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FORMAL REPORT

Proceedings of RIKEN BNL Research Center Workshop Volume 48

RHIC Spin Collaboration Meeting XIV

December 20, 2002

Organizer:

Brendan Fox

RIKEN BNL Research Center

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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 spin physics, lattice QCD, and RHIC physics through the nurturing of a new generation of young physicists.

During the first year, the Center had only a Theory Group. In the second year, an Experimental Group was also established at the Center. At present, there are seven Fellows and seven Research Associates in these two groups. During the third year, we started a new Tenure Track Strong Interaction Theory RHIC Physics Fellow Program, with six positions in the first academic year, 1999-2000. This program had increased to include ten theorists and one experimentalist in academic year, 2001-2002. With recent graduations, the program presently has eight theorists and two experimentalists. Beginning last year a new RIKEN Spin Program (RSP) category was implemented at RBRC, presently comprising four RSP Researchers and five RSP Research Associates. In addition, RBRC has four RBRC Young Researchers.

The Center also has an active workshop program on strong interaction physics with each workshop focused on a specific physics problem. Each workshop speaker is encouraged to select a few of the most important transparencies from his or her presentation, accompanied by a page of explanation. This material is collected at the end of the workshop by the organizer to form proceedings, which can therefore be available within a short time. To date there are fifty proceeding volumes available.

The construction of a 0.6 teraflops parallel processor, dedicated to lattice QCD, begun at the Center on February 19, 1998, was completed on August 28, 1998. A 10 teraflops QCDOC computer in under development and expected to be completed in JFY 2003.

T. D. Lee
November 22, 2002

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

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Summary of the AGS Polarization Workshop (Ann Arbor Highlights)

T. Roser, BNL

December 20, 2002

for

RHIC Spin Collaboration Meeting XIV

RIKEN BNL Research Center

Ann Arbor Workshop Highlights

2

Experience with Existing Facilities

AGS depolarization

Strong Snake

Weak AGS resonances

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Thomas Roser
RHIC Spin Collaboration Meeting
December 20, 2002

Experience With Existing Facilities (1)

COSY (A. Lehrach)

$G\gamma(max) = \sim 7$; $P = 75\%$

50 MeV injection energy; 1e10 protons

Correction dipoles (spin flip) and tune jump quads,

Problem: marginal tune jump for strongest intrinsic resonance

KEK PS (C. Ohmori)

1986 $G\gamma(max) = \sim 8.4$; $P = 40\%$

1988 $G\gamma(max) = \sim 11.2$; $P = 25\%$

Depolarization in Booster (500 MeV) and PS corrected with sextupole

Correction dipoles and pulsed quads

Problem: strong intrinsic resonances, tune jump small

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Experience With Existing Facilities (2)

1980's AGS (L.A. Ahrens, A.D. Krisch)

1986 $G\gamma$(max) = 41.5; P = 45%   60 pi   x,y emittances are exchanged

1988 $G\gamma$(max) = 35.5; P = 45%   25 pi

No Booster; Intensity about an order of magnitude lower.

Corrector dipoles and tune jump quads, set-up using polarization info.

Problem: long tuning time, marginal correctors and tune jump at high $G\gamma$, loss not understood (!)

1990's AGS (TR, H. Huang, M. Bai)

2000 $G\gamma$(max) = 46.5; P = 41%

2002 $G\gamma$(max) = 46.5; P = 35%

With Booster, high intensity source

Partial snake and rf dipole, set-up using beam info.

Problem: coupling resonances, weak intr. resonances, but loss understood (?)

Internal Polarimeters

(C. Ohmori, A. Lehrach, G.M. Bunce)

KEK (pp elastic [inclusive]): 150 μm Carbon target, 220 μm polyethylene target, polarization measurement on ramp (~ 60 min), ~ 20 min. for 5% measurement

COSY (pC quasi elastic): 8 μm Carbon target, polarization measurement on ramp(10 - 20 min), few minutes for 5% measurement at flat top

AGS (old, pC quasi elastic): 7 x 8 μm Carbon target (100 μm Nylon target), 10 min. for 5% measurement at flat top

AGS(new, pC CNI): 0.01 μm x 500 μm Carbon target, polarization measurement on ramp (~ 60 min), 5 seconds for 5% measurement at flat top

Overcoming AGS Spin Resonances

	Imperfection	Strong Intr.	Weak Intr.	Coupl. Res.	Set-up info
1980's	96 corr. dipoles	10 pulsed quads	10 pulsed quads	N/A	Pol.
1990's	5% solenoid snake	rf dipole	Did nothing	Did nothing	Beam/Pol.
Plan 1	25% helical snake	25% helical snake	25% helical snake	N/A	Beam
Plan 2	5% helical snake	rf dipole	4-8 pulsed quads/ Intr. spin matching	N/A	Beam/Pol.
Plan 3	5% solenoid snake	rf dipole	4-8 pulsed quads/ Intr. spin matching	Hor. rf dipole (?)	Beam/Pol.

25% Partial Snake

(TR, H. Huang, E.D. Courant, W. MacKay)

Pro:

- **Can overcome depolarization from all resonances**
- (Including sidebands and higher order)
- No tuning based on pol. Measurement

Con:

- Large perturbation of lattice -> Need additional matching quadrupoles
- Vertical tune close to integer
- Stable spin direction not vertical -> Need injection and extraction spin matching schemes (extraction to RHIC looks OK)
- Never tried before!

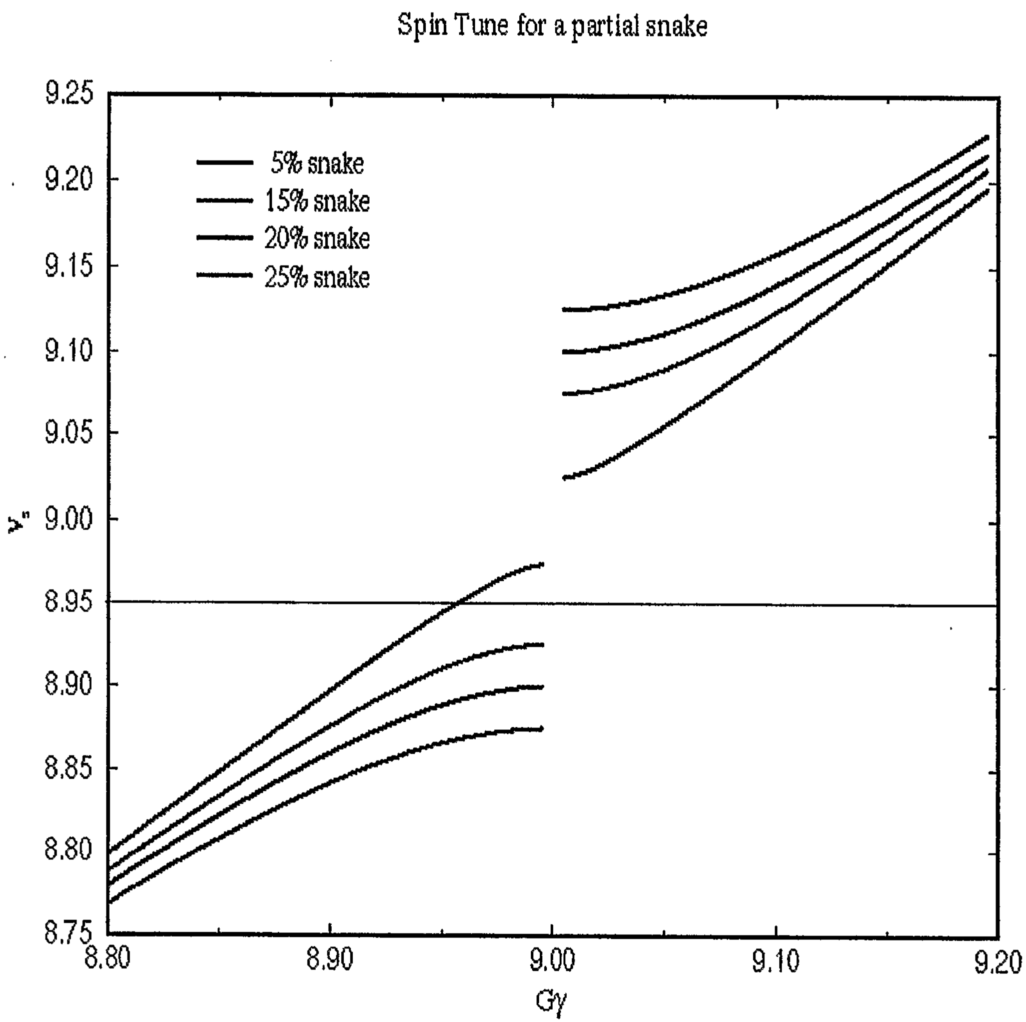
[Horizontal intrinsic resonance due to horizontal stable spin direction is weak]

Strong Partial Siberian Snake for AGS

A strong partial Siberian snake generates large spin tune gap for $G\gamma=N$. With strong enough snake gap is large enough to cover both imperfection and intrinsic spin resonances.

Helical snake will not generate coupling spin resonances

Note: With a strong snake, the stable spin detection will deviate from vertical direction (18 degree for 20% snake).



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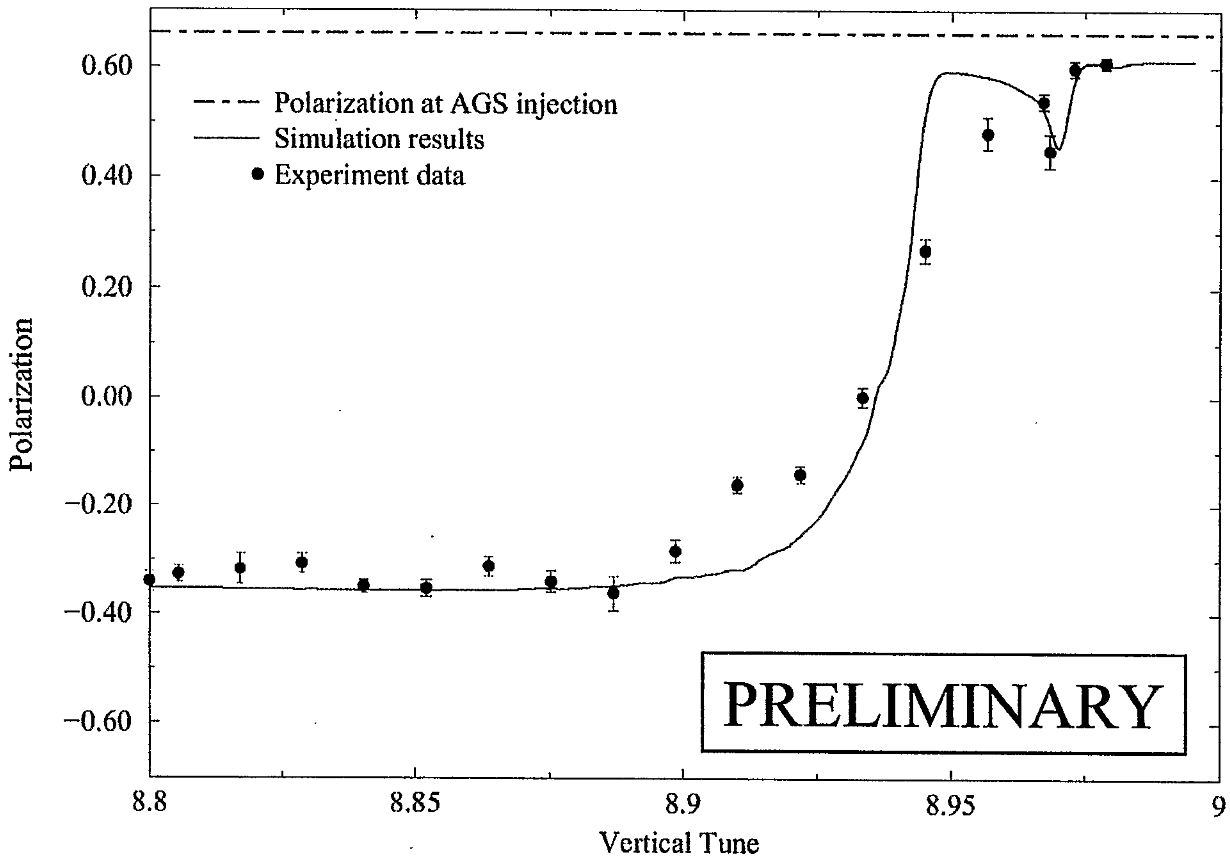
Test results with 10% snake at 0 + ν

The difference between the red measurements and blue line is due to the coupling resonance and tilted stable spin direction.

Good agreement with model.



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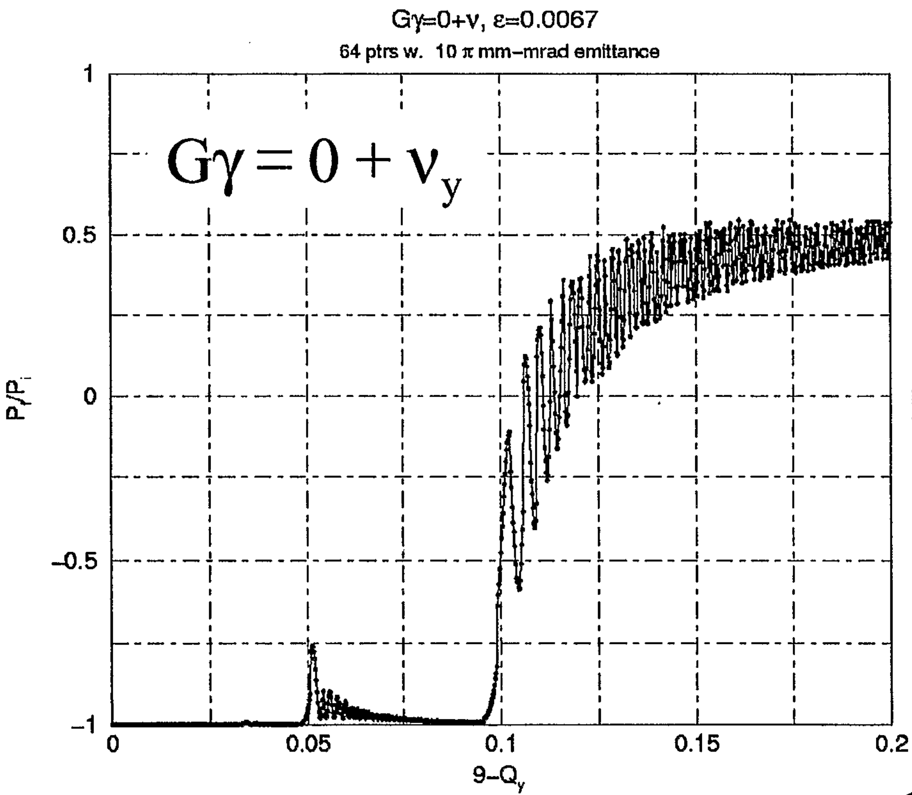
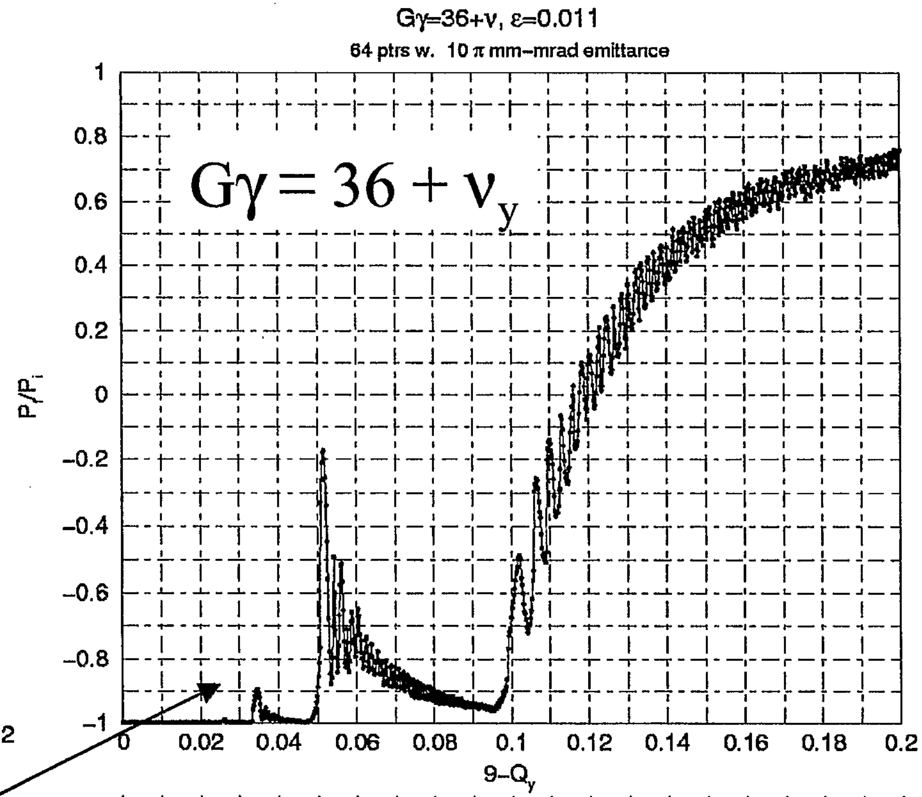
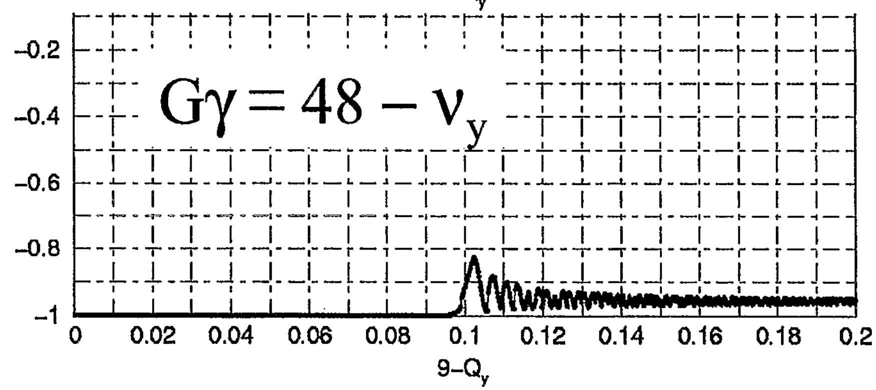
Modeling of AGS resonances with 20% Snake







"Partial Snake Resonances"
if $\nu_{sp} = n\,\nu_y$

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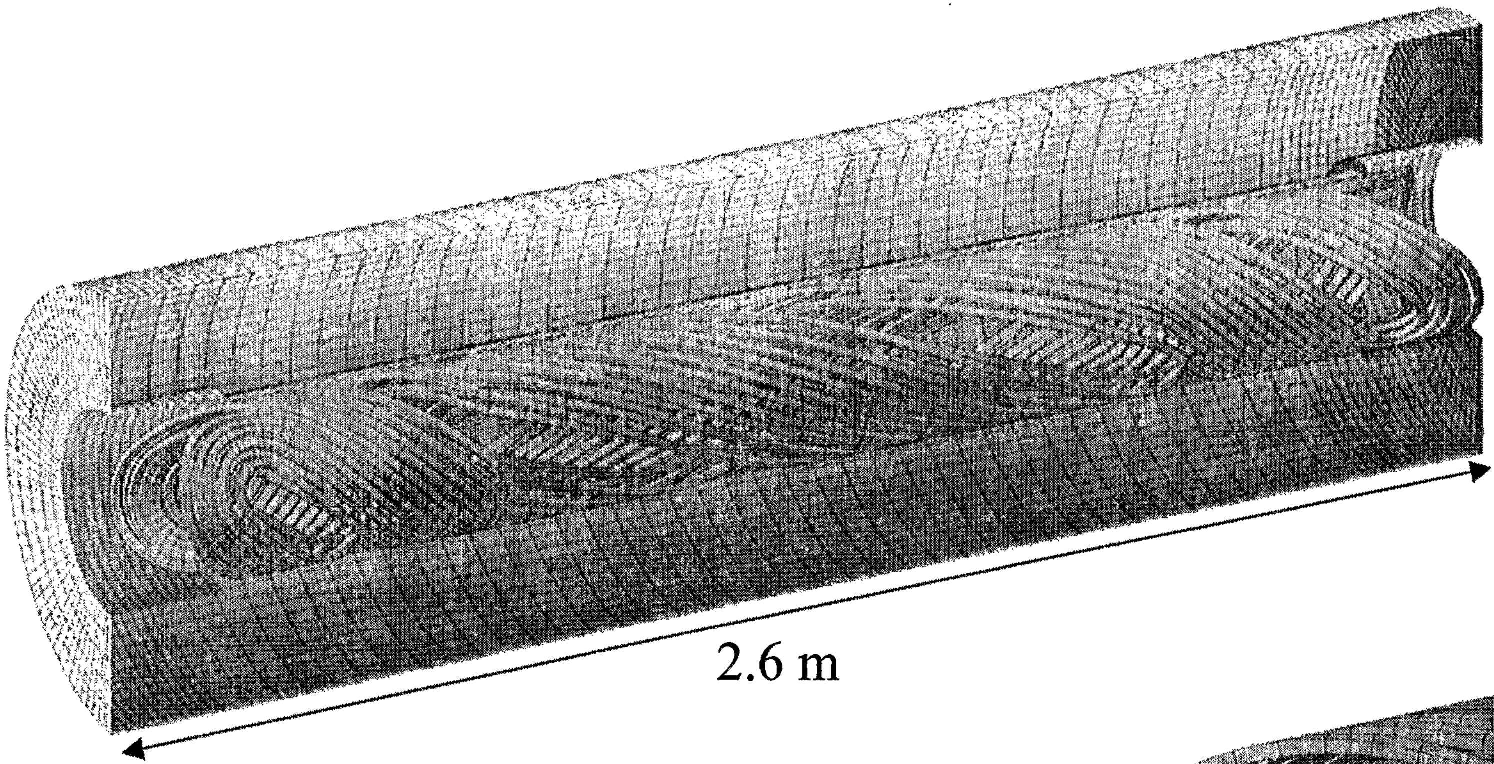
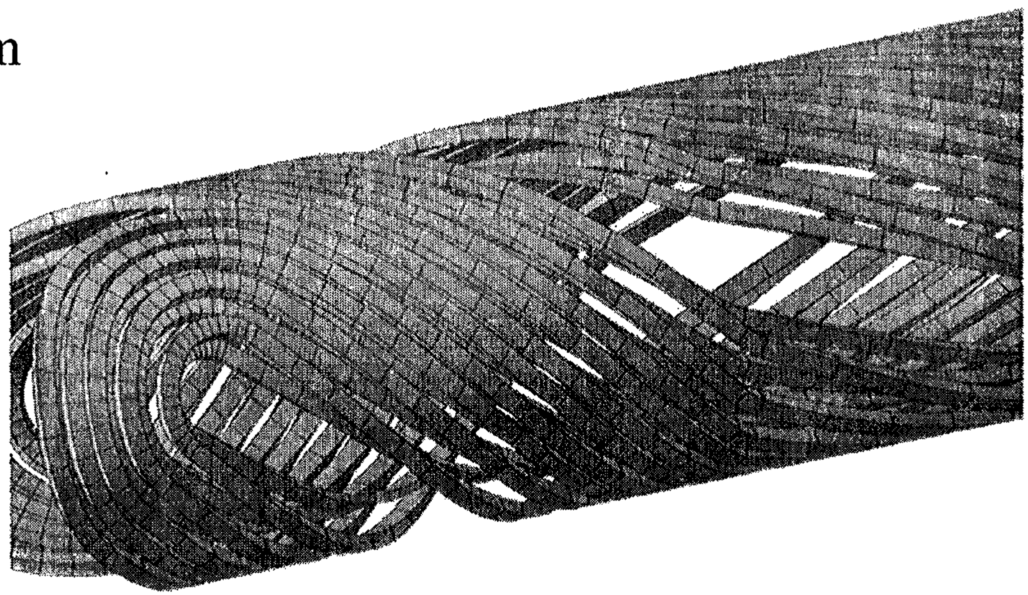
(Tracking by M. Bai)

