RHIC Run 10 Actual vs. PAC & Guidelines for Runs 11/12

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RHIC/AGS PAC Meeting

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BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

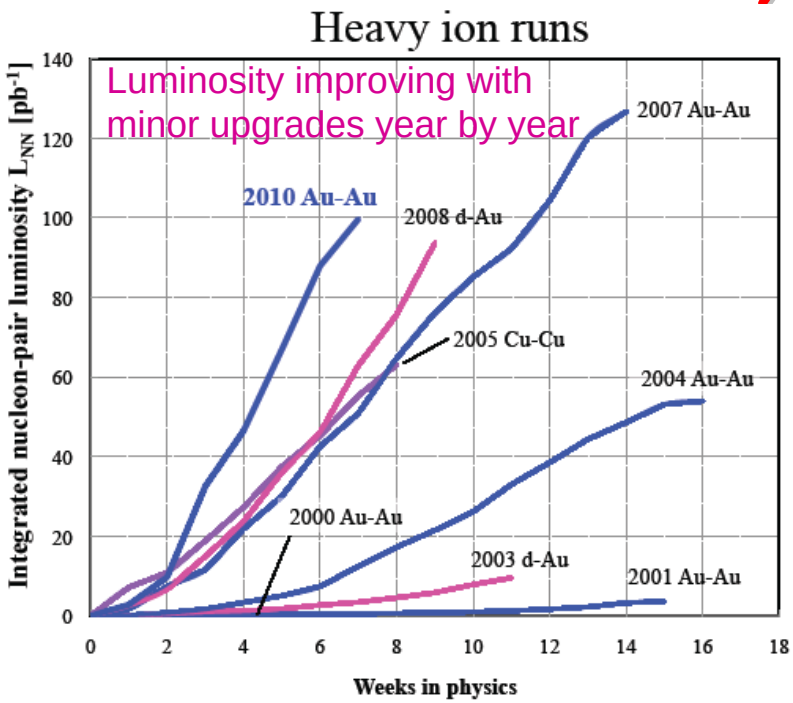
Office of Science
U.S. DEPARTMENT OF ENERGY

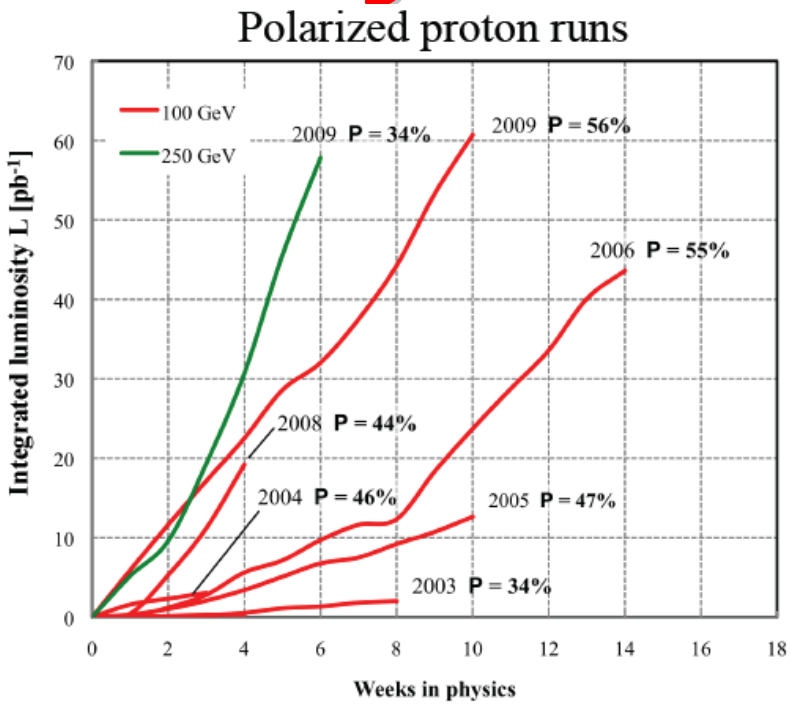
Improvements in Recent RHIC Operations Budgets and Efficiency

