RHIC Run 12 Actual vs. PAC & Guidelines for Runs 13/14

Steve Vigdor

RHIC/AGS PAC Meeting

June 7, 2012

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

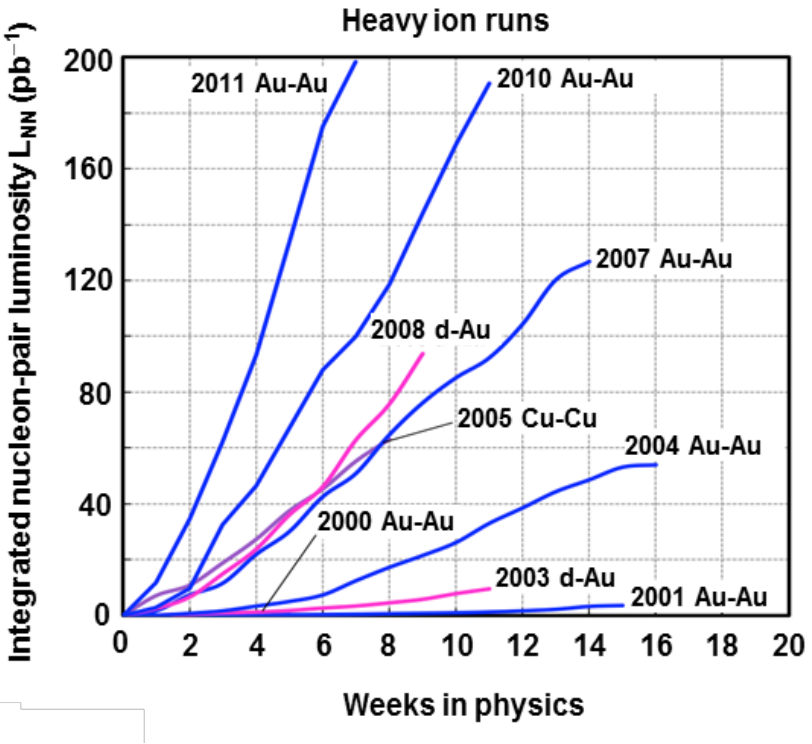
Office of Science
U.S. DEPARTMENT OF ENERGY

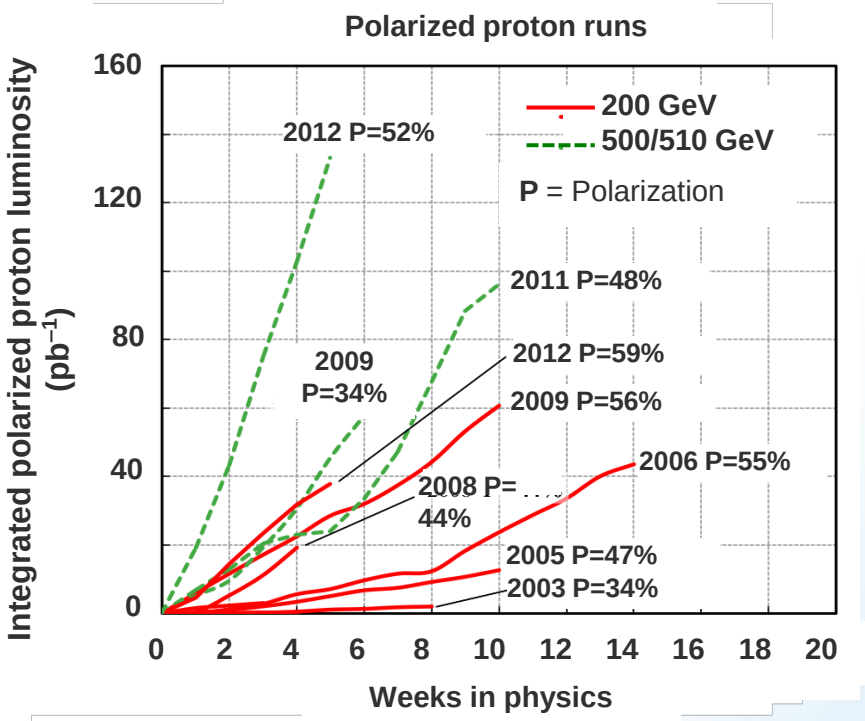
Flat Budgets ⇒ Shrinking Run Lengths

	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013P
RHIC Ops. $M	135.5	137.0	149.8	158.7	159.4	157.6	156.6
# cryowks.	20	19	22	28	26	~23	~15
Comments	Budget arrived late, other-wise could have supporte d more weeks	Unexpec-ted Omnibus bill causes early run termina-tion	Budget could have suppor-ted 25 weeks, but long CR led to very late start	Robust run, should maintain carry-over for early start on Run 11 even with CR	Long run possible due to carryover from FY10 + salary freeze. Finished end of June 2011	Extended via Xmas $3M add + lower power costs w/ new NYPA contract. Will end June 27.	Mandated 2-year salary freeze ends. @ BNL $ guidance for power, get to 15 wks. only by post-poning AIP

1) *"RHIC Ops"= (collider + det.) [Ops. + R&D + CE] + AIP*
2) *"Optimal" RHIC run ≈33 cryoweeks; 22 = minim. for healthy 2-species run*
3) *Flat budgets ⇒ lose ~$5M, or 12 cryoweeks/year, to inflation w/o mitigation*
4) *House & Senate FY13 markups add $3-5M, so plan for 20 week Run 13*
5) *More on long-term problems for U.S. NP later in presentation*

