We will start with β decay experiment in a magnetic bottle

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G_V and G_A measurement

n β-decay: mixture of Fermi and Gamow Teller transitions
Two independent observables are necessary

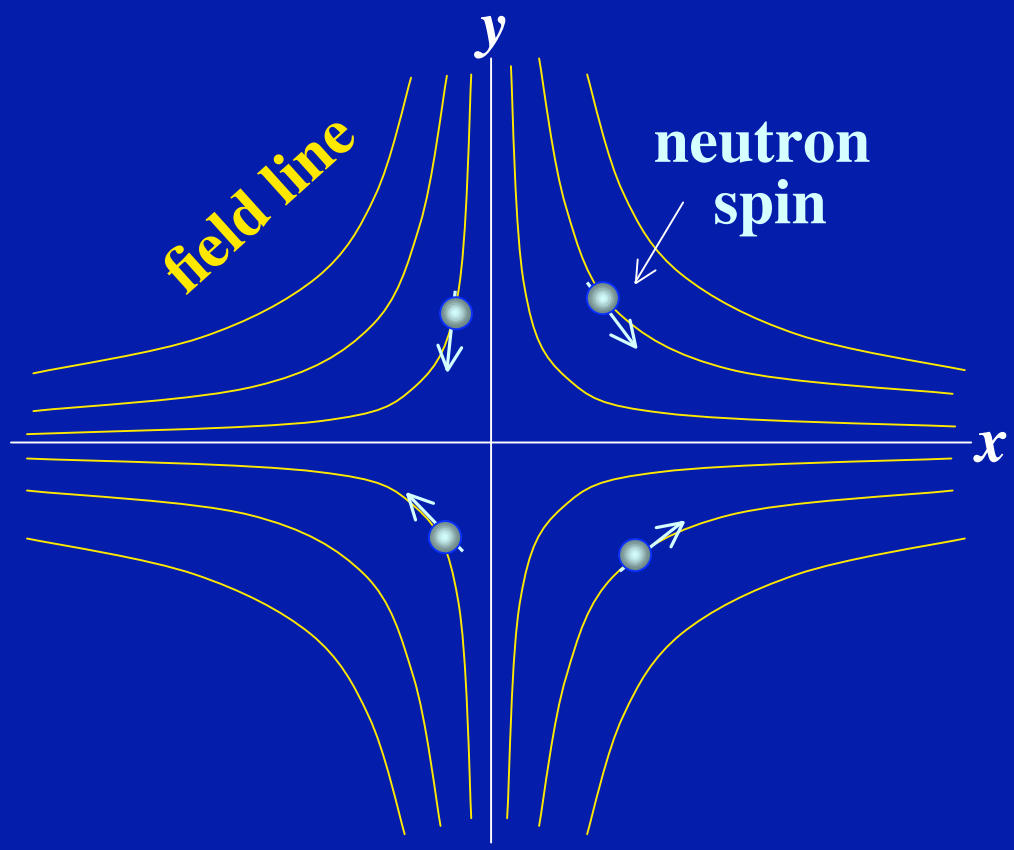
ILL, PNPI $\tau = 885.7 \pm 0.7$ **s by UCN in material bottles**
Heidelberg $A_\beta = -0.1162 \pm 0.0013$ **by cold neutron beam**

At NIST **lifetime in a UCN magnetic bottle**

At Los Alamos **asymmetry by UCN**
magnetic spin filter

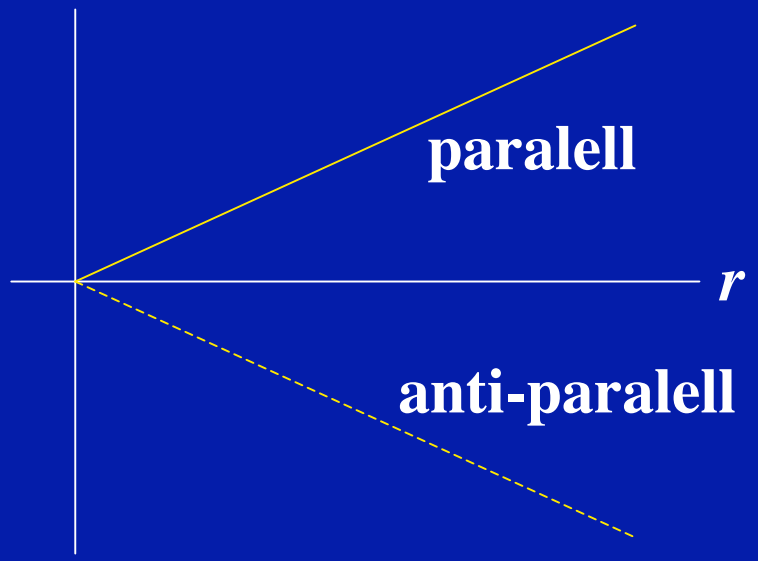
UCN in quadrupol field

Neutron spin direction is always in the magnetic field line and changes adiabatically.



