Summary Overview Session

Fulvia Pilat, CAD

RHIC Retreat Close-Out, July 20 2009

Retreat Goals and Organization

GOALS

- Review machine performance and operations of Run-9
- Planning for Run-10 and Run-11 (ions, low energy, polarized proton operations)
- Review present and future upgrades, programs and R&D in CAD – identify resources

RETREAT ORGANIZATION

Steering Committee: K. Brown, W. Fischer, M. Mint, F. Pilat, T. Roser

J. Sandberg, J. Tuozzolo

Workshop Support: F. Naase, A. Petway

Financial Support: ALD, CAD Management

N. Boyle, M. Heimerle, S. Lamontagne

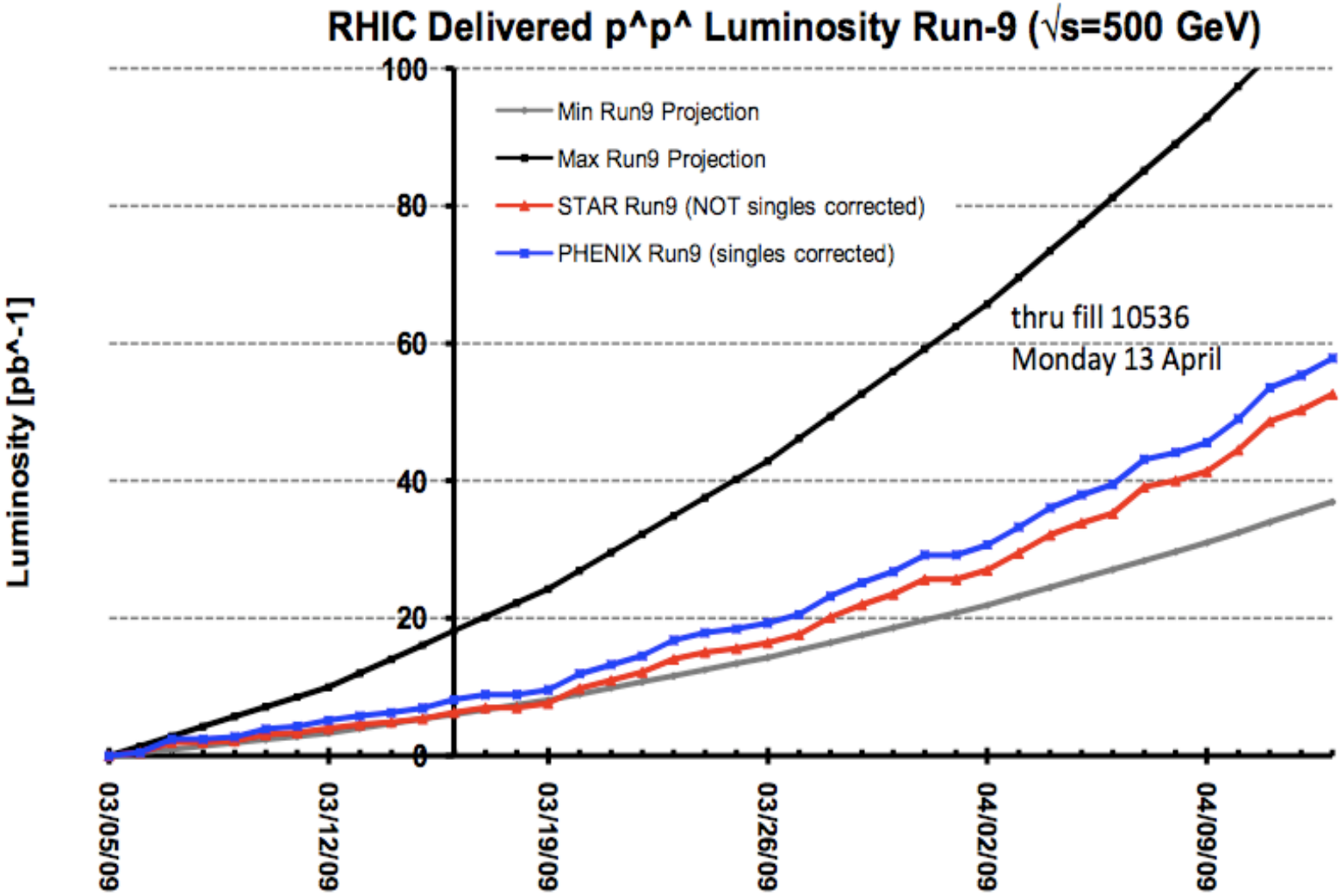
Retreat Sessions

Overview	F. Pilat
Performance	M. Bai (PP), K. Brown (ions) Chair: W. Fischer
Operations	G. Marr, V. Schoefer Chair: P. Ingrassia
Systems	W. Fischer, P. Sampson Chair: J. Tuozzolo
Programs & Resources	M. Minty, F. Pilat Chair: T. Roser
Close-out	F. Pilat Chair: D. Lowenstein

