Results from Vernier Scans in RHIC from 2001/02 Au–Au and pp Operation

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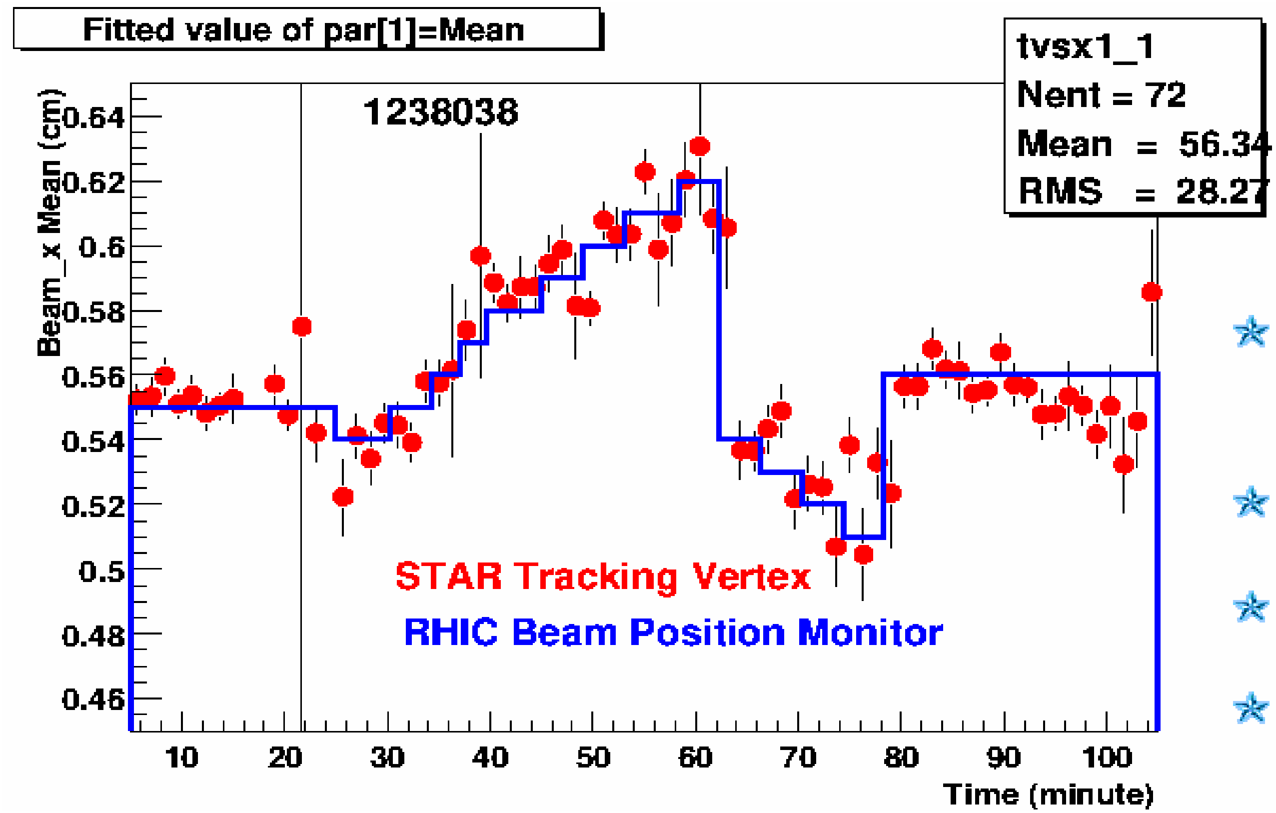
What are Vernier Scans?

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 or other collision monitors (BBC ...) 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.

