Collision Experiments at HITRAP with Reaction Microscopes

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Collaboration:

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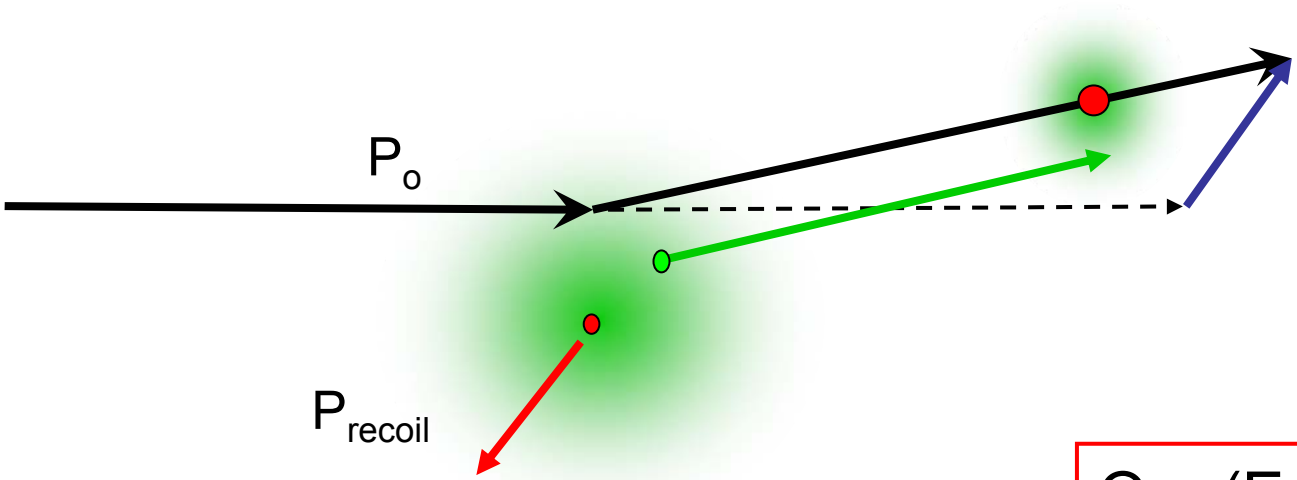
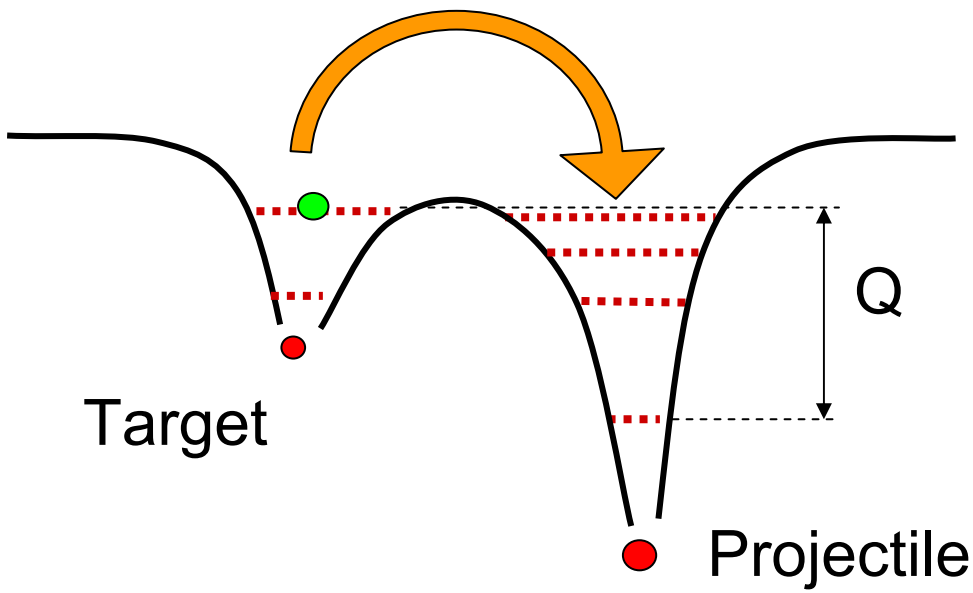
Short Outline:

- Electron capture reactions
  - single and multiple electron transfer
- Technical aspects
- Further (future) options

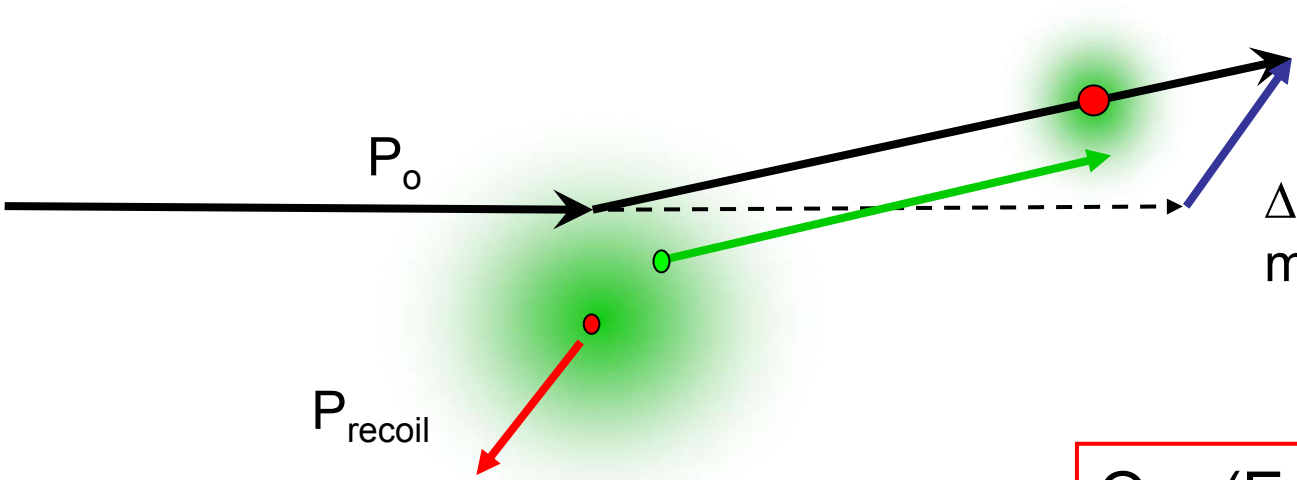
Charge transfer in collisions of HCI with atoms



$$Q = (E_{Targ}^{bound} - E_{Proj}^{bound})$$



Charge transfer in collisions of HCI with atoms



$\Delta P = -P_{recoil}$
momentum conservation

$$Q = (E_{Targ}^{bound} - E_{Proj}^{bound})$$

Spectroscopy and Dynamics !!

