NIGERIAN NUCLEAR
REGULATORY AUTHORITY
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XENON BACKGROUND MEASUREMENTS AND ANALYSIS IN NIGERIA IN THE EQUATORIAL REGION OF AFRICA

By

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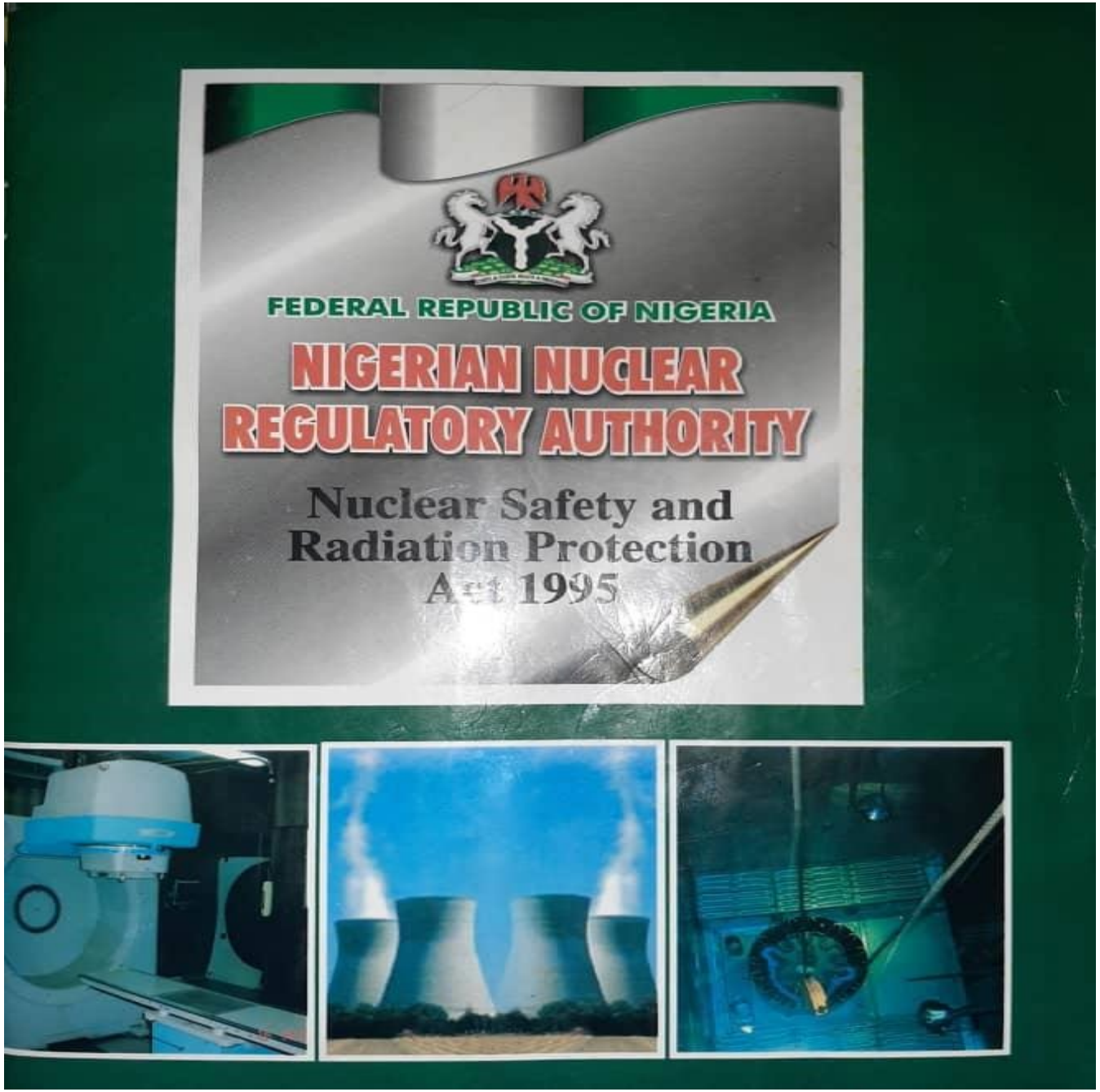
SELF/ORGANIZATION

