Control system for ion Penning traps at the AEgIS experiment at CERN

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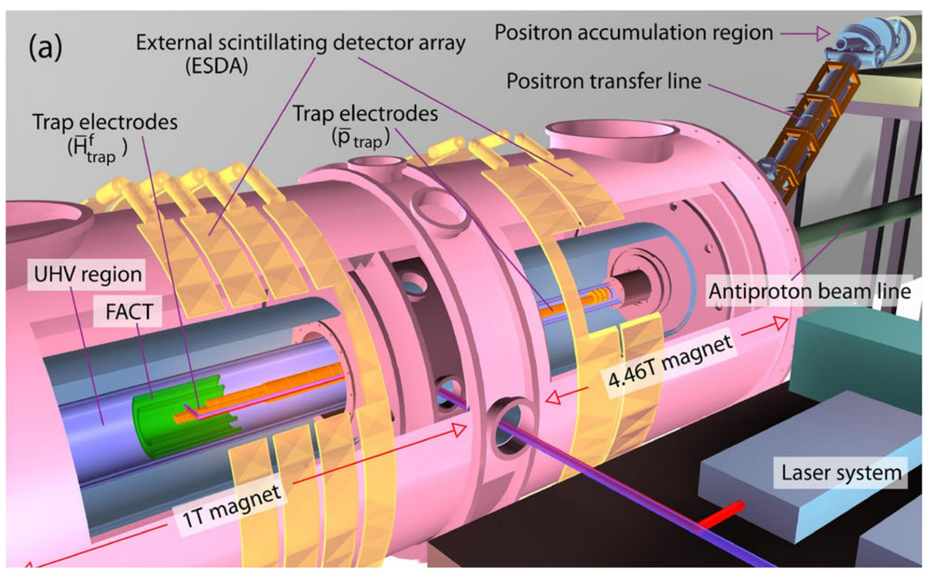
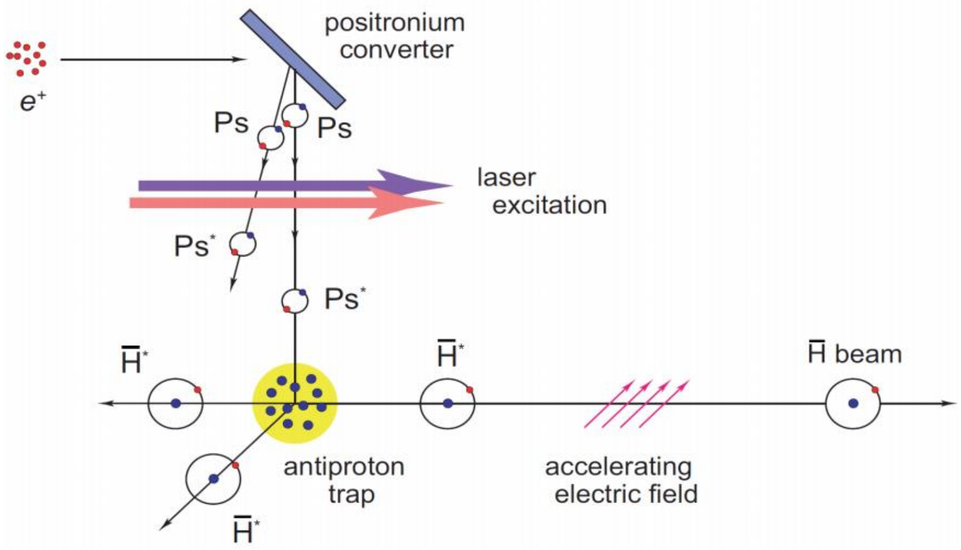
on behalf of the AEgIS Collaboration (CERN)

The AEgIS experiment

The primary scientific goal of the Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy (AEgIS) is to test the Weak Equivalence Principle with antihydrogen atoms by the direct measurement of the Earth's gravitational acceleration, *g*, on antihydrogen. The pulsed source is generated by the charge-exchange reaction between Rydberg positronium atoms and antiprotons, trapped, cooled and manipulated in electromagnetic traps. Further physics topics also made possible by pulsed production address similar symmetry tests on the basis of Positronium and antiprotonic atoms. The AEgIS is located at the antimatter accelerator (AD) facility at CERN in Geneva.



Charge exchange: $\bar{p} + Ps^* \rightarrow \bar{H}^* + e^-$



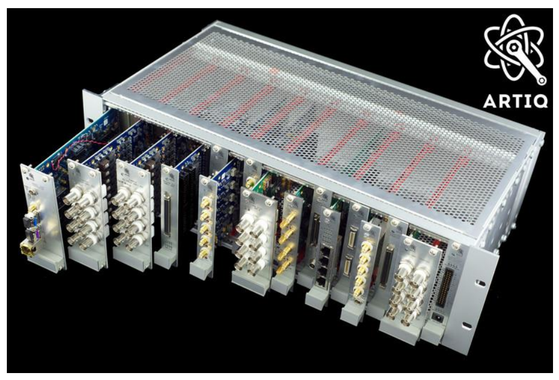
AEgIS Trap Control System

	Timing (order)
Triggering DAC	ms
Trigger response	µs
Triggering synchronicity	ns

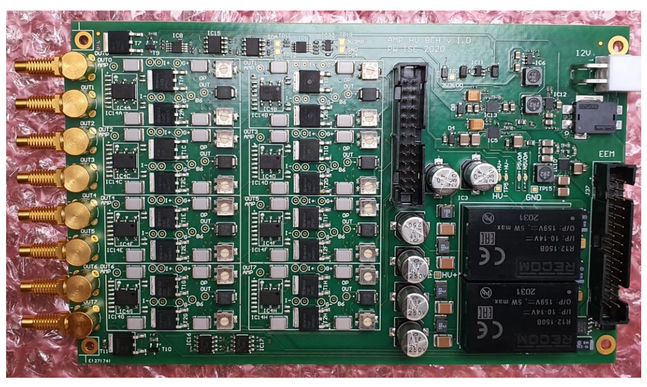
The current custom electronics designed to operate the 5 and 1 T Penning traps are going to be replaced by a control system based on the Sinara and ARTIQ ecosystem. Due to the new functionalities brought by it, the new system is more scalable, maintainable and gives the possibility to have an abstract and object-oriented approach to traps control. The optimal values of potential on the electrodes will be found automatically with self-maximizing methods.

ARTIQ & Sinara

Sinara is an open-source hardware ecosystem designed by physicists for use in quantum science laboratories largely focused on work with trapped atomic ion qubits. It offers modular, well tested, based on FPGA technology solutions for AMO experiments with sub-ns time resolution. Sinara is designed to work closely with the ARTIQ control software (Advanced Real-Time Infrastructure for Quantum physics). This system allows one to operate and control the entire data acquisition and electronics system.



New Amplifier



- 8 channel HV amplifier dedicated to large ion traps
- +/-200 V range
- quick output disconnect controlled via EEM using OptoMos to limit the noise
- 1 MHz bandwidth
- 50 Ohm output impedance, able to drive a few meters of cable
- overtemp protection
- HV capacitors rapid discharge circuit

References

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3. G. Kasprowicz, "HV_AMP_8CH” https://github.com/sinara-hw/HV_AMP_8CH/wiki
4. AEgIS Collaboration, "AEgIS Experiment – CERN”, https://aegis.web.cern.ch/home.html
5. M Kimura et al., "Testing the Weak Equivalence Principle with an antimatter beam at CERN”, 2015 J. Phys.: Conf. Ser. 631 012047

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