for multi-keV collisions:

full kinematics

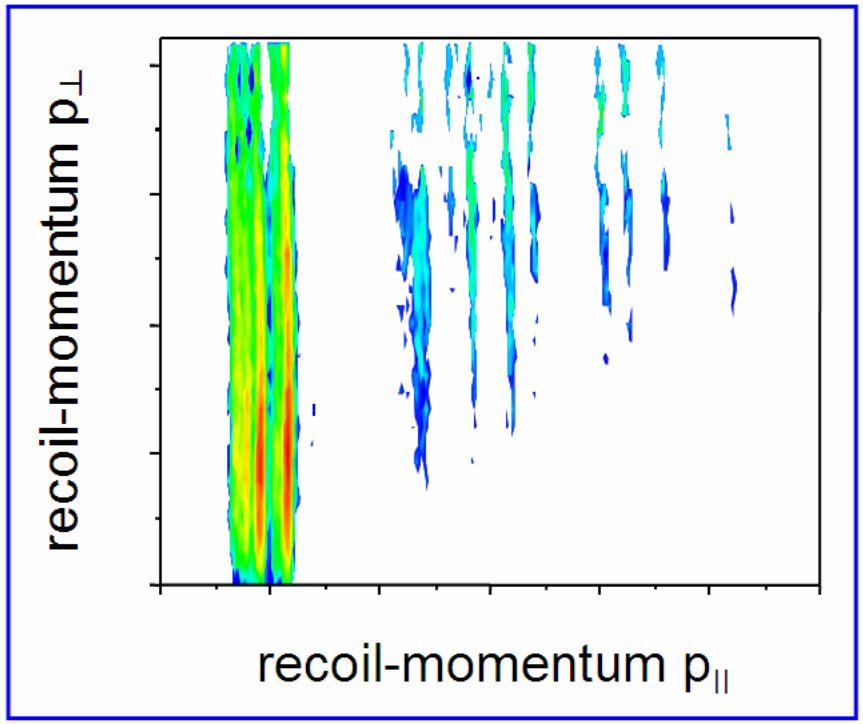
Recoil Momentum

Along the beam direction : $P_{||} = -Q / v_p - 1/2 v_p$

Perpendicular to beam : $P_{\perp} = P_o \cdot \vartheta$

Charge transfer in collisions of HCI with atoms

Example:
9 keV/q Ne^{7+} => He



Recoil Momentum
Along the beam direction :
Perpendicular to beam :

Target

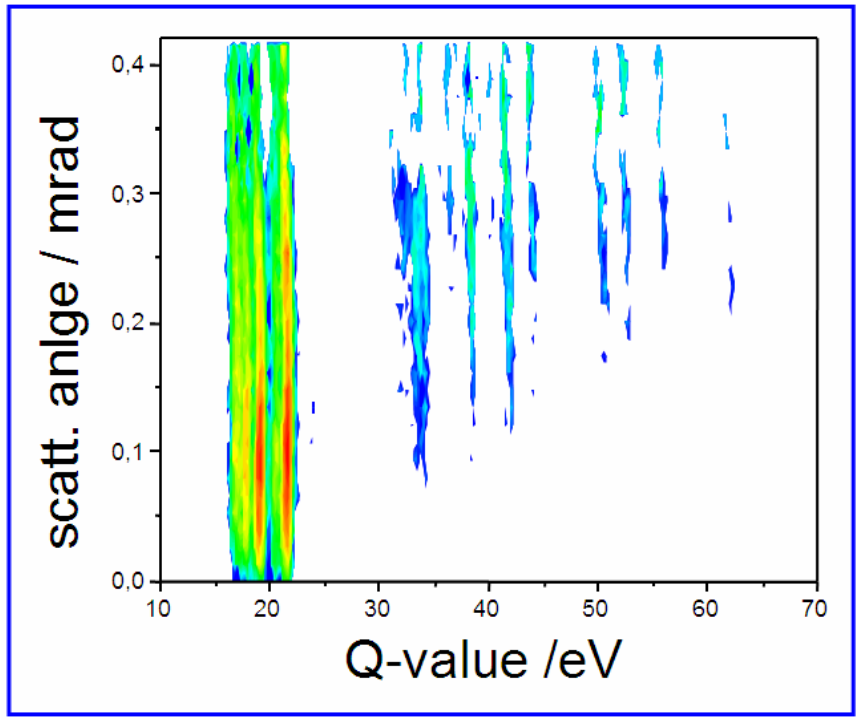
full kinematics

$P_{||} = -Q / v_p - 1/2 v_p$

$P_\perp = P_a \cdot \vartheta$

Charge transfer in collisions of HCI with atoms

Example:
9 keV/q Ne^{7+} => He



full kinematics

Recoil Momentum

Along the beam direction :

Perpendicular to beam :