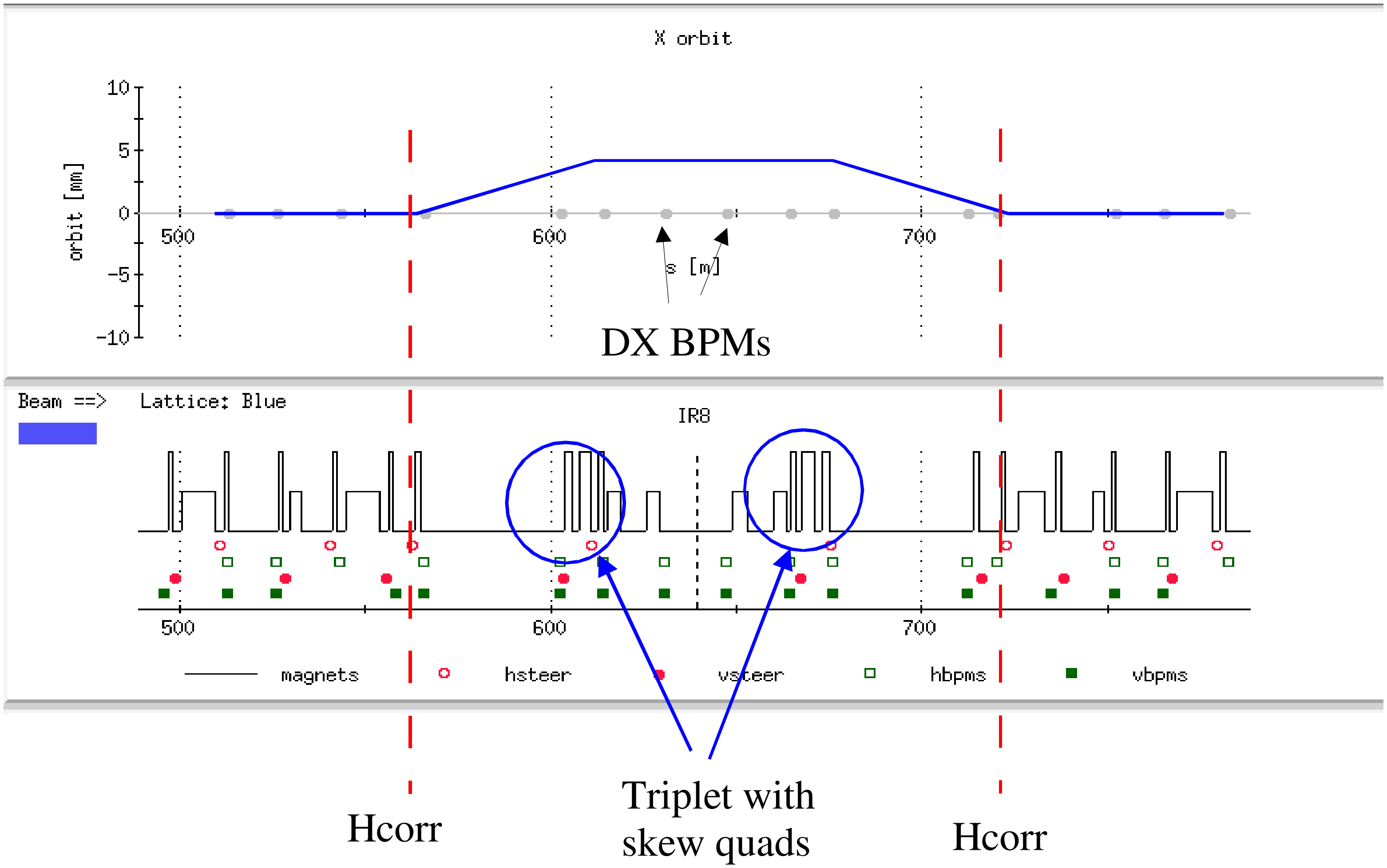
The Method



- Sweeping blue or yellow beam
- Stepsize: 100–500 μm
- approx. 2 min./point
- good agreement with STAR data

STAR reconstructed vertex during a horizontal scan in 2000 (arbitrary offset added to adjust both data sets).

