Bound Electron g-factor Measurements at ARTEMIS

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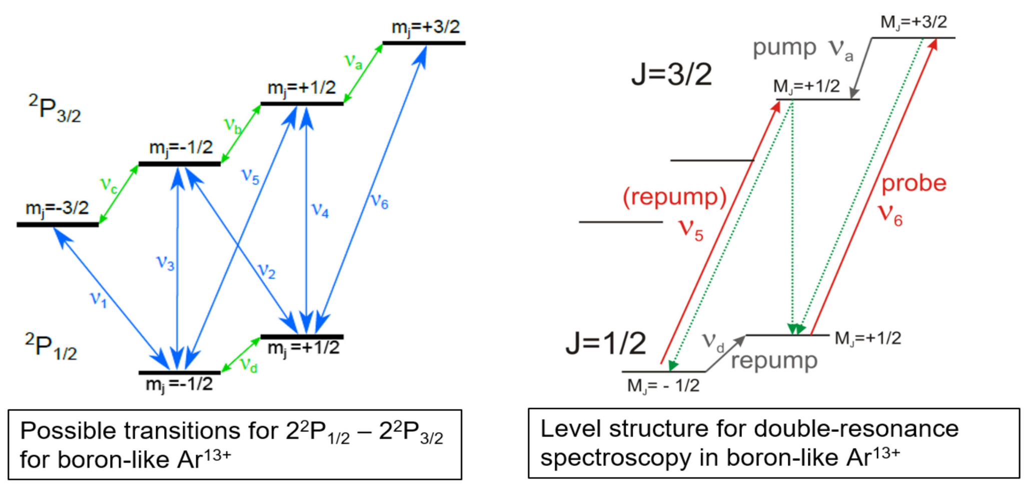
Measurement Principle

LASER-MICROWAVE DOUBLE-RESONANCE SPECTROSCOPY



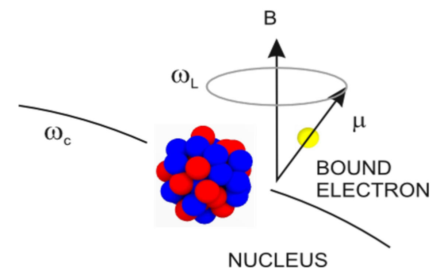
Possible transitions for $2^2P_{1/2} - 2^2P_{3/2}$ for boron-like Ar^{13+}

Level structure for double-resonance spectroscopy in boron-like Ar^{13+}

2p fine structure splitting ~ Z^4; here: λ = 441nm, ν_a = 130GHz, ν_d = 65GHz

Larmor frequency of the bound electron:

$$\omega_L^e = \frac{g_J}{2}\frac{e}{m_e}B$$



Ion cyclotron frequency:

$$\omega_c^{ion} = \frac{Q}{M_{ion}}B$$

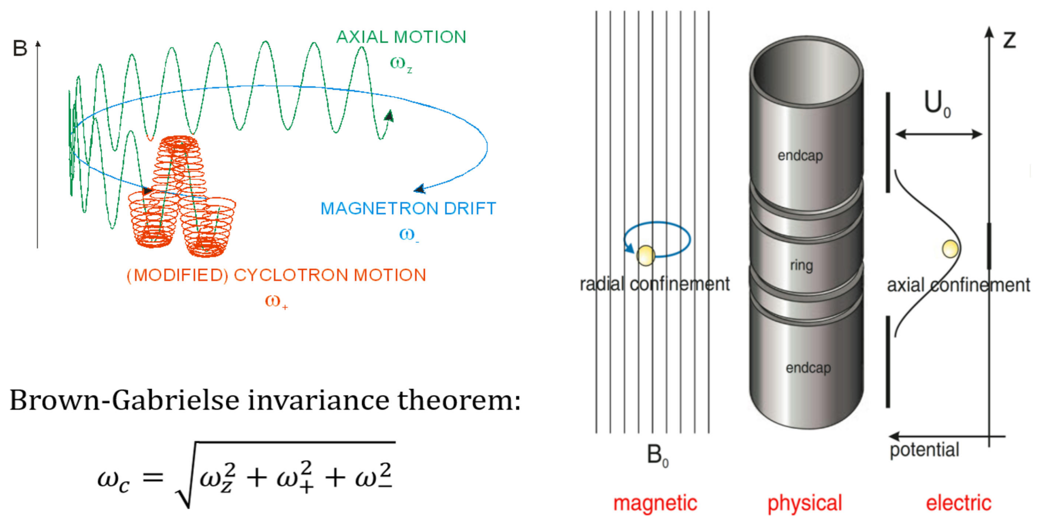
$$g_J = 2\cdot\frac{\omega_L^e}{\omega_c^{ion}}\cdot\frac{m_e}{M_{ion}}\cdot\frac{Q^{ion}}{e}$$

