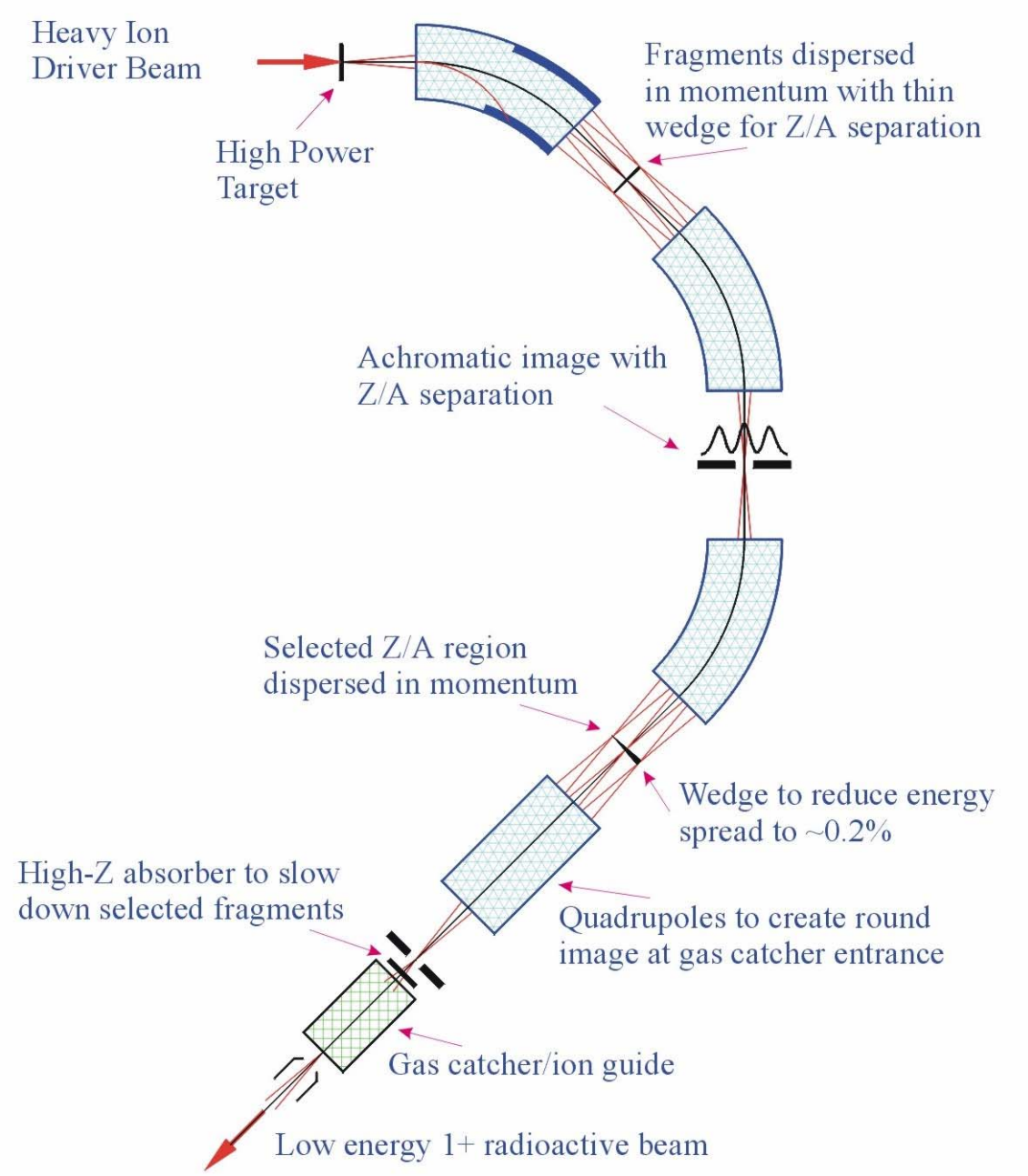
Gas Cell Fragment Separator



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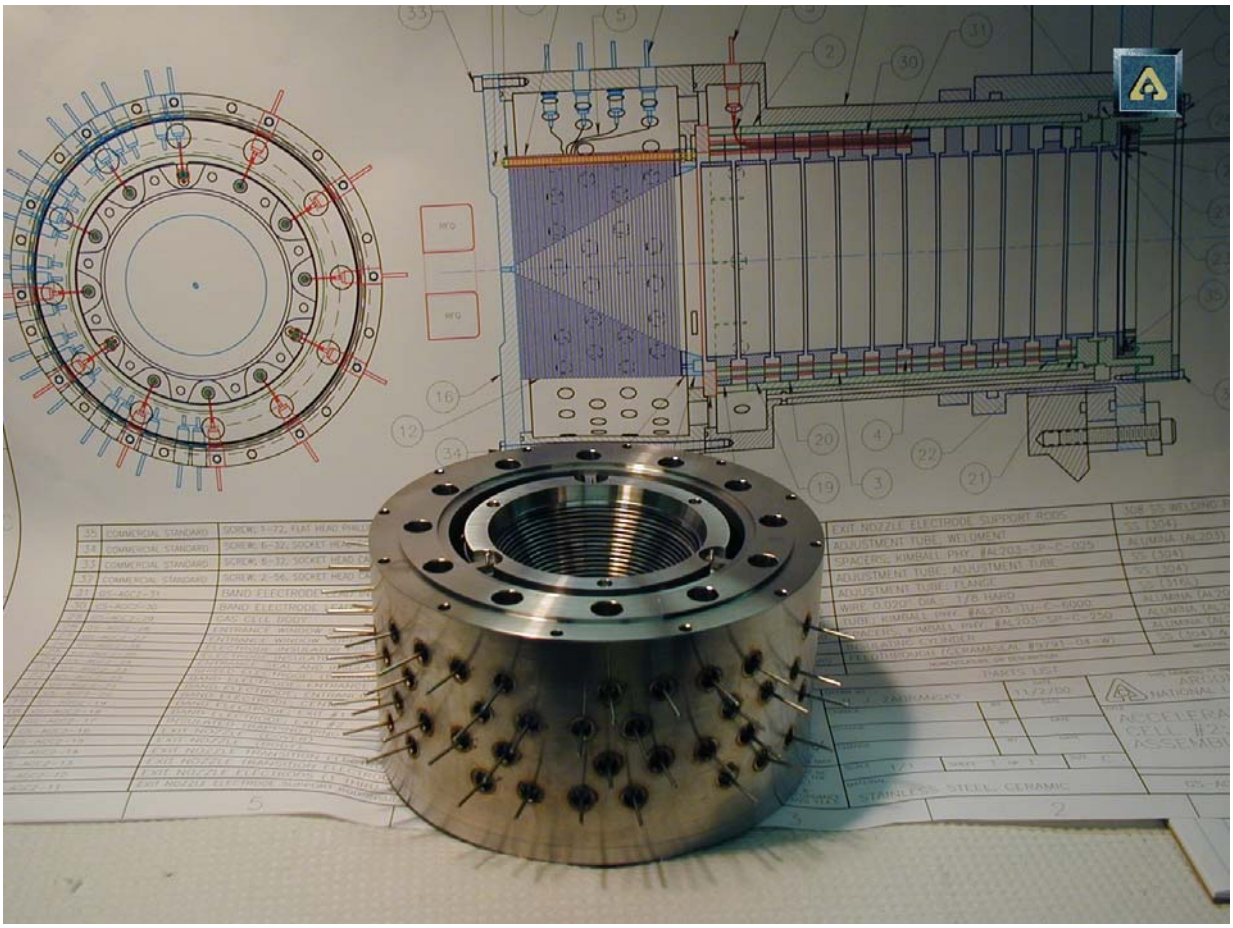
Gas Cell Fragment Separator System

