TEXAS A&M UNIVERSITY
Cyclotron Institute

Radiation Effects Facility

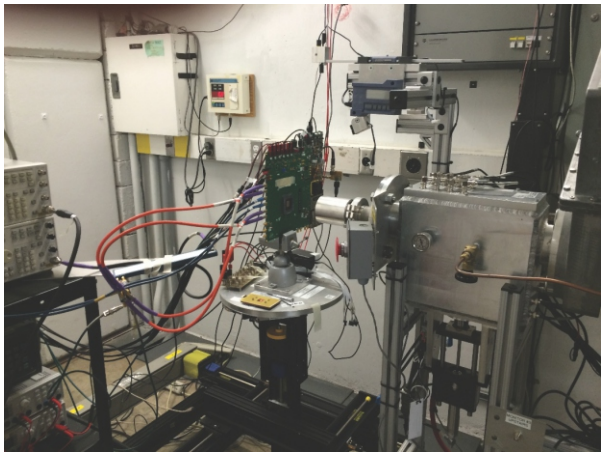
cyclotron.tamu.edu/ref

979.845.1411

The Cyclotron Institute's Radiation Effects Facility provides a convenient and affordable solution to commercial, governmental and educational customers in need of studying, testing and simulating the effects of ionizing radiation on electronic and biological systems. The facility features a dedicated beam line with diagnostic equipment for complete dosimetry analysis and beam quality assurance. A beam energy degrader system allows for a change of linear energy transfer (LET) without cyclotron re-tuning or target rotations. As a part of the Cyclotron Institute the facility is fully staffed, and includes electronic and machine shops that are readily available for customer assistance.

The Cyclotron Institute's K500 superconducting cyclotron in combination with an advanced ECR ion source allows for the acceleration of ions to energies as high as 60 MeV per nucleon. Featured at the facility is a set of 15 MeV/u ion beams. These beams provide a broad LET range of 1 to 93 MeV•cm^2/mg in silicon at normal incidence and allow for quick ion changes. For greater range needs, two sets of higher-energy beams (24.8 MeV/u and 40 MeV/u) are also available.

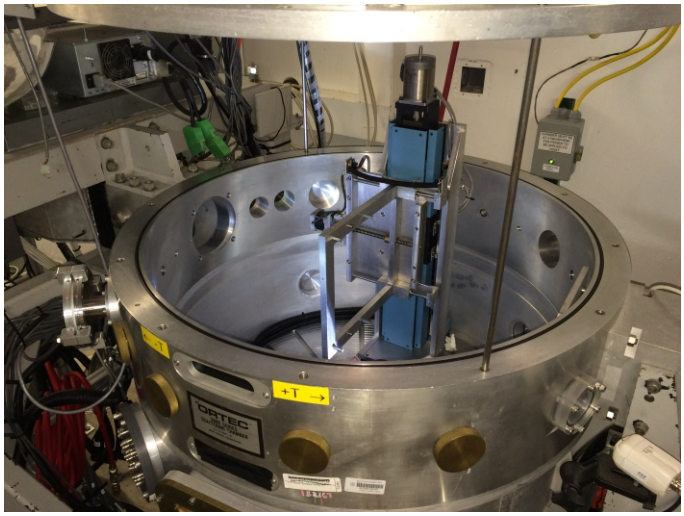
In-Air Test Station



With our high-energy beams it is possible to conduct testing in air. An in-air test station is installed at the end of our dedicated beam line. The station consists of a 10” x 10” removable mounting frame attached to a 15” diameter platter capable of supporting up to 40 lbs. Positioning in x, y, and z directions in addition to rotations in the plane of the target (φ) and about a vertical axis (θ) are computer controlled. In most cases targets may be positioned as close as one centimeter from the beam exit window. Target position verification is provided by the means of a CCD camera aligned with the beam path. The in-air test station offers several advantages compared to vacuum-chamber testing. These advantages include quick setup changes, shorter cabling with no vacuum feed-throughs, and ease of heating and cooling.

