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Beam Sizes From Q4 to Q4 for Seven Different Operation Scenarios

S. Tepikian

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Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

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The beam sizes for RHIC operations under seven different scenarios is presented. The profiles include the large warm-drift space and the triplet quadrupoles through the crossing point.. The table below gives the details of the scenarios considered.

Table 1: Operation Scenarios

Scenario	Species	Energy	$\beta\gamma$	Emittance at 95% [π μm]	β^* [m]
0	Au	Injection	12.6	40	10
1	Au	Storage	108.4	40	10
2	Au	Storage	108.4	40	1
3	p	Injection	31.2	10	10
4	p	Injection	31.2	10	194.3
5	p	Storage	268.2	20	1
6	p	Storage	268.2	10	194.3

The figures that follow are the beam profiles for the scenarios listed above. We used the RHIC 92 revision 0.5 lattice for the optics calculations. Refer to Tech note RHIC/AP/25 for other profiles and additional information.

Maximum Crossing Angle

The maximum crossing angle that can be achieved in RHIC depends on the maximum beam size and the geometry of the split beam tube coming out of the DX magnet. The beam tube begins to split 13.792886m from the crossing point. At this point the aperture is 5.625" OD (0.142875m).

We first calculate the beam size at the critical aperature point. The beta function is found from:

$$\beta(s) = \beta^* + \frac{s^2}{\beta^*}$$

where s is the distance from the crossing point and β^* is the beta function at the crossing point. Hence, the beta function at aperture point is 191.44m. The beam size can be found from:

$$\sigma = \sqrt{\frac{\varepsilon_N \cdot \beta}{6\pi(\beta\gamma)}}$$

where ε_N is the normalized emittnace (40π mm-mrad for Au), β is the beta function and $(\beta\gamma)$ is the lorentz factor (108.4 for Au at top energy). Thus, the beam size is 3.43128mm.

The maximum crossing angle that can be acheived can be found from:

$$6\sigma + B_{cen}(\alpha) \leq Aperture$$

where α is the crossing angle and B_{cen} is a function of the crossing angle giving the distance of the beam center at the point in question to the central axis of the DX magnet.

The beam center function consists of three parts: (1) the region from the crossing point to the DX magnet; (2) the DX magnet itself; and (3) the region from the DX magnet to where the beam pipe splits as follows:

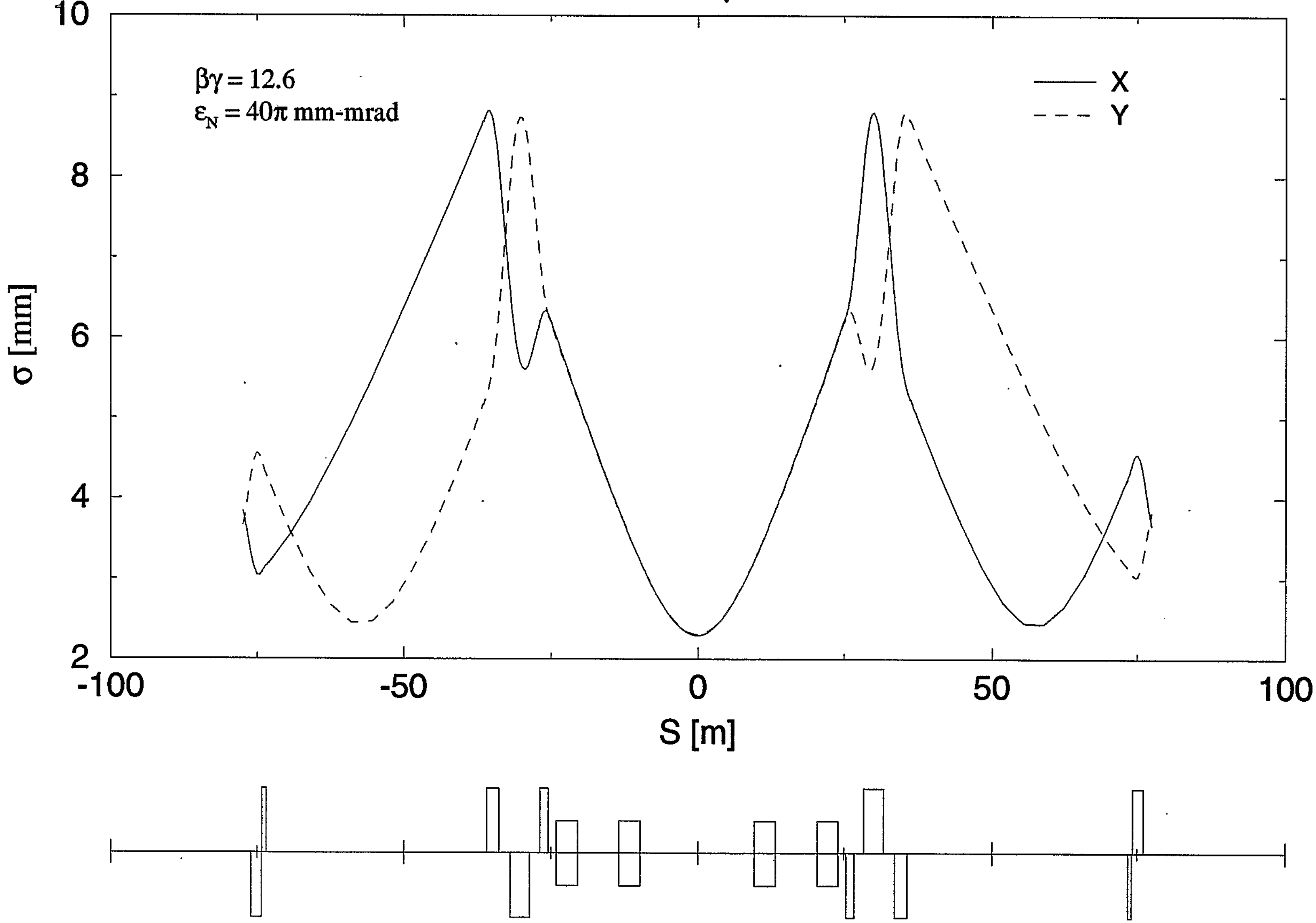
$$B_{cen}(\alpha) = 9.8\tan\frac{\alpha}{2} + \rho_{DX}\left(\cos\frac{\alpha}{2} - \cos\left(\frac{\alpha}{2} + \theta_{DX}\right)\right) + 0.292886\tan\left(\frac{\alpha}{2} + \theta_{DX}\right)$$

where ρ_{DX} is the bending raduis (196.1858m) and θ_{DX} is the bend angle of the DX magnet (18.86079mrad).

