An intercomparison experiment between a SAUNA III and a SAUNA II - system

A prototype for the next generation of the SAUNA system - SAUNA III – has for several months been operating in parallel to the SAUNA II - system installed at the IMS station RN63 in Stockholm, Sweden. The first results gives confidence to the new system concept, which consists of a major upgrade of SAUNA II, and demonstrates the improved verification capability that will result using SAUNA III.

Authors

Anders Ringbom, Mattias Aldener, Anders Axelsson, Tomas Fritioff, Johan Kastlander, Anders Mörtsell, FOI, Swedish Defence Research Agency

Experimental

The newly developed SAUNA III - prototype has since December 2016 been running in full operation in parallel with the SAUNA II - IMS system SEX63 in Stockholm, Sweden. The two systems are installed according to Fig. 1. The SAUNA III runs with twice the time resolution and more than doubled sample volume compared to SAUNA II (3 ml stable xenon in 6 h vs. 1.1 ml in 12 h) . This study reports results based on 464 SAUNA III and 262 SAUNA II samples measured in parallel between Feb. 10 and June 15, 2017.

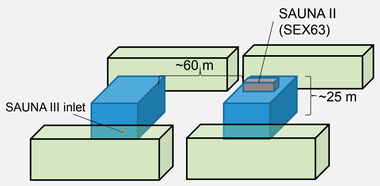

Fig. 1: Schematic drawing of the buildings where the radioxenon systems are installed.

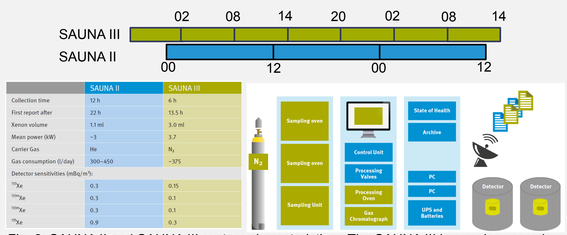

Fig. 2: SAUNA II and SAUNA III system characteristics. The SAUNA III is a major upgrade of the SAUNA II system. The new/upgraded components are shown in green. The collection times used in the experiment are shown at the top.

Data analysis

Beta-gamma spectra from both systems were analyzed using a new analysis method developed at FOI, named the Gross-Count Method (GCM)*. The description of this method is out of scope for this presentation, but we expect the GCM to result in more realistic detection statistics close to the critical level compared to the Net-Count Calculation (NCC) method traditionally used. The differences between the results from the GCM and the NCC methods are negligible at activity concentrations greater than ~0.5 mBq/m^3.

Due to increased radioxenon releases this spring from a nearby Nuclear Power Plant (Forsmark; distance 110 km), caused by damaged fuel elements at one of the reactors, an unusually high number of multi-isotope samples containing three or even four isotopes were measured.

A. Axelsson and A. Ringbom, to be published.

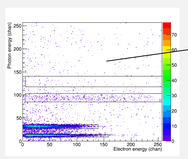

Fig. 3: SAUNA III beta-gamma spectrum containing 65 mBq/m^3 ^{133}Xe and 3.10 mBq/m^3 ^{135}Xe.

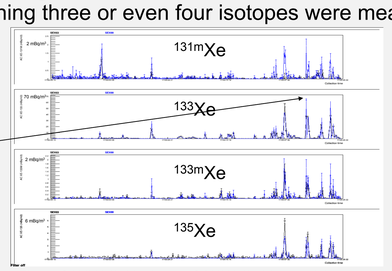

Fig. 4: SAUNA II (black) and SAUNA III (blue) activity concentration measurements from Stockholm air (Feb 10 – June 15, 2017).

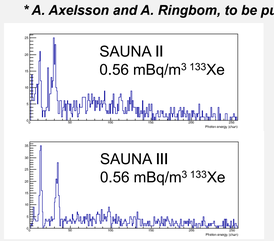

Fig. 5: Two gamma energy spectra illustrating the difference in measurement quality between SAUNA II and SAUNA III. Both samples contain 0.56 mBq/m^3 of ^{133}Xe. Note the improved counting statistics for SAUNA III, in spite of the shorter measurement and collection times.

