Elemental composition analysers based on the tagged neutron method

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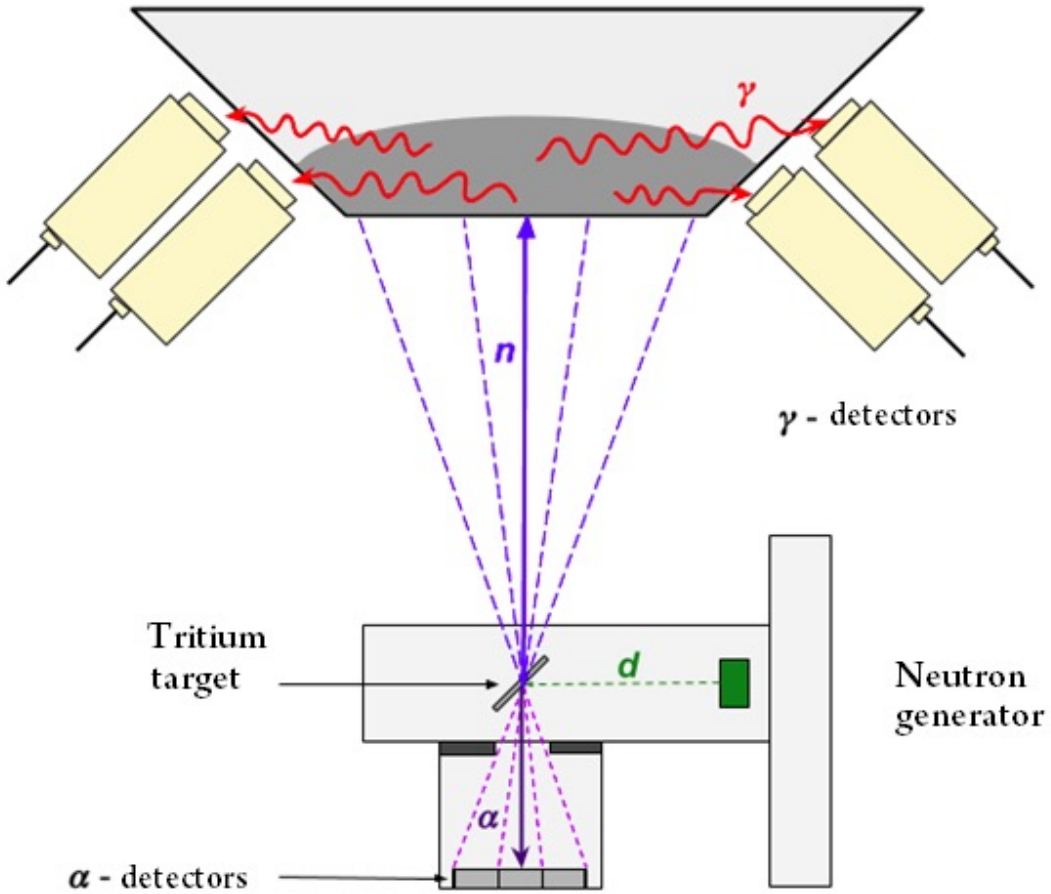
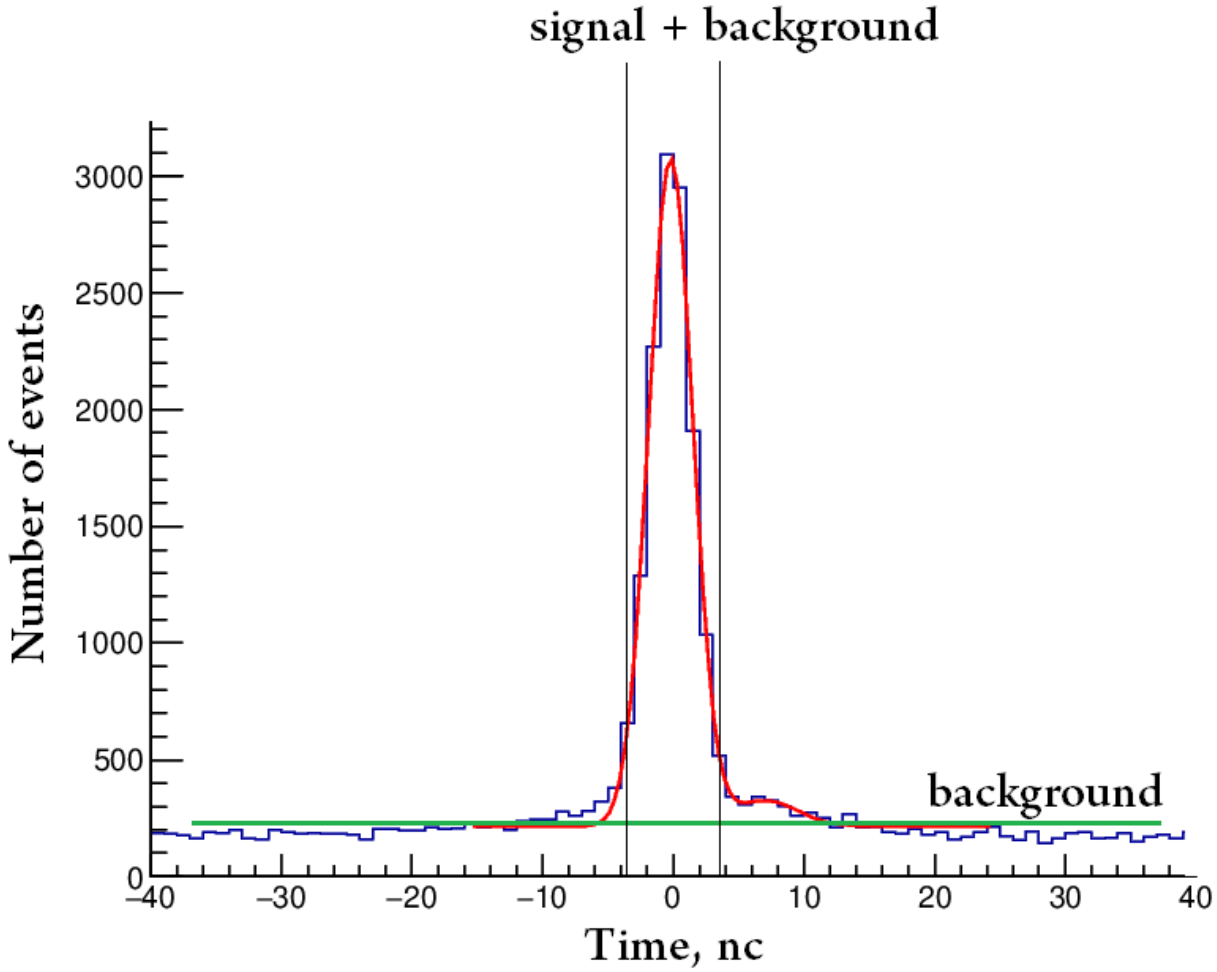
ДИАМАНТ

