Radiation Effects Facility

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This year's activity of the Radiation Effects Facility (REF) has increased significantly over the previous reporting year. In this reporting period, the facility was used for 548 hours, which is a 40% increase over the 389 hours used in the 1998-1999 reporting period. Users of the facility (and hours used) over the past year were: Hughes Space and Communications (184), International Rectifier (84), Prairie View A&M University (74.25), Harris Electronics (32), NASA-JSC (30), TRW (29.5), JPL (26), Novous Technologies (24), Motorola (22), Intersil (18), Spectrum Sciences (12), and St. Jude Medical (9). From the list above, Novous Technologies, Intersil, Spectrum Sciences and St. Jude Medical were all new customers to the facility.

Table I compares the facility usage by commercial and government customers. The ratio from this reporting year (74% to 26%) is different from the trend observed from the previous three reporting years (~50% to 50%). The increase in commercial usage may be attributed to the strong US economy. The decrease in government usage can be attributed to defense and government project reductions.

Table I. Radiation Effects Facility usage by commercial and government customers for this and previous reporting years.

Reporting Year	Total Hours	Commercial Hours (%)	Government Hours (%)
1999-2000	548	418 (76%)	131 (24%)
1998-1999	389	171 (44%)	218 (56%)
1997-1998	434	210 (48%)	224 (52%)
1996-1997	560	276 (49%)	284 (51%)
1995-1996	141	58 (41%)	83 (59%)

Table II lists the beams used this year and the number of times each was requested. From the current REF list [1] O, Cu, 13.6 MeV/nucleon Kr, 11.1 MeV/nucleon Nb and Bi were requested only once or not at all. The most frequently requested were the 15 and 25 MeV/nucleon noble gas beams and Au. These beams give experimenters energies that are higher than provided by Brookhaven and Berkeley.

Table II. Beams used and the number of times requested. The 30 MeV proton and 50 MeV alpha particle beams were added this year.

Particle Type	Energy/nucleon (MeV/nucleon)	Requests
H-D	30	2
H-H	55	6
^{4}He	12.5	2
^{12}C	560	3
^{20}Ne	14.9	2
^{22}Ne	24.8	6
^{40}Ar	15.0	4
^{40}Ar	25.0	4
^{63}Cu	16.0	1
^{84}Kr	15.3	4
^{84}Kr	12.0	5
^{84}Kr	25.0	7
^{93}Nb	9.8	2
^{129}Xe	15.2	10
^{129}Xe	24.8	4
^{197}Au	10.5	7

While most applications of the facility this year were for testing microchips to be used in space environments, the facility was also used for two unique applications which required the addition of two new beams: 50 MeV alpha particles and 30 MeV protons. St. Jude's Medical and Spectrum Sciences used 5, 10, 15 and 20 MeV alpha particle beams to study the failure rate of the microprocessors (due to the natural decay of the packaging material) within their cardiac pace makers. The different energies were created by first degrading the 50 MeV beam down to 20 MeV directly out of the cyclotron and then set to the desired energy using the degrader foils of the REF setup. NASA-JSC used the 55 and 30 MeV proton beams to calibrate dosimeters that will be used by space station astronauts.

Hardware and software improvements have been made to the facility. The features that have been implemented since last year's report include the following listed below.

Hardware:

1) A duplicate indicator panel has been installed outside the vault, next to the remote control station. This way the status of the chamber light, the camera, the laser pointer, the beam energy detector, the shutters, the beam line valve, the shield wall plug, and the main Faraday cup (FC02) can be easily verified without going inside the vault.

2) For the purpose of accurately determining the beam fluence on target, the role of the upstream shutter has been taken by an electronic "beam quencher" which shifts the phase of the cyclotron RF system in and out of the operating range, thus allowing and preventing the extraction of the beam from the cyclotron.

3) A remote-controlled system for degrading the energy of the beam before it enters the REF vault has been installed for the purpose of (a) expanding the capabilities of the existing degrader system and (b) allowing for the reduction in the beam energy without introducing excessive energy straggling. The system is monitored by means of a CCTV.

Software:

1) A Control system for the beam energy degrader foils has been improved by incorporating a software routine that can (a) display the current beam parameters, which include the total energy in MeV, as well as the nominal and effective initial linear energy transfer (LET) and range in silicon, (b) determine the degrader foil settings required to change the effective initial LET of the current beam to any specified value within the available range, and (c) position the appropriate degrader foil accordingly. The calculations are based on the known parameters of the selected beam, the current degrader settings and the current target tilt angle.

2) The preset fluence feature has been replaced by the preset effective fluence. This eliminates the need to recalculate and re-enter the preset fluence every time the target angle changes.

3) The current and the default values of the program preferences, tolerances, restrictions, and hardware parameters can now be seen all on one page. This information can also be printed out together with the appropriate header generated by the software.

4) An "intelligent" warning system has been added to the REF control system software. Before each "test" the system checks the beam uniformity, central shift, preset and actual axial gains, flux level, degrader position, and dimensions of the aperture, and compares them with the specified tolerance levels.

5) The test run file now contains all the information pertinent to the run plus eventual experimenters comments.

6) To protect the scintillation detectors, the upstream shutter will close and the beam quencher will activate whenever the beam flux exceeds the preset level (currently 10^7 particles per cm^2 per second) after more than 10 seconds of idle time.