Basic detection statistics

	Xe-131m		Xe-133		Xe-133m		Xe-135	
	II	III	II	III	II	III	II	III
Mean AC	0.024	0.083	2.32	2.15	0.037	0.050	0.158	0.108
Mean LC	0.136	0.118	0.191	0.106	0.118	0.068	0.372	0.138
Mean MDC	0.282	0.246	0.394	0.221	0.255	0.152	0.794	0.295
AC>=LC	14.6%	23.9%	60.8%	65.3%	9.05%	11.2%	12.1%	9.48%

A comparison of basic detection statistics for the two systems, calulated for the period Feb 10 - June 15, 2017.

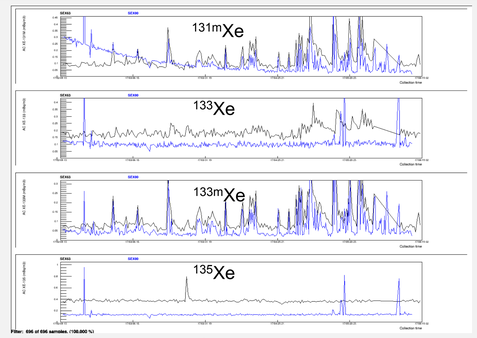

Fig. 6: Critical Limit (mBq/m^3) for all measured samples and isotopes. SAUNA II data: black; SAUNA III- data : blue.

Activity concentrations

The SAUNA II and SAUNA III data sets show a very strong correlation. In order to investigate this further, the SAUNA III data was transformed to the SAUNA II collection cycle (both start time and duration). The result, compared to SAUNA II data, is shown in Fig. 7. A linear fit results in a regression coefficient > 0.8 for all isotopes except for ^{135}Xe. The reason for the results, in particular for ^{135}Xe, is still under investigation.

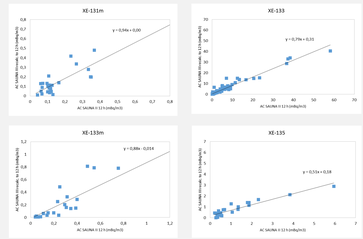

Fig. 7: Comparison between measured activity concentrations for the two systems. The SAUNA III data has been transformed to the SAUNA II collection cycle. Only data resulting in detections in both systems are used in the fit.

Isotopic ratios

The SAUNA III data set show a substantial increase in number of detected ratios as well as a lowered ratio uncertainty. See Fig. 8.

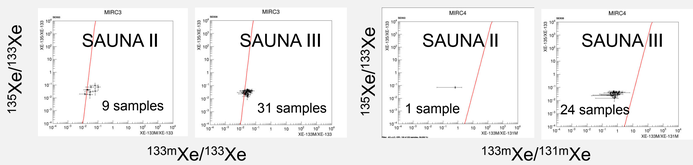

Fig. 8: Observed multi-isotope plots for the two data sets.

Plume shapes

The decreased collection time (6 vs. 12 hours) revealed a more complex plume time structure (see Fig. 9). This should in general result in improved location capabilities. In this particular case, the dominating source was only 110 km away, which will require further studies using atmospheric transport modelling with higher spatial resolution than normally used at the Swedish NDC.

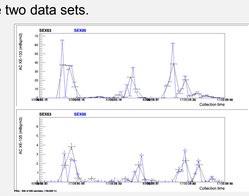

Fig. 9: Examples of observed plume time structures. SAUNA II (black), and SAUNA III (blue).

Summary and Conclusions

Data from the SAUNA II-III system intercomparison show that the SAUNA III performs according to expectations. Data agree very well between the two systems, and the increased measurement sensitivity for SAUNA III, in combination with shorter collection and response time, will substantially improve the verification capability compared to earlier state-of-the art systems.

www.foi.se