Vacuum Test Chamber

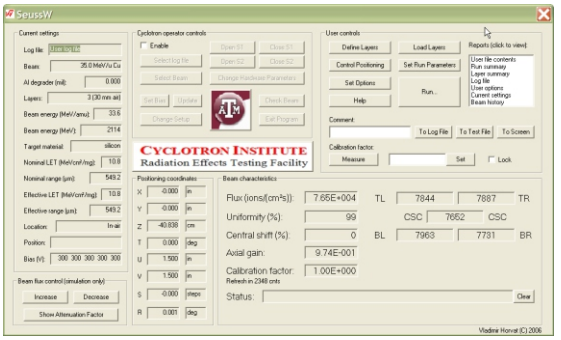
A vacuum chamber is also available for radiation testing. The chamber has an inside diameter of 30” and a height of 30”. Inside the chamber is a target mounting fixture measuring 10” x 10”. Movement of the frame in x, y, z, and θ directions is computer controlled. Pumping time to an operating pressure in the low 10^{-4} Torr range is approximately ten minutes, while the chamber vents in two and a half minutes. Target position verification is provided by means of a CCD camera aligned with the beam path. The size of the exposed area (up to 1.5” x 1.5”) is controlled by a pair of remotely adjustable horizontal and vertical slits. Five 50-pin hermetically sealed D-shell male connectors and 19 BNC connectors are provided for communication with the devices under test.



Please visit our website at **cyclotron.tamu.edu/ref** for more information.

Dosimetry and Beam Quality

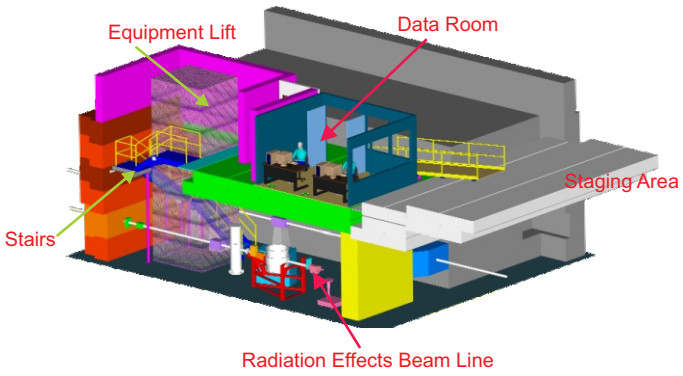
Beam uniformity and dosimetry are determined using an array of five detectors comprised of plastic scintillators coupled to photo-multiplier tubes. These detectors are located in the diagnostic chamber adjacent to and upstream from the target. The control software determines beam uniformity, axial gain, and beam flux (in particles/cm^2•s) based on detector count rates. The results are displayed and updated once every second. Beam exposure can be limited to a certain amount of time, limited to total fluence, stopped by an external signal, or stopped manually. A demo version of the control software (SeussW) can be downloaded from our website (http://cyclotron.tamu.edu/ref).



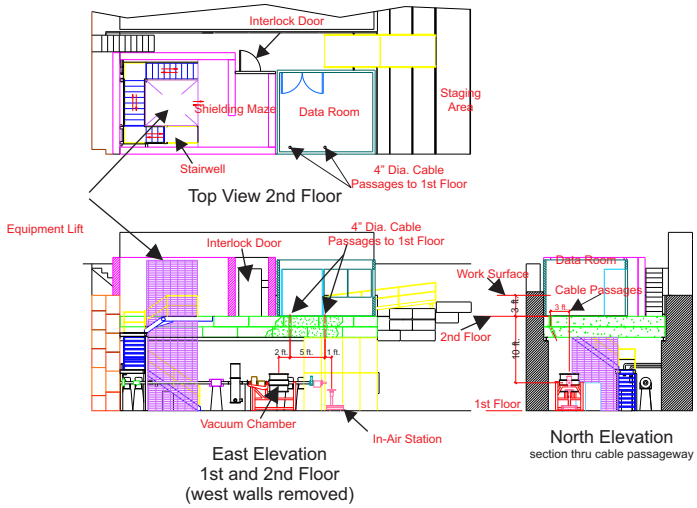
Screen capture of SeussW software.

Testing at our Facility

Staging Area and Data Room.



