Neutron rebuncher for pulsed ultracold neutrons

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Neutron Optics and Physics

Contents

UCN at J-PARC

Neutron Rebuncher

Summary

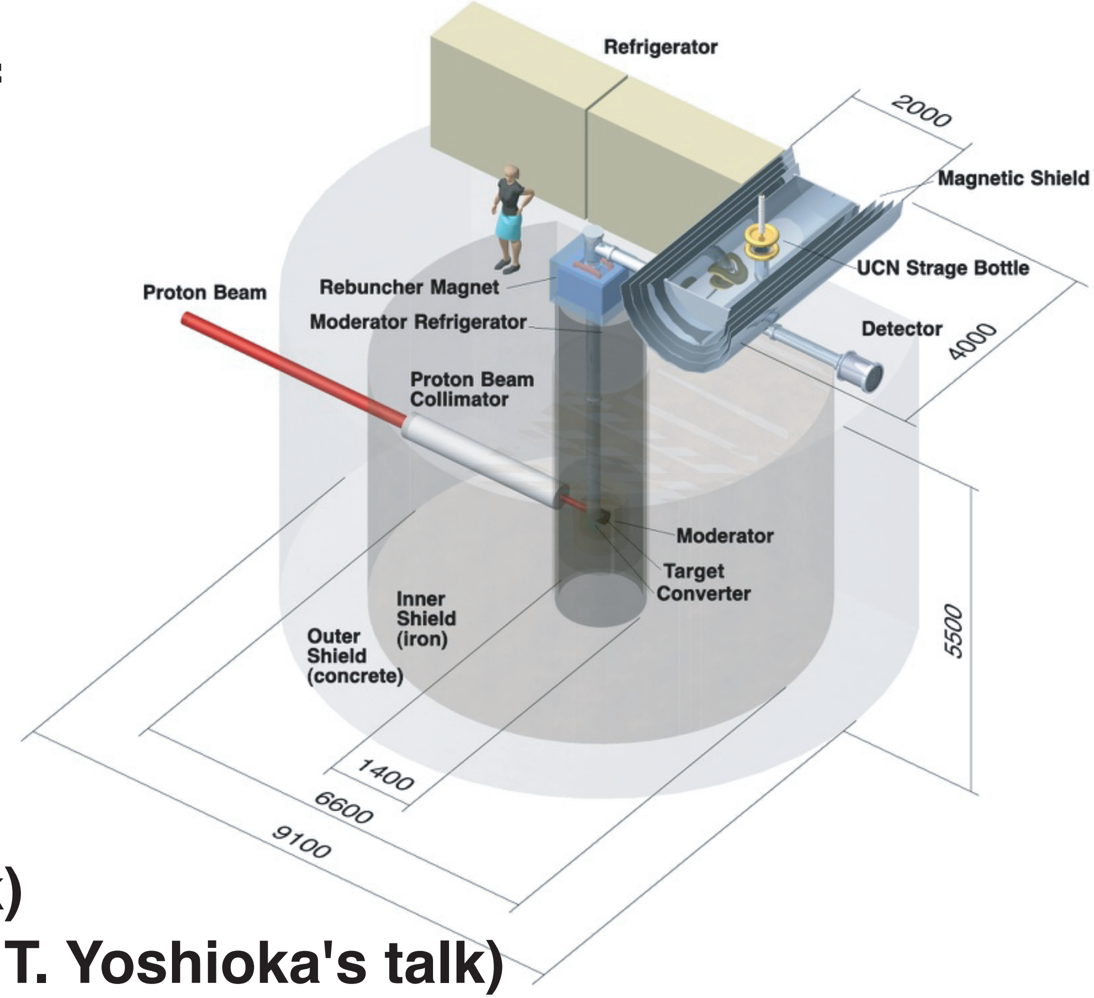
Neutron Rebuncher

UCN by using proton beam of J-PARC LINAC

Can we increase the density of pulsed ultra-cold neutron ?

Very high density is achieved at the source in the time of production by proton pulse.

