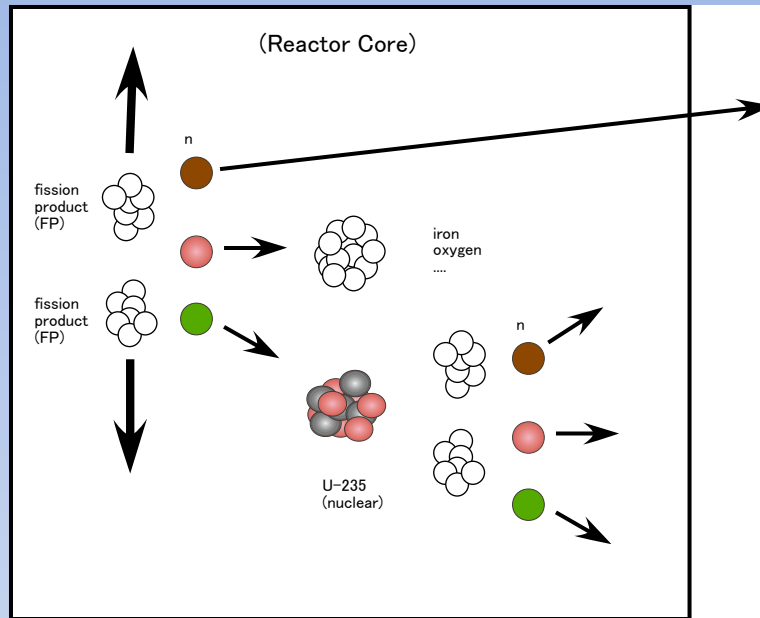


原子力と放射線の物理
第一歩
PHYSICS OF
NUCLEAR POWER & RADIATION
(FIRST STEP)

大谷 暢夫
OHTANI, Nobuo

#3-01

Criticality (臨界)



Chain Reaction & Criticality (連鎖反応と臨界)

mean number of neutrons (ν) = ~ 2.5

- * absorbed in material(iron, water, control material ...)
- * leak_out from the system
- 1.0 absorbed U-235 introducing next fission

Criticality & Fuel Enrichment (臨界の為の燃料－1)

Natural Uranium (天然ウラン)

U-235 : 0.7%

U-238 : 99.3%



Enriched Uranium

U-235 : ~3%

U-238 : ~97%

Uranium(Isotope) Enrichment (ウラン濃縮)

Gas-Diffusion (ガス拡散法)

Centrifugal (遠心分離)

Critical by Natural Uranium

N.U.+Graphite (黒鉛)

N.U.+Heavy Water (重水)

Heavy Water (D_2O) 重水

Isotopes of H

Hydrogen (Light Water)

Deuterium (Heavy Water)

