PERSPECTIVES OF NUCLEAR PHYSICS APPLICATIONS

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ATOMS FOR PEACE

the speech delivered on 8 December 1953 by president of the United States Dwight Eisenhower, United Nations General Assembly

„…The United States knows that if the fearful trend of atomic military build-up can be reversed, this greatest of destructive forces can be developed into a great boon, for the benefit of all mankind… The capability, already proved, is here today. Who can doubt that, if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, this capability would rapidly be transformed into universal, efficient and economic usage?...”

Atoms for Peace programs initiated creation of the International Atomic Energy Agency and EURATOM (both in 1957), as well as organization of two international conferences on the peaceful uses of atomic energy, in Geneva, Switzerland, in 1955, and again in 1958. A total of 1,428 delegates from 73 nations participated in the first conference, and 1,067 scientific and technical papers were submitted for discussion. The 1958 conference was even larger than the first "peaceful uses" conference, with approximately twice as many delegates, technical papers, and exhibits.

„Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine and other peaceful activities. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world…."

Nuclear energy „will provide electricity too cheap to meter" (L.L.Srauss, Chairman of the US Atomic Energy Commission, 1954)

Stagg Field Stadium, site of the first controlled nuclear reaction

"On December 2, 1942, man achieved here the first self-sustaining chain reaction and thereby initiated the controlled release of nuclear energy."

20 December 1949 – Idaho Falls, USA, the first nuclear reactor (EBR I) producing electric energy

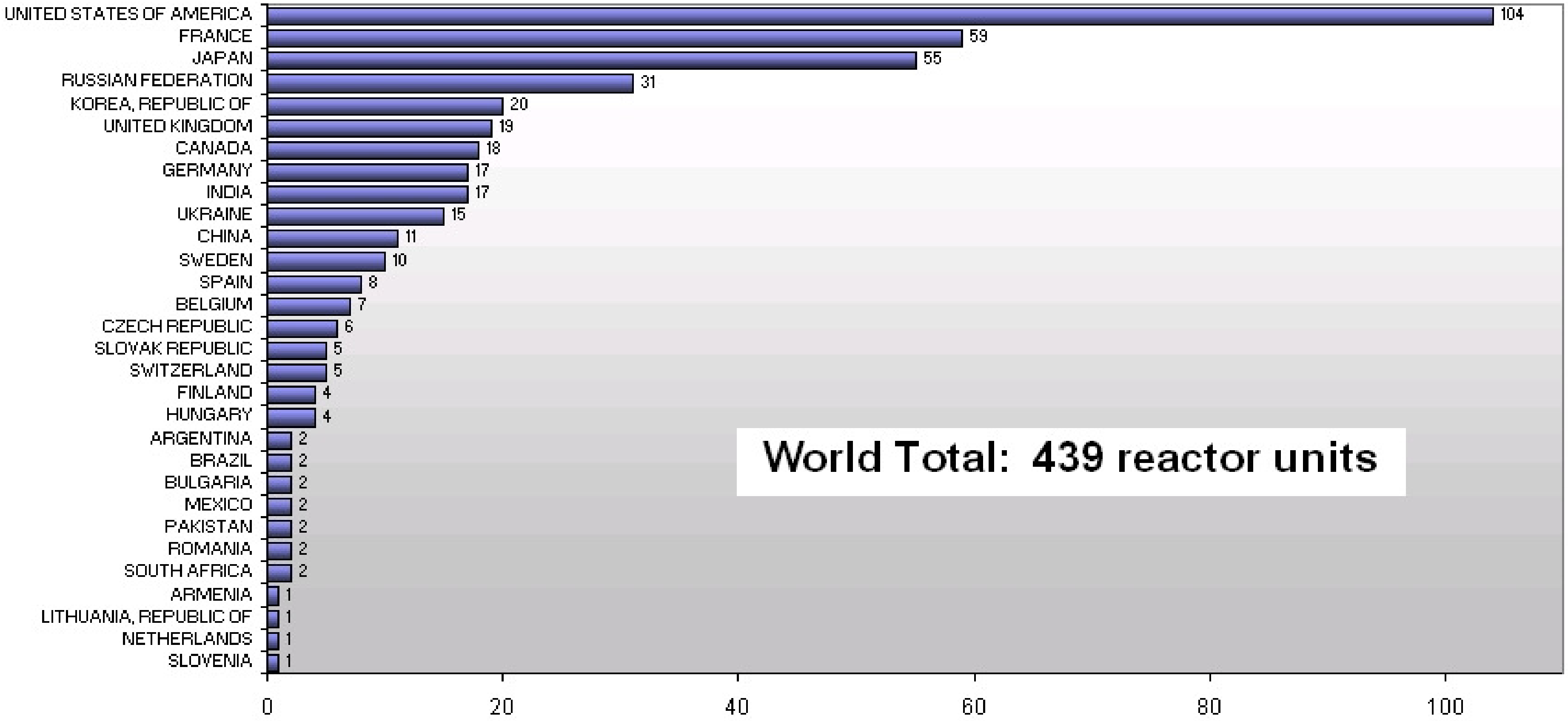
1954 – Obninsk, USSR, the first experimental nuclear power plant (5 MWe)

1955 – the first nuclear submarine (Nautilius, USA)

1956 – Calder Hall, Great Britain, the first industrial nuclear power plant with GCGR type reactor, 50 MWe.

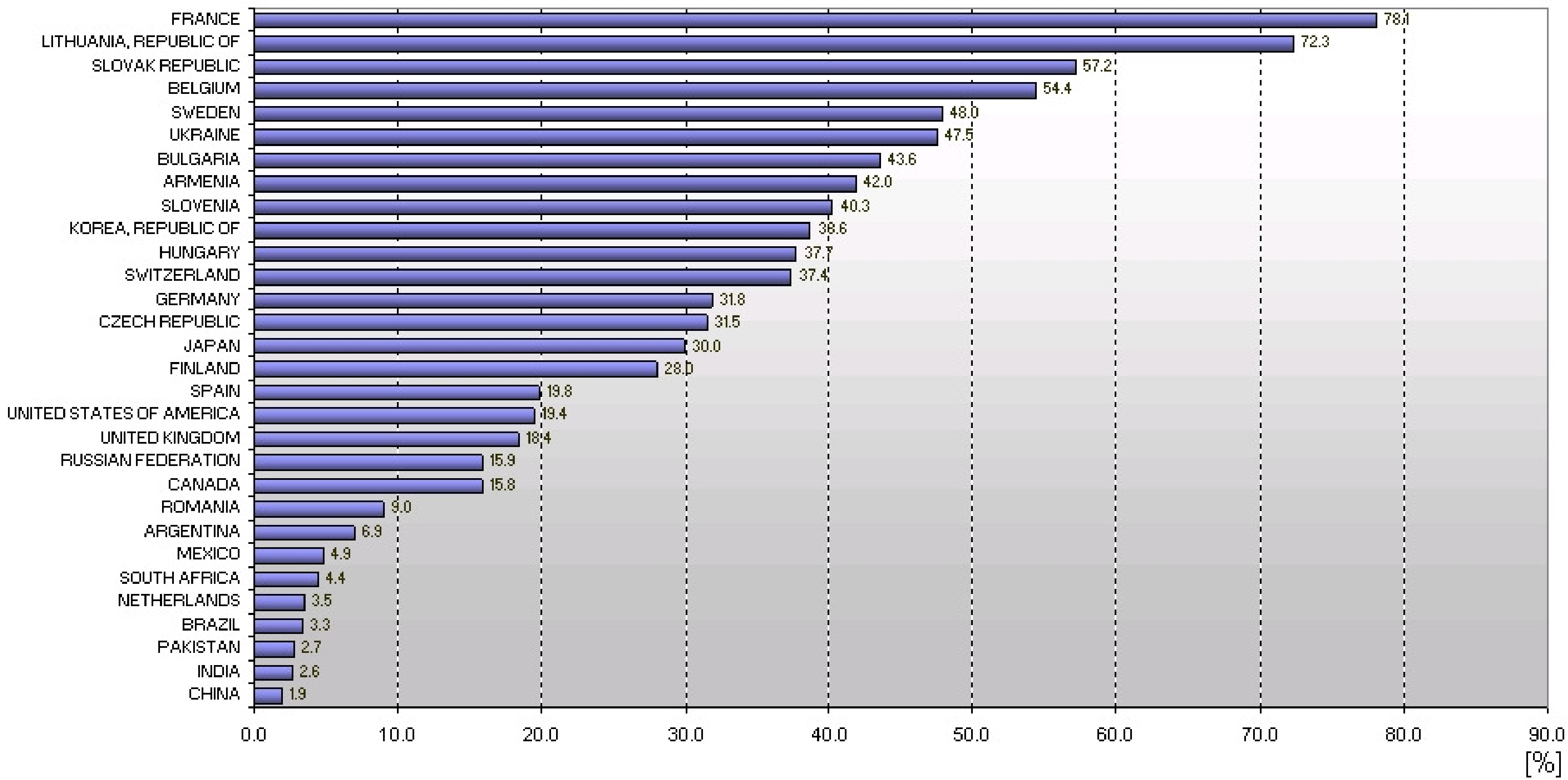
Number of Reactors in Operation Worldwide

(as of 8 of August 2007)



Note:Long-term shutdown units (5) are not counted

Nuclear Share in Electricity Generation in 2006



in 2007

the following reactors were connected to the grid:

Kaiga 3 (202 MW(e), PHWR, India) – (11 April)

Tianwan 2 (1000 MW(e), PWR – WWER, China) – (14 May)

Cernavoda 2 (655 MW(e), PHWR-CANDU, Romania) – (7 August)

Browns Ferry 1 (1065 MW(e), PWR, USA) – (2 June) (restart after a long term shutdown)

in 2007

construction of the following reactors was initiated :

Qinshan II-4 (610 MW(e), PWR, China)- (28 January)

Severodvinsk – Akademik Lomonosov 1 & 2 (2x30 MW(e), PWR-KLT40, Russia)- (15 April)

Shin Kori 2 (960 MW(e), PWR, Rep.of Korea)-(5 June)

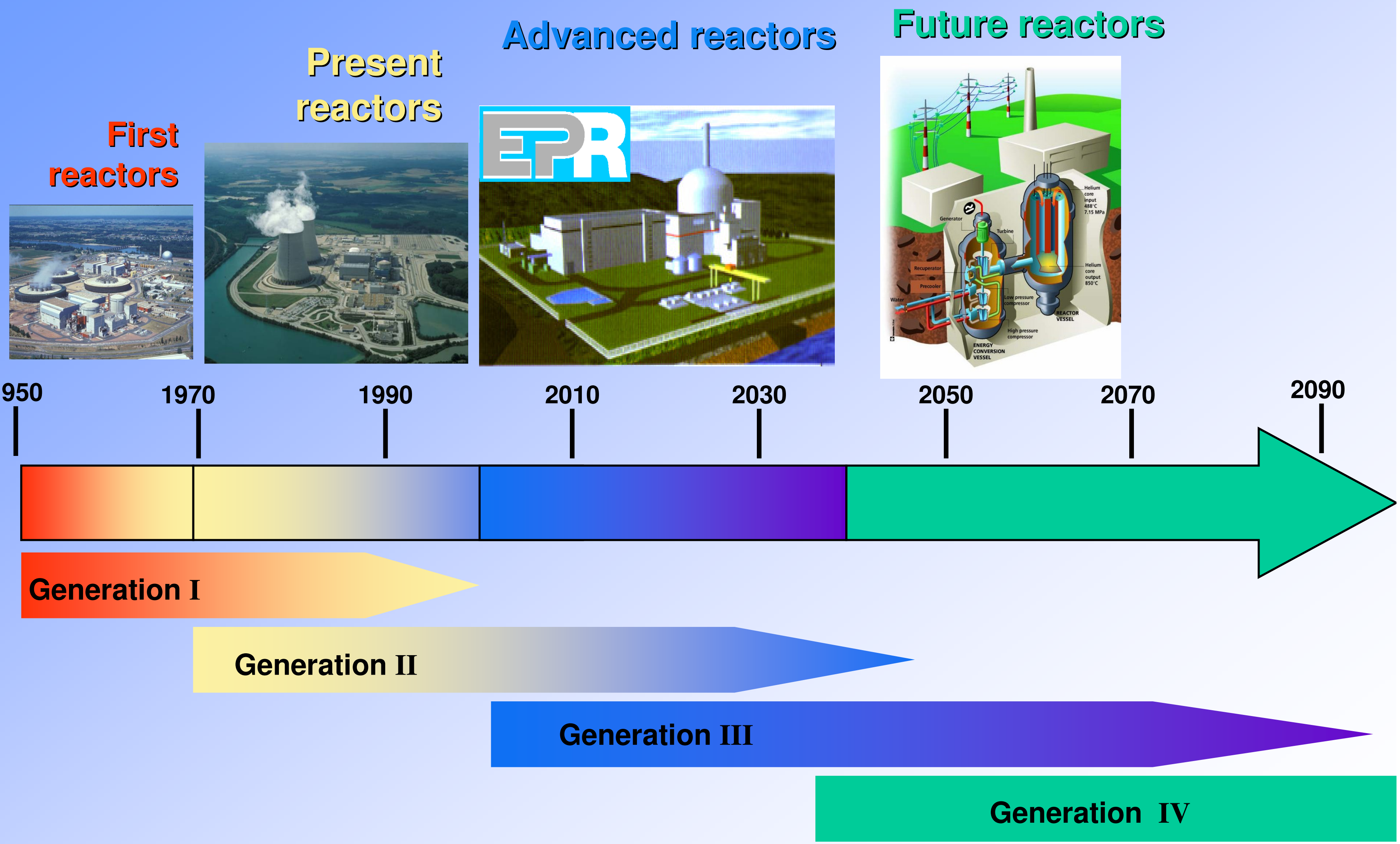
Hongyanhe 1 (1000 MW(e), PWR, China)-(18 August)

NUCLEAR POWER STATION in Olkiluoto (Finland)

The OECD International Energy Agency reports that if current consumption trends continue, we will see a 53% increase in global energy consumption by 2030 (70% in developing countries)

„the increased use of nuclear power would help to meet the increase in energy demand, enhance the security of energy supplies and mitigate carbon emissions" (Director General of the International Atomic Energy Agency dr. M. ElBaradei)

EVOLUTION OF NUCLEAR POWER REACTORS



*Years of Uranium Availabilty for Nuclear Power**

Reactor/fuel cycle	*identified conventional resources*	*total conventional resources*	*total conventional and unconventional resources*
Current once-through fuel cycle with light water reactors	*85*	*270*	*675*
Pure fast reactor fuel cycle with recycling	*5000-6000*	*16000 – 19 000*	*40 000 – 47 000*

**/ at 2004 generation electricity level; source: NUCLEAR TECHNOLOGY REVIEW 2007, IAEA, Vienna 2007.*

Survival of mankind may depend on a further development of nucler energy– safe to produce, safe to use, taking into account security, reliability, dependability, flexibility, sustainability, economic efficiency, environment degradation, intergenerational equity, accessibility, affordability.

