TARGETS: A PERSPECTIVE FROM THE TECHNICAL AND COMMERCIAL POINT OF VIEW

2013 Mo-99 Topical Meeting

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Prepared by Marcelo Salvatore & Carlos Pavón
Nuclear Division
salvator@invap.com.ar
capavon@invap.com.ar


Bariloche
Río Negro
Patagonia Argentina

EMPLOYEES

1000

(85% professionals and technicians)

400 Contractors

SALES

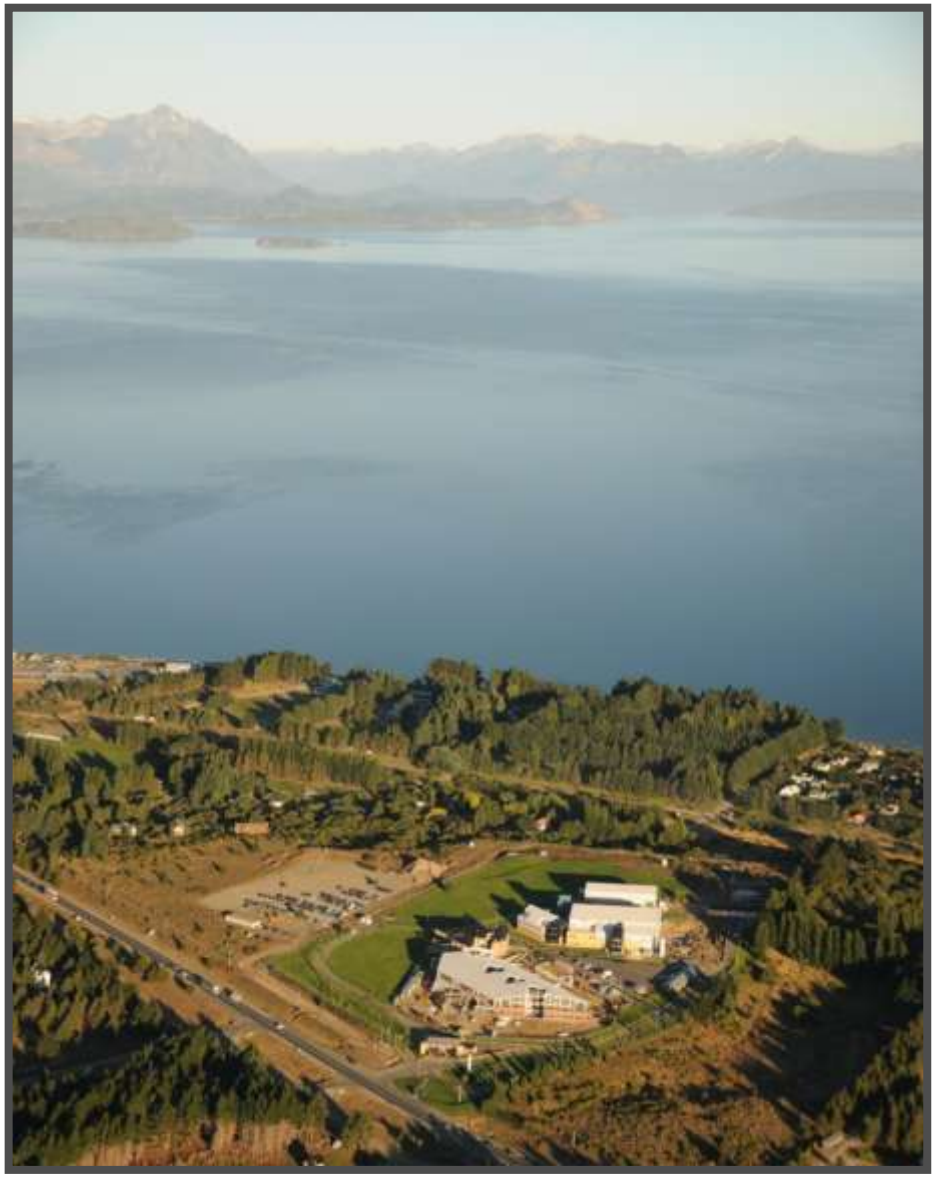
+ $ 200 M USD / YEAR

BACKLOG

$ 500 M USD

NEW CONTRACTS

$ 700 M USD



INVAP

CUSTOM DESIGN TECHNOLOGY

REACTORS & FACILITIES

ARGENTINA
0.5MW

PERÚ
10 MW

ALGERIA
1MW

EGYPT
22MW

AUSTRALIA
20MW

ARGENTINA
30MW

SATELLITES

SAC-B
200 Kg

SAC-A
100 Kg

SAC-C
500 Kg

SAC-D
1600 Kg

SAOCOM
1900 Kg

ARSAT I
3000 Kg

RADARS

SAR
SAOCOM
2001

INKAN
2003

RPA
2005

MET III
2009

MET V
2011

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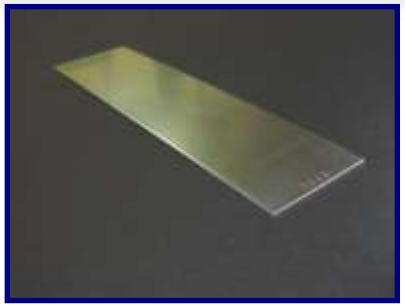
- Alternatives
- Final Comments

ISO 9001 CERTIFIED
ISO 14001 CERTIFIED

Design Principles & Considerations



Mo 99 Total Production Requirements + **Plate / Target Characteristics** + Reactor Core Characteristics + Safety Considerations = **Final Irradiation Rig Design**

Target Parameters: frozen today!

Only Place for Design Optimization!

Comparison with fuel plates - I

Since their conception, molybdenum production targets have been fabricated following “extremely similar” design criteria used for MTR fuel plates (except for adjustments to optimize the transportation to the processing plant and some requirements related to their chemical processing).

