RHIC

Presentation to NSAC Subcommittee

Operations and Upgrade Scenarios

T. Ludlam

April 4, 2005

- Operations plans to exploit near-term science opportunities
- The impact of various budget scenarios
- The longer view

Office of Science
U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY
Brookhaven Science Associates
U.S. Department of Energy

Compelling and Unique Science from RHIC over The next 5 years (Near-term goals)

Heavy Ion Program

Address fundamental questions raised by the discoveries in Runs 1-4, while making definitive experimental statements about the existence and properties of the quark gluon plasma.

What is the degree of thermalization of the hot, dense state?

Is it quarks and gluons? What is the mechanism of deconfinement?

Does the postulated Color Glass Condensate accurately describe the initial state from which QGP is formed in heavy ion collisions?

Spin Program

Determination of the spin-dependent gluon structure functions at 200 and 500 GeV c.m. energy; transversity measurement.

First look at anti-quark polarization through parity-violating production of W bosons with measurements at 500 GeV

Data sets needed for the near-term physics goals

Heavy Ion Program

- A high-statistics Au-Au run, with PHENIX HBD and STAR DAQ upgrades, and enhanced charm capability

- A high-statistics d-Au run, with enhanced charm detection capability for PHENIX and STAR.

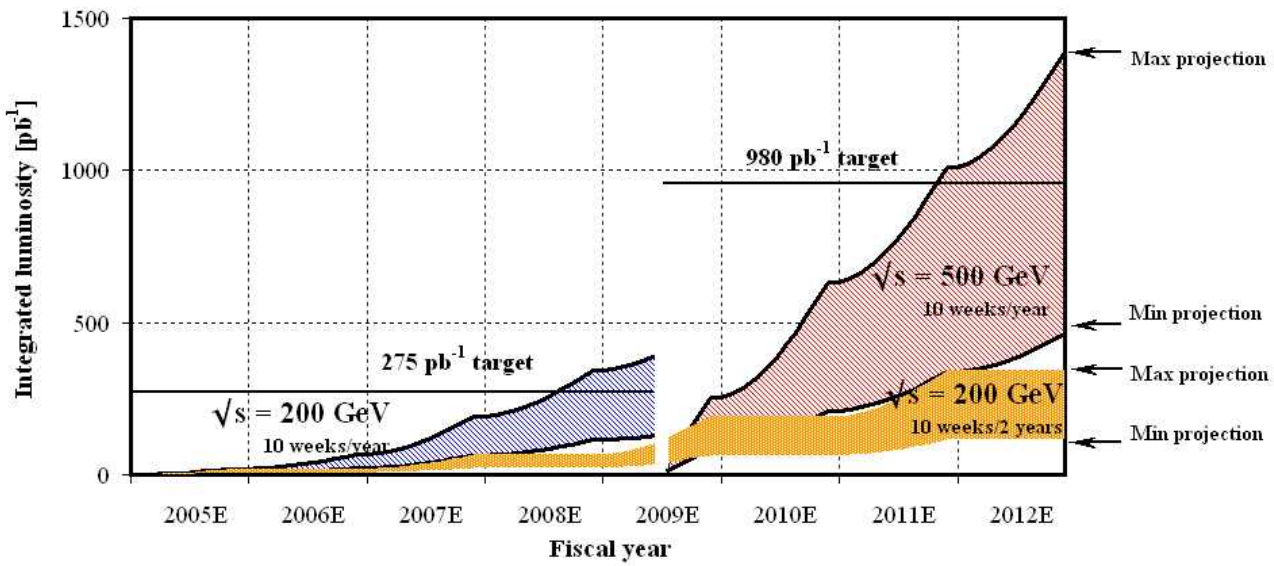
- Complete the systematic study of energy and geometry dependence, with intermediate ion species (e.g. Si, Ag) and a pp run at 62 GeV. (Detailed plan to be established after the Run 4-5 analyses are more complete)

Data sets needed for the near-term physics goals

Spin Program

- Annual runs of at least 10 weeks with polarized protons to develop the full luminosity and polarization capability of the present machine, and providing data samples of ~275 pb^{-1} at 200 GeV and ~ 500 pb^{-1} at 500 GeV.

- Forward tracking upgrades for PHENIX should be completed by the end of the 5-year period, providing needed sensitivity to W-decay



Critical Detector Upgrades

Timeline assumes funding for RHIC operations at FY 2005 level

FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012

High statistics Au Au; 500 GeV Spin Runs

TOF and VTX construction;
+ “Small” upgrades

STAR HFT & PHENIX FVTX

Next Generation Upgrades
STAR Forward/Inner Tracker System
PHENIX Inner Tracker and Nosecone Cal
Other approaches?

