ADNA Corporation Perspectives on the Roadmap Reference Program

by

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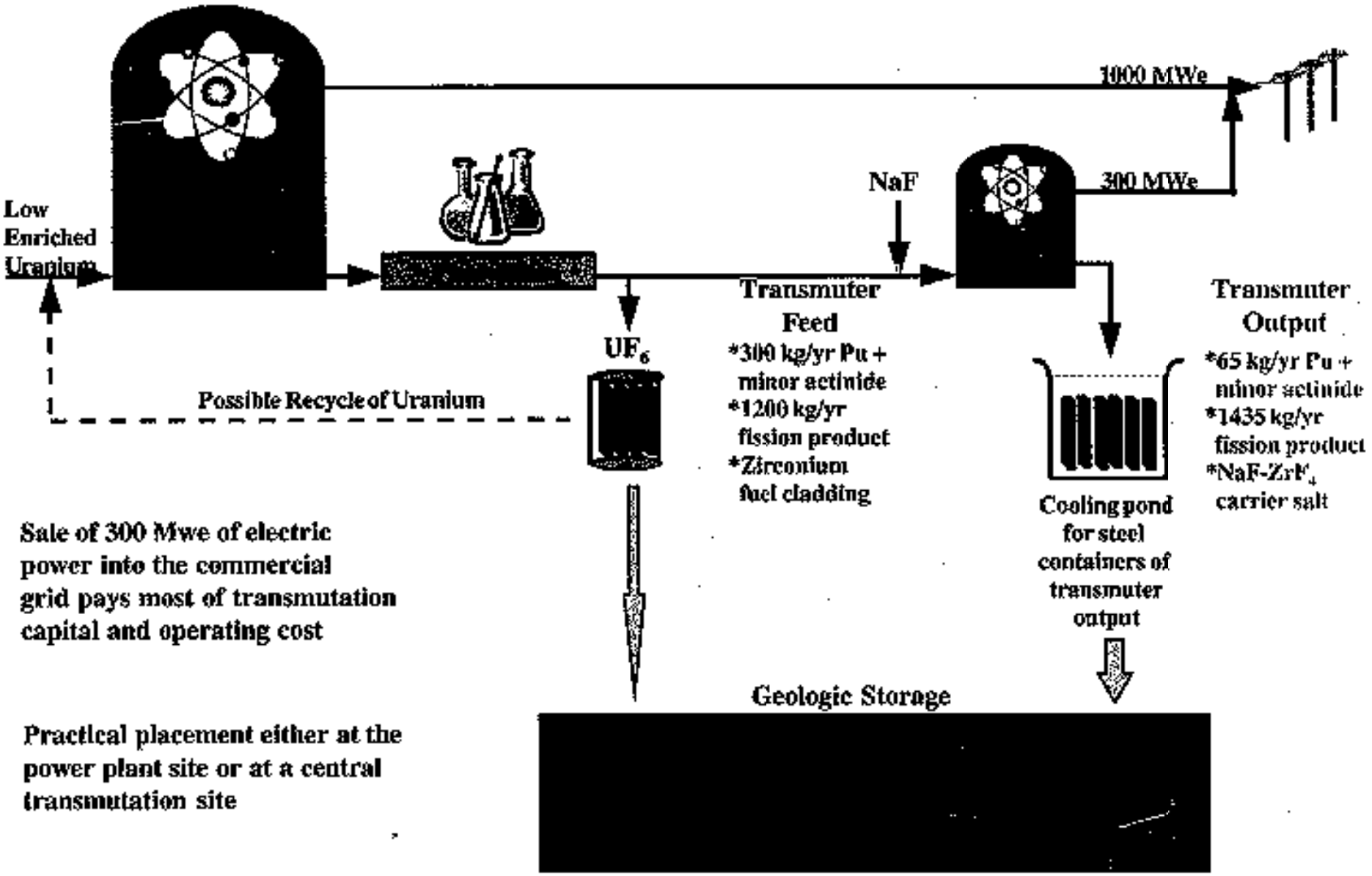
to

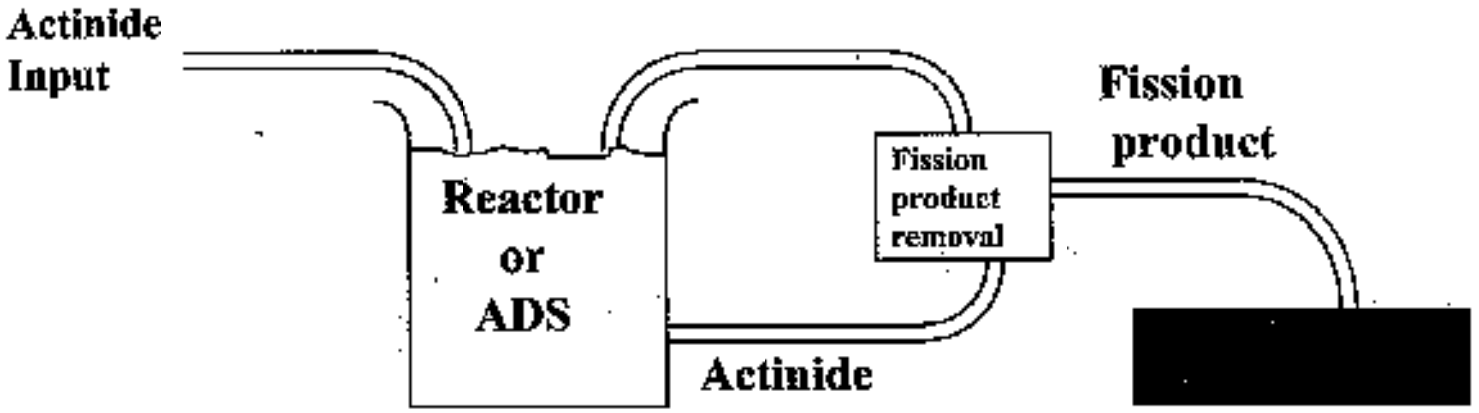
Accelerator Transmutation of Waste
World Experts Workshop No. 2
Crystal City Marriott
Arlington, VA
July 15-16, 1999

Implementation of Open-Cycle Accelerator-Driven Transmutation System for Commercial Reactor Waste

