The APEX Program
Run-10

Fulvia Pilat

Machine-Experiments Meeting

BNL, December 8, 2009

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Outline

- Quick review of APEX Run-9
- Summary of APEX Workshop 2009 (CFN, November 12-13 2009)
- Proposals for Au high-energy run
- Outlook towards low-energy run
- Prioritization – AEAC Committee December 2009

	Physics production or beam studies weeks	
$\sqrt{s_{NN}}$ (GeV)	25-cryoweek run	27-cryoweek run
200	10	10
62.4	4	4
39	1.5	1.5
27	0	0
18	0	0
11.5 @ STAR	0	2
7.7	4	4
Beam studies @ 5 GeV and @ $\nu \approx 0.67$	0.5	0.5

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APEX operations statistics

Run	Scheduled / Planned %	Beam / scheduled % (availability)
Run-3	80	65
Run-4	90	84
Run-5	84	83
Run-6	89	86
Run-7	92	72 (physics: 49%)
Run-8	97	83.4 (physics: 59%)
Run-9	98	82.9 (physics: 54%)

Old accounting

"Ops" accounting

Run-9 APEX average availability: 83% (ops accounting)

Run-9 Operations time at store : 54%

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Run-9 statistics in details

Run9 date	scheduled interval	scheduled duration (h)	actual interval	actual duration (h)	APEX hours(OpLog)	Failure hours	APEX/scheduled %
17-Mar	2300-0700	8	2346-0700	7.23	6.92	0.32	86.5%
25-Mar	0600-1800	12	1010-1738	9.47	3.85	4.87	32.1%
31-Mar	2000-0800	12	2000-0830	12.50	12.37	0.13	103.1%
8-Apr	0700-1900	12	0700-1658	9.97	8.15	2.80	67.9%
28-Apr	1900-0700	12	1845-0700	12.25	11.58	0.67	96.5%
4-May	0900-1600	7	1638-2142	5.03	5.07	0.00	72.4%
12-May	1900-0700	12	1900-0700	12	11.75	0.25	97.9%
20-May	0700-1900	12	0700-1130	4.5	4.5	7.5	37.5%
26-May	1900-0700	12	1900-0900	14	13.67	0.3	113.9%
4-Jun	0700-1900	12	0728-1915	11.78	11.12	2.25	92.7%
10-Jun	1200-2400	12	1257-2347	10.87	8.25	3.25	68.8%
16-Jun	1900-0700	12	1900-0700	12.00	11.18	0.82	93.2%
24-Jun	0700-2100	14	0700-2125	14.42	12.97	2.23	92.6%
4-Jul	1000-1000	24	1009-1000	23.85	20.15	2.92	84.0%
5-Jul	1000-1000	24	1000-1000	24	21.78	2.22	90.8%
totals		197		183.87	163.31	30.53	82.9%

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APEX Schedule End of Run-9 July 4-5

pp94nearInt 250 GeV Ramp development Move Q closer to integer BBQ	Ramps 100 GeV BBQ	Store 100 GeV	Ramps 100 GeV	Injection	
Development pp94nearInt Bai + Ptitsyn + team + operations	Yellow transmission Schoefer, Fischer operations	BBLR Fischer Calaga	Main PS Transient Schultheiss	Spin Flippers Bai, Roser	
10am	midnight	6am	9am	noon	4pm

Store 100 GeV	Injection Store	Ramp+ store 100 GeV	Store 100 GeV	Store 100 GeV BBQ			
Spin Tune Bai Ptitsyn	Linear Optics Correction Wang Bai	Blow-up Emittance Schoefer	Beta* Measure Ptitsyn	IR Octupole Pilat Marr	Polarimeter Huang +team		
4pm	10pm	midnight	2am	4am	7am	8am	10am ?

