The concept of the UCN source at a periodic pulsed reactor

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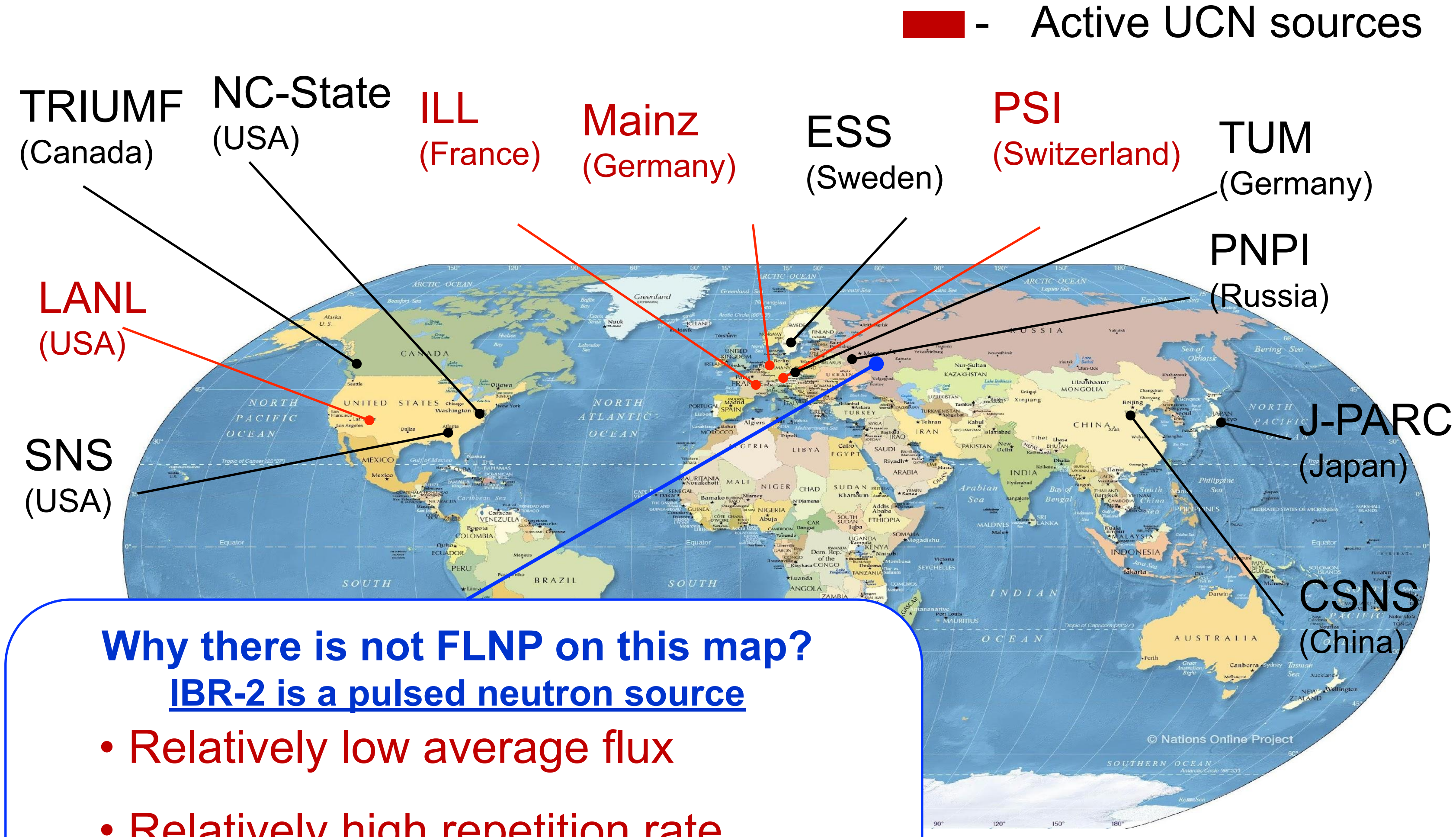
Ultra Cold Neutron sources

UCNs are important tools for:

- Search for the neutron EDM
- Measurement of the neutron lifetime
- Quantization of neutron states in a gravitational field and search for new interactions
- Non-stationary quantum mechanics and neutron optics
- Measurement of angular correlation coefficients of neutron beta decay
- Search for neutron-antineutron oscillations



Why there is not FLNP on this map?