- Primary responsibility for ensuring nuclear safety and radiological protection regulation in Nigeria
- The NNRA:

  Registers licences, **inspects** and **enforces nuclear safety** and **radiological protection** in all practices in Nigeria .
- Research & Training activities
- Environmental Monitoring
- Kabo Centre



Introduction

- Nuclear technology is fast developing in Nigeria, in the past three decades, the country has been using various radiation generating equipments and sources.
- The practices in Nigeria cover the following main areas: medicine, industry, research and teaching
- Currently operates a 34 KW research reactor
- Nigeria is regarded as an embarking NPP country

Main Specifications of NIRR-1

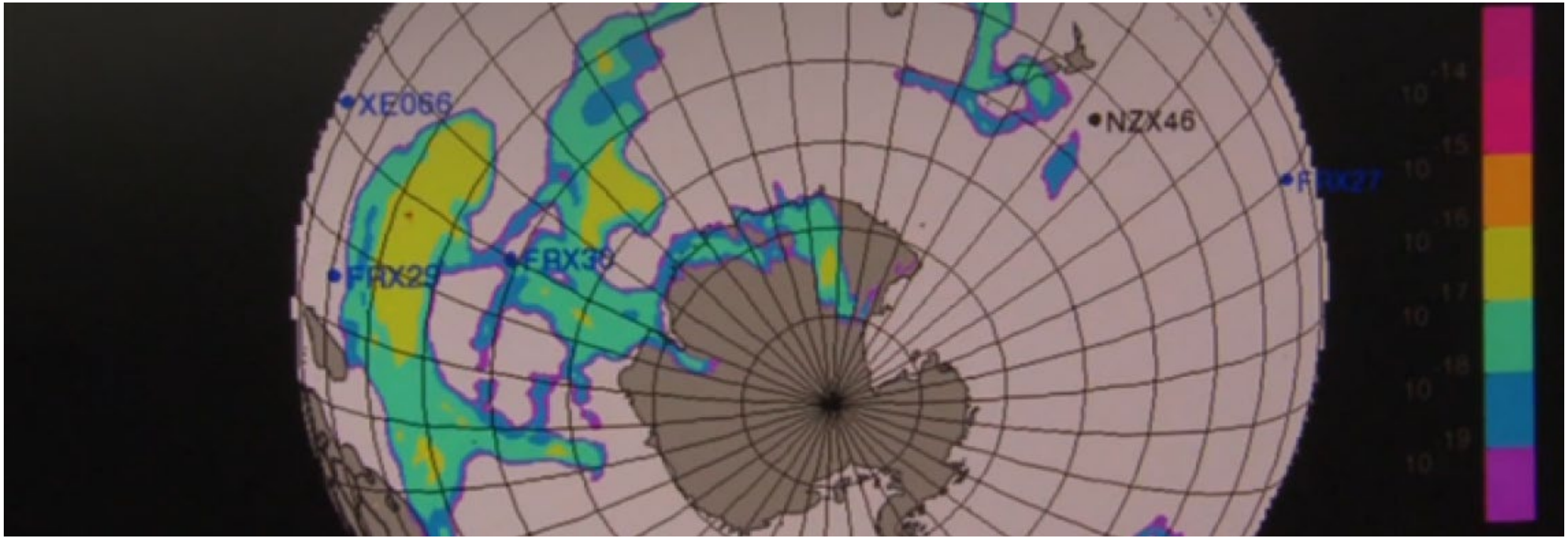
Type	Tank-in-pool
Nominal core power	31 kW (th)
Coolant/Moderator	De-ionised light water
Loading of U-235 in core	1006.65 g
Reflector	Metallic beryllium
Excess Reactivity-cold, clean	3.77 mk
Daily operation fluence in inner irradiation sites	$< 9 \times 10^{15}$ cm^{-2}
Fuel life in core	$> 3.24 \times 10^{19}$ cm^{-2}
Neutron flux at inner irradiation sites	1×10^{12} cm^{-2}s^{-1}, stability ± 1 %, horizontal and vertical variation < 3 %
Number of irradiation sites	10 sites (5 inner and 5 outer) 6 sites connected (4 inner and 2 outer)
Control rod	1, Stainless steel clad, Cadmium absorber
Reactor operation mode	Manual and automatic
Temperature in irradiation sites	Inner site < 54 ^{0}C; outer sites < 40 ^{0}C (at pool temperature of 20 ^{0}C).
Core reactivity temperature coefficient	-0.1 mk/^{o}C; for core temperature 15-40 ^{o}C
Average radiation dose in reactor hall	< 1 µSv/h

