# RHIC pp RUN5 Performance

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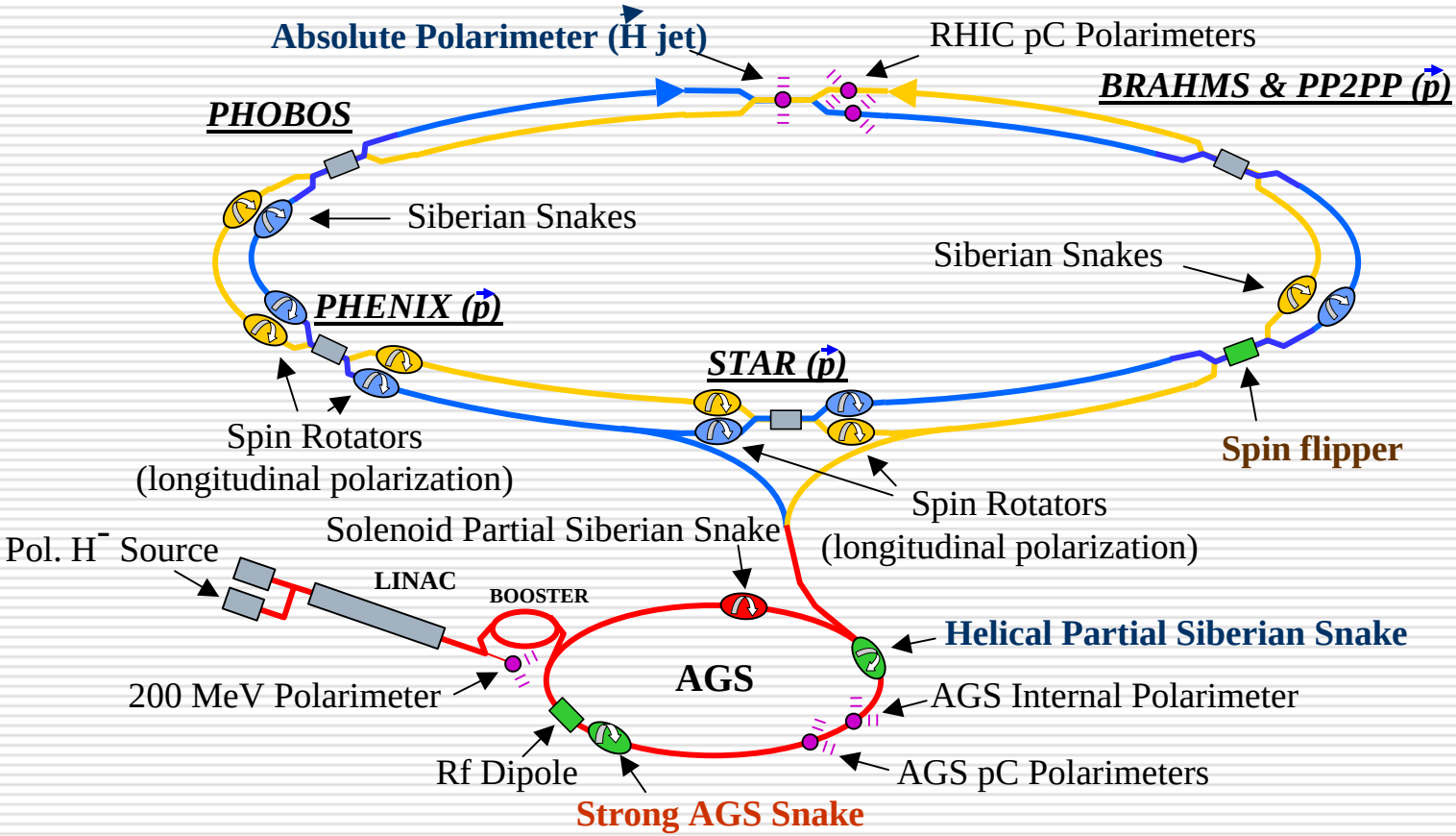
# Outline

- The Goal of pp RUN5
- The performance of RUN5
  - $\sqrt{s}$ = 200 GeV program
  - $\sqrt{s}$ = 410 GeV development
  - AGS cold snake development
- Summary

# RHIC pp accelerator complex




- Installed and commissioned during FY04 run
- installed and commissioned during FY05 run

# Goal of RHIC pp Run 05

- Provide collisions at $\sqrt{s}$ = 200 GeV for experiments STAR, PHENIX and Brahms

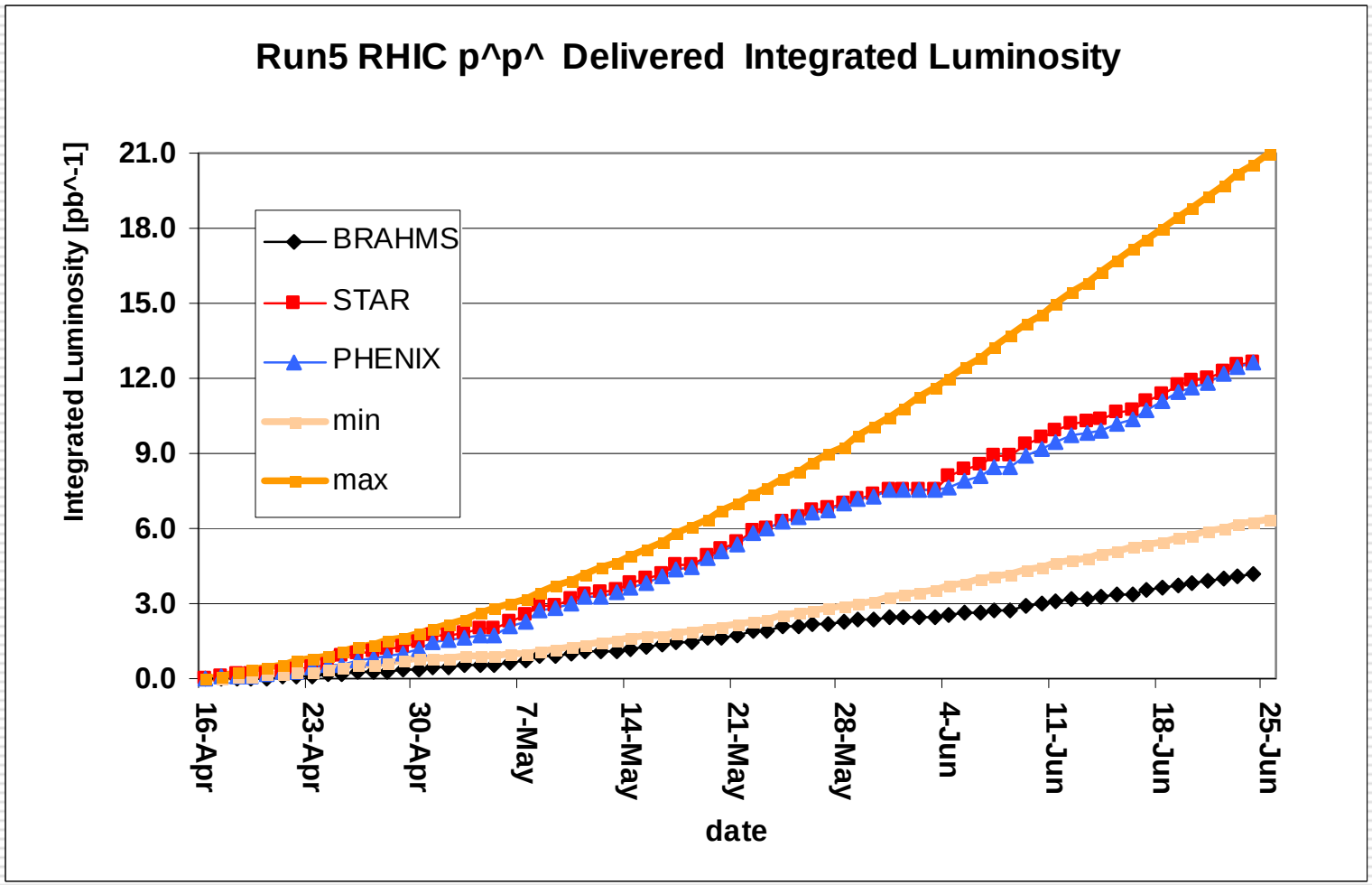
| | Bunch intensity $X10^{11}$ | # of Bunches | $L_{peak}$ $X10^{30}$ $cm^{-2}s^{-1}$ | $L_{store}$ $X10^{30}$ $cm^{-2}s^{-1}$ | $L_{week}$ $pb^{-1}$ | Time in store | Pol at Store Blue/Yellow |
|---|---|---|---|---|---|---|---|
| FY05 min | 0.7 | 56 | 5.4 | 4.0 | 0.9 | 40% | 40% |
| FY05 max | 1.0 | 79 | 16 | 8.2 | 3.0 | 50% | 45% |

