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Scenario For The Case Of No RF Stacking

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RHIC-PG-10

SCENARIO FOR THE CASE OF NO RF STACKING

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(BNL, December 5, 1983)

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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 $= \sqrt{1 + \rho^2}$

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

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
γ	107.60
β	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	1.87×10^{9}
Total No. of ions /Ring	1.07×10^{11}
AGS Cycle Time	2.0 sec
Filling Time	2 rings × 2 min

AGS Bunch Area at Transfer	0.1 eV/A-sec
Normalized Emittance, H and V	10. π mm-mrad
Emittance @ 100 GeV/A (95% of beam population)	0.1 π mm-mrad
RF Harmonic Number, h	171
RF Frequency, f_{RF}	13.37 MHz
Transition Energy, γ_T	35
Average Beam Current, particle	1.34 mA
electric	0.106 Amp
Regular Cell, average β-value	30. m
average η-value	0.5 m

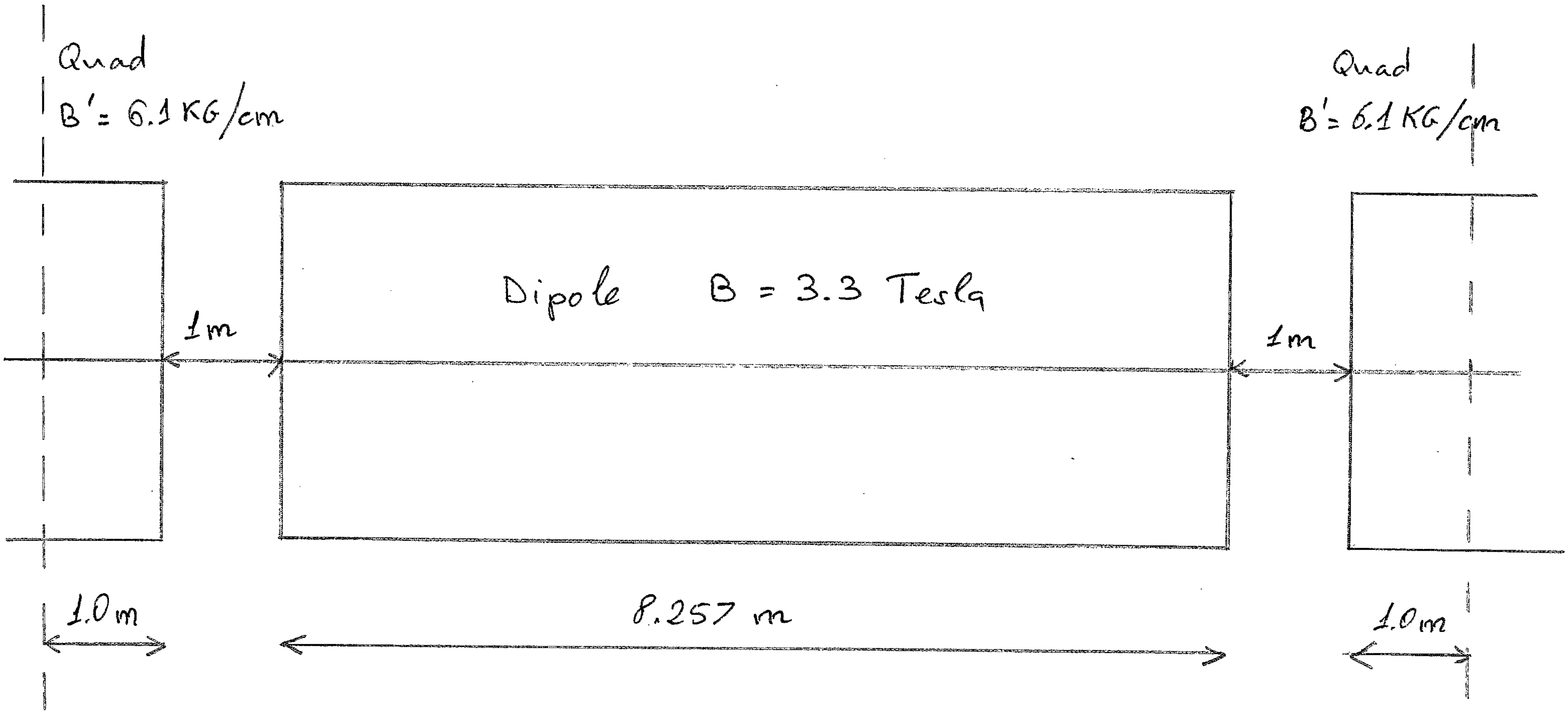
	no special magnet	septum magnet	common magnet
Crossing Angle, α mrad	8.	2.	0.
No. of Bunches/Beam, B	171	171	57
No. of Ions/Bunch, N	6.24×10^{8}	6.24×10^{8}	1.87×10^{9}
Rms Bunch Length, σ_e, cm	15.	15.	90.
Rms Energy Spread, σ_E/E	$1. \times 10^{-3}$	$1. \times 10^{-3}$	$.3 \times 10^{-3}$
Bunch Area, eV/A-sec	0.625	0.625	1.125
RF Voltage, kV	200	200	100
β_V^* m	2.0	2.0	1.0
β_H^* m	32.	2.0	1.0
σ_V^* cm	0.0183	0.0183	0.013
σ_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, $cm^{-2}s^{-1}$	0.25×10^{27}	1.0×10^{27}	0.8×10^{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, 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°
β_{max}	56.6 m
β_{min}	3.4 m
η_{max}	0.722 m
η_{min}	0.278 m
Bending Angle / Half Cell	32.151 mrad
Contribution to β-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, ρ	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 (± 2.5 σ)		Width (± 2.5 σ)	
100 GeV/A	± 2.4	mm	± 3.0 / 4.2	mm
12	6.6		6.8 / 8.4	
5	9.7		9.9 / 11.5	