~ 25 % AGS super-conducting helical snake



15 cm warm bore
Helix with changing pitch



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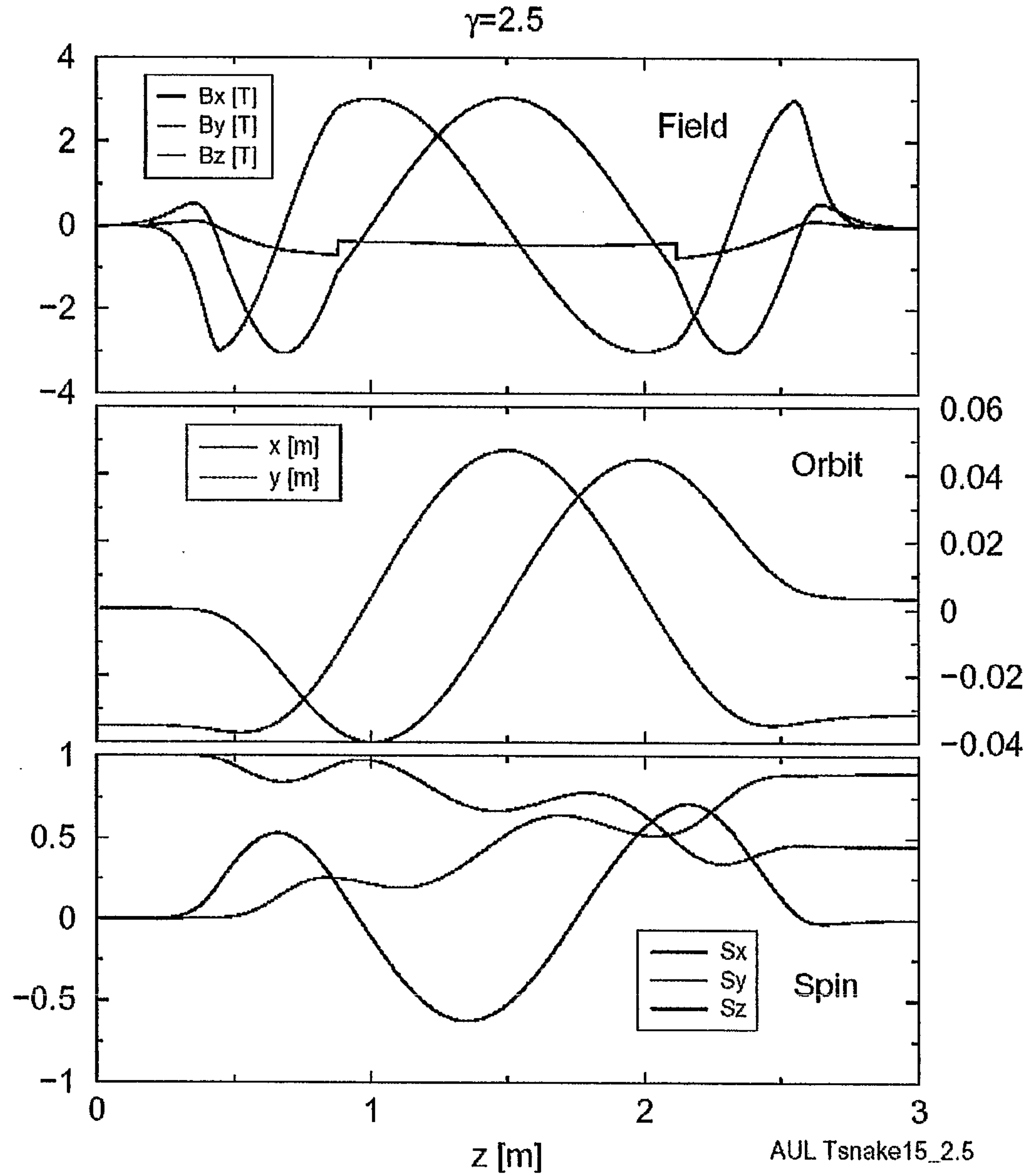
Design of ~ 25% partial snake

Changing pitch helix

Horizontal orbit offset

~ 4 cm max. excursion

Central solenoid for coupling correction



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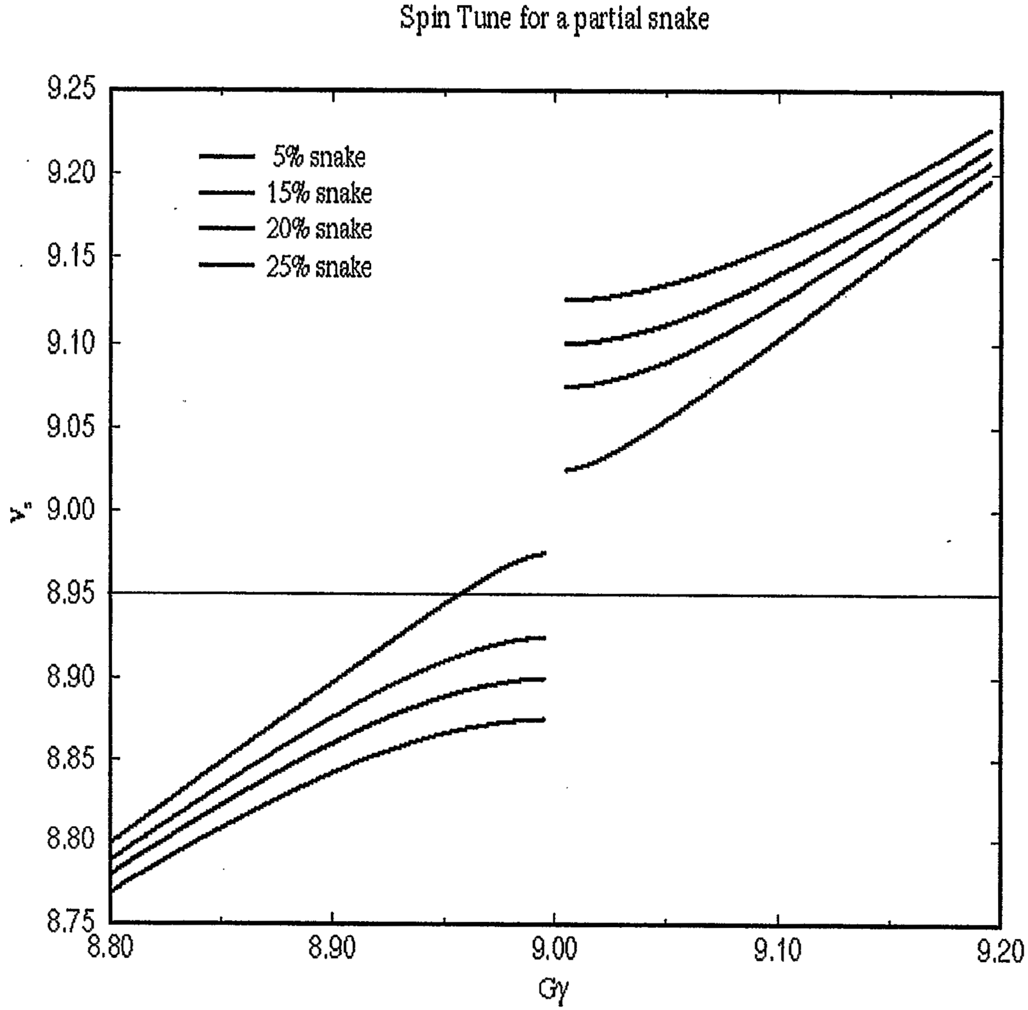
5% Helical Partial Siberian Snake for AGS

Weak helical dipole snake:

No or little coupling

Use rf dipole for strong intrinsic resonances

Use jump or spin matching for weak intrinsic resonances



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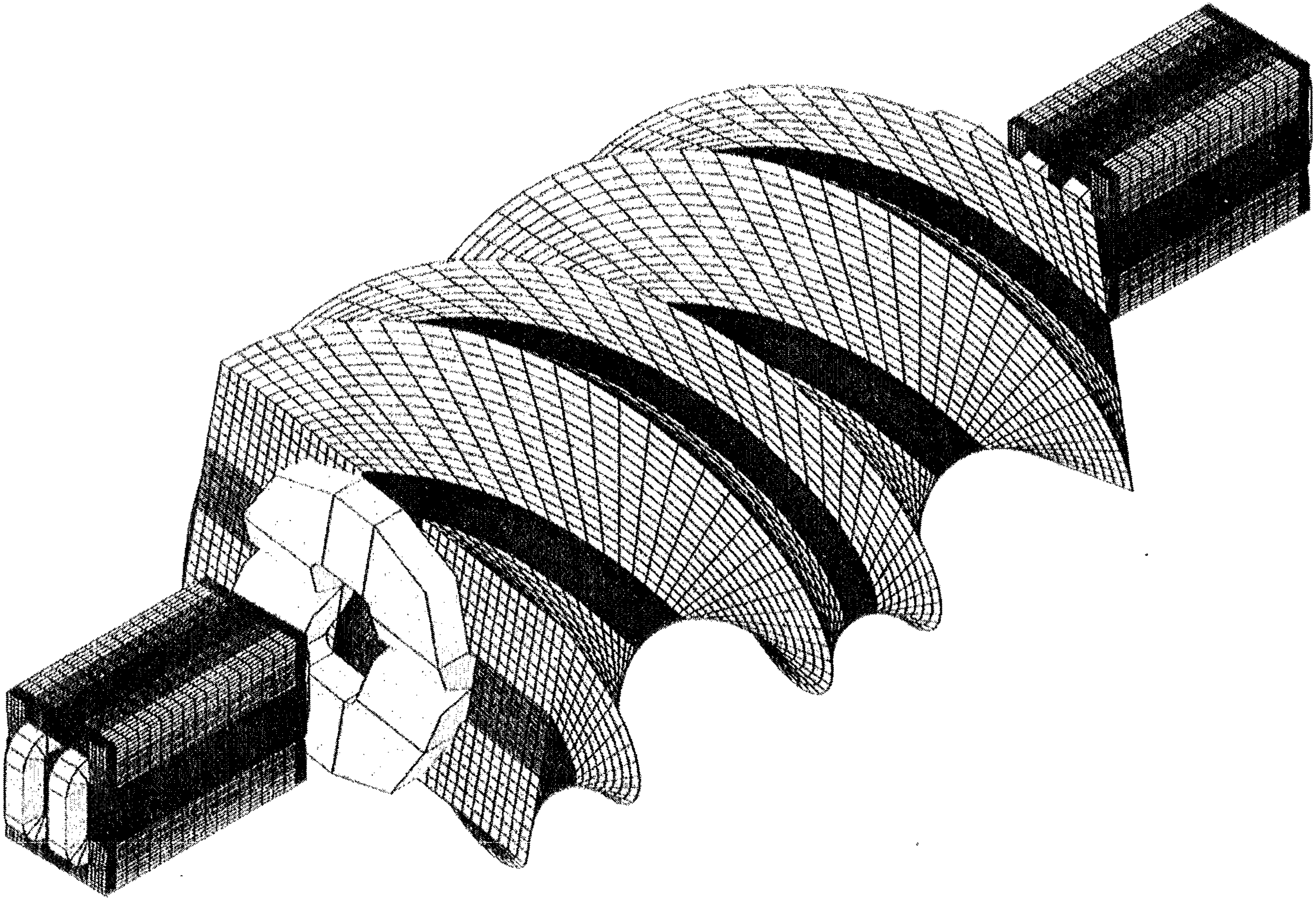
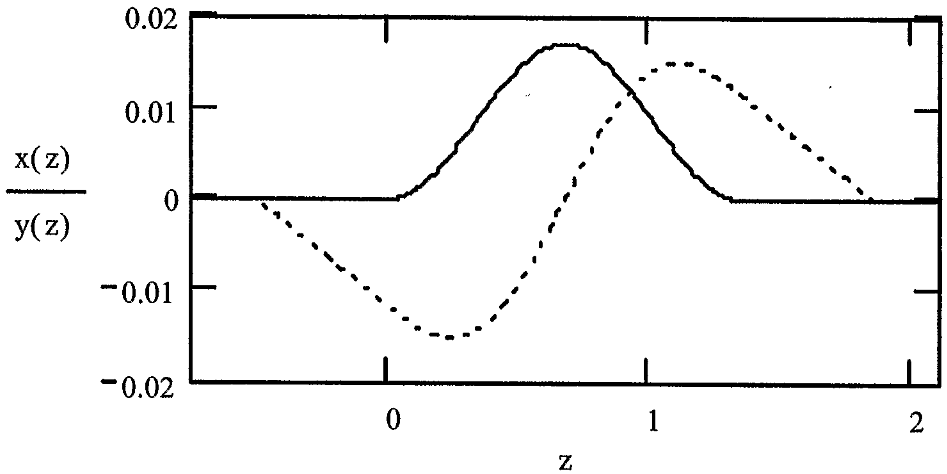
AGS normal conducting 5% helical snake

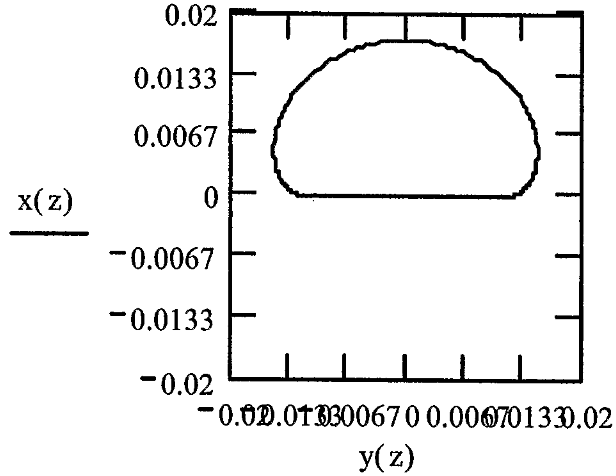


Full twist helix plus two dipoles

1.5 Tesla full twist helix plus two vertical dipoles

6 ends -> not enough space





Design of ~ 5% partial snake

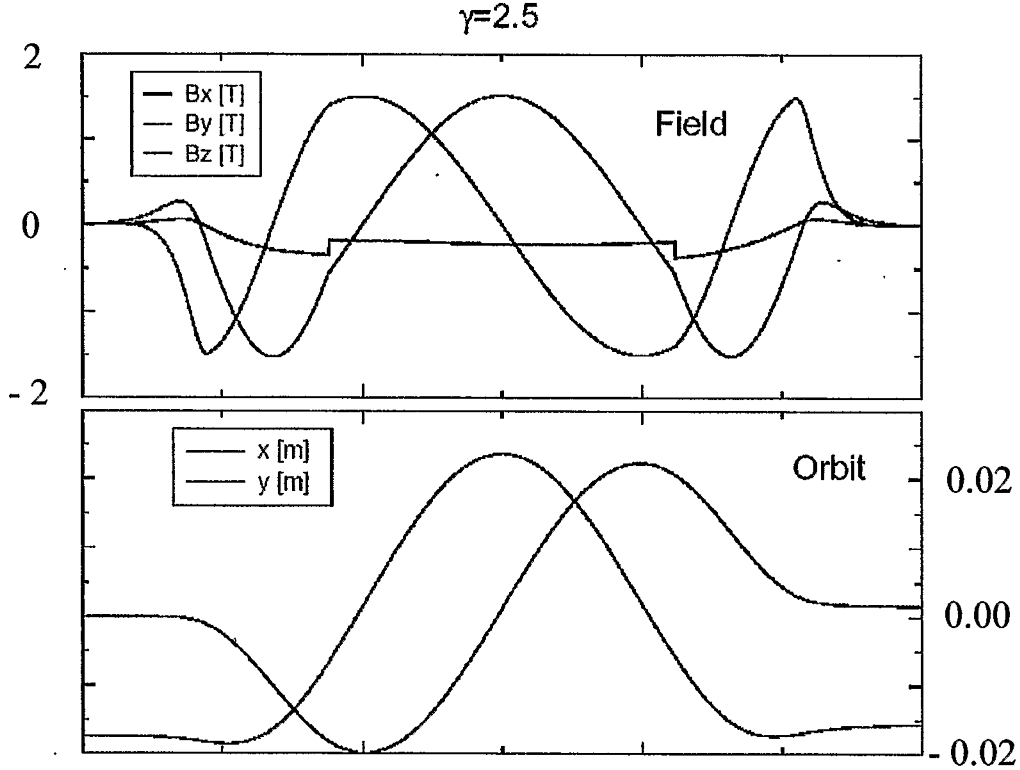
Changing pitch helix with 1.5 T

~ 2 cm max. excursion

-> ¼ of coupling, sextupoles,... of 25% snake

Central solenoid for coupling correction

Fits into 10-foot SS (I10)



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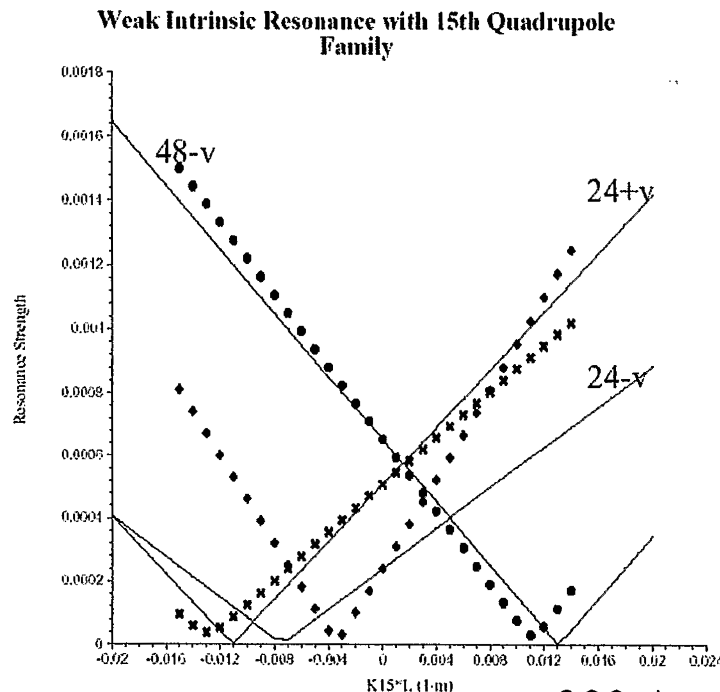
Overcoming weak intrinsic resonances

Betatron tune jump(M. Bai, A.D. Krisch):
Works well up to $\varepsilon \sim 0.002$, rise time: 10 – 100 μs
Possible beam emittance growth

Harmonic spin matching (A. Lehrach, V. Ranjbar):
Tested at COSY. 12 quads in location 15 (and/or 5) -> zero res. strength
± 0.25 tune variations



~ 300 A

Energy jump:
Inexpensive, jump speed too small

Rf spin rotator: (D.W. Sivers)
Requires too strong rf magnets

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Proposed Plan

- Build warm helical 5% snake w/o coupling for installation before Run 4
  - No coupling resonances (~ + 20 % pol.)
- Install quads in #15 straight sections with power supply before Run 4
  - Reduced weak intrinsic resonance strength (~ +10% pol.)
- Explore possibility of using jump quads
  - Eliminate depolarization from weak resonances (~ +15%)
- Build cold helical 25% snake w/o coupling for installation before Run 5 or maybe Run 6
  - Will take time to commission, large effect on orbit properties
  - Can eliminate depolarization from all resonance.
  - Only alternative method to overcome strong intrinsic resonances (Intensity effects and other sources of tune spread can effect rf dipole method!)

