BROOKHAVEN
NATIONAL LABORATORY

NSRL-4 RUN

FINAL REPORT

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EXECUTIVE SUMMARY

During the fall of 2004, an extensive series of radiobiological and physics experiments were performed using the NASA Space Radiation Laboratory to accelerate heavy ion beams (NSRL-4). These experiments were part of the fourth NSRL scientific run sponsored by NASA's Space Radiation Health Program (SRHP) heavy ion radiobiology research program at BNL.

A total of 33 proposals were approved by the BNL' SACR to participate in the NSRL-4 run. Twenty two institutions from the United States and 14 from foreign countries were represented, totaling 101 users. More than 1800 biological samples and passive and active detectors were exposed at the NSRL beam line, employing 394.5 hours of beam time (98 hours for in vivo studies, 42.5 hours for in vitro studies and 143 hours for physics experiments). In addition, 22 hours were used for beam development and, 77 hours for set-up and dosimetry. A total of 24 hours of beam time were lost due to accelerator related problems.

During NSRL-4, Booster provided iron (0.577 and 0.969 GeV/nucleon, LET: 176.1 and 151.1 keV/μm) titanium (1.019 GeV/nucleon, LET: 107 keV/μm), silicon (0.571 GeV/nucleon, LET: 151.1 keV/μm), oxygen (1 and 0.6 GeV/nucleon, LET: 14.1 and 16.2 keV/μm) and protons (1 GeV/n, LET: 0.021 keV/μm) beams for biology and physics experiments. The dose/rates used were as low as 0.1 cGy/min and as high as 2000 cGy/min. The spill rate employed was 20 for Fe, with duration of 400 msec/spill. The spill fluence was (particles/spill) 3 x 10^9 (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. For the second time Tandem-Booster-NSRL complex was able to deliver a mix field composed by iron and protons with energies of 1 GeV/n with a steady and repeatable switching from protons to iron. The longest switching time was 7 minutes and the shortest was 1 minute. The typical one was ~2 minutes. .

Tandem-Booster set-up started on August 25 with the transport and circulation of Ti beams at the NSRL complex. Beam was tuned into cave on August 27. 1000 MeV/n Ti beams were available for tuning on August 30. Biology studies started on the afternoon of August 30 using Ti beams (Held) and proceeded through August 31. On September 1, AGS-Booster tuned 0.6 GeV/n silicon beams for biology ending on September 2. From September 3 to late September 15, NSRL delivered 1 GeV/n iron beams for biological experiments. On September 14 and the 16, Tandem-Booster complex delivered iron ions and protons 1 GeV/n for biology studies. 0.6 GeV/n iron beam were delivered from September 17-23 and for the first time NSRL delivered oxygen ions for physics studies. These studies were carried out on September 29 to 30. NSRL-4 officially ended at 2000 pm, October 1, 2004.

One of the highlights of NSRL-4 was the participation of an international consortium of physicists (ICCHIBAN) representing 10 countries and around 10 institutions. This group exposed different passive and active detectors to different ions (p, Fe and O) in order to compare various radiation instruments and detectors.

NSRL-4 Projects Reviewed by the BNL's Scientific Advisory Committee in Radiobiology (SACR):

Proposal	PI	Sponsor	NSRL-4 Participation
B7	Rabin	NASA	Yes
B10	Chang	NSBRI	Yes
B44	Durante	ASI	Yes
B52	Gewirtz	NSBRI	Yes
B66	Narici	ASI	No
B67	Blakely	NASA	Yes
B73	Sutherland	NASA/DOE	Yes
B75	Ford	NASA/DOE	No
B76	Green	NASA/DOE	Yes
N80	Gonda	NASA	Yes
N86	Wang	NASA	Yes
N88	Sutherland	NASA	Yes
N89	Held	NASA	Yes
N91	Rydberg	NASA	Yes
N99	Zhao	NASA	Yes
N102	Hall	NASA	Yes
N103	Barcellos-Hoff	NASA	Yes
N104	Weil/Ullrich	NASA	Yes
N105	Chatterjee/Bedford	NASA	Yes
N106	Gatley	NASA	Yes
N108	Pecaut	NASA	Yes
N110	Nelson	NASA	Yes
N111	Obenaus	NASA	Yes
N112	Obenaus	NASA	Yes
N113	Pecaut	NASA	Yes
N115	Bacher	NASA	Yes
N118-1	Miller	NASA	Yes
N118-2	Miller	Others	Yes
N119	Archambeau	NASA	Yes
N120	Redpath	NASA/DOE	No
N123	Radeka	NSBRI	Yes
N124	Li	NASA	Yes
N126	Kennedy	NASA/NSBRI	Yes

NSRL-4 PARTICIPANTS

Exp.	Participants	Affiliation	Title
B-7	**B. Rabin**	UMBC, Baltimore, MD	Ph.D, Principal Investigator
	J. Joseph*	HNRCA, USDA-ARS, Boston, MA	Ph.D., Co-Worker
	B. Shukitt-Hale	"	Ph.D., Co-Worker
	A.Carey	"	B.S., Co-Worker
	K. Carrahill	"	B.S., Co-Worker
B-10	**P. Chang**	SRI International, CA	Ph.D, Principal Investigator
	J. Bakke	"	B.S., Co-Worker
	J. Orduna	"	B.S., Co-Worker
B-44	**M. Durante**	University Federico II, Italy	Ph.D, Principal Investigator
	G. Grossi	"	Ph.D, Co-Worker
	M. A. Tabocchini	Instituto Superiore di Sanita, Italy	Ph.D, Co-Worker
	E. Sorrentino	"	Ph.D, Co-Worker
	D. Bettega	University Milano, Italy	Ph.D, Co-Worker
	P. Calzolari	"	Ph.D, Co-Worker
B-52	**A. Gewirtz***	University of Pennsylvania	Ph.D, Principal Investigator
	B. Sutherland	BNL, Upton, NY	Ph.D., Co-P.l Investigator
	P. Bennett	"	M.S., Co-Worker
	M. Naidu	"	Ph.D., Co-Worker
	D. Roy	"	Ph.D., Co-Worker
	M. Hada	"	Ph.D., Co-Worker
	G. Zhou	"	Ph.D., Co-Worker
	J. Sutherland	"	Ph.D., Co-Worker
	S. Tafrov	"	Ph.D., Co-Worker
	D. Monteleone	"	B.S., Co-Worker
	J. Trunk	"	B.S., Co-Worker
	N. Cuomo	"	B.S., Co-Worker
B-67	**E. Blakely**	LBNL, Berkeley, CA	Ph.D, Principal Investigator
	P. Chang	SRI International, Menlo Park, CA	Ph.D., Co-Worker
	J. Bakke	"	B.S., Co-Worker
	J. Orduna	"	B.S., Co-Worker
	K. Bjornstad	LBNL, Berkeley, CA	B.S., Co-Worker
	C. Rosen	"	B.S., Co-Worker
B-73	**B.Sutherland**	BNL, Biology Dept., Upton, NY	Ph.D, Principal Investigator
N-88	P. Bennett	"	M.S., Co-Worker
	M. Naidu	"	Ph.D., Co-Worker
	D. Roy	"	Ph.D., Co-Worker
	M. Hada	"	Ph.D., Co-Worker
	G. Zhou	"	Ph.D., Co-Worker
	J. Sutherland	"	Ph.D., Co-Worker
	S. Tafrov	"	Ph.D., Co-Worker
	D. Monteleone	"	B.S., Co-Worker
	J. Trunk	"	B.S., Co-Worker
	N. Cuomo	"	B.S., Co-Worker
B-76	**L. Green**	Loma Linda University, CA	Ph.D, Principal Investigator
	B. Bianski	"	Ph.D, Co-Worker
N-80	**S. Gonda**	NASA, Johnson Space Center, TX	Ph.D, Principal Investigator
	E. Behravesh	"	Ph.D, Co-Worker
	K. Emami	"	Ph.D, Co-Worker
	D. Houston	"	B.S., Co-Worker