Objective

To present the Basis for background study of Xenon in Nigeria / Africa, so as to have a semi-dense network in an interesting Equatorial region of the Earth and to gain the additional necessary knowledge for a correct understanding weather transport and categorization of radioxenon detections

Justification!

Studying the radioxenon background will allow CTBTO IMS to identify suspicious detections more accurately as this source in low concentration occurs naturally.
Even in the Equatorial Region of the World



IMS Monitoring stations in Africa

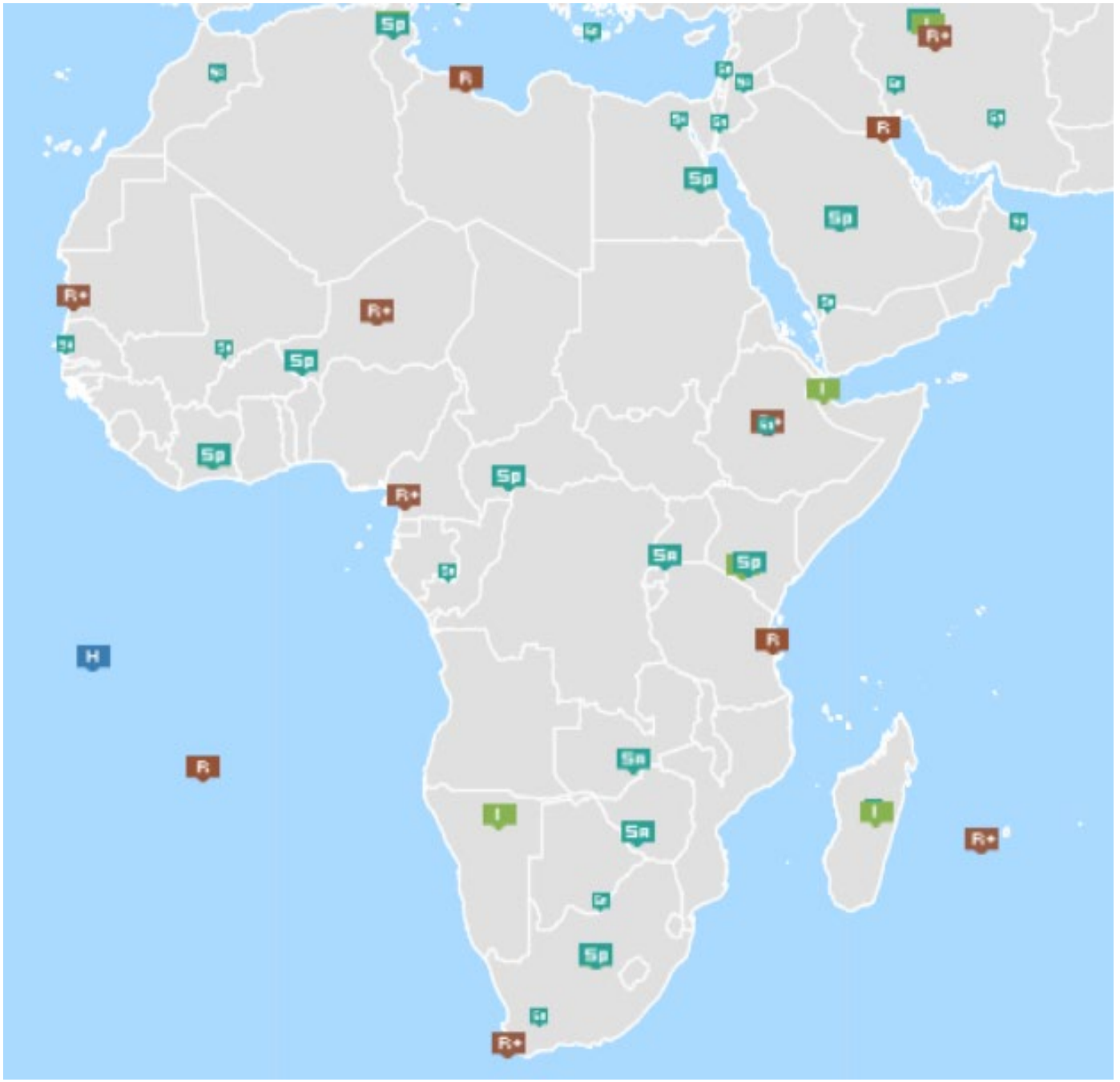
- Africa is the region with the largest number of States hosting IMS) facilities when completed :
  - 38 IMS facilities located in 24 African States
  - 21 seismic stations,
  - 9 infrasound stations
  - 7 radionuclide stations
  - 1 radionuclide laboratory

