RIKEN BNL Research Center

SCIENTIFIC PRESENTATIONS

8th MEETING OF THE MANAGEMENT STEERING COMMITTEE OF THE RIKEN BNL COLLABORATION

RIKEN, Wako, Japan

March 11-12, 2002

RBRC Scientific Articles

Volume 5

Building 510A, Brookhaven National Laboratory, Upton, N.Y 11973-5000, USA

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Preface to the Series

The RIKEN BNL Research Center (RBRC) was established in April 1997 at Brookhaven National Laboratory. It is funded by the "Rikagaku Kenkyusho," (RIKEN) The Institute of Physical and Chemical Research, of Japan. The Center is dedicated to the study of strong interactions, including hard QCD/spin physics, lattice QCD and RHIC (Relativistic Heavy Ion Collider) physics through nurturing of a new generation of young physicists. The Director of RBRC is Professor T. D. Lee.

The first years were dedicated to the establishment of a theory group. This has essentially been completed consisting of Fellows, Postdocs, and RHIC Physics/University Fellows, with an active group of consultants. The center also organizes an extensive series of workshops on specific topics in strong interactions with an accompanying series of published proceedings. In addition, a 0.6 teraflops parallel processor computer has been constructed and operational since August 1998. It was awarded the Supercomputer 1998 Gordon Bell Prize for price performance. An active experimental group centered around the spin physics program at RHIC has subsequently also been established at RBRC.

Members and participants of RBRC on occasion will develop articles such as this one, in the nature of a status report or a general review.

N. P. Samios

*Work performed under the auspices of U.S.D.O.E. Contract No. DE-AC02-98-CH10886.

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RIKEN BNL SPIN PHYSICS PROJECT AT RHIC

Satoshi Ozaki

RIKEN BNL Spin Physics Project at RHIC

Satoshi Ozaki

RIKEN/BNL Spin Physics Collaboration
Management Steering Committee Meeting

March 11-12, 2002
At RIKEN, Wako, Saitama, Japan

Brookhaven Science Associates
U.S. Department of Energy

BROOKHAVEN
NATIONAL LABORATORY

The Spin Physics Project

Equipment Construction to Enable Collisions of Polarized Protons at RHIC

- Experimental Apparatus, 11/95 – 9/01
Muon Magnet and Muon ID Steel,
Muon Tracking and Muon ID Detectors
Muon ID In-panel Preamplifier
FEM for PHENIX EMCAL, etc.
- Accelerator Hardware, 3/97 – 12/01
Superconducting Helical Dipole Development
4 Siberian Snakes and 4 Spin Rotators
Polarimeters
Measurement Probe
16 Helical Dipoles for Spin Rotators No. 5 – 8, etc.

Total Spent at BNL	\$ 16.93 M
Total Spent in Japan	¥ 350.0 M

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RHIC Layout for SPIN Physics

RIKEN-BNL Collaboration in Spin Physics:

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First Siberian Snake in RHIC Tunnel

Siberian Snake: 4 superconducting helical dipoles, 4 Tesla,
2.4 m long with full 360° twist
All 4 Snakes in the Tunnel

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Spin Rotators #1-4 in Storage

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U.S. Department of Energy

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Helical Superconducting Dipoles

16 helical dipoles
fabricated

Snake and Spin Rotator look alike:
Both made of 4 helical dipoles
Helicity configuration

Snake: RH-RH-RH-RH

Spin Rotator: RH-LH-RH-LH

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Helical Dipole Fields

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Polarization During Ramp and Store

The asymmetry remains almost fixed during acceleration and store

Asymmetry:

A measure of the polarization

This plot made by
Osamu Jinnouchi

X Physics Asymmetry (1/13/02)

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U.S. Department of Energy

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The First Complete Siberian Snake

July 1999

Four Helical dipoles:
4T, 2 m long,
& 360° Twist

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PHENIX South Muon ID and Tracker

South Muon ID Panels

South Muon Magnet and
Tracking Detector

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Muon Tracking Detector Panel

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Completed PHENIX South Muon Arm

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RHIC FACILITY OPERATIONS REPORT

Thomas B. W. Kirk

RHIC Facility Operations Report

**Presented to the
Management Steering Committee
of the
Riken - BNL Collaboration**

11

**by
Thomas B.W. Kirk
Associate Laboratory Director
HENP**

**Wako, Japan
March 11, 2002**

**US Department of Energy
Brookhaven Science Associates**

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NATIONAL LABORATORY

BNL's Current Status and Operations

- **BNL commissioned Au x Au and pol. p x p beams in FY2001-2002**
 - full energy and luminosity were achieved with Au running
 - polarized proton beams were accelerated to 100 GeV without loss of pol.
 - the need for a stronger, SC AGS snake magnet for pol. was demonstrated
- **Data was taken by all RHIC experiments in Au x Au and pp beams**
 - 14 weeks of Au x Au at 100 GeV/amu was taken by 4 RHIC experiments
 - 3 weeks of polarized proton data were taken by 5 experiments
 - mean polarizations in the proton beam averaged <30%
- **R&D has been started to improve the RHIC polarized proton ops.**
 - the solenoidal AGS partial snake magnet inhibits high polarization
 - the backup Westinghouse AGS main power supply held down pol in AGS
 - the Siemens power supply is being repaired; it will be ready for FY 2003
- **RHIC operations has been raised by \$16M in the FY03 PB**
 - the number of RHIC running weeks will rise from 19 to 29 cryo weeks
 - the number of data weeks will rise from 9 to 22 weeks in FY2003

Current RHIC-related Research Programs

The following RHIC-related research programs are currently active at BNL:

- **RHIC Experiments using Au x Au and polarized proton collisions**

- **BRAHMS** Experiment (2-arm spectrometer with tracking & particle ID)
- **PHOBOS** Experiment (all Si detector with 4π acceptance and magnetic tracking)
- **STAR** Experiment (large TPC in 0.5T B-field with EM calorimetry + partial TOF/particle ID)
- **PHENIX** Experiment (large, multi-function magnetic detector with extensive particle ID)
- **pp2pp** elastic scattering experiment with polarized protons
- integration of RHIC spin physics with **RIKEN BNL Research Center** experimenters

- **Theoretical Nuclear Physics**

- a growing and active nuclear theory group emphasizing HI and spin physics
- close collaboration of BNL NP theorists with the RIKEN BNL Research Center at BNL
- a sponsor and partner in many workshops and topical conferences on theory subjects

- **Accelerator and Detector R&D Program**

- continuing upgrades, improvements and evolution studies in the RHIC-AGS complex
- continuing detector R&D in BNL's Physics and Instrumentation Divisions

RHIC makes news, and physics....

N.Y. Times covers QuarkMatter 2001

THE NEW YORK TIMES, TUESDAY, JANUARY 23, 2001

Trying to Cook a Soup of Free-Range Quarks

Since the first collision event, June 16, 2000
15 Letter-Journal physics articles in print...

BRAHMS: 2 [1 Phys. Rev. Lett.;
1 Phys. Lett.]
PHOBOS: 4 Phys. Rev. Lett.
PHENIX: 3 Phys. Rev. Lett.
STAR: 6 Phys. Rev. Lett.

PHYSICAL REVIEW LETTERS

14 January 2001

Volume 88, Number 2

Abstracts of the Physics Division
Library of Congress Cataloging in Publication

PHENIX High Pt suppression
Data: PRL 88, 022301(2001)
Featured on PRL cover

RHIC Facility Evolution - R&D Program

- **RHIC will operate unchallenged until LHC begins research in FY07/08**
 - there exist no other **Heavy Ion** facilities in the world in the QGP energy regime
 - the RHIC **Polarized Proton** capability is unique for frontier spin physics
- **Continuing upgrades are needed to keep RHIC at the research frontier**
 - AIP funding is expected to provide continuing accelerator complex improvements
 - Facilities Cap. Eqp. Funds will enable continuous improvement of RHIC & RCF
 - Research Cap. Eqp. Funding will enable detector improvements to continue
- **RHIC R&D was supported in the NSAC 'FY 2001 Long Range Plan' Report**
 - RHIC luminosity upgrades of a factor 40 can be foreseen - '**RHIC II**'
 - detector/trigger upgrades can match the increased luminosity capability of RHIC II
 - new detector capabilities to respond to new physics discoveries will be pursued
 - **R&D funding** is essential for success of the long term RHIC Program
 - ***RHIC will be superior for phase-transition studies even after LHC starts***
- **The long-term evolution of RHIC was studied during the LRP process**
 - new or transformed RHIC detectors will be studied as the physics unfolds
 - '**eRHIC**' physics is an attractive direction for future facility evolution

SPIN PHYSICS AT RHIC

Naohito Saito

PHYSICS of RHIC SPIN

– RIKEN and RBRC Activities–

BNL RIKEN Management Steering Committee Meeting
March 11-12, 2002

Naohito Saito
RIKEN / RIKEN BNL Research Center

Spin Physics at RHIC

Measure Spin Asymmetries in pp collision to pin down

- ❑ Spin Structure of the Nucleon
 - Proton Spin Sum Rule
 - Transversity Distributions
- ❑ Spin Dependence of Fundamental Interactions
 - Parity Violating Interaction
 - CP Violation in Quark Sector and Higgs Sector
- ❑ Spin Dependence of Fragmentation
 - E.g. Lambda fragmentation function
- ❑ Spin Dependence in pp elastic scattering

Naohito Saito (RIKEN/ RBRC)

Why Spin Physics?

“Spin” is a fundamental observable.

$\Delta\Sigma = 0.1 \sim 0.2$

Total fraction of the proton spin carried by the quark spin: Scheme dependent.

Proton Spin

Quark Spin Gluon Spin Orbital Motion

$J = \frac{1}{2}$

• *Axial vector* nature is useful in symmetry tests

Versus

• **Parity**

• **Time**

• **Reversal**

	$\mathcal{P}$	$\mathcal{T}$
position	x	$-x$
momentum	p	$-p$
spin	σ	$-\sigma$

RIKEN Naohito Saito (RIKEN/RBRC)

RHIC Achievements

• **Year-1**

- ▣ First Collision of Gold beams at 56 and 130 GeV/A last year
- ▣ 10% of Designed Luminosity achieved
- ▣ Successful Physics Run
- ▣ Successful Spin Commissioning!

