

View of BNL Nuclear and Particle Physics

Peter Bond
Interim Associate Director
for Nuclear and Particle Physics
RHIC/AGS/NSRL User Meeting
June 21, 2007



Background

- You have heard and will hear a lot detailed talks on science so I will focus on some recent events and proposed future directions in NPP
- Sam Aronson will cover the Lab-wide perspective

User input has been and will be key

Recent Changes

- Steve Vigdor will arrive as the new Associate Lab Director for Nuclear and Particle Physics (Sept)
- Michael Ernst has been in place as the Head of RHIC/ATLAS computing since February. Bruce Gibbard did a wonderful job in building the organization and facility
- 100-teraflops Blue Gene computer is in place courtesy of New York State – called New York Blue
- The User Office and user check-in have move to the new RSB !

Nuclear Physics

Priorities, Vision, Outlook

The #1 priority for Nuclear Physics at BNL, present and future centers on

RHIC

- Over the years RHIC has delivered wonderfully for both for HI and for polarized p – although this year was more difficult than in previous years

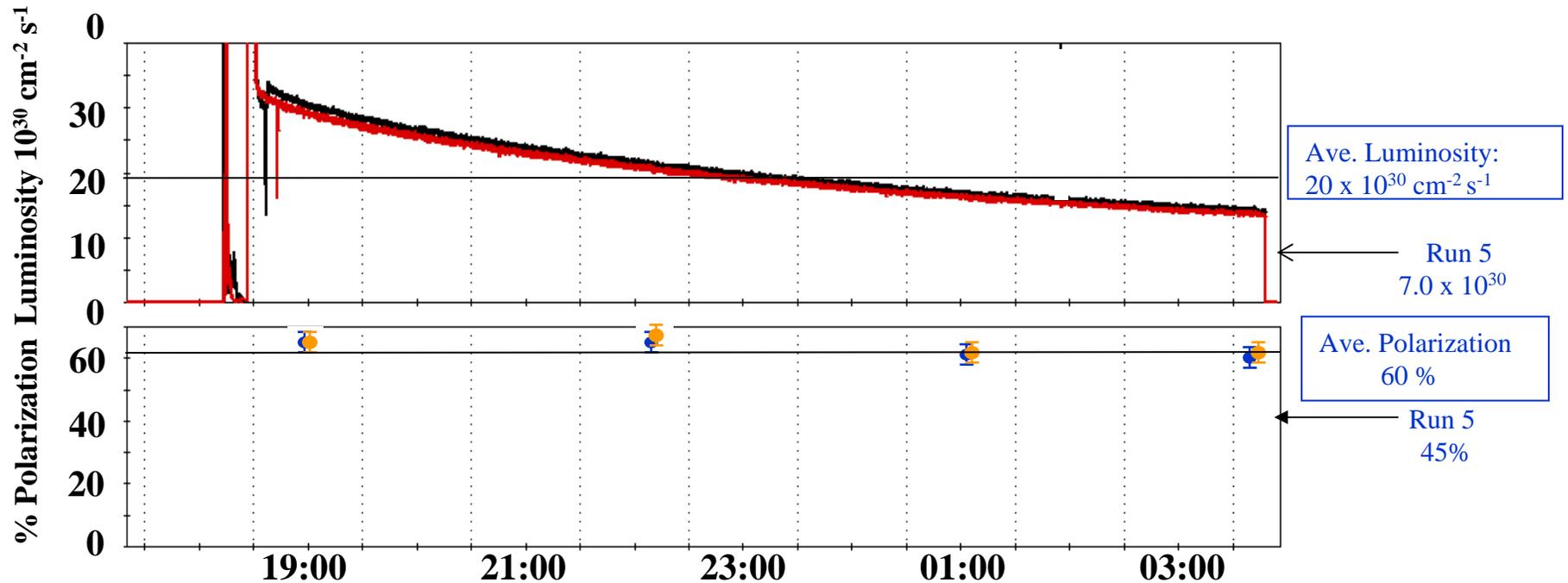
Budget and Run Issues

- Planning regular runs at RHIC have been difficult the last two years.
- In FY2006 it took a grant from Renaissance Technologies and we started late
- This year Congress did not act until March and thus the run was shortened
- FY08 is starting out promising again – stay tuned

Results from last year's p-p run

(Run 6)

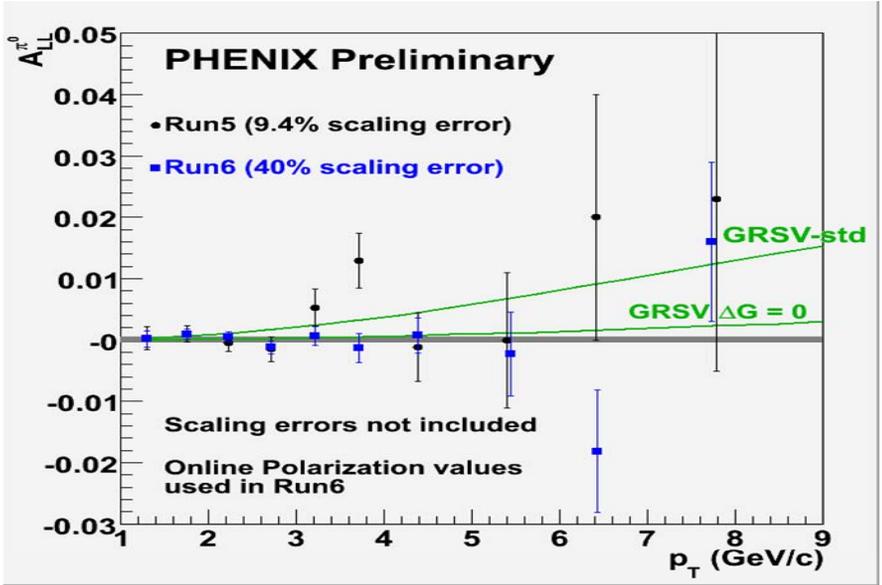
Luminosity and Polarization at $\sqrt{s} = 200$ GeV for Run-6



