More Than Fissile Material: Building a Bomb, The Historical Experience

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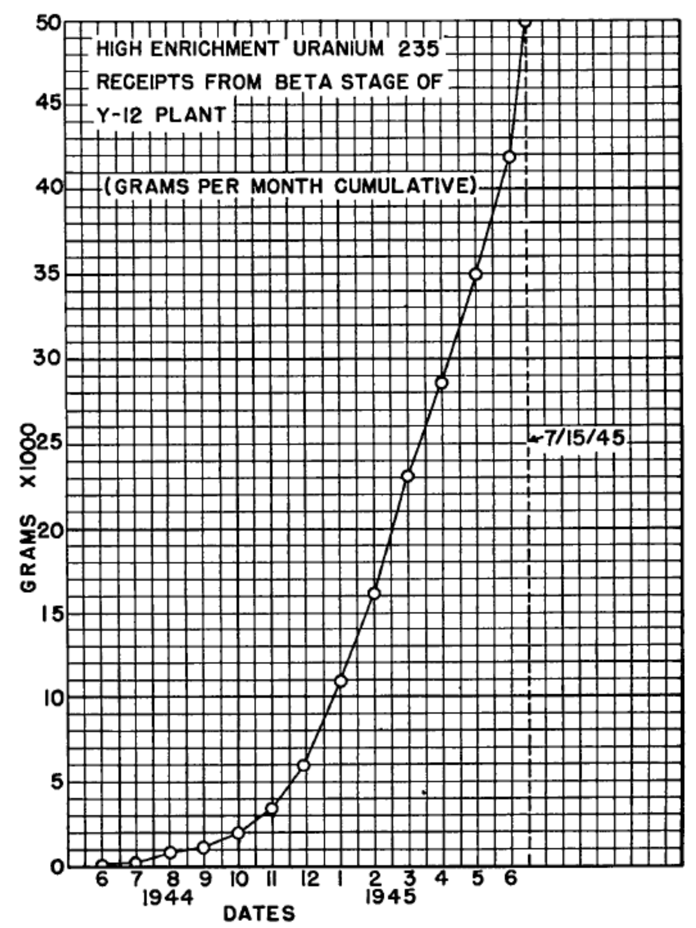
Acquiring Nuclear Weapons

- Nuclear material
  - HEU or Pu
  - Acquire and convert into weapon core
- Non-nuclear weapon components
  - In parallel, not in sequence
- Delivery systems
  - Compact lightweight weapons, levitation

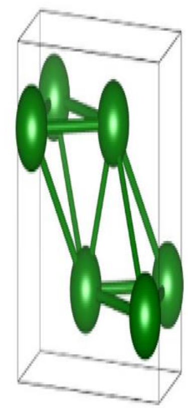
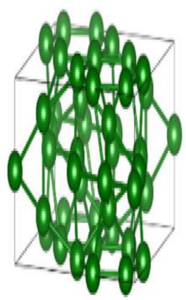
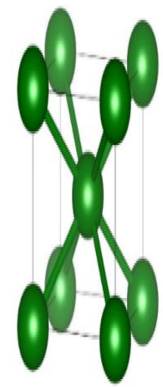
Producing HEU Weapon Core

- Some have claimed that core production can take up to 6 months and involve large wastage
- HEU production continuing until 7/15/45, components completed 7/24/45
- Valuable material, wastage 3%–6%



