Vernier Scans
(How to Make Friends and Influence Cross Sections)

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Spin Fest

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Overview

- What is a vernier scan?
- Why is it useful?
- How do we make the measurement?
- Hardware
- Analysis procedure
- BBC Cross section

Introduction to Vernier Scan

- What is the Vernier Scan?
  - A way to measure the size and shape of the beam used at our experiment.
  - The Main Control Room steps one beam vertically then horizontally while holding the other steady
  - We (PHENIX) use the GL1P scalers to count hits in our detectors, here BBC, while keeping track of where the beam has moved
  - The beam width found by the vernier scan used in luminosity calculations:

$$L = \frac{f_{rev} N_b N_y}{2\pi \sigma_x \sigma_y}$$

  - Once the Luminsity is obtained we are able to calculate quantities such useful quantities as the BBC cross section.

$$\sigma_{bbc} = \frac{\dot{N}}{L}$$

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Why do we need them?

- In order to calulate cross sections for different reactions measured at PHENIX, we need to know the luminosity
- If we know the luminosity we are able to extract important information about our detector, (cross sections, efficiencis, etc...)
- We can double check the main control room, and let them know how they are doing

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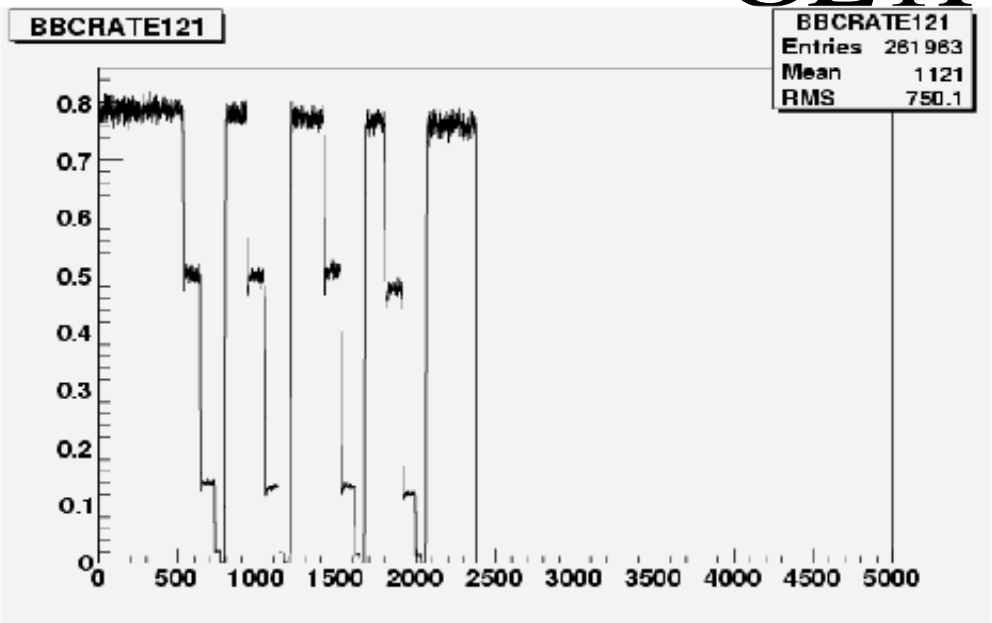
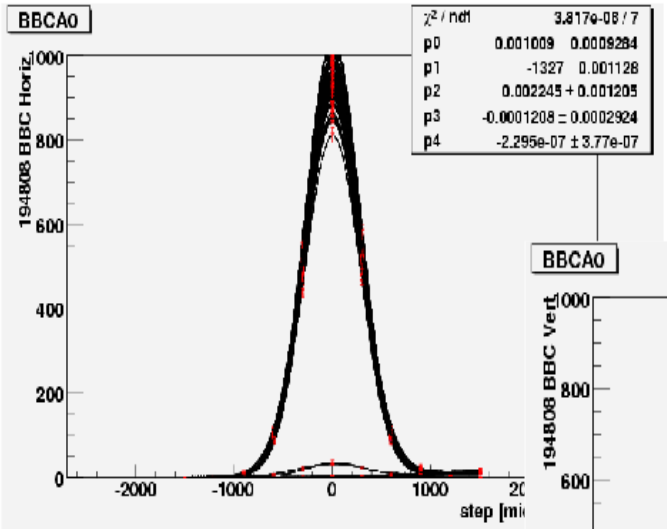
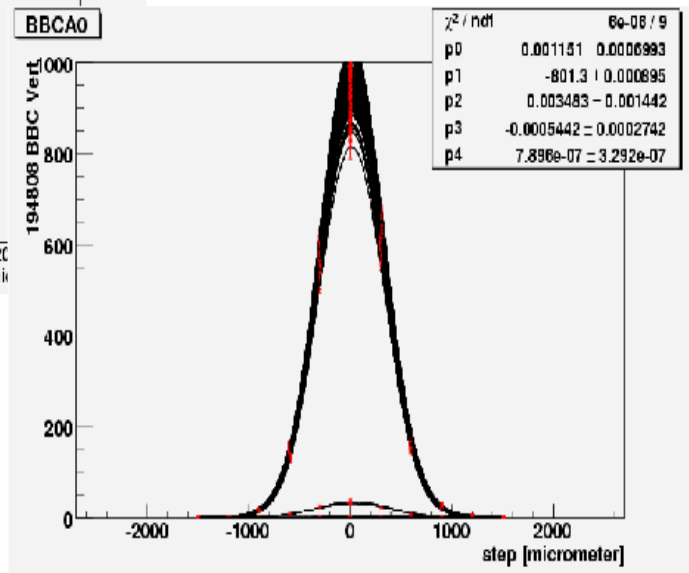
GL1P Scalers







