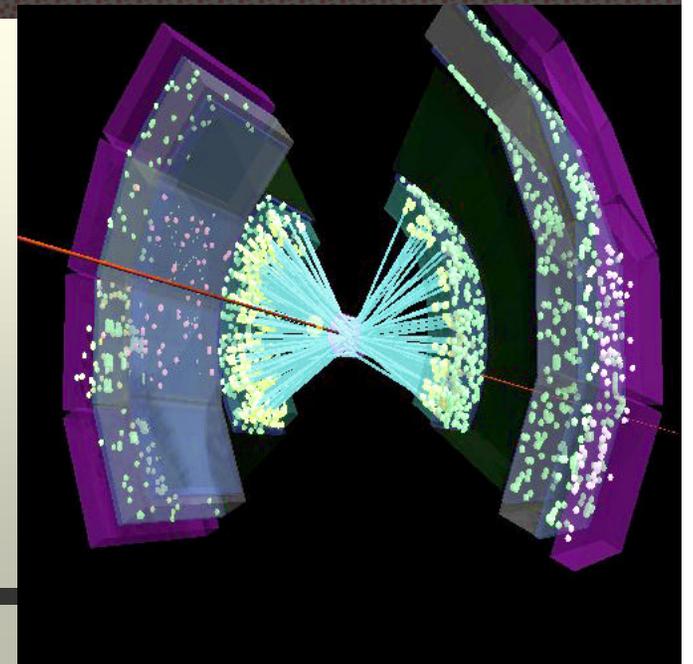


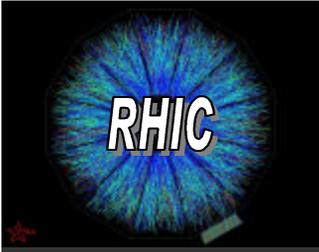
RHIC Remote Operations

Fulvia Pilat



Shelter Island
Workshop





RHIC Remote Operations

Outline:

□ RHIC Complex and Control System Overview

1999 engineering run (infancy...)

2000 first operation (teenager...)

2001 operation (youth....) → 2003+ run (maturity?)

□ Remote operations at RHIC → limited scale test of GAN and remote ops

“Local-remote” operations

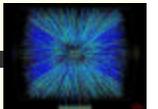
Beam experiments

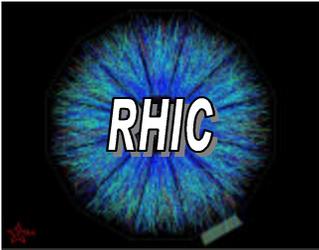
RHIC – LHC instrumentation testing

SNS ring commissioning

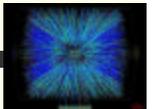
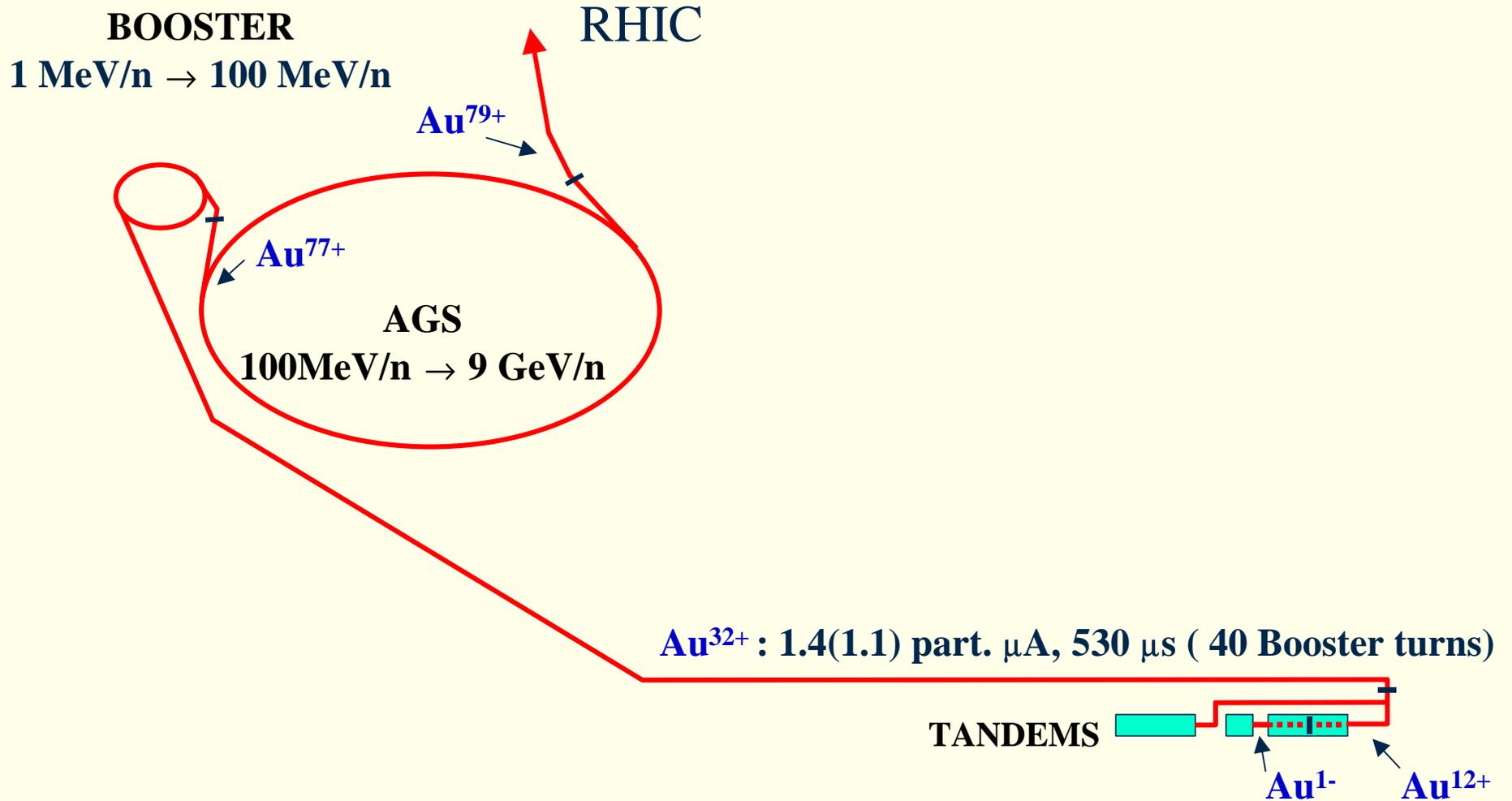
US-LHC LARP's

