

# **RHIC Spin program and the very early days of RBRC**

On the 25<sup>th</sup> anniversary of RIKEN BNL Research Center (RBRC)

June 22,2023

Masayasu Ishihara

Congratulations to RBRC on its great accomplishment  
through these 25 years !!

Congratulations to BNL on its ever growing prosperity !!

## Brief Introduction of Myself

The person,  
who launched the **RIKEN project of RHIC Spin Physics**, and  
who originally issued the proposal to establish the RIKEN Research  
Center to be located at BNL, now called **RBRC**.

## Short note on the early History of RBRC

- 1994; the **proposal** of the **RIKEN RHIC Spin project** was issued.  
the **proposal** of **RBRC** was **appended** to the above proposal
- Base camp of the RIKEN researchers for **RHIC Spin program**
  - Due to open in 2000, when RHIC commissioning expected.
- 1995; **RIKEN project of RHIC Spin Physics** started.
- 1996; Call from the office of **STA(Science & Technology Agency)**
- **Center** better start in 1997; needs a reason for the early start.
  - My suggestion; What about adding the **Theory Division**.
- 1997; **RBRC** started with Theory Division alone.  
**Prof. T.D. Lee** became the **Center Director**.

**Prof. Lee's** leadership; Scope of the Center was drastically enlarged.  
Newly introduced mission of **nurturing a new generation of young  
physicists in the fields** has made RBRC superior.

On top of this;

**The Original mandate** of serving for **RIKEN RHIC Spin Project** was maintained.

Then, What is **RIKEN RHIC Spin Project**?

How was **it** started ?    How has **it** worked?

## How did RIKEN's RHIC Spin Program get started?

March 1993;

Visit of **Satoshi Ozaki** (RHIC Project Leader) accompanied by **Dave Hendry** (DOE officer in charge of RHIC funding) to the then RIKEN President, Prof. **Minoru Oda**



**S. Ozaki**

Nowadays; RHIC carries two major programs;

- **Heavy-Ion Physics program** on QGP (Quark Gluon Plasma)
- **Spin Physics program** on Proton Spin Puzzle

At that time;

**Heavy Ion program** was funded with top priority, while **Spin program** was left aside without any funding.

**Ozaki** had a strong intension to realize **both the programs**. **Hendry** was quite reluctant to spend any money for **Spin**.



**M. Oda**

At their meeting, where **I** was incidentally invited to join, **Ozaki** argued intensively for the merits of **Spin program**, and asked Oda to encourage RIKEN researchers to work on it.

**Oda** was so much moved by **Ozaki** that he, in turn, started to persuade **me** to take charge of **RIKEN part of the program**