RHIC Machine Performance History

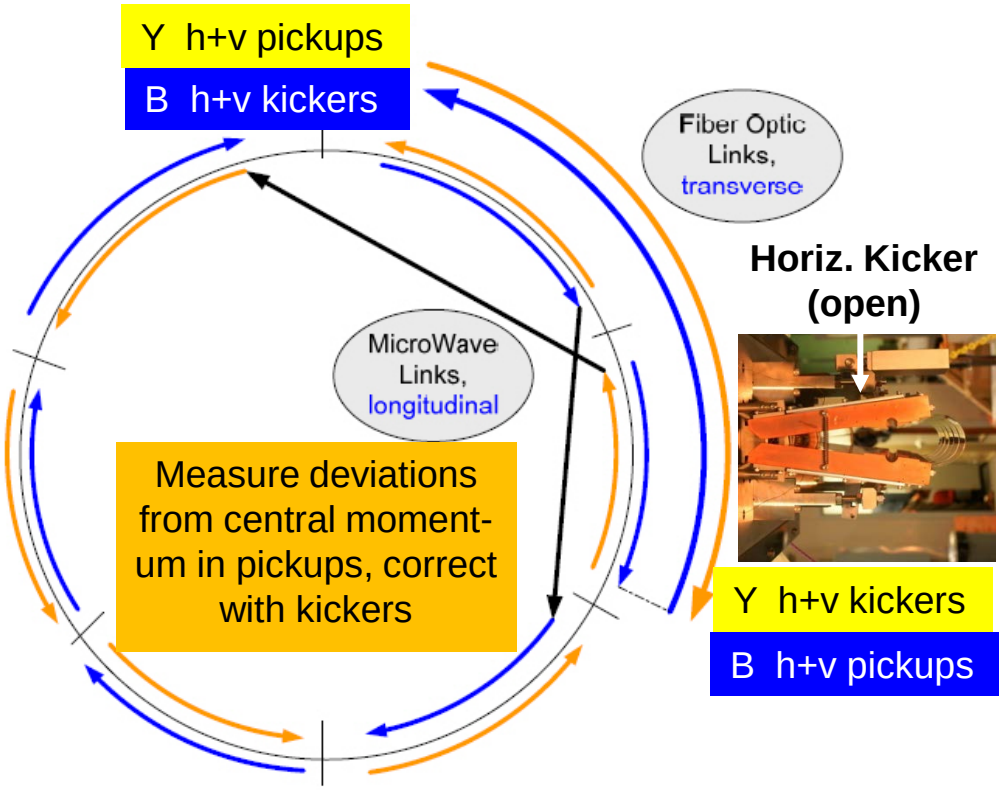




New systems and conditions installed for Run 12:

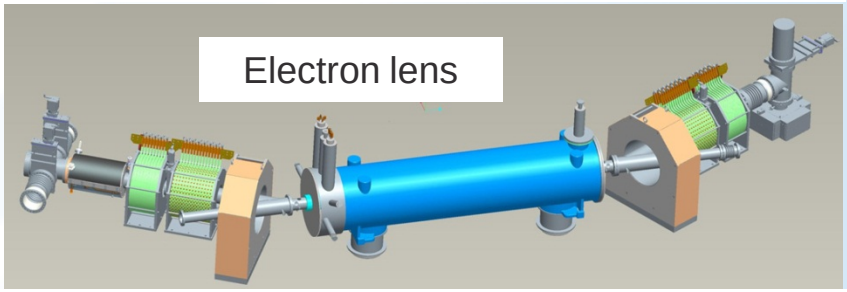
- ***Complete 3-dim'l stochastic cooling in each RHIC ring***
- ***Repaired 9 MHz RF system for pp***
- ***EBIS as RHIC HI pre-injector ⇒ first U+U and first asymmetric (Cu+Au) runs***
- ***Complete PHENIX μ trigger upgrade***
- ***PHENIX FVTX upgrade + refurbished VTX***
- ***Partial STAR FGT upgrade***

Recent and Ongoing Cost-Effective Machine Upgrades



Horiz. Kicker (open)

- ***RHIC breakthrough in bunched-beam stochastic cooling facilitates ~x10 improvement in heavy-ion collision rates, 4 years earlier and at ~1/7 the cost envisioned in 2007 NP Long Range Plan, saving ~$80M***
- ***All (6 planes of pickups & kickers) of the new system commissioned during 2010-12, new 56 MHz SRF cavity anticipated for 2014 run.***
- ***Electron lenses to be installed for 2013 run to improve polarized pp luminosity by factor ~2***



- ***New Electron Beam Ion Source (EBIS, 2012) expands range of ions available (e.g., U) and enhances cost-effectiveness of operations***

PAC Recommendations from June 2011

Assuming 26 cryoweeks:

For Run 12 the PAC recommends the following (in order of priority):
1. 5 weeks of running with polarized proton collisions at 200 GeV.
2. 7 weeks of running with polarized proton collisions at 500 GeV.
3. 5 weeks of running with Cu+Au collisions at 200 GeV.
3. 3 weeks of running with U+U collisions at 193 GeV.

Predicated on assumption that high-priority 27 GeV Au+Au would be completed at end of Run 11 – **it was**.