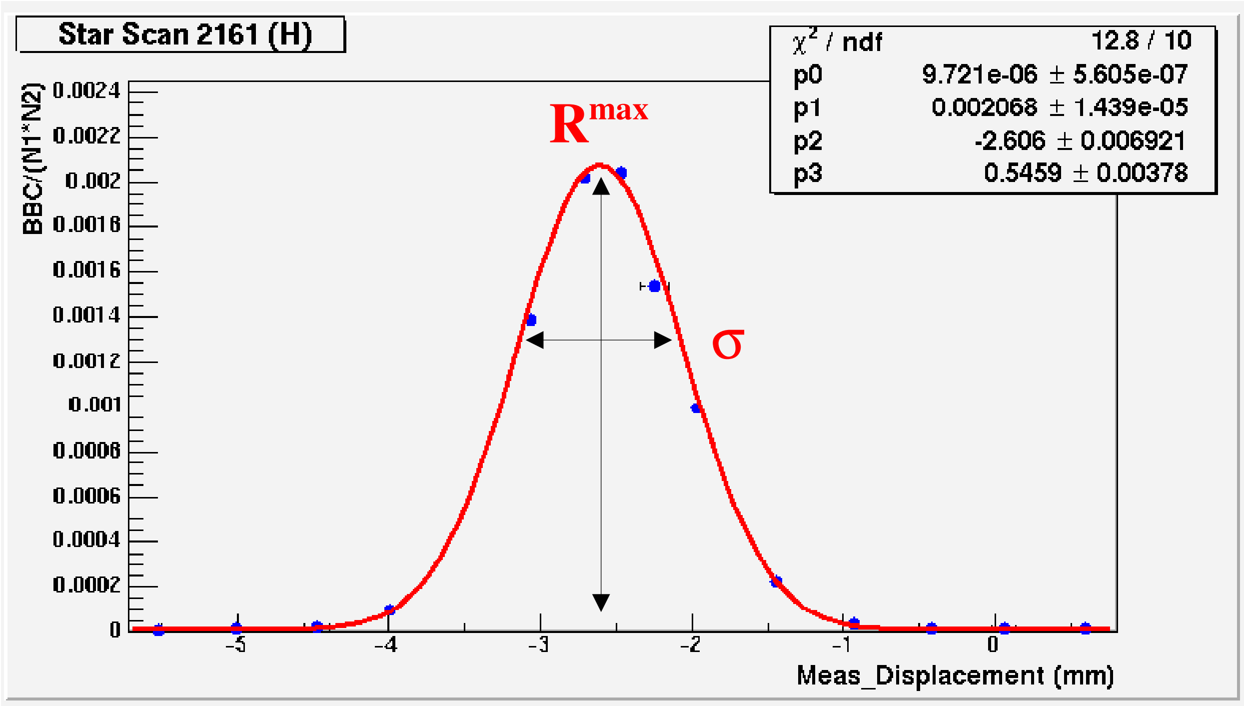
Method: IR bumps



New in 2001–02: skew quads in triplets!
Different optics (b*) required different corrector settings.

Available Data from Scans

	Fill number	IR2	date	β*	comment
Au–Au	1056	STAR	9/21/01	5 m	
	1090	PHENIX	9/25/01	5 m	problem with gh8 bpr
	1153	PHENIX	10/1/01	5 m	problem with gh8 bpr
	1413	STAR	10/22/01	2 m	
	1646	PHENIX	11/6/01	1 m	problem with gh8 bpr
	1717	STAR	11/11/01	2 m	no bpm
	1717	PHENIX	11/11/01	1 m	no bpm
	1763	STAR	11/15/01	2 m	
	1766	PHENIX	11/16/01	1 m	problem with gh8 bpr
pp	2119	STAR	12/30/01	3 m	horiz. only, no ZDC
	2136	PHENIX	1/3/02	3 m	no ZDC
	2161	STAR	1/6/02	3 m	
	2161	PHENIX	1/6/02	3 m	
	2193	STAR	1/10/02	3 m	no bpm
	2193	IR2	1/11/02	3 m	one side bpm
	2233	IR2	1/15/02	3 m	one side bpm
	2277	STAR	1/20/02	3 m	
	2277	PHENIX	1/20/02	3 m	



