Technology for reduction of ^{85}Kr content in Xe

Simakov Grigoriy

SSC RF ITEP of NRC “Kurchatov institute”&NRU MIPT (SU)

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The WIMP search experiments of next generation Xe detectors require extremely low levels of ^{85}Kr: $< 10^{-12}$ of natural Kr in Xe

^{85}Kr in natural Kr: ~ 2.5×10^{-11}

Traditional way: direct purification of Xe from Kr

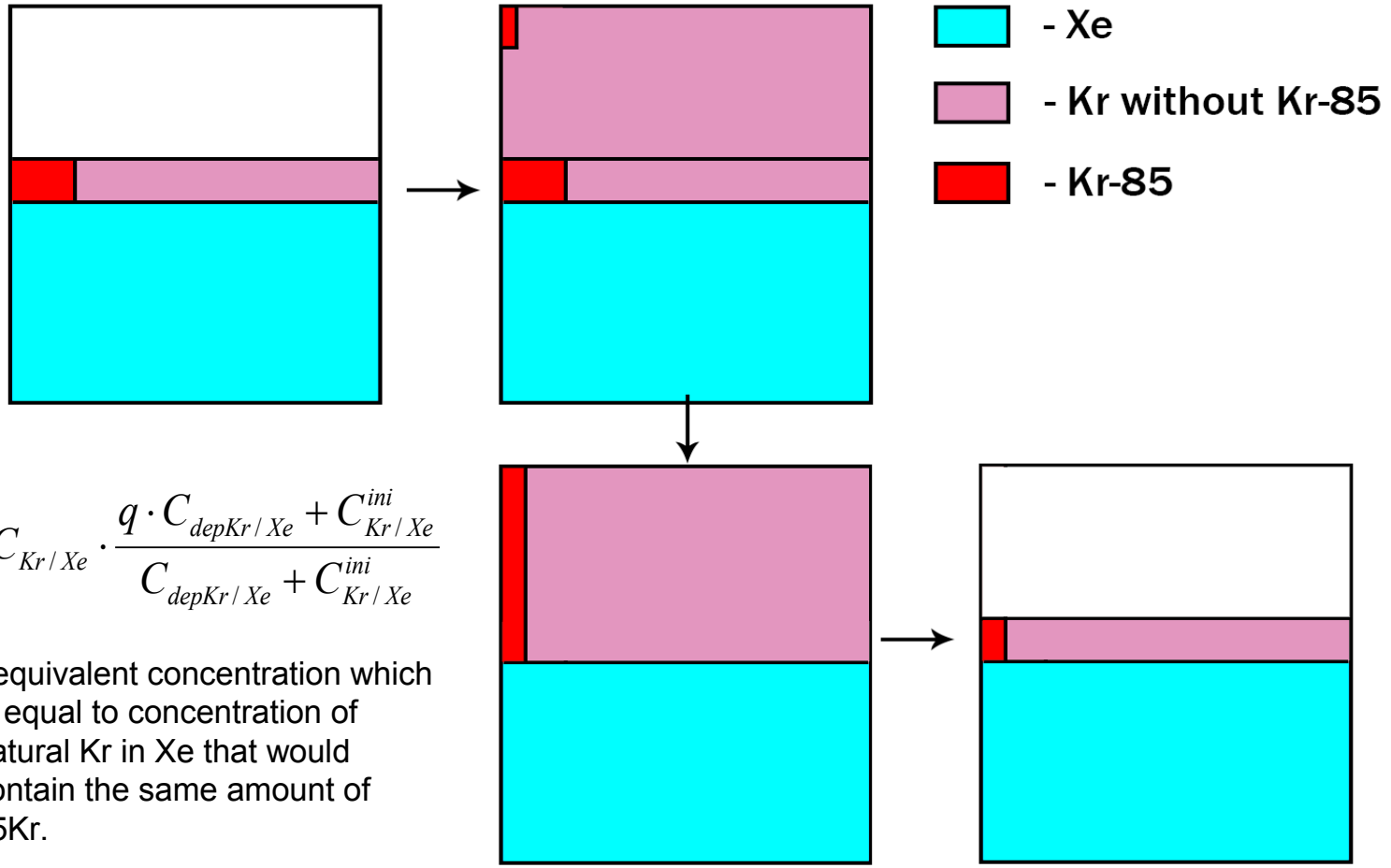
Alternative way: depleting of ^{85}Kr in Kr

then

Adding to Xe, then purification to the same level of Kr, but now less radioactive

We need to know the real activity of ^{85}Kr in the Kr which is added to Xe!