**My instant answer** was absolutely **NO**;

**I** am none of spin physicists, while busily engaged in **RIB physics**.

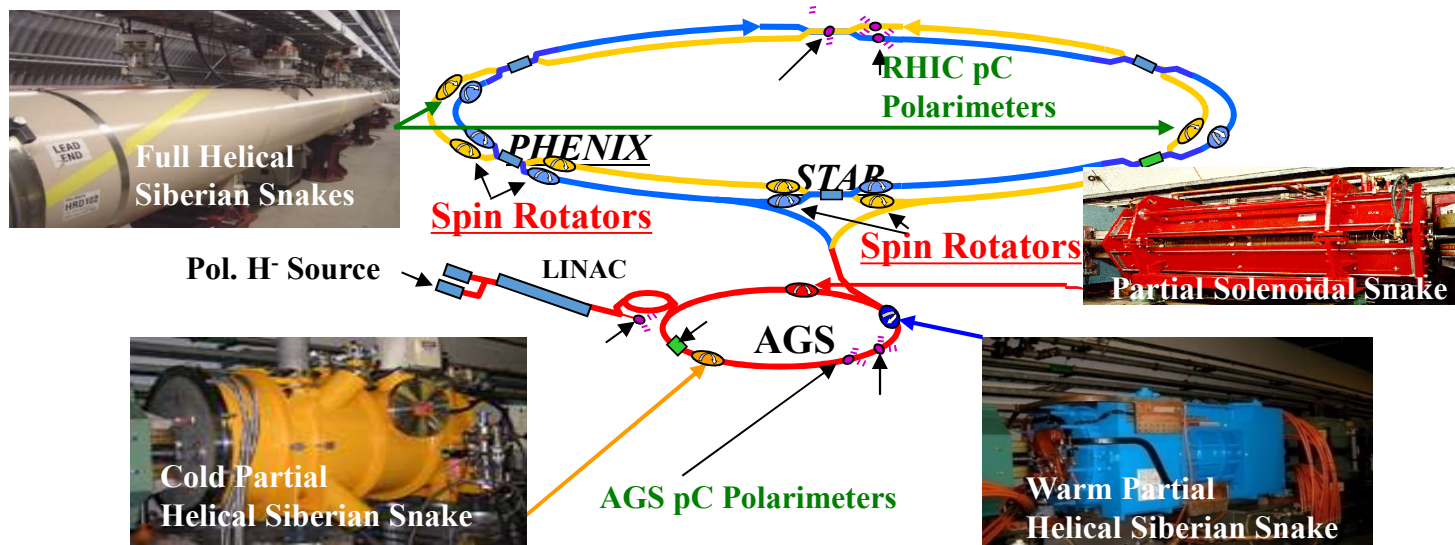
**After all, however, I accepted the offer, since, otherwise, no one would take the job resulting in possible collapse of *entire RHIC SPIN Program*.**

**Once Committed to RIKEN's Spin Project, I had 3 major tasks to work out !**

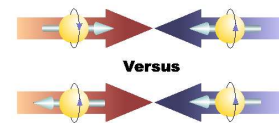
# Task 1; To acquire the funds to construct crucial devices

- **Spin Physics** requires acceleration of *spin polarized protons*, hence a set of **Siberian Snakes**, costing about 6M\$, to be installed in RHIC

## Polarized proton acceleration at RHIC



- **Spin Physics** also requires a set of **Spin Rotators**, costing about 4M\$, to facilitate the measurement of double helicity asymmetry  $A_{LL}$ .



- **PHENIX Detector Assembly** required **South Arm of Muon Tracker**, costing ~10M\$.

In 1995, **STA** provided us with full of 20M\$ as for the start-up investment. The total investment by **STA** for our project (1995—2023) amounted to >100M\$.

## Task 2; To form an experimental team from scratch

**The most crucial job; I had to start with no spin people!!**

**In Japan:** A lot of [enthusiastic responses to my invitation call](#);

Kyoto University;

Kenichi **Imai**, Hideto **En'yo**, (Akira Masaike)

Naohito Saito, Yuji Goto, plus several other graduate students

Tokyo Institute of Technology;

Toshiaki Shibata, Hideyuki Kobayashi

Nagoya University;

Naoaki Horikawa, Naoki Hayashi

Tokyo University;

Kazuyoshi Kurita

RIKEN

Takashi Ichihara, Yasushi Watanabe

**In US:** Workshop at LANL, in fall of 1994, organized by [Joel Moss](#)

Dozens of Spin physicists from over US gathered,  
[welcoming RIKEN initiative to promote RHIC Spin Program.](#)

In particular, **Gerry Bunce**, Mike Tannenbaum, Yousef Makdisi from BNL pledged themselves tightly to collaborate with us

