The ALPHA Experiment

Summer Student Sessions

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Program

- Reasons for antihydrogen research

- Goals of the ALPHA experiment

- One of the techniques - EVC

- Future measurements

Antihydrogen research

Antihydrogen research

- Simplest pure antimatter atomic system
- Antimatter equivalence
- CPT symmetry
- Antigravity?

Goals for ALPHA

- Long term goal: Precision spectroscopy using the 1S-2S transition

  $f(1S-2S) = 2\ 466\ 061\ 102\ 474\ 851(34)$ Hz - Hänsch et al.

- Main goal with current apparatus: Trap antihydrogen (Nature 2010)

- Need atoms trapped in the ground state and for considerable time to do spectroscopy (Nature Physics, July 2011)

Trapping antihydrogen

Interaction of an (anti) atom with a magnetic field:

$$U = -\boldsymbol{\mu}_{\bar{H}} \cdot \mathbf{B} \approx \pm \mu_B B \qquad \text{(ground state)}$$
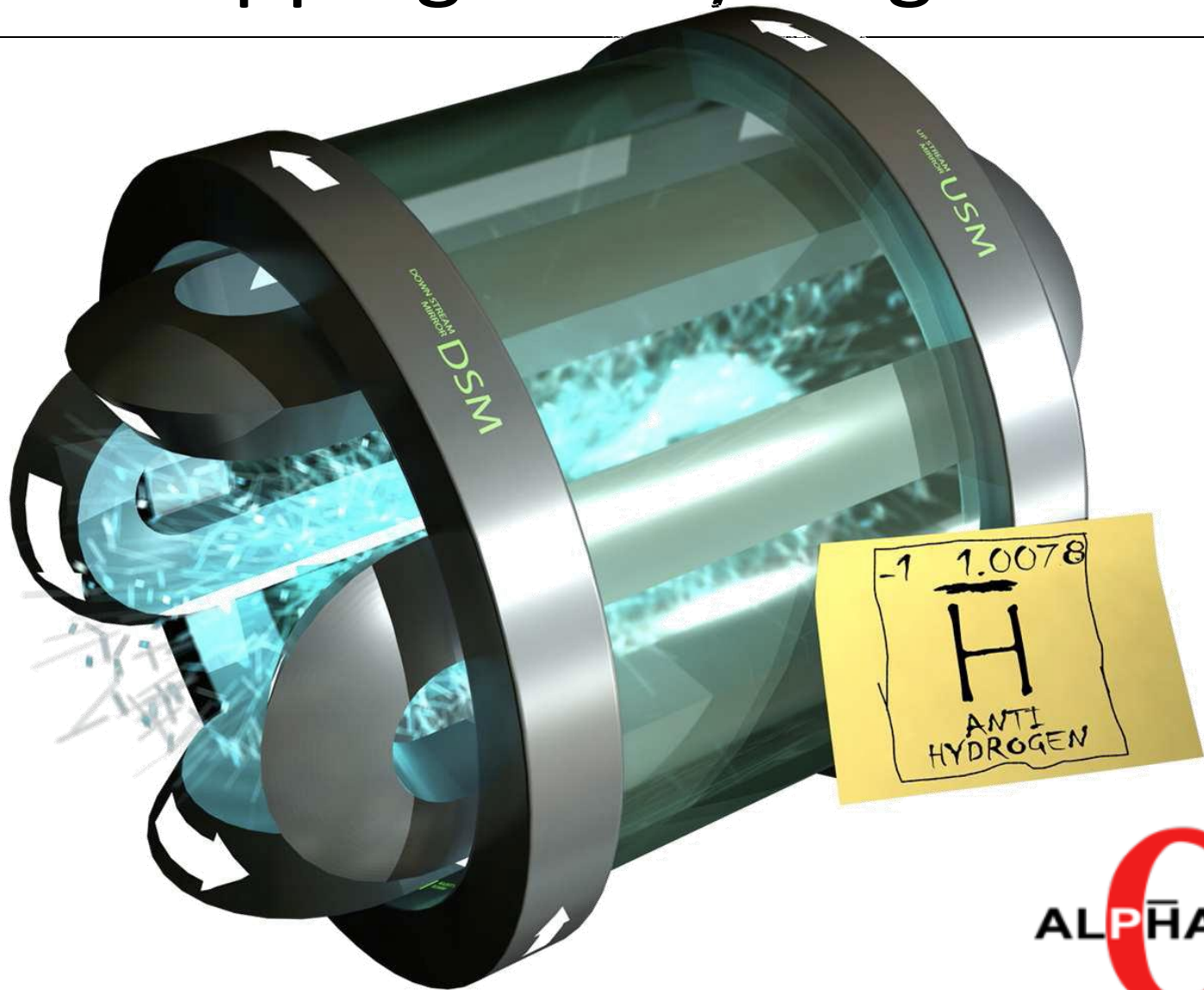
Two kinds of atoms:

Low field seeking

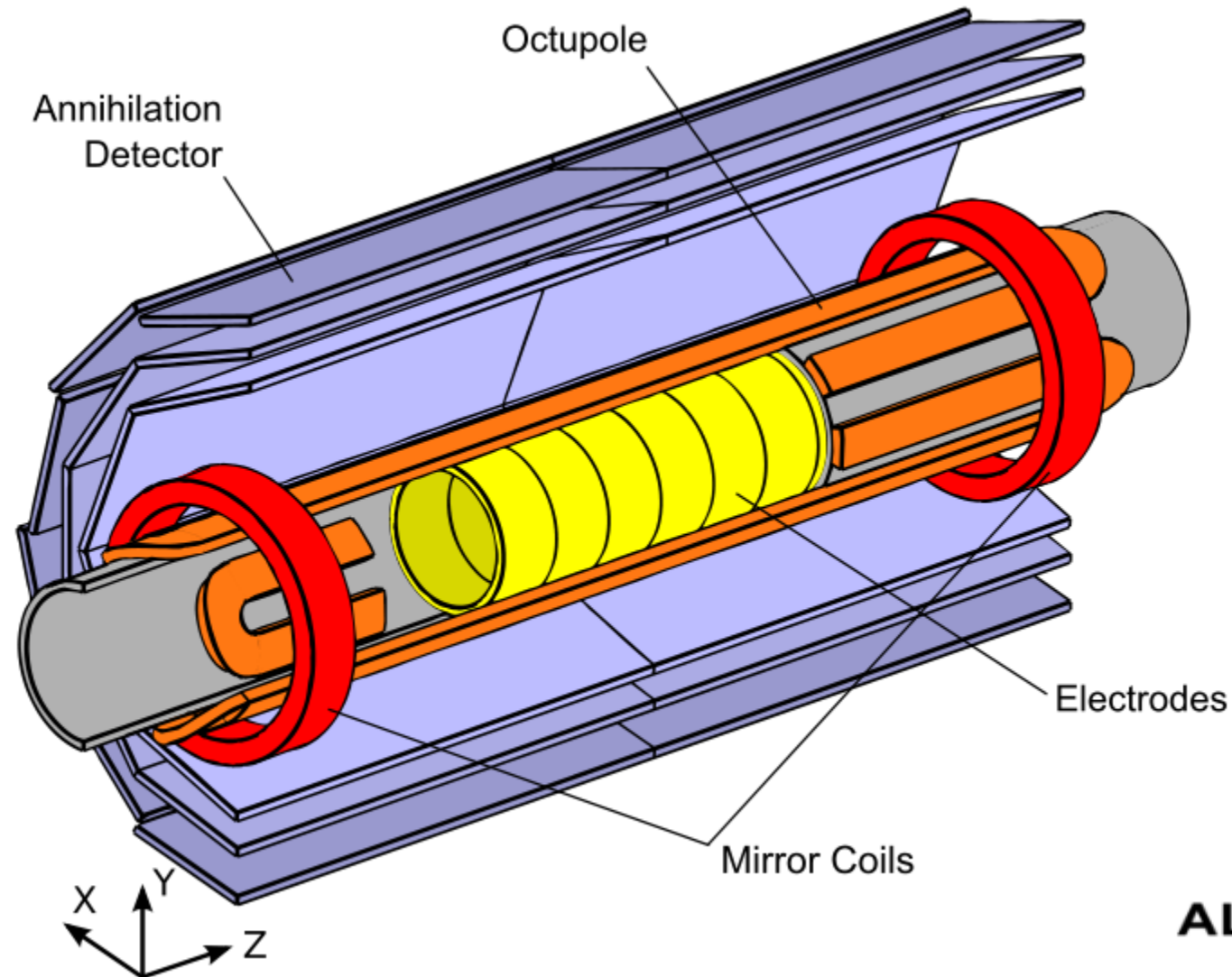High field seeking

Trapping antihydrogen

Some challenges

- Interaction of an (anti)atom with a magnetic field:

$$U \approx \pm \mu_B B \approx 0.7K \qquad \text{(In 1T field)}$$

- Constituent particles do not exist freely on earth (or are rapidly destroyed)
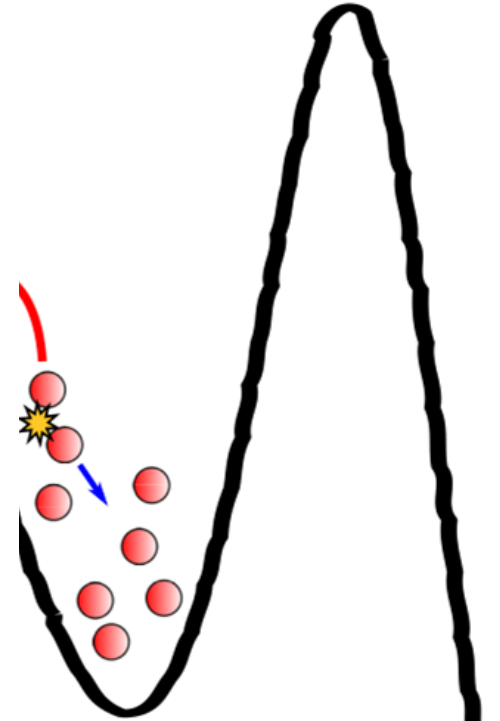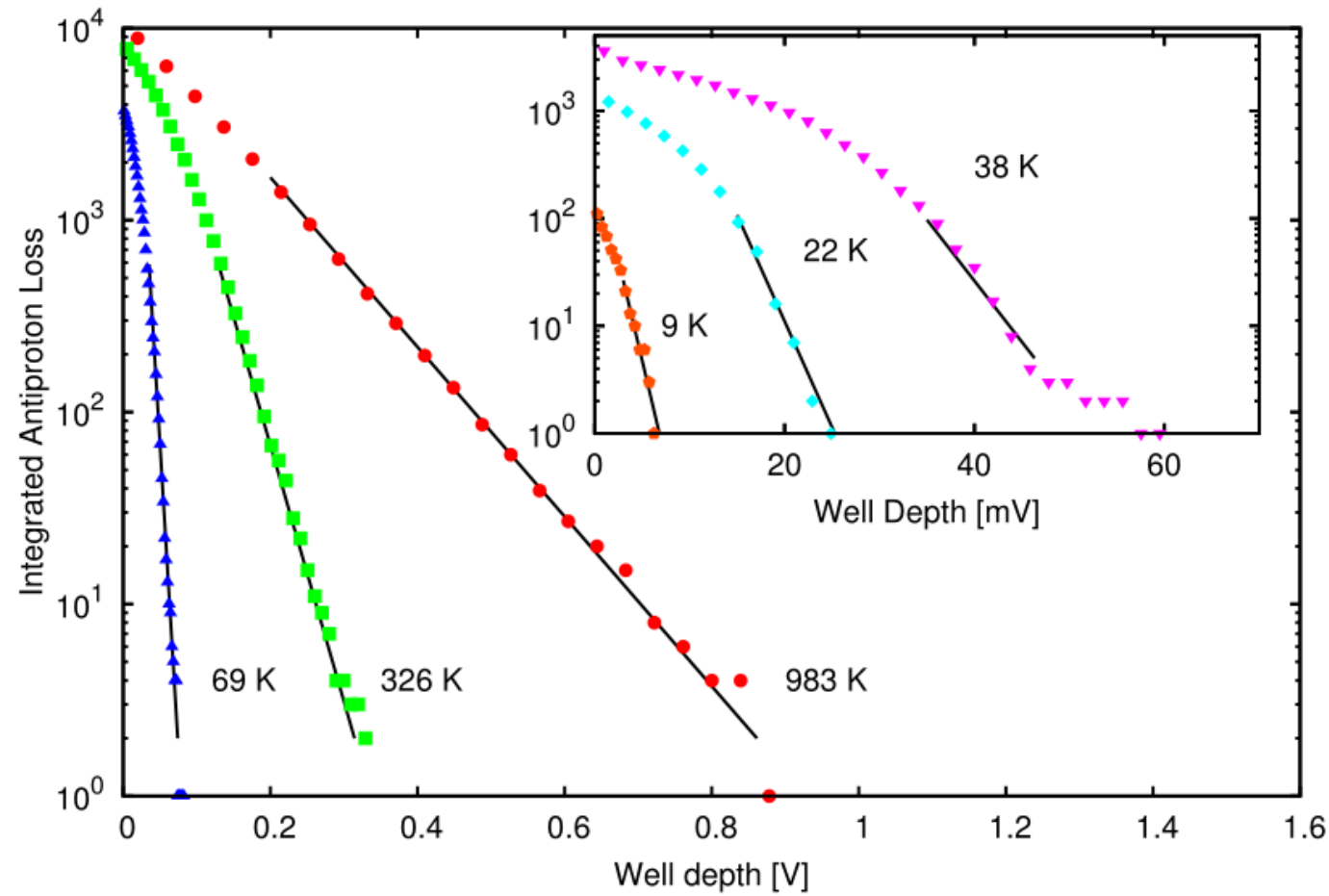
Trapping antihydrogen

Cool Particles

Antiprotons delivered from AD at 5.3MeV

Trappable antihydrogen

$$0.5\,\mathrm{K} \approx 5 \cdot 10^{-5}\,\mathrm{eV}$$

- Degrader
- Electron cooling
- EVC

EVC (Evaporative Cooling)

Future

Ground state hyperfine transition

Switch from low field seeking to high field seeking

$$U = -\boldsymbol{\mu}_{\bar{H}} \cdot \mathbf{B} \approx \pm \mu_B B$$

Laser access - 2012

Antigravity?

ALP$\overline{\text{H}}$A α

Questions