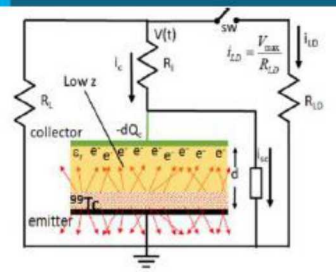
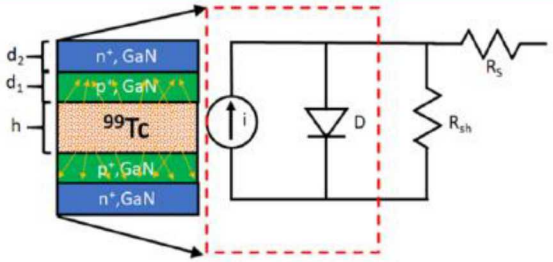
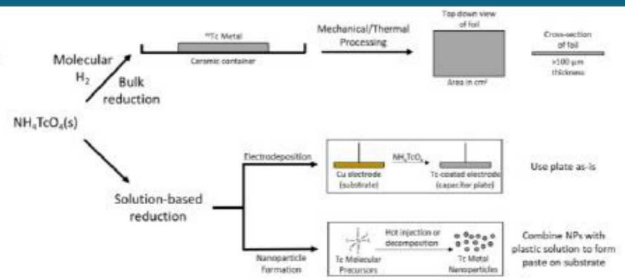
SAND2020-3376PE

