PS/AA/CH/afm 20 August 1982

AA LONG TERM NOTE No. 16

Summary of the meeting of August 17, 1982

Present : B. Autin, T. Dorenbos, S.X. Fang, F. Ferger, L. Henny, C. Johnson, C. Metzger, W. Pirkl, G. Nassibian, L. Rinolfi, K.H. Schindl, J.C. Schnuriger, R. Sherwood, C. Taylor, H.H. Umstaetter, E.J.N. Wilson

Topic : Pulsed Target and AC Acceptance.

The copies of the transparencies for this talk are attached. A discussion on the possibilities of the current carrying target, including the effect of proton beam defocusing was presented.

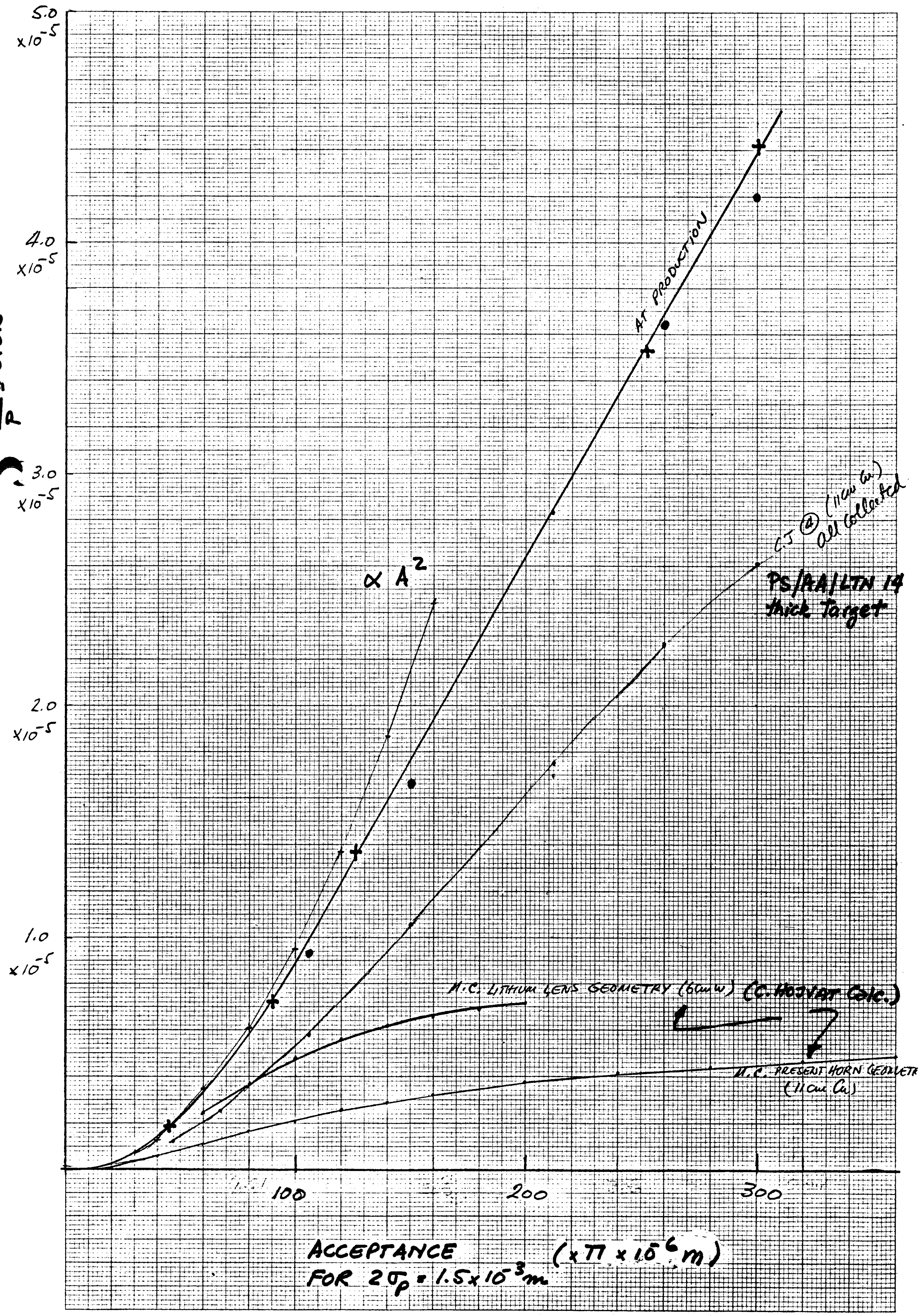
Although more detail calculations on antiproton yields are required it looks that the AC acceptance can be limited to 200π mm.mrad to obtain greater than 10^8 $\bar{p}$/pulse for a total $\Delta p/p$ of 0.06.