RN48

Agadez,
Niger
Technology: Radionuclide with Noble Gas detection
Status: Certified

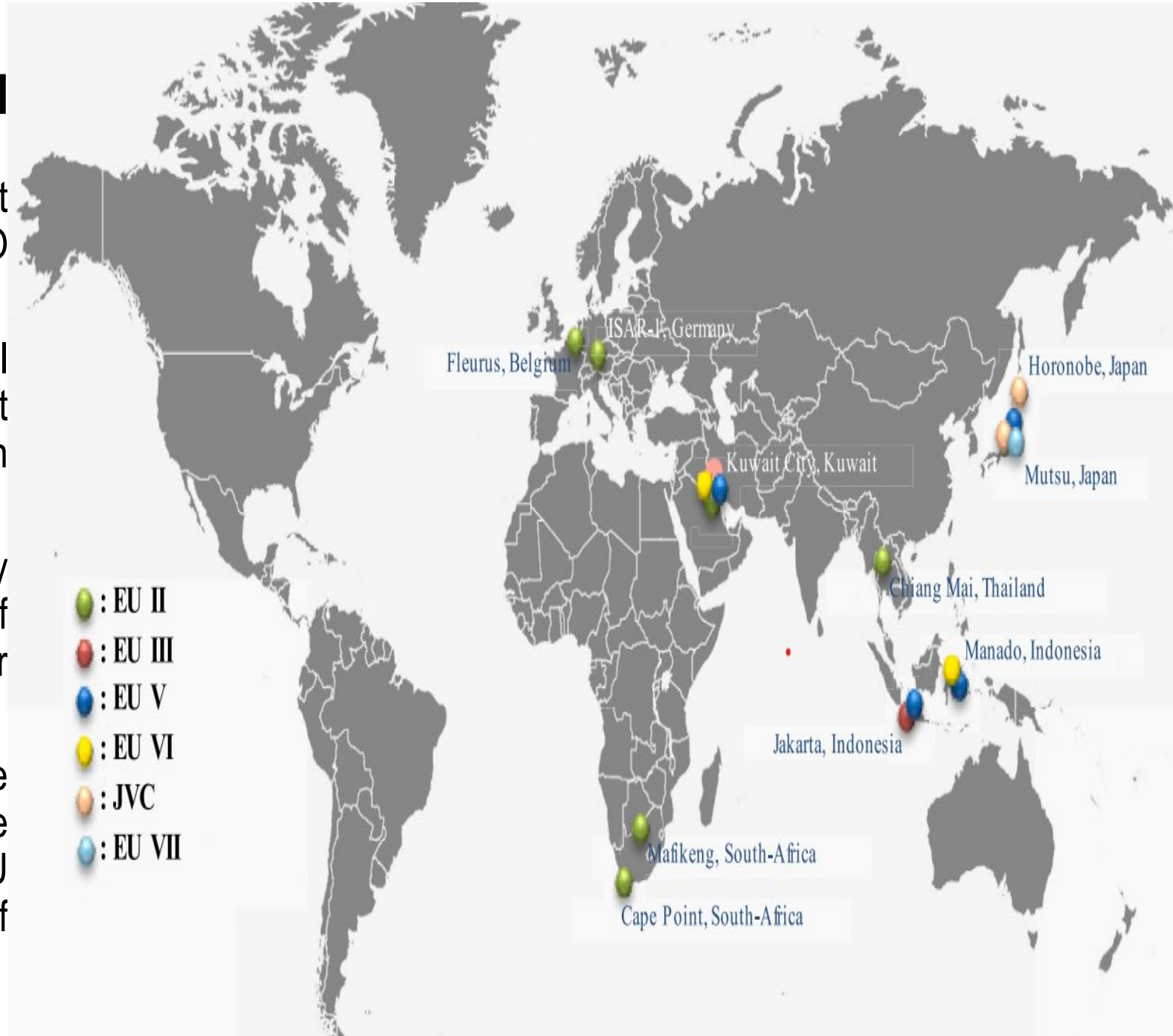
RN13

Edea,
Cameroon
Technology: Radionuclide with Noble Gas detection
Status: Certified



History of xenon background measurements across the world

- Radioxenon background measurement campaigns was conducted for the CTBTO between 2008 and 2018
- The objective was to gain the additional necessary knowledge for a correct understanding & categorization of radioxenon detections
- The xenon radioisotopes are the most likely observable noble gas signatures of underground & underwater nuclear explosions
- Projects were primarily sponsored by the Council of the European Union in the framework of the implementation of the EU strategy against Proliferation of Weapons of Mass Destruction through different funding



Continuation of History of xenon background measurements across the world

- The Government of Japan also made a voluntary financial contribution (JVC) to further support the verification activities of the CTBTO, i.e to procure, deploy and operate a third transportable noble gas detection system
- On-site measurements were organised by the CTBTO over the course of 2008–2009 and were carried out collaboratively with the Swedish Defence Research Agency (FOI) and the Pacific Northwest National Laboratory (PNNL)
- Measurements campaign took place in the following countries ; Kuwait City (Kuwait), Cape Point (South Africa) and Chiang Mai (Thailand), were identified as locations where there was no IMS noble gas system but nuclear facilities in a broader area and specific measurement campaign was perfomed near Isar-I nuclear facility, in Essenbach (Germany) and Japan

Some of the Outcome of the study

- A modular measurement system was deployed in six different locations in Europe, Africa and Asia. Samples were collected
