Hyperfine anomaly measurements in Francium

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FrPNC Collaboration

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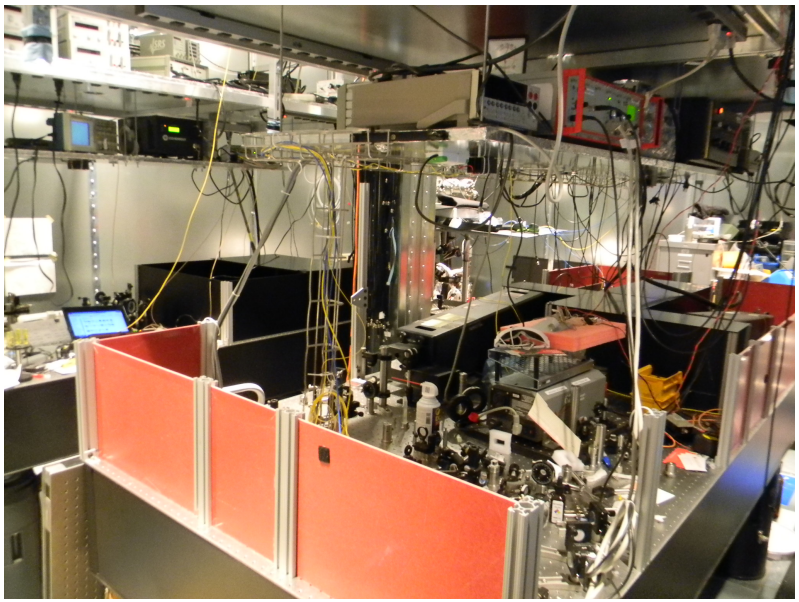
Overview

- Francium trapping facility
- Francium trapping November 2012
- Hyperfine anomaly
- Isotope Shift

