O2.3-272

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

[1,2]R. Plukienė, [1,2]E. Maceika, [1]O.A. Olechnovič, [1]V. Milinkevičius, [1]A. Ševčik, [1]O. Chudikaitė,[1]D. Sinkevičius, [1]J. Žiliukas, [2]A.Plukis

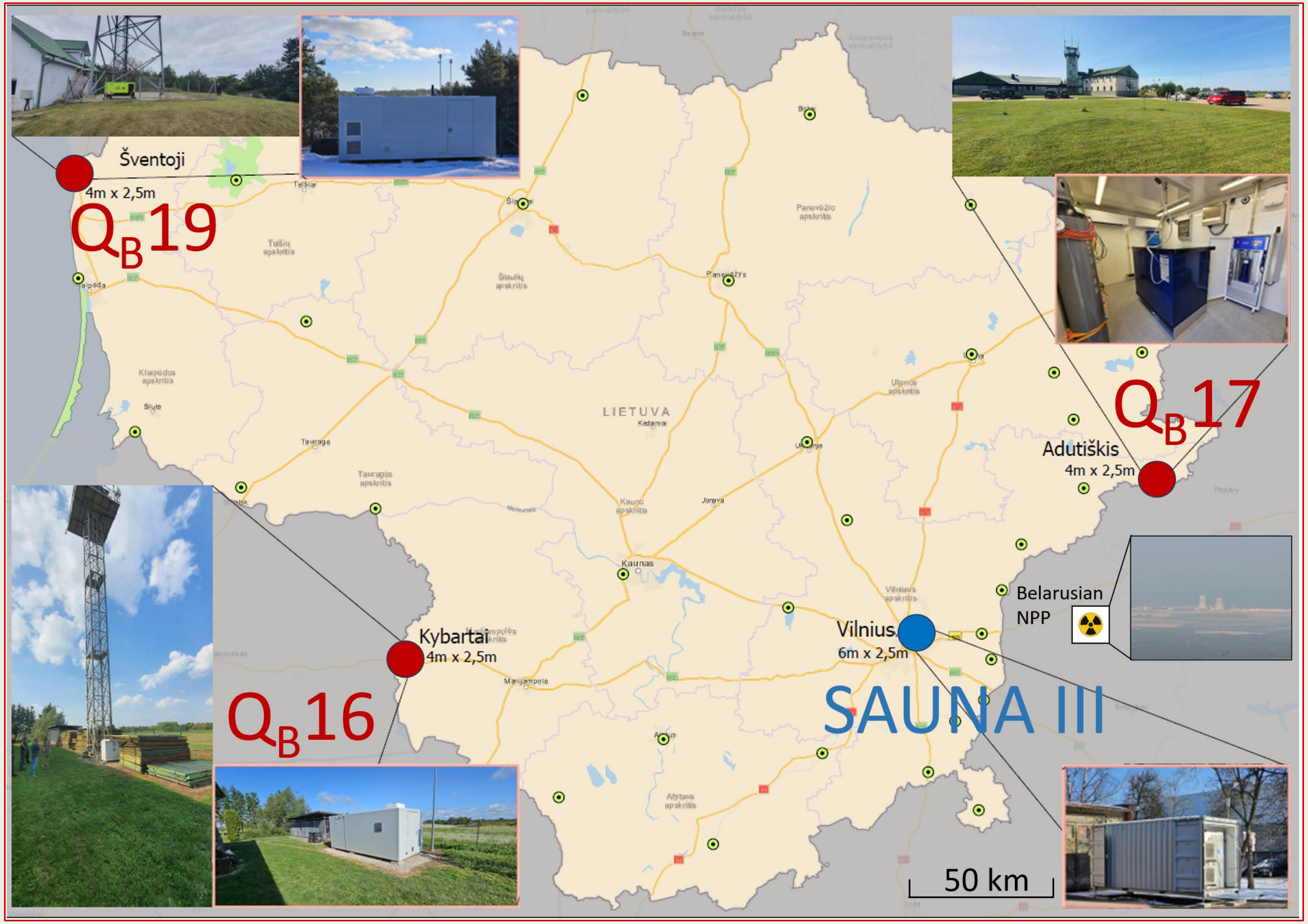
[1] Radiation Protection Centre, Lithuania
[2]Center for Physical Sciences and Technology, Lithuania

10 September 2025

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

R. Plukienė, E. Maceika, O.A. Olechnovič, V. Milinkevičius, A. Ševčik, O. Chudikaitė, , D. Sinkevičius, [1]. Žiliukas, A.Plukis

O2.3-272



SAUNA **QB17 from 2024/9/30**
SAUNA **QB16 from 2024/12/20**
SAUNA **QB19 from 2024/12/20**
SAUNA **TXLIII from 2024/12/25**

It is expected that Xe measurements will help to learn about the operation of the Belarusian NPP reactor:

- whether it is operating at full power,
- whether it is shut down, etc.,
- after accumulating enough data, draw conclusions about the condition of the operating reactor,

+ identification of other sources

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

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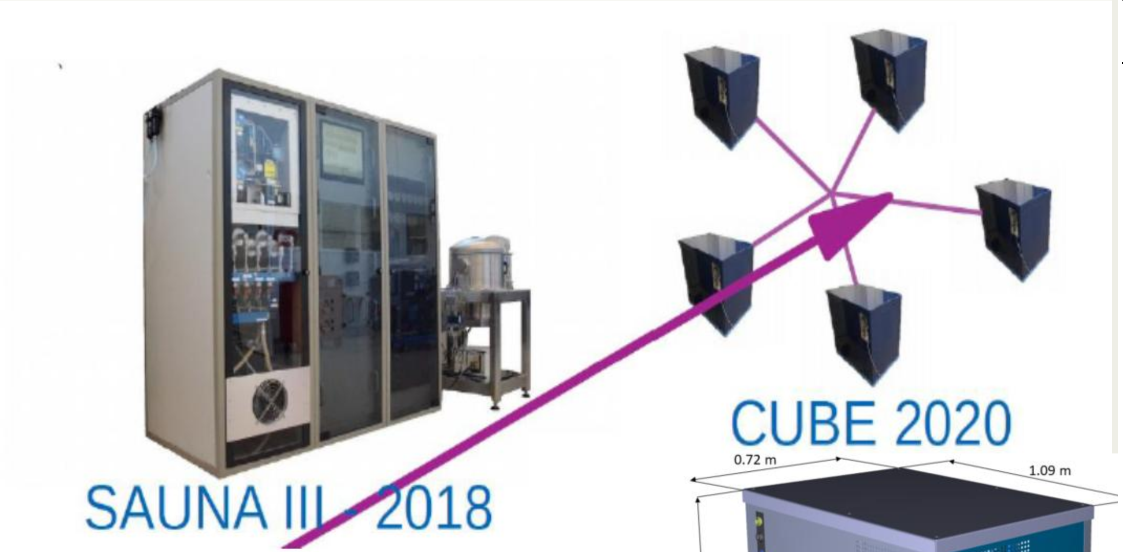

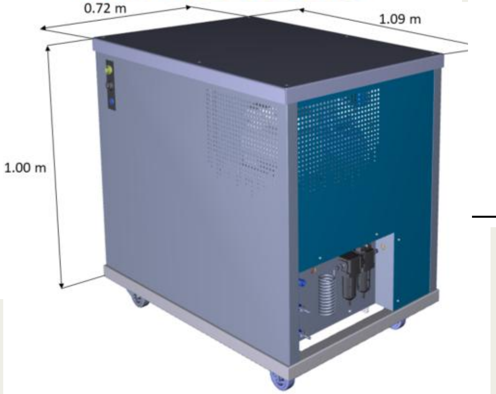

Swedish Automatic Unit for Noble gas Acquisition

	SAUNA II	SAUNA III	SAUNA Q_B
Air collection time (h)	12	6	12
Processing time (h)	7.1	5.2	3.0
Activity measurement time (h)	11.1	6.2	10.7
Sampling airflow (m^3/h)	1.3	7	1.2
Carrier gas	Helium	Nitrogen	Nitrogen
Stable xenon volume per sample (ml)	1.3	3	1.1-1.4
Mean/max power consumption (kW)	2.3/4.9	3.8/5.9	0.9/1.5
Width × Depth × Height (cm)	280 × 122 × 200	280 × 122 × 200	73 × 109 × 100
Weight (kg)	1800	1800	370
Automatic detector drift correction	No	Yes	Yes
MDC ^{133}Xe (mBq/m^3)	0.3	0.15	0.4
MDC ^{131m}Xe (mBq/m^3)	0.2	0.15	0.25
MDC ^{133m}Xe (mBq/m^3)	0.3	0.15	0.25
MDC ^{135}Xe (mBq/m^3)	0.9	0.36	1.1

A. Ringbom et al. Journal of Environmental Radioactivity 261 [2023]

SAUNA III – 1 main automatic Xe gas detection and measurement system
SAUNA $\boldsymbol{Q_B}$ - 3 automatic Xe gas detection and measurement systems - measurement systems network

First results of radioxenon detections of SA... II and 3 SAUNA Q_B network in Lithuania

R. Plukienė, E. Maceika, O.A. Olechnovič, V. Milinkevičius, A. Ševčik, O. Ch

Xe sources in Europe

NPP	Distance (to Vilnius), km	
Ringhals	PWR	861
Forsmark	BWR	743
Oskarhamn	BWR	614
Loviisa	VVER	644
Leningrad	RBMK	616
Belarussian	VVER	44
Smolensk	RBMK	486
Kalinin	VVER	570
Rivno	VVER	456

MIG	Distance (to Vilnius), km
Maria	340
Obninsk	725
Petten	1366
Dimitrovgrad	1565
Fleurus	1470

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

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Summary of data:

Name of Xe measurement station at place	QB17 Adutiškis	QB16 Kybartai	QB19 Palanga	SAUNAIII Vilnius
Constant operation since:	9/30/2024	12/20/2024	12/20/2024	12/25/2024
Number of measurements	**623**	**487**	**490**	**965**
max Xe-133, mBq	***24.5***	***20.3***	***12.6***	***19.7***
date	**2/12/2025**	**7/19/2025**	**2/09/2025**	**7/18/2025**
max Xe-131m, mBq	***2.9***	***3.1***	***6.1***	***3.2***
date	**10/21/2024**	**4/19/2025**	**1/28/2025**	**4/19/2025**
max Xe-133m, mBq	***0.4***	***0.6***	***0.4***	***0.7***
date	>MDC	>MDC	>MDC	**7/18/2025**
max Xe-135, mBq	***2.4***	***3.5***	***0.5***	***0.3***
date	>MDC	>MDC	>MDC	>MDC

