A novel technique to increase the UCN density for J-PARC UCN source

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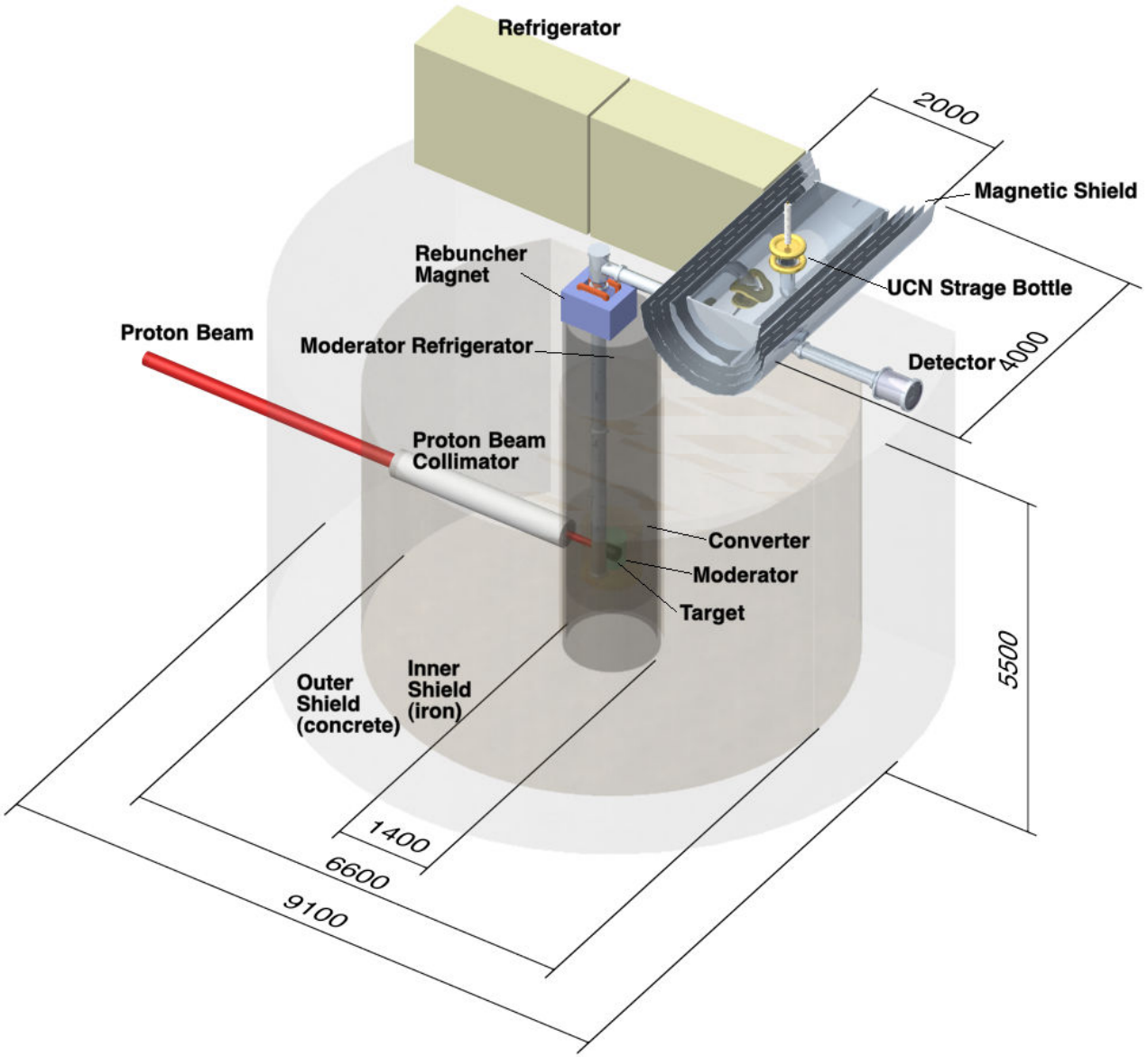
and the NOP collaboration

UCN2010 @ RCNP
International Workshop on UCN
and Fundamental Neutron Physics

Neutron Optics and Physics

J-PARC UCN Source (P33)



J-PARC UCN Source (P33)

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Spallation source and superthermal converter using sD2 for intense UCN source