• **Year-2**

- ▣ First Collision of Gold beams at 200 GeV/A !!!
 - 42 μb^{-1} delivered & 24 μb^{-1} recorded
 - 170 M events processed
- ▣ First Collision of Polarized Proton Beams at 200 GeV!!!
 - 3.7 Ge events processed
 - 0.15 pb^{-1} recorded

STAR

PHENIX

RIKEN Naohito Saito (RIKEN/RBRC)

PHENIX Detector System

- Inner Detectors:
 - BBC
 - MVD
 - NTC
- Central Arms
 - EMCal
 - Tracking
 - PID
 - RHIC
 - TOF
- Muon Arms
 - South Completed
 - North in construction

Naohito Saito (RIKEN/ RBRC)

PHENIX Run2 Configuration

- Fully equipped Central Arms
 - EMCal
 - Trk Chambers
 - RICH
- Newly installed Muon Arm
 - Muon Tracker
 - Muon Identifier
- New Counter
 - NTC
- EMC-RICH Trigger

Naohito Saito (RIKEN/ RBRC)

RHIC Spin Plan (PHENIX and STAR)				
Year	CM Energy	Weeks	Int. Lum.	Remarks
2001	200 GeV	5	7 pb ⁻¹	Gluon pol. with pions / TT*
2002	200 GeV	8	160 pb ⁻¹	Gluon pol. with direct γ , jets/ TT
	500 GeV	2	90 pb ⁻¹	PV W production, u-quark pol.
2003	200 GeV	8	160 pb ⁻¹	Gluon pol. with γ + jet/ TT
	500 GeV	2	120 pb ⁻¹	First ubar,dbar pol. meas..
2004	500 GeV	8	480 pb ⁻¹	Gluon pol. with γ +jet, γ jet+jet, heavy flavor, ubar, dbar pol.
	200 GeV	2	48 pb ⁻¹	Gluon pol. with γ , γ +jet, heavy flavor/TT
2005	500 GeV	5	300 pb ⁻¹	More statistics
	200 GeV	5	120 pb ⁻¹	
2006	200 GeV	10	210 pb ⁻¹	

* TT Transverse Spin Physics

Naohito Saito (RIKEN/ RBRC)

RIKEN and RBRC Activities	
• PHENIX Muon Arm Doug, Atsushi, Jiro, Hiroki, Mao, Hideyuki, Nobuyuki	
• PHENIX EMCal	
• Analysis of Au-Au Data Sasha, Hisa	
• FEE QA Hisa, Yuji	
• High Energy Beam Test Yuji, Hisa and Naohito	
• PHENIX Trigger	
• EMCal + RICH Matthias, Kensuke	
• Charged Hadron Trigger Yuji and Kensuke	
• MuID Hiroki	
• PHENIX NTC Brendan, Abhay	
• PHENIX CC-J Takashi, Yasushi, Yuji, Satoshi, Osamu	
• PHENIX Spin Monitor Yuji, Hiroki	
• Polarimeter	
• RHIC Polarimeter Kazu, Osamu, Junji, Doug, Gerry and Naohito	
• Local Polarimeter Brendan, Abhay, Yuji, Manabu, Yoshi, Yasushi, Kiyoshi, Gerry, Ken and Naohito	
• Global Analysis of Polarized Data Masanori, Yuji, Naohito, Hideyuki	
• Fragmentation Functions Matthias, Akio

Naohito Saito (RIKEN/ RBRC)

Motivation of Local Polarimeter

Naohito Saito (RIKEN/ RBRC)

Confirm Spin Dynamics in RHIC Ring

- Especially for the operation with *SPIN ROTATORS*
 - Spin Dynamics between Spin Rotators is completely transparent to the rest of accelerator "by design"
- Very important to be ready for Run3, where we use Spin Rotators

Local Polarimeter Test at IP12

Naohito Saito (RIKEN/ RBRC)

Brendan, Abhay, Yoshi, Manabu, Yuji, Kiyoshi, Yasushi, Yousef, Gerry, Ken, Sasha, Naohito

Array of PbWO4

Summary

- First Spin Physics Run was **SUCCESSFUL**
 - Many accomplishments by RIKEN, RBRC, and BNL
- Polarization at AGS has to be improved!!
- Thanks:
 - Advisory Group:
 - T.D. Lee, N. Samios
 - T. Roser, Y. Makdisi, M. Tannenbaum and R.L. Jaffe
 - Strong Supports from Japan
 - RIKEN I. Tanihata and M. Ishihara
 - Kyoto University K. Imai
 - Tokyo Institute of Technology T.-A. Shibata
 - Super Secretaries
 - R. Greenberg, P. Esposito, T. Heinz, and T. Ito
 - N. Kiyama and Y. Kishino
 - Strong Support from ICO
 - H. Horie → C. Shimoyamada
 - T. Noda, M. Yokota, E. Nagahama, M. Funami → S. Asaka
 - Special Support from BNL
 - B. Kirk

RIKEN

Naohito Saito (RIKEN/ RBRC)

RHIC Spin Structure Studies at a Glance

• Δg measurements

process	measure	PHENIX	STAR
$A_{LL}(pp \rightarrow \square(jet)X)$	$\square g \times A_1^p$	yes	yes
$A_{LL}(pp \rightarrow \square X)$	$\square g \times (\square g + \square \square)$	yes	yes
$A_{LL}(pp \rightarrow jet X)$	$\square g \times (\square g + \square \square)$	no	yes
$A_{LL}(pp \rightarrow QQbar X)$	$\square g \times \square g$	yes	no
$A_{LL}(pp \rightarrow J/\psi X)$	$\square g \times \square g$	yes	no
$A_{LL}(pp \rightarrow \square_2 X)$ *	$\square g \times \square g$	yes?	no

• Lepton, Photon, and Hadron

• Rare Process

→ Trigger

• Δq measurements

process	measure	PHENIX	STAR
$A_L(pp \rightarrow W^+ X)$	$\square u, \square dbar$	yes	yes
$A_L(pp \rightarrow W^- X)$	$\square d, \square ubar$	yes	yes
$A_{LL}(pp \rightarrow l^+ l^- X)$	$\square q \times \square qbar$	yes	yes?
$A_L(pp \rightarrow WcX)$ *	$\square s, \square sbar$	yes	yes

• δq measurements

process	measure	PHENIX	STAR
$A_T(pp \rightarrow (\square^+ \square^-)X)$	$\square q \times D$	yes	yes
$A_{TT}(pp \rightarrow l^+ l^- X)$	$\square q \times \square qbar$	yes	yes?
* $A_T(pp \rightarrow \square \square^+ \square^- X)$	$\square q \times D$	yes	yes

* L/E Upgrade desirable

RIKEN Naohito Saito (RIKEN/ RBRC)

BNL RHIC SPIN GROUP

Gerry Bunce

BNL RHIC Spin Group

1. Mission: Develop and lead the spin program at RHIC

---Core group at Brookhaven for the spin program
Develop permanent staff of spin physicists at BNL to lead, develop and participate in the spin program, in collaboration with the RIKEN BNL Research Center (RBRC) and RIKEN staff at Brookhaven.
Members of STAR, PHENIX, PP2PP experiments

2. Proposed to DOE Medium Energy Symons Committee in 1998, received strong support.

3. Group formed starting in 2001:

STAR: Les Bland (from Indiana U.), Sandro Bravar (from COMPASS), Bernd Surrow (from ZEUS, Goldhaber Fellow)

PHENIX: Gerry Bunce (Group Leader)

PP2PP: Wlodek Gryn (Spokesman, PP2PP), Ron Gill, Stephan Bueltmann (from SMC and JLab)

4. Immediate contributions:

Forward π^0 detectors and beam-beam counters for STAR—major contribution to broaden STAR spin program—important measurements this year.

PP2PP experiment installed roman pots, silicon detectors, took data for elastic scattering—major success.

Contributions in collaboration with RBRC on PHENIX and 12 o'clock test, organize and help lead the RHIC spin run.

5. Future:

Expect the group to grow to 4-5 physicists for STAR and PHENIX.

Major responsibilities, in collaboration with RBRC and other groups for

---new AGS CNI polarimeter

---detectors for and polarization measurements with polarized jet target

---spin and heavy ion physics with forward π^0 detectors and STAR TPC

---develop jet detector for PHENIX muon arms with RBRC

---set up local polarimeters for STAR and PHENIX based on forward n

---continue PP2PP measurements with Roman pots

---continue to serve as coordinator/leader of RHIC spin program

6. Collaboration with BNL and RBRC Theorists

We are fortunate to have Werner Vogelsang as a member of RBRC/BNL.

---we have frequent visitor and workshop programs bringing in many important spin theorists who provide many ideas for the program

---it is very important to add one (and later more) spin theorists to the staff at RBRC/BNL to work with Werner and us!

Remarks: the BNL RHIC Spin Group is underway, it already provides new ideas, leadership, and new physics potential to the RHIC spin program. It is modeled after and works in close collaboration with the RIKEN BNL Research Center. And, the first spin run was a great success!

RIKEN CCJ

Takashi Ichihara

RIKEN CCJ

Computing Center in Japan for spin physics at RHIC

T. Ichihara

RIKEN, RBRC

Presented on 11 March 2002
at RIKEN-BNL MSC at RIKEN

Plan and Current Status of RIKEN CCJ

System upgrade in JFY2001

△ Hardware upgrade in JFY 2001

- CPU : 192 ⇒ 330 (total clock 168 GHz → 374 GHz)
- Disk : 9.2 TB ⇒ 25.2 TB
- HPSS Tape Library : 100 TB ⇒ 350 TB (addition of a new silo)

New silo will be installed in the end of March 2002

- Hardware (CPU, Disk, HPSS library etc.) reaches to the designed requirement in the end of March 2002, except for HPSS tape drives.