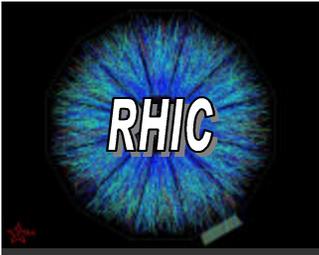
□ Issues for the workshop





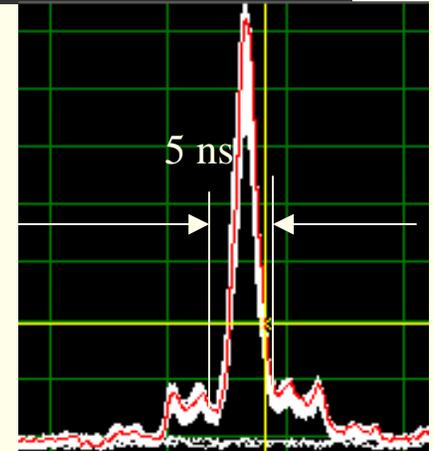
RHIC Complex - gold



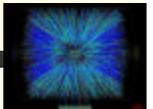
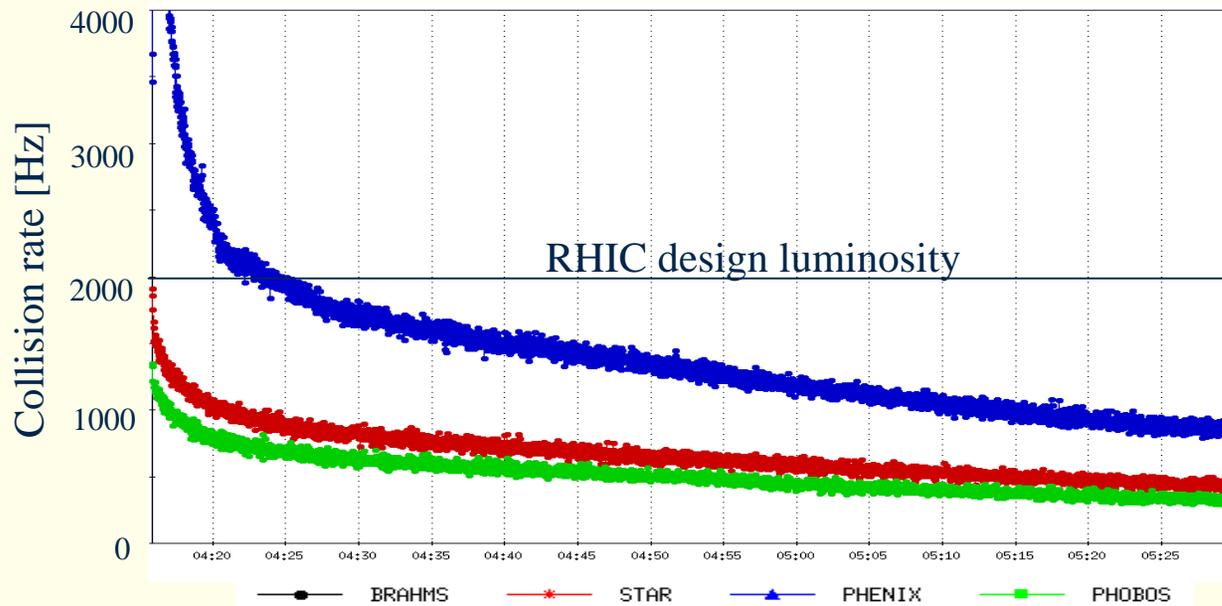


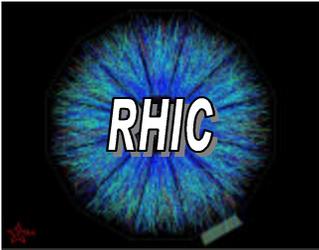
2001 Performance with gold

- Collisions at RHIC design beam energy (**100 GeV/nucleon**)
- 200 MHz rf system operational
 - 5 ns bunch length and an interaction region with $s \sim 25$ cm
- Luminosity exceeding RHIC design luminosity of $2 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$
- 40% availability is limiting total integrated luminosity

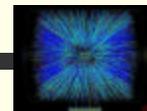
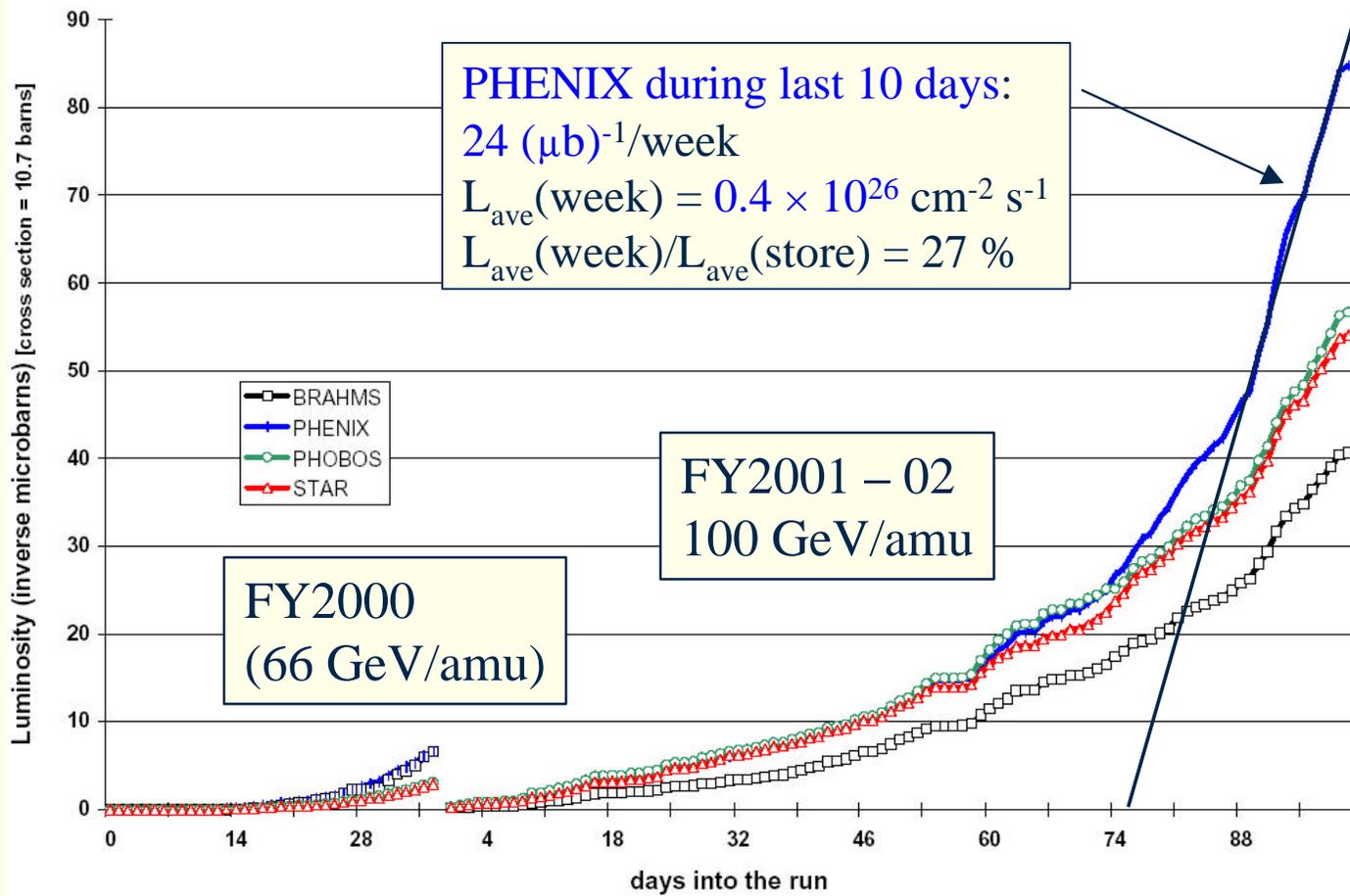