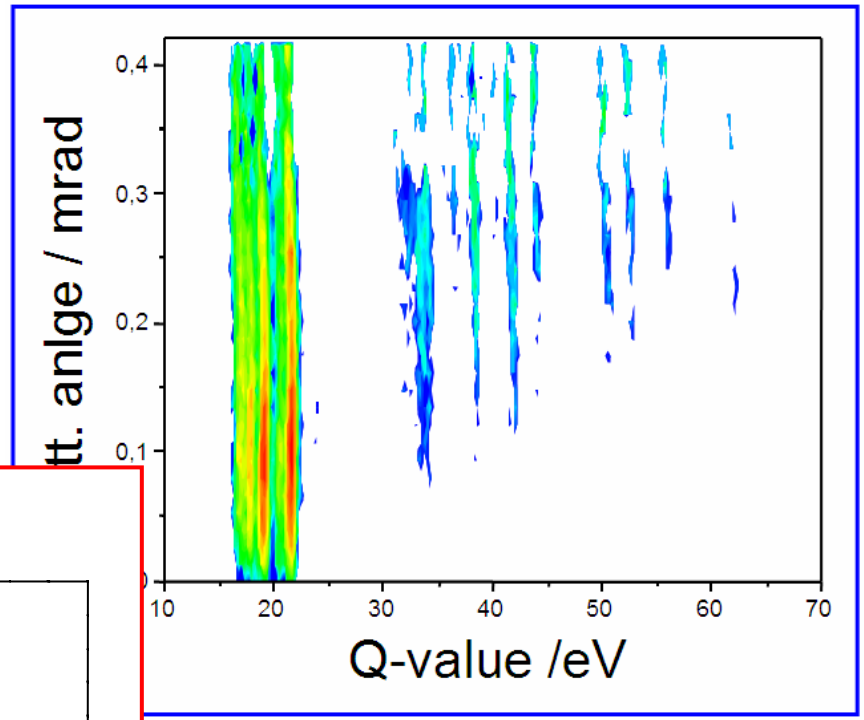
Target

$P_{||} = -Q / v_p - 1/2 v_p$

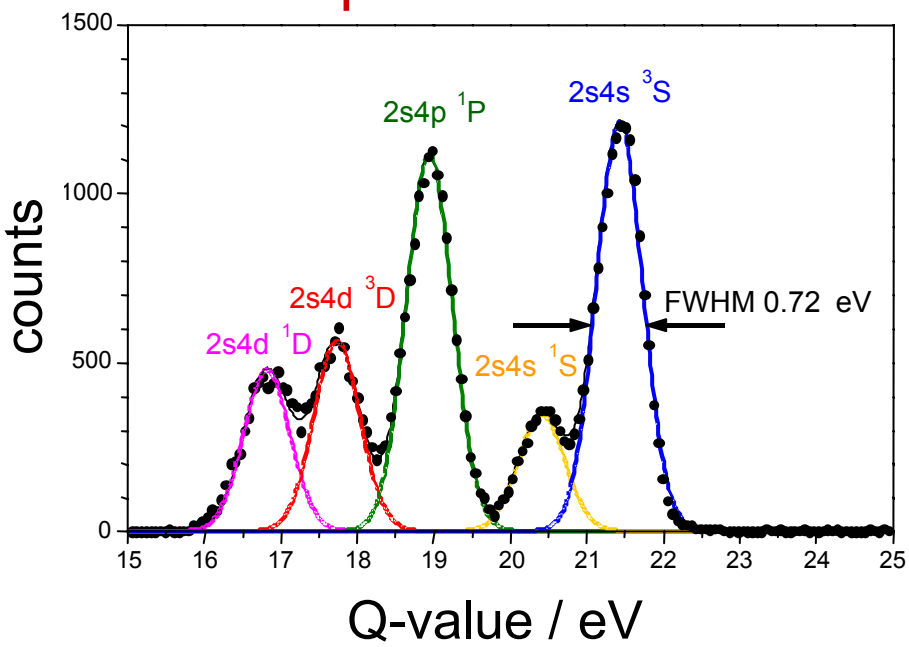
$P_{\perp} = P_{\alpha} \cdot \vartheta$

