Total cross section from Van–der–Meer Scans: status and plans

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- ⋆Van–der–Meer Scans: the method
- ⋆Data taken during RHIC 2000 run
- ⋆Analysis
- ⋆Conclusion
- ⋆Outlook

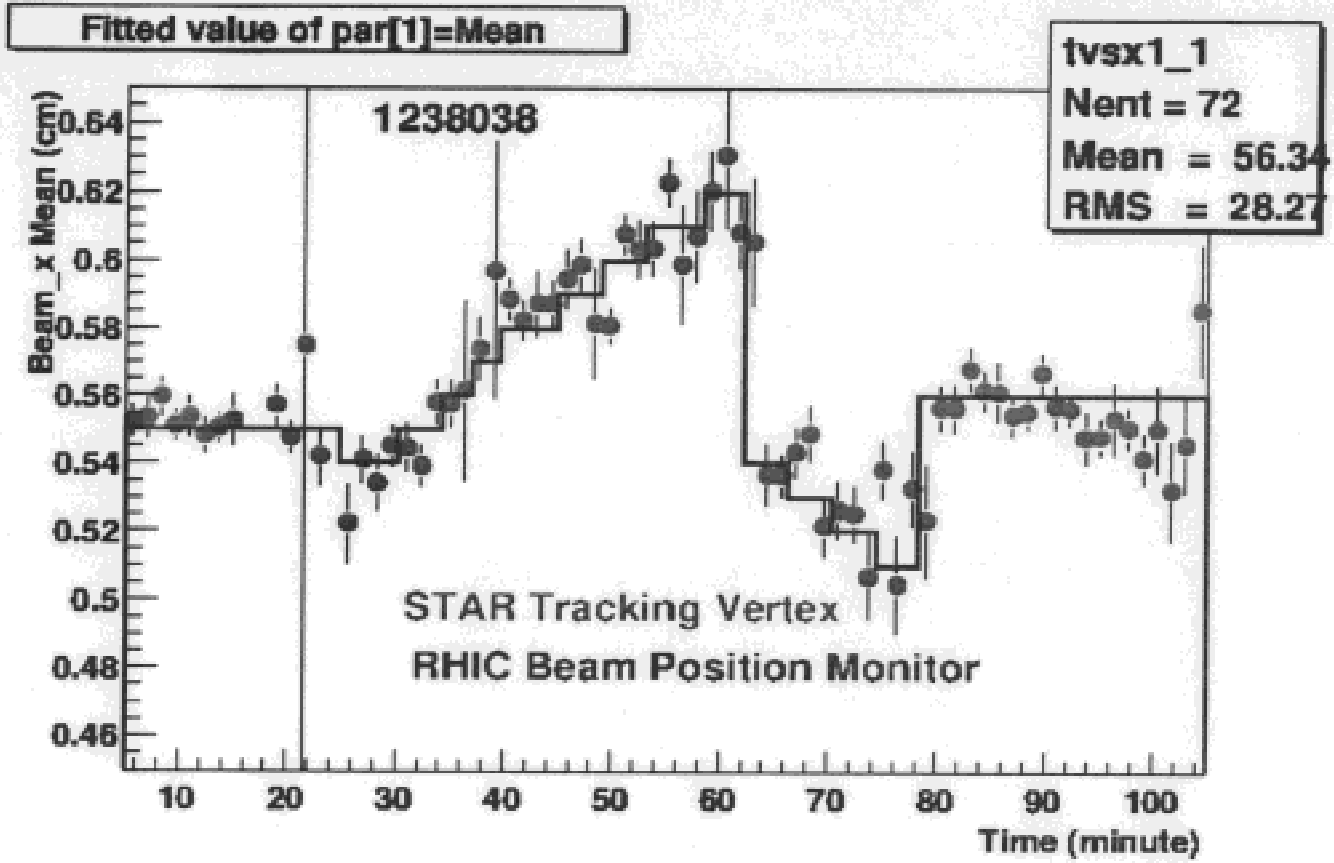
The Method

Van–der–Meer scans or vernier scans are done by stepwise sweeping one beam across the other while measuring collision rates as a function of beam displacement. This is done in both planes.

Needed basic instrumentation: the ZDCs at the various IRs, corrector magnet control to apply 4–bump at IR, DX Beam Position Monitors (BPM) and beam current measurements from Wall Current Monitor (WCM).

A Gauss function is fitted to the result yielding the maximum rates (R_x^{max}, R_y^{max}) the location of the maximums (x_{max}, y_{max}) and the effective beam widths (σ_x, σ_y) in both planes.

