# The AD/CDF/D0 Luminosity Task Force

Vaia Papadimitriou

All Experimenters' Meeting

September 12, 2005

## OUTLINE

- History and Goals
- Organization
- Topics addressed so far
- Some recent results

# History - Goals

- Started as a small beta* group in the summer of 2003 with the goal of providing to AD the measured $\beta^*$'s (beam widths) by CDF and D0 in a systematic way.
- When differences started arising between the measured CDF and D0 luminosities in January 2004, our small $\beta^*$ group and its goals got broadened; The CDF and D0 luminosity counter groups as well as other experts from CDF, D0 and AD joined the effort and this broader group became the "Luminosity Task Force".

# History - Goals

- Our goal is to communicate relevant information among CDF,D0 and AD, share tools and expertise, cross check results, and collaborate in understanding the various luminosity issues and in increasing the integrated luminosity at both IPs.

# People who participate(d) in the LuminosityTask Force

- **AD:** Yu. Alexahin, J. Annala, N. Gelfand, V. Lebedev, M. Martens,V. Papadimitriou, V. Shiltsev, J. Slaughter, M. Syphers, C. Tan, A. Tollestrup, A. Valishev, A. Xiao
- **CDF:** C. Bromberg, S. Jindariani, B. Kirby, J. Konigsberg,  A. Kraan, S. Lai, C. Neu, L. Ristori, R. Roser, R. Rossin, S. Sabik, W. Sakumoto, A. Shukanov, W. Trischuk, S. Wang
- **D0:** B. Casey, A. Chandra, D. Denisov, J. Estrada , G. Ginther, G. Gutierrez, B. Lee, A. Meyer, L. Mundim, H. Schellman, M. Weber, T. Yasuda
- **Directorate:** J. Appel

# Organization

- We exchange information continuously. We meet in smaller groups as needed and as a big group every one or two months. We often have other interested colleagues attending the meetings. You are welcome to participate and help out!

- Our WEB page is : http://www-bd.fnal.gov/SDA_Viewer/VaiaLuminosity/index.html

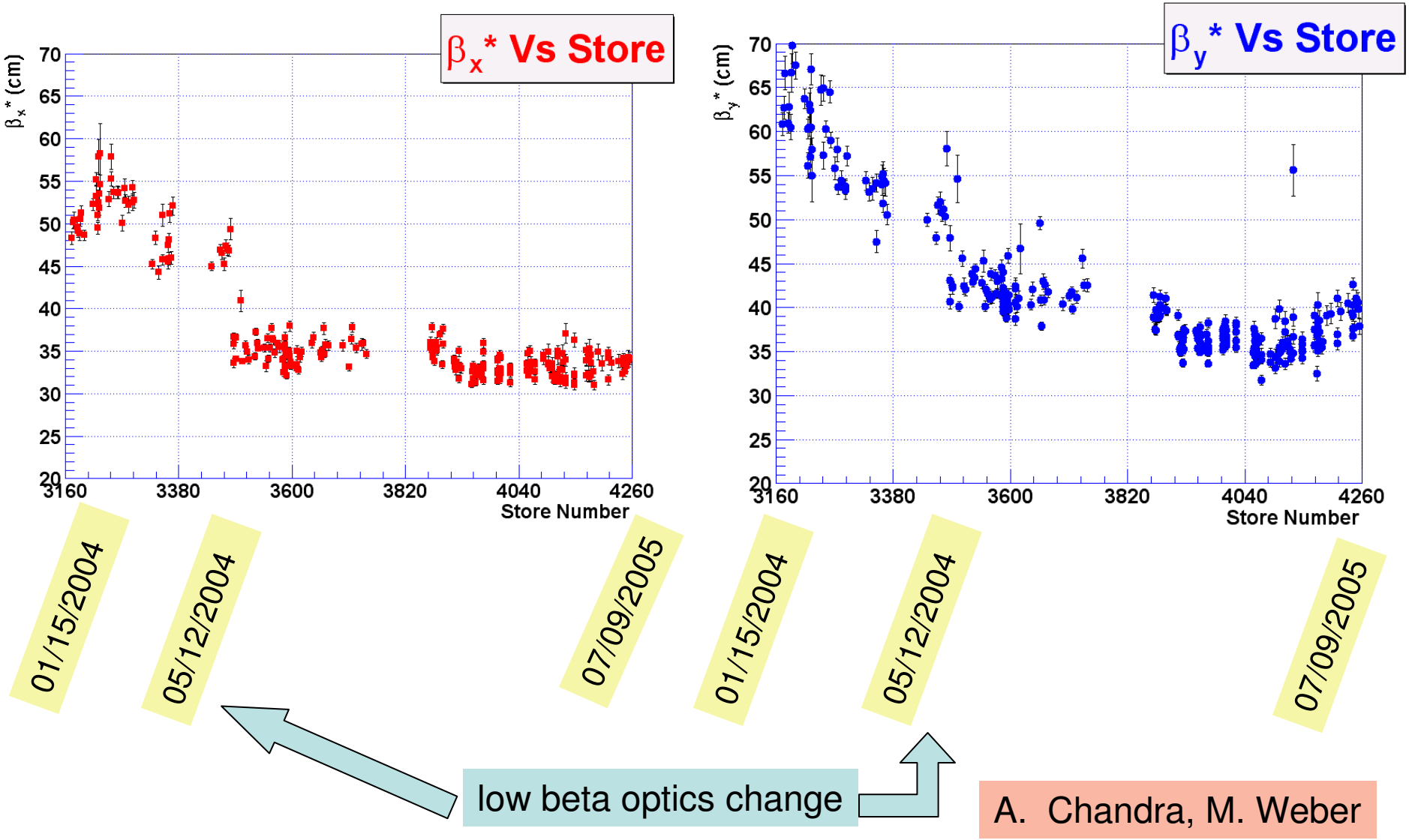
# Some of the topics addressed so far

- Beam optics. Direct and indirect measurements of $\beta^*$ by AD. Proton vs pbar beam waists. Beam-beam effects. Crossing angle measurements. Vacuum studies.
- Measurements of $\beta^*$, beam position and coupling by CDF and D0. Offline and online measurements.
- CDF/D0 luminosity ratio and what it depends on.
- Integrity of the CDF and D0 luminosity measurements (hardware, trigger studies, physics measurements).
- Comparisons of CDF and D0 luminosities with AD predictions. Bunch by bunch studies.

# Some accomplishments so far

- Systematic offline analysis of D0 beam widths: http://www-clued0.fnal.gov/~avdhesh/Beam_main.html
- Systematic offline analysis of CDF beam widths, which has been gradualy replaced by online analysis. Very challenging project. In ACNET for several months now, under validation. Results are legitimate; online data available for people to use.
- We help validate the beam optics changes implemented periodically by the Tevatron group (eg. low beta optics of May 2004, 28 cm lattice now, etc.)

