Science and Service at a University Research Reactor

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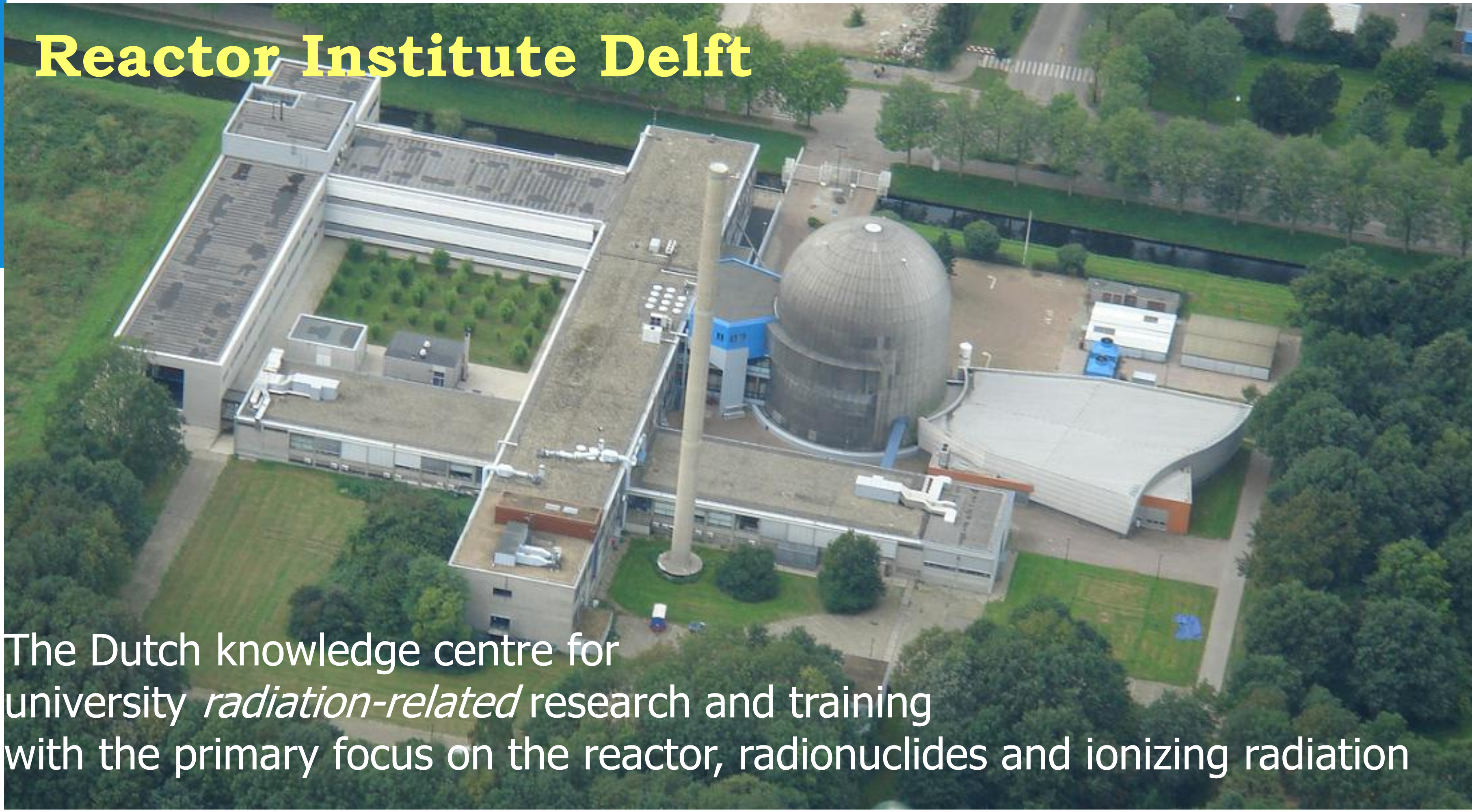
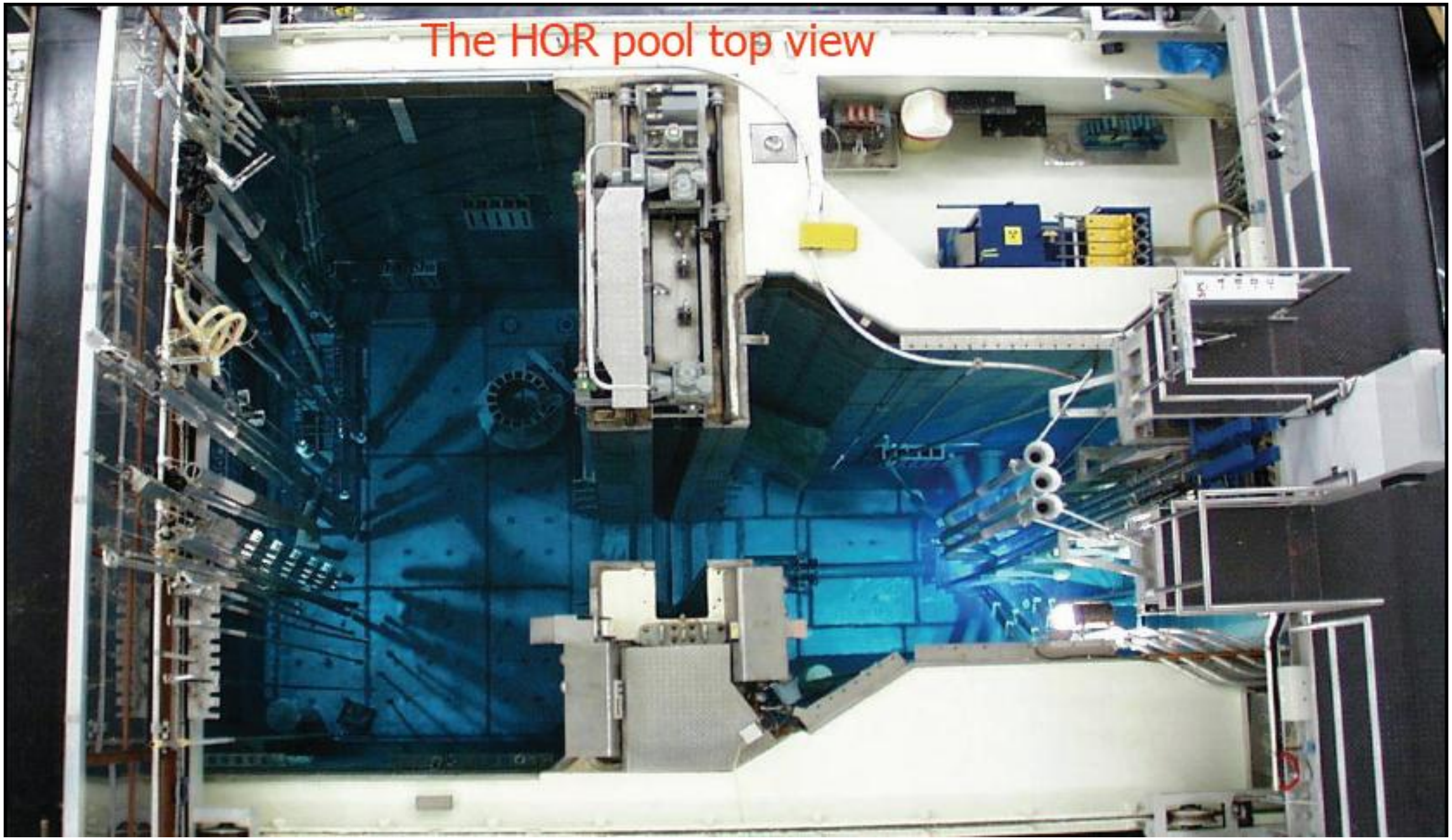
Reactor Institute Delft



