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Laboratori Nazionali di Frascati

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ECT*
EUROPEAN CENTRE
FOR THEORETICAL STUDIES
IN NUCLEAR PHYSICS AND RELATED AREAS

Cascade models for atomic transitions

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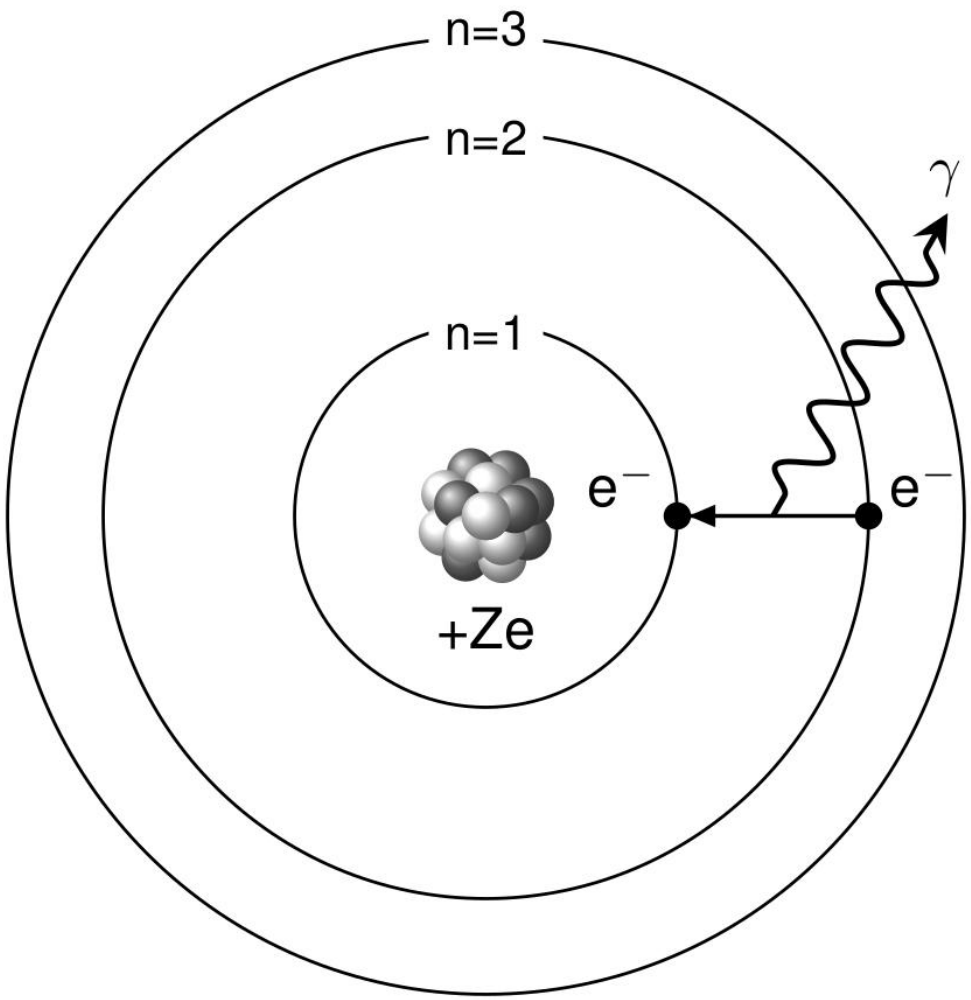
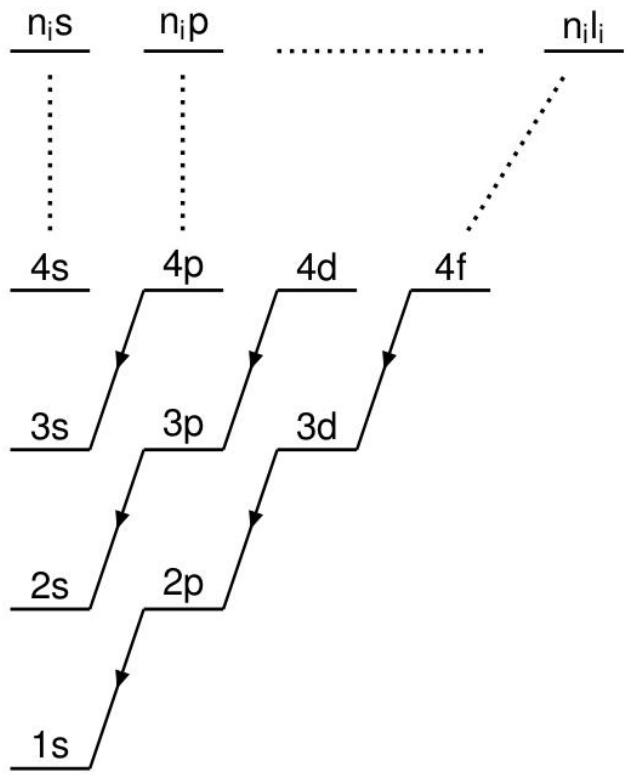
22 September 2022

