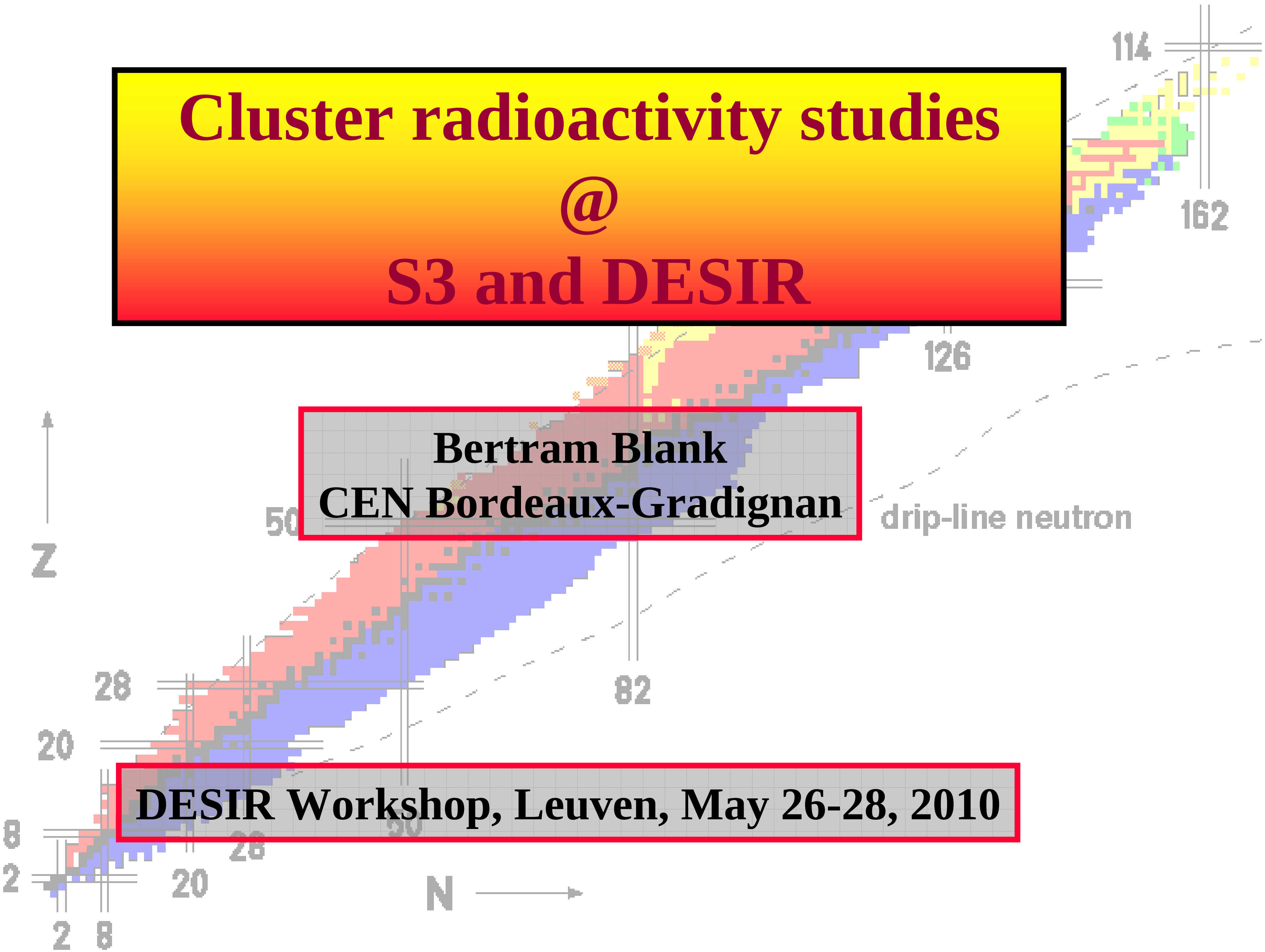
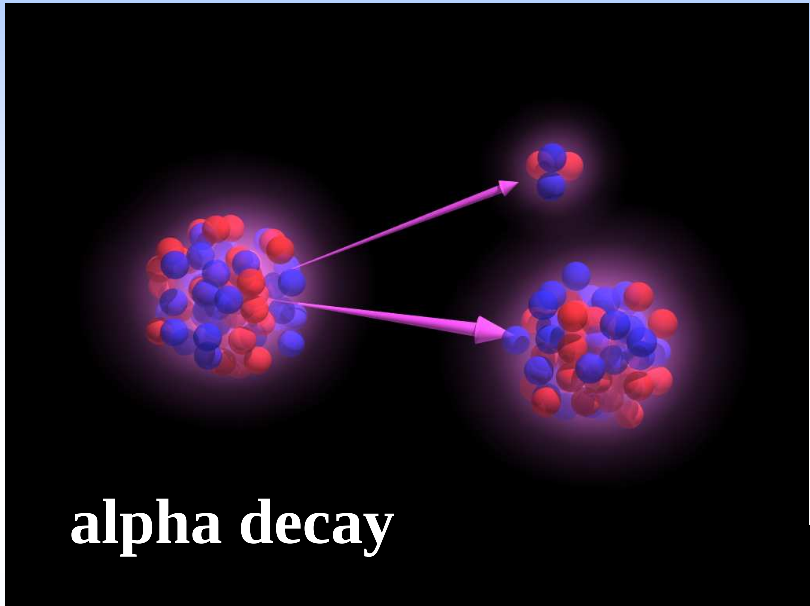
Cluster radioactivity studies
@
S3 and DESIR

