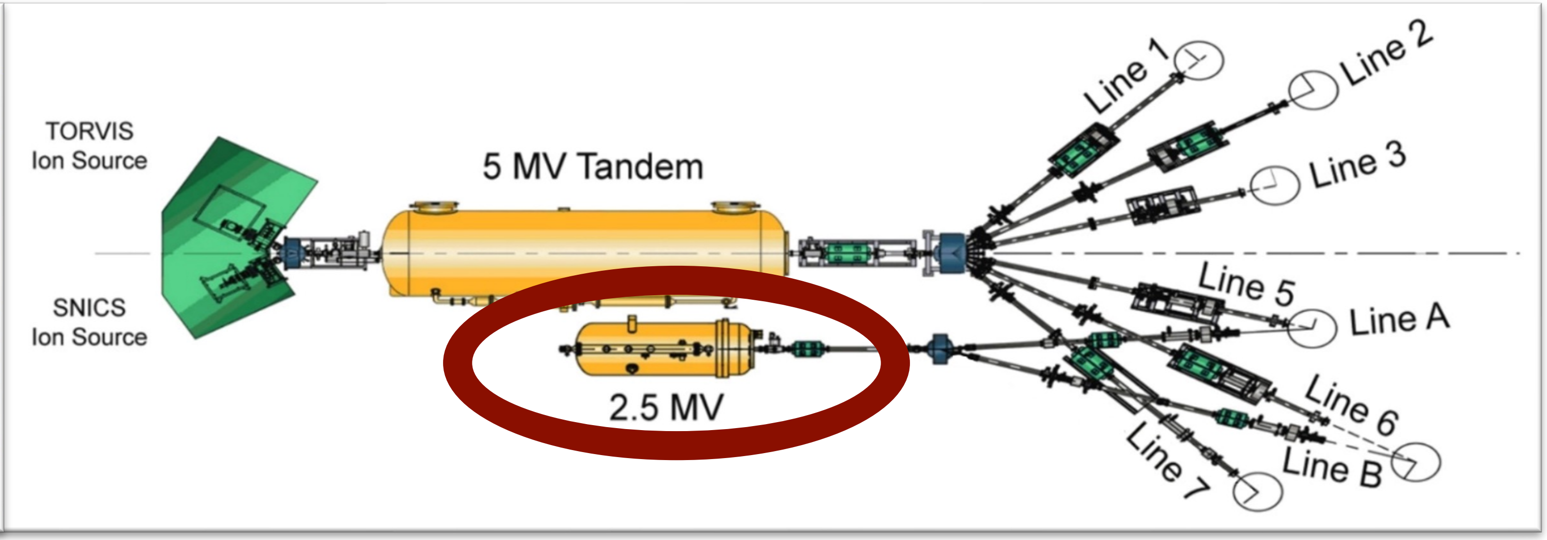
Energy Calibration of the 2.5MV Pelletron at the Dalton Cumbrian Facility

Experiment 141

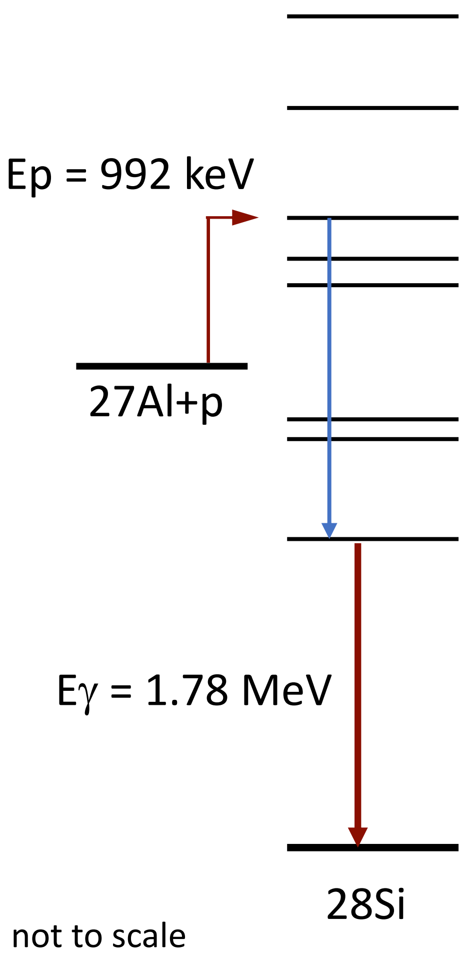
Goal: Energy calibration of the 2.5MV Single-ended Pelletron accelerator at Dalton Cumbria Facility



Method: thick-target yield measurement of resonance strengths in well-known $^{27}Al(p,\gamma)^{28}Si$ reaction