But it also means

- mandatory and universal international system of safequards and safety inspection

- global solution for safe and secure management of spent nuclear fuel and radioactive waste.

Negotiations on the Nuclear Non-Proliferation Treaty were completed in 1968. In this photo from July 1 of that year, U.S. Ambassador Llewellyn E. Thompson, left, signs the treaty in Moscow with Soviet Foreign Minister Andrei A. Gromyko. Among U.S. embassy and Soviet government officials witnessing the ceremony is Soviet Premier Alexei N. Kosygin, standing third from right.

At the Kremlin on May 24, 2002, President George W. Bush and Russian President Vladimir Putin signed the Moscow Treaty, which will reduce the number of strategic warheads operationally deployed by the U.S. and Russia to 1700-2200.

Standing in a cornfield near Holden, Missouri, on October 28,1995, U.S. Secretary of Defense William Perry, left, and Russian Minister of Defense Pavel Grachev watch a cloud of smoke rise after they pushed a detonation button setting off an implosion that destroyed an underground Minuteman 11 missile silo. The event symbolized the ending of the Cold War.

An excavator with giant scissors attached cuts off the nose of a Tu-160 strategic bomber at a Ukraine airbase on 2 February 2001. Elimination of the last Tu-160 was carried out under terms of the U.S.-Ukrainian Cooperative Threat Reduction Program.

NON-POWER APPLICATIONS

OF NUCLEAR PHYSICS?

NUCLEAR TECHNIQUES in tumor identification and therapy:

- ***diagnosis - e.g positron emission tomography (PET/CT) and nucler magnetic resonance imaging (MRI)***
- ***radiotherapy - in France 360 radiotherapeutic units with 1800 accelerators and 29 cobalt sources,***
- ***brachytherapy***
- ***nuclear medicine***
- ***new methods – new isotopes, hadron therapy…***

SOME OTHER NON-POWER (non-medical) NUCLER APPLICATIONS:

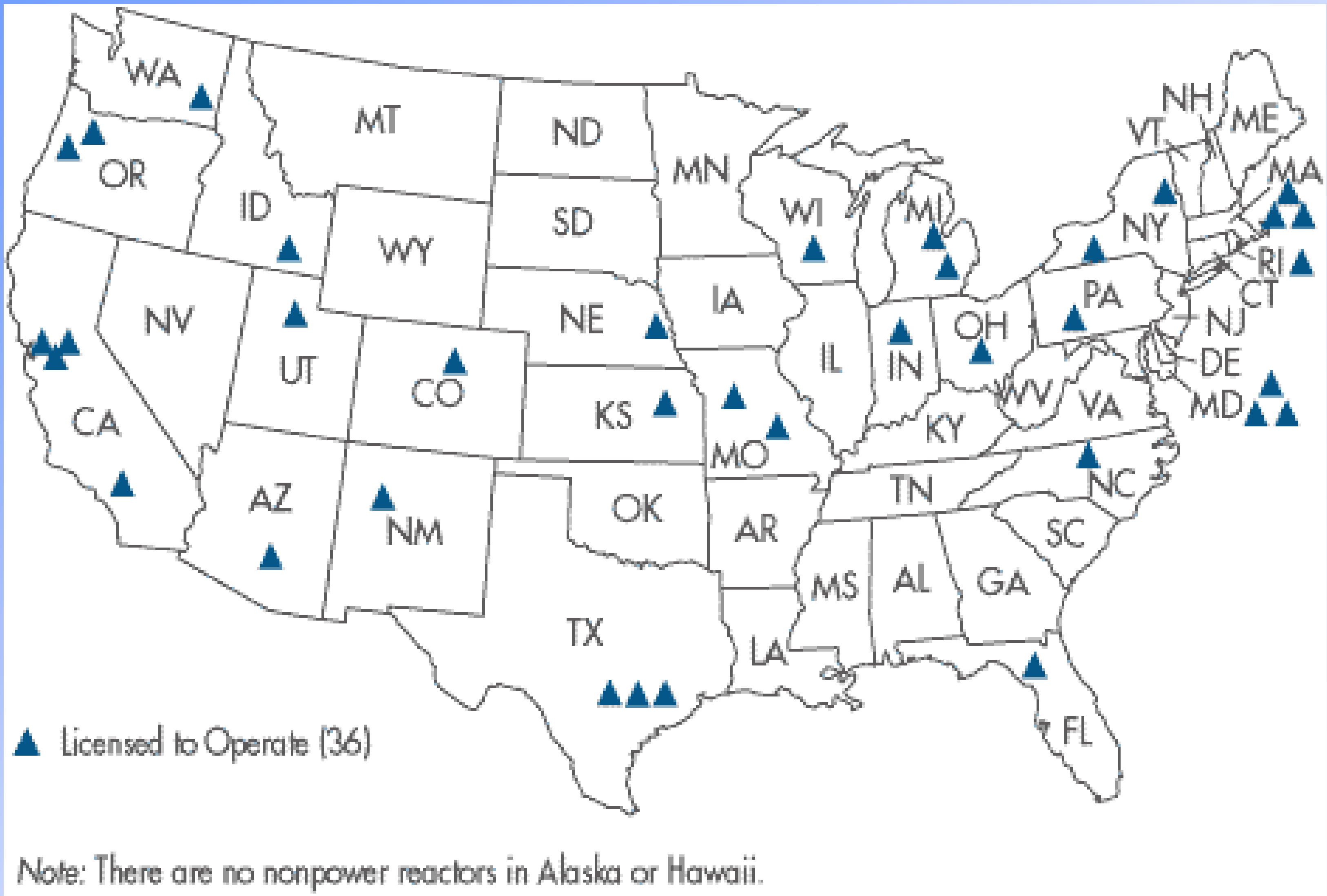
- ***non-power nuclear reactors** (research, production of radioisotopes)*
- ***accelerators** (research, production of radioisotopes, industrial irradiations - grafting of polymers, induced mutation, insect sterilization, sterilization of medical stuff, food irradiation etc)*
- ***isotope techniques: in marine and terrestrial environment protection** (localization and elimination of toxic metals etc), **in water management and climate studies, in agriculture** (improvement of water use efficiency in agriculture, nutritional interventions), **in various branches of industry, in geophysics***

*Research reactors in the world:**

operational	*245*
shut down	*242*
decommissioned	*170*
under construction	*10*
planned	*4*
Total	*671*

**/ source: NUCLEAR TECHNOLOGY REVIEW 2007, IAEA, Vienna 2007.*

NUCLEAR NON-POWER REACTORS IN THE UNITED STATES



Proceedings of the Second United Nations International Conference on the Peaceful Uses of *Atomic* Energy

Held in Geneva 1 September -13 September 1958

UNITED NATIONS
Geneva 1958

Volume 14 Nuclear Physics and Instrumentation

SOME OF THE GENEVA'58 CONFERENCE PAPERS:

P/2390 USA

- **The Atomic Triad—Reactors, Radioisotopes and Radiation**
  *By Wiliard F. Libby **

P/1465 UK

- **Photomultiplier Tubes and Scintillation Counters**
  *By J. Sharpe and E. E. Thomson**

P/675 USA

- **Measurements of the Energies and Widths of Certain Narrow Resonances**
  *By R. O. Bondelid and C A. Kennedy**

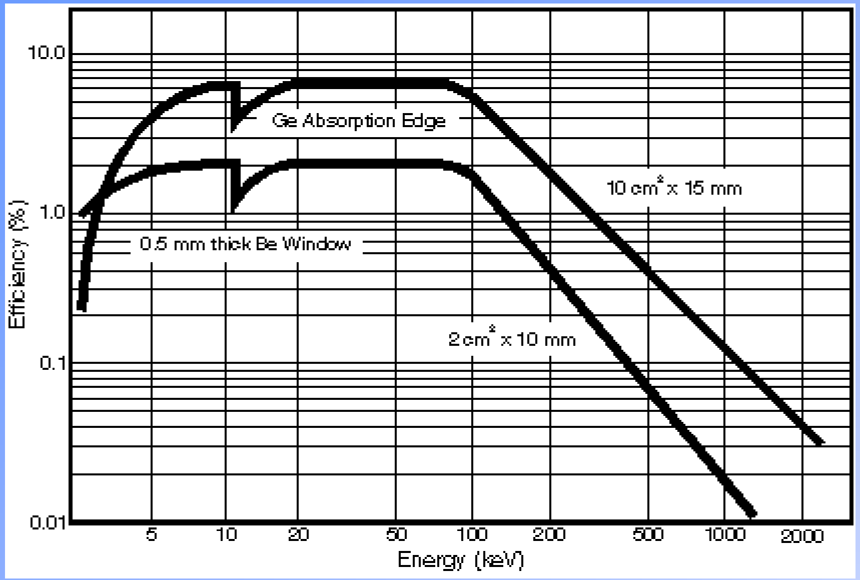
P/1591 Poland

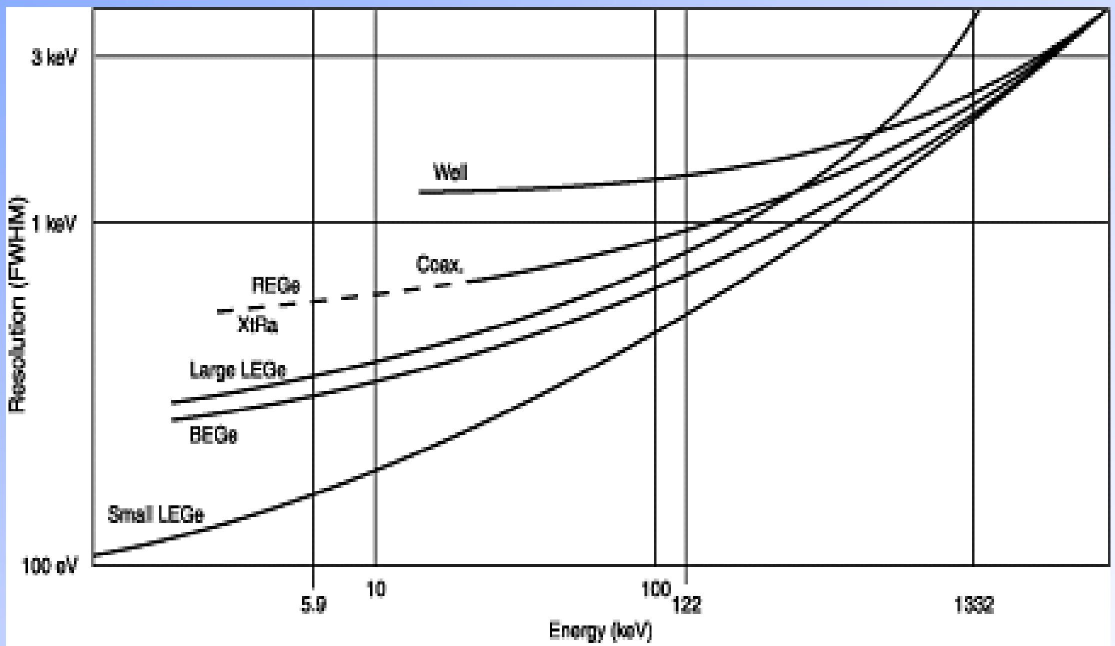
- **Radioactive Well-logging in Horizontal Bore-holes in Prospecting for Potassium Salts***
  By J. Czubek, B. Dziunikowski, L. Jurkiewicz, J. Krzuk, J. Niewodniczanski, T. Owsiak, K. Przewłocki and A. Zuber

Since 1958 most of the subjects have moved from research to commercial applications, some of them becoming routinely used in various branches

(methods, procedures, devices etc. - usually not published, sometimes patented, advertised in the professional journals)

e.g. detectors:





In the USA

income from non-power nuclear industrial applications is about 3 times higher than income from electricity production in nuclear power stations (103 reactors, 98446 MWe capacity)

NUCLEAR GEOPHYSICS?

