



# NSRL-1 RUN

## FINAL REPORT

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**BNL/NASA webpage:**  
**<http://www.bnl.gov/medical/NASA/NASA-home%20frame.htm>**

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## **EXECUTIVE SUMMARY**

During the summer of 2003, a series of radiobiological and physics experiments were performed using the NASA Space Radiation Laboratory to accelerate iron, carbon and titanium beams (NSRL-1). These experiments were part of the NSRL commissioning run sponsored by NASA's Space Radiation Health Program (SRHP) heavy ion radiobiology research program at BNL.

A total of 27 proposals were approved to participate in the NSRL-1 run. Twenty one institutions from the United States and 2 from Italy were represented, totaling 73 users. More than 2000 biological samples were exposed at the NSRL beam line, employing 285 hours of beam time (36.5 hours for in vivo studies, 96 hours for in vitro studies and 20 hours for electronics and calibration). In addition, 36 hours were used for physics experiments (Fe and Ti), and a total of 23 hours were necessary for beam characterization, tuning, dosimetry, and calibration. A total of 42.5 hours of beam time were lost (15%) due to accelerator or power supply related problems.

During NSRL-1, AGS-Booster provided iron (780 and 0.970 GeV/nucleon, LET: 159.6 and 151.3 keV/ $\mu\text{m}$ ), Carbon (0.294 GeV/n, LET: 12.8 keV/ $\mu\text{m}$ ) and Titanium (0.980 GeV/n, LET: 108.1 keV/ $\mu\text{m}$ ) ion beams for biology and physics experiments. The dose/rates used were as low as 1 cGy/min and as high as 2.5 Gy/min. The spill rate employed was 20 for Fe, Ti and C with duration of 400 msec/spill. The spill fluence was (particles/spill)  $1.2 \times 10^{10}$  (max) and 500 (min). Square beam spots as big as 20 x 20 cm and small as 1 x 1 cm was employed for biology and physics experiments.

Tandem-Booster set-up started on October 25 with the transport and circulation of Fe beams at the NSRL complex. Beam was tuned into cave on October 26. 800 MeV/n Fe beams were available for tuning on October 27. The next several shifts were spent on physics experiments (J. Miller: beam characterization). Biology studies started on the evening of October 28 using 1 GeV/n iron beams (B. Rydberg, LBNL) and proceeded through November 11. On November 13, AGS tuned 1 GeV/n titanium beams for biology studies. Physics studies started on November 18 and continued for 20 hours. The titanium run ended on November 21. On November 19, AGS complex delivered carbon beams biology experiments running until late afternoon on November 24. NSRL-1 officially ended at 1700 pm, November 24 2003.

Radiobiological experiments employed cells, tissues, and intact specimens, which required a complex coordination and planning of their respective logistic support. Biological studies used human, mouse, rat and hamster cell lines, human-hamster hybrid cell lines, tumor cell lines and intact specimens (rodents). The full program was completed in 27 days.

**NSRL-1 Projects Reviewed by the BNL's Scientific Advisory Committee in Radiobiology (SACR):**

<b>Proposal</b>	<b>PI</b>	<b>NSRL-1 Participation</b>
<b>B-7</b>	<b>Bernard Rabin</b>	<b>Yes</b>
<b>B-10</b>	<b>Polly Y. Chang</b>	<b>Yes</b>
<b>B-44</b>	<b>Marco Durante</b>	<b>Yes</b>
<b>B-52</b>	<b>Alan Gewirtz</b>	<b>Yes</b>
<b>B-54</b>	<b>Ann Kennedy</b>	<b>Yes</b>
<b>N-64</b>	<b>Marcelo Vazquez</b>	<b>Yes</b>
<b>N-65</b>	<b>Marcelo Vazquez</b>	<b>Yes</b>
<b>B-66</b>	<b>Livio Narici</b>	<b>Yes</b>
<b>B-67</b>	<b>Eleanor A. Blakely</b>	<b>Yes</b>
<b>B-73</b>	<b>Betsy Sutherland</b>	<b>Yes</b>
<b>B-74</b>	<b>J.S. Bedford</b>	<b>Yes</b>
<b>N-76</b>	<b>Laura Green</b>	<b>No</b>
<b>N-80</b>	<b>Steve Gonda</b>	<b>Yes</b>
<b>N-82</b>	<b>Andre Obenaus</b>	<b>Yes</b>
<b>N-86</b>	<b>Ya Wang</b>	<b>Yes</b>
<b>N-87</b>	<b>Hiroki Nagase</b>	<b>No</b>
<b>N-88</b>	<b>Betsy Sutherland</b>	<b>Yes</b>
<b>N-89</b>	<b>Kathryn D. Held</b>	<b>Yes</b>
<b>N-90</b>	<b>Susan M. Bailey</b>	<b>Yes</b>
<b>N-91</b>	<b>Bjorn Ryberg</b>	<b>Yes</b>
<b>N-93</b>	<b>K. Rithidech</b>	<b>Yes</b>
<b>N-94</b>	<b>Jeff Bacher</b>	<b>Yes</b>
<b>N-95</b>	<b>Micheal Story</b>	<b>Yes</b>
<b>N-96</b>	<b>Gregory Nelson</b>	<b>No</b>
<b>N-97</b>	<b>Amy Kronenberg</b>	<b>Yes</b>
<b>N-99</b>	<b>Yongliang Zhao</b>	<b>Yes</b>
<b>N-100</b>	<b>Jack Miller</b>	<b>Yes</b>