→ 'experimental g-factor' → comparison with theory

our measurement

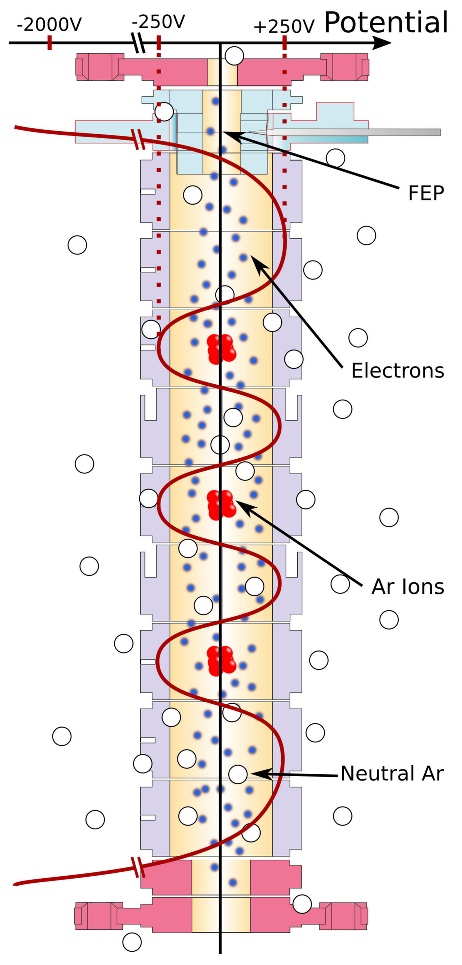
external input parameter