Charge transfer in collisions of HCI with atoms

Example:
9 keV/q Ne^{7+} => He



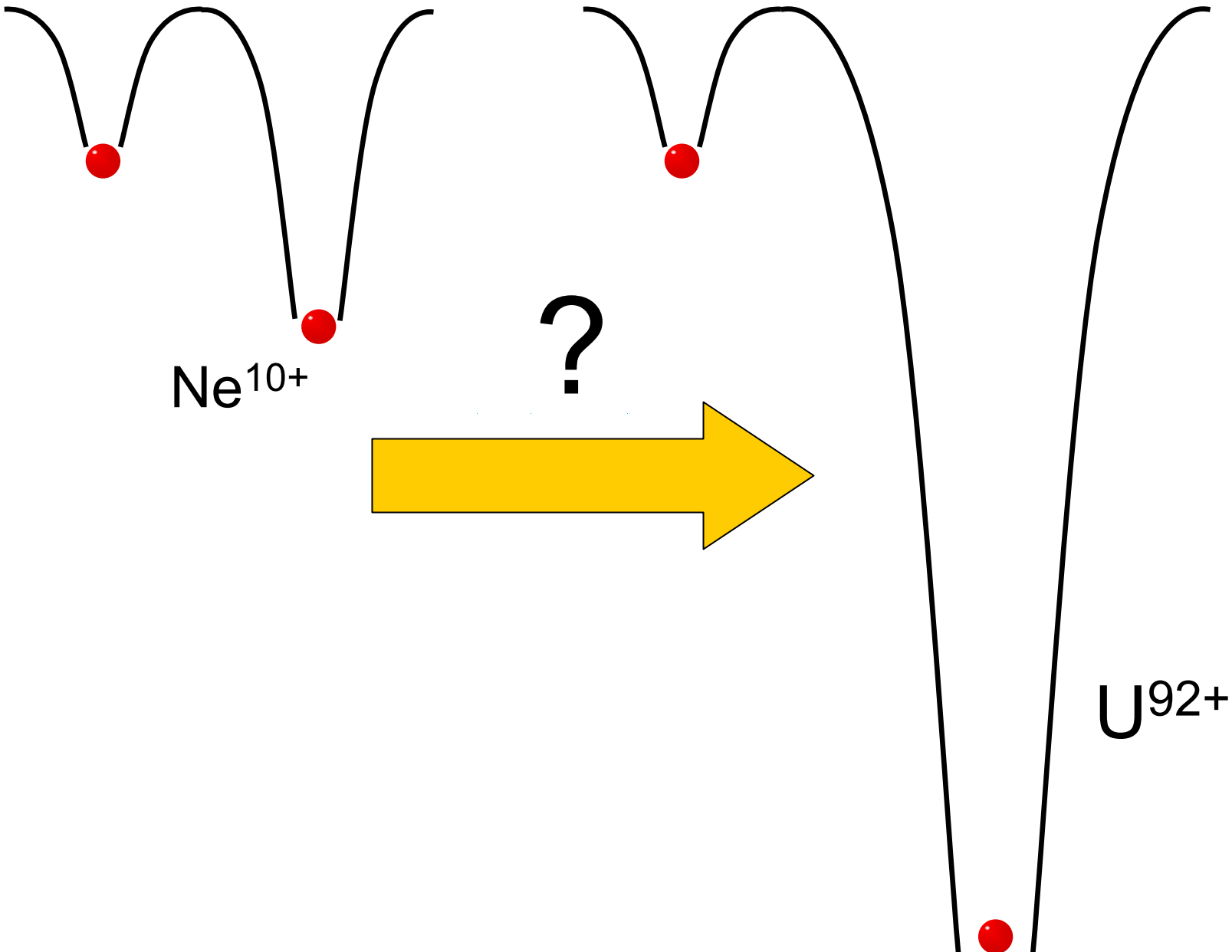
capture into n=4



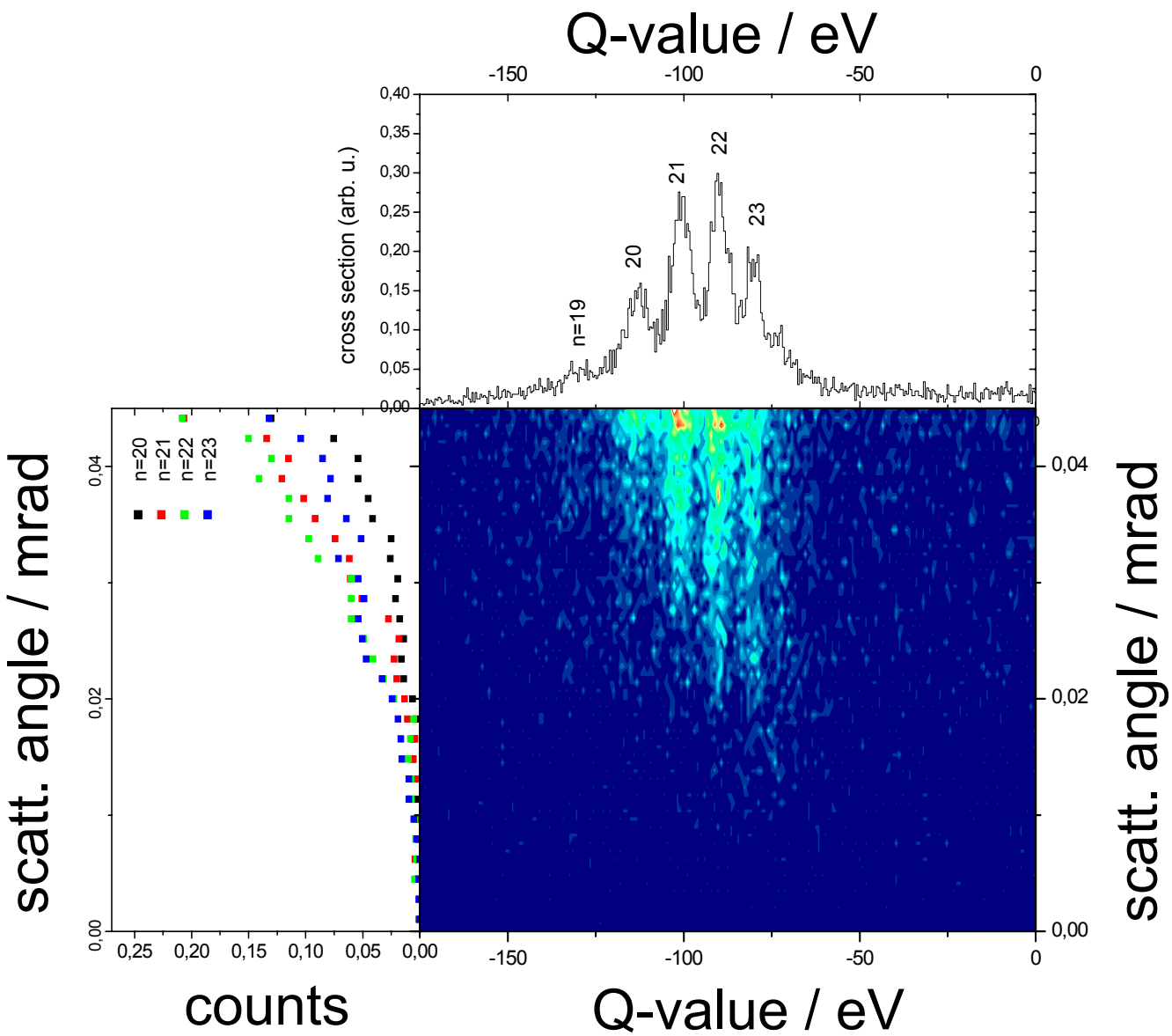
- No (dipole) selection rules
- Precision: 3-100 meV
- Resolution: 0.7 eV FWHM

$$\Delta Q \sim 1/v_p$$

From Light to Heavy Projectiles

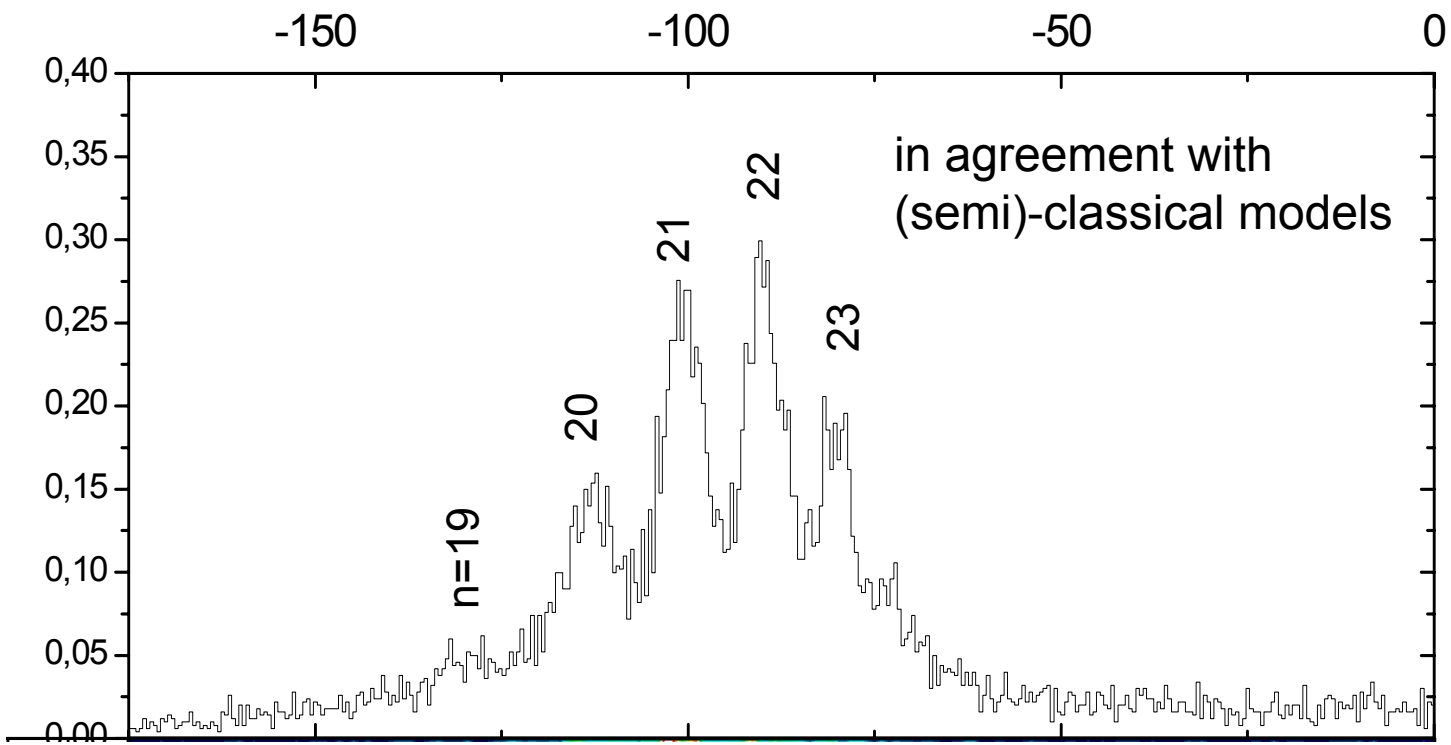


HD-EBIT: 14 keV/q $U^{64+} \rightarrow$ He



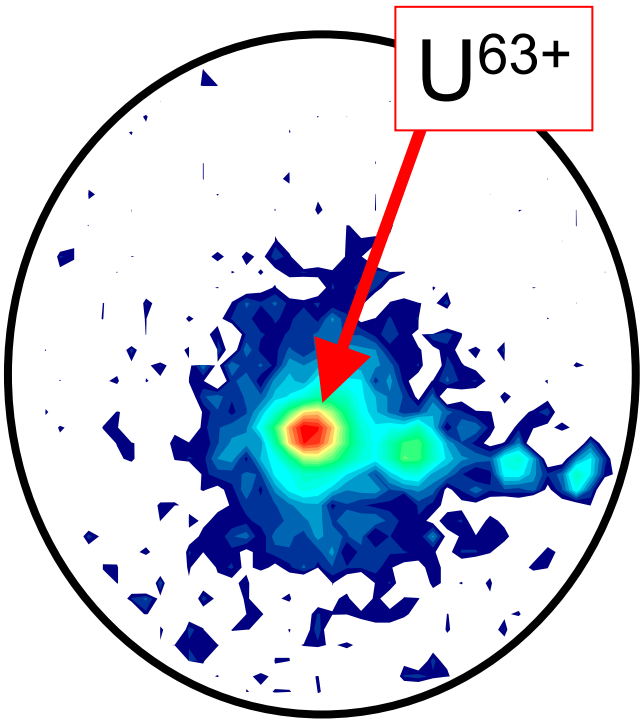
HD-EBIT: 14 keV/q $U^{64+} \rightarrow$ He

Disappointing !!
It seams that there is not much to learn here !!