Overview Session

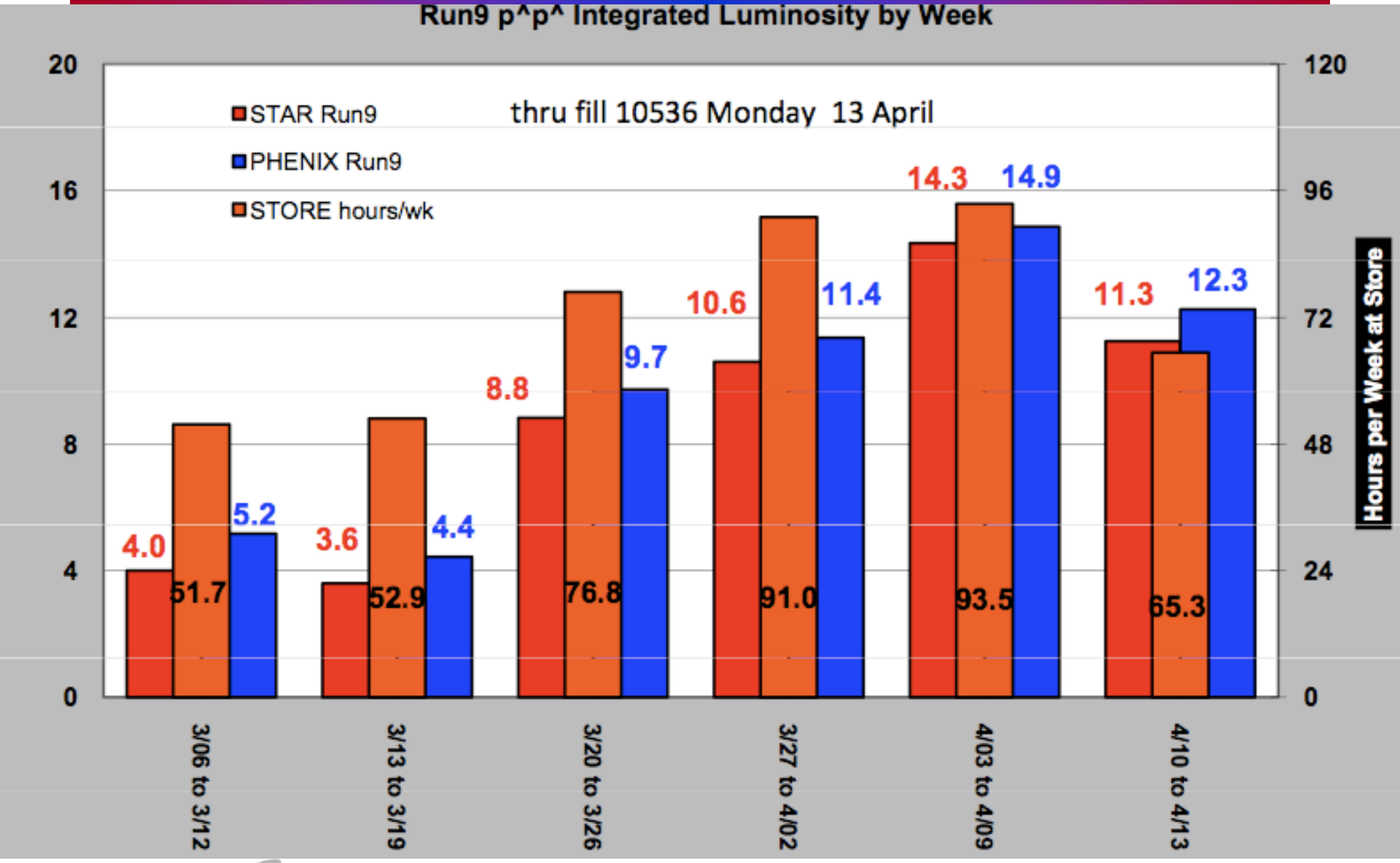
9:00	Pilat	Welcome	(5)
9:05	Bai	Run-9: 250 GeV	(15)
9:20	Montag	Run-9: 100 GeV	(15)
9:35	Pile	Overview of non-RHIC programs	(15)
9:50	Roser	Overview of RHIC future program and R&D	(25)
10:15	Lessard	What can shut us down	(15)
10:30 – 11:00		Coffee break	
11:00	Christie	Feedback from STAR	(15)
11:15	Haggerty	Feedback from PHENIX	(15)
11:30	Pozdeyev	Feedback from the Scheduling Physicist	(15)