# D0 $\beta^*_{x,y}$ vs store #

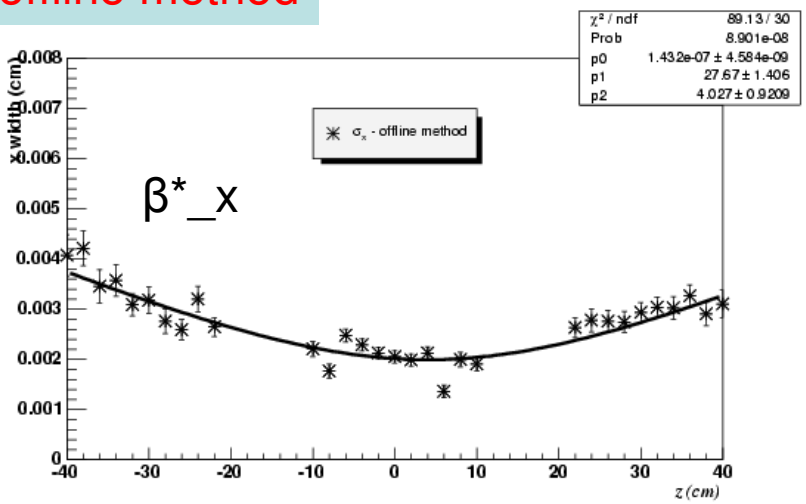


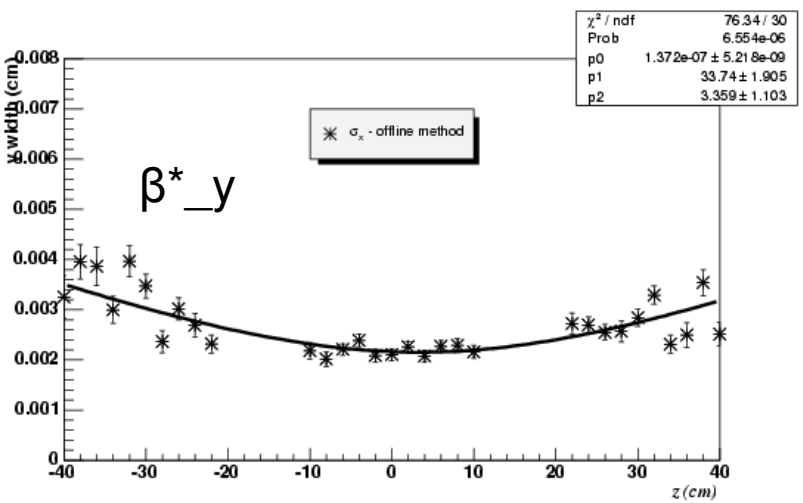

A. Chandra, M. Weber

# Recent CDF History: $\beta^*$ versus time

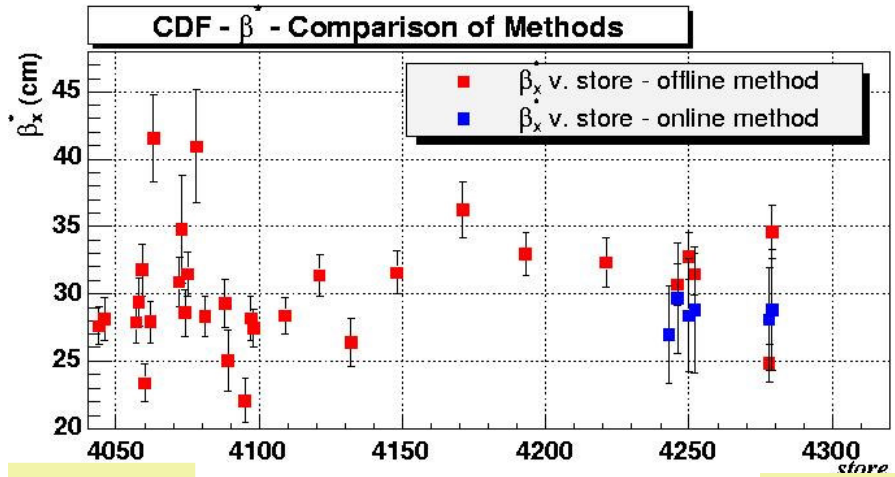
C. Neu, S. Lai, S. Sabik, W. Trischuk

offline method



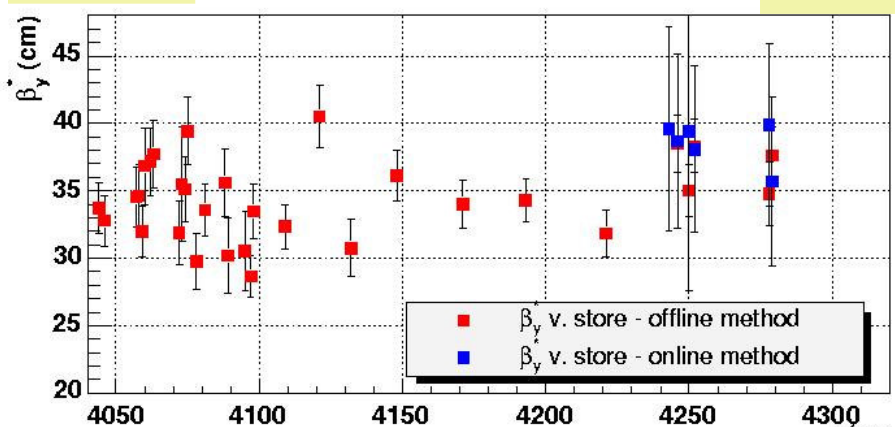




z (cm)




03/19/05

07/18/05




Offline method

Online method

Store #

Replacing gradually offline by online

# Status

- Recent D0 offline measurement of $\beta^*$ indicate that $\beta^*_x \cong 33$ cm and $\beta^*_y \cong 36$ cm on average.
- Recent CDF offline $\beta^*$ measurements indicate that $\beta^*_x \cong 30$ cm and $\beta^*_y \cong 35$ cm on average.
- Statistical uncertainties are of the order of 1.0 cm for D0 and 1.5 to 2.0 cm for CDF. Store to store variations by a few cm for both CDF and D0.
- Both experiments observed $\beta^*_y$ to be bigger than $\beta^*_x$.

