

## Beam Based Experiments

F.Pilat

### Introduction

motivation, context, plans

### Experiments for future hadron colliders

**BNL Workshop** - February 2000  
developments

### The RHIC experimental program

**RHIC Commissioning - Run 2000**  
Overview of **beam studies** in 2000  
**Results:** highlights (analysis in progress)  
Future plans

### Beam experiments for VLHC

**Topics**  
Towards an experimental program

# Beam Based Experiments - Introduction

## motivations

improve **existing** machine performance

design guidelines for **future** machines

→ LHC, VLHC...

## LHC

**defined project**

dynamic effects  
correction systems  
techniques.....

## VLHC

**design project**

experiments fundamental  
influence overall design

correction, feedback



cheaper (more realistic?) machine

# Accelerator Physics Experiment for Future Hadron Colliders

Workshop BNL, February 21-22, 2000

## goals

to **plan experiments** in the LHC era and beyond  
to plan **(re)commissioning machine studies** relevant to the  
LHC and future hadron colliders  
to investigate new **experimental techniques**  
to form **experimental collaborations**

## context

RHIC Test Run	June-August 1999	
<b>RHIC Run 2000</b>	March- September 2000	
<b>Tevatron Run II</b>	engineering run	summer 2000
	Run II	march 2001

## participation

BNL, CERN, Cornell, DESY, FNAL, LBL

## proceedings, talks, information:

<http://www.agsrhichome.bnl.gov/LHC/org/Beam2000/index.html>

## Studies and issues discussed

### Single beams

**Dynamic aperture**  
**IR Corrections** (RHIC system ~ LHC system)  
**Diffusion processes (IBS)**  
**Time-dependent effects**

### Beam-beam

(overlap Tevatron-LHC-RHIC)  
**long-range interactions**  
synchro-betatron resonances by X-ing angle  
**PACMAN bunches**  
**coherent modes:** existence, feedback?

### Experimental Techniques

**BPM turn-by-turn data**  
linear & nonlinear **model**  
**Luminosity measurement**  
**Operational coupling correction**  
**AC dipole** (coherent oscillations w/o emittance growth)  
**Transverse echoes, Crystal collimators** (-> diffusion)

## Workshop “output”

A small number of **initial collaborative studies** were selected in the following areas:

**Interaction Region Correction**  
**IBS, time dependent effects**  
**Beam-Beam**  
**Collimation (diffusion)**  
**Luminosity measurements**  
**(studies with AC dipole)**

**Core teams** of people to carry out the studies were identified

**Proposals** for initial machine studies at **RHIC (Run 2000)** and **FNAL (Run II)** written (and reviewed by local laboratory management)

Essential that the primary goal of studies be **performance enhancement** of RHIC and the Tevatron.

# Timeline of RHIC Commissioning Run 2000

Feb 5	Cryogenics operations starts
Mar 30	RHIC Rings AT 4K
Apr 7	<b>BLUE</b> Circulating beam at INJECTION, good aperture, lifetime 3-5 minutes
Apr 12	2 weeks machine shutdown (repairs and maintenance)
May 1	<b>BLUE</b> back at INJECTION, lifetime of > 1 hour
May 7	<b>YELLOW</b> at INJECTION, good aperture and lifetime
May 17	<b>BLUE</b> first acceleration through TRANSITION ( $\gamma=28$ )
May 25	<b>RHIC</b> first simultaneous CIRCULATING BEAMS
June 1	<b>YELLOW</b> Accelerated to $\gamma=66$ and <b>BLUE</b> to $\gamma=70$
June 7	<b>BLUE</b> and <b>YELLOW</b> beams COGGED and STEERED at 30 GeV
June 12	Blue and Yellow at $\gamma=30$ , <b>FIRST COLLISIONS</b> <b>STAR</b> first EVENTS (IP6) <b>PHOBOS</b> first EVENTS (IP10)
June 14	<b>PHENIX</b> first EVENTS (IP8)
June 15	<b>BRAHMS</b> first EVENTS (IP2)
June 25	<b>COLLISIONS</b> at $\gamma=70$ in <b>ALL FOUR EXPERIMENTS</b> (65 GeV/nucleon, Total collision energy: 26 TeV)
July 18	Start commissioning of <b>FAST RAMPS</b> ( 6 A/sec --> 25 A/sec)
July 25	<b>COLLISIONS</b> at $\gamma=70$ in <b>ALL 4 EXPERIMENTS</b> with fast ramps
July 28	Tried successfully injection of 60 bunches
Aug 4	<b>Slow down early part of the ramp</b>
Aug 10 - Sep 4	Reproducible, long stores for Physics, with ~80% ramp efficiency Steady increase in <b>beam intensity</b> , > <b>10% design luminosity</b> (run 2000 goal)

