SABER Optics

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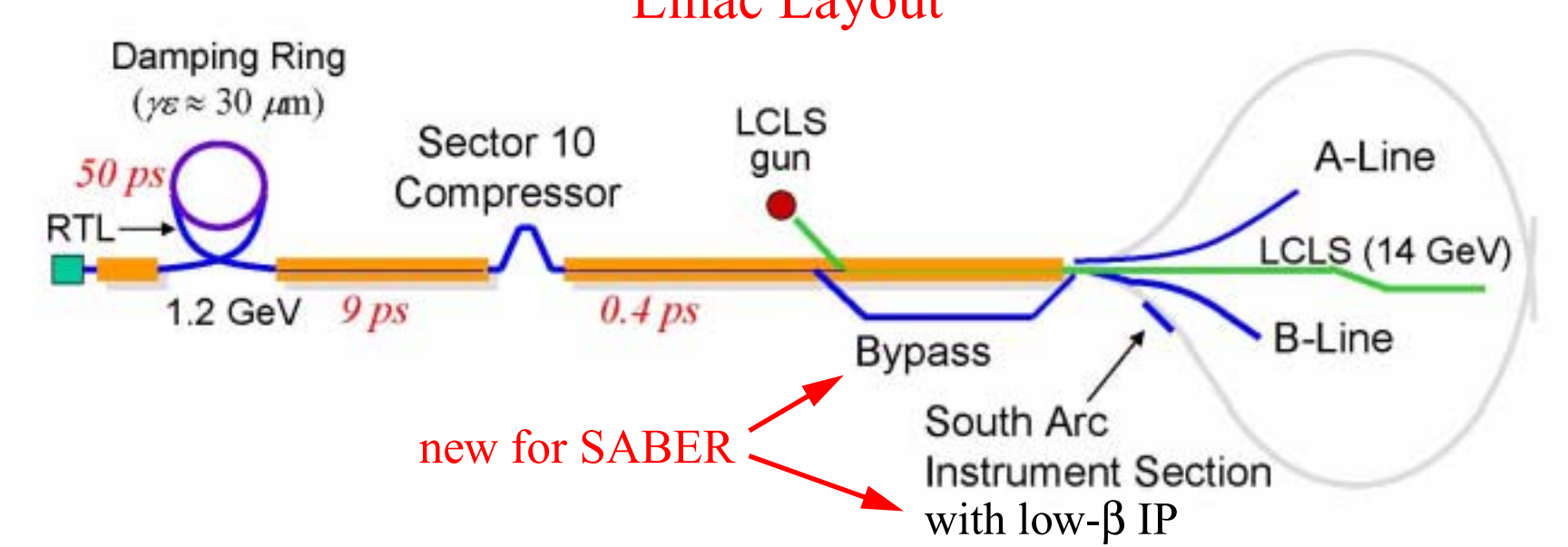
SABER Workshop, SLAC, March 15 - 16, 2006

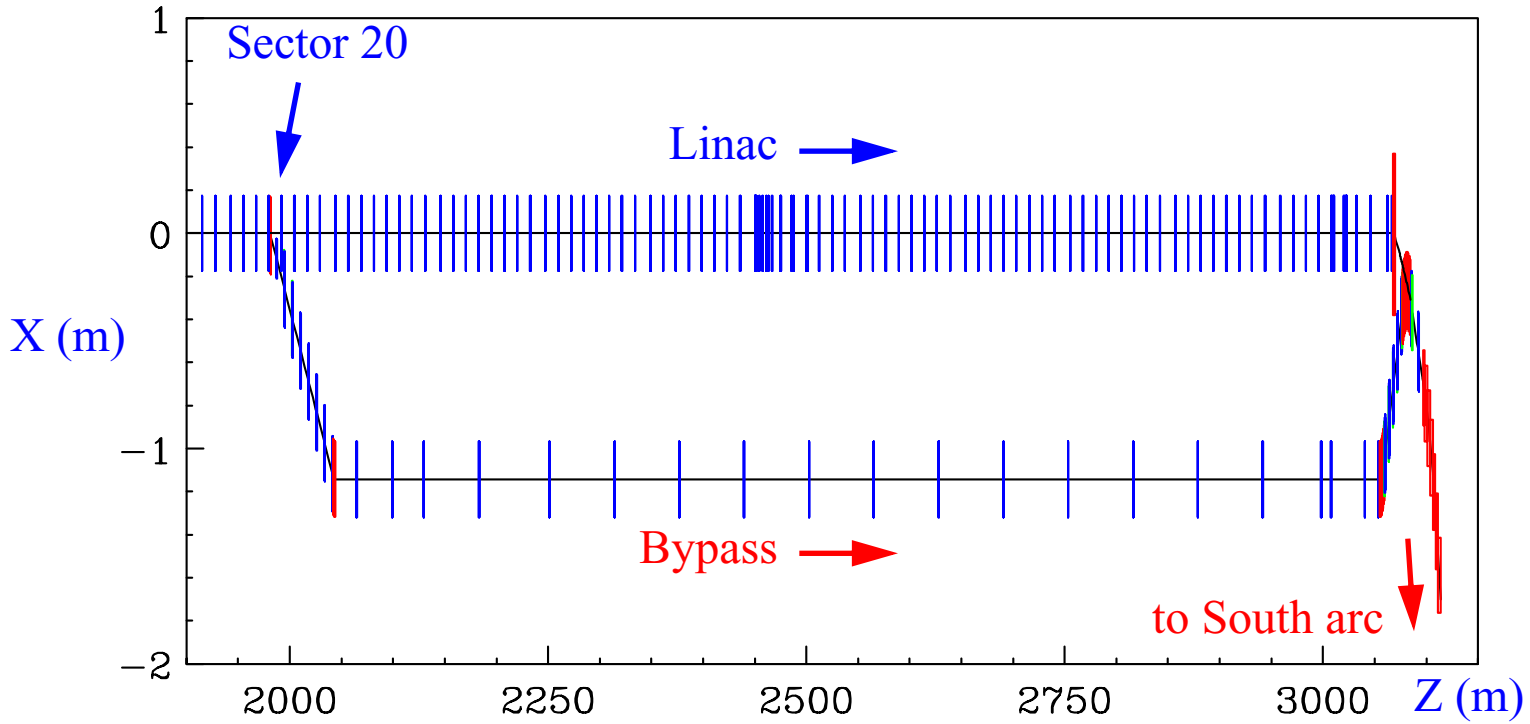
Outline

- "White paper" optics design
- Beam tracking for SABER and for the old South Arc
- Magnet overlap in the BSY and solution
- Field and alignment sensitivities

