



Department of Neutron Activation Analysis & Applied Research
Division of Nuclear Physics
Frank Laboratory of Neutron Physics
Joint Institute for Nuclear Research

THE 50-th ANNIVERSARY OF NEUTRON ACTIVATION ANALYSIS AT FLNP JINR

Marina Frontasyeva

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ISINN-21, May 20-25, 2013, Alushta, Crimea

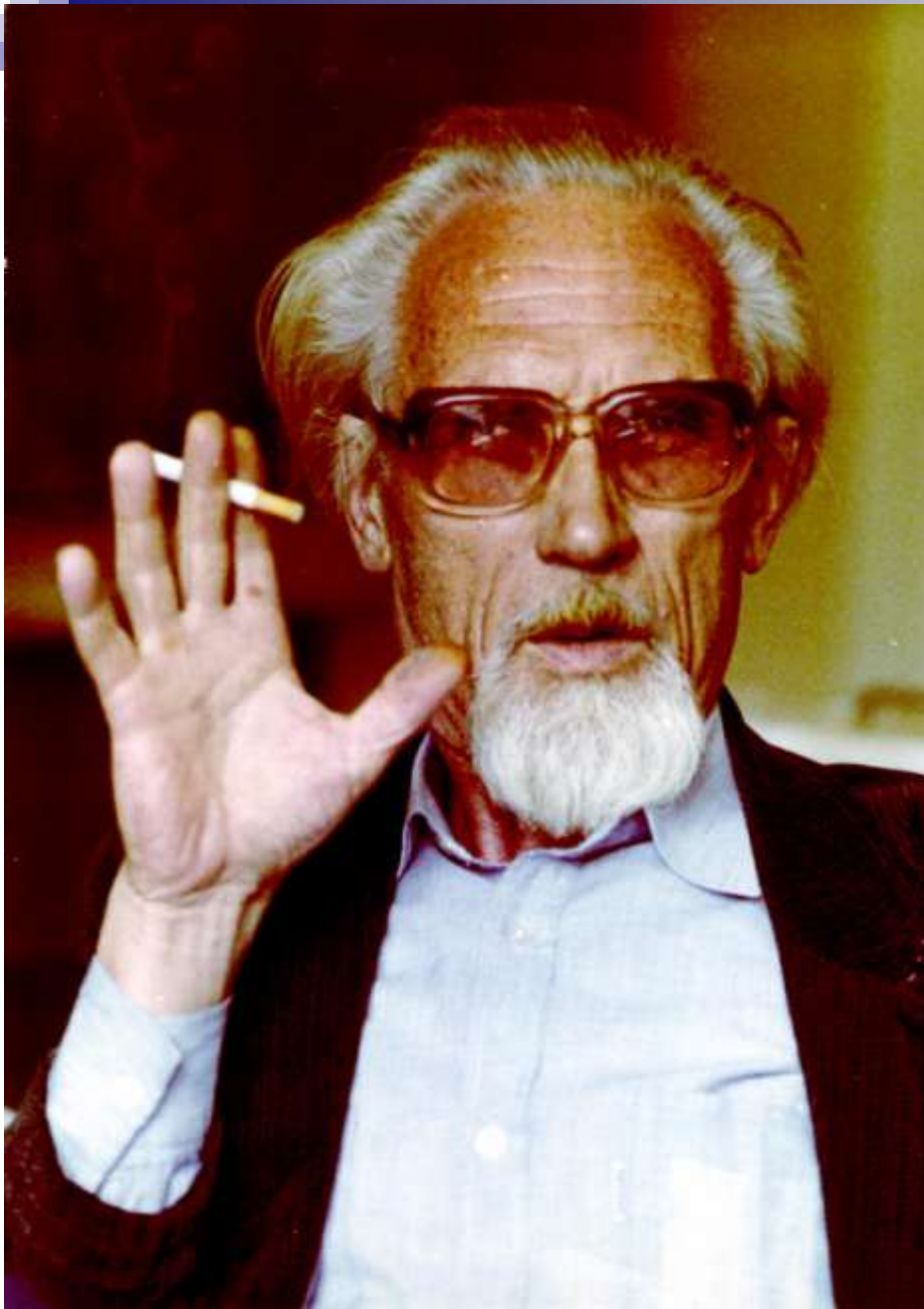
Neutron activation analysis is an isotope specific analytical technique for the qualitative and quantitative determination of elemental content

P. Bode, J. J. M. de Goeij, '**Activation Analysis**', Encyclopedia of Environmental Analysis and Remediation, J. Wiley & Sons, New York, **1998**, ISBN 0-471-11708-0, pp 68–84

The method is based upon the conversion of stable atomic nuclei into radioactive nuclei by irradiation with neutrons and the subsequent detection of the gamma radiation emitted during the decay of these radioactive nuclei. Activation by neutrons may result in radionuclides from all elements (that have radioactive daughter products) present in the sample, with sometimes strongly different production rates

Contents

1. Introduction (2013: the 50th anniversary of NAA at FLNP JINR)
2. Upgrade of radioanalytical complex REGATA and automation of NAA (IAEA CRP) (accreditation)
3. Outline of scientific activity (international projects)
4. Educational programme (Schools & Practicals)

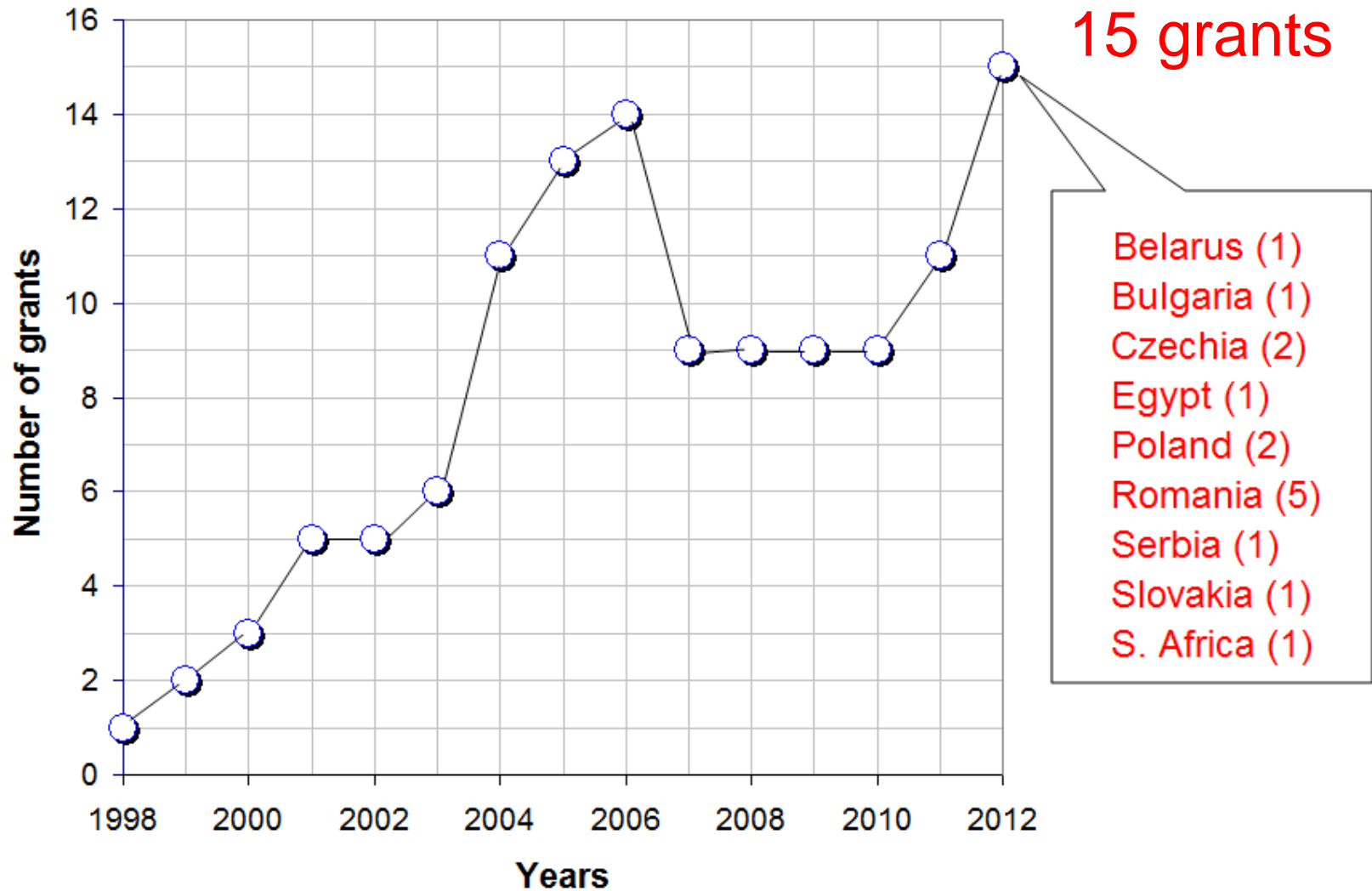


V.M. Nazarov

10.12.1931 - 30.12.1994



Grants of Plenipotentiaries of JINR member-states



IAEA Coordinated Research Projects

1994–1997 — **Workplace monitoring and occupational health studies...**
(Contract No. 9480/RBF)

1997–2002 — **Biomonitoring air pollution in Chelyabinsk Region**
(Ural Mountains, Russia) (Contract No: 9939/RBF)

2002–2005 — **Use of INAA, AAS and XRF in studying health impacts of toxic elements consumed through foodstuffs**
(Contract No. 11927/RBF)

2002–2003 — **Selenium containing blue-green algae *Spirulina platensis* for preventive health care** (Contract No. 11528/RBF)

