
MOLYBDENUM-99 TOPICAL MEETING
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La Fonda Hotel
Santa Fe, New Mexico
INVAP

BARILOCHE, ARGENTINA

Background and Projects on LEU based production technologies of Molybdenum 99 within INVAP

By: Marcelo Salvatore, C. Daniel Amaya, Nique Alaniz, Carlos Vindrola, Juan José Gil Gerbino

Content

Argentina:

CNEA history & efforts, present situation

An integral approach

International Experiences:

Australia & Egypt

Projects characteristics / Results

New Developments - MIPS

Other Projects

The Future

Conclusions and Remarks

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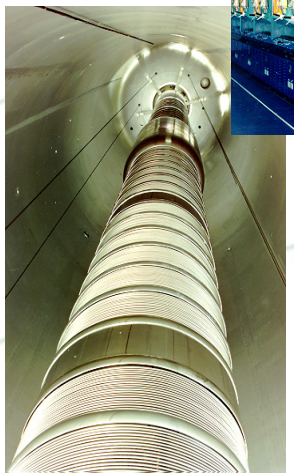
The Nuclear Program in Argentina – General Overview

Responsibility of: **The National Atomic Energy Commission**



- Argentina a Nuclear Country
- 2 NPPs in Operation
- 1 NPP in Construction
- 1 SMNP Launched
- CNEA in charge:
  - Basic R&D
  - Fuel Cycle
  - Radioisotopes
  - Waste Management
  - HHRR

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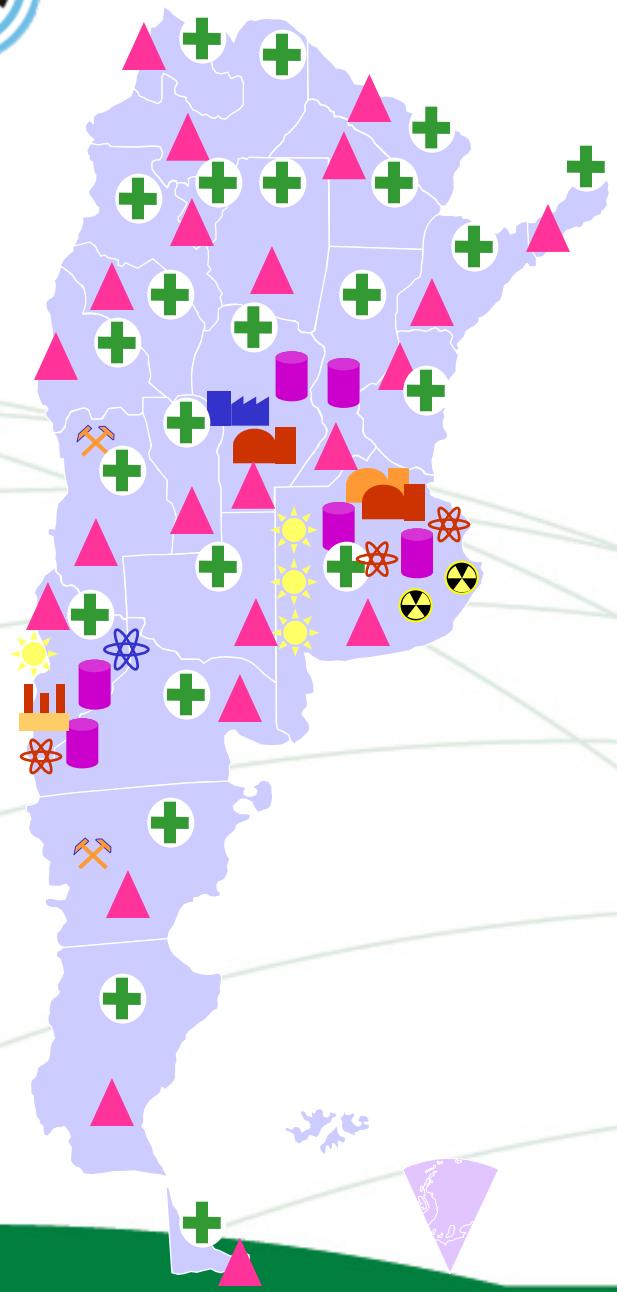
ARGENTINA



2 NUCLEAR POWER PLANTS IN OPERATION

1 NPP UNDER CONSTRUCTION

6 RESEARCH REACTORS

4 PARTICLE ACCELERATORS

3 ATOMIC CENTERS

1 TECHNOLOGY CENTER

1 HEAVY WATER PLANT

2 IRRADIATION FACILITIES

2 URANIUM MINING

1 URANIUM PURIFICATION PLANT

376 INDUSTRIAL APPLICATIONS

NUCLEAR MEDICINE

3 NUCLEAR MEDICINE SCHOOLS

68 TELETHERAPY CENTERS

57 BRACHYTHERAPY CENTERS

309 NUCLEAR MEDICAL CENTERS

45 LINEAR ACCELERATORS

408 RADIOIMMUNOASSAY LABORATORIES

NUCLEAR ACTIVITIES *(Excluding Medicine)*

>7.000 Employees

>u$s 600 millions/year

NUCLEAR MEDICINE *(Diagnostics & treatments)*

>1.500.000 Treatments/year

1.300 Facilities

3.000 Employees

u$s 350 millions

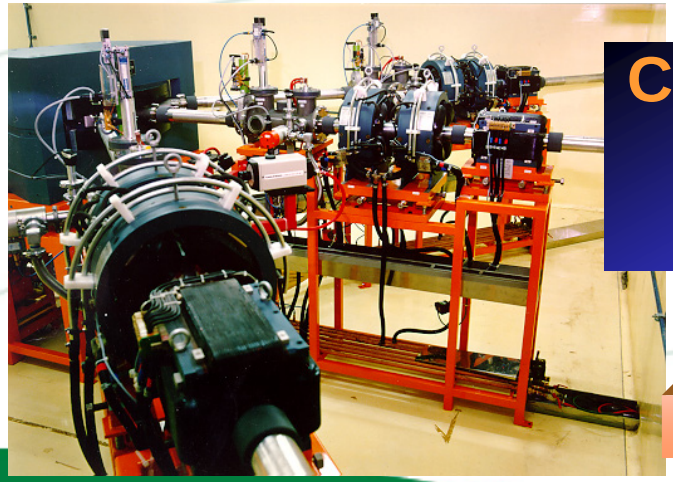
Radioisotopes Production

MTR Reactor

Moly, Iodine, Phosphorous, Samarium, Iridium, Potassium, Sodium, Gold.

