Recoil Separator — Curse or Promise for SHE One-Atom-At-A-Month Chemistry

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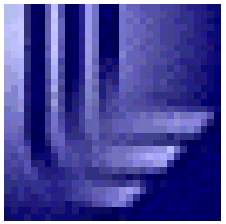
Acknowledgement



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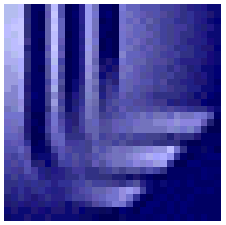
- All the great people, I met during my career—starting in Germany and going on in the US

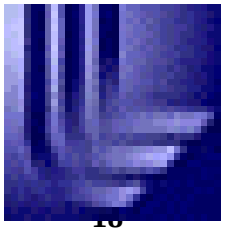
How realistic is our desire to explore chemistry of heavier transactinides ?



Many ~~constraints~~ challenges from today have still to be overcome

- Cross sections: ≤ pb, or production rate of one atom a week to a month
- Half-lives in the ms to min range, or basically unknown
- Chemical methods to explore those elements/isotopes known to us at such minute quantities are not established
  - Existing technologies (manual and automated) are incapable of performing experiments of such long duration as needed
  - Efficiencies are limiting us....
    - A gas-filled separator—a good pre-separator 30 – 75 %
    - Gas-jet transport system 10 – 80 %
    - Chemical yields 10 – 80 %

Periodic Table of the Elements



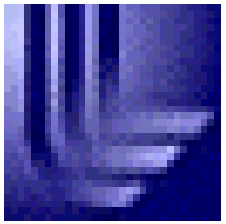
1																	
1 H	2											13	14	15	16	17	2
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc		23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-71 Ln*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103 An*	104 Rf	105 Db	106 Sg	107 Bh	108 Hs										
								109 Mt	110	111	112	(113)	114	(115)	116	(117)	(118)

Actinides	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
89 Ac														
Lanthanides	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
57 La														

