In–source Laser Photoionization Spectroscopy of $^{191-218}$Po isotopes at ISOLDE

Maxim Seliverstov

ISOLDE Workshop and Users meeting 2009

18-20 November 2009 CERN

In–source Laser Photoionization Spectroscopy of $^{191-218}$Po isotopes at ISOLDE

IS 456: Study of polonium isotopes ground state properties by simultaneous atomic- and nuclear-spectroscopy

Collaboration:
CERN/ISOLDE - IKS Leuven-Mainz University- PNPI Gatchina- IPN Orsay

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In–source Laser Photoionization Spectroscopy of $^{191\text{-}218}$Po isotopes at ISOLDE

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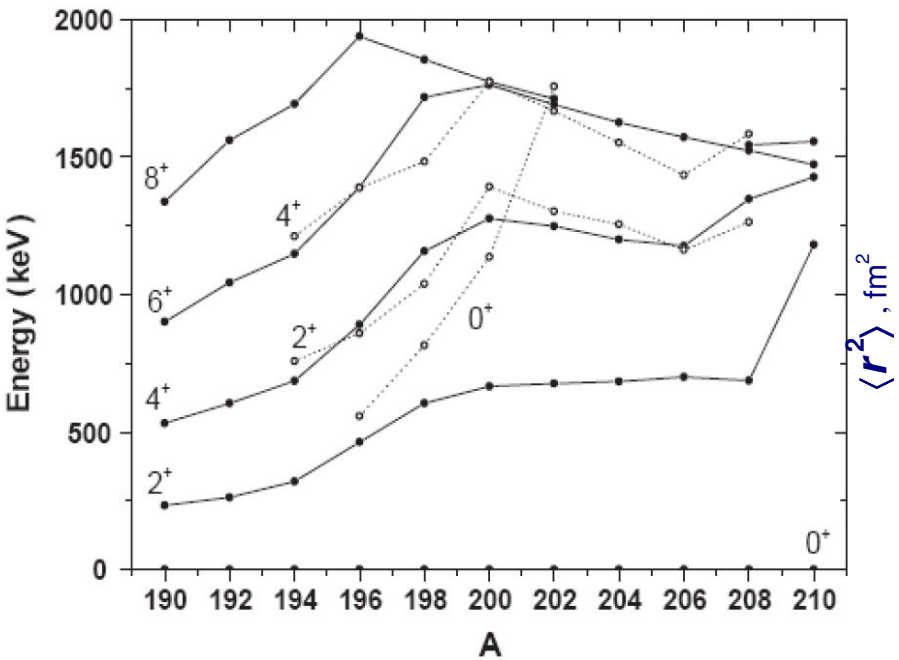
  - Motivation
  - In-source resonant photoionization spectroscopy at ISOLDE
  - Isotope shifts and charge radii for even-*A* neutron-deficient Po isotopes:

    A = 192-198

    A = 200-210

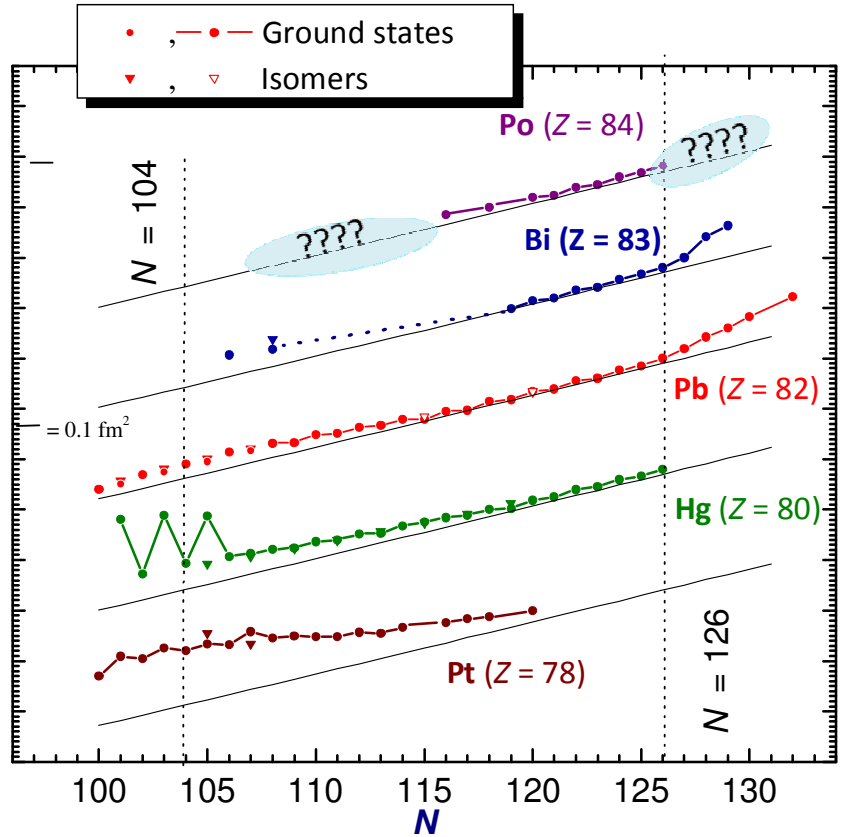
    A = 200-218
  - Hyperfine structure of the odd-*A* Po isotopes and isomers
  - Conclusions and outlook