- These campaigns demonstrated that a few major sources of radioxenon (MIPFs, but also NPPs to a lesser extent) contribute in great part to the radioxenon background, impacting the highly sensitive IMS noble gas systems that have the purpose of monitoring compliance with the CTBT
- To complement the knowledge, measurement campaigns were also performed in more remote areas. In these regions, the radioxenon background is in general low and often below the detection limit
- All four isotopes of interest to the CTBTO were frequently observed – up to several Bq/m3 for ^{133}Xe and ^{135}Xe when near large xenon source emittors
- Performing radioxenon background measurements using transportable systems has still a lot to offer in terms of scientific knowledge development
- Japan campaign provided are most relevant opportunities for testing and optimizing source location algorithms, refine current atmospheric dispersion models (including small scale high resolution ATM); further develop ratio analysis for screening purposes, cross-correlate detections, cross-validate systems, etc

Note for Future Campaign !!!

Future campaigns may be designed around the following scientific considerations and objectives :

- ✓ to refine knowledge on typical release profiles and further develop isotopic ratio screening methods (in the vicinity of specific source types),
- ✓ to further improve ATM capabilities, including more accurate estimates of the possible source region or screening flags based on backtracking to know sources (in locations that are impacted by facilities with well-characterized emissions), which is especially difficult in equatorial regions
- ✓ to further understand the effects and influences of specific geographical area configurations that are not well-known today (in areas that are challenging for ATM, e.g. mountains or sea-land boundaries)
- ✓ to investigate the advantages of co-locating transportable systems with sensors for other tracers of interest, e.g. ^{131}I or ^{37}Ar.