HEU Fuel Plates → HEU Moly Targets → **LEU Moly Targets**

Parameters / Comparison	Fuel Plate	Mo Target
Enrichment [%U-235]	19.75	19.75
Plate thickness [mm]	1.5	1.4
Meat thickness [mm]	0.71	0.70
Meat width [mm]	65.0	30.0
Meat composition	U_3Si_2-Al	UAl_x-Al
Uranium density in meat [g/cm^3]	4.8	3.0

Comparison with fuel plates - II

In the last 12-15 years a transition from HEU to LEU based Moly 99 production became a must, leading to the current production plates geometry and composition.

	HEU - Target	LEU - target
Enrichment [%U-235]	90	19.75
U235 content [g]	1.3	1.4
Total U content [g]	1.4	7.2
Total U density [g/cm3]	0.58	~3.0
U235 density [g/cm3]	0.53	~0.6
Clad material	Al 99.5%	Al 6061 or similar

Reflections on quality requirements - I

Standards from ASTM, ANSI or EPRI are employed in areas:

- Aluminum Sheet and Plate
- Metal Powder
- Uranium Quality
- Boron Content
- Aluminum / Frame Welding
- Utilization of commercial grade items in nuclear applications

Reflections on quality requirements - II

Others Design / Construction areas have no reference standards and so must be established by the Target Designer / Manufacturer:

- Design / Assembly Drawings
- Material Specifications
- Characterization and production of the uranium powder (U_3O_8, UAl_x-Al, etc.)
- Fabrication Procedures & Acceptance Criteria
- Corrosion Limits
- Fuel Qualification Program / PIE
- Quality Controls

Operational / Irradiation differences

Fuel plates and Molybdenum targets differ greatly in their Irradiation programs within the core.