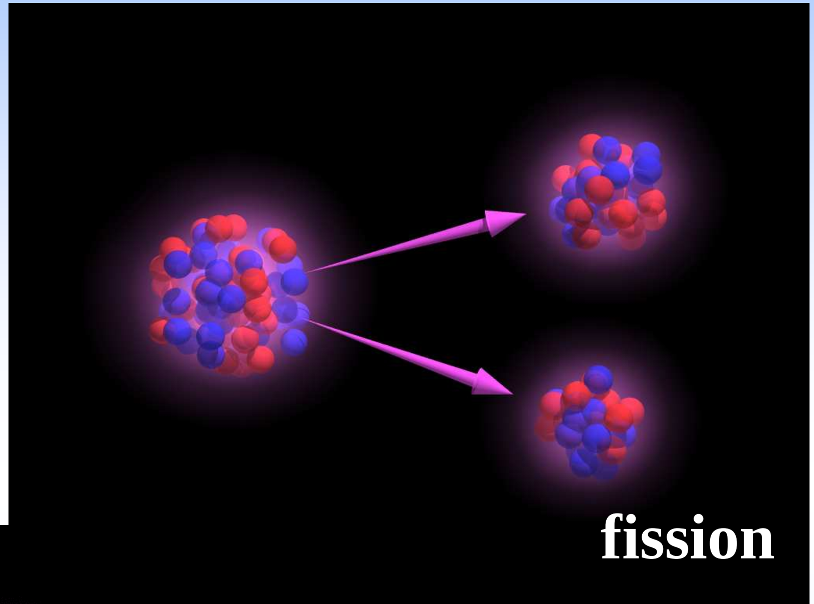
Bertram Blank
CEN Bordeaux-Gradignan

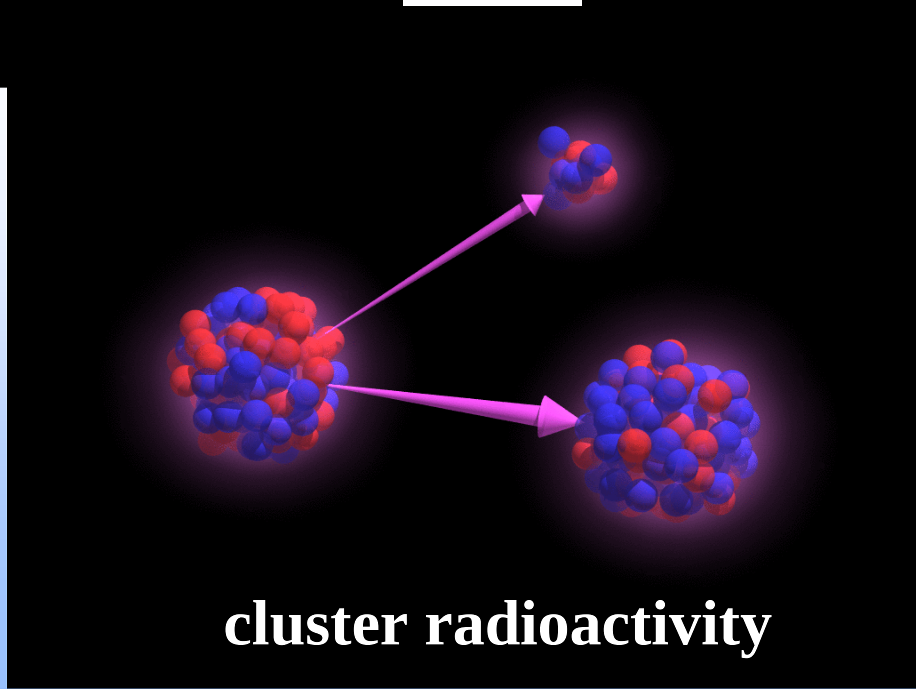
DESIR Workshop, Leuven, May 26-28, 2010



