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Report:APPLICATION OF THE TAGGED NEUTRON METHOD FOR DIAMONDS DETECTION IN KIMBERLITE

Organization: "Diamant", LLC

Country: Russian Federation

Russian Academy of Sciences

ИПКОН РАН

MISIS
National University of Science and Technology

Problem:

"Since the time of the caveman mining hasn't changed much. You pulverize the rock and take out what you want"

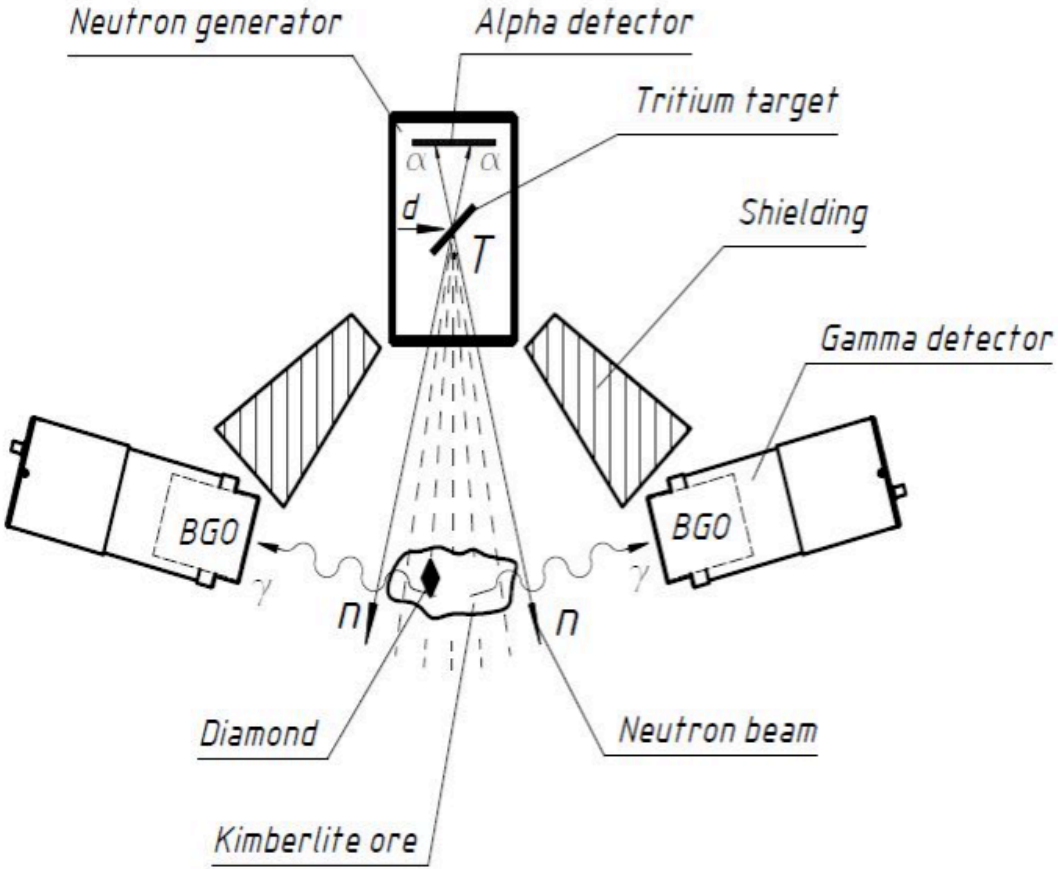
C.Elphick, CEO "Gem Diamonds"

- The ore is processed in crushers or grinding rolls with subsequent grinding in wet mills down to a size of 0.2 mm.
- Crushing kimberlite ore can break the most valuable large diamonds of few carats.
- For ALROSA mines from 35 to 65% of diamonds have some defects resulting in an average weight loss of 12%.

