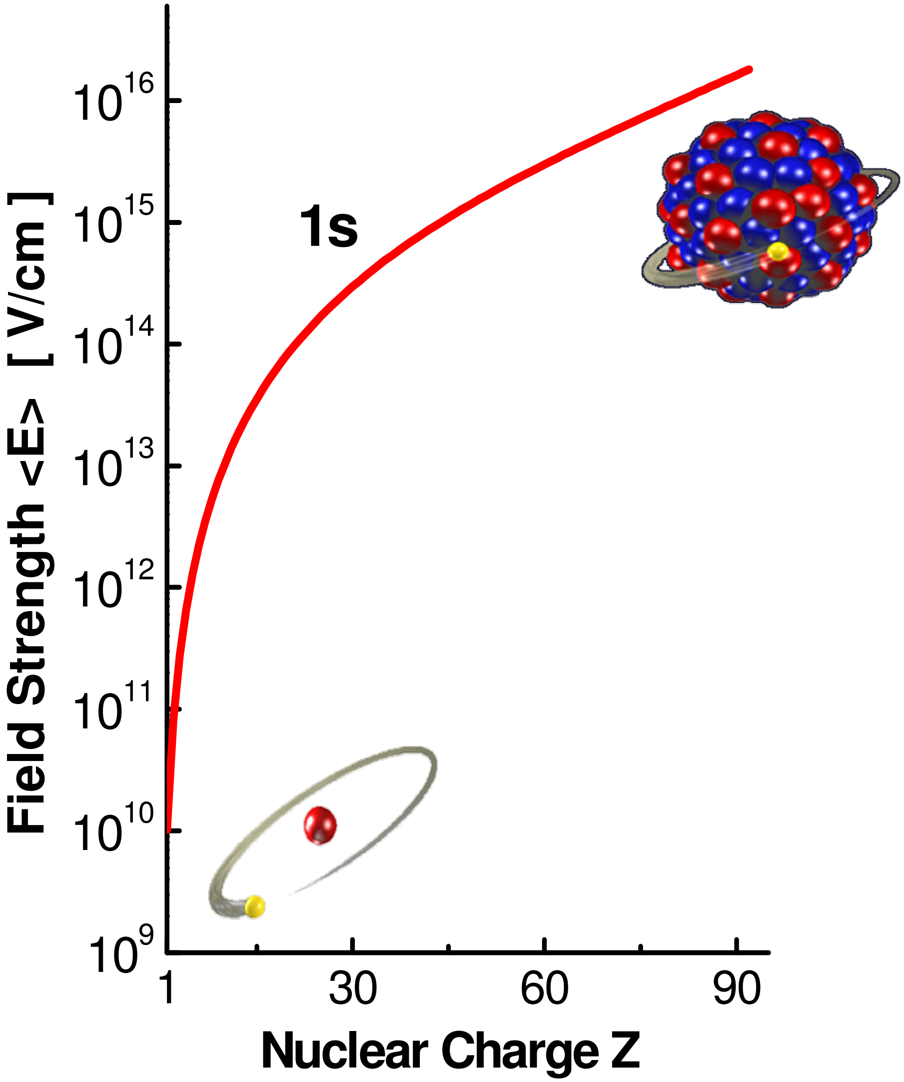
Radiative processes studied in collisions of U^{92+} with a H_2 target

Outline:

- **Motivation**
  - ➢ **Why highly charged, high-z ions?**
- **Experiment**
  - ➢ **GSI facility**
  - ➢ **Experimental set-up**
- **Results**
  - ➢ **REC**
  - ➢ **Ly-α alignment**
  - ➢ **Bremsstrahlung**

Why spectroscopy with highly charged, heavy ions?