Motivation



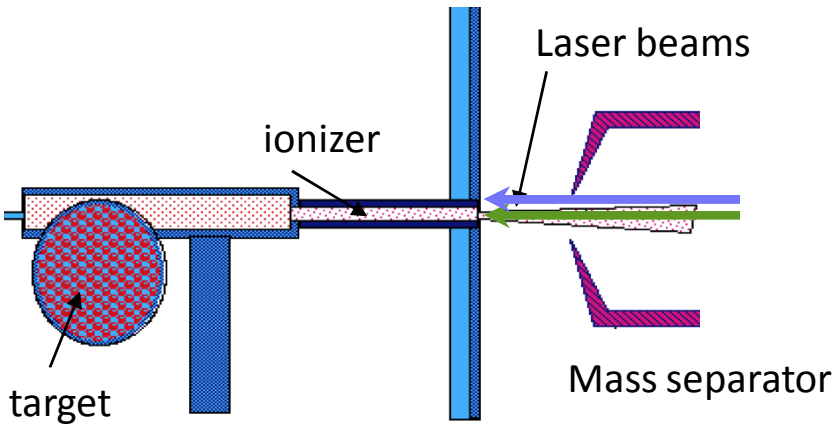
Level systematics for the neutron-deficient polonium isotopes.

R. Julin et al., *J. Phys. G: Nucl. Part. Phys* ***27*** *R109 (2001).*



nuclear ground and isomeric state properties : $\delta \langle r^2 \rangle$

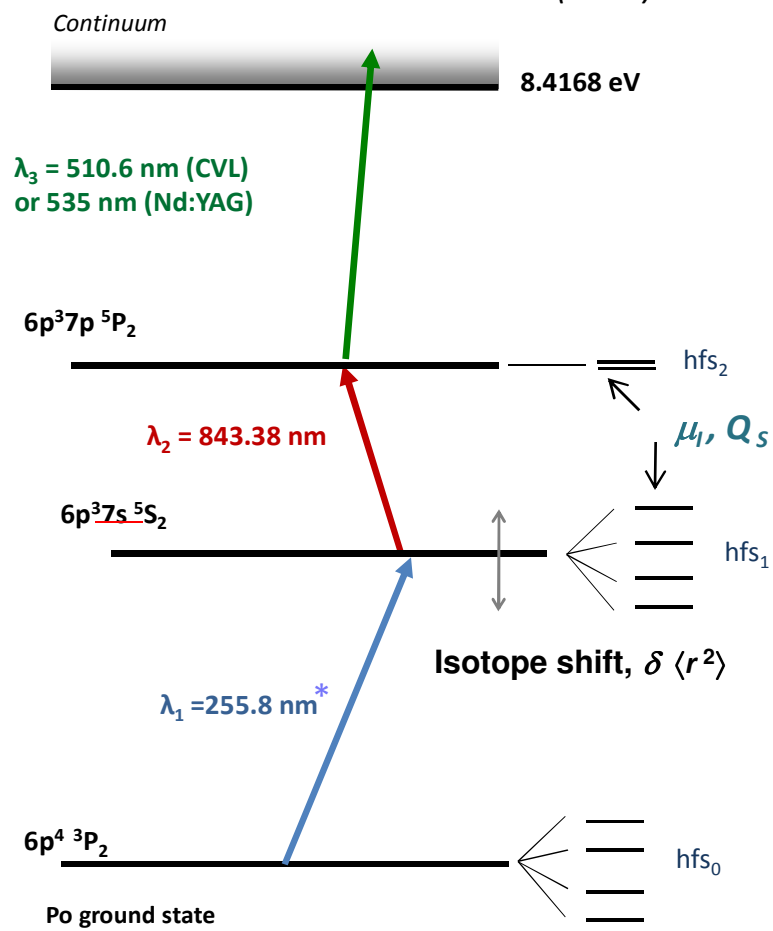
In–source Laser Photoionization Spectroscopy at ISOLDE



Laser Ion Source (LIS)

Photoionization scheme for Po

T.E. Cocolios et al. NIM B 266 (2008) 4403



Detection:
Faraday Cup
α-detection (Windmill)
β-detection (tape-station)
γ-detection (tape-station)

*This tranistion was already used for optical spectroscopy (Kowalewska *et al*, *Phys. Rev. A*, ***44*** *R1442, 1991.*)

Isotope shifts of the even-*A* Po isotopes

A	$\Delta\nu_{A,196}$, MHz	$T_{1/2}$, s	Detection
192	–1037(150)	32 ms	α
194	–372(120)	392 ms	α
196	0	5.56 s	α
198	–162 (130)	1.77 m	α
200	–905(40)	11.5 m	γ
202	–2009(100)	44.7 m	β
204	–3315(50)	3.53 h	γ
206	–4692(60)	8.8 d	FC
208	–6104(60)	2.9 a	FC
210	–7735(45)	138 d	FC
216	–16555(55)	145 ms	α
218	–19259(75)	3.1 m	α