## NSRL-1 PARTICIPANTS

Exp.	Participants	Affiliation	Title
<b>B-7</b>	<b>Bernard Rabin</b> James Joseph Barbara Shukitt-Hale Amanda Carey	UMD, Baltimore City “ “ “	Ph.D., Principal Investigator Ph.D. Ph.D. B.A.
<b>B-10</b>	<b>Polly Chang</b> James Bakke Juan Orduna	Stanford Research Institute “ “	Ph.D., Principal Investigator B.S. B.S.
<b>B-44</b>	<b>Marco Durante</b> Gianfranco Grossi Antonella Tabocchini Guistina Simone Daniela Bettega Paola Calzolari	University “Federico II”, Napoli, Italy “ “ “ “ “	Ph.D., Principal Investigator Ph.D. Ph.D. Ph.D. Ph.D. Ph.D.
<b>B-52</b>	<b>Gewirtz Alan</b> Betsy Sutherland	University of Pennsylvania Brookhaven National Laboratory	Ph.D., Principal Investigator Ph.D.
<b>B-73</b> <b>N-88</b>	<b>Betsy Sutherland</b> Debashish Roy Mamta Naidu Megumi Hada Sunirmal Paul Prem Kumar Guangming Zhou Paula Bennett Denise Monteleone John Trunk James Jardine	Brookhaven National Laboratory “ “ “ “ “ “ “ “ “ “ “	Ph.D., Principal Investigator Ph.D. Ph.D. Ph.D. Ph.D. Ph.D. Ph.D. (observer) M.S. B.S. B.S. N/A
<b>B-54</b>	<b>Ann Kennedy*</b> Jeffrey Ware Jun Guan Jelena Stewart Jeremiah Donahue	University of Pennsylvania “ “ “ “	Sc. D., Principal Investigator Ph.D. Ph.D. Ph.D. M.S.
<b>N-64</b> <b>N-65</b>	<b>Marcelo Vazquez</b> Peter Guida Magalie Bruneus Bea Pyatt Stacey Russell Adele Billups	Brookhaven National Laboratory “ “ “ “ “	MD, Ph.D., Principal Invest. Ph.D. M.A. M.S. B.S. B.A.
<b>B-66</b>	<b>Livio Narici</b> Adele Rinaldi Francesco Belli Vittorio Bidoli	University of Rome “ “ “	Ph.D., Principal Investigator Italian Laurea Deg. Ph.D Stud. Italian Laurea Degree Senior Technician
<b>B-67</b>	<b>Eleanor A. Blakely</b> Polly Chang Kathleen Bjornstad	Lawrence Berkeley National. Laboratory SRI Lawrence Berkeley National. Laboratory	Ph.D., Principal Investigator Ph.D. B.S.
<b>B-74</b>	<b>J.S. Bedford</b> Paul Wilson	Colorado State University “	Ph.D., Principal Investigator B.S./B.A.
<b>B-82</b>	<b>A. Obenaus*</b> M. Vazquez	Loma Linda University Brookhaven National Laboratory	Ph.D., Principal Investigator Ph.D., M.D., CoWorker
<b>N-86</b>	<b>Ya Wang</b>	Thomas Jefferson University	Ph.D., Principal Investigator
<b>N-89</b>	<b>Kathryn Held</b> Hongying Yang Aruna Karkala	Massachusetts General Hospital “ “	Ph.D., Principal Investigator Ph.D. Ph.D.

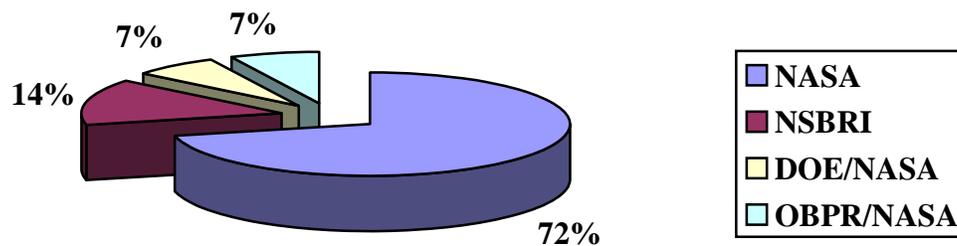
<b>Exp.</b>	<b>Participants</b>	<b>Affiliation</b>	<b>Title</b>
<b>N-90</b>	<b>Susan M. Bailey*</b> Betsy Sutherland	Colorado State University Brookhaven National Laboratory “	Ph.D., Principal Investigator Ph.D.
<b>N-91</b>	<b>Bjorn Rydberg</b> Torsten Groesser Brian Cooper	Lawrence Berkeley National. Laboratory “ “	Ph.D., Principal Investigator Ph.D. Ph.D.
<b>N-93</b>	<b>Kanokporn Rithidech</b> Prantika Som Robert A. Brown	SUNY Stony Brook “ “	Ph.D., Principal Investigator D.V.M., Sc. M. B.A.
<b>N-94</b>	<b>Jeff Bacher</b> Richard Halberg	Promega Corporation “	Ph.D., Principal Investigator Ph.D.
<b>N-95</b>	<b>Michael Story</b> Uma Giri	University of Texas, MD Anderson “	Ph.D., Principal Investigator Ph.D.
<b>N-97</b>	<b>Amy Kronenberg</b> Mitchell Turner Stacey Gauny Lanelle Connolly	Lawrence Berkeley National. Laboratory “ “ “	Sc. D., Principal Investigator Ph.D. M.S. B.S.
<b>N-99</b>	<b>Yongliang Zhao</b> Changqing Piao	Columbia University “	Ph.D., Principal Investigator M.D.
<b>N-100</b>	<b>Jack Miller</b> Cary Zeitlin Lawrence Heilbronn Steve Guetersloh	Lawrence Berkeley National. Laboratory “ “ “	Ph.D., Principal Investigator Ph.D. Ph.D. Ph.D.
<b>N-80</b>	<b>Steve Gonda</b> Essy Behravesh Kamal Emami	NASA, Johnson Space Center “ “	Ph.D., Principal Investigator Ph.D. M.S.

**\*Not Present During Actual Run**

## NSRL-1 PARTICIPANTS STATISTICS

<b>PARTICIPANTS</b>	<b>NSRL-1</b>
<b>Ph.D., Principal Investigators</b>	<b>19</b>
<b>M.D., Ph.D., Principal Investigators</b>	<b>1</b>
<b>Sc.D., Principal Investigators</b>	<b>1</b>
<b>Co-Workers</b>	
<b>Ph.D.</b>	<b>24</b>
<b>M.D.</b>	<b>1</b>
<b>D.V.M., Sc.M.</b>	<b>1</b>
<b>Sc. M.</b>	<b>1</b>
<b>Italian Laurea Degrees</b>	<b>2</b>
<b>Ph.D. Students</b>	<b>1</b>
<b>M.S.</b>	<b>5</b>
<b>B.S.</b>	<b>8</b>
<b>B.A.</b>	<b>3</b>
<b>B.S./B.A.</b>	<b>1</b>
<b>M.A.</b>	<b>1</b>
<b>Senior Research Associates</b>	<b>1</b>
<b>Italian Laurea Degree</b>	<b>1</b>
<b>Total:</b>	<b>72</b>

## RESEARCH PROJECT SPONSORS:



## PARTICIPANT INSTITUTIONS

### NASA related centers/institutes (4)

- NASA, Headquarters, DC
- NASA, Johnson Space Center, TX
- National Space Biomedical Research Institute, TX
- Marshall Space Flight Center,