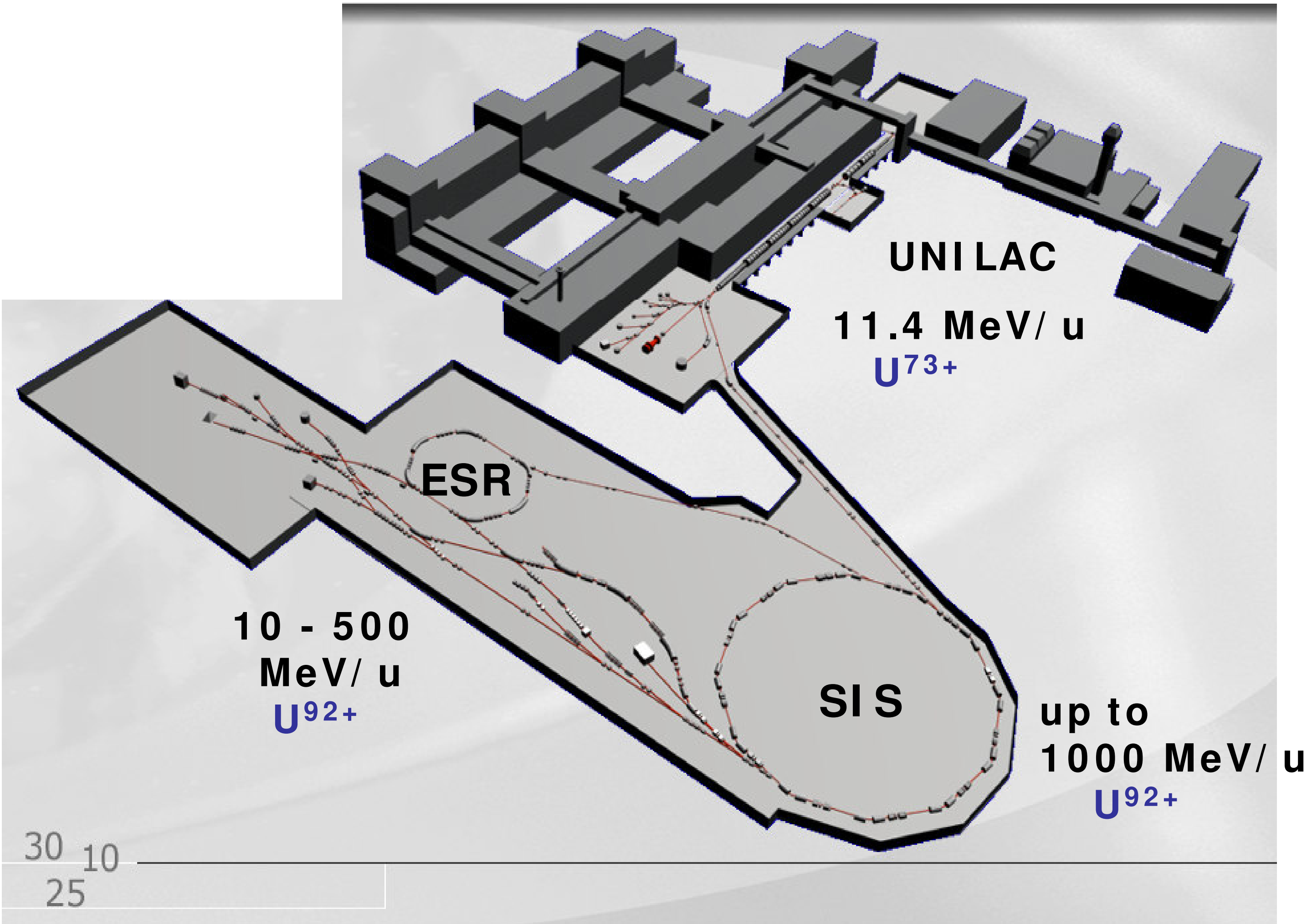


$\Delta E \approx 500$ eV
$Z \cdot \alpha \approx 1$

***Q**uantum*
***E**lectro-*
***D**ynamics*

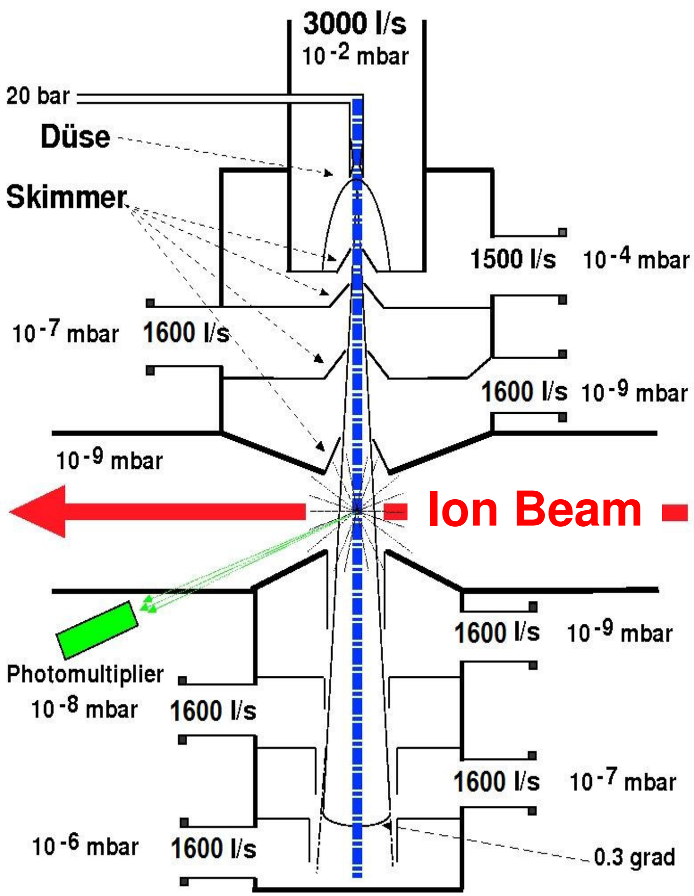
$\Delta E \approx 10^{-6}$ eV
$Z \cdot \alpha \approx 10^{-2}$

