

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:

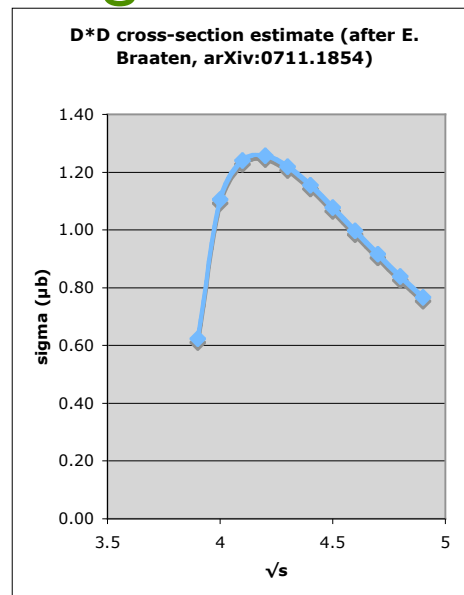
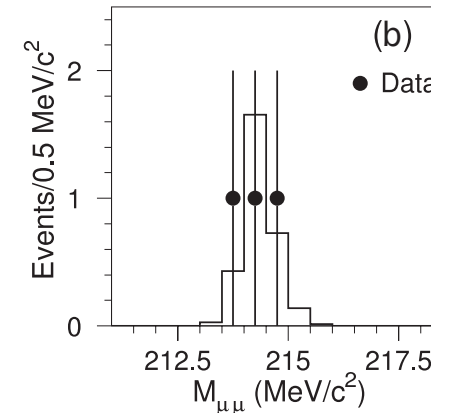
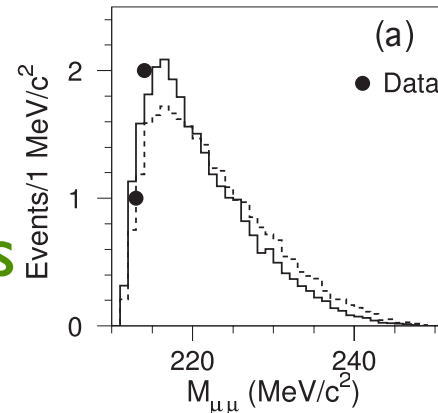
- Keith Gollwitzer, FNAL [Review of E835](#)
- Dan Kaplan, IIT Reprise of [Antiproton Summary Talk](#) from 1st
Project X Workshop
- Ted Barnes, ORNL/U. Tenn. [pbar-p and Charmonium](#)
- Paolo Lenisa, Ferrara [Polarization Physics](#)
- Frank Rathmann, Juelich [Towards Polarized Antiprotons](#)
- Gerry 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

Back to [A New pbar Experiment for Fermilab](#) home page

$p\bar{p}$ Physics Overview

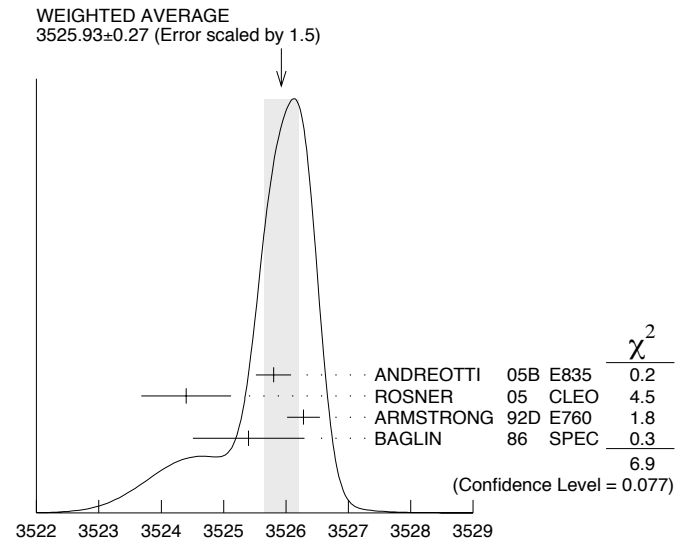
$p\bar{b}$ Physics Overview

- Search for new physics in
 - hyperon ~~CP~~ & rare decays
 - charm mixing & ~~CP~~



$p\bar{p}$ Physics Overview

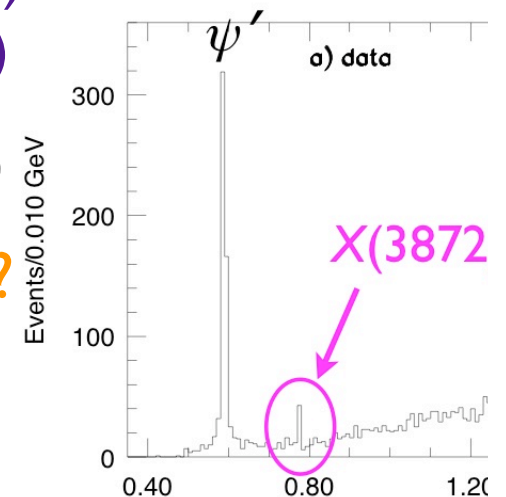
- Search for new physics in
 - hyperon ~~CP~~ & rare decays
 - charm mixing & ~~CP~~
- Charmonium – test of QCD



