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Introduction to lab 3:

Study of the E_p = 992 keV resonance of the $^{27}Al(p,\gamma)^{28}Si$ reaction

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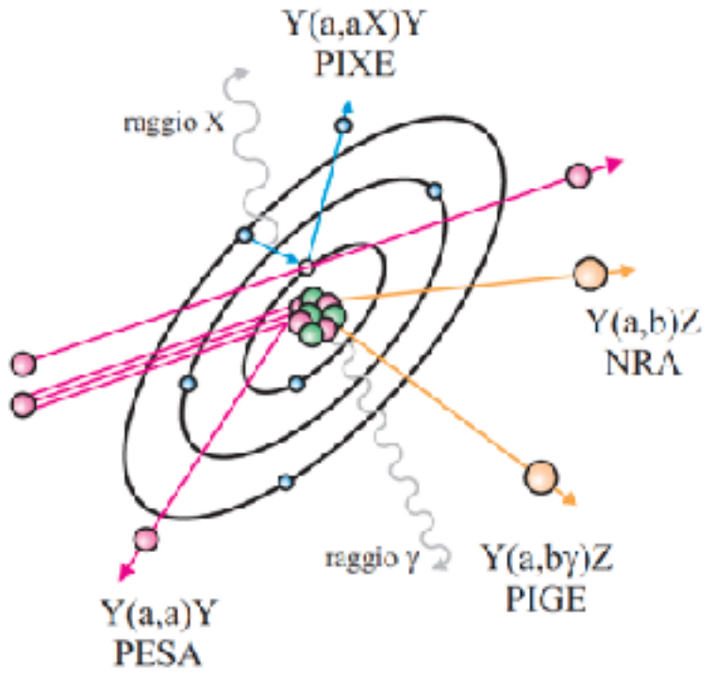
Cross Section



beamspot area

cross section

# of reaction

$$n = I\sigma N A t$$

# of particles in the beam

# of nuclei / Volume

target thickness

$$Y(E_0) = \int \sigma(x)N(x)\,dx = \int \sigma(x)N(x)\,dx \frac{dE(x)}{dx}\frac{dx}{dE(x)}$$

$$= \int_{E_0-\Delta E}^{E_0} \frac{\sigma(E)}{\varepsilon(E)}\,dE$$

effective stopping power

and resonances

Breit Wigner

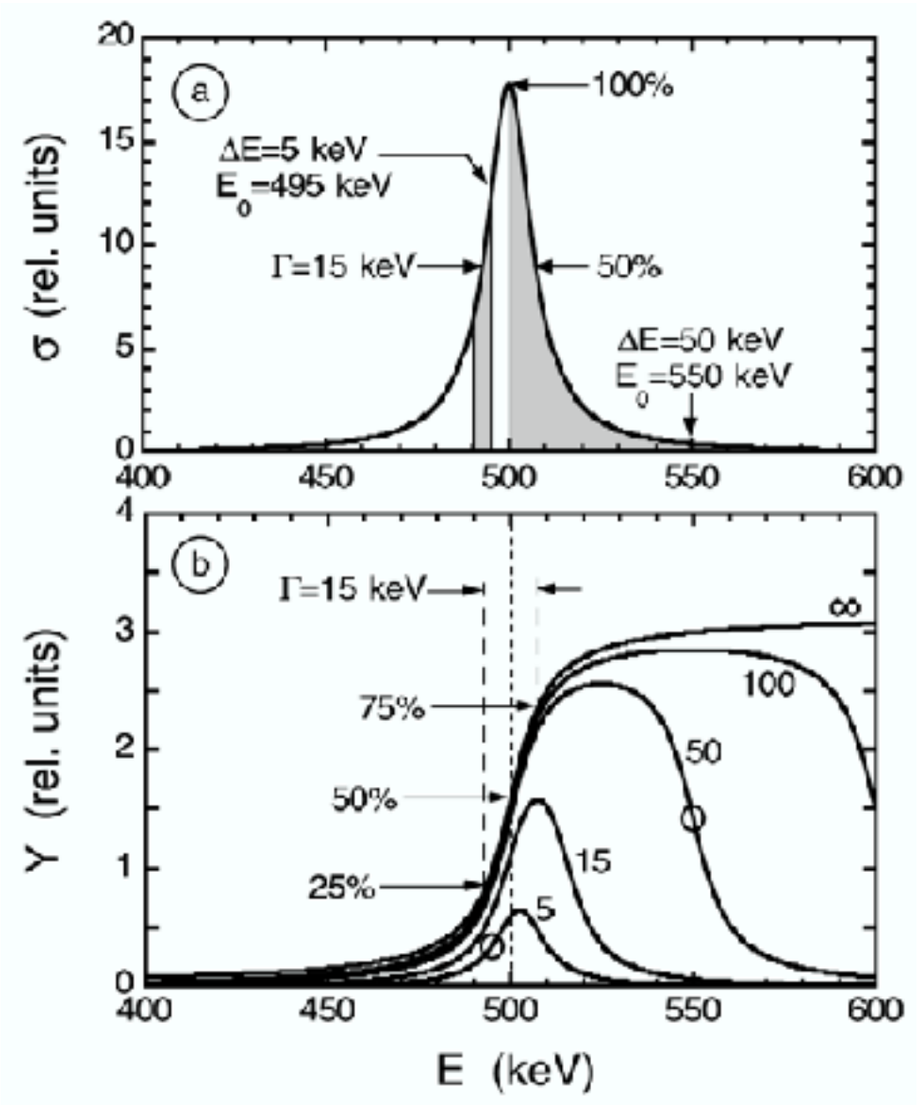
$$Y(E_0) = \int_{E_0-\Delta E}^{E_0} \frac{1}{\varepsilon(E)} \frac{\lambda^2}{4\pi} \omega \frac{\Gamma_a \Gamma_b}{(E_r - E)^2 + \Gamma^2/4} \, dE$$