Tagged Neutron Method



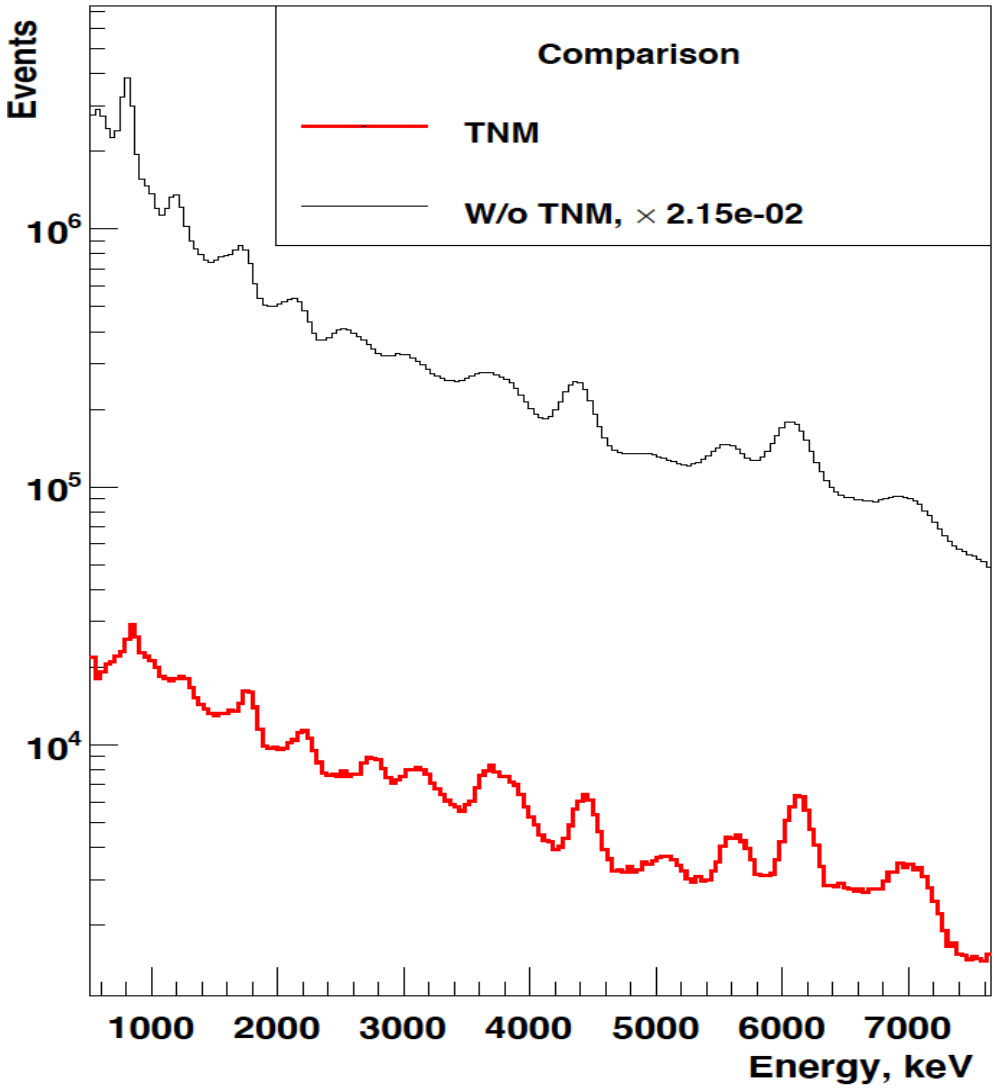
- d+ $^{3}H \rightarrow {}^{4}He$ +n
- The samples is irradiated with 14 MeV fast neutrons
- The direction of neutron momentum is tagged by an α-particle.
- Only gamma-quanta from analysed object are recorded
- (n, n'γ)