### National Laboratories/Institutes (2)

- Brookhaven National Laboratory, NY
- Lawrence Berkeley National Laboratory, CA

### Universities (9)

- Loma Linda University, CA
- University of Pennsylvania, PA
- University of Texas M.D. Anderson Center, TX
- Thomas Jefferson University, PA
- Colorado State University, CO
- State University Of New York Stony Brook, NY
- Columbia University, NY
- University of Maryland, Baltimore County, MD
- Praire View A&M University

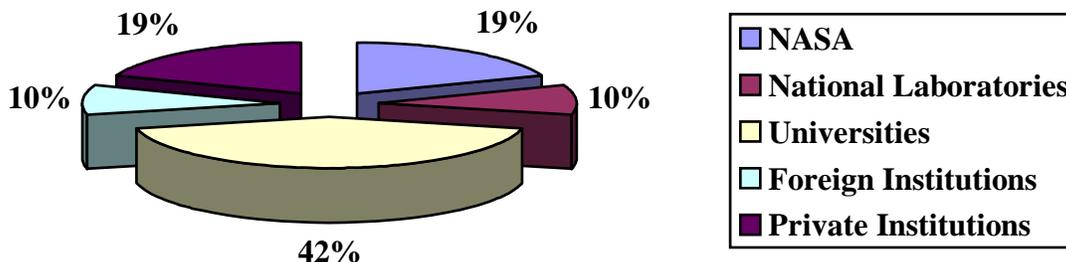
### Private Institutions (4)

- Promega Corporation, WI
- Massachusetts General Hospital, MA
- Stanford Research Institute, CA
- ERIL Research Inc., CA

### Foreign Institutions (2)

- University “Federico II”, Napoli, Italy
- University of Rome, Italy

## INSTITUTIONS STATISTICS:



## NSRL-1 IRON RUN DESCRIPTION

### RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	10/27	0700	10/27	0700
Run end	10/12	1600	10/12	1630
Tuned into cave	10/26	1100	10/26	2359
Beam delivered for Physics				
Fe 0.8 GeV/n	10/27	1500	10/27	1500
End run	10/28	1900	10/28	0700
Beam delivered for Biology				
Fe 1 GeV/n	10/28	1300	10/28	1600
End run	11/12	1600	11/12	1630

### BEAM TIME DESCRIPTION (hours)

<b>Total Clock Time</b>	<b>(from 10/27 0700 to 11/12 1630)</b>	<b>174.5</b>
<b>Total Beam-on time</b>		<b>158.5</b>
<b>Total Beam-off time</b>		<b>16.0</b>
<b>Beam Time for Biology</b>		
Fe 1 GeV/n In Vitro Studies	<b>68.0</b>	
Fe 1 GeV/n In Vivo Studies	<b>23.0</b>	
Fe 1 GeV/n Others (gels, testing)	<b>18.5</b>	
<b>Sub-total</b>		<b>109.5</b>
<b>Beam Time for Physics</b>		
Fe 0.8 GeV/n	<b>16.0</b>	
<b>Sub-total</b>		<b>16.0</b>
<b>Set Up Time for Physics</b>		
Fe 1 GeV/n	<b>8.0</b>	
<b>Sub-total</b>		<b>8.0</b>
<b>Set Up Time for Biology</b>		
Fe 1 GeV/n	<b>25.0</b>	
<b>Sub-total</b>		<b>25.0</b>
<b>Totals</b>		<b>158.5</b>
<b>Contingency T. Planned</b>	<b>16.0</b>	
<b>Contingency T. Used</b>	<b>9.0</b>	

# NSRL-1 TITANIUM RUN DESCRIPTION

## RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	11/13	0700	11/13	0700
Run end	11/18	2030	11/18	2100
Tuned into cave	11/13	0200	11/13	0200
Beam delivered for Physics				
Ti 1 GeV/n	11/17	2230	11/17	1500
End run	11/18	2030	11/18	1300
Beam delivered for Biology				
Ti 1 GeV/n	11/13	1300	11/13	1300
End run	11/17	2130	11/18	2100

## BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 11/13 0700 to 11/18 2100)	64.5
Total Beam-on time		52.0
Total Beam-off time		12.5
Beam Time for Biology		
Ti 1 GeV/n In Vitro Studies	15.5	
Ti 1 GeV/n In Vivo Studies	4.0	
Ti 1 GeV/n Others (gels, testing)	1.0	
Sub-total		20.5
Beam Time for Physics		
Ti 1 GeV/n	20.0	
Sub-total		20.0
Set Up Time for Physics		
Ti 1 GeV/n	3.0	
Sub-total		3.0
Set Up Time for Biology		
Ti 1 GeV/n	8.5	
Sub-total		8.5
Totals		56.5
Contingency T. Planned	8.0	
Contingency T. Used	6.0	

## NSRL-1 CARBON RUN DESCRIPTION

### RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	11/19	0700	11/19	0700
Run end	11/24	1500	11/24	1700
Tuned into cave	11/19	0200	11/19	0200
Beam delivered for Biology				
C 0.29 GeV/n	11/19	1300	11/19	1630
End run	11/24	1500	11/24	1700

### BEAM TIME DESCRIPTION (hours)

<b>Total Clock Time</b>	<b>(from 11/19 0700 to 11/24 1700)</b>	<b>46.0</b>
<b>Total Beam-on time</b>		<b>32.0</b>
<b>Total Beam-off time</b>		<b>14.0</b>
<b>C 0.29 GeV/n In Vitro Studies</b>	<b>13.0</b>	
<b>C 0.29 GeV/n In Vivo Studies</b>	<b>9.5</b>	
<b>C 0.29 GeV/n Others (gels, testing)</b>	<b>1.0</b>	
<b>Sub-total</b>		<b>23.5</b>
<b>Set Up Time</b>		
<b>C 0.29 GeV/n</b>	<b>8.5</b>	
<b>Sub-total</b>		<b>8.5</b>
<b>Totals</b>		<b>32.0</b>
<b>Contingency T. Planned</b>	<b>4.0</b>	
<b>Contingency T. Used</b>	<b>4.0</b>	

## NSRL-1 FINAL RUN DATES

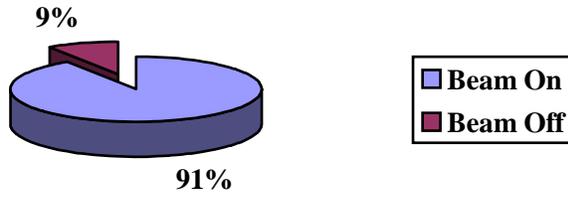
Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	10/27	0700	10/27	0700
Run end	11/24	1500	11/24	1700
Tuned into cave	10/26	1100	10/26	2359