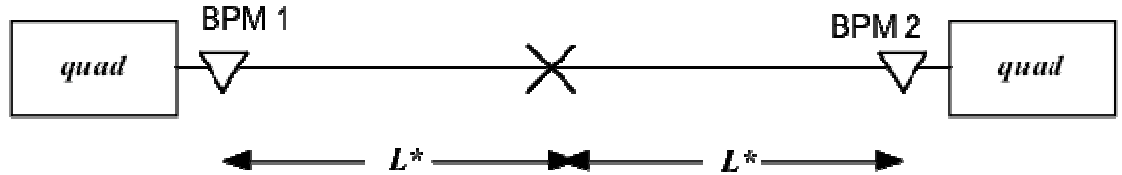
# AD measurements of $\beta^*$

- As discussed by A. Valishev at AEM of 08/29/05, using differential orbit measurements, an orbit response matrix fit and the new Tevatron BPM system allows for the determination of $\beta^*$ at an accuracy of ~5% (compare to ~15% before).

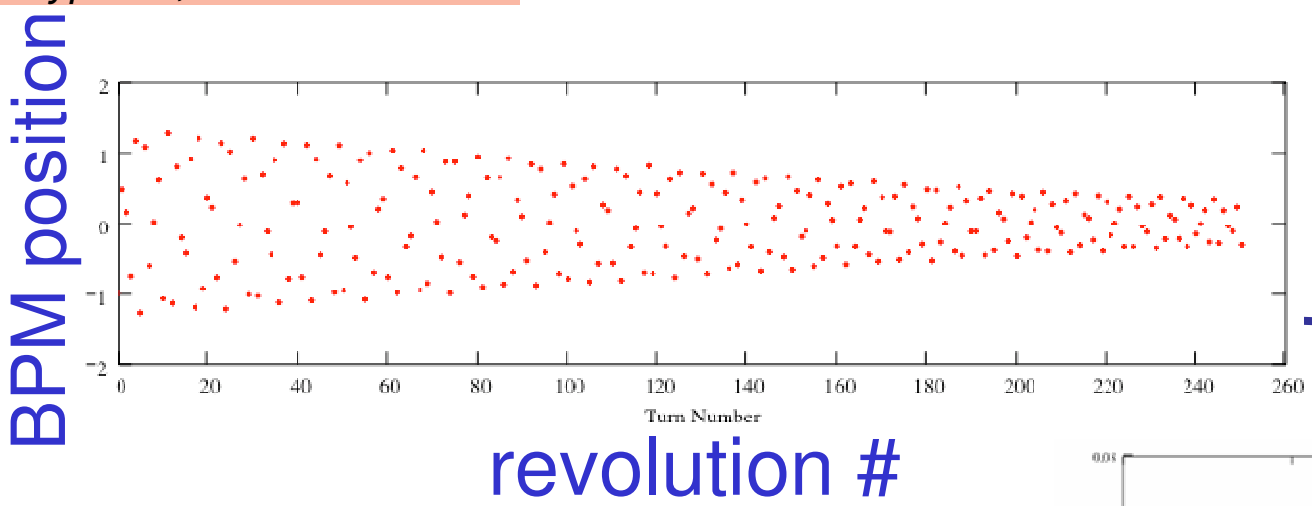
| | $\beta^*_x$ | $\beta^*_y$ | |
|---|---|---|---|
| CDF | 32.0 | 37.1 | ±5% |
| D0 | 35.8 | 40.0 | ±5% |

Beam-beam effects can reduce $\beta^*$ by about 10%.

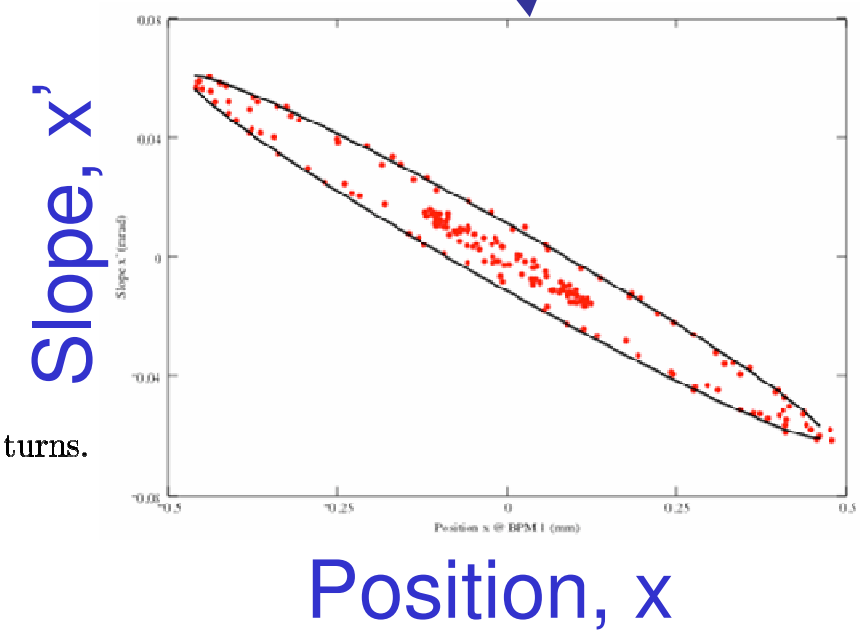
# Direct Measurement of β*




*M. Syphers, beams-doc-1880*




Kick beam, record turn-by-turn positions w/ new Tevatron BPM system; reconstruct phase space




From phase space ellipses at the two BPMs, can reconstruct amplitude function through the region; determine minimum value and its location:

Table 3: Amplitude Functions at 980 GeV, 2005 June 23, using 1500 turns.

| | | $\beta^*$ | $\delta\beta^*$ | $\Delta s^*$ | $\delta\Delta s^*$ |
|---|---|---|---|---|---|
| **CDF** | Hor | 34.6 cm | ±0.6 cm | +34.2 cm† | ±0.4 cm |
| | Ver | 38.7 cm | ±0.3 cm | -4.8 cm | ±0.4 cm |
| **D0** | Hor | 38.7 cm | ±1.6 cm | +1.1 cm | ±0.4 cm |
| | Ver | 40.3 cm | ±0.2 cm | +2.3 cm | ±0.2 cm |

