Disposition of Excess Uranium-233 in the Waste Isolation Pilot Plant (WIPP)

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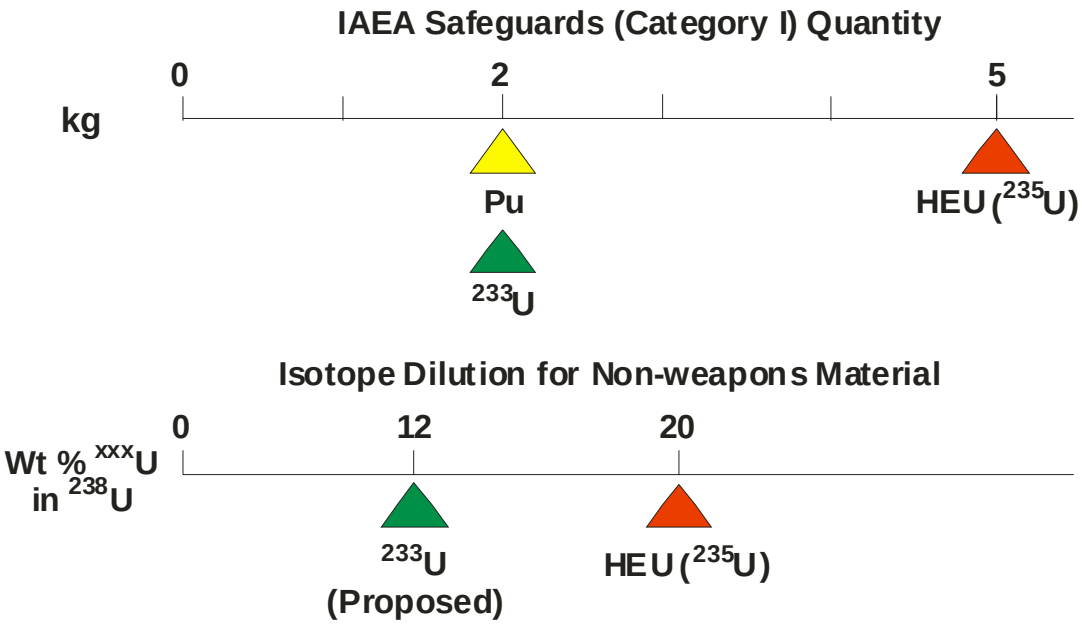
Outline

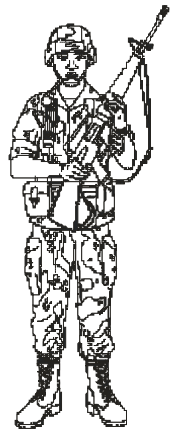
- **Properties of ^{233}U**
- **Inventories**
- **Disposal Requirements**
- **Disposal Options**
- **Conclusions**

Properties of ^{233}U

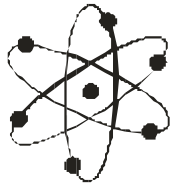
Nuclear Characteristics of the Three Fissile Materials That Can Be Produced in Large Quantities



HIGH SECURITY



CRITICALITY SAFETY



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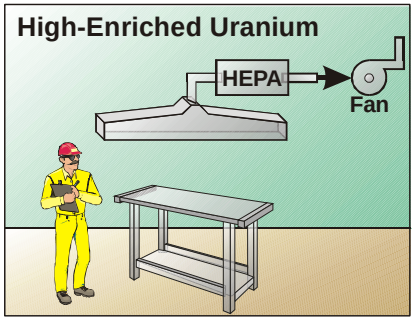
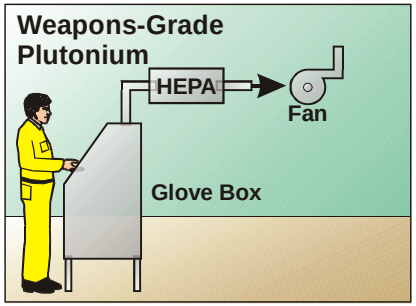
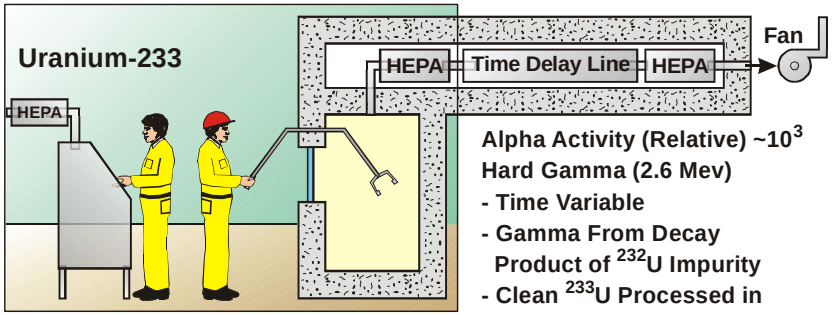
Different Fissile Materials Have Different Handling Requirements



Alpha Activity (Relative) = 1
No Significant Gamma

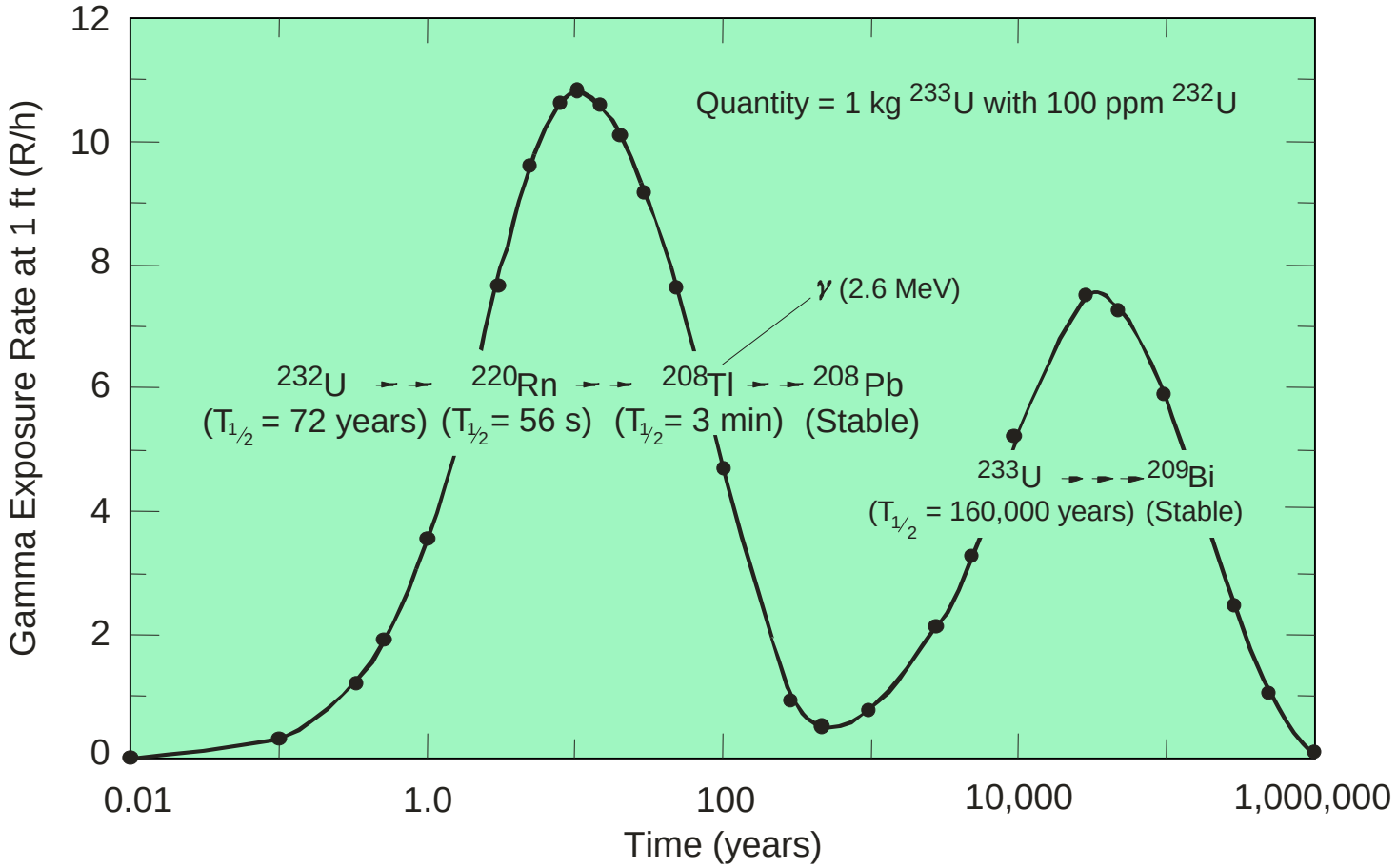


Alpha Activity (Relative) ~10^4
Soft Gamma
- Minimal Shielding
- Leaded Gloves Acceptable