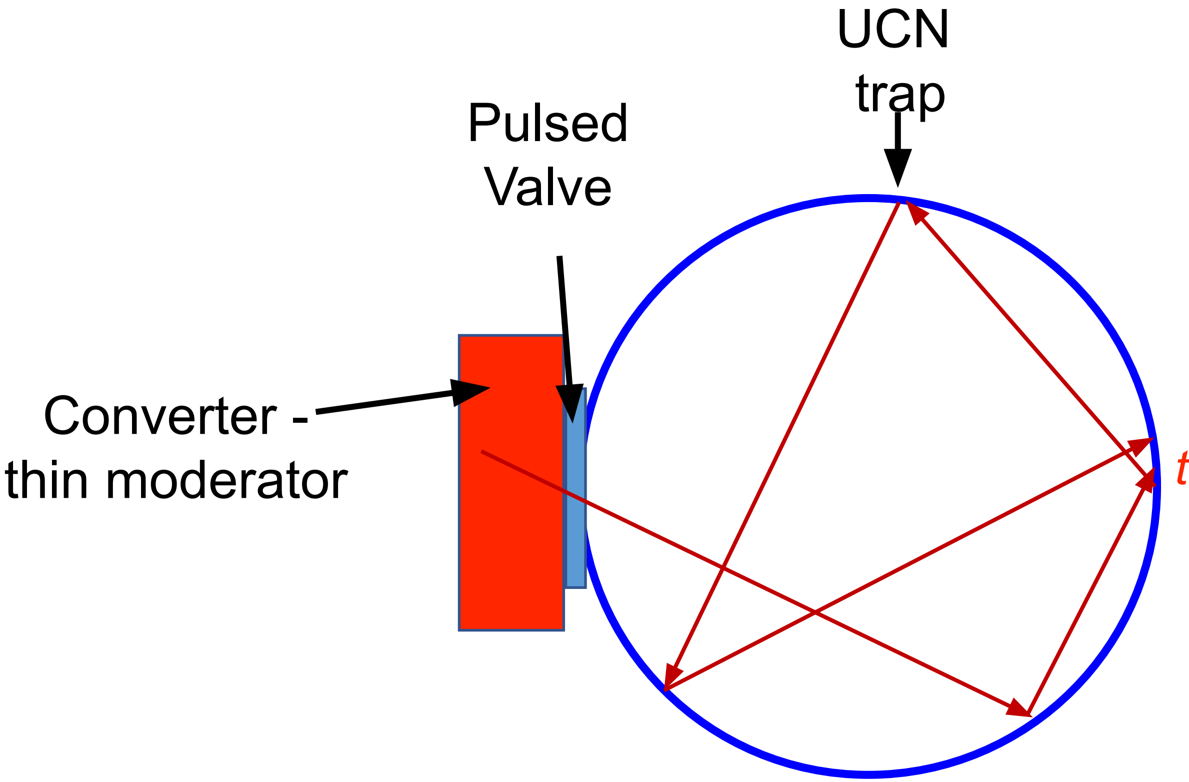
IBR-2 is a pulsed neutron source

- Relatively low average flux
- Relatively high repetition rate

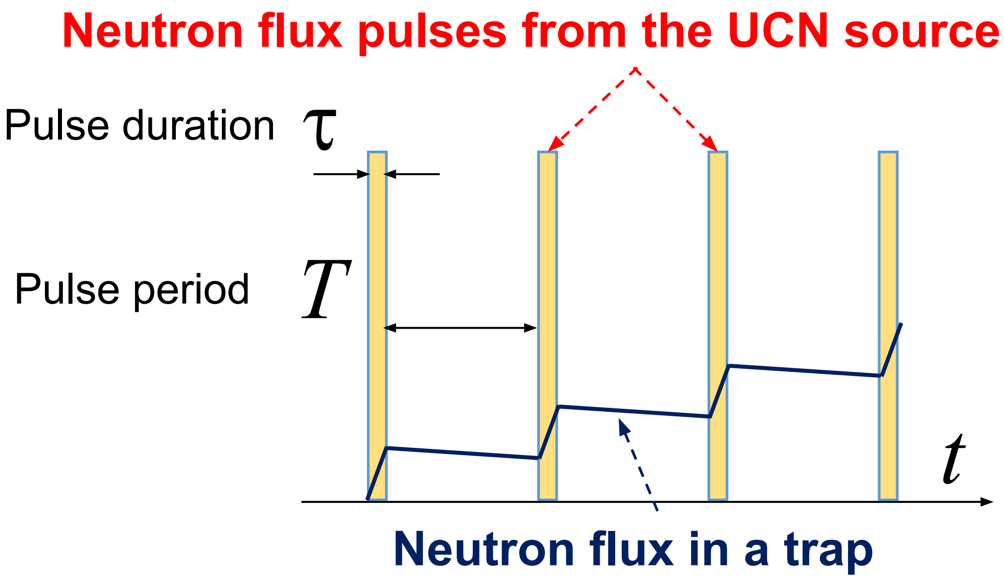
But HIGH neutron peak flux density $\sim 10^{16}$ n/cm^2/s

Pulsed source and UCN accumulation in a trap

The <u>main idea</u> is **pulsed accumulation** of UCN in a trap.



$$0 < E_n < E_{trap} \approx 250 \text{ neV}$$



