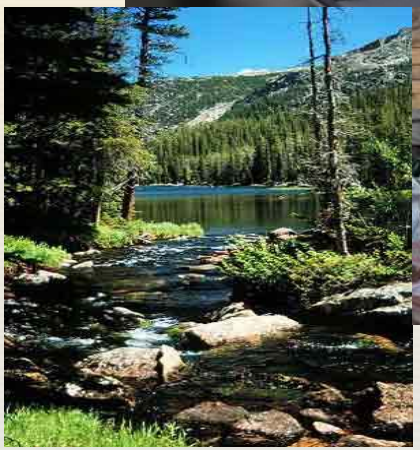
Nuclear Sciences and Applications:

Serving Basic Human Needs



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International Atomic Energy Agency

“We will not enjoy development without security, we will not enjoy security without development, and we will not enjoy either without respect for human rights.”

Kofi A. Annan
March, 2005

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The Department of Nuclear Sciences and Applications

Our Mission:

To contribute to sustainable development in Member States by the use of nuclear sciences and their applications in food and agriculture, human health, industry, water resource management and environmental monitoring and protection

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Core NA Topics

Diagnosis and Treatment of Disease

Environment

Water Resources

Food Safety

Human Health

Sustainable Agriculture

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Pursuing the Millennium Development Goals

Nuclear techniques can contribute to:

- ✓ Providing better health care
- ✓ Improving agricultural productivity and food security
- ✓ Improving management of scarce water resources

- ✓ Improving understanding of and management of the environment
- ✓ Achieving sustainable development

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Implementation Mechanisms: I. Coordinated Research

Applied Research: **Research to evaluate technology or concepts to determine whether these can be usefully "applied", with or without further refinement, for the achievement of development objectives**

Adaptive Research: **Research to adapt already existing and well tested knowledge or technology for adoption by beneficiaries ("local tailoring").**

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Objectives of Coordinated Research Projects

- To promote research, development and transfer of nuclear technology
- To assist developing countries in building indigenous research and technical capabilities
- To provide opportunities for collaboration and exchange of experience among scientists in developing and developed countries
- To be forerunners of new projects
- To generate new knowledge

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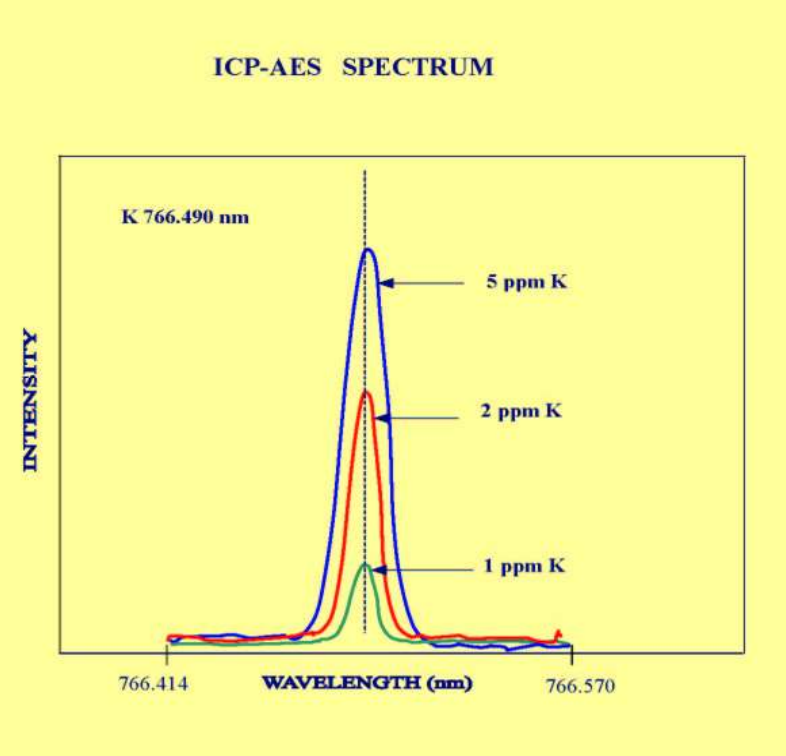
Implementation Mechanisms: II. Database Services

The IAEA plays a key international role as a repository and provider of scientific data and knowledge

- ✓ Reactors
- ✓ Fusion
- ✓ Medicine
- ✓ Water resources
- ✓ Atmospheric and marine data



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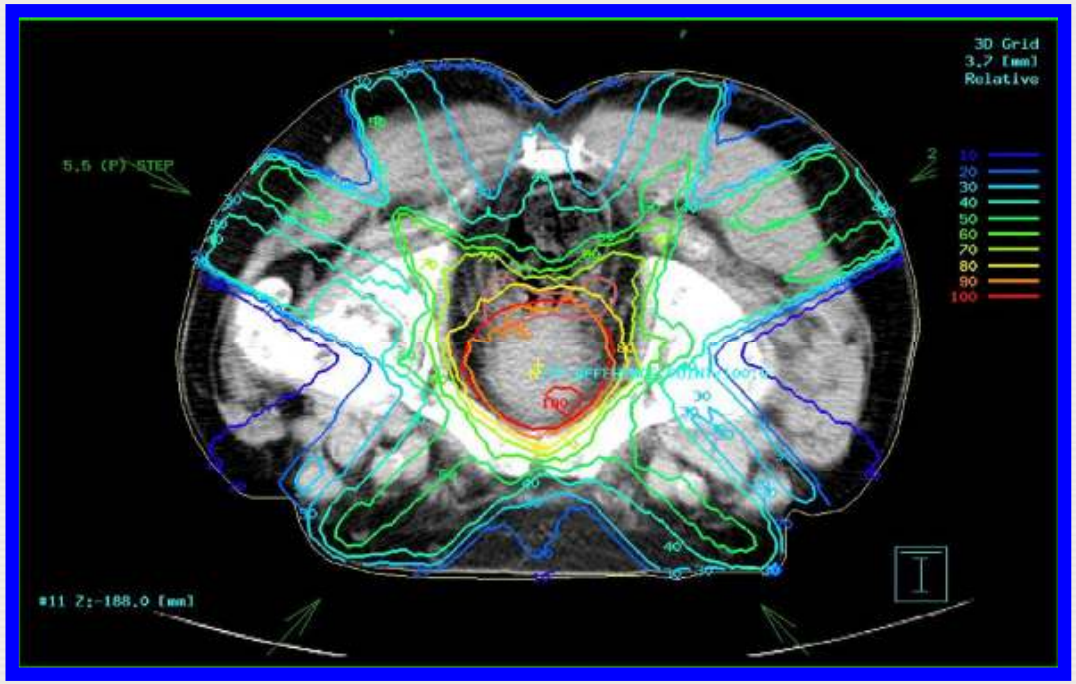
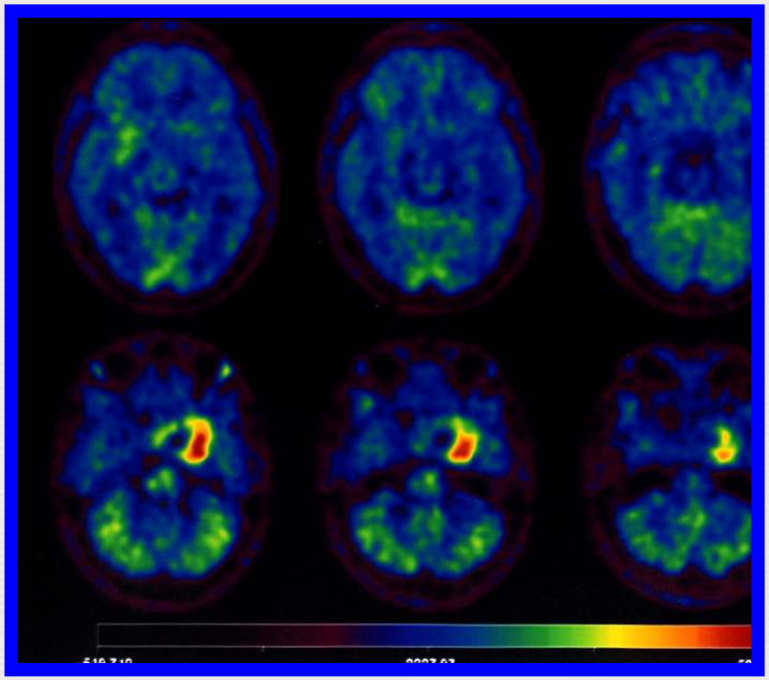
Nuclear Data for medical applications

Rationale: **Cancer therapy** **&** **Diagnosis**





Beneficiaries: **MS medical physicists, radioisotope producers, scientists …**

Objective: **Improve data for medical radioisotope production, and for patient dose delivery calculations in radiotherapy**