<u>Example</u>

Diamond of 69 ct. Initially its mass was ≈ 100 ct (line of cleavage is clearly seen). Lost of value ≈ 1.3 m$

Tagged neutron method



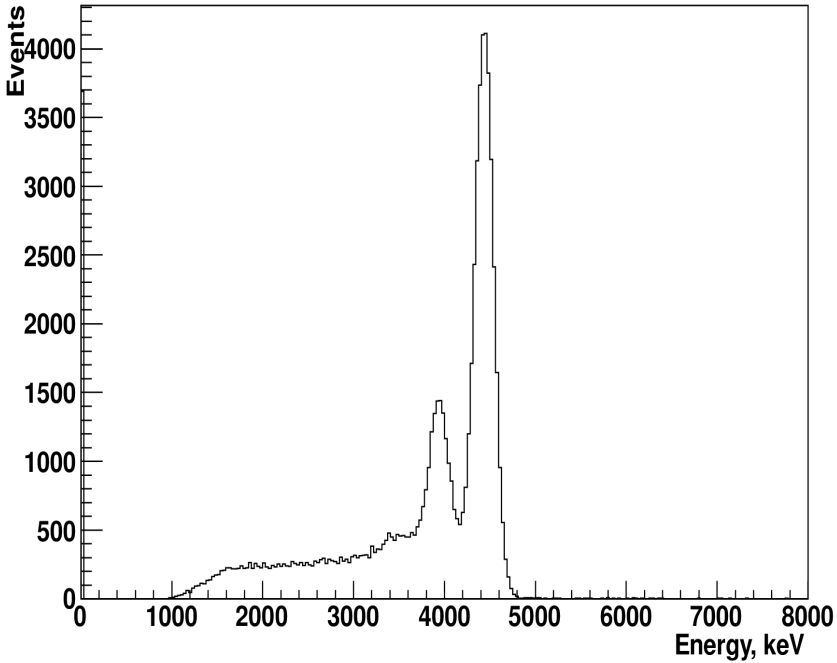
The tagged neutron method allows to find diamond without its crashing.

The kimberlite is irradiated by fast 14 MeV neutrons from reaction

$d + {}^{3}H \rightarrow {}^{4}He + n$

Tagging means detection of ^{4}He that accompanies the neutron.

The diamond signature



Energy spectrum of γ from carbon.

- The 4.44 MeV gamma-line of carbon is used to determine carbon distribution in the ore.
- Signature of diamond is increasing of local concentration of carbon.
- The place of diamond in the kimberlite rock is determined.
- No false alarms on the rocks with carbon.

Real diamonds was found inside the kimberlite stones

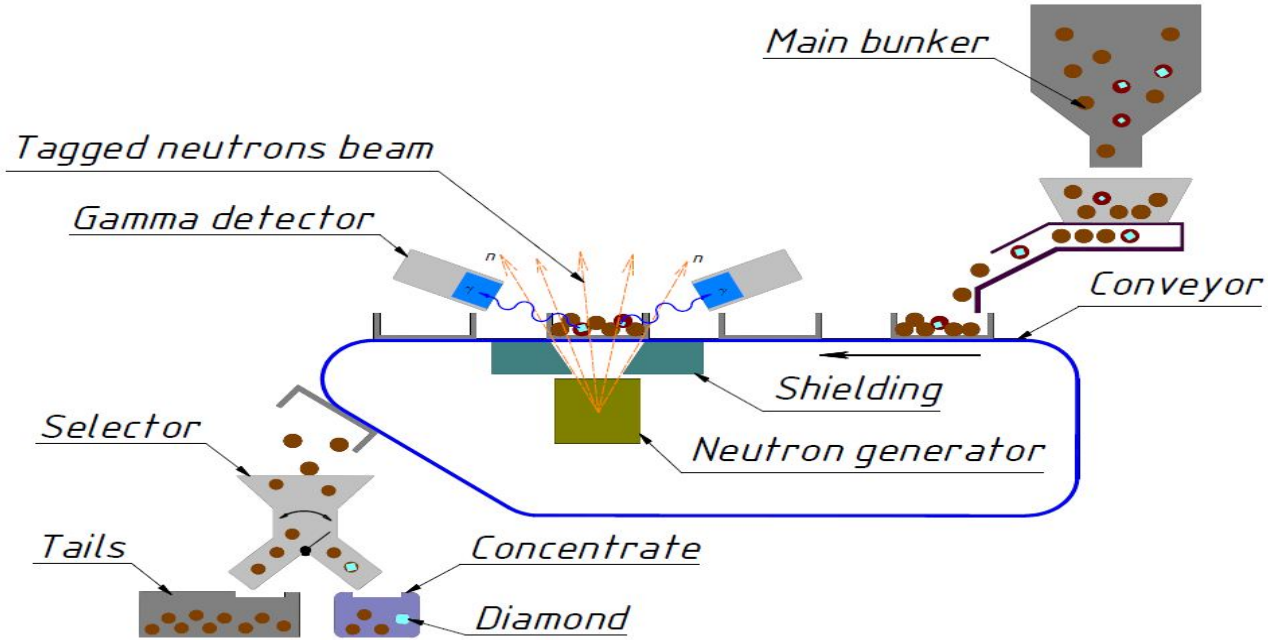
The method was tested on kimberlite ore provided by ALROSA

