



**BROOKHAVEN**  
NATIONAL LABORATORY

# NSRL-08C RUN

October - November 2008

## FINAL REPORT

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## EXECUTIVE SUMMARY

During the autumn of 2008, a series of radiobiological and physics experiments were performed using the proton and heavy ion beams available at the NASA Space Radiation Laboratory (NSRL). These experiments were part of the seventeenth NSRL scientific run (NSRL-08C) sponsored by NASA's Space Radiation Health Program (SRHP) heavy ion radiobiology research program at BNL.

A total of forty-five proposals were approved for participation in the NSRL-08C run. Of the 45 approved, 41 proposals took part and 4 proposals were withdrawn or deferred. One hundred and thirty-six users from thirty-five institutions were represented, all from the United States. More than 6200 biological samples were exposed at the NSRL beam line, employing 234:44:38 hours of beam time (60:39:09 hours for in vivo studies, 124:31:45 hours for in vitro studies, and 49:33:44 hours for physics experiments) delivered in an eight week period. In addition, 40:38:58 hours were used for dosimetry and beam development. Machine set-up and wrap-up took a total of 143:50:24 hours. Accelerator problems with the NSRL beam accounted for 34:53:24 hours lost. This gave a total NSRL usage time of 474:27:24 hours. Since we were not running concurrently with RHIC, there was no time lost while due to RHIC. As a byproduct of this, all accelerator down-time counted towards the NSRL total.

During NSRL-08C, Booster provided protons (100, 150, 200, and 1000 MeV), carbon (135 MeV/n), oxygen (226, 600, and 1000 MeV/n), silicon (94, 150, 316 and 1000 MeV/n), iron (100, 300, 440, 600, and 1000 MeV/n) and sequential fields of protons and iron (1000 MeV/n) beams for biology and physics experiments. The low energy protons were delivered as part of the Solar Particle Event Simulator. Experimenters are becoming more interested in studying the effects of low doses and low dose rates. For this reason, our attention has been on developing stable low fluence beams with the same dosimetry capability of the higher intensity beam. The maximum dose rates used for biology experiments were as high as 3.0 Gray/min using both 600 and 1000 MeV/n Iron beams. The largest dose used by experimenters was 5 Gray total from 1000 MeV/n Iron, although a number of users delivered doses of 4 Gray or more with proton beams. The general spill rate employed was 15 spills per minute with durations of 300 msec/spill for all ions other than protons. In order to attain higher fluencies, we reduced the Booster cycle time from the standard 4 seconds to 2.5 seconds giving 24 spills per minutes. Spill duration was unchanged at approximately 300 msec. The spill fluence (particles/spill) ranged from  $2 \times 10^2$  (min) to  $6.4 \times 10^{11}$  (max). Square beam spots as big as  $20 \times 20 \text{ cm}^2$  and as small as  $1 \times 1 \text{ cm}^2$  were employed for biology and physics experiments.

The Tandem and Booster were started up on 22 September 2008. NSRL-08C officially ended at 4:01 PM 22 November 2008.

## Projects Reviewed by the BNL Scientific Advisory Committee in Radiation Research

Proposal	PI	Sponsor	NSRL-08C Participation
B-7	RABIN	NASA	Yes
B-10	CHANG	NASA	Yes
B-44	DURANTE †	ASI	No
B-67	BLAKELY	NASA	Yes
N-88	SUTHERLAND	NASA	Yes
N-89	HELD	NASA	Yes
N-90	BAILEY	NASA	Yes
N-103	BARCELLOS-HOFF †	NASA-NSCOR	Yes
N-108	OBENAU	NASA	No
N-115	BACHER	NASA	Yes
N-129	LIMOLI	NASA	Yes
N-134	CHEN, D †	NASA	Yes
N-135	PLUTH	NASA	Yes
N-153	MINNA†/STORY	NASA-DOE	Yes
N-155	RABER	NASA	Yes
N-159	HALL †	NASA	No
N-163	WIESE	NASA	Yes
N-167	BURMA	NASA	Yes
N-173	GEARD †	NASA	Yes
N-175	FIKE	DOE NASA-NSCOR	Yes
N-176	CUCINOTTA	NASA-DOE	Yes
N-177	MORGAN †	NASA	Yes
N-185	SUTHERLAND	NASA-DOE	Yes
N-187	REDPATH	NASA	Yes
N-188	GREEN	NASA	Yes
N-190	IANZINI	NASA	Yes
N-192	ENGLEWARD †	NASA-DOE	Yes
N-194	KUCIK	NSBRI	Yes
N-196	AZZAM	NASA	Yes
N-197	FORNACE †	NASA	Yes
N-198	GLOBUS	NASA	Yes
N-203	BRITTEN	NASA	Yes
N-204	AMUNDSON	NASA-DOE	Yes
N-205	KLEIMAN	DOE-NASA	Yes
N-208	CHEN, B †	NASA	Yes

N-209	WANG †	NASA	No
N-211	RITHIDECH	NASA	Yes
N-212	SMILENOV	NASA	Yes
N-213	TAFROV	NASA	Yes
N-214	BAULCH	NASA	Yes
N-220	DILMANIAN	SBU	Yes
E-9	KOUBA	NASA JSC	Yes
E-11/N-156	PISACANE	NSBRI	Yes
E-13/N-160	SPENCE †	NASA-ESMD	Yes
E-16	HEILBRONN	NASA-MSFC	Yes

† Did not check in with Guest Users Visitors Center for run.