Exp.	Participants	Affiliation	Title
N-86	**Y. Wang**	Thomas Jefferson University, PA	Ph.D, Principal Investigator
	G. Iliakis	"	Ph.D, Co-Worker
	H. Wang	"	Ph.D, Co-Worker
	H. Wang	"	B.S., Co-Worker
	X. Wang	"	Ph.D, Co-Worker
N-89	**K. Held**	Massachusetts Gen. Hosp./Harvard M. School	Ph.D., Principal Investigator
	H. Yang	Massachusetts General Hospital	Ph.D., Co-Worker
	V. Anzenberg	Massachusetts General Hospital/MIT	B.S., Co-Worker
	M. Mohiuddin	"	B.S., Co-Worker
N-91	**B.Rydberg**	LBNL, Berkeley, CA	Ph.D, Principal Investigator
	T. Groesser	"	M.S., Co-Worker
	B. Cooper	"	Ph.D., Co-Worker
N-99	**Y. Zhao**	Columbia Universiy, NY	Ph.D, Principal Investigator
	P. Changqing	"	Ph.D., Co-Worker
N-102	**E. Hall***	Columbia University, NY	Ph.D, Principal Investigator
	L. Smilenov	"	Ph.D., Co-Worker
	R. Baker		Ph.D., Co-Worker
N-103	**M. Barcellos-Hoff***	LBNL, Berkeley, CA	Ph.D, Principal Investigator
	S. Costes		Ph.D., Co-Worker
	B. Rydberg		Ph.D, Co-Worker
N-104	**M. Weil**	Colorado State University, CO	Ph.D, Principal Investigator
	R. Ullrich	"	Ph.D., Co-P.Investigator
	P. Genik	"	M.S., Co-Worker
	A. Ray	"	M.S., Co-Worker
	M. Callan	"	B.S., Co-Worker
N-105	**A. Chatterjee***	LBNL, Berkeley, CA	Ph.D, Principal Investigator
	J. Bedford*	Colorado State University, CO	Ph.D, Co-P. investigator
	P. Wilson	"	B.S., B.A., Co-Worker
N-106	**S. Gatley**	BNL, Medical Dept., Upton, NY	Ph.D, Principal Investigator
	O. Rice	"	Ph.D, Co-Worker
	M. Vazquez	"	M.D, Ph.D, Co-Worker
	A. Billups	"	B.S., Co-Worker
N-108	**T. Krucker***	Scripps Research Institute, CA	Ph.D, Principal Investigator
N-113	M. Pecaut	Loma Linda University, CA	Ph.D., Co-P. Investigator
	G. Nelson	"	Ph.D, Co-Worker
	A. Smith	"	B.S, Co-Worker
	T. Jones	"	B.S, Co-Worker
	A. Mosley	Scripps Research Institute, CA	B.S, Co-Worker
	R. Vlkolinsky	"	Ph.D., Co-Worker
N-110	**G. Nelson***	Loma Linda University, CA	Ph.D, Principal Investigator
	A. Smith	"	B.S, Co- Worker
	S. Rightnar	"	B.S, Co-Worker
	T. Jones	"	B.S, Co-Worker
	J. Archambeau	"	M.D, Co-Worker
	M. Pecaut	"	Ph.D, Co-Worker
	X. Mao	"	M.D, Co-Worker
N-111	**A. Obenaus***	Loma Linda University, CA	Ph.D, Principal Investigator
N-112	G. Nelson	"	Ph.D, Co-Worker
	A. Smith	"	B.S, Co-Worker
	C. Quesada	"	B.S., Co-Worker
	S. Chong	"	B.S, Co-Worker
	S. Shin		B.S., Co-Worker

