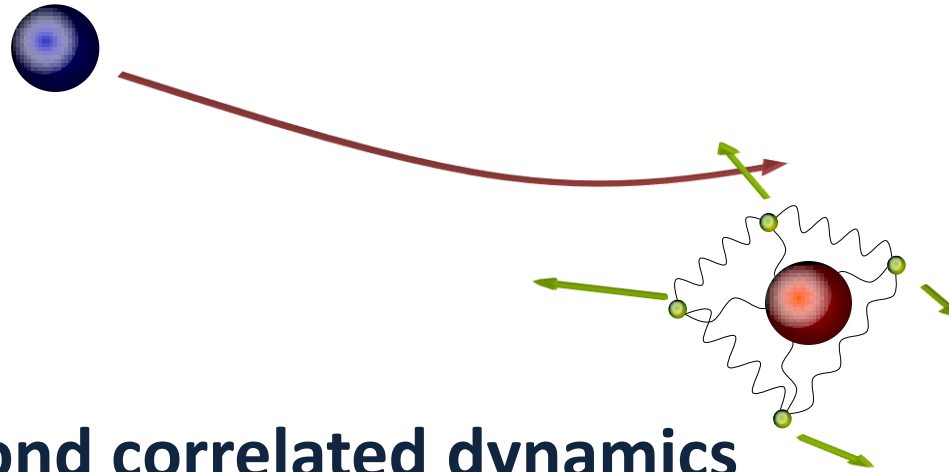


The ReMi-Experiment



**sub-femtosecond correlated dynamics
probed with antiprotons**

D. Fischer, R. Moshhammer, J. Ullrich (Heidelberg),
Yasunori Yamazaki (Tokyo), Masaki Hori (CERN), Ulrik
Uggerhøj, Helge Knudsen (Aarhus), et al.

Correlated Atomic Dynamics

Collisions:

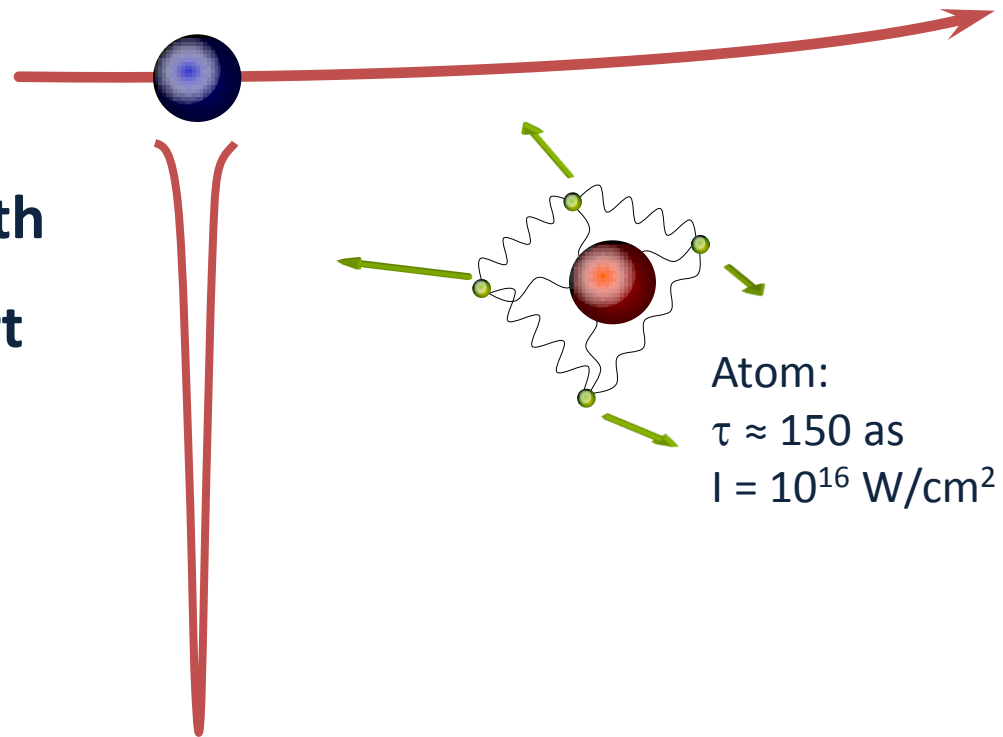
- vary the interaction strength
- vary (and access) ultra-short interaction times
- vary the charge sign

