Physics with Tagged Forward Protons at STAR

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For The STAR Collaboration

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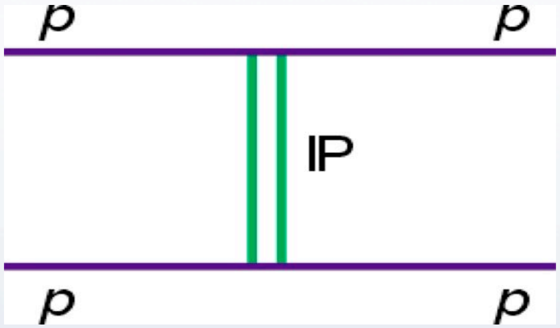
Outline

- Physics Program and Motivation
  - Physics with Tagged Forward Protons and the STAR detector
- Very-Forward Detectors at STAR (RHIC) - Roman Pots at STAR
  - Experimental Technique
  - Experimental Setup and Data Collection during RHIC 2009 Run (Run09)
- Detector Performance during Run09
  - Silicon Detector Efficiency
- Elastic event selection and preliminary single spin asymmetry result

Physics with Tagged Forward Protons and the STAR Detector

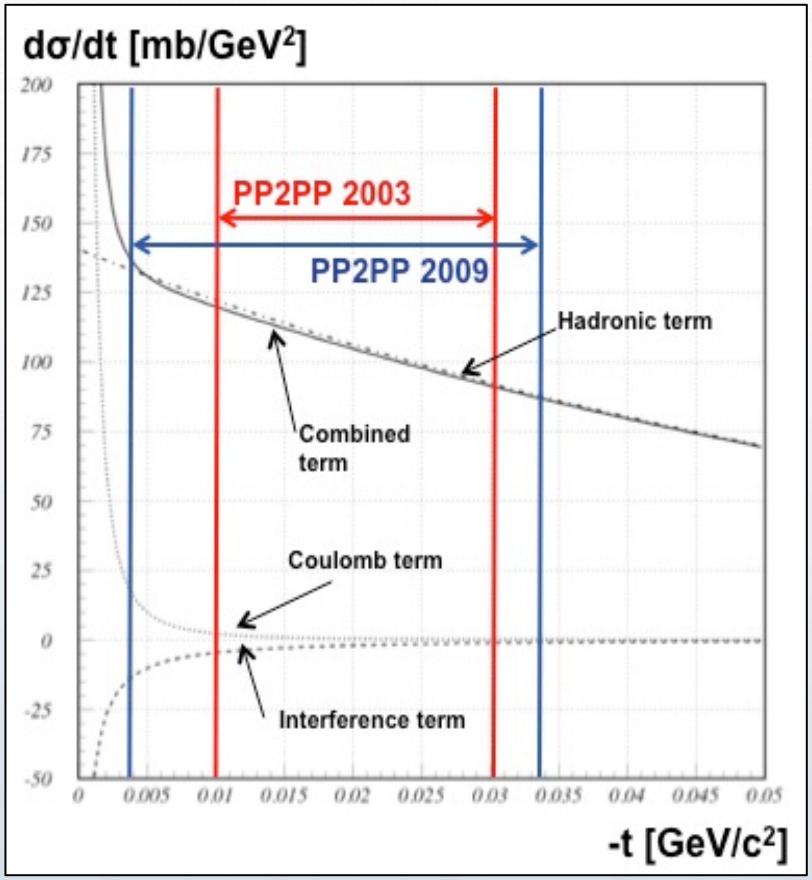
Elastic Scattering

p + *p* -> *p* + *p*



Detect protons in the very forward direction using Roman Pots

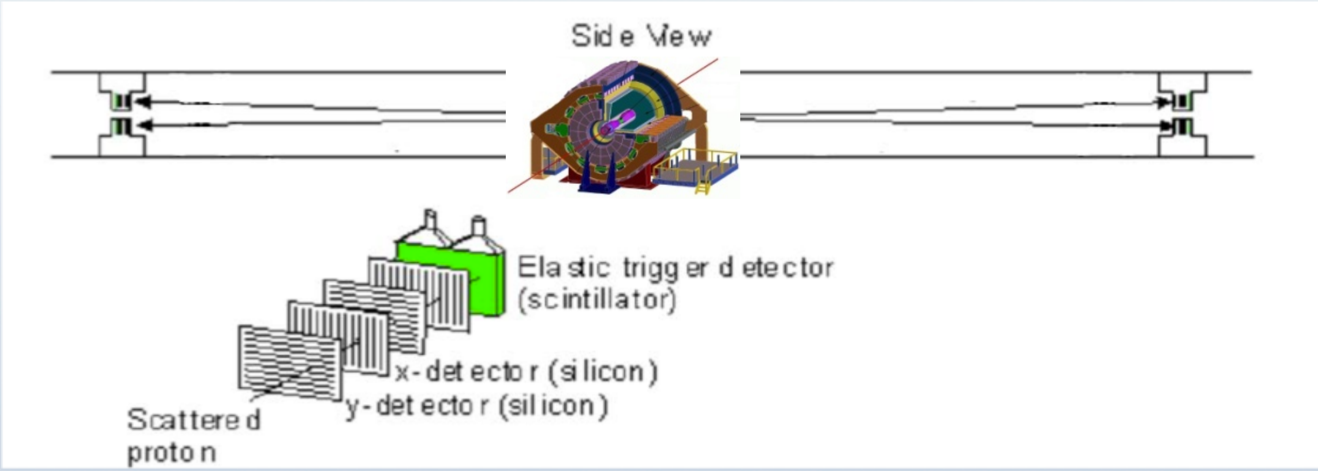
- In elastic scattering protons remain intact.
- A *Pomeron* (P) is exchanged.
- *Pomeron* exchange in pQCD consists of a color singlet combination of gluons.



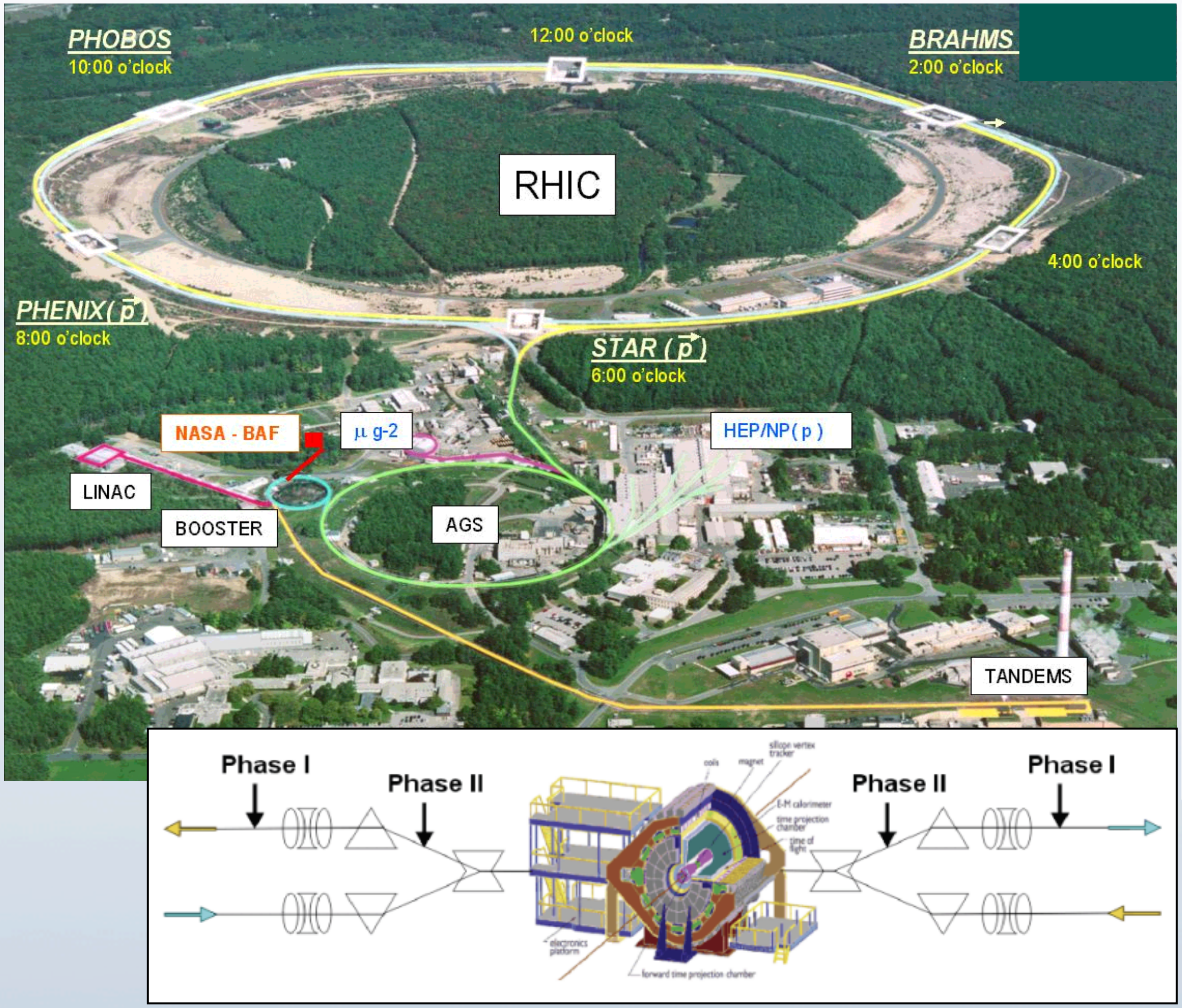
- Accessible ***t*-region**: **Coulomb Nuclear Interference region.**