ION MOTION IN A TRAP

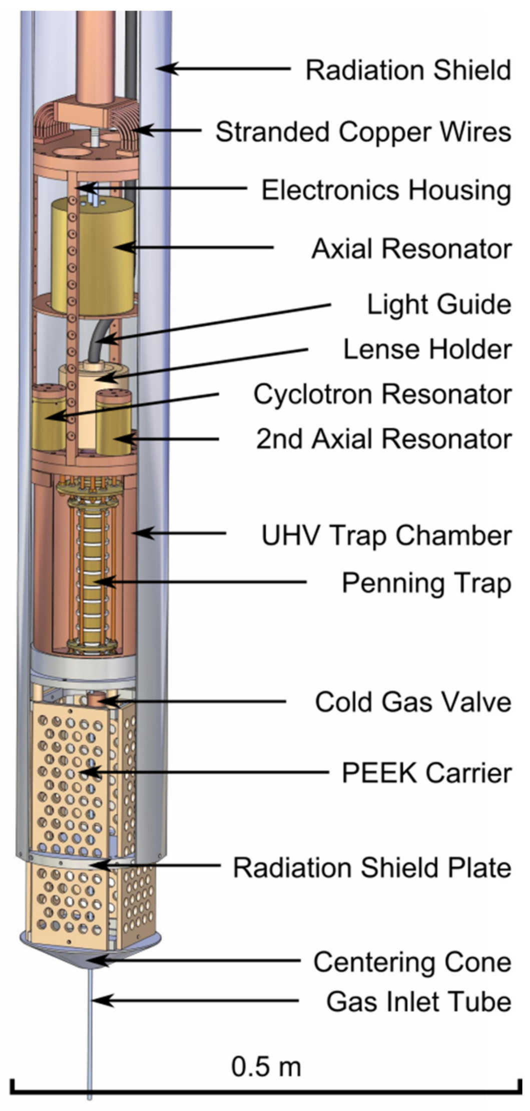


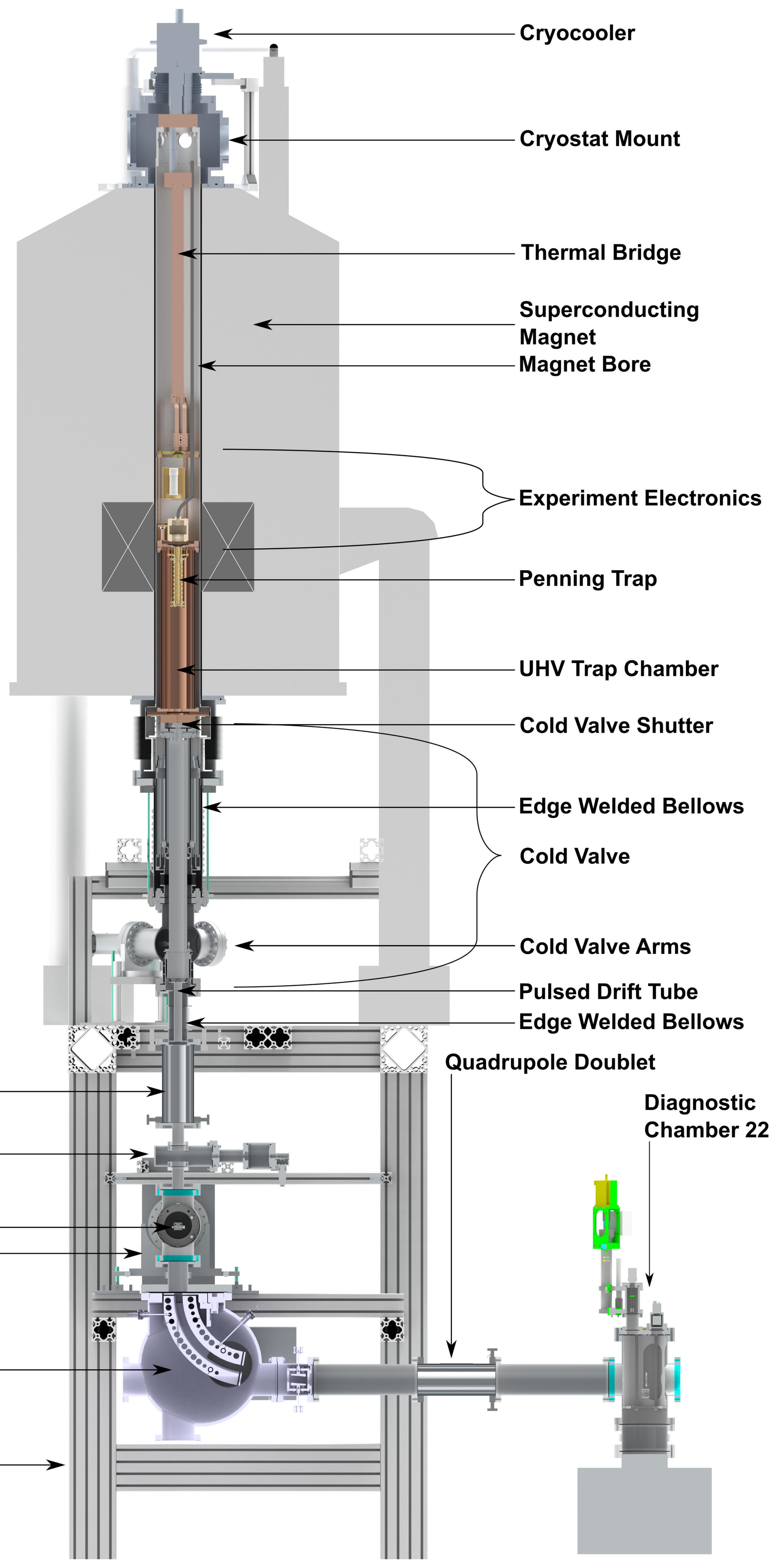
Brown-Gabrielse invariance theorem:

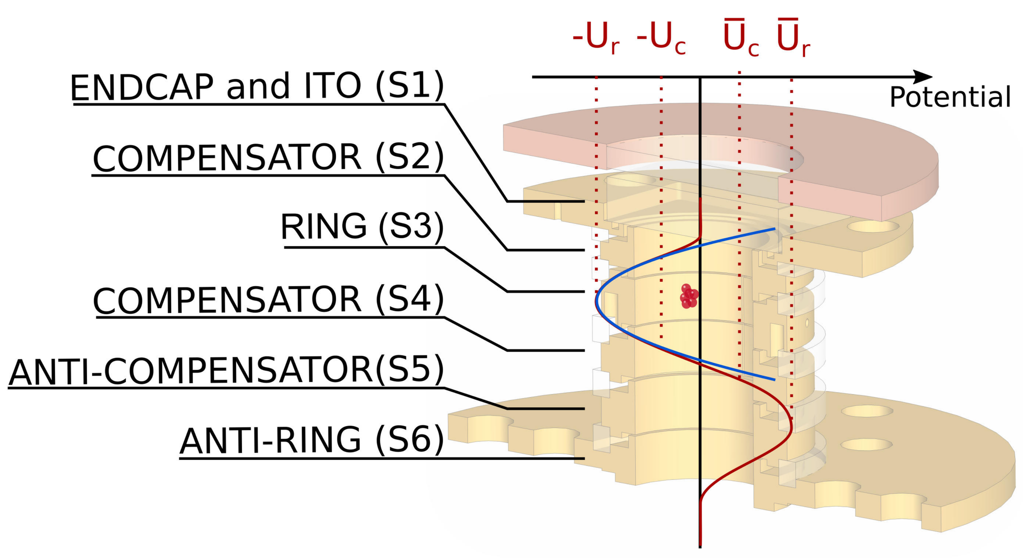
$$\omega_c = \sqrt{\omega_z^2 + \omega_+^2 + \omega_-^2}$$



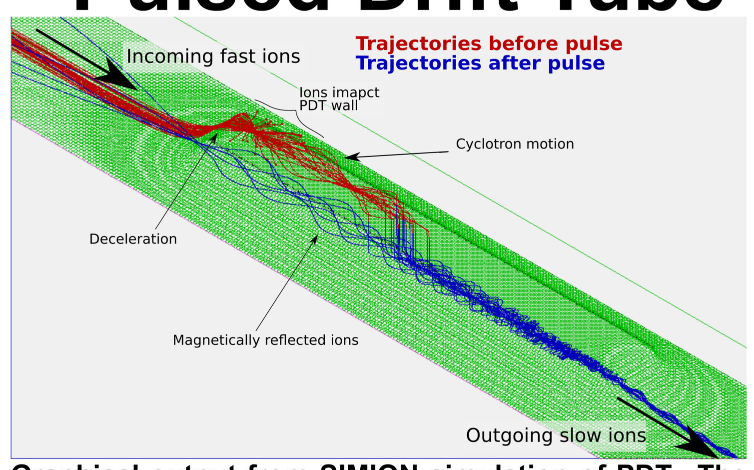
The CT can be used as a mini-EBIT to directly create ions inside. A field emission point creates an electron current that ionizes neutral gas atoms inside the trap. The trap potential is nested so that both the electrons and resulting ions are contained. The neutral gas atoms are injected from a crogenic valve at the bottom of the trap container.