**PARTICIPANTS (Principal Investigators are highlighted)**

<b>Exp.</b>	<b>Name</b>	<b>Guest Title</b>	<b>Employer</b>
<b>B-7</b>	<b>Rabin, Bernard</b> Carrihill, Kirsty Luskin, Katharine Shukitt-Hale, Barbara	<b>Ph.D, Principal Investigator</b> Guest Research Associate Guest Scientific Associate Guest Scientist	<b>University of Maryland</b> University of Maryland Tufts University Tufts University
<b>B-10</b>	<b>Chang, Polly</b> Bakke, James Wang, Abraham	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate Guest Scientific Associate	<b>SRI International</b> SRI International SRI International
<b>B-67</b>	<b>Blakely, Eleanor</b> Bjornstad, Kathleen Rosen, Christopher	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate Guest Scientific Associate	<b>Lawrence Berkeley National Laboratory</b> Lawrence Berkeley National Laboratory Lawrence Berkeley National Laboratory
<b>N-88</b>	<b>Sutherland, Betsy</b>	<b>Ph.D, Principal Investigator</b>	<b>Brookhaven National Laboratory</b>
<b>N-89</b>	<b>Held, Kathryn</b> Chakraborty, Asima Lumpkins, Sarah Magpayo, Nicole	<b>Ph.D, Principal Investigator</b> Guest Scientist Guest Jr. Research Associate Guest Scientific Associate	<b>Massachusetts General Hospital</b> Massachusetts General Hospital Massachusetts General Hospital Massachusetts General Hospital
<b>N-90</b>	<b>Bailey, Susan</b>	<b>Ph.D, Principal Investigator</b>	<b>Colorado State University</b>
<b>N-103</b>	<b>Barcellos-Hoff, Mary Helen</b> Chou, William Costes, Sylvain Kronenberg, Amy Rydberg, Bjorn E.	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate Guest Scientist Guest Scientist Guest Scientist	<b>Lawrence Berkeley National Laboratory</b> New York University Medical Center Lawrence Berkeley National Laboratory Lawrence Berkeley National Laboratory Lawrence Berkeley National Laboratory
<b>N-115</b>	<b>Bacher, Jeffery</b> Bourdeau-Heller, Jeanne Leisemann, Rachel	<b>Ph.D, Principal Investigator</b> Guest Research Associate Guest Research Assistant	<b>Promega Corporation</b> Promega Corporation Promega Corporation
<b>N-129</b>	<b>Limoli, Charles</b> Giedzinski, Erich Suarez, Vannina	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate Guest Scientific Associate	<b>University of California @ Irvine</b> University of California @ Irvine University of California @ Irvine
<b>N-134</b>	<b>Chen, David</b> Aroumougame, Asaithamby	<b>Ph.D, Principal Investigator</b> Guest Scientist	<b>University of Texas Southwestern</b> University of Texas Southwestern
<b>N-135</b>	<b>Pluth, Janice</b> Whalen, Mary	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate	<b>Lawrence Berkeley National Laboratory</b> Lawrence Berkeley National Laboratory

<b>Exp.</b>	<b>Name</b>	<b>Guest Title</b>	<b>Employer</b>
<b>N-153</b>	<b>Story/Minna</b> Delgado, Oliver Ding, Lianghao Kitten, Erin Park, Seongmi Perez, Vanessa Peyton, Michael Jess	<b>Ph.D, Principal Investigator</b> Guest Jr Research Associate Guest Scientist Guest Scientific Associate Guest Research Associate Guest Scientific Associate Guest Scientist	<b>University of Texas Southwestern</b> University of Texas Southwestern University of Texas Southwestern University of Texas Southwestern University of Texas Southwestern University of Texas Southwestern University of Texas Southwestern
<b>N-155</b>	<b>Raber, Jacob</b> Villasana, Laura	<b>Guest Scientist</b> Guest Jr Research Associate	<b>Oregon Health &amp; Science University</b> Oregon Health & Science University
<b>N-163</b>	<b>Wiese, Claudia</b> Seidler, Sara	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate	<b>Lawrence Berkeley National Laboratory</b> Lawrence Berkeley National Laboratory
<b>N-167</b>	<b>Burma, Sandeep</b> Camacho, Cristel	<b>Ph.D, Principal Investigator</b> Guest Jr Research Associate	<b>University of Texas Medical Branch</b> University of Texas Southwestern
<b>N-173</b>	<b>Geard, Charles</b> Grabham, Peter William Hu, Burong	<b>Ph.D, Principal Investigator</b> Guest Scientist Guest Research Associate	<b>Columbia University</b> Columbia University Columbia Nevis Lab
<b>N-175</b>	<b>Fike, John</b> Huang, Lei Obenaus, Andre	<b>Ph.D, Principal Investigator</b> Guest Scientist Guest Scientist	<b>University of San Francisco</b> Loma Linda University Loma Linda University
<b>N-176</b>	<b>Cucinotta, Francis</b> Hada, Megumi	<b>Ph.D, Principal Investigator</b> Guest Scientist	<b>NASA - Johnson Space Center</b> Universities Space Research Association
<b>N-177</b>	<b>Morgan, William</b> Goetz, Wilfried Malkiel, Nechama	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate Guest Research Assistant	<b>University of Maryland School of Medicine</b> University of Maryland University of Maryland
<b>N-185</b>	<b>Sutherland, Betsy</b>	<b>Ph.D, Principal Investigator</b>	<b>Brookhaven National Laboratory</b>
<b>N-187</b>	<b>Redpath, John</b> Elmore, Eugene	<b>Ph.D, Principal Investigator</b> Guest Scientist	<b>University of California @ Irvine</b> University of California @ Irvine
<b>N-188</b>	<b>Green, Lora</b> Bianski, Brandon Sanchez, Martha	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate Guest Research Assistant	<b>Loma Linda University</b> Loma Linda University Loma Linda University
<b>N-190</b>	<b>Ianzini, Fiorenza</b> Napoli, Eleonora	<b>Ph.D, Principal Investigator</b> Guest Scientist	<b>University of Iowa</b> University of Iowa
<b>N-192</b>	<b>Engleward, Bevin</b> Kiralay, Orsolya Olipitz, Werner	<b>Ph.D, Principal Investigator</b> Guest Scientist Guest Research Associate	Massachusetts Institute of Technology Massachusetts Institute of Technology Massachusetts Institute of Technology