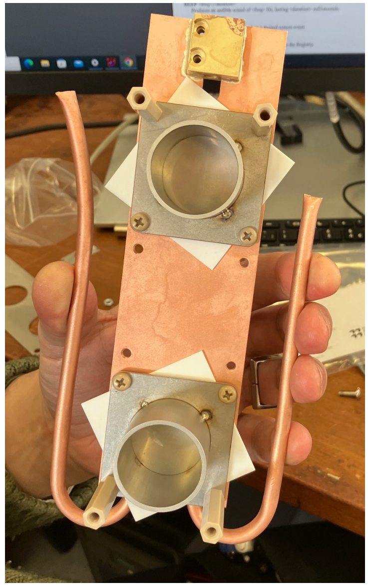
Setup: proton beam (of various energies) onto ^{27}Al target + γ-ray detector (NaI or similar)

Well-known Resonances in $^{27}Al(p,\gamma)^{28}Si$



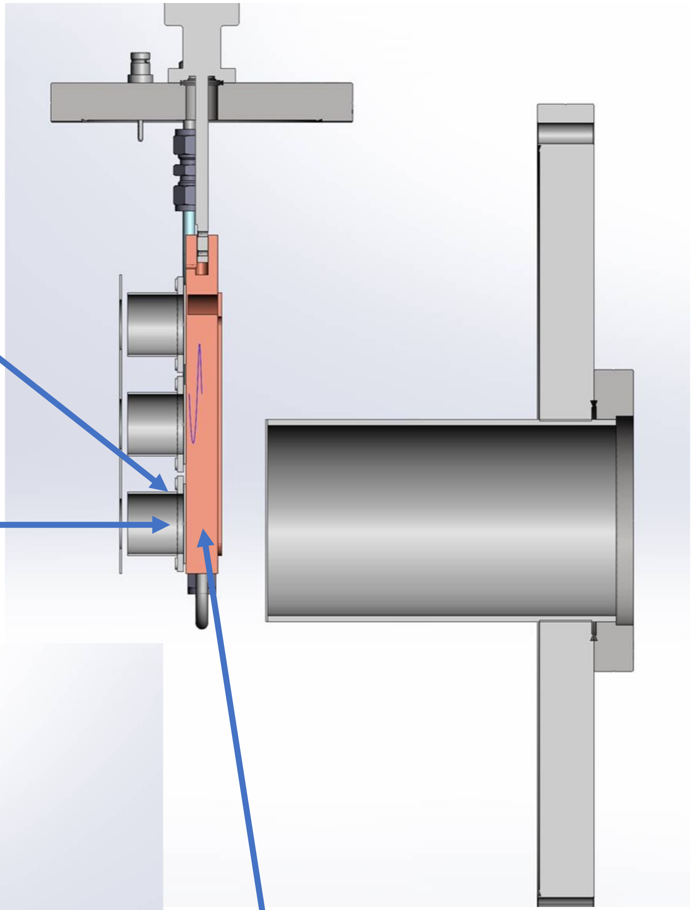
E_R (lab) [keV]	Gamma width [eV]	notes
632.2	6.7 (5)	
773.6	< 80	faint resonance
991.8	70 (10)	reference + stability test
1213.1	< 100	
1381.6	780 (80)	very wide resonance
1587.5	< 200	
1799.7	< 200	

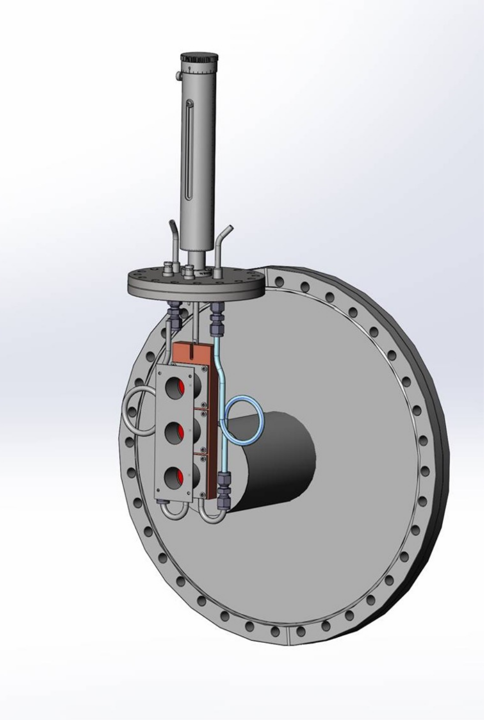
Experimental Setup



Al targets
(on Ta backing)

proton beam





water-cooled
Cu target holder

detector (NaI)

Standard NIM electronics
DAQ: MAESTRO running on desktop

all equipment provided by Edinburg,
except water-cooling system

Thick-target Resonant Yield

Experimental Procedure (for each resonance)

