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

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

$^{85}\text{Kr}$ in natural Kr: $\sim 2.5 \times 10^{-11}$

Traditional way: direct purification of Xe from Kr

Alternative way: depleting of $^{85}\text{Kr}$ 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 $^{85}\text{Kr}$ 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

Thermo control

Vacuum or N\textsubscript{2}

Gas

PMT

LKr sample

LN\textsubscript{2} bath
Test cell and scheme of measurement

PMT divider → ORTEC 570 → ORTEC 927

Amplifier

Multi channel analyzer

PMT

30 mm

LKr

77 g

diam 35 mm

33.3 mm
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 $\sim$ 100 ns

Typical waveform of scintillation from LKr

![Graph showing typical waveform of scintillation from LKr with decay time around 200 ns.](image)
56 ± 5 Bq/g (of Kr) is obtained from measurements at different shaping time and gain.

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.
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.

It is in quite good agreement with:

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

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**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 $^{85}\text{Kr}$ by a factor of $\geq 1000$


Thus, we may have for $^{85}\text{Kr}$ a depletion factor of at least 6300 with respect to $^{85}\text{Kr}$ 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 $^{85}\text{Kr}/^{\text{nat}}\text{Kr} \sim 2 \cdot 10^{-11}$

(how old is it? $2.5 \cdot 10^{-11}$ is in the present day Kr)

This degree of purification will be equivalent to $\sim 0.65$ 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.