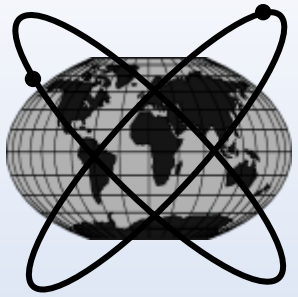

Lares LLC

High Sensitive Xe Measurement

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CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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Outline of the Large Sample approach:

- New approach to **high sensitive Xe measurement:**

- aim of the **Large Sample** technology application;
- advantages;
- equipment.

- First results
- Conclusions

The aim of the Large Sample approach

- The important task of the approach is defining the ratio of the following isotopes - Xe^{133m}/Xe^{133}; Xe^{131m}/Xe^{133} - at the Xe^{133} background level **10^{-3} Bq/m³**.
- It is necessary for identification of the injection source.

- There are two ways to achieve this goal: either significant MDA improvement or large volume sample measurements; the Large Sample approach is focused on the second point.

What is the Large Sample technology?

1. The volume of **pure Xe** sample is more than **100 ml**.
2. Honeycomb structure of beta-detectors based on SiPIN diodes affords to manufacture detectors of various volume: from **50 ml** to **500 ml**.
3. Use of air separation plants (ASP) products allows to measure Xe isomers with **MDC n*10^{-7} Bq/m^3**.

How does the Large Sample technology work?

Preparation of the Xe spectrometric sample includes the following steps:

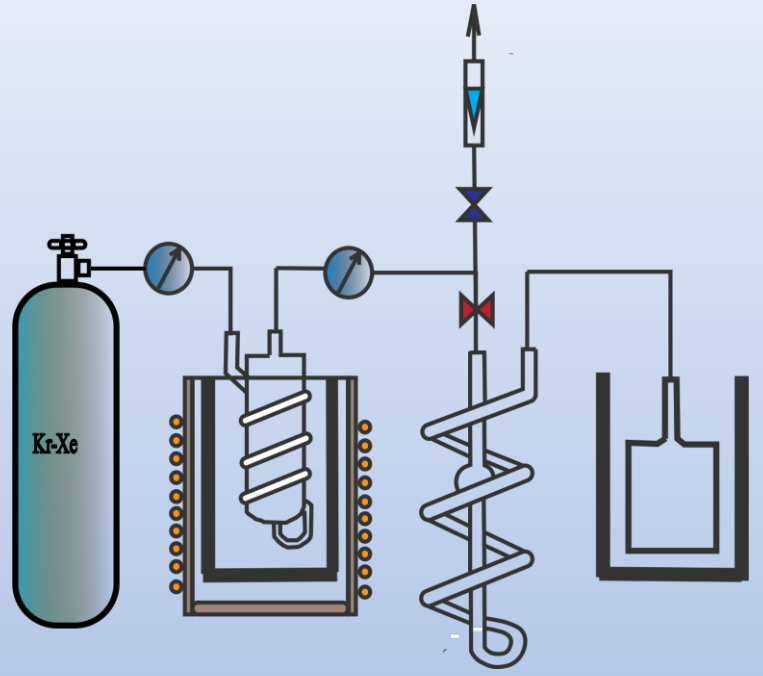
- taking out the Xe-Kr concentrate, produced by ASP (air separating plants) (92% Kr, 7% Xe, Rn), the sampling start and stop time is known;
- enrichment of the Xe sample and cleaning it from Rn;
- splitting the sample into pure Xe and Kr.

How does the Large Sample technology work?

- A large ASP processes more than 10^9 m^3 per day. There are more than 100 large ASPs around the globe.
- We developed and tested a mobile unit which can produce more than 1 L of pure Xe from Xe-Kr concentrate.
- The cost of Xe-Kr concentrate is less than $3 per L

Separation and purification unit for the large sample

The installation has robust design and is easy in operation
The unit can extract up to 1 L Xe per day
Duration of one working cycle is approximately 4 h



The main technological steps:

- *Xe extraction from Xe-Kr concentrate in Xe trap;*
- *cleaning from **Rn** (more than **10^7** times) and removing the rest part of Kr. The final concentration of Kr in the sample should not exceed 0.1%.*
- *dozing Xe sample into detector measuring cell and volume concentration analysis*
- *the installation weight is **15-20 kg**.*

The technology was developed by Y. Popov and V. Prelovsky. More than 5,000 Xe large samples samples have been produced using this technology since 70s.