Alpha Activity (Relative) ~10^3
Hard Gamma (2.6 Mev)
- Time Variable
- Gamma From Decay Product of ^{232}U Impurity
- Clean ^{233}U Processed in Glove Box

Uranium-233 with Significant Quantities (100 ppm) of ^{232}U Is a Significant Radiation Hazard



Inventories

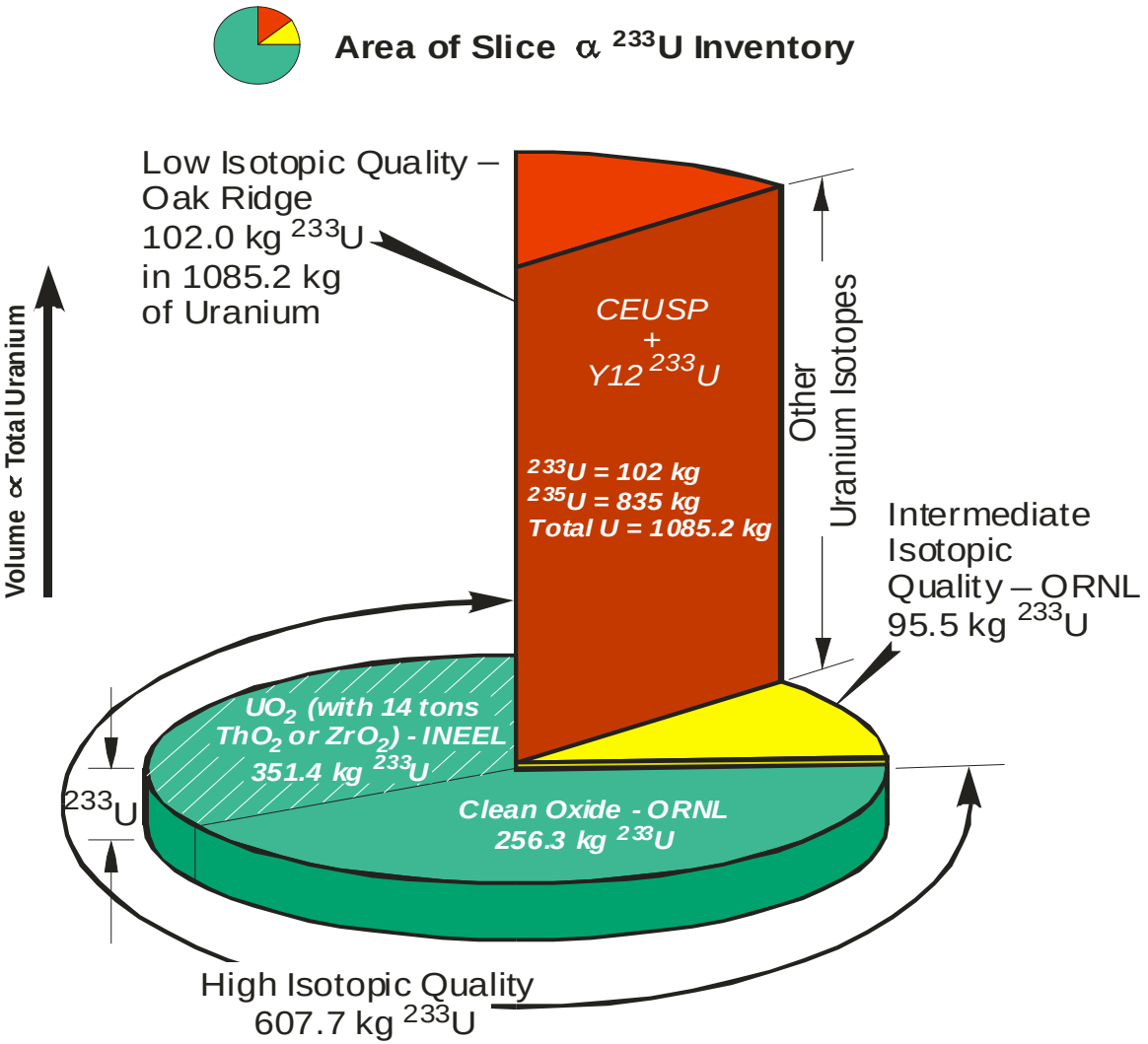
The Existing Separated ^{233}U Inventory Can Be Divided into Three Major Categories

- High-Isotopic-Quality ^{233}U
  - Greater than 95% ^{233}U
  - Low ^{232}U content with relatively low gamma-radiation levels

- Intermediate-Isotopic-Quality ^{233}U
  - Greater than 95% ^{233}U
  - High ^{232}U (>15 ppm) content with high gamma-radiation levels

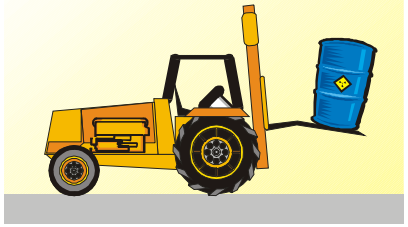
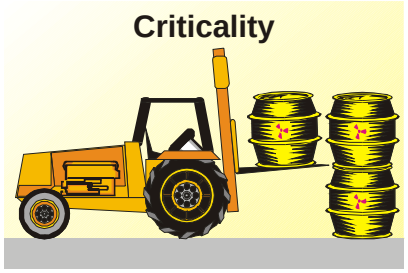
- Low-Isotopic-Quality ^{233}U
  - Less than 50% ^{233}U

Separated ^{233}U Inventory (U.S.)

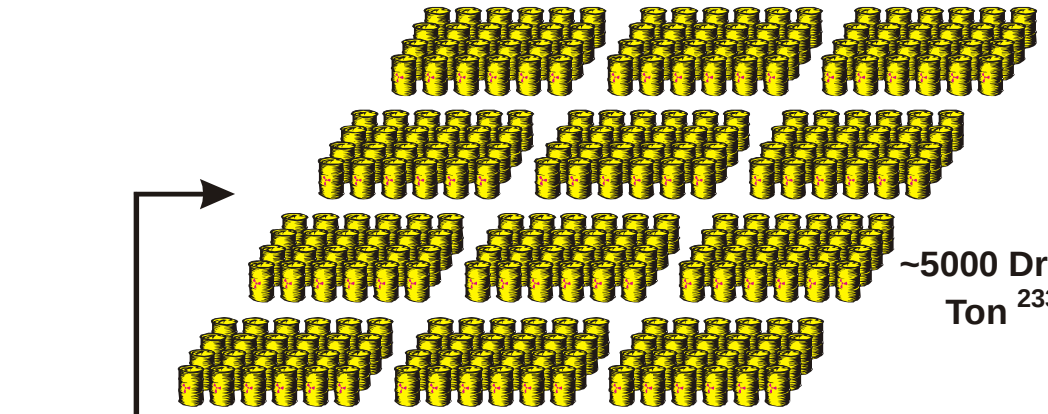


Disposal Requirements

Technical WIPP WAC Constraints

Criteria		TRU Waste Category: Contact Handled (55-gal Drum)	TRU Waste Category: Remote Handled (RH Container Accepts 3 Drums)
Weight 		≤450 kg	≤3600 kg
Accident Consequence Control (Radioactivity) 	Untreated Waste	≤1.3 kg ^{233}U	≤16 kg ^{233}U
	Treated Waste	≤29 kg ^{233}U	≤16 kg ^{233}U
Criticality 	Fissile Mass Limit	≤200 g ^{233}U/ Drum	≤325 g ^{233}U/ RH Container
	Isotopic Dilution Limit	No Limit	No Limit

Impact of Criticality Control Strategy on Waste Volumes to WIPP-type Disposal Site