Close-up view of Data Room.



The Radiation Effects Facility is located on a dedicated beam line within the Cyclotron Institute building. A climate-controled data room is situated directly above the beam line area. This has been designed so that the required cable lengths between the data room and the beam line area can be as short as16-feet. A staging area located directly outside of the data room includes tables and work benches for test preparation and set-up. Both the staging area and the data room are wired for internet access. For your convenience, a coffee maker, full-sized refrigerator, and microwave oven are provided. Users' equipment can be transferred to the beam line area using a lift that is located in the stairwell descending to the beam line area and is easily accessible immediately outside of the data room.

For beam-time scheduling and for current rates please contact Dr. Henry Clark.
Email: clark@comp.tamu.edu / Phone: 979-845-1411 / Fax: 979-845-1899

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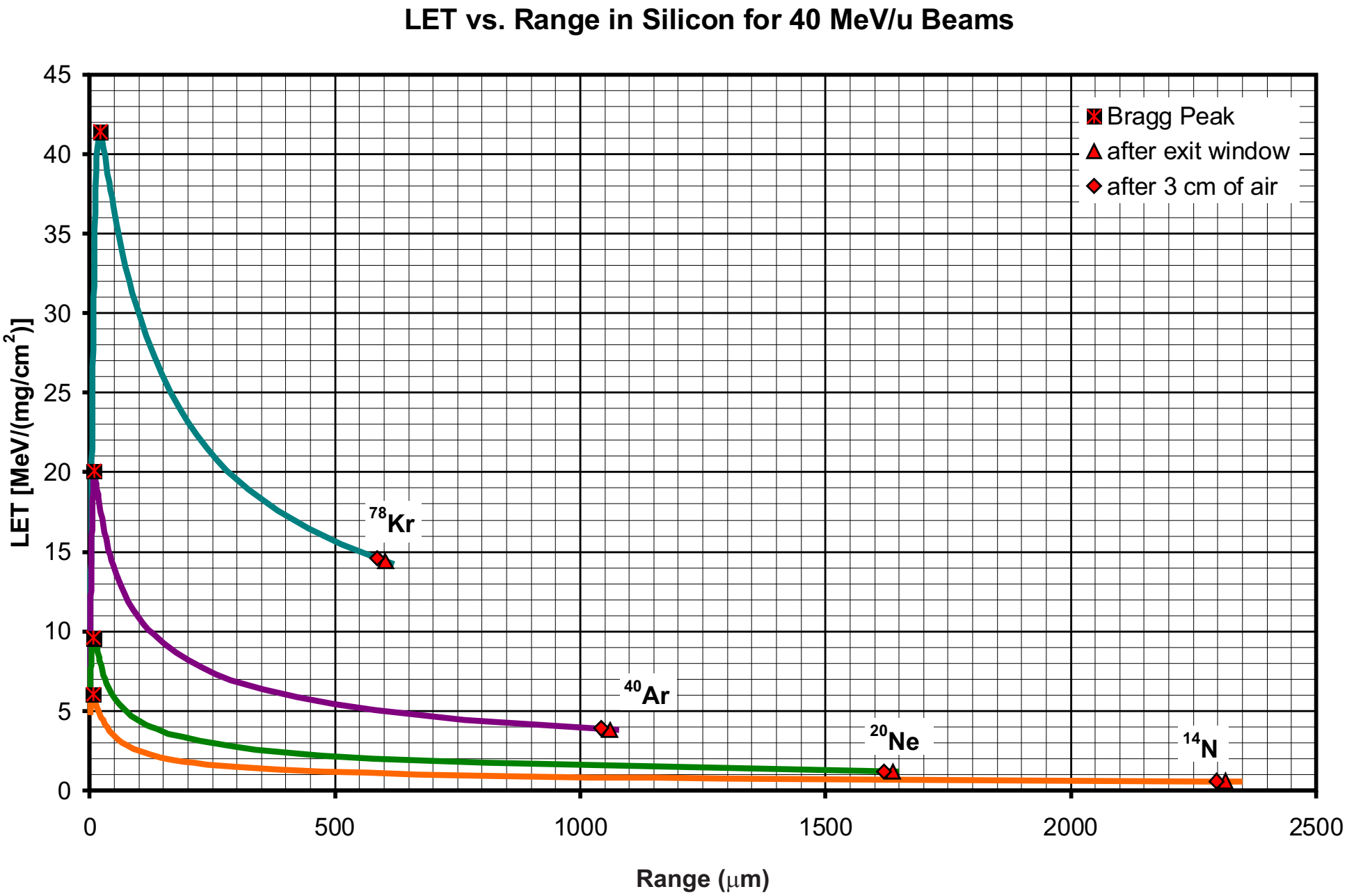