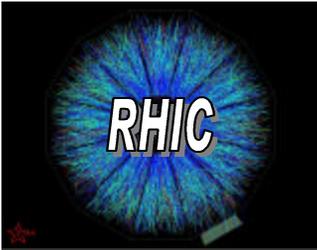
RHIC bunch profile



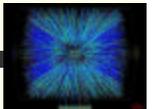
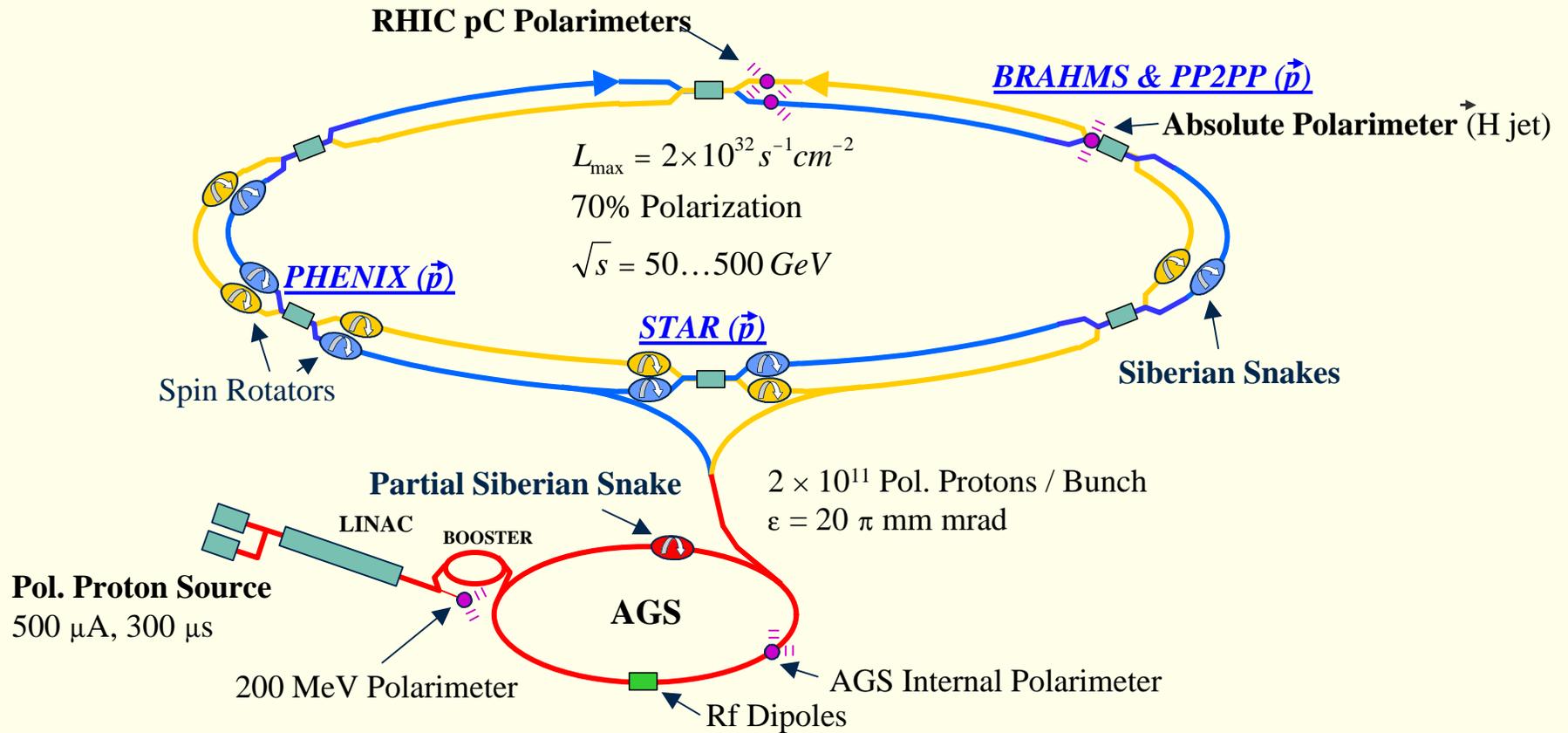


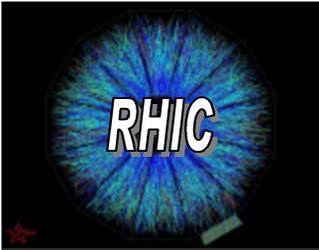
Integrated Au-Au luminosity





RHIC polarized p complex





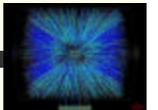
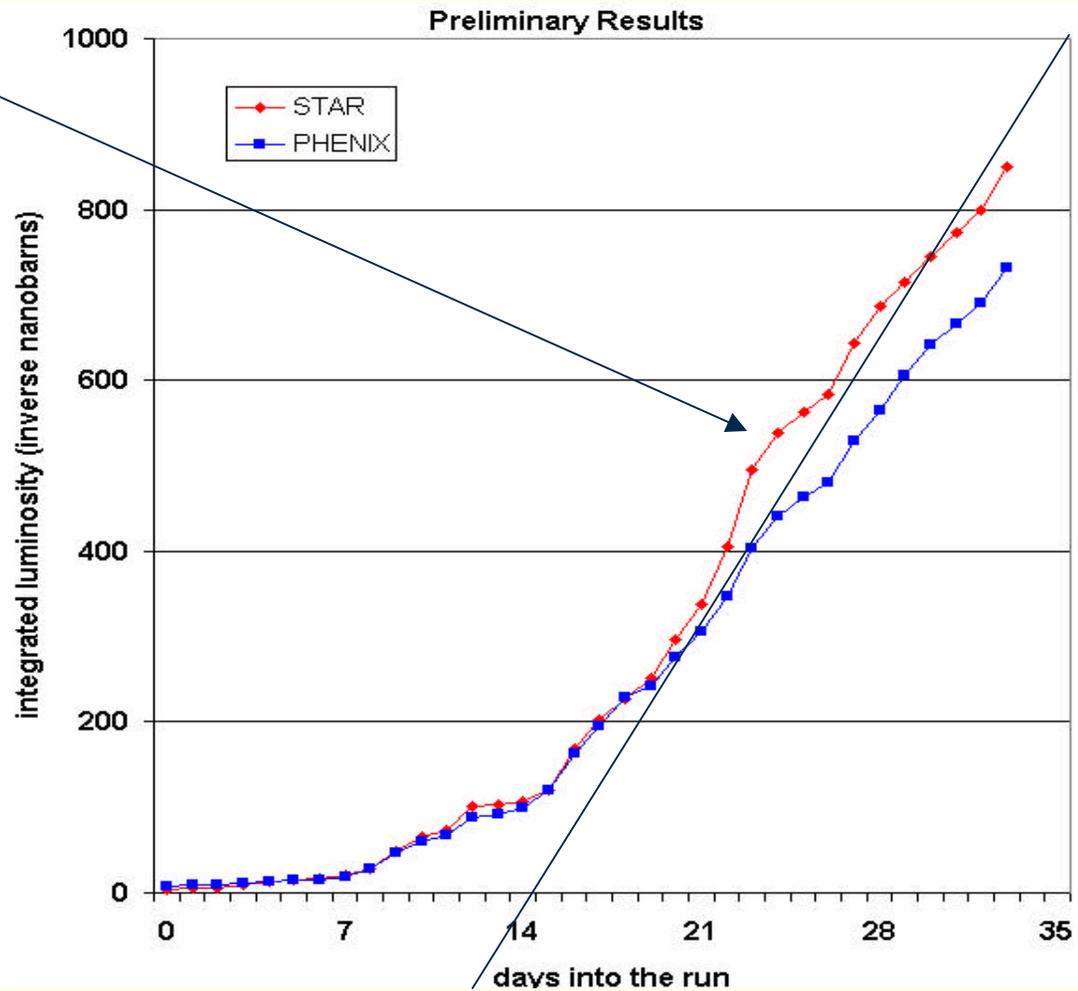
Integrated p - p luminosity

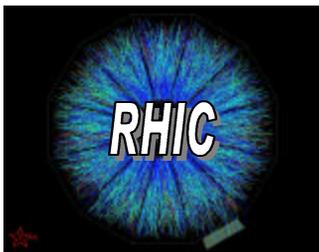
STAR during last 20 days:

290 (nb)⁻¹/week

$L_{\text{ave}}(\text{week}) = 0.5 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$

$L_{\text{ave}}(\text{week})/L_{\text{ave}}(\text{store}) = 42 \%$





2003 – running scenarios

Estimate for integrated luminosity for **29 week FY2003 run**:

- 4 weeks cool down, 1 week warm-up, 2 weeks setup (for each mode), 3 weeks ramp up (for each mode): →

29 weeks of cryo ops.: 2 modes: 7 weeks at “final” luminosity / mode

3 modes: 3 weeks at “final” luminosity / mode

4 modes: 1 week at “final” luminosity / mode

Running modes considered for 2003:

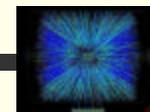
- **d-Au** at 100 GeV/u
- **Polarized pp** at 100 GeV
- **Au-Au** at 100 GeV/u
- **Au-d** at 100 GeV/u
- **Polarized pp** at 250 GeV
- **Au-Au** at different energies