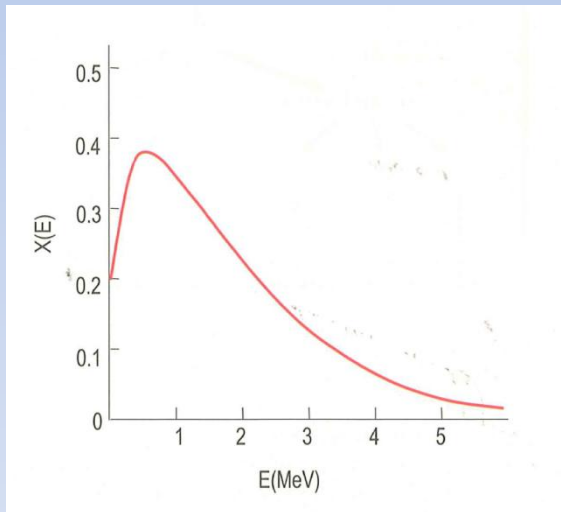
Tritium

Heavy Water (Isotope) Enrichment

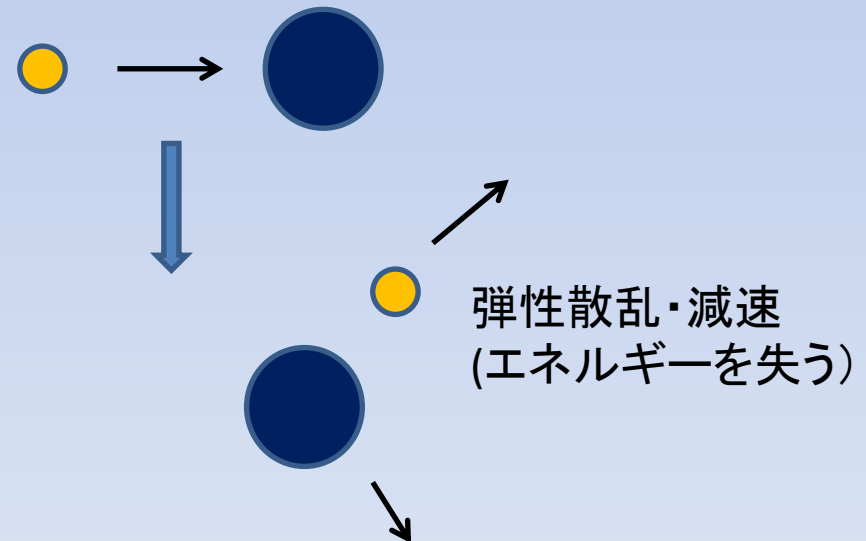
Ion Exchange

Fission Neutron (核分裂で発生する中性子)

Number of Fission Neutrons (ν) : 2.5 ± 0.1
(核分裂でててくる中性子の個数)
uranium-235 fission by slow neutrons



Fission Neutron
Energy Distribution



Criticality & Fuel Enrichment (臨界の為の燃料－1)

Natural Uranium (天然ウラン)

U-235 : 0.7%

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Heavy Water (D_2O)

Isotopes of H

Hydrogen (Light Water)

Deuterium (Heavy Water)

Tritium

Heavy Water (Isotope) Enrichment

Ion Exchange

Plutonium & U-233

(臨界の為の燃料ー2、ウランとプルトニウム)

Fissile Materials (核燃料物質)

: 核燃料として利用可能な核分裂性核種

U-235

Isotope Enrichment

Pu-239

$U-238 + n \rightarrow Pu-239$

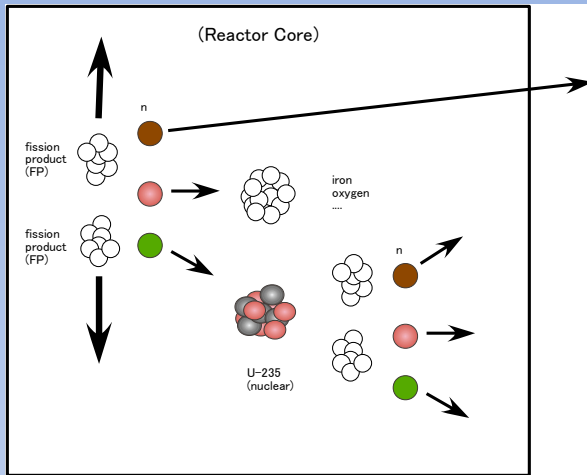
(irradiation in reactor \rightarrow fuel reprocessing)

U233

$Th-232 + n \rightarrow U-233$

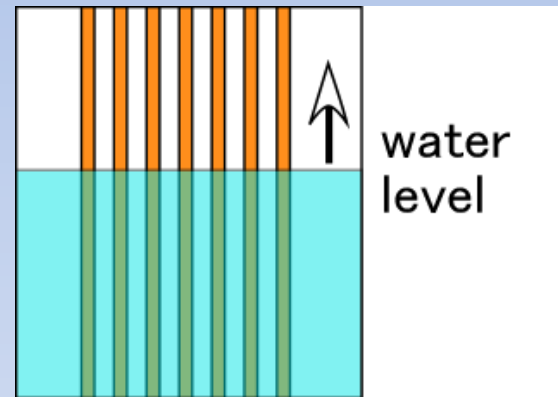
(irradiation in reactor \rightarrow fuel reprocessing)