1. set beam energy above resonance energy
2. acquire gamma-ray spectrum ($E\gamma$ = 1.78 MeV)
3. calculate yield
4. lower beam energy
5. repeat [2-4] to fully scan resonance energy
6. associate mid point of rising edge to known E_res
7. determine calibration function (E vs HV)

E_R (lab) [keV]	Gamma width [eV]	notes
632.2	6.7 (5)	
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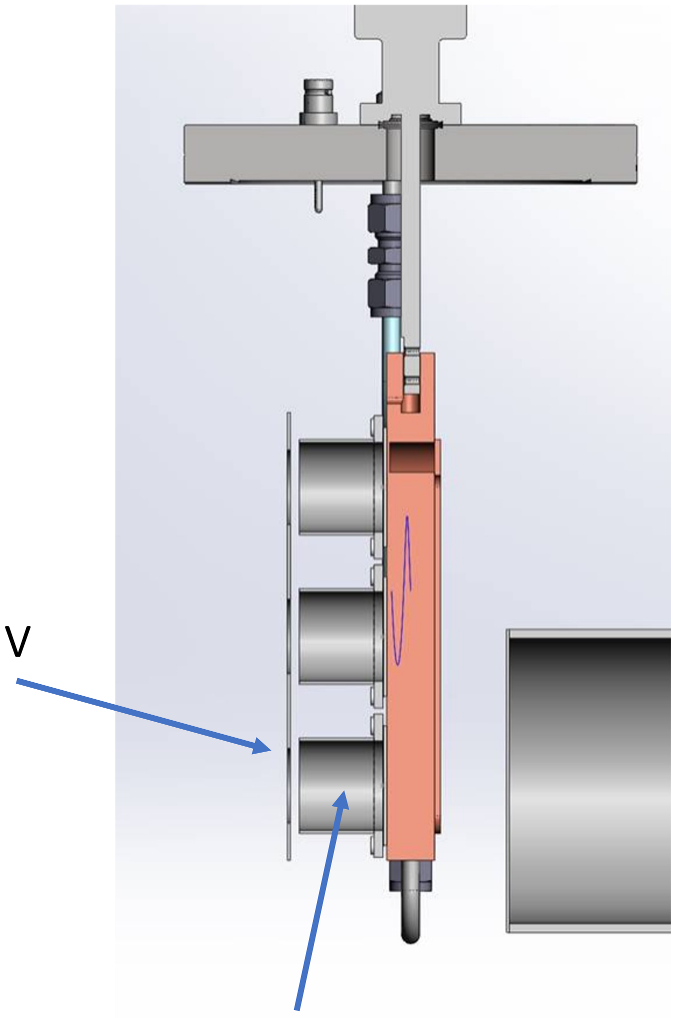
Experimental Procedure

rather than changing beam setting parameters at each resonance in small increments, obtain resonance scan by applying HV to target (up to ~2.5kV in 100V steps)

1. start with nominal beam energy (above resonance)
2. bias target and collimator (with constant DV = -300 V)
3. send beam on target
4. acquire γ-ray spectrum
5. stop beam in FC
6. change bias to target and collimator
7. repeat [3-6] until resonance scan is completed

depending on resonance strength and beam current, each scan could be completed in a few hours

