



Introduction

After several years of R&D on RadioXe monitoring system (SPALAX), CEA contractualized in Nov. 2015 with Cegelec Defense for the delivery of a SPALAX-New Generation prototype. After 3 years of design study, construction and tests of this prototype, CEA started the qualification process required by PTS for implementation on the IMS network on the 1st October 2018. This first phase (phase 1), that consisted in operate the system at the developer premises for 6 month and provide the associated data at PTS, has been successfully validated in April 2019. That launches the official commercialization of the SPALAX-NG by Cegelec Defense. In parallel, in the PTS process, the phase 2 consists in the same operation into a site where station is operated by an independent organism. This 2nd and last phase will take place at the Health Canada premises (Ottawa, Canada).

1. SPALAX-NG principle

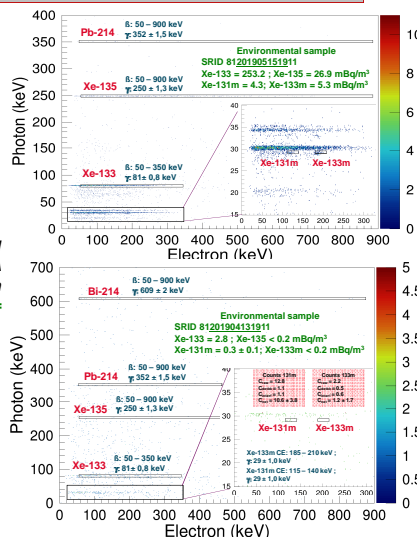
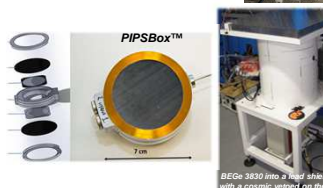
→ Sampling & Purification on permeation membranes. Self production of the carrier gas (N₂).

→ Xe-Rn separation on charcoals (TSA process) and Xe concentration on Silver exchanged zeolite Ag@ZSM-5 (VSA+TSA process). Sample production ≈ 4.5 cm³ Xe into N₂ / 8 h.

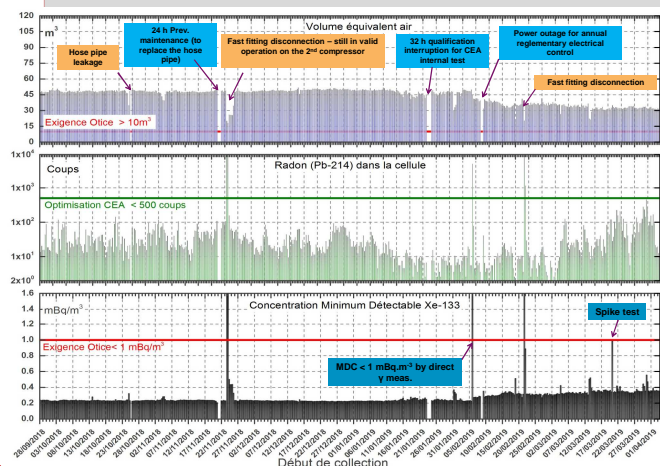
→ Detection with 2 Silicon PIN (PIPSBox™ – Mirion® under CEA licence) detectors in coincidence with a BEGe detector. High resolution = low interference = High Data Quality

→ Removable sub-unit with quick connectors to simplify the maintenance operation. Easy installation < ½ day. No specific equipment required.

The overall system can be seen during SnT at the Cegelec Defense Stand!



2. Validation phase 1: Feedback on 6 month operation



→ Phase 1: from Oct 18 to April 19

→ 542 valid spectra produced / 546 expected

→ > 99 % Data availability

→ 4 invalid spectra:

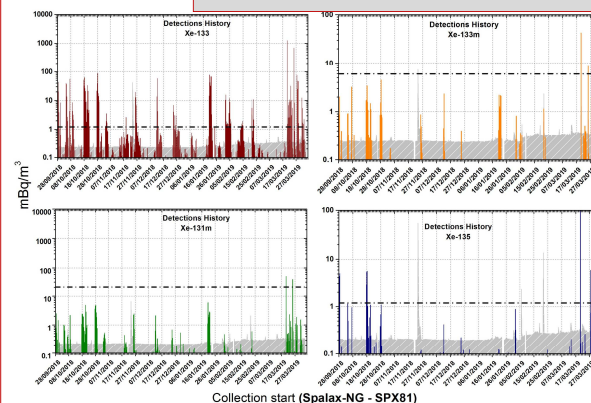
- hose (pipe) leakage (- 1 spectra). All these hose pipes have been replace.
- Disconnection of a fast fitting (Staubli) on the compressors (- 3 spectra). This fast fitting has been replaced by a standard fitting