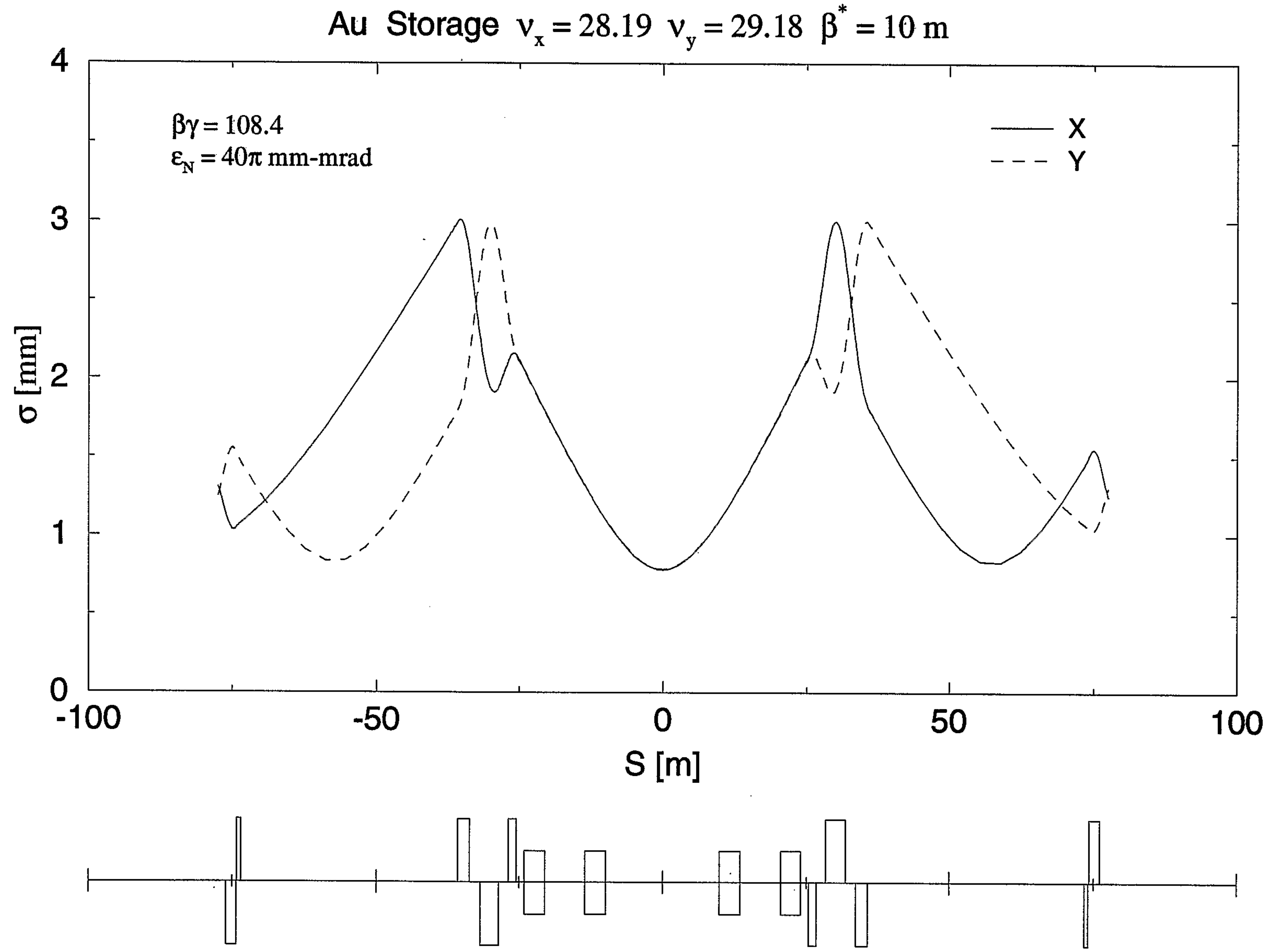
Using the above equations we find the maximum crossing angle to be 1.513mrad.