Sample №17

- Strong signal of carbon was found in one of 33 samples.
- Analysis of this sample reveals two regions with 7 mm diamonds.

V.Alexakhin et al., Detection of Diamonds in Kimberlite by the Tagged Neutron Method, Nuclear Instruments and Methods A785 (2015) 9 .

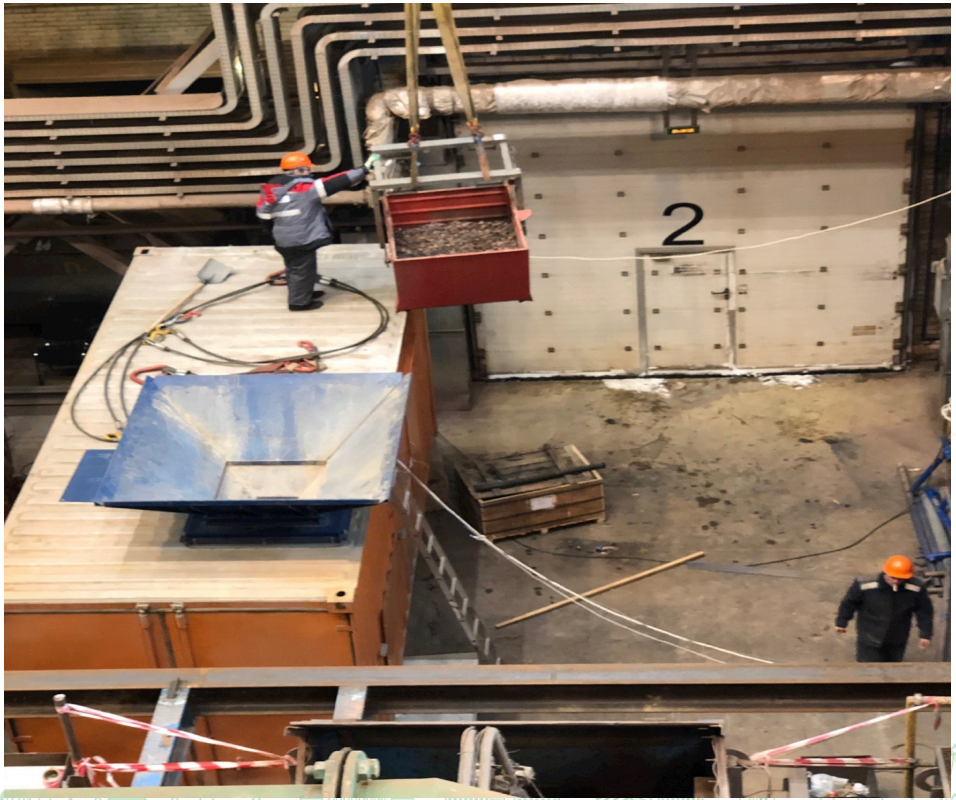
Scheme of neutron separator



Tests at processing factory of “Severalmaz” Lomonosov’s mine

- Transport container – 20 ft
- Dosator
- Trays conveyer
- Neutron module
- Ore separation system