Fuel Plate		Mo Target
> 60	Residence Time [FPd]	5 – 6
45 – 60	Burn Up [% U-235]	2 – 3

This differences allow us to infer that many of the limitations imposed on the fuel are too restrictive i.e. **there must be some room for relaxing and reducing margins**

Potential Alternatives: Design / Manufacturing Changes & Implications

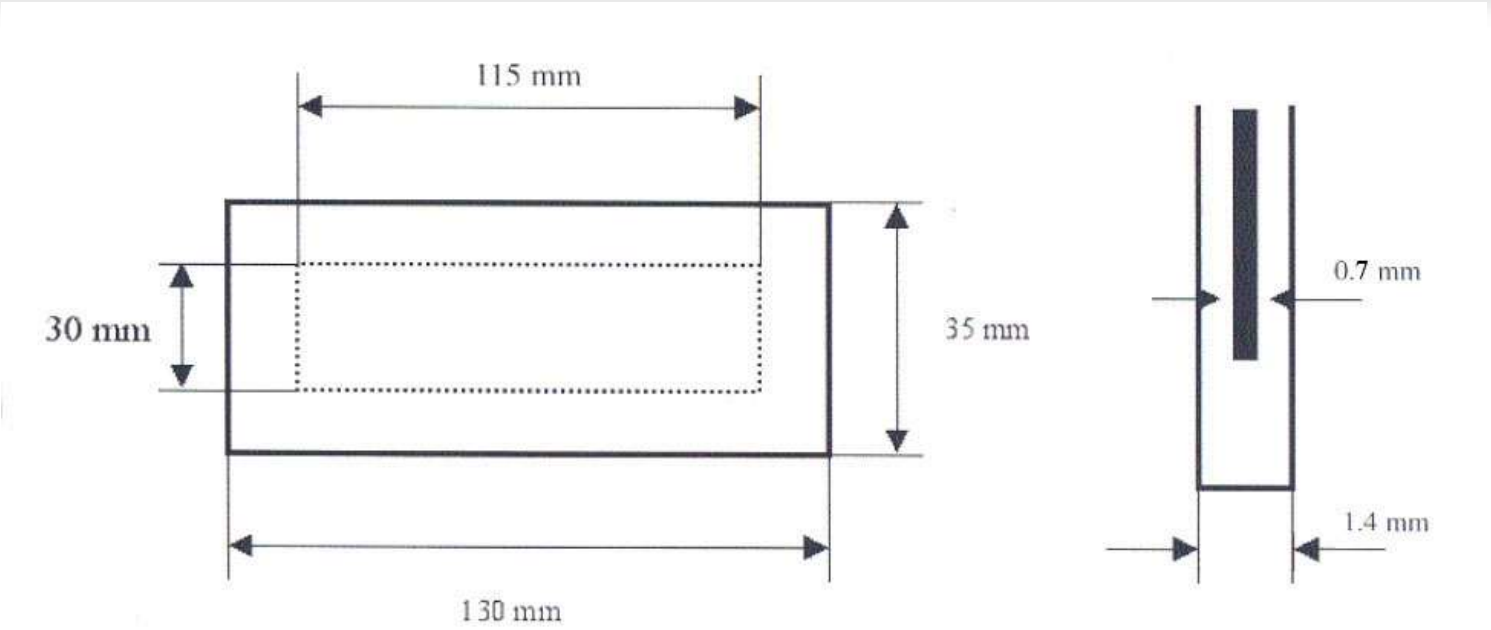
A simple method to improve the Molybdenum production is to increase the uranium content through:

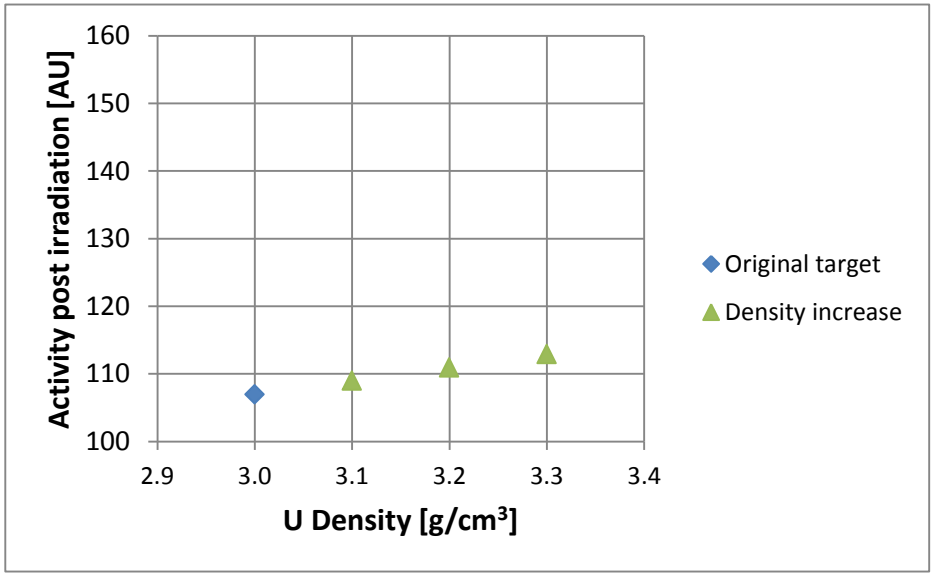
- An increase in the uranium density inside the target “meat”
- A decrease in cladding thickness

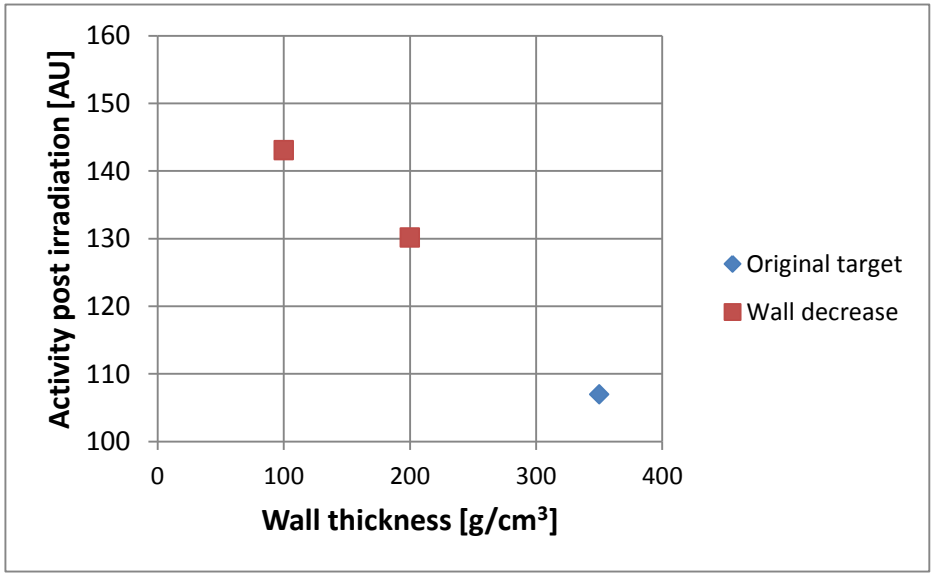
Seven cases were simulated & analyzed.

Case	U Density [g/cm3]	Wall thickness [um]	U-235 content [g]	Increment [%]
1	3.0	350	1.45	0.00
2	3.1	350	1.50	3.33
3	3.2	350	1.55	6.67
4	3.3	350	1.59	10.00
5	3.0	200	2.07	42.86
6	3.0	100	2.48	71.43
7	3.3	100	2.73	88.57

