TIMING SEQUENCE FOR P REINJECTION IN THE CPS
AND \( \bar{p} \) INJECTION IN SPS

1. Single-bunch reinjection in CPS

The single bunch circulating on the SPS 26 GeV/c flat bottom is synchronized on the injection frequency (synthesizer). The SPS \( f_{\text{rev}} \) clock distributed around the ring has a constant phase with respect to the bunch.

The 43 kHz train sent to the CPS via the optical fibre link is also synchronized with the bunch, but the relative phase may be varied in the RF equipment. During reinjection experiments however, this phase must be kept constant; only during \( \bar{p} \) injection tests is this phase changed to allow injection of the \( \bar{p} \) bunch into the right bucket.

In the CPS the slow ejection elements are started by the CPS C train (1 kHz). One pulse of the 43 kHz train received in the CPS starts the count down at the CPS RF frequency (\( h = 6 \)). It is essential for the CPS RF to be synchronized with the 43 kHz even in this particular case where there is no beam accelerated in the CPS. This is done in the CPS RF equipment.

One of the CPS RF pulses is sent back to the SPS (-70 \( \mu \)s prepulse) to trigger SPS ejection equipment. The delay between this pulse and the start of the count down must be kept constant in order to maintain a fixed time relationship between the SPS ejection trigger and the circulating bunch. By adjusting the delay between trigger and kicker the bunch can be properly ejected. The ejected proton bunch should be visible on one of the first directional coupler PU's in the transfer line TT70, and the relative phase between the bunch signal and the kicker pulse should be measured to provide a means for adjusting the kicker timing in the \( \bar{p} \) injection mode.

In the CPS the same procedure applies: the kicker delay (from the start of the count down or the -70 \( \mu \)s prepulse) is varied in order to properly inject the bunch. The situation here is far less critical because the kicker length is 5/6 of a CPS turn. As a consequence the CPS kicker, which has a resolution not better than \( \sim 350 \) ns, cannot be used to ensure a proper phasing of the fast (180 ns) \( \bar{p} \) injection kicker in the SPS.
2. **p** injection in SPS

The initial situation in the SPS is the same as before and the -70 µs pulse is generated in the CPS in the same way. However, the CPS RF is now active and the **p** bunch is synchronized with the 43 kHz clock received by the CPS.

The CPS kicker is left at the same position as before with respect to the -70 µs. However, there is a possibility that the **p** bunch falls into the "hole" (1/6 of a CPS turn), because the relative phase of the **p** bunch in the machine and the 43 kHz train is not known. As a consequence, the CPS kicker delay may have to be slightly adjusted (fraction of a CPS turn) to properly centre the bunch in the middle of the kicker plateau. The first **p** pulse can be used for that purpose as well as for CPS RF manipulations.

Assuming the **p** bunch has been properly ejected and transferred through TT70, it should be seen on the directional coupler PU at the bottom of the transfer line. This implies that the bunch is short enough (< 5 ns at the base) because of the frequency response of the directional coupler PU. It means that before attempting any injection in the CPS the synchronization and bunch compression of the **p** bunch must work properly.

To observe the **p** bunch a trigger derived from the -70 µs prepulse is used. The exact delay of the bunch is not known to better than one CPS turn (2.1 µs) but is perfectly reproducible. As the output pulse of the PU circuitry is ~ 200 ns long, there should be no problem in localizing the bunch.

The kicker pulse will be displaced from its original timing by twice the time of flight in the transfer line, but as explained before this only gives a coarse adjustment and this is why the PU signal is necessary. Looking again at the relative delay between kicker pulse and bunch signal one can easily adjust the kicker timing exactly, knowing the time of flight between PU and kicker.

The whole sequence remains unaltered when changing the phase of the 43 kHz train sent to the CPS in order to shoot the bunch into the right bucket.

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or circulating bunch

43 kHz train to CPS

Start count-down
RF h = 6 synchronized on 43 kHz

-70 \mu s prepulse  SPS kicker  CPS kicker

fixed  adjust delay
adjust delay  PU signal
measure

\( f_{\text{rev}} \) SPS or circulating bunch

43 kHz train to CPS (phase varied)

Start count-down
RF h = 6 synchronized (phase will be different)

-70 \mu s prepulse  SPS kicker

fixed  delay + \approx 2 \times \text{time of flight}

CPS \( \bar{p} \) bunch

CPS kicker  fine adjustment

measure and adjust fine kicker timing