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Kr-85 monitoring in St.-Petersburg, 2007-2008

**Abstract.** <sup>85</sup>Kr monitoring in USSR-Russia ended in 1993, at that time <sup>85</sup>Kr activity concentration was 0.9-0.92 Bq/m<sup>3</sup>. <sup>85</sup>Kr activity concentration in 1995 was 1.0 Bq/m<sup>3</sup> according measurement result Kr from old commercial Kr balloon. The monitoring of Xe and <sup>85</sup>Kr radionuclides was renewed in August 2006, and was performed at the sampling station in Cherepovets city, located 220 km north of the Kalinin NPP. A balloon was filled with the Kr-Xe gas mixture with charcoal and analysed at the Radium Institute. For the period of monitoring on 2006-2008 in Cherepovets city the concentration of <sup>85</sup>Kr varied from 1.3 to 1.8 Bq/m<sup>3</sup> and amounted to 1.55 ± 0.12 Bq/m<sup>3</sup> on average. The mean <sup>85</sup>Kr activity concentration in atmospheric air in St.-Petersburg was 2.11 ± 0.66 Bq/m<sup>3</sup>, which is 37% higher than that in Cherepovets. Air masses with elevated <sup>85</sup>Kr concentration are mainly transferred from the West and the South-west directions, i.e. from NPPs location regions. Air masses with lowered <sup>85</sup>Kr concentration moved from the North (Greenland Sea, Northern and Norwegian Seas), where there are no NPPs located. Measurement of commercial Kr in June 2015 determinate <sup>85</sup>Kr activity concentration equal 1.1 Bq/m<sup>3</sup> with uncertainty 10%.

<sup>85</sup>Kr monitoring in USSR-Russia ended in 1993, at that time the <sup>85</sup>Kr concentration activity was 0.9-0.92 Bq/m<sup>3</sup> [1,2]. The monitoring of Xe and <sup>85</sup>Kr radionuclides was renewed in August 2006, and was arranged at the sampling station in Cherepovets city ( 59,12o N. и 37,85o E.), Vologda province, located 220 km north of the Kalinin NPP.



Fig.1 Container for sampling of Kr-Xe mixture

Xe-Kr concentrate volume of 2.5 L (Fig.1) is delivered to St.- Petersburg ( Khlopin Radium Institute) and separated on Kr and Xe fractions in laboratory. The volume of Kr in measuring container for gamma

spectrometer varied from 400 to 1400 cm<sup>3</sup> ( STP); it was equivalent to ~ 350 -1200 m<sup>3</sup> of processed atmospheric air. <sup>85</sup>Kr monitoring results in atmospheric air of Cherepovets are presented in Fig.2.