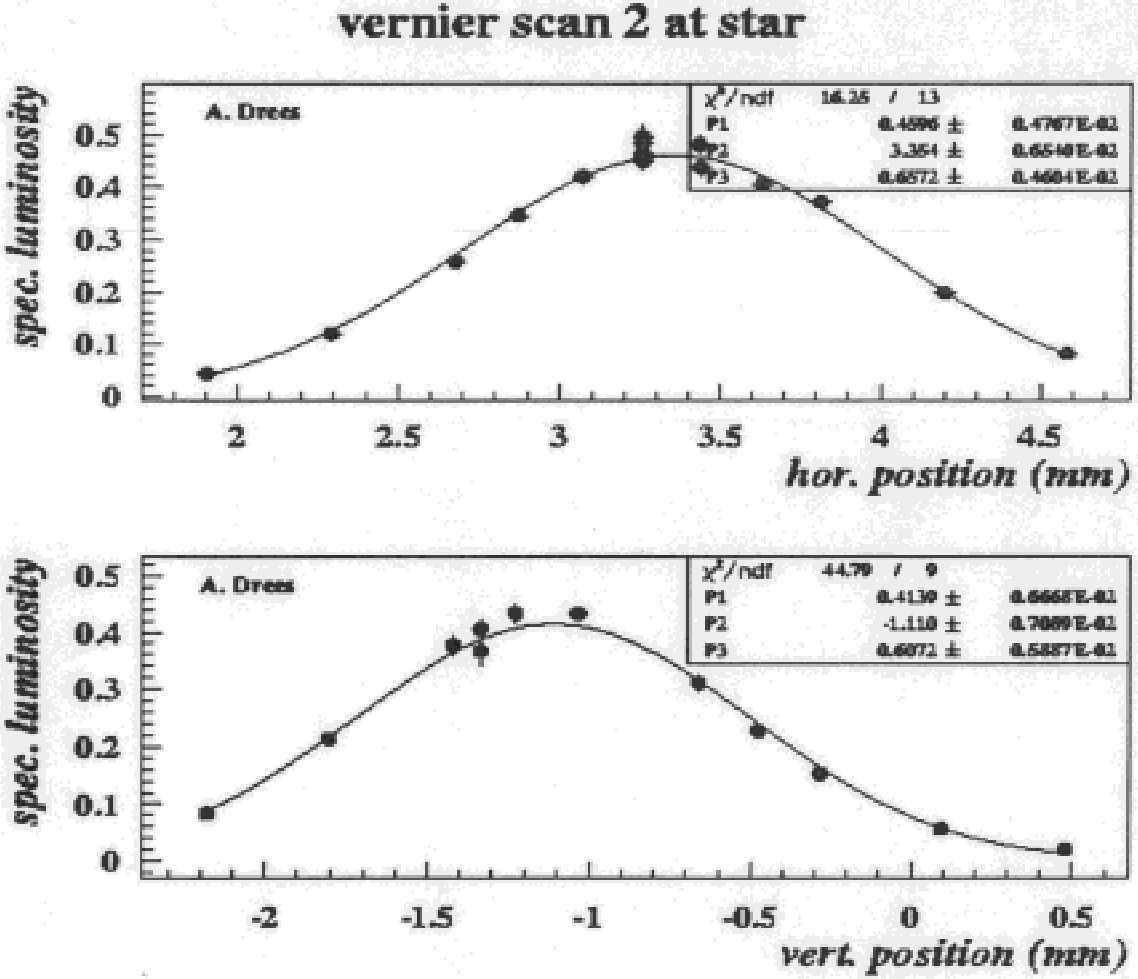
The Method (continued)



STAR reconstructed vertex during a horizontal scan (arbitrary offset added to adjust both data sets).

- ⋆ **Sweeping blue beam**
- ⋆ **Stepsize: 200 μm**
- ⋆ **approx. 2 min. /point**
- ⋆ **good agreement with STAR data**

The Method (continued)



- ⋆ **Horizontal scan first**
- ⋆ **approx. 30 min. / scan**
- ⋆ **fit Gauss function to data**
- ⋆ **reasonable x2/ndf**
- ⋆ **get fit parameters**
- ⋆ **Use to calculate:**

$$\sigma_{(Au+Au)} = R^{max} 2\pi\sigma_x\sigma_y k_b / f_{rev}$$

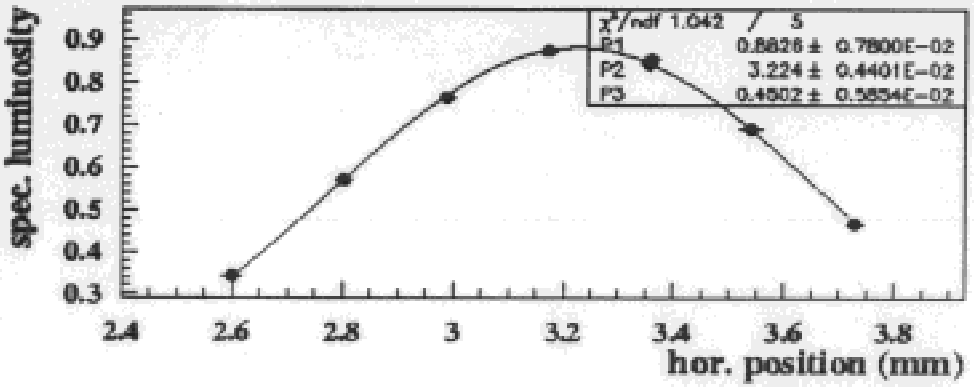
$\sigma_x \sigma_y$: horz./vert. profiles