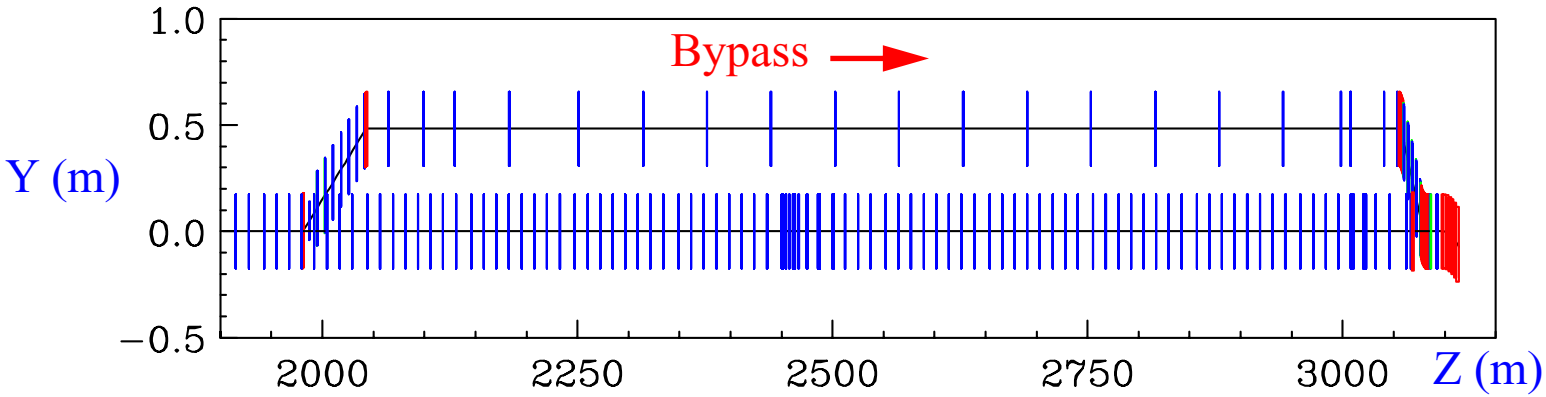
Linac Layout

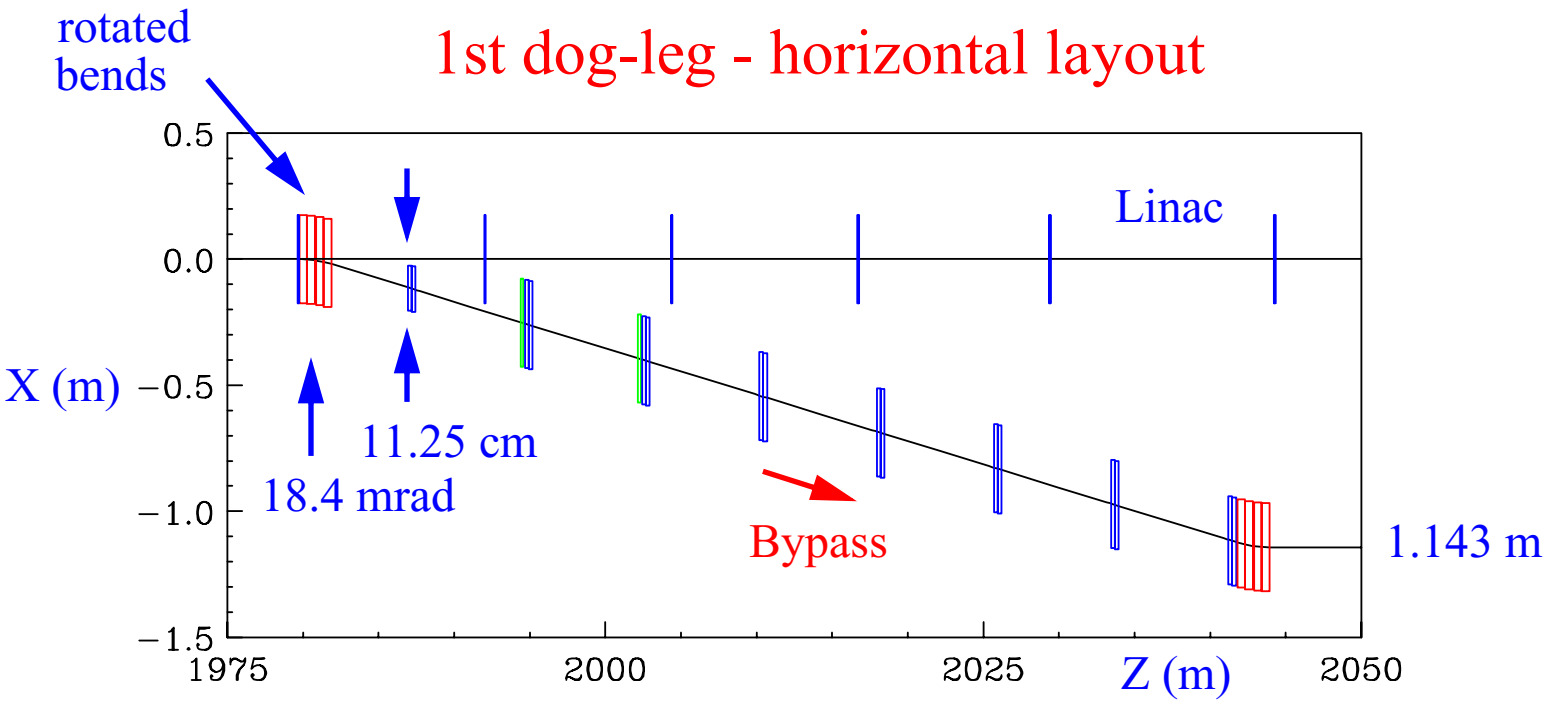


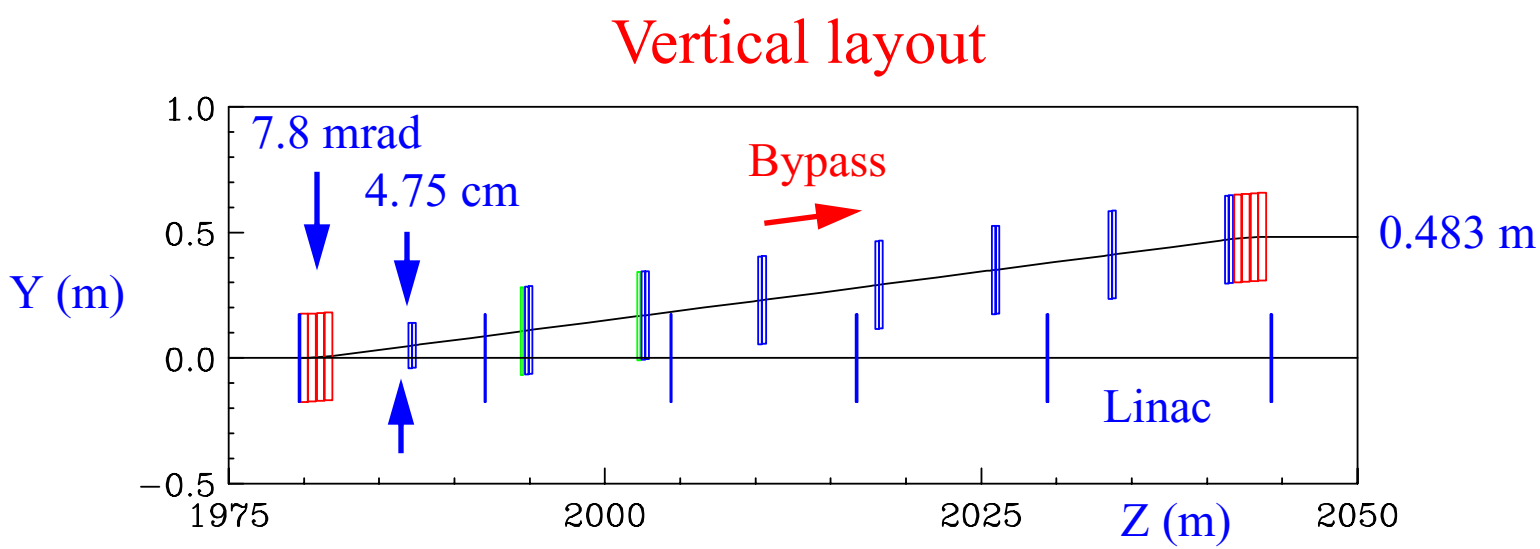
Horizontal layout



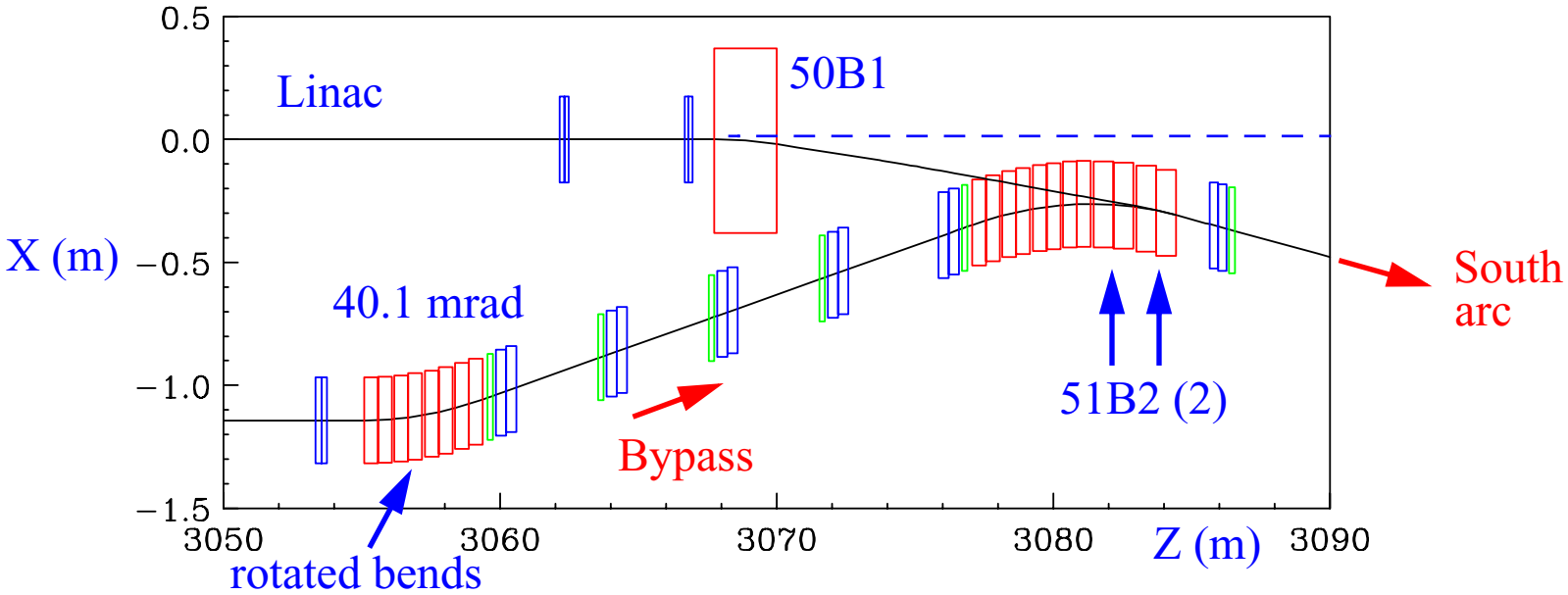
Vertical layout



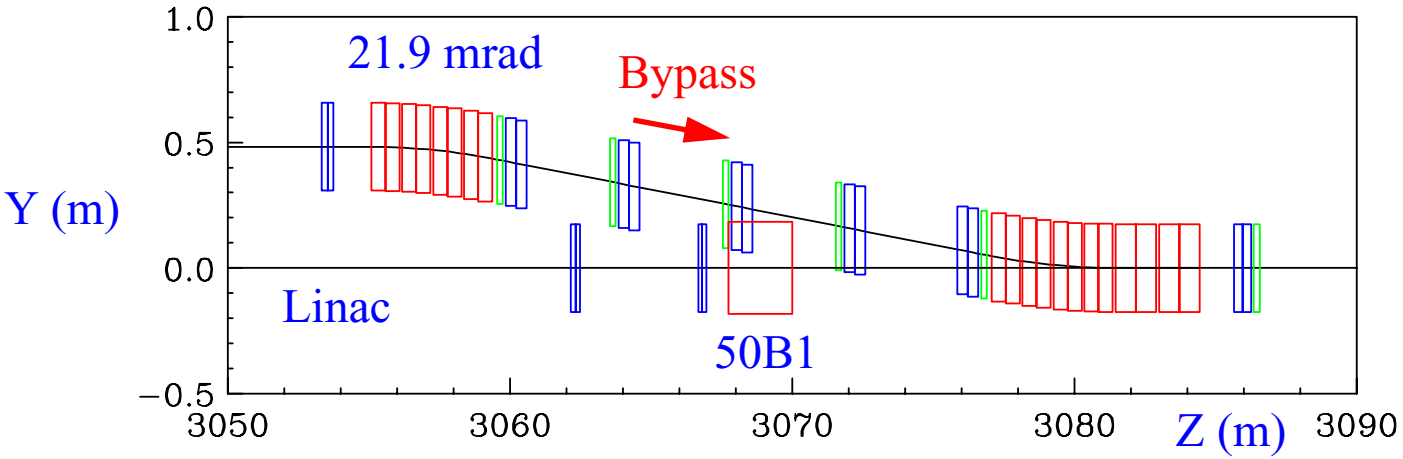

1st dog-leg - horizontal layout
rotated
bends
0.5
0.0
−0.5
−1.0
−1.5
X (m)
Linac
11.25 cm
18.4 mrad
Bypass
1.143 m
1975
2000
2025
Z (m)
2050


Vertical layout
1.0
0.5
0.0
−0.5
Y (m)
7.8 mrad
4.75 cm
Bypass
0.483 m
Linac
1975
2000
2025
Z (m)
2050

2nd dog-leg - horizontal layout



Vertical layout

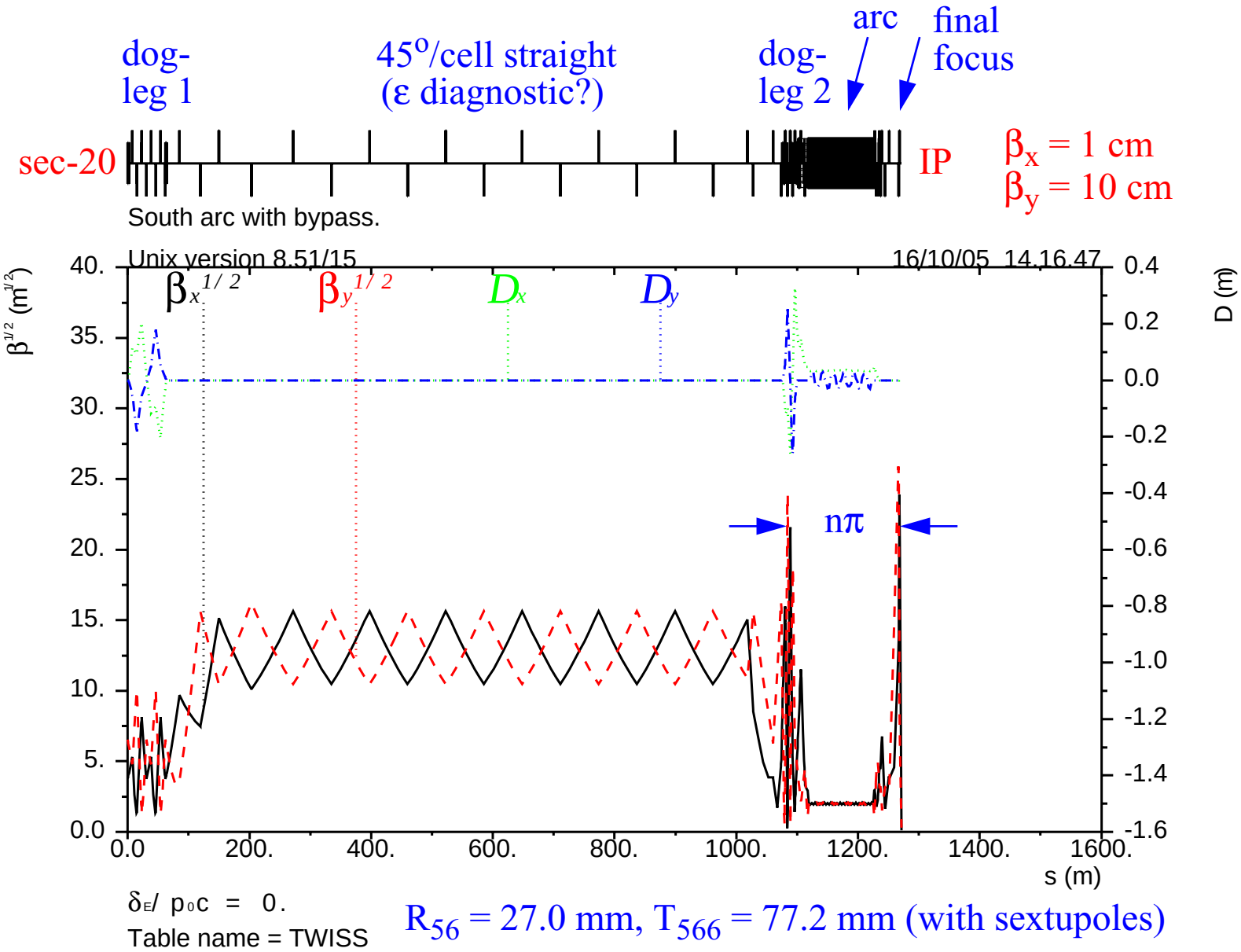


"White paper" version

Magnet x-y size may not be right

Magnet overlap discussed later

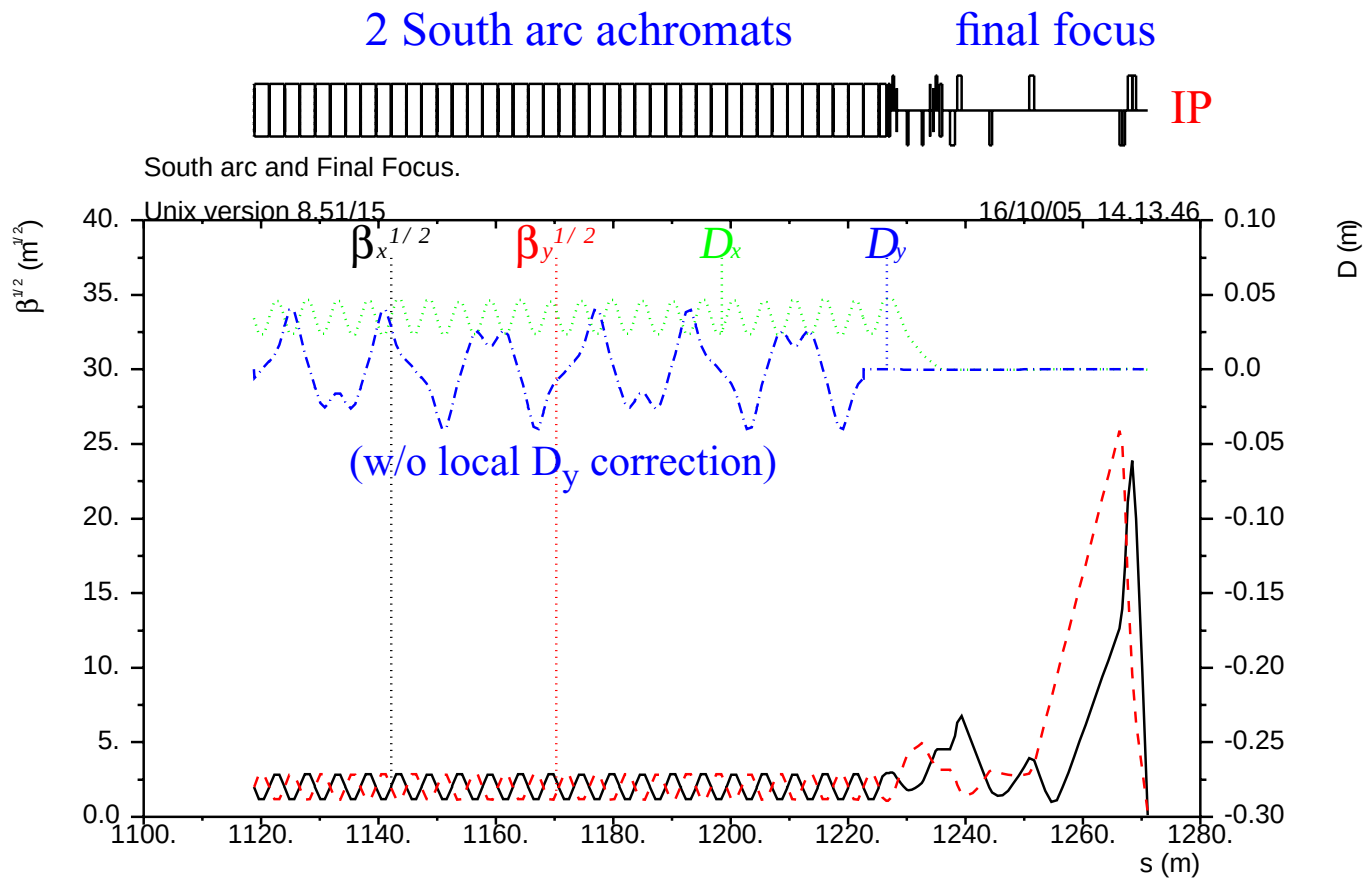
Beta and Dispersion from Bypass to IP



R_{56} = 27.0 mm, T_{566} = 77.2 mm (with sextupoles)