Infinite Lifetime Power Technologies Based on Technetium-99

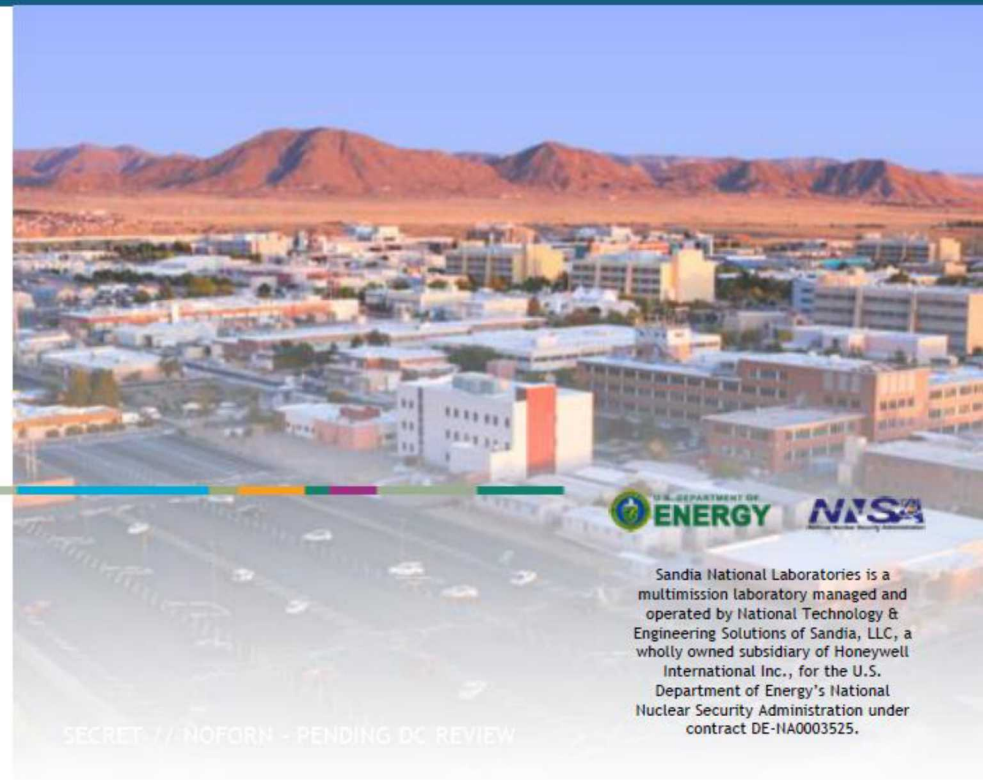






PRESENTED BY

Cody Corbin, Sandia National Laboratories



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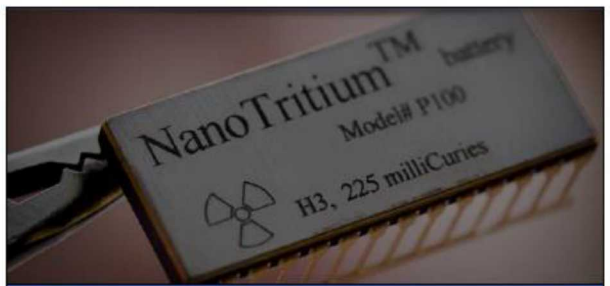
Beta-Based Batteries



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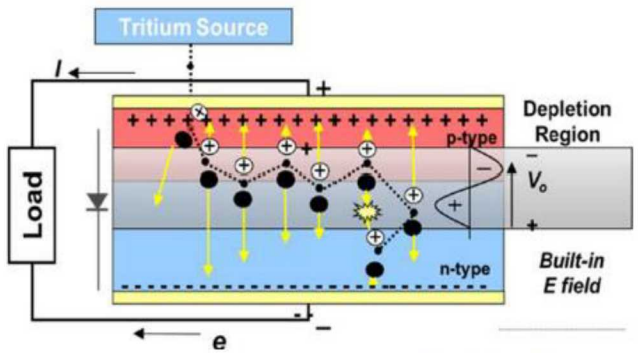

POWER SPECIFICATIONS			
P100 Series		P200 Series	
Open Circuit Voltage	Short Circuit Current*	Open Circuit Voltage	Short Circuit Current*
0.8 Volts	50-350 nanoamps	0.8 Volts	156 microamps
1.6 Volts		1.6 Volts	78 microamps
24 Volts		24 Volts	52 microamps

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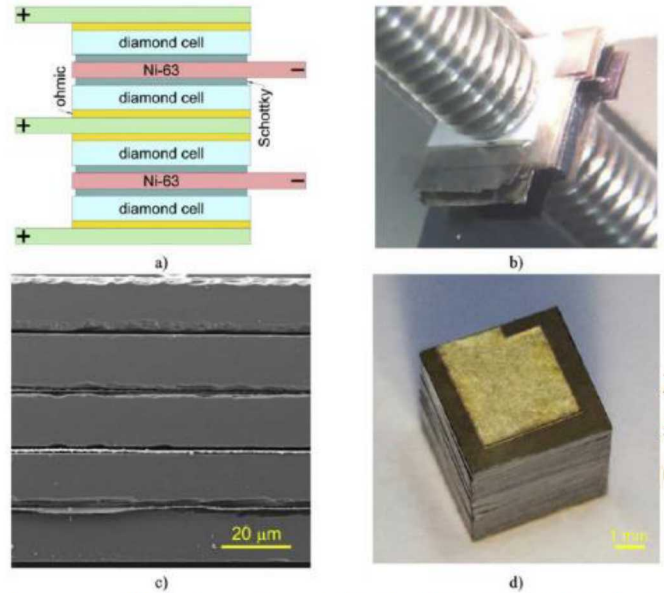
High power density nuclear battery prototype based on diamond Schottky diodes



24% enriched Ni-63
5 x 5 x 3.5 mm^3
0.55 Ci of ^{63}Ni

The maximum output power of 0.93 μW was obtained at about 0.9 V and the normalized optimal electrical load of 70 kΩ cm^3

Output power density of about 10 μW/cm^3 and the specific energy of 3300 mWh/g

[a] *Technological Institute for Superhard and Novel Carbon Materials, 7a Centralnaya Str., Troitsk, Moscow 142190, Russia*
[b] *National University of Science and Technology MISiS, 4 Leninsky Ave., Moscow 119049, Russia*
[c] *Moscow Institute of Physics and Technology, 9 Institutskii per, Dolgoprudny, Moscow Region 141700, Russia*