CANDU Reactor

Cobalt-60



CICLOTRON

Thallium, Fluorine

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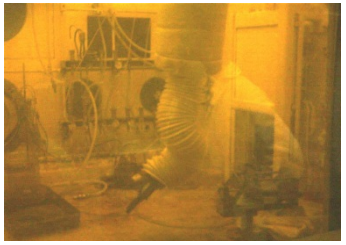
History

- Early 70s initial Radioisotope Production, I 131 and Mo99 by activation
- Middle 80s – development of Tc Generator locally and initial production of Moly 99 (with importing)
- 1998 – Partial Privatization of the Supply Chain – Generators
- 2001 – Big Economic Crisis / No cash for importing moly / No access to HEU
- 2002 – initial R&D effort to produce with LEU
- 2005 – full implementation of the LEU process / very limited importing
- 2007 – process scale up for ANSTO contract

Mo99 Situation in Argentina

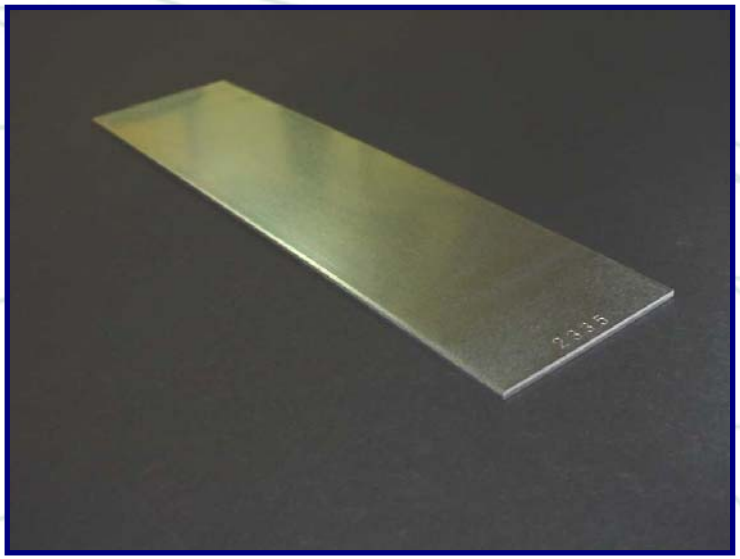
- Production of Radioisotopes on a regular basis (weekly)
- Employing the RA3 reactor (10 MW thermal-MTR type) and the radioisotope plant at the Ezeiza Atomic Center (Buenos Aires)
- **100% LEU based since 2005**
- **Product Quality: equivalent or superior to the previous HEU process**
- 400 Ci (6 day) of Mo99 per week
- Supplying (weekly), 100 % of the local market, but also 50% of Brazil demand and minor demands like the ones in Paraguay, Chile and Uruguay through third parties



PRODUCTION OF Mo-99 TARGETS

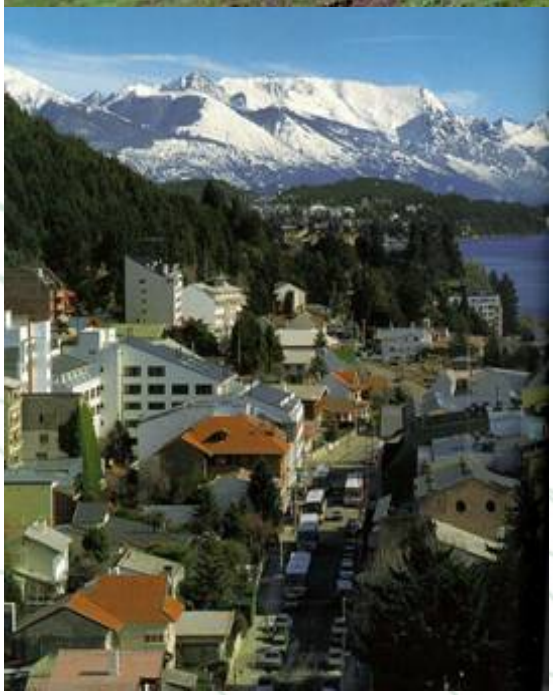
IN ARGENTINA

LEU U-AL_x TARGET



The Company

Founded:	September 1st, 1976
Company:	State owned – Rio Negro
Operation:	As a private company
Headquarters:	Bariloche, Argentina
Subsidiaries:	Australia, Brazil, Egypt, USA
Revenues:	~$ 100 MM USD
Staff:	930 (over 80% highly skilled)
Exports:	> 800 MUSD



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The Company – Main Locations

100 % Argentinean Company

Headquarters, Main Facilities and Laboratories in Bariloche – Province of Rio Negro - Patagonia

Management Office in Buenos Aires – Argentina Capital City

Business Areas

- ✓ Nuclear
- ✓ Aerospace & Government
- ✓ Industrial
- ✓ Nuclear Medicine Systems
- ✓ Telecommunications

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INVAP – some milestones in Project History