Kr-85 monitoring in Cherepovets city

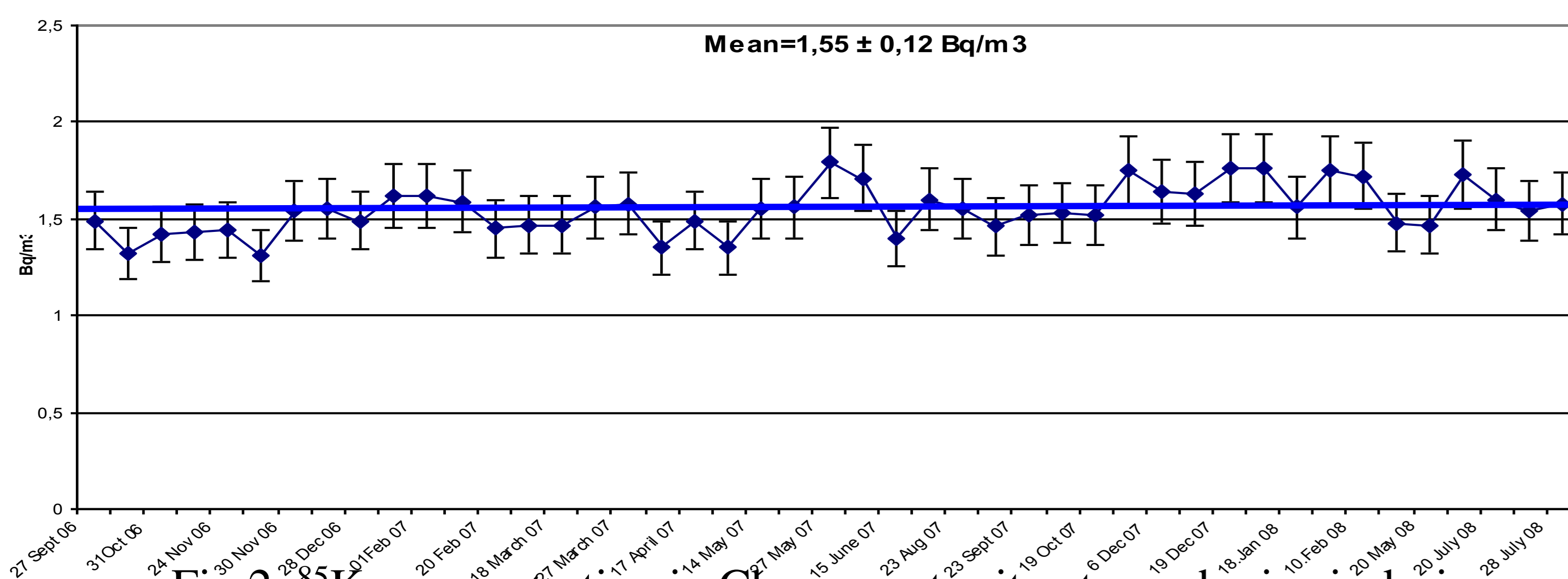


Fig.2. <sup>85</sup>Kr concentration in Cherepovets city atmospheric air during period September 2006 –July 2008

<sup>85</sup>Kr concentration was changing in the limits from 1.31 to 1.79 Bq/m<sup>3</sup>, with uncertainty 10%. and was on average 1.55 Bq/m<sup>3</sup>. MSD for a given series (45 analyses) equals is 0.12 Bq/m<sup>3</sup>, coefficient of variation V (MSD x 100/ mean value) equals to V=7.7%, median coincides with mean value, being 1.55 Bq/m<sup>3</sup>.

Comparing the data obtained with monitoring results in the USSR in early 90s, <sup>85</sup>Kr concentration can be seen to be considerably increased.

<sup>85</sup>Kr concentration increased up to 1.5-1.6 Bq/m<sup>3</sup> in Europe and Japan in 1995-1996 as spent fuel was reprocessed in some countries [3-5].

As it can be seen from of Fig. 2, the value of average concentration was exceeded on 27 May 2007, 16 November 2007, 19 December 2007, 16 January 2008, 08 February 2008, 10 February 2008, and 17 July 2008, and concentration was lower, than average value on 23 October 2006, 27 November 2006, 14 April 2007, and 11 May 2007.