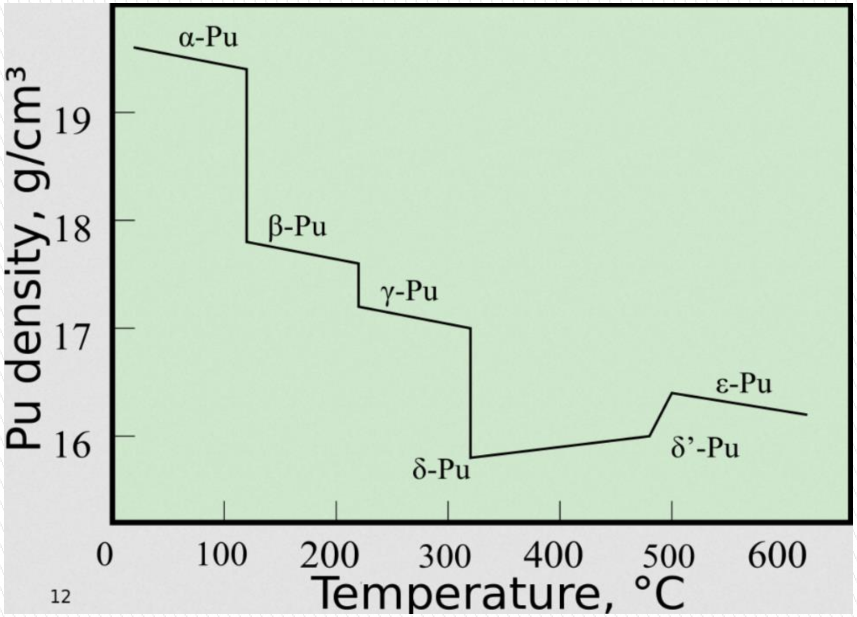
Metallurgy: Allotropes Uranium Example

- Allotropes are different forms of the same element
- Temp changes causes some metals to change
- Lowest temp alpha, next beta, etc.
- These changes affect density and physical properties

Allotrope	α-U	β-U	γ-U
Temperature (°C)	<667.7	667.7~774.8	774.8~1132.3
Crystal structure			
Density (g/cm^3)	19.05	18.13	17.91

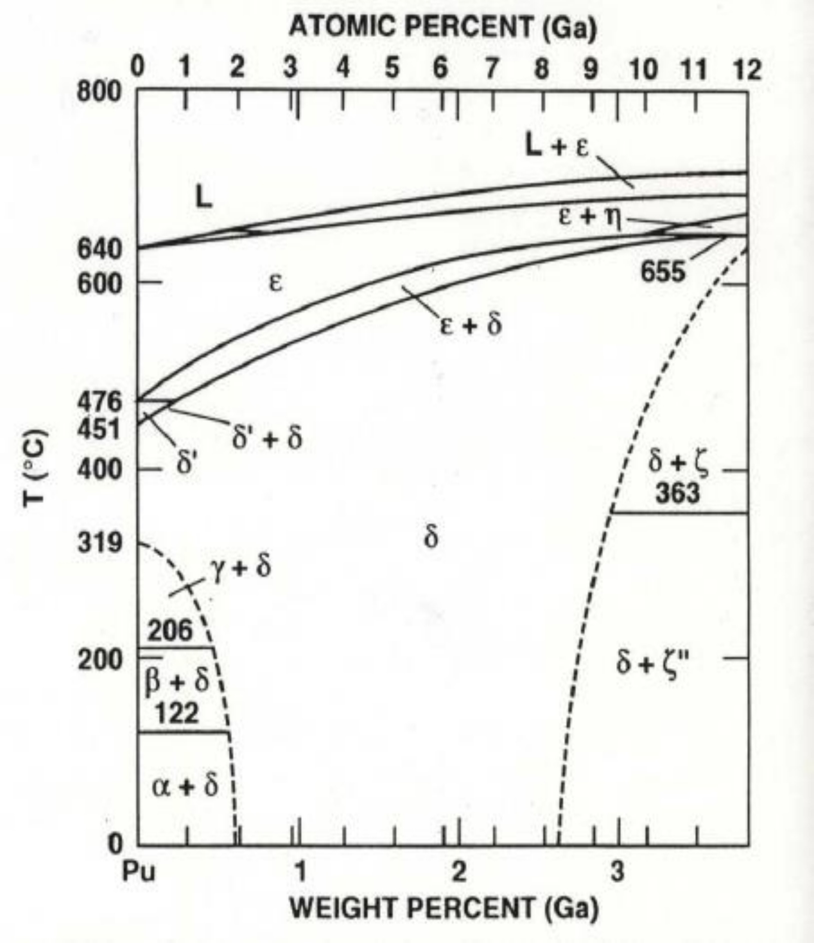
Allotropes Plutonium

- Plutonium has an unprecedented 6 allotropes
- Alpha brittle and low temp (122 C) for large density changes
- Alpha chosen for FM due to neutronics ruling out Pu-Al alloy (delta)