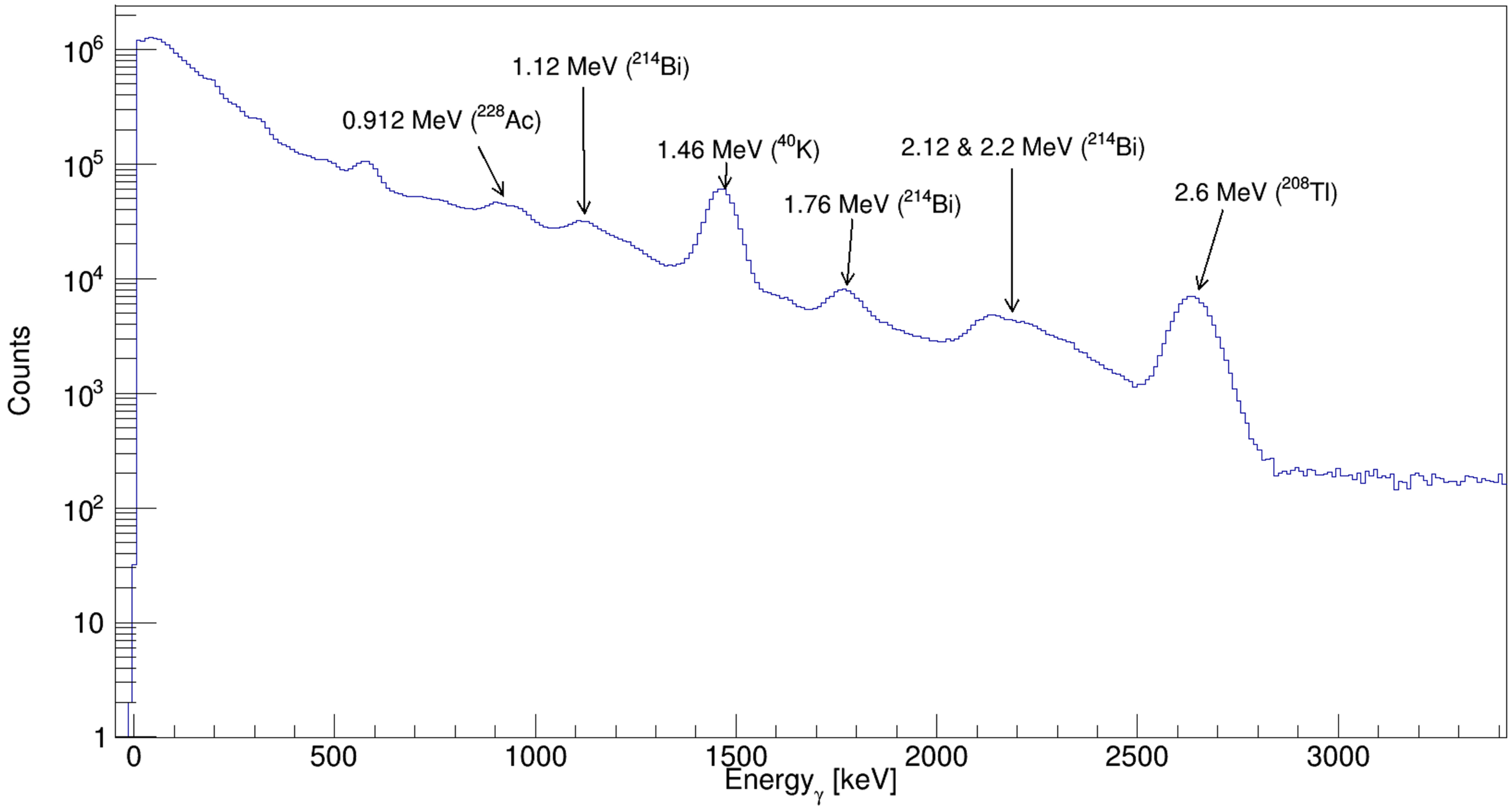


collimators
kept at -300 V
wrt target

cylinder + target (electric contact)
bias target to +HV to slow reduce beam energy

Current Status of Preparation

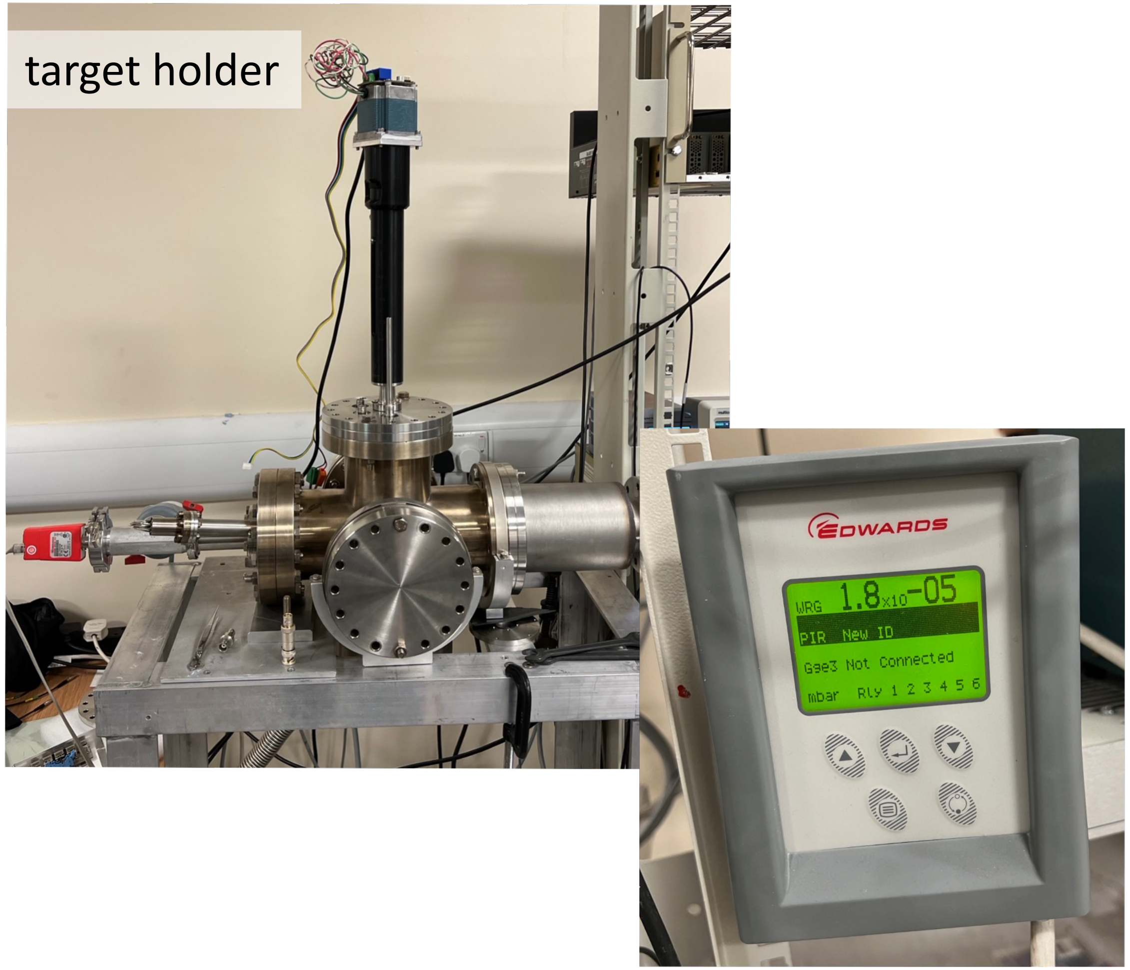
Detector Calibration (already performed, to be repeated)