Projection

- Explore the polarized proton acceleration beyond 100 GeV beam energy
  - Evaluate the spin dynamics beyond 100 GeV beam energy
  - Provide guidance of re-alignment during the summer shutdown

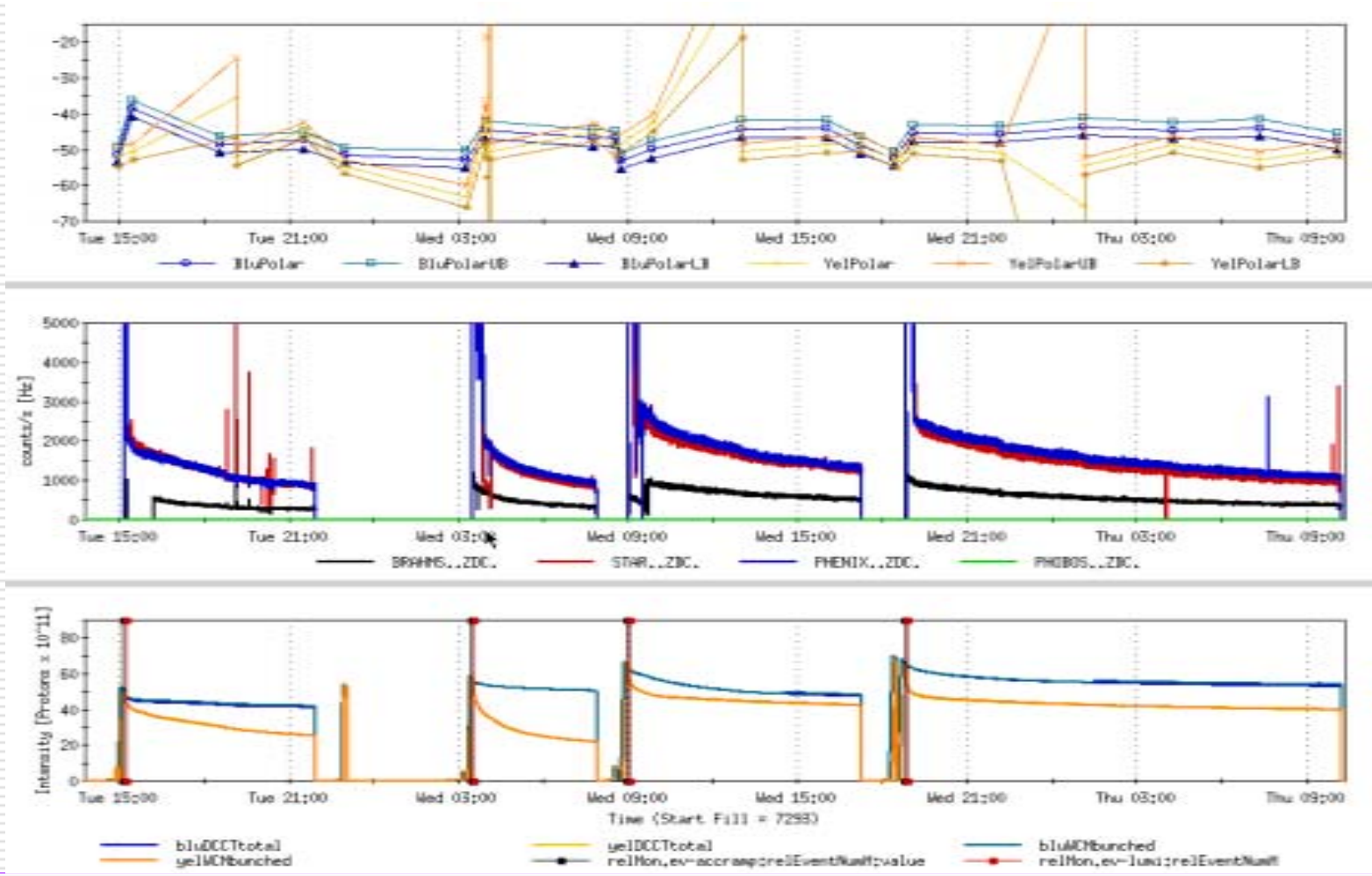
# RHIC pp performance: Luminosity (longitudinal)

- Provided a total of 12.6 $pb^{-1}$ luminosity with longitudinal polarization at STAR and PHENIX

