NIST Center for Neutron Research

Evaluation of Gaseous Effluent Monitor Major Scram Setpoint

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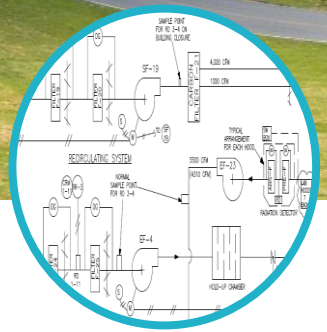
NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Today I will discuss the methods used to evaluate a major scram setpoint of a new gaseous effluent monitor




U.S. NUCLEAR REGULATORY COMMISSION

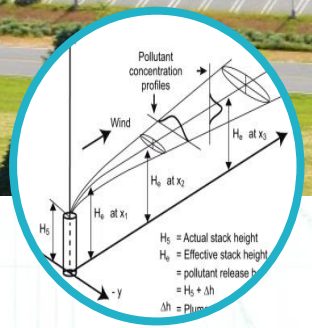
REGULATORY GUIDE

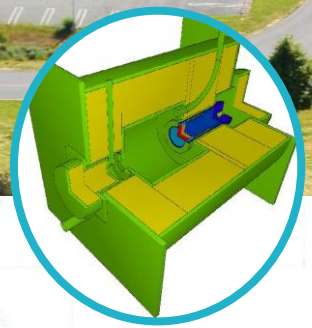
OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 4.20

CONSTRAINT ON RELEASES OF AIRBORNE RADIOACTIVE MATERIALS TO THE ENVIRONMENT FOR LICENSEES OTHER THAN POWER REACTORS

A. INTRODUCTION





About us

Regulations

Dilution Factors

Detection System

NIST Center for Neutron Research

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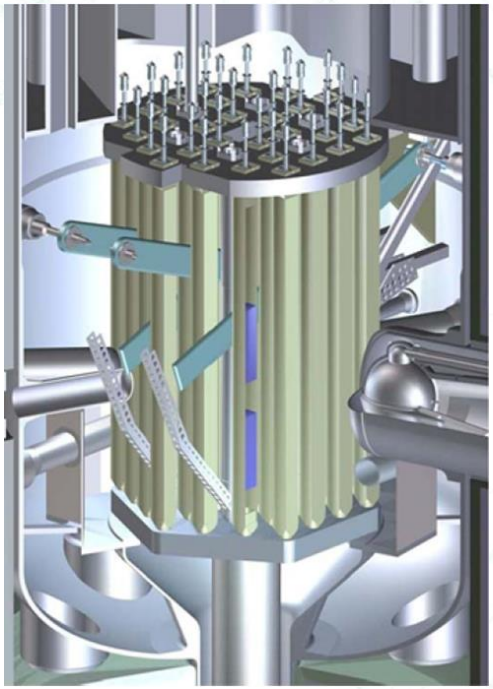
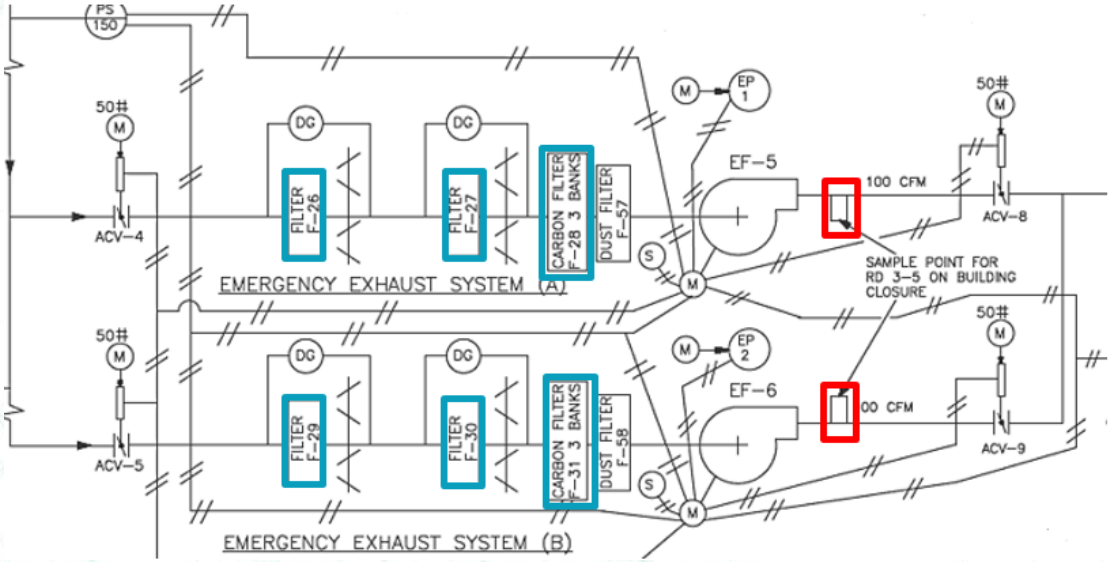
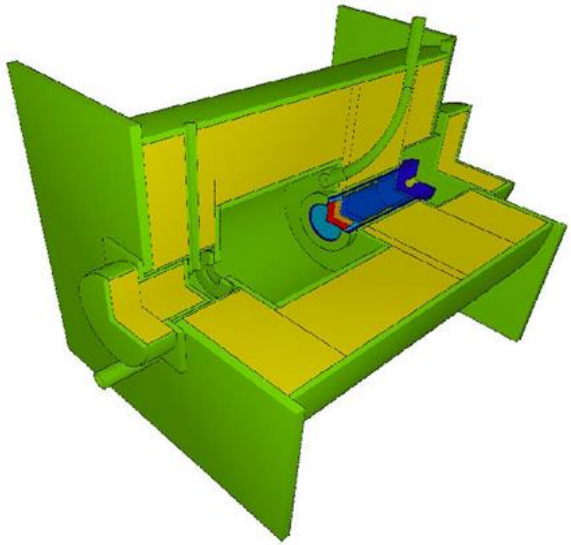
If the trip levels of the Normal Air Monitor, the Irradiated Air Monitor, or the Stack Monitor channels exceed their trip set point, a Major Scram is initiated.

