MANCHESTER 1824

The University of Manchester

The Cockcroft Institute of Accelerator Science and Technology

Cold free electron bunches from cold atoms trapped in an AC-MOT

Matthew Harvey

Cockcroft Institute &

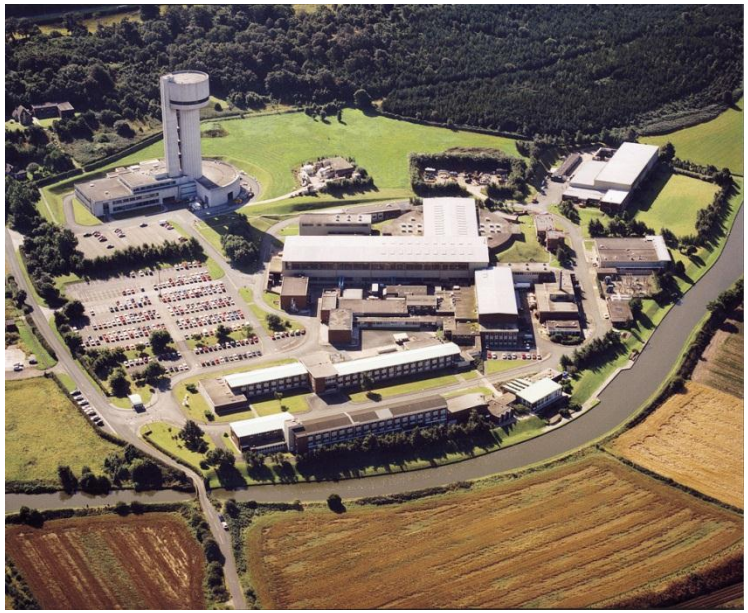
The University of Manchester

Outline

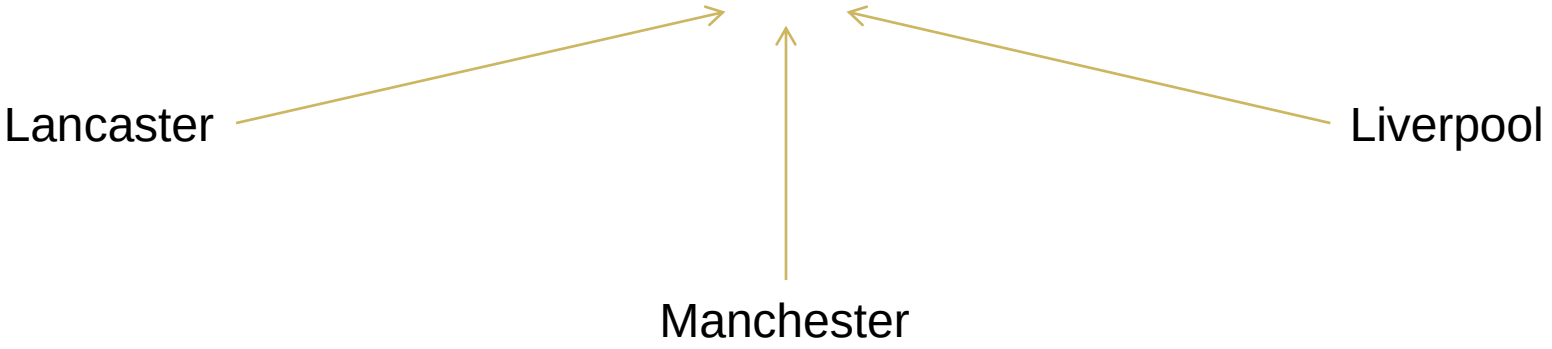
- Building a new cold electron source from trapped atoms
- Who are we?
- How we hope to produce cold electrons
- AC-MOT for rapidly switching off trap B field

The Cockcroft Institute
Daresbury Laboratory

Photon Science Institute
University of Manchester



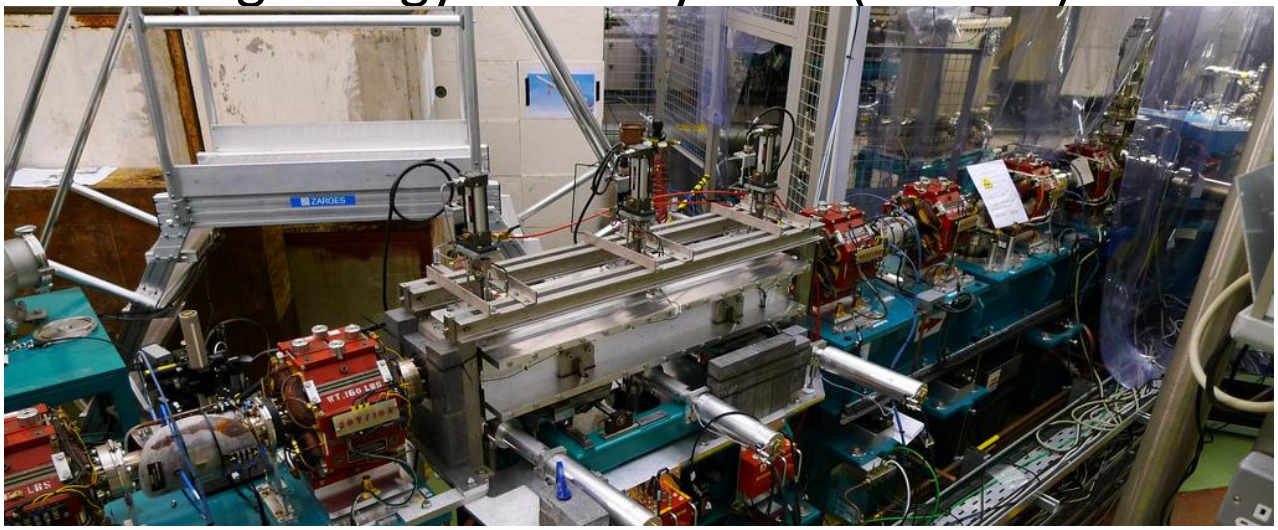
Cockcroft Institute



- Based at Daresbury laboratory
- Brings together academia, national labs and industry
  - Accelerator scientists and engineers
- Designs, develop and tests cutting edge accelerator technology
- Good vacuum research laboratory
- Home to Accelerator Physics Group
- Laser wakefield acceleration research

ALICE FEL

- ALICE (Accelerators and Lasers In Combined Experiments)
- 35 MeV superconducting energy recovery linac (EU first)
- 5-9µm
- ~1ps FWHM
- 3.6MW (peak)



Laser wakefield acceleration

- Cockcroft Institute developing a new type of accelerator
- World records: 1 GeV/cm (LBNL), 42 GeV in 85 cm (SLAC)
- Best conventional RF accelerator takes 64 m to reach 1 GeV
- Problem is shot to shot variation
- Possible solution to increase brightness and coherence is to inject with cold electrons

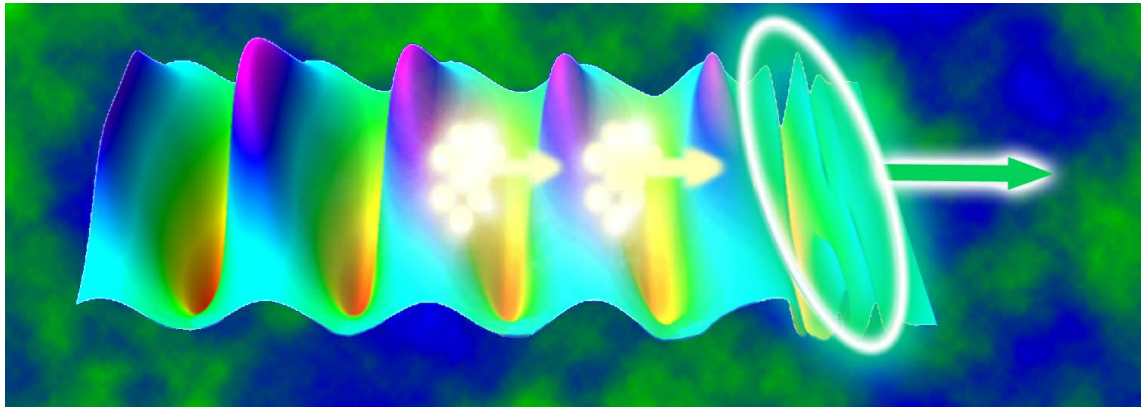


*image from Berkeley Nat. Lab website

X-FEL

- No X-ray mirrors
- Need long undulators for SASE (self amplified stimulated emission)
- Current X-FELs require > 1 GeV and high current beam