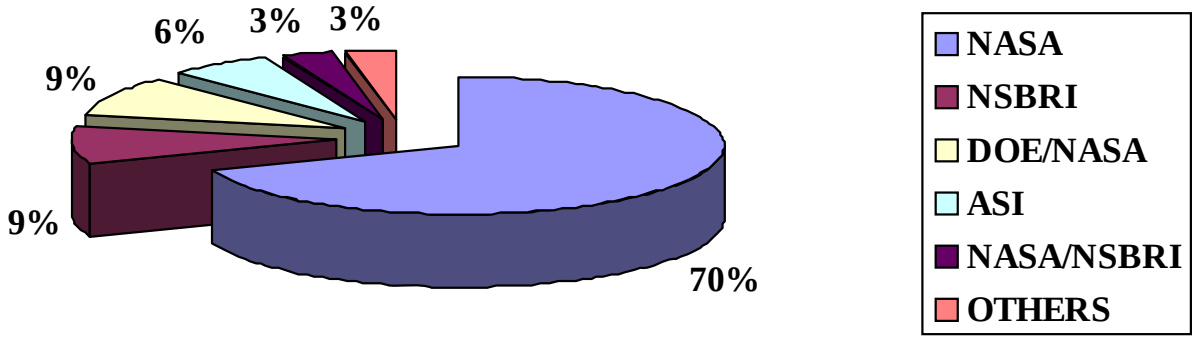
Exp.	Participants	Affiliation	Title
N-115	**J. Bacher**	Promega	Ph.D, Principal Investigator
	R. Halberg	"	Ph.D, Co-Worker
	L. Motta	"	Ph.D, Co-Worker
N-118-1	**J. Miller**	LBNL, CA	Ph.D., Principal Investigator
	C. Zeitlin	"	Ph.D., Co-Worker
	L. Heilbronn	"	Ph.D., Co-Worker
	S. Guetersloh	Center for Applied Radiation Research (CARR PV A&M U)	Ph.D., Co-Worker
	B. Gersey		Ph.D., Co-Worker
N-118-2	**J. Miller**	LBNL, CA	Ph.D., Principal Investigator
	E. R. Benton	Eril Research, Inc. (ERI), CA	Ph.D., Co-PI
	B. Gersey,	Center for Applied Radiation Research (CARR PV A&M U)	Ph.D., Co-Worker
	J. Wedeking	"	Ph.D., Co-Worker
	J. Sodolak	LBNL, CA	Ph.D., Co-Worker
	C. Zeitlin,	"	Ph.D., Co-Worker
	L. Heilbronn,	"	Ph.D., Co-Worker
	S. Guetersloh	"	Ph.D., Co-Worker
	T. Komiyama	NASA, JSC, TX	Ph.D., Co-Worker
	P. Dulane	Nat. Institute for Radiological Sciences, JP	Ph.D., Co-Worker
	Y. Uchihori	University of Kiel, Germany	Ph.D., Co-Worker
	R. Beaujean	"	Ph.D., Co-Worker
	S. Burmeister	"	Ph.D., Co-Worker
	T. Doke,	Waseda University, Japan	Ph.D., Co-Worker
	K. Terasawa,	"	Ph.D., Co-Worker
	K. Takizawa	"	Ph.D., Co-Worker
	T. Sakaguchi	"	Ph.D., Co-Worker
N-119	**J. Archambeau**	Loma Linda University, CA	M.D, Principal Investigator
	G. Nelson	"	Ph.D, Co-Worker
	X. Mao	"	M.D, Investigator
	A.Smith	"	B.S, Co-Worker
	P. Archambeau	"	B.S, Co-Worker
	D. Crockett	"	B.S, Co-Worker
N-123	**V. Radeka**	BNL, Upton, NY	Ph.D., Principal Investigator
	B. Yu	"	Ph.D, Co-Worker
	J. Mead	"	Ph.D, Co-Worker
N-124	**C. Li**	Duke University, NC	Ph.D., Principal Investigator
	B. Yan	"	Ph.D., Co-Worker
	Q. Chen	"	Ph.D., Co-Worker
	S. Liu	"	Ph.D., Co-Worker
N-126	**A. Kennedy**	University of Pennsylvania, PA	Ph.D., Principal Investigator
	J. Ware	"	Ph.D., Co-Worker
	J. Guan	"	Ph.D., Co-Worker
	J. Donahue	"	M.S., Co-Worker

***Not Present During Actual Run**

NSRL-4 PARTICIPANTS STATISTICS

PARTICIPANTS	NSRL-4
Ph.D., Principal Investigators	17
M.D., Principal Investigators	1
Ph.D., Co-Principal Investigators	1
Co-Workers	
Ph.D.	50
M.D., Ph.D.	1
M.D.	1
M.S.	5
B.S.	24
B.S./B.A.	1
Total:	101

RESEARCH PROJECT SPONSORS:



PARTICIPANT INSTITUTIONS

NASA related centers/institutes (2)

- **NASA, Johnson Space Center, TX**
- **National Space Biomedical Research Institute, TX**

National Laboratories/Institutes (3)

- **Brookhaven National Laboratory, NY**
- **Lawrence Berkeley National Laboratory, CA**
- **HNRCA, USDA-ARS, MA**

Universities (12)

- **Loma Linda University, CA**
- **University of Pennsylvania, PA**
- **Thomas Jefferson University, PA**
- **Colorado State University, CO**
- **Columbia University, NY**
- **University of Maryland, Baltimore County, MD**
- **Praire View A&M University, TX**
- **Texas A&M University, TX**
- **Harvard Medical School, MA**
- **Massachusetts Institute of Technology, MA**
- **Duke University, NC**
- **Oklahoma State University, OK**

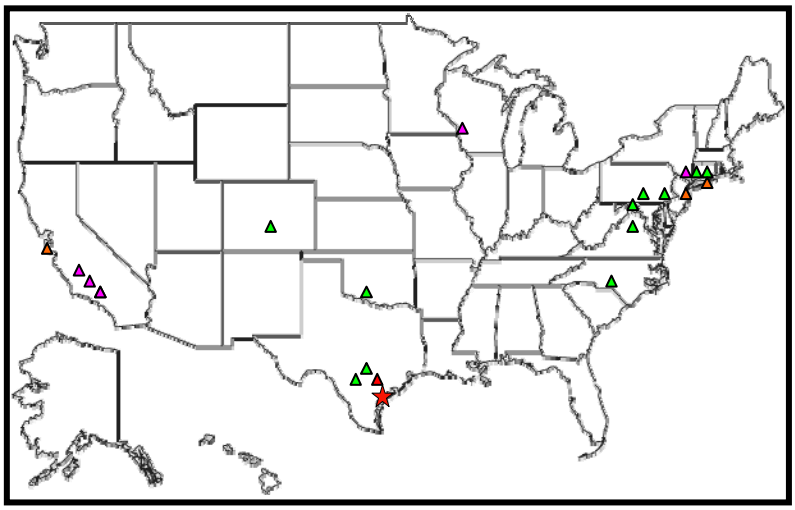
Private Institutions (5)

- **Massachusetts General Hospital, MA**
- **ERIL Research Inc., CA**
- **Scripps Research Institute, CA**
- **Promega Corporation, WI**
- **SRI International, CA**

Foreign Institutions (14)

- **University Federico II, Italy**
- **Instituto Superiore di Sanita, Italy**
- **University Milano, Italy**
- **Atominstitute of the Austrian Universities (ATI), Austria**
- **Deutschen Zentrum für Luft- und Raumfahrt (DLR), Germany**
- **Studiecentrum Coor Kernenergie – Centre D'Etude De L'Energie Nucleaire, Belgium**
- **Institute for Nuclear Physics (INP), Poland**
- **Japanese Aerospace Exploration Agency (JAXA), Japan**
- **KFKI Atomic Energy Research Institute, Hungary**
- **National Institute for Radiological Sciences (NIRS), Japan**
- **Nuclear Physics Institute (NPI), Czech Republic**
- **National Radiological Protection Board (NRPB), UK**
- **University of Kiel, Germany**
- **Waseda University, Japan**