How to be critical? (1) (臨界の達成と制御)



Water Level raise
(水位の上昇)
(critical assembly)

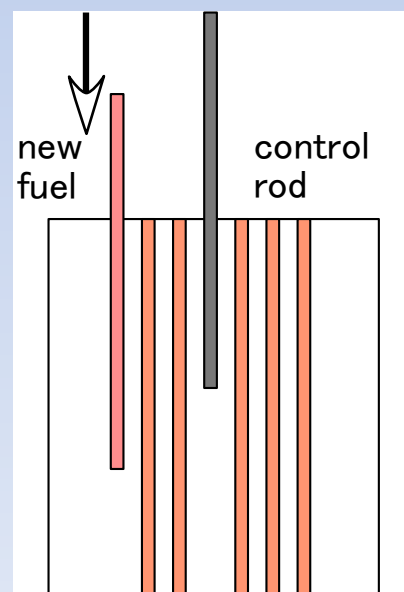
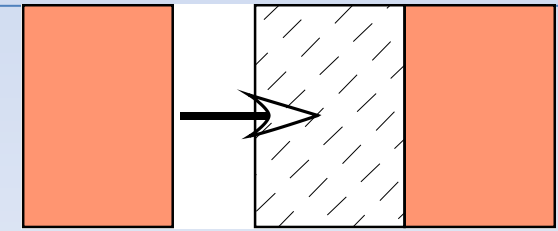
Fuel Addition (燃料の追加)
initial criticality approach



燃料(燃料領域)を増やして
体系を大きくする。

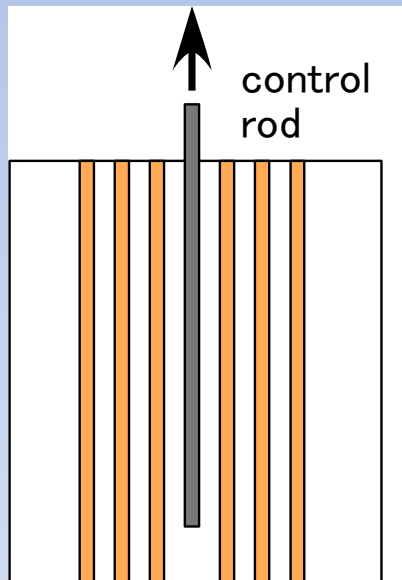
核分裂の数に対して、
外に逃げていく中性子を
減らす。

2 Fuel Blocks to 1



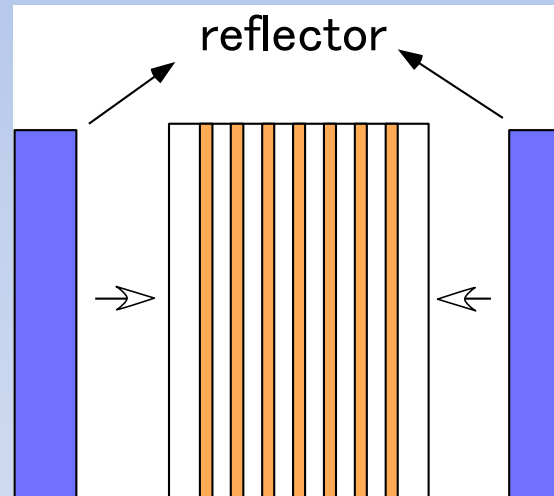
How to be critical?(2) (臨界の達成)

Control Rod draw out
(制御棒の引抜)



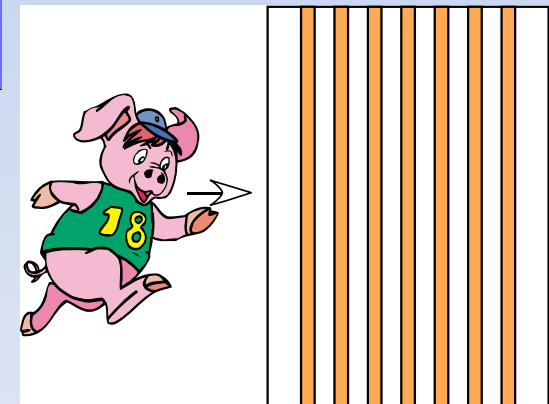
燃料以外の物質に吸収される中性子を減らす。

Reflector Addition
(反射体の追加)