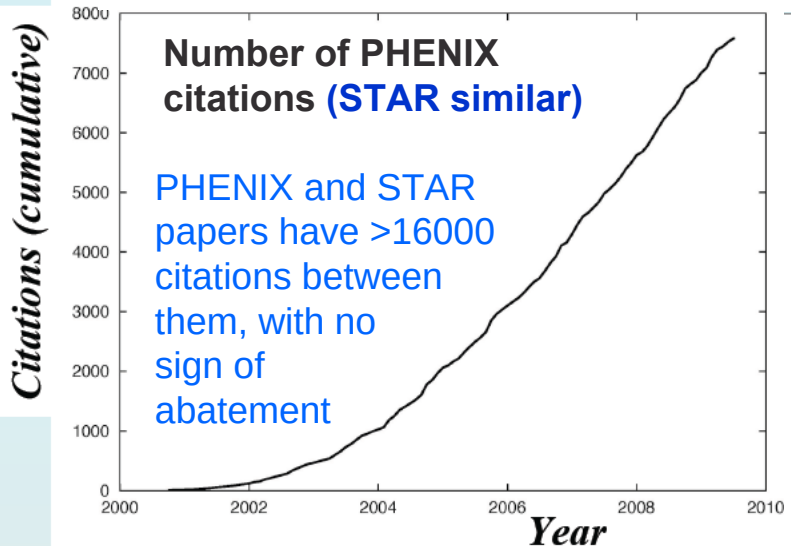
	FY2006	FY2007	FY2008	FY2009	FY2010	FY2011P
RHIC Ops. $M	116.4	135.5	137.0	149.8	158.7	164.8
# cryoweek ops.	21	20	19	22	27	28-30
Comments	Supple-mented by Renais-sance Technol-ogies to facilitate pp run	Budget arrived late, other-wise could have supported more weeks	Unexpec-ted Omnibus bill causes early run termina-tion	Budget could have suppor-ted 25 weeks, but long CR led to very late start	Robust run, should maintain carryover for early start on Run 11 even with CR	Could be even better if power costs remain moderate, Congress doesn't slash

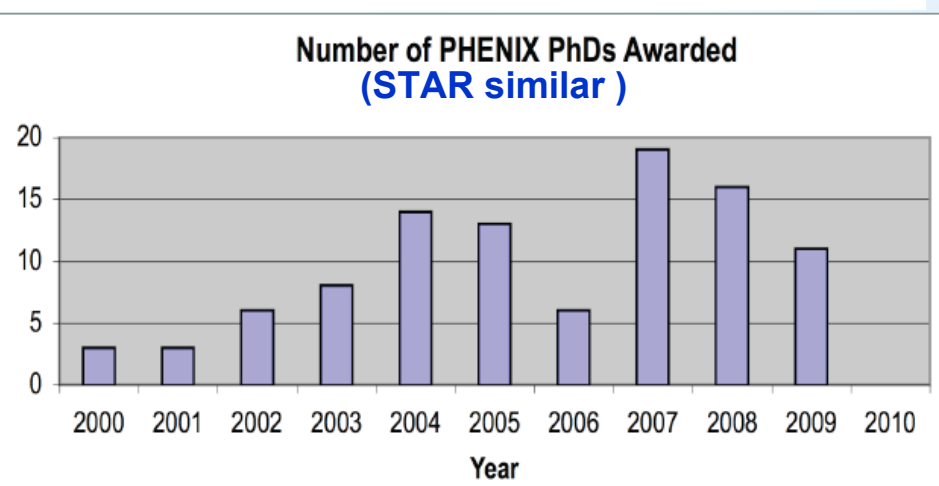
1) ***"RHIC Ops"= (collider + det.) [Ops. + R&D + CE] + AIP***
2) ***"Optimal" RHIC run ≈33 cryoweeks; 22 = minimum for healthy 2-species run***
3) ***Run 10 outstanding, President's FY11 budget very encouraging, but anticipate LONG Continuing Resolution***

RHIC Machine Performance, User Morale & Productivity Remain High







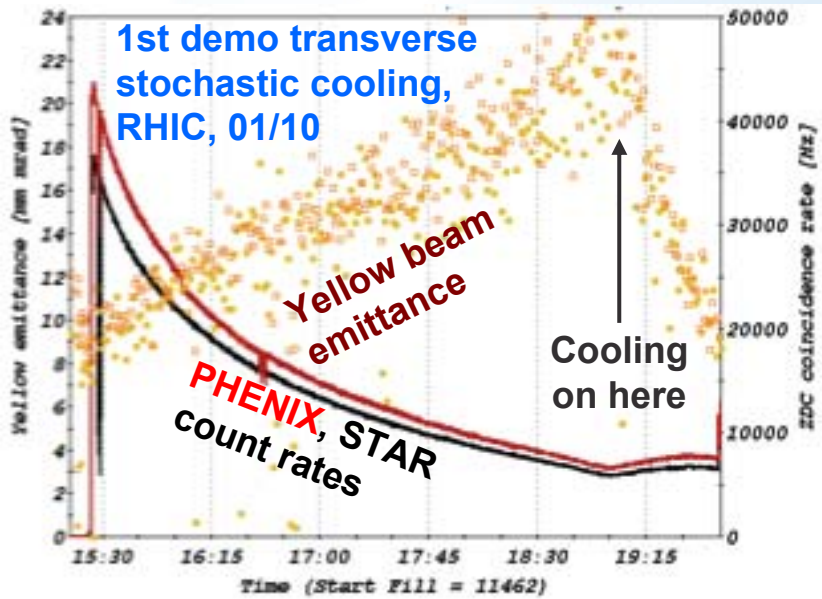


STAR + PHENIX have produced > 200 Ph.D.'s to date

FY10 RHIC Run Plan (as of 11/25/2009)