CN spectrum
→ 6200 UCN/cm^3

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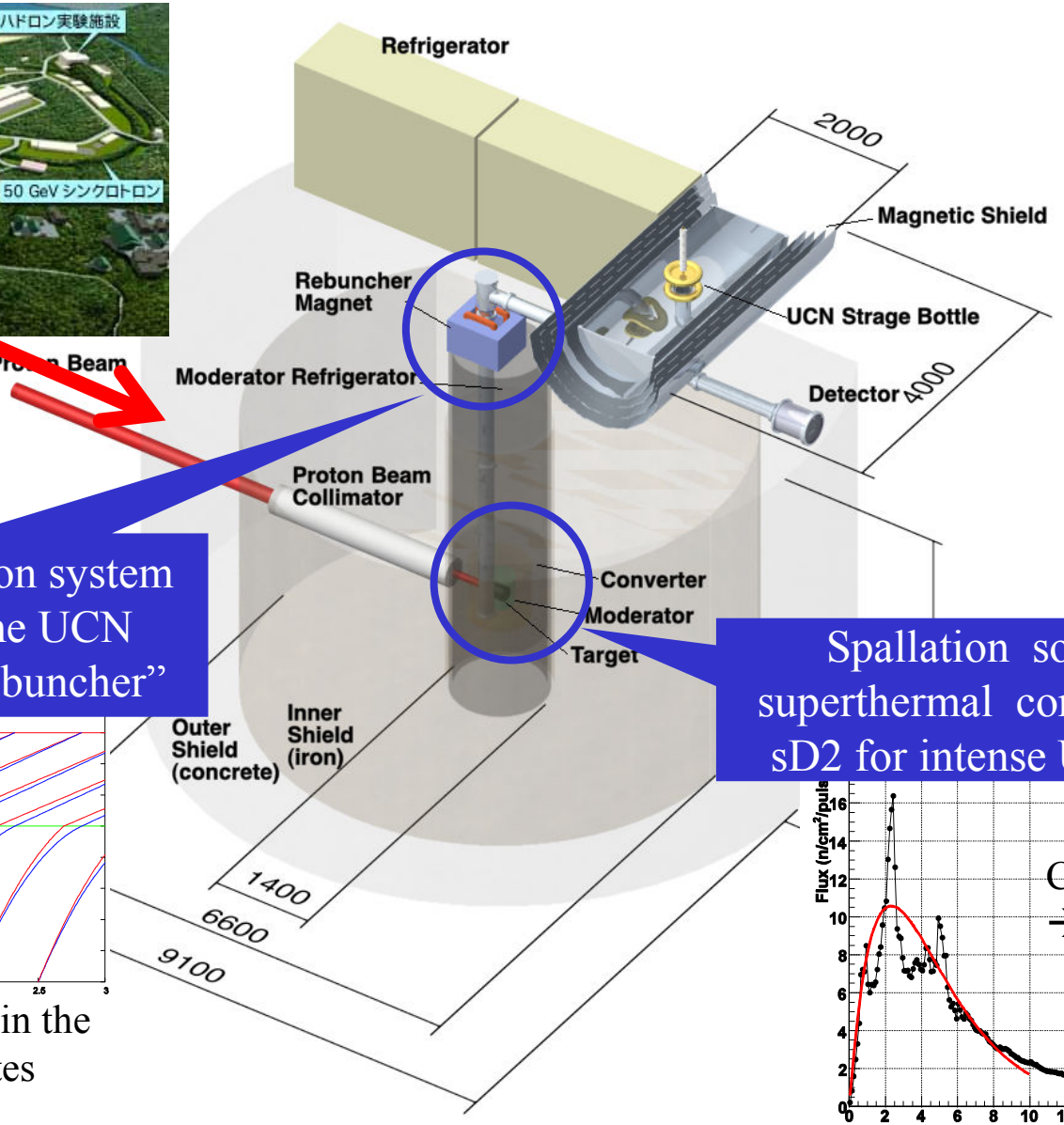
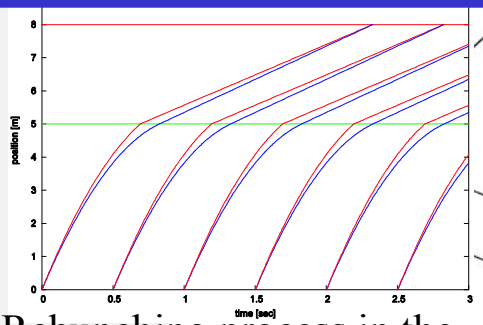


Novel transportation system for preserving the UCN density; called "rebuncher"