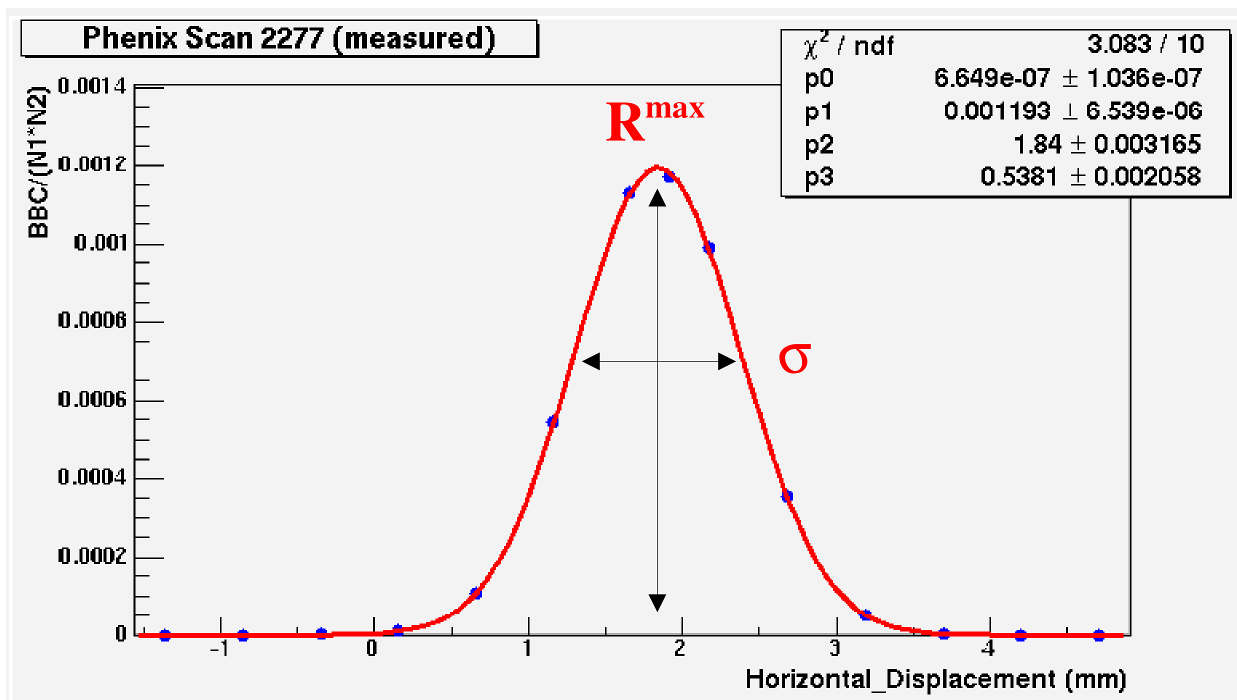
- do both planes (varying order)
- approx. 30 min. / scan
- fit Gauss function to data
- reasonable x2/ndf
- get fit parameters to calcu–late luminosity and cross section

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

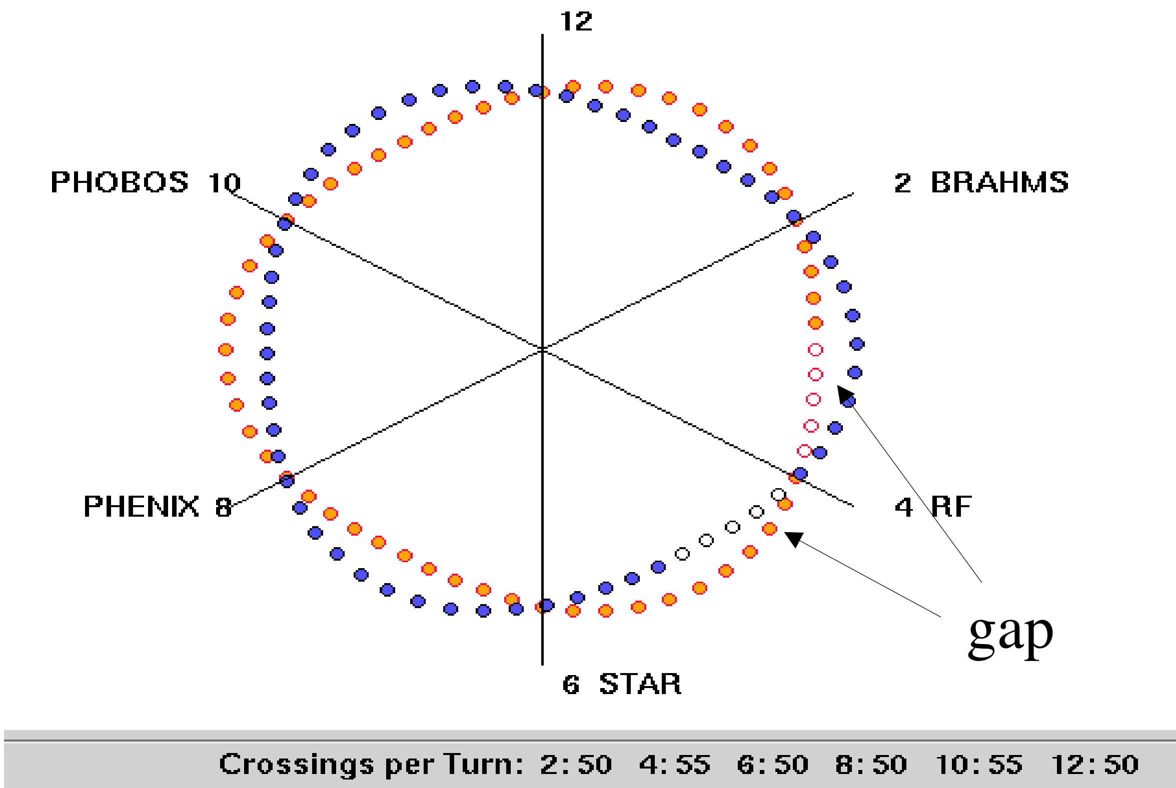
$\sigma_x\sigma_y$: horz./vert. profiles

