

# *Trapped* Non-Physics uses of Stopped Pbars

Portable trap

Antiproton therapy

➔Brings in outside money

➔Good public relations

– (politically helpful)

# Fermilab Physics with <sup>Trapped</sup> Stopped Pbars

Antimatter gravity

Pbar magnetic moment

Spectroscopy

- Hyperfine splitting

- First order in CPT violating terms
- Does not require trapping antihydrogen

➔ Uses Fermilab's intensity advantage

- Would benefit from deceleration ring, but not essential

➔ Does not compete directly with CERN

# MACHINE CONSIDERATIONS

Inventory  
Extraction Energy  
Supercycle

$2 \times 10^{12} \bar{p}'s$   
 $< 2 \text{ GeV}/c$   
210 sec

$\Rightarrow$  Extract  $2 \times 10^{10} \bar{p}'s$  every 210, 420, ... sec

Degrade to 0... 50 keV using Osmium

from 1 GeV/c:

$2.8 \times 10^5 \bar{p}'s$

Range:

10 cm

Yield:

$1.4 \times 10^{-5}$

$\phi$

:

2.4 cm

from 2 GeV/c

$9.8 \times 10^3 \bar{p}'s$

Range:

34.1 cm

Yield:

$4.9 \times 10^{-7}$

$\phi$

:

11.0 cm

$\Rightarrow$  Feasible to start up program if  
beam is decelerated to  $\sim 1 \text{ GeV}/c$

## Medium Term:

Add Energy analyzer and wedge  
Degrador to enhance # of  $\bar{p}$ 's  
by 2(-3) orders of magnitude

$$\Rightarrow 10^6 \bar{p}'s @ 2 \text{ GeV}/c$$

$$5 \cdot 10^7 \bar{p}'s @ 1 \text{ GeV}/c$$


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## Long Term:

Use small ring @ 100 MeV/c  
with  $2 \times 10^{10}$  (or more)  $\bar{p}$ 's in 20 ns

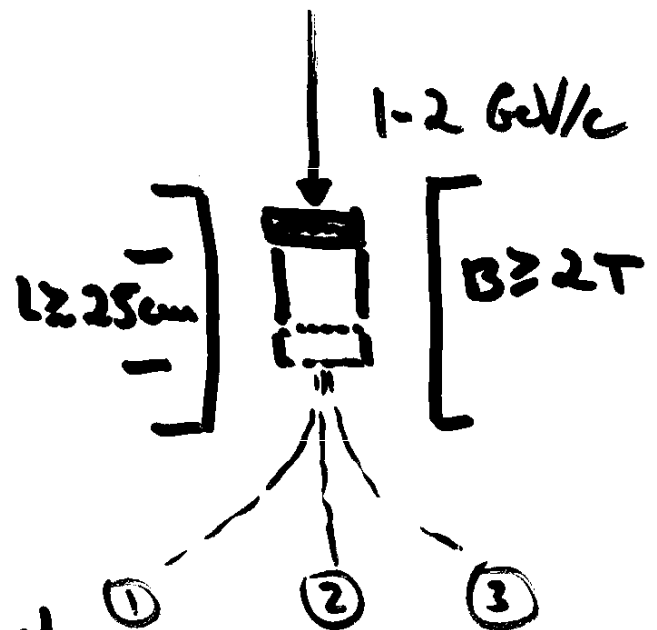
$$\epsilon = 3\% \Rightarrow 6 \times 10^8 \bar{p}'s \text{ trapped} \\ \text{from single extraction}$$


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Note: In All Cases: Possible to  
Stack multiple bunches if  
Reprate  $< \frac{1}{T_{e-cool}}$   
Lifetime  $> N \times \text{Time interval}$

## I. CAPTURE TRAP

10 cm Osmium,  $V = 50 \text{ keV}$   
 $e^-$  cool in 3 minutes  
 may be Room Temperature  
 and permanent Magnets



## II. Extract cooled $\bar{p}$ 's

①  $M_P / \bar{M}_P$  : Vertical SC Magnet  
 2 Tesla, SC Vacuum  
 Need small #  $\bar{p}$ 's  
 $e^-$  cooling

②  $M_H / M_{\bar{H}}$  : Horizontal SC Magnet  
 2-6 Tesla, EH Vacuum  
 $e^+$  accumulator  
 $e^-$  cooling

⇒ produce  $\bar{H}$  beam ⇒ Also HFS measurement

③ Portable Trap / Test beam line

Issues: Extraction optics, transfer,  
 Vacuum (life time) if non-cryogenic  
 $e^-$  cooling for dense bunches  
 Stacking (lifetime & Vacuum)