With following recommended strategy:

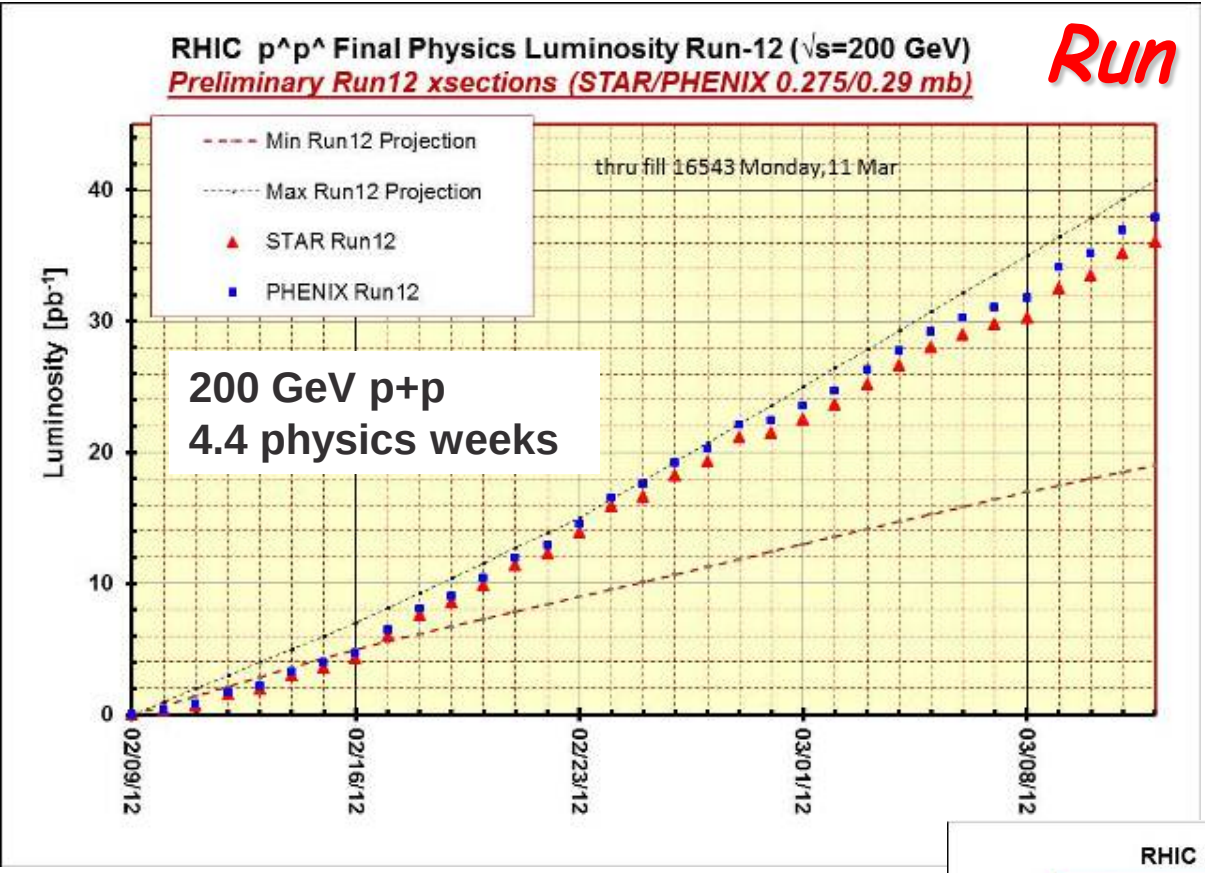
The 200 GeV pp running should occur before 500 GeV running in order to allow commissioning of the RPC-1 component of the muon trigger prior to taking W data…The period in Run 12 could then also serve for commissioning of the STAR FGT, prior to the switch to 500 GeV.

PAC recommends that *if* the full 5 weeks of data cannot be delivered, shorter studies of U+U collisions should take priority over Cu+Au.

With regard to DY asymmetry test (AnDY) in IP2:

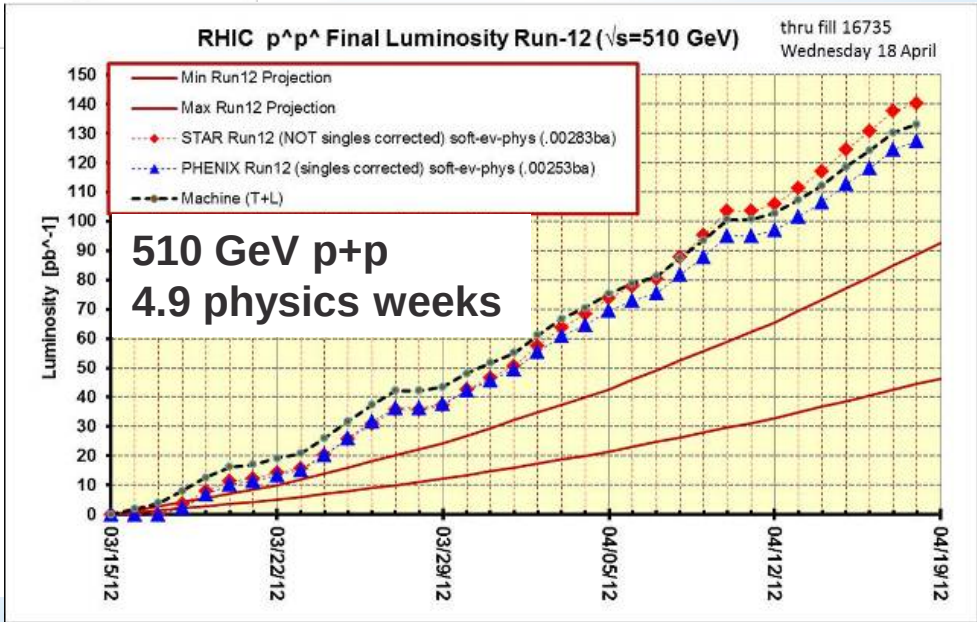
We endorse running AnDY in Run 12 to make the first of the two measurements needed to obtain the results discussed above…The committee's principal concern is the full $1.3M apparently needed to complete the present detector design — a figure which is not mentioned in the BUR. The PAC urges the collaboration to write a full proposal to secure this sizable amount of funding.