Cluster emission 1984







emitted clusters:

^{14}C, ^{20}O, ^{23}F,

$^{22,24,25,26}Ne$,

$^{28,29,30}Mg$,

$^{32,34}Si$

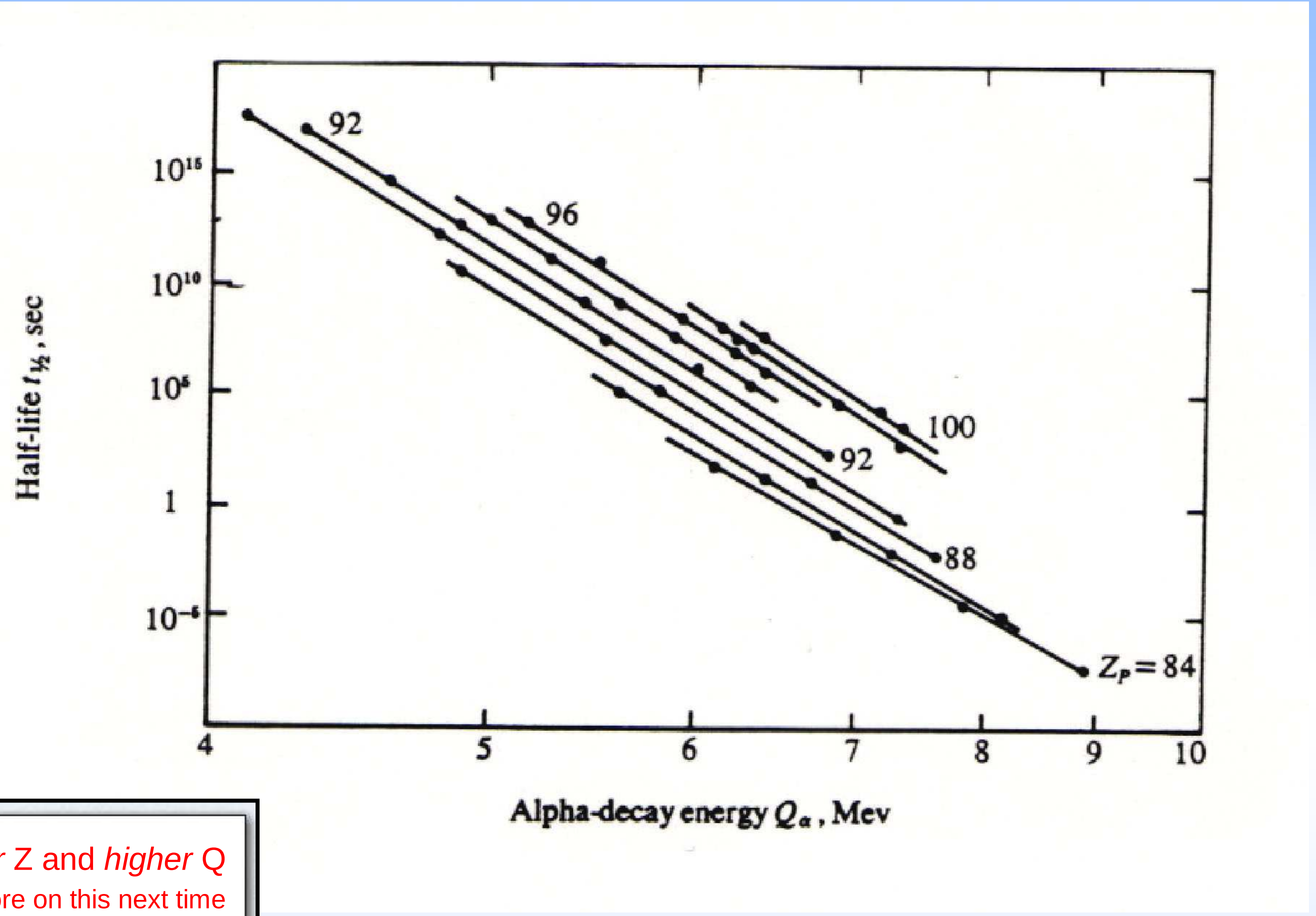
cluster emitters:

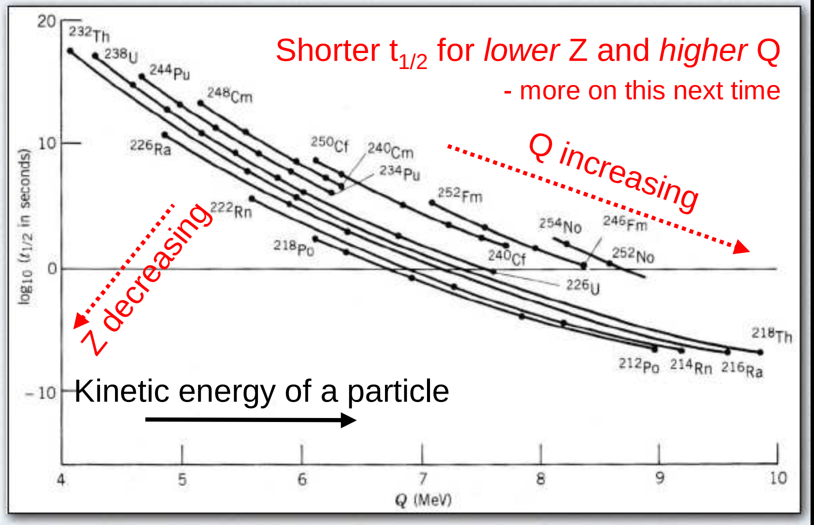
^{221}Fr …. ^{242}Cm

daughter nuclei:

^{208}Pb region

The Geiger-Nuttal rule for alpha emitters

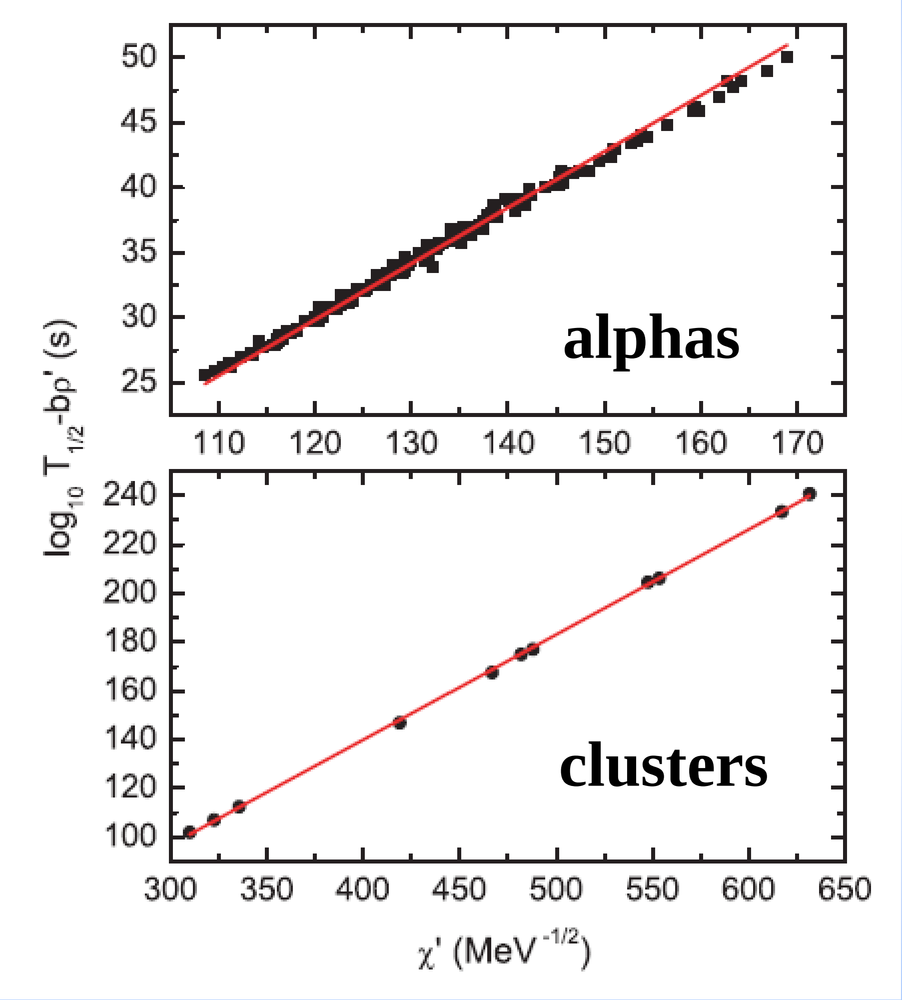


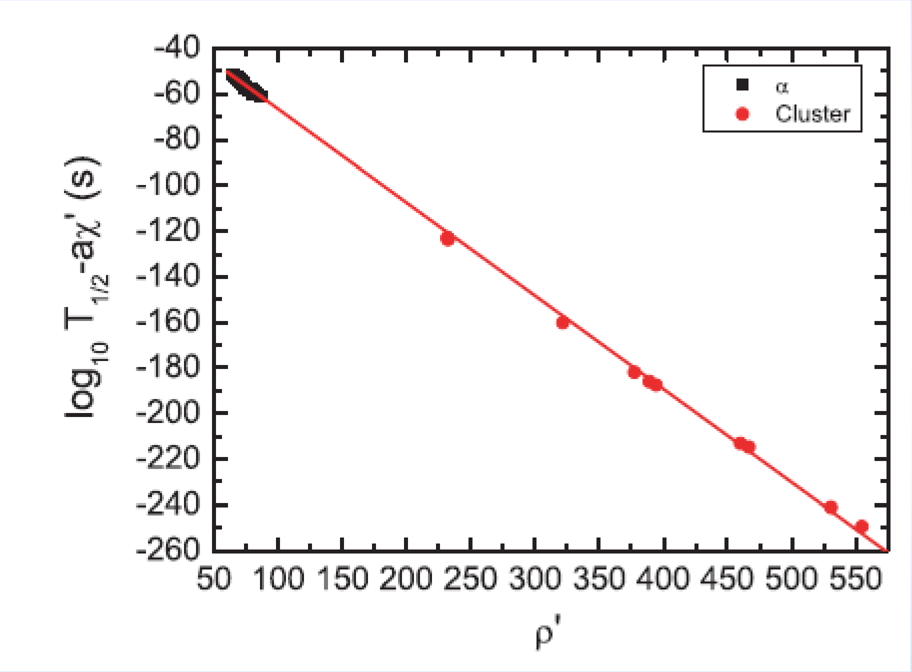


For even-even nuclei: Krane Figure 8.1

