



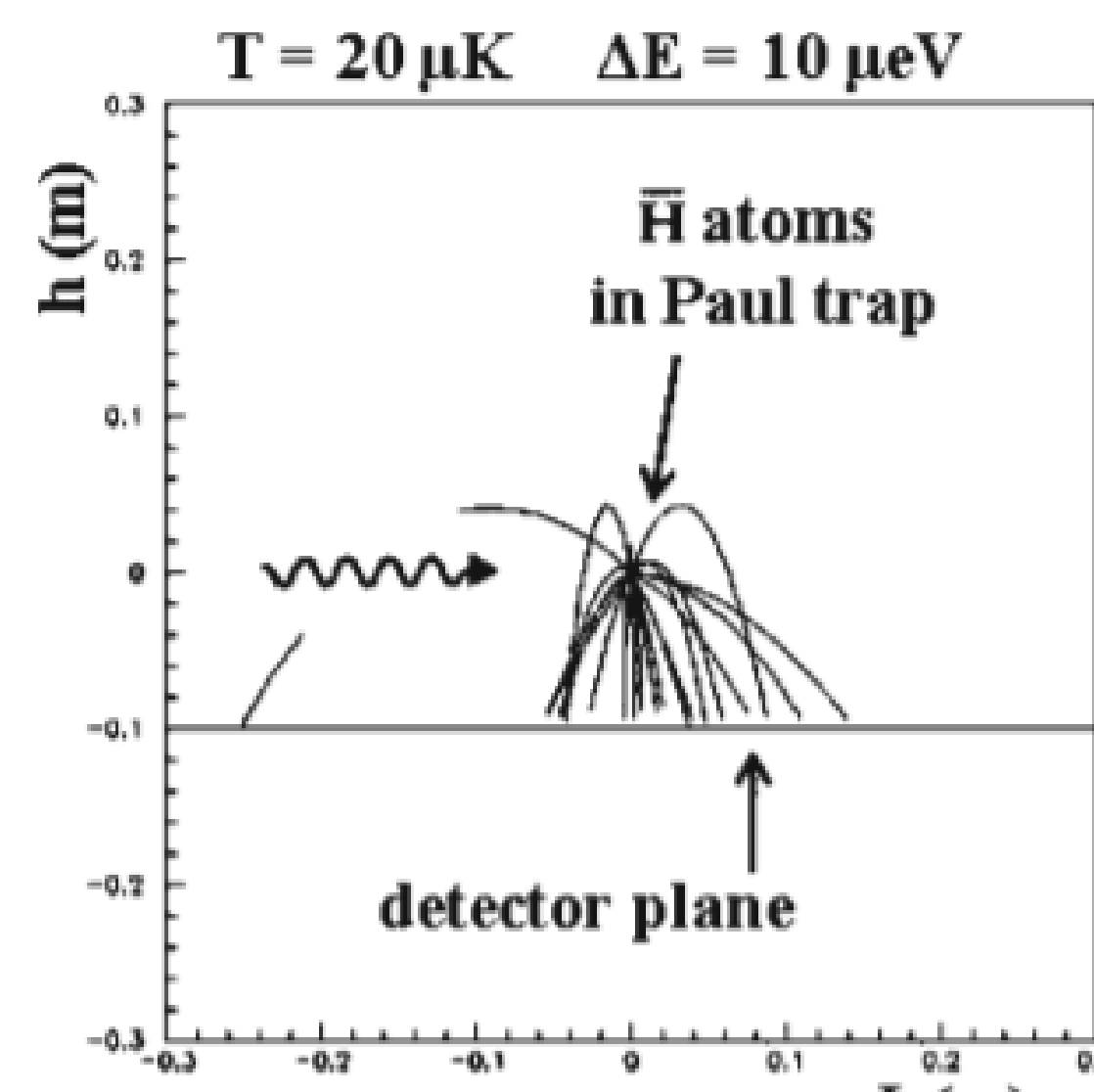
Control system of the GBAR antiproton trap

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1. GBAR Experiments



The GBAR experiment (Gravitational Behaviour of Anti hydrogen at Rest) aims to measure the free fall acceleration of ultracold neutral anti hydrogen atoms in order to test the Equivalence Principle in a direct way.

Debu, Pascal, and GBAR collaboration.
"Gbar." *Hyperfine Interactions* 212.1-3 (2012): 51-59.

Anti-Hydrogen ions are cooled below 10uK and photo-detached by laser. Then neutral anti-hydrogens fall freely under Earth's gravitational field.