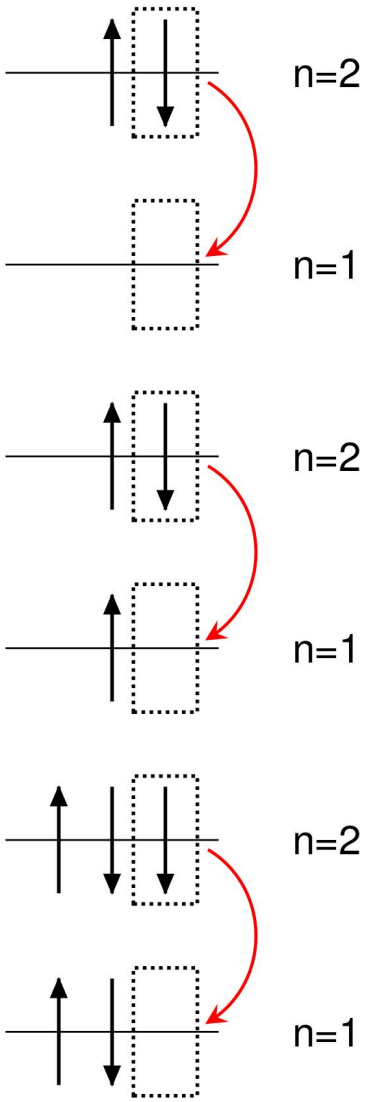
Cascade model for atomic transitions

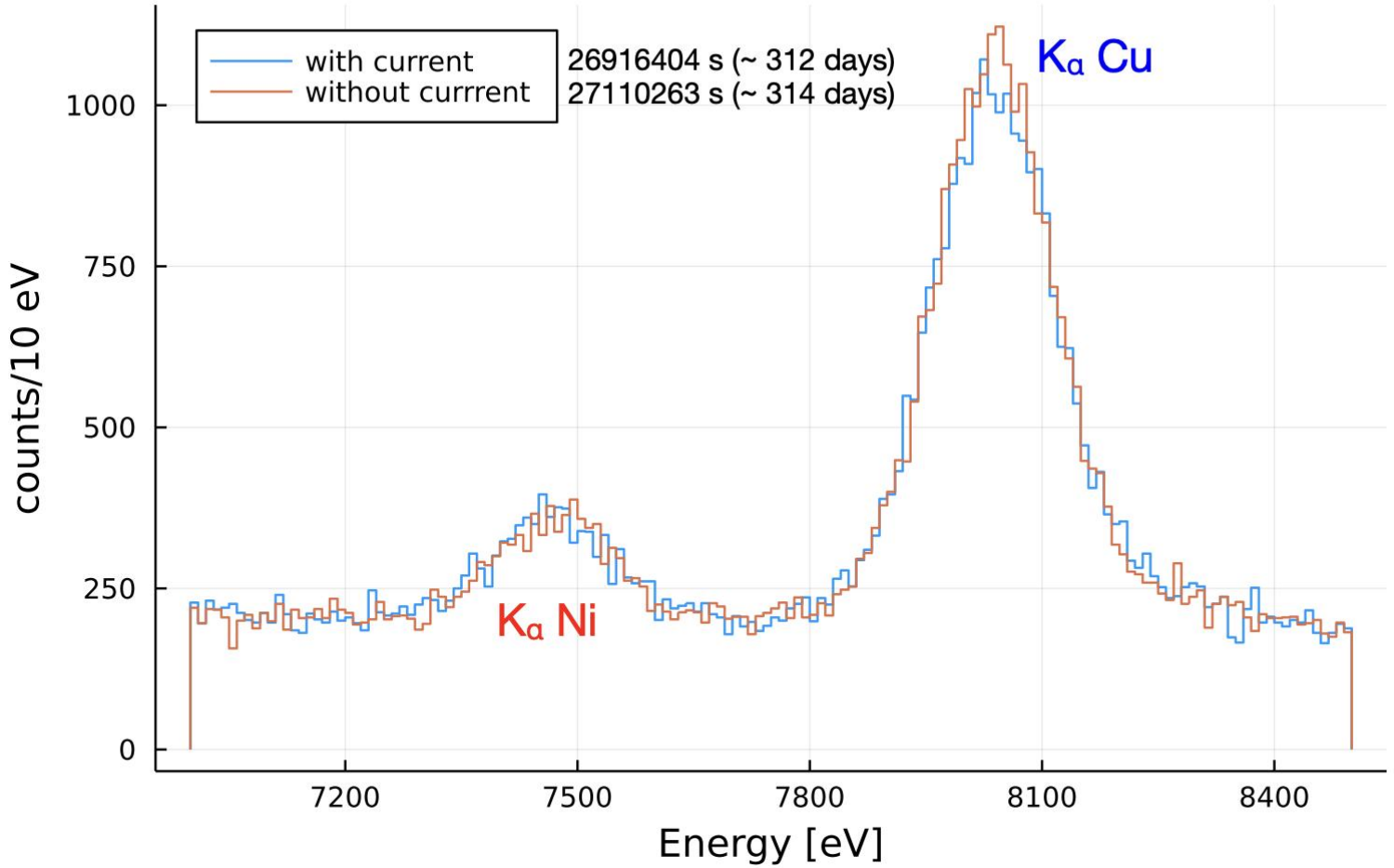




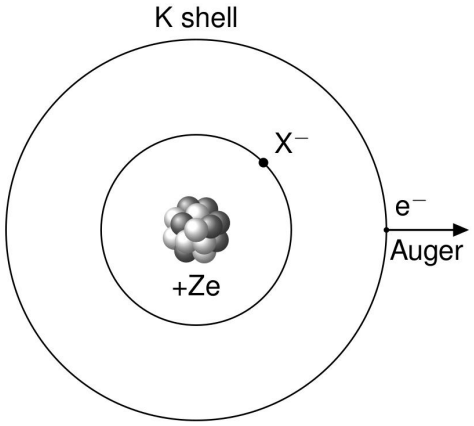
Jensen, T., Markushin, V. Collisional deexcitation of exotic hydrogen atoms in highly excited states . Eur. Phys. J. D 21, 271–283 (2002)

Cascade model for Pauli Violating Principle transitions





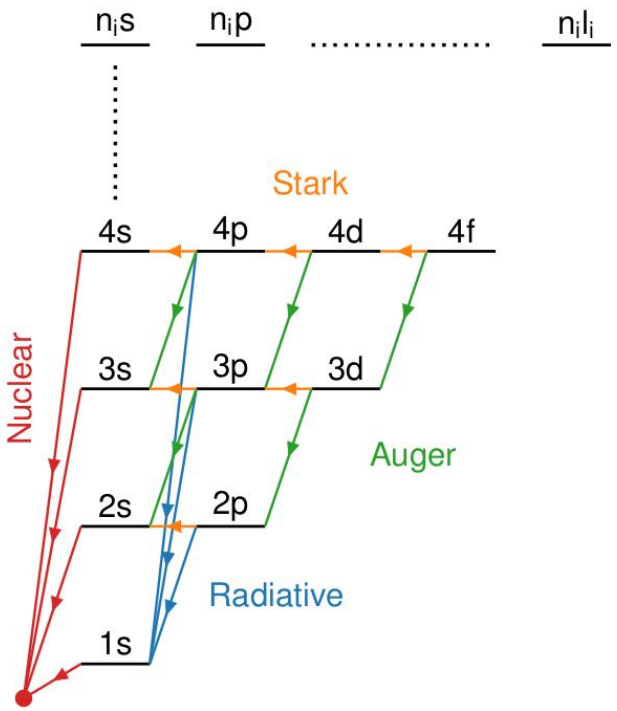
Cascade model for exotic atoms (KN)