Run 12 pp As Achieved

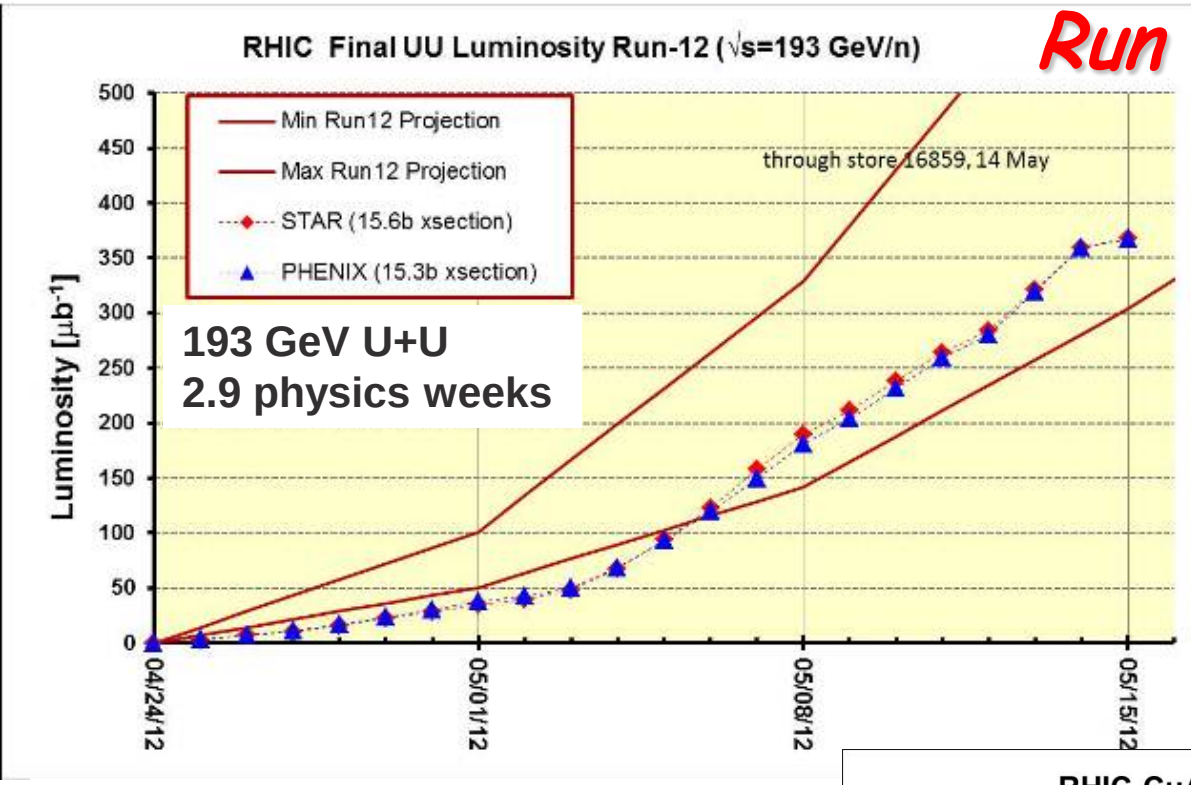


- *At run start, planned for 20 weeks, and needed at least one HI run, in anticipation of Quark Matter and Tribble Panel*
- *Therefore limited length of pp runs below PAC plan*
- *But achieved STAR & PHENIX goals thanks to luminosities at or above maximum projection, and improved polarizations*

- *Ran @ 255 GeV p beam energy, rather than 250, in hopes of improving spin orientation stability and polarization decay during fill*
- *Though pol'n improved by ~10% (relative) over Run 11, still observe pol'n decay*
- *Allocated significant time to APEX runs to study origin of pol'n losses*