k_b : number of bunches

f_{rev} : revolution frequency



Correction: Fill Pattern



- Total beam current has to be corrected for actual colliding pairs of bunches at the IRs.

- With 55 bunches (and 60 bunch pattern) this is 9% (5 out of 55) at all IPs except IR8 and IR2 (Au−Au) or IR4 and IR10 (pp). Correction varies from fill to fill slightly.

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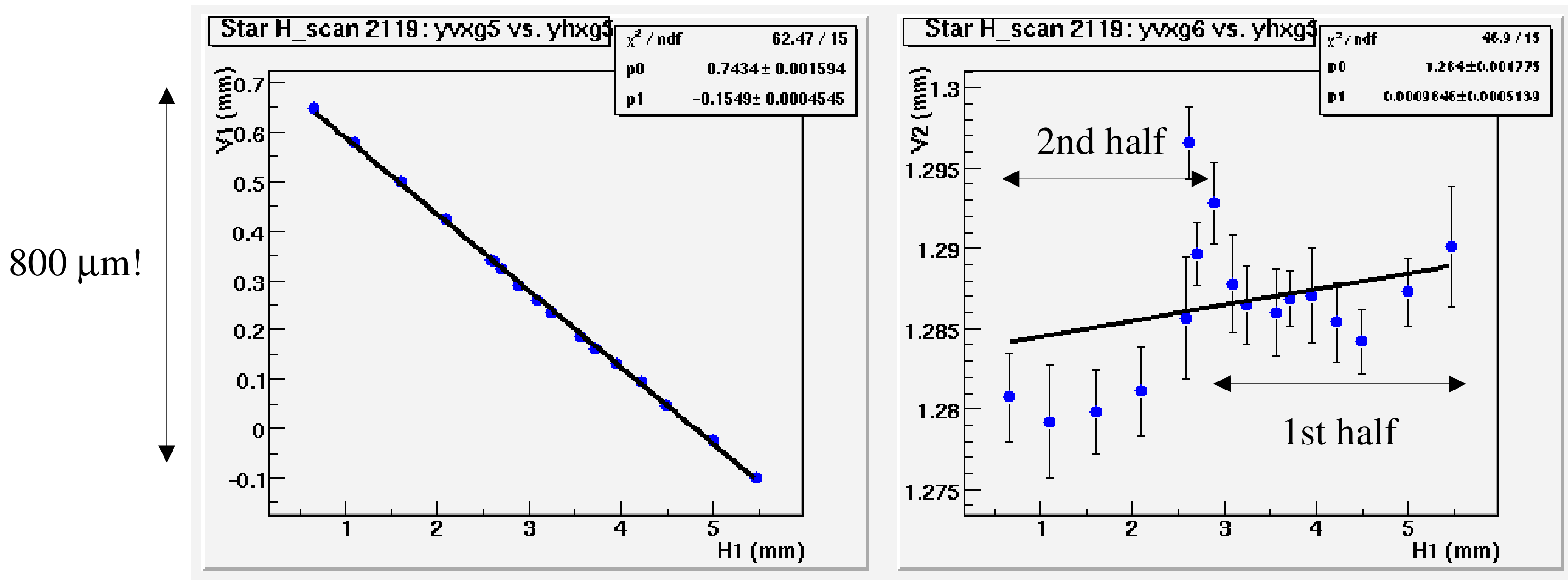
Coupling and Model Corrections at STAR