Typical time distribution

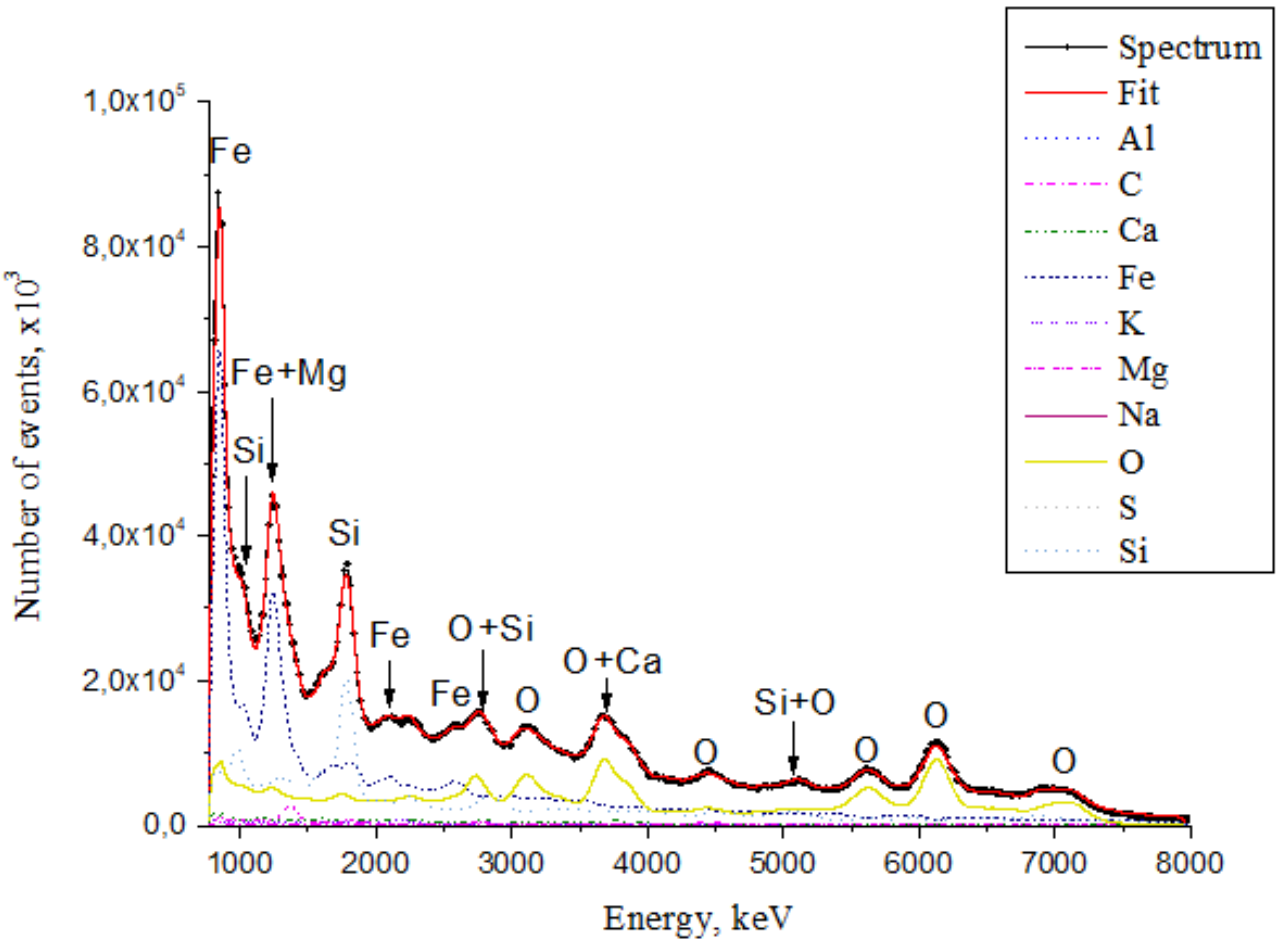


Cutting off the background of random coincidences allows you to reduce the influence of the background by 200 times.

