New Optics for the Tevatron

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Contents

Orbit response matrix fit

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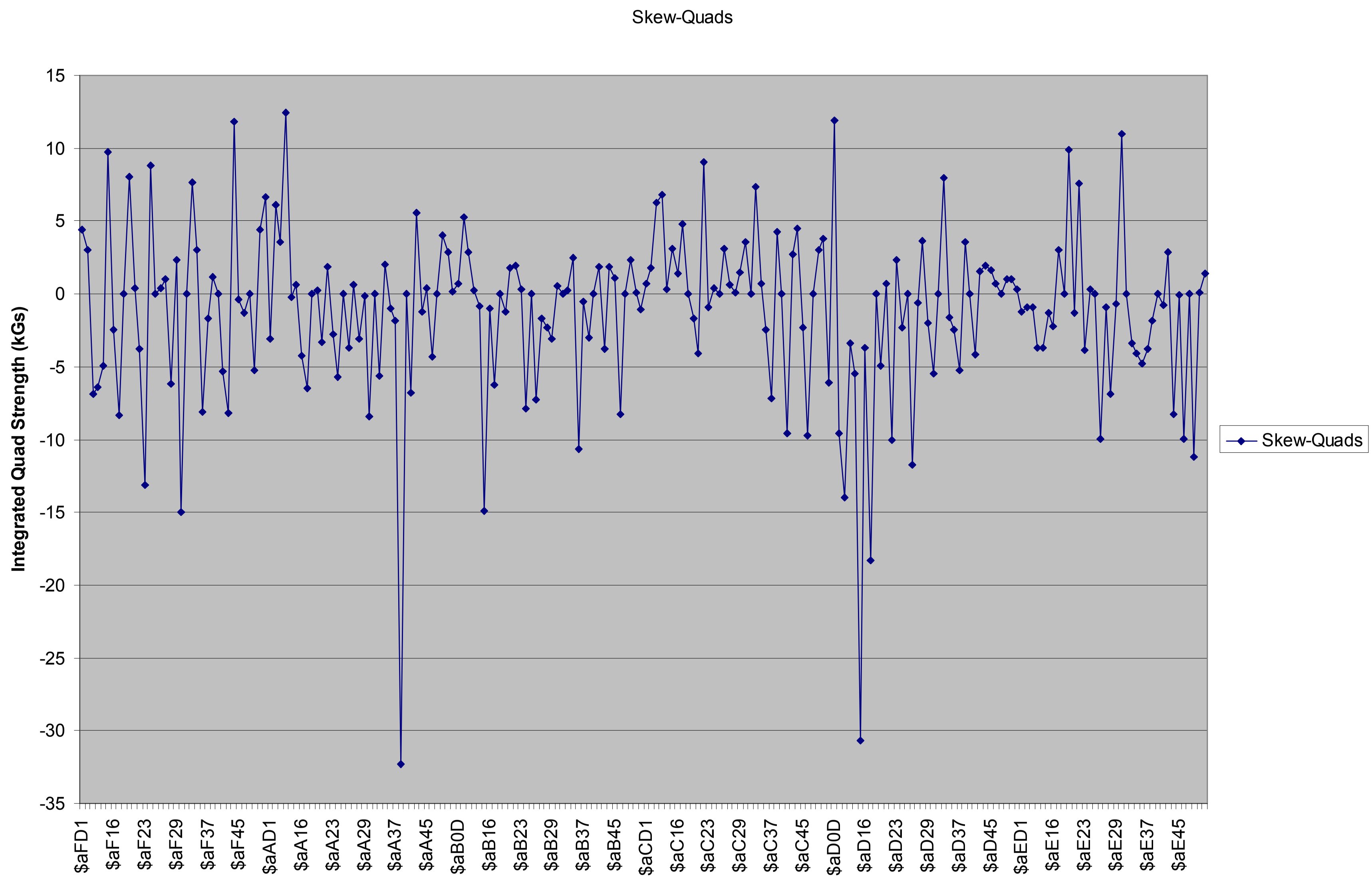
Using the differential orbit measurements and response matrix fit we find the following machine parameters:

- Quadrupole gradient errors (~2e-3)
- Quadrupole tilts
- Steering magnet calibrations
- Steering magnet tilts
- BPM gains
- BPM tilts

A computer model was built based on the measurements with beta function accuracy of ~5% (cross-checked with other methods)