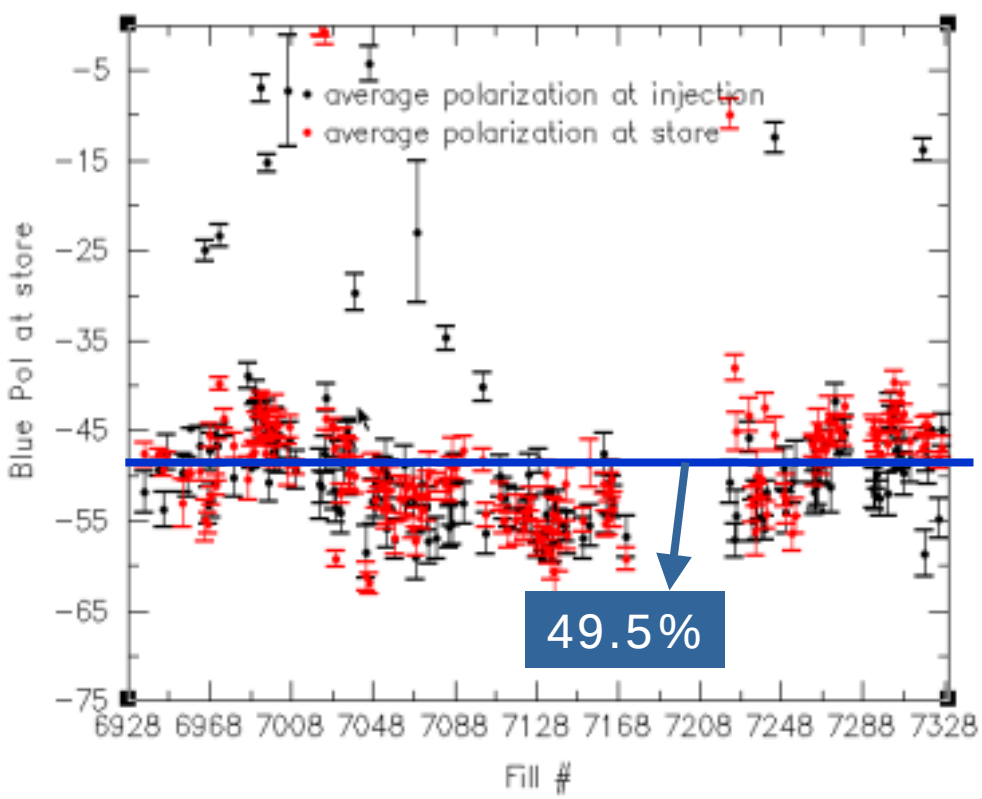


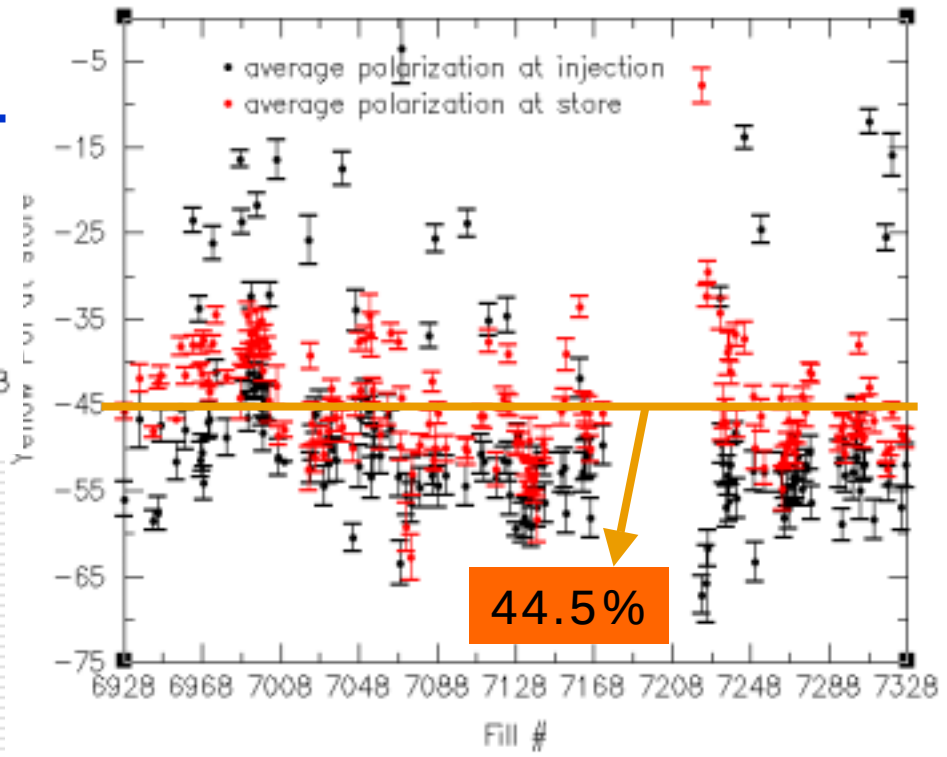
# RHIC pp performance: Luminosity (transverse)

- Provided a total of 425nb$^{-1}$ luminosity with transverse polarization to STAR and PHENIX, out of which 160 nb$^{-1}$ was recorded by experiments



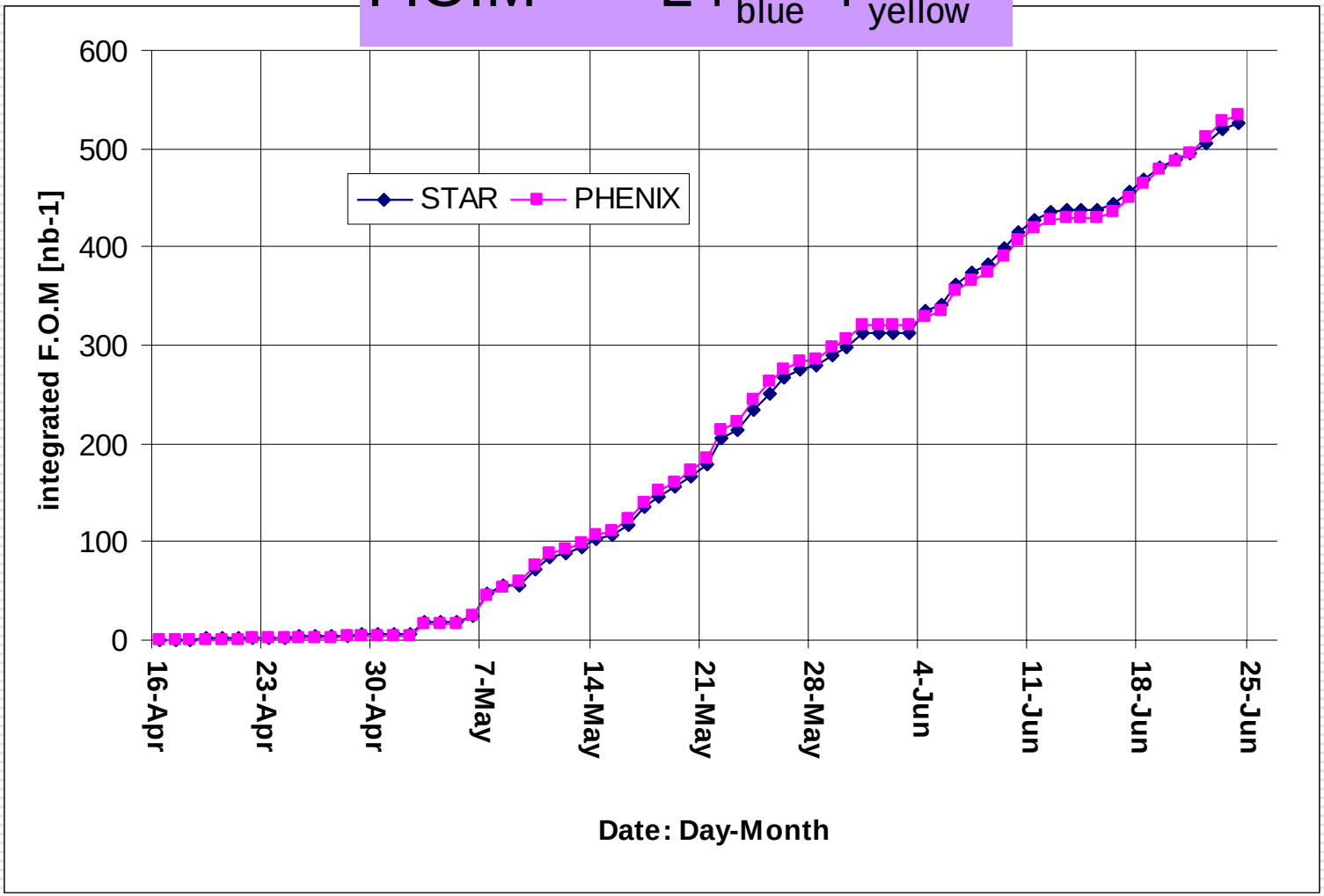
# RHIC pp performance: average polarization at store



