



*First experiments with the In-Ring
Reaction Microscope in the ESR at
GSI*

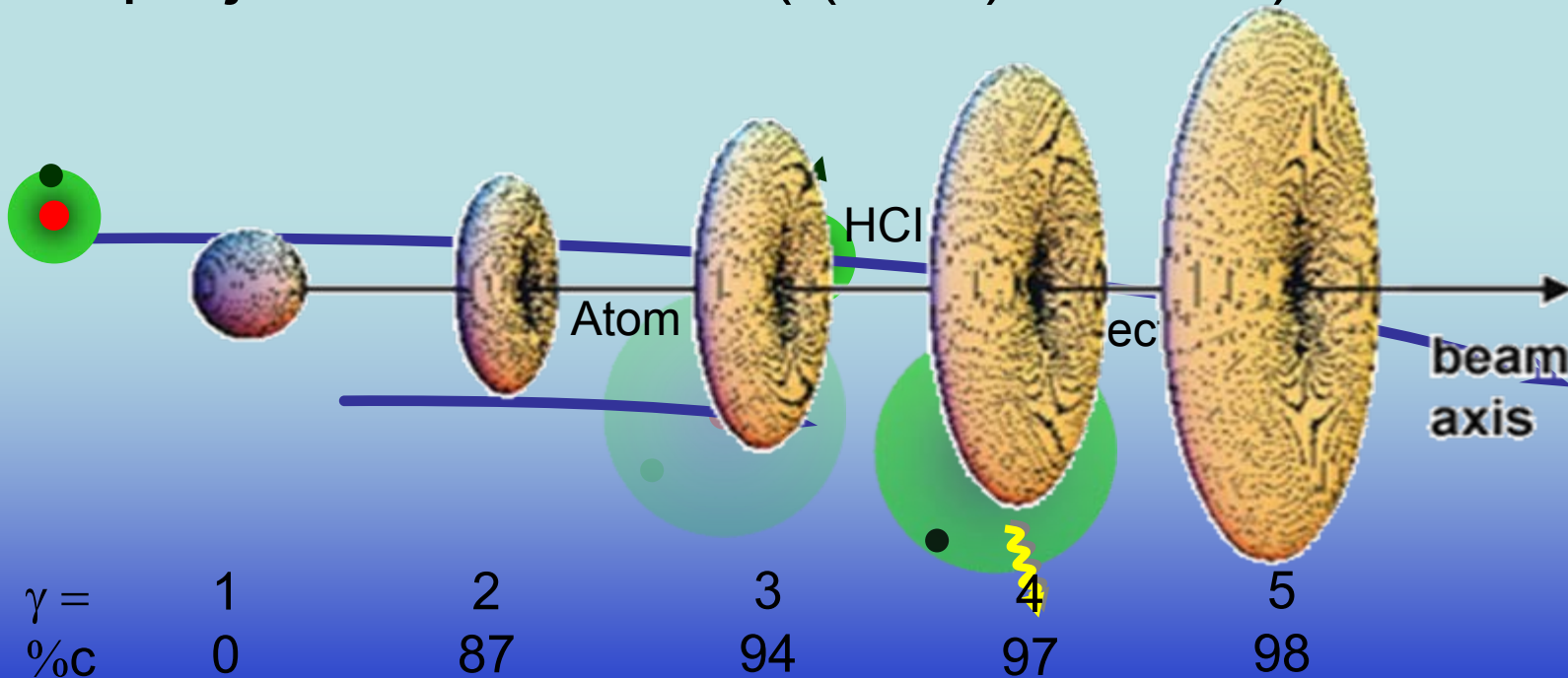
Kai-Uwe Kühnel



Motivation

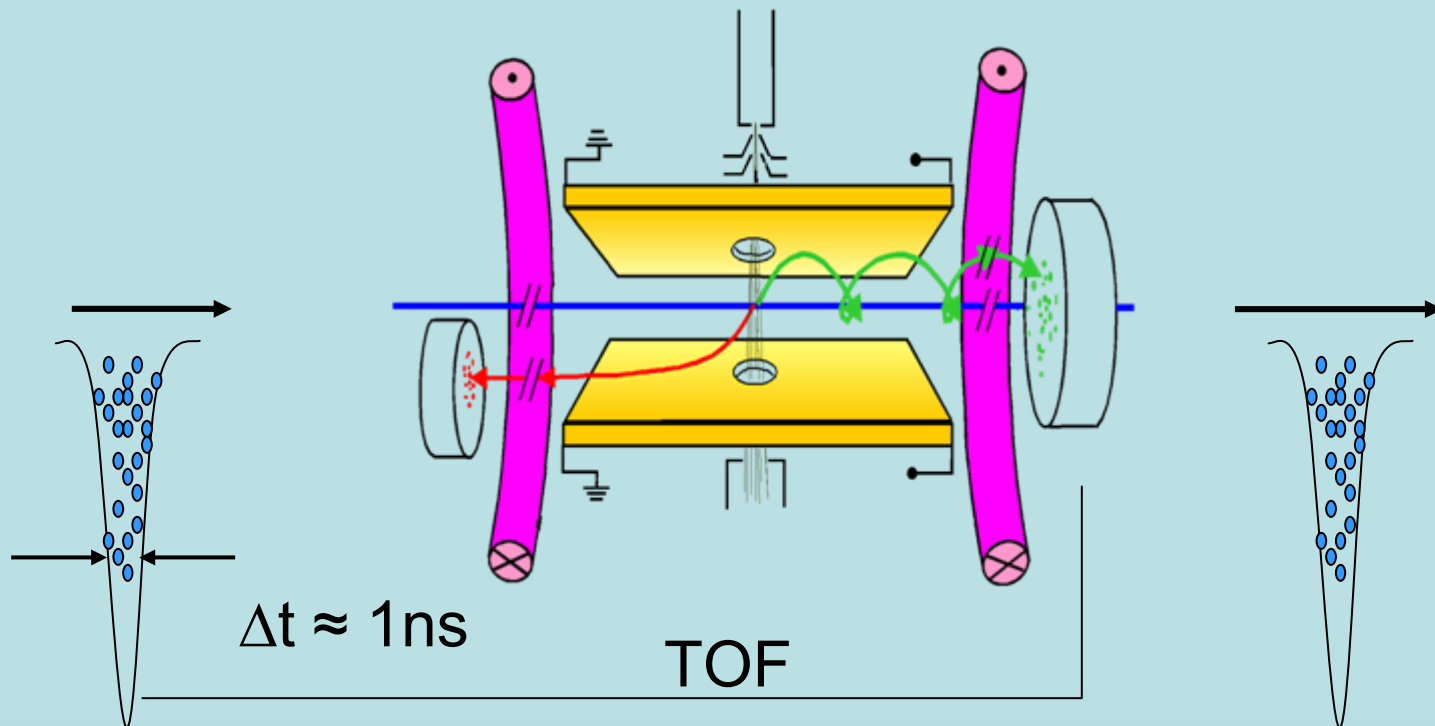
- An Attosecond microscope
- Dynamics of charge transfer processes (REC, RTE, ...)
- projectile ionisation ((e,2e) on Ions)

$b \sim 10^2$ a.u.
 $E \approx 10^{11}$ V/cm
 $\Delta t < 10^{-18}$ sec
 $I \approx 10^{20}$ W/cm²





