

# Neutron Activation Analysis NAA for Life sciences.

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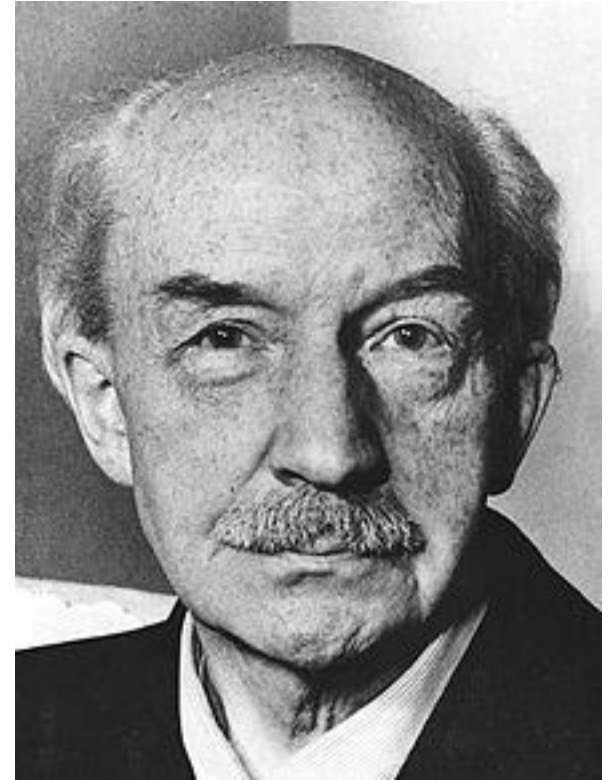
Dr. Wael Badawy.

# Outline.

- History and discovery of Neutrons
- Definition of NAA
- Types of NAA
- Detection/Measurement.
- Application of NAA.
- Comparison of NAA with other techniques.
- Advantages and limitations of NAA.
- Joint projects JINR-RSA.

# History and Discovery.

- **1930** Walter Bothe and Herbert Berker found that the alpha radiation from polonium produced high penetrating radiation when directed to light atoms like Beryllium.
- The radiation was uncharged so they thought it was gamma radiation.



Walter Bothe

# Continued.

- **1932** Irene and Fredric Joliot-curie showed that if this new penetrating radiation fell on hydrogen rich materials it emitted protons.
- The observation was not inconsistent with the nature of gamma radiation(Compton scattering)
- But the problem is that the 'gamma ray' would have to have impossible high energy to scatter the proton.