Rebunching process in the space-time coordinates

Spallation source and superthermal converter using sD2 for intense UCN source

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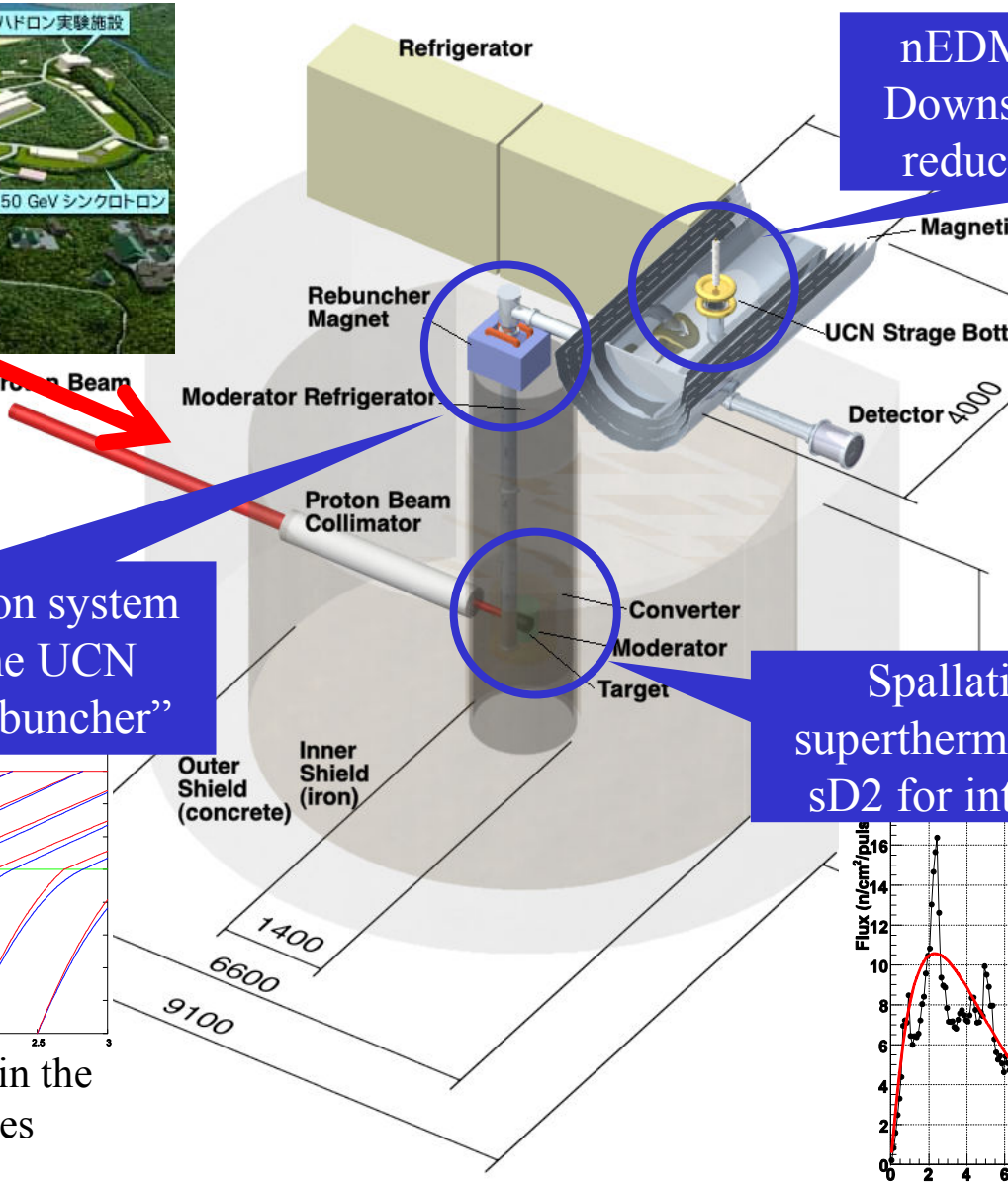
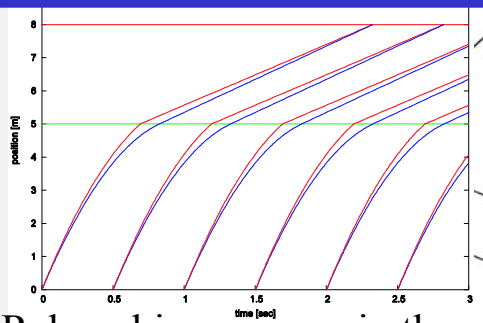
J-PARC UCN Source (P33)



nEDM measurement cell. Downsizing the volume for reducing systematic error

Deuterated Polystyren

Novel transportation system for preserving the UCN density; called "rebuncher"



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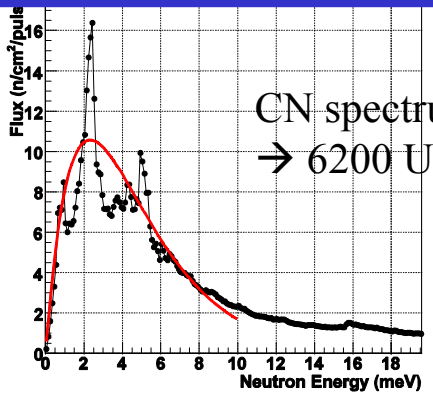


CN spectrum
→ 6200 UCN/cm^3

Production of UCN by a Pulse

By rebunching technique,

ρ_{UCN} achieves 3100 UCN/cm^3/pulse (polarized).

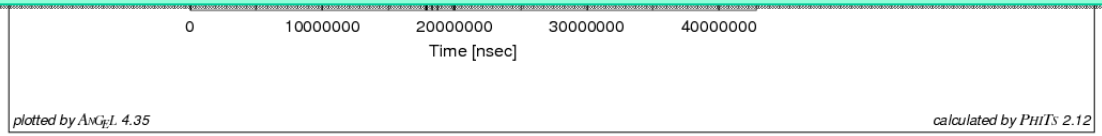
Production time is only 1.3ms.

Maximum UCN density = P × τ

Storage time τ is 140 ms in D_2 for T < 4K

100 times of multiplication is possible!!

