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Development of a radionuclide expert technical analysis based on isotopic ratios for characterization of CTBT relevant nuclear events

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CTBTO PREPARATORY COMMISSION

INTRODUCTION

The purpose of a radionuclide expert technical analysis (ETA-RN) is to assist State Parties to identify the source of a specific event.

METHODS/DATA

The ETA-RN software suite is based on isotopic ratios detected in samples collected at the IMS network.

START

RESULTS

The functionalities are demonstrated via typical case studies.

CONCLUSION

Evolution of isotopic activity ratios over time through activities released to concentrations in the plume can be used for event characterization.

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Introduction

- The purpose of a radionuclide expert technical analysis (ETA-RN) is to assist States Parties to identify the source of a specific event.
- The output of an ETA-RN is a State Requested Methods Report (SRMR), which builds on routinely generated results from standard International Data Centre products like the radionuclide reviewed report and radionuclide laboratory report.
- The ETA-RN software suite is based on isotopic activity ratios detected in samples collected in International Monitoring System (IMS) network.
- The analysis modules include the event definition based on radioxenon detections at IMS radionuclide stations, calculations of isotopic ratios using different methods, sample association based on consistency analysis of isotopic ratio evolution, simulations of release scenarios using Bateman equations, event discrimination based on relationship plots of four/three radioxenon detections, event timing using a function of isotopic ratios over time and SRMR generation.

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OBJECTIVES
METHODS/DATA
RESULTS
CONCLUSION

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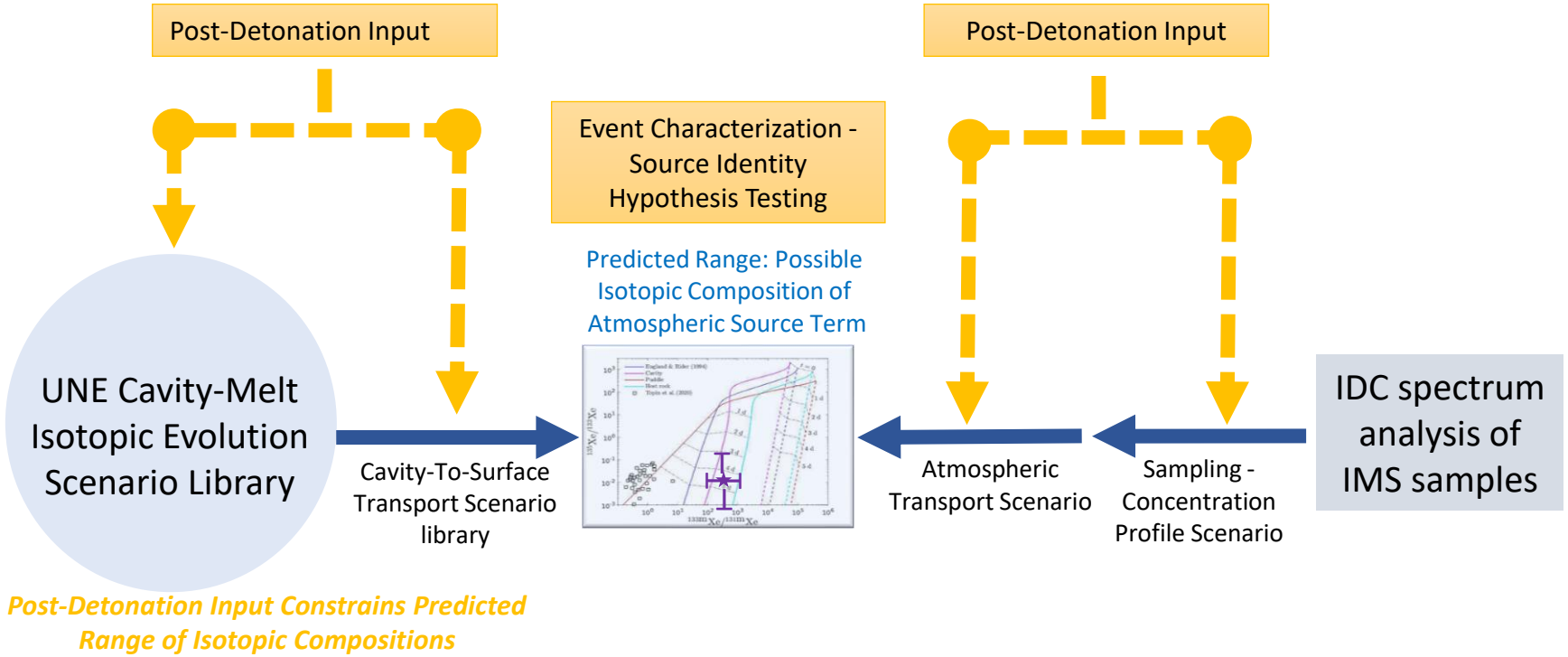
Objectives

- Radionuclide stations in the IMS network routinely collect air samples and assess activity concentrations.
- Activities collected in samples are often caused by emissions from nuclear facilities, but they could also indicate a noble gas release from a nuclear explosion.
- Characterization of CTBT-relevant nuclear events may use the evolution of isotopic ratios over time, which goes from the release of an assumed nuclear explosion, through atmospheric transport, to sample collection and measurements.