2. Experimental Overview

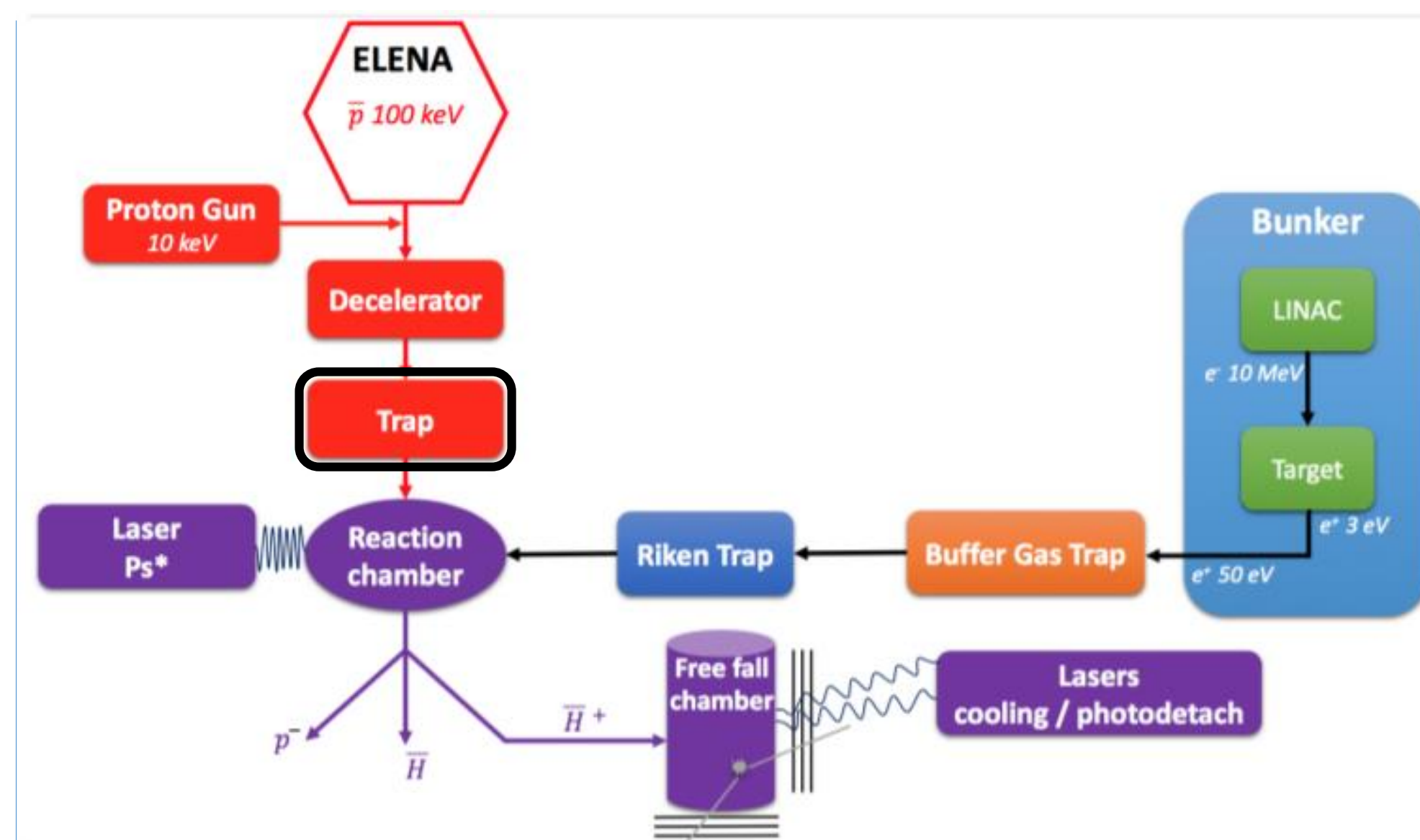
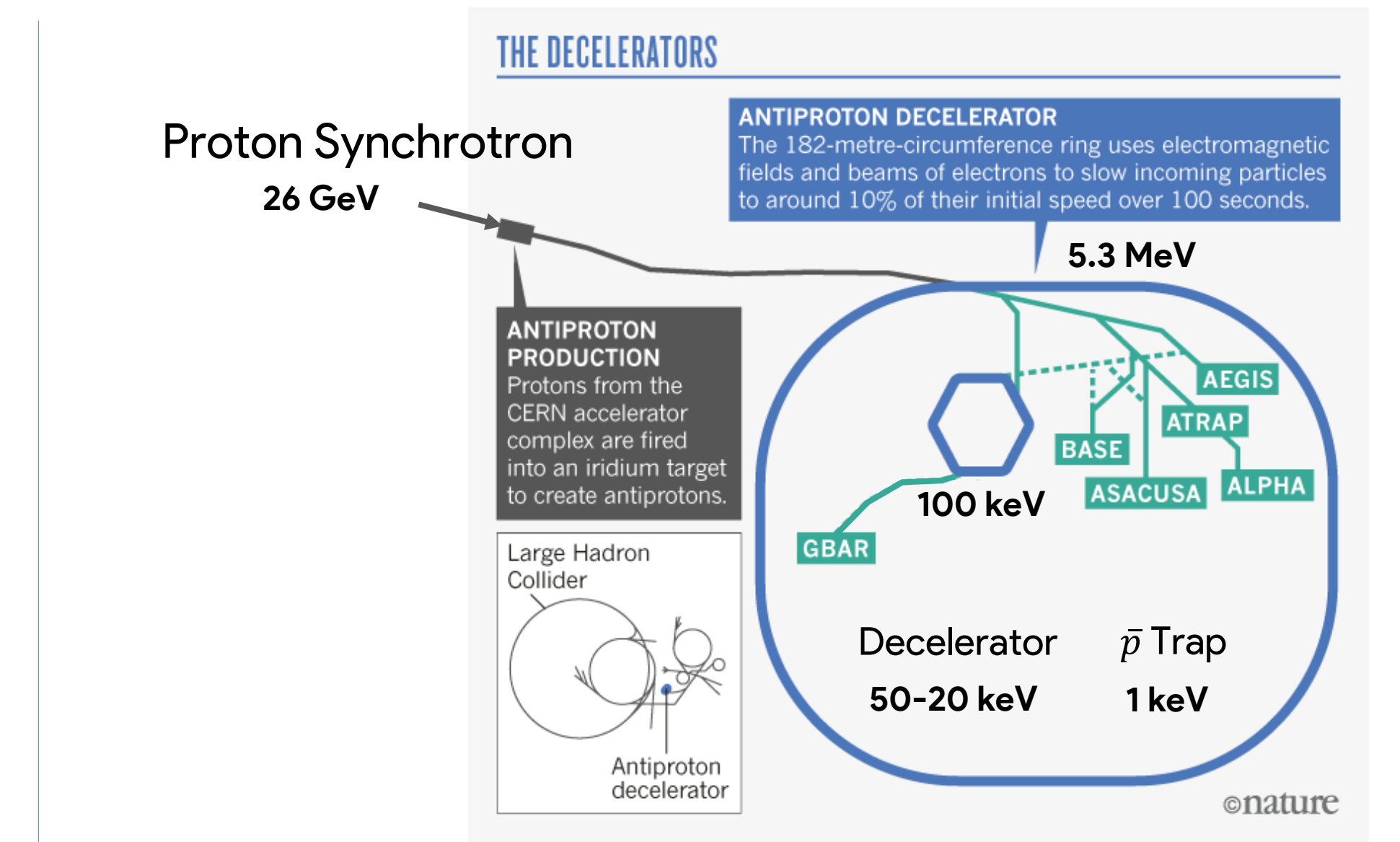