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Relevant Beta Sources

Beta-based Sources	Half-Life (yrs)	Specific Activity (Ci/g)	E_{max} & E_{avg} (keV)	Density (g/cm^3)	Radiotoxicity[1]
Tritium (H-3)	12.3	~ 9,650	19 & 6	Low	Low
Nickel-63	~ 100	~ 9.6	67 & 17	8.9	Medium
Technetium-99	~ 212,000	0.017	296 & 86	11.5	Low

The deliverable from this R&D will include all data related to the electrical variables and power efficiencies that can be achieved in a definitive size.

[1]DOE/LLW-126: National Low-Level Waste Management Program Radionuclide Report Series, Volume 10: Nickel-63

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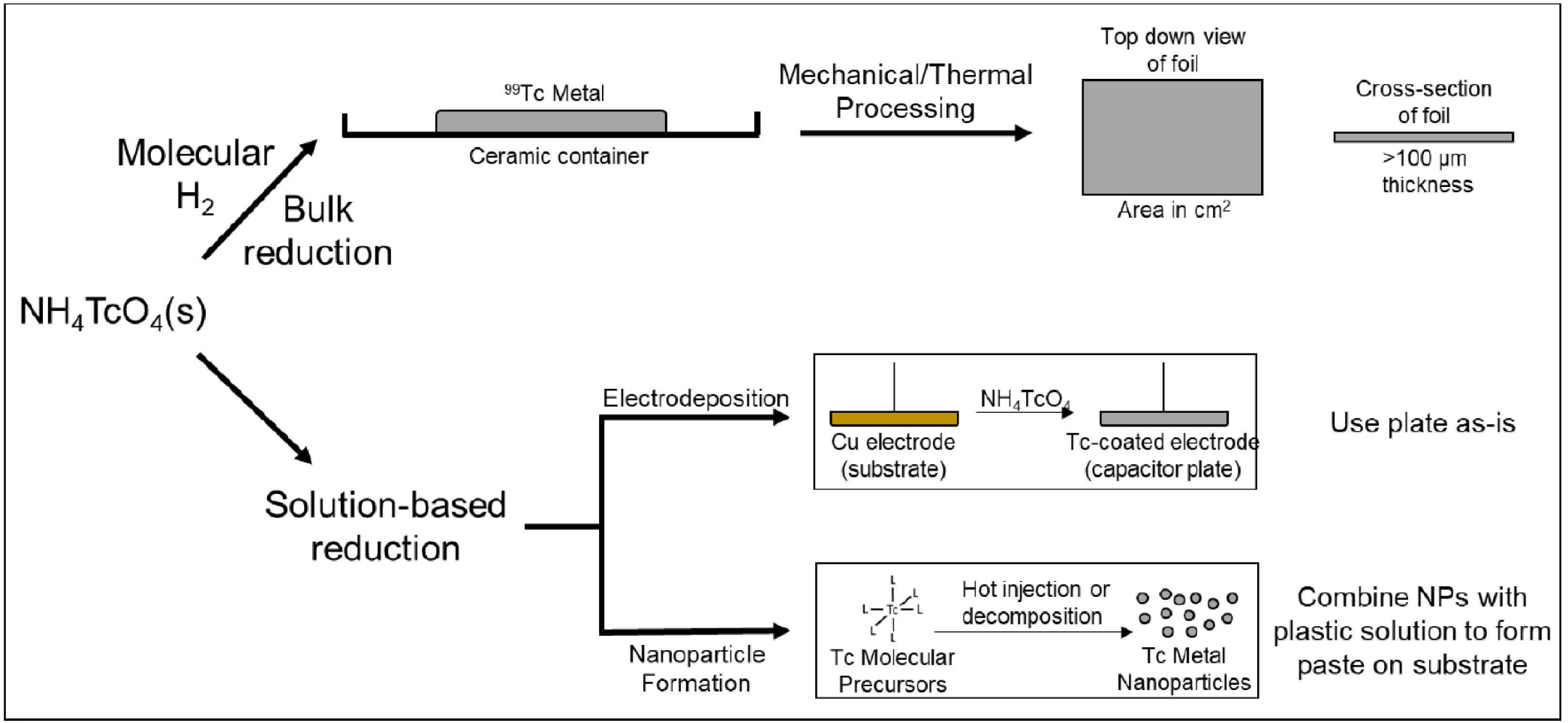
Task 1: Tc Metal Preparation & Processing