Energy distribution of gamma-quanta

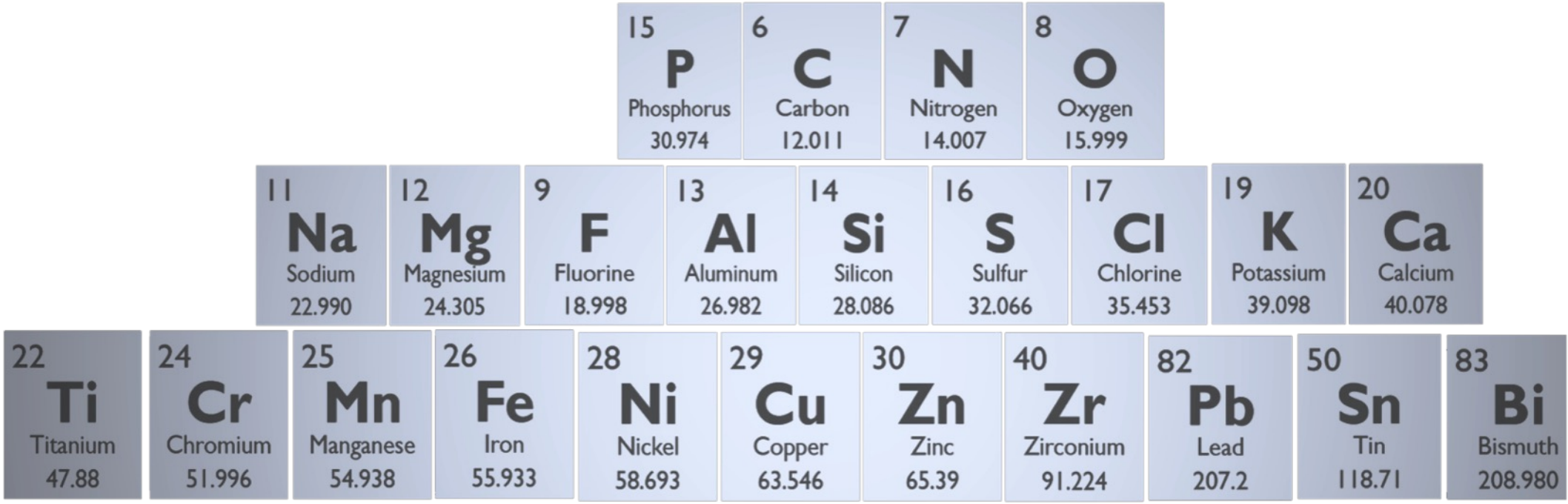


Typical energy spectrum of gamma quanta of a sinter sample

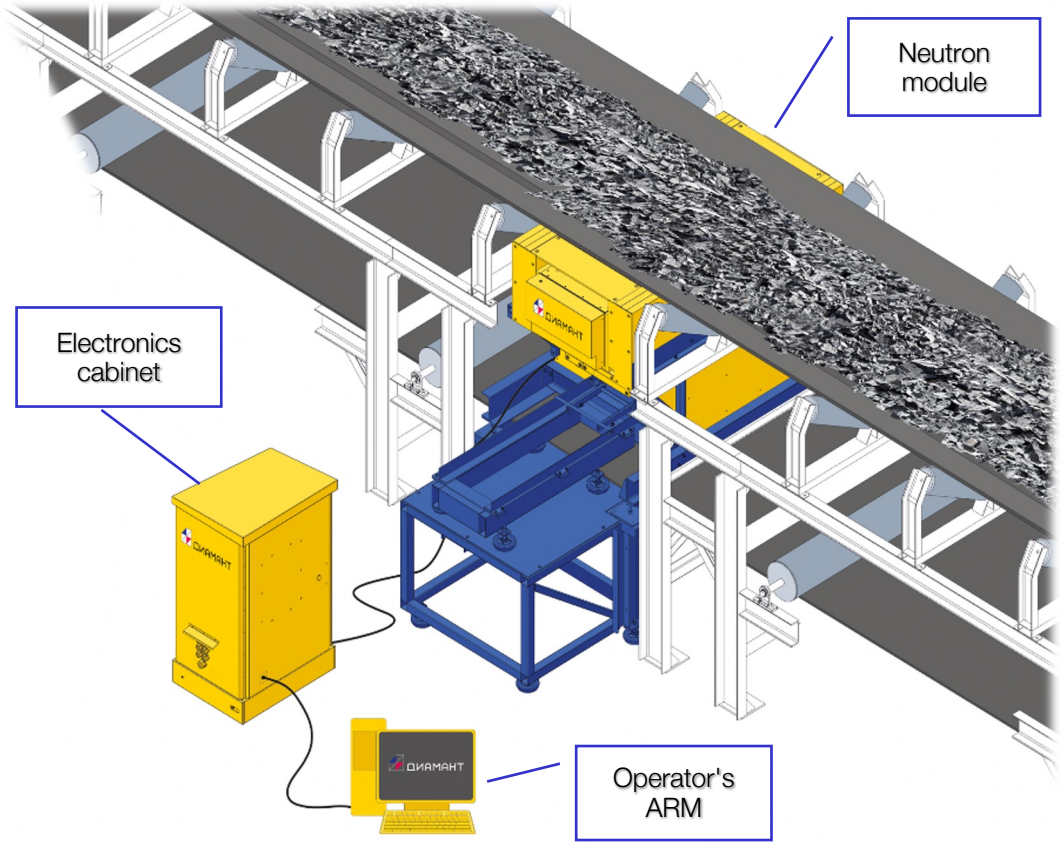


Concentrations of Al, Ca, C, Fe, Mg, Na, O, P, Si, Ti are measured and converted to the corresponding oxides

Concentrations of 25 elements are determined



Conveyor analyzer AGP-K



- Results on elementary concentration a every 40-60 seconds
- Depth of analysis ~ 300 mm
- No samples preparation required
- The concentrations of all elements are determined simultaneously
- Tagged neutron method increases signal/background ratio by factor 200

The general design of the conveyor analyzer AGP-K

The analyzer consists of:

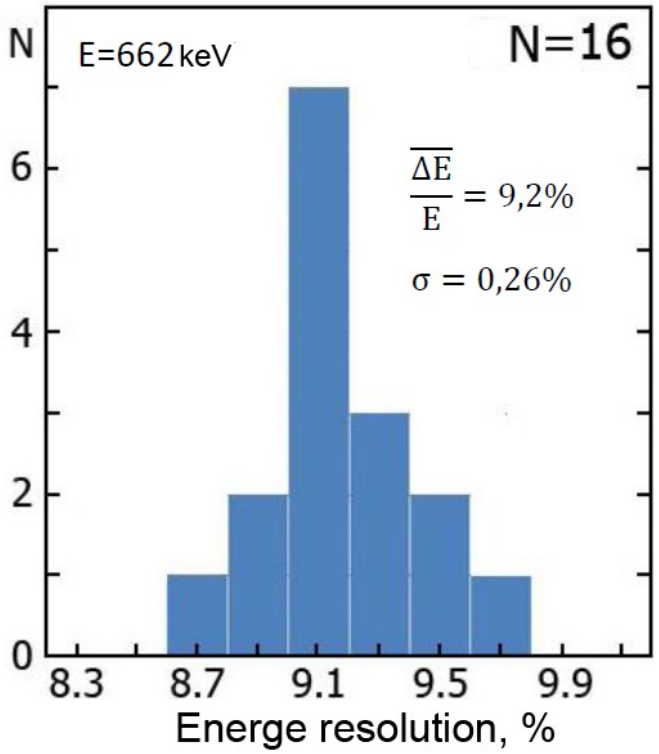
- ING-27 neutron generator with alpha-detector
- System of 14 scintillation detectors based on a BGO crystal
- Electronics cabinet
- Control computer