# RHIC pp performance: Integrated F.O.M

$$F.O.M = L\, P_{blue}^{2}\, P_{yellow}^{2}$$

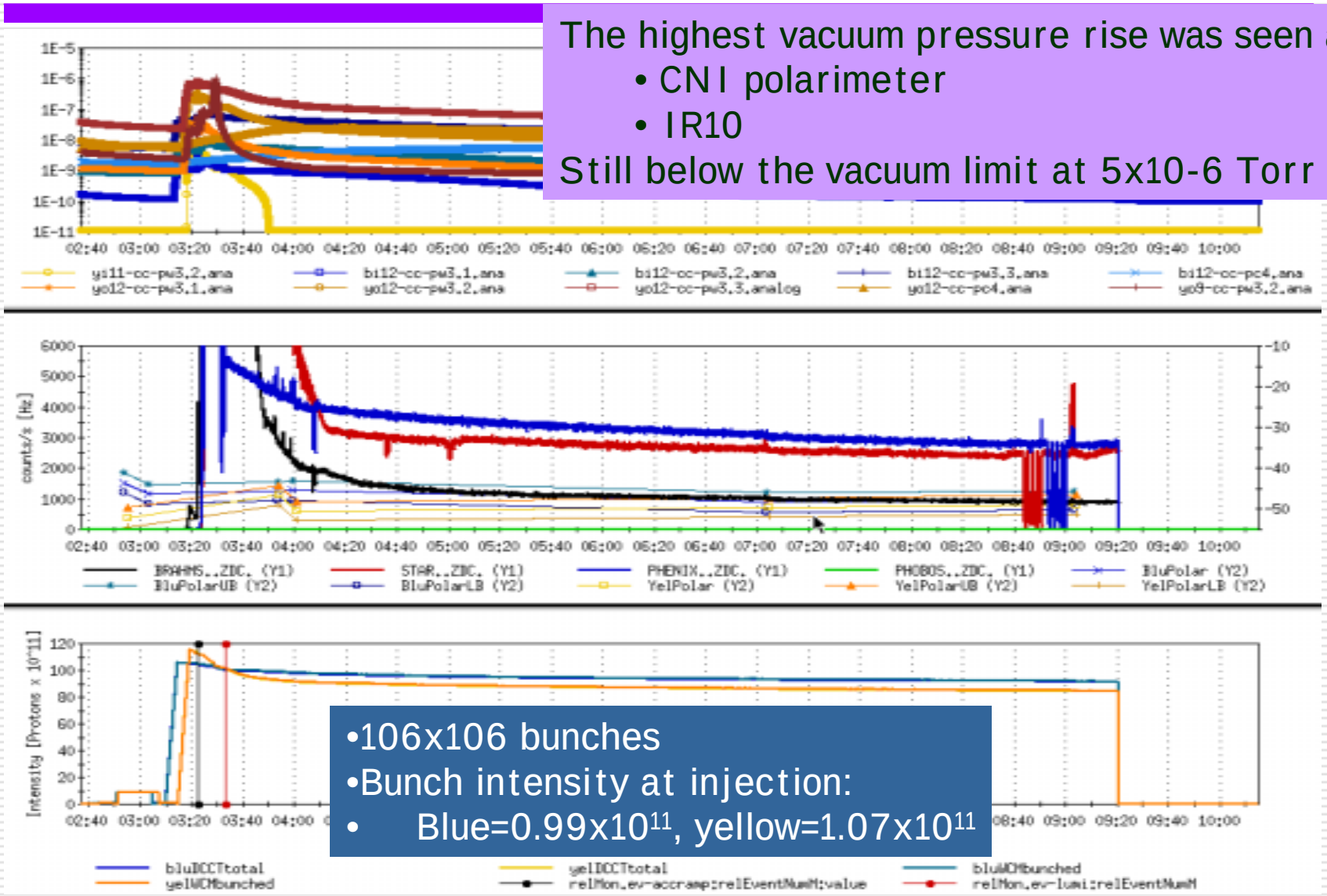


# RHIC pp Run05 Performance: achieved total intensity

The highest vacuum pressure rise was seen at

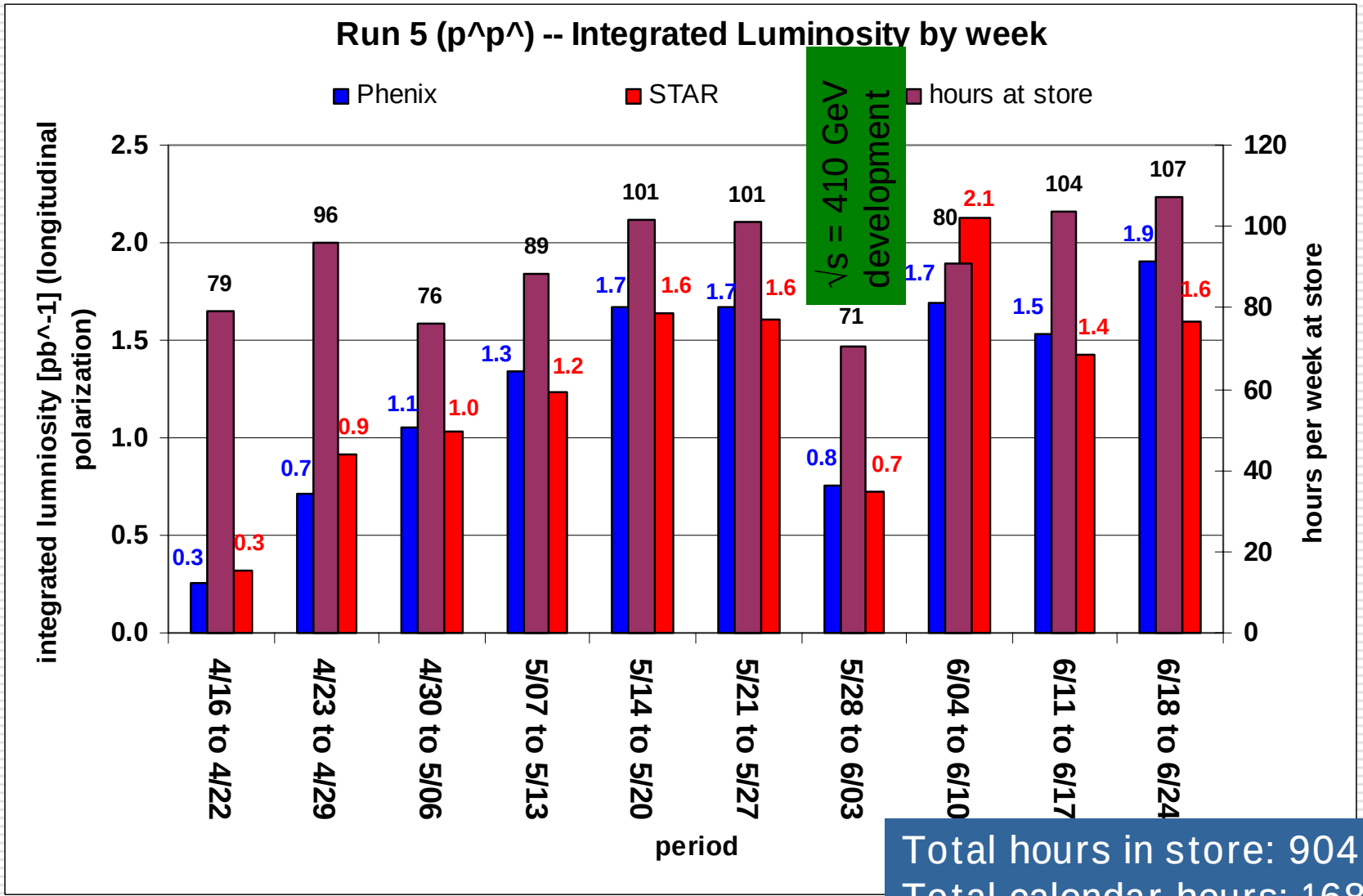
- CNI polarimeter
- IR10

Still below the vacuum limit at 5x10-6 Torr




- 106x106 bunches
- Bunch intensity at injection:
- Blue=0.99x10$^{11}$, yellow=1.07x10$^{11}$

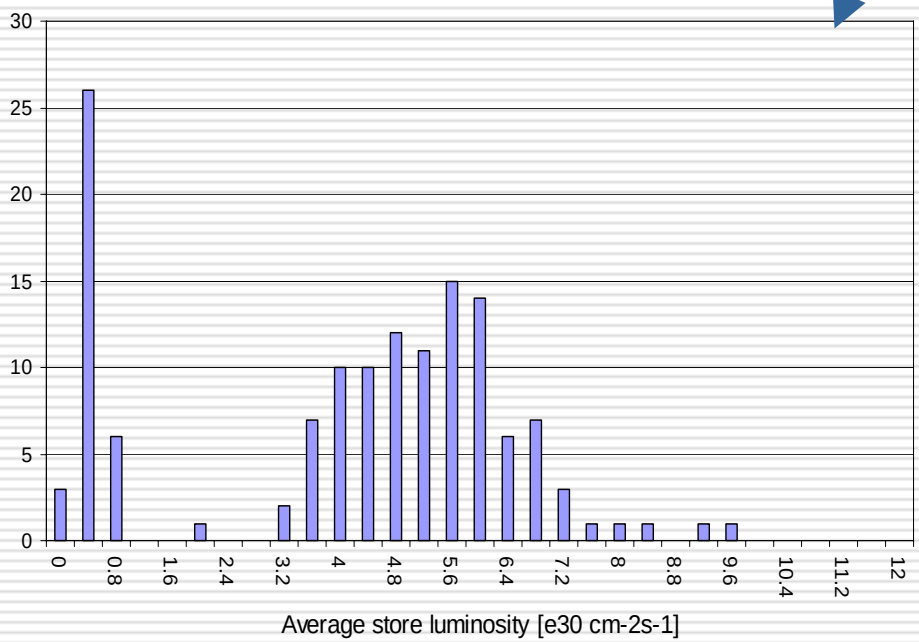
# RHIC pp Performance: machine weekly performance

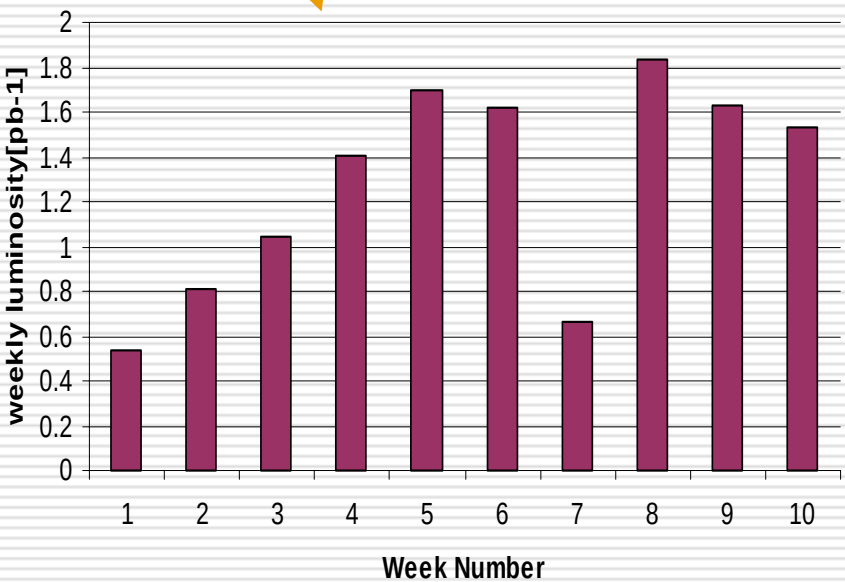



Total hours in store: 904
Total calendar hours: 1680
Total hour for 205 GeV: 72

# RHIC pp Run05 performance: achieved machine parameters

| | Bunch intensity $X10^{11}$ | # of Bunches | $L_{peak}$ $X10^{30}$ $cm^{-2}s^{-1}$ | $L_{store}$ $X10^{30}$ $cm^{-2}s^{-1}$ | $L_{week}$ $pb^{-1}$ | Beta* at IP6/8/2 [m] | Avg. Pol. at store Blue/Yellow |
|---|---|---|---|---|---|---|---|
| FY04 | 0.7 | 56 | 5.4 | 4.0 | -- | 1/1/3 | 40.0/40.0 |
| FY05 | 0.9 | 106 | 10.3 | 7.6 | 1.83 | 1/1/3 | 49.5/44.5 |