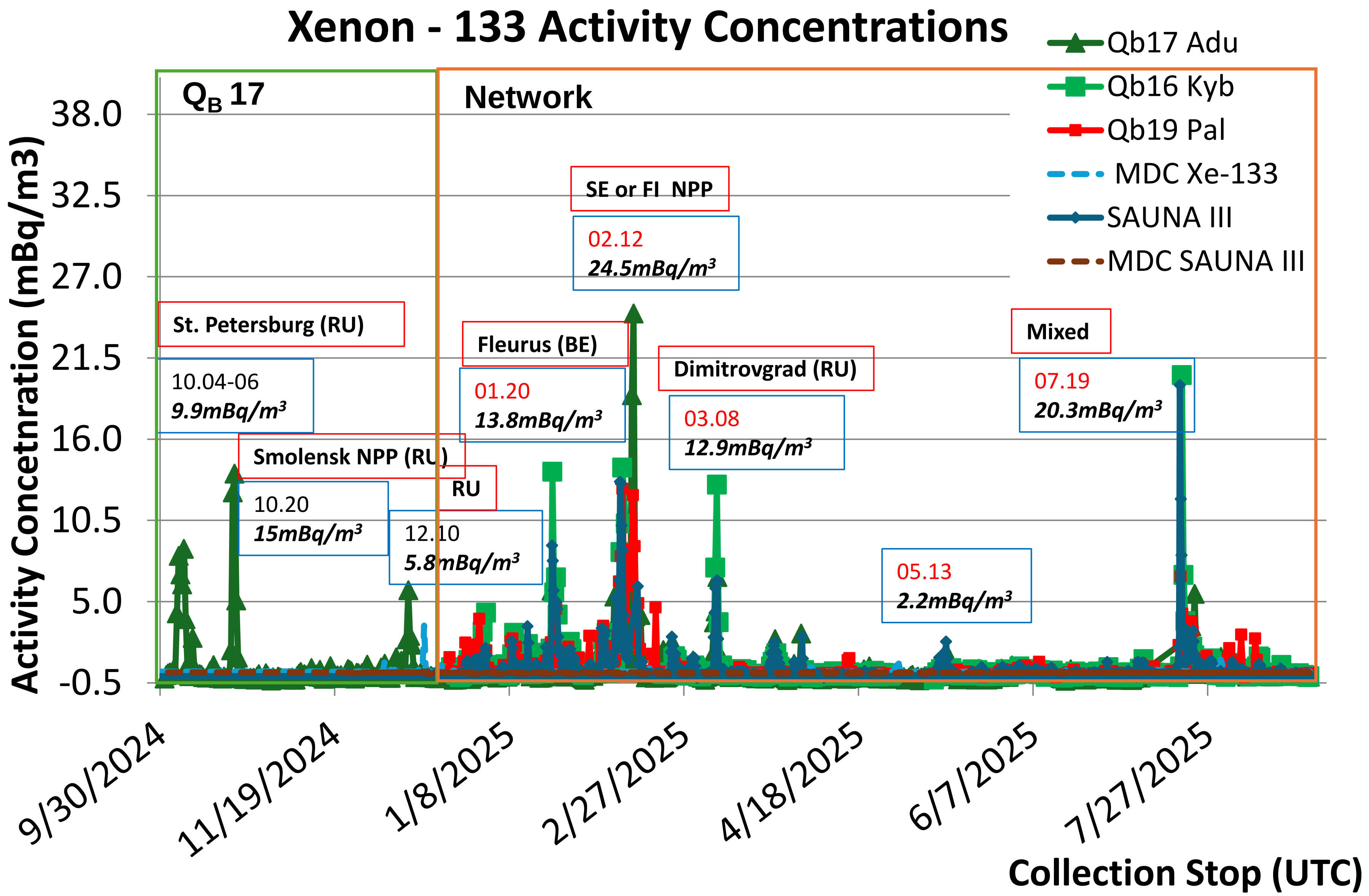
Xe-133

Lithuanian Network : 3 SAUNA Q_B, SAUNA III

9 significant Xe-133 elevated activity episodes were registered during the whole measuring period
2024: 10.04-06, 10.20, 12.10;
2025: 01.20, 02.09-12, 03.08, 07.19

Lithuanian Network on-line monitoring
Scientaenvinet desk 13

O2.3-272



Dates in red mark periods when several Xe isotopes were measured

Possible Xe source

In details are examined episodes when Xe-133 activity exceeded 5 mBq/m³ or several Xe isotopes are detected

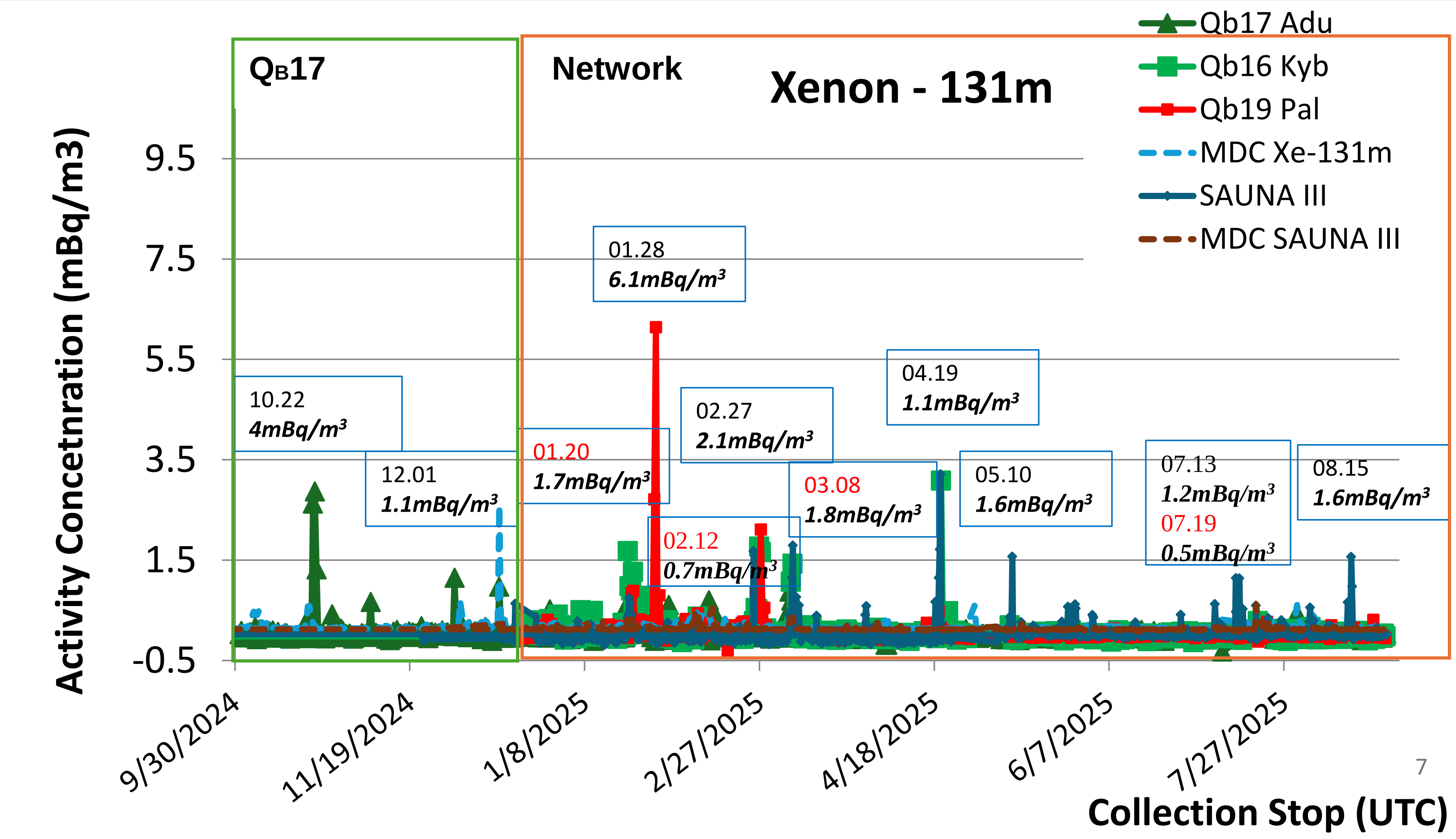
First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

Lithuanian Network: 3 SAUNA Q_B, SAUNA III

Xe-131m Activity Concentrations

12 Xe-131m detection episodes were registered :
2024: 10.22, 12.01
2025: 01.20, 01.28, 02.12, 02.27, 03.08, 04.19, 05.10, 07.13, 07.19, 08.15

O2.3-272



Dates in red mark periods when several Xe isotopes were measured

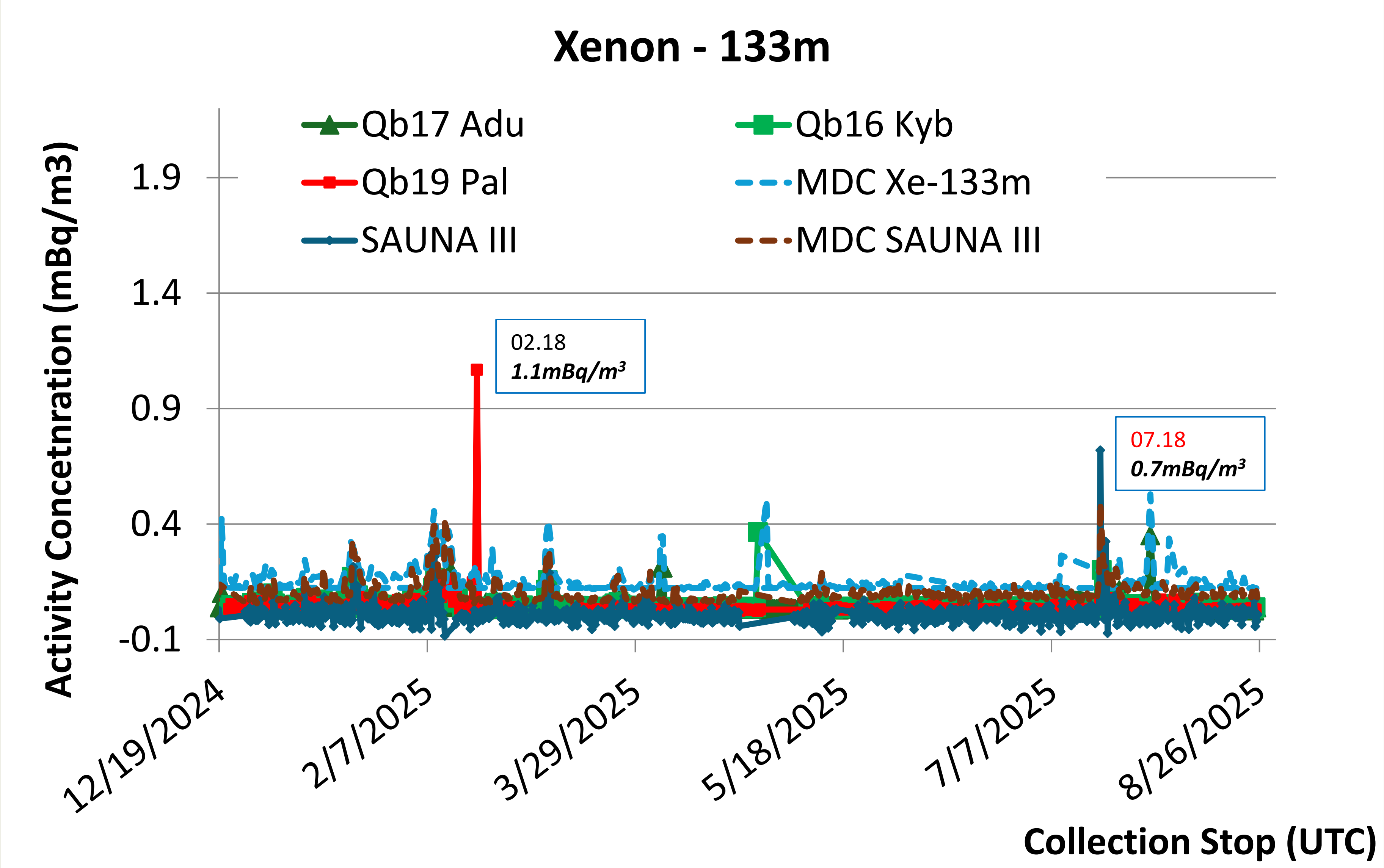
Considered cases when Xe-131m isotope activity exceeded ~1 mBq/m³