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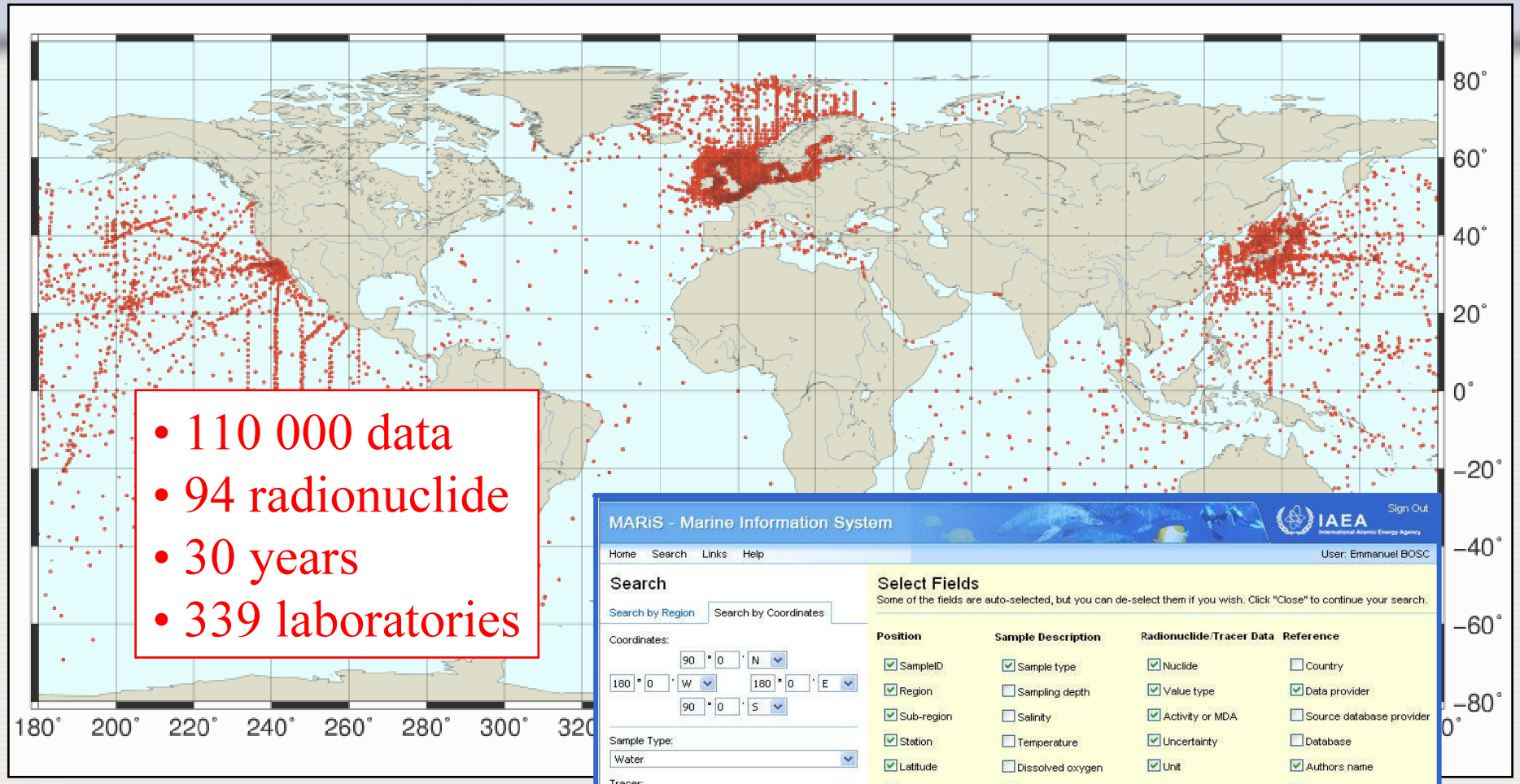
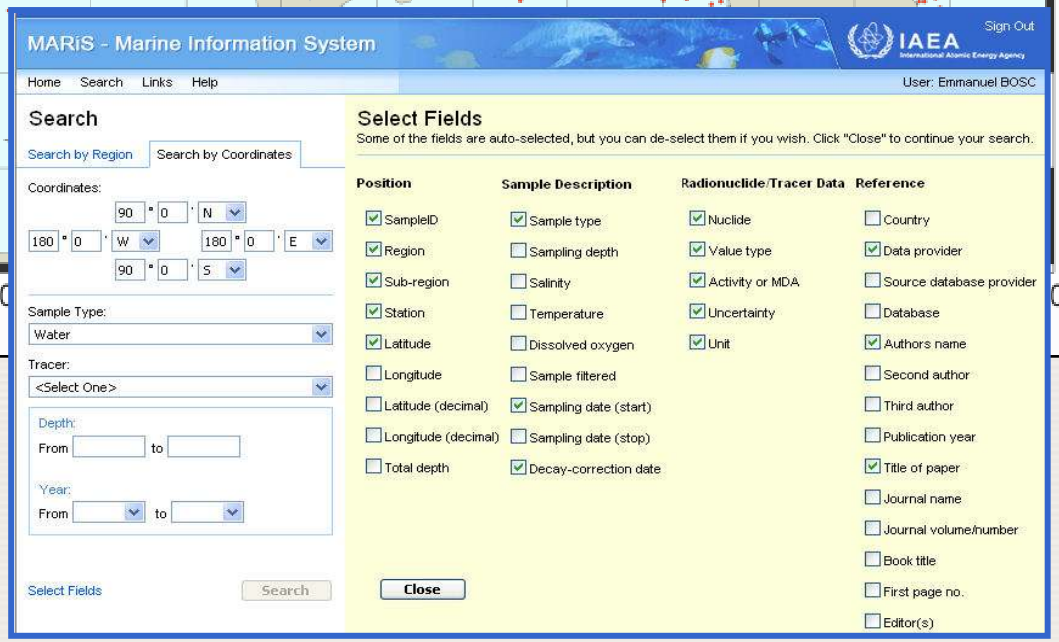
On-line access to world-wide marine radioactivity data



- 110 000 data
- 94 radionuclide
- 30 years
- 339 laboratories



http://maris.iaea.org/

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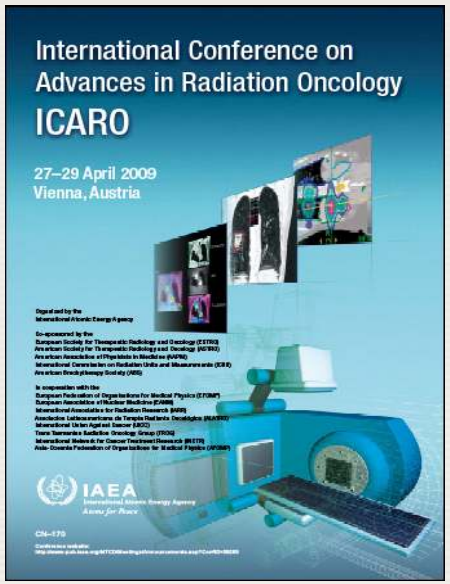
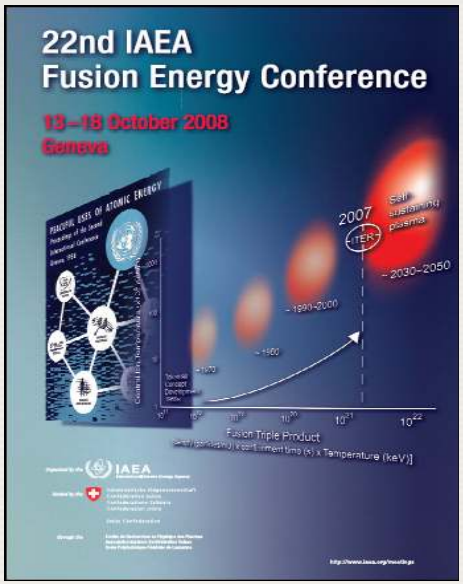
Implementation Mechanisms: III. Meetings, Publications, Norms and Standards etc.

Meetings:

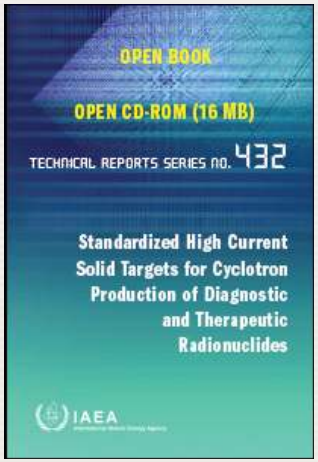
- Symposia
- Workshops
- Advisory Groups
- Seminars etc.