Peak proton power = 20MW

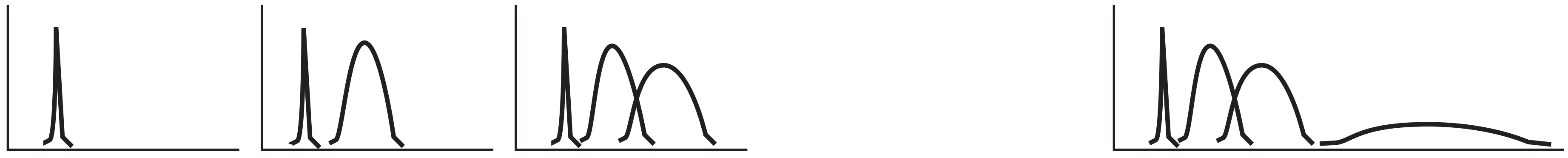


-> Neutron Condenser
= Neutron Rebuncher (this talk)
+ Neutron Juggler (tommorow T. Yoshioka's talk)
+ ...

Neutron Rebuncher

UCN by using proton beam of J-PARC LINAC

At source (converter) UCNs are produced like a pulse, however, the pulse will broaden spatially.



not different from continuous UCNs ...

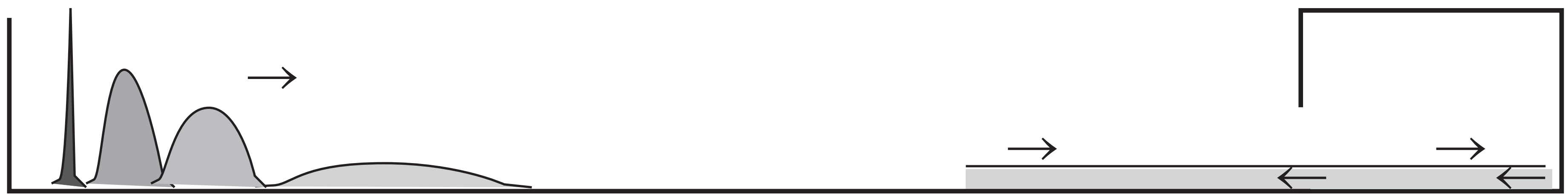
Peak proton power = 20MW

Average proton power = 250kW

We want to transport UCNs from source to storage bottle with keeping its density.

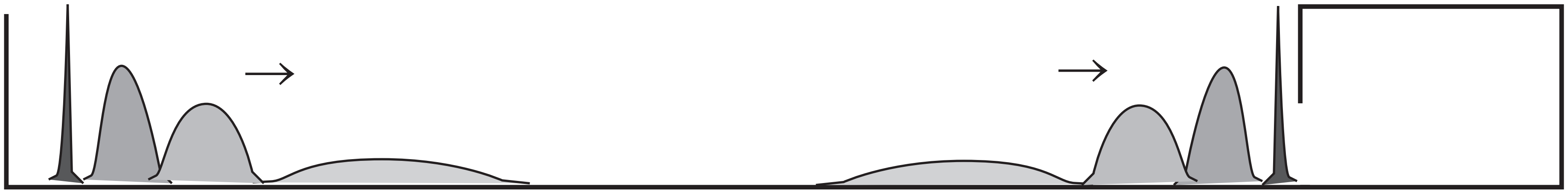
Neutron Rebuncher

While the door is open,
continuous UCNs not only come into the bottle
but also overflow from the bottle.
-> The density does not increase although keep the door open.



Neutron Rebuncher

If UCNs arrive at the door at the same time,
the door can be opened only at that moment
in order to take all UCNs into the storage bottle.
-> The density does increase with repetition of the door opening.



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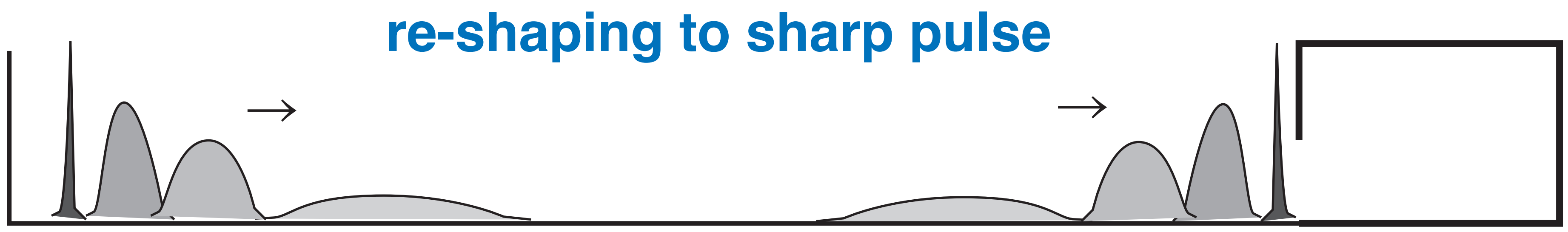