A major scram will shutdown the reactor and activate the confinement isolation system and emergency exhaust.





The NCNR is focusing efforts on installing a new monitoring system to replace the failed Normal Air Channel.



The major scram setpoint is calculated to ensure that the alarm will occur prior to exceeding the limits of 10 CFR 20.

- **100 mrem in a year** TEDE to individual members of the public
- **2 mrem in any one hour** in any UNRESTRICTED AREA from external sources

The setpoint can be calculated using effluent concentration limits in Table 2, Col. 1, in Appendix B to 10 CFR Part 20.

$$\sum_{i=1}^{N} f_i D_i \, e_i \, ECL_i$$

Where,

- f_i = the fractional abundance of the activity for the nuclides considered
- D_i = the nuclide specific dilution factor
- e_i = nuclide specific detection efficiency (cpm per µCi/ml)
- ECL_i = the effluent concentration limits in Table 2, Col. 1, in Appendix B to 10 CFR Part 20

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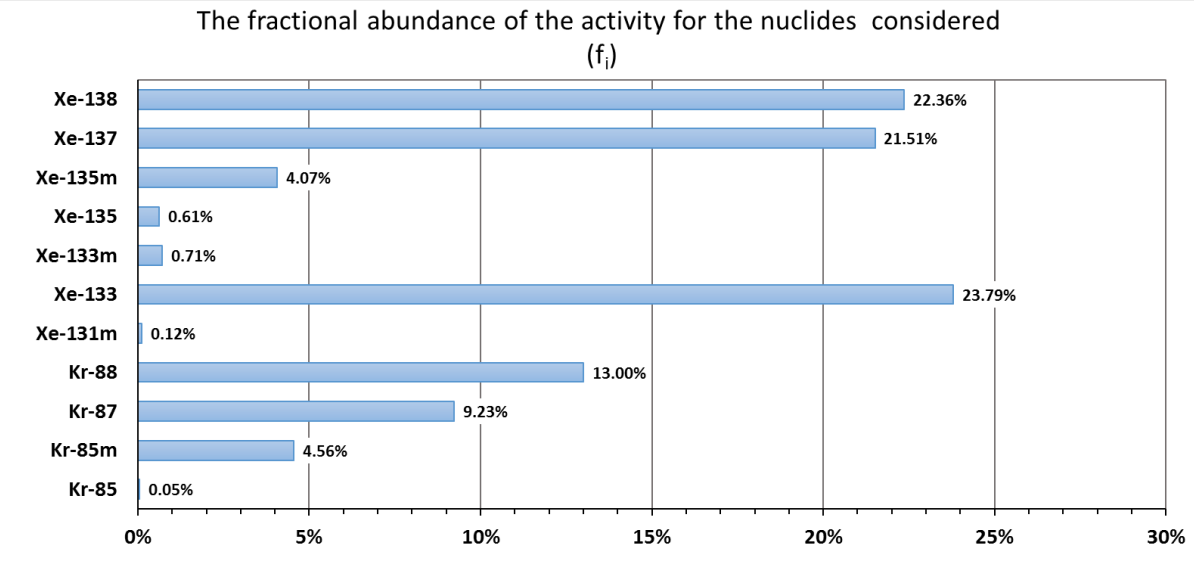
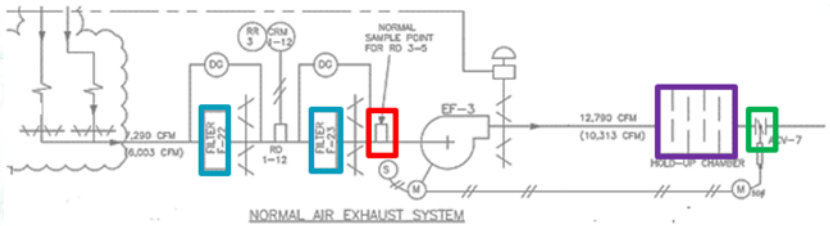
The source term is based on the inventory of noble gas fission products in a fuel element after 8 cycles.



