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Title: A New Gravito-Magnetic Trap for Measuring the Neutron Lifetime using Ultracold Neutrons

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A New Gravito-Magnetic Trap for Measuring the Neutron Lifetime using Ultracold Neutrons

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The neutron lifetime

- From the Standard Electroweak model

$$\tau = \frac{4908.7 \pm 1.9}{|V_{ud}|^2(1+3\lambda^2)}$$

- From A and the neutron lifetime we get V_{ud}

$$A = -\frac{2\lambda(\lambda+1)}{1+3\lambda^2}, \quad \lambda = \frac{g_A}{g_V}$$

- World average is 885.7 ±0.8 sec, but…
- A. Serebrov *et al.* (PL, 2005) measured 878.5 $\pm 0.7_{stat}$ $\pm 0.4_{syst}$

"The most recent result, that of SEREBROV 05, is so far from other results that it makes no sense to include it in the average…."

"…It is up to workers in this field to resolve this issue. Until this major disagreement is understood our present average of 885.7±0.8 s must be suspect."

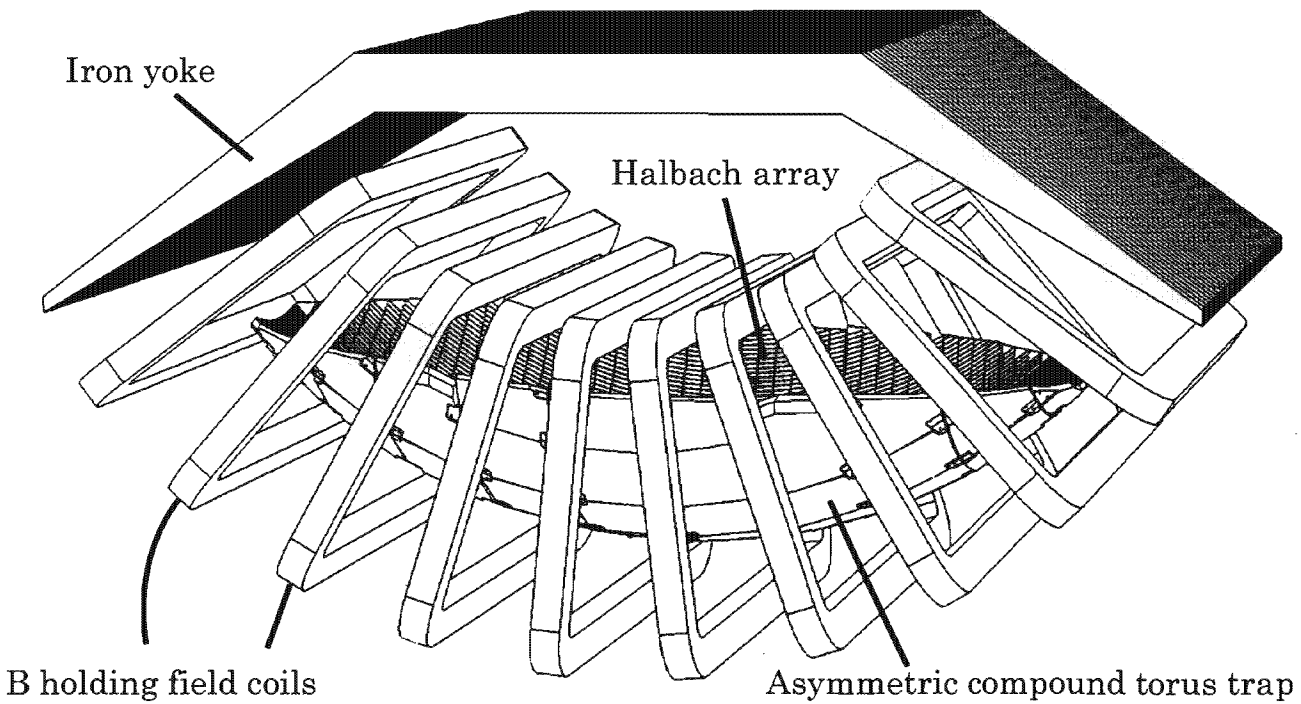
- PDG, July 2008

New neutron lifetime experiment at LANSCE

- Will use operating UCN D_2 spallation source at LANSCE in Los Alamos, NM
- Next to UCNA experiment
- PPM and spin flipper can select spin state
- >10 UCN/cm^2 at gatevalve