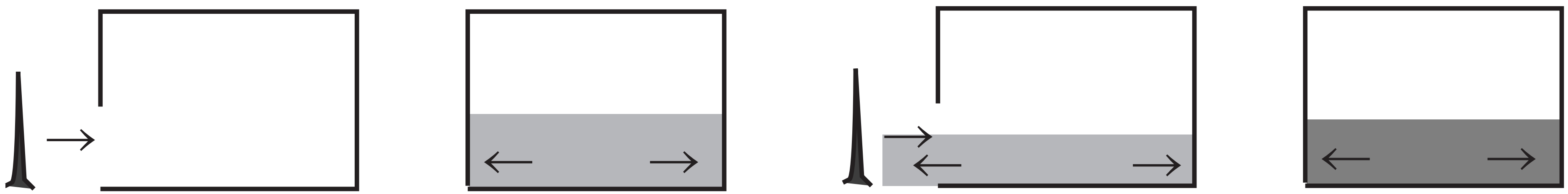

take in pulsed UCN
while door is open

the door closes,
UCNs broaden
in the bottle

take in next pulsed UCN.
some UCNs overflow,
the others stay.

the door closes,
the density increases
by the pulse

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Neutron Rebuncher

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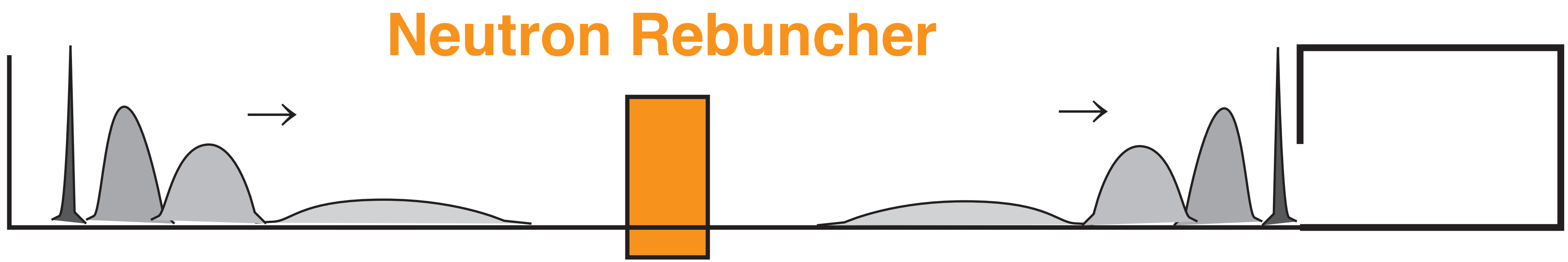

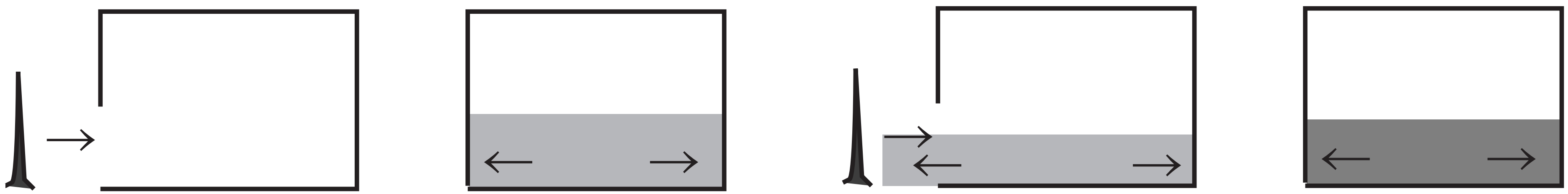

take in pulsed UCN while door is open

the door closes, UCNs broaden in the bottle

take in next pulsed UCN. some UCNs overflow, the others stay.

