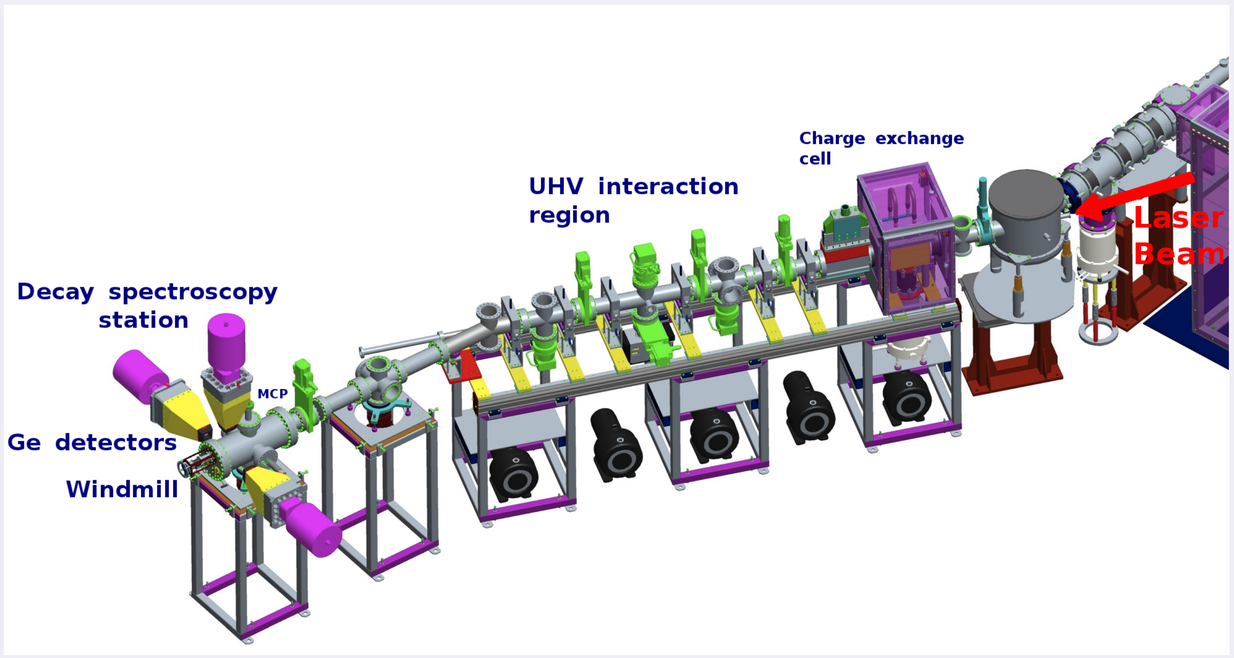
Isomer Selection by Resonant Ionization Spectroscopy

J. Billowes[1], M.L Bissell[2], I. Budincevic[2], T.E. Cocolios[1,3], R. De Groote[2], S. De Schepper[2], V. Fedosseev[4], K.T. Flanagan[1], S. Franco[3], R.F. Garcia Ruiz[2], H. Heylen[2],F. Le Blanc[3], K.M. Lynch[1,3], B.A. Marsh[4], P.J.R. Mason[5], I. Matea[3], G. Neyens[2], J. Papuga[2], T.J. Procter[1], M.M. Rajabali[2], R.E. Rossel[4,6], S. Rothe[4,6], G.S. Simpson[7], A.J. Smith[1], H.H Stroke[8], D. Verney[3], P.M. Walker[5], K. Wendt[6], R.T Wood[5]

[1]The University of Manchester, United Kingdom. [2]IKS-KULeuven, Belgium. [2]Physics Department, CERN, Switzerland. [3]IPN-Orsay, France. [4]Engineering Department, CERN, Switzerland. [5]University of Surrey, United Kingdom. [6]University of Mainz, Germany. [7]LPSC, France. [8]New York University, USA

Collinear Resonance Ionization Spectrocopy (CRIS)