△ Hardware update plan in JFY 2002

- Tape drive : RedWood drive (4 units) ⇒ 9940B (10 units)
 - Current : RedWood 11.2 MB/s 50 GB/volume : Prod. discontinued
 - 9940B 30 MB/s 200 GB/volumes
- HPSS server :

System Requirement and Achievement of CCJ

Annual Data amount

• DST	150 TB
• micro-DST	45 TB
• Simulated Data	30 TB
• Total	225 TB (380TB)

• CPU (SPECint95)

Simulation	8200
Sim. Reconst	1300
Sim. ana.	170
Theor. Mode	800
Data Analysis	2000

Hierarchical Storage System

- Handle data amount of 225 TB/year
- Tape I/O bandwidth: 112 MB/s (44 TB/s)
- HPSS system

Total	12470 SPECint95 (295 GHz)
	15300 SPECint95 (374 GHz)

Disk storage system

- 20 TB capacity (25 TB-40TB)
- All RAID system
- I/O bandwidth: 520 MB/s (620 MB/s)

• Data Accessibility

- Data Duplication Facility (tape cartridge)
- Wide Area Network (Korea/JAPAN-ESnet)

• Software Environment

- AFS, Objectivity/DB, Batch Queuing System

System requirement

System upgrade in March (the end of March 2002)

CCJ growing history

	c	Mar.99	Jan.00	Jun.00	Dec.00	Jun.01	Nov.01	Mar.02
CPU (unit)	0	16	64	96	160	192	224	330
CPU (GHz)	0	8	34	56	136	168	200	374
Disk (0.1 TB)	0	3	19	35	92	152	212	252
HPSS (TB)	0	100	100	100	100	100	100	350

Components of RIKEN CCJ

CPU Farm of 224 CPUs 5.7 TB Data server 12TB Data servers
 Gigabit Network Switch RAID (SUN E450) RAID (SUN E450)

StorageTek Tape Robot (100TB [250 TB])

HPSS Server (IBM RS-6000/SP)

proposals/plans in CCJ

Simulation

submitted	title	contact	status	resource	webpage
2000/07/11	<u>Gamma experiments of EMCs</u>	T. Sakaguchi	finished		
2000/08/01	<u>CCJ-run02a</u>	N. Hayashi	finished (pisa)	/ccj/w/tmp01	CCJ-run02a
2000/09/13	<u>1997-run02b</u>	N. Hayashi	finished (pisa/DST)	/ccj/w/tmp01	1997-run02b
2000/11/00	<u>CCJ-run03c</u>	N. Hayashi	finished (pisa/DST)	/ccj/w/tmp01	CCJ-run03c
2001/05/10	<u>Run 1-DST</u>	T. Thomas / H.D. Sato	finished	/ccj/w/data06 (650GB)	

Research Plan

submitted	title	contact	status	resource	expiration date
2000/11/14	<u>Test DST production for EMCA</u>	T. Matsunaga	finished	/ccj/w/tmp02 (100GB)	2001/03/31
2001/01/03	<u>Simulation of electron beam transport in the SASE FEL</u>	T. Hachiya	finished	/ccj/w/tmp03 (100GB)	2001/03/31
2001/02/09	<u>Simulation of electron beam transport in the SASE FEL</u>	A. Kpononchi	finished (2001/03/05)	/ccj/w/tmp04 (100GB)	2001/03/31
2001/03/26	<u>Simulation of electron beam transport in the SASE FEL</u>	H. Terai	finished	/ccj/w/data05 (100GB)	2001/04/30
2001/04/23	<u>Simulation of electron beam transport in the SASE FEL</u>	H. Kobayashi / N. Kamihara	finished	/ccj/w/data04 (100GB)	2001/09/30
2001/11/06	<u>Simulation of electron beam transport in the SASE FEL</u>	R. Oyama	in progress	/ccj/w/tmp02 (100GB)	2001/11/30
2001/11/21	<u>Simulation of electron beam transport in the SASE FEL</u>	K. Nomura	in progress	/ccj/w/data07 (300GB)	2001/12/05
2001/11/21	<u>Simulation of electron beam transport in the SASE FEL</u>	Y. Goto	in progress	/ccj/w/data08,12 (2TB) (for pp raw data)	2002/01/31

2001/12/22	<u>Simulation of electron beam transport in the SASE FEL</u>	H. Ohnishi	in progress	/ccj/w/data04 (500GB)	2002/01/31
2002/01/09	<u>Simulation of electron beam transport in the SASE FEL</u>	R. Sato	in progress	/ccj/w/data05,10,15 (5TB) (large raw data)	2002/03/31
2002/01/09	<u>Simulation of electron beam transport in the SASE FEL</u>	T. Sakaguchi	in progress	/ccj/w/data17 (400GB) (for uDST production)	2002/07/31
2002/01/11	<u>Simulation of electron beam transport in the SASE FEL</u>	K. Kato	finished	/ccj/w/data17 (400GB)	2002/01/31
2002/01/17	<u>Simulation of electron beam transport in the SASE FEL</u>	M. Tamai	in progress		2002/02/15
2002/01/18	<u>Simulation of electron beam transport in the SASE FEL</u>	Y. Goto	in progress	/ccj/w/data04 (200GB)	2002/01/31
2002/01/29	<u>Simulation of electron beam transport in the SASE FEL</u>	H. Marui	in progress	/ccj/w/data01 (500GB)	2002/03/31
2002/02/26	<u>Simulation of electron beam transport in the SASE FEL</u>	K. Kato	in progress	/ccj/w/data12 (500GB)	2002/07/31
2002/02/27	<u>Simulation of electron beam transport in the SASE FEL</u>	K. Tachikawa	in progress	/ccj/w/data04 (500GB)	2002/09/31

- 11 research plans were finished and 12 research plans are now in progress
- Several simulations and calibration for RUN 2 is now in progress
- Data transfer of RUN 2 is now in progress

CCJ Operation

Operation, maintenance and development of CC-J are carried out under the charge of the CCJ Planning and Coordination Office (PCO).

CCJ Director (Chief Scientist of the Radiation Lab.)

H. En'yo

Planning and Coordination Office

manager	T. Ichihara	(RIKEN and RBRC)
technical manager	Y. Watanabe	(RIKEN and RBRC)
scientific programming coordinator		
	H. En'yo	(RIKEN and RBRC, PHENIX-EC)
	H. Hamaguchi	(CNS-U-Tokyo, PHENIX-EC)
PHENIX liaison	N. Saito	(RIKEN and RBRC)
computer scientists	S. Yokotaichi	(RIKEN)
	O. Jimmouchi	(RIKEN)
	Y. Goto	(RBRC)
	S. Sawada	(KEK)

Technical Management Office

Manager, Data duplication	Y. Watanabe	(RIKEN and RBRC)
System engineer	N. Ohno (IBM Japan)	
Tape duplication operator	(TBD)	

Maintenance and Operation cost

in k Yen

HPSS Operation and Maintenance

• HPSS software	29,600
• HPSS Hardware maint.	11,200
• HPSS System Engineer	25,200
HPSS subtotal	66,000

Data Server Maintenance

• Sun Hardware E450x6	4,000
• Sun Software (Solaris)	2,000
• RAID Hardware (24TB)	9,000
• Network switch	2,000
• UPS maintenance	1,800
Data Servers subtotal	18,800

CPU farm Maintenance

• Alta cluster (256 CPU)	9,600
• 1u CPU (72 CPU)	1,400
• LSF software (328 CPU)	4,500
CPU farm subtotal	15,500

Data Duplication at BNL

• Hardware maint (sun&ibm)	2,600
• Operator for tape duplication	11,000
Data Duplication subtotal	13,600

Tape cartridge

• 2000 volumes (100TB)	24,000
Tape cartridge subtotal	24,000

Maintenance and Operation cost

Total	137,900
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Upgrade cost in 2002	53,000
(tape drives, HPSS server)	

Grand total in JFY2002

190,900

RBRC OPERATION-THEORY GROUP

T. D. Lee

RBRC Theory Group

(February 2001 – March 2002)

T. D. Lee

Presentation

**8th Meeting of The Management Steering Committee of
RIKEN BNL Collaboration**

**RIKEN, Wako, Saitama, Japan
March 11-12, 2002**

T. D. Lee, RBRC Director
N. P. Samios, RBRC Deputy Director
Hideto En'yo, RBRC Associate Director

* * * *

RBRC Research Scientists (2001 – 2002)

Theory Group

T.D. Lee, Group Leader

Anthony Baltz, Deputy Group Leader

Research Associates

(Post Docs)

Aoki, Y.
Itakura, K.
Nara, Y.
Nemoto, Y.
Noaki, J.
Orginos, K.
Ikeda, Takashi (4/1/02)

Advisory Committee

Baltz, A.
Creutz, M.
Gyulassy, M.
McLerran, L.
Pisarski, R.

Fellows

Blum, T.
Dawson, C.
Vogelsang, W.

Consultants/

Visiting Scientists

Gyulassy, M.
Jaffe, R.
Ohta, S.
Shuryak, E.

Tenure Track/RHIC Fellows

Bass, S.	(Duke)
Kusenko, A.	(UCLA)
Jeon, S.	(McGill)
Schaefer, T.	(SUNY, SB)
Stephanov, M.	(U. of IL, Chicago)
van Kolck, U.	(Arizona)
Venugopalan, R.	(BNL)
Wettig, T.	(Yale)

Collaborators/

Associates

Mawhinney, R.

Computer Scientist

Dong, Z.