Time Line of Transactinide Discovery and their Chemical Identification

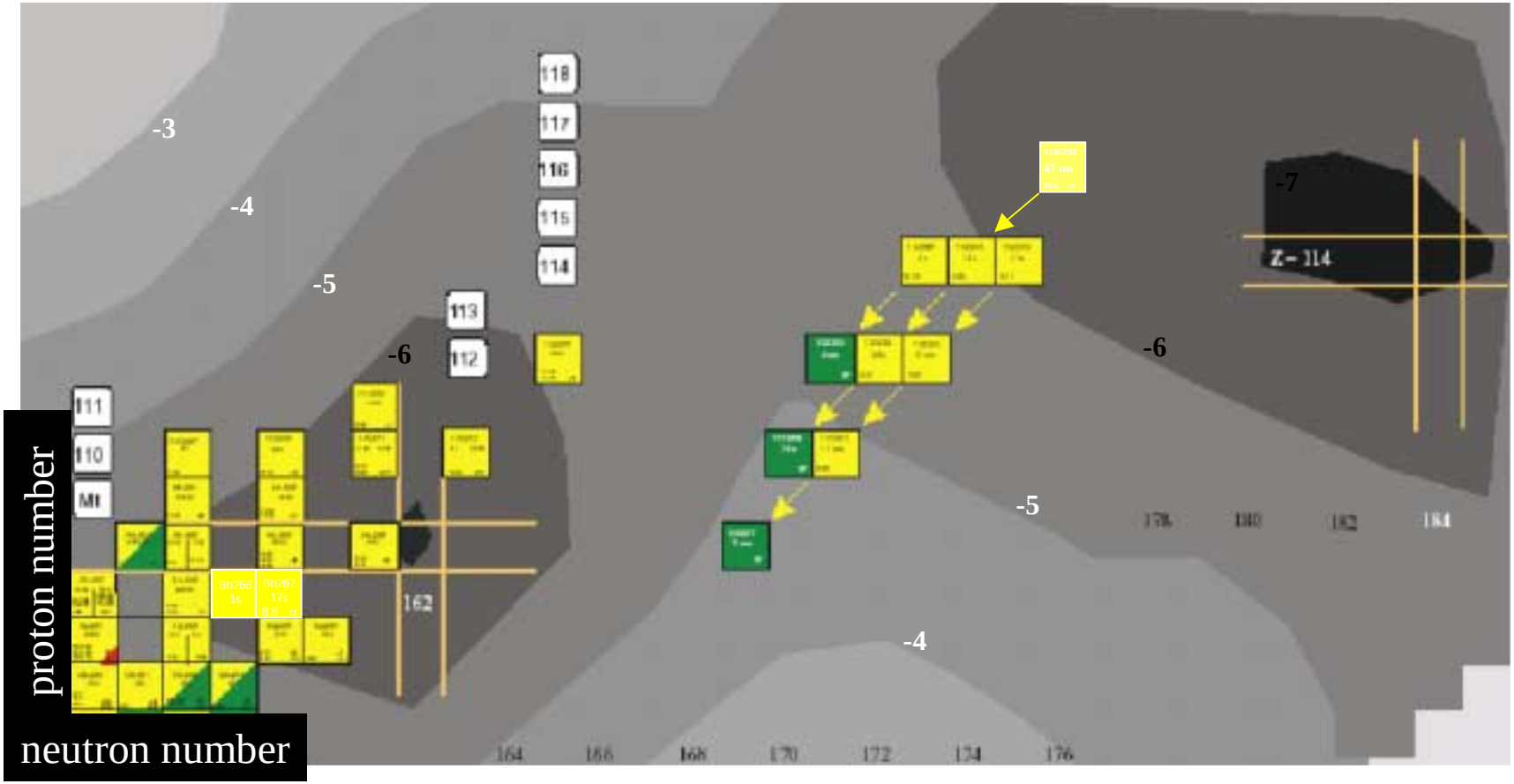
Element	Discovery		Chemical Characterization gasphase		aqueous	Theoretical paper on E
104	1964	2	1966	4	1970	1988
105	1970	4	1974	14	1988	1992
106	1974	22	1996	1	1997	1994
107	1976	24	2000			2000
108	1984	17	2001			2001
109	1982					
110	1994					
111	1994					(1999)
112	1996					(1999)
114	1999					(1999)
116	2000					

