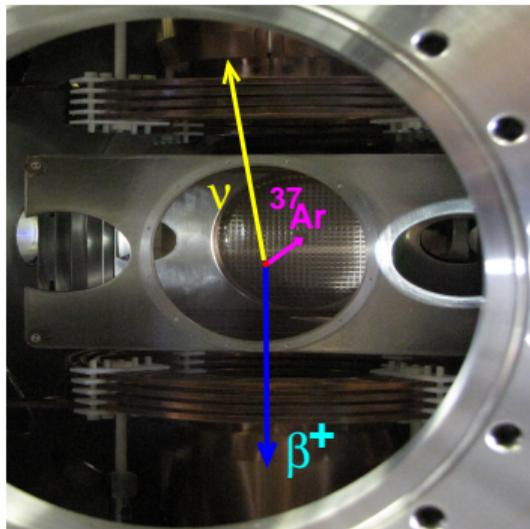
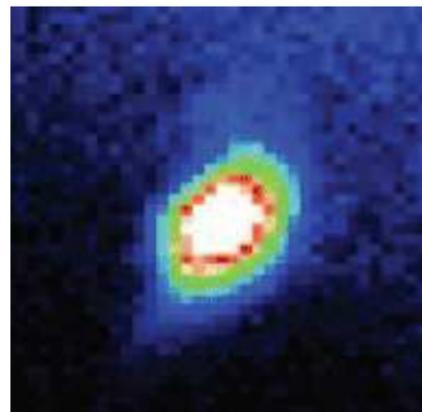


John D'Auria, the relativistic chemistry of francium, and MeV-mass ν 's



Otto Häusser,
Peter Jackson, and
John D'Auria started
TRLumf's Neutral Atom
Trap "TRINAT"



M. Kalita and T. Hucko
showed recent Fr
physics results Monday

- JDA's interest: Chemistry of francium for its own sake
S-states are sucked in by relativity
- We tried to trap ^{226}Fr with TRINAT at TISOL
Searched for MeV-mass ν 's instead



"Traps for Antimatter and Radioactive Nuclei" 1993

Organizers:

J. D'Auria,

D. Gil,

A. Yavin



T. Goldman HI 1993 tossing \bar{p} at ceiling

D'Auria HI 81 275 1993 TISOL

Behr, Orozco, Sprouse, Gwinner et al.

HI 81 197 (1993) but I didn't go ("\$\$") 😞.

I did read the conference summary:

O.Hausser HI 81 197 (1993) 😊:

- We trapped ^{79}Rb at Stony Brook
- Otto hired me (4th choice) for TRINAT

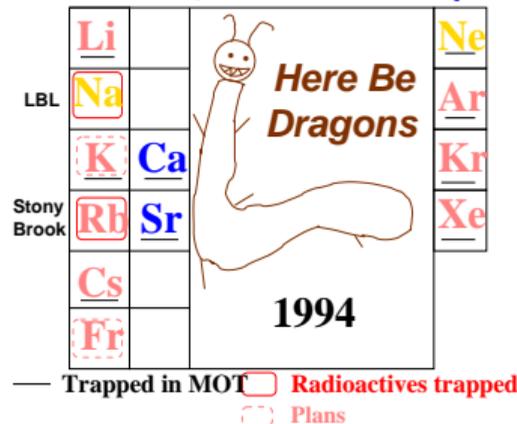
'1st TRINAT meeting'