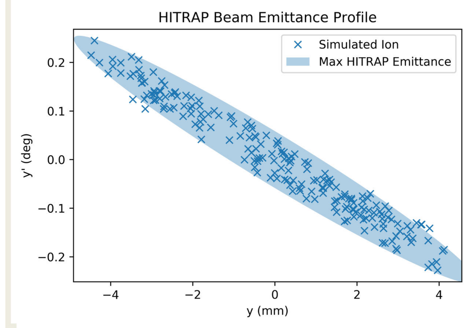




Pulsed Drift Tube

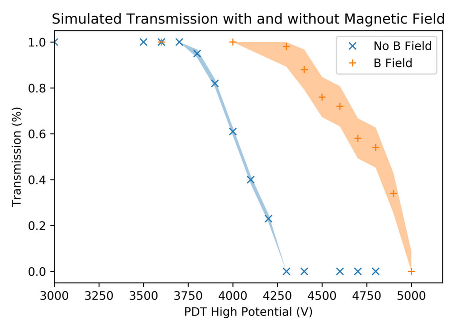


Graphical output from SIMION simulation of PDT. The effects of electrostatic lensing, magnetic mirror and cyclotron motion can be seen.

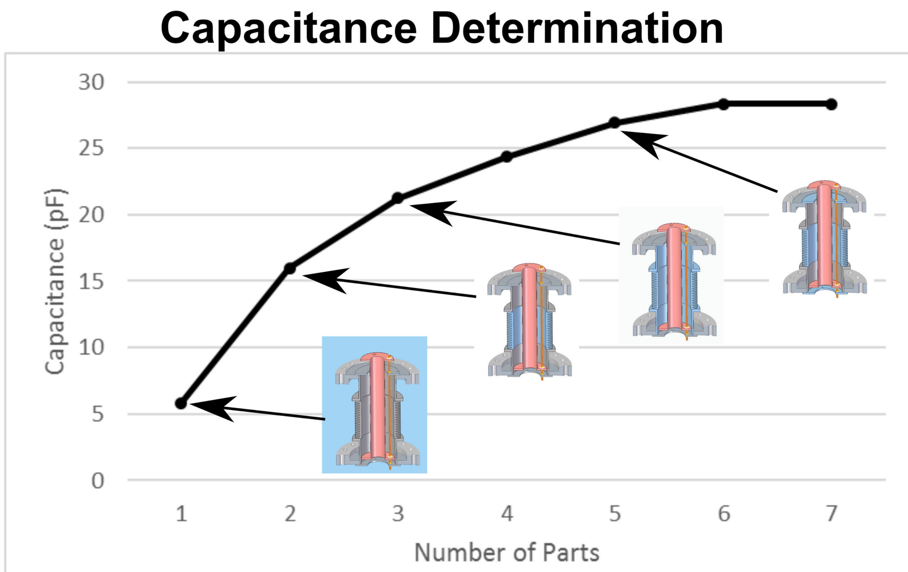


HITRAP beamline emmitance is about 5π mm mrad. Here the emittance of an ion bunch in SIMION is shown to have the same profile at maximum convergence.

Strong lensing as the ions enter the PDT limits the transmission. However, the strong magnetic field gradient significantly increases the possible PDT voltages.