	Physics prod'n/beam studies weeks		Weeks achieved / science goals met?
$\sqrt{s_{NN}}$ (GeV)	25-cryoweek run	27-cryoweek run	
200	10	10	10.5 / ✓
62.4	4	4	2.9 / ✓+
39	1.5	1.5	1.9 / ✓++
27	0	0	Outstanding collider & detector performance!
18	0	0	
11.5 @ STAR	0	2	1.5 / ✓+
7.7	4	4	4.7 / ✓
Beam studies @ 5 GeV and @ $\nu \approx 0.67$	0.5	0.5	0.5 / ✓

- ***Improve high-E Au+Au statistics, esp. for e^+e^- studies with PHENIX Hadron Blind Det.***
- ***Launch low-energy scan searching for evidence of QCD critical endpoint***
- ***Commission 4 planes stochastic cooling***
- ***Carry out beam tests relevant to improve polarized pp performance in FY11***



PHENIX and STAR Data Samples Acquired

Table 1: PHENIX Data Sets in Run-10

SPECIES	$\sqrt{s_{NN}}$	Requested	Recorded	Recorded (events)	Data size
Au+Au	200	1.4 nb^{-1}	1.3 nb^{-1}	8.2G	885 TB
Au+Au	62.4	350M events	0.11 nb^{-1}	700M*	76 TB
Au+Au	39	50M events	40 μb^{-1}	250M**	34 TB
Au+Au	7.7		0.26 μb^{-1}	1.6M	6 TB

*** Larger data set permits meaningful J/ψ suppression analysis @ 62.4 GeV**

**** Larger data set permits significant results on dilepton enhancement at 39 GeV**

Beam Energy ($\sqrt{s_{NN}}$, GeV)	Minbias (Million)	Central (Million)	High-Tower Sampled Luminosity	FTPC+PMD (Million)
200	355/300	265/250	2.6/2 (nb^{-1})	5/5
62.4	143/(N/A)	33/(N/A)	175(ub^{-1})/(N/A)	3.5/(N/A)
39	250/25		62/9 (ub^{-1})	23/5
11.5	≥ 7.5/5	N/A	N/A	
7.7	5/5	N/A	N/A	
5	Commissioning	N/A	N/A	

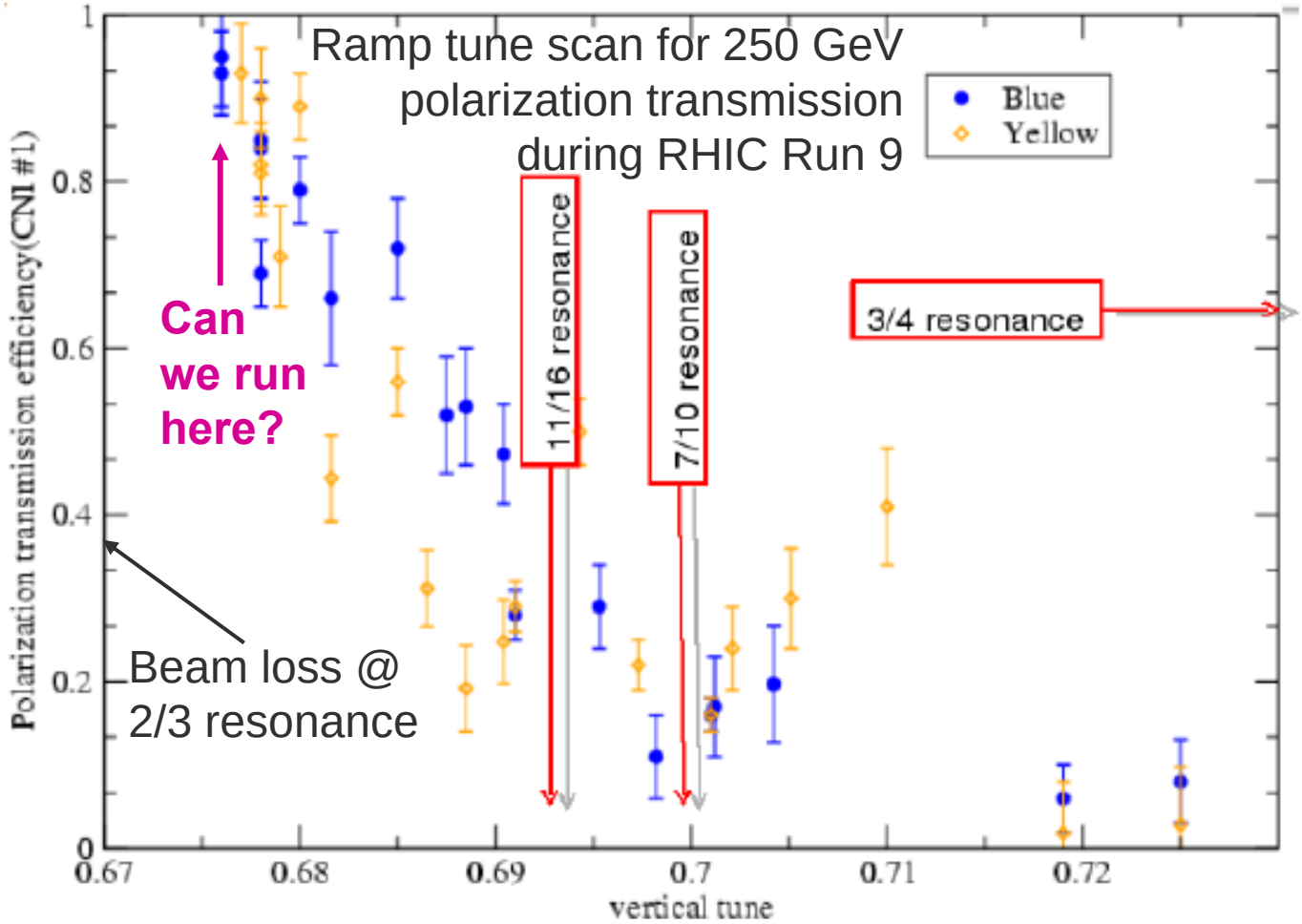
Table 2.3: Actual data taken and the STAR Run10 BUR requests.