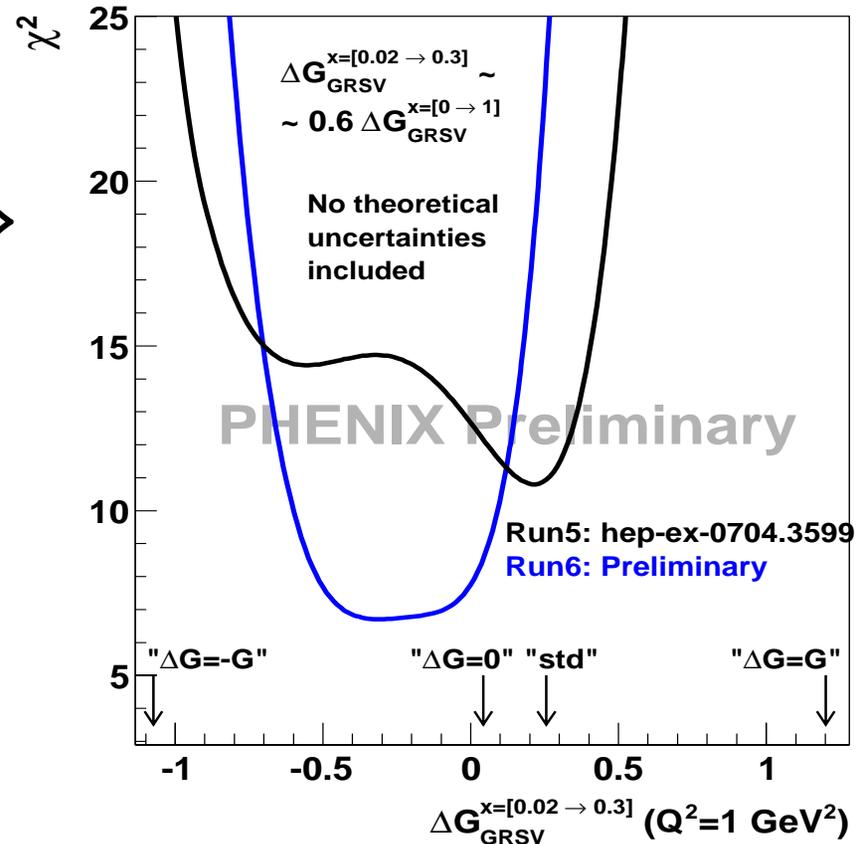
AND

45 % polarization on first acceleration to 250 GeV beam energy!

From A_{LL} to ΔG (PHENIX)



Calc. by W.Vogelsang and M.Stratmann



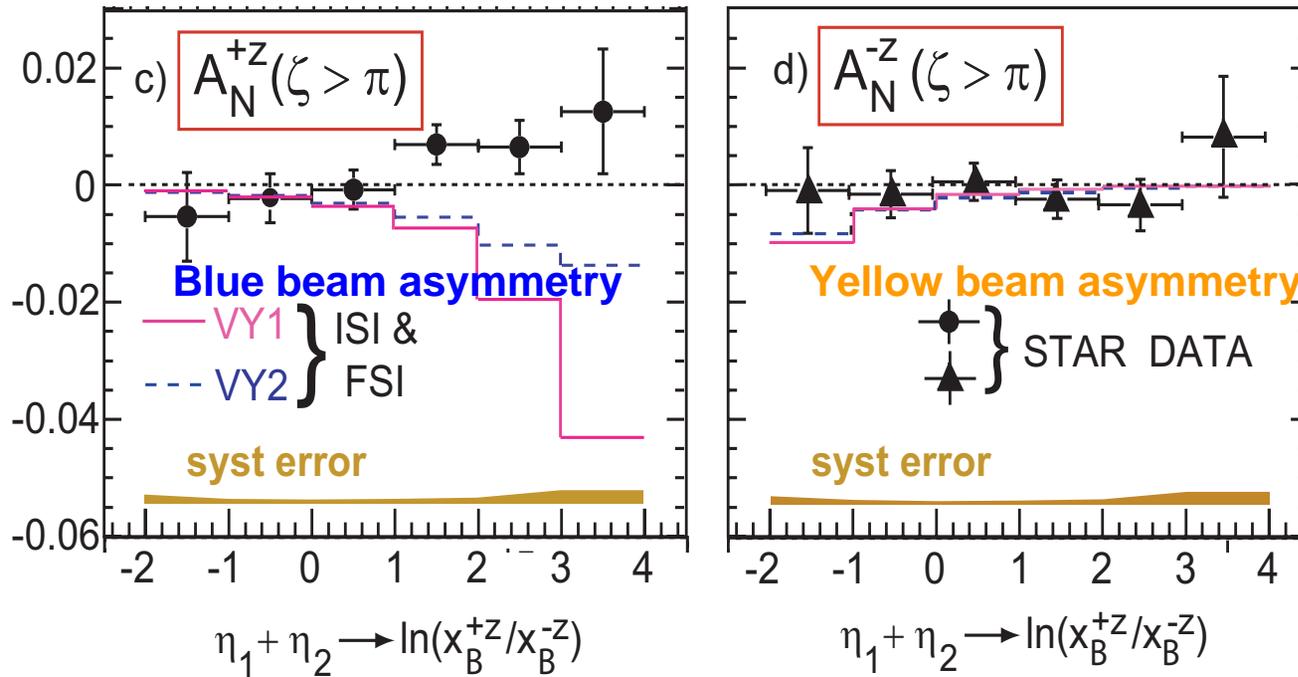
“std” scenario, $\Delta G(Q^2=1\text{GeV}^2)=0.4$, is excluded by data on >3 sigma level: $\chi^2(\text{std})-\chi^2(\text{std})>9$
 Theoretical uncertainties are not included
 Experimental syst. uncertainties are not included (the effect is expected to be small in the final results)