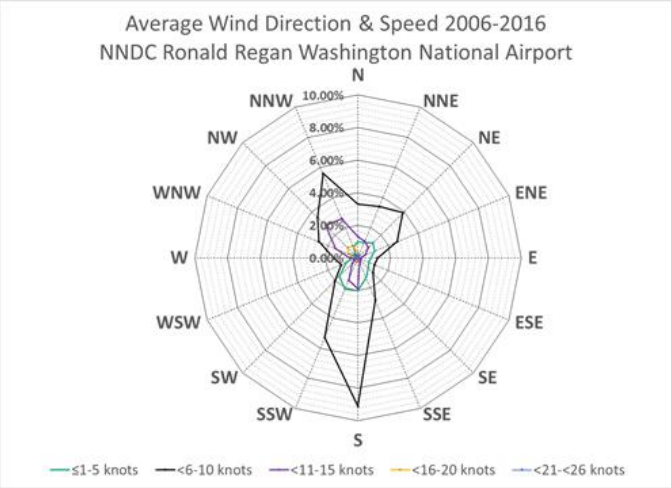
Isotope	Activity Inventory in an element after 8 cycles (Ci)
Kr-85	7.91E+01
Kr-85m	7.01E+03
Kr-87	1.42E+04
Kr-88	2.00E+04
Xe-131m	1.78E+02
Xe-133	3.66E+04
Xe-133m	1.10E+03
Xe-135	9.42E+02
Xe-135m	6.26E+03
Xe-137	3.31E+04
Xe-138	3.44E+04

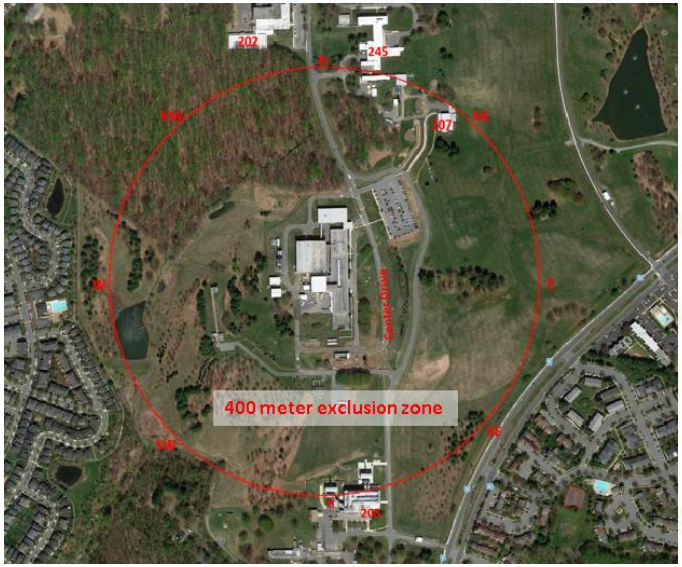
Determined by ORIGEN2



$$\sum_{i=1}^{N} f_i D_i e_i ECL_i$$

Dose coefficients (mrem/kCi) from the EPA COMPLY code can be used to estimate site specific dilution factors.





