FROM RESEARCH TO INDUSTRY

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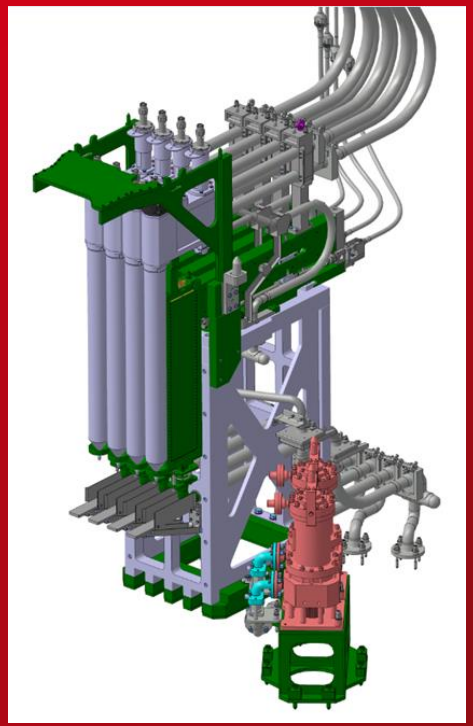

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MOLY PRODUCTION IN THE JULES HOROWITZ REACTOR

CAPACITY AND STATUS OF THE DEVELOPMENT

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CONTENTS

1 - THE JULES HOROWITZ REACTOR (JHR)

- MTR currently under construction at the CEA-Cadarache (FRANCE)
  - *More than 90% of civil works are done*
  - *Realization/qualification phase of several components (pumps, valves, diesel generator, equipment of the block core, …)*

- Main objectives:
  - R&D in support to nuclear Industry (material and fuel behaviour under irradiation)

See "Experimental Devices in Jules Horowitz reactor and first orientations for the experimental programs" (C. GONNIER & all)

  - <u>Radioisotopes production</u>

$$^{99}_{42}\mathrm{Mo} \xrightarrow[66h]{\beta^- 1.216\mathrm{Mev}} {}^{99m}_{43}\mathrm{Tc} \xrightarrow[6h]{\gamma\ 141\mathrm{keV}} {}^{99}_{43}\mathrm{Tc}$$

Nuclear medicine: ^{99m}Tc used as tracer in 80% of the scintigraphy

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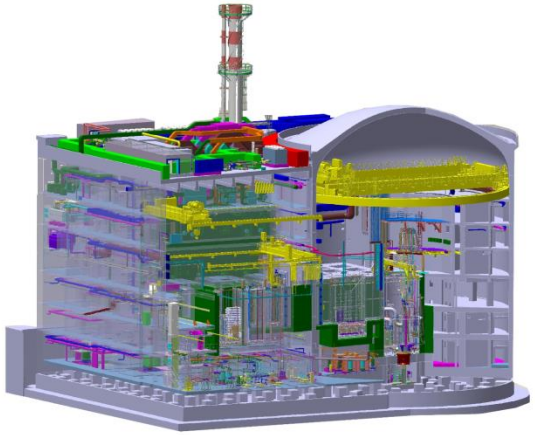
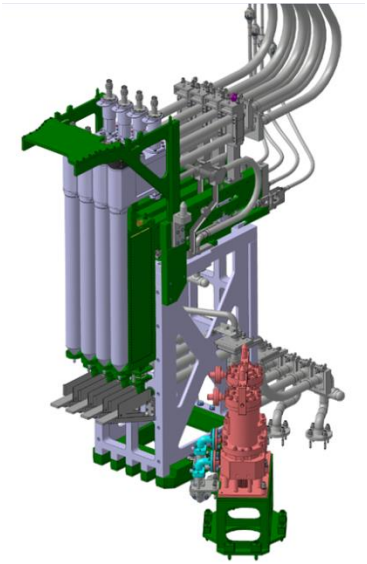
2 – MOLY PROJECT OBJECTIVES