## TOTAL BEAM TIME DESCRIPTION (hours)

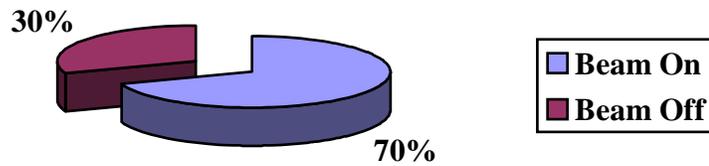
Total Clock Time	(from 11/27 0700 to 11/24 1700)		285
<b>Total Beam-on Time</b>			
Fe 1 GeV/n	158.5		
Ti 1 GeV/n	52.0		
C 0.29 GeV/n	32.0		
<b>Total</b>			<b>242.5</b>
<b>Total Beam-off time</b>			
Fe 1 GeV/n	16.0		
Ti 1 GeV/n	12.5		
C 0.29 GeV/n	14.0		
<b>Total</b>			<b>42.5</b>
<b>Total Beam Time for Biology</b>			
In Vivo Studies	36.5		
In Vitro Studies	96.5		
Others (gels, testing)	20.5		
<b>Total</b>		<b>153.5</b>	
<b>Beam Time for Physics</b>	36.0	36.0	
<b>Total</b>			
<b>Set Up Time</b>	53.0		
<b>Total</b>		<b>53.0</b>	
<b>Totals</b>		<b>242.5</b>	
<b>Contingency T. Planned</b>	28.0		
<b>Contingency T. Used</b>	19.0		