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APEX Run-9: studies with 250 and 100GeV PP

Operations		ORM
Operations		Nonlinear chromaticity
Operations		IR nonlinear corrections
08-29 08-10	0A	Polarimeter studies
09-10	0A	BTF – BBQ calibration
08-27	0A	Beta measurements
Development		**pp93lowbeta (at 250 GeV)**
09-05	0A	Dx-D0 study
09-22	0A	Spin tune vs. orbit
08-17	0A	**pp93lowbeta preparation and commissioning**
09-26	0B	DA with AC dipole (injection)
07-19 07-20	0A	Noise PS
08-08	1A	Long range beam-beam
09-17	1A	Space charge an beam-beam
09-21	1A	Bunch length limit
09-06	1A	Off momentum beta-beat
08-27	0A	Linear optics corrections
Development		**pp94nearInt commissioning**
		Spin flippers

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APEX Workshop 2009

Opening Session (THURSDAY Nov 12 8:30 – 12:15 am)

8:30	T. Roser	15	The RHIC upgrade plan
8:45	W. Christie	15	Goals run-10, Beam studies for STAR
9:00	S. Bathe	15	Goals run-10, Beam studies for Phenix
9:15	K. Brown	20	and studies for Run-10
9:35	F. Pilat	10	APEX Program Overview
9:45	V. Litvinenko	15	APEX goals, criteria and selection process
10:00	A. Fedotov	20	Beam development and studies for low energy
10:20	*Coffee Break*	*20*	
10:40	V. Ptitsyn	20	Beam studiesfor MeRHIC
11:00	V. Yakimenko	20	Beam studies at the ATF
11:20	W. Guo	20	Accelerator physics at the NSLS-II
11:40	Y. Semertzidis	20	Beam studies for the EDM experiment

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Results of Run-9 and plans for PP studies (THURSDAY Nov 12 2:00 – 5:45 pm)

2:00	H. Huang	20	Injector studies for polarized protons
2:20	N. Tsoupas	15	Optical properties of the AGS helical partial snakes
2:35	C. Montag	15	Summary of lumi development at 100 GeV
2:50	A. Zelenski	20	Results of polarimeter studies
3:10	M. Bai	25	Polarization and operations at the near integer Results and status of spin flippers
3:35	*Coffee break*	*25*	
4:00	V. Ptitsyn	25	Spin tune measurement Beta* measurement
4:25	V. Schoefer	15	The yellow transmission
4:40	M. Minty	20	Effect of 10 Hz on performance at the nominal WP
5:00	W. Fischer	20	Summary of the beam-beam wire tests
5:20	G. R-Demolaize	20	Dynamic beta* squeeze

Studies and plans for Run-10 (gold) (FRIDAY Nov 13 9:00 – 12:15 am)

9:00	L. Ahrens	15	Injector studies with gold
9:15	S. Tepikian	15	Lattices for beta 0.5m
9:30	V. Litvinenko	20	IBS suppression lattices
9:50	G. Wang	20	Linear optics measurements and corrections
10:10	M. Blaskiewicz	20	Studies for stochastic cooling
10:30	*Coffee break*	*30*	
11:00	W. MacKay	20	DX-D0 experiment
11:20	G. Marr	20	Ramp RHIC next the 2/3
11:40	C. Zimmer	20	Results and plans for IR corrections
12:00	W. Fischer	20	10 and 12 pole IR corrections

APEX workshop 2009

Diagnostic developments (FRIDAY Nov 13 2:00 – 5:00 pm)

2:00	R. Moore	30	Beam Experiments at the Tevatron Discussion
2:30	C. Montag	20	Studies for the e-lens
2:50	R. Michnoff	20	Fast orbit feedback
3:10	R. Hulsart	20	RHIC BPMs status and improvements
3:30	*Coffee break*	*30*	
4:00	C. Dawson	25	Instrumentation developments for APEX
4:25	T. D'Ottavio	20	Controls developments for APEX
4:45	F. Pilat	15	Requirements for IR and DA measurements

