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XENON RADIOISOTOPE SIGNATURES FROM NPP POWER VARIATIONS AND THEIR IMPACT ON THE CTBTO VERIFICATION REGIME

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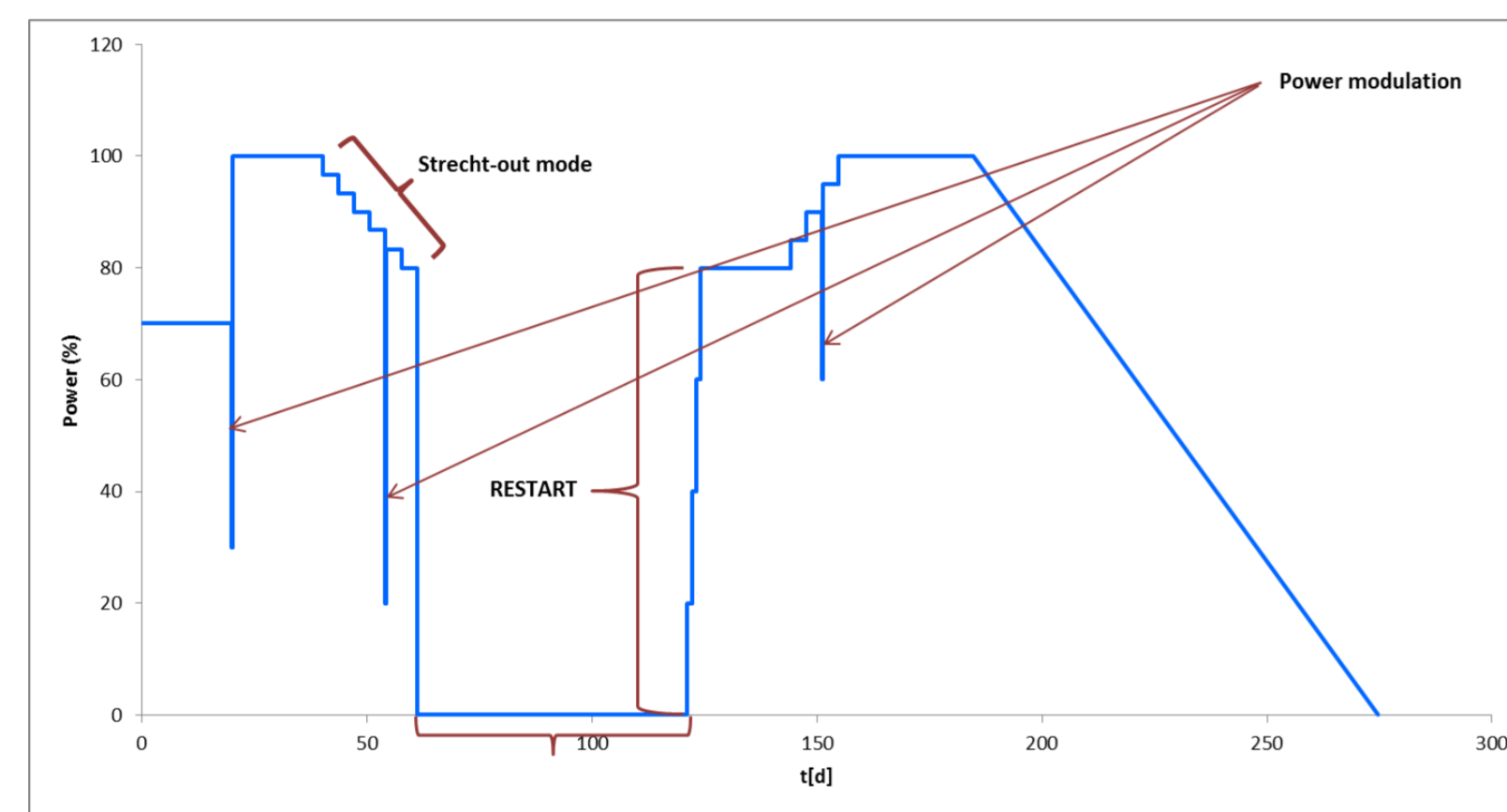
(2) Preparatory Commission for the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO).