• Liquid lithium target system	$2.0M
• Rad-Hard Quad Triplet (1)	$2.5M
• Rad-Hard Dipole (1)	$0.9M
• Dipole Magnet Systems (2)	$1.1M
• Quad Triplet Systems (5)	$3.0M
• Quad Doublet System (1)	$0.4M
• Corr. Magnets	$0.1M
• Power Supplies	$0.7M
• Degrader System	$0.4M
• Beam dump/shielding	$2.0M
• Vacuum & Other Support Systems	$0.6M
• Total (w/o cont.)	$13.7M

Gas Cell Prototype



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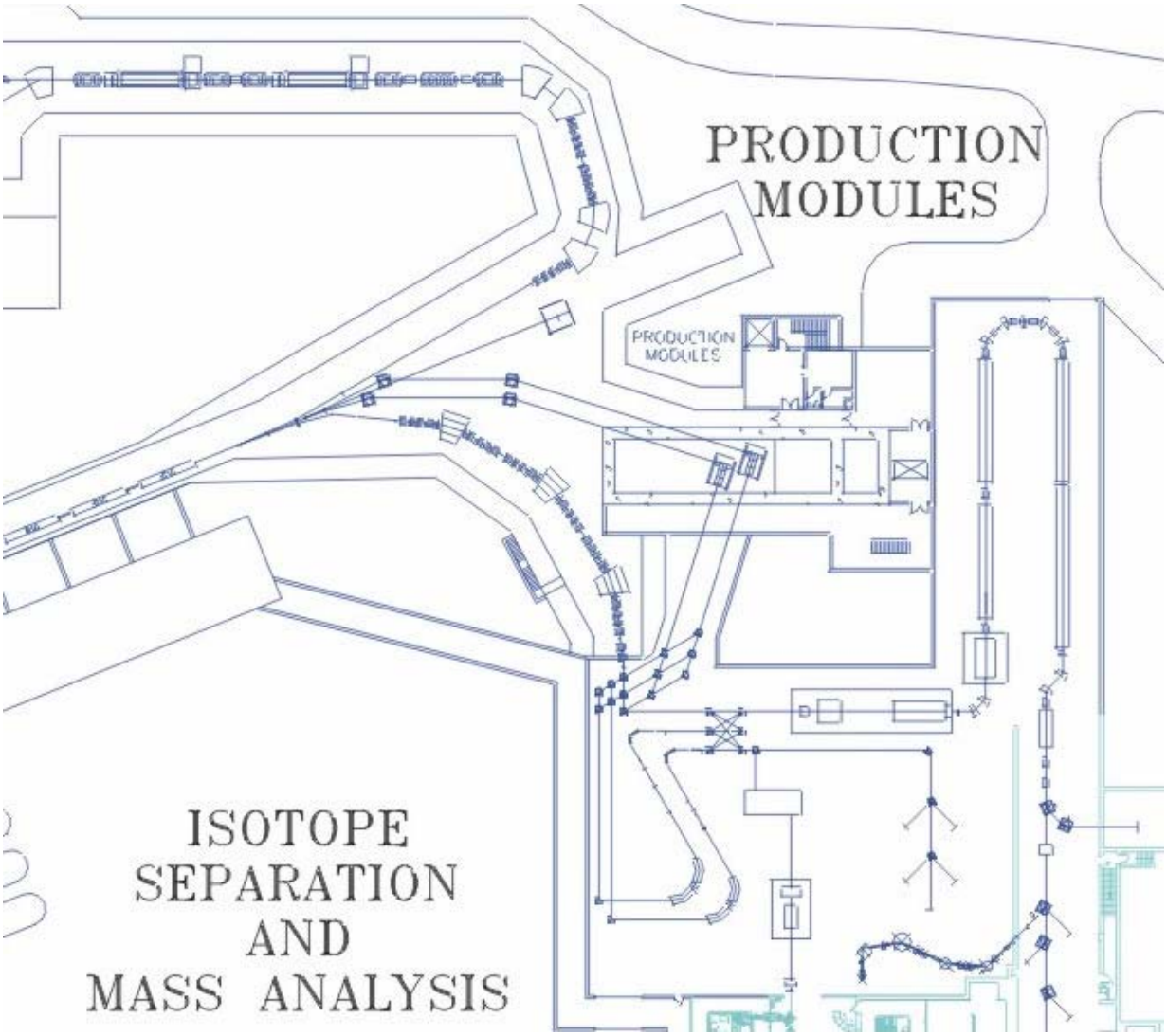
Gas cell system