Low Beta Final Focus

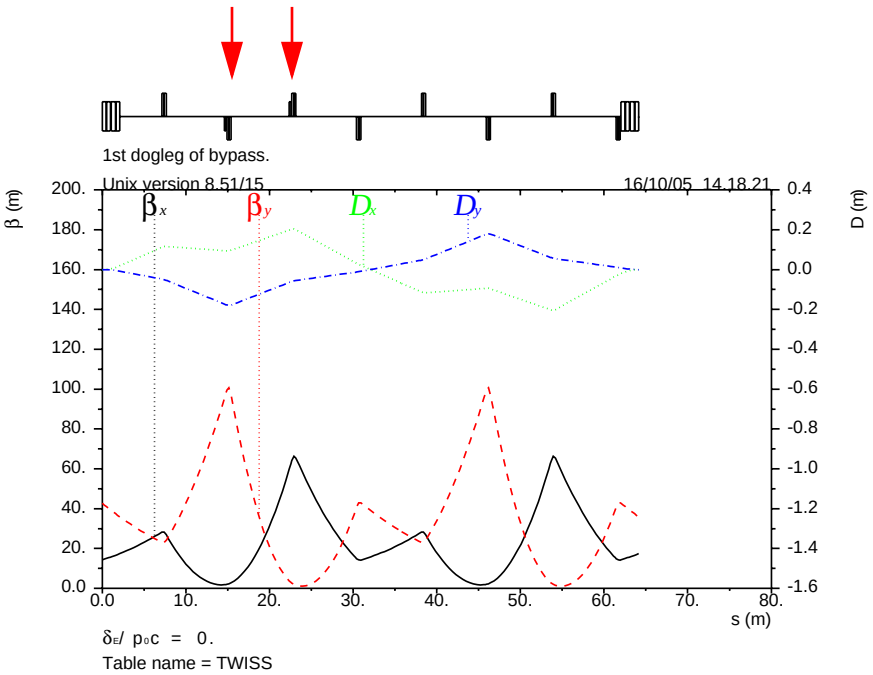
- Required at IP: $\sigma_{xy} < 10$ μm, $\eta = 0$, $\eta' = 0$.
- IP design: 6 quads for $\beta_x / \beta_y = 1 / 10$ cm, $\eta = 0$, $\eta' = 0$, L* = 2 m.
- At 30 GeV and $\gamma\varepsilon_x / \gamma\varepsilon_y = 50 / 5$ μm ➔ $(\beta_x\varepsilon_x)^{1/2} = (\beta_y\varepsilon_y)^{1/2} = 2.9 / 2.9$ μm. But errors and energy spread will increase the size.
- IP is at $\Delta z = +10.65$ m from the old straight center, and 13.7 m from the next arc.



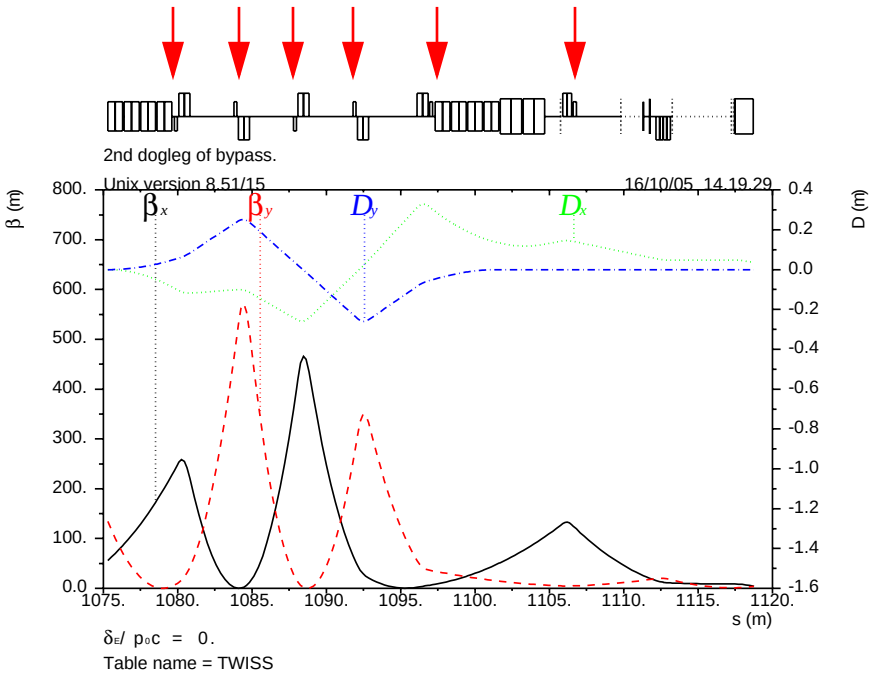
Sextupoles for Chromaticity Correction

- 8 sextupoles are included to compensate beam size growth due to the large energy spread.
- Since there is no dispersion in the FF, the sextupoles are placed in the bypass dog-legs.
- The sextupoles minimize the 2nd order dispersion and W-functions (dβ/dδ).

