Slip Stacking

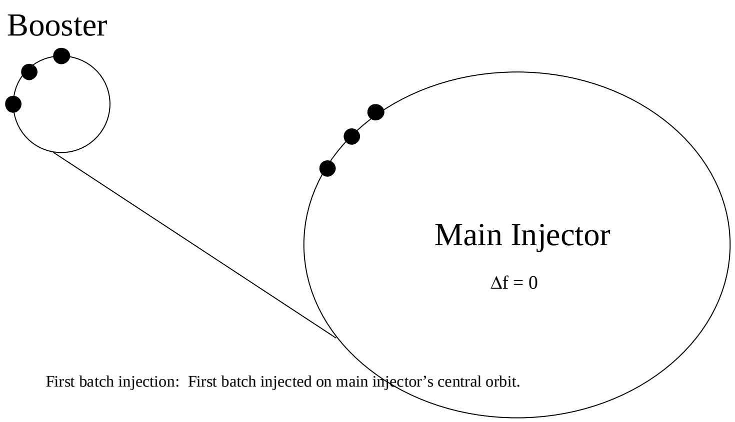
Objective: Increase total proton flux on pbar target by 80%.

Solution: Slip stack two booster batches into one double charged batch while maintaining reasonable longitudinal emmitance.

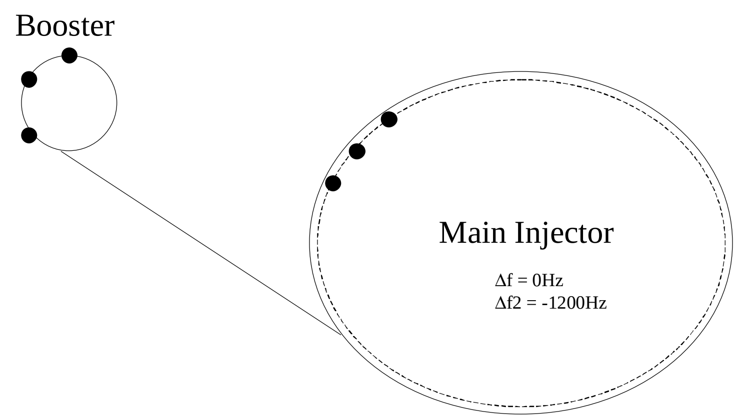
Work to do:

- Make necessary system changes to facilitate slip stacking mechanics.
- Beam loading compensation.