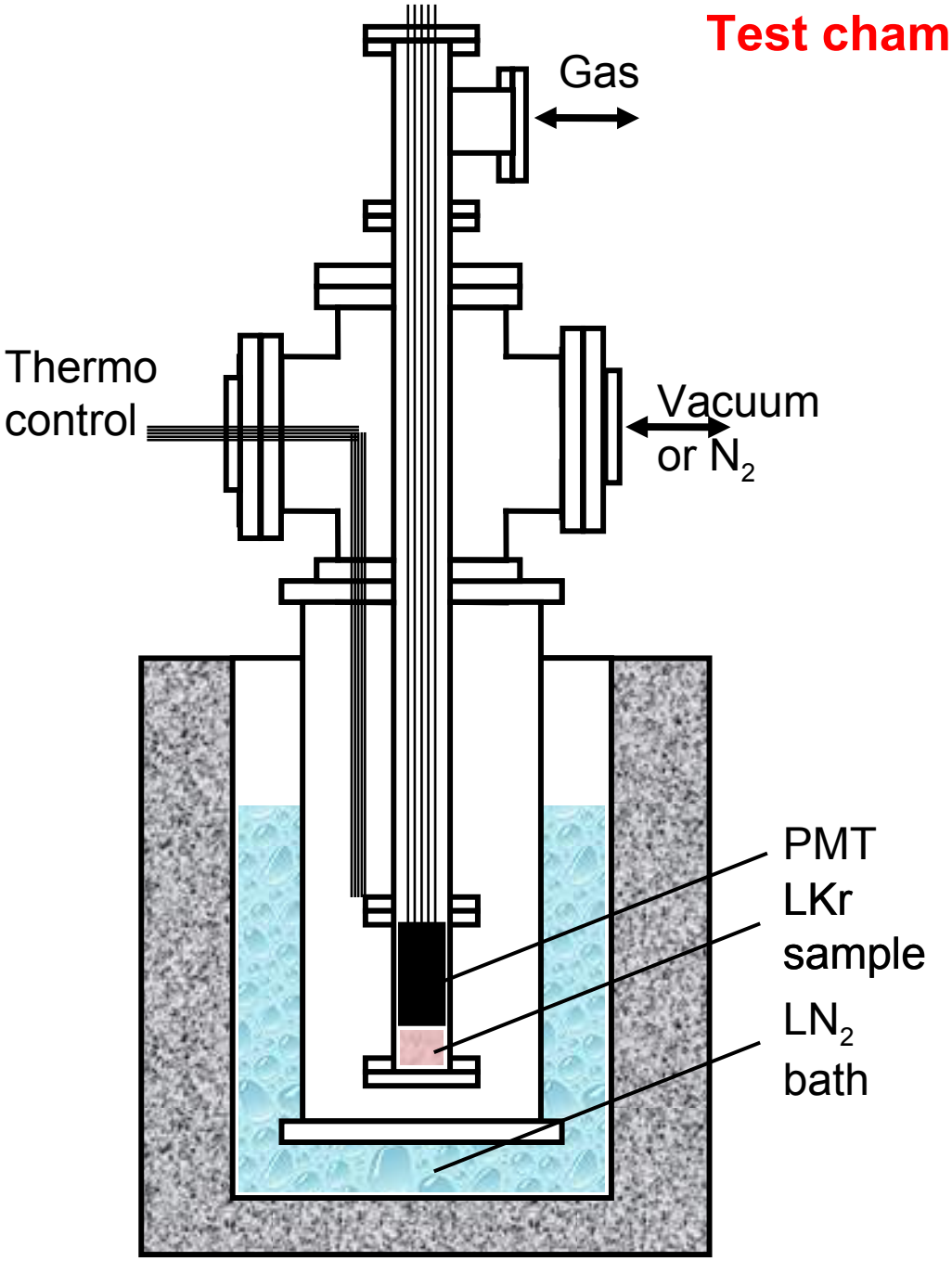
Simple illustration to the depletion method