- JHR operation
  - 220 days/year
- Moly production
  - Flexible according to customer's orders
  - Extendable for limited periods
  - Weekly max. capacity (*)
    - ↳ Up to 4 800 ^{99}Mo 6-days Ci/week
  - Yearly max. capacity (*)
    - ↳ Up to 115 200 ^{99}Mo 6-days Ci/year

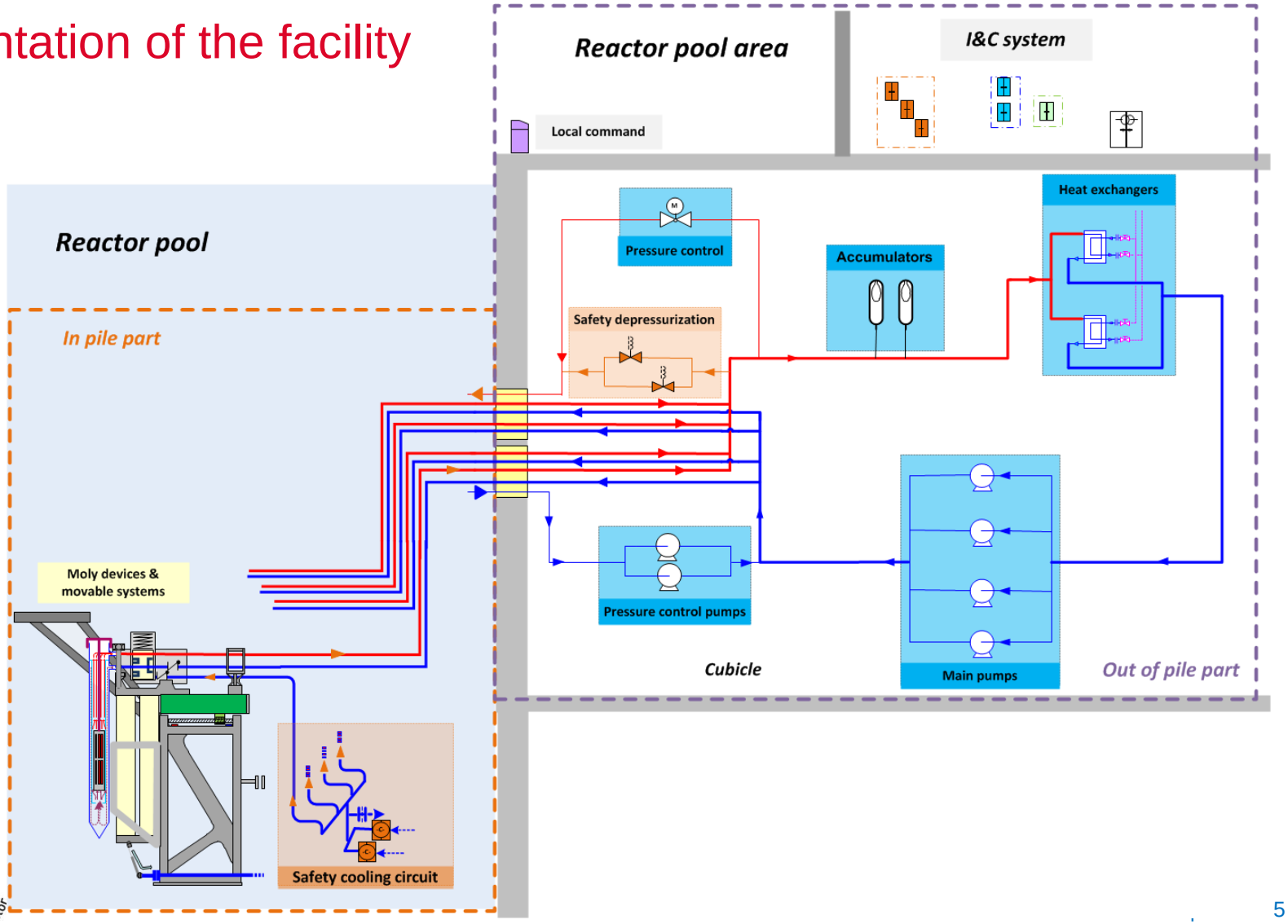




(*) With the use of the Outage Reserve Capacity (ORC)