Publications Standards:

- Proceedings
- Technical documents
- Manuals
- Standard Operating Procedures



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Implementation Mechanisms: IV. Technical Cooperation

A partnership (MS, TC and TDs) for sharing of nuclear expertise and technology through training and transfer of technology to contribute to Member States activities in human development, nuclear power, and nuclear safety

Technical departments assure the technical integrity of project concepts and throughout the life cycle of actual projects

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The Department's Partners



- The Food and Agriculture Organisation (FAO)
- World Health Organisation (WHO)
- World Bank
- United Nations Environment Programme (UNEP)
- International Centre for Theoretical Physics, Trieste

…… and many, many others

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Nuclear Applications for Food Safety and Security

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Sterile Insect Technique for Insect Pest Control

Pests reduce world food production by 25 to 35% and hinder agricultural trade

Heavy reliance on pesticides (~US$25 billion) causes environmental damage

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SIT Implementation

1. Large-scale production of insects and sterilization by radiation

2. Release of sterile insects by air on scheduled basis into target areas

3. When they mate with wild insects no offspring is produced: *population falls*

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SIT Successes in Libya: New World Screwworm

- New World Screwworm (NWS) causes *myiasis*, destructive and potentially fatal for livestock and humans
- Discovered in Libya in 1988, reaching a high of 12,000 cases in 1990 and presenting serious risk to surrounding countries

Screwworm, *Cochliomyia hominivorax*

- Estimated annual costs of continuing NWS presence were US$28 million for Libya, $280 million for the region
- SIT, as part of an integrated, area-wide approach, eradicated NWS within one year, at a total cost of $66.5 million

➢ **Cost-benefit ratio of 50:1, with total economic benefits estimated at $300 milllion per year**

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SIT for Combating Malaria?

- Malaria, transmitted by *Anopheles* mosquitoes causes
  - 2 million deaths annually
  - 300 – 500 million cases of clinical malaria annually

- Feasibility studies for SIT underway, long-term effort with uncertain outcome, but great humanitarian value

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Plant Mutation Breeding

- Integrated technologies for enhanced mutation induction
- Irradiation of plant material can be used to induce changes for desired characteristics
- Rice in Vietnam

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Plant Mutation Breeding: Healthier, More Productive Crops

- Cotton in Pakistan - higher yield by factor of 2, grown on 70% of acreage
- Sorghum in Mali – drought tolerant; higher yielding by 10-30%
- Mutant durum wheat varieties in Bulgaria
- Pears in Japan - resistant to black spot disease; saving pesticide by factor of 4

New variety of pear more resistant to disease

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Land Management

Sustainable agriculture for Greenhouse Gas (GHG) control

- Assessing farming practices to reduce GHG emission
- Adaptation to climate change for sustainable food production

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Food Safety: Public health, international trade, economic growth

- Food irradiation used by over 30 countries to ensure the safety and quality of foods and to reduce spoilage

- Products treated include meat and meat products, fresh fruits, spices, dried vegetable seasonings
- IAEA, FAO and WHO continue to support the harmonization and application of standards on irradiation by providing assistance and training

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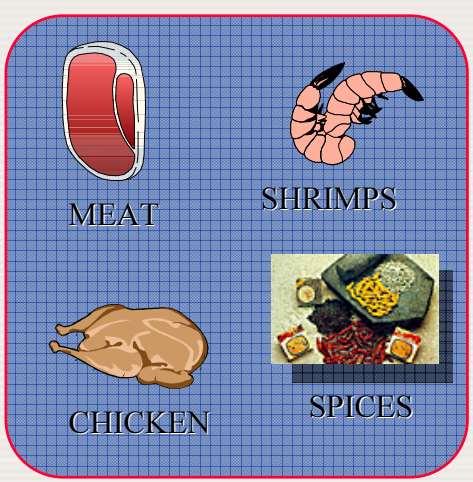
The Economics of Food Irradiation

Codex General Standard for Irradiated Foods

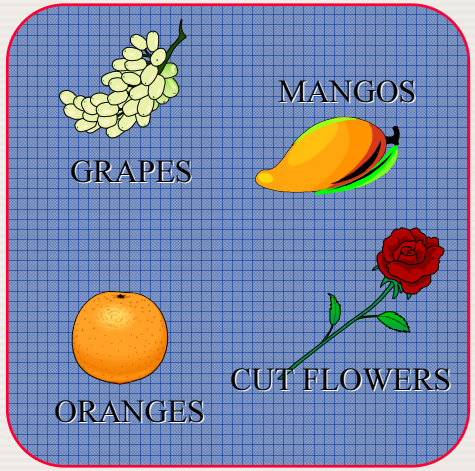


ENSURE FOOD HYGIENE

FOOD SAFETY

OVERCOME QUARANTINE BARRIERS

TRADE



applied

in over 20 countries including USA, GER, NET, FRA, CPR, INS, MEX

accepted

USA, CANADA, MEXICO, ASEAN

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New Developments and Frontiers

Traceability as an Approach to Control Food Contaminants and Improve Food Safety

Stable isotope ratio measurements provide a unique and powerful tool to ***control***:

- Food contamination at source (safety)
- Food authenticity (trade)
- Food adulteration (quality)

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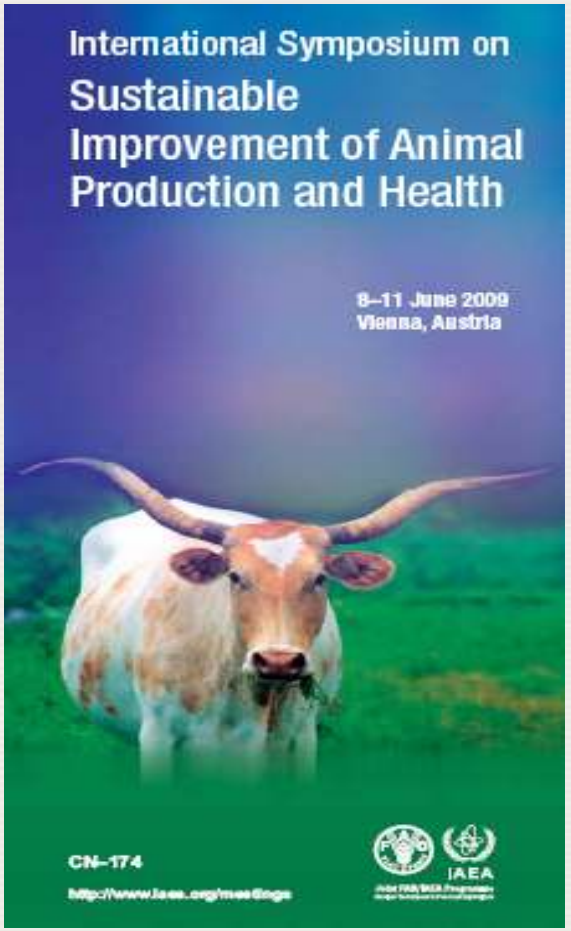
Supporting Animal Health and Breeding

Productivity increased through nuclear techniques that help to:

- Diagnose and treat livestock disease
- Promote reproduction and breeding
- Develop new strategies for feeding livestock
- Establish environmentally sensitive and resource efficient production methods



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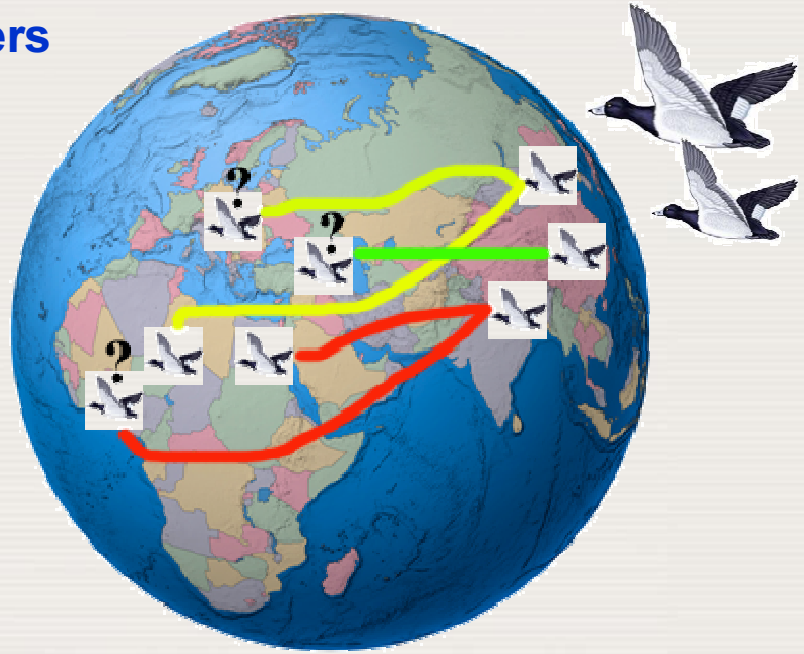
New Developments and Frontiers