The GSI Facility



ESR & internal gas target

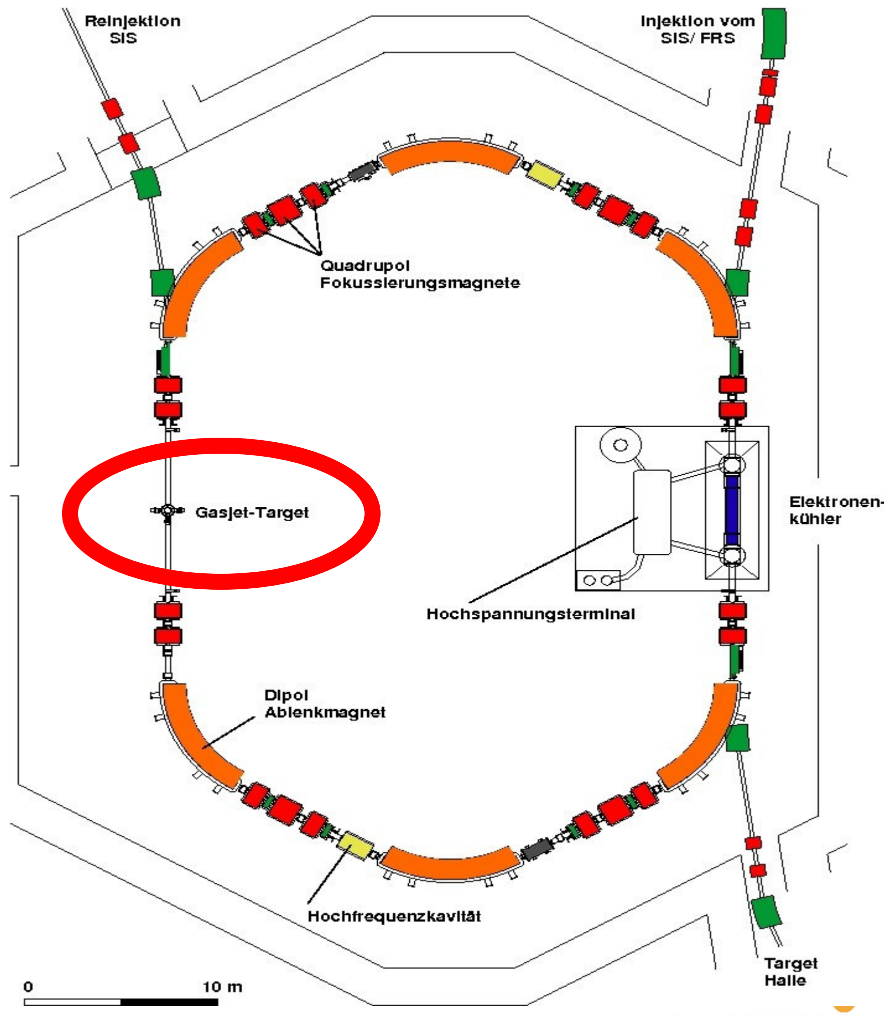
Internal Gasjet-Target



available Targets: H_2, N_2, Ar, Kr, Xe

typical density: 10^{12} particles/cm^3

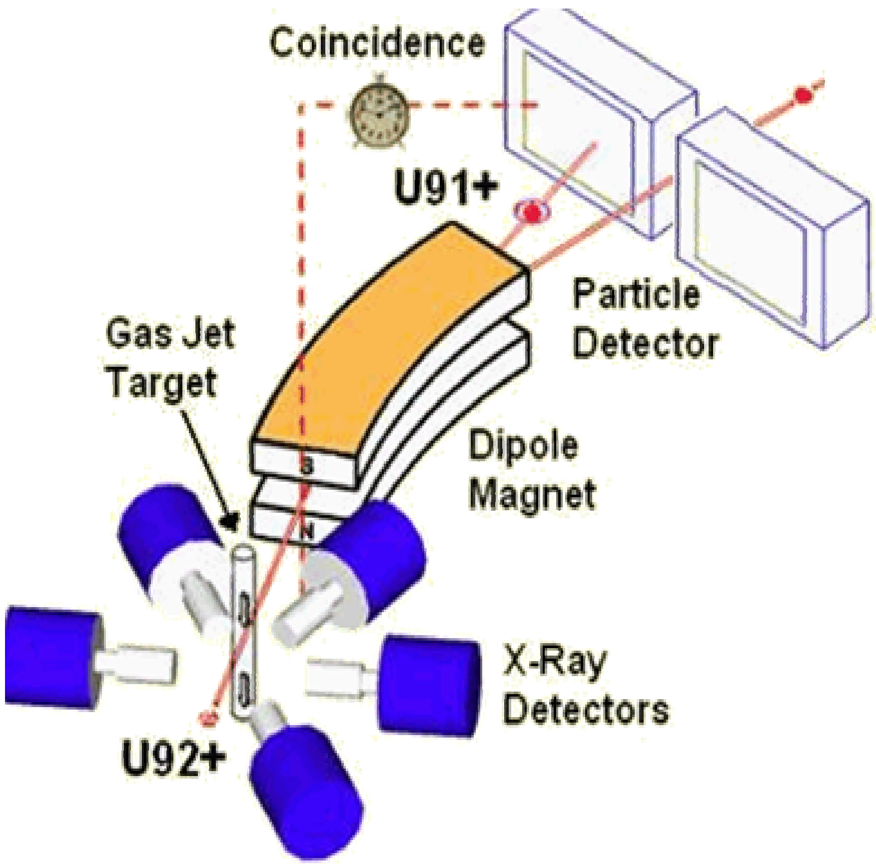
Experimental Storage Ring (ESR)