Skew-Quadrupole Errors



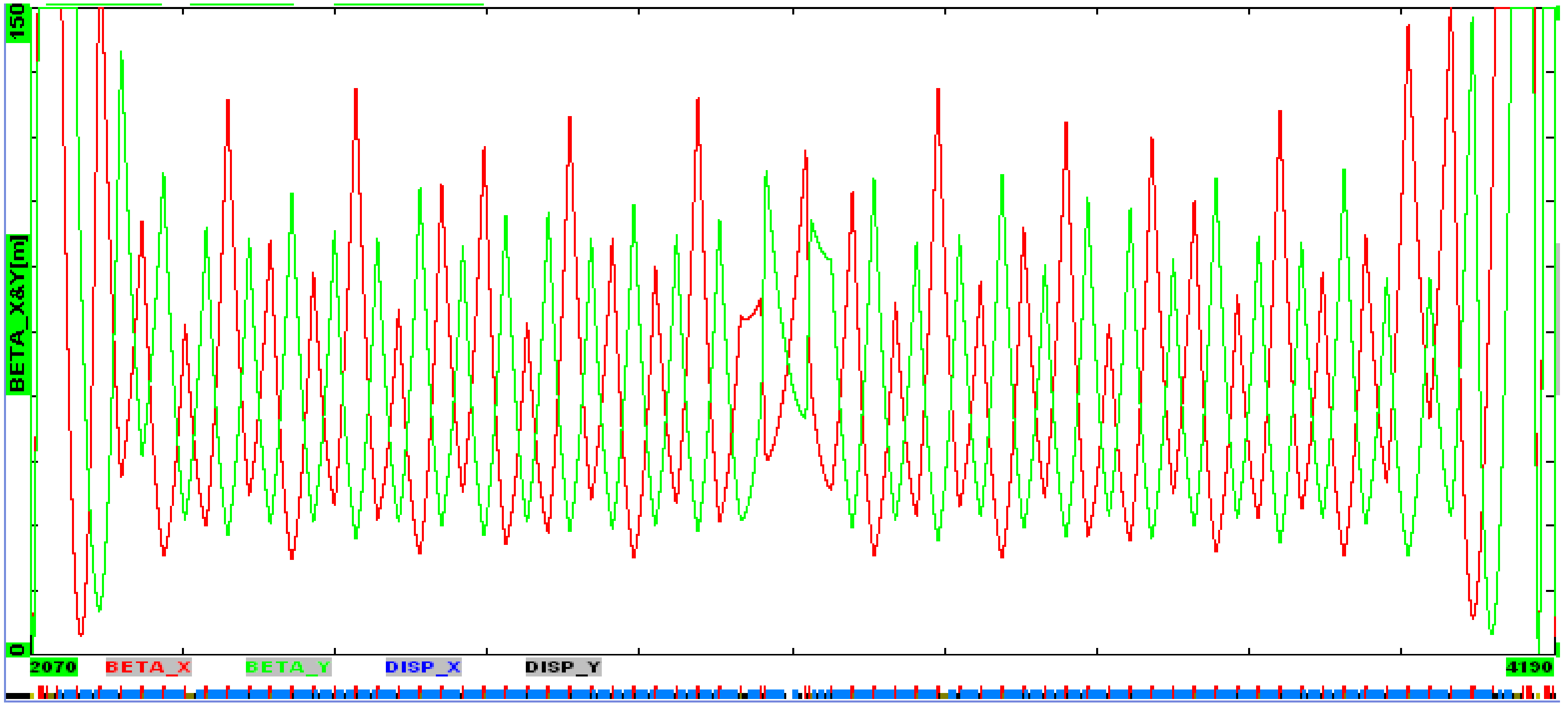
Skew Quadrupole Errors at D16 and A38

Based on Tech data:

- At D-16, quadrupole TQ184D has the lugs set incorrectly for the roll angle. If we call the correct orientation straight up, when the lugs are set level the field is pointing 12 mr toward the aisle.

- At A-39, quadrupole TQ096D has the lugs set incorrectly for the roll angle. If we call the correct orientation straight up, when the lugs are set level the field is pointing 10 mr toward the aisle.

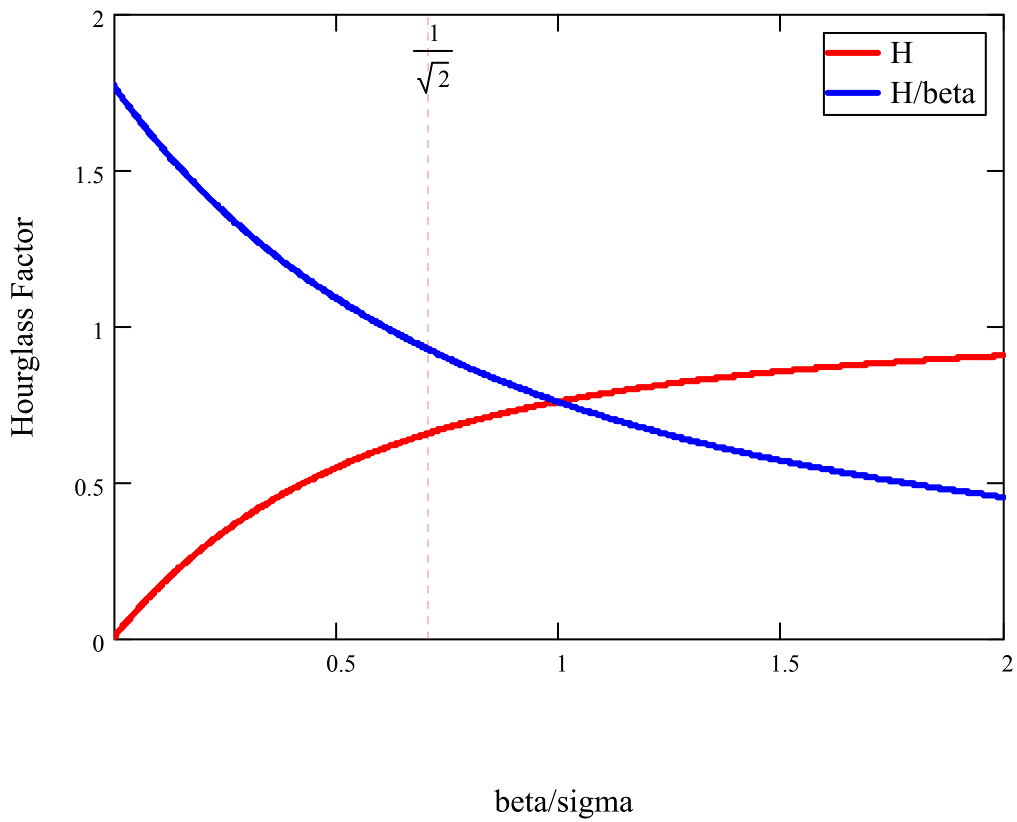
Present Beta Functions



	β_x^* (cm)	β_y^* (cm)	
CDF	32.0	37.1	$\pm 5\%$
D0	35.8	40.0	$\pm 5\%$

Lattice and Luminosity

$$L = \frac{N_p N_a f \cdot H(\beta^* / \sigma)}{2\pi \sqrt{\sigma_{p,x}^2 + \sigma_{a,x}^2}\sqrt{\sigma_{p,y}^2 + \sigma_{a,y}^2}} = \frac{N_p N_a f \cdot H(\beta^* / \sigma)}{2\pi \sqrt{\varepsilon_{p,x}\beta_{p,x} + \varepsilon_{a,x}\beta_{a,x}}\sqrt{\varepsilon_{p,y}\beta_{p,y} + \varepsilon_{a,y}\beta_{a,y}}}$$