Scenario 0

Au Injection $\nu_x = 28.19$ $\nu_y = 29.18$ $\beta^* = 10$ m

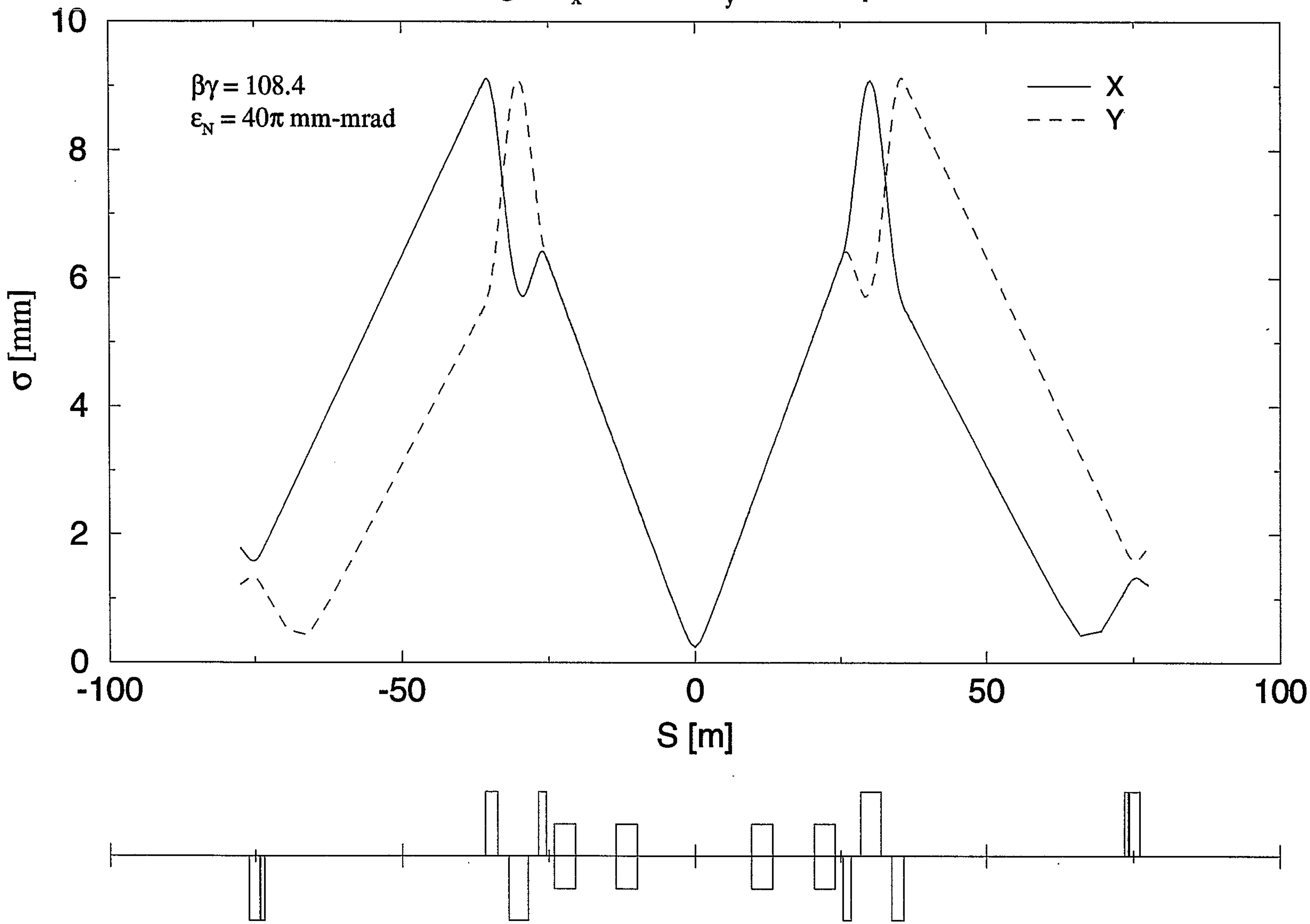


Scenario 1

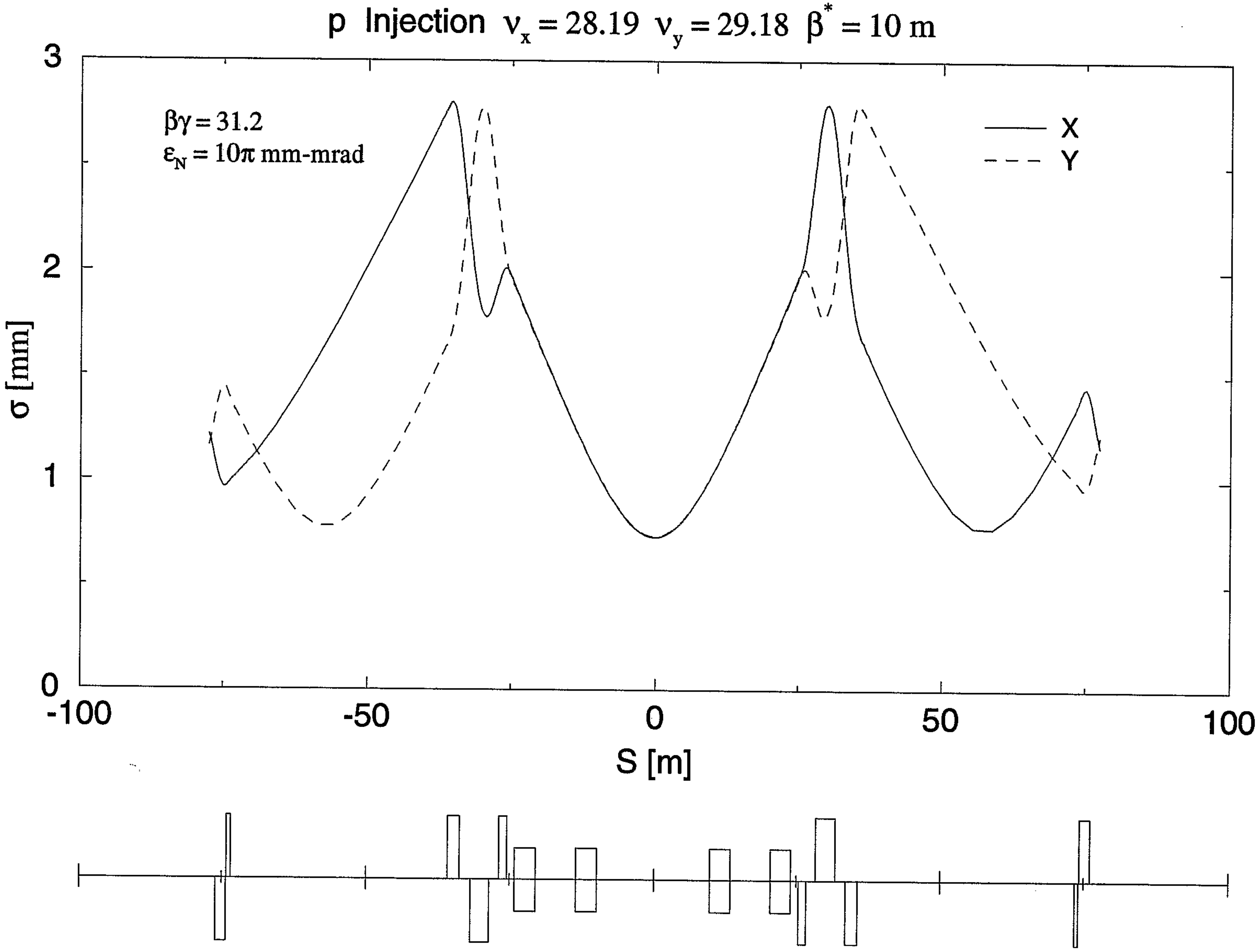

Au Storage $\nu_x = 28.19$ $\nu_y = 29.18$ $\beta^* = 10$ m
$\beta\gamma = 108.4$
$\varepsilon_N = 40\pi$ mm-mrad
X
Y
σ [mm]
S [m]
0
1
2
3
4
-100
-50
0
50
100