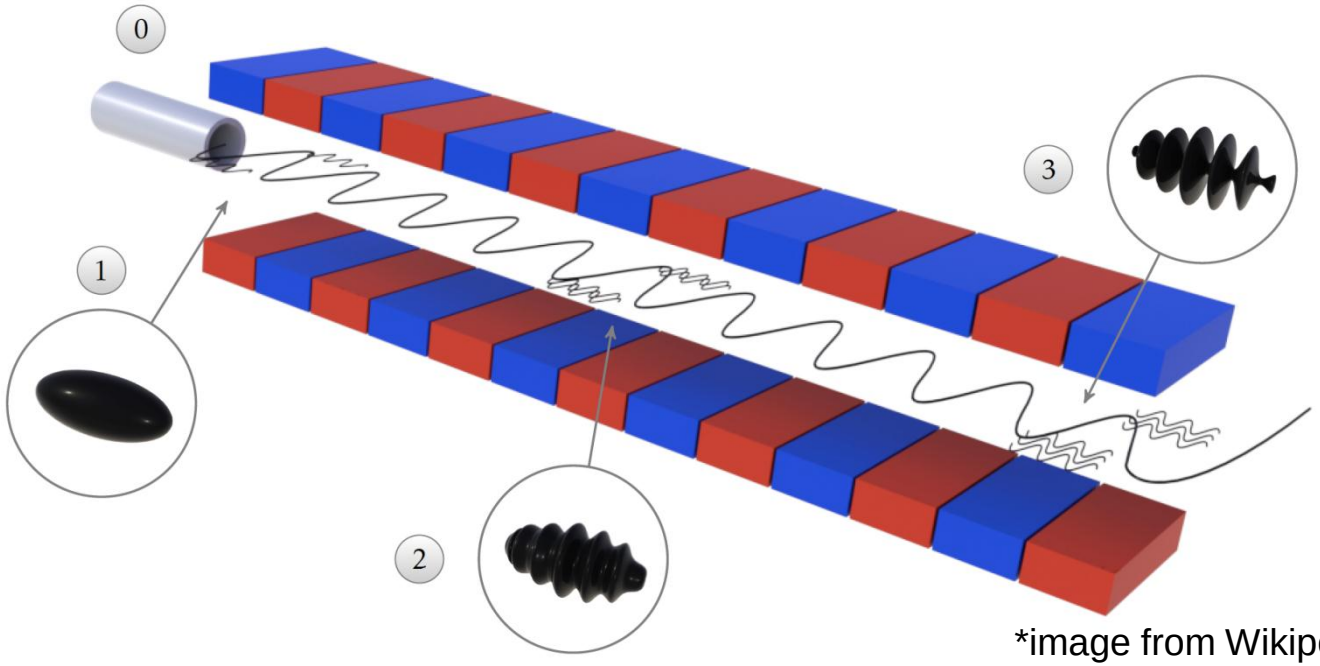
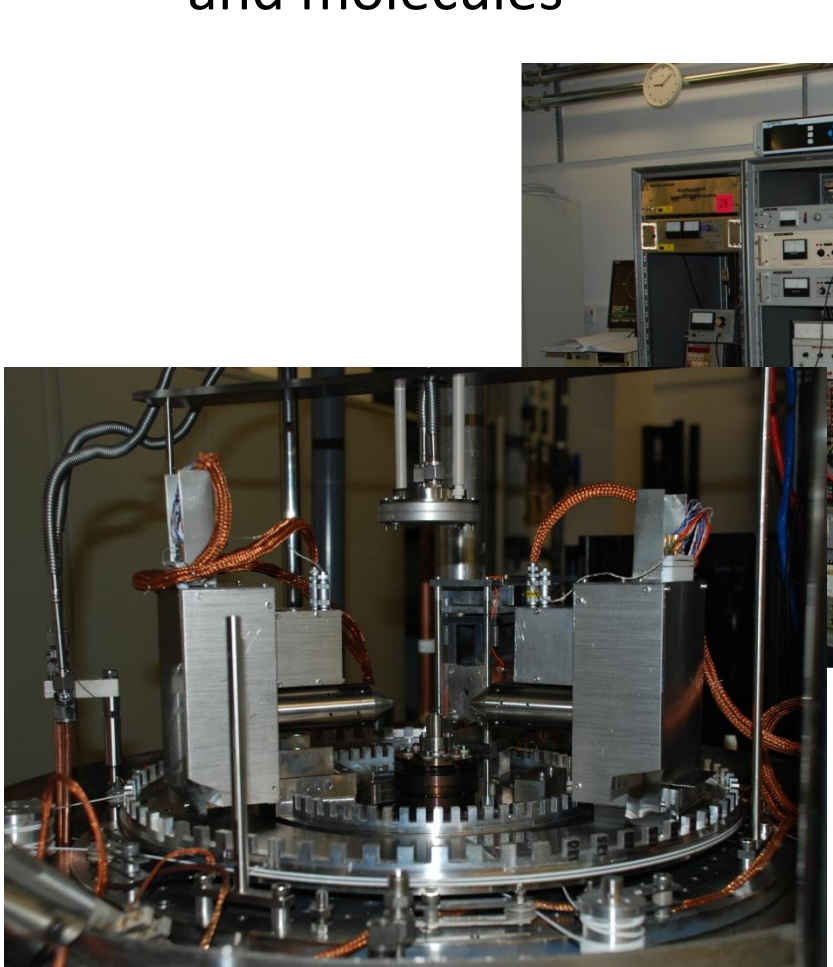
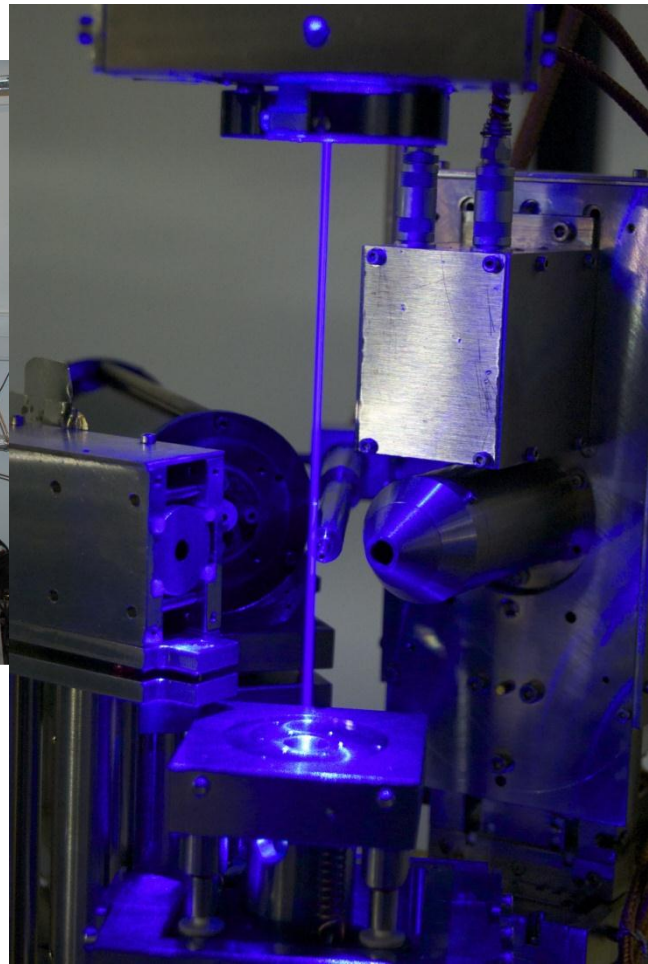