燃料領域から漏れ出す中性子を反射させて炉心領域に戻す。

fat-man effect



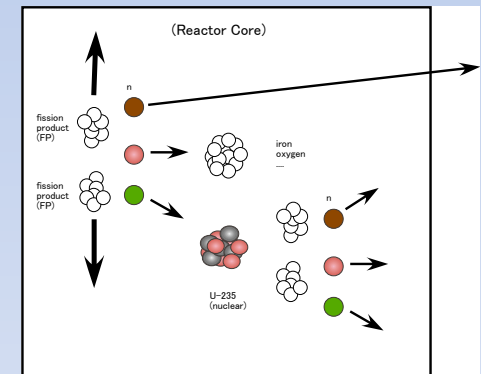
Reactivity Control (臨界の制御)

Fission Products & Delayed Neutron (核分裂生成物と遅発中性子)

Average (Spontaneous即発) Neutron Lifetime : **0.001 sec.**

Delayed(遅発) Neutrons from Fission Products

Group (g)	Decay constant ($\lambda_g, \text{sec}^{-1}$)	Yield (β_g)
1	0.0124	0.00053
2	0.0305	0.00355
3	0.111	0.00318
4	0.301	0.0064
5	1.14	0.00187
6	3.01	0.00068



Effective Lifetime of a neutron : **$\sim 0.1 \text{ sec.}$**



制御棒の機械的駆動

Development of Reactor 原子炉(炉心)の開発

Critical Assembly「臨界集合体」
(Zero Power Reactor)

Experiments of Reactor Physics (原子炉物理の実験研究)
Criticality, Flux Distribution,
Reactivity
(fuel, structure material, control rod)

Experimental Reactor (実験炉)

small thermal power, no electric generation
irradiations of fuel & structure materials

Power Reactor (動力炉)

Chicago Pile 1 (1942)



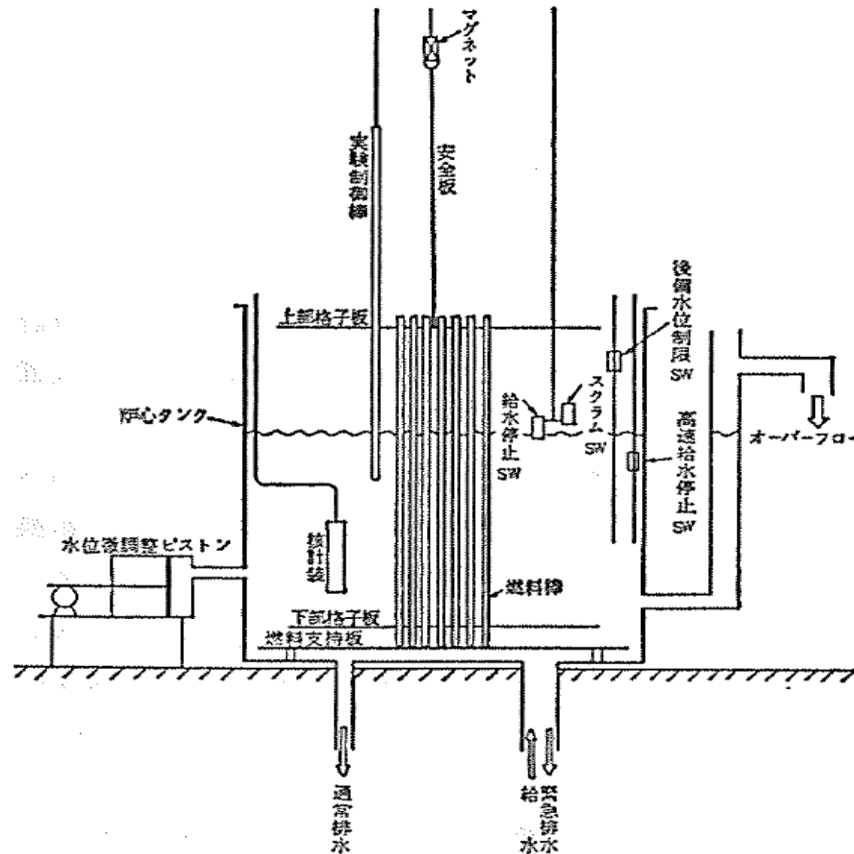
(From web page 'Chicago Pile')