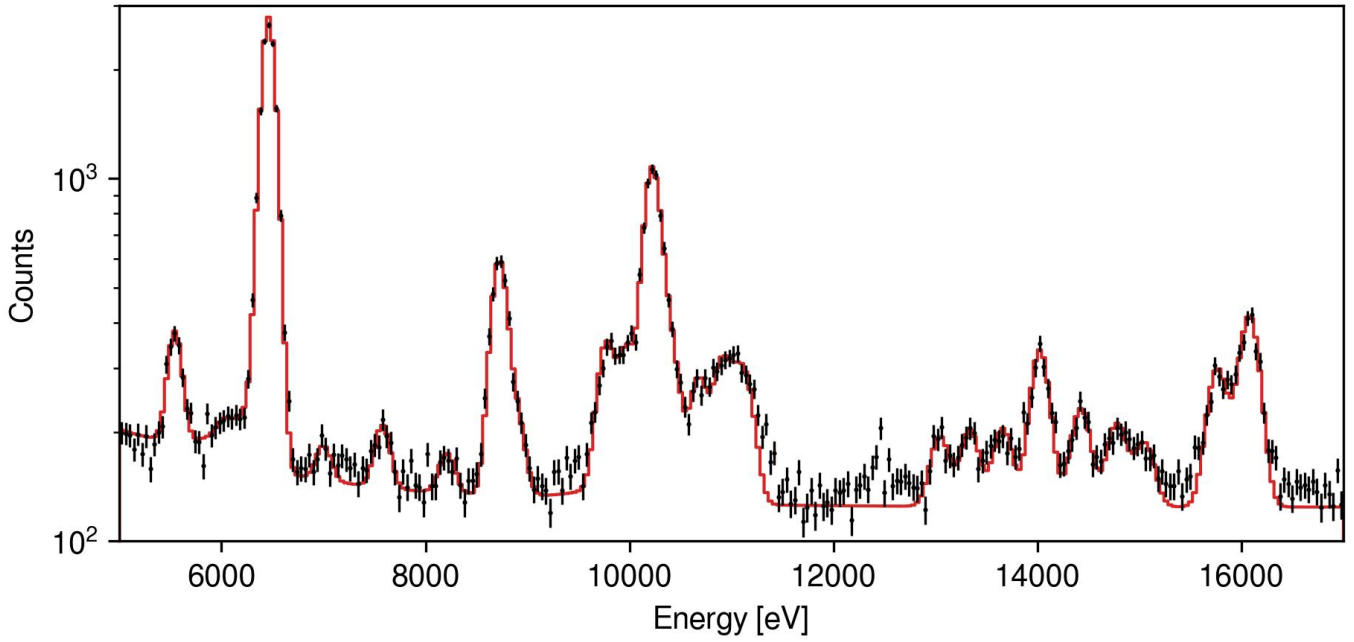


Exotic atom = Atom + X^-

$X^- = \mu^-, K^-,$

$$E_n = -\frac{\mu Z^2}{2n^2} \qquad r_n = \frac{n^2}{\mu Z}$$



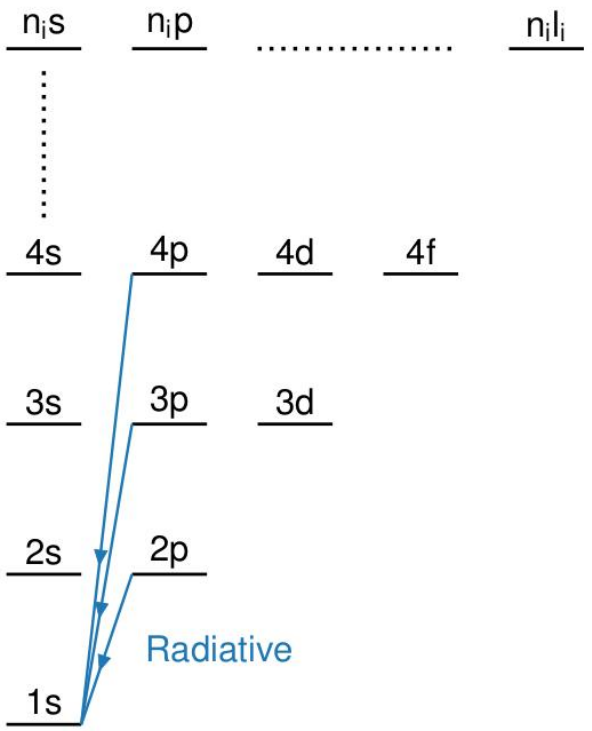


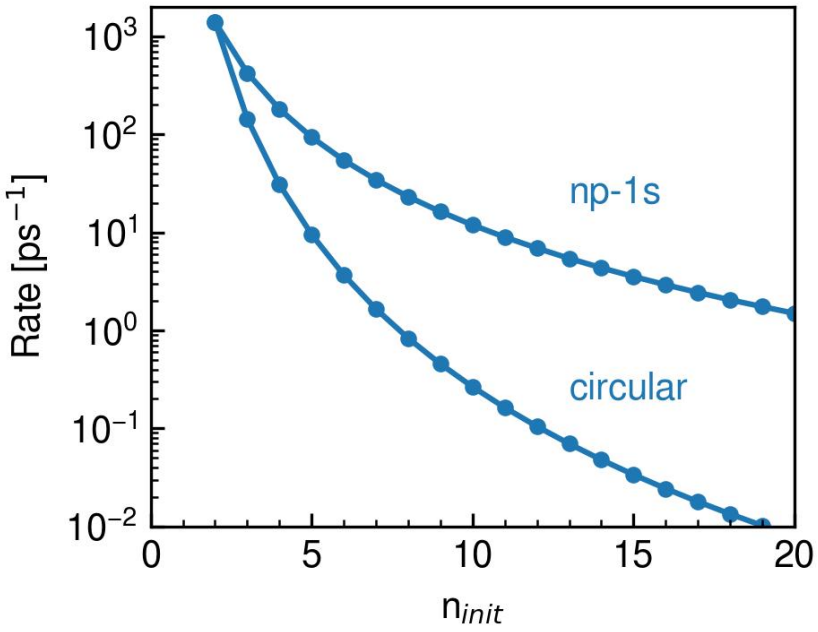
Radiative rate from scaling the (Z,μ)-hydrogen rate

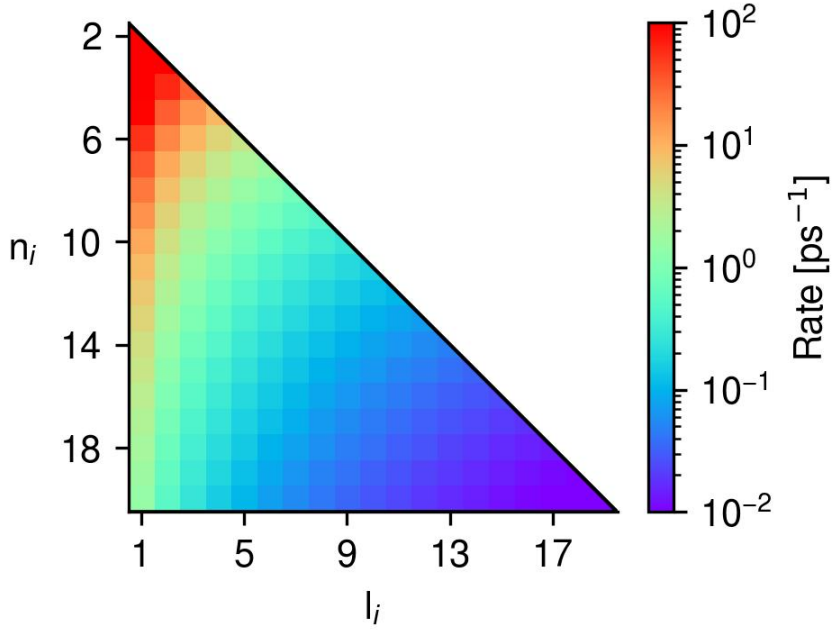
$$(x^{-}X)_{n_i l_i} \rightarrow (x^{-}X)_{n_f l_f} + \gamma$$

$$\Gamma^{rad}_{n_i l_i \rightarrow n_f l_f} = \mu Z^4 \Gamma^{rad}_{n_i l_i \rightarrow n_f l_f}(H)$$

$$\Gamma^{rad}_{n_i l_i \rightarrow n_f l_f}(H) = \frac{4}{3}\alpha^3 R^2_{if} \omega^3_{if}$$