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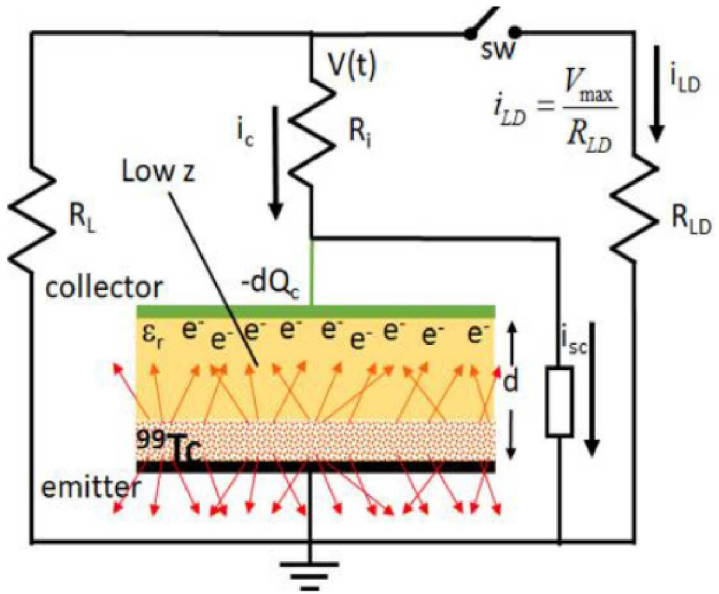
Task 2: Circuit Design, Modeling, and Testing

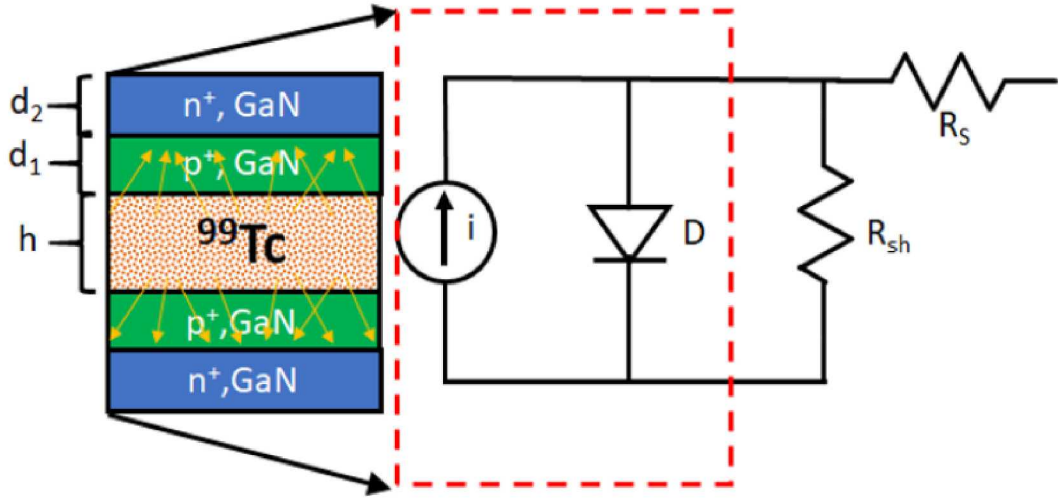
Capacitor Design



Accumulated Voltage

Maximum Electrical Power

p-n Junction Design



Generation Rate

Maximum Short-Circuit Current Density

Open Circuit Voltage

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Shielding from Radiation

Schwochau, K. 2000. Technetium. 1st Ed. Wiley-VCH, Federal Republic of Germany.