Logging in boreholes, surface or „face analysis" in exploration or avaluation of deposits of:

oil

gas

<u>coal</u>

metals

uranium

water aquifers

e.g. coal:

determination of coal seams due to low natural radioactivity

Table 1. Concentrations of determined radioactive elements in carboniferous rocks of the Upper Silesia Coal Basin

Type of rock No. of samples	K wt% Min.	K wt% Mean	K wt% Max.	Th wt% Min.	Th wt% Mean	Th wt% Max.	U ppm Min.	U ppm Mean	U ppm Max.
Coal 193	<0.02	0.23	0.68	0.14	1.97	8.67	0.31	4.32	18.66
Shale 130	0.46	1.80	2.69	2.88	8.45	12.90	3.06	14.94	31.87
Mudstone 52	1.38	1.93	2.13	8.06	9.83	11.49	15.07	17.06	17.71
Sandstone 14	1.02	1.10	1.26	3.24	4.07	4.91	3.06	5.31	7.24

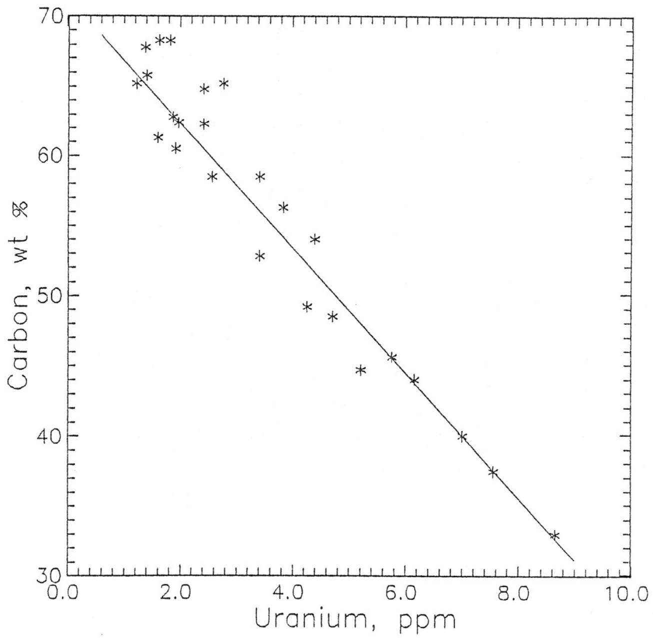
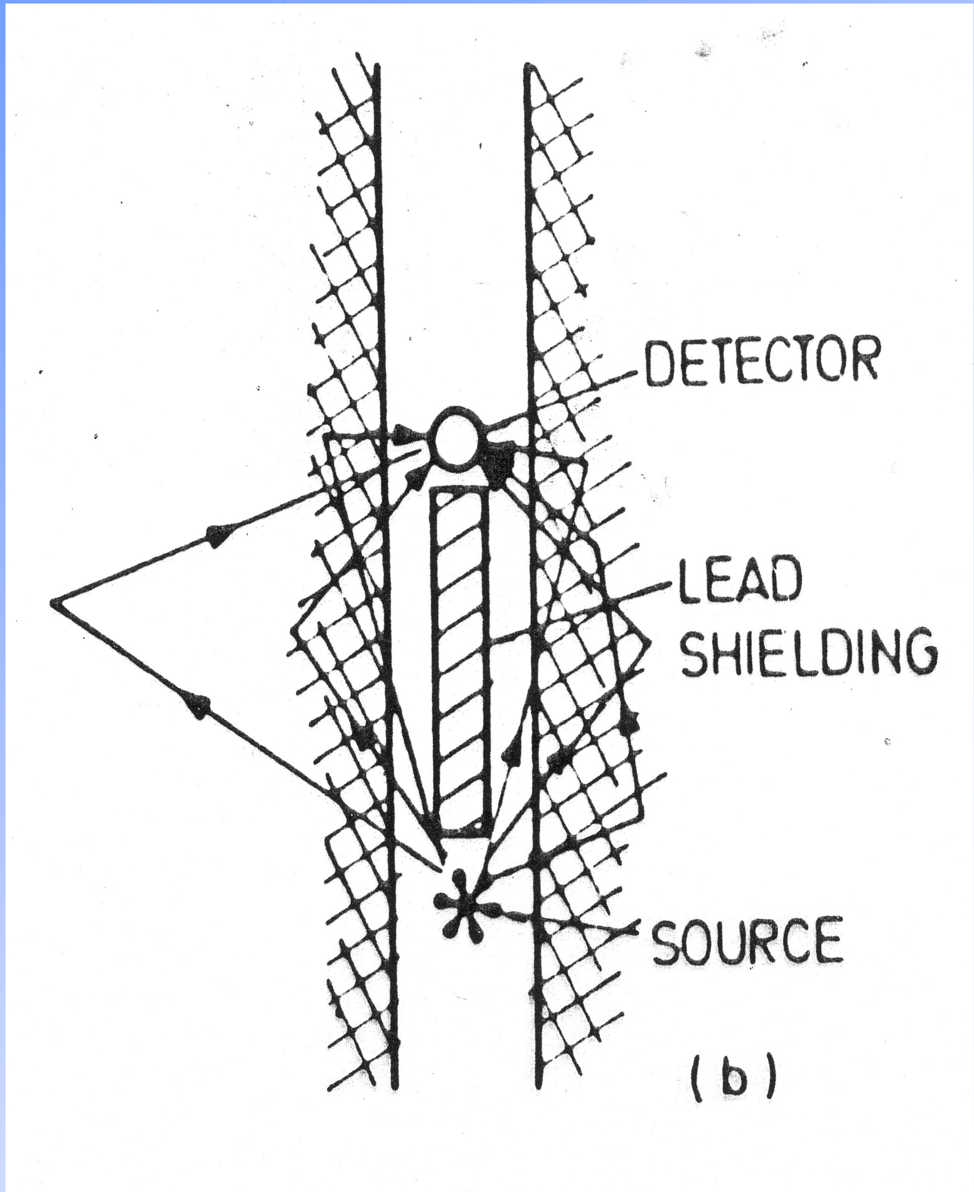


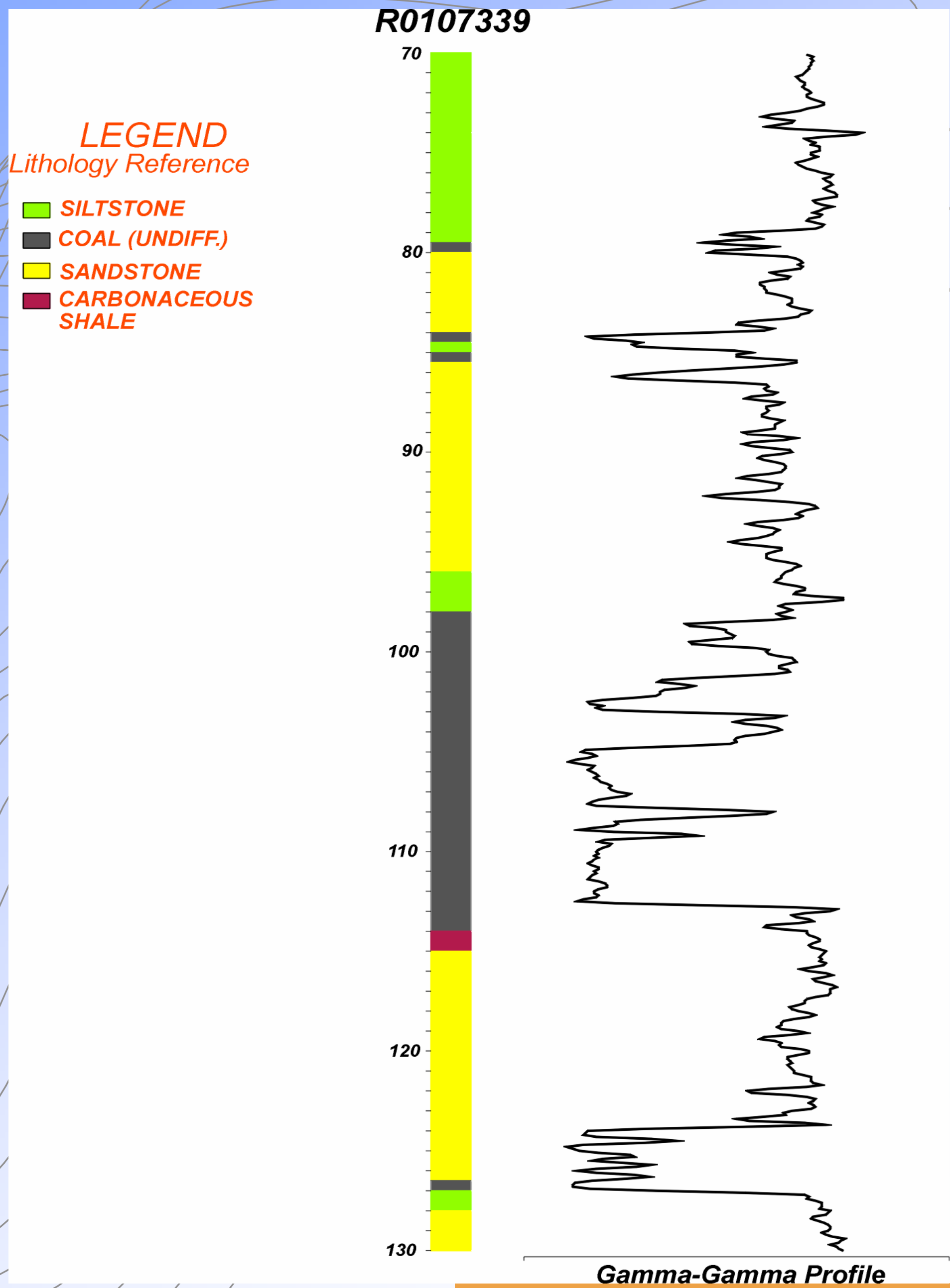
Fig. 1. Comparison of carbon content and uranium concentration in Upper Silesian coal.

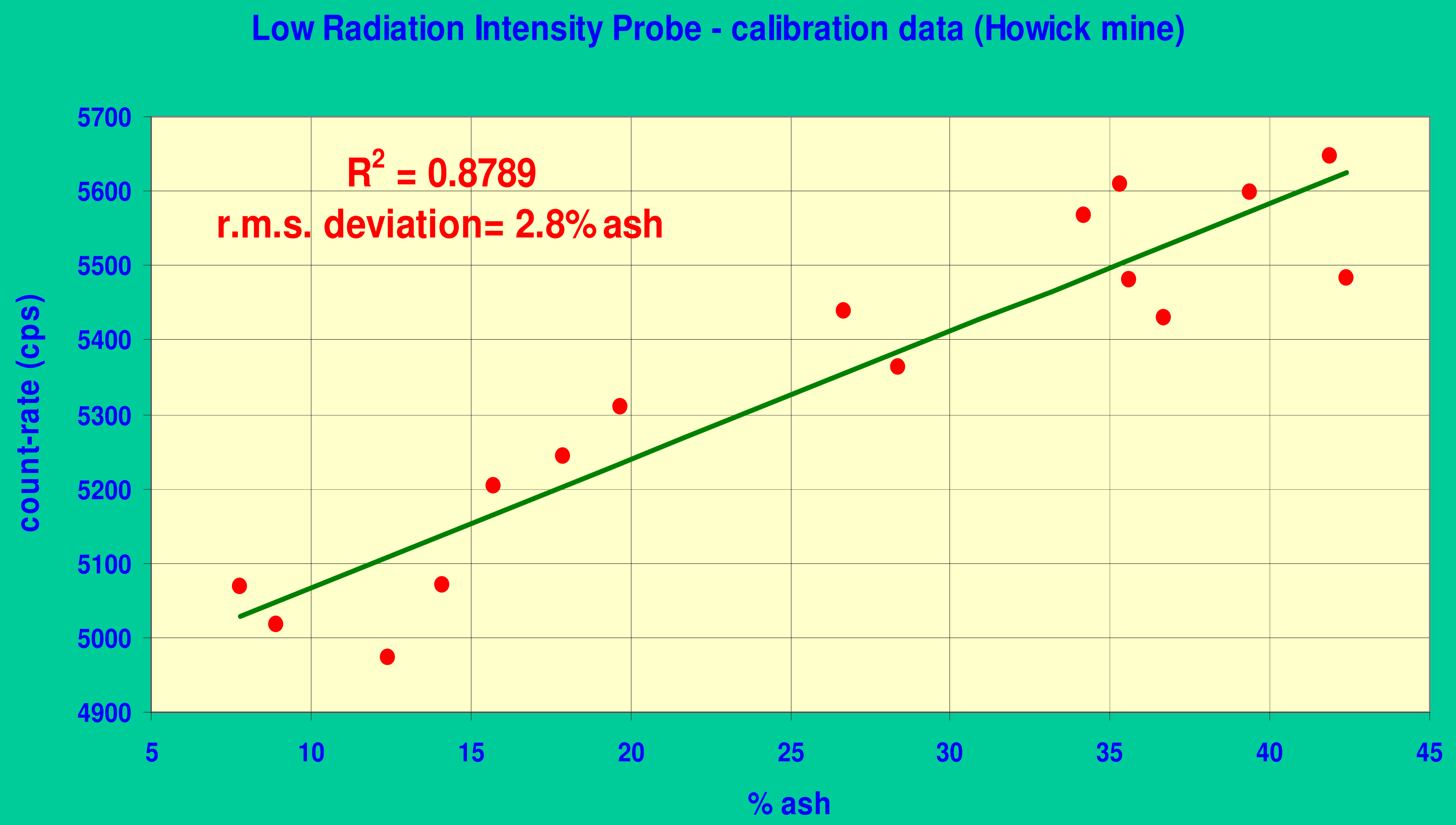
determination of coal seams and ash in coal through density determination