$$= \frac{\lambda_r^2}{2\pi} \frac{\omega\gamma}{\varepsilon_r} \frac{\Gamma}{2} \int_{E_0-\Delta E}^{E_0} \frac{dE}{(E_r - E)^2 + (\Gamma/2)^2}$$

$$= \frac{\lambda_r^2}{2\pi} \frac{\omega\gamma}{\varepsilon_r} \left[\arctan\left(\frac{E_0 - E_r}{\Gamma/2} \right) - \arctan\left(\frac{E_0 - E_r - \Delta E}{\Gamma/2} \right) \right]$$

$$\frac{\lambda_r^2}{2} = 2\pi^2 \frac{\hbar^2}{2 m_{01} E_r} = \left(\frac{M_0 + M_1}{M_1} \right)^2 \frac{4.125 \times 10^{-18}}{M_0 E_r^{\text{lab}}} \qquad (\text{cm}^2)$$

and resonances



$$\Upsilon_{\max,\Delta E\to\infty} = \frac{\lambda_r^2}{2}\frac{\omega\gamma}{\varepsilon_r}$$

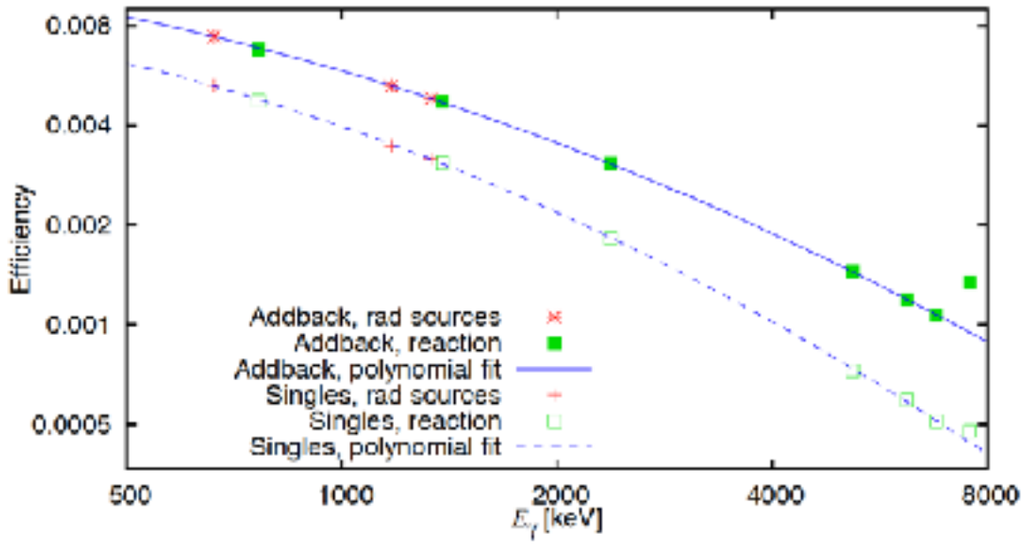
$$E_{0,50\%,\Delta E\to\infty} = E_r$$

$$\omega\gamma \equiv \frac{(2J+1)(1+\delta_{01})}{(2j_0+1)(2j_1+1)}\frac{\Gamma_a\Gamma_b}{\Gamma}$$

