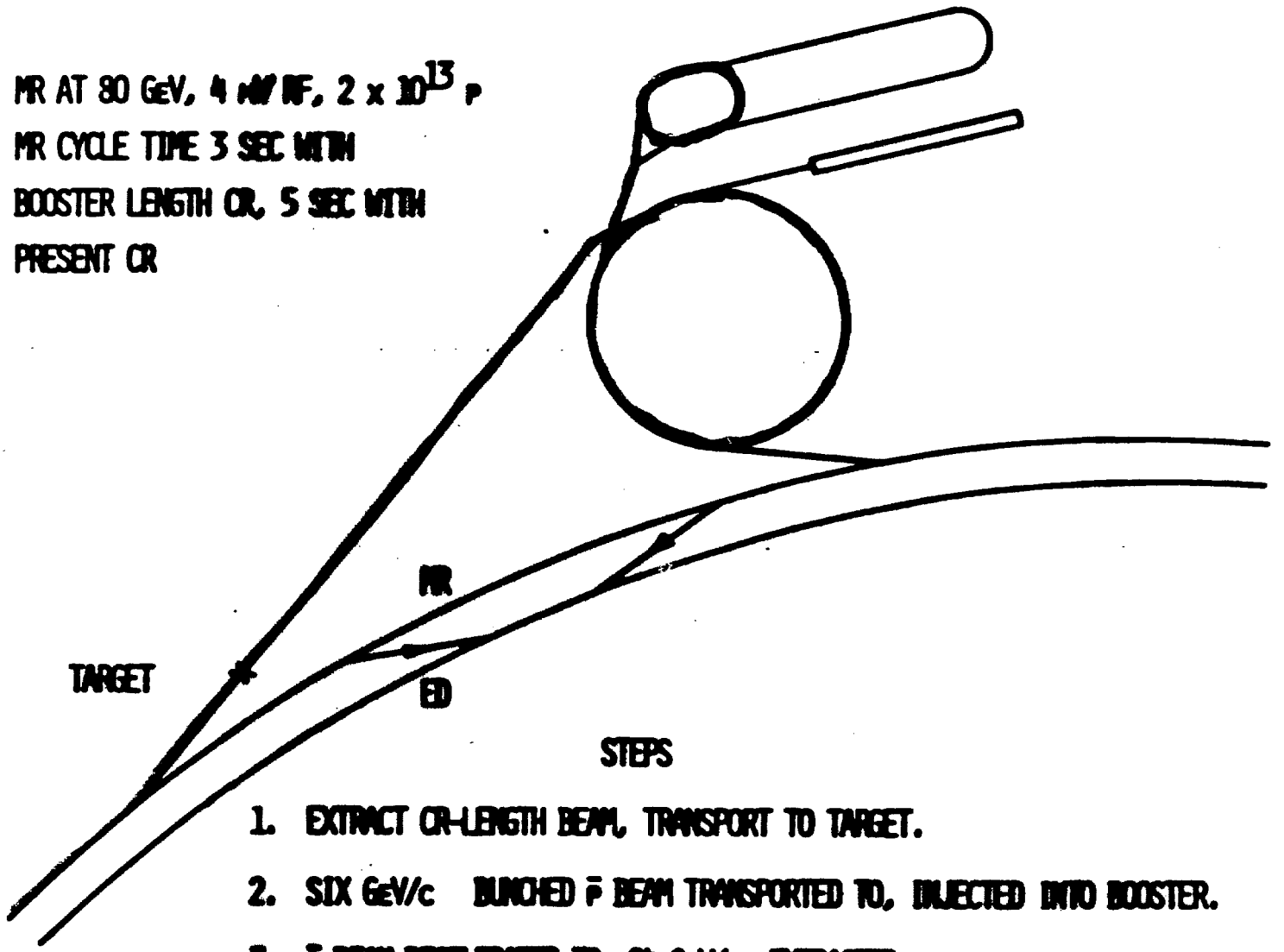
UPC 074

Mills Transparencies

on $\bar{p}p$

COLLECTING ANTIPROTONS