- Gas cell $180k
- Roots blower $80k
- RF cooler $30k
- Vacuum pumps $40k
- Gas recirculation $50k
- High voltage platform $150k
- Mechanical support $30k
- Electronics $40k

- Total (w/o cont.) $600k

Isotope Production Area



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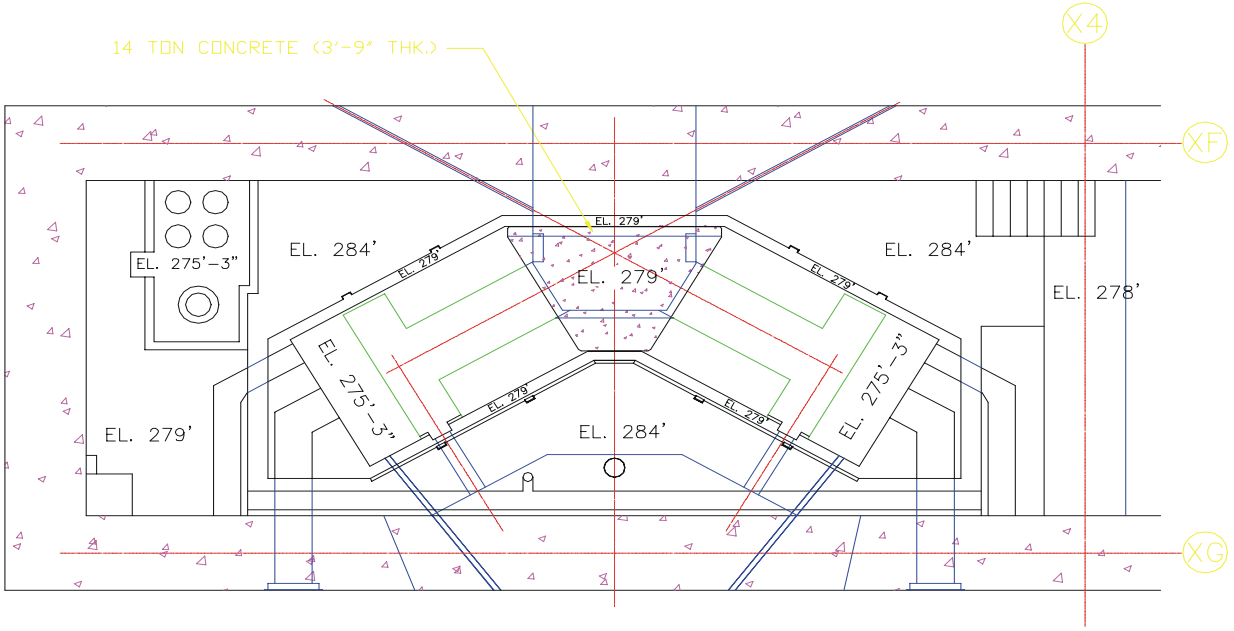
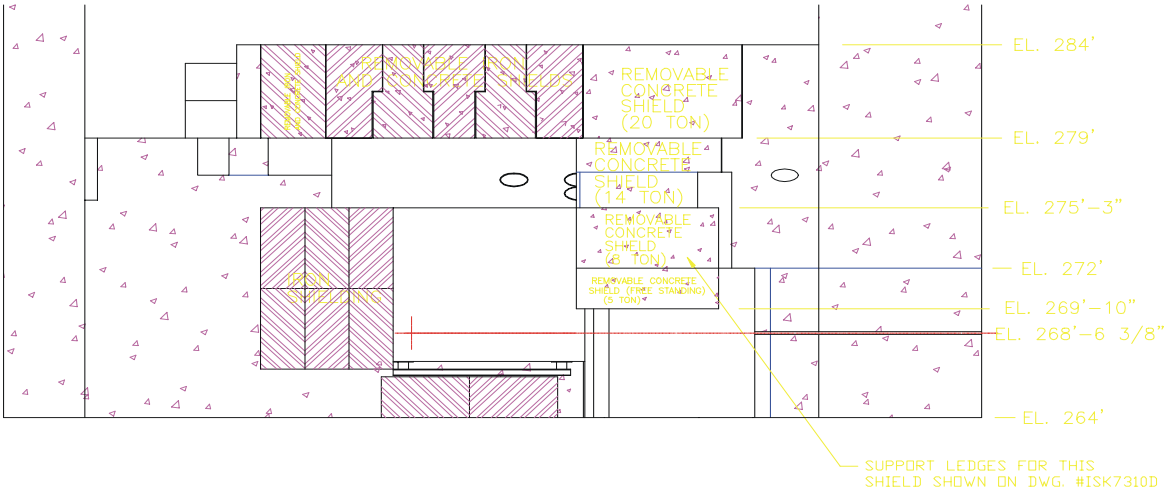
Target Stations and Shielding Layout at ISAC