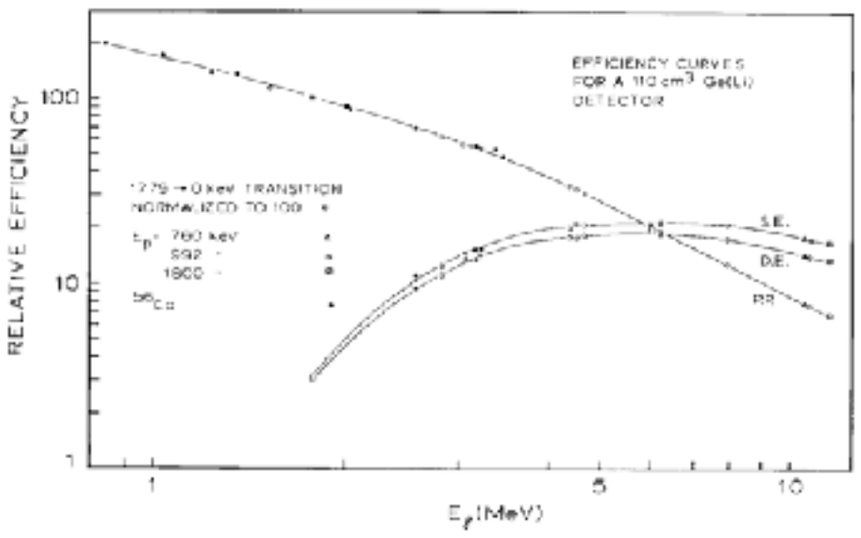
$$\Gamma\cdot\sigma_{BW}(E=E_r) = \Gamma\cdot\frac{\lambda_r^2}{\pi}\omega\frac{\Gamma_a\Gamma_b}{\Gamma^2} = \frac{\lambda_r^2}{\pi}\omega\gamma$$

a resonance as a tool

Detector energy calibration and efficiency calibration



$^{14}N(p,\gamma)^{15}O$ at LUNA
E_R = 259 keV



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USE OF THE $^{27}Al(p, \gamma)^{28}Si$, $E_p = 992$ keV RESONANCE AS A GAMMA-RAY INTENSITY STANDARD