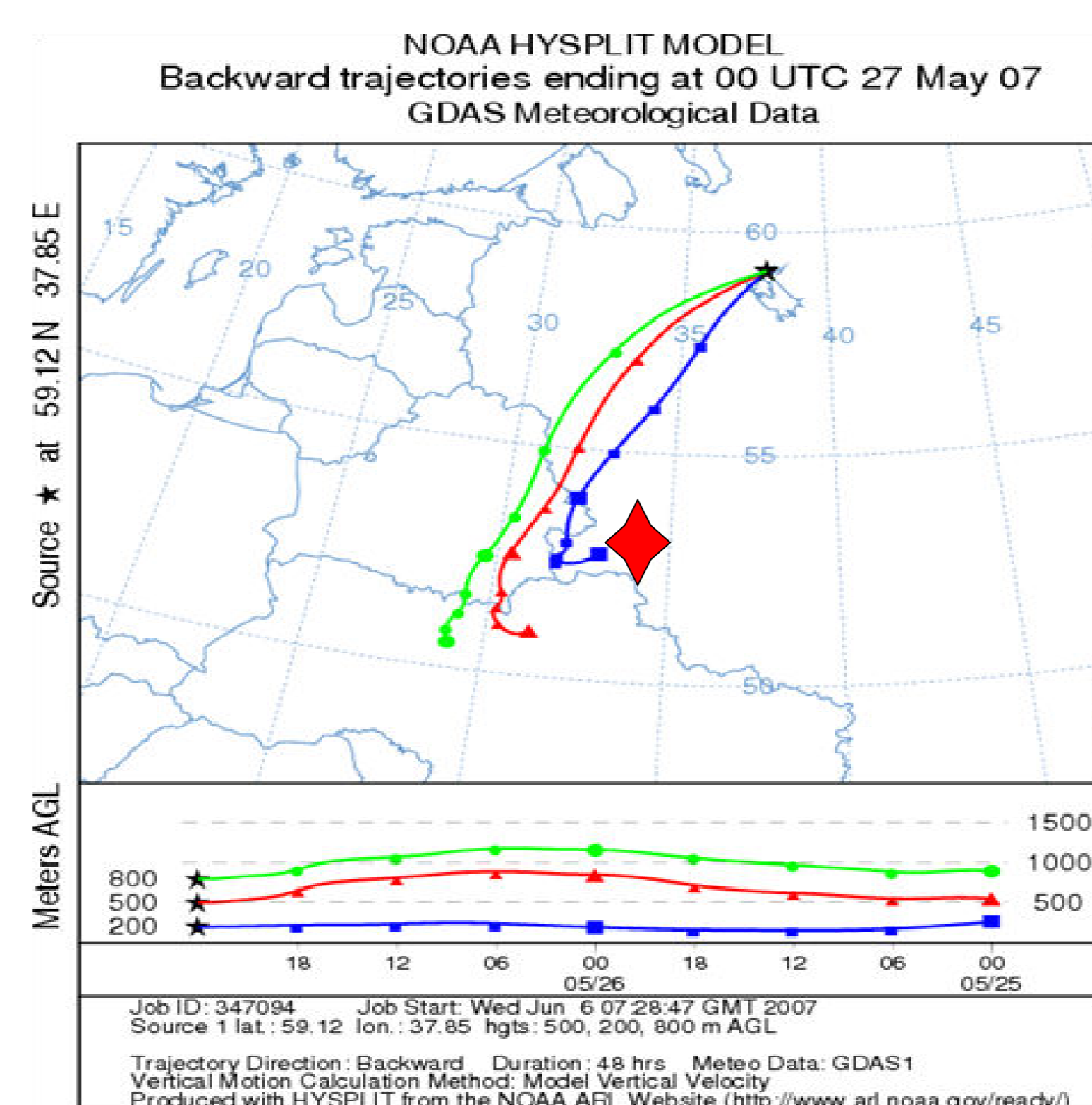


Fig.3. Two-day backward trajectories on the levels 200 m, 500 m, and 800 m to Cherepovets control site on 27 May 2007, approximate location of the Smolensk NPP (54o10'N, 33o14'E) is marked with red rhomb

Two days before 27 May 2007 the air mass had come at the level of 200 m from border territory of Northern Ukraine and Russia, and at the levels of 500 m and 800 m - from Northern Ukraine's regions; and then after entering the above Russia space it was moved within the region of Smolensk NPP.

On 14 April 2007 (<sup>85</sup>Kr = 1.35 Bq/m<sup>3</sup>) the air mass on heights of 500 m and 800 m had its rise to the east from the White Sea's Dvinskaya Guba (Bay) and then was moved through Arkhangelsk province towards the region of Cherepovets city (Fig.4).