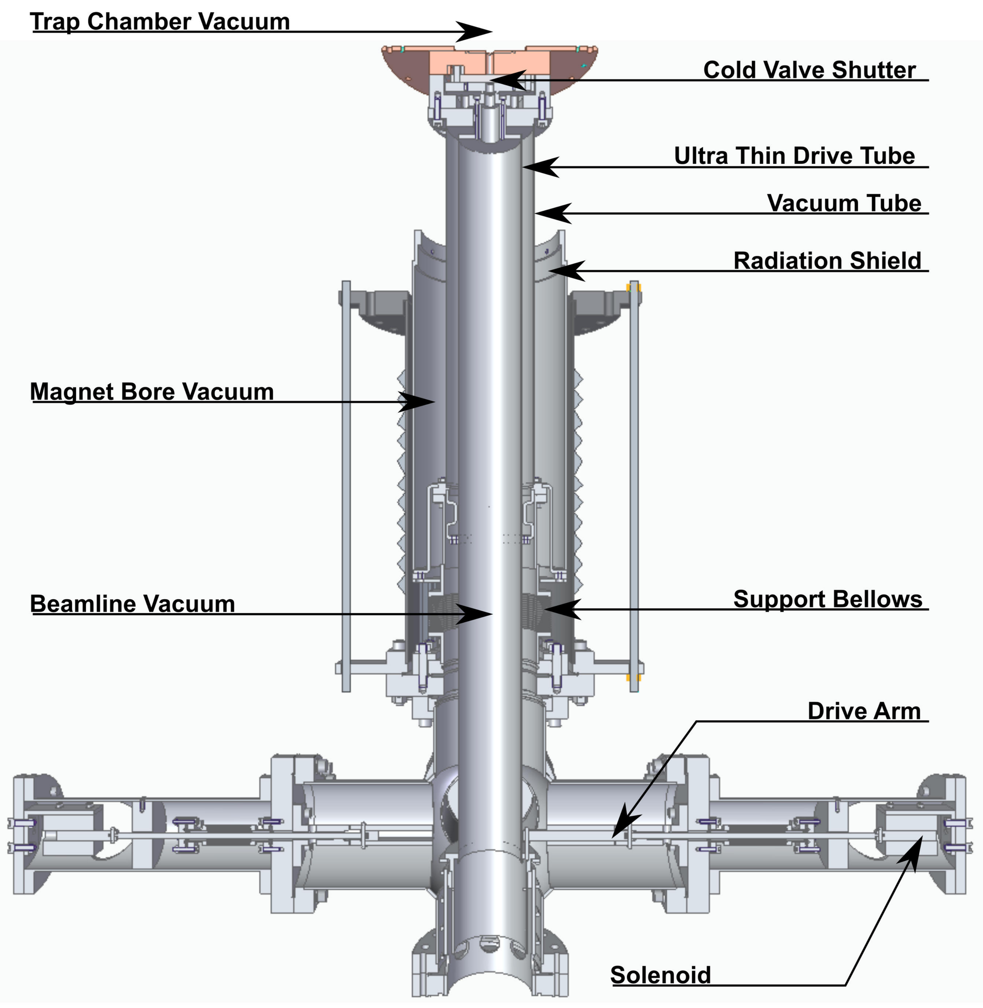


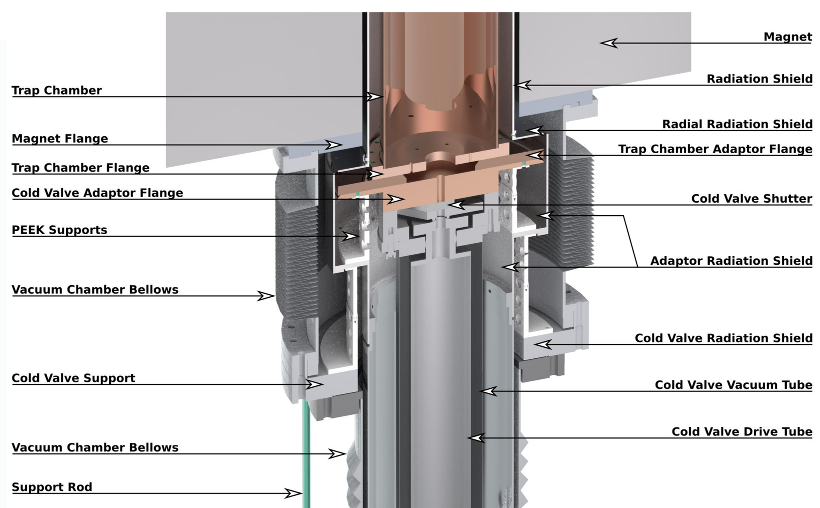
Capacitance Determination



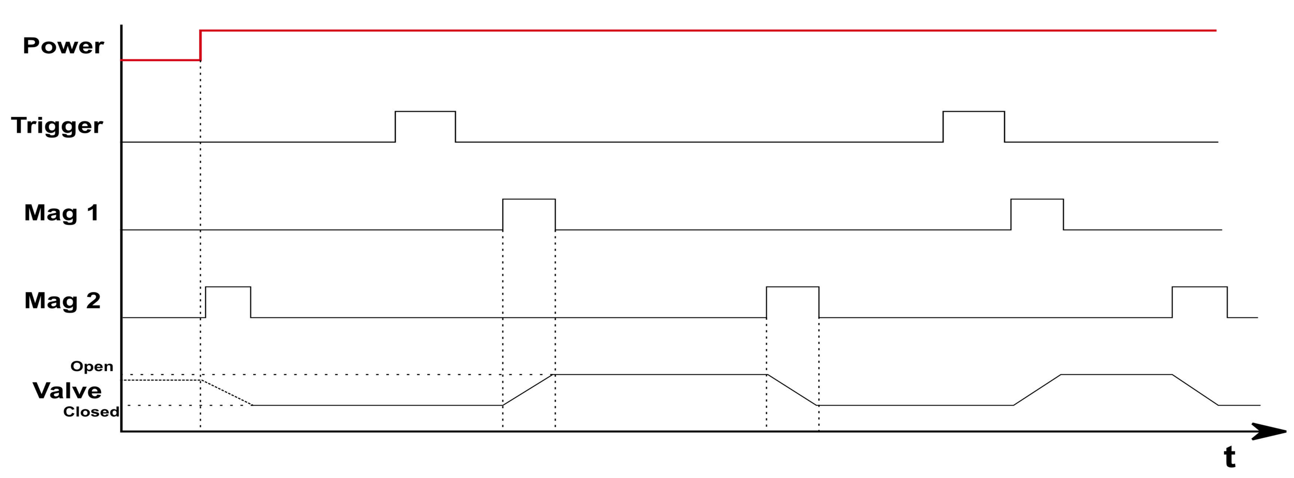
To determine the appropriate pulser for the PDT the capacitance as seen by the pulser is needed in addition to the required pulse time and voltages. Here the capacitance was simulated with varying ground conditions, as shown in blue. The capacitance converges to less than 50 pF when all neighbouring conductors are added.