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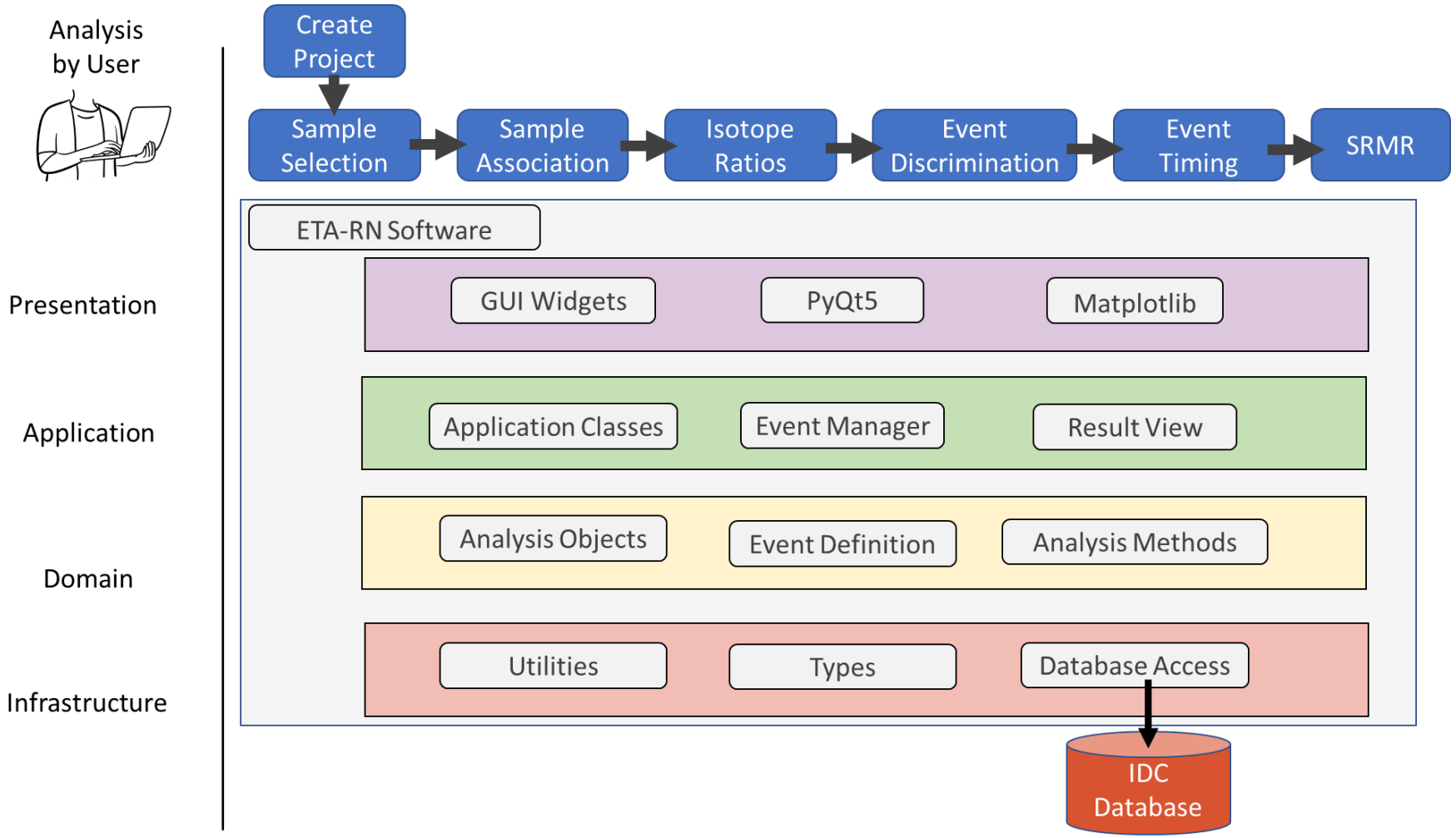
Methods and software design concepts

- Software architecture follows a domain-specific design pattern
- Database schema RMSETA, Connecting to RMS-EXTODB