Coupling to be implemented

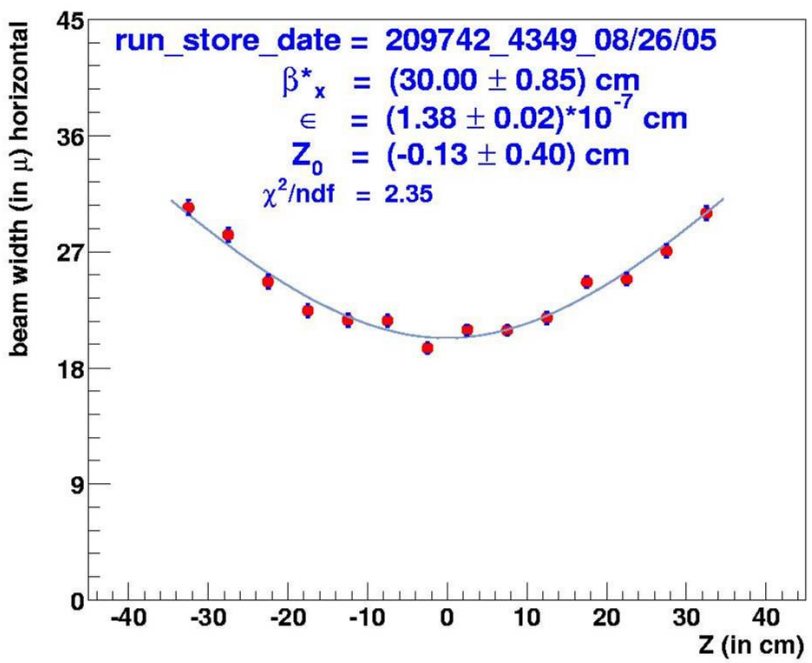
# Status

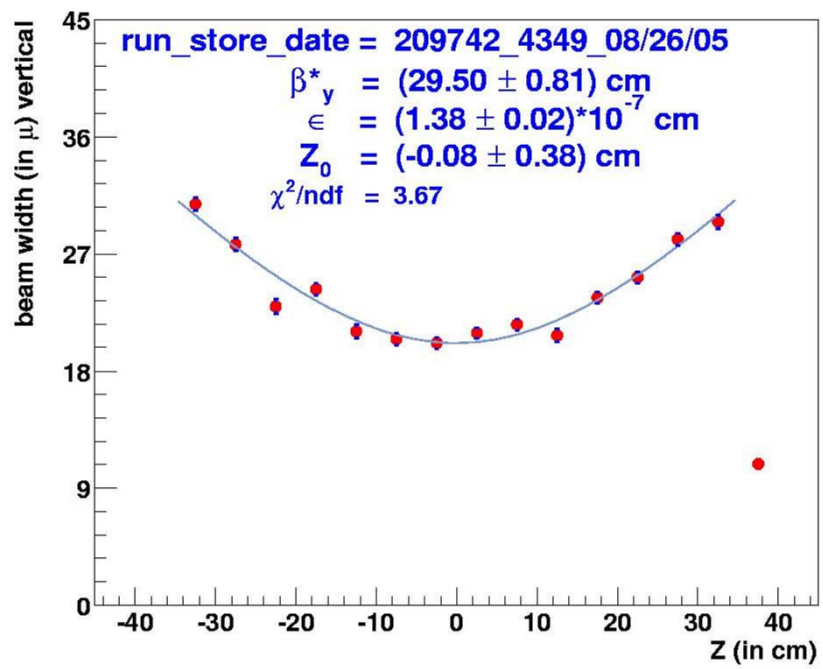
- Although more studies are needed, the preliminary results of the improved AD $\beta^*$ measurements are consistent with the corresponding measurements of CDF and D0. This indicates that about 5% of the luminosity difference between CDF and D0 could be explained by smaller $\beta^*$s in CDF. (Uncertainties of $\beta^*$ measurements still not sufficiently small to allow for a firm conclusion).
- AD in the process of equalizing both IPs,correcting beta-beating in the arcs and implementing a 28 cm lattice.