from A. Bazilevsky User's Meeting talk

STAR Run 6 di-jet Sivers effect measurement

arXiv:0705.4629, Submitted to PRL May 27

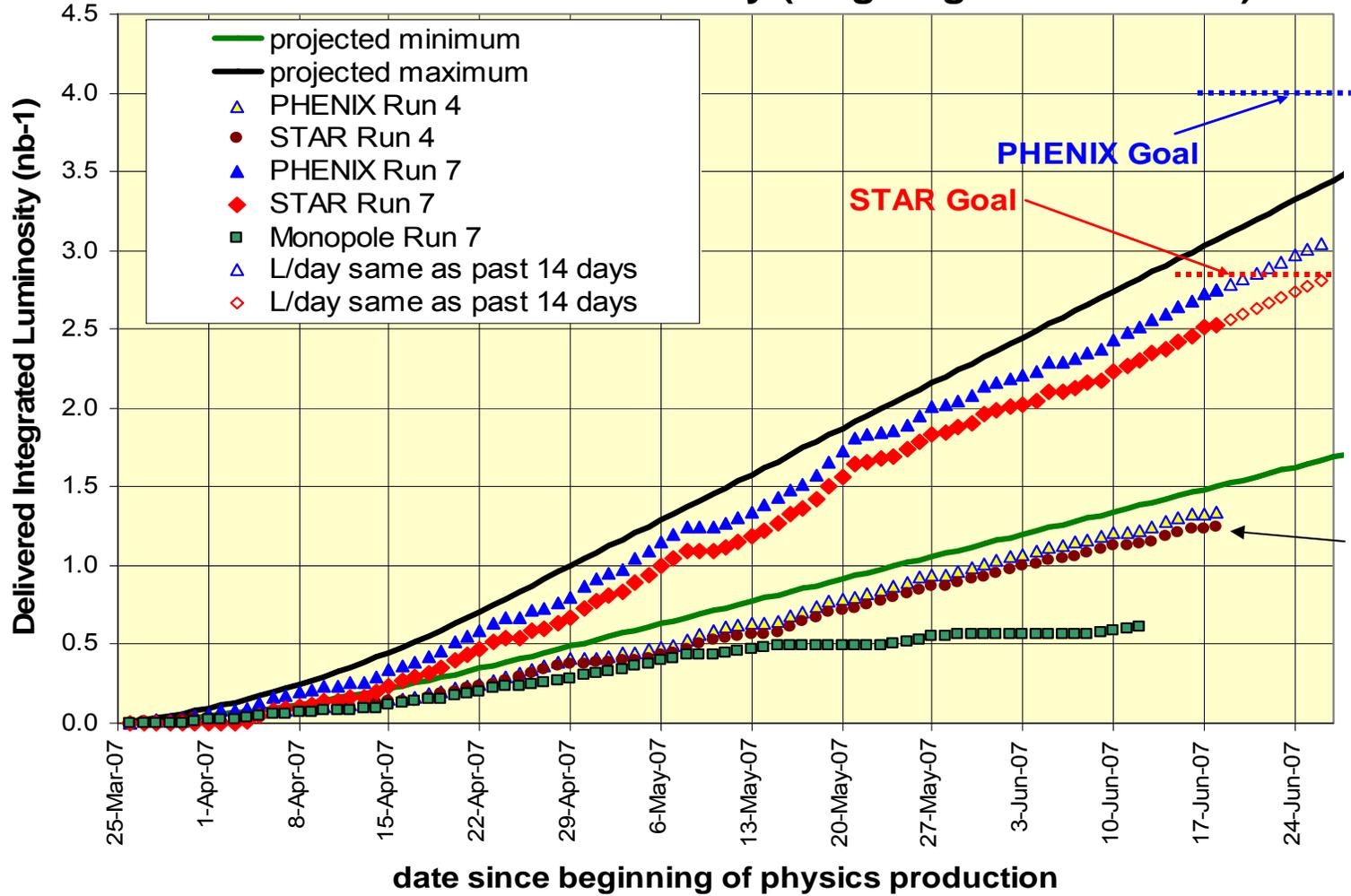


This data would take too long to explain, but the measurements are sensitive to the contribution to the proton spin from orbital motion of quarks and gluons.

