Cluster radioactivity studies at S3

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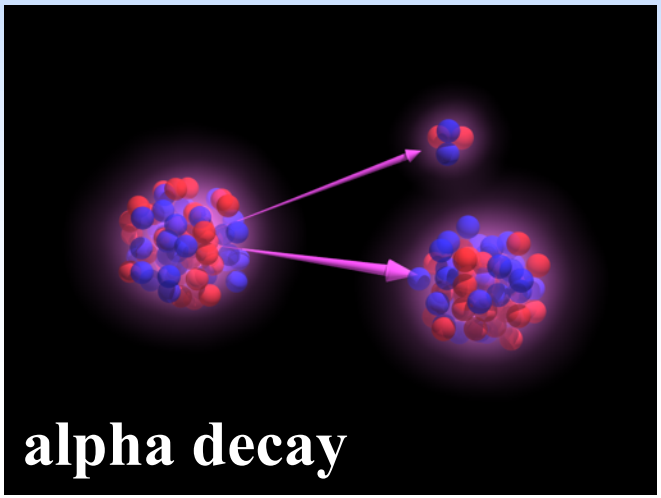
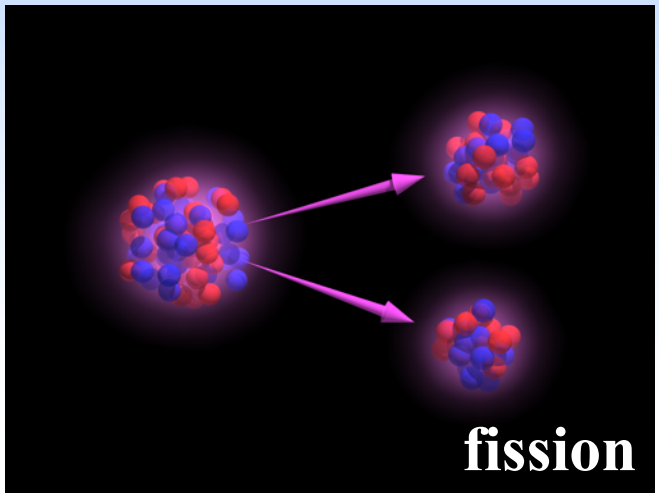
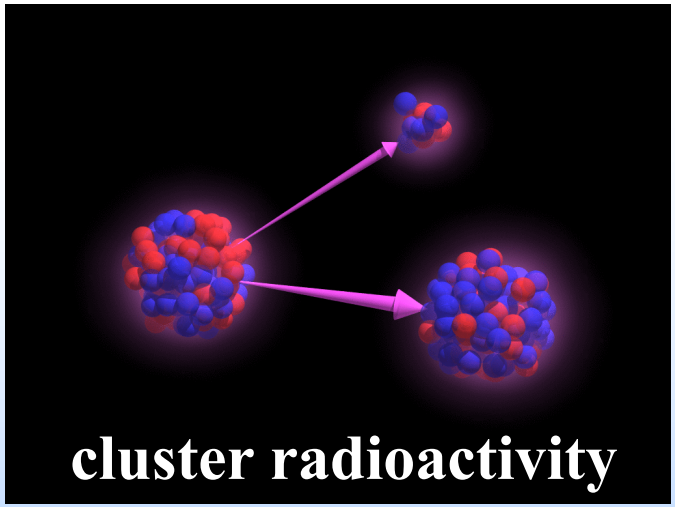
- **Physics case**
- **Predictions**
- **Rates**

First physics with S3, IRFU Saclay, 27-30 March 2017

Cluster emission 1984







emitted clusters:
^{14}C, ^{20}O, ^{23}F,
^{22,24,25,26}Ne,
^{28,29,30}Mg,
^{32,34}Si

