Engagement Between the Medical Isotope Production and the Nuclear Explosion Monitoring Communities

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Outline

- Overview of the Issue
- Description of the CTBT and the IMS
- How Much Xe does MIP Contribute?
- Potential Solutions
- Current and Planned Collaborations
- A Plug for WOSMIP
- Summary

Overview of the Issue

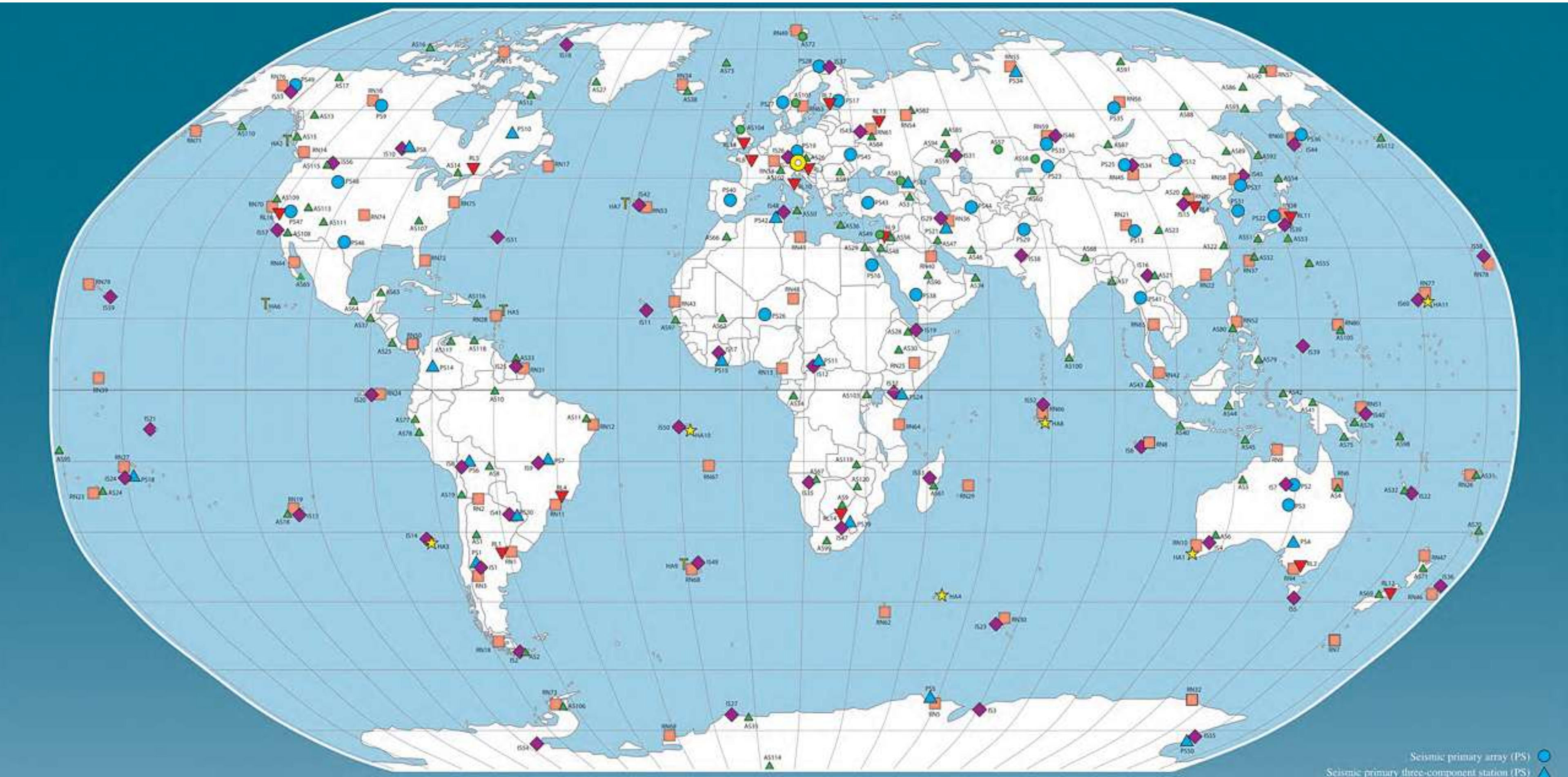
- Fission-based production of Mo-99 produces fission gases including Xe-131m, Xe-133, Xe-133m, and Xe-135

