Did you know?

- Delay Channel Editor
  - Easy interface to control any v102, v202 delay channel
  - Used for both ado and SLD styles
  - Double left-click on device name or choose from Device/ or Tools/ menu.
- Mouse sonar
  - Use ctrl-alt on any linux console to find the mouse cursor.

Introduction to RHIC Operations

Part III: RHIC Injection

Objectives

- Following this presentation, operators should:
  - Have a basic understanding of the systems involved in RHIC injection
  - Be familiar with the managers and applications used for RHIC injection.
  - Be able to recognize and troubleshoot some common failures of RHIC injection.
- This presentation does not cover injection start-up/setup, but should introduce the tools needed to follow other setup documents to that end.

Overview

- All AGS extraction, transport, and RHIC injection parameters are based on RHIC injection RF frequency as the fundamental.
  - Historically, calculated for a rigidity equal to protons at $G\gamma = 46.5$
  - AGS extraction frequency, field, radius
  - AtR magnet (design) currents
  - RHIC injection field
- Successful injection requires three elements
  - x/y arc steering through lambertson
  - Injection kicker timing
  - Closed orbit at proper dipole field, tune, etc.

RHIC injection

- See RMS Web page Start-up instructions for injection setup.
- In order to proceed, AGS RF sweep frequency at extraction should match RHIC injection RF frequency (proportionally).
- Tools to use
  - RHIC Injection Tuning
  - pet pages
    - RHIC/Injection/Tuning
    - AGS/eXtraction/Tune
  - Ramp Editor

AGS-RHIC synchro

- Ensures extraction from AGS at a phase and frequency that matches the desired RHIC bucket.
- Independent of AGS-RHIC synchro, extraction depends on proper first transfer marker (FXM) setting from Booster-AGS synchro.
- Relevant timing includes arf.synch_start.gt, ARF.SYNCH_LOOP.ST

RHIC injection

- Tuning concerns
  - ODTC: Orbit, Decoupling, Tune, Chromaticity
  - Avoid steering AtR to bad RHIC closed orbit
    - Watch arc, first turn losses
  - Persistent current effects, chromaticity
    - Below transition: negative chromaticity stable
    - Above transition: positive chromaticity stable
    - Persistent current effect causes horizontal drift positive, vertical drift negative.

RhicInjection Current Fill No: 8148

File Pattern Help

Horizontal plane

Norm power max1: 0.7316 max2: 0.7330 error: 0.0002 Hanning+interpolation

DQmin: 0.0844 (from 40-turn map)
Error: 0.0062 (1sig statistical)
DQmin: 0.0047 (after correction)

Horizontal tune

[rad/hr]

Beam ==> Lattice: sextant

Vertical plane

Norm power max1: 0.7210 max2: 0.7242 error: 0.0002 Hanning+interpolation

DQmin: 0.0844 (from 40-turn map)
Error: 0.0062 (1sig statistical)
DQmin: 0.0047 (after correction)

Vertical tune

- Inject orbit
- Closed orbit
- TBT & coupling
- FFT & coupling
- Emittances xy
- Longitudinal
- Kickers & WCM
- Summary

Blue Au / Yellow Au

Low intensity pilot | Take pilot bunch | Take 1 bunch | Take 1 AGS cycle | Fill both | Blue | Stop Fill | Cogging reset

Next bucket 1 | Injected 0 | Remaining 1 | Reinitialize | Acquisition ON

new	Sat Jun 10 02:02:26 2006	1021	turns	-0.44	H1 av [mm]
old	Sat Jun 10 02:03:54 2006	1021	turns	0.55	H1 av [mm]
tgt			turns		H1 av [mm]

	BPM [mm]	turn 1	turn 2	closed orbit	target orbit	status
H	bo6-b8	-0.01	-0.52	-1.18	--	ok
H	bo6-bh10	-2.06	0.48	-0.64	--	ok
H	bo6-bh12	-2.43	-1.05	-0.26	--	ok
V	bo6-b8	23.12	-1.78	-1.59	--	ok
V	bo6-bv9	-31.50	7.82	0.00	--	error
V	bo6-bv11	0.63	0.26	0.20	--	ok
V	bo6-bv13	0.24	0.98	0.46	--	ok

