AD/RHIC-AP-66

Intrabeam scattering results for a high frequency RF system

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7/6/88

BNL

The results given in this note replace the results given in the previous note, AD/RHIC-AP-63.

Factors Leading to Growth

1) $\frac{1}{\sigma}\frac{d\sigma}{dt} \sim (Q^2/A)^2$

2) $\frac{1}{\sigma}\frac{d\sigma}{dt} \sim N_b$ / 6-dimensional Phase Space

3) Distance from "Equilibrium State"

Invariant, $\sigma_E^2 - 2\sigma_x^2 = \text{Constant}$

$\sigma_E = X_p \sigma_p$

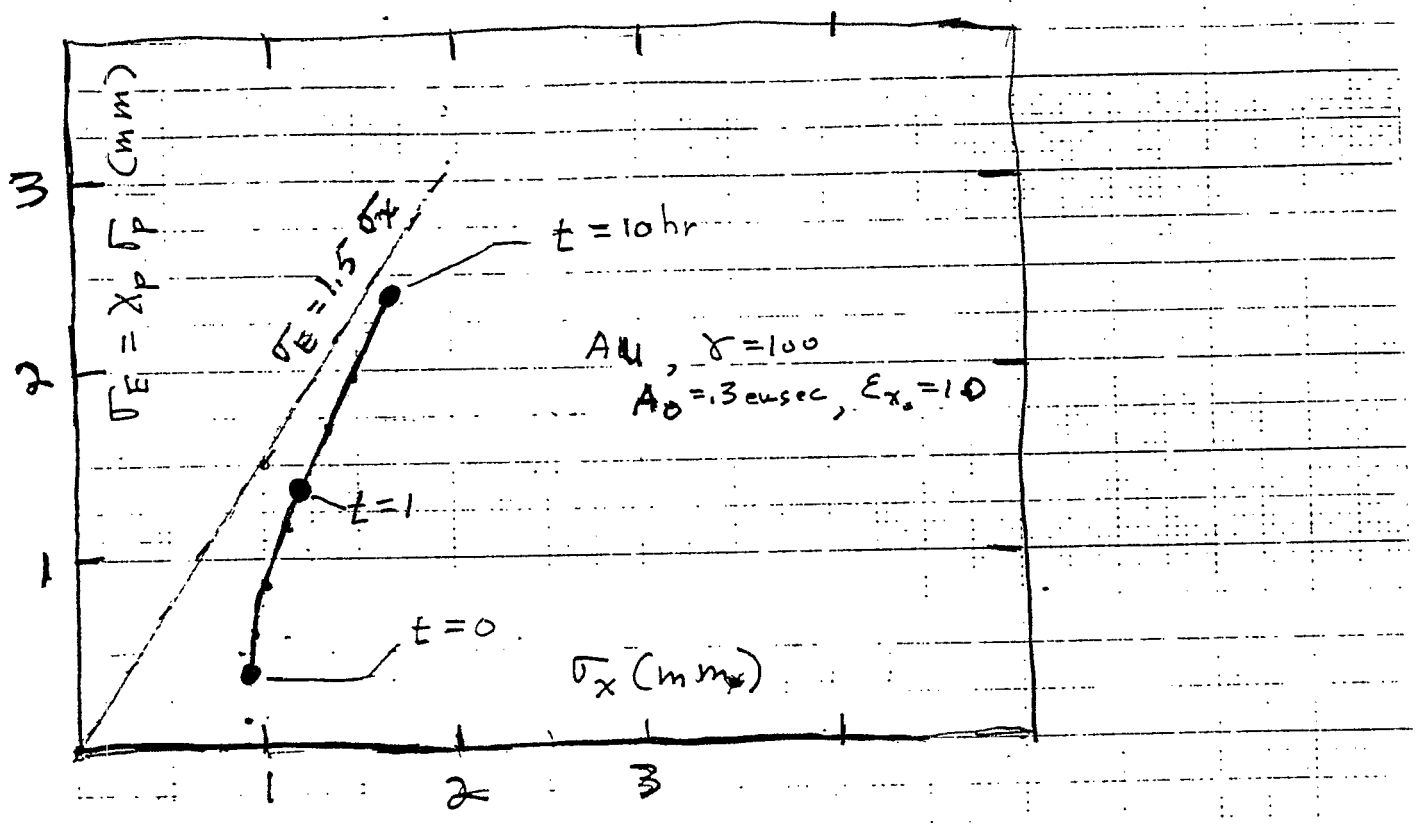
holds for $\gamma > \gamma_t$, cells only lattice

complete coupling, bunched beams

a) $t \to \infty$, $\sigma_E \sim 1.4 \sigma_x$

b) $\frac{1}{\sigma_p}\frac{d\sigma_p}{dt} = 2\left(\frac{\sigma_x}{\sigma_E}\right)^2 \frac{1}{\sigma_x}\frac{d\sigma_x}{dt}$

