Alpha particle induced reactions on Sr isotopes

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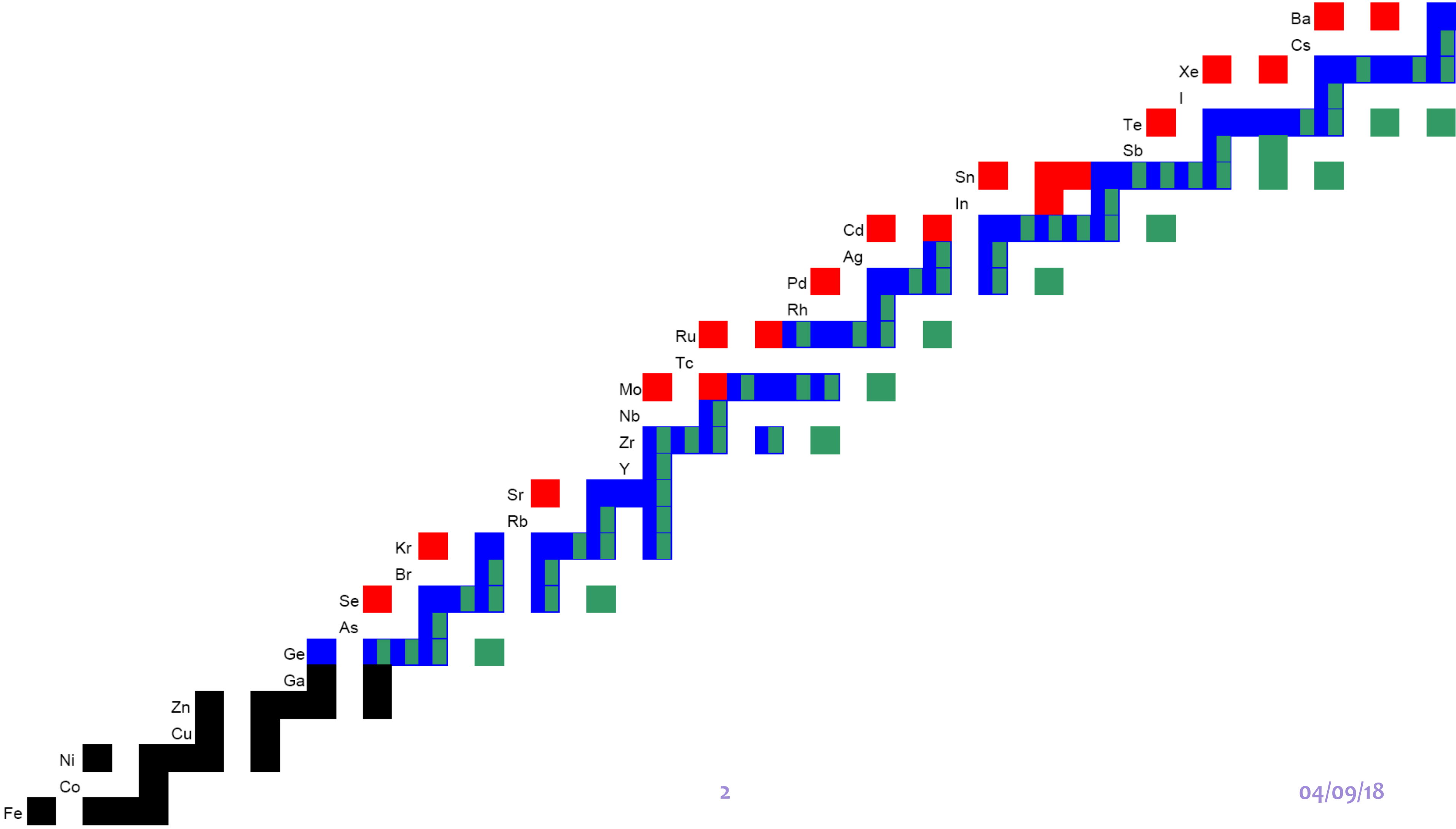
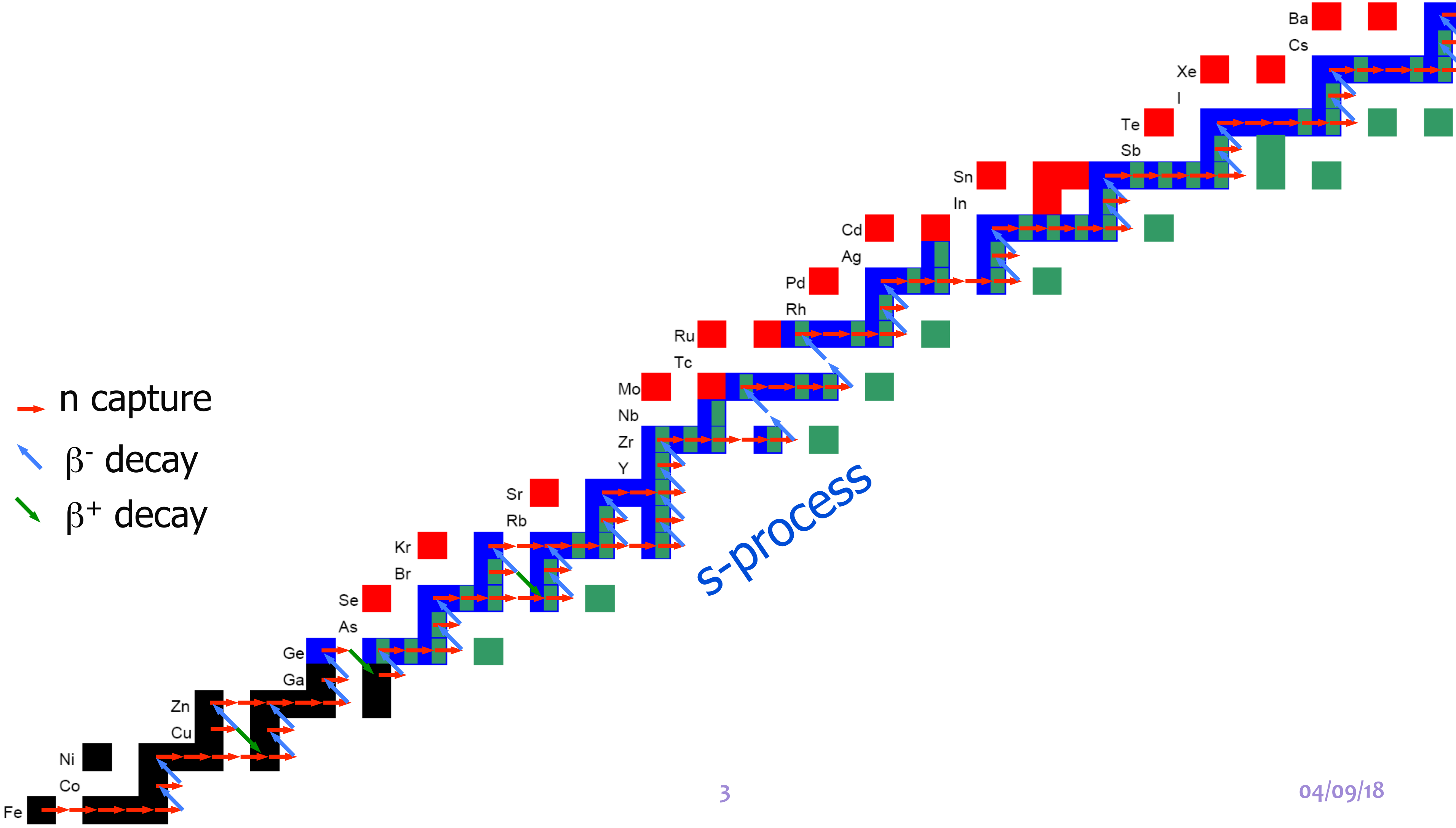
Heavy element nucleosynthesis



Heavy element nucleosynthesis



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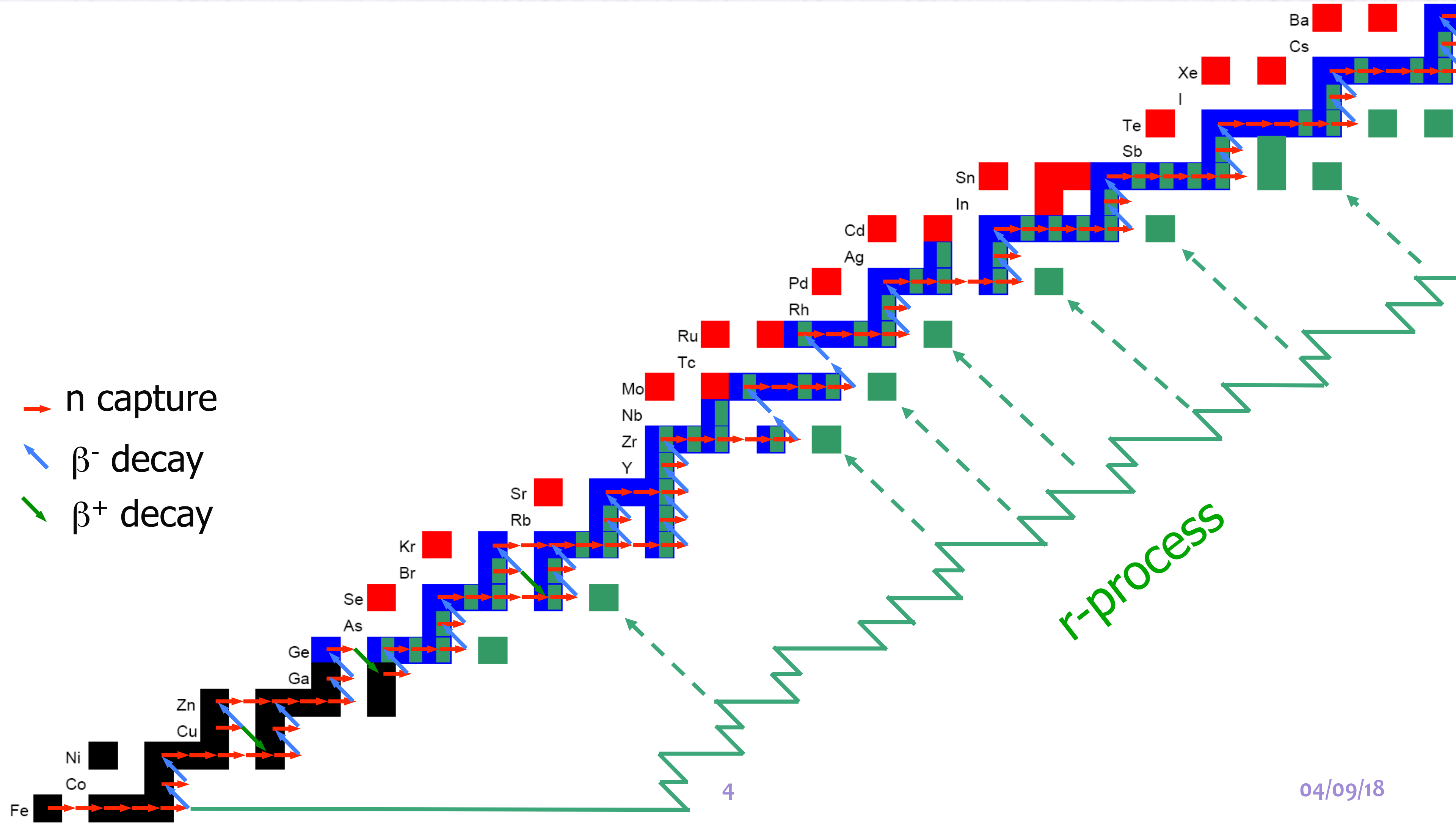