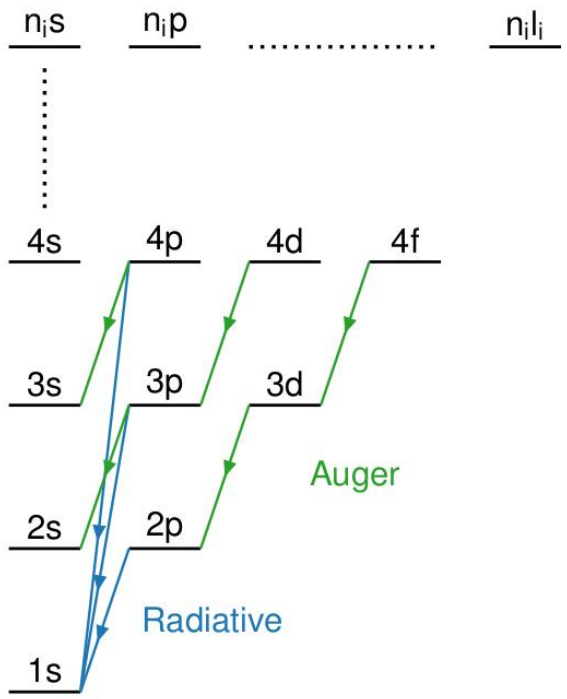


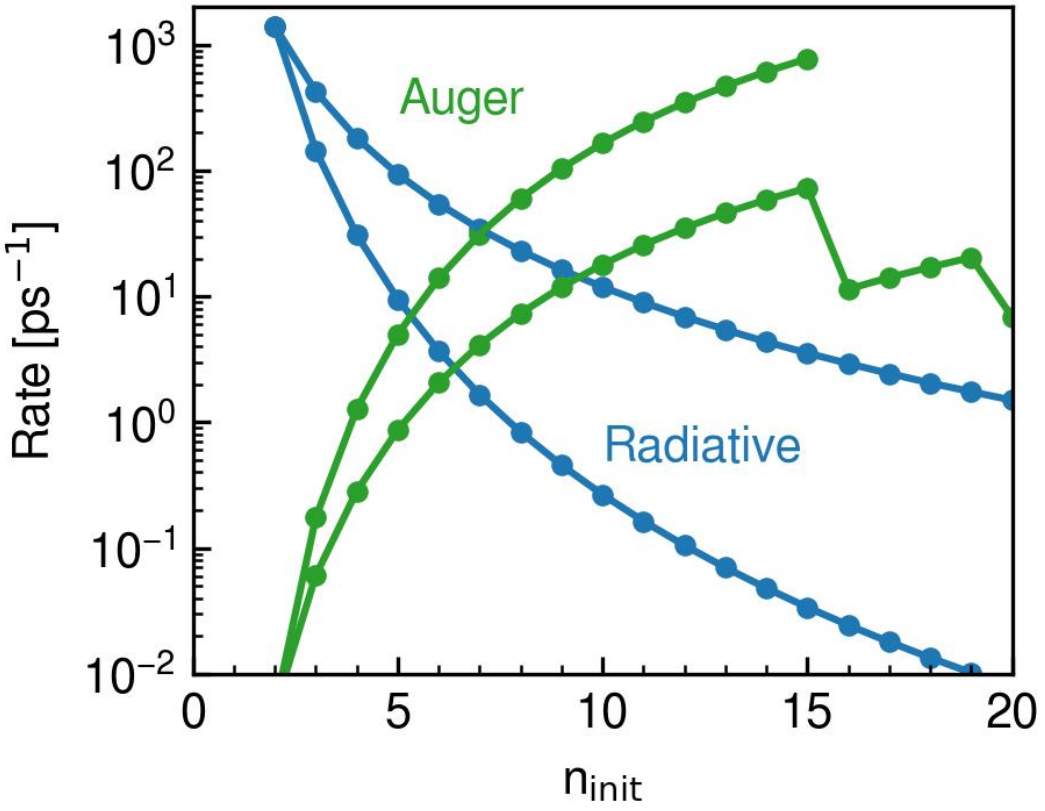


Auger rate from the e-K coulombic interaction

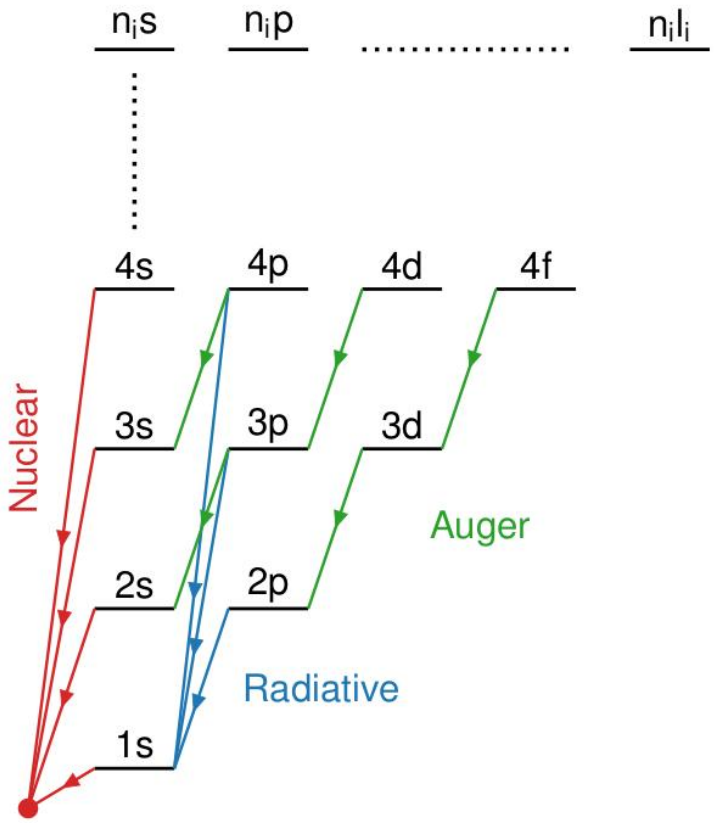
$$(x^{-}X)_{n_i l_i} 2e^{-} \rightarrow (x^{-}X)_{n_f l_f} e^{-} + e^{-}$$

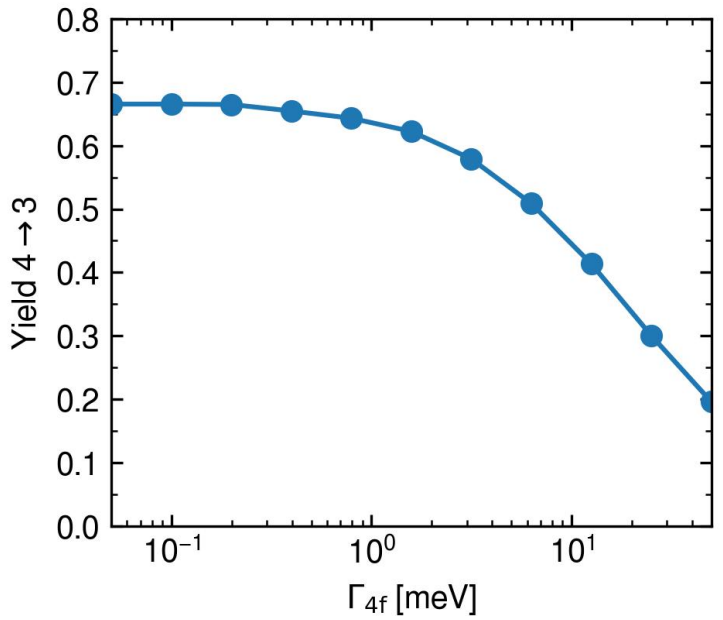
$$\Gamma^{\text{Auger}} = \left| \int \int \chi_f^*(\mathbf{r}_1)\psi_f^*(\mathbf{r}_2)\frac{1}{r_{12}}\chi_i(\mathbf{r}_2)\psi_i(\mathbf{r}_1)d\mathbf{r}_1 d\mathbf{r}_2 \right|^2$$