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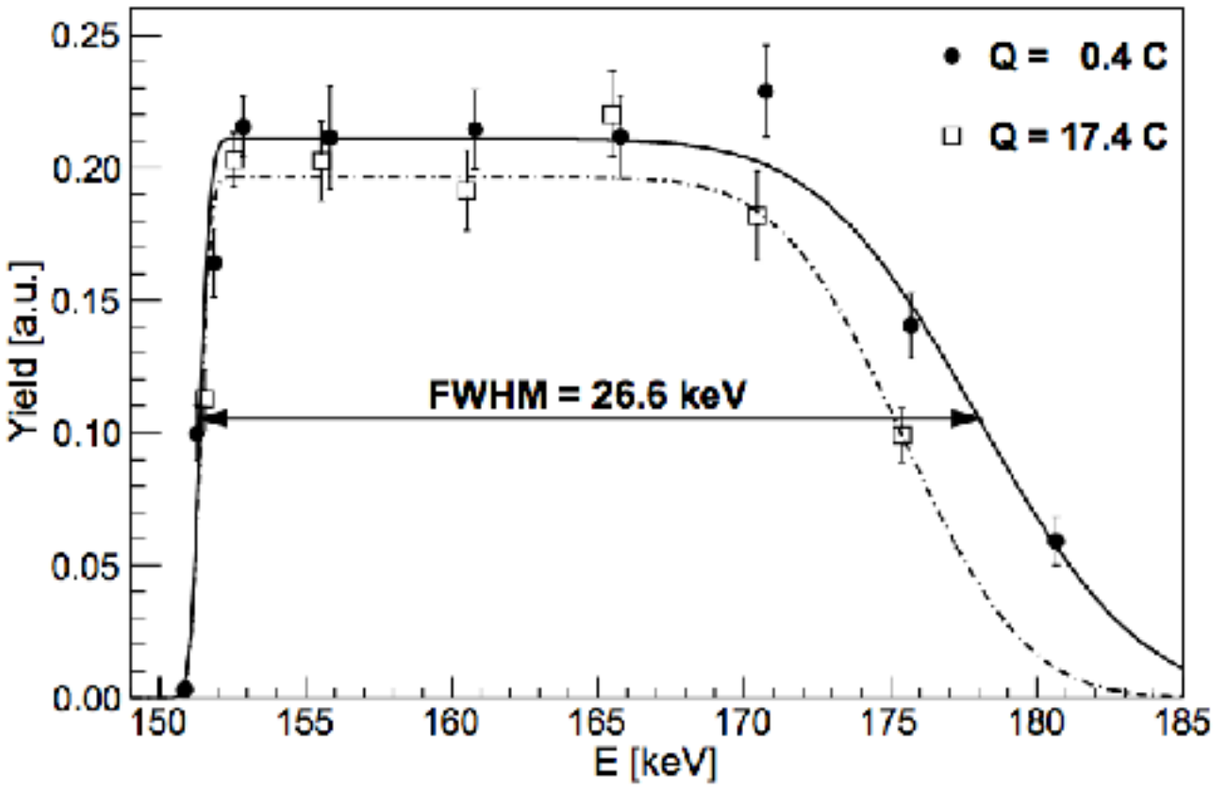
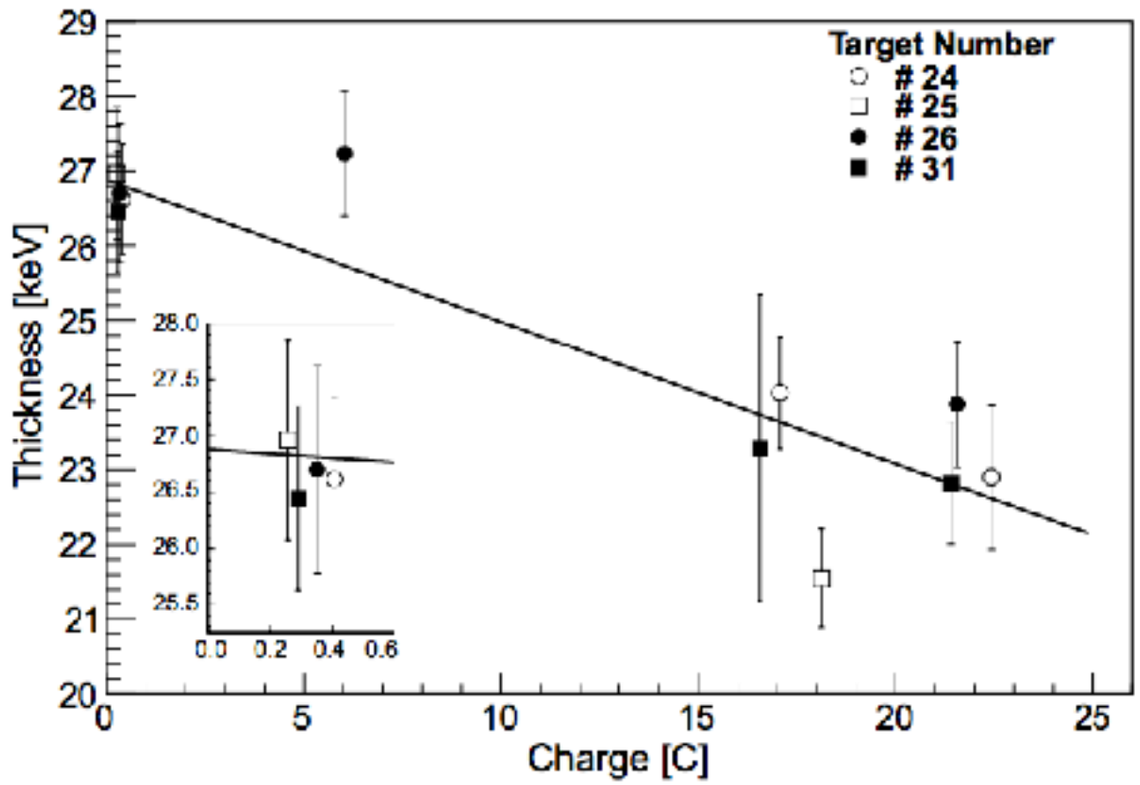
Received 24 May 1977

Utilization of the $E_p = 992$ keV resonance in the $^{27}Al(p, \gamma)^{28}Si$ reaction is proposed for relative and absolute γ-ray intensity measurements. Thorough experimental study of the decay schemes and γ-ray angular distributions for the $E_p = 760$, 992 and 1800 keV resonances in the $^{27}Al(p, \gamma)^{28}Si$ reaction is reported and revised decay schemes are given.