$$\rightarrow \frac{N_p N_a f \cdot H(\beta^* / \sigma)}{2\pi(\varepsilon_p \beta_p + \varepsilon_a \beta_a)}$$

$$\rightarrow \frac{N_p N_a f}{4\pi\varepsilon} \frac{H(\beta^* / \sigma)}{\beta^*}$$

$$\beta(z) = \beta^* + z^2 / \beta^*$$

Beta* 35cm -> 28cm
gain is 11% not 25%!

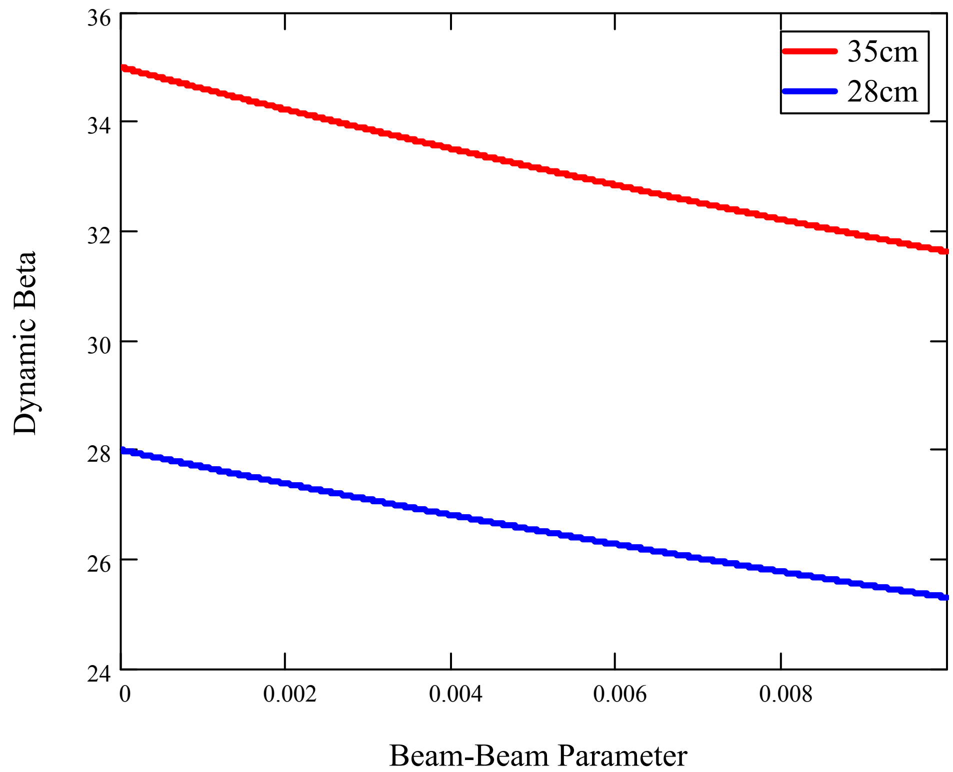
Dynamic Beta Effect

Beam-Beam parameter $\xi = \dfrac{N_p r_p}{4\pi\varepsilon_p} = 0.01$

$$M = \begin{pmatrix} \cos\mu & \beta^* \sin\mu \\ -\dfrac{1}{\beta^*}\sin\mu & \cos\mu \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -\dfrac{4\pi}{\beta^*}\xi & 1 \end{pmatrix}$$