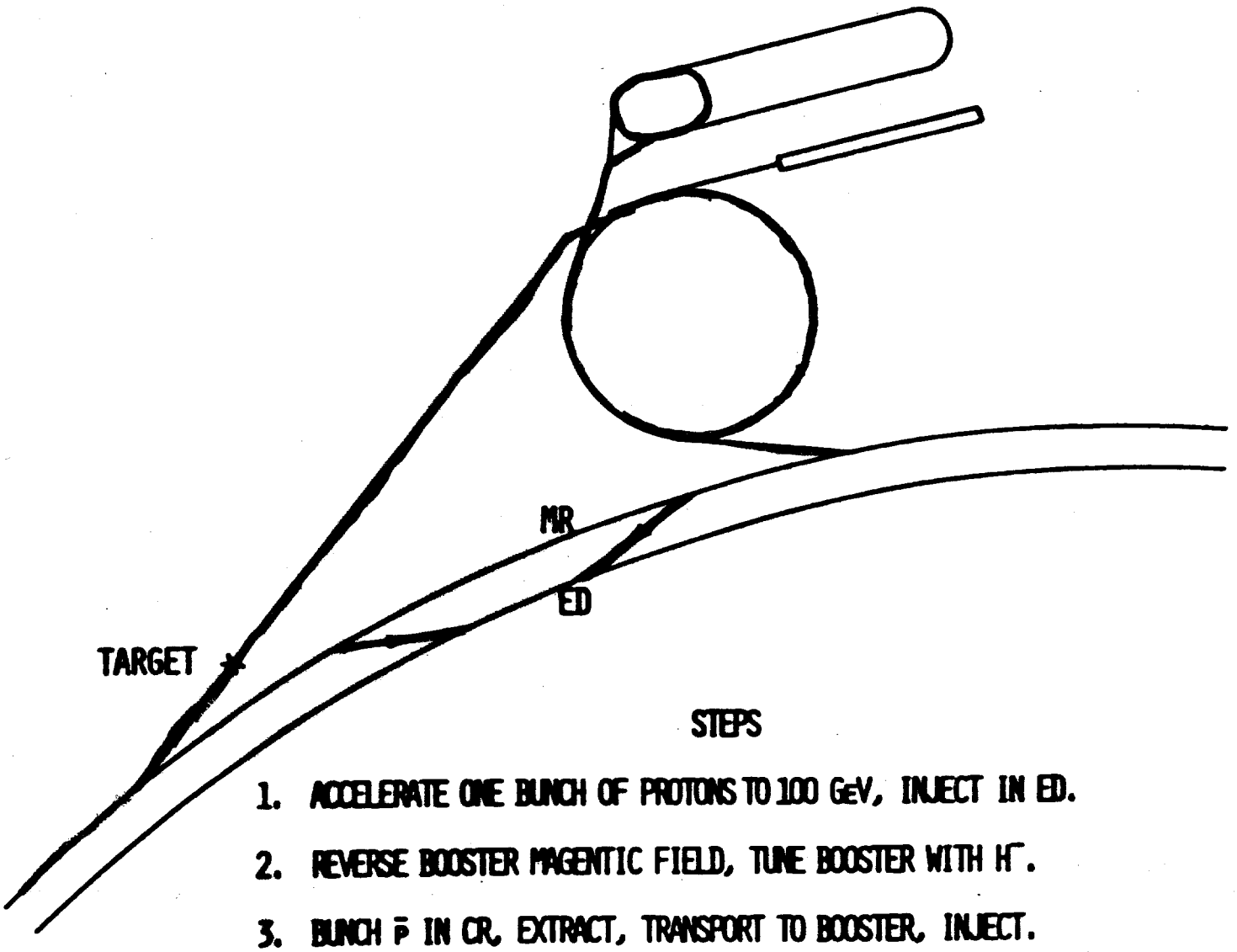
MR AT 80 GeV, 4 MV RF, 2×10^{13} p
MR CYCLE TIME 3 SEC WITH
BOOSTER LENGTH CR, 5 SEC WITH
PRESENT CR