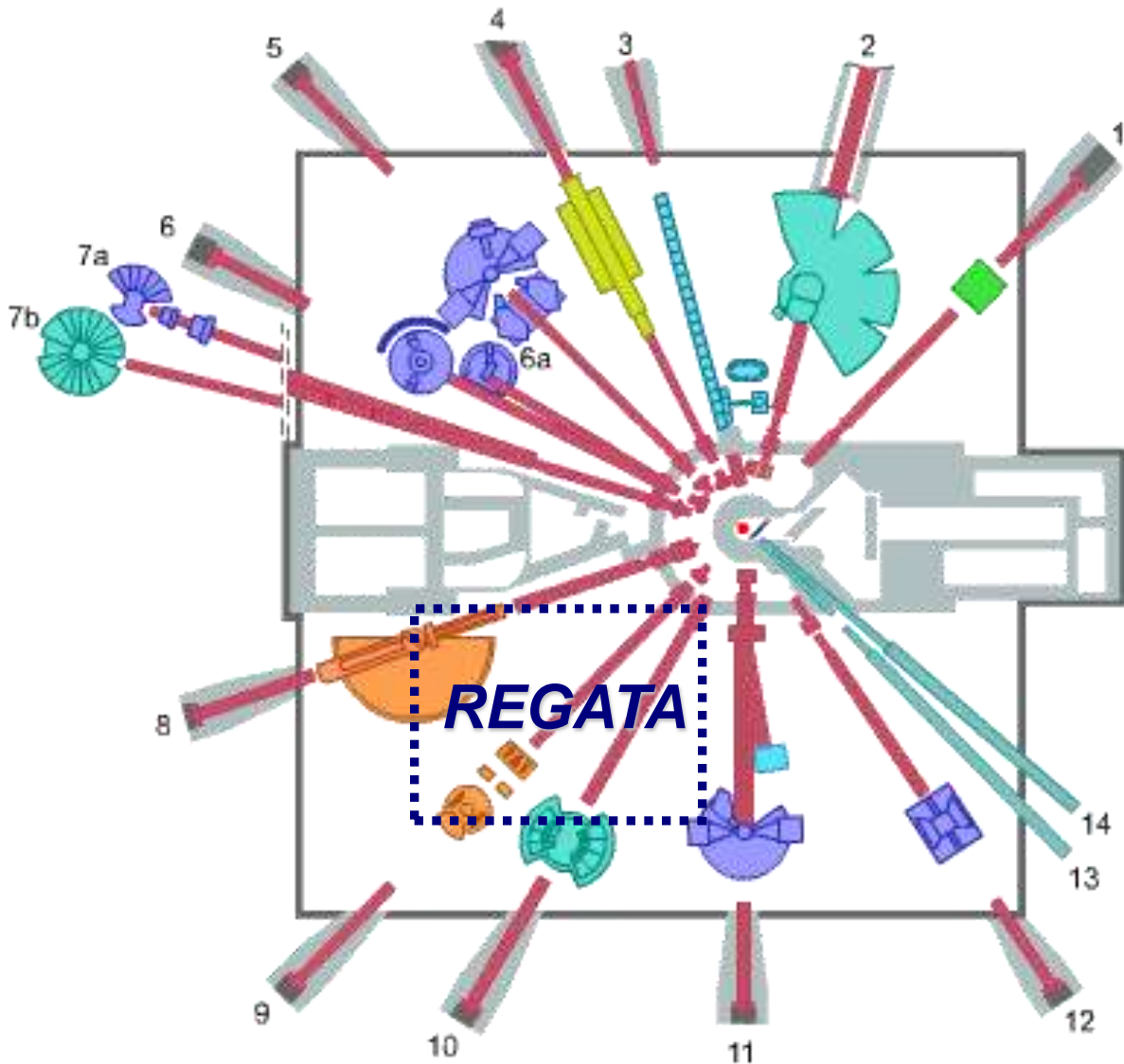
2005–2007 — **Assessment of exposure to toxic/potentially toxic elements (Hg, Pb, As, Mn, etc)** (Contract No. 13249/RBF)

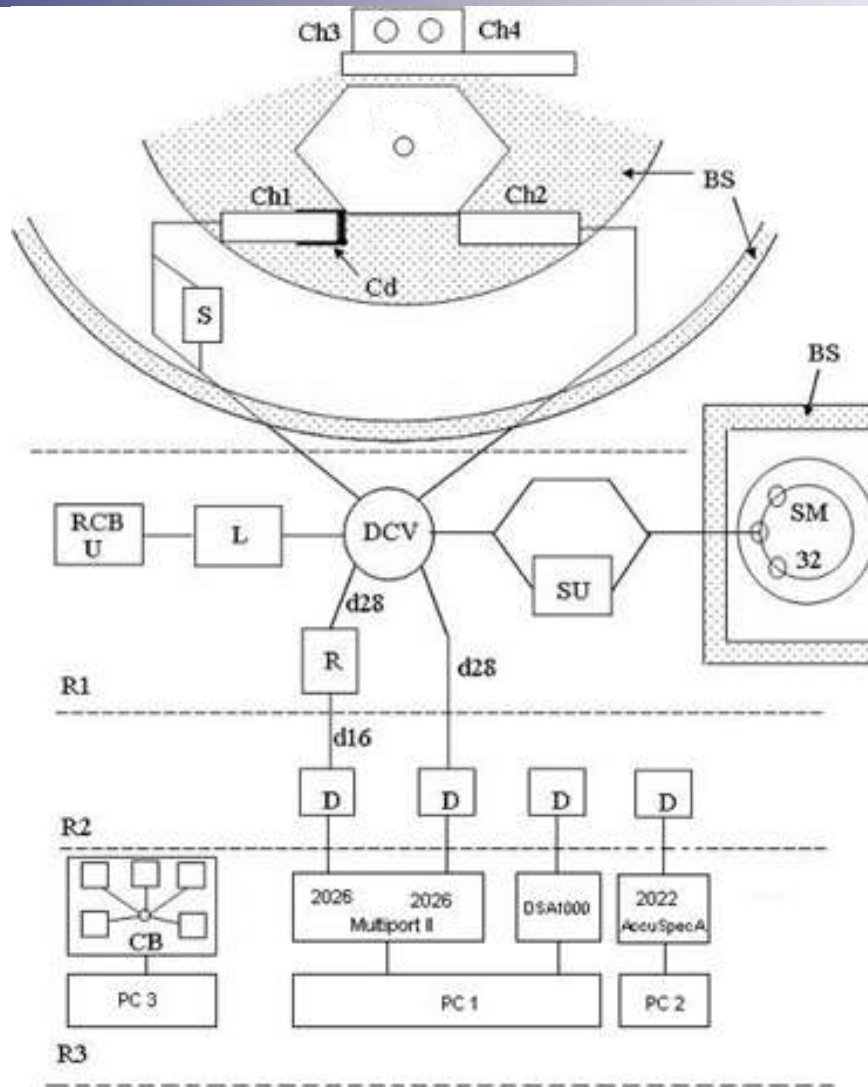
IAEA Technical Cooperation Projects

2003–2005 — **Investigation of Health Effects on Children** from the Consumption of Foods Grown in Industrially Contaminated Areas

2007 –2008 — **Quality Assurance & Quality Control** (International harmonization of QA/QC systems according to ISO standards in nuclear analytical laboratories of the Russian Federation)

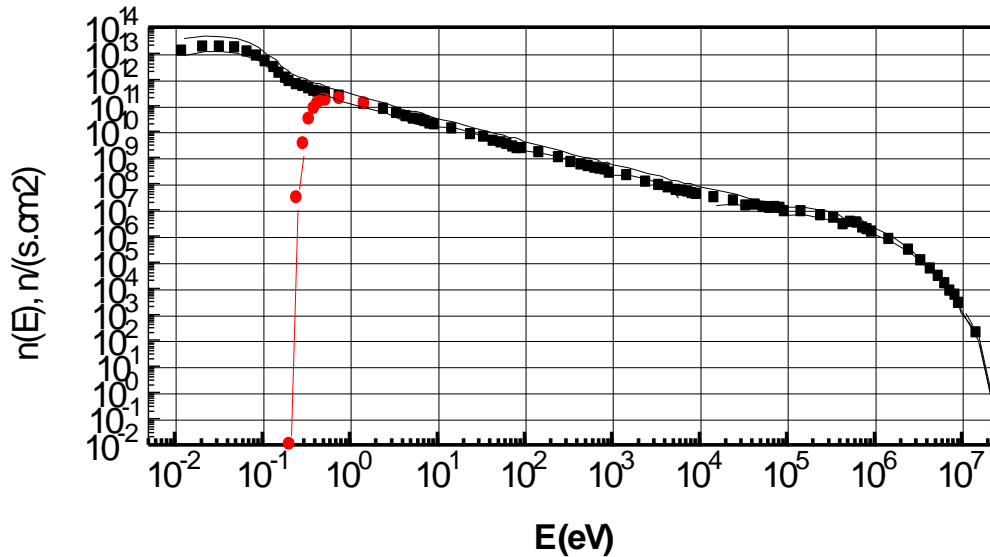
IBR-2 Pulst Fast Reactor and Radioanalytical complex REGATA





Ch1-Ch4 –irradiation channels, S- intermediate storage, DCV- directional control valves, L- loading unit, RCB- radiochemical glove-cell, U- unloading unit, SU- separate unit, SM- storage magazine, R- repacking unit, D- Ge(Li) detector, AA- amplitude analyzer, CB- control board, CC- CAMAC controller, R1-R3- the rooms where the system is located


Neutron energy spectra and irradiation channels



Neutron energy spectra
in irradiation channels
CH1(■) and CH2 (curve)

The main characteristics of the irradiation channels at 1.5 MW

Irradiation site	Neutron flux density ($n/cm^2 s$) 10^{12}			$T^{\circ}C$	Channel diam., mm	Channel length, mm
	Thermal	Resonance	Fast			
Ch1	Cd-coated	3.31	4.32	70	28	260
Ch2	1.23	2.96	4.1	60	28	260
Ch3	Gd-coated	7.5	7.7	30-40	30	400
Ch4	4.2	7.6	7.7	30-40	30	400



During the IBR-2 reconstruction period chemical laboratory for samples preparation and radioanalytical complex REGATA at IBR-2 were completely renovated and equipped at the level of the requirements of ISO and International Standards in Nuclear Analytical Laboratories

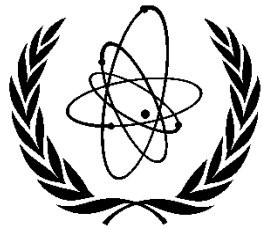
Chemical laboratory of Dept. NAA & Applied Research

and some equipment for
sample preparation



Sample preparation





IAEA

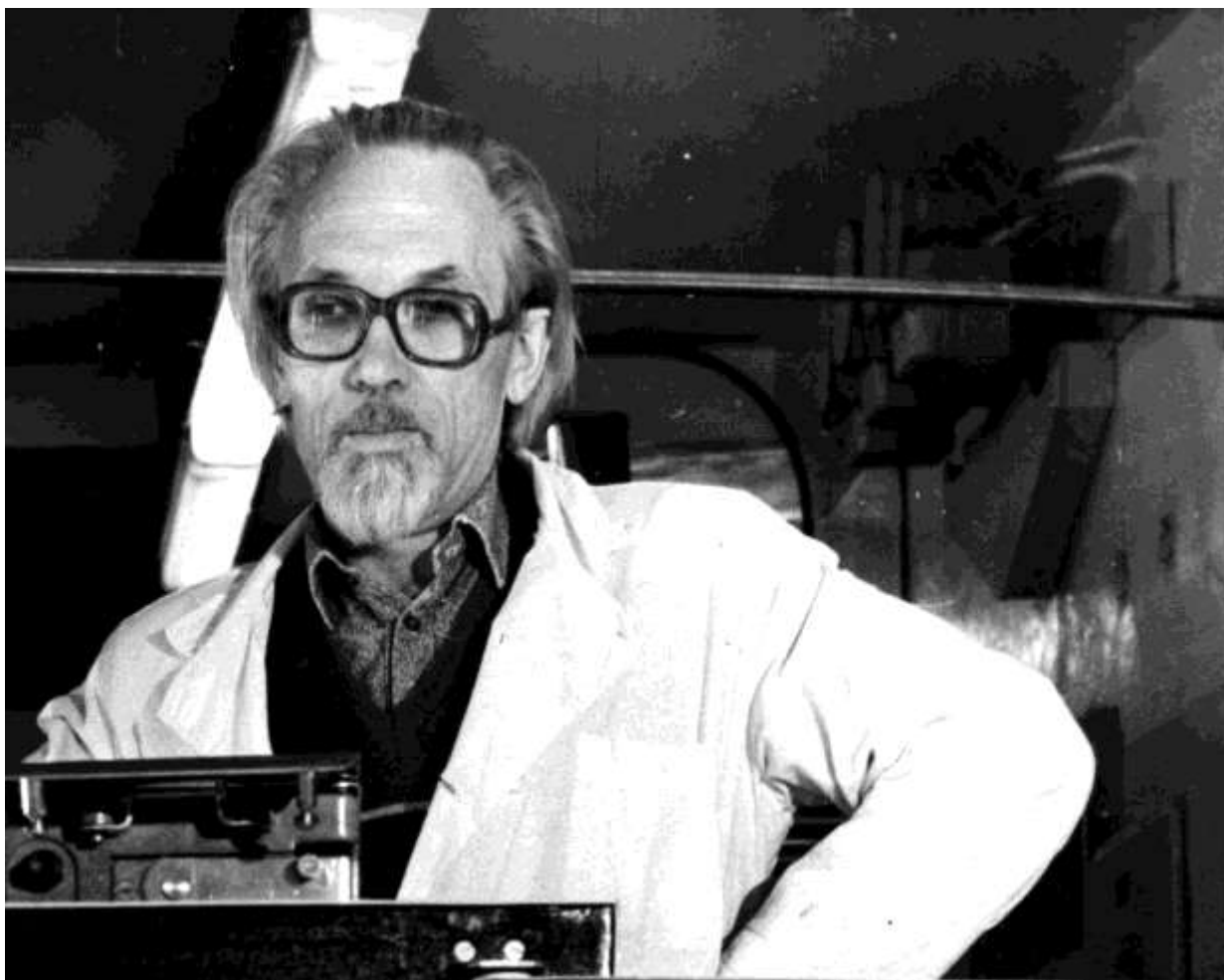
International Atomic Energy Agency

TITLE OF RESEARCH CONTRACT:

Automation of Reactor Neutron Activation Analysis

Part of the IAEA's Coordinated Research Project (CRP):

Development of an Integrated Approach to Routine
Automation of Neutron Activation Analysis
(Ref. F1.20.25 / CRP1888)



V.M. Nazarov

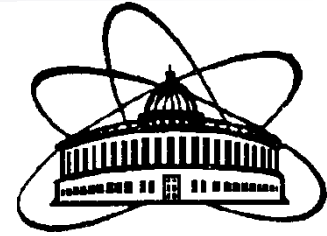
(10.12.1931 – 30.12.1994)







IAEA Technical Cooperation Project

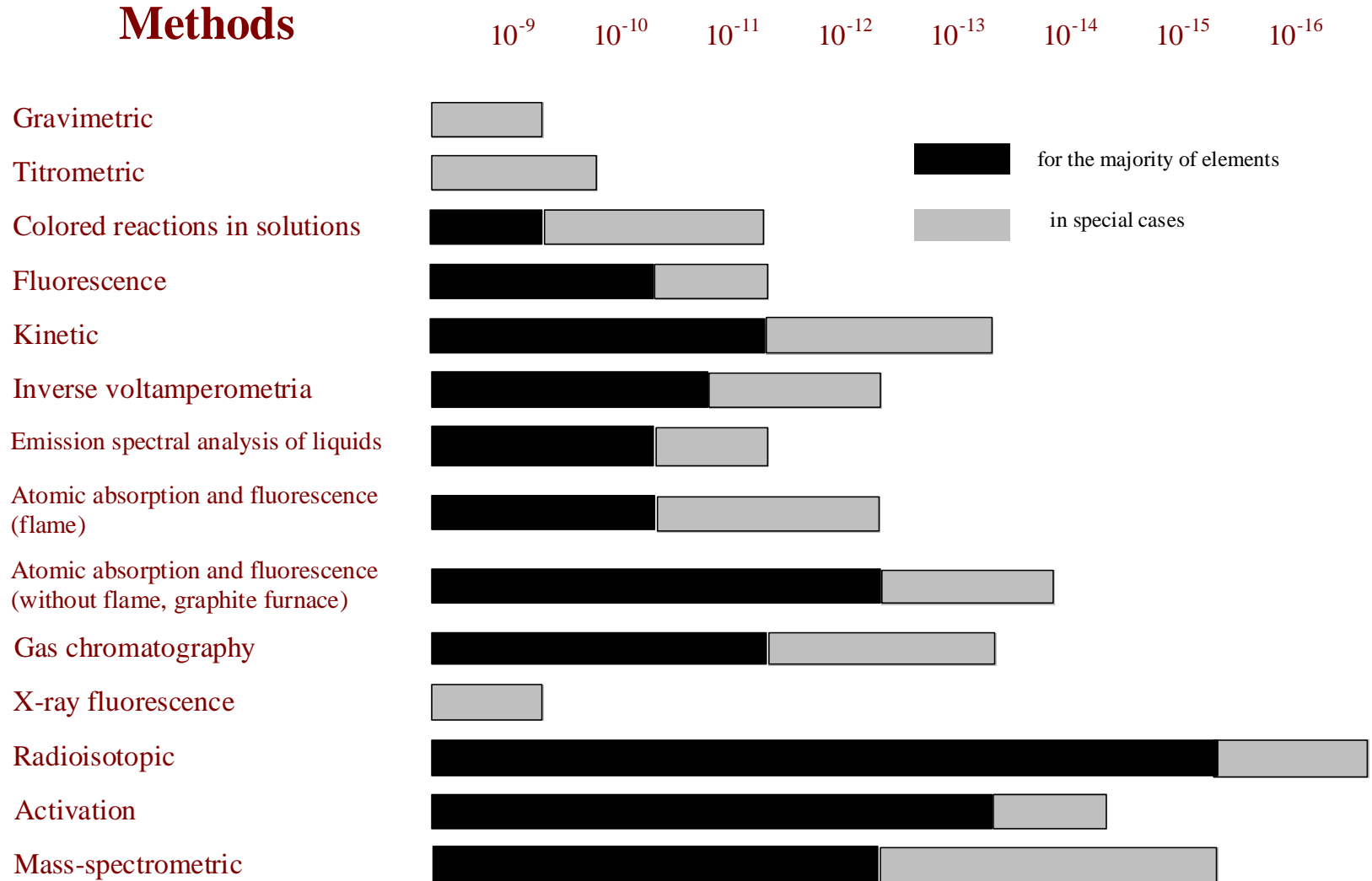


Harminization of QA/QC System According to ISO and International Standards in Nuclear Analytical Laboratories of the Russian Federation

(IAEA TC Project RUS7003, 2009-2011)

**Гармонизация системы контроля качества в соответствии с ISO и
международными стандартами в лабораториях Российской Федерации,
использующих ядерно-физические аналитические методы**

Absolute detection limit, g



NAA + AAS

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**											Rf	Db	Sg	Bh	Hs
	*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
	**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lw		

NAA ~ 55 elements

ANALYTICAL INVESTIGATIONS AT IBR-2M REACTOR

*Instrumental
neutron activation analysis*
INAA

*Epithermal
neutron activation
analysis*
ENAA

*Cyclic
neutron activation
analysis*
CNAA

Life Sciences

Material Science

- **Biomonitoring** of atmospheric deposition of heavy metals and other elements (Project **REGATA**)
- Control of quality and safety of **foodstuffs**, grown in industrially contaminated areas
- Assessment of different ecosystems and their impact on **human health**
- **Analysis of cosmic dust**
- **Biotechnologies:** development of new pharmaceuticals, cleaning the environment from toxic elements (biosorption) and synthesis of nanoparticles
- NAA for the technological process of synthesis of **diamonds and NB (boron nitride)**
- Analysis of **archaeological and museum objects** from Russia and other countries
- NAA for **decommissioning of Nuclear Power Plants** and **utilization of industrial wastes**

ANALYTICAL INVESTIGATIONS AT IBR-2M REACTOR

*Instrumental
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INAA

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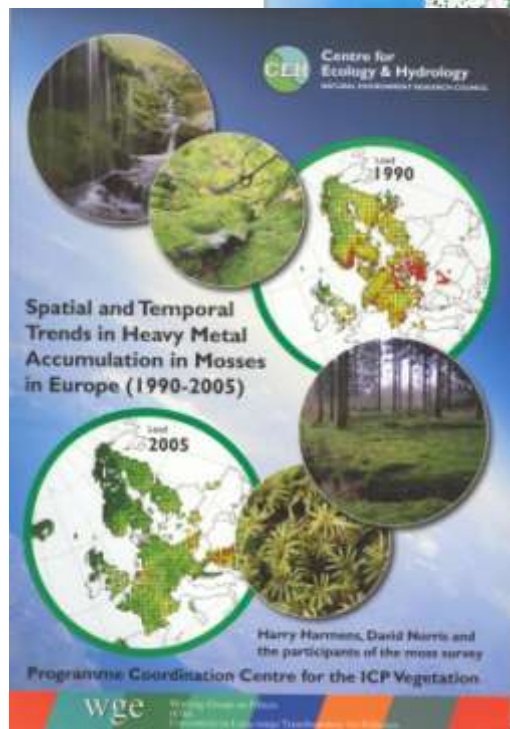
Life Sciences

Material Science

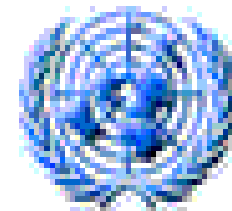
- **Biomonitoring** of atmospheric deposition of heavy metals and other elements (Project **REGATA**)
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Air pollution studies based on moss analysis



UNECE



United Nations Economic Commission for Europe

International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

Working Group on Effects - 1981



Project REGATA

(1995-2000-2005-2010-2015)

Title

Heavy metal atmospheric deposition study in selected European and Asian countries using nuclear and related analytical techniques

Participating countries:

Russia, Ukraine, Belarus, Bulgaria, Croatia, Poland, Romania, Slovakia, Greece, Macedonia, Serbia, Croatia, Albania, Montenegro, Turkey, Mongolia, Vietnam, South Korea, Thailand



International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

<http://icpvegetation.ceh.ac.uk/>

http://icpvegetation.ceh.ac.uk/publications/documents/Finalmossreportwithmaps_110708_proofedits_180708_highquality.pdf

http://icpvegetation.ceh.ac.uk/research/heavy_metals.html

Moss survey protocol

http://icpvegetation.ceh.ac.uk/manuals/moss_survey.html

Presentations by Marina V. Frontasyeva:

<http://icpvegetation.ceh.ac.uk/events/documents/Frontasyeva.pdf>

http://icpvegetation.ceh.ac.uk/events/documents/Frontasyeva_000.pdf



Centre for Ecology & Hydrology

NATURAL ENVIRONMENT RESEARCH COUNCIL

The role of the ICP Vegetation

Thirty four countries of Europe plus the USA contribute experimental data and modelling expertise to the ICP Vegetation, an International Cooperative Programme reporting to the United Nations Convention on Long-range Transboundary Air Pollution (LRTAP Convention) on the effects of air pollution on natural vegetation and crops. Data and maps are used to inform international policy on the effectiveness of air pollution control and future requirements, leading ultimately to improvements in air quality across Europe.

Data collection and maps

The Programme Coordination Centre for the ICP Vegetation has collated data on the heavy metal concentrations in mosses since 2000. Naturally growing mosses were sampled according to a standardised protocol and their heavy metal concentrations were determined. Results were mapped on the EMEP 50 km x 50 km grid.