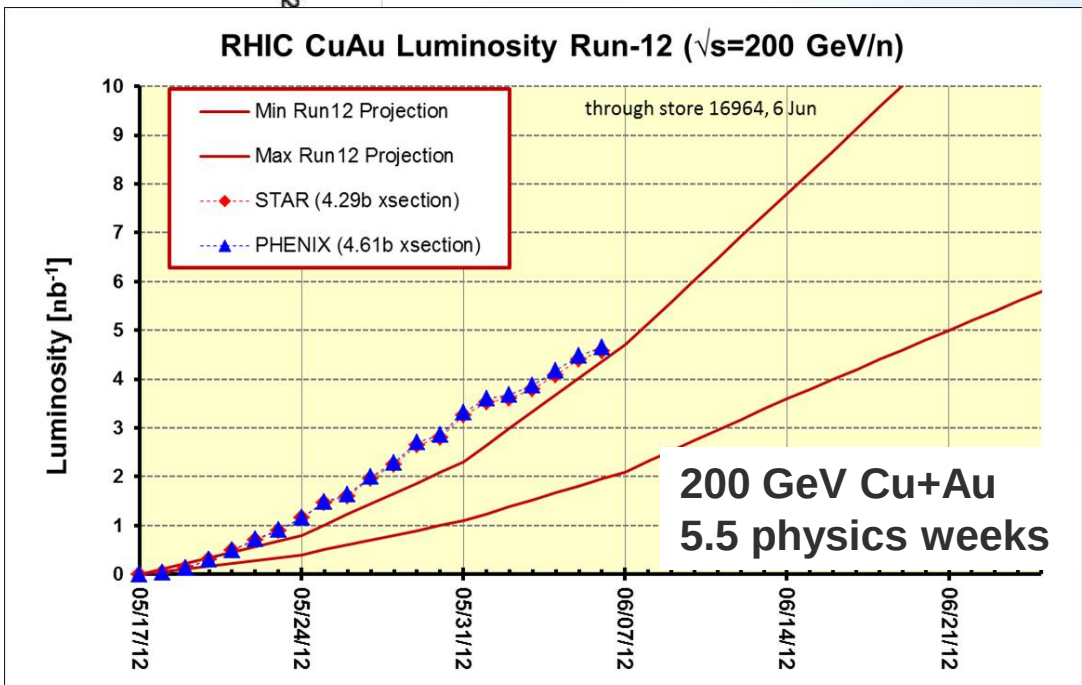


Run 12 HI As Achieved



- *Commissioned EBIS during pp runs ⇒ U strip efficiency ~30% low ⇒ ℒ/2*
- *Began U+U mid-April. By that time, power rates were sufficiently far below BNL balanced billing rate to extend run by 3 weeks*
- *Outstanding stochastic cooling performance allowed goals to be met*

- *Can now accommodate full intended Cu+Au run*
- *On track to meet goals, though ℒ has not quite recovered from eagle/groundhog power dip*
- *Overall, an excellent Run 12, meeting or exceeding all goals*
- *Machine reliability has been >85% (compared to 77% in Run 11) and exp't data-taking efficiencies have improved*



AnDY Proposal and Review

For any project of this magnitude, we require a full approved funding proposal and project plan before we can commit beam time. A proposal suitable for review was submitted in late February and reviewed on 3/30/12.

Excerpts: The proposal estimates that building AnDY would require $1.6M that would come from RHIC experimental capital funds in FY12 and FY13…. and extensive polarized p-p collisions at 500 GeV in both Run 13 and Run 14. From the Committee's discussions with BNL management … in the light of current DOE budget guidance, it is not clear that there will be two long p-p runs during this period.

The proposed experiment has strong scientific justification, and the group has taken significant preliminary steps in tests with beam collisions at IP2… Nonetheless … the experiment as proposed presents very steep challenges….While the Committee was impressed by the capabilities of the AnDY team, it … finds the present strength of the collaboration to be inadequate.

Primary Recommendation: ***Given the very challenging schedule constraints and the large number of management, resource, and technical issues that remain to be addressed, we recommend that the AnDY project leaders meet with RHIC management in the near future to discuss alternative scenarios that might enable a revised version of the project to go forward.***

Such a meeting took place on April 6, but no mutually acceptable solution for an experiment to be carried out over the next 2-3 years could be found.

PAC/Experiment Guidance for Run 13/14 Plans

- ***Clear priorities within 20 cryoweeks each for Run 13 and Run 14***
  - ***Hoping for Congressional FY13 budget additions and better than flat-flat FY14 budget***
  - ***2 weeks cooldown/warmup overhead + 2 weeks commissioning per colliding beam species run (~1-2 days for energy change)***
- ***Exclusive use of EBIS for heavy ions, with improvements in bunch intensity as assumed in Fischer luminosity projections***
- ***6 stochastic cooling planes for Runs 13 & 14, but count only on commissioning 56 MHz SRF system (needed for ultimate Au+Au full-energy luminosity gain) in Run 14***
- ***Proton beam polarizations and luminosities as per Fischer projections***
- ***Electron lenses should be installed for commissioning in Run 13, but should not be counted on to improve pp luminosities before Run 14***
- ***Anticipate increased coverage by Run 13 for PHENIX VTX (reinstall some refurbished ladders) and STAR FGT, though installation tight in each case***
- ***Anticipate STAR Heavy Flavor Tracker prototype installed for Run 13, full detector for Run 14. Also >40% Muon Telescope Detector installation in STAR for Run 13, full installation for Run 14***

