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## Scenario For The Case Of No RF Stacking

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**U.S. Department of Energy**

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SCENARIO FOR THE CASE OF NO RF STACKING

A. G. RUGGIERO

(BNL, December 5, 1983)

Scenario for the case  
of no RF stacking

A.G. Ruggiero

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## Formulae

Luminosity :

$$L = \frac{N^2 B f_{rev}}{4\pi \sigma_v^* \sigma_H^* f}$$

Beam-Beam Tune-Shift :

$$\Delta\nu = \frac{N r_0 \beta_v^* Z^2}{4\pi \sigma_v^* \sigma_H^* f \gamma A}$$

$f$ , correction factor =  $\sqrt{1 + \rho^2}$

$$\rho = \frac{\alpha \sigma_e}{2\sigma_H^*}$$

## General Parameters

Circumference, $2\pi R$	3833.8 m
Revolution Frequency, $f_{rev}$	78.194 kHz
Element:	Gold (Au)
$A$ , atomic mass	197
$Z$ , atomic number	79
Kinetic Energy	100 GeV/A
Rest Energy	0.9381 GeV/A
$\gamma$	107.60
$\beta$	0.999957
Rigidity, $B\rho$	839.72 T·m
Momentum	100.93 GeV/c/A
No. of AGS pulses / Ring	57 box-car
No. of bunches / AGS pulse	1
No. of ions / AGS bunch	$1.87 \times 10^9$
Total No. of ions / Ring	$1.07 \times 10^{11}$
AGS Cycle Time	2.0 sec
Filling Time	2 rings $\times$ 2 min

AGS Bunch Area at Transfer  
Normalized Emittance,  $H$  and  $V$   
Emittance @ 100 GeV/A  
(95% of beam population)

0.1 eV/A-sec  
10.  $\pi$  mm-mrad

0.1  $\pi$  mm-mrad

RF Harmonic Number,  $h$

171

RF Frequency,  $f_{RF}$

13.37 MHz

Transition Energy,  $E_T$

35

Average Beam Current, particle  
electric

1.34 mA

0.106 Amp

Regular Cell, average  $\beta$ -value  
average  $\eta$ -value

30. m

0.5 m

no special magnet

septum magnet

common magnet

	no special magnet	septum magnet	common magnet
Crossing Angle, $\alpha$ mrad	8.	2.	0.
No. of Bunches/Beam, B	171	171	57
No. of Ions/Bunch, N	$6.24 \times 10^8$	$6.24 \times 10^8$	$1.87 \times 10^9$
Rms Bunch Length, $\sigma_e$ , cm	15.	15.	90.
Rms Energy Spread, $\sigma_E/E$	$1. \times 10^{-3}$	$1. \times 10^{-3}$	$.3 \times 10^{-3}$
Bunch Area, eV/A-sec	0.625	0.625	1.125
RF Voltage, kV	200	200	100
$\beta_v^*$ m	2.0	2.0	1.0
$\beta_H^*$ m	32	2.0	1.0
$\sigma_v^*$ cm	0.0183	0.0183	0.013
$\sigma_H^*$ cm	0.073	0.0183	0.013
$p = \alpha \sigma_e / 2\sigma_H^*$	0.82	0.82	0.
$f = \sqrt{1+p^2}$	1.2932	1.2932	1.
rms Interaction length, cm	7.5	7.5	45.
Luminosity, $\text{cm}^{-2} \text{s}^{-1}$	$0.25 \times 10^{27}$	$1.0 \times 10^{27}$	$0.8 \times 10^{28}$
Beam-Beam Tune Shift, $\Delta \nu$	0.0003	0.0012	0.0047
Peak Current, particle, mA	80.	80.	40.
electric, Amp	6.3	6.3	3.15
$ Z/n $ allowable, ohm	114	114	20.5
Initial Luminosity Loss Rate, $\text{h}^{-1}$	0.732	0.732	0.945