Boer, D. (Post Doc—left 6/27/01)

Schaffner-Bielich, J. (Post Doc—10/31/01)

Bödeker, D. (RHIC Physics Fellow, BNL—12/31/01)

Son, D. T. (RHIC Physics Fellow, Columbia—3/31/02)

RHIC Physics Fellow (established in '99)

RBRC Graduates

Name	Dates at RBRC	RBRC Position	New Position Title	New Position Institution
Bödeker, Dietrich	12/2000 to 12/2001	RHIC Physics Fellow, BNL	Professorship, C-4	U. of Bielefeld, Germany
Boer, Daniël	10/1998 to 06/2001	Research Associate	Academy Researcher, Tenure Track	Dutch Royal Academy of Sciences, Free University, Amsterdam
Fujii, Hirotugu	09/1997 to 09/1999	Research Associate	Assistant Professor	U. of Tokyo, Komaba, Inst. of Physics
Kharzeev, Dmitri	08/1997 to 09/1999 10/1999 to 03/2000	RIKEN BNL Fellow RHIC Physics Fellow, BNL	Physicist, Tenured Staff	BNL
Kurita, Kazuyoshi	[04/1997 to 09/1997 10/1997 to 03/2000] 04/2000 to 03/2002	[Postdoc. Res. RIKEN Special Postdoc Res., RIKEN] RIKEN BNL Fellow	Associate Professor	Rikkyo University, Tokyo
Nara, Yasushi	10/1999 to 09/2002	Research Associate	Research Associate	U. of Arizona, Tucson
Rischke, Dirk	09/1997 to 09/2000 10/2000 to 01/2001	RIKEN BNL Fellow RHIC Physics Fellow, BNL	Professorship, C-4	Inst. f. Theor. Phys. J.W. Goethe-Univ. Frankfurt, Germany
Saito, Naohito	[04/1995 to 03/1996] 04/1996 to 03/2001 04/2001 to 03/2002	[RIKEN Special Postdoc. Fellow] RIKEN/RBRC Res. RIKEN Spin Prog. Res.	Associate Professor	Kyoto U., Japan
Sasaki, Shoichi	09/1998 to 09/2000	Research Associate	Assistant Professor	U. of Tokyo, Japan
Schaffner-Bielich, Jürgen	09/1998 to 10/2001	Research Associate	Research Associate	Columbia University
Son, Dam Thanh	10/1999 to 03/2002	RHIC Physics Fellow, Columbia U.	Tenured Position	U. of Washington, Seattle, Natl. Inst. for Nuclear Theory
Wingate, Matthew	09/1997 to 09/2000	Research Associate	Assistant Professor	Ohio State U., Columbus
Yasui, Yoshiaki	09/1997 to 09/2000	Research Associate	Appointment Title?	Radiation Lab, RIKEN, KEK, Theory Group, Japan

publication list (theory)

RBRC 1 - RBRC 31

at the first Anniversary Celebrations

October 16, 1998

RBRC 32 - RBRC 54

at the 4th Management Steering
Committee Meeting, February 28, 1999

RBRC 55 - RBRC 81

at the 5th Management Steering
Committee Meeting, January 27, 2000

RBRC 82 - RBRC 174

at the 7th Management Steering
Committee Meeting, February 13, 2001

RBRC 175 - RBRC 246

at the 8th Management Steering
Committee Meeting, March 11

Since the RBRC Scientific Review Committee Meeting November 29-30, 2001

RBRC/#

232. Ania Kulesza, George Sterman, Werner Vogelsang, "Joint Resummation in Electroweak Boson Production," [hep-ph/0202251] Phys. Rev. D (submitted).
233. Y. Aoki, T. Blum, N. Christ, C. Cristian, C. Dawson, T. Izubuchi, R. Mawhinney, G. Liu, S. Ohta, K. Orginos, A. Soni, and L. Wu [RBC Collaboration], "Chiral Properties of Domain Wall Fermions with Improved Gauge Actions," Phys. Rev. D (to be submitted).
234. Thomas Schaefer, "Instanton Effects in QCD at High Baryon Density," [hep-ph/0201189] SUNY-NG-02-01, 26 pp., January 2002.
235. Thomas Schaefer, "Superdense Matter," [nucl-th/0201031] Talk presented at the International Conference on Physics and Astrophysics of Quark-Gluon Plasma (ICPAQGP 2001), Jaipur, India, November 26-30, 2001; Pramana (submitted).
236. Anthony Baltz, "Probing an Extended Region of Δm^2 with Rapidly Oscillating ^7Be Solar Neutrinos, Phys. Rev. D 65, 053005 (2002).
237. B. Schlittgen and T. Wettig, "Color-Flavor Transformation for the Special Unitary Group," [hep-lat/0111039], Nucl. Phys. B (to be published).
238. Steffen A. Bass, "Strangeness Production in Microscopic Transport Models," [nucl-th/0112046], J. Phys. G (in press).
239. Sven Soff, Steffen A. Bass, David H. Hardtke and Sergey Y. Panitkin, "(Strange) Meson Interferometry at RHIC," [nucl-th/0202019], J. Phys. G (in press).
240. M. Bleicher, F.M. Liu, A. Keranen, J. Aichelin, S.A. Bass, F. Becattini, K. Redlich, and K. Werner, "Overpopulation of Anti-Omega in pp Collisions: A Way to Distinguish Statistical Hadronization from String Dynamics," [hep-ph/0111187], Phys. Rev. Lett. (submitted).
241. Steffen A. Bass, "QGP Theory: Status and Perspectives," [nucl-th/0202010], Pramana (in press).

242. A. Ohnishi, Y. Hirata, Y. Nara, S. Shinmura, and Y. Akaishi, "Lambda, Lambda Correlation in K^-K^+ Reaction: Is There A Virtual Pole?" Nucl. Phys. A 691, 242 (2001).

243. Y. Hirata, A. Ohnishi, Y. Nara, T. Kido, T. Maruyama, N. Otuka, K. Niita, H. Takada, S. Chiba, "Sideward Peak of Intermediate Mass Fragments in High Energy Proton Induced Reactions," [nucl-th/0111019], Nucl. Phys. A. (accepted).

244. S. Cheng, Scott Pratt, Peter Csizmadia, Yasushi Nara, Denes Molnar, Miklos Gyulassy, Stephen E. Vance, Bin Zhang, "The Effect of Finite-range Interactions in Classical Transport Theory," Phys. Rev. C 65, 024901 (2002).

245. N. Otuka, P. K. Sahu, M. Isse, Y. Nara, A. Ohnishi, "Re-hardening of Hadron Transverse Spectra in Relativistic Heavy Ion Collisions," [nucl-th/0102051], Poster Presentation given at *15th International Conference on Ultrarelativistic Nucleus-Nucleus Collisions (QM2001)*, Stony Brook, New York, 15-20 Jan 2001; Nucl. Physics A (submitted).

246. Se-yong Kim, Shigemi Ohta, "Zero Temperature Phase Structure of Multiflavor QCD," [hep-lat/0111040], Presented at *19th International Symposium on Lattice Field Theory (LATTICE 2001)*, Berlin, Germany, 19-24 August 2001; Nucl. Phys. Proc. Suppl. 106, 873-875 (2002); Berlin 2001, Lattice Field Theory, 873-875 (2002).

Weekly Seminars

Spin Physics (<i>Theory & Exp</i>)	Tuesdays (10:00 a.m.)	Organized by Y. Goto and W. Vogelsang
Nuclear Physics	Tuesdays (11:00 a.m.)	Organized jointly with BNL Staff
High Energy-RIKEN Theory	Wednesdays (1:30 p.m.)	Organized jointly with BNL Theorists
QCD and RHIC Physics (<i>Theory & Exp</i>)	Thursdays (12:30 p.m.)	Organized by C. Dawson
High Energy Theory Lunch Talks	Fridays (12:00 Noon)	Organized by S. Dawson
Nuclear Physics-RIKEN Theory	Fridays (2:00 p.m.)	Organized jointly with BNL Staff

RBRC Workshop Proceedings

- Volume 32 RHIC Spin Physics V (BNL 52628)
February 21, 2001
Organizing Committee: Gerry Bunce, Naohito Saito, Steve Vigdor, Thomas Roser,
Hal Spinka, Hideto En'yo, Leslie C. Bland, Wlodek Guryn
- Volume 33 Spin Physics At RHIC in Year-1 and Beyond (BNL-52635)
May 14-18, 2001
Organizing Committee: Leslie Bland, Daniël Boer, Naohito Saito,
Werner Vogelsang
- Volume 34 High Energy QCD: Beyond the Pomeron (BNL-52641)
May 21-25, 2001
Organizing Committee: John Dainton, Wlodek Guryn, Dmitri Kharzeev, and
Yuri Kovchegov
- Volume 35 RIKEN Winter School, Quarks, Hadrons and Nuclei-QCD Hard Processes and the
Nucleon Spin (BNL 52643)
December 1-5, 2000, RIKEN, Japan
Organizers: N. Saito, T.-A. Shibata, and K. Yazaki
- Volume 36 RHIC Spin Collaboration Meeting VI (BNL-52642)
October 1, 2001
Organizers: Les Bland and Naohito Saito

- Volume 37 RHIC Spin Collaboration Meeting VI (Part 2) (In preparation)
November 15, 2001
Organizers: Les Bland and Naohito Saito
- Volume 38 RBRC Scientific Review Committee Meeting (BNL-52649)
November 29-30, 2001
Organizers: T. D. Lee and N. P. Samios

RBRC Workshops in 2002

- Date:** January 13 to April 19, 2002
Title: RBRC Workshop on Theory Studies for RHIC-Spin
Organizer: Werner Vogelsang
The aim of this workshop is to attract several spin theorists to the Center for longer stays of about 4 weeks (to promote closer collaborations between theorists and experimentalists for RHIC spin).
Participants include: Jianwei Qiu (Iowa State U)
Mauro Anselmino (University and INFN, Torino, Italy)
Umberto d'Alesio (INFN, Torino)
Jiro Kodaira (Hiroshima U.)
Students: Michhiro Hori (Hiroshima U.)
Hiroshi Yokoya (Hiroshima U.)
Marco Stratmann (U. of Regensburg, Germany)
- Date:** February 22, 2002
Title: RHIC Spin Collaboration Meeting VII
Organizer(s): Brendan Fox
- Date:** March 18-22, 2002
Title: RBRC Workshop on Hadron Structure from Lattice QCD
Organizers: Thomas Blum, Daniël Boer, Michael Creutz, Shigemi Ohta, Kostas Orginos
- Date:** March 28-30, 2002
Title: Baryon Dynamics at RHIC
Organizers: Nu Yu (LBL), Miklos Gyulassy (Columbia), Dmitri Kharzeev (BNL)

Other RBRC Scientific Articles Proceedings Volumes:

Volume 1 Prospects for Spin Physics at RHIC

**Gerry Bunce, Naohito Saito, Jacques Soffer, Werner Vogelsang
July 2000**

Volume 2 Status Report on the Calculation of ϵ'/ϵ

**RBRC-Brookhaven-Columbia Collaboration
November 2000**

Volume 3 Scientific Presentations: 7th Meeting of the Management

**Steering Committee of the RIKEN BNL Collaboration, RIKEN,
Wako, Japan, February 13-14, 2001.**

Volume 4-CP Violation in K Decay From Lattice QCD

**Thomas Blum and Robert Mawhinney
RBRC-Brookhaven-Columbia QCDSF Collaboration
July 26, 2001**

- Outstanding Junior Investigator Award

In Nuclear Theory - 2001, the two

OJI selected by U. S. DOE are

both RBR C members:

M. Stephaan

U. van Kolck

- Both Stephaan and Van Kolck are

also awarded the prestigious

Alfred Sloan Fellowship in 2002.