INTRODUCTION

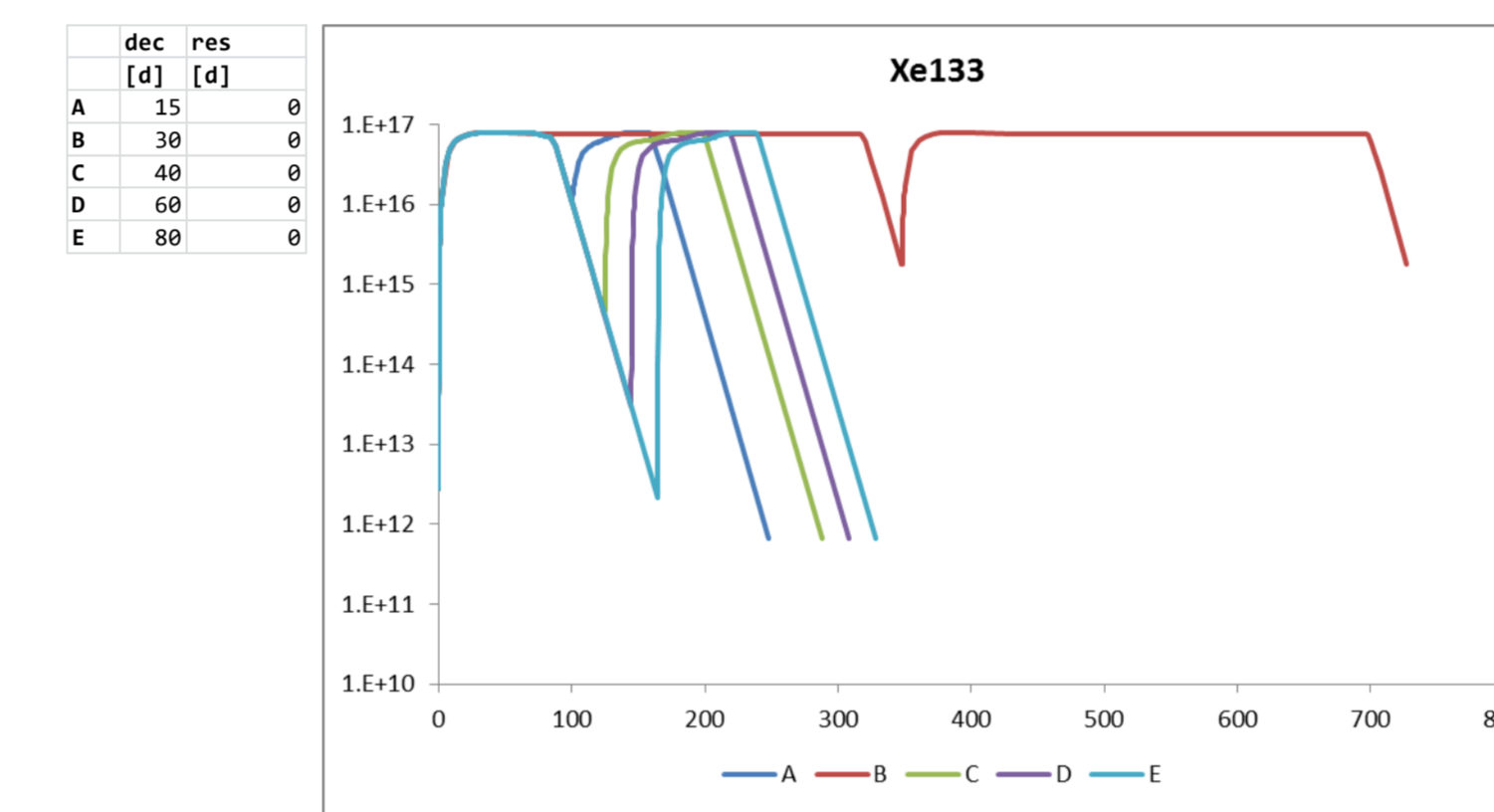
Xenon radioisotopes may be a clear signature of nuclear explosions, so that their detection, by the International Monitoring System (IMS) of the CTBTO, is of paramount importance. However, the emission of Xenon radioisotopes also from other sources, challenges the capability of the IMS to identify significant events out of this background, the isotopic composition of the Xenon trace becoming the actual discriminant for detection. Among the main background sources, there are Nuclear Power Plants (NPPs), which may release Xenon radioisotopes during normal operation cycles. Whilst the typical isotopic signatures of NPPs differ from those of a nuclear explosion, some peculiar conditions - for example, a rapid decrease of power - may impact the composition of radioxenon. In such cases, the power variation velocity has a crucial role in determining the amplitude of 135Xe overshooting, in turn implying variations in the isotopic ratios used to discriminate the released sources. In this work, the variation in 135Xe overshooting as a function of the NPP power ramping-down rate, is investigated through a parametric analysis using the SCALE 6.1 ORIGEN-S code, as well as its impact on the discrimination of the related isotopic ratios with respect to the threshold of the corresponding screening flags.