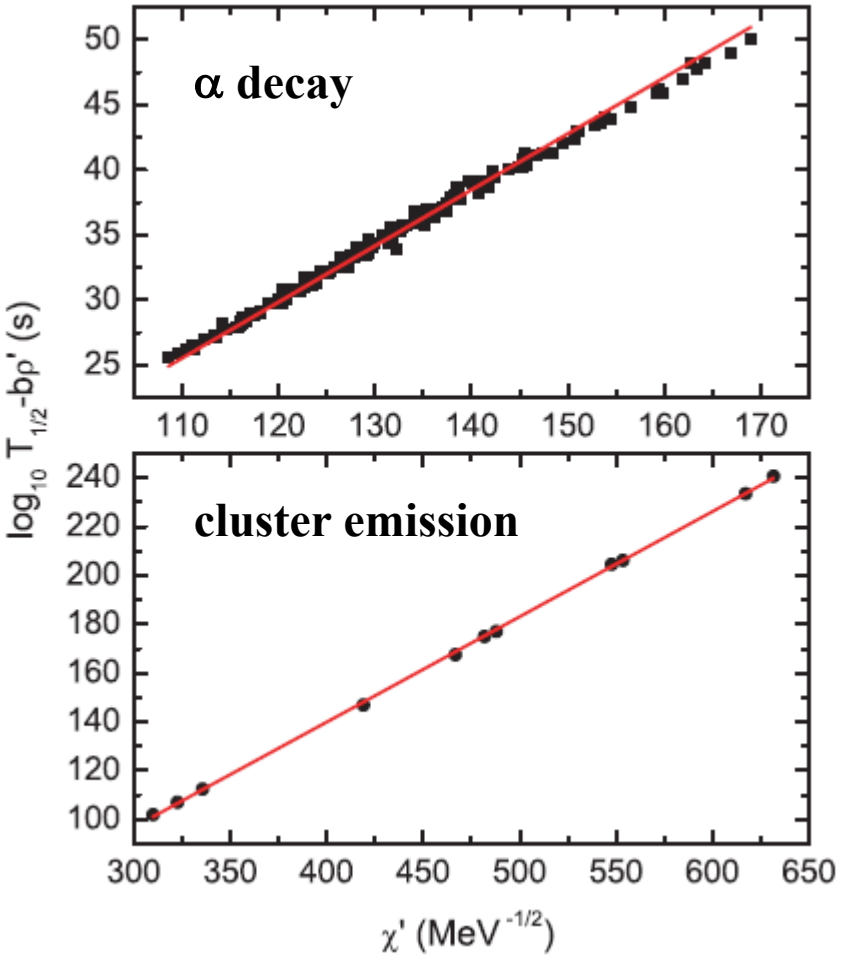
cluster emitters:
^{221}Fr …. ^{242}Cm

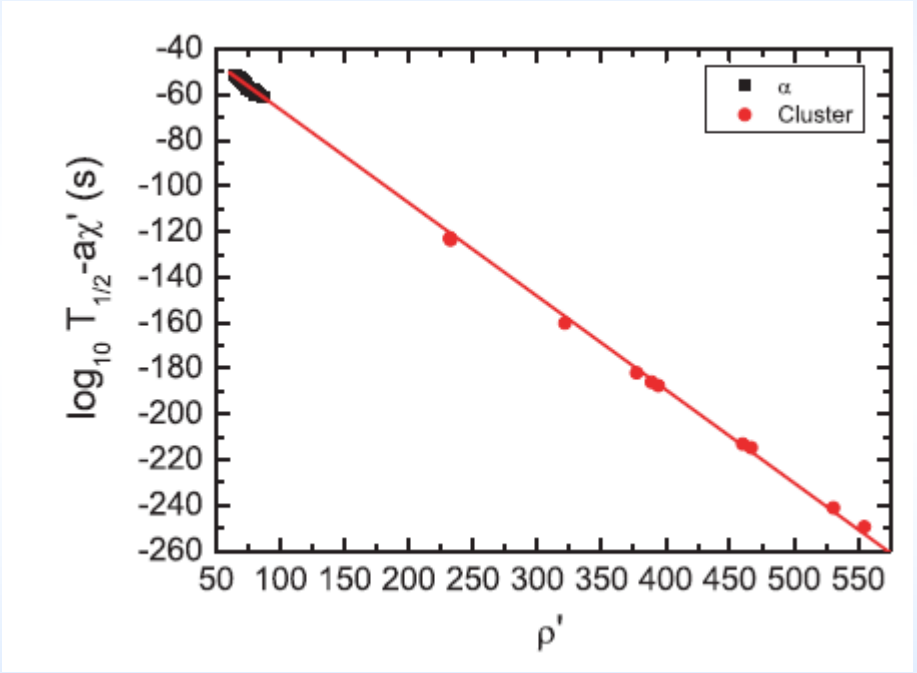
daughter nuclei:
^{208}Pb region
➔ large binding