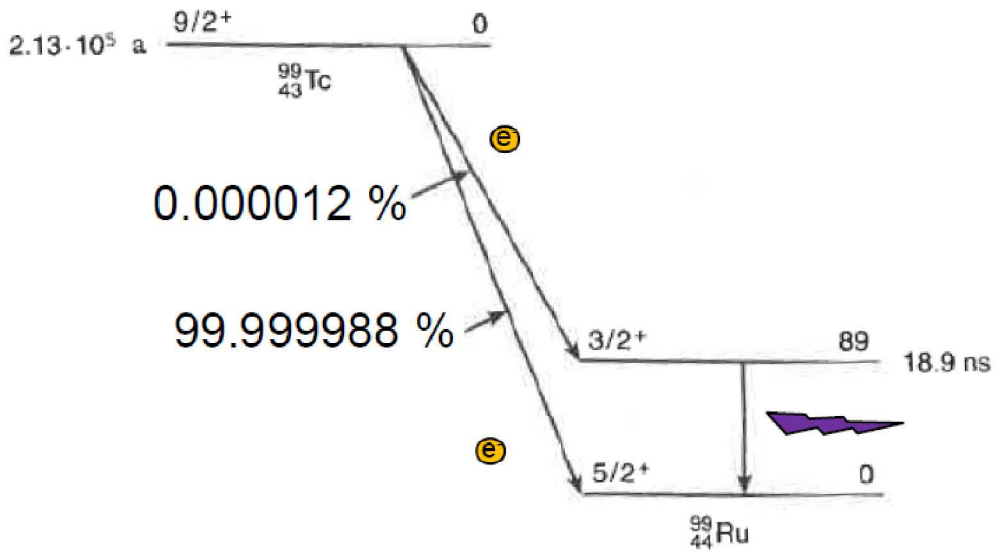
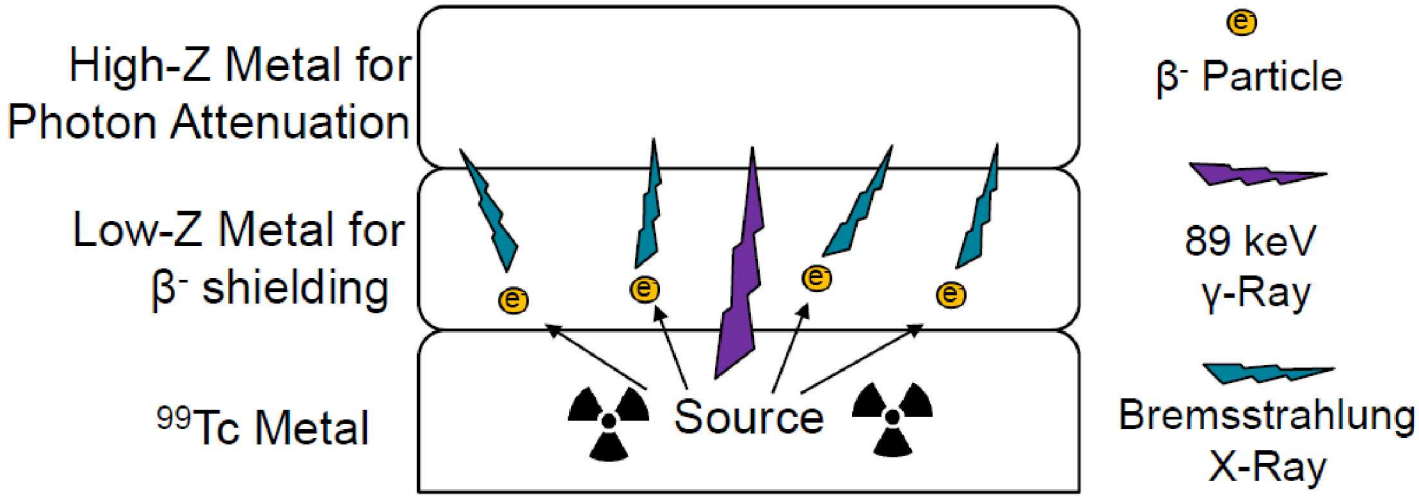
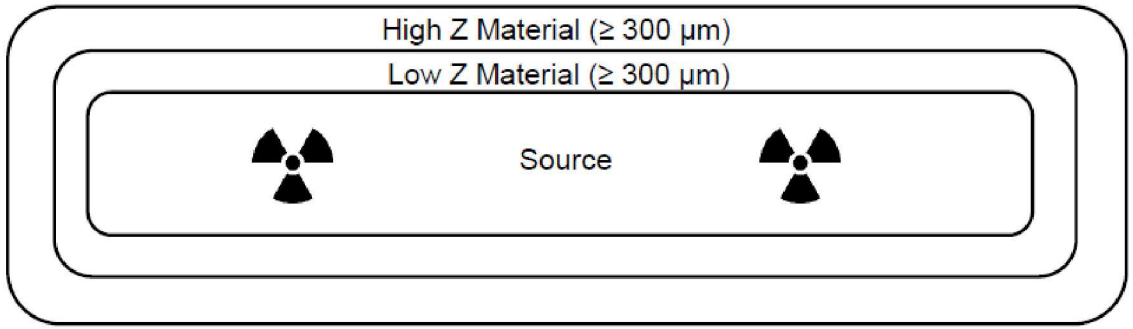