250 GeV: Integrated Luminosity

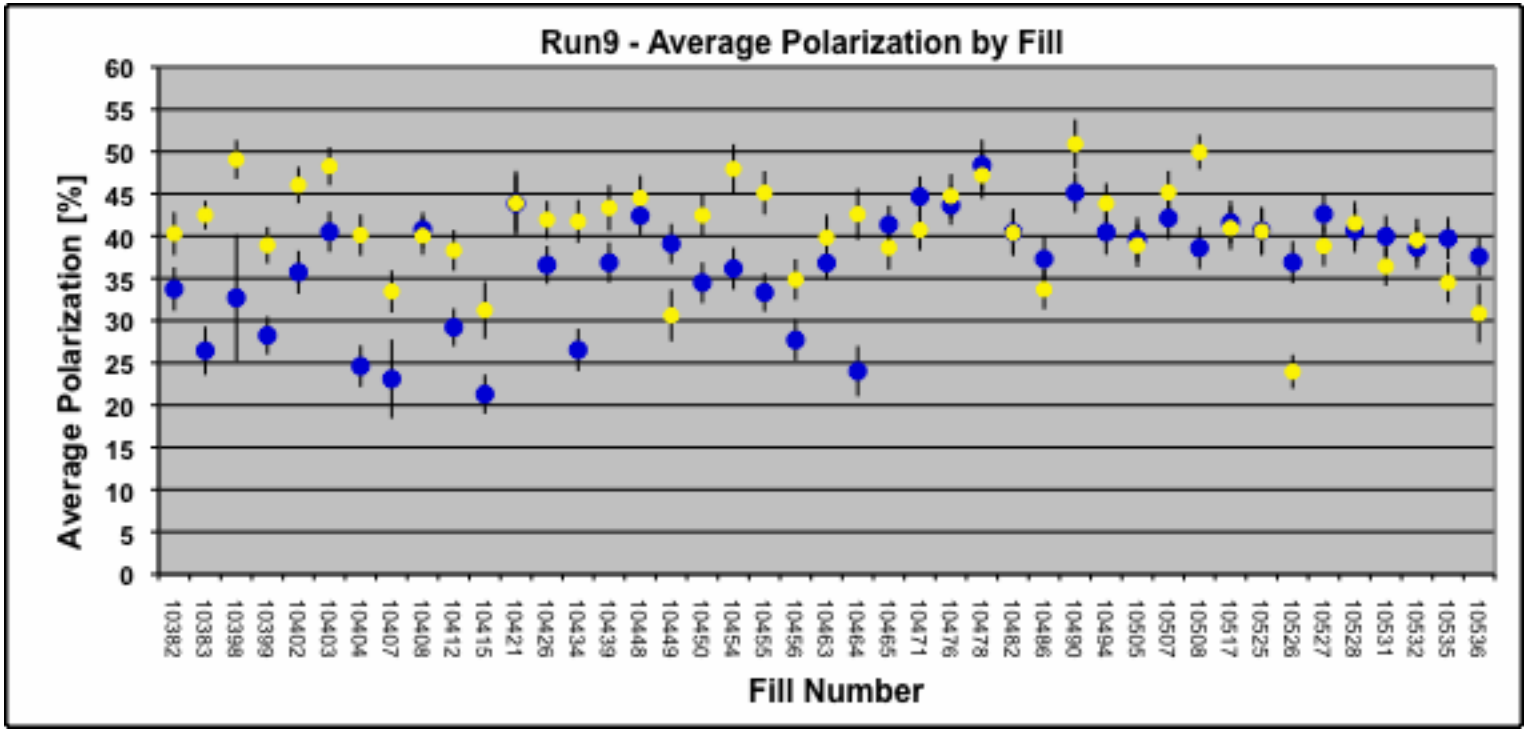


Courtesy of P. Ingrassia

250 GeV: Weekly performance



250 GeV: Average Store Polarization



- Average beam polarization: Yellow ~40.6%, Blue ~36.6%
- Best polarization achieved: Yellow ~50.9%, Blue ~48.4%

Outlook for future 250 GeV runs

- **Polarization**

  Revisit **spin tracking**

  – Bench-marking the spin simulations with the data of 250 GeV run

  – Explore what's the best working point for polarization

  Explore the possibility of accelerating polarized protons at working point between 0.67-0.675

  Keep the working point between injection and 100 GeV above 0.7.

  Eliminate the **mains glitch**

- **Polarimetry**

  - Resolution for **rate**

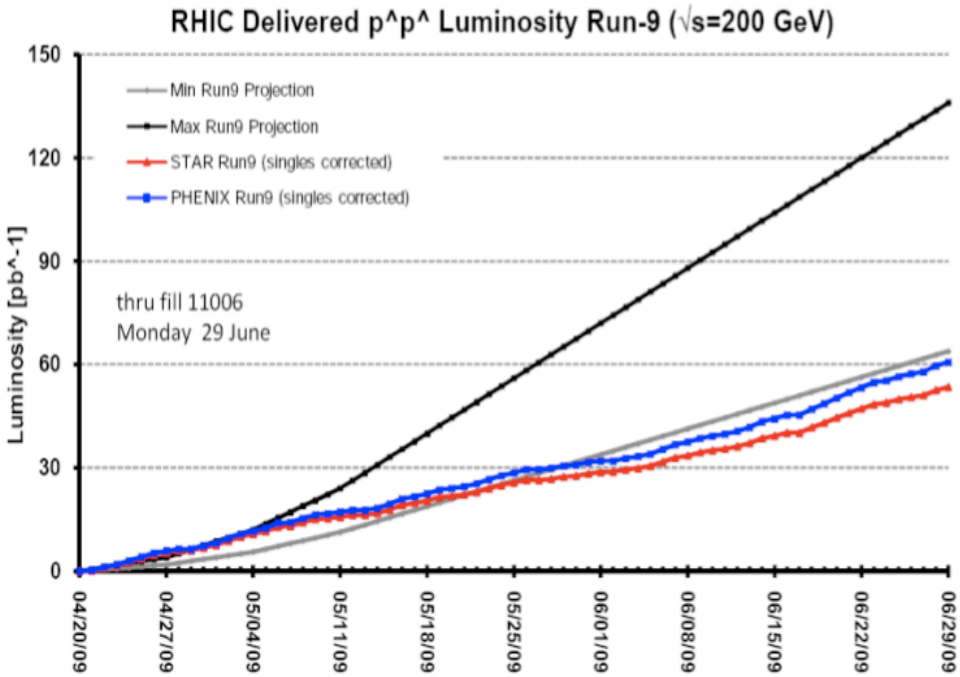
    - CNI: How to correct the rate dependence?

    - Add a PHENIX-type of polarimeter which allows a continuous polarization monitoring