a resonance as a tool

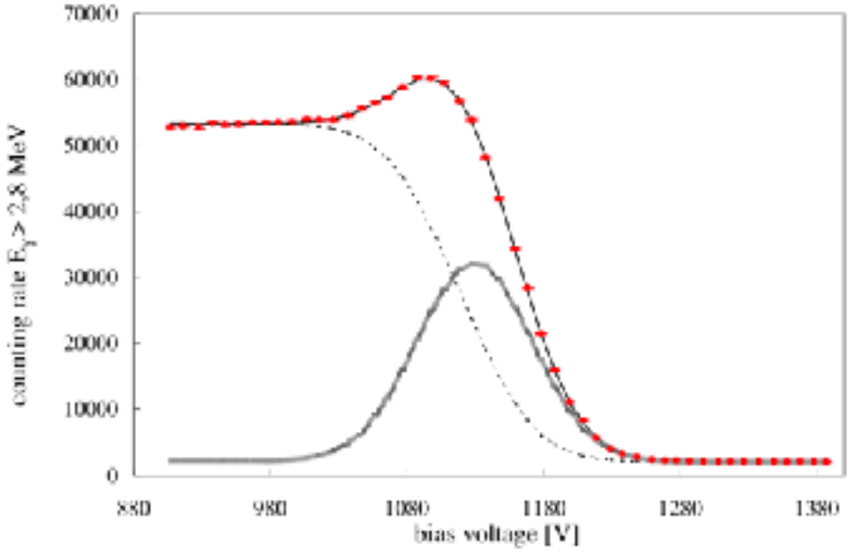
Target characterisation





a resonance as a tool

Accelerator calibration and beam characterisation (in some cases)



Nuclear Instruments and Methods in Physics Research A 340 (1994) 436–441
North-Holland

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

Accelerator beam energy calibration with the $^{27}Al(p, n)$ and $^{27}Al(p, \gamma)$ reactions

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(Received 4 October 1993)

The energies of resonances in the $^{27}Al(p, \gamma)$ reaction at 992 and 1317 keV and of the threshold of the $^{27}Al(p, n)$ reaction at 5804 keV have been measured accurately with respect to a 1 V standard. Both calibration energies and energies suitable for Q value calculations are given. Corrections are made for the effects of the energy distribution of the proton beam, of nonuniform energy loss of the protons in the target and of ionisation of the target atoms.

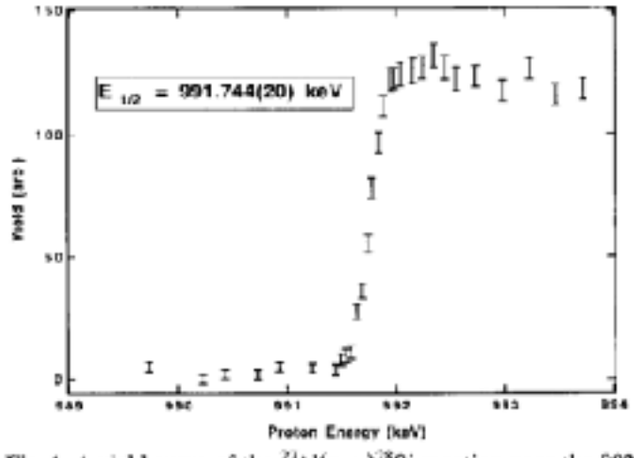


Fig. 1. A yield curve of the $^{27}Al(p, \gamma)^{28}Si$ reaction near the 992 keV resonance.