*image from Wikipedia

Atomic & Molecular Interactions Group

- Specialises in low energy electron collision studies with atoms and molecules





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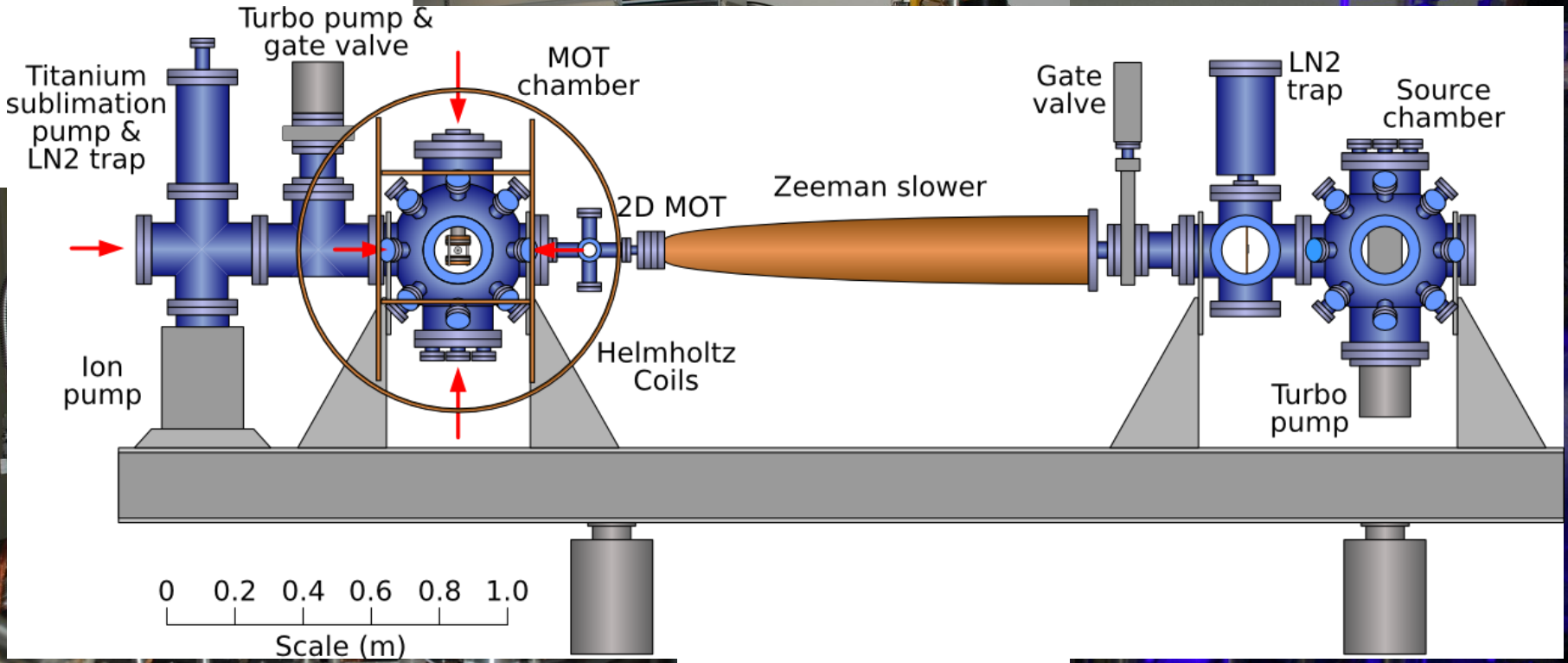
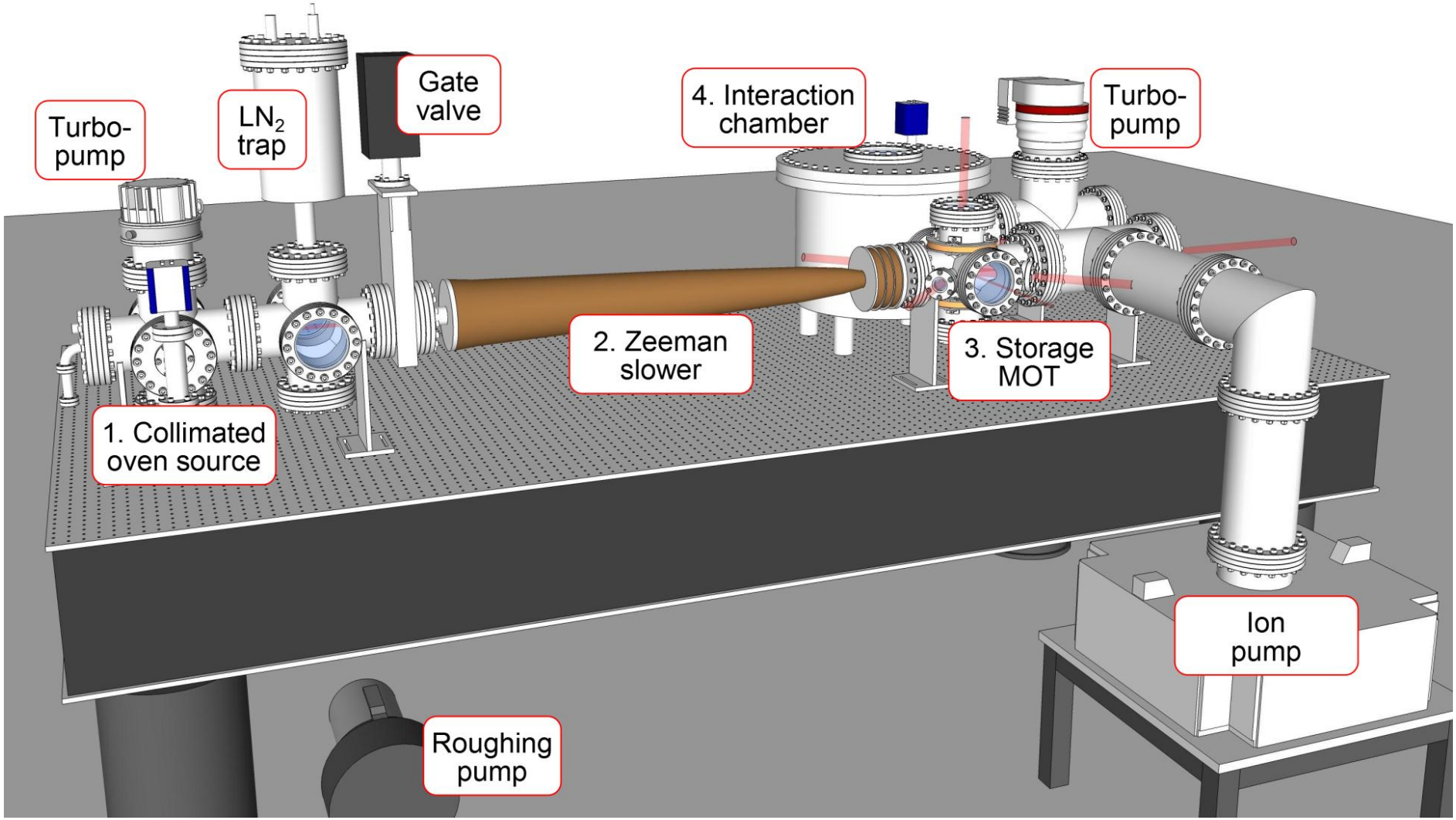