Nitrogen and POPs

In 2005, the majority of countries also determined the total nitrogen concentration in mosses for the first time. The total nitrogen concentration in mosses complement deposition measurements, helping to identify areas in Europe at risk from high nitrogen deposition at a high spatial resolution. In 2010, six countries determined also the concentration of selected persistent organic pollutants (POPs), particularly polycyclic aromatic hydrocarbons (PAHs), to assess whether mosses can be used as biomonitors of POPs deposition. **The results of the 2010 moss survey will be published in 2013.**

Further Information

For further information and a copy of the recent report, please visit our website (icpvegetation.ceh.ac.uk) or contact:

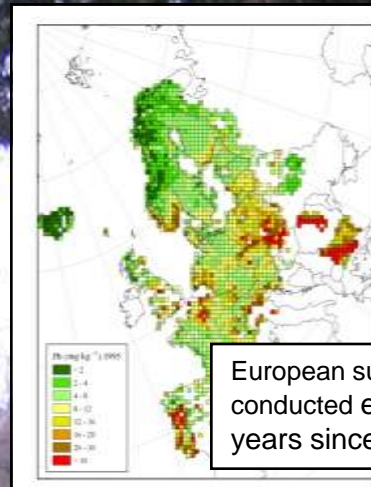


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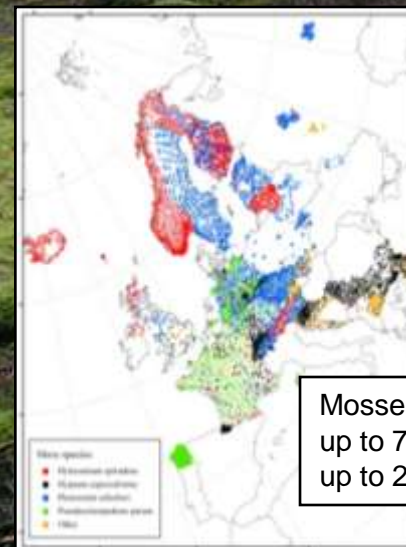
Acknowledgements

We wish to thank Defra, NERC and the LRTAP Convention for financial support of the ICP Vegetation, and participants and their funders for their contributions.

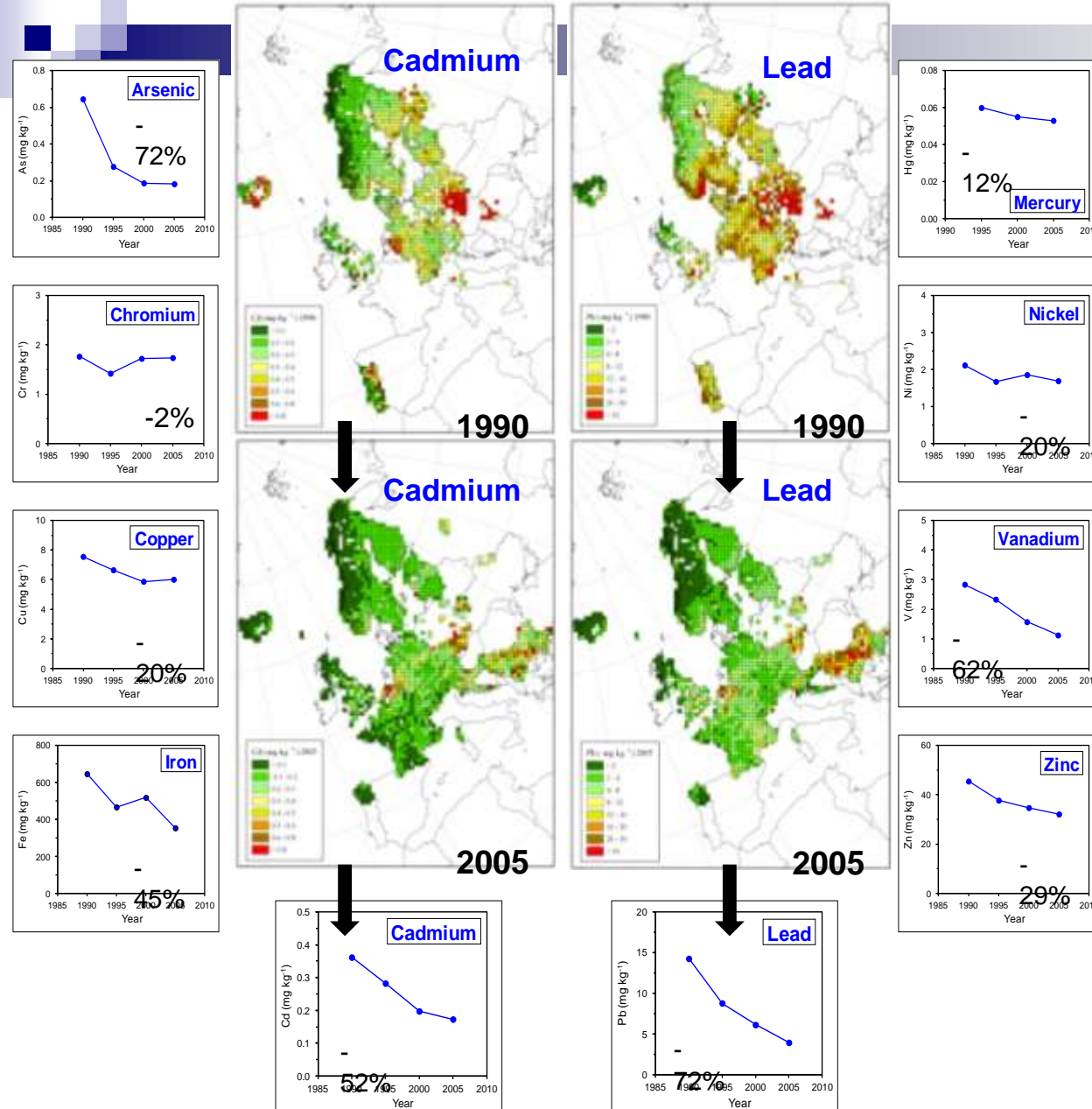


European surveys conducted every five years since 1990

Mosses as biomonitors of atmospheric heavy metal pollution in Europe



Mosses sampled at up to 7,300 sites in up to 29 countries



Mosses provide a complementary method to assess spatial patterns and temporal trends of atmospheric heavy metal deposition:

- Carpet forming mosses obtain trace elements and nutrients directly from the atmosphere.
- In recent years, the lowest concentrations of heavy metals in mosses were found generally in northern Europe and the highest concentrations in Belgium and eastern Europe .
- Europe-wide the concentration in mosses of arsenic, cadmium, lead and vanadium has declined the most between 1990 and 2005, with hardly any reduction being observed for chromium and mercury.
- Temporal trends were country-specific.
- Spatial patterns and temporal trends for cadmium and lead agree quite well with those modelled by the European Monitoring and Evaluation Programme (EMEP).