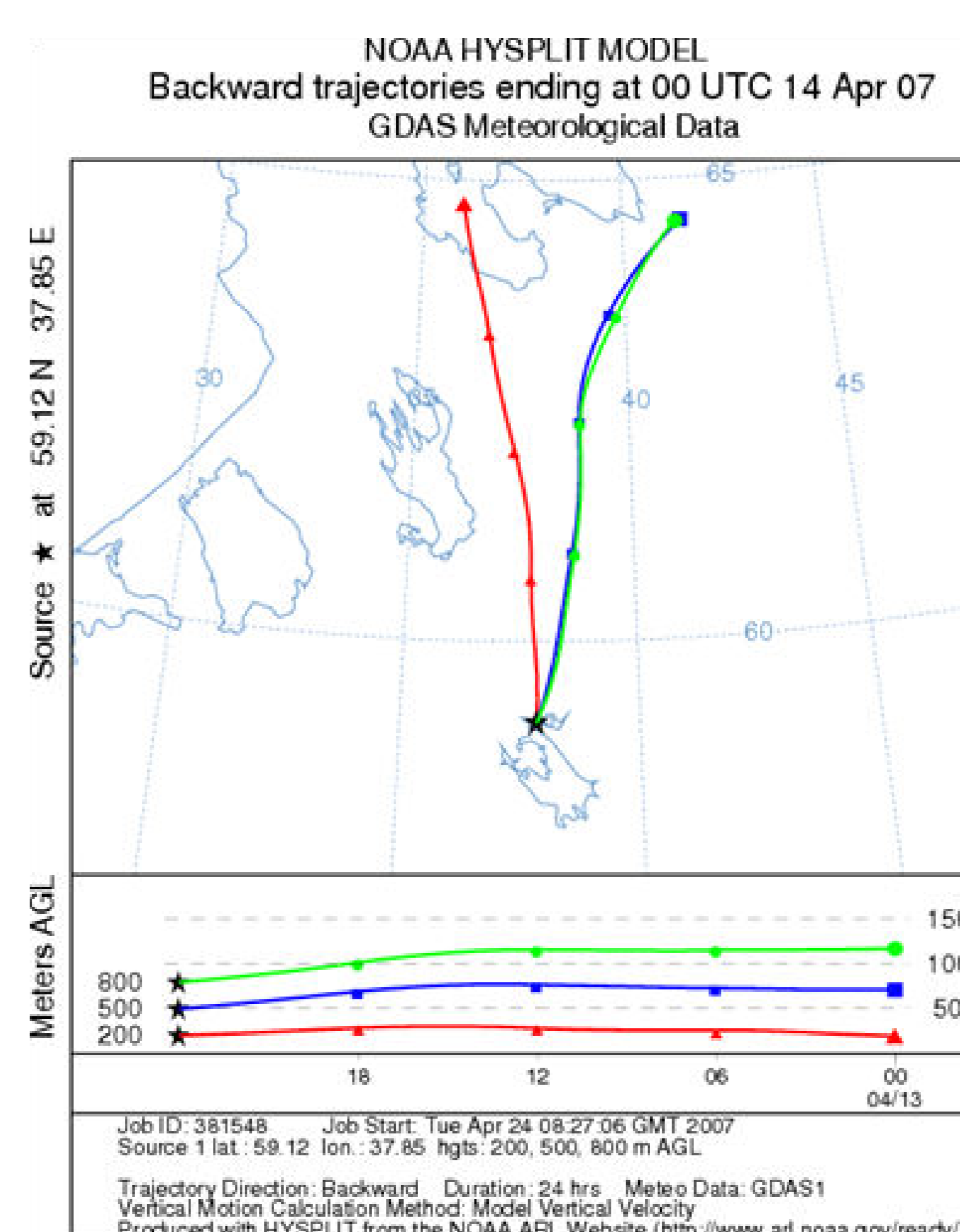


Fig.4. Diurnal backward trajectories to Cherepovets site at 00UTC 14 April 2007

<sup>85</sup>Kr monitoring was also performed in St.-Petersburg. Kr fraction was extracted from liquid technical oxygen samples with further measuring in HPGe -detector spectrometer with well. Sampling was carried out twice a week; 115 samples were analyzed in all. The analyses results are presented in Fig.5.

To the middle of 2012 krypton samples were separated from liquid technical oxygen in St.-Petersburg, and <sup>85</sup>Kr activity concentration was measured by HPGe detector with well spectrometer. <sup>85</sup>Kr concentration values were changed in the interval of 0.92-2.50 Bq/m<sup>3</sup>, mean value for this observation period equal 1.55±0.5 Bq/m<sup>3</sup> (n=15), and 1.5 Bq/m<sup>3</sup> for median.