## DESCRIPTIVE STATISTICS

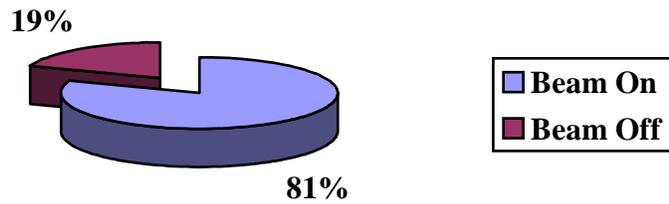
- **FE 1 GEV/N BEAM AVAILABILITY**



- **C 290 MEV/N BEAM AVAILABILITY**

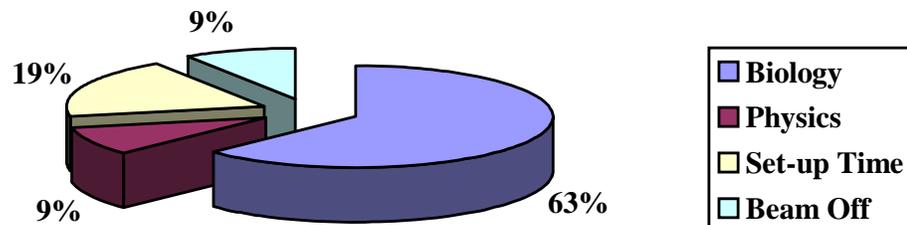


- **TI 1 GEV/N BEAM AVAILABILITY**

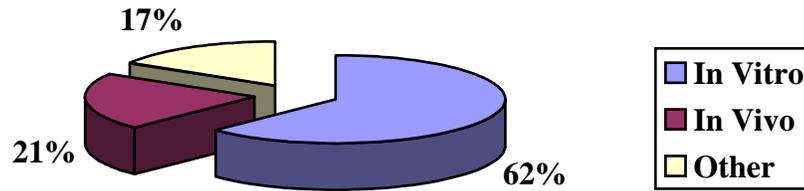


### **IRON ION RUN:**

- **FE 1 GEV/N DISTRIBUTION OF BEAM TIME USAGE:**

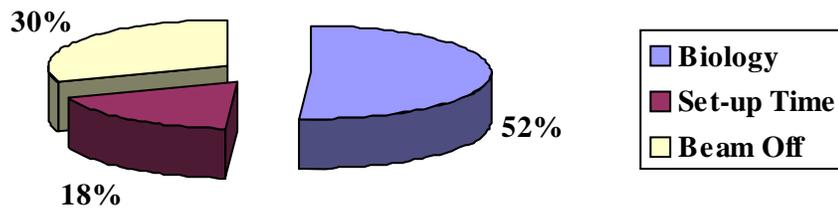


- **FE 1 GEV/N DISTRIBUTION OF BEAM TIME FOR BIOLOGY:**

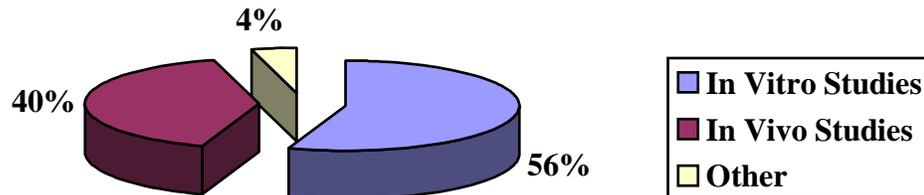


### CARBON ION RUN

- **C 0.29 GEV/N DISTRIBUTION OF BEAM TIME USAGE:**

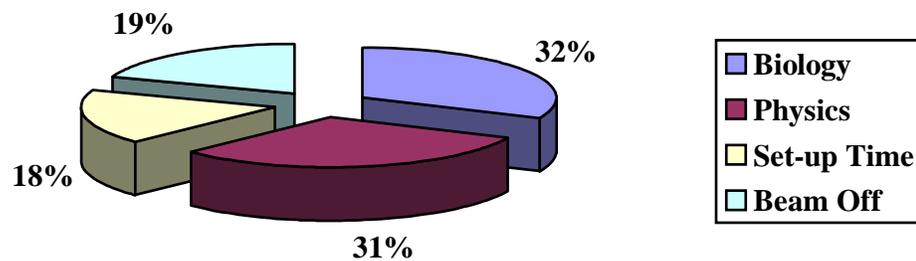


- **C 0.29 GEV/N DISTRIBUTION OF BEAM TIME FOR BIOLOGY:**

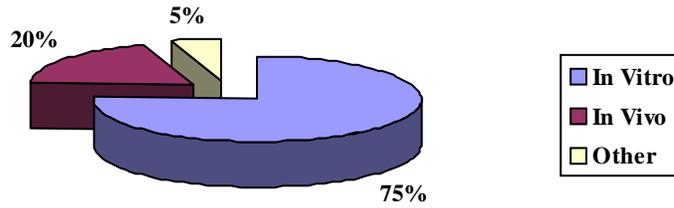


### TITANIUM ION RUN

- **SI 1 GEV/N DISTRIBUTION OF BEAM TIME USAGE:**

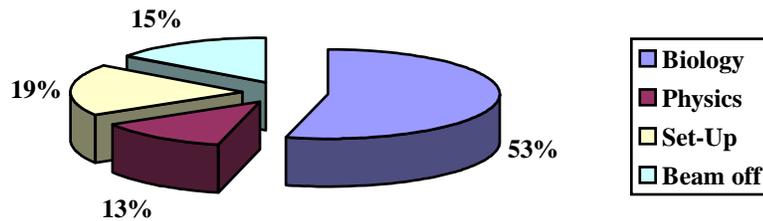


- **TI 1 GEV/N DISTRIBUTION OF BEAM TIME FOR BIOLOGY:**

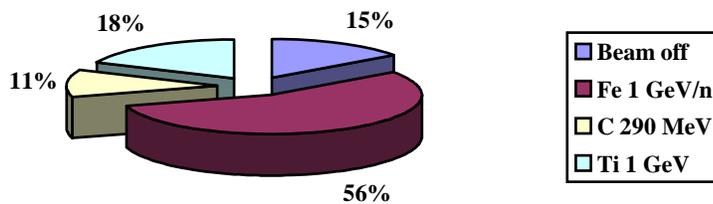


**NSRL-1 TOTAL BEAM TIME SUMMARY**

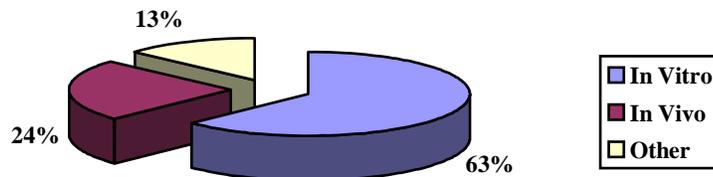
- **DISTRIBUTION OF BEAM TEAM USAGE:**



- **DISTRIBUTION OF BEAM TEAM BY SPECIES AND ENERGIES:**



- **DISTRIBUTION OF BEAM TEAM FOR BIOLOGY EXPERIMENTS:**



## BEAM CHARACTERISTICS

Ion	$^{56}\text{Fe}^{26}$	$^{48}\text{Ti}^{22}$	$^{12}\text{C}^6$
Fluence (particles/cm <sup>2</sup> /sec) Maximum on target Minimum on target	TBD	TBD	TBD
Spill Period (sec)	3.0	3.0	5.4
Spill rate (spills/min)	20	20	20
Spill length (msec)	400	400	400
Particles/spill Maximum Minimum	1000 500	$1.0 \times 10^9$ 500	$4.0 \times 10^8$ 500
Beam Cut Off Accuracy	~ 0.5 %	~ 0.5 %	~ 0.5 %
Actual Energy (MeV/n) Extracted On Target	800 780	1005 970	1007 980
Actual LET on Target (keV/ $\mu\text{m}$ )	159.6	151.3	108.1
Max. Dose Rate (Gy/min)/ Beam Size (cm x cm) 20 x 20 10 x 10 7 x 7 7 x 30 1 x 1	0.001	7.0 30.0 70.0 12.0	2.5 10.0 20.0 4.0
Total Dose (Gy) Maximum Minimum	0.1	200 0.1	200 0.1

Listed below are the ions extracted and used for biology experiments at NSRL-1. Maximum intensity and dose-rate are shown only. To achieve lower dose-rates, we use the two-jaw collimator at the extraction to reduce the beam flux without changing its shape. Changing the beam size changes the (dose-rate: the dose-rate are measured at the center of the ion-chamber, and only scales roughly with area). Energy at extraction is deduced from frequency measurements in the Booster. Energy at the NSRL target area is obtained from Bragg-curve measurements (done daily during the run). The LET given here is that for the primary ion at the “on target” energy, in water. Spill period can stay short, around 3 second, as long as NSRL is running alone, without RHIC. Otherwise, when using PPM (pulse to pulse modulation), during which each super-cycle can deliver either a RHIC pulse, an NSRL pulse or BOTH, the length of the period becomes about 6 seconds (for example, see the C run