Moss surveys 2010/2011 – 2015

Leningradskaya Region, Tikhvin

Yekaterinburg, the Urals

Kostroma Region

Smolensk Region

Ivanovo Region

Kola Peninsula

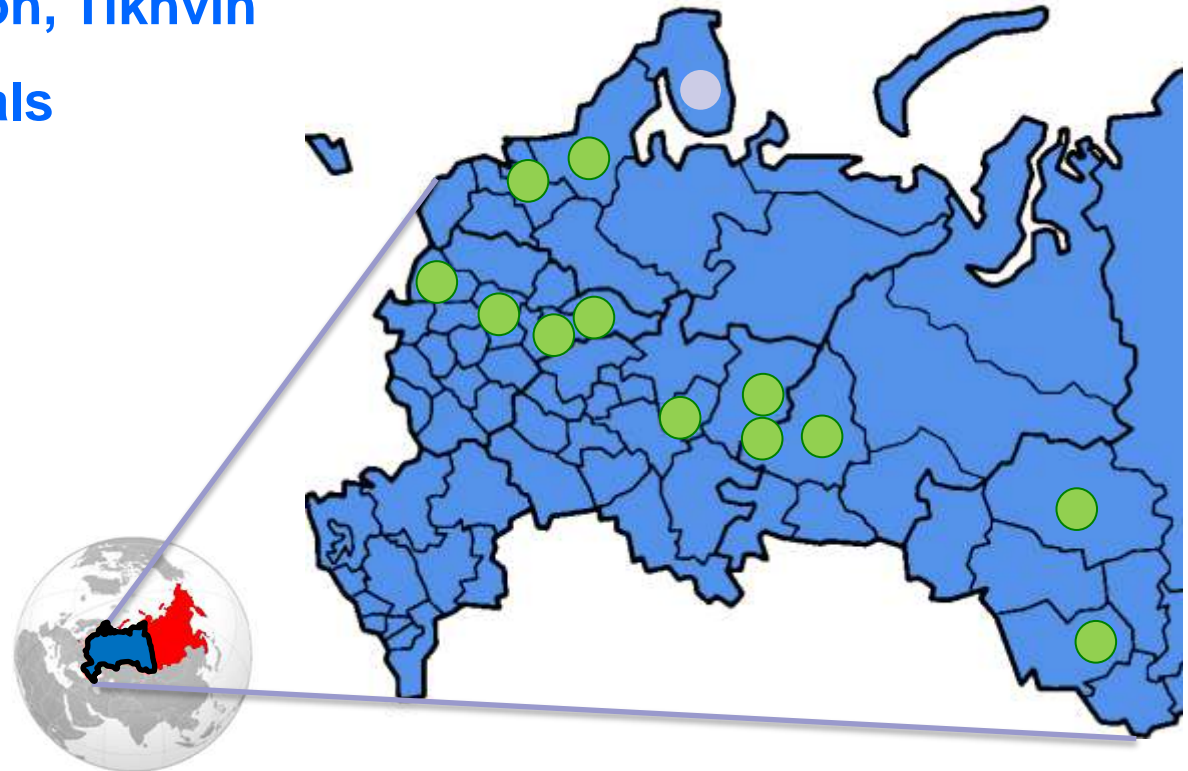
Moscow

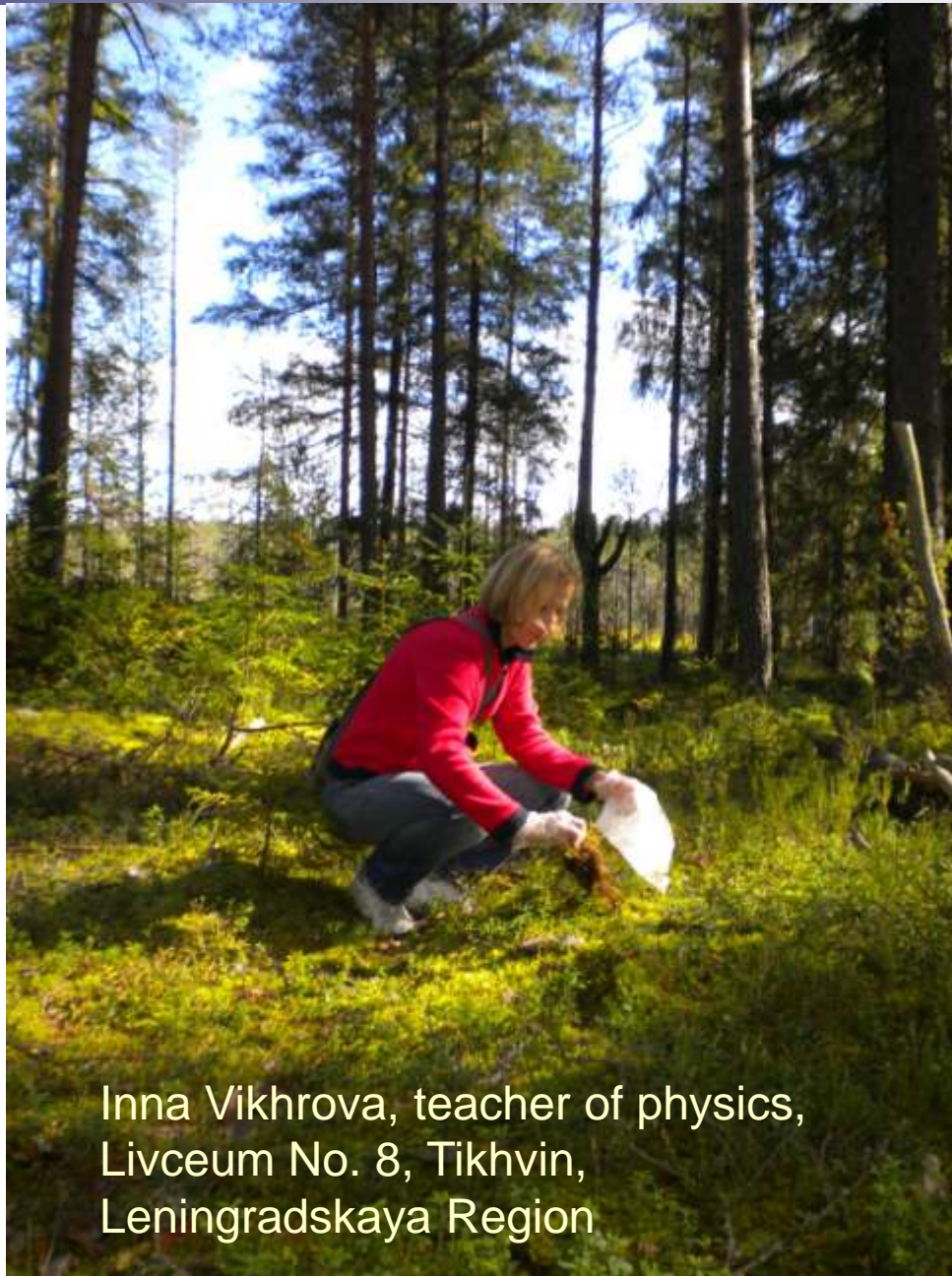
Tomsk

Dubna

Altay

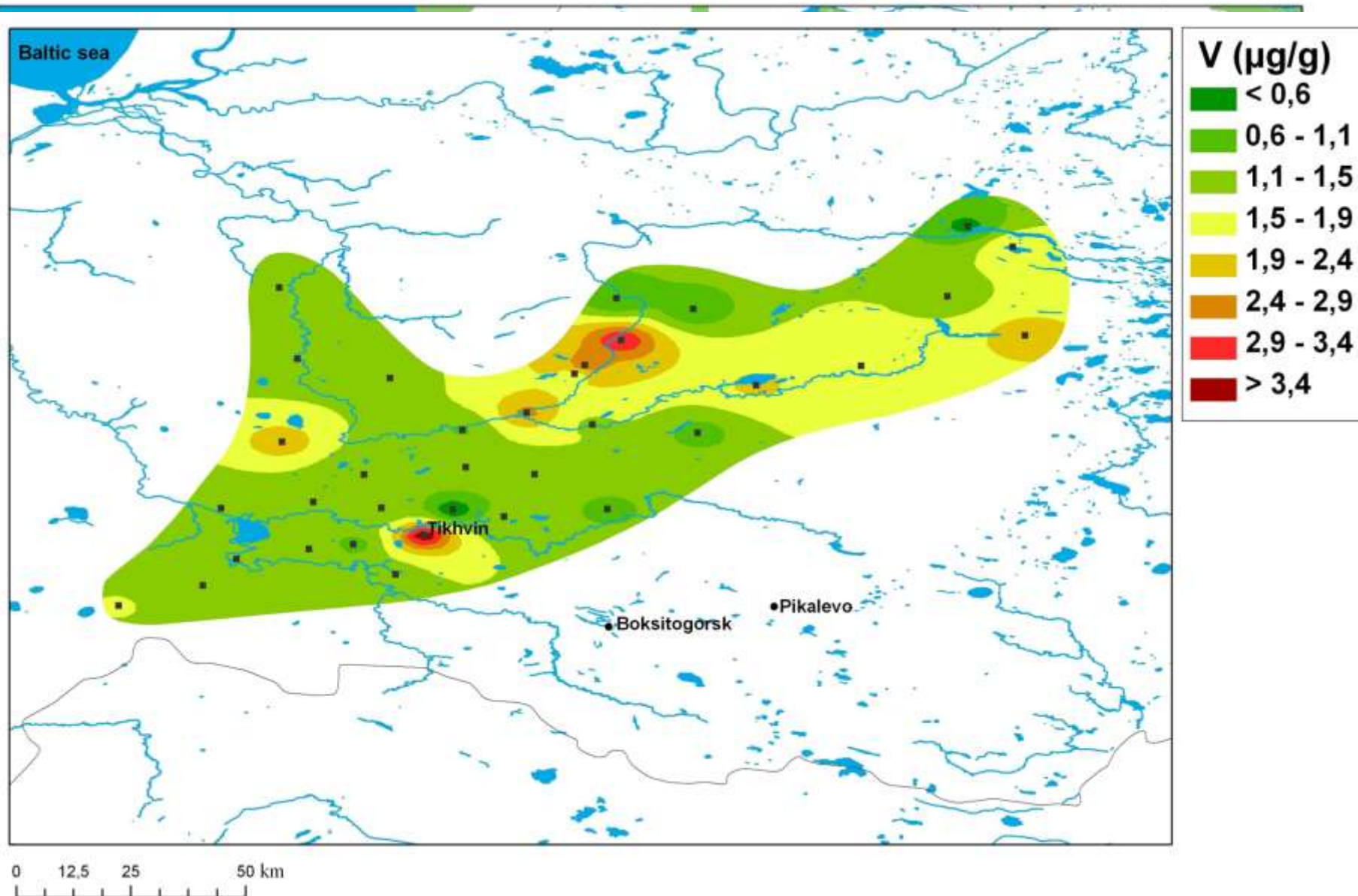
.....





Inna Vikhrova, teacher of physics,
Livceum No. 8, Tikhvin,
Leningradskaya Region

Tikhvin, Leningradskaya Region





Дата съемки: 7.5.2010

55°43'29.03" С 37°36'20.71" В Высота над уровнем моря: 133 м Высота камеры над уровнем моря: 41.08 км

Thermal Power Plant in Moscow in Ochakovo-Matveevskoe







Olga Kapturova and Alexandra Volokhova, school No. 814, Moscow



- Bulgaria



- Bulgaria



necsa
We're in your world



Atmospheric Deposition of Trace Elements in the Western Cape, South Africa, Studied with the Biomonitoring Technique, NAA, ICP-MS and GIS Technology (PhD student study)

Study on Levels of Priority Aquatic Pollutants in South African Cultivated Bivalve Mollusks ("The South African Mussel Watch"

Use of INAA to determine rare earth element contents in different fresh and weathered South African fly ash (PhD student study)

Инициативные проекты (1) "The South African Mussel Watch"



СНААПИ – Stellenbosch University

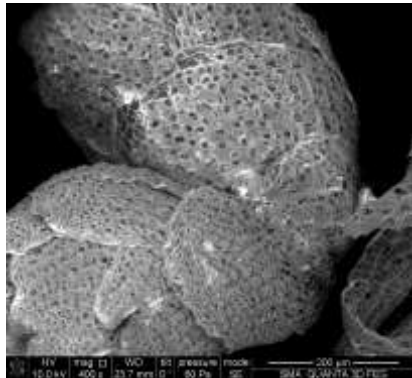


28 ноября 2012- Атлантический океан

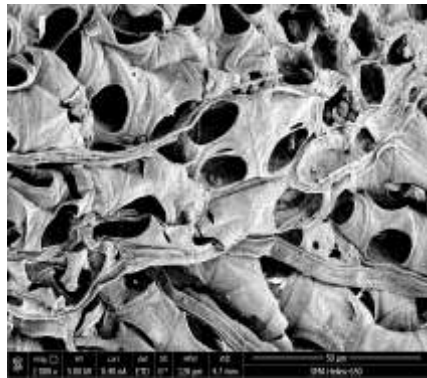


Изучение приоритетных водных поллютантов в южно-африканских культивируемых двустворчатых моллюсках

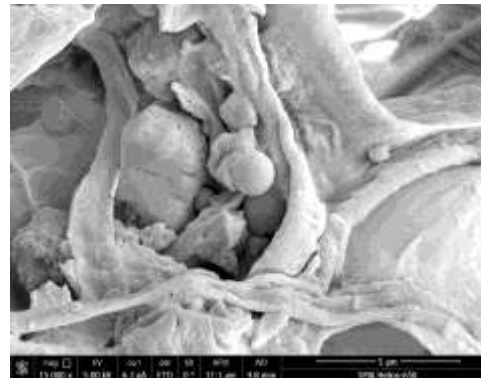
(2) Анализ космической пыли в торфяных колонках Сибири СНААПИ – Центр микроанализа в Сколково



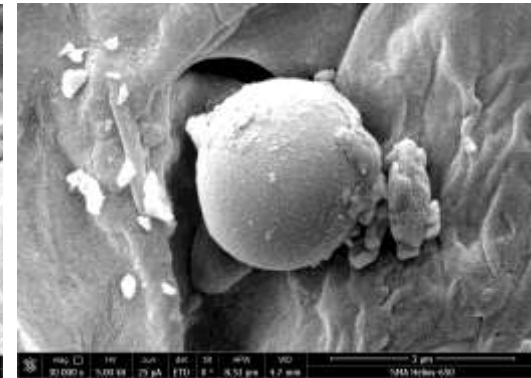
400 x



2000 x



15000 x



30000 x

НАА на реакторе ИБР-2: Na, Mg, Al, Cl, K, Ca, S, Ti, V, Cr, Mn, Fe, Ni, Co, Zn, As, Se, Br, Rb, Sr, Cs, Sb, I, Ba, La, Ce, Sm, Tb, Hf, W, Th, U + **ААС (ГИН РАН, Москва):** Pb, Cd, Ni, Cu



Most important publication

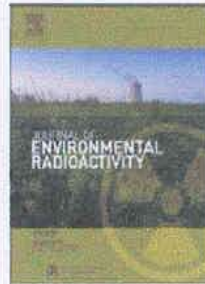
Journal of Environmental Radioactivity xxx (2012) 1–6



Contents lists available at SciVerse ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad



Distributions of ^{137}Cs and ^{210}Pb in moss collected from Belarus and Slovakia

Yu.V. Aleksiyaynak^{a,*}, M.V. Frontasyeva^a, M. Florek^b, I. Sykora^b, K. Holy^b, J. Masarik^b, L. Brestakova^b,
M. Jeskovsky^b, E. Steinnes^c, A. Faanhof^d, K.I. Ramatlhape^e


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^b Dept. of Nuclear Physics and Biophysics, Comenius University, Bratislava, Slovakia

^c Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

^d South African Nuclear Energy Corporation, Pretoria, South Africa

^e Centre of Applied Radiation Science and Technology, North-West University, (Mafikeng Campus), Mmabatho, South Africa

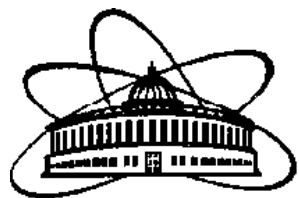


The moss technique is supposed to be used for assessing **sequences of the Fukushima disaster in the Far East** of Russia (mapping of radionuclide distribution around the city of Vladivostok).