Chicago Pile 1 (1942)



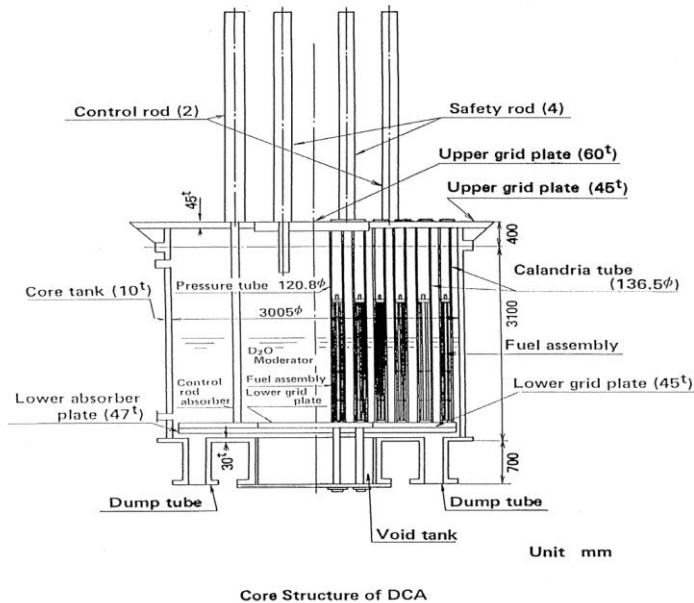
(From web page 'Chicago Pile')

TCA(JAEA)



第1図 TCA炉心構成の概要

Deuterium Critical Assembly(closed) (重水臨界実験装置)