- Australia – OPAL > $250 MUSD
- Egypt – ETRR2, FMPP and RMP > $150 MUSD
- Algeria – NUR Reactor
- Argentina / USA – Space - SAC C > $40 MUSD
- Argentina / USA – Space - Aquarius > $260 MUSD
- Argentina – Uranium Enrichment Complex
- Argentina – RA8
- Argentina – RA6
- Argentina – Small NPP / CAREM 25: Project Launched
- **Biggest Technology Exporter of Argentina (> $ 800 MUSD)**

ETRR II
&
THE RADIOISOTOPE PRODUCTION FACILITY (RPF)
EGYPT

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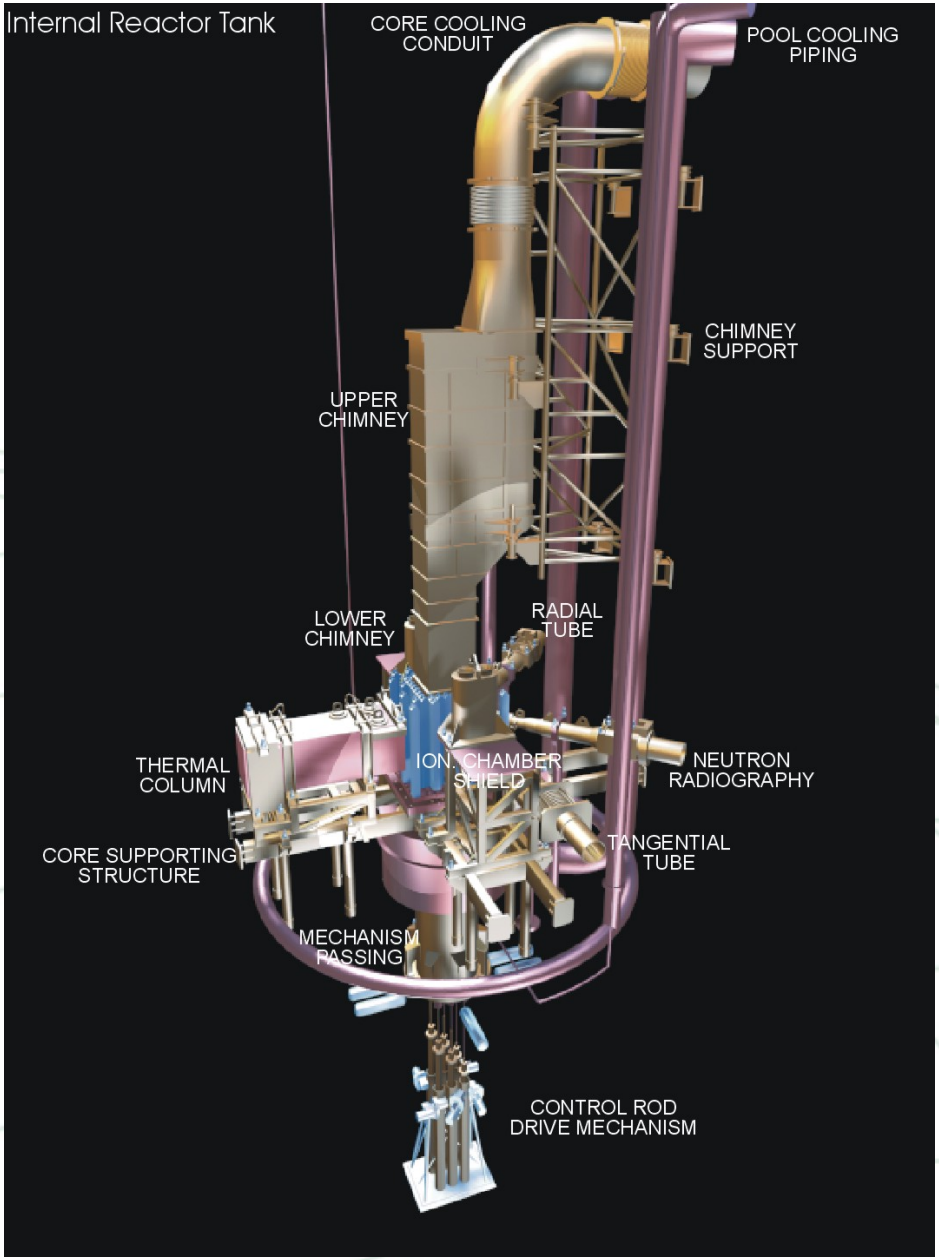
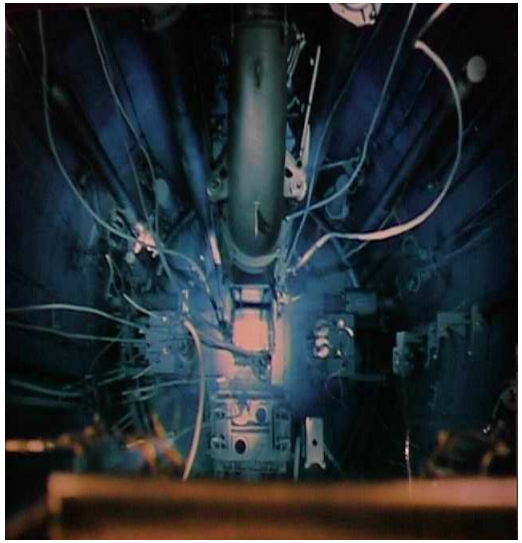

Internal Reactor Tank
CORE COOLING CONDUIT
POOL COOLING PIPING
CHIMNEY SUPPORT
UPPER CHIMNEY
LOWER CHIMNEY
RADIAL TUBE
THERMAL COLUMN
ION CHAMBER SHIELD
NEUTRON RADIOGRAPHY
CORE SUPPORTING STRUCTURE
TANGENTIAL TUBE
MECHANISM PASSING
CONTROL ROD DRIVE MECHANISM