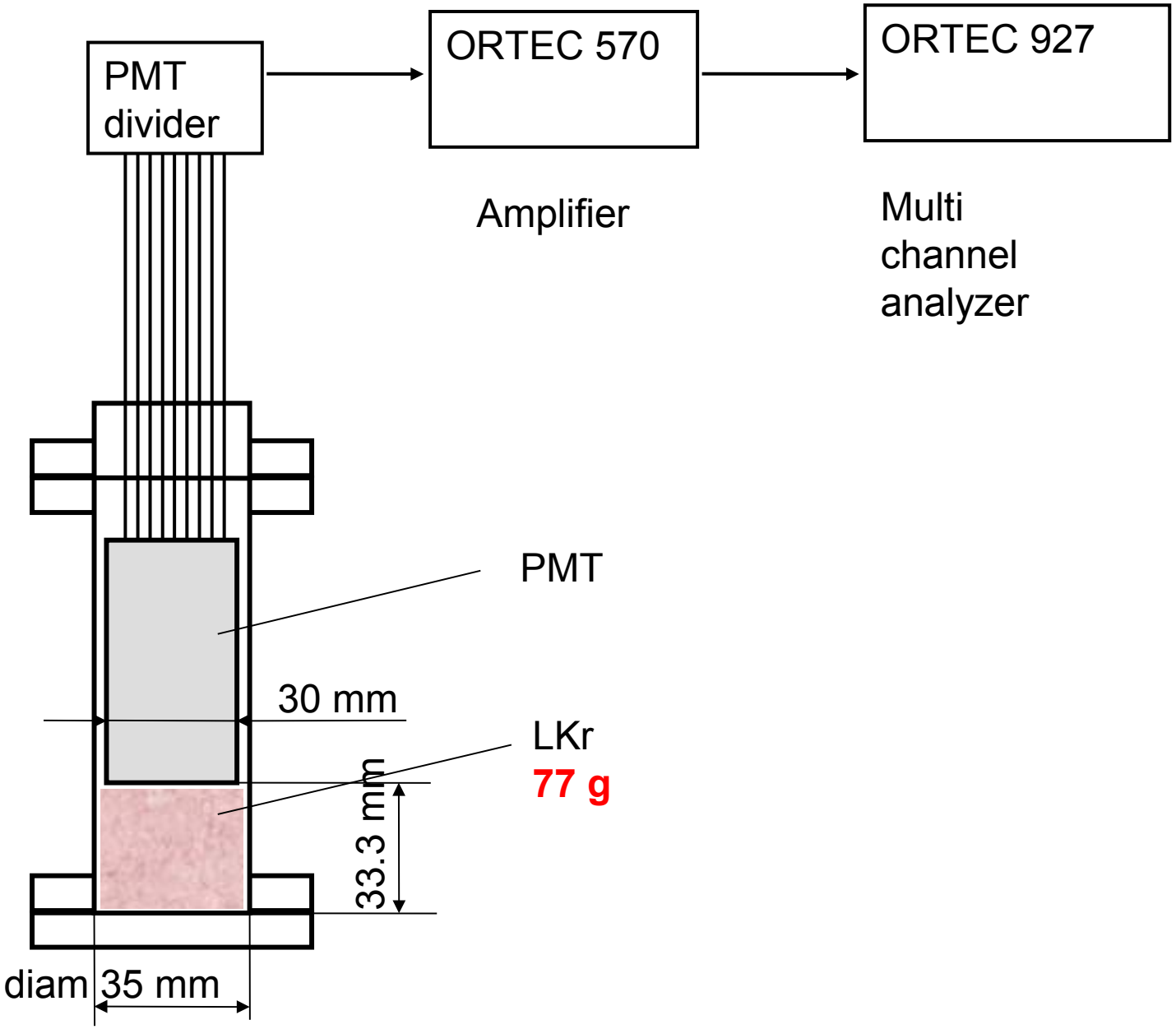
$$C^{eq}_{Kr/Xe} = C_{Kr/Xe} \cdot \frac{q \cdot C_{depKr/Xe} + C^{ini}_{Kr/Xe}}{C_{depKr/Xe} + C^{ini}_{Kr/Xe}}$$

$C^{eq}_{Kr/Xe}$ - equivalent concentration which is equal to concentration of natural Kr in Xe that would contain the same amount of 85Kr.