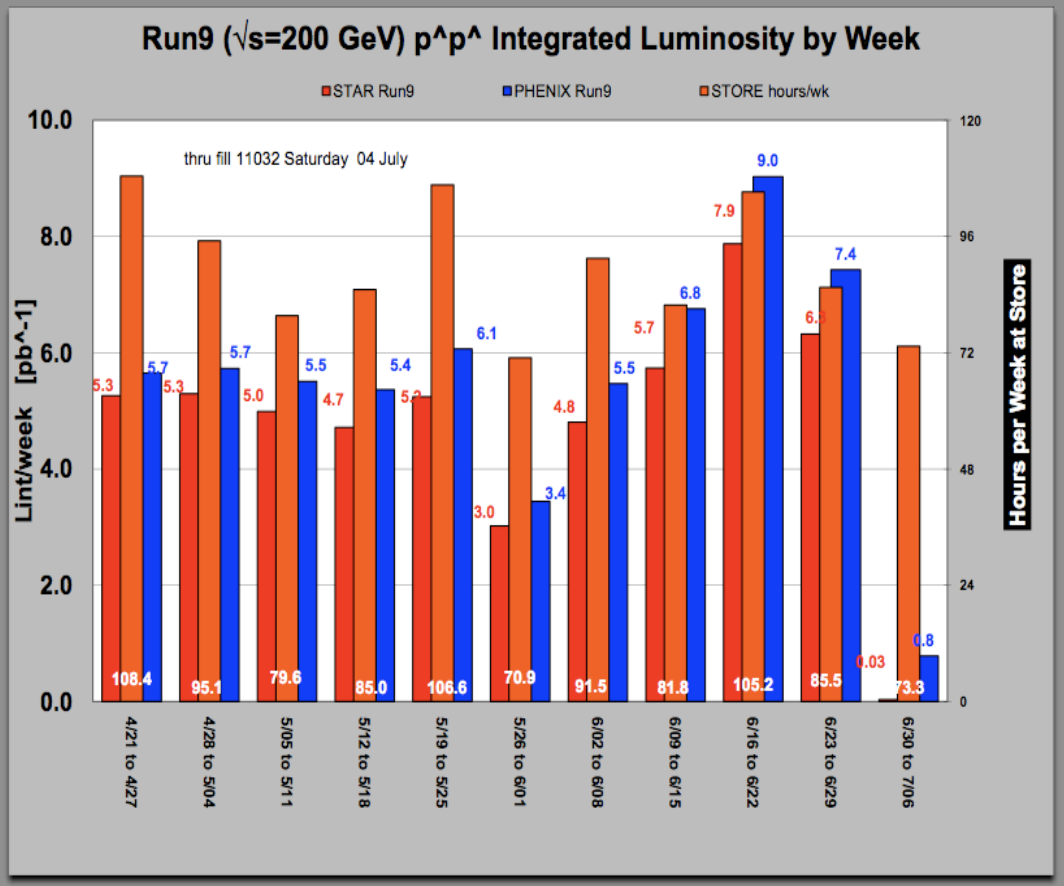
  - **Automatic ramp measurement**

100 GeV: integrated luminosity

Integrated luminosity



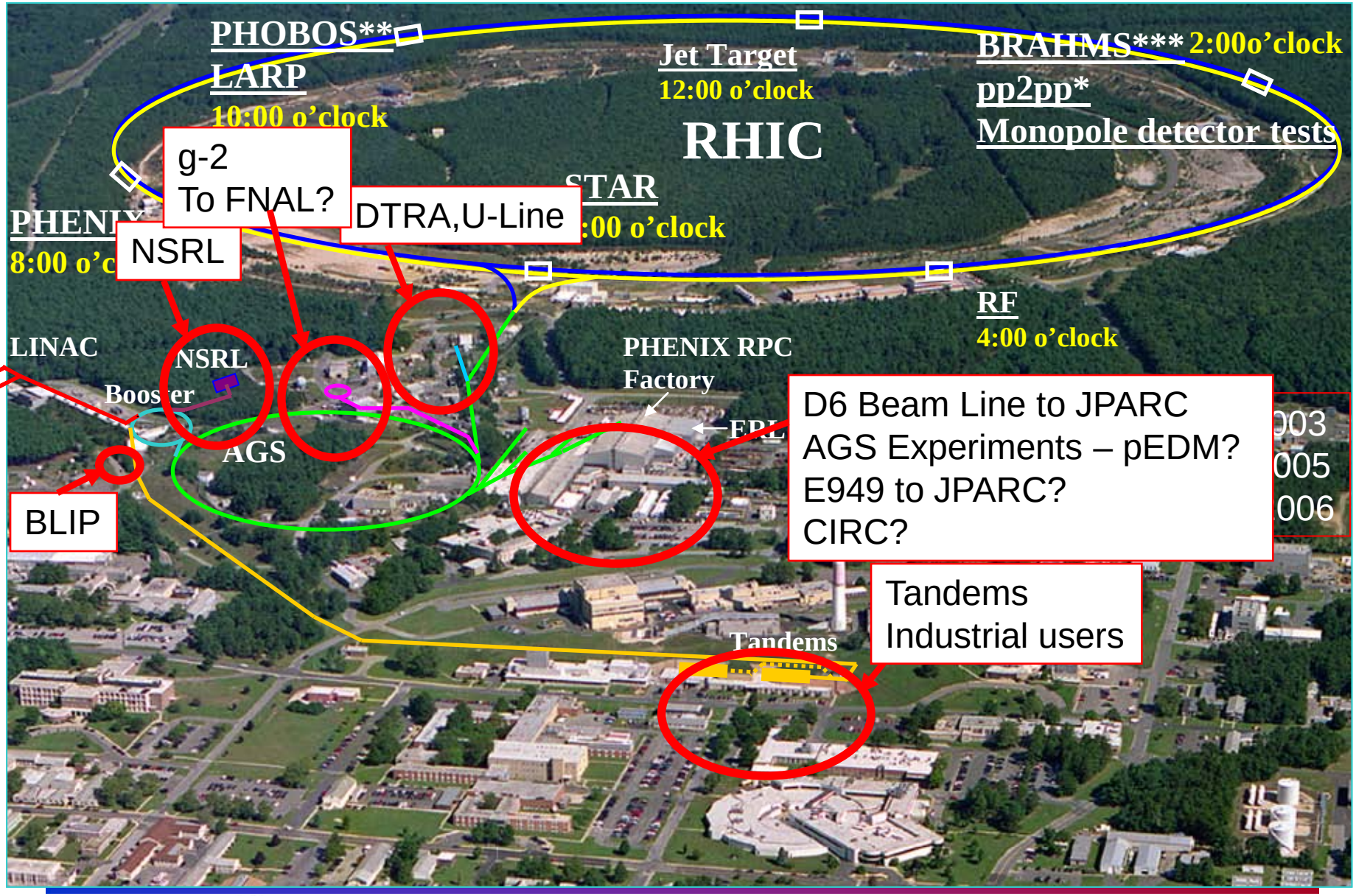
100 GeV: Weekly performance



250 GeV: Summary

- 100 GeV start-up was extremely **fast**, declared physics after 5 days
- **Integrated luminosity** increased almost linearly during the entire run; the first week was already as good as any other week
- **Peak luminosity** 50 percent higher than in Run-6/8.
- Spent considerable time on understanding the **luminosity lifetime limitation**
- **Yellow transmission limitation**
- Many **planned new systems** or **upgrades** did **NOT** provide the expected returns because late or only partially commissioned (LLRF, 9 MHz, Spin flippers, AGS jump quads)
- RHIC ran at its limit during the entire run. Future improvements for PP require **hardware upgrades** (10 Hz orbit feedback to allow near-integer tunes, 9 MHz RF for shorter bunches)
- **pp2pp** during the last week was very successful; set-up is very different from regular running (low intensity, small emittance, lots of collimation/scraping).