Institute for Nuclear Theory, U. of Wash.
Lattice QCD and Hadron Phenomenology
9/24 - 12/7 / 2001

RBRC invitees: Y. Aoki, C. Dawson,
K. Itakura, J. Noaki & K. Orginos

Institute for Theoretical Physics, Santa Barbara
QCD and Gauge Theory Dynamics in the
RHIC Era

4/1 / 02 - 6/28 / 02

RBRC invitees: S. Bass, T. Blum,
T. Schaefer, D. Son, M. Stephanov,
R. Venugopalan

D. Khazeev, formerly a RBRC Fellow
is one of the organizers

Outstanding Theory Contributions

I. Cold dense quark matter :

1. Dam Son , Misha Stephanov + Dirk Rischke
on color superconductivity + confinement
2. T. Schaefer on color - flavor - locked
condensate

II RHIC process :

1. Raju Venugopalan , Yasushi Nara (with
L. McLerran) on color glass condensate
2. QCD Plasma by Dietrich Bodecker

III Spin structure fn analysis by Werner Vogelsang

IV. Dark matter analysis by Alexander Kusenko , ... etc.

RBRC – QCDSPP

Percent of Uptime

RBRC-BNL-CU (RBC) Collaboration

February 2002

- **RIKEN-BNL Research Center:**

Visiting Faculty: Shigemi Ohta (KEK)

Fellows: Tom Blum, Chris Dawson

Postdoc: Yasumichi Aoki, Jun-Ichi Noaki,
Yukio Nemoto, Kostas Orginos,

Former Postdoc: Shoichi Sasaki, Matt Wingate

- **BNL:**

Faculty: Mike Creutz, Amarjit Soni

Visiting Faculty: Taku Izubuchi (Kanazawa)

Postdoc: Saša Prelovšek

- **Columbia:**

Faculty: Norman Christ, Robert Mawhinney

Postdoc: Thomas Manke, Azusa Yamaguchi

Student: Calin Cristian, Changhoan Kim,
Xiaodong Liao, Ludmila Levkova, Guofeng
Liu

- **Columbia/BNL:**

Postdoc: Chulwoo Jung (SciDAC)

Major Achievements from QCOSP (2001 - 2002)

1. Massive Domain Wall Fermion Lattice Calculations (to maintain chiral sym.) *
2. Completion of the First Calculation on $\Delta I = \frac{1}{2}$ rule and ϵ'/ϵ in Kaon Decay (in the quenched approx.) *
3. Discovery of the Highly Effective DBW II Lattice Action
4. Testing G_A/G_V in β -decay (Gateway to First Principle Calculations on Spin Structure Functions)
5. First Anisotropic Lattice Calculation on QCD Phase Transition Diagram

* Also by CP-PAC

chiral symmetry

$$\text{chirality} = \vec{\sigma} \cdot \hat{p} \quad (\text{or } \Gamma_5)$$

-1

left hand

+1

right hand

Chirality is a good (exact) quantum no.
only for a zero mass particle

The Goldstone - Nambu boson of a
chiral sym. vacuum = a zero mass pion

(quark)

- Chirality can be an approx. quantum no. for a theory with nonzero, but small, mass particles (quarks)

$$\therefore E = \sqrt{p^2 + m^2} \approx p \quad \text{if } p \gg m$$

$$\therefore \boxed{m_{\text{pion}}^2 = 0 \quad \text{if } m_{\text{quark}} = 0}$$

RIKEN BNL Research Center

CP VIOLATION IN K DECAY FROM LATTICE QCD

**Thomas Blum and Robert Mawhinney
RBRC-Brookhaven-Columbia QCDSP Collaboration**

July 26, 2001

RBRC Scientific Articles

Volume 4

Building 510A, Brookhaven National Laboratory, Upton, N.Y. 11973-5000, USA

Comparison with Experimental Results

Quantity	Experiment	This calculation
$\text{Re } A_0(\text{GeV})$	3.33×10^{-7}	$3.26(19) \times 10^{-7}$
$\text{Re } A_2(\text{GeV})$	1.50×10^{-8}	$1.279(57) \times 10^{-8}$
$\frac{A_{\text{exp}}(K \rightarrow 2\pi)_{I=0}}{I=0} \omega$	22.2	25.5(57)
$\frac{A_{\text{exp}}(K \rightarrow 2\pi)_{I=2}}{I=2} \text{Re } (\epsilon'/\epsilon)$	$15.3(26) \times 10^{-4} \text{ (NA48)}$	$-4.4(24) \times 10^{-4}$
	$20.7(28) \times 10^{-4} \text{ (KTev)}$	

$$\frac{\frac{A_{\text{th}}(K_L^0 \rightarrow \pi^+\pi^-)}{v(K_S^0 \rightarrow \pi^+\pi^-)}}{\frac{A_{\text{th}}(K_L^0 \rightarrow \pi^+\pi^-)}{v(K_S^0 \rightarrow \pi^+\pi^-)}} = \left| \frac{\epsilon + \epsilon'}{\epsilon - 2\epsilon'} \right|^2 \approx 1 + 6 \text{Re}(\epsilon'/\epsilon)$$

Nucleon Matrix Element

- confirming $G_V = 1$ and $Z_A = Z_V$
- testing $G_A/G_V = 1.26$?

goal

evaluating all spin structure

functions from lattice QCD

β -decay

Nucleon axial vector coupling

(Feb. 2001)

charged weak current $V_A - A_A$

⇒ $G_A/G_V = 0.63(14)$ by linear extrapolation to $m=0$

⇒ Also get $\Delta u/G_V = 0.50(14)$ and $\Delta d/G_V = -0.15(7)$

(RBC) S. Sasaki

Nucleon g_A

- Measured with DBW2 gauge actions with $a^{-1} \sim 1.3$ GeV.
- Two volumes: $8^3 \times 24$ and $16^3 \times 32$.
- Blum, Sasaki, Ohta

Evidence for finite volume effects, but better statistics required.

Objective

Minimize Chiral Symmetry breaking in the space of Gauge Actions.

Actions Tested:

- Wilson: $S_g = \frac{\beta}{3} \text{Re Tr} \langle 1 - \square \rangle$

- One loop Symanzik:

$$S_g = \frac{\beta}{3} \text{Re Tr} \left[c_0 \langle 1 - \square \rangle + 2c_1 \langle 1 - \text{rectangle} \rangle + \frac{4}{3} c_2 \langle 1 - \text{pentagon} \rangle \right]$$

c_i computed by 1-loop tadpole improved perturbation theory.

[Lüscher & Weisz Phys.Lett. B158 (1985)]

[Alford et.al. Phys.Lett. B361 (1995)]

- Iwasaki:

$$S_g = \frac{\beta}{3} \text{Re Tr} \left[(1 - 8c_1) \langle 1 - \square \rangle + 2c_1 \langle 1 - \text{rectangle} \rangle \right]$$

With $c_1 = -0.331$ computed by perturbative RG blocking.

[Iwasaki (1983)]

- DBW2: Same as Iwasaki but $c_1 = -1.4067$ computed non-perturbatively by RG blocking.

[Takaishi Phys.Rev. D54 (1996)]

K. Orginos, Y. Aoki
(2001)

^{full}
 domain fermion
 (full chiral symmetry ^q with dynamic fermion)
 and $L_s \rightarrow \infty$

1/n quenched approx. $m_\pi^2 = 0$ if $m_f + m_{ho} = 0$

fluctuations in m_{res} are due (largely) to zero-modes
 & near zero modes

$16^3 \times 32$ $\beta = 6.0$ $L_s = 16$
 (Wilam)

RBC - QCDSF

Domain Wall Fermion

$$m_{res} \approx +8 \text{ MeV}$$

$$16^3 \times 32 \quad \beta = 6.0 \quad L_5 = 48 \quad (\text{Wilson})$$

RBC - QCD 5P

(2001)

used in ϵ'/ϵ calculation

Residual Mass for Quenched QCD

Which gauge action gives the smallest m_{res} ?

Compare Wilson and DBW2 gauge actions for lattice spacing $a \sim 0.1$ fermi. (K. Orginos, Y. Aoki)

DBW2 shows marked improvement

For $L_s = 16$, DBW2 m_{res} is 100 times smaller.

02-20-02:4

Anisotropic Staggered Thermodynamics

1. Keep a_s fixed and a_t fixed. Vary N_t to vary temperature. Levkova, Manke
2. $N_t = 4, 8, 12, 16, 24, 28$ and 64 .

Only temperature varies through transition, nothing else.

The phase transition

$$\xi = \text{anisotropy} = a_s / a_T$$

02-20-02:8

Progress in Lattice Gauge Theory

Staggered and Wilson fermions

- $T = 0$ and $T \neq 0$ lattice QCD being investigated
- Large scale simulations by CP-PACS, CU, JLQCD, MILC, RBC, UKQCD, APE/ROME, QCDSF,
- Formulation breaks chiral and/or flavor symmetry

Domain wall fermions

- Full flavor and chiral symmetry ($L_s \rightarrow \infty$)

	Quenched QCD	QCD
$T = 0$	Chiral limit $\left. \begin{array}{l} \text{(RBC)} \\ \text{(CP-PACS)} \end{array} \right\}$ NPR (RBC) Spectrum $\left. \begin{array}{l} \text{(RBC)} \\ \text{(CP-PACS)} \end{array} \right\}$ $B_K, \epsilon'/\epsilon$	Spectrum (RBC) Residual mass (RBC) Improved algorithms (RBC)
$T \neq 0$		T_c (RBC) $U_A(1)$ breaking (RBC)

Future Projects

With Domain Wall Fermions

1. Full QCD with DWF
 - Improve action, allowing smaller L_s
 - Lay groundwork for 10 Teraflops QCDOC.
2. Quenched studies of $K \rightarrow \pi\pi$ physics
 - Use DBW2 and smaller lattice spacing.
 - Check systematic effects in calculations
3. g_A and nucleon spin matrix elements with DBW2.