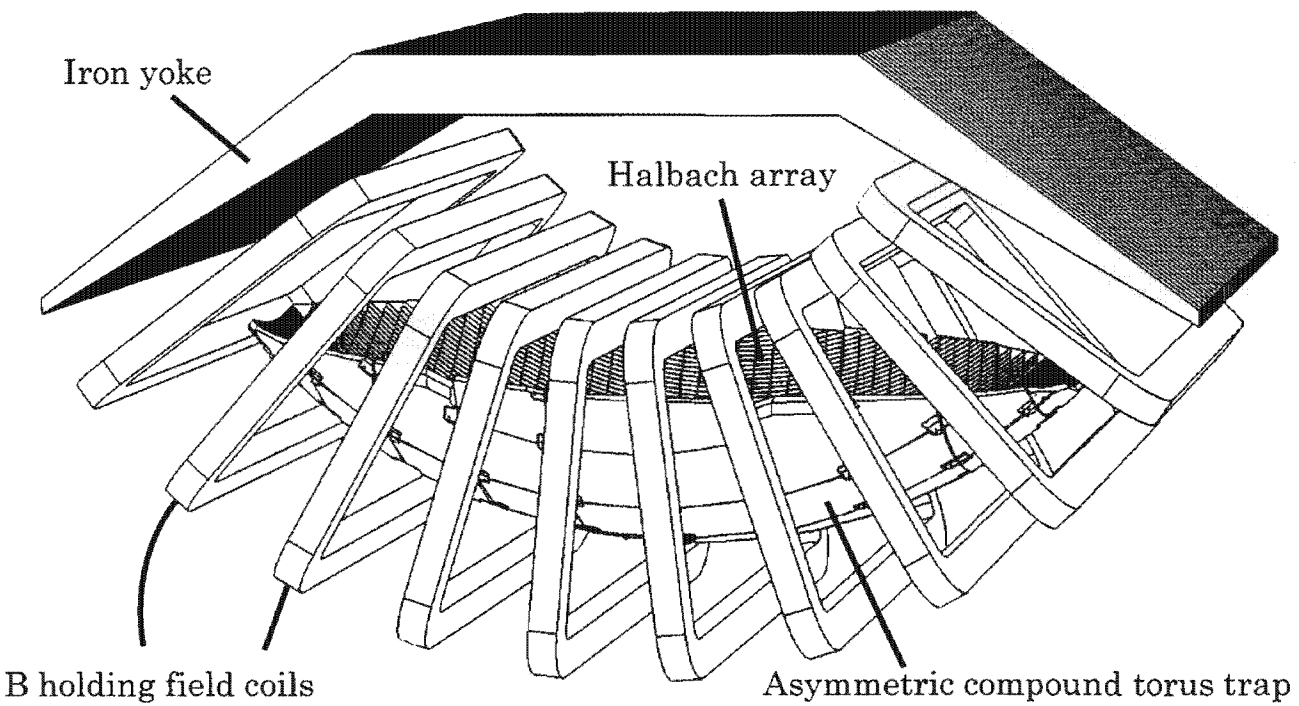
Overview of Experiment

- Asymmetric compound toroidal trap
- UCN trapped by gravity in open-top bowl ("the bathtub")
- Permanent magnet repels UCN on bottom
- Minimize material interactions