$$\mu' = \mu + 2\pi\xi$$

$$\beta' = \beta^* \frac{\sin\mu}{\sin\mu'}$$

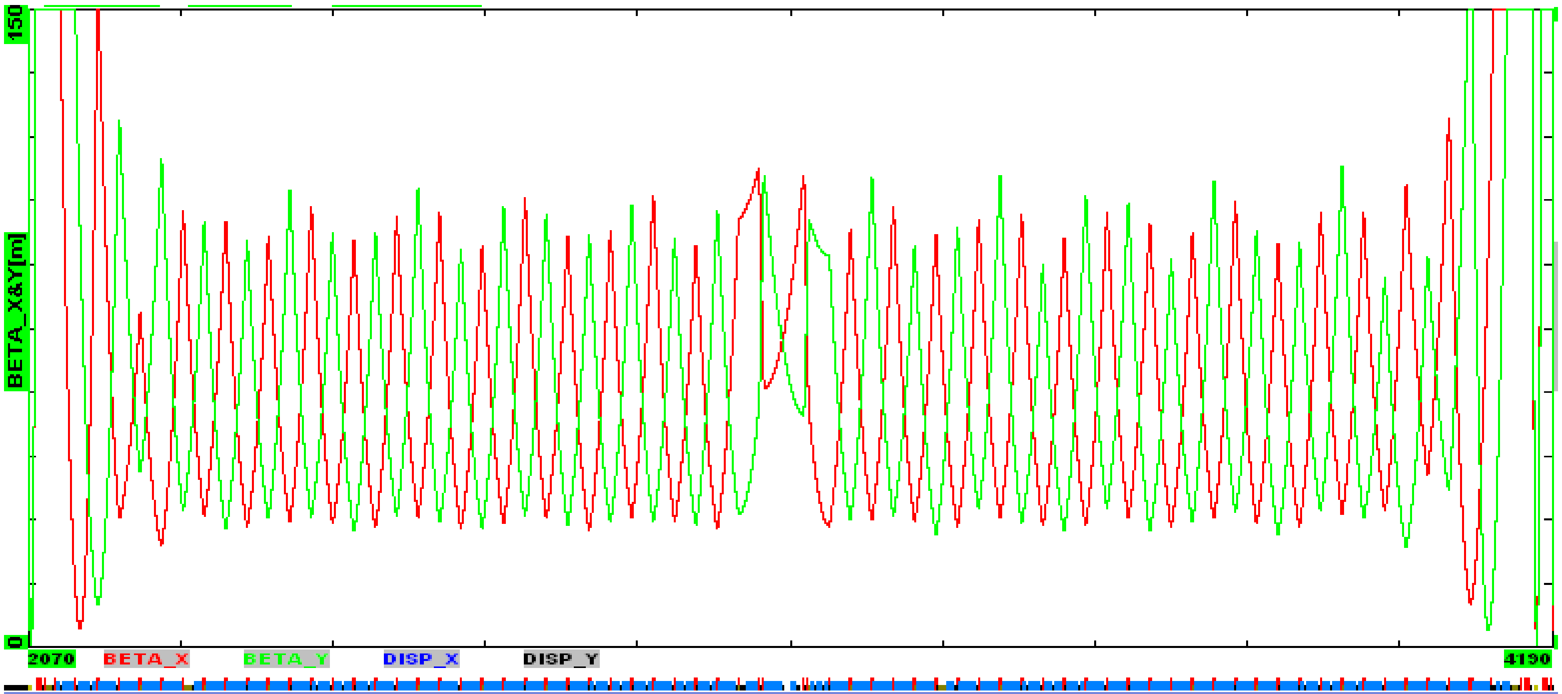


The Proposed Optics Correction

- Decrease beta* from 35 to 28 cm
- Eliminate difference between B0 and D0 IPs
- Correct beta-beating in the arcs

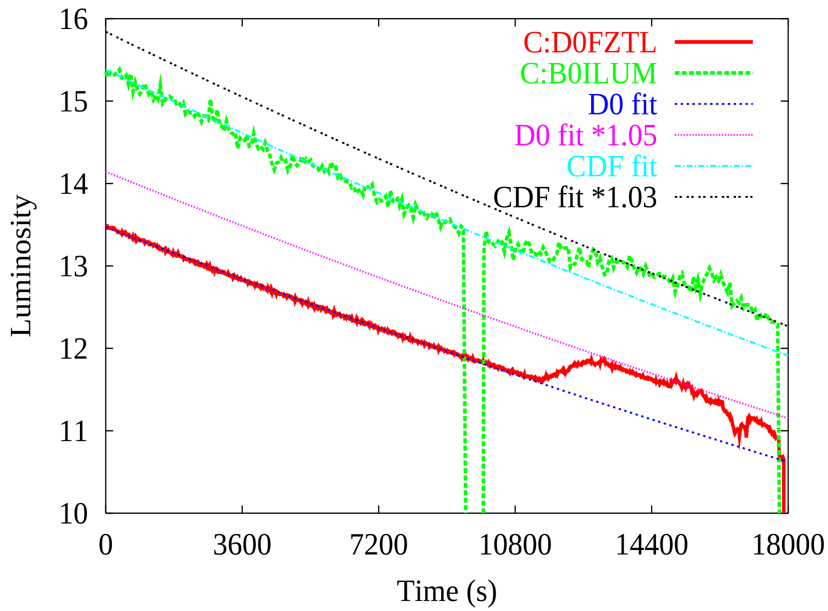
Element	Present I (A)	Delta I (A)	New I (A)
C:AQ0F	100.7	100	200.7
C:AQ9F	555.6	-50	505.6
C:AQ7F	602.6	100	702.6
C:B0Q6F	3647.4	780	4427.4
C:B0QT6F	-22.9	5	-17.9
C:B0Q5F	1972.5	-30	1942.5
C:B0Q2F	4718.9	-2	4716.9
C:B0QT2F	5.4	0.5	5.9
C:B0Q3F	4655.2	-9	4646.2
C:B0QT3F	8.7	2	10.7
C:BQ7F	680.1	100	780.1
C:BQ9F	479.7	-150	329.7
C:BQ0F	49.8	70	119.8
C:CQ0F	100.7	-40	60.7
C:CQ9F	555.6	-140	415.6
C:CQ7F	601.0	80	681.0
C:D0Q6F	3647.4	490	4137.4
C:D0QT6F	-22.9	5	-17.9
C:D0Q5F	1972.5	280	2252.5
C:D0Q2F	4704.8	-1	4703.8
C:D0QT2F	31.2	2	33.2
C:D0Q3F	4631.7	-9	4622.7
C:D0QT3F	31.6	0	31.6
C:DQ7F	654.5	60	714.5
C:DQ9F	479.7	-40	439.7
C:DQ0F	46.3	80	126.3