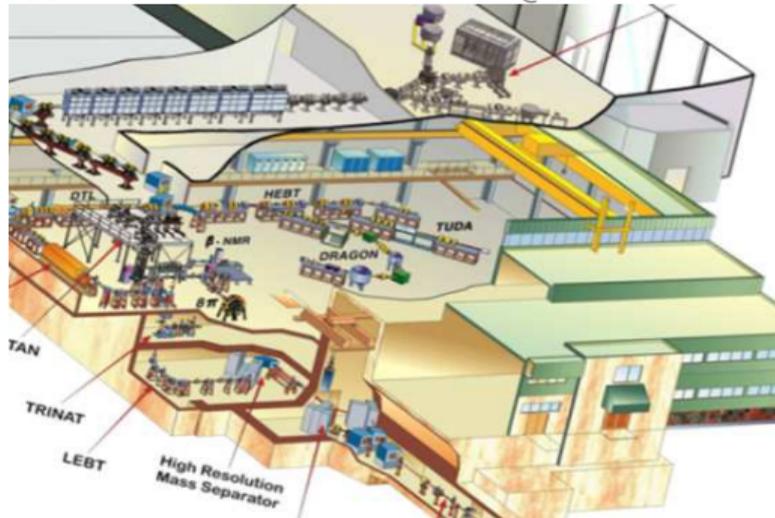
JD'A, JB Apr'94 APS meeting:

JD'A: We wanna trap Fr and study it for its own sake

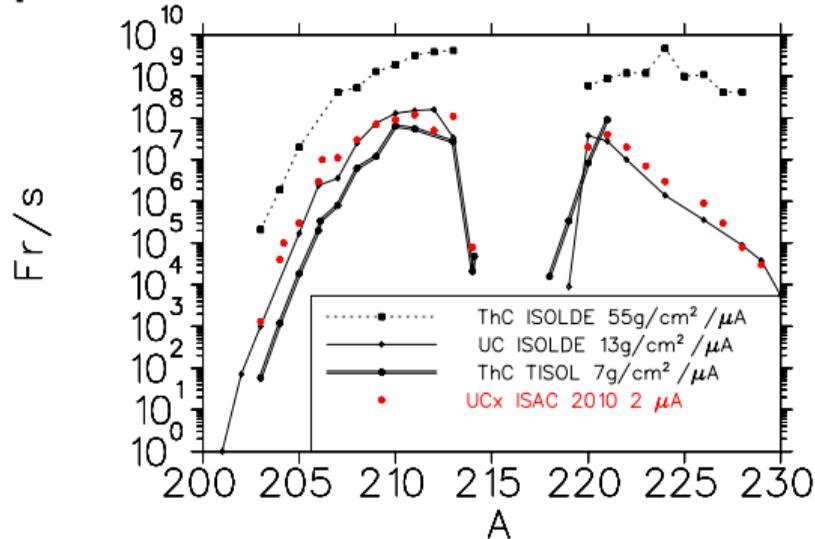
JB: I thought we were mostly doing β - ν correlations?

JD'A: Eh, that's Otto (cough)