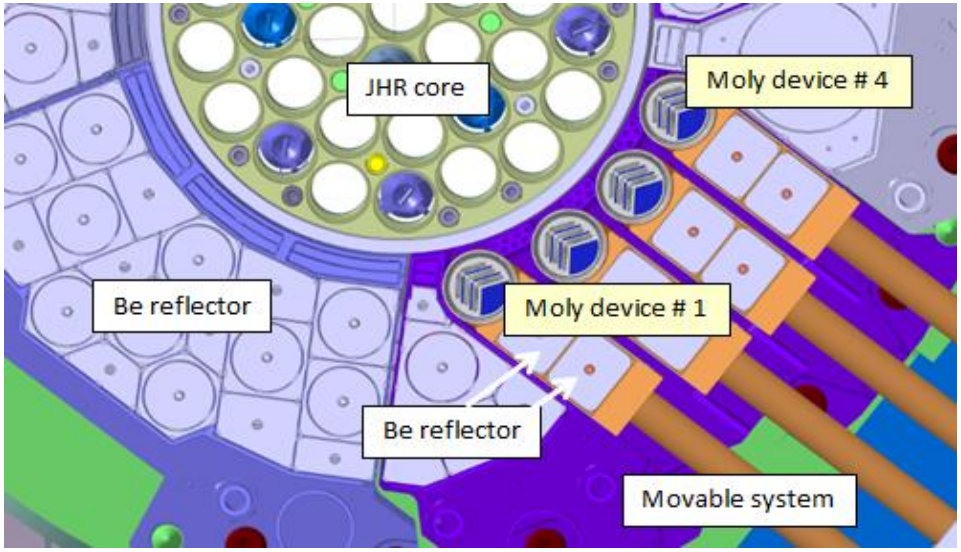
3 – DESCRIPTION OF MOLY FACILITY

Implantation of the facility



3 – DESCRIPTION OF MOLY FACILITY

In pile part



- 4 Moly devices in the JHR Beryllium reflector ⇨ large production capacity
- Moly devices on movable systems ⇨ great flexibility
  - Radial displacement to load/unload targets while JHR is at power state
  - Adjustment of the irradiation positions as a function of the reactor power (70 MW or 100 MW)
- 2 blocks of Be at the back of each Moly device to close the reflector

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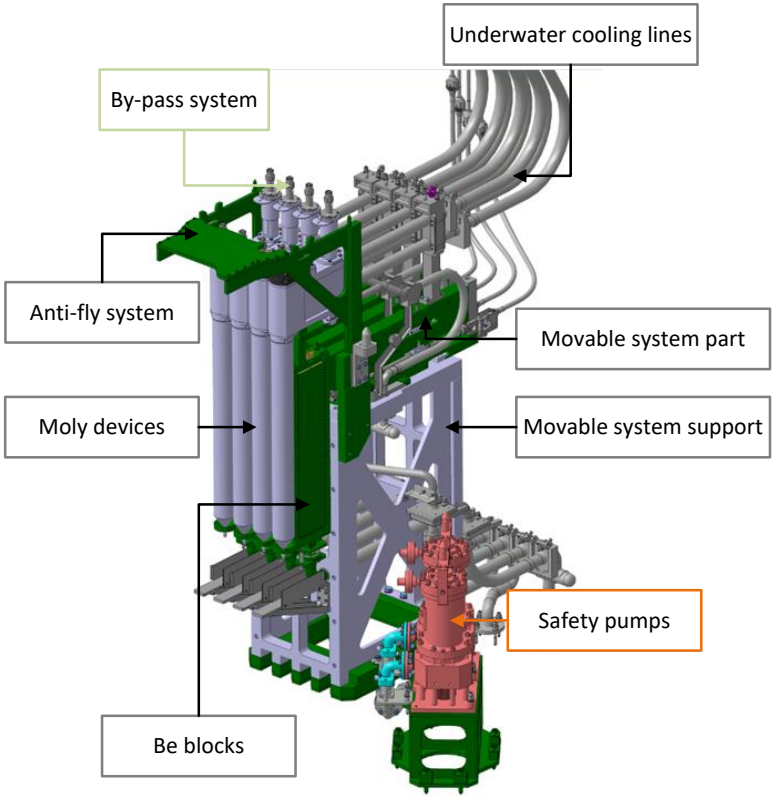
3 – DESCRIPTION OF MOLY FACILITY