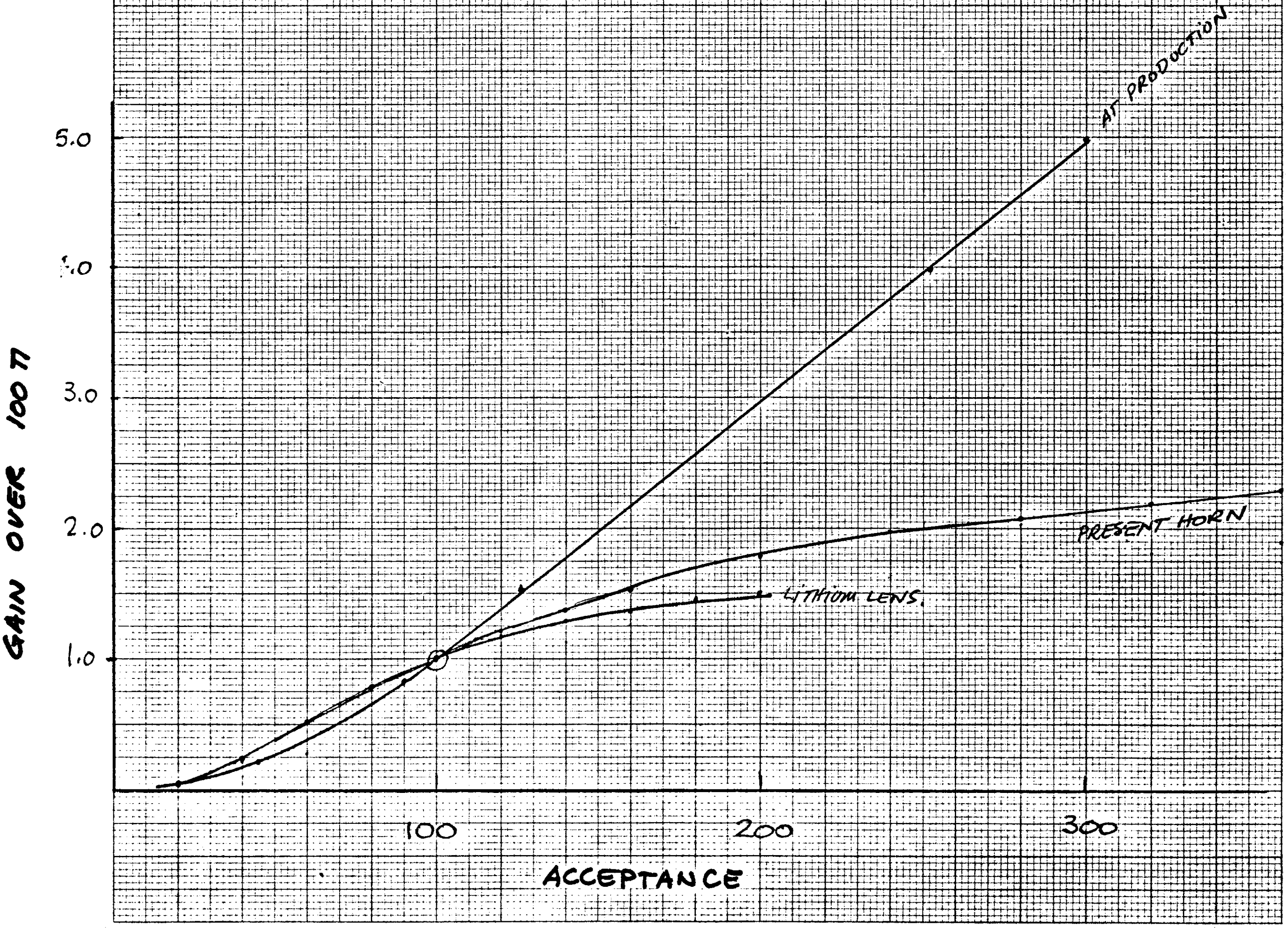
The geometry and magnetic fields for the first conducting target experiment in the AA were also presented.