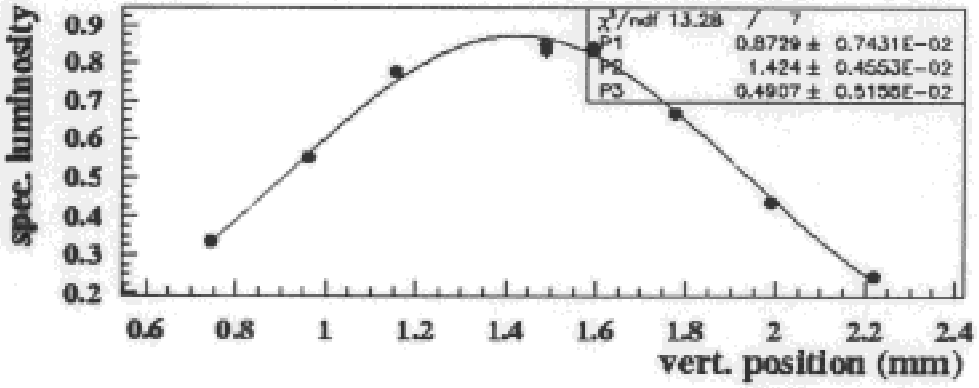
k_b : number of bunches

f_{rev} : revolution frequency

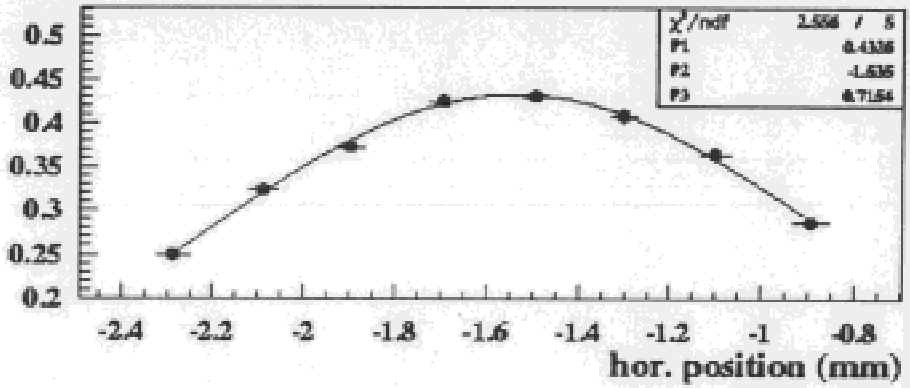
The Data

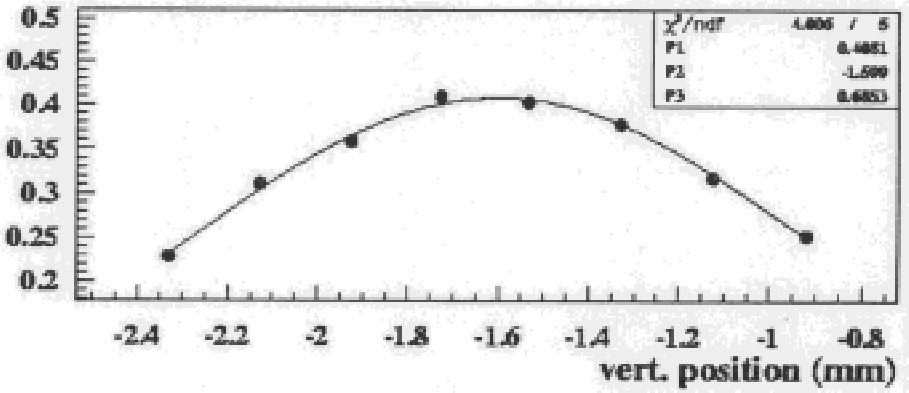
vernier scan at phenix





Vernier scan at phobos





A total of 8 scans: 1 in PHENIX, 3 in STAR, 4 in PHOBOS

The Data

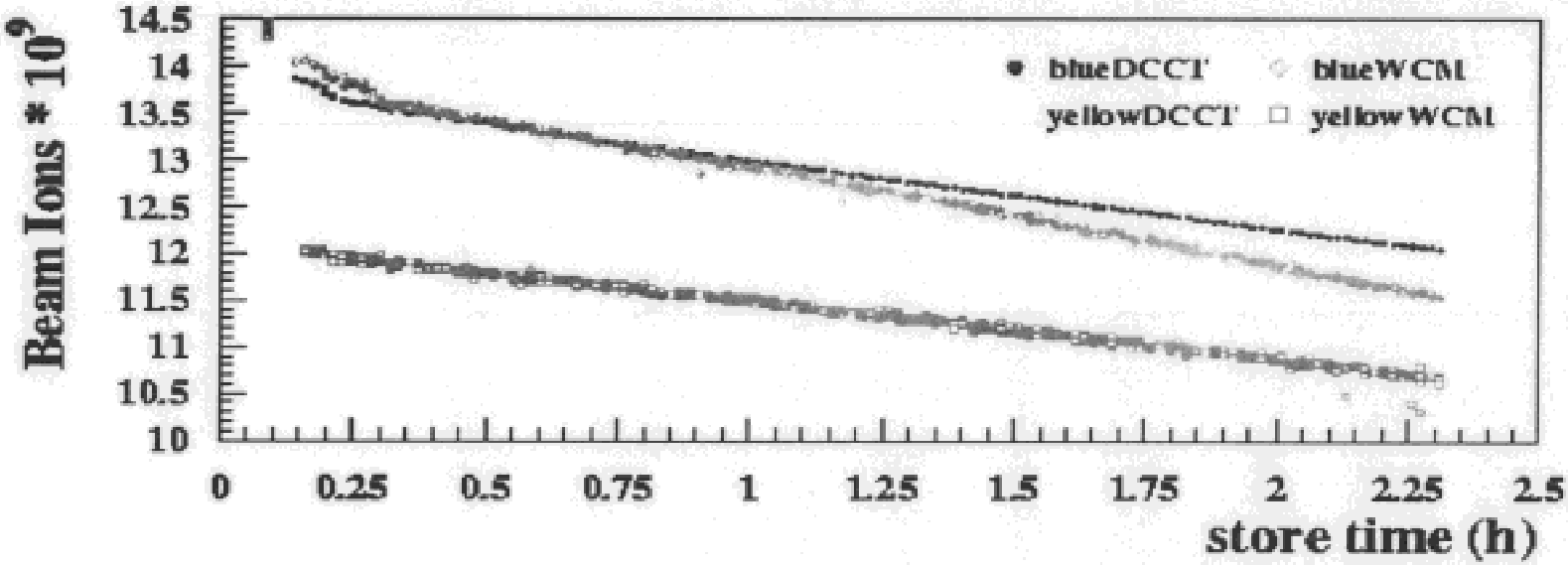
index	IR	β^* [m]	start time	end time	t_{fill} [h]	Xsec (raw)
PHENIX	8	3	AUG 22, 07:55	AUG 22, 08:35	1.9	8.3
PHOBOS1	10	8	AUG 23, 21:55	AUG 23, 22:28	1.4	9.3
PHOBOS2	10	8	AUG 23, 23:52	AUG 24, 00:17	3.3	8.3
STAR1	6	8	AUG 25, 18:00	AUG 25, 19:42	5.1	9.4