Gamma-gamma logging

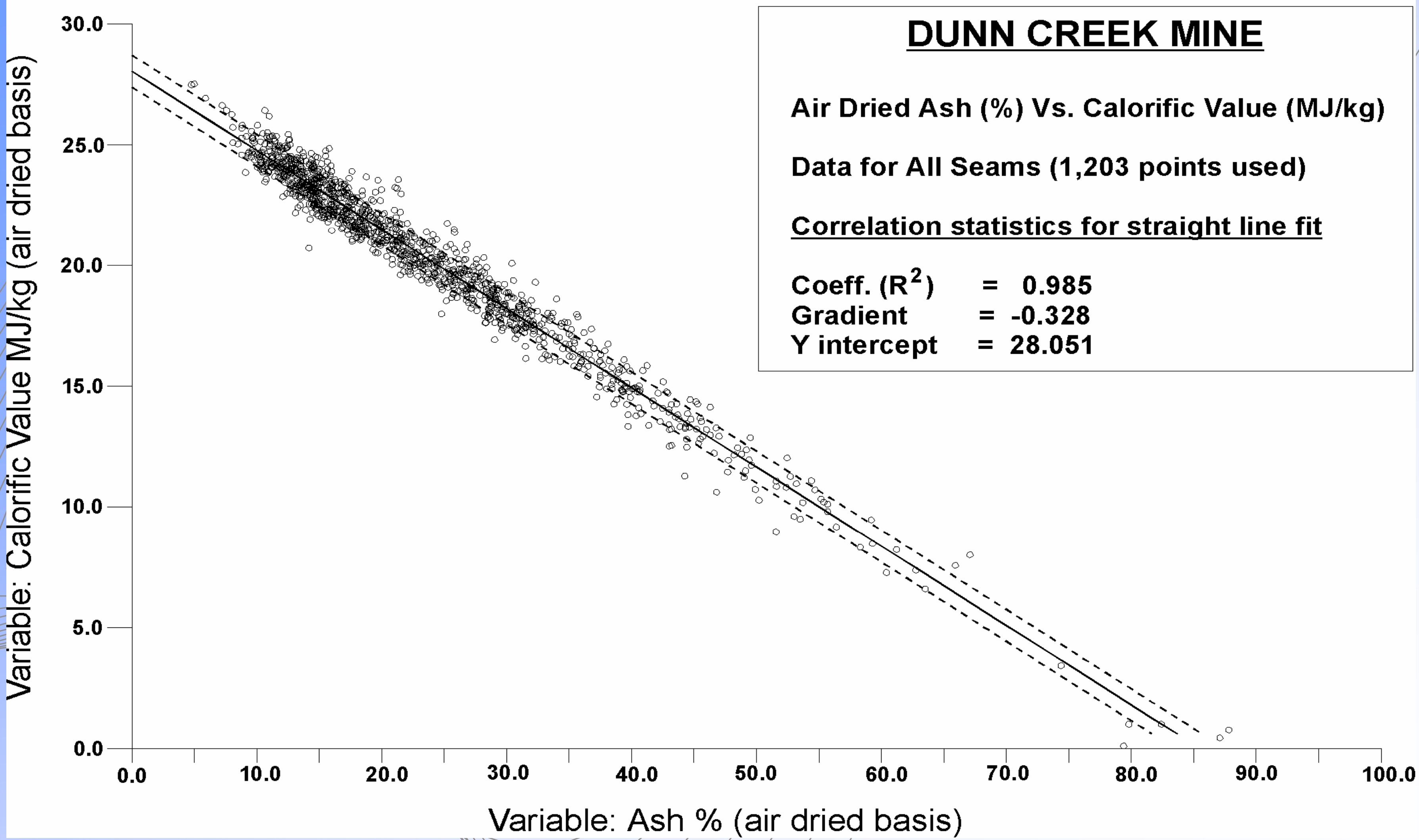
Geological & Geophysical (gamma-gamma logging) profiles of an exploration (rotary chipped) hole





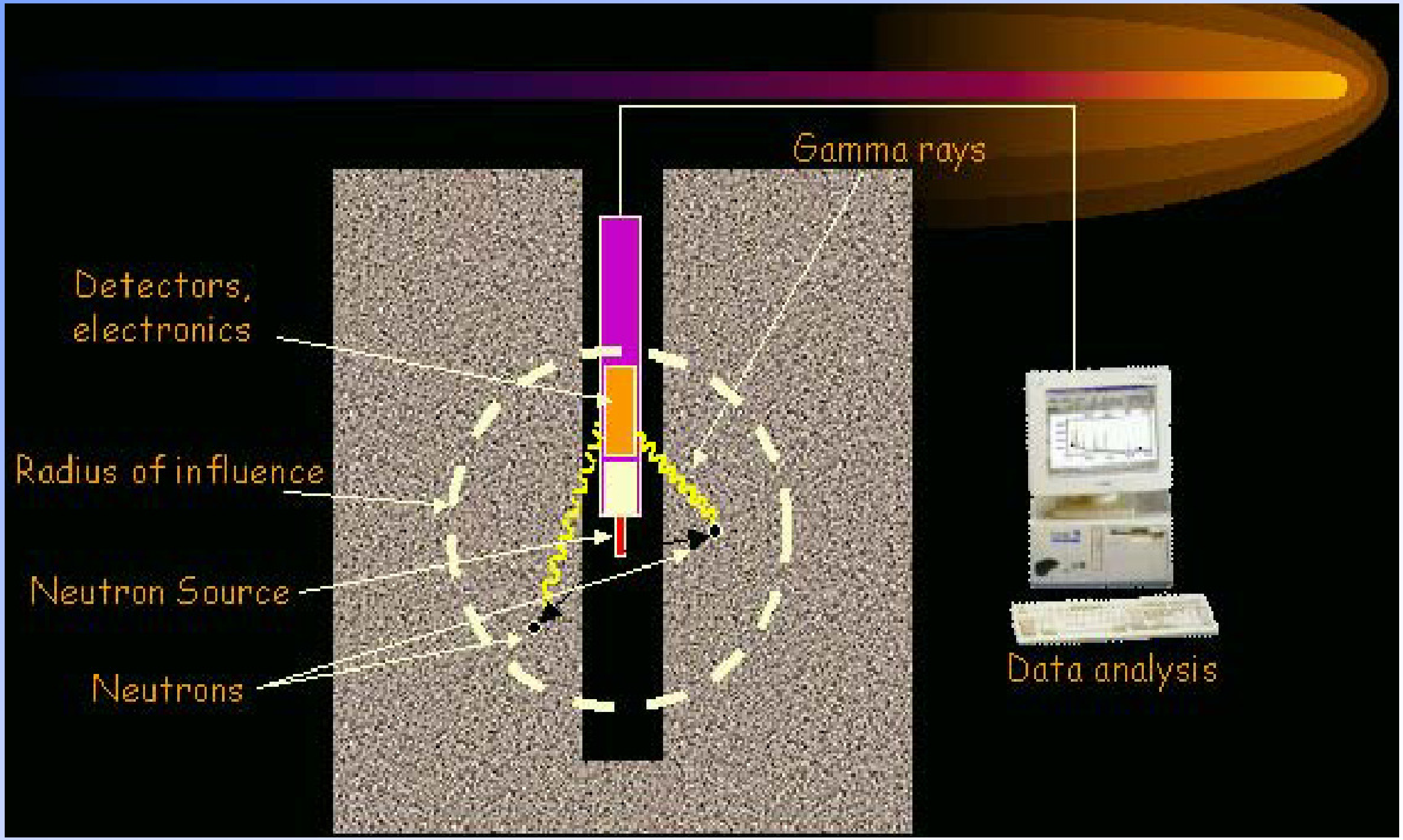
CSIRO, Exploration and Mining

Correlation between Calorific Value (ad) and Ash (ad)

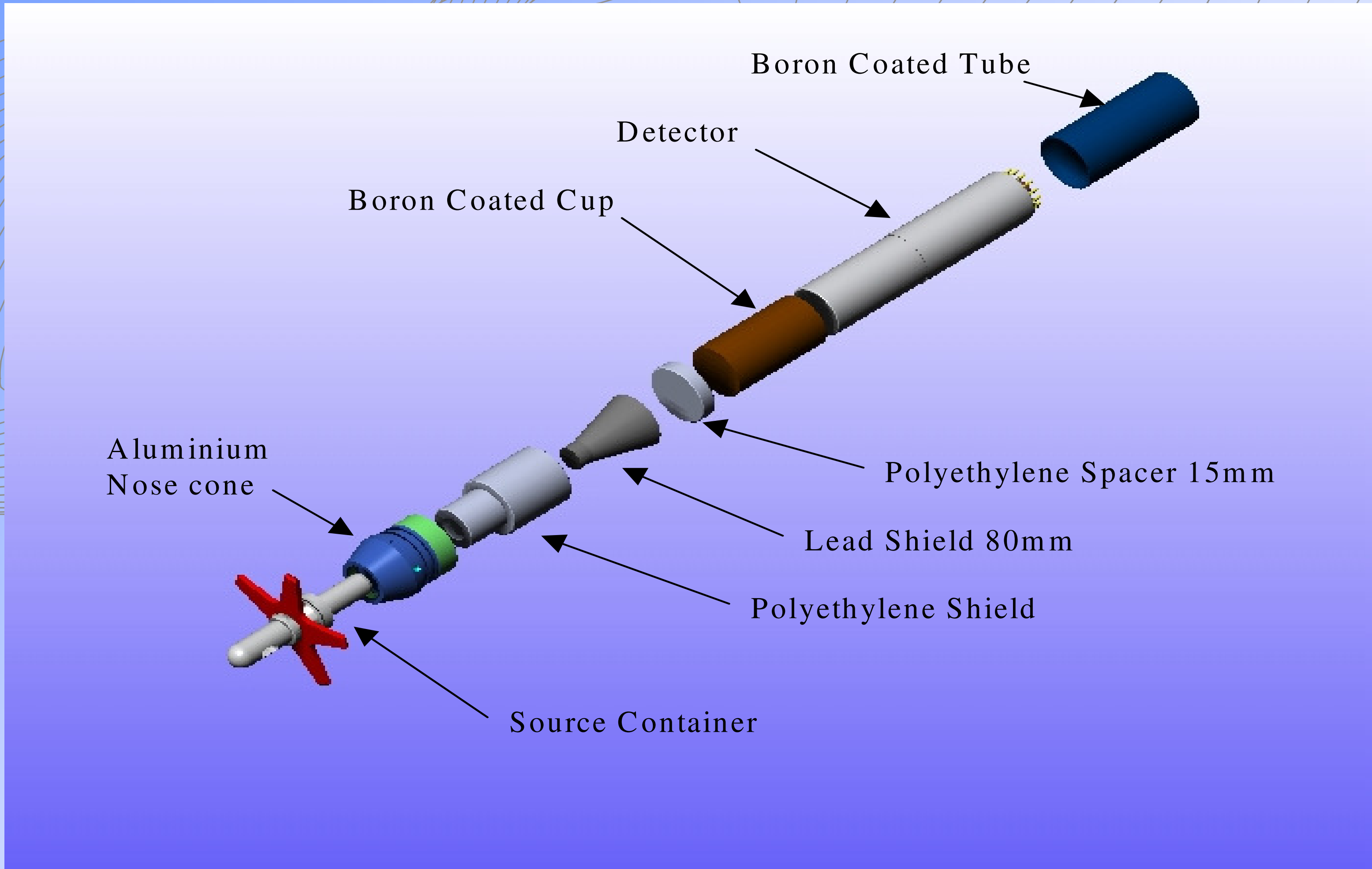


Neutron – gamma logging

used mainly for porostity and hydrogen (water, oil…) content detrmination



Borehole probe for Prompt Gamma Neutron Activation Analysis (PGNAA) logging



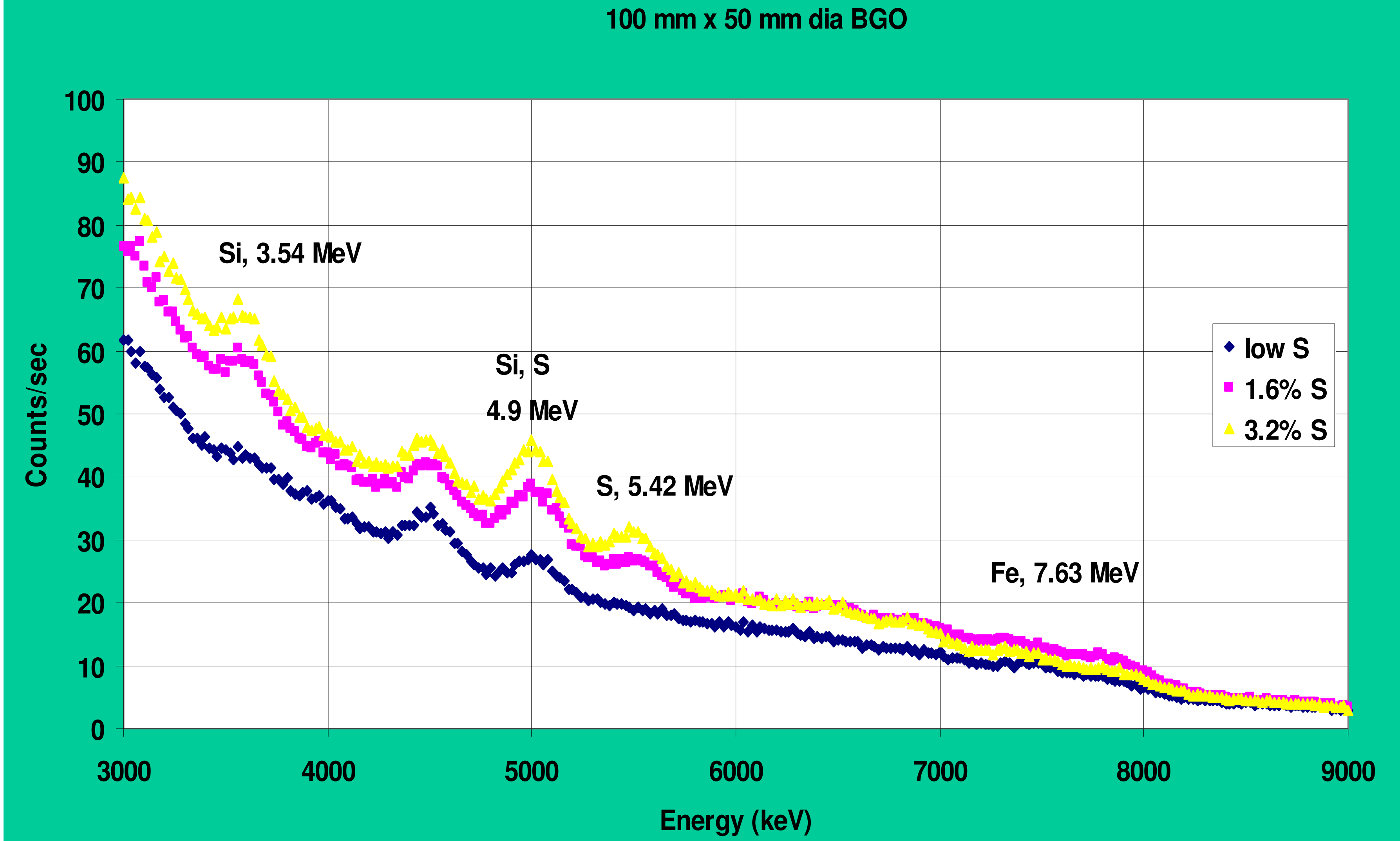
Elements of the 100 mm CSIRO PGNAA probe