The increasing of the neutron flux in the trap due to pulsed filling of the trap

$$g = 1 + \frac{1 - \frac{\tau}{T}}{\frac{\tau}{T} + \frac{\Sigma\mu}{S}}$$

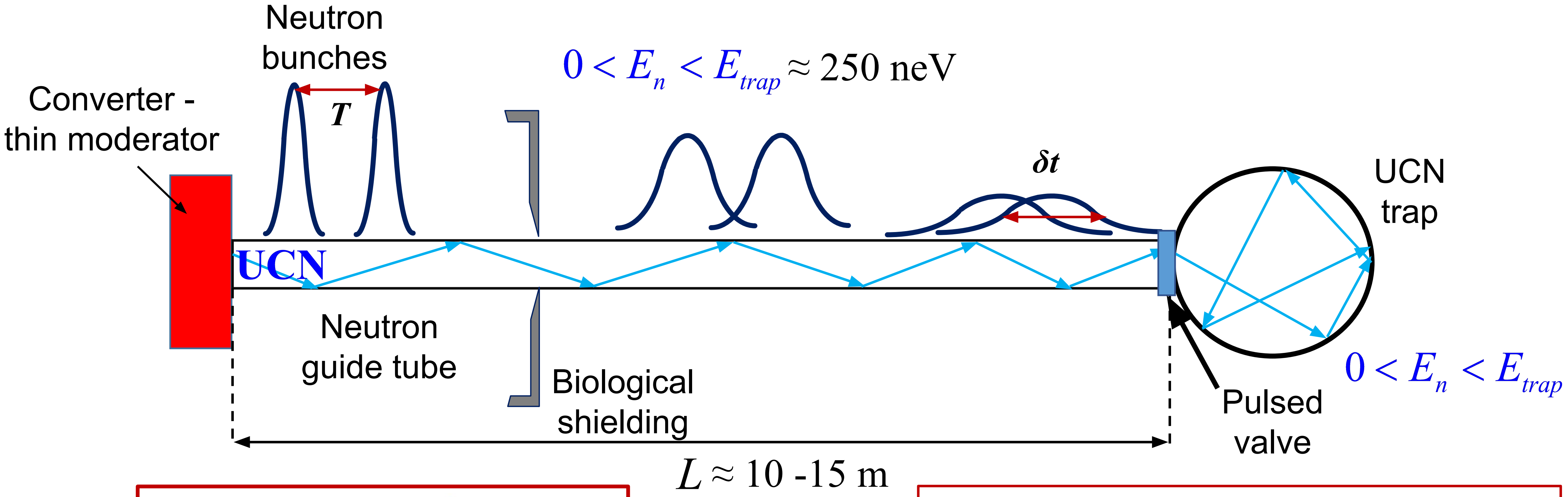
S - converter area
Σ - area of the trap surface
μ - probability of the UCN lost

$g \rightarrow 10^2 \div 10^3$ (ideal case)

F.L. Shapiro, PEPAN Letters, **2**, 4, 975 (1972).