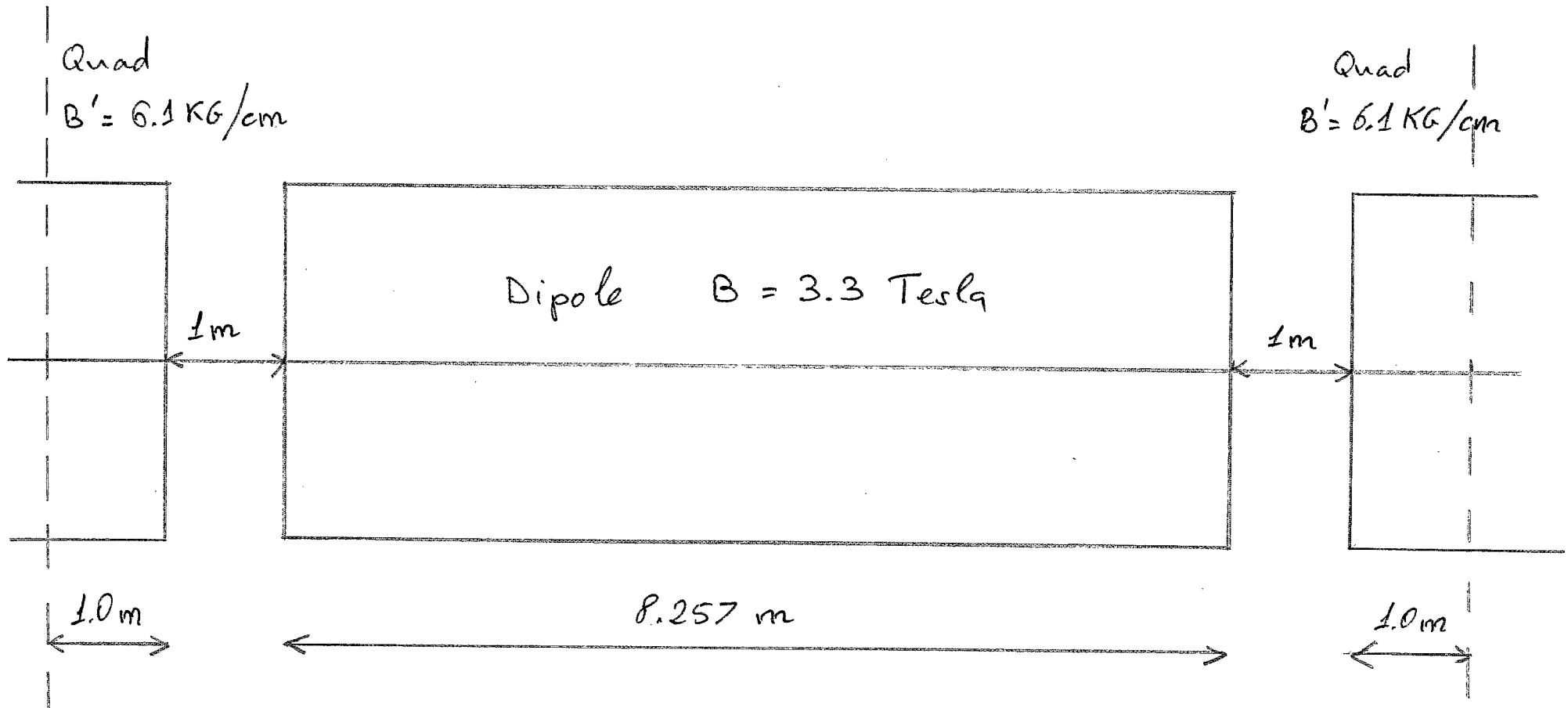


## Lattice :

### Regular Cells :

No. of Regular Cells	96
Length (Full)	24.514 m
Phase Advance (Full)	125.2°
$\beta_{max}$	56.6 m
$\beta_{min}$	3.4 m
$\eta_{max}$	0.722 m
$\eta_{min}$	0.278 m
Bending Angle / Half Cell	32.151 mrad
Contribution to $\beta$ -Tune	32.
$B' \times l_q$	121.65 Tesla
Quadrupole Gradient, $B'$	6.1 KG/cm
Quadrupole Length, $l_q$	2.0 m
Dipole length, $l_B$	8.257 m
Dipole Field	3.27 Tesla
Sagitta	3.3 cm
Bending Radius, $\rho$	256.8 m
Drift between dipole and quad	1.0 m

# Half-Regular Cell



No. of Dipoles / Ring = 192

No. of Quads / Ring = 192

Special Dipoles and Quads not included

## Beam Size (Max.)

Energy	Height ( $\pm 2.5\sigma$ )	Width ( $\pm 2.5\sigma$ )
100 GeV/A	$\pm 2.4$ mm	$\pm 3.0 / 4.2$ mm
12	6.6	6.8 / 8.4
5	9.7	9.9 / 11.5

Circular Vacuum Chambers  
with i.d.