2 sextupoles in the 1st dog-leg

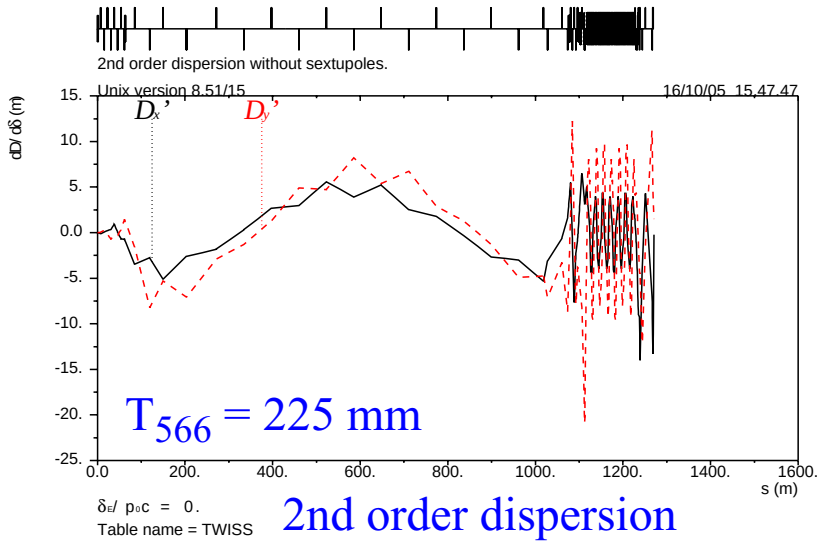


5 sextupoles in the 2nd dog-leg and 1 in arc matching section



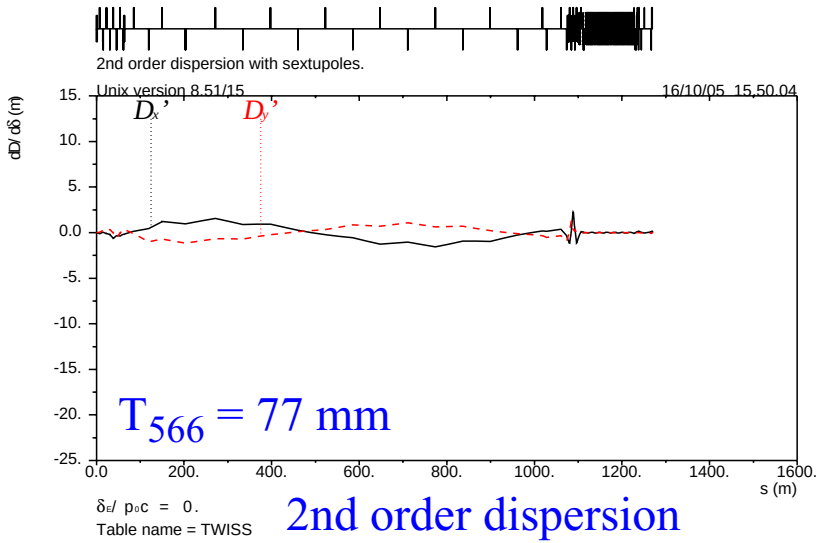
2nd Order Dispersion and W-functions

Without sextupoles

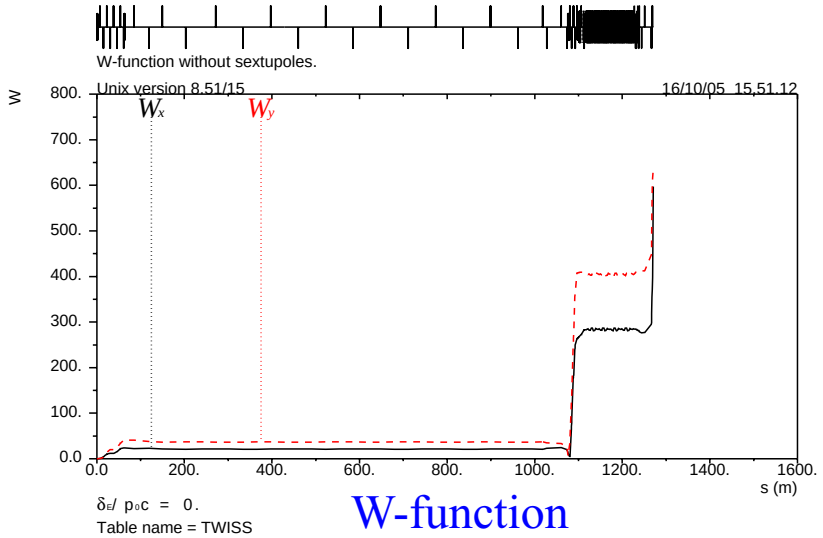


2nd order dispersion

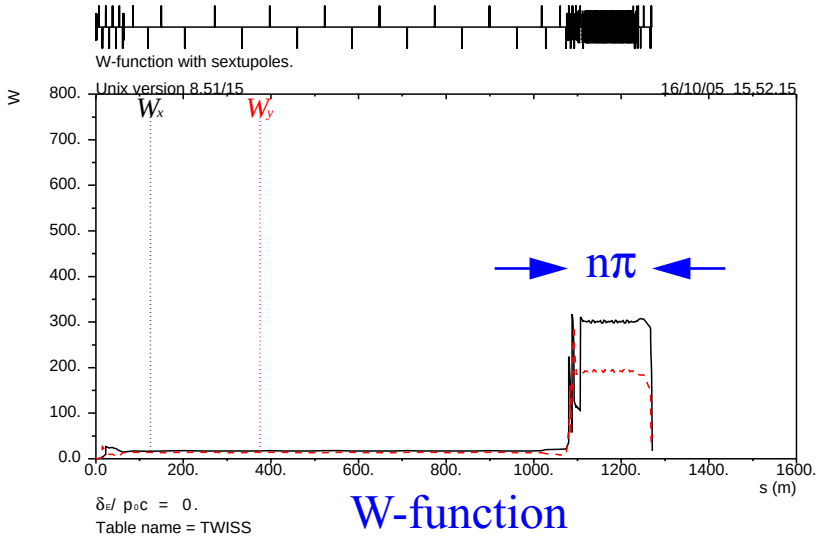
With sextupoles



2nd order dispersion

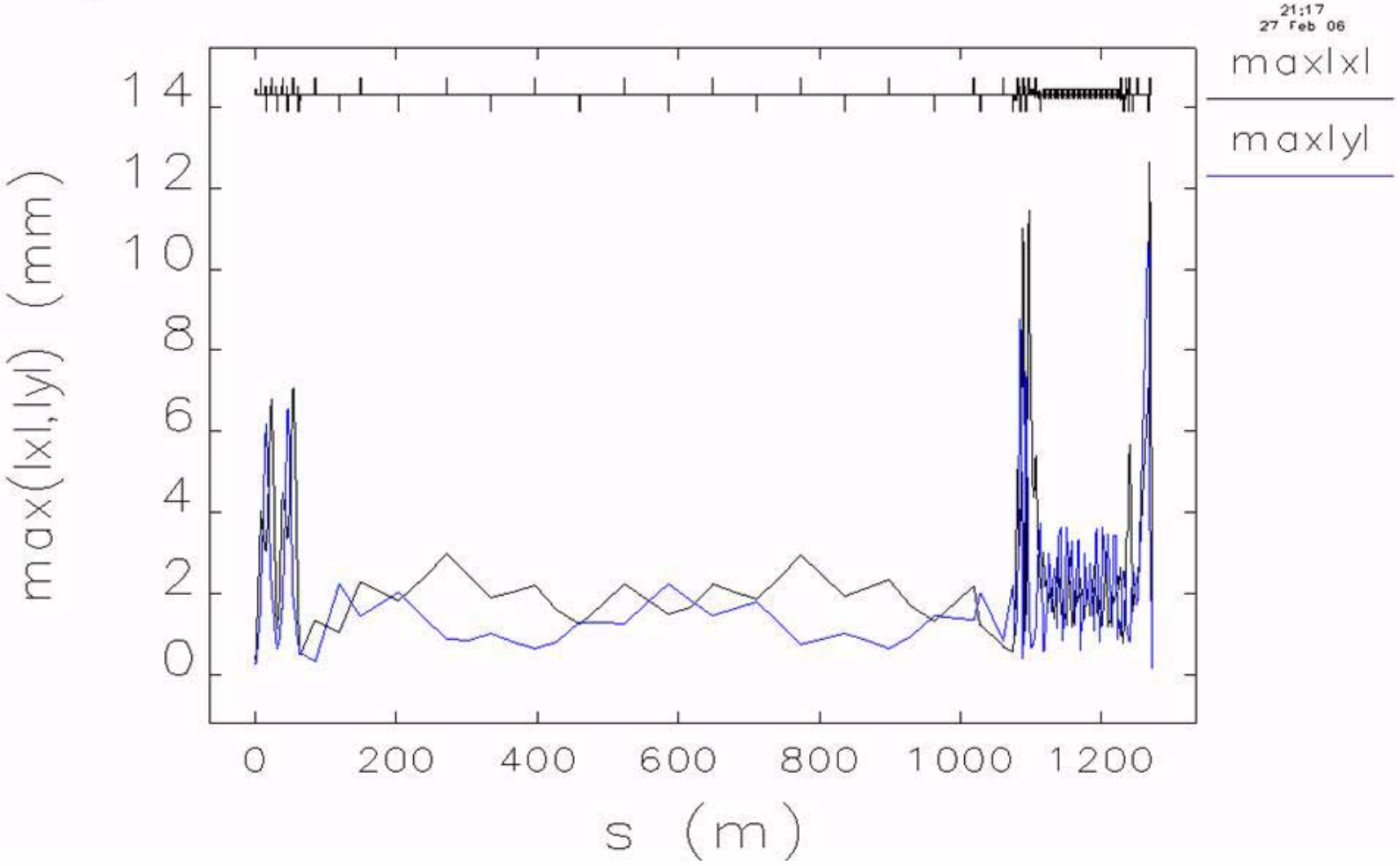


W-function



W-function

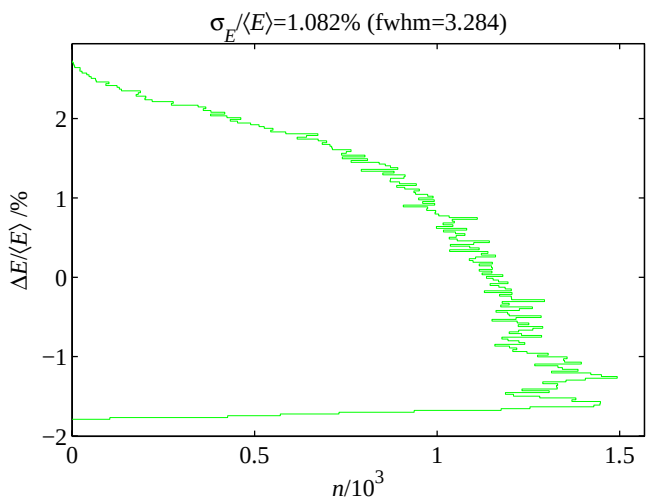
Maximum $|x|$ and $|y|$ particle extent (2nd order) (Gaussian initial distributions with $\pm 3\sigma$ cutoff)

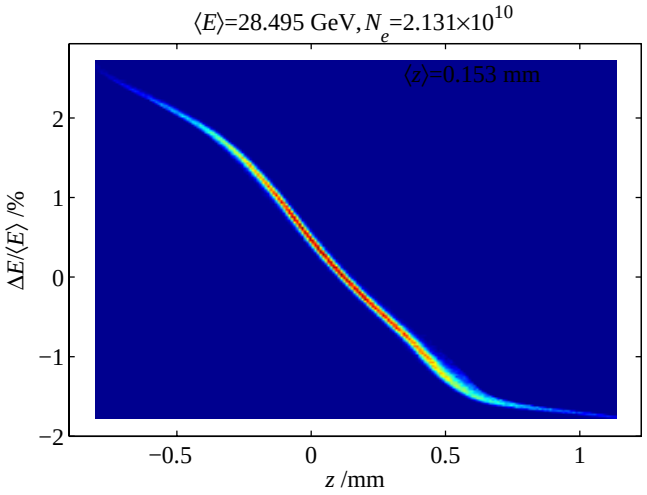


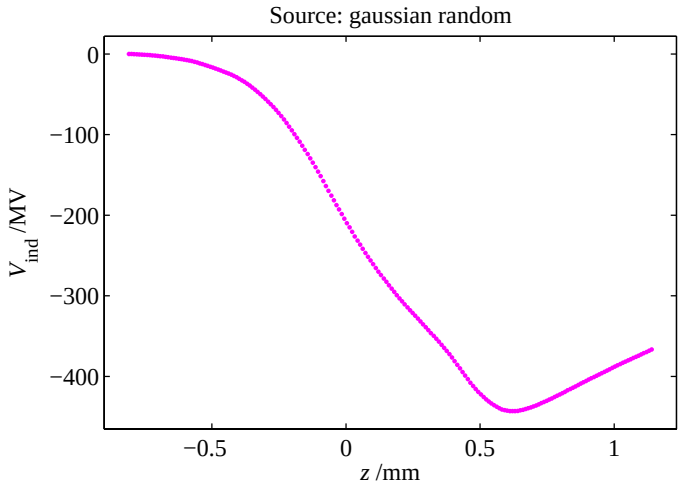
Initial Beam Z and ΔE/E at Entrance to the Bypass Beam case 1: short bunch length, but large ΔE/E

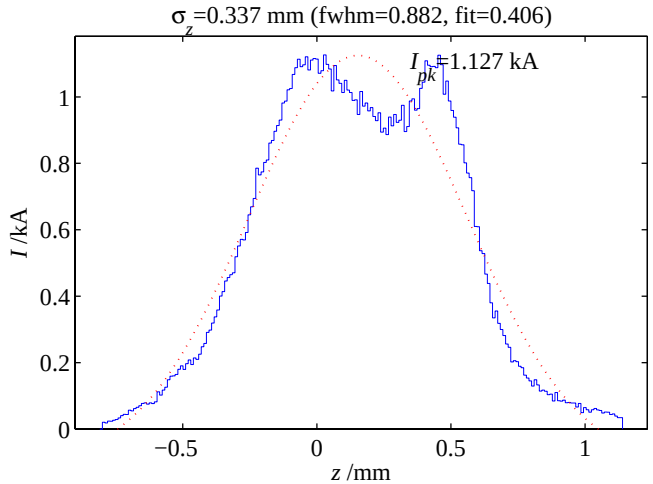
E = 28.5 GeV, σ_E =1.08%, σ_z = 406 μm, N = 2.13x10^{10}

~4.5%



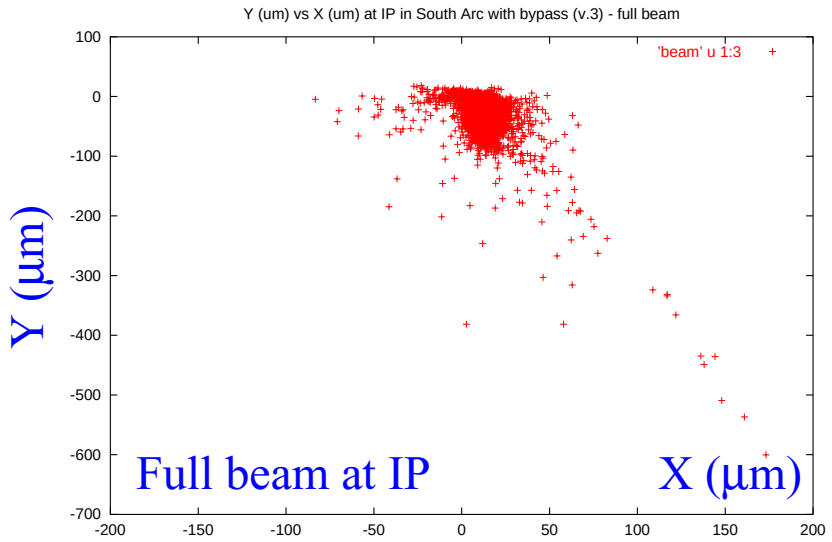


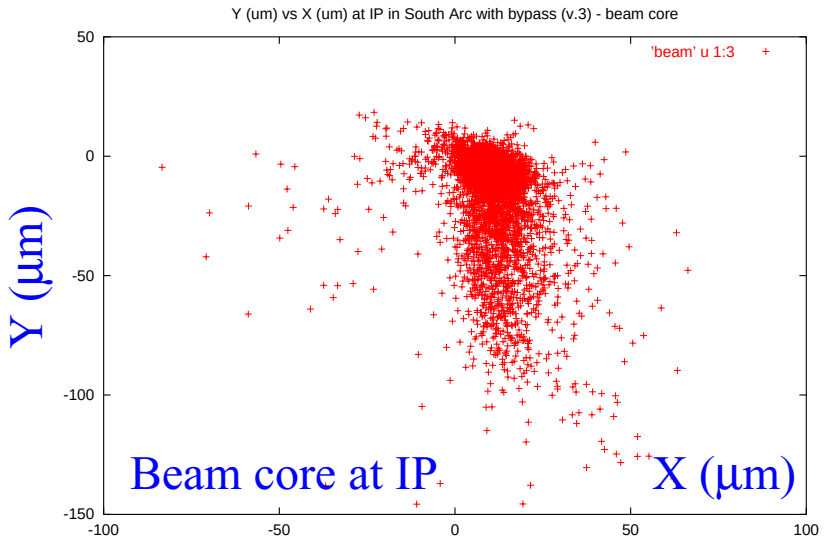




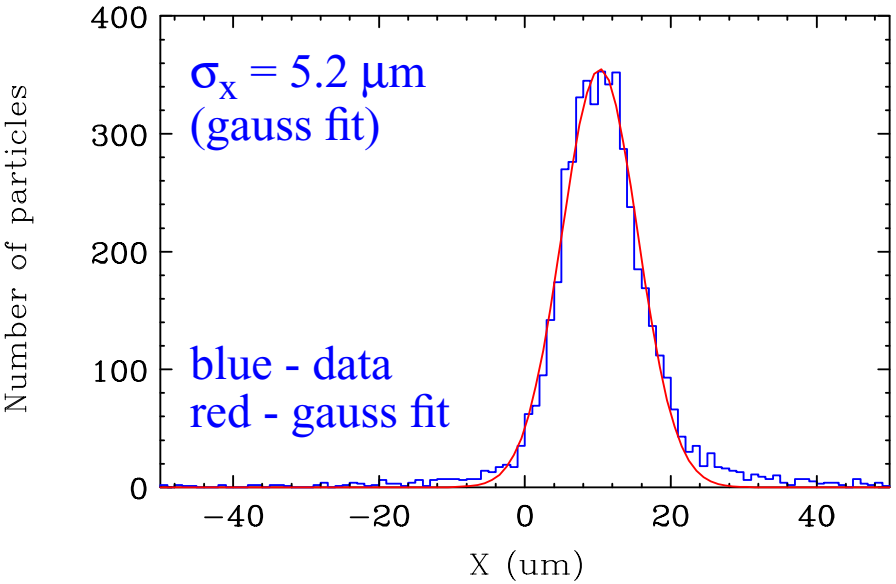
GUI: saber: sarc with bypass; Yuri's correction of T566, Paul's overcompress; output particles
30−SEP−2005 16:56:45; [−10 28.5 0 0.104969 5 936]

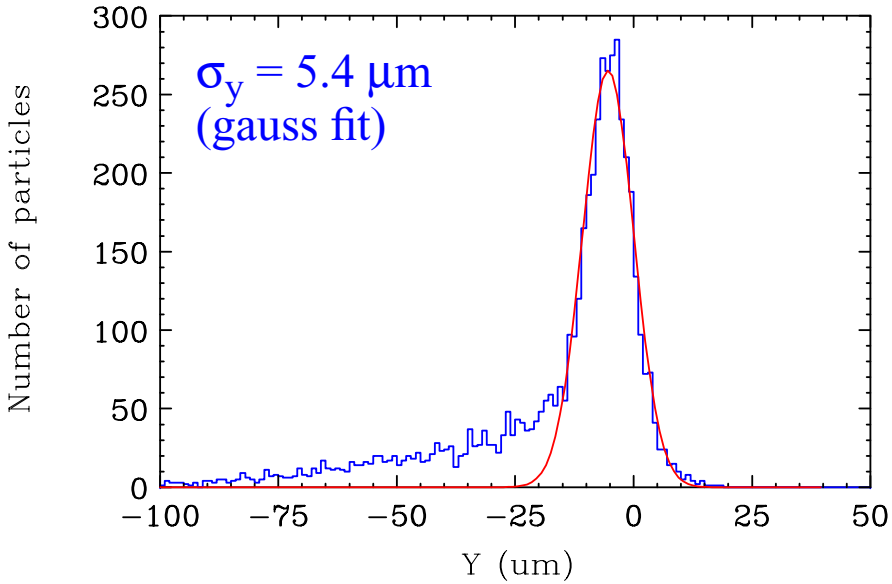
X-Y Tracking from Bypass to IP, $\gamma\varepsilon_{x(y)}$ = 50(5) μm, no errors