Test chamber for Kr activity measurement



Test cell and scheme of measurement



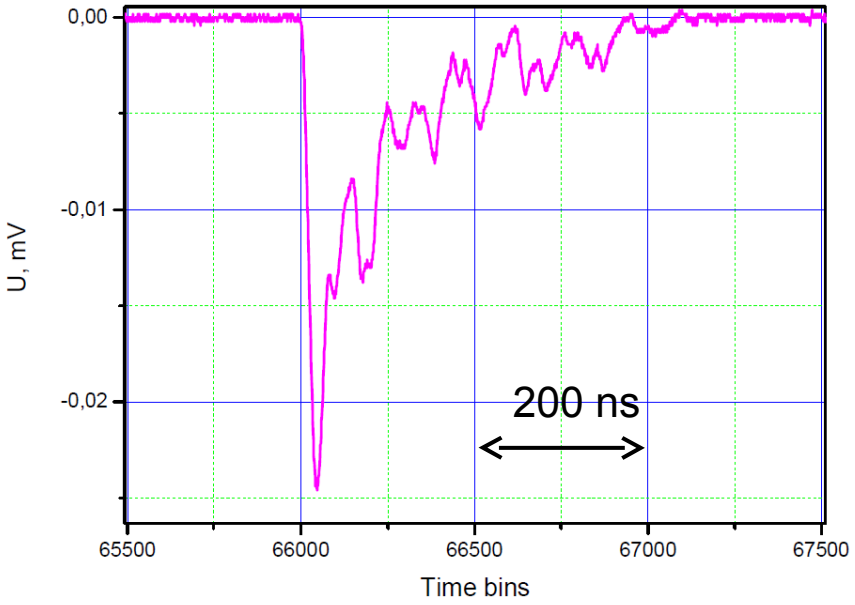
PMT FEU-181 MELZ (Moscow)

VUV-sensitive: MgF_2 windowed multialkali photocathode

can operate at cold (down to LN_2 temp.)