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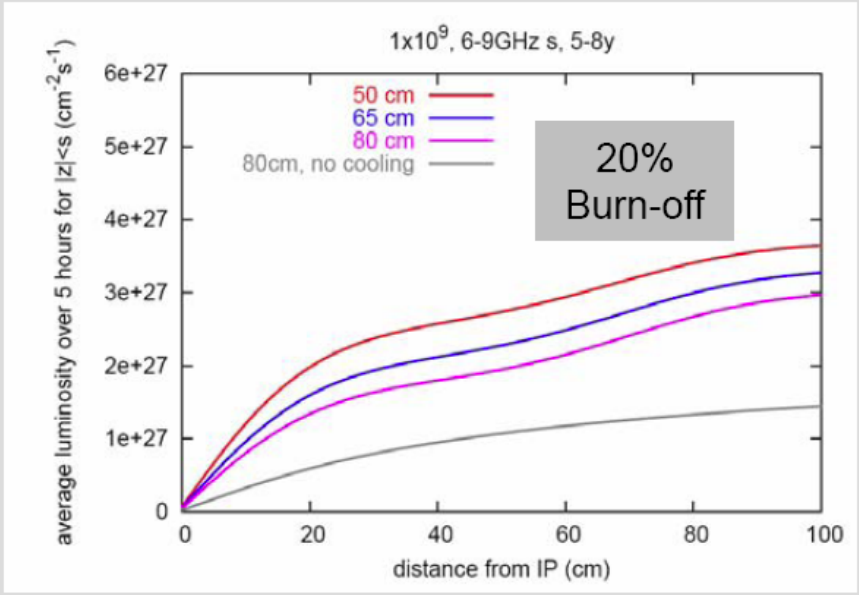
Dynamic beta squeeze – Motivation

Demolaize, Malitsky, Marusic, Pilat, Satogata, Tepikian

- Run10: longitudinal and vertical Stochastic Cooling (SC) should be operational => improve luminosity by a factor 2 for $\beta^* = 0.8$

- **To help reaching higher peak luminosity, an application is being developed using the RHIC online model to further push the squeeze of β^* in the experimental insertions IR6 and IR8.**

This year with 4 planes of cooling



- The goal is to have an application similar to the one used for orbit correction at store: β^* as a function of time should follow the change in emittance as "controlled" by SC.

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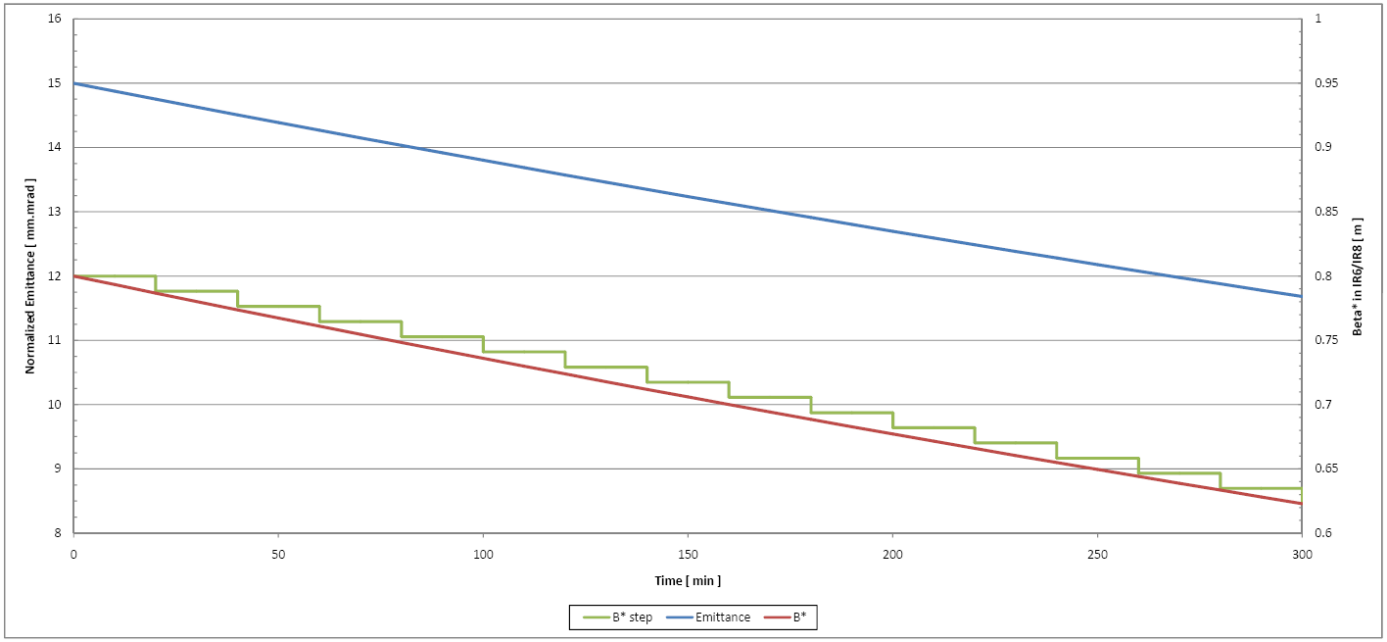
Dynamic beta squeeze – Plans for Run10