the door closes, the density increases by the pulse

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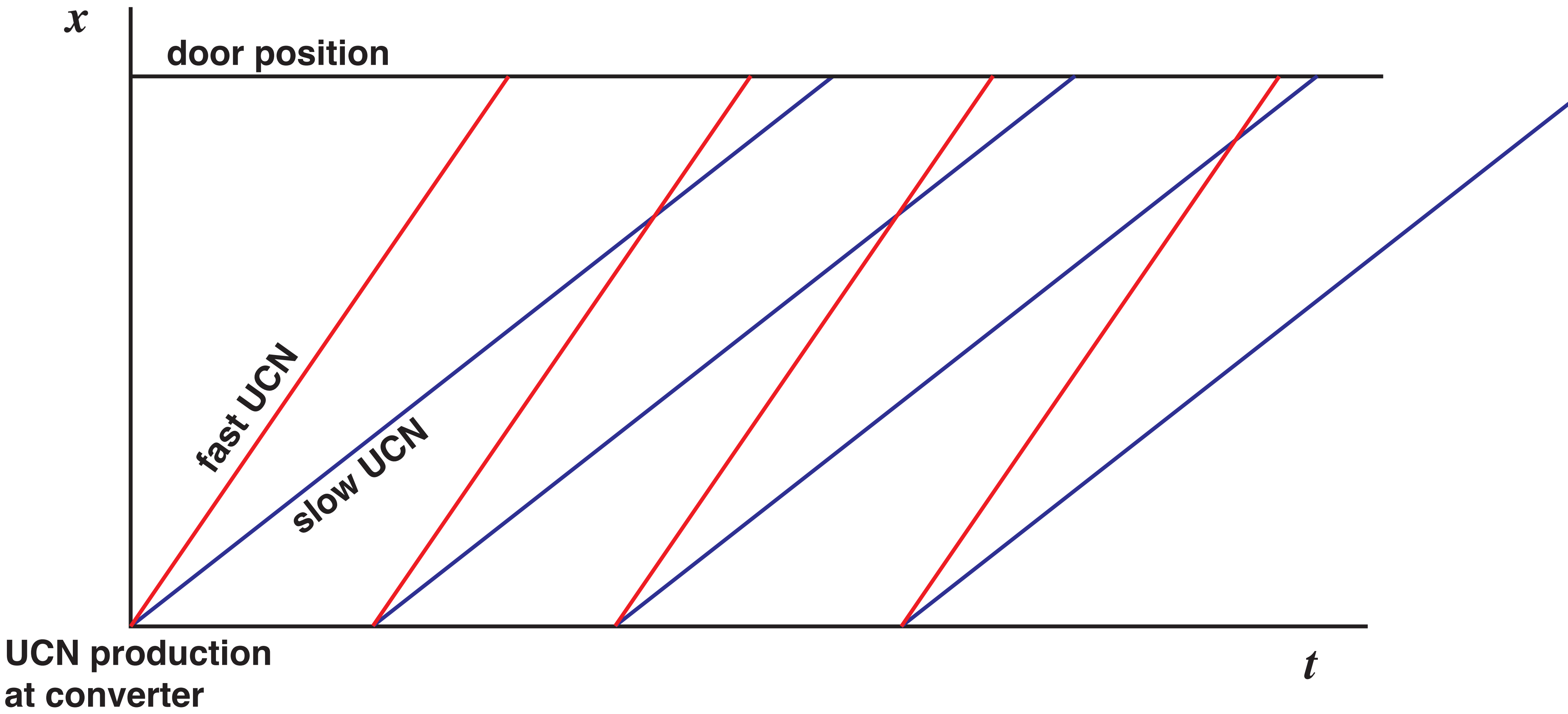
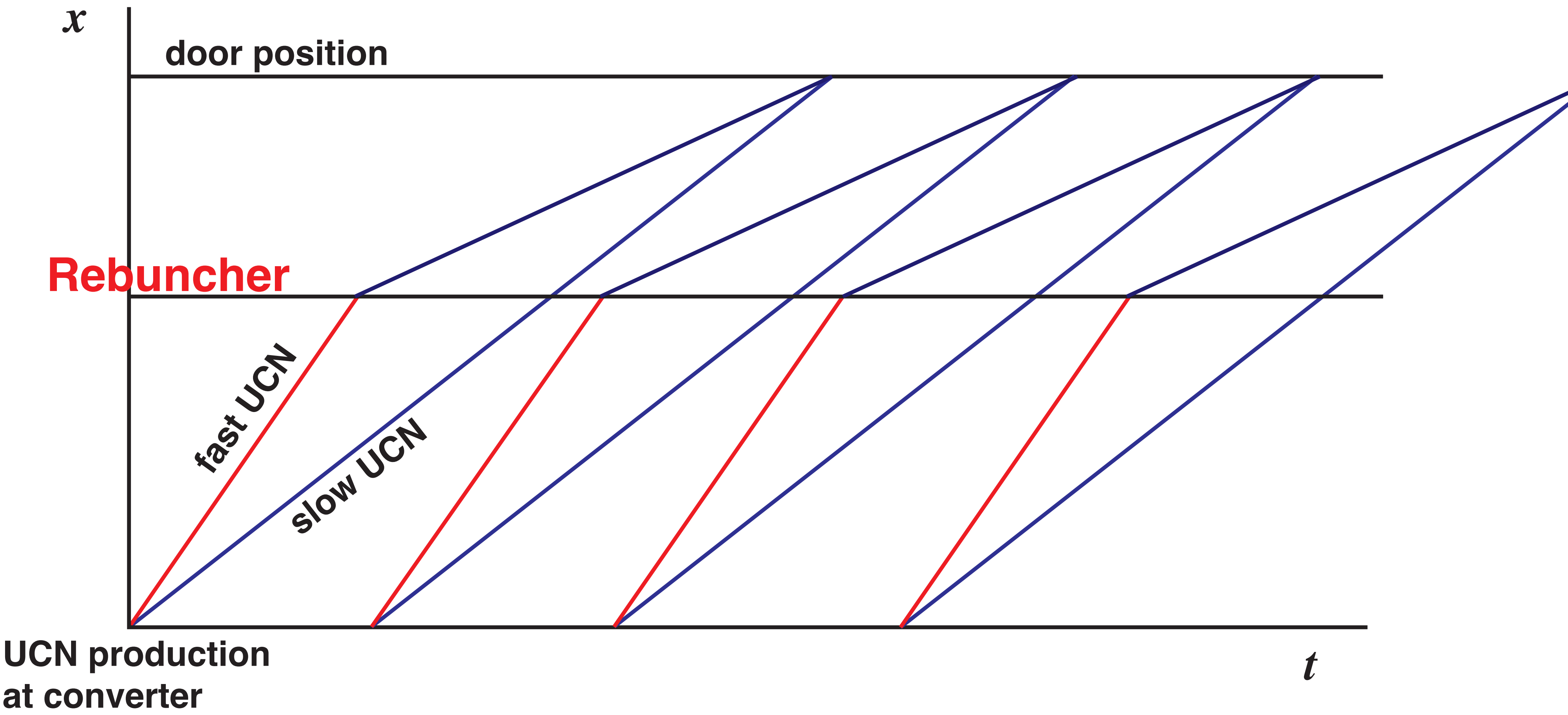
Neutron Rebuncher