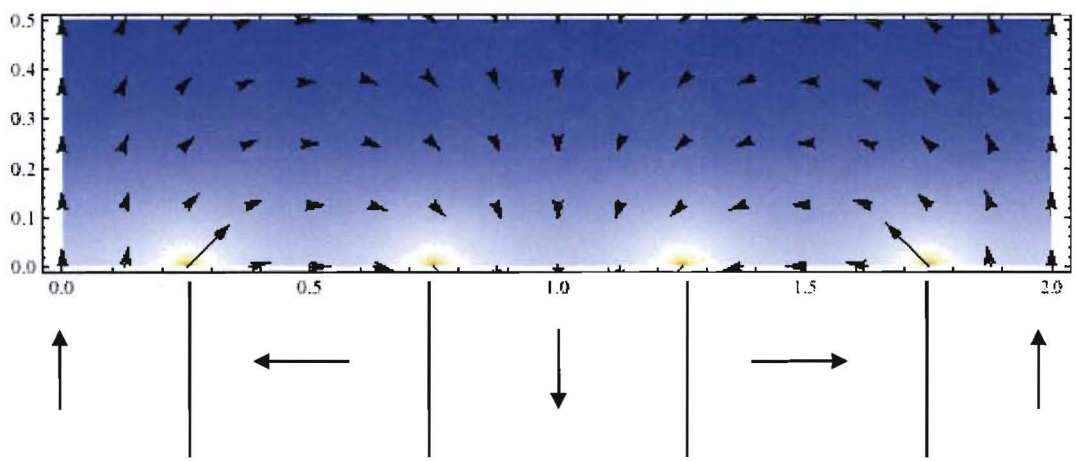
Overview of Experiment

- **Polarized** UCN ("low-field seekers"or "positive energy eigenstates)
- High strength neoymium-iron-boron (NdFeB) magnet **Halbach array** walls.
- Halbach array surface strength near 0.8 T