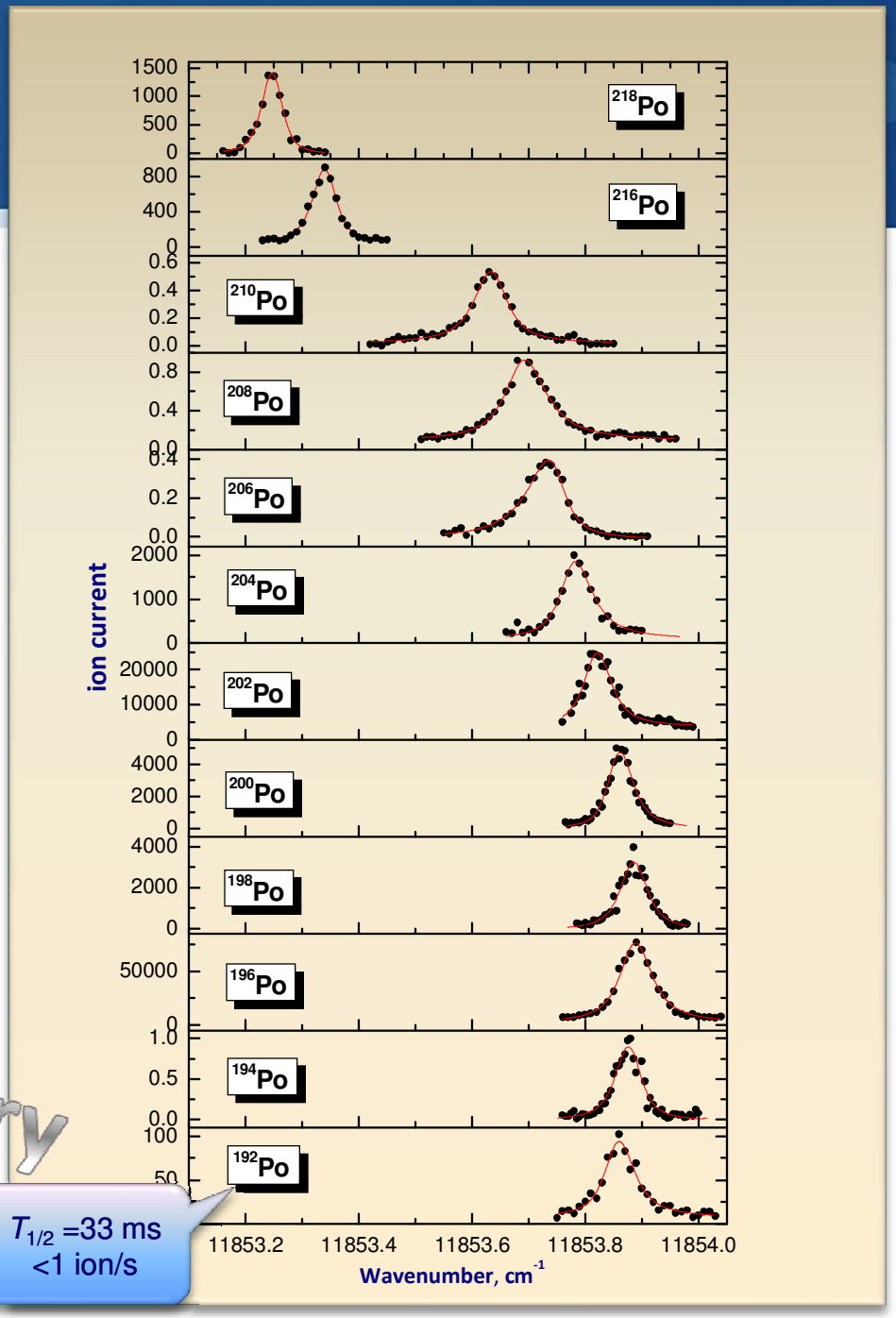
Preliminary

Isotope shift $\Delta\nu_{A,A'}$:

$$\delta\nu_{A,A'} = F * \lambda_{A,A'} + (\text{NMS+SMS})$$

Rms charge radius :

$$\lambda_{A,A'} = \langle r^2 \rangle + C_2 \delta\langle r^4 \rangle + \ldots \approx 0.93\ \delta\langle r^2 \rangle$$



Isotope shifts for $^{200\text{-}210}$Po: λ=255 nm and λ=843 nm

Limited knowledge on the atomic structure of polonium: the electronic *F*-factor for the transition of interest in unknown.

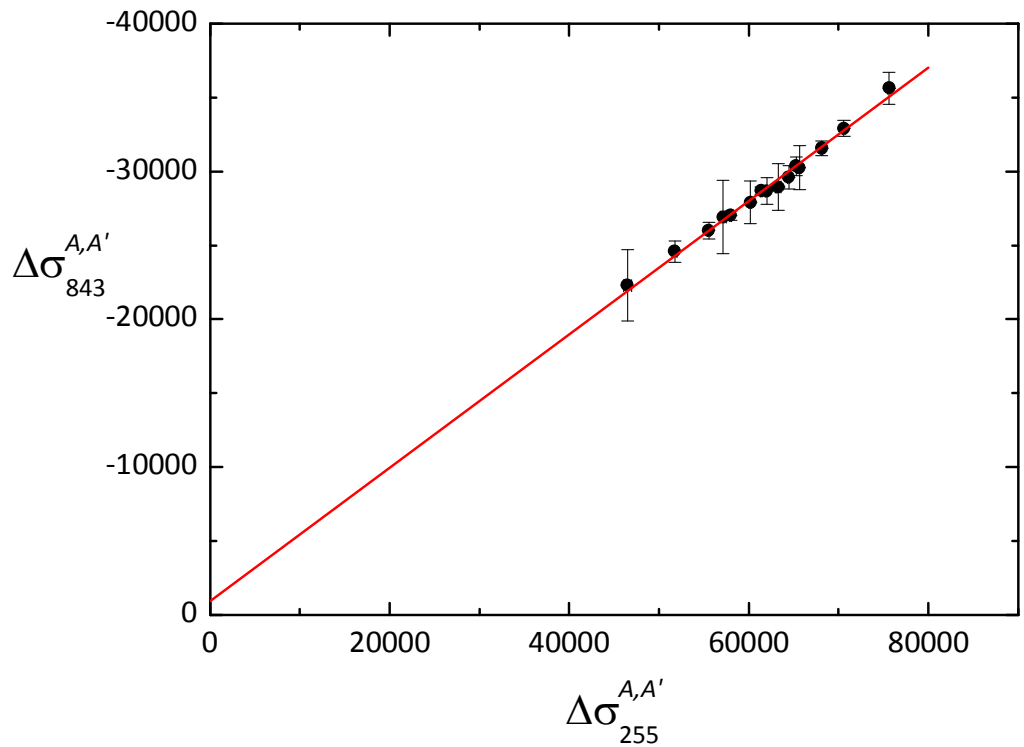
Previous work by Kowalewska *et al.* is locked on the FRDM at *A*=206-208 to extract the *F*-factor for the transition at 255.8 nm.