Rebuncher reshapes UCNs into sharp pulse.



Neutron Rebuncher

Rebuncher reshapes UCNs into sharp pulse.



Rebuncer decelerates the UCNs according to the velocity, synchronized with time of flight in pulsed source.

Neutron Rebuncher

Rebuncer decelerates the UCNs.

The kinetic energy of neutron can be reduced with spin flip by using RF field.

Resonance spin flipper

resonance condition $2\mu B_z = \hbar\omega$

change Bz and ω with TOF

Adiabatic fast passage

resonance condition $2\mu B_z = \hbar\omega$

gradient of Bz with position
changing ω with TOF

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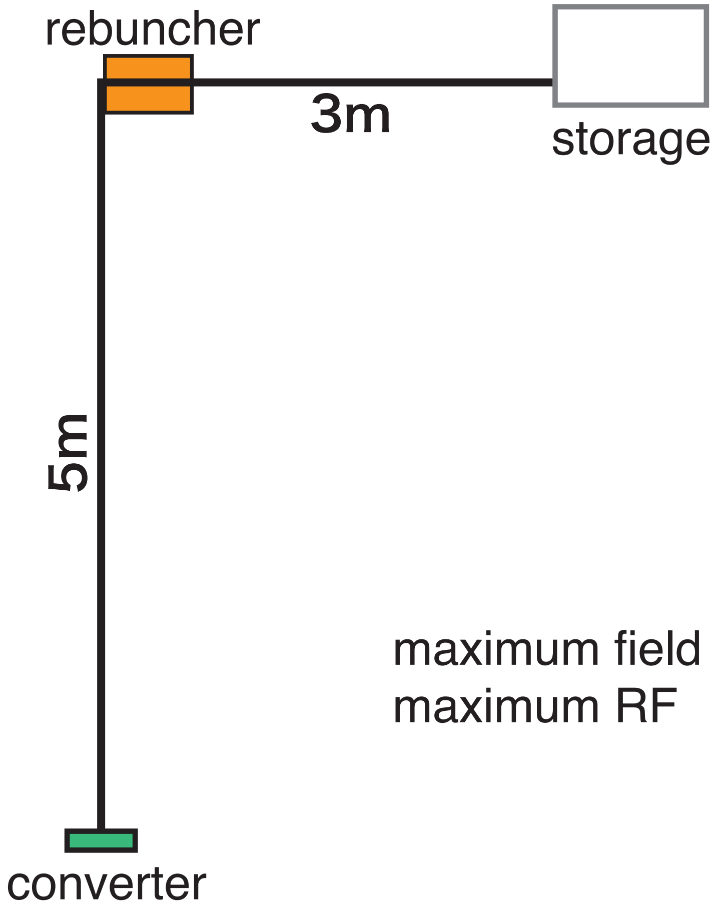
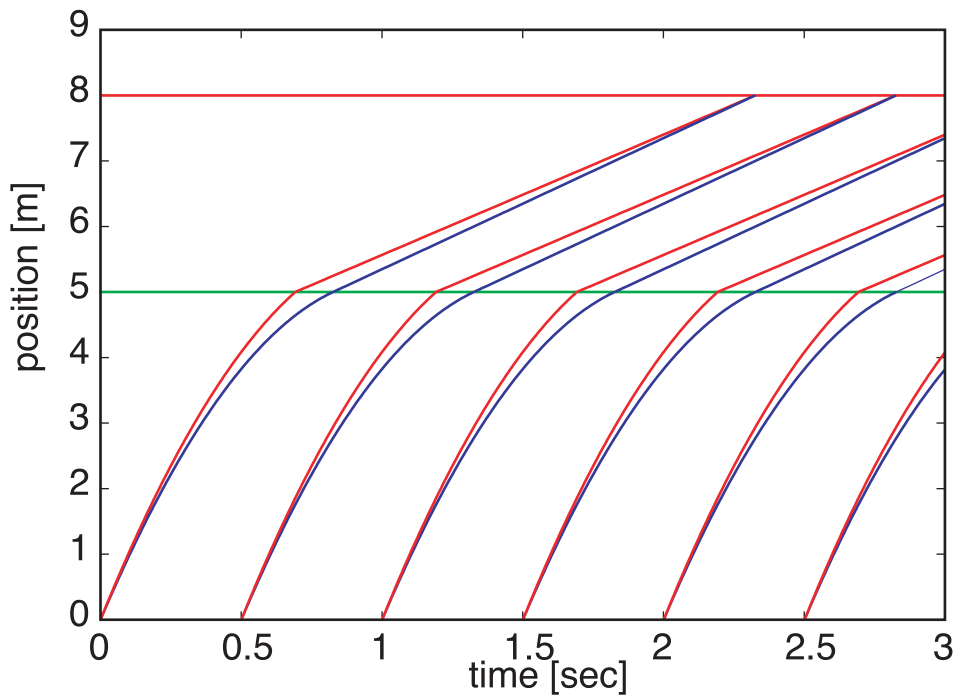
Neutron Rebuncher