Figure 1 - Scheme of the GBAR experiment

Pérez, P. AD-7/GBAR status report for the 2019 CERN SPSC. No. CERN-SPSC-2019-005. 2019.

3. Proton Line

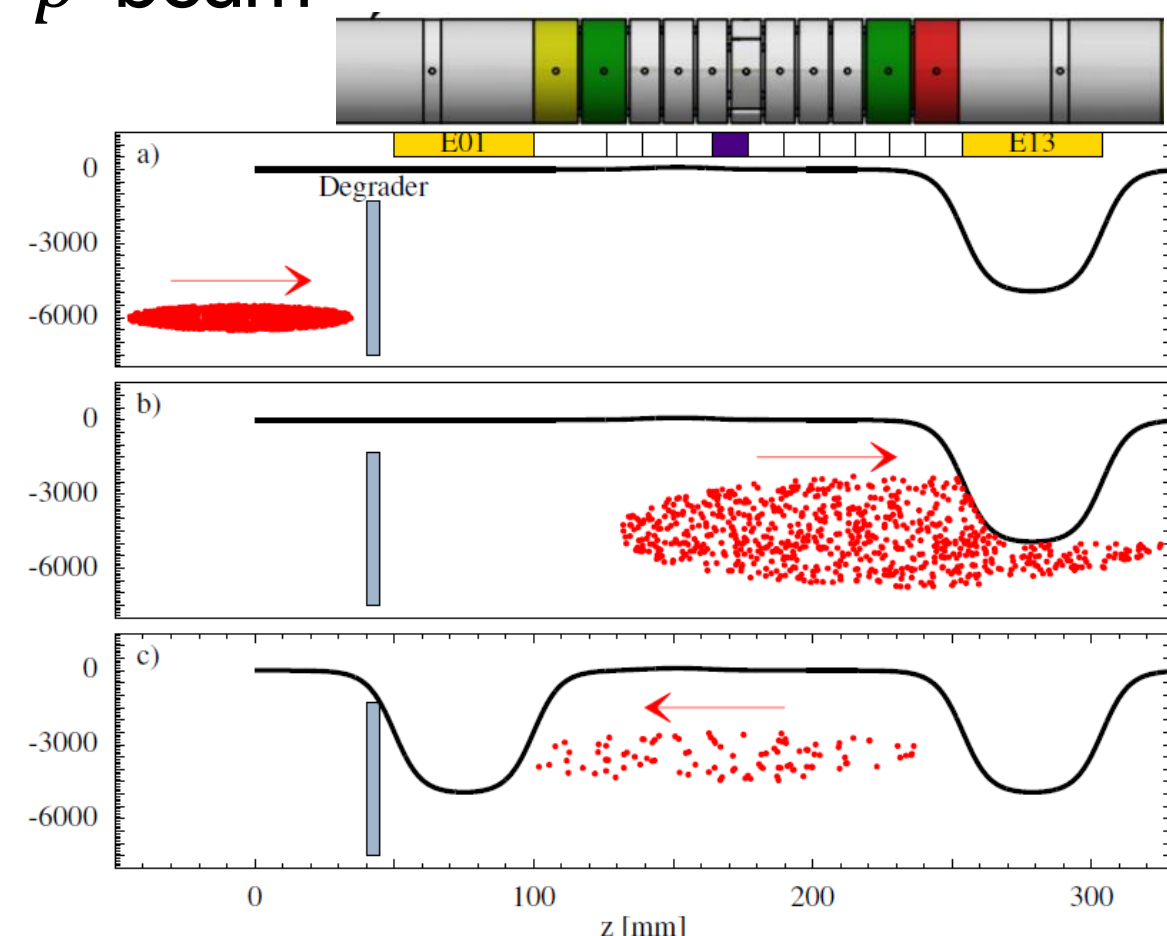


Gibney, Elizabeth. "The race to reveal antimatter's secrets." *Nature News* 548.7665 (2017): 20-23.