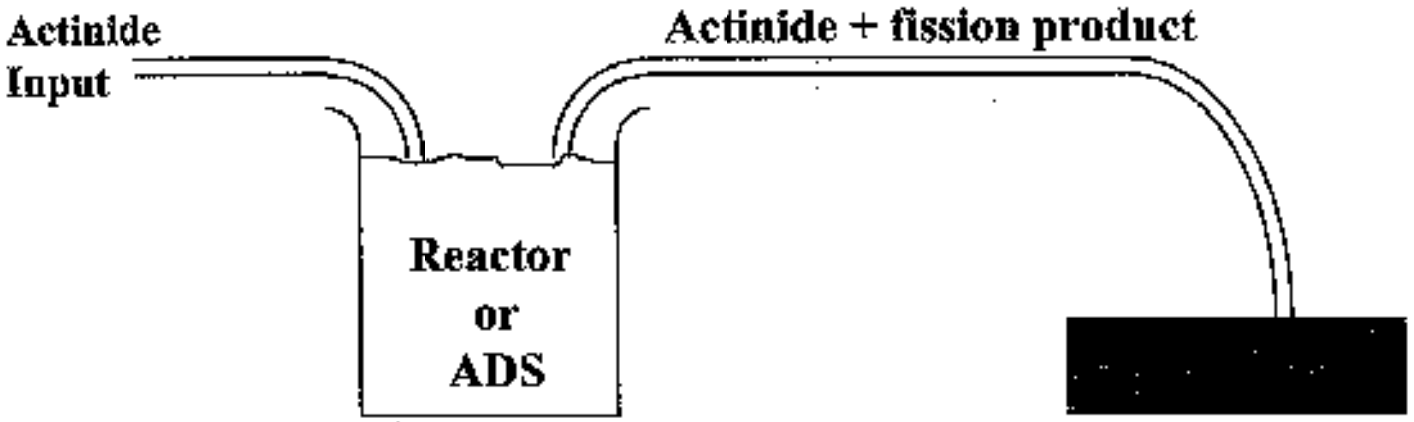


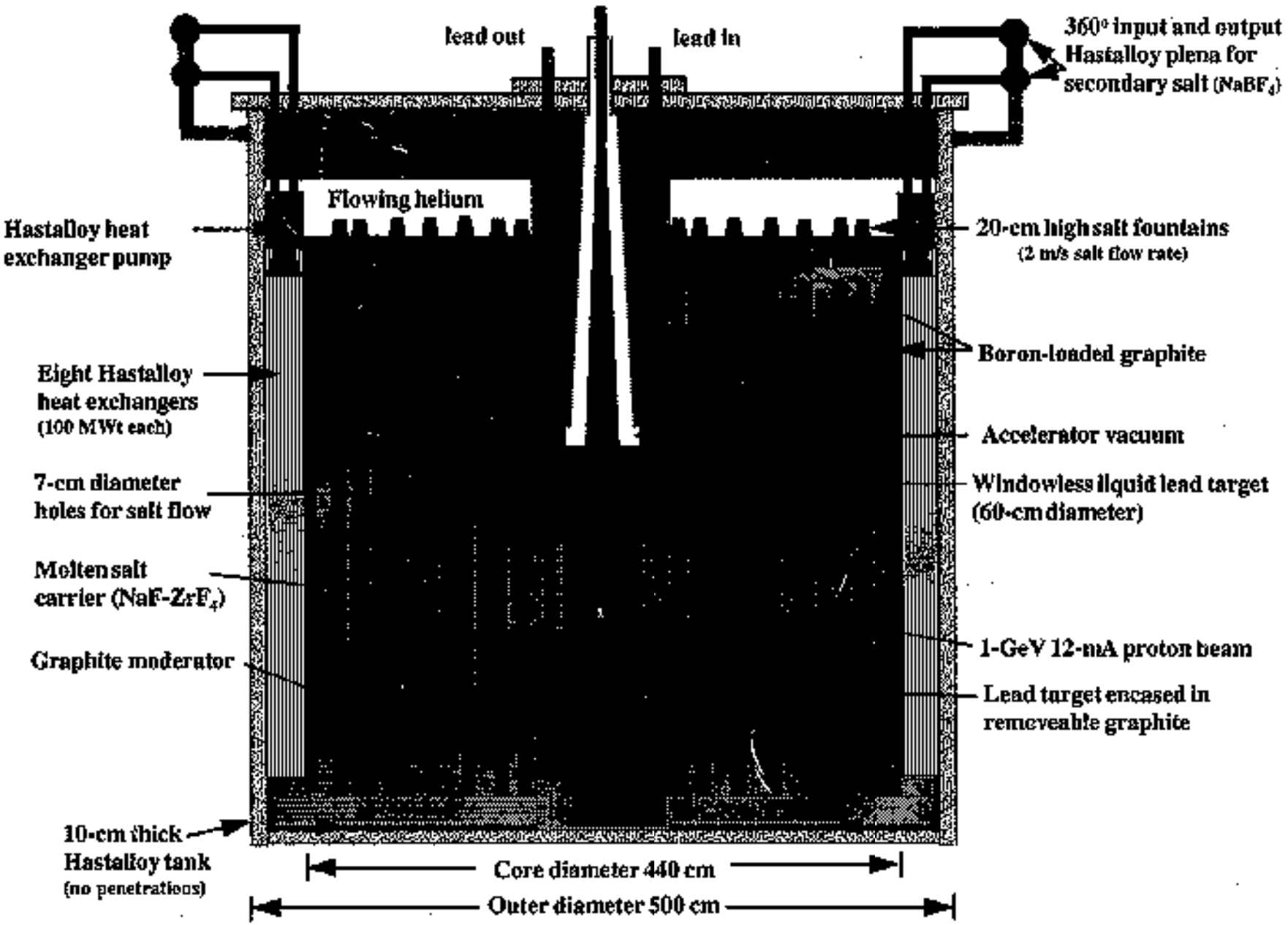
Liquid Fuel Implementation

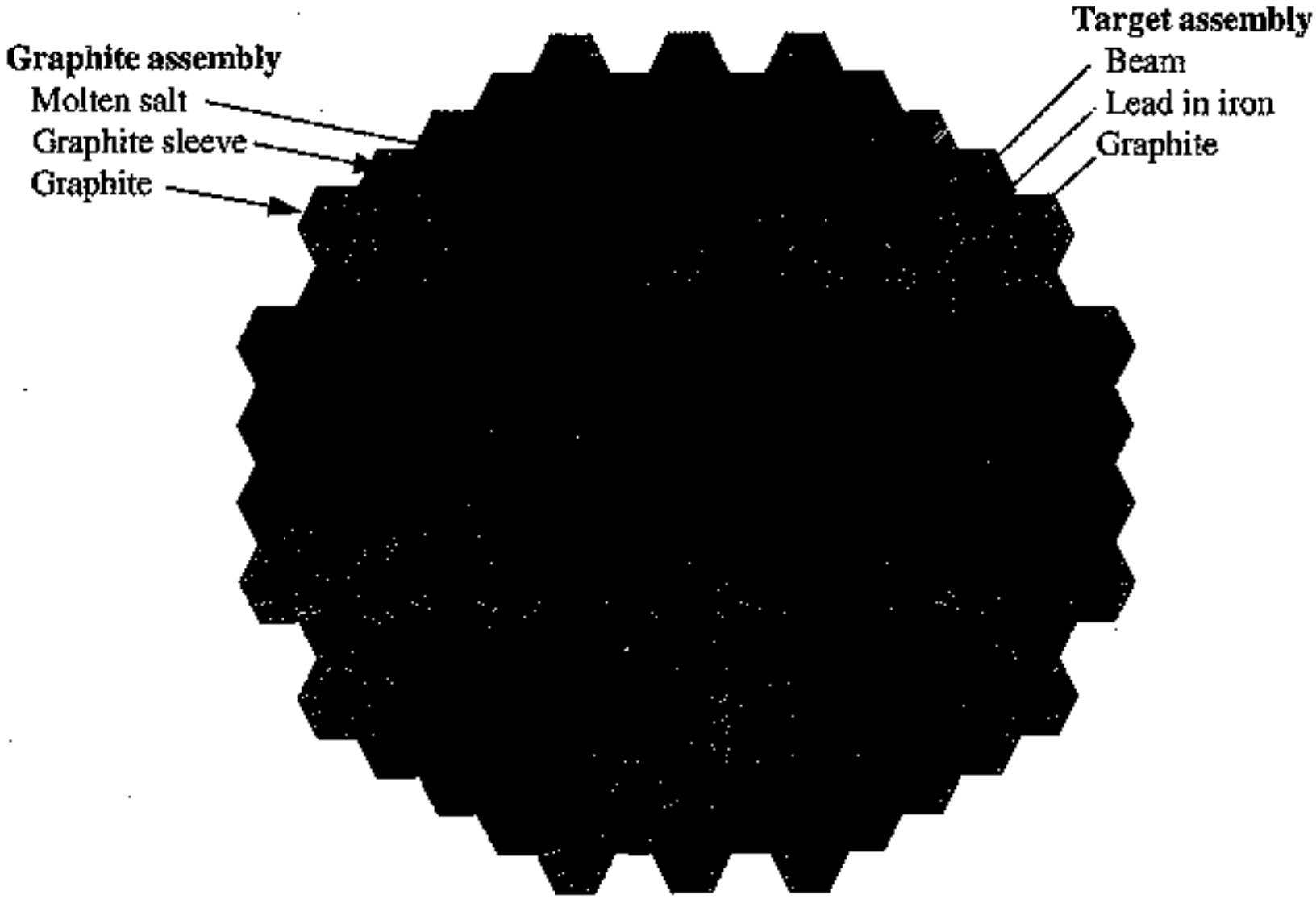
Early



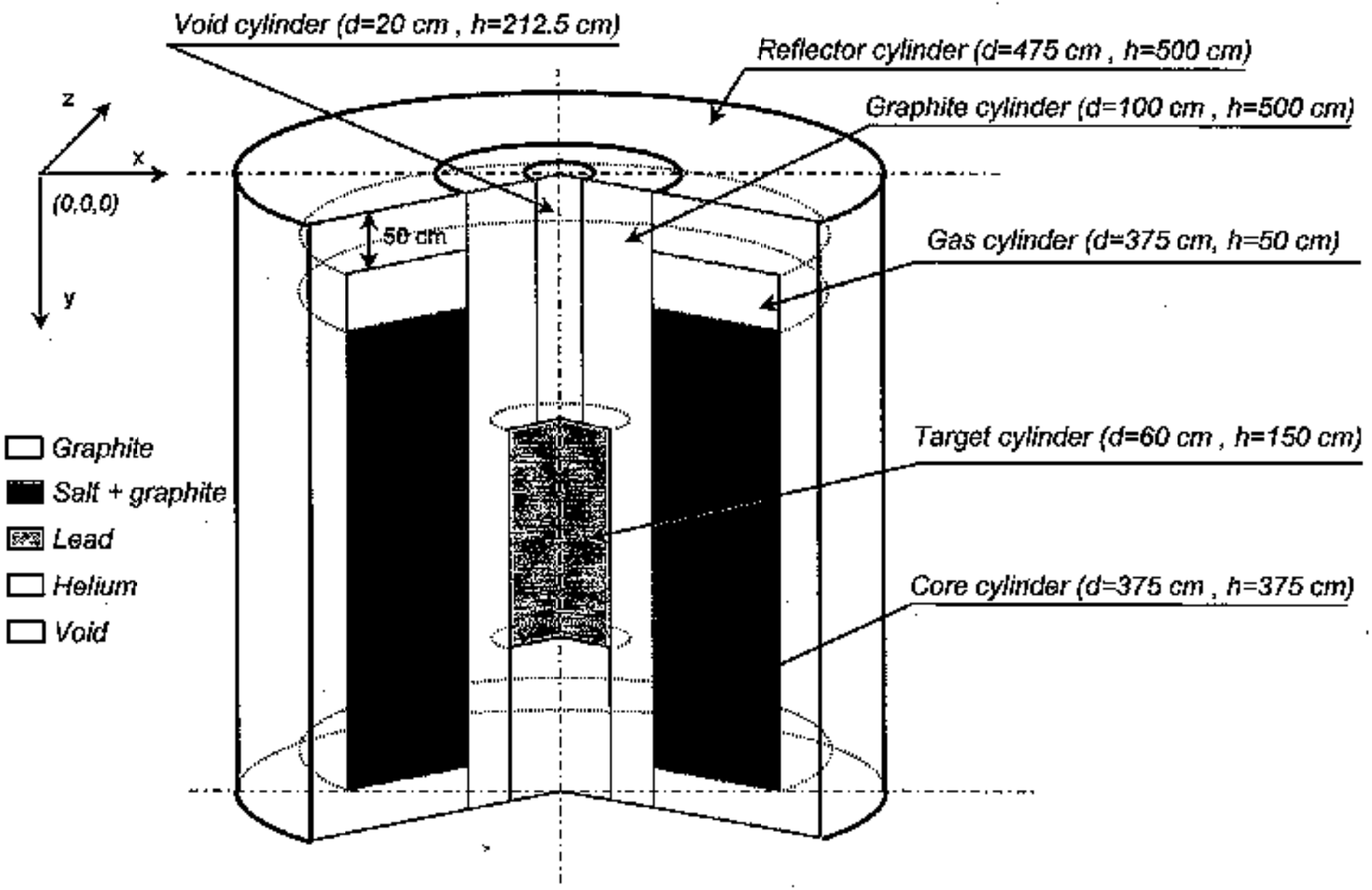
New Option

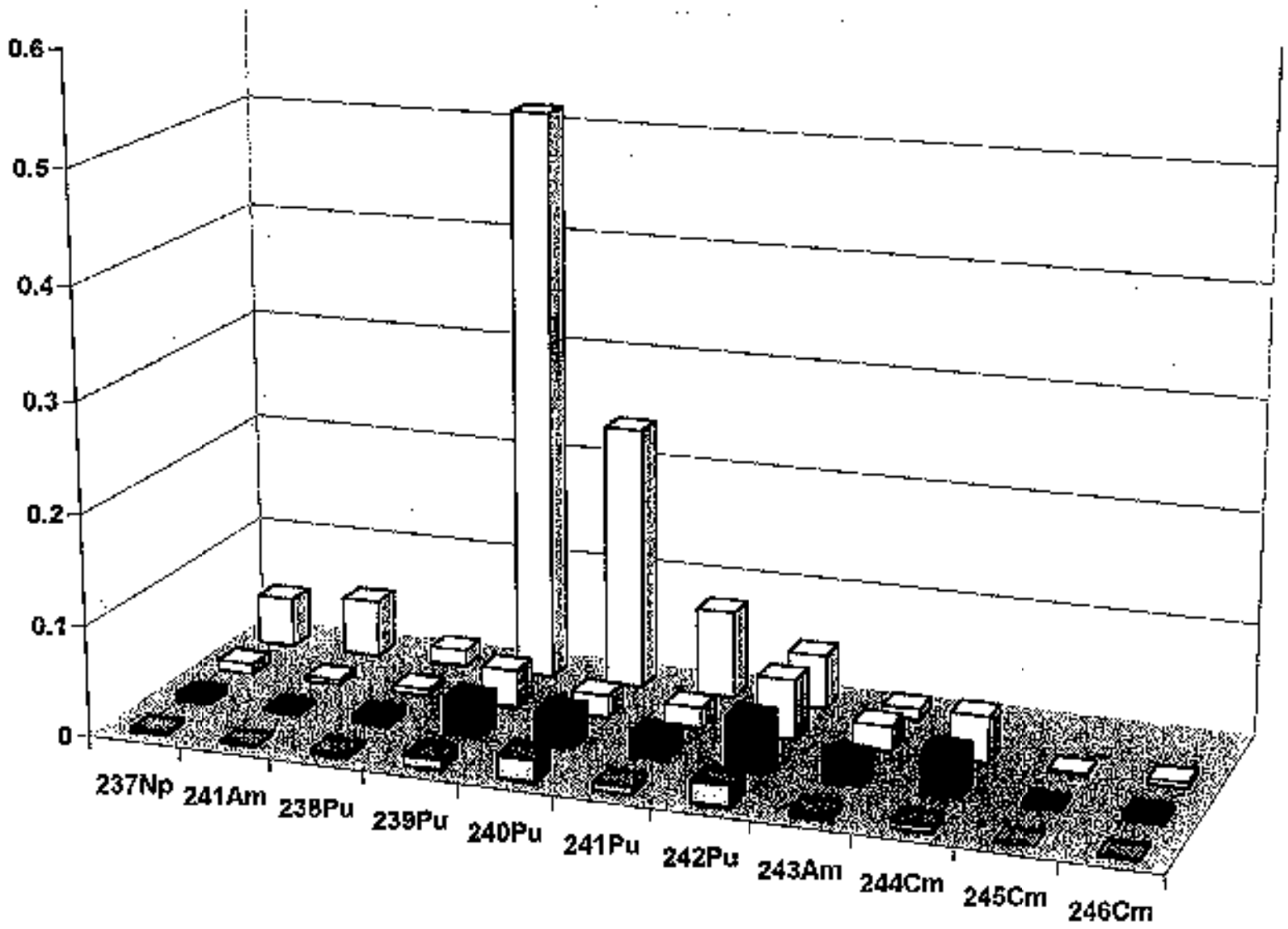


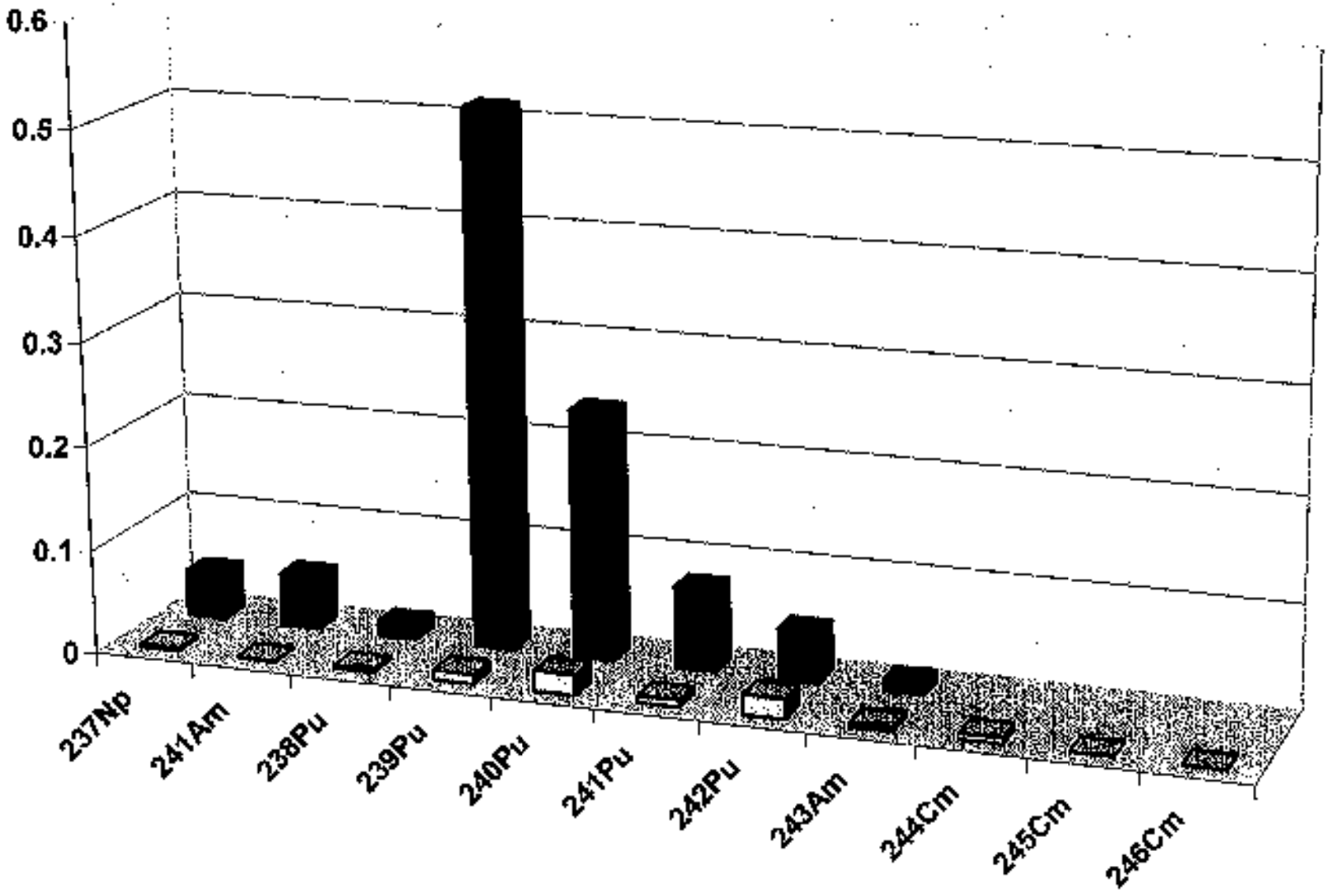

lead out
lead in
360° input and output Hastalloy plena for secondary salt ($NaBF_4$)
Flowing helium
Hastalloy heat exchanger pump
20-cm high salt fountains
(2 m/s salt flow rate)
Boron-loaded graphite
Eight Hastalloy heat exchangers
(100 MWt each)
Accelerator vacuum
7-cm diameter holes for salt flow
Windowless liquid lead target (60-cm diameter)
Molten salt carrier (NaF-ZrF_4)
Graphite moderator
1-GeV 12-mA proton beam
Lead target encased in removeable graphite
10-cm thick Hastalloy tank
(no penetrations)
Core diameter 440 cm
Outer diameter 500 cm