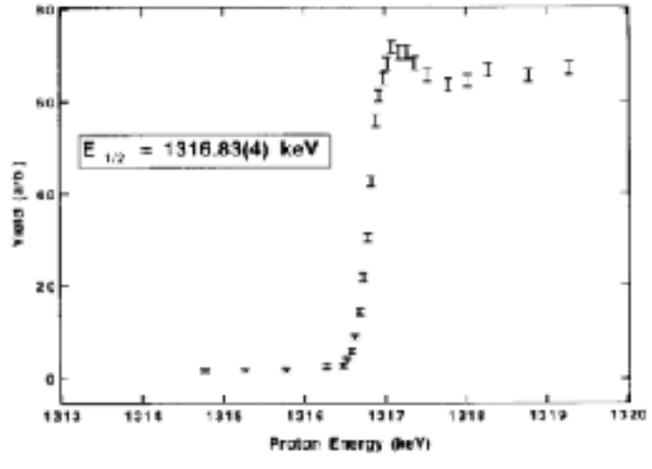
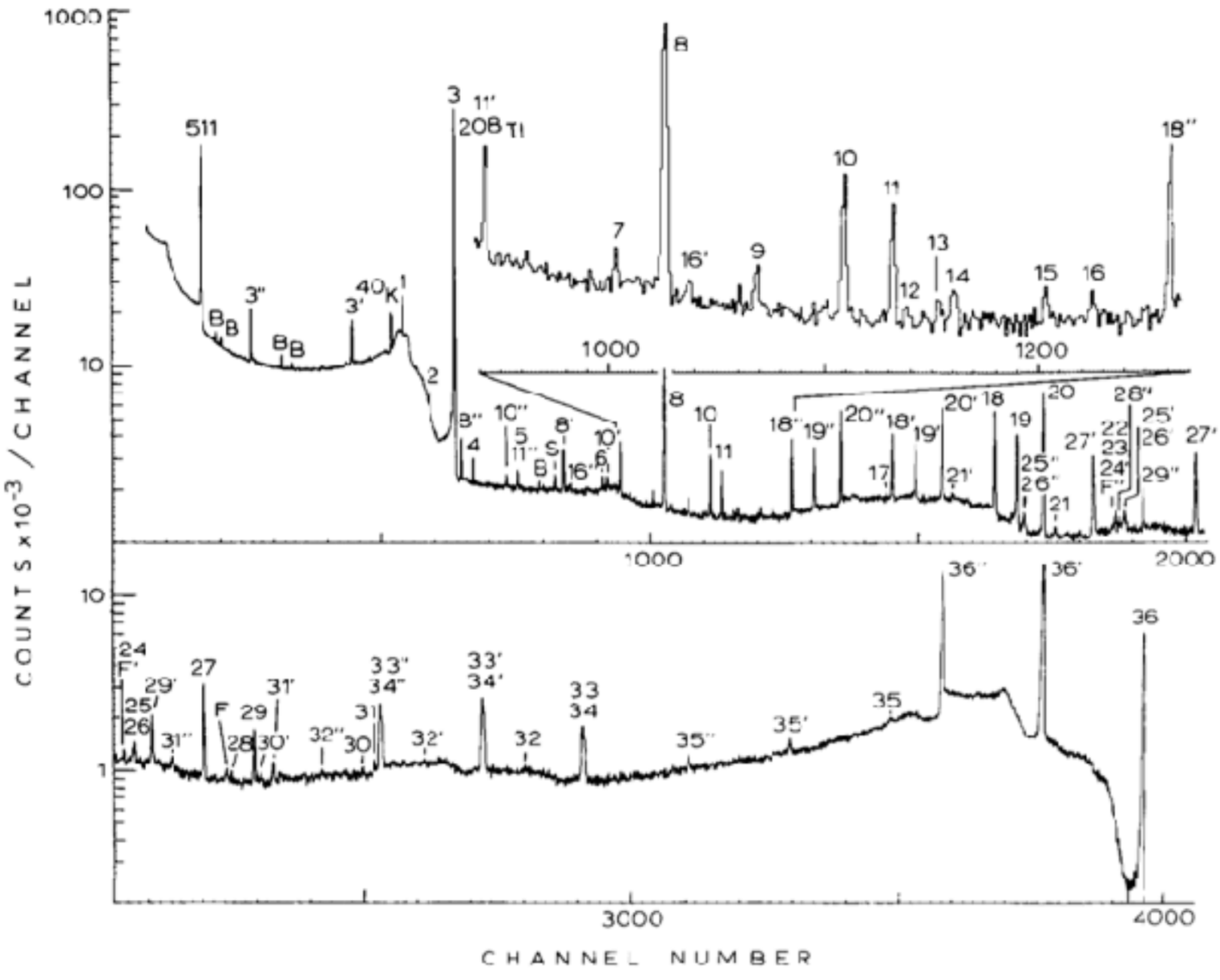


Fig. 3. A yield curve of the $^{27}Al(p, \gamma)^{28}Si$ reaction near the 1317 keV resonance.