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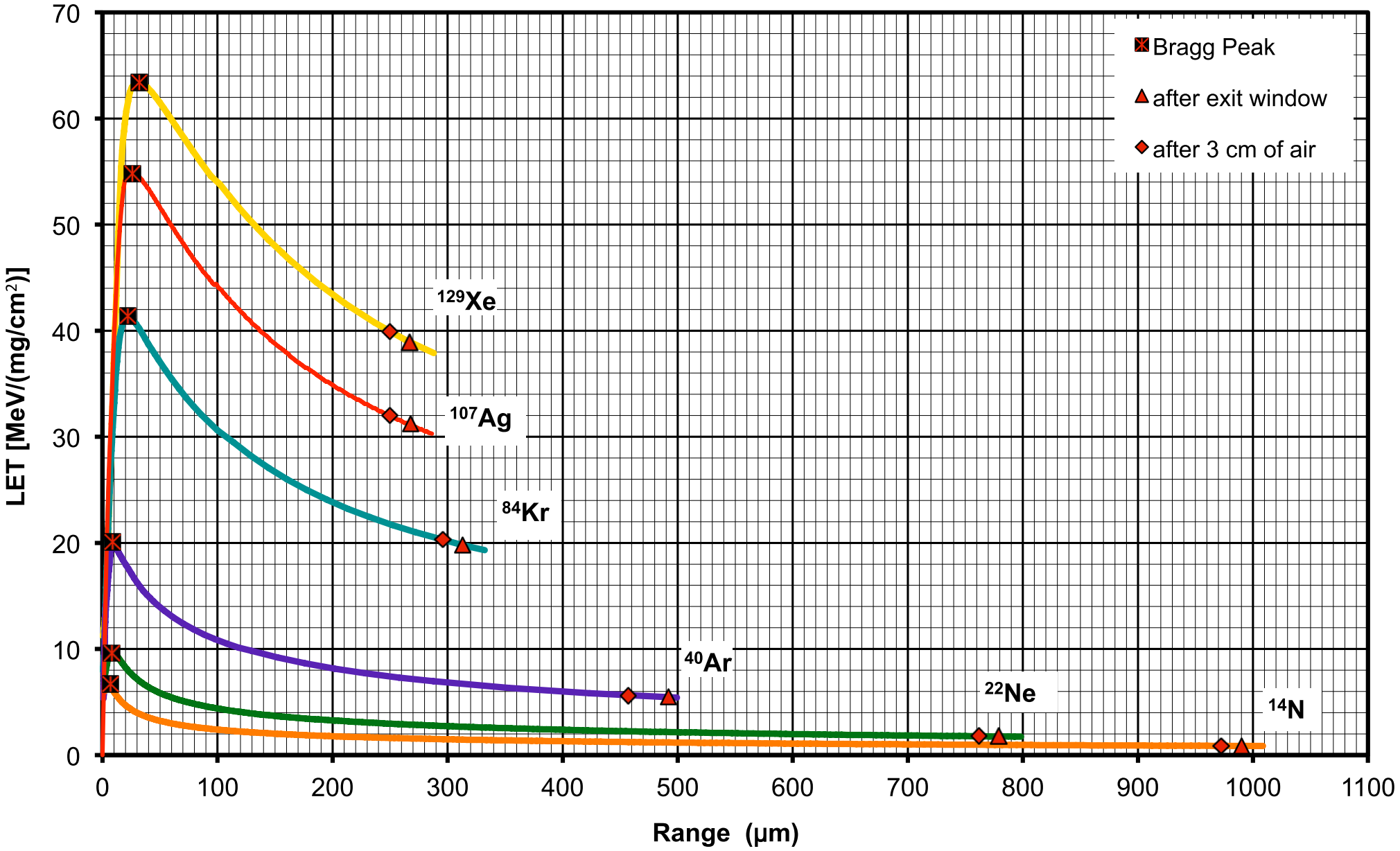
LET vs Range in Silicon for 24.8 MeV/u Beams