Neutron generator

- Neutron generator ING-27 manufactured by FSUE VNIIA named after N.L.Dukhov
- I= 5 x 10^7 c^{-1}
- Weight – 8 kg
- Height – 300 mm
- Alpha-detector - the matrix 3x3 (10x10 mm)

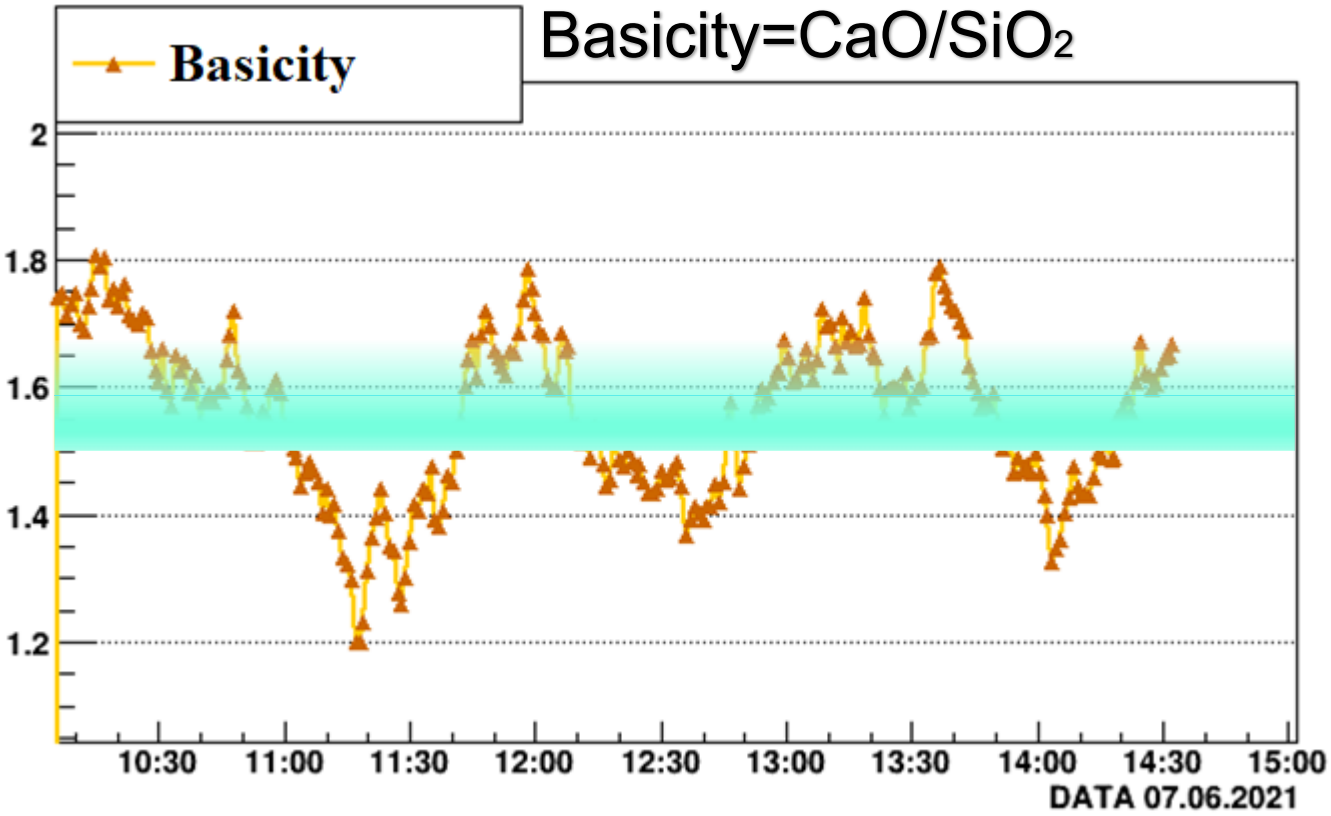
Gamma detectors

- BGO scintillator from Novosibirsk
- The size of the scintillator is 76x65 mm
- Operating temperature range from +5 to +50^0C
- Weight 3.4 kg
- Overall dimensions 89 x265 mm
- Photoelectronic multiplier R6233 by Hamamatsu
- Energy resolution 9.2 % at Cs line



- CherMK (PJSC Severstal) – 2 analyzers for sinter charge have been operating since 2021.
- NWPC JSC - an analyzer for apatite ore from the Oleniy Ruchey underground mine was delivered.
- JSC "Evraz-ZSMK" - 2 analyzers for sintering charge have been operating since 2022.