UCN Juggler

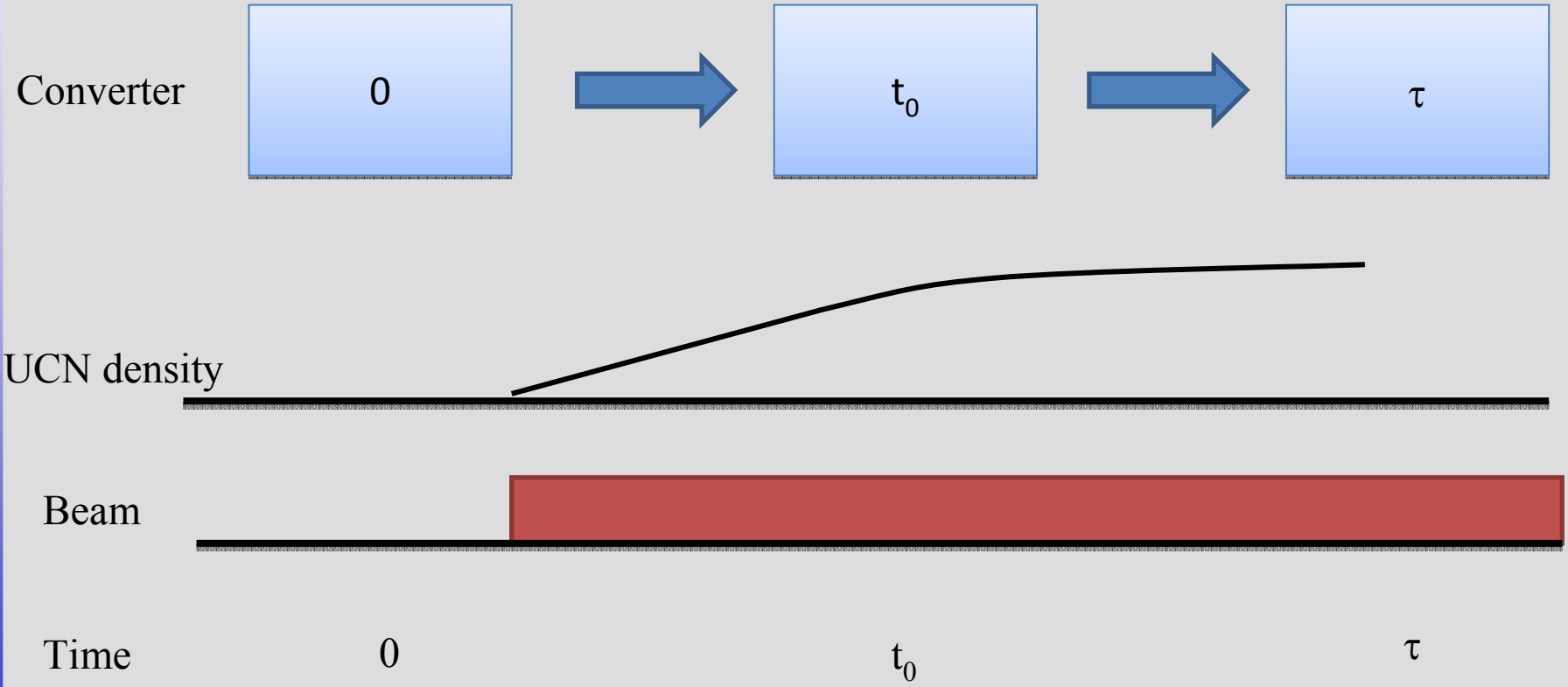


UCN Production and Storage

DC Beam

Production Rate is fixed as 1 for simplicity.

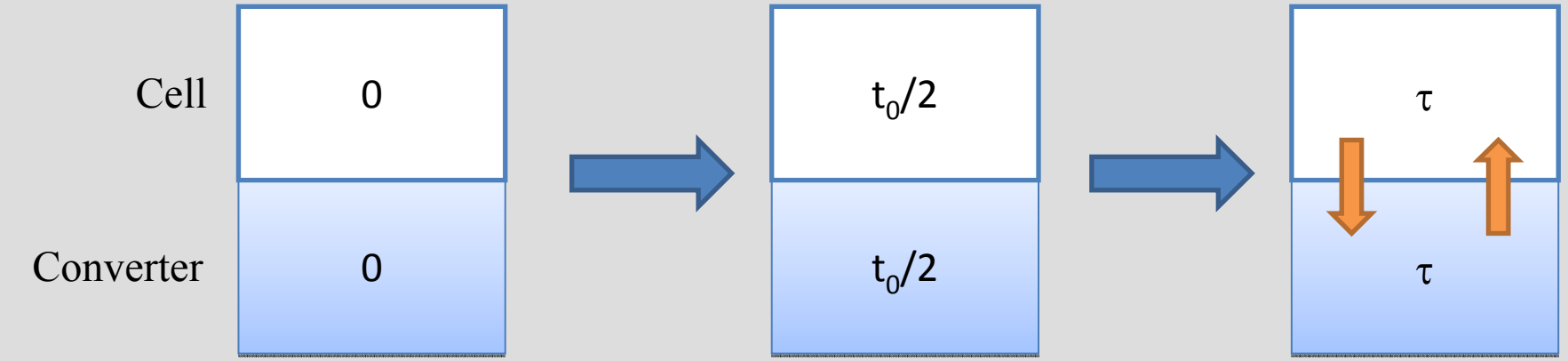
Production and loss rate
is at equilibrium condition.