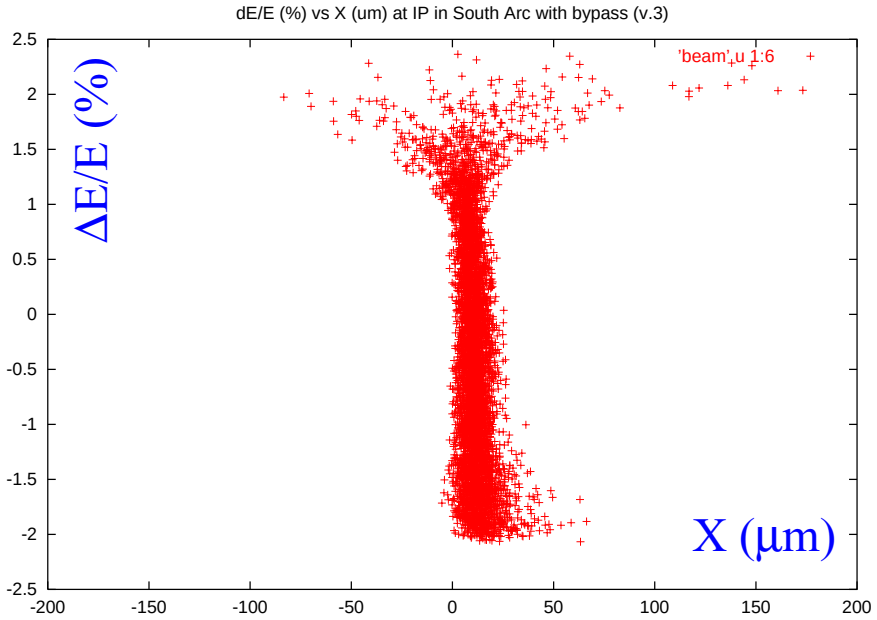
Beam core size within specification < 10 μm

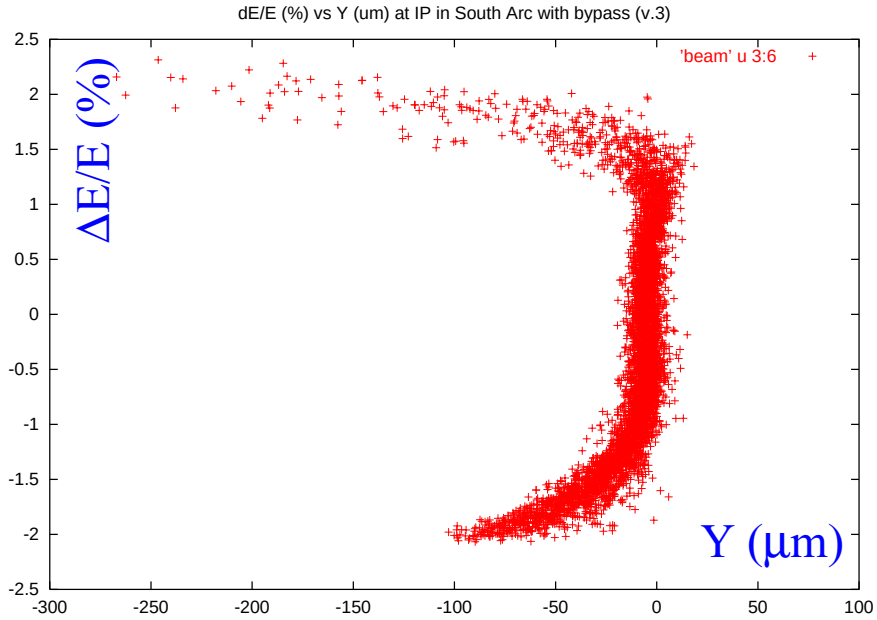




X and Y vs. ΔE/E at IP

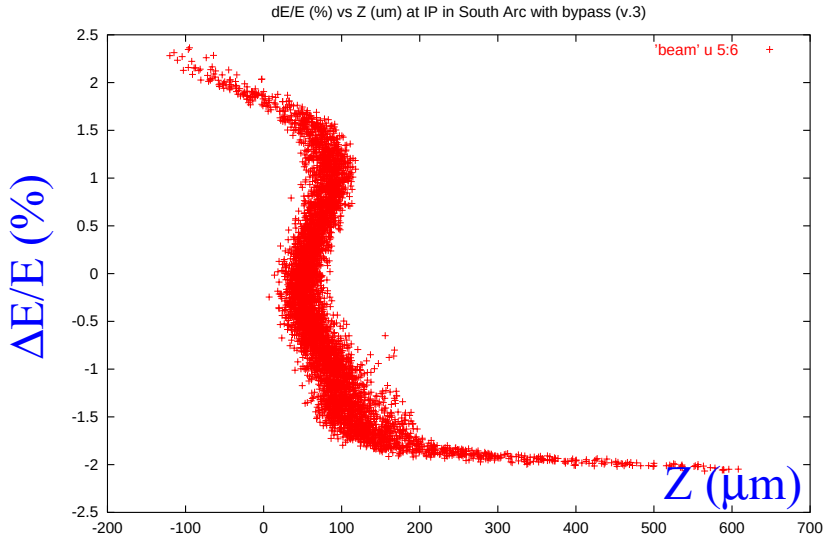
- Good chromatic correction for ΔE/E < 1.5%.
- Without sextupoles, there would be a significant beam size growth and beam loss.

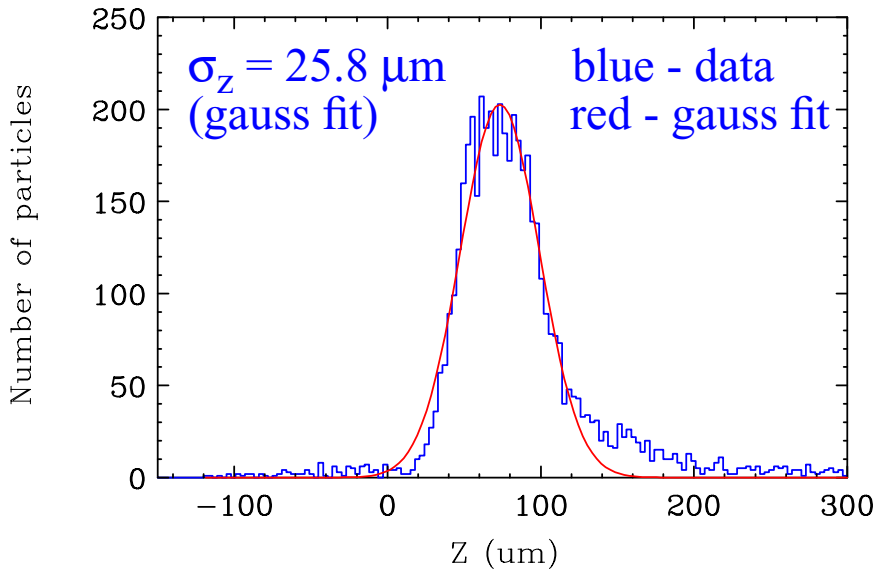


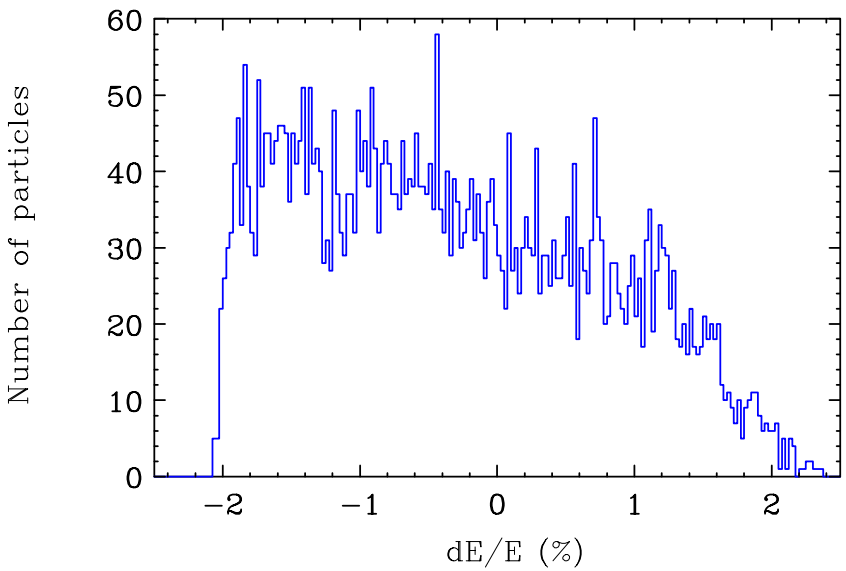


Z and ΔE/E at IP

Gaussian fit σ_z = 25.8 mm (86 fs)

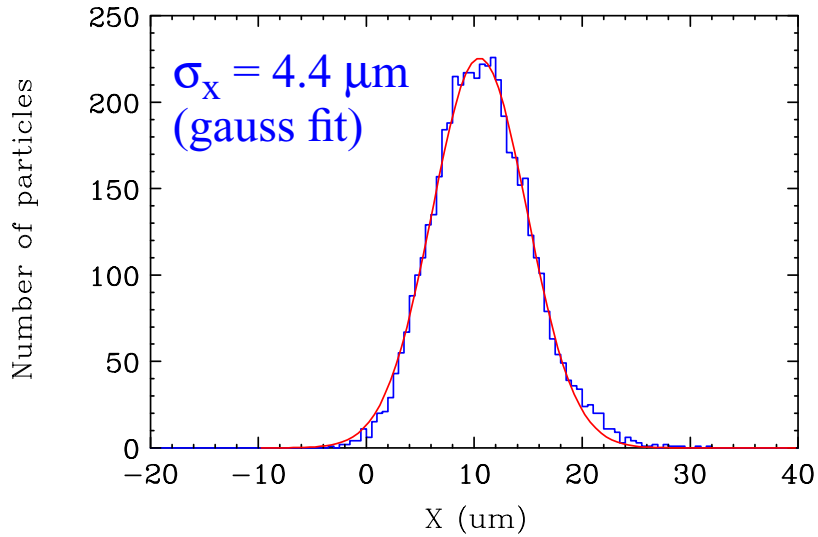


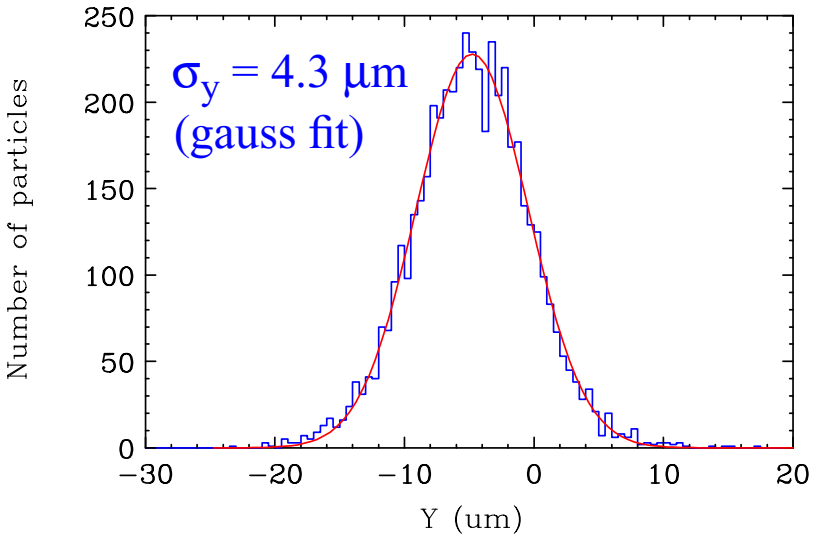


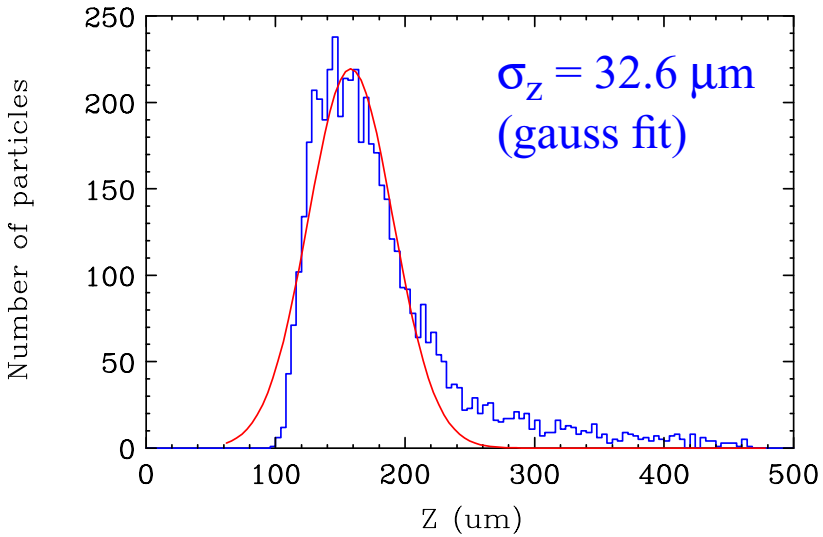


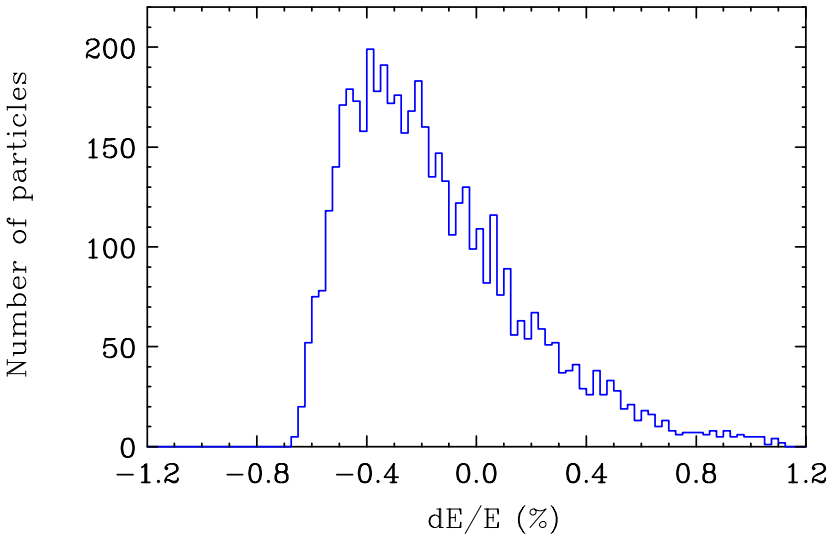
Beam case 2: reduced ΔE/E, but longer bunch length