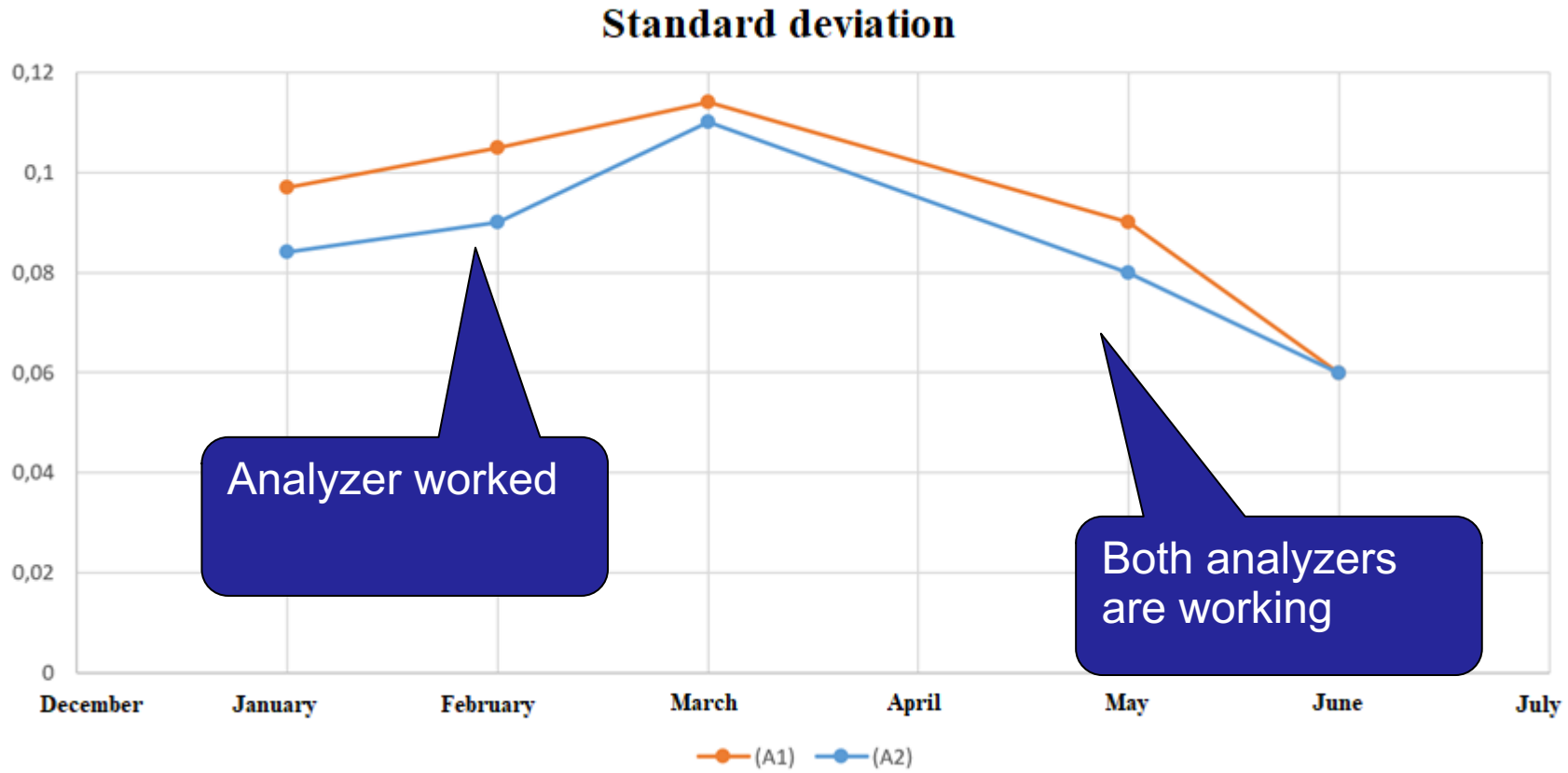
Time dependence of basicity of the sinter



The operator must keep the basicity within this interval

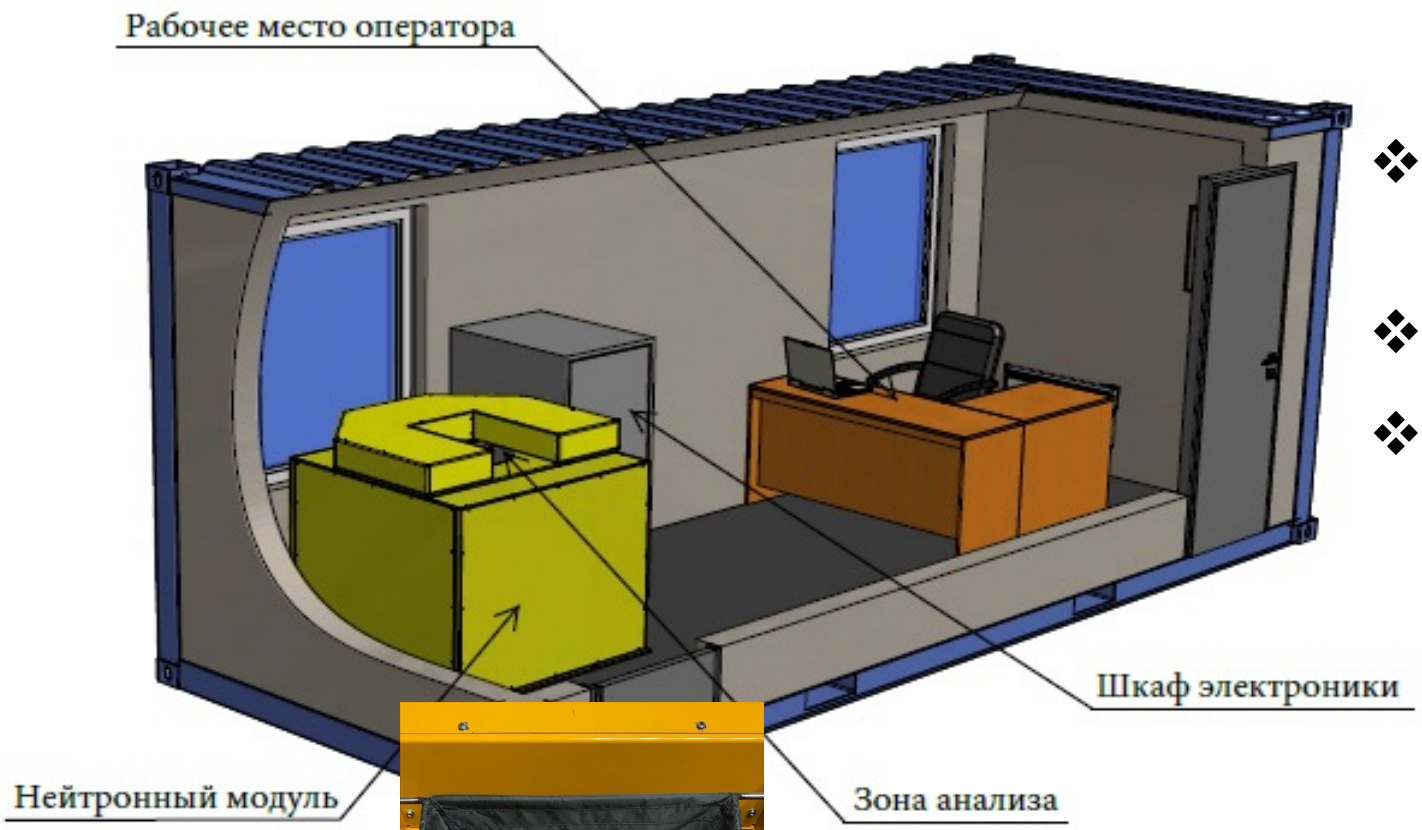
- Chemical analysis results appear every 2 hours
- Time interval between points - 40-60 sec
- In 30 minutes, the basicity can drop from 1.8 to 1.2 and increase again