PHOBOS3	10	8	AUG 29, 17:03	AUG 29, 17:35	2.8	8.7
PHOBOS4	10	8	AUG 29, 19:49	AUG 29, 20:17	5.5	11.9
STAR2	6	8	AUG 30, 01:20	AUG 30, 02:30	1.0	8.2
STAR3	6	8	AUG 30, 05:00	AUG 30, 06:25	4.8	8.7

						9.1 b

Table 1: List of vernier scans performed during the year 2000 RHIC run. t_{fill} is the (center-)time of the scan with respect to the start of the fill, i.e. the time when the flattop energy is reached.

Analysis: The WCM

WCM and DCCT readings during a store as fct. of time



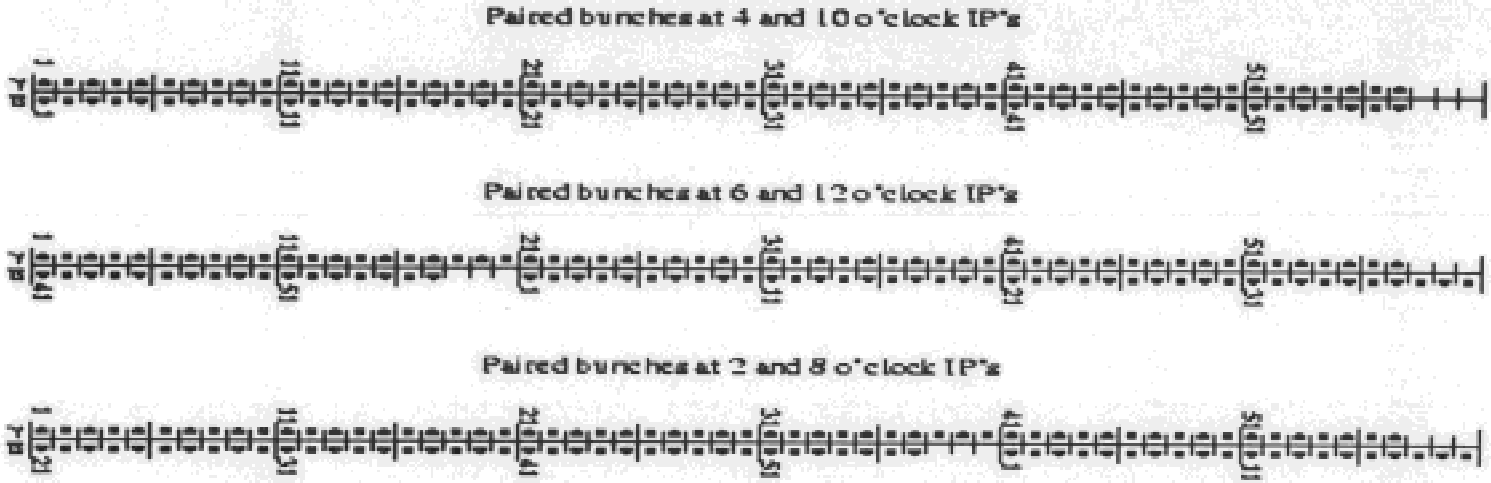
★DCCT: accurate (0.2%) device to measure ANY coasting beam in RHIC