Results from Au-Au run

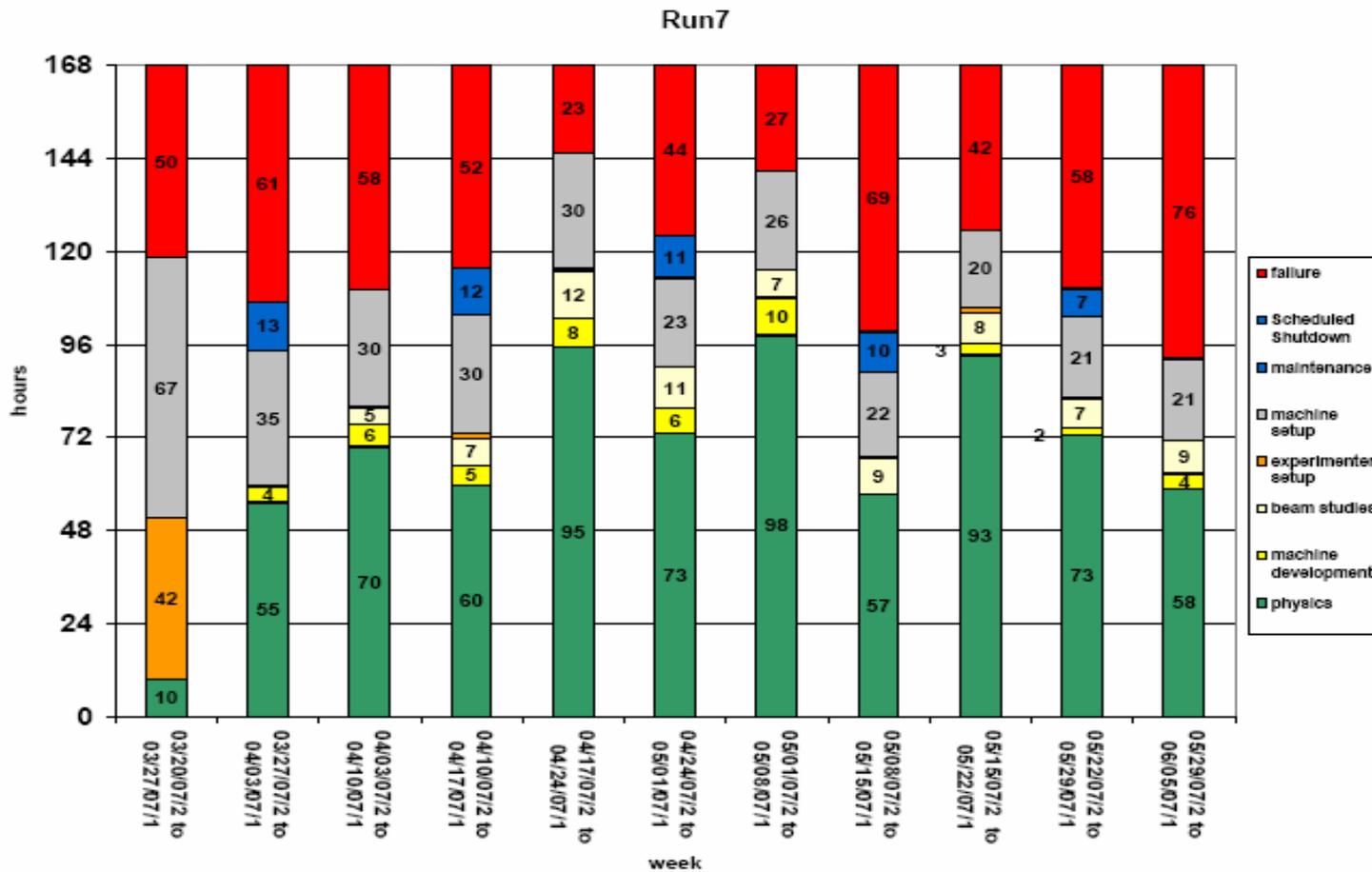
Run 7

Run 7 100 GeV/n Au-Au Luminosity (singles/goals corrected)

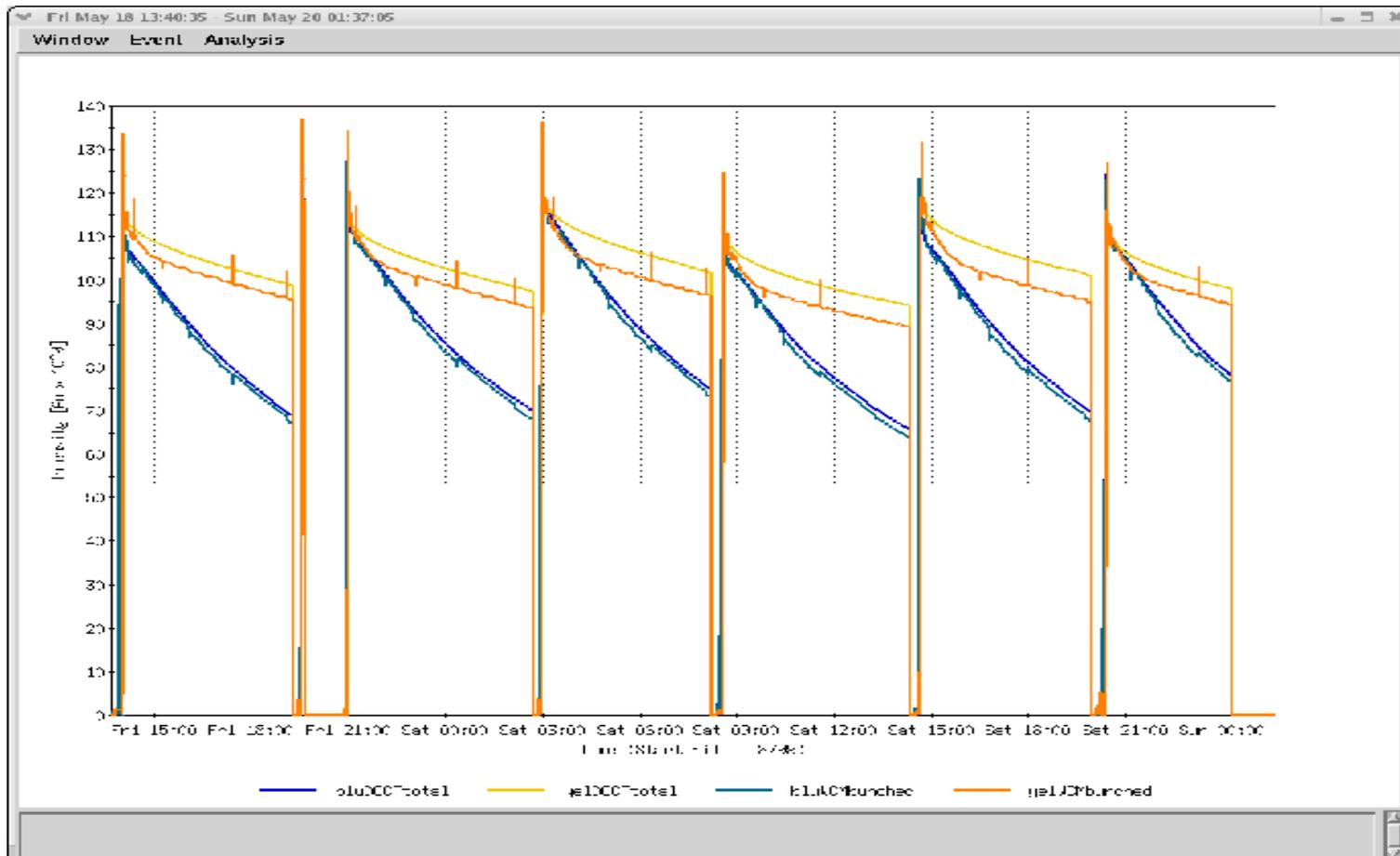


Run 4

Run 7 Reliability an Issue



Longitudinal Stochastic Cooling Works !!