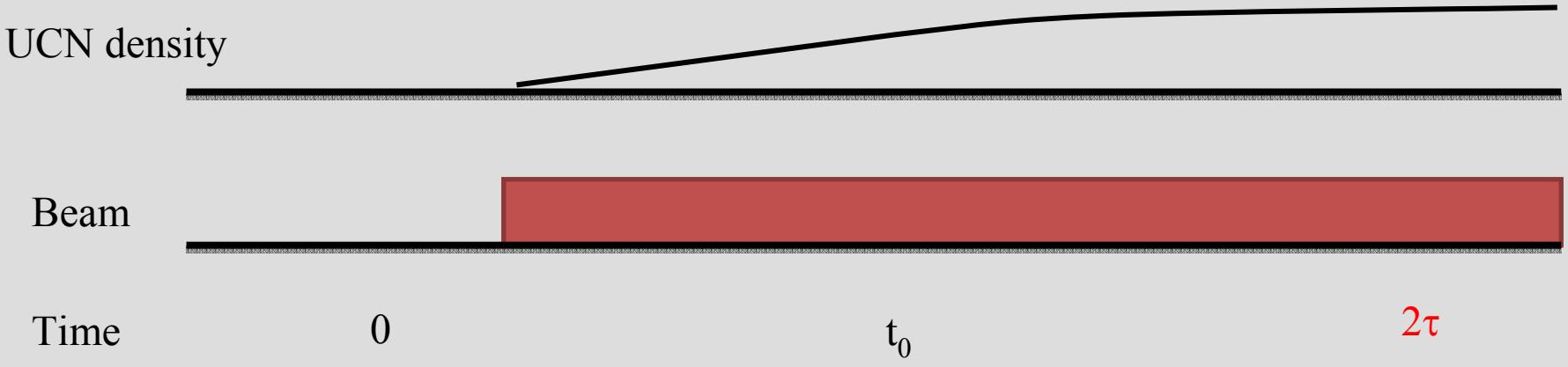


UCN Production and Storage

DC Beam with storage cell

Converter to Cell, and
Cell to Converter is
at equilibrium.

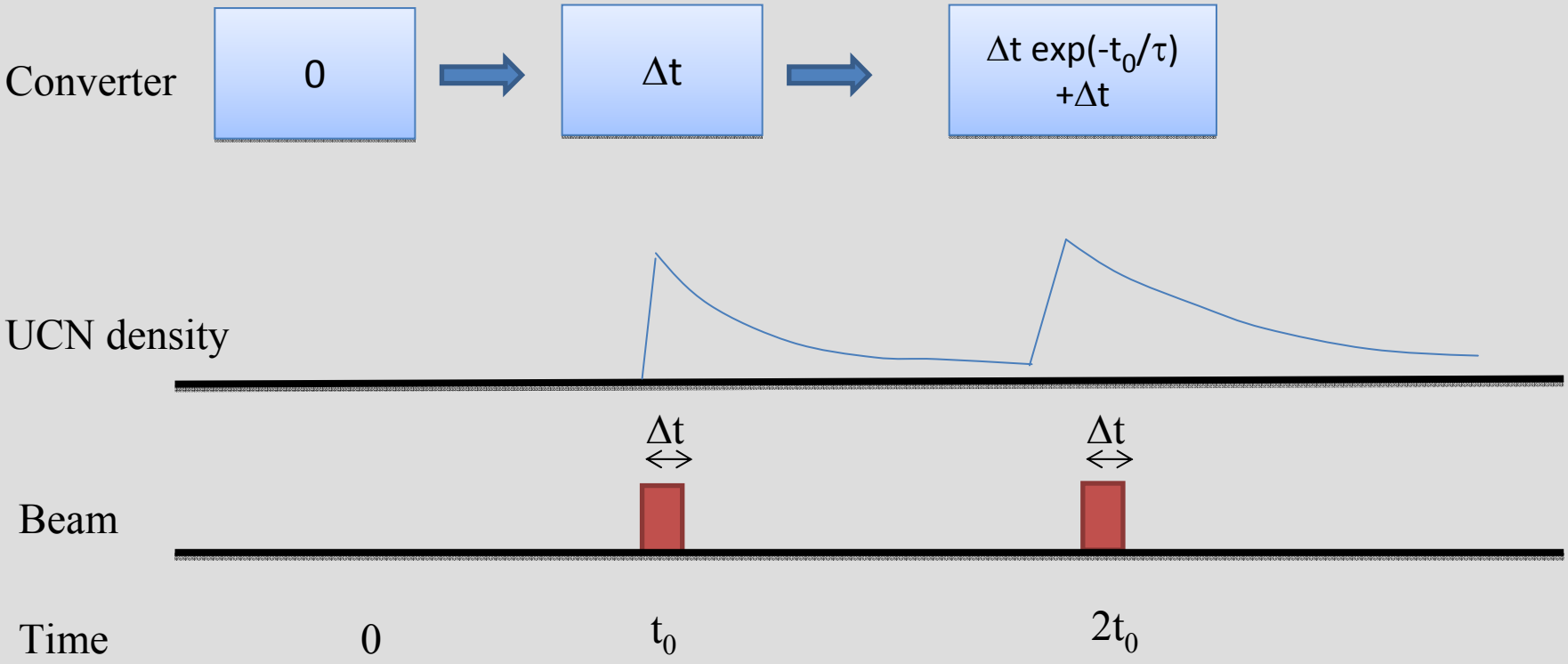




UCN Production and Storage

Pulse Beam

For D_2 converter
$\tau \sim 146$ ms
$t_0 \sim 40$ ms to 500ms
$\Delta t \sim 0.5$ ms