RHIC Detector R&D

LHC Heavy Ion Program

Balancing the Budget:
Operations/Upgrades/R&D

Detailed budget control of manpower, MS&T, elec. power and capital costs…

A. Base Costs

- Accelerator complex
  - including R&D for future upgrades (e-cooling), capital costs of machine improvements (AIP), and major upgrade (EBIS)
- Detectors
  - Including R&D and capital costs for upgrades
- RHIC Computing Facility RCF
  - Including capital costs to replace ~1/4 of cpu and storage hardware annually

B. Incremental costs of machine and detector operation

- Electrical power and consumables
  - ~ $500K per week of cryogenic operation of the machine ("Cryo Week")

A run of N cryo weeks includes 2 weeks to cool down and 1 week to warm up.
Each beam scenario (e.g. pp, or Au Au) requires about 4 weeks of set-up and tune-up before Physics Running begins: N cryo weeks = N-7 physics weeks for 1 beam run
= N-11 physics weeks for 2 beam runs, etc.

A segment of the BNL/DOE RHIC operations working spread sheet

A comprehensive, multiparameter tool to balance resources and running time

Fiscal Year Cryo. Weeks/Yr	2005 BNL[2] (FY05 $M) 31	2006 Pres (FY05 $M) 12	Increm Ops Cost/wk* ($K/wk)
PHENIX			
Ops. Costs	4.3	3.7	42
M&S	1.3	0.5	
R&D	0.8	0.5	
Ops. Equip.	0.9	0.8	
Res. Equip.	0.0	0.0	
	VTXb	VTXb	
STAR			
Ops. Costs	4.5	3.8	40
M&S	1.2	0.5	
R&D	0.8	0.5	
Ops. Equip.	0.7	0.4	
Res. Equip.	0.0	2.4	
	TOF	TOF	
PHOBOS			
Ops. Costs	0.6	0.2	10
M&S	0.3	0.1	
Ops. Equip.	0.1	0.0	
BRAHMS			
Ops. Costs	0.4	0.1	10
M&S	0.3	0.1	
Ops. Equip.	0.0	0.0	
Summed Exps Ops. Eq.	4.5	3.4	
RCF			
Ops. Costs	5.8	5.8	
Ops. Equip.	2.5	2.0	
C-AD RHIC OPS			
Ops. Costs	78.2	74.5	400
Base Power	3.8	4.8	
Incr. Power	5.9	3.6	
Base M&S	5.0	5.0	
Incr. M&S	6.2	2.4	
Total RHIC OPS	**99.1**	**90.3**	
R&D	2.0	1.9	
Ops. Equip./AIP	4.3	4.3	
Res. Equip. (EBIS)[3]	0.0	2.6	
Users/CAP	1.0	1.0	
Accel. + Expt Ops	118.8	106.0	

Fiscal Year Cryo. Weeks/Yr	2005 BNL[2] (FY05 $M) 30	2006 Pres (FY05 $M) 12
Accel. + Expt Ops	118.3	106.0
eCooling R&D	2.0	1.9
Detector R&D	1.5	1.0
Total Cost (FY05 Dollars)	121.8	108.9
Total Cost with Inflation	121.8	111.9
Total Budget	121.8	112.1
Difference	0.0	0.2

Impact of FY 2006 Presidential Budget

- FY 06 running time reduced from 31 to 12 cryo weeks
  - necessitates combined runs over 2 fiscal years
- Operations manpower reductions of ~40 FTE
  - 30-34 in Accelerator Dept.; 8-10 in Physics
- Terminate BRAHMS and PHOBOS detector operations
- Operate STAR, PHENIX, RCF for reduced running time
  - Reduced investment in RCF, consistent with smaller data volumes
- Reduced R&D effort
  - Slow down effort in electron cooling R&D
  - Delay plans for some detector upgrades

Scientific priorities are put forth in multi-year Beam Use Proposals from each experiment. Final plans are set after advice from the Laboratory's HENP Program Advisory Committee.

Impact of constant effort at President's 2006 budget level

Assume we continue to invest in upgrades and development for a long-term RHIC program

- EBIS is completed in this 5-year period
- "Near-term" detector upgrades completed by 2010, others delayed

Combine operations across fiscal years to achieve physics runs of viable length:

- combined runs in 06 and 07 [24 cryo weeks total]
- suspended running in 08 [re-programming power costs to help fund EBIS]
- combined runs in 09-10 [30 cryo weeks total]

Five-year run plan for RHIC at FY 2006 buget level + COL
With EBIS Construction

Run Years	Species	Energy	Physics Weeks	Delivered Data Sample
06-07	pp	200 GeV	17	50 pb^{-1}
09-10	pp Au-Au	200 GeV 200 GeV	10 9	50 pb^{-1} 1800 μb^{-1}

Five-year run plan for RHIC at FY 2006 constant effort budget

With EBIS Construction

Physics Impact

Spin Program:

- Gluon structure function measurements would improve on world results (HERMES, COMPASS), but would not provide the definitive measurement. Results limited to relatively large x (no 500 GeV data), with small data sample (large errors).
- No measurement of quark-antiquark flavor separation via parity-violating W boson production in this period

Heavy Ion Program:

- Relatively high-statistics Au-Au run, with charm detection capability, but no comparison data in d-Au collisions, hence findings may not be definitive.
- No further data on intermediate ion species and energies, precluding detailed parametric comparison with theoretical predictions.
- Without further data on d-Au collisions, no further progress toward understanding Color Glass Condensate

Overall:

- *Critical loss of momentum and leadership at time when LHC is having an impact*
- *Failure to achieve 500 GeV W physics in this time period would be a serious breach of faith with our Japanese supporters.*

An Alternative Scenario, with no EBIS Construction
FY 2006 constant effort budget

- Sacrifice some run time to complete TOF and VTX in time for running in 2008-9
- Need to invest more heavily in RCF, to accommodate larger data volumes
- Need to invest ~$2M/year 2007-2009 in refurbishing the Tandems
  - **A run of 20 cryo weeks in 2006**
  - **Combined runs in 07-08 [26 cryo weeks total]**
  - **Combined runs in 09-10 [33 cryo weeks total]**

Alternative 5-year run plan at FY 06 budget level + COL; No EBIS Construction

Run Years	Species	Energy	Physics Weeks	Delivered Data Sample
06	pp	200 GeV	14	80 pb^{-1}
07-08	pp d-Au	200 200	10 5	100 pb^{-1} 25 nb^{-1}
09-10	pp pp Au-Au	200 500 200	5 5 10	50 pb^{-1} 180 pb^{-1} 2000 μb^{-1}

- **Gain: higher statistics spin runs, and a short d-Au run ~25 cryo weeks**
- **Forego: cost savings and performance benefits of EBIS for future operation**

Impact of Flat-Flat funding at President's 2006 budget level

At this budget level we cannot sustain a plan that includes upgrades and development for a future long-term program at RHIC:

- **EBIS would not be constructed**
- **PHENIX HBD and one-half of STAR TOF would be completed (with funds provided in 06 budget)**
- **One half of the PHENIX VTX would be completed (with RIKEN funds)**
- **No further detector upgrades would be undertaken**

- **A run of 20 cryo weeks in 2006**
- **Combined runs in 07-08-09 [16 cryo weeks total]**
- **No RHIC operations in 2010 and beyond**

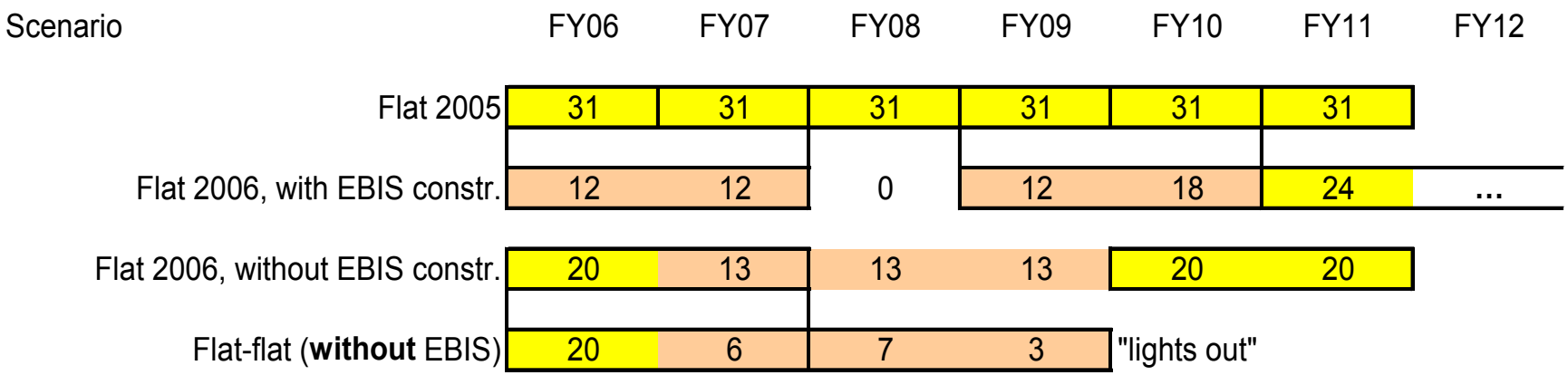
Run Years	Species	Energy	Physics Weeks	Delivered Data Sample
06	pp	200 GeV	12	100 pb^{-1}
07-09	Au-Au	200	11	1800 μb^{-1}

The RHIC program would conclude without completing the baseline spin program, and without realizing the compelling and unique opportunities for new science opened up by the discoveries of runs 1-4.

Run Plan for RHIC Five-year Physics Goals
Constant effort at FY 2005 Budget Level
31 cryo weeks/year

Run Years	Species	Energy	Physics Weeks	Delivered Data Sample
06	pp	200 GeV	25	50 pb^{-1}
07	Int. ion scan pp	Tbd 200	10 10	Tbd 100 pb^{-1}
08	pp d-Au	200 200	10 10	100 pb^{-1} 50 nb^{-1}
09	pp pp Au-Au	200 500 200	5 5 8	50 pb^{-1} 180 pb^{-1} 1600 μb^{-1}
10	pp Au-Au	500 200	10 10	300 pb^{-1} 2000 μb^{-1}

RHIC Operations scenarios: cryo-weeks



LOOKING AHEAD

- RHIC has the capacity to address fundamental questions about QCD in the next five years—

  while setting the stage for a long-term program of world-class discovery physics.

- Extended funding scenarios based on the FY 2006 Presidents budget will severely curtail this capacity.