Nuclear absoprtion rate

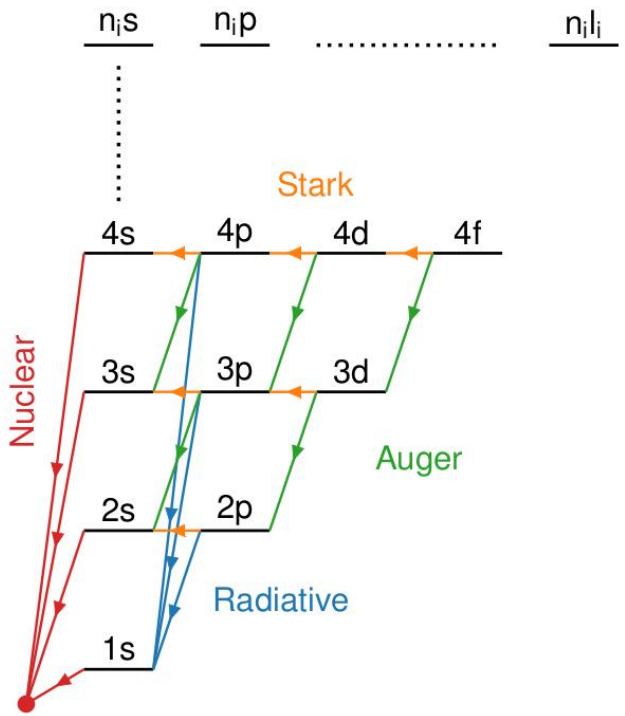


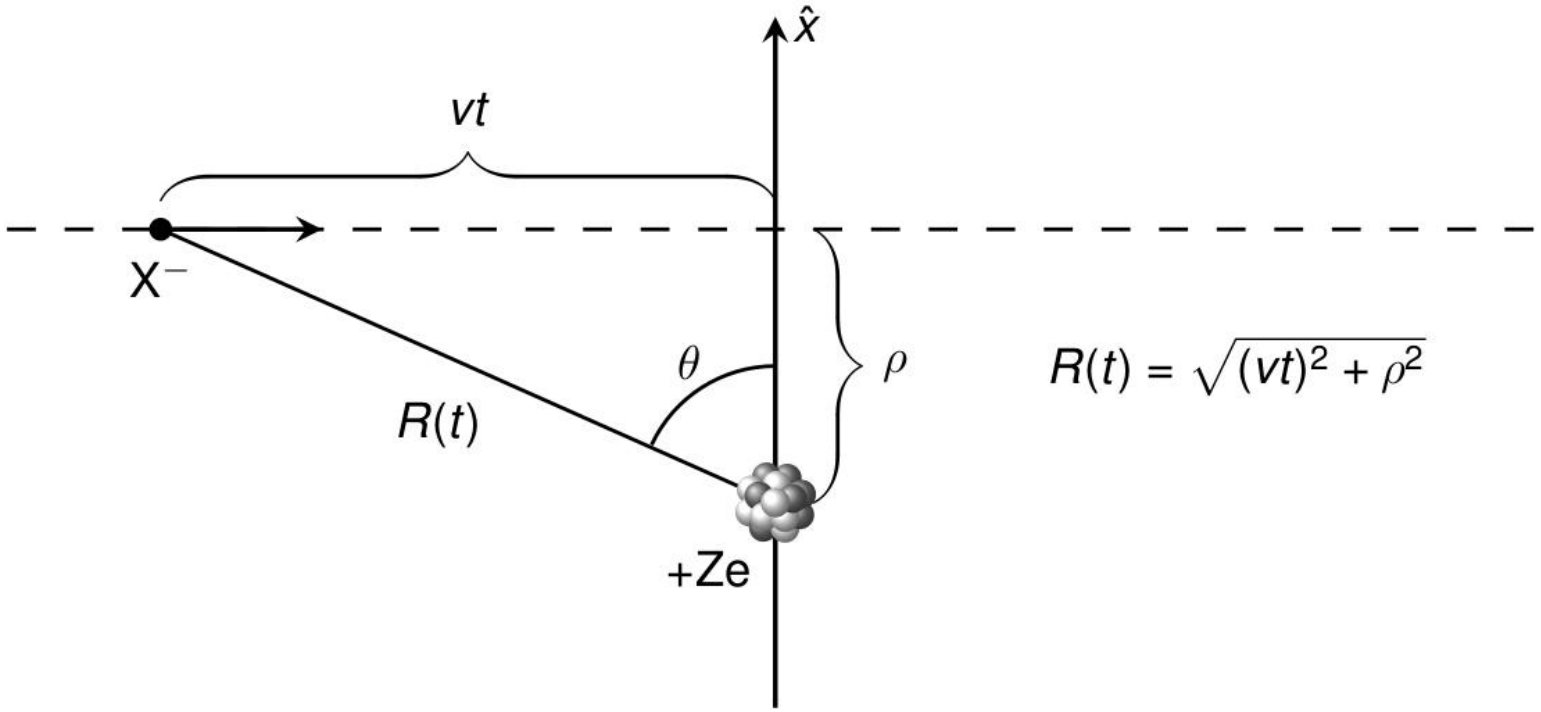


$$\frac{\Gamma^{nucl}_{n+1,l}}{\Gamma^{nucl}_{n,l}} = \left(\frac{n}{n+1}\right)^{2l+4} \frac{n+l+1}{n-l}$$

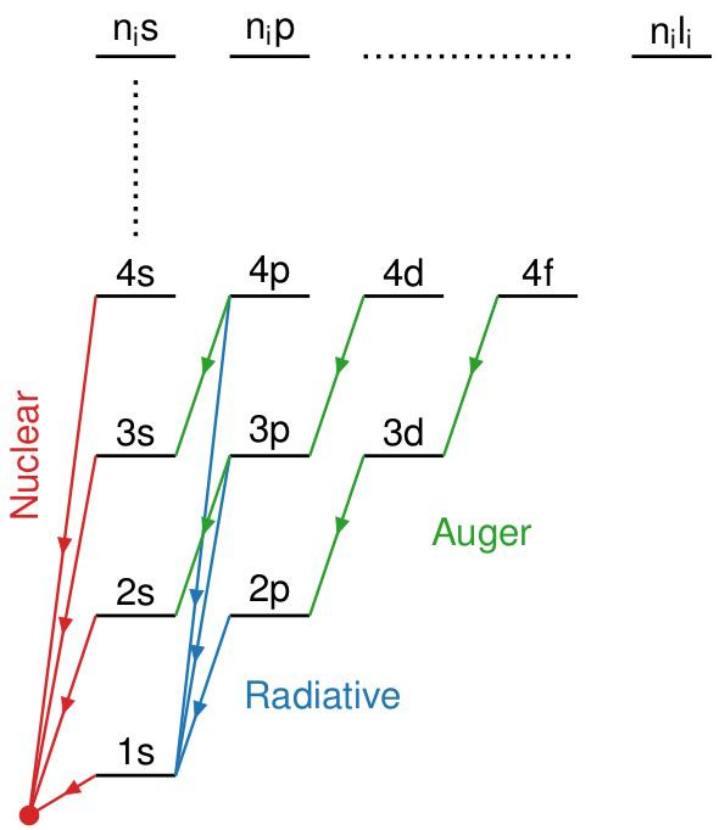
$$\Gamma^{nucl}_{ns} = \frac{\Gamma^{nucl}_{1s}}{n^3}$$