AMI's interest

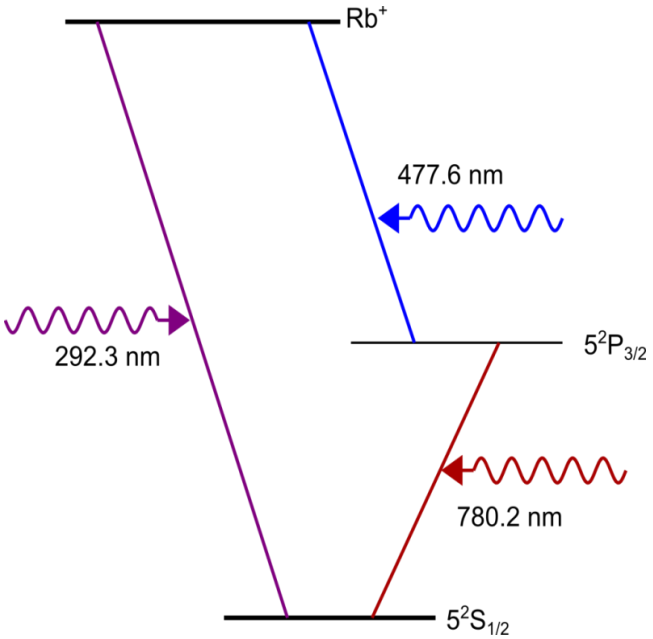
- Tune the source for large flux with low energy and spread
- Open a range of new experiments
- Look for negative ion resonances in noble gases
  - very sharp features (~ meV)
  - e.g. Argon 2s2 resonance: 19.366 eV with width 9 meV
- Metastable excitation in noble gases
  - Sharp onsets
  - Sufficient energy to be detected by channeltron
- Modify a commercial LEED spectrometer by replacing its electron source.

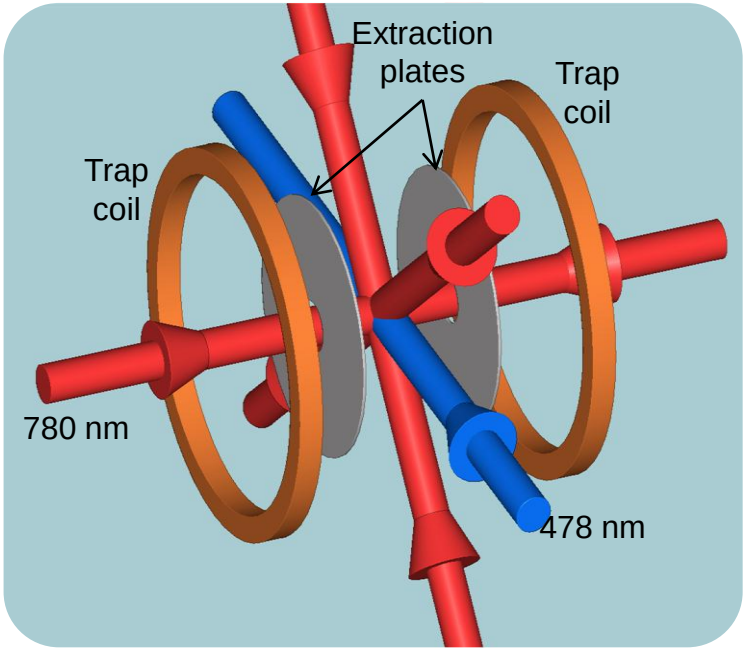
New cold electron source



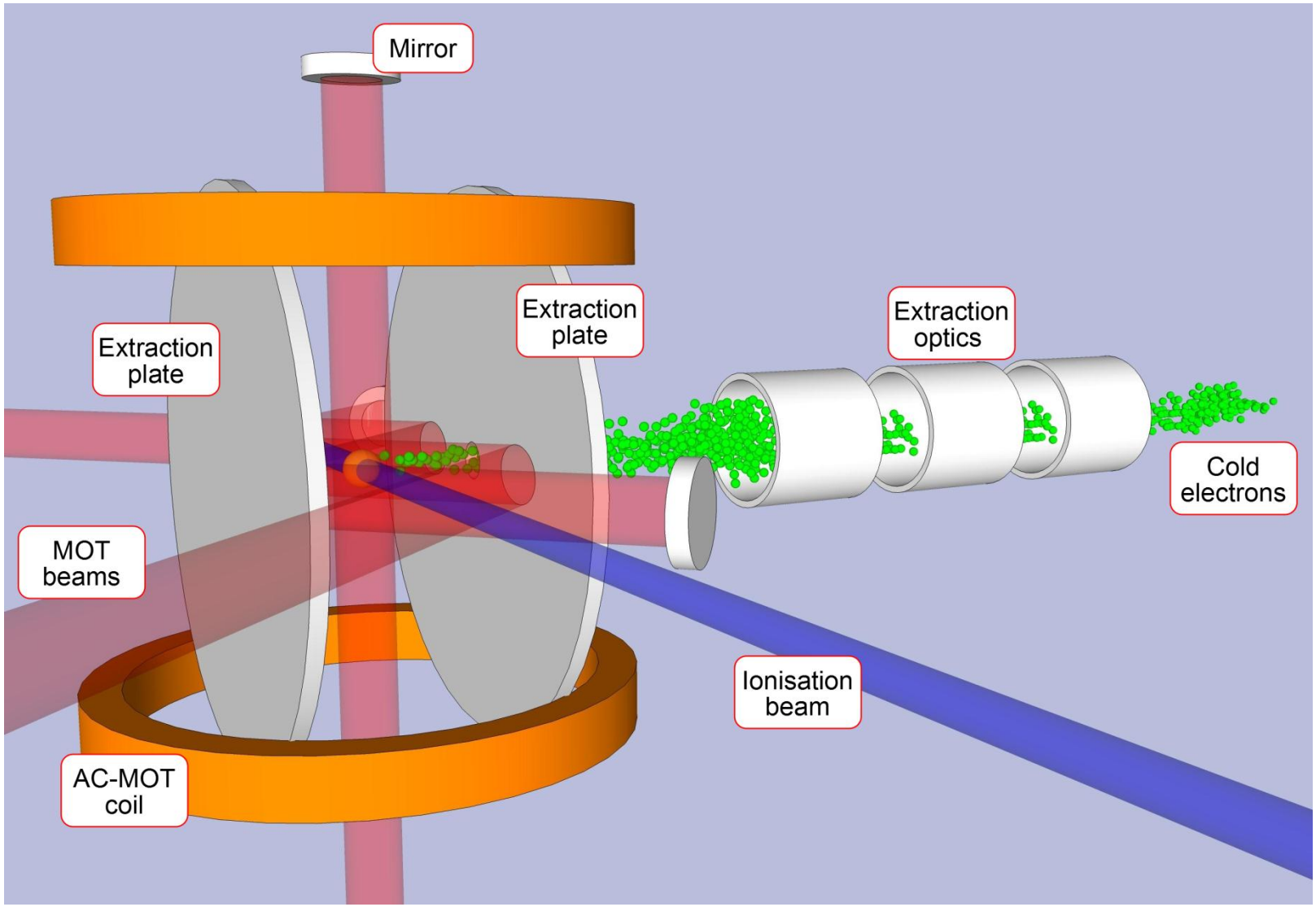
Photoionization and extraction

- Direct ionization from $S_{1/2}$ ground state
  - Freq. doubled CW or pulsed dye laser
- Excitation to $P_{3/2}$ excited state followed by ionization
  - Freq. doubled CW or pulsed Ti:Sapph
  - More options to shape charge cloud