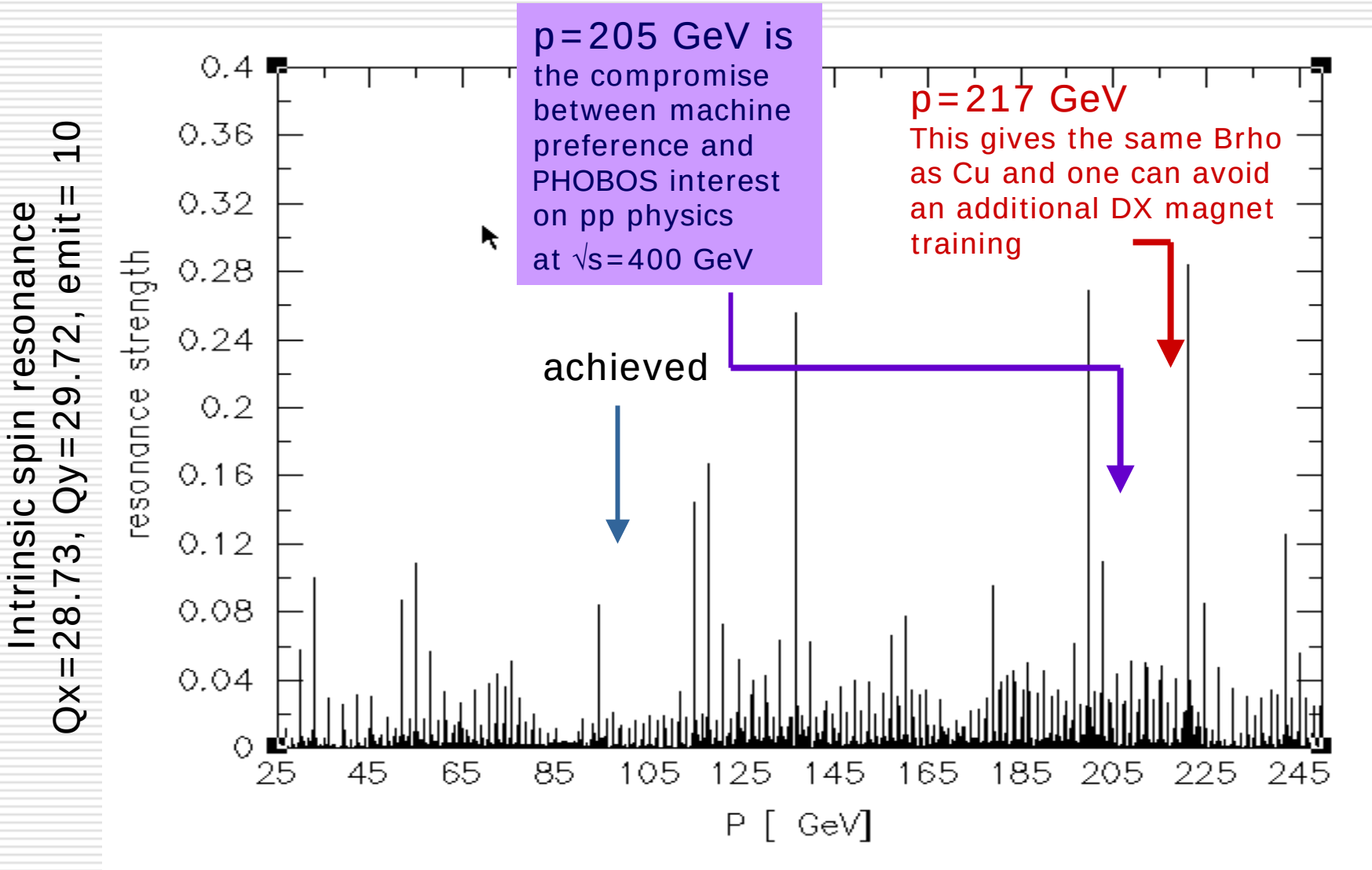


# RHIC pp Run05 performance: achieved physics performance

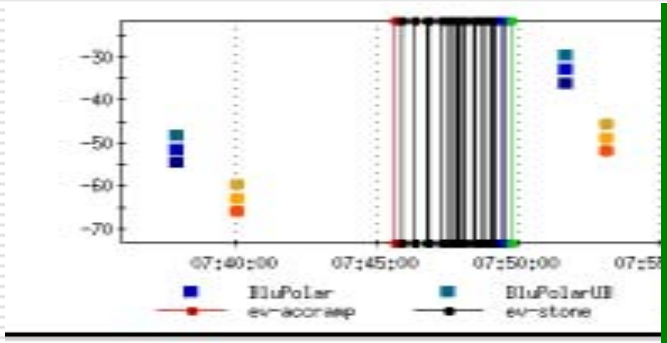
| | Time in store | Pol at Store Blue/Yellow | $L_{total}$ $pb^{-1}$ | *F.O.M* $nb^{-1}$ |
|---|---|---|---|---|
| FY05 Longitudinal | 56% | 49.5/44.5 | 12.6 | 534.8 |
| FY05 Vertical | -- | 45.5/48.2 | 0.425 | 21.3 |