Linking bird migration to Avian Influenza

Stable Isotope (SI) 'profile' in feathers

define habitats of wild birds



- **Non invasive monitoring of birds**
- **Relate SI patterns found in different locations to identify origin of migratory birds**
- **Relate SI identified birds with Avian influenza (AI) outbreaks or virus isolations**

Learn about bird migration to better understand the RISK of spread of Avian Influenza which could infect MAN

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Improving Water Resources Management

Over 1.2 billion people lack access to safe, reliable supplies, and their numbers are increasing

The World Summit on Sustainable Development's Challenge:

To halve the number of people without access to clean water/sanitation by 2015

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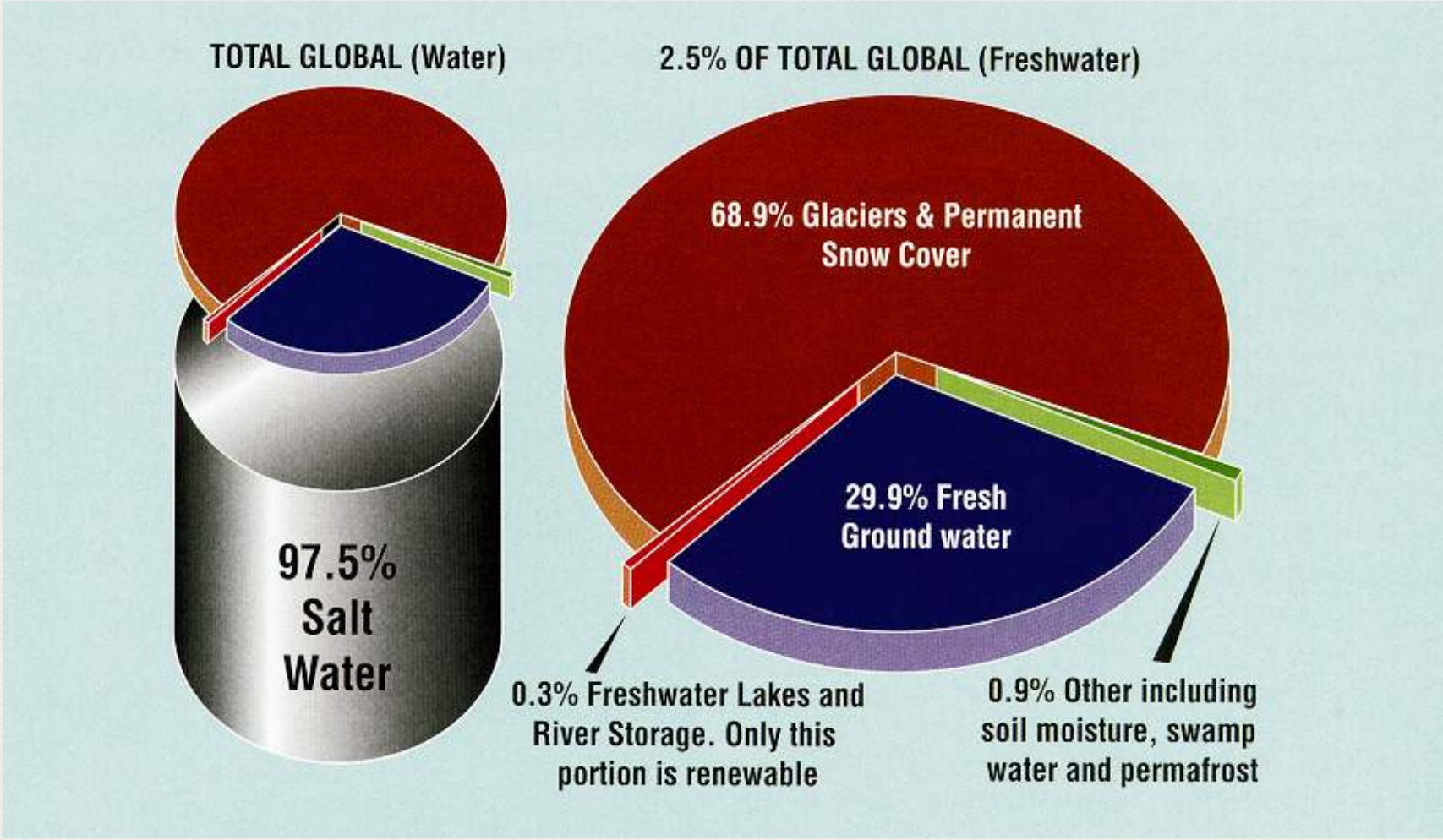
Global Water Resources



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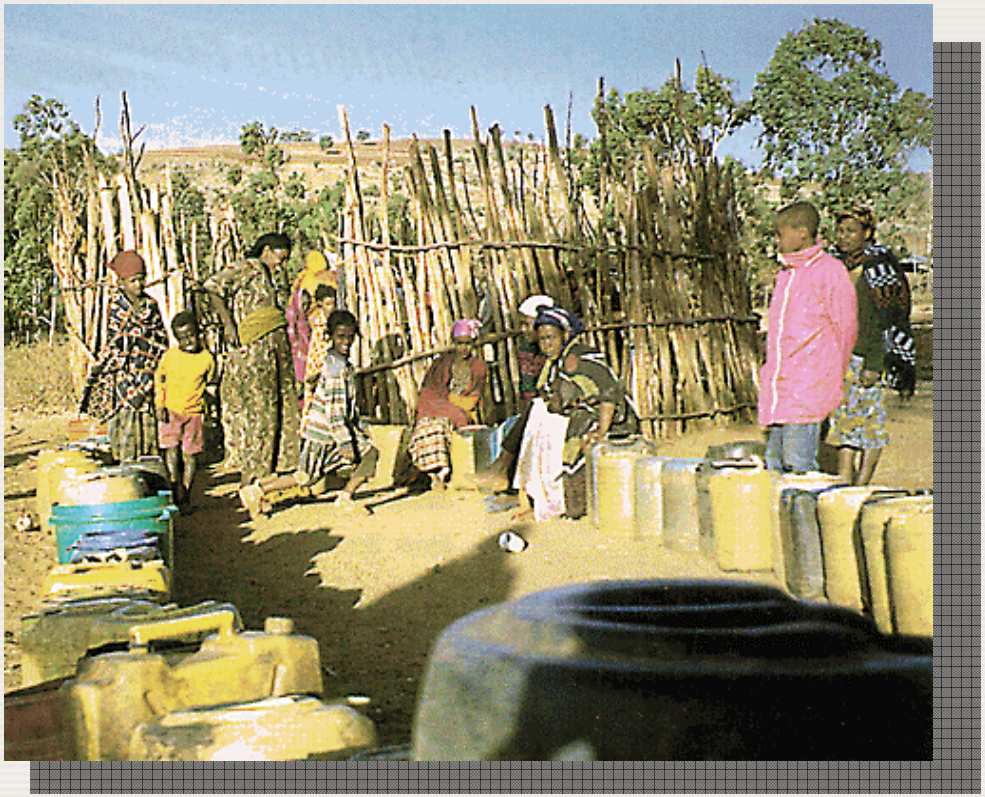
Isotope Hydrology: A Unique Approach for Assessing Water Resources and Dynamics



Isotopes can be used to:

- Understand the origins and dynamics of water
- Map underground water streams and aquifers
- Investigate supply contamination

This information is vital for developing effective strategies for sustainable usage

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Increasing Water Availability and Sustainability

Groundwater assessment in Caracas, Venezuela

- reduced the severe drinking water deficit (260 million liters per day) by 30%

Shallow groundwater assessment in the Nile valley, Egypt

- pointed to a reserve of deep groundwater (Nubian sandstone aquifer) allowing an increase in the water supply of up to 20%