Fig. 5.3.A Decay scheme of ^{99}Tc. Energies in keV [21].



Graded-Z Shielding



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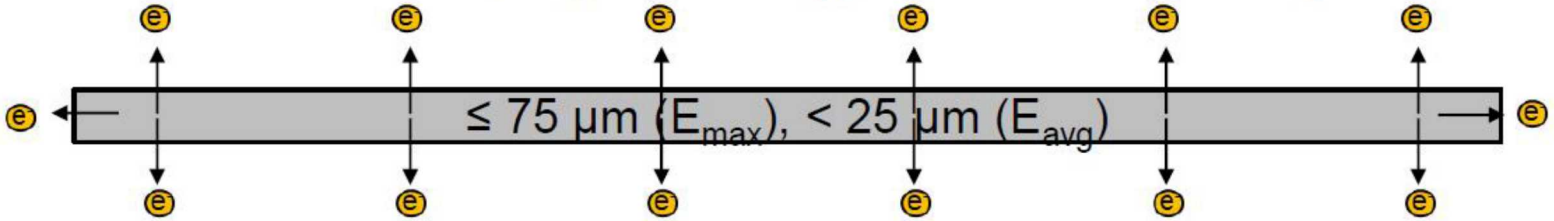
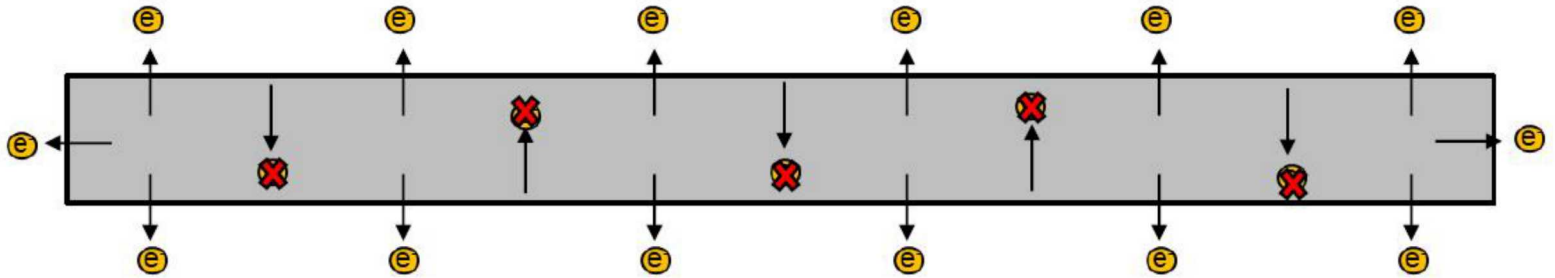
Processing of ^{99}Tc Metal Into Sheets

Scenario 1: Thin Foil, High Efficiency, Difficult Processability



Scenario 2: Thick Foil, Low Efficiency, Facile Processability



Example - Electroplating on substrate (such as Si) and removing substrate may yield usable double-sided Tc foils.