Potential Alternatives: Design / Manufacturing Changes & Implications





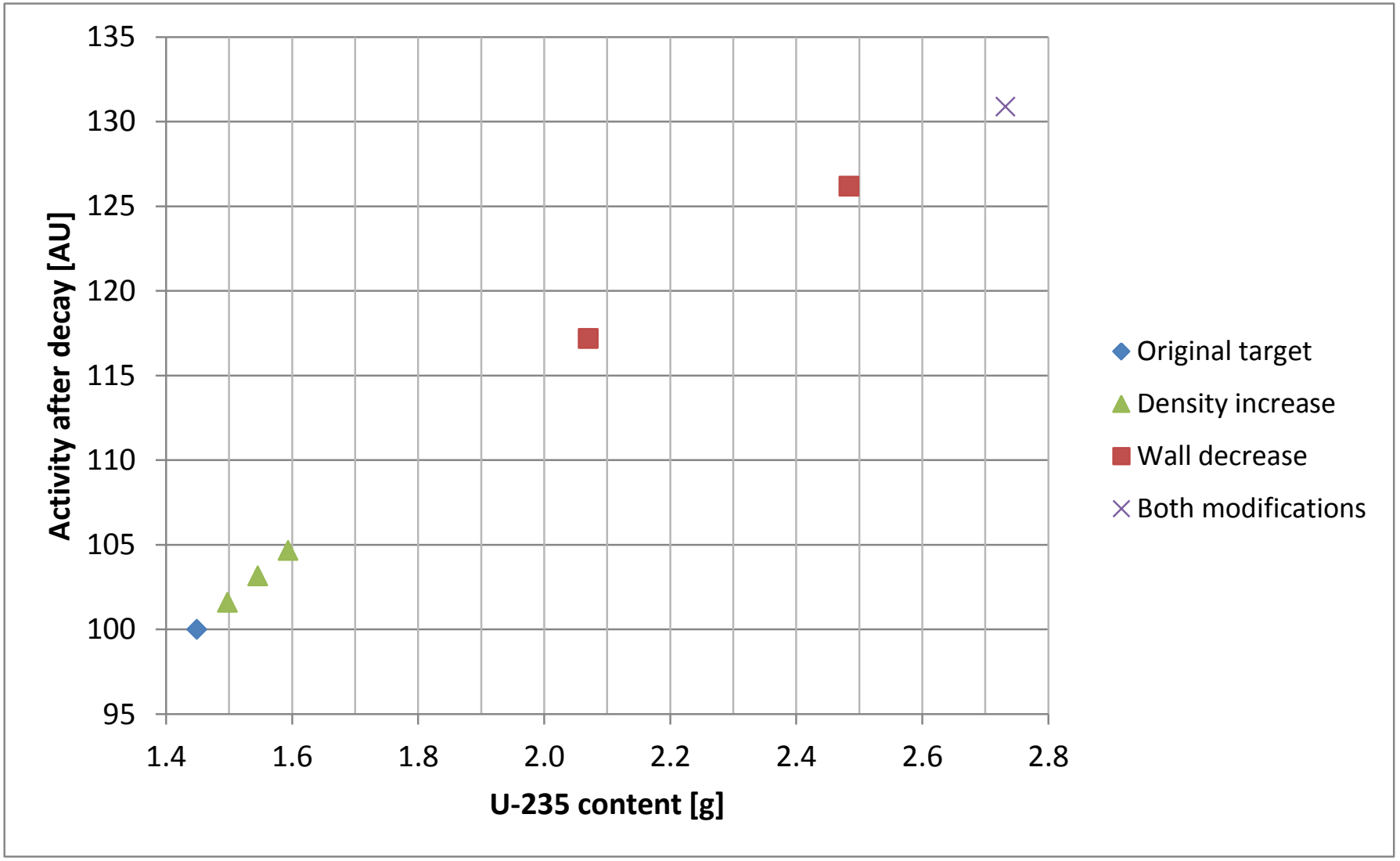


Potential Alternatives: Design / Manufacturing Changes & Implications

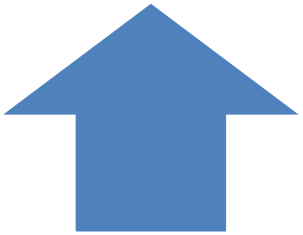
The achieved increment in the target heat load leads to a slightly larger decay time in order to maintain safety margins for target transfer in air.