- The GL1P scalers take 4 inputs
  - In our case the RHIC clock, BBC LL1, ZDC Wide and ZDC NS
  - The GL1P scalers simply count
- By counting the number of BBC/ZDC events and Clock events during the vernier scan we obtain event rates for the given detector.
- The decrease in the rates can be clearly seen as the beam is stepped away from the center
- The rates are ploted as a funtion of beam postion and a gaussian+constant is fit to the data
- The resulting width of the gaussian gives us the beam width for the Luminosity formula

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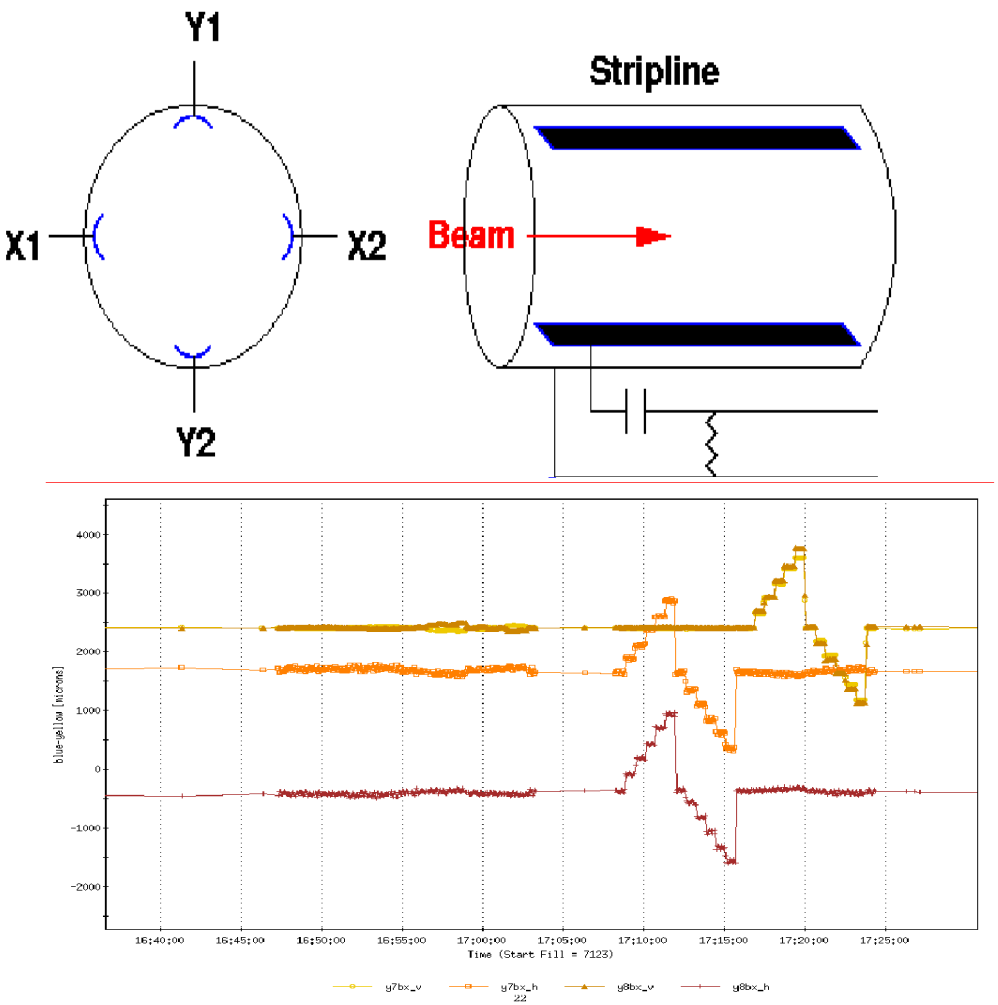
Measuring Beam Position