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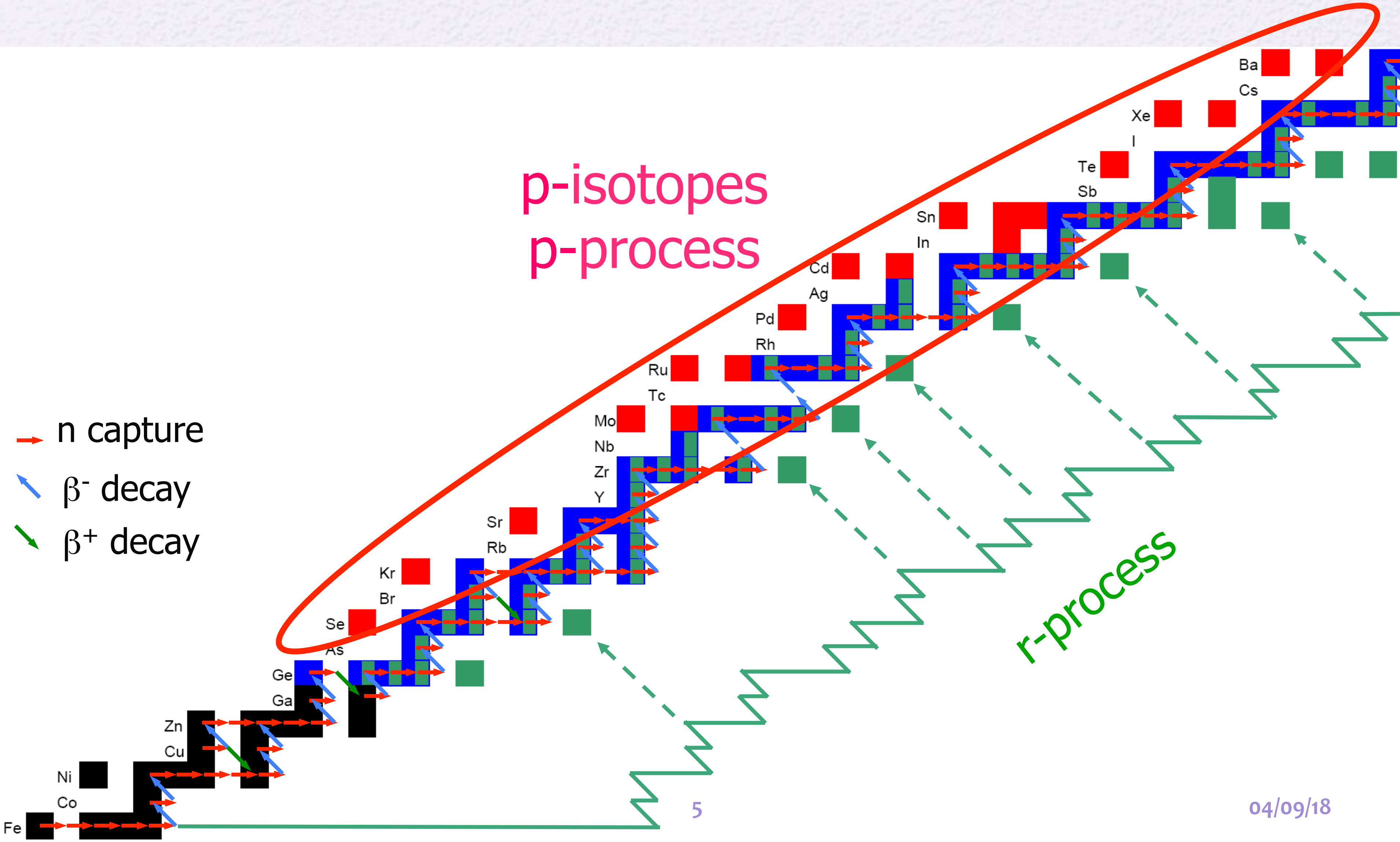
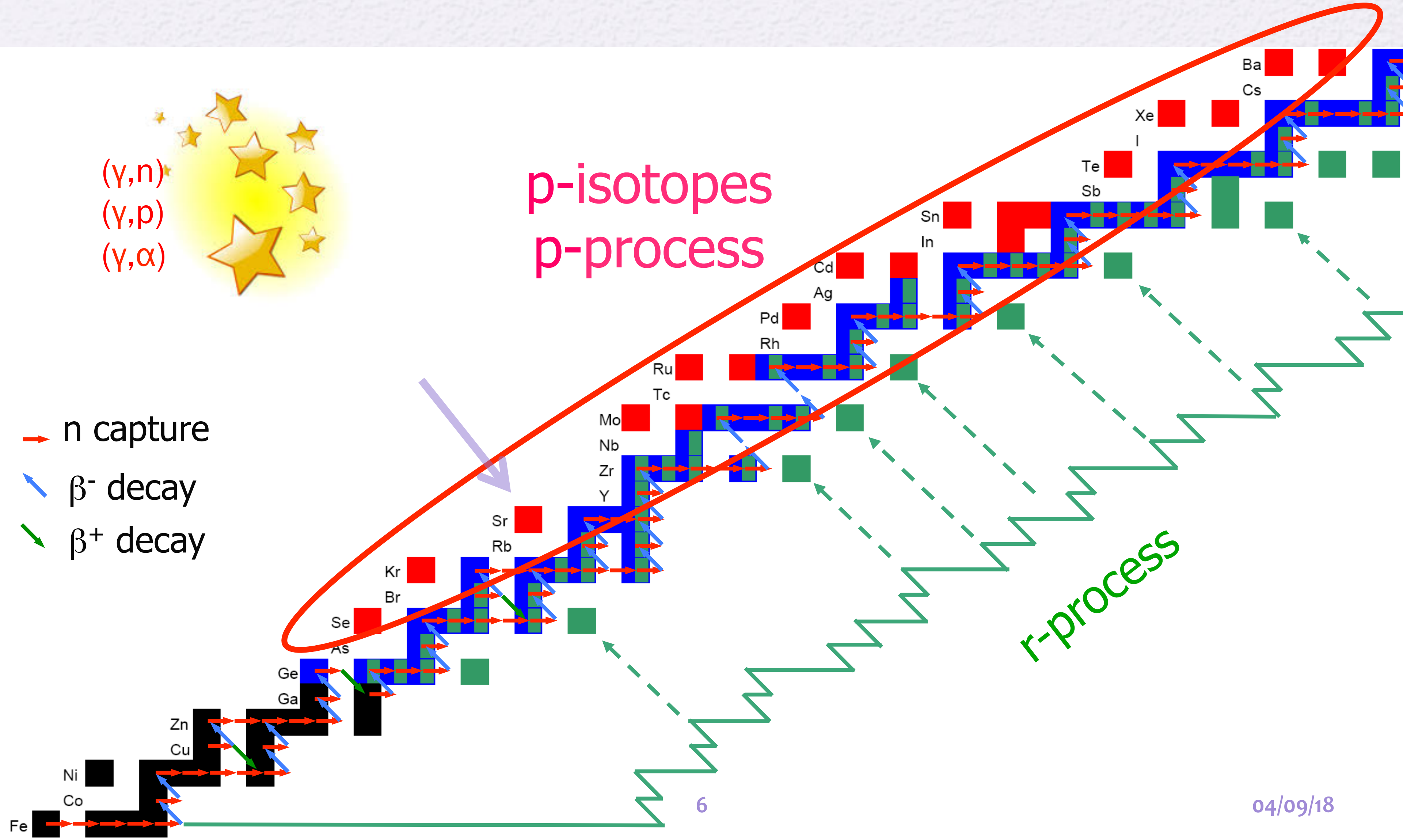
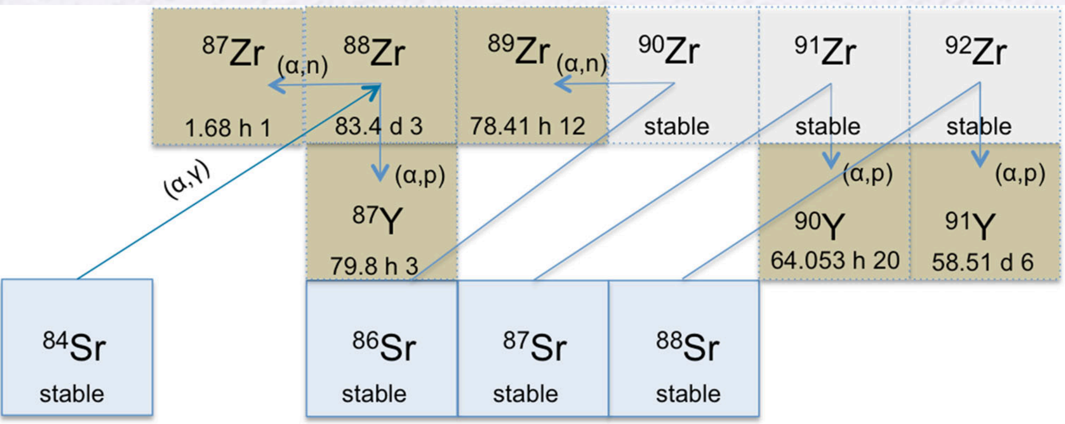