~5000 Drums/ Ton ^{233}U

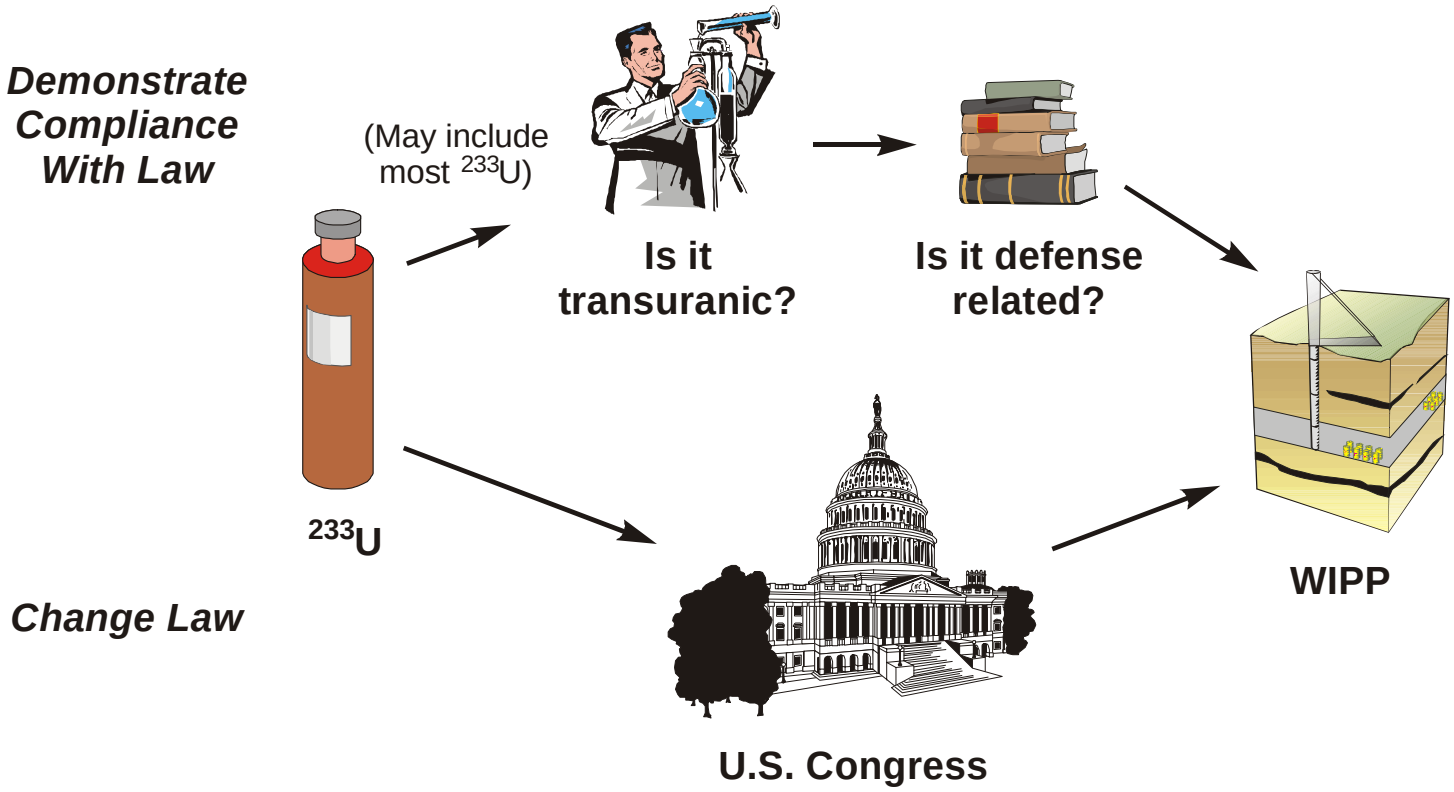
^{233}U

- No Isotopic Dilution
- WIPP WAC Constraint: 200 g ^{233}U/55-gal Drum
- Option to Mix with Low TRU Content Waste to Reduce Additional Waste Volume

~200 Drums/Ton ^{233}U

- Isotopic Dilution (0.66 wt % ^{233}U in ^{238}U; 0.53 wt % ^{233}U in DU with 0.2 wt % ^{235}U)
- WIPP WAC Constraint: Drum Gross Weight (^{233}U, DU)