METHODS and DESCRIPTION

Using the Scale 6.1 Origen-S code, a validated code for performing burnup, depletion and decay calculation of fissile materials, a typical NPP with a 17x17 fuel assembly configuration, 3,2% enrichment and 38,3 MWd power , has been simulated. Two main cases, a Xenon 4-isotope ratios (Xe133m/Xe131m, Xe135/Xe133) and a Xenon 3-isotope ratios (Xe133m/Xe131m, Xe133m/Xe133, excluding Xe135), have been studied. For each case, five parametric sub-cases have been studied: two sub-cases, increasing the restart time (0, 3, 6 days) with a fixed decay time (30 or 60 days) and three sub-cases, increasing the decay time (from 0,5 to 80 days) with a fixed restart time (0 or 3 or 6 days). In each graph, the CTBTO thresholds have been plotted, including the Kalinowski-plot.

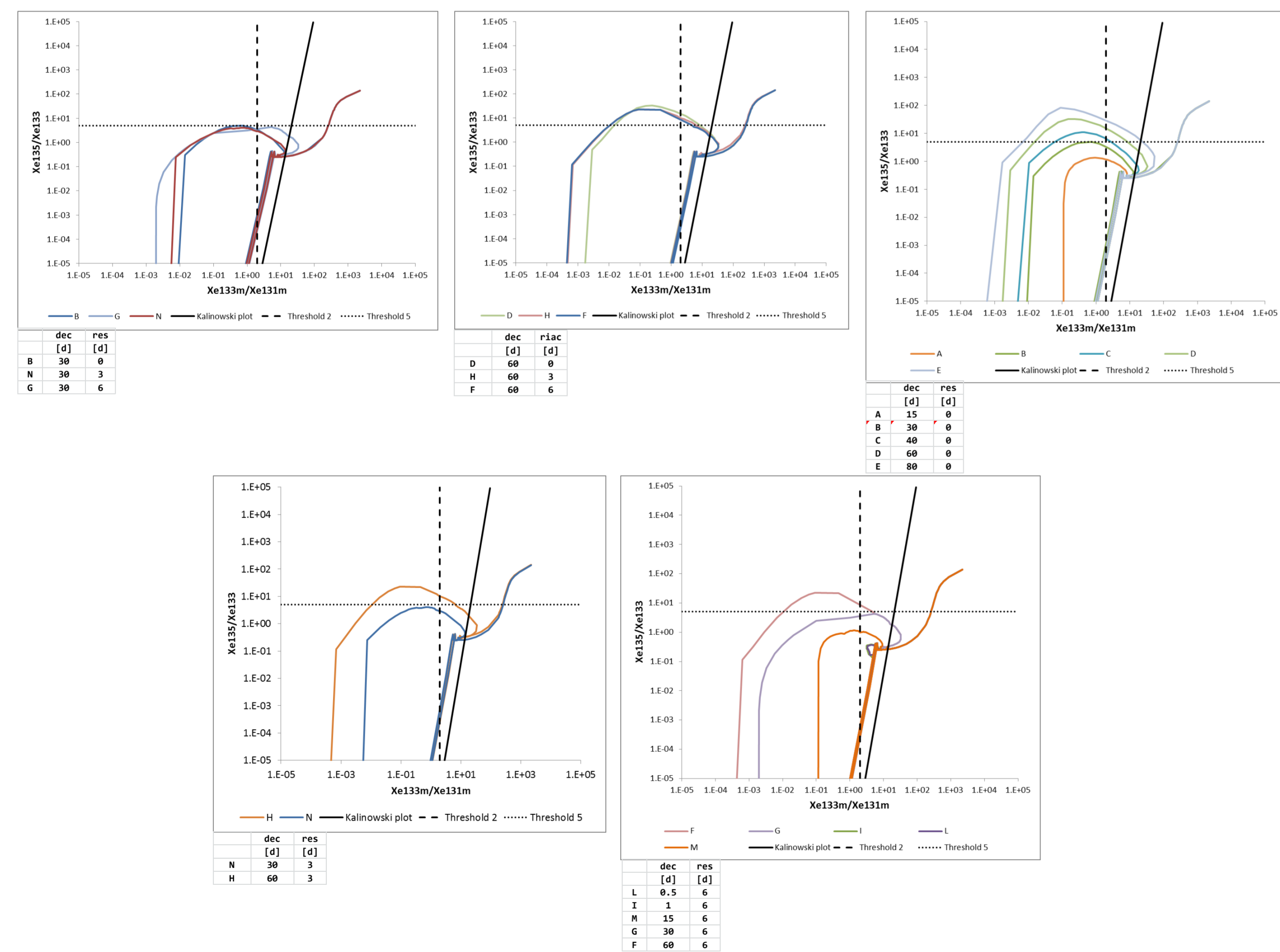


The figure on the left shows an example of the typical time-trend implemented for the simulation of the reactor cycles.