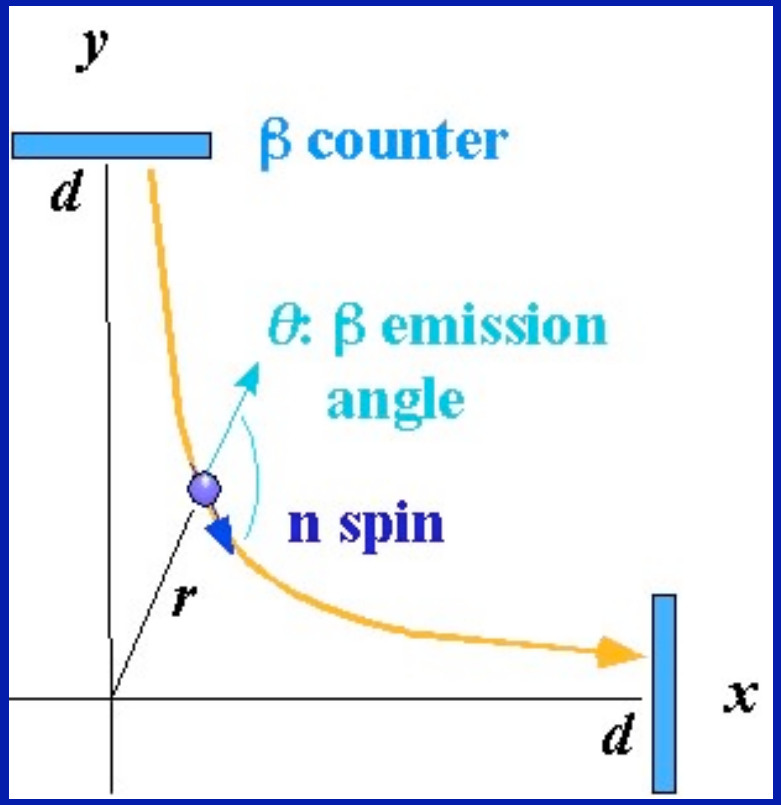
Magnetic potential for UCN

$-\mu B = -\mu cr$



β decay in quadrupole field

$$n \rightarrow p + e^- + \bar{\nu}$$



β ray angular distribution $W(\theta)$:

$$W(\theta) \propto 1 + P_n A_\beta \cos\theta$$

P_n : neutron polarization

β particles in the loss cone,

$$\theta < \theta_c ,$$

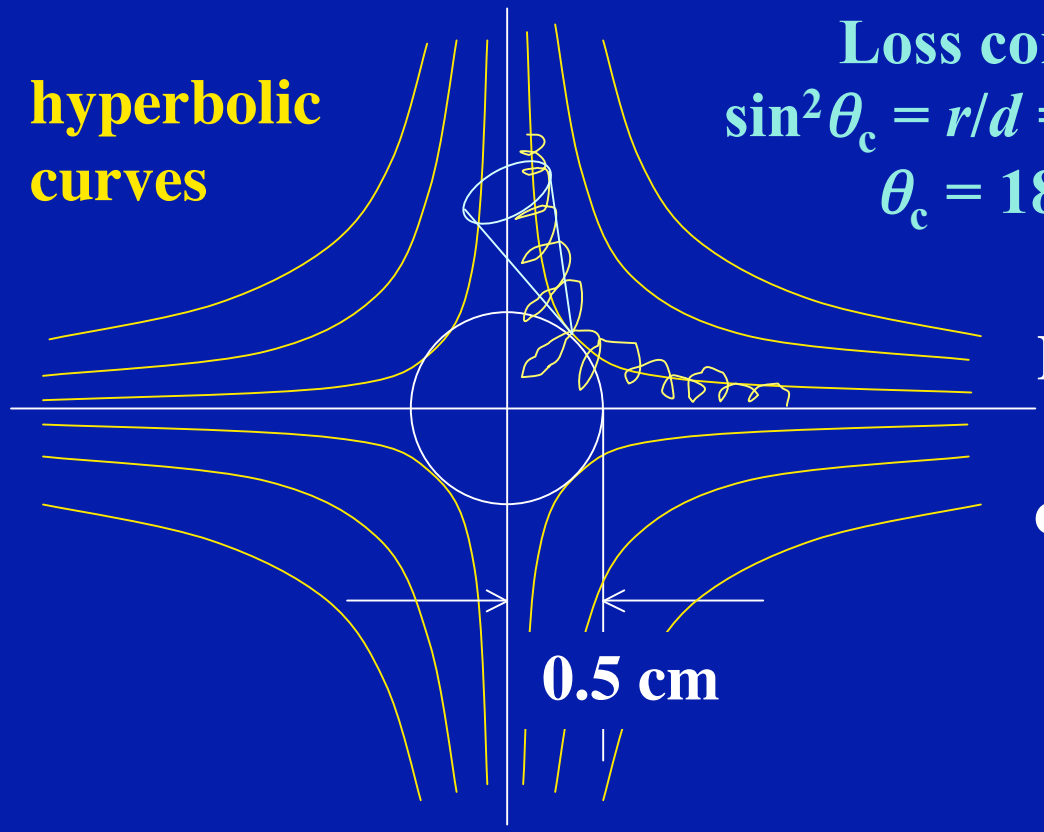
$$\sin^2\theta_c = B(r)/B(d) = r/d,$$

(mirror field effect)

enter into the counter

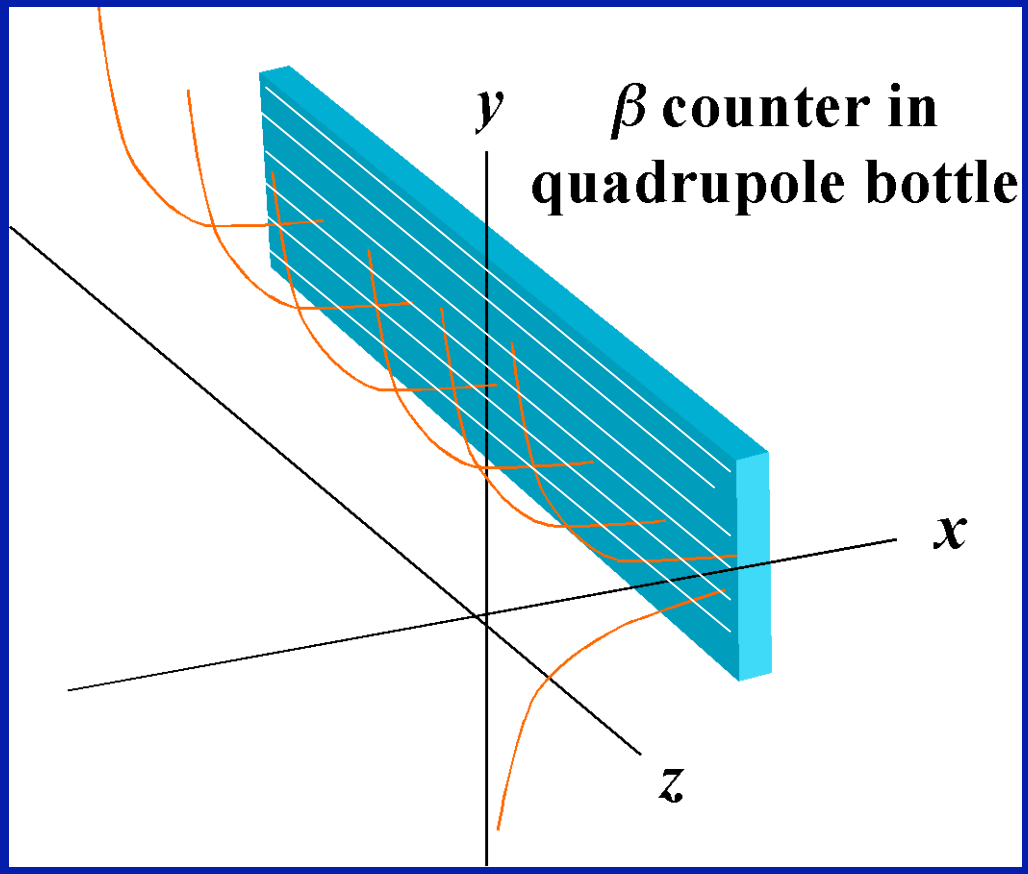
Spiral motion of β

Q value: 782 keV
At E_β = 400 keV
ρ = 5 mm at 5 kG, $\partial B/\partial r$ = 1 T/cm