Producing Pu Weapon Core

- Due to alpha manufacturing failures, in late May 1945 decided to use Pu–Ga alloy (delta)
- Critical mass only determined 6/24/45
- Core ready 7/1/45



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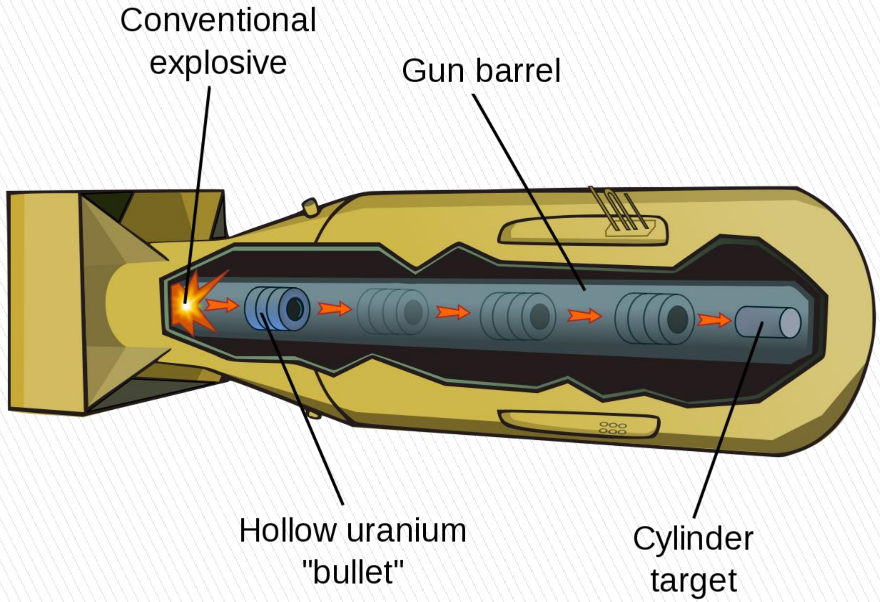
Producing Non-Nuclear Components in Parallel

- William Penney 11/46
- "… the ordnance part, that is, the manufacture and assembly of the components causing the explosion of the active material… the work could be begun and completed without the need to use fissile material at any stage."

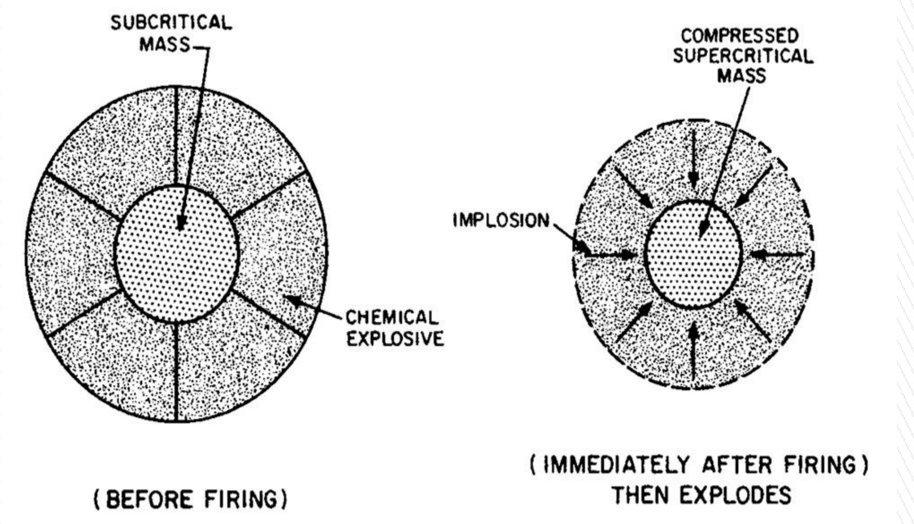
Gun Type Weapon

- Took from 8/44 to 12/44 to complete preliminary weapon design
- Design finalized 4/45 (determined critical mass)
- Further 4 months waiting for the HEU



