PP2PP EXPERIMENT AT RHIC

Silicon Detectors Installed in Roman Pots For Forward Proton Detection Close to the Beam

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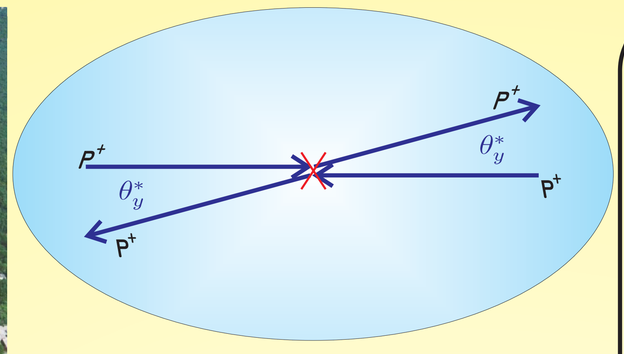
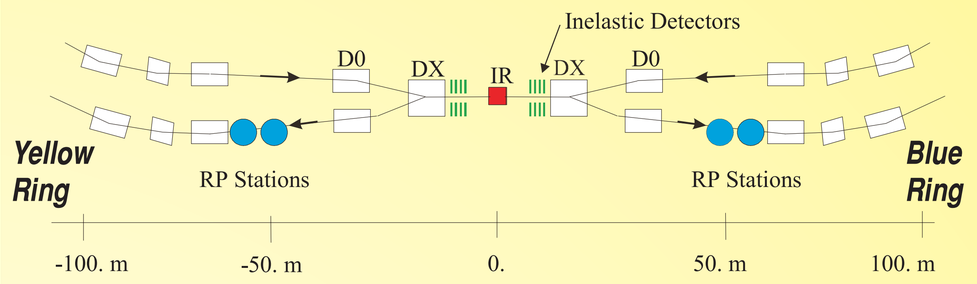
Relativistic Heavy Ion Collider (RHIC)

RHIC is a 3.9 km circumference machine designed to collide gold ions at $\sqrt{s}$ = 130-200 GeV/nucleon as well as polarized protons in the range $\sqrt{s}$ = 200-500 GeV. PP2PP is one of five experiments at RHIC and is dedicated to the spin physics program.



PP2PP Roman Pot Locations at RHIC 2 O'Clock



PP2PP is designed to measure proton elastic scattering at small four-momentum squared $4 \cdot 10^{-4} < |t| < 1.3$ (GeV/c)^2. The detectors are installed in "Roman Pots" that must be placed far from the interaction region where the scattered protons separate from the beam and can be detected.

MEASUREMENT TECHNIQUE

To an excellent approximation the magnet transport equations that connect the initial scattering angle θ_y^* of the scattered proton in the vertical direction and the initial interaction position y_0 to the measured position y and angle θ_y at the detector are ;

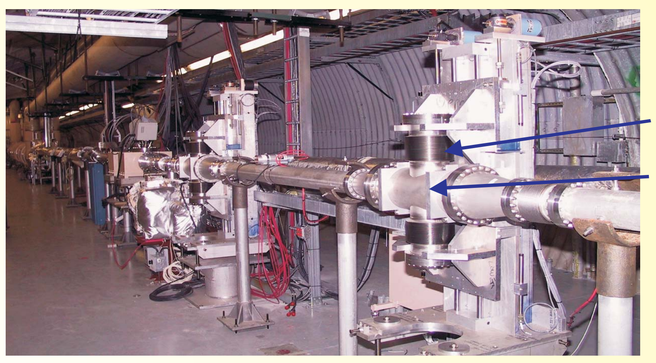
$$y = a_{11} \cdot y_0 + L_{eff}^y \cdot \theta_y^*$$
$$\theta_y = a_{12} \cdot y_0 + a_{22} \cdot \theta_y^*$$

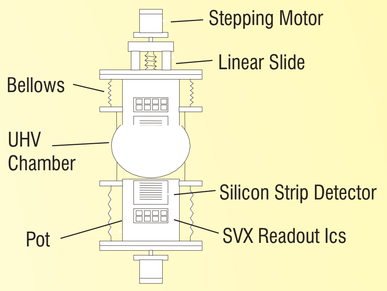
where a_{ij} and $L_{eff}^y \equiv a_{21}$ are coefficients of the beam transport matrix. The position of the two Roman pots closest to the IR were chosen such that a_{11} vanishes and L_{eff}^y is large, so that;

$$y \approx L_{eff}^y \cdot \theta_y^*$$

The hit position depends only on the scattering angle (parallel to point focusing). The large L_{eff}^y maximizes low |t| acceptance.