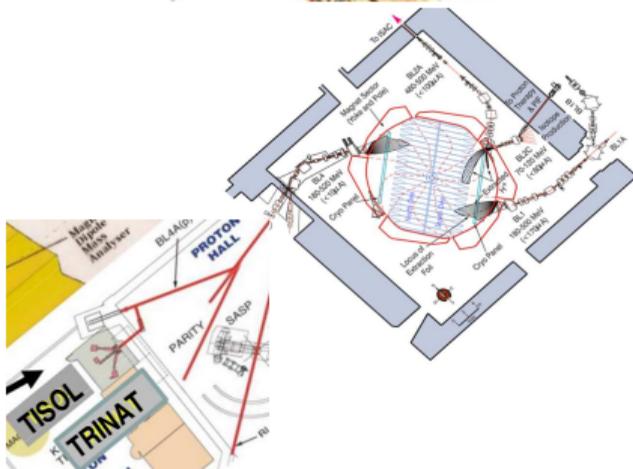




TRINAT at TISOL: A good match for surface ion source for alkali production

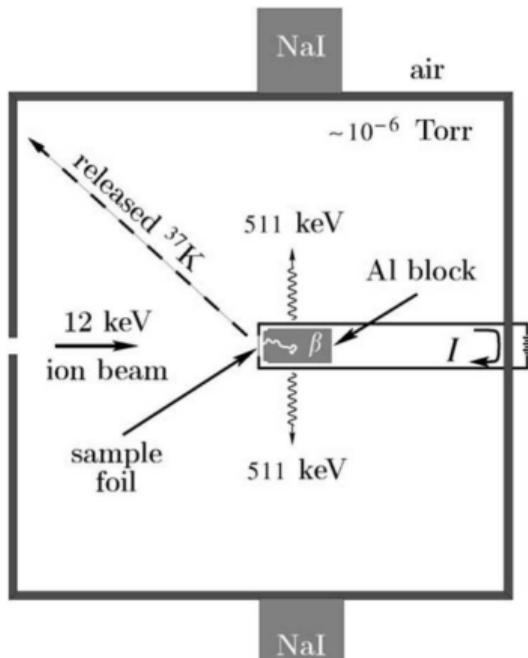


- Developed stopper/neutralizer (flexible beamtime)
- Tried, then trapped ^{37}K and measured $\langle r^2 \rangle$ (flexible beamtime)
- Tried to trap ^{226}Fr

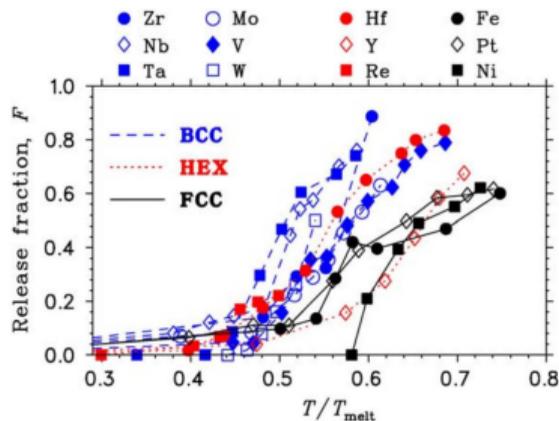


'Simpler chemistry': 1997 Neutralizer development

One day the trap was not working 😞, so we scrounged foils and tried out release:

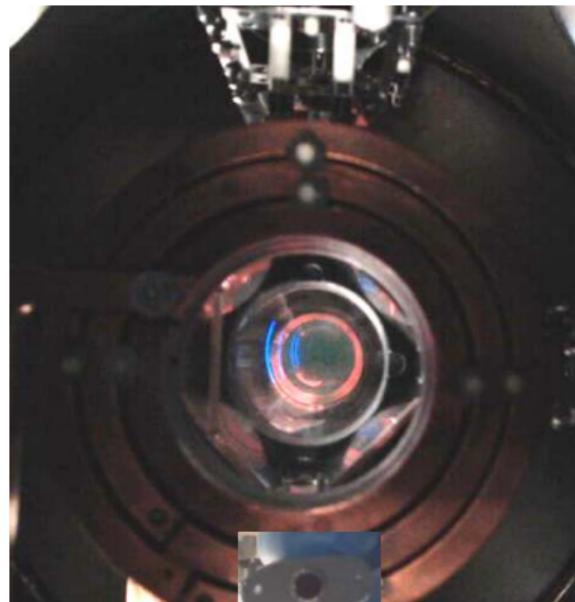


Best release from BCC



Melconian et al 2005 NIMA

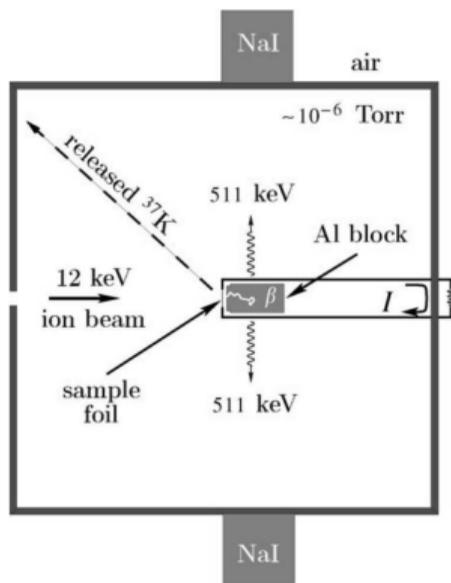
Miedema and Dorleijn Surf. Sci. 95 (1980) 477:
 adsorption enthalpy related to bulk properties like T_{melt} and work function →