<b>Exp.</b>	<b>Name</b>	<b>Guest Title</b>	<b>Employer</b>
<b>N-194</b>	<b>Kucik, Dennis</b> Gupta, Kiran Khaled, Saman Wu, Xing	<b>Ph.D, Principal Investigator</b> Guest Jr Research Associate Guest Jr Research Associate Guest Scientist	<b>University of Alabama</b> University of Alabama University of Alabama University of Alabama
<b>N-196</b>	<b>Azzam, Edouard Iskandar</b> Autsavapromporn, Narongchai Buonanno, Manuela de Toledo, Sonia Maria Gonon, Geraldine Zhang, Jie	<b>Ph.D, Principal Investigator</b>  Guest Jr Research Associate Guest Research Assistant Guest Scientist Guest Jr Research Associate Guest Jr Research Associate	<b>University of Medicine and Dentistry of NJ</b>  University of Medicine and Dentistry of NJ University of Medicine and Dentistry of NJ University of Medicine and Dentistry of NJ University of Medicine and Dentistry of NJ University of Medicine and Dentistry of NJ
<b>N-197</b>	<b>Fornace Jr., Albert</b> Doiron, Kathryn E	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate	<b>Georgetown University</b> Georgetown University
<b>N-198</b>	<b>Globus, Ruth</b> Almeida, Eduardo Yumoto, Kenji	<b>Ph.D, Principal Investigator</b> Guest Jr Research Associate Guest Jr Research Associate	<b>NASA – Ames Research Center</b> NASA – Ames Research Center NASA – Ames Research Center
<b>N-203</b>	<b>Britten, Richard Antony</b> Chabriol, Anne-Olivia Keeney, Sonia Mitchell, Shamina Singletary, Sylvia J	<b>Guest Scientist</b> Guest Jr Research Associate Guest Research Assistant Guest Jr Research Associate Guest Scientist	<b>Eastern Virginia Medical School</b> Eastern Virginia Medical School Eastern Virginia Medical School Eastern Virginia Medical School Eastern Virginia Medical School
<b>N-204</b>	<b>Amundson, Sally A.</b> Mezentsev, Alexandre	<b>Ph.D, Principal Investigator</b> Guest Scientist	<b>Columbia University</b> Columbia University
<b>N-205</b>	<b>Kleiman, Norman</b> David, Janice	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate	<b>Columbia University</b> Columbia University
<b>N-208</b>	<b>Chen, David</b> DeCarolis, Nathan Malhotra, Shveta	<b>Ph.D, Principal Investigator</b> Guest Jr Research Associate Guest Scientist	<b>University of Texas Southwestern Medical Center @ Dallas</b> University of Texas Southwestern University of Texas Southwestern
<b>N-211</b>	<b>Rithidech, Kanokporn</b> Brown, Robert	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate	<b>SUNY at Stony Brook</b> SUNY at Stony Brook
<b>N-212</b>	<b>Smilenov, Lubomir</b> Templin, Thomas	<b>Guest Scientist</b> Guest Research Associate	<b>Columbia University, Nevis Laboratories</b> Columbia University
<b>N-213</b>	<b>Tafrov, Stefan</b>	<b>Ph.D, Principal Investigator</b>	<b>Brookhaven National Laboratory</b>
<b>N-214</b>	<b>Baulch, Janet</b> Aypar, Umut	<b>Ph.D, Principal Investigator</b> Guest Research Assistant	<b>University of Maryland</b> University of Maryland
<b>N-220</b>	<b>Dilmanian, Avraham</b>	<b>Ph.D, Principal Investigator</b>	<b>Brookhaven National Laboratory</b>

<b>Exp.</b>	<b>Name</b>	<b>Guest Title</b>	<b>Employer</b>
<b>E-9</b>	<b>Dungan, Larry</b> Moore, Kevin Smith, Nahtan Tucker, Andrew	<b>Ph.D, Principal Investigator</b> Guest Scientific Associate Guest Scientific Associate Guest Scientific Associate	<b>NASA - Johnson Space Center</b> NASA – Johnson Space Center NASA – Johnson Space Center NASA – Johnson Space Center
<b>E-11/N-156</b>	<b>Pisacane, Vincent</b> Dicello, John Malak, Henryk	<b>Ph.D, Principal Investigator</b> Guest Scientist Guest Scientist	<b>U.S. Naval Academy</b> U.S. Naval Academy U.S. Naval Academy
<b>E-13/N-160</b>	<b>Spence, Harlan</b> Case, Anthony Golightly, Michael	<b>Ph.D, Principal Investigator</b> Guest Research Assistant Guest Scientific Associate	<b>Boston University</b> Boston University Boston University
<b>E-16</b>	<b>Heilbronn, Lawrence</b> Maurer, Richard Roth, David Zeitlin, Cary	<b>Ph.D, Principal Investigator</b> Guest Scientist Guest Scientist Guest Scientist	<b>Lawrence Berkeley National Laboratory</b> John Hopkins University John Hopkins University Southwest Research Institute
<b>NSRL</b>	Guida Peter‡	Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Tafrov, Stefan ‡	Associate Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Victorie Stisova‡	Postdoctoral Fellow	Brookhaven National Laboratory
<b>NSRL</b>	Pankaj Chaudhary ‡	Postdoctoral Fellow	Brookhaven National Laboratory
<b>NSRL</b>	Keszenman, Deborah‡	Associate Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Pyatt, Beatrice ‡	Medical Associate	Brookhaven National Laboratory
<b>NSRL</b>	Abele, William ‡	Associate Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Sutherland, John ‡	Senior Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Bennett, Paula ‡	Biology Associate I	Brookhaven National Laboratory
<b>NSRL</b>	Trunk, John ‡	Senior Technical Associate	Brookhaven National Laboratory
<b>NSRL</b>	Bernadette Whelan‡	Laboratory Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Petry, Maryann‡	BLAF Manager	Brookhaven National Laboratory
<b>NSRL</b>	Jardine, James ‡	Laboratory Specialist	Brookhaven National Laboratory
<b>NSRL</b>	Sivertz, Michael‡	Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Naidu, Mamta ‡	Associate Scientist	Brookhaven National Laboratory
<b>NSRL</b>	Kim, Angela ‡	Medical Associate	Brookhaven National Laboratory
<b>NSRL</b>	Thompson, Laura‡	Medical Associate	Brookhaven National Laboratory
<b>NSRL</b>	Forrette, Elise‡	Administrative Assistant	Brookhaven National Laboratory
<b>NSRL</b>	Bonti, Kerry‡	BLAF Staff	Brookhaven National Laboratory
<b>NSRL</b>	Snyder, Deborah‡	BLAF Staff	Brookhaven National Laboratory
<b>NSRL</b>	Reiszel, Corrine‡	BLAF Staff	Brookhaven National Laboratory
<b>NSRL</b>	Rusek, Adam‡	Scientist	Brookhaven National Laboratory

