# THE VALUATION OF CALCULATION AND EXTRAOLATION EXPERIMENTAL RESULT ON CHINA ADS SUB-CRITICAL EXPERIMENTAL ASSEMBLY – VENUS-1

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# Contents

# Introduction

**The concept of ADS system is good to solve exploitable natural uranium resources and long-lived radioactive nuclear wastes.**

**From 1990's, focuses on the topic of "Accelerator Driven System".**

**Since 2000, one project of "the major state basic research program (973)" in energy domain, which is sponsored by the China Ministry of Science and Technology (MOST), a five years program of basic research for ADS physics and related technology has been launched.**

**China ADS Venus 1 Sub-critical Assembly is one aspect of research.**

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# Design objectives

(1) Test and Verify Parameters in Sub-Critical Reactor.

(2) Test and Verify ADS Reactor Physics and Nuclear Date

(3) Research Neutron Spectrum Measurement Technology

(4) Research Monitor keff Technology in ADS operation

(5) Research MA Transmutation

**Design requirement**

**Keff : 0.90—0.98**

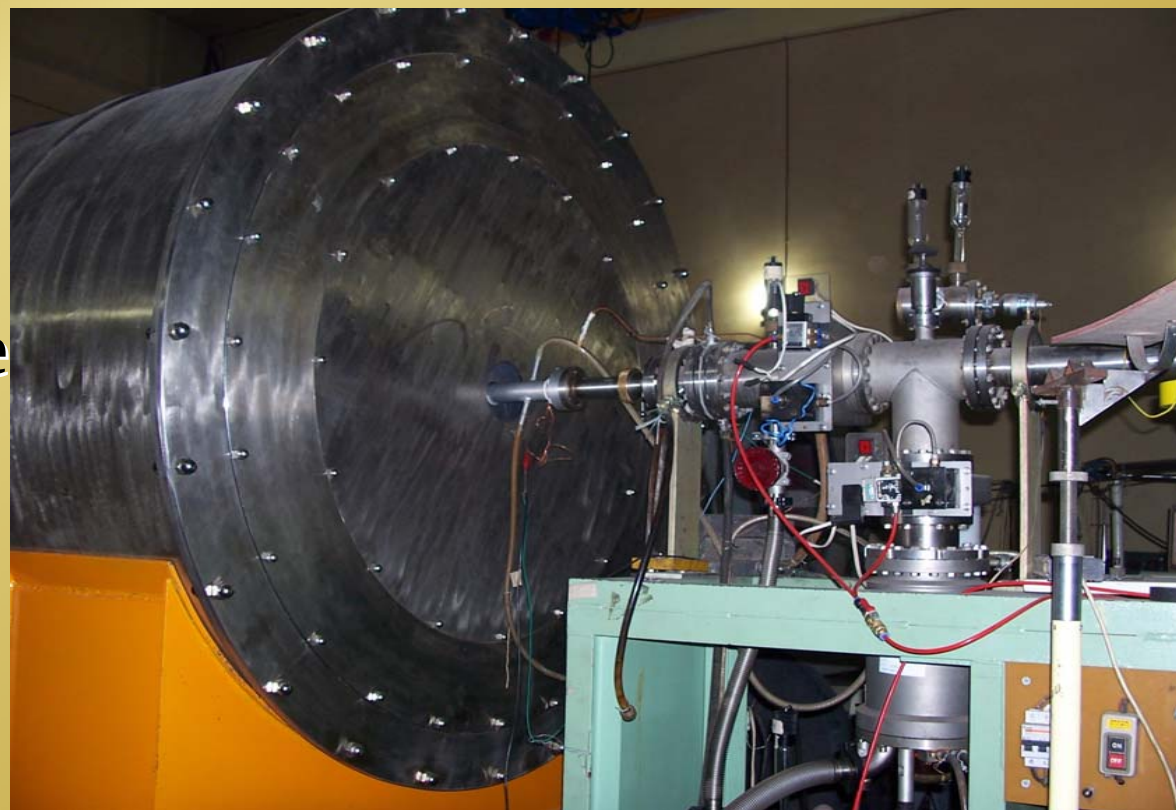