November 6-9, 2002 Workshop on Increasing the AGS Polarization

Thursday, November 7, 2002 (Spin Physics Center, 1239 Kipke Drive)

Chair Ya S Derbenev JLab

09:00	Welcome and Introduction (15 min)	A D Krisch	Michigan
09:20	RHIC and AGS Polarization Facilities Status (60 min)	T Roser	Brookhaven
11:00	AGS Beam Optics with a 20% Siberian snake (25 min)	E D Courant	Brookhaven/UM
11:25	Discussion (35 min)	ADK - leader	
12:00	AGS Polarized Beam in the 1980's (25 min)	L A Ahrens	Brookhaven
12:25	Discussion (35 min)	TR - leader	
13:00	***Lunch***		

Chair L C Teng Argonne

14:30	RF Dipole for Strong Depol. Reson. (25 min)	M Bai	Brookhaven
14:55	Discussion (35 min)	ADK - leader	
15:30	Overcoming Depol. Reson. at COSY (25 min)	A Lehrach	COSY
15:55	Discussion (35 min)	TR - leader	
17:30	20% Snake in the AGS (25 min)	H Huang	Brookhaven
17:55	Discussion (35 min)	ADK - leader	
18:30	***End***		

Friday, November 8, 2002 (Spin Physics Center, 1239 Kipke Drive)

Chair Yu F Orlov Cornell

09:00	New AGS CNI Polarimeter (25 min)	G M Bunce	Brookhaven
09:25	Discussion (35 min)	TR - leader	
10:00	Matching of Siberian Snakes (25 min)	G Hoffstaetter	Cornell
10:25	Discussion (35 min)	ADK - leader	

Chair W B Tippens DoE

11:45	Pulsed Quads to Minimize Weak Intrin Res Depol (25 min)	M Bai	Brookhaven
12:10	Discussion (35 min)	TR - leader	
12:45	2003 OPPIS Polarization Upgrade	A N Zelenski	Brookhaven
13:10	Discussion (35 min)	ADK - leader	
16:00	**Spin Physics Seminar in room 335 West Hall (Main Campus)**		
	"Deuteron Spin Flipping and Quantum Mechanics"	D W Sivers	Portland Phys Inst/UM

Saturday, November 9, 2002 (Spin Physics Center, 1239 Kipke Drive)

Chair V K Wong Michigan

09:00	AGS Lattice Changes to Eliminate Weak Res (25 min)	A Lehrach	COSY
09:25	Discussion (35 min)	TR - leader	
10:00	Cross Strong Intrin & Coup Res with Hor RF Dipole (25 min)	M Bai	Brookhaven
10:25	Discussion (35 min)	ADK - leader	
11:00	***Coffee***		
11:30	Quantum Mechanical Model of Spin Flipping (25 min)	B B Blinov	Michigan
11:55	Discussion (35 min)	TR - leader	
12:30	Roundtable		
13:15	***Lunch***		

Chair A N Zelenski Brookhaven

15:00	Spin Matching with a 20% Snake (25 min)	W MacKay	Brookhaven
15:25	Discussion (35 min)	ADK - leader	
16:00	Open	ADK - leader	
17:00	***Coffee***		

Chair C Ohomori KEK/JHF

17:30	Workshop Highlights and Discussion	T. Roser	Brookhaven
18:45	***End***		

Status Report on the Accelerator Run-03 Preparations

L. Ahrens, BNL
December 20, 2002

for
RHIC Spin Collaboration Meeting XIV
RIKEN BNL Research Center

AGS P-P Pre work

20 Dec 02
Ahrens

o AC dipole / tune meter (use same (new) magnet)

tune meter "working"
AC dipole - waiting in line - (required controls work...) {Luf + Mei}
some progress in infrastructure

o old polarimeter (C20) {Huang}

o new (CNI) polarimeter (C15) (access last week) {Bravar}
d in AGS "regularly" but never very long now - present running mode
this should change when RHIC gets to store

o schedule - pp to 200 meV = linac early Jan {T mdas / Mathieu}

start mode switch to pp in Boo/AGS mid Jan
{presently "working out" (Au-d), this will be (Au-d-p) [illegible]} {Roger [illegible]}

o AGS tune space exploration just beginning {Woody Leif}

Status Report on the AGS CNI Polarimeter

I. Alekseev, ITEP

December 20, 2002

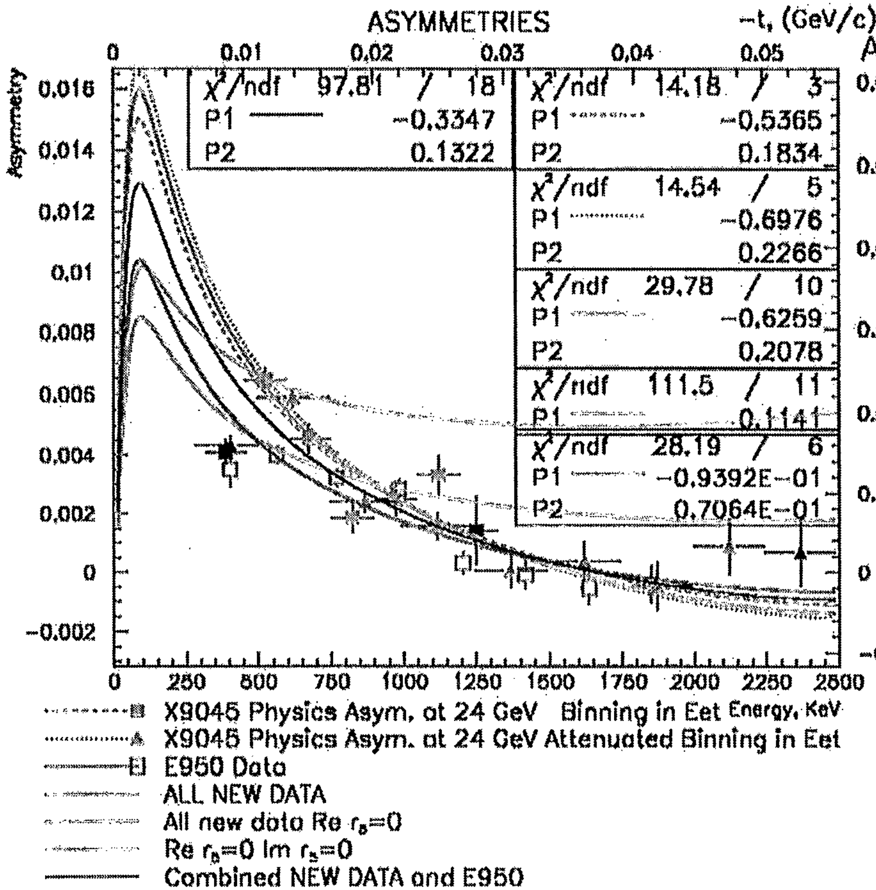
for

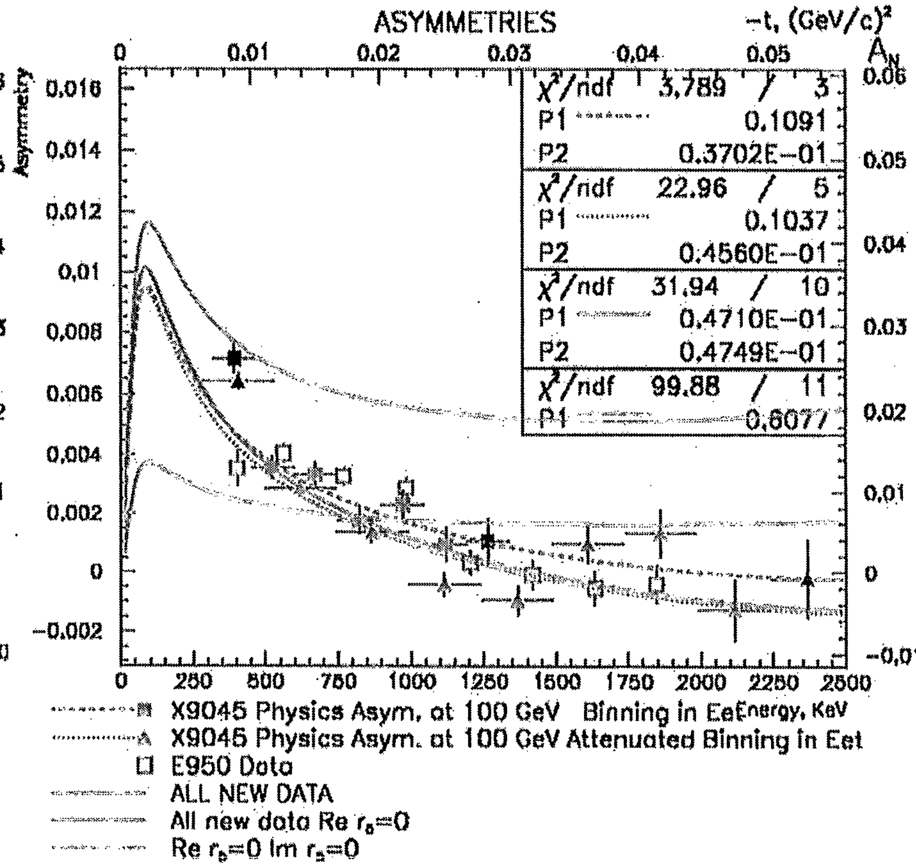
RHIC Spin Collaboration Meeting XIV

RIKEN BNL Research Center

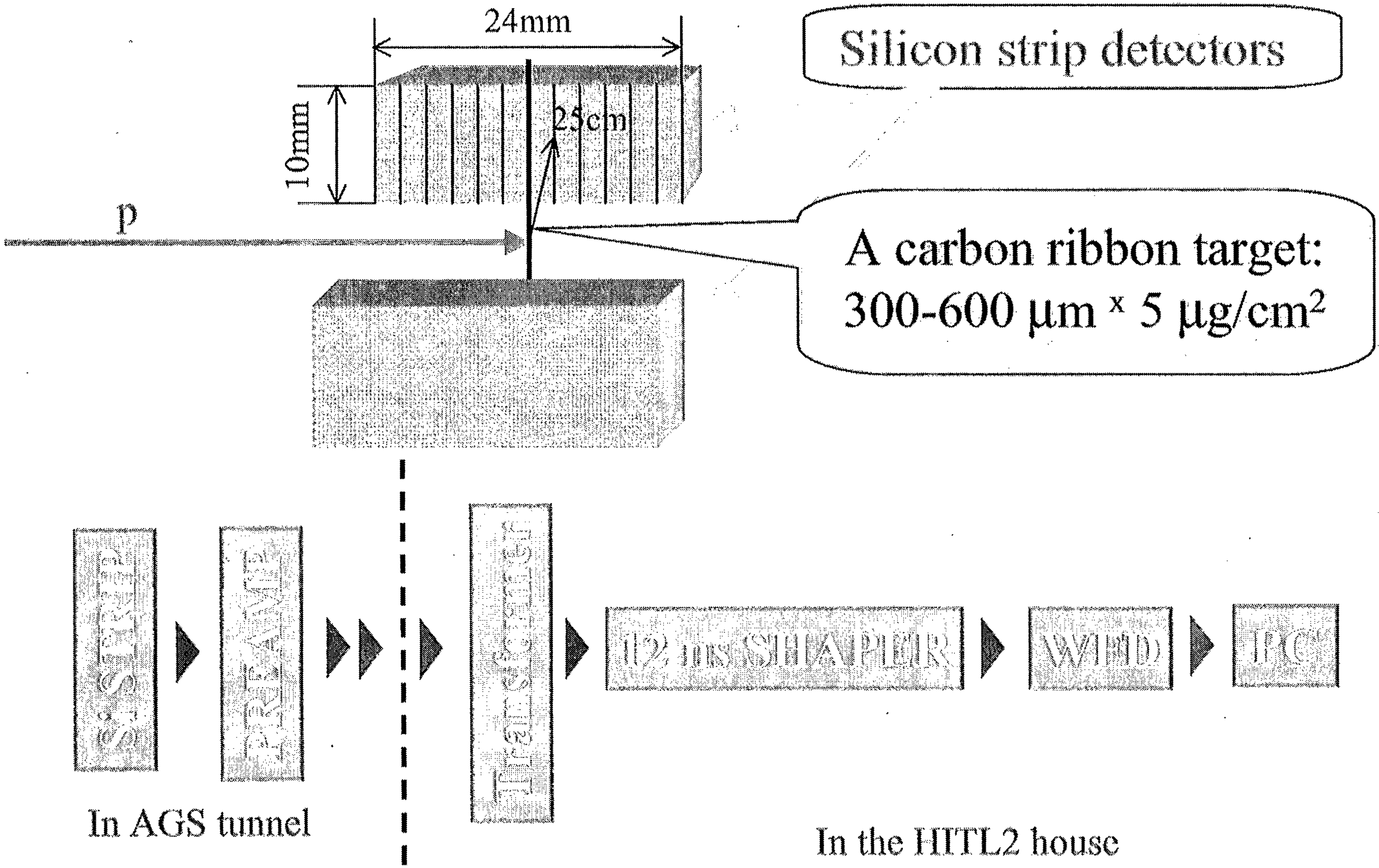
AGS CNI polarimeter. Current Status.

Elastic scattering of polarized beam protons on a extremely thin carbon target with a small (~0.01 $(GeV/c)^2$) momentum transfer. Large cross-section and a few percent analyzing power.

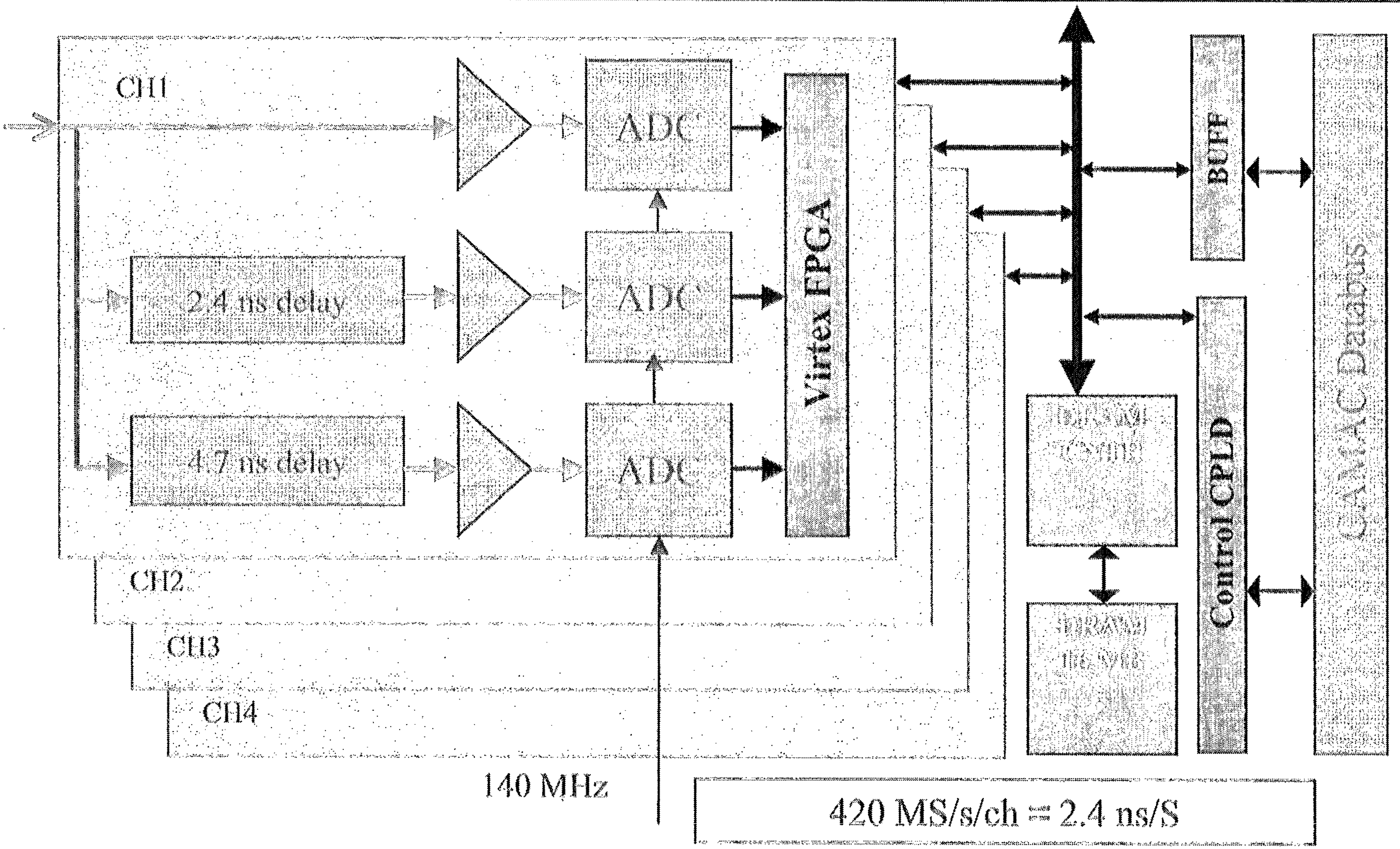




AGS setup

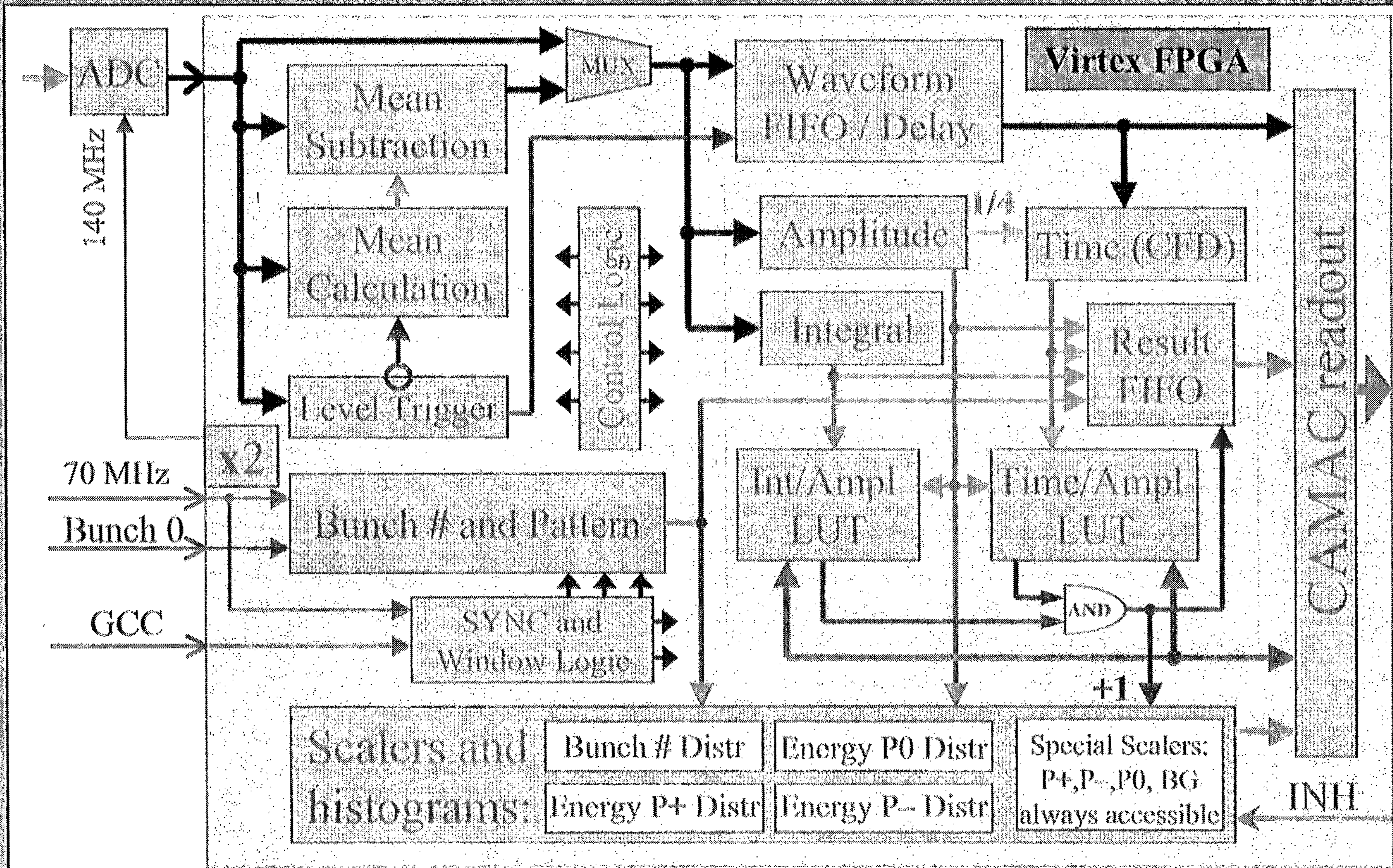

24mm
10mm
25cm
p
Silicon strip detectors
A carbon ribbon target:
300-600 μm x 5 μg/cm2
12 ns SHAPER
WFD
PC
In AGS tunnel
In the HITL2 house

WFD Block Diagram



FPGA Block Diagram

RSC Meeting



WFD features (V8)

- ✓ 8-bit amplitude and integral
- ✓ 1.2 ns time resolution
- ✓ Bunch # information
- ✓ Windowed sensitivity with 2.4 ns precision
- ✓ Digital filter
- ✓ Time/amplitude and integral/amplitude LUTs
- ✓ LUTs programmable trough CAMAC
- ✓ Bunch pattern memory
- ✓ 5 always accessible scalers (P+,P–,P0, 2*BG)
- ✓ 120 ch bunch distribution
- ✓ 3*128 ch amplitude distributions for P+,P–,P0
- ✓ 32*32 or 16*64 amplitude versus time histogram
- ✓ Crate or front panel INHIBIT stops event recognition
- ✓ 16 MB of onboard SDRAM ~ $2.5 \cdot 10^6$ events
- ✓ Special input for Gauss Clock Counts
- ✓ Zero deadtime
- ✓ Flexible FPGA configuration

Expected performance

RSC Meeting

- Ramp measurement: 2.4 – 24.5 GeV/c ⇒ a challenge for timing.
- Event rate compare to RHIC:

	RHIC (60-bunch mode)	AGS (6-bunch mode)	Factor
Target width	10 μm	500 μm	50
Bunch frequency	4.7 MHz	2.3 MHz	0.5
φ-acceptance	32^o	4.6^o	0.14
Beam energy	100 GeV	25 GeV	0.5
Bunch filling	10^{11}	$1.5 \cdot 10^{11}$	1.5
Total	$6 \cdot 10^5$ events/s	$1.6 \cdot 10^6$ events/s	2.6

- CAMAC readout ~ 10^6 events / 3s ~ one spill.
- $5 \cdot 10^8$ events per ramp measurement ~ 500 spills · 10^6 events ~ 40 min.
- Radiation damage to silicon. The whole RHIC statistics ~ 20 ramp measurements: one day !
- Event rate per strip ~ 0.1 event per bunch crossing.

Current status

RSC Meeting

DONE:

✓Silicon detectors, preamplifiers and BIAS power supplies are installed in the ring and tested.

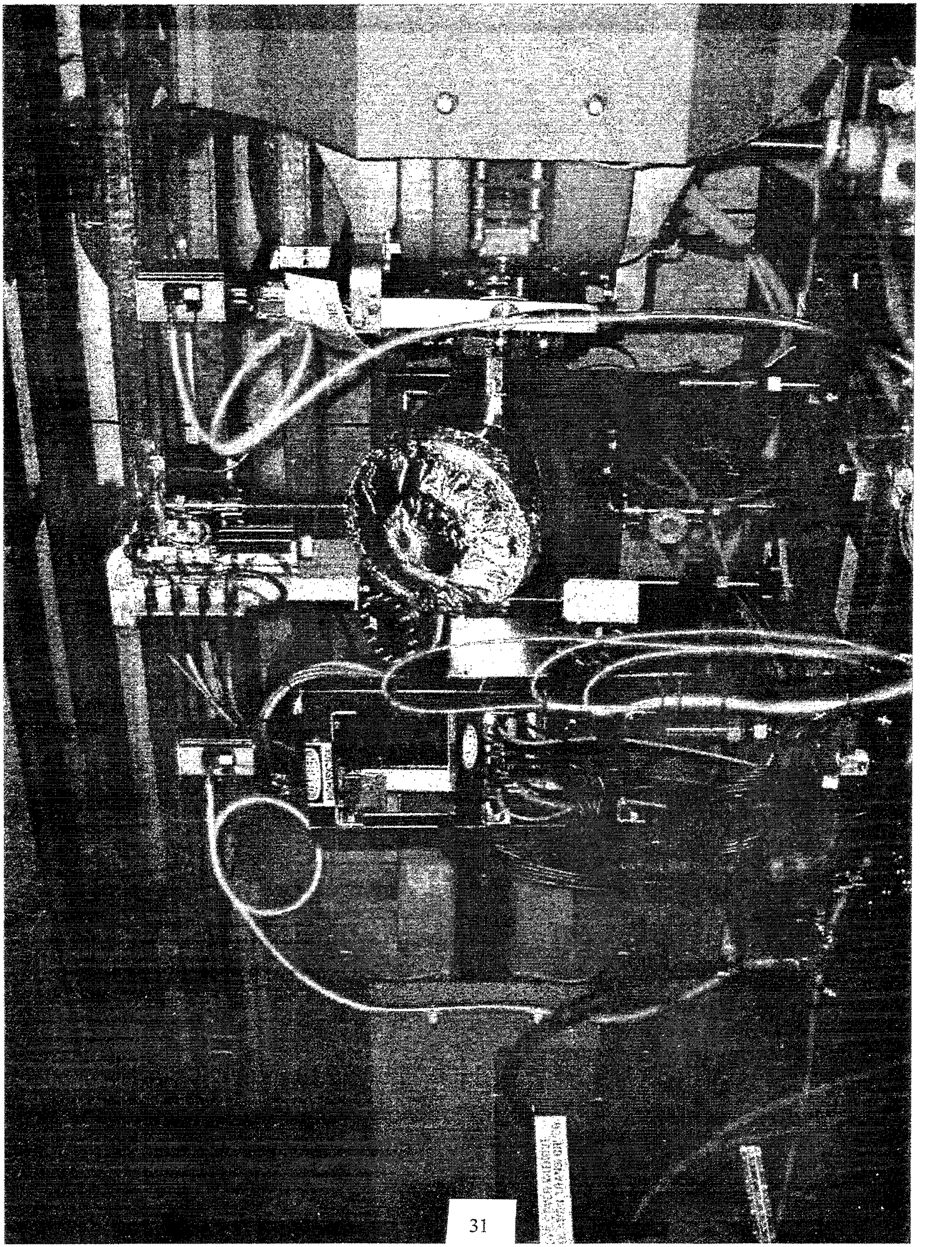
✓ Insulation transformers and shaping preamplifiers are installed in HITL2 and tested.