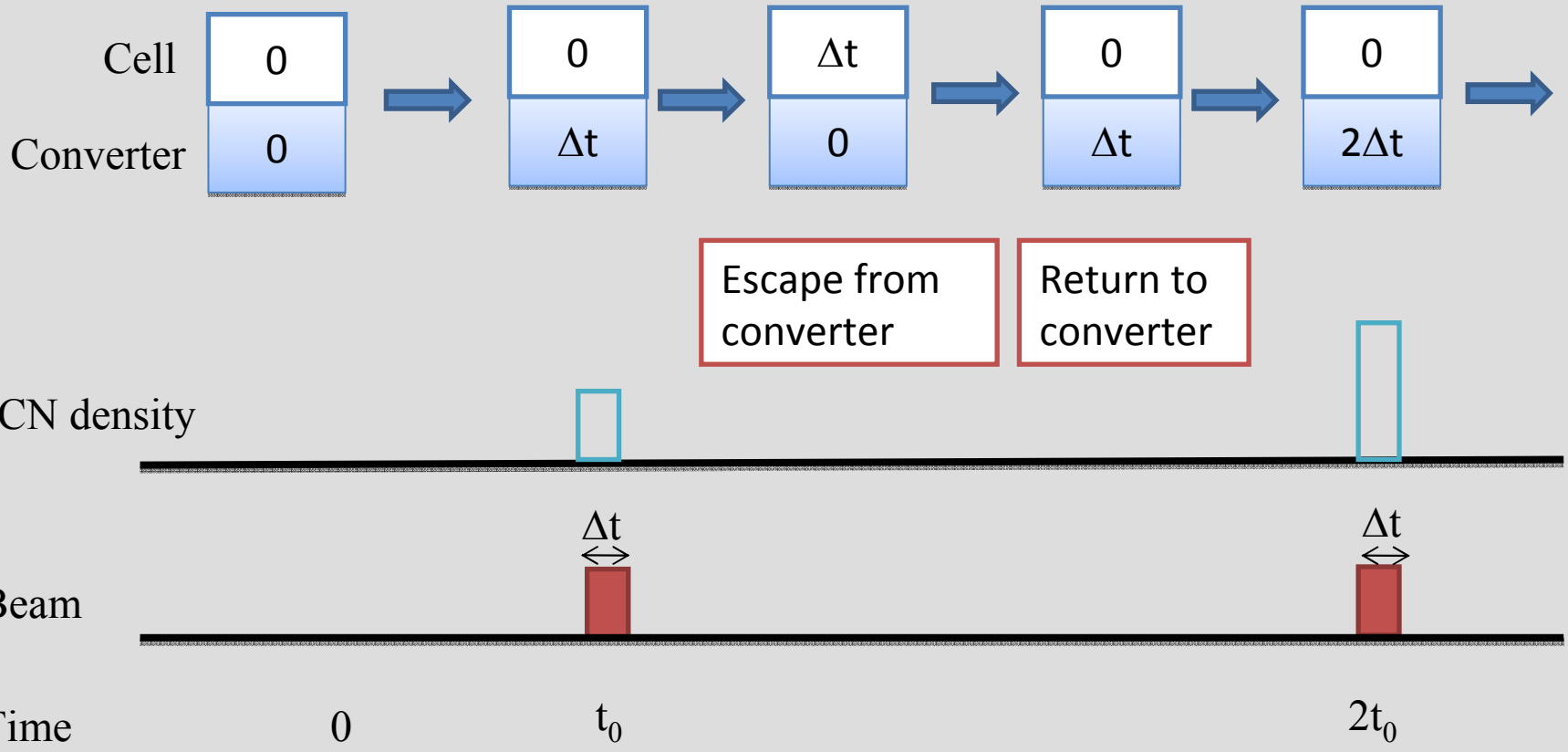


UCN density never achieve to τ

UCN Production and Storage

Pulse Beam with cell

Loss in the converter is critical.
UCN have to out of the converter until next pulse.



Finally UCN density achieve to P×τ !!