USE OF THE $^{27}Al(p, \gamma)^{28}Si$, $E_p = 992$ keV RESONANCE AS A GAMMA-RAY INTENSITY STANDARD

A. ANTTILA, J. KEINONEN, M. HAUTALA and I. FORSBLOM



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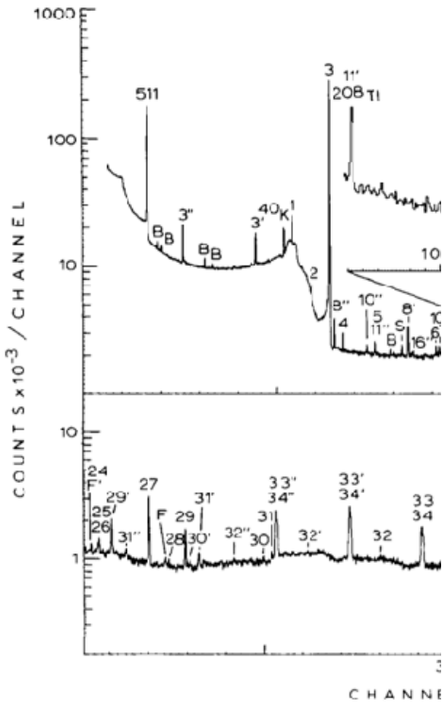
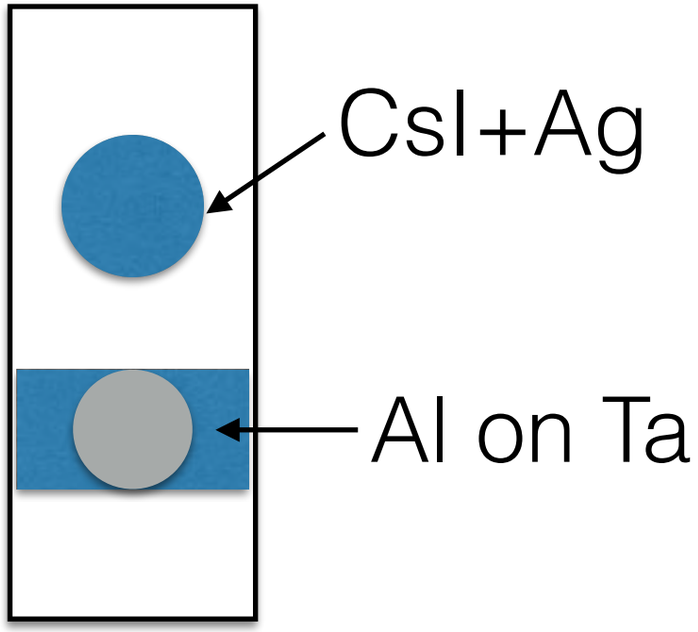
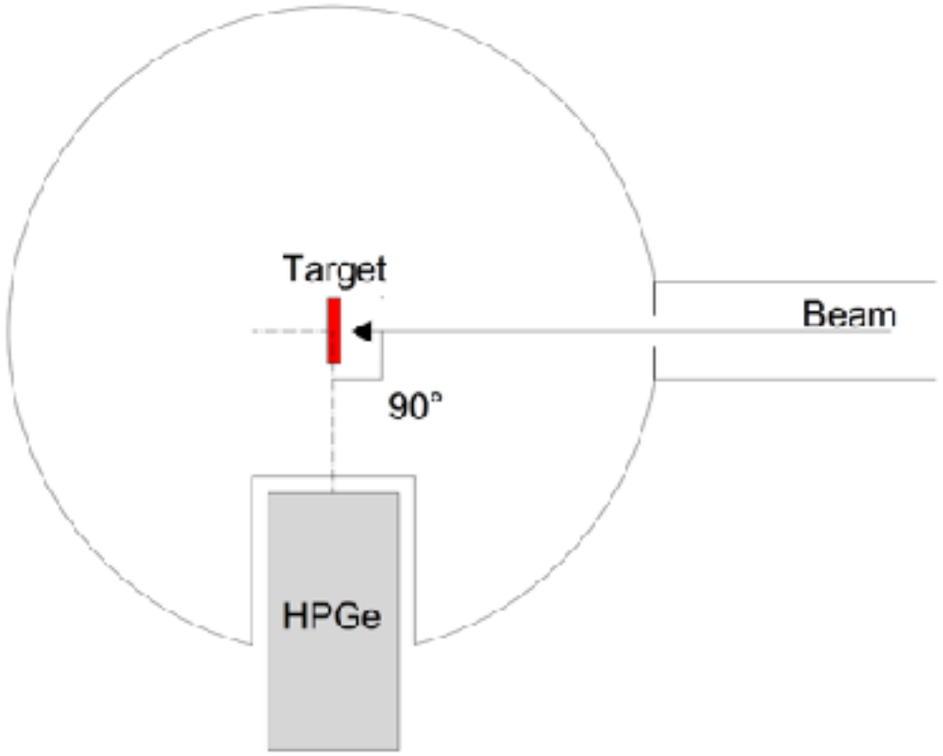