# D0 $\beta^*_{x,y}$ for store 4349 (08/24/05)

$\beta^*_x = 32.8 \pm 0.6$ cm **35 cm lattice** $\beta^*_y = 34.3 \pm 0.6$ cm

$\beta^*_x = 30.0 \pm 0.9$ cm **28 cm lattice** $\beta^*_y = 29.5 \pm 0.8$ cm



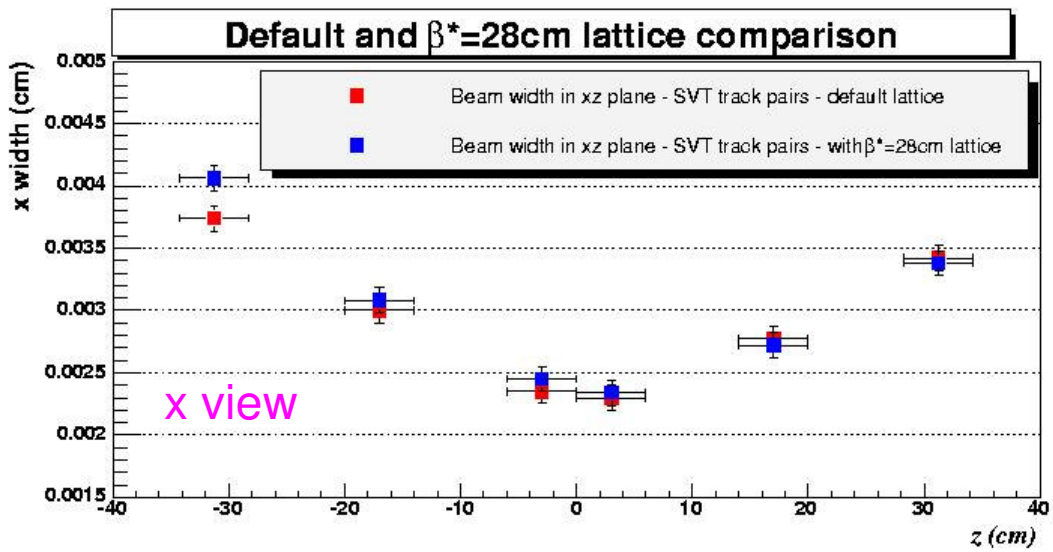

Vaia Papadimitriou

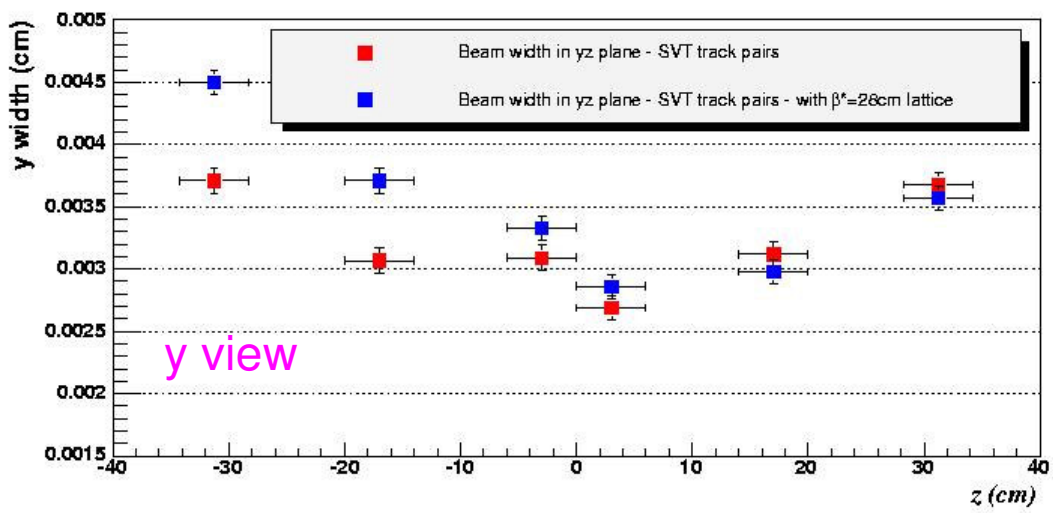
A. Chandra, M. Weber

# CDF $\beta^*_{x,y}$ for store 4349 (08/24/05)

C. Neu

online method




**35 cm lattice**

$\beta^*_x = 25.7 \pm 2.5$ cm

$\beta^*_y = 38.5 \pm 4.1$ cm