The Reaction Microscope

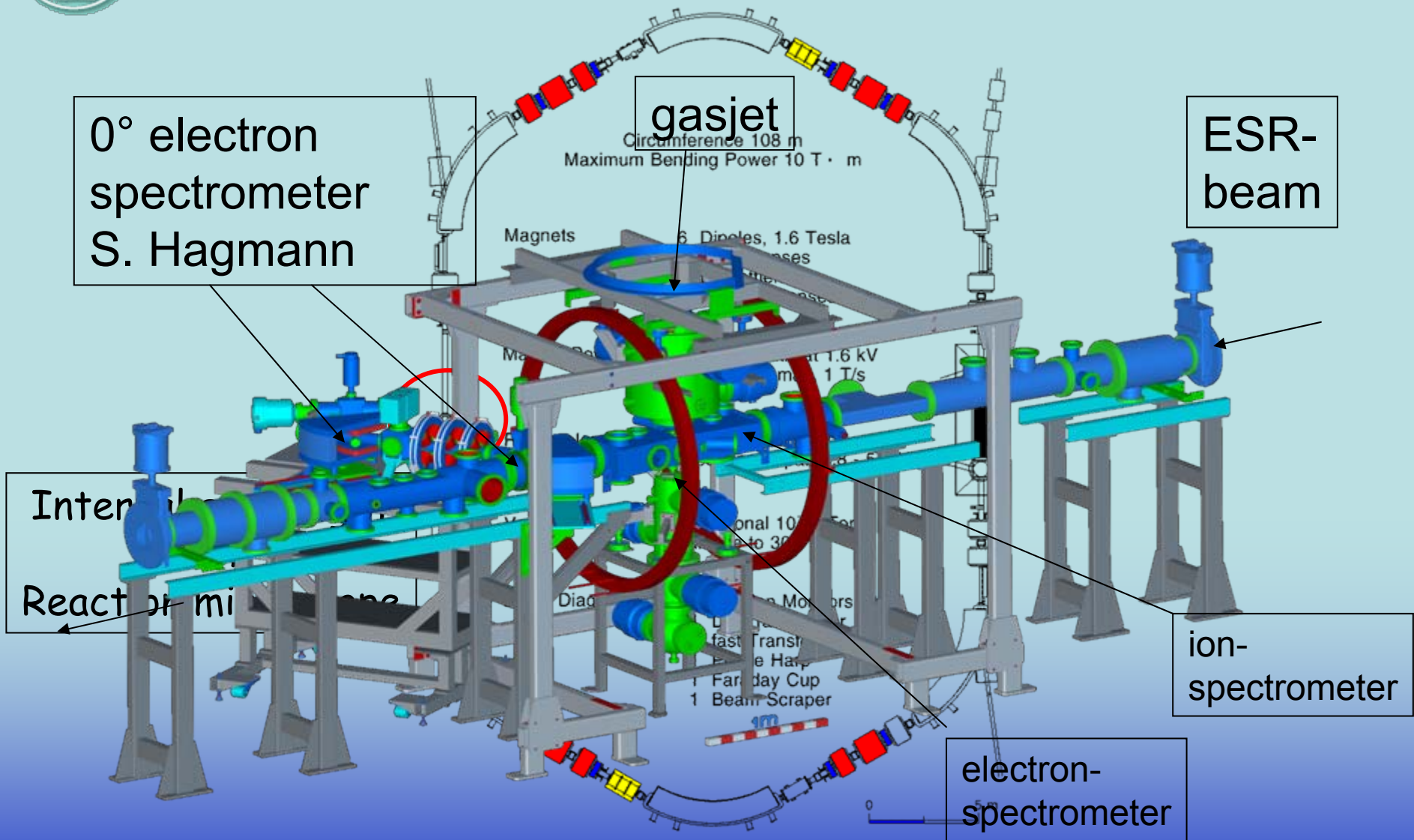


Challenges and difficulties:

- pulse width $\Delta t \approx 1\text{ns}$
- data acquisition and analyses for high rates ($\sim 2\text{ MHz}$)
- ESR-target
- ...