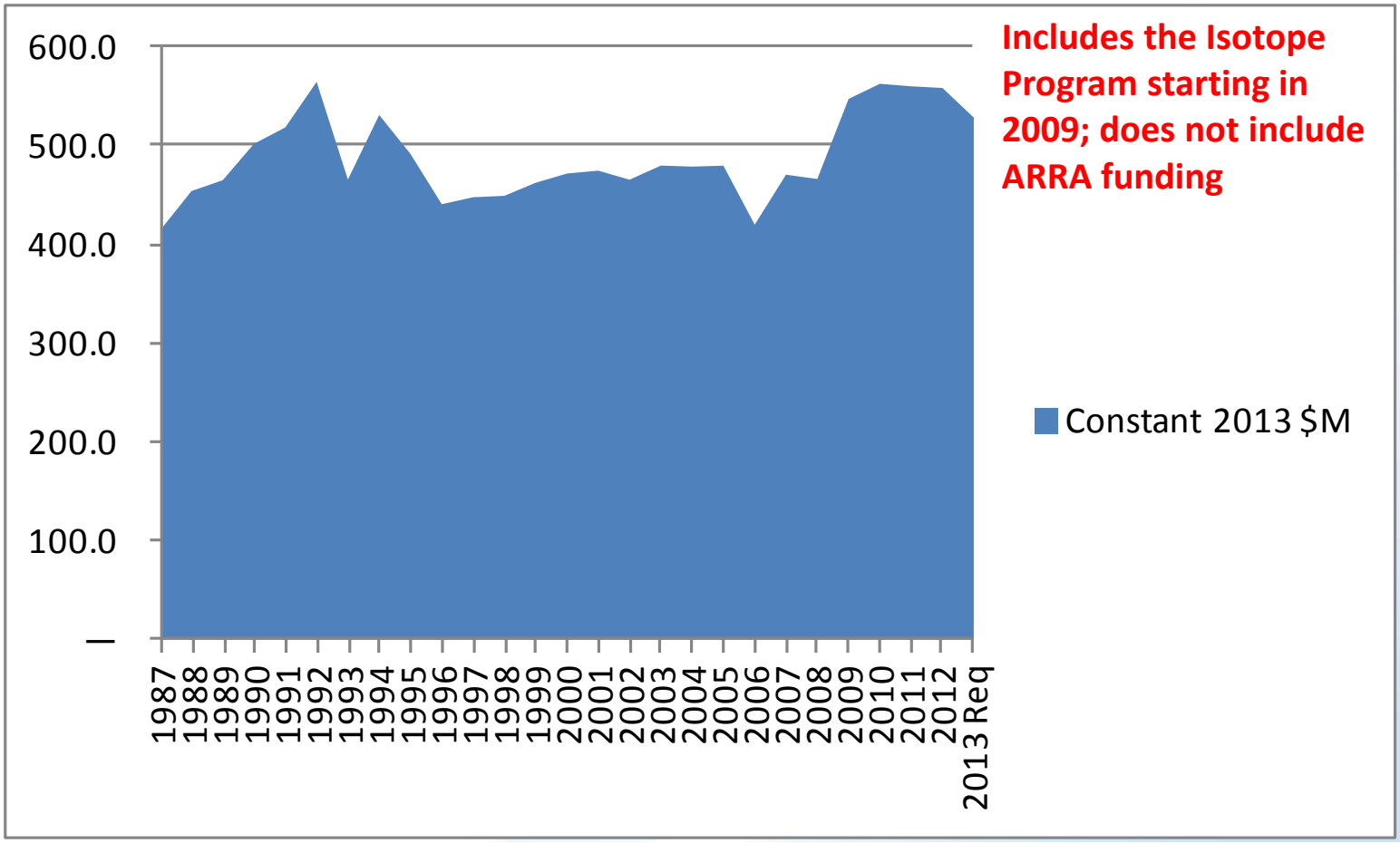
Context for the NP Crisis: Quotes From the 2007 LRP

When faced with a choice of improving research funding or developing our facilities, **the consensus, as exemplified in the recommendations, was to maintain a near constant level of effort for the research program and facility operations, based on the FY2008 President's budget request, and to invest additional resources in the tools needed to make new discoveries in the future.**

Implementing the four principal recommendations of this Plan can be accomplished with a funding profile consistent with doubling the DOE's Office of Nuclear Physics budget, in actual year dollars, over the next decade, together with NSF funding for DUSEL including some of the equipment for experiments to be carried out in DUSEL.

Constant effort funding falls far below the level needed to carry out the four recommendations in the Plan. … If budgets were restricted to constant effort, proceeding with any of the new initiatives presented in this Plan would be possible only by reduced funding for operations and research, with clear adverse and potentially dire consequences for core components of the U.S. nuclear physics program. Since nuclear science, like all areas of basic research, evolves in time, it is impossible now to forecast what strategy would minimize damage to the field if future budgets dictated such stark choices.