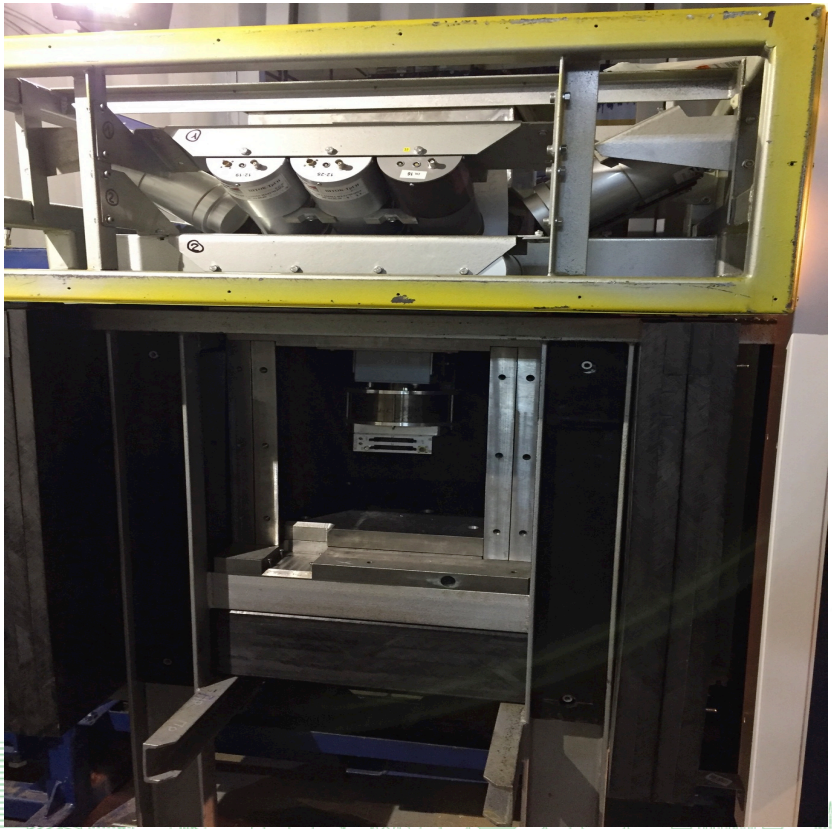
Feed hopper – 2 t



Trays conveyer

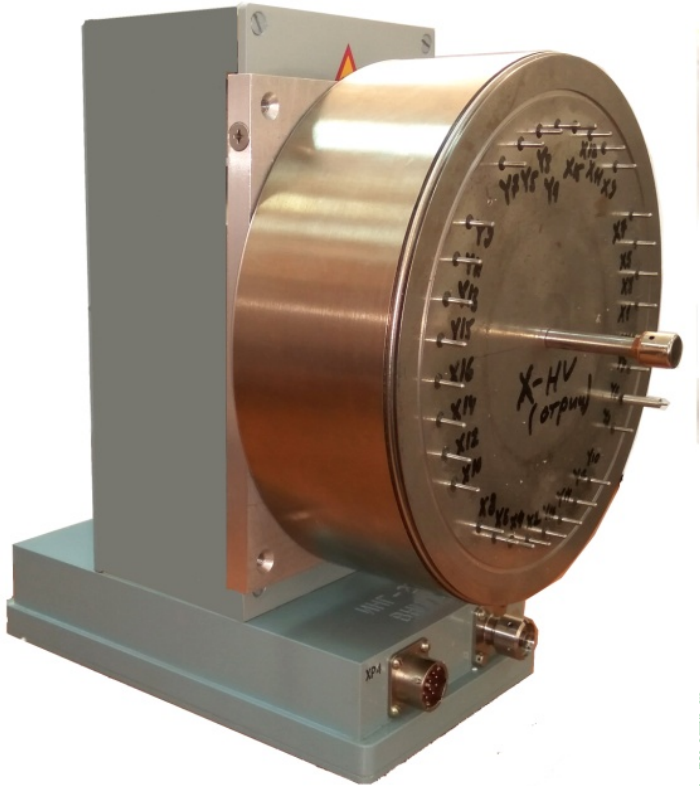
- Tray size - 143 (260) mm, height – 100 mm