★WCM : measures **BUNCHED** beam only

★Calibrate WCM with DCCT at beginning of store only

★Observed deviation around 2 %, max up to 3% in one case

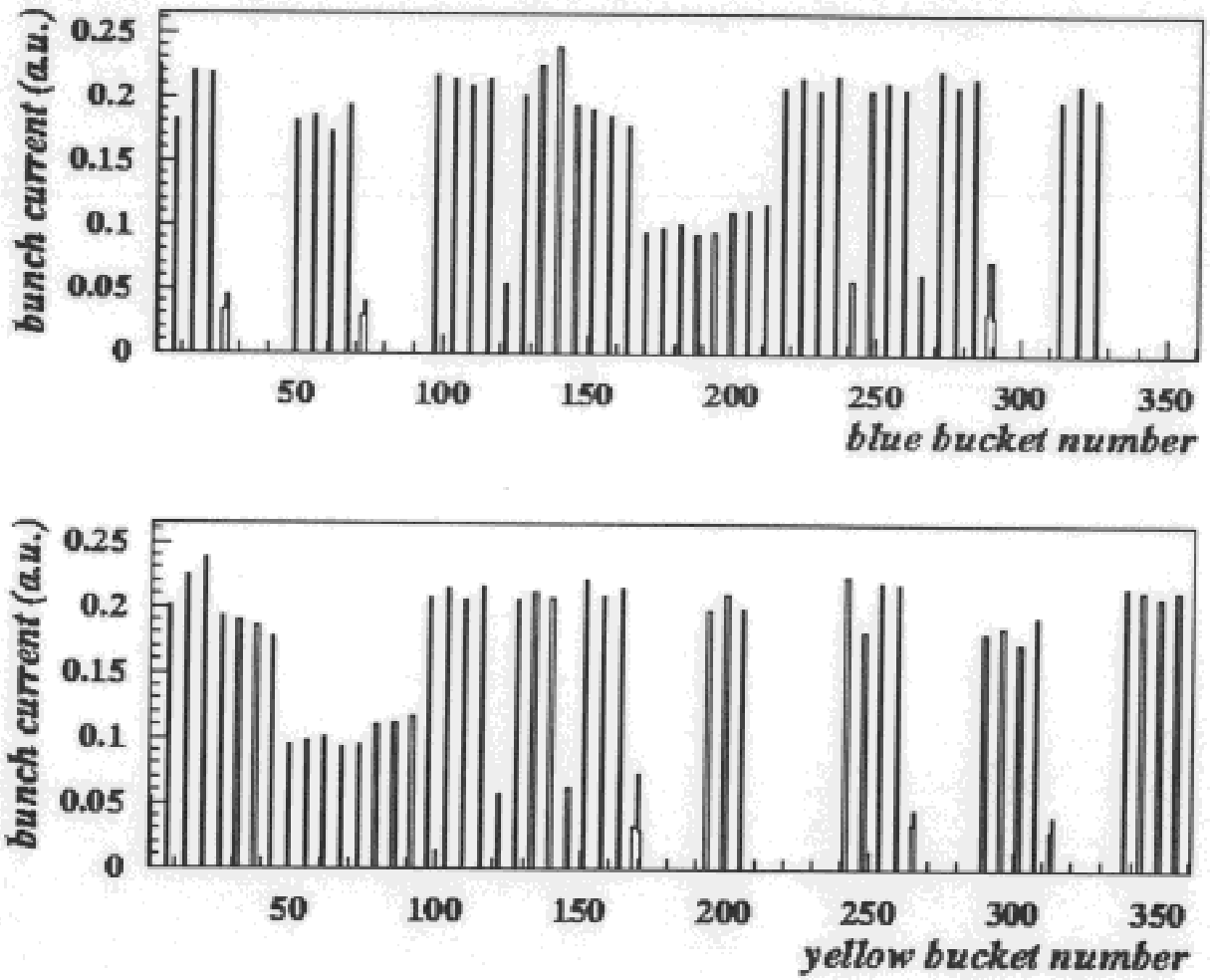
Analysis: Fill Pattern



★ Total beam current has to be corrected for actual colliding pairs of bunches.
★ Collision pattern different at the IPs.
★ With 55 bunches (and 60 bunch pattern) this is 10% (5 out of 55) at all IPs except 4 o'clock and 10 o'clock.