Bionanotechnology:

**synthesis of Ag and Au nanoparticles by
blue-green alga *Spirulina platensis* and
some microbial strains**



M.V. Frontasyeva, S.S. Pavlov
*Frank Laboratory of Neutron Physics ,
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**T. Kalabegishvili, E. Kirkesali, I. Murusidze,
D. Pataraya, E.N. Ginturi**
Andronikashvili Institute of Physics, Tbilisi , Georgia



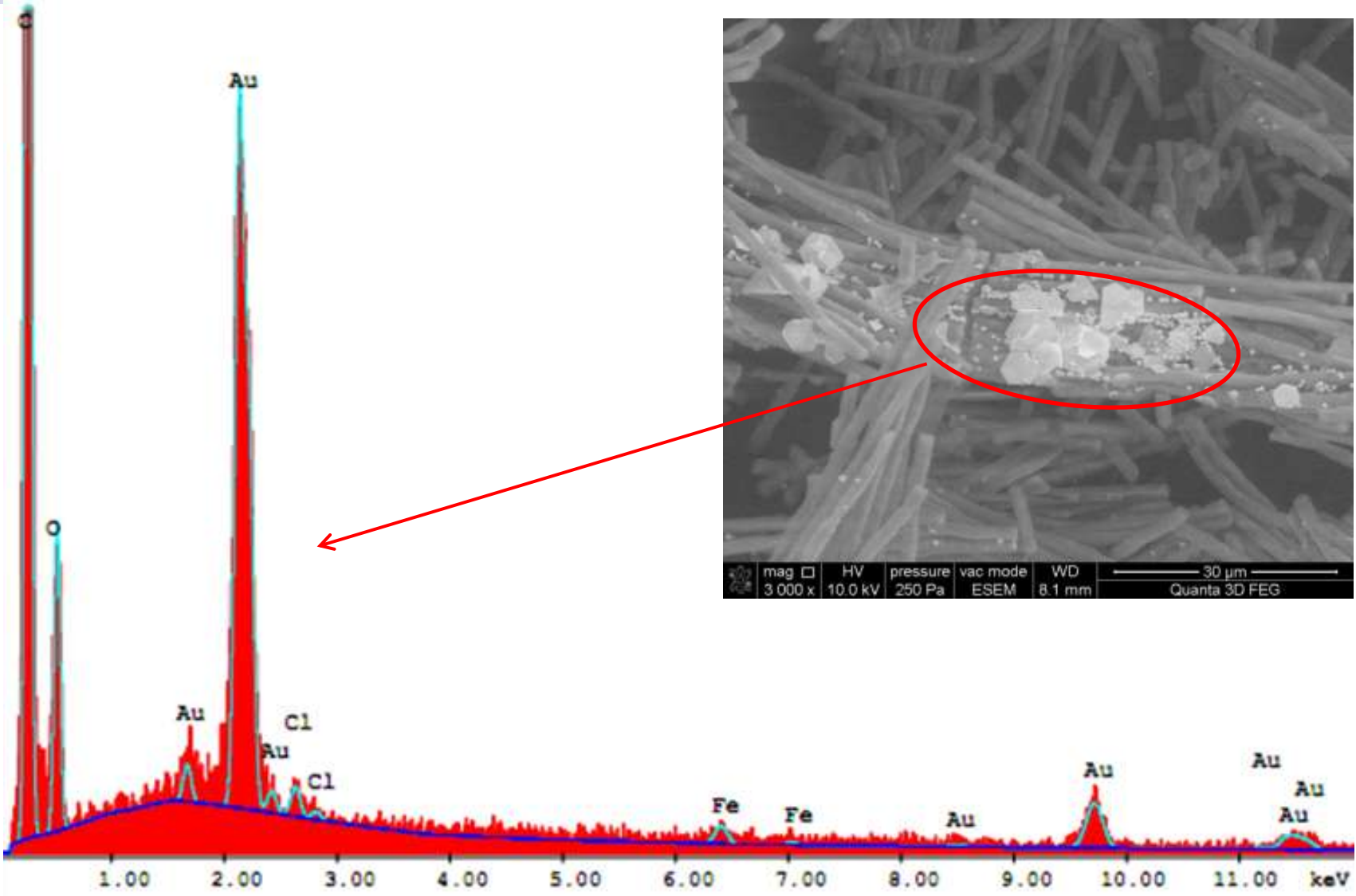
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A. Faanhof
North-West University (Mafikeng Campus), South Africa

Elemental concentration in biomass of *Streptomyces glaucus* (irradiation time 8 s)

Element	Energy, keV	Concentration, µg/g	Error, %
Ag	657.76	37	5
K	1524.58	3290	8
La	1596.21	15	14
Mn	846.75	25.0	6
Na	1368.55	381	5
Sb	564.24	1.3	15



EDAX spectrum of *Sp. platensis* cells after exposure to hydrated gold chloride solution



AMERICAN
SCIENTIFIC
PUBLISHERS

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Advanced Science,
Engineering and Medicine
Vol. 4, pp. 1–7, 2012
(www.aspbs.com/asem)

Synthesis of Gold Nanoparticles by Blue-Green Algae *Spirulina Platensis*

T. Kalabegishvili^{1,2}, E. Kirkesali¹, A. Rcheulishvili¹, E. Ginturi¹, I. Murusidze²,
N. Kuchava¹, N. Bagdavadze¹, G. Tsertsvadze³, V. Gabunia⁴, M. V. Frontasyeva^{5,*},
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⁷*Centre of Applied Radiation Science and Technology, North-West University (Mafikeng Campus),
Mafikeng, South Africa*



Synthesis of Gold Nanoparticles by Some Strains of Arthrobacter Genera

Tamaz Levan Kalabegishvili^{1,2}, Elena Ivan Kirkesali¹, Alexander Nikoloz Rcheulishvili¹, Etery Nikoloz Ginturi¹, Ivane Giorgi Murusidze², Dodo Trofim Pataraya³, Manana Amiran Gurielidze³, Giorgi Ilia Tsertsvadze⁴, Vakhtang Nikoloz Gabunia⁵, Levan Giorgi Lomidze², David Nugzar Gvarjaladze², Marina Vladimirovna Frontasyeva⁶, Sergey Sergeevich Pavlov⁶, Inga Ivanovna Zinicovscaia⁶, Marianne Janette Raven⁷, Ntsoaki Maditselana Francinah Seaga⁷ and Arnaud Faanhof⁸

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2. *Ilia State University, 3/5 K. Cholokashvili Ave., Tbilisi 0162, Georgia*

3. *Durmishidze Institute of Biochemistry and Biotechnology, Georgian Agrarian University, D. Agmashenebeli Kheivani, 10 km, 0159, Tbilisi, Georgia*

4. *P. Melikishvili Institute of Physical and Organic Chemistry, I. Javakhishvili State University, 5 Politkovskaya str., 0186 Tbilisi, Georgia*

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6. *Joint Institute for Nuclear Research, 6 Joliot-Curie Str., 1419890, Dubna, Russia*

7. *Nuclear Energy Corporation of South Africa (NECSA), Pelindaba, Pretoria, South Africa*

8. *North-West University (Mafikeng Campus), Private Bag X2046, Mmabatho, South Africa*



**Study of Cosmic Dust using
natural planchettes: peat-bog
cores from Siberia**

JINR and Adam Mickiewicz University

Barbara Fiałkiewicz-Kozieł PhD

Department of Biogeography and Paleoecology

Faculty of Geographical and Geological Sciences

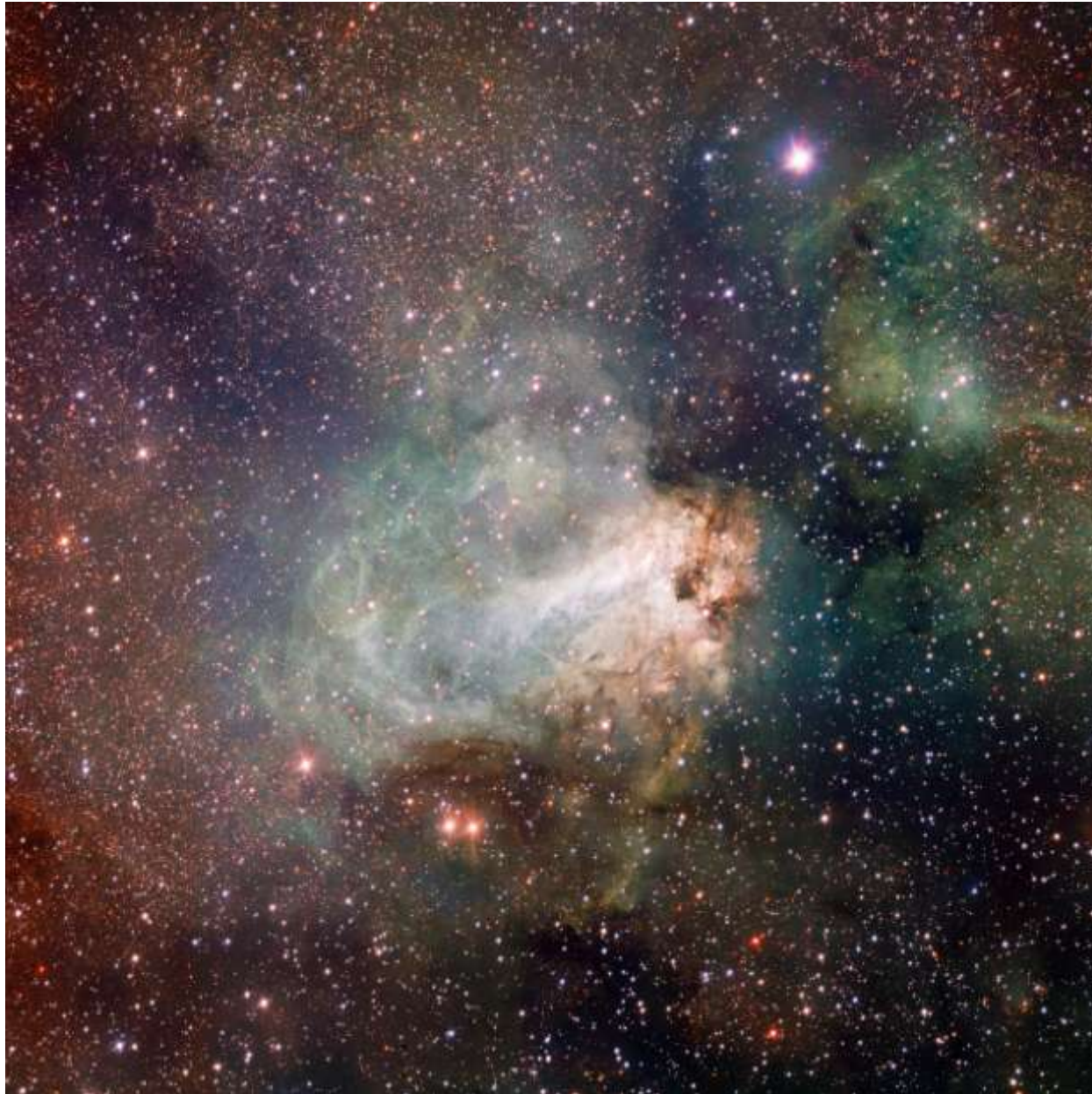
Herschel Detects Cosmic Dust From Supernova