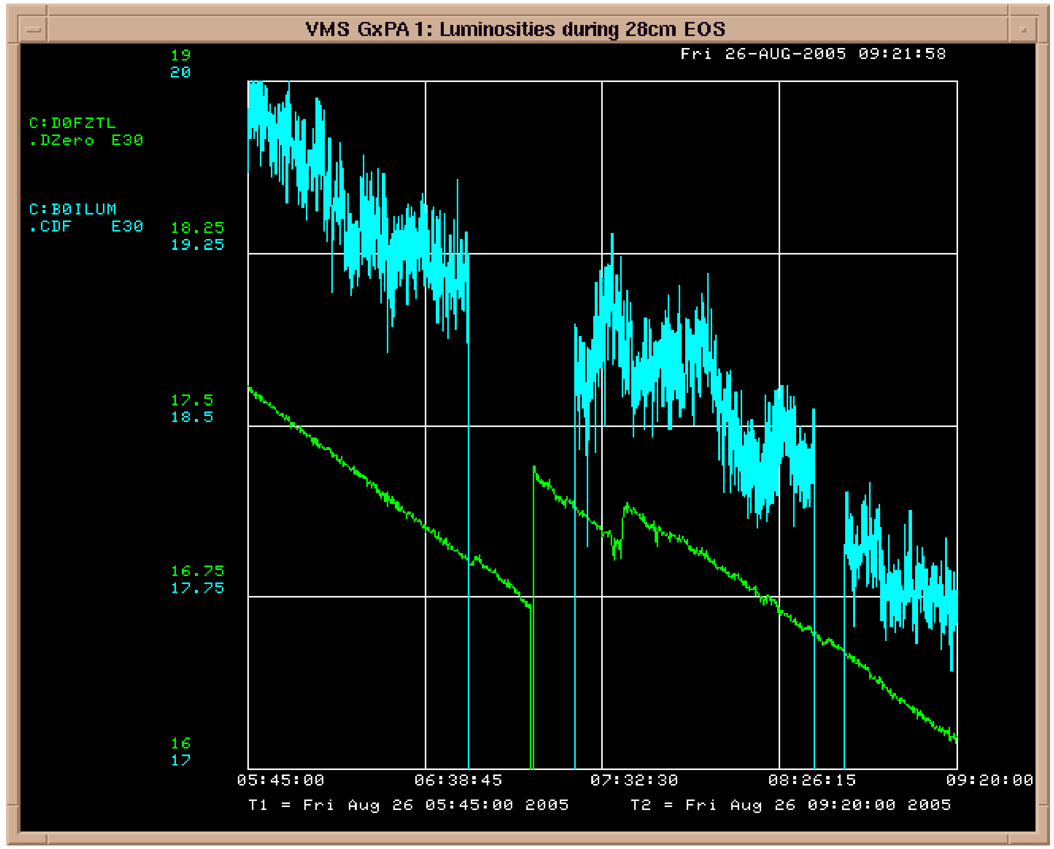
Beta Functions After Correction



	β_x^* (cm)	β_y^* (cm)	
CDF	30.3	29.1	$\pm 5\%$
D0	29.2	28.2	$\pm 5\%$

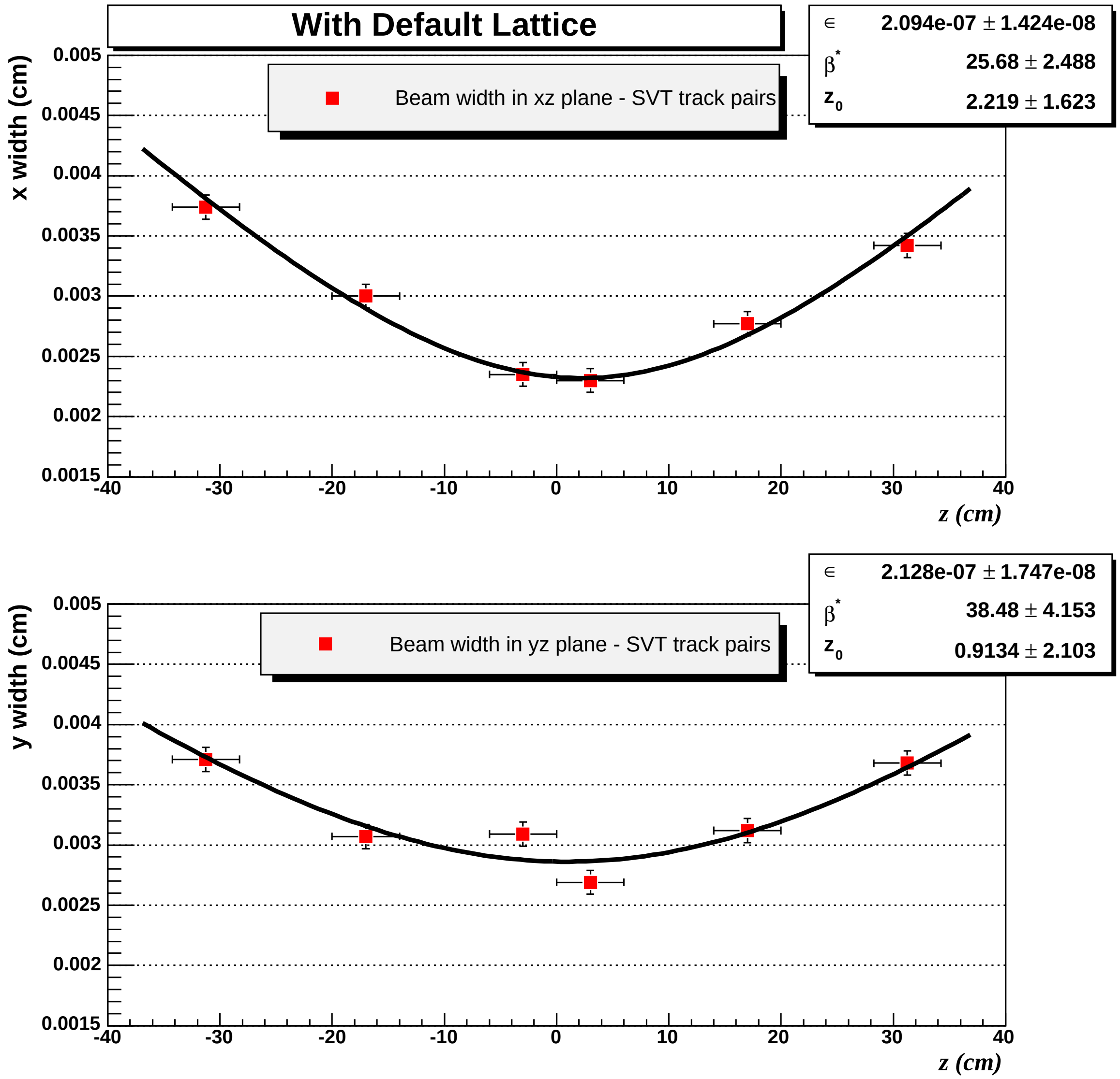
End of Store Studies 8/4 and 8/26