U.S. Participant Institutions and State Distribution



- **NASA Related Centers**
- **National Laboratories**
- **Universities**
- **Private Institutions**

California
- Lawrence Berkeley National Laboratory, Berkeley
- Loma Linda University, Loma Linda
- Scripps Research Institute / NSCOR, San Diego
- ERIL Research Inc., San Francisco
- SRI International, Palo Alto

Colorado
- Colorado State University, Fort Collins

Maryland
- UMBC, Baltimore

Massachusetts
- Massachusetts General Hospital, Cambridge
- MIT / Mass General Hospital, Cambridge
- Harvard Medical School, Cambridge
- HNRCA, USDA-ARS, Boston

New York
- Brookhaven National Laboratory, Upton
- Columbia University, New York

North Carolina
- Duke University, Durham

Oklahoma
- Oklahoma State University, Oklahoma

Pennsylvania
- University of Pennsylvania School of Medicine, Philadelphia
- University of Pennsylvania, Philadelphia

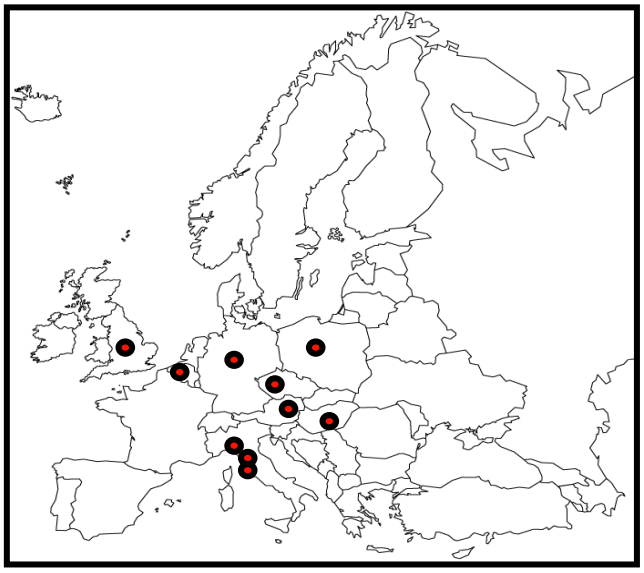
Texas
- NASA Johnson Space Center, Houston
- National Space Biomedical Research Institute, Houston
- Praire View A&M University

Virginia
- NASA Langley Research Center

Washington
- Washington University / NSCOR

Winsconsin
- Promega Corporation, Madison

Foreign Participant Institutions and Country Distribution



Europe:

Austria
- Atominstitute of the Austrian Universities (ATI),

Belgium
- Studiecentrum Coor Kernenergie – Centre D'Etude De L'Energie Nucleaire

Czech Republic
- Nuclear Physics Institute

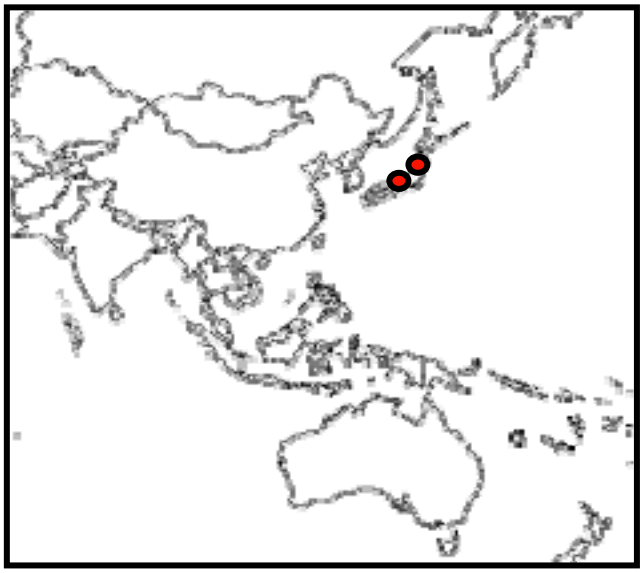
Germany
- Deutschen Zentrum für Luft-undRaumfahrt
- University of Kiel

Hungary
- KFKI Atomic Energy Research Institute

Italy
- University Federico II,
- Instituto Superiore di Sanita
- University Milano

Poland
- Institute for Nuclear Physics

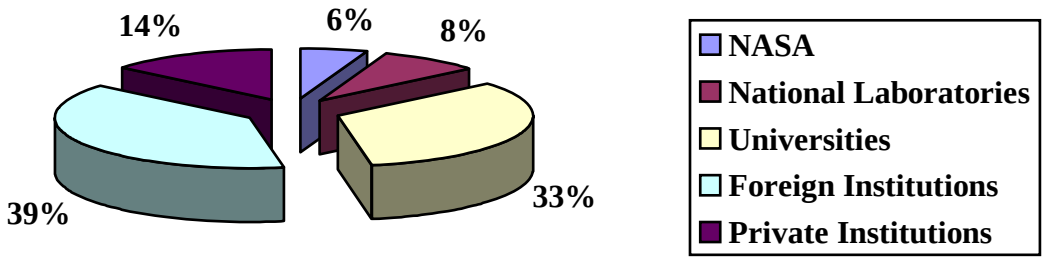
UK
- National Radiological Protection Board



Asia:

Japan
- Waseda University
- National Institute for Radiological Sciences
- Japanese Aerospace Exploration Agency (JAXA),

INSTITUTIONS STATISTICS:



NSRL-4 TITANIUM RUN DESCRIPTION

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	08/30	0700	08/30	0700
Run end	08/31	2000	08/31	1730
Tuned into cave	08/27	1000	08/27	1456
Beam delivered for Biology				
Ti 1 GeV/n	08/30	1300	08/30	1300
End run	08/31	1900	08/31	1730

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(08/30 0700 to 08/31 1730)		25
Total Beam-on time			23.5
Total Beam-off time			1.5
Ti 1 GeV/n In Vitro Studies	14.5		
Ti 1 GeV/n In Vivo Studies	0.0		
Sub-total		14.5	
Beam Development Time	0.0		
Sub-total		0.0	
Set-Up & Spill Structure	8.0		
Sub-total		8.0	
Wrap-up Time	1.0		
Sub-total		1.0	
Total			23.5
Contingency T. Planned	2.0		
Contingency T. Used	1.0		

