



ATRAP

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Overview



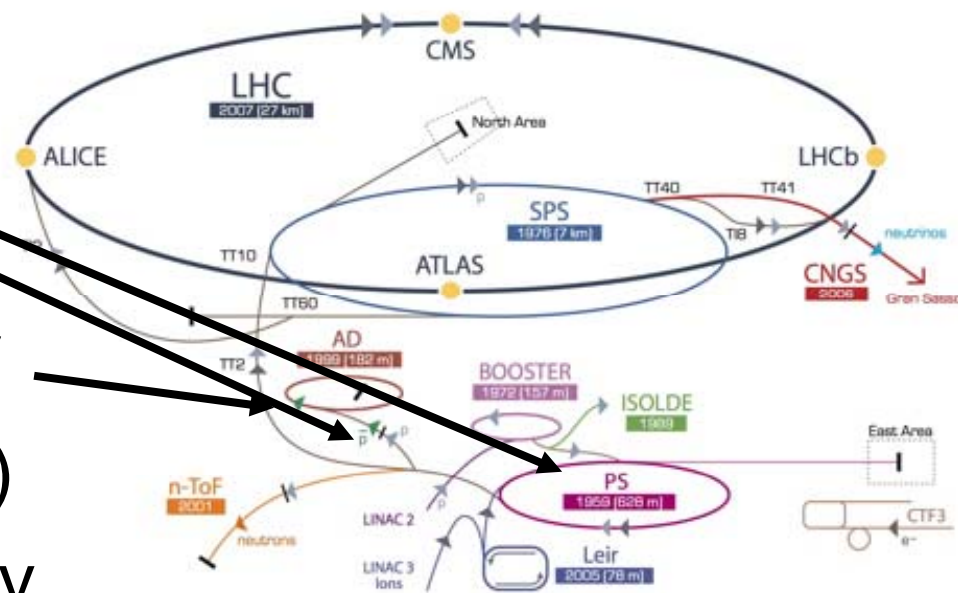
- Antimatter
 - CERN's Antiproton Decelerator (AD)
 - Why Antihydrogen?
 - Trapping Challenges
- XY Moveable Stage
 - Design
 - Implementation
 - Testing
- Trap Installation



Antimatter: The AD



- PS delivers 26 GeV protons
- Reaction:
 $p + p \rightarrow p + p + p + \bar{p}$
- AD slows \bar{p} to 5.3 MeV (Stochastic; RF cooling)
- Delivers $3 \times 10^7 \bar{p}$ every 100 sec

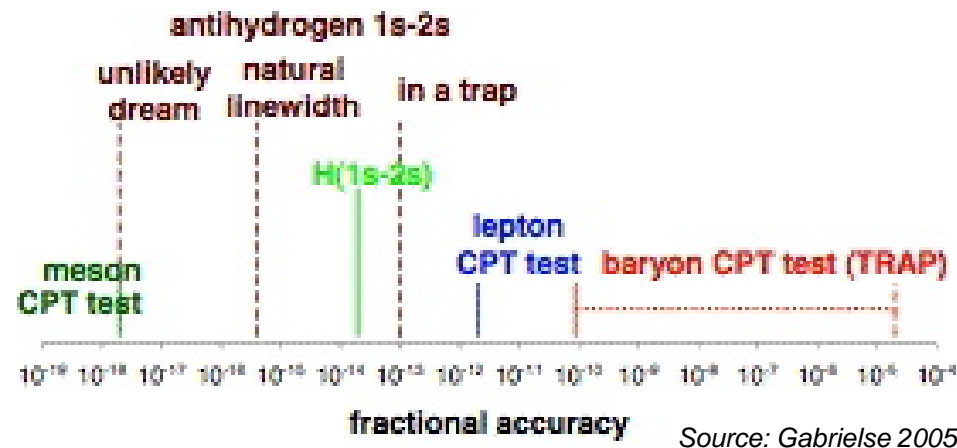




Antimatter: Why \bar{H} ?