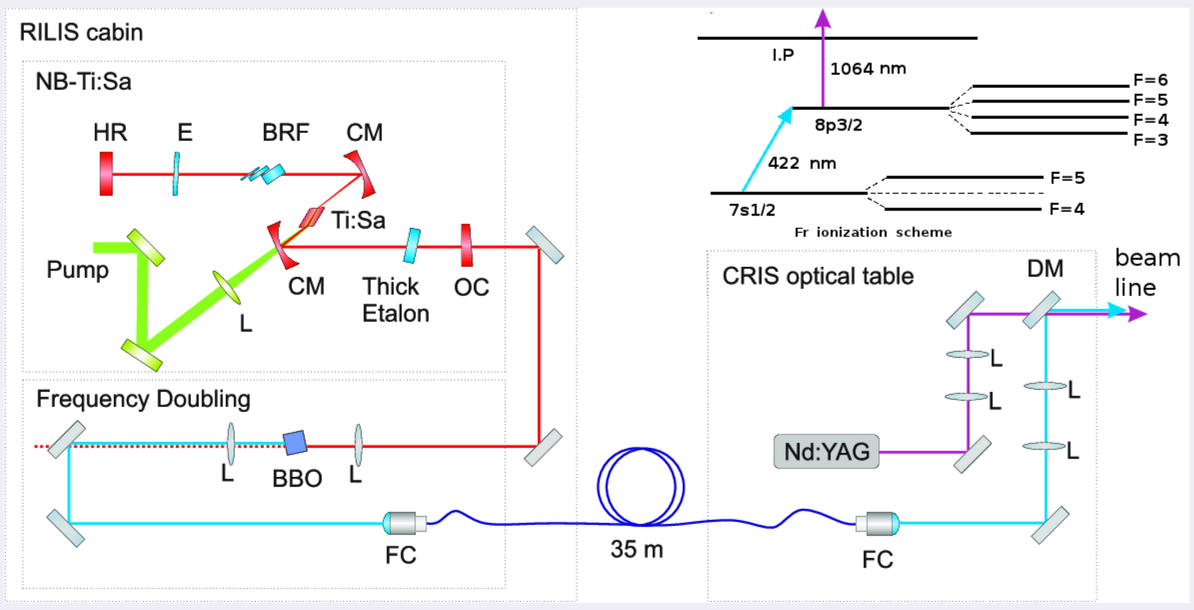
The CRIS beam line facility at CERN-ISOLDE [1] combines the high resolution of collinear laser spectroscopy with the high efficiency of ion detection reached with resonant ionization. High sensitivity hyperfine structure (HFS) measurements and isotope shifts can be achieved.



Two successful experimental campaigns (August and October, 2012) have proved the effectiveness of this technique. Hyperfine structure of Francium isotopes was measured for both neutron deficient and neutron rich.

Laser System

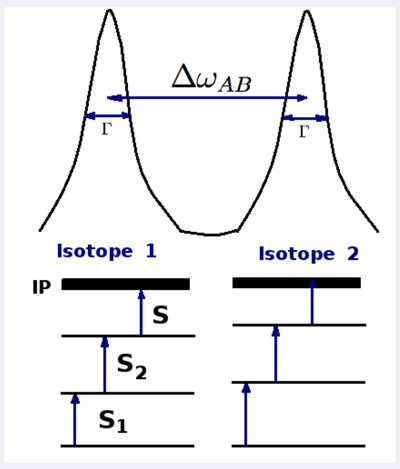
HFS can be obtained by detecting the ionized ions as a function of the the laser frequency. Fr isotopes were ionized in two steps; 422 nm for the resonant transition, and 1064 nm for the ionization step.



The resonant step of the ionization scheme was scanned using the narrow line-width (0.7 GHz) tunable Ti:Sa laser of the ISOLDE-RILIS installation [2]. A high energy Nd:YAG laser at CRIS laser table was used for the ionization step.

Laser Spectroscopy and Isomer Selectivity

- Spin and nuclear moments can be extracted from the hyperfine structure. Isotope shifts are used to obtain the charge radii.
- When the laser frequency is equal to the HFS component, the isomer is resonantly ionized, and the isotope of interest can be selected.



The selectivity of one isotope is expressed as

$$S = \left(\frac{\Delta\omega_{AB}}{\Gamma}\right)^2, \qquad (1)$$

where the total selectivity given by

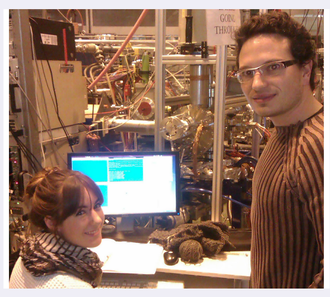
$$S = \prod_i S_i. \qquad (2)$$

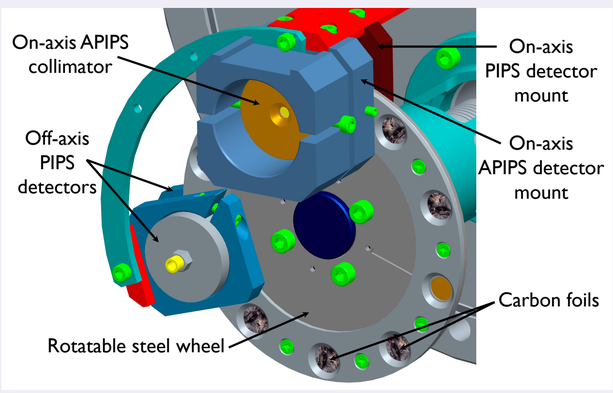
$S \propto$ number of excitation steps.