NSRL-4 SILICON RUN DESCRIPTION

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	09/01	0700	09/01	0700
Run end	09/02	1900	09/02	1730
Tuned into cave	09/01	0500	09/01	0500
Beam delivered for Biology				
Si 0.6 GeV/n	09/01	1300	09/01	1200
End run	09/02	1800	09/02	1730

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 09/01 0700 to 09/02 1730)		24.5
Total Beam-on time			24.5
Total Beam-off time			0.0
Si 0.6 GeV/n In Vitro Studies	8.5		
Si 0.6 GeV/n In Vivo Studies	0.0		
Sub-total		8.5	
Beam Development Time	8.0		
Sub-total		8.0	
Set-Up & Spill Structure	7.0		
Sub-total		7.0	
Wrap-up Time	1.0		
Sub-total		1.0	
Totals			24.5
Contingency T. Planned			
Contingency T. Used			

NSRL-4 IRON 1 GeV/n RUN DESCRIPTION (run in progress)

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	09/03	0700	09/03	0700
Run end	09/27	0200	09/27	0000
Tuned into cave	09/03	0500	09/03	0500
Beam delivered for Physics				
Fe 1 GeV/n	09/11	0700	09/11	0700
End run	09/27	0200	09/27	0000
Beam delivered for Biology				
Fe 1 GeV/n	09/03	1100	09/03	1230
End run	09/15	2200	09/15	2030

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 09/03 0700 to 09/13 1800, from 09/15 0700 to 09/15 2100, from 09/26 0000 to 09/27 0000)		124.0
Total Beam-on time			116.5
Total Beam-off time			7.5
Fe 1 GeV/n In Vitro Studies	44.0		
Fe 1 GeV/n In Vivo Studies	10.0		
Sub-total		54.0	
Fe 1 GeV/n Physics	33.5		
Sub-total		33.5	
Beam Development Time	2.5		
Sub-total		2.5	
Set-Up & Spill Structure	21.5		
Sub-total		21.5	
Wrap-up Time	5.0		
Sub-total		5.0	
Totals			116.5
Contingency T. Planned	8.0		
Contingency T. Used	0.0		

NSRL-4 IRON 0.6 GeV/n RUN DESCRIPTION

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	09/17	0700	09/17	0700
Run end	0/23	2300	09/23	2330
Tuned into cave	09/17	0500	09/17	0500
Beam delivered for Biology				
Fe 0.6 GeV/n	09/17	1300	09/17	1130
End run	09/23	1800	09/23	2030

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 09/17 0700 to 09/23 2330)		69.5
			66.5
Total Beam-on time			
			3.0
Total Beam-off time			
Fe 0.6 GeV/n In Vitro Studies	10.0		
Fe 0.6 GeV/n In Vivo Studies	32.5		
Sub-total		42.5	
Fe 0.6 GeV/n Physics	0.0		
Sub-total		0.0	
Beam Development Time	9.0		
Sub-total		9.0	
Set-Up & Spill Structure	12.5		
Sub-total		12.5	
Wrap-up Time	2.5		
Sub-total		2.5	
Totals			66.5

Contingency T. Planned	8.0
Contingency T. Used	1.0

NSRL-4 IRON/PROTON 1 GeV/n RUN DESCRIPTION

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	09/14	0700	09/14	0700
Run end	09/16	2000	09/16	1800
Tuned into cave	9/14	0500	9/14	0500
Beam delivered for Biology				
Fe 1 GeV/n	09/14	1100	09/14	1130
End run	09/16	1900	09/16	1800

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 09/14 0700 to 09/14 2000, (from 09/16 0700 to 09/16 1800))		24.5
Total Beam-on time			23.0
Total Beam-off time			1.5
Fe + p 1 GeV/n In Vitro Studies	14.5		
Fe + p 1 GeV/n In Vivo Studies	0.0		
Sub-total		14.5	
Fe + p 1 GeV/n Physics	0.0		
Sub-total		0.0	
Beam Development Time	0.5		
Sub-total		0.5	
Set-Up & Spill Structure	7.0		
Sub-total		7.0	
Wrap-up Time	1.0		
Sub-total		1.0	
Totals			23.0
Contingency T. Planned	2.0		
Contingency T. Used	0.0		

NSRL-4 PROTON 1 GeV/n RUN DESCRIPTION

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	09/24	0500	09/24	0700
Run end	10/01	1900	10/01	2000
Tuned into cave	09/24	0500	09/24	0500
Beam delivered for Physics				
p 1 GeV/n	09/24	2300	09/24	2200
End run	10/01	1900	10/01	2000
Beam delivered for Biology				
p 1 GeV/n	09/24	0900	09/24	1030
End run	09/24	1630	09/24	2200

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 09/24 0700 to 09/26 0000, from 09/30 1030 to 10/01 2000)		74.5
Total Beam-on time			68.5
Total Beam-off time			6.0
p 1 GeV/n In Vitro Studies	6.5		
p 1 GeV/n In Vivo Studies	0.0		
Sub-total		6.5	
p 1 GeV/n Physics	43.5		
Sub-total		43.5	
Beam Development Time	2.0		
Sub-total		2.0	
Set-Up & Spill Structure	15.0		
Sub-total		15.0	
Wrap-up Time	1.5		
Sub-total		1.5	
Totals			68.5
Contingency T. Planned			
Contingency T. Used			

NSRL-4 OXIGEN 1 GeV/n RUN DESCRIPTION

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	09/27	0200	09/27	0600
Run end	09/28	1000	09/30	1030
Tuned into cave	09/27	0200	09/27	0300
Beam delivered for Physics				
O 1 GeV/n	09/27	1000	09/27	1000
End run	09/30	1000	09/30	1030

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 09/27 0600 to 09/29 1430, from 09/30 0900 to 09/30 1030)		58.0
Total Beam-on time			54.0
Total Beam-off time			4.0
O 1 GeV/n Physics	50.0		
Sub-total		50.0	
Beam Development Time	0.0		
Sub-total		0.0	
Set-Up & Spill Structure	4.0		
Sub-total		4.0	
Wrap-up Time	0.0		
Sub-total		0.0	
Totals			54.0
Contingency T. Planned	0.0		
Contingency T. Used	0.0		

NSRL-4 OXIGEN 0.6 GeV/n RUN DESCRIPTION

RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	09/29	1000	09/29	1430
Run end	09/30	1400	09/30	0900
Tuned into cave	09/29	1000	09/29	1430
Beam delivered for Physics				
O 0.6 GeV/n	09/29	1400	09/29	1630
End run	09/30	1400	09/30	0900

BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 09/29 1430 to 09/30 0900)		18.5
Total Beam-on time			18.0
Total Beam-off time			0.5
O 0.6 GeV/n Physics	16.0		
Sub-total		16.0	
Beam Development Time	0.0		
Sub-total		0.0	
Set-Up & Spill Structure	0.0		
Sub-total		0.0	
Wrap-up Time	0.0		
Sub-total		0.0	
Totals			18.0
Contingency T. Planned	0.0		
Contingency T. Used	0.0		

TOTAL BEAM TIME DESCRIPTION (hours)

Total Clock Time	**(from 08/30 0700 to 10/01 2000)**		**418.5**
Total Beam-on Time			
Ti 1 GeV/n	**23.5**		
Si 0.6 GeV/n	**0.0**		
Fe 1 GeV/n	**116.5**		
Fe 0.6 GeV/n	**66.5**		
p 1 GeV/n	**68.5**		
Fe + p 1 GeV/n	**23.0**		
O 1 GeV/n	**54.0**		
O 0.6 GeV/n	**18.0**		
Total		**394.5**	
Total Beam-off time			
Ti 1 GeV/n	**1.5**		
Si 0.6 GeV/n	**0.0**		
Fe 1 GeV/n	**7.5**		
Fe 0.6 GeV/n	**3.0**		
p 1 GeV/n	**6.0**		
Fe + p 1 GeV/n	**1.5**		
O 1 GeV/n	**4.0**		
O 0.6 GeV/n	**0.5**		
Total		**24.0**	
Total Beam Time for Biology			
In Vivo Studies	**98.0**		
In Vitro Studies	**42.5**		
Total		**140.5**	
Total Beam Time for Physics	**143.0**		
Sub-total		**143.0**	
Beam Time for Beam Dev.	**22.0**		
Total		**22.0**	
Set Up & Spill Structure	**77.0**		
Total		**77.0**	
Wrap-up Time	**12.0**		
Sub-total		**12.0**	
Totals			**394.5**

Contingency T. Planned	
Contingency T. Used	

NSRL-4 FINAL RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start			08/30	0700
Run end			10/01	2000
Tuned into cave (Ti 1 GeV/n)			08/27	1456

BEAM CHARACTERISTICS

Ion	$^{56}Fe^{26}$		H^{1}	O		Ti	Si
Fluence (particles/cm^2/sec)							
Maximum on target	1.6×10^{6}	1.6×10^{6}	5.4×10^{7}	6.4×10^{6}	6.4×10^{6}	3.2×10^{5}	4.8×10^{6}
Minimum on target	500	500	500	500	500	1000	500
Spill Period (sec)	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Spill rate (spills/min)	20	20	20	20	20	20	20
Spill length (msec)	400	400	400	400	400	400	400
Particles/spill							
Maximum	1×10^{9}	1×10^{9}	3.4×10^{10}	4×10^{9}	4×10^{9}	2×10^{8}	3×10^{9}
Minimum	2×10^{5}	2×10^{5}	2×10^{5}	2×10^{5}	2×10^{5}	4×10^{5}	2×10^{5}
Beam Cut Off Accuracy	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %	0.5 %
Actual Energy (MeV/n)							
Extracted	600	1005	1000	1000	600	1030	600
On Target	577	968	NB	NB	NB	1019	575
Actual LET on Target (keV/µm)	176.1	151.4	0.024	14.2	16.4	107.3	51.1
Max. Dose Rate (Gy/min)/ Beam Size (cm x cm)							
20 x 20	7	7	0.2	SB		2	5
7 x 7	50	50	1.5			15	25
Total Dose (cGy)							
Maximum	400	400	2500	NA	**NA**	20,000	300
Minimum	15	0.1	15			0.03	0.02

NB: No Bragg Curve done, usually because the particular ion at the given energy has a range too large for the binary filter. For example, O at 1000 MeV/n has a range of 81 cm, well beyond the current 35 cm range of the binary filter.

SB: Small Beam, that is, the beam used for physics. If a beam is only used for physics, usually no dosimetry is done or recorded. **For user's planning purposes, O will have dose rates similar to those for Ti.**

The Fe/p beam conditions are the same as those for the individual ions.

NSRL-4 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 Fe, 0.6 GeV/n	4 2.5	3.0 1.5	150 25-150	150 100	42 21
B-10	Chang	Fe, 0.6 GeV/n	7	3.5	10-400	20-150	24
B-44	Durante	Ti, 1 GeV/n Si, 0.6 GeV/n Fe, 1 GeV/n	10 5 5	7.5 4.0 3.0	0.01-2000 0.01-300 0.01-300	0.1-1000 0.1-100 0.1-100	30 20 20
B-52	Gewirtz	Si, 0.6 GeV/n	3	1.0	TBD	50-250	TBD
B-67	Blakely	Fe, 0.6 GeV/n	3.5	3	50-400	8-167	128
B-73/ N-88	Sutherland	Si, 600 MeV/n Fe + P, 1 GeV/n	7 16	3.5 14.5	TBD TBD	50-250 TBD	TBD TBD
B-76	Green	Fe, 1 GeV/n	2	2.0	10	50	8
N-80	Gonda	Fe, 1 GeV/n	2.5	2.5	10-200	100	21
N-86	Wang	Fe, 1 GeV/n	6	4.0	100-500	100	124
N-89	Held	P, 1 GeV/n Fe, 1 GeV/n Ti, 1 GeV/n	4.5 9 5	6.5 9.5 7.0	10,000 part/cm^2 - 300	Very low fluences-200	100 250 120
N-91	Rydberg	Fe, 0.6 GeV/n	6	3.0	5-500	10-250	60
N-99	Zhao	Fe, 1 GeV/n	1.5	1.0	30-100	0.5	13
N-102	Hall	Fe, 1 GeV/n	3	1.0	10-300	50	24
N-103	Barcellos-Hoff	Fe, 1 GeV/n	12	10.0	20-400	100	48
N-104	Weil/Ullrich	Fe, 1 GeV/n	7.5	5.0	10-100	10-50	83
N-105	Bedford/Chatterjee	Fe, 1 GeV/n	1	2.0	100-400	120-260	24
N-106	Gatley	Fe, 0.6 GeV/n	4	4.5	120-240	200	30
N-108	Pecaut	Fe, 0.6 GeV/n	3	1.5	50-400	150-175	35
N-110	Nelson	Fe, 0.6 GeV/n	3.7	1.5	50-400	150-175	35
N-111	Obenaus	Fe, 0.6 GeV/n	3	3	100-400	150-175	63
N-112	Obenaus	Fe, 0.6 GeV/n	3	1.5	50-400	150-175	35
N-113	Pecaut	Fe, 0.6 GeV/n	2	1.5	50-400	150-175	35
N-115	Bacher	Fe, 1 GeV/n	4	3.0	50-300	50	82
N-118-1	Miller	O, 1 GeV/n O, 0.6 GeV/n P, 1 GeV/n	24 24	26.0 16.0 25.0	TBD TBD TBD	TBD TBD TBD	TBD TBD TBD
N-118-2	Miller "ICHIBAN"	O, 1 GeV/n P, 1 GeV/n Fe, 1 GeV/n	24 24 24	24.0 18.5 21.0	TBD TBD TBD	TBD TBD TBD	TBD TBD TBD
N-119	Archambeau	Fe, 0.6 GeV/n	9	14.0	65-520	10-100	60
N-123	Radeka	Fe, 1 GeV/n	11.2	12.5	NA	NA	8
N-124	Li	Fe, 0.6 GeV/n	8	4.0	5-500	3-100	79
N-126	Kennedy	Fe, 1 GeV/n	5	8.0	10-60	40	252
Totals			**298.9**	**283.5**	**<0.1-2000**	**<0.1-1000**	**1874**