Pulsed source and UCN accumulation in a trap

The problem of UCN transport



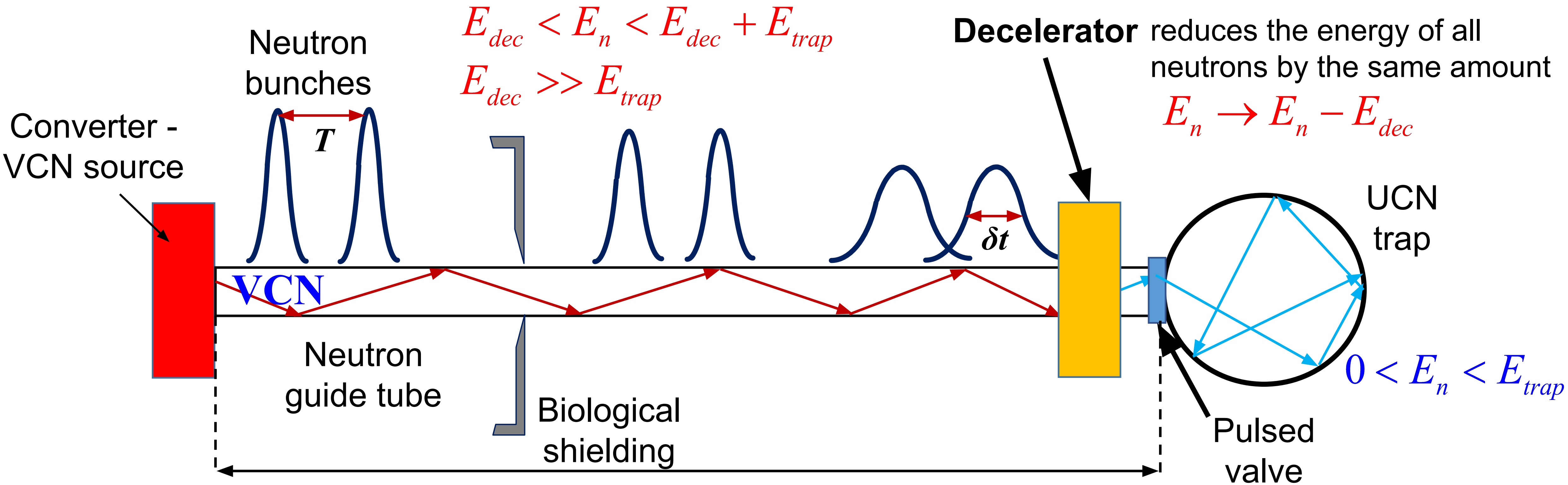
$$\delta t \approx t = \frac{L}{\sqrt{E_{trap}/(2m)}}$$

$$\delta t \gg T$$

The pulse structure of the beam **disappears** at the entrance to the trap

T - pulse repetition time, ***t*** -flight time, ***δt*** - flight time dispersion at the trap entrance

Concept of the UCN source



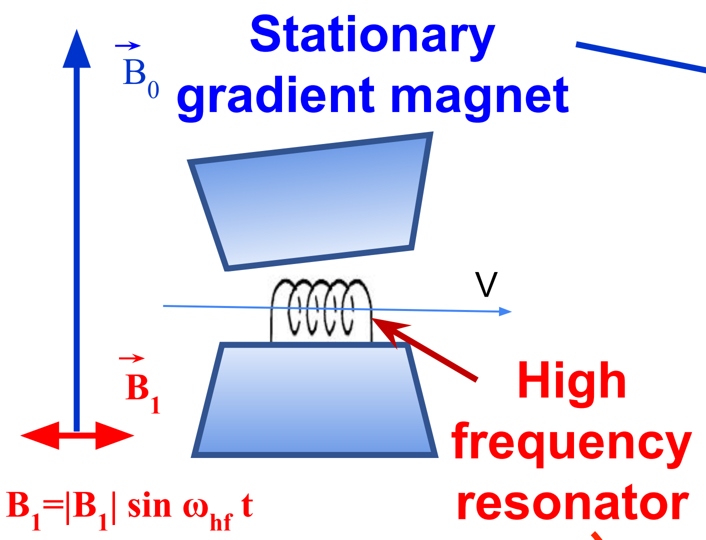
$$\frac{\delta t}{t} = \frac{\delta V}{V} = \frac{\delta E}{2E} = \frac{E_{trap}}{2E_{dec}} \ll 1$$

