Analysis of the hyperfine splitting of the 5 → 4 transitions in muonic ^{185}Re and ^{187}Re

S.M. Vogiatzi[1,2] on behalf of the muX collaboration

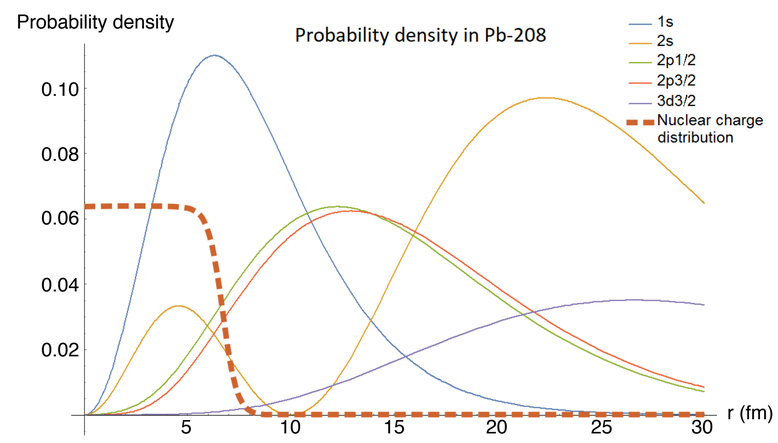
[1]Paul Scherrer Institut, 5232 Villigen, [2]ETH Zurich, IPA, 8093 Zurich

I. Motivation

- An ongoing experiment at PSI aims to determine the nuclear charge radius of ^{226}Ra - needed by an experiment aiming at measuring atomic parity violation in a Ra^+ ion - by means of muonic atom spectroscopy.
- Rhenium is a deformed nucleus as ^{226}Ra and shows similar nuclear structure effects. Moreover, it is the last stable element whose nuclear charge radius has not yet been measured.