If $\sigma_E \ll \sigma_x$ at $t=0$, then σ_E will grow much faster than σ_x until $\sigma_E \sim 1.4\,\sigma_x$



Protons may show large growth in σ_E, if $\sigma_E \ll \sigma_x$ at $t = 0$

$$\frac{1}{\sigma_x}\frac{d\sigma_x}{dt} \simeq \boxed{\frac{\sigma_E}{(\sigma_E^2 + \sigma_x^2)^{1/2}}}$$

$$\frac{1}{\sigma_p}\frac{d\sigma_p}{dt} \simeq \boxed{2\,\frac{\sigma_x}{\sigma_E}\,\frac{\sigma_x}{(\sigma_E^2 + \sigma_x^2)^{1/2}}}$$

High Frequency RF system

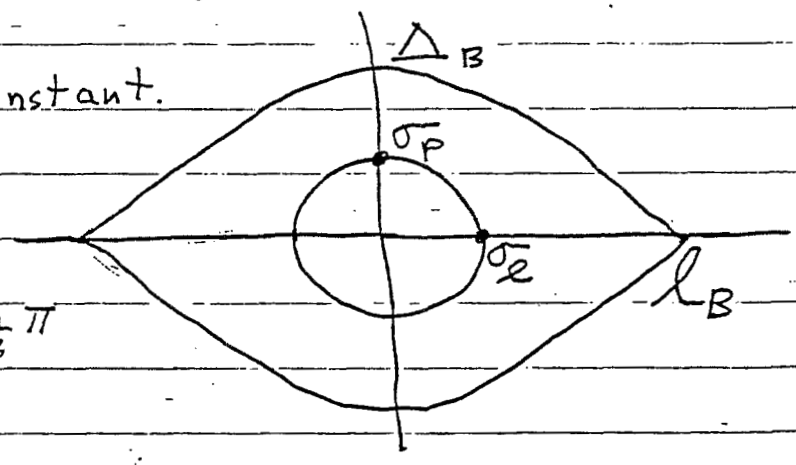
To get shorter σ_ℓ, suggests $f \sim 200$ MHz

New Suggested Procedure

V varied with time so that bucket just contains the bunch, $\Delta_B = 2\sigma_p$ at all times.

For fixed σ_p/Δ_B, σ_ℓ is constant.

$$\frac{\sigma_p}{\Delta_B} = \sin \phi/2$$



For $\Delta_B = 2\sigma_p$, $\phi = 60^\circ = \frac{1}{3}\pi$

$$\sigma_\ell = \frac{1}{3}\ell_B$$

Proposed RF System

$f = 160$ MHz , $h = 2052$

$\sigma_\ell = 31$ cm , $A_0 = .3$ eV-sec

$\Delta_B = 2\sigma_p$

frequency dependence

Initially, $\sigma_\ell \sim 1/f$, $\sigma_p \sim f$, $V \sim f^3$

For final state , $V \sim f^{1.54}$ for one case.