Graphite assembly
Molten salt
Graphite sleeve
Graphite
Target assembly
Beam
Lead in iron
Graphite

TIER-1 design's homogeneous geometry for MCNP code (PV2.inp)




0.6
0.5
0.4
0.3
0.2
0.1
0
237Np
241Am
238Pu
239Pu
240Pu
241Pu
242Pu
243Am
244Cm
245Cm
246Cm


0.6
0.5
0.4
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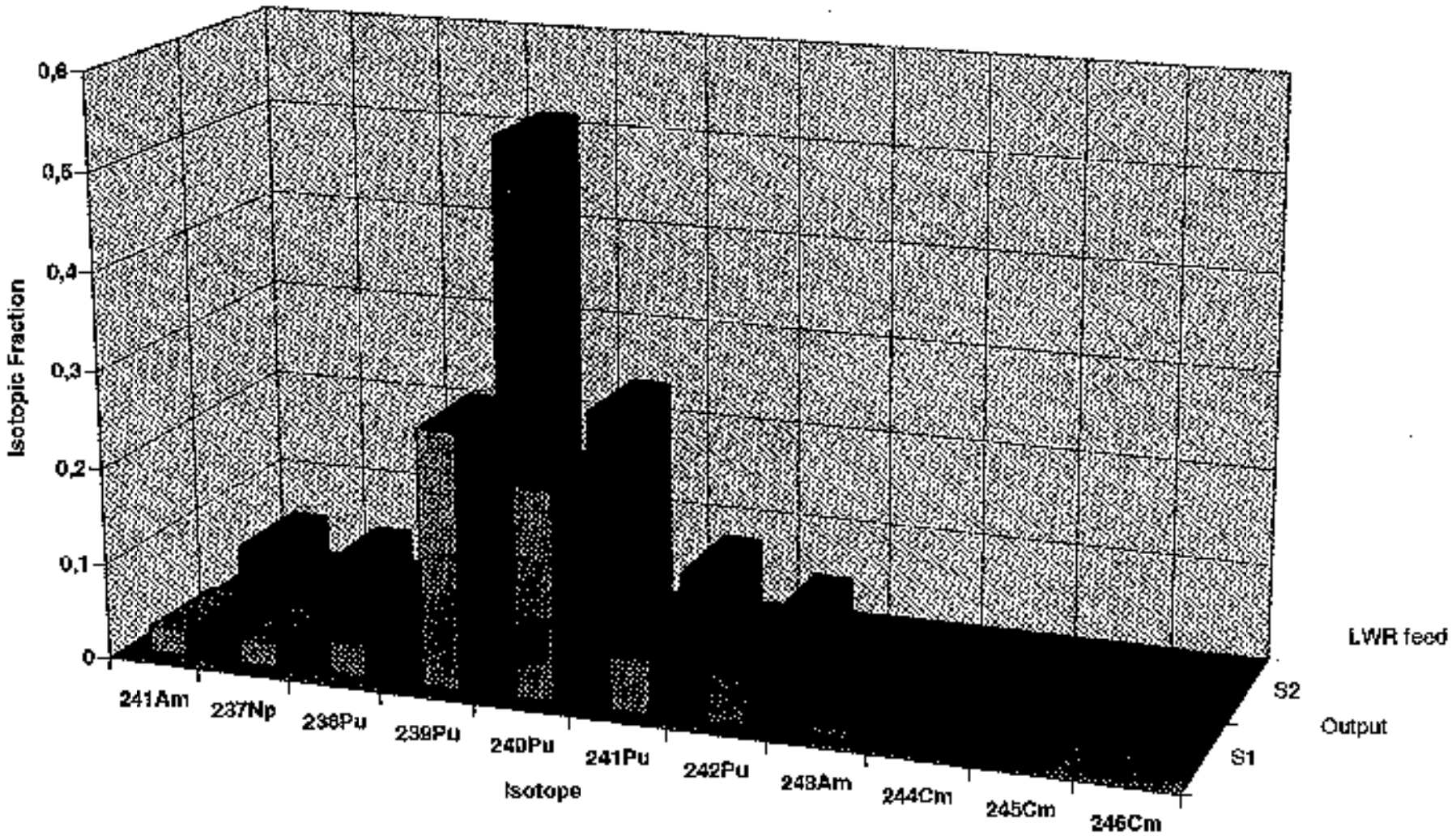
0.2
0.1
0
237Np
241Am
238Pu
239Pu
240Pu
241Pu
242Pu
243Am
244Cm
245Cm
246Cm