C. Hojvat

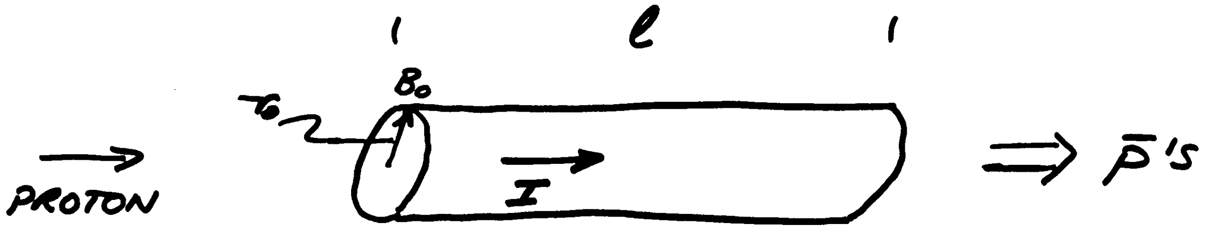
Distribution

PS/2 list


5.0 x10^-5
4.0 x10^-5
3.0 x10^-5
2.0 x10^-5
1.0 x10^-5
p̄ YIELD/INTER. PROTON INTO ΔP/P = 0.015
100
200
300
ACCEPTANCE (x π x 10^-6 m)
FOR 2σ_p = 1.5x10^-3 m
AT PRODUCTION
∝ A^2
C.J @ (11cm ω) all collected
PS/AA/LTN 14 thick Target
M.C. LITHIUM LENS GEOMETRY (6cm ω)
(C. HOJVAT Calc.)
M.C. PRESENT HORN GEOMETR
(11cm ω)


AT PRODUCTION
PRESENT HORN
LITHIUM LENS.
5.0
4.0
3.0
2.0
1.0
GAIN OVER 100 π
100
200
300
ACCEPTANCE

COMMENTS ON PULSED TARGET



current density

J(in general J(r)) due to skin effect

For the case J = cte $\quad B(r) = \mu_0 \frac{r}{2} J \,, \; g = \frac{\mu_0}{2} J$

Like a quadrupole for both planes (x, y)

① For $\bar{p}$'s (FOCUSING CASE)

$$M(A|B) : \begin{pmatrix} \cos\mathcal{L} & \frac{1}{\sqrt{K}} \sin\mathcal{L} \\ -\sqrt{K}\sin\mathcal{L} & \cos\mathcal{L} \end{pmatrix} \Rightarrow \begin{cases} \beta = \beta_0 \cos^2\mathcal{L} + \frac{1}{K\beta_0} \sin^2\mathcal{L} \\ \alpha = \left(\sqrt{K}\beta_0 - \frac{1}{\sqrt{K}\beta_0}\right) \sin\mathcal{L}\,\mathrm{co} \end{cases}$$

where:

(Around a weist β_0, $\alpha = 0$)

$$\mathcal{L} = l\sqrt{K}$$

$$K = 0.31952 \frac{g}{\beta\gamma} \quad (\text{protns}/\bar{p})$$

1 period:

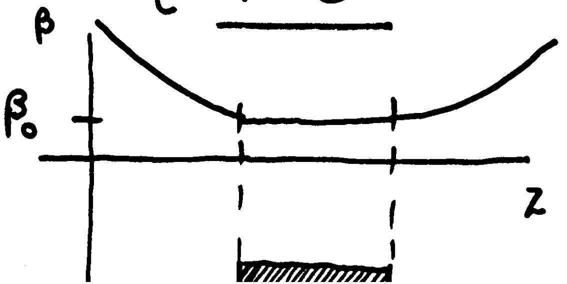
$\mathcal{L} = 2\pi$

$l\sqrt{K} = 2\pi$

$l = 2\pi/\sqrt{K}$

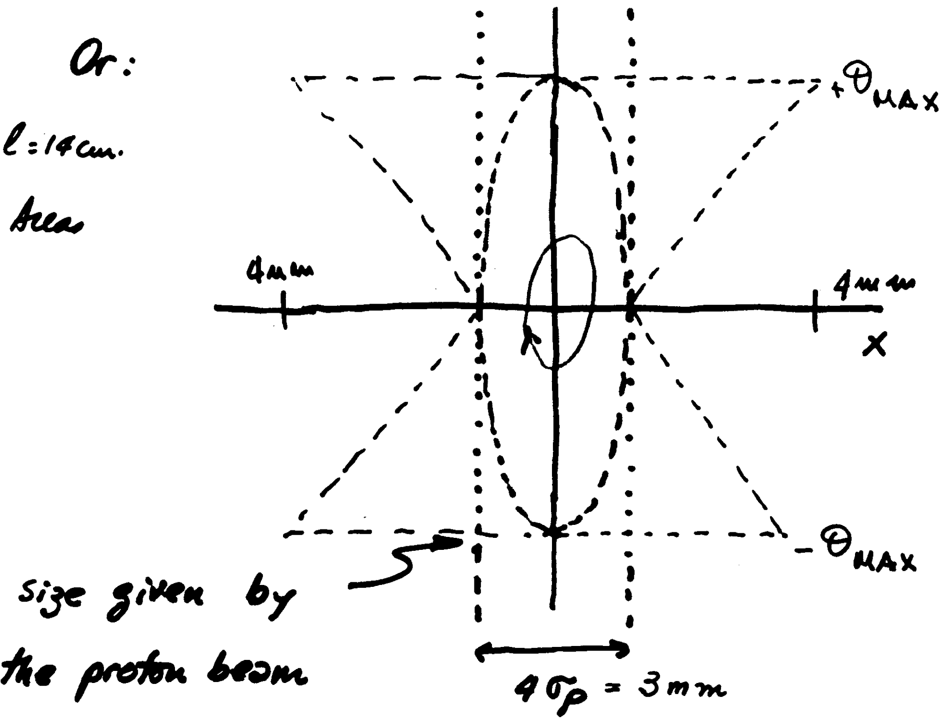
FOR $\boxed{\sqrt{K} = \frac{1}{\beta_0}}$ then

$$\begin{cases} \underline{\beta = \beta_0} \\ \underline{\alpha = 0} \end{cases}$$ throughat the target



Or:

@ 100π l : 14cm.
Ratio of Areas
2.5



σ_p AS SMALL AS COMPATIBLE WITH BEAM INTENSITY

In order not to dilute, then:

$$2\sigma_p = \sqrt{\beta_0 \epsilon_{\bar{p}}} \Rightarrow \boxed{\beta_0 = \frac{(2\sigma_p)^2}{\epsilon_{\bar{p}}}}$$

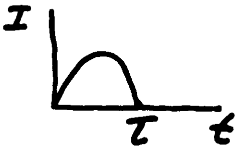
$\boxed{\text{Assume } 2\times\sigma_p = 1.5\times10^{-3} m}$ 3.575 GeV/c $r_{Tgt} = 2\sigma_p = 1.5\times10^{-3} m$