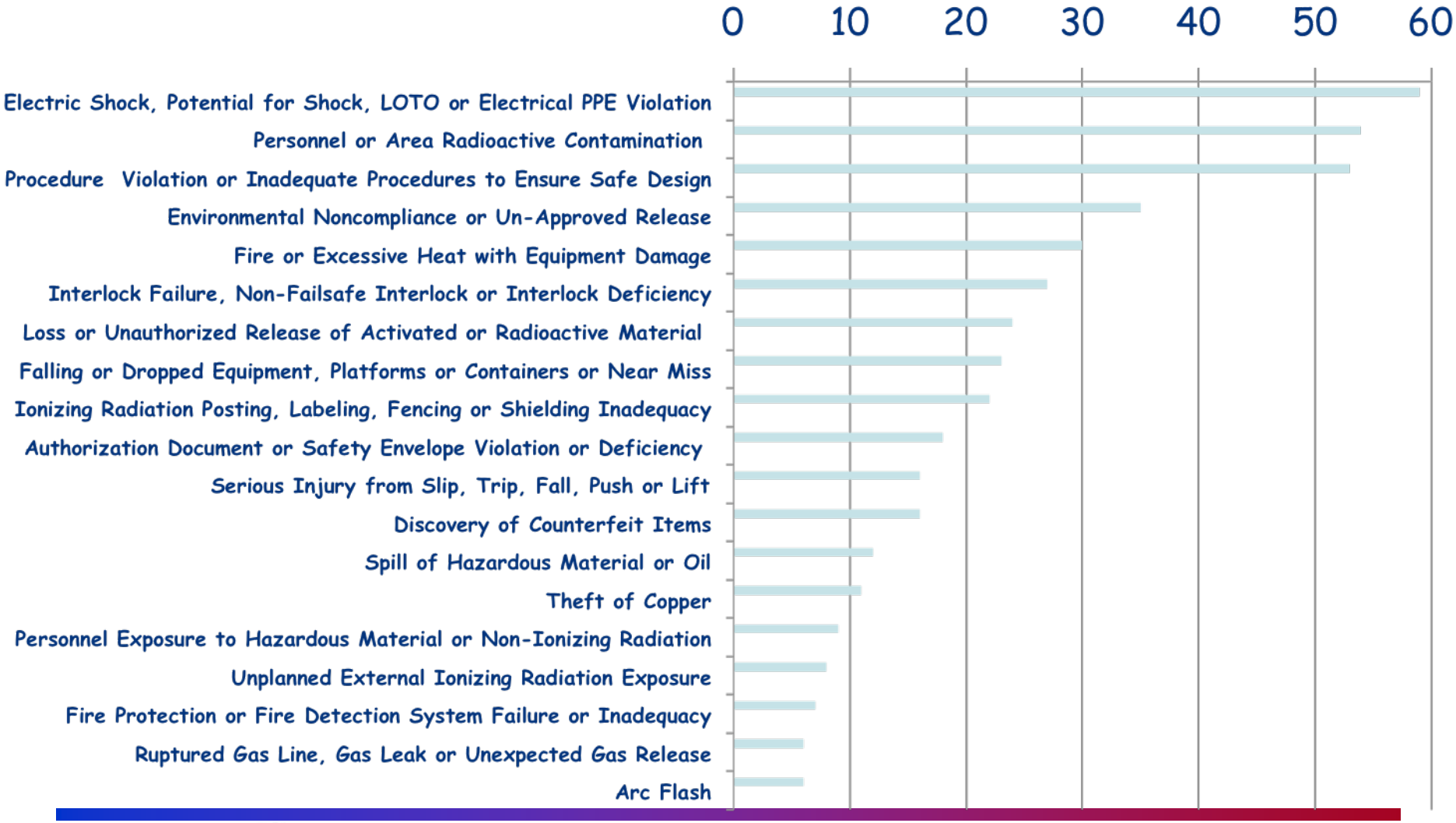
The C-AD Accelerator Complex - 2008



ES&H: Significant Accelerator Events

- Explosion, Cambridge, MA, 1965
- Radiation Exposure, Protvino, Russia, 1978
- Radiation Exposure, PRC, 1985
- Therapy Over-Exposures, Zargoza, Spain, 1990
- Radiation in Uncontrolled Area, AGS, 1990
- Radiation Exposure, Hanoi, 1992
- Electrical Arc Flash, FNAL, 1997
- Electrical Arc Flash, SLAC, 2004
- Electrical Arc Flash, C-AD, 2006
- Radioactive Contamination, Holifield, 2008
- Electrical / Mechanical Failure, CERN, 2008

ES&H: Number of Accelerator Occurrences out of 54,000 DOE occurrences



ES&H: Summary

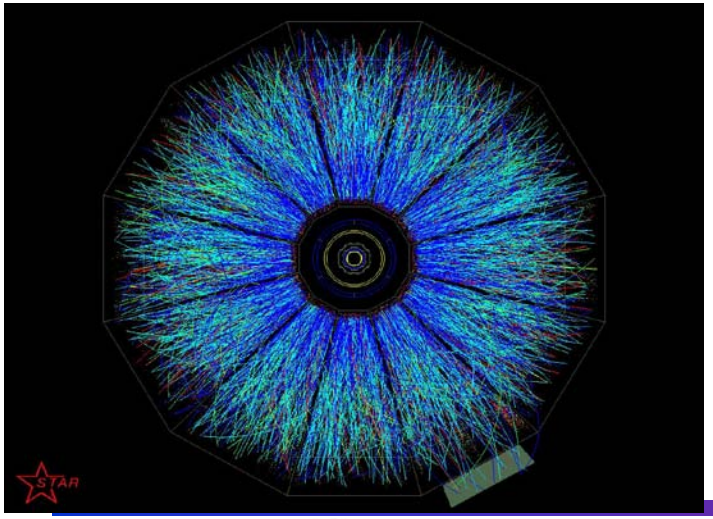
- **If aiming for outstanding performance, then cost of improvements is offset by long term benefits; i.e.,**
  - **Zero injuries, no shutdowns and no occurrences**
- **Events that caused shutdown at accelerators:**
  - **Fire**
  - **Electrical safety violation plus injury**
  - **Tritium release to environment**
  - **Unplanned radiation exposure**
  - **Electrical / mechanical failure**
- **Spending on ESH programs that demonstrate manager commitment, improve line accountability and increase worker involvement will eliminate these bad events**

STAR Goals and Performance, 2009 Run

W.B. Christie, BNL

Outline

- Summary of STAR Goals for RHIC Run 9
- Brief Summary of STAR Changes for Run 9
- STAR Performance in 500 GeV pp run
- STAR Performance in ongoing 200 GeV pp run
- Comments



DAQ1000 TPC Electronics Upgrade Complete

New TPC Low Voltage supplies installed

New TPC readout computers

New TPC FEEs, RDOs, cables, and fibers installed

Physics Run Summary

First 500 GeV Run a success:

- Established and calibrated local polarimetry for 500 GeV beams with the ZDC SMD
  - Achieved BUR goal of $10pb^{-1}$ sampled luminosity. Expect first RHIC W measurement
  - First chance to determine environment STAR will have to deal with for 500 GeV program. Collider backgrounds essentially non-existent. Charge loading in TPC significant. W triggers commissioned.
  - Low polarization, and hence missed FOM goal, makes W A_L extraction problematic

200 GeV Run a mixed bag:

-Portions of this data set, relevant as Heavy Ion references, will far surpass all earlier STAR pp data sets

-Due (primarily) to luminosity lifetime issues we fell short of our Spin sampled luminosity and FOM goals by factors of a few. Will need to complete in future run.