**Average neutron energy**

**600-900kev.**

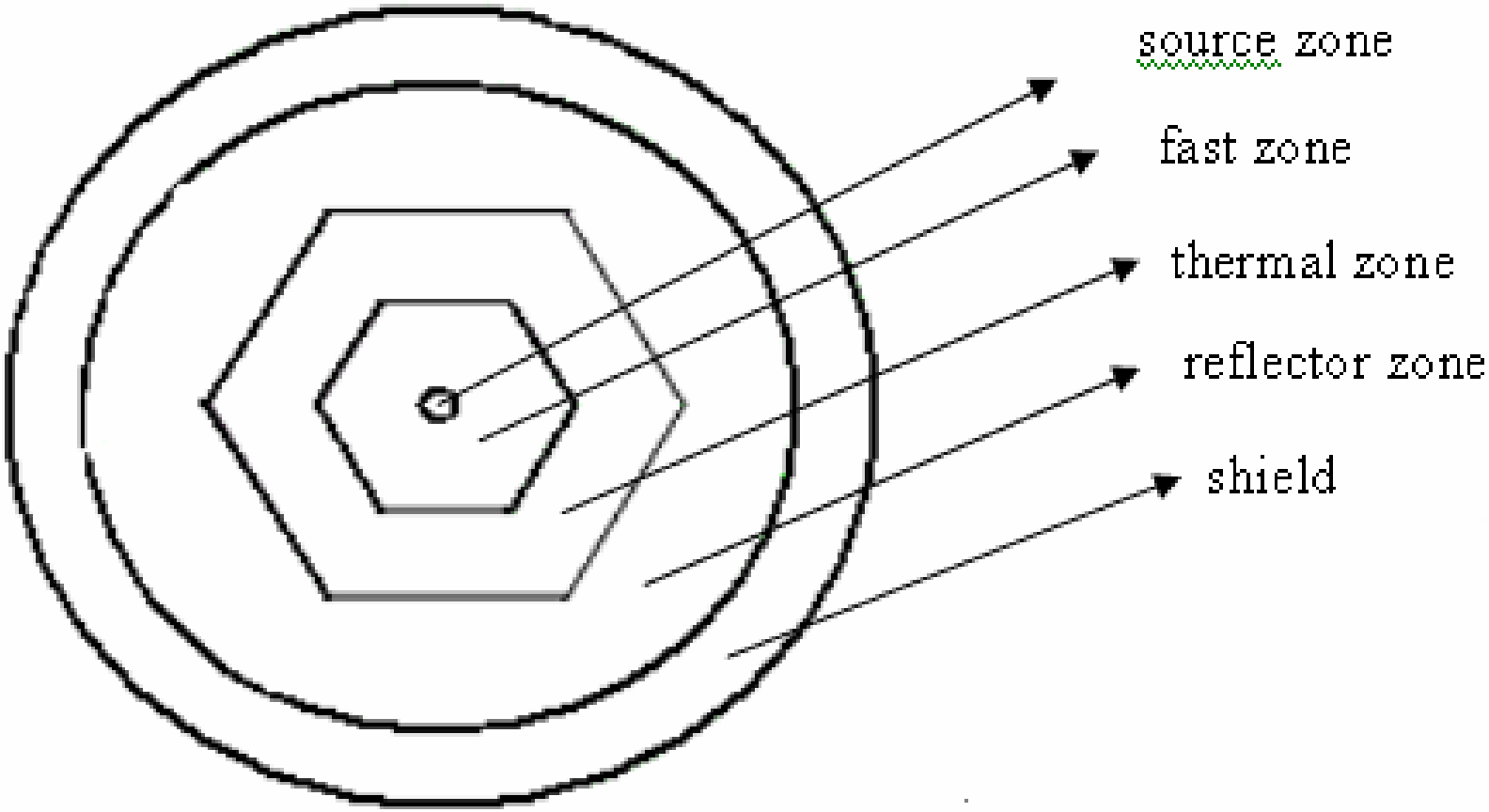
**Simple Structure**

**Horizontal**

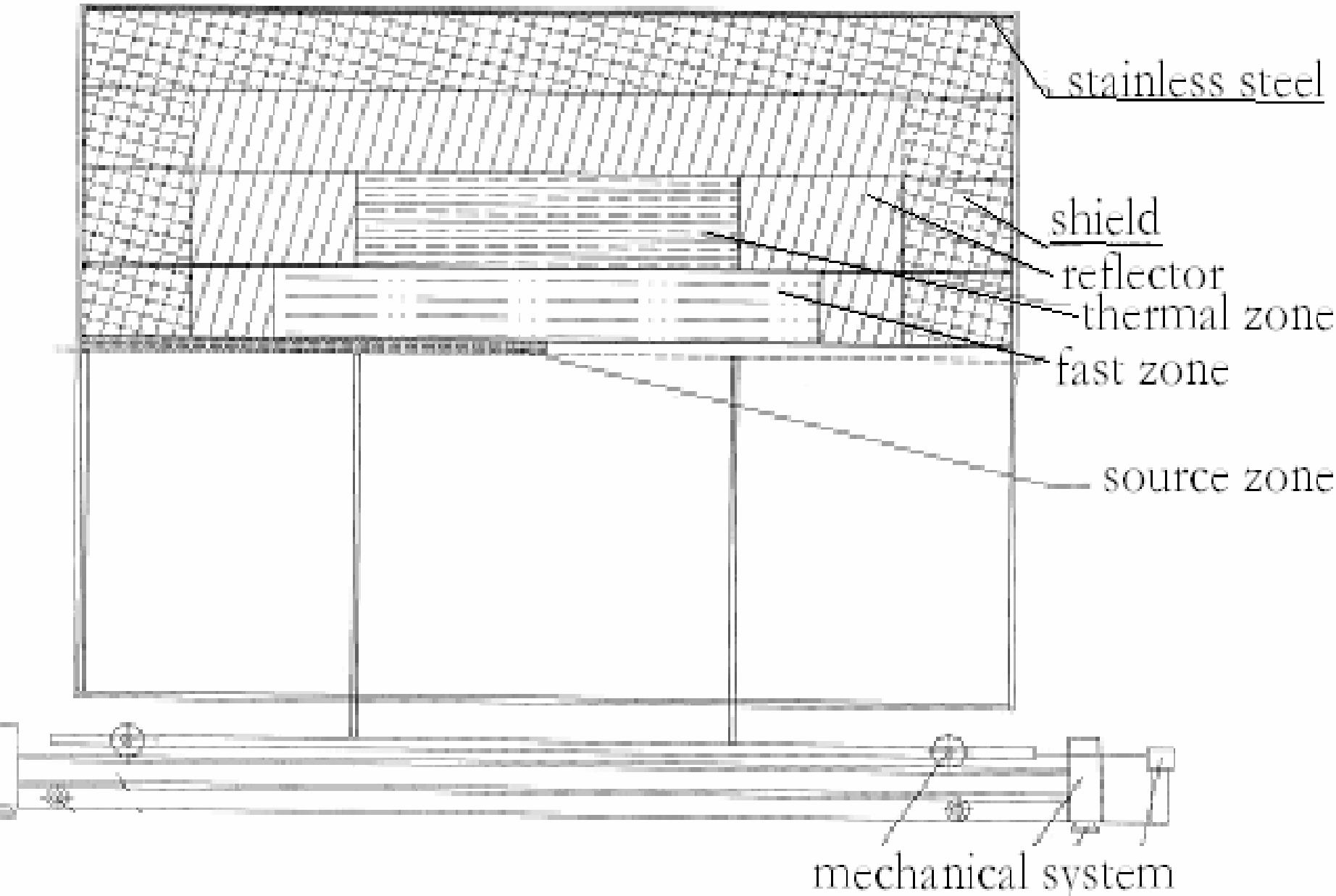
**Adjustable**



# Structure of China ADS Venus-1



# Structure of China ADS Venus-1



# Structure of China ADS Venus-1

## Table 1 parameters of Natural fuel and LEU 3% UO2

| Item | Natural fuel | LEU fuel |
|---|---|---|
| Fuel meat diameter /mm | 20 | 6.5 |
| Fuel density /g/cm$^3$ | 18.6 | 10.5 |
| Fuel length /mm | 1000 | 700 |
| Cladding material | Al | Zr-2 |
| Cladding diameter /mm | 22 | 8 |
| Fuel element weight /kg | 6.2 | 0.25 |