6.0 cm

Requirement on Good Field  
Region :

@ 5 GeV/A

$\pm 2.5$  cm

100 GeV/A

$\pm 1.0$  cm

$$\sigma_E/E = 10^{-3}$$

$$\gamma = 100$$
$$I = 1 \text{ A-electric}$$

Gold

# 57

$E_N$	$\chi_E^{-1}$	$\chi_H^{-1}$	$\chi_V^{-1}$
$5 \pi \text{ mm.mrad}$	$.1538 \text{ h}^{-1}$	$.2523 \text{ h}^{-1}$	$-.0554 \text{ h}^{-1}$
$\rho$	$.1007$	$.1032$	$-.0227$
10	$.0816$	$.0669$	$-.0147$
12	$.0684$	$.0467$	$-.0103$

$$E_N = 10 \pi \text{ mm.mrad}$$

$\sigma_E/E$	$\chi_E^{-1}$	$\chi_H^{-1}$	$\chi_V^{-1}$
$0.5 \times 10^{-3}$	$.5415 \text{ h}^{-1}$	$.1110 \text{ h}^{-1}$	$-.0244 \text{ h}^{-1}$
0.8	$.1547$	$.0812$	$-.0178$
1.0	$.0816$	$.0669$	$-.0147$
1.2	$.0474$	$.0560$	$-.0123$

Comparison of Diffusion Rates vs. normalized emittance  $E_N$  and rms energy spread  $\sigma_E/E$

# Comparison of Diffusion Rates with Lattice Choice

$\bar{\beta}$	m	25	30	35	40		
$\bar{\eta}$	m	.5	.5	.5	.5	←	
case #		46	57	68	79		
$\alpha_E^{-1}$	$h^{-1}$	.0964	.0816	.070	.0607		
$\alpha_H^{-1}$	$h^{-1}$	.1012	.0659	.0453	.0307		
$\alpha_V^{-1}$	$h^{-1}$	-.0145	-.0147	-.0147	-.0146		
$\bar{\beta}$	m	25	30	35	40		
$\bar{\eta}$	m	1.0	1.0	1.0	1.0	←	
case #		47	58	69	80		
$\alpha_E^{-1}$	$h^{-1}$	.0837	.0744	.0665	.0596		
$\alpha_H^{-1}$	$h^{-1}$	.3891	.2842	.2139	.1646		
$\alpha_V^{-1}$	$h^{-1}$	-.0126	-.0134	-.0140	-.0143		
$\sigma_E/E = 10^{-3}$				$\gamma = 100$			
$E_N = 10 \pi \text{ mm. mrad}$							
Gold				$I = 1.0 \text{ Amp-electric}$			