Global linear coupling correction

	corrector [1e-3/m]	design	old trim	present trim	target trim	status
S	b-sq1	0.000	0.000	0.000	0.000	ok
S	b-sq2	0.000	0.000	0.000	-0.042	ok
S	b-sq3	0.000	0.000	0.000	0.406	ok

Apply | Revert | Optimize | Cancel

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Auto setup | Auto revert

RhicInjection Current Fill No: 8148

File Pattern Help

Injection kickers and timing

Sat Jun 10 02:02:21 2006 Kicker current wave forms and bunch signals

Kicker current signal[V]

Bunch at s = -100 m vs. AGS extraction trigger: 0.035 usec
Bunch at s = 599 m vs. RHIC injection trigger: 56.815 usec

Time [usec]

Bunch dI/dt bo6-bv9 [arb.]

[rad/hr]

Beam ==> Lattice: sextant

Wall current monitor

Profile length(rms): 5.3 nsec dp/p(rms): 0.58e-03 S(95%): 0.42 eV.s/n

Bunch current [A]

Time [nsec]

- Inject orbit
- Closed orbit
- TBT & coupling
- FFT & coupling
- Emittances xy
- Longitudinal
- Kickers & WCM
- Summary

Blue Au / Yellow Au

Low intensity pilot | Take pilot bunch | Take 1 bunch | Take 1 AGS cycle | Fill both | Blue | Stop Fill | Cogging reset

Next bucket 1 | Injected 0 | Remaining 1 | Reinitialize | Acquisition ON

new	Sat Jun 10 02:02:26 2006	1021	turns	-0.44	H1 av [mm]
old	Sat Jun 10 02:03:54 2006	1021	turns	0.55	H1 av [mm]
tgt			turns		H1 av [mm]

	BPM [mm]	turn 1	turn 2	closed orbit	target orbit	status
H	bo6-b8	-0.01	-0.52	-1.18	--	ok
H	bo6-bh10	-2.06	0.48	-0.64	--	ok
H	bo6-bh12	-2.43	-1.05	-0.26	--	ok
V	bo6-b8	23.12	-1.78	-1.59	--	ok
V	bo6-bv9	-31.50	7.82	0.00	--	error
V	bo6-bv11	0.63	0.26	0.20	--	ok
V	bo6-bv13	0.24	0.98	0.46	--	ok

Kicker timing correction

	corrector [usec]	design	old trim	present trim	target trim	status
V	xki1	54.370	-0.024	-0.024	-0.024	Off
V	xki2	54.370	-0.002	-0.002	-0.002	Off
V	xki3	54.370	-0.034	-0.034	-0.034	Off
V	xki4	54.370	0.017	0.017	0.017	Off

Apply | Revert | Optimize | Cancel

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Auto setup | Auto revert

RhicInjection Current Fill No: 8148

File Pattern Help

Horizontal plane

End of AtR and 1st sextant of ring, 1st turn minus closed orbit

AtR left | Ring outside | AtR right | Ring inside

Orbit deviation [mm]

Longitudinal position [m]

[rad/hr]

Beam ==> Lattice: sextant

Vertical plane

End of AtR and 1st sextant of ring, 1st turn minus closed orbit

AtR up | Ring up | AtR down | Ring down

Orbit deviation [mm]

Longitudinal position [m]

- Inject orbit
- Closed orbit
- TBT & coupling
- FFT & coupling
- Emittances xy
- Longitudinal
- Kickers & WCM
- Summary

Blue Au / Yellow Au

Low intensity pilot | Take pilot bunch | Take 1 bunch | Take 1 AGS cycle | Fill both | Blue | Stop Fill | Cogging reset

Next bucket 1 | Injected 0 | Remaining 1 | Reinitialize | Acquisition ON

new	Sat Jun 10 02:02:26 2006	1021	turns	-0.44	H1 av [mm]
old	Sat Jun 10 02:03:54 2006	1021	turns	0.55	H1 av [mm]
tgt	Sat Jun 10 02:02:26 2006	1021	turns	-0.38	H1 av [mm]