Case	Activity post irradiation [AU]	Increment [%]	Activity after decay (AU)	Increment [%]
1	107	0	100	0
2	109	1.9	102	1.6
3	111	3.8	103	3.2
4	113	5.6	105	4.7
5	130	21.7	117	17.2
6	143	33.8	126	26.2
7	150	40.4	131	30.9

Potential Alternatives: Design / Manufacturing Changes & Implications



A Way Forward, Ideas for consideration



Evolutionary – Improvements based on Existing Targets (narrowing deign & manufacturing margins)

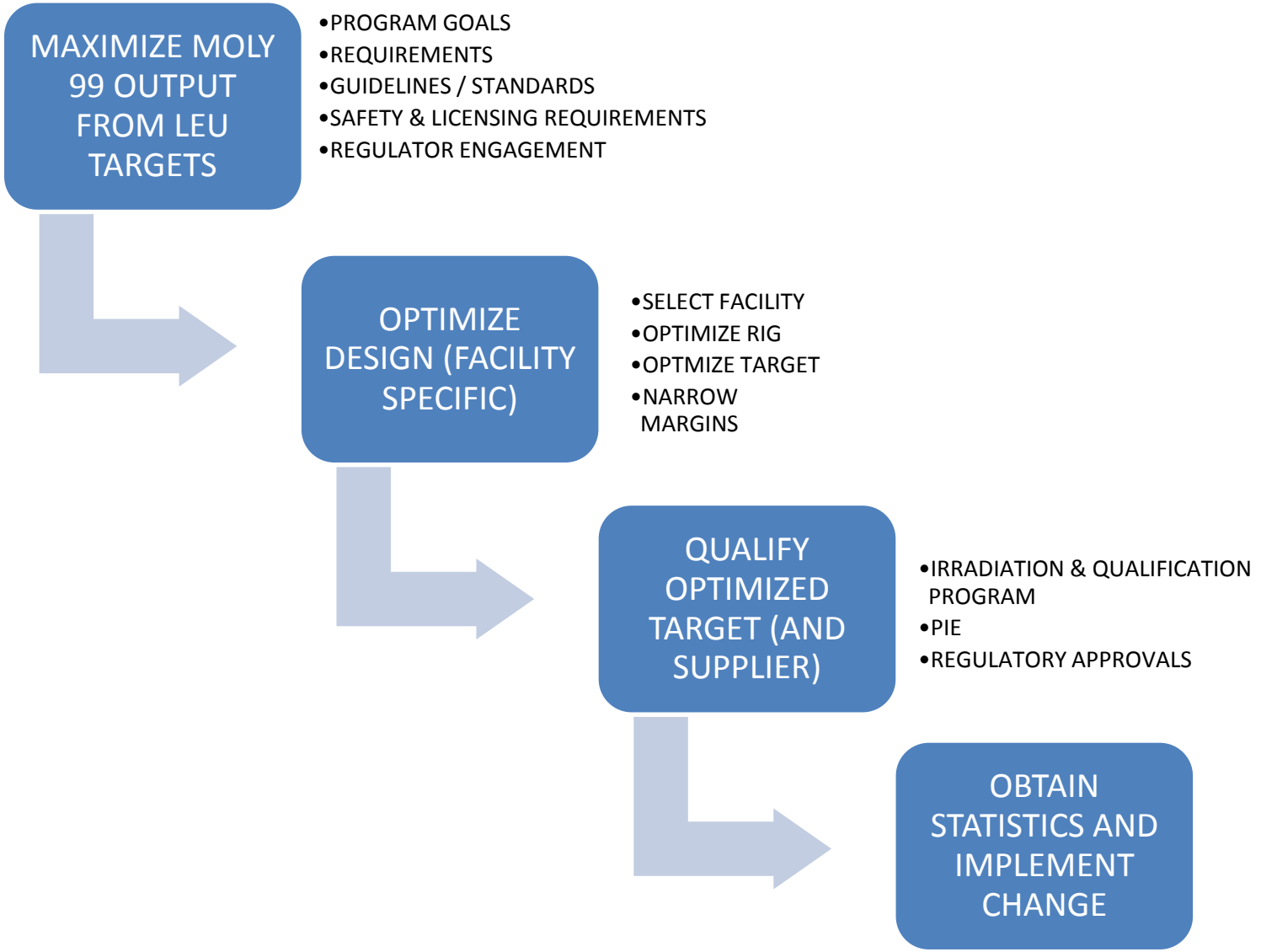
Revolutionary – Game changing new targets (essentially different "meats")