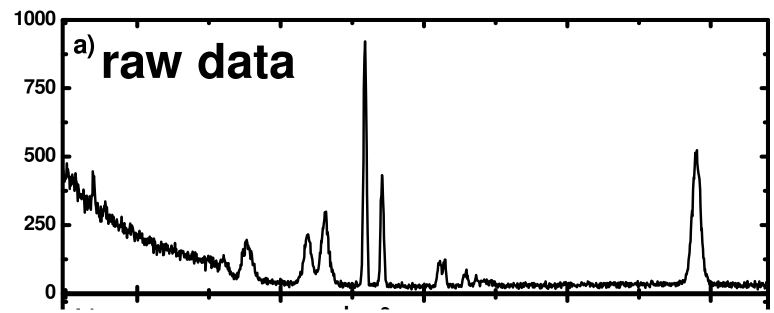
The Experiment

U^{92+} -> H_2 @ 96.6 MeV/u

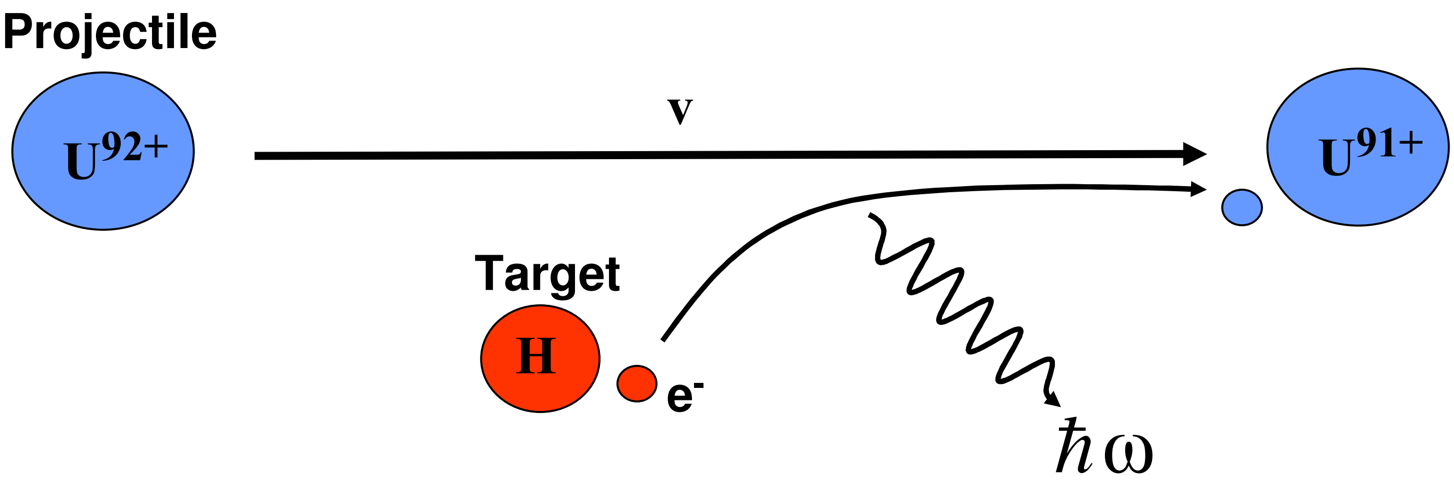
Experimental Set-up

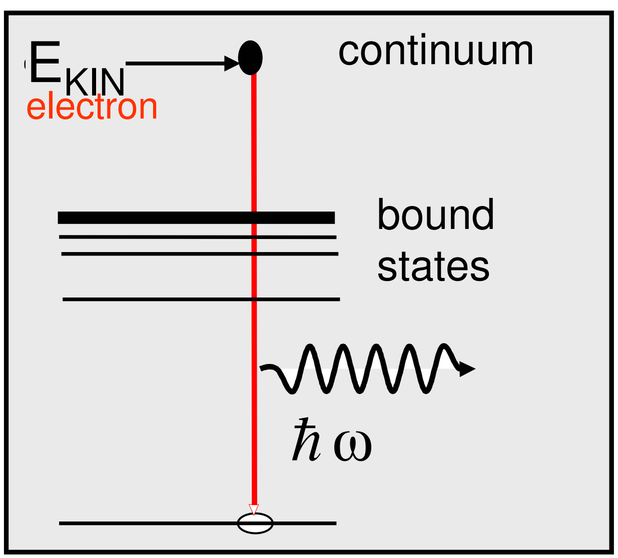


X-ray Spectra at 150°



Radiative Electron Recombination (REC)