Fill Pattern (continued)

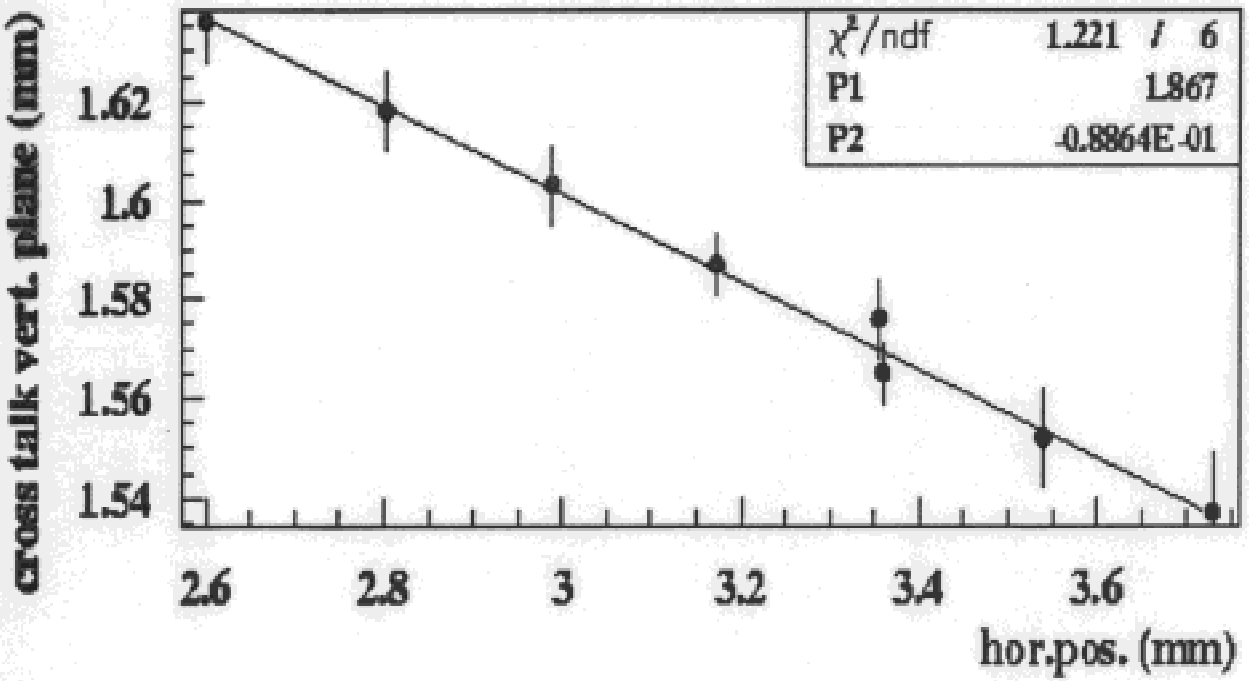
Measured fill pattern during PHENIX scan



Total beam current has to be corrected for bunch–to–bunch variations.

This correction is usually below +/–2% but in the worst case (PHENIX) –14%.