# Fast neutron zone and Neutron zone

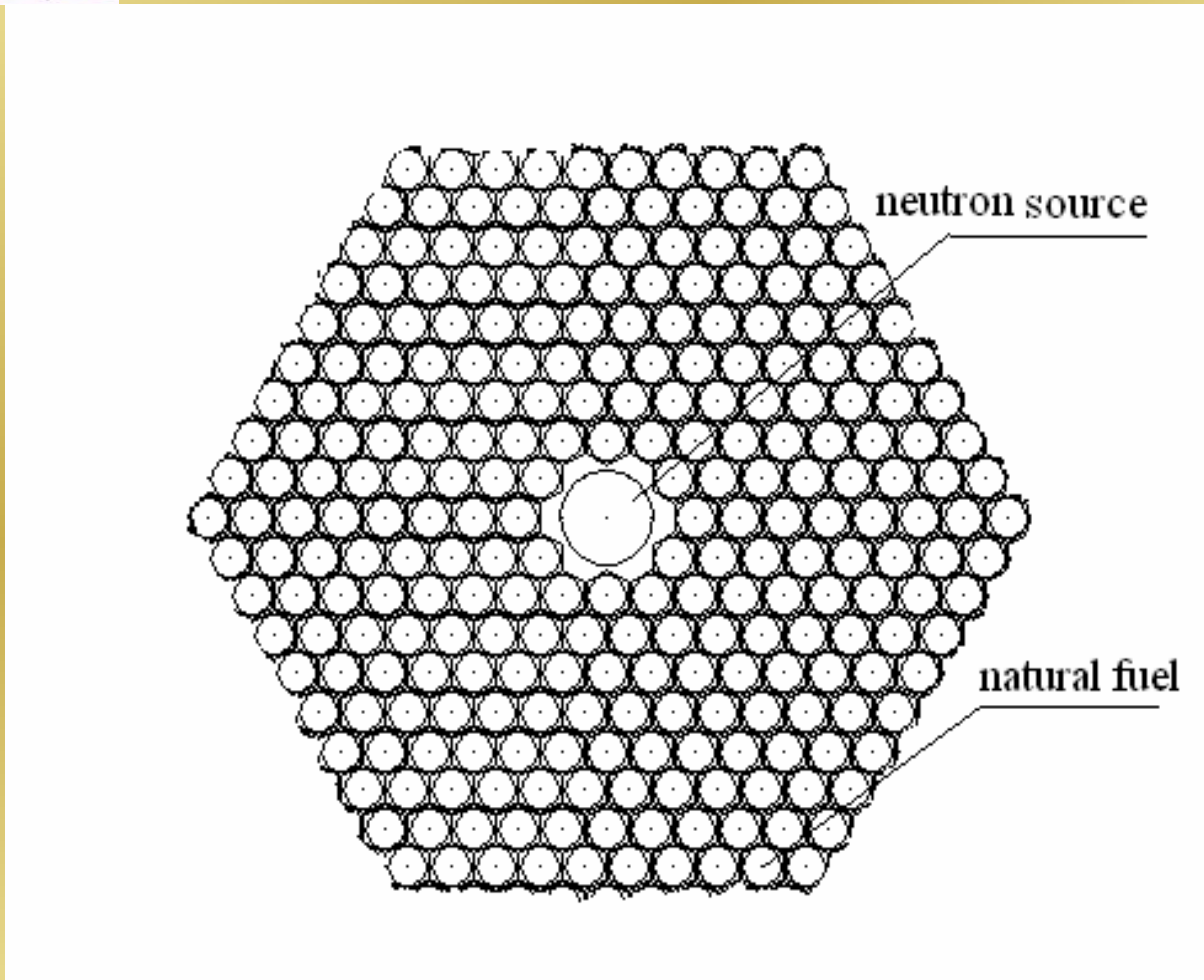