UCN Production and Storage

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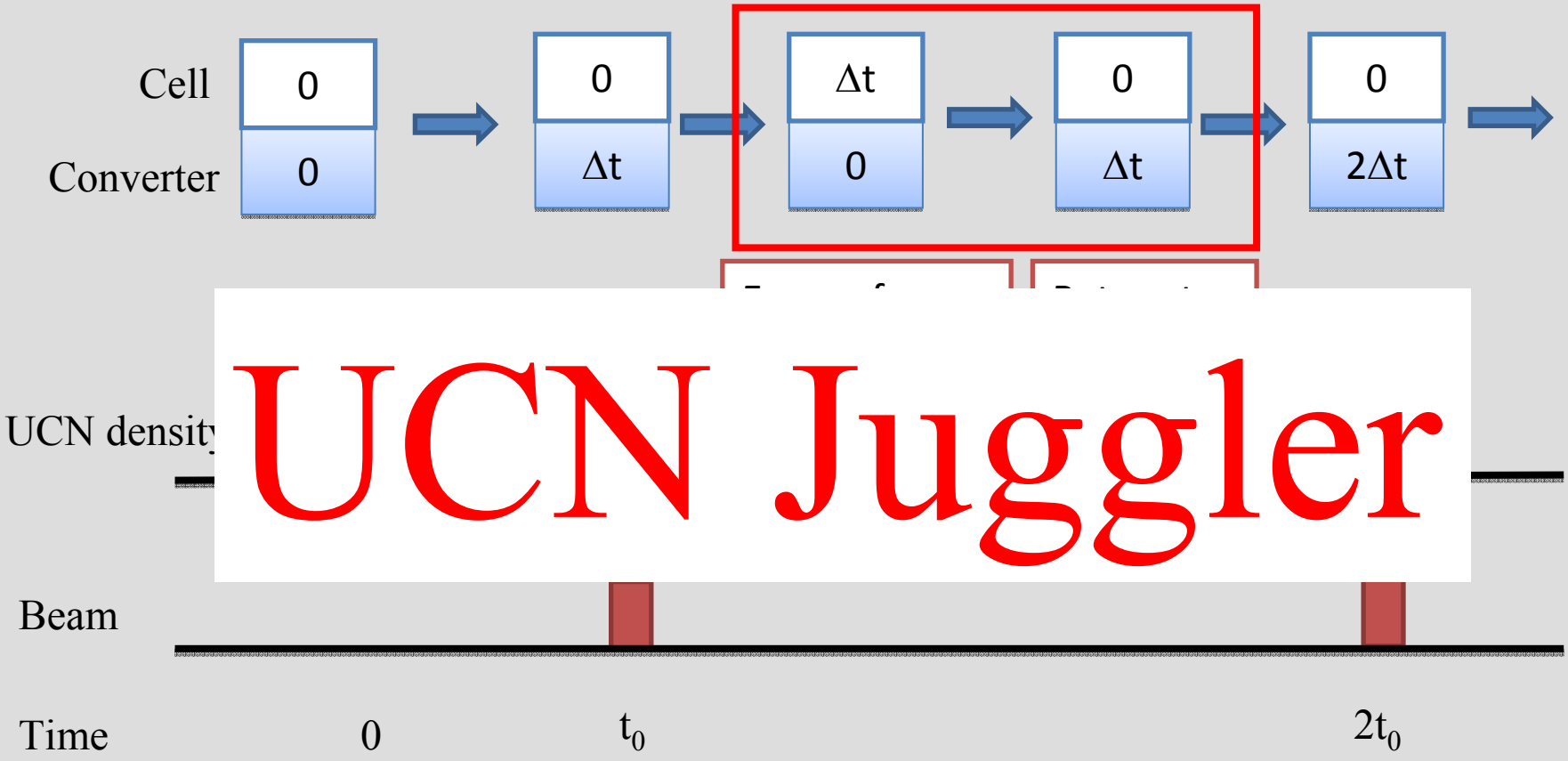
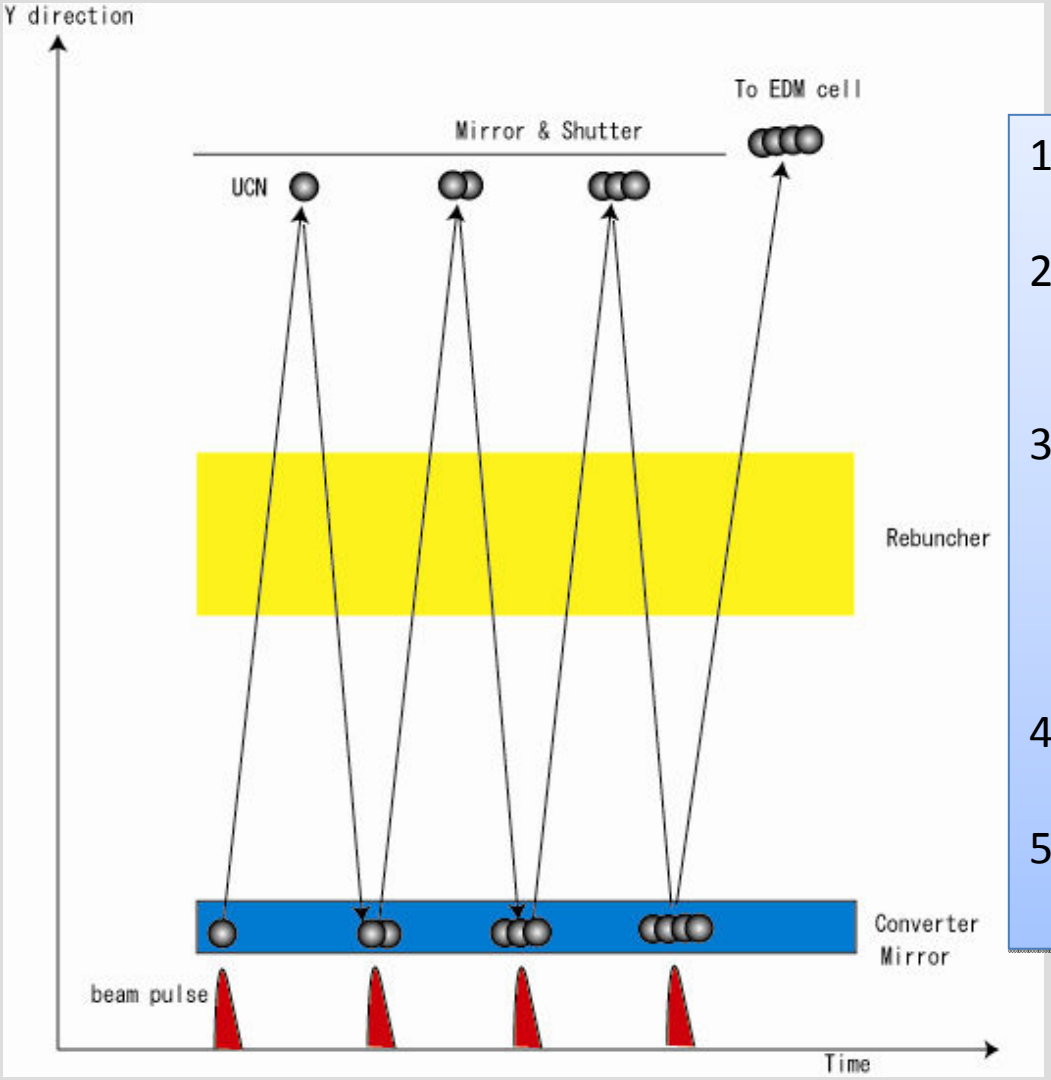