Isotope	Dose Coefficient @ 400 meters (mrem/kCi)
Ar-41	1.30E+00
Kr-85	2.20E-03
Kr-85m	2.00E-01
Kr-87	9.00E-01
Kr-88	2.70E+00
Xe-131m	8.40E-03
Xe-133	3.40E-02
Xe-133m	2.90E-02
Xe-135	2.00E-01
Xe-135m	4.00E-01
Xe-137	n/a
Xe-138	1.40E+00

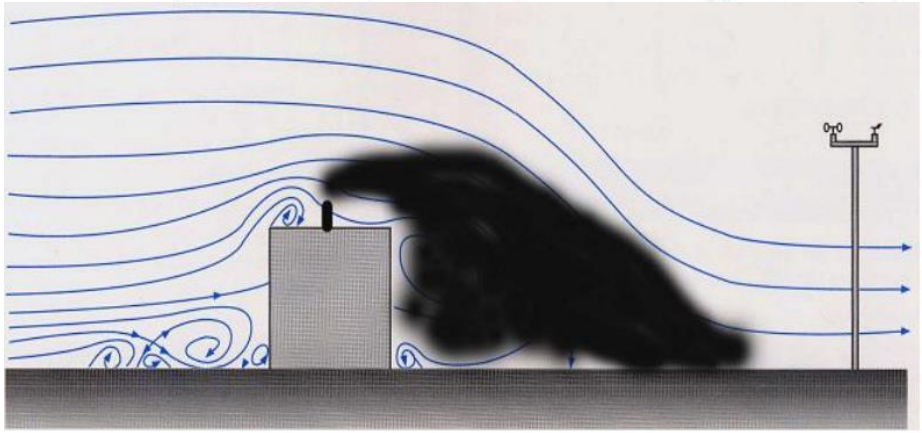
The E.C. Limit fo Xe-137 was based on the unlisted E.C. limit for nuclides with decay mode other than alpha emission or spontaneous fission and with a radioactive half-life less than 2 hours. Also Xe-137 is not listed in EPA COMPLY V 1.7.1 the dilution factor was based on the average of the dilution factors from the other Xe isotopes

$$\sum_{i=1}^{N} f_i D_i e_i ECL_i$$

Dose coefficients (mrem/kCi) from the EPA COMPLY code can be used to estimate site specific dilution factors.

Isotope	Dose Coefficient @ 400 meters (mrem/kCi)	Avg. annual concentration in stack to give 100 mrem @ 400 meter boundary (µCi/ml)	E.C. Limit (µCi/ml)	Dilution Factor to 400 meter boundary
Ar-41	1.30E+00	1.71E-04	1.00E-08	17,114
Kr-85	2.20E-03	1.01E-01	7.00E-07	144,465
Kr-85m	2.00E-01	1.11E-03	1.00E-07	11,124
Kr-87	9.00E-01	2.47E-04	2.00E-08	12,360
Kr-88	2.70E+00	8.24E-05	9.00E-09	9,155
Xe-131m	8.40E-03	2.65E-02	2.00E-06	13,243
Xe-133	3.40E-02	6.54E-03	5.00E-07	13,087
Xe-133m	2.90E-02	7.67E-03	6.00E-07	12,786
Xe-135	2.00E-01	1.11E-03	7.00E-08	15,891
Xe-135m	4.00E-01	5.56E-04	4.00E-08	13,905
Xe-137	n/a	n/a	1.00E-09	12,810
Xe-138	1.40E+00	1.59E-04	2.00E-08	7,946