James Chadwick



George Charles de Hevesy

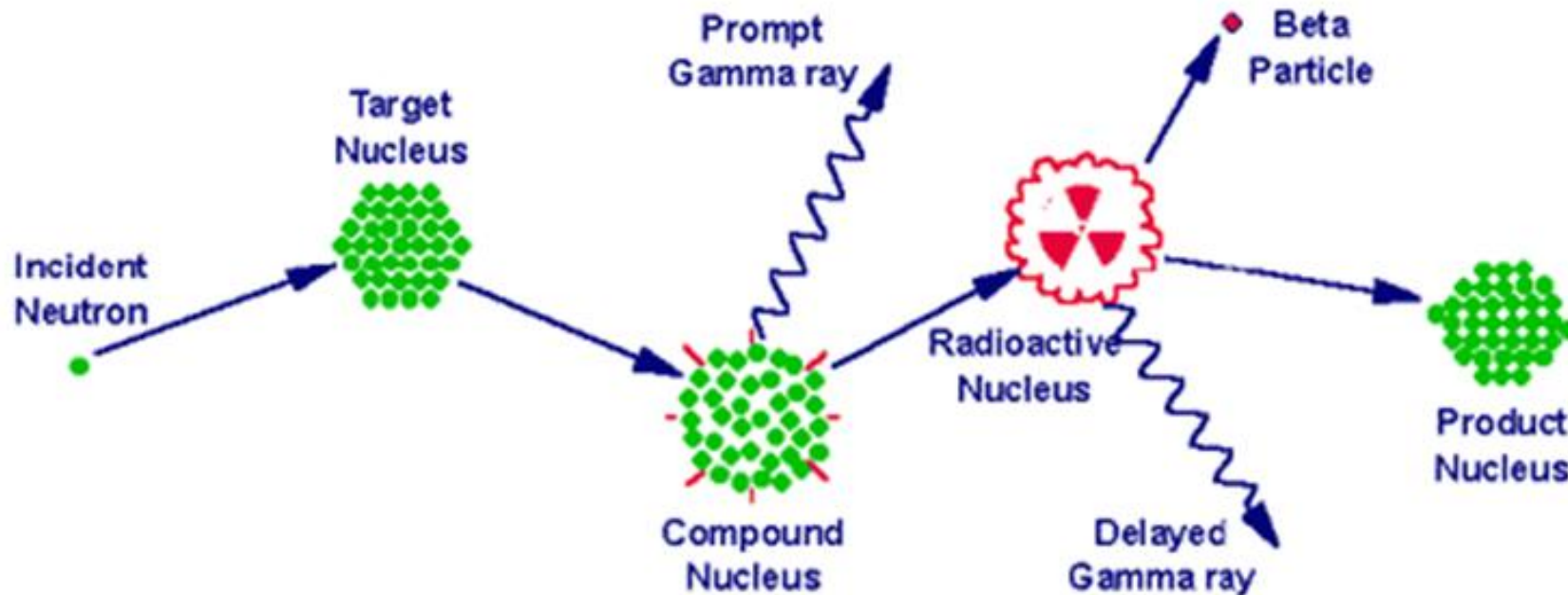


Hilde Levi

- **1932** James Chadwick then used Beryllium to produce this new radiation and he aimed the radiation at paraffin wax and protons were ejected.
- He measured the range of the protons found that the new radiation consisted of not gamma rays, but uncharged particles with about the same mass as the proton
- **1934** Hilde Levi exposed dysprosium to neutrons but the GM, indicated no activity. This was explained by the dead time 100%.
- She put away the tray and later when she needed it she observed that GM counter start to register some pulses.

# NA A

- Neutron activation analysis is a method for the qualitative and quantitative determination of elements based on the measurement of characteristic radiation from radionuclides formed by irradiating materials by neutrons.



# Types of NAA

- **Destructive**

(radiochemical) – the resulting radioactive sample is chemically decomposed and the elements are chemically separated.



## **Non-destructive**

(instrumental) – sample is kept intact and the radionuclides are determined, taking advantage of the differences in decay rates via measurements at different decay intervals