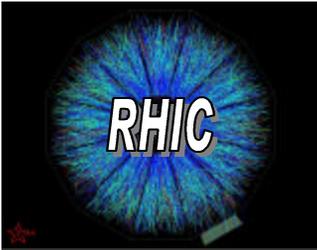
Plan for 2003

- **d-Au** at 100 GeV/u
- **Polarized pp** at 100 GeV

d-Au: dec 02 → mar 03

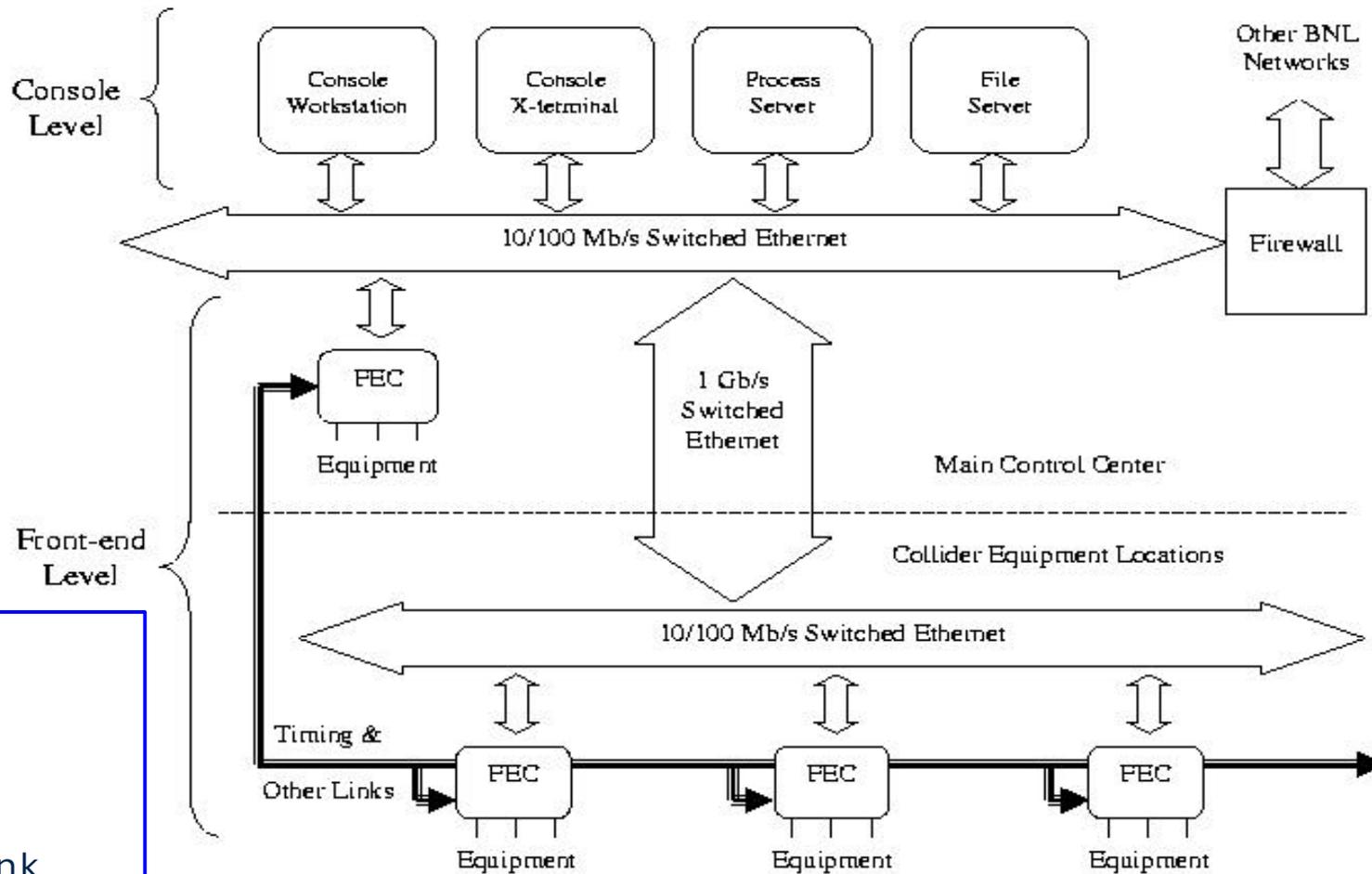
pp: mar 03 → may 03





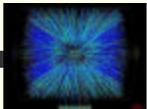
RHIC Controls Hardware

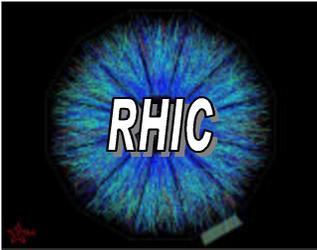
Sun
Linux



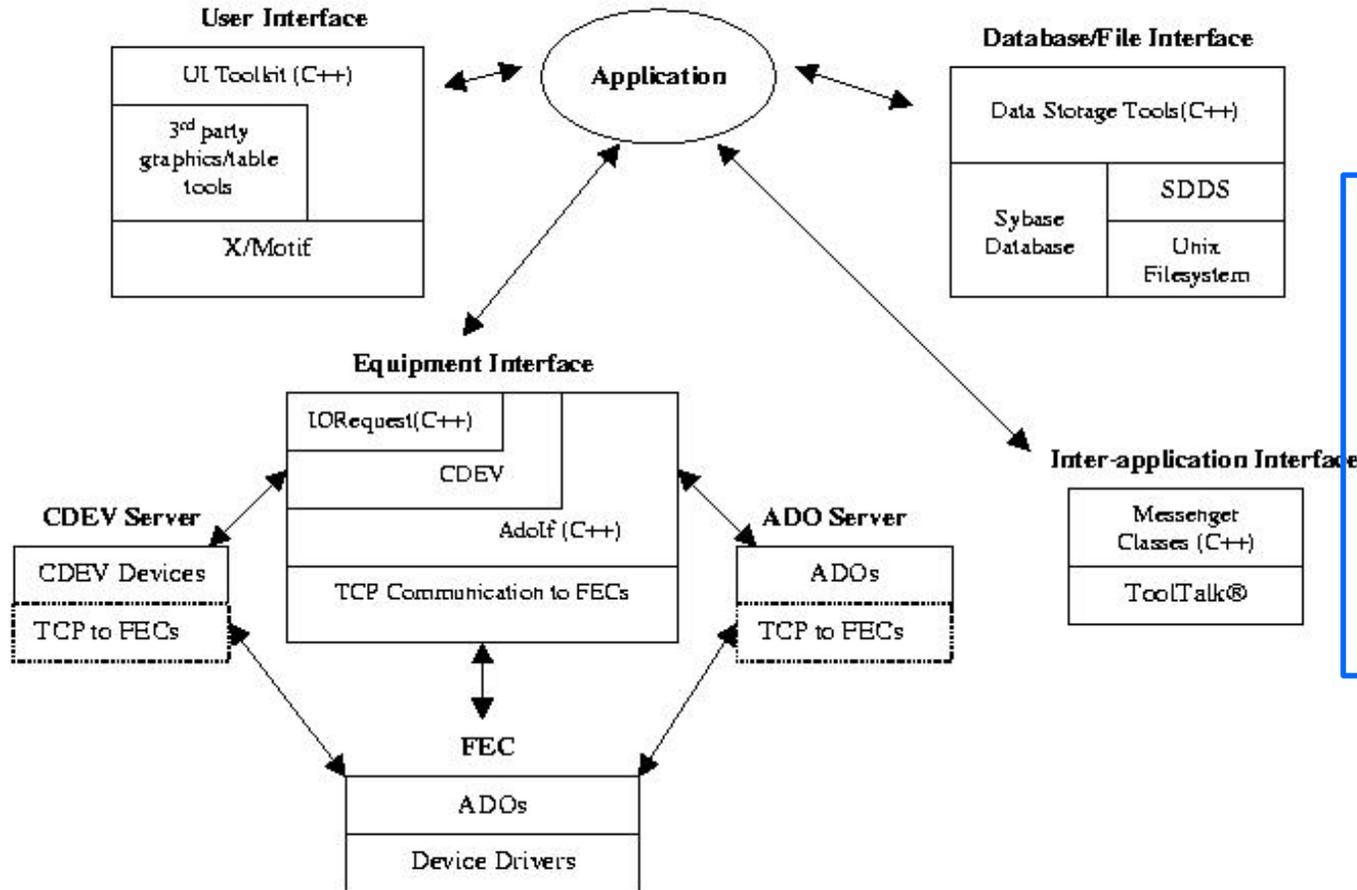
VME

- Links:
- EventLink
- RTDL
- Permit
- Quench link
- 2 beam-synch

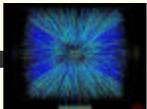


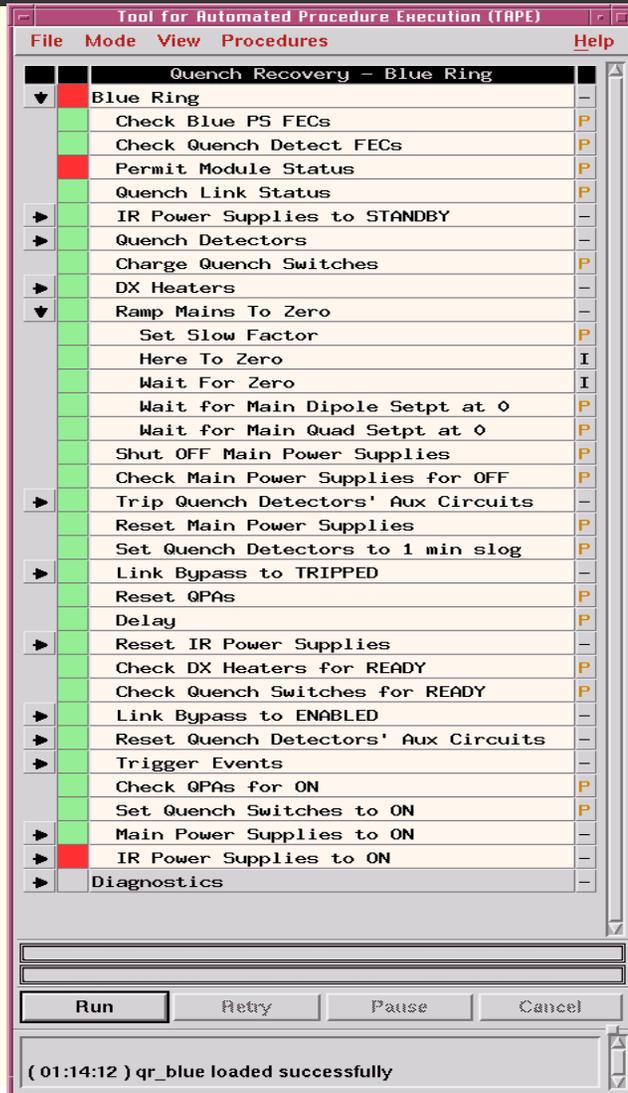


RHIC Controls Software



- FEC level:
- Device drivers
 - ADO's
- C++ objects
- ADOIf** (interface)
 - ADOfgen**
 - UIToolkit** (X/Motif)
 - C++ class → Sybase
 - CDEV interface (TCL)**





❑ Sequencing language

supports nested sequences

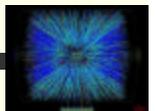
(no logics or parallel)

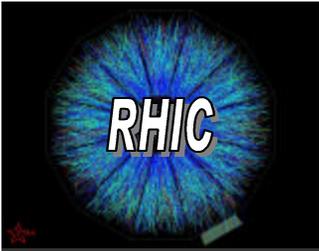
❑ Supporting servers

❑ Sequencer GUIs

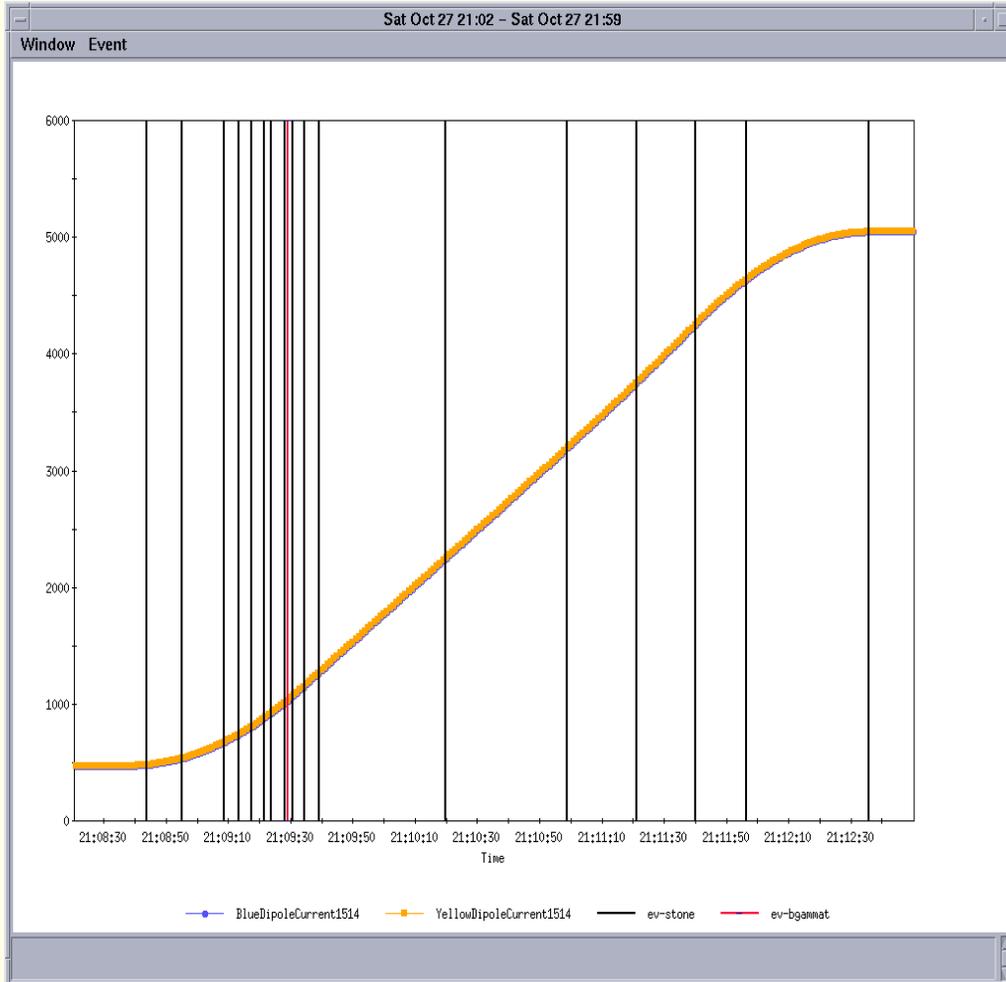
during operations in 2001

(ops sequences, instrument

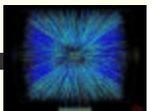


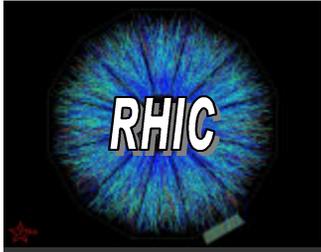


Model Driven Ramp Control



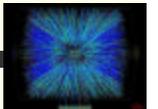