	BPM [mm]	turn 1	turn 2	closed orbit	target orbit	status
H	bo6-b8	-0.01	-0.52	-1.18	--	ok
H	bo6-bh10	-2.06	0.48	-0.64	--	ok
H	bo6-bh12	-2.43	-1.05	-0.26	--	ok
V	bo6-b8	23.12	-1.78	-1.59	--	ok
V	bo6-bv9	-31.50	7.82	0.00	--	error
V	bo6-bv11	0.63	0.26	0.20	--	ok
V	bo6-bv13	0.24	0.98	0.46	--	ok

Transverse injection oscillation correction

	corrector [mrad]	design	old trim	present trim	target trim	status
H	xth9	0.000	0.000	0.000	-0.071	on
H	xlamb	0.000	0.000	0.000	-0.027	on
V	xtv6	0.000	0.000	0.000	0.003	on
V	xp1	0.000	0.000	0.000	0.008	on

Apply H | Apply V | Revert | Optimize | Cancel

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Auto setup | Auto revert

RhicInjection Current Fill No: 8148

File Pattern Help

Horizontal plane

Beam coherence at bo6-bh10 (#2), 1024 turns, synchrotron motion subtracted

DQ(rms emitt. +/-): 0.1e-4

DQmin: 0.0844 (from 40-turn map)
Error: 0.0062 (1sig statistical)
DQmin: 0.0047 (after correction)

Beam position [mm]

Turn number

[rad/hr]

Beam ==> Lattice: sextant

Vertical plane

Beam coherence at bo6-bv11 (#3), 1024 turns

DQ(rms emitt. +/-): 0.1e-4

DQmin: 0.0844 (from 40-turn map)
Error: 0.0062 (1sig statistical)
DQmin: 0.0047 (after correction)

Beam position [mm]

Turn number

- Inject orbit
- Closed orbit
- TBT & coupling
- FFT & coupling
- Emittances xy
- Longitudinal
- Kickers & WCM
- Summary

Blue Au / Yellow Au

Low intensity pilot | Take pilot bunch | Take 1 bunch | Take 1 AGS cycle | Fill both | Blue | Stop Fill | Cogging reset

Next bucket 1 | Injected 0 | Remaining 1 | Reinitialize | Acquisition ON

Summary for Sat Jun 10 02:02:26 2006

	quantity	unit	value	lower limit	upper limit
V	t1 at bo6-bv9	mm	-31.50	0.00	9.00
H	co at bo6-bh10	mm	-1.19	-2.50	2.50
H	co at bo6-bh12	mm	0.47	-2.50	2.50
V	co at bo6-bv11	mm	0.10	-2.50	2.50
V	co at bo6-bv13	mm	-0.00	-2.50	2.50
H	t1-co at bo6-bh10	mm	-1.01	-2.00	2.00
H	t1-co at bo6-bh12	mm	-1.77	-2.00	2.00
V	t1-co at bo6-bv11	mm	0.16	-1.50	1.50
V	t1-co at bo6-bv13	mm	-0.34	-1.50	1.50
H	tune	...	0.7316	0.7300	0.7380
V	tune	...	0.7210	0.7100	0.7300
S	DQmin	...	0.0844	0.0000	0.0080
H	chromaticity (+/-)	...	0.9	-100.0	100.0
V	chromaticity (+/-)	...	0.9	-100.0	100.0
L	phase error	deg	-1.4	-10.0	10.0
L	AGS field error	Gauss	0.19	-1.00	1.00
L	synchrotron freq	Hz	27	20	40
H	norm 95% emittance	mm.mrad	8.4	0.0	999.0
V	norm 95% emittance	mm.mrad	125.6	0.0	999.0
L	norm 95% bunch area	eV.s/n	0.42	0.00	3.00
l	maximum loss	rad/hr	11	0	150
l	max loss location	m	583.8	490.0	1110.0

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Auto setup | Auto revert

Application Demos

- RHIC Injection Tuning
  - Bunch, pilot bunch, low-intensity pilot
    - Low-intensity pilots avoid snake quenches
    - Pilot bunches necessary for coupling calculations
- RHIC Orbit Display
- Loss Monitor Display
- ARTUS/Tune Display
- Chromaticity Control

For more information...

- RMS web page
- C.J. Gardner, "Booster, AGS, and RHIC Parameters for the 2004-2005 RHIC Run" January 2005.
- W. Fischer et al, "Beam-based Measurements of Persistent Current Decay in RHIC", C-A/AP Note #32, November 2000.