NSRL Status for Run 07A

Run 07A (13 March - 21 May) followed immediately by

Run 07B (21 May - 29 June) for a total of 16 weeks.

All running has been concurrent with RHIC operations, causing

- longer access times (+5 minutes per access)
- waiting during RHIC fills, (~90 minutes down every 6 hours)
- occasional downtimes associated with RHIC problems.

45 Experiments completed by 151 users from 45 institutions
(57% cells, 26% physics, 16% animals, 1% plants)

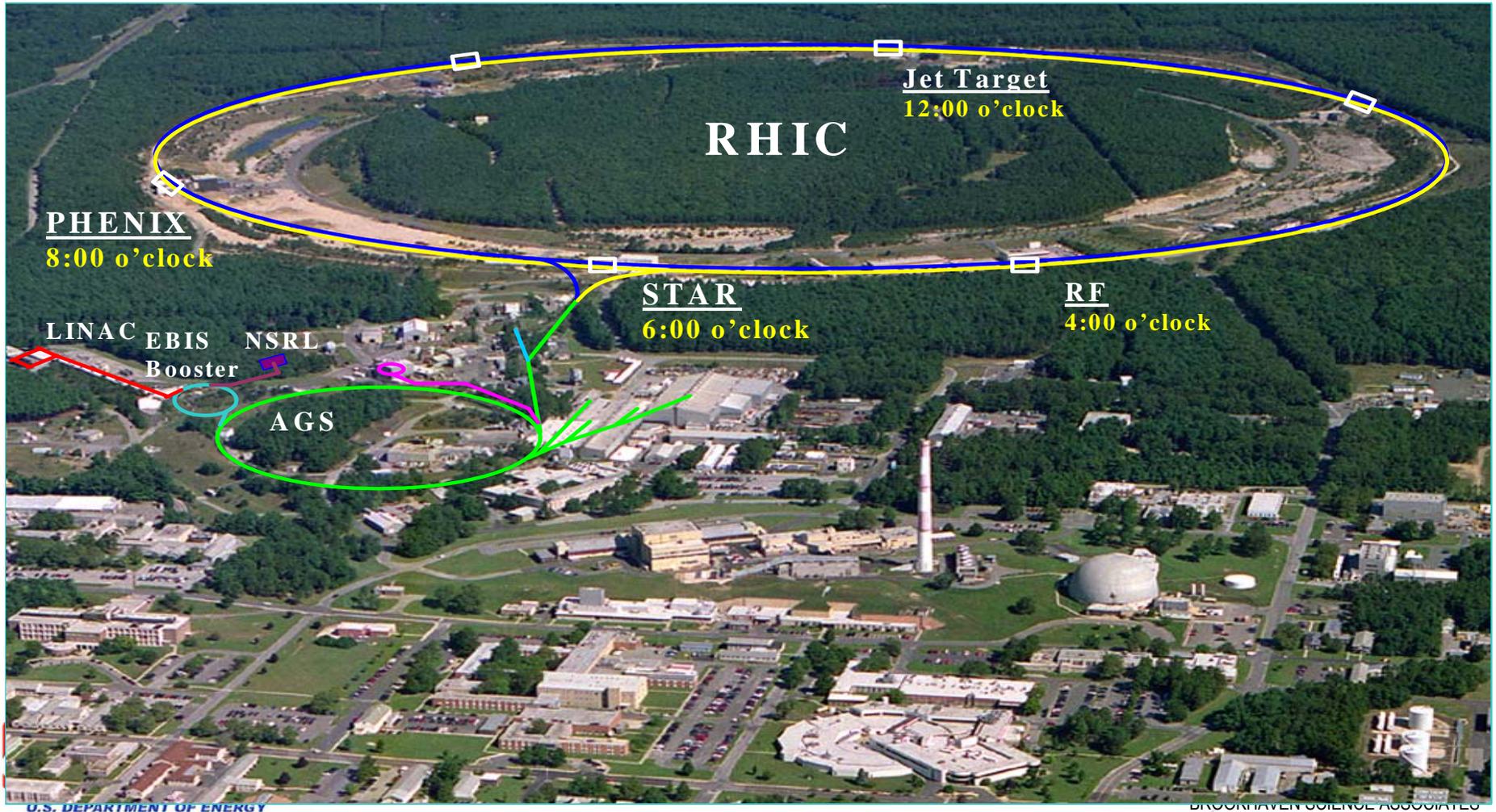
5 Different Ions (H, C, Si, Ti, Fe) at energies from 200-1000 MeV per nucleon.

417 hours of operation: (66% science, 22% set-up, 5% wrap-up, 3% beam development, 4% down time)

Progress this year on other issues

- Test of how low in energy RHIC can run – in a very short run were able to see some collisions at 4.6 GeV/A per beam
- Electron Beam Ion Source (EBIS) has CD-3 and DOE funding ! NASA funding was already in place so moving ahead for FY2010 operation (looking for ways to “catch up” time due to funding delays)

With EBIS the operation (and RHIC photo) will change
(2 experiments, no tandems nor 1800 ft transfer line)



RHIC Upgrade Science

<p>QCD at High T and ρ</p>	<p>Is there a QCD Phase Transition to QGP; what are its properties? Thermalization: How do we evolve from a low-entropy initial state to a maximal entropy state on short time scales? Deconfinement: Do the degrees of freedom in the initial state have deconfined color charges? Chiral Symmetry: Is chiral symmetry restored at high T and ρ?</p>
<p>QCD at High E, Low x</p>	<p>What is the nature of gluonic matter in strongly interacting particles? Is this gluonic matter a CGC and is it the source of QGP? Is the low-x structure of nucleons in nuclei different from that of free nucleons?</p>
<p>QCD & Hadron Structure</p>	<p>How do gluons contribute to the proton spin? What are the u, d, s quark & antiquark polarizations in the proton? What orbital angular momentum is carried by the partons in a proton? What role does transverse spin play in QCD?</p>