In pile part

- By-pass system
  - Allow loading/unloading of the target holder without disturbing the cooling of the other irradiation devices
  - Operated with a pole when the device is in the back position

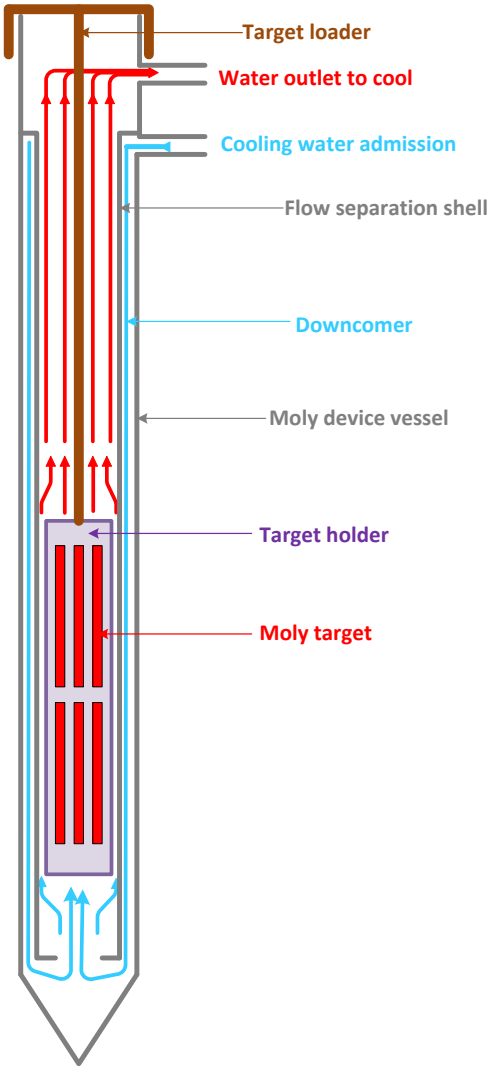


- Safety cooling flow injection
  - 2 safety pumps, non-return valves and safety pipes
  - Located in the reactor pool ⇨ avoid a common mode in the cubicle
  - Targets cooling in accidental or seismic situations