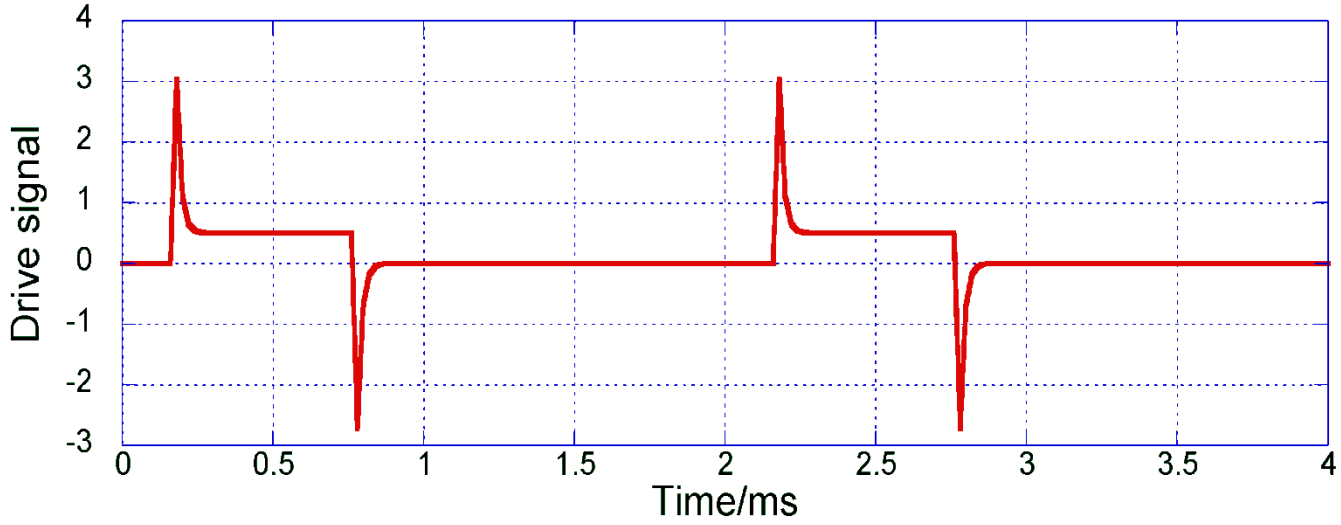
Photoionization and extraction



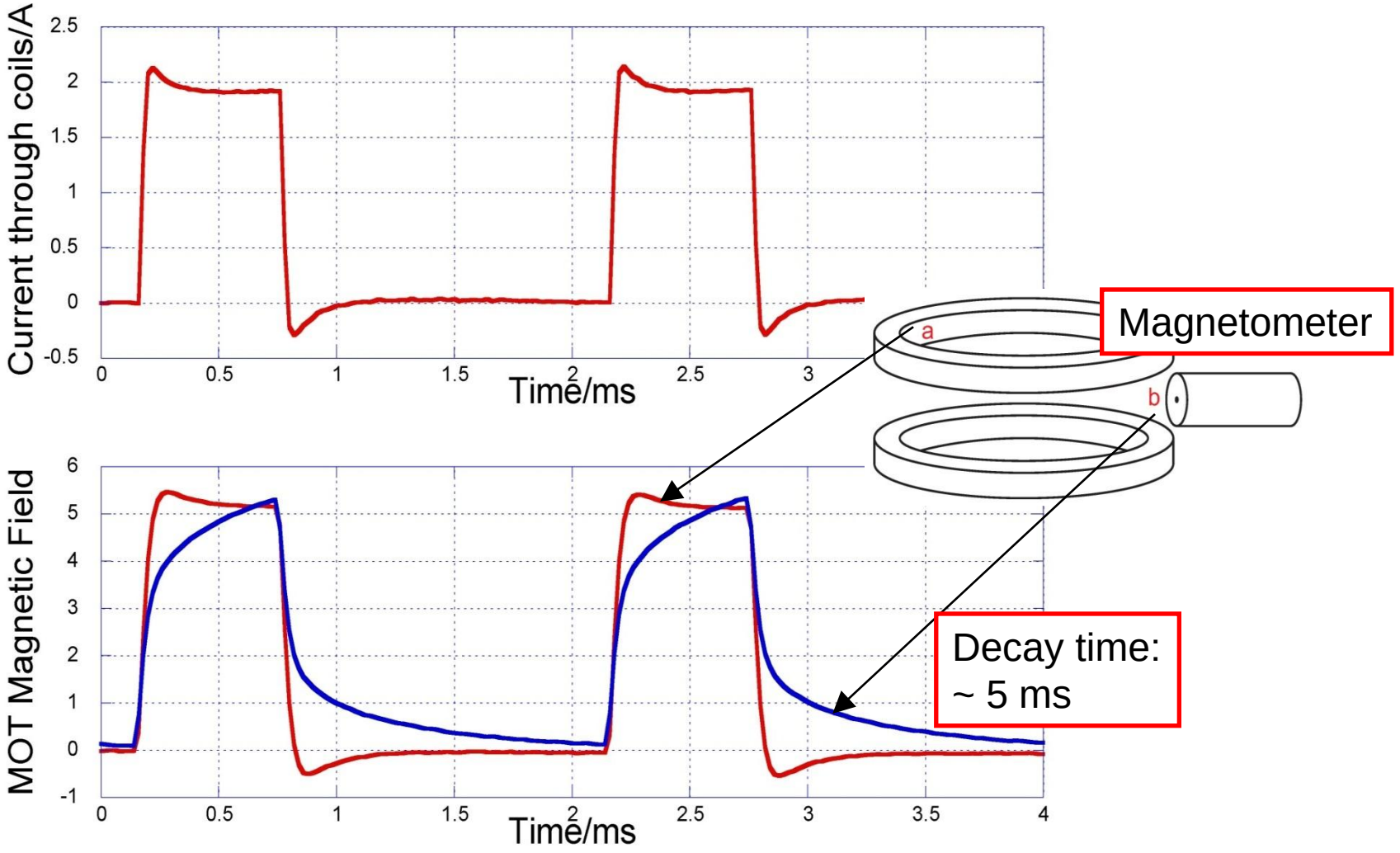
Problem: Magnetic field

- Can not perform low energy electron scattering in presence of magnetic field
- Can not just switch off current
  - Coils and chamber surroundings **inductive**
  - Get significant eddy currents in chamber and components inside
- Tried things like e.g. using feedback to actively shape current to desired square waveform