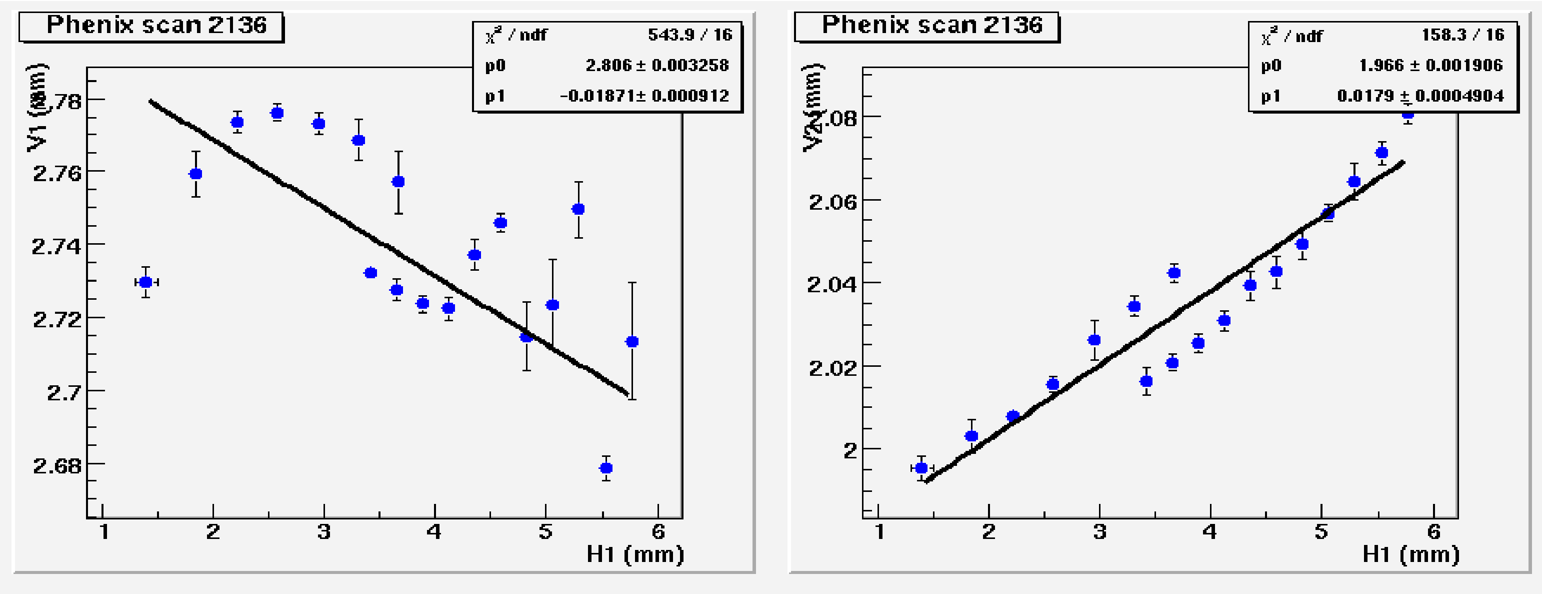
- **model correction** (meas. displacement vs. set value):
  - Au−Au: $(H_1+H_2)/2 = 6\%$, $(V_1+V_2)/2 = -4\%$ (β^* 2m)
  - pp: $(H_1+H_2)/2 = 2\%$, $(V_1+V_2)/2 = -3\%$ (β^* 3m)
- **coupling** (scan induces changes in the other plane):



- shows non−linearities and hysteresis effects (corrector magnets)
- varies by one order of magnitude from fill to fill:
  at z=0: from 2 µm/mm to 70 µm/mm!
- depends on corrector magnets and skew quad settings −> check