- These isotopes are also used to detect nuclear explosions for the Comprehensive Nuclear-Test-Ban Treaty (CTBT)
  - CTBT International Monitoring System (IMS) detects Xe from isotope production regularly

- Detections of high levels of Xe-133 can create ambiguity for highly sensitive IMS systems
  - Releases at the largest plants can be in the range of 10^{14} Bq per week (or higher)
  - IMS has much lower detection threshold

The International Monitoring System (IMS)

- When completed, the IMS will constitute 321 stations
  - Seismic, Hydroacoustic, Infrasound, Radionuclide
    - There will be 80 radionuclide monitoring stations



IMS Xenon Detection Systems

- Using Xe to monitor for nuclear explosions is relatively new
  - Several automatic sampler-analyzer systems have been developed
- Four Xe isotopes are important
  - Xe-133 T½ = 5.3 d
  - Xe-133m T½ = 2.2 d
  - Xe-131m T½ = 11.9 d
  - Xe-135 T½ = 9.1 h
- Sensitivity: (Xe-133)
  - ~300 microBq/m^3
  - Or ~5000 atoms

Swedish Automatic Unit for Noble Gas Acquisition (SAUNA)
-Scienta SAUNA Systems

Automated Radio Xenon Sampler/Analyzer (SPALAX)
-Environment S.A. (France)

Sources of Radioxenon in the Atmosphere

Source	Order of magnitude of radioxenon release
Hospitals	~ 10^6 Bq/d
Nuclear power plants	~ 10^9 Bq/d
Medical Isotope Production	**~ 10^9-10^{13} Bq/d**
1kTon nuclear explosion	~10^{14}-10^{16} Bq

Production of Mo-99 from irradiated uranium targets

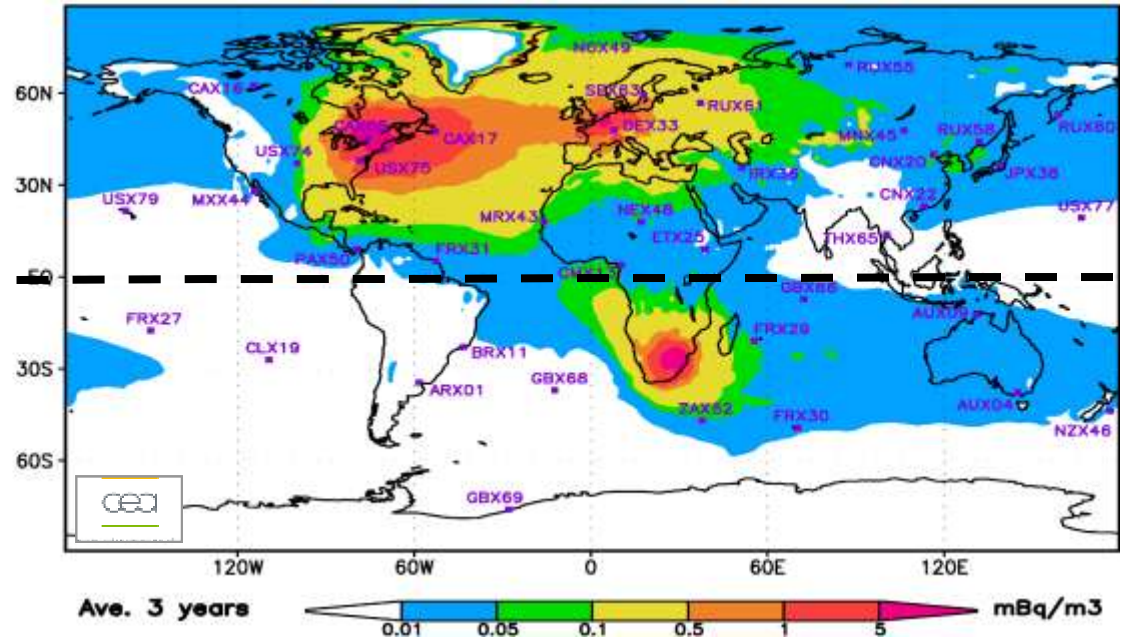
Producer	Country	Average release/day [Bq]
Nordion	Canada	1.6 10^{13} Bq
Covidien	The Netherlands	2.5 10^9 Bq
IRE	Belgium	4.6 10^{12} Bq
NTP	South Africa	1.3 10^{13} Bq

Note – these releases are FAR below health and safety regulation thresholds

Xenon Contribution from MIP

- Xe-133 worldwide background is impacted by the major fission based Mo-99 production facilities
- Note: This picture is incomplete (e.g. production was not modeled in Australia, Argentina, Indonesia, etc.)