Experimental Technique

- Elastically scattered protons have very small scattering angles Θ^*, hence **beam transport magnets** determine their trajectory.
- The optimal position of the detectors is **where scattered protons are well separated from beam protons.**
- Need Roman Pot to detect scattered protons **close to the beam** without breaking accelerator vacuum.
- Beam transport equations **relate measured position at the detector to the scattering angle.**



Data Collection during Run09



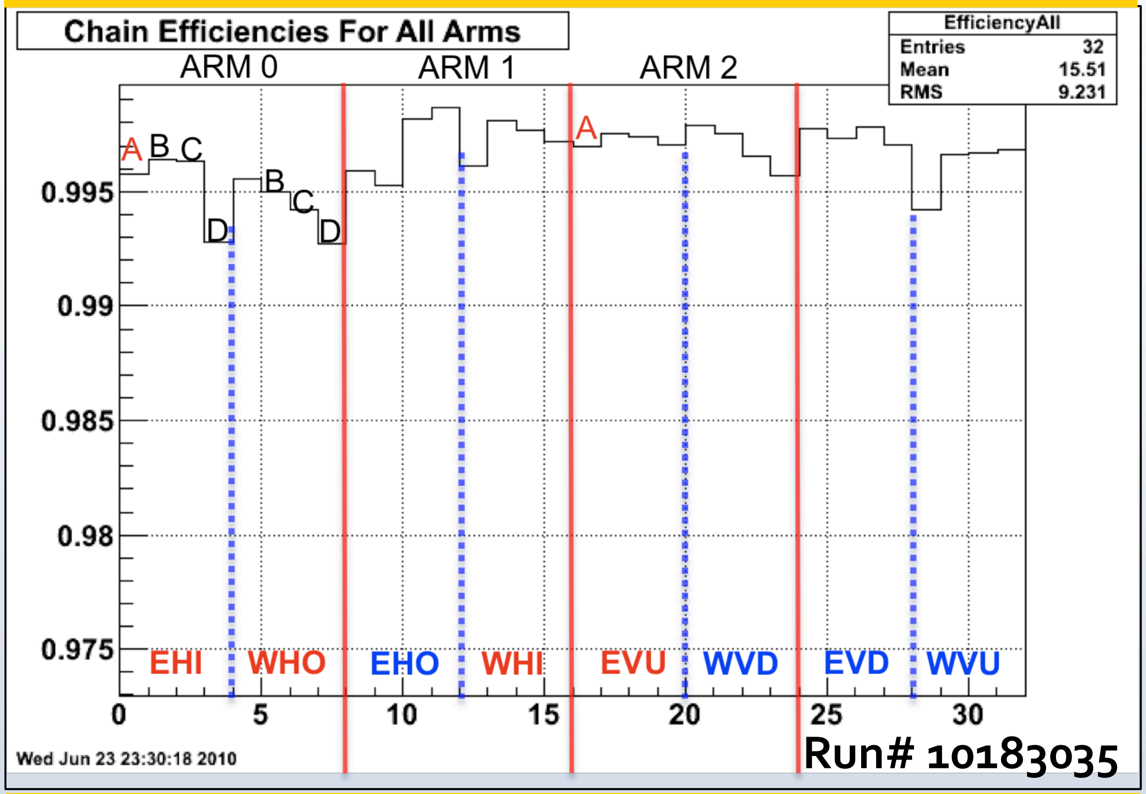
Run Conditions:

- Proton beam **momentum** = 100 GeV/c
- Beam **Polarization** (average for 4 fills):
  - $P_B \sim 0.60$ $P_Y \sim 0.62$
- **Luminosity** ~ $1.5 \cdot 10^{29}$ cm^{-2} sec^{-1}
- Good data sample (see co-linearity plots on page 7)
- **40 hrs of data taking**
- 35M Elastic Triggers Recorded (Elastic trigger using **Roman Pot co-linearity)**

Silicon Detector Efficiency

- Exclude all edge clusters and all identified hot/dead Si strips.
  - Not critical due to redundancy: 2 Si planes for each coordinate (x,y)
- Only ~20 dead/noisy strips per ~14000 active strips (Active area limited by acceptance)
- **Overall plane efficiency above 99%.**

After excluding clusters (**3 strips from the edge)** + all **hot/dead** strips



RP Labeling Scheme:
- **E** – East, **W** – West, **H** – Horizontal, **V** – Vertical, **I** – Inner, **O** – Outer

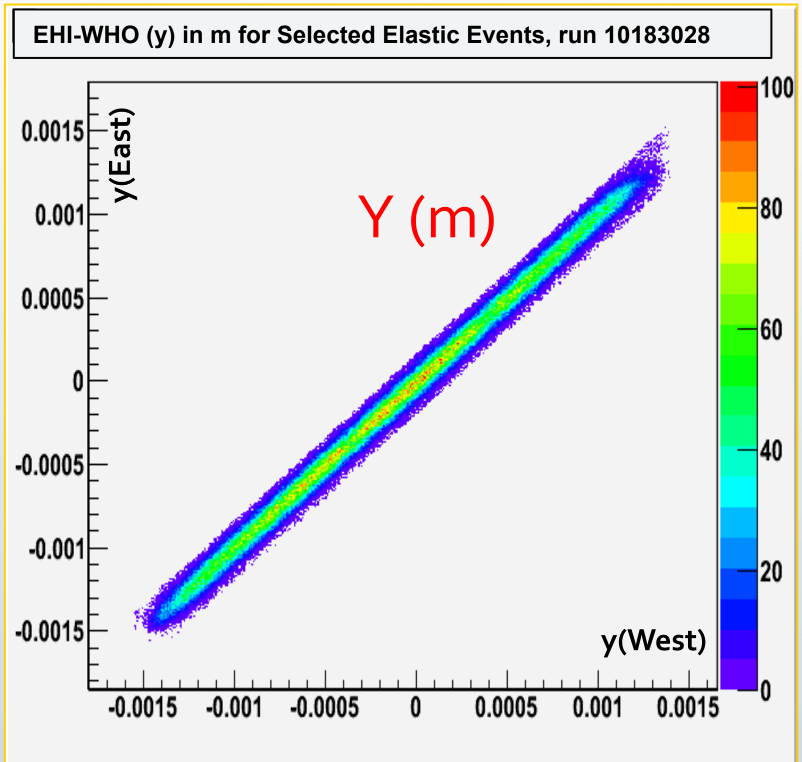
Silicone Detector Planes:
- A, B, C, D

Selected Elastic Events

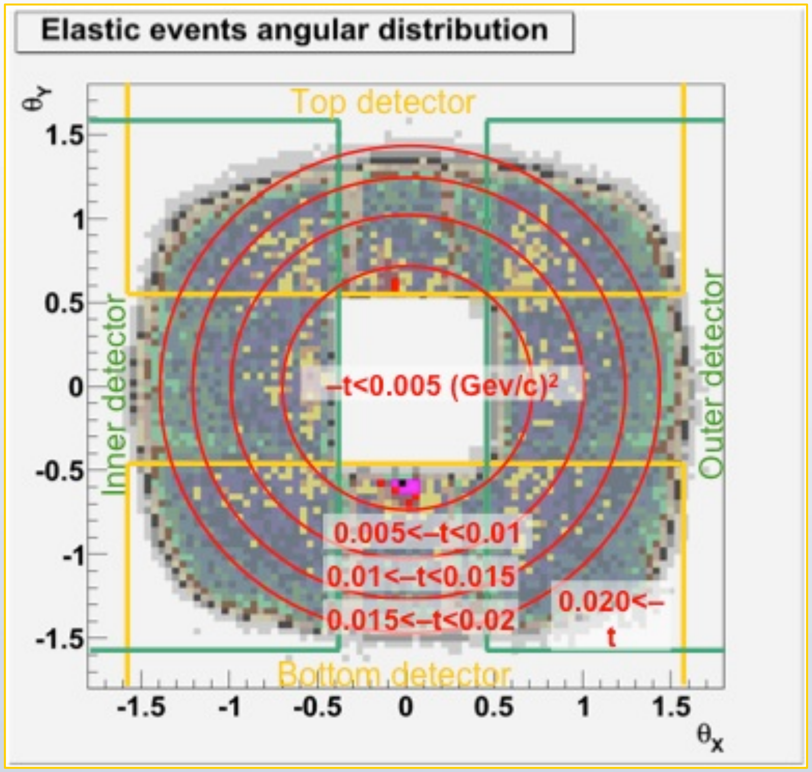
Very good data sample:

Out of ~35M of elastic triggers recorded during RUN09, ~20M were selected after all cuts have been applied

(for more info look at: **https://www.congressa.de/SPIN2010/upload/pp2pp-spin2010-a.ppt**).



East-West Collinearity for Selected Elastic Events with elastic trigger condition and after all cuts applied



Single spin asymmetry (analyzing power) A_N

- The interference between the hadronic non-flip and electromagnetic spin-flip amplitudes gives rise to the single spin asymmetry in the CNI region.

$$A_N = \frac{\sigma^{\Uparrow} - \sigma^{\Downarrow}}{\sigma^{\Uparrow} + \sigma^{\Downarrow}}$$