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

Lithuanian Network: 3 SAUNA Q_B and 1 SAUNA III

Xe-133m isotope was observed two times since operation

O2.3-272



Dates in red mark periods when several Xe isotopes were measured

2025.02.18 at Palanga Q_B

2025.07.18 at Vilnius SAUNA III

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

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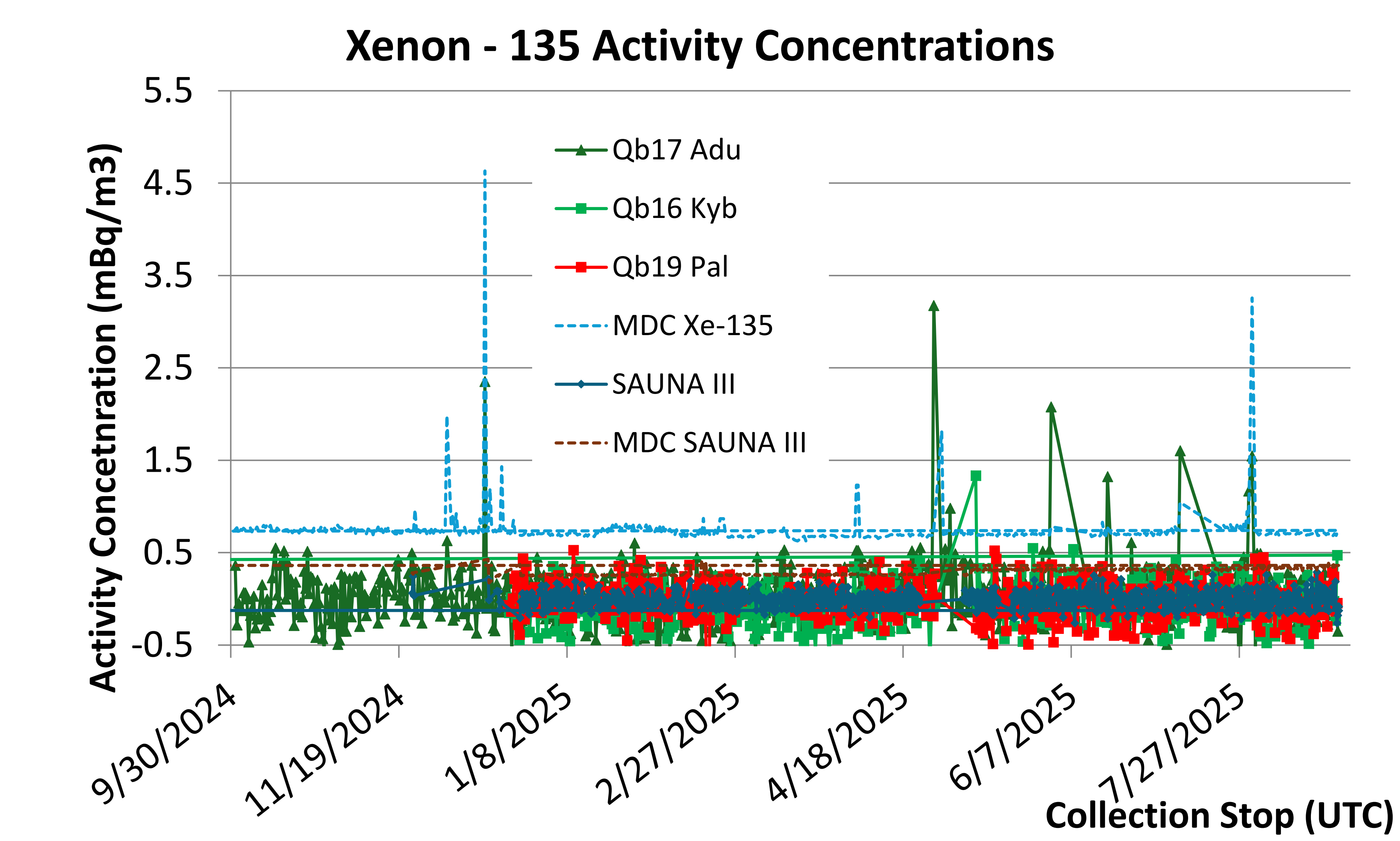
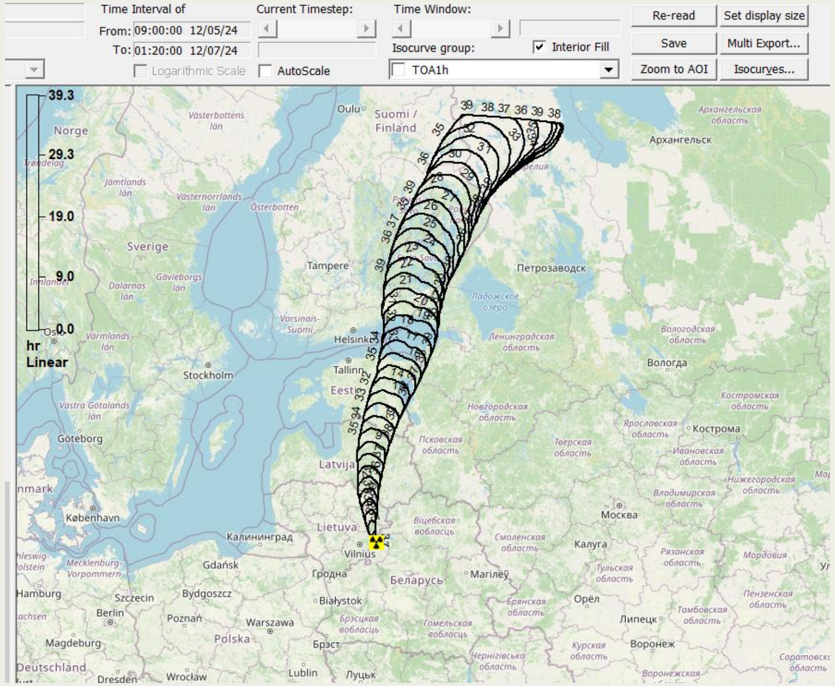
Lithuanian Network: SAUNA Q_B and SAUNA III



Xe-135 isotope was not observed during all period, False detections due to measurements problems QC, Membrane change procedures etc..

2024 12 05 identified possible ^{133}Xe release from Belarusian NPP.

O2.3-272



Identification of radioxenon sources by modelling Xe transport by using HYSPLIT and ARGOS programs

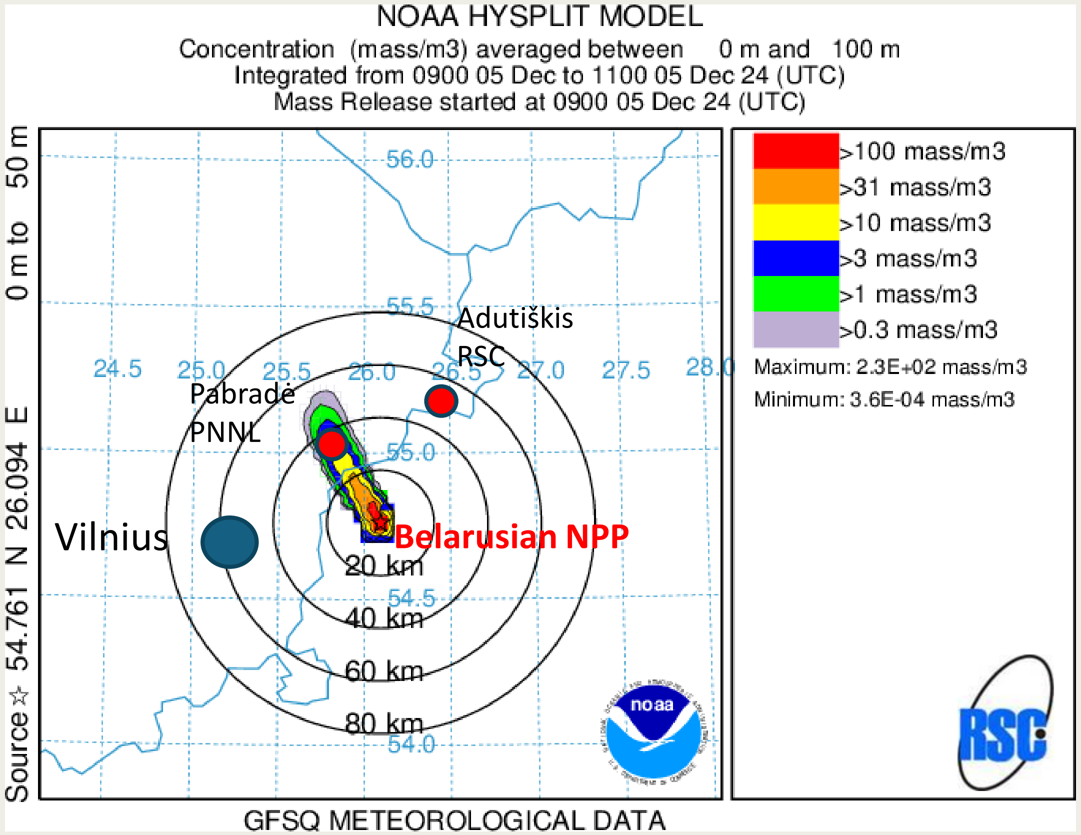
Pacific Northwest NATIONAL LABORATORY

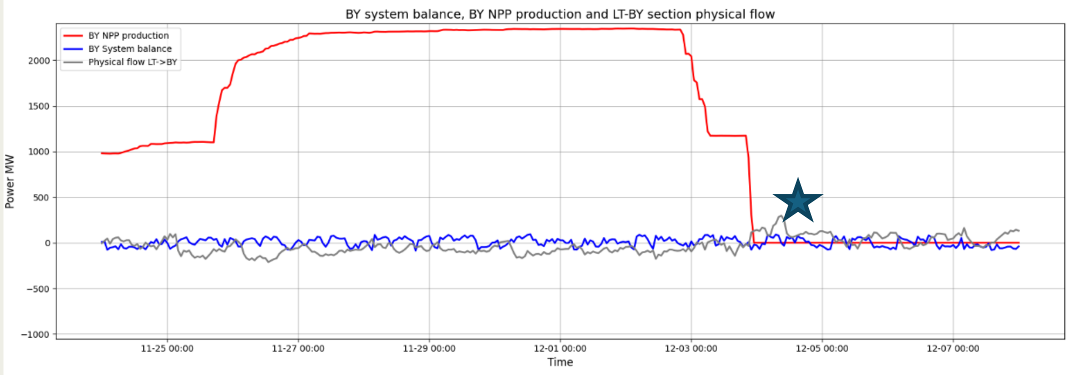
Activity concentration of ^{133}Xe :

- PNNL (USA), SAUNA II station - **have detected** ^{133}Xe [L. Lidey, M. Mayer PNNL P2.3-712]
- Adutiškis RSC (LT), SAUNA Q_b station – **background**/MDC value (0.18 mBq/m^3)

Evaluated ^{133}Xe release from Belarusian NPP:

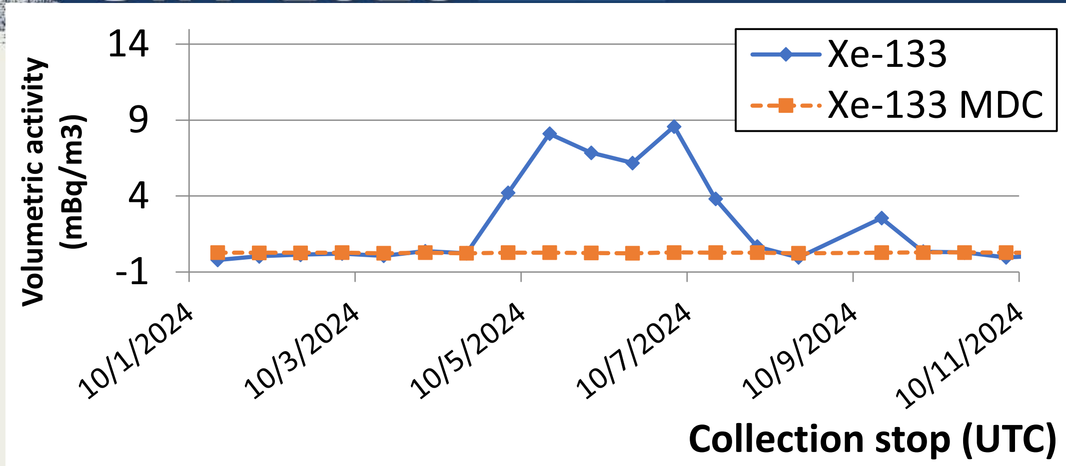
- **Date - 2024 12 05,**
- **Time - 9:00 (UTC)**
- **Duration – up to 12 h.**
- **Release ~ 10^{10} Bq**