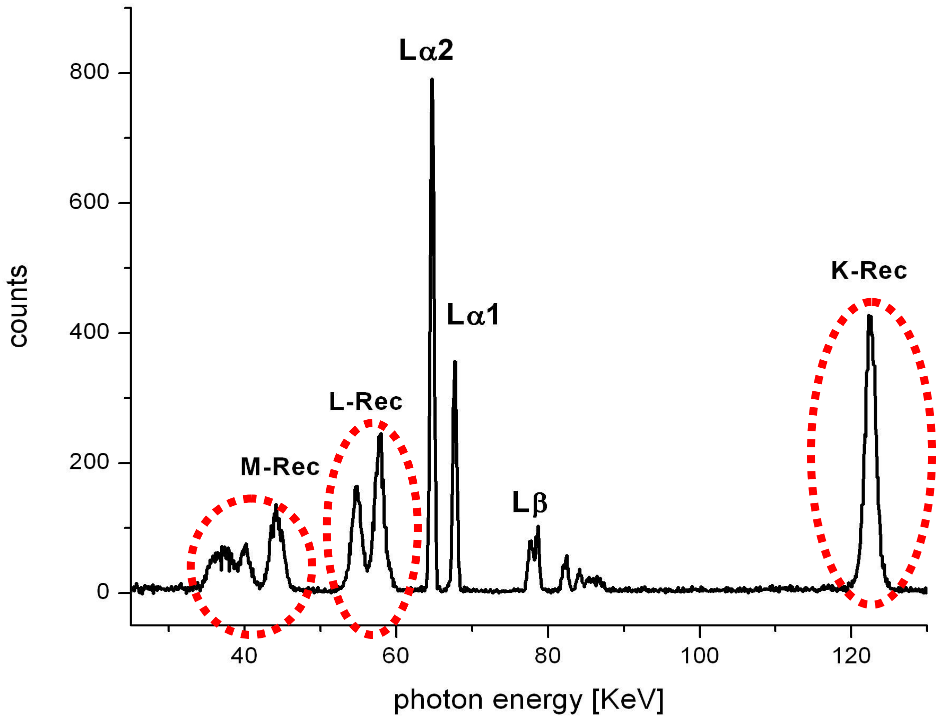


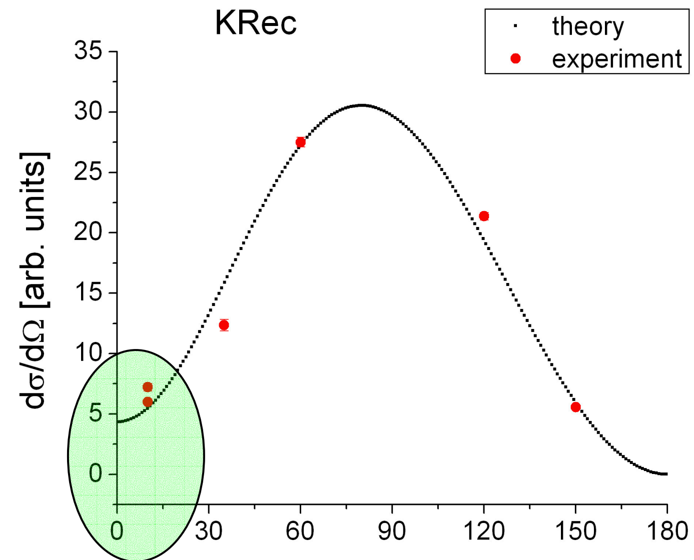


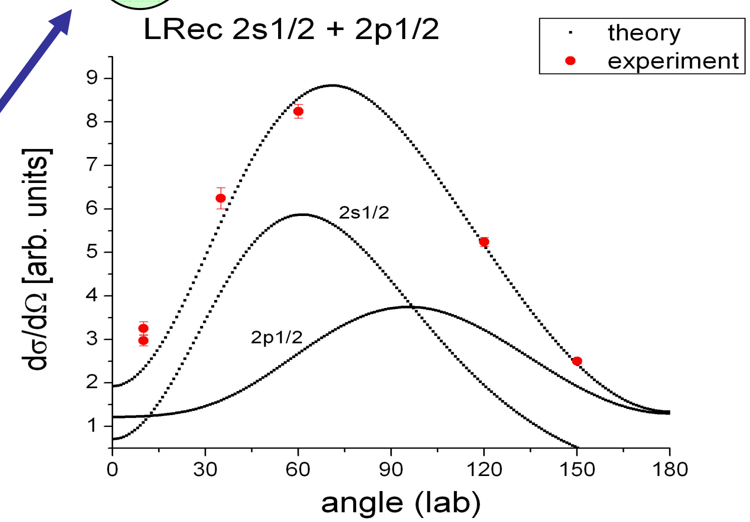
X - ray energy

$$\hbar\omega = E_B + E_{KIN}$$

Results: REC lines