The Core



RADIOISOTOPE PRODUCTION FACILITY (RPF) | AEA

- **INVAP** is providing **AEA** with a **turn-key facility** for the production of Radioisotopes for Medicine, Industry and Research activities

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RADIOISOTOPE PRODUCTION FACILITY (RPF) | AEA

Main Features:

- The facility operates with targets irradiated at the ETRR-2 Research Reactor
- It will be capable of producing the following radionuclides (contracted values):
  a) **Chromium -51 (0.5 Ci per week)**
  b) **Iodine -131 (10 Ci per week)**
  c) **Iodine -125 (5 Ci per week)**
  d) **Iridium -192 (~100 Ci per month)**
  e) **Molybdenum -99 from fission (200 Ci [6 day] per batch, 2 to 3 batches per week)**
  f) **Loading of Molybdenum-99/Technetium-99m generators**
- One multipurpose cell is included for labelling of compounds and/or
- Implementation of new processes.
- Fulfilment of Nuclear Safety Standards and Radiopharmaceutical requirements

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RPF Egypt - Current Status

- Under Hot Commissioning – final phase
- The ETRR 2 Reactor operated for sustained periods
- All the Radioisotopes have been produced in the last 2 months
- Results surpassing contracted values by 5 to 10 %
- Replica of the CNEA LEU based process
- Excellent effort from AEA

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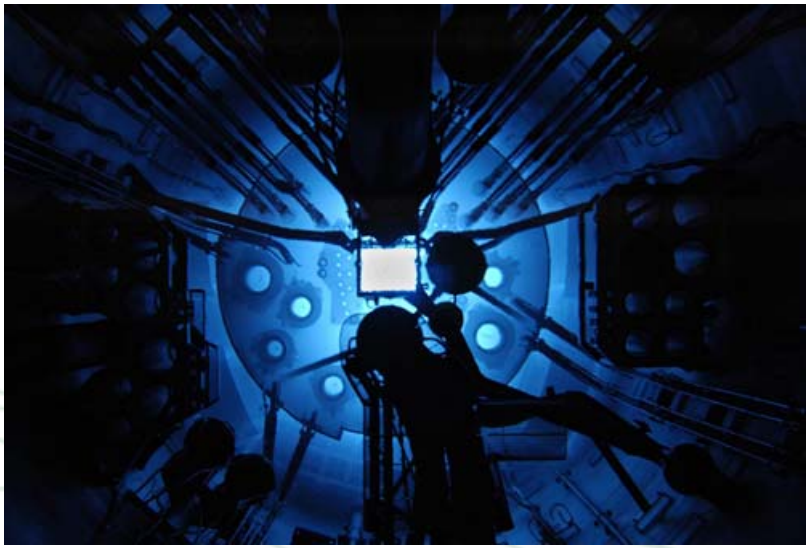

OPAL
&
MOLYBDENUM 99 LEU PROCESS
AUSTRALIA

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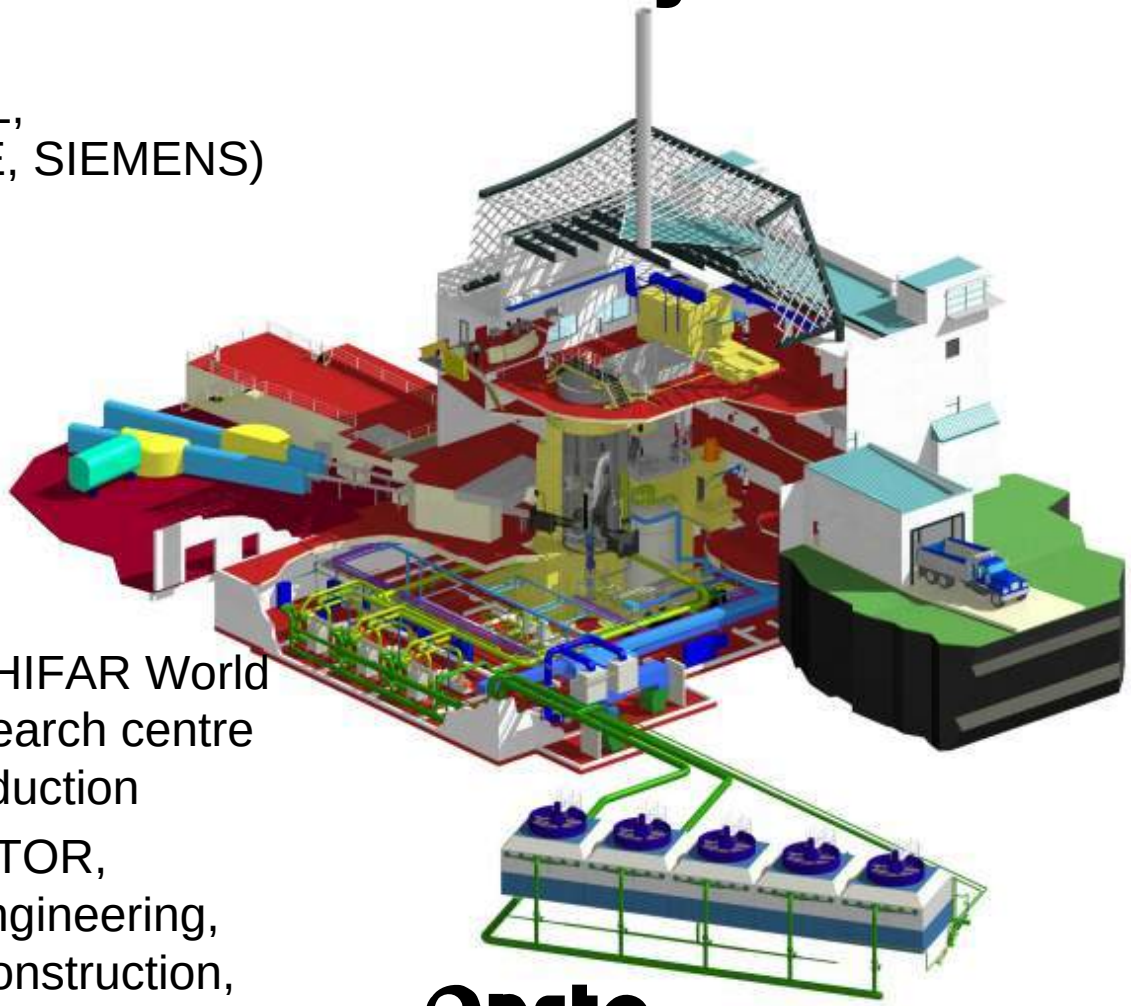
Australia - OPAL Project