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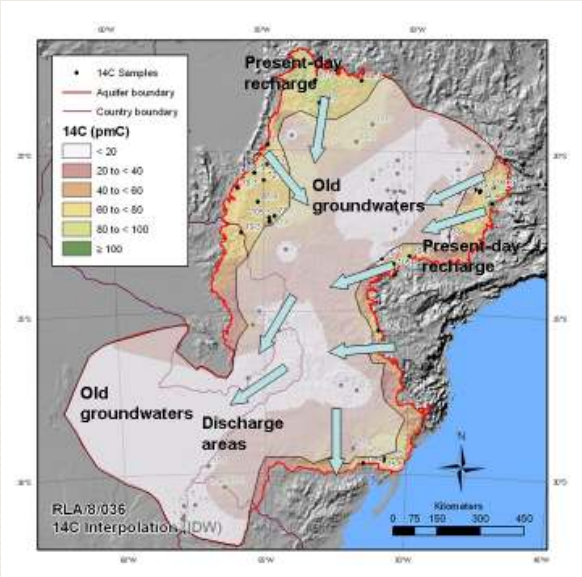
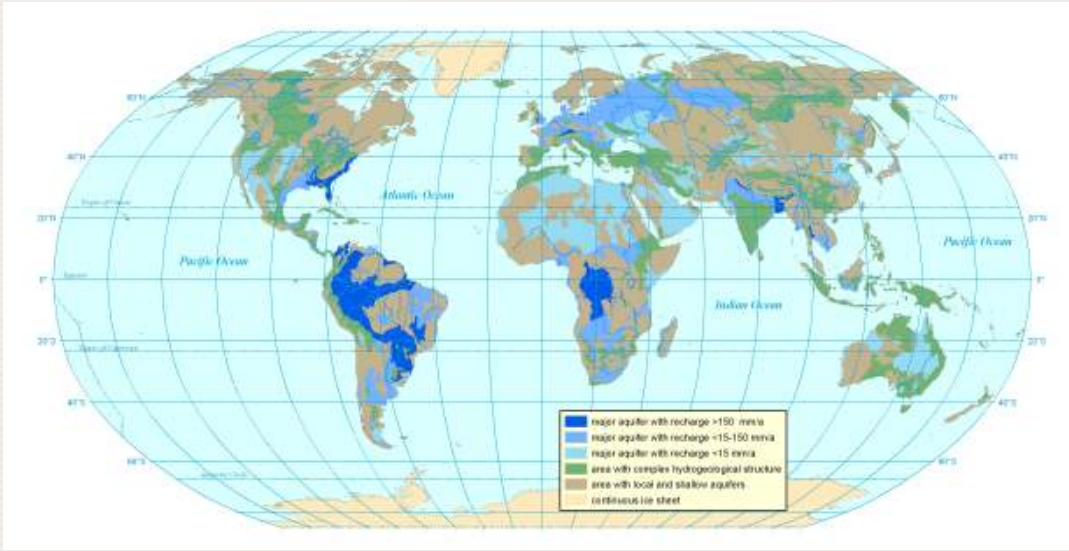
Improving Management of Transboundary Waters



Water ages & flow directions of the large Guarani transboundary aquifer in South America



World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) "Groundwater Resources of the World" (scale 1:50 000 000)

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Isotope Hydrology Laboratory

The Isotope Hydrology Laboratory contributes to the Water Resources Programme as:

- A provider of the isotopic data necessary to perform hydrological analysis
- A provider of training, technical assistance and quality assurance for other hydrology laboratories
- A leader in the development and improvement of new and existing analytical techniques
- A leading provider of reference materials that are of critical importance to the hydrology community

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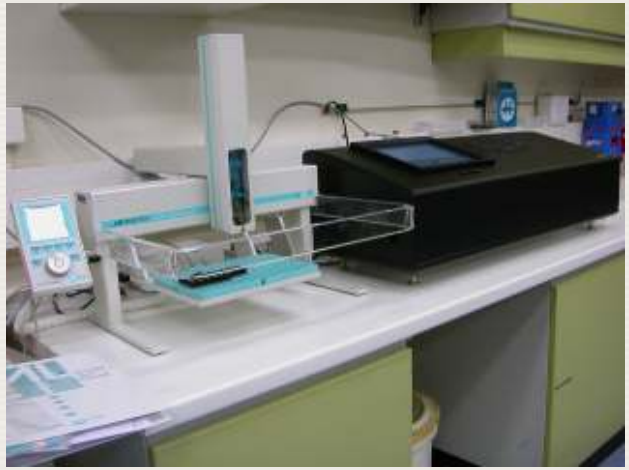
New Developments and Trends

Making isotope measurements easier and less costly through new analytical approaches

Low cost, portable radon-222 analyzers can map groundwater discharges directly in the field. This system was used on board a laboratory ship during the International Joint Danube Survey-2.

Easy to use laser based systems for stable isotope analyses will also dramatically increase the use of isotopes in hydrologic, atmospheric, and ecologic studies.



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Monaco Marine Environmental Laboratory

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Understanding the Marine Environment

- *The ocean covers 70% of the planet*
- *Marine ecosystems are vital for food supplies*
- *Oceans play crucial roles as regulators and indicators of climate conditions*

Testing for harmful algae blooms that can deposit toxins in seafood

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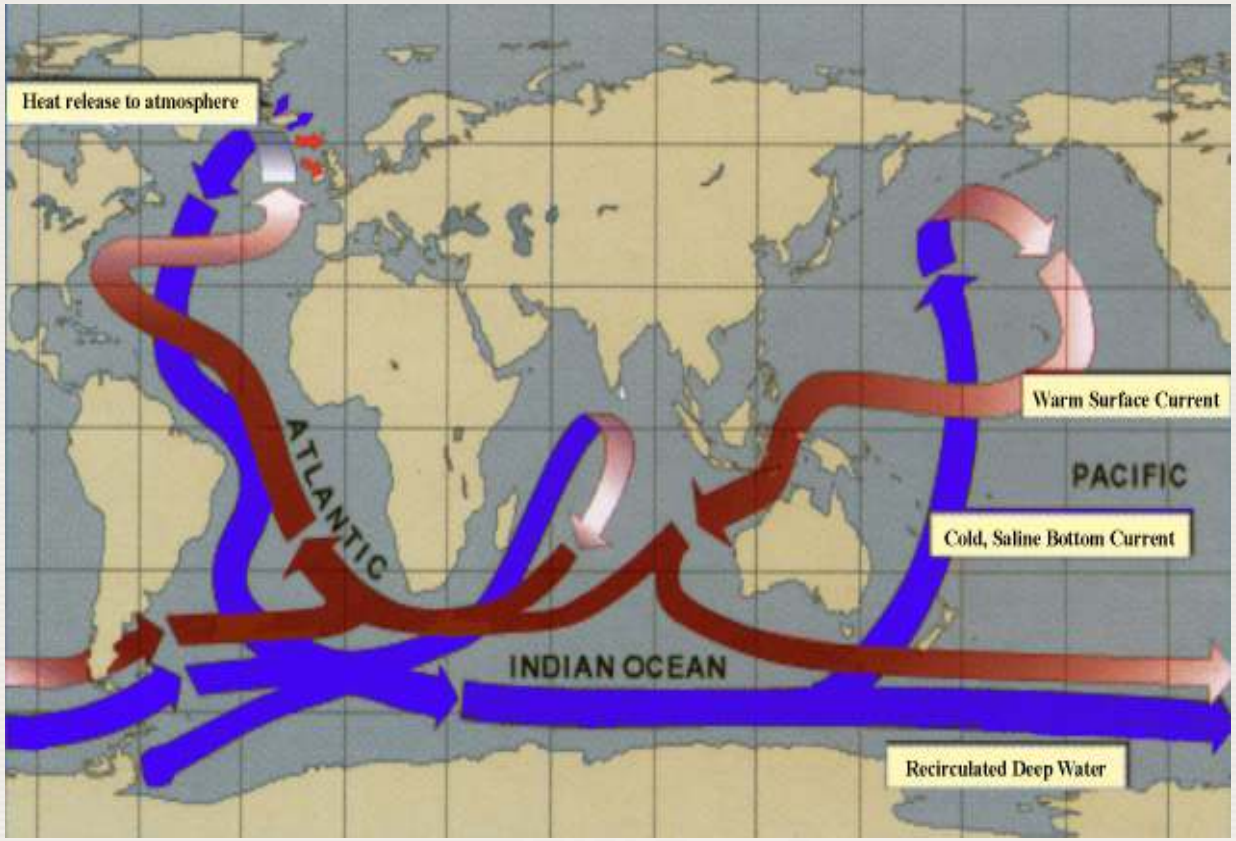
The Oceans and our Global Environment



The global ocean circulation “conveyor” belts form a key climate system that is monitored using radionuclides