STEPS

1. EXTRACT CR-LENGTH BEAM, TRANSPORT TO TARGET.
2. SIX GeV/c BUNCHED $\bar{p}$ BEAM TRANSPORTED TO, INJECTED INTO BOOSTER.
3. $\bar{p}$ BEAM DECELERATED TO .64 GeV/c, EXTRACTED.
4. TRANSPORT $\bar{p}$ TO CR, INJECT.
5. RF STACK $\bar{p}$ AT COOLING ENERGY.
6. REPEAT UNTIL ALL MR PROTONS ARE USED.
7. RECYCLE MR, REPEAT 1 - 6.

COLLIDING p WITH $\bar{p}$ AFTER ACCUMULATION



STEPS

1. ACCELERATE ONE BUNCH OF PROTONS TO 100 GeV, INJECT IN ED.
2. REVERSE BOOSTER MAGENTIC FIELD, TUNE BOOSTER WITH H^-.
3. BUNCH $\bar{p}$ IN CR, EXTRACT, TRANSPORT TO BOOSTER, INJECT.
4. ACCELERATE $\bar{p}$ TO 8 GeV, EXTRACT, REVERSE INJECT IN MR.
5. ACCELERATE TO 100 GeV, EXTRACT, INJECT IN ED.
6. ACCELERATE TO COLLIDING ENERGY.

LUMINOSITY COMPARISON

	FERMILAB	CERN
PRODUCTION		
PROTON ENERGY (GeV)	80	26
PROTONS/SEC	6.7×10^{12}	3.8×10^{12}
$\bar{p}$ MOMENTUM (GeV/c)	6	3.5
$\Delta p/p$	2.6×10^{-3}	15×10^{-3}
ACCEPTANCE (mm-mrad)	$2.8\pi\times1.4\pi$	$100\pi\times100\pi$
PRODUCTION ANGLE (mrad)	12	67
ρ^* (target) (cm)	2	2.3
$(E\,d^3\sigma/dp^3)$ (mb/GeV^2)	0.6	0.2
TARGET EFFICIENCY (ϵ_T)	0.15	0.15
$N_{\bar{p}}/N_p$	8.3×10^{-8}	190×10^{-8}
$N_{\bar{p}}$/sec.	5.5×10^{5}	72×10^{5} -
$N_{\bar{p}}$/hr.	2.0×10^{9}	26×10^{9} -
COLLIDING BEAMS		
ENERGY (GeV)	1000	270
N_p	2×10^{10}	6×10^{11}
$N_{\bar{p}}$	6×10^{9} (3hrs)	6×10^{11} (24hrs)
N_B	1	6
$\sqrt{\beta_x\beta_y}$ (m)	2.5	2.2 -
ϵ_{Hp} (m-rad)	$2.6\pi\times10^{-8}$	$6.9\pi\times10^{-8}$
ϵ_{Vp} (m-rad)	$2.6\pi\times10^{-8}$	$3.5\pi\times10^{-8}$
$\epsilon_{H\bar{p}}$ (m-rad)	$0.8\pi\times10^{-8}$	$3.8\pi\times10^{-8}$
$\epsilon_{V\bar{p}}$ (m-rad)	$0.8\pi\times10^{-8}$	$1.9\pi\times10^{-8}$
$\mathcal{L}$ (cm^{-2}-sec^{-1})	10^{28}	10^{30}

Antiproton Collection

$$N_{\bar{p}}/N_p = \frac{1}{\sigma_{abs}} \; E\frac{d^3\sigma}{dp^3} \; \frac{dp_\perp^2 \, dp_\parallel}{E} \; \varepsilon_T$$

$$dp_\perp^2 = 4p^2 \, \theta_x \theta_y$$

$$\theta_x = \sqrt{\frac{\varepsilon_x}{\pi\beta^*}} \qquad \theta_y = \sqrt{\frac{\varepsilon_y}{\pi\beta^*}}$$