Once-Through Fast-Spectrum Burn-Down of LWR Spent Fuel



ADNA-HYTEC Goals for Transmutation of Commercial Nuclear Waste

* Elimination of weapons-useful material in commercial nuclear waste

* Recovery of the fission energy from waste actinides

* Elimination of reprocessing

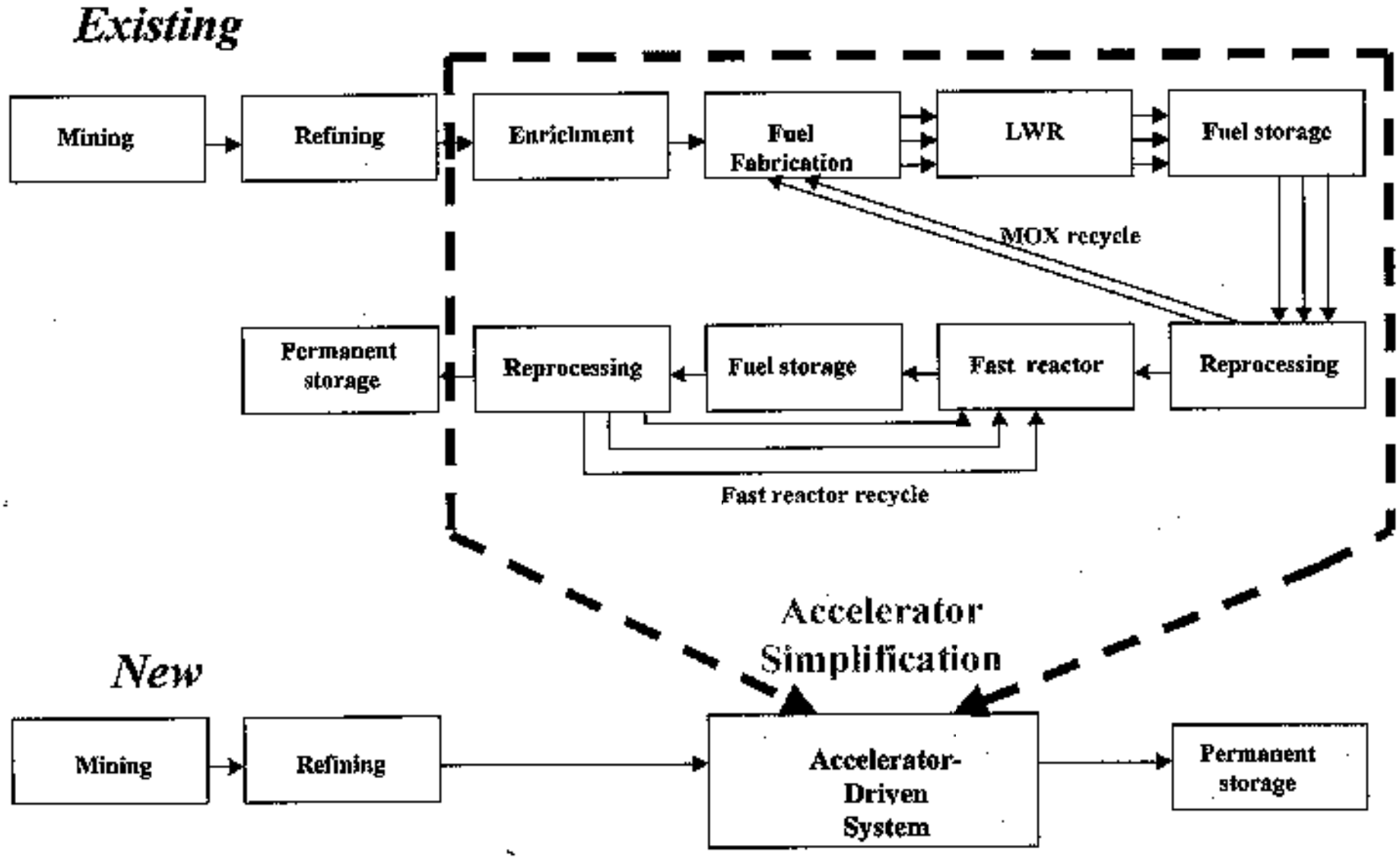
* Transmutation pays its own way
  (Capital and operating costs paid by electric power sales)

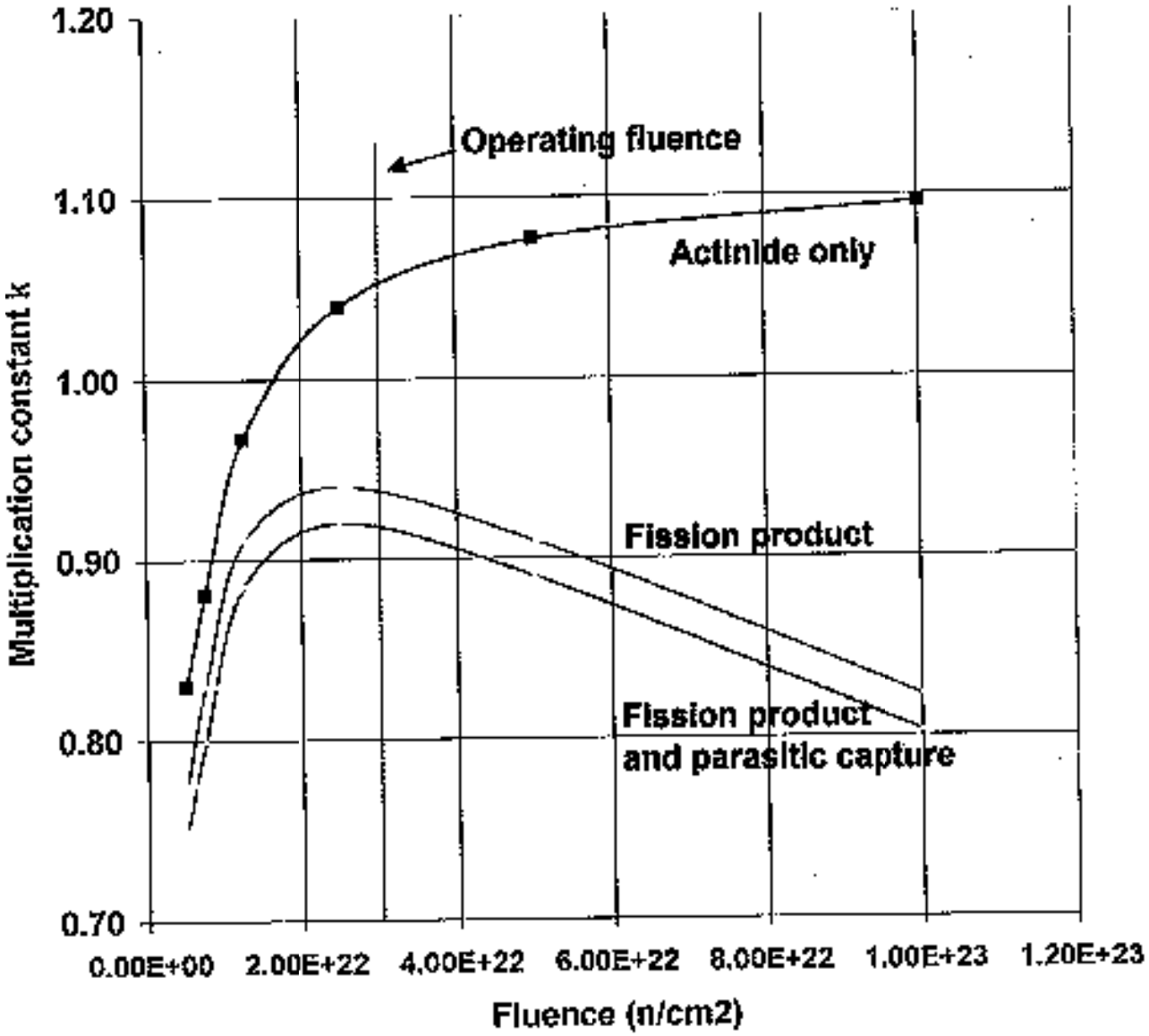
* Elimination of lengthy technology development
  (Deployment beginning by about 2012)