$\epsilon_p = 2\sigma_p \theta_{MAX}$

	$\epsilon_{\bar{p}}$ $\times\pi 10^{-6}$ m	θ_{MAX} mrad	β_0 m	$\sqrt{K}$ m^{-1}	g T/m	J kA/cm^2	I kA
	50	33.3	0.045	22.22	5887	937	66
14cm oal period	100	66.6	0.0225	44.44	23548	3.75×10^3	265
							300
	150	100	0.0150	66.67	53000	8.4×10^3	596
	200	133	0.0113	88.89	94210	15×10^3	1060
	250	166	9×10^{-3}	111.11	147.2 k	23×10^3	1657
	300	200	7.5×10^{-3}	133.33	212 k	34×10^3	2385

e.g. ENTHALPY CONTENT of Cu (500°C) ø 3mm 11 cm long ~ 1700 JOULES

FOR $\frac{\delta}{r} = 0.64$ (or J ~ cte)



τ = 36 μs

$\boxed{500°C\ I_{MAX} = 300\ kA}$

BEAM ~ 1.25 kW ~ 3000 Joules

② FOR PROTONS (DEFOCUSING CASE)

$$M(A|B) = \begin{pmatrix} \cosh \ell & \frac{1}{\sqrt{k}} \sinh \ell \\ \sqrt{k} \sinh \ell & \cosh \ell \end{pmatrix} \Rightarrow \begin{cases} \beta = \beta_0 \cosh^2 \ell + \frac{1}{k\beta_0} \sinh^2 \ell \\ \alpha = -\left(\sqrt{k}\beta_0 + \frac{1}{\sqrt{k}\beta_0}\right) \sinh \ell \cosh \ell \end{cases}$$

(around a waist β_0 $\alpha = 0$)

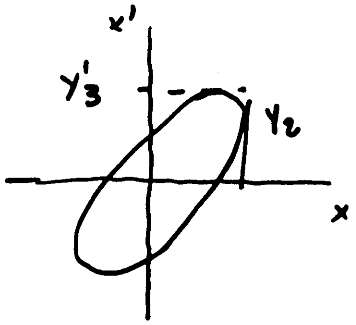
now $\sqrt{k}$ is for the same gradient g as for $\bar{p}$ but for the proton energy:

eg $\sqrt{K} = 44.44$ $\therefore$ $\sqrt{k} = 16.21$

For a waist at the Target centre then at a distance d away: $\beta_0 = (1.5\times10^{-3})^2 / 2.5\times10^{-6} = 0.915$ m

CASE OF $\epsilon_{\bar{p}}$ 100π

d m	β m	α	y_2	$y'_3 = \sqrt{\epsilon\gamma}$ radians
− 0.07	2.7	+ 35.7	2.6×10^{-3}	0.022
− 0.06	2.1	+ 25.5	2.3×10^{-3}	0.018
− 0.04	1.4	+ 12.6		0.0108
− 0.02	1.0	+ 5.2		0.0.052
+ 0.02	1.0	− 5.2		
+ 0.04	1.4	− 12.6		
+ 0.06	2.1	− 25.5		
+ 0.07	2.7	− 35.7		
0.0	0.92	0		0.0105



VERY STRONG DEFOCUSING EFFECT

→ LIMITS THE "EFFECTIVE" TGT LENGTH

→ REQUIRES MORE THAN CONVENT. FOCUSING

The production length (effective) due to the change in size of the proton beam is given by:

$$L_{prod} = \int \frac{\beta_0}{\beta} \, dl$$

$$L_p = \int \frac{\beta_0}{\beta_0 \cosh^2 \mathcal{L} + \frac{1}{k\beta_0} \sinh^2 \mathcal{L}} \, dl$$

$$L_p = \int_{-\frac{L}{2}}^{\frac{L}{2}} \frac{1}{\cosh^2 \mathcal{L} + \frac{1}{k\beta_0^2} \sinh^2 \mathcal{L}} \, dl$$

from L.C. Teng note:

$$L_p = 2\beta_0 \tan^{-1}\left(\frac{1}{\beta_0 \sqrt{k}} \tanh \frac{\mathcal{L}}{2}\right)$$

For case above: (where β_0, k are for 26 Gev protons)

$l = 0.14$

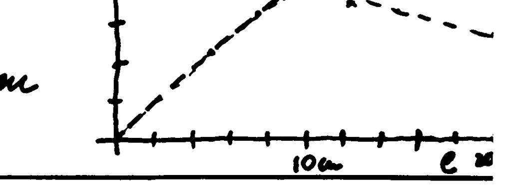
$\beta_0 = 0.915$ m

$\sqrt{k} = 16.21$

$\mathcal{L} = 0.14\text{m} \cdot \sqrt{k}$

$L_p = 0.10$ m (NOT TOO BAD)!