➤ Chance for rigorous theory

Half-cycle pulses:

$\tau \sim 5 \text{ fs} \dots 1 \text{ as}$

$I = 10^{16} \text{ W/cm}^2$



Correlated Atomic Dynamics

Collisions:

- e^- impact

ionization threshold

- ion impact

electron transfer / quasi-molecules

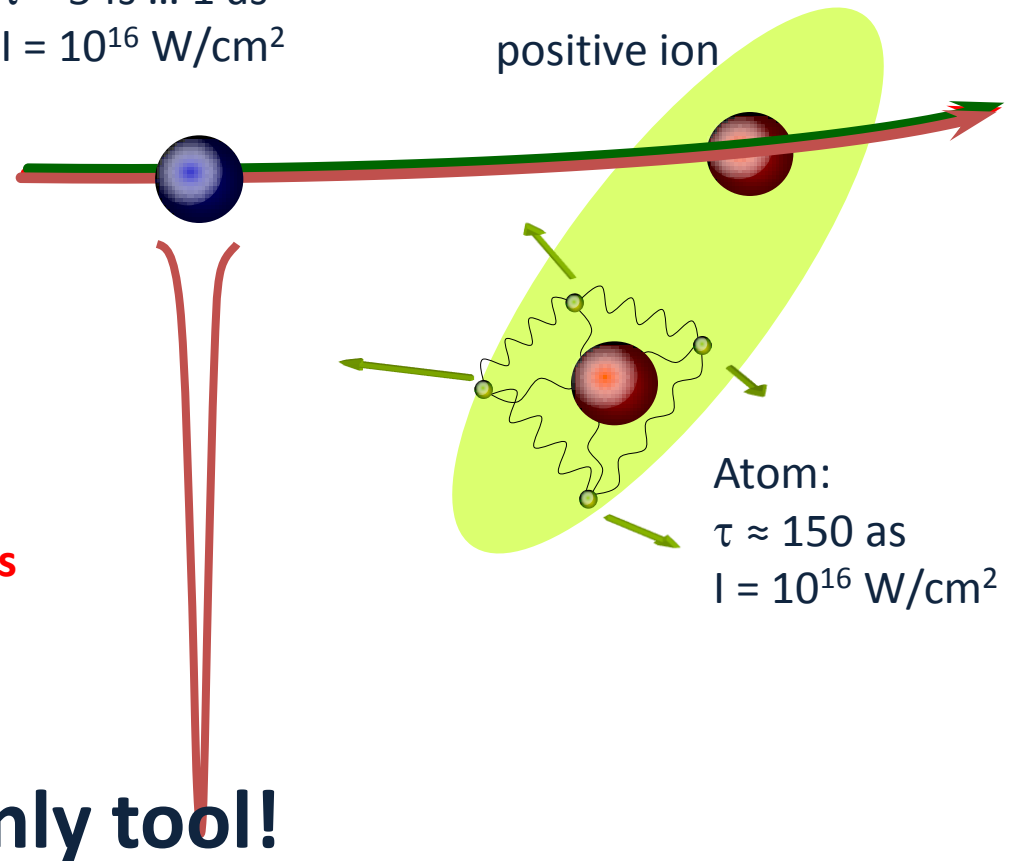
- \bar{p} impact

a unique and the only tool!