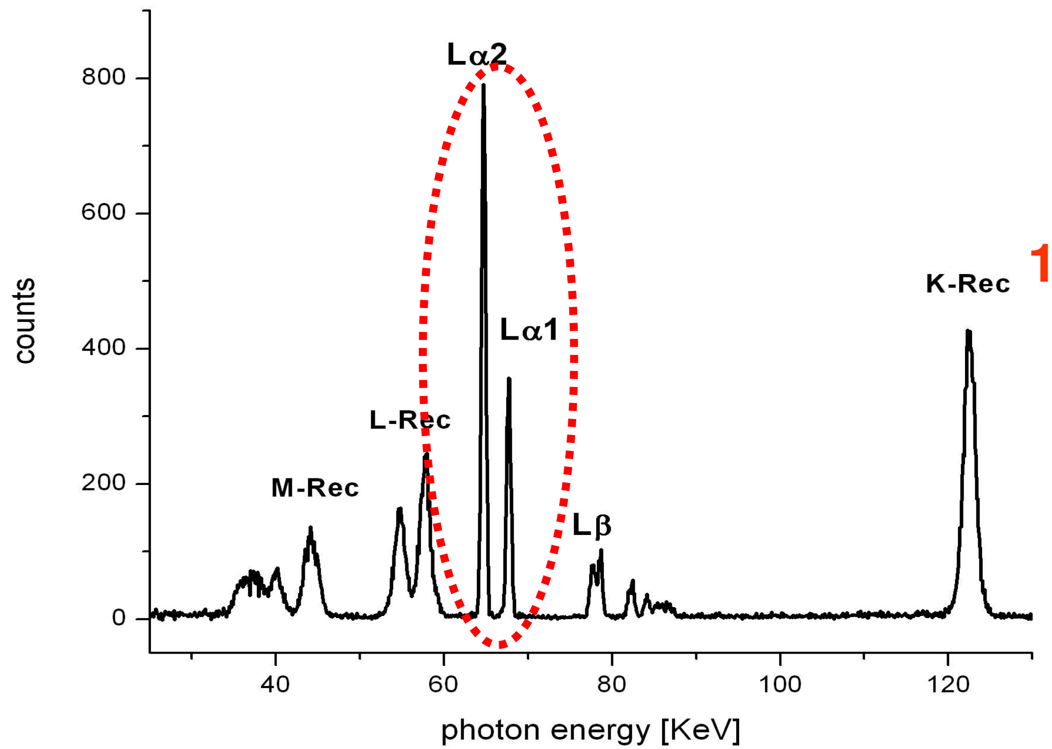


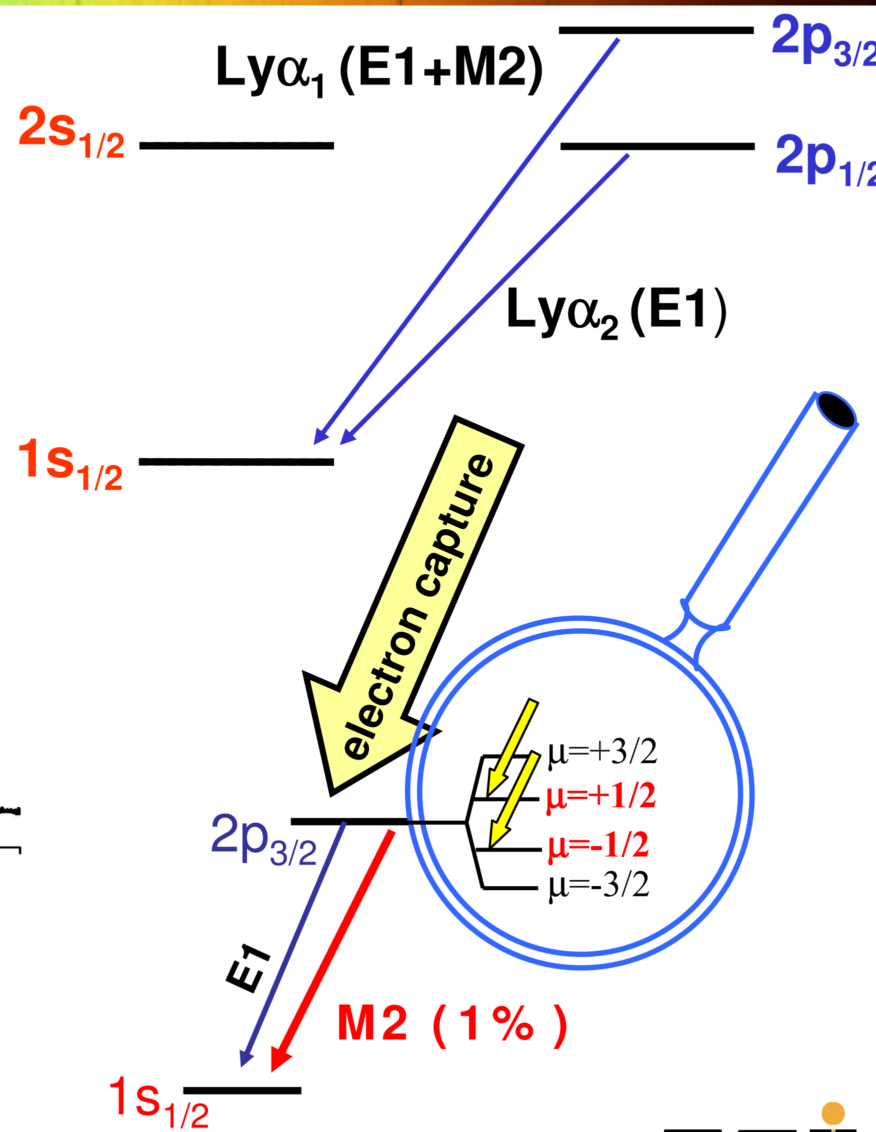




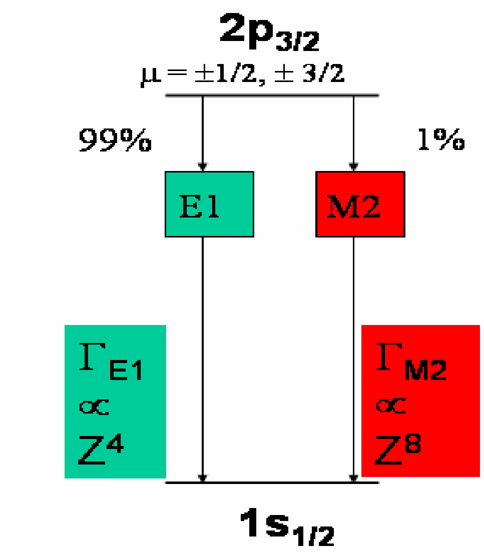
non-zero because of magnetic interactions (‚spin flip‘)