The Dutch knowledge centre for
university *radiation-related* research and training
with the primary focus on the reactor, radionuclides and ionizing radiation

IAEA
International Atomic Energy Agency

IAEA COLLABORATING CENTER FOR
NEUTRON ACTIVATION BASED METHODOLOGIES OF RESEARCH REACTORS



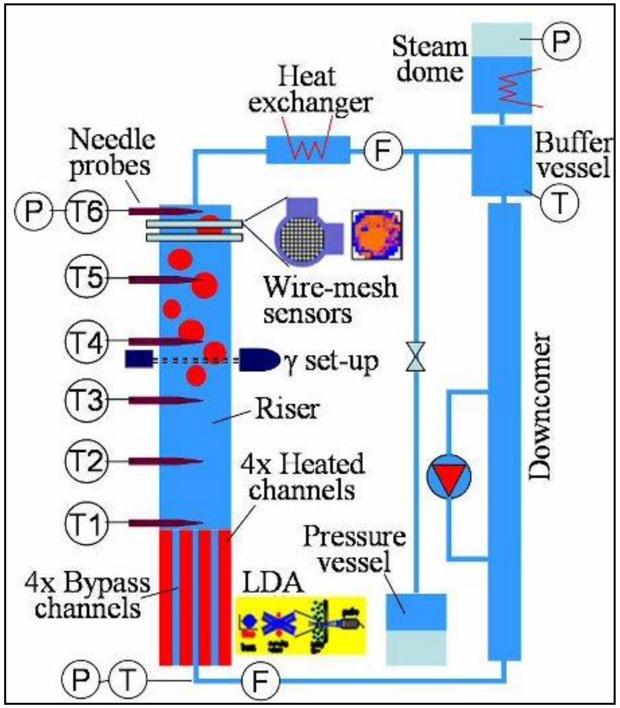
Operational power level 2 MW

Availability 100 h/week continuous operation, 40 weeks/year

Thermal neutron fluence rate in-core	4×10^{13} $cm^{-2}s^{-1}$
Thermal neutron fluence rate at core surface	1×10^{13} $cm^{-2}s^{-1}$
Integral fluence rate at neutron-guide exits	3×10^{7} $cm^{-2}s^{-1}$
Positron yield	2×10^{8} s^{-1}

Some Experimental Facilities

Neutron beam and positron beam instruments + reactor physics test loops

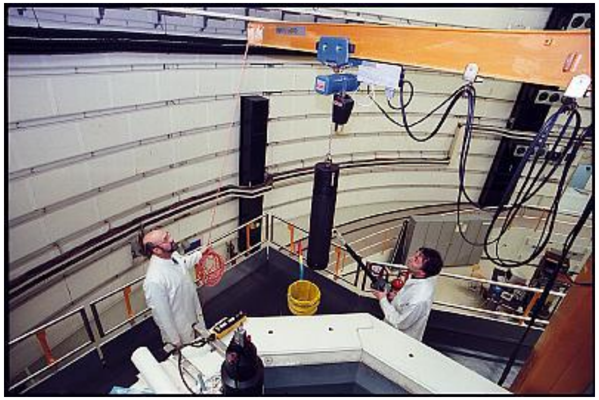


Test loop for low pressure stability of natural circulation BWRs

World's brightest positron beam

Some Experimental Facilities

Neutron Activation Analysis



Large sample analysis

Some Experimental Facilities

Radiological training course facilities

History

1957 Reactor Institute Delft initiated

1963 1st criticality Hoger Onderwijs Reactor

1969 Interuniversity Reactor Institute

1985 Interfaculty Reactor Institute of Delft University of Technology

Evaluation criteria of university research

Criterion	Evaluation mechanism
Relevance	External funding
Quality	Science citation impact factors Citation frequency
Viability	Networking, number of students
Productivity	Number of publications, project proposals, PhD dissertations, patents

2004-2005 : the threat....