It is evident that <sup>85</sup>Kr concentration during the period from 2008 through 2012 in St.-Petersburg air was decreased from 2,1 up to ~1,6 Bq/m<sup>3</sup>. Also volumetric activity <sup>85</sup>Kr concentration, containing in old cylinder with Kr, filled in 1995 r has been measured in June, 2012, at the moment of measurement its volumetric activity with error 10 % was equaled 0,32 Bq/m<sup>3</sup>, that there corresponds to 1,0 Bq/m<sup>3</sup> on the middle 1995. Measurement of commercial Kr in June 2015 shown that <sup>85</sup>Kr activity concentration equal 1.1 Bq/m<sup>3</sup> with uncertainty 10%.

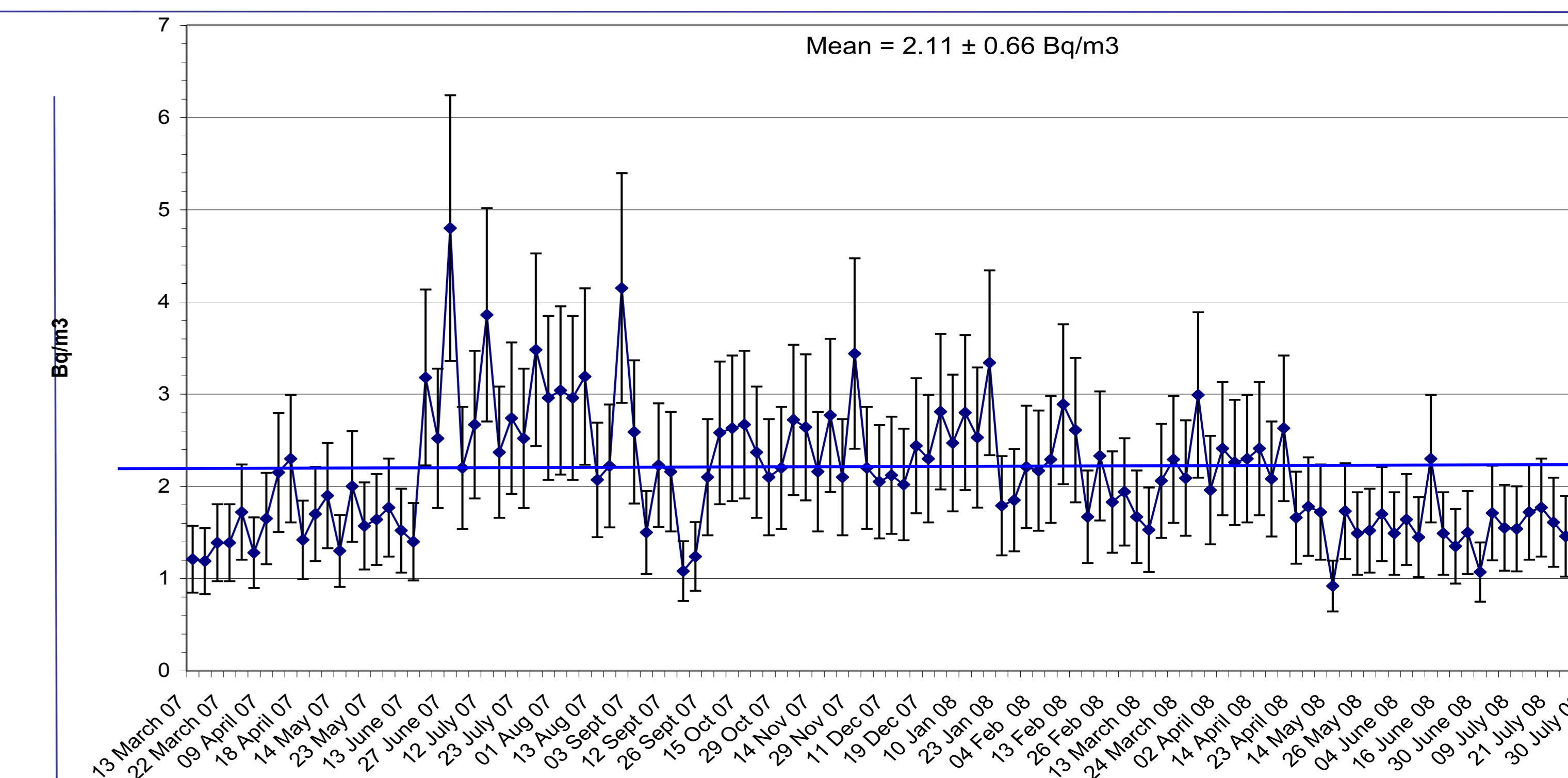


Fig.5. <sup>85</sup>Kr concentration activity in St.-Petersburg atmospheric air during 2007 – 2008, blue line- mean concentration activity