The first STAR pp2pp run was very successful.

Expanded STAR Capabilities:

- New, **fast TPC electronics** an unqualified success!
  - New capability allows STAR to simultaneously run **multiple physics programs** and **sample majority of delivered luminosity**.
- New TOF system (94/120 in Run 9, rest this summer) adds significant PID capability for STAR data sets. Large increase in Signal/Background for many analyses.

Summary Retreat Comments on RHIC Run 9.

1.) A key role of the **9 am meetings** during a run are to efficiently gather relevant status information and then effectively plan the strategy/plan to optimize the operation of the Collider and achieve the physics goals for the run.

- When it becomes clear that there is ambiguity about the values of critical collider parameters some mechanism outside of the 9 am meetings should be set up which studies/deliberates (argues) these issues and then delivers that best input possible to the 9 am mtgs. Time consuming debates in the 9 am mtg that don't lead to consensus on these issues should be avoided as much as possible.

2.) For Spin running **FOM should be the standard plot** by which progress in the run is measured.

- If polarization is unknown this will stress resolving the issues early.
- It will hopefully avoid C-AD deriving false comfort from the delivered Luminosity.

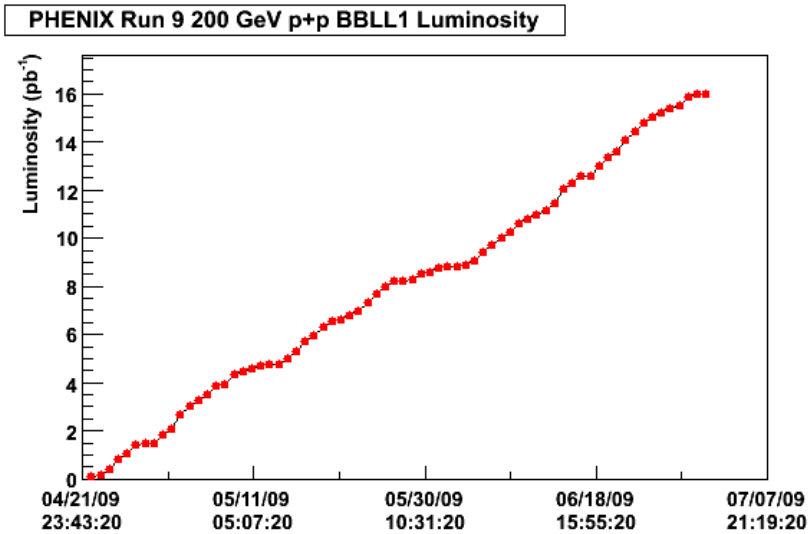
3.) I'd like to suggest that there be a clear distinction and demarcation during a given physics run when a transition is made between the mode where plans for that day's collider development are made at the 9 am meeting, and when the **development plans** must be at least scheduled as defined blocks of time at the Monday Scheduling mtg.

- Instances after this point where the Run Commissioner feels that extraordinary circumstances require immediate scheduling of development time would then be clearly announced at the 9 am mtg.

4.) Given this year's experience, it is important that C-AD's pre run estimated **collider performance estimates be as accurate as possible**.

5.) It seems that the Collider may need to devise more precise plans, pre run, on what level of tuning should/must be done and then maintained on critical collider parameters.

Phenix: 200 GeV pp in Run 9



Run 6 analysis was based on **6.5 pb^{-1}** with polarization ~0.56

Run 9 will be based on ~**16 pb^{-1}** (2.5 times Run 6) and about the same polarization

	Luminosity	Polarization	FOM
Goal	25 pb^{-1}	60%	3.24
Achieved	16 pb^{-1}	55%	1.46

Phenix: 500 GeV pp in Run 9

- First look at 500 GeV pp
- We must complete our muon arm upgrades to measure W in the forward region, but this run gave us a critical first look at backgrounds, luminosity, polarization
- Looked for W→e in central region
  - Calibrated and reconstructed *all* W triggers during the run in the "Fastrak" analysis

Phenix: Lessons learned

- Accelerator components need to be installed **before** the run begins, don't waste beam time trying to install them while running
- Coordinated planning with the experiments is necessary *before* the run
- Is there any way to imagine **ramp development** taking less cryo time?
- **More concentrated development and study periods** would allow better experimental operation—longer APEX periods less frequently?

What worked, what didn't

- Communication with MCR was very good
- PASS worked well
- Magnets worked very well
- Came to agree on backgrounds
- Eliminated "beam hours" reporting

- Weekdays were not productive
- Power dips wreak havoc
- Air Conditioning!
- High polarization is what will make this program live or die

Phenix: Conclusion

- Run 9 has some significant **firsts**
- The future will hold detector improvements (forward muon triggering, vertex detectors) that require
  - **More luminosity** in 200 GeV pp
  - **Higher polarization** in 500 GeV pp
- Our physics requires:
  - **Spin flipper** when systematic errors near statistical errors
  - **Shorter vertex** distribution to exploit the vertex detectors
- We cannot ignore **infrastructure improvements**

Feedback SP: 500 GeV run planning

- 500 GeV plan was too aggressive (unrealistic?)
  - develop uncharted **500 GeV** territory
  - commission a great deal of **new hardware**
    - Linac front end, upgraded polarimeters at 250 GeV, LLRF, 9 MHz
  - get **substantial physics data**

in 3 weeks!