- Contract: July 2000
- Award: Via intl. bid (AECL, TECHNICATOME, SIEMENS)
- Budget: $200 MM USD
- Name: OPAL
- Location: Sydney, Australia
- Power: 20 MW
- Customer: ANSTO



- Objective: Replacement for HIFAR World class neutron research centre Radioisotope production
- INVAP: MAIN CONTRACTOR, responsible for Engineering, Manufacturing, Construction, Installation, Commissioning

ansto

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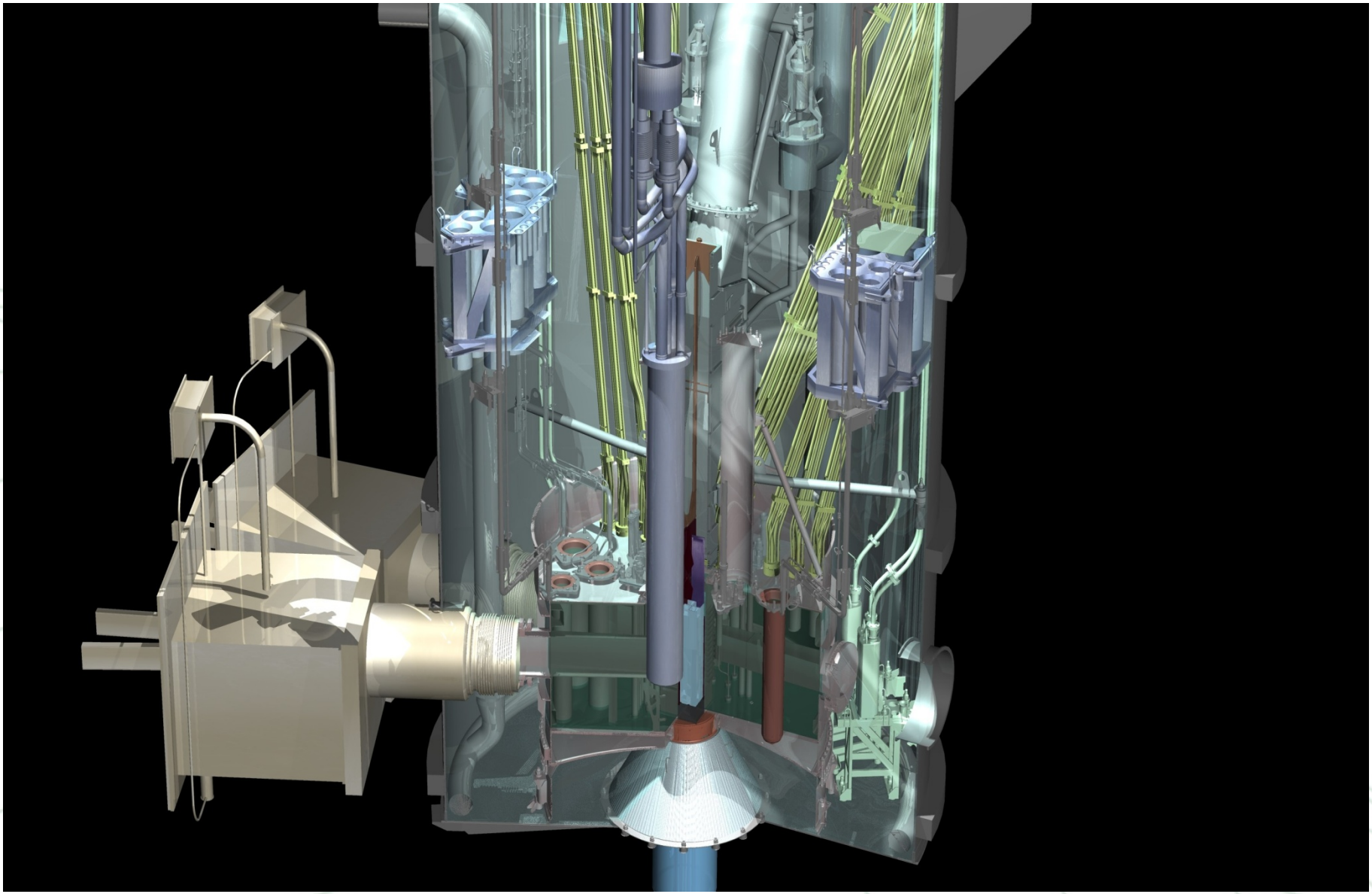
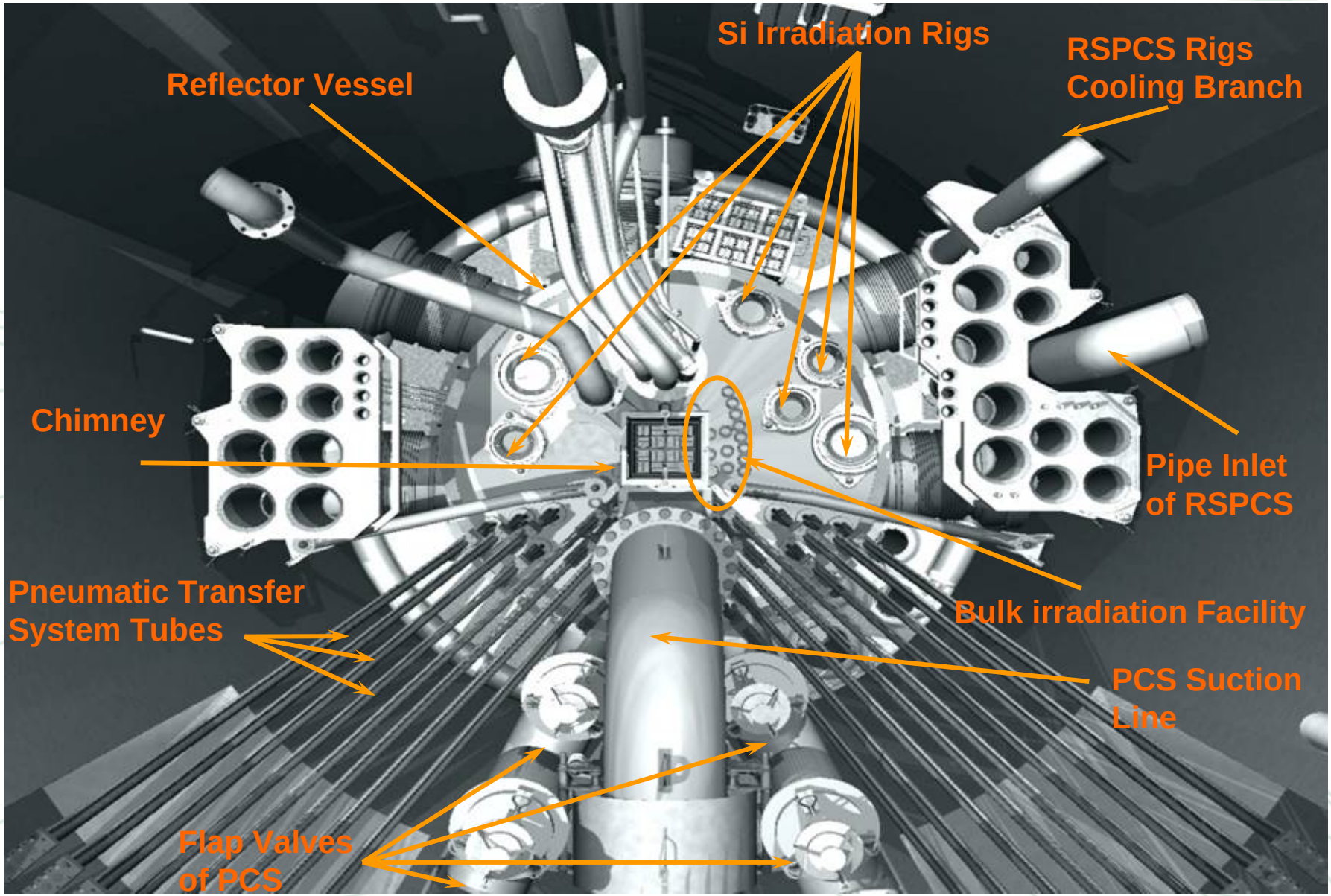
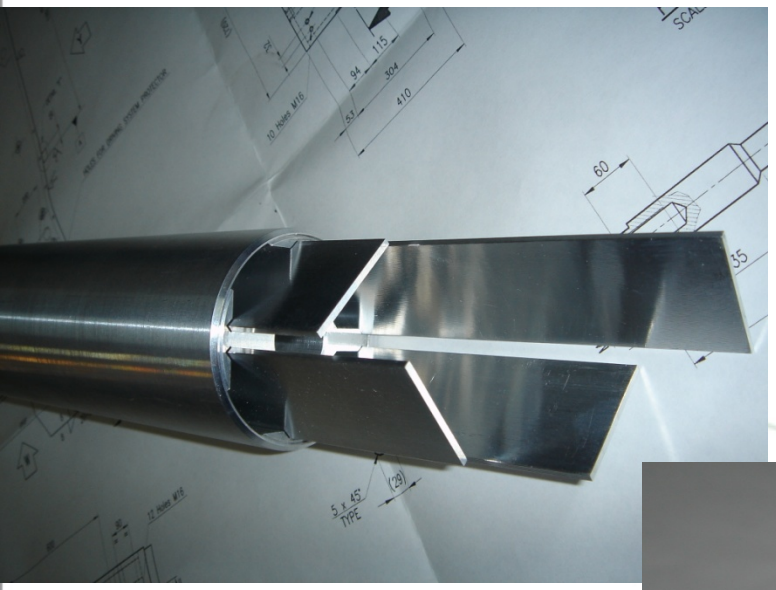
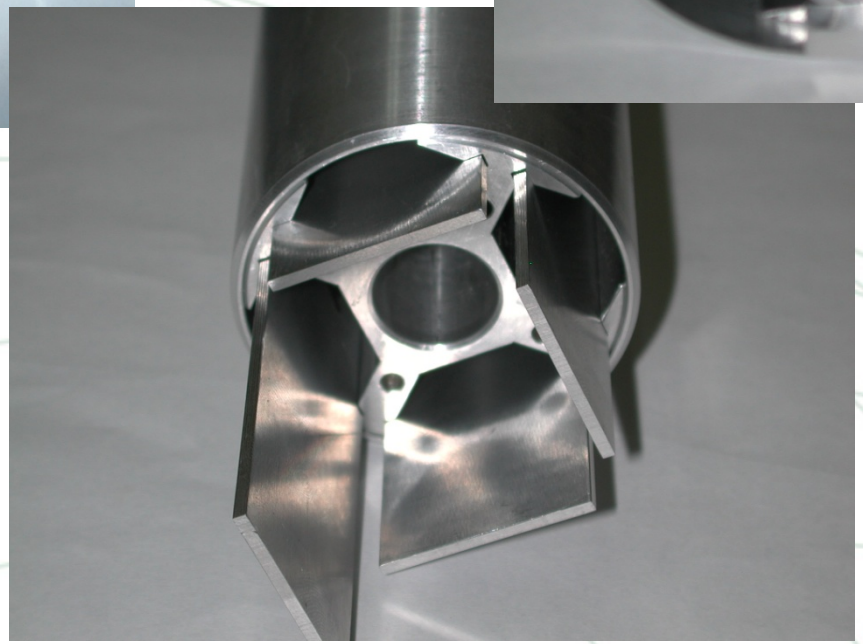