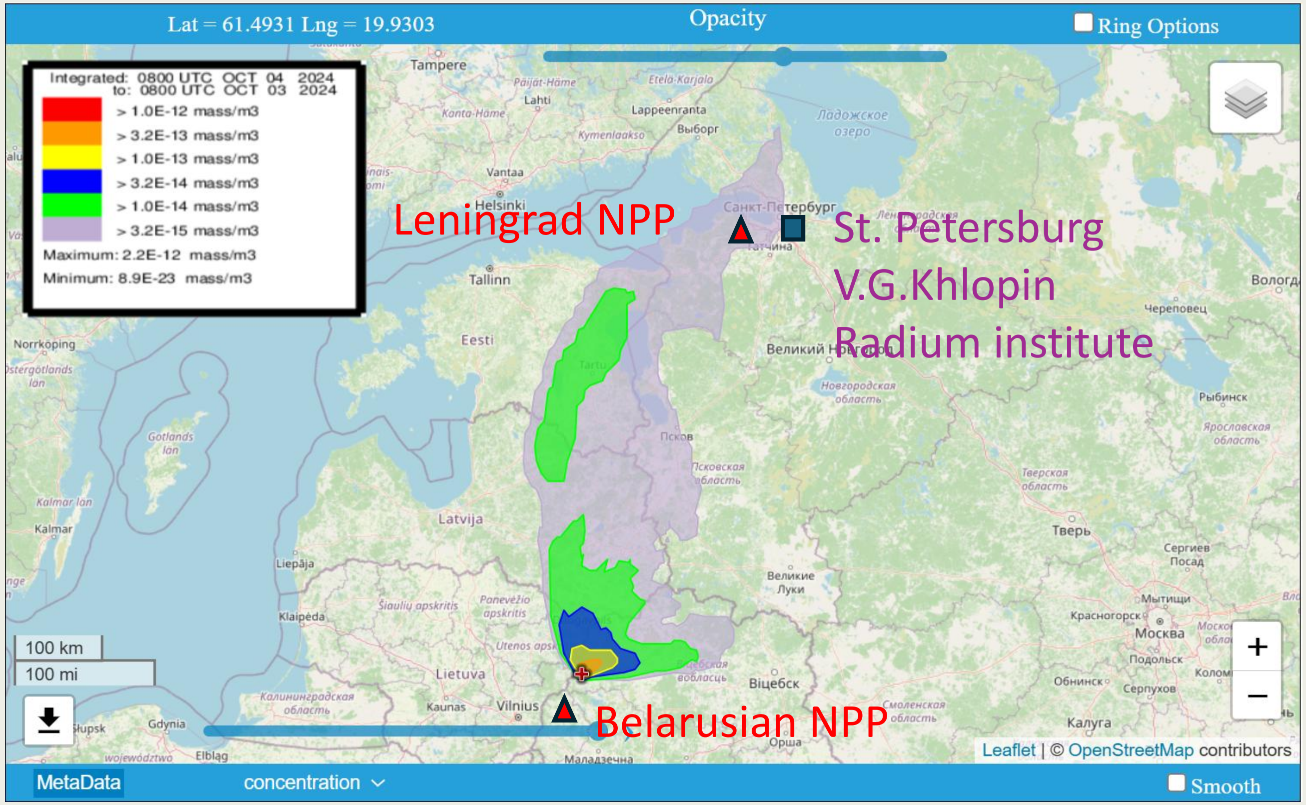
First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

2024 10 04-06 at Adutiškis (Qb17) HYSPLIT possible ^{133}Xe release source in Russia (Leningrad NPP or St. Petersburg Radium institute)



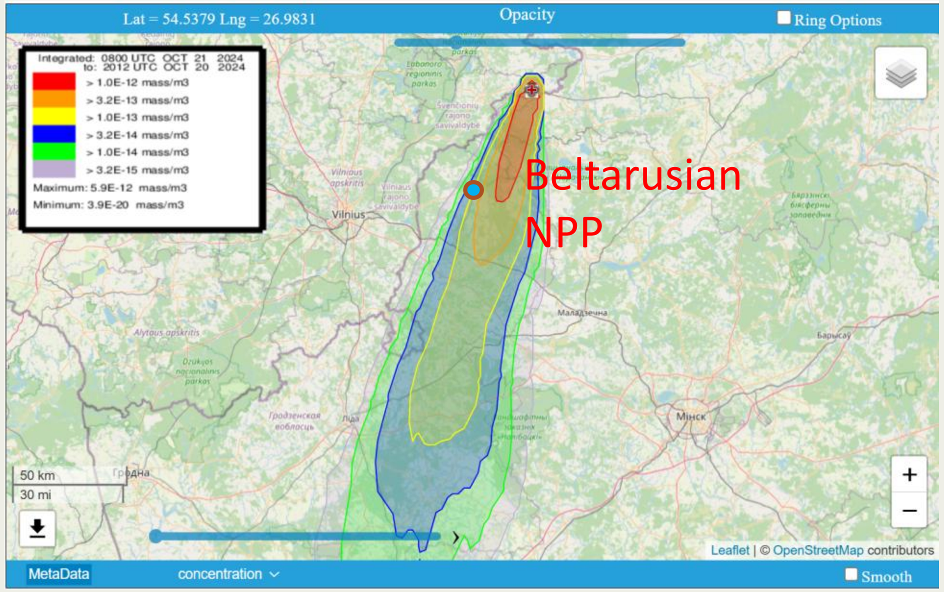
HYSPLIT backward trajectory

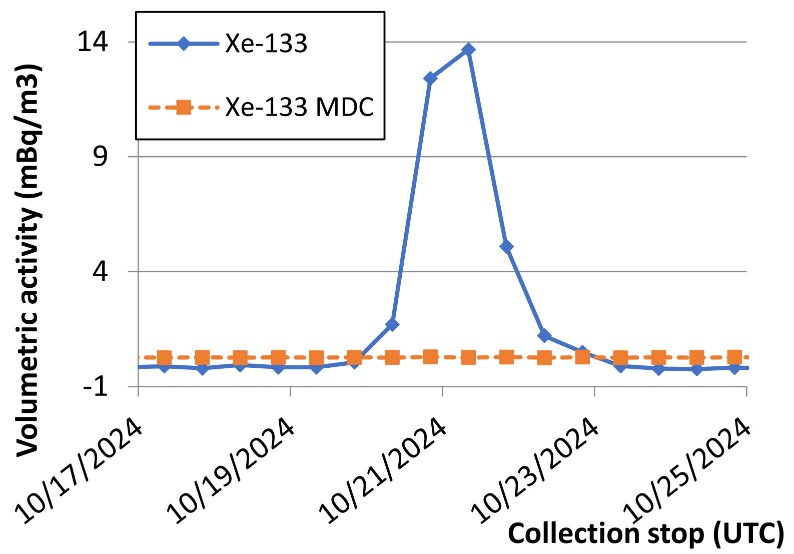
HYSPLIT backward dispersion modeling

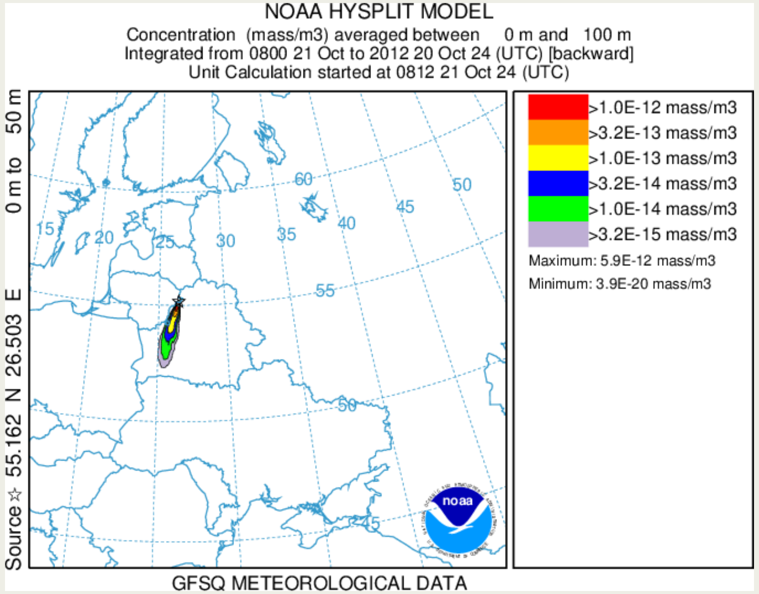


2024 10 20-21 at Adutiškis (Qb17) HYSPLIT modeling possible ^{133}Xe and ^{133m}Xe source of Smolensk NPP

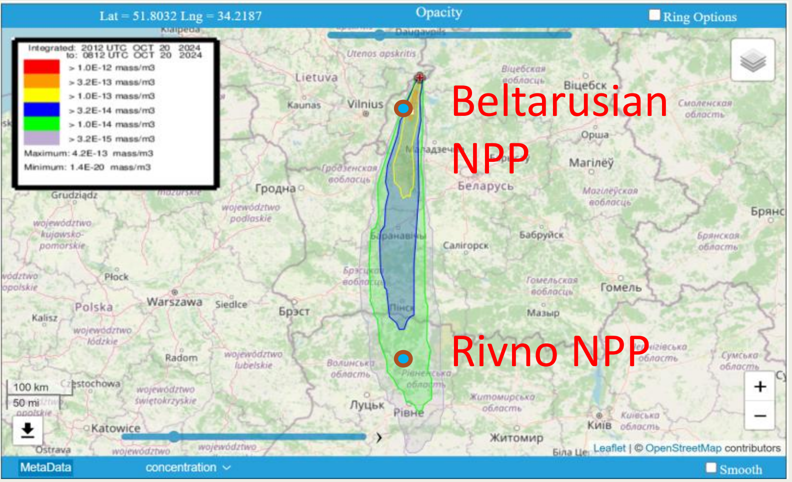
O2.3-272

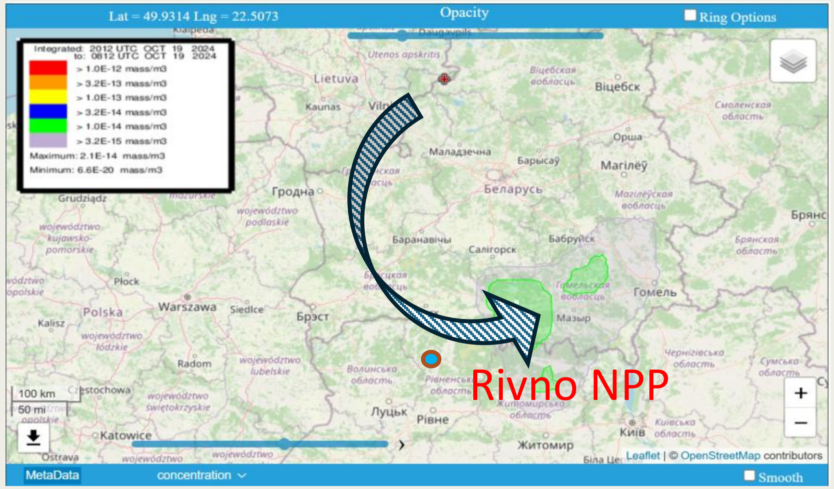


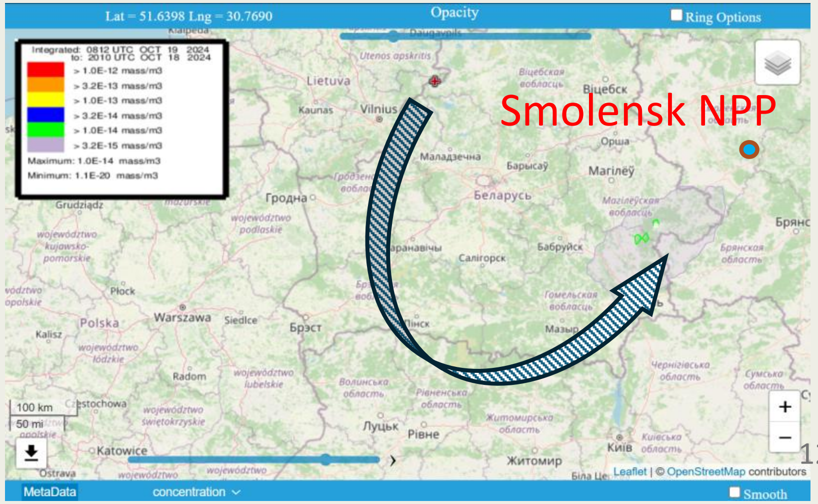




It would seem that it could have been brought from the Belarusian NPP or the Rivne NPP, but after comparing Xe measurements from Sweden, the Smolensk NPP was identified.