Somewhat contradictory to previous two

  - power supplies failures hindered the effort (surprise!)
  - because of new run, confusion with polarimeters, unavailability of the Jet, attempts to commission 9 MHz, and time lost due to PS failures and glitches the need to understand the machine collided with the need to run physics
  - *substantial effect on schedule and smooth physics running*

SP: 200 GeV Run Machine Development

- Run timeline:
  - Fast transition from 500 GeV to 200 GeV
  - Luminosity lifetime was shorter than before
  - Machine performed worse than expected (limited by B-B?) but reasonably well comparatively to previous years (when running)
  - After 5 weeks of running, a week was taken for MD
  - Supported by experiments (not a scheduling issue)
- My impression: **MD was not well thought through**
  - $\beta^* = 70$ cm -> 80 cm -> 100 cm -> 70 cm
  - No substantial improvement right after studies
- Starting MD earlier in the run and distributing MD (8h a week), until understanding comes, might have worked better
  - distributed approach let one to analyze data, think, and regroup
  - keep more sustainable schedule

Hardware commissioning

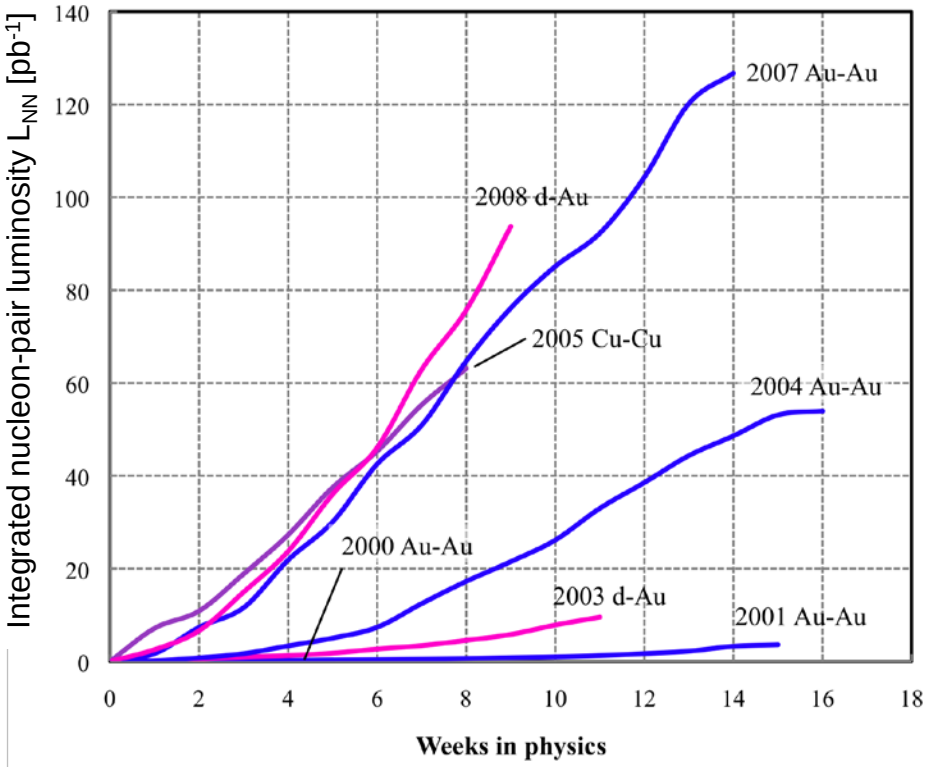
- Hardware installation/commissioning efforts can be underestimated, interfere with physics running.
  - CAD hardware installed and (being) commissioned
    - Linac front end (affected BLIP operations)
    - CNI polarimeters at 250 GeV (great deal of confusion)
    - LLRF (should have been spread over the run from the beginning)
    - 9 MHz (took too long although we knew it needs new LLRF)
    - spin flippers (commissioning took physics time, underestimated)
    - jump quads (extended a couple of maintenance days)
  - it takes time from physics, maintenance days, and APEX
  - *it is not easy to determine exact time needed, to be fair*
    - ***best approach in this case: new commissioning plan has to be re-submitted and approved (or not) by all involved parties***
  - Include additional time in Run plans - or expect physics losses

SP: Conclusions

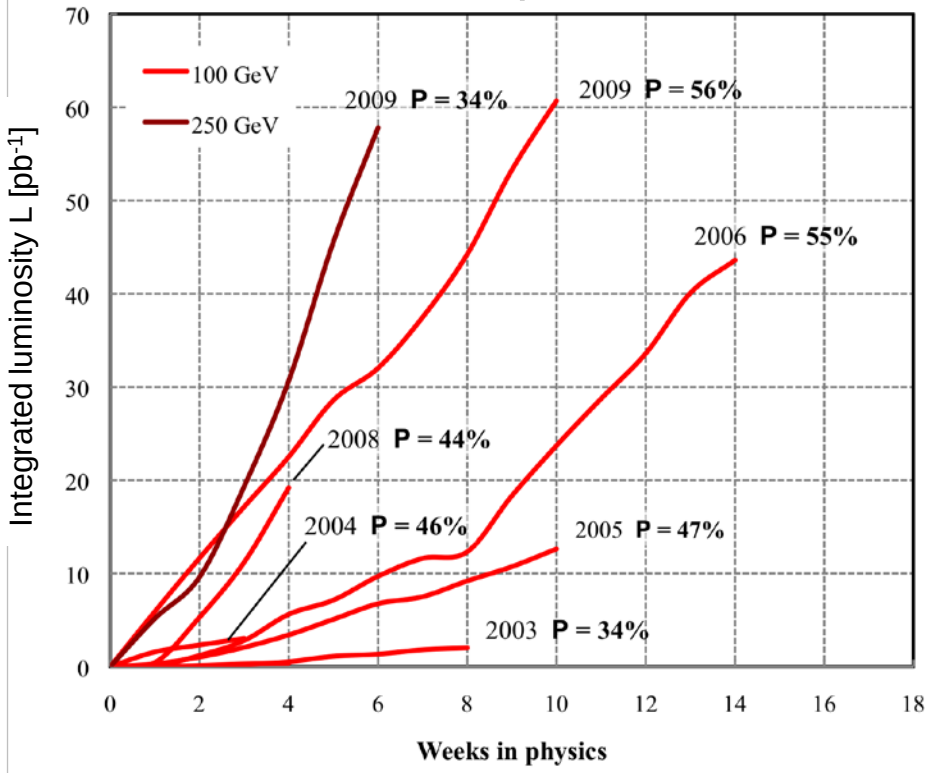
- A great overall job was done by everybody during this run
- We did not have major scheduling problems, IMHO.
- **I did not have outstanding problems communicating with anybody within expected personal deviations.**
- Reasonable level of communication was achieved. Number of **"stealth fighters"** progressively decreased towards the end of the run.
- New development runs, like the 500 GeV, should include scheduled MD time independently of physics program. MD should be distributed over the run.
- Either run plans have to include realistic estimate of commissioning/development efforts or expect lost physics time
- We have to do something with hardware reliability