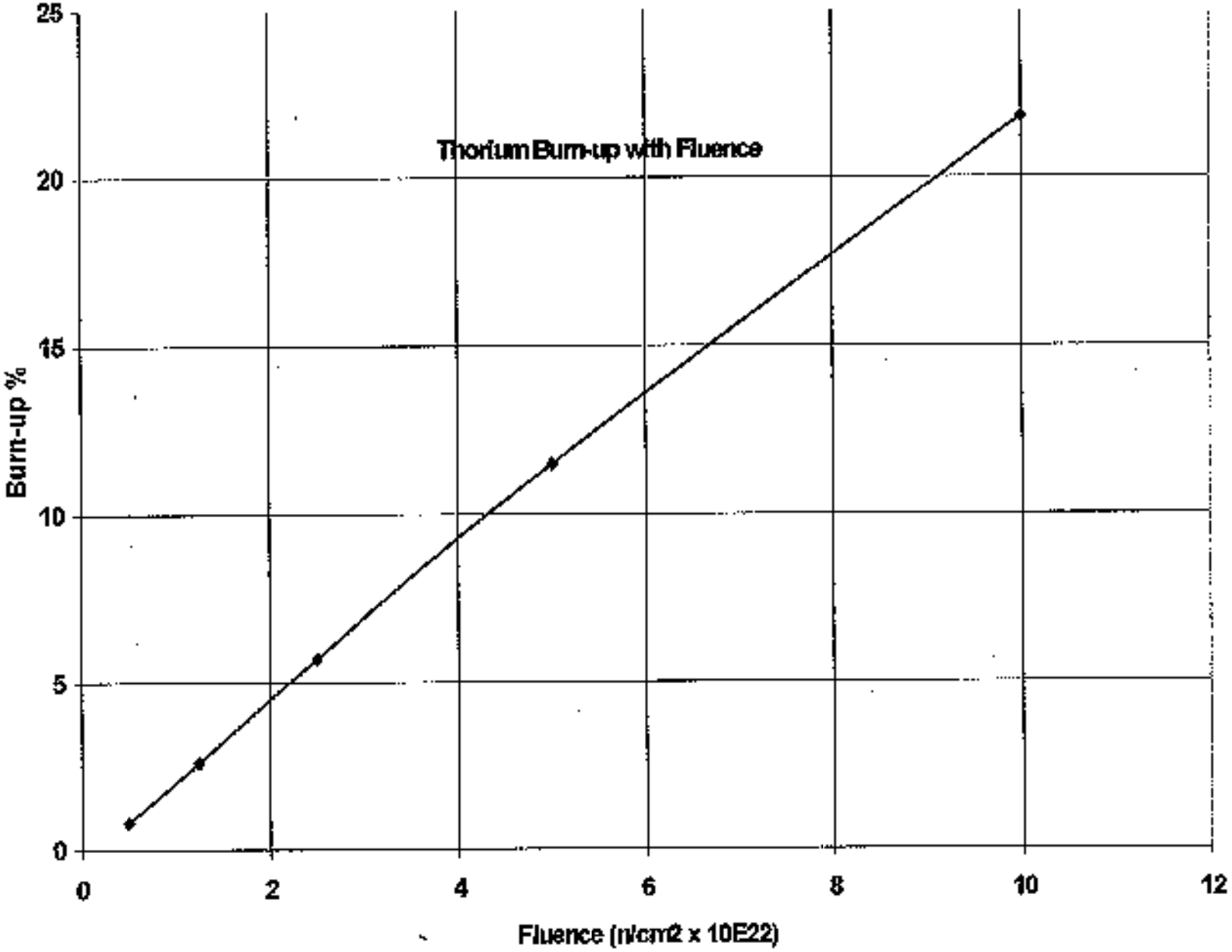
* Remnant actinides and f. p. still require geologic storage (Tier-1)

* Further development for complete burn-up if needed (Tier-2)

Accelerator Simplifies Infrastructure




1.20
1.10
1.00
0.90
0.80
0.70
Multiplication constant k
Operating fluence
Actinide only
Fission product
Fission product
and parasitic capture
0.00E+00
2.00E+22
4.00E+22
6.00E+22
8.00E+22
1.00E+23
1.20E+23
Fluence (n/cm2)

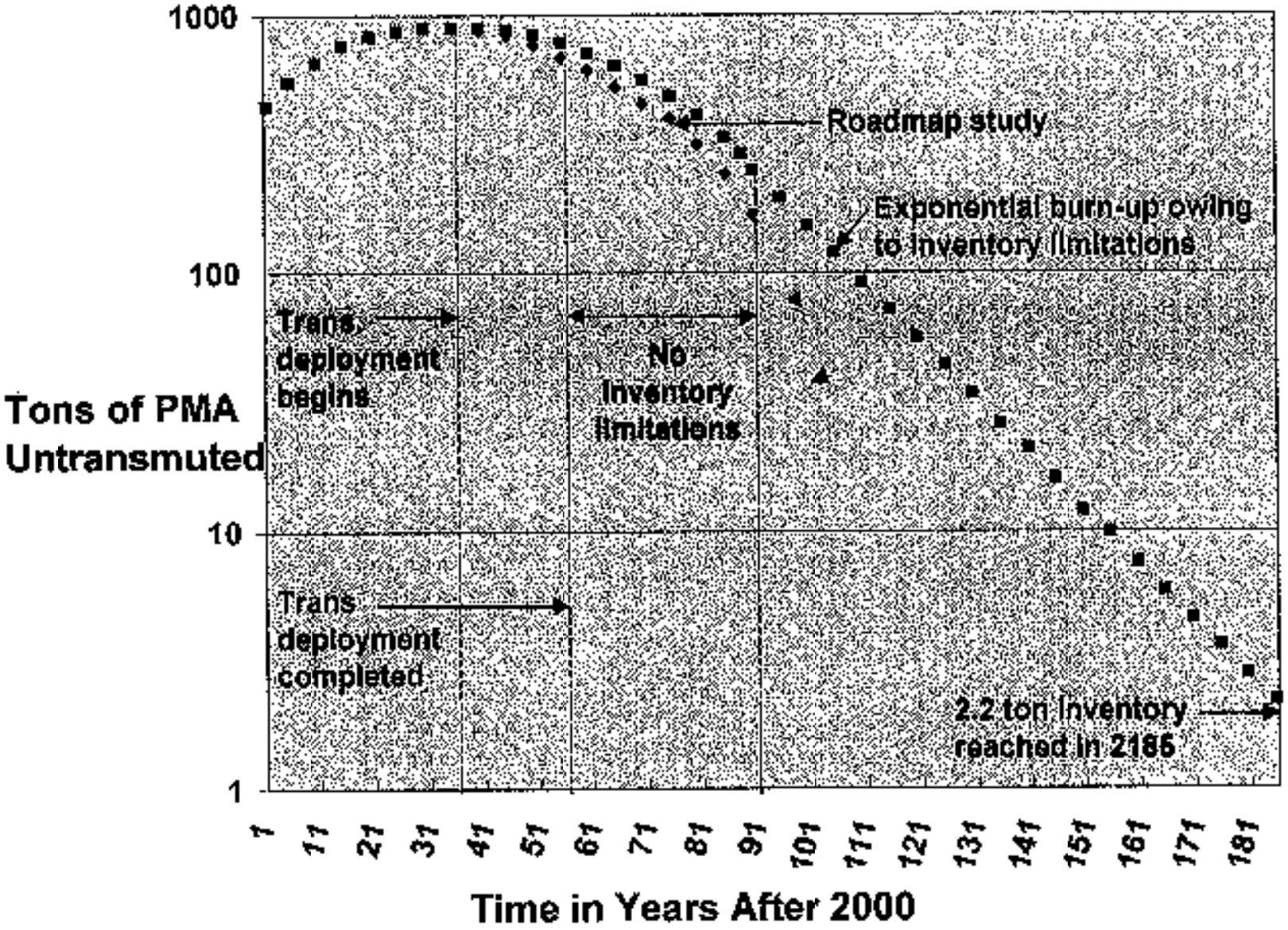

Thorium Burn-up with Fluence
Burn-up %
25
20
15
10
5
0
0
2
4
6
8
10
12
Fluence (n/cm2 x 10E22)