✓ A new 2.5 GHz PC, CAMAC and 6 WFD modules installed in HITL2 and tested.

✓ LeCroy 2367 universal module programmed to produce all necessary spill timing signals and prescale GCC.

TO BE DONE:

- Get proper signals from AGS.
- Get, install and test frequency multiplier.
- Write DAQ and analysis software.



Summary/Outcome of the Jet Target/Experiment Review

Y. Makdisi, BNL
December 20, 2002

for
RHIC Spin Collaboration Meeting XIV
RIKEN BNL Research Center

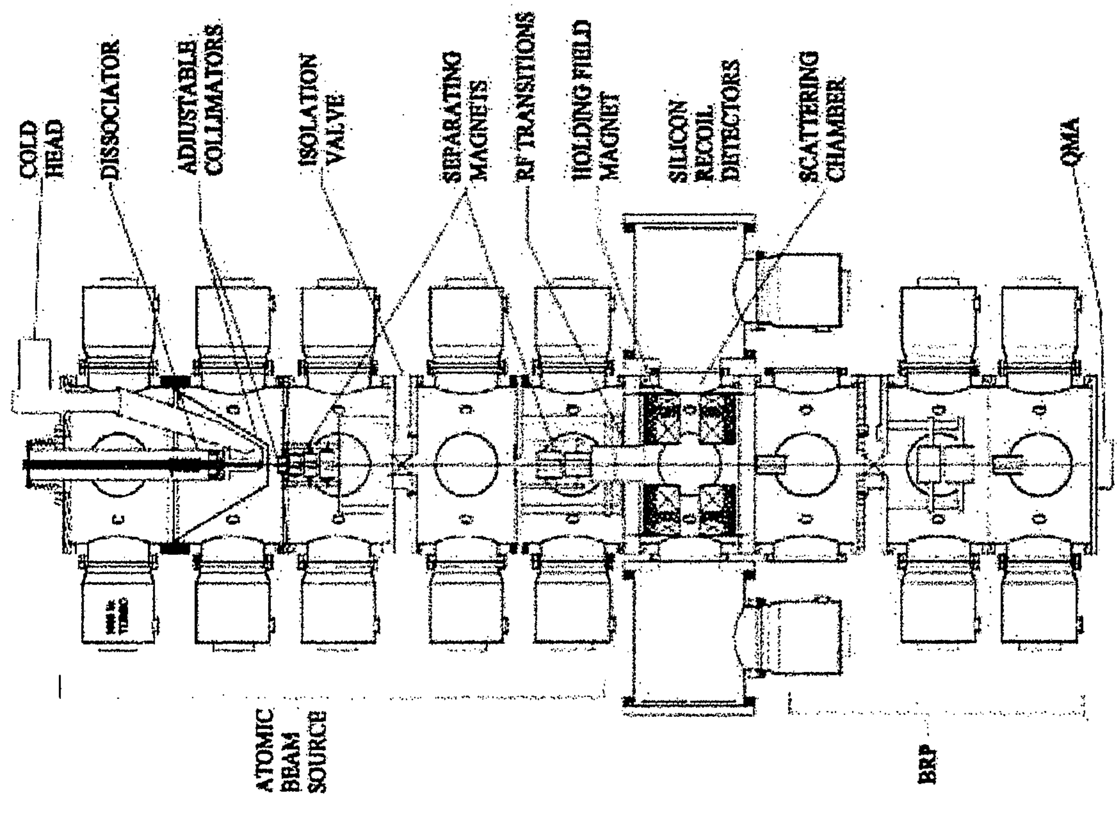
RHIC Polarized Jet Target Review
November 18-19, 2002
BNL Collider Center (Bldng. 1005), 3rd Fl. Conf. Room

Monday November 18, 2002

08:30	Executive session	
09:00	Status of RHIC as a polarized proton collider	Thomas Roser, BNL
09:20	The Jet Target: status and plans: Response to the Review charge	Yousef Makdisi, BNL
09:50	Jet design considerations: The concept, intensity, resonances	Tom Wise, Wisconsin
10:50	Break	
11:05	The holding field magnet: Design, and fabrication plans	George Mahler, BNL
11:35	Impact on RHIC: target chamber, vacuum, RF impedance	Anatoli Zelenski, BNL
12:05	Working Lunch	
13:30	Mechanical Assemblies and Installation at 12 o'clock	John Ritter, BNL
14:00	Beam Polarization measurement with recoil arms: physics, detectors, simulations stats, syst. etc.	Alessandro Bravar, BNL
15:00	The DAQ and WFD systems	Dmitry Svirida, ITEP
15:30	Break	
15:45	Target polarization measurement: BRP stage and systematics	Tom Wise, Wisconsin
16:30	Combined measurements beam and target	Ed Stephenson, IUCF
17:00	The P-Carbon CNI polarimeters and sytemetics	Gerry Bunce, BNL
17:30	Summary and discussion	Makdisi/Bunce
18:00	Committee Executive session	
19:30	Committee Dinner (Y. Makdisi, host)	

Tuesday November 19, 2002

08:30 RHIC tour (meet at 1005)
10:00 Additional presentations if necessary — Makdisi (Timeline) Resources; Bunce (Collaborative nature of Polarimetry @ AGS/RHIC
11:00 Preparing draft reports
12:00 Working Lunch
13:00 Closeout with the collaboration


COLD HEAD
DISSOCIATOR
ADJUSTABLE COLLIMATORS
ISOLATION VALVE
SEPARATING MAGNETS
RF TRANSITIONS
HOLDING FIELD MAGNET
SILICON RECOIL DETECTORS
SCATTERING CHAMBER
QMA
ATOMIC BEAM SOURCE
BRP

The RHIC Polarized Jet Target Review

Brookhaven National Lab
November 18-19, 2002

Final Draft —— Final Draft —— Final Draft

The RHIC spin physics program has been from the beginning a unique opportunity and an important component of the overall RHIC physics program. Essential to this spin physics program are the polarized proton beams which enable the studies of spin physics phenomena in high energy collisions. The technical challenges to be faced to realize this program include the production and acceleration of the polarized beams, manipulation of the spin direction at the interaction points, and the accurate measurement of the beam polarization and related asymmetries. This review is focused on the RHIC Polarized Jet Target, which is the system chosen to provide absolute polarimetry for RHIC proton beams.

Thomas Ludlam convened the Review Panel on November 18-19, 2002 to review the status of the RHIC Polarized Jet Target project. The charge given to the Panel asked us to assess:

1) The design criteria and technical issues associated with the development of the polarized hydrogen jet target. This is to include progress attained so far, engineering design and integration, installation plans, impact on the RHIC luminosity performance, schedules and cost estimates.

2) The proposed plan to measure the polarization of the atomic hydrogen jet and the circulating proton beam as well as the expected backgrounds and the resulting systematic errors. Is the goal of a 5% absolute proton beam calibration at a beam energy of 100 to 250 GeV feasible, and is this sufficient to carry out the proposed physics program?

The Committee was chaired by Charles Prescott (SLAC), with the following panel members: Thomas Clegg (North Carolina/TUNL), Dieter Eversheim (Bonn), David Lynn (BNL), Hans-Otto Meyer (IUCF), and Hal Spinka (Argonne). The schedule of talks presented to the Panel is appended to this report.

SUMMARY AND RESPONSE TO CHARGES

For the Review Panel, this meeting was the first opportunity to see the plans for the Polarized Jet Target Project. It also offered the Panel a chance to see the status of the RHIC program and to meet and talk to the collaboration members involved in this program. In the past 20 years, polarized targets have been implemented at a number of facilities around the world. Brookhaven has considerable experience with the technologies involved and with other types of polarimeters, and with the help of experienced collaborators from outside institutions, has pulled together an optimal design for a RHIC polarimeter.

With regard to the first part of the Charge, serious work on building the systems started in early 2002. Design of the many components of the target required first optimizing the specific geometry, positioning, and sizes of the internal components. Magnetic fields and field elements were also optimized for the RHIC requirements. This work was largely done at Wisconsin. Although this work held up making design choices, the result looks very promising (in simulation) for significantly increasing the atomic beam density over that obtained in previous similar targets. RHIC polarimetry will benefit considerably if these gains are realized.

On the other hand, construction has been slow to get started. At the request of the Panel, an updated schedule was generated on the evening of the first day and provided the next morning for discussion. The schedule shows work on the numerous components going on in parallel. Many components must be scheduled for fabrication and delivery in the next several months. This work needs close watching to assure meeting the stated goal of commissioning beginning in May 2003 and installation in RHIC for a dry run in November 2003. Strong management oversight is required.

The main recommendation is therefore:

> *Identify a full-time Polarized Jet Target Manager to start immediately and carry the project through to initial operation.*

Regarding costs, the Panel was shown a list of technical components and estimates of their costs. Without more detailed information, we were not able to assess the accuracy of these estimates. The contingency is set at 19%, which appears to the Panel to be low. This part of the cost probably should be raised. The understanding of the costs and the budget should be an early task of the project manager. The usual approach to a cost review would be to look at the Work Breakdown Structure, in which the major systems are broken down into the lower levels of detail. Cost contingency is assigned to each subsystem component according to its status in the design phase, procurement phase, etc.

A second recommendation is therefore:

> *The RHIC management should call for future reviews of the Polarized Jet Target Project, at 6 months and 12 months from now. These reviews should be primarily focused on cost, schedule and progress toward the timely completion of construction and the commissioning of the project.*

With regard to the second part of the Charge, the physics goals establish the required level of accuracy and precision needed in the spin physics program. There have been many studies of spin physics with polarized protons. Over the past ten years and more, the understanding of the spin structure of a polarized proton has been evolving. Scattering of leptons (electrons or muons) at high energies have revealed the spin content contributed by the quarks to be considerably smaller than at first expected. The role of the gluon in the proton spin structure naturally comes into question, and RHIC can directly study this topic. Present information from lepton scattering is limited because charged leptons do not scatter from the (uncharged) gluons, and only through structure function evolution with Q^2 do we see hints of large gluon contributions to the spin. Errors are 50-100% on these "hints". The spin structure community has been waiting for the commissioning of RHIC to gain further understanding of this puzzle. Measurements at the 10% level or better are both desired and possible. To reach this goal, the absolute beam polarization must be known to $\approx$ 5%.

Large asymmetries from transversely polarized beams on unpolarized targets have long been known to exist, based on Fermilab data (E704). Recent theoretical and experimental interest in these unexplained phenomena has increased considerably. Accurate measurements, at the 10% level, using polarized RHIC beams would raise considerable attention and would stimulate further theoretical work to understand the asymmetries. To carry out such studies, accurate and reliable polarimetry is required. At this time, RHIC features two efficient polarimeters based in small-angle p-carbon scattering ("pC CNI polarimeters"). Since their analyzing power is based on a theoretical estimate only, an *absolute* calibration is needed.

The Polarized Jet Target system has been designed to meet this goal. Based on the experience from recent systems of similar design, the parameters have been thoroughly studied and optimized. The atomic beam source intensity appears in simulation studies to exceed previous designs by a factor of $\approx$ 4, while meeting the requirements for beamline operation at RHIC. Accuracy at the 5-6% level appears feasible and would be sufficient for the physics program to achieve its goals. The target specialists felt this level of accuracy would not be achieved in the first year of operation, but with experience and tuning, should be reached quickly thereafter.

Because polarimeters are so important to the spin physics program, and because effective coordination of the RHIC polarimeters with the experimental groups is crucial, a liaison person will be needed by the time commissioning is underway.

A third recommendation is therefore:

A full time BNL staff physicist should be identified who will be responsible for hardware, operations, and data analysis of all the

RHIC polarimeters, and for liaison to the experimental groups.

Discussion and Comments

Management and Project Organization

The declared goal of the RHIC Polarized Jet collaboration is that a physically complete jet system exist and be ready to support the experimental program by the end of FY 2004. Their interim goal is that Polarized Jet hardware be complete and installed in the 12 o'clock IR by no later than November 2003 for an early systems test in the RHIC ring.

A PERT chart covering January 2002 to December 2003 has been distributed. This chart was drawn up on short notice at the request of the Panel. The list shows both jobs that were completed during 2002, as well as the future job sequence needed to reach the 11/03 goal. This future job list represents a very aggressive schedule.

To keep to such a schedule requires that the status of all active jobs be monitored closely (on a daily basis), that the critical path be clearly recognized, and that the impact of departures from the schedule be understood. This Panel feels that without a committed, full-time project leader there is little hope to reach the 11/03 goal. The project leader should also be responsible as a liaison to the representatives of the collaboration who are carrying out some of the work at their home institutions. (see our first recommendation)

Little time and effort was spent to produce the present PERT chart. It is necessary that the jobs listed and their completion dates be consistent with available manpower. Thus the PERT chart has to be refined and combined with the names of contributing people and their respective involvement in this project. This Panel suggests that follow-up reviews of the Jet Target Project be conducted at 6 months and 12 months from now, i.e., prior to the first installation effort and after the first test in the 12 o'clock IR. The purpose of these reviews is to report the progress of this project to the RHIC management, to the Jet Target collaboration, and to the users of the RHIC polarized beams. (see our second recommendation)

Atomic Beam System (ABS)

There seem to be no real showstoppers as far as the ABS jet systems are concerned. The committee was impressed with the overall level of understanding of technical issues and challenges associated with development of the jet. Thus, the four issues highlighted below are not surprising. Generally, most have been considered already by the design group, or are acknowledged by individual group members to be worthy of further consideration.

1) One must design and map magnetic field shapes very carefully, especially around the ABS RF transitions and beam interaction regions, to assure proper spin handling and depolarizing resonance avoidance. Mutual proximity of these regions, each of which needs critically shaped electromagnetic fields to accomplish its intended physical process, is a technical challenge which will likely take time to resolve. Sufficient time must be allocated after assembly of these systems on the test stand for careful field mapping and correction of unwanted electromagnetic interactions.

2) Protection from the unlikely, but potentially damaging break of a pyrex dissociator tube dictates careful attention to interlocks and possible fast-acting valves to isolate critical regions of the source from the accelerator. Early discussion is needed with responsible parties in accelerator operations to fix the design of appropriate protection measures.

3) Desire for rapid jet target and Breit-Rabi polarimeter installation in the RHIC ring, especially during early systems development and refinement, means that rapid pumpdown capability will be advantageous. Thus, early consideration should be given to facilitating bakeout of critical Jet Target regions nearest the RHIC ring. This would likely require designs for proper heat sinks and thermal shielding of critical components like the permanent magnet sextupoles and Si detectors.

4) Minimizing the background H_2 and H_2O contributions to the expected scattering asymmetry will be very important for overall minimization of polarimetry errors. Because this is so important in reducing the overall uncertainty of the RHIC beam polarization, plans need to be in place to devote enough effort and resources, probably over an extended time period, to assure first that these background contributions can be analyzed and monitored, and later that they can be understood as well as possible.

Breit-Rabi Polarimeter (BRP)

The Breit-Rabi Polarimeter for the RHIC Polarized Jet Target is similar to the one used at HERMES, where this method has been developed to its present level of maturity and accuracy. At HERMES the BRP serves as the standard for the atomic beam polarization measurement. Systematic errors related to the target polarization measurement have been shown to be negligible except for i) the ballistic background from hydrogen gas and water; the contribution of the latter has been found at COSY to be exceptionally high (7%); and ii) the bunch field depolarization of the target by the beam.

Both effects should be checked at RHIC as soon as possible to serve as a quality control of the complete RHIC Polarized Jet Target and to give a realistic assessment of the attainable accuracy of the RHIC Polarized Jet Target polarization.

The costs for the RF-transitions are believed to be realistic assuming that there is substantial support and RF knowledge, both from and within the group responsible for building these devices.

Silicon Detectors, Readout Electronics, and Data Acquisition

The collaboration presented their plans to measure asymmetries (and thus analyzing powers) in the elastic scattering of RHIC beam protons with jet target protons, where one or both of the protons are polarized. Asymmetries are measured through detection of the jet recoil proton at scattering angles near ±90 degrees to the beam direction and in the horizontal plane (i.e., in the direction perpendicular to both the RHIC beam and jet direction). Measurement of the scattering angle provides a measurement of |t|, the four-momentum transfer squared of the scattering process.

The collaboration proposes to use twelve silicon detector arrays to measure the scattering angle of the recoil proton, as well as the proton energy and time of flight. The detectors are sufficiently thick to stop protons up to 8 MeV. The acceptance of the detectors around the 90 degree angle is sufficient to see elastic scattering from both the Yellow and Blue RHIC beams, but easily has sufficient resolution to identify which beam is involved in each event. It was shown that background signals primarily in the form of beam-gas interactions and diffractive proton-proton interactions are kinematically suppressed by using |t| vs. scattering angle correlations.

The detectors are to be read out with an existing preamp followed by signal-shaping electronics that are currently under design. The signals are recorded with CAMAC "Waveform Digitizers" (WFD) that sample each channel at approximately 370 MHz. It is noted that the readout (preamps through the WFDs) are slight modifications of a system that has been successfully implemented in the pC CNI polarimeters at RHIC.

We see no significant technical challenges in either the silicon detectors or readout electronics. The technologies are mature and there is sufficient expertise with these technologies either directly within the collaboration or within groups assisting it.

A timeline was presented for production of the detector system beginning with a December 2002 start of silicon detector fabrication and ending with a completed system by December 2003. The proposed schedule to build the detector and readout system within a year appears to be adequate and allows some contingency. However we point out that the fabrication of silicon detectors is a process that often causes delays because of design and yield issues, as well as clean room equipment failures. As the collaboration only requires 4 working detectors in the first year to initiate a polarization measurement we believe there is sufficient contingency in the schedule to obtain these detectors. But the collaboration should carefully monitor the production to see that it proceeds in a timely fashion.

No information was presented on grounding and shielding of the detectors. We recognize that some collaboration members have experience with a similar detector system through their work on the pC CNI polarimeters. But there may be additional pickup problems arising from the jet source itself. We recommend that consideration be given to grounding and shielding before construction of the detectors and their mounting assemblies.

While bake-out of the polarimeter is not currently planned by the collaboration, we suggest that they consider in the design of the detector mounts sufficient heat sink capability to protect the detectors should a bake-out become necessary.

Systematic Uncertainties

The process of establishing a known beam polarization when only the target polarization is a priori known was described. Basically, measurement of asymmetries in two detectors (left, right) with four beam-target spin states (++,+-,-+,--) provides sufficient information to solve for the beam polarization multiplied by an analyzing power, A, and separately the target polarization times A. The ratio eliminates A, and the BRP measurement of the jet target polarization allows for determination of the beam polarization. Solid angle acceptances and luminosity factors cancel out, and other effects are minimized. A generalized matrix version of an analysis scheme was described in which no unpolarized running is required, and the spin independent luminosity for each spin state is not needed. Through calibration of the beam polarization, the pC CNI polarimeters would be calibrated at each RHIC running energy.

A summary of the expected uncertainties contributing to the knowledge of the absolute beam polarization was presented. These are all dominated by systematic uncertainties, and when combined in quadrature give $\Delta P_{beam}/P_{beam} \approx \pm 0.06$.

The three largest contributions are all about ±3% and include: a) the error in measurement of the absolute jet target polarization, dominated by the uncertainty of the fraction of water and molecular hydrogen in the interaction region, b) the systematic error in the asymmetry measured in the pC CNI polarimeter, and c) the uncertainty in the pC CNI polarimeter analyzing power when the silicon strip detectors are replaced, due to the unknown depth of the dead layer on their surface. The Panel believes that the accuracy $\Delta P_{beam}/P_{beam} \approx \pm 0.06$ is a realistic estimate, based on the results shown, and that it will not seriously impact the RHIC polarized program, which specifies an accuracy of ±0.05 for the beam polarization.

We believe (with one reservation) that the proposed detector system will be capable of measuring the analyzing power of elastic proton scattering. Our reservation concerns whether there is sufficient rejection of background signal in the detectors. Though there appears to be sufficient rejection of beam-gas and diffractive interactions (through kinematic techniques described by the collaboration), there is concern that additional sources (e.g. from scattered jet beam) may alter the measurement if these sources have a non-negligible analyzing power. However we recognize that estimation of these backgrounds (and analyzing power) is very difficult and can only be fully understood once the device is built.

Among the three largest contributions to the total error, the Panel believes that the first has a good chance to be reduced with careful study, although it may take more than 1-2 years to achieve this reduction. The second largest contribution is caused by a presently unknown source of systematic error in the pC CNI polarimeter from the 2002 run. It is urged to pursue vigorously the source of this error, as it has the potential to be present also in the jet target polarimeter. Note that for polarized pp collisions when the jet target is collecting data, $\Delta P_{beam}/P_{beam} \approx \pm 0.04$ would be expected, and the Panel encourages significant RHIC polarized running with the jet target in order to achieve the smaller uncertainty in absolute beam polarization.