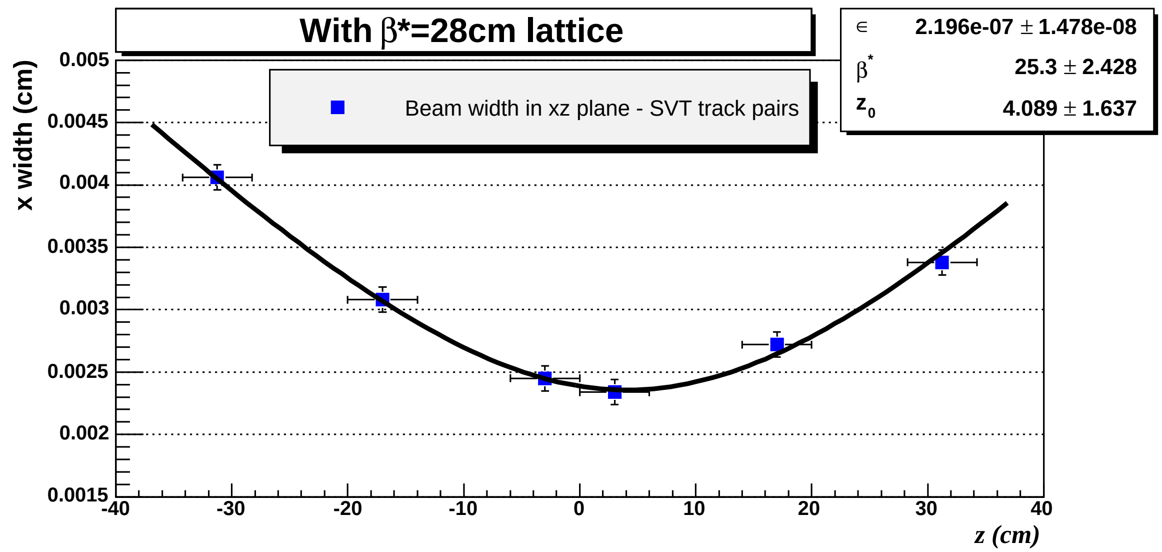


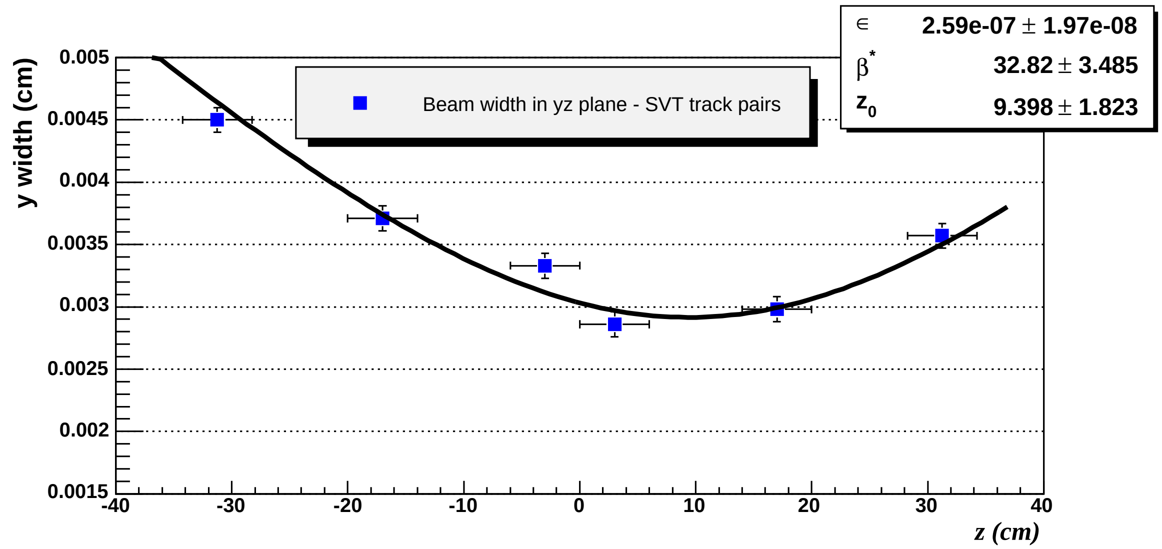
Fast (30 s) transition to the new optics with sequencer works.
No increase of losses.
Luminosity gain was ~3% in CDF, ~5% in D0.