ε_T includes
p absorption
$\bar{p}$ absorption
depth of focus
chromatic aberration

Design by G. Chadwick

gives $\beta^* = 2\,cm$ $\quad \varepsilon_T = .15$

Booster Acceptance $\quad \varepsilon_x = 2.8\pi \times 10^{-6}\,m$
$\varepsilon_y = 1.4\pi \times 10^{-6}\,m$
$\Delta p/p = 2.6 \times 10^{-3}$

For $\sigma_{abs} = 40\,mb$

$$E\frac{d^3\sigma}{dp^3} = 0.6\ mb/GeV^2 \quad , \quad N_{\bar{p}}/N_p = 0.83 \times 10^{-7}$$

$$\frac{dN_p}{dt} = 2.4 \times 10^{16}\ p/hr \qquad \frac{dN_{\bar{p}}}{dt} = 2 \times 10^{9}\ \bar{p}/hr$$

Colliding at 1 Tev

$$L = \frac{4 N_p N_{\bar{p}} f}{N_B \sqrt{\beta_x \beta_y (\varepsilon_{px} + \varepsilon_{\bar{p}x})(\varepsilon_{py} + \varepsilon_{\bar{p}y})}}$$

Gaussian beams, ε includes 98% of beam

Emittance: 10^{12} p at 400 Gev : Gaussian, $\varepsilon = .05\pi \times 10^{-6}$ m for 98% of beam. At 2×10^{13}, ε increases by 30%. (Ohnuma)

1 Tev p's $\varepsilon_{x,y} = \frac{400}{1000} \times 5\pi\times10^{-8} \times 1.3 = 2.6\times10^{-8}\pi$ m

$N_p = 2\times10^{10}$, $N_{\bar{p}} = 6\times10^{9}$, $\sqrt{\beta_x \times \beta_y} = 2.5$ m

$\varepsilon_{\bar{p}} = \frac{N_{\bar{p}}}{N_p}\varepsilon_p = 0.8\times10^{-8}\pi$ m

$f = 4.8\times10^{4}$ Hz

$L \cong 10^{28}$ cm^{-2} sec^{-2}

High Luminosity $\bar{p}p$

Critical Parameters

$N_p/N_b \leq 10^{11}$ at ~100 GeV

$N_{\bar{p}}/N_b < 10^{10}$ in booster at low energy

$\mathcal{L}/N_b < 6\times10^{29}$

$\Delta\nu < .002$ without cooling

Elements of High Luminosity Scenarios

1. Improvements in present scheme
2. Precooler Ring
3. High Energy electron cooling
4. AA Ring

I Improvements in present

Collection

MR Intensity	x 1.5
Targetry	x 2
Booster Acceptance	x 2
	6

$N_{\bar{p}} \approx 3.6\times10^{10}$ in 3hr Collection

Collision Parameters

MR Rebunch → 10^{11}		x 5
Low β	1.4m	x 1.8
		x 9

6 bunches

$\mathcal{L} = 5 \times 10^{29}$ $\Delta\nu_{\bar{p}} = .002$ per crossing

II Precooler

Assume X10 collection rate. 3.6×10^{11} $\bar{p}$ in 3hr. Rebunch at 54th, Accelerate through booster to Precooler, debunch, stochastically cool if necessary, rebunch at 12th harmonic (12 bunches)

$\mathcal{L} \approx 5 \times 10^{30}$, 12 bunches same $\Delta\nu_{\bar{p}}$

$n_{\bar{p}}$/bunch $= 3 \times 10^{10}$, does not pass through booster at low energy

III HE Cooling

1. without precooler $\Delta\nu \rightarrow .01$

$\mathcal{L} \rightarrow 2.5 \times 10^{30}$ 6 bunches

2 with precooler can go to $\Delta\nu = .01$, but $\mathcal{L}/N_B$ is too high, need more bunches, must put on one side of ring.