Circular Vacuum Chamber with i.d. 6.0 cm

Requirement on Good Field Region : @ 5 GeV/A ± 2.5 cm

100 GeV/A ± 1.0 cm

$\sigma_E/E = 10^{-3}$ $\gamma = 100$ Gold

57 $I = 1$ A-electric

ε_N	τ_E^{-1}	τ_H^{-1}	τ_V^{-1}
5 π mm·mrad	.1538 h^{-1}	.2523 h^{-1}	−.0554 h^{-1}
8	.1007	.1032	−.0227
10	.0816	.0669	−.0147
12	.0684	.0467	−.0103

$\varepsilon_N = 10$ π mm·mrad

σ_E/E	τ_E^{-1}	τ_H^{-1}	τ_V^{-1}
0.5×10^{-3}	.5415 h^{-1}	.1110 h^{-1}	−.0244 h^{-1}
0.8	.1547	.0812	−.0178
1.0	.0816	.0669	−.0147
1.2	.0474	.0560	−.0123

Comparison of Diffusion Rates vs. normalized emittance ε_N and rms energy spread σ_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	
τ_E^{-1}	h^{-1}	.0964	.0816	.070	.0607	
τ_H^{-1}	h^{-1}	.1012	.0669	.0453	.0307	
τ_V^{-1}	h^{-1}	-.0145	-.0147	-.0147	-.0146	