Detector system for the large sample

Main description of the detector design:
- operation in beta-gamma coincidence mode;
- NaI (Tl) crystal for gamma detection;
- SiPIN beta-cell (**11 independent SiPIN** diodes); if one SiPIN diode is out of order, the others stay functional.

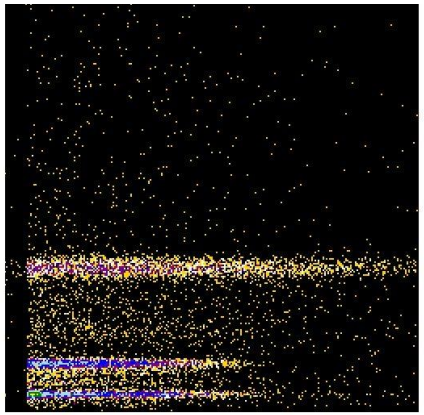
Main technical specifications of the detector:
- 11 SiPIN detectors mounted in cylinder shape cell with **45 ml** volume (Ø37 mm x 50 mm);
- operation pressure range up to 2 atm;
- **resolution at 200 keV - 11 keV.**

First results:

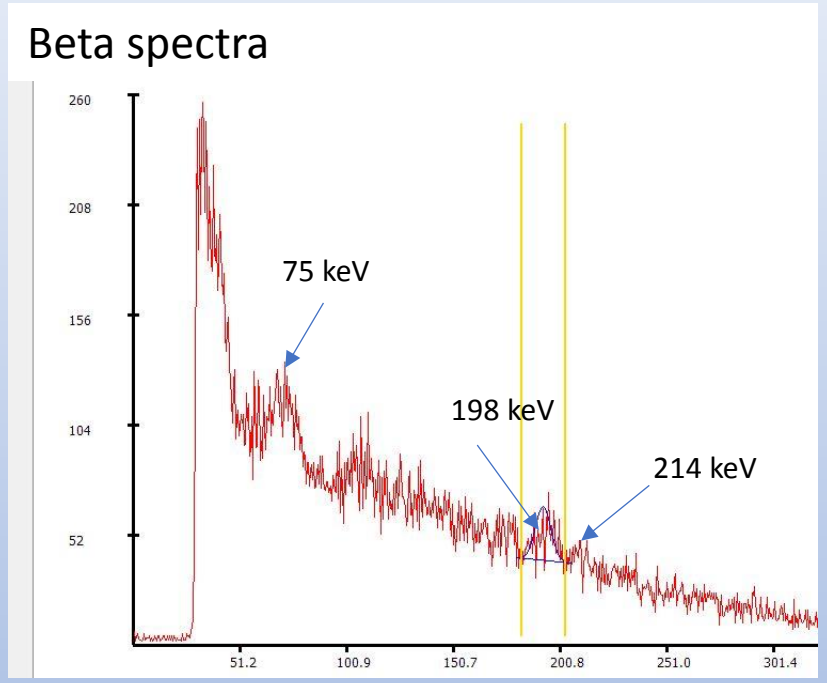
- **25 samples** were produced from Xe-Kr concentrate during tuning and testing the detector system.
- **Xe-Kr concentrate** was delivered to St. Petersburg from different ASPs with 1-5 days delay.
- **Xe^{133}** along with **one or two metastable Xe isotopes** were measured in all samples. **Xe^{135}** was very often registered in fresh samples.
- After testing phase all measurements were performed under atmospheric pressure.
- **MDC** for **Xe^{133}**, **Xe^{135}**, **Xe^{133m}** and **Xe^{131m}** was always < **10^{-5} Bq/m^3.**