Scenario 2

Au Storage $\nu_x = 28.19$ $\nu_y = 29.18$ $\beta^* = 1$ m



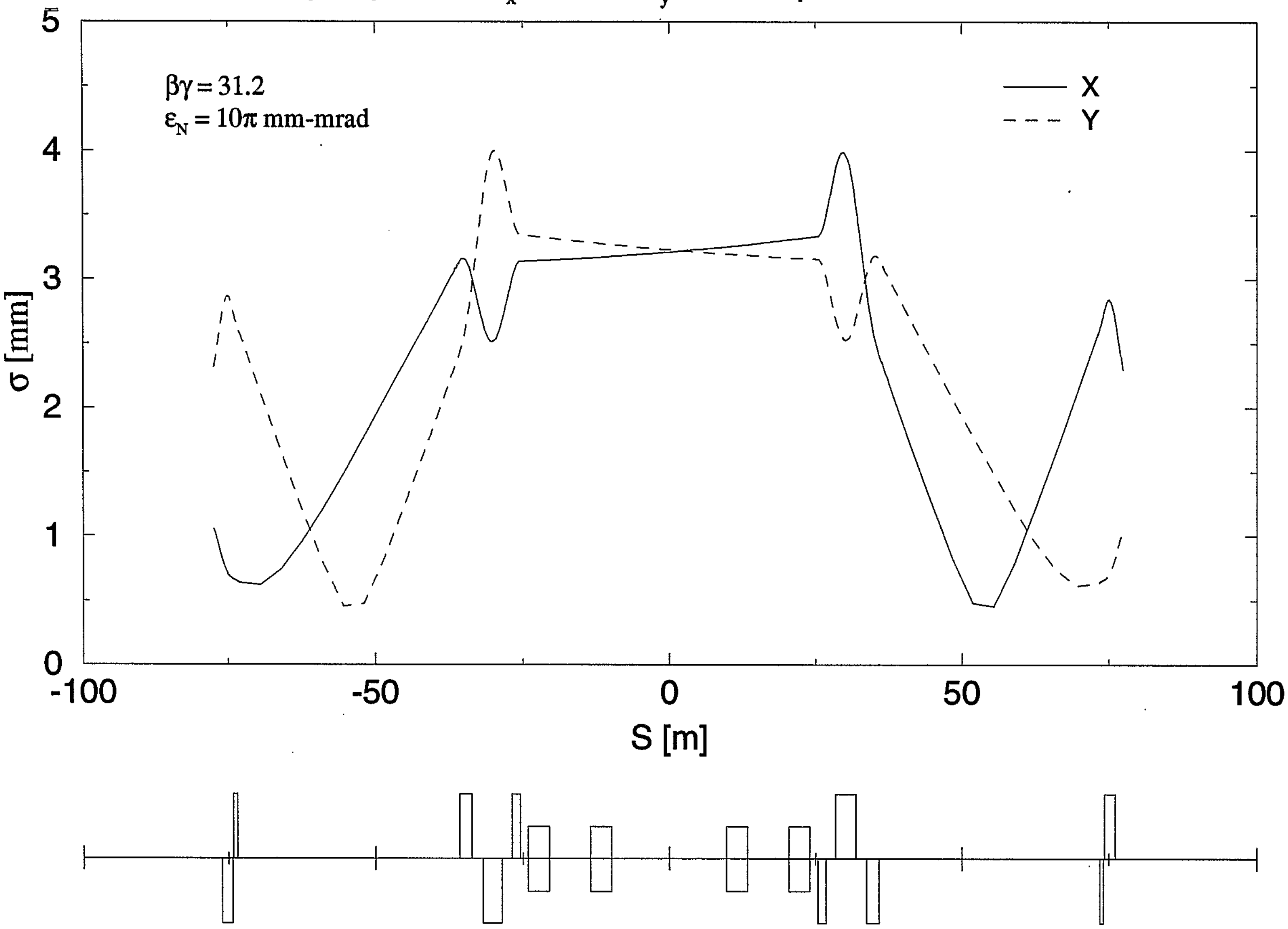
Scenario 3



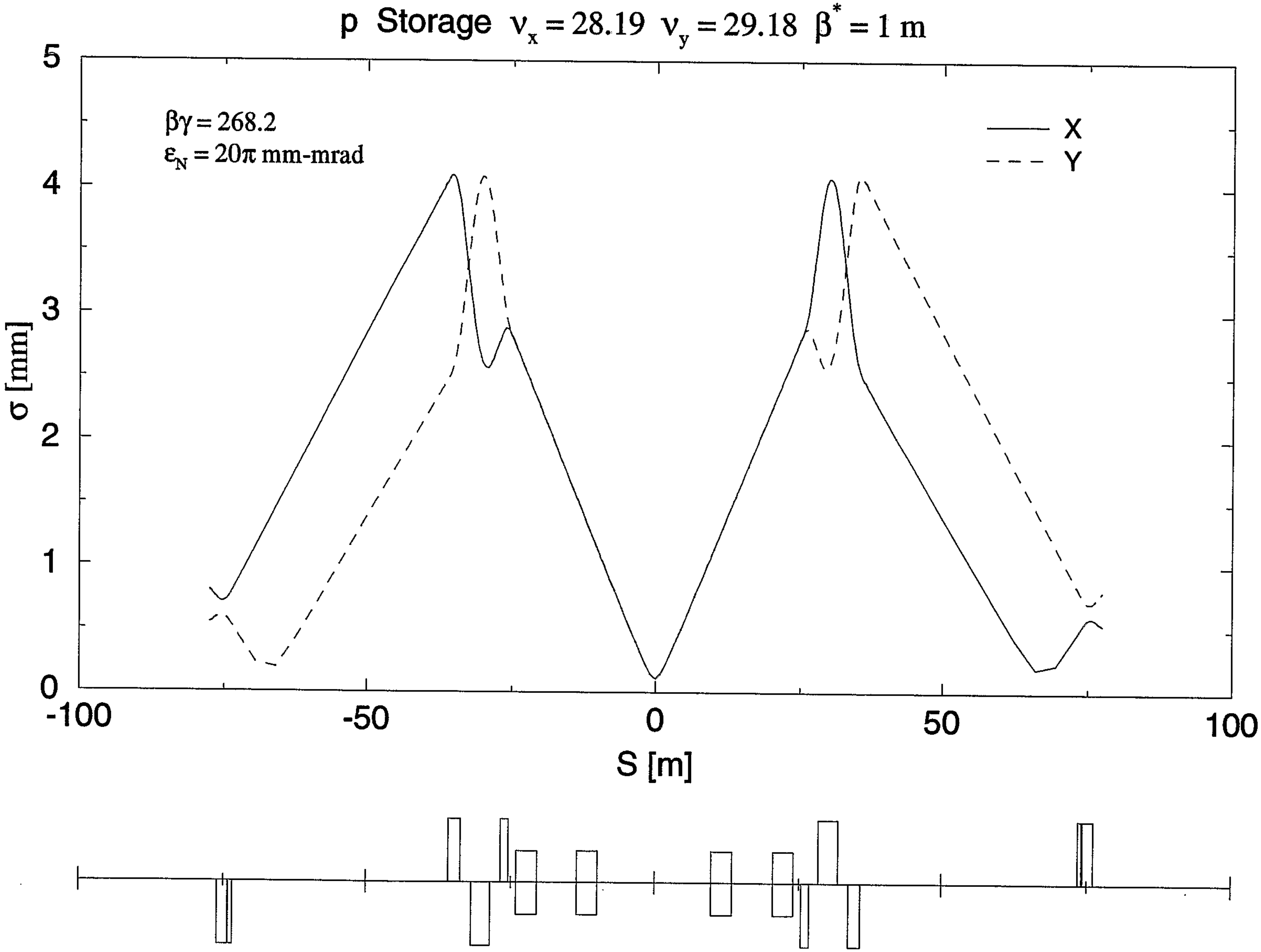
p Injection $\nu_x = 28.19$ $\nu_y = 29.18$ $\beta^* = 10$ m
$\beta\gamma = 31.2$
$\varepsilon_N = 10\pi$ mm-mrad
X
Y
σ [mm]
S [m]
3
2
1
0
-100
-50
0
50
100