ALD's Interim Run 10 Plan, as of 08/07/2009

$\sqrt{s_{NN}}$ (GeV) for Au+Au	PAC-recommended # weeks, 30-cryoweek scenario	PAC priority	# weeks in 25-cryoweek scenario	# weeks in 30-cryoweek scenario
200	10	1	10	10
62.4	4 (400M PHENIX)	2	4	4
39	0.5	3	1.0	1.5
27	0.5	3	2.5	4.5
18	1.0	3	0	1.5
11.5	2.0	3	1.5	2.5
7.7	4.0	3	1.0	1.0
$\sqrt{s}$ (GeV) for p+p				
500	3.0 beam devel.	4	0.0	0.0
22.4	≤ 1	5	0.0	0.0

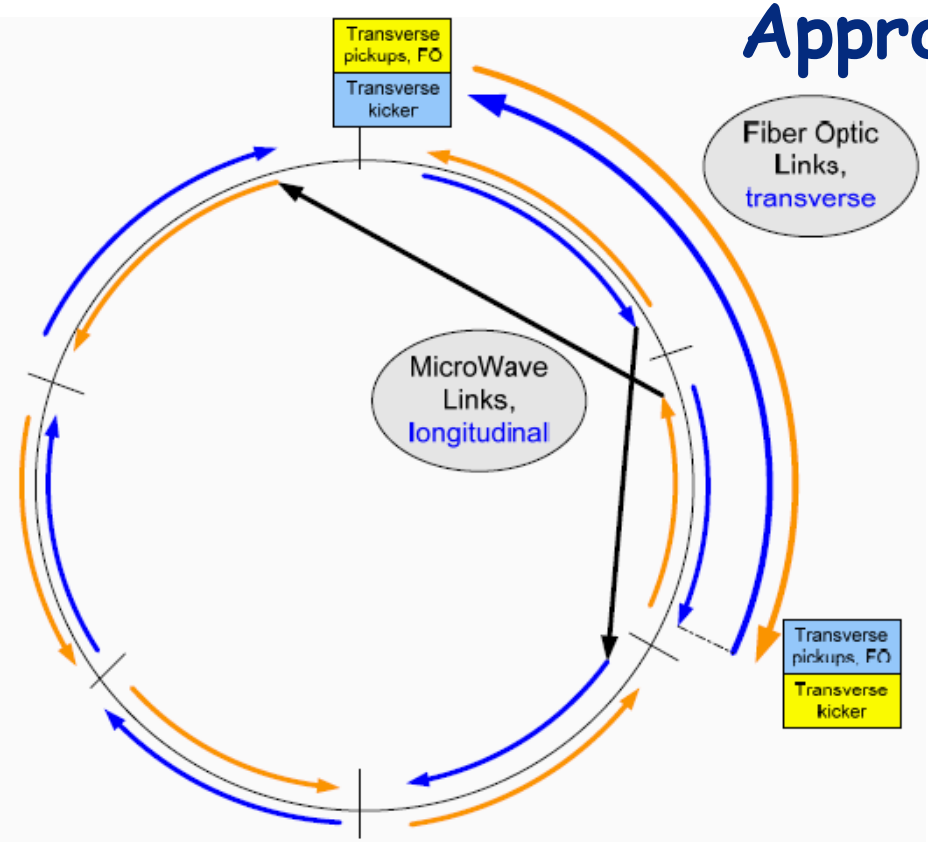
- ***With PHENIX's then-current understanding of their triggering limitations @ low E, PAC plan would have called for 7 weeks of RHIC operation with PHENIX not acquiring data. Much of the low-E running was then to be postponed to Run 11, when PHENIX would have had an upgraded trigger barrel. Subsequent analyses rendered these considerations invalid.***
- ***It was felt that the critical tests for improving 250 GeV proton beam polarization could be carried out with Au beams in Run 10.***

Improving Polarization Performance at 250 GeV Requires High Machine Stability



Power supply improvements during summer 2009 ⇒ improved stability in 2010. Tests with Au beams ⇒ very encouraging indications of ability to run sufficiently close to 2/3-integer machine resonance. Also working on polarized source and AGS improvements for higher polarization.