Implosion Type Weapon

- Took from 8/44 to 2/45 to finalize design
  - Conservative no levitation
- Took from 2/45 to 7/45 to build weapon
- Due to Pu-Ga alloy, changes to the core after 6/24/45, tested 7/16/45



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For Deliverability Levitation Key

- Air gap that allows the implosion wave to gain speed and compress the nuclear material more efficiently

- Ted Taylor 1974

“When you hammer a nail…Do you put the hammer on the nail and push?”

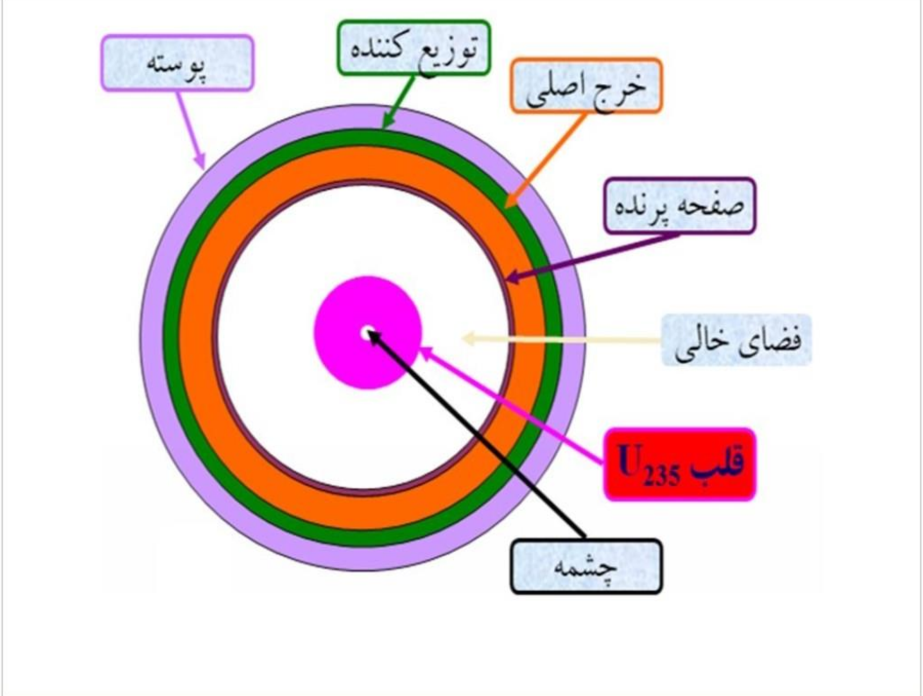
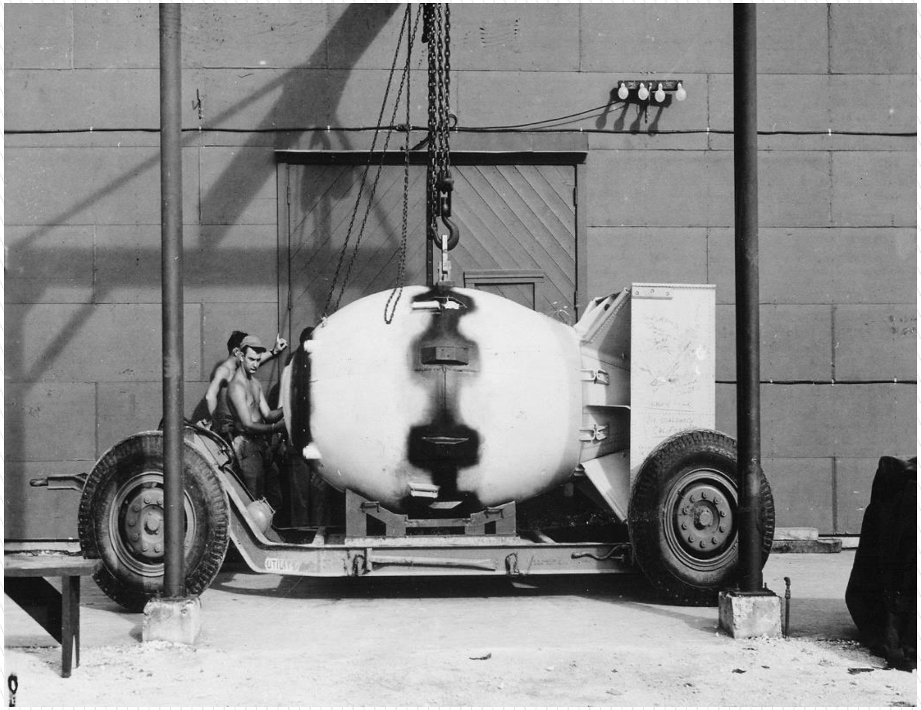