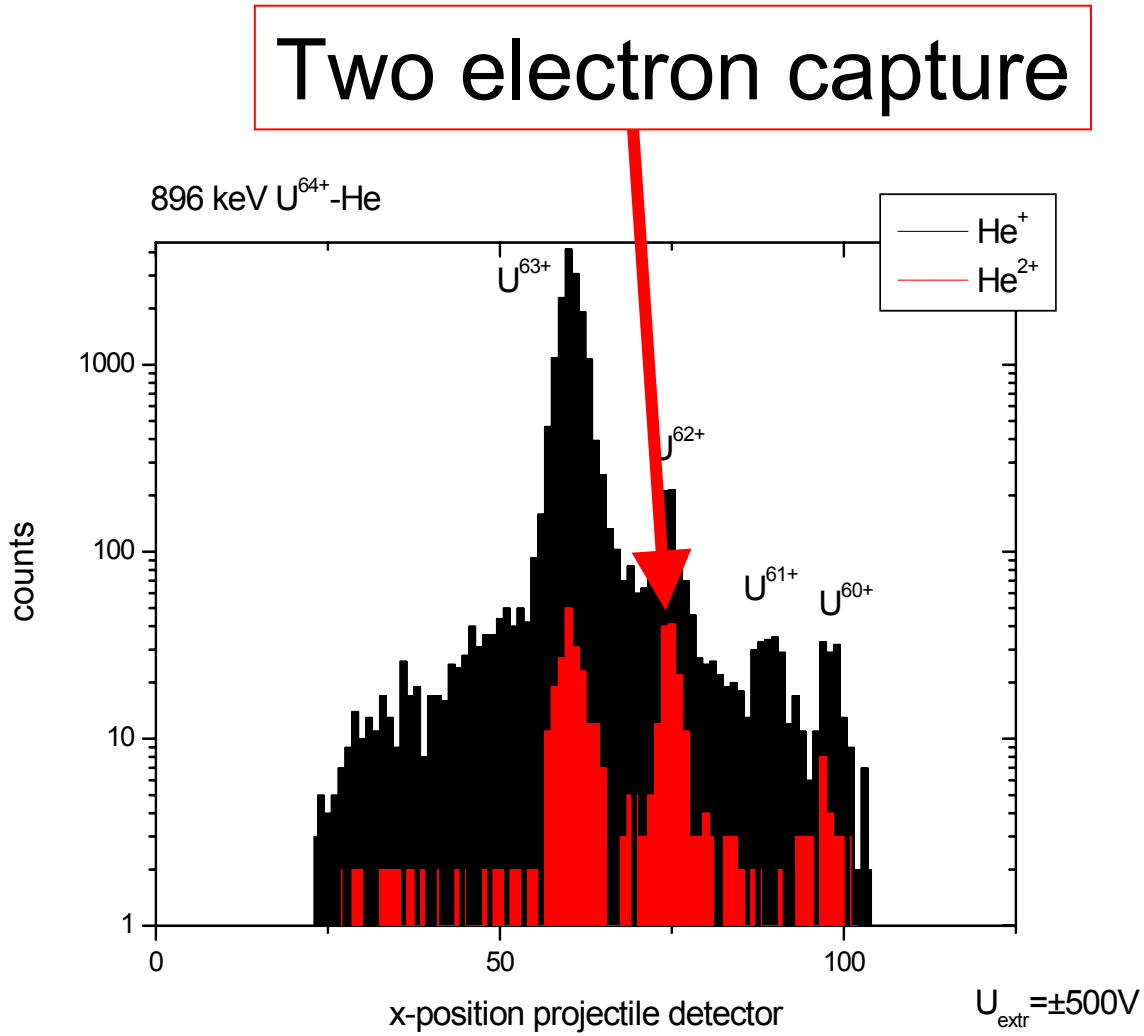


HD-EBIT: 14 keV/q $U^{64+} \rightarrow$ He

after projectile
charge-state analyzer

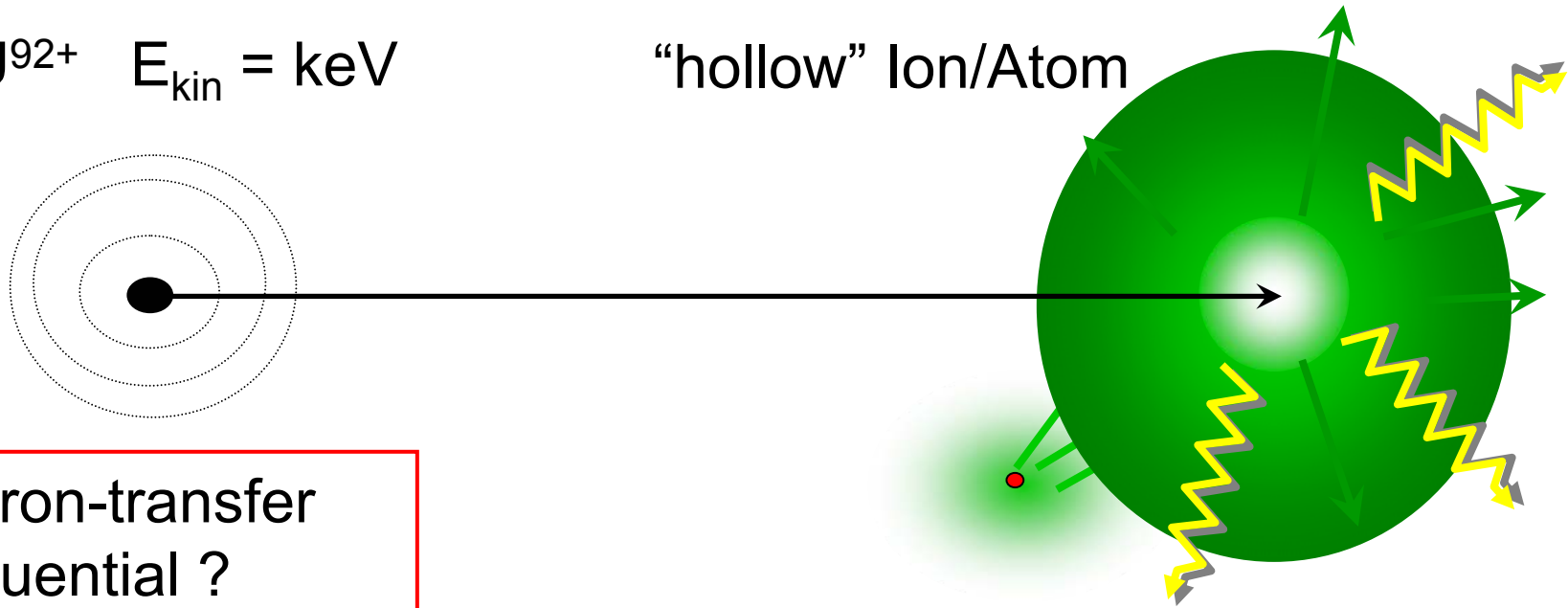


projectile detector



Multiple electron transitions

e.g.: U^{92+} E_{kin} = keV