CDF Measurement of beta* in 8/26 EOS
(Chris Neu)



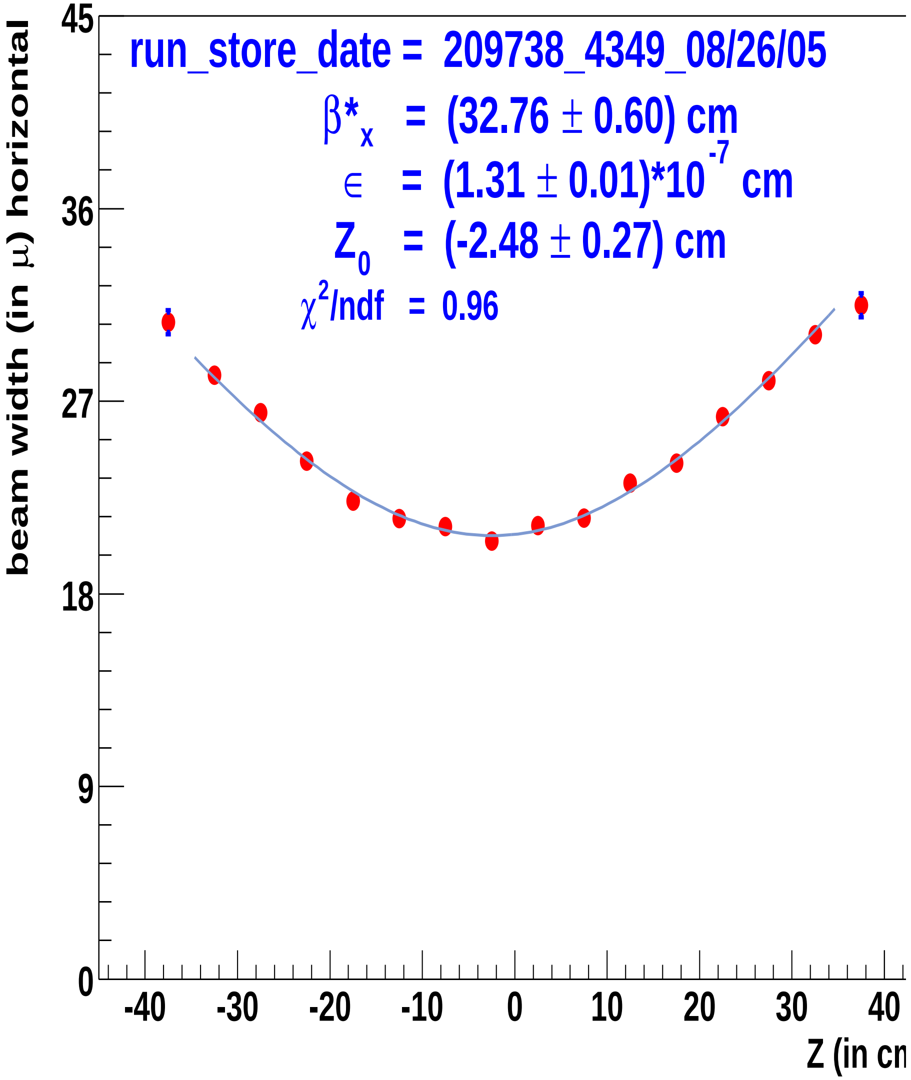
CDF Measurement of beta* in 8/26 EOS
(Chris Neu)