Coupling at PHENIX

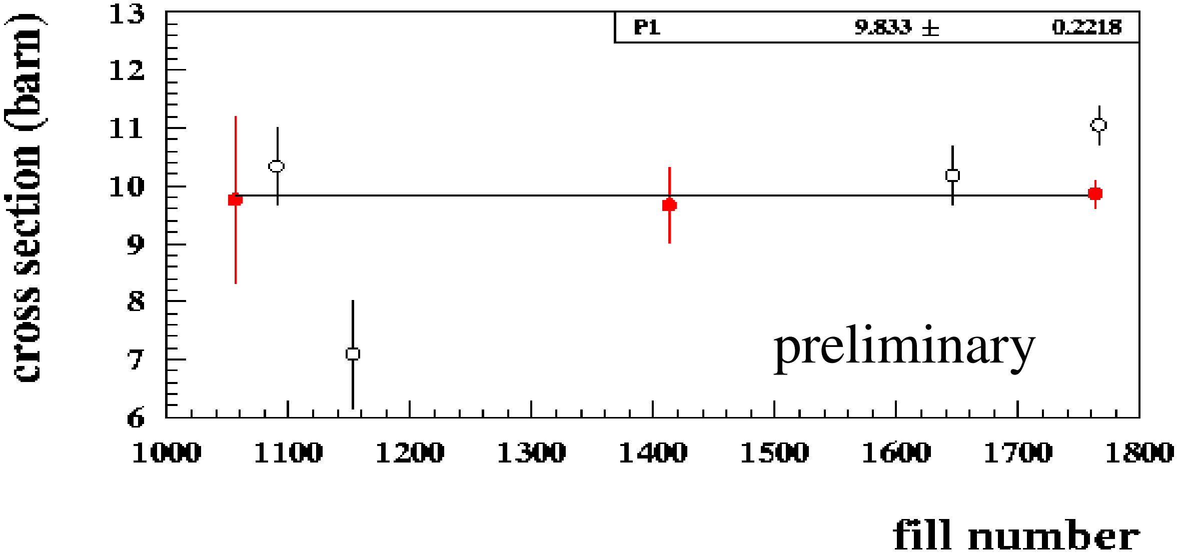
- **model correction** (meas. displacement vs. set value):
  - Au–Au: $(H_1+H_2)/2 = 18\%$, $(V_1+V_2)/2 < 2\%$ (β^* 1m) (only 1 fill)
  - pp: $(H_1+H_2)/2 < 2\%$, $(V_1+V_2)/2 < 1\%$ (β^* 3m)
- **coupling** (scan induces changes in the other plane):



  - shows non–linearities and hysteresis effects
  - smaller fill to fill variations (pp):
    at z=0: from –5 μm/mm to 3 μm/mm!

Au–Au: Results from run 2001:

Only STAR data (red circles) used. PHENIX data (open circles) not included.



Preliminary total cross sections from the 2001 Au–Au data (200 GeV), corrected for fill pattern, statistical error bars shown

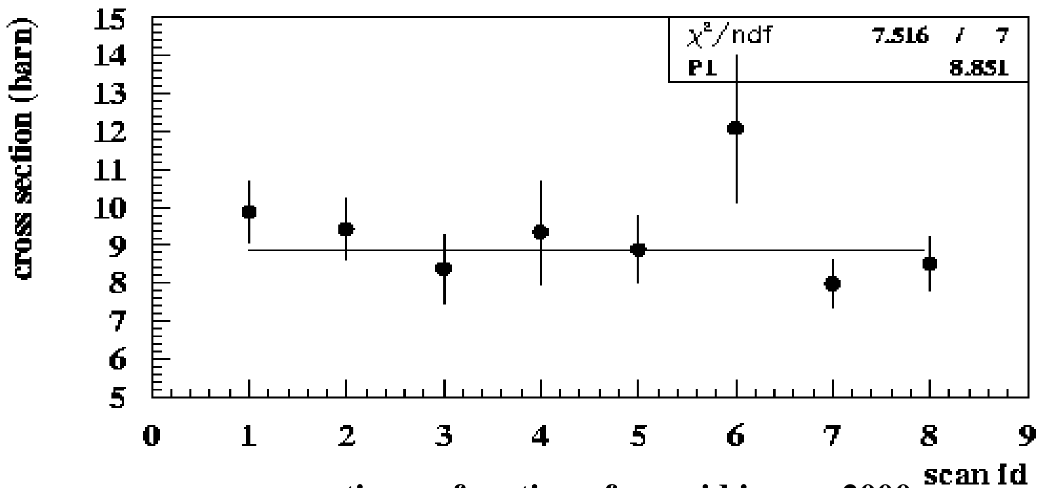
preliminary:

Total cross section @ 200 GeV: σ_{Au+Au} **= 9.8 +/– 0.2 (stat.) barn +/– 1.2 (sys.) barn**

compare to:

Total cross section @ 130 GeV: σ_{Au+Au} **= 8.9 +/– 0.3 (stat.) +/– 0.6 (syst.) barn**