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Heavy Ion Beams

	Ion	Mass (amu)	Total Energy (MeV)	Range in Si (μm)	Range to Bragg Peak (μm)	Initial LET (vac)	Initial LET (air)	LET at Bragg Peak
15 A MeV	^{4}He	4.003	60	1423	1421	0.11	0.11	1.5
	^{14}N	14.003	210	428	421	1.3	1.3	6.7
	^{20}Ne	19.992	300	316	308	2.5	2.6	9.6
	^{40}Ar	39.962	599	229	220	7.7	8.0	20.1
	^{63}Cu	62.930	944	172	156	17.8	18.7	34.0
	^{84}Kr	83.912	1259	170	149	25.4	26.6	41.4
	^{109}Ag	108.905	1634	156	130	38.5	40.3	54.8
	^{129}Xe	128.905	1934	156	124	47.3	49.3	63.4
	^{141}Pr	140.908	2114	154	117	53.8	56.0	69.6
	^{165}Ho	164.930	2474	156	112	64.3	66.7	79.2
	^{181}Ta	180.948	2714	155	109	72.2	74.8	86.4
	^{197}Au	196.967	2954	155	102	80.2	82.8	93.5
25 A MeV	^{4}He	4.003	99	3449	3447	0.07	0.07	1.5
	^{14}N	14.003	347	1009	1002	0.9	0.9	6.7
	^{22}Ne	21.991	545	799	791	1.7	1.8	9.7
	^{40}Ar	39.962	991	493	484	5.4	5.5	20.1
	^{84}Kr	83.912	2081	332	311	19.3	19.8	41.4
	^{107}Ag	106.905	2651	287	260	30.3	31.1	54.8
	^{129}Xe	128.905	3197	286	255	37.9	38.9	63.4
40 A MeV	^{14}N	14.003	560	2334	2327	0.6	0.6	6.7
	^{20}Ne	19.992	800	1655	1647	1.2	1.2	9.7
	^{40}Ar	39.962	1598	1079	1070	3.8	3.8	20.1
	^{78}Kr	77.920	3117	622	602	14.2	14.4	41.4