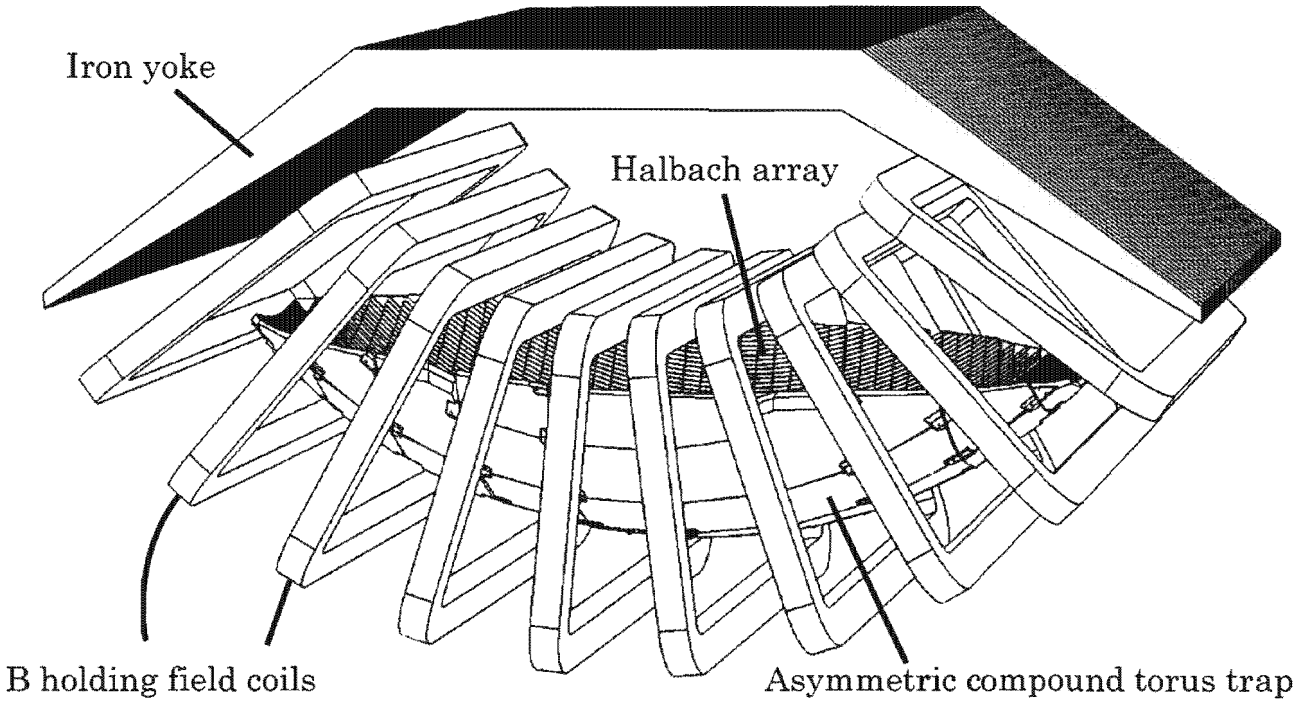
Halbach array

- Each magnet 90º out of phase with its neighbor.
- The array has B field "ripples" of scale L/4 = 0.5"
- Rotating field is orthogonal to holding field B_0



Overview of Experiment

- Orthogonal holding B field of 0.05-0.1 T prevents depolarization by eliminating field zeros
- Possible because of of torodial topology