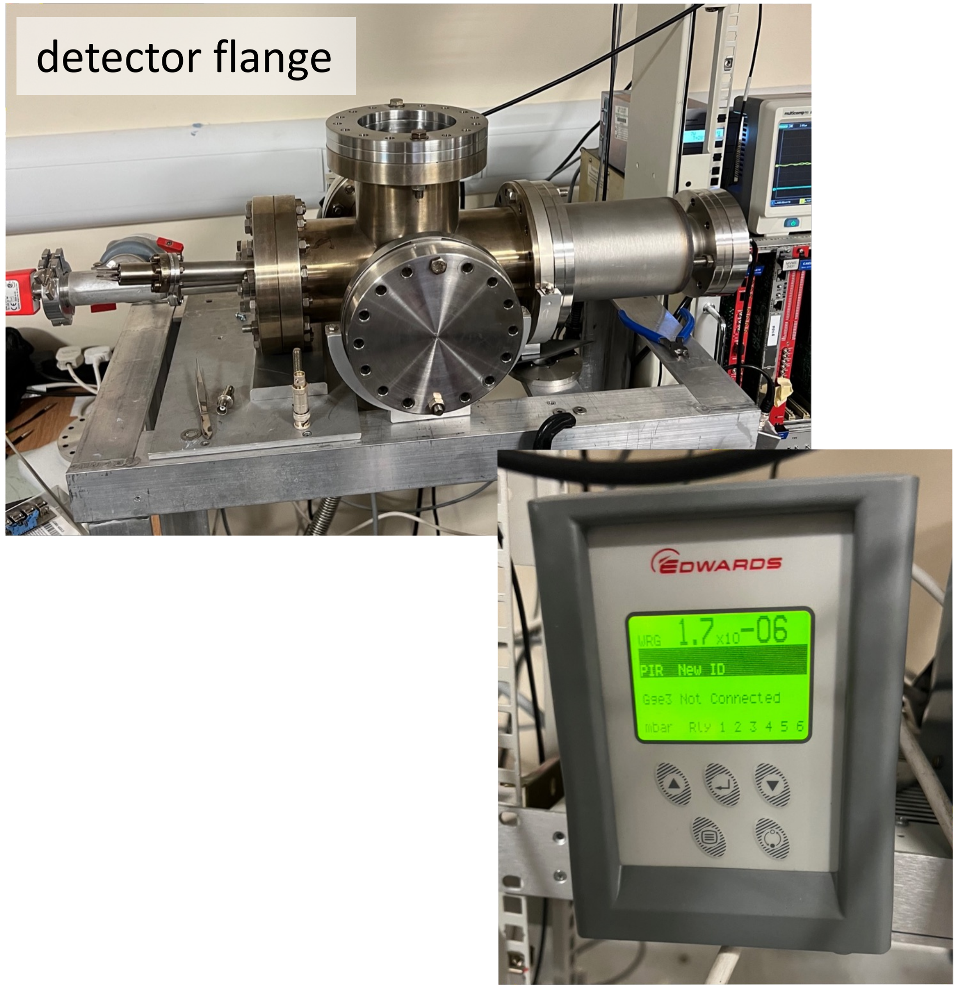


Detector 1
Serial No. 60022-01305-1

Detector 2
Serial No. 60022-01305-2

Vacuum Tests in progress





Still to be done…

- check target positioning on target ladder
- test water-cooling system
- assemble entire setup and vacuum test
- (re-)calibrate both detectors
- check scripts for target ladder movement and for target-bias supply work well
- bias target and collimator under vacuum (check no sparks occur)
- …
- prepare paperwork to access DCF