‡ BNL Personnel who participated in many different experiments throughout the run.

## **PARTICIPANT INSTITUTIONS**

### **Universities (25)**

Baylor College of Medicine  
Boston University  
Colorado State University  
Columbia University  
Columbia University, Nevis Laboratories  
Eastern Virginia Medical School  
Georgetown University  
Johns Hopkins University  
Loma Linda University  
Massachusetts Institute of Technology  
Oregon Health & Science University  
Southwest Research Institute  
SUNY at Stony Brook  
Texas A&M University  
Tufts University  
Universities Space Research Association  
University of Alabama  
University of California @ Irvine  
University of Iowa  
University of Maryland  
University of Medicine and Dentistry of New Jersey  
University of Rochester  
University of San Francisco  
University of Texas Southwestern  
U.S. Naval Academy

### **National Laboratories/Institutions (2)**

Brookhaven National Laboratory  
Lawrence Berkeley National Laboratory

### **NASA Related Centers/Institutions (2)**

NASA - AMES Research Center  
NASA - Johnson Space Center

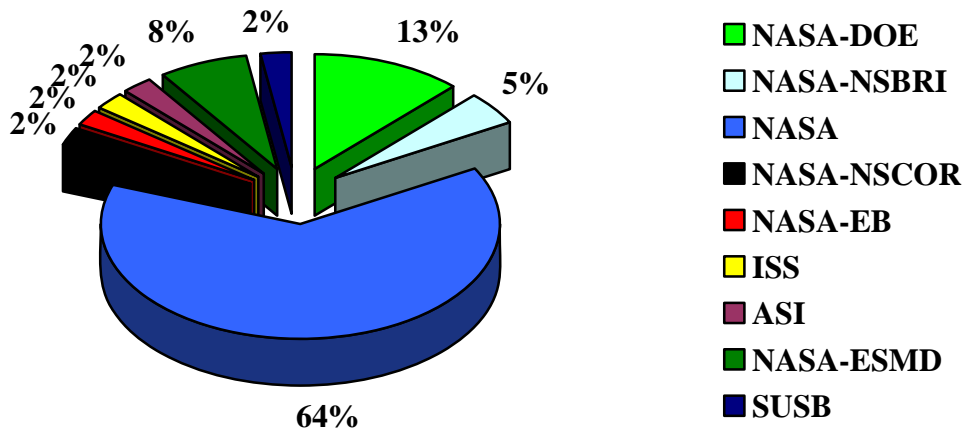
### **Private Institutions(2)**

Massachusetts General Hospital  
New York University Medical Center

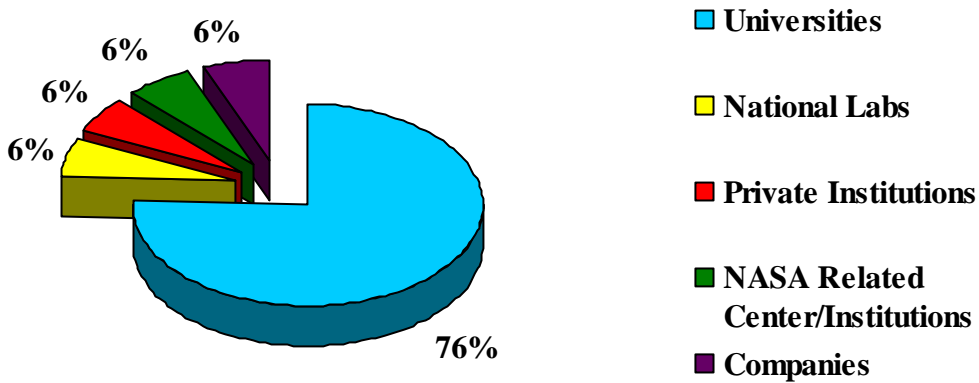
### **Company (2)**

Promega Corporation  
SRI International

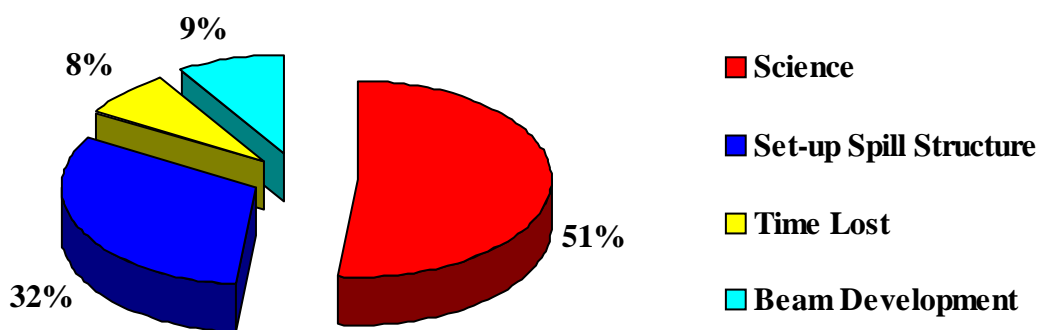