Zr won

We tried lower-T foils →

lower-T foils

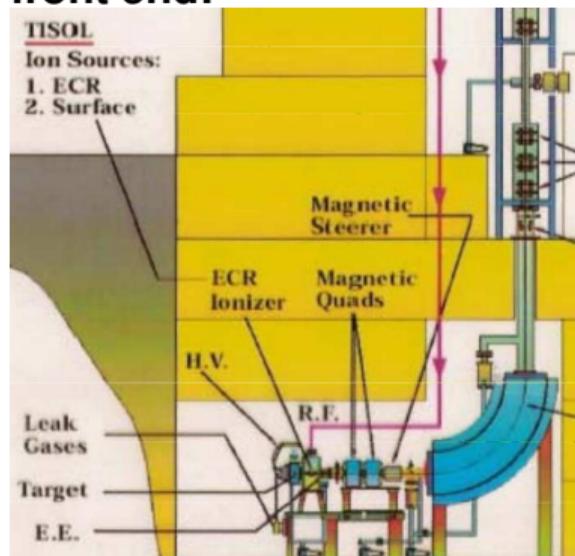


When Gorelov and I blew up the Lithium foil and went to lunch, JD'A cleaned box

Al didn't work either

further backup from JD'A

J.B.'s only visit to TISOL front end:



One day, vacuum valves closed.

After 8 hrs: 5 Rem/hr

P.M. reconnaissance:
Polyethelyne (auxiliary) tubing cracked



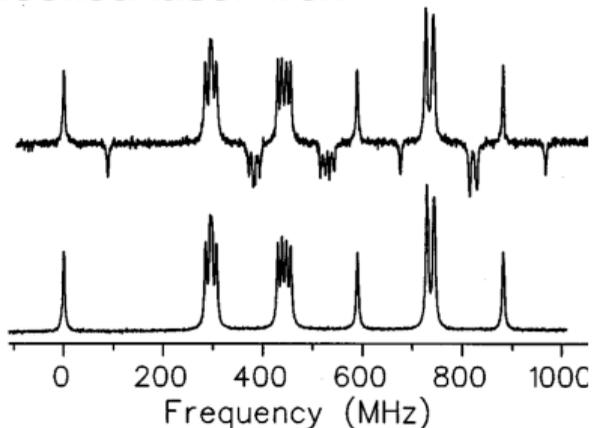
J.B. capped the PolyFlo (50 sec), knocked over the cooling fan.

JD'A fixed the fan



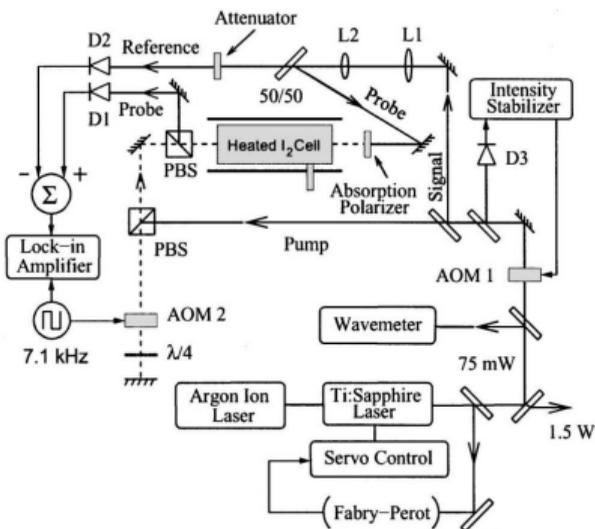
1997 Attempt to trap ^{226}Fr at TISOL

Dube and Trinczek JOSA B
Iodine saturation spectr.
locked laser well



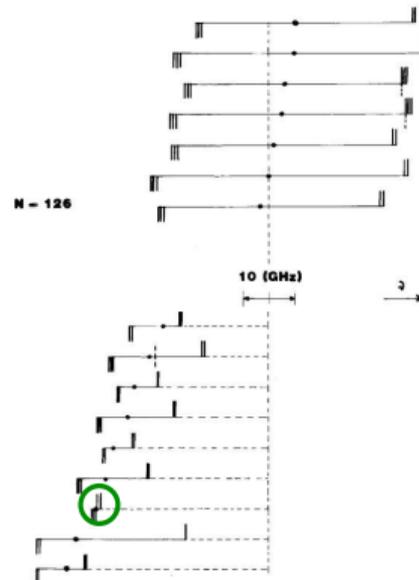
- ^{226}Fr frequencies covered by existing AOM's
- ThO+egg white \rightarrow 'ThC' was fine (chef JD'A) but low yields for 226, β decay geometry collected few photons
- EEC: 'If you're going to do this, you have to do it right'