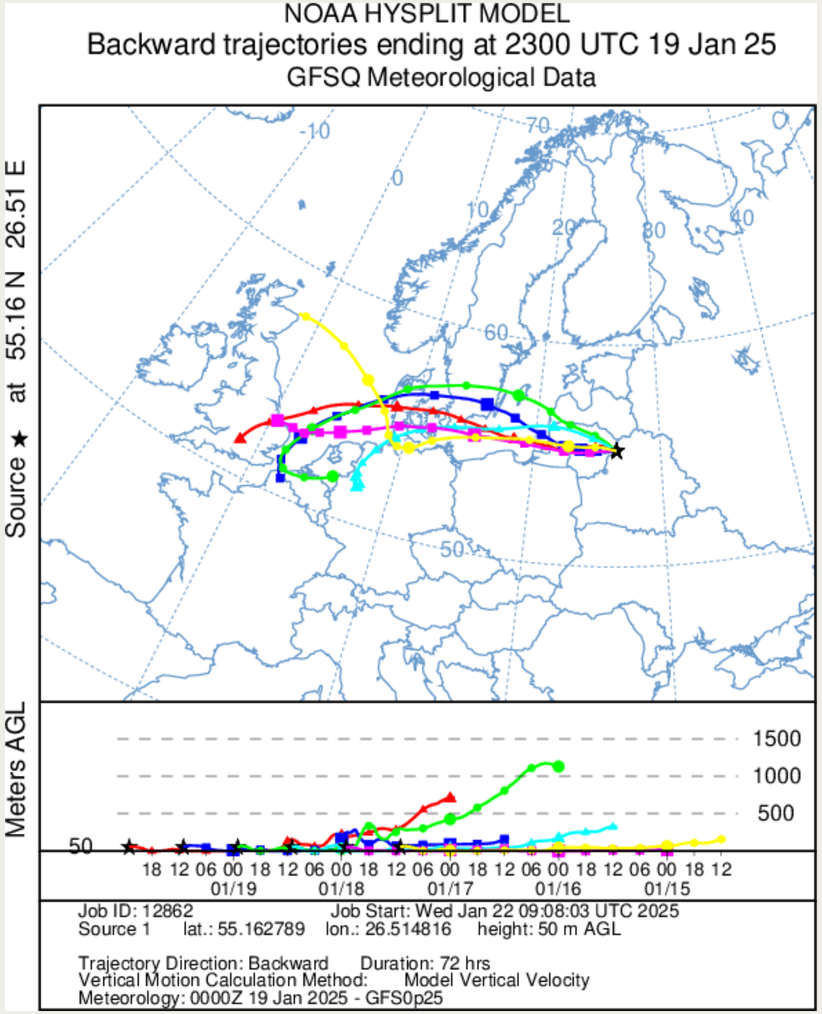




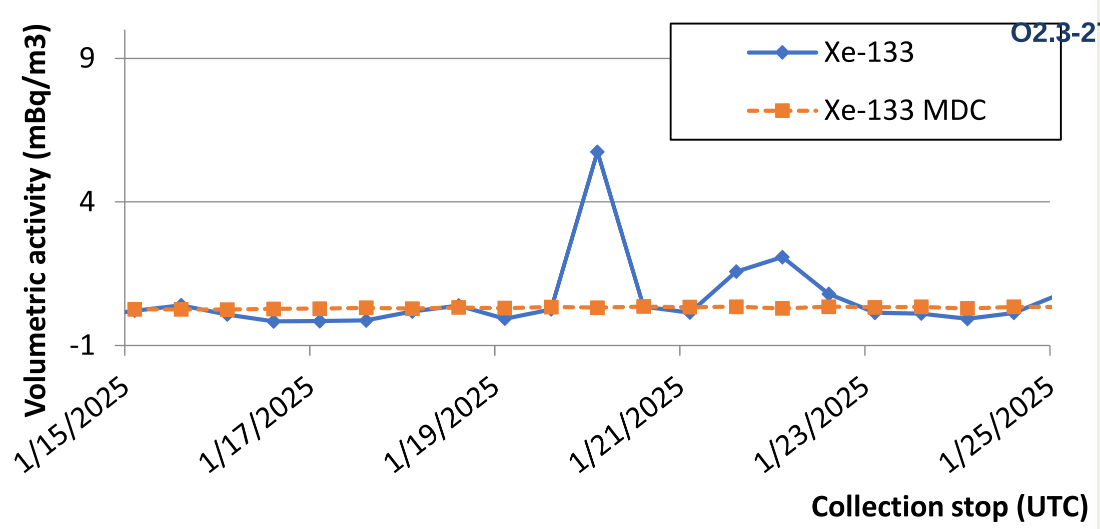
First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

O2.3-272

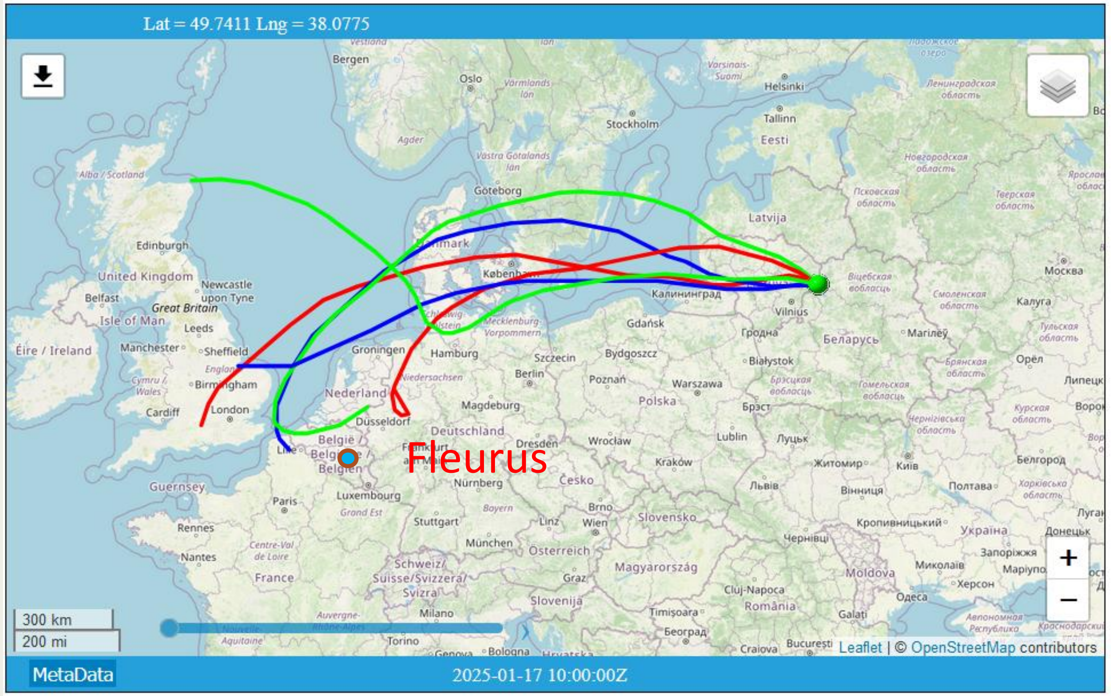
The spike in ^{133}Xe concentration in Adutiškis was recorded for a very short period (2025 01 19 14:33 - 2025 01 20 02:33). The HYSPLIT backtracking simulations hit Fleurus BE for exactly that period (green and blue trajectories).



Dispersion modelling for Adutiškis (Qb17)

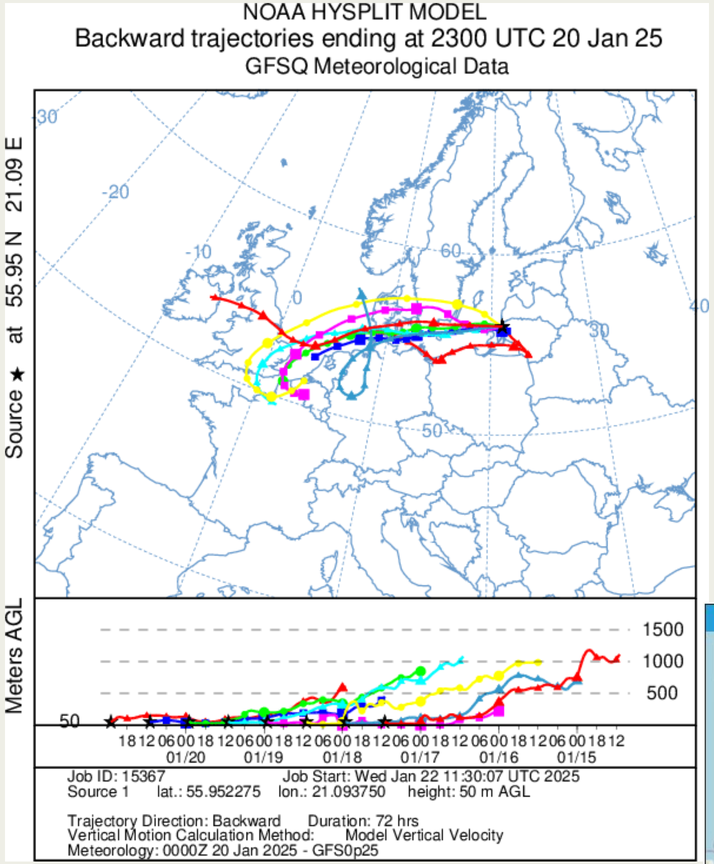


2025 01 19 HYSPLIT possible source of ^{133}Xe and ^{133m}Xe at Fleurus (Belgium)