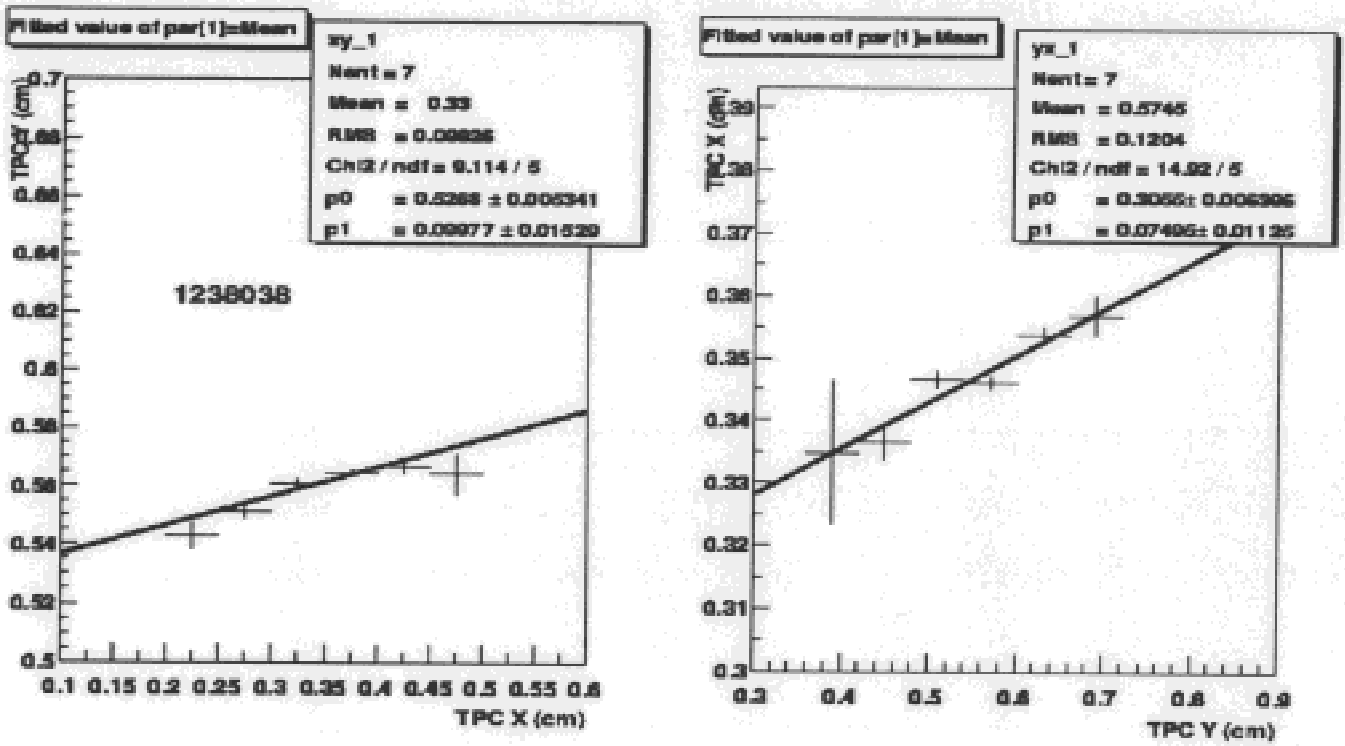
Analysis: Cross Talk



Measured cross talk in vertical plane at PHENIX while scanning the horizontal.

- Horizontal and vertical positon was mesured during all scans.
- Up to 10% of the motion is seen in the other plane.
- All scans/fits were coHrrected for being off–center in the other plane.
- Correction is up to 5% in terms of cross section