$$\log(t_{1/2}) = A + \frac{B}{\sqrt{Q_\alpha}}$$

Prediction of half-lives





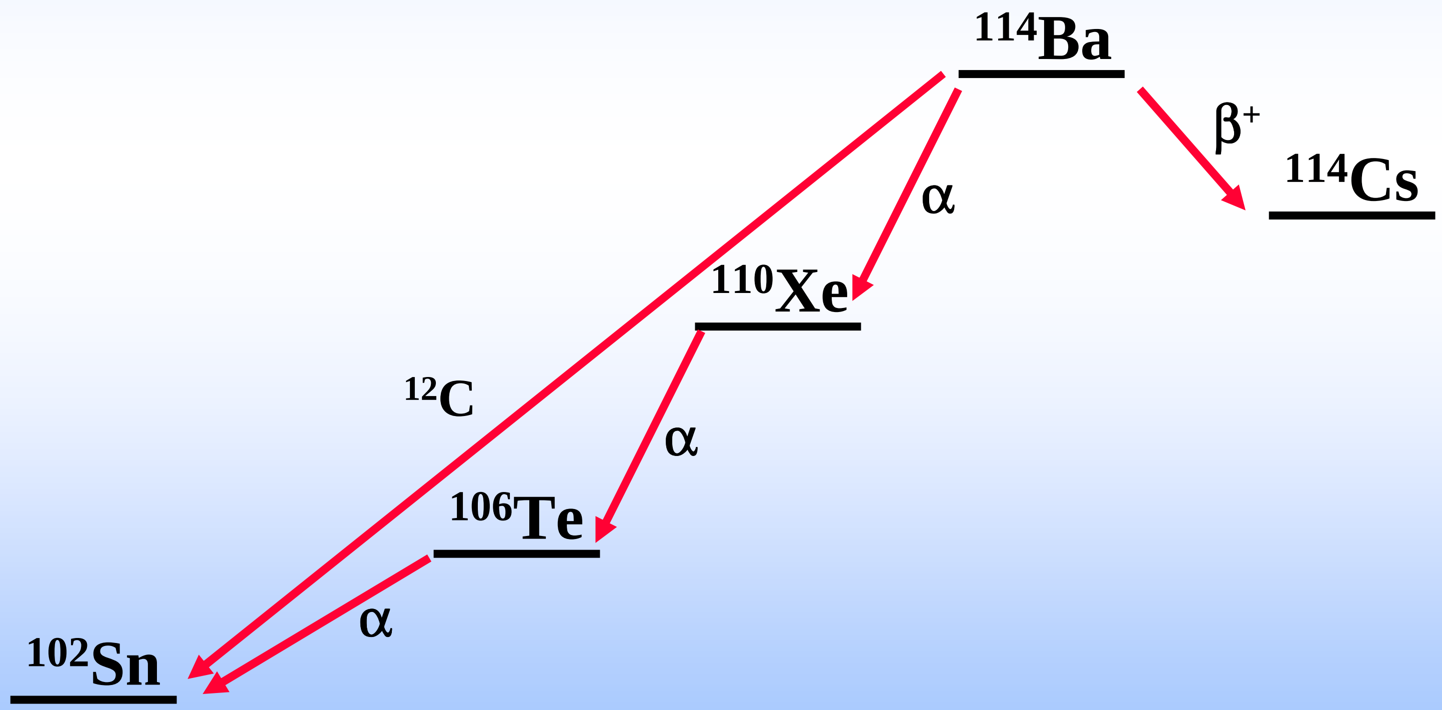
- good description of exisiting data
- possibility of predictions