(example) Resonance spin flipper



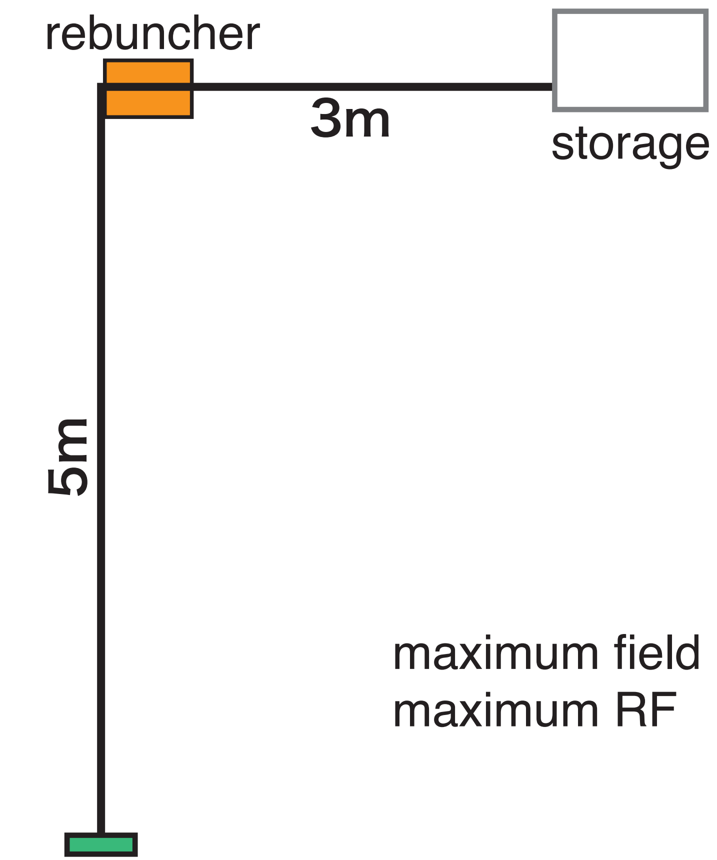


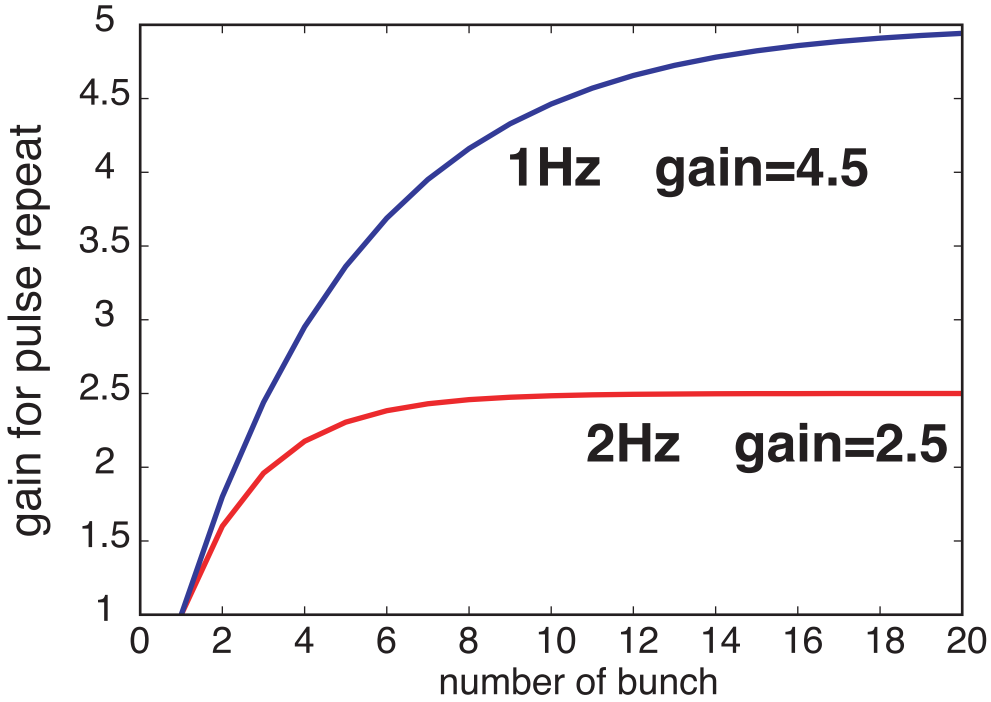
maximum field 0.49T
maximum RF 14.3MHz

initial velocity ->rebuncher->storage
10.62m/s -> 3.84m/s -> 1.84m/s
10.10m/s -> 2m/s -> 2m/s