Scenario 4

p Injection $\nu_x = 28.19$ $\nu_y = 29.18$ $\beta^* = 194.3$ m

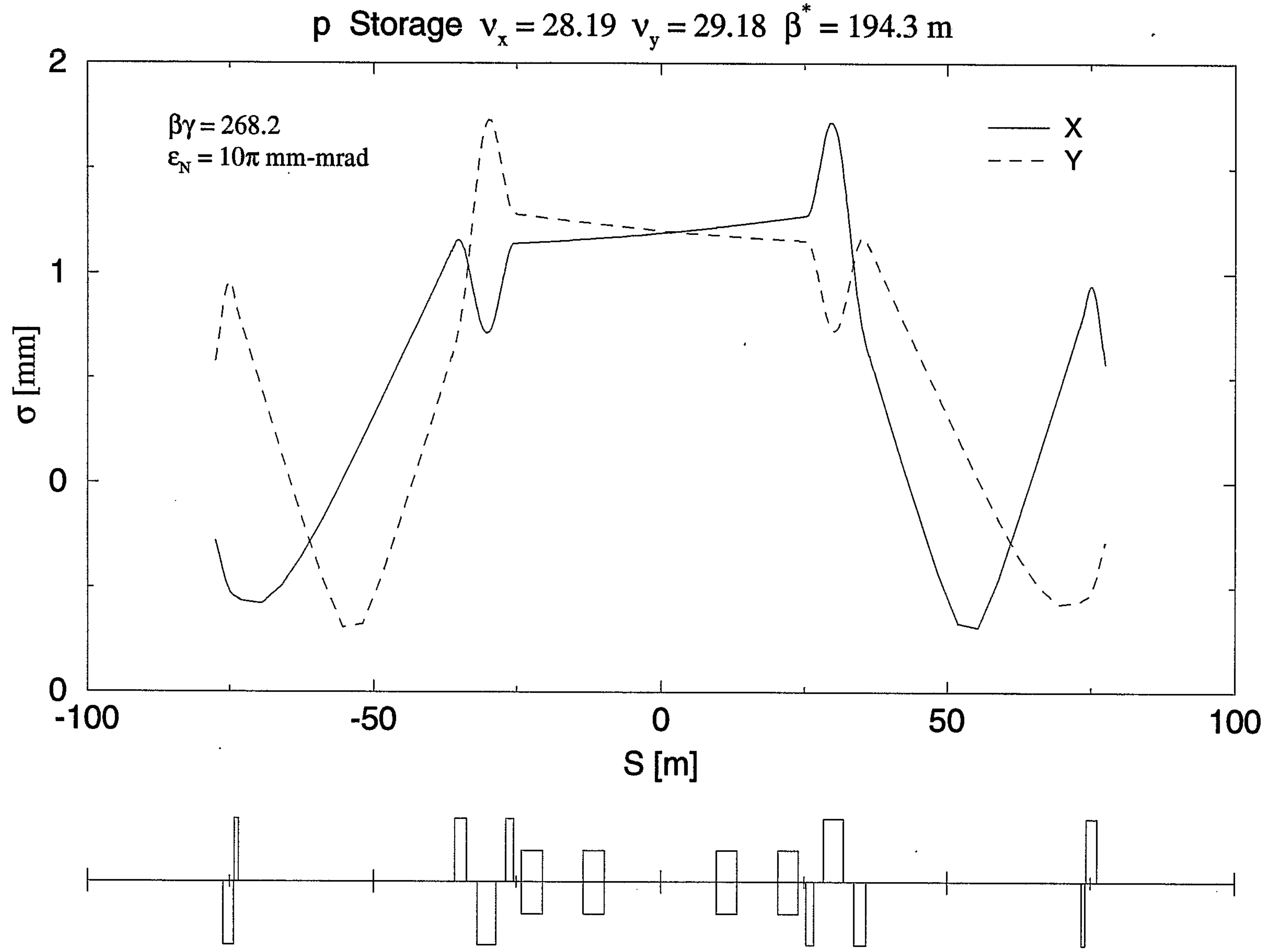


Scenario 5



p Storage $\nu_x = 28.19$ $\nu_y = 29.18$ $\beta^* = 1$ m
$\beta\gamma = 268.2$
$\varepsilon_N = 20\pi$ mm-mrad
X
Y
σ [mm]
S [m]
0
1
2
3
4
5
-100
-50
0
50
100

Scenario 6



p Storage $\nu_x = 28.19$ $\nu_y = 29.18$ $\beta^* = 194.3$ m
$\beta\gamma = 268.2$
$\varepsilon_N = 10\pi$ mm-mrad
X
Y
σ [mm]
S [m]
2
1
0
0
-100
-50
0
50
100