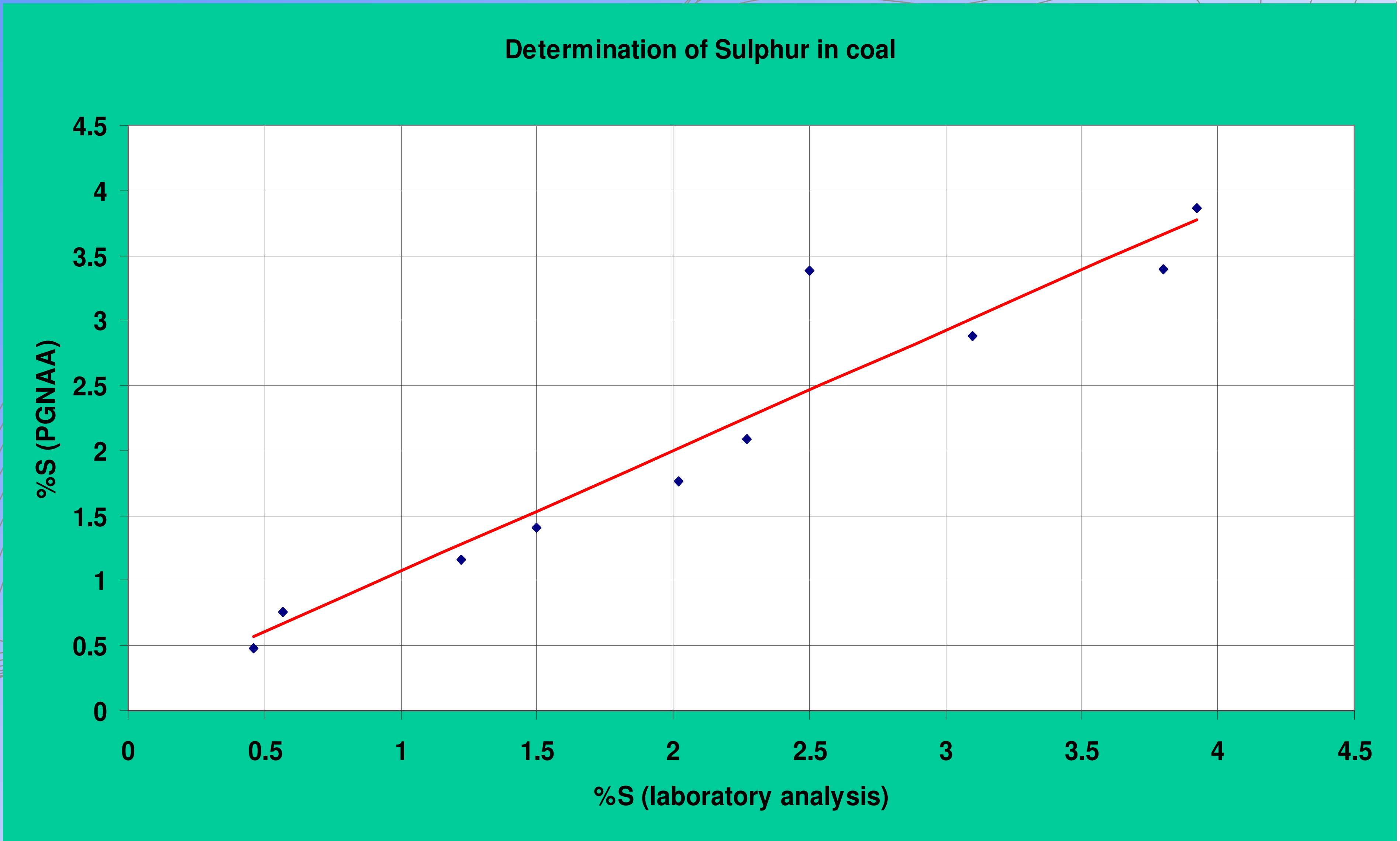
^{252}Cf neutron source

(ok. 100 MBq=1,1x10^{7} n/s)

BGO ($Bi_4Ge_3O_{12}$)
scintillation detector

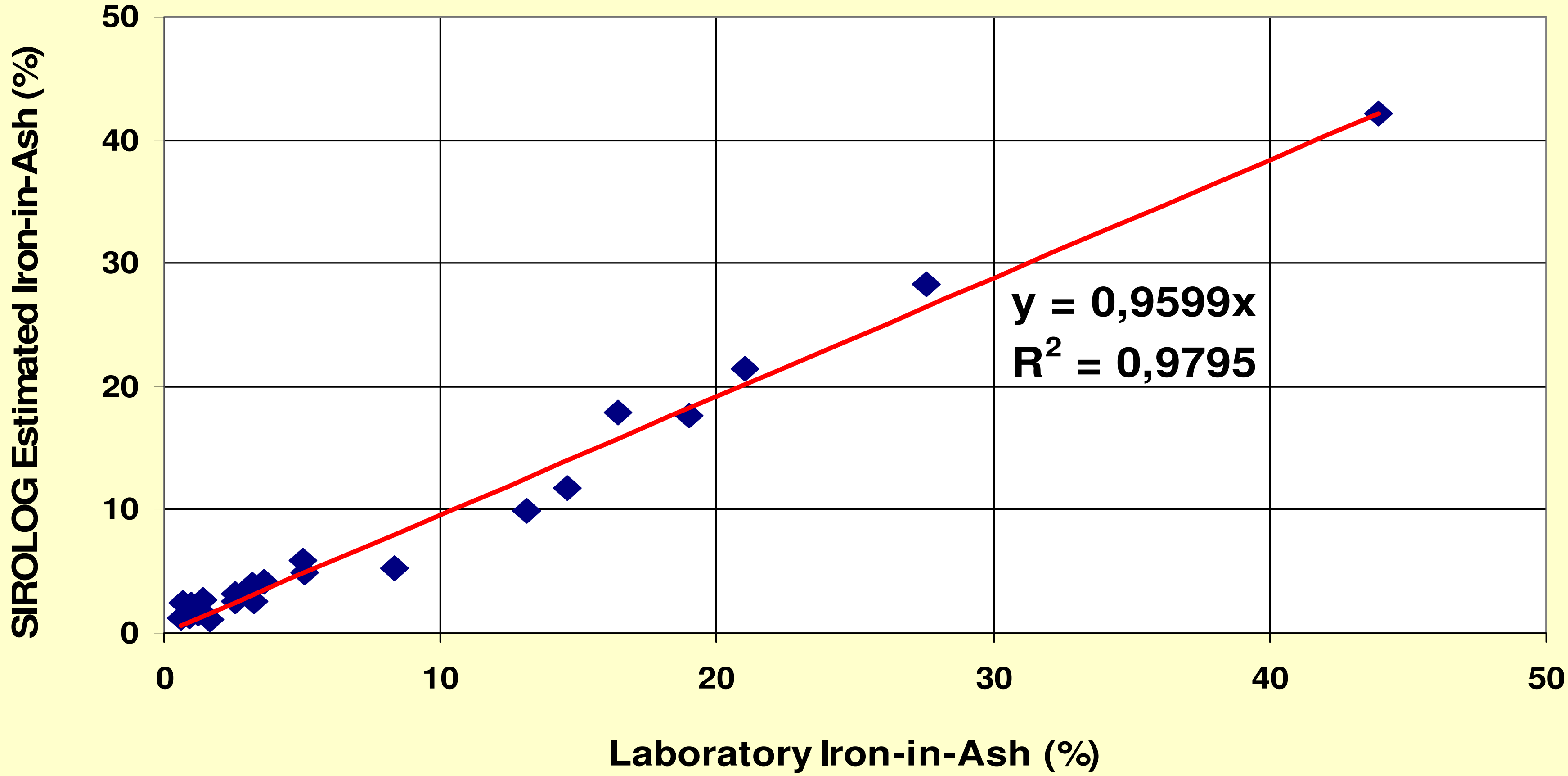
Sulphur in coal and iron in ash through thermal nuetron capture (n,γ reaction)- PGNAA method