Although a commissioning plan was not presented, it is anticipated that many systematic studies will be needed. Many of the tests for systematic errors performed for the pC CNI polarimeter should be repeated with the jet target detectors, since they are similar in design. Other tests might involve varying the spacing of the Yellow and Blue beams at the interaction region, cross checks of the pC analyzing power with a carbon beam on the polarized jet target, mapping of the polarization profile as the target is moved relative to the beam, and perhaps a cross check of the energy dependence of the analyzing power by acceleration and deceleration of the beam within a fill. Will Come

Since the polarized jet target polarimeter is anticipated to be an important instrument for future polarized proton running at RHIC, a BNL staff physicist should be responsible for its hardware, operations, and data analysis. The RHIC pC CNI polarimeters are complementary to the polarized Jet Target and equally important to the measurement of the polarization of the beams. The *same* staff person should oversee and coordinate work with these polarimeters. He/she should work with collaborators from the RHIC spin community to derive beam polarizations, study systematic effects, and make hardware repairs and improvements. (see our third recommendation)

Appendices:

Review Agenda

Response

- Makdisi is the Full time PM.
- Makdisi et al are preparing a MS Project management & tracking [met with Jehanne Simon Gillo this morning & she is happy with the development & progress]
- Makdisi to call JSG monthly.
- Joe Scaduto is assigned the Liaison Engineering task.
- Haixin Huang to look after the Polarimeters Liaison.

Makdisi, Yousef I

From: Fox, Brendan
Sent: Tuesday, December 03, 2002 8:40 AM
To: Roser, Thomas; Mackay, William W; Saito, Naohito; Bland, Leslie C; Goto, Yuji; Makdisi, Yousef I
Cc: Bunce, Gerry M; Heinz, Tammy A
Subject: Proposed Agenda for the next RHIC Spin Collaboration Meeting (Wed, Dec 18th)

Hi y'all,

In consultation with Gerry, I have cobbled together the following itinery for the next RHIC Spin Collaboration Meeting:

09:00 to 09:45 - Summary of the AGS Polarization Workshop
(Thomas Roser)
09:45 to 10:30 - Summary/Outcome of the Jet Target/Experiment Review
(Yousef Makdisi/TBA)
10:30 to 10:45 - Coffee Break
10:45 to 11:30 - Status Report on the Accelerator Run-03 Preparations
(Loif Ahrens)
11:30 to 12:00 - Status Report on the AGS CNI Polarimeter
(Jeff Woods)

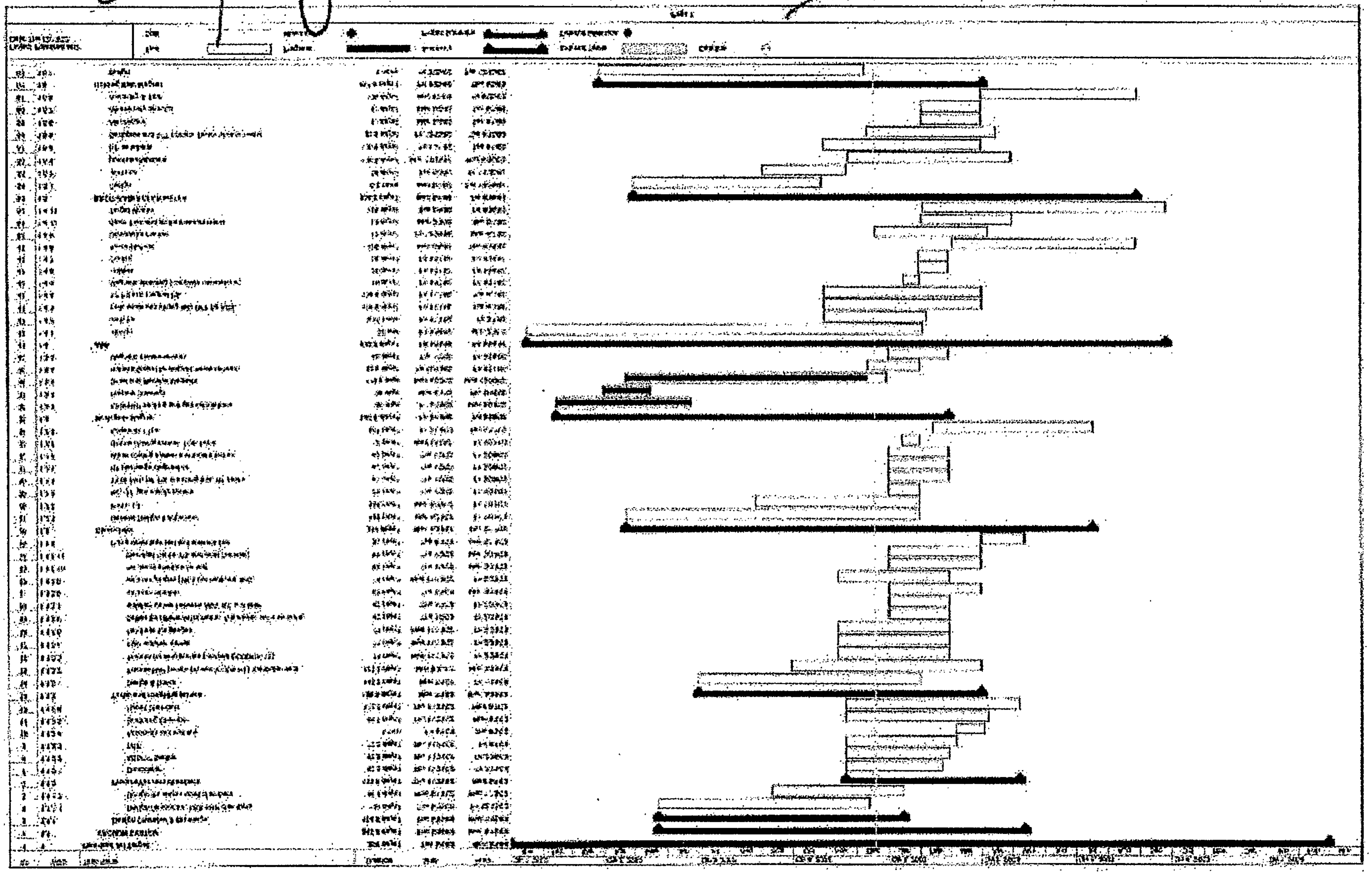
02:30 to 02:50 - Update on PHENIX Readiness for Run-03
(Matthias Grosse-Perdekamp/TBA)
02:50 to 03:10 - Update on STAR Readiness for Run-03
(Les Bland/TBA)
03:10 to 03:30 - Update on RHIC Polarimetry Readiness for Run-03
(Osamu Jinnouchi/TBA)
03:30 to 03:45 - Coffee Break
03:45 to 04:15 - Conclusions about RHIC Polarimetry for Run-02
(Osamu Jinnouchi)
04:15 to 05:00 - Run-02 BBC Asymmetry Results from PHENIX
(Kiyoshi Tanida)

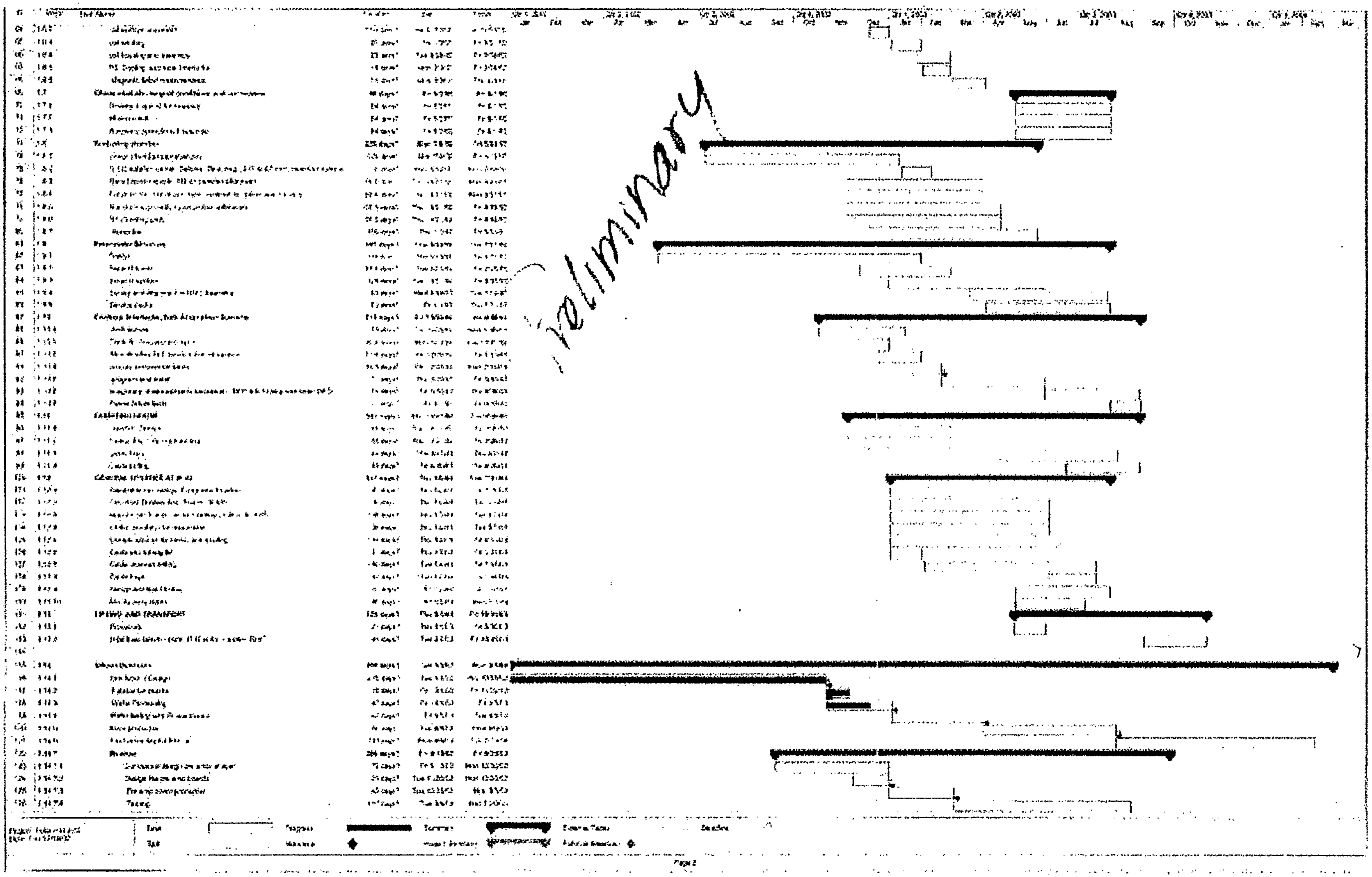
where I have indicated either speaker or, via the "/TBA" the person who I will ask to tell me who should speak on this topic.

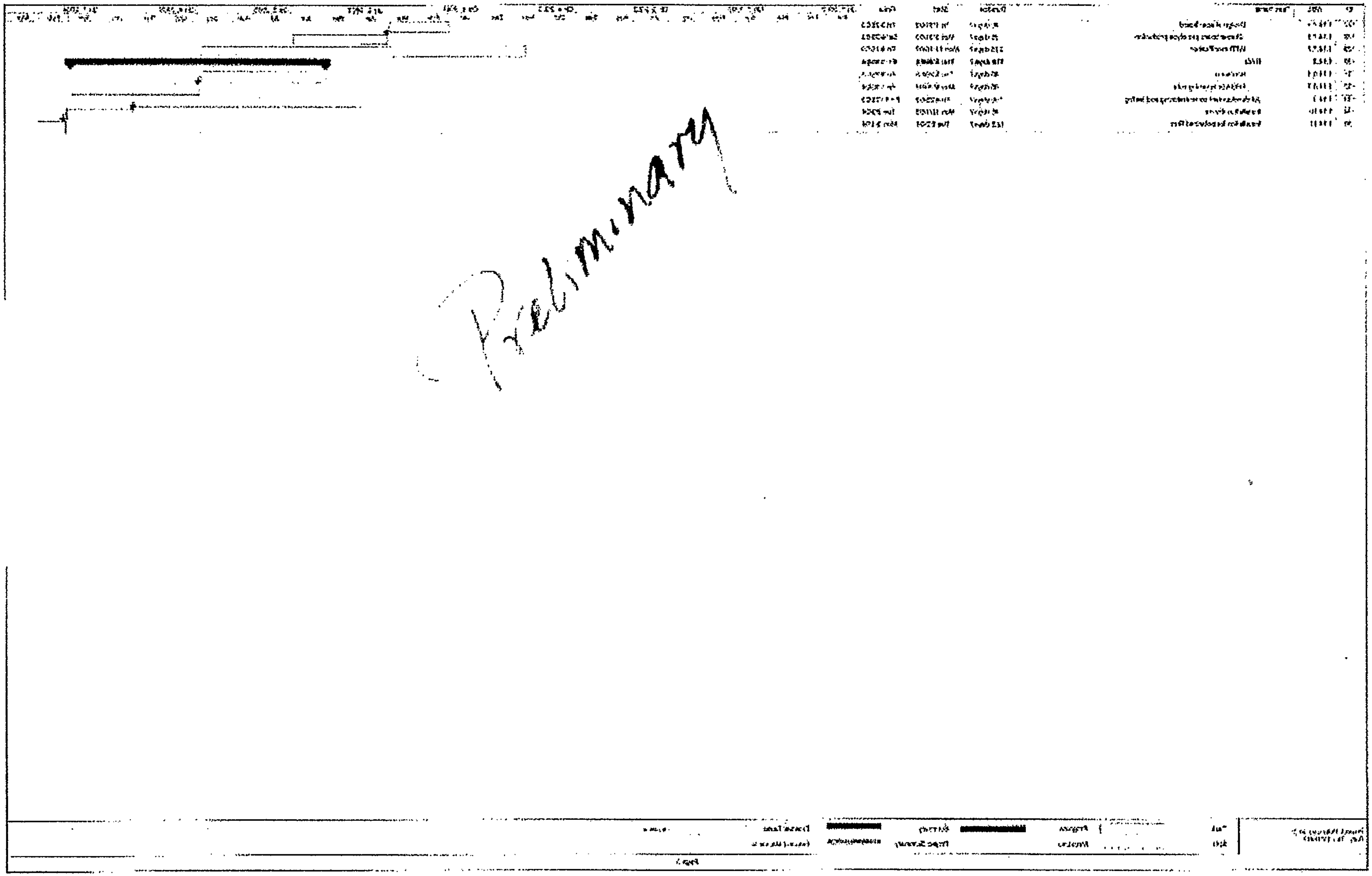
Please let me know if there is anything additional which you feel should be covered in this meeting ... thanks ...

... brendan

In progress! Preliminary




Preliminary


Preliminary

Conclusions About RHIC Polarimetry for Run-02

O. Jinnouchi, RBRC

December 20, 2002

for

RHIC Spin Collaboration Meeting XIV

RIKEN BNL Research Center

Conclusions about RHIC Polarimetry for Run-02

Osamu Jinnouchi

12/20/2002 RHIC SPIN Collaboration meeting

Based on the Spin2002 contribution article,
"RHIC pC CNI Polarimeter: Status and Performance from the First Collider Run"

Systematic error estimation

- List of error sources
  - False asymmetry distribution
    - Distribution of null asymmetry measurement (Y, Cross)
    - Difference of two independent detector set (X90-X45)
  - Bunch fluctuation (χ^2/ndf distribution)
  - Bunch dependent effect (mixing spin pattern)

  - Other sources
    - Backgrounds, pile-up
    - Si dead-layer, E950 …

False asymmetries

- The width of distribution includes both *systematic* and *statistical* contributions in the form of quadratic sum
- Systematic error can be unfolded from the distribution with equation,

$$\sigma_{systematic} = \sqrt{\sigma^2_{observed} - \sigma^2_{statistics}}$$

- ***Independent measurement***

(X90-X45)/Err
Mean 0.25(B) / –0.02(Y)
Sigma 1.11(B)/ 1.10(Y)

→ σ_{syst} = B: $0.5\sigma_{stat}$, Y: $0.5\sigma_{stat}$

- ***Null asymmetry measurement***

Y45/Err
Mean 0.16(B) / –0.30(Y)
Sigma 1.11(B)/ 1.43(Y)

→ σ_{syst} = B: $0.5\sigma_{stat}$, Y: $1.0\sigma_{stat}$

Cross/Err
Mean -0.17(B) / –0.32(Y)
Sigma 1.30(B)/ 1.26(Y)

→ σ_{syst} = B: $0.8\sigma_{stat}$, Y: $0.8\sigma_{stat}$

(X90-X45)/Stat.Err

- Dec.22th-End, no energy correction
- bunch selection level-2 (tight cut)

The systematic error for each measurement is estimated as,

$$\sigma_{syst} = (0.5\text{-}1.0)\,\sigma_{stat}$$

- Each regular measurement contains 20M events (including both 45+90 degree detectors)
- $1/\sqrt{20\times10^6} = 2.2\times10^{-4}$ but actually is 2.8×10^{-4} (due to analyzing power difference)

χ^2/ndf distribution

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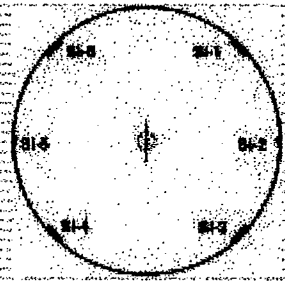
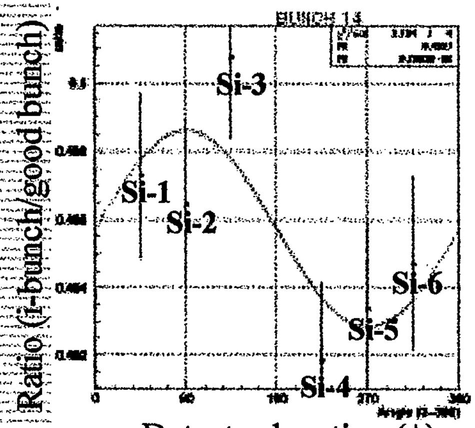
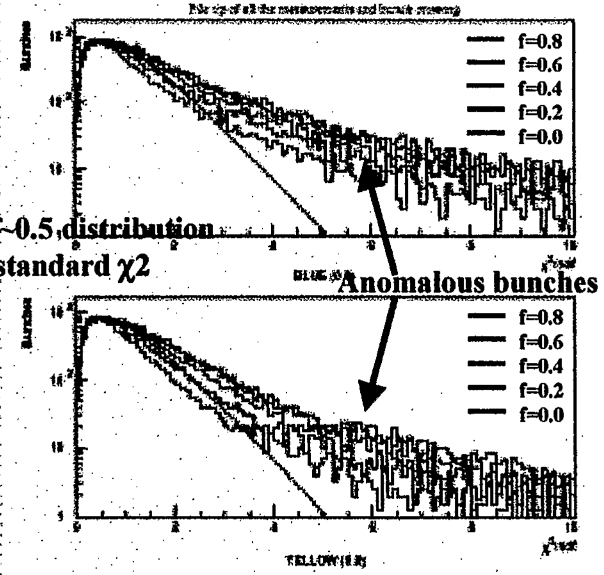
☐ Bunch by bunch check

- Event counts in 6 detectors of certain bunch are compared with the standard (or good) bunch
- The ratios are fit with sinϕ function and yield the fitting χ^2/ndf







$$\chi^2 = \sum_{\text{detector}} \left(\frac{(x_i - \bar{x}_i)^2}{\sigma_{stat}^2 + \sigma_{sys}^2} \right)$$

$$= \frac{1}{(1+f^2)} \sum_{\text{detector}} \left(\frac{(x_i - \bar{x}_i)^2}{\sigma_{stat}^2} \right)$$

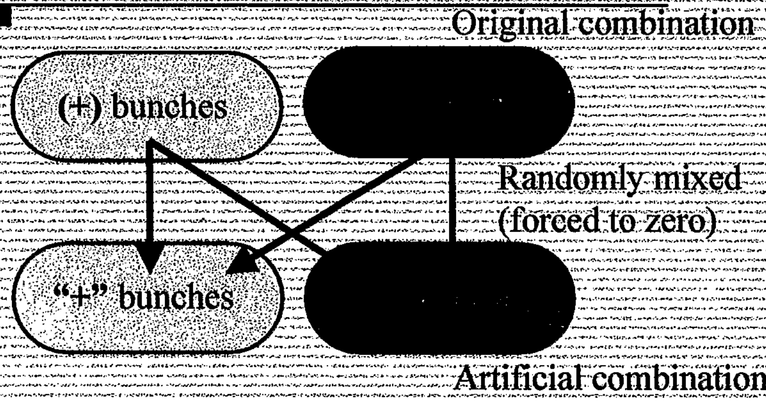
- The distribution (f=0.0) is broader than standard χ^2
- Accountable with f ~ 0.5, this means

$$\sigma_{syst} = 0.5\,\sigma_{stat}$$

- Distributions are normalized with the maximum contents
- Anomalous bunches are removed from analysis

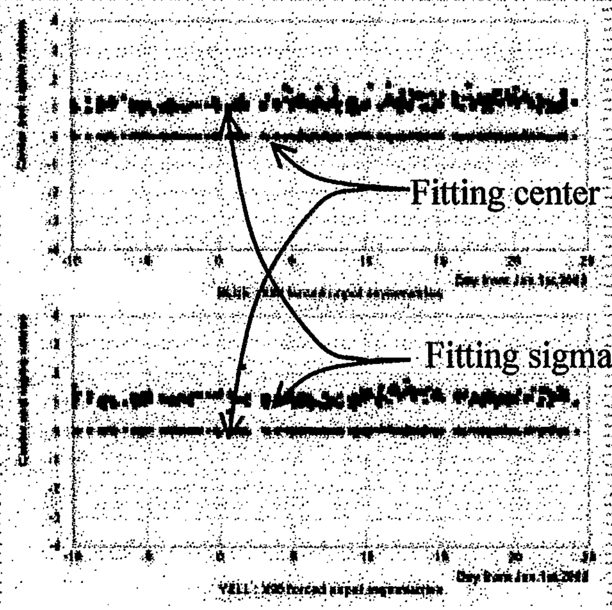
Randomly mixed spin pattern

- Mixing (+) and (-) bunches randomly into artificial "+" and "-" groups, and recalculate the asymmetry for enough times (x1000 for each run)
- Distribution is Gaussian shape. The deviation from statistical fluctuation represents the systematic error



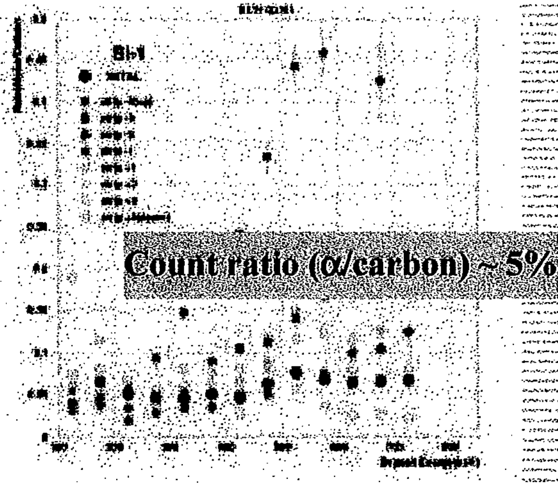
σ_{false}(BLUE) = 1.12
σ_{false}(YELLOW) = 1.11