Dependence on $f_B = \Delta_B / \sigma_p$

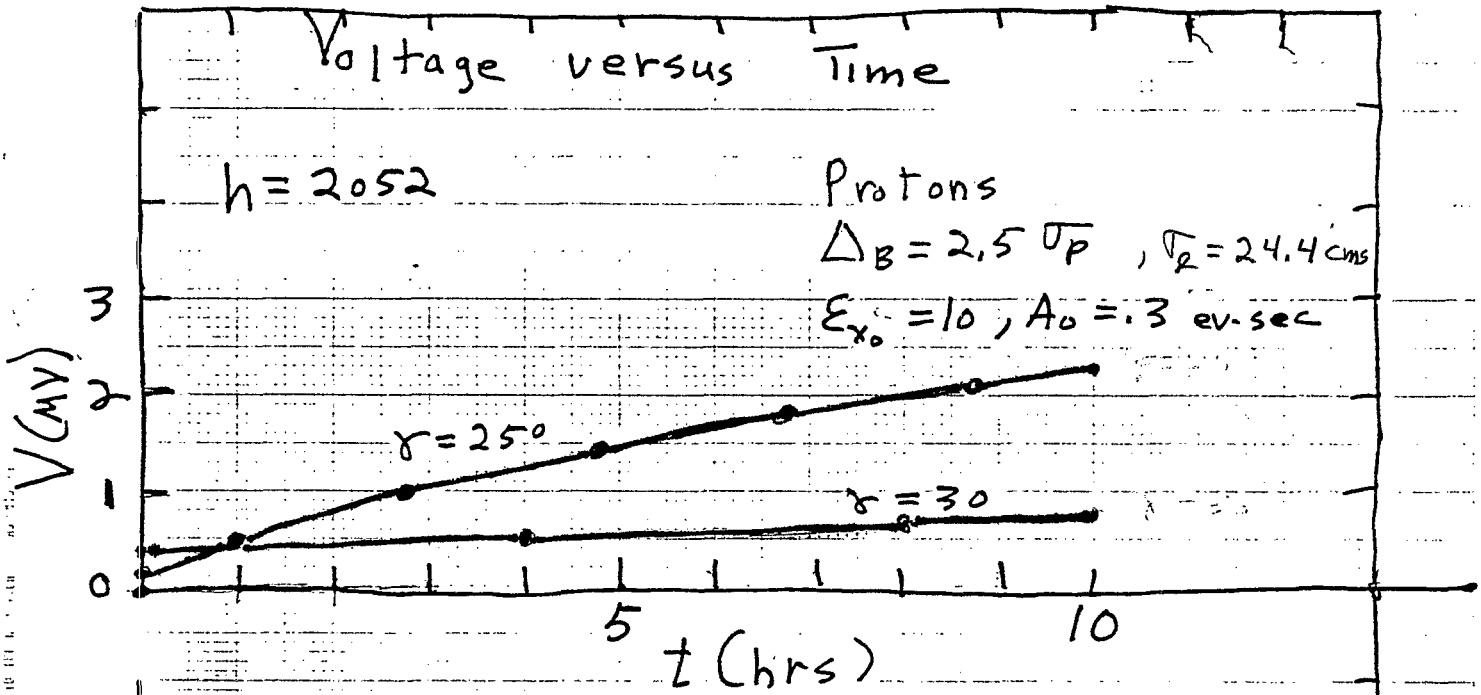
Initially, $\sigma_\ell \sim 1/f_B$, $\sigma_p \sim f_B$, $V \sim f_B^4$