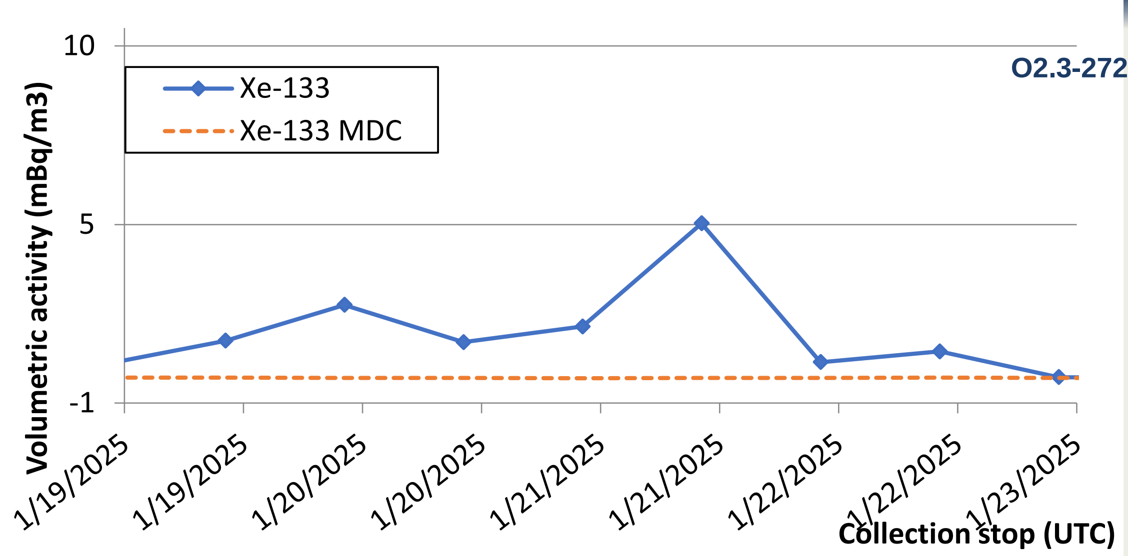


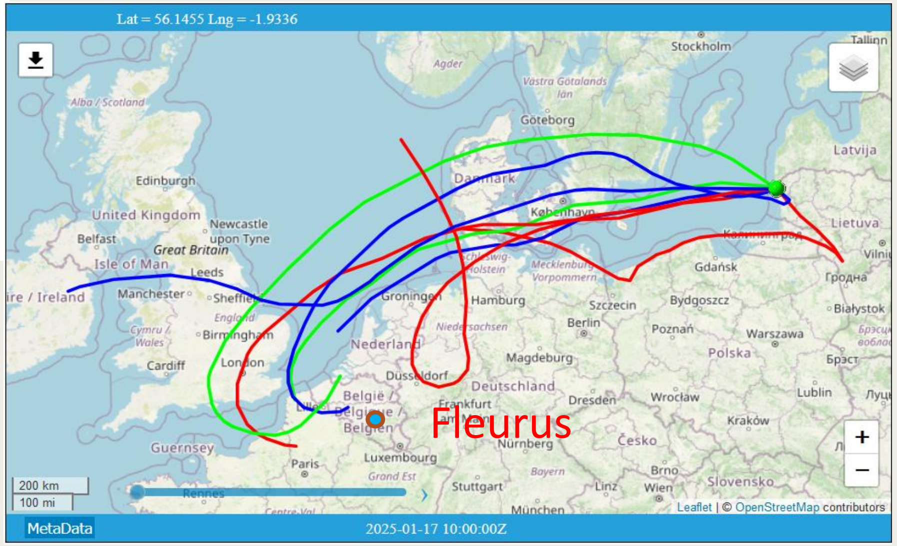
First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

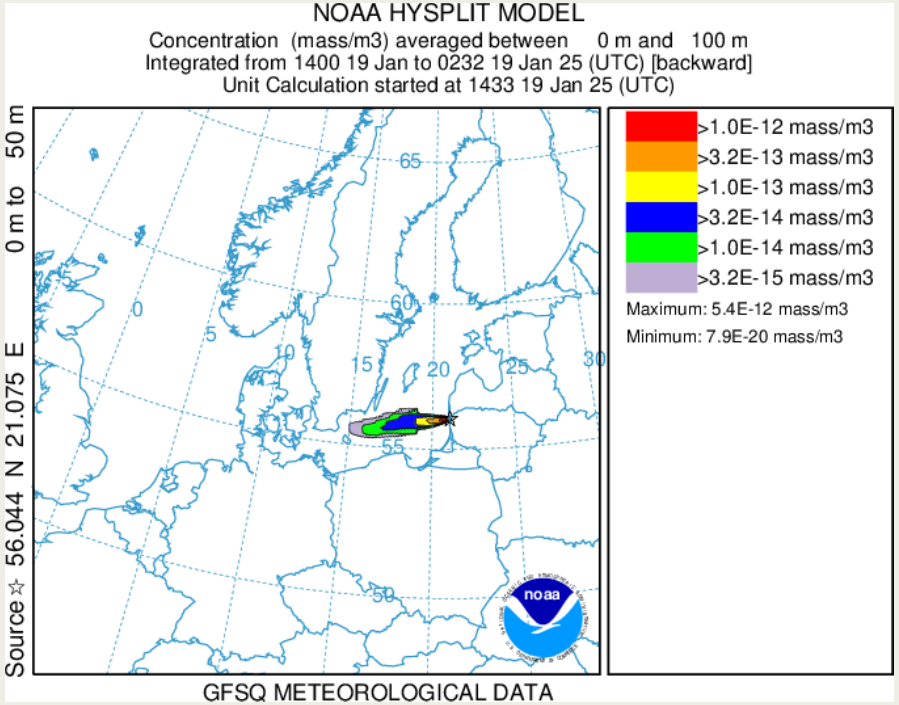
O2.3-272



2025 01 19 HYSPLIT also suggest ^{133}Xe and ^{133m}Xe from Fleurus







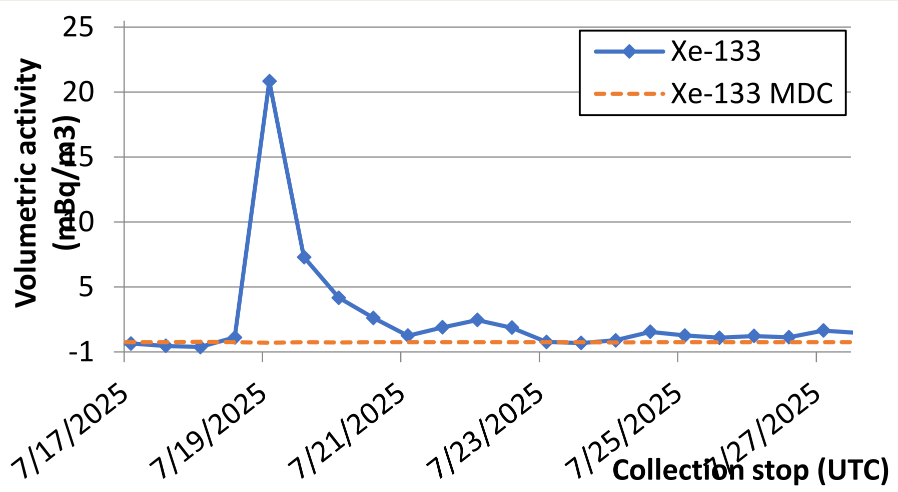
Dispersion modelling for Palanga Qb19

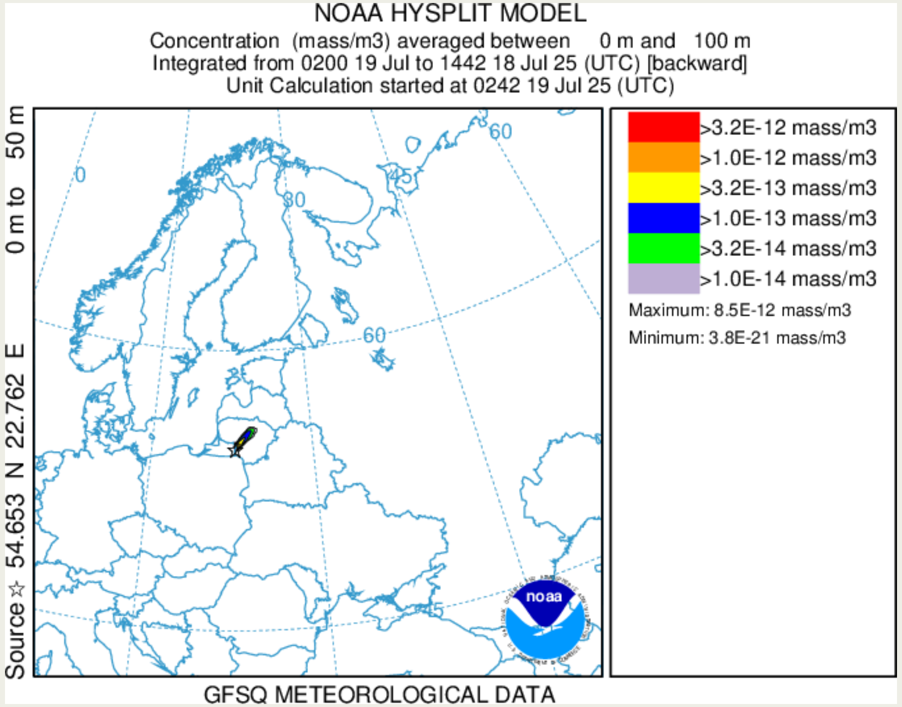
First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

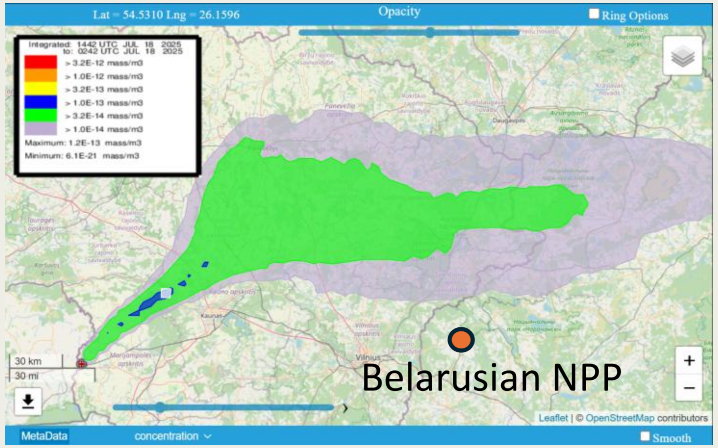
O2.3-272

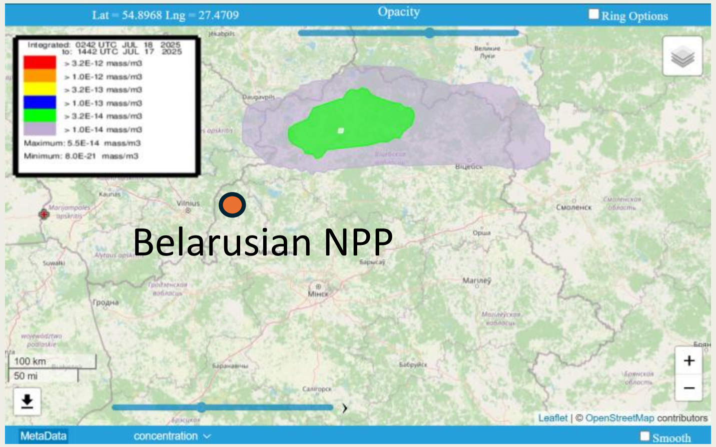
Backward calculation Kybartai (Qb16) 2025 07 19

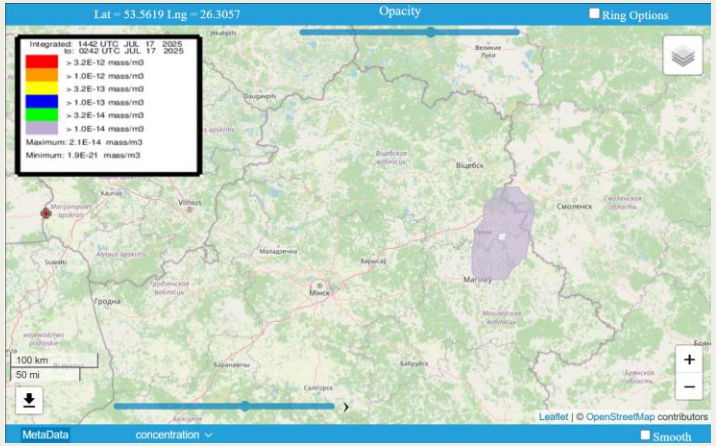
HYSPLIT modeling shows a possible Xe transfere from the Belarusian NPP on a curved trajectory.