With Anisotropic Lattices

1. Extend anisotropic thermodynamics to DWF
2. Heavy quark physics
 - Heavy-heavy spectrum calculated
 - Extended to other heavy quark physics

QCDOC status

- **ASIC Design:**
 - All major components complete
 - Large scale simulation using QCD code with communications ongoing
 - Physical chip layout underway at chip vendor
- **Prototype chips delivered this summer**
- **Board and cabinet design started**
- **2 Teraflops machine available toward end of JFY02**
- **10 Teraflops machine in JFY03**

Schedule for QCDOC Design and Construction

ID	Task Name	Q1 '02	Q2 '02	Q3 '02	Q4 '02	Q1 '03	Q2 '03	Q3 '03	Q4 '03	Q1 '04
1	Develop Architecture									
4	Design ASIC chip									
18	IBM ASIC Support									
26	Design printed circuit boards									
33	QCD ASIC Evaluation/Test Software									
36	OS Software, Level I									
39	OS Software, Level II									
42	Physics Applications Software									
43	Construction of Prototype									
58	Phase I Construction (Columbia)									
59	Construction of 8-MBD Machine									
66	Construction of 32-MBD Machine									
75	Phase II Construction (RBRC)									

RBRC OPERATION-EXPERIMENT

Hideto En'yo

RBRC Experimental Group

Activity Summary from
organizational point of view.

Hideto En'yo

Executive summary of the run2

- Excellent achievement as the 1st year of polarized proton collision
- Still need significant progress in Polarization and Luminosity. *Important addition will be the AGS snake.*
- RBRC/RIKEN personnel exhibited great jobs

Member of RBRC experiment '01

RBRC

Group Leaders:

- Hideto Enyo (Wako)
- Gerry Bunce(deputy)

Fellows/Postdoc

- Matthias Grosse Perdekamp
- Abhay L Deshpande
- Brendan Fox
- Yuji Goto
- Kazuyoshi Kurita
- Douglas Fields (New Mexico)
- Alexander Bazilevsky

22 active members

RIKEN Spin Program

Tenure researcher

- Naohito Saito
- Atsushi Taketani
- Takashi Ichihara (WakoCCJ)
- Yasushi Watanabe(WakoCCJ)

Postdoc

- Satoshi Yokkaichi(WakoCCJ)
- Hideyuki Kobayashi
- Jiro Murata (Wako)
- Kensuke Okada (June)
- Osamu Jin-nouchi (April)

Students

- Hisa Torii
- Junji Tojo
- Hiroki Sato

Graduations from RBRC/RIKEN

- Naohito Saito; to Kyoto Univ. Asc. Prof. 1st April '02
- Kazu Kurita; to Rikkyo Univ. Asc. Prof. 1st April '02
- Yuji Goto; becomes RIKEN tenure, 1st April '02
- Jiro Murata; became RIKEN tenure, July '01
- Matthias Perdekamp; RBRC joint appointment with Illinois Univ. Mid of 2002.

- Results of good performance of this project.
- We miss them, but we will be paid back more in a few years of scale.
- Extending our Empire.

Polarimetry

one of the important area charged for RBRC
personnel

- ✧ CNI-pol: served excellently well through the runs.
 - ✧ started with Junji Tojo's pioneering work
 - ✧ built in RHIC by Kazu Kurita
 - ✧ Osamu Jinnouchi (new RIKEN postdoc) takes it over.
- ✧ Local Polarimeter (12O'clock) gave us a surprising gift
 - ✧ Started with Yuji Goto's initiative
 - ✧ Abhay, Brendan for detector construction and setup
 - ✧ New Kyoto students will finalize the result

Central Arm(electrons and photons)

- Trigger for spin: excellent achievement
 - ✧ Yuji Goto's initiative
 - ✧ Matthias G. Perdekamp realized the trigger
 - ✧ Kensuke Okada (new RIKEN postdoc) takes it over
- Analysis
 - ✧ Sasha Bazilevsky readings the analysis efforts
 - ✧ Hisa Torii will finish his thesis in 2002

Muon Arm

South Muon Arm: well commissioned,

- Doug E. Fields + Hideyuki Kobayashi in Tracking
- Atsushi Taketani + Hiroki Sato in Identifier
- Hiroki Sato will finish his thesis in 2002. This will be the first thesis from PHENIX-SPIN
- New Student from T.I.Tech expected

Belle Activity initiated (Electron Positron Collider in KEK)

Belle can provide us vital input for the transversity study in *RHIC spin experiment*.

RBRC is now the member of Belle Collaboration

- Matthias Perdekamp leading the project
- Akio Ogawa and Soeren Lange (both are not in PHENIX) have joined with newly established "RBRC visiting scientist" scheme
- New postdoc to be assigned
- New student from Heidelberg is expected.

Wako activity

- CCI: almost reached to the full scale. Spin analysis is about to start.
 - Akio Kiyomichi will join us as a RIKEN postdoc
- PHENIX detector Upgrade (silicon tracker):
 - New tenure Researcher in Radiation Lab, Kiyoshi Tanida started from October 1st to be charged for the electronics development and the support structure
 - Silicon pixel detector developments with CERN ALICE/NA60
 - Hiroaki Ohnishi (BNL) 1st Jan. '02
 - Johann Heuser (SUNY) 1st April '02
 - Rykov Vladimir (Wayn State U) 1st May '02
 - Si-Strip R&D with BNL instrumentation division (Z. Li); Yuji Goto is in charge in RBRC side.

Major events

- RBRC Visiting Researcher (unpaid) is established
 - Analysis Proposal to Belle in KEK (Spin in Fragmentation)
 - M.G.Perdekamp (RBRC, Contact person for BELLE)
 - Soeren Lange (Frankfurt, STAR)
 - Akio Ogawa (Penn State U, STAR)
 - New postdoc for Belle (seeking)
 - Si tracker development (will soon be established in RBRC with the BNL instrumentation division)
 - This is also a contract of RIKEN (trip etc can be supported)
 - RBRC Theory is also using this framework

Major events

- Special Doctoral Fellow Ship of RIKEN (For Japanese only) is open through RBRC and Radiation Lab in Wako.
 - From April 1st. Takahiro. Kawabata (Kyoto-U) and Junji.Tojo (Kyoto-U , currently RBRC student) will start with RBRC experimental group. Takashi Ikeda (U-Tokyo) will start with RBRC theory group
- Junior Research Associate of RIKEN is called through RBRC exp+theory and Radiation Lab.(for Japanese only)
 - Yoshitaka Hatta will join the RBRC theory Group
- Scheme for wider student support (also for non-Japanese) is under development.

Experiment G. Organization JFY02

BELLE

Soeren Lange (Visitor)
Akio Ogawa (Visitor)
New postdoc

RBRC

Hideto Enyo (@Wako)
Gerry Bunce
Matthias Grosse Perdekamp
Abhay L. Deshpande
Brendan Fox
Douglas E. Field
Alexander Bazilevsky

RBRC STUDENT

Hisa Torii
Hiroki Sato
Nobuyuki Kamihara
Manabu Togawa
+more ?

New appointments;
selection on going

~30 active member
+~3 active visitors

UPGRADE

Kiyoshi Tanida
Hiroaki Ohnishi
Johann Hauser
Rykov Vladimir

RIKEN/RBRC

Naohito Saito(Visitor)
Yuji Goto
Atsushi Taketani
Hideyuki Kobayashi
Kensuke Okada
Osamu Jin-nouchi
T. Kawabata
J. Tojo

WAKO/CCJ

Takashi Ichihara
Yasushi Watanabe
Satoshi Yokkaichi
Akio Kiyomichi

3rd RIKEN Winter School on QCD

'Quark-Gluon Structure of the Nucleon and QCD'

➤ will be held at the end of this month at
Wako Campus for 3 days

■ Lectures by

Soper 'Basics of QCD Perturbation Theory' ,

Oka 'Properties of Hadrons in Non-Perturbative
QCD'

Hatsuda 'Introduction to Hot and Dense QCD'

+ 6 short lectures

■ More than 50 (Japanese) students !

Our future relays on the young generation

Special Thanks to
Administrative Staffs
in BNL and Wako

Especially to M.Yokota and H.Horie

RBRC OPERATION-EXPERIMENT

Gerry Bunce

RBRC Experimental Group---a few remarks

Much to be proud of !

RBRC Workshops led to coordinated plan between experiments and accelerator which resulted in the September 2000 commissioning and the December 2001-January 2002 first spin run.

RBRC, with important collaborators, led the new RHIC polarimeter development and realization. These devices were invented for RHIC and work beautifully, measuring the polarization to 2% in one minute.

RBRC initiated and led design and realization of high rate event selection for spin for PHENIX. These triggers worked beautifully, increasing the number of events by x100 over min-bias.

RBRC designed and built additional beam-beam counters for pp for PHENIX. These worked well.

RBRC designed special electronics to keep track of luminosity for each crossing for PHENIX. This is necessary for spin and worked.

RBRC designed, built, calibrated (at Stanford), installed a photon detector for very forward polarization measurements. This worked and we observed very large online spin asymmetry for neutrons.

RBRC and collaborators led triggering for the PHENIX muon arm, and we expect to have cross sections and spin asymmetries for forward muons and pions. This was very successful.

RIKEN funded the Siberian Snakes for RHIC. This was a great success—the first time Snakes were used at high energy.