- High overhead by reactor and security results in too high costs per publication
- Insufficient externally financed projects
- Insufficient services by reactor facilities other than INAA
- Too many conflicts of interest between science and services; income generation had higher priority than doing science
- Relevance in radiochemistry driven by external users, not by own vision
- "Commercial services" by academic groups were not officially allowed…

History

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1963 1st criticality Hoger Onderwijs Reactor

1969 Interuniversity Reactor Institute

1985 Interfaculty Reactor Institute of Delft University of Technology

2005 Major reorganization

Reactor Institute Delft

Department Radiation, Radionuclides & Reactors

Faculty Applied Sciences,

Delft University of Technology

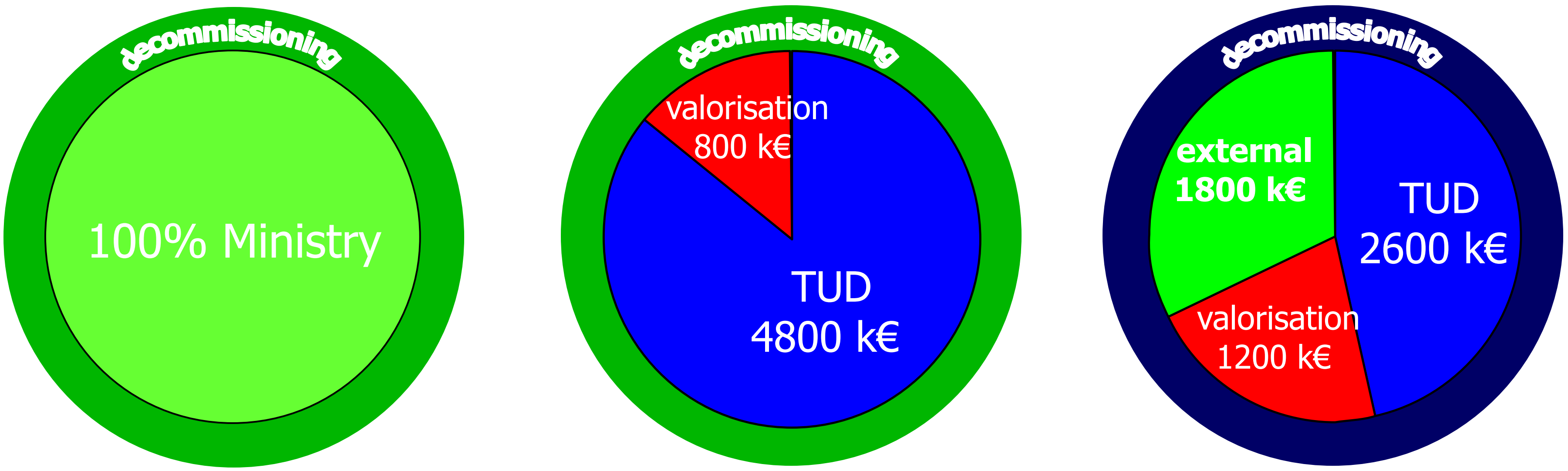
A final chance to survive...

- Until 2005: IRI, Interfaculty Reactor Institute
  - Research institute
  - No classroom teaching obligations at university
  - Only PhD projects

- Since 2005: Reactor Institute Delft (Reactor+ facilities)
  (University Facility)
  and
  Department Radiation, Radionuclides and Reactors
  - Faculty of Applied Sciences
  - Education and research institute
  - Undergraduate and graduate projects
  - Start of classroom teaching nuclear sciences
  - Rapidly increasing no. of PhD projects, MSc & BSc projects

Change in Financing

IRI < 1985	IRI 1985 → 2004	RID 2009
Interuniversity	Interfaculty	Facility + Scientific department



Science: Current Research Themes

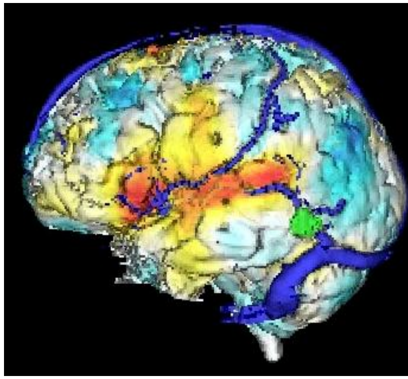
Energy

- Solar cells (Semiconductor nanocrystals)
- Lithium ion batteries
- Hydrogen storage

} materials research

- Nuclear reactors physics (BWR dynamics, HTR, super critical water reactors, molten salt reactor, gas cooled fast reactors, two-phase flow thermal hydraulics and diagnostics)

Health



- Radiation and radio-isotopes for therapy
- " and " for diagnostics
- Development of production routes for radio-isotopes
- Radiation detection (tissues, food, metabolism)

MSc Programme

Chemical Engineering and Applied Physics

Specialisation

Nuclear Science and Engineering

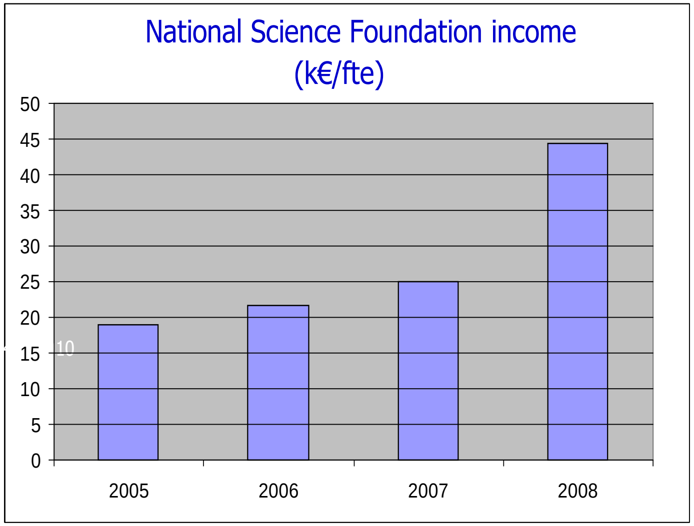
Throughout the twentieth century, scientists made enormous progress in unlocking the secrets of nuclear science – and as they did, a new field developed to take advantage of these discoveries. Applications of nuclear science were key, of course, in the development of nuclear weapons and nuclear energy, but also in major breakthroughs in medical diagnostics and treatment; in sensing devices like smoke detectors for the home and environmental monitoring devices for chemical production facilities; in materials science; in important security activities like mine detection and de-mining, and explosives detection at airports and in food safety measures, to cite just a few examples.