$\Rightarrow$ σ_{syst} = BLUE: $0.5\sigma_{stat}$
YELLOW: $0.5\sigma_{stat}$



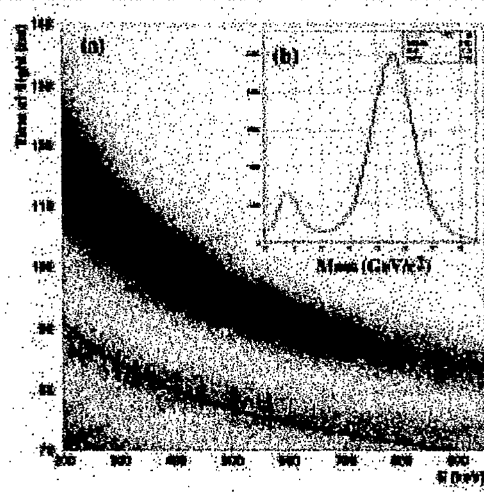
These studies are not independent, each study indicates the size of systematic error of (0.5-1.0)x σ_{stat}.
Conservatively we decided to use 1.0x σ_{stat} in order to reflect our uncertainty on the origin of systematics

Other contributions…(1)



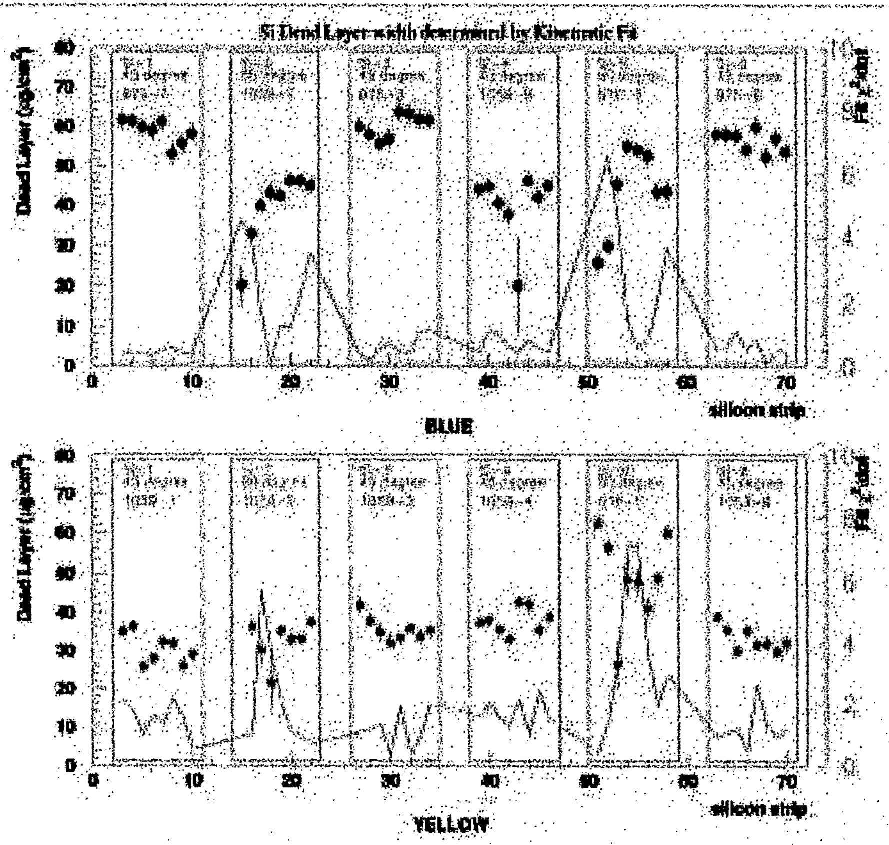
- Background events under Carbon locus
  - inelastic reactions (from carbon mass peak) under 1% level is expected (count ratio is 5%)
  - De-bunched beam effect can be evaluated using the counts in abort gap. Usually well under 1%, and a few % for bad cases

- Pile-up events
  - Estimated well under 1% from dedicated run data



Other contributions…(2)

- Si dead layer
  - thickness can be determined by kinetic fit to carbon band
  - }10% determination power
  - This will propagate to A_N uncertainty of }4%
- E950 error propagation
  - The }31% total error is expected, where it is a linear sum of
    - The statistical
    - Raw asymmetry systematic
    - Beam polarization systematic



Measured polarization

- Fills with > 4 hours long and most stringent bunch selection are applied
- Significance of our measurements are huge
- From the mean values,

At injection energy (24GeV/c).

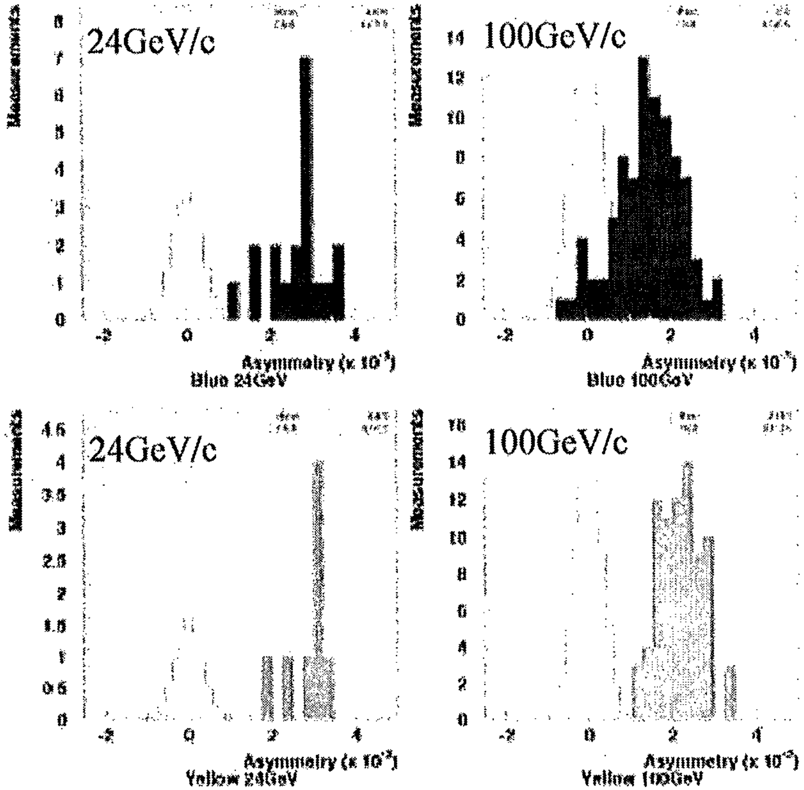
$$\overline{P_{blue}(24GeV/c)} = 0.21 \pm 0.005(stat.) \pm 0.02(sys.) \pm 0.07(scale)$$

$$\overline{P_{yellow}(24GeV/c)} = 0.22 \pm 0.007(stat.) \pm 0.02(sys.) \pm 0.07(scale)$$

If we assume the same analyzing power at 100GeV/c,

$$\overline{P_{blue}(100GeV/c)} = 0.11 \pm 0.002(stat.) \pm 0.02(sys.) \pm 0.03(scale)$$

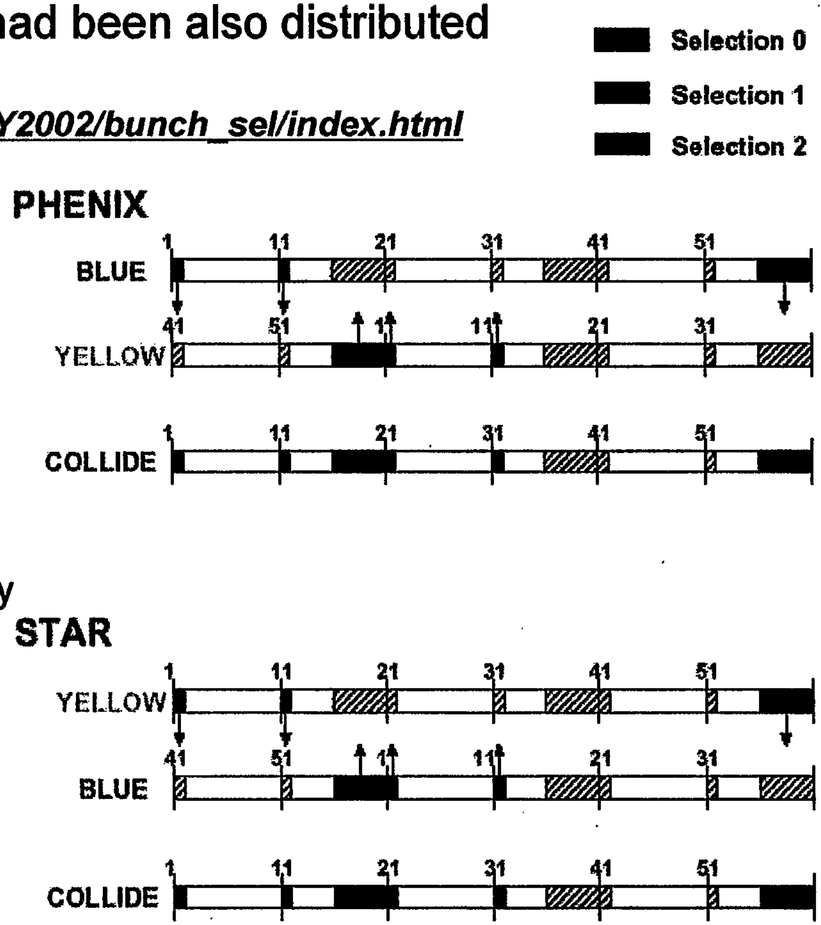
$$\overline{P_{yellow}(100GeV/c)} = 0.16 \pm 0.002(stat.) \pm 0.02(sys.) \pm 0.05(scale)$$



Open : Asymmetries with <u>random</u> spin pattern
Closed: Asymmetries with <u>actual</u> spin pattern

Run-02 polarization for each run

- For a practical use, run-by-run results had been also distributed to experiments at *http://spin.riken.bnl.gov/~jinnai3/polarimeter/FY2002/bunch_sel/index.html*
- In the page above, three types of bunch selection conditions are provided to fit with experiments
  - Condition 0
    - counter bunches for abort gaps
  - Condition 1
    - 1st,11th ,condition 0
    - Anomaly bunches for specific luminosity
    - χ^2/ndf > 5
  - Condition 2
    - Condition 1
    - Influence from the other IP



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Conclusion and outlook

- Average polarization values are obtained with full systematic error estimations
  - P_{blue}(24GeV)= 0.21 }0.005(stat.) }0.02(sys.) }0.07(scale)
  - P_{yellow}(24GeV)= 0.22 }0.007(stat.) }0.02(sys.) }0.07(scale)
- The point-to-point systematic error was 10% level for 20% polarization
- Major contribution propagated from E950 error
- In next run, recalibration measurement for pC CNI process using a new AGS polarimeter (with other internal polarimeter, E880) is planned

Run-02 BBC Asymmetry Results from PHENIX

K. Tanida, RIKEN
December 20, 2002

for
RHIC Spin Collaboration Meeting XIV
RIKEN BNL Research Center

BBC asymmetry

K. Tanida (RIKEN)
RSC meeting 12/20/02

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Outline

- Introduction
- Event selection
- Bunch fitting method
- Results
- Discussion
- Summary and prospects

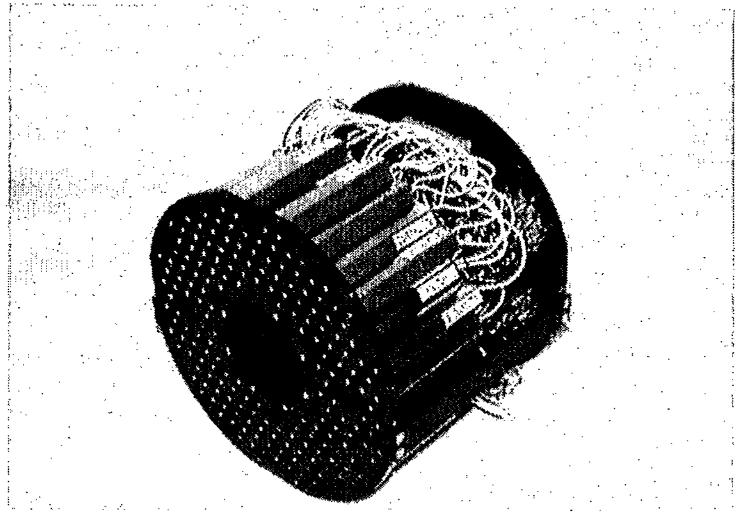
Introduction

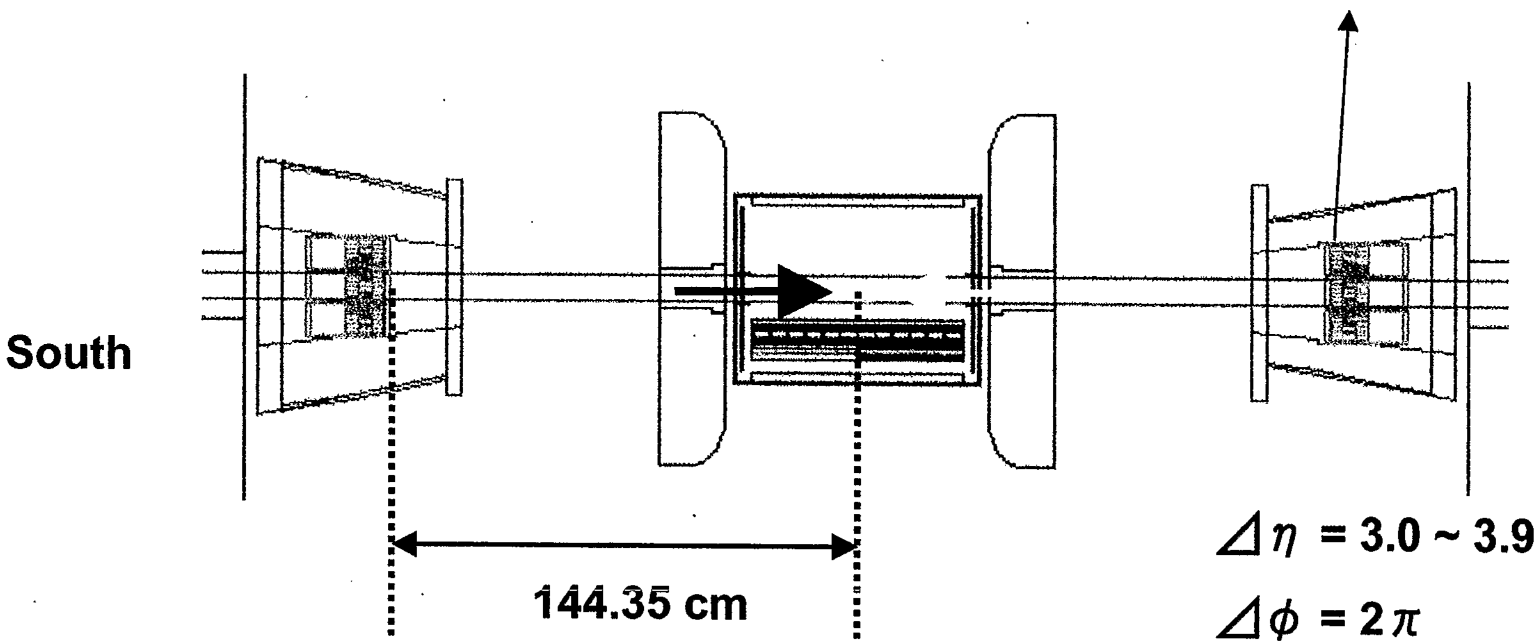
- FNAL E704: observed large single spin asymmetry (A_N) of pions in forward region with transversely polarized pp reaction at sqrt(s) = 20 GeV.
- BBC: most forward detector in PHENIX that can measure asymmetry.

  → Measure A_N of inclusive (charged) particles by BBC.
- STAR observed finite $A_N \sim 0.005$ in their preliminary analysis.

PHENIX BBC

- 2 identical parts (BBC-north and -south)
- Quartz Cherenkov counter, 64 segments each.



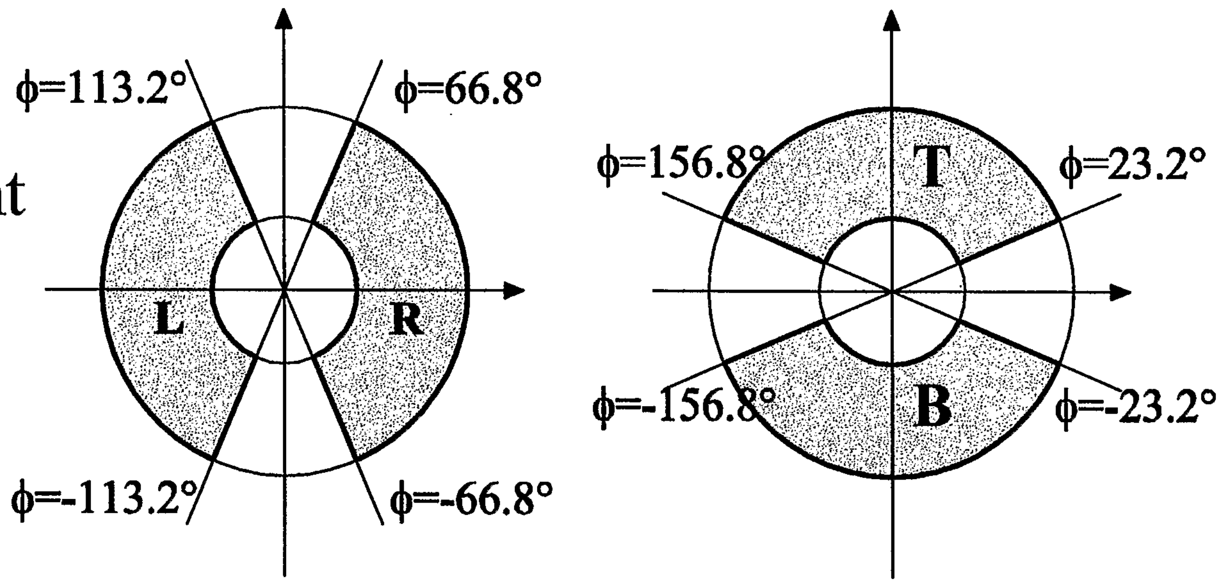


Event selection

- Data from 11 fills (2257, 2258, 2265, 2266, 2275, 2277, 2281, 2289, 2290, 2301, 2304) after 01/18/02 were analyzed.
  - earlier fills are severely contaminated by beam-gas backgrounds.
- Trigger: BBC LL1
- Beam gas contamination:
  - events in abort gaps < 10^{-3} of normal bunch
  - three fills (2257, 2265, 2266) rejected
- Bad bunches:
  - unpol: 0, 20, 40
  - abort gaps: 15-19, 55-59
  - other bad bunches: 10, 30

Definition of left-right

- View from collision point (BBC-south)



Flip left-right in BBC-north

- 66.8 deg ← maximize figure of merit (S^2/N)
- Finite angle correction for $\cos\phi$ dependence
  - 0.788

Inclusive and exclusive hit counting

- Left: n_L segments have hit
  Right: n_R segments
- Inclusive counting:
  left: n_L counts, right n_R counts
  - sensitive for high-multiplicity events, e.g., jets.
  - $\delta N_L > \mathrm{sqrt}(N_L)$ because
    # one particle can hit two segments
    # two particle correlation strong
- Exclusive counting:
  count one for left only if $n_L > 0$ and $n_R = 0$
  - favors low multiplicity events

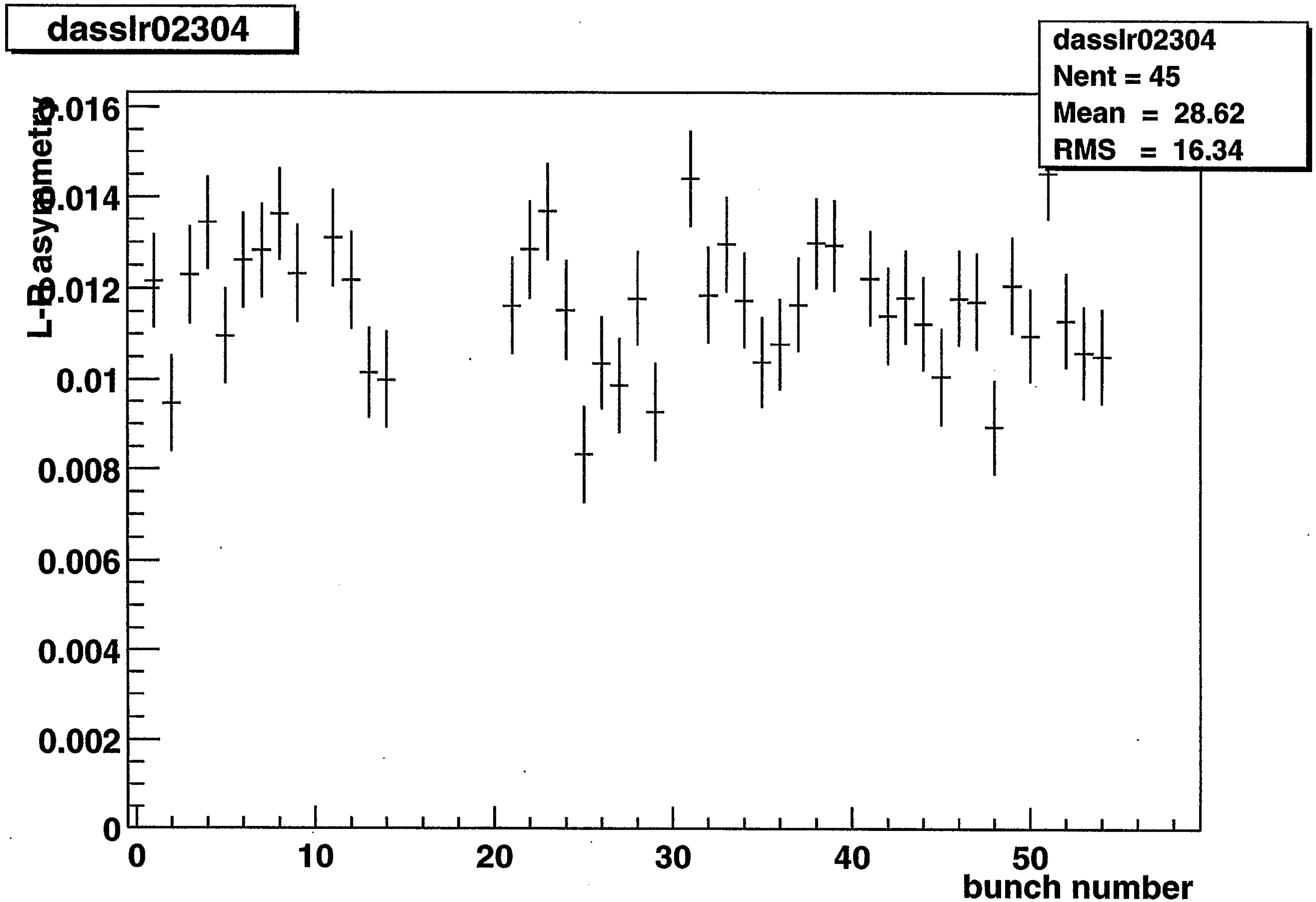
Bunch fitting method

- An alternative method of square root formula
  - for details see
  http://rarfaxp.riken.go.jp/~tanida/spinpwg/bunch-formula-note.tex (or .ps)
- Take **crossing-by-crossing** left-right asymmetry for each fill (crossing number: i):

$$a_{LR}(i) = \frac{N_L(i) - N_R(i)}{N_L(i) + N_R(i)}$$

$$\delta a_{LR}(i) = 2\sqrt{\frac{N_L(i)N_R(i)}{[N_L(i) + N_R(i)]^3}}$$

crossing by crossing LR asymmetry (fill 2304, north)



Fitting function

$$N_L(i) = C(1+D)[1+A_B P_B(i)+A_Y P_Y(i)]$$
$$N_R(i) = C(1-D)[1-A_B P_B(i)-A_Y P_Y(i)],$$

$$\Downarrow$$

$$a_{LR}(i) = \frac{D + A_B P_B(i) + A_Y P_Y(i)}{1 + D[A_B P_B(i) + A_Y P_Y(i)]}$$

D: detector asymmetry

$A_{B(Y)}$: physics asymmetry for blue (yellow) beam

$P_{B(Y)}(i)$: blue (yellow) beam polarization

Linear approximation

- For small D, $A_B P_B$, and $A_Y P_Y$, we can use
  $a_{LR}(i) = D + A_B P_B(i) + A_Y P_Y(i)$.
  - systematic deviation is at third order.
- We can exactly solve the problem. The answer is:

$$\begin{pmatrix} D \\ A_B \\ A_Y \end{pmatrix} = \hat{M}^{-1}\vec{V}, \text{ where } \quad \hat{M} = \begin{pmatrix} \langle 1 \rangle & \langle P_B \rangle & \langle P_Y \rangle \\ \langle P_B \rangle & \langle P_B^2 \rangle & \langle P_B P_Y \rangle \\ \langle P_Y \rangle & \langle P_B P_Y \rangle & \langle P_Y^2 \rangle \end{pmatrix},$$

$$\vec{V} = \begin{pmatrix} \langle a_{LR} \rangle \\ \langle a_{LR} P_B \rangle \\ \langle a_{LR} P_Y \rangle \end{pmatrix}, \text{ and } \langle x \rangle = \sum_i \frac{x(i)}{\delta a_{LR}(i)^2}.$$

- I will do discussions using this approximation.