- Test the online model for limitations on squeeze steps.

- Main goal: use the effect of SC on emittance changes along a store to increase luminosity by dynamically reducing β* (i.e. keep the ratio ε/β* constant).



- This can be done in stages: first a step function, then a fitted exponential

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2/3 integer development - Motivation

Marr + Commissioning Team

- Why?
  - Ramping near the 2/3 resonance has proved to be a stable area of tune space from the polarization standpoint. Above 100 GeV, polarization loss is suspected to occur crossing resonances when the tune is too close to 7/10.
  - Beam transmission is good near, but not close to, the 2/3 fractional tune; this limit needs further characterization.
- Why now?
  - Demonstrating this ability prior to the next long proton run is important.
  - A switch of species to investigate a small set of issues is not feasible.
    - A switch of species is a prohibitive cost of operating time.
    - Polarization cannot be maintained in the yellow ring, which prohibits other pp activities.
    - Beam dynamics is independent of species.

2/3 integer – Issues, Plans

- Ramping near 2/3 at low energy is still not possible due to beam losses at flattop → ramp main supply switchover.
  - Tune swing from >0.7 to <0.7 is still necessary but should not affect polarization if swing occurs below 100 GeV.
- No clear path for tuning to reduce 2/3 resonance strength.
- How close to 2/3 is sufficient?
  - $0.67 < Q_y < 0.675$
- Develop a new ramp
  - Au beam at fractional tune of 0.67
  - Use tune swing equivalent to pp ramp, in order to avoid power supply transients early in ramp
- Commission new ramp
  - Evaluation by power supply group?
- Experiments require multiple ramps over one or more sessions

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10 Hz global orbit feedback

Plan for this Run

Minty, Marusic, Michnoff, Ptitsyn, Satogata, Robert-Demolaize

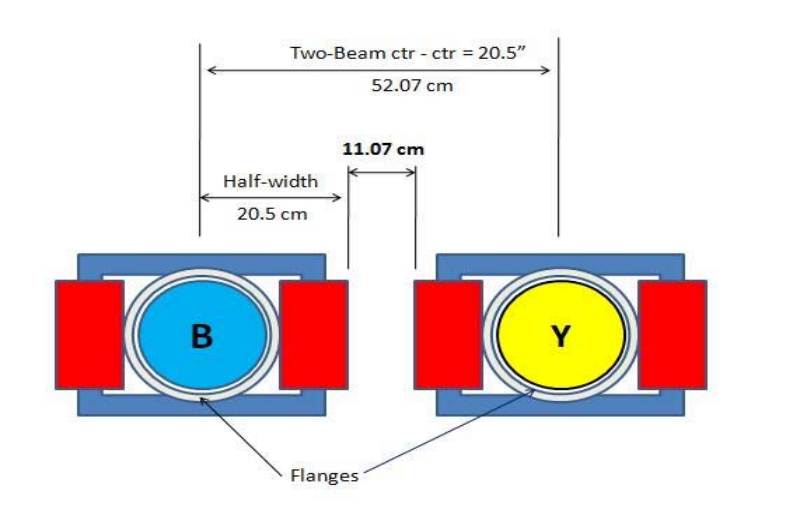
BPM data distribution tests (parasitic)