Half-cycle pulses:

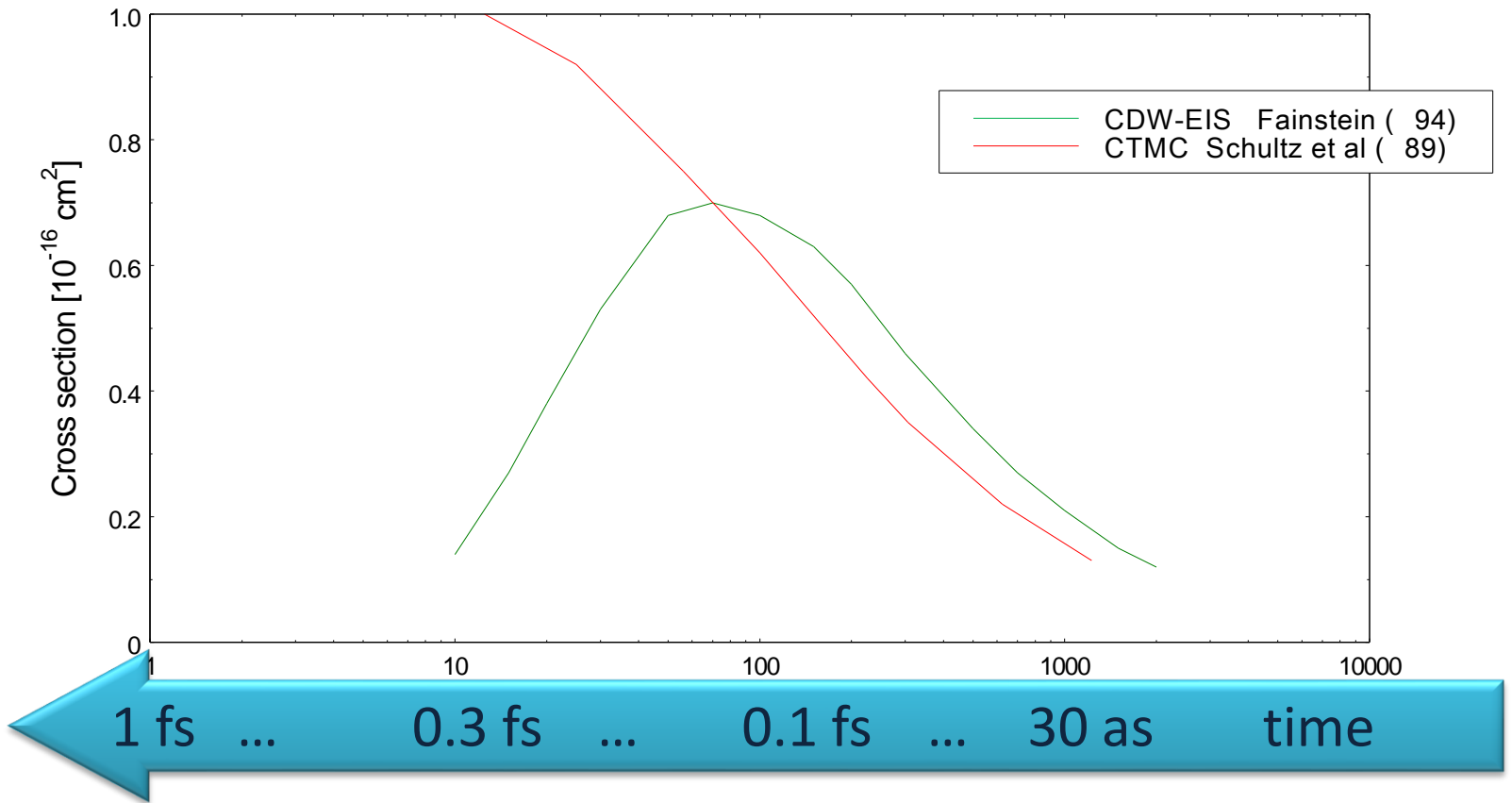
$\tau \sim 5 \text{ fs} \dots 1 \text{ as}$