Si Irradiation Rigs
RSPCS Rigs
Cooling Branch
Reflector Vessel
Chimney
Pipe Inlet
of RSPCS
Pneumatic Transfer
System Tubes
Bulk irradiation Facility
PCS Suction
Line
Flap Valves
of PCS

OPAL RIGS AND PLATES





MOLYBDENUM PRODUCTION PROCESS FOR ANSTO

Main Features:

- Turn Key supply of an LEU **process**
- Based on CNEA process slightly modified
- **in an existing facility / building with hot cells & associated support systems, services and auxiliary equipment**
- Capable of producing the following radionuclides:

a) **Iodine -131**
b) **Molybdenum -99 from fission**

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MOLYBDENUM PRODUCTION PROCESS FOR ANSTO

Prior to shipment: FAT
& HOT Process Demonstration in Argentina

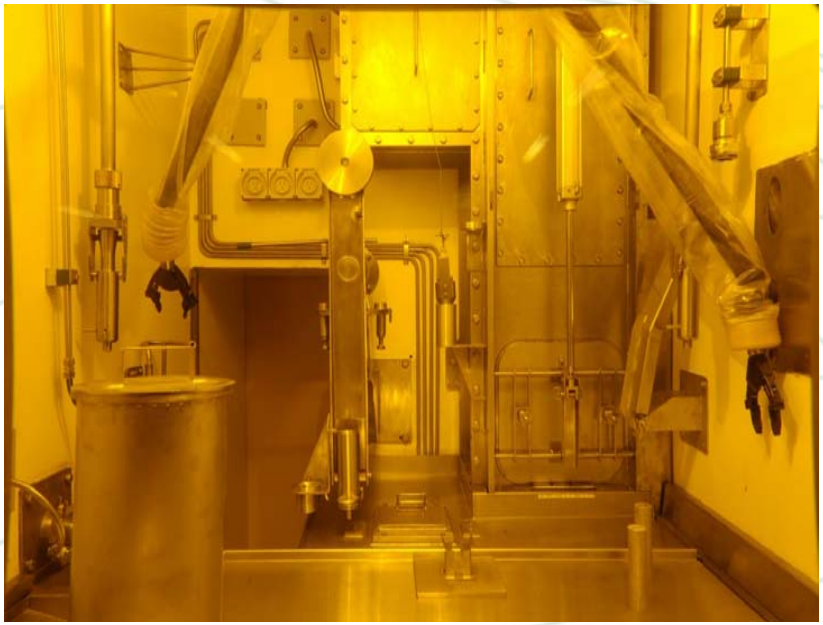
Preparations for installation
in Australia

MOLYBDENUM PRODUCTION PROCESS FOR ANSTO

Installation
in existing
Hot Cells

MOLYBDENUM PRODUCTION PROCESS FOR ANSTO

Installation
in existing
Hot Cells



ANSTO LEU MOLYBDENUM 99 PROJECT ACHIEVEMENTS

- 100% Project progress
- Verification & Validation of key technological concepts at CNEA installations at full scale size
- Support for Licensing (ARPANSA) and TGI provided successfully
- Cold & Hot Commissioning accomplished
- GMPs (Good Manufacturing Practices demonstrated)
- Product approved in Australia (TGI), USA (FDA), Canada, Japan
- 4 batches per week, regularly produced

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MIPS R&D Support Program

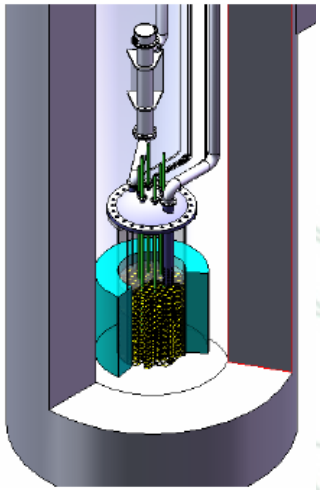
- INVAP started work on homogeneous reactors in 2001
- During 2006 to 2007 discussions with B&W
- Goal: to demonstrate Moly99 could be obtained
- From an LEU Uranile Nitrate solution

Advantages:

- simplified more efficient process (for the use of the LEU and with optimized waste streams)
- target free

Contract:

- Initial Contract in 2008 for the R&D portion



MIPS R&D Support Program

- R&D Program on a turnkey basis!!!
- Risk Minimization through Staging

Theoretical Evaluations → Cold Runs w/tracers → Hot Runs with Moly99 → Solution Irradiation in a LINAC → **Tests in the RA6 Miniloop**