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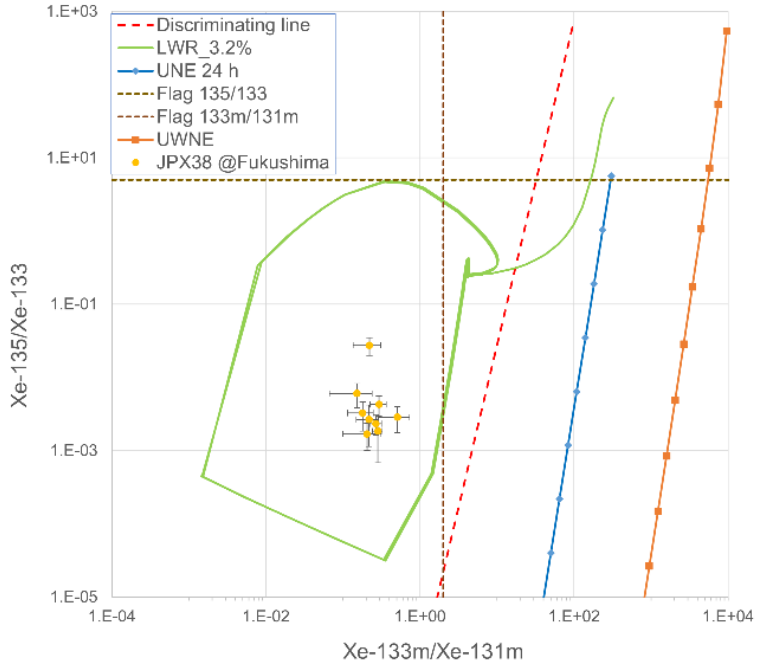
Results

Four radioxenon plot

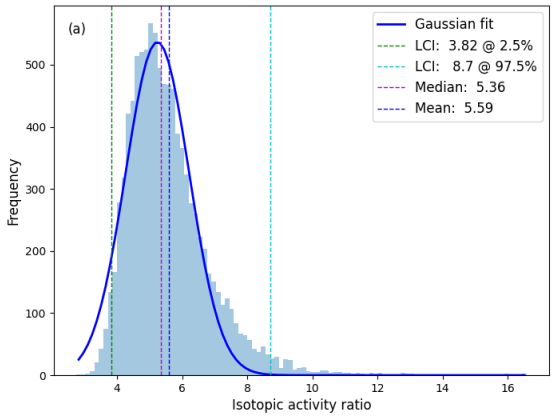
- Hypotheses based on isotopic ratios
  - ✓ H_0: nuclear facility releases
  - ✓ H_1: nuclear explosion release
- Activity evolution of nuclear explosion scenarios



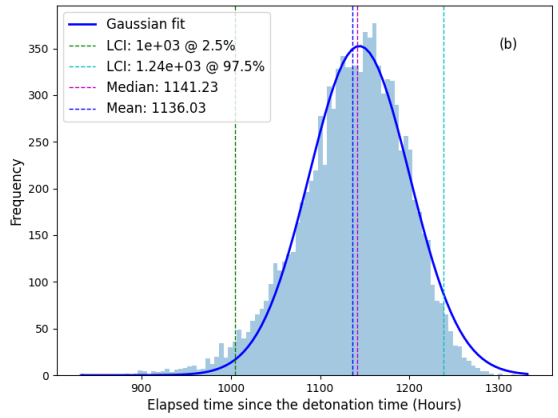
DPRK2013 case study using the Monte Carlo method

- The second sample at JPX38 at 19:00 on 8 April 2012 (the stop of collection)
  - Xe-133: 3.05±0.14; Xe-131m: 0.57±0.11 (mBq/m3).
  - The ratio of 133Xe/131mXe: 5.35±1.06 (nominal value).
- The isotopic ratio and detonation time were estimated
  - U235 (full-ingrowth): 47.3±2.5 days (actual 54.5 days)
  - Limits of the coverage interval (95%): (41.7, 51.7)

Distribution of $R(t_2) = \frac{C_{133}(t_2)}{C_{131m}(t_2)}$



Distribution of detonation times



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Summary

- Evolution of isotopic activity ratios over time through activities released at the explosion site to concentrations in the plume over IMS stations is used for the characterization of CTBT-relevant nuclear events.
- Decay corrections on isotopic ratios of activity concentrations in the plume can be estimated based on the concentration profile in addition of the activities measured in the sample.
- Isotopic activity ratios and their associated uncertainties can be estimated with different methods, including associated characterization limits, which are dependent on the uncertainty level.
- The event discrimination is performed by using the four xenon plot by the coverage interval with given probability.
- Samples of a nuclear event defined by the IDC categorization are refined based on event discrimination and sample association, confirmed by a possible source region analysis of atmospheric transport simulations.
- Event timing is performed by solving the function of isotopic ratios over time, based on detections in one sample or multiple samples.

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