Heavy element nucleosynthesis



Isotopes produced in natural strontium targets by α irradiation. The half-lives of the unstable isotopes are given

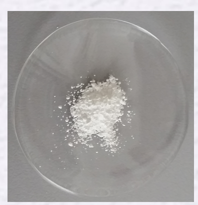


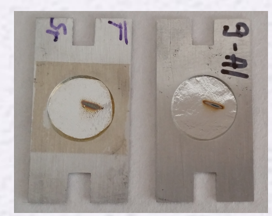
Nuclear data used to obtain experimental (α, n), (α, p) and (α, γ) cross sections on Sr isotopes; The half-time decay is written in minutes (m), hours (h) or days (d).

Nuclear reaction	$T_{1/2}$	E_γ (keV)	I_γ (%)
$^{84}Sr(\alpha,\gamma)^{88}Zr$	83.4(3) d	392.87 (9)	97.29
$^{84}Sr(\alpha,n)^{87}Zr$	1.68(1) h	1227 (1)	2.8
		1210 (1)	0.92
$^{86}Sr(\alpha,n)^{89}Zr$	78.41(12) h	909.15 (15)	99.04
$^{84}Sr(\alpha,p)^{87}Y$	13.37(3) h	380.79 (7)	78.05
	79.8 (3) h	388.52 (23)	82.2
		484.805 (5)	89.9
$^{87}Sr(\alpha,p)^{90}Y$	3.19(1) h	202.53 (3)	97.3
		479.51 (5)	90.74
$^{88}Sr(\alpha,p)^{91}Y$	49.71(4) m	555.57 (5)	95.0

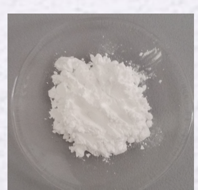
Targets

SrF_2





$SrCO_3$



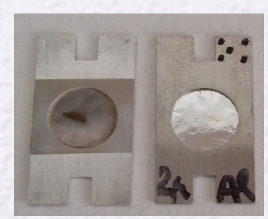
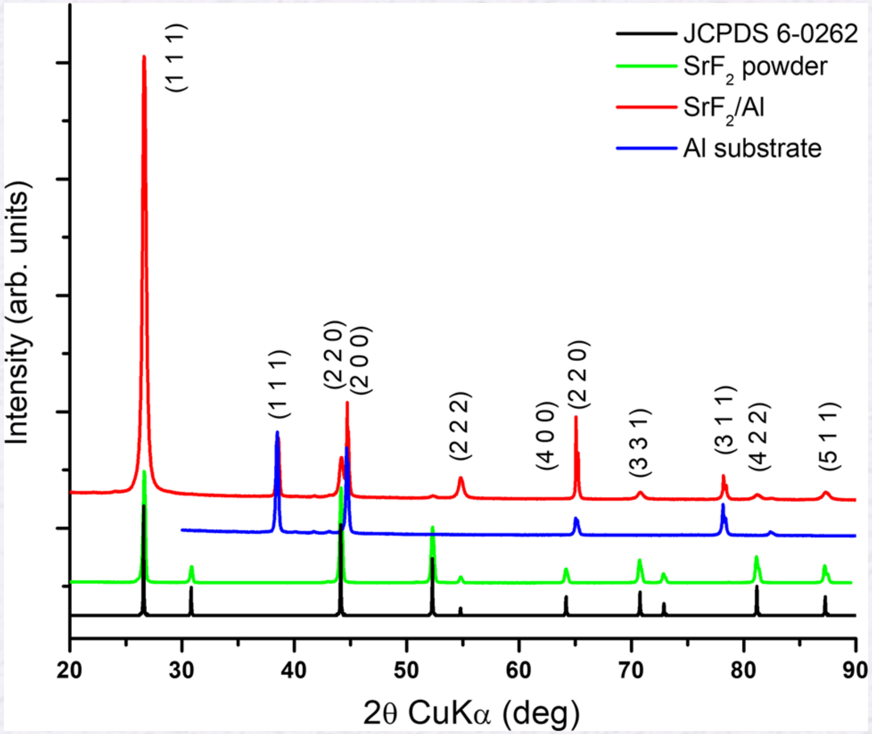
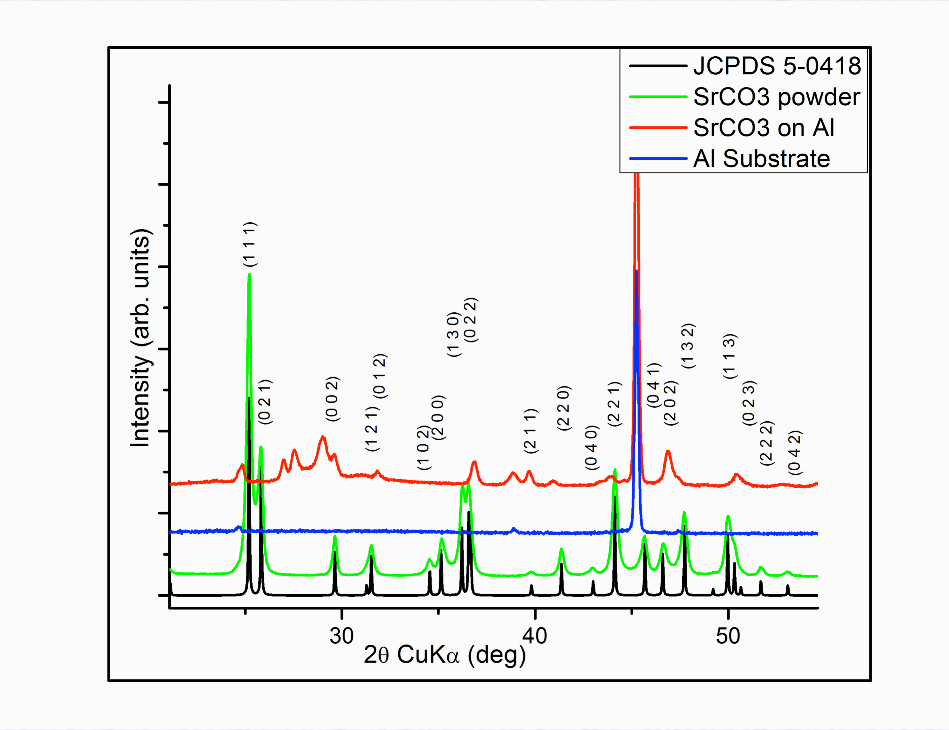


Fig. 1 XRD patterns of Al substrate, SrF2 powder and SrF2/Al target

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





Mitu A., Oprea A. et al., Journal of Radioanalytical and Nuclear Chemistry (2018) 316:725–731

Table 1 SrF_2 target composition by EDX analysis

Element, line	at.%	Error (%)
F, K	61.9	4.6
Sr, K	38.1	17.9
Total 100.00		

Table 2 $SrCO_3$ target composition by EDX analysis

Element, line	at.%	Error (%)
C, K	31.8	1.3
O, K	40.6	0.6
Cu, L	15.2	0.6
Sr, L	12.4	0.9
Total 100.0		

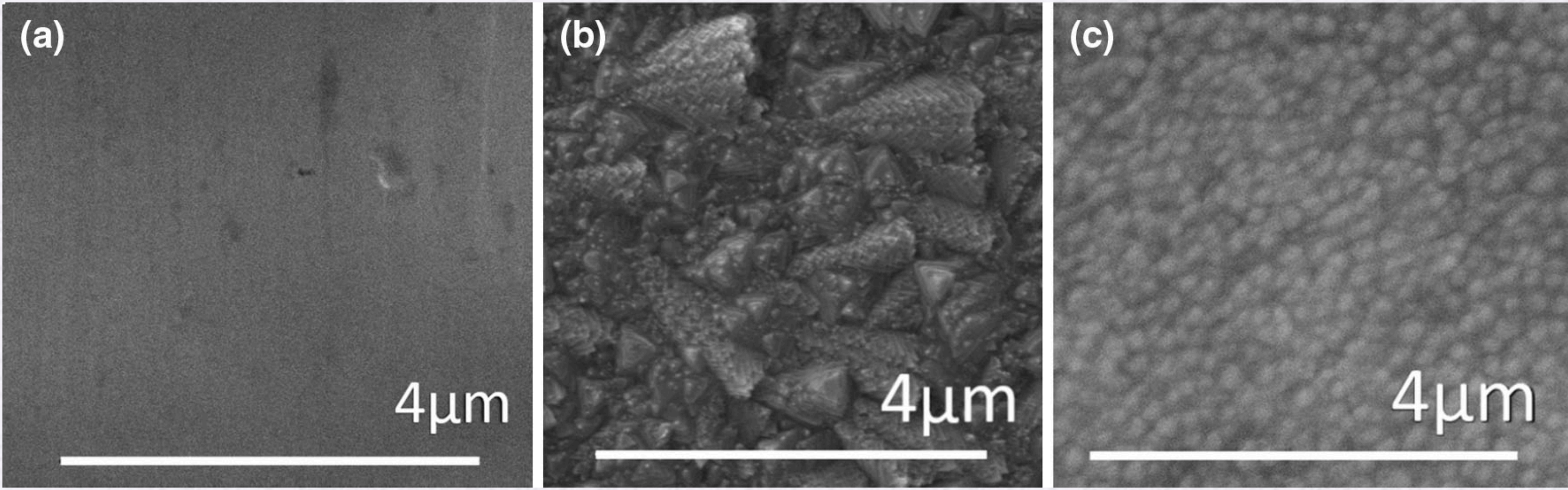


Fig. 3 SEM micrographs of Al substrate (a), SrF_2/Al (b) and $SrCO_3$/Al (c)

