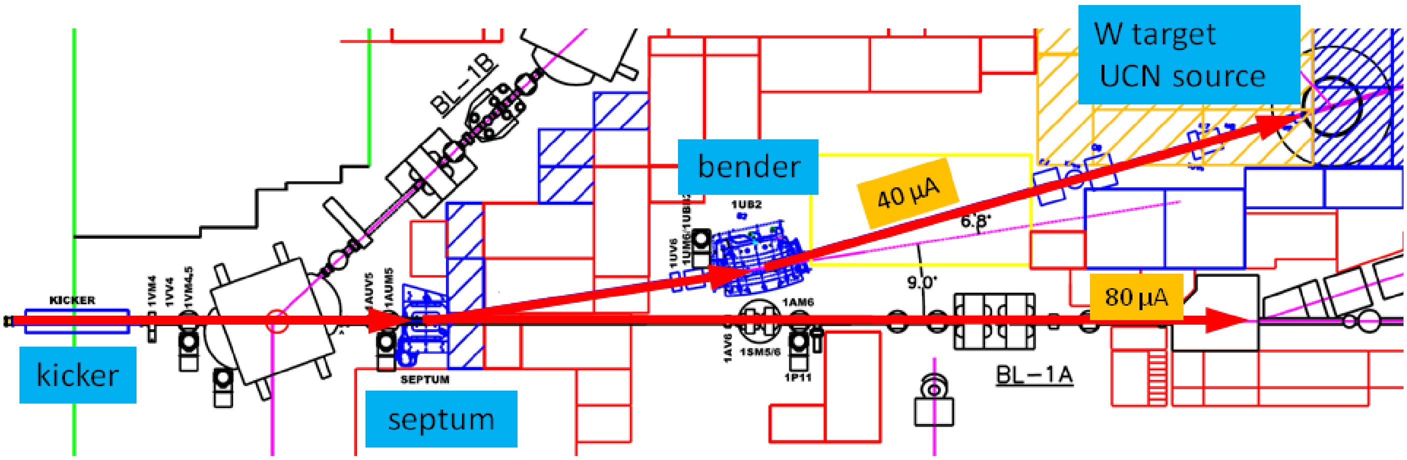
UCN Kicker Diagnostics and Control

During operation of the Ultracold Neutron Facility, beam will be shared between the existing meson hall users (beamline 1A) and the new UCN line (beamline 1U). The UCN line is designed to take up to one-third of the total current, for example 40 µA to UCN and 80 µA to the meson hall, as shown here:



The beam from the cyclotron is delivered in 1 ms "buckets" separated by shorter periods were the beam is blanked by the ion source pulser. During UCN operation the blanking interval will be required to be 50 µs or longer (normally in the range 50µs to 100 µs).

Beam sharing will be done by deflecting a certain fraction of the beam buckets to UCN. For the 2:1 split shown above, 1 bucket is deflected to UCN, 2 buckets allowed to pass undeflected, and so on.

To deflect a beam bucket to UCN, the kicker magnet ramps up during the 50 µs blanking interval, deflects the bucket to the UCN line, then ramps down again in the 50 µs following the beam bucket.

The Kicker Diagnostics and control must deliver a signal synchronized with the arrival of the beam *at the kicker.* Since the beam takes approximately 330 µs to travel from the ion source to extraction, and the time can vary by some tens of µs depending on the machine tune, it is necessary to have a suitable beam current monitor near the kicker. This is currently provided by the 1VM4 capacitive beam monitor located just downstream of the kicker (see "UCN Kicker Time Pickoff" below). The kicker control system must use the 1VM4 signal to produce a kicker trigger locked to the real beam at the kicker magnet.