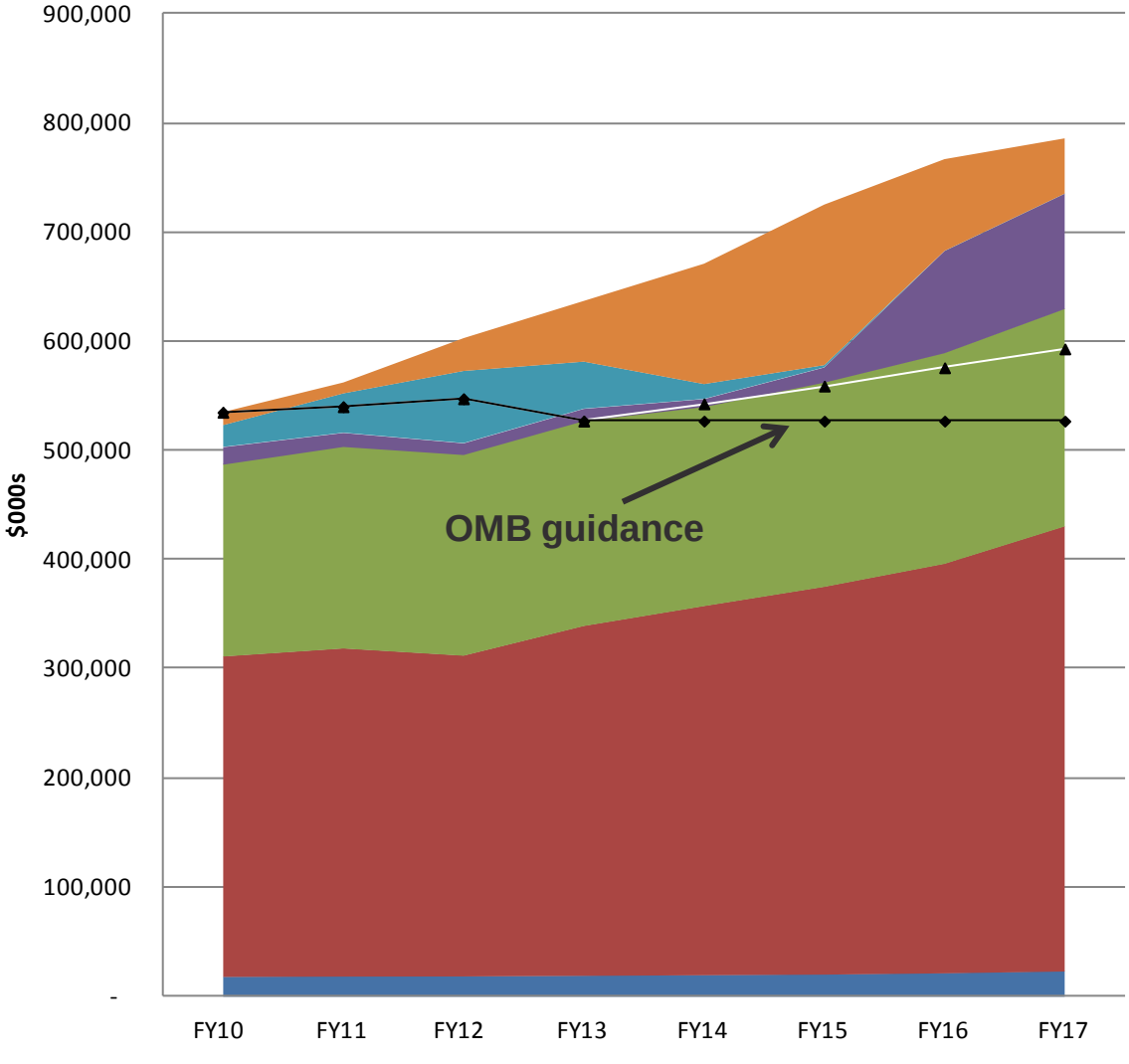
DOE Nuclear Physics Funding
1987-2013
(in constant dollars)



Bottom line: ~constant effort budget for field over past 25 years, with occasional bumps that raise the community's hopes, but no real sign of budget doubling!

Defining the ONP Problem

- This chart reflects the estimated funding needed to implement the majority of elements of the NSAC 2007 Long Range Plan (LRP) – not including EIC.
- The FY 2013 Congressional Request is reflected as two lines, one assuming 3% cost-of-living into the outyears and the other assuming flat funding into the outyears.



- ***FY13 shortfall ~$100M → ~$250M by FY17***
- ***Requires serious re-prioritization by NSAC***
- ***NSAC process will complete by Jan. 2013***
- ***Poses clear & present danger for RHIC ops.***

NSAC Charge to Tribble SubPanel II

We seek advice from NSAC on implementing the priorities and recommendations of the 2007 Long Range Plan in light of projected budgetary constraints and for guidance on developing a plan to implement the highest priority science in the context of likely available funding and world-wide capabilities. We request that NSAC examine the existing research capabilities and scientific efforts, assess their role and potential for scientific advancements, and advise the two agencies regarding the time and resources needed to achieve the planned programs. Your report should describe how to optimize the overall nuclear science program over the next five years (FY 2014-2018), under at least the following funding scenarios for the nuclear science budgets at the two agencies: (1) flat funding at the FY 2013 request level, and (2) modest increases over the next five years.

NSAC should submit the report by January 2013.

House and Senate E&W subcommittees, in marking up FY13 budget (both add $3-5M for RHIC ops.), call for NSAC process – e.g., Senate E&W markup says:

The Committee believes that the budget request puts at risk all major research and facility operations activities without significantly advancing nuclear physics goals. … The Committee directs the Office of Science to charge the Nuclear Physics Advisory Committee to submit a report by December 1, 2012 to the Office of Science and the Committee that proposes research and development activities for nuclear, physics under a flat budget scenario over the next 5 fiscal years. **The report should specifically identify priorities for facility construction and facility decommissioning to meet those priorities.**

Today's Agenda:

Room 2-84, Bldg. 510
8:30 PAC Executive Session

Hamilton Seminar Room, Bldg. 555
9:00 Run 12 as achieved, plus guidance for Runs 13+14 (S. Vigdor, 25+5)
9:30 Machine performance and projections (W. Fischer, 30+10)
10:10 Coffee break
10:30 STAR Beam Use Proposal (N. Xu, 40+20)
11:30 PHENIX Beam Use Proposal (B. Jacak, 40+20)