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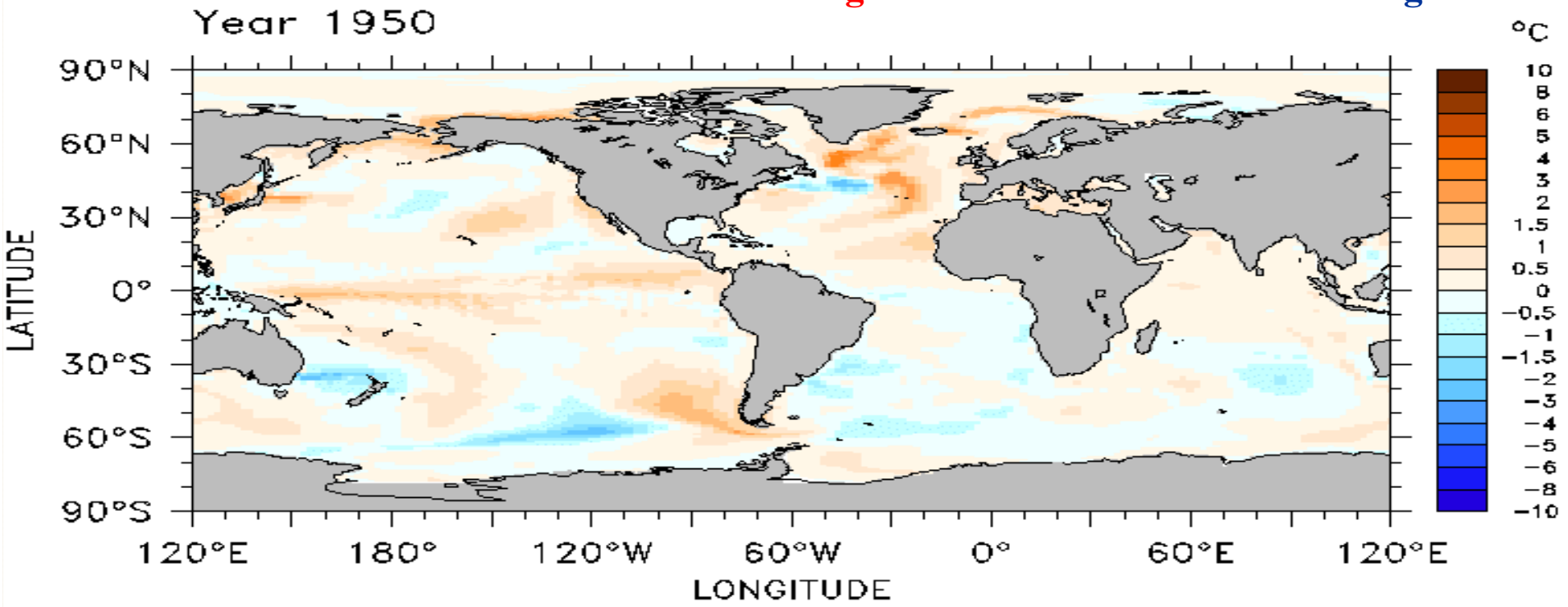
The Oceans and Global Warming

Future Change* in Sea Surface Temperature

Reddening indicates surface water warming



Coupled climate-carbon model results from IPSL/FRANCE:

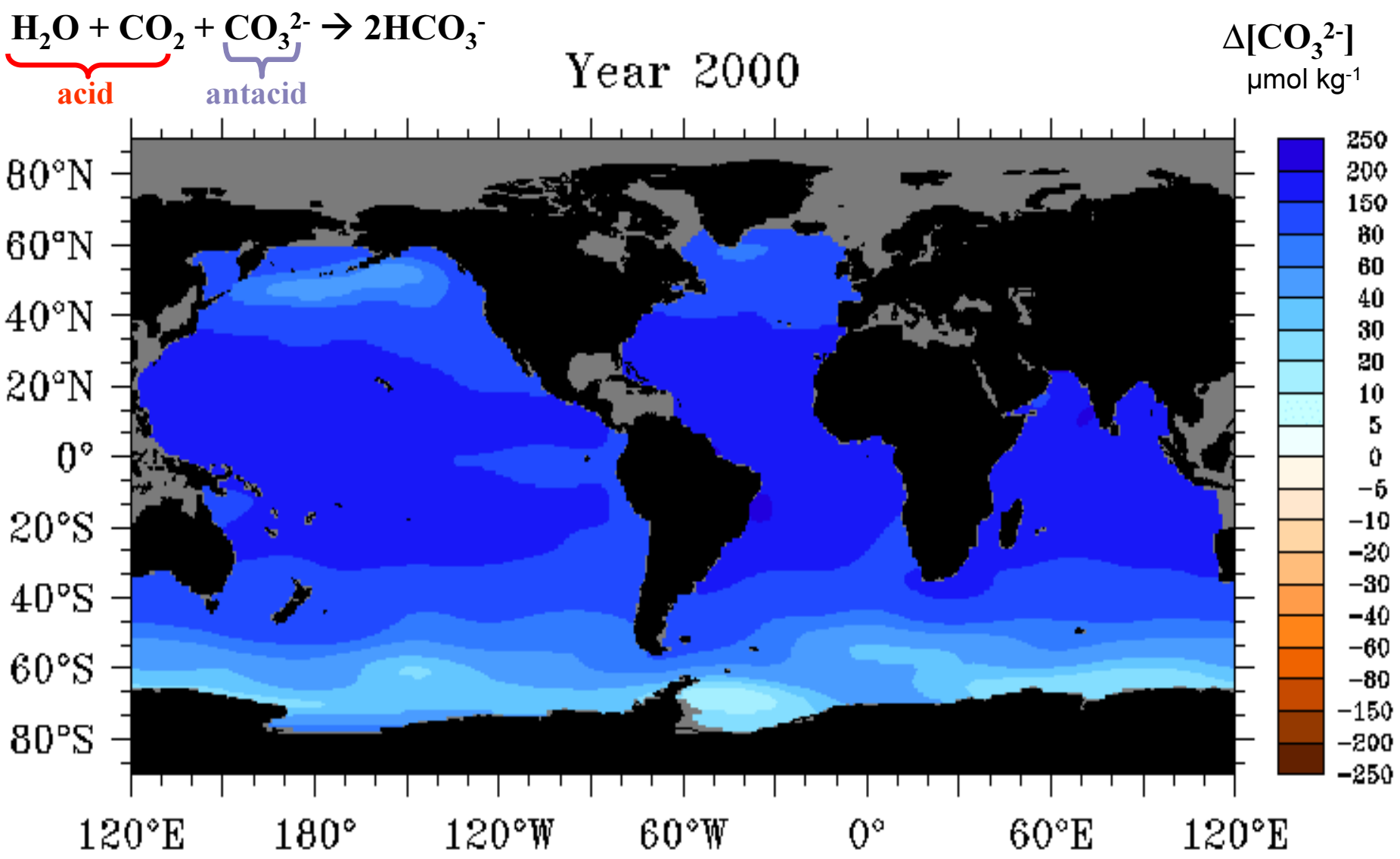
Simulation IPSL.CM4,
LOOP2 – LOOP1

**relative to preindustrial ocean*

Ocean Acidification

$H_2O + CO_2 + CO_3^{2-} \rightarrow 2HCO_3^-$

acid antacid

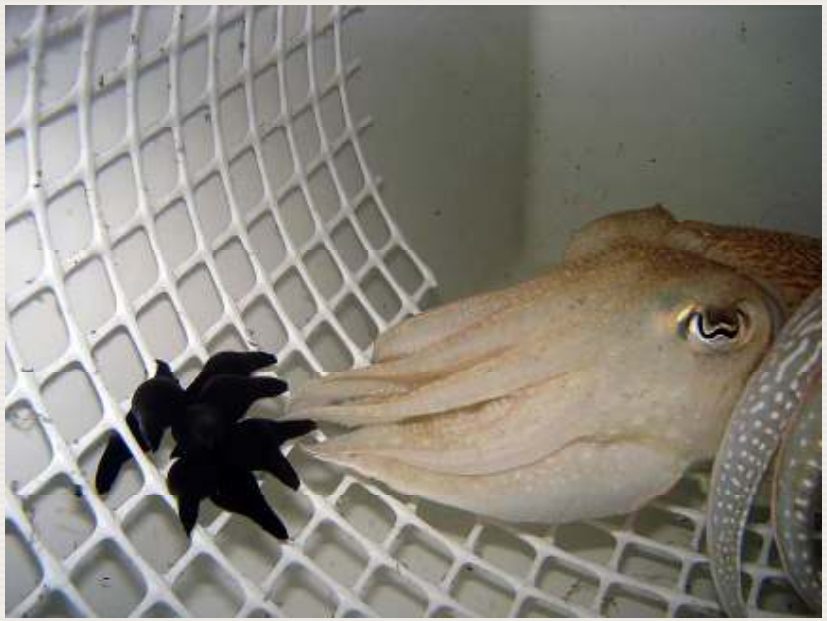


Reddish colours: seawater becomes corrosive to some marine animal shells

Orr et al. 2005 (Nature)

New Developments and Trends

Predicting the impacts of ocean acidification on seafoods and marine biodiversity



Experimental radiotracer studies assess future negative effects on marine food chains and biodiversity, which sustain commercial fisheries