There Are Two Approaches to Meet WIPP Legal Requirements for ^{233}U

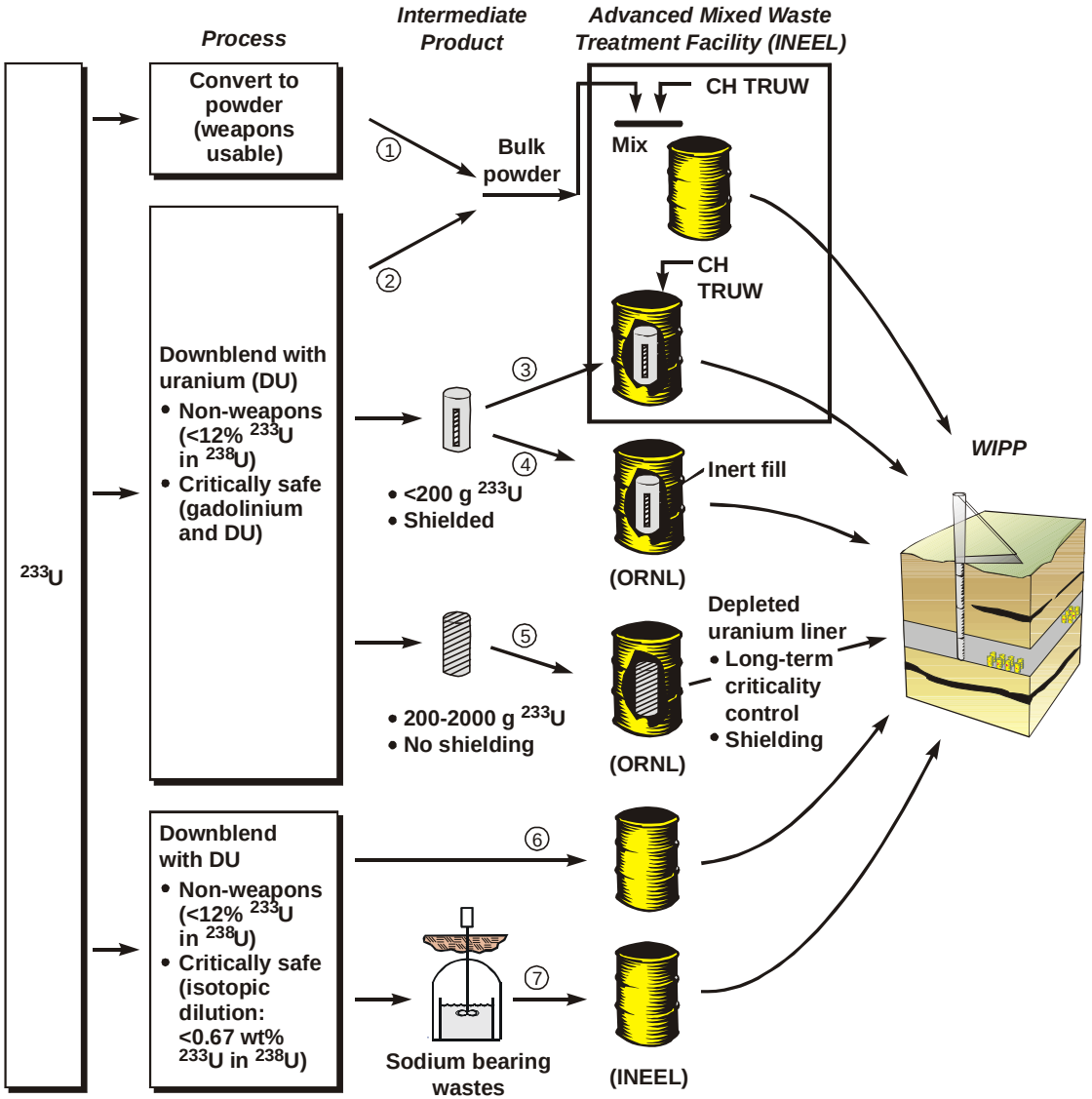


Disposal Options

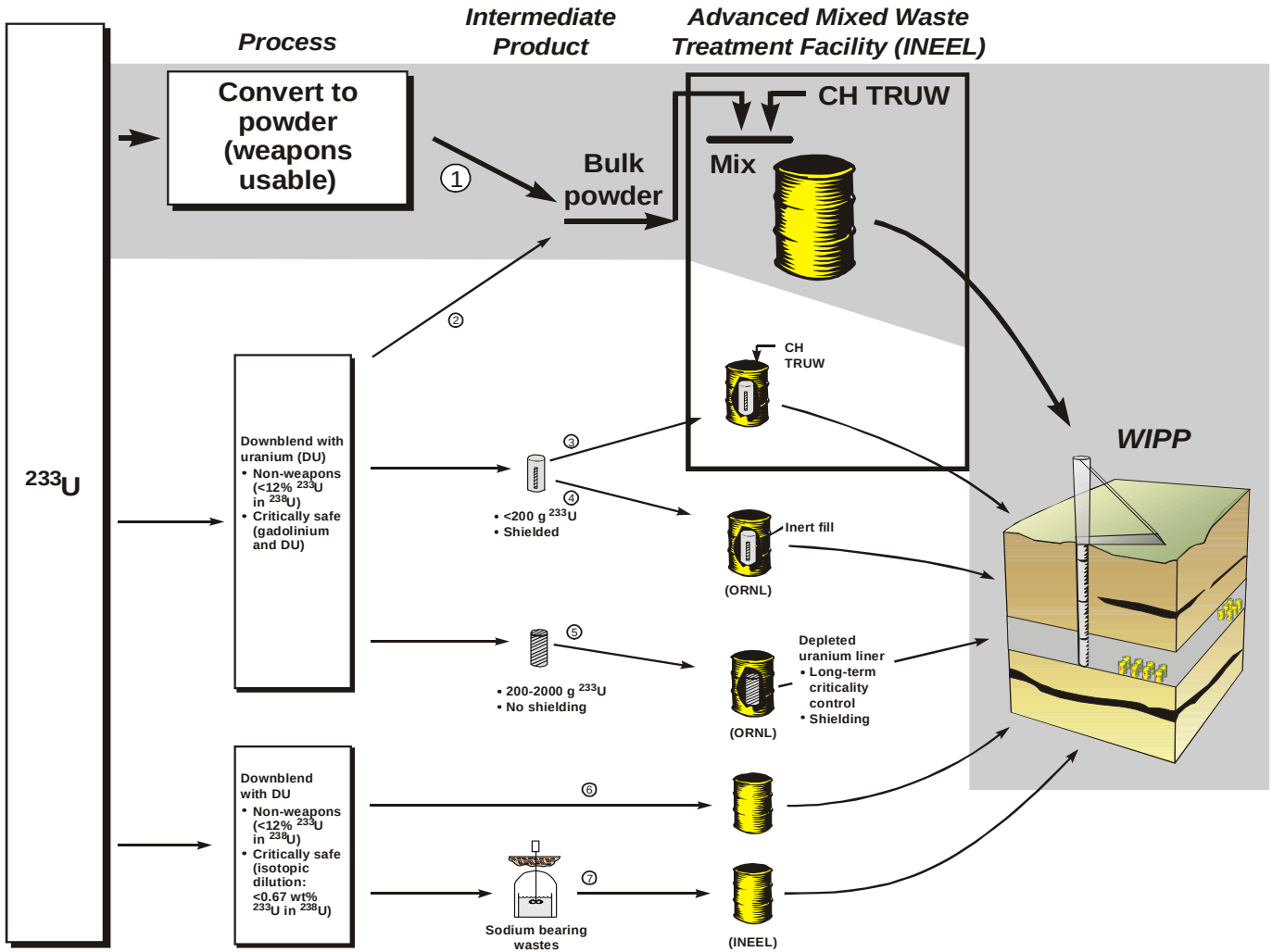
Disposal of ^{233}U in WIPP Requires Addressing Three Technical Issues

- **Criticality Control**
  - **Isotopic dilution (<0.66 % ^{233}U in ^{238}U)**
  - **Mass limit (200 g ^{233}U equivalent/package)**
- **Safeguards**
  - **Isotopic dilution with DU (<12% ^{233}U in ^{238}U)**
  - **Chemical dilution**
- **Radiation**
  - **Shielding**
  - **Chemical dilution**

WIPP ^{233}U Processing and Disposition Options



Mass Dilution of ^{233}U with Transuranic Waste and Disposal at WIPP



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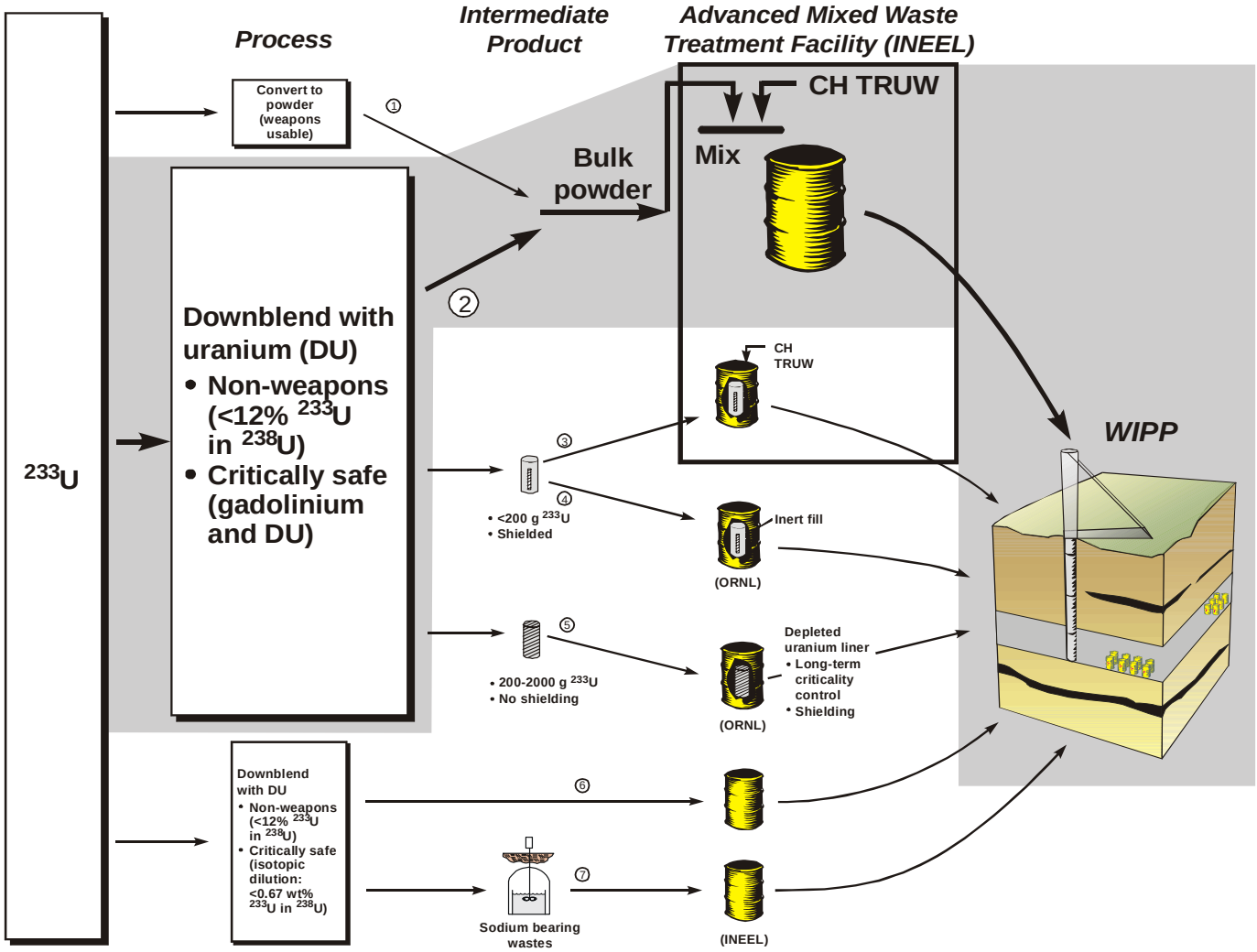
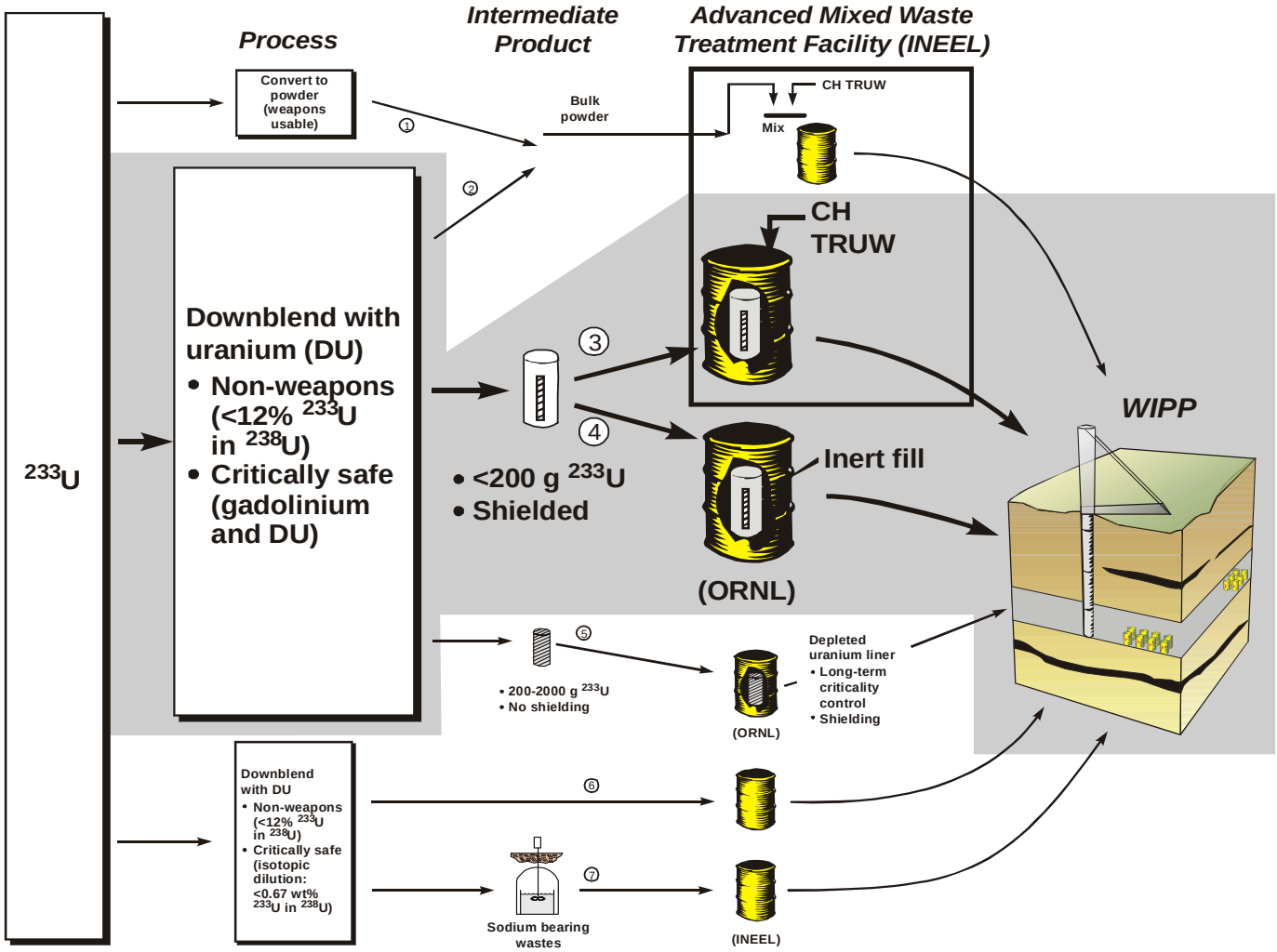
Conversion to Non-Weapons-Usable ^{233}U, Mass Dilution with TRU Waste, and Disposal at WIPP