# Sample collection.



Soil



Moss



Sediments



# Sample preparation



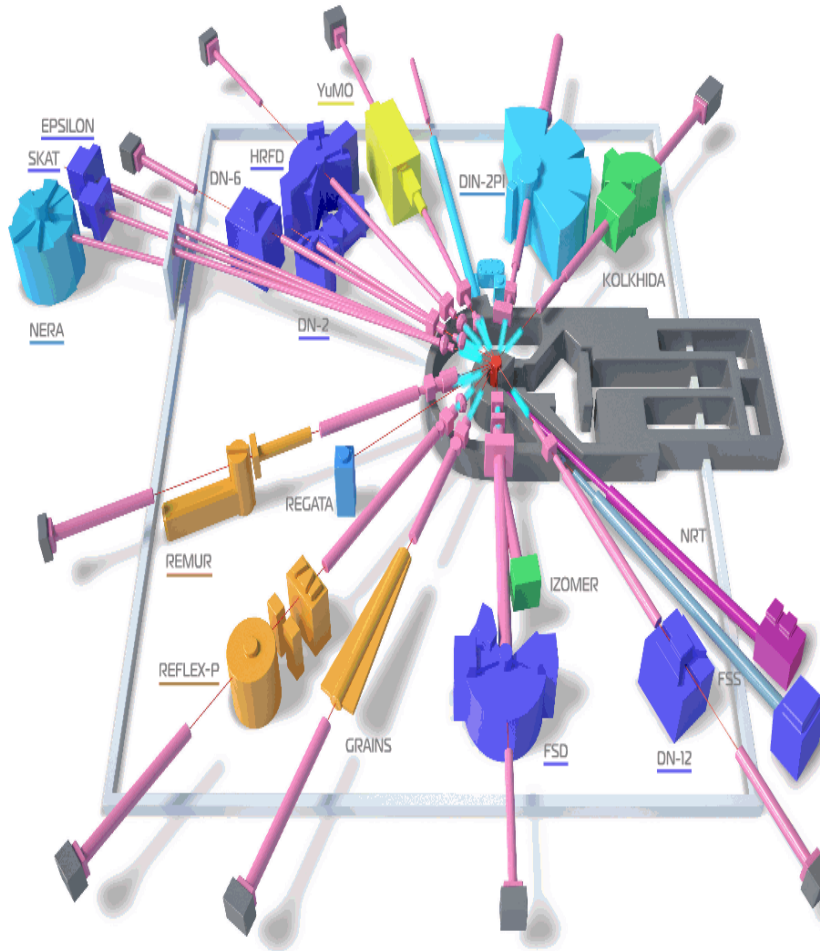
# Sample Irradiation



# IBR-2

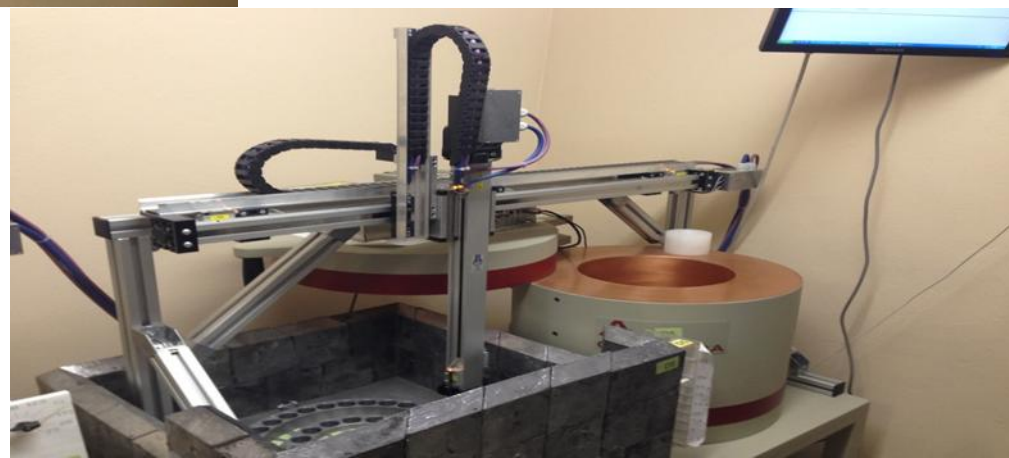
Experimental facilities

# REGATA

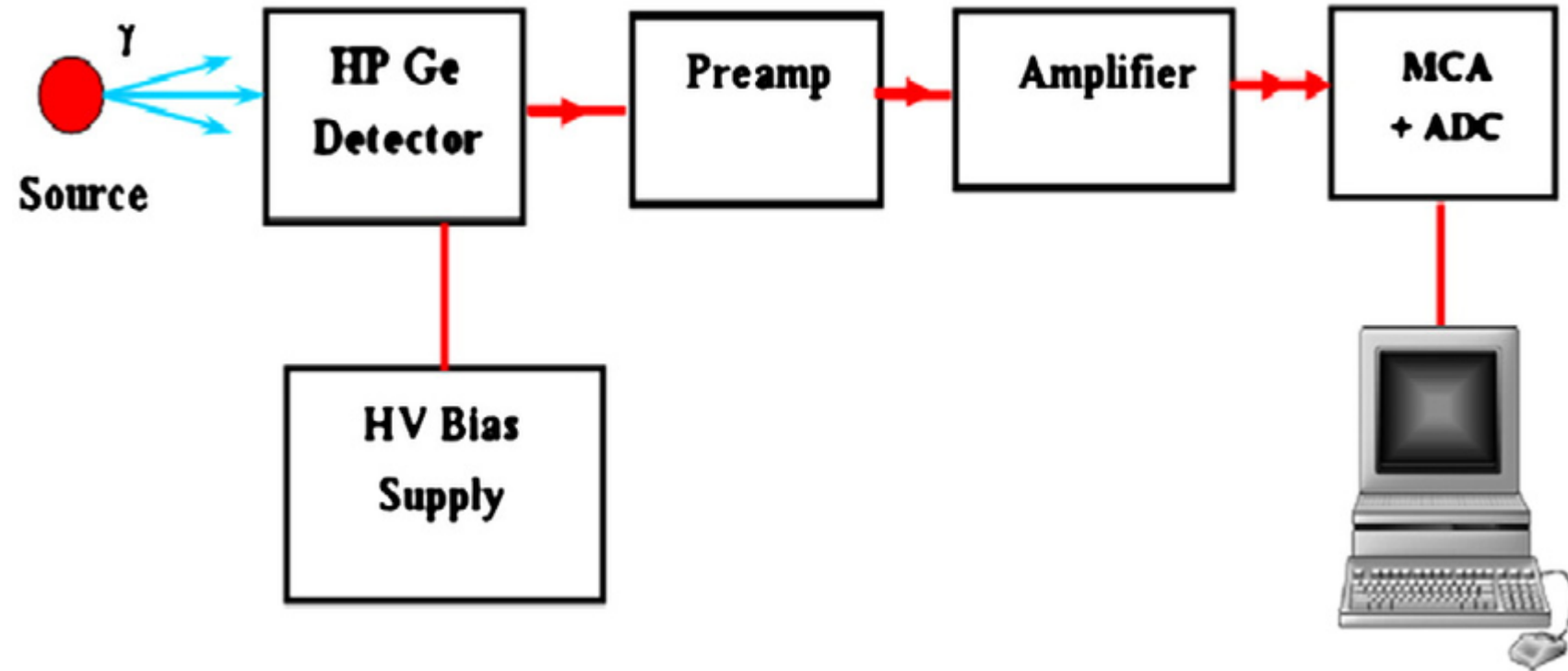


- Diffraction**  
DIN-2, DN-12, DN-6, FSD, FSS, HRFD, SKAT, EPSILON
- Small-angle scattering**  
YuMO
- Reflectometry**  
GRAINS, REFLEX-P, REMUR
- Inelastic scattering**  
DIN-2PI, NERA
- Nuclear Physics**  
IZOMER, KOLKHIDA
- Neutron Activation Analysis**  
REGATA
- Neutron imaging**  
NRT