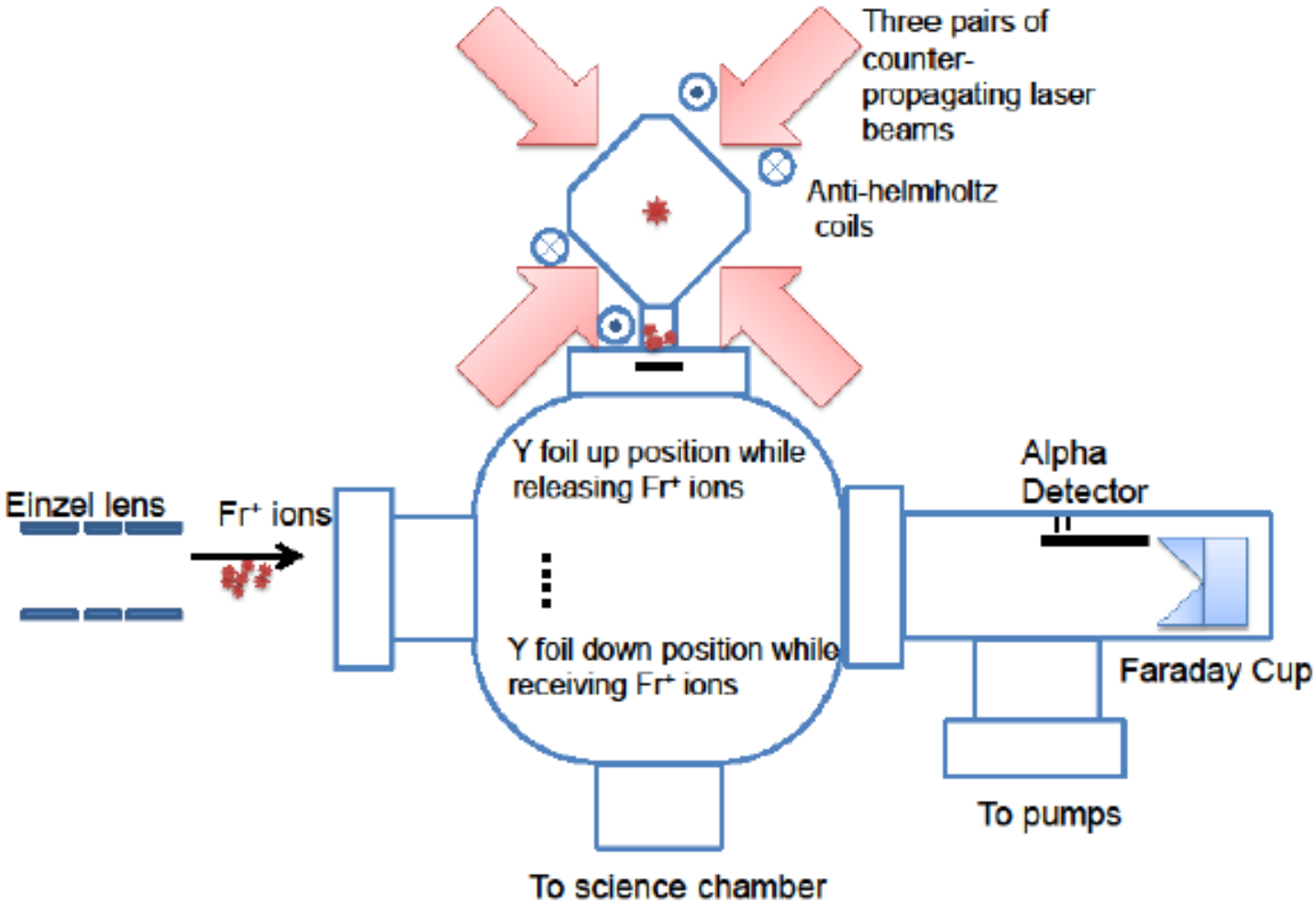
The facility

- Francium trapping facility in ISAC I located beneath TITAN platform
- Magneto-optical trap to cool & collect atoms for further experiments