Convert to Non-Weapons-Usable ^{233}U, Place in Self-Shielded Package, Add to TRU Container, and Dispose of at WIPP



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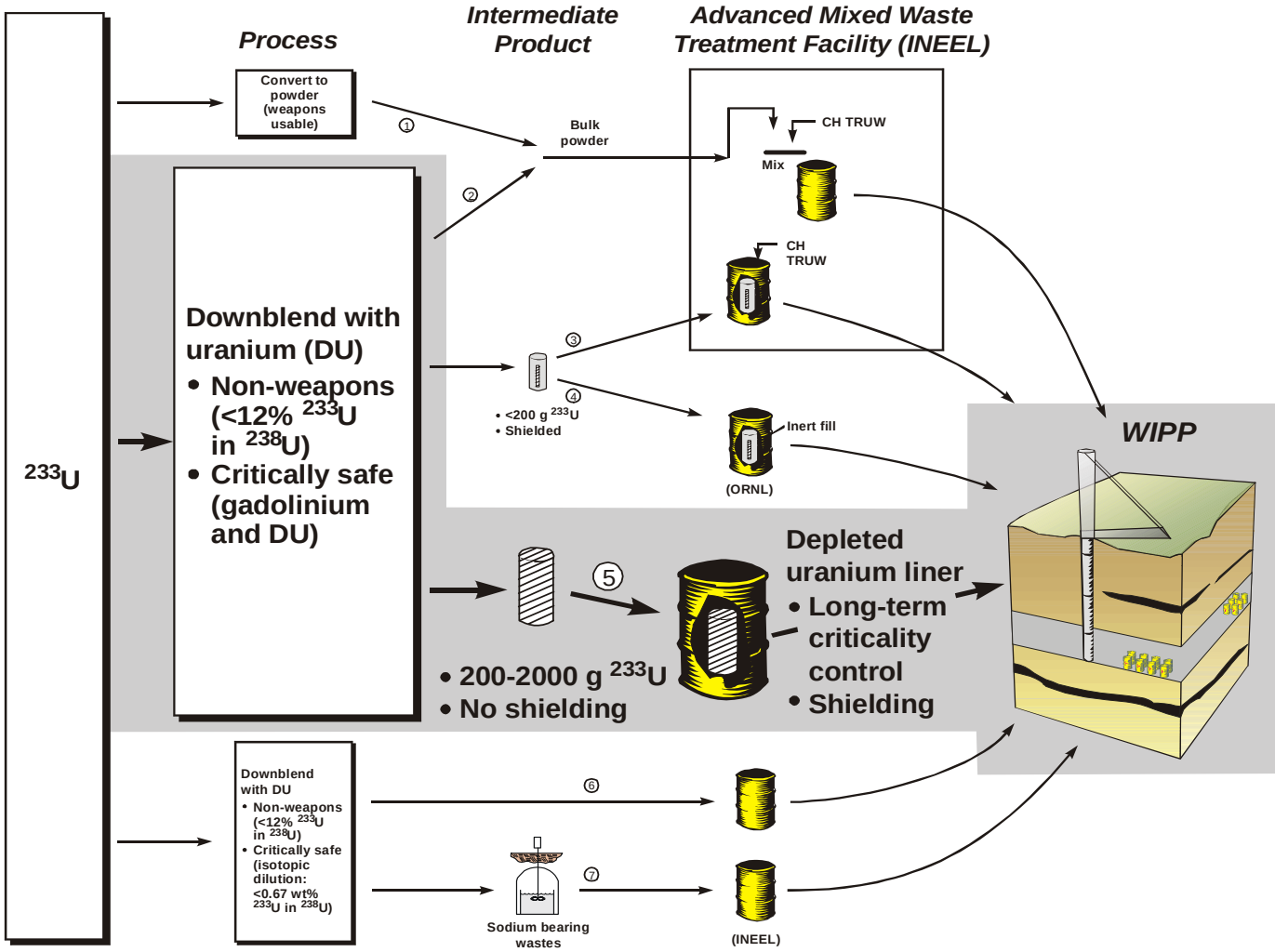
Convert to Non-Weapons-Usable ^{233}U, Place in Depleted Uranium Package, and Dispose of at WIPP