Neutron module



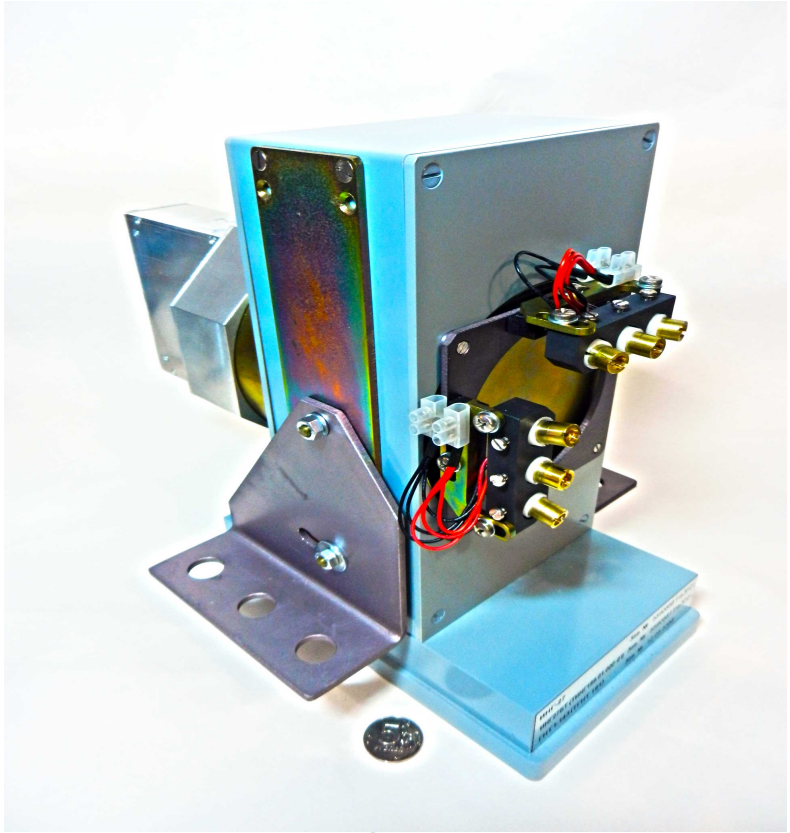
- Size (LxWxH):1040×1040×1650 mm
- Neutron generator on 256 tagged beams
- 22 gamma-detectors
- Biological sheilding

Neutron source – key element



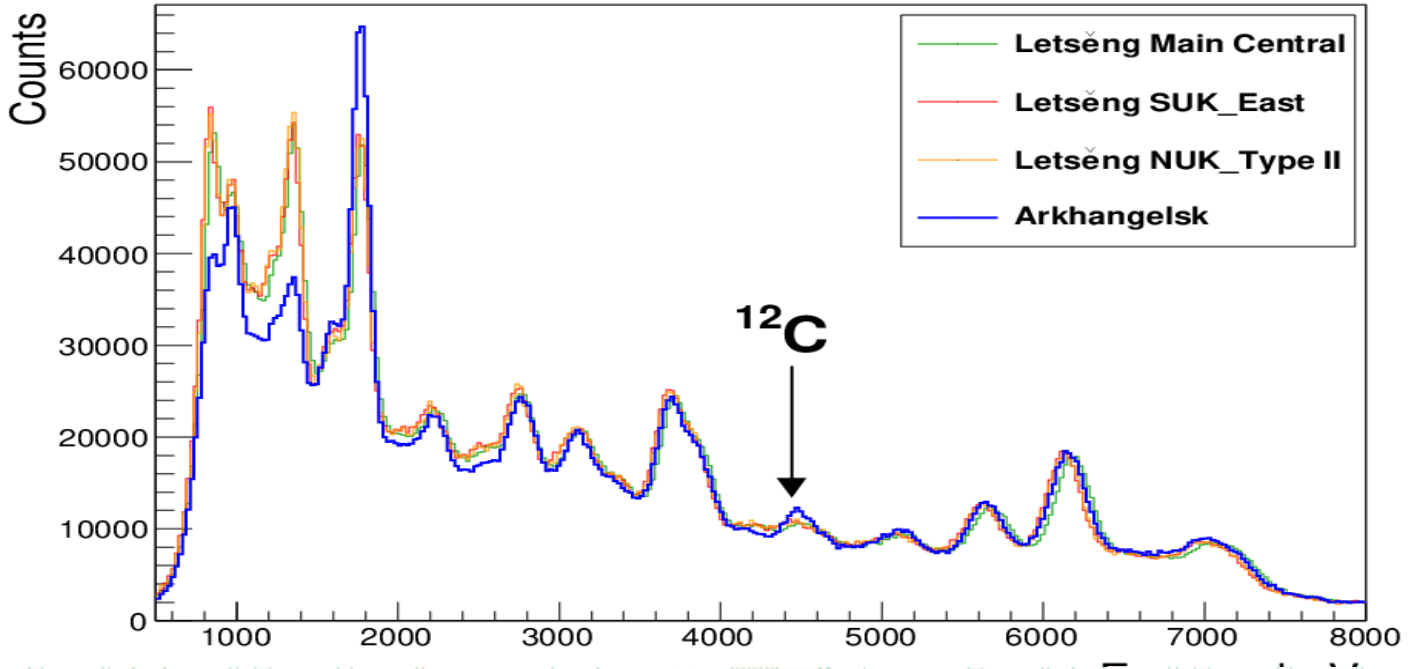
- Produced by Dukhov Institute
- of Automatics, Moscow
- Unique development
- I= 5 ·10^{7} c^{-1}
- Mass – 8 kg
- Height – 300 mm
- Alpha-detector on 256 channels