→ Progressive decrease of the volume due to compressor wear after about 1 yr operation: Sample still valid, 2 compressors in operation allow to prevent unavailability

→ Memory effect = 0.1% (spec < 1%)

→ Cross contamination < 0.4 % (spec < 1%)

3. SPALAX-NG performance over phase 1



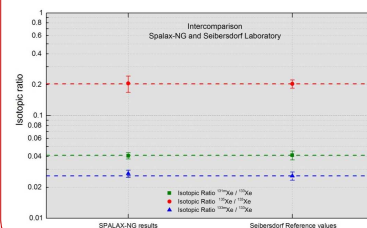
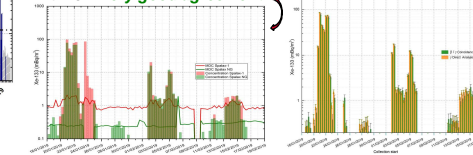
Detection chronic for the 4 Rxe of interest

→ Very low MDC – 0.2 mBq m⁻³ for the 4th isotopes in 8h vs Spalax 1 – 0.3; 6.0; 2.0; 0.9 mBq m⁻³ in 24 h respectively for Xe-133, Xe-131m, Xe-133m and Xe-135

→ Detectability increase for 8h cycle (SNG vs Spalax-1):
x2 for Xe-133: 118 detections (SNG) vs 79 (Spalax-1)
x4.5 for Xe-135: 22 detections (SNG) vs 4 (Spalax-1)
x35 for Xe-131m: 70 detections (SNG) vs 2 (Spalax-1)
x47 for Xe-133m: 47 detections (SNG) vs 1 (Spalax-1)

→ Good agreement between the βγ and the direct γ detection

→ Available comparison with a Spalax-1 for a short period of time = very good agreement



→ Concentration (mBq m⁻³) in very good agreement with FRL08 remeasurement of the spiked samples

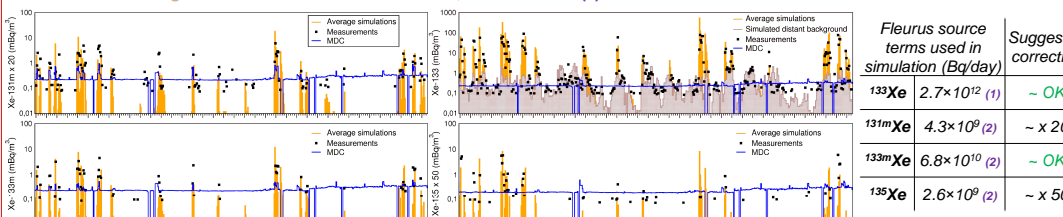
→ Isotopic ratio in very good agreement with reference values from Seibersdorf

4. SNG contribution to the Xe Background knowledge

□ ATM* reproduces 6 months of SNG measurements in Paris, and shows contributions from :

- Mainly **Fleurus MIP*** (Belgium), calculated as an average of FLEXPART runs using 4 sets of meteorological data: WRF (5km / 1 hr) and NCEP: FNL 0.25°, GFS 0.25° and 0.5° (6 hrs)
- Distant ¹³³Xe background due to worldwide MIP and NPP*, calculated as in (1)

□ ATM versus SNG suggests following first guess corrections to Fleurus average source terms used in the simulations:



Fleurus source terms used in simulation (Bq/day)	Suggested correction
¹³³ Xe 2.7 × 10 ¹² (1)	~ OK
^{131m} Xe 4.3 × 10 ⁹ (2)	~ x 20
^{133m} Xe 6.8 × 10 ¹⁰ (2)	~ OK
¹³⁵ Xe 2.6 × 10 ⁹ (2)	~ x 50

(1) ACHIM ET AL. (2016) J. GEOPHYS. RES. ATMOS., VOL. 121, PP. 4951-4966

(2) Estimated from isotopic ratios in GUEIBE ET AL. (2017). J. ENV. RAD. VOL.178-179, PP. 297-314, assuming the ¹³³Xe source term given in (1)

Conclusions & Perspectives

- First qualification phase of SNG successfully achieved in April 2019: DA > 99 % with only few issues on the hose pipes and a fitting. Confirmation that memory effect and cross contamination meet the requirement.
- Outstanding performances are confirmed on a long period of measurement: detectability is drastically increased compared to a Spalax-1 and the high resolution enable to fully avoid the false positive detections as confirmed by the good agreement between βγ and direct γ detections
- SPALAX-NG contributes widely to improve the knowledge on Xe background: Source terms for the main emitter have been corrected for Xe-131m and Xe-135