Large-scale electronic computations by S. Fritzsche using the GRASP code also give the *F*-factor from a theoretical approach for both transitions.

F_{255} =29140 MHz/fm^2
F_{843} = -12976 MHz/fm^2
F_{843}/F_{255}= 0.44

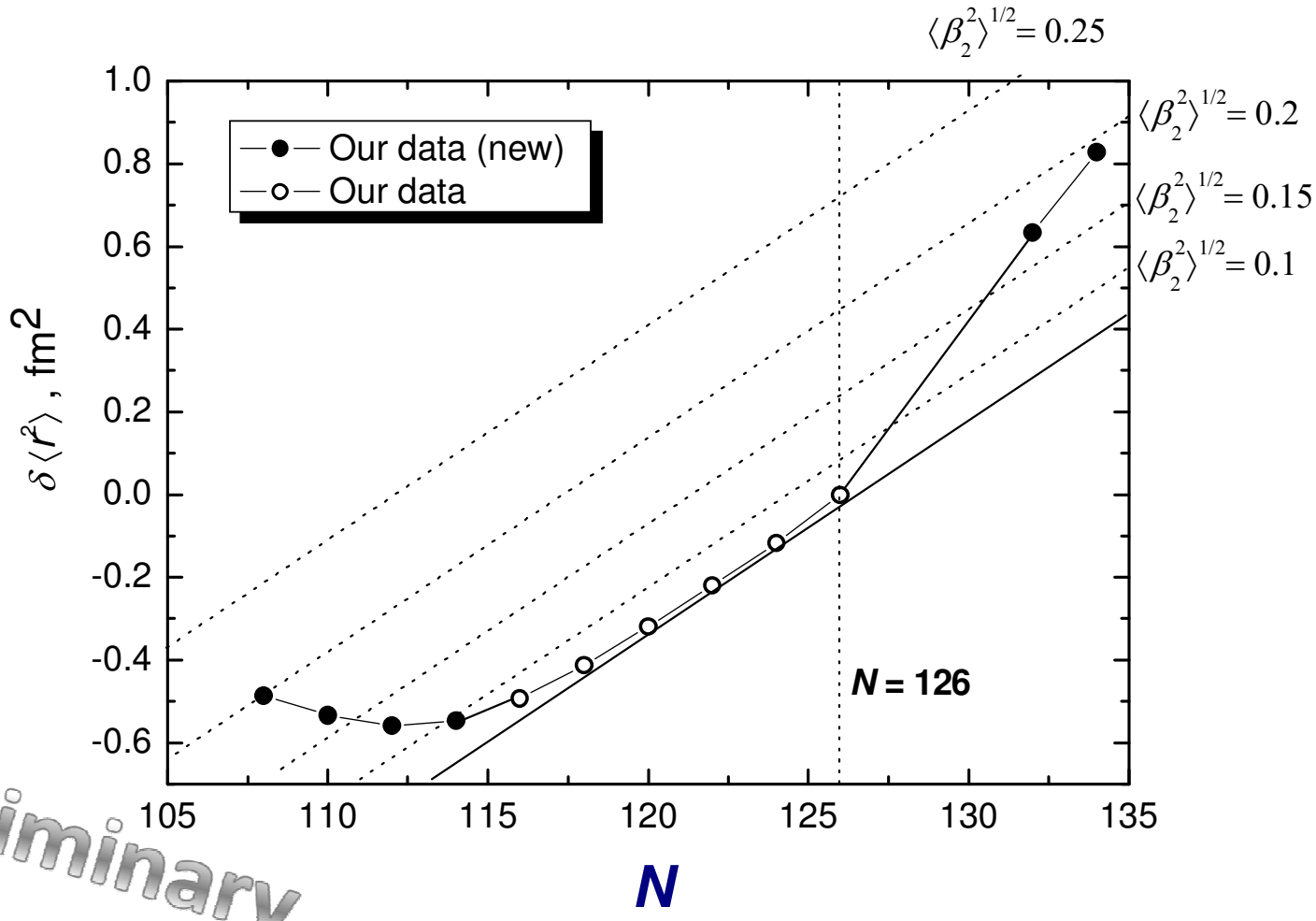
F_{843}/F_{255}= 0.45(3) *from King plot*

King plot:



$\Delta\sigma_{A,A'} = \Delta\nu_{A,A'}\, AA'/(A-A')$

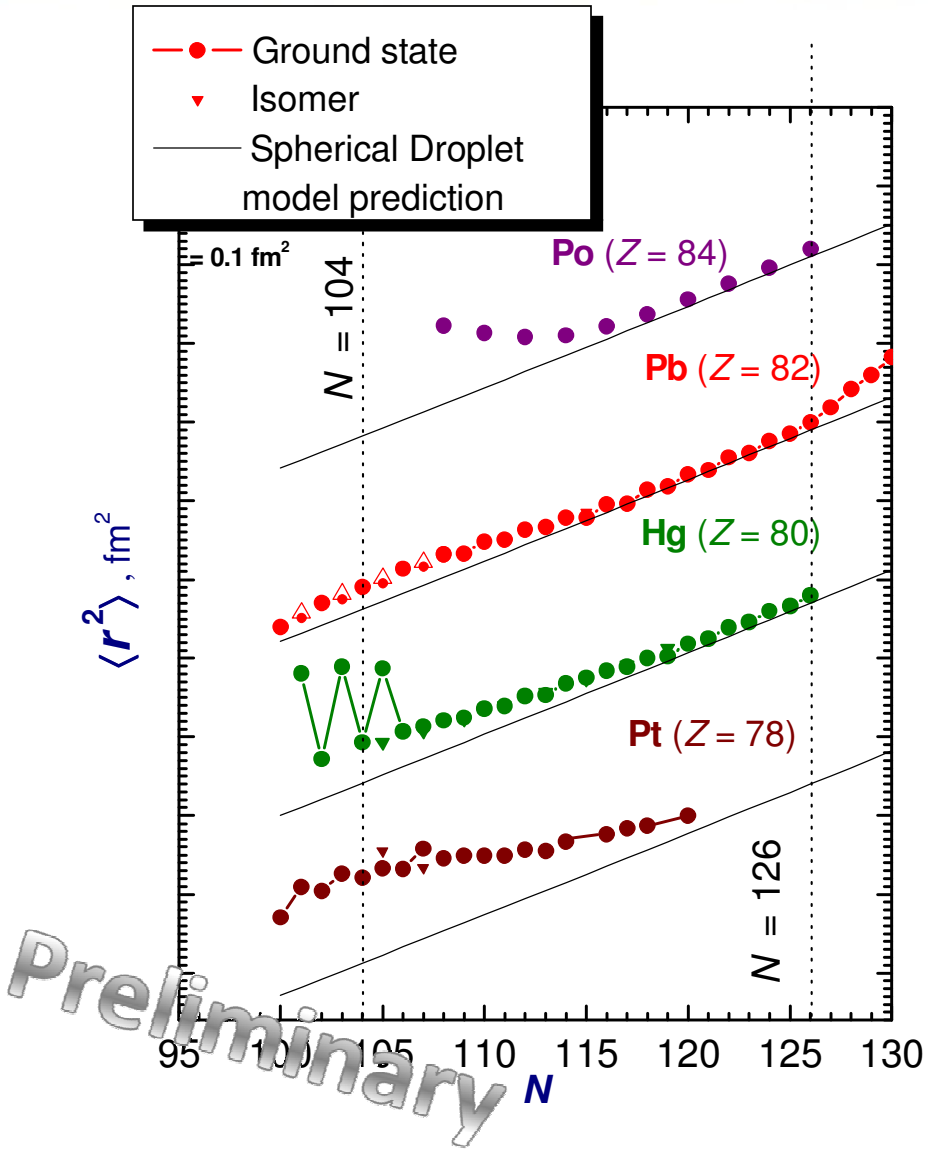
Charge radii for $^{192\text{-}218}$Po



Preliminary

The experimental error bars are smaller than the symbol size.

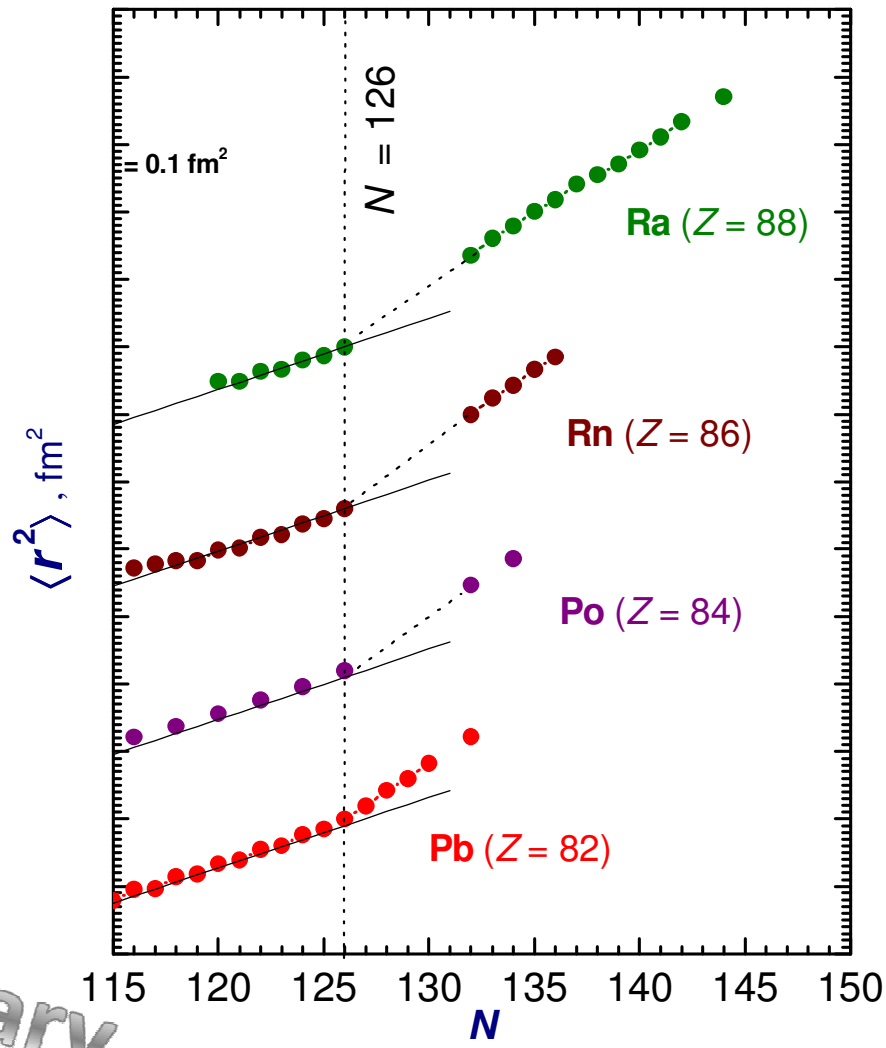
Charge radii of neutron-deficient Po isotopes