- CPT comparison with hydrogen;
1 part in 10^{12-15} !
- Current baryon
precision: 10^{-9}



- Not an easy goal. Need:
 - Cold Antihydrogen (ground state)
 - Coherent Lyman- α source (121.6 nm)



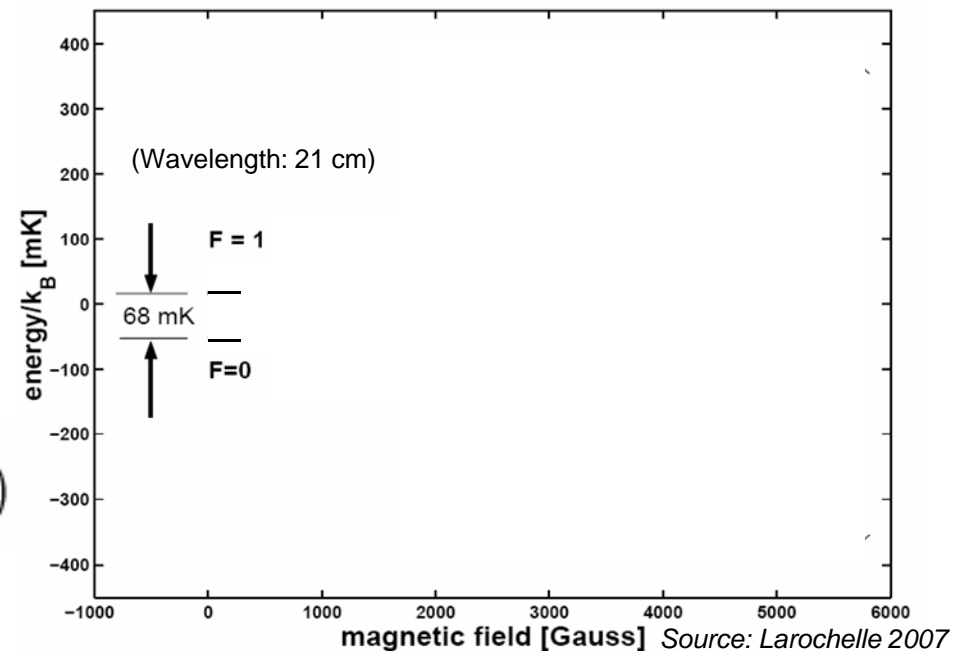
How to Trap \bar{H}



An (anti)atom is neutral! Electric fields won't work...

Exploit hyperfine levels of the 1S state.

$$\Delta E(J) = \mu_B(|\vec{B}|_{Max} - |\vec{B}|_{Min})$$



Reported for Hydrogen:

H. F. Hess, G. P. Kochanski, J. M. Doyle, N. Masuhara, D. Kleppner, and T. J. Greytak, Phys. Rev. Lett **59**, 672 (1987).