The In-Ring Reaction Microscope

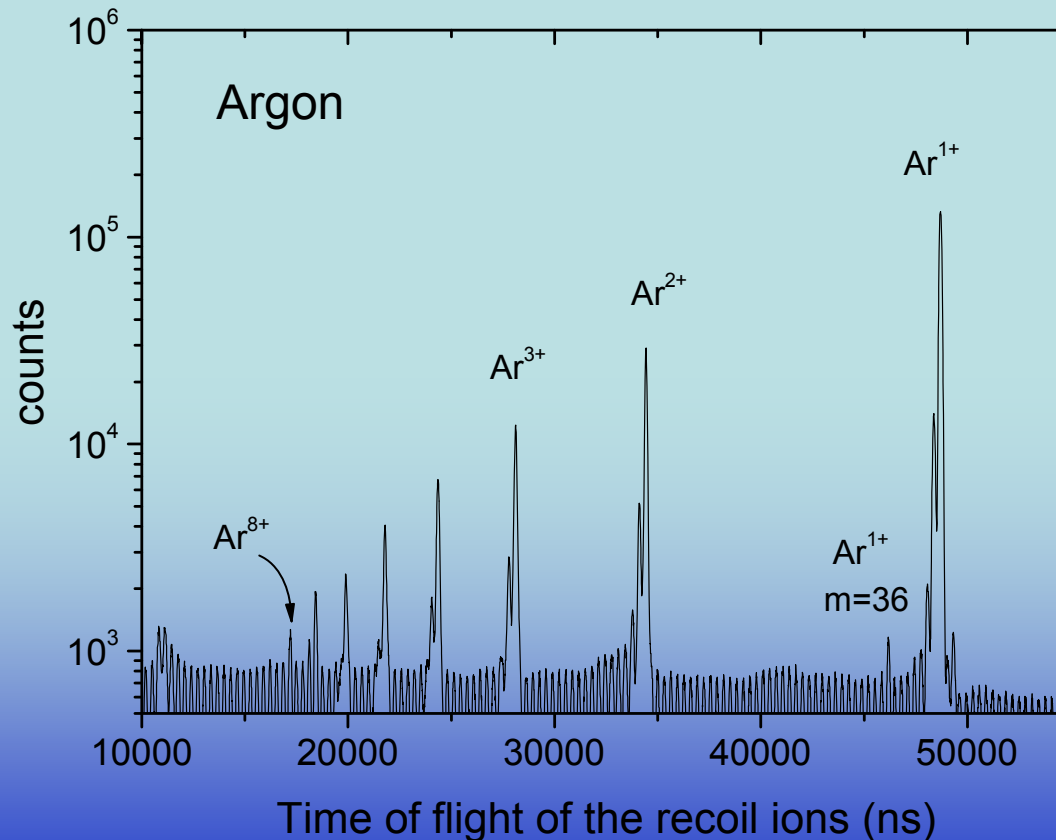




First Commissioning Experiments



Single- and multiple ionization of neon and argon by 230 AMeV U^{90+} impact ($v \sim 0,6c$)



Dec. '06

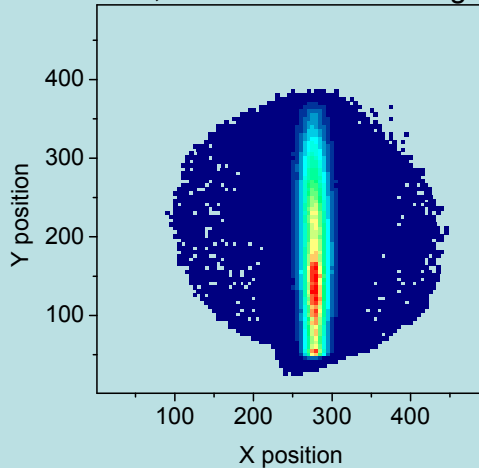


Recoil resolution



230 AMeV $U^{90+} + Ar$

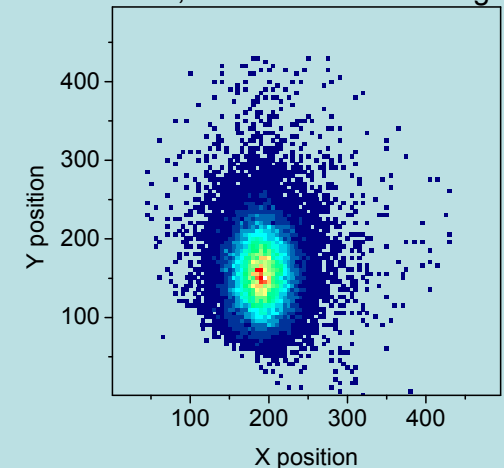
Ar^{1+} , 17 V extraction voltage



Smaller nozzle

400 AMeV $Ni^{28+} + He$

He^{1+} , 30 V extraction voltage



- Gasjet quality is crucial for high resolution experiments
- Further improvement by a factor of 3 to 4 expected with a more confined target