## NSRL-1 Run Statistics and Incidents

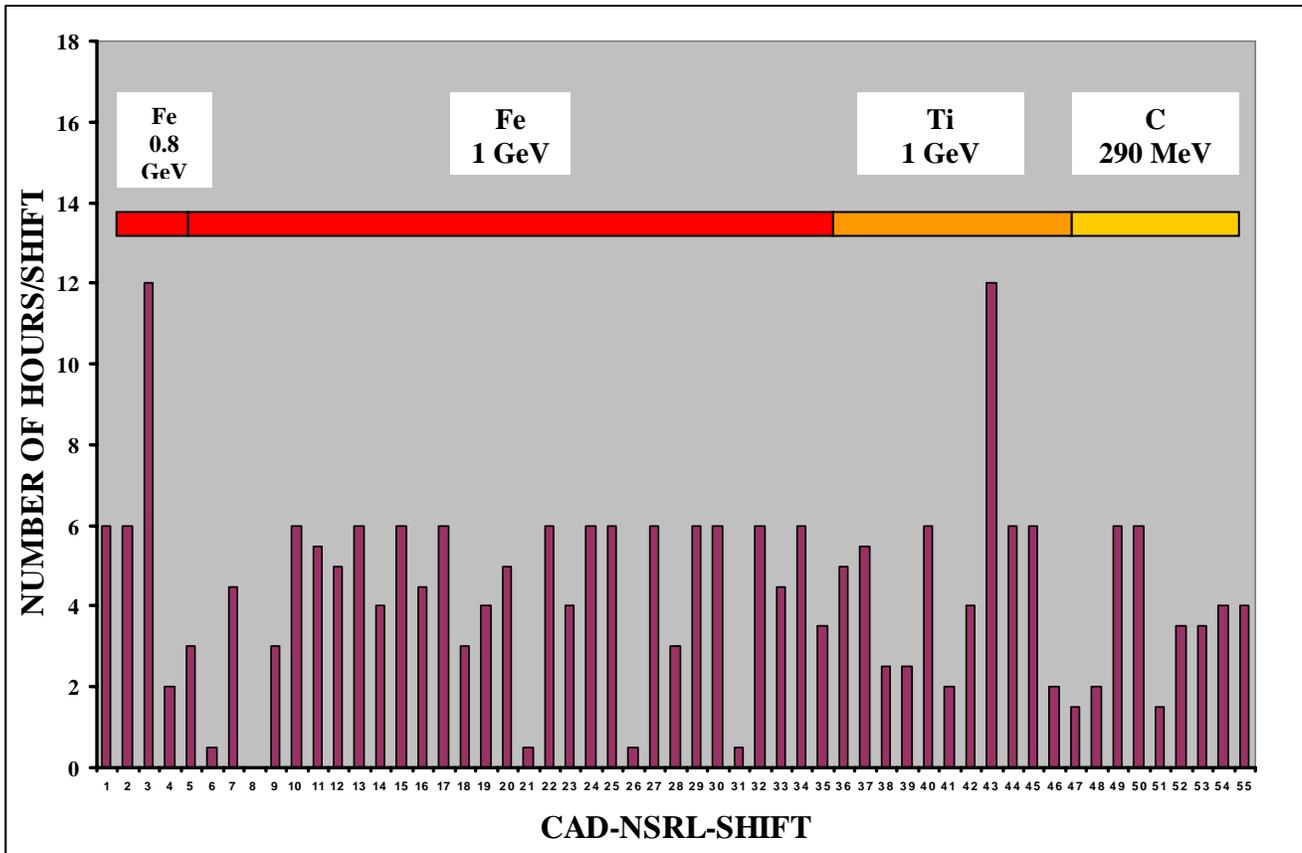
Date	Shift *	HIP Avail. (set-up t.)	Non-HIP**	Remarks (CAD 2 shift/day: 7-14/14-21 hr)
10/27/03	1	6 (6)	0	0.8 GeV/n Fe run setup.
	2	6 (2)	0	Physic run start
	3+	12	0	Physics run continues
10/28/03	1	2 (2)	4	Set up for 1 GeV/n Fe for biology. Magnet overheat.
	2	3	3	Booster main magnet power supply trip. Bio. start
	3+	0.5	0	First biology experiment end
10/29/03	1	4.5 (2)	1.5	Biology experiment. Beam uniformity problems.
	2	5.5	0.5	No incidents.
	3+	3	0	No incidents.
10/30/03	1	6 (2)	0	No incidents.
	2	5.5	0.5	Booster main magnet trip. Sweep lost by MCR
	3+	5	3	Problems continues.
10/31/03	1	6 (2)	0	Biology continues.
	2	4	0	No incidents.
11/01/03	1	6 (2)	0	No incidents.
	2	4.5	0	No incidents.
11/03/03	1	6 (2)	0	No incidents.
	2	3	0	No incidents.
11/04/03	1	4 (1)	2	Beam transport problems.
	2	5	1	Sweep lost and activation check
	3+	0.5	0	No incidents.
11/05/03	1	6 (2)	0	No incidents.
	2	4	0.5	Sweep lost.
11/06/03	1	6 (2)	0	No incidents.
	2	6	0	No incidents.
	3+	0.5	0	No incidents.
11/07/03	1	6 (2)	0	No incidents..
	2	3	0	No incidents.
11/10/03	1	6 (2)	0	No incidents.
	2	6	0	No incidents.
	3+	1	0	No incidents.

Date	Shift	HIP Avail. (set-up t.)	Non-HIP*	Remarks (CAD 2 shift/day: 7-14/14-21 hr)
11/11/03	1	6 (2)	0	No incidents.
	2	4.5	0	No incidents.
11/12/03	1	6 (2)	0	No incidents.
	2	3.5	0	No incidents.
11/13/03	1	5 (5)	1	Setup for 1 GeV/n Ti for biology. Power dip.
	2	5.5	0.5	First biology experiment. Computer crash
	3+	2.5	1.5	Computer crash
11/14/03	1	2.5 (1.5)	3.5	Tandem source problems
	2	6	0	Biology continues
11/17/03	1	2 (2)	4	Cooling failure in power supply
	2	4 (2)	2	Set up for physics
	3+	12	0	No incidents.
11/18/03	1	6	0	Physics run end. Magnet cooling system problems.
	2	6 (1)	0	Biology run continues
	3+	2	0	Ti run ends.
11/19/03	1	1.5 (1.5)	4.5	Set up for C 290 MeV/n. Septum power supply prob.
	2	2 (1)	2.5	Problems continues. First biology experiment.
11/20/03	1	6 (2)	0	Biology experiment continues.
	2	6	0	No incidents.
	3+	1.5	0	No incidents.
11/21/03	1	3.5 (2)	2.5	Beam uniformity problems.
	2	3.5	2.5	Beam unstable and power supply failure
11/24/03	1	4 (2)	2	Beam intensity fluctuations.
	2	4	0	NSRL-1 ends.
<b>Totals:</b>	<b>18</b>	<b>242.5 hr.</b>	<b>42.5 hr.</b>	

\*Shift 1: 7AM to 1PM, Shift 2: 1PM to 7Pm, Shift 3: beyond 7PM

\*\*Time loss due to machine or power supply problems, setting up operations.

## NSRL-1 BEAM TIME AVAILABILITY SUMMARY



**NSRL-1 operational schedule assumptions:**

- 7 to 9 am: set-up, initial dosimetry (2 hr)
- 9 to 17 pm: experimental run (8 hr)
- 17 to 19 pm: contingency and wrap up operations (2 hr)