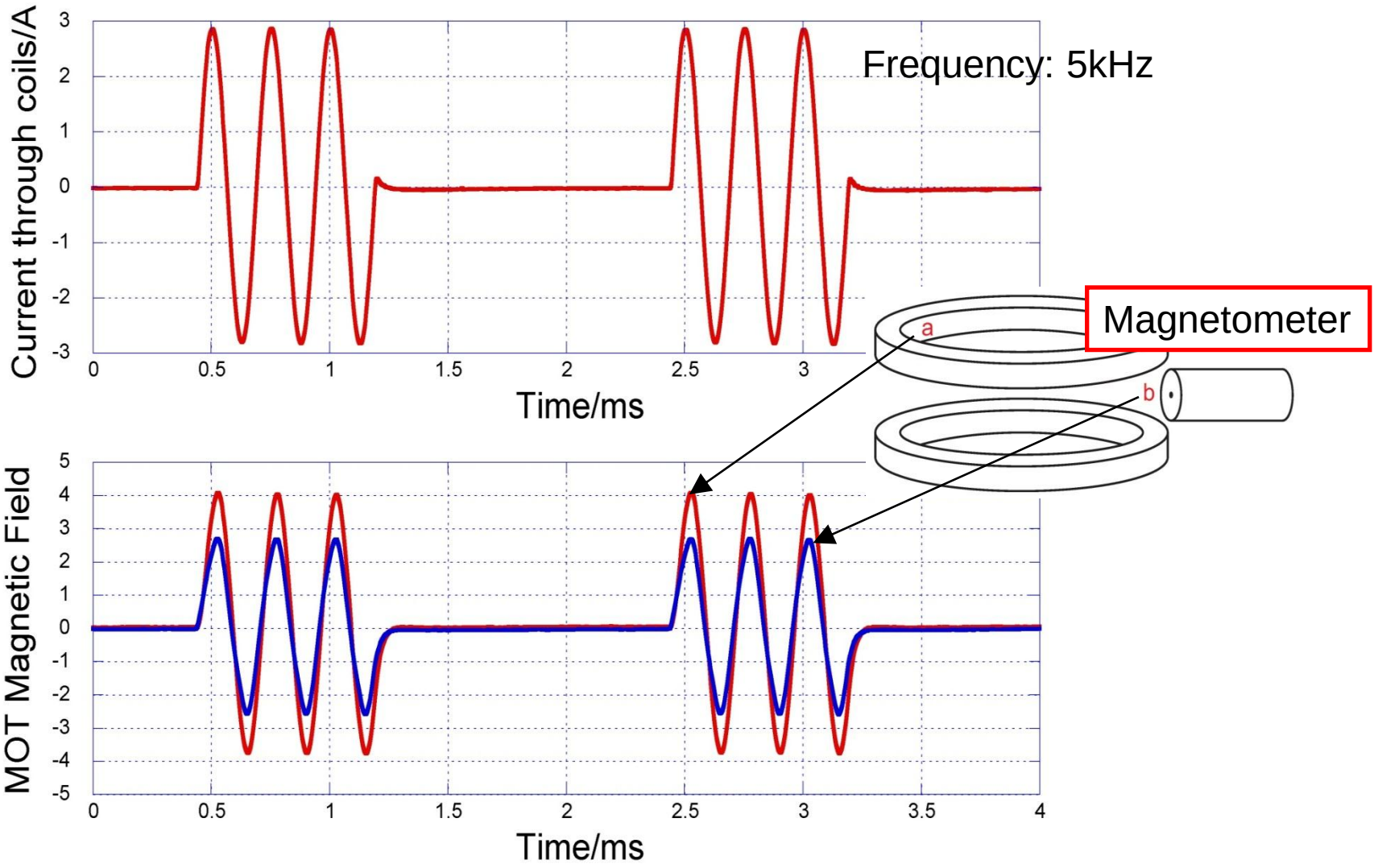
  C. J. Dedman et al., Rev. Sci. Instrum. 72, 4055 (2001)