No errors, 28.5 GeV, $\gamma\varepsilon_{x(y)}$ = 50(5) μm, N = 2.13x10^{10}

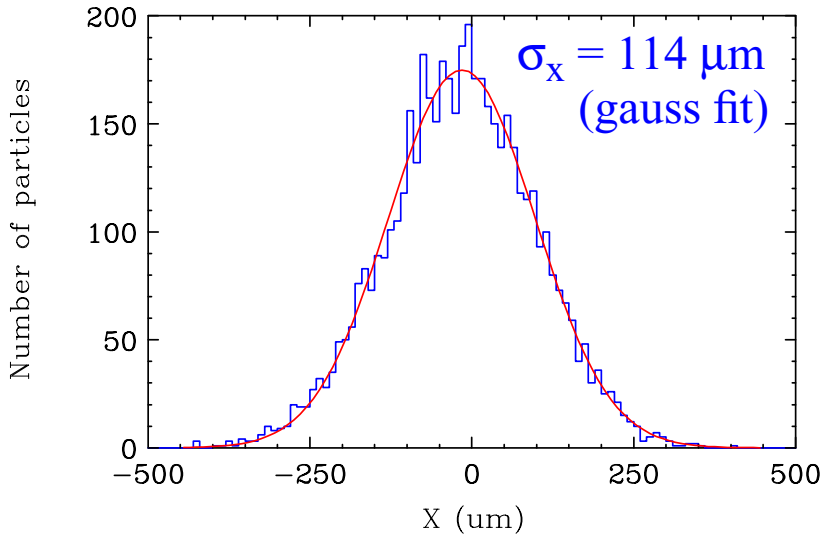


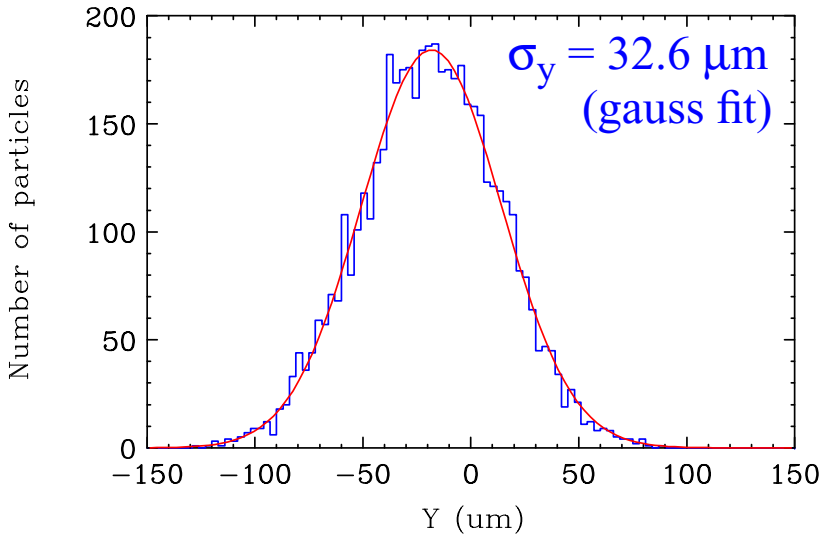


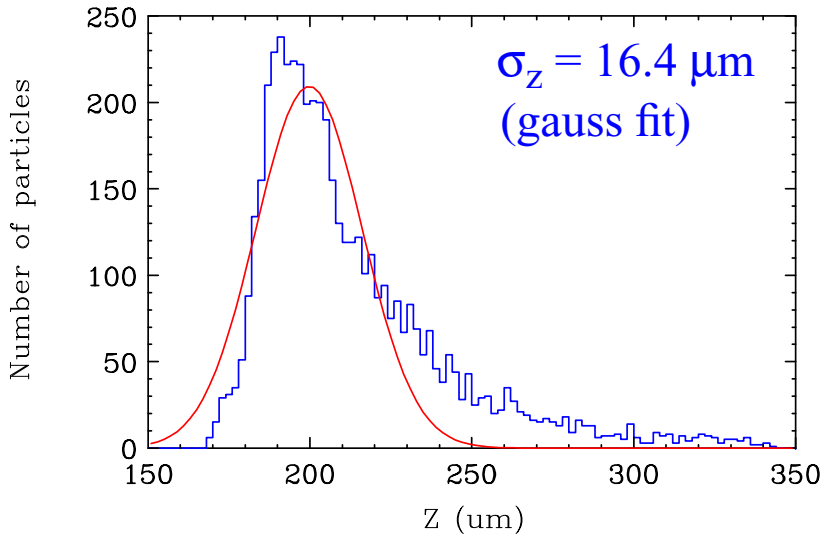


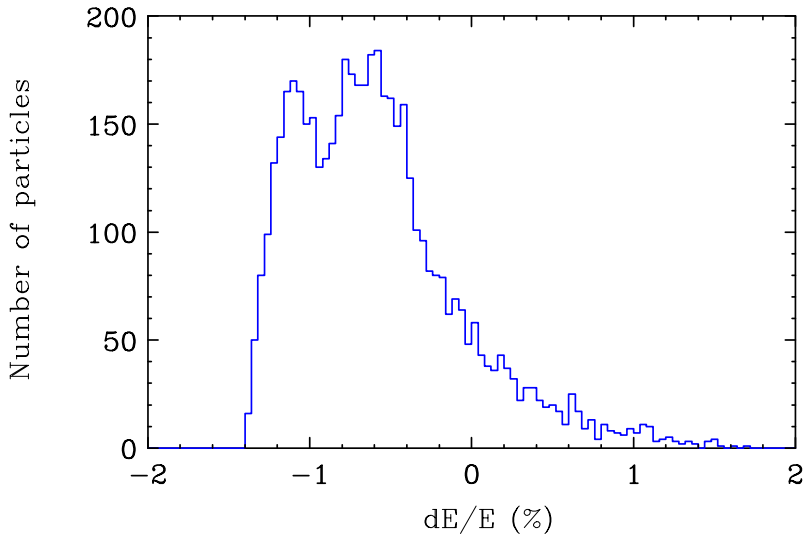


South Arc Phase 1: with chicane, but w/o bypass and low beta
Tracking from 50B1 to the Old IP with β* = 11.2 m



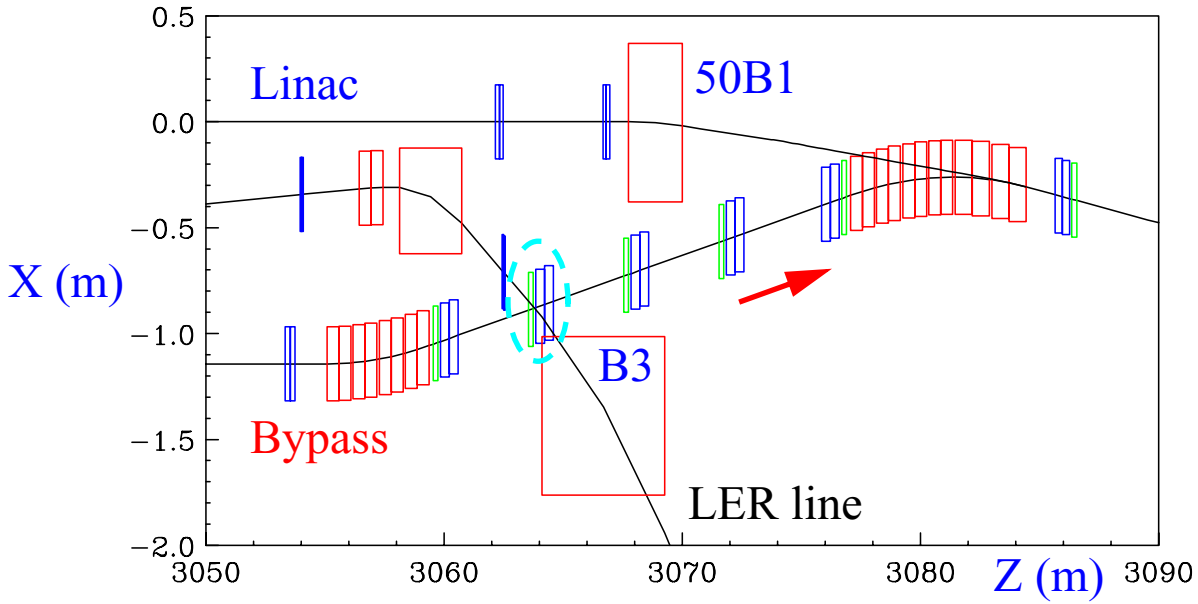






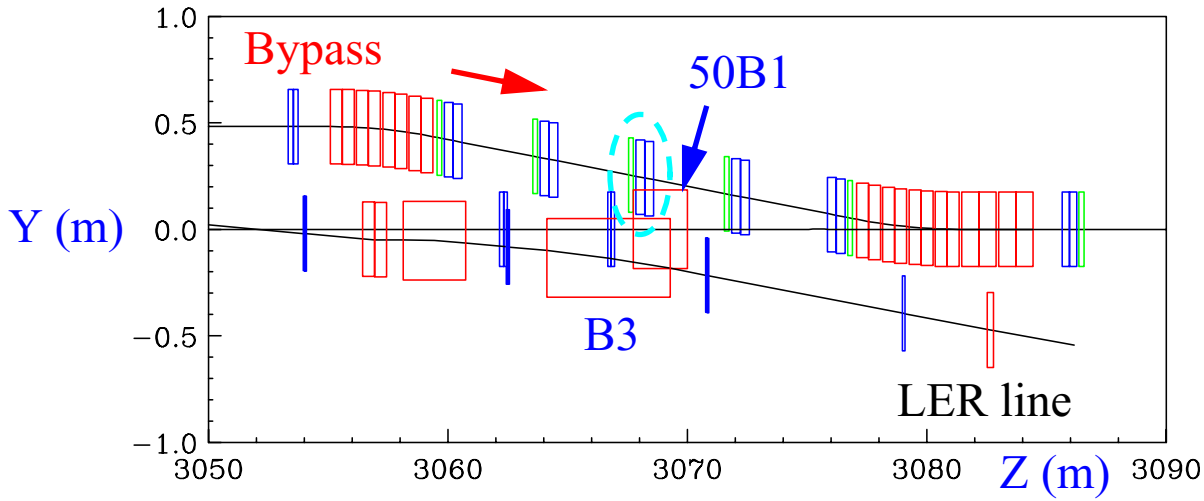
Magnet Overlap in the Bypass 2nd Dog-Leg