Production of SHE's

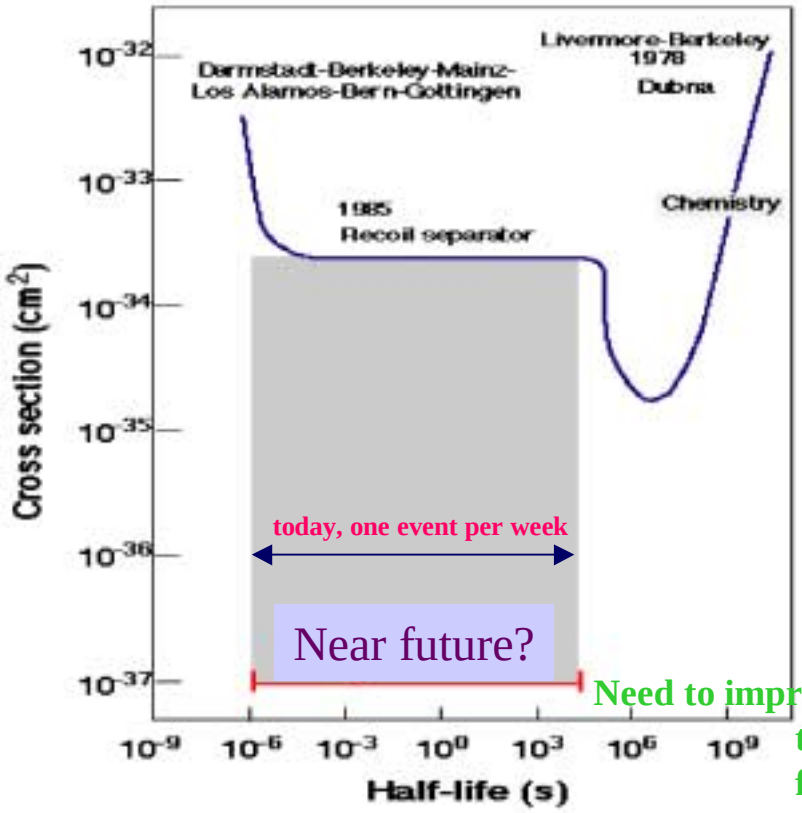


Reaction	Target	Projectile	Goal region
Hot fusion	**Actinides**	**Stable isotopes low Z**	**Lower trans-actinides**
Warm fusion		**Stable isotopes high Z**	**Z ~ 114/116**
		Rare isotopes	**?**
Cold fusion	**Stable isotopes (Pb, Bi)**	**Stable isotopes**	**Actinides ≤Z≤112**
		Rare isotopes	**?**

Island of Stability

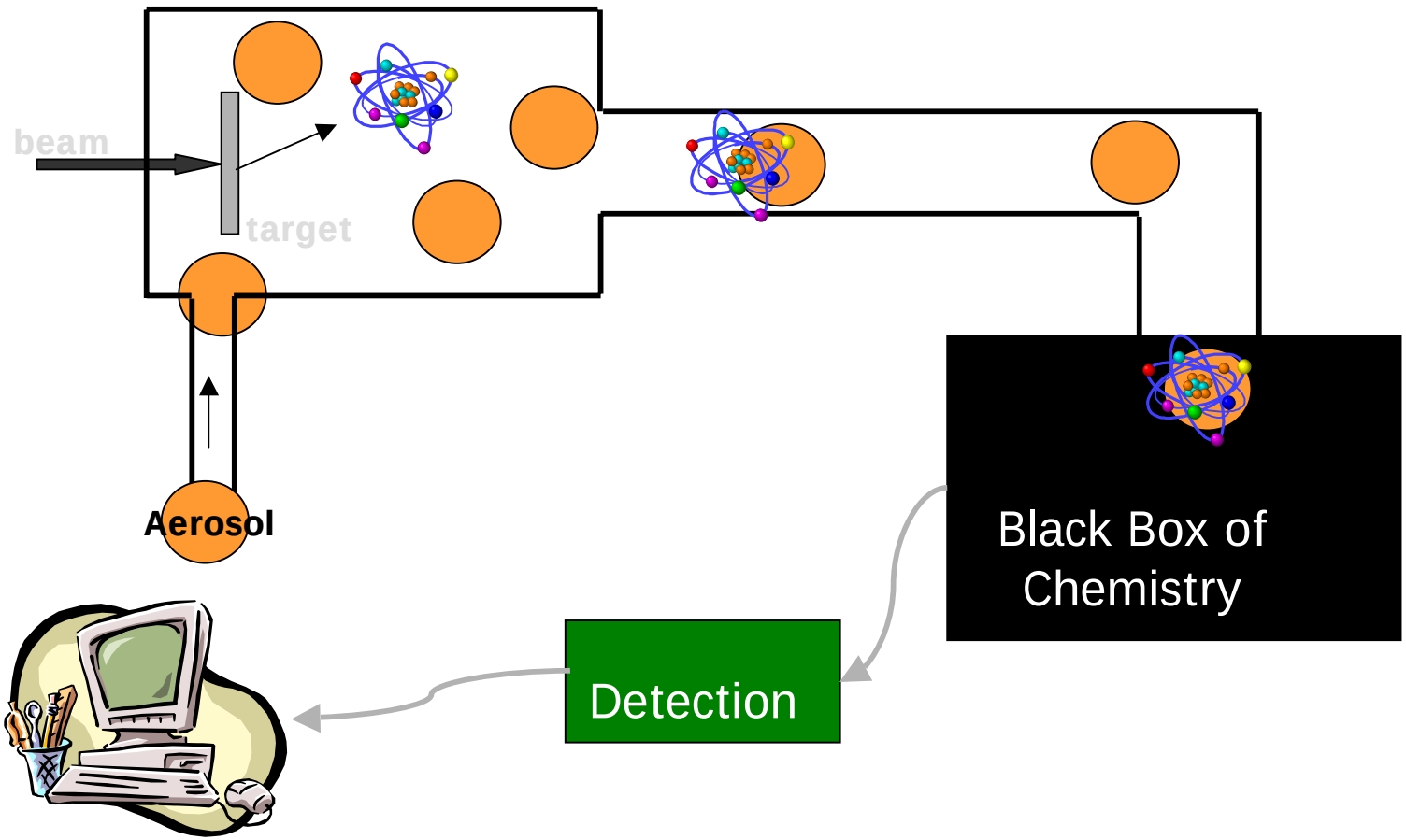


Sensitivities of previous and current accelerator-based superheavy element experiments, compared with the sensitivity required for success.