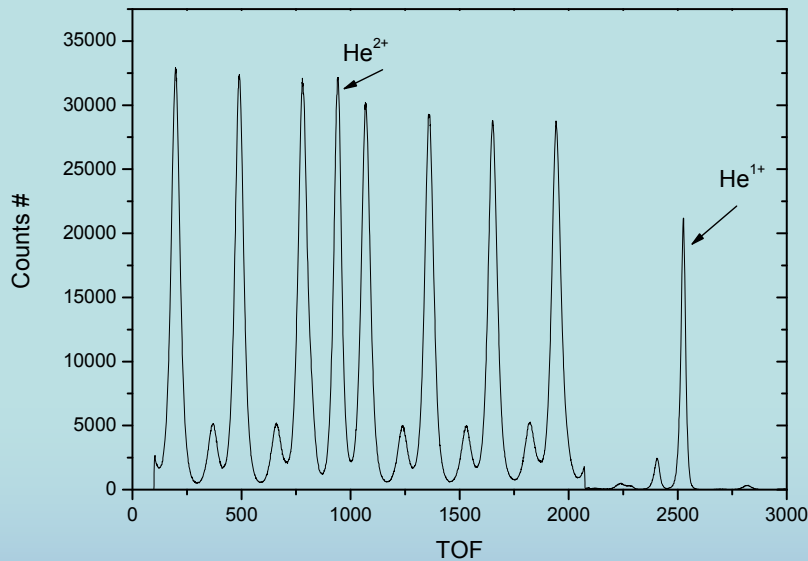
He double Ionisation



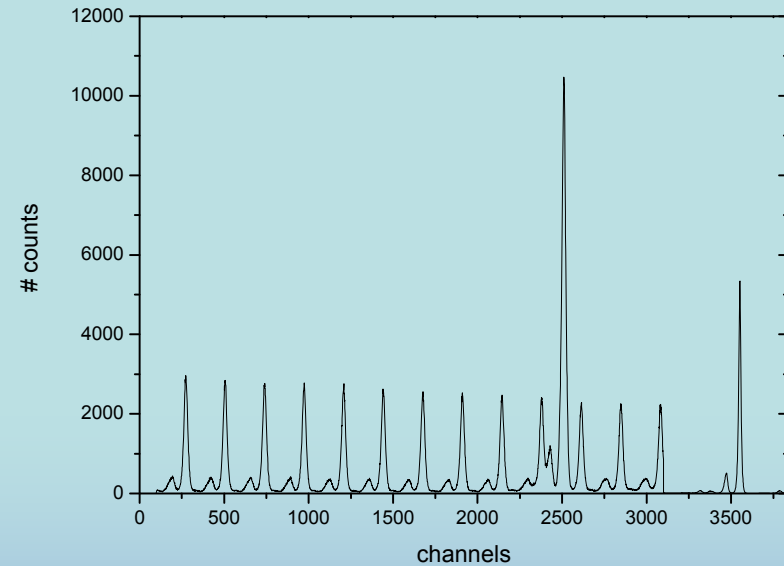
Apr. '07: 400 AMeV Ni²⁸⁺

June '07: 27 AMeV U⁹²⁺

Helium



Helium

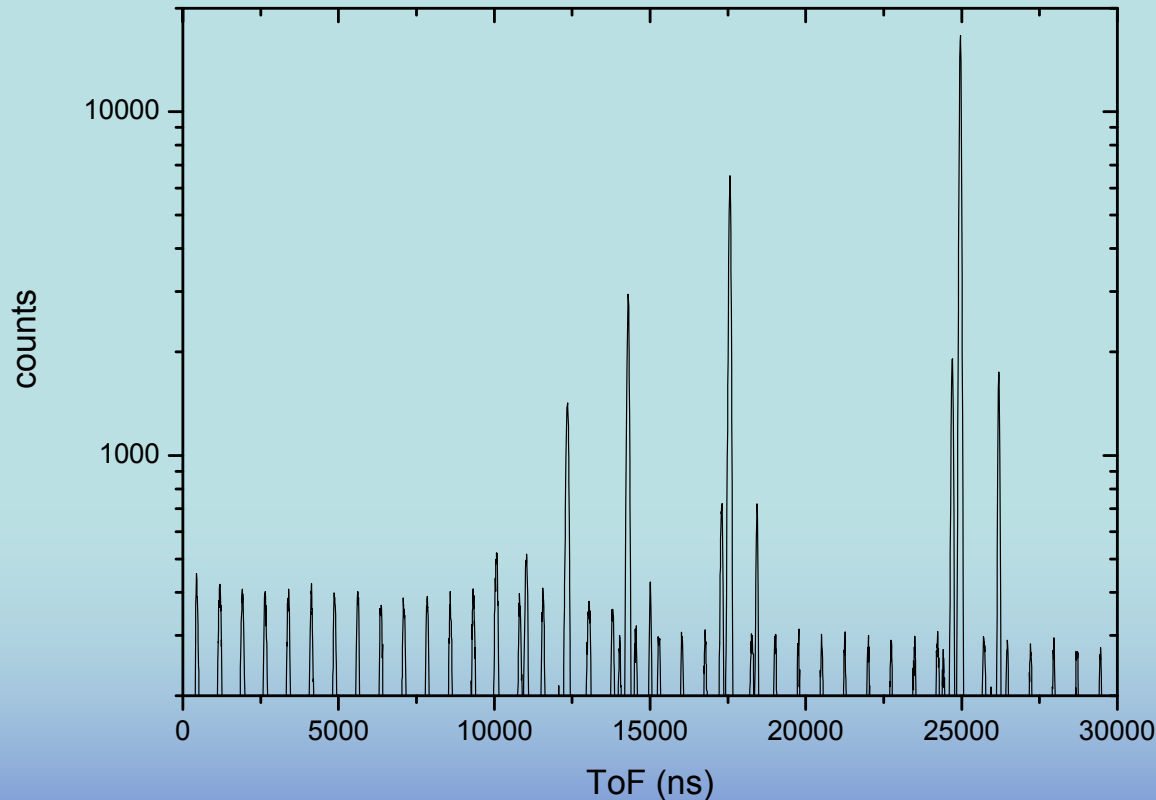


New data complementary to previous measurements:

- relativistic collision ($Z/v \sim 0.3$ a.u., $\gamma \sim 1.4$)