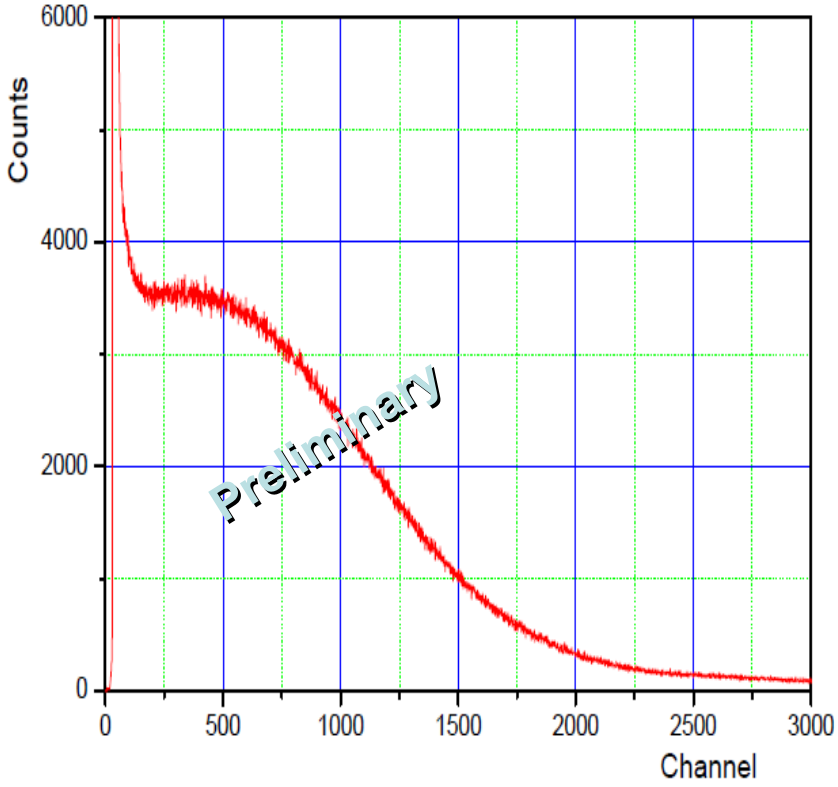
LKr emission – 147 nm

Decay time ~ 100 ns

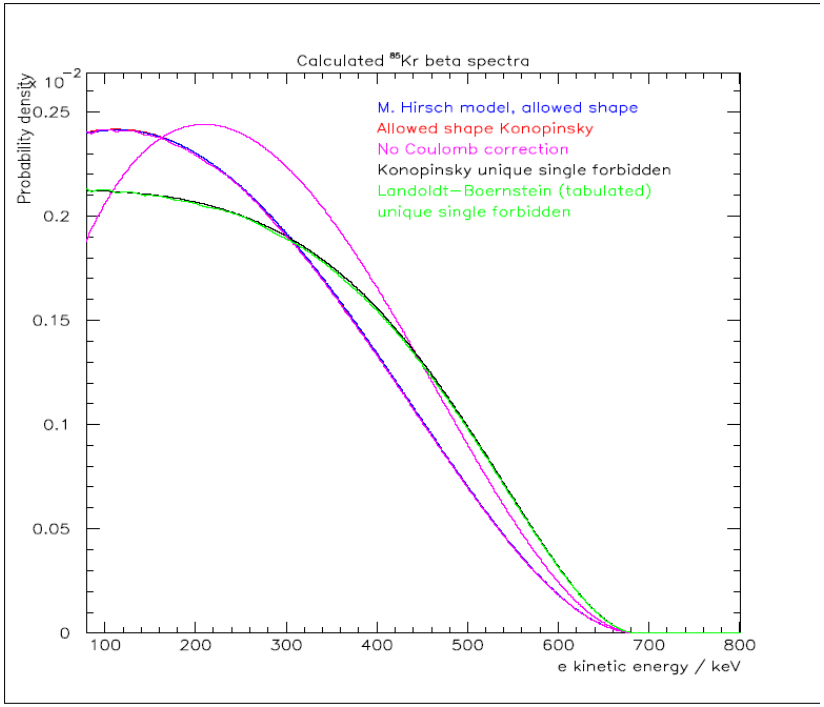


Typical waveform of scintillation from LKr

1-st measurement with 25-y old Krypton



56 ± 5 Bq/g (of Kr) is obtained from measurements at different shaping time and gain.



Theoretical β-spectra from

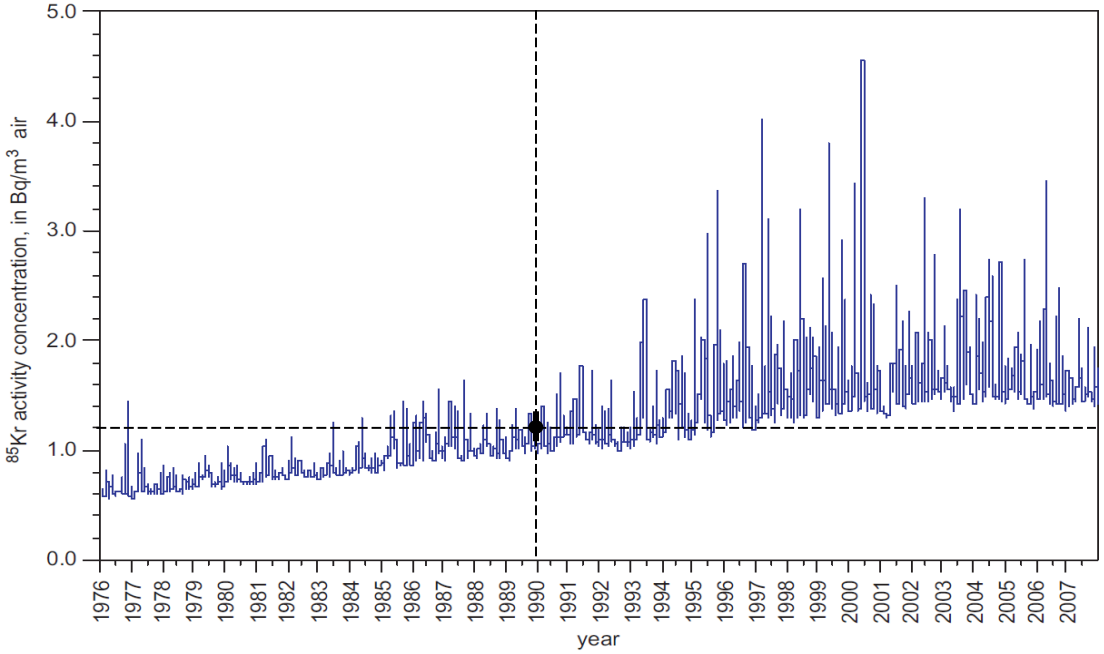
bama.ua.edu/~andreas/ps_files/ ***beta****.pdf*