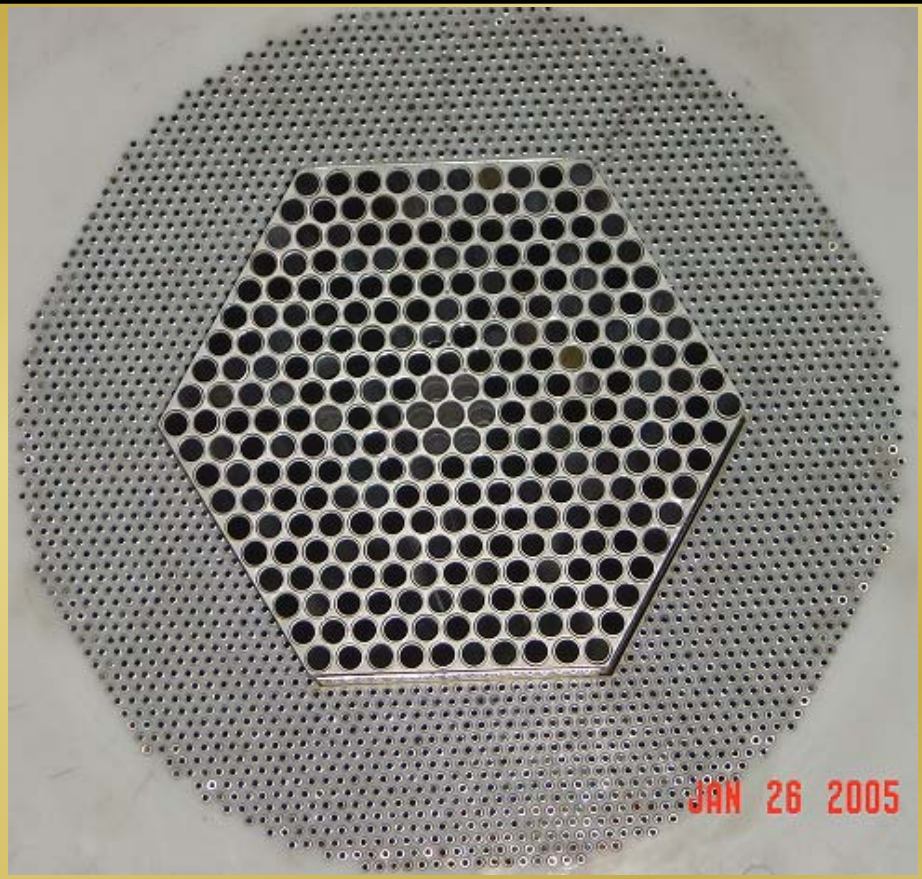