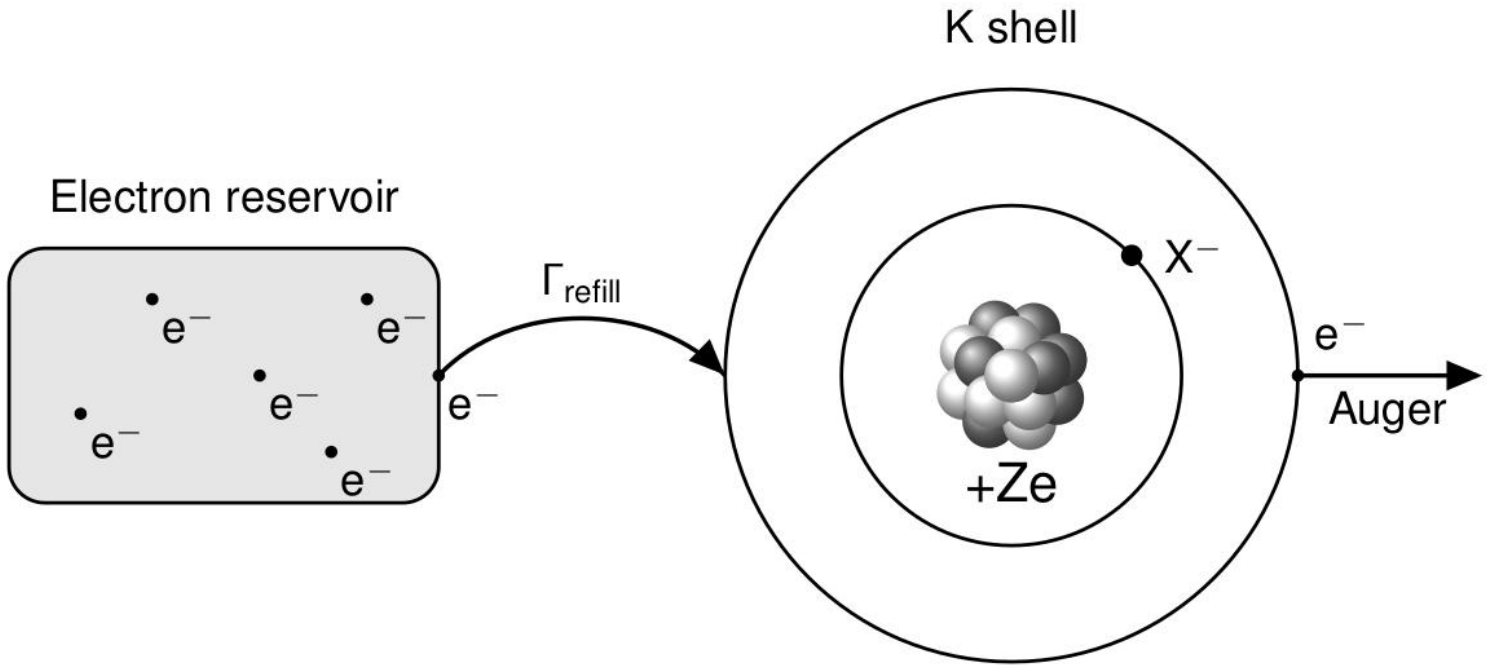
The Stark effect couples the n^2 degenerate sublevels



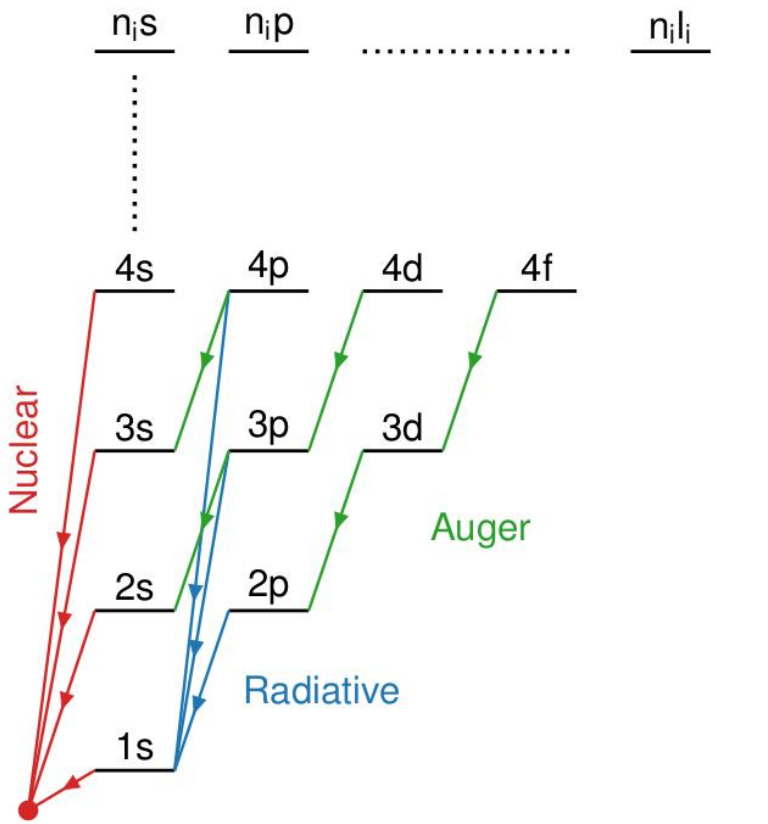


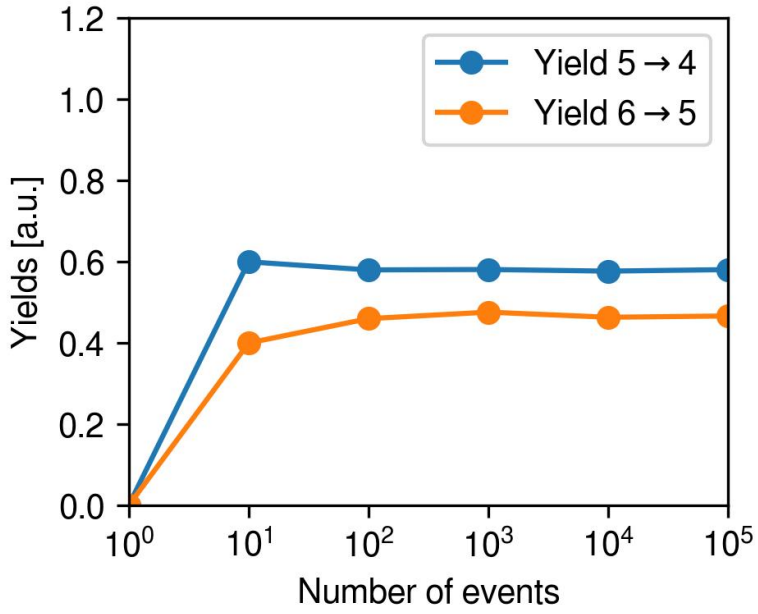
Refilling rate to include the effect of the density