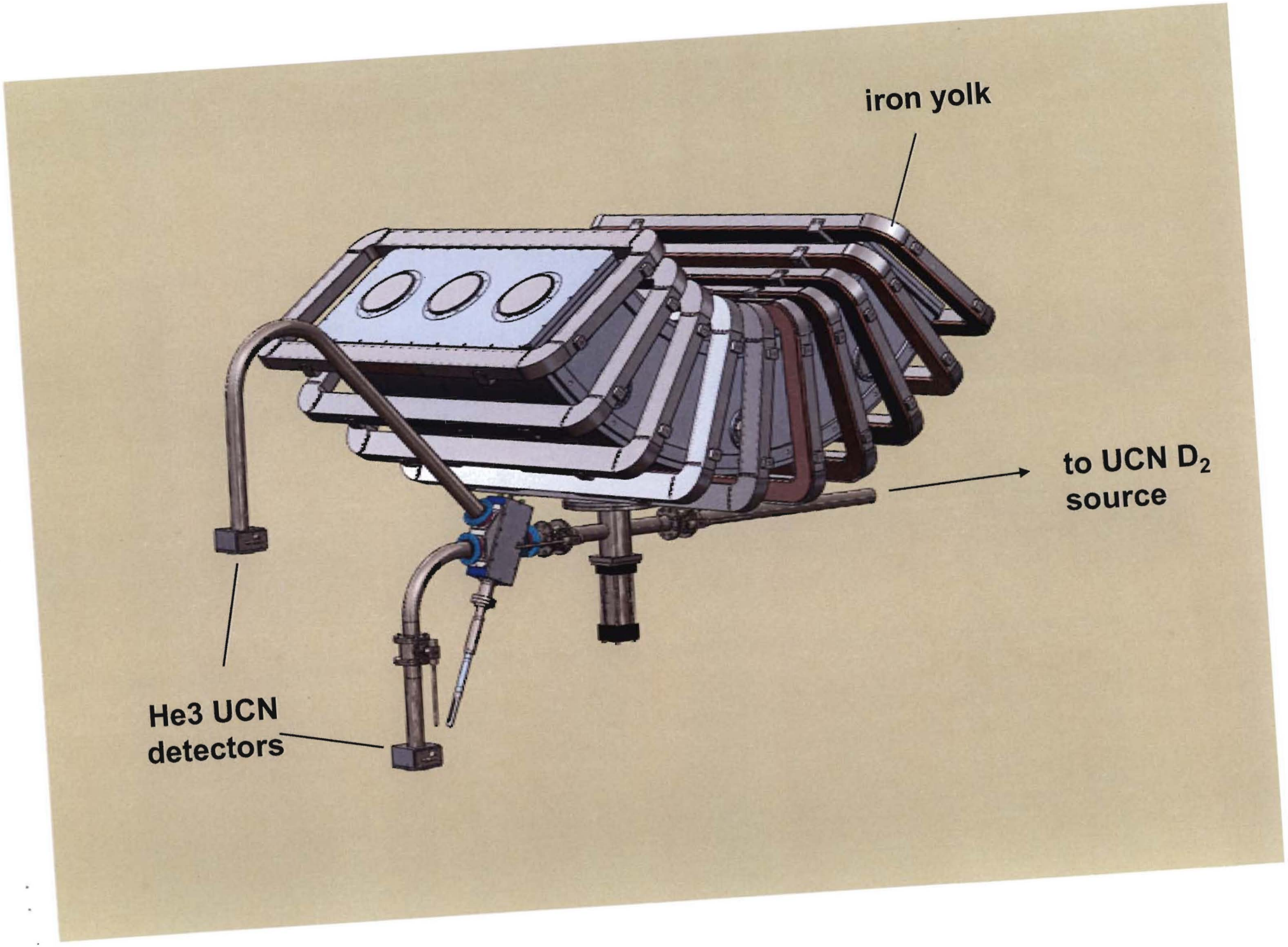


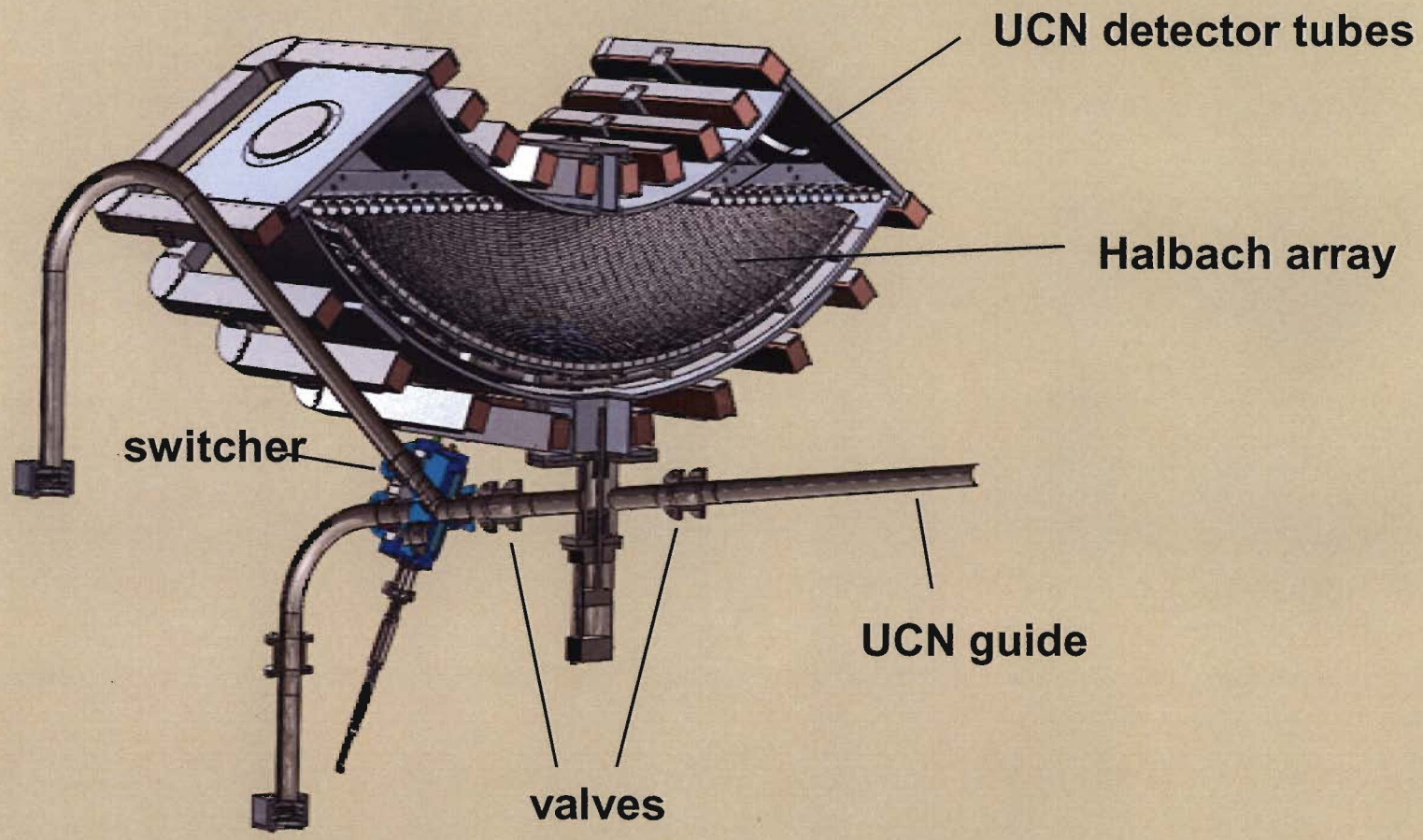