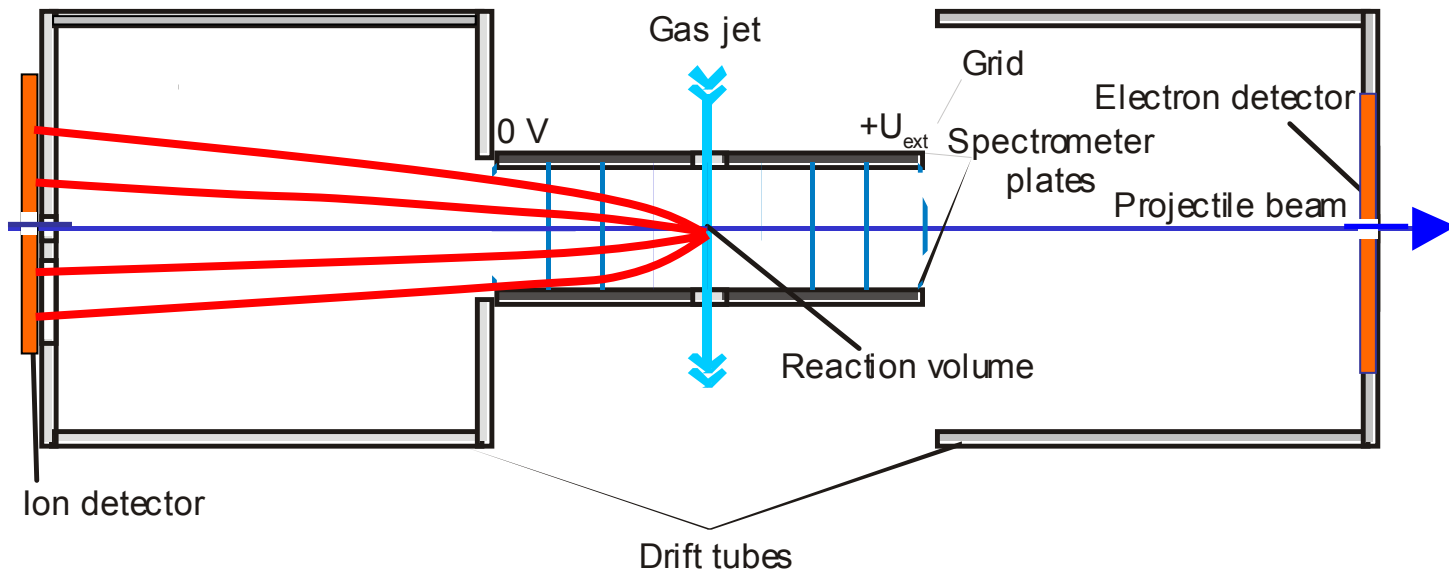
Electron-transfer
- sequential ?
- correlated ?

Highly excited systems
- populated states ?
- relaxation and rearrangement (Auger-e, Photons) ?

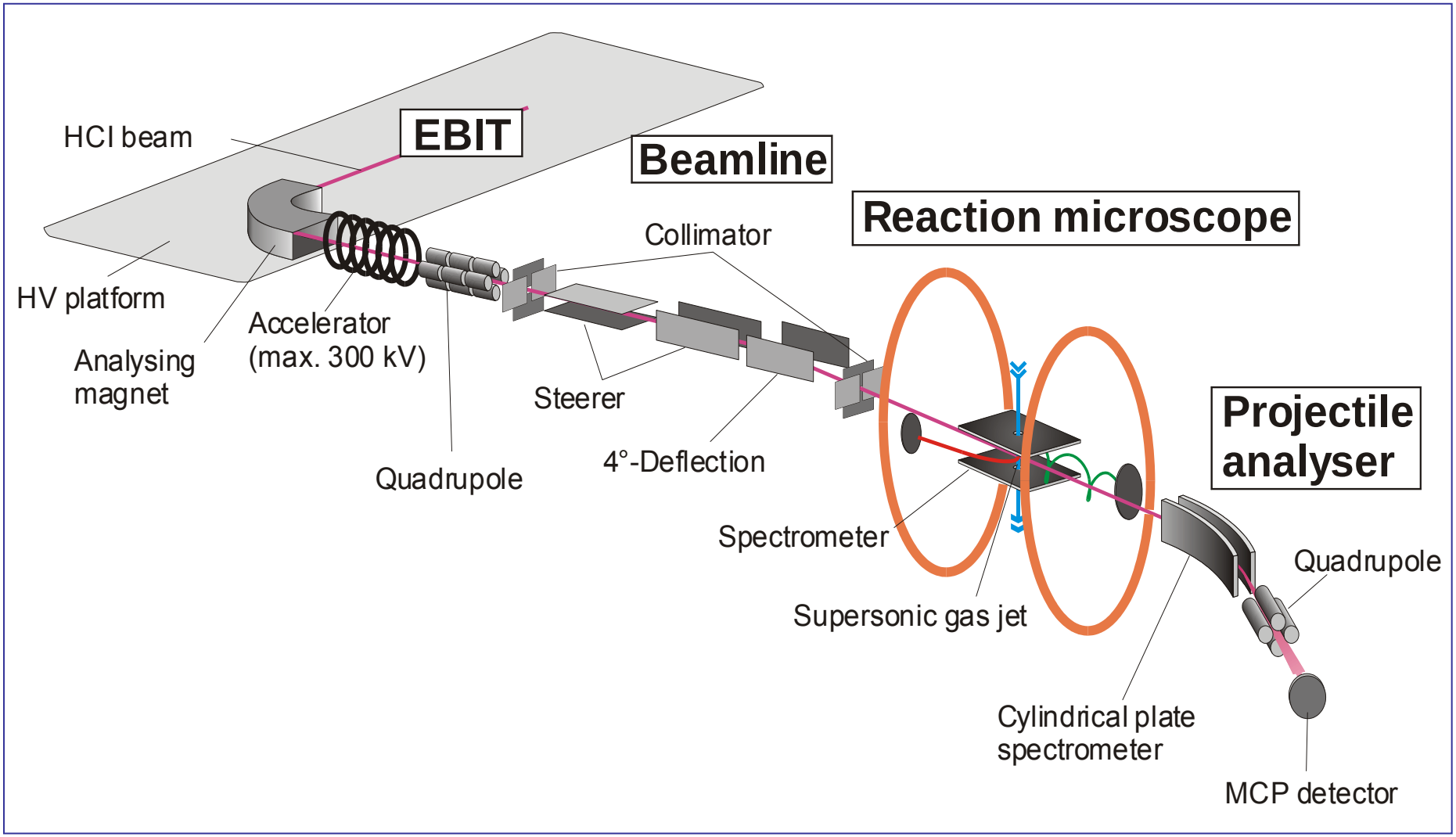
Coincident detection of ions, electrons and photons