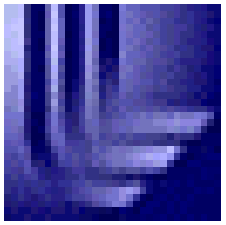


Need to improve: beam intensities, target technologies and discrimination from background

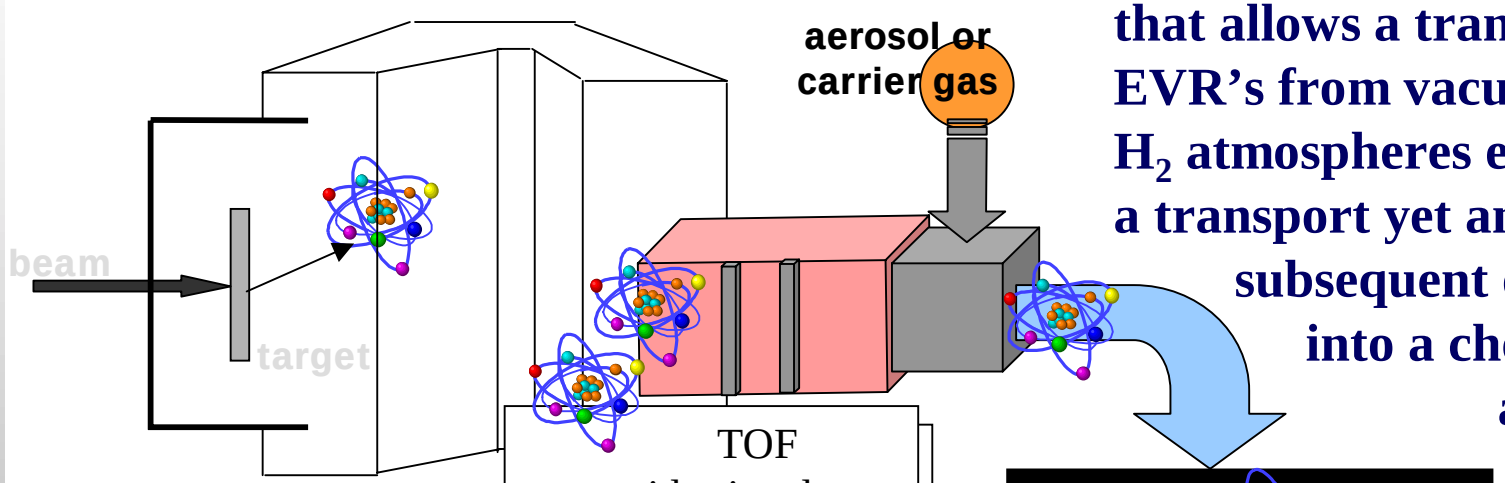
Challenges w/o Recoil Separator



Challenges w/ Recoil Separator



Necessitating an interface that allows a transfer of EVR's from vacuum, He or H_2 atmospheres either into a transport yet and subsequent or directly into a chemical apparatus