Near term Plans

Exploit the scientific opportunities at RHIC

- Enormous gains in knowledge will continue to be made (in A+A and Spin) with near term upgrades and incremental improvements
 - Luminosity, polarization, 500 GeV p-p, 10 GeV Au-Au
 - DAQ, particle ID, η coverage
- Optimized operations continually being evaluated
 - Running time vs. investment (for efficiency and the future)

Mid term plan and status

- RHIC II
 - EBIS to increase the range of ion species available and improve operations efficiency – **under way !**
 - e-cooling to be constructed to increase the HI luminosity by a factor of 10 – **R&D ongoing**
 - Science case for RHIC II has been made in working group white papers led by user community – **external validation early FY08 ?**
- Detector upgrades to take advantage of these capabilities **ongoing**
- Theory , including lattice gauge, are key to progress

Longer Term Plan

Evolve RHIC into "QCD Laboratory"

- Address the compelling questions in QCD revealed by the discoveries at RHIC
- Involve the RHI, Spin and DIS communities in articulating the future science of RHIC and eRHIC
- R&D/investments → the tools and techniques needed to address the scientific questions

What is QCDFLab ?

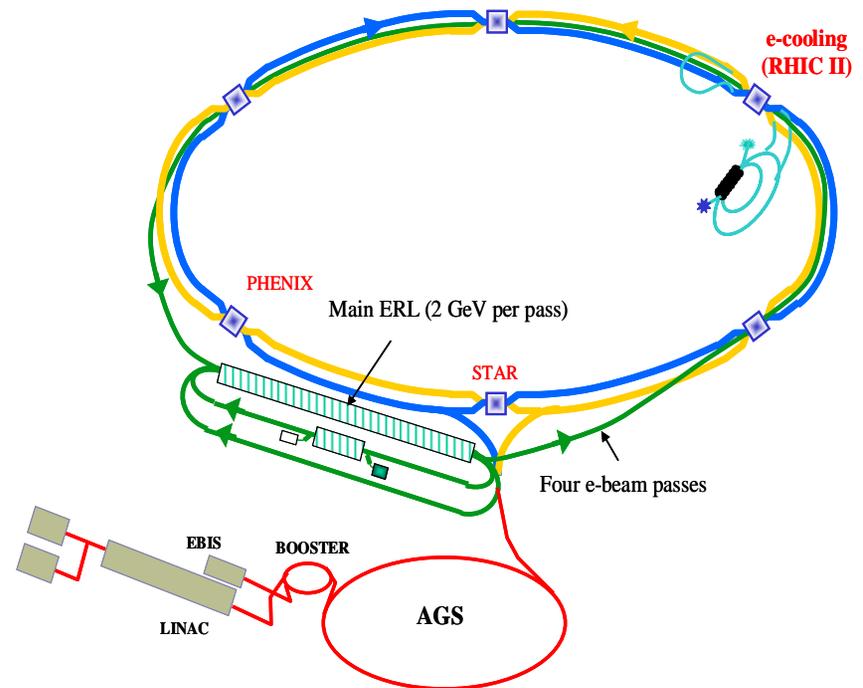
- e-cooling is implemented, detectors are upgraded
- A 10 GeV electron injector and polarized electron source is added to RHIC
- Computing power (e.g. BlueGene-L) is added to allow more powerful theory calculations
- The result – $A-A, A-B, \vec{p}-\vec{p}, e-A, \vec{e}-\vec{p}$ all possible

a phenomenal facility for study of QCD

RHIC → RHIC II/eRHIC (QCDLab)

- RHIC II
 - An additional order of magnitude in average luminosity (beyond near term incremental increases)
 - Detector enhancements
- eRHIC
 - Electron ring or linac
 - New detector

Critical technologies (principally electron cooling and Energy Recovery Linac) enable both RHIC II and eRHIC Higher integrated luminosity through longer luminosity lifetime



Nuclear Physics Long Range Plan and RHIC

- As most of you know every 5-6 years NSAC puts together a LRP that lays out priorities in the field
- The 2007 NSAC LRP resolution committee met in early May and has made its highest level recommendations
- What were the results of the resolution meeting ?
- Do we have to change our vision of the future ?