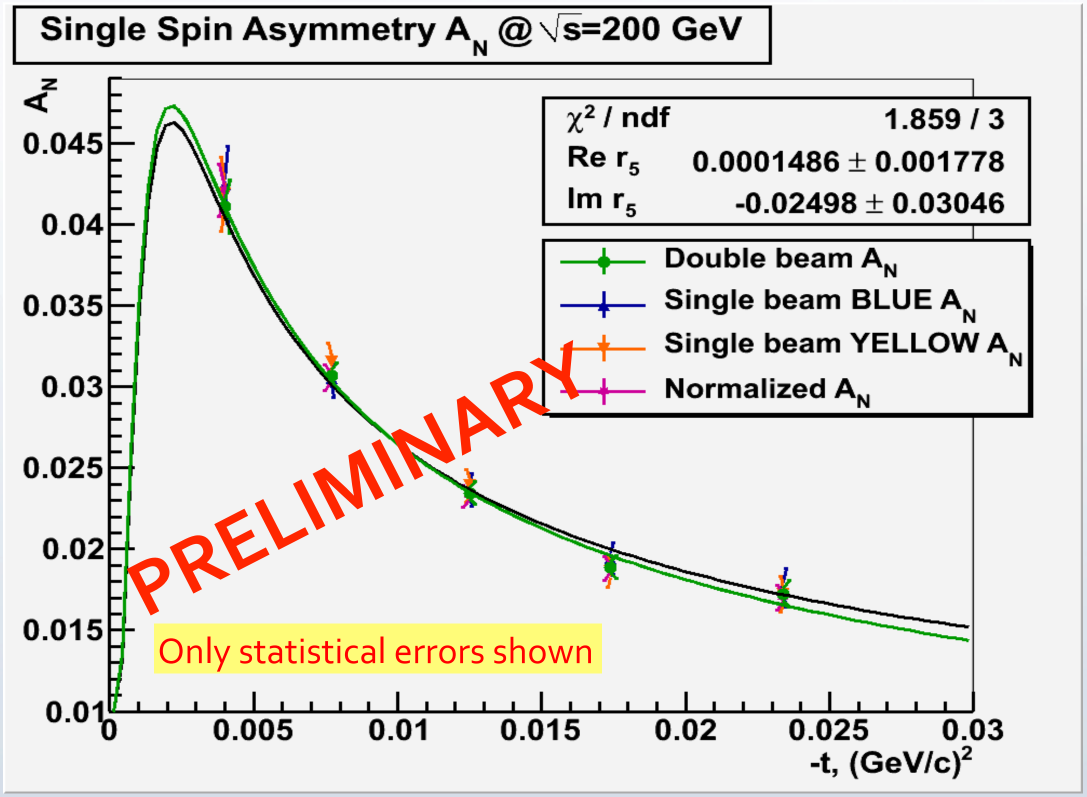
$$A_N(t) \approx \frac{\mathrm{Im}\left(\phi_{flip}^{em*}\phi_{non-flip}^{had} + \phi_{flip}^{had*}\phi_{non-flip}^{em}\right)}{d\sigma/dt}$$

- In the absence of hadronic spin flip A_N can be calculated (From known total cross section, ratio of real to imaginary parts of nuclear amplitude and QED).

- Measure $\boldsymbol{A_N}$ and its **|*t*|-dependence** to probe the contribution from the interference of hadronic spin-flip and electromagnetic amplitudes.

Single spin asymmetry A_N

- We have all bunch polarization combinations: ↑↑, ↑↓, ↓↑, ↓↓ -- can build various asymmetries



The result is compatible with no hadronic spin flip contribution

$$A_N(t) = \frac{\sqrt{-t}}{m} \frac{[\kappa(1-\rho\,\delta) + 2(\delta\,\mathrm{Re}\,r_5 - \mathrm{Im}\,r_5)]\frac{t_c}{t} - 2(\mathrm{Re}\,r_5 - \rho\,\mathrm{Im}\,r_5)}{\left(\frac{t_c}{t}\right)^2 - 2(\rho+\delta)\frac{t_c}{t} + (1+\rho^2)}$$

$$r_5 = \frac{m_p}{\sqrt{-t}} \frac{\phi_5^{had}}{\mathrm{Im}(\phi_1^{had} + \phi_3^{had})/2}$$

Summary and Conclusion

- Use of Roman Pots at STAR, provides measurements in the **low-*t* region**.

- **Unique opportunity** for *Spin-Dependent Measurements* at RHIC
- Run09 Performance:
  - **~20·10⁶ Elastic Events** (after all cuts applied) recorded in 5 days, at $\sqrt{s}$=200 GeV and with β^*=21 m.
  - Excellent detector performance provided **very clean data set**.
  - Si Detector Inefficiency: Mainly due to the dead/noisy Si channels (~0.04% of the channels excluded from analysis).
- Analysis: Analysis is in progress. **First preliminary results on spin asymmetries** are available.