Posted on: Friday, 8 July 2011, 07:06 CDT



ESO Releases First Images From The VLT Survey Telescope

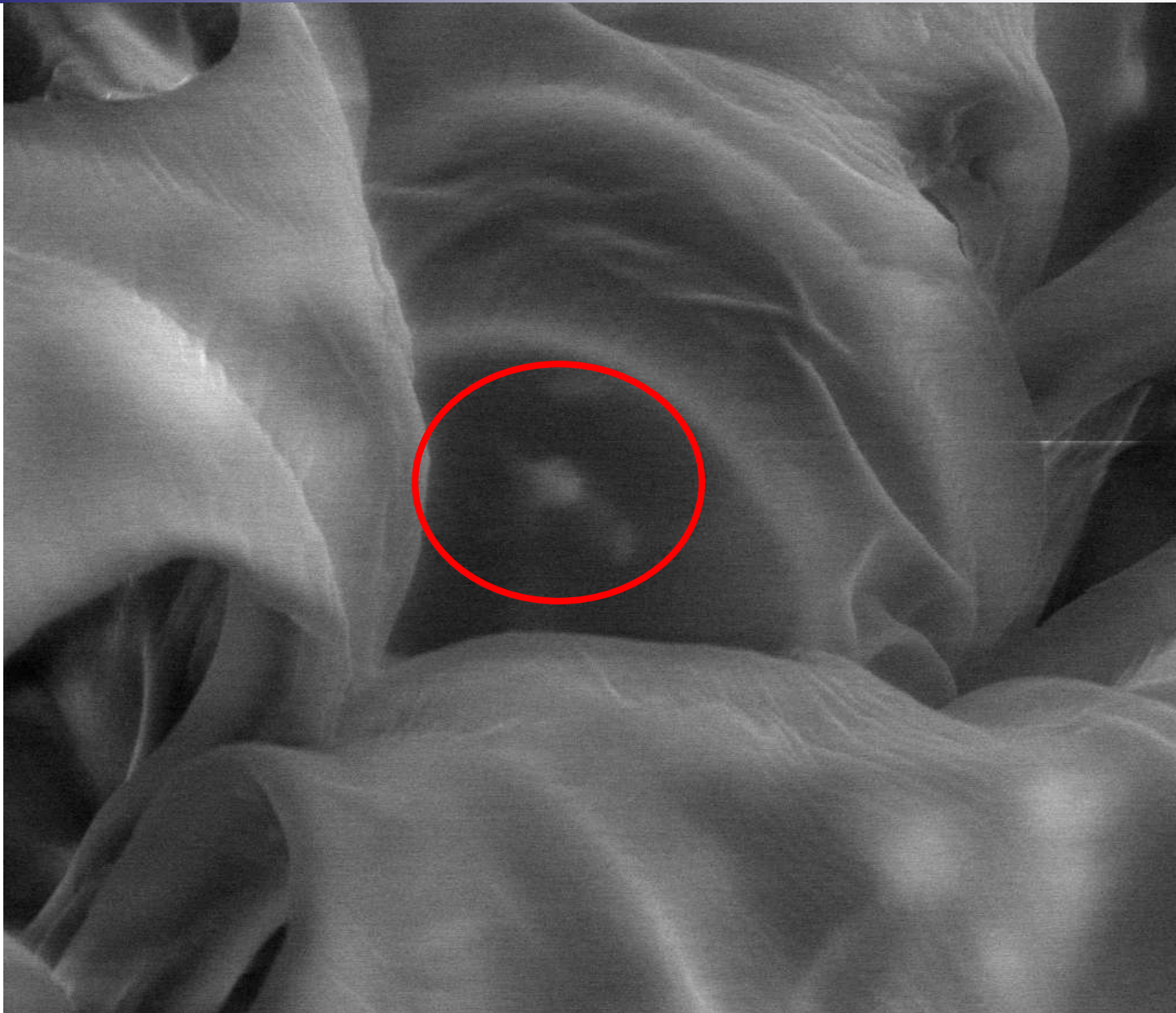
Posted on: Wednesday, 8 June 2011, 10:50 CDT | [Related Video](#)




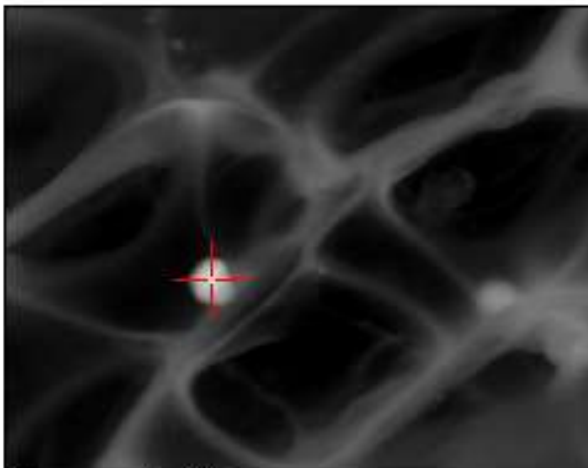
Spiral Spins Both Ways

Credit: ESA/Hubble & NASA, Posted on: Monday, 20 June 2011, 06:29 CDT



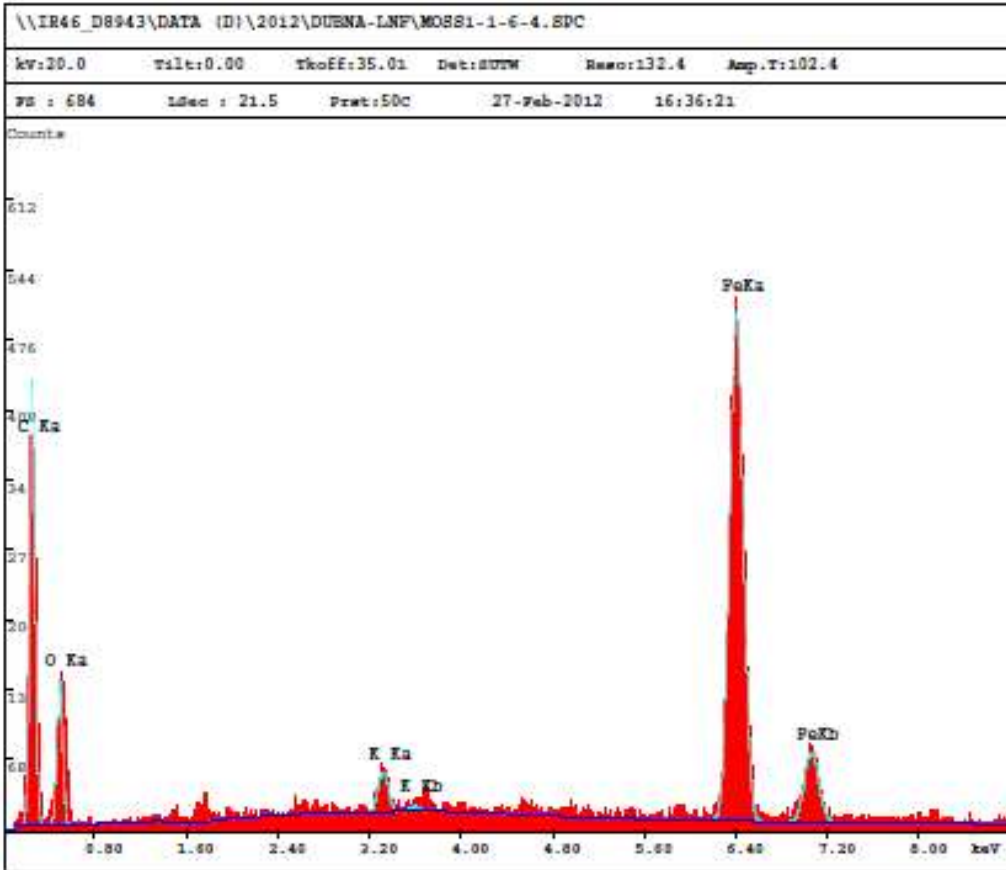


	HV 10.0 kV	mag <input type="checkbox"/> 12 000 x	WD 10.0 mm	tilt 0 °	pressure 150 Pa	mode SE	5 μm
							SMA QUANTA 3D FEG



Matrix: 1024x800
 Data Type: SE1(ADC)
 Magnification: 8569x
 Image Size: 0.0329x0.0257mm
 kV: 20.0
 Tilt: 0

SE1 12µm



JINR-SA School (September 22–October 12, 2008)



Two young specialists (**Ntsoaki Seaga** (NECSA) and **Itumeleng Ramatlhape** (NWU, Mafikeng)) and **Marja Raven** (NECSA) were trained in the Sector of NAA during the School 2008

JINR-SA School (September 22–October 12, 2011)



Dream Team





Thank you for attention!

**You are welcome to join
our collaboration!**



Проект ОИЯИ-Сербия, 2011-2013

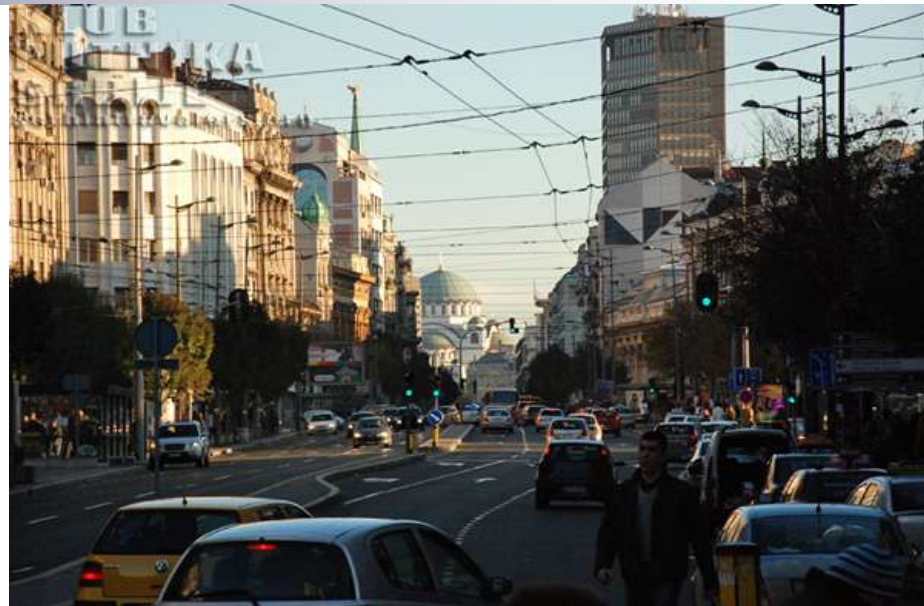
Изучение атмосферных загрязнений в уличных каньонах Белграда и Москвы