For l very large ($\int_{-\infty}^{+\infty}$) $L_p = 0.123$ m



CONCLUSIONS FOR 100π CASE

① IT LOOKS PROMISING

② GAIN: SAME # OF $\bar{p}$'S CONTAINED IN A ELLIPSE AT TGT EXIT
(NOW ALL SUFFER ABSORPTION IN TARGET)

③ PROTON FOCUSING NEEDS TO BE LOOKED AT

PULSED TARGET:

LOWER POWER DISSIPATED AND TRADE $\bar{P}$ FOCUSING WITH P DEFOCUSING.

① Lower Corrent below $\sqrt{K} = \frac{1}{\beta}$ (L. Teng for FNAL)

② Lower skin depts by reducing pulse length or ρ

③ Utilize $\frac{1}{r}$ field outside target (R.S/E.J.)

POWER IN TARGET:

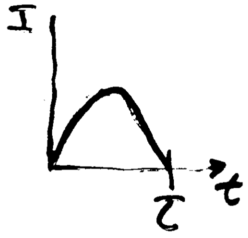
$J = cte$

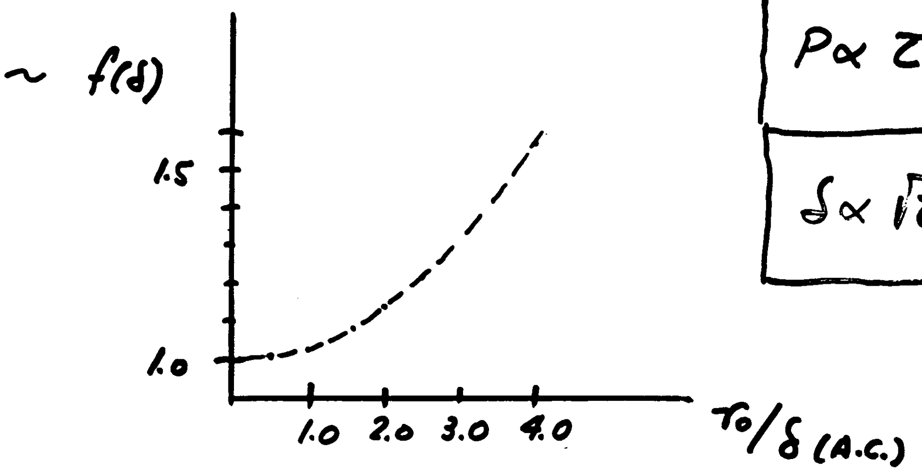
$$P = \frac{4\pi\rho\ell}{\mu_0^2} B_0^2 \underset{\uparrow\ \text{Skin effect}}{f(\delta)}$$

$\boxed{P \propto B_0^2}$

$\boxed{P \propto \tau}$

$\boxed{\delta \propto \sqrt{\tau}}$ $\boxed{\delta \propto \sqrt{\rho}}$





① and ③ Lower P

② Increases P (depending on choice of τ or ρ)

SAME IS TRUE FOR LITHIUM LENS

LIMITS: 1.- MAGNETIC FORCES

2.- POWER DISSIPATED

INCOMPLETE   YIELD OF ANTIPROTONS

IN $\frac{\Delta p}{p} = 0.015$

FOR 1×10^{13} incident protons.