Roser: Delivered Integrated Luminosity and Polarization

Heavy ion runs



Polarized proton runs



Nucleon-pair luminosity: luminosity calculated with nucleons of nuclei treated independently; allows comparison of luminosities of different species; appropriate quantity for comparison runs.

RHIC Facility Upgrade Plans

- **EBIS (~ 2011)** (low maintenance linac-based pre-injector; all species including U and polarized ^{3}He)
- **RHIC luminosity upgrade (~ 2012)**:
  [Au-Au: 40 × 10^{26} cm^{-2} s^{-1}(× 4); 500 GeV p-p: 1.5 × 10^{32} cm^{-2} s^{-1}]
  - **0.5 m β*** for Au – Au and p↑ – p↑ operation
  - **Stochastic cooling** of Au beams and **56 MHz storage rf** system in RHIC
- **Further luminosity upgrade for p↑ – p↑ operation (~ 2014)**:
  [500 GeV p-p: ~ 3× 10^{32} cm^{-2} s^{-1}]
  - 0.3 m β* for 500 GeV p↑ – p↑ operation (× 1.6)
  - Electron lens in RHIC for head-on beam-beam compensation (× 2)
- **Low energy** (√s=5…30 GeV) Au-Au collisions for critical point search
  - ~ 1…5 MeV electron cooling of Au beams at injection
- **eRHIC**: high luminosity (≥ 1 × 10^{33} cm^{-2} s^{-1}) e-A and pol. e-p collider using 4 GeV and later 10 - 30 GeV electron driver, based on an Energy Recovering Linac (ERL), and strong cooling of hadron beams (~ **2020**)
  Exploring gluons at extreme density.

RHIC Physics Plan 2009 - 2014

Fiscal Year	Colliding Beam Species/Energy	Comments
2009	500 GeV p+p	4 physics weeks to commission collisions, work on polarization &luminosity, obtain first W production signal to meet 2011 RIKEN milestone; STAR DAQ1000 fully operational
	200 GeV p+p	10 physics weeks for 200 GeV ALL measurements
2010	**Au + Au** at assorted low E	1st energy scan for critical point search – energies and focus signals to be decided; commission PHENIX VTX (at least prototype)
	200 GeV Au+Au	9-10 physics weeks with PHENIX HBD, STARDAQ1000 & TOF permits low-mass dilepton response map and 1st HI collision test of transverse stochastic cooling
2011	**200 GeV U+U**	1st U+U run with EBIS, to increase energy density coverage
	500 GeV p+p	1st long 500 GeV p+p run, with PHENIX muon trigger and STARFGT upgrades ~ 100 pb^{-1} recorded for substantial statistics on W production and ΔG measurements
2012	?	
	200 GeV Au+Au	Long run with full stochastic cooling, PHENIX VTX and prototype STARHFT installed; focus on RHIC-II goals: heavy flavor, γ-jet, quarkonium, multi-particle correlations
2013	**500 GeV p+p**	Reach ~ 300 $pb^{-1}$to address 2013 DOE performance milestone on W production
	200 GeV Au+Au 2nd low-E scan	To be determined from 1st low-E scan and 1st upgraded luminosity runs, progress on low-E e-cooling, and on installation of PHENIX FVTX and full STARHFT
2014	200 GeV Au+Au or 2nd low-E scan	Run option not chosen for 2013 run –low-E scan addresses 2015 DOE milestone on critical point, full-E run addresses 2014 (γ-jet) and 2016 (identified heavy flavor) milestones. Proof of principle test of coherent electron cooling.
	200 GeV p+p	Address 2015 DOE performance milestone on transverse SSA for γ-jet; reference data with new detector subsystems; test e-lenses for p+p beam-beam tune spread reduction

Schedule of Upgrades and R&D Projects

- To be completed in **FY2009** for **Run 10**:
  - Blue and Yellow longitudinal/vertical **stochastic cooling** installation/upgrade
  - AGS **L10** cavity replacement/upgrade
  - Remaining 3 **IPM**' s upgraded
  - Stripper in **AGS J5**
  - AGS horizontal **tune jump system** completion
  - RHIC **10 Hz orbit feedback test**
  - **Spin flipper test** (AC dipole 3-bump)
- To be completed in **FY2010** for **Run 11**:
  - **EBIS** (CD4 date: 9/2011)
  - **9 MHz** rf system
  - RHIC **10 Hz orbit feedback**
  - **Spin flipper complete**
  - **P□ LEBT** upgrade
  - RHIC polarimetry upgrade (?)
  - Polarized source upgrade (new solenoid) (maybe in FY2011?)
  - Beam dump upgrade (?)
  - Collimator upgrade (?)
  - **Gun-to-dump test and completion of ERL**

Schedule of Upgrades and R&D Projects

- To be completed in **FY2011** for **Run 12**:
  - **56 MHz** superconducting rf system
  - Blue and Yellow **horizontal stochastic cooling** installation*
  - **Electron lenses** in blue and yellow ring*
  - **ERL commissioning**
- To be completed in **FY2012** for **Run 13**:
  - **Transverse damper** for transition (?) [modeled on stochastic cooling?]
- To be completed in **FY2013** for **Run 14**:
  - **Low energy electron cooling** in RHIC (?)
  - **Coherent electron cooling test** using ERL (?)

* ARRA projects