Room 2-84, Bldg. 510
12:30 Lunch + PAC Executive Session

Hamilton Seminar Room, Bldg. 555
14:00 Case for continuing RHIC operations to be made to Tribble Panel (S. Vigdor, 30+15)
14:45 Future PHENIX upgrades and science program (J. Nagle, 30+15)
15:30 Coffee break
15:50 Future STAR upgrades and science program (C. Gagliardi, 30+15)

Room 2-84, Bldg. 510
16:35 PAC Executive Session

Backup Slides

Updated RHIC 5-Year Run Plan

Assumes sufficient ops. funding for healthy 2-species run each year; aimed at meeting NP Performance Milestones on schedule; will be updated as we have definitive information about upgrade schedule and/or budget changes

Year	Likely Beam Species	Science Goals	New Detector Sub-systems	New Machine Upgrades	Gain from Machine Upgrades	Comments
FY10 ✓	Au+Au at 200, 62.4 GeV + assorted lower E	Low-mass dilepton spectrum; early collision temp.; improved jet quenching studies (especially e^- from heavy quarks); begin energy scan for critical pt.	STAR TOF completed; PHENIX HBD for heavy ions	Blue ring longitudinal + yellow and blue vertical stochastic cooling; yellow longitudinal cooling (μwave link) upgrade	Factor >2 increase in average store luminosity for full-energy Au+Au	Need 4-8 weeks early in run to (re)com-mission all 4 stoch. cooling systems, demonstrate gain in lumi. lifetime
FY11	200 GeV Au+Au; 500 GeV p+p; short 200 GeV U+U; continue low-E Au+Au scan	Bottom vs. charm suppression, flow; antiquark pol'n from W production; 1st characterization of deformation effects in U+U centrality distrib'ns; continue critical pt. search	PHENIX VTX engineer-ing run; AnDY installed, commis-sioned in IP2	EBIS commis-sioning; 9 MHz cavity; RHIC beam dump; AGS tune jump quads (comm'd in Run 10); RHIC spin flipper	U beam capability; improved pp vertex distrib'n; improved pol'n from AGS; reduced syst. errors	9MHz requires upgrade to main PS + "bouncer" cavity for both rings + longitudinal damper or Landau cavity for each ring.

Year	Likely Beam Species	Science Goals	New Detector Sub-systems	New Machine Upgrades	Gain from Machine Upgrades	Comments
FY12	Au+Au and U+U at 200 GeV; 500 GeV p+p	RHIC-II HI goals: heavy flavor, γ-jet, quarkonium, multi-particle correlations; anti-quark and low-x gluon polariza-tions in proton	PHENIX FVTX and μ trigger; PHENIX DAQ/trig upgrades; STAR FGT	Full yellow + blue horiz. stoch. cooling (6 planes in all);	Further heavy-ion luminosity improve-ments + improved proton polarization	"Proton cannon" increases pol. source current, to allow scraping to improve polarization
FY13	200 + 500 GeV p+p; further heavy-ion running to comple-ment earlier runs	Continue RHIC-II heavy-ion goals; transverse spin asymmetry for Drell-Yan (2015 spin milestone); pp reference data for new subsystems	STAR HFT prototype	Polarized source upgrade; Electron lenses	improved pp luminos-ity	Electron lens commission-ing $\Rightarrow$ Run 13 gains possible; detailed collimator upgrade plans still to be developed
FY14	200 GeV Au+Au; low-E Au+ Au dictated by Run 10+ 11 results	Continue pursuit of γ + jet, energy scan and identified heavy flavor (DM10-12) milestones; quarkonium prodn	STAR HFT pixel det. (full HFT in Run 15); 50% STAR MTD ?	RHIC collimator upgrade; 56 MHz SRF; coherent e-cooling install starts in IP2	Full RHIC-II heavy-ion luminosity + improved vertex & store length	

Plans and Upgrades for Coming ~5 Years Address All New RHIC-Related Performance Milestones…

	Year	#	Milestone
spin	2013	HP8	Measure flavor-identified q and $\bar{q}$ contributions to the spin of the proton via the longitudinal-spin asymmetry of W production.
spin	2013	HP12 (update of HP1)	Utilize polarized proton collisions at center of mass energies of 200 and 500 GeV, in combination with global QCD analyses, to determine if gluons have appreciable polarization over any range of momentum fraction between 1 and 30% of the momentum of a polarized proton.
spin	2015	HP13 (new)	Test unique QCD predictions for relations between single-transverse spin phenomena in p-p scattering and those observed in deep-inelastic lepton scattering
Heavy ion	2014	DM9 (new)	Perform calculations including viscous hydrodynamics to quantify, or place an upper limit on, the viscosity of the nearly perfect fluid discovered at RHIC.
Heavy ion	2014	DM10 (new)	Measure jet and photon production and their correlations in A≈200 ion+ion collisions at energies from medium RHIC energies to the highest achievable energies at LHC.
Heavy ion	2015	DM11 (new)	Measure bulk properties, particle spectra, correlations and fluctuations in Au + Au collisions at √sNN between 5 and 60 GeV to search for evidence of a critical point in the QCD matter phase diagram.
Heavy ion	2016	DM12 (new)	Measure production rates, high pT spectra, and correlations in heavy-ion collisions at √sNN = 200 GeV for identified hadrons with heavy flavor valence quarks to constrain the mechanism for parton energy loss in the quark-gluon plasma.
Heavy ion	2018	DM13 (new)	Measure real and virtual thermal photon production in p + p, d + Au and Au + Au collisions at energies up to √sNN = 200 GeV.

Making clear progress toward all the above!