Reazione	E_p(keV)	Γ_{CM}(keV)
^{27}Al(p,γ)^{28}Si	991.86±0.03	0.070±0.014
^{27}Al(p,p'γ)^{27}Al	1664.4±0.2	0.45±0.05
	1683±0.13	< 0.2
^{27}Al(p,p)^{27}Al	2876±2	4.0±0.2
^{16}O(p,p)^{16}O	3470±5	1.53±0.2
^{12}C(p,p)^{12}C	4808±10	11.0±0.5

Table 1. Thick target yields Y_∞ and resonance strengths $\omega\gamma$. The resonance energies E_R have been adopted from [3]. The given Y_∞ values are the average result of at least two independent efficiency corrected yields that have been determined using different targets.

E_R (keV)	Y_∞ (Counts/μC)	$\omega\gamma$ (eV)
202.8	0.094(13)	$1.10(15)\times10^{-5}$
222.7	0.40(3)	$5.0(4)\times10^{-5}$
292.6	1.9(1)	$2.80(15)\times10^{-4}$
326.6	13.3(7)	$2.10(11)\times10^{-3}$
405.3	58(3)	$1.04(5)\times10^{-2}$
446.7	9.4(7)	$1.80(15)\times10^{-3}$
504.9	151(19)	$3.1(4)\times10^{-2}$
506.4	204(24)	$4.1(5)\times10^{-2}$
611.5	26(3)	$5.8(7)\times10^{-3}$
632.2	1296(130)	0.29(3)
654.7	538(53)	0.12(1)
679.3	249(26)	$5.8(6)\times10^{-2}$
731.4	591(34)	0.142(8)
736.5	726(52)	0.175(15)
743.0	94(10)	$2.30(25)\times10^{-2}$
760.4	556(39)	0.14(1)
767.2	802(57)	0.200(15)
773.6	1696(170)	0.42(4)
887.8	44(5)	$1.20(15)\times10^{-2}$
923.0	551(55)	0.145(15)
937.3	721(72)	0.19(2)
991.9	7308(517)	2.00(15)
1025.3	1318(132)	0.36(4)
1089.7	303(22)	$8.4(6)\times10^{-2}$
1097.3	150(16)	$4.2(4)\times10^{-2}$
1118.6	2978(298)	0.85(9)

Table 4. Compilation of resonance strengths for $^{27}Al(p,\gamma)^{28}Si$ at $E_p = 0.2$–1.12 MeV.