# Post Irradiation.

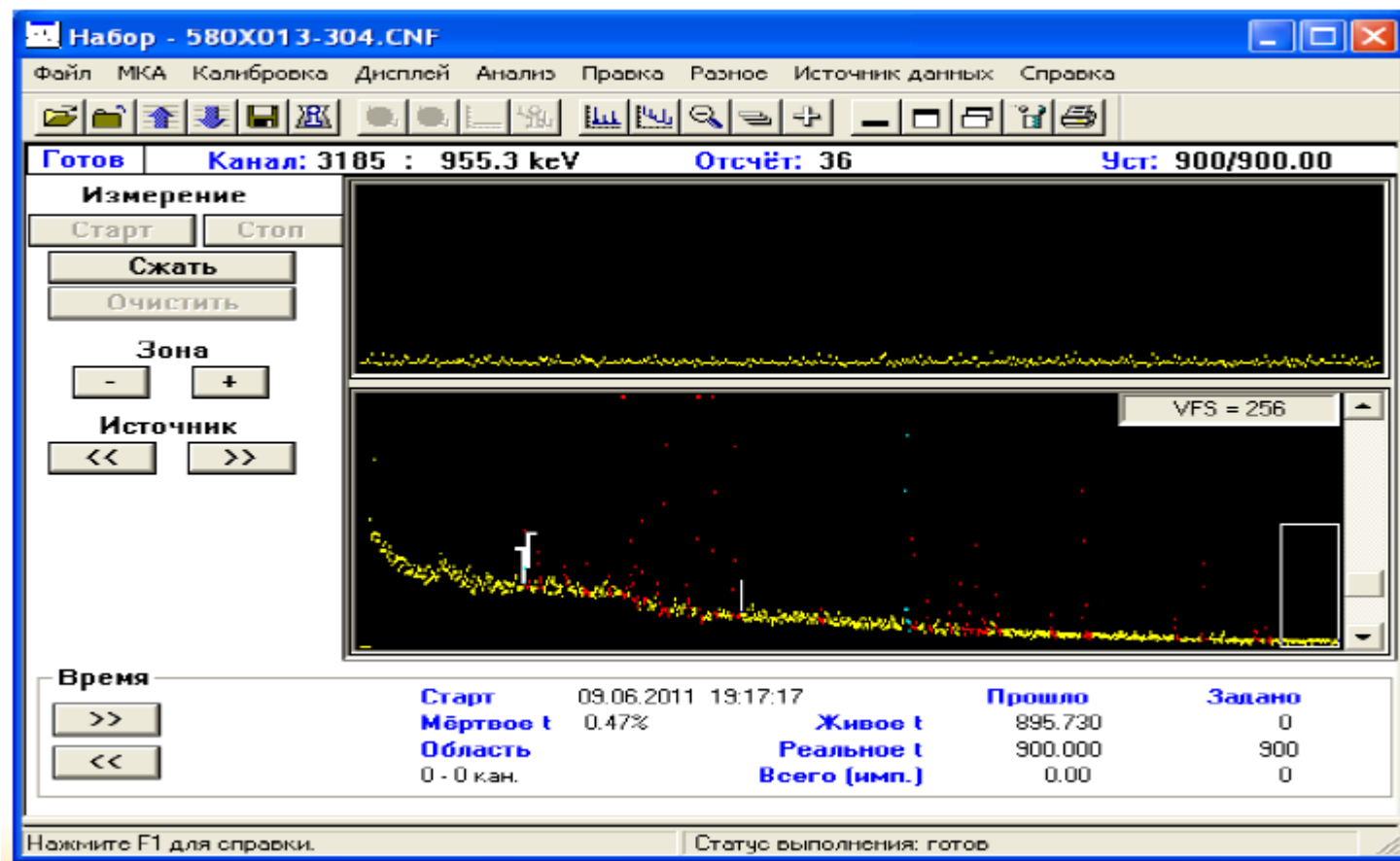


# Detection/Measurement





# Genie 2000



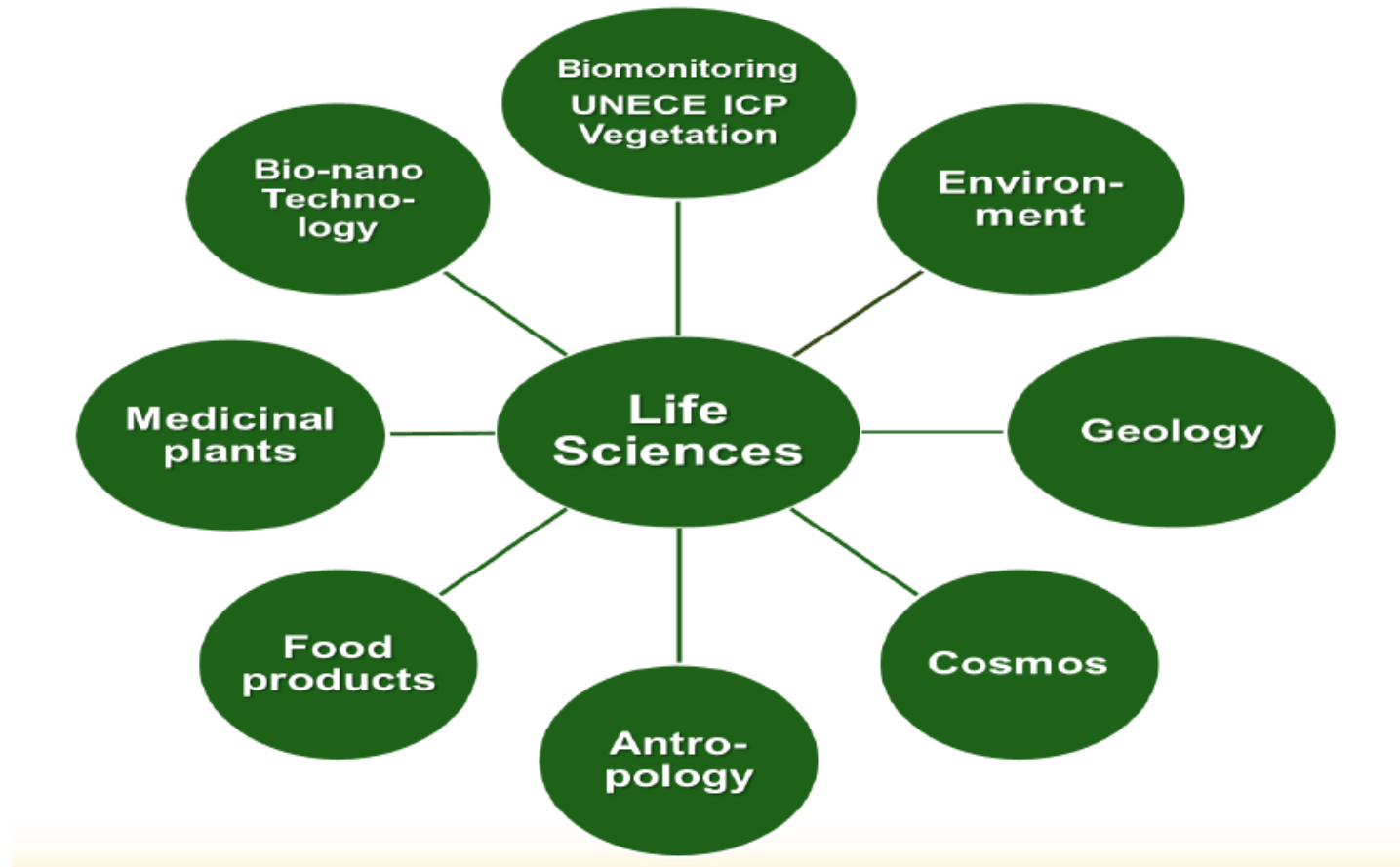
# Supporting programs.