The experimental error bar is smaller than the symbol size. The distance between the different chains is chosen arbitrarily for better display. One minor division on the vertical scale corresponds to 0.1 fm^2

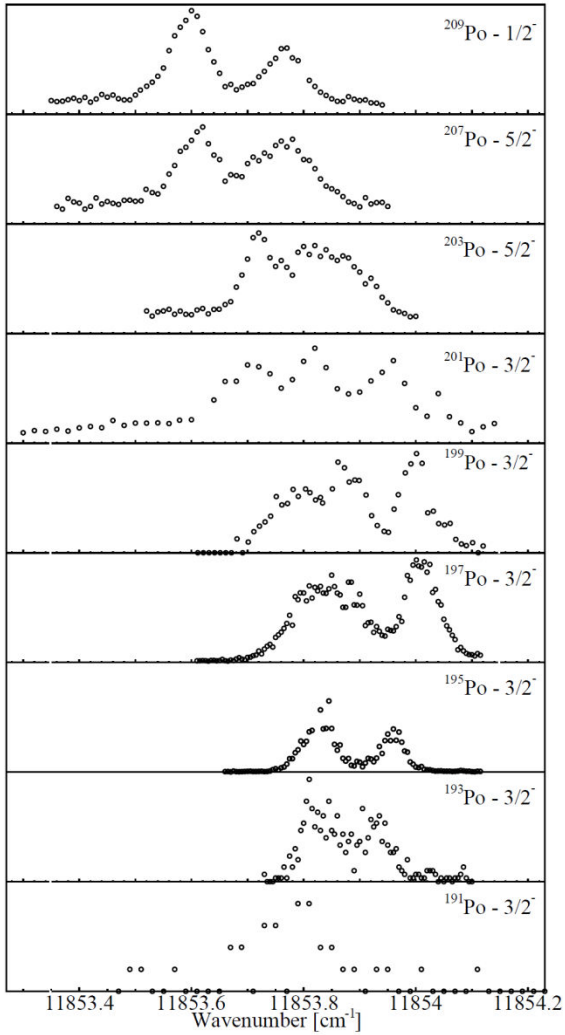
Charge radii of neutron-deficient Po isotopes: shell-closure effect at N = 126

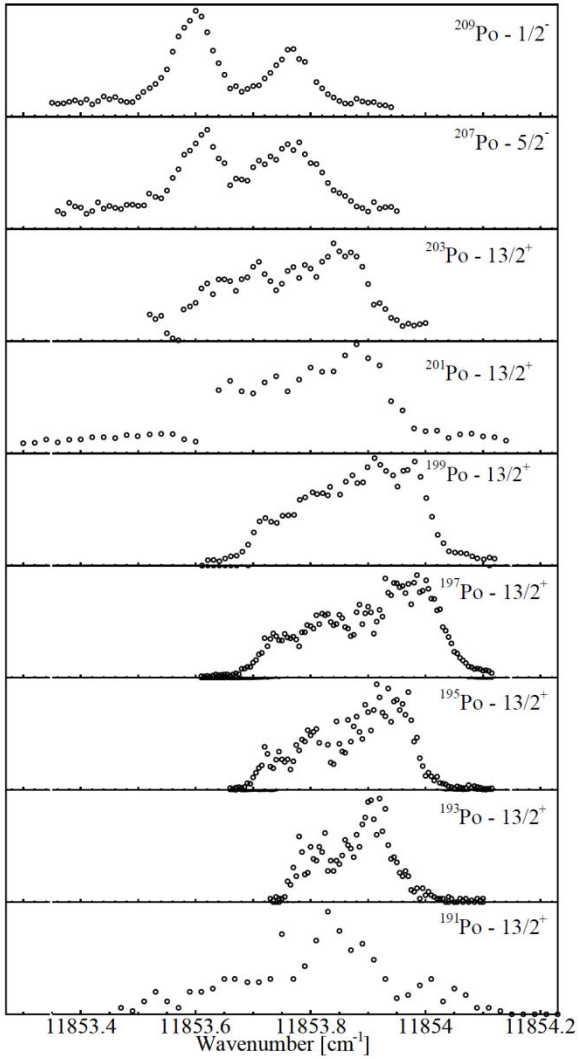
Element	$\frac{\delta\langle r^2\rangle_{N,N-2}(N>126)}{\delta\langle r^2\rangle_{N,N-2}(N<126)}$
Pb	1.9
Po	2.1
Rn	2.2
Ra	2.2