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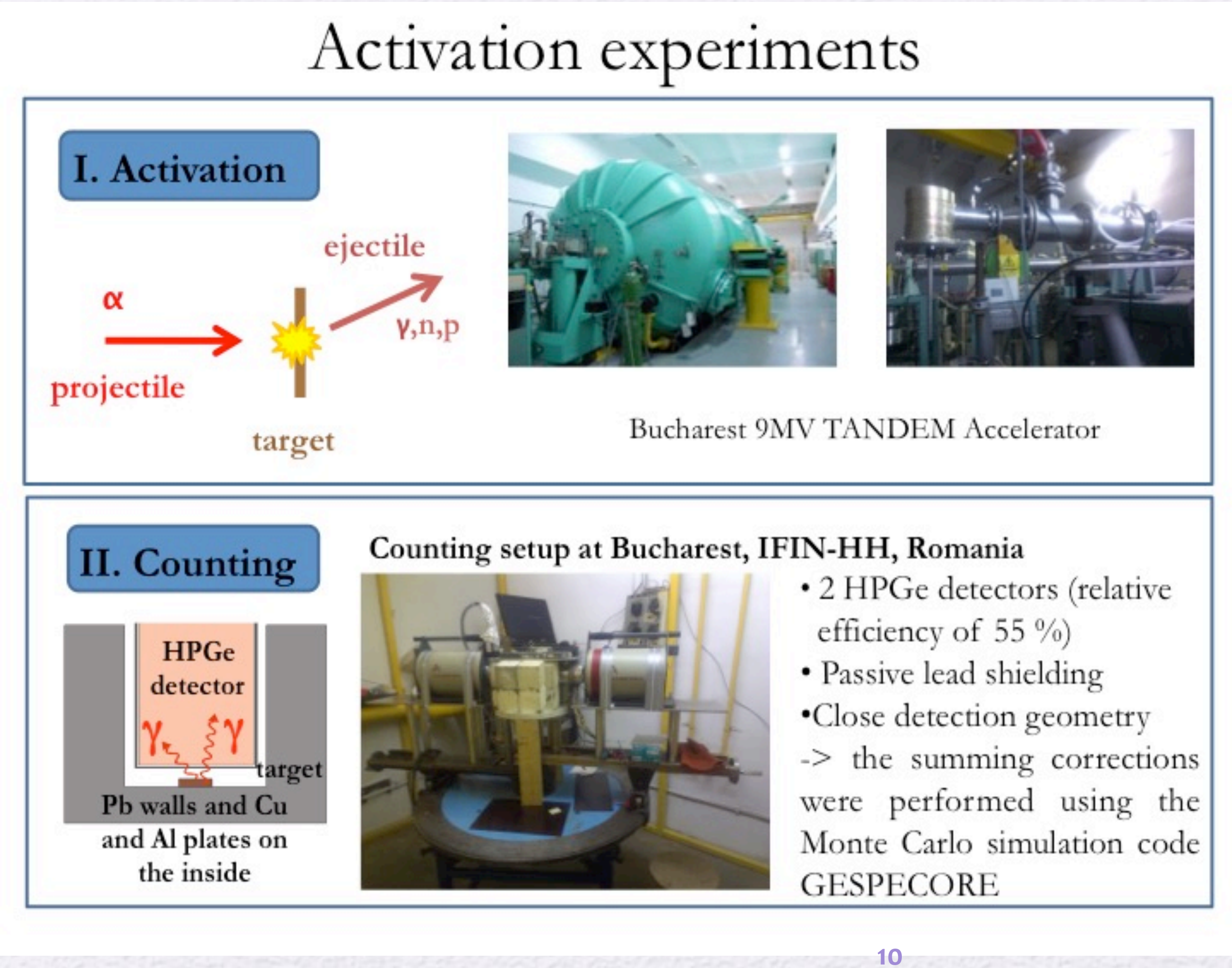
Experimental Setup



- 5 Stacks (SrF_2 on Al backing/Ti/Al)
- Faraday Cup (guard ring -300V)
- 5 α-beam energies
- TRIM Simulations
- Thickness (Weighing+α transmission measurements)
- α source: mixture of ^{241}Am & ^{244}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$_2$ foils

- Weighing

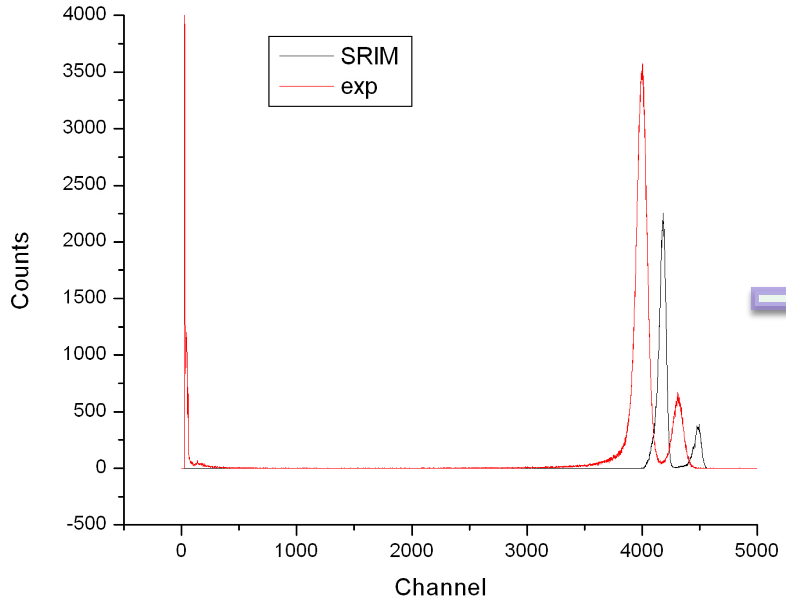
- α transmission measurements

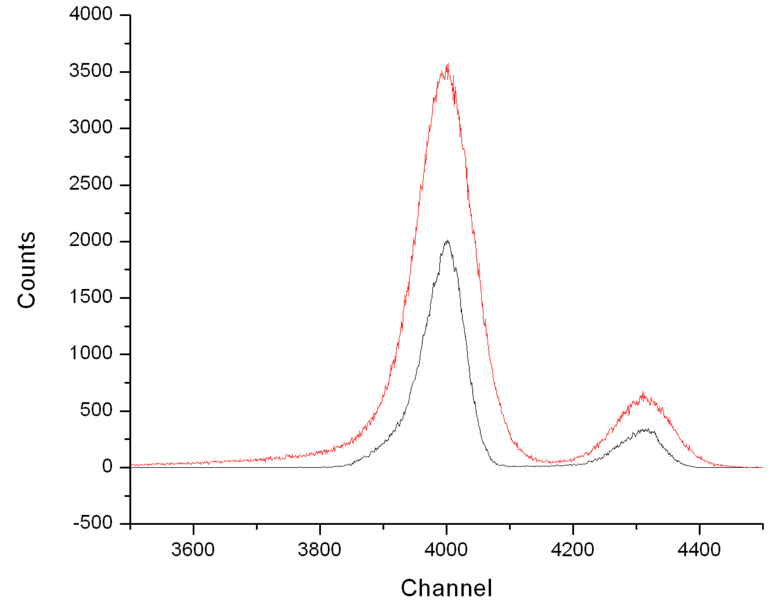
-α source: mixture of ^{241}Am & ^{244}Cm

-Totally depleted silicon detector

-Successive TRIM simulations

Target No.	Thickness (mg/cm^2)		Thickness (μm)	
	Weighing	Trim	Weighing	Trim
#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

Alpha beam energy:

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

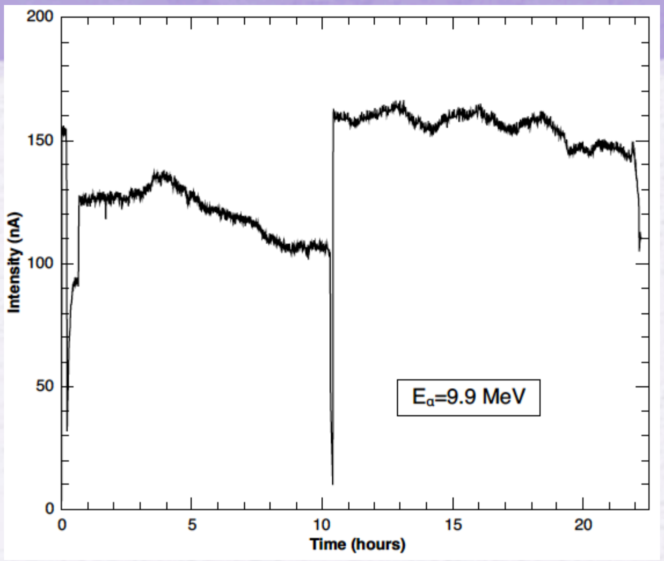
Gamow Window:

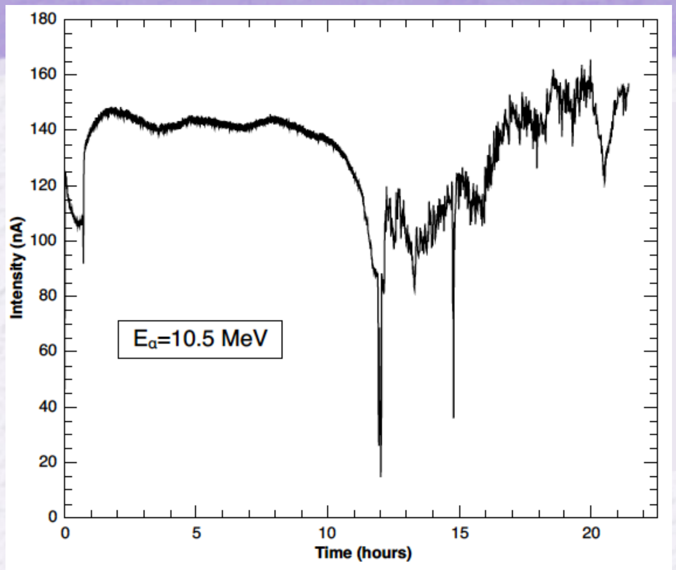
5.6- 8.7 MeV (T=3 GK)

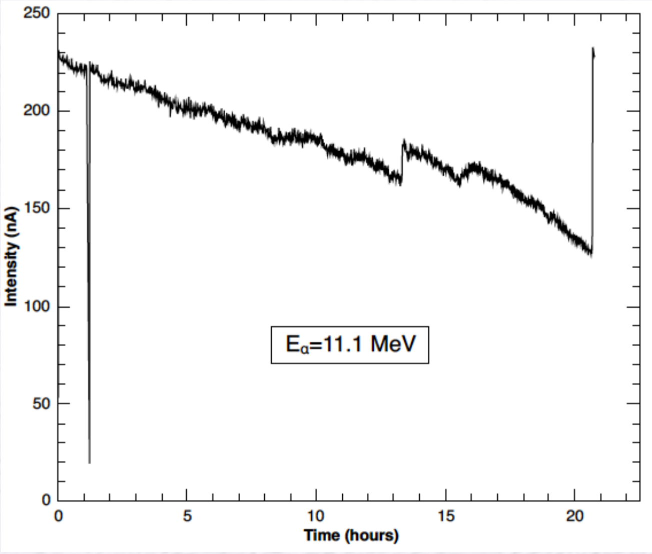
The incident beam energies and straggling on the successive target foils were determined based on the energy loss in the aluminum and SrF_2 foils using dE/dx values obtained using the TRIM code.

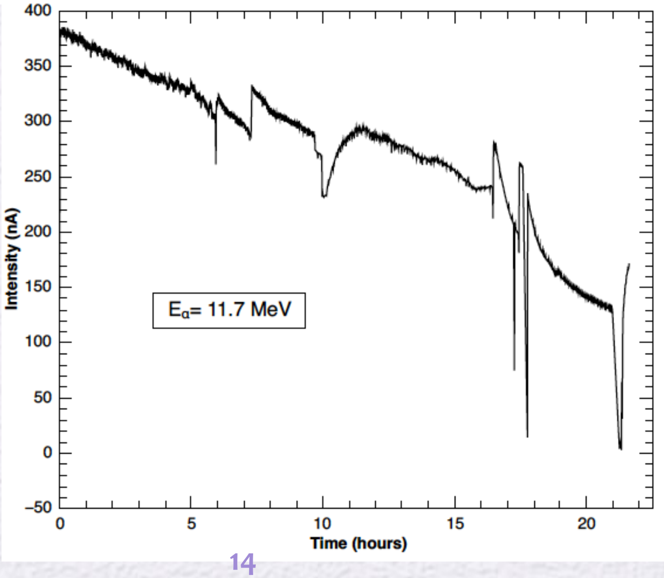
• Beam intensity

8.1 and 9.0 MeV ?

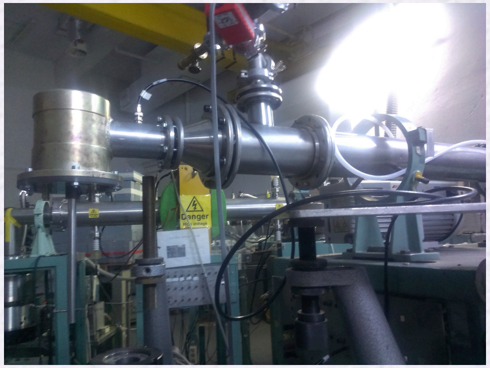




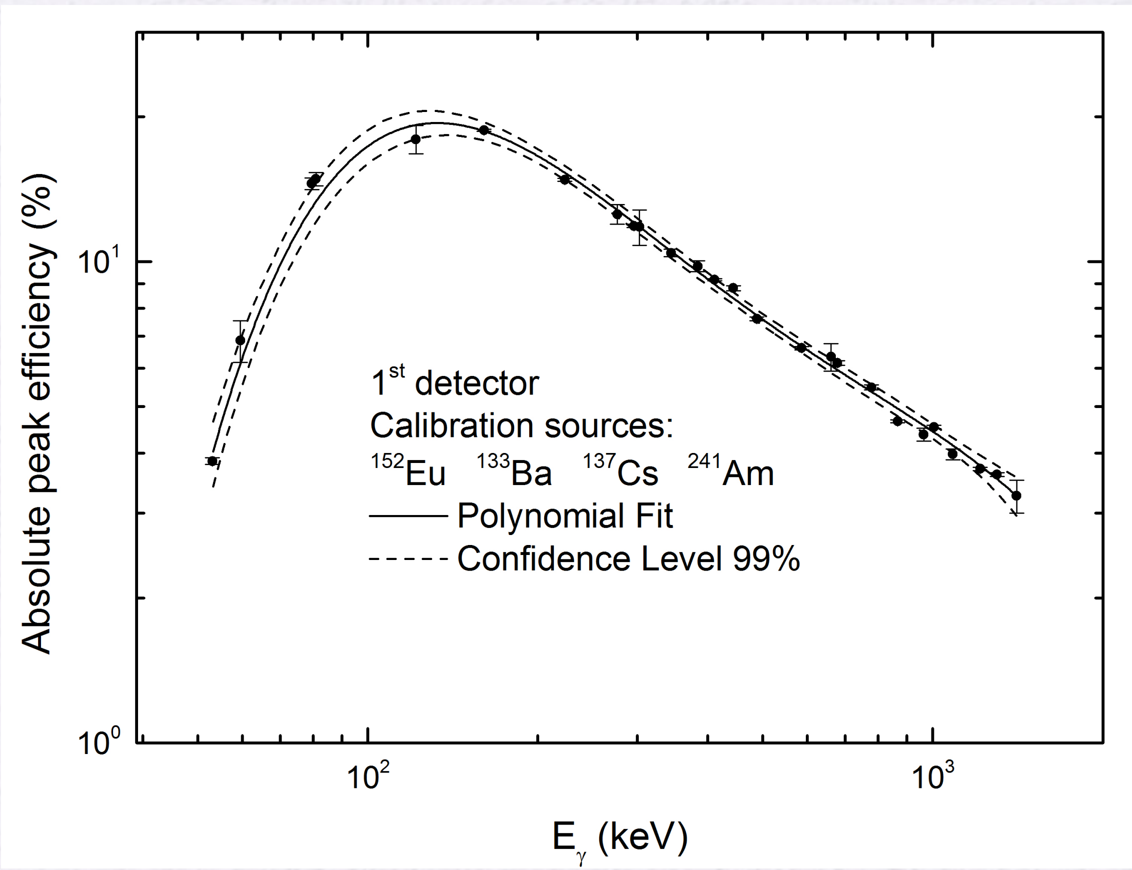




The beam intensity was recorded in real time, in steps of one second, using an ORTEC 439 digital current integrator.



• Absolute peak efficiency



- # Time

Irradiation:

22 - 23 hours

Waiting:

few minutes – 2 weeks

Measuring:

24 - 40 hours

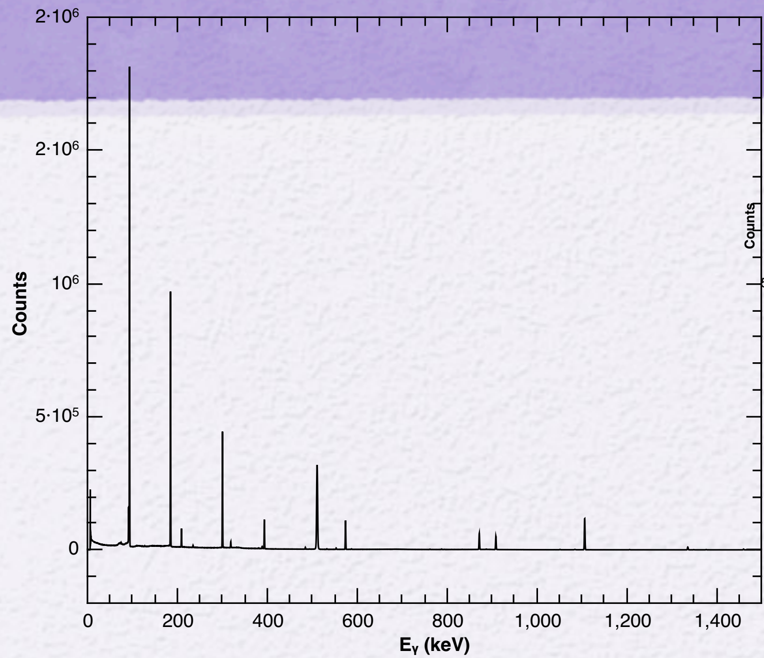
• Peak areas

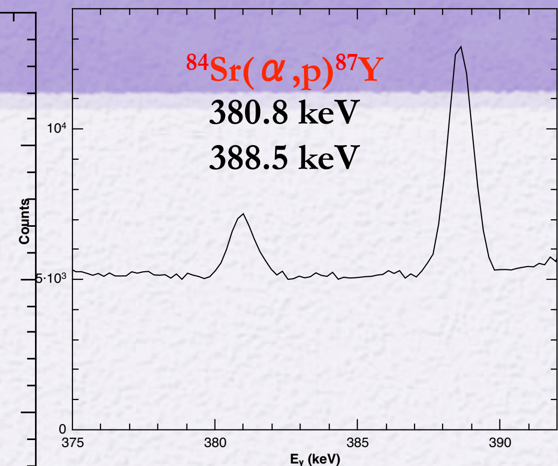
SrCO$_3$	
E_γ (keV)	10 MeV
380.79	11 137 (451)
388.52	41 171 (926)
484.805	36 277 (706)
909.15	429 179 (11732)