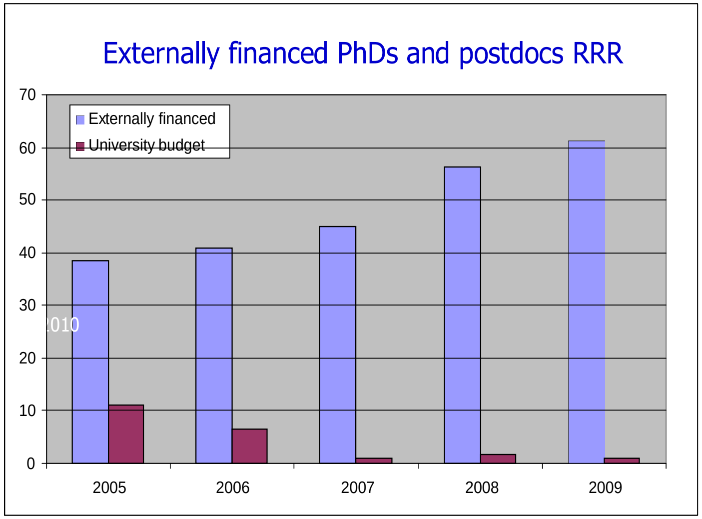
The field of nuclear science and engineering continues to grow rapidly, and as it does, so does the demand for qualified nuclear scientists and engineers. The principle objective of the TU Delft Nuclear Science and Engineering specialisation is to train nuclear scientists to meet that growing demand. TU Delft offers two variations on the Nuclear Science and Engineering concentration: the programme can be taken as focus of the Research & Development (R&D) Specialisation within the Radiation, Radionuclides & Reactors Track of the Master's Programme in Applied Physics or as a Specialisation within the Master's Programme in Chemical Engineering.

Nuclear Technology for Health and Energy

In either case, you will follow a curriculum that combines academic classes with the opportunities to participate for a shorter or longer period in the ongoing research in nuclear science at the University's reactor institute. In addition to technical studies, your programme will include academic modules covering such topics as ethics, risk perception and safeguarding, and radiological health courses, qualifying you for an internationally recognised Level-3 diploma.

Science: Success





Target for valorization in 2009, set in 2005	1200 keuro
Accomplishment in 2009	1250 keuro

Service: Reactor Institute Delft

Mission

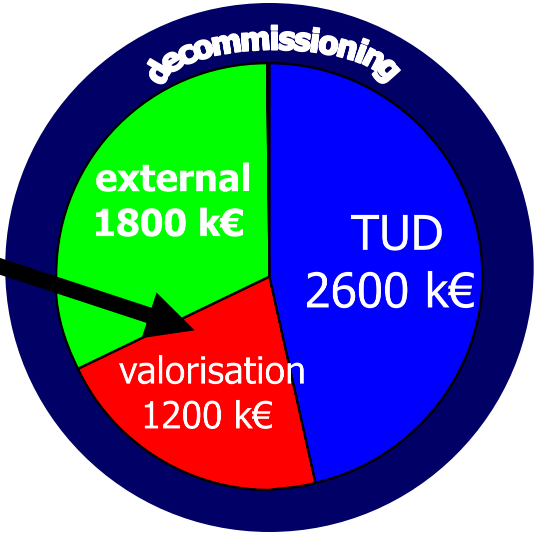
Operating the 2 MW reactor

Making facilities available for use in science and for services

Quality management

National Centre for Radiation Protection

Member of the network of the European neutron facilities for transnational access EU-FP7-NMI3



Service: Reactor Institute Delft

Facilities and Services

Opportunities for use of facilities by external scientists

Training courses

INAA

Luminescence dating

Technical irradiations

Service: Reactor Institute Delft

Facilities and Services

Opportunities for use of facilities by external scientists

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Service: Reactor Institute Delft

Facilities and Services:

Radioisotope production/Silicon doping ?

No….

Service: Reactor Institute Delft

Facilities and Services:

Radioisotope production/Silicon doping ?

No….

Conflict of interest with the routine isotope production at the 45 MW HFR reactor in Petten (NL)

Exception:

Own research (e.g. no-carrier added ^{99}Mo)
Research at universities (e.g. ^{166}Ho for microspheres)
Short half-life radiotracers (e.g. ^{41}Ar for leak detection)

Service: Reactor Institute Delft

Facilities and Services: Training courses

National Centre for Radiation Protection Courses

Health physics (4 levels)

Basic Course LSC

Radiation Protection in X-ray diffraction

Ionizing Radiation for Medical Personnel

Radioisotope Techniques

Health Physics for Medical Electrical Engineers

Service: Reactor Institute Delft

Facilities and Services: Neutron activation analysis

- In-house developed software, based on single comparator method since 1970
- 3 well type detectors, 3 coaxial detectors (all with sample changers)
- 2 fast rabbit systems (1 with sample changer)
- Typical throughput 2,500 samples/year (capacity ~ 10,000)
- Management system accredited since February 1993 (ISO/IEC17025:2005)
- Large sample NAA facility

History of INAA services in Delft

1970s Universities
First contracts from governmental institutions

1980s Development of ‘laymen’ system; analyses done by employees from other universities
Fast growth of automation
First contracts from industry
Additional personnel on contract basis

1990s Development of quality management system, accreditation
Start of first business unit with manager and administration
Development of LIMS
Contracts via international science fund supporting projects

2000s (2005-) Separation of business unit from research department
Fully commercialized INAA services
European Center for Transnational Access

History of INAA services in Delft

1970s Archaeology
Rocks, Sediments
Air filters
Toenails

1980s Environmental samples (plants, air filters, lichens)
Plastics

1990s Plastics
Toenails
High-tech materials

2000s Toenails
High-tech materials
(Food) supplements

History of INAA services in Delft

1970s-1980s:

Services by research group

Analyses done by regular analysts and/or by guests/scientists from outside group

1980s-1990s:

Services by special personnel, integrated in research group

Additional personnel paid either directly by customers or from revenues of services

1990s:

Business unit, semi-integrated in research group

Manager and administrative staff

2005-present:

Business unit fully separated from research group

Organizational aspects

Services by research group

\+ Commitment can be high
Return of revenues results in upgrading and expanding of facilities
Scientific collaborations and publications

\- Services may get higher priority than scientific core activities

Organizational aspects

Business unit separated from research group

+ Safeguarding capacity for scientific core activities
  Transparent structure and policies

- Conflicts of interest w.r.t. use of facilities
  No opportunities for (cost-free) feasibility studies
  No opportunities for compensating price by joint scientific publications
  High risk of loosing scientific network