$z_{0x} = 2.2 \pm 1.6$ cm

$z_{0y} = 0.9 \pm 2.1$ cm

**28 cm lattice**

$\beta^*_x = 25.3 \pm 2.4$ cm

$\beta^*_y = 32.8 \pm 3.5$ cm

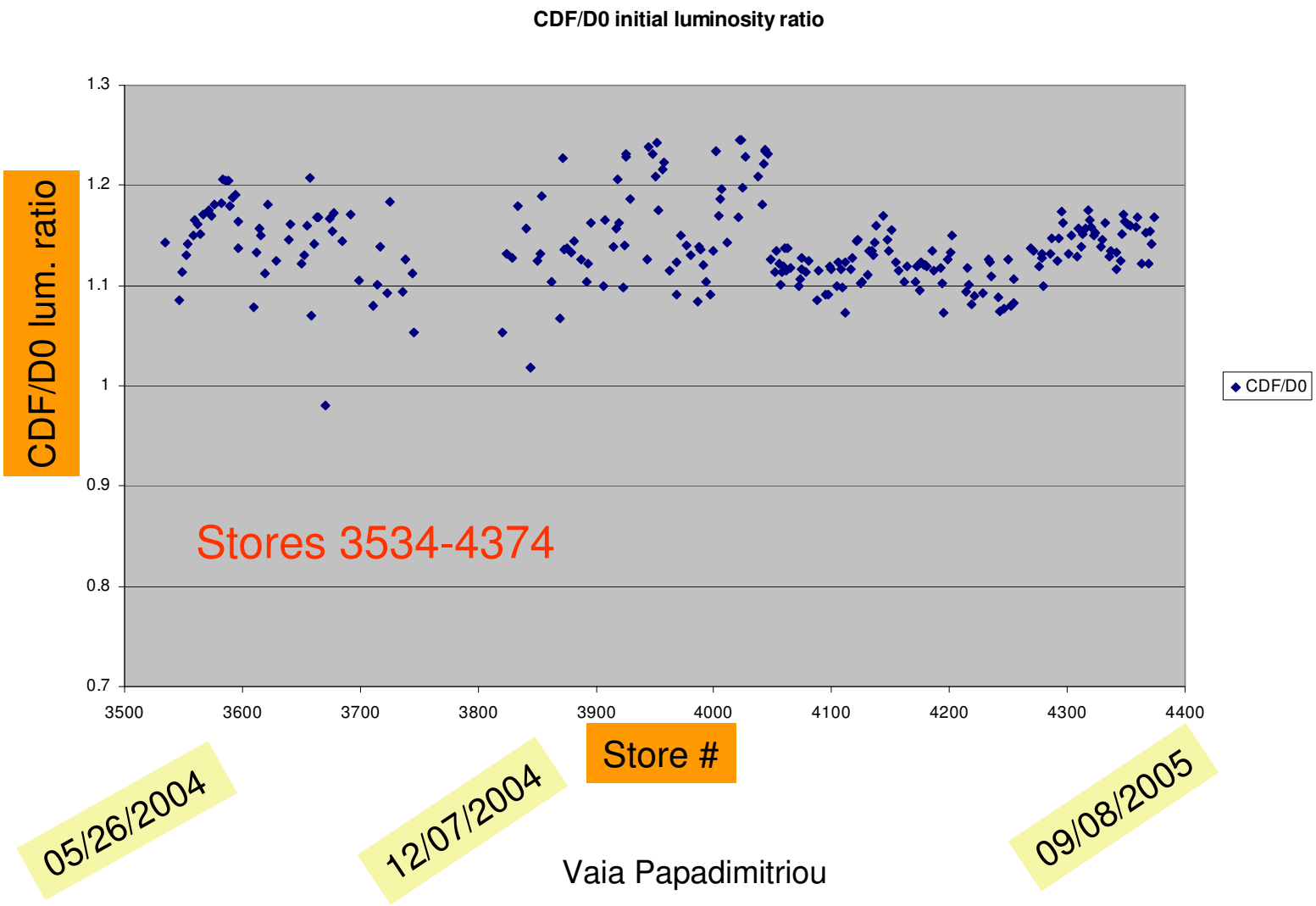
$z_{0x} = 4.1 \pm 1.6$ cm

$z_{0y} = 9.4 \pm 1.8$ cm

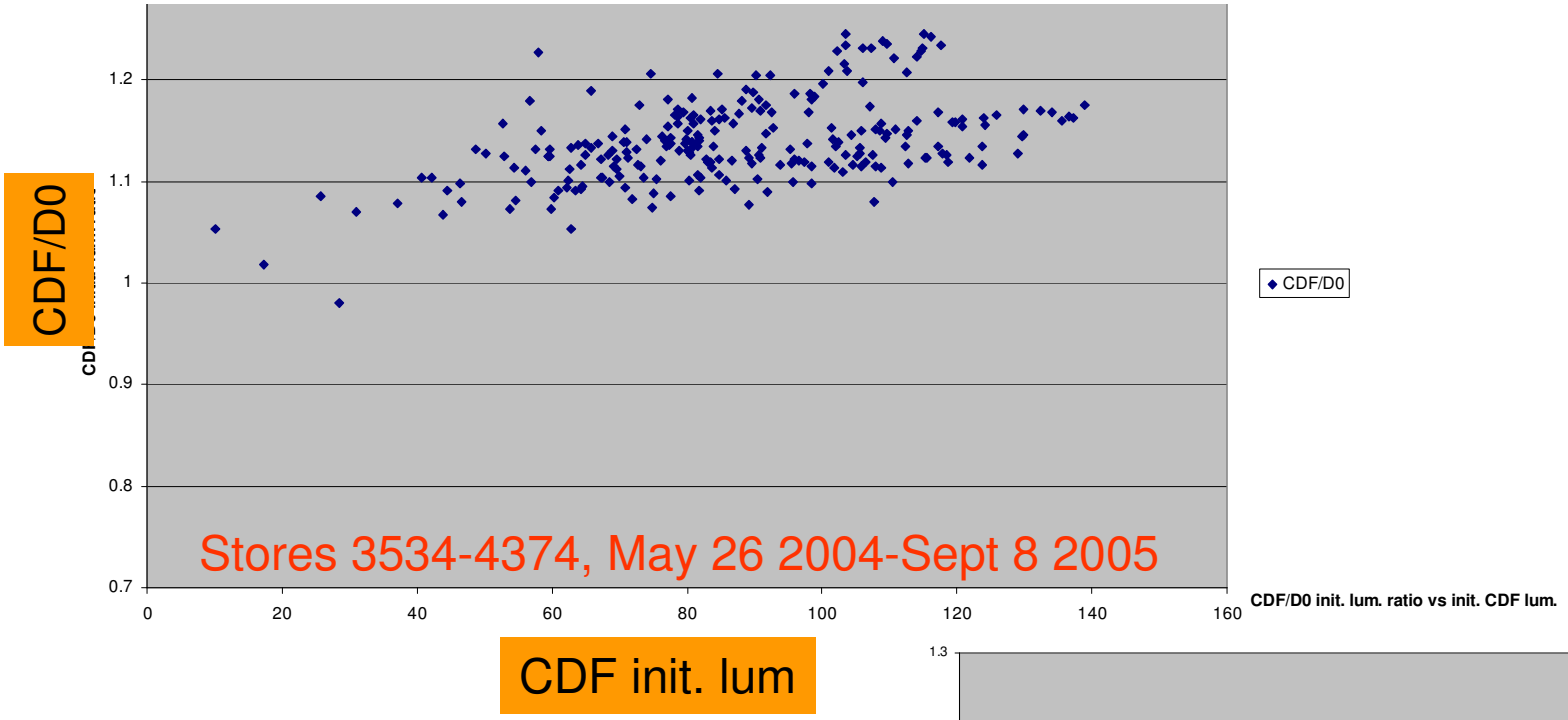
# AD β* expectation for the 28 cm lattice

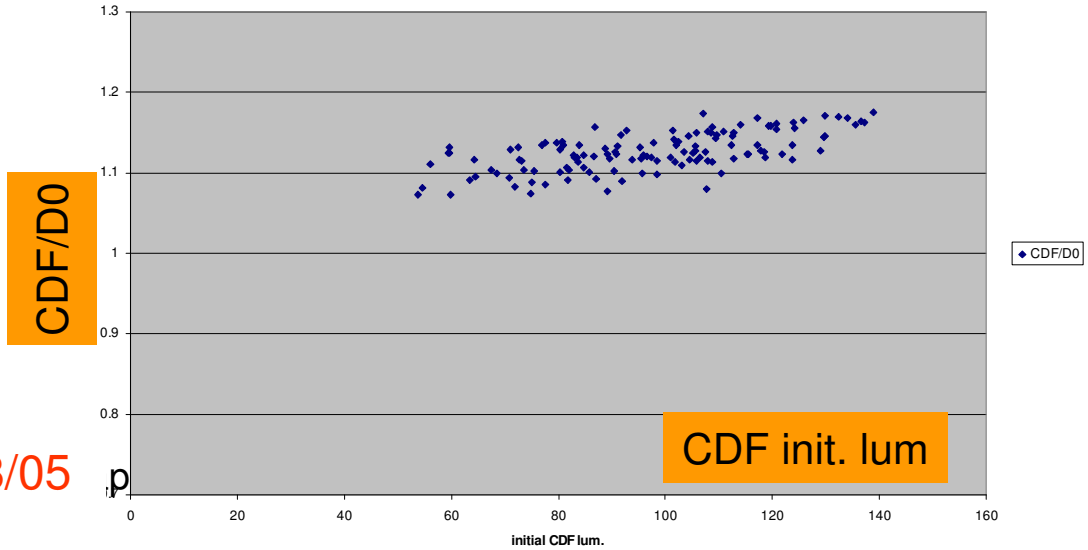
| | $\beta^*_x$ | $\beta^*_y$ | |
|---|---|---|---|
| CDF | 30.3 | 29.1 | ±5% |
| D0 | 29.2 | 28.2 | ±5% |