- High velocity, high disturbance ($v \sim 34$ a.u., $Z/v \sim 2.7$ a.u.)



U^{92+} 27 AMeV Neon Multiple Ionisation



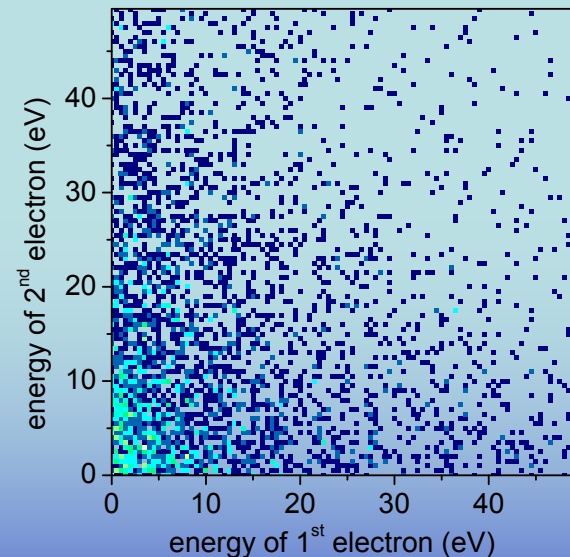
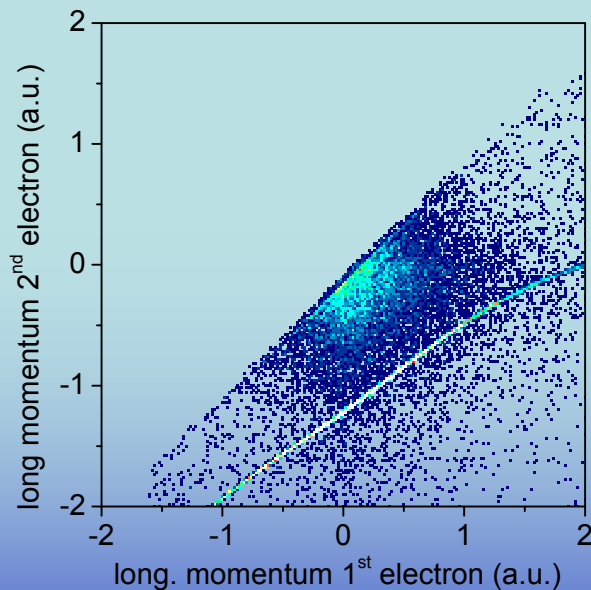
- Multiple Ionisation up to Ne^{4+}
- look at electron continuum