**Thus, the job was very Well Done!!**

**G. Bunce:** to become the Deputy Leader of Exp. Group of RBRC.

## Task 3; To set up the **base camp at RHIC for RIKEN Spin**

Proposal was made in 1994; **RBRC** was thus started in 1997

### **Division of Experimental Group of **RBRC** has served a dual purpose;**

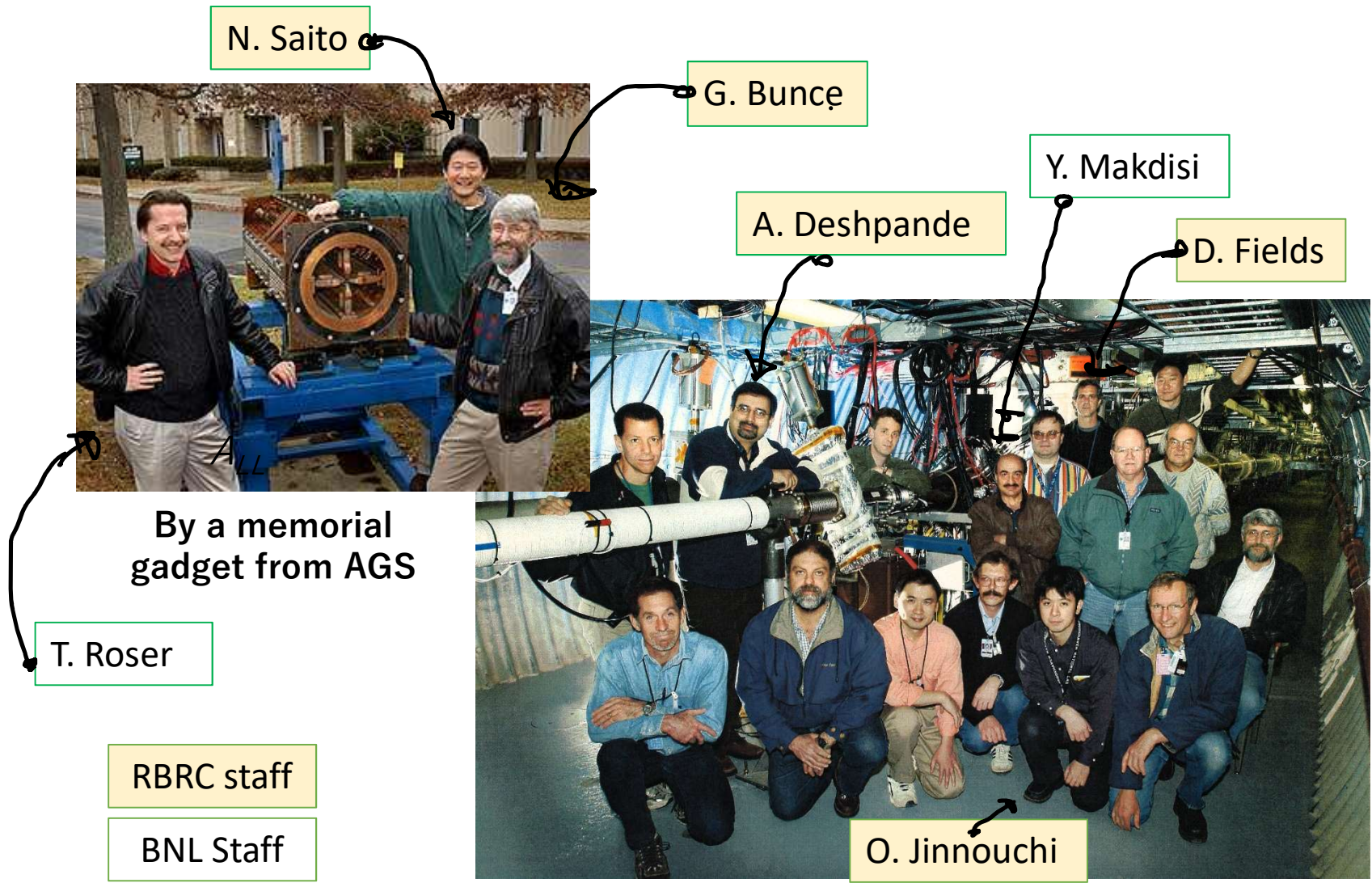
- **Base camp** at RHIC for **RIKEN's Spin** researchers.
- **Headquarter**, in effect, of the **RHIC SPIN Project**  
by often organizing/driving meetings such as  
Spin Physics Working Group and RHIC Spin Collaboration