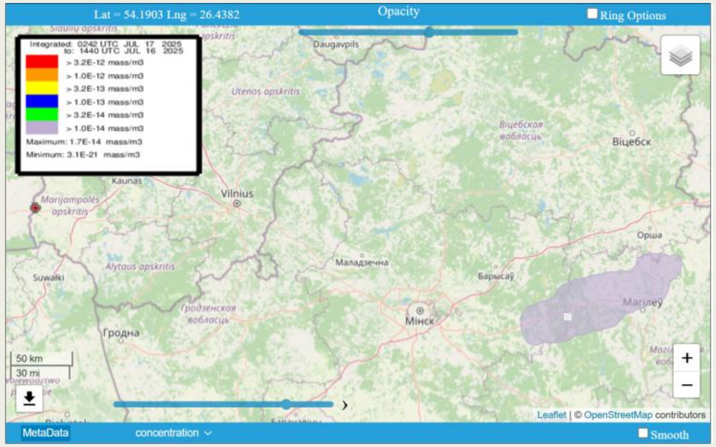












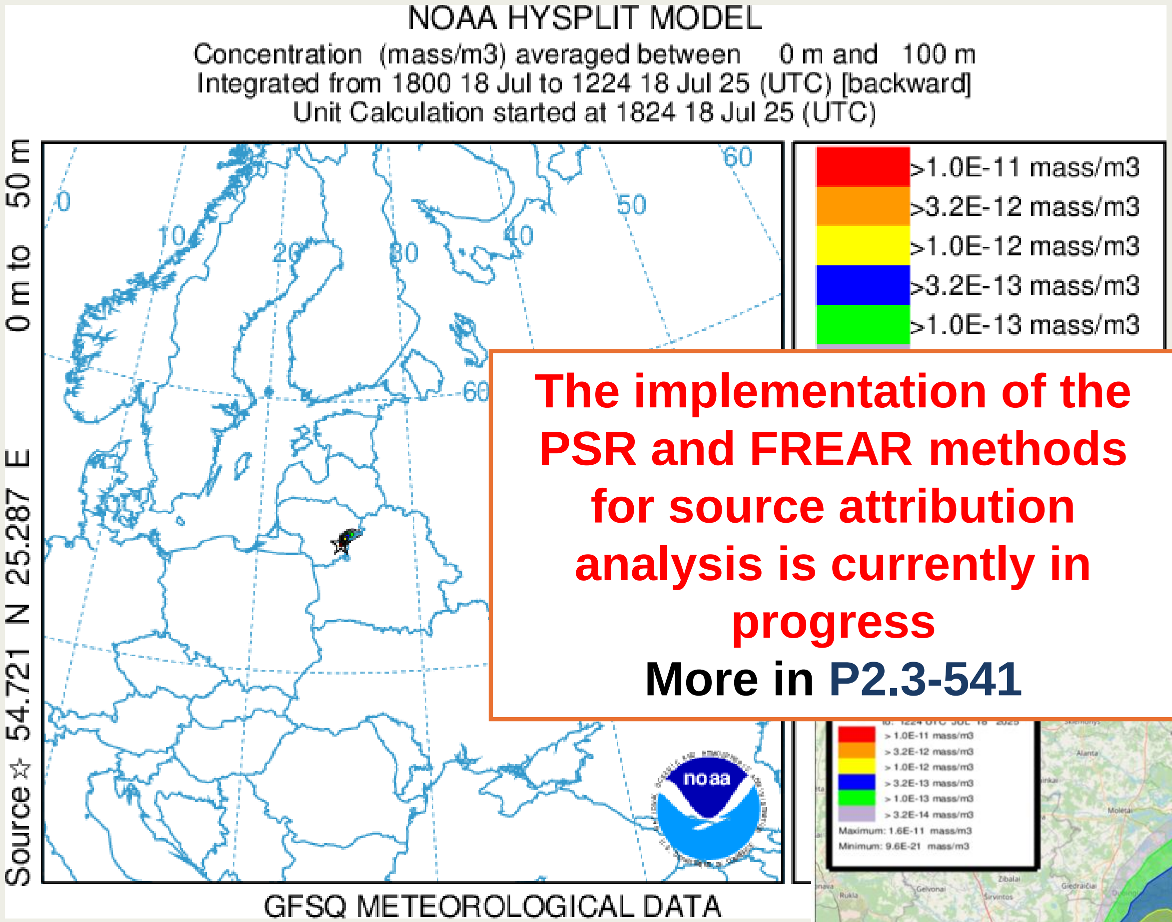
2025 07 19 probable release of ^{133}**Xe** from the Belarusian NPP identified

SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

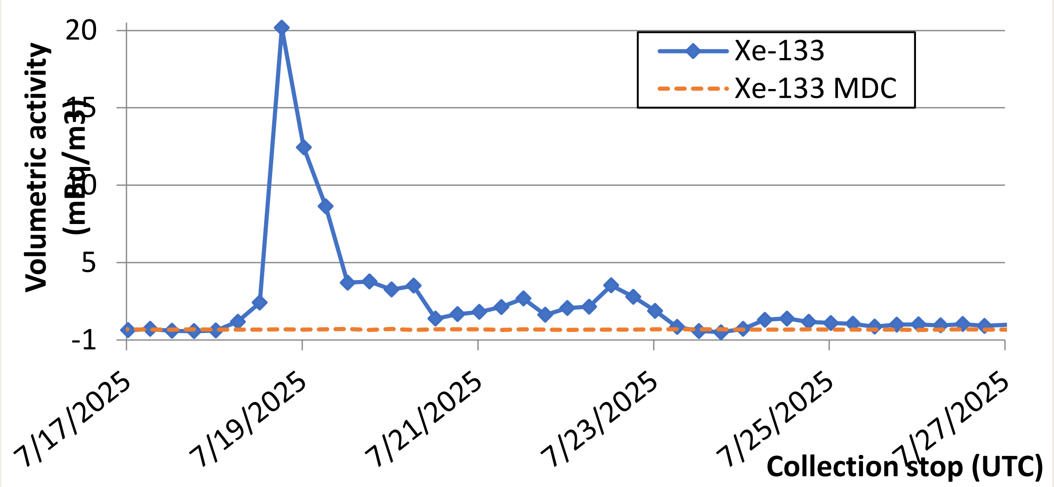
O2.3-272

Backward calculation Vilnius (SAUNA III) 2025 07 19

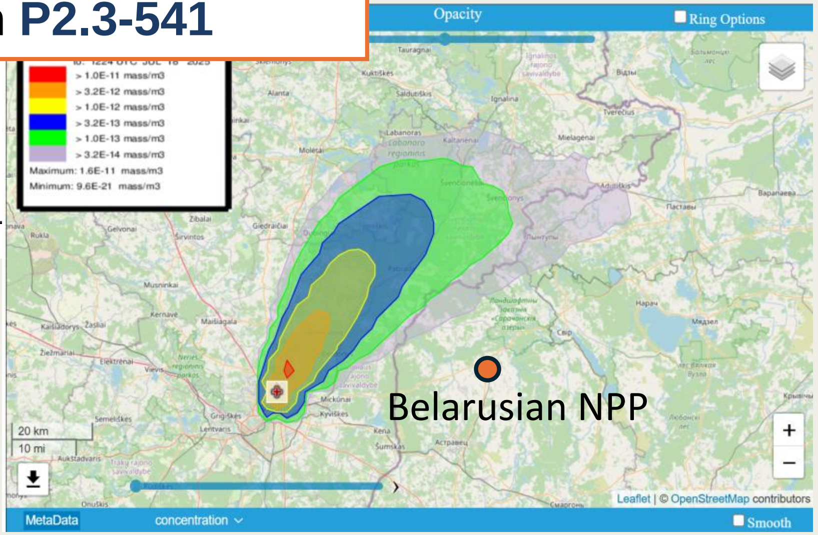


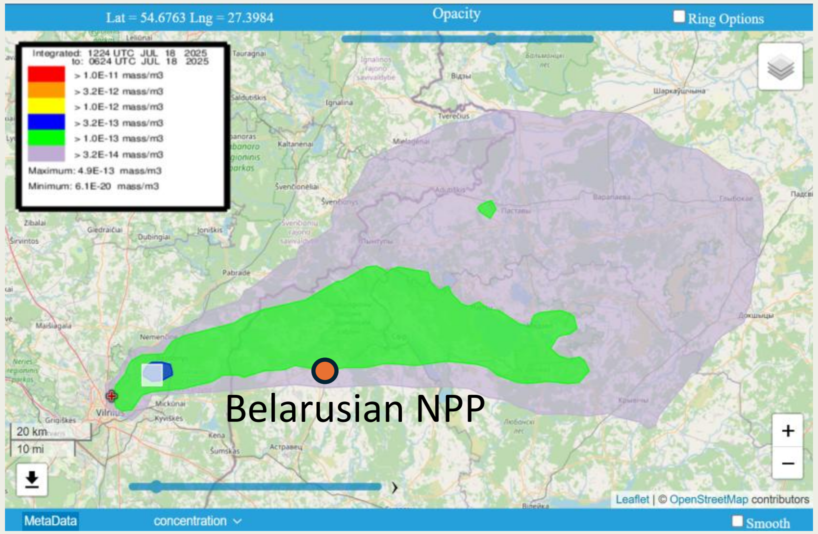
The implementation of the PSR and FREAR methods for source attribution analysis is currently in progress

More in P2.3-541



HYSPLIT simulation shows Xe transfere from Belarusian NPP





2025 07 19

There is probability that ^{133}Xe, ^{131m}Xe, ^{133m}Xe ir ^{135}Xe are released from the Belarusian NPP.

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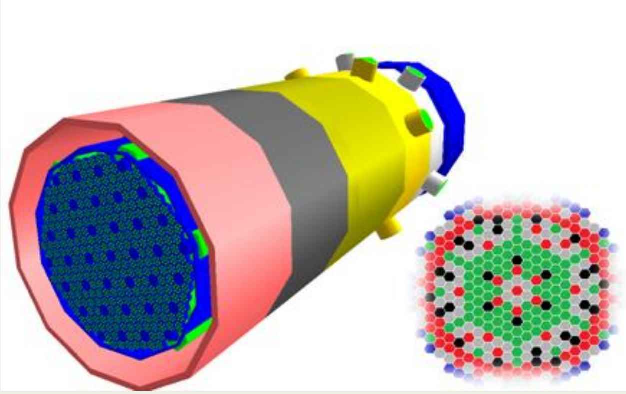
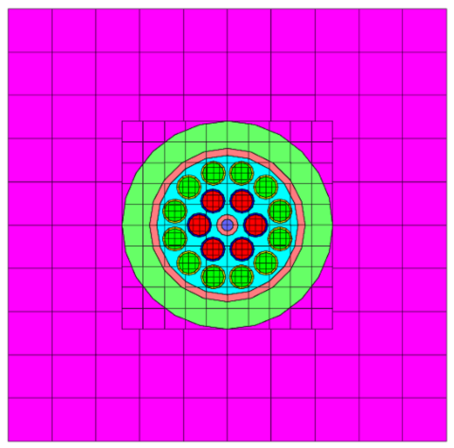
Xe source identification from Xe isotope ratios

Modelling of Xe isotopes generation at different reactors

Models of VVER-1200 reactor (Belarusian), RBMK-1000 (Leningrad) , PWR (Ringhals) and BWR (Forsmark) fuel assemblies using SCALE 6.2.3 code

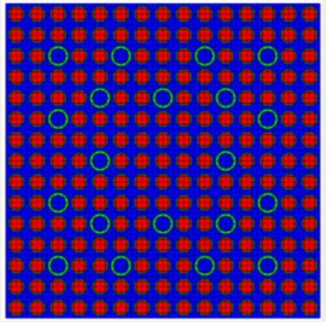


VVER reactor core (MCNP)