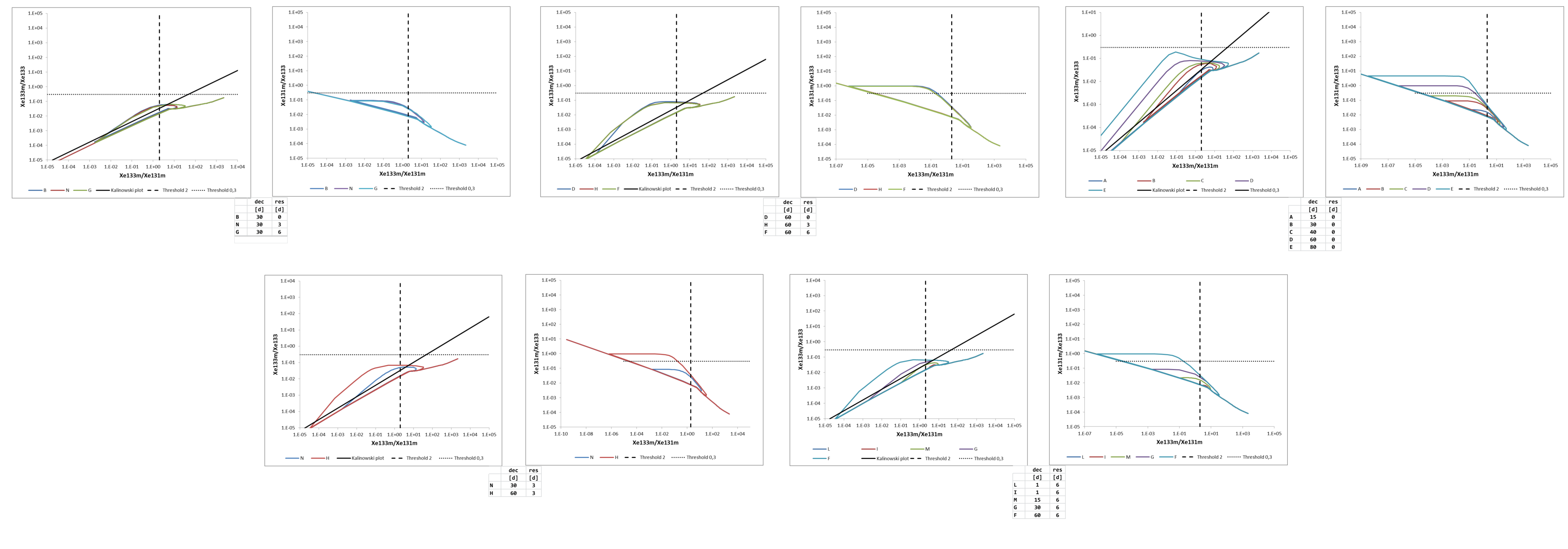


The figure on the left shows an example of the Xenon time-trend (in this case, Xe133) for one of the parametric sub-cases.

4-isotope plots



3-isotope plots



RESULTS

The figures above show the trend of the reactor cycles for each of the parametric sub-cases. In the parametric analysis performed has been verified, for each sub-case, the trespassing of at least one of the indicated thresholds. Moreover, in order to give an idea about the detectability by the IMS stations, of the NPP radioxenon emissions, the value of the MDC from the "State of Health" categorization for samples, has been considered and has been implemented in the equation on the right.

Equations for MDC: Ai / (MTU \* FA / R) \* CR \* FD >= MDC and Ai / (MTU \* FA / R) \* (CFC \* CCA) \* FD >= MDC. Below is a numerical example: 10^11 [Bq/MTU] \* (0,4) [MTU/FA] \* (157) [FA/R] \* (10^-3 \* 10^-1) \* 10^-15 [m^-3] >= 10^-6 [Bq/m^3]

Legend and reference values.

- FA: Fuel Assembly. R: Reactor. CR: dispersion fraction. CFC: dispersion fraction, from Fuel to Coolant. CCA: dispersion fraction, from Coolant to Air. FD: Dilution Factor. Ai/MTU: 10^11 + 10^12 [Bq/MTU] CFC: 10^-3 + 10^-2 CCA: 10^-1 + 1