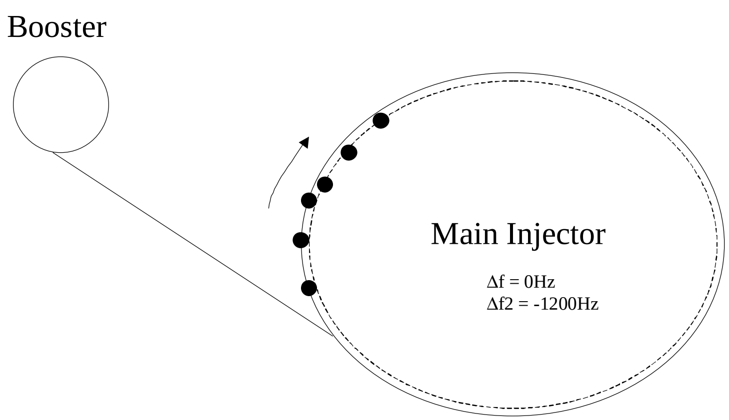
Slip Stacking Process



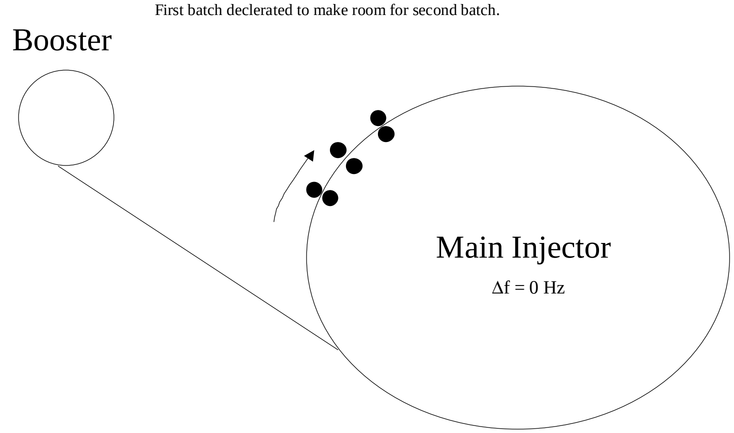
First batch injection: First batch injected on main injector's central orbit.



First batch declerated to make room for second batch.

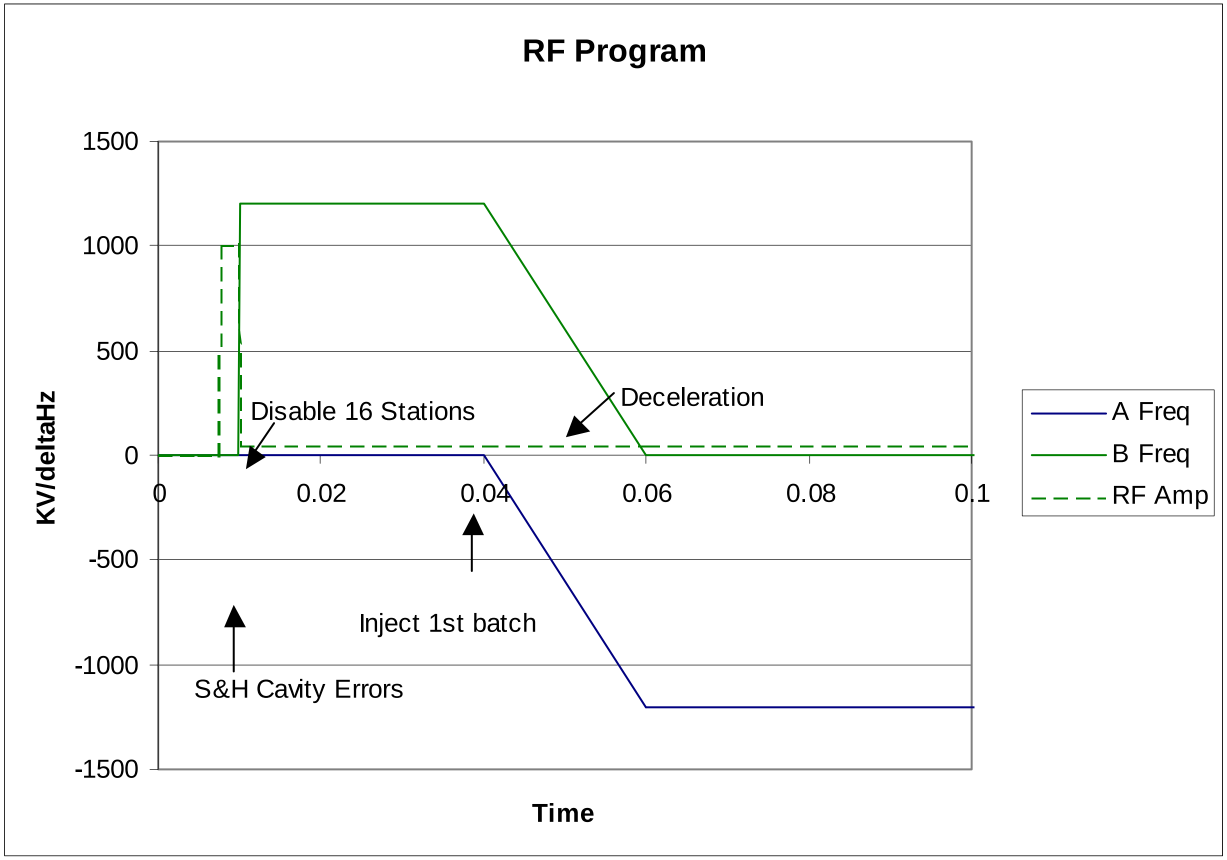


Second batch injection on the main injector central orbit, just behind the first batch.