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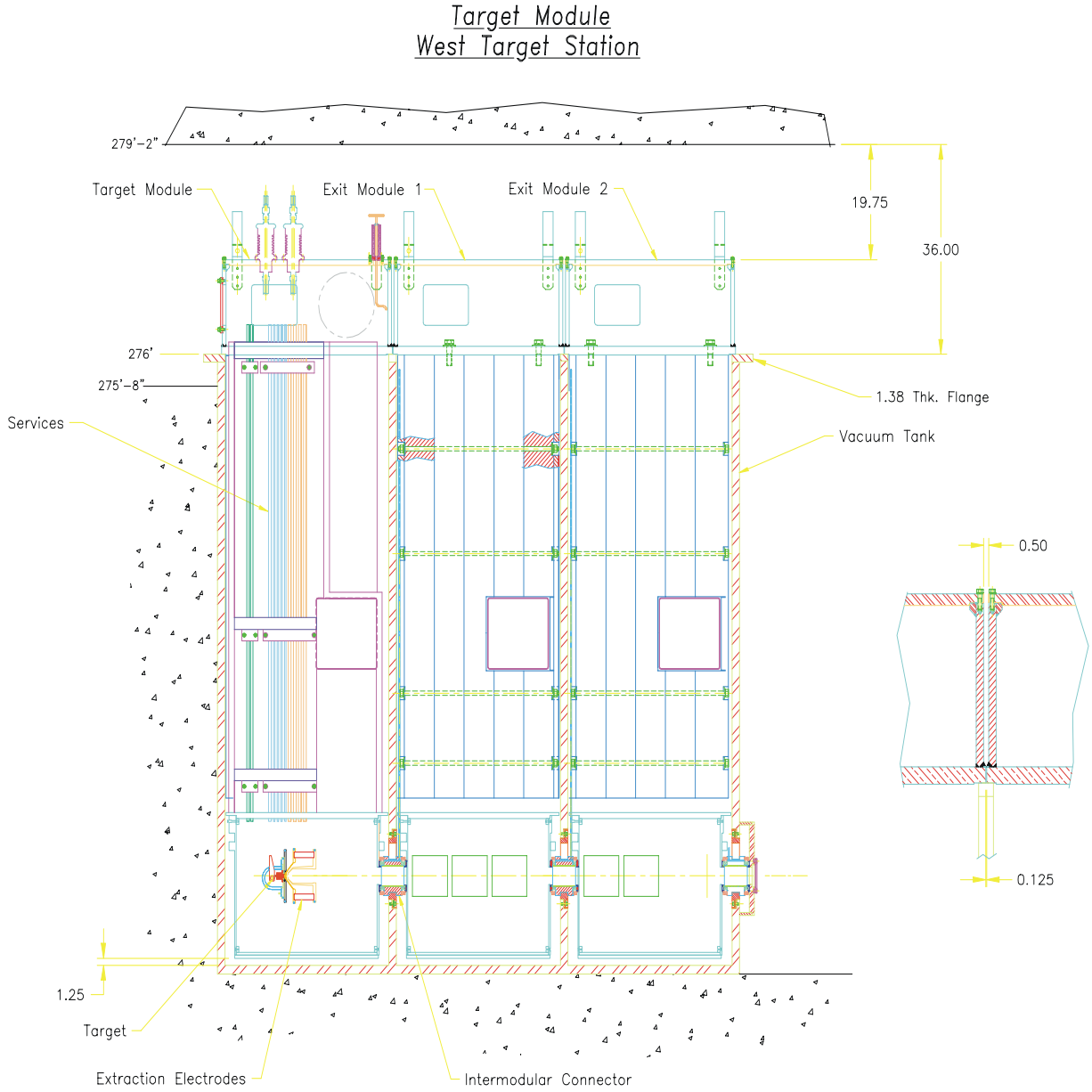
ISAC Target Modules



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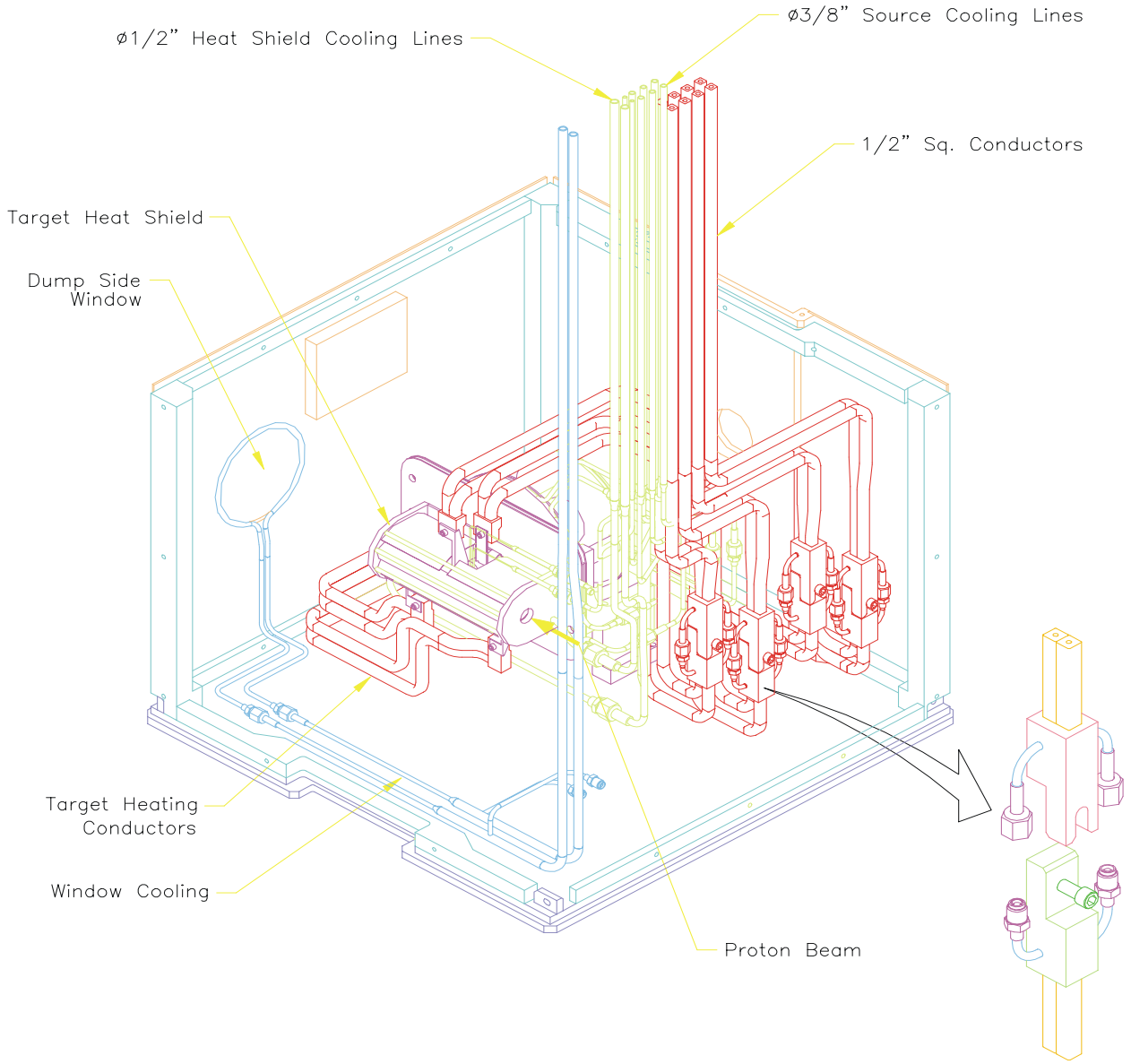
Target/Ion Source