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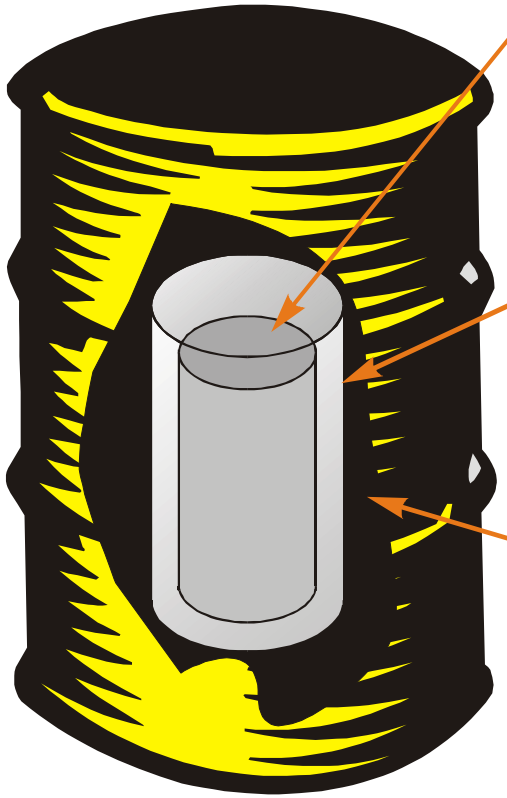
Contact-Handled, Stand-Alone Disposal of ^{233}U in WIPP With No ^{233}U Mass Limit



^{233}U TRU Waste

- Non-weapons-usable ^{233}U (<12 wt % ^{233}U in ^{238}U)
- Critically safe (gadolinium)
- Mass ^{233}U (200-2000 g/drum)

Uranium Metal or Cermet Shield

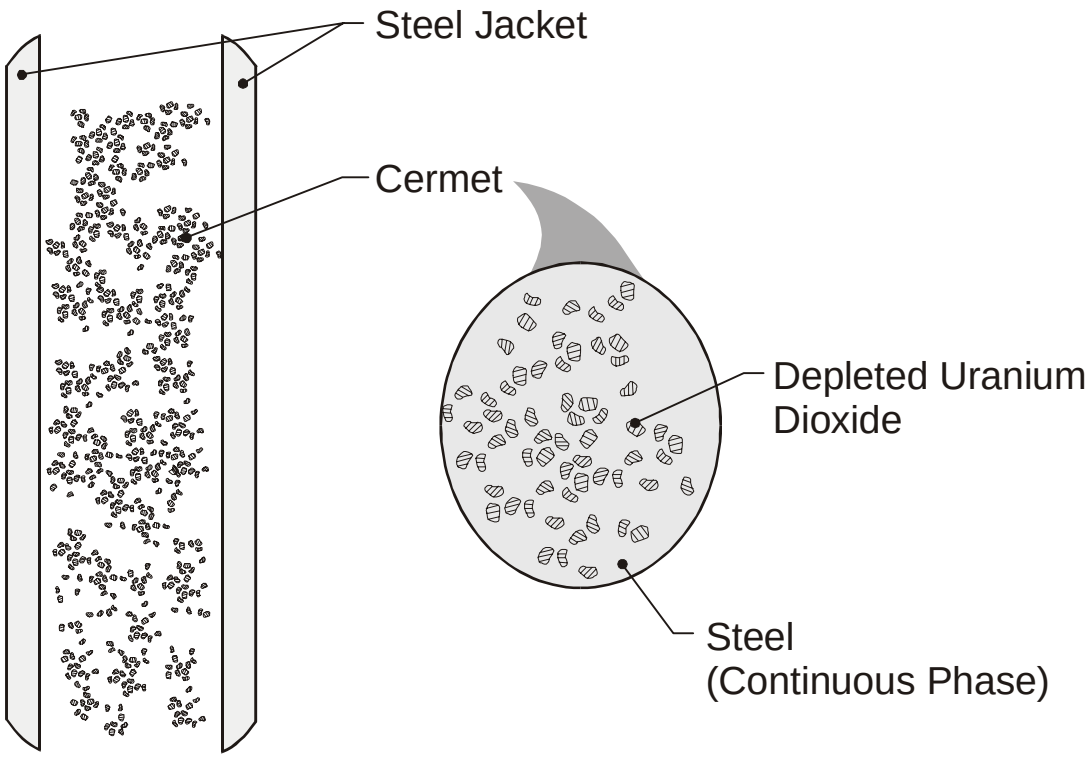
- Low radiation dose
- Isotopic criticality safety
  - <0.65 wt % ^{233}U in ^{238}U