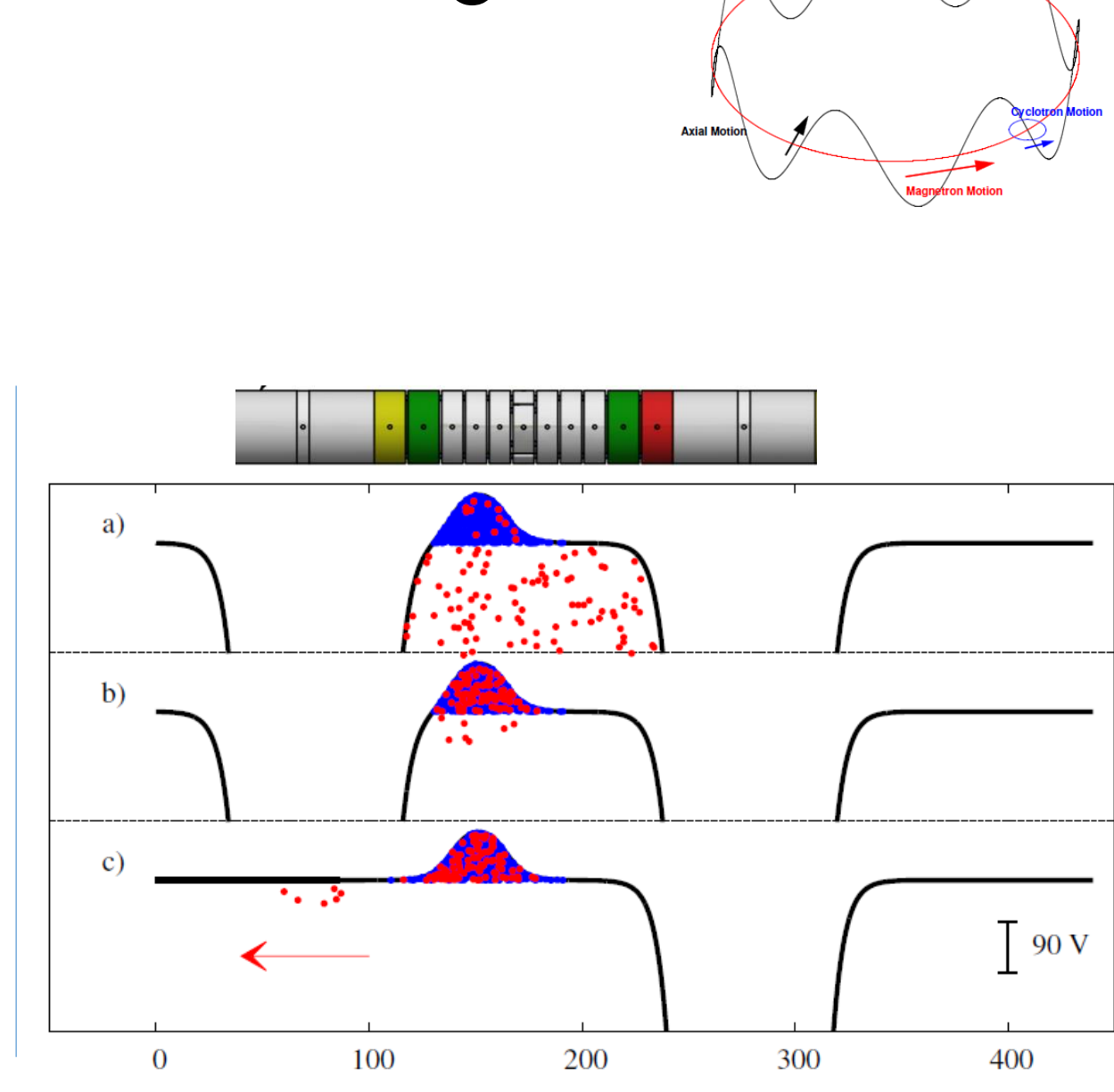
4. Sequence

4.1 Capture

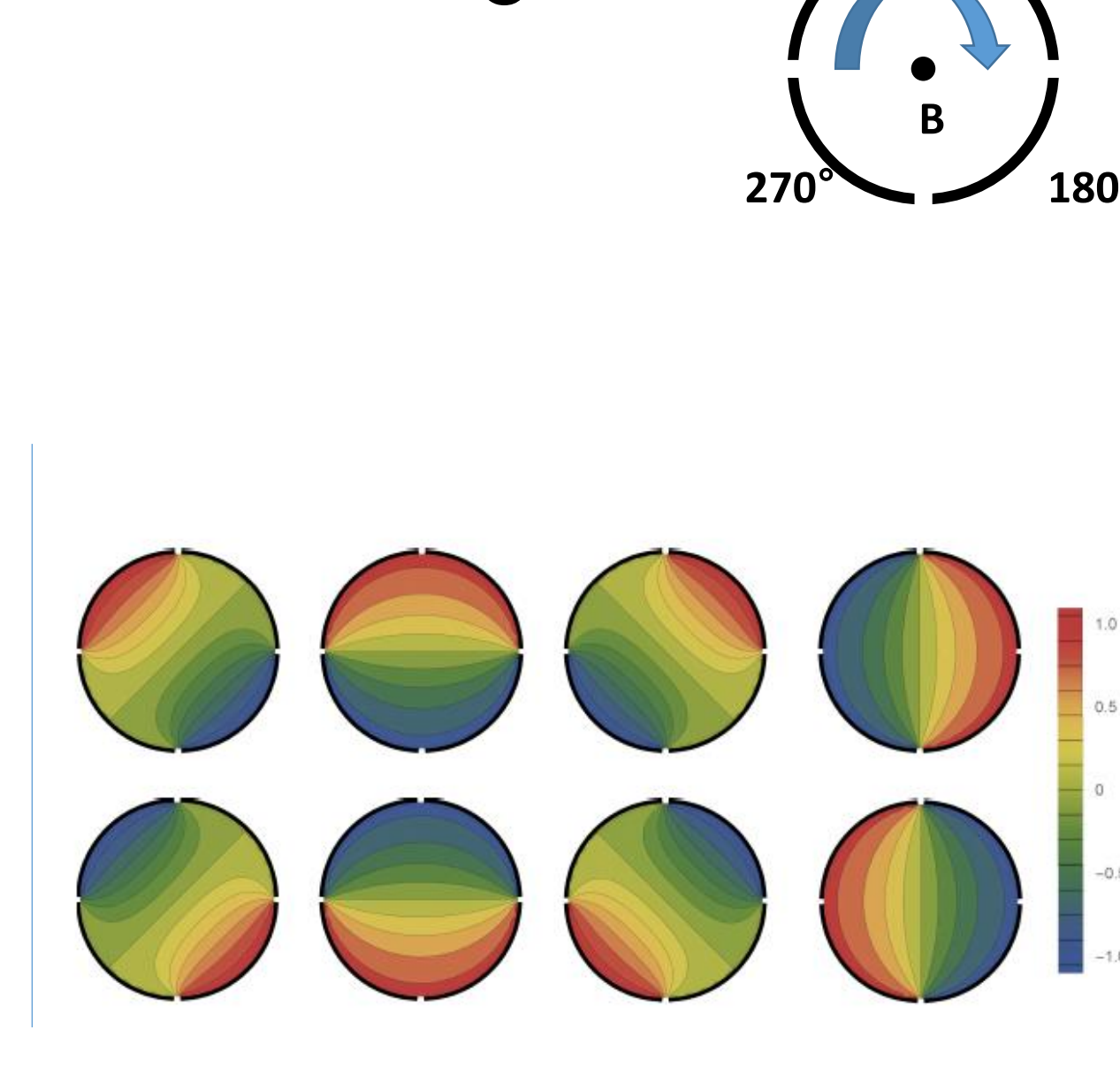
Apply High voltage (~5 kV) at both end of MRE to constrain $\bar{p}$ -beam