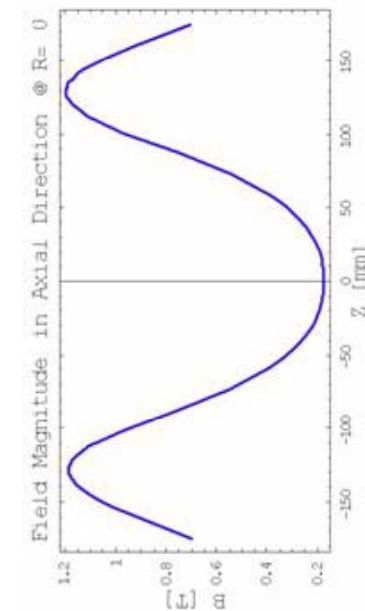
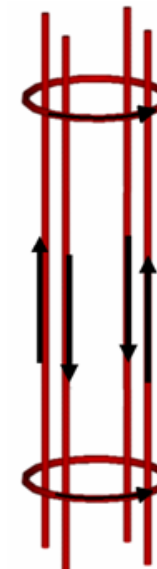
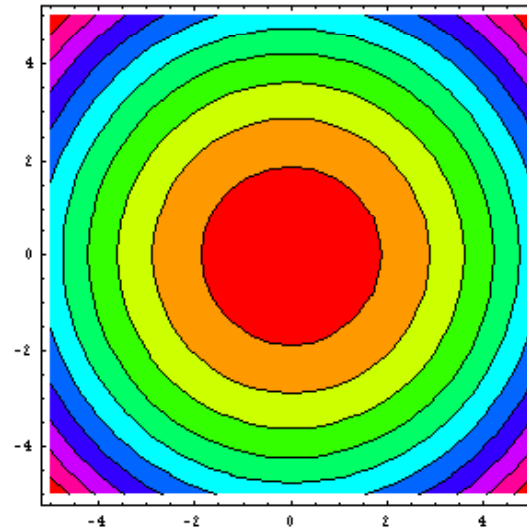
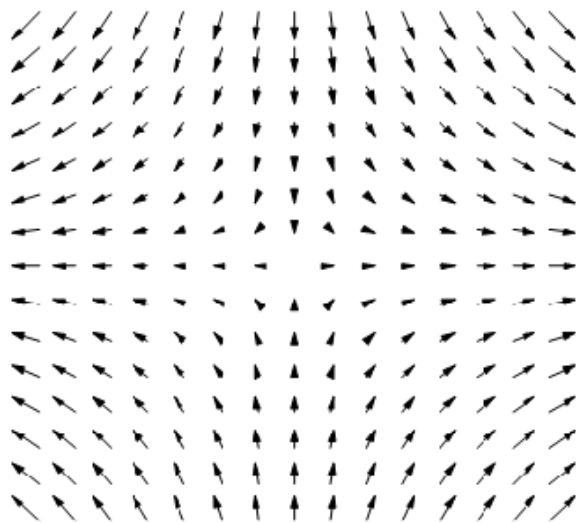
Solution: The Ioffe Trap



Need a magnetic minimum in all directions.

Radial: Quadrupole

Axial: Pinch coils





Project: XY Stage



Moveable stage controls positron, electron loading.

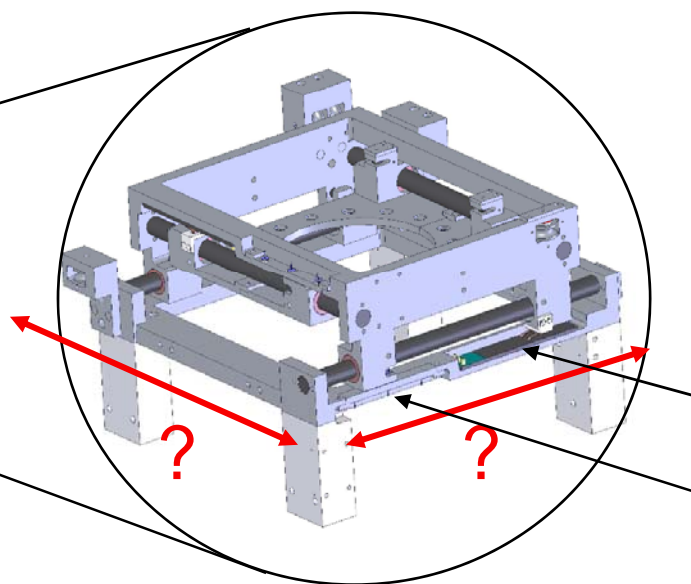
Problem:

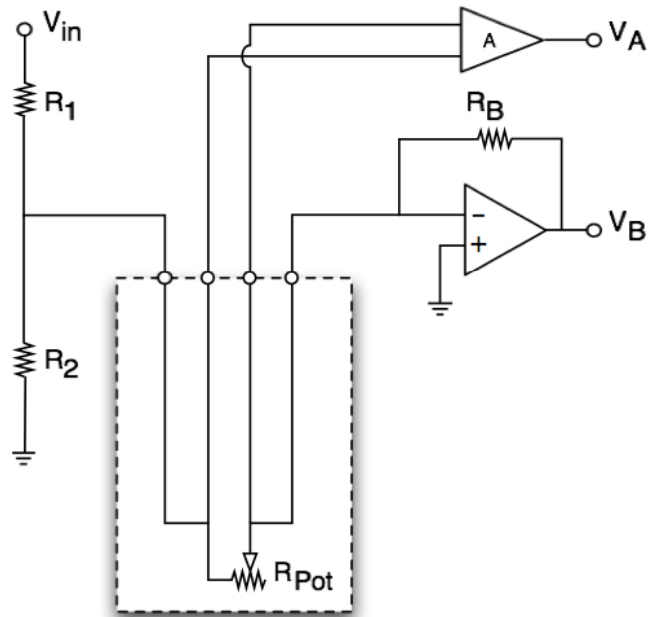
Where is the stage located?

Solution:

Potentiometer

LEDs / Photodiode



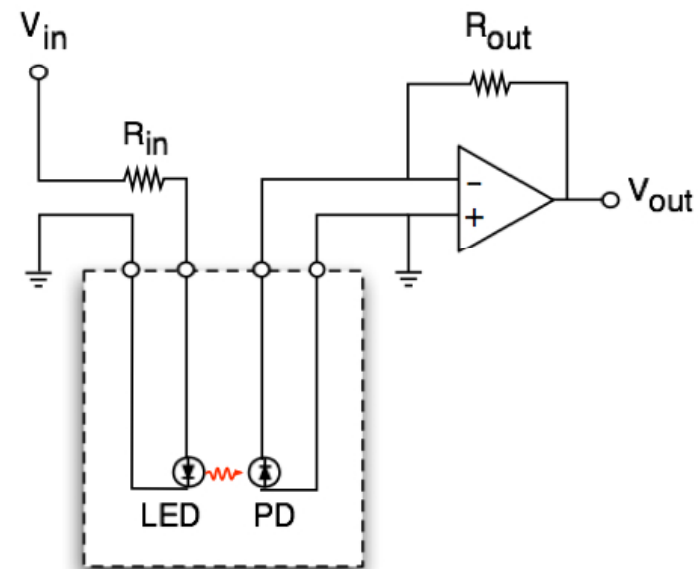


Potentiometer: 4-Wire
resistance measurement

$$R_{Pot} = (-V_A R_B) / V_B$$

LEDs and Photodiode:

V_{out} is nonzero when
photodiode receives a
signal (in front of LED)