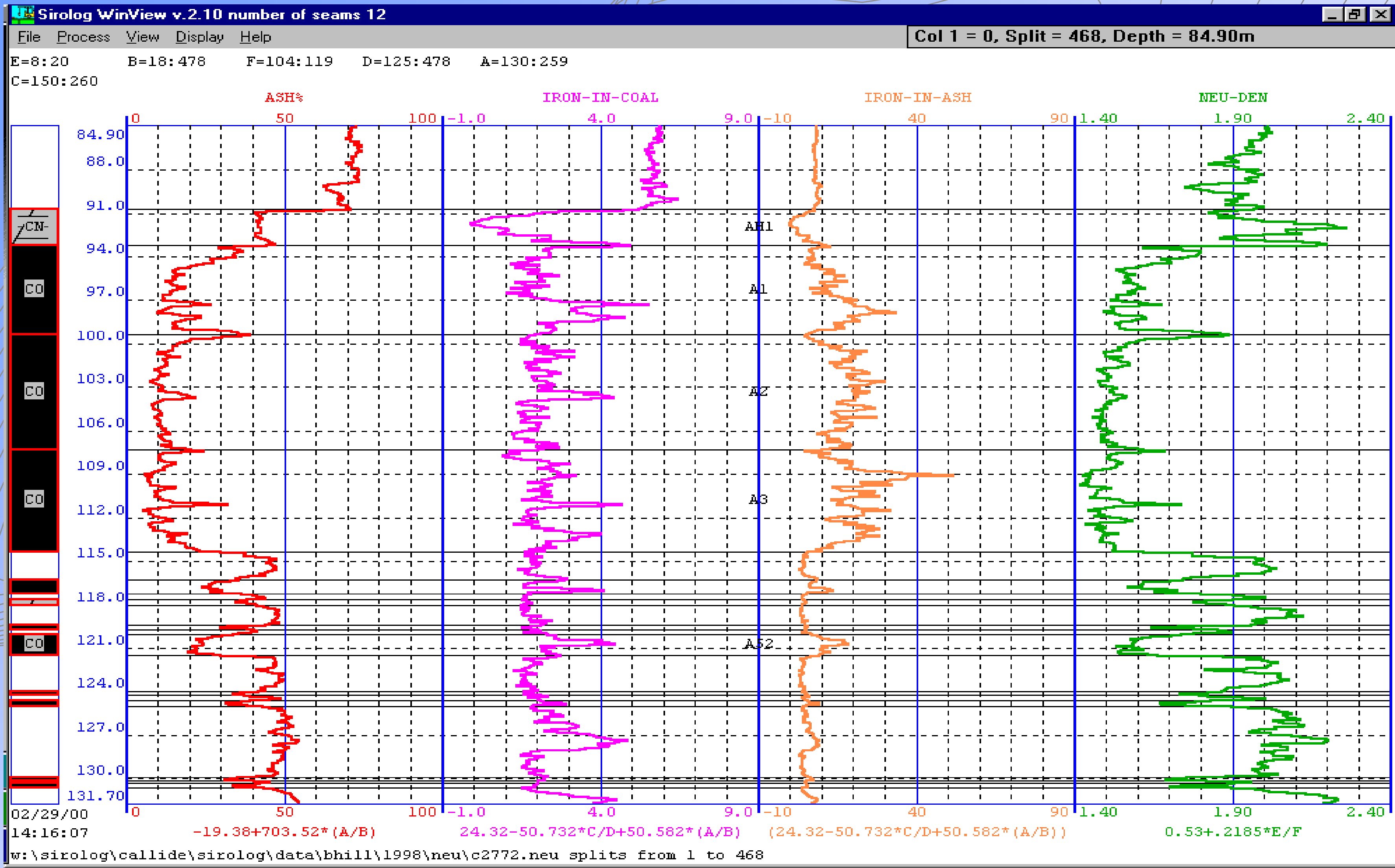
CSIRO, Exploration and Mining

SIROLOG Iron-in-Ash Estimations vs. Chemical Assays' Values

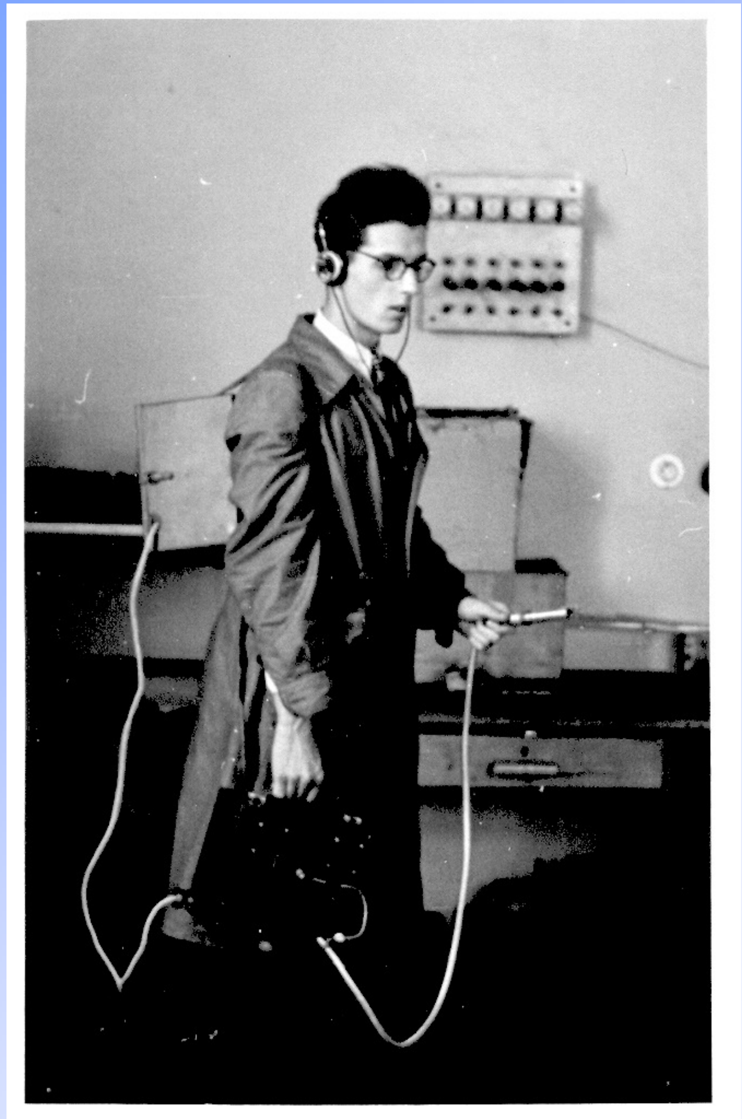


CSIRO, Exploration and Mining

WINVIEW profiles of PGNAA coal logging

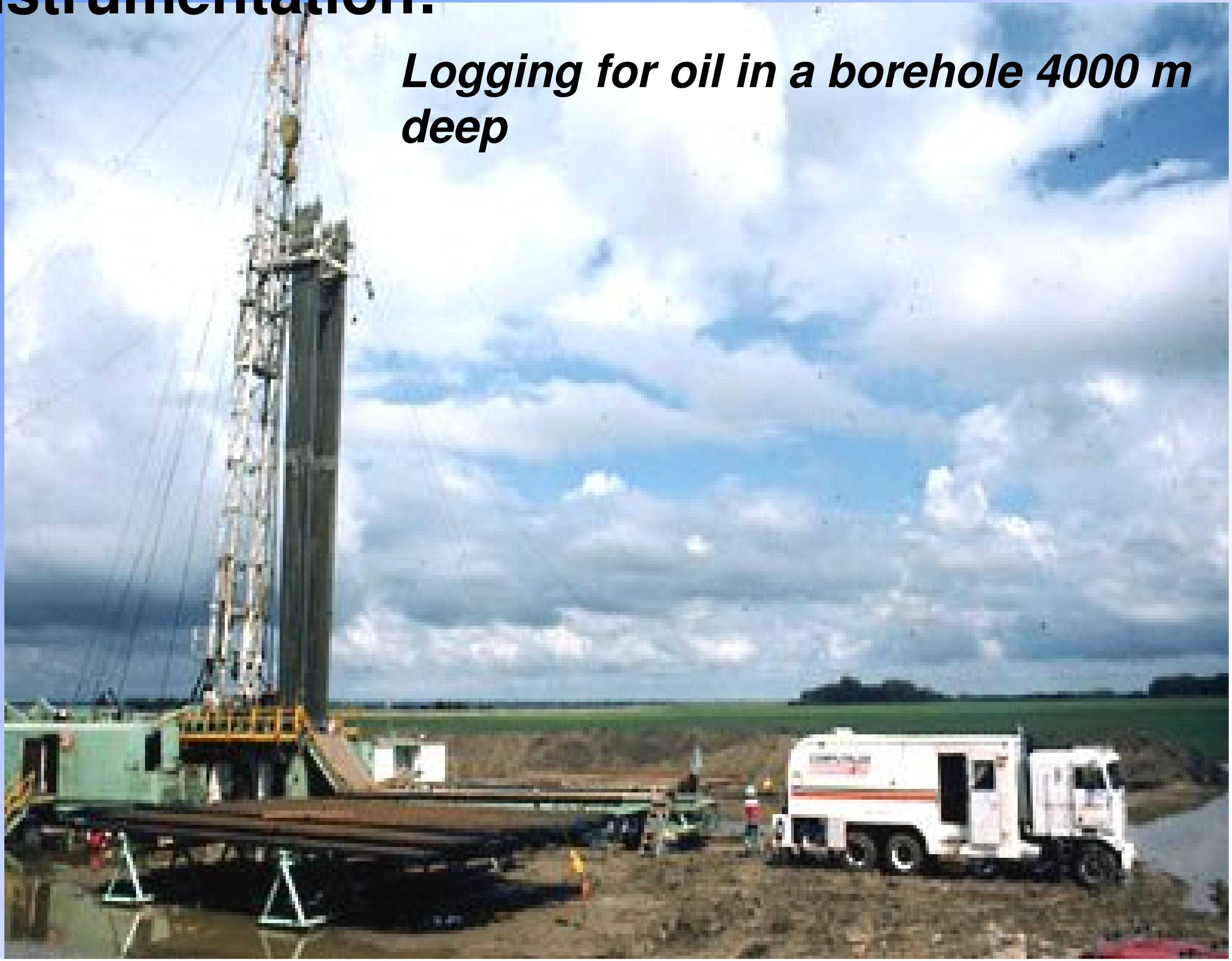


INSTRUMENTATION?



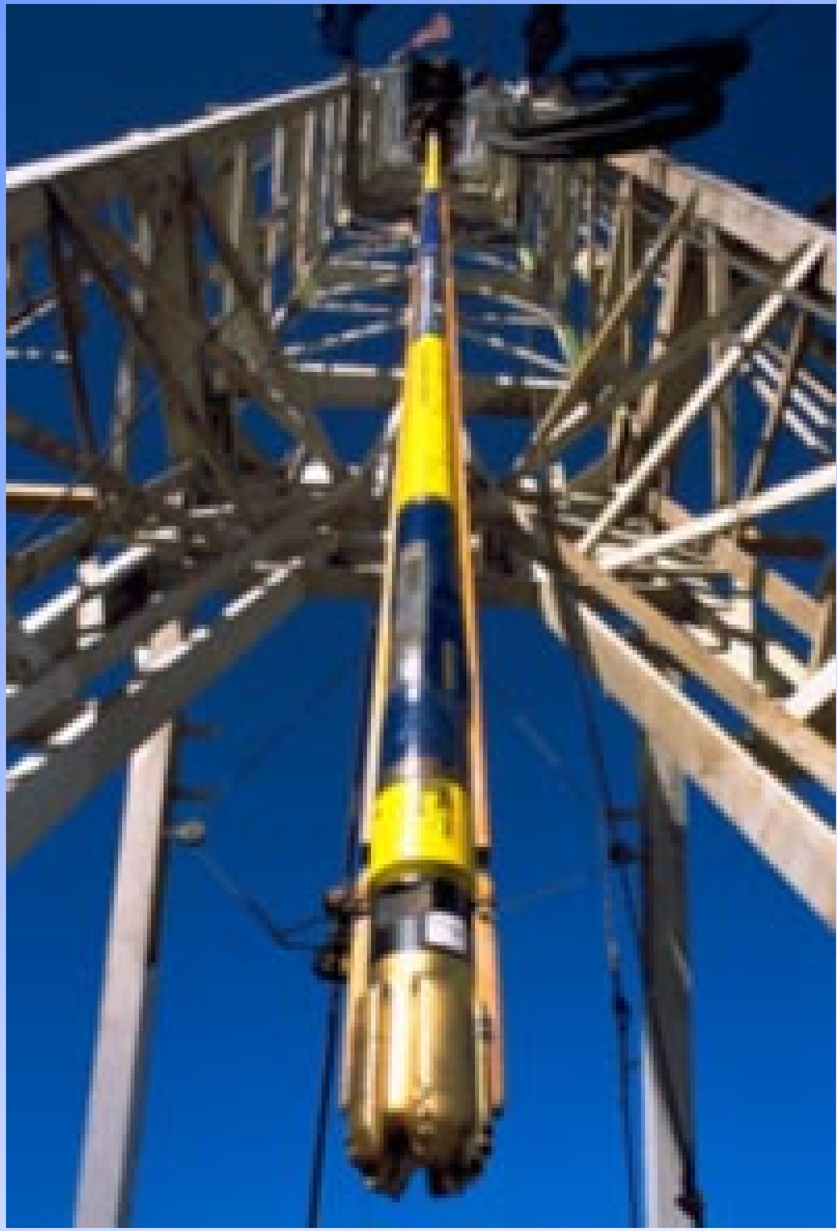
20 mm probe for gamma-gamma logging in 50 m deep boreholes (AGH Kraków, 1962)

Instrumentation:



Logging for oil in a borehole 4000 m deep

AUTO TRAK ROTARY CLOSED LOOP SYSTEM(RCLS) – automatic and oriented rotary dilling tool with a programmed control system adapted for LWD method



AutoTrak 3-1/8" RCLS tool for drilling of the holes 3-7/8" to 4-3/4" in diameter


675·DPY

Portable PGNAA logging tool

CSIRO, Exploration and Mining

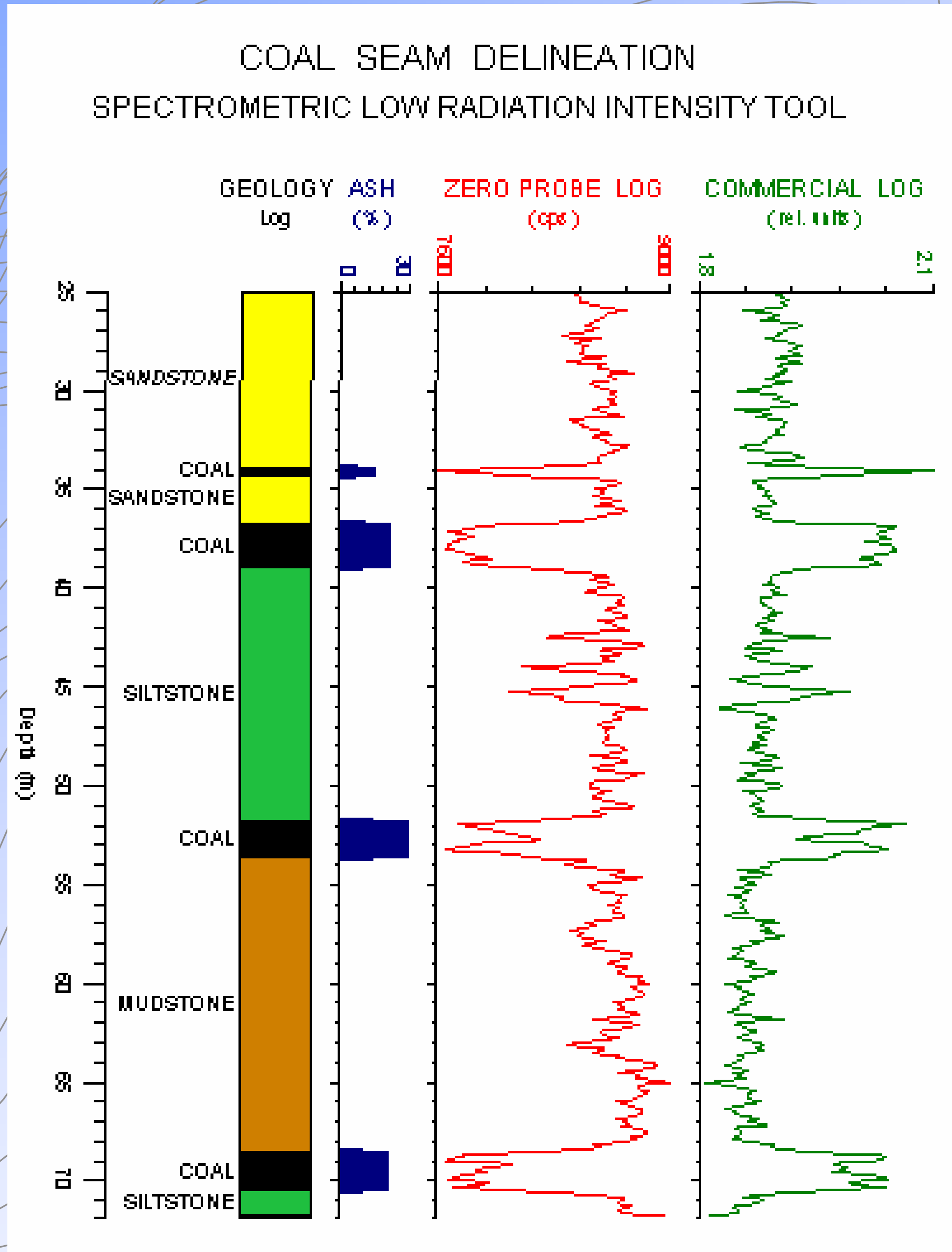
- *The Low Radioactivity Borehole Logging Probe uses a 137Cs source of activity 1.1 -1.8 MBq (30-50 µCi).*