Lyman-α alignment





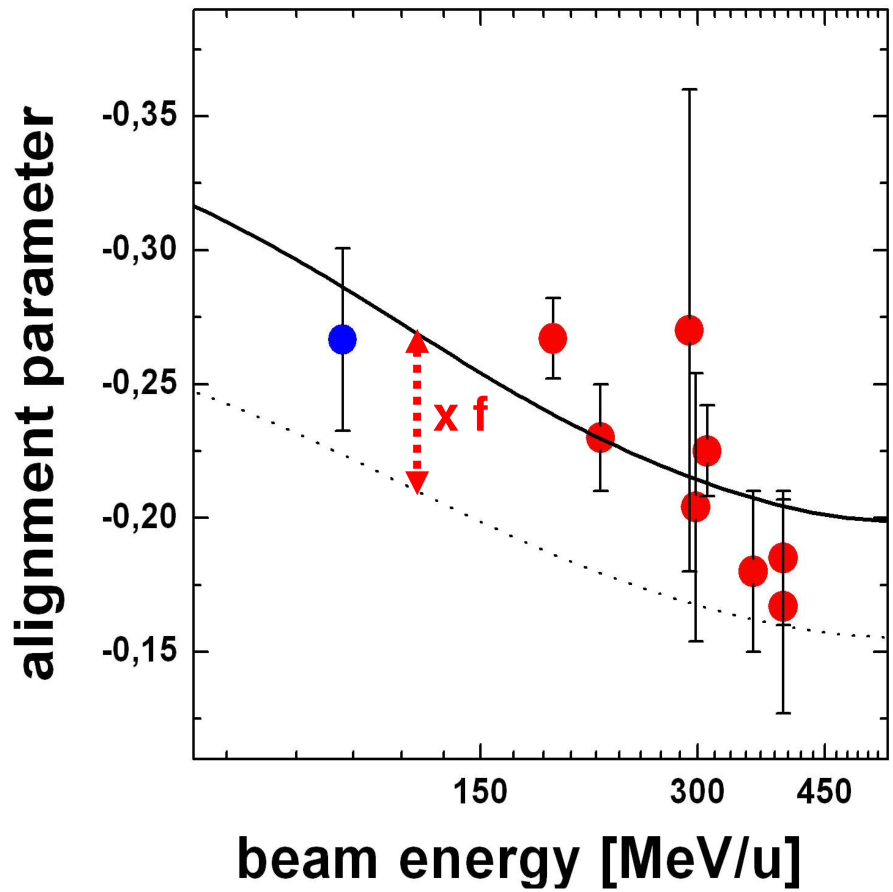
Results: Lyman-α alignment



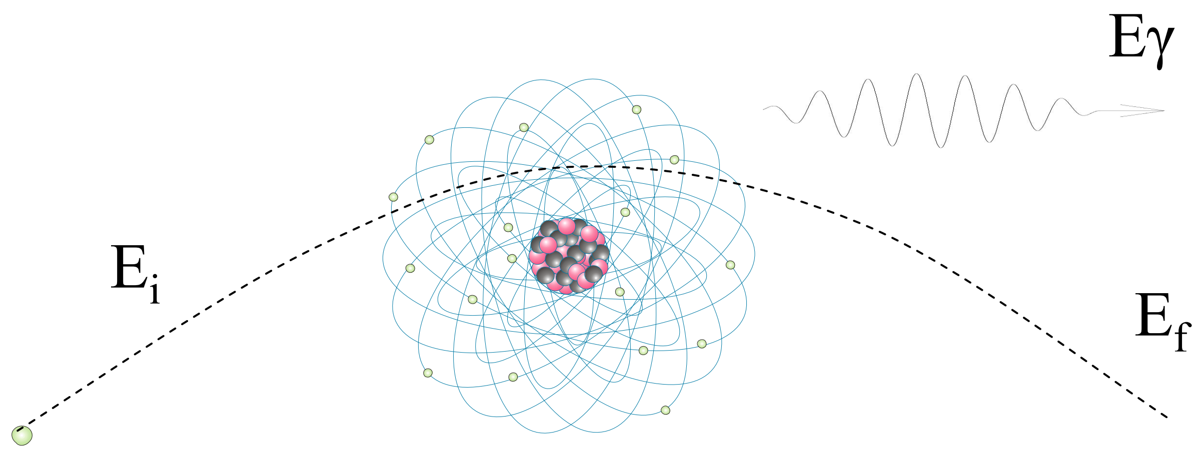
$$W(\theta) \propto 1 + f\left(\frac{a_{M2}}{a_{E1}}\right) \bullet \beta_A \bullet \left[1 - \frac{3}{2}\sin^2\theta\right]$$

$$f\left(\frac{a_{M2}}{a_{E1}}\right) \propto \left[1 + 2\sqrt{3}\,\frac{\langle \| M2 \| \rangle}{\langle \| E1 \| \rangle}\right]$$