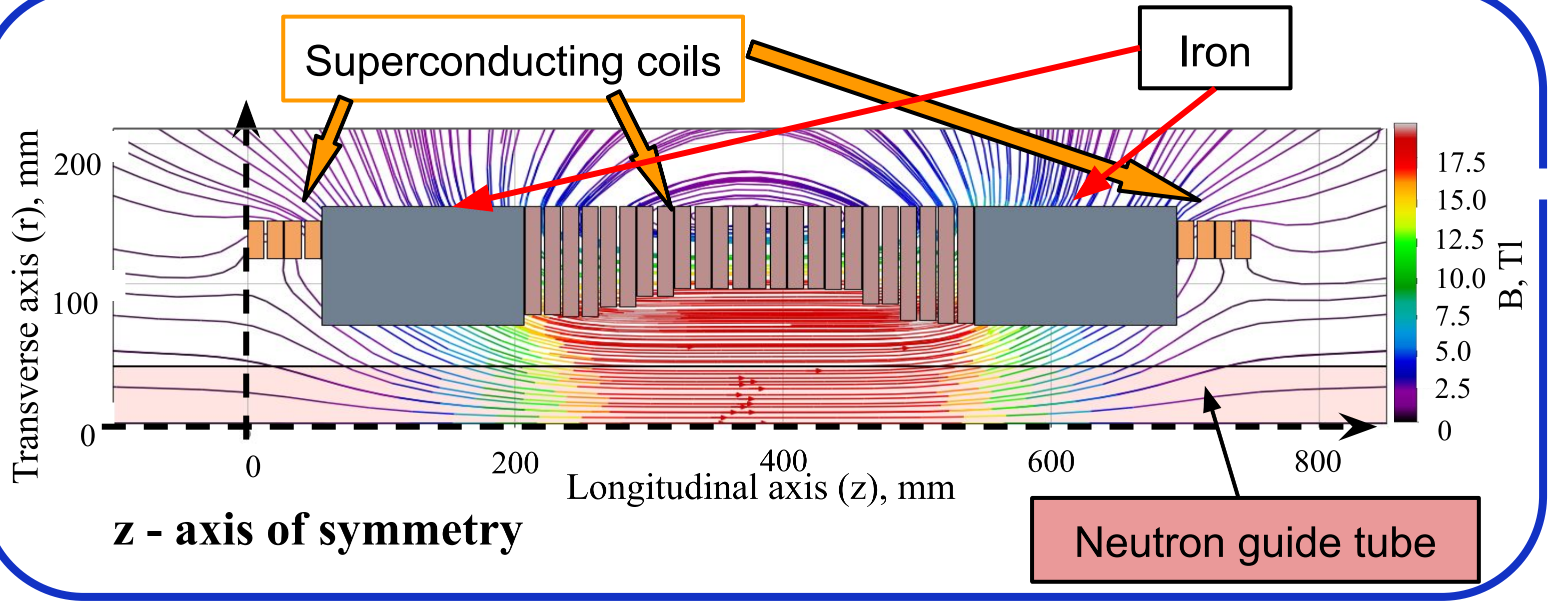
$$\delta t \ll T$$

The flux of neutrons, which can be trapped after deceleration, has a **pulsed structure**

T - pulse repetition time, ***t*** -flight time, ***δt*** - flight time dispersion at the trap entrance