Cold Valve

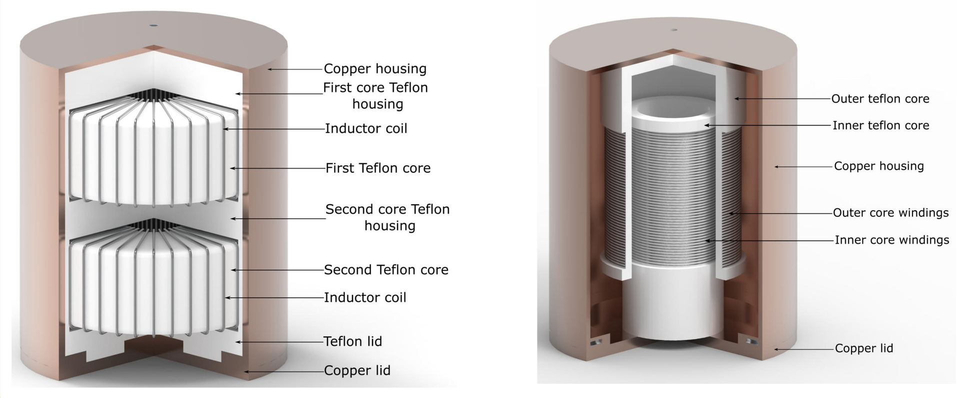




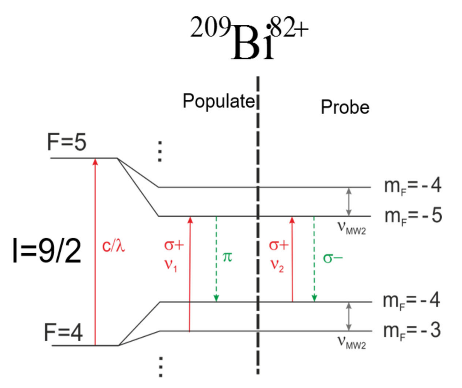
The Cold Valve isolates the ultra high vacuum in the trap chamber (~ 10^-15 mbar) from the HITRAP beamline. The strong temperature gradient is possible due to the ultra thin drive tube that serves as vacuum isolation between the beamline vacuum and the magnet bore. This temperature gradient (from 300K to <10K) will also create a large pressure gradient as residual gas molecules stick to the walls. A straight path from the beamline to the trap chamber is blocked by a rotatable shutter, which is controlled by the drive tube.



Dual-core resonator design

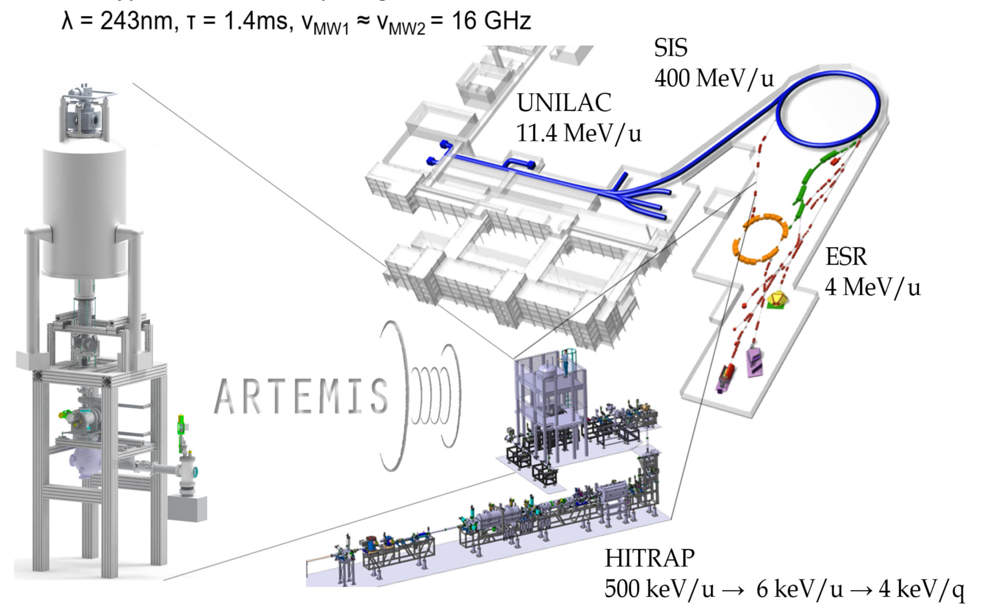


Outlook



Laser-microwave double-resonance technique to be used to measure the g-factor of heavy highly charged ions such as H-like Bismuth and H- like Uranium.

1s hyperfine-structure splitting ~ Z^3, here: λ = 243nm, τ = 1.4ms, $\nu_{MW1} \approx \nu_{MW2}$ = 16 GHz



Measurements