Cleaning marginally trapped UCN

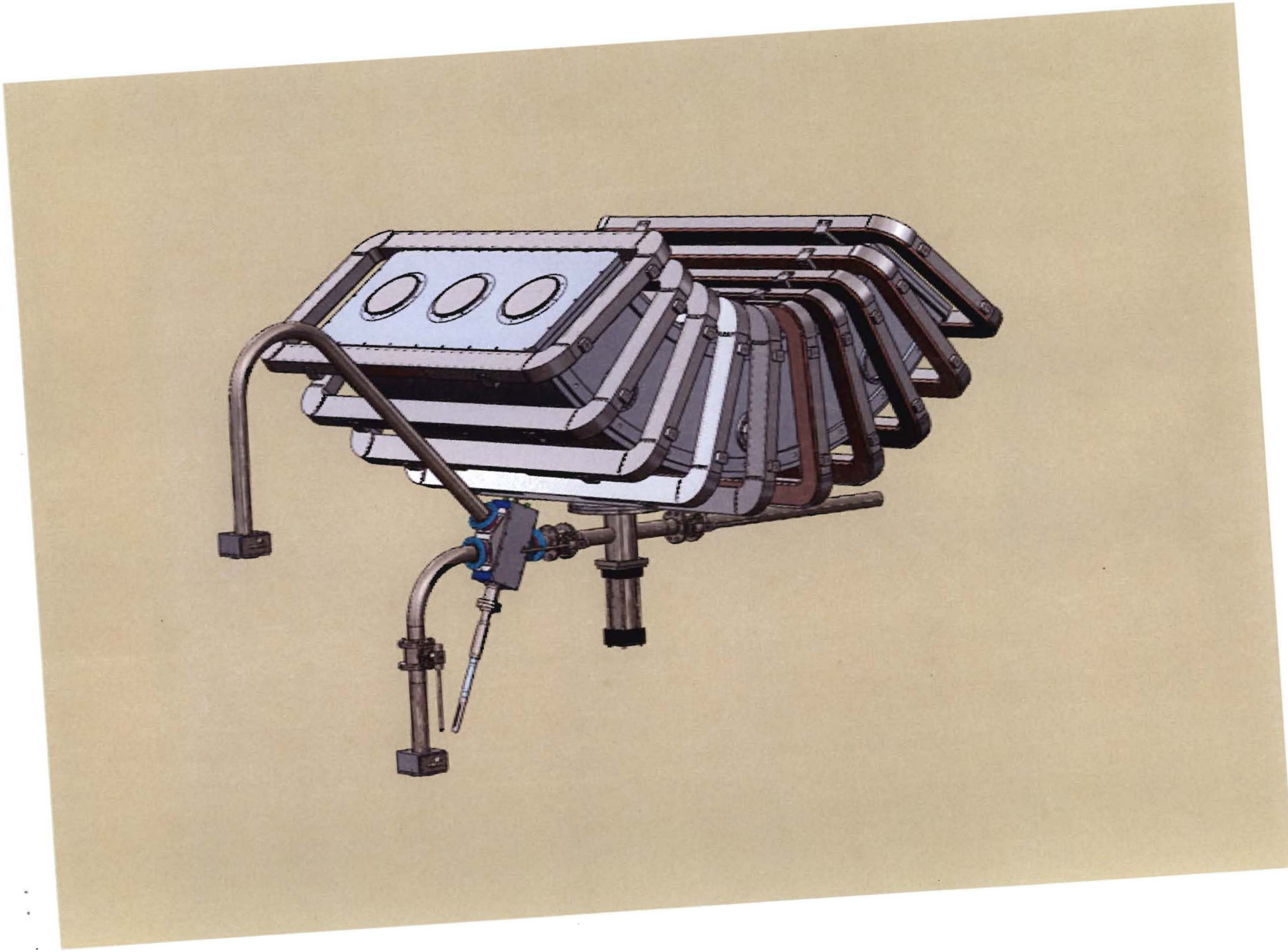
- The trap must be free of **quasi-trapped states** (and *fast*)