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$\gamma = 100$

$I = 1 \text{ Amp- electric}$

$\bar{\beta} = 30 \text{ m}$

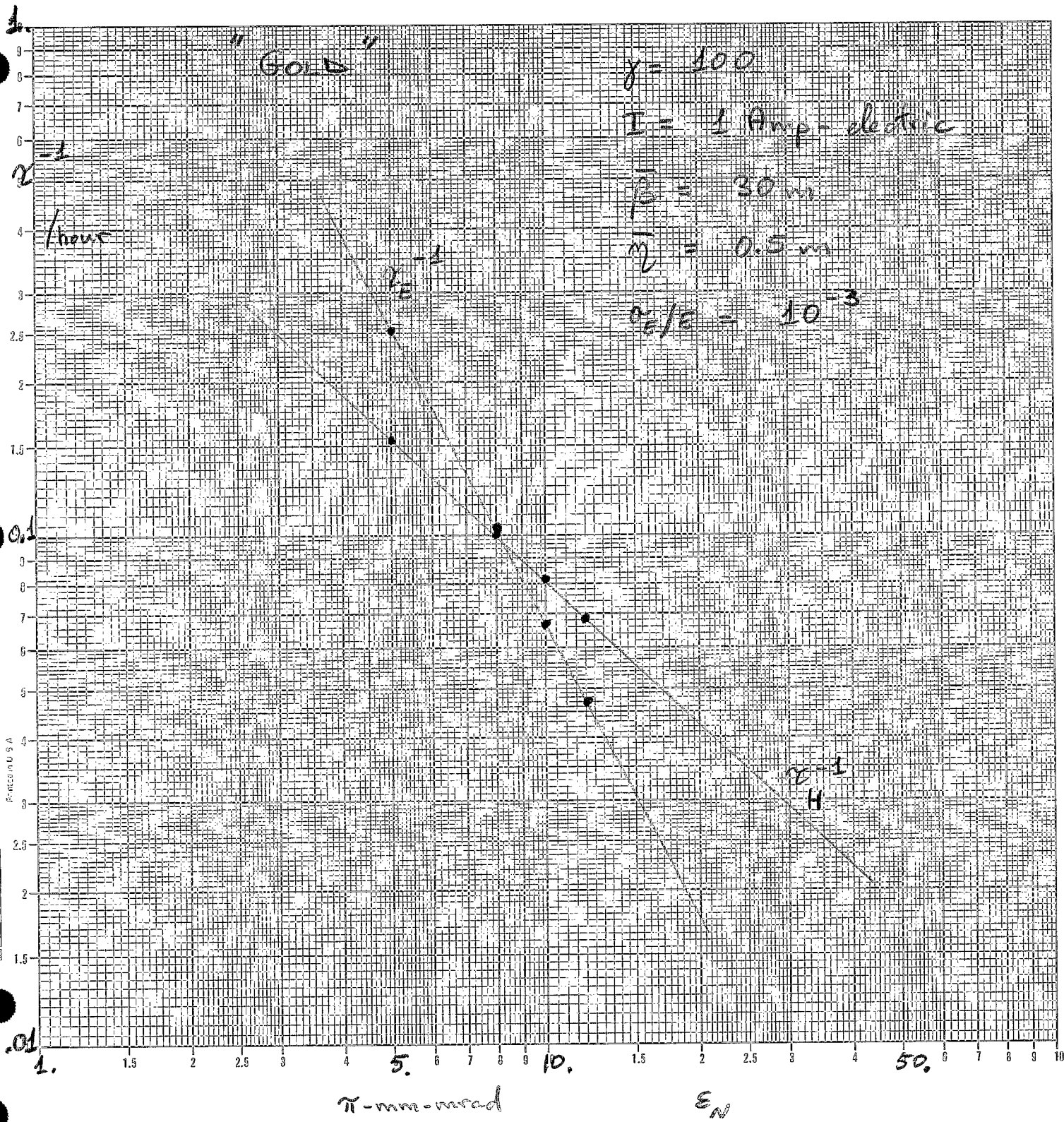
$\bar{\eta} = 0.5 \text{ m}$

$\sigma_s/\epsilon = 10^{-3}$

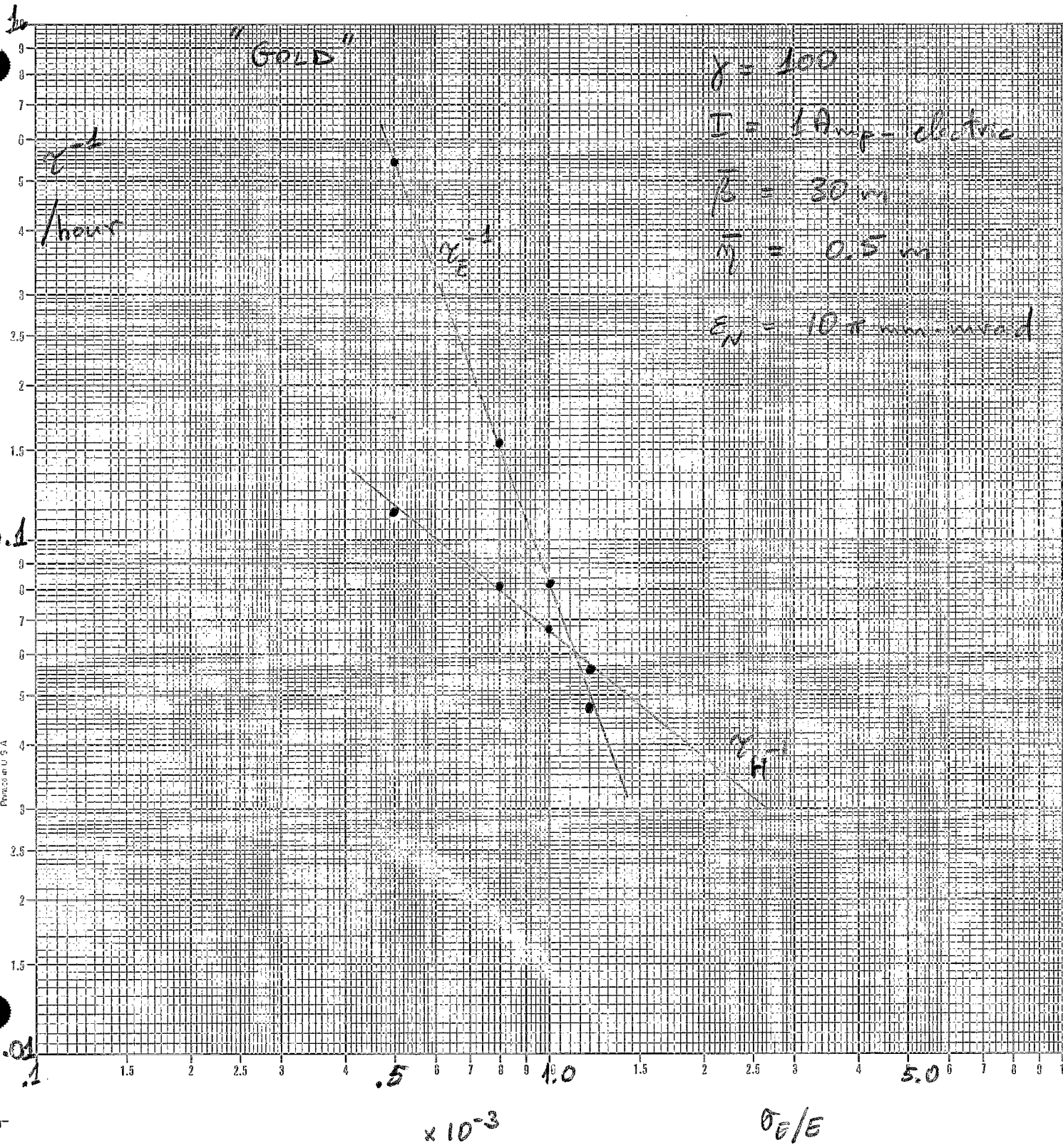
$\tau = 1$   
/hour

$\tau = 1$

$\tau = 1$   
H



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$$\sigma_E/E = 10^{-3}$$

$$E_N = 10 \pi \text{ mm} \cdot \text{mrad}$$

Gold

$$I = 1 \text{ Amp} \cdot \text{electric}$$

$\gamma$	$\chi_E^{-1}$	$\chi_H^{-1}$	$\chi_V^{-1}$
5	-3.7099 $h^{-1}$	12.904 $h^{-1}$	13.0858 $h^{-1}$
10	-0.6270	1.0605	1.1229
12	-0.315	0.4332	0.4709
20	0.0911	-0.0637	-.0818
40	0.1614	-0.0081	-0.0726
60	0.1293	0.0388	-0.0388
80	0.1017	0.0585	-0.0229
100	0.0816	0.0669	-0.0147

Comparison of Diffusion Rates vs.  $\gamma$ -



$$\bar{m} = 0$$

$$\gamma = 100$$

Gold

$$\sigma_E/E = 10^{-3}$$

$$\epsilon_N = 10\pi \text{ mm} \cdot \text{mrad}$$