### **Members of Experimental Group in the very early days :**

|                           |  |
|---------------------------|--|
| ISHIHARA, Masayasu        | (1998-2000 as Group Leader)                                      |
| BUNCE, Gerry              | (1998-2008 as Deputy Group Leader)                               |
| SAITO, Naohito            | (1998-2001; → Director, J-PARC, then<br>Institute for P&NP, KEK) |
| GOTO, Yuji                | (1999-2002; → RIKEN)   |
| GROSSE PERDEKAMP, Mattias | (1999-2007; → University of Illinois)                            |
| BAZILEVSKY, Alexander     | (1999-2003; → BNL)   |
| DESHPANDE, Abhay          | (2000-2017; → SUNY; Director, EIC Science, BNL)                  |
| KURITA, Kazuyoshi         | (2000-2001; → Rikkyo University)                                 |

These are the very people who have played the central roles  
in promoting the **RHIC Spin Program!!**

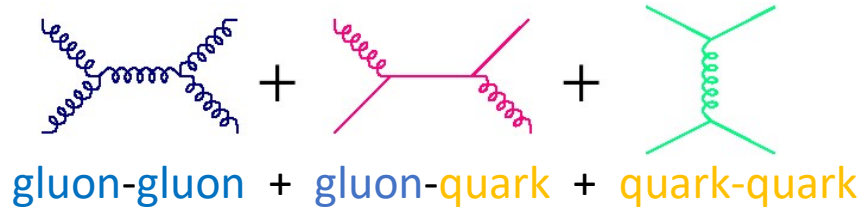
# Spin Physics Scientists gathering on celebrations



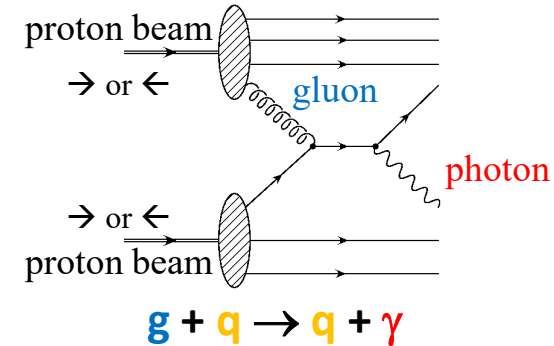
On Completion of AGS PC Polarimeters

# Determination of **Gluon** polarization by measuring $A_{LL}$ (double helicity asymmetry)

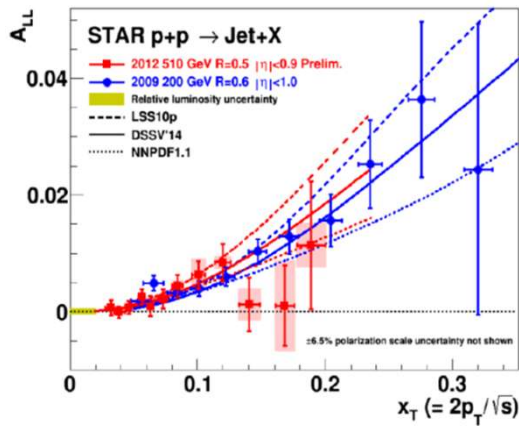
- $A_{LL}$  of **jet** and  $\pi^0$   
Mixture of **g-g**, **g-q**, **q-q**



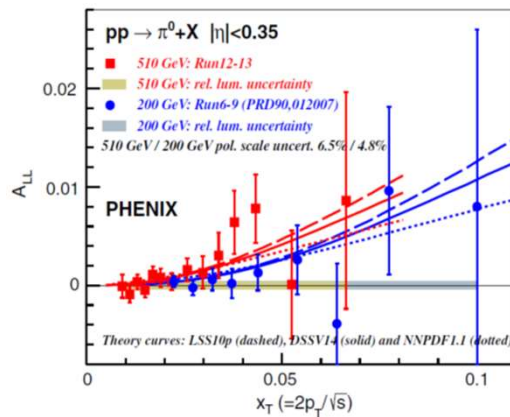
- $A_{LL}$  of **direct photon** ( $\gamma$ )  
Gluon Compton scattering