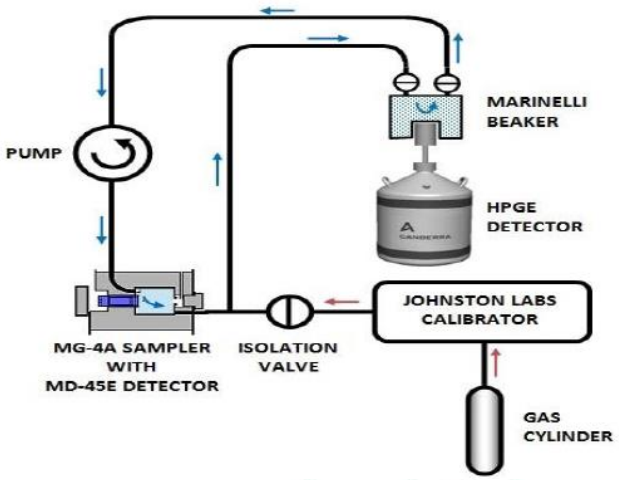
The E.C. Limit fo Xe-137 was based on the unlisted E.C. limit for nuclides with decay mode other than alpha emission or spontaneous fission and with a radioactive half-life less than 2 hours. Also Xe-137 is not listed in EPA COMPLY V 1.7.1 the dilution factor was based on the average of the dilution factors from the other Xe isotopes

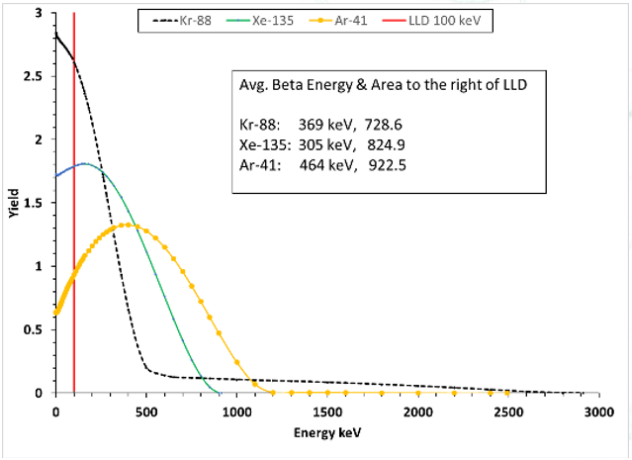


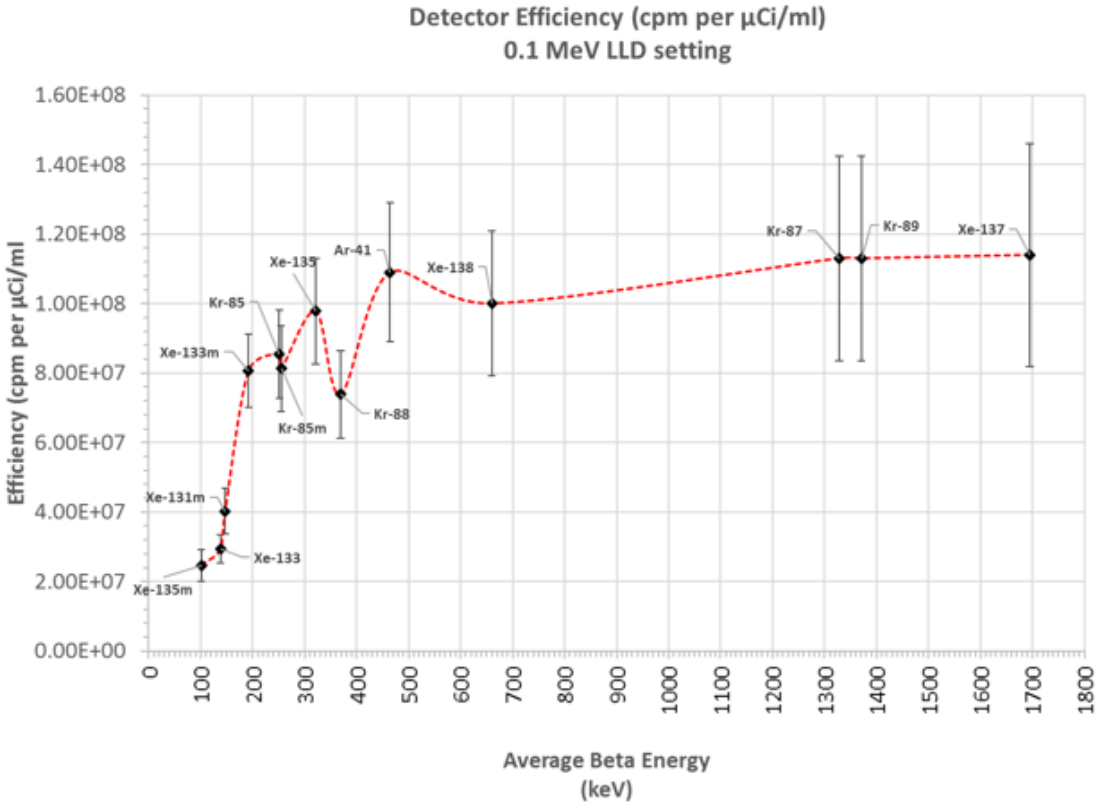
- 30,180 CFM stack exhaust rate
- 4.49×10^{14} ml/year stack exhaust rate
- Kr-85 adjusted to 10,880 (based on avg. dilution factor for other Kr isotopes)
- Xe-137 dilution factor based on avg. dilution factor from other Xe isotopes

