## Alpha particle induced reactions on Sr isotopes

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Isotopes produced in natural strontium targets by  $\alpha$  irradiation. The half-lives of the unstable

Nuclear data used to obtain experimental  $(\alpha, n), (\alpha, p)$  and  $(\alpha, \gamma)$  cross sections on Sr isotopes; The half-time decay is written in minutes (m), hours (h) or days (d).

isotopes are given					Nuclear reaction	T <sub>1/2</sub>	$E_{\gamma}(keV)$	$I_{\gamma}$ (%)	
	solopes	aregiv	en			$^{84}$ Sr( $\alpha,\gamma$ ) $^{88}$ Zr	83.4(3) d	392.87 (9)	97.29
						<sup>84</sup> Sr( $\alpha$ ,n) <sup>87</sup> Zr	1.68(1) h	1227 (1)	2.8
								1210 (1)	0.92
<sup>87</sup> Zr (a	<sub>,n)</sub> <sup>88</sup> Zr	<sup>89</sup> Zr <sub>(α,n)</sub>	<sup>90</sup> Zr	<sup>91</sup> Zr	<sup>92</sup> Zr	<sup>86</sup> Sr(α,n) <sup>89</sup> Zr	78.41(12) h	909.15 (15)	99.04
1.68 h 1	83.4 d 3	78.41 h 12	stable	stable	stable	<sup>84</sup> Sr(α,p) <sup>87</sup> Y	13.37(3) h	380.79 (7)	78.05
(a,V)	🗸 (α,p)			<b>ν</b> (α,p)	💙 (α,p)		79.8 (3) h	388.52 (23)	82.2
	87 <b>Y</b> 79.8 h 3			90 <b>Υ</b> 64.053 h 20	91 <b>Υ</b> 58.51 d 6			484.805 (5)	89.9
						<sup>87</sup> Sr( <i>a</i> ,p) <sup>90</sup> Y	3.19(1) h	202.53 (3)	97.3
	<sup>86</sup> Sr	<sup>87</sup> Sr	<sup>88</sup> Sr					479.51 (5)	90.74
	stable	stable	stable			<sup>88</sup> Sr( <i>a</i> ,p) <sup>91</sup> Y	49.71(4) m	555.57 (5)	95.0
						and the second sec			A CONTRACTOR OF A



<sup>84</sup>Sr stable







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Fig. 1 XRD patterns of Al substrate, SrF2 powder and SrF2/Al target

## Fig. 2 XRD patterns of Al substrate, SrCO3 powder and SrCO3/Al target



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#### Table 1 SrF2 target composition by EDX analysis Element, line at.% Error (%) F, K 61.9 4.6 Sr, K 38.1 17.9 Table 2 SrCO3 target composition by EDX analysis Total 100.00 Error (%) Element, line at.% С, К 31.8 1.3 **O,** K 40.6 0.6 Cu, L 15.2 0.6 Sr, L 0.9 12.4 Total 100.0 (a) (b) (c)

Fig. 3 SEM micrographs of Al substrate (a), SrF2/Al (b) and SrCO3/Al (c)

4µm

 $4\mu m$ 

 $4 \mu m$ 

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## **Experimental Setup**

### Activation experiments







Bucharest 9MV TANDEM Accelerator



#### Counting setup at Bucharest, IFIN-HH, Romania

- 2 HPGe detectors (relative efficiency of 55 %)
- Passive lead shielding
- •Close detection geometry -> the summing corrections were performed using the Monte Carlo simulation code GESPECORE

- 5 Stacks (SrF<sub>2</sub> on Al backing/Ti/Al)
- Faraday Cup (guard ring -300V)
- 5 α-beam energies
- **TRIM Simulations** 
  - Thickness (Weighing+α transmission measurements)
- a source: mixture of <sup>241</sup>Am & <sup>244</sup>Cm
- Totally depleted silicon detector

## Input parameters:

- Thickness of the target
- Alpha beam energy
- Beam intensity
- Absolute peak efficiency
- Time
- Peak areas

## • Thickness of the target

	SrF <sub>2</sub> foils
	Weighing
•	α transmission measurements
	- $\alpha$ source: mixture of <sup>241</sup> Am & <sup>244</sup> Cm
	-Totally depleted silicon detector
	-Successive TRIM simulations