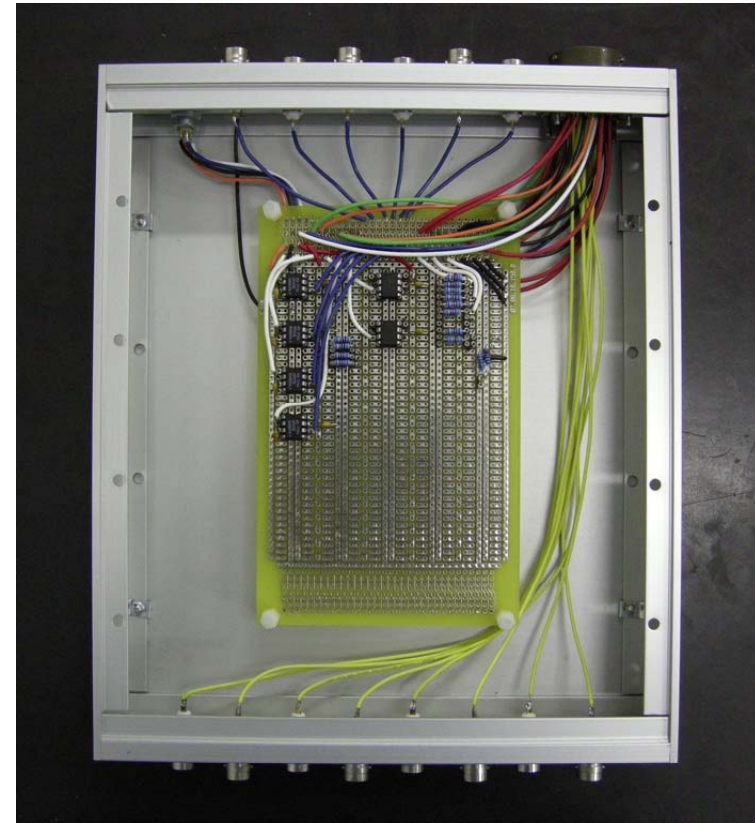




XY Stage: Design



- Input: 32-pin cable from experiment
- Output: 6 Chassis-Isolated BNCs
- Constructed mostly with components I scrounged from the lab
- Communicates via TCP/IP with LabVIEW (not yet)





XY Stage: Testing



Results:

Potentiometer: consistently too high (calibration)

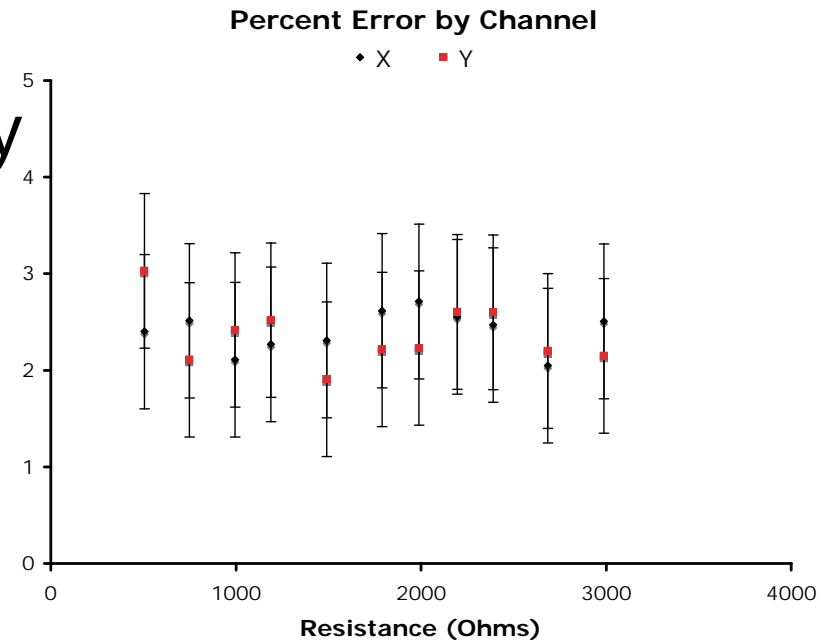
Off by $2.4 \pm 0.3\%$

Uncertainty: ± 0.2 mm

Photodiode works!

Signal ~ 100 mV,
background ~ 1 mV

Peak width 1.1 ± 0.1 mm (FWHM)

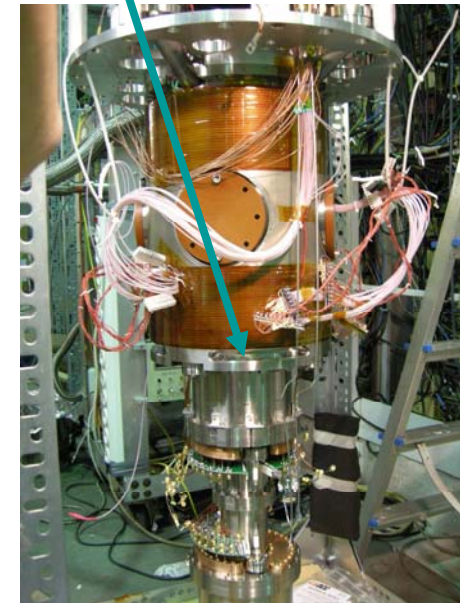




Trap Installation



Leak fixed!