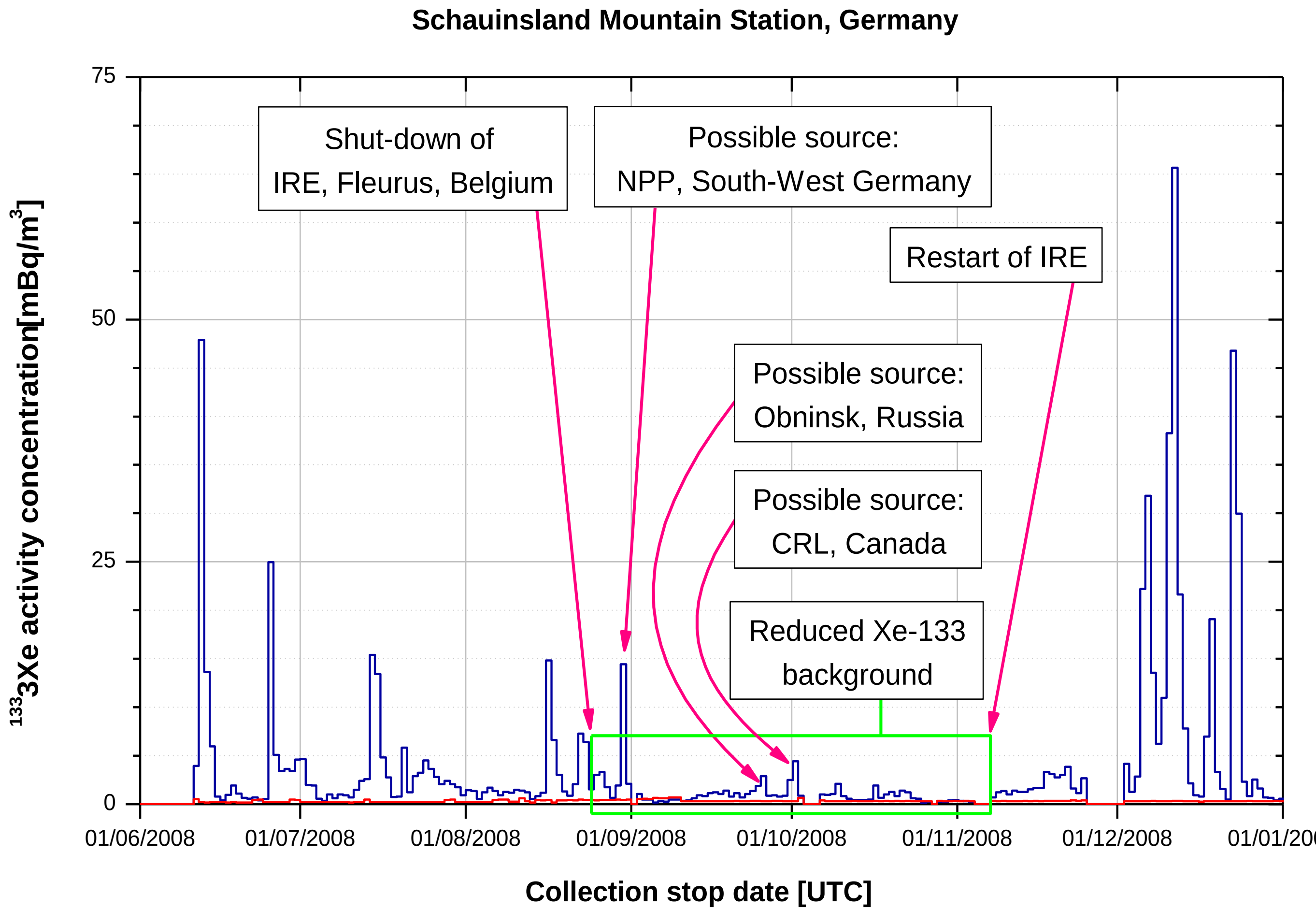
Average contribution of MIP to Xe-133 atmospheric background over 3 years