Discard at center but count is negligible

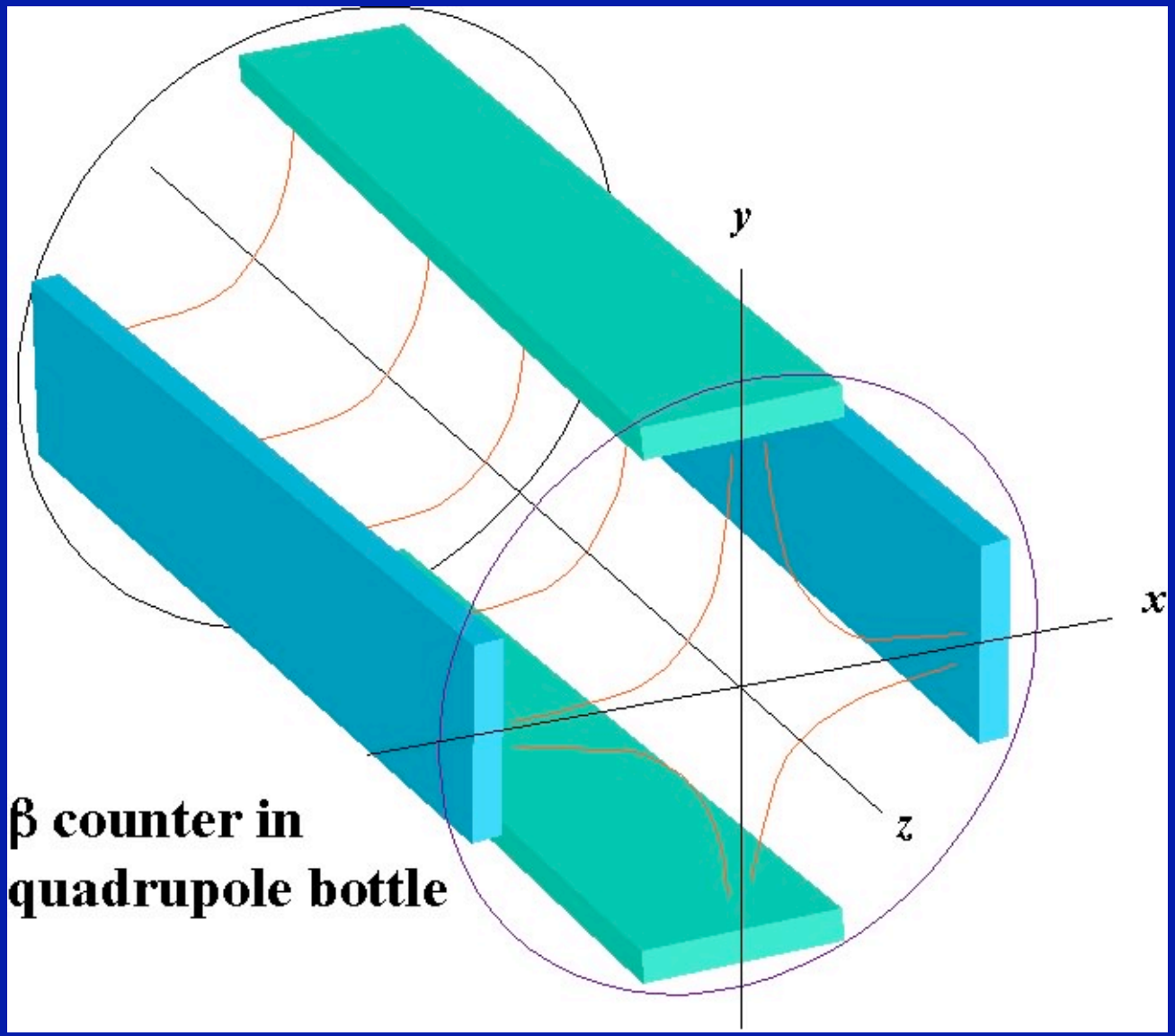
β ray counting in quadrupole field



β particles go to the counter with spiral motion.

segmented counter analyzes β emission points, senses change in UCN radial distribution.