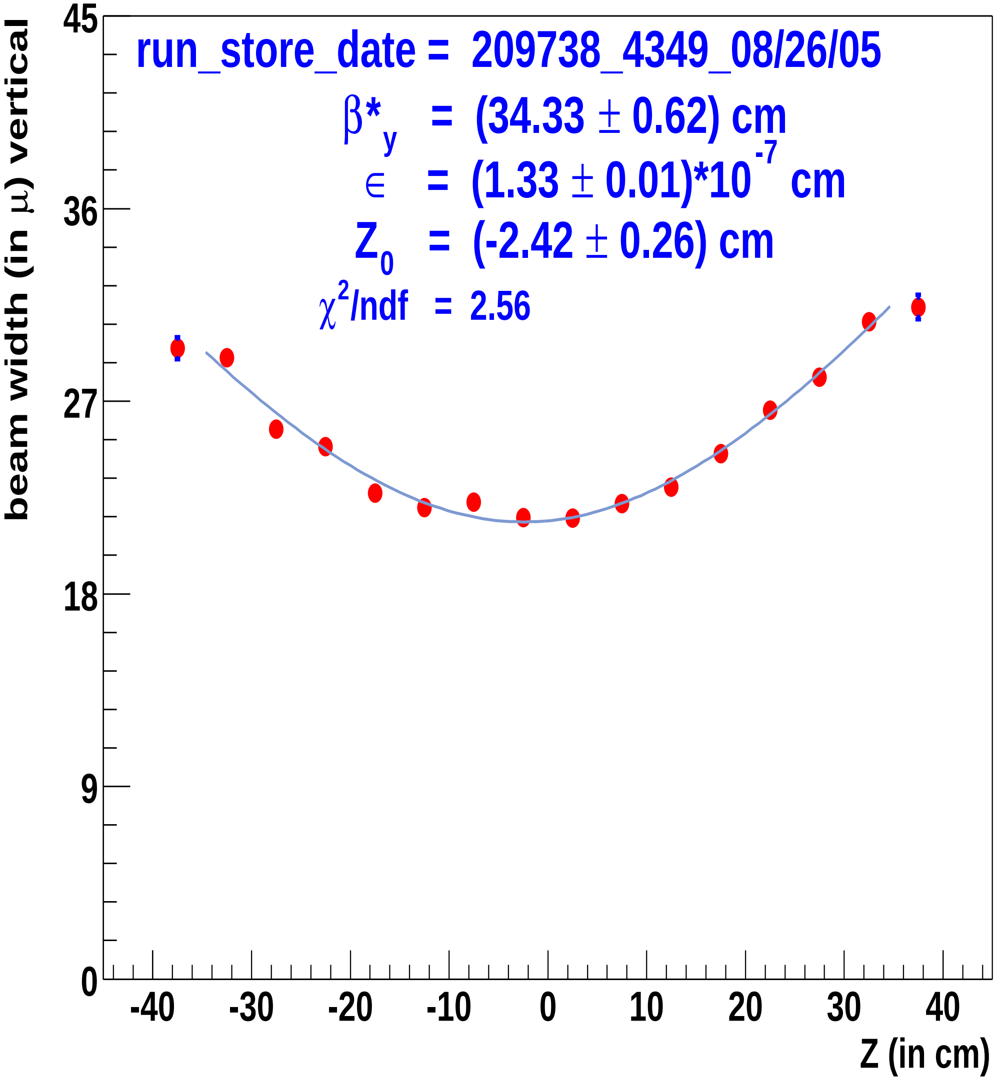




D0 Measurement of beta* in 8/26 EOS

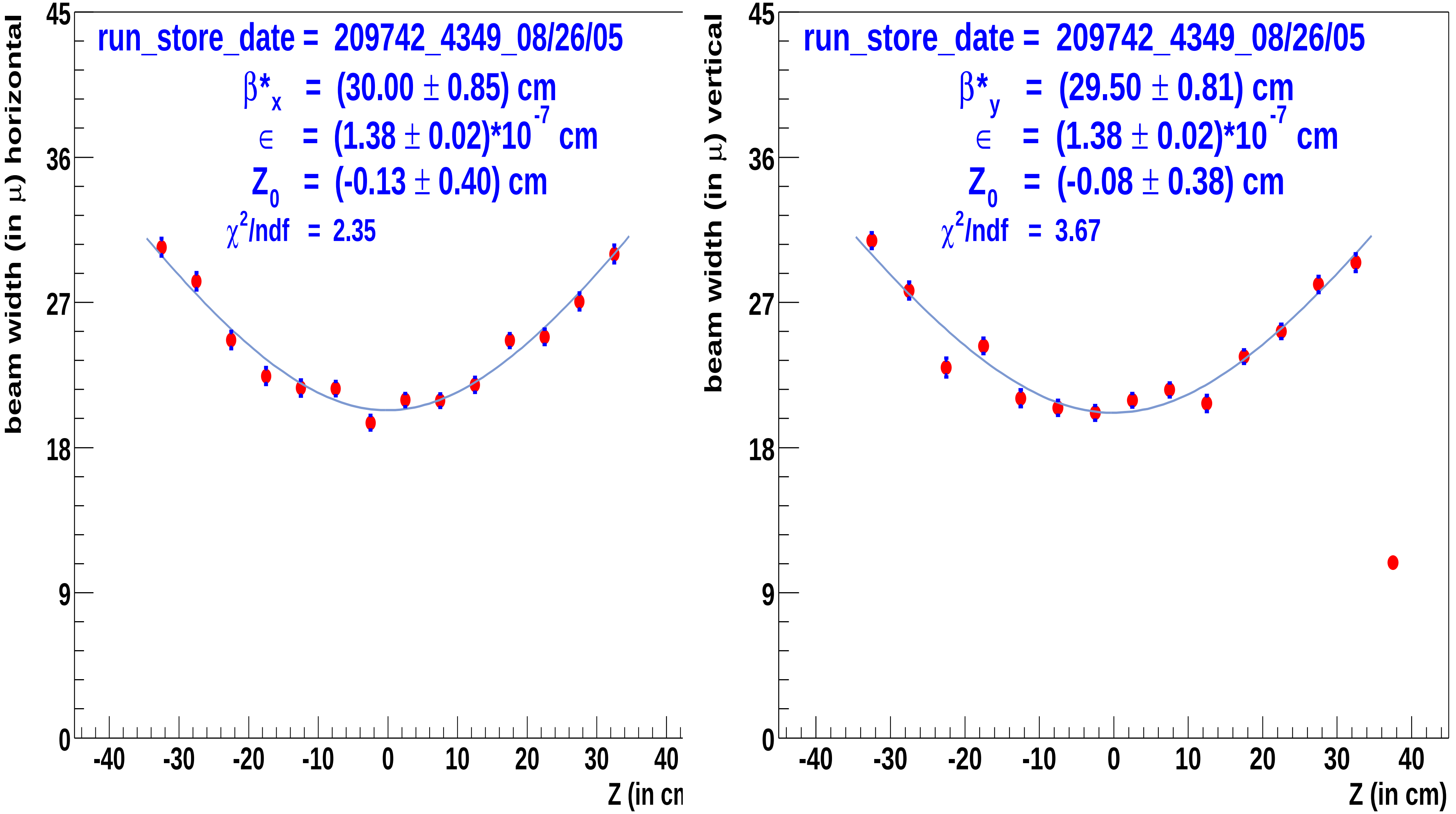
(Michele Weber) 35cm beta* optics





D0 Measurement of beta* in 8/26 EOS

(Michele Weber) 28cm beta* optics



Summary

- Response matrix fit method with the new BPM system allows beta function measurement with the accuracy of 5%
- The optics modification has been developed in order to:
  - Correct beta-beating in the arcs
  - Eliminate the difference between the two IPs
  - Decrease the beta* from 35 to 28 cm
- Expected increase of the peak luminosity is ~7% in CDF and ~12% in D0
- The new optics has been implemented during EOS Tev studies with the positive effect immediately observed
- Beta* reduction is confirmed by both CDF and D0 measurements
- The new optics is ready for use earlier in a store. Minor adjustments can be made without interference with collider operation