- The beam position is measure by the Beam Position Monitors (BPM's)
- The voltage induced between the electrodes is proportional to the distance from the strips.
- $$X \propto \frac{X_1 - X_2}{X_1 + X_2}$$
- Vertical and Horizontal beam positions for both the blue and yellow beams can be measured with ~1% error at 7o'clock and 8 o'clock

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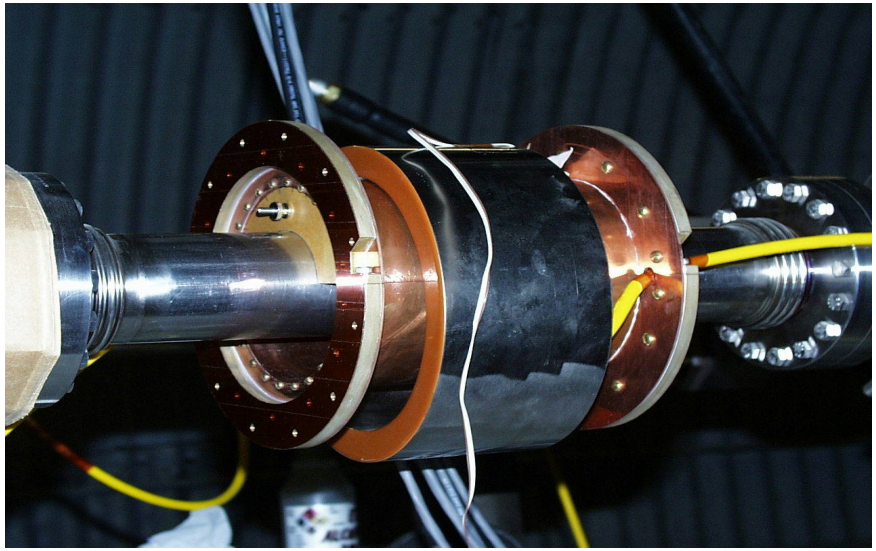
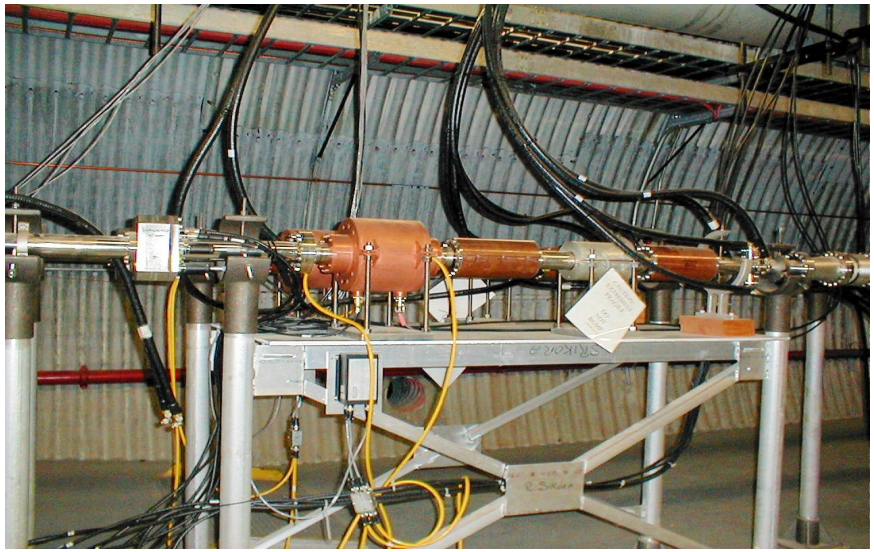
Number of Protons