Feedback results

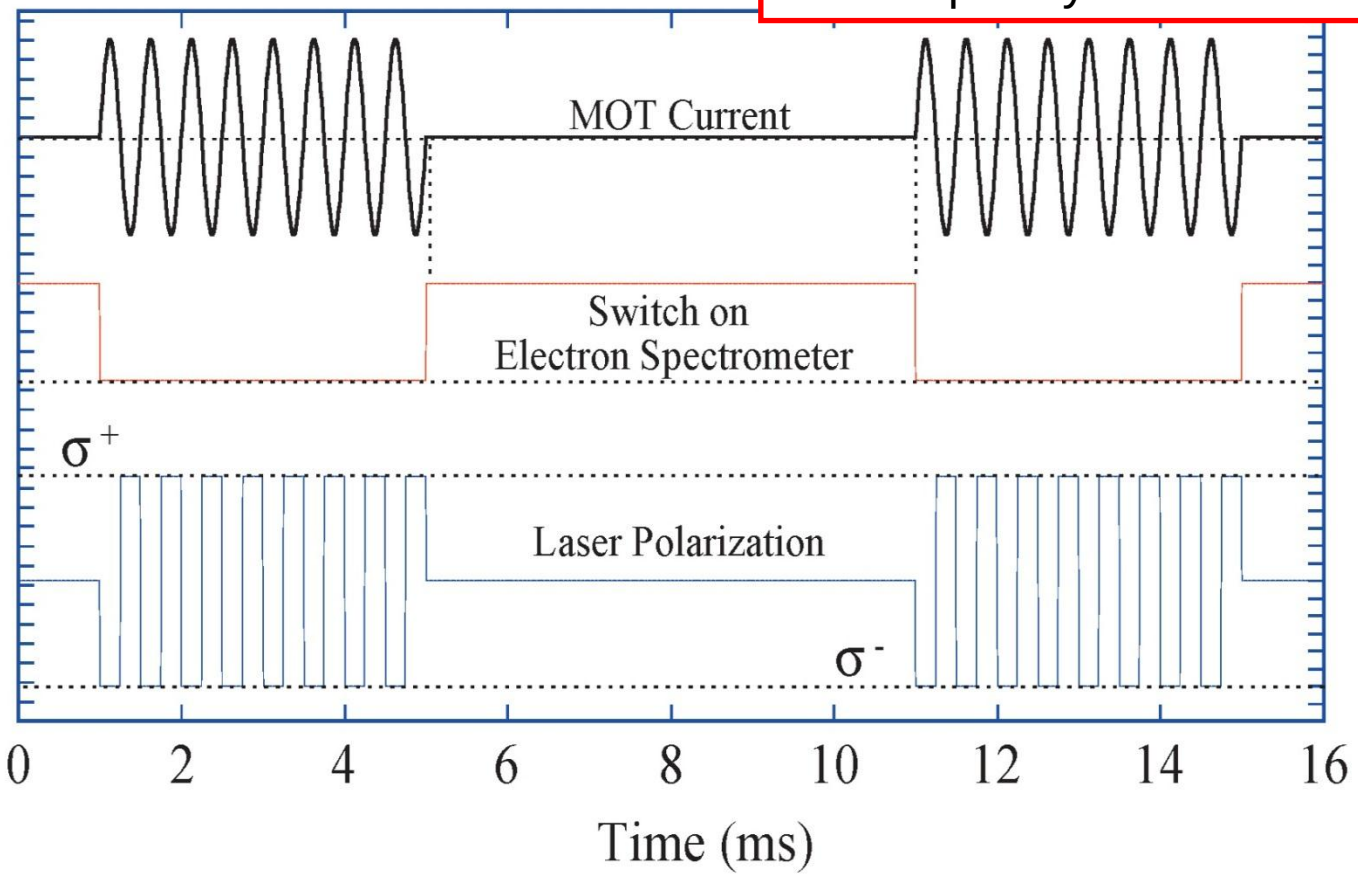


Solution: use alternating current

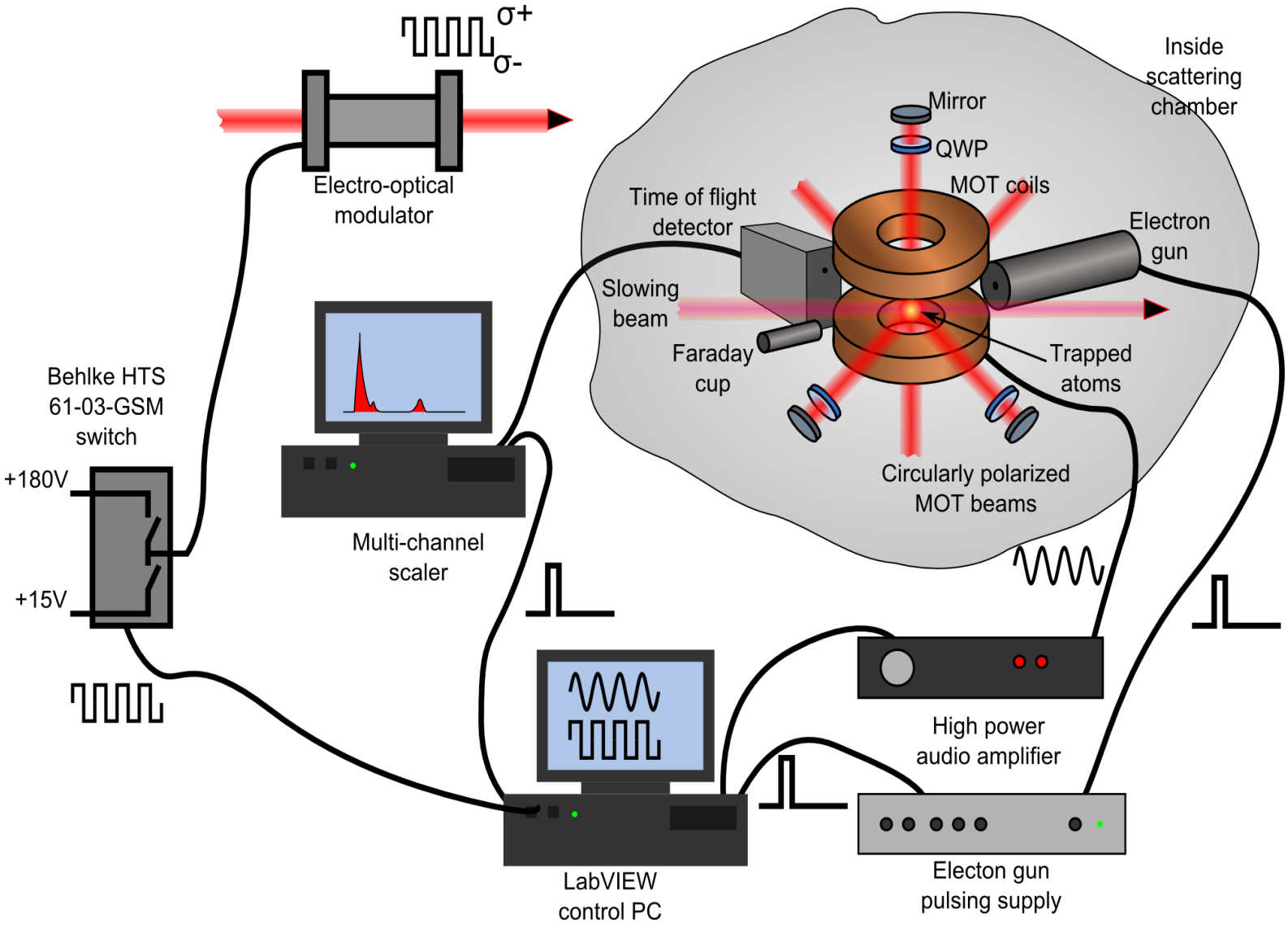


AC-MOT Pulsing Scheme

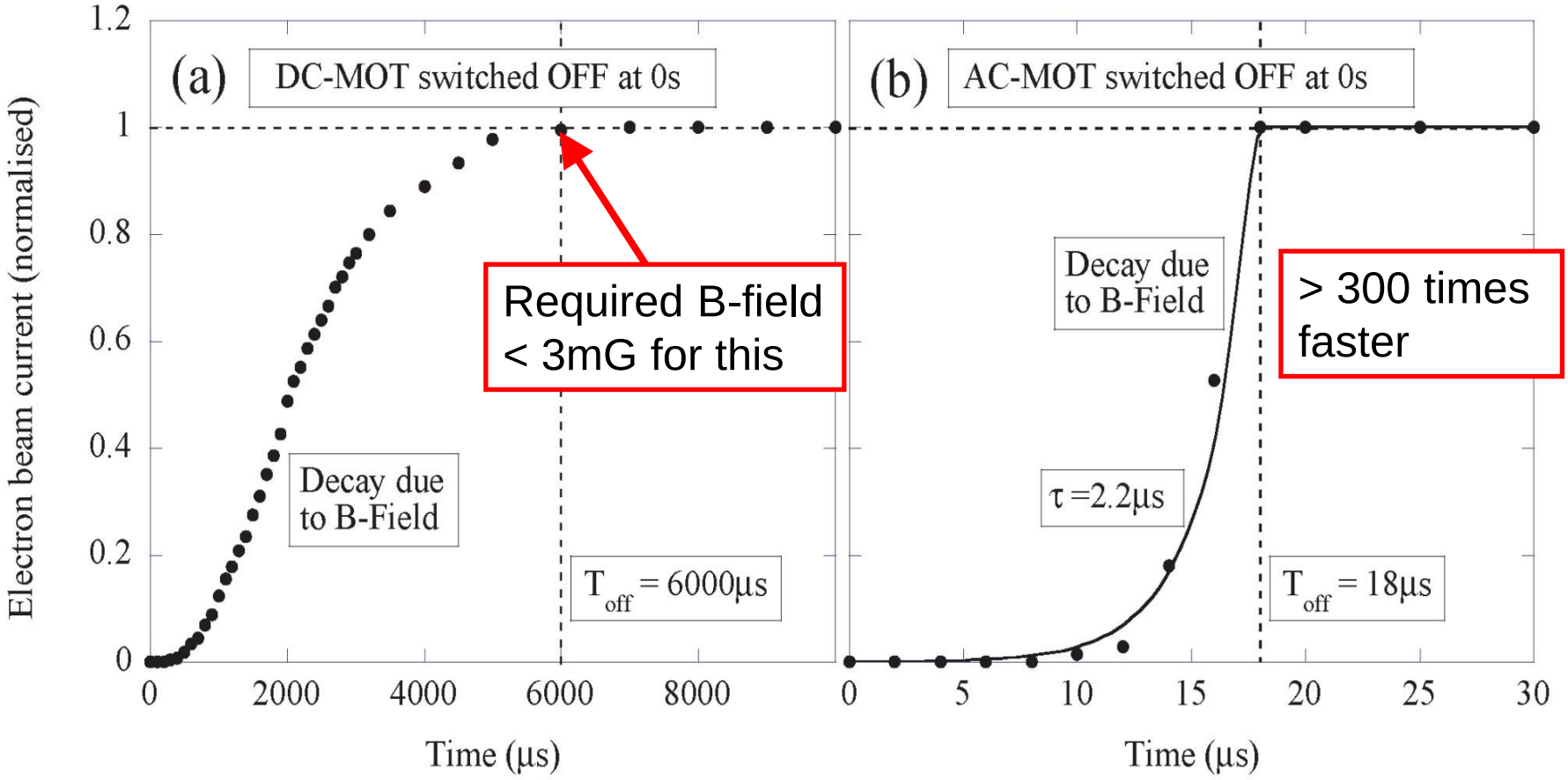
AC Frequency: 1kHz - 8kHz tested



The experiment

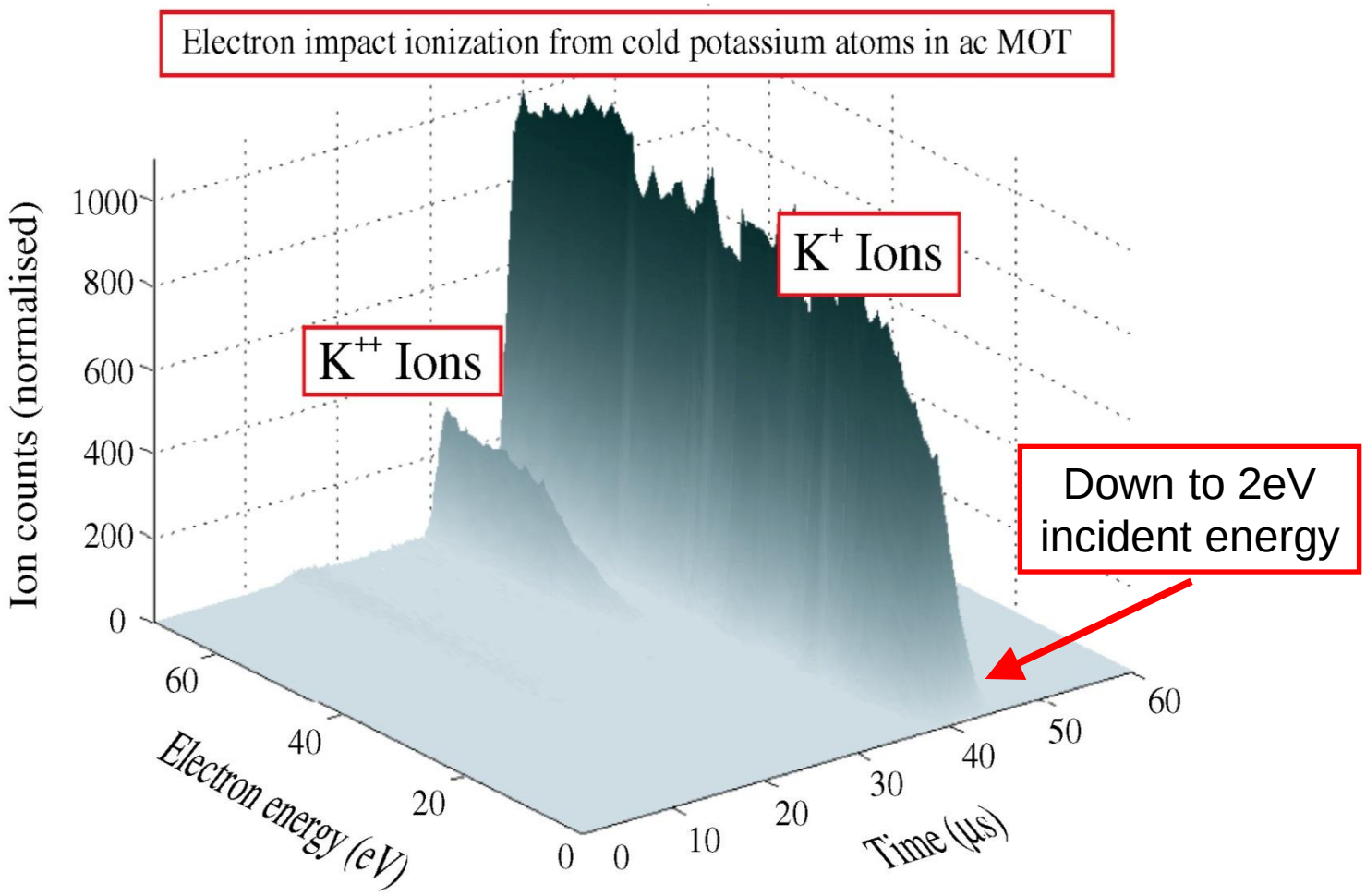


AC-MOT

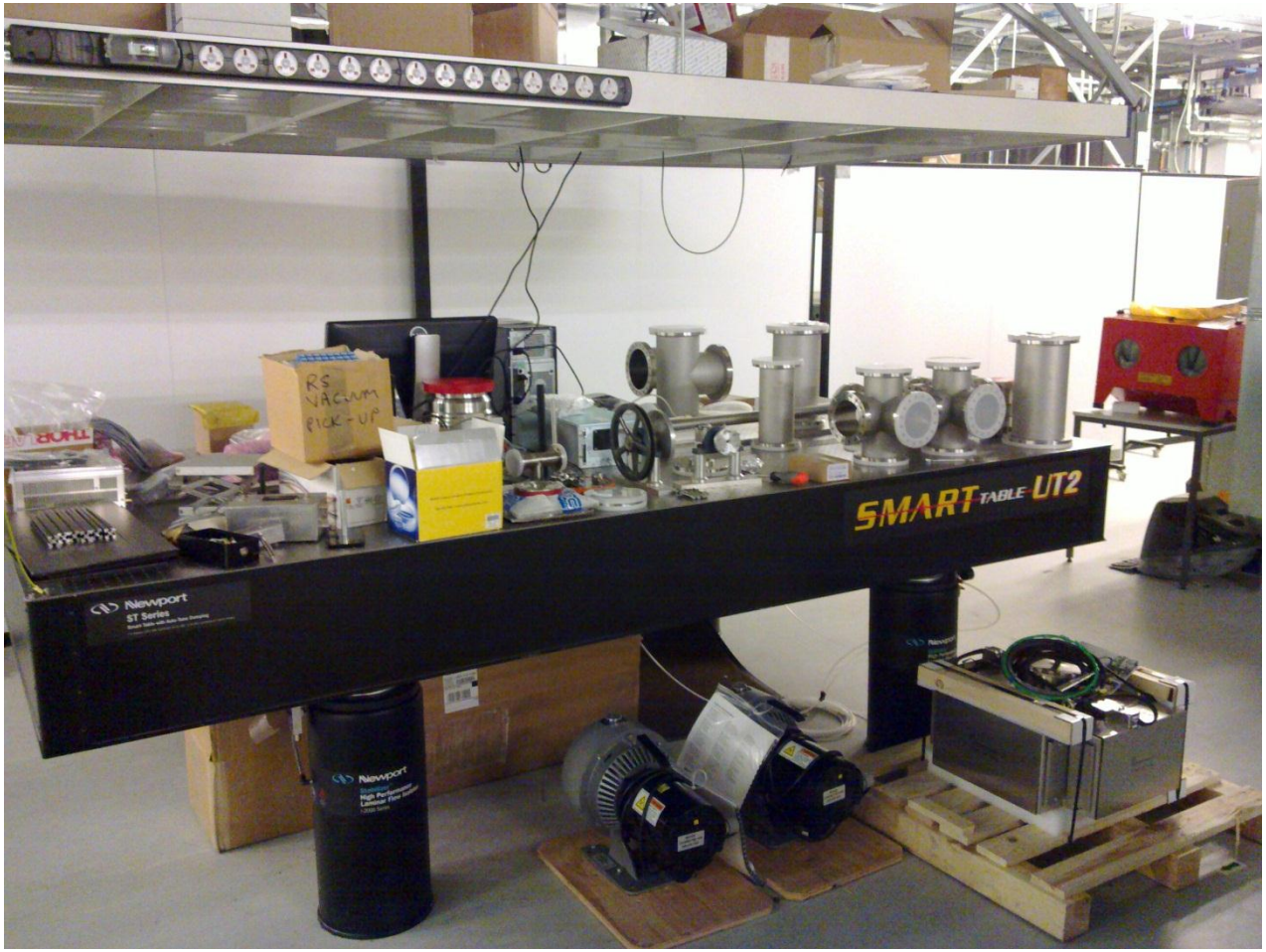


M Harvey, A J Murray, Phys. Rev. Lett. 101, 173201 (2008)

Time of flight data



Current status…



Summary

- Collaboration between Cockcroft Inst. and Uni. Manchester
- New cold electron source being developed
  - LWFA
  - Diffraction experiments
- Investigate energy, resolution and flux
- Using AC-MOT to remove B field

Acknowledgements

- Swapan Chattopadhyay (Director of Cockcroft Institute)
- Andrew Murray (University of Manchester)
- STFC
- Thank you all for listening

matthew.harvey@manchester.ac.uk