Francium trapped at ISAC 😊 15 years later



Coc (Orsay/ISOLDE) PLB
1985 hyperfine structure

Fr	Half life	Spin
207	14.8s	9/2
208	55.6s	7
209	50s	9/2
210	192s	6
211	186s	9/2
212	1200s	5
213	34.6s	9/2
214	5×10^{-5} s	
215	0.09×10^{-6} s	
216	0.7×10^{-6} s	
220	27.4s	1
221	294s	5/2
222	654s	2
223	1308s	3/2
224	198s	1
225	236s	3/2
226	48s	1
227	148.2s	1/2
228	39s	2

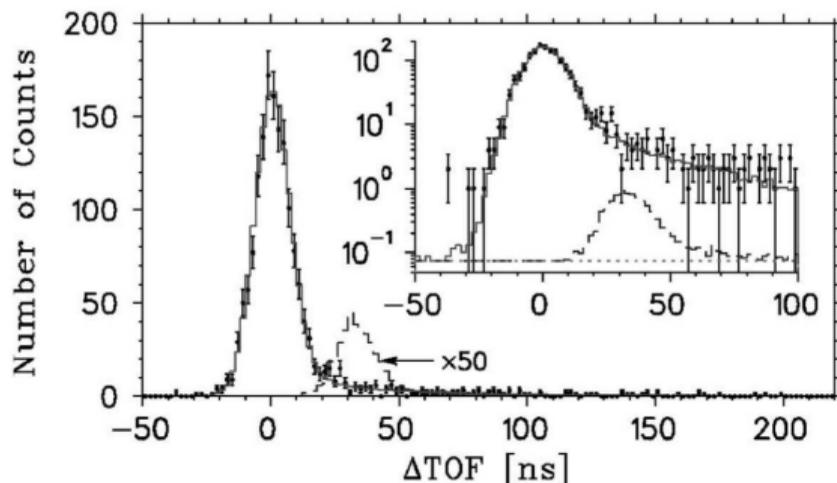




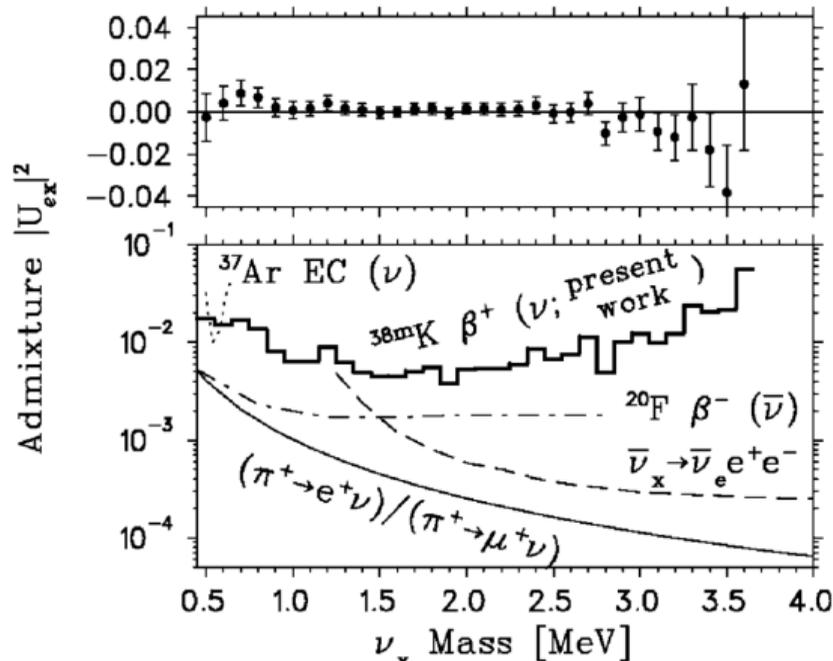
MeV-mass ν 's and cosmology