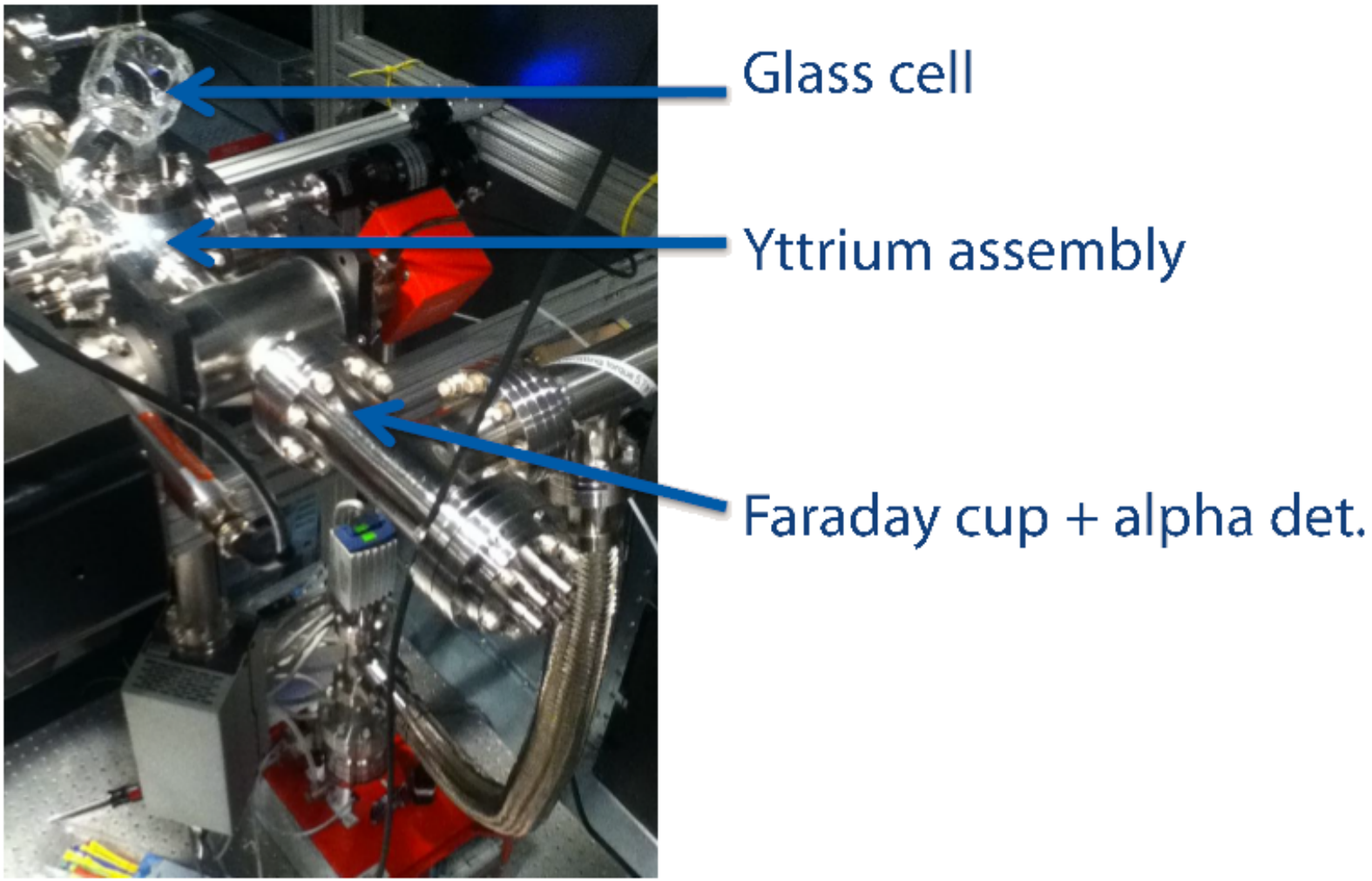
The facility

- Upper trap chamber, commisioned September 2012