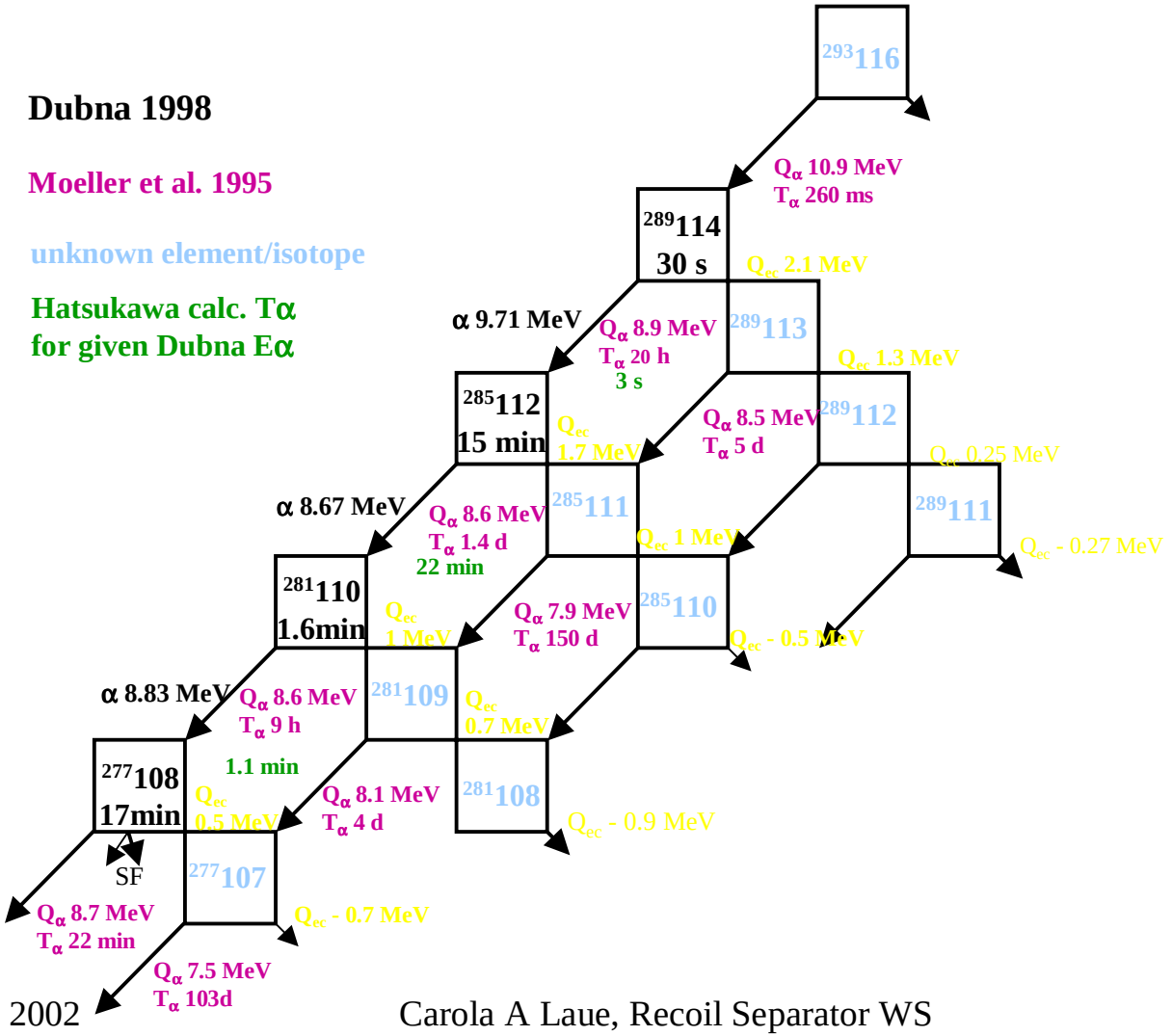


TOF
to provide signal, when promising EVR is passing, to trigger start of chem.

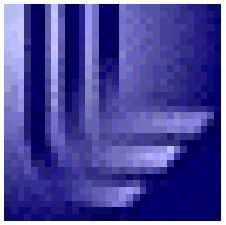
Black Box of Chemistry

Detection

Possible longevity of isotopes of the SHE's might necessitate different approaches to chemical methods



Criteria Wish List
to make Recoil Separator feasible



- Higher efficiency
  - atom of interest that entered the separated should be seen leaving it
- Higher resolution
  - separated mass fraction should be more specific in order to be able to simplify chemical characterization methods
- Trigger system
  - TOF detector system initiating the start of chemical procedure the moment an EVR of interest passes them