**Total daily operation: 12 hrs**

## NSRL-1 EXPERIMENTERS AND RUN STATISTICS

Exp. ID	Principal Investigator	Ion & Energy	Beam Time Approved	Beam Time Used	Dose Range (cGy)	Dose/Rate (cGy/min)	Number of Samples
B-7	Rabin	Fe, 1 GeV/n	7	4.5	50-200 cGy	150	80
		Ti, 1 GeV/n	7	2.5			44
B-10	Chang	Fe, 1 GeV/n	6	2.0	10-200	10-150	51
		Ti, 1 GeV/n	3	1.5	“		48
		C, 290 MeV/n	0	3.5	“		48
B-44	Durante	Fe, 1 GeV/n	9	10.5	1-20000	10-1500	60
		Ti, 1 GeV/n	9	7.0	1-20000	10-1500	60
		C, 290 MeV/n	4	1.0	100-800	150	15
B-52	Gewirtz	Fe, 1 GeV/n	2	2	NA	NA	NA
		Ti, 1 GeV/n	2	1			
		C, 290 MeV/n	2	1.5			
B-54	Kennedy	Fe, 1 GeV/n	7	11	10-800	20-200	248
N-64	Vazquez	Fe, 1 GeV/n	6	6.5	30-240	20-100	181
		C, 290 MeV/n	7	6.0	60-480	“	215
N-65	Vazquez	Fe, 1 GeV/n	4	5.0	15-200	30-100	100
		Ti, 1 GeV/n	4	2.0	“	“	100
		C, 290 MeV/n	4	1.0	“	“	100
B-66	Narici	Fe, 1 GeV/n	16	16.5	1	NA	NA
B-67	Blakely	Fe, 1 GeV/n	14	5	50-400	36-117	120
B-73	Sutherland	Fe, 1 GeV/n	3	2.5	NA	NA	NA
		Ti, 1 GeV/n	3	3			
		C, 290 MeV/n	3	3			
B-74	Bedford	Fe, 1 GeV/n	5	2.5	50-600	10-125	15
N-80	Gonda	C, 290 MeV/n	3.5	2.5	10-200	20-100	72
N-82	Obenaus	Fe, 1 GeV/n	1.3	2.0	20-1500	50-300	20
		Ti, 1 GeV/n	1.3	1.0			20
		C, 290 MeV/n	2.3	1.0			20
N-86	Wang	Fe, 1 GeV/n	3	3	100-2000	100	62
B-88	Sutherland	Fe, 1 GeV/n	2.5	2.5	NA	NA	NA
N-89	Held	Fe, 1 GeV/n	4.5	4.0	0.1-200	0.1 to 100	288
		Ti, 1 GeV/n	4.5	2.5			
		C, 290 MeV/n	4.5	3.5			
N-90	Bailey	Fe, 1 GeV/n	1	1	NA	NA	NA
N-91	Rydberg	Fe, 1 GeV/n	8	8.5	1-1000	2-130	94
N-93	Rithidech	Fe, 1 GeV/n	8	8	10-100	100	272
N-94	Bacher	Fe, 1 GeV/n	2	1.5	10-500	50	32
N-95	Story	Fe, 1 GeV/n	4.5	2.5	25-200	100	110
		C, 290 MeV/n	4.5	2.5	50-300	200-300	120
N-97	Kronenberg	Fe, 1 GeV/n	9	5.5	0-300	100	18
N-99	Zhao	Fe, 1 GeV/n	1	1	60-100	50	12
N-100	Miller	Fe, 1 GeV/n	20	16.0			
		Ti, 1 GeV/n	20	20.0			
<b>Totals</b>			<b>232.4</b>	<b>189.5</b>	<b>0.1 to 20000</b>	<b>0.1 - 1500</b>	<b>2625</b>

## NSRL-1 PARTICIPANTS, EXPERIMENTAL SAMPLES AND ENDPOINTS

<b>Exp.</b>	<b>Participants</b>	<b>Samples</b>	<b>Endpoints</b>
B-7	Effects of Exposure to Heavy Particles <b>B. Rabin (PI)</b>	Sprague Dawley Rats	Behavioral paradigms and neurochemistry
B-10	Charged Particle Radiation-induced Genetic Damage in Transgenic Mice <b>P. Chang (PI)</b>	LacZ transgenic mouse with different p53 genotypes	Mutation frequency, micronucleous formation and chromosomal aberrations
B-44	Influence of the Shielding on the Space Radiation Biological Effectiveness. <b>M. Durante (PI)</b>	Human lymphocyte, human cell lines (AG1522, H184B5, F5-1 M/10, SQ20B and SCC25)	Cell survival, chromosomal aberrations, DNA fragmentation
B-52	Effect of Deep Space radiation on Human Hematopoietic Stem Cells. <b>A. Gewirtz (PI)</b>	Human bone marrow cells	DNA complex damages, DNA replication and apoptosis, gene expression
B-54	Screening of Agents for Protection of Radiation Induced Oxidative Stress. <b>A. Kennedy (PI)</b>	Sprague-Dawley rats  HTori Cells	Blood and tissue chemistry (antioxidant status). Gene expression and survival Effect of several compounds
B-64	Risk Assessment and Chemoprevention of HZE-Induced CNS Damage <b>M. Vazquez (PI)</b>	NT2 human neural stem cells, oligodendrocytes	Survival, apoptosis, gene expression.
B-65	CNS Damage and Countermeasure <b>M. Vazquez (PI)</b>	C57Bl/6 Mice	Behavioral Testing: Locomotor activity and Morris Water Maze. Neurochemistry.
B-66	ALTEA-Mice: Effects of Transient Heavy Ion Radiation on the Electrophysiology of the Mouse Visual System. <b>L. Narici (PI)</b>	Solid state detectors and electrophysiology equipment	Test beam characteristics, beam collimation and electronics check-out
B-67	Lens Epithelium and Proton-Induced Cataractogenesis. <b>E. Blakely (PI)</b>	Human lens epithelial cells	RNA or protein analyses
N-73	DNA damage clusters in low level radiation responses of human cells. <b>B. Sutherland (PI)</b>	T7 DNA, Human monocytes Supercoiled DNA	DNA damage cluster induction and repair at the molecular and cellular levels.
B-74	Chromosomal Damage Measurements. <b>J. Bedford and A. Chatterjee (PIs)</b>	Ag155 human fibroblats	Chromosomal aberration scoring
N-80	Comparison of Cell and Tissue 3D Models for Assessment of Genotoxic Damage by High Energy Charged Particles. <b>S. Gonda (PI)</b>	Normal & Transgenic fibroblast cells Normal & Transgenic epithelial cells	Mutation types and frequency induced in target genes at molecular level Dose relationships
N-82	Dosimetry Gels (Magic Gels) as Biological Reporters of Radiation Dose. <b>A. Obenaus (PI)</b>	Dosimetry Gels (Magic Gels)	Dosimetry, calibration.
N-86	Cellular Response to High Energy Particle Exposures.	GM 847 and ATR-kd human fibroblasts	Clonogenic survival, G2 checkpoint, DNA replication, CHK1 phosphorylation