# CDF/D0 init. lum. vs store #



# CDF/D0 init. lum vs CDF init. lum




Stores 4048-4374, 03/18/05-09/08/05

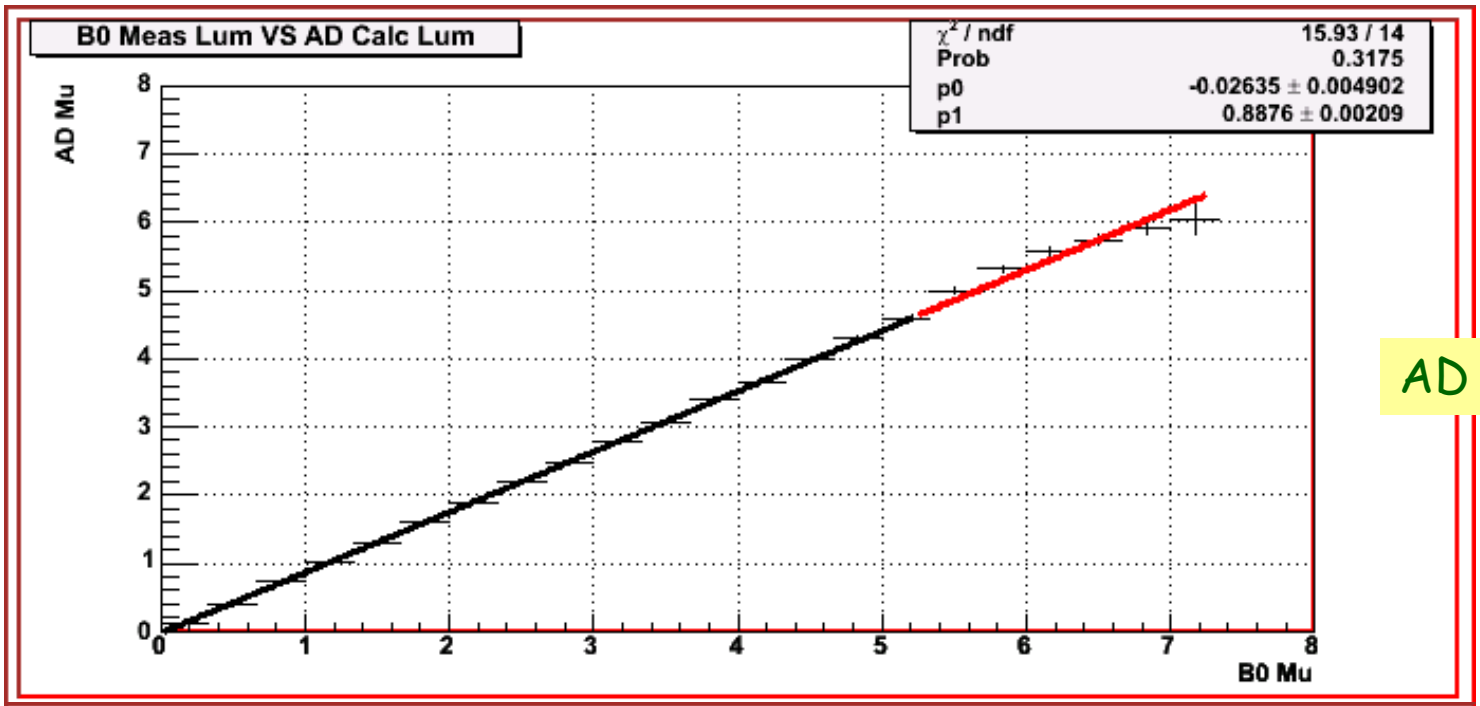
# Some accomplishments so far

- In July 2004 we helped identify the cause of the dependence of the CDF/D0 luminosity ratio on the magnitude of the luminosity itself.
- As discussed by B. Casey at AEMs of 09/27/04 and 03/21/05, D0 has found and significantly reduced sensitivity to backgrounds and nonlinearities. They are in the process of re-evaluating the absolute efficiency of the detector to account for new magnetic field, new coupling scheme and new corrections. All corrections are expected to be implemented soon.

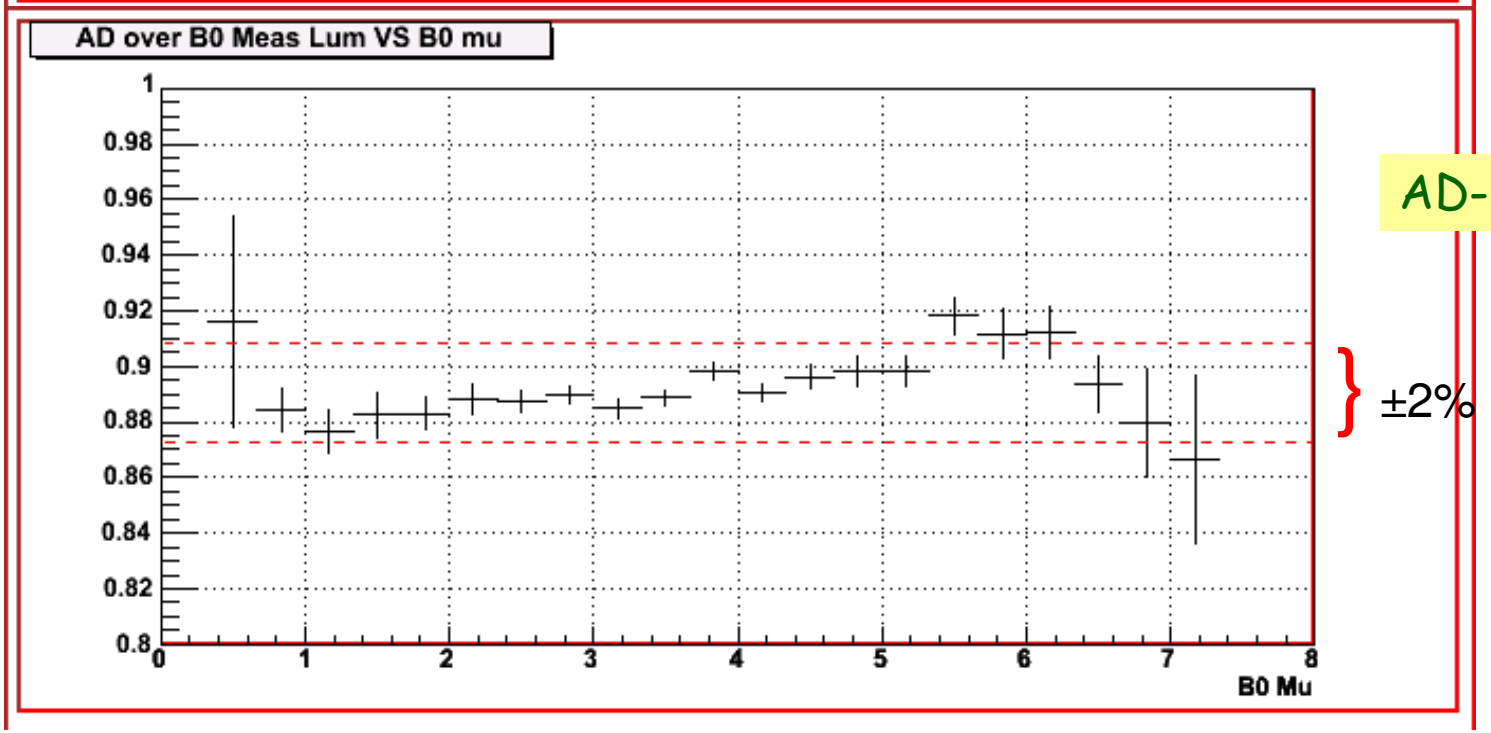
# Some accomplishments so far

- CDF finds good linearity dependence between their measurements and AD "predicted" luminosities up to $\mu$=5 (average number of interactions per bunch crossing) which corresponds to L~ 1.8E32 $cm^{-2}s^{-1}$. This was done by studying the luminosity information on a bunch by bunch basis. More data are needed to check higher luminosity regimes.
- D0 is performing similar studies.