**Fig1 Arrangement for neutron source zone and fast neutron zone.**

# Thermal neutron zone

## Table 3. [3% UO2] fuel rods in each layer

| Layer No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuel elements | 126 | 132 | 138 | 144 | 150 | 156 | 162 | 168 | 174 | 180 | 186 | 174 | 156 | 126 | 96 |



# Experiment results

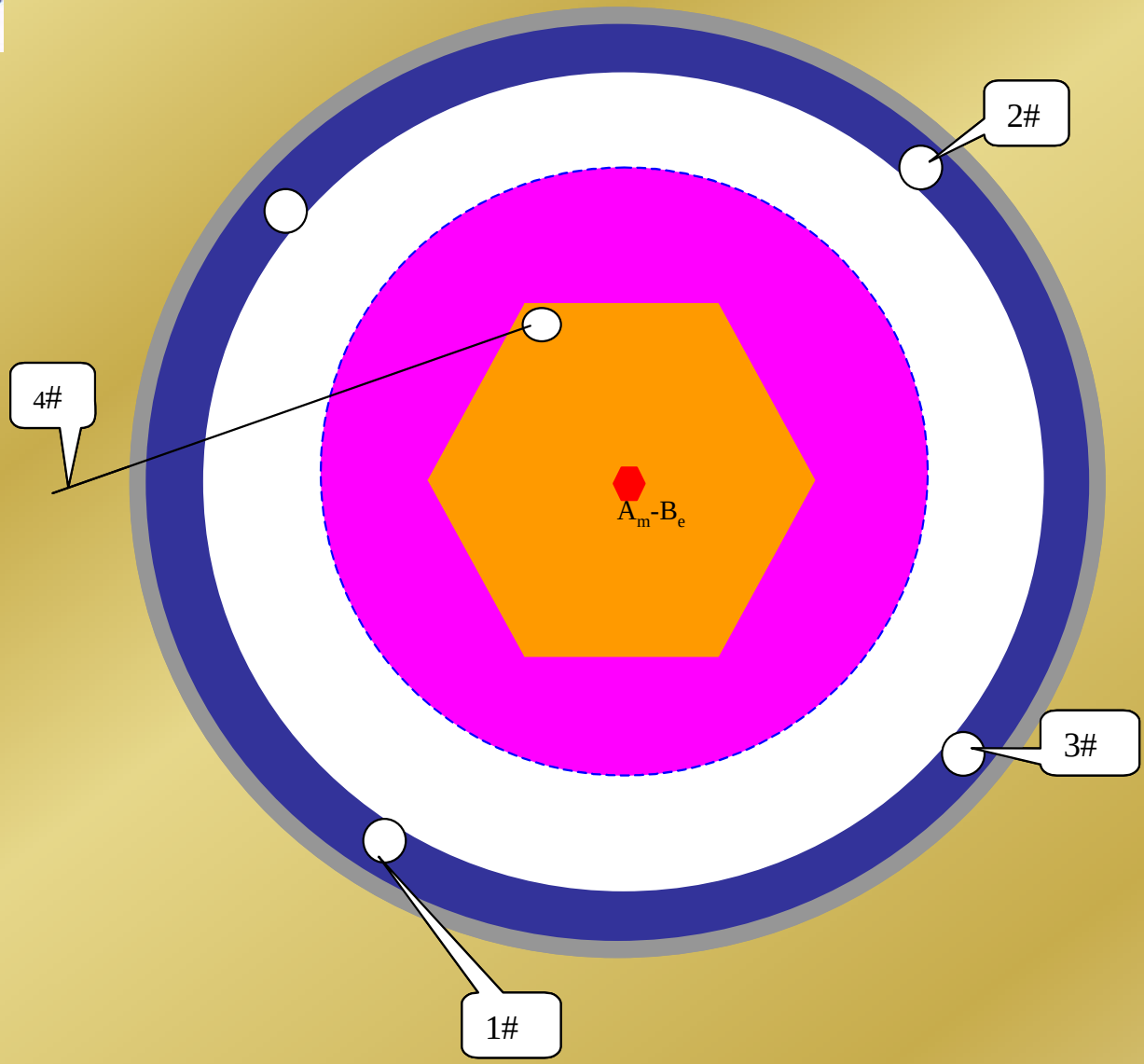
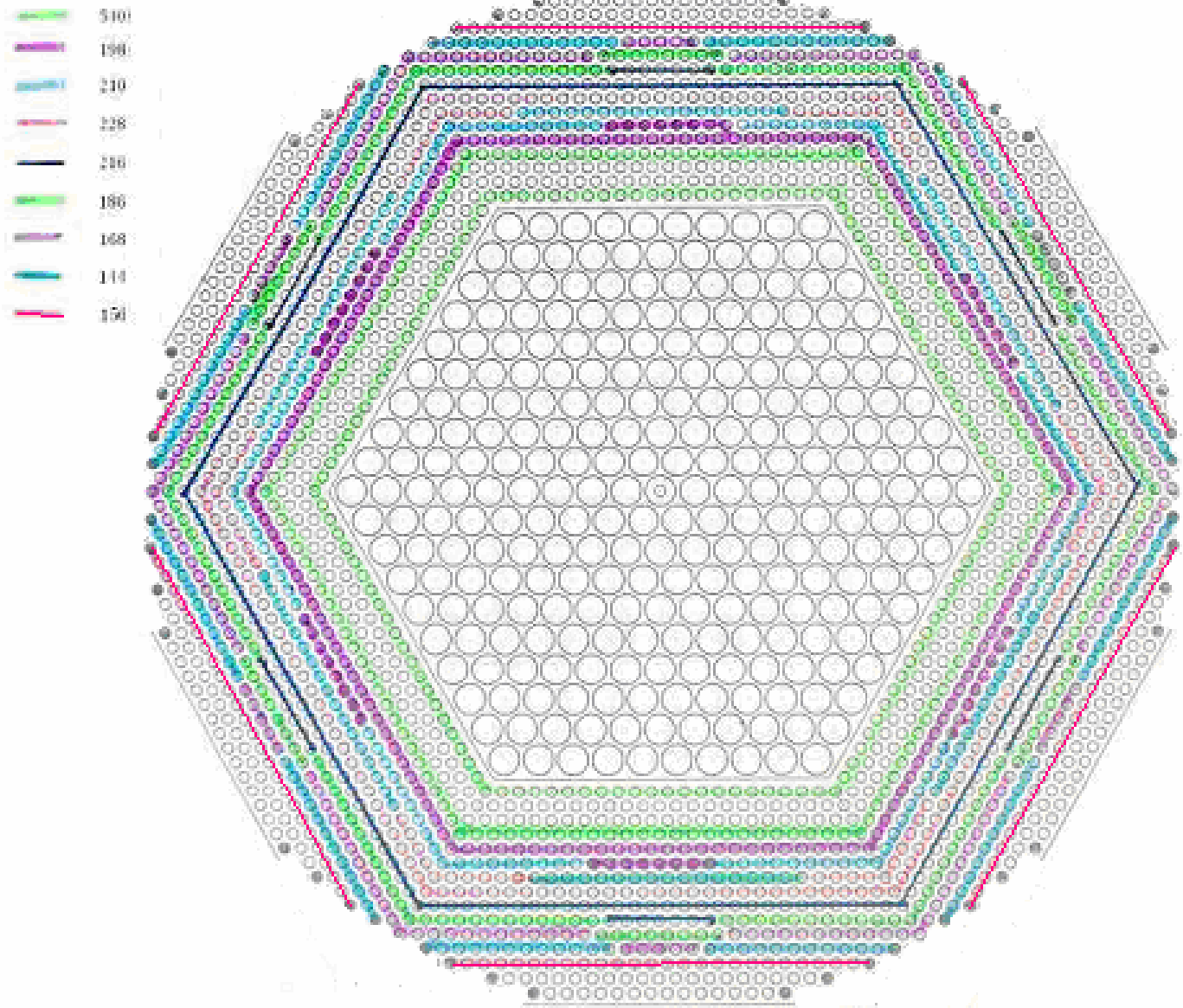