We took the first data ever at $\sqrt{s}=200$ GeV with colliding polarized protons, providing our first look at the spin structure of the proton using quark and gluon probes. We have beautiful data, and our sensitivity to transverse spin effects is 10x better than previous experiments, and at 10x the energy.

And, we should be very proud of our graduating class:

Naohito Saito, Kazu Kurita, Matthias Perdekamp, Yuji Goto

as well as our present members.

FUTURE PERSPECTIVES—RHIC LONG RANGE PERSPECTIVES

Thomas B. W. Kirk

RHIC Long Range Perspectives

**Presented to the
Management Steering Committee
of the
Riken - BNL Collaboration**

**by
Thomas B.W. Kirk
Associate Laboratory Director
HENP**

**Wako, Japan
March 11, 2002**

**US Department of Energy
Brookhaven Science Associates**

BROOKHAVEN
NATIONAL LABORATORY

Major New Accelerator Initiatives

- **RHIC Luminosity Upgrade (RHIC II) [NP]**
 - RHIC luminosity upgrade 'White Paper' for NP LRP completed
 - RHIC beam cooling at colliding energy
- **Electron-(Heavy Ion, Pol. Proton) Collider (EIC) [NP]**
 - 'White paper' for NP LRP completed
 - RHIC beam cooling R&D
- **Neutrino factory or superbeam [HEP]**
 - Design for 1- 4 MW AGS upgrade completed (MC study II):
 - 1.2-1.5 GeV Superconducting Proton Linac
 - 2.5 - 5 Hz AGS Repetition Rate
 - CAP study for neutrino superbeam from AGS underway

Laboratory Initiative - RHIC II

• Motivation

- collider programs require **periodic upgrades to stay at the frontier**
- 'rare' processes will enhance physics reach with more luminosity
- RHIC collider has already identified clear luminosity upgrade paths
- DOE and BNL mutually plan on this evolution path for RHIC

• Scope & Timing

- accelerator project scope is x40 luminosity increase
- detector upgrades meet higher luminosity & address rare processes
- planning for the RHIC upgrades began with '01 **NP Long Range Study**
- RHIC II Construction Project transpires over the period FY 05 - 11

• Cost

- accelerator upgrades \$54M; detector upgrades \$80M; TEC = \$134M
- no *new* detectors included but may be needed (cost scale >\$50M)

• Scientific Benefits

- **expansion of physics** in the RHIC facility $\Leftrightarrow$ **rare processes**
- extend detector capabilities $\Leftrightarrow$ **explore new phenomena in H1 events**

The RHIC Electron Beam Cooler

Courtesy Thomas Roser, BNL C-A Dept.

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R&D issues:

High intensity photocathode electron gun

High efficiency energy recovering SC linac with magnetized electron beam

Efficient electron beam transport and debunching/bunching

High precision (10 ppm) solenoid for 30 m cooling section.

Laboratory Initiative - eRHIC

• Motivation

- extends and leverages an existing major NP facility for new physics
- exploits existing BNL research capabilities for **new science reach**
- multi-program future facility benefits (NP + BES)

• Scope & Timing

- 10 GeV electron beam plus one new **e-A Detector** in RHIC ring
- physics & conceptual design thru FY06; constr. project FY09-15
- key to success is starting **PERL R&D** next year for **electron ion cooling**

• Cost

- R&D funding at ~\$200K/year
- eRHIC Construction Project estimated at \$295M

• Scientific Benefits

- opens a new field of NP - **high energy probes of cold nuclear matter**
- investigates a wholly new phenomenon, the '**color spin glass**'
- could be leveraged to provide new FEL photon capability at BNL

**OVERALL AND FUTURE PERSPECTIVES
RIKEN BNL RESEARCH CENTER**

T. D. Lee

RIKEN BNL Research Center

Overall and Future Perspectives

T. D. Lee

Presentation

**8th Meeting of The Management Steering Committee of
RIKEN BNL Collaboration**

**RIKEN, Wako, Saitama, Japan
March 11-12, 2002**

- R B R C aims to be the intellectual leader in the new field of High Energy Nuclear Physics
- Through RHIC and Spin Physics, R B R C will explore
 1. the Relativistic Nature of Nucleon and Nuclear Structure ,
 2. the Complex Intrinsic Structure of the Physical Vacuum ,
 3. New Form of Nuclear Matter.

Importance of Spin

- All elementary particles have non-zero spin

lepton ($e, \nu, \mu, \dots$)	Spin $\frac{1}{2}$
quark ($u, d, s, \dots$)	" $\frac{1}{2}$
photon (γ)	" 1
gluon (g)	" 1
graviton (G)	" 2

- Vacuum has spin 0 (with parity $+$ or $-$ $\because$ parity non conservation related to excitations)

- All zero spin ($0^+ / 0^-$) are $\uparrow$ excitations of Vacuum

pion (0^-) : Nambu - Goldstone excitation

Higgs ($0^\pm$) : vacuum excitation

Therefore non-elementary!

RBRC

RIKEN BNL Research Center

物之通

道生物

物生道

道为物之印

物为道之纹

天地之是物之道

李岐道 · 二〇〇一

The Tao of Matter

Tao Creates Matter

Matter Generates Tao

Tao Shapes the Action of Matter

Matter Forms the Completion of Tao

The Art of the Universe is the Tao of All Matter

MC First Collisions
June 12, 2000

Azimuthal asymmetry of high p_t particles

$$* \text{ Finite } dE/dx \Rightarrow v_2(p_t) \rightarrow 0 \text{ for } p_t \rightarrow \infty *$$

$$dN/dy dp_t^2 d\phi \propto 1 + 2v_2(p_t) \cos(2\phi)$$

Raimond Snellings

MG, I. Vitev and X.N. Wang, PRL(01)

Conversion of particle signals to volume measurements (Hanbury-Brown/Twiss)

Special case $t_1 = t_2$ (originally for stars)

$$| \text{Amp} |^2 \propto | e^{i \vec{k}_1 \cdot \vec{r}_1} + e^{i \vec{k}_2 \cdot \vec{r}_2} + e^{i \vec{k}_2 \cdot \vec{r}_1} + e^{i \vec{k}_1 \cdot \vec{r}_2} |^2$$

$$= 1 + \cos \vec{q} \cdot \vec{r} \quad (\text{varies from 1 to 2})$$

$$\vec{q} = \vec{k}_1 - \vec{k}_2 \quad \& \quad \vec{r} = \vec{r}_1 - \vec{r}_2$$

Here, π can be any bosonic channel.

For fermionic channel:

$$| \text{Amp} |^2 \propto 1 - \cos \vec{q} \cdot \vec{r}$$

Hanbury-Brown, Twiss (1954) Intensity Interferometry $\langle I(t_1)I(t_2) \rangle$

Goldhaber, Goldhaber, Lee, Pais (1960) $pp \rightarrow \pi^- \pi^- X$ $C_{\pi\pi}(k_1, k_2)$

Kopylov & Podgoretsky, Shuryak, Coconni (1973)

Yano & Koonin (1978)

Gyulassy, Kauffmann, Wilson (1979)

Zajc, Two Pion Correl in Heavy Ion Collisions, PhD 1982

AGS-SPS-RHIC

Pion Interferometry

120

- Central AuAu (PbPb)
- $R_{out} \sim R_{side} \sim R_{long} \sim 6 \text{ fm}$ at any s ??

2/7/02

Gyulassy-2

Surprising Weak Energy dependence!

- R_{out} and R_{side} are energy independent within error bars.
- Weak energy dependence of R_{long}
- No indication of different physics from AGS to RHIC
- Fit R_{long} to:

$$\frac{A}{\sqrt{m_T}}$$

- AGS: $A = 2.19 \pm 0.05$
- SPS: $A = 2.90 \pm 0.10$
- RHIC: $A = 3.32 \pm 0.03$

M. Lisa *et al.*, PRL **84**, 2798 (2000)
 R. Soltz *et al.*, to be sub PRC
 C. Adler *et al.*, PRL **87**, 082301
 I.G. Bearden *et al.*, EJP **C18**, 317 (2000)

The Pion Interferometry Problem at RHIC

The Space-Time Puzzle

- Instead of slowly burning QGP $\Delta\tau \sim R/v_{\text{def}} \gg R$
- Evidence for Sudden freezeout $\Delta\tau \ll R$!
- $R_{\text{out}} \sim R_{\text{side}} \sim R_{\text{long}} \sim 6\text{fm}$ indep of $1 < KE_{\text{cm}} < 100 \text{ AGeV}$?
- Yet huge $v_2 \sim 0.15$ out to 6 GeV, transverse flow ,
hadro equilibration, $p_{\text{bar}} > p_{\text{pi-}}$, ...

PHENIX and STAR at RHIC

HBT correlation projects

$$\vec{q} \quad , \quad (\vec{x}_1 - \vec{v}_K t_1) - (\vec{x}_2 - \vec{v}_K t_2)$$

to

$$\vec{q} \quad \cdot \quad \vec{K}$$

Since $\Delta \vec{q} \cdot \Delta \vec{x} \geq \frac{\hbar}{2}$

perhaps quantum correlation is

important in RHIC

The present quasi-classical
description of QGP is inadequate!

A New Method to Derive N -dim.
Quantum Wave Functions by Integrations
Along a Single Trajectory

RBR C # 89, 151, 152

Annals of Physics 288 (2001) 52-102

A New Convergent Formulation of
Quantum Field Theory

RBR C # 176

Annals of Physics 294 (2001) 67-133

TOL, R. Friedberg, W. C. Zhao

RBR C / Columbia / CCAST

The New Method

1. Reduce any N -dim. eigenvalue problem in Quantum Mechanics (2nd order partial differential equation) to a series of First Order One-Dimensional Differential Equations, which can be readily integrated along a single trajectory.

usual divergent

2. Recast the λ perturbative series into a new series based on integrals along a single trajectory. The new series is convergent!

Stark Effect

$$H = -\frac{1}{2} \nabla^2 - \frac{Ze^2}{r} + \epsilon r \cos \theta$$

discovered by Stark (1913)

studied by Bethe (1915)

Schramschild (1916)

Kramers (1920)

Schrodinger (1926)

Dirac (1926) . . .