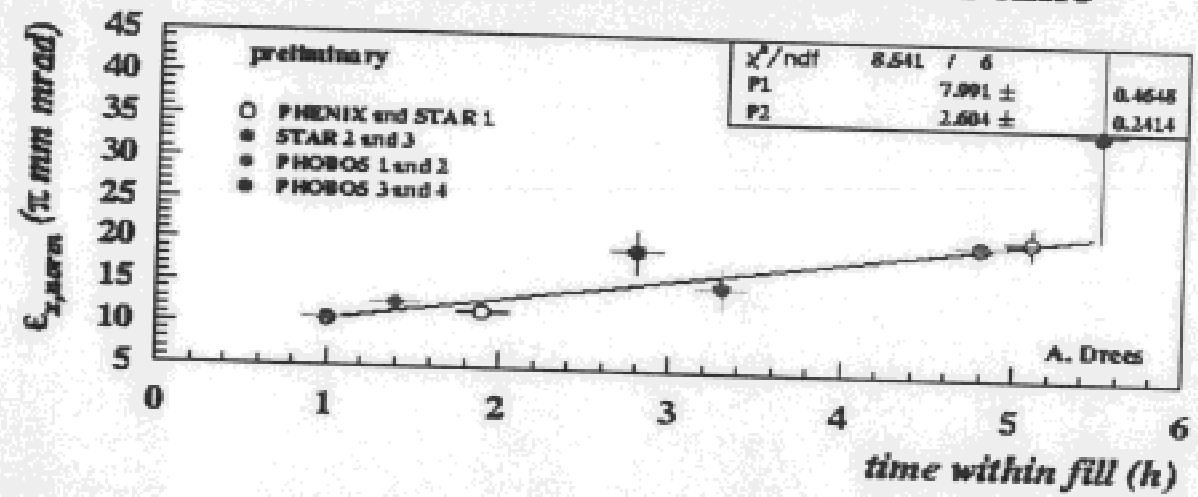
Axes Misaglignment

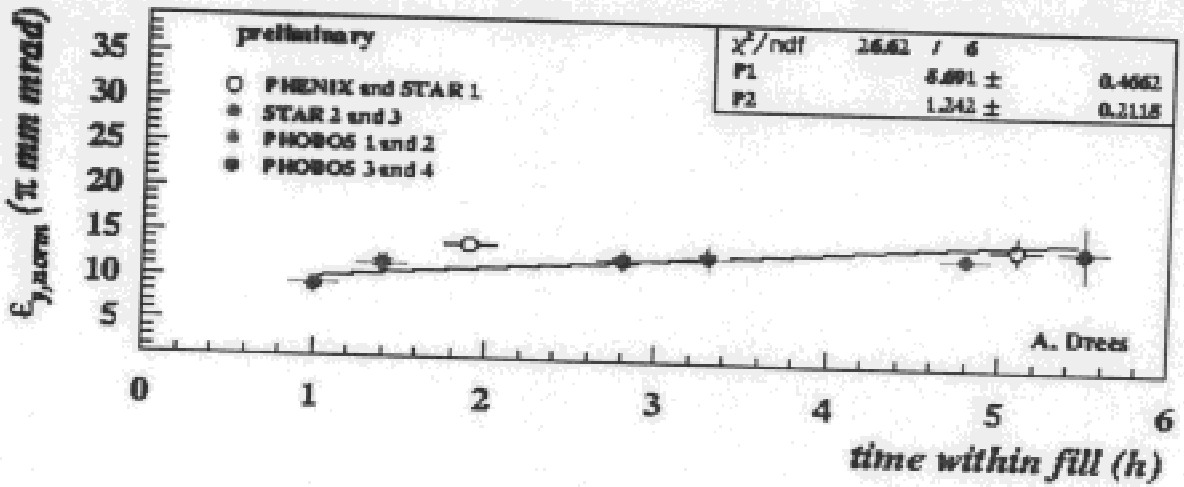


Correlation between horizontal and vertical STAR vertex position.
=> Θ, angle between scan axes and principal beam ellipse axes: 0.087
Systematic error due to this misalignment is negligible (0.2%)

Analysis: Beam Blow Up

transverse emittance as a function of time





Maximum collision rates were corrected for beam blow–up during the time of the scan. A systematic error of 0.6% is applied.

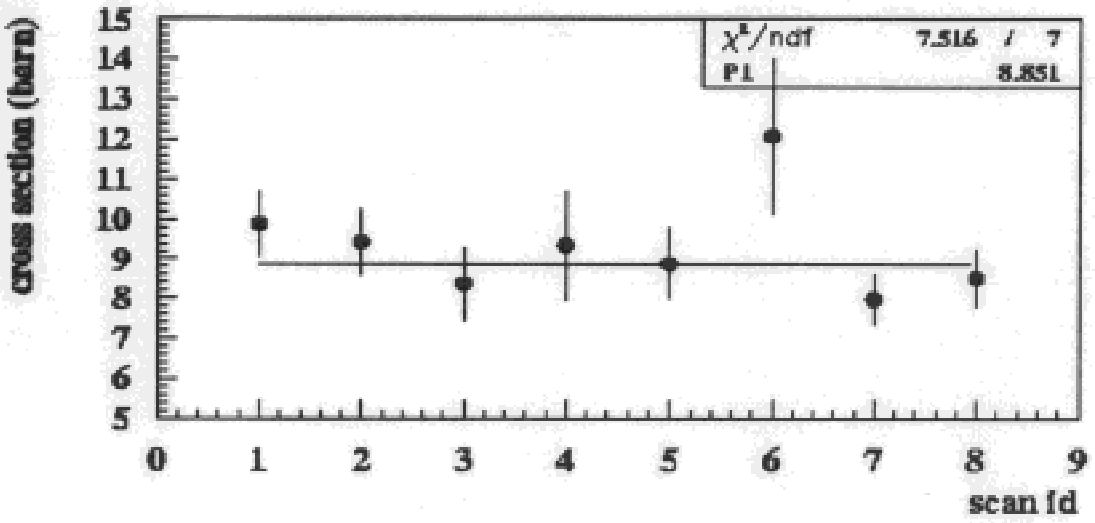
Cross check: emittance vs. time yields consistent emittance at the start of the fill.

Fit Results (corrected)

scan	norm. R_{max} 10^{-18} Hz	hor. profile μm	ver. profile μm	Cross Sec. 1 barn	Cross Sec. 2 barn
PHENIX	0.883	450	491	8.7	9.9
PHOBOS 1	0.433	715	685	9.4	9.4
PHOBOS 2	0.334	782	722	8.4	8.4
STAR 1(*)	0.292	932	768	9.4	9.5
PHOBOS 3	0.318	885	707	8.8	8.8
PHOBOS 4	0.300	1179	764	12.0	12.0
STAR 2	0.460	657	607	8.2	8.0
STAR 3	0.289	917	734	8.6	8.5

List of Vernier Scans and resulting cross sections after correction for being off–center (CS1) and for the fill pattern (CS2). (*) uncorrected, no data available.

Conclusion



cross section as function of scan id

Final cross sections after correction with statistical errors.

Result:

$\sigma_{Au+Au} = 8.9 +/- 0.3$ b (stat.)

Conclusion (continued)

tot stat.	axis alignment	beam blow–up	beam current	beam–gas	tot. syst.
3.3 %	0.2 %	0.6 %	3%+3%	0.3%	7 %

most conservative approach:

$$\sigma_{Au+Au} = 8.9 \text{ +/– } 0.3 \text{ (stat.) +/– } 0.6 \text{ (syst.) barn}$$

Outlook for 2001

* Do scans @ 100 GeV
* If possible repeat scans @ 65 GeV
* Improve procedure (automize)
* faster: less blow–up
* more reliable
* Use profile monitors to cross check blow–up vs. time
* Use profile monitors to predict luminosity
* Calibrate WCM at the beginning of every store
* suggestions ?