To better serve the Radiation Effects Facility customers, an improved REF homepage (http://cyclotron.tamu.edu/see) has been developed. All information about the facility is now accessible from the main page through four sections: Technical Information, Support and Contacts, Safety Issues and Local Information. Beam time request forms can be downloaded (in PDF format) and the Cyclotron Institute beam schedule can be accessed from all five sections. Additions to the updated website are listed below.

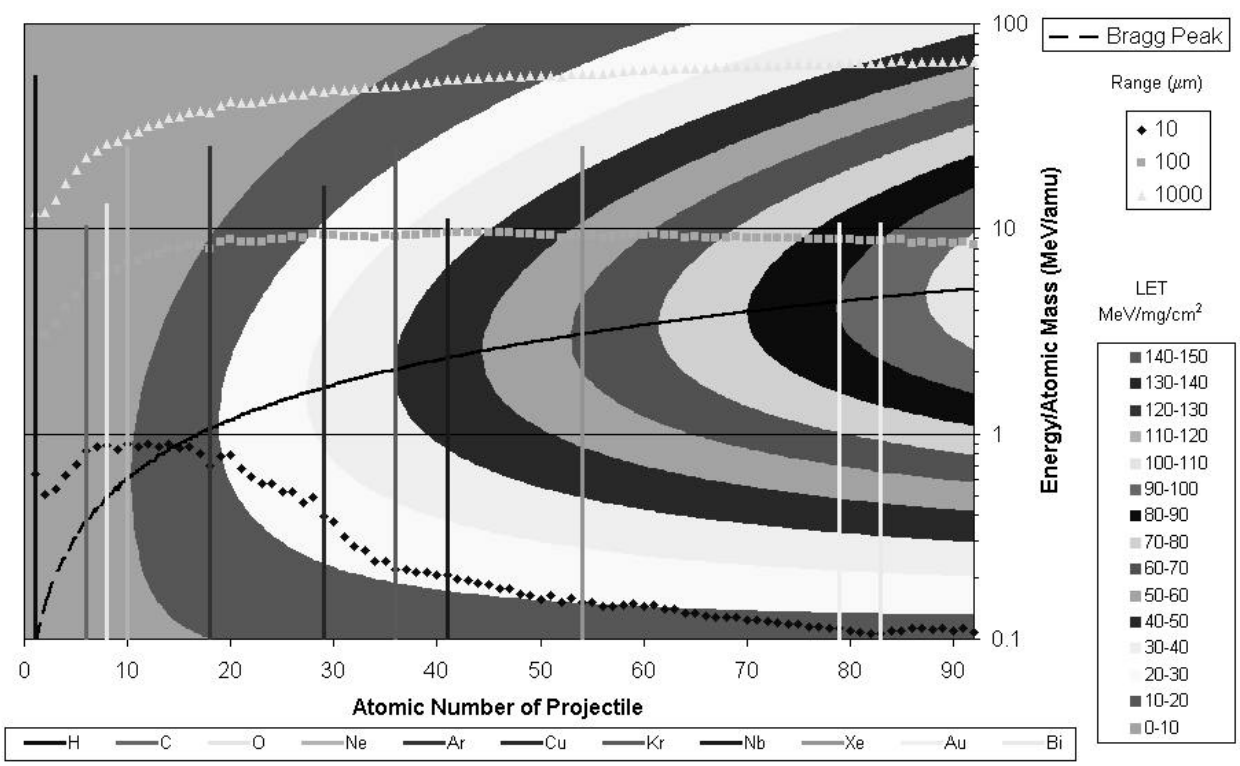
In the Technical Section:

1) The formulas used to calculate the beam uniformity, flux, axial gain, and fluence are given.

2) Photographs, detailed drawings and downloadable AutoCAD (and/or PDF) files of the REF beam line, target chamber, mounting frame and electrical feed-through panels are provided.

3) Two Microsoft Excel spreadsheet programs were developed and are provided for (linear energy transfer) LET and range calculation of any ion in any material. The first program calculates the LET as a function of projectile

Figure 1. Plot of LET as a function of atomic number and energy per atomic mass. Range data, available beams, and the Bragg Peak are included. The vertical lines indicate beams from the REF beam list [1].



atomic number and energy per atomic mass for protons up to ^{238}U for a specified solid target. A sample plot is shown in Fig. 1 for silicon. The second spreadsheet program provides both LET and range data as a function of total energy for any projectile ion incident upon any solid target. These programs were developed based on similar programs found at the Sandia National Laboratory website [2]. The methods used in the spreadsheets to calculate the LET and range values agree with the results from TRIM [3] to within 5%.

In the Local Information section:

1) Directions and downloadable maps (in PDF format) to the Cyclotron Institute from nearby airports (College Station, Bush Intercontinental, Hobby, Austin and Dallas) are provided.

2) A hotel and restaurant listing with a local area map indicating proximity to the Cyclotron Institute.

3) Link to local current and predicted weather conditions.

References

[1] R.C. Rogers, V. Horvat and D. Utley, *Cyclotron Institute Progress in Research April 1, 1998 – March 31, 1999*, p. V5.

[2] Barney L. Doyle, private communication, http://www.sandia.gov/1100/1111/dedx6.xls.

[3] J.F. Ziegler, computer code SRIM, IBM-Research, Yorktown, NY, 1999.