	Target No.	Thickness	(mg/cm <sup>2</sup> )	Thickness (µm)		
		Weighing	Trim	Weighing	Trim	
1	#1	1.16	1.61(20)	2.74	3.75	
	#2	1.01	1.58(17)	2.38	3.65	
	#3	1.64	2.38(27)	3.87	5.61	
	#4	1.65	2.15(22)	3.89	5.07	
	#6	1.45	2.03(20)	3.42	4.80	
	#8	1.10	1.59(14)	2.59	3.74	



## Alpha beam energy

<u>Alpha beam energy:</u> 8.1 MeV => 7.64 MeV 9.0 MeV => 8.603 MeV 9.9 MeV => 9.543 MeV 10.5 MeV => 10.226 MeV 11.1 MeV => 10.834 MeV 11.7 MeV => 11.446 MeV <u>Gamow Window:</u> 5.6- 8.7 MeV (T=3 GK)

The incident beam energies and straggling on the successive target foils were determined based on the energy loss in the aluminum and  $SrF_2$  foils using dE/dx values obtained using the TRIM code.

### • Beam intensity

#### 8.1 and 9.0 MeV ?



The beam intensity was recorded in real time, in steps of one second, using an ORTEC 439 digital current integrator.



## • Absolute peak efficiency





### Irradiation:

22 - 23 hours

### Waiting:

few minutes - 2 weeks

### Measuring:

24 - 40 hours

### • Peak areas

			Peak areas for $SrF_2$ target at each $\alpha$ beam energy						
			#3	#4	#6	#1	#8	#2	
SrCO <sub>2</sub>		(Kev)	8.1 MeV	9.0 MeV	9.9 MeV	10.5 MeV	11.1 MeV	11.7 MeV	
5		280.70		43 368	318 064	594 454	1 638 247	4 930 805	
$E_{\gamma}$ (keV)	10 MeV	580.79		(472)	(839)	(1 240)	(3 605)	(16 239)	
380.79	11 137 (451)	200 52	5 454	27 381	175 475	178 408	479 304	1 604 980	
ST 182 (F.S.)		388.32	(832)	(661)	(825)	(476)	(1 555)	(3 784)	
	41 171	404 005		17 365	158 841	170 160	487 277	1 637 674	
388.52		484.803		(486)	(871)	(915)	(1 127)	(3 060)	
Fine 4	(926)	000.15	19 927	240 139	2 137 861	2 795 303	7 881 832	24 955 582	
484.805	36 277	909.15	(324)	(975)	(975)	(7 624)	(23 010)	(93 844)	
	(706)	202.52	-	-	-	15 499	40 953	113 468	
		202.55				(531)	(1 058)	(1 938)	
909.15	429 179 (11732)	470.51	-	-	-	6 452	17 371	44 788	
and the second		479.51				(572)	(511)	(685)	
1.18-18-13		1274 5	4 555 588	4 167 909	5 811 063	1 862 655	2 107 325	3 777 766	
		12/4.3	(17 642)	(16 958)	(21 100)	(5 625)	(5 2 3 9)	(17 737)	

# Preliminary



#### First Spectra - SrCO<sub>3</sub> 2·106 $^{84}$ Sr( $\alpha$ ,p) $^{87}$ Y $^{84}$ Sr( $\alpha$ ,p) $^{87}$ Y 380.8 keV 104 484.8 keV 104 2.106 388.5 keV Counts Counts 5·103 Counts 106 5·10<sup>5</sup> 484 485 486 487 483 375 380 390 385 E<sub>v</sub> (keV) E<sub>y</sub> (keV) 909.1 keV 0 6·104 0 200 400 600 800 1,000 1,200 1,400 E<sub>y</sub> (keV) 6.104 <sup>86</sup>Sr( $\alpha$ ,n)<sup>89</sup>Zr 4·10<sup>4</sup> 909.1 keV Counts 4·10<sup>4</sup> 380.8 keV Counts 388.5 keV 2.104 2.104 484.8 keV 0 907 908 909 910 911 912 E<sub>v</sub> (keV) 04/09/18 0 800 1,000 1,200 200 400 1.400 0 600 E<sub>v</sub> (keV)

First Spectra - SrF,













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