Neutron Rebuncher

(example) Resonance spin flipper





maximum field 0.49T
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initial velocity ->rebuncher->storage
10.62m/s -> 3.84m/s -> 1.84m/s
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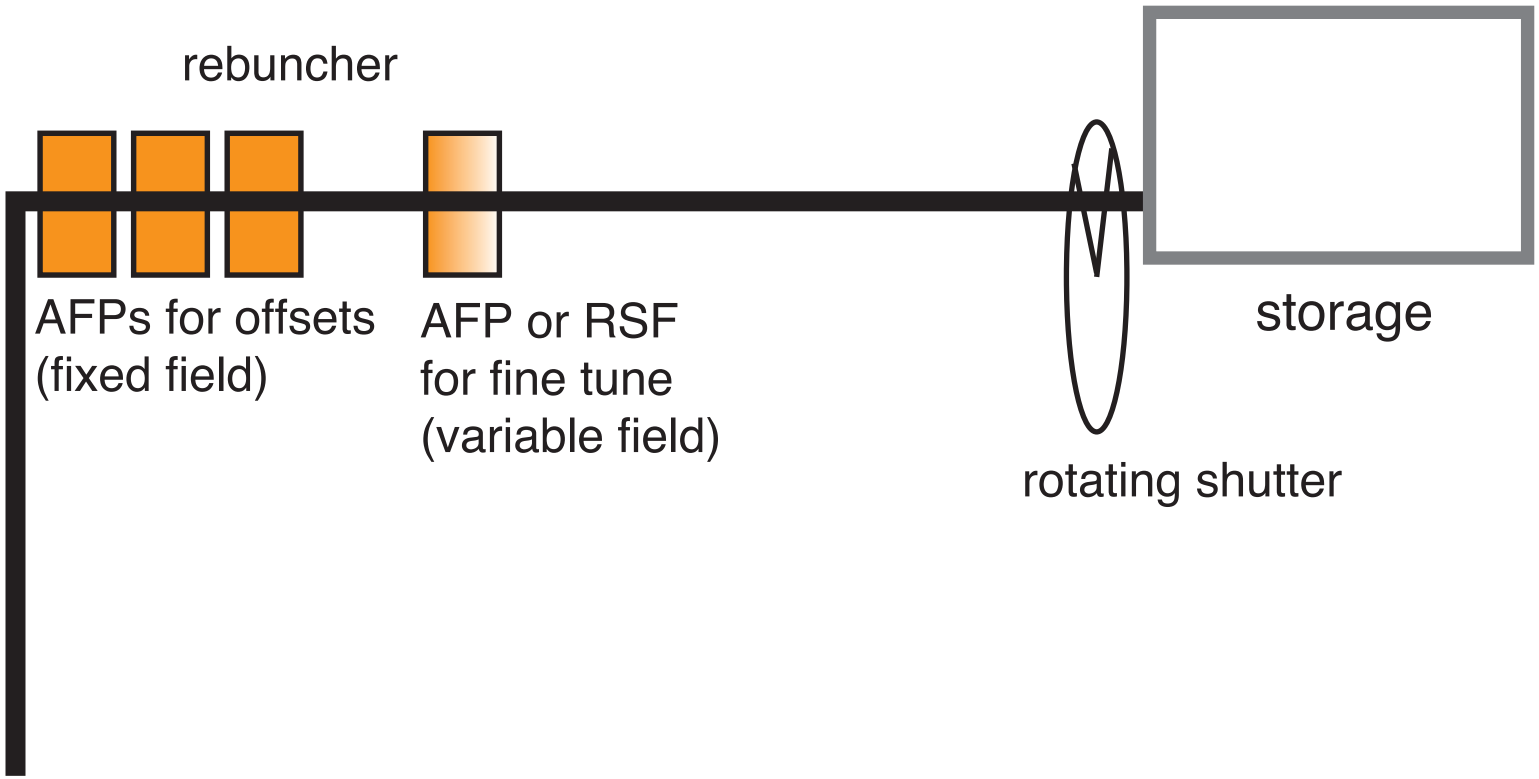
Neutron Rebuncher

combination of flippers



Total deceleration can be controlled only by switching on/off of RF field in flippers.

Summary

UCN density can be increase by using rebunching for pulsed source.

The door opens only when rebunched UCN pulse comes to reduce overflow from the storage.

The neutron rebuncher decelerates UCNs by using spin flipper with RF field.

Deceleration is synchronized with TOF for pulsed source.

Now we discuss the design of the rebuncher for J-PARC UCN.

The density can be 10 times larger than the case without rebuncher.

One more idea to storage more dense UCNs is 'Neutron Juggler'.