Correction tests in blue ring only using 4 air-core magnets installed in IR 6 and IR 8 (APEX)

Correction tests in blue ring only using 4 new steel laminated core magnets installed in IR 6 and IR 8 (APEX)

Measure effect of magnet in blue ring on the yellow beam (APEX)

Prototype Steel Laminated Core Magnet



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New Proposals for 100 GeV/u (so far)

10-01	Pi-modes vs. betatron phase advance	C. Montag
10-02	Effect of long Gaussian tails on beam lifetime in the oncoming beam	C. Montag
10-03	10 Hz Global Orbit Feedback	Rob Michnoff
10-04	Electron lens straightness requirements	C. Montag
10-05	Slow global orbit feedback, ramp	Minty
10-06	Slow global orbit feedback, at store	Minty
10-07	Dynamic beta squeeze	Guillaume Robert-Demolaize
10-08	High order nonlinear IR corrections	C. Zimmer
10-09	RHIC Energy Limits	V.Ptitsyn
10-10	Transition Single Bunch Instabilities	R. De Maria
10-11	Development and evaluation of IBS suppression lattices	Vladimir N Litvinenko
10-12	Development of lattice with 90-degrees phase advance for near 2/3 resonance operation	Vladimir N Litvinenko

Beam dynamics luminosity limits for RHIC operation at low energies

Fedotov, Satogata

The beam lifetime observed during lower energy test runs was limited by machine nonlinearities – this performance can be improved provided sufficient time is given for machine development.

Other, more fundamental, limitations come from:

Intra-beam Scattering (IBS):

- Strong IBS growth at lowest energies- can be counteracted by Electron Cooling (luminosity improvement needed for $\sqrt{s_{NN}}$ = 5-9 GeV)

Beam-beam:

- Becomes significant limitation for RHIC parameters only at $\gamma > 10$

Space-charge:

- At lowest energies, the ultimate limitation on achievable ion beam peak current is expected to be given by space-charge effects.

Need for experiments

- Intensity limit and acceptable space-charge tune shift in RHIC under collisions is crucial question in order to understand benefits from Low-Energy Electron Cooling @γ=2.7-10 ($\sqrt{s_{NN}}$ = 5-20 GeV)

- Understanding this question is also needed for Low-E RHIC luminosity projections for future Low-E physics runs (FY11, FY14, …)

We started looking into this with APEX experiments in 2009, using protons at injection energy γ=25 (high beam intensity and low longitudinal emittances can result in large space-charge tune shift):

Two APEX experiments were done:

1. May 12, 2009
2. June 17, 2009

The question still remains:

What is the limit on space-charge tune shift in RHIC under collisions for Low-E RHIC regime ($\Delta Q_{sc} >> \xi$)?

Possible 2010 APEX experiments:

1. Sqrt[s] = 11.5 GeV (γ=6.13)

-Typical (expected) parameters: N=1e9, ΔQ_{sc}=0.05, ξ=1.6e-3; $\Delta Q/\xi$=30

- For higher bunch intensity and quad pumping can reach ΔQ_{sc}=0.1

2. Au@injection energy (γ=10.6):

- Typical parameters: N=1e9, ΔQ_{sc}=0.024, ξ=1.6e-3; $\Delta Q/\xi$=16
- To get to higher space charge we need both high intensity and quad pumping: should be able to reach ΔQ_{sc}=0.07, $\Delta Q/\xi$=27

It would be useful to have Run-10 APEX time to study beam limits:

1. Start with Au ions at typical injection energy

   With high intensity and quad pumping explore high space-charge regime.

2. Although getting APEX time for γ=6.13 (1.5 weeks run) will be probably difficult, we may have sufficient data from physics stores with high intensity bunches.

It is important that we have good measurement of beam parameters. IPM should work reliably in all planes.

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APEX Run-10

- AEAC meeting in December 2009
- Physics ~22 December
- APEX program with high energy

During high energy run:

- Evaluate study proposals at low energy

Dedicated ½ - 1 week for beam studies and development

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