The HITRAP Reaction Microscope

Increased Acceptance for recoil ions:
large ion detector (MCP) with hole (in preparation)



Present set-up at MPI-K



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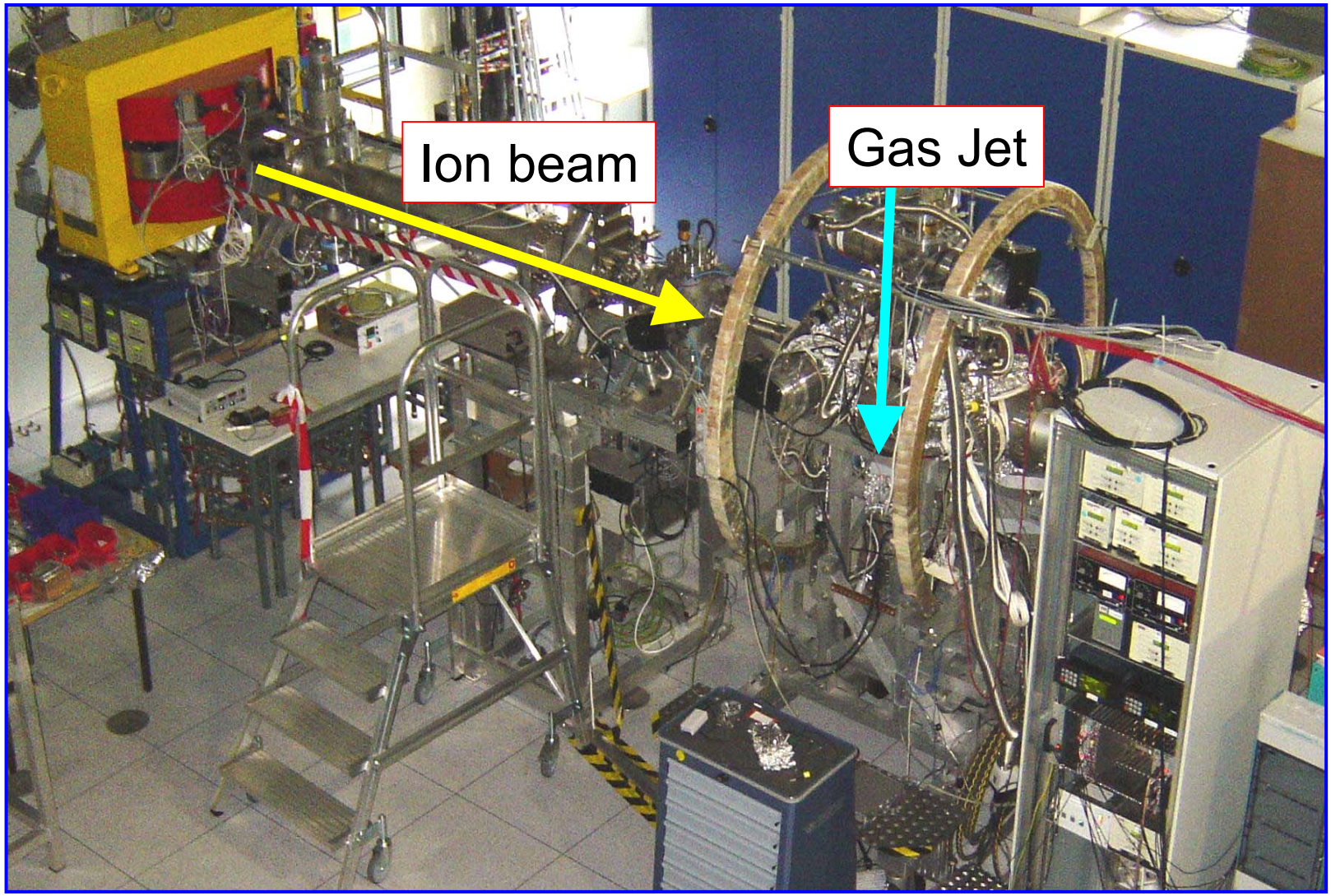

Requested beam intensities

capture cross-section: 10^{-14} - 10^{-13} cm^2
target density: 10^{11} cm^{-2}

10^4 ions/s => 10 – 100 events/s

We can only estimate the cross-sections !!

multiple e-capture: < 10^{-14} cm^2
detection efficiency : 10^{-1} (recoil-ion & 1 e-)

10^5 ions/s => less than 10 events/s

multiple e-capture: < 10^{-14} cm^2
detection efficiency : 10^{-3} (recoil-ion, 1 e^- & photon)

10^6 ions/s => less than 1 event/s

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multiple e-capture: < 10^{-14} cm^2

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10^5 ions/s => less than 10 events/s

Most likely scenario

Experimentalist to Operator:

"We need more beam !!"