The basis for success

Quality

=

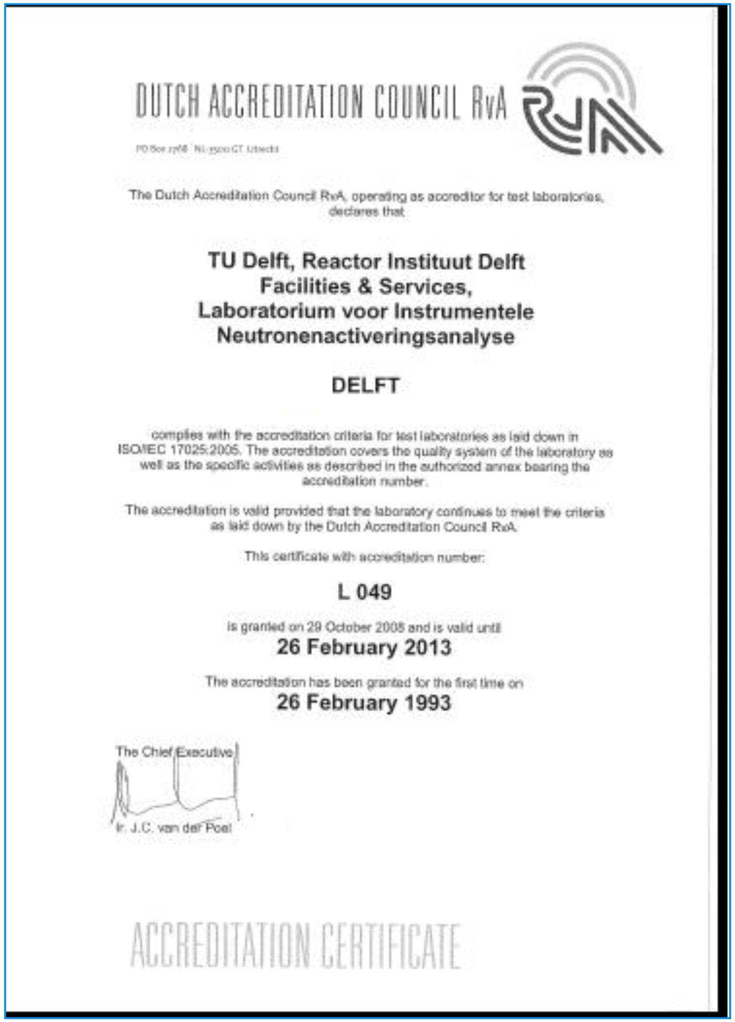
Fitness for the purpose

+

Believability

+

Trueness



DUTCH ACCREDITATION COUNCIL RvA

The Dutch Accreditation Council RvA, operating as accreditor for test laboratories, declares that

TU Delft, Reactor Instituut Delft
Facilities & Services,
Laboratorium voor Instrumentele
Neutronenactiveringsanalyse

DELFT

complies with the accreditation criteria for test laboratories as laid down in ISO/IEC 17025:2005. The accreditation covers the quality system of the laboratory as well as the specific activities as described in the authorized annex bearing the accreditation number.

The accreditation is valid provided that the laboratory continues to meet the criteria as laid down by the Dutch Accreditation Council RvA.

This certificate with accreditation number:

L 049

is granted on 29 October 2008 and is valid until
26 February 2013

The accreditation has been granted for the first time on
26 February 1993

The Chief Executive

Ir. J.C. van der Poel

ACCREDITATION CERTIFICATE

Fitness for the purpose !

"Good is good enough"

Need for smart protocols:

- Optimize to what the customer wants, not to what the technique may be able to offer
- Optimize by minimizing the turnaround time

- Use short half-life radionuclides
- Large sample masses
- Other detector types
- Higher count rates

Fitness for the purpose !

Smart protocols

Sample receipt:	Thursday morning
Irradiation:	Thursday afternoon
Cooling:	Friday-Saturday-Sunday
Start counting:	Sunday evening
Analysis and reporting:	Monday morning 12-15 elements
Total turnaround time	5 days
Perception of client:	2 (working) days….

Fitness for the purpose: everywhere!

- Small batches of samples, sometimes only 1 or 2 samples: Relatively high overhead
- Contact point needed; some customers want direct communication with laboratory staff
- Non-scientific customers: Avoid jargon in communications
- Non-scientific customers: interpretation of reports ("E-format"; chemical symbols; typographic symbols "<")
- Turnaround times as short as possible, but 1 -2 weeks are often acceptable
- Reporting date is the date on which the report is in the hands of the customer; not the date when the report is printed in the lab...

Difficulties with entering markets

	Strong points	Problems/competition
Geology/mining	non destructive national importance	ICP, XRF turnaround time used to very low prices
Environment	matrix insensitive	need for Pb water organics
Lichens, mosses	demonstrated suitability	need for automation funding
Reference materials	demonstrated suitability	funding