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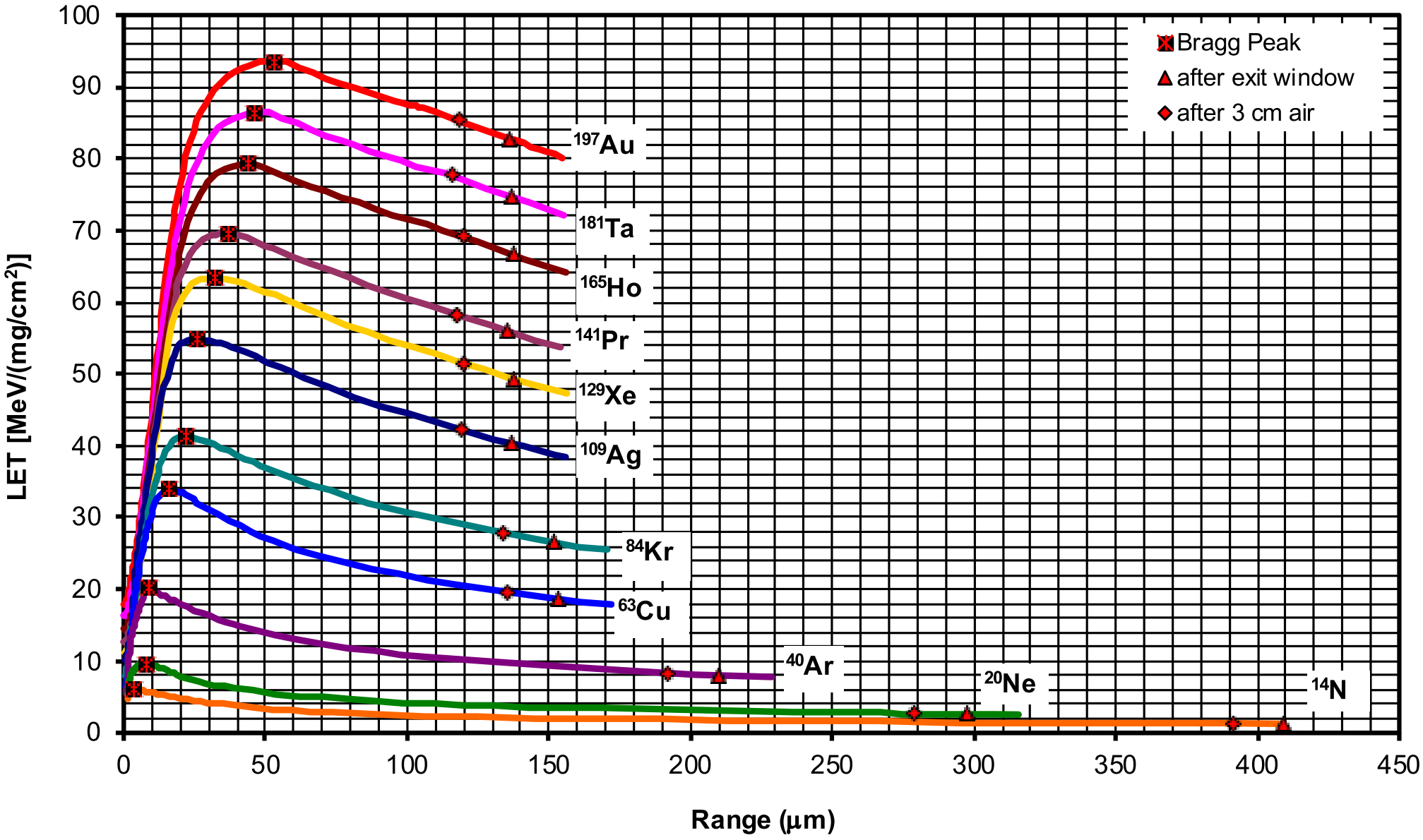
LET vs Range in Silicon for 15 MeV/u Beams



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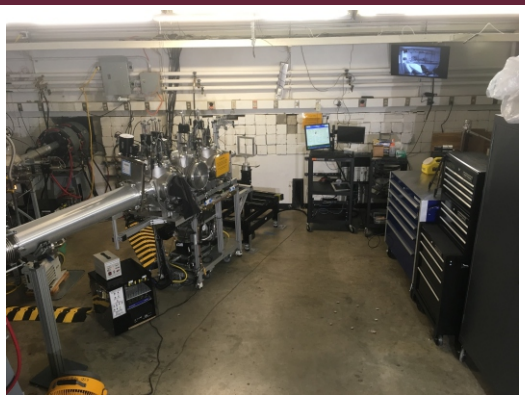
Proton Beam Line

The Cyclotron Institute's Radiation Effects Facility now offers a dedicated beam line for proton testing. Combining an H-minus ion source with the re-commissioned K150 cyclotron, we offer protons with tunable energiesfrom 6.3 to 45 MeV. Additional energies can be provided as low as 2 MeV with our degrader system. Maximum flux for these beams is on the order of $1x10^{10}$ particles/cm^2/s.