Метод мхов-трансплантов

Ленинский проспект в районе площади Гагарина

1 – 5 – 9 этажи

Белград, Сербия



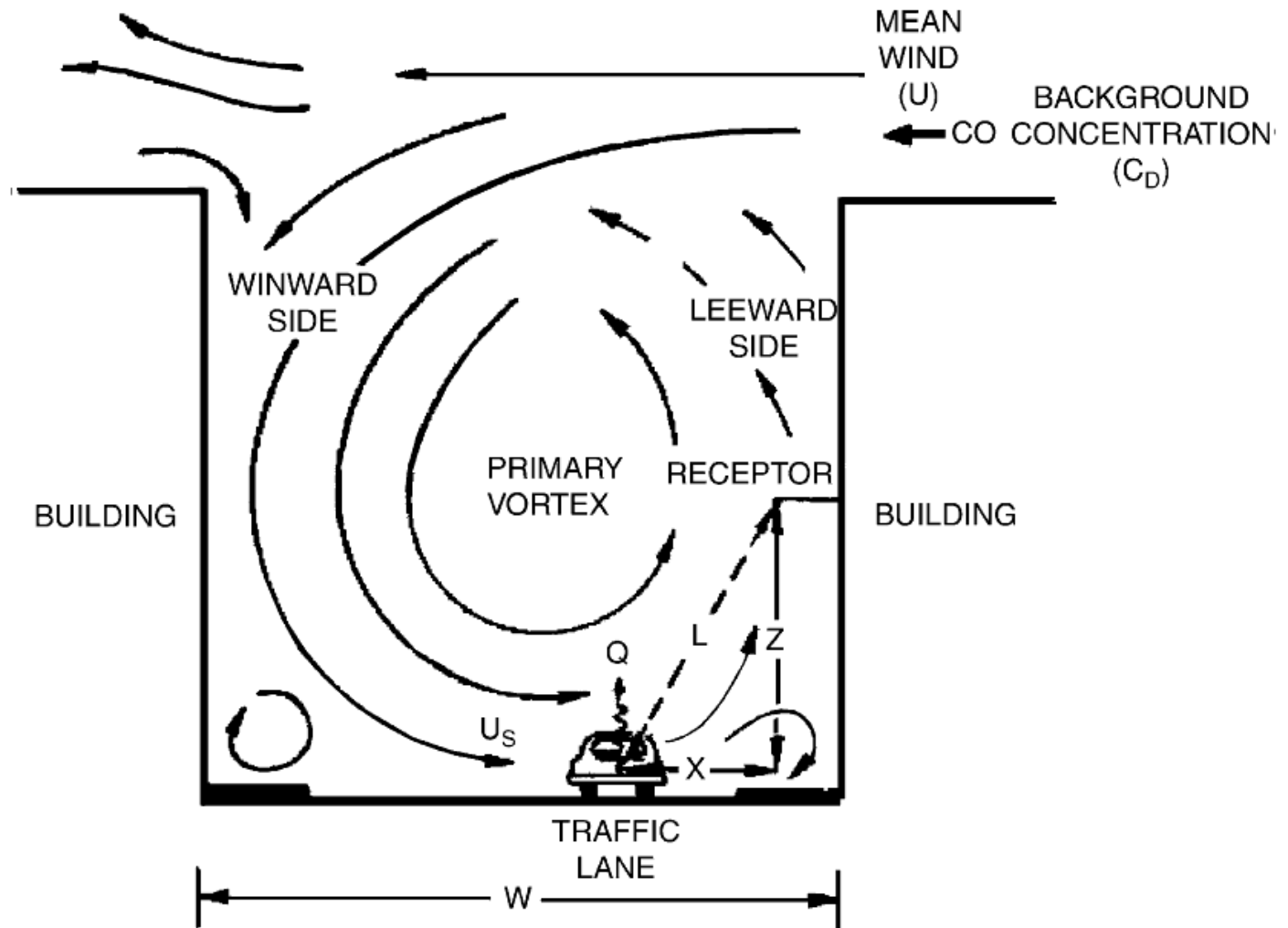


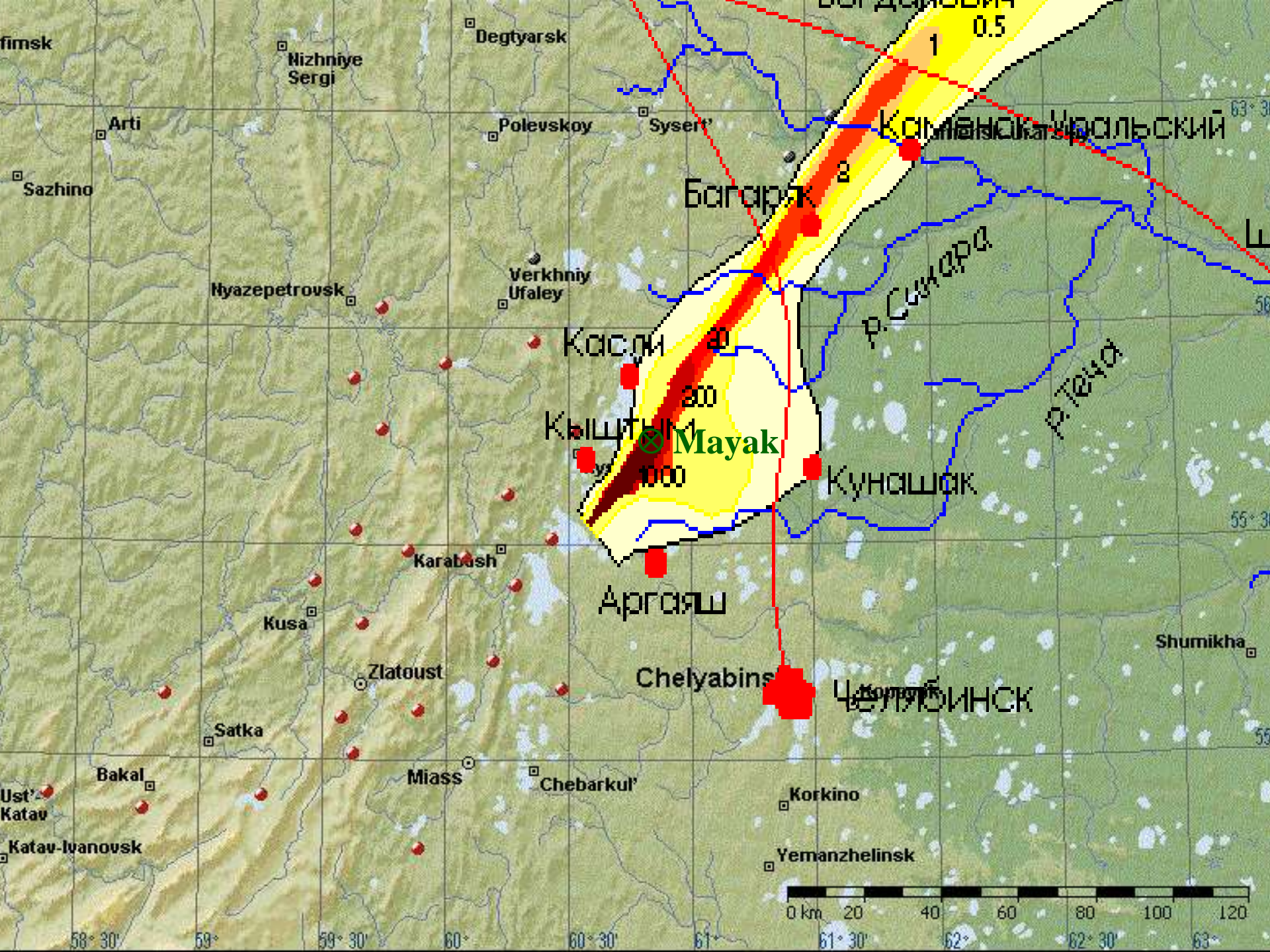
Fig. 1. Pollutant dispersion in a regular street canyon (Dabberdt et al., 1973).

Сбор образцов ...

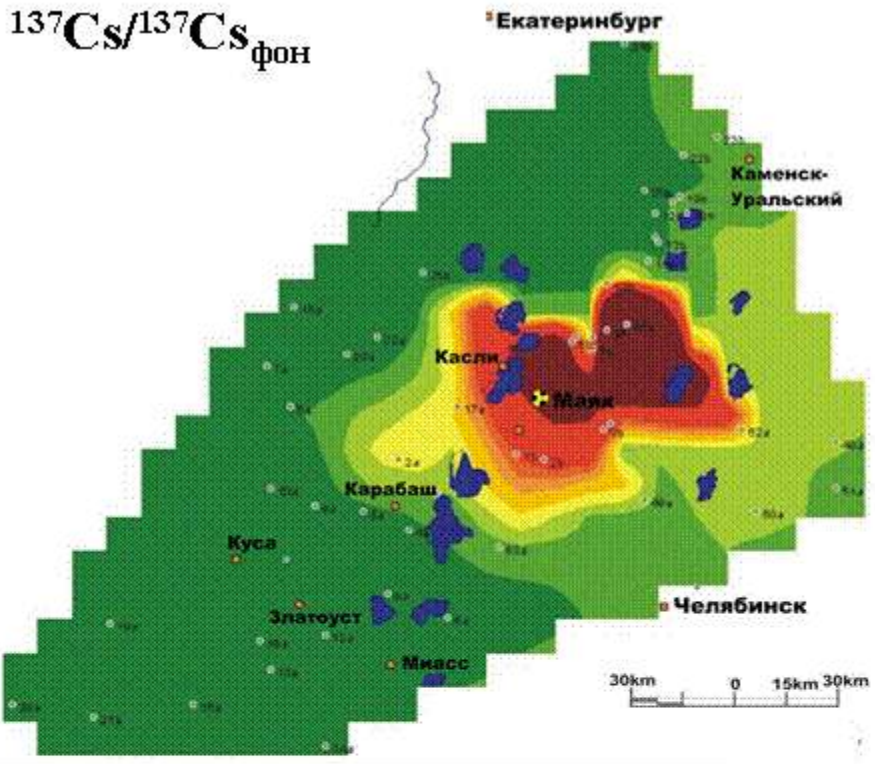
Sphagnum girgensohnii Russow

Фоновая территория – Домкинский залив Иваньковского водохранилища - 140 км к северу от Москвы





$^{137}\text{Cs}/^{137}\text{Cs}_{\text{фон}}$



- < 2.0
- 2.0 - 3.1
- 3.1 - 4.2
- 4.2 - 5.5
- 5.5 - 7.0
- 7.0 - 8.2
- 8.2 - 9.4
- 9.4 - 16
- > 16

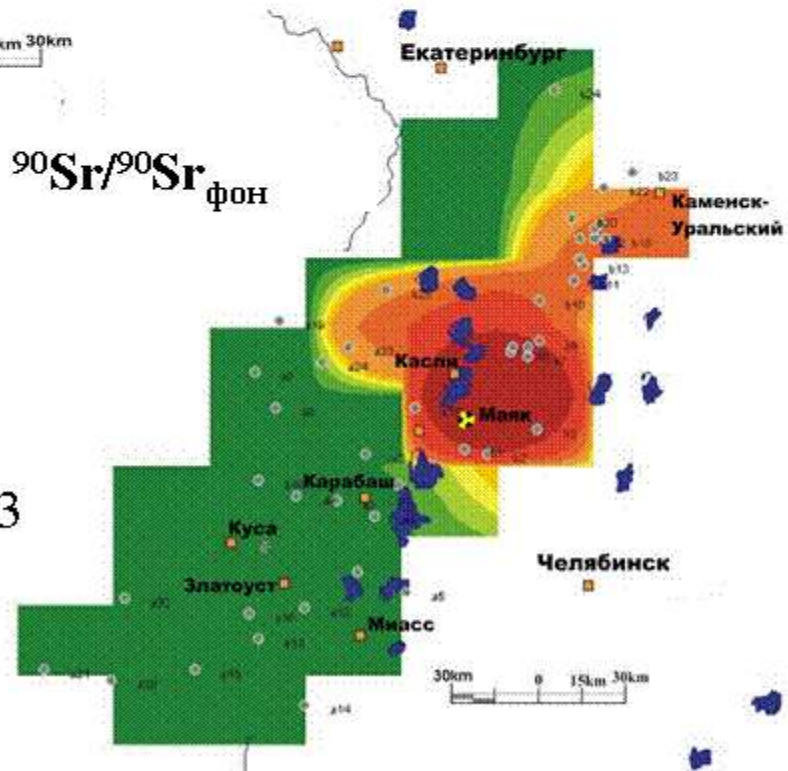
1995 (Arkog et al.) +
1998 (our sampling)

^{90}Sr local baseline value
1.6 KBq /m²

^{137}Cs local baseline value
2.56 KBq /m²

1957: Kyshtym accident: Sr/Cs= 70
1967: Karachai emissions: Sr/Cs=0.3

$^{90}\text{Sr}/^{90}\text{Sr}_{\text{фон}}$



- < 1.44
- 1.44 - 2.7
- 2.7 - 3.9
- 3.9 - 5.0
- 5.0 - 6.3
- 6.3 - 13
- 13 - 25
- 25 - 63
- > 63

Most important publication

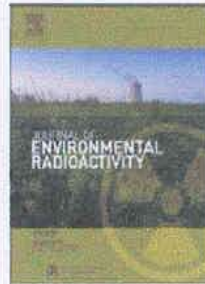
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Distributions of ^{137}Cs and ^{210}Pb in moss collected from Belarus and Slovakia

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Dream Team