Approaching RHIC-II Science

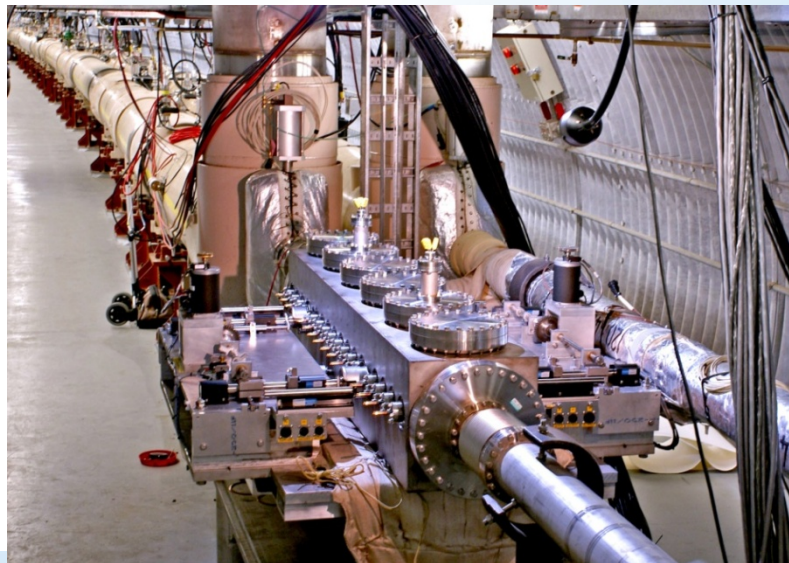


- ***Accelerator technology break-throughs @ RHIC facilitate ~x10 improvement in heavy-ion collision rates, 4 years earlier and at 1/7 the cost envisioned in 2007 NP Long Range Plan.***

- ***Much of the new system commissioned during ongoing Run 10, rest anticipated for 2013 run (aided by ARRA funds).***

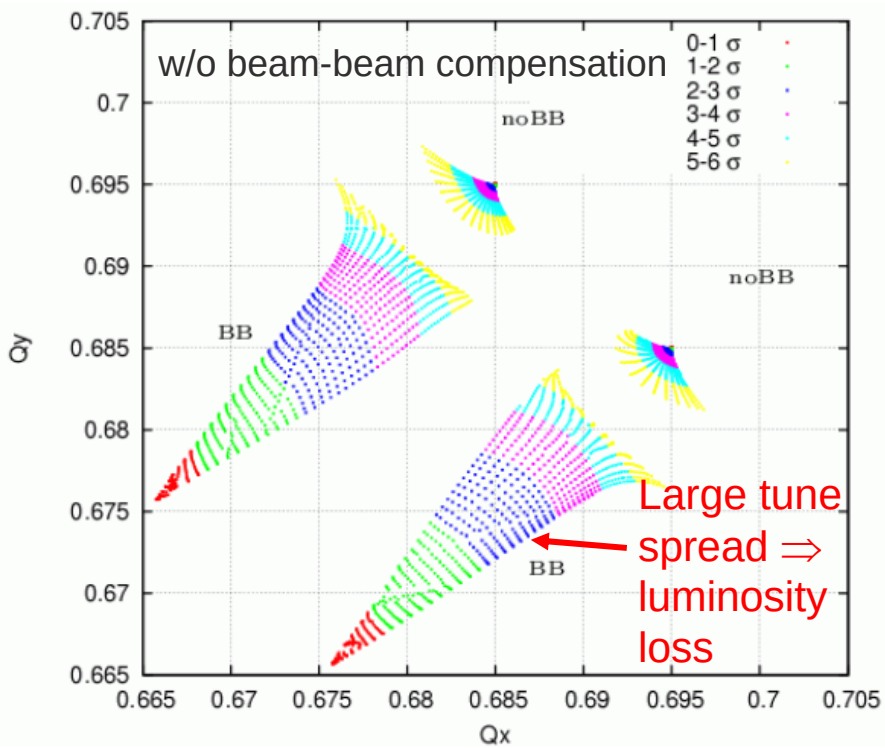
- ***With detector upgrades, permits quant-ifying properties of near-perfect liquid QGP, searching for QCD critical point, studying local symmetry violation, etc.***