This corresponds to 280 ± 25 Bq/g back in 25 years (to 1990; $T_{1/2}$=10.756), greater by a factor 5 than now

280 ± 25 Bq/g corresponds to 1.155 ± 0.1 Bq/m^3 of air

It is in quite good agreement with:

S. Lindemann. Purification and detection of inert gases using miniaturized proportional counters.



The present day activity of the air due to ^{85}Kr is 1.45 Bq/g, practically stable

This corresponds to 364 Bq/g for the present day produced Krypton

Thus, the activity of the measured Krypton sample is less than the activity of the present day Krypton

by a factor of 6.3

Centrifuging may deplete ^{85}Kr by a factor of ≥1000

From V. V. Kuz'minov, V. M. Novikov, A. A. Pomanskii et al., Radioactive85 Kr in krypton enriched with a light isotope. Atomic Energy, 73 (1992), Issue 6, p. 1010.

Thus, we may have for ^{85}Kr a depletion factor of at least 6300 with respect to ^{85}Kr in the present day Krypton!

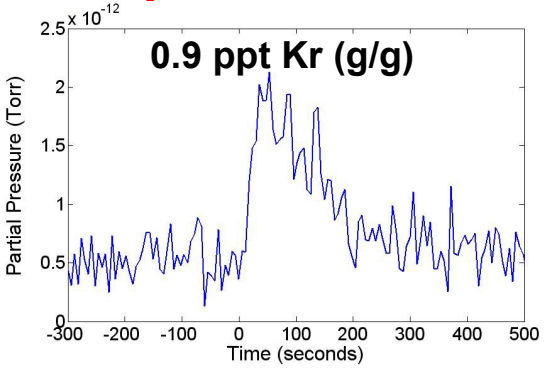
In Xe by "Chromium", Russia (99,99999 %), Kr content is 5 ppb

or 5 mg of Kr in 1 ton of Xe

adding 100g of depleted Kr to 1 ton of Xe and purification down to the same 5 ppb level will give reduction by a factor of 6300, i.e. equivalent to 0.8 ppt level of the present day Krypton in the Xenon by **"Chromium"**

The ppt level is well controllable by the Coldtrap/RGA LUX system:

From C.Hall talk at LXe MEPhI & LZ 2014 meeting



The LUX Xe has been purified down to 4 ppt level of Kr with ^{85}Kr/^{nat}Kr ~ 2·10^{-11} (how old is it? 2.5·10^{-11} is in the present day Kr)

This degree of purification will be equivalent to ~ 0.65 ppq level of the present day Krypton in Xenon

CONCLUSION

- We've assembled a test cell for measurement of Kr beta-radioactivity and performed measurements with the 25-y old sample of Kr
- The measured radioactivity of the 77-g LKr sample is in a good agreement with other data
- With the use of the 25-old Kr and depletion factor of 1000 (pessimistic), the LUX purification system may achieve ~ 0.65 ppq equivalent level of the present day Krypton in Xenon