## RESEARCH PROJECT SPONSORS



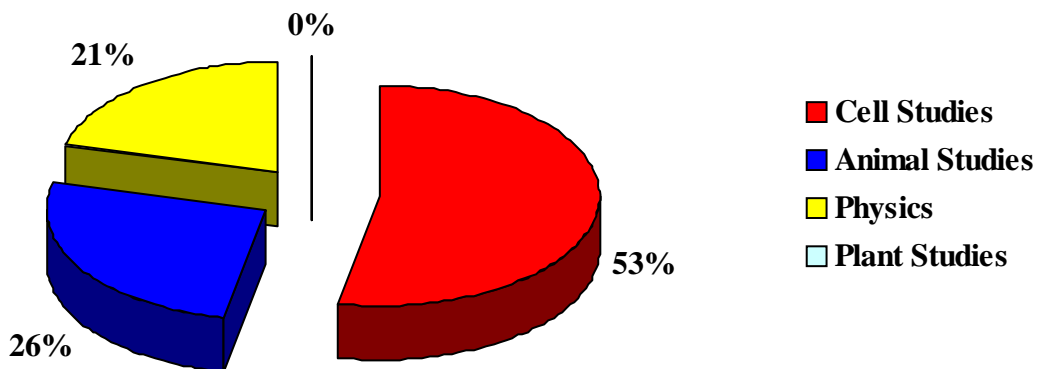
## INSTITUTION STATISTICS



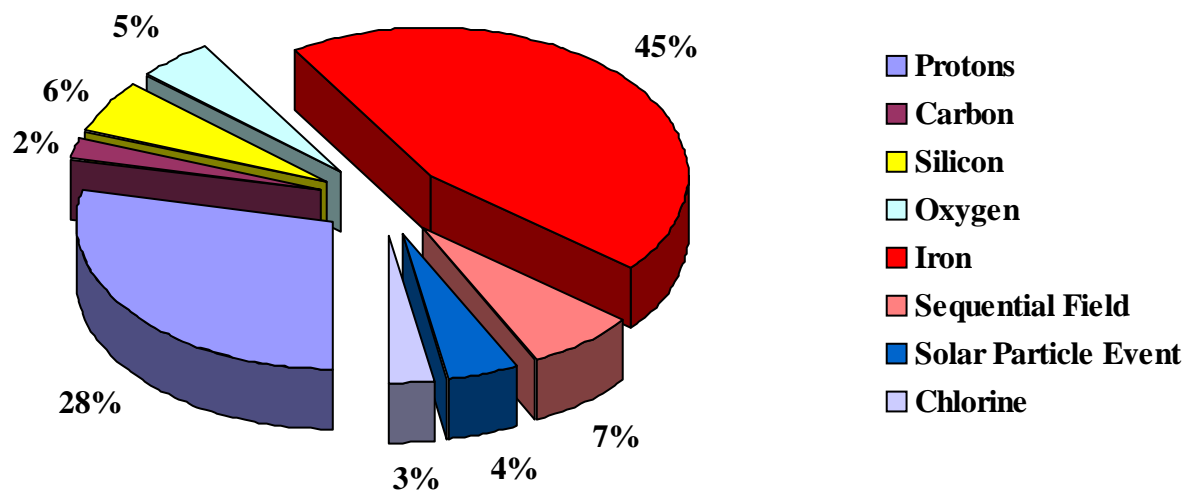
### TOTAL RUN-TIME STATISTICS



### SCIENCE STUDIES STATISTICS



## ION SPECIES DISTRIBUTION



**RUN TIME DESCRIPTION (hours)**

NSRL-08C	ION SPECIES AND ENERGIES (MeV/nucleon)											
	H				C	O			Si			
	100	150	200	1000	135	226	600	1000	94	150	316	1000
<b>Machine Set-Up</b>	7:42:36	0:00:00	0:00:00	40:55:12	2:34:48	0:00:00	0:00:00	8:00:00	4:43:12	0:00:00	0:58:37	6:49:12
<b>Development</b>	0:00:00	2:26:55	4:02:16	13:05:14	0:00:00	0:00:00	2:29:57	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00
<b>SCIENCE</b>												
<b>In Vitro</b>	13:40:36	8:43:47	5:18:31	20:19:10	0:00:00	1:07:33	0:00:00	1:19:50	3:03:18	1:23:33	0:27:00	0:00:00
<b>In Vivo</b>	2:33:11	0:00:00	2:04:04	3:50:28	7:29:59	0:00:00	2:50:53	2:49:02	0:00:00	0:00:00	0:00:00	0:00:00
<b>Others</b>	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00
<b>Physics</b>	3:17:59	0:00:00	0:00:00	6:38:39	0:00:00	0:00:00	0:00:00	3:13:47	0:00:00	0:00:00	0:00:00	7:42:42
<b>NSRL Time Lost</b>	0:00:00	0:00:00	0:00:00	1:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:52:12	0:00:00	0:00:00	0:00:00
<b>Totals</b>	<b>23:56:23</b>	<b>11:10:42</b>	<b>11:24:51</b>	<b>88:28:43</b>	<b>10:04:47</b>	<b>1:07:53</b>	<b>5:20:50</b>	<b>15:42:39</b>	<b>9:38:42</b>	<b>1:23:33</b>	<b>1:25:37</b>	<b>14:46:54</b>

(continued next page)