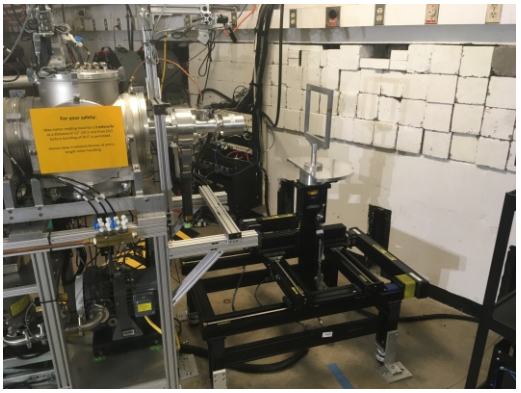
Dosimetry and Beam Quality



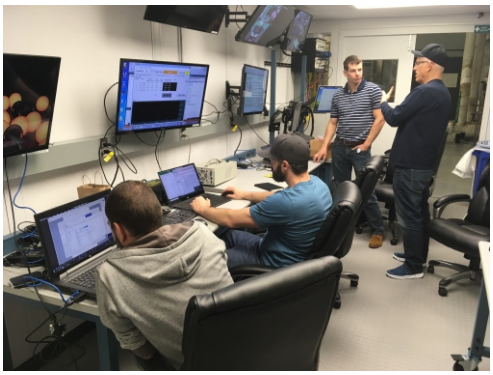
As with our heavy ion testing beam line, we provide diagnostic equipment for complete dosimetry analysis and beam quality assurance. Test control and monitoring are conducted with the same custom SEUSS software that is used for heavy ion testing. Dosimetry at low flux ($1x10^7$ particles/cm^2/s and lower) is conducted using an array of five detectors comprised of plastic scintillators coupled to photomultiplier tubes. For higher fluxes, uniformity is first adjusted at a lower flux and then a set of four tantalum foils are used to back-scatter protons into four additional detectors. After a calibration measurement, dosimetry relies on these back-scattering measurements.

In-Air Testing

Testing is conducted in air. A thin aluminum window allows the beam to exit the beam line with minimal energy loss. A positioning system, identical to that used on our heavy ion beam line, is located at the exit of the beam line. A test frame and a platter are provided, also identical to those of our heavy ion testing beam line. Positioning in x,y,z and theta directions can be controlled remotely using our custom SEUSS software. A degrader system consisting of aluminum plates on a rotatable wheel is available and can be used to change beam energy without cyclotron re-tuning.



Proton Testing at Our Facility



The proton beam line is located in the K150 cyclotron vault. A dedicated data room is located directly above the vault. A BNC, CAT6, and serial patch panel are available for customer use. Additional cabling can be run through a cable conduit between the vault and the data room. We provide carts with 2” thick borated polyethylene on three sides to shield equipment during testing.

For beam-time scheduling and for current rates please contact:
Dr. Henry Clark
Email: clark@comp.tamu.edu
Phone: 979-845-1411 / Fax: 979-845-1899

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Proton Testing at TAMU

Proton energies (tunable): 6.3-45 MeV

Proton energies with degraders: As low as 2 MeV

Available Fluxes: 10^2 to 10^{10} (particles/cm^2/sec)

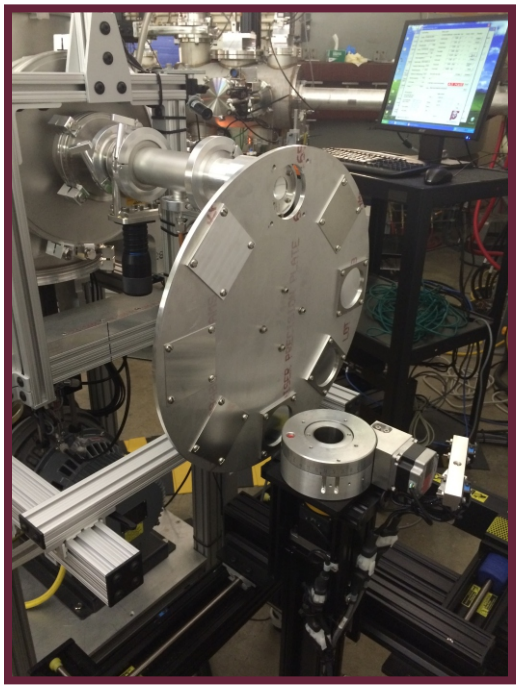
Uniformity: >90% over a 1.0", 1.5", or 1.75" diameter opening

In-Air testing

Remote device positioning

Convenience of testing heavy ions and protons in the same visit

Equipment carts shielded with borated polyethylene.



Degrader wheel.