It is also important to measure the amount of beam present during the blanking notch. During this time, the beam sweeps from the straight-through port of the septum magnet to the magnetic field section that deflects the beam to UCN. If any beam is present during the sweep, it will hit the steel of the septum. The slower the beam sweeps, the more will be spilled on the septum. Assuming the slowest of 50 µs for the full sweep, the beam will cross the septum steel and beam pipe wall during the time from 18 µs to 32 µs after firing the kicker. In this interval the beam current should be below 430 nA to limit the spill to 1 nA averaged over the UCN cycle (1 minute on, 3 minutes off). If the beam monitor indicates notch contamination exceeding this limit, we can blank the kicker trigger and not kick until the contamination is once again under the limit.

For good signal to noise ratio, the 430 nA limit based on long term beam spills could be be measured with several seconds of averaging. Spills large enough to cause a radiation trip of the cyclotron will be detected by the nearby TRIUMF beam spill monitors. We should also consider if the UCN current pick-off could be designed to detect such very high notch contamination quickly enough prevent a rad trip caused by errant UCN beam. It could blank the kicker and if that doesn't work, indicating some other source of the spill, either trip the cyclotron, or let the usual beam spill monitor do it. Such a system would have to be properly integrated with the standard TRIUMF safety system.

UCN Kicker Time Pickoff

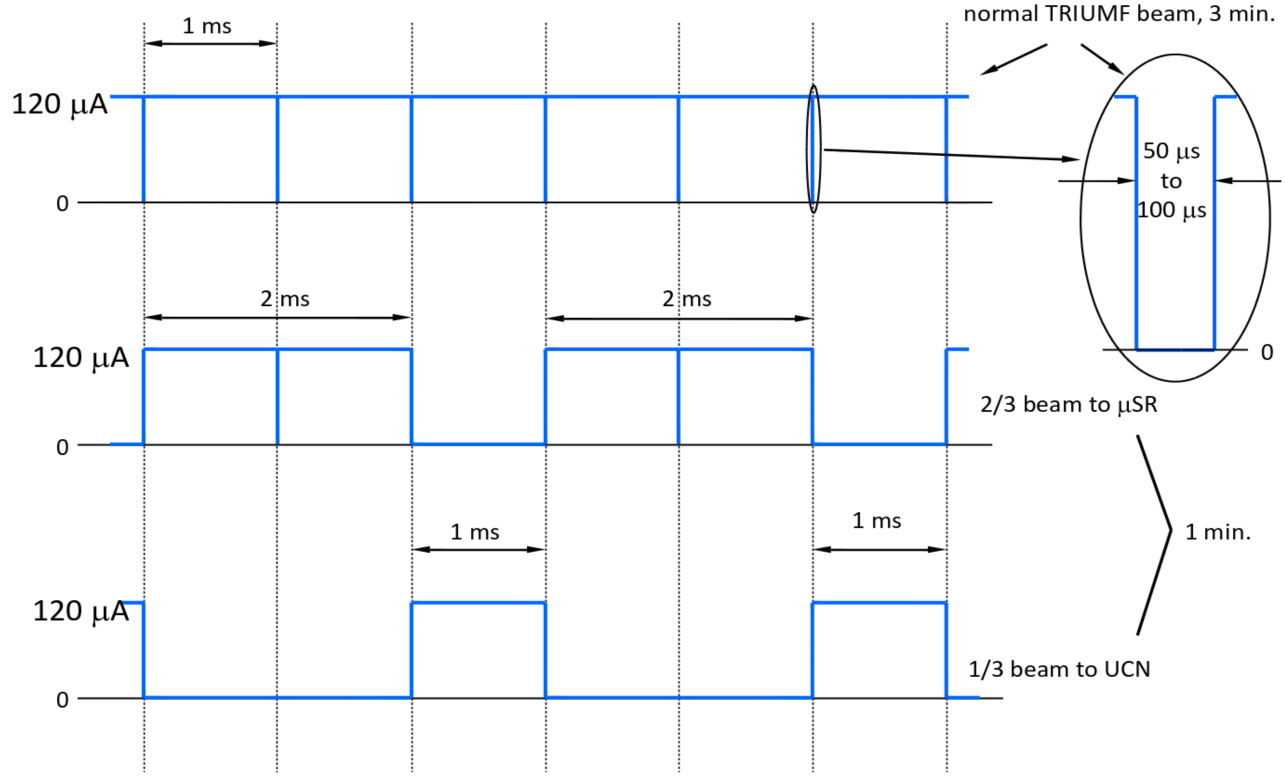
The TRIUMF beam has a microstructure of bursts a few nanoseconds wide separated by 43 nanoseconds (RF frequency 23 MHz). The time monitor is a capacitive pickoff, 1VM4, located just downstream of the kicker. The pickoff is sensitive to the 23 MHz microstructure. The raw signal is fed to a broadband preamp followed by a tuned second stage operating at the second harmonic, 46 MHz. The output of the tuned stage is a 46 MHz sine wave whose envelope follows the beam current. The bandwidth of the second stage can be adjusted to trade settling time against noise (low noise = long settling time). It is now set to settle (several 1/e time constants) in 1 µs. At this time constant, the electronic noise is 0.15 µA. The monitor and front-end electronics are already in place.