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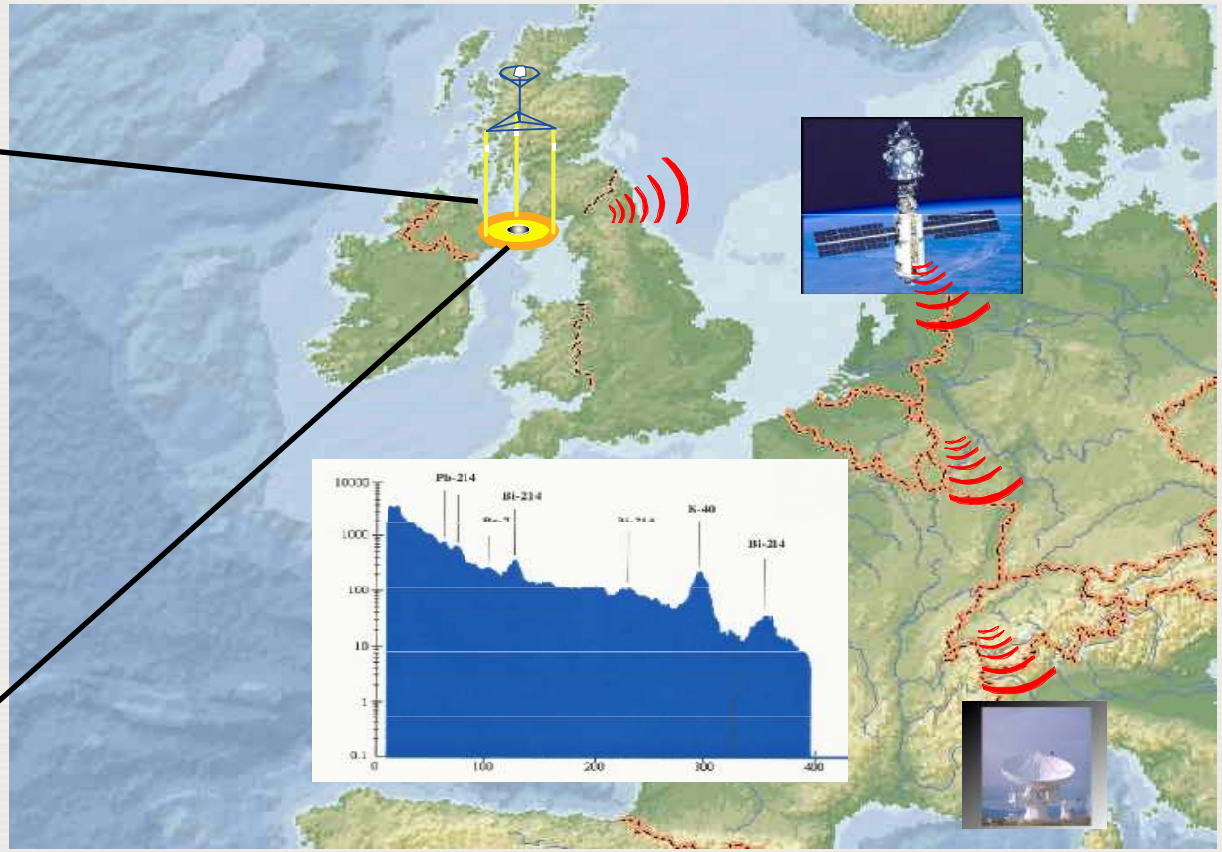
Marine Radiometrics

Stationary monitoring of gamma-activity of seawater in the Irish Sea with satellite data transmission to IAEA-Monaco



IAEA-MEL Monaco

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Seibersdorf

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The Terrestrial Environment

- Strengthening capabilities to study radionuclides in the atmosphere to measure pollution and radioactivity
- Strengthening capabilities to study radionuclides in the atmosphere for climate assessment
- Cooperating with relevant international and regional organizations, national research partners and NGOs
- Accreditation of laboratory activities in Member States (calibrations, measurements, reference material production)

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AQCS Reference Materials

The IAEA is the major world-wide provider of reference materials

These materials are critical for harmonizing laboratory measurements that impact international trade, environmental policy and emergency response

Reference materials are produced by the Agency's laboratories in Seibersdorf, Monaco and Vienna

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ALMERA Network

- To ensure reliable worldwide response to issues of international concern or emergency situations involving the release of radionuclides, the Seibersdorf laboratories coordinate the network of Analytical Laboratories for the Measurement of Environmental RAdioactivity (ALMERA)

- ALMERA currently consists of of 117 laboratories in 72 countries

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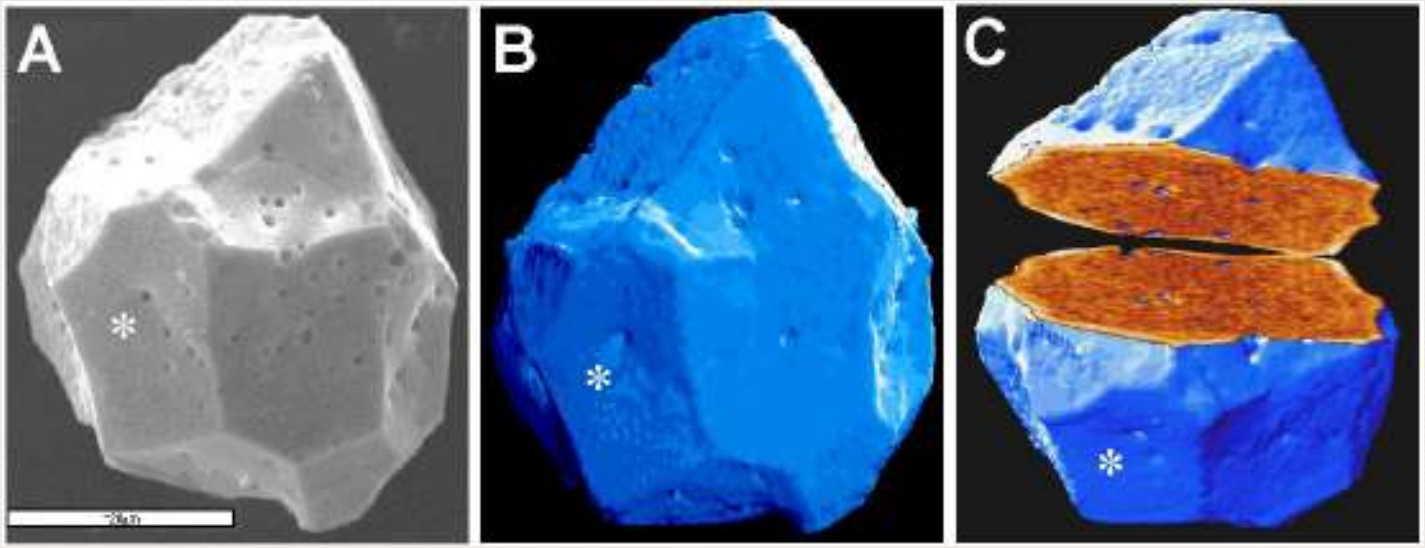
Assessing Hot Particles



"Hot particles" remain in the environment as a result of accidents or nuclear activities…

They are of interest due to their implications for radiological dose assessment, and their use for applications such as safeguards and nuclear-forensic investigations.

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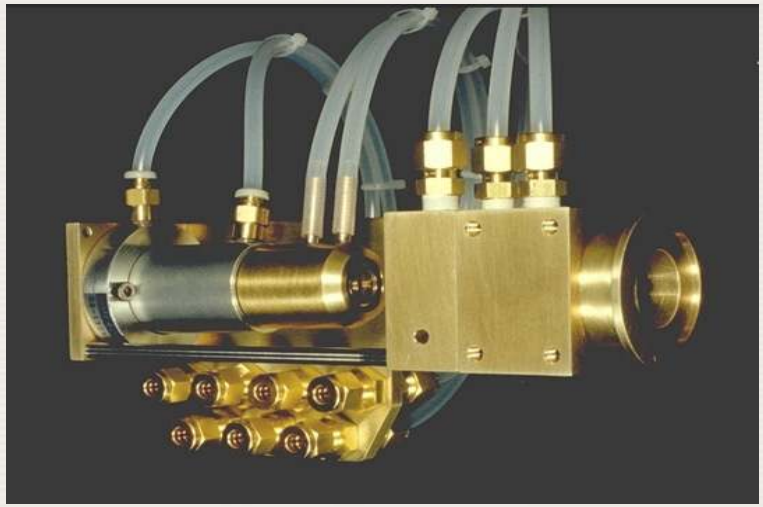
Industrial Applications of Nuclear Techniques

The many useful industrial applications of radiation technology include:

- Production of radiopharmaceuticals for medical imaging and treatment
- Non-destructive testing for structural flaws in building, bridges, ships and planes
- Treatment of industrial waste and effluents for recycling and environmental protection
- Analysis of industrial production processes to optimize input efficiency
- Development of micro and nano structures for use in improving healthcare and producing consumer goods



Accelerator for medical radioisotope and X ray production

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Preserving Cultural Heritage

- The *Saliera*, a golden 16th century Cellini sculpture stolen from a Vienna museum in 2003

- Found buried in a forest in 2006
- Using an X-ray fluorescence spectroscopy machine lent by the Agency, the original chemical composition of the sculpture is being identified and assessed for damage and optimal restoration

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Addressing an emerging crisis

Production shortages affect security of supplies of reactor-produced medical isotopes: Molybdenum-99

Diagnostic imaging using Technetium-99m is vital for management of cardiac and cancer patients.