The 'Samples info-2.0' window features a menu bar with 'File' and 'Help'. It includes input fields for 'Sample ID', 'Sample type', 'Latitude (dec. degrees)', 'Longitude (dec. degr.)', and 'Collection place'. A 'Determined elements' section contains a 'Select all' button and a grid of checkboxes for 30 elements: F, Na, Mg, Al, Si, S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Nb, Mo, Ru, Pd, Ag, Cd, In, Sn, Sb, I, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Th, and U. Below the grid is a 'Notes (e.g. most important elements)' text area. At the bottom, there is a table with columns: '№', 'Sample ID', 'Sample type', 'Sample subtype', 'Latitude', 'Longitude', 'Collection place', and 'Determined element'. A toolbar at the very bottom contains buttons for 'Replace', 'Add', 'Delete', 'Close', and 'Save'.

The 'Client info' window has a menu bar with 'File', 'Language', and 'Help'. It contains a 'Country' dropdown menu and several text input fields for 'Postal code', 'Republic', 'Region', 'District', 'City', 'Street', 'House', and 'Building'. There is an 'Organization' text area. Personal information fields include 'Title', 'Gender', 'Last name', 'First name', and 'Middle name'. Contact details are provided for 'Phone 1', 'Phone 2', 'Fax', and 'Mobile phone', each with a 'Country code' and 'Code' dropdown. There are also fields for 'E-mail 1' and 'E-mail 2'. A 'Notes' text area is at the bottom. The window concludes with 'Save' and 'Close' buttons.