$$I = 1 \text{ A electric}$$

$\bar{\beta}$		$\tau_E^{-1}$	$\tau_H^{-1}$ ( $= \tau_V^{-1}$ )
1.	m	1.1403 $h^{-1}$	-.0068 $h^{-1}$
2		.7361	-.0088
3		.5624	-.0101
5		.3926	-.0118
70		.0258	-.0108
100		.0123	-.0074
200		-.0028	.0034
300		-.0069	.0125
500		-.0090	.0270
700		-.0091	.0384
1000		-.0087	.0520

# Initial luminosity loss Rates

$$\tau_L^{-1} = \frac{P^2}{f^2} \tau_E^{-1} + \left(2 - \frac{P^2}{f^2}\right) (\tau_H^{-1} + \tau_V^{-1})$$

Gold,  $\gamma = 100$ , # 57,  $I = 1$  Amp-electric

$$\sigma_E/E = 1 \times 10^{-3}$$

$\epsilon_N$	$P = 0.82$	$P = 0$
	$\Downarrow$	$\Downarrow$
	$\tau_L^{-1}$	$\tau_L^{-1}$
5 $\pi$ mm.mrad	.3765 $h^{-1}$	.3938 $h^{-1}$
8	.1691	.1610
10	.1162	.1044
12	.0857	.0728

$$\epsilon_N = 10 \pi \text{ mm.mrad}$$

$\sigma_E/E$	$\tau_L^{-1}$	
	$\tau_L^{-1}$	
0.5 $\times 10^{-3}$	.3561 $h^{-1}$	.1732 $h^{-1}$
0.8	.1635	.1268
1.0	.1162	.1044
1.2	.0889	.0874