Antiproton Summary

Daniel M. Kaplan

2nd Project X Physics Workshop
Fermilab
Jan. 26, 2008
2nd Project X Physics Workshop: Antiproton Parallel Session

Jan. 25, 2008, 10:30 am - 3:30 pm

Video connection will be via ES-NET. Passcode will be:

88pbar (or 887227).

If you are connecting by phone, dial 1.510.883.7860 and use the passcode 88pbar followed by the pound sign.
If prompted for a second passcode, dial the pound sign.

List of Talks:

Keith Gollwitzer, FNAL Review of E835
Dan Kaplan, IIT Reprise of Antiproton Summary Talk from 1st Project X Workshop
Ted Barnes, ORNL/U. Tenn. pbar-p and Charmonium
Paolo Lenisa, Ferrara Polarization Physics
Frank Rathmann, Juelich Towards Polarized Antiprotons
Gerry Jackson, Hbar Technologies Non-Particle Physics Applications of Antimatter
All Discussion of strategic experimental plan and R&D plan
Dan Kaplan, IIT Preview/discussion of Antiproton Summary Talk for this workshop

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pbar Physics Overview
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- Search for new physics in
  - hyperon $CP$ & rare decays
  - charm mixing & $CP$
pbar Physics Overview

- Search for new physics in
  - hyperon $\mathcal{CP}$ & rare decays
  - charm mixing & $\mathcal{CP}$
- Charmonium – test of QCD
  - improved understanding of (nonperturbative) QCD
    important for interpreting above (and other) physics
pbar Physics Overview

- Search for new physics in
  - hyperon $C\bar{P}$ & rare decays
  - charm mixing & $C\bar{P}$

- Charmonium – test of QCD
  - improved understanding of (nonperturbative) OCD
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- New charmonium-region states ($X, Y, Z...$)
  - glimpsing one or more new forms of matter?
pbar Physics Overview

- Search for new physics in
  - hyperon $CP$ & rare decays
  - charm mixing & $CP$
- Charmonium – test of QCD
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- New charmonium-region states ($X, Y, Z...$)
  ▶ glimpsing one or more new forms of matter?
- Antihydrogen: $CPT$ & antimatter-gravity tests
Charmonium Highlights

- $\bar{p}p$ forms all $J^{PC}$ (unlike $e^+e^-$) $\Rightarrow$ good for singlet states

- Superb precision of antiproton beam energy (100 keV) and momentum spread:
  - E760/835 @ FNAL AA made very precise measurements of charmonium parameters
  - best measurements of $\eta_c$, $\chi_c$, $h_c$ masses, widths, branching ratios,...
  - interference of continuum & resonance signals

- Still more to do!
  - e.g., improve $\eta_c$, $h_c$, and $\eta'_c$ mass and width
New States

- Much interest lately in new states observed in charmonium region

- \( X(3872) \) of particular interest b/c may be the first meson-meson (\( D^0 \bar{D}^{*0} + \text{c.c.} \)) molecule
New States

• Much interest lately in new states observed in charmonium region

• $X(3872)$ of particular interest b/c may be the first meson-meson ($D^0 \bar{D}^{*0} + \text{c.c.}$) molecule

  ➡ need very precise mass & width measurements to confirm or refute

  ➡ $p\bar{p} \rightarrow X(3872)$ formation *ideal* for this
Antihydrogen

• CPT tests:
  - making antihydrogen in traps is big ongoing R&D effort at CERN AD (ATRAP, ATHENA, ALPHA)
  - cf. relativistic antihydrogen formed “automatically” in E835 jet target [G. Blanford et al., PRL 80, 3037 (1998)]
  - can test CPT in flight (e.g., anti-H Lamb shift) thx to Lorentz-shifted $B$ field in $\approx 0.7$-T magnet [G. Blanford et al., PRD 57, 6649 (1998)]

• Unknown whether antimatter falls up or down or whether $g - \bar{g} = 0$ or $\varepsilon$
  - in principle a simple interferometric measurement with slow anti-H beam
Antiproton Menu
Antiproton Menu

Experiment

• p-pbar annihilation in Accumulator

• Antihydrogen-in-flight

• Stopping-antiproton facility

• New experiment ring
# Antiproton Menu

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• p-pbar annihilation in Accumulator  small      2011

• Antihydrogen-in-flight  tiny       2009

• Stopping-antiproton facility  tiny      2010

• New experiment ring  small      ~2015
Impact

• pbar program addresses at least 5 of Quantum Universe “Big Questions”

• Will substantially broaden scope of physics investigated at Fermilab

• Serves an international community of 300+ interested physicists

• Possible because of Fermilab’s world-leading antiproton source – both now and in the future – thanks to many years of investment
Summary
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- Fermilab has the best-ever pbar source by orders of magnitude
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• Fermilab has the best-ever pbar source by orders of magnitude

• Best experiments ever on hyperons, charmonia, charm, and antihydrogen may run a few years from now at Fermilab
Drafting LoI and soliciting collaborators

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See http://capp.iit.edu/hep/pbar