- ❑ Optics specific data step to ramp acceleration
- ❑ server converts chrom to currents
- ❑ Wave Form Generators

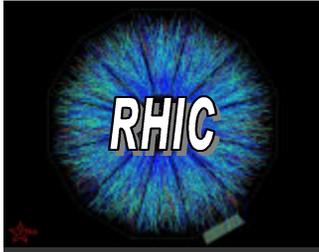




Control system performance

- ❑ Very little collider downtime for Controls
 - 1.5% of scheduled physics hours in 2001*
 - 2.0% of scheduled physics hours in 2000*
- ❑ Accomplished for 2001
 - ❑ Low Front End Computer failure rates
 - ❑ Greatly reduced graphics bottlenecks
- ❑ Increased availability by
 - ❑ Reporting problems early via alarms
 - ❑ Non-disruptive recovery mechanisms

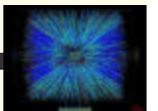


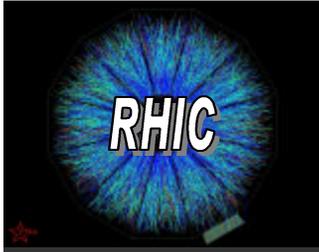


RHIC remote operations

Possible limited scale tests of Remote Ops at RHIC
(in increased order of complexity and necessary commitment....):

- ❑ **“Remote” ops** in within RHIC complex (1 lab)
- ❑ **Beam experiments** (2 labs – study time)
small in time and resources
yet all the complexity of operations
- ❑ **RHIC-LHC** collaboration, **PLL+tune feedback**
(2 labs – testing and operations)
- ❑ **SNS commissioning** remote ops (2 labs –
operations)
- ❑ **US-LHC** LARP's: (3 US labs + CERN comm.)