The electronics handles beam currents of 0 µA – 120 µA. The input is triax cable from the capacitive pickoff and the output is normal Coax. Leonid Kurchaninov has the details.

We have to use the signal from the time pickoff to deliver a kicker signal synchronized with the arrival of the beam at the kicker, and to prevent kicking if the contamination in the beam-off-notch is too high.

Des Ramsay
8 June 2015

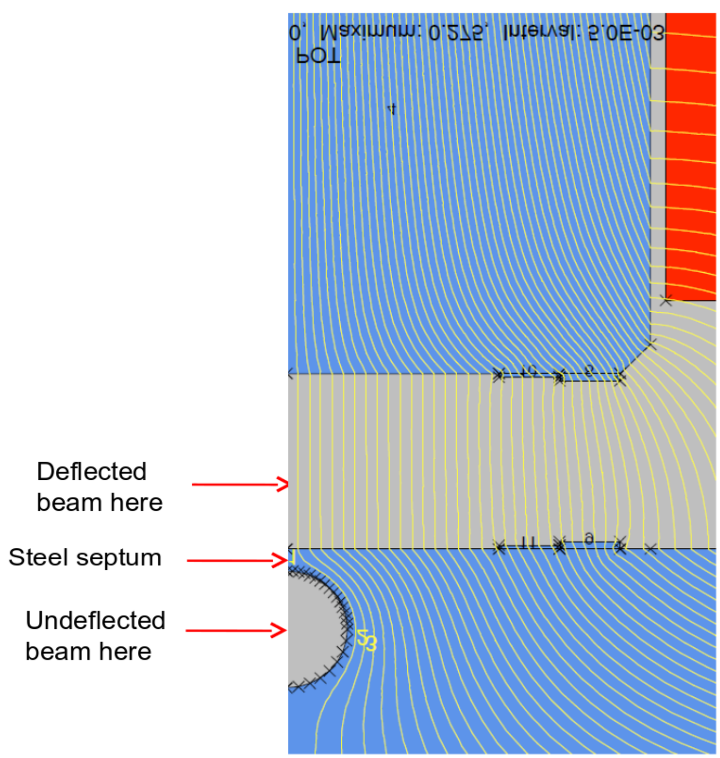
Proposed time division of beam