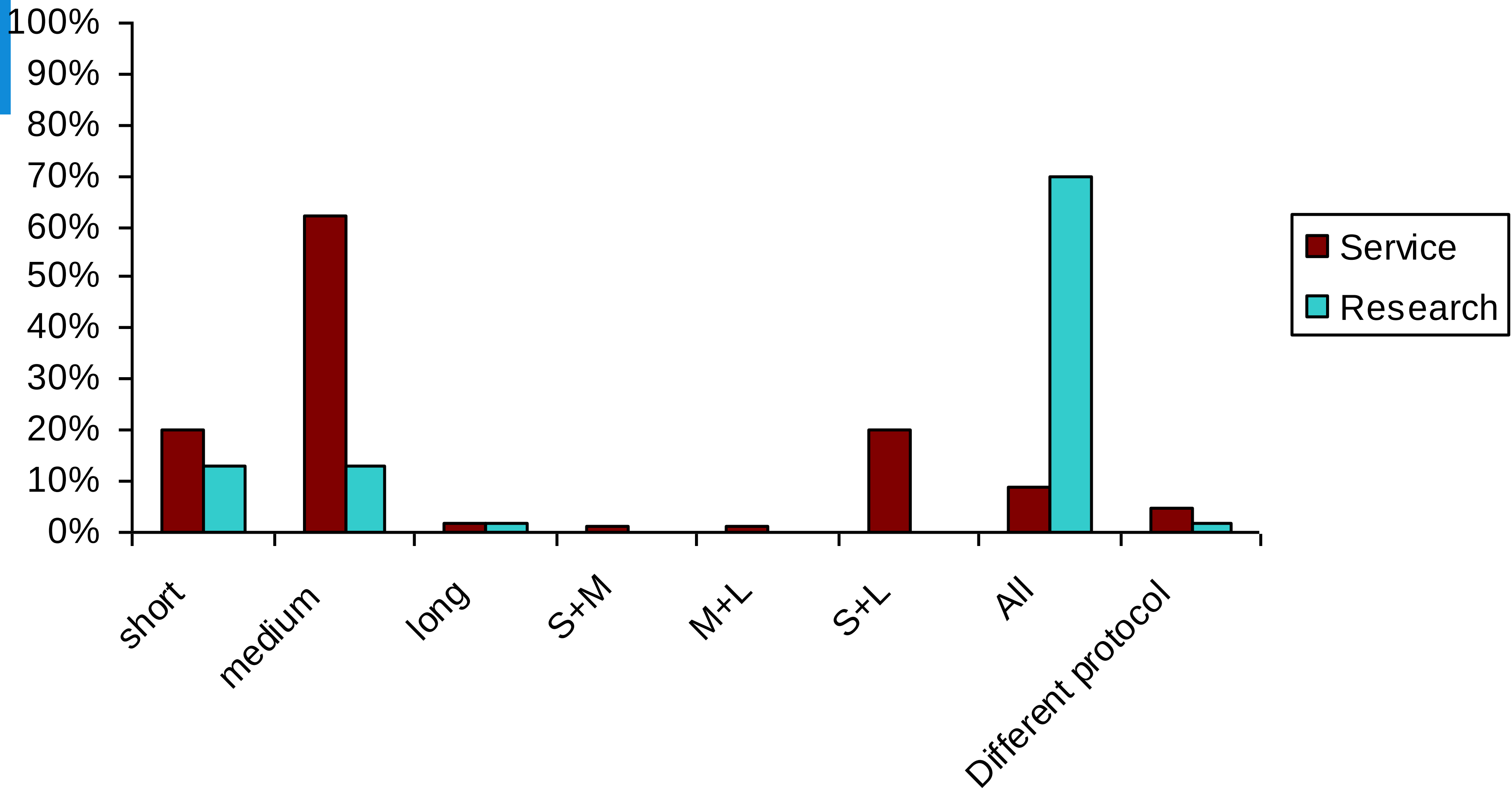
Market segments with opportunities

	Strong points	Problems/competition
Catalysts, zeolites, plastics	matrix non-destructive	small batches XRF, turnaround time
Glass	matrix	B and Na levels
Ultra high purity Si, C	matrix large samples	long irradiations small batches
Human bio indicators	matrix non-destructive	long preparation need for automation
Food	matrix allergens	sensitivity matrix
Forensics	non-destructive	sensitivity small batches
Art objects	non-destructive	insurance sensitivity