Xe^{133}, Xe^{135} and Xe^{133m} background spectra

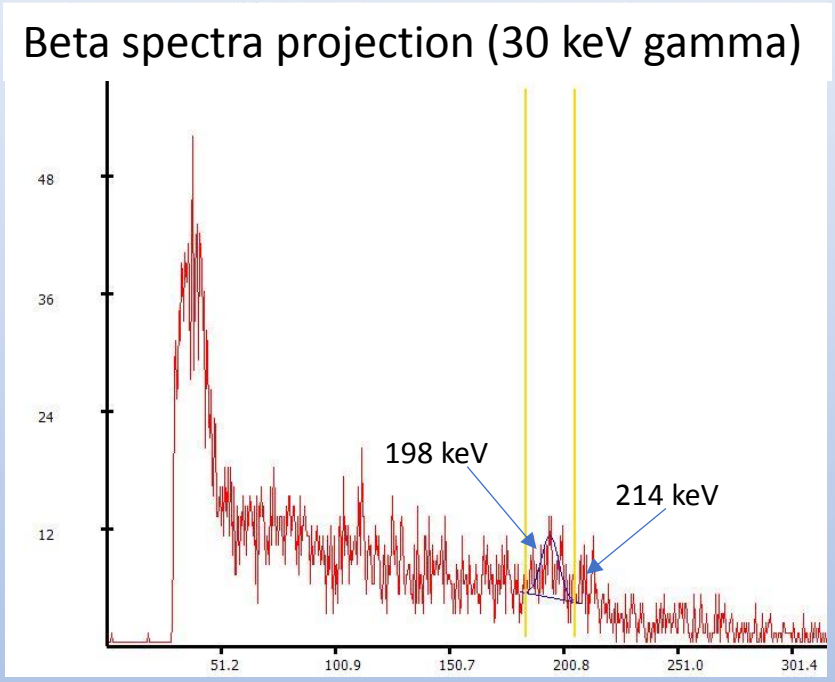
2D beta –gamma Histogram



Beta spectra



Beta spectra projection (30 keV gamma)



Xe^{133} – **0.92 mBq/m³**;

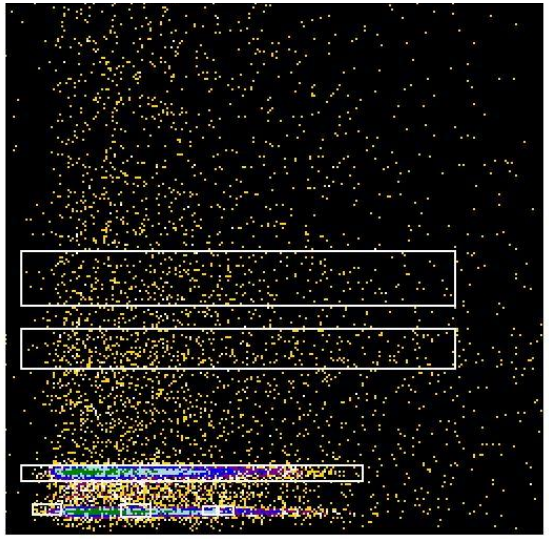
Xe^{135} – **0.12 mBq/m³**;

Xe^{133m} – **0.02 mBq/m³**;

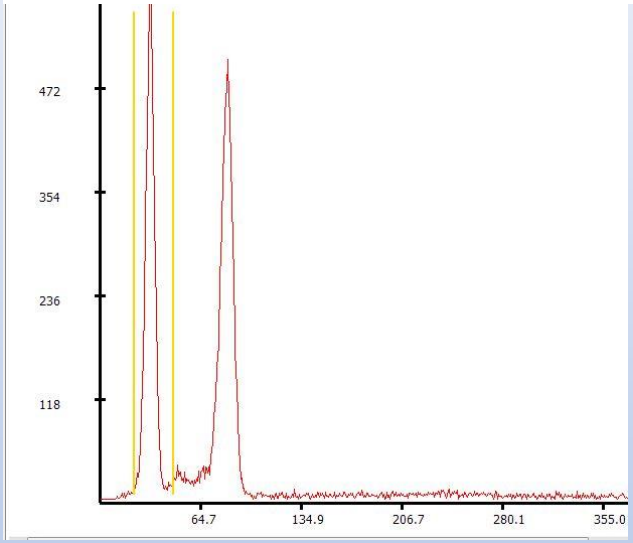
Xe Volume – **51 ml (586 m³)**.