3 – DESCRIPTION OF MOLY FACILITY

Internal layout of the device

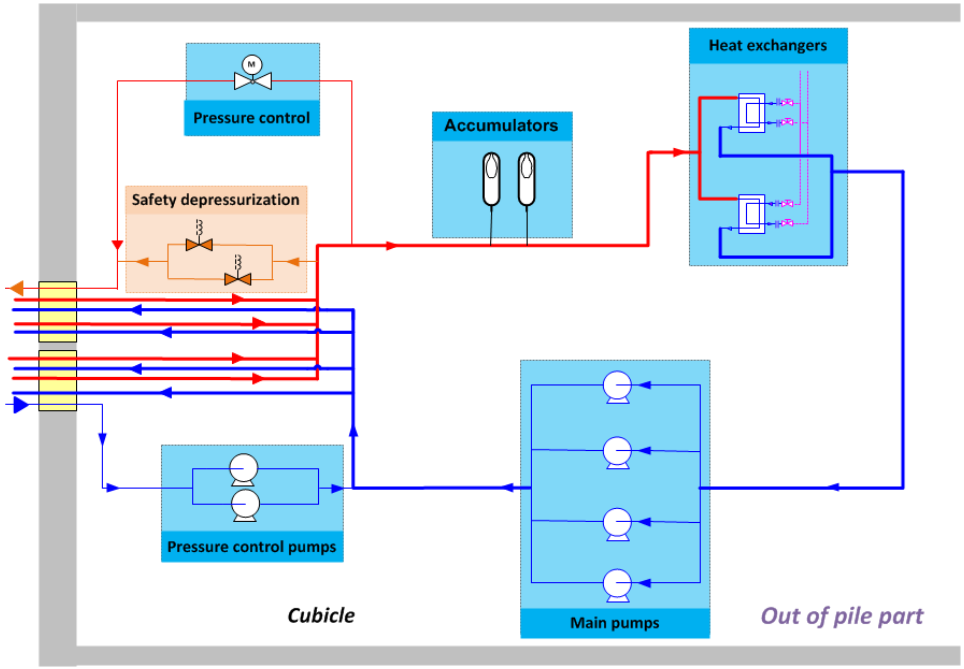
- Designed to accommodate LEU targets
- The cooling water enters through the downcomer ⇨ cooling of the external vessel
- Targets cooling by upward movement of the water inside the target holder
- Target holder
  - 12 targets location : 2 levels of 6 targets
  - Internal arrangement to guarantee the required neutron performance and good refrigeration
  - Number of targets to be irradiated depending on costumers needs
- Target loader
  - Closing the device
  - Handling the target holder under water to the radioisotope table



3 – DESCRIPTION OF MOLY FACILITY

Out of pile part

- Piping penetrations ⇨ link between the in pile cooling circuit part and the cubicle cooling circuit part
- Main circuit
  - 4 main pumps
  - 2 heat exchangers
  - 2 accumulators
  - 2 pressure pumps + water discharge line with a motorized valve
  - Pressure, flow and temperature sensors
- Safety part of the circuit
  - 2 solenoid valves for depressurization of the circuit in accidental or seismic situations

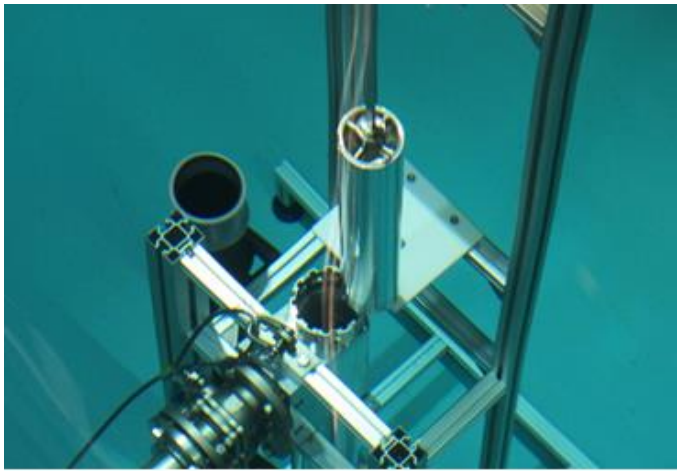


4 – MOCK-UPS IN SUPPORT TO THE DESIGN

Moly device mock-up (scale 1)

- Manufacturing process test
- Hydraulic test
  - Influence of 3 different bottom shapes (water turnover zone) for total pressure drop
- Handling test
  - Loading/unloading the target holder from the mock-up (8 to 9 m of distance)
- Test in fatigue strength
  - Bayonet coupling process