Trinczek... JD'A et al PRL 2003

Would produce slower nuclear recoils in



Limits are in PDG

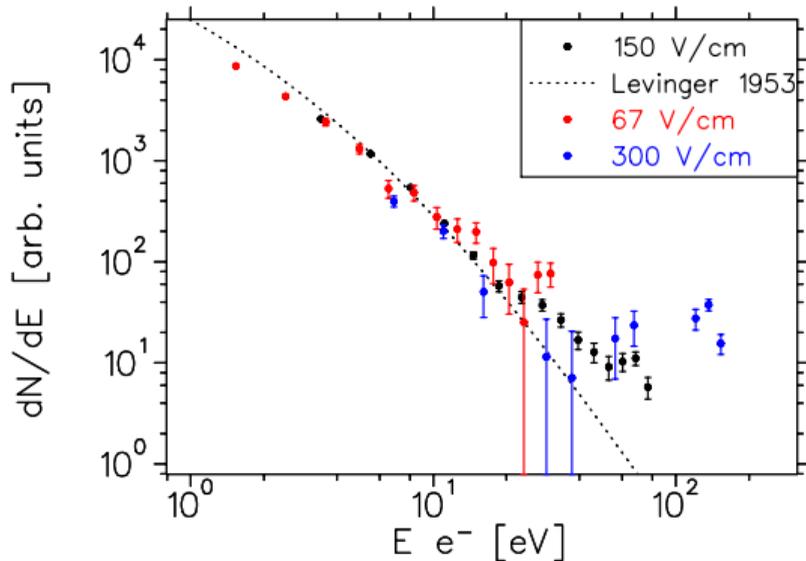
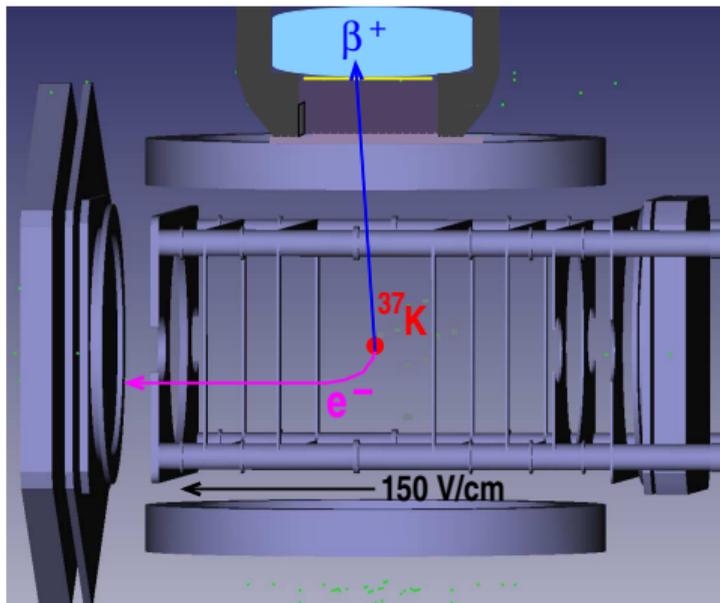


Gelmini PRL 2004 Such ν 's don't overclose the universe in cosmologies with low reheating temperature (MeV's, enough to make BBN)



Low-energy e^- 'shakeoffs' from $^{37}\text{K} \beta^+$ decay

JD'A+J. Vincent: Can TRINAT trap rhodium and measure e^- energies? No, but:



**Levinger '53: $\langle \psi_i | \psi_f \rangle$ hydrogen-like
with K/Ar E_{bind}, n^***

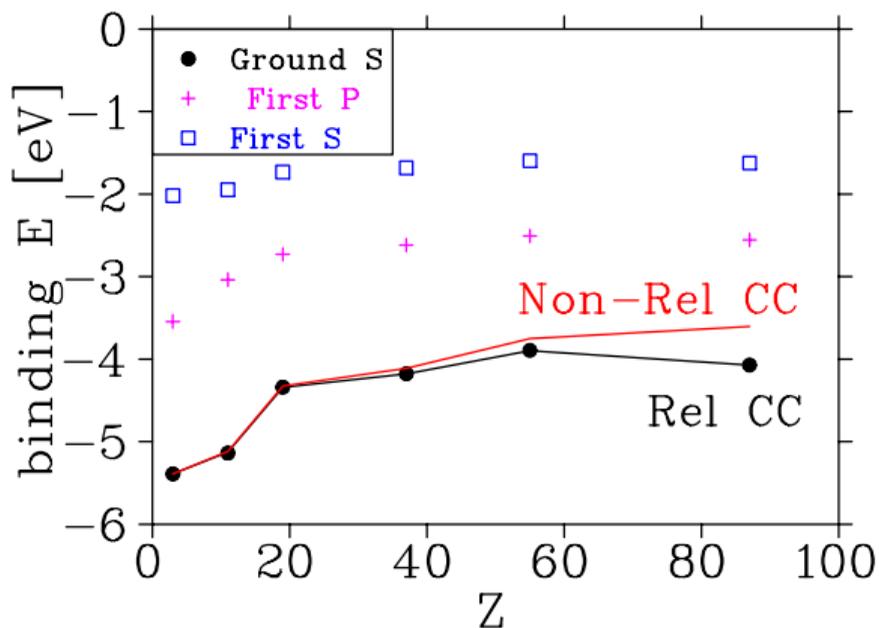
**Some higher-energy shakeoff e^- , but very few above threshold for
double-strand DNA breaks, ~ 25 eV [Friedland Rad Res 150 172 (1998)]**

Relativity binds S states deeper, changes e^- g-factors

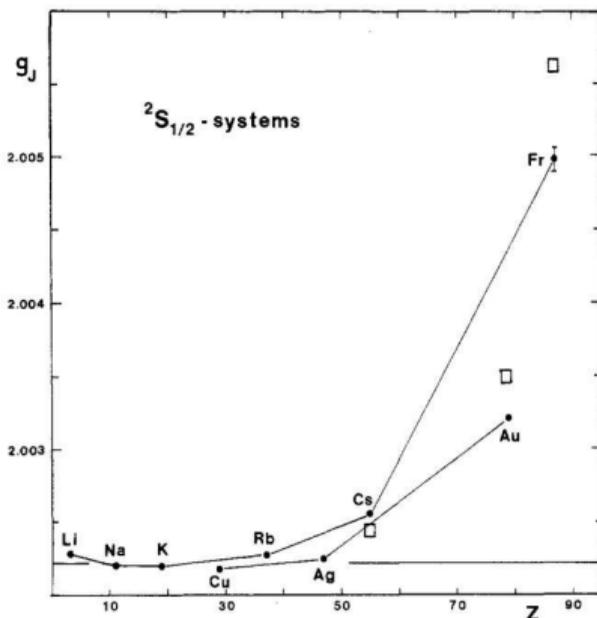
Au is gold

Hg is a liquid

ekaRn Z=118 may have e^- affinity > 0



Relativity has $\sim 10\%$ effect on Fr ionization potential
 [Eliav Phys Ref A 50 (1994) 1121]



g-factor of $S_{1/2} e^-$ increases 0.1% with Z
 [Ekstrom 1986 Phys Scr 34;
 Dzuba 1985 Phys Scr Rel H-F]