6 floors neutron generator in Dubna

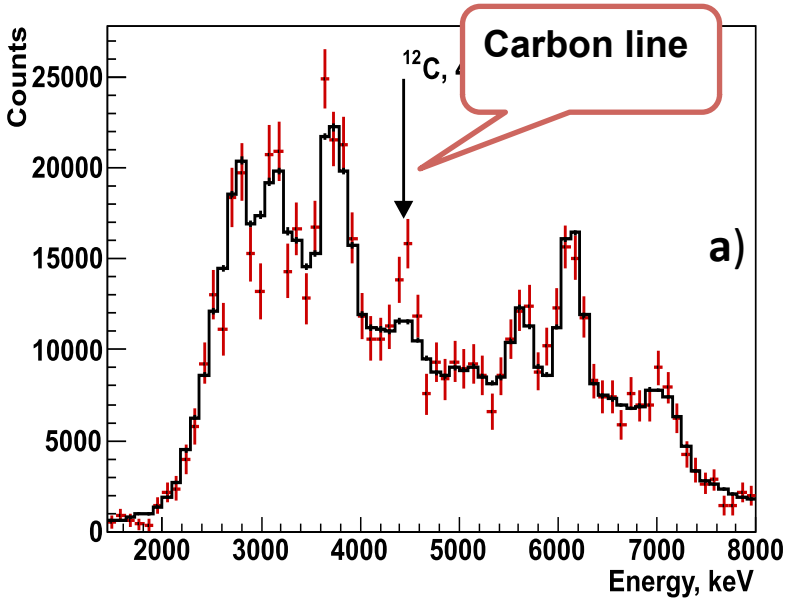


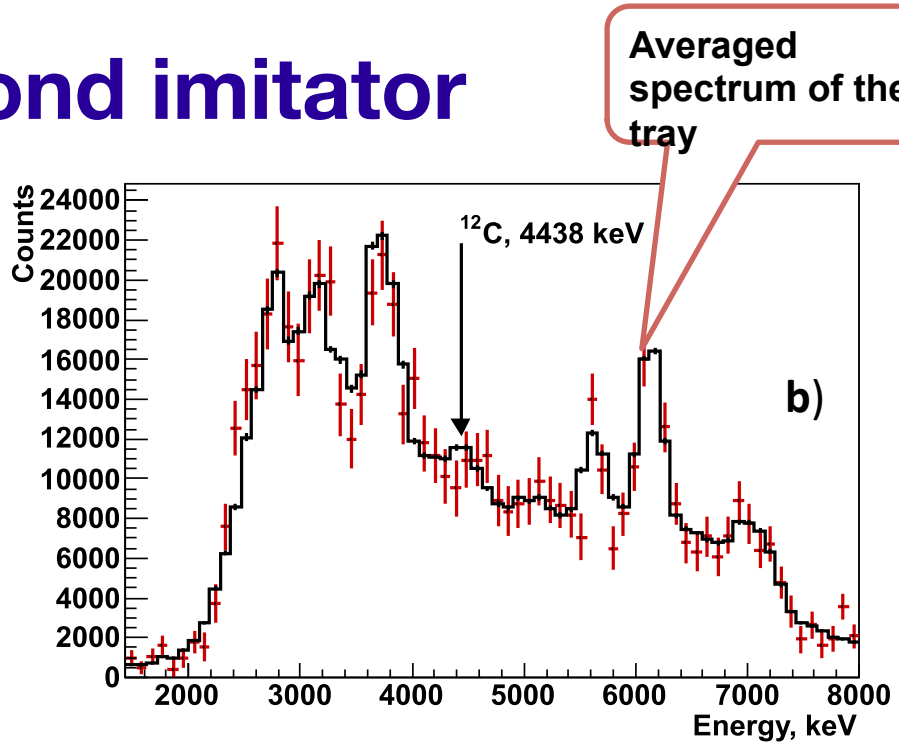
300 mm neutron generator of The Dukhov Institute