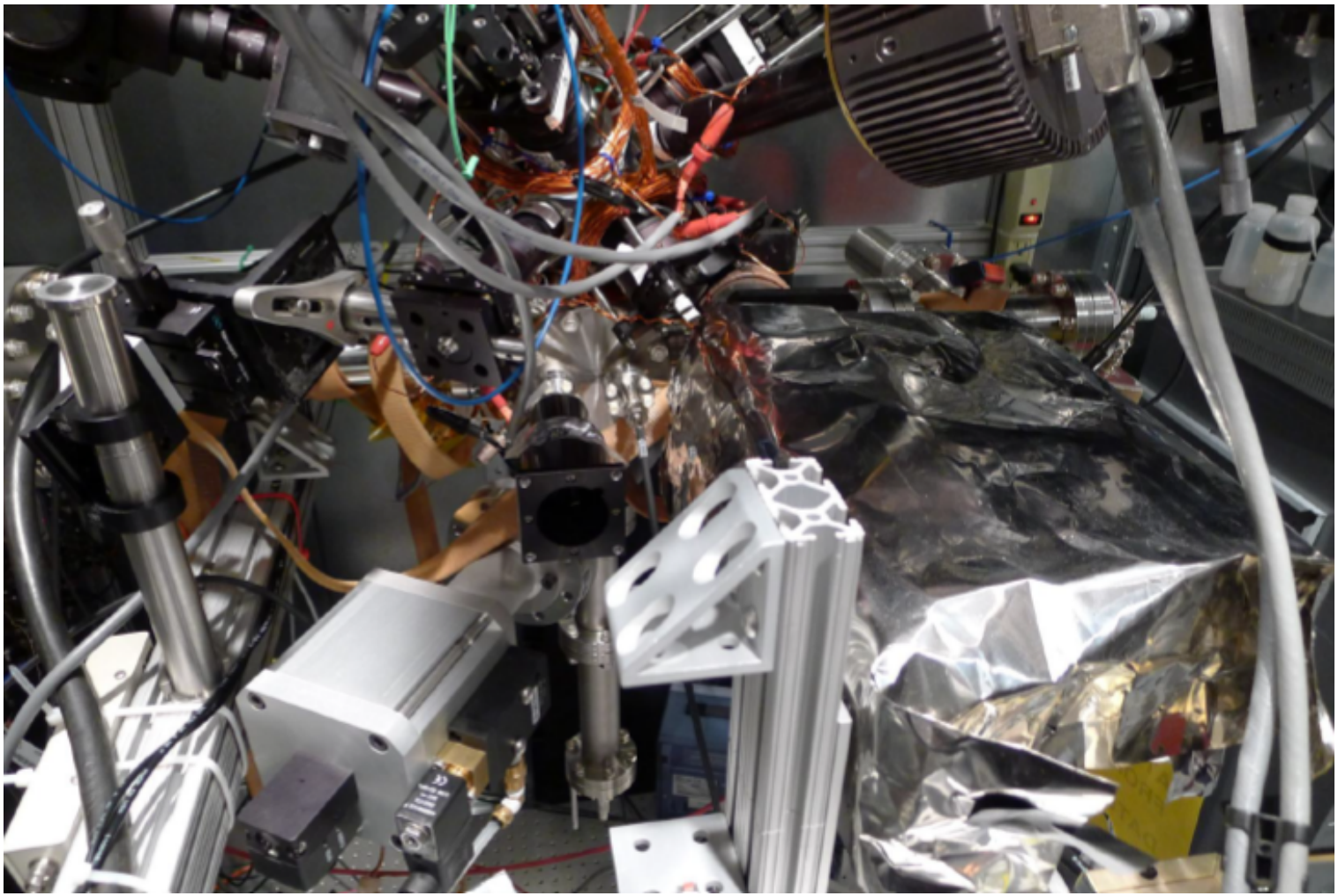
The facility

- Upper trap (before optics)



The facility

- Upper trap (after optics)