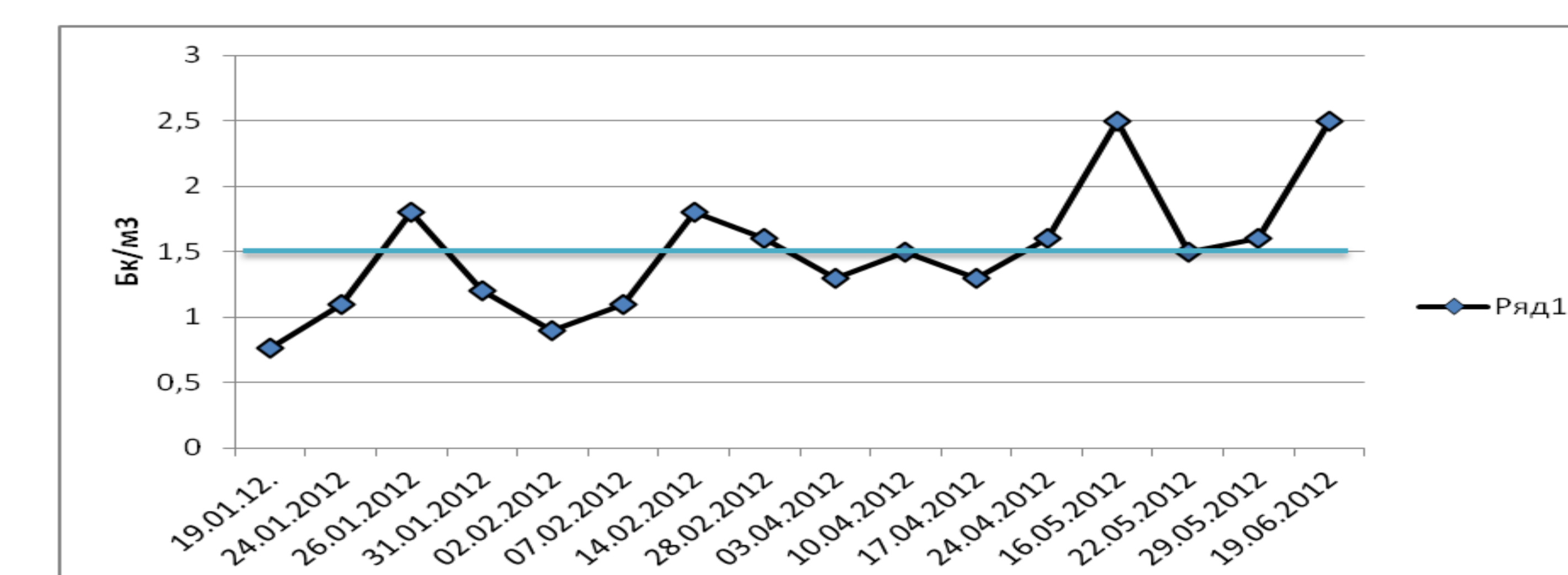


Fig.6 <sup>85</sup>Kr concentration activity in St.-Petersburg atmospheric air during 2012, blue line- mean concentration activity

### Conclusion

Thus, our investigation showed that in the period from 1993 to 2006 <sup>85</sup>Kr activity concentration in the North-western Region of Russia increased up to 1.5 times, and equal 1.55 ± 0.12 Bq/m<sup>3</sup>, and in 2012 <sup>85</sup>Kr concentration in atmospheric air in St.-Petersburg is decreased from 2,1 up to 1,6 Bq/m<sup>3</sup>.

For <sup>85</sup>Kr monitoring it is expedient to use Kr-Xe concentrate obtained in different regions of the country. Method of Kr and Xe separation from samples of liquid technical oxygen available practically in any city could also be used. In order to implementation this method, mobile gas analytical laboratory equipped with high resolution gamma spectrometer is to be design.

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