#2-3

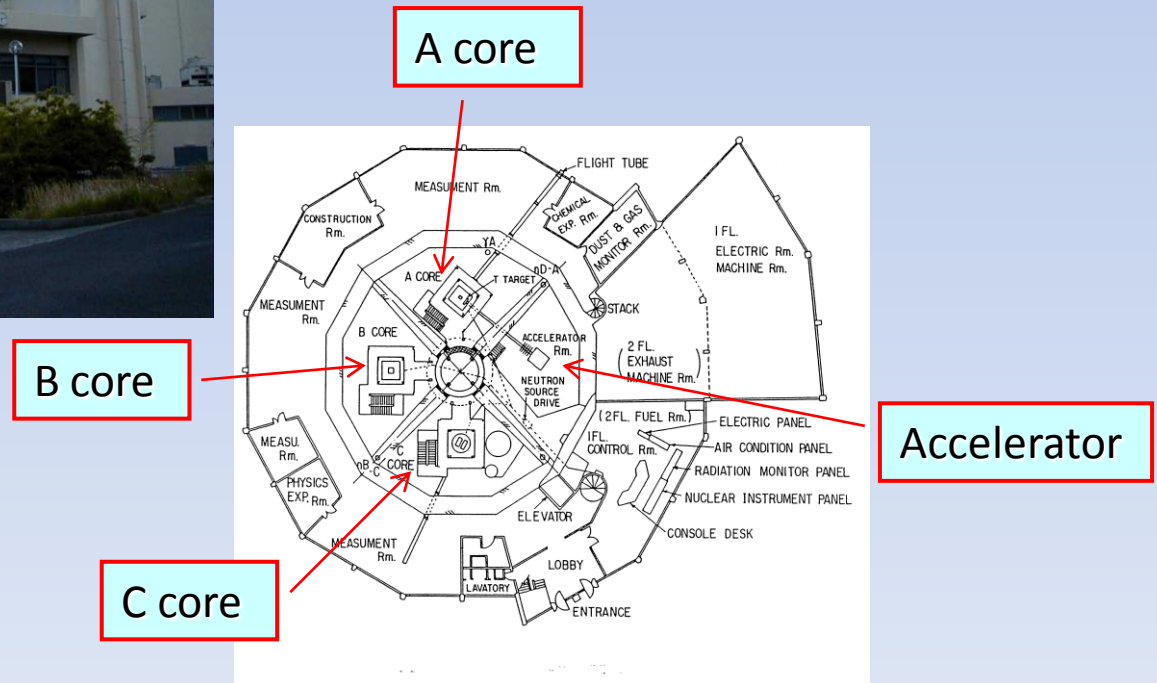


#3-14

KUCA (京都大学臨界実験装置) (Kyoto-University-Critical-Assembly)