“Remote-local” RHIC ops

RHIC-AGS MCR ops core of complex

Ops not (yet) completely remotely connected from MCR:

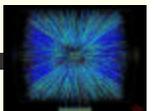
- ❑ Experiments magnets
- ❑ Polarimeters
- ❑ Instrumentation houses
- ❑ RF control room
- ❑ Tandem control room

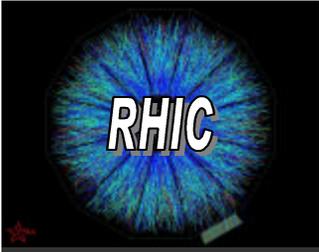
Integration of 1-3 planned at the RHIC Retreat (mar 02) and in place for run 2003 to improve efficiency in RHIC ops

Remote Ops → improvement local ops efficiency (lab management support)

Examples of testing scenarios of remote ops in within complex:

- ❑ Dumping collider store
- ❑ Beam studies periods





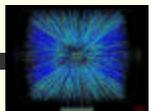
Beam experiments as Remote Ops tests

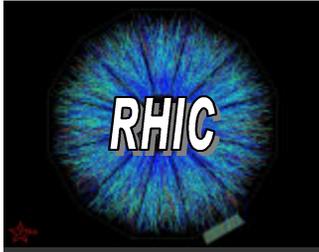
Limited in scope/time/resources but all **complexity** of operations

Ingredients:

- ❑ Interested and committed small **group at 2 labs**
- ❑ **Beam study** (common expertise, previous experience)
- ❑ **Scheduled time** (few hours to a shift)
- ❑ **Supporting Infrastructure**
 - ❑ Console in CR, for access to remote applications
 - ❑ (remote and local control room support)
 - ❑ Remote e-log access
 - ❑ Communication (ideally video conferencing but continuous voice communication would do...)
 - ❑ Data access and sharing

Time scale at RHIC : ~ 6 months (run dec 02 → may 03)





2001 RHIC Beam Experiments

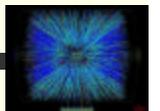
Beam studies program in parallel to Operations and Machine development for

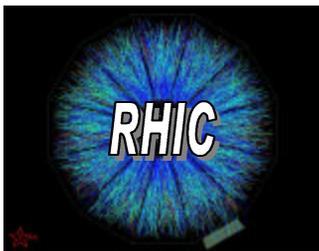
- ❑ **Testing new techniques** (→operations)
- ❑ **Collaborative beam experiments** (CERN, FNAL,...)

70 h (gold run) and 20 h (PP run)

Main activities/results:

- ❑ **IR measurements/corrections**
- ❑ **Beam-beam** studies
- ❑ **Longitudinal** and **transverse impedance**
- ❑ **Resonance** compensation
- ❑ **Spin** manipulations
- ❑ **Pressure rise** investigations / 110 bunches
- ❑ Testing of new **decoupling techniques**
- ❑ **Beam dynamics** studies





RHIC Beam Experiments 2003

RHIC Beam Experiments 2003

Next Meeting: Fri October 4

[RHIC Run 2003](#)

[Beam Experiments 2001](#)

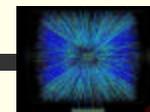
Beam Ex 2003 Organization

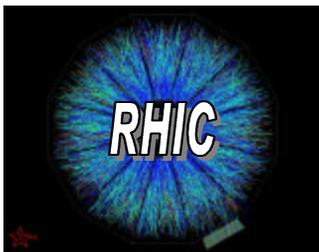
Beam Ex Program	Beam Ex Info/Proposals	Beam Ex Material
<u>AC Dipole</u> (M. Bai)	<u>AC dipole memo</u>	
Beam-beam (W. Fischer)	<u>Beam-beam WEB page</u> <u>List of beam-beam experiments</u>	<u>RHIC beam-beam papers</u>
<u>Chromaticity</u> (S. Tepikian)	<u>Chromaticity on the ramp -Horizontal</u> <u>Chromaticity on the ramp - Vertical</u>	<u>chromaticity via head-tail</u> <u>SPS RF phase modulation</u>
<u>Collimation</u> (A. Drees)		
<u>Flattop, Nonlinear, IR</u> (V. Ptitsyn)		
<u>Instabilities</u> (M. Blaskiewicz)	<u>Instabilities memo</u>	
<u>Pressure rise / e-clouds</u> (S.Y.Zhang)	<u>Pressure rise paper</u>	
Stochastic Cooling (M. Blaskiewicz)	<u>Stochastic cooling (M.Brennan)</u>	
Transition (alpha-1) (C. Montag)		

RHIC 2003 BEAM EXPERIMENTS WORKSHOP

BNL September 26-27, 2002 [WEBPAGE](#)

<http://www.agsrhichome.bnl.gov/AP/RHIC2003/BeamEx2003>





RHIC Beam Experiments Workshop



RHIC Beam Experiments Workshop

September 26-27, 2002

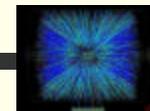
[BNL Science Education Center](#)

WORKSHOP Goals:

- beam experiments program for RHIC run 2003
- analysis of results from RHIC run 2001
- beam diagnostics and techniques for beam experiments

DRAFT AGENDA

Thursday, Sep 26 - morning Run 2003 goals and organization	Friday Sep 27 - Morning Diagnostics for beam experiments
Thursday, Sep 26 - Afternoon Beam Experiments Program	Friday Sep 27 - Afternoon Remote operations Closout





IR corrections: linear, nonlinear

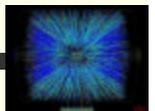
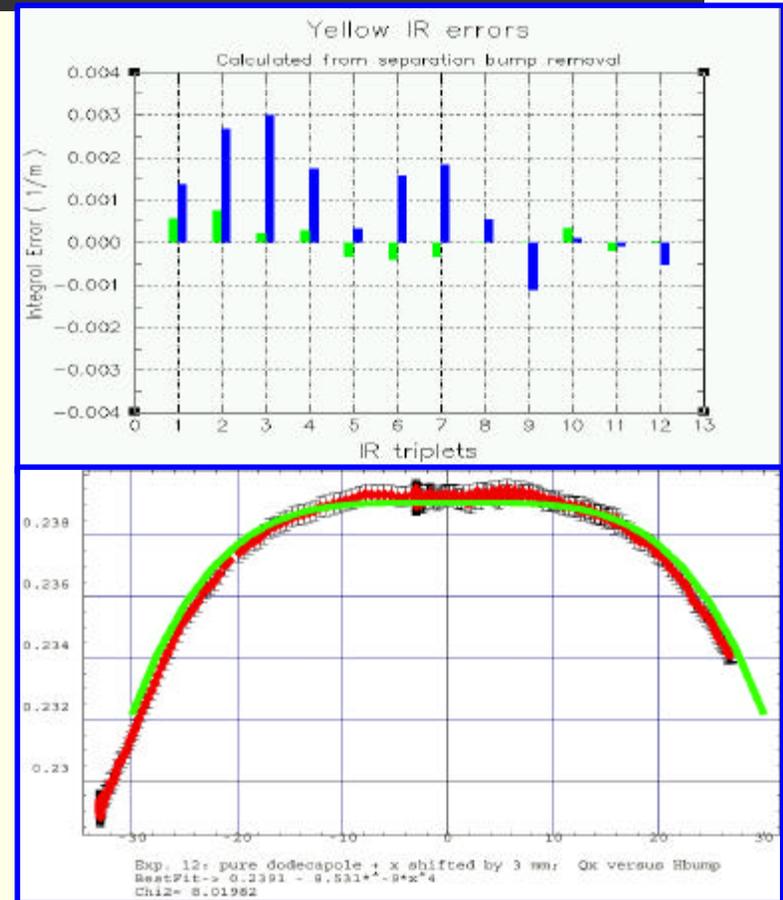
2 methods: **IR bumps**, **action-phase jump**