Fig 5  1#,2#,3# Neutron detectors position

# Experiment results



# Experiment results

Table 4 Results of extrapolated experiment with reflector

| Fuel loading | Thermal Fuel adding | Source Detector | Center | 17.5cm | 35 cm | Average Critical loading | Critical level $K_{eff}$ |
|---|---|---|---|---|---|---|---|
| | | | Extrapolation result | | | | |
| $267.5_{Nature}+540_{Low}$ | 540 | 1 | 929.3 | 1041 | 886 | 1005±148 | 0.8247 |
| | | 2 | 905.6 | 957.6 | 1349 | | |
| | | 3 | | 964 | 1008 | | |
| $267.5_{Nature}+738_{Low}$ | 738 | 1 | 1163 | 1181 | 1250 | 1272±110 | 0.8190 |
| | | 2 | 1228 | 1230 | 1454 | | |
| | | 3 | 1167 | 1364 | 1413 | | |
| $267.5_{Nature}+948_{Low}$ | 948 | 1 | 1426 | 1430 | 1430 | 1413±50 | 0.8771 |
| | | 2 | 1390 | 1391 | 1311 | | |
| | | 3 | 1494 | 1442 | 1405 | | |
| $267.5_{Nature}+1176_{Low}$ | 1176 | 1 | 1580 | 1590 | 1674 | 1636±70 | 0.8992 |
| | | 2 | 1661 | 1715 | 1721 | | |
| | | 3 | 1508 | 1603 | 1670 | | |
| $267.5_{Nature}+1392_{Low}$ | 1392 | 1 | 1845 | 1872 | 1794 | 1859±93 | 0.9147 |
| | | 2 | 1774 | 1833 | 1859 | | |
| | | 3 | 1810 | 1852 | 2091 | | |
| $267.5_{Nature}+1578_{Low}$ | 1578 | 1 | 1984 | 1987 | 2115 | 1995±49 | 0.9358 |
| | | 2 | 1977 | 1944 | 2005 | | |
| | | 3 | 1968 | 1969 | 1918 | | |
| $267.5_{Nature}+1746_{Low}$ | 1746 | 1 | 2100 | 2111 | 2078 | 2109±27 | 0.9529 |
| | | 2 | 2117 | 2136 | 2148 | | |
| | | 3 | 2061 | 2112 | 2115 | | |
| $267.5_{Nature}+1890_{Low}$ | 1890 | 1 | 2205 | 2245 | 2277 | 2251±38 | 0.9570 |
| | | 2 | 2232 | 2287 | 2313 | | |
| | | 3 | 2210 | 2219 | 2273 | | |
| $267.5_{Nature}+2046_{Low}$ | 2046 | 1 | 2304 | 2314 | 2319 | 2312±21 | 0.9681 |
| | | 2 | 2298 | 2324 | 2311 | | |
| | | 3 | 2266 | 2338 | 2332 | | |

# Calculations

## Table 6 The $K_{eff}$ Calculation result for the experiment result

| Fuel loading | Fuel adding | Keff | Fuel rod worth /mk | Critical Adding | Critical loading |
|---|---|---|---|---|---|
| 267.5Nu | | 0.457221±0.0010 | | | |
| $267.5_{Nature}+540_{Low}$ | 540 | 0.660819±0.0011 | 0.3770 | 899.6 | 1439.6 |
| $267.5_{Nature}+738_{Low}$ | 198 | 0.727929±0.0010 | 0.3389 | 802.7 | 1540.7 |
| $267.5_{Nature}+948_{Low}$ | 210 | 0.783438±0.0009 | 0.2643 | 819.3 | 1767.3 |
| $267.5_{Nature}+1176_{Low}$ | 228 | 0.833387±0.0009 | 0.2191 | 760.5 | 1936.5 |
| $267.5_{Nature}+1392_{Low}$ | 216 | 0.872844±0.0008 | 0.1827 | 696.0 | 2088.0 |
| $267.5_{Nature}+1578_{Low}$ | 186 | 0.901488±0.0008 | 0.1540 | 639.7 | 2217.7 |
| $267.5_{Nature}+1746_{Low}$ | 168 | 0.923257±0.0008 | 0.1296 | 592.3 | 2338.3 |
| $267.5_{Nature}+1890_{Low}$ | 144 | 0.940375±0.0007 | 0.1189 | 501.6 | 2391.6 |
| $267.5_{Nature}+2046_{Low}$ | 156 | 0.959429±0.0010 | 0.1221 | 332.2 | 2378.2 |

## Summary and Discussion

- **The worth of fuel rod is decrease when the Fuel load is adding**
- **The critical loading of facility is also changed during the extrapolation experiment.**
- **There are some error between the experiment and simulation. More study is needed to analyze the reason of these errors.**
- **The loading of sub-critical reactor is affected by efficiency of fuel rods, efficiency of detector, external neutron source.**
- **Accurate $K_{eff}$ value of the loading of facility is being planned to study for measurement by other method in the future.**

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# Thanks for your attention!