$$\sum_{i=1}^{N} f_i D_i e_i ECL_i$$

Detection efficiency for Model MG4 Gas Sampler

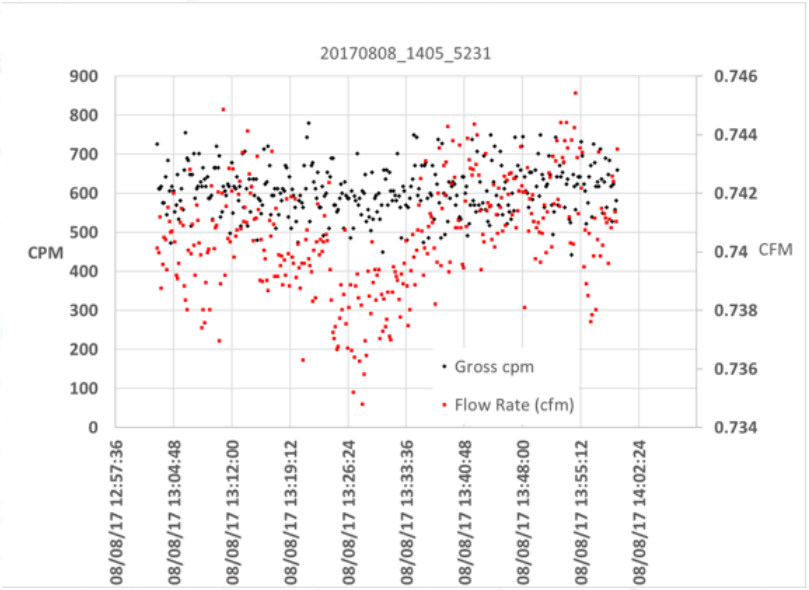


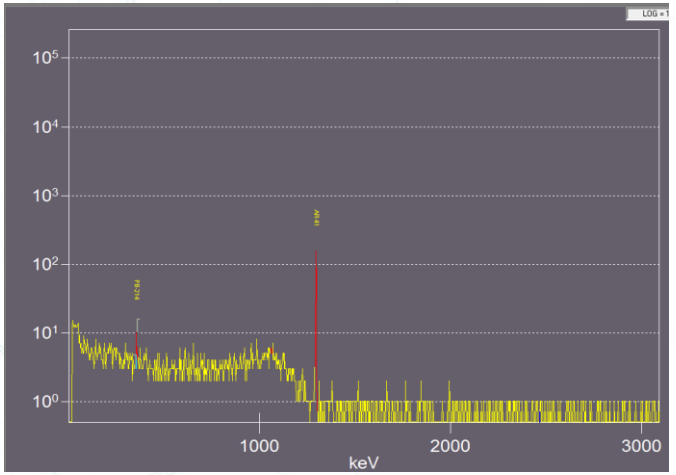




$$\sum_{i=1}^{N} f_i D_i e_i ECL_i$$

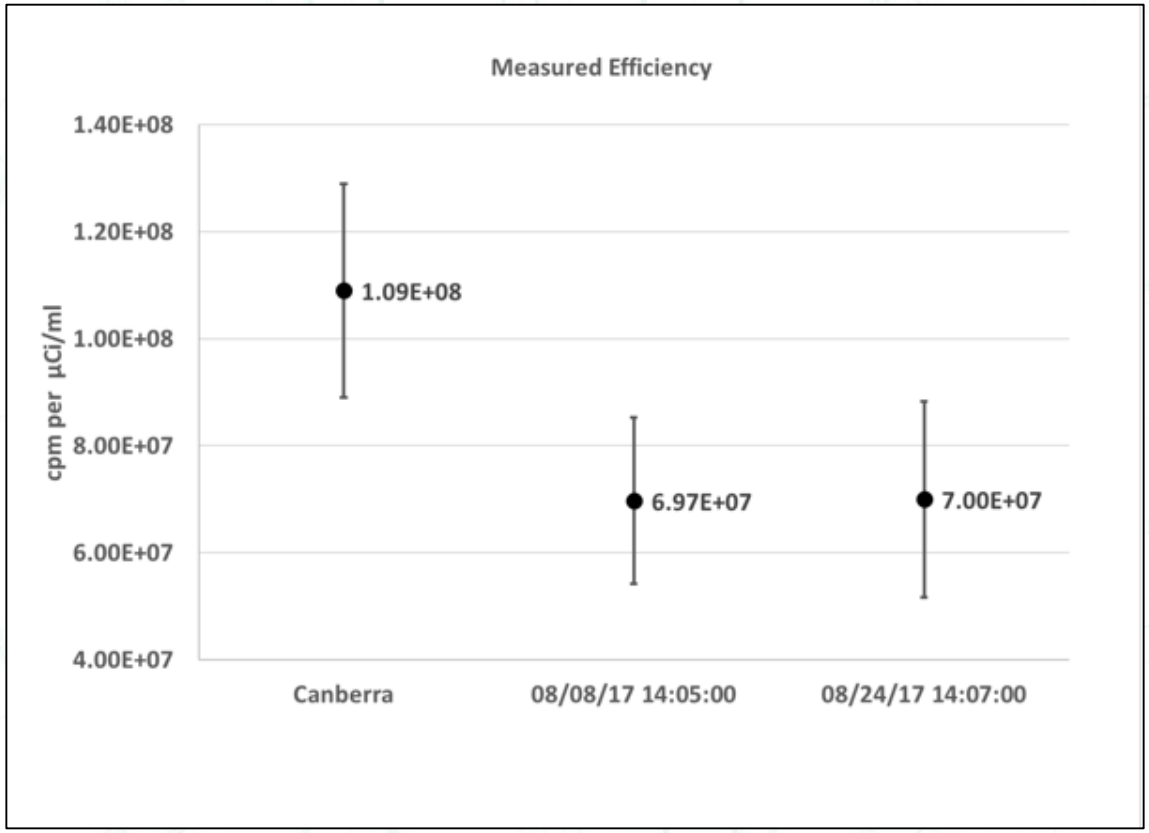
Ar-41 benchmark measurements





$$\sum_{i=1}^{N} f_i D_i e_i ECL_i$$

Ar-41 grab samples were obtained to benchmark the detectors efficiency



$$\sum_{i=1}^{N} f_i D_i e_i ECL_i$$

Isotope	E.C. Limit (μCi/ml)	f_i	0.1 MeV LLD setting (cpm per μCi/ml)	Dilution Factor to 400 meter boundary $D_{400\,i}$	Contribution to total count rate that would lead to a 100 mrem averaged over a year @ 400 meter boundary (cpm)
Ar-41	1.00E-08		1.09E+08	1.71E+04	18,654
Kr-85	7.00E-07	5.14E-04	8.55E+07	1.09E+04	335
Kr-85m	1.00E-07	4.56E-02	8.13E+07	1.11E+04	4,120