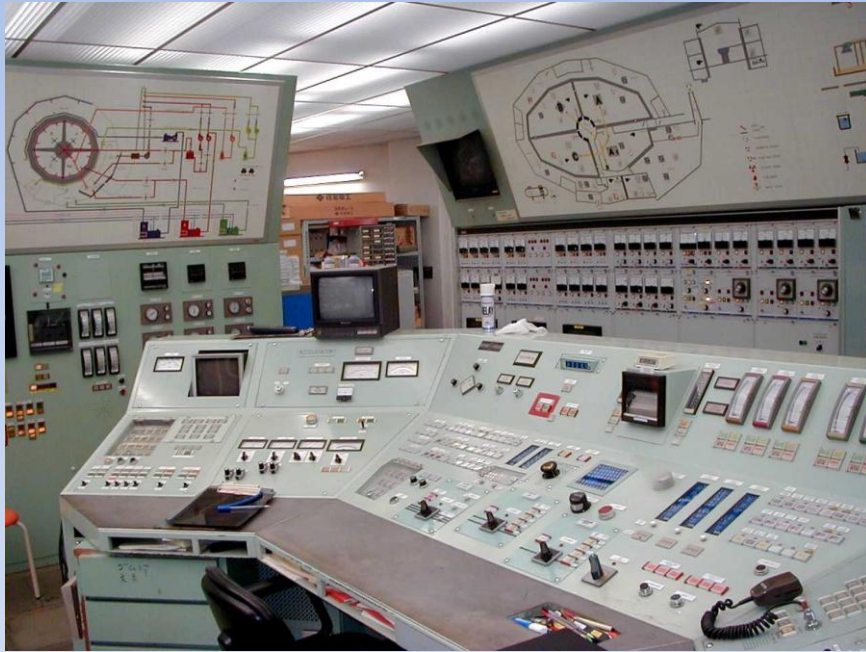
1974~
100W



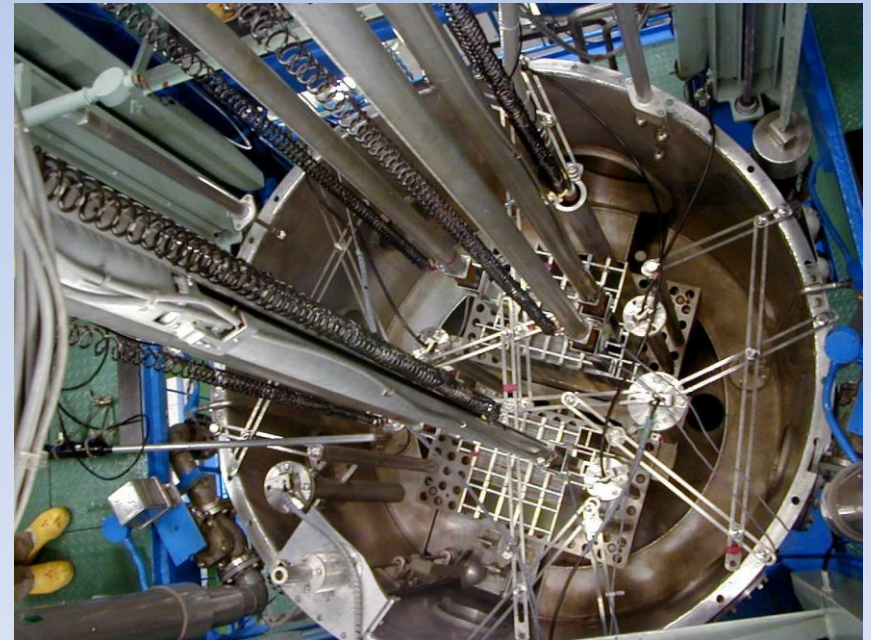
#3-15

KUCA(京都大学臨界実験装置)

control desk 制御卓



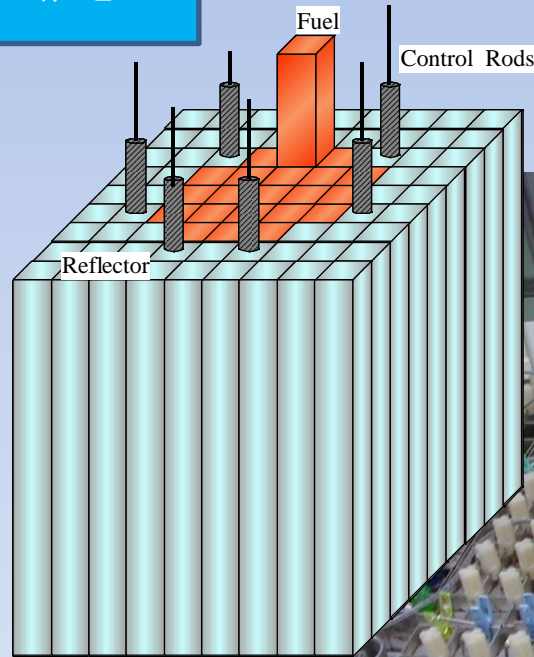
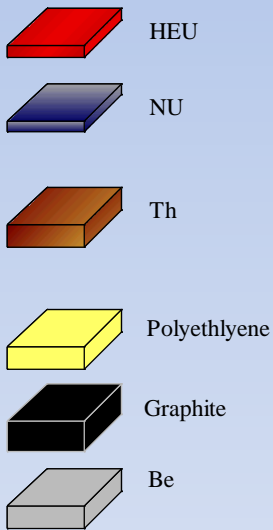
Light Water Moderator Core
軽水減速炉心



KUCA – 固体減速材炉心

KUCA Solid Moderated Core

燃料・減速材要素 燃料体 炉心



Material Plates

Fuel Elements
Reflector Elements

Core



Tower Shielding Facility(ORNL, USA, closed)



PNC ZN9600 93-003

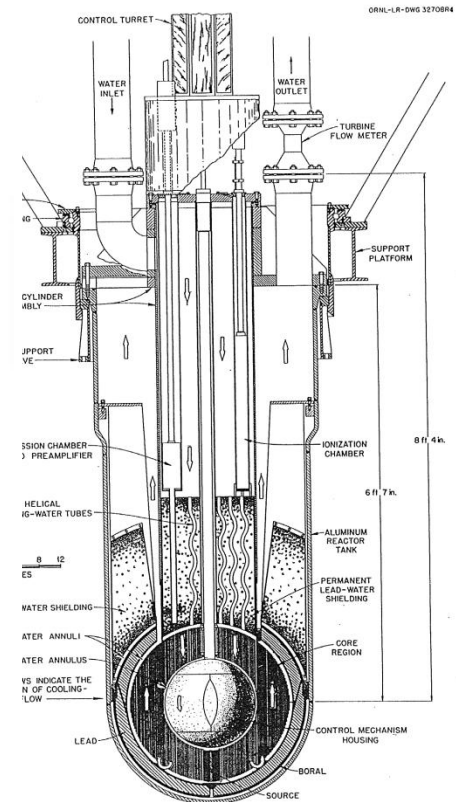


図 2.1 遮蔽実験用原子炉 タワー・シールドング・ファシリティ TSF (米岡オークリッジ国立研究所)