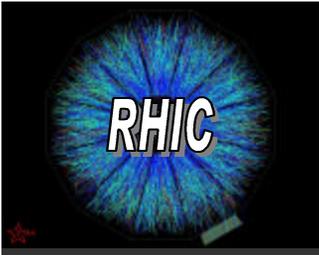
LINEAR

- ❑ Measurement and correction of IR **coupling** (roll in IR triplets) → operations
- ❑ Good agreement with cold mass **alignment**
- ❑ Measurement of triplet **gradient errors**
- ❑ **“Exported” to FNAL TeV (august 2003)**

NONLINEAR

- ❑ Measurement of bump amplitude dependent **tune shifts** in IP8 IP2
- ❑ Mathematica analysis to derive **multipoles**
- ❑ **Correction of tune shift in IR8** (octupole and sextupole)
- ❑ **Collaboration with CERN**





Beam-beam studies

RHIC operates in a strong-strong beam-beam regime

☐ Measure **beam-beam tune shift**

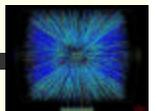
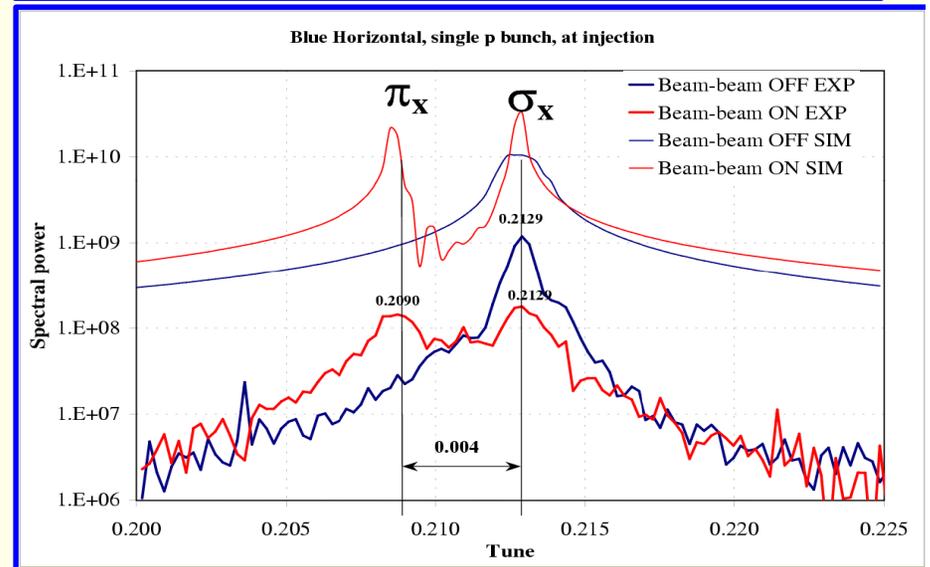
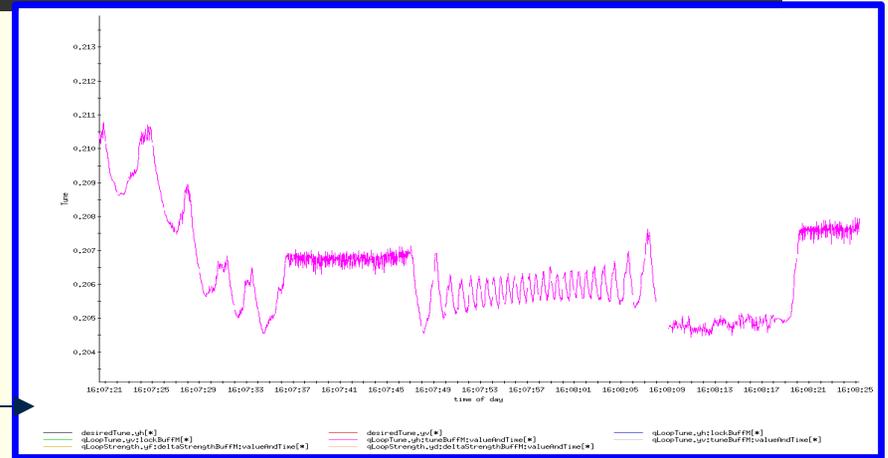
with PLL

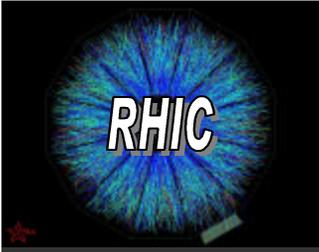
(cogged, uncogged, cogged again)

☐ Experimental evidence of **coherent beam-beam modes**

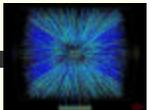
in a hadron collider
(dedicated experiment)

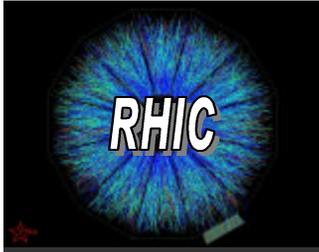
collaboration with FNAL





Chromaticity via RF phase modulation





RHIC – LHC instrumentation

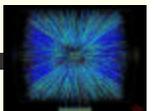
Collaboration is in the making between the RHIC and LHC instrumentation groups

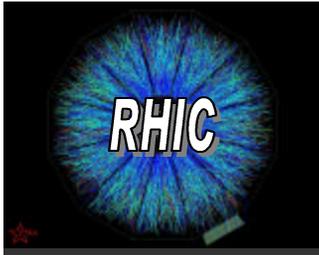
- ❑ **Phase lock-loop** system
- ❑ **Tune feedback** ("day 1")
- ❑ **Chromaticity feedback** ("day 1.5")
- ❑ **Head-tail monitor**: instabilities, chromaticity measurement
- ❑ Pickup studies

(after commissioning: Multiple carrier DSP code, chromaticity measurements)

Possible test case for remote operations once the building blocks are in place

Time scale: 6-18 months (rhic run 2003 and 2004)





RHIC PLL system

RHIC PLL

- accuracy ($< 10^{-5}$)
- resolution (a few 10^{-6})
- Auto-lock
- chromaticity control essential
- coupling control desirable

Run 2001

- system commissioning
- Q measurement on the ramp

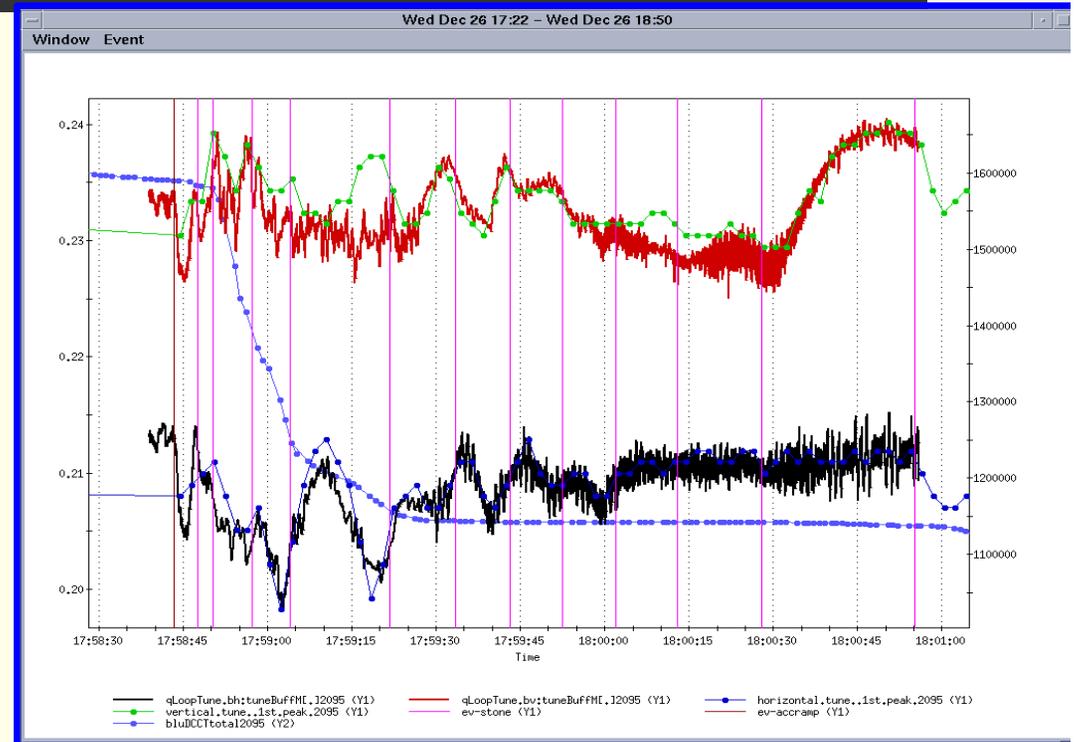
beam experiments

tune feedback (pp run)