	<b>Y. Wang (PI)</b>		and DNA repair.
N-88	Complex Space Radiation-induced DNA damage Clusters in Human Cell Transformation: Mechanisms, relationships and Mitigation. <b>B. Sutherland (PI)</b>	Human normal fibroblasts	DNA damage cluster and transformation
N-89	Induction of Bystander Effects by High LET Radiation in Cells <b>K. Held (PI)</b>	Human keratinocytes and fibroblasts	Micronuclei formation, expression of p21 and foci formation of $\gamma$ H2AX
N-90	HZE Radiation Modulation of Genetic Effects by RNA Interference of NHEJ <b>S. Bailey (PI)</b>	Human lymphoblast cells transfected with siRNA for the proteins related to NHEJ repair system	Mutation frequency, chromosome aberrations and telomere fusions.
N-91	Repair of HZE-induced DNA Double Strand Breaks and PCC Breaks. <b>B. Rydberg (PI)</b>	HeLa cells, CHO cells and xrs6 cells	DSB determination, PCC and bystander effects
N-93	In Vivo Induction of Chromosomal Damage: A Spectral Karyotyping Study. <b>K. Rithidech (PI)</b>	C57Bl6 and CBA/Ca mice	Cell cycle study and spectral karyotyping
N-94	Sensitivity of DNA Repair Loci to Radiation-Induced Mutations <b>J. Bacher (PI)</b>	MLH1 mismatch repair proficient (HCT116+chr3) and deficient (HCT116) cells	Analysis of DNA repeat loci and mutation quantification
N-95	Gene Expression Profile Analysis. <b>M. Story (PI)</b>	Human fibroblast cell lines	Gene expression by microarray studies
N-97	Comparative Analysis of Fe ion-induced Autosomal Mutations <b>A. Kronenberg (PI)</b>	Mouse kidney epithelial cells	Cell killing and mutation at the aprt locus
N-99	Tranformation of hTERT-immortalized human bronchial epithelial Cells by High Energy Heavy Ions. <b>Y. Zhao (PI)</b>	hTERT-immortalized human bronchial epithelial Cells and MEF cells	Cell survival and transformation
N-100	Cross Section, Fluence and Materials Measurements with Heavy Ions. <b>J. Miller (PI)</b>	Solid state silicon detectors, CR39 detectors and TEPC	Nuclear fragmentation on elemental and material targets.

## List of personnel that participated in the planning, organization and execution of NSRL-1 run

### BNL Management:

- Laboratory Director: **Peter Paul**
- Associate Director for High Energy and Nuclear Physics: **Tom Kirk**
- Associate Laboratory Director for Life Sciences: **Helene Benveniste**

### NASA Management:

- Headquarters: **Walter Schimmerling, David Tomko**
- JSC: **Frank Cucinotta, Frank Sulzman, Barbara Corbin**

### Scientific Advisory Committee:

- **Betsy Sutherland** (Chair), BNL
- **Louis Pena**, BNL
- **Richard Setlow**, BNL
- **Joel Bedford**, CSU
- **Les Braby**, PNL
- **Charles Geard**, Columbia University

### Collider Accelerator Department-AGS

- Chairman: **Derek Lowenstein**
- Deputy Chairman: **W.T. Weng**
- Associate Chair of Operations: **A.J. McNerney**
- Experimental Planning and Support Head: **Philip Pile**
- Associate Chair for ESHQ: **Ed Lessard**
- ESHQ Division Head: **Ray Karol**
- ESH Coordinator: **Asher Etkin**
- Facility Support Representative: **Chuck Schaefer / Henry Kahnhauser**
- Environmental Coordinator: **Joel Scott**
- Training and Procedures Manager : **John Maraviglia**
- Main Control Room: **Peter Ingrassia**
- Work Control Manager: **Peter Cirnigliaro**
- BNL Laser Safety Officer: **Chris Weilandics**
- Experimental Safety Review Committee: **Yousef Makdisi (Chair)**
- Radiation Safety Committee: **Dana Beavis (Chair)**
- Accelerator Safety Review Committee: **Woody Glenn (Chair)**
- ALARA Committee: **Chuck Schaefer (Chair)**
- Associate Chair for ES&H/Q.A: **E. Lessard**
- Accelerator Division Head: **Thomas Roser**
- Chief Electrical Engineer: **J. Sandberg**

- Chief Mechanical Engineer: **J. Tuozzolo**
- Accelerator Physicist lead by: **Leif Aherns**
- Tandem Group leader: **Peter Thieberger**
- Physics Support: **Yusef Makadisi**
- CAD Components and instrumentation support: **David Gassner**
- AGS Radiation Safety Committee: **Ken Reece**
- C-A Dept Training Manager: **John Maraviglia**
- AGS Control Section lead by: **Don Barton**
- Liaison Engineering Group lead by: **David Phillips**
- Liaison physicist: **Adam Rusek**
- RHIC&AGS Users Center: **Susan White-DePace, Angela Melocoton**
- Mechanical Service Technicians led by: **Fred Kobasiuk**
- Survey Group led by: **Frank Karl**
- Beam Service Technicians led by: **Paul Valli**
- Electronic Service Technicians led by: **Bill Anderson**
- AGS Instrumentation Group led by: **Pete Stillman**
- AGS Main Control Room and Operations led by: **Pete Ingrassia**
- **AGS MCR Operation Coordinators:**
  - Jim Jamilkowski**
  - Greg Marr**
  - Sanjee Abeytunge**
  - Jennifer Kozak**
  - Brian van Kuik,**
  - Travis Shrey**
- AGS Electricians led by **Bill Softye**
- AGS Riggers led by: **Nick Cipolla**
- Carpenter and Welder Support Service and Technical Support led by: **Roger Hubbard**

**Dosimetry:**

- **Don Lazarus**
- **Adam Rusek**
- **I-Hung Chiang**
- **Kin Yip**
- **Peter Oddo**
- **Bart Frak**

## **Medical Department:**

### **NASA LTSF TEAM:**

- **Medical Liaisons: Marcelo E. Vazquez, Peter Guida**
- **Technical support: Bea Pyatt, Stacey Russell, Adele Billups**
  - Dept. Chair: **John Gatley**
  - Building Manager: **Chris Harris**
  - Administration: **Denise White and Donna Russo**
  - Animal Care Facilities: **Maryann Kershaw, Kerry Bonti, Patricia Leone**
  - Training Coordinator: **Ann Emrick**
  - **RCD**
    - Kay Conkling
    - Dennis Ryan
    - Deana Buckallew
    - Jim Williams
    - Bob Colichio

## **Plant Engineering:**

- BLAF Custodian, **P. Abrams**
- Plumbers: **B. McCafferty**
- Painters/Carpenters: **B. Laakmann**
- Electricians: **T. Baldwin**

## **Biology Department:**

- Chairman: **Carl Anderson**
- Biology Liason: **Betsy Sutherland**
- Technical Support: **Mamta Naidu, Debasish Roy**
- Cesium Source Manager: **Richard Sautkulis**

## **Lawrence Berkeley National Laboratory Dosimetry Technical Support:**

- **R. P. Singh**