β counter in quadrupole



β ray counts

$N^{\pm}$ ($\pm$: sign of the magnetic field) depends on

UCN radial distribution: $2\pi r\{(E_u - \mu cr)^{1/2}/E_u^{1/2}\}\rho(E_u)$,

μ: neutron magnetic dipole moment

$\rho(E_u)$: UCN density, E_u : UCN energy at $r = 0$

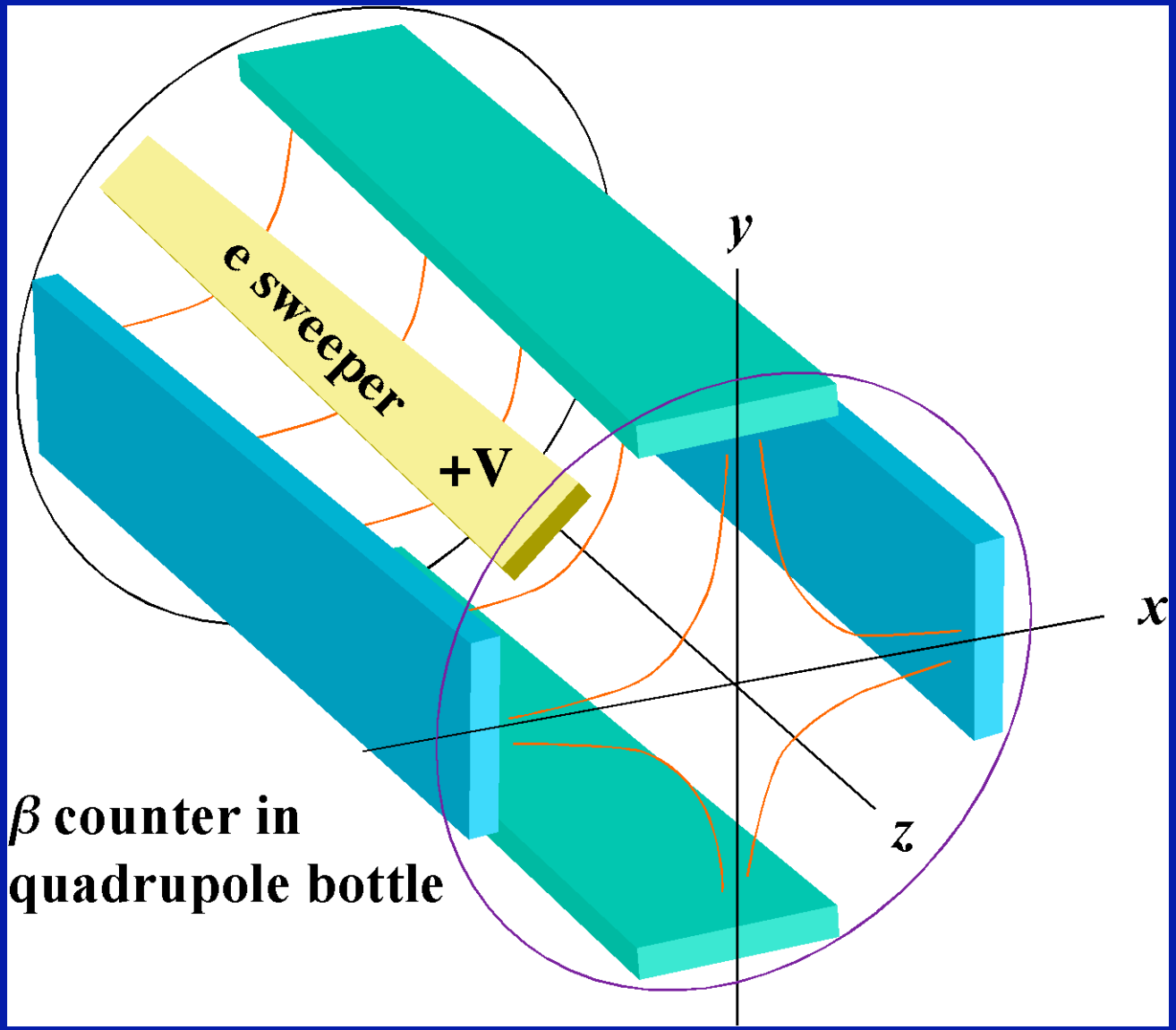
UCN dwelling time: $\propto E_u^{1/2}/(E_u - \mu cr)^{1/2}$,

$\cos\theta_c = (1 - r/d)^{1/2}$,

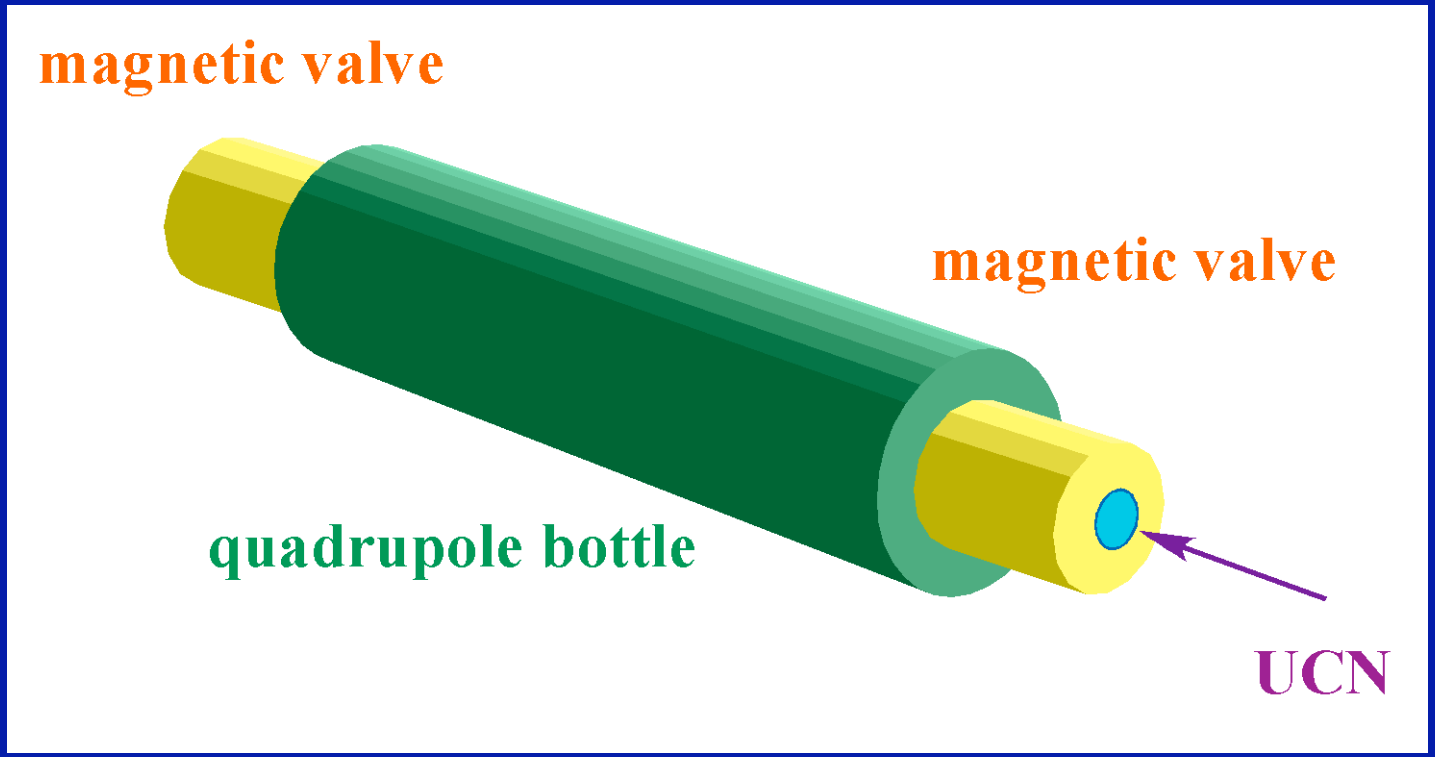
(the effect of gravity is neglected)