NSRL-4 PARTICIPANTS, EXPERIMENTAL SAMPLES AND ENDPOINTS

Exp.	Participants	Samples	Endpoints
B-7	Effects of Exposure to Heavy Particles **B. Rabin (PI)**	Sprague Dawley Rats	Behavioral paradigms and neurochemistry
B-10	Charged Particle Radiation-induced Genetic Damage in Transgenic Mice **P. Chang (PI)**	LacZ transgenic mouse with different p53 genotypes	Mutation frequency, micronucleus formation and chromosomal aberrations
B-44	Influence of the Shielding on the Space Radiation Biological Effectiveness. **M. Durante (PI)**	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. **A. Gewirtz (PI)**	Human bone marrow cells	DNA complex damages, DNA replication and apoptosis, gene expression
B-67	Lens Epithelium and Proton-Induced Cataractogenesis. **E. Blakely (PI)**	Human lens epithelial cells	RNA or protein analyses
B-73	DNA damage clusters in low level radiation responses of human cells. **B. Sutherland (PI)**	T7 DNA, Human monocytes Supercoiled DNA	DNA damage cluster induction and repair at the molecular and cellular levels
B-76	Response of Thyroid Tissue Units to Space-Like Radiation Fields. **Lora Green (PI)**	FRTL-5 cells (rat thyroid)	RNA gene arrays, Analysis of fixed tissue/cells for specific quantification of structural components
N-80	Comparison of Cell and Tissue 3D Models for Assessment of Genotoxic Damage by High Energy Charged Particles. **S. Gonda (PI)**	Normal & Transgenic fibroblast cells Normal & Transgenic epithelial cells	Mutation types and frequency induced in target genes at molecular level Dose relationships
N-86	Cellular Response to High Energy Particle Exposures. **Y. Wang (PI)**	GM 847 and ATR-kd human fibroblasts	Clonogenic survival, G2 checkpoint, DNA replication, CHK1 phosphorylation and DNA repair.
N-88	Complex Space Radiation-induced DNA damage Clusters in Human Cell Transformation: Mechanisms, relationships and Mitigation. **B. Sutherland (PI)**	Human normal fibroblasts	DNA damage cluster and transformation
N-89	Induction of Bystander Effects by High LET Radiation in Cells **K. Held (PI)**	Human keratinocytes and fibroblasts	Micronuclei formation, expression of p21 and foci formation of γH2AX
N-91	Repair of HZE-induced DNA Double Strand Breaks and PCC Breaks. **B. Rydberg (PI)**	HeLa cells, CHO cells and xrs6 cells	DSB determination, PCC and bystander effects
N-99	Tranformation of hTERT-immortalized human bronchial epithelial Cells by High Energy Heavy Ions. **Y. Zhao (PI)**	hTERT-immortalized human bronchial epithelial Cells and MEF cells	Cell survival and transformation

Exp.	Participants	Samples	Endpoints
N-102	Exposure of Mouse Cells to Graded Doses of One GeV/nucleon Fe(56) Ions. **E. Hall (PI)**	Thymocytes from wild type knock out mice	Apoptosis assays
N-103	Mechanism of HZE Damage and Repair in Human Epithelial Cells. **M. Barcellos-Hoff (PI)**	HMEC 184	Survival assays, Gene expression, Immunostaining
N-104	Radiation Leukemogenesis **M. Weil/R. Ullrich (PI's)**	CBA/CaJ strain mice	Determination of RBE for the induction of AML using slope constants
N-105	Predicted and Observed Dose-Responses for Simple and Complex Chromosomal Aberrations after Exposure of Human Cells to HZE Radiations: Effects of Beam Fileration. **A. Chatterjee/J. Bedford (PI's)**	GM2149 low passage normal human fibroblasts	FISH Chromosome painting, chromosomal aberrations
N-106	MicroPET Studies of Brain Damage by Heavy Ion Particles. **S. Gatley (PI)**	Rats	Neurochemical analysis, MicroPET imaging
N-108	Progressive Alterations of Central Nervous System Structure and Function Are caused by Charged Particle Radiation. **M. Pecaut (PI)**	APP23 Transgenic Mice	Neuronal excitability, membrane and synaptic properties, local circuit interactions, synaptic plasticity, using electrophysiology techniques
N-110	Charged Particle Irradiation Causes a Progressive Loss of Cells and a Remodeling of CNS Tissue as a Function of Dose, Time, and LET. **G. Nelson (PI)**	C57BL/6 Mice	Immunohistochemical analysis, stereology *in situ*, immunocytochemistry
N-111	Non-Invasive Assessment of Neuropathology Following CNS Radiation Exposure. **A. Obenaus (PI)**	Sprague-Dawley Rats	MRI and spectroscopy to assess altered tissue characteristics, image analysis, general histology, immunohistochemistry, phagocytic cell quantification, SWI processing
N-112	Charged Particle Alterations of the Functional Output of the Brain as a Function of Dose, Time, and LET **A. Obenaus (PI)**	C57BL/6	EEG Recordings, In Vitro brain slice preparation, Extracellular recordings and Long Term Potentiation, Quantitative estimates of venous CBV
N-113	The Effects of Charged Particle Radiation on the CNS Response to an Immunological Stressor. **M. Pecaut (PI)**	C57BL/6	Histological Analysis of the hippocampus
N-115	A Novel Biodosimetry Method for Monitoring Radiation Induced Mutations. **J. Bacher (PI)**	Mice, HCT116, HEC-59 and MEF cells from MHL1 and MSH2 deficient mice	Multiplex Assays, Mutational Load Profiles