E_R^{lab} (keV)	Present $\omega\gamma$ (eV)	NACRE [6] $\omega\gamma$ (eV)	Others (the refs. are given in brackets at the end of the coressponding $\omega\gamma$ values) $\omega\gamma$ (eV)
202.8	$1.10(15)\times10^{-5}$	$1.4(7)\times10^{-5}$	$1.4(7)\times10^{-5}$ [22]
222.7	$5.0(4)\times10^{-5}$	$9(2)\times10^{-5}$	$11.4(35)\times10^{-5}$ [21], $7.8(25)\times10^{-5}$ [18]
292.6	$2.80(15)\times10^{-4}$	$3.8(7)\times10^{-4}$	$3.7(11)\times10^{-4}$ [21], $3.5(18)\times10^{-4}$ [18]
326.6	$2.10(11)\times10^{-3}$	$1.5(3)\times10^{-3}$	$1.71(53)\times10^{-3}$ [21], $2.3(5)\times10^{-3}$ [18], $1.92(42)\times10^{-3}$ [8], $0.8(3)\times10^{-4}$ [20]
405.3	$1.04(5)\times10^{-2}$	$0.9(1)\times10^{-2}$	$0.71(22)\times10^{-2}$ [21], $1.25(25)\times10^{-2}$ [18], $1.0(2)\times10^{-2}$ [8], $0.65(28)\times10^{-4}$ [20]
446.7	$1.80(15)\times10^{-3}$	$1.4(2)\times10^{-3}$	$1.43(44)\times10^{-3}$ [21], $1.5(5)\times10^{-3}$ [8], $1.42(61)\times10^{-3}$ [20]
504.9	$3.1(4)\times10^{-2}$	$6.1(7)\times10^{-2}$	$3.7(12)\times10^{-2}$ [17], $4.5(19)\times10^{-2}$ [20]
506.4	$4.1(5)\times10^{-2}$	$4.2(9)\times10^{-2}$	$3.7(12)\times10^{-2}$ [17], $5.5(24)\times10^{-2}$ [20]
611.5	$5.8(7)\times10^{-3}$	$4(1)\times10^{-3}$	$14.3(44)\times10^{-3}$ [21], $4.92(75)\times10^{-3}$ [20]
632.2	0.29(3)	0.266(14)	0.286(88) [21], 0.208(53) [17], 0.442(67) [23], 0.25(3) [8] 0.30(4) [24], 0.26(3) [25], 0.268(13) [26], 0.216(43) [27]
654.7	0.12(1)	0.12(9)	0.114(35) [21], 0.125(33) [17], 0.116(14) [8], 0.125(26) [25], 0.129(56) [20]
679.3	$5.8(6)\times10^{-2}$	$4.5(5)\times10^{-2}$	$4.3(13)\times10^{-2}$ [21], $3.92(125)\times10^{-2}$ [17], $5.4(7)\times10^{-2}$ [8], $6.5(28)\times10^{-2}$ [20]
731.4	0.142(8)	0.12(1)	0.114(35) [21], 0.15(4) [17], 0.129(16) [8], 0.110(47) [20]
736.5	0.175(15)	0.160(16)	0.157(48) [21], 0.167(50) [17], 0.159(21) [8], 0.181(78) [20]
743.0	$2.30(25)\times10^{-2}$	$2.1(3)\times10^{-2}$	$2.86(88)\times10^{-2}$ [21], $1.42(4)\times10^{-2}$ [17], $2.67(58)\times10^{-2}$ [8], $2.6(11)\times10^{-2}$ [20]
760.4	0.14(1)	0.135(16)	0.143(44) [21], 0.133(42) [17], 0.126(17) [8], 0.181(78) [20]
767.2	0.200(15)	0.16(2)	0.171(53) [21], 0.158(50) [17], 0.175(25) [8], 0.135(58) [20]
773.6	0.42(4)	0.41(3)	0.457(141) [21], 0.39(13) [28], 0.458(142) [29], 0.408(50) [8], 0.442(83) [24], 0.613(264) [20], 0.383(77) [27]
887.8	$1.20(15)\times10^{-2}$	$1.5(2)\times10^{-2}$	$2.00(66)\times10^{-2}$ [21], $1.33(25)\times10^{-2}$ [8], $2.00(86)\times10^{-2}$ [20], $1.20(10)\times10^{-2}$ [7]
923.0	0.145(15)	0.140(18)	0.171(53) [21], 0.130(17) [8], 0.213(92) [20], 0.140(13) [7]
937.3	0.19(2)	0.176(21)	0.171(53) [21], 0.175(53) [30], 0.175(25) [8], 0.194(10) [20], 0.183(17) [7]
991.9	2.00(15)	1.9(1)	3.17(50) [31], 1.83(20) [8], 1.88(23) [25], 1.93(13) [26], 2.00(17) [32], 1.94(7) [7]
1025.3	0.36(4)	0.31(3)	0.314(97) [21], 0.325(42) [8], 0.245(106) [20], 0.342(68) [27], 0.35(3) [7]
1089.7	0.084(6)	0.08(1)	0.071(22) [21], 0.090(11) [8], 0.065(28) [20], 0.080(23) [27]
1097.3	0.042(4)	0.04(1)	0.034(11) [21], 0.045(5) [8], 0.029(13) [20], 0.043(12) [7]
1118.6	0.85(9)	0.73(13)	0.60(18) [21], 1.208(125) [33], 0.85(9) [8], 1.208(125) [34], 0.708(75) [35], 0.574(247) [20], 0.80(6) [7]

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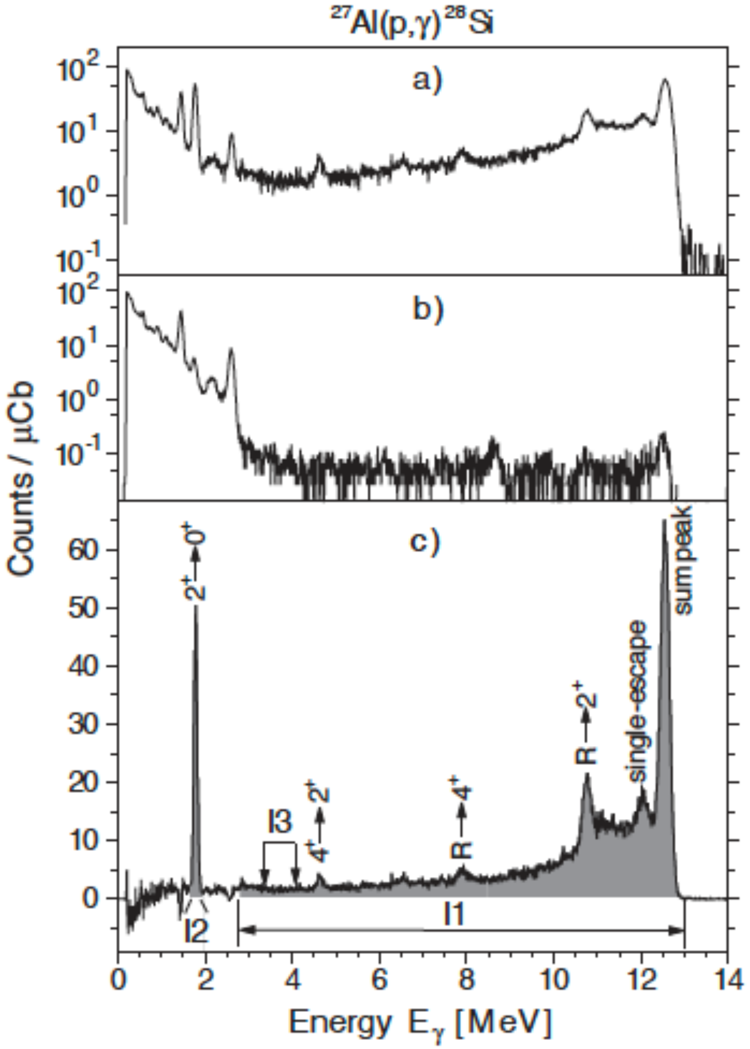