**RUN TIME DESCRIPTION (hours) (continued from previous page)**

NSRL-08C	ION SPECIES AND ENERGIES (MeV/nucleon)								
	Cl	p/Fe	Fe					SPE	Total
	1000	1000	100	300	440	600	1000	N/A	
<b>Machine Set-Up</b>	7:39:00	6:25:48	0:00:00	4:07:48	0:00:00	0:00:00	47:52:48	7:00:00	<b>143:50:24</b>
<b>Development</b>	2:23:56	0:00:00	0:00:00	3:32:58	0:00:00	0:00:00	14:03:01	0:00:00	<b>40:38:58</b>
<b>SCIENCE</b>									
<b>In Vitro</b>	0:00:00	11:52:50	1:02:29	4:29:42	1:30:00	4:05:39	46:07:47	0:00:00	<b>124:31:45</b>
<b>In Vivo</b>	1:49:30	7:38:05	0:00:00	0:58:57	0:00:00	6:12:18	22:22:42	0:00:00	<b>60:39:09</b>
<b>Others</b>	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	<b>0:00:00</b>
<b>Physics</b>	3:27:47	0:00:00	0:00:00	0:00:00	0:00:00	0:52:51	13:46:43	13:51:15	<b>49:33:44</b>
<b>NSRL Time Lost</b>	0:15:00	5:31:48	0:00:00	1:07:48	0:00:00	0:22:00	26:06:36	0:00:00	<b>34:53:24</b>
<b>Totals</b>	<b>13:41:17</b>	<b>32:58:31</b>	<b>1:02:29</b>	<b>1:27:12</b>	<b>1:30:00</b>	<b>11:10:48</b>	<b>184:24:37</b>	<b>20:51:15</b>	<b>474:27:24</b>

Total hours of science is 234:44:38.

Note: Hours of Set-Up and Wrap-Up have been combined into a single category since much of the work done at the end of each day involves preparations for the next day's exposures.

## BEAM CHARACTERISTICS

Ion	H				C	O			Si			
<b>Energy (MeV/n)</b>												
<b>Planned</b>	<b>100</b>	<b>150</b>	<b>200</b>	<b>1000</b>	<b>135</b>	<b>226</b>	<b>600</b>	<b>1000</b>	<b>94</b>	<b>150</b>	<b>316</b>	<b>1000</b>
<b>Extracted</b>	104.1	154.0	200	1000	135	226.7	597.8	1000	96.29	151.7	316	993.6
<b>On Target</b>	104.1	154.0	200*	1000*	135*	226.7	597.8	1000*	96.29	151.7	316*	993.6
<b>Fluence (particles/cm<sup>2</sup>/sec)</b>												
<b>Maximum on target</b>	3.1E7	4.1E7	2.5E6	2.4E8	5.2E6	8.5E4	N/A	7.8E5	7.5E4	2.1E5	1.7E5	N/A
<b>Minimum on target</b>	7.8E5	2.0E6	2.5E6	2.5E6	5.2E6	4.2E4	N/A	7.8E4	7.5E4	5.2E3	1.7E5	N/A
<b>Spill Period (sec)</b>	2.5	2.5	2.5	2.5	4	4	4	4	4	4	4	4
<b>Spill rate (spills/min)</b>	24	24	24	24	15	15	15	15	15	15	15	15
<b>Spill length (msec)</b>	300	300	300	300	300	300	300	300	300	300	300	300
<b>Particles/spill</b>												
<b>Maximum</b>	8.0E10	1.1E11	6.3E9	6.0E11	1.3E10	2.2E8	N/A	2.0E9	1.9E8	5.4E8	4.2E8	N/A
<b>Minimum</b>	2.0E9	5.0E9	6.3E9	6.0E9	1.3E10	1.1E8	N/A	2.0E8	1.9E8	1.3E7	4.2E8	N/A
<b>Beam Cut Off Accuracy</b>	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
<b>Actual LET on Target (keV/μm)</b>	0.7138	0.539	0.4528	0.223*	21.21	26.67	16.45	14.24	147.9	106.4	67.31	43.66
<b>Max. Dose Rate (Gy/min)</b>												
<b>20 cm x 20 cm</b>	0.34	0.5	1.0	1.0	1	0.5	N/A	1.2	1.0	1.0	1.0	N/A
<b>Total Dose (Gy)</b>												
<b>Maximum</b>	2.0	2.0	0.1	4.7	10	0.2	N/A	1.0	1.0	2.0	1.0	N/A
<b>Minimum</b>	0.05	0.1	0.1	0.05	10	0.1	N/A	0.1	1.0	0.05	1.0	N/A

\* No Bragg results are available for H running at 200 or 1000 MeV, C at 135 MeV/n , O at 1000 MeV/n, Si at 316 MeV/n, Cl at 1000 MeV/n, or Fe at 100 MeV/nucleon. For these energies, only calculated LET is quoted.

(continued next page)

**BEAM CHARACTERISTICS Continued from previous page)**

Ion	Cl	p/Fe	Fe					SPE
Energy (MeV/n)								
<b>Planned</b>	<b>1000</b>	<b>1000</b>	<b>100</b>	<b>300</b>	<b>440</b>	<b>600</b>	<b>1000</b>	N/A**
<b>Extracted</b>	1000	1000	100	299.0	440.5	593.9	965.1	N/A**
<b>On Target</b>	1000*	1000*	100*	299.0	440.5	593.9	965.1	N/A**
<b>Fluence (particles/cm<sup>2</sup>/sec)</b>								
<b>Maximum on target</b>	3.5E5	N/A**	2.3E4	9.3E4	5.7E4	1.9E5	3.7E5	N/A**
<b>Minimum on target</b>	6.9E4	N/A**	2.3E3	2.3E3	5.7E4	1.3E3	3.7E3	N/A**
<b>Spill Period (sec)</b>	4	2.5/4	4	4	4	4	4	2.5
<b>Spill rate (spills/min)</b>	15	24/15	15	15	15	15	15	24
<b>Spill length (msec)</b>	300	300	300	300	300	300	300	300
<b>Particles/spill</b>								
<b>Maximum</b>	8.9E8	N/A**	5.8E7	2.4E8	1.5E8	4.9E8	9.4E8	N/A**
<b>Minimum</b>	1.8E8	N/A**	5.8E6	6.0E6	1.5E8	3.3E6	9.4E6	N/A**
<b>Beam Cut Off Accuracy</b>	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
<b>Actual LET on Target (keV/μm)</b>	64.29	0.223*/151	494.3	239.2	196.8	173.6	151.5	N/A**
<b>Max. Dose Rate (Gy/min)</b>								
<b>20 cm x 20 cm</b>	1.0	0.5	1.0	1.0	1.0	3.0	3.0	N/A**
<b>Total Dose (Gy)</b>								
<b>Maximum</b>	2.0	1.0	1.0	2.0	1.0	3.0	5.0	N/A**
<b>Minimum</b>	0.4	0.001	0.1	0.05	1.0	0.02	0.05	N/A**

For beams and energies employed for physics experiments only, we did not always make measure of dose rates or integrated doses. For these beams, we indicate “N/A\*\*”. Similarly, the SPE was comprised of many differing beams, each with different characteristics.