Roman Pot Stations



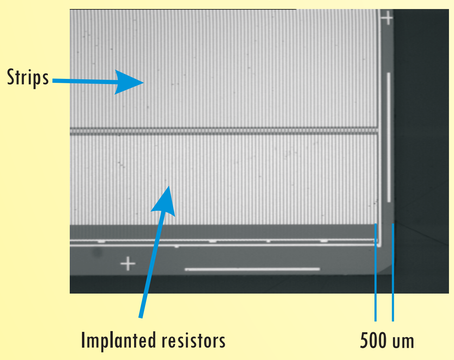


Roman Pot Detector System

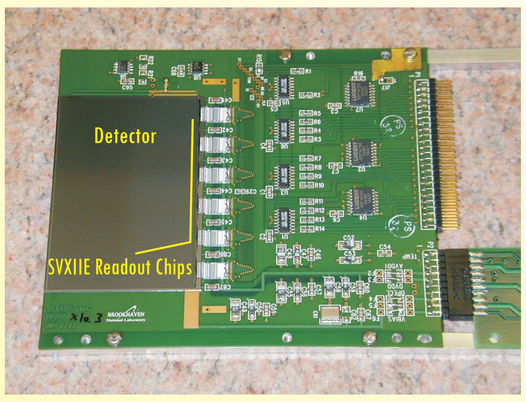
The Detector System consists of cylindrical vessels "Roman Pots" that house the detectors and can be inserted into the vacuum for data taking and retracted during beam fills. The verical position of the pots is measured to a precision of 25 um. During experimental running the pots were moved to within 15 mm $\approx 15\sigma$ to the beam.

Silicon Strip Detectors

BNL Y-View Strip Detector

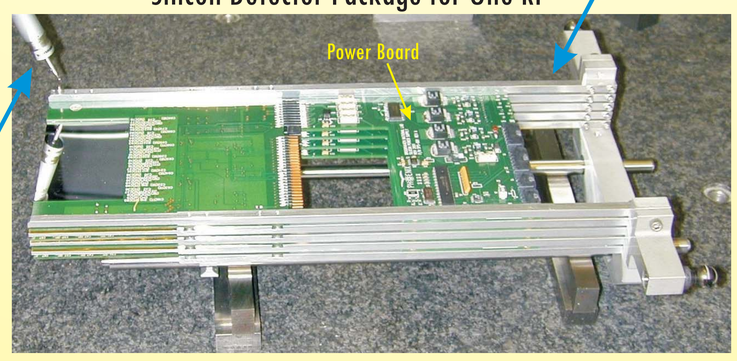


X-View Detector Board

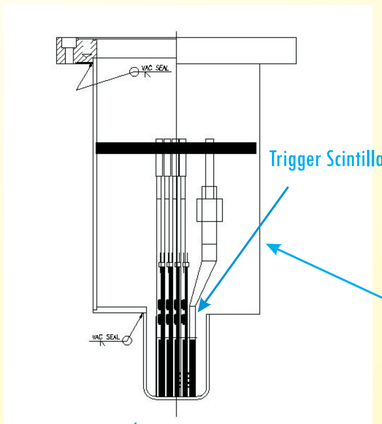


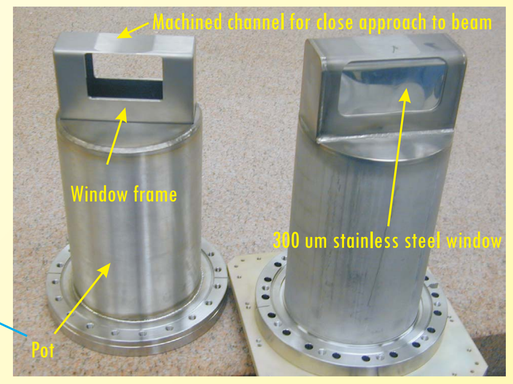
- *32 Hamamatsu Silicon Strip Detectors- 2003 Run*
  - *Polysiilcon Resistors*
  - *Dual purpose guard/bias ring minimizes inactive area*
- *16 BNL Detectors - 2002 Run*
  - *Implanted Resistors*
  - *500 um cut edge to first strip closest to beam*
- *Two types*
  - *X-View : vertical strips*
  - *Y-View: horizontal strips*
- *74 x 45 mm area, 400 um thick*
- *AC coupled*
- *Integrated Fan-in to connect 100 um strips to 48 um pitch readout*
- *Readout with 128 channel SVXIIe chip (courtesy of D0 experiment at Fermilab)*

Silicon Detector Package for One RP



Roman Pot Design



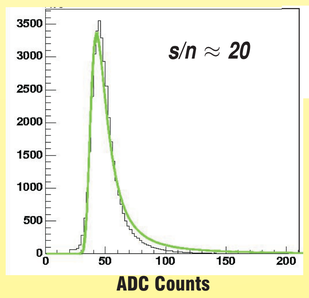


- Interior of pot is at atmospheric pressure and electronics are air cooled. Must minmize pot cross section to minimize atmospheric force on pot and moveable support.
  → make detector package as compact as possible.
- Thin stainless steel window to minimize material through which proton must pass. 300 um was the minimum allowed for safety reasons: window must maintain strength in the event proton beam is lost through the pot.
- Window frame serves to prevent window from deforming into beam.

Performance

- *Hit reconstruction efficiency 93% in 2002 (inefficiency mostly due to Al-implant shorts)*
- *Percentage working strips in 2003 was 99.96%!! (due to very high quality Hamamatsu detectors and very careful wirebonding and assembly)*
- *S/N ≈ 20 in 2003 (11 in 2002)*
- *No RF pickup from beam*
- *Efficient triggering/reconstruction of elastic events*

dE/dx distribuition - single strip hits



Y and X coordinate of protons detected in yellow ring versus oppositely scattered protons detected in blue ring

- *indicates efficient triggering on elastic events*
- *Spread in correlation due to beam angular divergence*