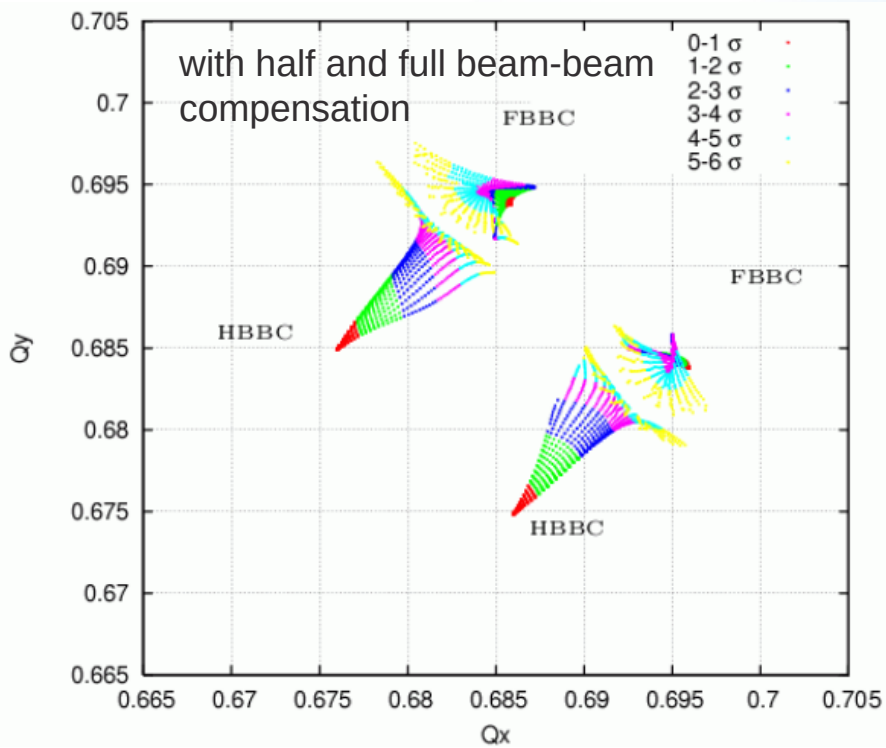
- ***Keeps RHIC world's premier facility to study matter under early-universe con-ditions, even as LHC turns on.***



Further p Beam Improvements Under Development: Electron Lenses

- p-p luminosity limited by head-on beam-beam tune spread
- Low energy (~5 keV) e^- beam interacting with proton beam can compensate head-on beam-beam tune spread ($\times$ 2 luminosity?)
- Single and multi-particle simulations promising
- Possible implementation in RHIC by 2012-13, aided by ARRA funds





Until e-lenses installed, expect 500 GeV running to be more efficient

PAC/Experiment Guidance for Run 11/12 Plans

- ***Priorities for 30 and 25 cryoweeks Run 11, 25 cryoweeks Run 12***
  - ***President's FY11 budget request would support 30 weeks, but anticipate long Continuing Resolution, possible Congressional cuts***
  - ***2.5 weeks cooldown/warmup overhead + 2 weeks commissioning per colliding beam species run (~1-2 days for energy change)***
- ***EBIS available for heavy ions Run 11, but in commissioning mode***
- ***Retrofits to stochastic cooling systems ⇒ not necessarily back to 4 planes in Run 11 ⇒ full-energy Au+Au luminosity may fall somewhat below best Run 10 performance***
- ***Use 50% as 250 GeV proton polarization goal for Run 11, with operation at 0.675 betatron tune***
- ***Anticipate 6 stochastic cooling planes installed for Run 12, but not yet 56 MHz SRF system for ultimate Au+Au luminosity gain***
- ***If one or more Drell-Yan LOI's encouraged, willing to have short test run in FY11 to calibrate IP2 collision impact on STAR, PHENIX pp luminosities. Longer detection equipment commissioning run will require approved proposal.***