June 2007



Many Electrons

- Electron continua have been measured for multiple ionisation
- Analysis in progress, details about electronic correlation and bound state wave functions expected



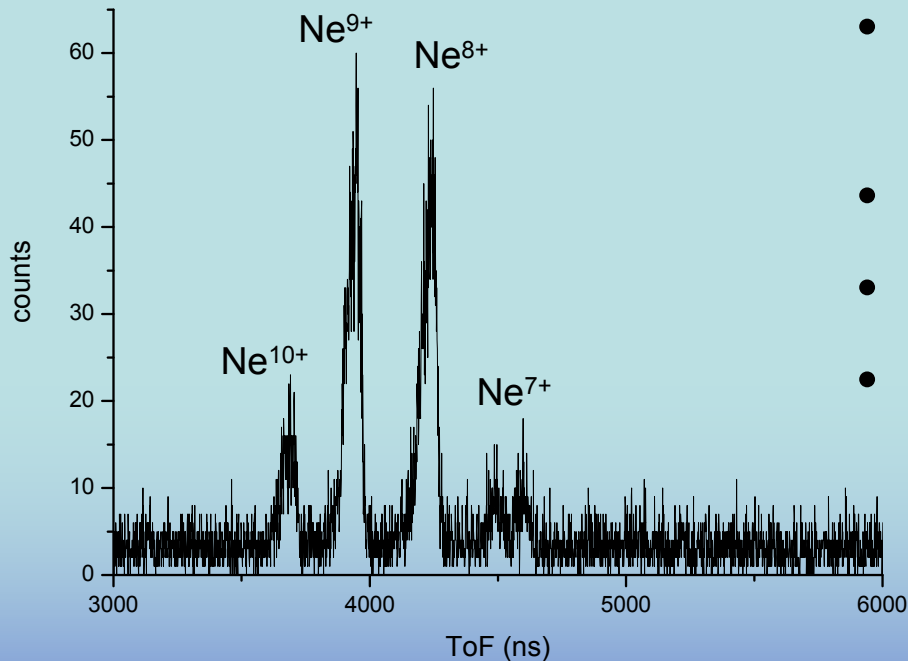
Outlook: two electron spectra in 230 AMeV U^{90+} -Ne collisions



Electron Capture



- 13 AMeV U^{90+} Ne Collision
- charge changed projectile in coincidence with recoil ions
- Low cross section ($\sim 10^{-18} \text{cm}^2$)
- Calibration difficult
- Background from random ionisation



Outlook: Coincidence with photons
→ spectroscopy on REC, RTE



Current Status



After three beamtimes the Reaction Microscope has been removed from ESR, next possible period for installation:
late 2008

In the meantime:

- Reaction Microscope will be installed in TSR (MPI Heidelberg)
- More beamtimes possible to test and improve resolution
- Room for improvements (target, fast recoil detector, pulsed spectrometer, background suppression, ...)



Conclusion



- The world-wide first in-ring Reaction Microscope works
- Storage ring provides ideal conditions for momentum spectroscopy
- First results mainly on multiple ionization in HCl-atom collisions obtained

Planned projects with in-ring Reaction Microscopes:

- FLAIR (USR)
- CSR (MPI-Heidelberg)



Outlook



Study of the dynamics in various collision induced processes:

- Coincidences with photons
 - REC and RTE
 - projectile excitation
- Coincidences with fast electrons (0° e⁻-spectrometer)



The People:



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Th. Zouros (*Heraklion, Crete*)

**Thank You
for your
attention!**