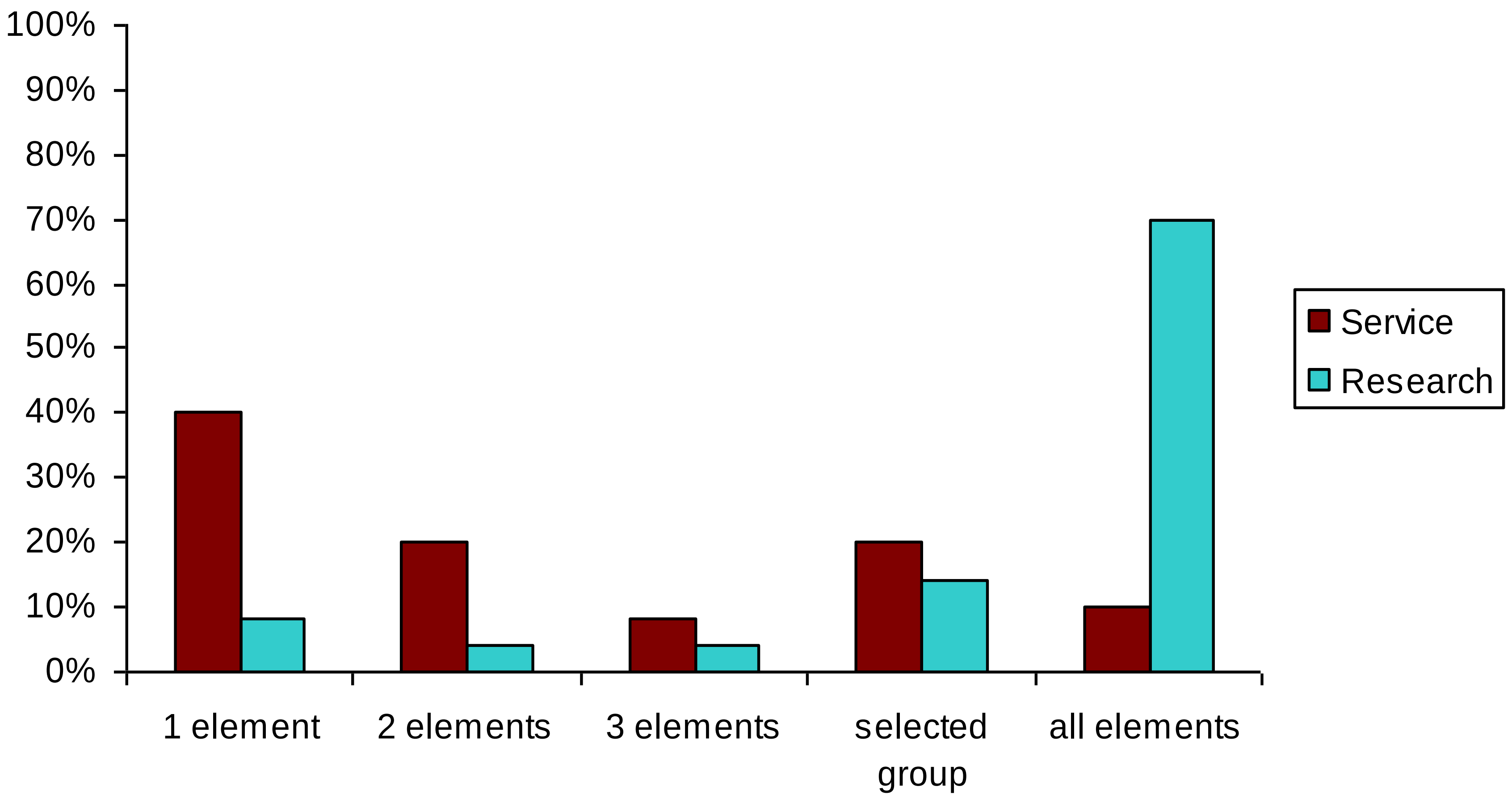
Market segments with opportunities

	Strong points	Problems/competition
Waste recycling	matrix insensitive non-destructive	need for large samples
Food supplements Cosmetics	easy	high trueness required
Environmental	matrix insensitive	need for national projects, Pb is missing

Fitness for the purpose : Protocols in Delft



Fitness for the purpose : Elements asked for in Delft



Fitness for the purpose : Accuracy

Accuracy = trueness + precision

Trueness: As high as possible

Precision: Often 10-30 % suffices;
sometimes even 100% can be acceptable

Marketing Strategies

	Requested turnaround time	Willingness to pay	No of samples /regularity	Ease of analysis
National economy: - industry - mining - agriculture	medium	+++	+	+/-
Trade - companies - customs	fast	++	++	+
Governmental agencies - environmental - health - agriculture - mining	slow	+/-	++	++
Universities/research institutes	slow	-	+++	++
Medical	medium/fast	+/++	+/+++	-/+++

Scientific customers

- Customers that use the service (test result, radioisotope…) in a scientific research project
  - Universities
  - Research Institutes
  - Government
  - Non-governmental organizations
  - Private sector
- Insufficient resources to pay for the service

Scientific customers

- Non-routine analyses
- Problem not always well defined
- Additional research/tests needed
- Extent of service (no. of tests, products to deliver) unclear
- Limited budget available

Scientific customers

So, why would you do it?

Scientific customers

So, why would you do it?

- It matches on-going research in the own facility
- It may end-up in a big project with ample budget for routine services
- Public relevance

Scientific customers

Relevance and reactor utilization are (sometimes, often) more important than generating income!

Scientific customers

Pragmatic approaches

- Price reduction and/or
- Payment ‘in-kind’:
  - Co-Authorship in publications
  - Equipment donation
  - Additional manpower by customer
  - Access to complementary facilities at customer
  - Co-applicant in externally funded project

Scientific customers

Advantages

- Enhanced research reactor utilization
- Involvement in other networks
- Publications in highly ranked journals
- Outreach of facility's opportunities

Scientific customers

Examples from Delft

Universities:

- 1970s-1980s: Geosciences, archaeology
- 1970s-1990s: Biomonitoring
- 1980s - present: Epidemiological research, Nail clippings
- 2000s: Drug targeting, radioisotope production
- Current: Medical/VeterinaryArchaeological research

Scientific customers

Example: Epidemiological research

1980s: Started as PhD project, Se and breast cancer
Medical doctor was trained to do all the analyses by himself in Delft (including irradiations)

....

Outcome:

2000s: All nail clipping projects fully externally funded
Projects funded in USA, outsourcing the analyses to Delft
EU funding for projects from UK, Poland, Italy, Israel

Publications: 21
incl. Cancer, Epidemiology, Biomarkers & Prevention
New. England J. of Medicine

Scientific customers

The New England Journal of Medicine

MERCURY, FISH OILS, AND THE RISK OF MYOCARDIAL INFARCTION

ELISEO GUALLAR, M.D., DR.P.H., M. INMACULADA SANZ-GALLARDO, M.D., M.P.H., PIETER VAN'T VEER, PH.D., PETER BODE, PH.D., ANTTI ARO, M.D., PH.D., JORGE GÓMEZ-ARACENA, M.D., PH.D., JEREMY D. KARK, M.D., PH.D., RUDOLPH A. RIEMERSMA, PH.D., JOSÉ M. MARTÍN-MORENO, M.D., DR.P.H., AND FRANS J. KOK, PH.D., FOR THE HEAVY METALS AND MYOCARDIAL INFARCTION STUDY GROUP*

ABSTRACT

Background It has been suggested that mercury, a highly reactive heavy metal with no known physiologic activity, increases the risk of cardiovascular disease. Because fish intake is a major source of exposure to mercury, the mercury content of fish may counteract the beneficial effects of its n−3 fatty acids.

Methods In a case–control study conducted in eight European countries and Israel, we evaluated the joint

coronary heart disease among residents of the Kuopio area in Finland whose hair samples had increased levels of mercury.[6,7] The participants in that study, however, had relatively high levels of mercury, which were derived largely from locally contaminated freshwater fish.

Fish intake is a major source of exposure to mercury, mainly in the form of methylmercury.[2] Intake of

Impact factor: 23.9

(J.Radioanal.Nucl.Chem. : ~ 0.5)

Scientific customers

Examples from Delft

Government, NGOs:

- 1990s: Plastics

Outcome:

National norm prescribing INAA as the preferred technique for the determination of Cd in plastics.

Massive number of requests for analyses by industry

Plastics from Household Waste as a Source of Heavy Metal Pollution

An Inventory Study Using INAA as the Analytical Technique

P. Bode,*,[1] M. De Bruin,[1] Th. G. Aalbers,[2] and P. J. Meyer[2]

Biological Trace Element Research Editor: G. N. Schrauzer © 1990 by The Humana Press Inc.

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Journal of Radioanalytical and Nuclear Chemistry, Articles, Vol. 167, No. 2 (1993) 361–367

THE USE OF INAA FOR THE DETERMINATION OF TRACE ELEMENTS, IN PARTICULAR CADMIUM, IN PLASTICS IN RELATION TO THE ENFORCEMENT OF POLLUTION STANDARDS

P. BODE

Journal of Radioanalytical and Nuclear Chemistry, Vol. 244, No. 3 (2000) 531–535

Sampling studies of plastics and its recycling process using normal and large sample INAA

S. J. Hogewoning, P. Bode*

Scientific customers

Examples from Delft

Medical institutions:

- Request for radionuclide purity assessment of radiolabeled compounds

Outcome:

New large externally financed project on drug targeting for radioimaging

Scientific customers

General

Scientific customers may have a higher impact to the sustainability of a (university) facility than fully paid services.