Decay Spectroscopy Station

A new decay spectroscopy station (DSS) has been developed and coupled to the CRIS beam line [3].

Ions are selected by isomer selective resonant ionization and implanted in a carbon foil. By using a rotating wheel, the ions can be implanted in a fresh carbon foil, and its decay can be studied.

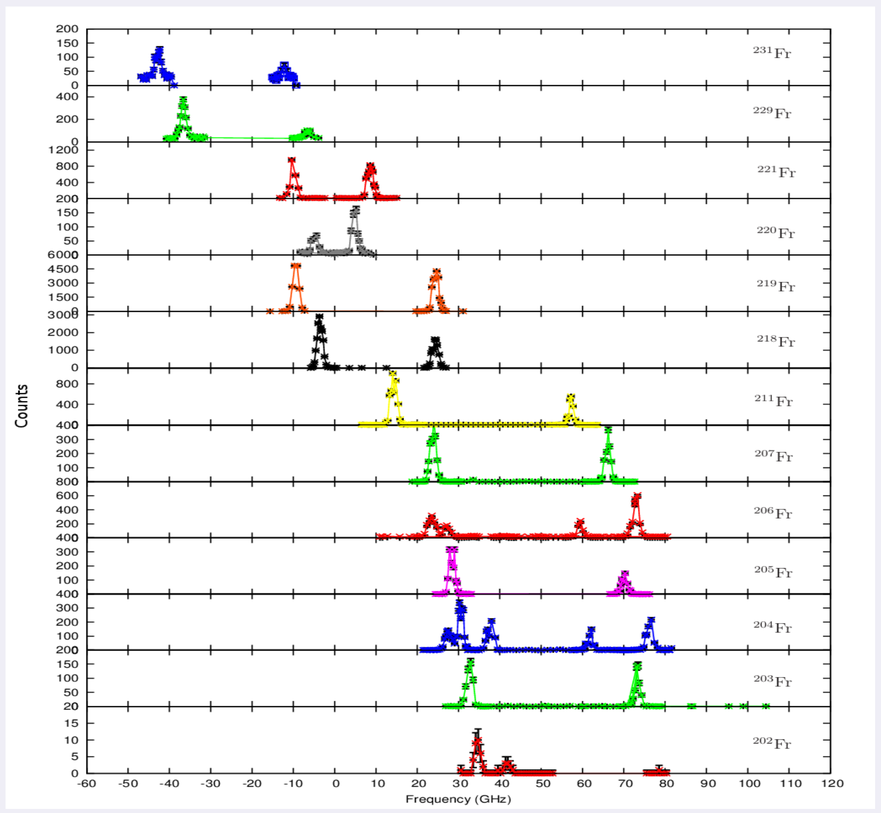




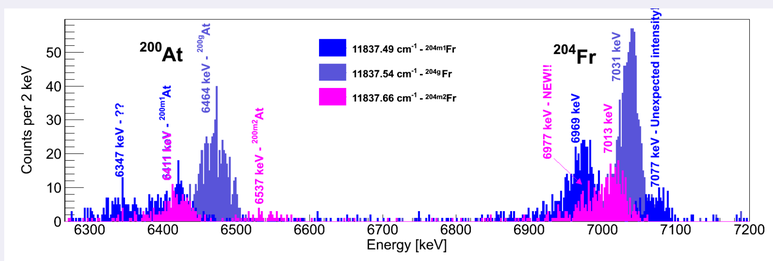
- Germanium detectors are used to detected the γ-rays.
- PIPS silicon detector for charged particle detection.

Latest Results

Successful measurements of the HFS were obtained for Fr isotopes. Efficiency reached was $\sim 1/100$ pps.



Ground state and two isomeric states of ^{204}Fr were clearly selected using each of its three left-hand HF resonances [4]. The figure below shows the measured alpha spectrum.



Conclusions

- Hyperfine structure and isotope shifts were measured for very exotic neutron deficient and neutron rich Fr isotopes. Magnetic moments and charge radii can be extracted from these measurements.
- Measurements of HFS for Fr isotopes very far from stability have proved the high sensitivity reached with the CRIS beam line ($\sim 1/100$ pps).
- CRIS in combination with the DSS is a tool to obtain clear isomer selection. The recent success for the ^{204}Fr and ^{202}Fr isomers was a proof of principle of the technique.

References

[1] T.J. Procter et al., J. Phys. Conf. Ser. 381 012070 (2012).
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