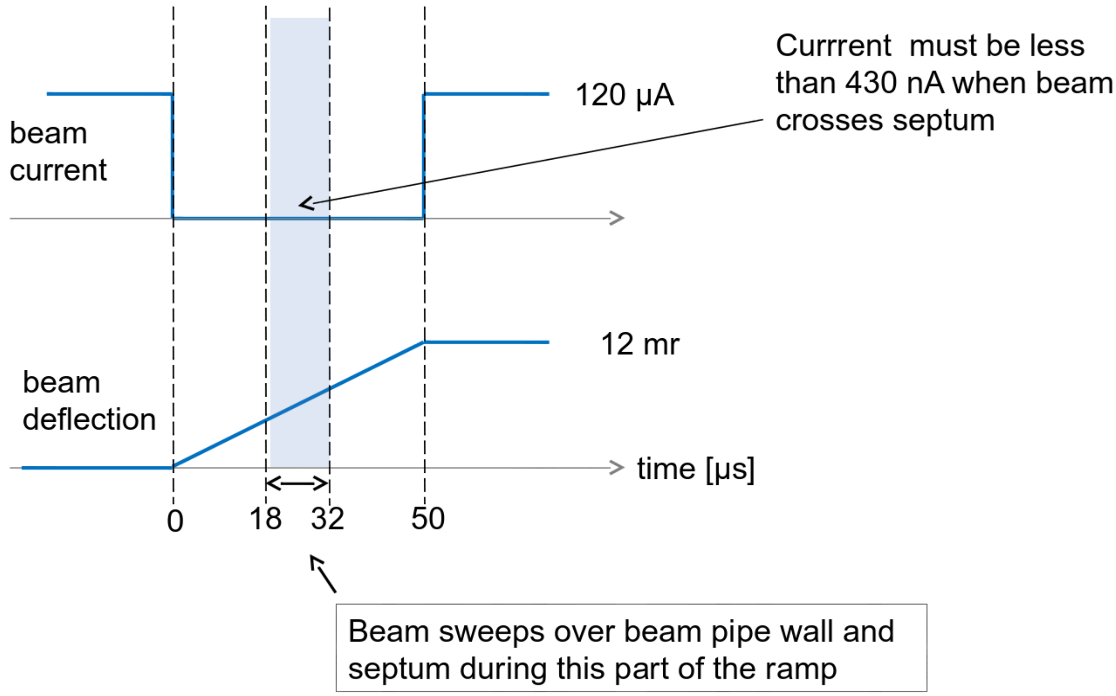
TRIUMF UCN Septum Magnet

Beam current must be less than 430 nA when it sweeps over the beam pipe wall and septum

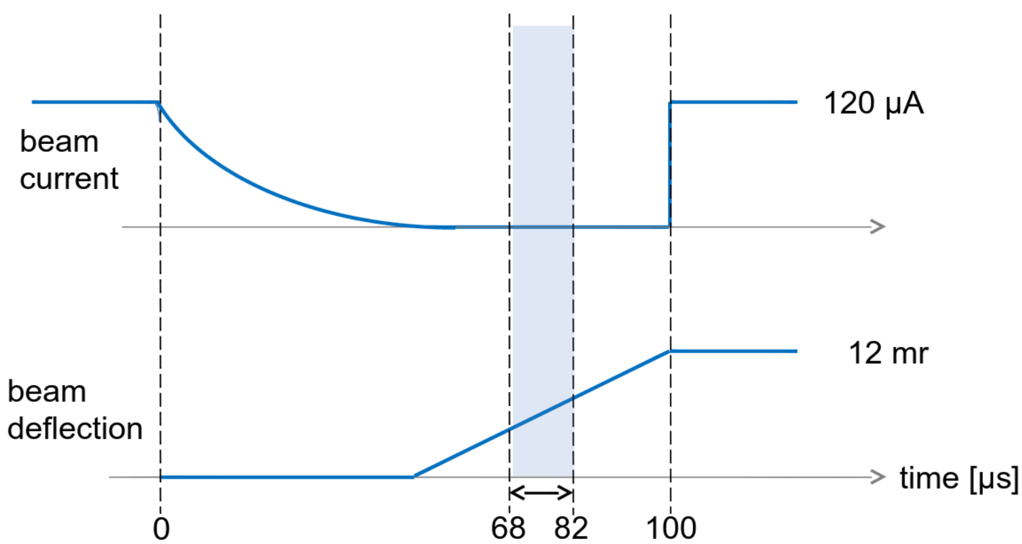
Keeps time averaged beam spill to <1 nA



Beam current and deflection at 95% duty cycle



Beam current and deflection at 90% duty cycle



If the beam does not cut off cleanly at the start of the pulser notch, the kicker sweep could be delayed. 90% duty cycle would give us the option of up to 50 μs delay.