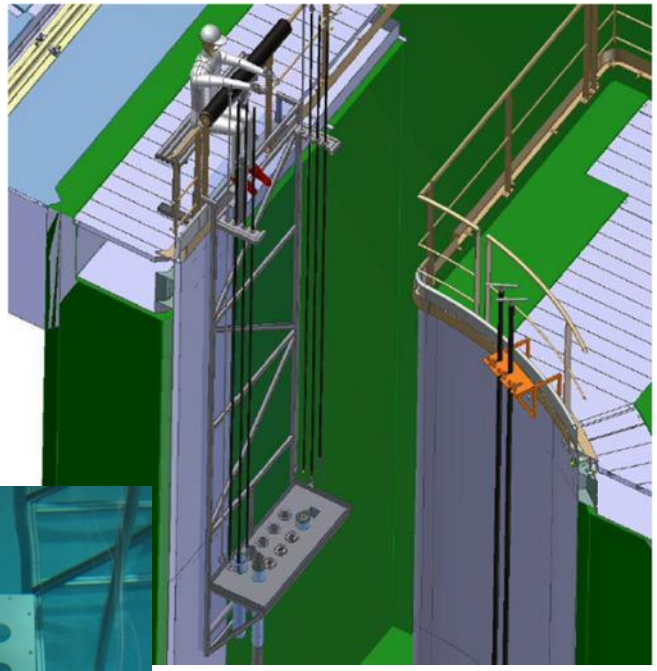
⇨ Validation of the design of parts of the Moly device



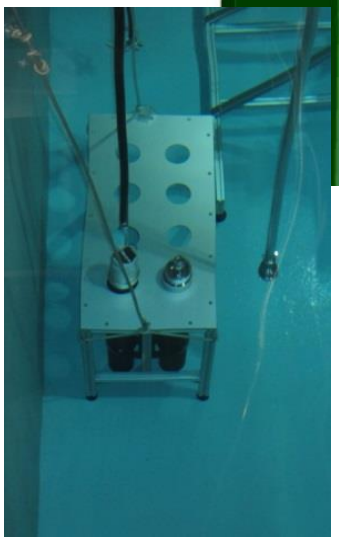
4 – MOCK-UPS IN SUPPORT TO THE DESIGN

Radioisotope table and handling tools

- Located in the intermediate storage pool (close to the reactor pool)
- Loading new targets in the target holder
- Coupling/uncoupling the target loader with the target holder and with the handling pole
- Unloading the irradiated targets



- Targets handling test in representative condition of operation in the JHR (4 to 5 m of distance)



⇨ Validate the design of the tools

⇨ Make human and organizational recommendations in complement of safety analysis

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4 – MOCK-UPS IN SUPPORT TO THE DESIGN

Safety cooling circuit mock-up

- Hydraulic representative mock-up of the Moly cooling circuit
- Validate the safety injection operation to support the hydraulic studies
- Bench test for the individual performances of equipment (pump, non-return valve and different sensors technologies)
- Compare experimental results and the simulating results, obtained by hydraulic modelling using the CATHARE 2 code

⇨ Preliminary data validates the fact that the general system operates correctly (normal pump, safety pump and non-return valve)

5 – PAST AND UPCOMING MILESTONES

Milestones achieved since 2011

- Physical studies of performances (neutronic, thermo hydraulic)
- Mock-up tests
- Safety analysis (irradiation and non-irradiation process)

- In pile part ⇨ Manufacturing contract (launched in October 2015)
- Out of pile part ⇨ Pre-dimensioning studies

Main milestones in 2018

- For licensing ⇨ the safety report will be sent to the French safety authority

- In pile part ⇨ Manufacturing of equipment, except safety pumps
  ⇨ Start of blank assembly of the JHR reflector ⇨ check interfaces
- Out of pile part ⇨ Call for tender and contracting
- Operating tools ⇨ Call for tender

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6 – CONCLUSION

- Studies and manufacturing of Moly facility are still on going
  - ↳ First Moly target production ASAP after the JHR phase of commissioning
- JHR reactor will be a major participant in the European production of ^{99m}Tc
  - ↳ from 25% up to 50% on an average basis to insure the supply in Europe
  - ↳ up to 25% of the world's annual demand in case of global shortage
  - ↳ 10 million patients could benefit yearly from ^{99m}Tc produced by JHR
- JHR reactor will also be able to produce other radioisotopes in support of nuclear medicine (diagnostic and therapy)

Thank you for your attention

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