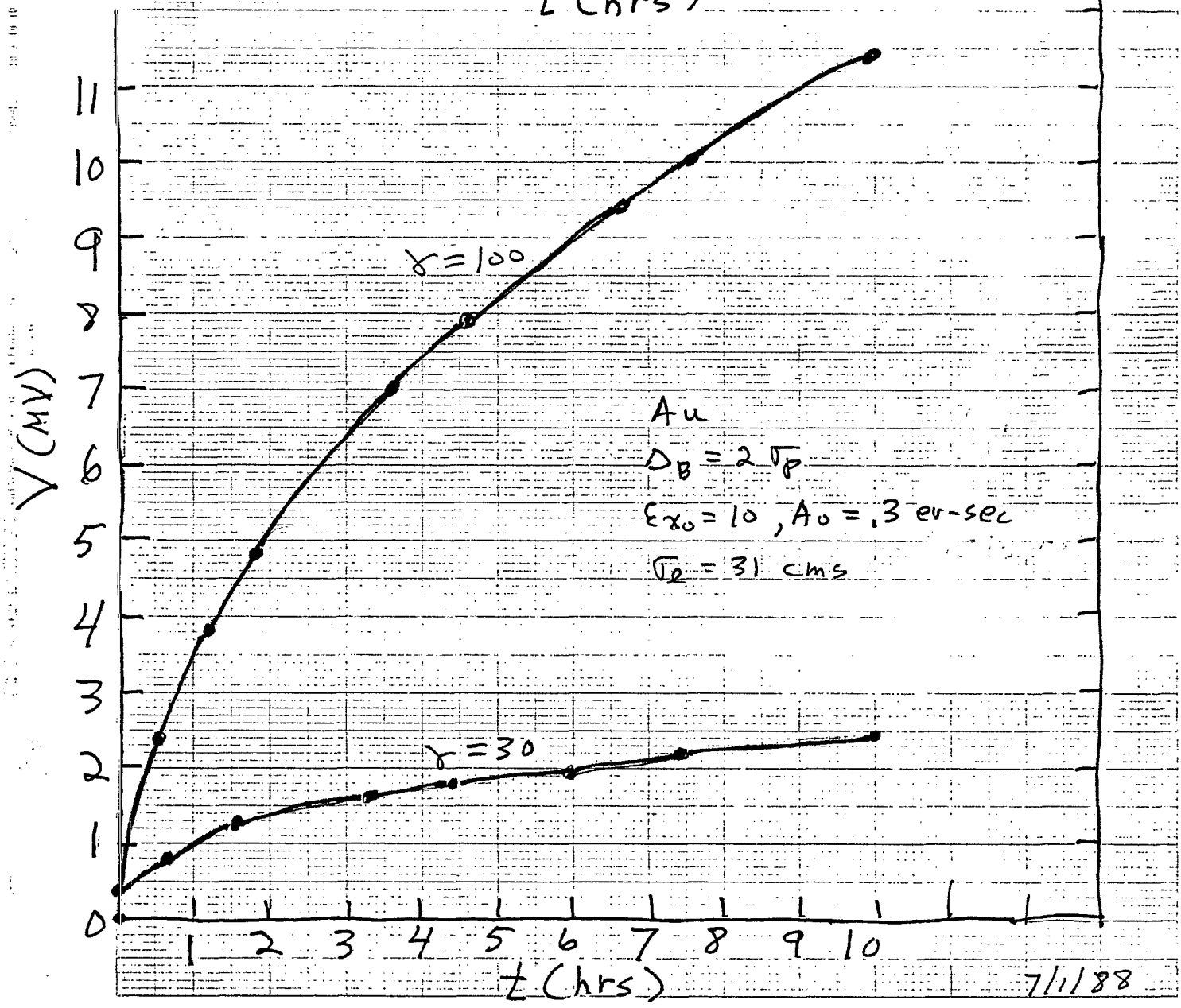
For final state , $V \sim f_B^{2.6}$ for one case.

Intrabeam Scattering Results, 10 hrs – G. Parzen, 6/28/88

	Au, 160 MHz $N_b = 1.1\times10^9$, $\Delta_B = 2\sigma_p$ $h = 2052$, $A = .3$ ev-sec, $\varepsilon_{x_0} = 10$		Au, 214 MHz $N_b = 1.1\times10^9$, $\Delta_B = 2\sigma_p$ $h = 2736$, $A = .3$, $\varepsilon_{x_0} = 10$	
γ	30	100	30	100
σ_{ℓ_0} (cm)	31	31	23.4	23.4
$\sigma_{p_0}/10^{-3}$	.827	.248	1.09	.327
σ_ℓ (cm)	31	31	23.4	23.4
$\sigma_p/10^{-3}$	2.27	1.58	2.42	1.70
σ_x (mm)	3.06	1.69	3.24	1.78
$\varepsilon_x/10^{-6}$	34	34	38	38
V (MV)	2.4	11.4	3.67	17.7
$\Delta p/p = 2\sigma_p/10^{-3}$	4.54	3.16	4.84	3.40
V_0 (MV)	.321	.283	.744	.656

	Au, 160 MHz $N_b = 1.1\times10^9$, $\Delta_B = 2.5\sigma_p$ $h = 2052$, $A = .3$, $\varepsilon_{x_0} = 10$		Protons, 160 MHz $N_b = 1\times10^{11}$, $\Delta_B = 2.5\sigma_p$ $h = 2052$, $A = .3$ $\varepsilon_{x_0} = 10$	
γ	30	100	30	100
σ_{ℓ_0}	24.4	24.4	24.4	24.4
σ_{p_0}	1.05	.315	1.05	.126
σ_ℓ	24.4	24.4	24.4	24.4
σ_p	2.40	1.68	1.53	.545
σ_x	3.21	1.76	2.14	.754
ε_x	37	37	16	17
V	4.22	20.2	.689	2.25
$\Delta p/p$	4.80	3.36	3.06	1.09
V_0	.810	.713	.324	.120