## **DOSIMETRY AND BEAM DEVELOPMENTS**

### **New Beams**

During NSRL 08C the following beams were developed and used for the first time:

- Carbon at 135 MeV/n,
- Oxygen at 226 MeV/n,
- Silicon at 94 and 150 MeV/n, and
- Iron at 100 and 440 MeV/n.

NSRL continued to develop Solar Particle Event Simulator, studying the type of proton beam energy spectrum that would be required to deliver a human-like dose to a mouse subject. One experimenter made use of the SPE capabilities.

**RUN DATES**

<b>Ion</b>	<b>Energy</b>	<b>Scheduled Start</b>	<b>Scheduled End</b>	<b>Actual Start</b>	<b>Actual End</b>
<b>Iron</b>	100-1000	9/29/08 7:00	10/2/08 18:00	9/29/08 8:48	10/2/08 13:31
<b>Silicon</b>	94-1000	10/3/08 7:00	10/6/08 18:00	10/3/08 7:00	10/6/08 16:55
<b>Oxygen</b>	226-1000	10/7/08 7:00	10/9/08 17:00	10/7/08 7:00	10/9/08 15:31
<b>Iron</b>	300-1000	10/10/08 7:00	10/13/08 17:30	10/10/08 7:00	10/13/08 16:04
<b>Protons</b>	100-1000	10/14/08 7:00	10/17/08 18:30	10/14/08 7:00	10/17/08 17:00
<b>Iron</b>	300-1000	10/20/08 7:00	10/21/08 20:00	10/20/08 7:00	10/21/08 15:54
<b>Fe/P</b>	1000	10/22/08 7:00	10/24/08 18:30	10/22/08 7:00	10/24/08 16:02
<b>Protons</b>	150-1000	10/27/08 7:00	10/31/08 19:00	10/27/08 7:00	10/31/08 18:40
<b>Iron</b>	300-1000	11/3/08 7:00	11/18/08 16:00	11/3/08 7:00	11/18/08 15:25
<b>Protons</b>	50-1000	11/19/08 7:00	11/20/08 18:30	11/19/08 7:00	11/20/08 16:59
<b>Chlorine</b>	1000	11/21/08 7:00	11/21/08 15:30	11/21/08 7:00	11/21/08 14:32
<b>Carbon</b>	135	11/22/08 7:00	11/22/08 15:00	11/22/08 7:00	11/22/08 16:01

## EXPERIMENTERS AND RUN STATISTICS

Note: Entries in **RED** indicate time approved by SACRR but not run during this Run 08C.

Entries marked with † indicate time that was deferred from previous running periods.

Proposal ID	Principle Investigator	Ion	Energy	Beam Time Approved	Beam Time Used	Dose Rate	Dose Range	Number of Samples
B-7	Rabin	Oxygen	600	5:00	2:50:53	0.1-100	0.1-25	60
B-7	Rabin	Oxygen	1000	0:00	2:49:02	1-120	0.1-100	98
<b>B-7</b>	<b>Rabin</b>	<b>Silicon</b>	<b>1000</b>	<b>4:30</b>	<b>0:00:00</b>	-	-	-
B-10	Chang	Fe/P	1000	6:00	3:50:07	50	25-100	30
B-67	Blakely	Iron	1000	0:00	0:48:04	50	10-100	50
B-67†	Blakely	Protons	1000	6:00	3:30:00	30-70	10-100	20
N-88	Sutherland	Fe/P	1000	4:00	1:14:13	20	10-40	12
N-88	Sutherland	Oxygen	1000	0:00	0:48:36		10-50	16
N-88	Sutherland	Protons	100	12:00	13:40:36	1.5-34	5-200	98
N-89	Held	Fe/P	1000	7:30	6:32:05	0.00001-1	0.00001-1	156
N-89	Held	Iron	1000	6:00	4:48:33	0.0001-200	0.00001-200	100
N-89	Held	Protons	1000	6:42	5:28:26	low - 35	low - 100	432
N-90	Bailey	Iron	1000	2:00	0:26:37	100	100-200	24
N-103	Barcellos-Hoff	Iron	100	0:00	1:02:29	20-100	10-100	8
<b>N-103</b>	<b>Barcellos-Hoff</b>	<b>Iron</b>	<b>300</b>	<b>5:00</b>	<b>0:00:00</b>	-	-	-
N-103	Barcellos-Hoff	Iron	440	0:00	1:30:00	100	100	6
N-103	Barcellos-Hoff	Iron	1000	10:00	0:56:12	100	100	2
N-103	Barcellos-Hoff	Oxygen	226	0:00	1:07:33	50	10-20	5
N-103	Barcellos-Hoff	Oxygen	1000	0:00	0:31:14	50	20	3
N-103	Barcellos-Hoff	Silicon	94	0:00	1:51:46	100	100	48
N-103	Barcellos-Hoff	Silicon	316	0:00	0:27:00	100	100	48
N-115	Bacher	Fe/P	1000	2:00	3:47:58	20	10-100	148
N-129	Limoli †	Iron	600	2:00	5:04:13	0-200	0-200	187
<b>N-129</b>	<b>Limoli †</b>	<b>Iron</b>	<b>1000</b>	<b>5:00</b>	<b>0:00:00</b>			
<b>N-134</b>	<b>Chen, D</b>	<b>Silicon</b>	<b>300</b>	<b>1:00</b>	<b>0:00:00</b>	-	-	-