Inert Fill

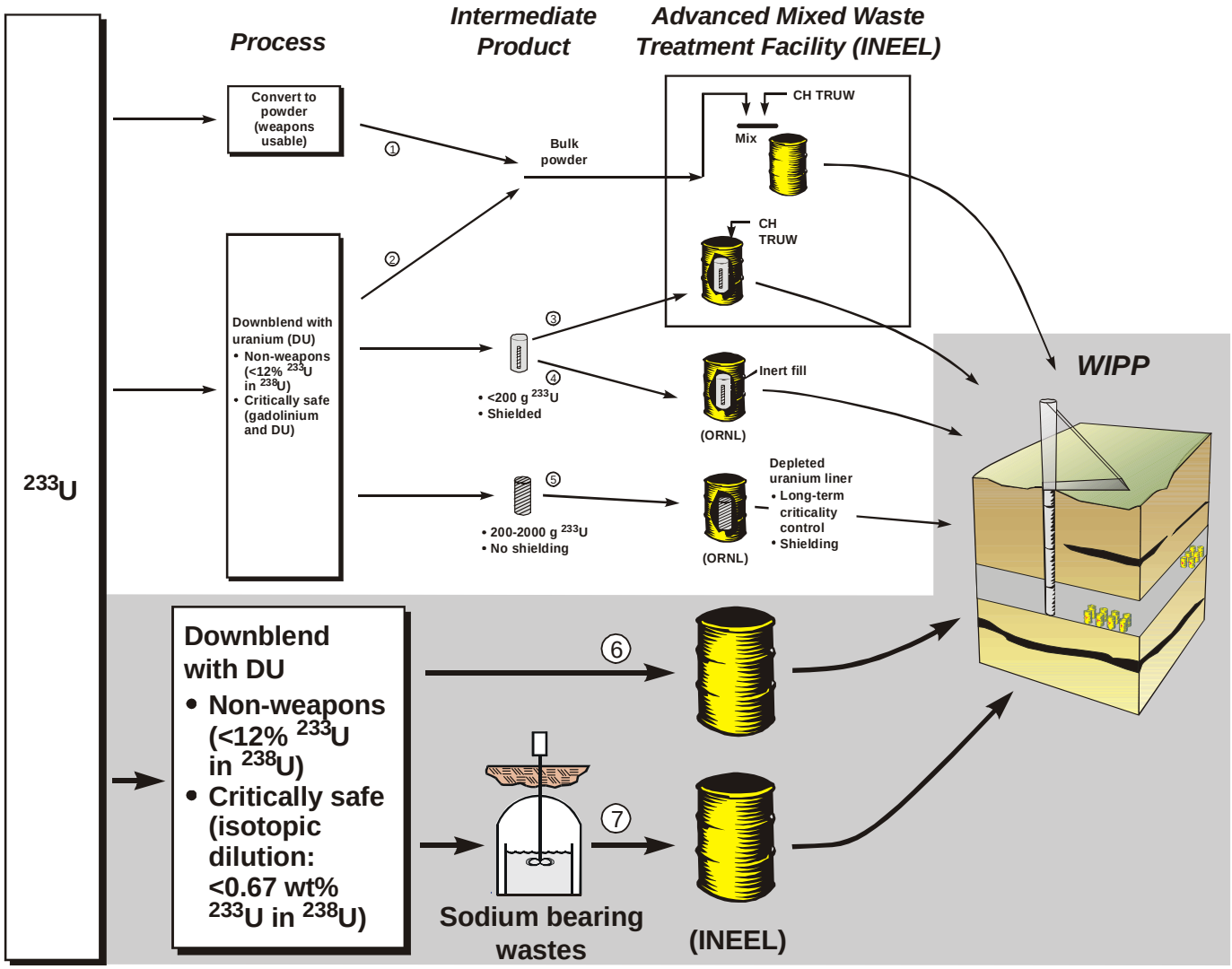
General Characteristics

- Stand alone
- Minimize transport
- Low waste volume

DUO_2-Steel Cermet



Convert to Critically Safe ^{233}U and Dispose of at WIPP



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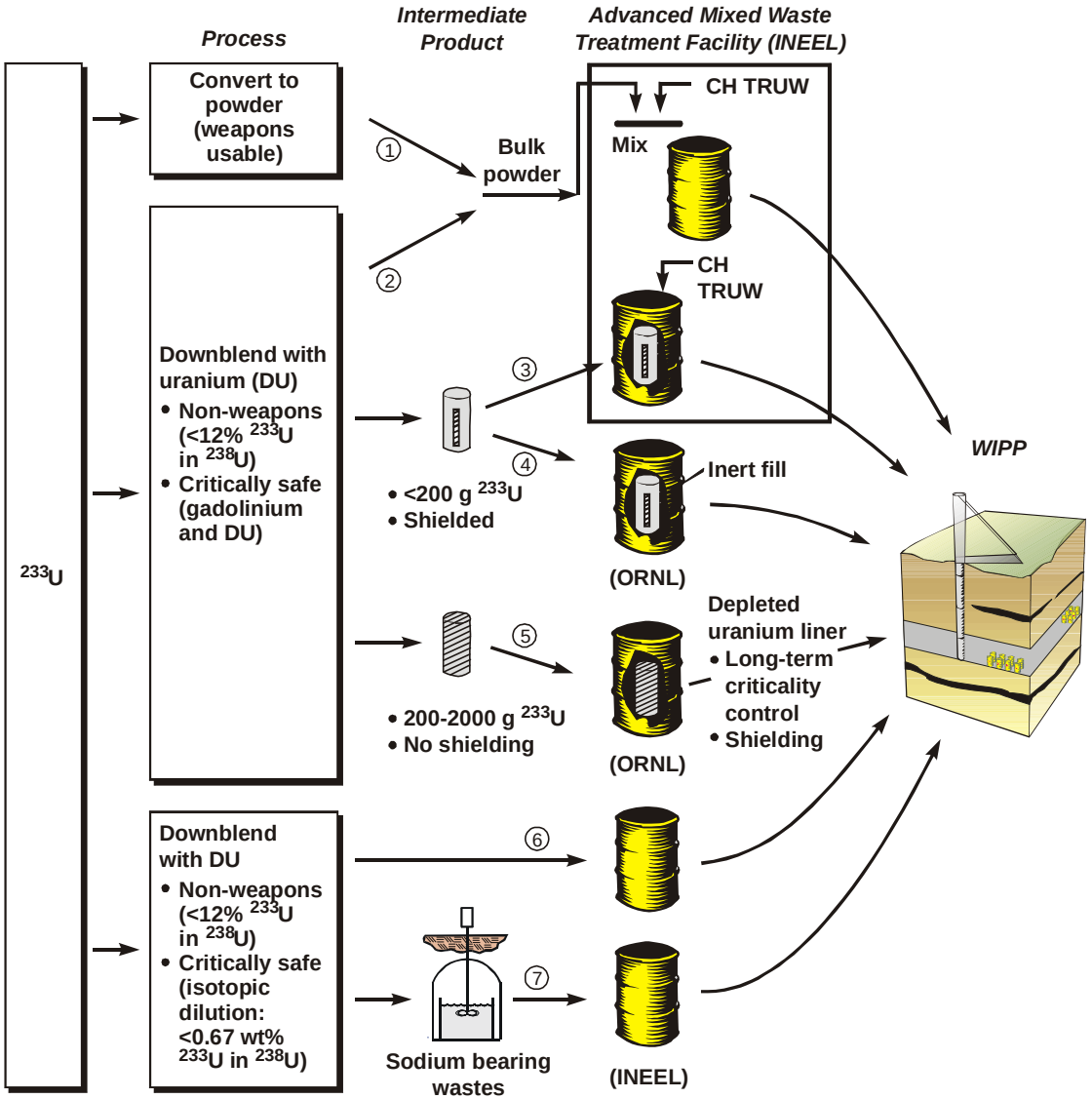
Comparison of Packages with Sufficient DU for Isotopic Criticality Safety

Characteristic	DU shield	DU mix
Non-weapons	Yes (<12%)	Yes (<0.66%)
DU quantity	Identical	Identical
Handling	Contact handled	Remote handled
Licensing	Analysis Required	Simple

Conclusions

There Are Multiple WIPP ^{233}U Disposal Options



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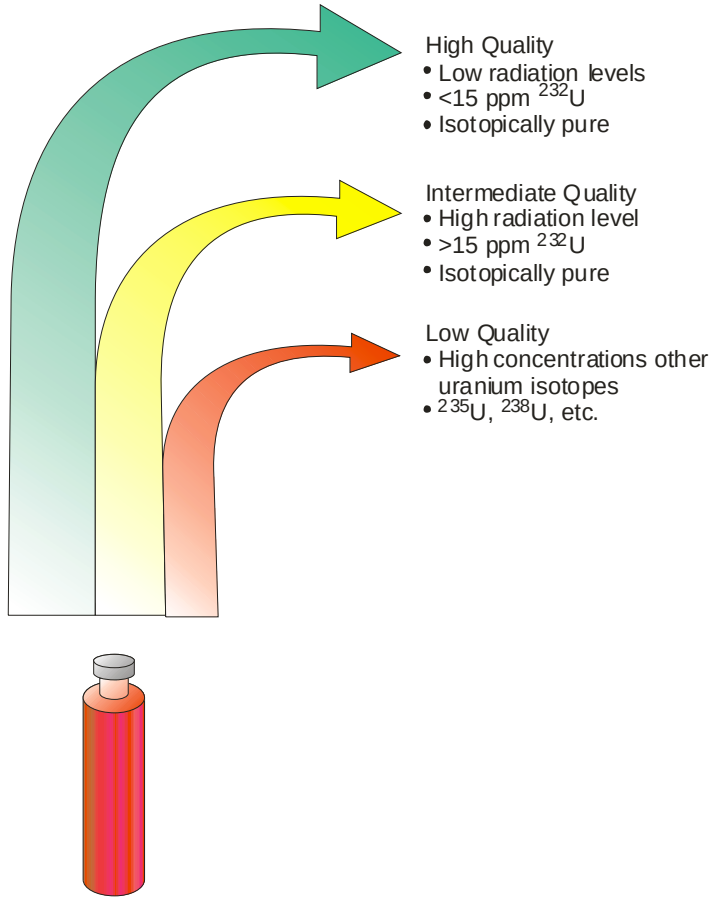
Conclusions

- **WIPP is a logical disposal site for ^{233}U (similar to plutonium)**
- **There are four issues**
  - **Institutional (definition of TRU wastes)**
  - **Conversion to non-weapons-usable ^{233}U**
  - **Ensure nuclear criticality safety**
  - **Limit radiation exposures**
- **Potentially attractive WIPP disposal options exist**

Backup Information

The ^{233}U Inventory Was Divided into Three Categories Based on Those Characteristics That Control Its Potential Future Usage



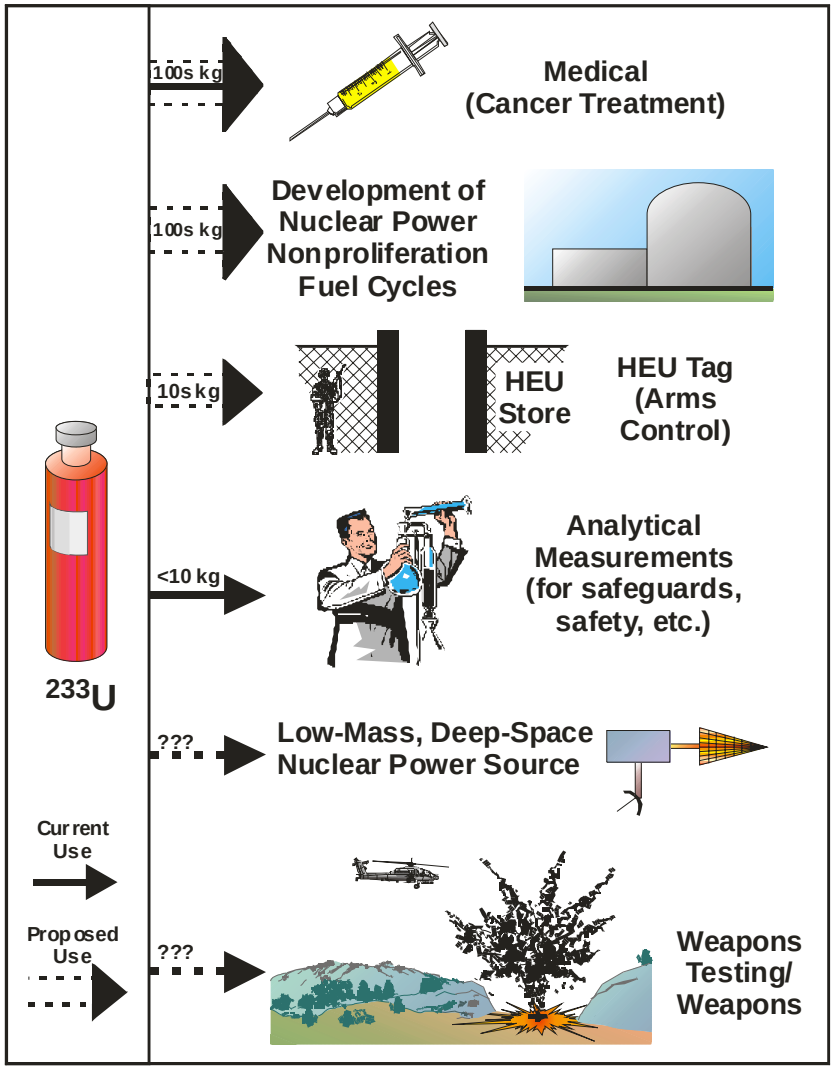
Characteristics of Major Batches of Separated ^{233}U in Inventory in Oak Ridge