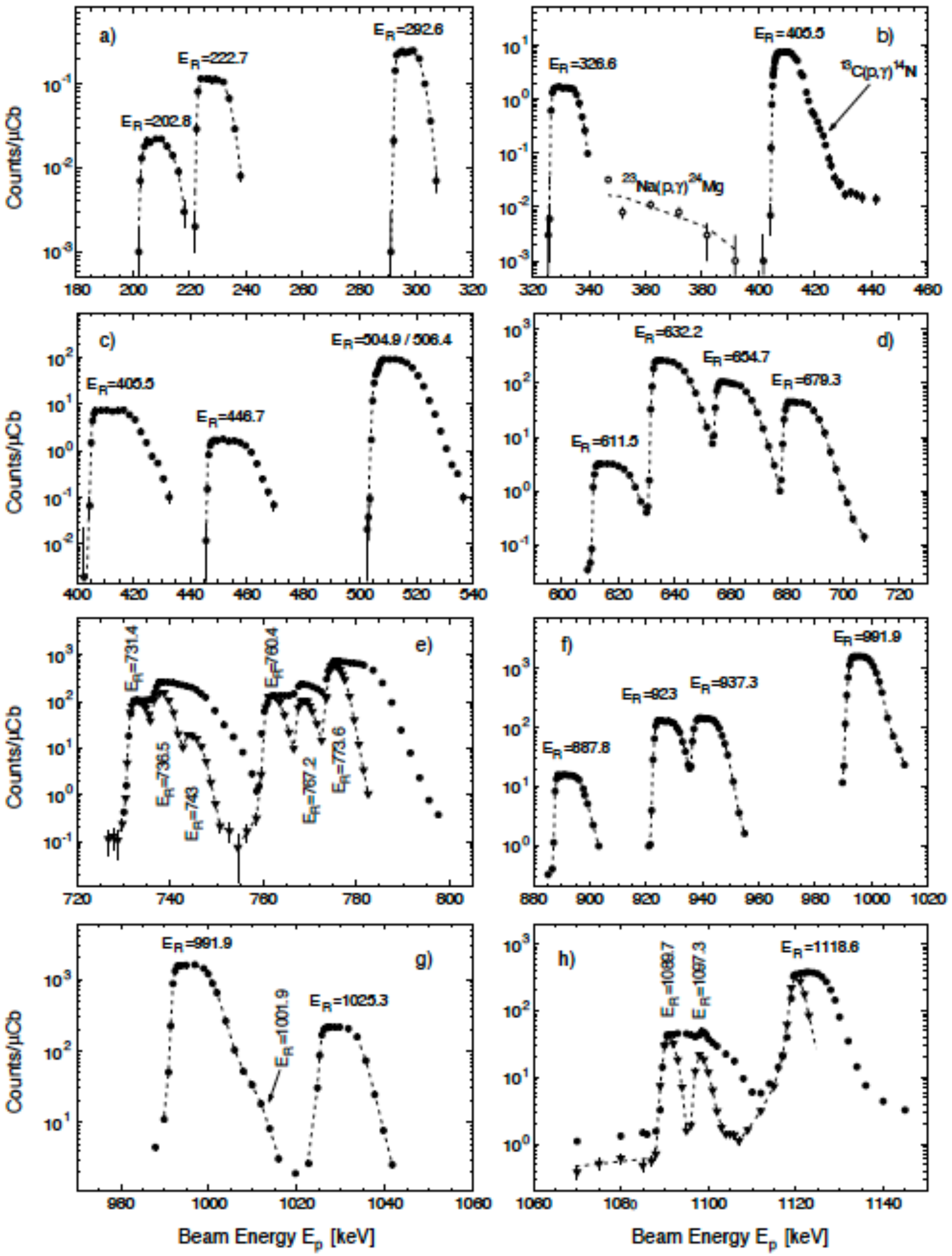

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