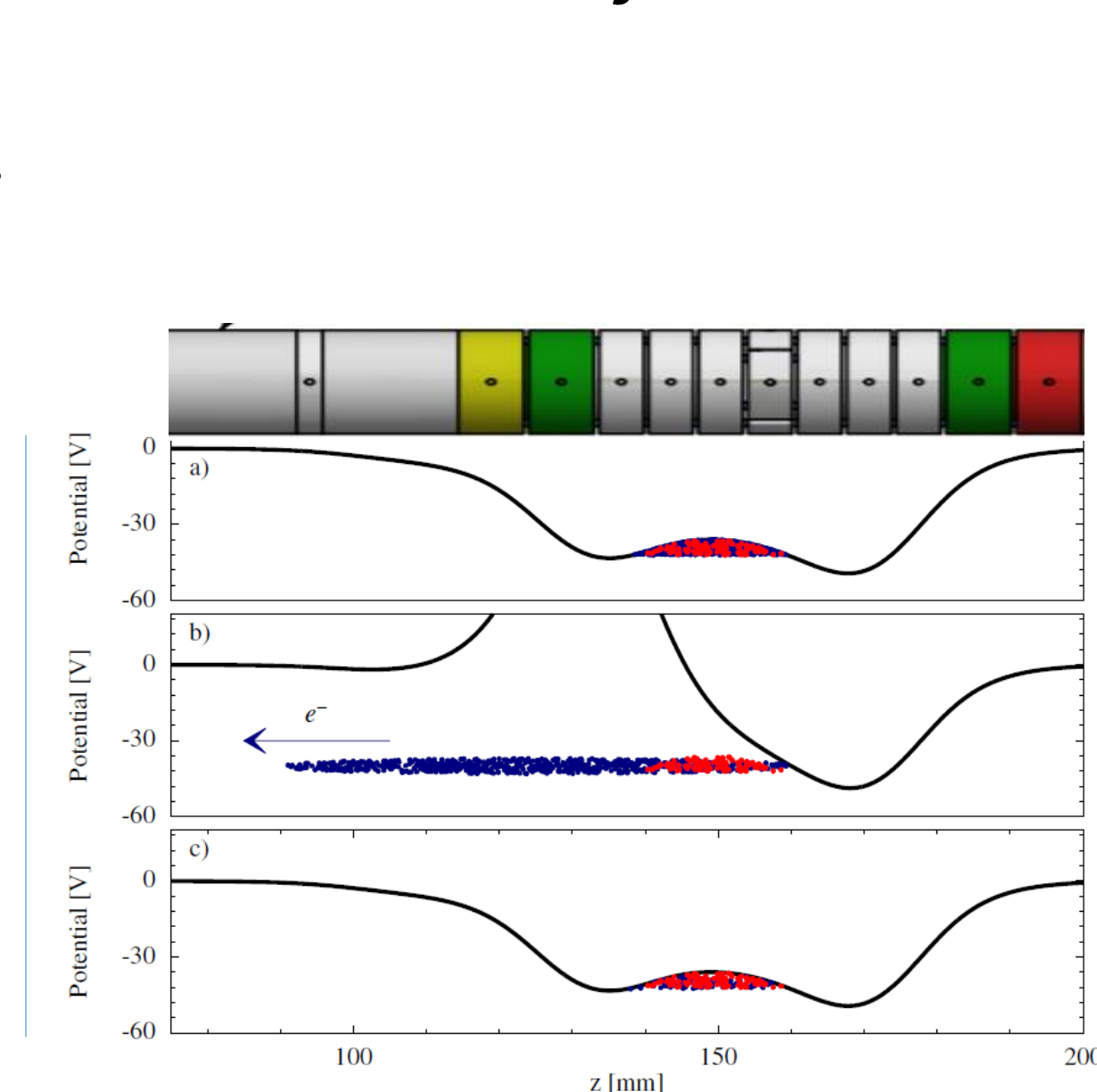
4.2 Cooling



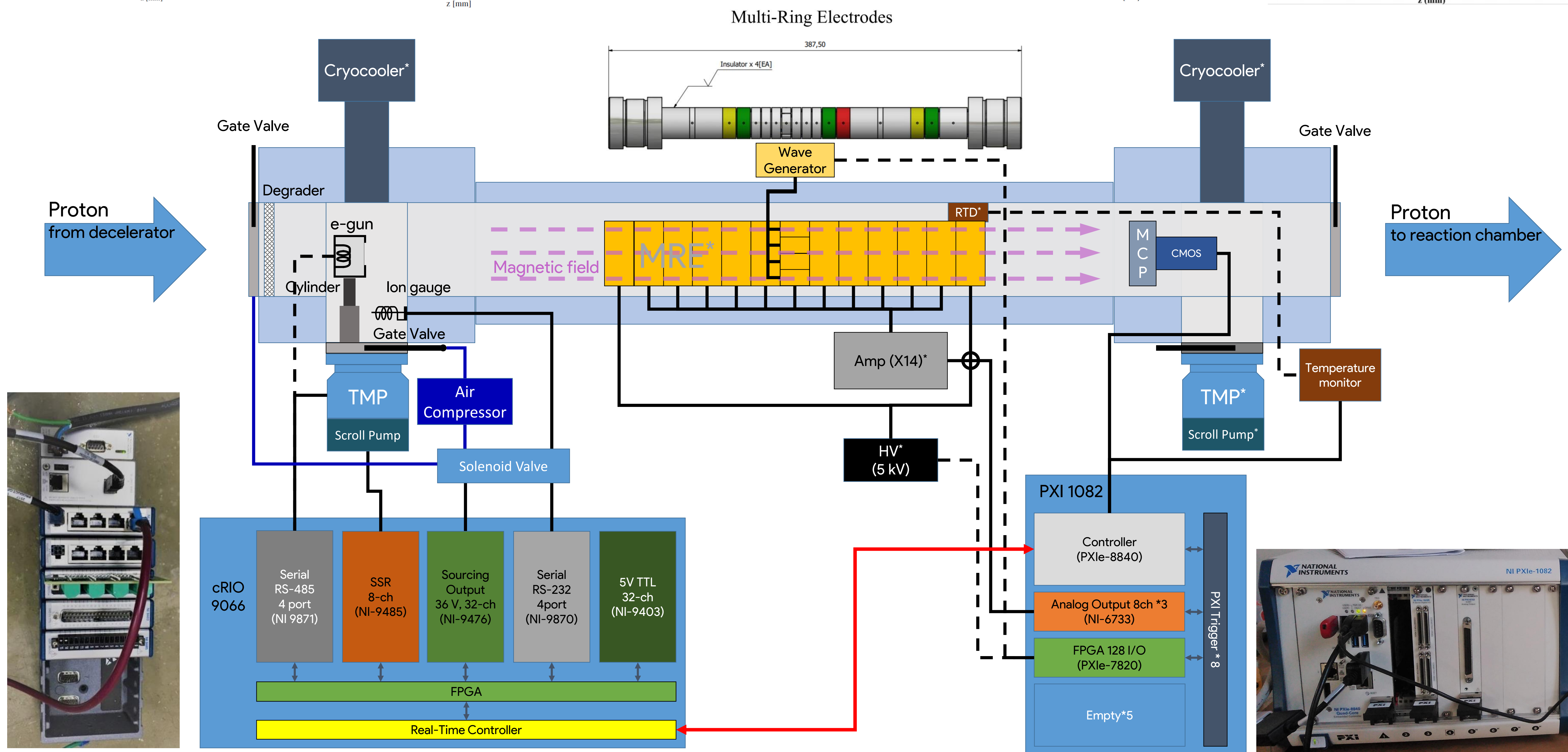
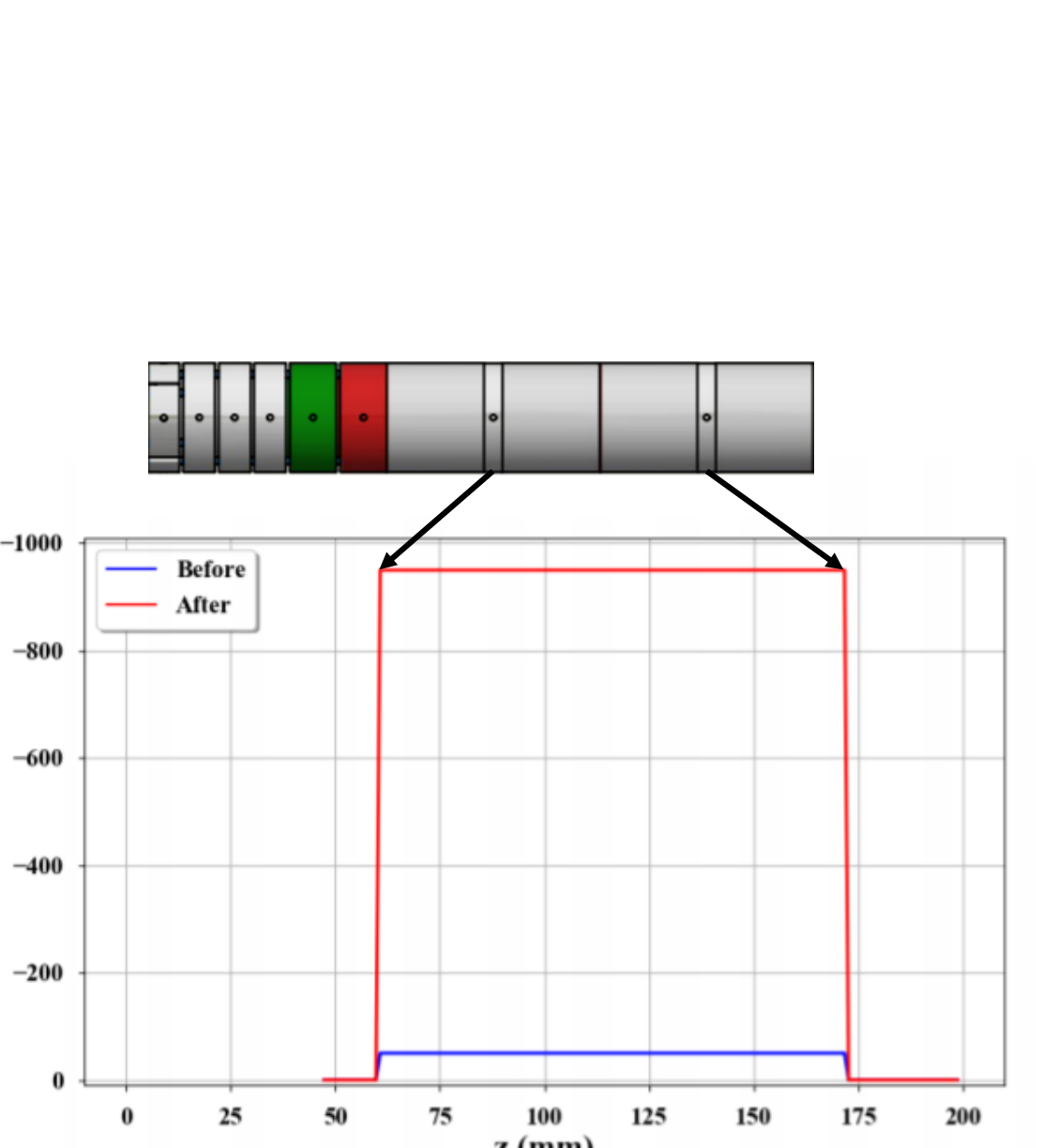
4.3 Rotating wall



4.4 electron Ejection



4.5 Re-acceleration



4. CompactRIO

- Real-Time (communication & signal process)
- FPGA (Safety Condition)
- Control and Monitor Vacuum parts
 - Gauges, Pump & Valves
- Control e-gun
 - E-gun & cylinder

6. Conclusion

5. PXI (PCI eXtensions for Instrumentation)

- Timing and synchronization trigger bus
- Controller
 - Human-Machine Interface
 - Monitor Beam & MRE Temperature
 - Communicate with cRIO
- FPGA
 - 12.5 ns time resolution
 - Sequence trigger
- Analog Output
 - Slew rate 15 V/μs
 - Control MRE voltage