Changes in standard deviation of sinter basicity



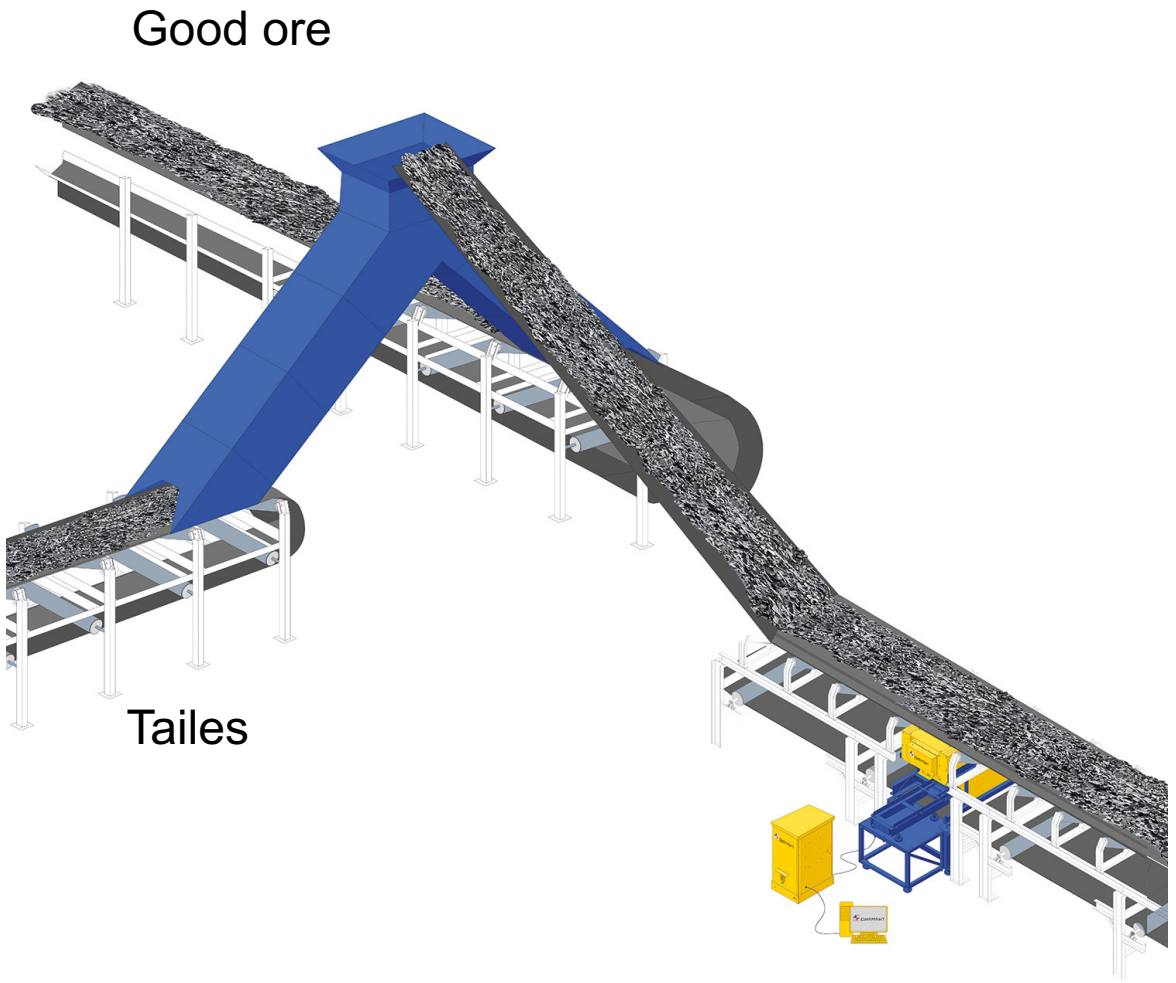
- On conveyor 1 - the analyzer was installed, on the adjacent conveyor 2 - there was no analyzer
- Both analyzers started working in May

