Neutron-induced activity studies of the ATLAS SCT strip detector module, glues and paint

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Layout

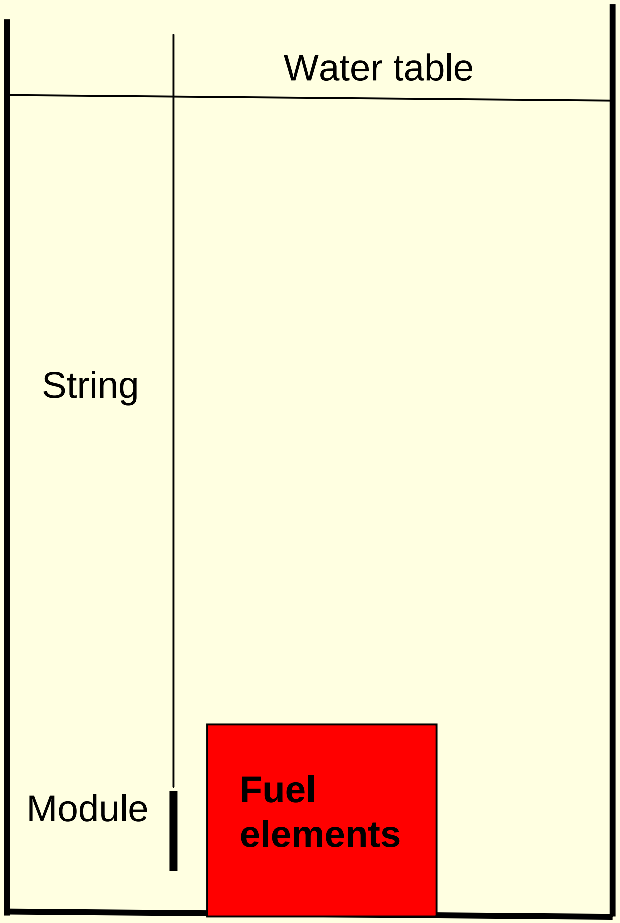
1. Motivation
2. Experimental setup for thermal-neutron activation study of the module
3. Data analysis
4. Example of a delayed gamma-ray spectrum of the module activated by thermal neutrons
5. Results
6. Experimental setup for the fast-neutron activation studies
7. Description of samples
8. Example of a delayed gamma-ray spectrum of the module activated by fast neutrons
9. Preliminary results
10. Conclusion

1. Motivation

- The neutrons arising during the interactions on the ATLAS detector will be moderated by environment matter of this detector.
- 60% of the all moderated neutrons will have their energy in thermal region.
- Two aims of activation studies are:
  - to specify the radiation protection of workers and
  - to study of background signal.
- The main goal of this work is:
  - to find out a neutron-induced activity in several components of the ATLAS detector.

2. Experimental setup for thermal-neutron activation study of the module

- The ATLAS SCT silicon strip end-cap detection module was activated.
- VR-1 CTU Prague training reactor was used.
- Two gold foils were used as neutron flux monitors.
- The module was situated ~3 cm from fuel elements.
- The activation time was 165 min. and the neutron flux was $(7.2 \pm 0.2) \times 10^{8}$ cm^{-2}.s^{-1}.



3. Data analysis

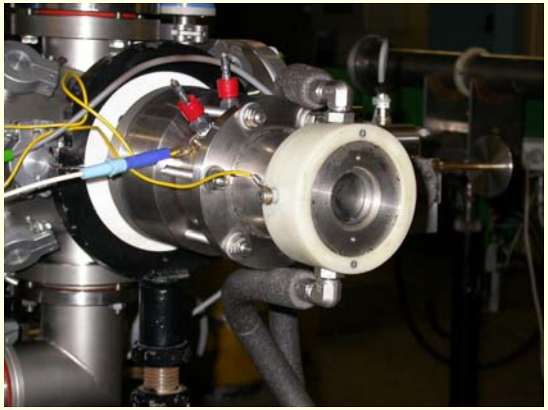
- The delayed gamma-ray spectra were measured by shielded HPGe detector.
- 8 spectra with increasing sequence of real-time periods (1,2,4,...,120 min.) and 22 spectra with fixed duration of 240 min. have acquired due to record of decreasing activity.
- Two parameters (gamma-ray energy and half-life) have been verified to obtain proper identification of the radioisotopes.
- For every identified radioisotope, its activity at the end on the activation was counted up.