- ▶ improved understanding of (nonperturbative) QCD
important for interpreting above (and other) physics

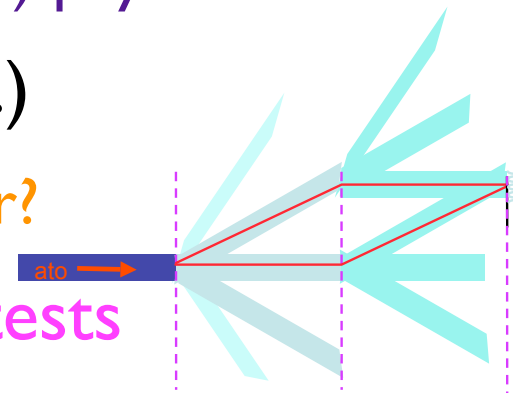
$p\bar{p}$ Physics Overview

- Search for new physics in
 - hyperon CP & rare decays
 - charm mixing & CP
- Charmonium – test of QCD
 - ▶ improved understanding of (nonperturbative) QCD important for interpreting above (and other)
- 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
 - ▶ improved understanding of (nonperturbative) QCD important for interpreting above (and other) physics
- 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 η_c, χ_c, h_c masses, widths, branching ratios,...
 - interference of continuum & resonance signals
- Still more to do!
 - e.g., improve η_c, h_c , and η_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
 - ➡ $\bar{p}p \rightarrow X(3872)$ 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 ≈ 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 ε
 - 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

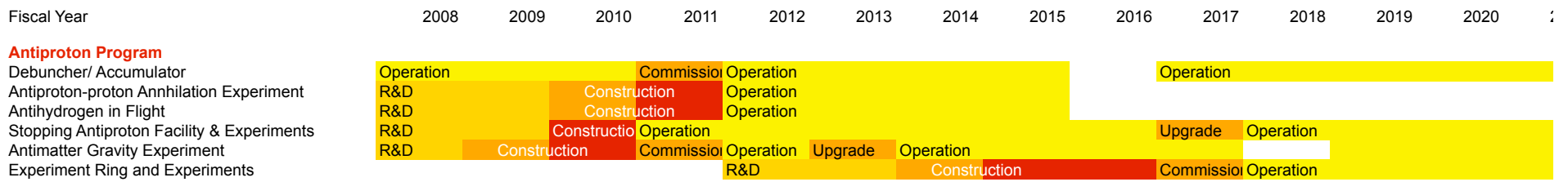
<u>Experiment</u>	<u>Scale</u>
● p-pbar annihilation in Accumulator	small
● Antihydrogen-in-flight	tiny
● Stopping-antiproton facility	tiny
● New experiment ring	small

Antiproton Menu

<u>Experiment</u>	<u>Scale</u>	<u>≈ Physics Start</u>
● p-pbar annihilation in Accumulator	small	2011
● Antihydrogen-in-flight	tiny	2009
● Stopping-antiproton facility	tiny	2010
● New experiment ring	small	~2015

Antiproton Menu

<u>Experiment</u>	<u>Scale</u>	<u>≈ Physics Start</u>
• 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

Summary

- Fermilab has the best-ever pbar source by orders of magnitude

Summary

- 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

Proto-Collaboration

- Drafting Lol and soliciting collaborators

Thomas J. Phillips

Duke University, Durham, N. Carolina 27708 USA

Giorgio Apollinari, Daniel R. Broemmelsiek, Charles N. Brown,
David C. Christian, Paul Derwent, Keith Gollwitzer, Alan Hahn,
Vaia Papadimitriou, Steven Werkema, Herman B. White

Fermilab, Batavia, IL 60510, USA

Wander Baldini, Giulio Stancari, Michelle Stancari

INFN, Sezione di Ferrara, Ferrara, Italy

Gerald P. Jackson

Hbar Technologies, LLC, West Chicago, IL 60185, USA

Daniel M. Kaplan,* Howard A. Rubin, Yagmur Torun, Christopher G. White

Illinois Institute of Technology, Chicago, Illinois 60616, USA

HyangKyu Park

KyungPook National University, DaeGu, Korea

Todd K. Pedlar

Luther College, Decorah, IA 52101, USA

Jerome Rosen

Northwestern University, Evanston, IL 60208, USA

E. Craig Dukes

University of Virginia, Charlottesville, Virginia 22903, USA

- See <http://capp.iit.edu/hep/pbar>