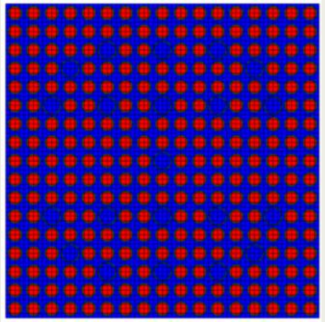


RBMK-1000 assembly with SCALE 6.2

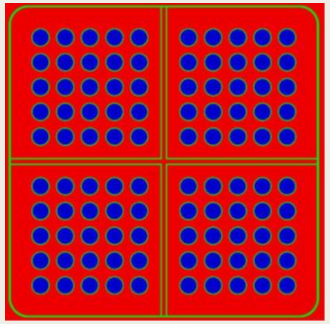
PWR (Ringhals) and BWR (Forsmark) assembly modeling with SCALE 6.2



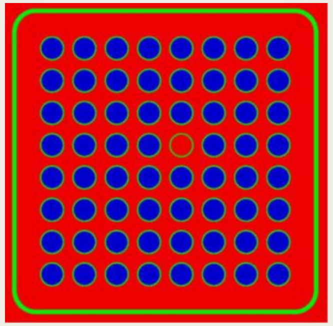
15x15 AFA



W 17*17



SVEA 100



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R. Plukienė, E. Maceika, O.A. Olechnovič, V. Milinkevičius, A. Ševčik, O. Chudikaitė, , D. Sinkevičius, [1]. Žiliukas, A.Plukis

Xe isotopes ratios at different reactors

(t=0)	PWR1	PWR2	BWR1	BWR3	VVER	RBMK
Power, MW	881	1081	1121	1121	1200	1000
U-235 enrichment %	4.1	3.5	3.42	2.33	3.6	2.4
Burnup, MWd/kg	38.1	36.3	18.9	16.4	35.0	11.5
Xe-135/Xe133	*0.28*	*0.26*	*0.26*	*0.27*	*0.21*	*0.27*
Xe-133m/Xe-131m	*5.61*	*4.32*	*3.79*	*4.89*	*5.22*	*5.02*
Xe-133m/Xe133	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*
Xe-135/Xe-133m	*9.14*	*9.05*	*9.70*	*9.37*	*6.85*	*9.75*
Xe-131m/Xe-133	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*

All 4 Xe isotopes are required to identify the source, and it is necessary to know the reactor operating parameters and the transfer time (t).

FIZINIŲ IR TECHNOLOGIJOS MOKSLŲ CENTRAS

R. Plukienė, E. Maceika, O.A. Olechnovič, V. Milinkevičius, A. Ševčik, O. Chudikaitė, , D. Sinkevičius, [1]. Žiliukas, A.Plukis

Xe transmission/detection time

Theoretically estimated Xe transmission time from Belarusian NPP (Astravas) to stations

Xe transfere from Belarusian NPP										scenarios:	
Atmospheric stability class			A	B	C	D	E	F	Slow	Fast
Wind speed, m/s			2	3	5	6	4	3	0.5	20
station	s, km	coll. t, h	t + collection time SAUNA, d							
Vilnius	51	6	0.5	0.4	0.4	0.3	0.4	0.4	1.4	0.3
Palanga	347	12	2.5	1.8	1.3	1.2	1.5	1.8	8.5	0.7
Kybartai	215	12	1.7	1.3	1.0	0.9	1.1	1.3	5.5	0.6
Adutiškis	52	12	0.8	0.7	0.6	0.6	0.7	0.7	1.7	0.5

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Model estimate of possible Xe ratios at Adutiškis station from NPPs with different types of reactors at 0.5m/s wind speed

SLOW scenario (Adutiškis)	Ringhals	Forsmark	Leningrad	Smolensk	Kursk	Astravets
Power, MW	1000	1100	1000			1200
U-235 enrichment %	3.5	3.4	2.4			3.6
Burnup, MWd/kg	36	19	12			35
Xe-135/Xe-133	0.00	0.00	0.00	0.00	0.00	**0.04**
Xe-133m/Xe-131m	0.02	0.04	0.21	0.44	0.06	**4.02**
Xe-131m/Xe-133	0.03	0.03	0.01	0.01	0.02	0.01

If wind speed is moderated at the Adutiškis, Vilnius and Kybartai stations

Xe-135 can only be detected from Belorusian NPP.

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Model estimate of possible Xe ratios at Adutiškis station from NPPs with different types of reactors at 20m/s wind speed

FAST scenario (Adutiškis)	Ringh2	Fors1	Leningrad	Smolensk	Kursk	Astravets
Power, MW	1000	1100	1000			1200
U-235 enrichment %	3.5	3.4	2.4			3.6
Burnup, MWd/kg	36	19	12			35
Xe-135/Xe-133	0.11	0.13	0.16	0.18	0.13	**0.17**
Xe-133m/Xe-131m	3.8	3.4	4.64	4.72	4.49	**5.05**
Xe-131m/Xe-133	0.01	0.01	0.01	0.01	0.01	0.01

If wind speed exceeds 20m/s wind speed , Xe-135 can also be detected from other NPPs at Adutiškis and all Lithuanian network stations

First results of radioxenon detections of SAUNA III and 3 SAUNA Q_B network in Lithuania

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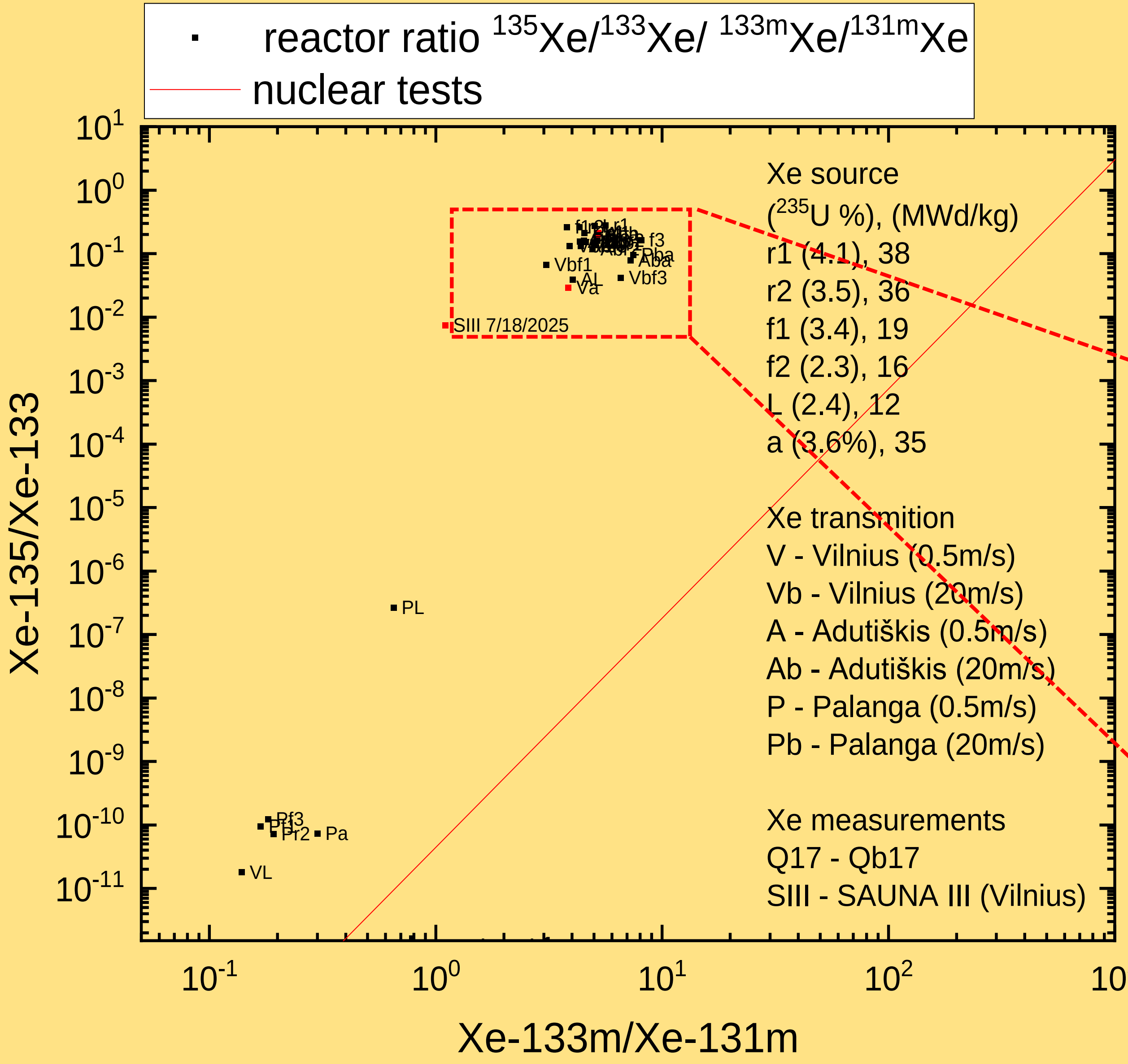
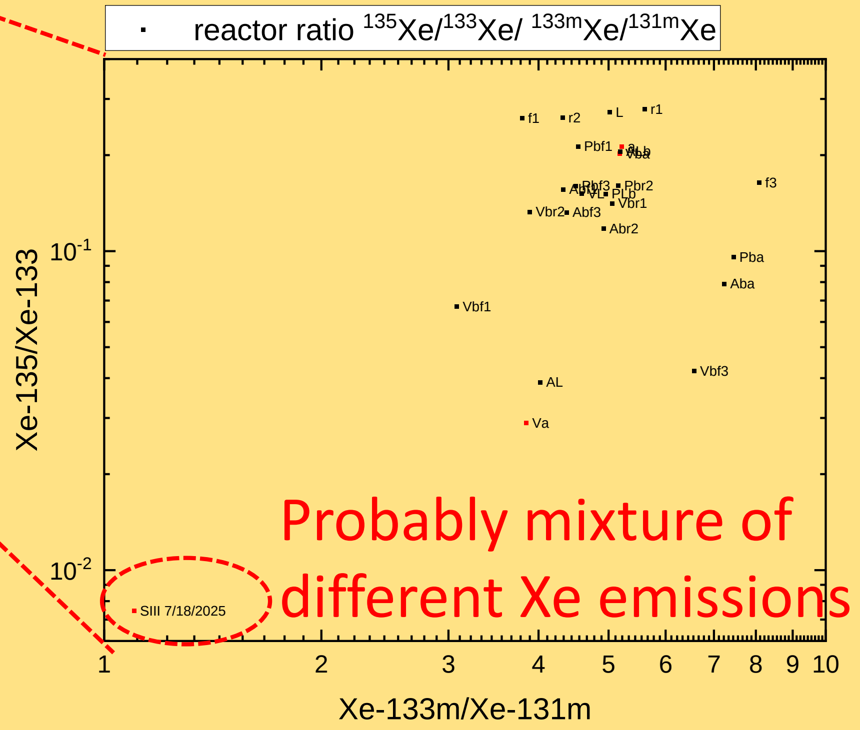
O2.3-272

Identification according to Xe isotope ratios and the ability to distinguish emissions from different nuclear reactors so far looks like this





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Conclusions

- The Sauna III and Q_B stations system has been installed in Lithuania, allowing for the recording of Xe emissions from the Belarusian NPP or other nuclear facilities.
- The Xe stations results will contribute to efforts to ensure the safety of the population in Lithuania in the event of nuclear accident.
- The Q_B stations in Adutiškis have been operating continuously since 2024 09 30, in Kybartai since 2024 12 20, in Palanga since 2024 12 20; SAUNA III in Vilnius since 2024 12 25.
- During the measurement period, the most frequently measured 2 Xe isotopes (^{131m}Xe and ^{133}Xe) were above the minimum detection concentration limit. However, there were no significant emissions and no risk to human health.
- By analyzing measurement data combined from several SAUNA stations and using atmospheric transport models with actual or predicted meteorological data, it is possible to identify radioxenon emission sources (with better precision).

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Thank you for your attention!
Any questions?