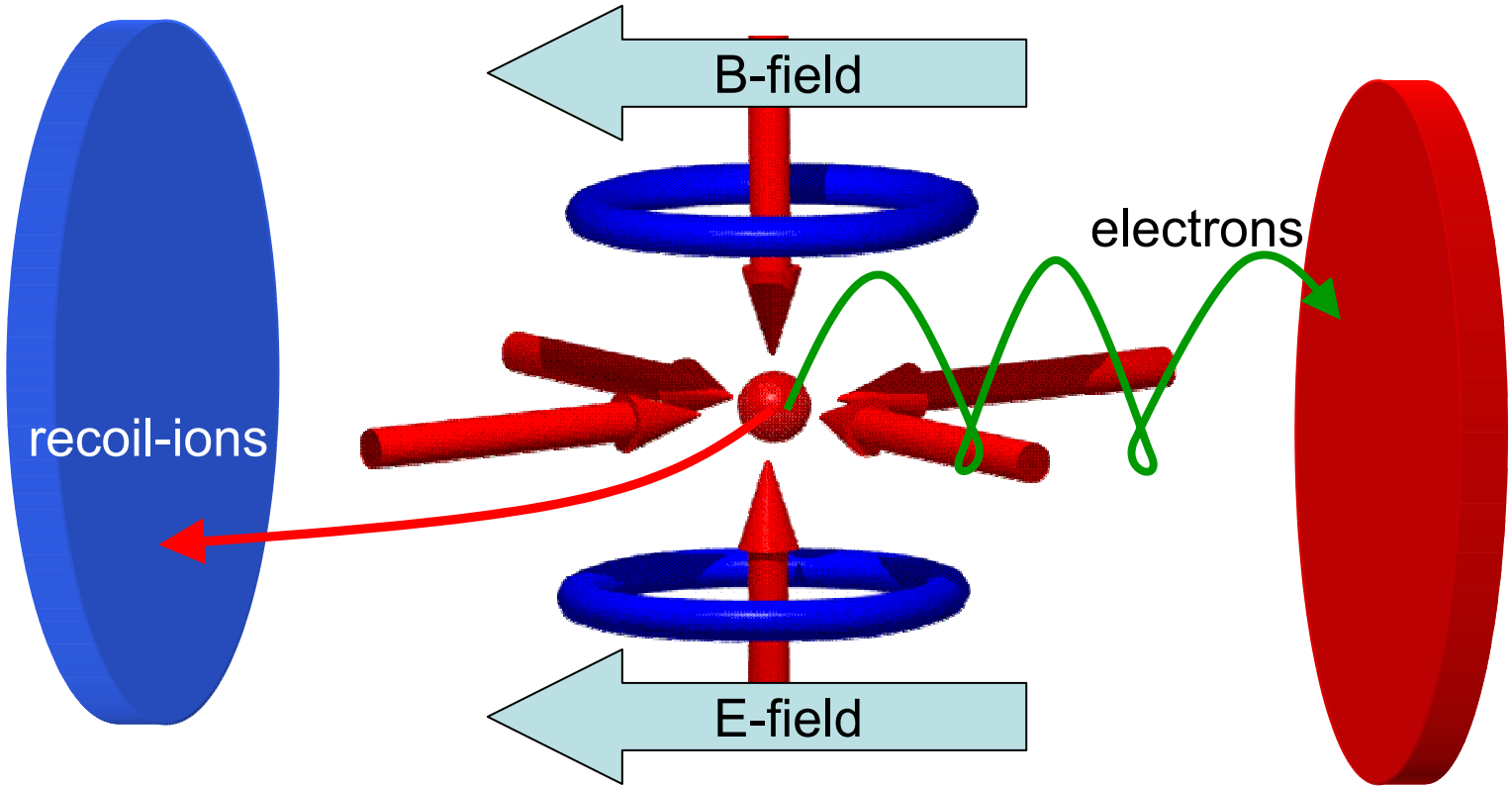
multiple e-capture: < 10^{-14} cm^2

detection efficiency : 10^{-3} (recoil-ion, 1 e$^-$ & photon)

10^6 ions/s => less than 1 event/s

Advanced targets

Cold atoms in a MOT as target



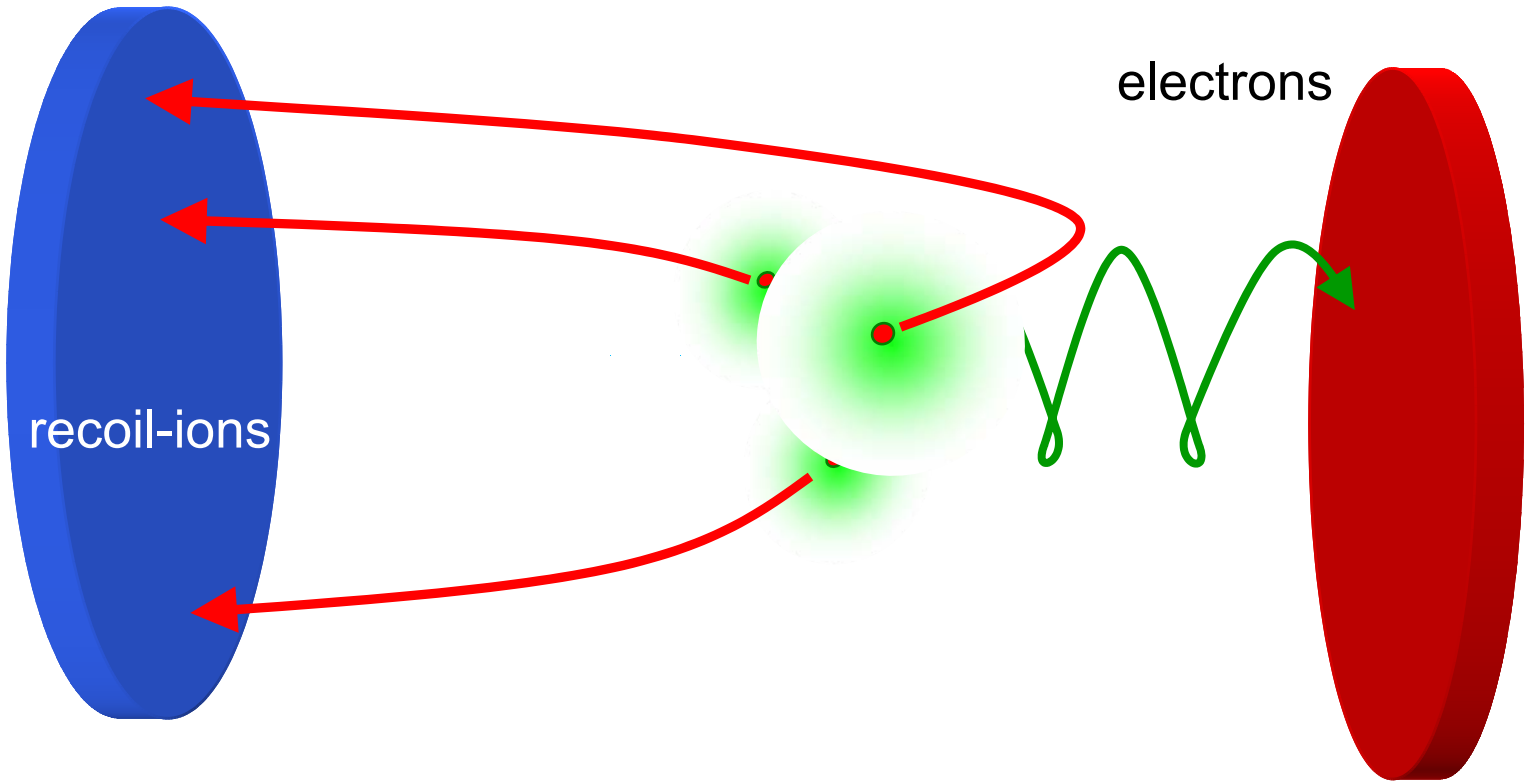
talk by M. Weidemüller

in preparation:
detection of electrons

Advanced targets

Cold molecular targets

Coulomb-Explosion in the field of (slowly moving) HCl



talk by T. Schlathölter