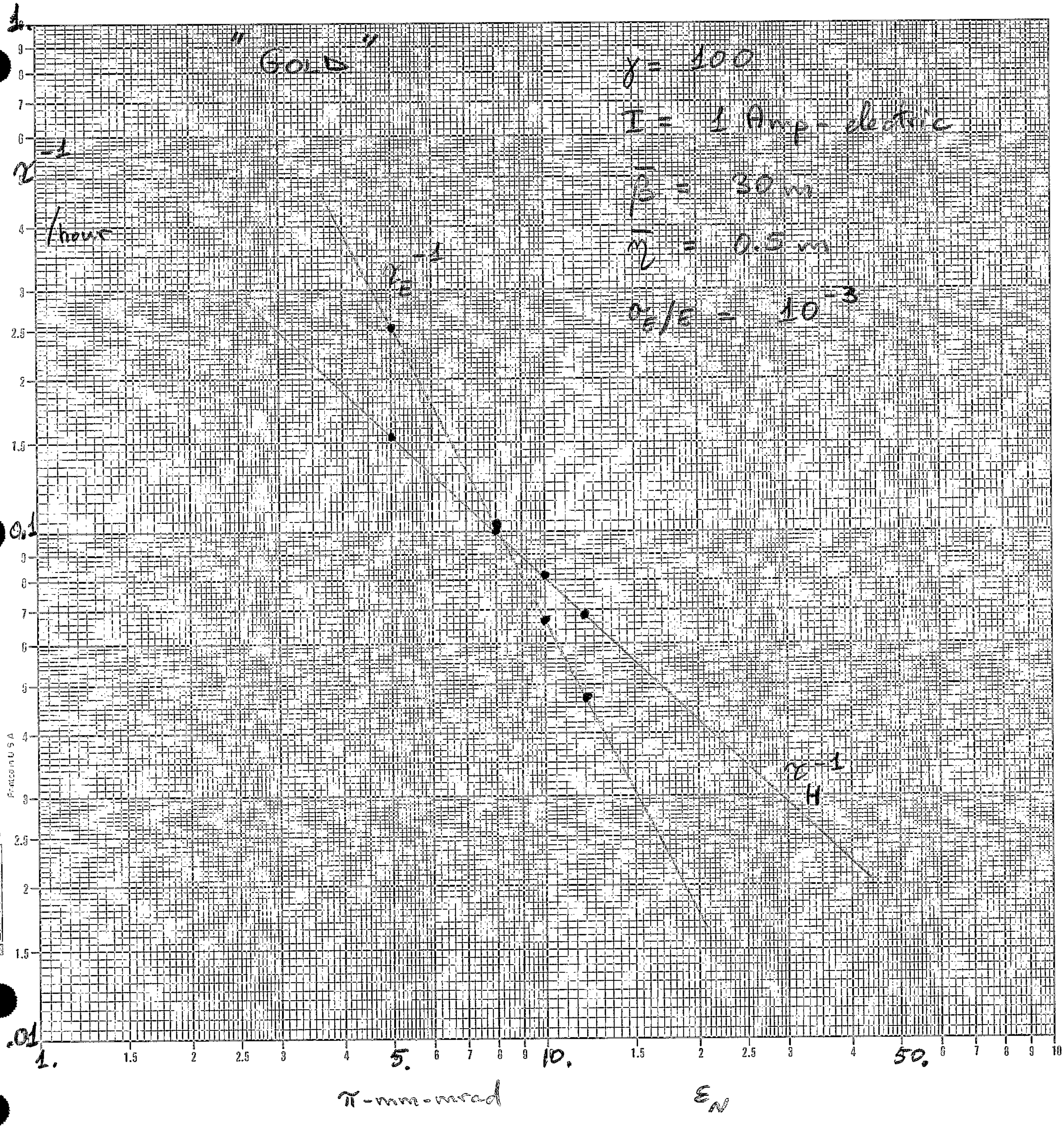
$\bar{\beta}$	m	25	30	35	40	
$\bar{\eta}$	m	1.0	1.0	1.0	1.0	⇐
case #		47	58	69	80	
τ_E^{-1}	h^{-1}	.0837	.0744	.0665	.0596	
τ_H^{-1}	h^{-1}	.3891	.2842	.2139	.1646	
τ_V^{-1}	h^{-1}	-.0126	-.0134	-.0140	-.0143	