Physics:
- first!
- cluster pre-formation
- super-allowed α decay

- A. Sandulescu, D.N. Poenaru, and W. Greiner, 1980
- H.J. Rose and G.A. Jones,1984

Prediction of half-lives





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

New island of cluster emission: above Sn-100

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

Emitter	Cluster	Q_α (MeV)	$T_{1/2}(\alpha)$ (s)	Q_{12C} (MeV)	$T_{1/2}(^{12}C)$ (s)	$T_{1/2}(\beta)$ (s)
^{112}Ba	^{12}C	4.65	0.01	21.37	335	0.04
^{114}Ba	^{12}C	3.53	725	18.98	10^7	0.43
^{114}Ba(exp)	^{12}C	3.60(3)	44	19.02(3)		$0.395^{+0.160}_{-0.089}$

case of ^{114}Ba: $10^7 / 0.43 = 2.3 * 10^7$ events

case of ^{112}Ba: $335 / 0.01 = 3.4 * 10^4$ events

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

S3 experiment rates: α decay

^{114}Ba: α decay

- **^{58}Ni beam: 248 MeV, 2.2 pμA, target: ^{58}Ni 1mg/cm2**
- **cross section: 0.2 μb (exp.: $0.2^{+0.13}_{-0.09}$ μb, 0.15(9) μb)**
- **transmission: 0.5**

➔ 15 pps

- **$BR(\alpha)_{predicted} = 6*10^{-4}$ ➔ 0.5 α decays per min**
- **$BR(\alpha)_{experiment} = 9*10^{-3}$ ➔ 8 α decays per min**

^{112}Ba: α decay

^{58}Ni beam: 280 MeV, 2.2 pμA, target: ^{58}Ni 1mg/cm2

- **cross section: ~ 0.1 nb**
- **transmission: 0.5**

➔ 0.01 pps

- **BR(α) = 0.8 ➔ 0.5 α decays per min**

S3 experiment rates: ^{12}C cluster decay

^{114}Ba:

- **^{58}Ni beam: 248 MeV, 2.2 pμA, target: ^{58}Ni 1mg/cm2**
- **cross section: 0.2 μb**
- **transmission: 0.5**

➔ 15 pps

- **BR(^{12}C) = $4*10^{-8}$ ➔ 1 ^{12}C decay in 20 days**

^{112}Ba:

^{58}Ni beam: 280 MeV, 2.2 pμA, target: ^{58}Ni 1mg/cm2

- **cross section: ~ 0.1 nb**
- **transmission: 0.5**

➔0.01 pps

- **BR(^{12}C) = $2*10^{-5}$ ➔ 1 ^{12}C decay in 60 days**

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^{58}Ni beam: 280 MeV, 11 pμA, target: ^{58}Ni 1mg/cm2

^{114}Ba: ➔ 1 ^{12}C decay in 4 days

^{112}Ba: ➔ 1 ^{12}C decay in 15 days

Possible experiments

First experiments with S3 focal plane detectors:

- **^{114}Ba:**
  - **confirm results from GSI and JYFL**
    - **identify α – α – α decay chain**
    - **improve precision on half-life and BR**
    - **search for cluster decay?**
      - **➔ Only with higher primary beam intensity…**

- **^{112}Ba:**
  - **search for α – α – α decay chain**
  - **determination of Q value for ^{12}C emission**
  - **new determination of cluster BR**

➔ ➔ following experiments depend on results

➔ ➔ development of dedicated setup?

➔ TPC?

Conclusions

- ^{114}Ba:
  - improve existing results
  - search for ^{12}C decay maybe with higher intensity

- ^{112}Ba:
  - search for $\alpha - \alpha - \alpha$ decay chain
  - search for cluster radioactivity depends on Q_{12C}

Thank you
for
your attention

New island of cluster emission: above Sn-100

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

Emitter	Cluster	Q_α (MeV)	$T_{1/2}(\alpha)$ (s)	Q_{12C} (MeV)	$T_{1/2}(^{12}C)$ (s)	$T_{1/2}(\beta)$ (s)	Q_{2p} (MeV)	$T_{1/2}(2p)$ (s)
^{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		

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