Surface Source

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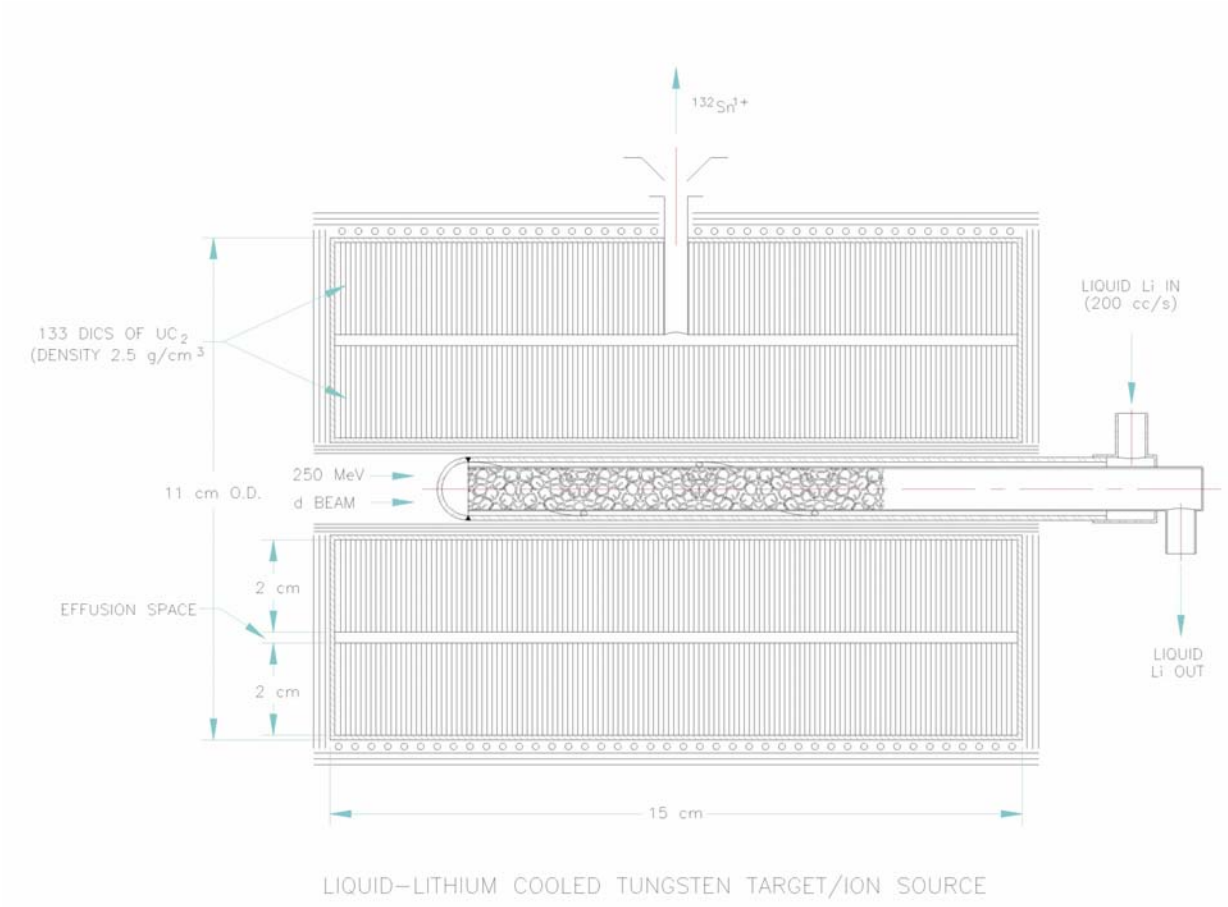
Two-Step Neutron Generator Target



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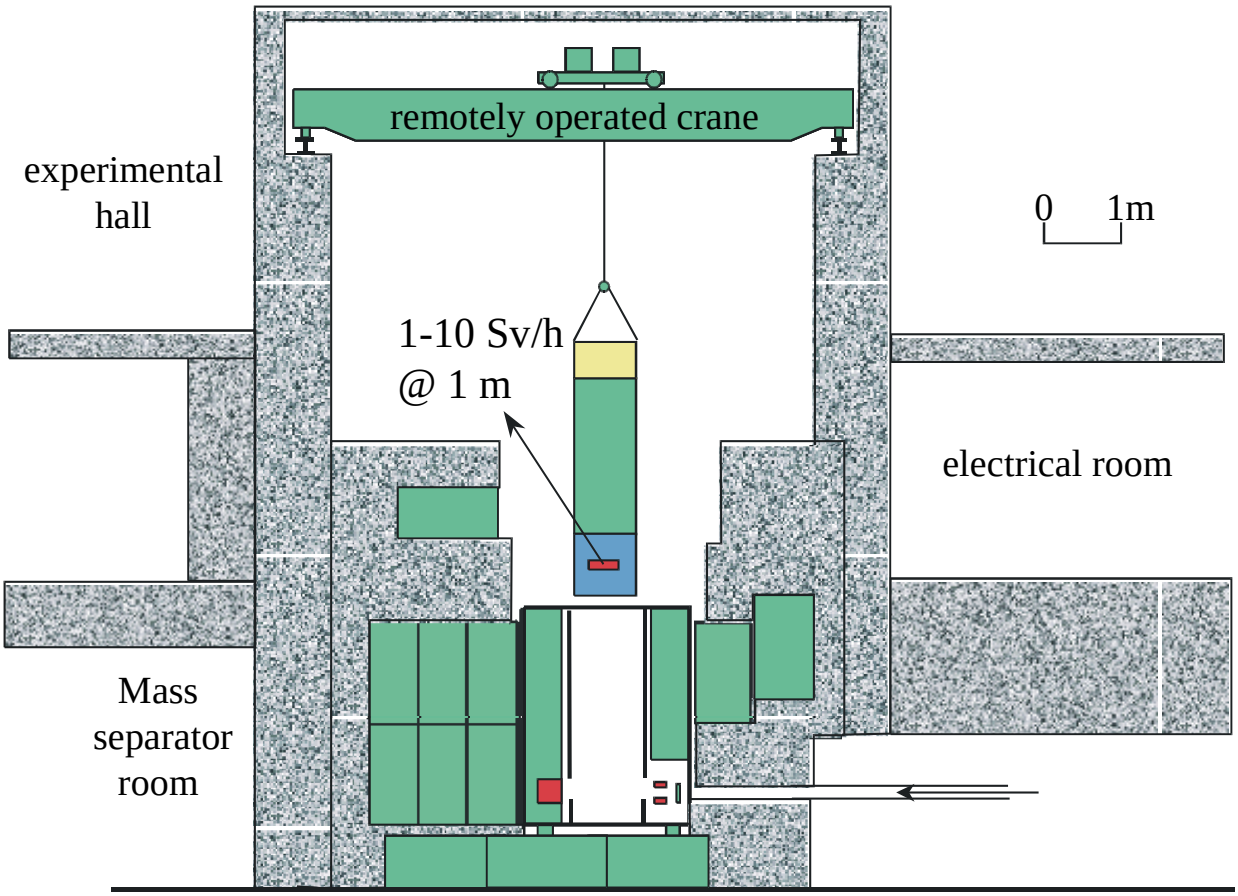
ISAC Target Servicing