Decelerator – gradient (adiabatic) spin flipper



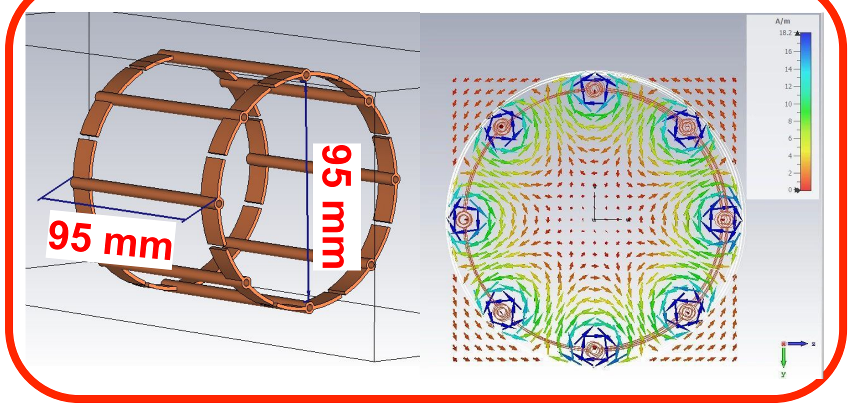


$\Delta E = \hbar\omega_{hf} = 2\mu B_{res}$
$\Delta E \gg E_{trap}/2$

$E_{trap} \approx 250$ nEv
$\Delta E \approx 2500$ nEv

$\Rightarrow$

$B_{res} \approx 18\text{-}20$ Tl
$B_1 \approx 0.7$ mTl
$f_{hf} = \omega_{hf}/(2\pi)$
≈ 600 MHz