$I = 10^{16} \text{ W/cm}^2$



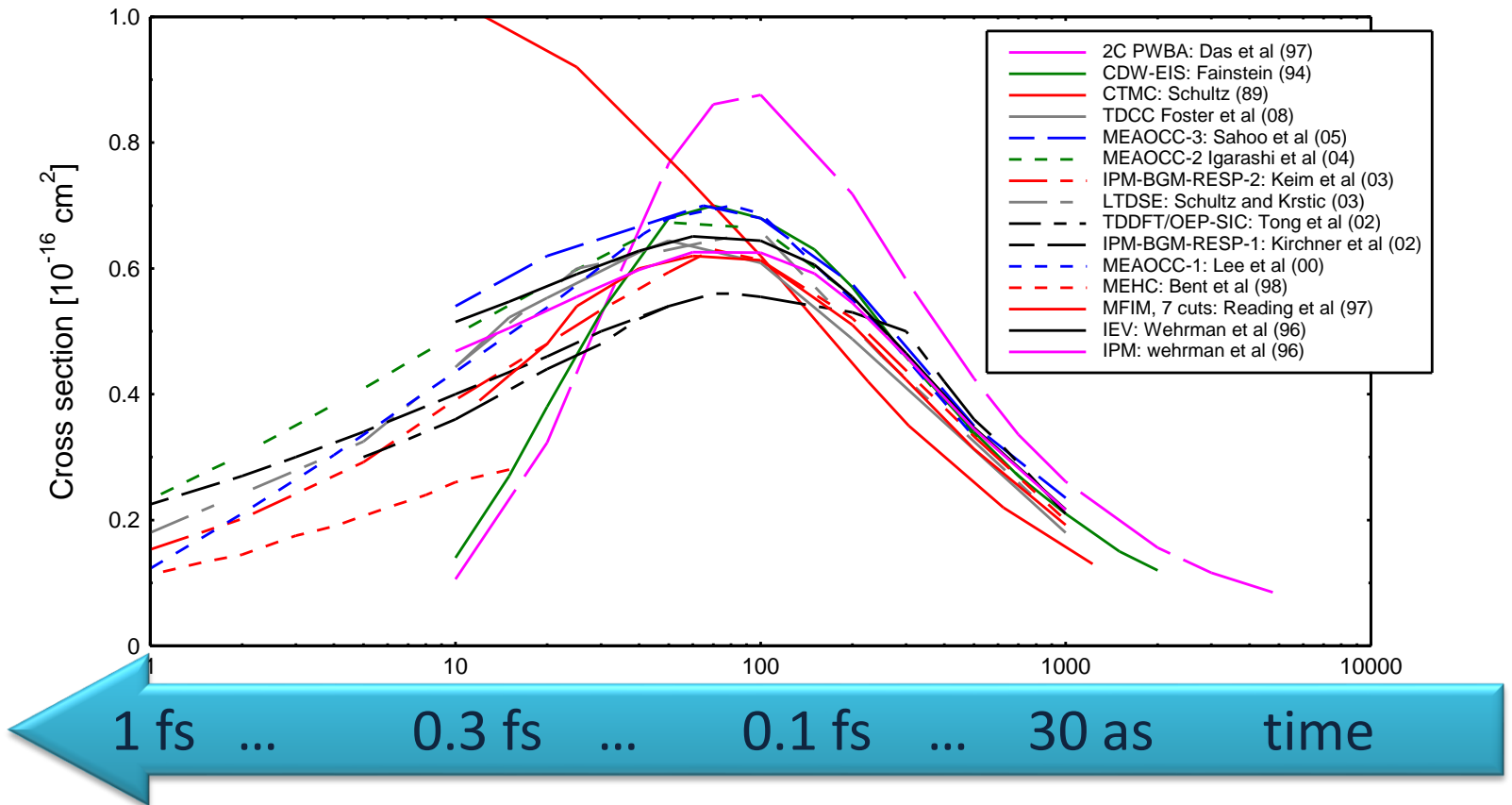
Total cross sections of single ionization of helium in slow antiproton collisions:

THEORY in the year 1994



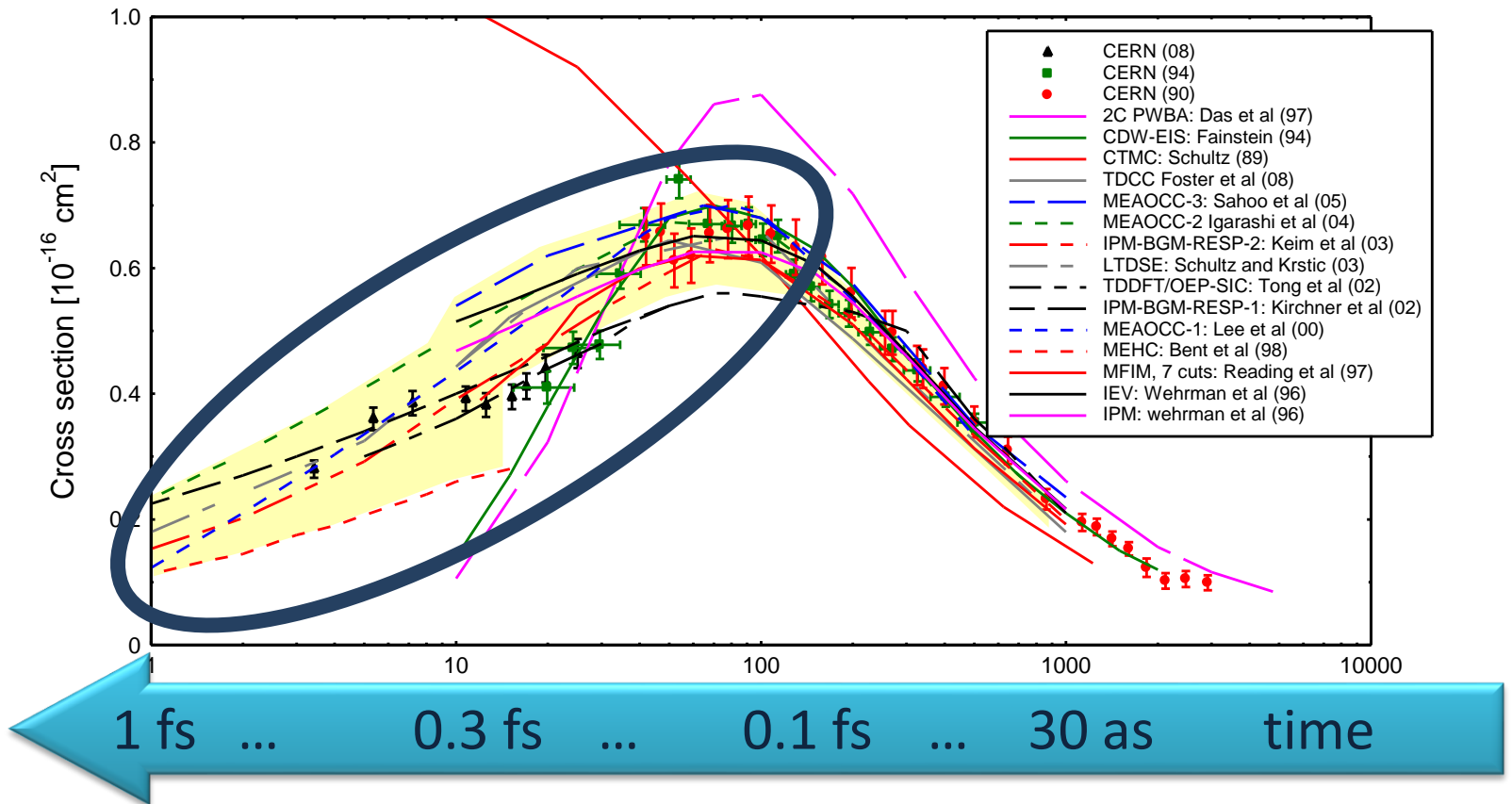
Total cross sections of single ionization of helium in slow antiproton collisions:

THEORY in the year 2008



Total cross sections of single ionization of helium in slow antiproton collisions:

THEORY in the year 2008

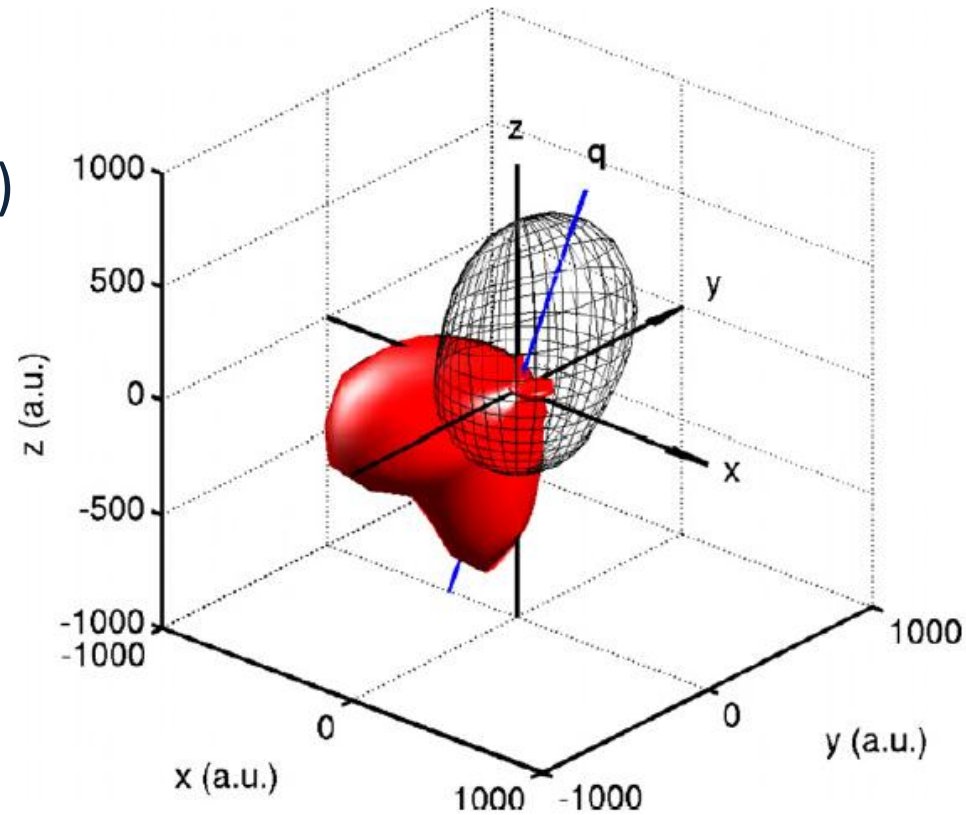


Fully differential cross sections