AU–AU: Results from previous run (2000)



cross section as function of scan id in run 2000

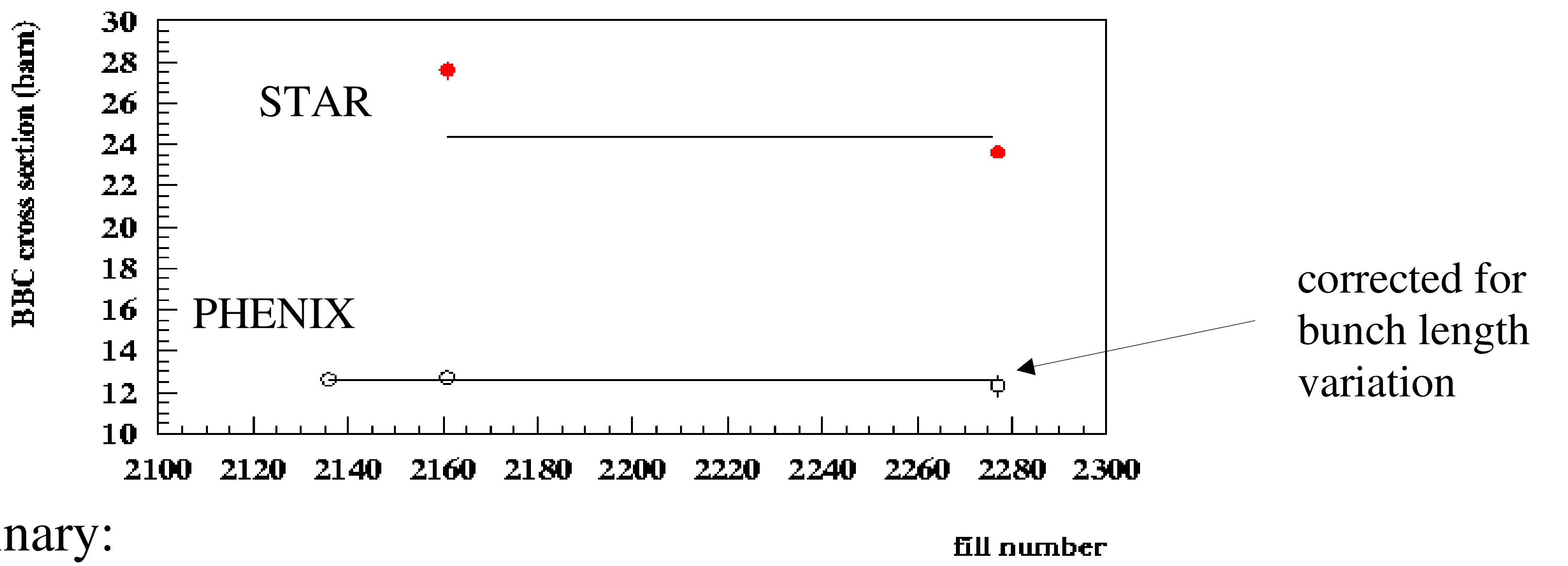
Final total cross sections in the year 2000 (130 GeV) after correction (statistical errors shown).

Total cross section @ 130 GeV:

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

C–A/AP

pp: Preliminary Results from Run 2002



Preliminary:

BBC: different detectors at IR6 and IR8:

$\sigma_{BBC,PHENIX}$ **= 12.6 +/– 0.1 (stat) +/– 1.0 (syst)** and

$\sigma_{BBC,STAR}$ **= 24.4 +/– 0.2 barn (stat)**

ZDC: consistent results from PHENIX and STAR scans:

cross–section for pp @ 200 GeV: σ_{zdc} **= 0.28 +/– 0.01 (stat) barn**

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Summary

- Vernier Scans are a powerful tool for both, EP and AP.
- Situation in 2001–02 was more difficult due to b–squeezing and the use of skew quads, probably corrector saturation.

- ***Preliminary*** results for cross sections:
  - ZDC (Au–Au): **9.8 +/– 0.2 (stat.) +/– 1.2 (sys.) barn**
  - PHENIX–BBC (pp): **12.6 +/– 0.1 (stat) +/– 1.0 (syst) barn**
  - STAR–BBC (pp): **24.4 +/– 0.2 (stat) barn**
  - ZDC (pp): **0.28 +/– 0.01 (stat) barn**

- More corrections need to be done and numbers might change slightly.
- Systematic errors need some more work and analysis.