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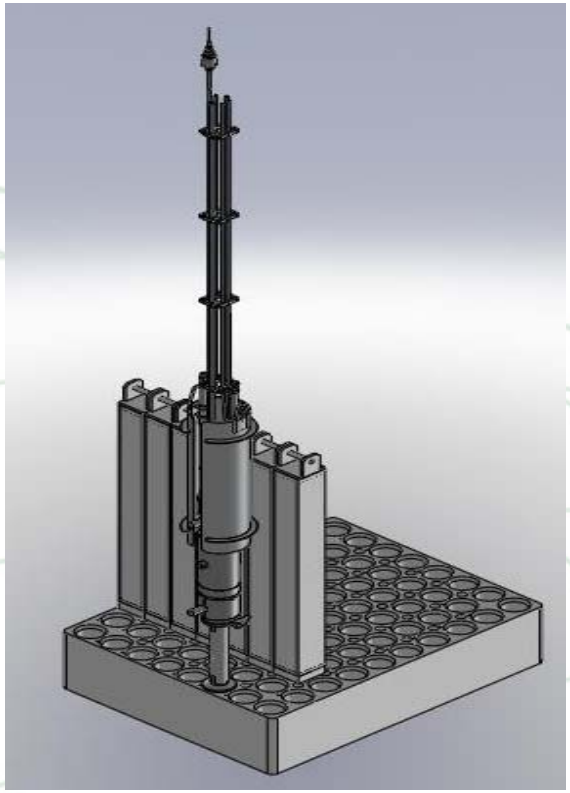
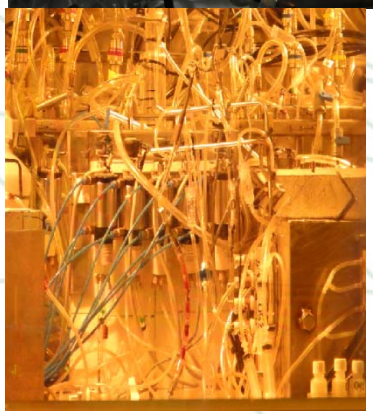
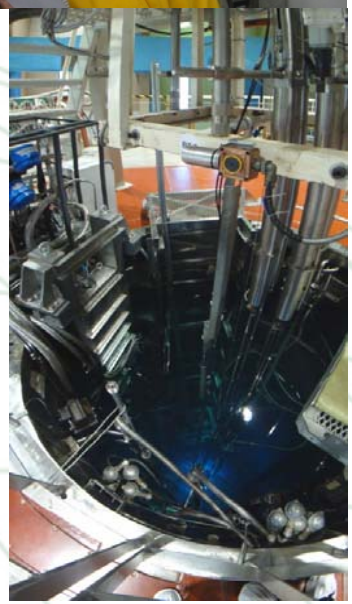
RA6 Miniloop / Hotcell







MIPS R&D Support Program - Results

- The Miniloop and the Hotcell were designed, built, comissioned and LICENSED in 2 years
- 6 months of operation have led to:
  - A successful separation of molybdenum 99
  - In a repetitive way
  - Within Radiopharmaceutical specs.
  - Succesfully shipped to the USA
  - Loaded into a generator
  - Demonstration of the process
  - Further work needed for optimization

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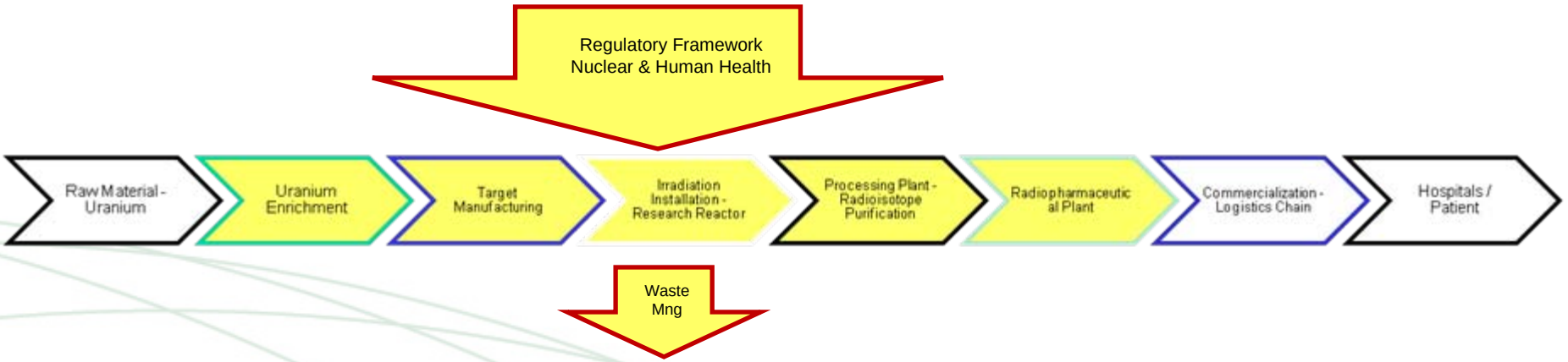
INVAP´s Role



- INVAP is a proven partner that can provide solutions based on mature technologies
- Delivers in time, cost and performance
- Does not have interest on the production itself or the commercialization side of the chain
- Provides integral customized solutions: design & engineering, manufacturing, installation, commissioning and full licensing support

The Future

- INVAP is analyzing with B&W the next steps to consolidate the MIPS R&D effort
- INVAP is working with Coqui Radiopharmaceuticals for the supply of an LEU based dedicated RR and the associated production plant. Conceptual Design and Project Approach delivered
- INVAP is also starting a relationship with IRE for the technological suupport to the conversion of their process in Belgium
- INVAP has just signed the Contract for the Engineering of the future RA10 reactor in Argentina, replacement of the RA3 which is close to 50 years old

REMARKS

- PRESENT CRISIS HAS TO BECOME AN OPPORTUNITY TO CONSOLIDATE ALL PREVIOUS NON – PROLIFERATION EFFORTS FOR CONVERSION FROM HEU TO LEU
- FISSION LEU BASED PRODUCTION TECHNOLOGIES ARE MATURE FOR ANY SIZE
- “NEW” PRODUCTION ALTERNATIVES CAN AND HAVE TO BE LEU BASED

Many thanks:

- To the DOE/NNSA
- To CNEA in Argentina
- To our Partners
- To all of You for your attention