– Mapping the electronic wave function

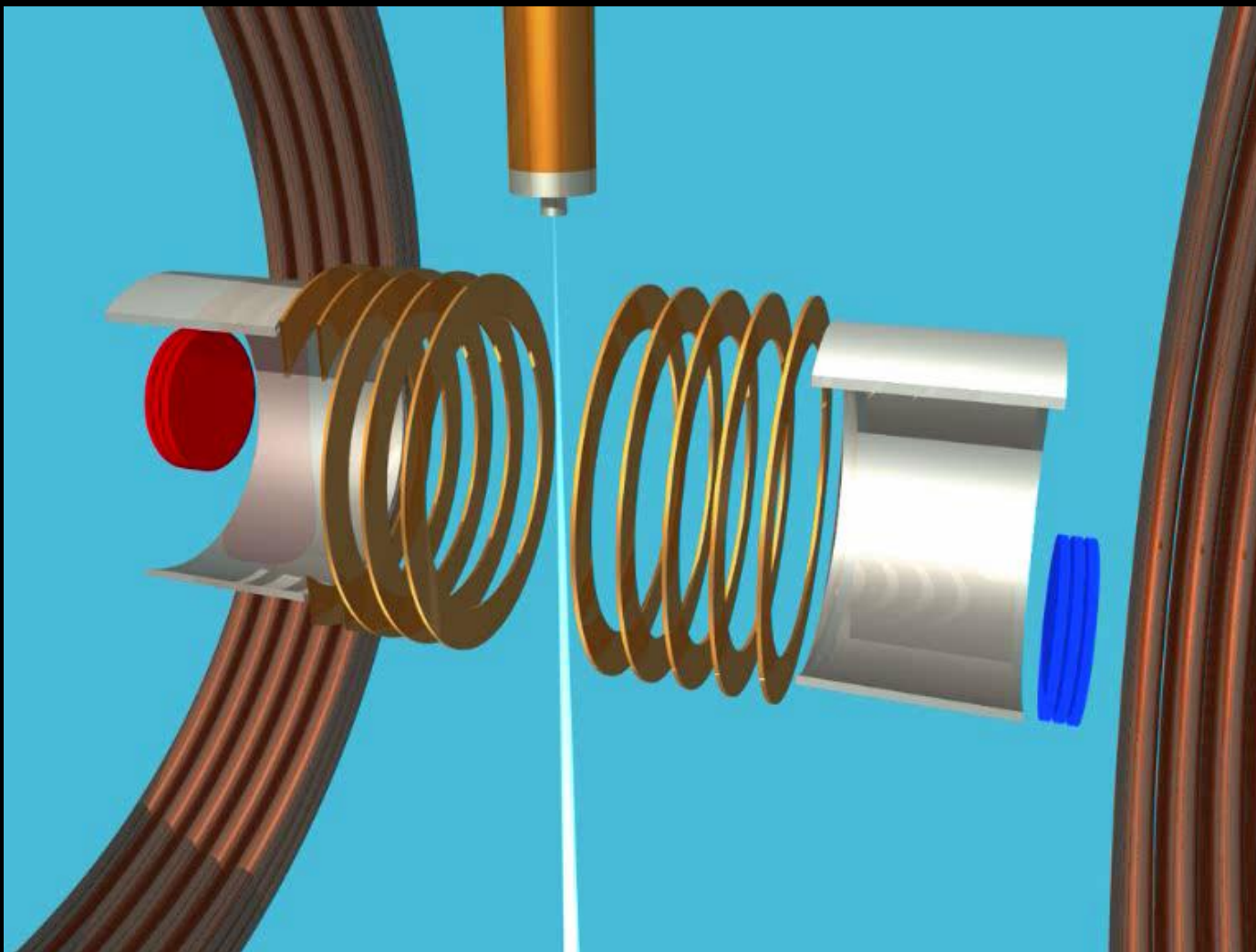
Theories:

- First Born Appr. (grid)
- Coupled Pseudostates (surface)



3 keV antiproton on helium
McGowern et al. (09)