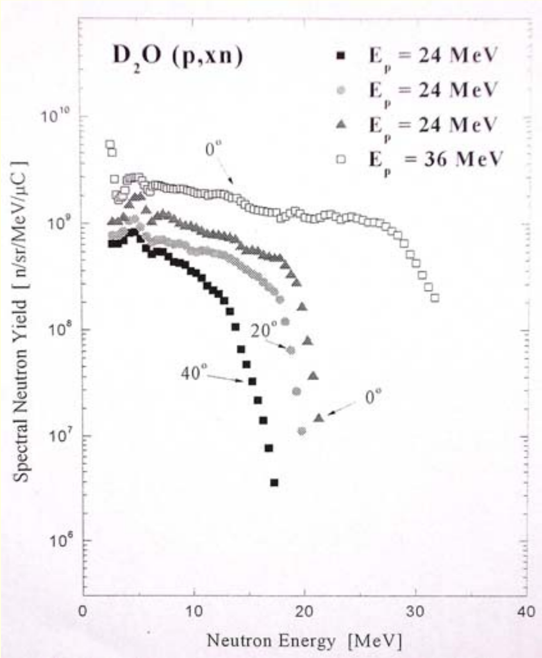
5. Results

#	^{A}X	$t_{1/2}$		Activity				#	^{A}X	$t_{1/2}$		Activity			
1	^{24}Na	15.0	h	37.0	±	5	kBq	14	^{110M}Ag	250.0	d	318.0	±	32	Bq
2	^{27}Mg	9.5	m	79.0	±	8	kBq	15	^{116M}In	54.3	m	4.2	±	0.4	kBq
3	^{28}Al	2.2	m	5.2	±	0.5	MBq	16	^{117M}Sn	13.6	d	59.0	±	7	Bq
4	^{38}Cl	37.2	m	1.6	±	0.3	kBq	17	^{123}Sn	40.1	m	2.0	±	0.2	kBq
5	^{42}K	12.4	h	5.5	±	0.6	kBq	18	^{125M}Sn	9.5	m	11.0	±	1	kBq
6	^{51}Ti	5.8	m	4.8	±	0.7	kBq	19	^{122}Sb	2.7	d	2.9	±	0.3	kBq
7	^{56}Mn	2.6	h	7.1	±	0.9	kBq	20	^{124}Sb	60.2	d	73.0	±	7	Bq
8	^{65}Ni	2.5	h	1.2	±	0.1	kBq	21	^{131}Ba	11.5	d	120.0	±	12	Bq
9	^{64}Cu	12.7	h	2.0	±	0.2	MBq	22	^{135M}Ba	28.7	h	840.0	±	100	Bq
10	^{66}Cu	5.1	m	3.8	±	0.5	MBq	23	^{137M}Ba	2.6	m	10.0	±	2	kBq
11	^{69M}Zn	13.8	h	496.0	±	51	Bq	24	^{139}Ba	83.1	m	79.0	±	8	kBq
12	^{82}Br	35.3	h	377.0	±	38	Bq	25	^{182}Ta	114.4	d	227.0	±	23	Bq
13	^{108}Ag	2.4	m	4.3	±	0.4	MBq	26	^{198}Au	2.7	d	35.0	±	4	kBq

6. Experimental setup for the fast-neutron activation studies

- Fast neutrons were produced from a cyclotron by means of (p,n) reaction on a thick beryllium target (right upper figure).
- Energy spectrum of the neutrons arising in the beryllium target is practically same as in the case of D_2O target (right lower figure).
- The target is roughly a point source of neutrons, and therefore, the distance between the target and the activated samples defines the neutron flux.
- The analysis was done by same way as in case of the thermal-neutron induced activity.





7. Description of samples

- The ATLAS SCT silicon strip end-cap detection module (pictured on the right side)
- Two samples of glue are:
  1. Araldite AW106/HV953,
     - which is an epoxide adhesive glue of the sample weight of 34.3 mg, and
  2. Eotite P102,
     - which is a special adhesive glue comprising silver sawdust of the sample weight of 21.3 mg.
- One candidate of fireproof white paint for the JM shielding
  - of the sample weight of 146.4 mg.

9. Preliminary results

- All samples have been activated. The total fluence of the SCT module is 1.54×10^{12} cm^{-2}; the total fluence of the other samples is 1.73×10^{14} cm^{-2}.
- For every sample, five delayed gamma-ray spectra were measured.
- The radioisotopes were produced by means of nuclear reactions the likes of (n,γ), (n,p), (n,2n), (n,np), ...
- The main peaks in the spectrum of the SCT module activated by fast neutrons are related to ^{27}Mg, ^{29}Al, and ^{24}Na radioisotopes arising by neutron reactions on Si, Al, and Mg elements.
- All spectra are still in processing.

10. Conclusion

- The activations by means of thermal as well as fast neutrons were done. The activated samples were:
    1. the ATLAS SCT silicon strip end-cap detection module,
    2. two samples of glue (Araldite AW106/HV953 and Eotite P102), and
    3. a candidate of fireproof white paint for the JM shielding.
- These experiments proved the necessity of taking into account the activation of ATLAS detector components.
- The results of the activation of the SCT module by the thermal neutron flux showed that 26 radioisotopes, some of them long lived, are generated.
- The data from the activation by means of the fast neutrons are in processing.

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