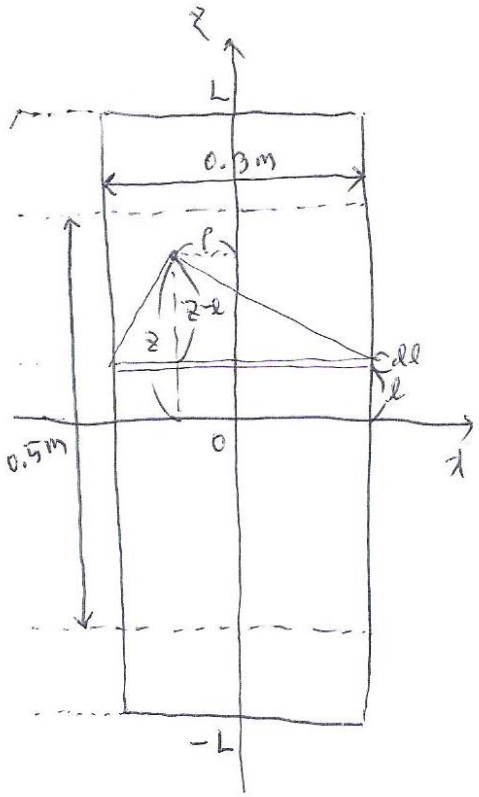
1. Solenoid Exercise

2. First Positron Cooling of antiprotons(2001)

Won Dong Hwan

1. Solenoid Exercise

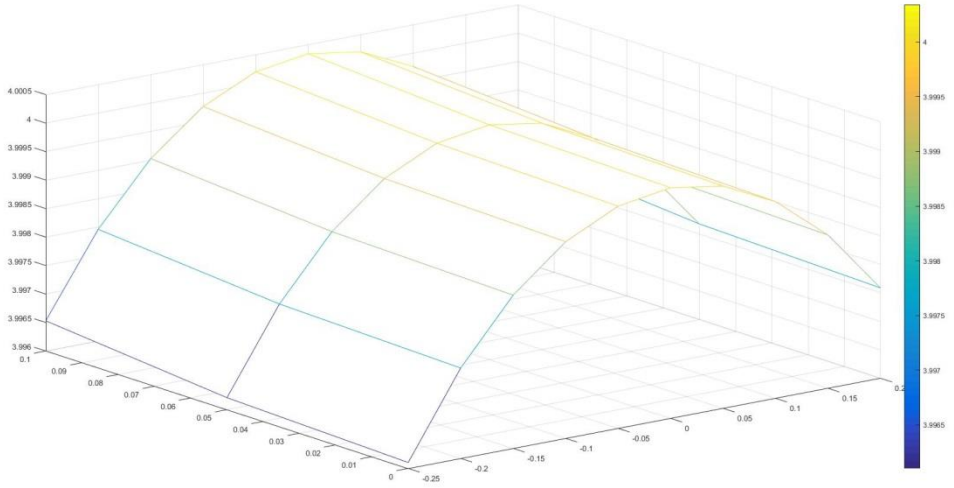


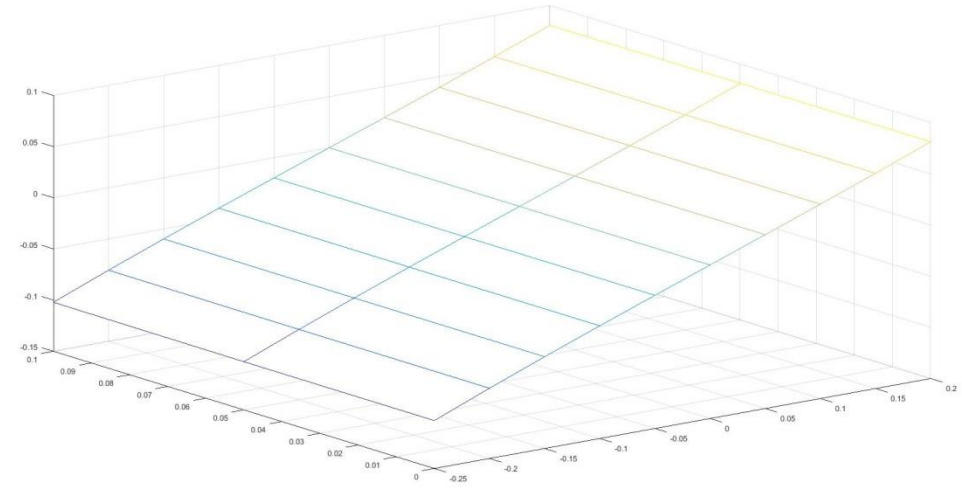
$$dB_z = \frac{\mu_0 n I R}{4\pi} dl \int_0^{2\pi} \frac{R + \rho\cos\theta}{(R^2 + \rho^2 + 2R\rho\cos\theta + (z-l)^2)^{3/2}} d\theta$$