Stationary anayser using TNM



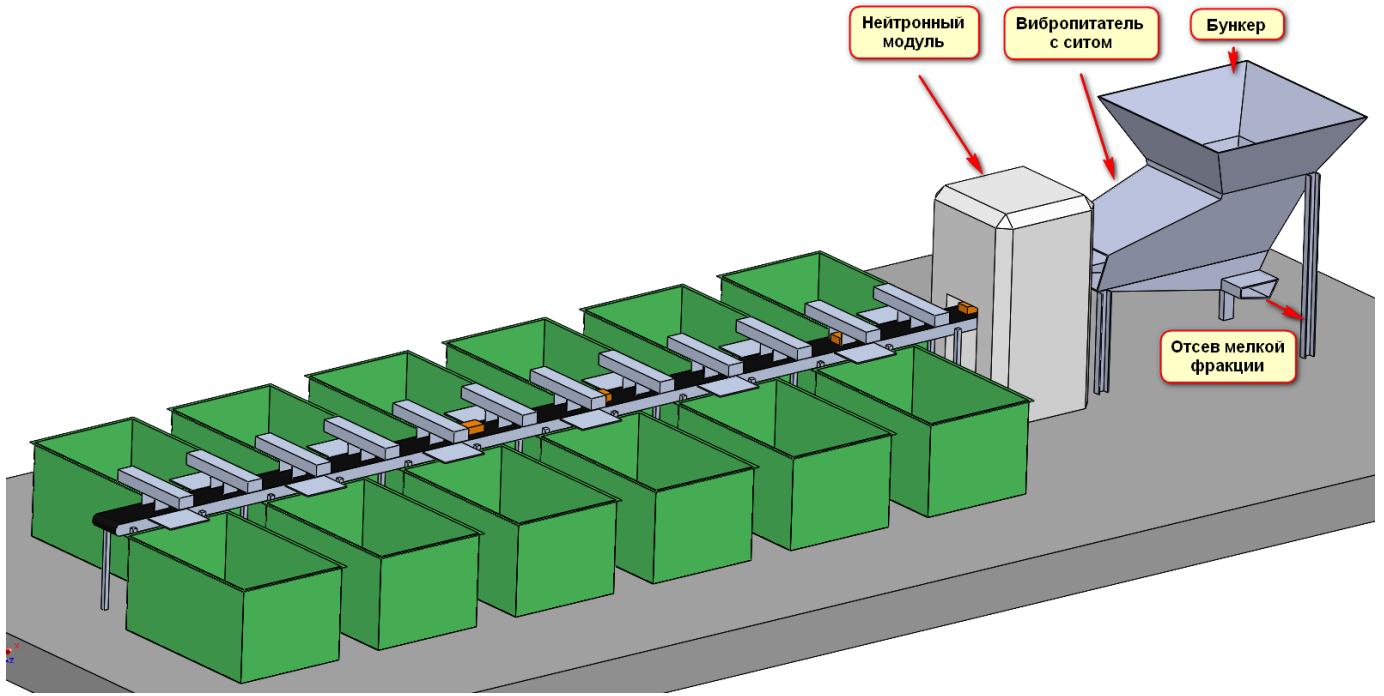
- Elemental analysis of probe.
- No probe preparation.
- Analysis time – 15 min

TNM separator



- Selected ore based on concentration of Fe, S, Si

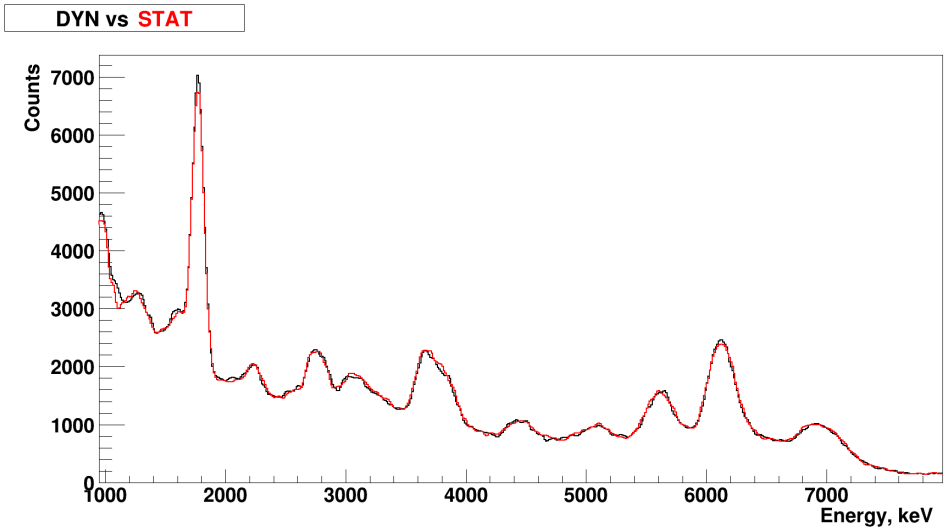
THM conveyor line for selecting used refractories



Selecting used refractories on 12 classes. Throughput – 10 000 ton/year

TNM for analysis carbon in soil

Neutron module irradiates soil and determine the concentration of carbon and other elements in real time



Energy spectrum of gamma quanta from soil.
Red line – at rest, black line – dynamical.

Conclusions:

- Neutron tagged method allows many practical applications:
  - Conveyor analysers of ore, coal, cement, sinter in real time
  - Stationary analysers for probes
  - Separators of ore
  - Separators of used refractories
  - Analyser of carbon in soil

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