Fermilab

$\bar{p}$ Note #387

Antiprotons and Heavy Ions Colliding in the Tevatron I

A.G. Ruggiero

5/22/84

Antiproton - Heavy Ion Colliding Beam in Tevatron I

As an example let us consider the case of the antiproton beam colliding with a beam of gold ions (Au)

$\bar{p}$'s	$Z=1$	$A=1$	$E = 1000$ GeV
Au	$Z=79$	$A=197$	$E = 400$ GeV

The two beams share the same magnet ring and therefore must have the energies shown.

The gold beam can be obtained at Fermilab with a cost of ~ 20 M$.

We can assume that each beam is made of 3 bunches (like in Tevatron I)

no. of antiprotons / bunch	1×10^{11}
no. of Au-ions / bunch	4×10^{8}

The two beams are expected to have about the same emittance then the luminosity for head-on collision

$$L \gtrsim 1.0\times10^{28}\ \mathrm{cm}^{-2}\,\mathrm{s}^{-1} \quad \text{(too much!!)}$$

The two beams have nevertheless unequal velocities. To preserve synchronism is required to run the $\bar{p}$-beam on an outer orbit corresponding to an off-momentum value of $\Delta p/p = +\delta$ and the ion-beam to the inner orbit corresponding to an off-momentum value of $\Delta p/p = -\delta$.

T, revolution time

$$T_{\bar{p}} = T_{\bar{p}0} - T_{\bar{p}0}\left(\frac{1}{\gamma_{\bar{p}}^2} - \frac{1}{\gamma_T^2}\right)\delta$$

$$T_{Au} = T_{Au_0} + T_{Au_0}\left(\frac{1}{\gamma_{Au}^2} - \frac{1}{\gamma_T^2}\right)\delta$$

Now

$\gamma_{\bar{p}} = 1066.80$ $\qquad$ $\beta_{\bar{p}} = 0.999999561$

$\gamma_{Au} = 430.74$ $\qquad$ $\beta_{Au} = 0.999997305$

$\gamma_T = 18.75$

Let $\eta = \frac{1}{\gamma^2} - \frac{1}{\gamma_T^2}$

$$\eta_{\bar{p}} = -0.002843566$$

$$\eta_{Au} = -0.002839055$$

Also

$$T_0 = \frac{2\pi R}{\beta c}$$

We require $T_{\bar{p}} = T_{Au}$ which is

$$\frac{1}{\beta_{\bar{p}}} - \frac{\delta}{\beta_{\bar{p}}}\eta_{\bar{p}} = \frac{1}{\beta_{Au}} + \frac{\delta}{\beta_{Au}}\eta_{Au}$$

or

$$\delta = \frac{\frac{1}{\beta_{\bar{p}}} - \frac{1}{\beta_{Au}}}{\frac{\eta_{Au}}{\beta_{Au}} + \frac{\eta_{\bar{p}}}{\beta_{\bar{p}}}} = 0.04\ \% \quad (\text{OK!})$$