Voltage versus Time
h = 2052
Protons
$\Delta_B = 2.5\,\sigma_p$, $\sigma_\ell = 24.4$ cms
$\varepsilon_{x_0} = 10$, $A_0 = .3$ ev-sec
$\gamma = 25°$
$\gamma = 30$
V (MV)
t (hrs)
0
1
2
3
5
10


$\gamma = 100$
$\gamma = 30$
Au
$\Delta_B = 2\,\sigma_p$
$\varepsilon_{x_0} = 10$, $A_0 = .3$ ev-sec
$\sigma_\ell = 31$ cms
V (MV)
t (hrs)
0
1
2
3
4
5
6
7
8
9
10
11

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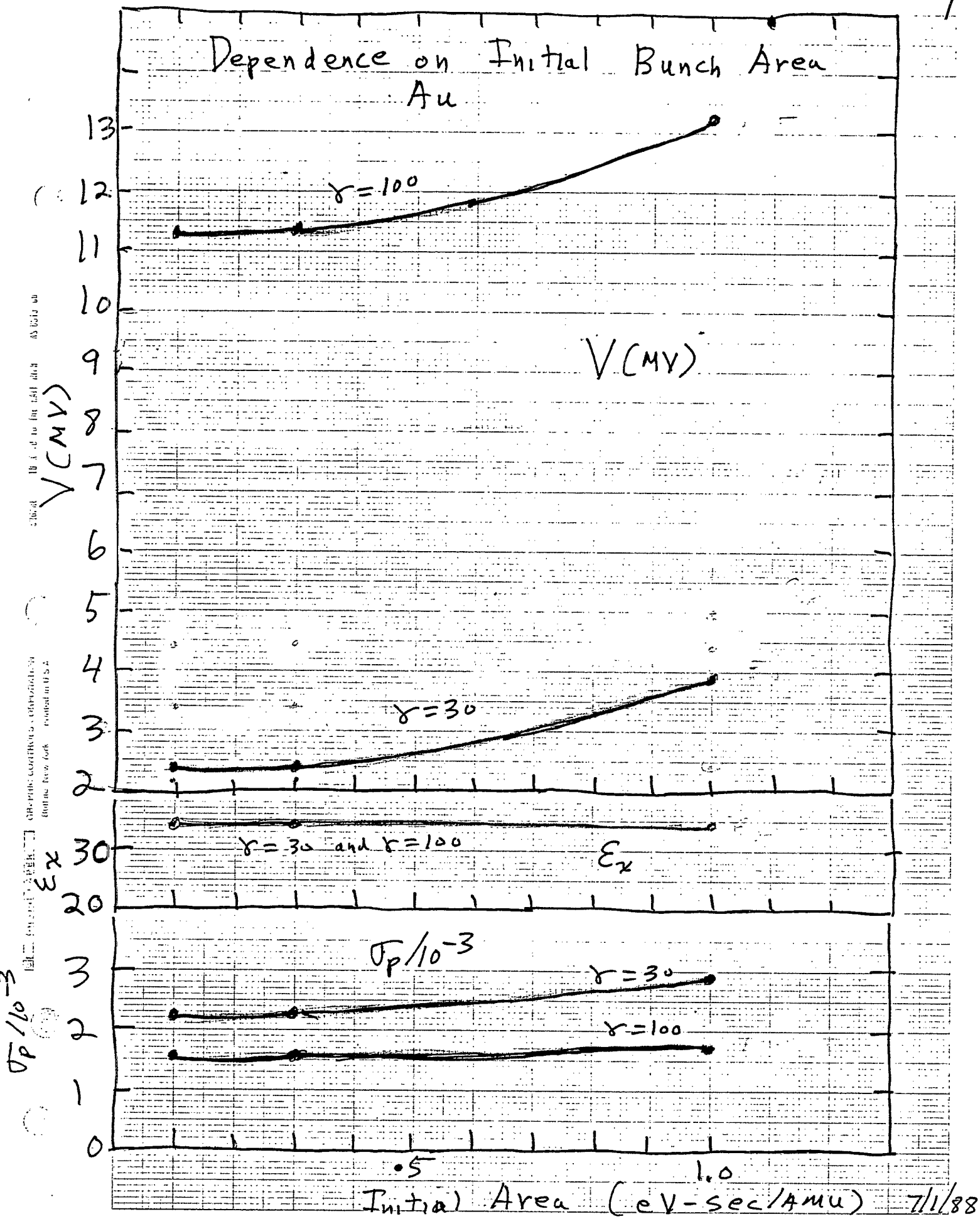
Dependence on Initial Bunch Area
Au
V (MV)
γ = 100
γ = 30
V (MV)
γ = 30 and γ = 100
ε_x
$\sigma_p/10^{-3}$
γ = 30
γ = 100
Initial Area (eV-sec/AMU)
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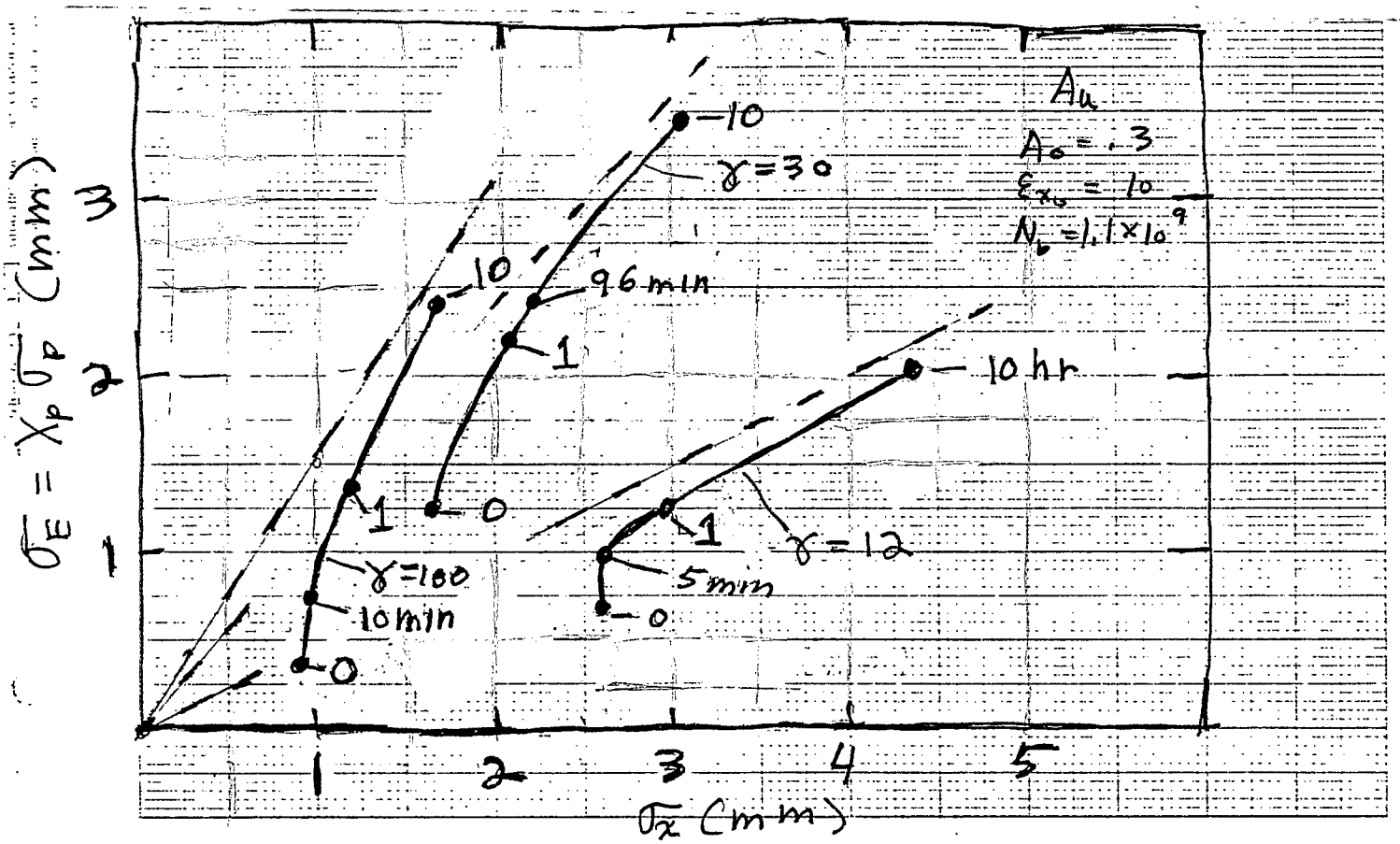
$\sigma_E - \sigma_x$ plots for Gold



Times given in minutes are doubling times for the longitudinal phase space.