P. Achim, et al, CEA (France)

Case Study: German Schauinsland IMS Station During Temporary Shutdown at IRE (Belgium)

- Note that Measurable Xe drops during shutdown (measurements boxed in green)
- Therefore, a decrease in Xe emissions should result in lower local Xe backgrounds



Short-Term Solution: High-Fidelity Monitoring of Effluents

- Facility stack data can be used by the CTBT International Data Centre (IDC) to further distinguish between civil and weapon sources
  - Current stack monitors would need to be improved, but COTS solutions exist
- Monitoring at the facility allows better understanding of detections at IMS stations
- Need improved ATM to better integrate new data with monitoring science

Mid-/Long-Term Solution: Emission Reduction & Abatement

- While monitoring offers promise, reduction of worldwide Xe background is always preferable to allow for greater sensitivity

- “Scrubbing” technologies (reduction of Xe emissions) would decrease backgrounds; however…
  - Requires knowledge of release pathways and quantities
    - Building off of facility monitoring experience
  - Pilot studies needed to prove Xe reduction techniques

- Ideal scenario: consult on the effluent control designs/processes of future facilities

Successful Collaborations

- Bilateral engagement with producers
  - Installation of stack monitor at ANSTO
  - Engagement with ANSTO on new facility design
  - Installation of stack monitor at BATAN Teknologi (Indonesia)
  - Calibrated release experiment at IRE
  - Regular engagement with prospective U.S. producers
- Workshops and Conferences
  - Science & Technology 2013 – June 17-21, 2013, Vienna
    - CTBTO-sponsored
    - Ambassador-level participation
    - Session dedicated to civil sources of IMS detections
  - Workshop on Signatures of Medical and Industrial Isotope Production (WOSMIP) – November 11-13, 2013, Vienna
    - PNNL-sponsored
    - Hosted this year by the CTBTO

Workshop on Signatures of Medical and Industrial Isotope Production (WOSMIP)

- Bringing together the nuclear explosion monitoring and medical isotope production communities
  - wosmip.pnnl.gov
  - Discussion topics:
    - Monitoring challenges
    - Abatement options
    - Chemistry options
  - Contact wosmip@pnnl.gov to be added to the mailing list

WOSMIP 2013 in Vienna, Austria – November 11-13, 2013

Ideas Generated at WOSMIP

Improve ability to discriminate between MIP and nuclear explosions

- Sharing of stack monitor data, by isotope if possible
- Understand the isotopic and temporal nature of production emissions

Reducing Xe emissions

- Improve abatement at existing plants, taking into account economic/infrastructure realities
- Establish voluntary emissions threshold of 5×10^9 Bq/day for new processing facilities (i.e., no higher than reactor emissions)