Theory for Z=92: $\boxed{f = 1.28}$

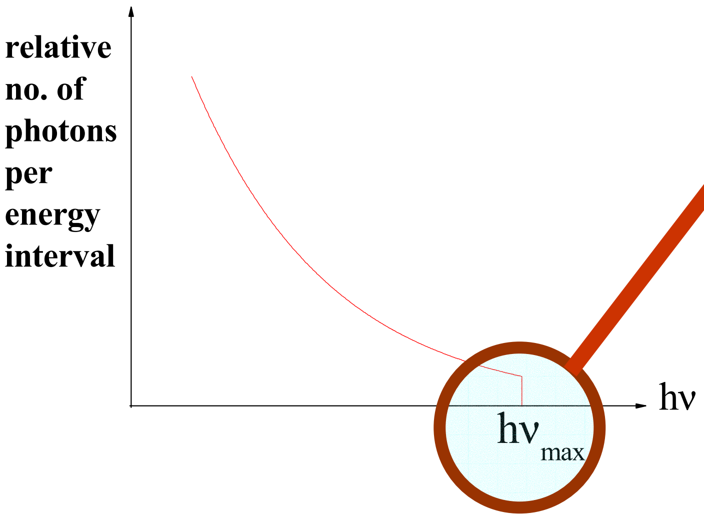


Electron Bremsstrahlung

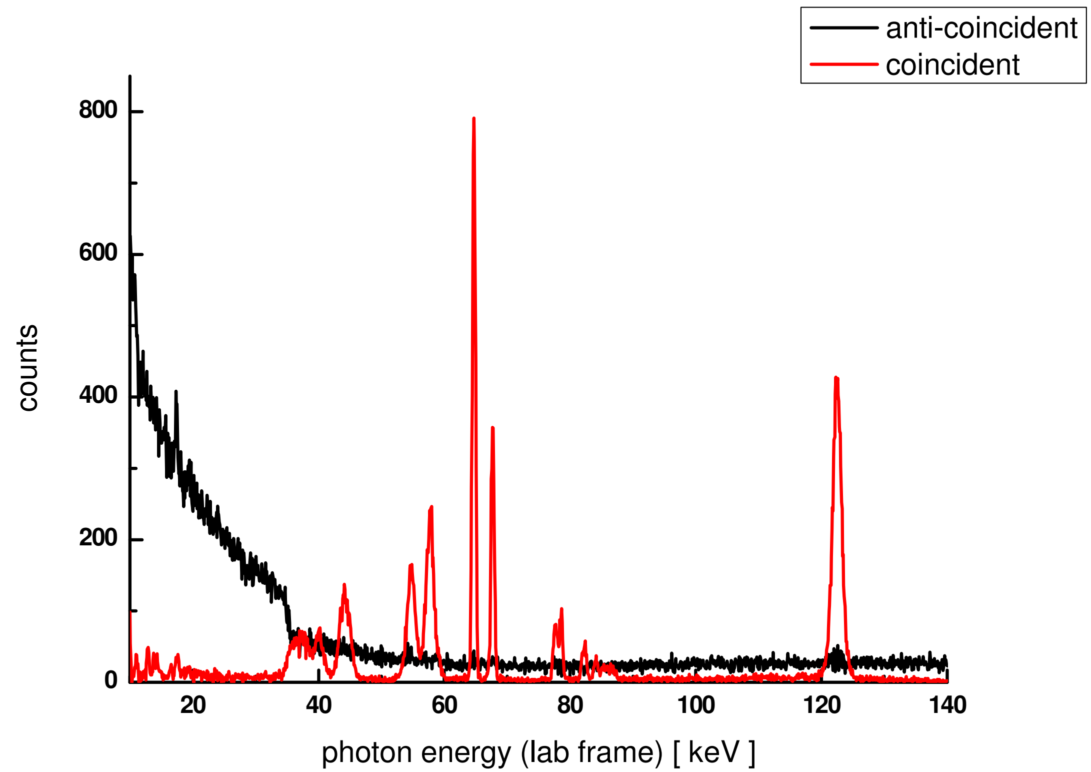


$$\boxed{E_i = E_f + E_\gamma}$$

Short wavelength limit of e^- Bremsstrahlung



Relativistic QM calculation: Finite cross section at the high frequency limit



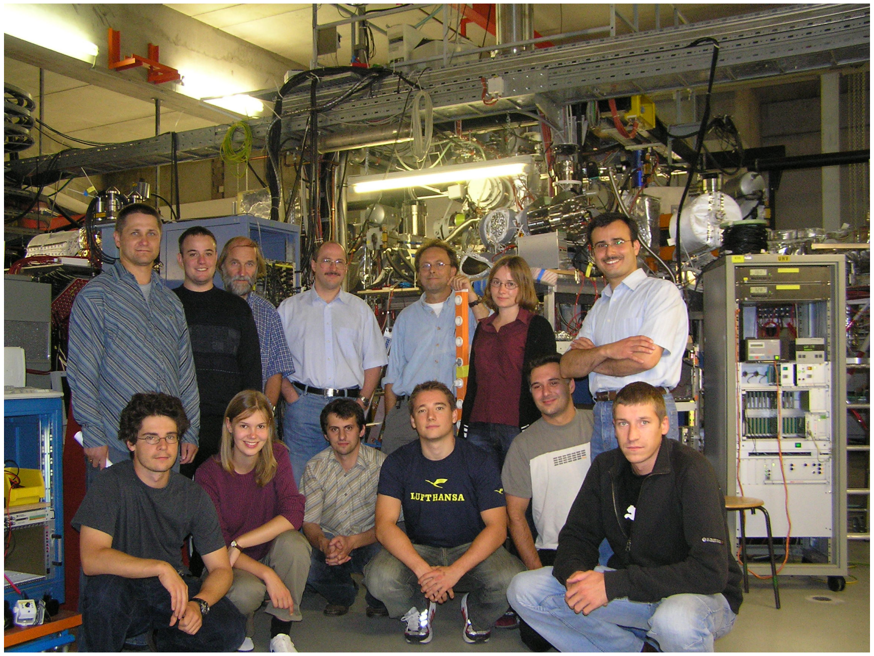
The short wavelength limit…

...shows the smooth transition from REC to capture into continuum states

…reflects details of the ions Coulomb potential

Thank you for your attention

… and many thanks to the working group!



Literature:

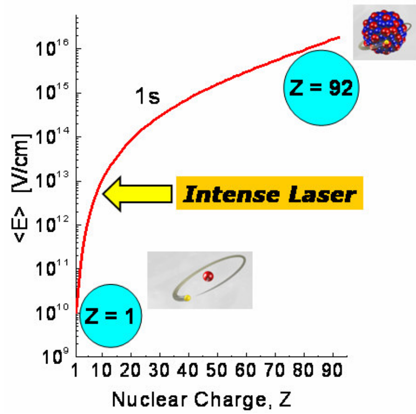
- **REC angular distribution**
  J. Eichler, Th. Stöhlker 'Radiative Electron Capture in Relativistic Ion-Atom Collisions and the Photoelectric Effect in Hydrogen-like High-Z Systems'. Physics Reports Vol 439 (2007)

- **Ly-α alignment**
  A. Surzhykov et al. 'Lyman- α1 Decay in Hydrogenlike Ions: Interference between the *E*1 and *M*2 Transition Amplitudes'. Phys Rev Vol 88 (2002)

- **Bremsstrahlung**
  T. Ludziejewski et al. 'Study of electron bremsstrahlung in strong Coulomb fields at the ESR storage ring'. Hyperfine Interactions Vol 144 (1998)

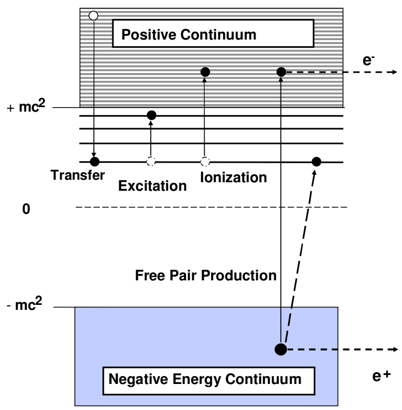
Atomic Physics in Strong Coulomb Fields

Structure Studies



- bound state quantum electrodynamics
- nuclear effects on the atomic structure
- effects of relativity on the atomic structure
- electron correlation in strong fields
- supercritical fields

Dynamics



- dynamically induced strong field effects
- correlated many body dynamics
- elementary atomic processes at high Z
- photon matter interaction, e.g. photon polarization correlation