Decadal Plan Charges to PHENIX and STAR

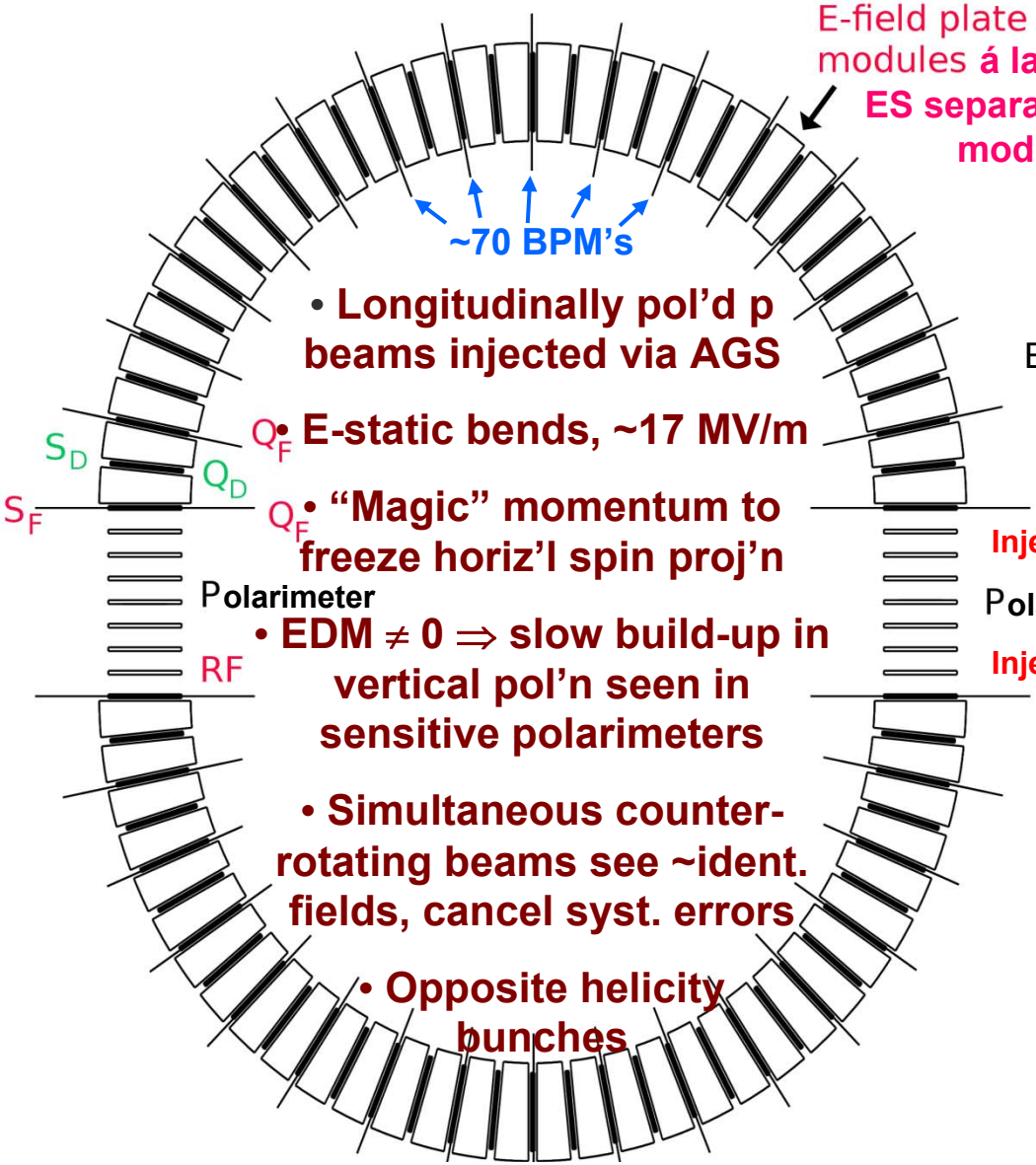
I am therefore asking you to generate a document for each Collaboration, to be delivered to me by ~~August~~ **October** 1, 2010, that provides the following information:

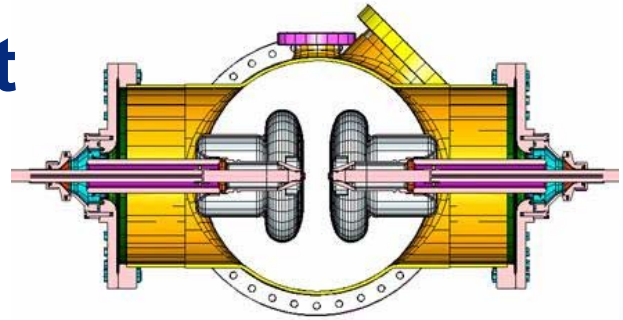
1) A brief summary of the detector upgrades already (or soon to be) in progress, the timelines for completing them, the new science capabilities each adds in combination with upgraded RHIC luminosity…
2) The compelling science goals you foresee for RHIC A+A, p+p, and d+A collisions that can only be carried out with additional upgrades (or replacements) of detector subsystems or machine capabilities (e.g., further luminosity or diamond size improvements). …
3) Prioritized, or at least time-ordered, lists of the major (above $2M total project cost) and more modest (below $2M total project cost) new detector upgrades your Collaboration foresees, together with R&D milestones that
4) **Want PAC feedback to me and collaborations on basic directions of decadal plan thinking, what is needed to make compelling arguments for continued upgrades and operations beyond ~FY15.**

electron-ion collisions with an eventual eRHIC upgrade. This is relevant only near the end of the decade addressed here, but will be important for planning purposes. …

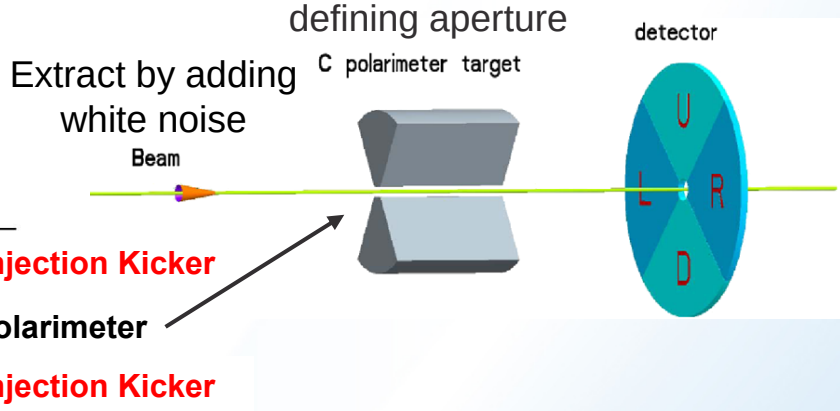
5) The envisioned evolution of your Collaboration through the decade: institutions that may leave, others that might join, any plans to keep your Collaboration healthy and vibrant as RHIC becomes a "mature" facility.