Xe^{133} and Xe^{133m} background spectra

2D beta –gamma Histogram



Gamma coincidence spectra

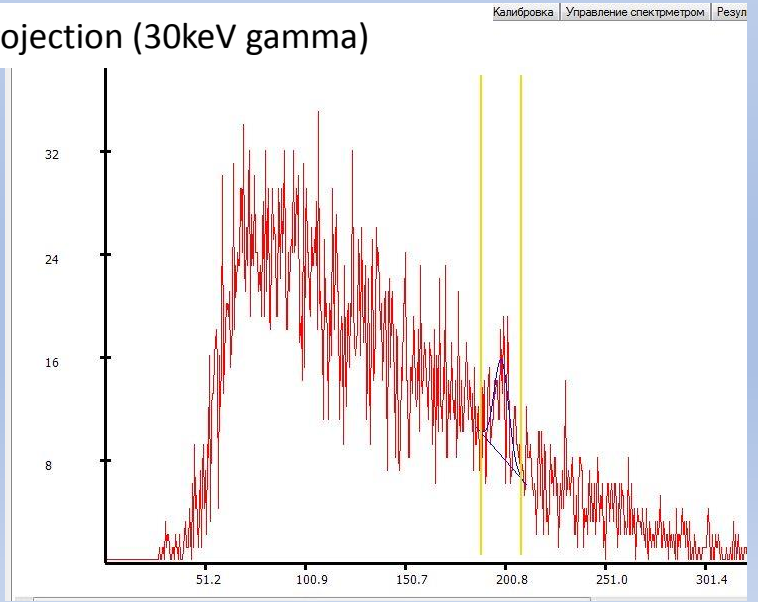


Xe^{133} – **1.1 mBq/m³**;

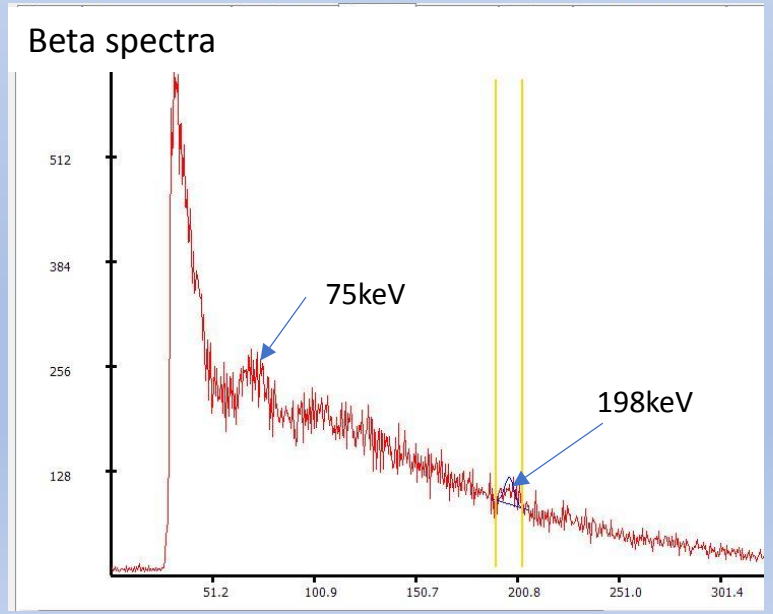
Xe^{133m} – **0.02 mBq/m³**;

Xe volume – **47 ml (540 m³)**.

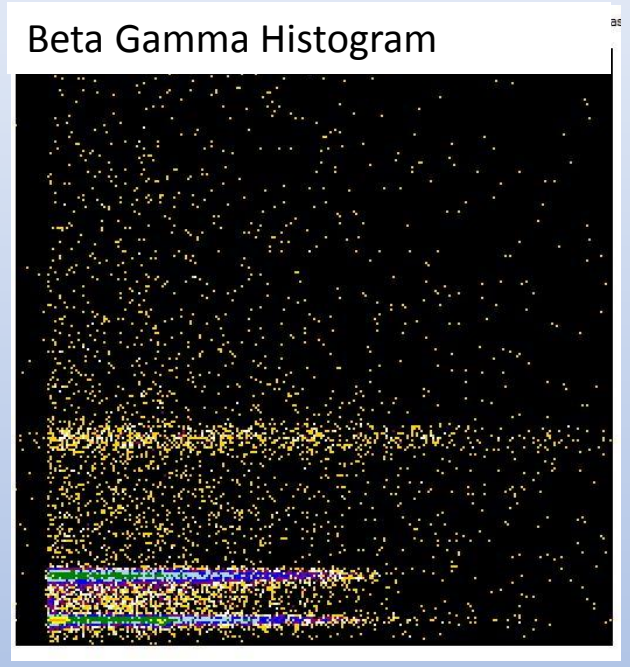
Beta spectra projection (30keV gamma)

