The ReMi-Experiment

sub-femtosecond correlated dynamics probed with antiprotons

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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:
$\tau \approx 5 \text{ fs} \ldots 1 \text{ as}$
$I = 10^{16} \text{ W/cm}^2$

Atom:
$\tau \approx 150 \text{ as}$
$I = 10^{16} \text{ W/cm}^2$
Correlated Atomic Dynamics

Collisions:

- $e^-$ impact
  ionization threshold

- ion impact
  electron transfer / quasi-molecules

- $p$ impact
  a unique and the only tool!

Half-cycle pulses:
$\tau \approx 5 \text{ fs} \ldots 1 \text{ as}$
$I = 10^{16} \text{ W/cm}^2$

Atom:
$\tau \approx 150 \text{ as}$
$I = 10^{16} \text{ W/cm}^2$
Total cross sections of single ionization of helium in slow antiproton collisions:

**THEORY in the year 1994**

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![Graph showing cross sections as a function of time.](image-url)
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.
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

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
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<tbody>
<tr>
<td>Helmholtz-coils</td>
<td></td>
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<tr>
<td>CF100 valves</td>
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<tr>
<td>gas-jet (from top)</td>
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<tr>
<td>e- Detector</td>
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<tr>
<td>recoil-Detector</td>
<td></td>
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<tr>
<td>CF100 beam-tube</td>
<td></td>
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<tr>
<td>CF200 chamber (NEG-coated)</td>
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<tr>
<td>Turbo-Pump</td>
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<tr>
<td>Free aperture</td>
<td>(is flexible up to 100 mm if needed)</td>
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</tbody>
</table>
• **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.