Irradiation of the kimberlite ore



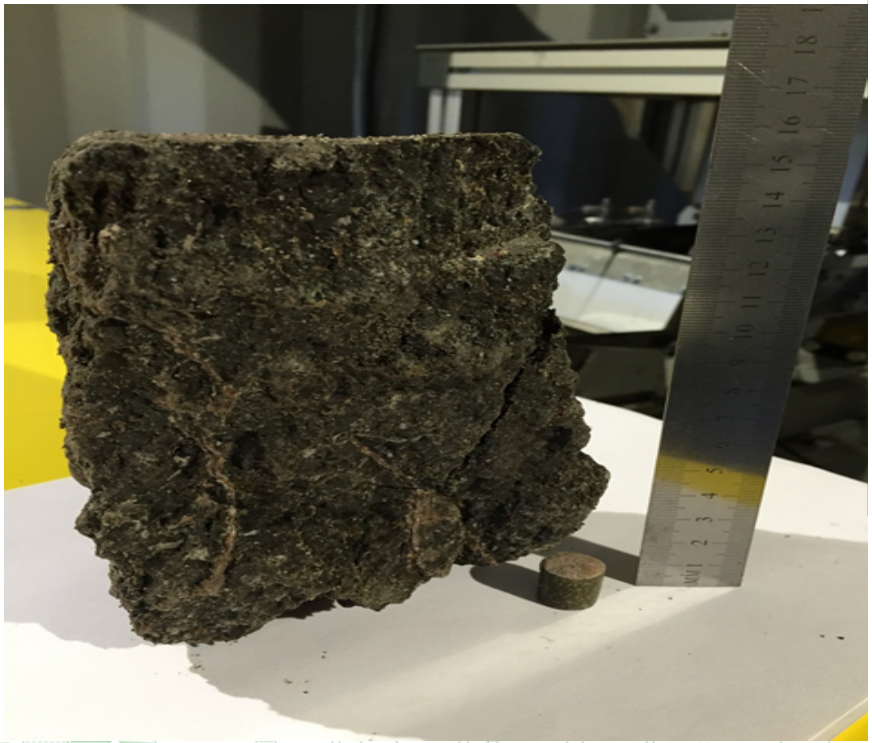
Ore with diamond imitator

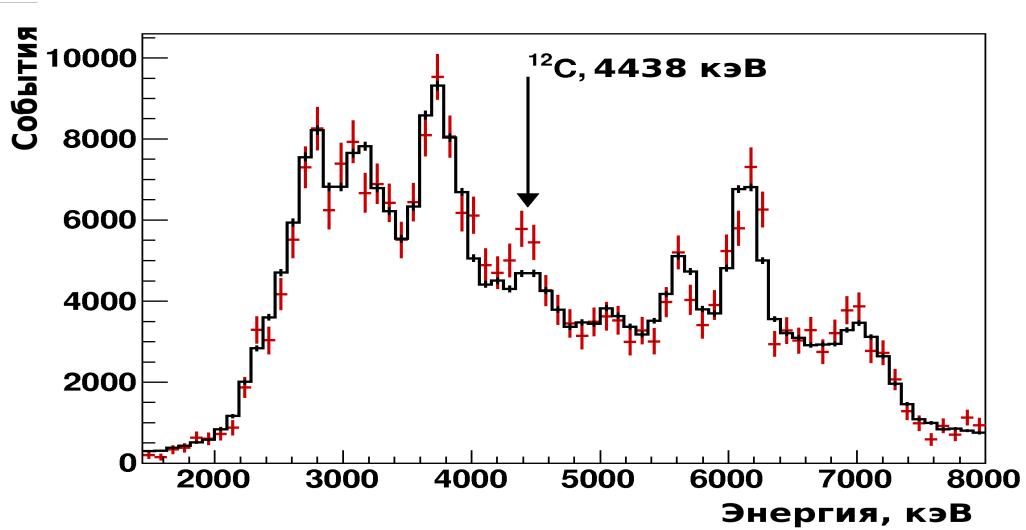




a) With 8 mm diamond imitator in the -50 mm ore
b) Without imitator

Possibility to work with large size ore



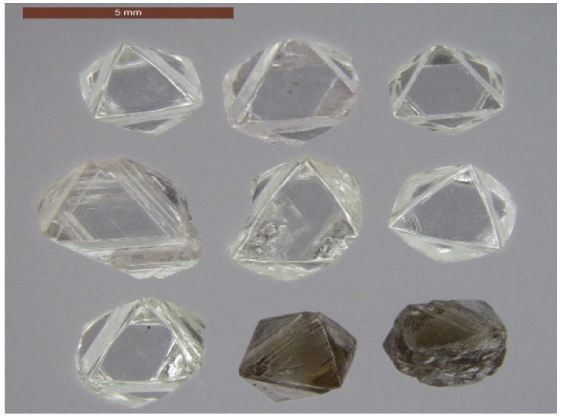


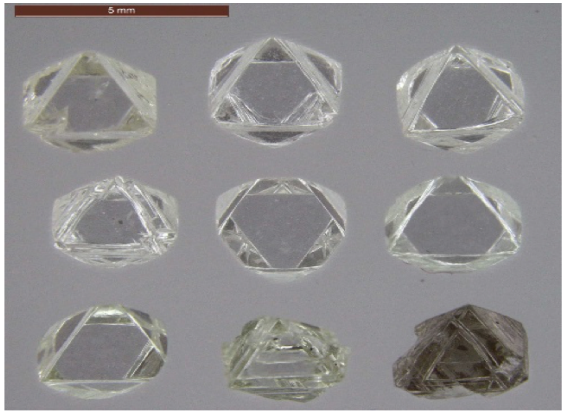
- Stone -160x90x90 mm
- Imitator of diamond – 14 mm
- Ratio of the diamond to ore size is 1:10

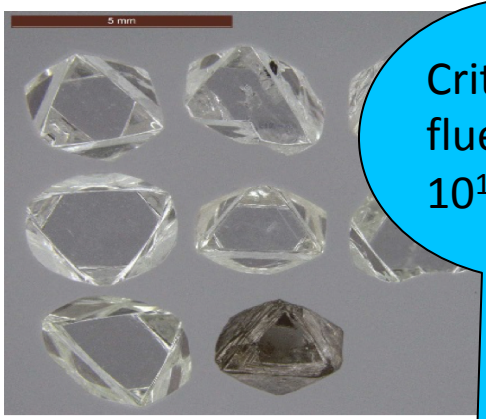
Summary of the tests

- Main characteristics of the prototype:
  - Throughput– 1060 kg/h
  - Inspection time – 10 s
  - Minimal detected diamond:
    - In the ore -75+40 mm - 12 mm,
    - In the ore -90+50 мм – 16 mm,
    - In the ore -150+100 mm - 20 mm.
  - Concentrate yield – 3 %
  - Electric power – 0.6 kWt/t

Is the radiation in neutron separator dangerous for the diamonds?







Critical fluence 10^{16}-10^{17}

	Number of trial					
	1	2	3	4	5	6
Number of diamonds	17	15	14	14	15	15
Irradiation time	4 s	2 min	4 min	8 min	16 min	32 min
Neutron fluence neutron/cm²	1.93×10^{4}	5.78×10^{5}	1.16×10^{6}	2.31×10^{6}	4.62×10^{6}	9.24×10^{6}

O.Kovalchuk et al, 2017, Irradiation of diamonds by fast tagged neutrons. JINR (Dubna) preprint, P-14-2017-54, 2017.

Plans for the future: neutron separator for 5 t/hour