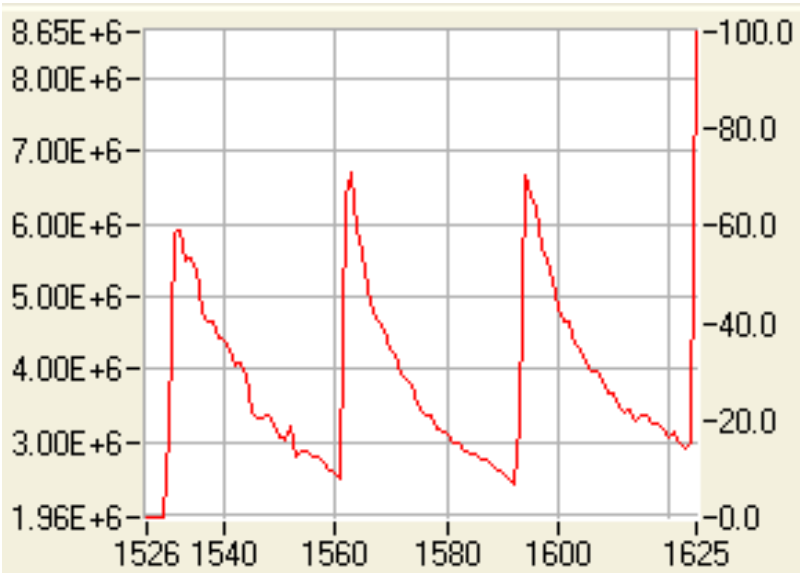


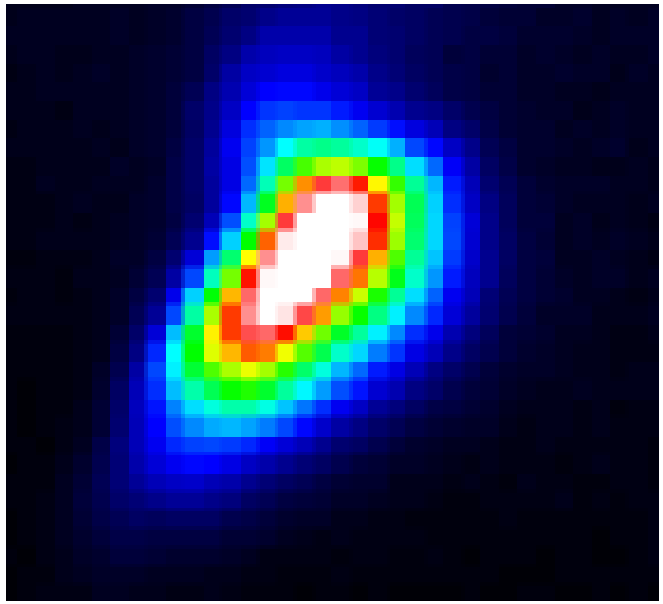
Francium trapping

- Trapped isotopes: ^{206}Fr,^{207}Fr,^{209}Fr,^{213}Fr

206Fr	207Fr	208Fr	209Fr	210Fr	211Fr	212Fr	213Fr
≈16 S	14.8 S	59.1 S	50.5 S	3.18 M	3.10 M	20.0 M	34.82 S
α≈ 84.00% ε≈ 16.00%	α: 95.00% ε: 5.00%	α: 89.00% ε: 11.00%	α: 89.00% ε: 11.00%	α: 71.00% ε: 29.00%	α: 87.00% ε: 13.00%	ε: 57.00% α: 43.00%	α: 99.44% ε: 0.56%

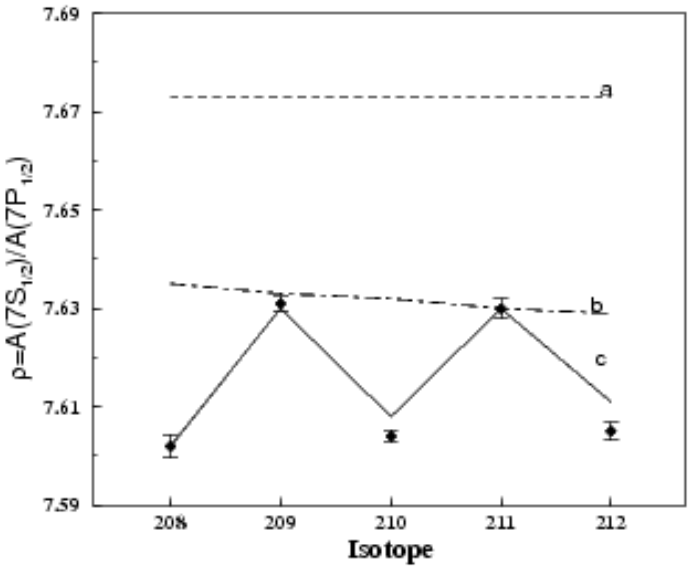
- Pulsed trap, cycle based on Y heating





Hyperfine anomaly

- Bohr-Weisskopf effect shifts atomic energy levels due to nuclear magnetization distribution
- Probe transition to $P_{1/2}$ level (no electric quadrupole contribution)

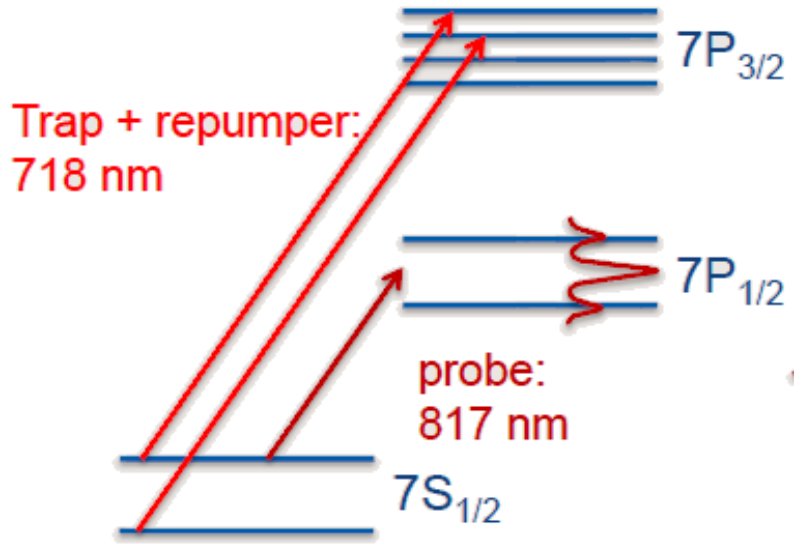


- Grossman et al., PRL **83**, 935-938 (1999)
  - isotopes ^{208}Fr to ^{212}Fr
- ^{213}Fr neutron shell closure
- ^{207}Fr neutron deficient, away from single-particle model?