NSAC LRP Recommendations

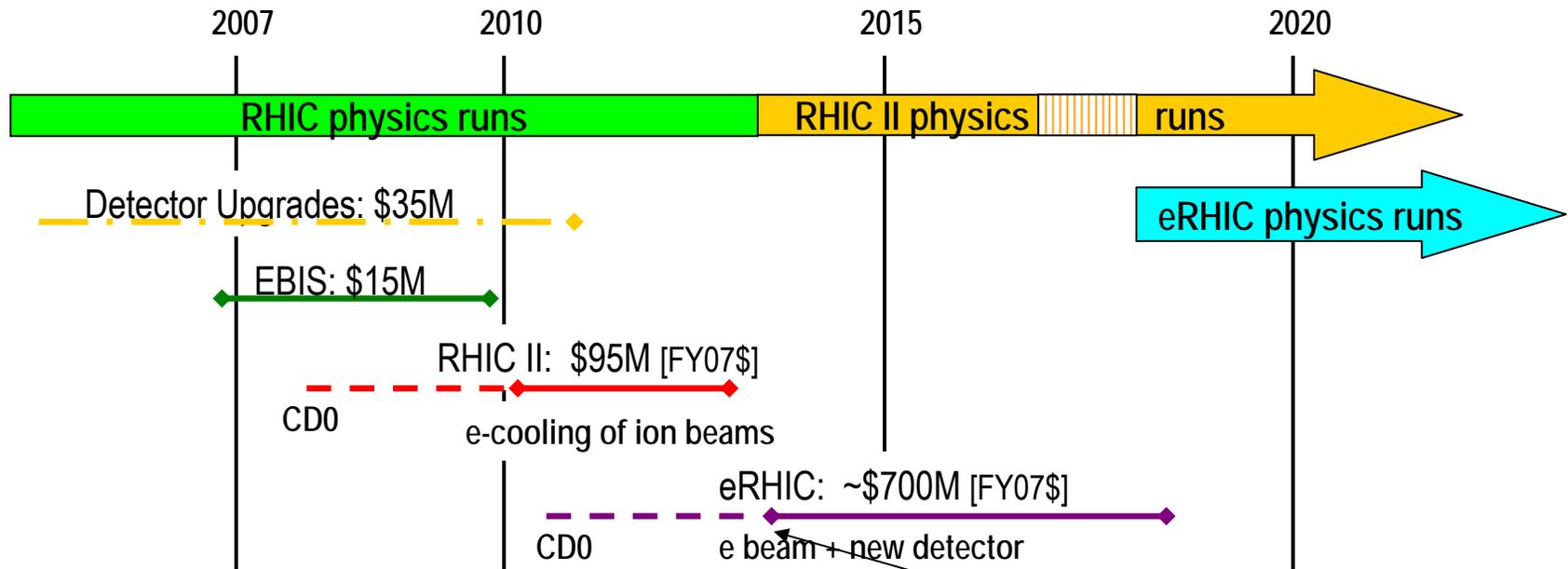
- We recommend completion of the 12 GeV Upgrade at Jefferson Lab. The Upgrade will enable new insights into the structure of the nucleon, the transition between the hadronic and quark/gluon descriptions of nuclei, and the nature of confinement.
- We recommend construction of the Facility for Rare Isotope Beams, FRIB, a world-leading facility for the study of nuclear structure, reactions and astrophysics. Experiments with the new isotopes produced at FRIB will lead to a comprehensive description of nuclei, elucidate the origin of the elements in the cosmos, provide an understanding of matter in the crust of neutron stars, and establish the scientific foundation for innovative applications of nuclear science to society.
- We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet unseen violations of time-reversal symmetry, and other key ingredients of the new standard model of fundamental interactions. Construction of a Deep Underground Science and Engineering Laboratory is vital to US leadership in core aspects of this initiative.
- **The experiments at the Relativistic Heavy Ion Collider have discovered a new state of matter at extreme temperature and density—a quark-gluon plasma that exhibits unexpected, almost perfect liquid dynamical behavior. We recommend implementation of the RHIC II luminosity upgrade, together with detector improvements, to determine the properties of this new state of matter.**

EIC Recommendation (unbulleted)

We recommend the allocation of resources to develop accelerator and detector technology necessary to lay the foundation for a polarized Electron Ion Collider. The EIC would explore the new QCD frontier of strong color fields in nuclei and precisely image the gluons in the proton.

Without gluons there are no protons, no neutrons, and no atomic nuclei. Interactions among gluons determine the unique features of strong interactions. However, gluon properties in matter remain largely unexplored. Recent theoretical breakthroughs and experimental results suggest that both nucleons and nuclei when viewed at high energies appear as dense systems of gluons, creating the strongest fields in nature. The emerging science of this universal gluonic matter drives the development of a next generation high luminosity electron ion collider. Polarized beams in the EIC will give unprecedented access to the spatial and spin structure of gluons in the proton. The EIC embodies our vision for reaching the next QCD frontier. Realization of an EIC will require advancements in accelerator science and technology, detector R&D, and continued theoretical development.

A Long Term View of RHIC



Legend:
 - - - - - R&D
 ◆————◆ Construction
 - · - · - Multiple small projects
 CD0: DOE Critical Decision, mission need

The start is too optimistic

What are the hurdles to be overcome ?

- The technical and science hurdles are the “easy” ones
- Issues
 - TJLAB (12 GeV), FRIB, other DOE offices for funding
 - Continuing to make the HI science case once LHC begins
 - Need to convince the NP community on science case for eRHIC
 - Cost
- *Must also make the case to other audiences*
 - DOE, OMB, and Congress

These audiences may require less detail, but need compelling reasons and each audience is *vital* to success

NP Summary

- RHIC's success has made BNL a world center for
 - Heavy Ion Physics
 - Spin Physics
 - Nuclear Theory (high T, high ε , high E, low x)
 - Accelerator science
- A clear (non-trivial!) path leading to a QCD Lab
 - $A + A, p + A, \vec{p} + \vec{p}, \vec{e} + \vec{p}, e + A$
 - New detector capabilities, higher luminosity and polarization

This path has *discovery potential* every step of the way!

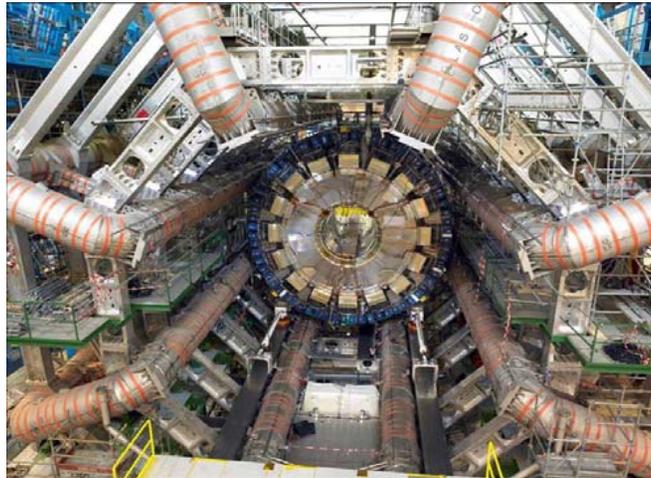
Particle Physics

The state of BNL Particle Physics

- Major redirection of program following cancellation of RSVP
 - No AGS program currently – but some new ideas have arisen
- **Collider physics**
 - ATLAS, D0
 - Mike Harrison is now the ILC America's Regional Director
 - ILC Detector R&D (with Instrumentation Div.)
- **Fixed target (neutrino) & non-accelerator based physics**
 - Neutrinos: MINOS, Daya Bay reactor θ_{13} , very long baseline
 - Cosmology, astrophysics: LSST (beginning)
- **Strong theory & accelerator groups**
 - Advanced Accelerator R&D (key to Muon Collaboration)
 - Accelerator Test Facility (HEP, BES)
 - Superconducting Magnet Division (NP, HEP, WFO)

Collider Physics - ATLAS

- Construction at LHC is completing and BNL's leading role in this has been a big success
 - U.S. is playing a vital role under leadership of Howard Gordon and David Lissauer



- M&O: Pre-operation testing of detector components including calibration/cosmic rays

Looking forward to Physics in 2008 !!!