<b>N-134</b>	<b>Chen, D</b>	<b>Silicon</b>	<b>1000</b>	<b>1:00</b>	<b>0:00:00</b>	-	-	-
N-135	Pluth	Iron	300	0:00	3:38:30	10-100	5-200	152
N-135	Pluth	Iron	1000	8:00	3:14:10	10-100	5-200	20
N-153	Story/Minna	Iron	1000	19:30	19:08:07	20-100	10-100	2169
N-155	Raber	Iron	600	6:45	2:00:37	100-300	100-300	86
N-163	Weise	Iron	1000	5:30	3:22:31	200	200	98
N-167	Burma	Iron	1000	4:00	0:59:34	50-100	10-100	30
N-173	Gear	Iron	1000	3:42	1:01:00	50-100	8-80	10
N-173	Gear	Protons	1000	1:48	0:38:06	60	20-320	24
<b>N-173</b>	<b>Gear</b>	<b>SPE</b>	-	<b>3:00</b>	<b>0:00:00</b>	-	-	-
N-175	Fike	Iron	600	3:00	2:00:00	100-300	100-300	86
N-176	Cucinotta	Iron	1000	4:00	1:55:05	10-100	12-200	106
N-176	Cucinotta	Silicon	94	0:00	1:11:32	10-100		50
N-176	Cucinotta	Silicon	150	0:00	1:23:33	10-100	5-200	50
<b>N-176</b>	<b>Cucinotta</b>	<b>Silicon</b>	<b>1000</b>	<b>3:30</b>	<b>0:00:00</b>	-	-	-
N-177	Morgan	Iron	1000	6:00	3:29:57	10-100	10-200	32
N-185	Sutherland	Iron	1000	1:30	0:30:00	20	10-40	6
N-185	Sutherland	Protons	1000	1:30	0:30:00	20	10-40	6
N-187	Redpath	Iron	1000	3:00	3:06:32	1-50	0.1-100	90
N-187	Redpath	Protons	1000	2:00	0:27:46	20-50	10-100	16
N-188	Green	Iron	1000	8:18	4:13:55	20-100	10-200	126
N-190	Ianzini	Iron	1000	7:00	4:03:46	100	50-200	45
N-192	Engleward	Iron	1000	1:30	0:35:04	100	100	26
N-194	Kucik	Protons	200	8:00	5:18:31			50
N-196	Azzam	Iron	1000	1:30	2:17:33	10-100	10-200	18
N-196	Azzam	Protons	1000	9:30	7:10:41	20-	10-400	84
N-197	Fornace	Iron	1000	1:42	0:24:11	200	50-400	33
N-197	Fornace	Protons	1000	2:36	1:17:00	100	188-470	11
N-198	Globus	Iron	1000	4:00	5:19:08	100	100	14
<b>N-203</b>	<b>Britten</b>	<b>Chlorine</b>	<b>500</b>	<b>1:42</b>	<b>0:00:00</b>	-	-	-
N-203	Britten	Chlorine	1000	4:00	1:49:30	50-100	40-200	76
<b>N-203</b>	<b>Britten</b>	<b>Iron</b>	<b>300</b>	<b>4:00</b>	<b>0:00:00</b>	-	-	-
N-203	Britten	Iron	600	1:42	1:13:07	50	30-200	44
N-203	Britten	Iron	1000	3:36	1:11:05	50	20-200	44

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N-204	Amundson	Iron	300	2:00	0:51:12	low	low	3
N-205	Kleiman	Iron	1000	2:30	2:52:14	50	10-100	16
N-205	Kleiman	Protons	200	0:00	2:04:04	50	10	14
N-205	Kleiman	Protons	1000	2:30	0:00:00	-	-	-
N-208	Chen, B	Iron	300	1:00	0:58:57	100	100	80
N-208	Chen, B	Iron	1000	1:00	0:47:10	30-100	10-100	120
N-211	Rithidech	Protons	100	4:36	2:33:11	1	100	15
N-212	Smilenov	Iron	1000	1:30	1:29:38	50	10-100	58
N-212	Smilenov	Protons	1000	1:30	1:36:33	50	25-100	8
N-213	Tafrov	Iron	300	1:00	0:00:00	-	-	-
N-213	Tafrov	Iron	1000	6:00	5:06:55	50	50	20
N-213	Tafrov	Protons	150	0:00	0:57:56	50	20	15
N-213	Tafrov	Protons	1000	1:00	4:01:06	80	20	7
N-213	Tafrov	Oxygen	190	2:00	0:00:00	-	-	-
N-213	Tafrov	Silicon	1000	2:00	0:00:00	-	-	-
N-214	Baulch	Iron	1000	6:00	3:29:57	10-100	10-200	32
N-214	Baulch	Protons	150	6:00	7:45:51	2	10-200	36
N-220	Dilmanian	Carbon	135	8:00	7:29:59	1-10	1-10	1
E-9	Dungan/Carson	Iron	600	0:00	0:52:51	low	low	1
E-9	Dungan/Carson	Iron	1000	6:00	6:43:12	low		1
E-9	Dungan/Carson	Protons	1000	6:00	6:38:39	low	low	1
N-156/E-11	Pisacane	SPE	-	12:00	13:51:15	-	-	1
N-156/E-11	Pisacane	Silicon	1000	8:00	7:42:42	low	low	4
N-160/E-13	Spence	Chlorine	1000	2:48	3:27:47	low	low	1
N-160/E-13	Spence	Oxygen	1000	2:48	3:13:47	low	low	1
E-16	Heilbronn	Iron	1000	6:30	7:03:31	low		1

Total number of hours of science that ran in Run 08C is 234:44:38.

Total hours of science approved to run in NSRL Run 08C was 304:15.

Total hours of science approved, excluding the hours deferred until future runs: 272:03.