- Here we use two pieces of equipment in tandem. The Direct Current Current Converter (DCCT) and the Wall Current Monitors (WCM)
- The DCCT is a high permeability toroid, surrounding the beam pipe, at 2'oclock.
  - The DCCT samples the beam current during ~1sec window.
  - It provides a very precise measure of the beam current but does not distinguish between bunched and unbunched beam.
- WCM's measure the image charge that is dragged along the beam pipe as the beam cirulates around RHIC
  - WCM can provide a “snapshot” of the beam.
  - It is not as precise as the DCCT but it is only sensitive to bunched beam

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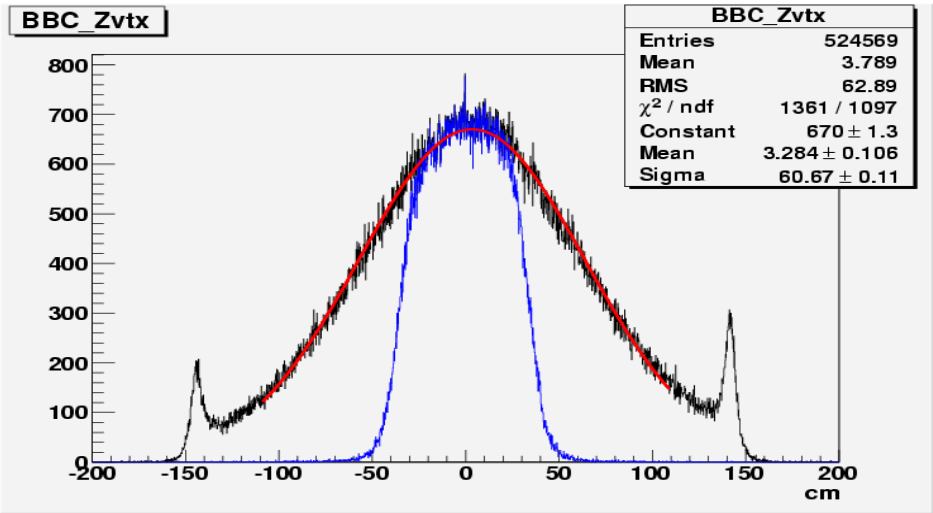
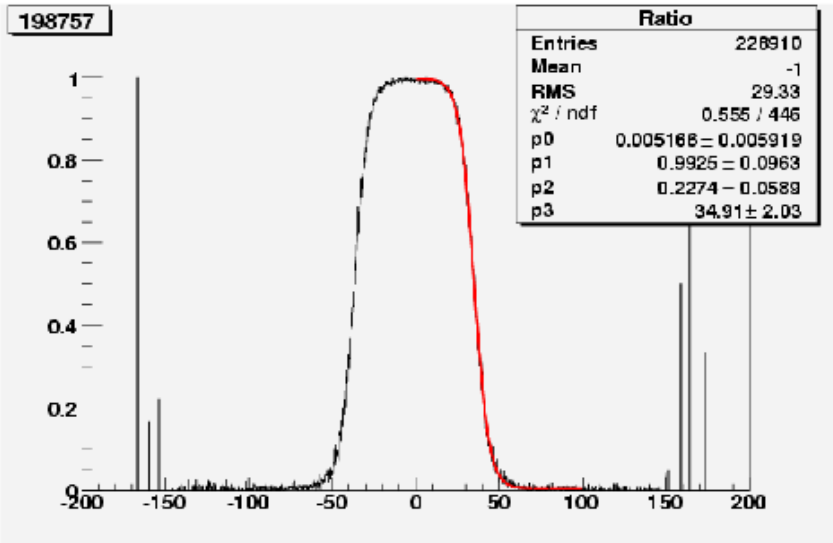
Vertex Distribution (BBC)





- In order to calculate the BBC cross section, L_eff is needed.
- $L_{eff} = L_{raw} * \epsilon$
  - Where e is the fraction of the vertex distribution triggered on by the detector.
- The fraction of the vertex seen by the detector can be found by dividing counts inside +/- 30cm by the total counts in the detector.
- The distribution is a little wider then 30 cm after dividing BBC noVtx by BBCLL1 the vertex with is take to be the midpoint of the rise