UCN Juggler

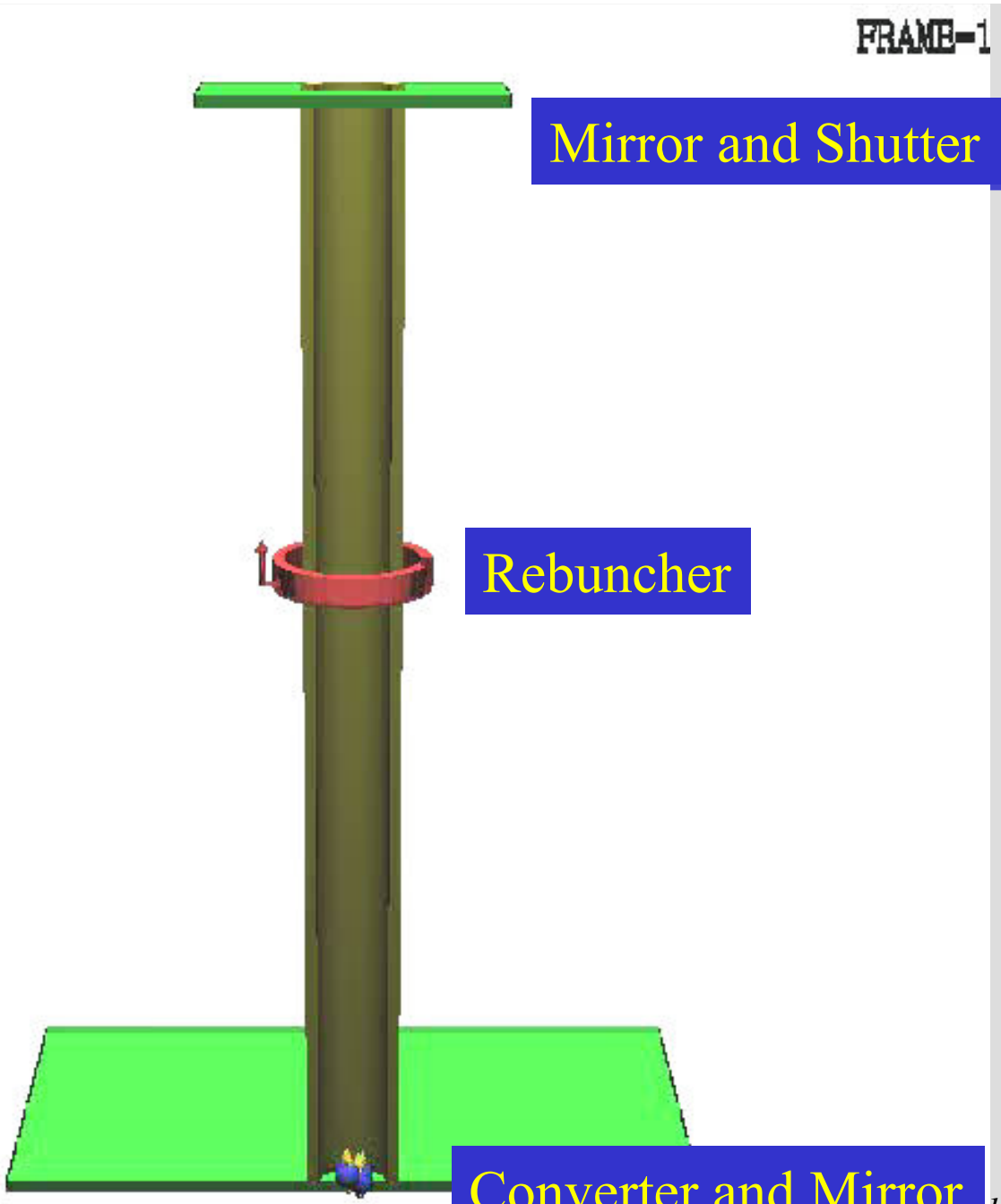
Finally UCN density achieve to P×τ !!

Possible Scheme of the UCN Juggler



1) Rebuncher focus UCN on mirror.
2) Reflected UCN focused on converter again.
3) Proton pulse synchronizes the returned UCN. Then phase space of incoming and produced UCN overlaps.
4) Repeat 1)~3)
5) Open the top mirror.

Neutron Optics and Physics


t=0000.00500s
FRAME=1
Mirror and Shutter
Rebuncher
Converter and Mirror

Some Concerns

- Spin exchange is critical; incoherent scattering of D_2, depolarization etc. (Spinless nuclei, ^{4}He, ^{16}O, or ^{208}Pb can be the candidates)

- Elastic scattering might be problem; Converter must be thinner.

- Loss of rebuncher must be less than 1%.

Ideal Maximum UCN Density (for sD2)

- By 400MeV-50mA-0.5ms (10kW) pulse,
  ρ_{UCN} = 6200 UCN/cm^3/pulse.

- Moderation time of cold neutron is 1.3 ms (FWHM).

- If UCN Juggler is ideally working, UCN density can achieve
  ρ_{UCN} = 6200 UCN/cm^3 × (146ms/1.3ms) × 1/2
  = 3.5 × 10^5 UCN/cm^3

- Note : Temperature increase is 0.15K for a pulse.

Summary

- UCN density in moderator is calculated to be 6200 UCN/cm^3/pulse. Rebuncher can transport 3100 UCN/cm^3/pulse.
- We propose new technique to increase the UCN density
  to utilize the pulse beam of J-PARC. → UCN juggler
- UCN juggler can multiply the UCN density of on pulse by 100 times.
- R&D studies will be performed by using the UCNs produced by newly constructed Doppler Shifter (Next Talk).