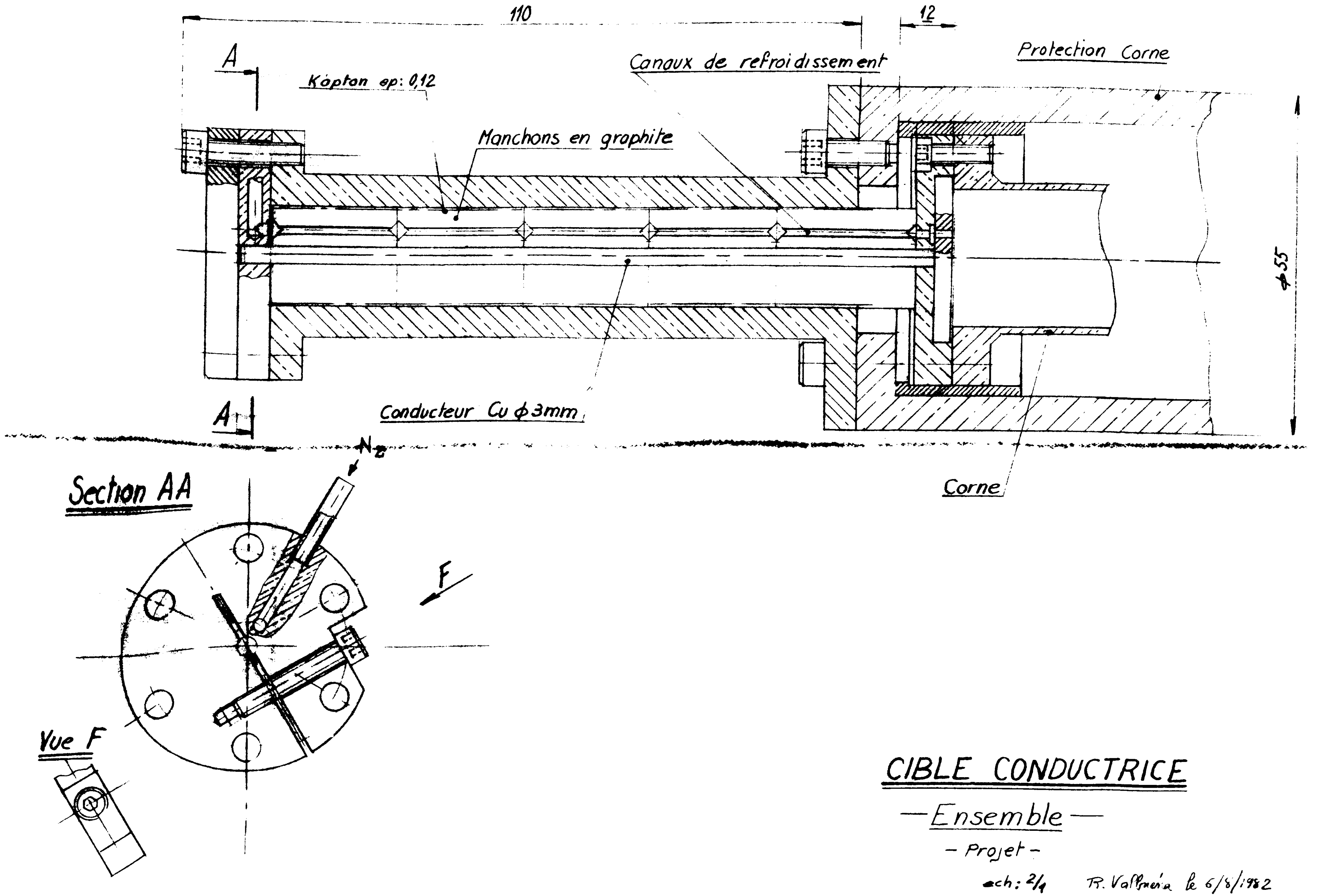
?

$\epsilon_{\bar{p}}$ $\pi\,10^{-6}\,m$	Relative at Production	Present Horn CH/AVG	Proposed Li Lens 1cm 1000T/m	Pulsed Target + Collector
100	1.0	1.4×10^{7} 1.0	2.2×10^{7} 1.0	E.J/R.S. HORN 3.2×10^{7} ~ Li Lens 5.0×10^{7}
200	3.0	2.5×10^{7} 1.8	3.3×10^{7} 1.5	?
300	5.0	3.0×10^{7} 2.1	4.0×10^{7} 1.8	?

