The AEgIS Experiment

Measuring the Gravitational Interaction of Antimatter

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AEgIS Collaboration

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Michael Doser
AEgIS Experimental Goal

- **Primary goal:**
  - Measurement of gravitational acceleration $g$ for antihydrogen with 1% accuracy

- **Secondary goals:**
  - Spectroscopy of antihydrogen
  - Study of Rydberg atoms
  - Positronium physics: formation, excitation, spectroscopy
  - PALS with different materials
AEgIS Experimental Strategy

- Produce ultra cold antiprotons
- Form positronium by interaction of positrons with a porous target (pulsed)
- Laser excite Ps to get Rydberg Ps (pulsed)
- Form Rydberg cold antihydrogen (pulsed) by $Ps^* + \bar{p} \rightarrow \bar{H}^* + e^-$
- Stark accelerate the antihydrogen with inhomogeneous electric fields

→ Pulsed production of a cold beam of antihydrogen

Storry et al., PRL 93, 263401 (2004)
Zone layout

AEGIS

Electron cooling

Stochastic Cooling

ASACUSA

ATHENA

4m
Experimental Apparatus @ CERN

- Positron accumulator

\( \bar{p} \) from AD

5T magnet (trapping)

1T magnet (formation & beam)

Gravity module / spectroscopy

1m
Experimental Installation

Zone early 2011
Experimental Installation

Zone early 2011

Zone late 2012
IT Formation Traps
Positron System

Ps spectroscopy
Ps* manipulations
nanostructured materials

Pulsed transfer line
~0.1T

800 MBq $^{22}$Na source
Solid neon moderator

Positron trap

Positron accumulator
Buffer gas cooling
Assembly completed end of November 2012; immediate pump-down and cool-down (10 days) during which commissioning with antiprotons and positrons could take place
Detector Tests: use $\bar{p}$ to test technologies

Parasitic tests:

Explore different candidate technologies for the (downstream) antihydrogen detector:
- high spatial resolution ($\sim 1\,\mu m$)
- good timing ($\sim 10\,\mu s$)

Silicon detectors (strip, pixel)       MCP       Emulsions
Silicon Detectors

CNM-55-3D pixel sensor bump-bonded to FE-I4 R/O chip designed for the ATLAS Insertable B layer upgrade

Strip sensors 50 and 80 um pitch 300 um thickness Beetle based - Alibaba readout

n+ p+ n+ p+

n+ p+ n+ p+

n+ p+ n+ p+

n+ p+ n+ p+

Silicon Strips on Alibaba - ADC vs. Channel

nuclear fragments (?)
Emulsion tests

- Exposure of emulsion
- Development in dark room
- Scanning on automated microscopes

S. Aghion et al., J. of Instrumentation 8 (2013) P08013
Emulsion tests

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Moiré deflectometer: 6” (full size) grating prototype
Test of moiré deflectometer with antiprotons

- First look at data in zone b)
  - 353 vertices in ~ 1 cm²

- Mini-Deflectometer
- CERN 2013: Philippe Bräunig

- ~100 keV antiprotons
- 7 hours exposure time
- Deflectometer and emulsion in the OVC
- No separation foil

Monday, January 13, 2014
First demonstration of the moiré deflectometer technique with antiprotons

vertex-to-vertex autocorrelation

353 vertices

First look at data in zone b) 353 vertices in ~ 1 cm²

→ Publication submitted
ongoing work: Positronium test station

installed and under commissioning

Monday, January 13, 2014
ongoing work: Proton source

\[ p + Ps \rightarrow H + e^+ \]

protons

positrons

antiprotons

completed and ready for installation

Monday, January 13, 2014
Conclusions and Outlook

- Installation of base apparatus largely completed and commissioned
- Parasitic measurements essential in converging to an optimal deflectometer/detector layout
  ➤ nice to have a test beam line @ ELENA

Ongoing work:
- install proton source, hydrogen detector
- commission Rydberg positronium formation (targets, lasers, atomic physics)
- work on hydrogen formation/characterization
- design gravity module, flight tube
- goal: be ready for antihydrogen formation in autumn 2014

In parallel:
- prepare deflectometer, microwave spectroscopy, interface, hybrid detector, ...