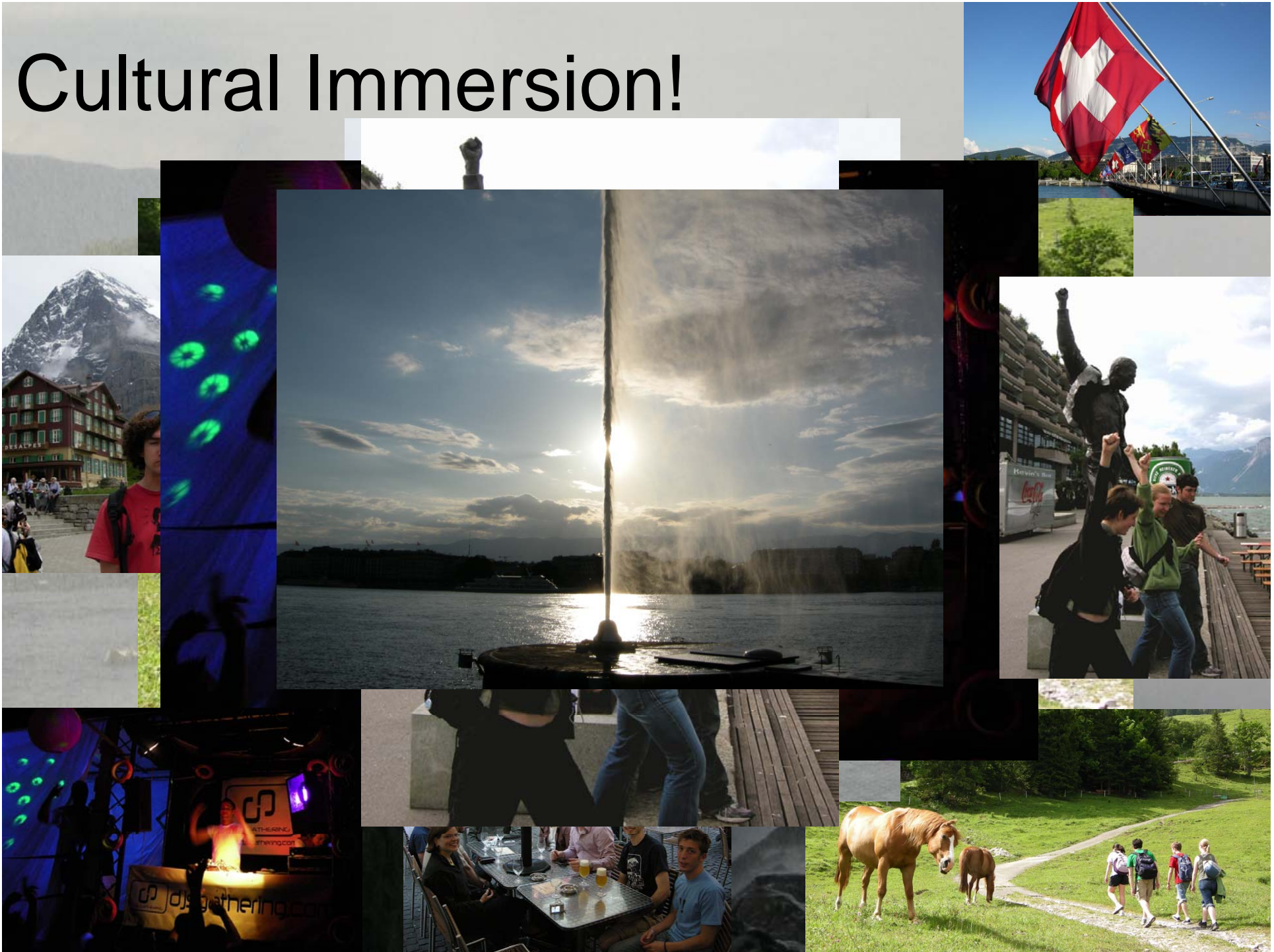


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Cultural Immersion!





Thanks!



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