Governmental support and international cooperation are essential for sustainable benefits to patients.

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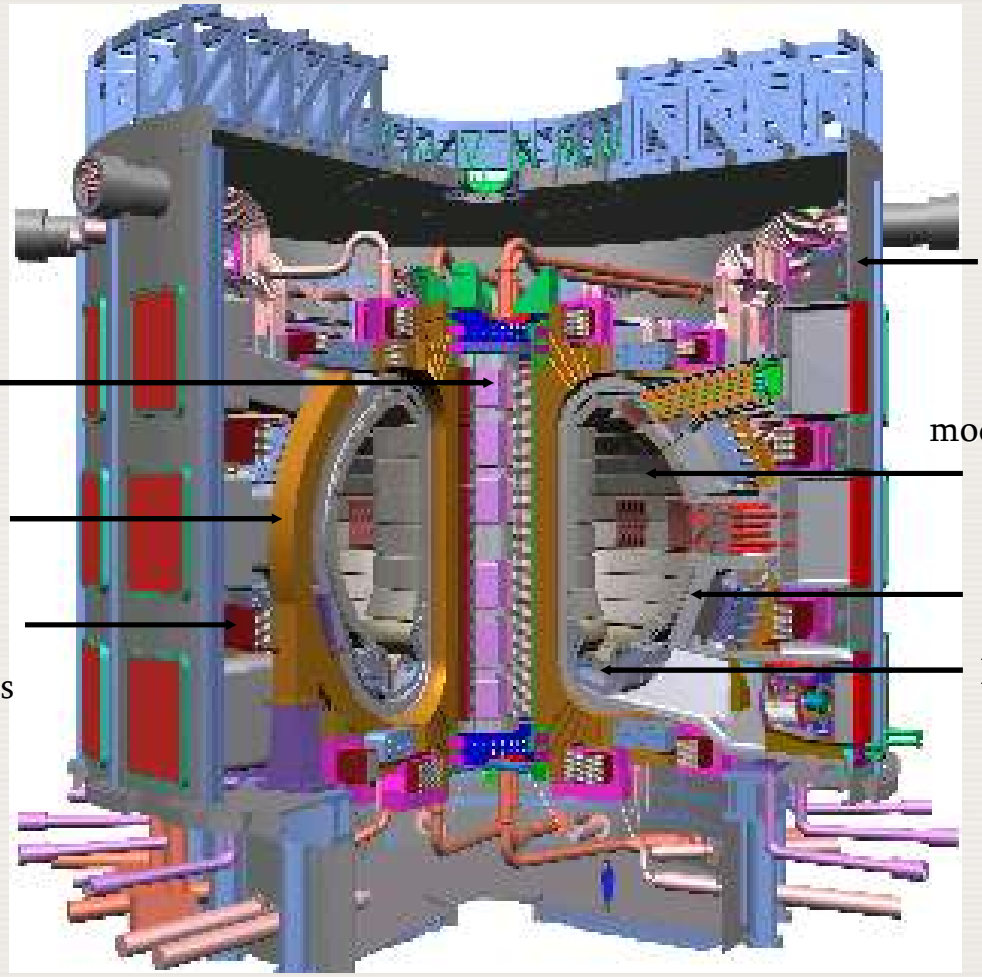
International Thermonuclear Experimental Reactor



The Agency:

Has been involved in ITER from the start

Is the depository of ITER agreement, ratified in 2007

Will help non-party Member States to benefit from ITER

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The Potential of Fusion

- A long term, sustainable, economic and safe energy source for electricity generation
- Minimal long-lived radioactive products
- Possible recycling of some reactor materials and unburned fuel
- No greenhouse gas production
- ➢ Auxiliary benefits of fusion research:

  Improvements in materials (such as ceramic, metals and coatings), industrial processes (such as welding and waste removal), electrical technology, transportation and other key areas

- *BUT*…ITER completion years away, outcome uncertain

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Atoms for Health: Disease Prevention and Control

- Nutrition
- Nuclear Medicine
- Radiobiology and Radiotherapy
- Dosimetry and Medical Physics
- Fighting a Global Cancer Epidemic

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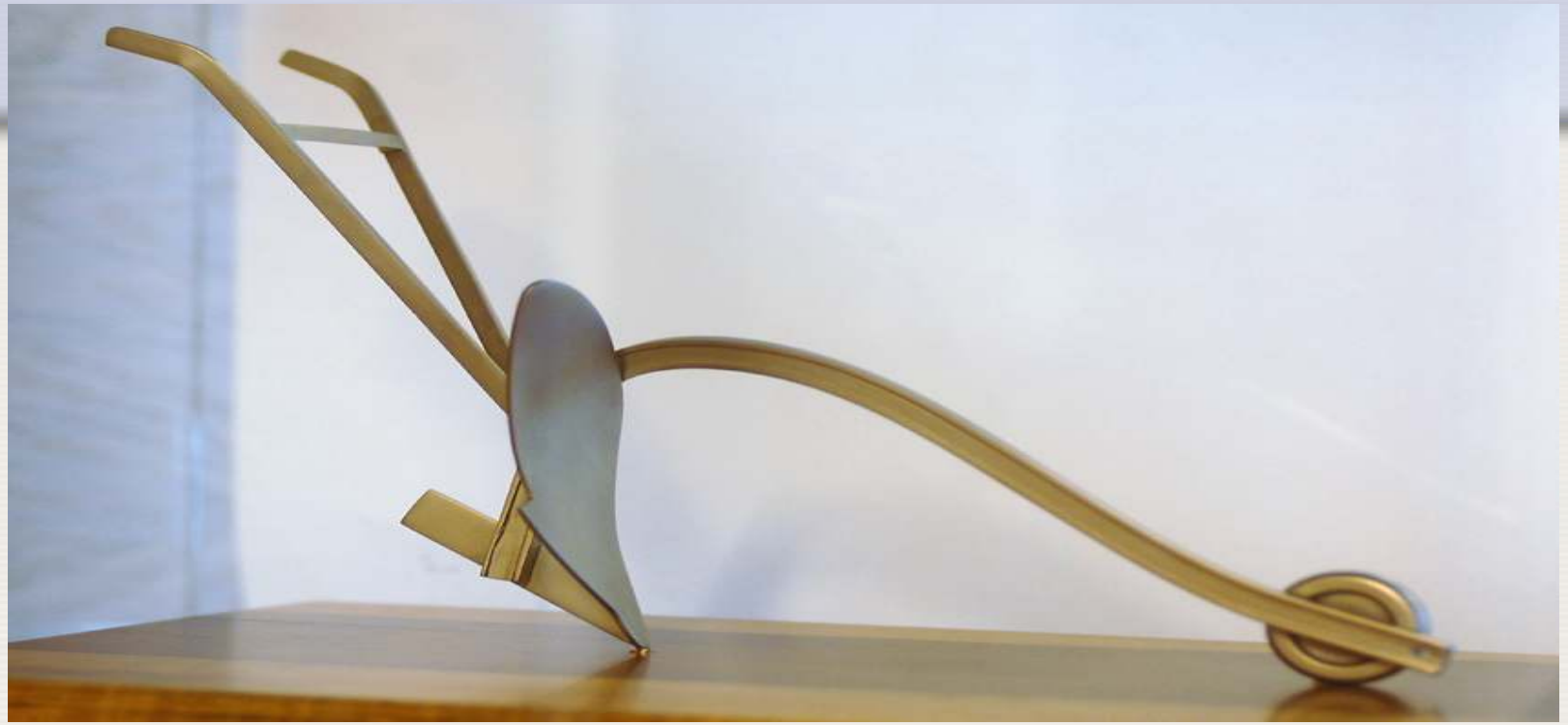

Made from material from a dismantled nuclear device, this sculpture symbolizes the commitment of the Republic of South Africa to the non-proliferation of nuclear weapons.

Presented to the IAEA by Minister Botha, 7 April 1994.

Isaiah 2:4 "And they shall beat their swords into ploughshares, and their spears into pruning hooks. Nation shall not lift up sword against nation, neither shall they learn war any more."

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Concluding Remarks

- *Global development challenges are significant, and growing*
- *Nuclear science and technology have great potential to contribute to their solutions and improve many lives*
- *The IAEA is a leader in promoting the benefits and value of these technologies, but the basic science remains to be done by the Member States*

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Thank you for your attention

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