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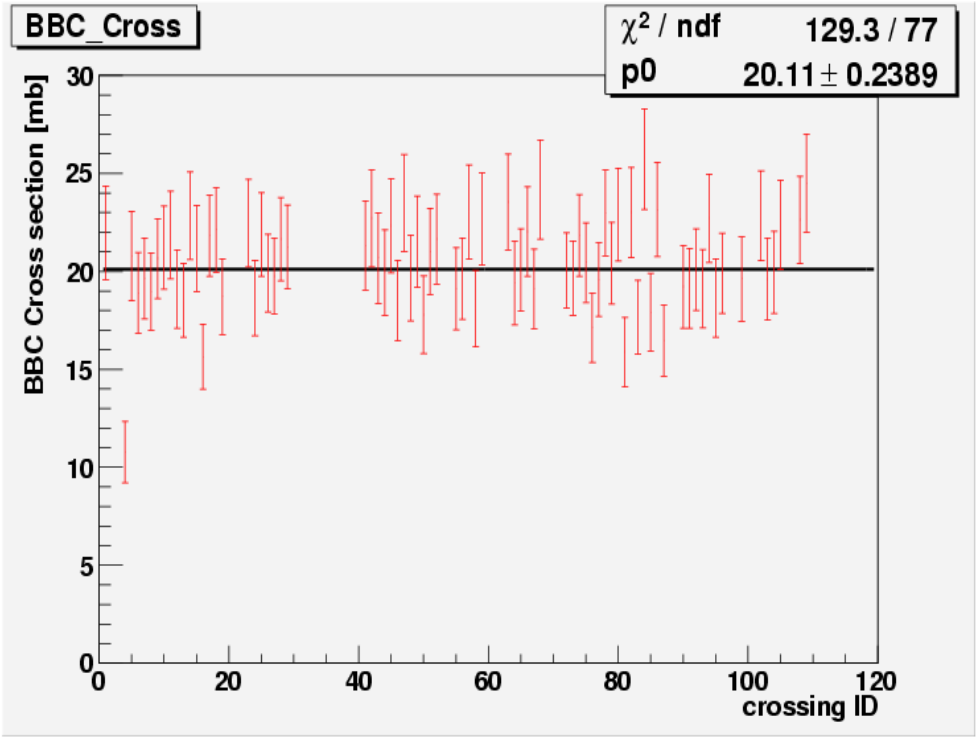
Bunch by Bunch BBC Cross-section



- We now have all of the information we need to calculate BBC cross section

$$\sigma_{bbc} = \frac{\dot{N}}{L_{eff}} \qquad L = \frac{f_{rev} N_y \times N_b}{\sigma_x \sigma_y}$$

- A bunch by bunch cross section is then calculated for each of the vernier scan runs
- A constant is fit to the resulting bunch by bunch cross sections and an average value is determined for the run

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Summary

- What you should take home...
  - Why we have vernier scans
  - How we do them
  - How are the results used to extract BBC Cross section
- Code & Other Info
- Vernier scan analysis code is on CCJ
  - /cc/u/rpb/Vernier/offline/analysis/vernier06/
    - VernierAnalyzer.C
    - VernierAnalyzer.h
  - .../macro/
    - analyze_vernier.C
- Webpage
  - http://www.phenix.bnl.gov/WWW/p/draft/rpb/Vernier/

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BACKUPS

BBC Cross section

	BBC Cross section
191115	20.11+/-0.24
192680	19.26+/-20
194808	21.27+/-0.22
198757	20.67+/-0.26
200257	23.84+/-0.24

- $\sigma_{BBC} = 20.90 \pm 0.10$
  - The errors shown for run 5 are only statistical

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Systematic Errors

- # of ions comparing the WCM and DCCT at flat top
  - There should be no debunched beam in the machine just after flat top. Comparing the sum of WCM and DCCT there is ~.15% difference bettween the two.
- Beam Position
  - There is an average 1% difference between Angelikas set step size and step size read from BPM
- Beam blow up, crossing angle, hour-glass effect have to be checked
- Just adding the two from above we are looking at at least a 1.4% systematic error.

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