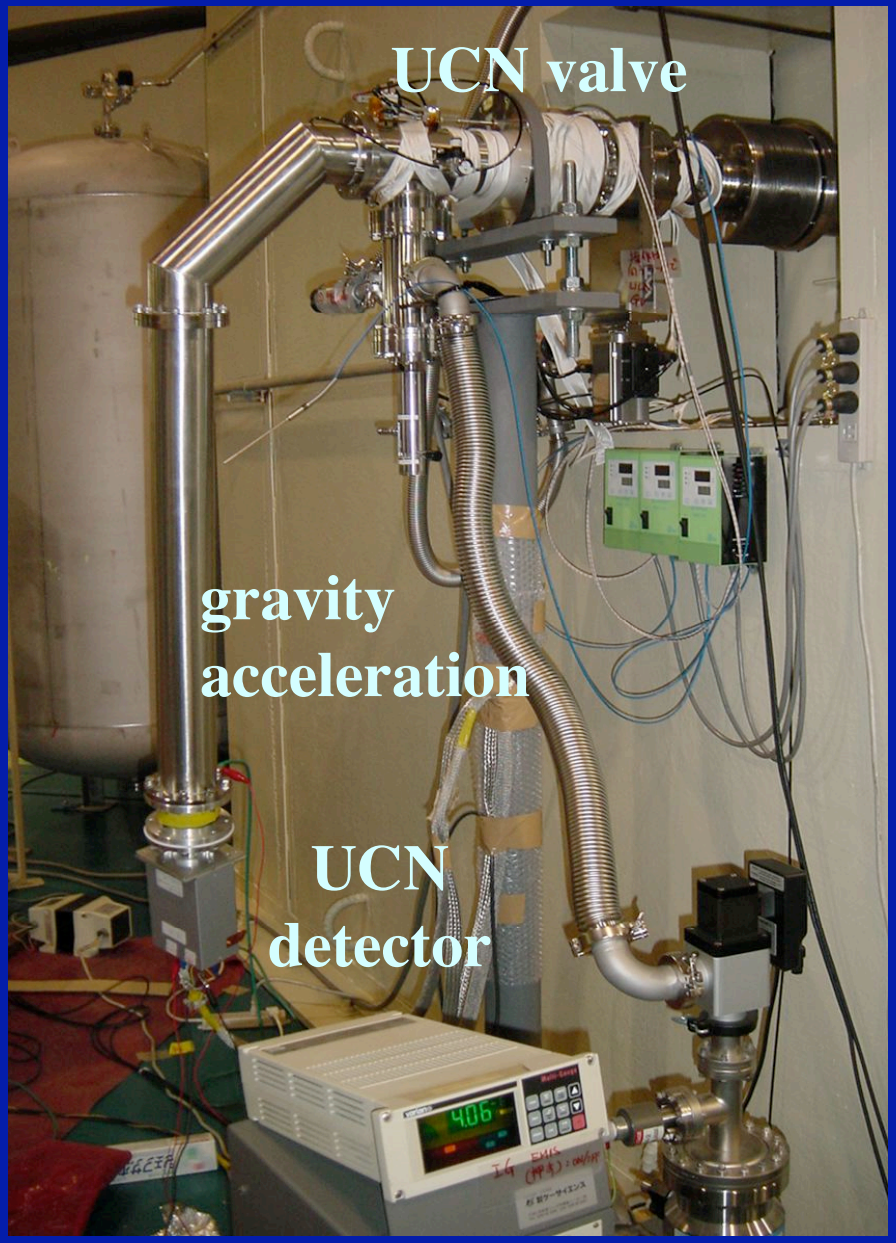
$$N^{\pm} \propto \int dE_u \int 2\pi r dr\, \rho(E_u) \left[\{1 - (1 - r/d)^{1/2}\} \pm (1/2)P_n A_\beta (r/d)\right].$$