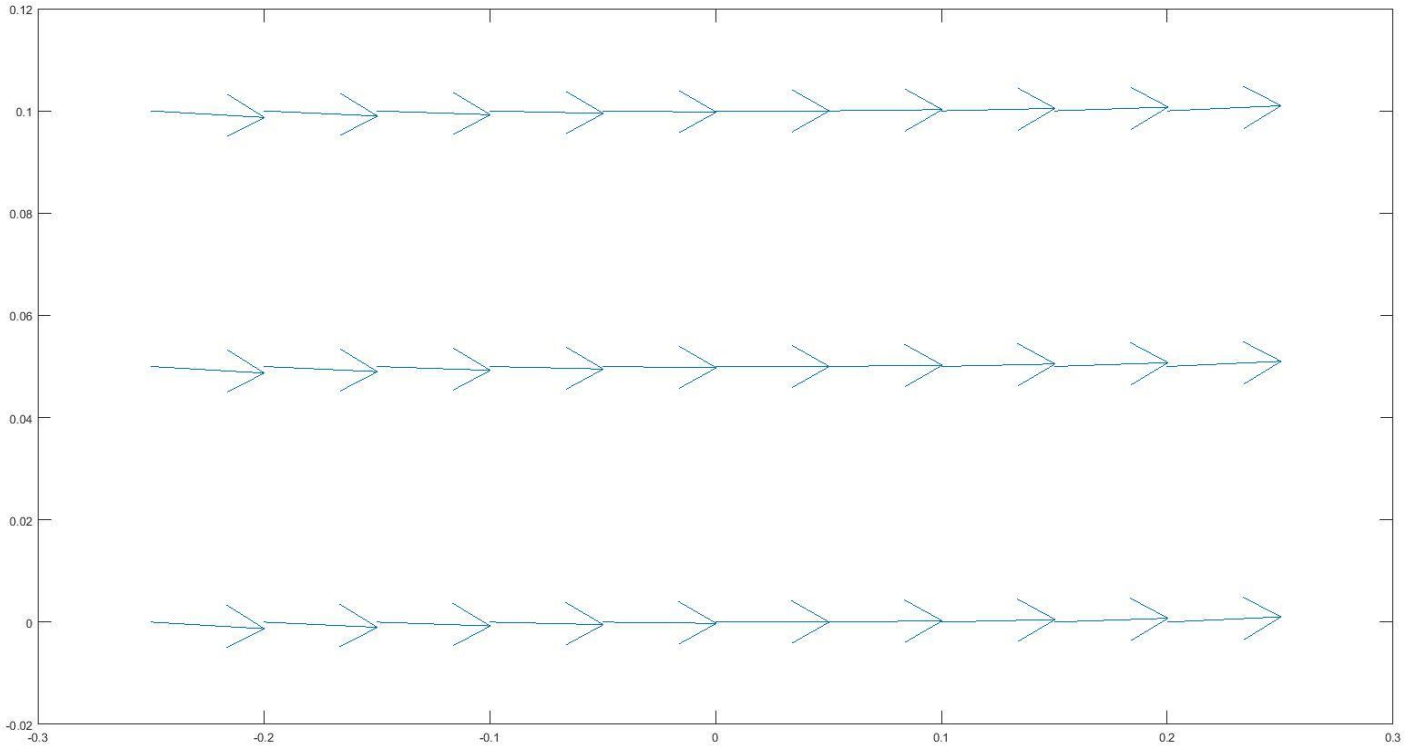
$$dB_\rho = \frac{\mu_0 n I R}{4\pi} dl \int_0^{2\pi} \frac{z - l}{(R^2 + \rho^2 + 2R\rho\cos\theta + (z-l)^2)^{3/2}} d\theta$$

L=1.22(m)

nI=3.2071*10^6(A/m)


4.0005
4
3.9995
3.999
3.9985
3.998
3.9975
3.997
3.9965
3.996
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2
4
3.9995
3.999
3.9985
3.998
3.9975
3.997
3.9965


0.1
0.05
0
-0.05
-0.1
-0.15
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.25
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15
0.2