# RHIC pp √s = 410 GeV development: Why 410 GeV?

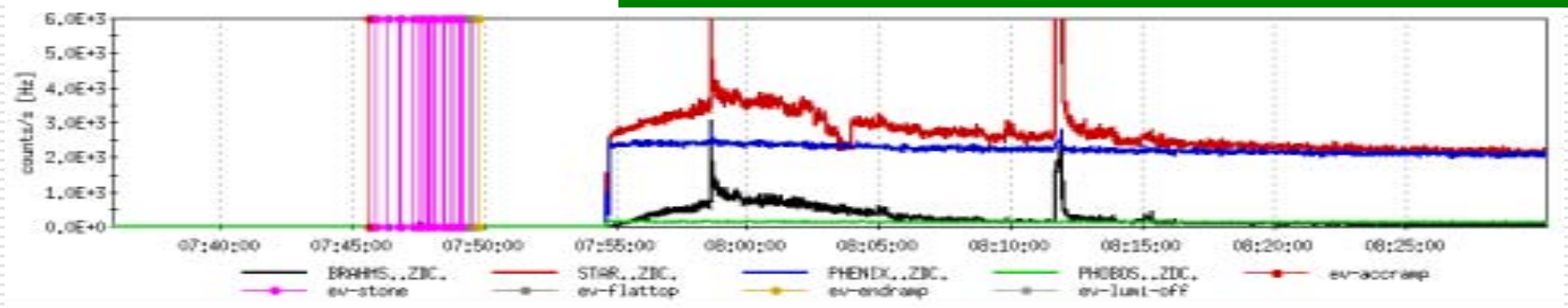


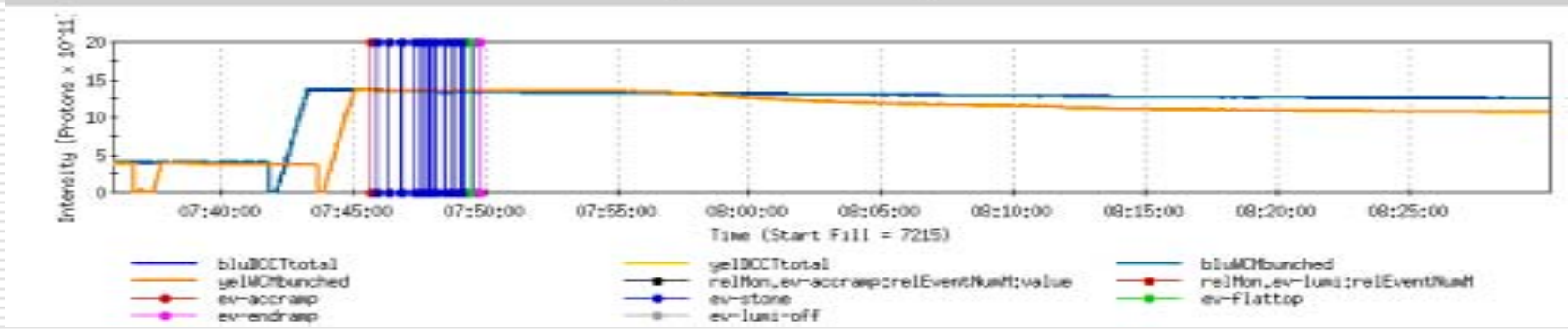
# RHIC pp √s = 410 GeV development

- Beams were accelerated and collided at √s = 410 GeV



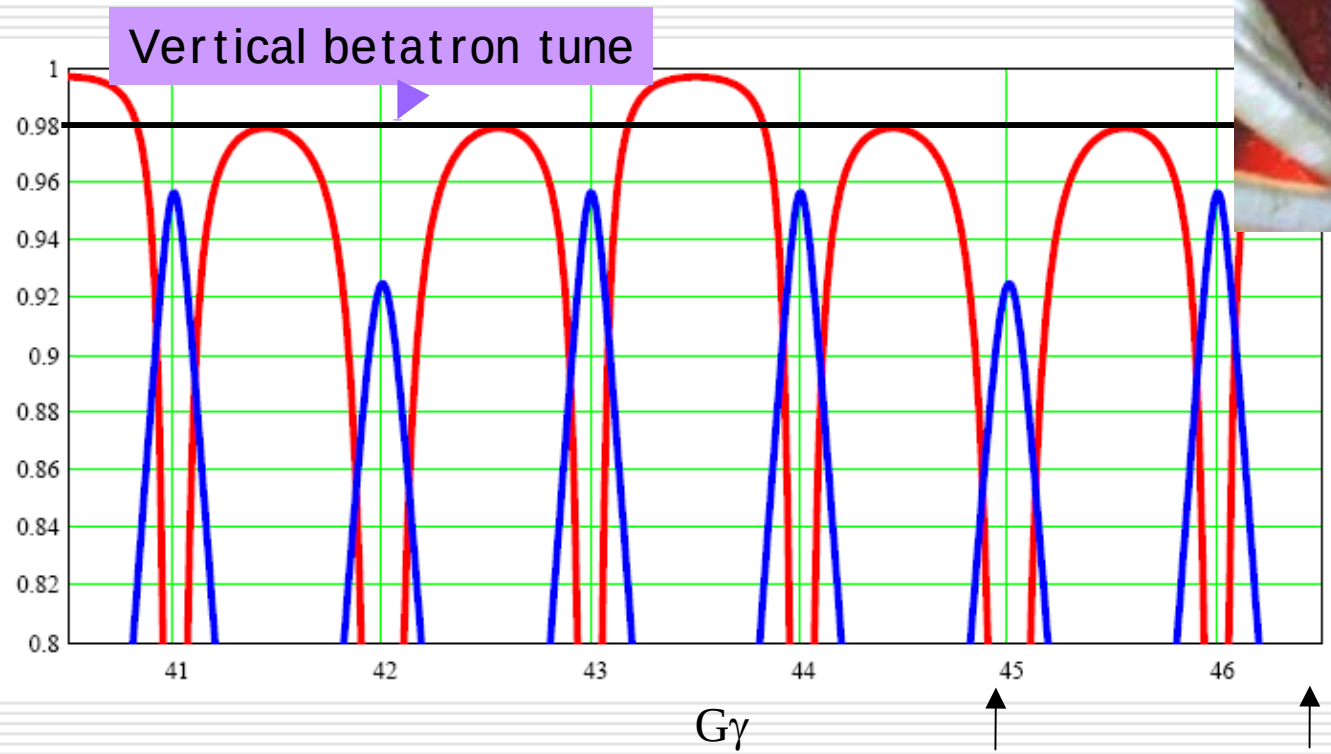

- 30% polarization was measured in both rings at 205 GeV per beam
- Two polarization ramp measurements shows an increase of 1mm vertical rms in yellow decreased the polarization transmission efficiency by close to a factor of 2

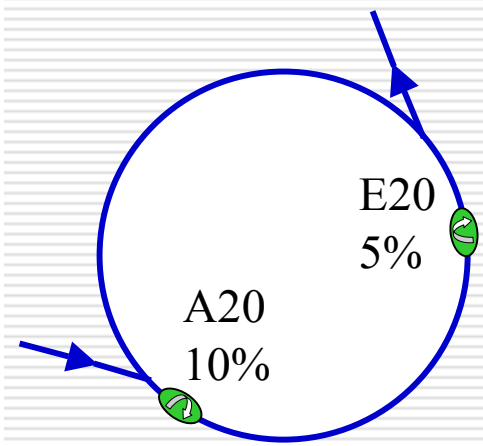


# AGS cold snake development

## Two partial snake scenario






36+ν intrinsic resonance

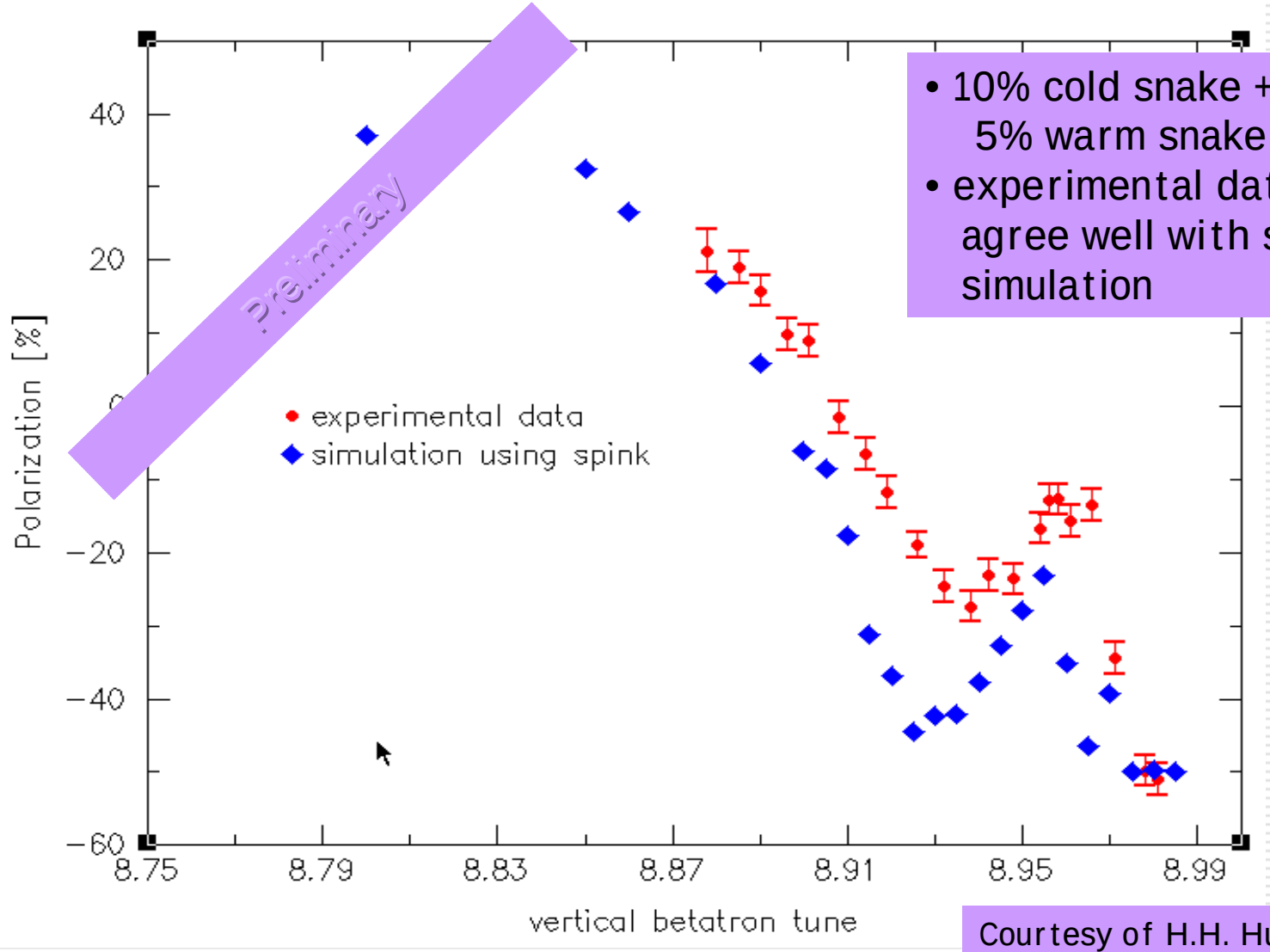
Extraction

Vertical component of stable spin

Spin tune

Courtesy of T. Roser

# AGS cold snake development: tune scan at 36+Qy




- 10% cold snake + 5% warm snake
- experimental data agree well with spin simulation