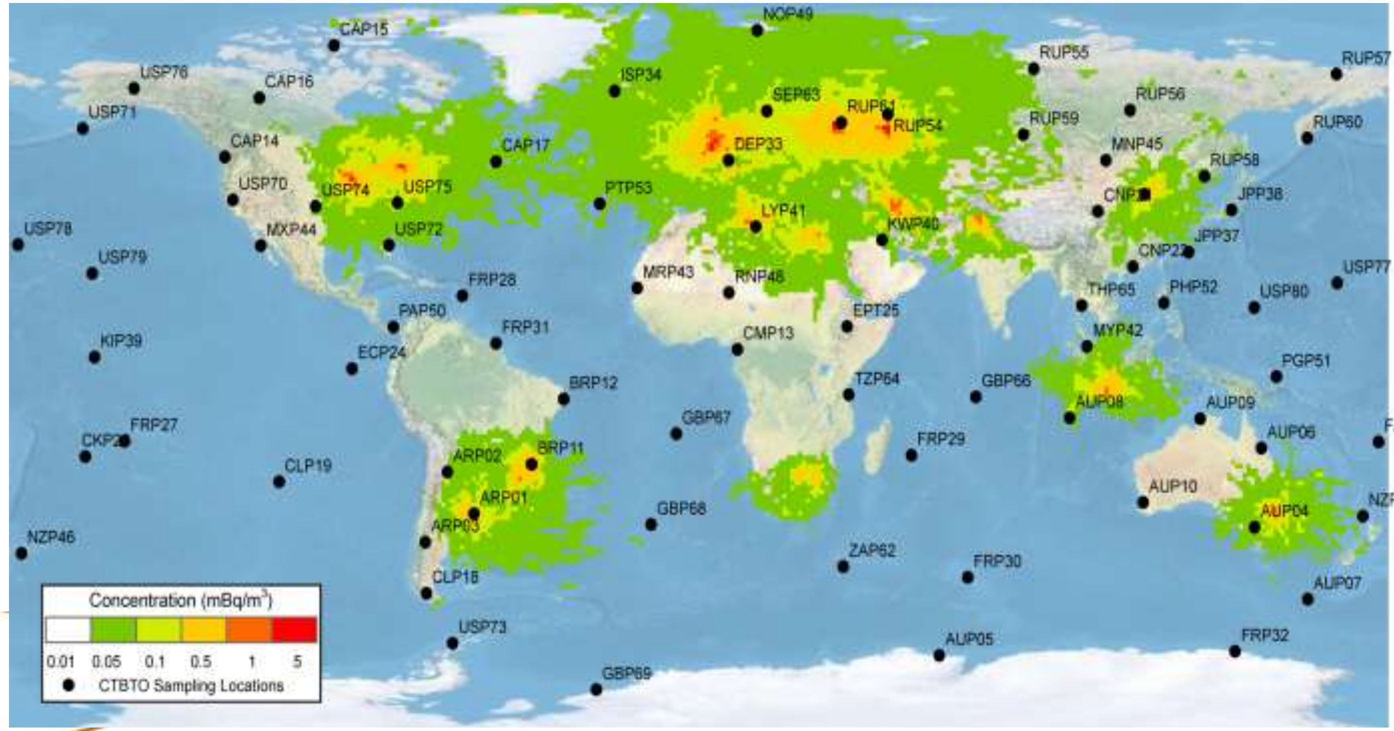
TW Bowyer, RF Kephart, PW Eslinger, JI Friese, HS Miley, PRJ Saey. 2013. "Maximum Reasonable Radioxenon Releases from Medical Isotope Production Facilities and Their Effect on Monitoring Nuclear Explosions." *J. of Environmental Radioactivity* 115:192-200, DOI 10.1016/j.jenvrad.2012.07.018

Reduced Emissions – 5 x 10^9 Bq/day

- Theoretical modeling of the 5 x 10^9 Bq/day standard based on current and potential future fission based producers

- Outlook is promising for a compromise between the need for Mo-99 and international monitoring for nuclear explosions.

TW Bowyer, RF Kephart, PW Eslinger, JI Friese, HS Miley, PRJ Saey. 2013. "Maximum Reasonable Radioxenon Releases from Medical Isotope Production Facilities and Their Effect on Monitoring Nuclear Explosions." *J. of Environmental Radioactivity* 115:192-200, DOI 10.1016/j.jenvrad.2012.07.018



Summary

- Fission-based production of Mo-99 can emit 10^{9}-10^{13} Bq of Xe-133 and other isotopes
  - Xe-133 emission levels can resemble those of an underground nuclear explosion
- The CTBT IMS detects Xe from Mo-99 production frequently
  - Likely to increase as more fission-based production facilities come on line
  - IMS sensitivity is very high
- PNNL seeks to engage with prospective U.S. producers, as well as international producers, to explore solutions
  - Wide array of technical collaborations could potentially be supported by our government sponsors
    - Limited "only" by budget and availability of collaborators
  - WOSMIP 2013, November 11-13 in Vienna, Austria
    - Wosmip.pnnl.gov

Acknowledgements

- Achim et al: 2010 International Noble Gas Experiment Workshop
- Kalinowski et al: http://onlinelibrary.wiley.com/doi/10.1002/cplx.20228/pdf
- Zaehringer EGU 2008: http://meetings.copernicus.org/www.cosis.net/abstracts/EGU2008/08595/EGU2008-A-08595.pdf
- Saey, PRJ: 2009 Workshop on the Signatures of Medical and Industrial Isotopes