➔ ➔ predictions for ^{100}Sn region

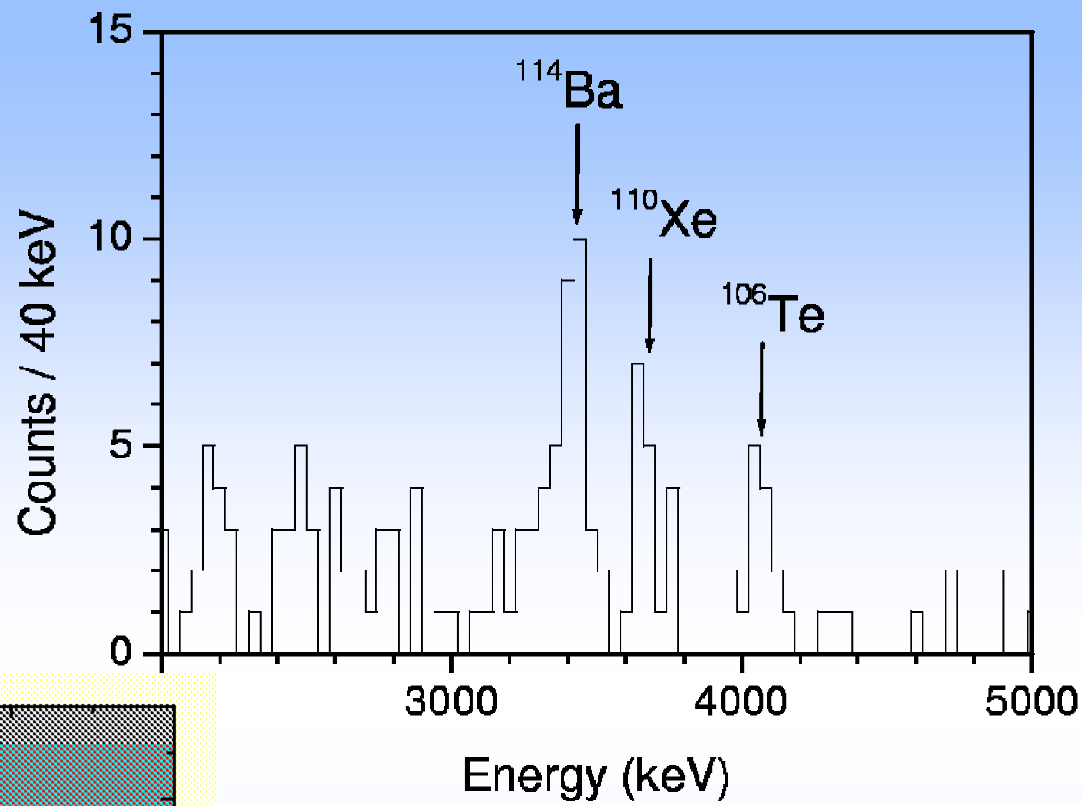
Qi et al., PRC 80, 044326 (2009)