Coupling of A_B and A_Y

- $\boldsymbol{M}$ has off-diagonal elements (luminosity asymmetry) → A_B and A_Y couples
- Effects of off-diagonal elements (at leading order):

$$\Delta D \sim -(A_B <P_B> + A_Y <P_Y>)/<1>$$

$$\Delta A_B \sim -(D <P_B> + A_Y <P_B P_Y>)/<P_B^2>$$

$$\Delta A_Y \sim -(D <P_Y> + A_B <P_B P_Y>)/<P_Y^2>$$

  - second order
  - sqrt formula does not cancel terms such as $A_B <P_B P_Y>$
- MC simulations tell the fitting method gives correct answers, while the sqrt formula does not.

Statistical and systematic errors

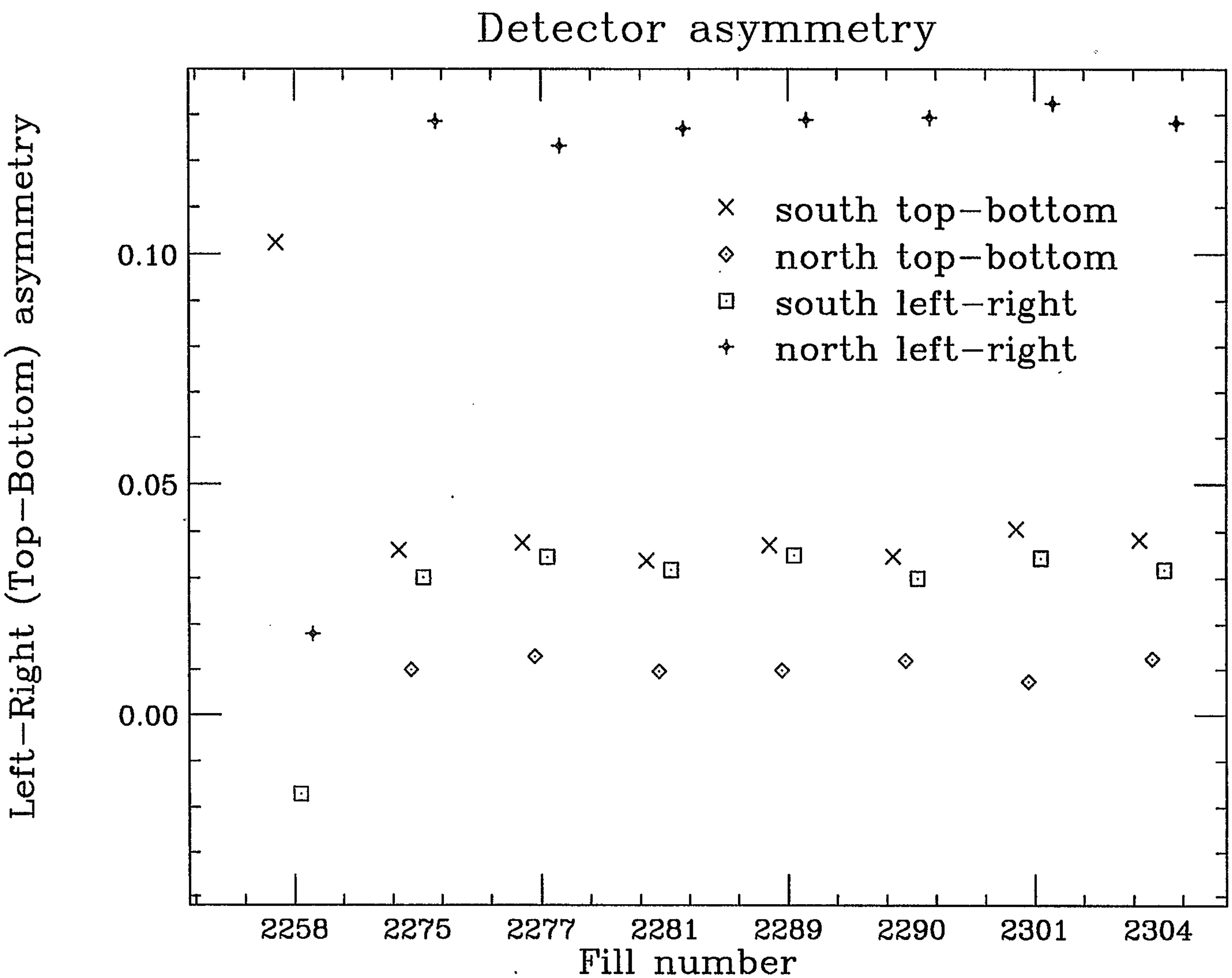
- If we neglect the off-diagonal elements of ***M***,
  $\delta D=<1>^{-1/2}$, $\delta A_B=<P_B{}^2>^{-1/2}$, $\delta A_Y=<P_Y{}^2>^{-1/2}$
- sqrt formula gives approximately the same statistical error.
- Systematic effects: can be checked by fitting χ^2
- Bunch-by-bunch fluctuation of detector asymmetry.
  - independent gaussian of σ_d
  → D fluctuates by σ_d/sqrt(I) (I: number of bunches)
  - multiplying χ^2/dof to fitting error gives approximately correct error estimation.
- Sqrt formula equally suffers from this effect, but it gives too small errors because χ^2 check and correction is impossible.

BBC analysis condition

We used

- Linear approximation.
  - very good approximation in this case.
- $P_B(i) = P_B S_B(i)$, $S_B(i) = +1$ (spin up) or -1 (down)
  - RHIC pol. doesn't give bunch-by-bunch polarization
  - average: P_B, $P_Y \sim 0.2$
- Fitting parameter: $\varepsilon_B = A_B P_B$ instead of A_B

  → avoid polarization measurement error



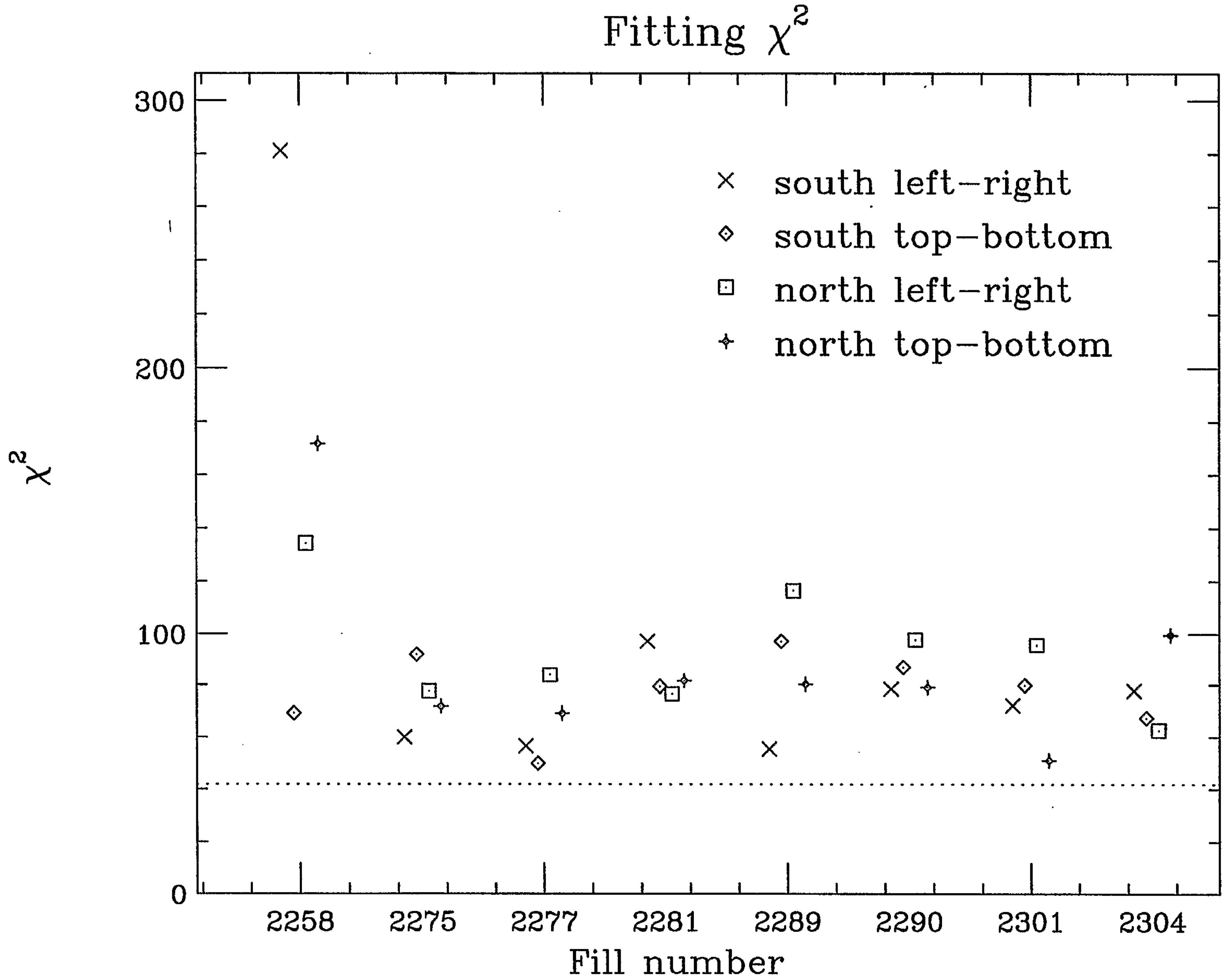
→ Detector asymmetry is resonably small

3 checks

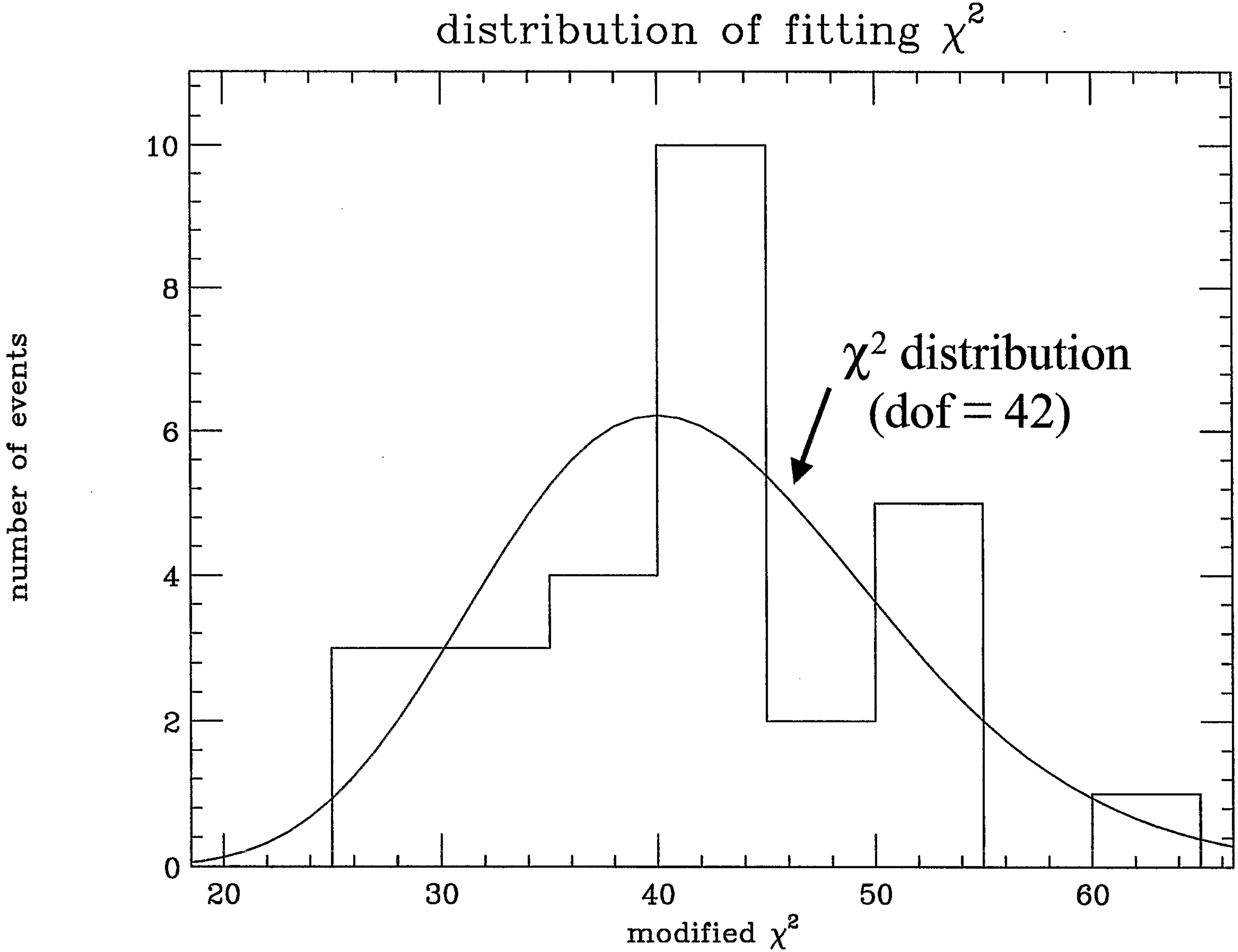
1. χ^2/dof(=42) should be near to 1

- All inclusive counting data are rejected
  - probably because δa_{LR} was too small
  - multiplying δa_{LR} by 1.37 makes χ^2 distribution reasonable (except for fill 2258).

Fill-by-fill χ^2 for inclusive counting



χ^2 -- Inclusive case (except fill 2258)



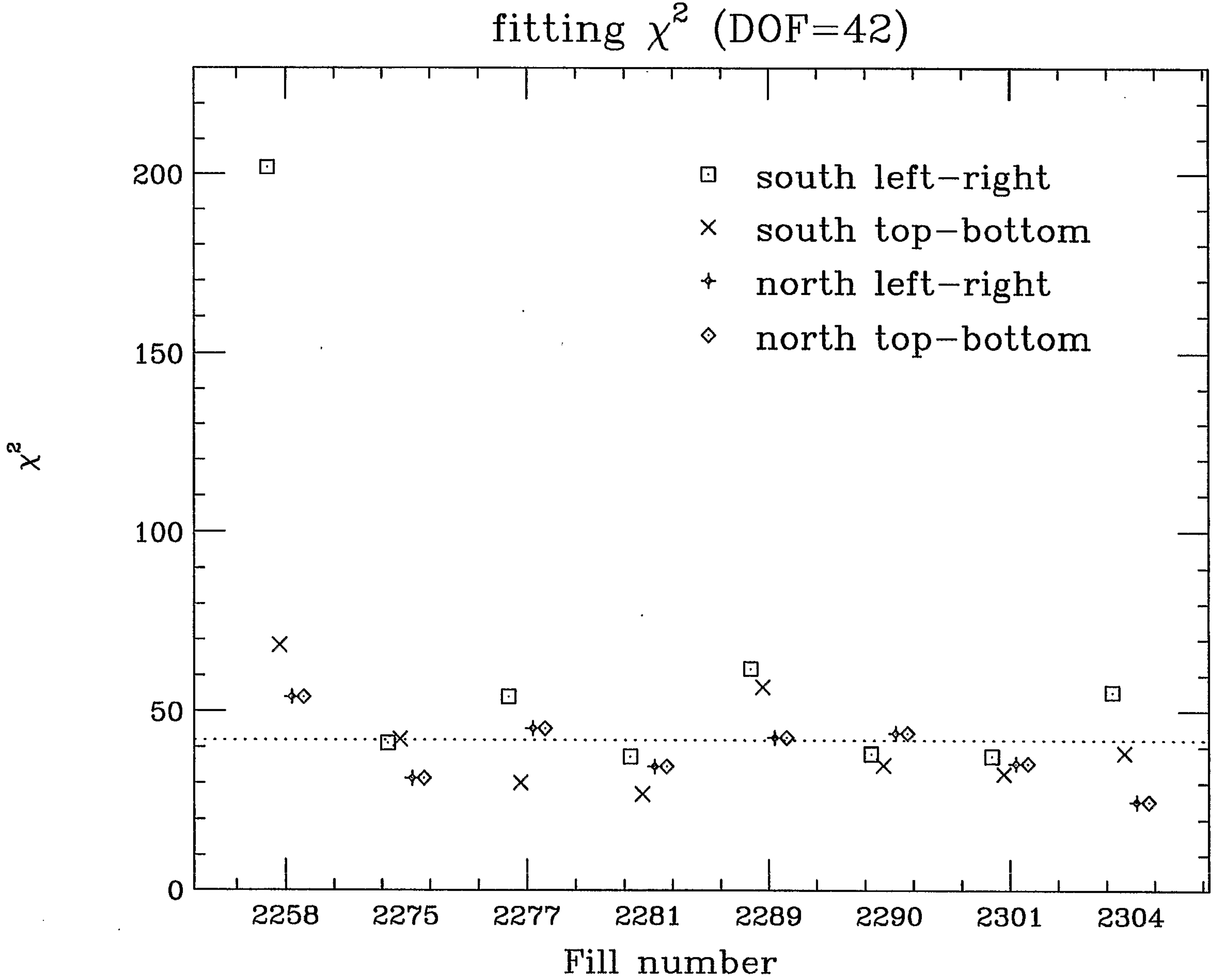
3 checks

1. χ^2/dof(=42) should be near to 1

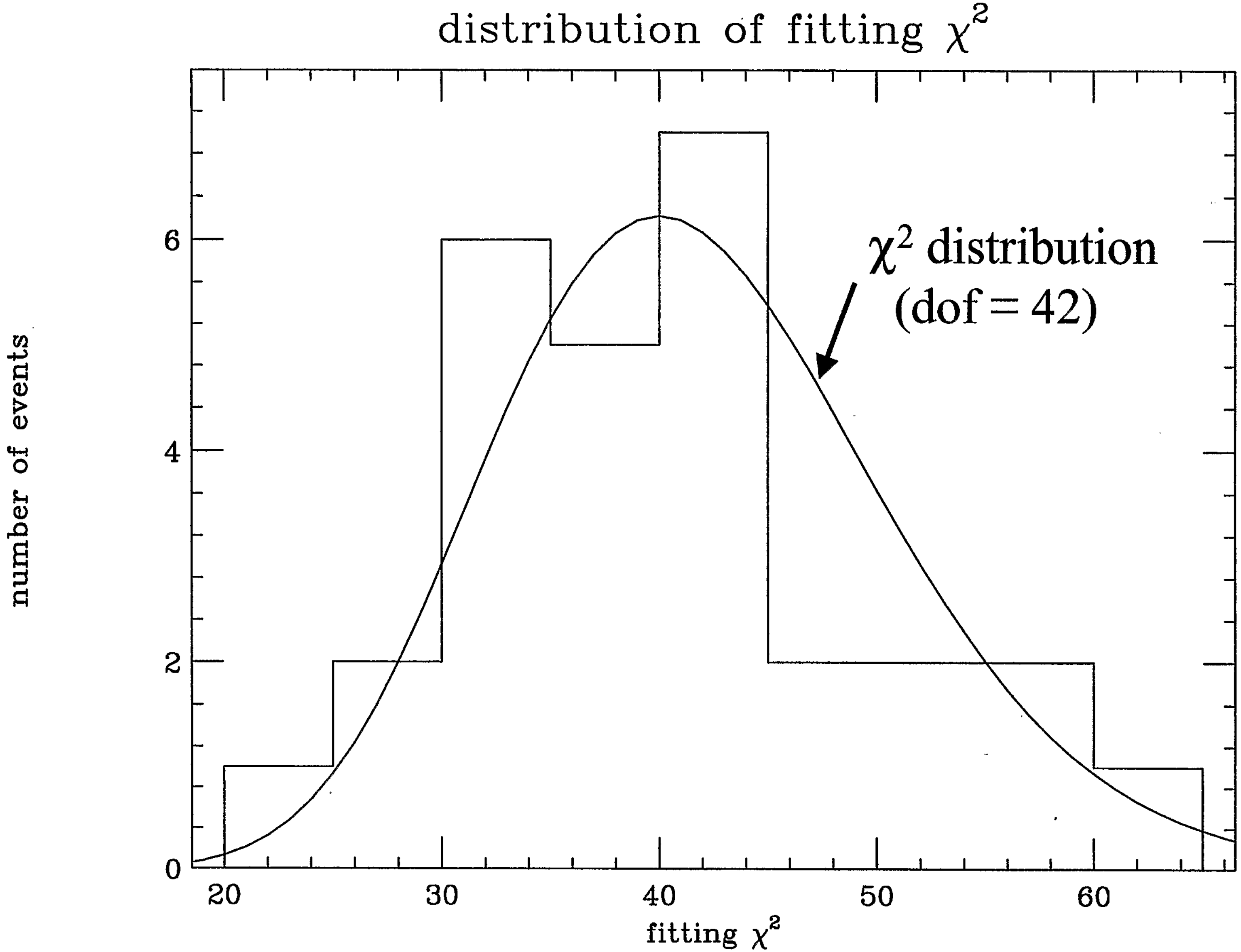
- All inclusive counting data are rejected
  - probably because δa_{LR} was too small
  - multiplying δa_{LR} by 1.37 makes χ^2 distribution reasonable (except for fill 2258).
- only one bad fill (2258) for exclusive counting
  - χ^2 distribution -- OK for the other fills