WITH PLANNED $\frac{\Delta p}{p} = 0.06$ (× 4 bigger than table)

10^{8} $\bar{p}$/pulse can be achieved

with $\frac{\Delta p}{p} = 0.06$ and $\epsilon_{\bar{p}} \leq 200\pi$



CIBLE CONDUCTRICE

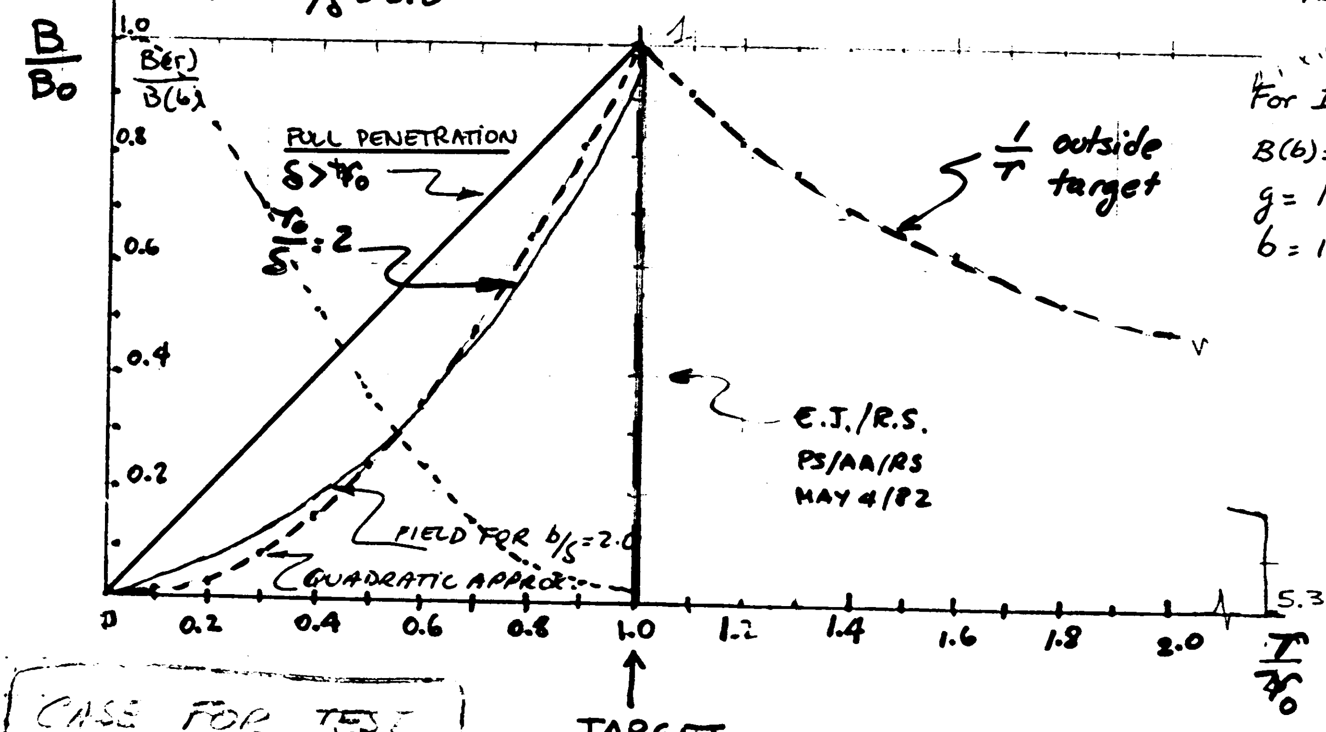
— Ensemble —

– Projet –

ech: 2/1 R. Vallmeria le 6/8/1982

approximated by

CASE $b/\delta = 2.0$



E.J./R.S.
PS/AA/RS
MAY 4/82

$r > b$

For $I = 170$ kA

$B(b) = 22.67$ T

$g = 15111$ T/m

$b = 1.5 \times 10^{-3}$ m

$b = 1.5$m

5.3 (8mm) !

$B = 0$

CASE FOR TEST
GRID TARGET