Exp.	Participants	Samples	Endpoints
N-118-1	Semi-inclusive Nuclear Fragmentation Cross Sections **J. Miller (PI)**	Active Radiation Monitoring Instruments	Measurements of double differential cross sections for the production of all secondaries produced by the colliding projectile and target nuclei.
N-118-2	Intercomparison of Space Radiation Detectors. **J. Miller (PI)**	Active and Passive Radiation Monitoring Instruments	Ground-based intercomparison of various radiation instruments and detectors
N-119	Non-Invasive Assessment of Neuropathology Following CNS Radiation Exposure. **J. Archambeau (PI)**	Sprague Dawley Rats	Endothelial cell loss, DNA double strand breaks, BrdU labeling index, dose response of microvessels in rat retina, brain cortex, and white matter
N-123	Heavy Ion Microbeam and Micron Resolution Detector for Single Cell Radiation Studies. **V. Radeka (PI)**	Stripixel Detector	Position resolution and linearity in position response
N-124	HZE Particle Induced Persistent Genetic Instability/Oncogenic Transformation and Their Prevention. **C. Li (PI)**	Mouse Fibroblast Cell Lines	Mechanistic studies of genetic instability/neoplastic transformation induced by HZE particles and to develop potential approaches to reduce/prevent it.
N-126	Countermeasures for Space Radiation Induced Myeloid Leukemia and Mechanisms by which Selenomethionine Protects Against Space Radiation Biological Effects. **A. Kennedy (PI)**	HTori-3 and ATCC CRL-9855 Cells	Gene Expression, DNA repair processes

International laboratories and investigators with active detectors that took part in the NSRL ICCHIBAN experiment. All listed investigators were present at NSRL during the experiment.

Laboratory	Investigators	Country	Instrument
Center for Applied Radiation Research (CARR PV A&M U)	B. Gersey, J. Wedeking, & J. Sodolak	USA	Shuttle-style TEPC
Eril Research, Inc. (ERI)	E. R. Benton	USA	Liulin-4U portable Si dosimeter
Lawrence Berkeley National Laboratory (LBNL)	J. Miller, C. Zeitlin, L. Heilbronn, S. Guetersloh, & T. Komiyama	USA	LBNL Si Spectrometer*
NASA Johnson Space Center (JSC)	P. Dulane & C. Zeitlin**	USA	MARIE Si telescope
National Institute for Radiological Sciences (NIRS)	Y. Uchihori	Japan	Liulin-4J portable Si dosimeter
University of Kiel	R. Beaujean & S. Burmeister	Germany	DOSTEL Si telescope
Waseda University	T. Doke, K. Terasawa, K. Takizawa & T. Sakaguchi	Japan	RRMD-III Si telescope

*Provided reference dosimetry and characterization of the beam.

**from LBNL

International laboratories and investigators with passive detectors that took part in the NSRL ICCHIBAN experiment.

Laboratory	Investigators	Country	Detector Type
Atominstitute of the Austrian Universities (ATI)	M. Hajek, & N. Vana	Austria	TLD-600 (^{6}LiF:Mg, Ti) TLD-700 (^{7}LiF:Mg, Ti)
Deutschen Zentrum für Luft- und Raumfahrt (DLR)	T. Berger, G. Reitz	Germany	TLD-600 (^{6}LiF:Mg,Ti) TLD-700 (^{7}LiF:Mg,Ti) TLD-600H (^{6}LiF:Cu,P) TLD-700H (^{7}LiF:Cu,P)
Studiecentrum Coor Kernenergie – Centre D'Etude De L'Energie Nucleaire (SCK-CEN)	P. Vanhavere	Belgium	TLD-100 (LiF:Mg,Ti) LiF:Mg,Cu,P TLD Al_2O_3:C OSL
Eril Research, Inc. (ERI)	E. R. Benton*, A. L. Frank & E. V. Benton	USA	CR-39 PNTD TLD-700 (^{7}LiF:Mg, Ti)
Institute for Nuclear Physics (INP)	P. Bilski & T. Horwacik	Poland	MTS-7 (LiF:Mg,Ti) MCP-7 (LiF:Mg,Cu,P) MTT-7 (LiF:Mg,Ti) CR-39 PNTD
Japanese Aerospace Exploration Agency (JAXA)	H. Tawara, A. Nagamatsu, & M. Masukawa	Japan	MSO TLD (Mg_2SiO_4:Tb) CR-39 PNTD
NASA Johnson Space Center (JSC)	E. Semones*	USA	TLD-100 (LiF:Mg,Ti) TLD-300 (CaF_2:Tm) TLD-600 (^{6}LiF:Mg, Ti) TLD-700 (^{7}LiF:Mg, Ti) CR-39
KFKI Atomic Energy Research Institute	S. Deme & I. Apathy	Hungary	Pille TLD System ($CaSO_4$:Dy)
KFKI Atomic Energy Research Institute	J. Palfalvi, J. Szabo	Hungary	CR-39 PNTD
National Institute for Radiological Sciences (NIRS)	N. Yasuda	Japan	CR-39 PNTD, TLD, Al-P Glass, OSL
Nuclear Physics Institute (NPI)	F. Spurny & K. Turek	Czech Republic	CR-39 PNTD Melinex/Bi PNTD Al_2O_3:C TLD Al-P Glass
National Radiological Protection Board (NRPB)	D. Bartlett & L. Hager	UK	PADC PNTD
Oklahoma State University (OSU)	S.W.S. McKeever & E. G. Yukihara	USA	Al_2O_3:C OSL Al_2O_3:C TLD TLD-100 (LiF:Mg,Ti)

*Present at NSRL

List of personnel that participated in the planning, organization and execution of NSRL-3 run

BNL Management:

- Laboratory Director: **Praveen Chaudhari**
- 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
- **Kathy Held,** MIT
- **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)**
- **Acc**elerator 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**
- Tanden 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
  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, Adele Billups**
  - Dept. Chair: **Helene Benveniste**
  - 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**
- Cesiun Source Manager: **Richard Sautkulis**