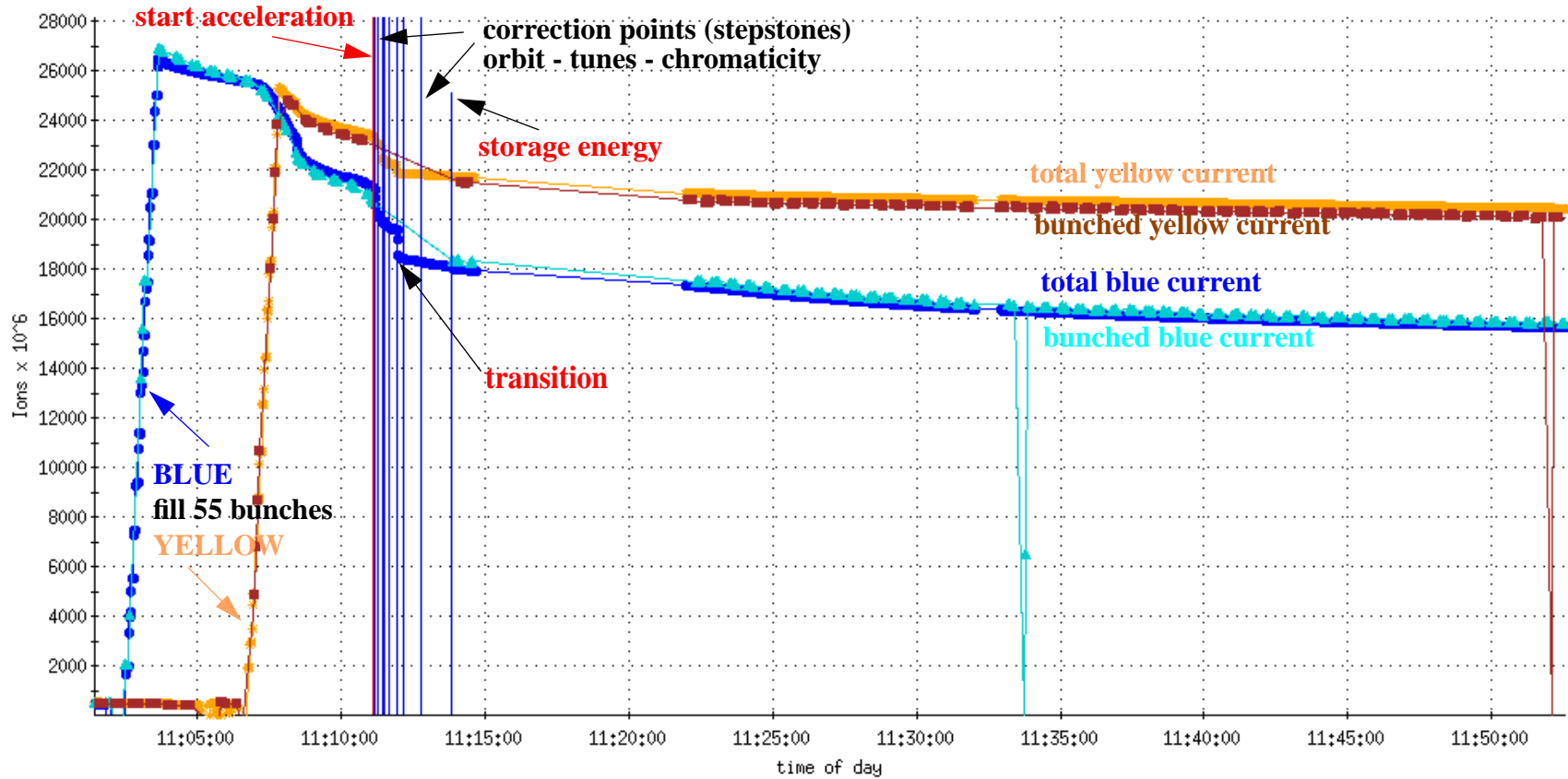
# RHIC Ramp: Blue and Yellow beams

ramp rate: 25 A/sec

55 bunches

File Setup Logging Diagnostics

Thu Aug 31 2000 RHIC - DCCT total beam & WCM bunched beam



bluDCCTtotal      yelDCCTtotal      bluWCMbunched  
yelWCMbunched      relMon.ev-accramp;relEventNumM:value      relMon.ev-ygammat;relEventNumM:value  
relMon.ev-stone;relEventNumM