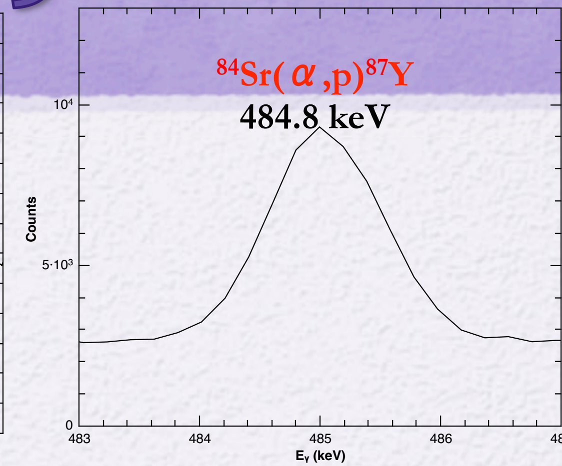
E_γ (keV)	Peak areas for SrF$_2$ target at each α beam energy					
	#3 8.1 MeV	#4 9.0 MeV	#6 9.9 MeV	#1 10.5 MeV	#8 11.1 MeV	#2 11.7 MeV
380.79		43 368 (472)	318 064 (839)	594 454 (1 240)	1 638 247 (3 605)	4 930 805 (16 239)
388.52	5 454 (832)	27 381 (661)	175 475 (825)	178 408 (476)	479 304 (1 555)	1 604 980 (3 784)
484.805		17 365 (486)	158 841 (871)	170 160 (915)	487 277 (1 127)	1 637 674 (3 060)
909.15	19 927 (324)	240 139 (975)	2 137 861 (975)	2 795 303 (7 624)	7 881 832 (23 010)	24 955 582 (93 844)
202.53	-	-	-	15 499 (531)	40 953 (1 058)	113 468 (1 938)
479.51	-	-	-	6 452 (572)	17 371 (511)	44 788 (685)
1274.5	4 555 588 (17 642)	4 167 909 (16 958)	5 811 063 (21 100)	1 862 655 (5 625)	2 107 325 (5 239)	3 777 766 (17 737)