"White paper" version



Horizontal overlap of LER B3 and bypass QDB2

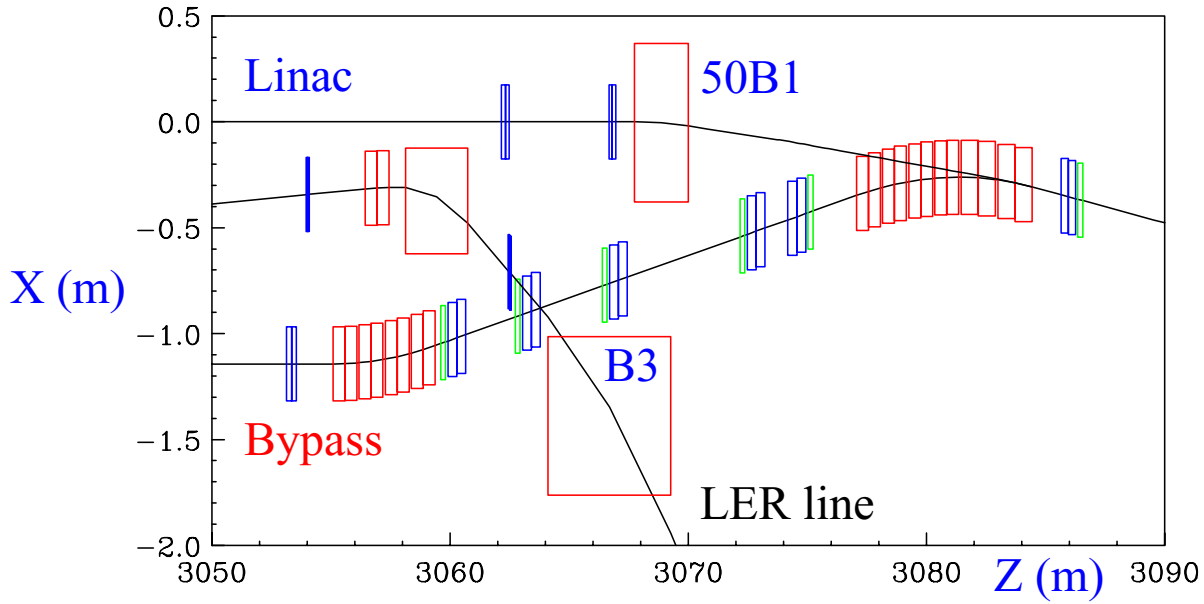
Solution: move QDB2 0.8 m upstream



Vertical overlap of linac 50B1 and bypass QFB3

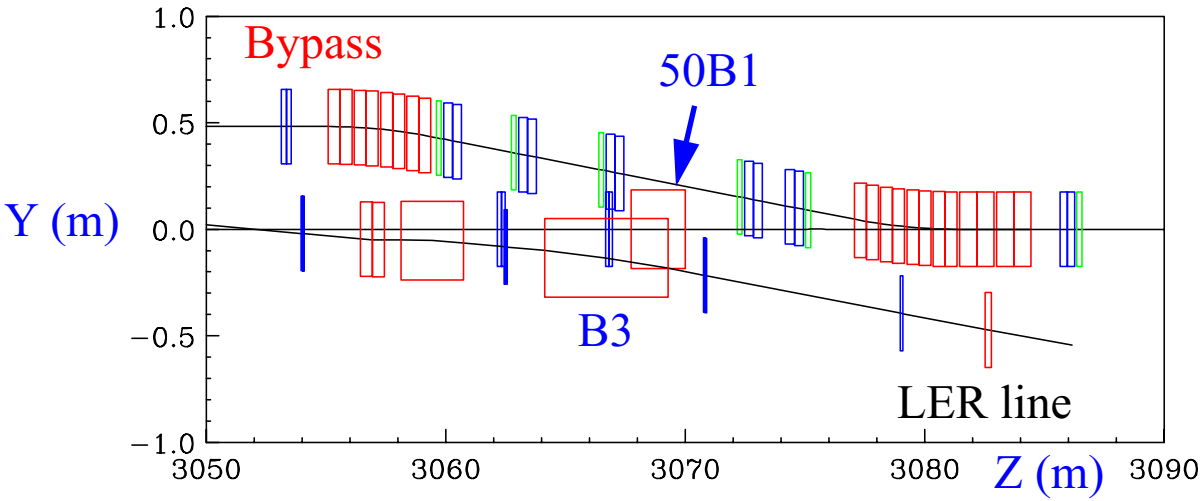
Solution: move QFB3 1.15 m upstream

Modified Bypass 2nd Dog-Leg without Overlap



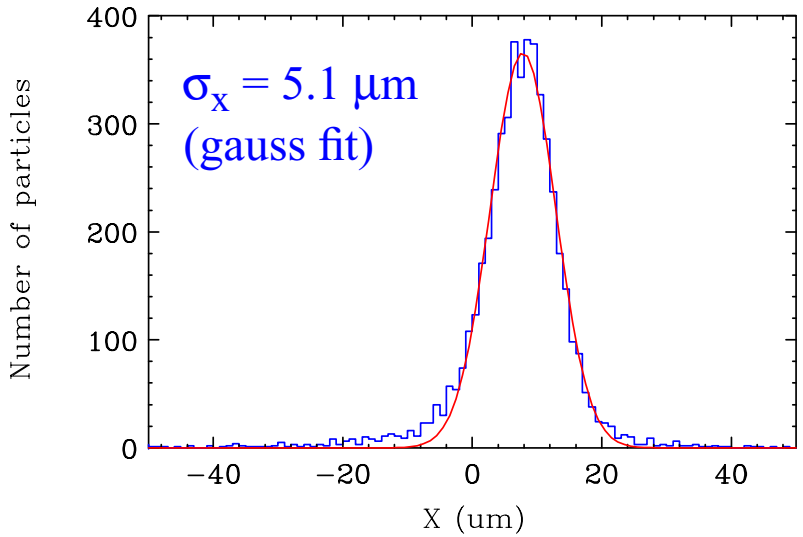
More checking is needed in this region.

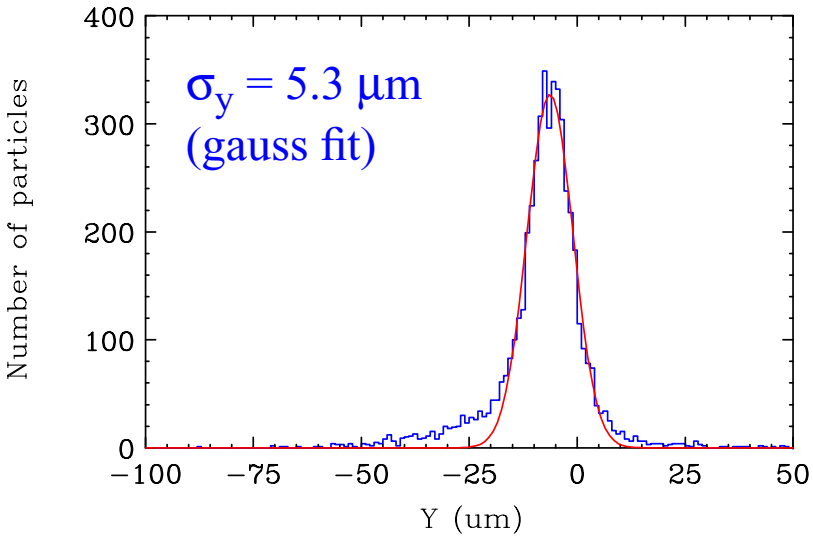
Optics is re-optimized.
Some magnet strengths increased.
R_{56} = -26.2 mm
T_{566} = -52.1 mm