ATLAS

- **Physics Analysis**

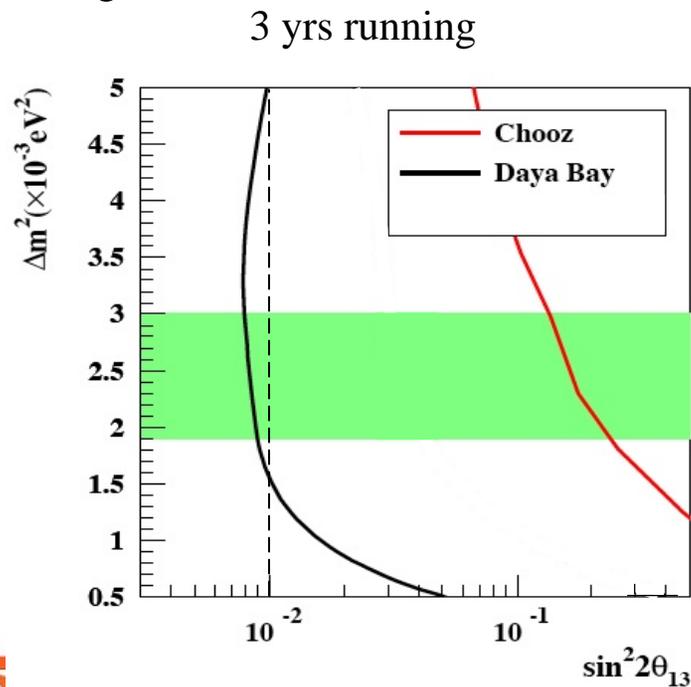
- BNL Tier 1 Computing Center performing at world class level
- BNL computer professionals making important contributions to the ATLAS software
 - Many tutorials, meetings and visitors in the last year
 - Vital support for US ATLAS community in analysis

- **Future Plans**

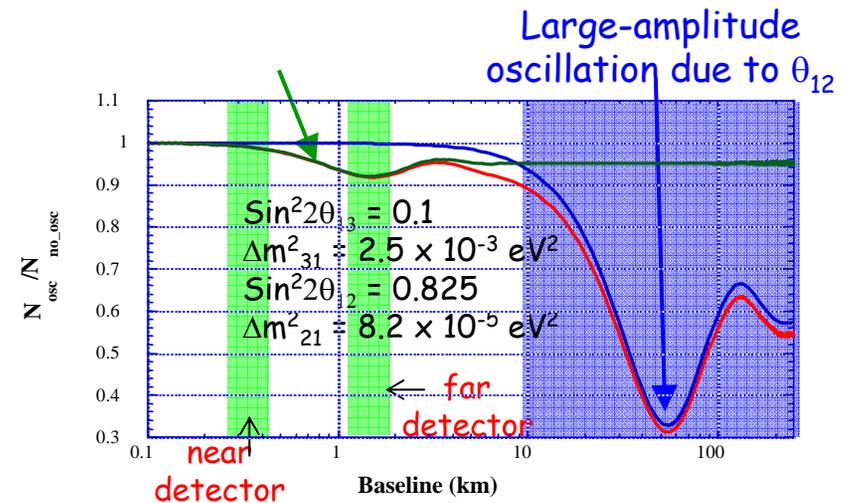
- D0 effort has been decreasing and effort will gradually transition to ATLAS - planned for end of 2008
- Analysis Support Center will continue vital support to Users
- Emphasis on Tier 1 and core software
- R&D on ATLAS upgrade
 - Work with Instrumentation Division on Liquid Argon devices to handle higher luminosity

Neutrino Effort – Daya Bay (China) Reactor Experiment

- BNL has joined Daya Bay Experiment CD-0, seeking CD-1
- Precision measurement of $\sin^2 2\theta_{13}$ - the last unknown neutrino mixing angle



$$P(\bar{\nu}_e \rightarrow \bar{\nu}_e) \approx 1 - \sin^2 2\theta_{13} \sin^2 \left(\frac{\Delta m_{31}^2 L}{4E} \right) - \cos^4 \theta_{13} \sin^2 2\theta_{12} \sin^2 \left(\frac{\Delta m_{21}^2 L}{4E} \right)$$



BNL role in Daya Bay

- BNL is a U.S. host lab, along with LBNL.
- BNL provides the Chief Scientist (S. Kettell) and Chief Engineer (R. Brown)
- BNL has the L2 Subsystem Managers for Muon System, Installation, and Integration
- BNL Chemistry department will provide Gd loaded liquid scintillator
- BNL ALD sits on the Laboratory Oversight Group along with LBNL and IHEP
- BNL will host the Research Program Office (we are defining this)

Accelerator Based Neutrino Efforts

- MINOS – measure Δm_{23}^2 and $\sin^2 2\theta_{23}$
 - First result
 - $\Delta m_{23}^2 = 2.74^{+.44}_{-.26} \times 10^{-3} \text{ eV}^2$
 - $\sin^2 2\theta_{23} > 0.87$ (68% C.L.)
 - BNL leads search for ν_e appearance in far detector
 - Should finish circa 2010 (?)
- Neutrinos from FNAL to DUSEL
 - National Effort
 - Recent BNL/FNAL White Paper of very long baseline experiments completed
 - What are physics trade-offs of various detector/beam options?
 - Construction of large detector 20XX ?

Conclusion

- In both NPP programs the future for BNL is focused on national priorities.
- The exciting science for Nuclear Physics is concentrated around RHIC and its evolution to RHIC II and eRHIC
- BNL Particle Physics focused on collider and neutrino experiments elsewhere with a U.S. ATLAS analysis focus at BNL Tier 1
- In both NPP areas there are exciting accelerator R&D projects ongoing
- The next decade will be an exciting one for both programs and we all need to work to make the vision real