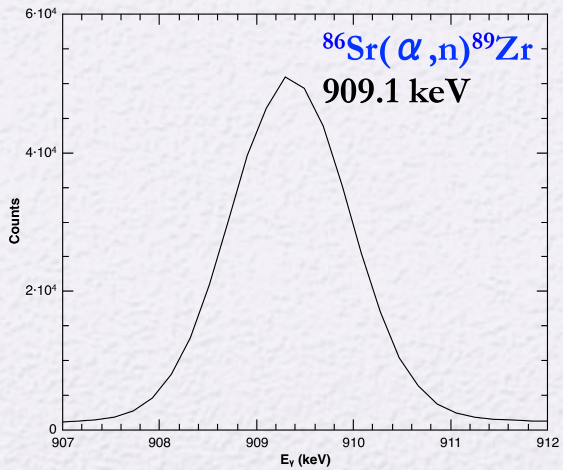
Preliminary

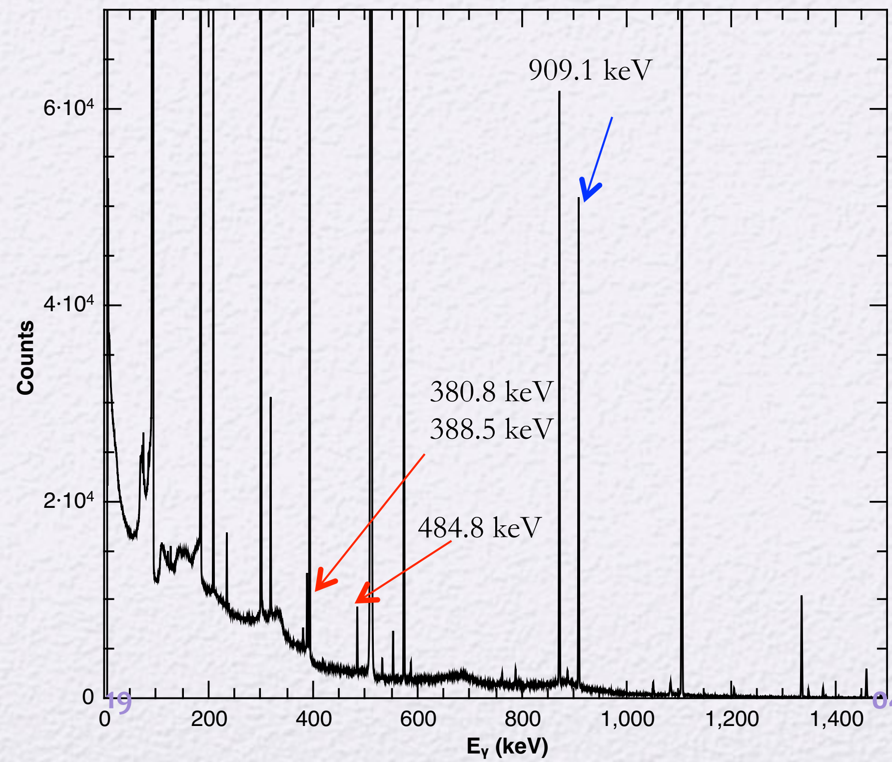
First Spectra - $SrCO_3$



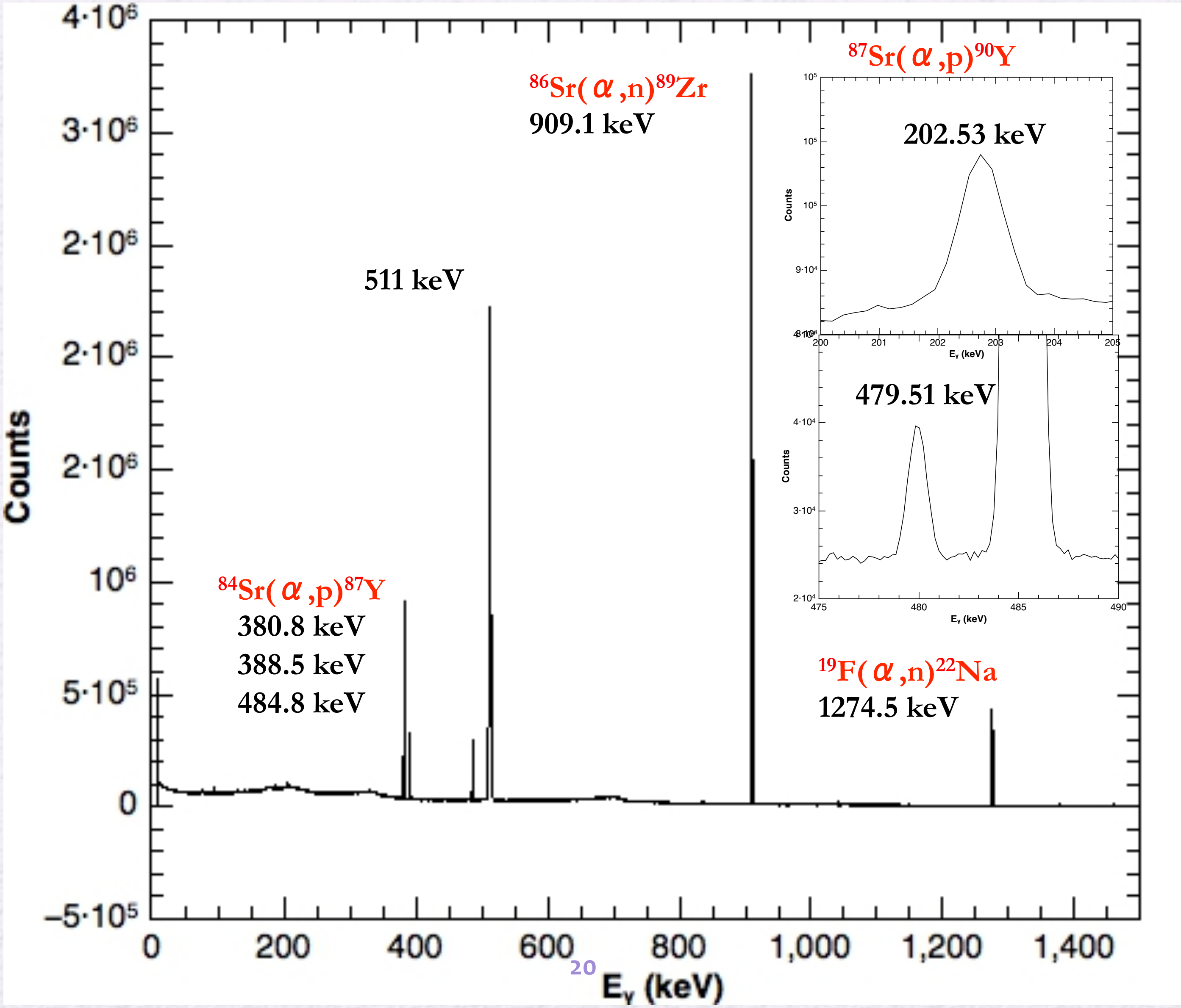




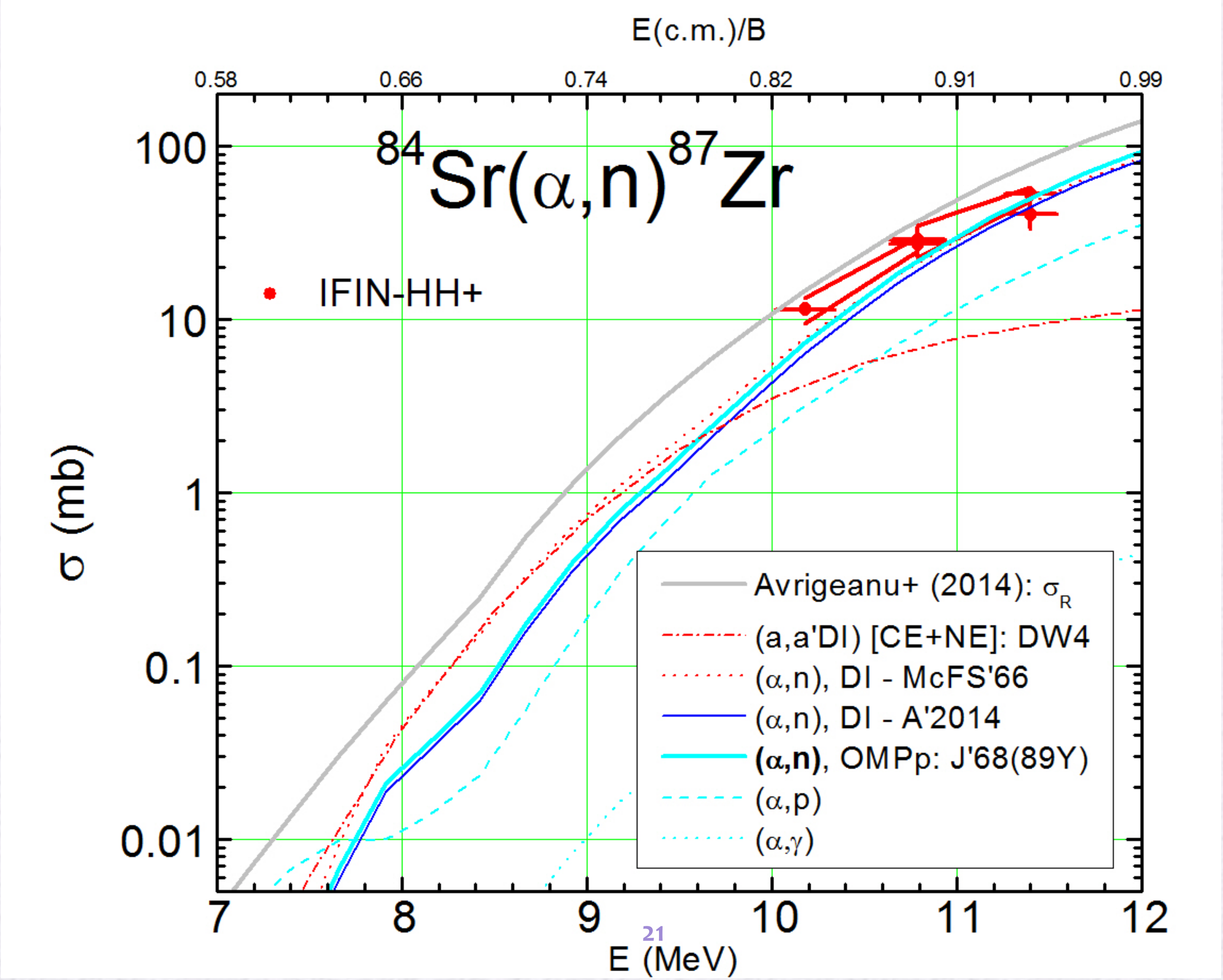




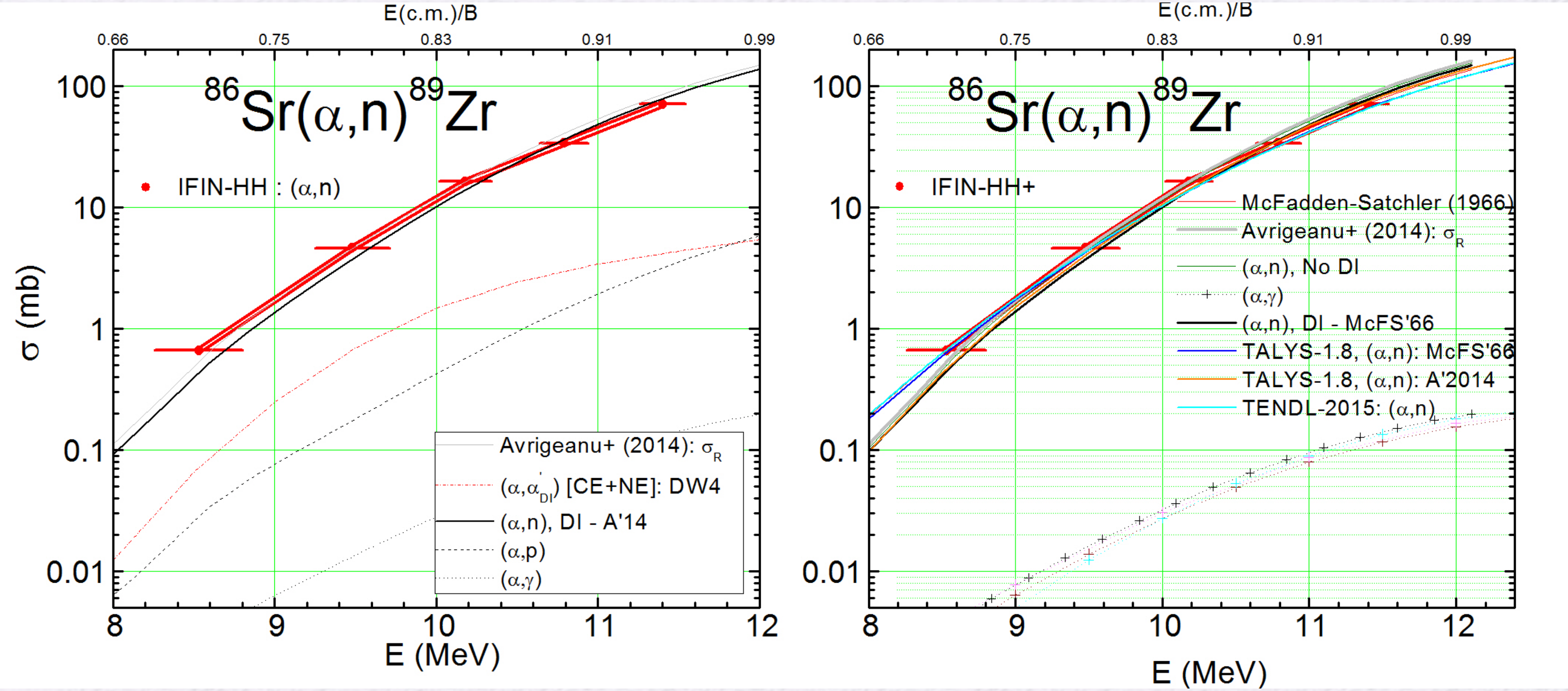
First Spectra - SrF_2



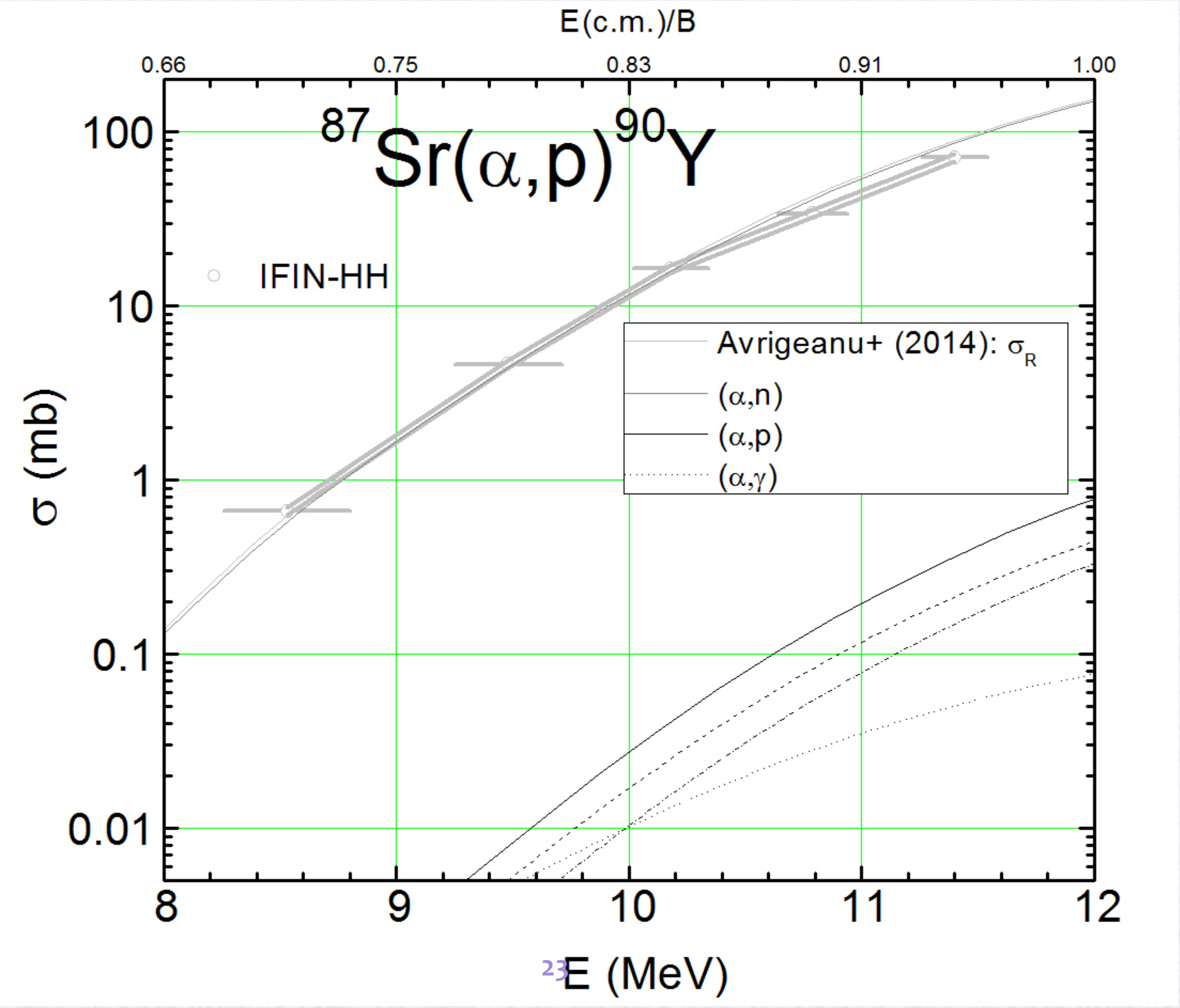
Experimental Results



Experimental Results



Experimental Results



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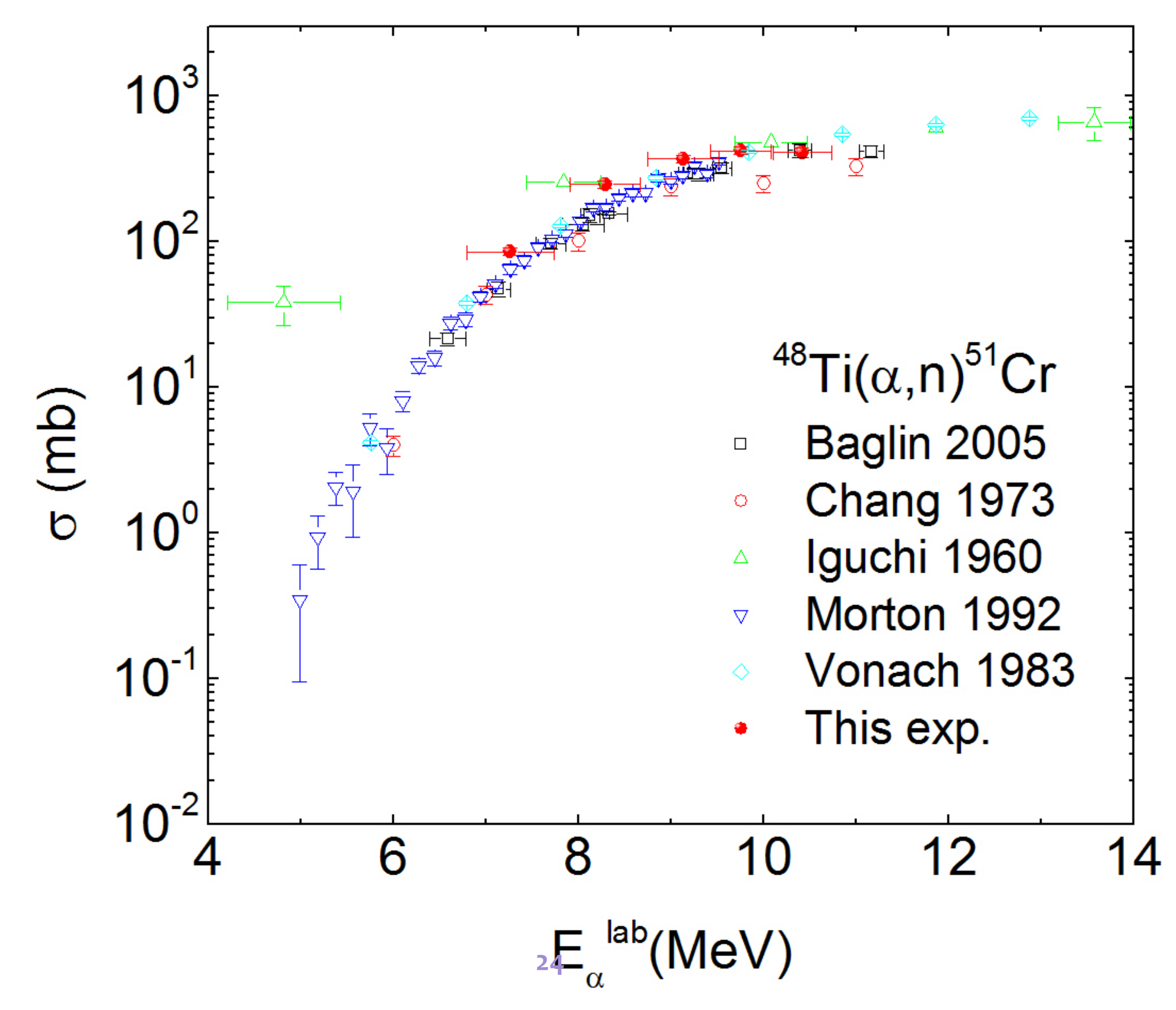