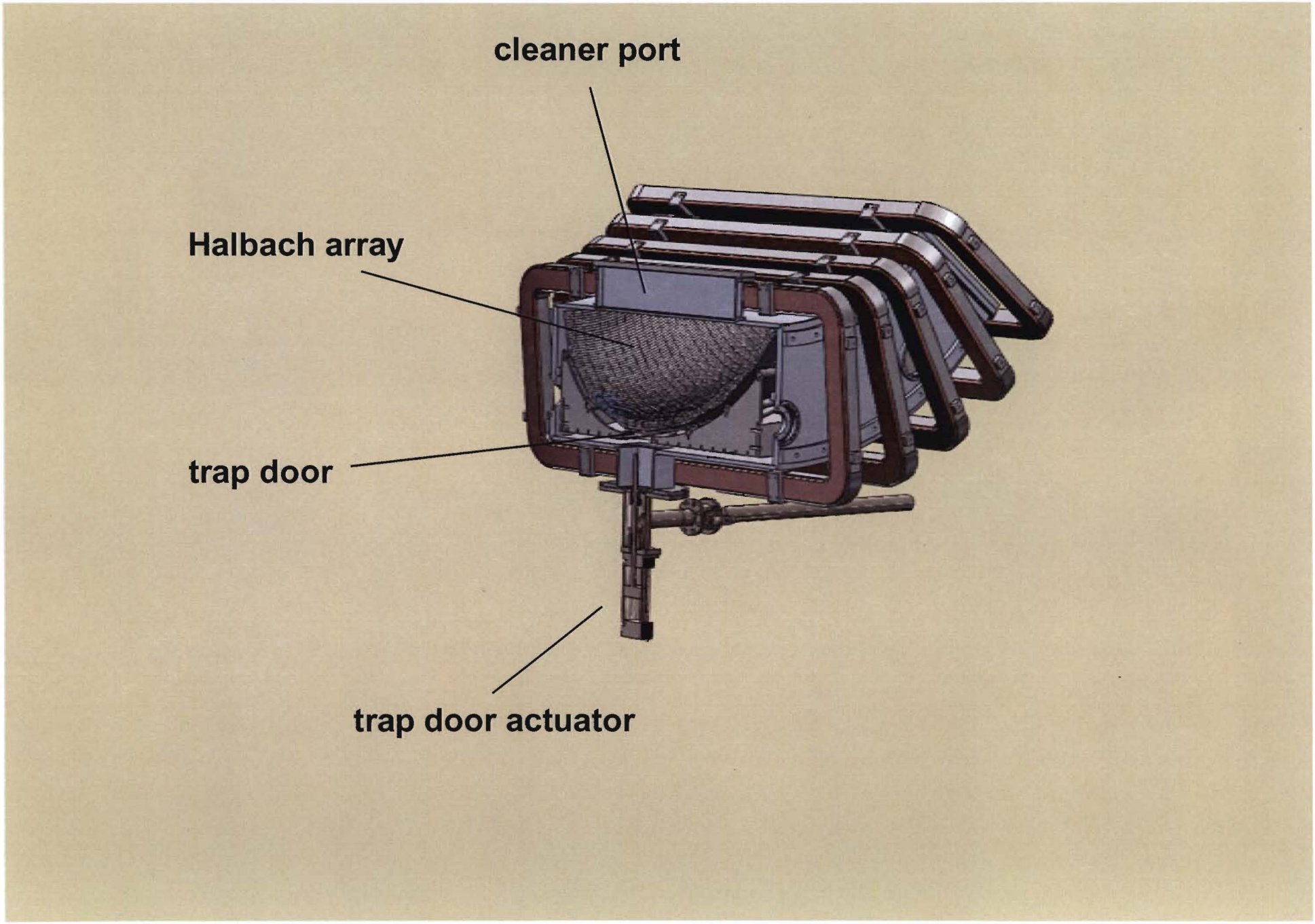
$$\tau_{\text{clean}} \ll \tau_n$$

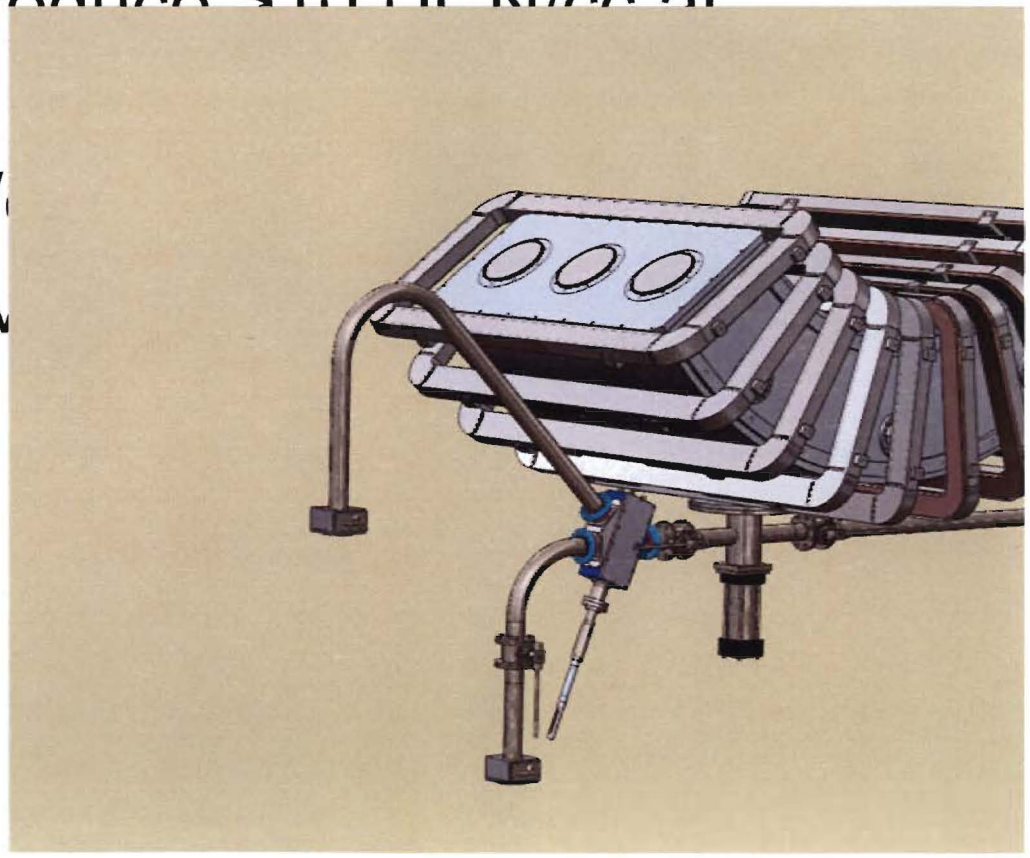
- A**symmetric** compound torus removes UCN angular momentum.
- The Halbach array introduces **high spatial-frequency ripples** in reflecting magnetic field to further destroy


iron yolk
to UCN D_2 source
He3 UCN detectors


UCN detector tubes
Halbach array
switcher
UCN guide
valves




cleaner port
Halbach array
trap door
trap door actuator

Summary

- Effective trap volume is 0.6 m^3
- UCN may trap up to E = 48 neV
- LANCE source can produce >10 UCN/cc at gatevalve
- Trap density >1 UCN/
- We hope for a sensitiv