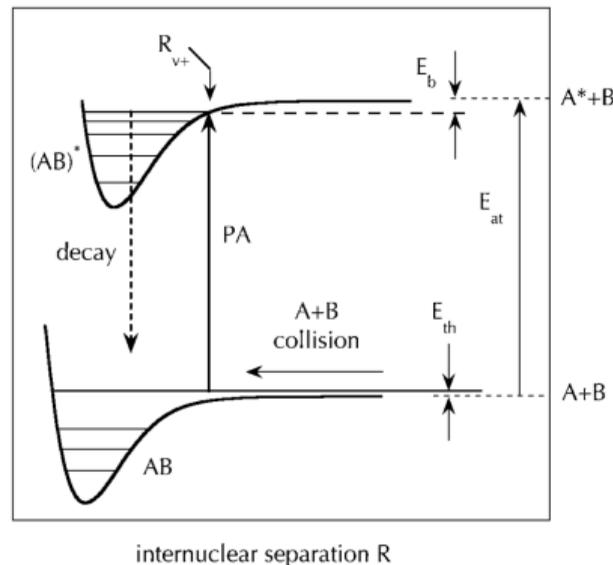
Cold chemistry: Photoassociation \rightarrow Fr₂ molecular dimers

- Excite one atom to a P state, making a dipole interaction with the other.

C₃ molecular potential \rightarrow quantitative info on $\langle s || E1 || p \rangle$ to interpret atomic PNC interpretation.

Stony Brook (Orozco, Gomez, et al.) looked for Fr₂ and FrRb, did not see.

Aymar et al. JPB 39 2006 predict: greater Fr spin-orbit coupling \rightarrow different dimer potential than Rb₂, Cs₂: similar rates, but fewer Fr₂ molecules near g.s.

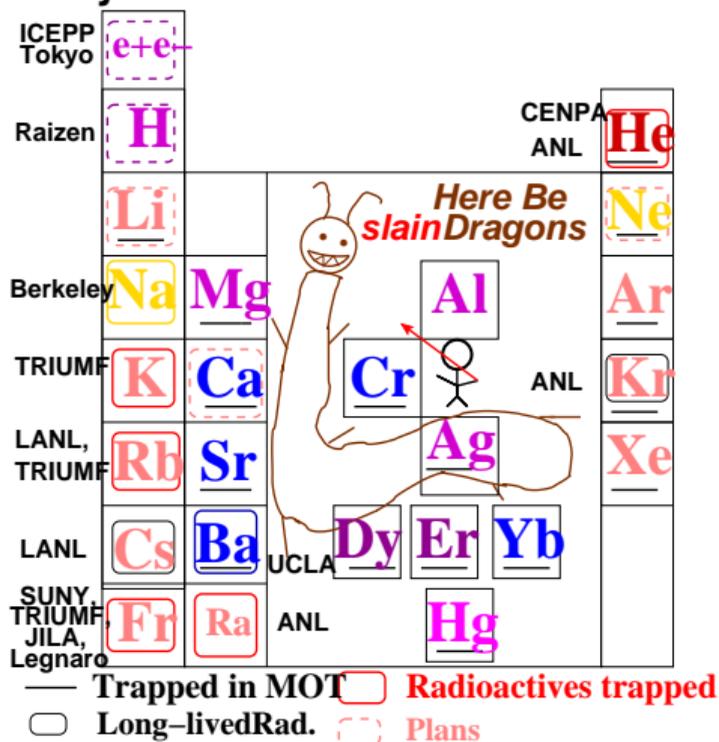


Jones et al. RevModPhys 2006

Most efficient probe by far is photoionization, so TRINAT may be a better facility than FranciumTrappingFacility to do this.

John D'Auria, the relativistic chemistry of francium, and MeV-mass ν 's

Many MOT's for radioactives now



TRINAT testing phase needed regular beamtime from TISOL

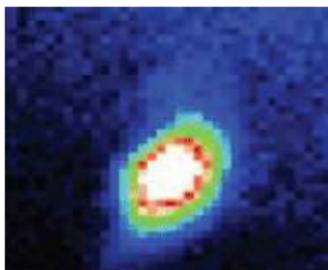
JD'A and TRINAT:

J.D'A, Buchmann, Dombisky, Jackson, Sprenger, JB, 1997 NIMB on TISOL

J.B. PRL 1997 Trapping 37K

Melconian NIMB 2005 NIMA

Trinczek PRL 2003



M. Kalita and T. Hucko showed recent Fr physics results Monday CAP