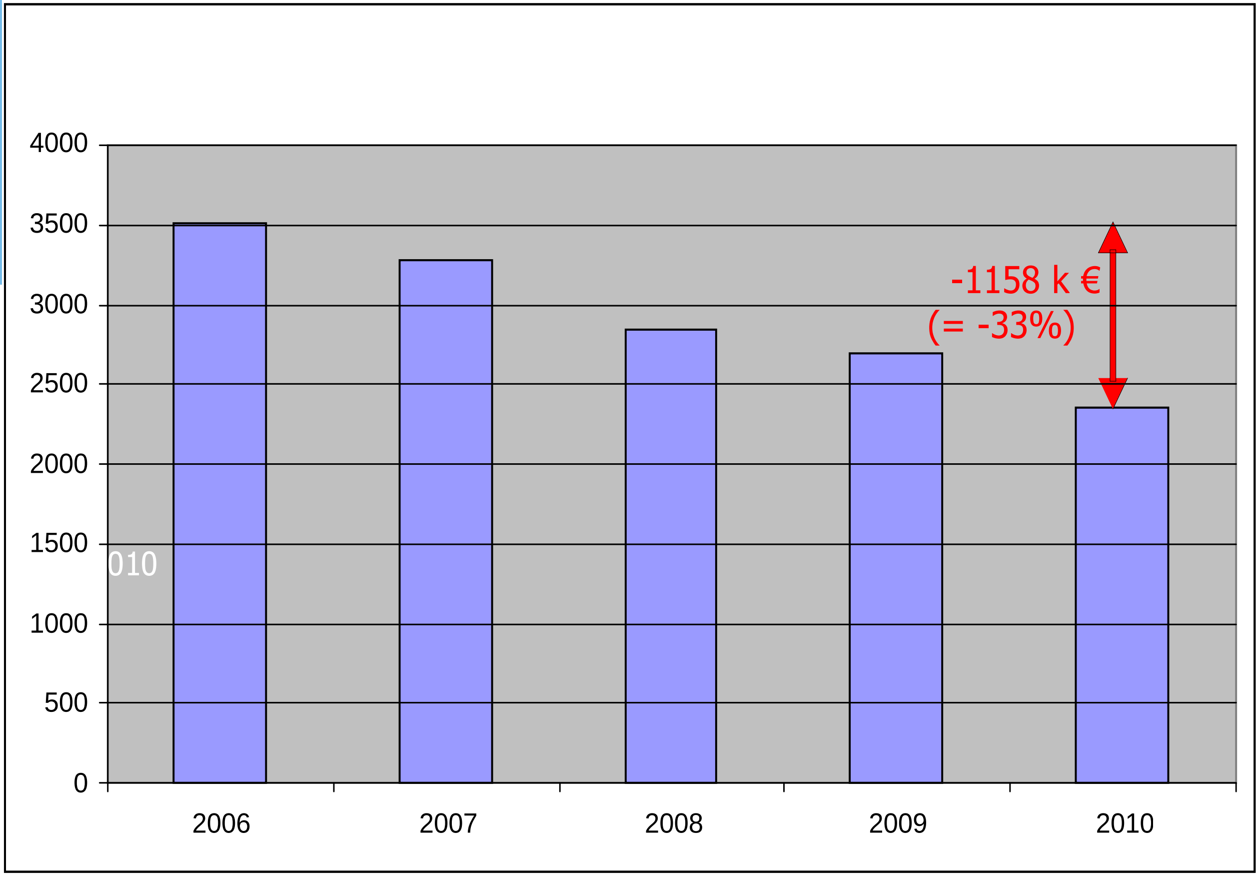
Current Services at Reactor Institute Delft

Facilities and Services: Practical aspects

+ Scientists do not have to spend time in routine analyses
+ F&S takes care of maintenance and availability of major instruments
+ F&S has all technical support staff
- Scientists have to pay benchfees for their 'own' instruments + facilities
- Priorities are based on income generated, not on impact/visibility/PR
- Very limited opportunities for exploring research without payment
- F&S staff does not support IAEA fellows, nor training of students using the facilities

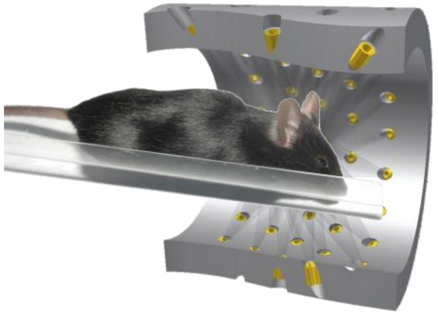
A bright future?

New budget cuts by government ….

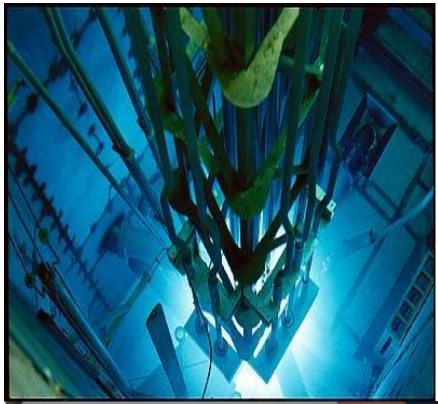


A bright future?

Yes: Exciting developments in Delft and beyond



- 2009: Young full professors at all positions
- 2009: MSc Nuclear Science & Engineering
- 2009: Radiotracer micro imaging: Micro-SPECT
- 2010: 500 keuro for n-diffractometer
  1000 keuro (4 years) for plant security
  1600 keuro for renewal of reactor instrumentation
- 2011: 900 keuro for RID operations
  Upgrade reactor and (beam)facilities: OYSTER?
- 2012/3: Energy Supply by Research Reactor?
- 2012/3: Proton Cancer Therapy Clinic?



The End (of this presentation)

www.rrr.tudelft.nl and ww.rid.tudelft.nl