Run 2003

System improvements

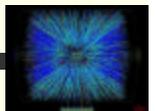
Q feedback from "day

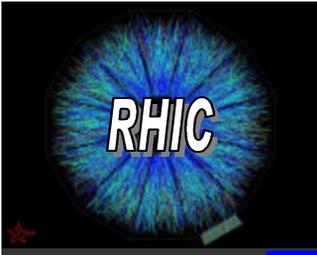


PLL measurement on the ramp

Good agreement PLL - Tune Meter

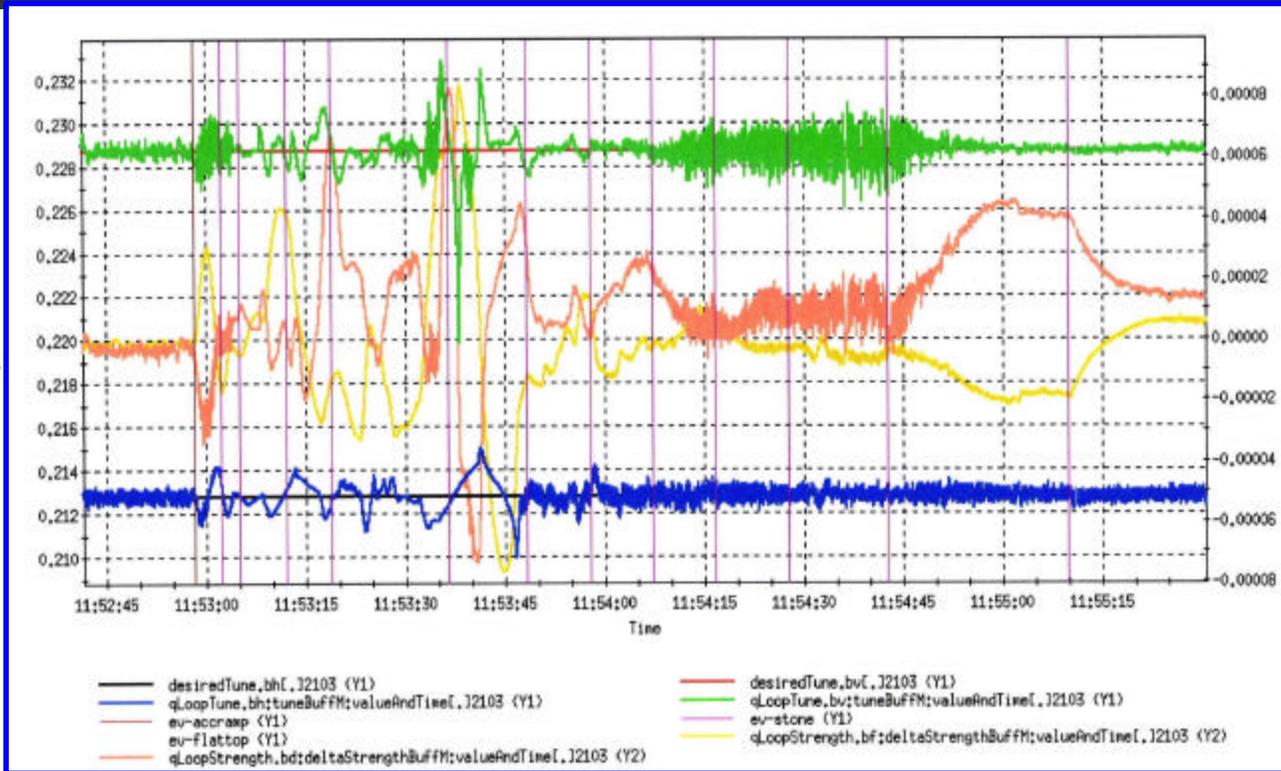
Radial modulation 0.2mm for chromaticity measurement





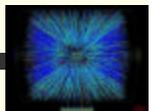
RHIC tune feedback

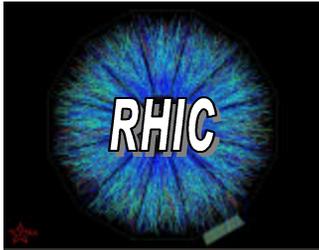
Q_V →
 Q_{loop} strengths →
 Q_H →



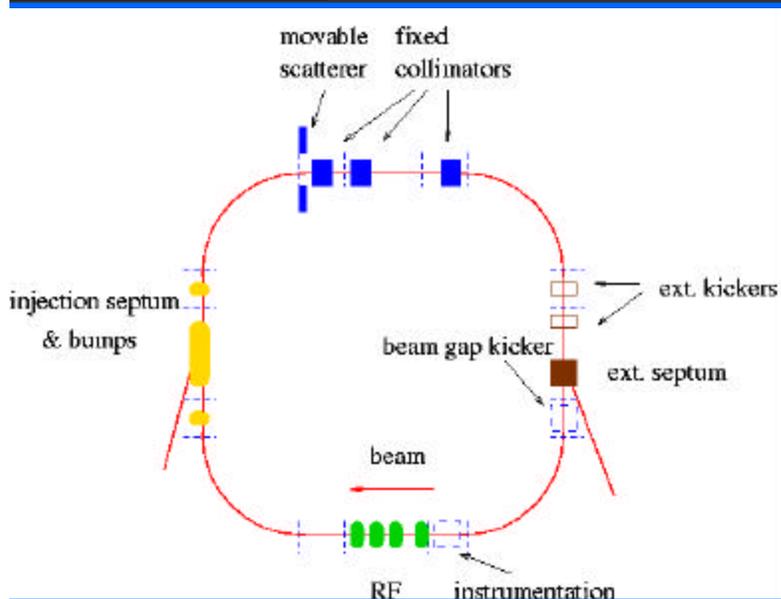
First ramp with tune feedback (PP)

Controlled tunes to **0.002** Corrected for up to **0.02**
PLL signal → **feedback** to main Q bus (blue ring feedback successful)
 Q-loop integrated into **sequencer**





SNS ring startup, commissioning



BNL responsible for SNS ring design and instrumentation

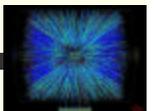
Scenario 1: power supply hardware examination/diagnosis

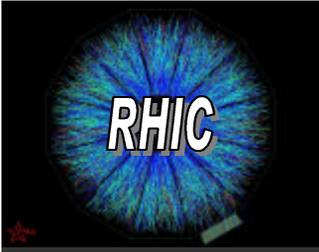
- Coordination on and off site engineers
- Telepresence
- Scenario for responsibility transfer?

Scenario 2: shared site commissioning

- Transfer of controls between BNL and Oak Ridge
- Site support and supervision
- All aspects of remote operations

Time scale: 4+ years





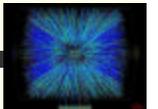
Shelter Island Workshop

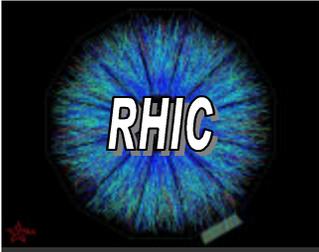
Select and plan limited scale GAN test cases:

- ❑ ~ 6 months time scale → next GAN workshop?
- ❑ 1-2 years scale
- ❑ 4+ years (global tests)

Example “6 months scale”: beam experiment at RHIC

- ❑ Select test (IR, beam-beam, RF phase modulation, others?)
- ❑ List remote control room requirements
- ❑ Virtually plan test
- ❑ Really plan test





Conclusions

- ❑ RHIC offers several ways to test **remote ops** at different levels of complexity and commitment:
 - intra-lab** 2-3 months
 - beam experiments** ~ 6 months
 - PLL commissioning and operations** 1-2 years
 - SNS commissioning** 3+ years
 - LHC MD's** 5+
- ❑ We can work at Shelter Island to define more precisely and plan the different scenarios