Highlight of data in equatorial Africa

- There are limited or close to no data on radio Xenon back ground measurement in Nigeria and equatorial Africa outside of existing IMS stations
- The last one know was presented by some colleagues in Burkina Faso during the SnT 2015
- The data presented had some limitations, due to equipments, limited knowledge and lack of support
- There is need to conduct another campaign with sensitive measurements of radioactive xenon isotopes (radioxenon) in the atmosphere to futher develop the science and methods to meet the requirements of the Comprehensive Nuclear-Test-Ban Treaty (CTBT)
- Sweden SAUNA QB – Array will be a great idea

SAUNA Q_B - Array: The realization of a new concept in radioxenon detection

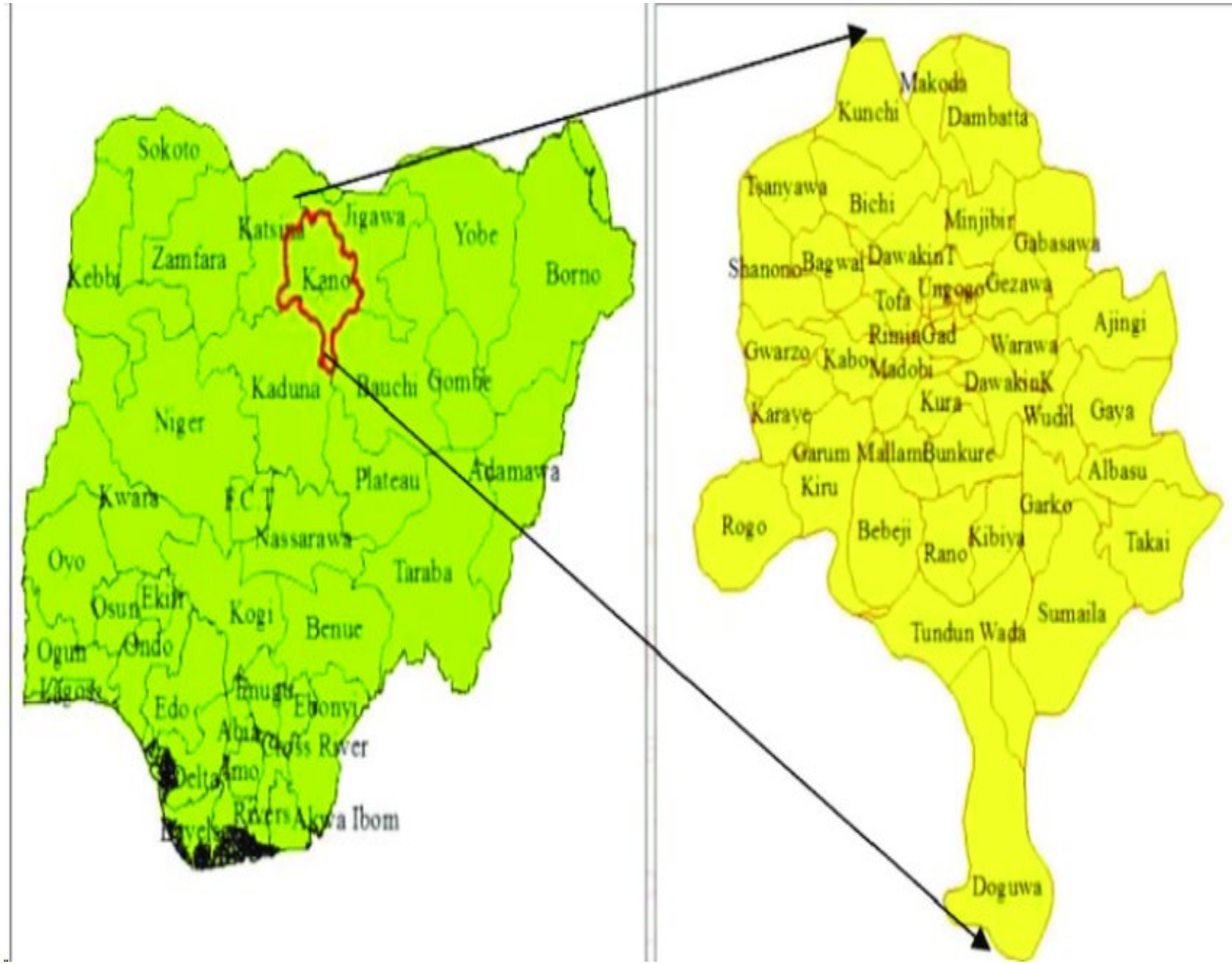
- Is a system development strategy, focussing on increased measurement sensitivity and time resolution, is a natural development and has resulted in excellent measurement capabilities.
- The Array is a system where air sampling and activity measurement is performed at multiple locations, typically separated by hundreds of kilometres
- The individual measurement units are less sensitive than state-of-the art radio xenon systems, and hence less costly, but when connected in an Array, they can collectively deliver a high verification performance.
- To investigate what can be achieved by the new concept in practice, a five-unit Array has been built and installed in Sweden and has been operating continuously since May 2021 with good performance