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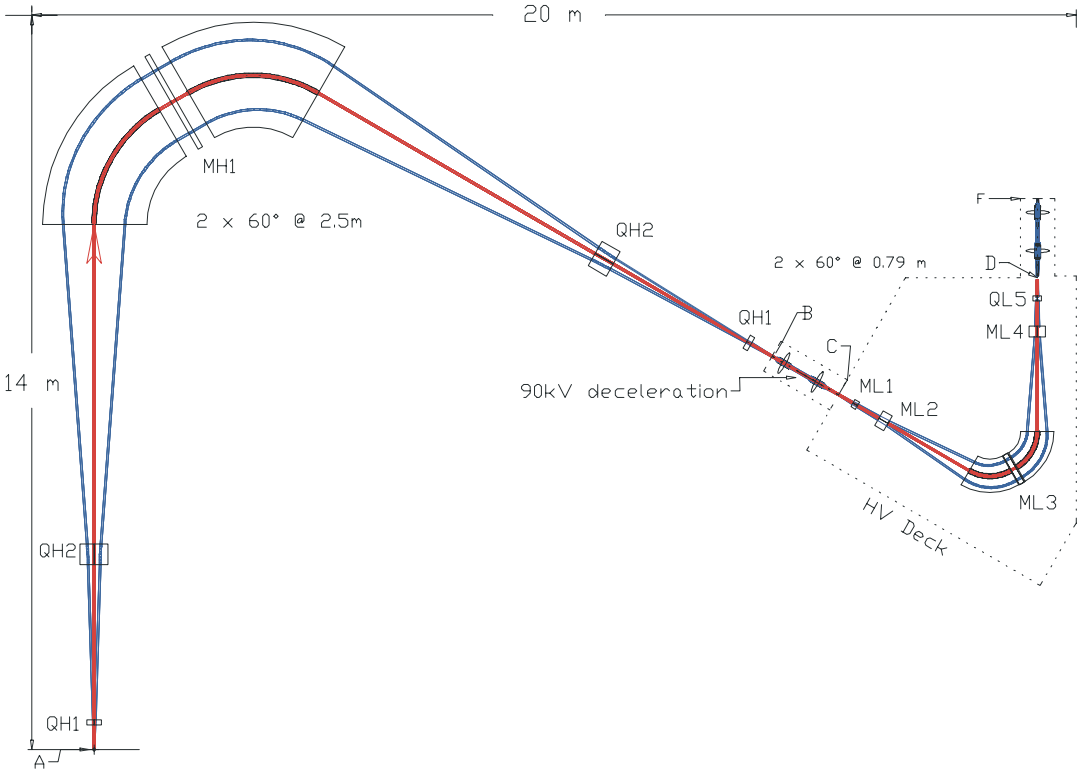
ISOL Target Stations

• Dump modules (2)	$115k
• Entrance modules (2)	$70k
• Exit 1 and exit 2 modules (2 of each)	$480k
• Target modules (4)	$445k
• Target station high-voltage systems	$140k
• Vacuum tanks (2)	$115k
• Total (w/o cont.)	$1365k
+ design/installation	51000 m-hrs