Commercial probe log:

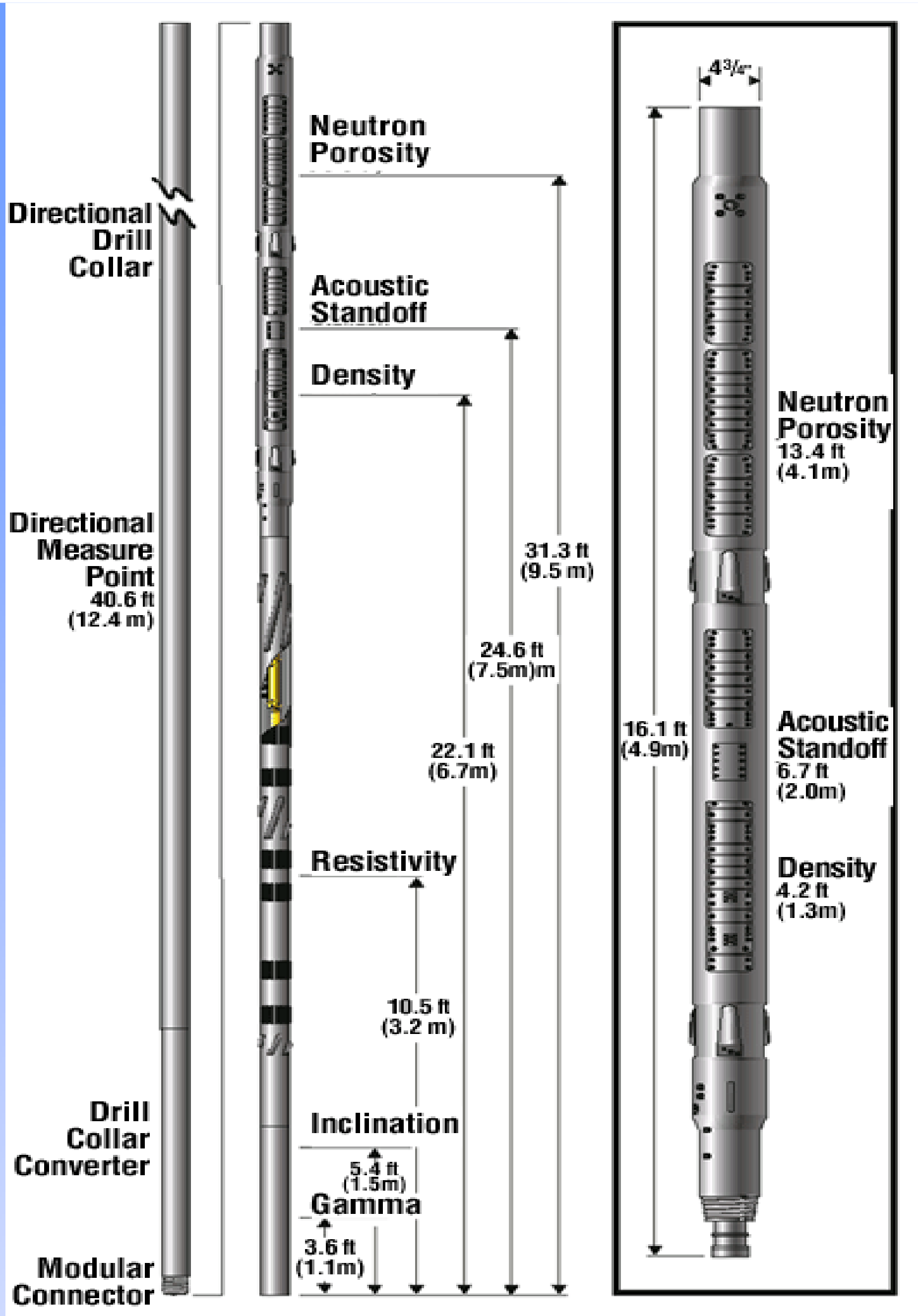
550 MBq (150 mCi),

Low Radioactivity Probe log:

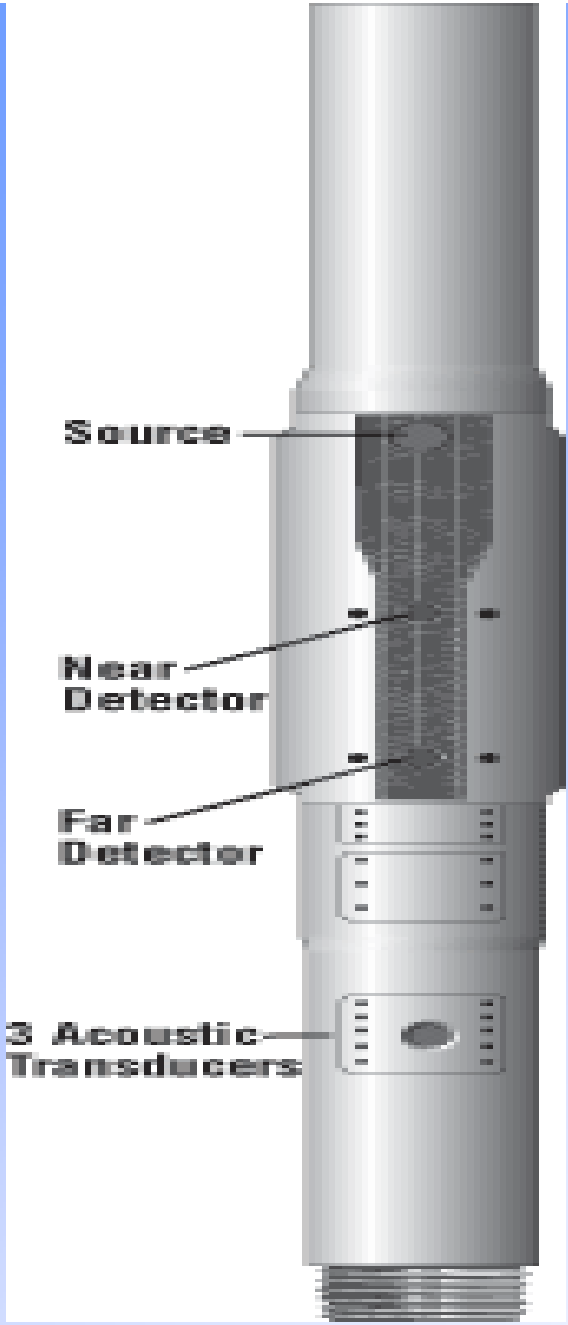
1.1 MBq (30 µCi)



CSIRO, Exploration and Mining



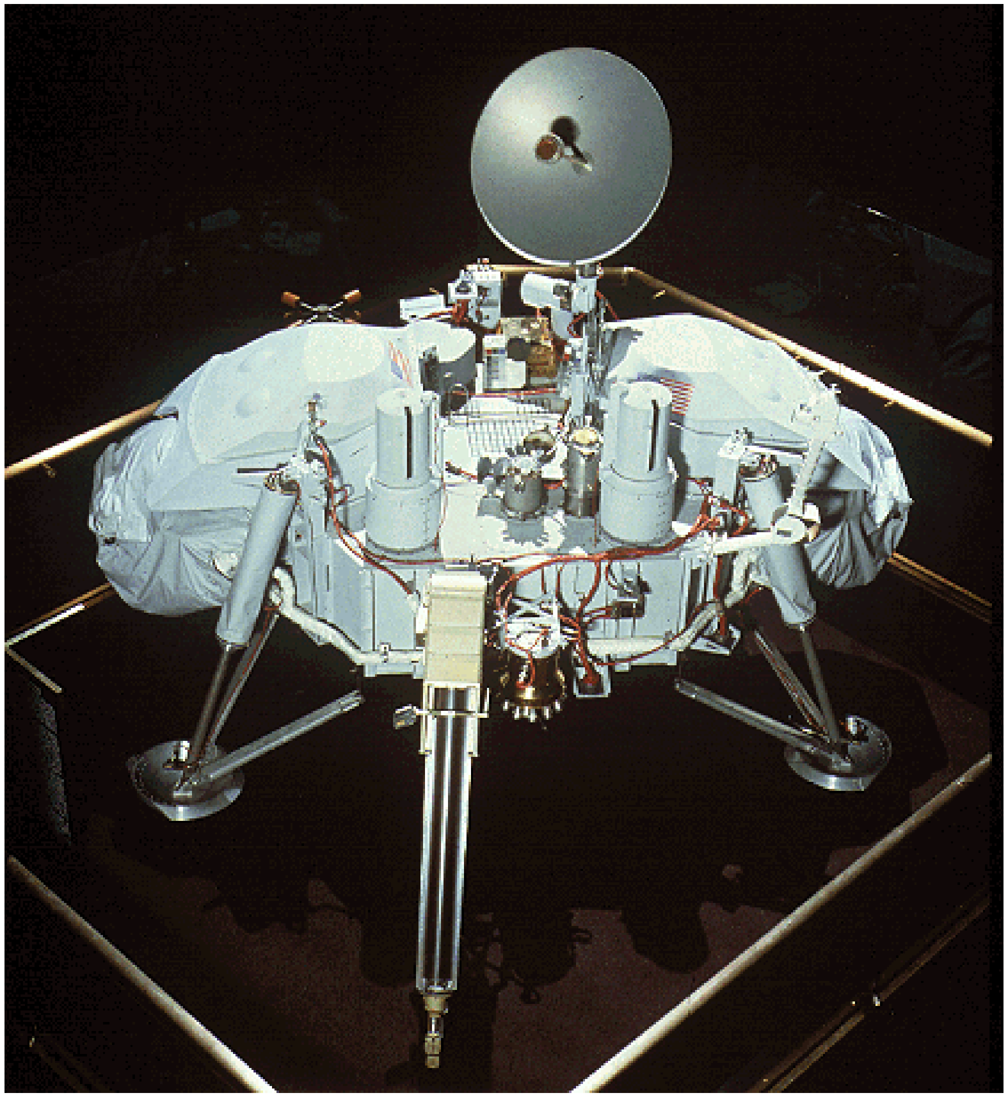
Multipurpose probe for logging by LWD method



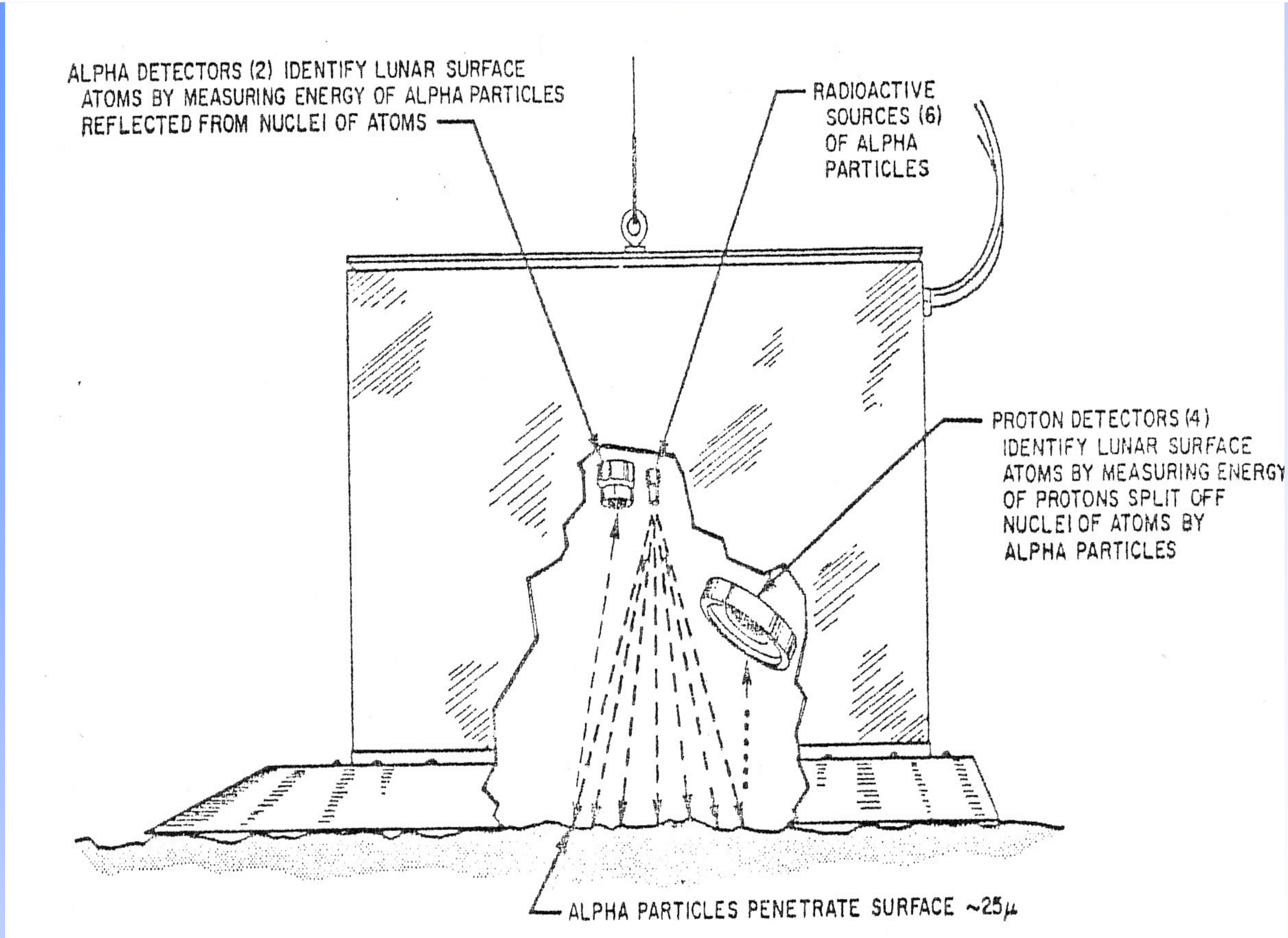
Gamma-gamma part of the probe for density determination through Compton scattering and photoelectric absorption and with acoustic tranducers