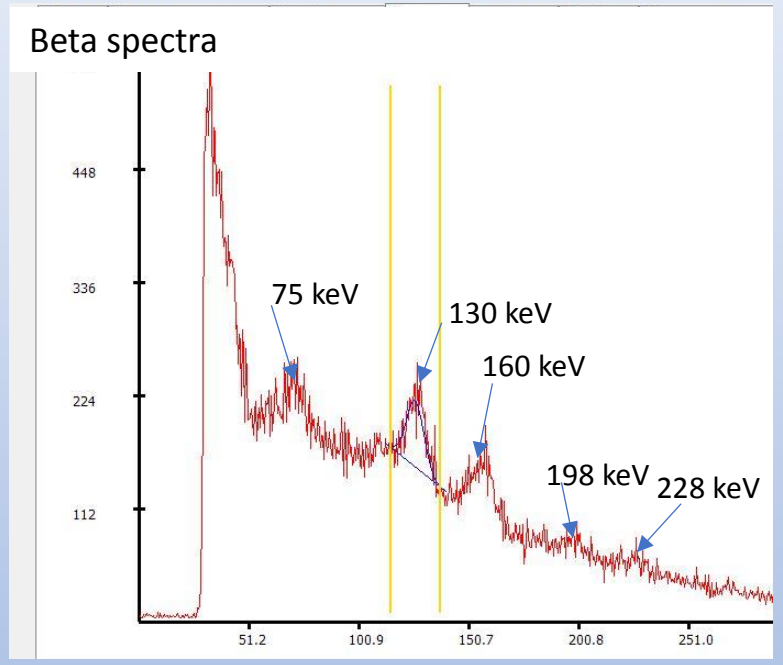


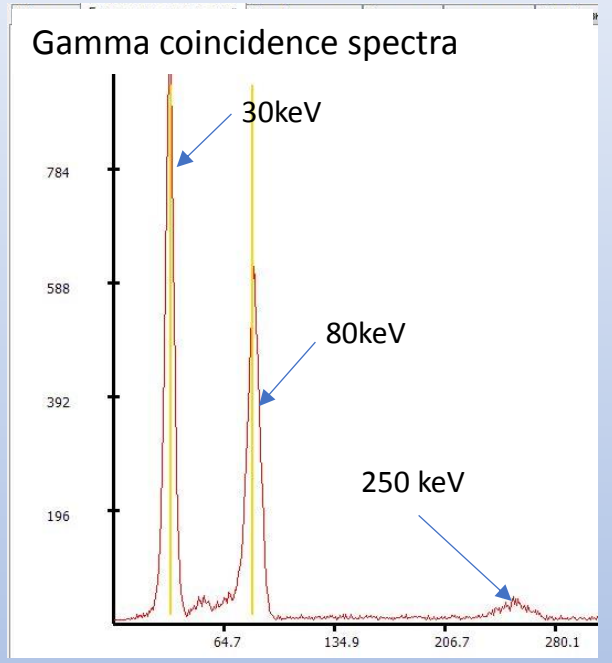
Beta spectra



Xe^{133}, Xe^{135} , Xe^{133m} and Xe^{133m} background spectra







Xe^{133} – **1.04 mBq/m³** Xe^{135} – **0.03 mBq/m³**;

Xe^{133m} – **0.01 mBq/m³** Xe^{131m} – **0.21 mBq/m³**

Xe Volume – **63 ml (724 m³)**

Conclusions

1. The Large Sample approach and equipment allows to reach MDC of Xe^{131m} and $Xe^{133m} \approx 5*10^{-5}$ Bq/m^3 at the 24 h measurement time and the sample volume < 100 ml.
2. Structural concept of the Large Sample facility allows to acquire spectrometric products of Xe in the volume up to 1,000 ml. Honeycomb structure of the measuring camera guarantees the measurement of Xe isomers in such sample at the level of $n*10^{-7}$ Bq/m^3.
3. The method allows to detect Xe at the lowest level for improving the criteria of radiation source identification by studying the following concentration ratios: Xe^{133m} /Xe^{133}; Xe^{131m}/Xe^{133}.
4. The approach provides additional Kr^{85} measurement in the atmosphere with the statistical uncertainty 1% considering 514 keV line at beta-gamma coincidences.
5. If one SiPIN gets out of order, the detector system remains functional.
6. The advantages of this detector system could be applied to the measurements of low-volume Xe products (3-7 ml Xe) at the resolution rate > 8 keV for conversion electrons and MDA = 3.5 mBq.

Thank you!