Background measurement campaign to study Equatorial Xenon transport in a semi-dense network !!!

- Nigeria may not have a Nuclear Power Plant, but it has a Research Reactor designed for use in universities, hospitals and research institutes mainly for Neutron Activation Analysis (NAA) and limited production of short-lived radioisotopes
- Efforts are also ongoing for the construction of a 2MW Multipurpose Research Reactor for the production of radioisotopes and training in Sheda, (8.8569° N, 7.0434° E) ,north central Nigeria
- Nigeria is in between two countries with noble gas IMS stations namely: **RN48**, at Bilma in Niger Republic and radionuclide station RN13 at Douala Cameroun
- It will make a very interesting background study to have a semi-dense network in an interesting region of the earth coupled with the fact that Nigeria does not host any radionuclide IMS stations

Proposed location for background measurement campaign study equatorial xenon transport

- Nigerian Government through the Nigerian Nuclear Regulatory Authority is also establishing the West Africa nuclear and radiation monitoring, detection and response centre in Kabo, (12.09758° N, 8.148850 °E) Kano State
- The Centre will collect radiation measurements and data's from various monitoring stations across the country, validate and transmit to the IAEA through the International Radiation Monitoring Information System IRMIS platform
- efforts to establish protocols and to link the centre to the CTBTO IDC/IMS
- Located in an Academic Institution



Benefits of Xenenon measurements in Nigeria/Africa

✓If Xenon background analysis is done in Nigeria it will contribute to the radionuclide background study in the Equatorial region of Africa

✓it will also provide more data and enhance more understanding to the global radionuclide background in the interesting and complex equatorial region

✓ It will give the local host Institution learning opportuniteis to operate the equipments

✓ The data will also help to support the NDC

✓Results of this assessment for a Xenon background study in Nigeria will be presented in the near future for analysis and study

Map of Nigeria showing hazard categories and local jurisdictions which fall within emergency zones.

●	*Proposed NPP*
■	*Existing Radiotherapy centers*
▲	*Proposed Radiotherapy centers*

Conclusion

- If Xenon source background analysis is conducted in Nigeria it will provide a better understanding and assessment of release and dispersion of Xenon in Nigeria and the equatorial region from background sources
- The geometry of the Array provides new opportunities for source localization
- The wealth of correlated data from multiple sensors can be used to test atmospheric transport models, in particular at distances. This is particularly true if also source release data are known

GRACIAS !!!!


Thank You
Gracias
Спасибо
Xièxie
Efharisto
Danke
Tak
Takk
Kiitos
Merci
Obrigado
Köszönöm
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Sagolun
Matondo
Dankjewel
Mauruuru
Hvala
Toda
Rahmat
Faleminderit
Misaotra
Terima Kasih
Mahalo
Mercé
Dankon
Gratias Tibi
ありがとう
شكرا
תודה

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