Identification in fig. 2	E_γ (keV)	E_i (keV)	E_f (keV)	Relative intensity (%) Present	Azuma et al.[9]	Scott and Lusby[2]	Meyer et al.[4][a]
1	1522.3	7798.8	6276.5	2.8 ±0.2	2.9±0.5	3.0 ±0.3	2.8
2	1658.7	6276.5	4617.8	0.52±0.05	0.6±0.1	0.49 ±0.04	0.4
3	1778.9	1778.9	0	94.8 ±1.5	94.0±9.4	94.1 ±9.4	95
4	(1874)	r	10668	0.29±0.03			
5	2099.7	9480.4	7380.7	0.24±0.02			0.2
	2267	r	10275		?		
6	2529.3	9418.1	6888.8	0.22±0.03		0.19 ±0.03	0.2
7	(2780.3)	r	9761.5	0.23±0.04			
8	2838.9	4617.8	1778.9	5.5 ±0.4	6.2±0.6	6.3 ±0.4	6.3
9	2954.3	7933.4	4979.1	0.24±0.02			0.2
10	3063.3	r	9478.5	1.15±0.11	1.1±0.3	1.2 ±0.1	1.3
11	3123.7	r	9418.1	0.70±0.07	1.1±0.3	0.80 ±0.06	0.9
12	3141.6	9418.1	6276.5	0.09±0.02		0.08 ±0.02	0.05
13	3181.0	7798.8	4617.8	0.16±0.04		0.16 ±0.06	0.1
14	3200.2	4979.1	1778.9	0.24±0.06			0.2
15	3315.6	7933.4	4617.8	0.21±0.04		0.34 ±0.05	0.3
16	(3377.9)	r	9163.9	0.19±0.05			0.4
17	3952.9	r	8588.9	0.19±0.04			0.3
18	4497.6	6276.5	1778.9	4.8 ±0.3	4.4±0.4	6.0 ±0.3	4.9
19	4608.4	r	7933.4	4.5 ±0.4	3.6±0.4	5.0 ±0.3	4.2
20	4743.0	r	7798.8	8.8 ±0.5	8.1±0.8	11.5 ±0.5	9.7
21	4800.3	9418.1	4617.8	0.31±0.04	1.0±0.3	0.29 ±0.07	0.3
22	5099.7	6878.6	1778.9	0.10±0.04	0.6±0.2	0.30 ±0.05	0.2
23	5109.9	6888.8	1778.9	0.50±0.06		0.52 ±0.09	0.5
24	5601.8	7380.7	1778.9	0.24±0.05			0.1
25	5653.0	r	6888.8	0.40±0.04	0.9±0.3	0.36 ±0.09	0.3
26	5663.2	r	6878.6	0.58±0.06		0.89 ±0.21	0.6
27	6019.9	7798.8	1778.9	6.0 ±0.5	5.9±0.6	7.8 ±0.4	6.8
28	6154.5	7933.4	1778.9	0.26±0.05		0.55 ±0.07	0.2
29	6265.3	r	6276.5	2.1 ±0.2	2.4±0.4	3.4 ±0.2	2.4
30	6810.0	8588.9	1778.9	0.24±0.05			0.3
31	6878.6	6878.6	0	0.63±0.06	0.5±0.2	0.59 ±0.04	0.4
32	7639.2	9418.1	1778.9	0.23±0.05		0.32 ±0.06	0.2
33	7924.0	r	4617.8	4.3 ±0.4	4.9±0.9	5.2 ±0.4	4.9
34	7933.4	7933.4	0	3.7 ±0.4	3.8±0.9	3.9 ±0.3	3.4
35	9478.5	9478.5	0	0.98±0.10	1.1±0.4	1.1 ±0.1	1.1
	10275	10275	0		1.1±0.4		
36	10762.9	r	1778.9	76.6 ±1.5	77.0±7.7	72.4 ±3.6	75
	12541.8	r	0			0.022±0.009	<0.02

[a] The intensities for the decay of the bound states are calculated using the branchings given in ref. 4.

Experimental Setup





at the AN2000 accelerator we will use a proton beam to perform a scan of the 992 keV resonance of the $^{27}Al(p,\gamma)^{28}Si$ reaction. We will characterise the target parameters and in particular its thickness and we will check the accelerator calibration and if possible the beam energy spread

what to do

- Focusing of the beam on the Al sample
- Energy calibration of the detector (HPGe)
- Efficiency calibration with sources (if enough time)
- Scan of the narrow resonance and the target thickness
- Determination of the target thickness and beam spread with a proper fit