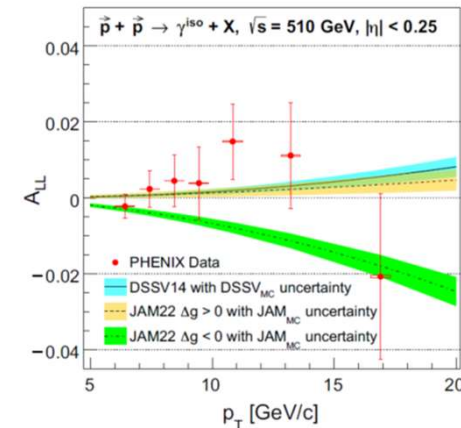
Midrapidity **jet** at STAR



Midrapidity  $\pi^0$  at PHENIX



Midrapidity **direct- $\gamma$**  at PHENIX



**Gluon Spin;**  
Only 20-30% of  
Proton Spin !!

$$Q^2 = 10 \text{ GeV}^2 \int_{0.05}^{0.2} dx \Delta g(x, Q^2)$$

NNPDFpol1.1  
DSSV14

$$+0.15 \pm 0.06$$

$$0.10^{+0.06}_{-0.07}$$

Sign of **Gluon** Polarization  
uniquely determined



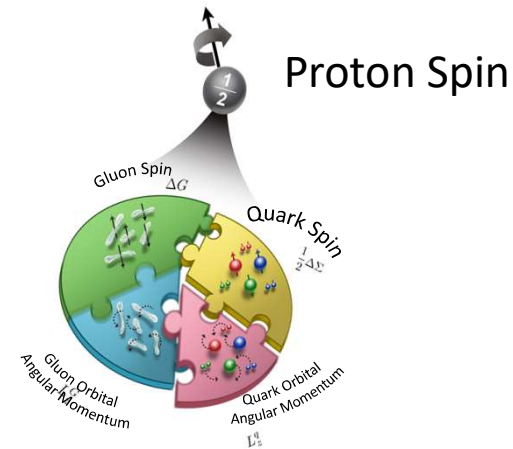
# Hop-Step-Jump in the endeavor on Proton Spin Puzzle

***Proton Spin Puzzle:***  
***What are the carriers***  
***of Proton Spin  $1/2 \hbar$  ?***

***Quark Spin ?***

***Gluon Spin ?***

***Orbital Angular momenta ?***



**Hop: European Muon Collaboration (EMC) at CERN, 1987**

Do **Quark Spins** account for 100% of proton spin as naively expected?

Answer; They account only for **~30%** of the proton spin of  $1/2 \hbar$ .

→ "Proton Spin Crisis"

**Step: RHIC Spin Physics Program at BNL, 2001-present**

What about **Gluon Spin** contributions?

Answer; Their contributions are only partial, at most **~40 %**.

→ Need to search for **the remaining contributors**.

**Jump: Electron-Ion Collider (EIC) project at BNL, from ~ 2030**

Do the **Parton's orbital Angular momenta** really matter?

→ One will soon find the Answer with EIC\_!!

# Hop-Step-Jump of BNL's Build-up of Spin Program

## Hop; RIKEN Project on RHIC Spin Program

proposed in 1994, funded in 1995.

- Funds for construction of **Siberian Snakes** and **Spin Rotators** were acquired, to **facilitate** acceleration and spin-rotation of **spin polarized protons**, thereby, **measurement of  $A_{LL}$**  to determine **Gluon Spin Pol.**
- **Triggered Full Commitment of RHIC to Spin Physics**

## Step; RHIC Spin Physics Program, 2001-present

- **Gluon contribution** to proton **spin** has been found to be minor.
- The 3<sup>rd</sup> component of Proton **Spin** is to be searched for.

## Jump; EIC Project, ~2030

- Features of **Parton's orbital angular momenta** will be studied.

I am pleased to see this diagram, which reminds us that RIKEN's efforts on RHIC Spin Project have certainly contributed to invoke this great flow of development at BNL on **Spin** inspired Physics.

Thank you for your attention!