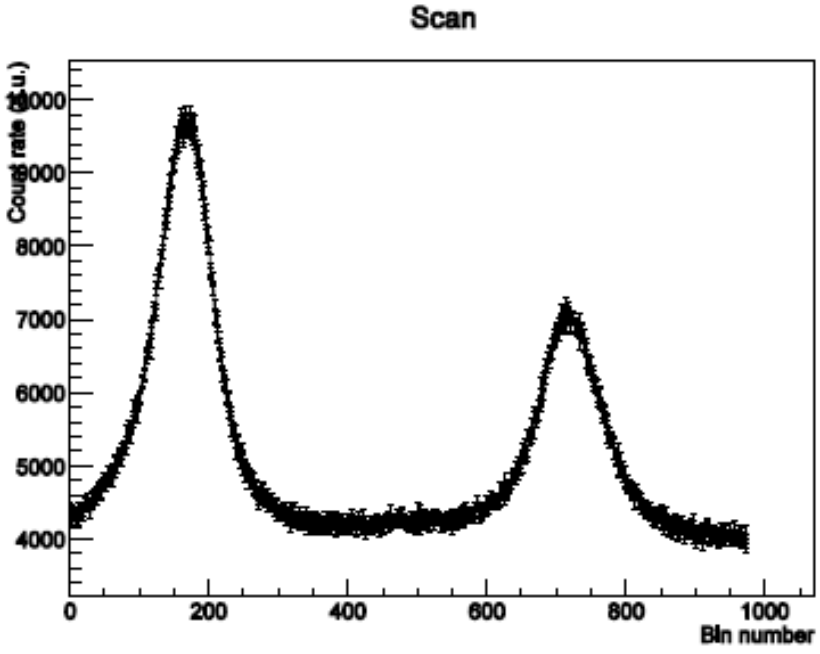
- Will contribute to better understanding of neutron radius of francium isotopes to be used for eventual parity non-conservation measurements

Hyperfine anomaly

- Trap and repump francium on $7P_{3/2}$ transition
- Probe laser set close to midpoint of hyperfine $7P_{1/2}$ states
- Sidebands on laser through fiber modulator at set frequency
- Sideband frequency swept quickly, reproducibly