Figure 12. A nuclear weapon schematic in the archives that shows a neutron source at its center. From the bottom, and proceeding counterclockwise, the terms in the boxes are neutron source, uranium 235 core, air gap, flyer plate, main charge, “detonation distributor,” and outer casing. Thanks to Behnam Ben Taleblu for translation.

Fat Man

- 60 inch diameter, 10,300 lb.
- Not levitated
- Needed B-29 to deliver
- Many still assume that first weapons are FM
  - North Korea



USSR and UK

- USSR produced levitated design
- Instead used FM based on intel info
  - Failure is a fatal option

- UK started with FM but introduced levitation due to criticality concerns—still large and heavy

France and China: Levitation From the Start

- First French device: 3,300 lb., 70 kt yield with Pu

- First Chinese devices: 3,400 lb., 22 and 35 kt with HEU

Tactical Delivery for Simple Fission Device

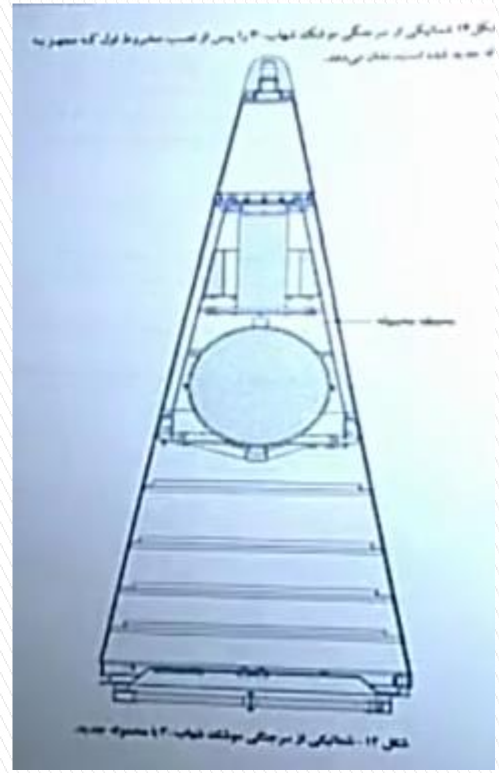
- U.S. Mark 7
- In service 1952-1967
  - Gravity bomb, ballistic missile warhead, depth charge, air to surface missile
- 30 inches in diameter, 1,700 lb., up to 60 kt
- Very popular, ~1,700 built

Tactical Delivery for Simple Fission Device-II

- French AN-52
  - Gravity bomb
- In service 1972-1991
  - Variant Pluton ballistic missile warhead
- 24 inches in diameter, 1,000 lb., up to 35 kt

Iran

- Starting at the AN-52 level
- ~ 2 feet in diameter
- Shown being carried on Shahab-3, 1000 km range



Conclusions

- U.S. WWII experience shows that HEU and Pu can be converted into metal weapon components in a week or two
- Non-nuclear components can be produced in parallel and will take a year or less
- Today, first nuclear weapons will be similar to AN-52: 2 feet in diameter, 1,000 lb.