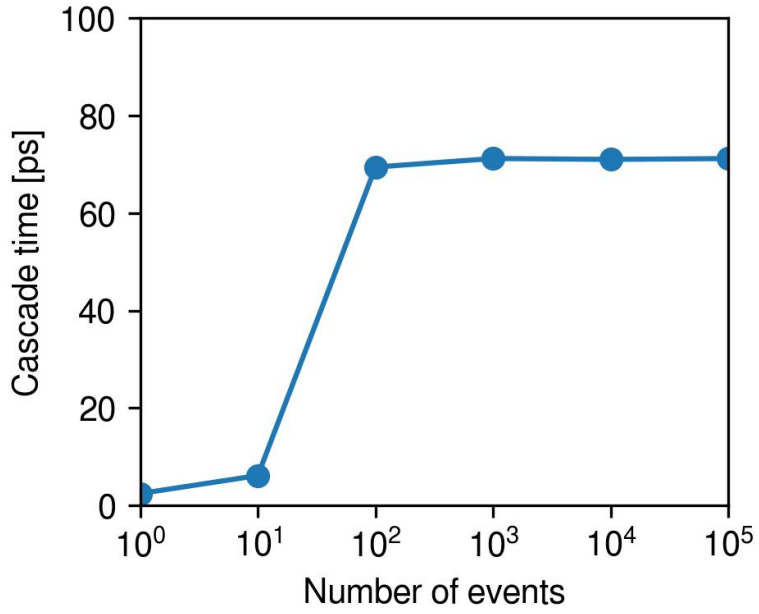




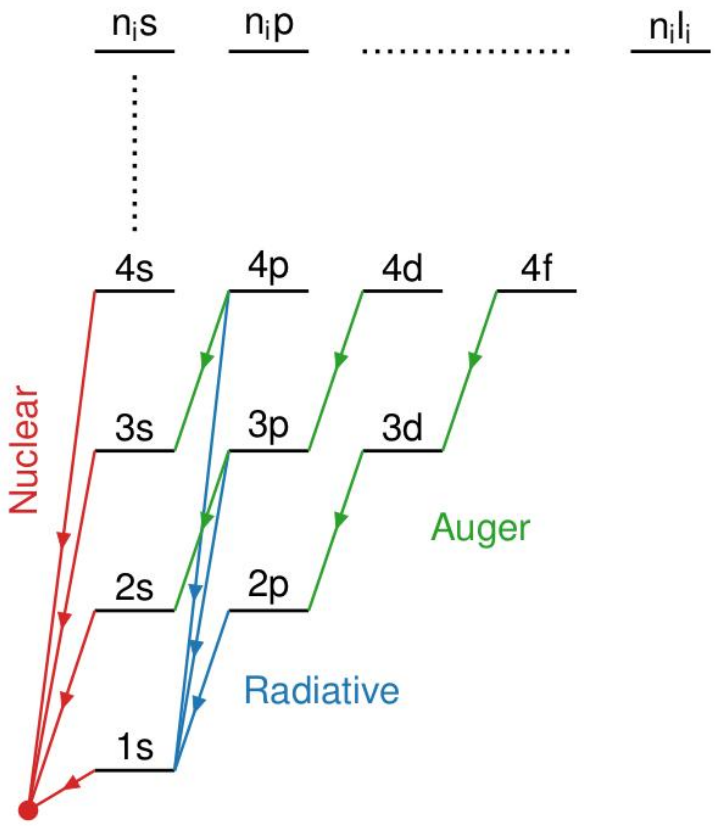
The cascade is converged respect to the number of events