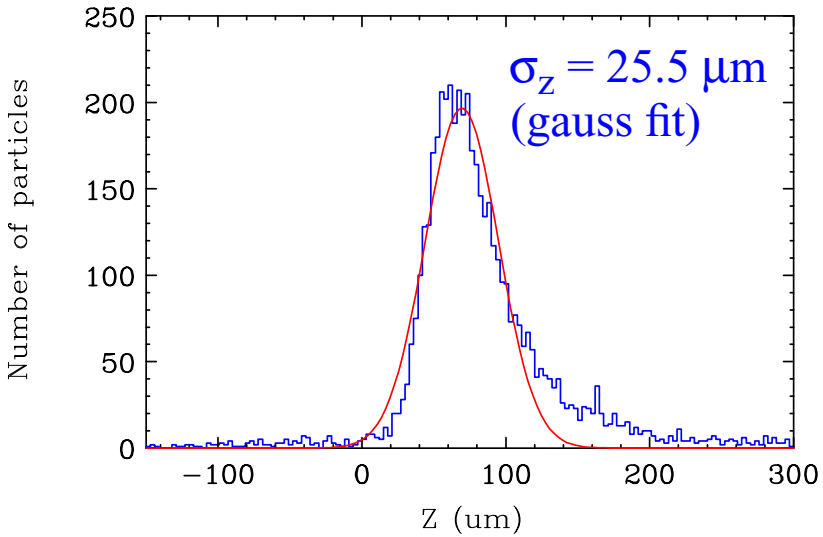


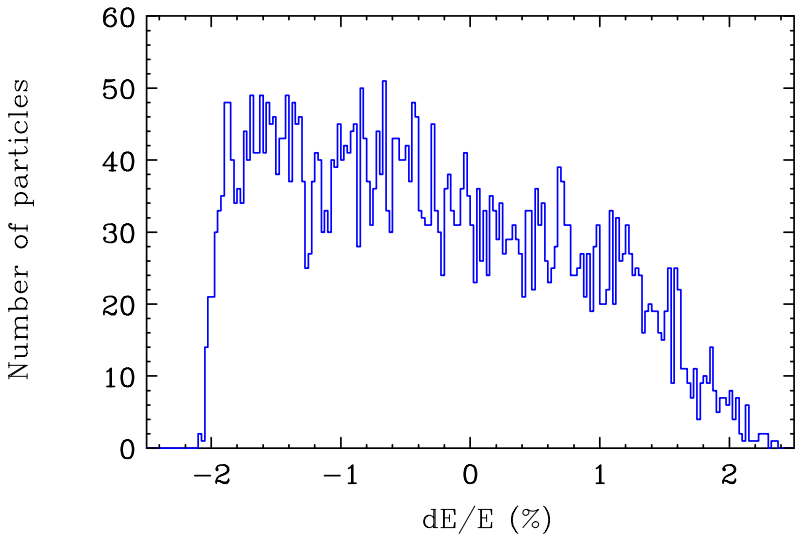
Tracking in the Modified Lattice

Beam case 1: 28.5 GeV, $\gamma\varepsilon_{x(y)}$ = 50(5) μm, N = 2.13x10^{10}

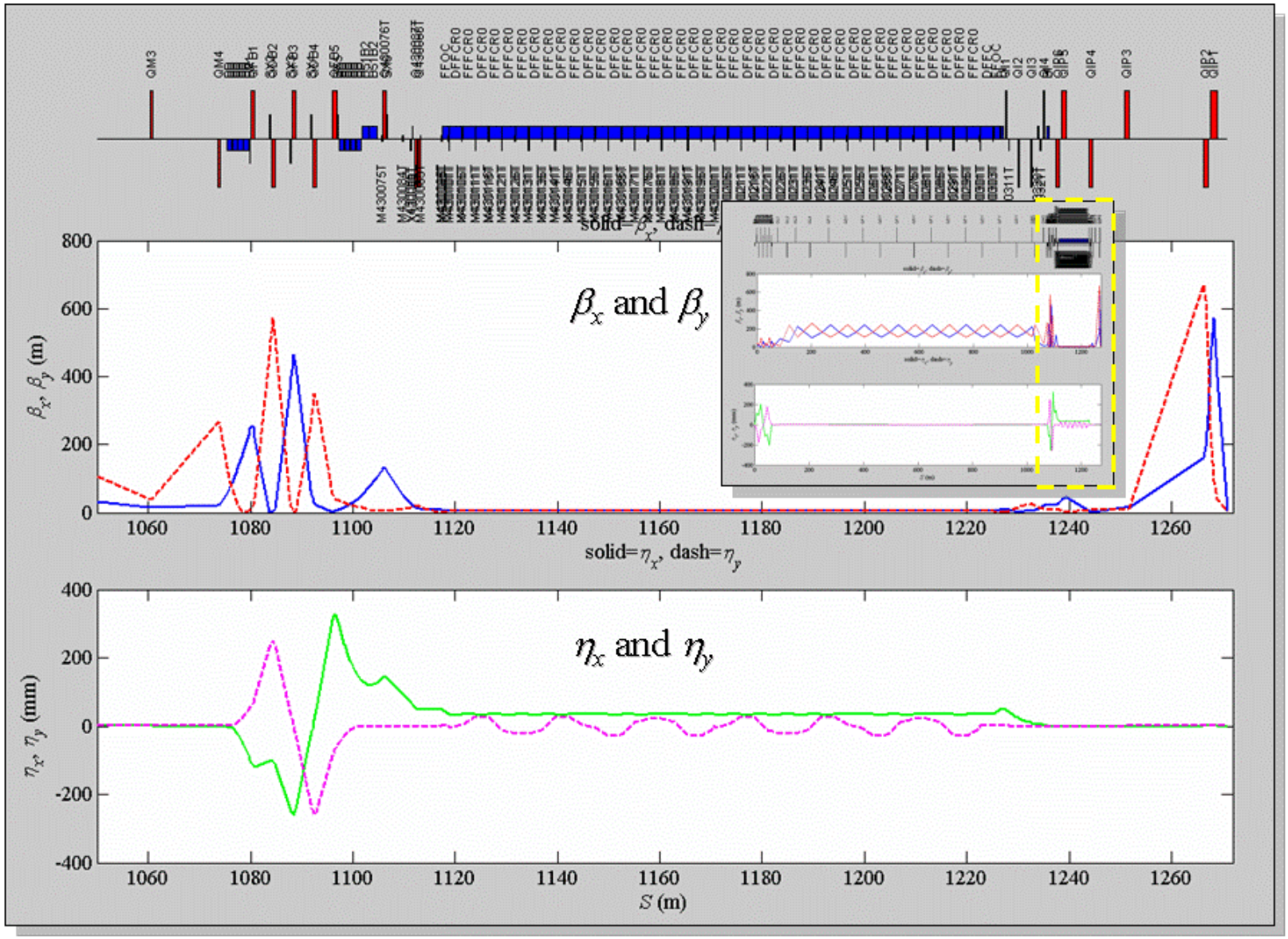




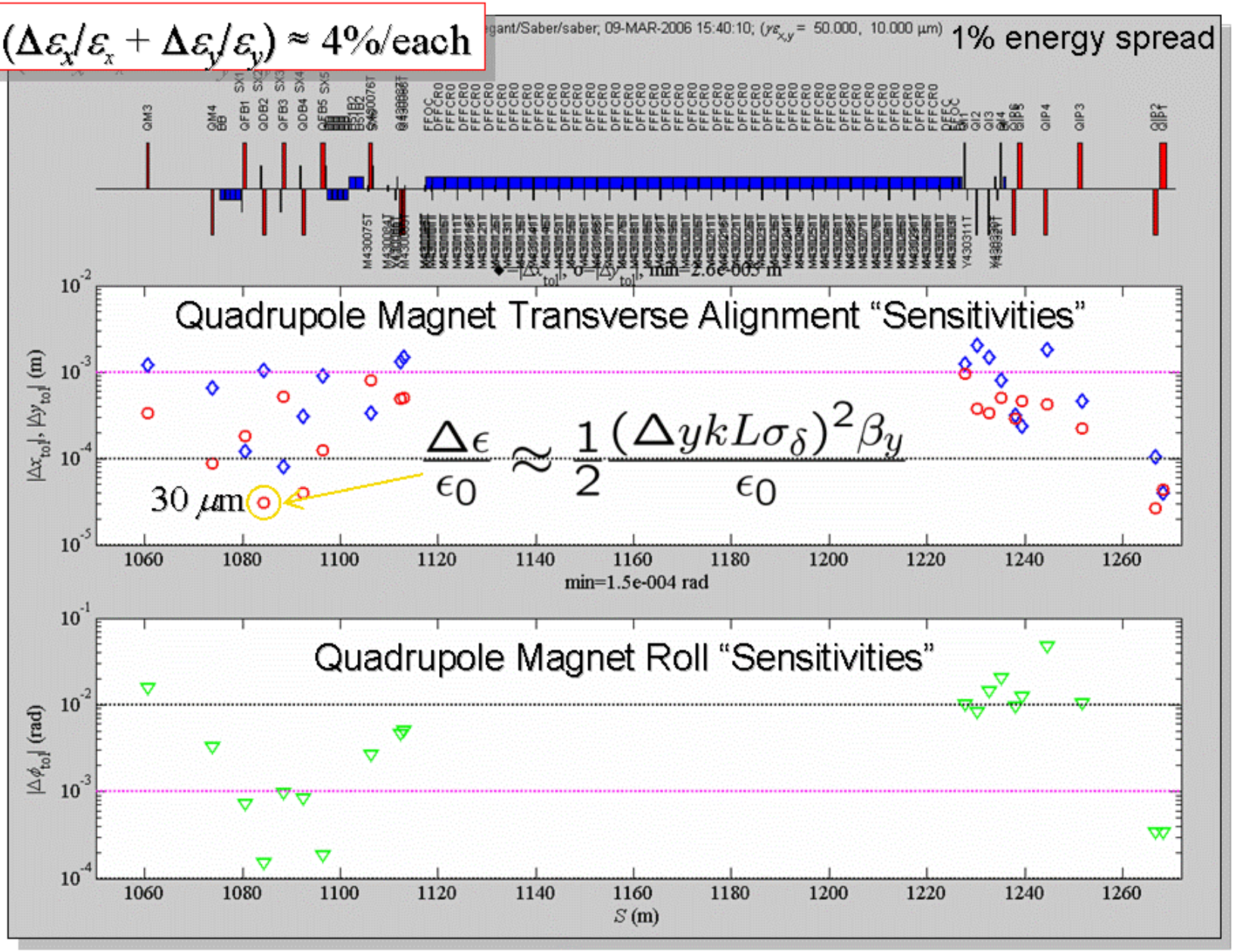




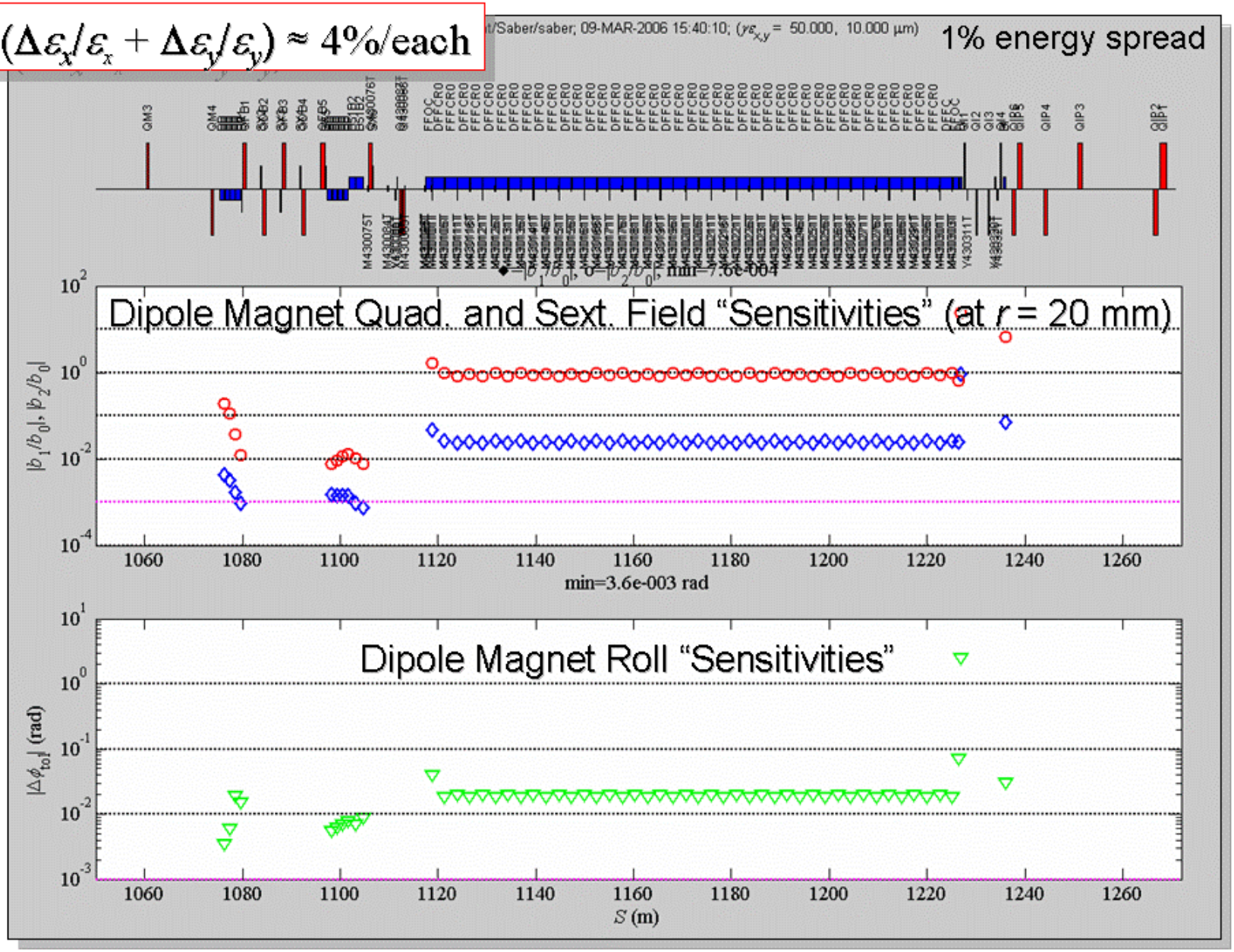
Approximate "sensitivity" study from end of by-pass to S. Arc IP



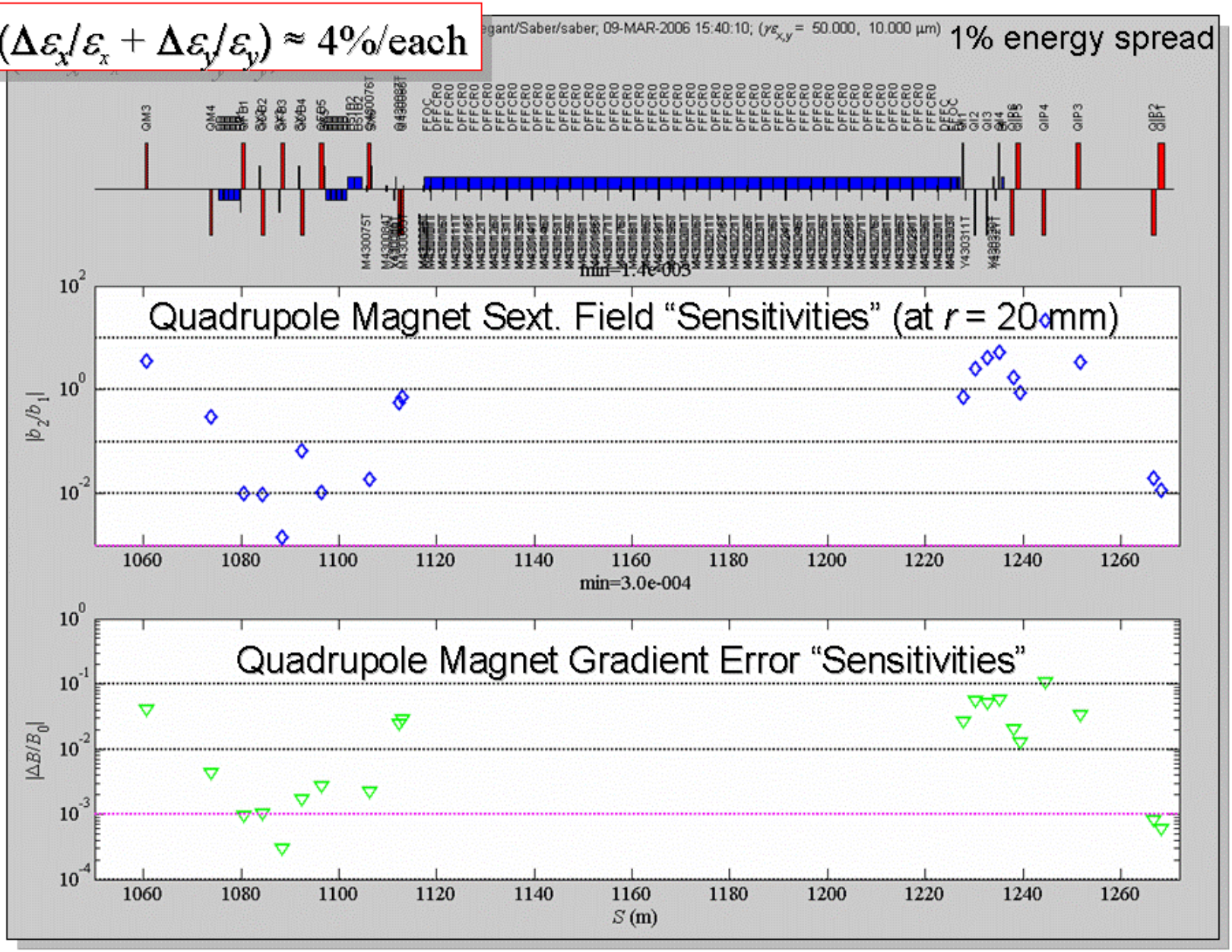
$(\Delta\varepsilon_x/\varepsilon_x + \Delta\varepsilon_y/\varepsilon_y) \approx 4\%/\text{each}$



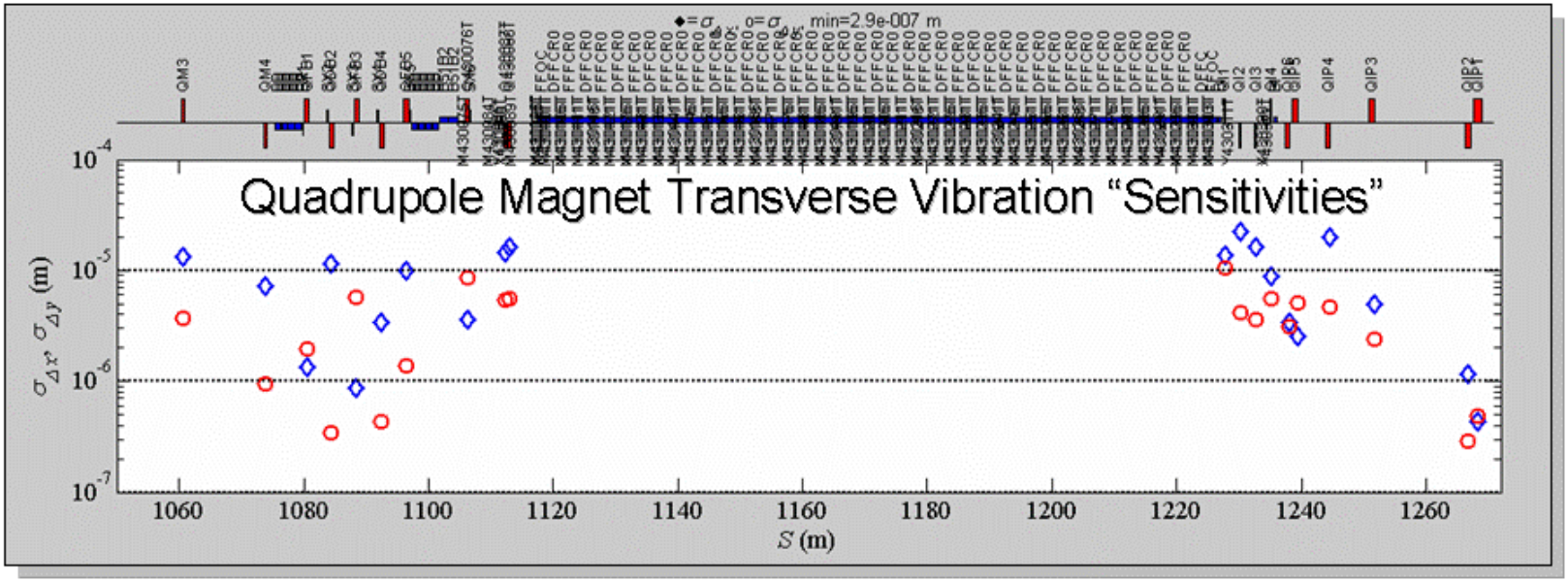
$(\Delta\varepsilon_x/\varepsilon_x + \Delta\varepsilon_y/\varepsilon_y) \approx 4\%/\text{each}$



$(\Delta\varepsilon_x/\varepsilon_x + \Delta\varepsilon_y/\varepsilon_y) \approx 4\%/\text{each}$



$$\{\langle \Delta x^2 \rangle / \sigma_x^2 + (\langle \Delta y^2 \rangle / \sigma_y^2\}^{1/2} \approx 4\%$$



Further Optics Action Items

- Resolve any remaining magnet overlaps with other beamlines.
- Research the available SLAC magnets for use in SABER and include in optics.
- Tracking with realistic errors and correction systems.
- More tolerance studies.
- Correction systems for IP tune-up.
- Dump line.
- Experimental space requirements.