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Start

## Beam studies at RHIC - Run 2000 - Overview

	Done (Au operations)	Planned (PP operations)
<b>IBS</b> <b>Nonlinear</b> W. Fischer	nonlinear detuning (inj) chromaticity vs. time (inj, sto) long. profile vs. time (inj, sto) IBS (IPM WCM Schottky) (inj)	“IBS” integrated Blue (inj) - p Phobos beam profile dynamic aperture (inj) (frequency analysis)
<b>IR Studies</b> <b>Linear/Nonlinear</b> F. Pilat	local decoupling IP8 Yellow IR bumps (inj) Blue IP2 IP6 IP8 IR bumps (inj) Yellow IP2 IP6 IP8	IR bumps (inj) - Blue Yellow IP10 IR bumps (sto) local decoupling (sto) local sextupole correction $\beta^*$ squeeze
<b>Collimation/ Luminosity</b> A. Drees	collimator performance Au Vernier scans	collimator performance p measure growth rates
<b>Machine Optics</b> T.Satogata	TM kick + TBT orbit (sto)->beta dispersion (sto) Blue Yellow	$\beta^*$ direct measurement
<b>Beam Beam</b> W. Fischer	beam-beam tune shift	beam-beam tune shift with p



## Interaction Region studies (coord. F.Pilat)

**commissioning** (linear/nonlinear correction layers)

**local IR (triplet) decoupling**

(Pilat, Ptitsyn, Cardona)

**IR bumps method**

(Koutchouk, Pilat, Ptitsyn)

**nonlinearity + frequency analysis**

(Fischer, Pilat, Schmidt)

### IR bumps method

**principle**

move beam locally (**bumps**) in triplet  
record **observables vs. bump amplitude**  
compare with expected behavior (**coupling, nonlinear fields**)

**observables**

**rms closed orbit** (outside bump - arcs)  
**tune** (**tune meter & Shottky** measurements)

**analysis**

**clean up** orbit data (BPM's, 2 sigma cuts, arcs....)  
**plot** rms orbit and tune vs. bump amplitude (5 --> 40 mm)  
**fit** data to infer multipole content

**results**

Yellow and Blue ring **IP6 IP8 and IP8**  
“by-products”: **orbit stability 1h 44 $\mu$ m, BPM resolution  $\sim$ 5 $\mu$ m**

## **IBS - Nonlinear** (coord. W.Fischer)

**nonlinear detuning at injection**

(Fischer)

**chromaticity vs. time**

(Fischer, Tepikian)

**IBS:**

(Cameron, Connolly, Fischer, Tepikian..)

**integrated measurements vs. time**

**longitudinal profiles** (WCM)

**transverse profiles** (IPM)

**Schottky data**

## **Collimation / Luminosity** (coord. A.Drees)

**collimator performance** (Au)

(Drees, Fliller)

**Vernier scans**

(Drees)

## **Beam - Beam studies** (coord. W.Fischer)

started measurement of **beam-beam detuning**

(Fischer)

**coherent modes** (2001)

(Fischer, Furman)

## RHIC Future Studies Plan

### Run 2000

studies as extension of **commissioning activities**  
**parasitic** or **integrated into shift time**  
**small groups:** commissioners + outside collaborators

### Preparation Run 2001

**RHIC Retreat**, Nov. 16-17, 2000 (session on beam studies)  
**Plan for 2001**, December 2000 -March 2001

### Run 2001

Goal: beam study time scheduled during **machine development**, negotiated among study teams, operations and experiments  
continue **collaborative studies**

### 2002 and/or beyond

goal of RHIC fully operational, design luminosity  
**beam experiments**  
*dedicated time*  
*planned*  
*collaboration with other labs*  
*formally approved*

# Beam experiments for VLHC

## hadron colliders experiments

beam-beam  
interaction regions  
time dependent effects  
beam based alignment and corrections  
electron clouds

*all relevant for VLHC design and planning*

## flat beams VLHC specific

VLHC Workshop on Flat Beams  
BNL, September 18-20, 2000

## optics

**flat beams at RHIC** (with existing power supplies):  
 $\beta_x/\beta_y = 2.5$  at **collision** energy  
 $\beta_x/\beta_y = 5.5$  at **injection** energy  
studies in conjunction with b-squeeze commissioning  
(IR correction, dynamic aperture, etc.)

## emittance ratio $k = \varepsilon_y/\varepsilon_x$

issues: what is **minimum k**? **IBS**, **noise sources**, etc.  
RHIC: no synchrotron radiation but  
**electron cooling** part of the **planned upgrade**

## Towards an experimental program for VLHC

**integration** with experimental program for RHIC, Tevatron, later LHC  
staged approach towards **formal beam experiments**

### Milestones

- February 2000**                      BNL Workshop on Beam Experiments for Future Hadron Colliders
- February 2001**                      VLHC Beam Experiment Workshop  
FNAL
- Snowmass 2001**                      **beam experiment session ?**  
review of studies at RHIC 2000-2001  
review of studies at Tevatron 2001 - Run II  
review of beam activities at other laboratories
- work out a **beam experiment plan for VLHC**  
2002 and beyond