Only until 1954, Foley et al found

$$E = -\frac{1}{2} Z^2 e^4 - \frac{9}{4} \frac{\epsilon^2}{Z^4 e^8} + O(\epsilon^4)$$

The new method (RBR 89) gives exact result in closed form to any order in ϵ^2

$$H\psi = E\psi \quad . \quad \text{Write } \psi = e^{-S}$$

$$S = Ze^2 r + \frac{\epsilon r}{Z^2 e^4} \cos \theta \cdot \left(1 + \frac{1}{2} Ze^2 r\right) - \frac{\epsilon^2 r^2}{Z^4 e^8} \left\{ \frac{7}{16} (1 + \cos^2 \theta) + \frac{1}{24} Ze^2 r (1 + 3 \cos^2 \theta) \right. \\ \left. + \frac{\epsilon^3 r}{Z^8 e^{16}} \cos \theta \left\{ \frac{5^3}{8} (1 + \frac{1}{2} Ze^2 r) + \frac{13}{48} (Ze^2 r)^2 (3 + \cos^2 \theta) \right. \right. \right. \\ \left. \left. + \frac{1}{16} (Ze^2 r)^3 (1 + \cos^2 \theta) \right\} + \dots \right.$$

$$E = -\frac{1}{2} Z^2 e^4 - \frac{9}{4} \frac{\epsilon^2}{Z^4 e^8} - \frac{355}{64} \frac{\epsilon^4}{Z^{10} e^{20}} + \dots$$

(divergent, as it should)

other examples of asymptotic
expansions :

$$1. \int_x^\infty e^{-qy^2} dy = \frac{e^{-qx^2}}{2qx} \left(1 - \frac{1}{2qx^2} + \frac{1 \cdot 3}{(2qx^2)^2} - \dots \right)$$

finite for any
 $q > 0$

divergent always

$$2. \left(\frac{q-2}{2} \right)_\mu = \frac{1}{2} \frac{q}{\pi} + 0.765\ 857\ 376 (27) \left(\frac{q}{\pi} \right)^2 \\ + 24.050\ 508\ 98 (44) \left(\frac{q}{\pi} \right)^3 \\ + 126.87 (41) \left(\frac{q}{\pi} \right)^4 + 930 (170) \left(\frac{q}{\pi} \right)^5 \\ + \dots$$

This is spin physics at its most
fundamental ; yet the theoretical
formula is divergent !

**FUTURE PERSPECTIVES
EXPERIMENTAL GROUP**

Hideto En'yo

Future Perspectives

Experimental Group

For 5 Years under the New MoU

- ❑ RHIC Spin Experiment is in *FULL SWING*
- ❑ Need 5 years to accomplish the measurements described in the proposal (200GeV/500GeV, with longitudinal spin and transverse spin).

RBRC in 2002

- **Core of the project**
 - Physics analysis of the data (using CCJ)
 - Preparation for the next run (Muon North etc.) and maintain the spin data taking
 - Build up the future beam time strategy with other spin experiments and accelerator
 - AGS polarimeter
- New fellows/postdocs will be appointed.

CCJ in JFY2002

- We got budget approved along the line of the last MSC:

- Tape Dive :
4 x redwood drive
10 x 9940B
- HPSS server

- Can store 3-year data from PHENIX

• Current : redwood 11.2 MB/s 50 GB/volume
 • 2002Q4: 30 MB/s 200 GB/volume

BELLE

- To study the spin in the quark fragmentation
 - Very important for the RHIC spin program
 - Belle provides the best data to be looked into.
 - 1 Fellow + 2 Visiting Scientists from RBRC + 1 postdoc from Wako.
 - Will be responsible for the fragmentation *analysis* and related *Monte Carlo studies*
- Will use CCJ (100GHz-year scale)

PHENIX Upgrade (Silicon Tracker)

- Will enhance the physics capabilities of PHENIX spin program.
 - gluon polarization
 - photon + jet
 - heavy flavor via b-tagging
 - anti-quark polarization
 - $W^\pm/Z^0$ /Drell-Yan via isolation cut

Straw man design

- PHENIX will submit a design report in a few months from now.
 - Typical silicon strip detectors are enough for the p-p runs. But in the Heavy Ion runs, occupancy will be 25%, 10%, 7%, 5% for the 1st to the 4th layer.
 - ⇒ Pixel detector for the 1st layer at least.

RIKEN-RBRC silicon project

- Microstrip layers
 - first prototype sensor at BNL
 - by Zheng Li (BNL instrumentation)
 - single-side two-direction readout strip
 - Will be tested as a telescope.
- Pixel layers (well advanced at CERN)
 - “*RIKEN-CERN silicon pixel project*”
 - H. Ohnishi, J. Heuser → NA60
 - K. Tanida, J. Tojo – α → ALICE
- Mechanical structure design started at RIKEN
 - to study cooling, cabling, ...
 - HYTEC inc. with ISU, LANL, ...

Prototype sensor (Strip)

- First prototype sensor by Zheng Li (BNL instrumentation)

Mechanical structure Study

sensor chip: $3\text{cm} \times 6\text{cm}$
 sensor strip: $80\mu\text{m}(\text{pitch}) \times 3\text{cm}(\text{length})$
 (1 chip = $375 \times 2\text{strips} \times 2\text{direction}$)
 readout chips on top of the sensor
 (12 readout chips for 1 sensor)

Half shell of the silicon detector

Mechanical structure

**FUTURE PERSPECTIVES
IMPROVEMENT AND MAINTENANCE OF
ACCELERATOR**

Satoshi Ozaki

How to Achieve High Polarization in the AGS

Satoshi Ozaki

RIKEN/BNL Spin Physics Collaboration
Management Steering Committee Meeting

March 11-12, 2002
At RIKEN, Wako, Saitama, Japan

Brookhaven Science Associates
U.S. Department of Energy

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The First RHIC Polarized Proton Run

- 55 bunches per ring with 0.8×10^{11} p $\uparrow$ /bunch
- Charge/bunch and total charge higher than with gold beams
- Lattice with constant β^* of 3 m during ramp
- Peak luminosity at beginning of store: $1.5 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
- Energy/beam: 100 GeV
- Beam polarization ~ 25 %
RHIC polarimeters work reliably
- Little if any depolarization in RHIC during acceleration and store
Siberian Snakes work
- ~ 60 % polarization loss in AGS; aggravated by lower ramp-rate from Westinghouse motor-generator
- **Strong Siberian snake in AGS (~ 30 % of full snake) could avoid all depolarization in the AGS**

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U.S. Department of Energy

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Present AGS Partial Snake

A room temperature solenoid: a conservative approach.

Needed superconducting helical dipole for a stronger snake

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U.S. Department of Energy

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Proton Polarization at the AGS

- Full spin flip at all imperfection resonances using partial (5%) Siberian snake
- Full spin flip at strong intrinsic resonances using rf dipole
- Remaining polarization loss from coupling and weak intrinsic resonances
- Larger polarization loss in FY2002 due to lower ramp-rate of WH motor-generator and higher bunch intensity (?)

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Helical Partial Snake for the AGS

Normal Conducting HELICAL Dipole MAGNET FOR AGS PARTIAL SNAKE

M. Okamura, T. Tominaka and T. Katayama, RIKEN, Japan,

N. Tsoupas, BNL; EPAC 2000

T. Roser, M. Syphers, E. Courant, L. Latner, BNL

M Okamura; RIKEN; March 1998

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U.S. Department of Energy

AGS 30% Snake

- Present AGS Partial Snake (5%)
- Room Temperature Solenoid: conservative approach
- Proposed AGS Partial Snake (30%)
- Use the superconducting helical dipole technology which was developed in the RIKEN collaboration for the RHIC snake and spin rotators.
- Rough parameter of the snake
 - one 360° superconducting helical dipole:
 - 20 cm ID, 1.8 m long, 3.5T
 - two normal superconducting dipole correctors:
 - 20 cm ID, 0.17 m long, 3.5T
- Detailed design work in progress

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AGS Superconducting Helical Snake

Rough parameter of the AGS snake

360° superconducting helical dipole:
20 cm ID, 1.8 m long, 3.5T

superconducting dipole correctors:
20 cm ID, 0.17 m long, 3.5T

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AGS Partial Snake Cost Estimate

Use superconducting helical dipole technology developed for RHIC snakes

- 1 superconducting helical dipole: 20 cm ID, 1.8 m long, 3.5T
- 2 normal superconducting dipole correctors: 20 cm ID, 0.17 m long, 3.5T
- Sextupole corrector winding on the cold bore

Costs in \$1,000

Item	Helical Coils	Dipole Corrector Coils	Assemble Storage Unit	Sextupole Coils	Assemble Cold Mass	Cryostat Assembly	Total Cost
Design	\$140	\$140	\$86	\$18	\$74	\$108	\$566
Production	\$396	\$229	\$225	\$95	\$197	\$267	\$1,409
Material	\$146	\$89	\$187	\$54	\$126	\$243	\$855
Labor	\$213	\$139	\$28	\$41	\$61	\$19	\$553
Warm/Cold Test	\$0	\$0	\$53	\$0	\$0	\$62	\$115
Total	\$536	\$369	\$364	\$113	\$271	\$437	\$2,090

Estimate includes normal Laboratory overhead and 20% contingency

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Estimated Cost of Spare Helical Dipole Magnets

Satoshi Ozaki

RIKEN/BNL Spin Physics Collaboration
Management Steering Committee Meeting

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Brookhaven Science Associates
U.S. Department of Energy

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Cost of 3 Spare Helical Dipoles

Cost in \$1,000,

Item	Cost, FY02\$	JFY02	JFY03
Production			
Material	\$110.0	\$110.0	
Labor	\$223.0	\$54.0	\$169.0
Cold Test			
Material	\$15.9		\$15.9
Labor	\$20.5		\$20.5
Total	\$369.4	\$164.0	\$205.4

Estimated costs include normal Laboratory overhead and 15% contingency.

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U.S. Department of Energy

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**PUBLICATION LIST
RBRC THEORY GROUP**

March 02

RIKEN BNL Research Center
Theory Group
Publication List

RBRC/#

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