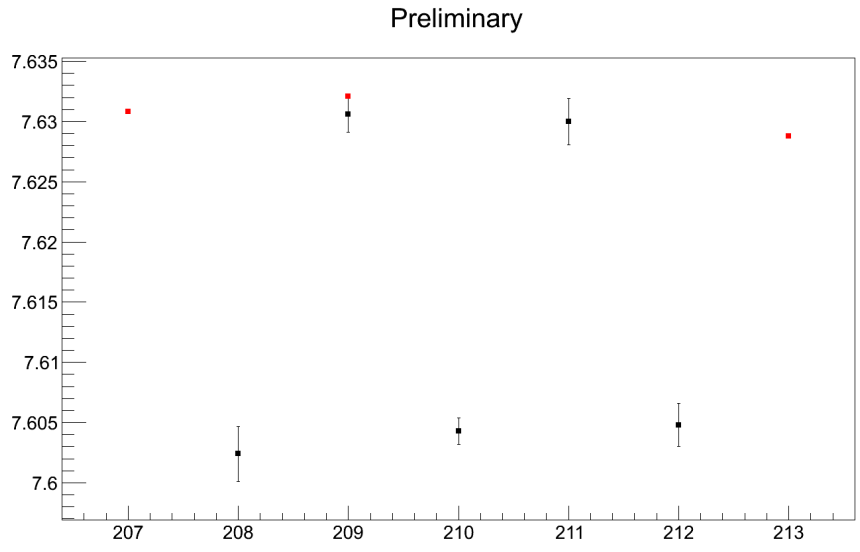


Hyperfine anomaly



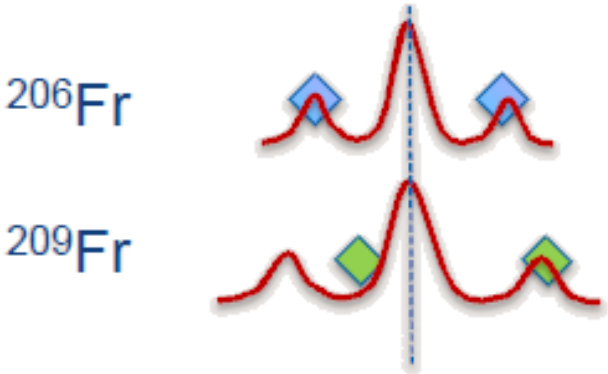
- 10 ms scans cover $\approx$ 140 MHz
- Peak separation = 2 x probe detuning
- Sum of peak frequencies = hyperfine splitting

- Preliminary results

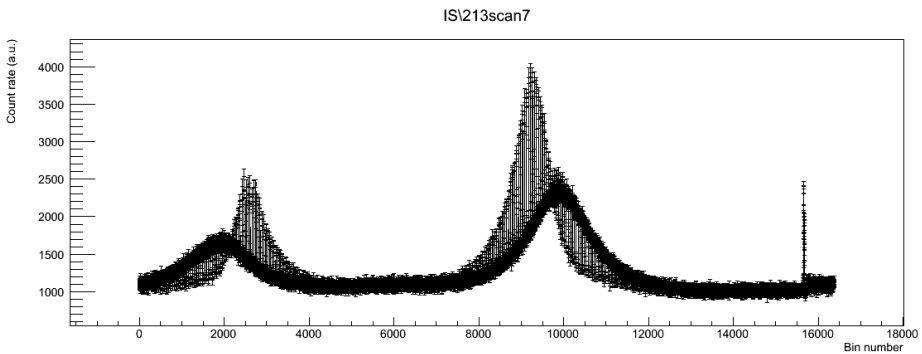


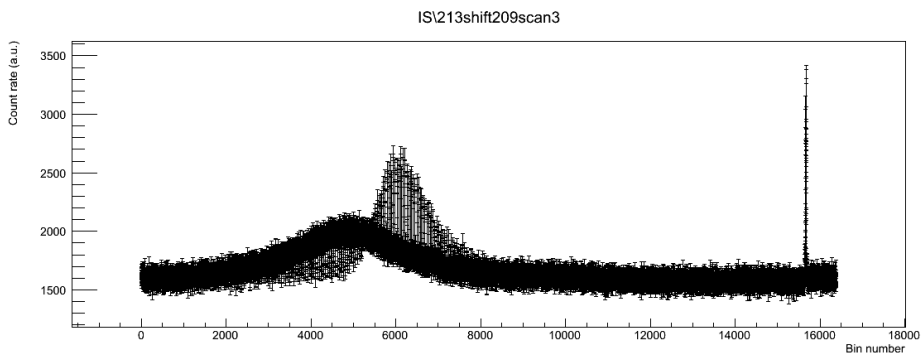
$7S_{1/2}$ to $7P_{1/2}$ isotope shift

- Isotope shift caused by change in charge radius (mass difference small for heavy nuclei)



- Relative measurements made with respect to ^{209}Fr
- Kept laser locked from HFA measurement, change RF sideband frequency





- Trap light chopped ∼10:1 on/off
- detailed comparison with known $7S_{1/2}$ to $7P_{3/2}$ (Coc et al. **PLB**, '85) may give info on atomic wavefunction overlap with nucleus

Conclusion and Outlook

- In conclusion:
  - ^{206}Fr, ^{207}Fr, ^{213}Fr splittings measured for $7P_{1/2}$
  - Isotope shifts for same
- Next:
  - More analysis: systematics, Rb measurements
  - more ^{206}Fr, lighter isotopes, possibly ^{221}Fr
  - Working towards parity non-conservation measurement

Acknowledgements

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