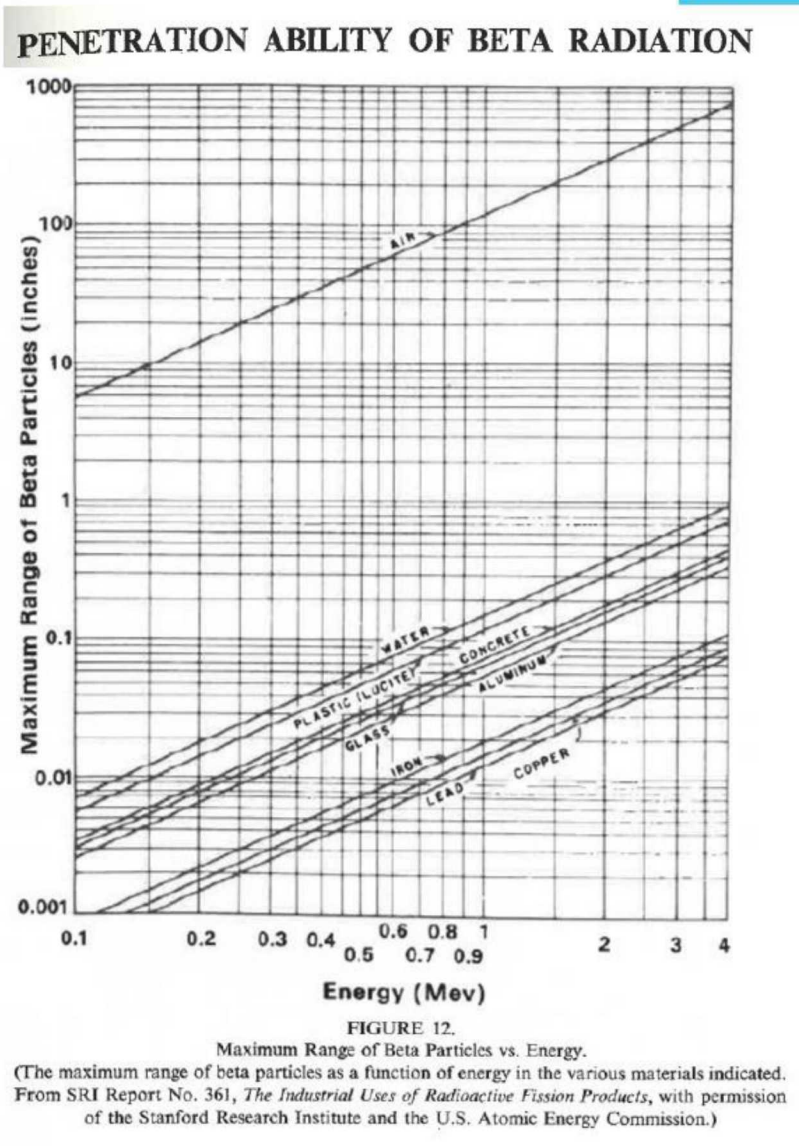


FIGURE 12.
Maximum Range of Beta Particles vs. Energy.
(The maximum range of beta particles as a function of energy in the various materials indicated. From SRI Report No. 361, *The Industrial Uses of Radioactive Fission Products*, with permission of the Stanford Research Institute and the U.S. Atomic Energy Commission.)