Batch no.	Location/designation	Material[a] and packaging	Total U (kg)	Uranium isotopics			Number of packages	
				^{233}U (kg)	^{235}U (kg)	^{232}U (ppm)	Current	After repackaging
High Isotopic Quality								
1	Oak Ridge National Laboratory (ORNL)	U_3O_8 monolith in 27 welded stainless steel cans with tin-plated cover (same as CEUSP)	65.2	60.3	0.0	15	27	27
2	ORNL (2 similar batches)	UO_x powder in 247 stainless steel screw-top cans	108.8	103.1	0.0	4–9	247	73
3	ORNL	U_3O_8 powder in 1,645 welded stainless steel plates in 130 packages	46.0	45.0	0.0	6	130	62
4	Multiple/remaining small lots	Multiple forms-60 packages	49.0	47.9	0.0	b	60	33
Subtotal			***269.0***	***256.3***	***~0.0***		***464***	***195***
Intermediate Isotopic Quality								
5	ORNL/Savannah River Site (SRS)	UO_3 powder in 140 welded inner aluminum-in-aluminum cans	67.4	61.6	0.0	156	140	140
6	ORNL/Molten Salt Reactor Experiment (MSRE)	49 NaF traps to be converted to UO_x monolith-powder in 49 welded Haynes alloy 230 cans	40.6	33.9	~1.0	160–200	49	49
Subtotal			***108.0***	***95.5***	***~1.0***		***189***	***189***
Low Isotopic Quality								
7	ORNL/Consolidated Edison Uranium Solidification Program (CEUSP)	U_3O_8 monolith in 403 welded stainless steel CEUSP cans; Monoliths also contain CdO and Gd_2O_3	1,042.6	101.1	796.3	120	403	403
8	Y-12	5 cans	42.6	0.9	38.7	0.15	5	5
Subtotal			***1,085.2***	***102***	***835***		***408***	***408***
Total			***1,462.2***	***453.8***	***836***		***1,061***	***792***

[a]With minor exceptions, most of the material is in oxide form. Current programs will convert most non-oxide ^{233}U into an oxide form for long-term storage.

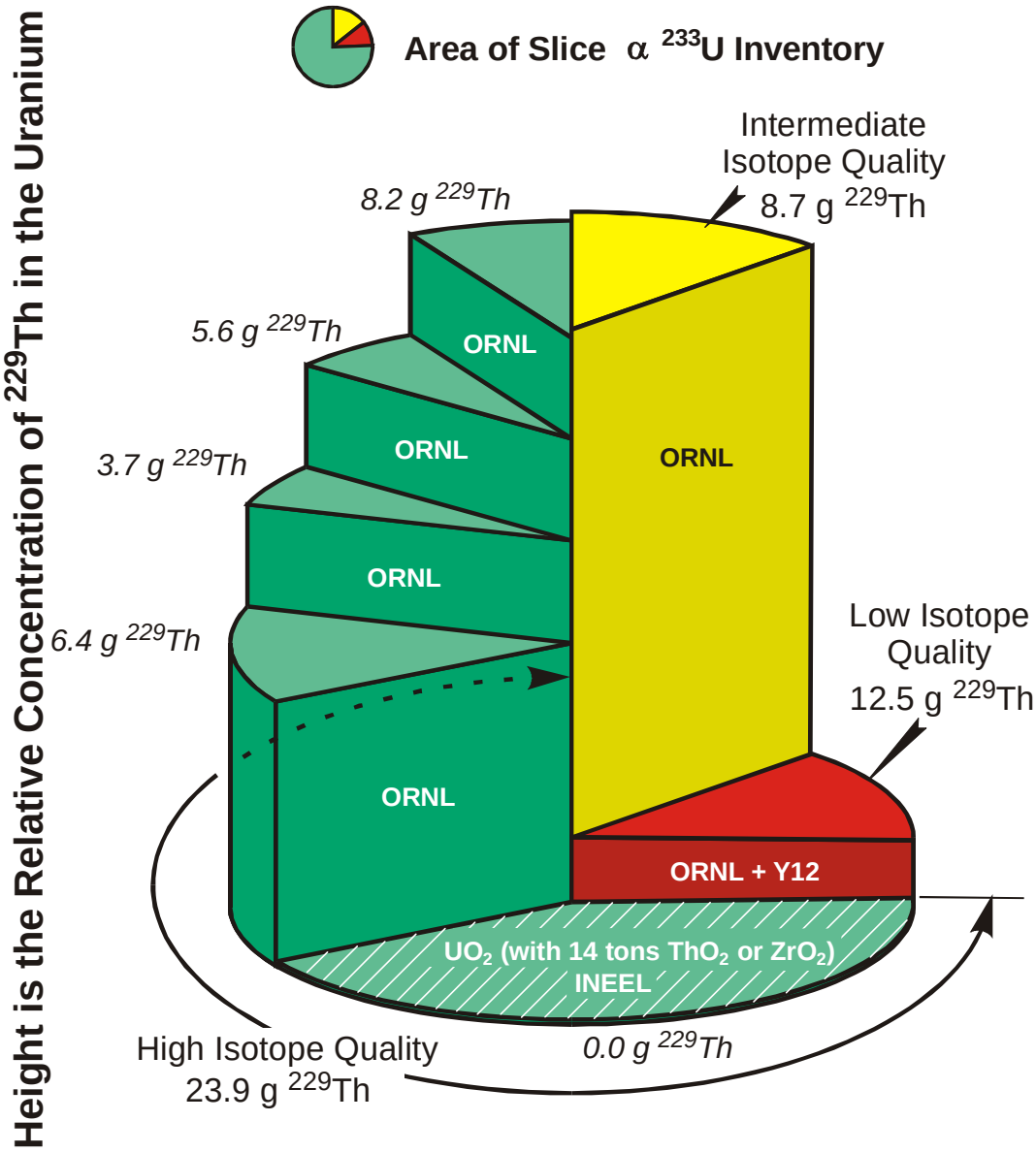
[b]Includes small lots to be shipped to Oak Ridge. Most small lots have <15 ppm ^{232}U, some lots have a higher ^{232}U content.

Potential Uses for ^{233}U



Uranium-233 Uses, Categories, and Potential Inventory Requirements

Use	Acceptable ^{233}U isotopic quality for different applications			^{233}U quantity to be kept (constraints)
	High	Intermediate	Low	
Medical (cancer treatment)	Yes	Yes	Yes	(High cost for ^{229}Th from low-quality ^{233}U)
Proliferation resistant fuel	Yes	Yes	No	(All high-quality ^{233}U is kept, intermediate quality ^{233}U is desirable)
HEU taggent	Yes	Yes	No	~100 kg of high or intermediate quality
Analytical (safeguards, etc.)	Yes	No	No	Small
All others	Yes	No	No	Small


Area of Slice α 233U Inventory
Height is the Relative Concentration of 229Th in the Uranium
Intermediate Isotope Quality
8.7 g 229Th
8.2 g 229Th
5.6 g 229Th
3.7 g 229Th
6.4 g 229Th
ORNL
ORNL
ORNL
ORNL
ORNL
Low Isotope Quality
12.5 g 229Th
ORNL + Y12
UO2 (with 14 tons ThO2 or ZrO2)
INEEL
High Isotope Quality
23.9 g 229Th
0.0 g 229Th