0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.3
-0.2
-0.1
0
0.1
0.2
0.3

2. First Positron Cooling of antiprotons(2001)

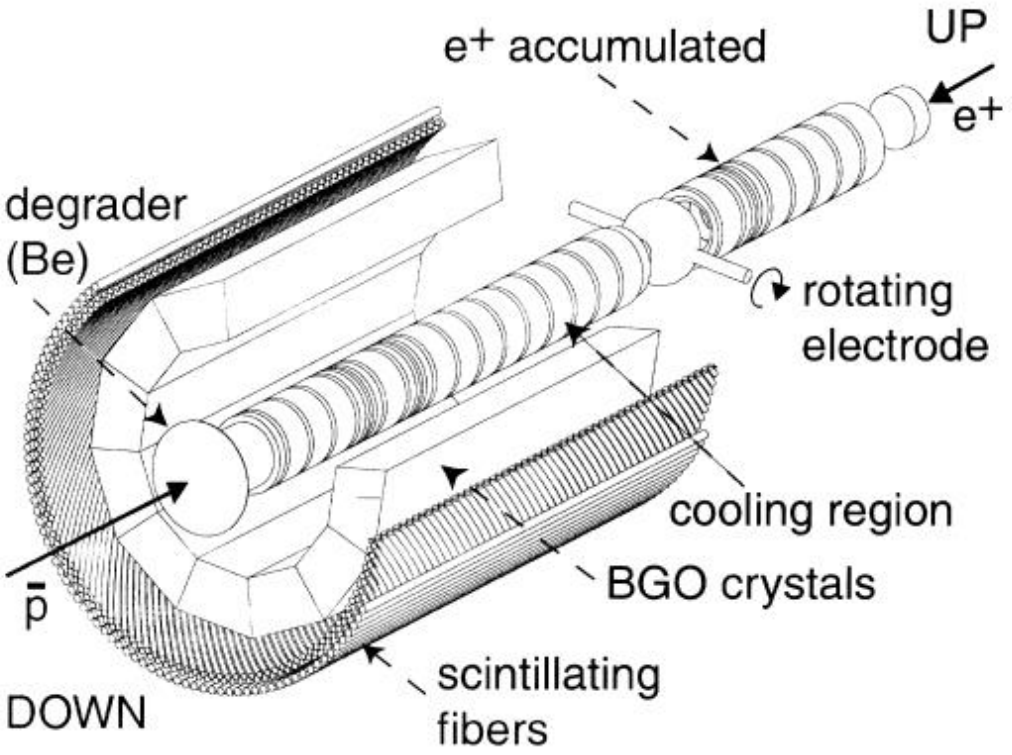
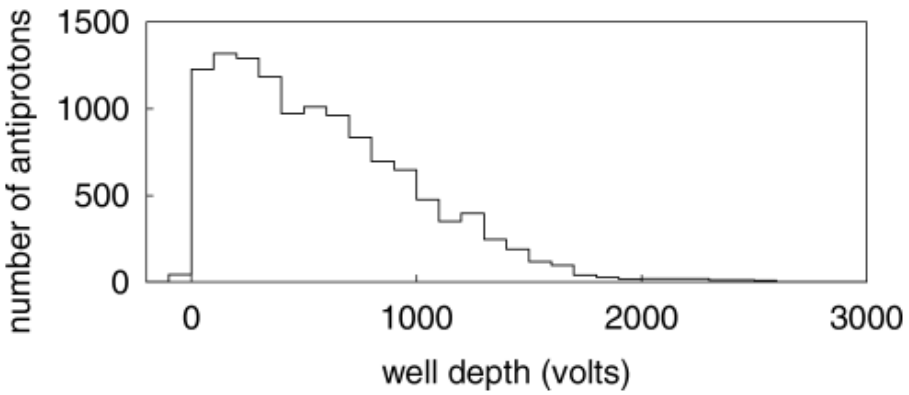


Fig. 1. Overview of the trap and detectors.