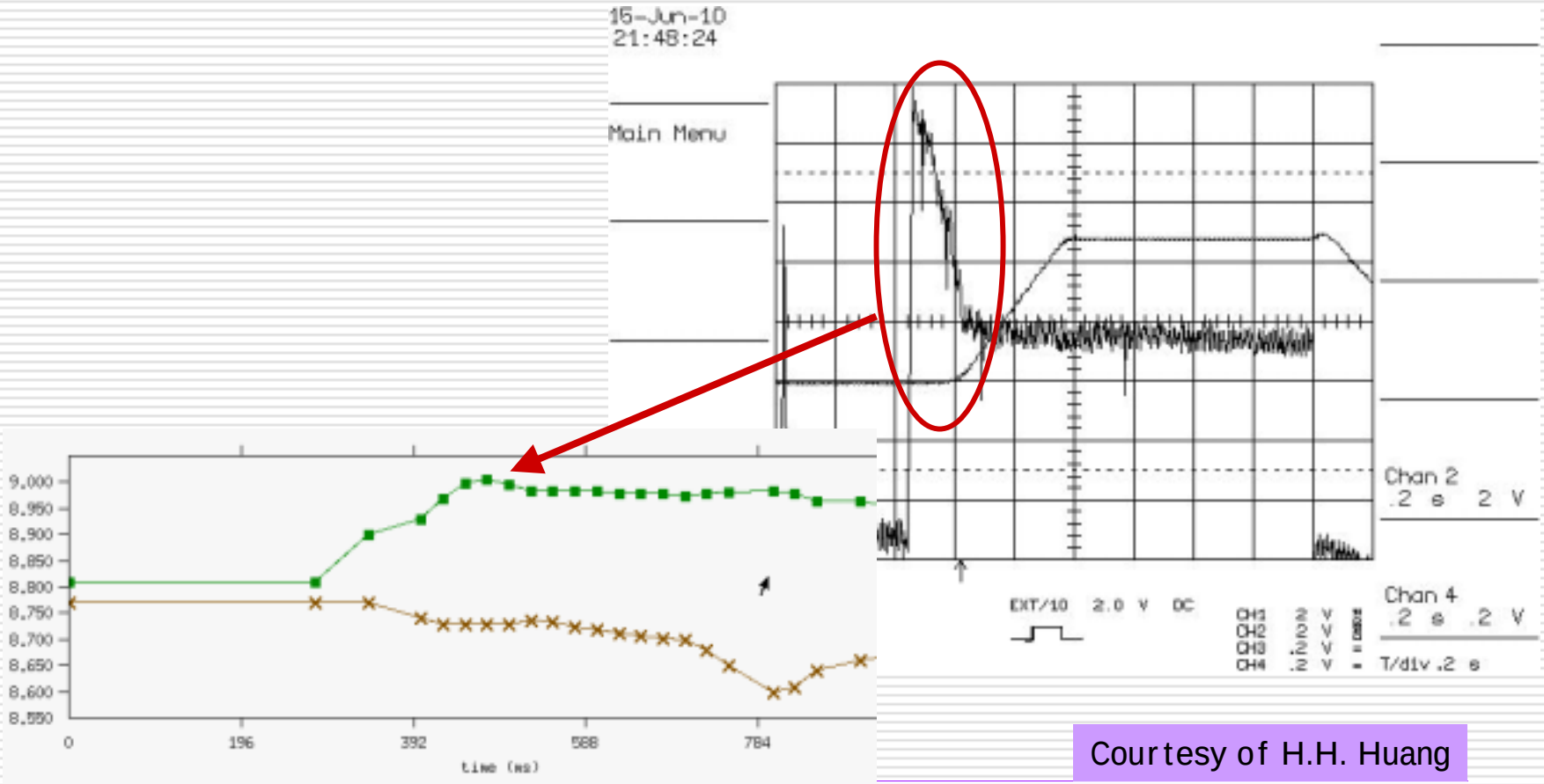
Courtesy of H.H. Huang

# Summary of AGS cold snake development

- 3 Tesla superconducting helical dipole snake installed in AGS
- Stable operation using four cryo-coolers
- Quickly reached performance of AGS without cold snake
  - Beam horizontal emittance is significantly smaller
- Maximum measured polarization:
  - ~ 56% with $0.3 \times 10^{11}$ protons per bunch
- Detailed studies show expected spin behavior
- Unexpected beam intensity dependence of polarization
  - Highest bunch intensity achieved $1.0 \times 10^{11}$ with measured polarization of ~ 41%
  - Investigate various reasons
    - Tune spread
    - Insufficient correction of $9^{th}$ harmonic of the vertical orbit
    - polarimeter saturation
    - Others ...

# Summary of AGS cold snake development

- Several scenarios of optics correction of lattice distortions by the helical snake(s) were successfully tested. Possibly more corrections are needed to minimize the beam loss at injection which is the dominant factor in the available bunch intensity




Courtesy of H.H. Huang

# Summary

- RHIC performed well. The total delivered luminosity is well within the C-AD projection. The achieved polarization is above the projection thanks to the great performance of the polarized proton source and the injectors.

- 410 GeV development demonstrated the depolarization resonance is sensitive to the orbit distortion. Machine re-alignment will be arranged during the shutdown

- The AGS cold snake development has achieved similar performance as the current AGS pp operational setup in a much shorter setup time. The results have proved the principle and are very promising. Further studies and investigations are ongoing to understand the unexpected polarization dependence on the beam intensity observed during the commissioning.

  Next year, we plan to start with the two snake setup and continue to improve the AGS performance with cold snake

# Acknowledgement

L. Ahrens, I.G. Alekseev, J. Alessi, J. Beebe-Wang, M. Blaskiewicz, A. Bravar, J.M. Brennan, D. Bruno. G. Bunce, J. Butler, P. Cameron, R. Connolly, J. Delong, T. D'Ottavio, A. Drees, W. Fischer, G. Ganetis, C. Gardner, J. Glenn, T. Hayes, H-C. Hseuh. H. Huang, P. Ingrassia, U. Iriso-Ariz, O. Jinnouchi, J. Laster, R. Lee, A. Luccio, Y. Luo, W.W. MacKay, Y. Makdisi, G. Marr, A. Marusic, G. McIntyre, R. Michnoff, C. Montag, J. Morris, A. Nicoletti, P. Oddo, B. Oerter, J. Piacentino, F. Pilat, V. Ptitsyn, T. Roser, T. Satogata, K. Smith, D.N. Svirida, S. Tepikian, R. Tomas, D. Trbojevic, N. Tsoupas, J. Tuozzolo, K. Vetter, M. Milinski. A. Zaltsman, A. Zelinski, K. Zeno, S.Y. Zhang