residual electrons are swept away



β decay apparatus



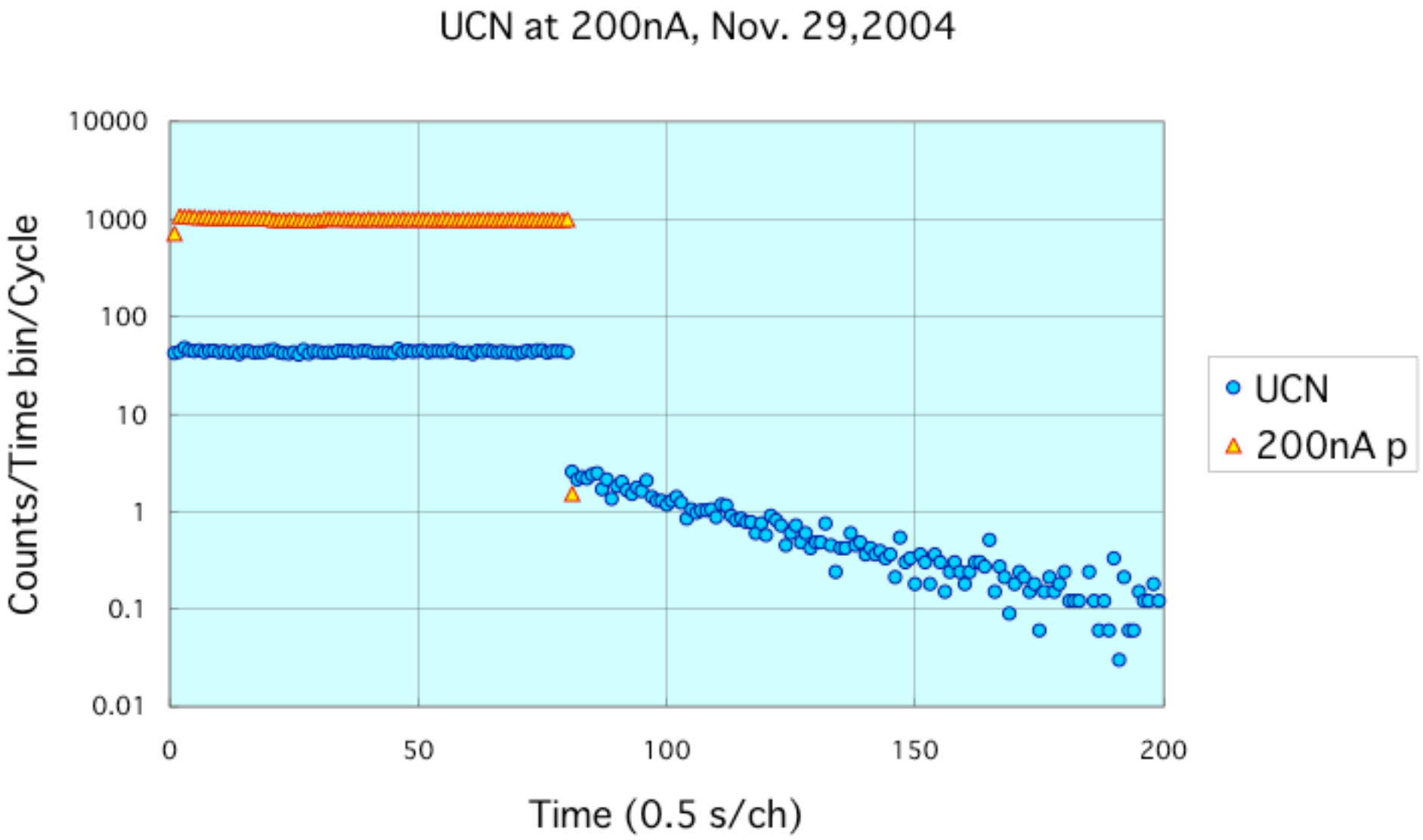


Experimental port

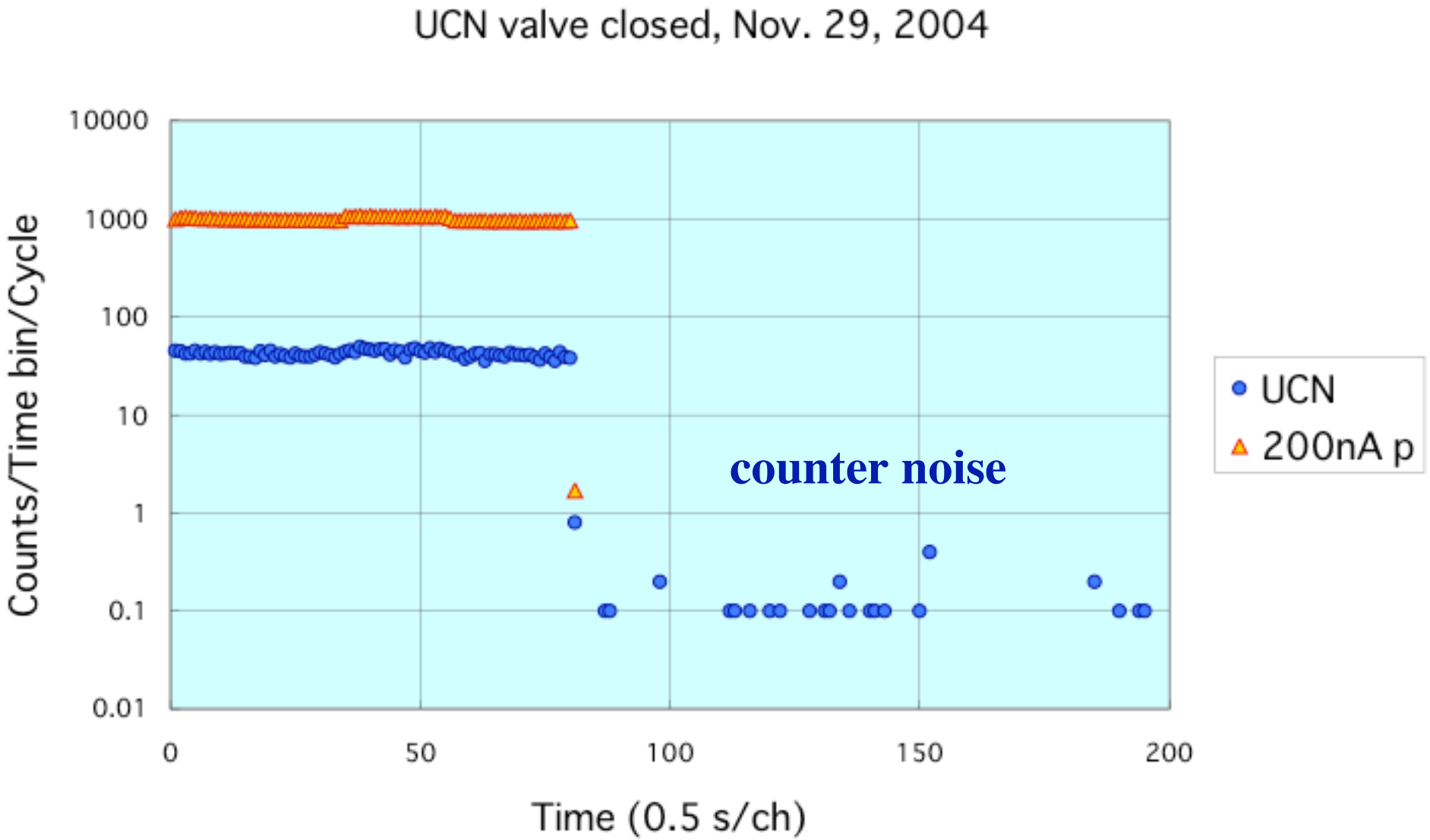
Neutron background ?

β and γ background ?

UCN counts


UCN at 200nA, Nov. 29,2004
Counts/Time bin/Cycle
10000
1000
100
10
1
0.1
0.01
0
50
100
150
200
Time (0.5 s/ch)
UCN
200nA p

UCN valve


UCN valve closed, Nov. 29, 2004
Counts/Time bin/Cycle
10000
1000
100
10
1
0.1
0.01
0
50
100
150
200
Time (0.5 s/ch)
counter noise
UCN
200nA p

Magnetic storage experiment

lifetime measurement for 5 *l* decay volume

$140/cm^3 \times 5\times10^3\ cm^3 \times 1/1000s$
$\times (24\times60\times60s) \times 1/2 \times 1/3 \times 1/5 = 2 \times 10^6$
1 day, spin, loss cone, duty factor
$\delta\tau/\tau = 10^{-3}$ for 1 day

improvement in He-II bottle and diffusion n reflector:
$1400/cm^3$
$\delta\tau/\tau = 10^{-4}$ for 10 day

Accuracy of asymmetry measurement

$\delta\theta$