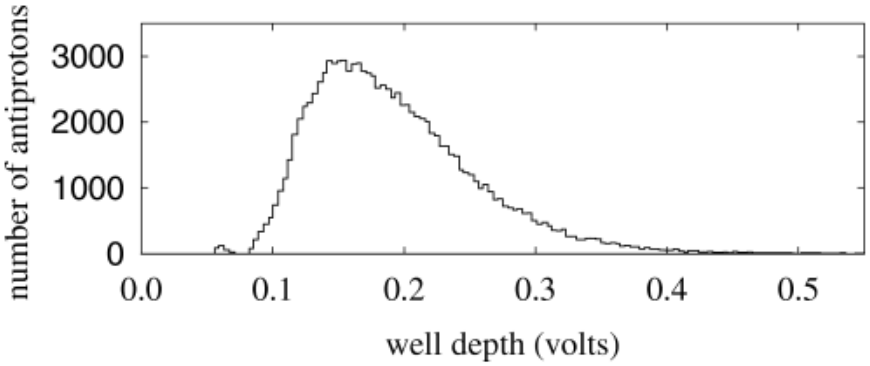
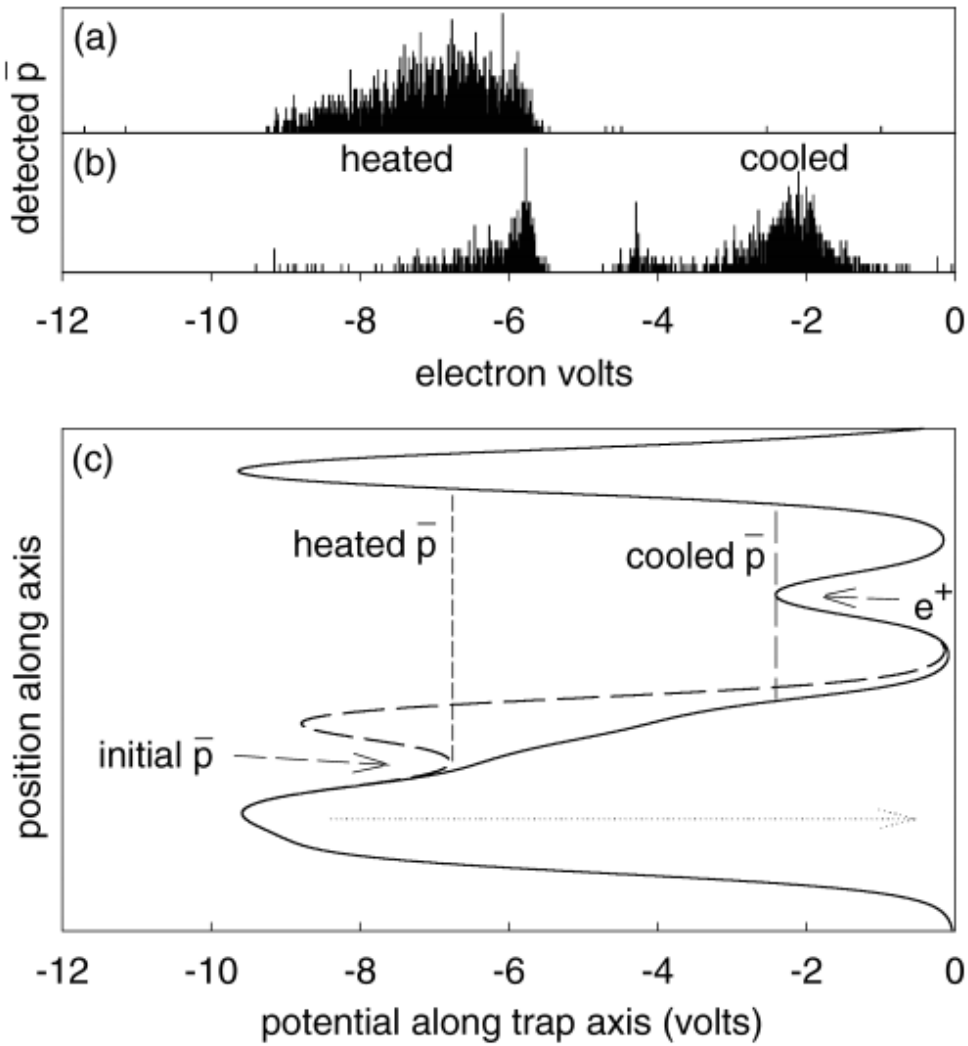


Fig. 3. Energy spectrum for 106000 of the first antiprotons electron-cooled and stacked at the AD.

- Up to 12000 antiprotons are captured in this 4 kV trap from a single pulse of antiprotons from the AD.
- The energy of the trapped antiprotons is analyzed by slowly reducing the depth of the potential well that confines them (Fig. 2), and counting the annihilations of antiprotons that leave the trap.
- Stack more than 105 antiprotons(Fig. 3).



- First, since the positrons and antiprotons have an opposite sign of charge, they cannot be confined in the same Penning trap well.
- The solution is the nested Penning trap.
- When no positrons are present in the nested trap, (a) shows the number of annihilations of antiprotons released from the trap as a function of the remaining barrier height.
- When we analyze the antiproton energy as before we see in (b) that most of the antiprotons have cooled to approximately the same level in the well that is occupied by the positrons.

- The cooled antiprotons have a low relative velocity with respect to the cold positrons that cooled them.

- A low relative velocity is one condition under which antihydrogen formation processes are expected to have their highest rates.

- Much remains to be done before cold antihydrogen is observed and precise laser spectroscopy is performed. However, this first positron cooling of antiprotons demonstrates that it is possible to make the ingredients of cold antihydrogen interact at very low energies, and is the closest approach yet to cold antihydrogen.