Minimum PMA with 1/1000 Separations Factor

Assuming total U. S. PMA of 900 tons

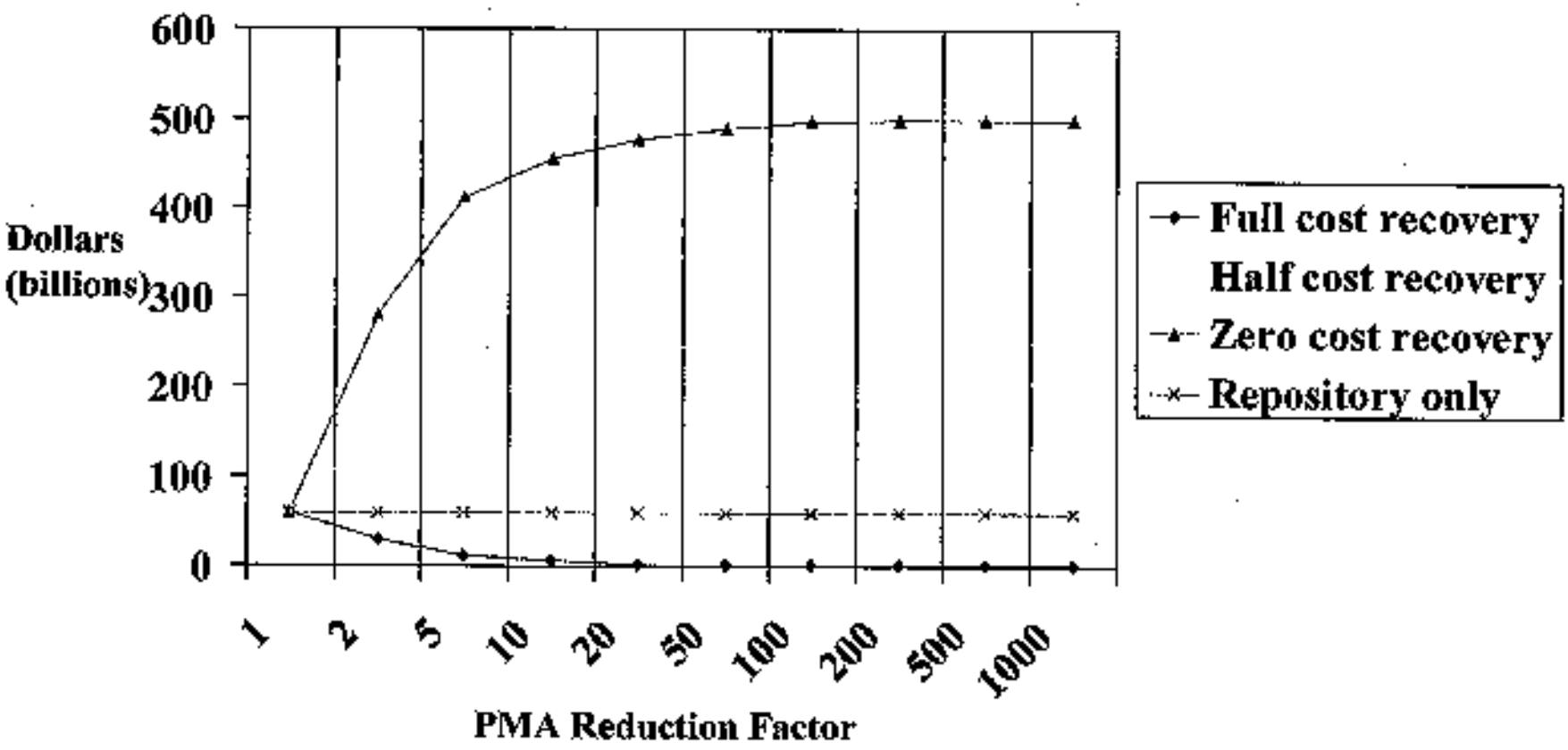
Lost in front-end separations	**0.9 Tons**
Remnant from last core	**2.2**
Lost in recycle with multiplication (3.3 x 0.9 tons)	**3.0**
Total	**6.1 Tons**

Reduction effectively to 0.68 % with 0.1 % separation factor and with about a 2-ton remnant of weapons-useful plutonium


1000
100
10
1
Tons of PMA Untransmuted
Roadmap study
Exponential burn-up owing to inventory limitations
Trans deployment begins
No inventory limitations
Trans deployment completed
2.2 ton inventory reached in 2185
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
161
171
181
Time in Years After 2000

Transmutation Cost Without Power Sales

Annual income from one LWR at $0.05/kwh	**$440 million**
Total income from 100 LWRs for 40 years	**$1660 billion**
Annual mass fissioned in one LWR	**1200 kg**
Annual mass of PMA produced in one LWR	**300 kg**
Income from fissioning 300 kg of PMA	**$110 million**
Total cost of fissioning all PMA from 100 LWRs for 40 years	**$440 billion**


600
500
400
300
200
100
0
Dollars (billions)
1
2
5
10
20
50
100
200
500
1000
PMA Reduction Factor
Full cost recovery
Half cost recovery
Zero cost recovery
Repository only

Comments on Roadmap Reference Technology

- Accelerator is a major addition in expense and complexity enabling only modest gains over a reactor
- Large inventory with fast spectrum extends burn-out period (150 years to 0.2 %)
- Never eliminates weapons plutonium; (two tons at least ~ 400 weapons NAS)
- Most likely a large increase (by four?) in expense over repository alone
- Only 30 % burn-up per pass multiplies separation chemistry work and spoils 0.1 separation factor
- Similar system rejected by STATS panel already owing to time scale and expense
- Poor basis for advancing ATW as new technology; will be viewed by Congress as "stalking horse" for IFR

Advantages of ADNA Thermal Spectrum Design

- 7 % single-pass remnant PMA (compared with 70 % for ATW reference design)
- Accelerator displaces recycle separations eliminating recycle costs and most difficult technology development
- Plutonium single-pass remnant not weapons useful
- Neptunium single-pass burn-down by a factor of 15
- Uses materials and technology demonstrated in the MSRE program
- Offers large nuclear energy resource extension (~40) from thorium without front or back end separations, weapons material production, or isotope separation
- LWR weapons material eliminated and most fission energy (> 90 %) recovered in a single pass and in one human generation thereby removing the two primary motives for disturbing the repository

Some Suggestions for Steering Committee Consideration

- Consider encouraging major changes in fast ATW technology to enable significant benefit over fast reactor (e. g., major increase in flux)
- Broaden focus beyond repository performance to include stronger emphasis on weapons material reduction and energy recovery from PMA
- Open support in FY 2000 to other ATW concepts; establish a dual track
- Prepare preconceptual designs on new concepts by Sept. 1, 2000
- Encourage modest experiments which enhance and validate the preconceptual designs
- Evaluate designs in Sept. 2000 for continuation to future down-select