  → use only exclusive counting data hereafter

Fill-by-fill χ^2 for exclusive counting



χ^2 -- Exclusive case (except fill 2258)



3 checks

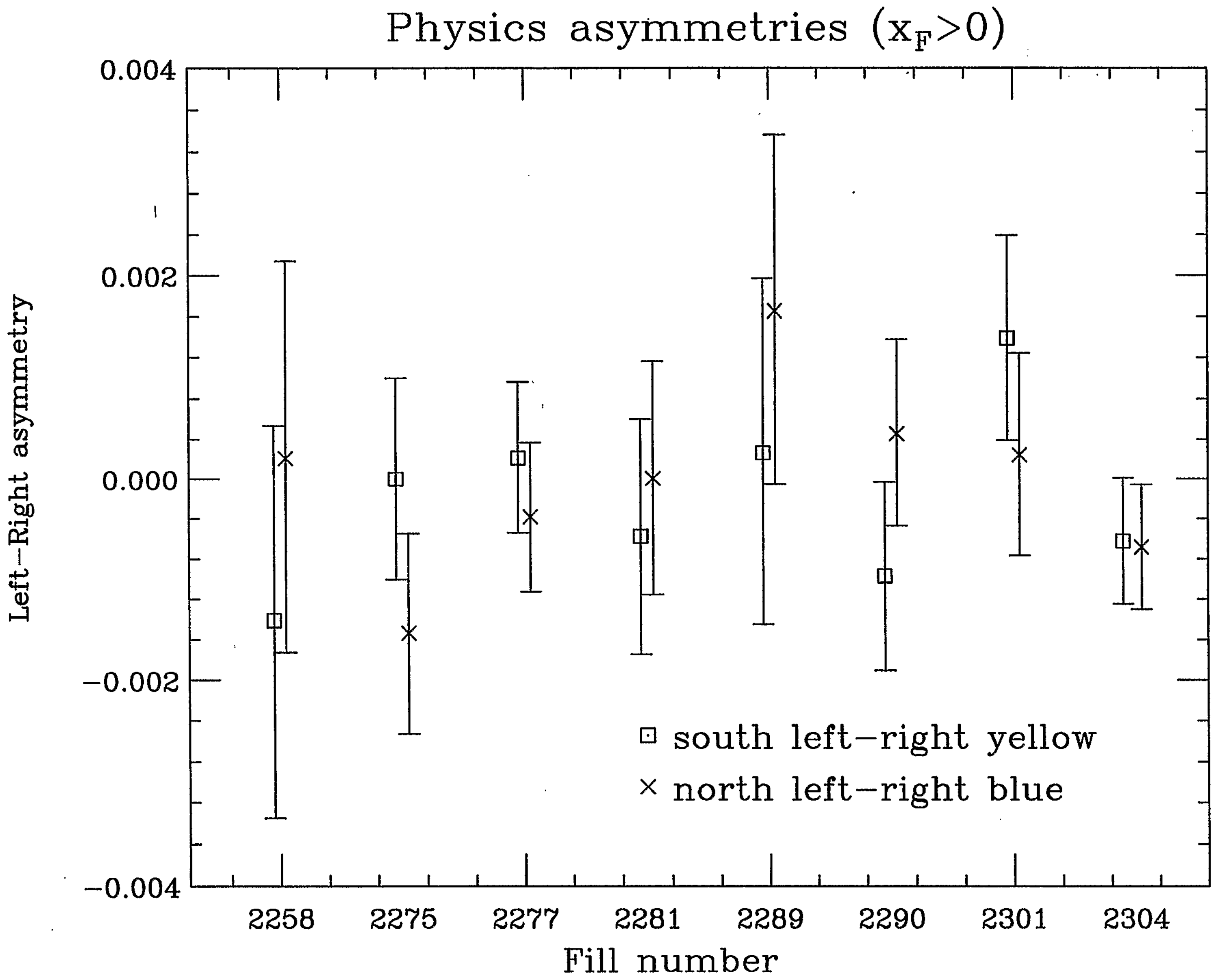
1. χ^2/dof(=42) should be near to 1

- All inclusive counting data are rejected
  - probably because δa_{LR} was too small
  - multiplying δa_{LR} by 1.37 makes χ^2 distribution reasonable (except for fill 2258).
- only one bad fill (2258) for exclusive counting
  - χ^2 distribution -- OK for the other fills

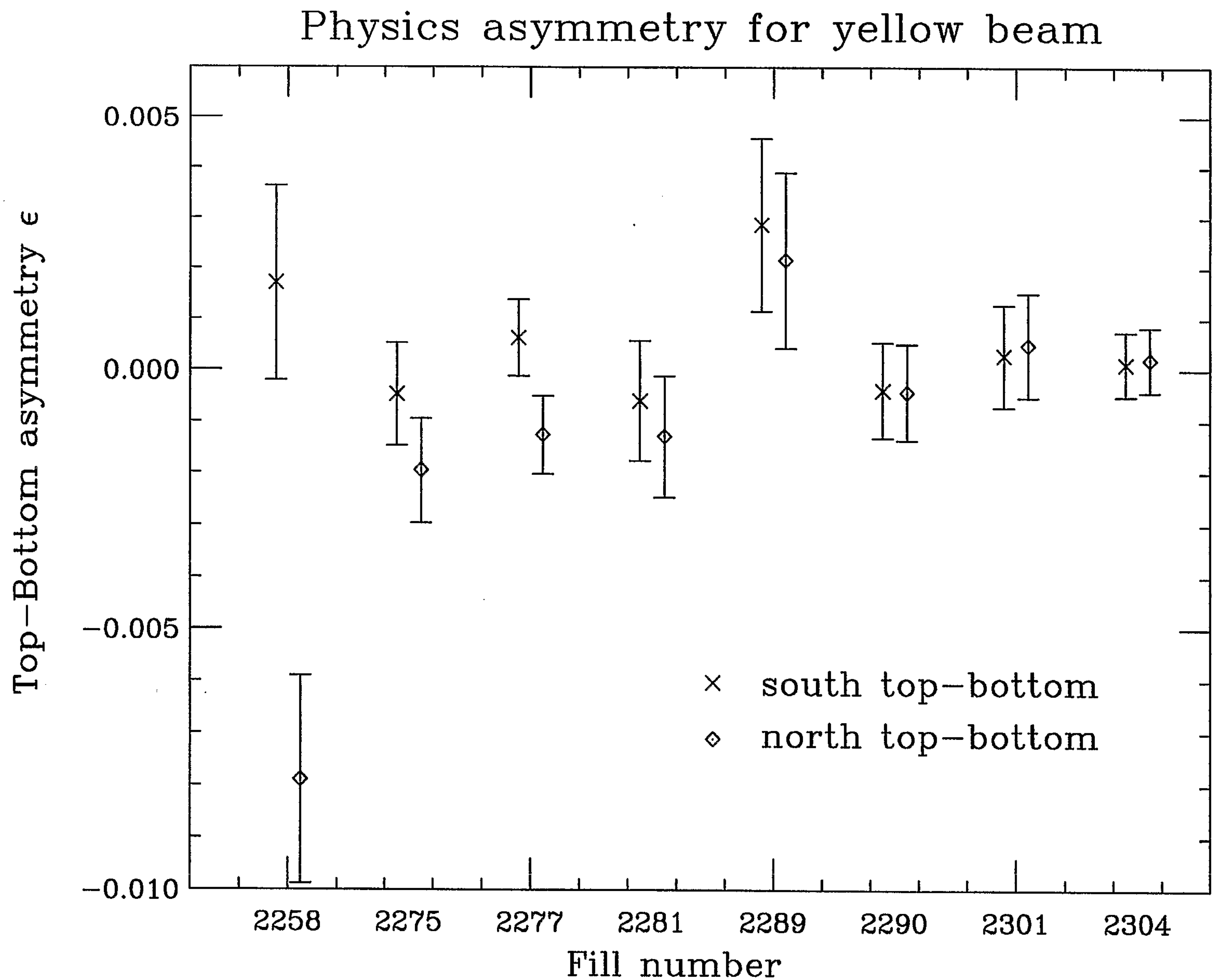
  → use only exclusive counting data hereafter

2. A_Y(north) = A_B(south) and vice versa
3. Parity-violating top-bottom asymmetry should be 0

Check of ε_B(yellow)=ε_Y(blue)



Top-bottom asymmetry for exclusive counting



3 checks

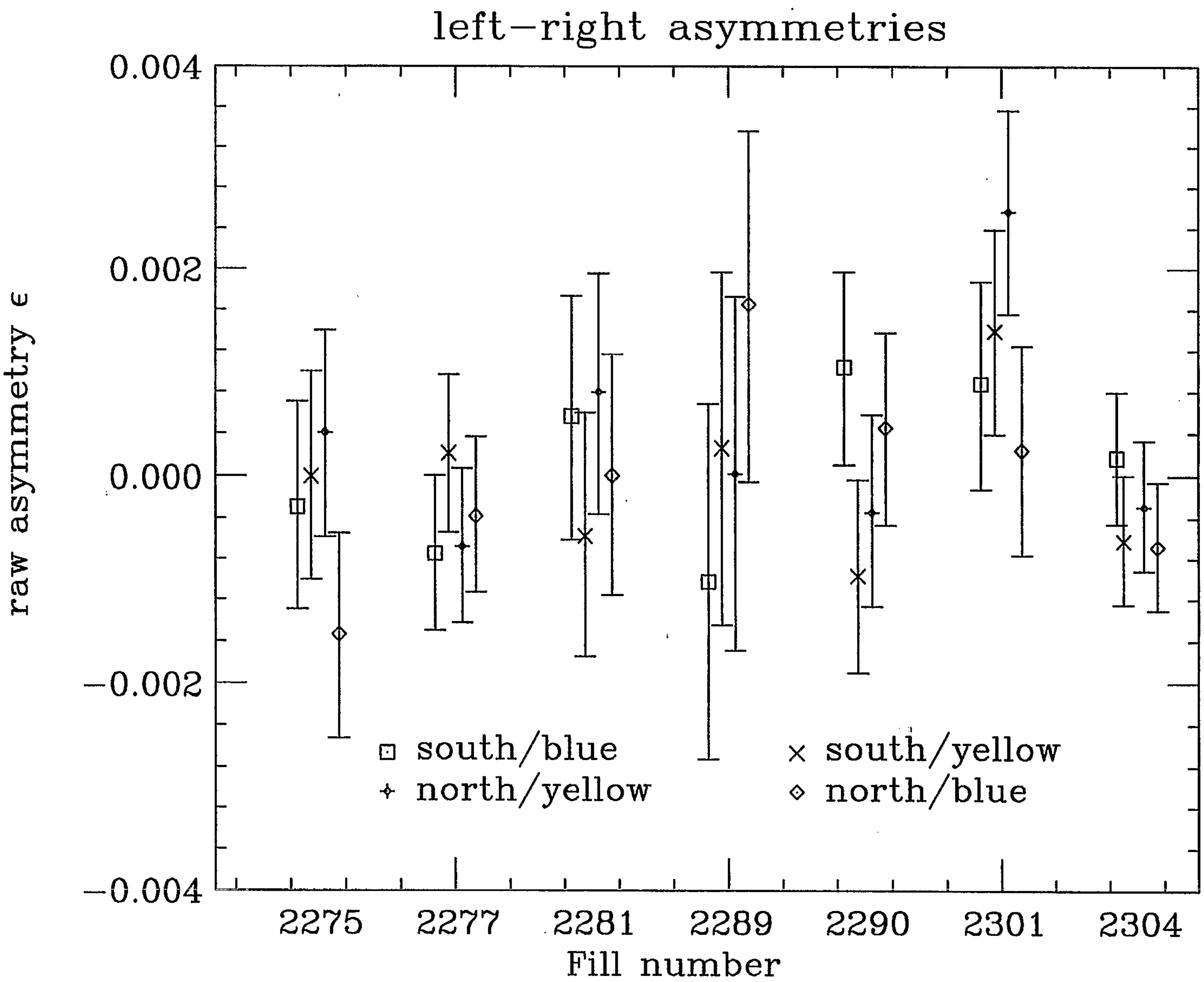
1. χ^2/dof(=42) should be near to 1

- All inclusive counting data are rejected
  - probably because δa_{LR} was too small
  - multiplying δa_{LR} by 1.37 makes χ^2 distribution reasonable (except for fill 2258).
- Only one bad fill (2258) for exclusive counting
  - χ^2 distribution -- OK for the other fills
  - → use only exclusive counting data hereafter

2. A_Y(north) = A_B(south) and vice versa

3. Parity-violating top-bottom asymmetry should be 0
  - OK within 3σ for exclusive data except fill 2258.
  - → fill 2258 is discarded.

Results



left−right asymmetries
0.004
0.002
0.000
−0.002
−0.004
raw asymmetry ε
2275
2277
2281
2289
2290
2301
2304
Fill number
south/blue
north/yellow
south/yellow
north/blue

Averaged asymmetry

- Divide ε by raw asymmetry of RHIC pol.
  → A/A^{CNI} (A^{CNI}: effective analyzing power of RHIC pol.)

		A_B/A_B^{CNI}	A_Y/A_Y^{CNI}
South	LR	0.15 +– 0.22	–0.09 +– 0.17
	TB	–0.22 +– 0.23	0.06 +– 0.17
North	LR	–0.11 +– 0.22	0.06 +– 0.17
	TB	–0.19 +– 0.23	–0.16 +– 0.17

- Errors are statistical only, but include statistical error in polarization measurement.

Analyzing power

- Assume $A_B^{CNI}=A_Y^{CNI}=0.0132$

	$A_B(10^{-3})$	$A_Y(10^{-3})$
South LR	1.9 +– 3.0	–1.2 +– 2.2 ($x_f > 0$)
TB	–2.9 +– 3.0	0.7 +– 2.2
North LR	–1.4 +– 3.0	0.8 +– 2.2 ($x_f < 0$)
TB	–2.6 +– 3.0	–2.1 +– 2.2

- Errors are statistical only, but include statistical error in polarization measurement.
- Systematic error in polarization measurement does not affect the significance of the asymmetry.

Systematic errors

- polarization measurement error:
  - unknown yet, but does not change $A/\delta A$.
  - ε is free from this. So, we show both A and ε.
- bunch-by-bunch polarization fluctuation:
  - effect is negligibly small for $A \sim 0$.
- Other systematic errors:
  - no evidence seen ($\chi^2/\mathrm{dof} \sim 1$)
  - probably negligible compared to statistical error.

  → We don't assign any systematic error other than coming from polarization measurement.

Comparison with sqrt formula

- In the present case, bunch fitting method gave the same result as sqrt formula down to $O(10^{-5})$
- Systematic deviation of sqrt formula
  - $\Delta A_B \sim A_Y \langle P_B P_Y \rangle / \langle P_B^2 \rangle$
  - $A_Y \sim 10^{-3}$
  - $\langle P_B P_Y \rangle / \langle P_B^2 \rangle \sim 10^{-2}$

  → $\Delta A_B \sim 10^{-5}$: small enough
- Systematic deviation of linear approximation.
  - $\Delta A_B / A_B$: $D(A_B P_B + A_Y P_Y) \sim 10^{-4}$

    i.e., $\Delta A_B \sim 10^{-3} \times 10^{-4} = 10^{-7}$

  → negligible

Discussion

- Our results are consistent with zero.
- E704 result
  - π^+ and π^- have opposite sign of A_N.

  → cancellation in BBC measurement
  - asymmetry is seen at large x_f

  <=> BBC can not measure x_f,
  probably small x_f events dominate

  → not inconsistent with E704 result.
- STAR preliminary result: $\varepsilon \sim 0.001$ ($A_N \sim 0.005$)
  - pseudorapidity is larger

  (PHENIX: $3.0 < \eta < 3.9$, STAR $3.4 < \eta < 5.0$)

Summary and prospects

- A_N of inclusive charged particles in a forward region was studied with PHENIX BBC.
- A new method to calculate physics asymmetries was used.
- We saw no evidence of systematic error.
- Results were consistent with zero.
- Analysis is still ongoing for various conditions, e.g.,
  - select inner segments of BBC (most forward region)
  - event selection (e.g., ZDC coincidence -- in relation with LocalPol results)
  - Photon (π^0) selection using ADC information.

RHIC Spin Collaboration Meeting XIV
December 20, 2002
RIKEN BNL Research Center

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RHIC Spin Collaboration Meeting XIV

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RIKEN BNL Research Center

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RIKEN BNL Research Center

RHIC Spin Collaboration Meeting XIV

December 20, 2002

Small Seminar Room, Physics Dept., Brookhaven National Laboratory

*****AGENDA*****

Morning Session

09:00 – 09:30	Summary of the AGS Polarization Workshop......................	T. Roser
09:30 – 10:00	Status Report on the Accelerator Run-03 Preparations............	L. Ahrens
10:00 – 10:30	Status Report on the AGS CNI Polarimeter........................	I. Alekseev
10:30 – 10:45	Coffee Break	
10:45 – 11:15	Summary/Outcome of the Jet Target/Experiment Review.......	Y. Makdisi
11:15 – 11:45	Conclusions about RHIC Polarimetry for Run-02................	O. Jinnouchi
11:45 – 12:15	Run-02 BBC Asymmetry Results from PHENIX.................	K. Tanida

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Additional RIKEN BNL Research Center Proceedings:

Volume 50 – High Performance Computing with QCDOC and BlueGene – BNL-71147-2003

Volume 49 – RBRC Scientific Review Committee Meeting – BNL-52679

Volume 48 – RHIC Spin Collaboration Meeting XIV – BNL-

Volume 47 – RHIC Spin Collaboration Meetings XII, XIII – BNL-71118-2003

Volume 46 – Large-Scale Computations in Nuclear Physics using the QCDOC – BNL-52678

Volume 45 – Summer Program: Current and Future Directions at RHIC – BNL-71035

Volume 44 – RHIC Spin Collaboration Meetings VIII, IX, X, XI – BNL-71117-2003

Volume 43 – RIKEN Winter School – Quark-Gluon Structure of the Nucleon and QCD – BNL-52672

Volume 42 – Baryon Dynamics at RHIC – BNL-52669

Volume 41 – Hadron Structure from Lattice QCD – BNL-52674

Volume 40 – Theory Studies for RHIC-Spin – BNL-52662

Volume 39 – RHIC Spin Collaboration Meeting VII – BNL-52659

Volume 38 – RBRC Scientific Review Committee Meeting – BNL-52649

Volume 37 – RHIC Spin Collaboration Meeting VI (Part 2) – BNL-52660

Volume 36 – RHIC Spin Collaboration Meeting VI – BNL-52642

Volume 35 – RIKEN Winter School – Quarks, Hadrons and Nuclei – QCD Hard Processes and the Nucleon Spin – BNL-52643

Volume 34 – High Energy QCD: Beyond the Pomeron – BNL-52641

Volume 33 – Spin Physics at RHIC in Year-1 and Beyond – BNL-52635

Volume 32 – RHIC Spin Physics V – BNL-52628

Volume 31 – RHIC Spin Physics III & IV Polarized Partons at High Q^2 Region – BNL-52617

Volume 30 – RBRC Scientific Review Committee Meeting – BNL-52603

Volume 29 – Future Transversity Measurements – BNL-52612

Volume 28 – Equilibrium & Non-Equilibrium Aspects of Hot, Dense QCD – BNL-52613

Volume 27 – Predictions and Uncertainties for RHIC Spin Physics & Event Generator for RHIC Spin Physics III – Towards Precision Spin Physics at RHIC – BNL-52596

Volume 26 – Circum-Pan-Pacific RIKEN Symposium on High Energy Spin Physics – BNL-52588

Volume 25 – RHIC Spin – BNL-52581

Volume 24 – Physics Society of Japan Biannual Meeting Symposium on QCD Physics at RIKEN BNL Research Center – BNL-52578

Volume 23 – Coulomb and Pion-Asymmetry Polarimetry and Hadronic Spin Dependence at RHIC Energies – BNL-52589

Volume 22 – OSCAR II: Predictions for RHIC – BNL-52591

Volume 21 – RBRC Scientific Review Committee Meeting – BNL-52568

Volume 20 – Gauge-Invariant Variables in Gauge Theories – BNL-52590

Volume 19 – Numerical Algorithms at Non-Zero Chemical Potential – BNL-52573

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Volume 17 – Hard Parton Physics in High-Energy Nuclear Collisions – BNL-52574
Volume 16 – RIKEN Winter School - Structure of Hadrons - Introduction to QCD Hard Processes – BNL-52569
Volume 15 – QCD Phase Transitions – BNL-52561
Volume 14 – Quantum Fields In and Out of Equilibrium – BNL-52560
Volume 13 – Physics of the 1 Teraflop RIKEN-BNL-Columbia QCD Project First Anniversary Celebration – BNL-66299
Volume 12 – Quarkonium Production in Relativistic Nuclear Collisions – BNL-52559
Volume 11 – Event Generator for RHIC Spin Physics – BNL-66116
Volume 10 – Physics of Polarimetry at RHIC – BNL-65926
Volume 9 – High Density Matter in AGS, SPS and RHIC Collisions – BNL-65762
Volume 8 – Fermion Frontiers in Vector Lattice Gauge Theories – BNL-65634
Volume 7 – RHIC Spin Physics – BNL-65615
Volume 6 – Quarks and Gluons in the Nucleon – BNL-65234
Volume 5 – Color Superconductivity, Instantons and Parity (Non?)-Conservation at High Baryon Density – BNL-65105
Volume 4 – Inauguration Ceremony, September 22 and Non -Equilibrium Many Body Dynamics – BNL-64912
Volume 3 – Hadron Spin-Flip at RHIC Energies – BNL-64724
Volume 2 – Perturbative QCD as a Probe of Hadron Structure – BNL-64723
Volume 1 – Open Standards for Cascade Models for RHIC – BNL-64722

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RIKEN BNL RESEARCH CENTER

RHIC Spin Collaboration Meeting XIV

December 20, 2002

Li Keran

Nuclei as heavy as bulls
Through collision
Generate new states of matter.
T.D. Lee

Speakers:

L. Ahrens
K. Tanida

I. Alekseev

O. Jinnouchi

Y. Makdisi

T. Roser

Organizer: Brendan Fox