(ORD – Optimized Rotational Density method)

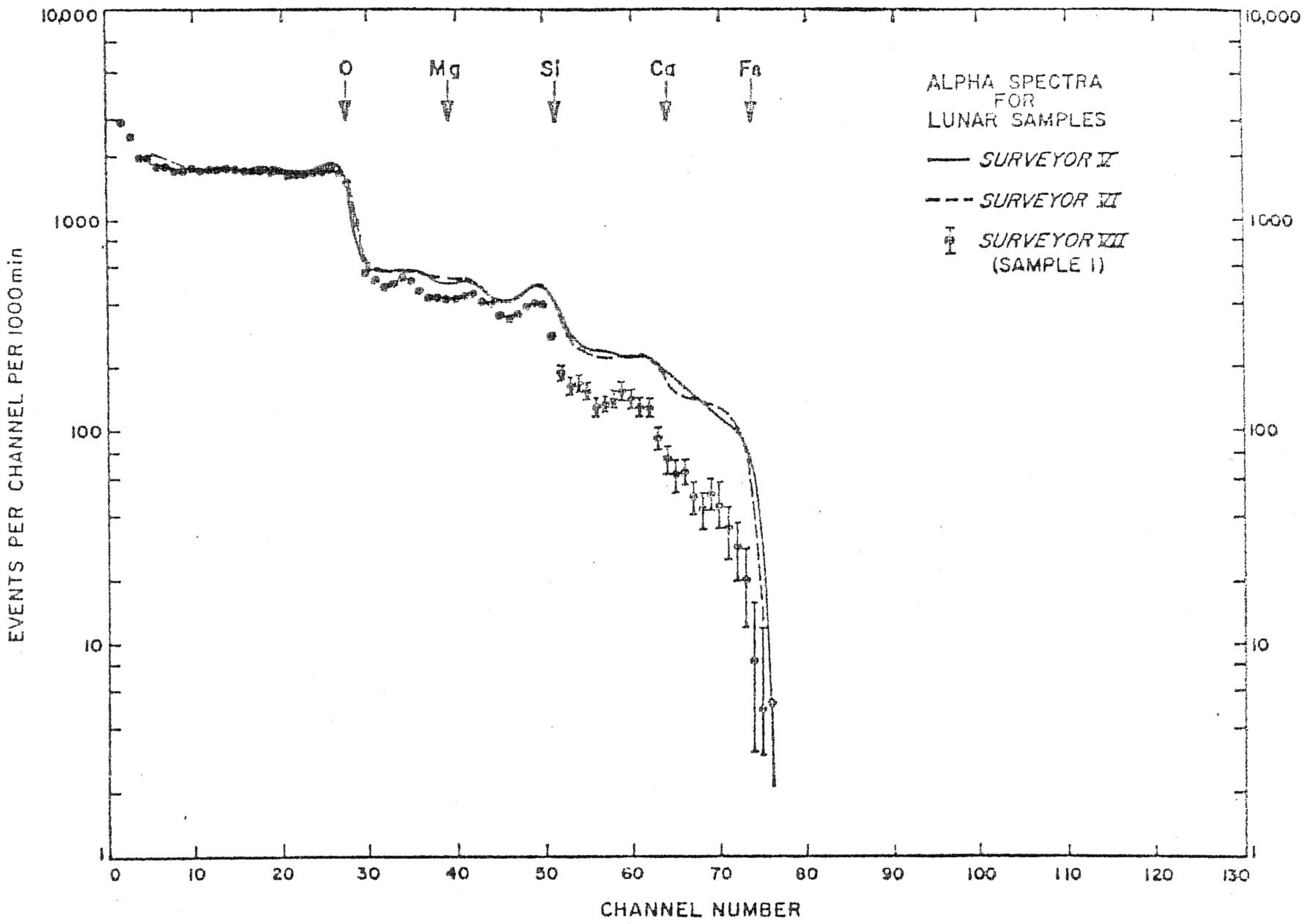
PLANETARY GEO(?)PHYSICS



Marsian probe VIKING

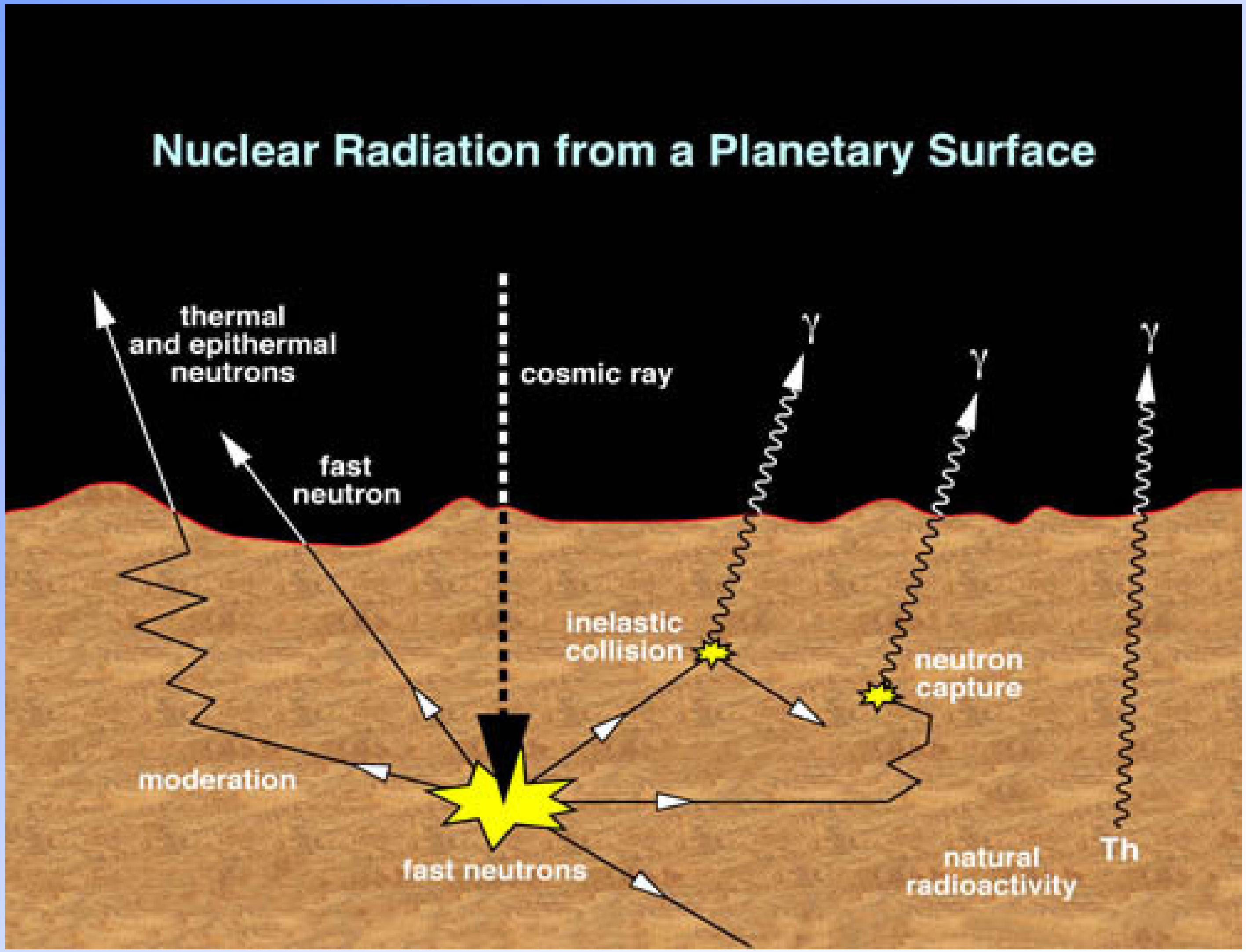


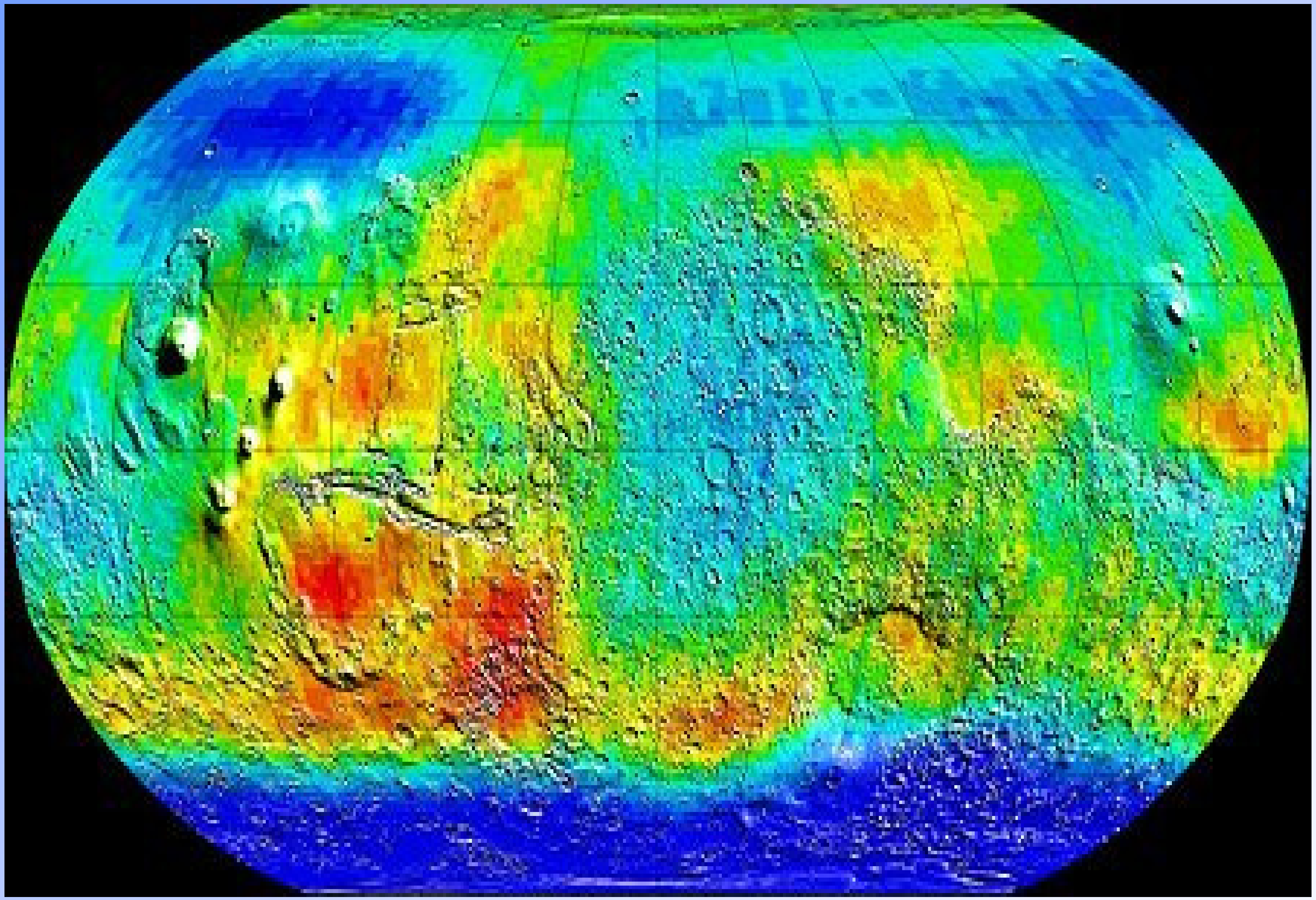
Schematic diagram of the probe applied at the SURVEYOR type moon landers



ALPHA SPECTRA FOR LUNAR SAMPLES
SURVEYOR V
SURVEYOR VI
SURVEYOR VII (SAMPLE 1)
O
Mg
Si
Ca
Fe
EVENTS PER CHANNEL PER 1000 min
CHANNEL NUMBER
10,000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
110
120
130

Nuclear measurements from the orbit





Ice on Mars as seen (indicated by blue colour) by the Marsian satellite ODYSSEY

Future applications of nuclear technologies?

- ***power (fission and fusion?)…***
- ***medicine…***
- ***drinking water (search for, desalination, purification…)***
- ***SIT (sterilization insect technique) and other irradiation techniques…***
- ***nutrition…***
- ***geological prospection…***
- ***various industrial applications - level-, density-, thickness-gauges, radiography, circuit typography etc..***

RADIATION MONITORING PORTALS
type VM – 250GN PL
(detection of gamma-rays and neutrons)