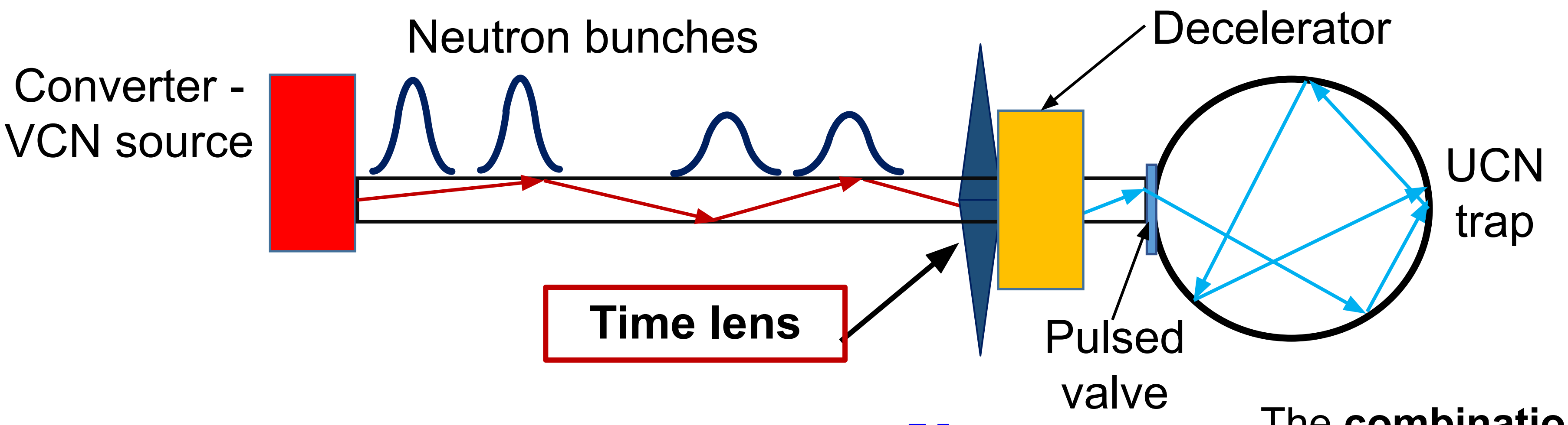


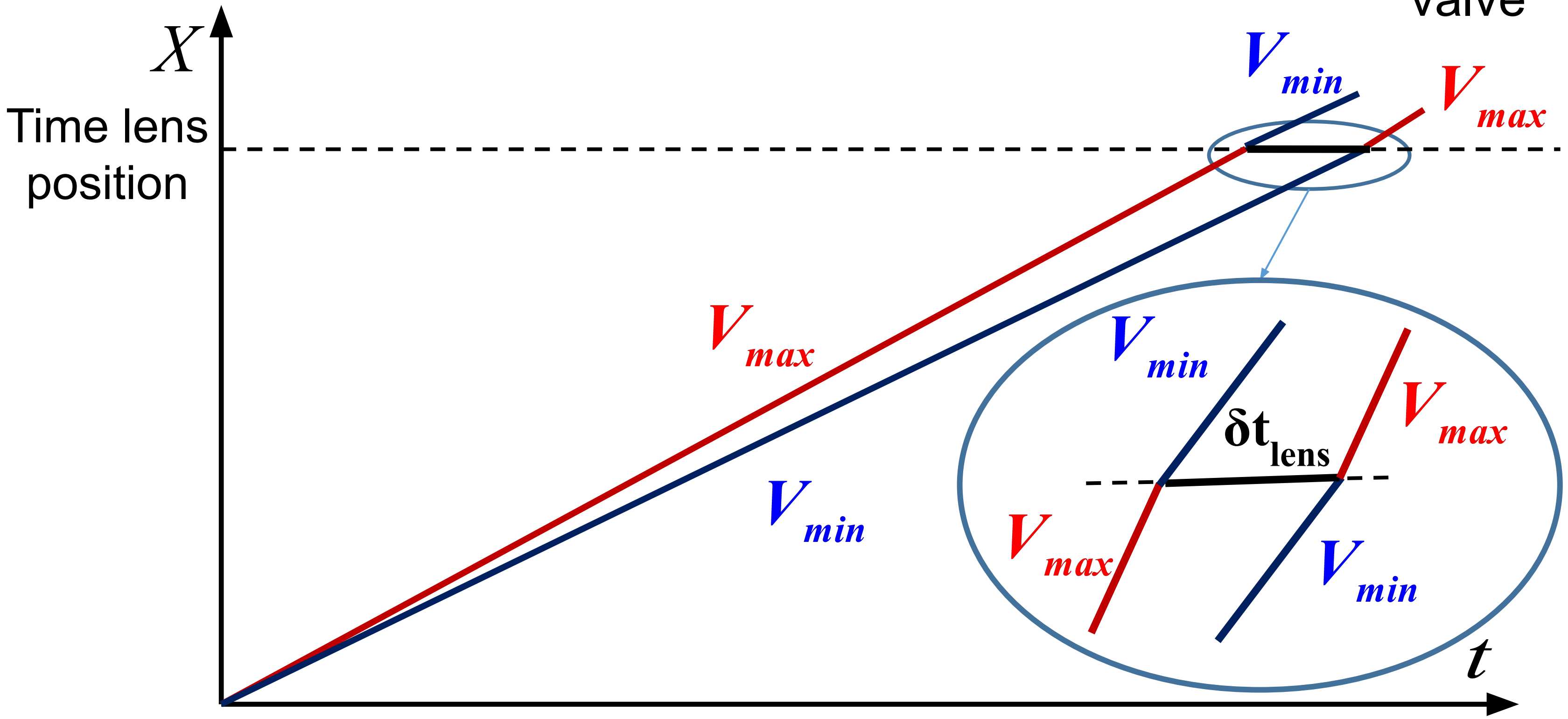
The problem of the deceleration time dispersion!

The **deceleration time** depends on the **neutron initial velocity**

V.I. Luschikov, Yu.V.Taran. NIM 228 (1984) 159
A.N. Bazhenov, V.M . Lobashev, A.N. Pirozhkov and V.N. Slusar. NIM A332 (1984) 534
S .V. Grigoriev, A.I. Okorokov, V.V. Runov. NIM A384 (1997) 451

Time lens





The **combination** of the *time lens* and the *decelerator* allows to minimize **bunch duration**