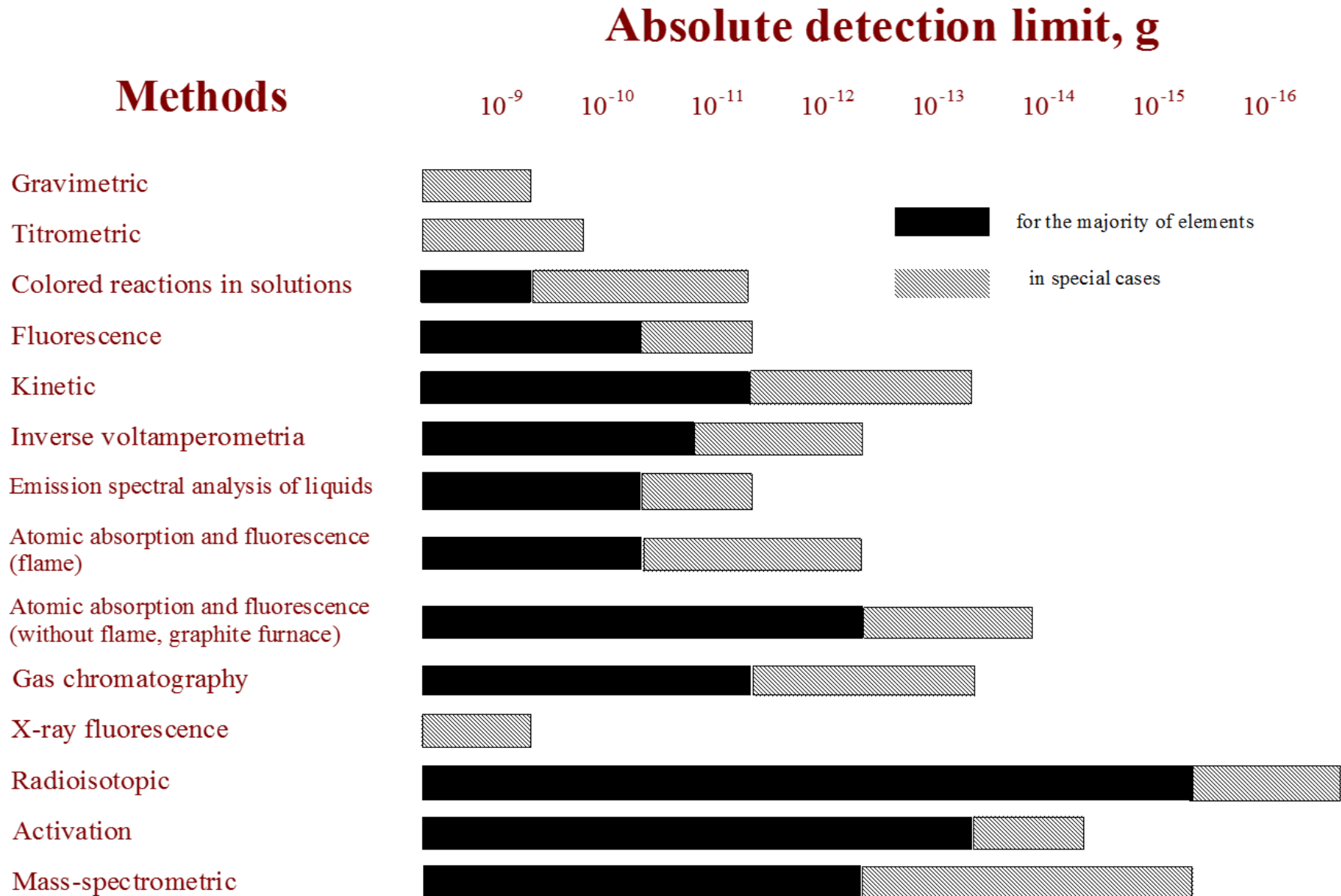
The 'Calculation of concentration 6.10.3' window features a menu bar with 'Calculation of standards activities', 'Concentration', 'Nuclids table', 'Re-launch application', and 'Russian'. It is divided into several sections: 'Recalculation of standards activities' with fields for 'Base file of standar.s monitor activity: not choosen', 'File of standar.s monitor activity: not choosen', and 'File(s) of standar.s activity: not choosen'; a 'Group standard' section with an 'Open GRS editor' button; a 'Concentration' section with fields for 'File(s) of observable sampl.s activity: not choosen', 'File of group standard: not choosen', 'Base file of standar.s monitor activity: not choosen', and 'File of sampl.s monitor activity: not choosen'; a 'SLI source' dropdown; checkboxes for 'Cancel of choosing monitors files' and 'Calculates for filters'; a 'Coefficient of neutrons flow changing' field set to '1.0'; and a 'Systematic error, %:' field set to '0'. A 'Calculate and save concentrations' button is present. At the bottom, there are buttons for 'Create intermediate table of concentration', 'Elements without calculated concentration', and 'Create final table concentration'. A 'Rounding accuracy %:' field is set to '1'.

# Applications





# Comparison of NAA with other techniques.



## **Advantages**

- Wide possibilities of applications
- Non destructive analysis
- Multi-element analysis
- Sensitivity to parts-per-billion for specific elements

## **Limitations.**

- Need for nuclear reactor
- Work with radioactive materials
- Time of analysis
- Sample preference

# Joint projects JINR-RSA.

Nuclear and related analytical techniques for environmental studies using aquatic biomonitors around the Southern African coastline. ACRONYM: Mussel Watch.

- 31 major and trace elements were found in the mussels.
- Seasonal accumulation of heavy metals was also studied. During winter accumulation was high compared to summer.
- Comparison between farmed and naturally occurring mussels—farmed mussels showed low accumulation of heavy metals than naturally growing.



Fig. 1. A Google Earth image indicating the positions of the four sampling sites. The map insert shows the position of Saldanha Bay with relation to South Africa



# Acknowledgements.

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