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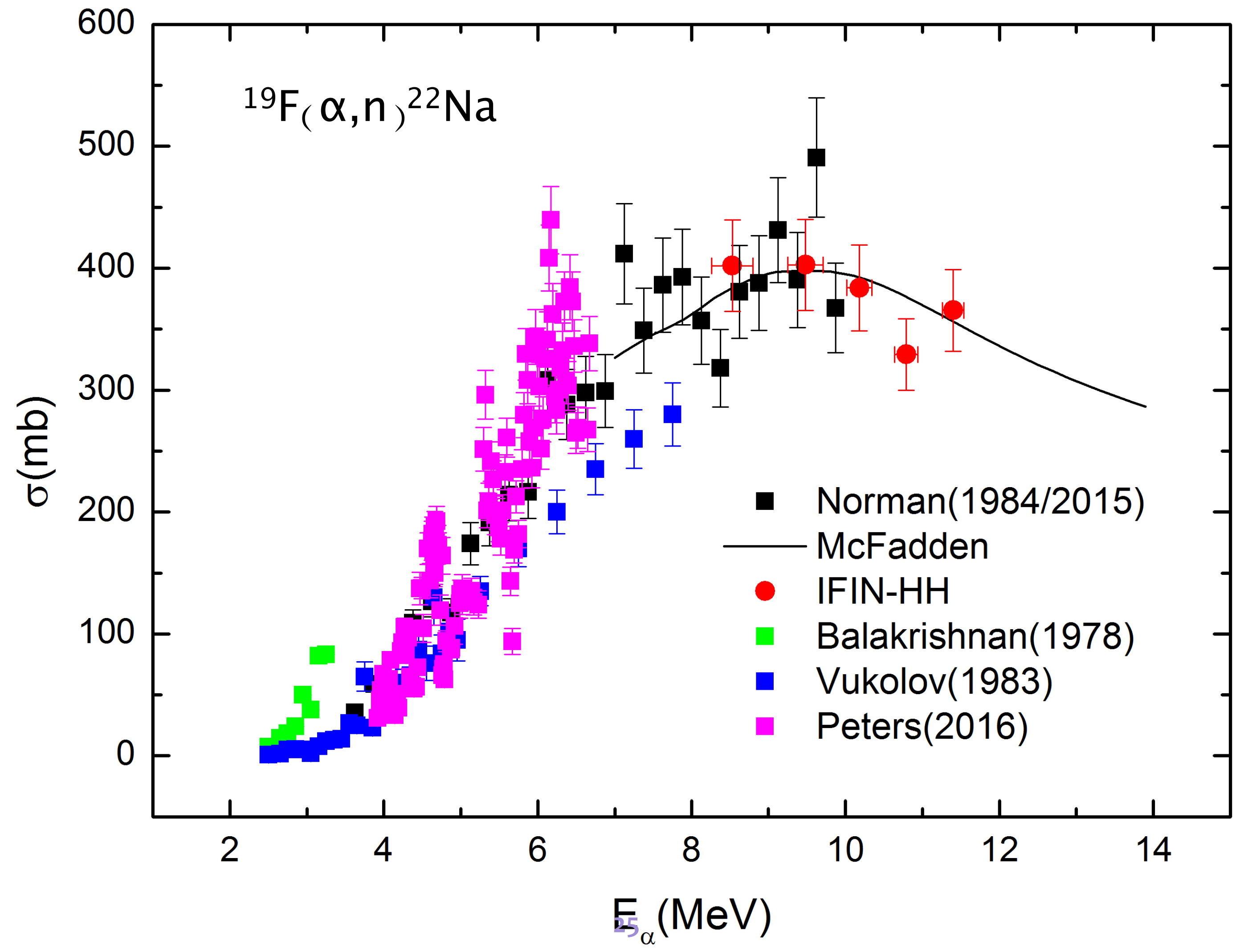

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Research group:

T. Glodariu, D. Filipescu, I. Gheorghe, V. Avrigeanu, N. Florea, A. Mitu, D. Bucurescu, C. Costache, A. Ionescu, N. Marginean, R. Marginean, C. Mihai, R. Mihai, A. Negret, C. Nita, A. Olacel, S. Pascu, R. Suvaila, L. Stan, L. Stroe, A. Serban, S. Toma, A.Turturica, S. Ujeniuc