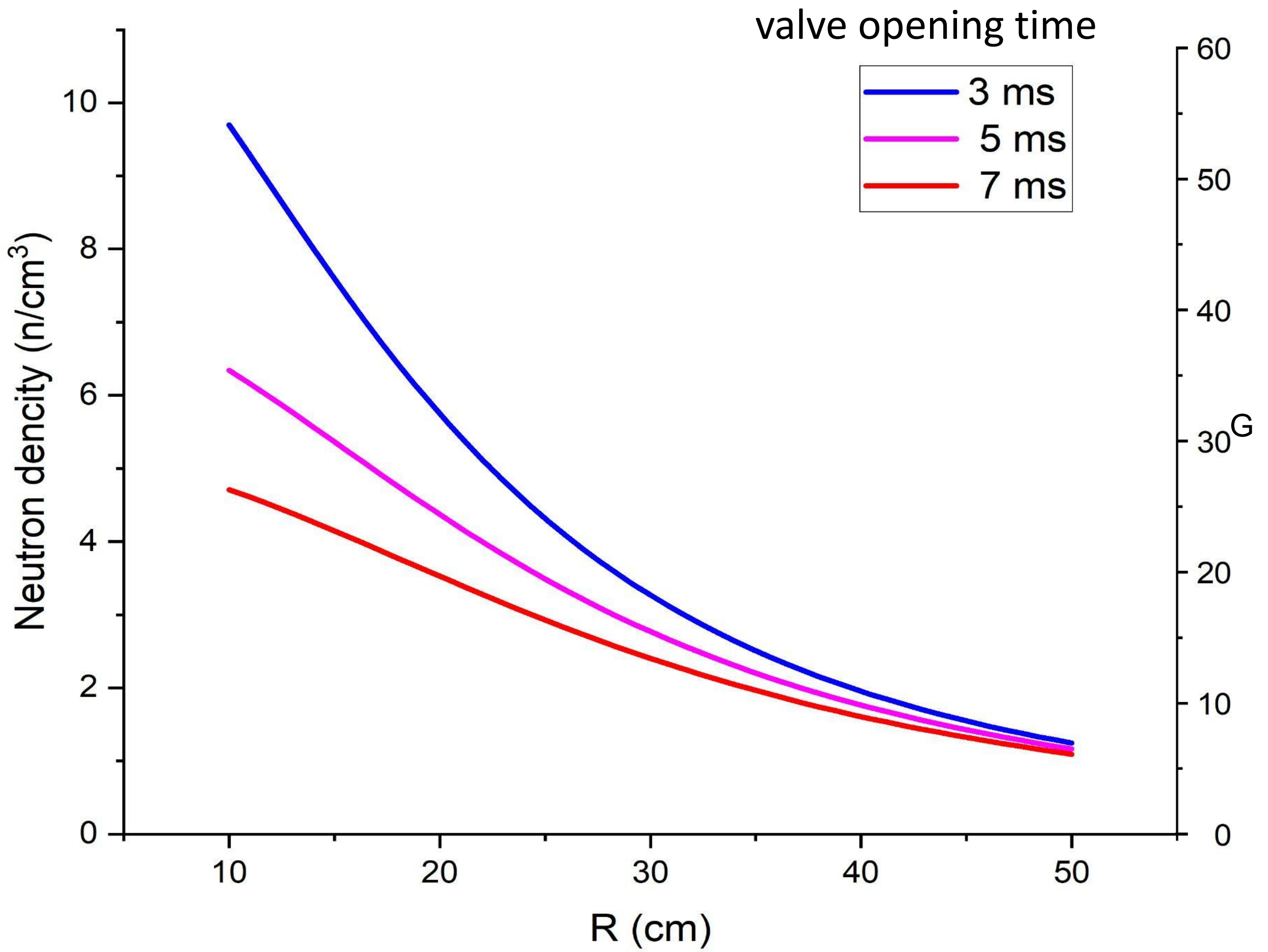
$$\delta t \approx \delta t_{dec} - \delta t_{lens}$$

$$\delta t \ll \delta t_{dec} \approx \delta t_{lens}$$

δt_{lens} - flight time dispersion

δt_{dec} - deceleration time dispersion

Neutron density in a spherical UCN trap (liquid H_2 converter)



Neutron density depending on the UCN trap radius

G is the ratio of the flux in the trap to the average flux at the trap entrance

For more effective converter, like **solid D_2**, the neutron density can be increased by **30** times

Thank you for your attention!!!

FLNP