THE EVOLUTIONARY APPROACH

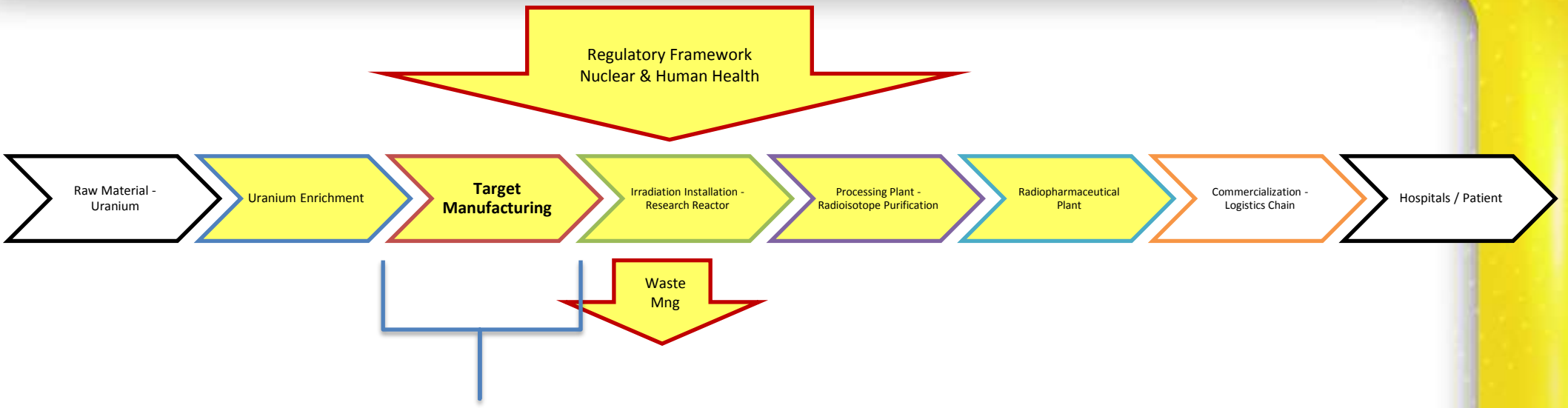
With minor changes in the target plate design a great benefit can be attained

- +40% increment in activity post irradiation.
- 30% increment in activity after decay.

A Way Forward, Ideas for consideration



Targets: Commercial Situation



NOT TOO MANY QUALIFIED SUPPLIERS (HEU or LEU)
NOT REAL COMPETITION
WHAT IF:

- A supplier faces a licensing problem
- A supplier faces an incident / accident that leads to production stops
- A supplier becomes too expensive or in practical terms a monopoly

Final Comments / Conclusions

- There is room for optimization in present LEU target design & manufacturing
- We propose improvements based on an Evolutionary approach
- Added Value: much less Al is involved in the Moly processing!!!
- A Development Program could be relatively simple & affordable
- INVAP is discussing w/CNEA a potential action plan in this regard
- There are User Acceptance & Regulator Risks
- On the commercial side the Moly 99 supply chain needs diversification with targets manufacturing & supply

Thank You
and
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salvator@invap.com.ar

WWW.INVAP.COM.AR

AV. CMTE. LUIS PIEDRABUENA 4950

(R8403AMU) SAN CARLOS DE BARILOCHE

RÍO NEGRO | PATAGONIA | ARGENTINA

TEL.: 54 (294) 440 9300

FAX: 54 (294) 440 9339

E-MAIL: INFO@INVAP.COM.AR

S 41°7'25 / O 71°14'35"

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