FYI: Storage Ring pEDM Concept





- Longitudinally pol'd p beams injected via AGS
- E-static bends, ~17 MV/m
- "Magic" momentum to freeze horiz'l spin proj'n
- EDM ≠ 0 ⇒ slow build-up in vertical pol'n seen in sensitive polarimeters
- Simultaneous counter-rotating beams see ~ident. fields, cancel syst. errors
- Opposite helicity bunches



Horizontal spin precession:

$$\vec{\omega}_a = \frac{e}{m}\left(a - \left(\frac{m}{p}\right)^2\right)\vec{\beta}\times\vec{E}$$

is frozen at "magic" momentum:

$$p = \frac{m}{\sqrt{a}}, \text{ with } a = \frac{g-2}{2} = 0.70 \text{ GeV/c for protons}$$

- Need ~1000s spin coherence time, ~2×10^7s counting time to attain 10^{-29} e·cm stat. sensitivity

First Technical Review of pEDM Concept, Dec. 7-8, 2009

Review Panel:

S. Vigdor, BNL (chair)
Y. Derbenev, JLab
B. Filippone, Caltech
R. Holt, ANL
T. Roser, BNL
E. Sichterman, LBNL

Review Charge Elements:

1) Technical showstoppers that make attainment of interesting sensitivity levels unlikely? Or, too many high-risk performance goals for significant probability of payoff?

2) Has the collaboration properly identified the highest risk assumptions and proposed an appropriate set of R&D milestones to manage the risk?

3) Are the collaboration's considerations of systematic errors and approaches to mitigate them unduly optimistic?

4) Aware of competitive plans for charged-particle ($\neq$ e) EDM measurements? Is need for p/d EDM measurements to complement n EDM sufficiently strong to proceed?

5) Cost estimates and timelines for the R&D stages reasonable? Is proposed sequence of p, then d, EDM measurement optimal? Are both measurements worth doing?

6) How much time do you estimate the collaboration needs to develop the proposal to a stage suitable for a DOE Critical Decision 0 ("mission need") review?

Comments from pEDM Review

The Committee judges the proton EDM experiment to be intriguing, important and very challenging, and the overall design to be informed by many clever ideas, especially the use of the magic momentum and simultaneously counter-rotating beams. A proton EDM measurement to the goal sensitivity of 10^{-29} e·cm would represent a profound contribution to the search for non-Standard Model CP violation in nature. Furthermore, the unique systematics of a storage ring EDM search allow it to provide crucial independent confirmation of an EDM signal from another, more conventional, EDM experiment. While the Committee expresses a number of significant concerns about technical performance requirements needed for the experiment and about some of the proposed solutions, it has not identified anything considered to be a technical showstopper at this point. The Committee is thus enthusiastic about seeing this project move forward…

The Committee makes a number of specific recommendations herein for how the Collaboration should proceed to an R&D stage and toward a DOE critical decision regarding mission need for this experiment. It also suggests a number of technical issues that it feels need greater conceptual attention and/or crisper presentation. Overall, it finds that the project is at a suitable stage to launch serious discussions with funding agencies and with potential collaborating institutions, in order to strengthen the efforts moving forward.

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	Continue low-E Au+Au; 500 GeV p+p; short 200 GeV U+U	Continue critical pt. search; gluon polarization at low x + antiquark pol'n from W production; 1st characterization of deformation effects in U+U centrality distrib'ns	PHENIX VTX engineer-ing run	EBIS (tandem as backup); 9 MHz cavity; 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 at 200 GeV; 500 GeV p+p	RHIC-II heavy-ion goals: heavy flavor, γ-jet, quarkonium, multi-particle correlations; anti-quark 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); OPPIS sole-noid + "proton cannon"	Further heavy-ion luminosity improve-ments + improved proton polarization	"Proton cannon" increases pol. source current, to allow scraping to improve polarization
FY13	200 GeV p+p; further heavy-ion running to comple-ment earlier runs	Continue RHIC-II heavy-ion goals; transverse spin asymmetry for γ + jet, start on Drell-Yan? (2015 spin milestone); pp reference data for new subsystems	STAR HFT prototype + forward hadron calorim't'r?	56 MHz SRF; e-lenses; RHIC collimator upgrade	Full RHIC-II heavy-ion luminosity + improved vertex & store length; 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.	Full STAR HFT	RHIC low-E electron cool-ing; coherent e-cooling test in RHIC	Factor of several increase in lowest-E Au+Au luminosity	Low-E cooling relies on Pelletron from FNAL in late 2011 if Tevatron terminates