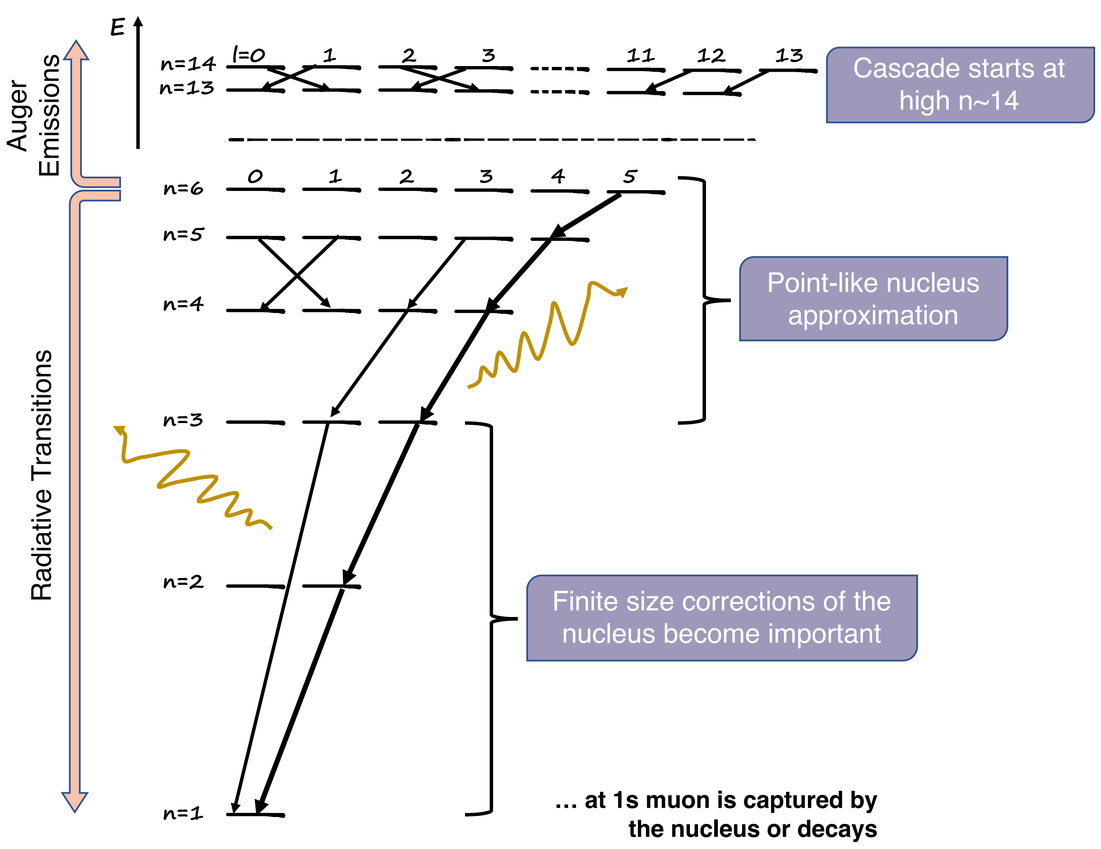
II. Muonic atom

- Due to the higher muon mass, the radius of muonic orbits is smaller than the radius of electronic orbits
- Large overlap of the low-lying muonic levels with the nuclear charge distribution

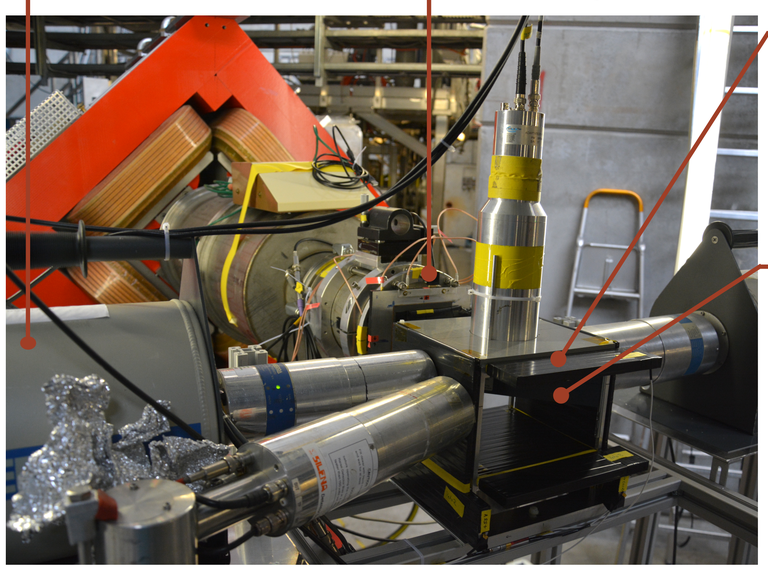


III. Principle of muonic atom spectroscopy

- Direct atomic capture: the muon beam interacts with the target, muon slows down in momentum and is captured by the Coulomb field of the target nucleus
- Muonic cascade to the ground state of the atom accompanied by X-ray emission for n<6



IV. Experimental setup of 2016

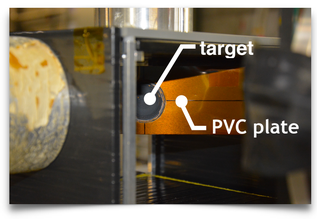


3 HPGe detectors detect the muonic X-rays

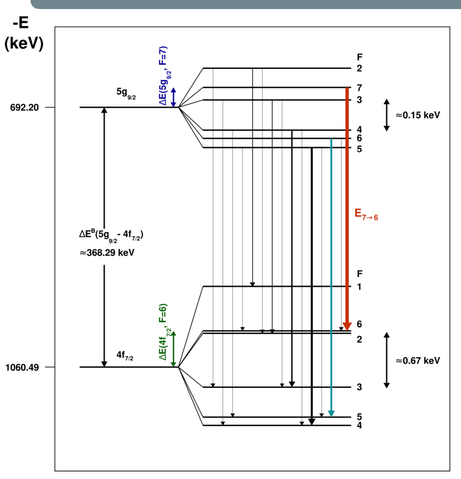
1 Entrance counter triggers the arrival of the negative muons (p_μ=29 MeV/c) on the target

4 Four **electron veto scintillators** reduce the background in HPGe detectors produced by Michel e^-

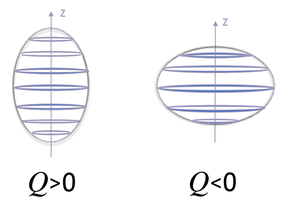
2 Target (^{185,187}Re)