R. Rossin




AD vs CDF

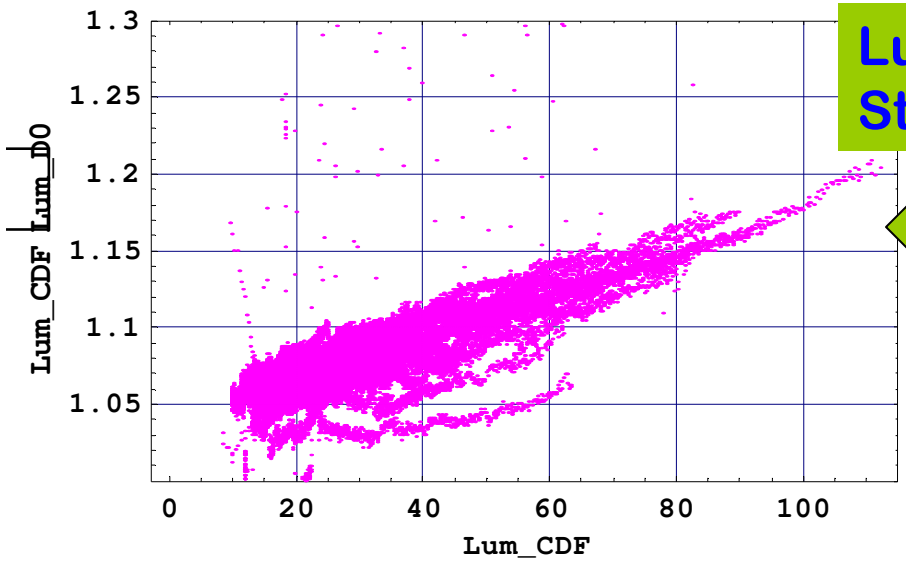



AD-Off/B0 vs CDF

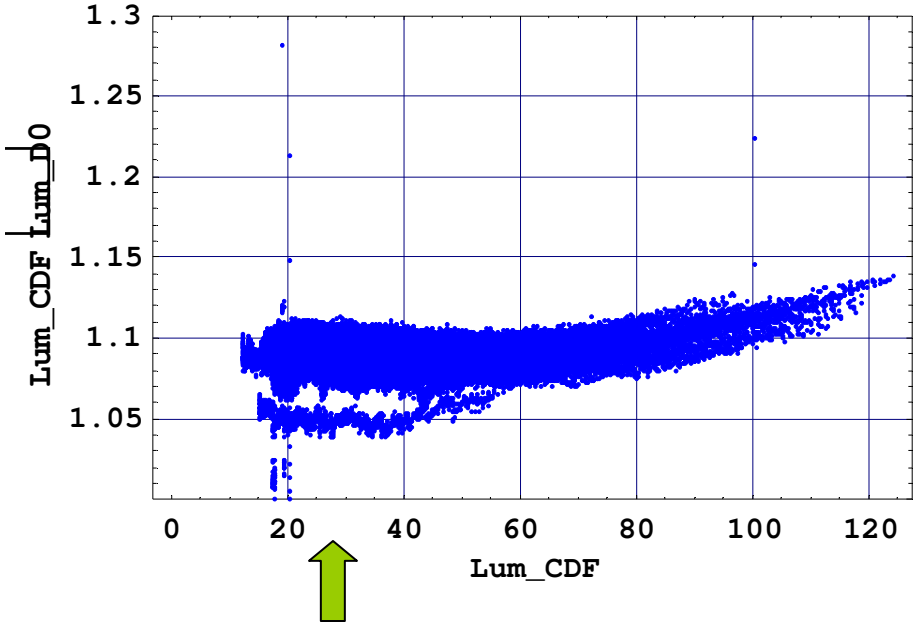
# Conclusions

- This is a joint AD/CDF/D0 effort and we went a long way... In the process we learned a lot about the CDF/D0 luminosity and beam width measurements, about beam optics and beam physics. Helped identify problems and contributed in validating solutions.
- The next milestones will be the upcoming D0 adjustment of the luminosity scale and the completion by AD of the introduction of a 28 cm lattice and IP equalization.
- At that point we will see where we are by performing again all relevant comparisons.

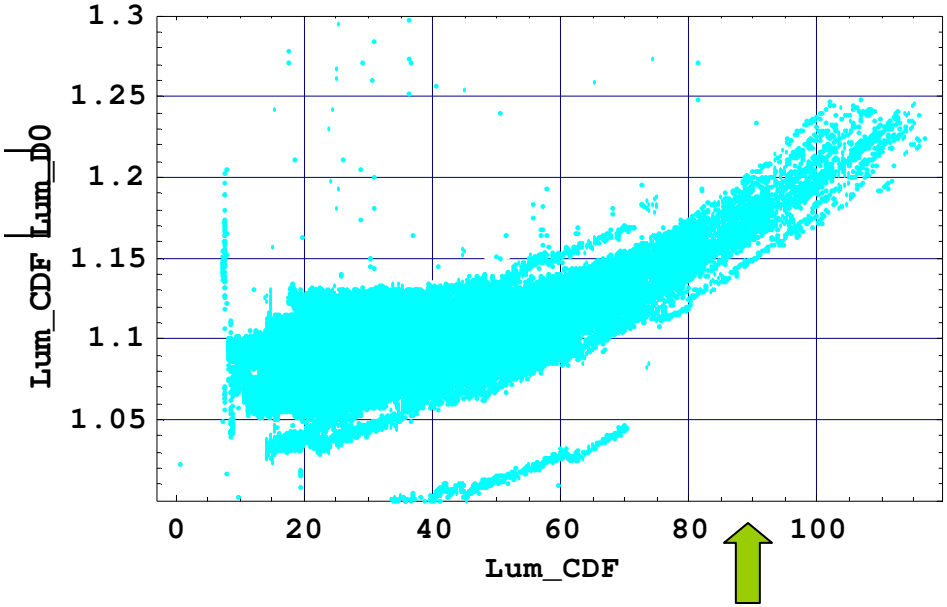
# BACKUP SLIDES




**Lum Ratio before Fall shutdown: Stores 3641 ~ 3745, total of 24 stores**




**Luminosity Ratio after 2nd set of D0 corrections (03/18/05): Stores 4048 ~ 4112, total of 29 stores**




**Lum Ratio after 1st set of D0 corrections after the Fall Shutdown: Stores 3845 ~ 4046, total of 59 stores**

# Recent D0 changes

- As discussed by B. Casey at AEM of 03/21/05, D0 has introduced on 03/17/05 additional deadtime corrections.Also switched from AC coupling with short time constant to DC coupling with active baseline restoration.

- CDF measures luminosity per bunch with the CLC
- AD calculates the luminosity per every bunch at the IPs by measuring beam parameters and using the formula:

$$L = \frac{6 \cdot 10^{-5} f_{bc} N_p N_a \beta_r \gamma_r}{4\pi\beta^* 0.5 \cdot \sqrt{(\varepsilon_p + \varepsilon_a)_h \cdot (\varepsilon_p + \varepsilon_a)_v}} \cdot H(\sigma_l / \beta^*)$$

The spread in luminosity among bunches is large (~2).

By comparing CDF and AD measurements we can investigate now
$\mu$=7 $\leftrightarrow$ L = 2E32 $cm^{-2}$ $s^{-1}$ ($L \cdot \sigma = f_{bc} \cdot \mu$)

Values measured at the beginning of the stores: Remove halo or HEP1