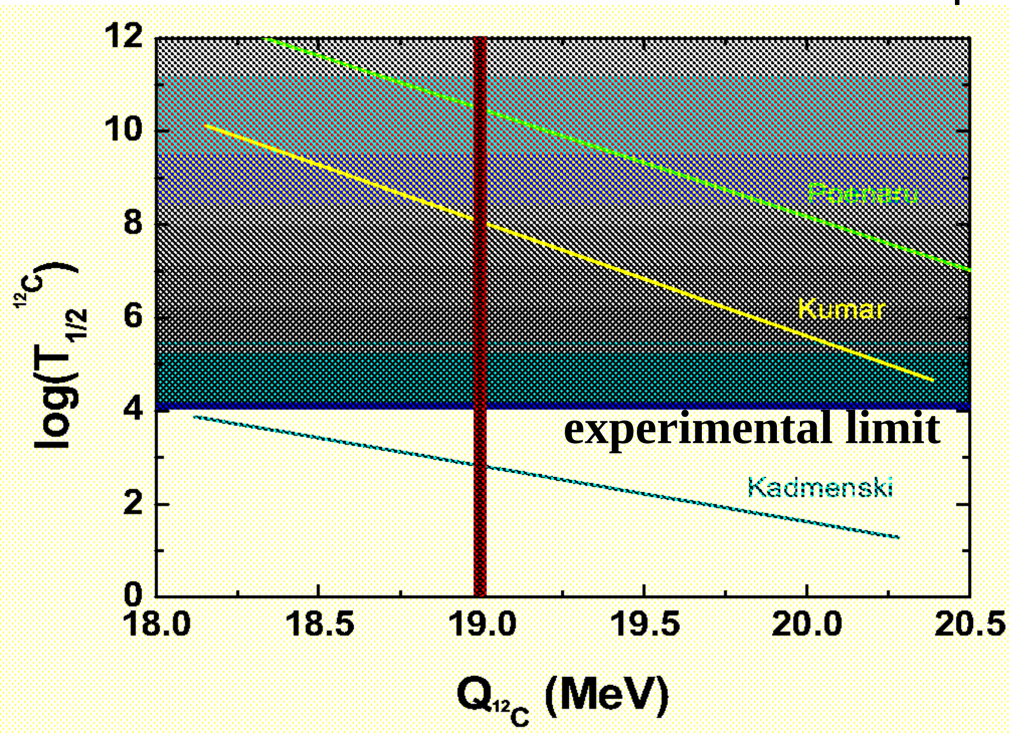
Cluster radioactivity

- in competition with alpha decay
- in competition with beta decay



Cluster radioactivity: Ba114





- decay energy: 3410(40) keV
- α-decay branching ratio: 0.9(3)%

C. Mazzocchi et al.,
Phys. Lett. B532 (2002) 29

New island of cluster emission: above Sn-100

- best candidates: ^{12}C emission from ^{114}Ba and ^{112}Ba

Emitter	Cluster	Q_α	$T_{1/2}(\alpha)$	Q_{12C}	$T_{1/2}(^{12}C)$	$T_{1/2}(\beta)$	Q_{2p}	$T_{1/2}(2p)$
^{110}Xe	^{12}C	3.89	0.164	15.73	10^{13}	0.2		
^{112}Xe	^{12}C	3.33	300	14.28	10^{17}	2.7		
^{112}Ba	^{12}C	4.65	0.01	21.37	335	0.04	1.912	10^6
^{114}Ba	^{12}C	3.53	725	18.98	10^7	0.43		

$T^{1/2}$ in seconds

^{114}Ba:
- $Br_\alpha(^{114}Ba) = \beta/\alpha = 0.43/725 = 0.59‰$
- $^{12}C/\alpha = 10^{-4}$
- $^{12}C/\beta = 10^{-7} - 10^{-8}$

^{112}Ba:
- $Br_\alpha(^{112}Ba) = \beta/\alpha = 0.01/0.04 = 0.25$
- $^{12}C/\alpha = 3*10^{-5}$
- $^{12}C/\beta = 10^{-4}$

Qi et al., PRC 80, 044326 (2009)

S3 experiment

^{114}Ba:

- **reaction: ^{58}Ni + ^{58}Ni at 220-240 MeV, 2 mg/cm^2**
- **cross section: 0.2 μb**
- **counts needed: ~ 10^8**
- **beam intensity: 10^{14}pps**
- **total efficiency: 10%**
- **40 pps ➔ 30 days**

^{112}Ba:

- **reaction: ^{58}Ni + ^{58}Ni at 300-340 MeV, 2 mg/cm2**
- **cross section: ~ nb**
- **counts needed: ~ 10^5**
- **beam intensity: 10^{14}pps**
- **total efficiency: 10%**
- **0.2 pps ➔ 6 days**

What do we learn?

- spectaculaire…
- preformation of clusters in nuclei
- tunneling of large clusters
- competition of alpha decay and cluster emission

How to detect?

- trace detectors?
- window-less and dead-zone-less silicon detectors?
- …?