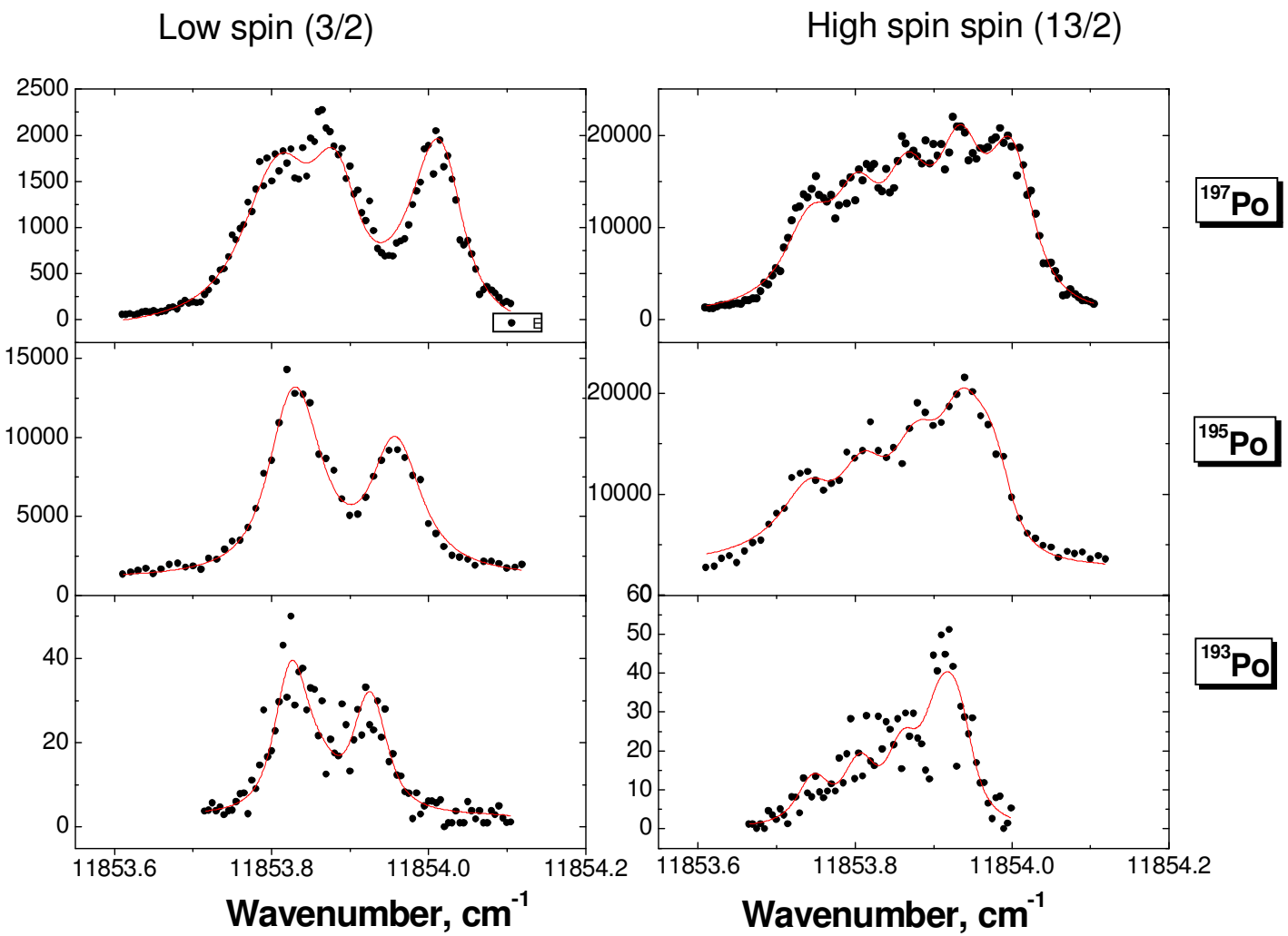
Preliminary

Hyperfine structure of the odd-*A* Po isotopes



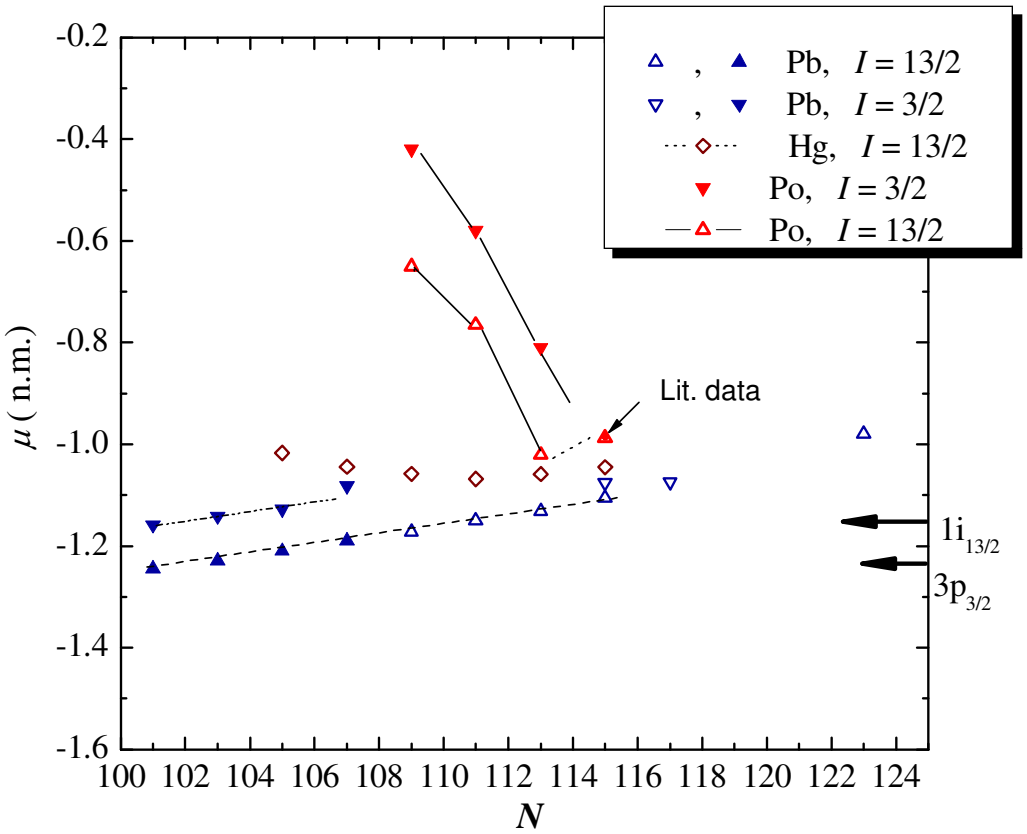


Odd-*A* Po isotopes: preliminary analysis



Odd-*A* Po isotopes: preliminary analysis

Estimations (preliminary) of magnetic moments ($^{193\text{-}197}$Po):



...to be continued
^{191}Po, $^{199\text{-}203}$Po...

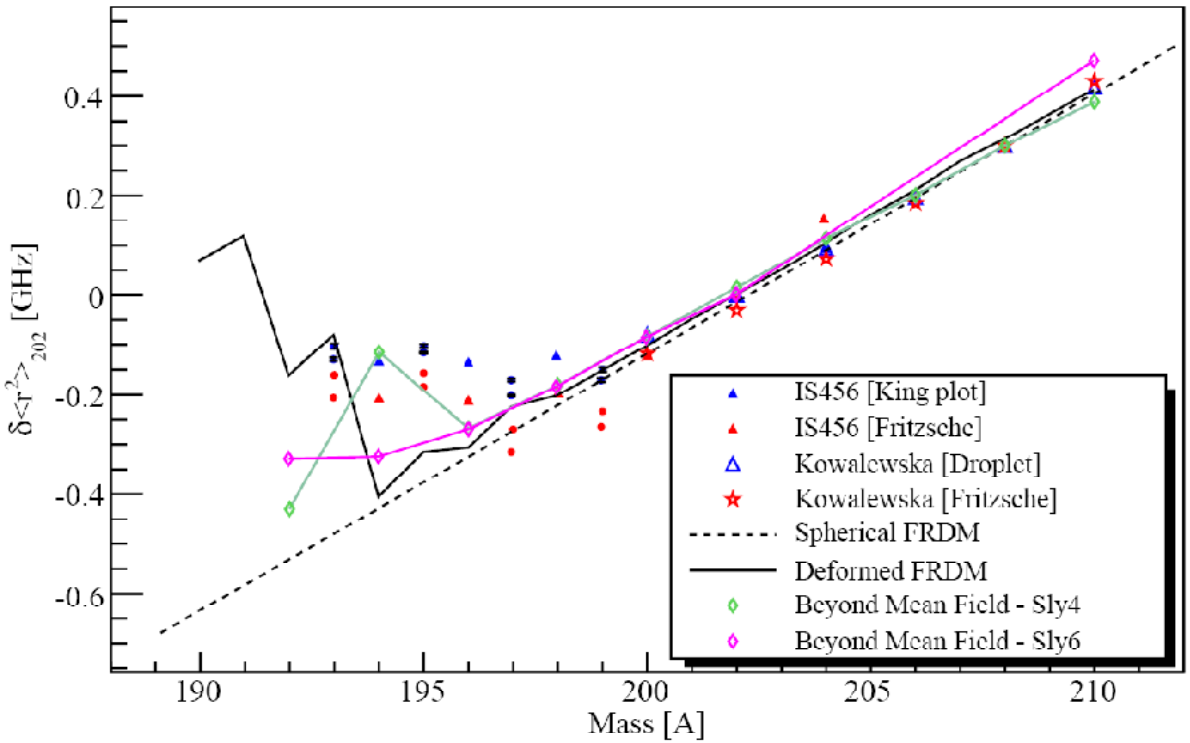
Preliminary!

Conclusions and outlook

- Extension of the laser spectroscopy studies to the neutron deficient and neutron reach isotopes (and isomers) of Po: from ^{191}Po to ^{218}Po:
  - Isotope shifts for the even-*A* $^{192\text{-}218}$Po are extracted
  - Data on charge radii of $^{192\text{-}218}$Po are obtained, but the analysis is ongoing…
  - Large and early departure of the charge radii from the Sperical Droplet Model prediction was observed for neutron deficient Po isotopes
  - Neutron shell closure effect (around N = 126) was observed
  - Spectra of the odd-*A* $^{191\text{-}211}$Po are obtained. Extraction of the isotope shifts and hyperfine splitting constants is ongoing…
  - Some interesting effects are expected: dramatic change of the magnetic moments for the light Po isotopes, inverse odd-even staggering…

Thank you for your attention

Comparison with the theory



This picture has all the data and calculation that we have available at the moment. It is very crowded but it is also complete.

the BMF calculations are on private communication from P.-H. Heenen