V. Muonic energy levels



- The coupling of the nuclear spin I with the total angular momentum of the muon J gives rise to the hyperfine splitting of the muonic energy levels ($\vec{F} = \vec{I} + \vec{J}$)
- This splitting can be expressed as a function of the electric quadrupole Q and magnetic μ_N moment of the nucleus
- Q describes the effective shape of the nucleus

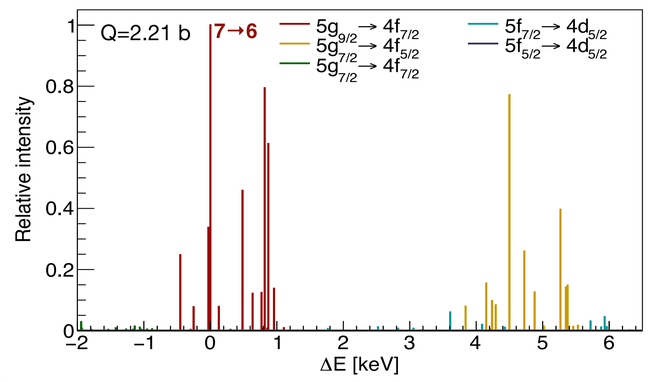


- In the 5g→4f region, the muon is far away from the nucleus: HF constants are independent on the details of the charge distribution and the energy splitting is directly proportional to Q

VI. Fitting of the 5→4 hyperfine splitting

- The 5g→4f, 5f→4d region contains 5 multiplets with a total of 76 transitions
- The energy E_i and intensity I_i of each transition can be expressed as

$$E_i = E_{7\to6} + \Delta E(\mu_N, Q)$$
$$I_i = I_{7\to6} + \Delta I(\mu_N, Q)$$



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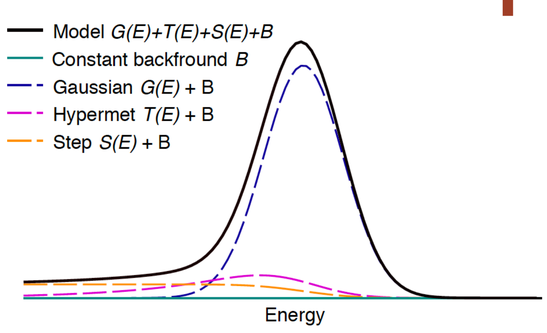

- The detector's line-shape was obtained by fitting four background peaks
- Then, it was applied to each of the 76 transitions of the 5g→4f, 5f→4d HFS with Q as a free parameter

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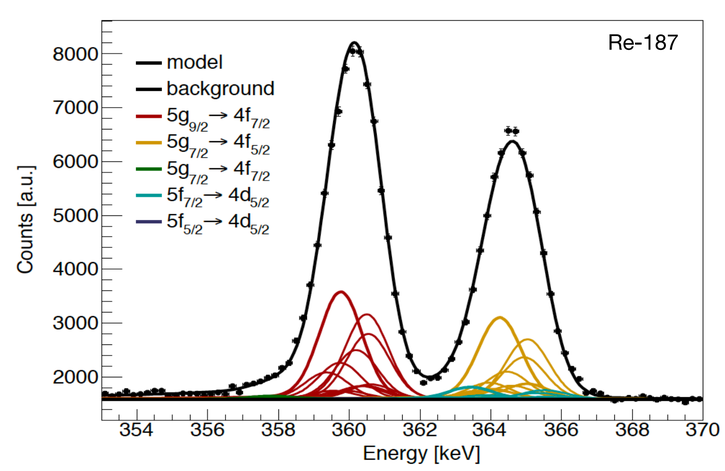

VII. Results

List of systematic uncertainties:

- Line-Shape
- Gaussian width
- Background slope
- Relative intensity of transitions

		muX	Konijn[1]
Q (b)	Re-185	**2.07 (5)**	2.21 (4)
	Re-187	**1.94 (5)**	2.09 (4)

- The discrepancy of the results is attributed to missing transitions in [1]

[1]J.Konijn et al., Nucl. Phys. A 360, 187 (1981)