COLTRIMS / Reaction Microscopes



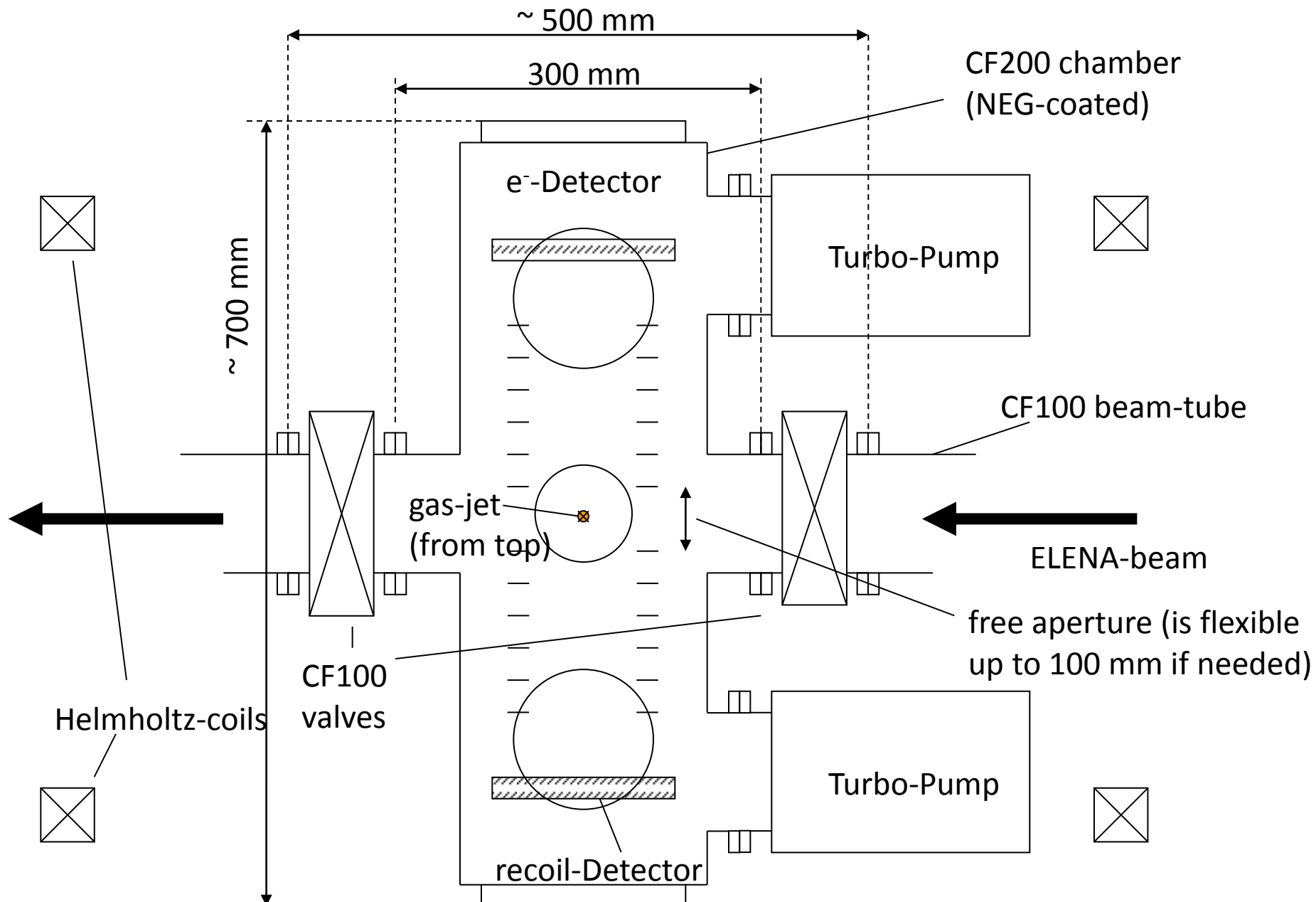
COLTRIMS: COLD Target Recoil Ion Momentum Spectroscopy

Fragmentation kinematically complete and in 3D

A Reaction Microscope in a storage rings



A Reaction Microscope for ELENA



- **Space requirements:**
About 500 mm free space in the beam-line (minimum).
- **Anticipated vacuum conditions:**
UHV or XHV in the main chamber (10^{-11} – 10^{-13} torr range).
- **Supersonic gas-jet:**
Several differential stages (ideally 4 for the source, 3 for the dump).
- **Desired ELENA beam parameters:**
 - Small beam diameter at interaction point (1 mm would be close to ideal).
 - Low energies (50 keV or less).
 - An option for bunched beams (with buckets of a few ns) would significantly extend the accessible physics program.