CRC Handbook of Radioactive Nuclides, 1969, The Chemical Rubber Company

LDRD

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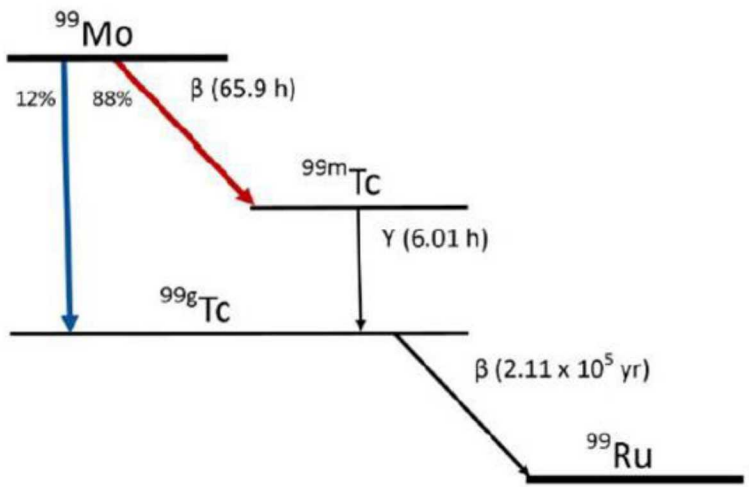
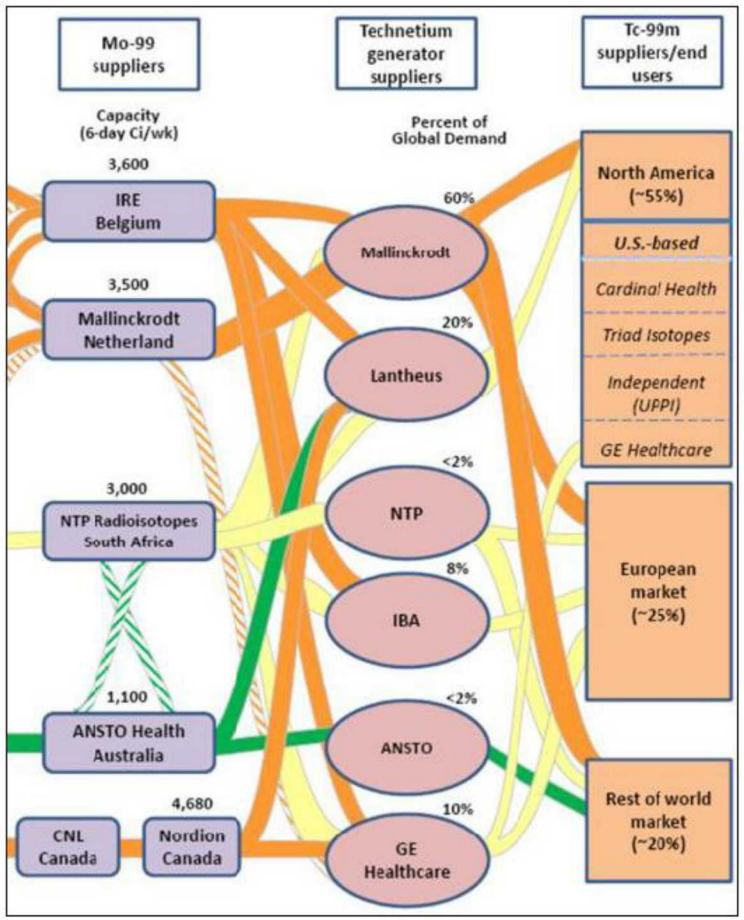
^{99}Tc Acquisition from Oak Ridge National Lab National Isotope Development Center (ORNL-NIDC)

- ~ 1 kilogram NH_4TcO_4 available
- Material cost - $110 – 115 per gram*
- Processing cost $8K
- Off-site Shipment Cost - $1.5K
- Maximum 6 week lead time for delivery of material

Alternate ^{99}Tc Source – ^{99m}Tc from Medical Diagnostic Field





National Academies of Sciences, Engineering, and Medicine. 2016. *Molybedenum-99 for Medical Imaging*. Washington, DC: The National Academies