High-Resolution Isobar Separator



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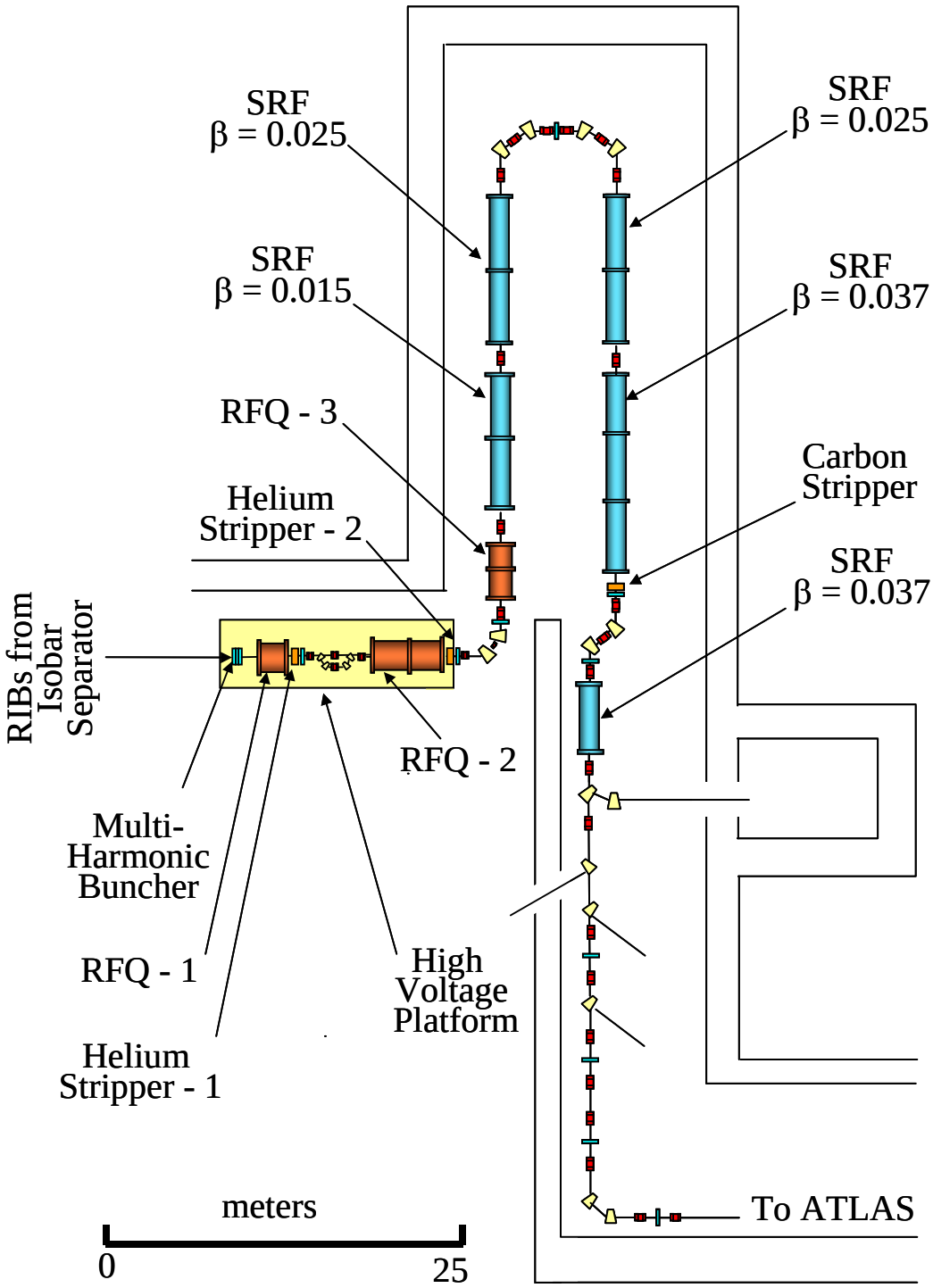
RIA Post-Accelerator



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RIA Post-Accelerator Components

Section	A/q	Beta = v/c	Frequency (MHz)	Temp. (K)	Number of Elements	Section Voltage (MV)
1^+ Ion source and Isobar separator	$6 \le A/q \le 240$	***(Ions from $^{6}He^{1+}$ to $^{240}U^{1+}$)***			***1***	**0.1**
RFQ-1	$6 \le A/q \le 240$	0.0021-0.0039	12.125	293	1	1.2
1st Stripper (Light Ions $67 \le A \le 132$)		***Helium Gas***				
RFQ-2	$6 \le A/q \le 240$	0.0039-0.0066	12.125	293	1	3.12
1st Stripper (Heavy Ions $133 \le A \le 240$)		***Helium Gas***				
RFQ-3	$6 \le A/q \le 66$	0.0066-0.0115	24.25	293	1	2.75
β_G=0.015	$6 \le A/q \le 66$	0.0115-0.0176	48.5	4.5	14	7.9
β_G=0.025	$6 \le A/q \le 66$	0.0176-0.0284	48.5	4.5	24	22.6
β_G=0.037	$6 \le A/q \le 66$	0.0284-0.0360	72.75	4.5	16	15.0
2nd Stripper		***Carbon Foil***				
β_G=0.037	$6 \le A/q \le 240/29$	0.036-0.0528	72.75	4.5	8	7.5
β_G=0.06	$6 \le A/q \le 240/29$	0.053-0.065	97.0	4.5	12	9.8
β_G=0.105	$6 \le A/q \le 240/29$	0.065-0.1206	97.0	4.5	36	40.3

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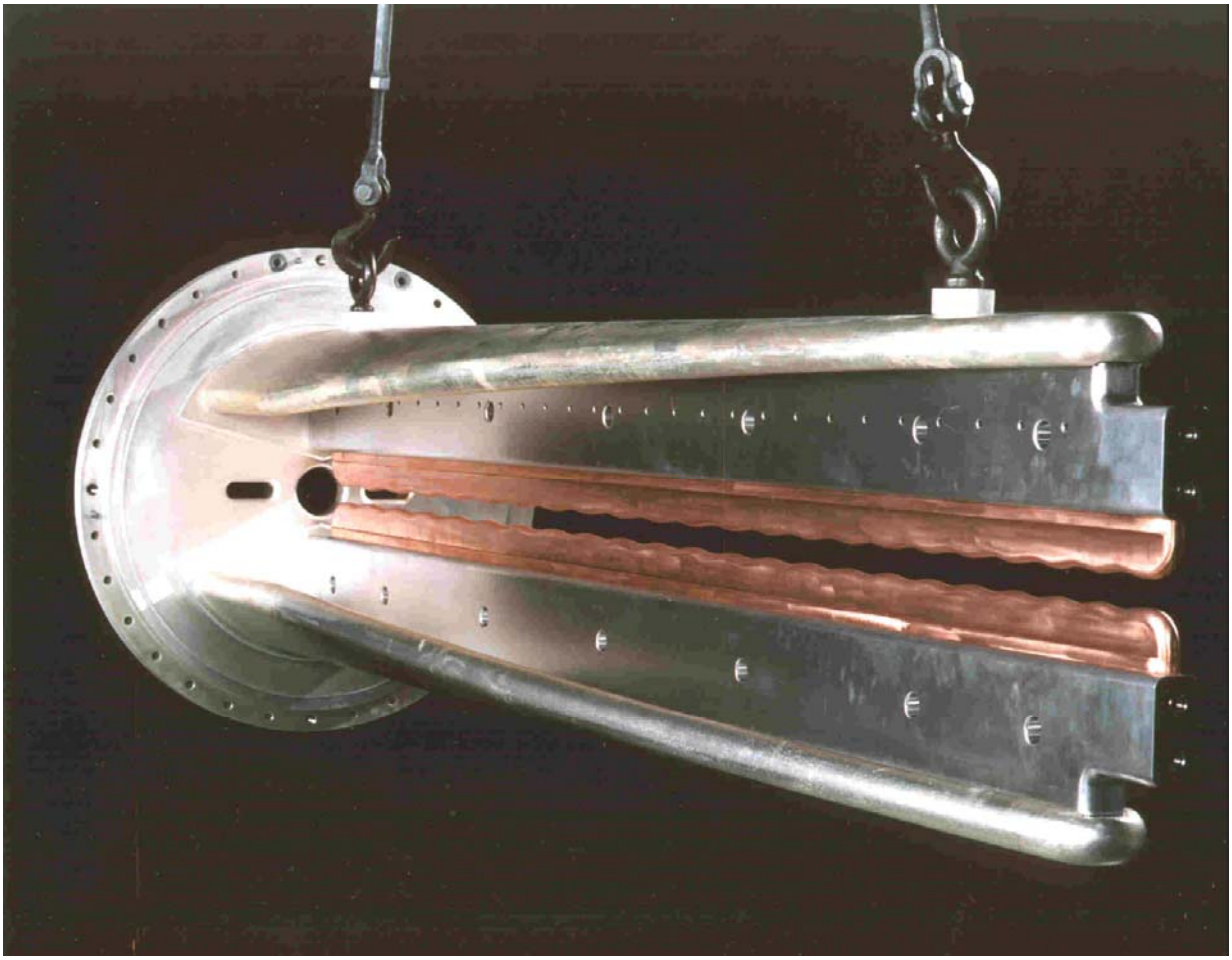
Split-Coax RFQ Accelerator