$\sigma_E/E = 10^{-3}$ $\gamma = 100$

$\varepsilon_N = 10\pi$ mm. mrad

$I = 1.0$ Amp - electric

Gold


"GOLD"
γ = 100
I = 1 Amp - electric
β̄ = 30 m
η̄ = 0.5 m
σ_E/E = 10^-3
τ^-1 /hour
τ_E^-1
τ_H^-1
1.
0.1
.01
1.
5.
10.
50.
π-mm-mrad
ε_N
GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo, New York
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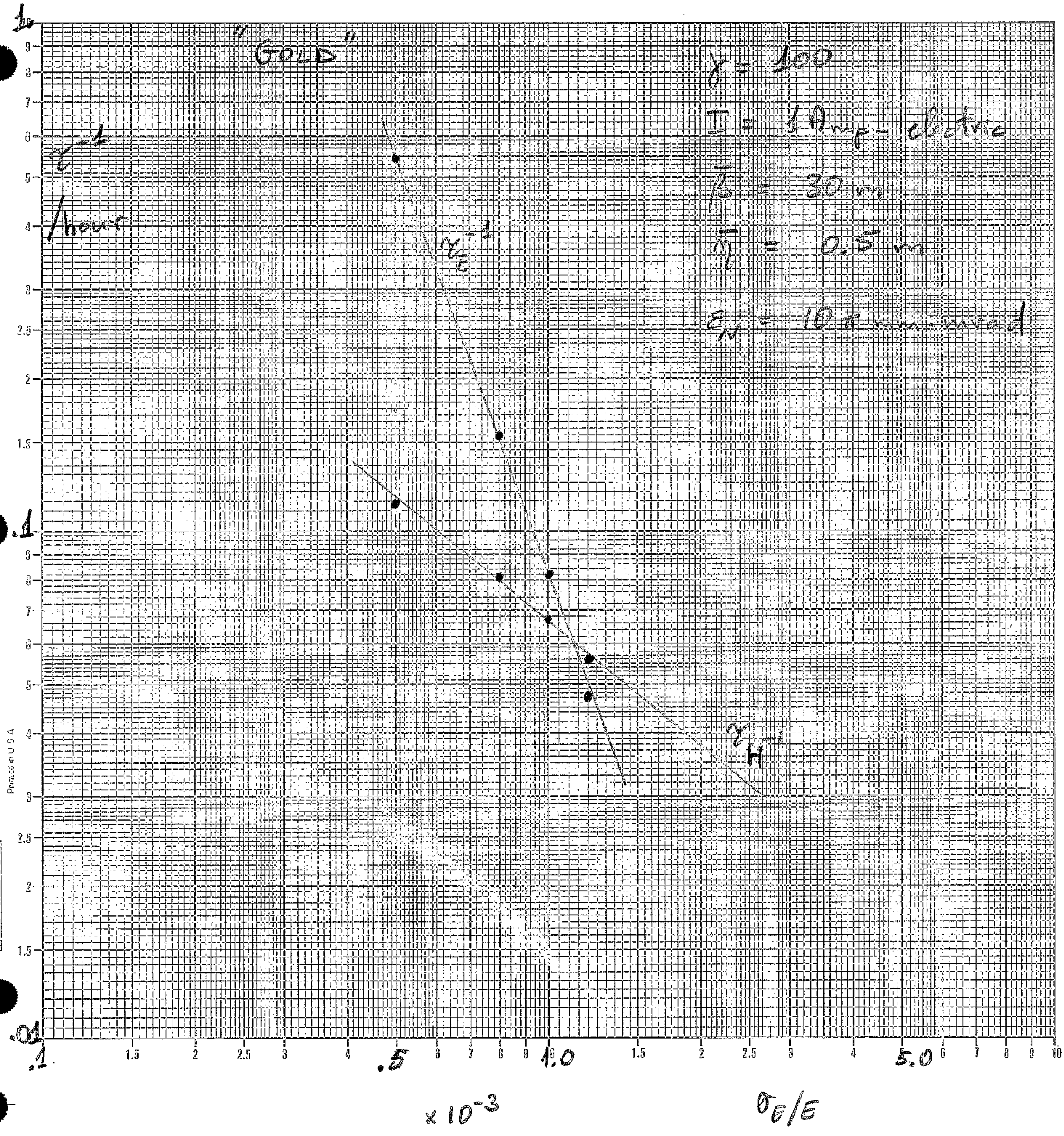
LOGARITHMIC 2 X 2 CYCLES


"GOLD"
γ = 100
I = 1 Amp - electric
β̄ = 30 m
η̄ = 0.5 m
ε_N = 10π mm·mrad
τ⁻¹ /hour
τ_E⁻¹
τ_H⁻¹
.1
.01
.5
1.0
5.0
× 10⁻³
σ_E/E
LOGARITHMIC 2 X 2 CYCLES
GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo, New York
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$\sigma_E/E = 10^{-3}$

$\varepsilon_N = 10\pi$ mm·mrad

Gold

$I = 1$ Amp - electric

γ	τ_E^{-1}	τ_H^{-1}	τ_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. γ -

$\bar{\eta} = 0$ $\gamma = 100$ Gold

$\sigma_E / E = 10^{-3}$ $\varepsilon_N = 10\pi$ mm·mrad $I = 1A$ electric

$\bar{\beta}$	τ_E^{-1}	τ_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

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

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

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

ε_N	$p = 0.82$ ⇓ τ_L^{-1}	$p = 0$ ⇓ τ_L^{-1}
5 π mm·mrad	.3765 h^{-1}	.3938 h^{-1}
8	.1691	.1610
10	.1162	.1044
12	.0857	.0728

$\varepsilon_N = 10\pi$ mm·mrad

σ_E/E	τ_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