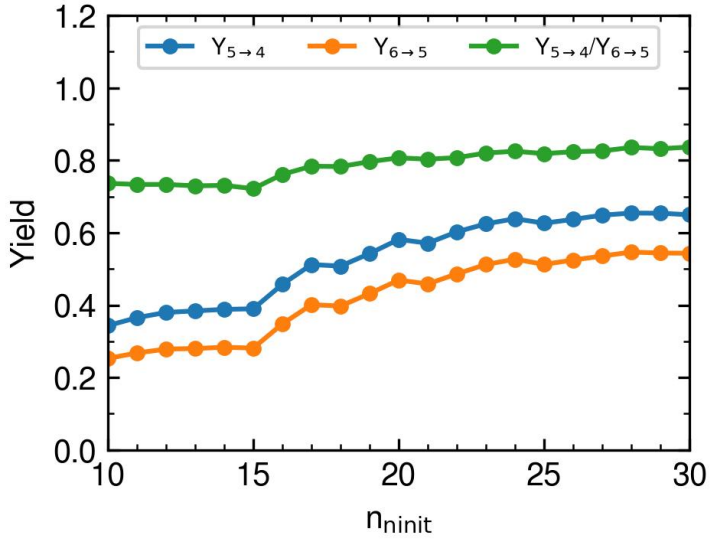


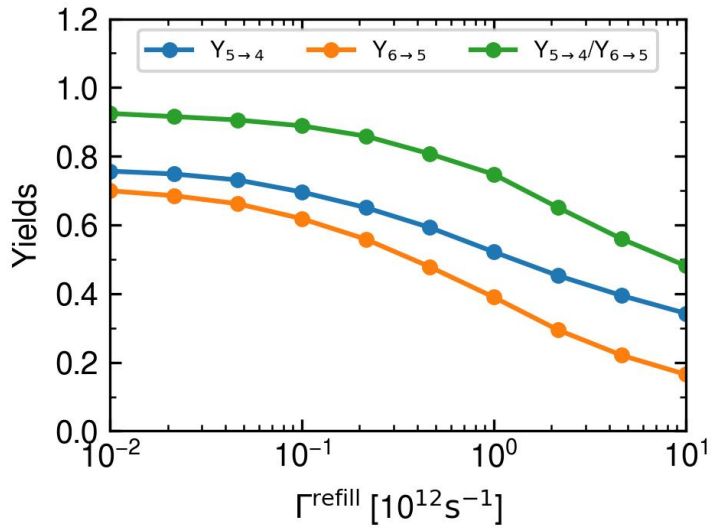


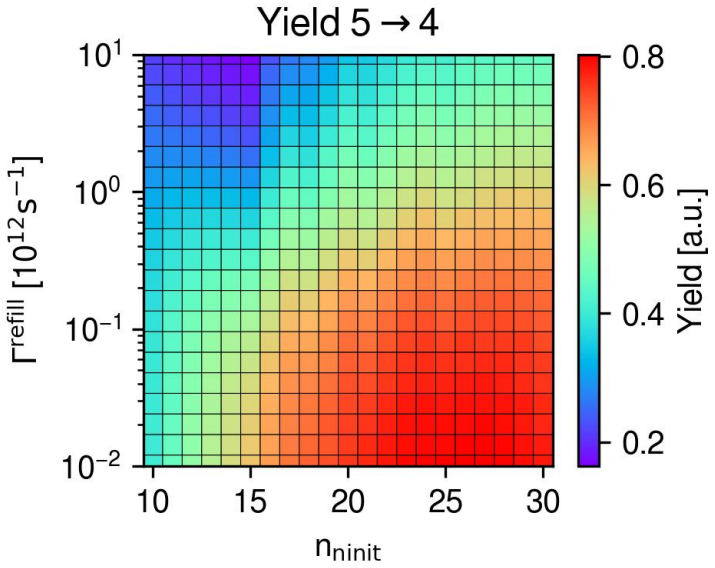


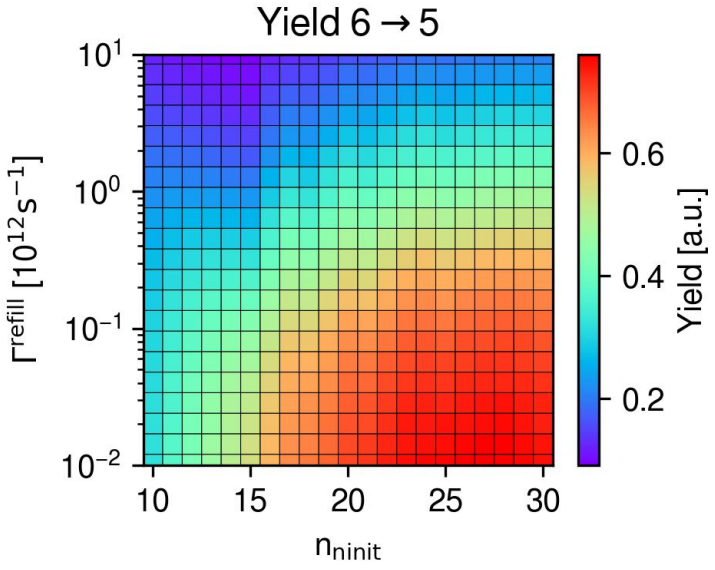
Cascade results: yields of interest



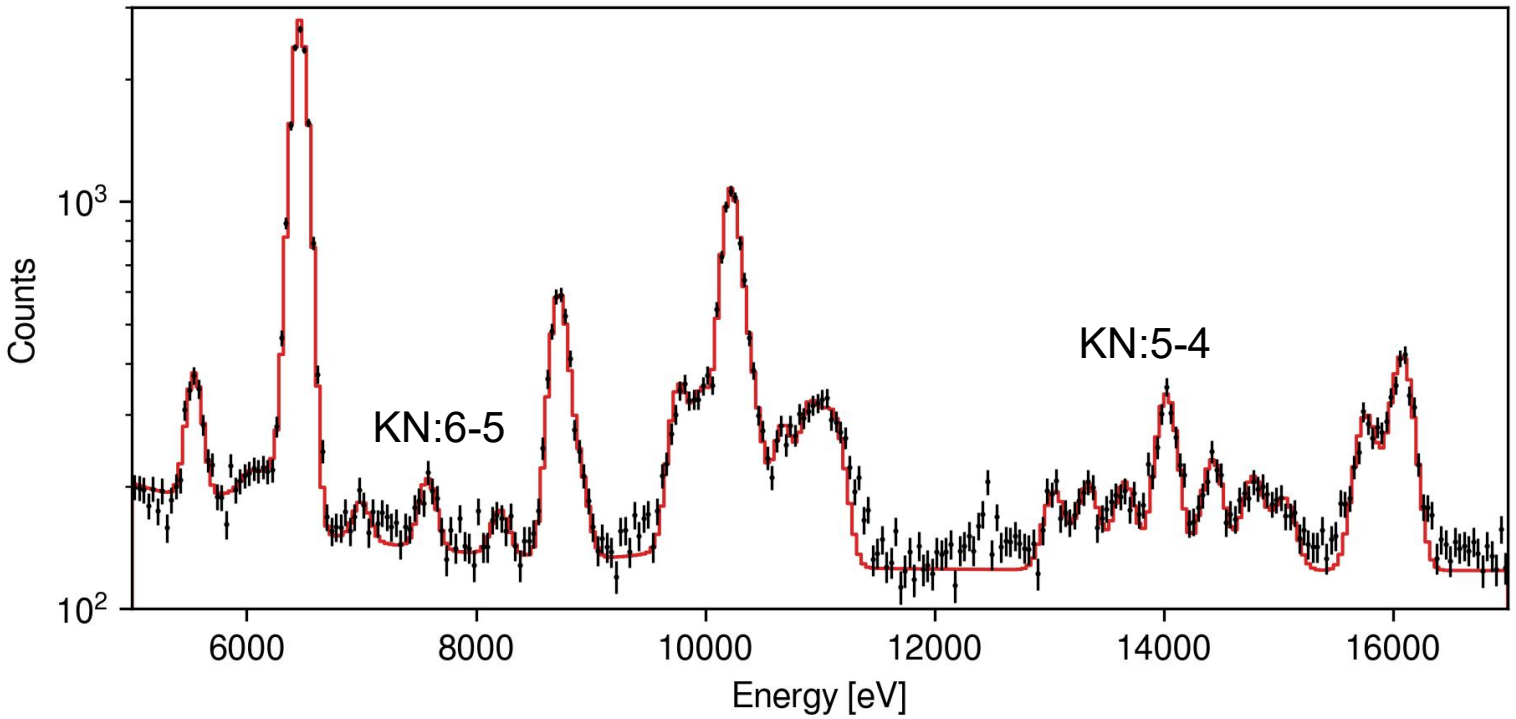




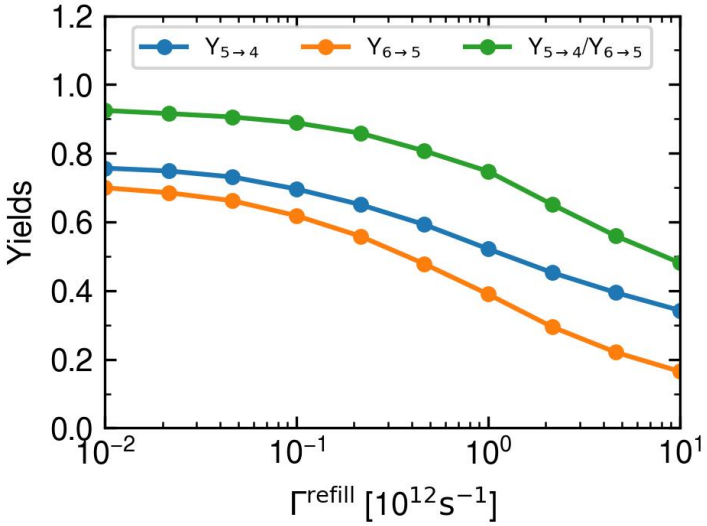


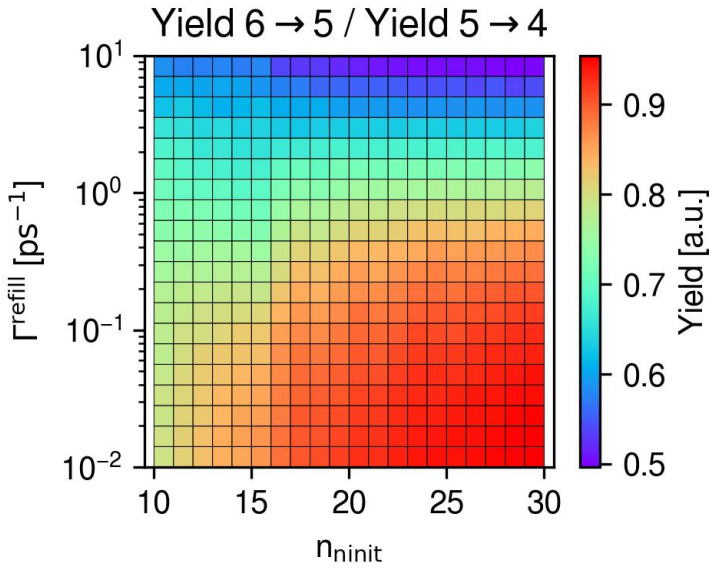


Cascade results: comparison with experiment



Experimental Yield 6,5 / Yields 5,4 = 0.29





Conclusion

1. Cascade models for atomic transitions

2. Cascade model for Pauli Violating Principle transitions

3. Application for Kaonic atoms