Kr-87	2.00E-08	9.23E-02	1.13E+08	1.24E+04	2,578
Kr-88	9.00E-09	1.30E-01	7.39E+07	9.16E+03	791
Xe-131m	2.00E-06	1.16E-03	4.03E+07	1.32E+04	1,235
Xe-133	5.00E-07	2.38E-01	2.94E+07	1.31E+04	45,760
Xe-133m	6.00E-07	7.15E-03	8.06E+07	1.28E+04	4,420
Xe-135	7.00E-08	6.12E-03	9.78E+07	1.59E+04	666
Xe-135m	4.00E-08	4.07E-02	2.47E+07	1.39E+04	559
Xe-137	1.00E-09	2.15E-01	1.14E+08	1.28E+04	314
Xe-138	2.00E-08	2.24E-01	1.00E+08	7.95E+03	3,553

100 mrem in a year @ 400 meter boundary: (normalized to 1 Effluent Concentration)

- **64,331 cpm** - mixture of noble gas fission products released from a fuel element after 8 cycles
- **18,654 cpm** – for Ar-41 continuously released for 1 year at the E.C. limit
- **A continuous dose rate of $\approx$ 11 μrem/hr**

$$\sum_{i=1}^{N} f_i D_i e_i ECL_i$$

Questions ?