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Low Energy RIB System

• Isobar Separator Systems	$2.0M
• Transport of unaccelerated RIBs	$5.9M
• RFQ High-Voltage Platform	$0.2M
• Buncher	$0.1M
• RFQ Tanks (3)	$1.8M
• 8 Resonator Cryomodule (8)	$11.8M
• Rebuncher	$0.5M
• Helium gas strippers	$0.7M
• Diagnostics, Controls & Software	$0.8M
• Beam Transport	$1.3M
• RF	$3.3M
• Total (w/o cont.)	$28.4M

ATLAS equivalent RIB LINAC System

• Design	$3.0M
• Cryodistribution	$2.0M
• RF	$1.5M
• Cavities	$4.1M
• Cryostats	$2.6M
• Control system	$2.2M
• Beamlines	$0.9M
• Rebunchers	$0.4M
• Project Management	$1.3M
• Total (w/o cont.)	$18.0M

Experimental Equipment

- Stopped beam area
- Low-energy recoil separator
- Gas target
- High-energy recoil separator
- Gas-filled magnet
- High-resolution spectrograph
- Gamma-ray detectors system
- Silicon particle detectors system
- Radioactive targets system

→ Upgraded numbers from Berkeley Equipment Workshop

Stopped Beam Area

• Laser farm	$900k
• Magneto-optical trap	$550k
• Ion-trap beam handler	$590k
• Mass spectrometer	$880k
• Dilution refrigerator	$450k
• NMR equipment	$50k
• Absorption spectrometer	$550k
• EBIT trap	$450k
• detectors/electronics	$410k
• Spectroscopy systems	$60k
• Mechanical systems	$290k
• Installation	3.0 my
• Total (w design,w/o cont.)	$5.5M

Low-Energy Recoil Separator

• Magnets (dipoles, quads)	$350k
• Electric dipoles	$250k
• Power supplies	$240k
• Vacuum vessels	$290k
• Mechanical supports	$40k
• Vacuum equipment	$270k
• Focal plane detectors	$60k
• Controls/electronics	$280k
• Shielding/interlocks	$60k
• Engineering	3.0 my
• Design	3.6 my
• Installation	0.8 my
• Total (w design, w/o cont.)	$1.93M

Gas Target

- Roots blowers $90k
- Vacuum pumps $95k
- Vacuum gauges $40k
- Control system $15k
- Mechanical systems $35k
- Recovery system $25k

- Design 0.5 my
- Installation 0.5 my

- Total (w design, w/o cont.) $361k

High-Energy Recoil Separator

• Magnets (dipoles, quads)	$500k
• Electric dipoles	$330k
• Power supplies	$260k
• Vacuum vessels	$290k
• RF resonator	$300k
• Mechanical supports	$120k
• Vacuum equipment	$380k
• Focal plane detectors	$90k
• Controls/electronics	$200k
• Shielding/interlocks	$60k
• Engineering	3.0 my
• Design	3.6 my
• Installation	0.8 my
• Total (w design, w/o cont.)	$2.62M

Gas-Filled Magnet

• Magnets	$540k
• Power supplies	$180k
• Vacuum/gas control	$300k
• Support structure	$50k
• Focal plane detectors	$100k
• Target/control systems	$50k

• Design	1.5 my
• Installation	0.5 my

• Total (w design, w/o cont.)	$1.28M

High-Resolution Spectrograph

- Magnets (dipoles, quads) $1200k
- Power supplies $260k
- Carriage/Vacuum chamber $510k
- Vacuum equipment $190k
- detector/electronics $200k

- Engineering 3.0 my
- Design 2.5 my
- Field mapping/Installation 1.0 my

- Total (w design, w/o cont.) $2.48M

Gamma-Ray Detector System

• Ge detectors (40)	$12000k
• Processing electronics	$3160k
• Data acquisition	$2200k
• LN2 filling system	$200k
• Mechanical system/ Annealing stations	$260k
• Digital design	3.0 my
• Installation/calibration	1.5 my
• Total (w design, w/o cont.)	$18.1M

Silicon Particle Detector Systems

• Detector costs	$460k
• Readout chips costs	$55k
• Hardware for assembly	$530k
• Electronics/DAQ/cables	$325k
• Mechanical assembly	$50k
• Development of readout chips	5.0 my

Associated Detectors

• CsI upgrade	$250k
• Neutron detectors	$170k
• Electronics	$340k
• Total (w/o cont.)	$2.18M

Radioactive Target System

- Radiochemical laboratory $500k
- Total (w/o cont.) $500k

Summary for ISOL Systems

- ISOL production complex $ 8.4M
- Gas cell + fragment separator complex $14.3M
- Post-accelerator $46.4M
- Experimental equip't $35.2M

- Total (w/o cont.) $104.3M