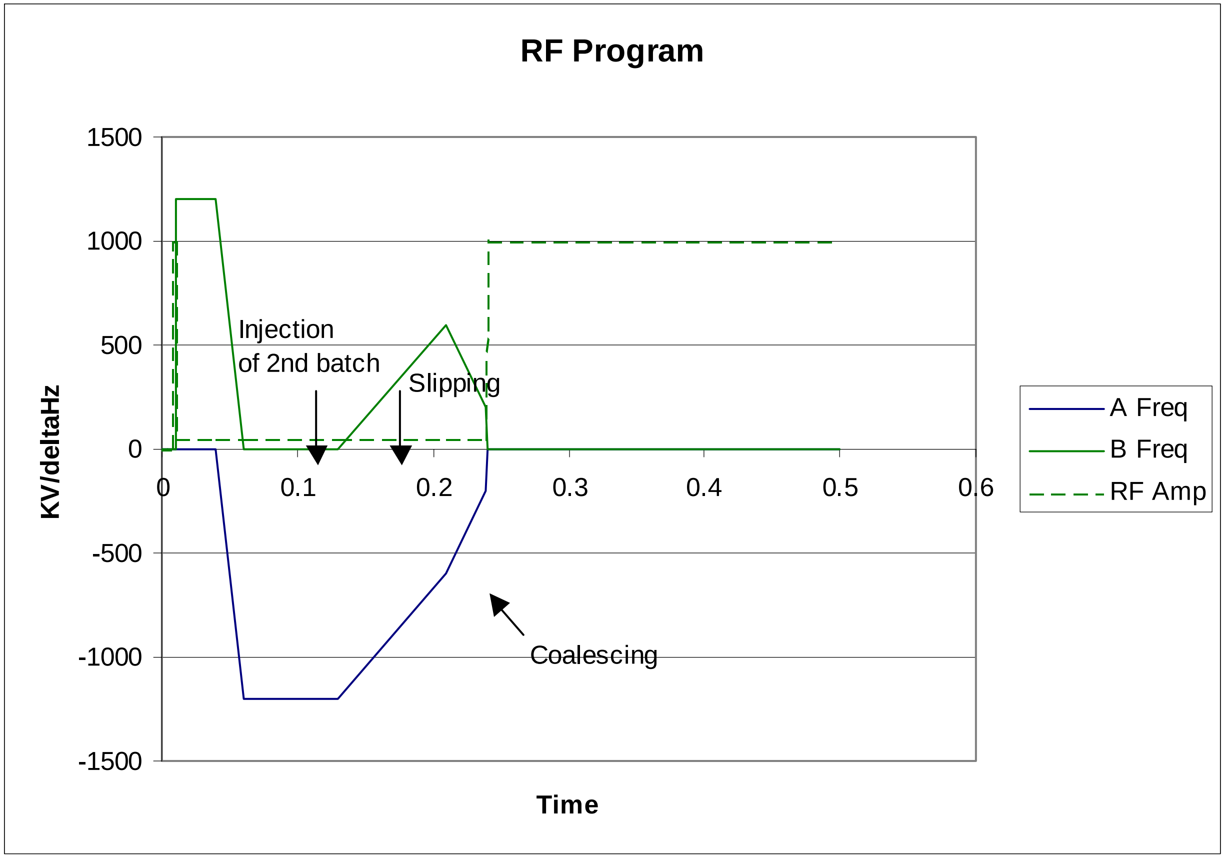
Batch profile immediately after capture.

Figure 3.1.2.1.5



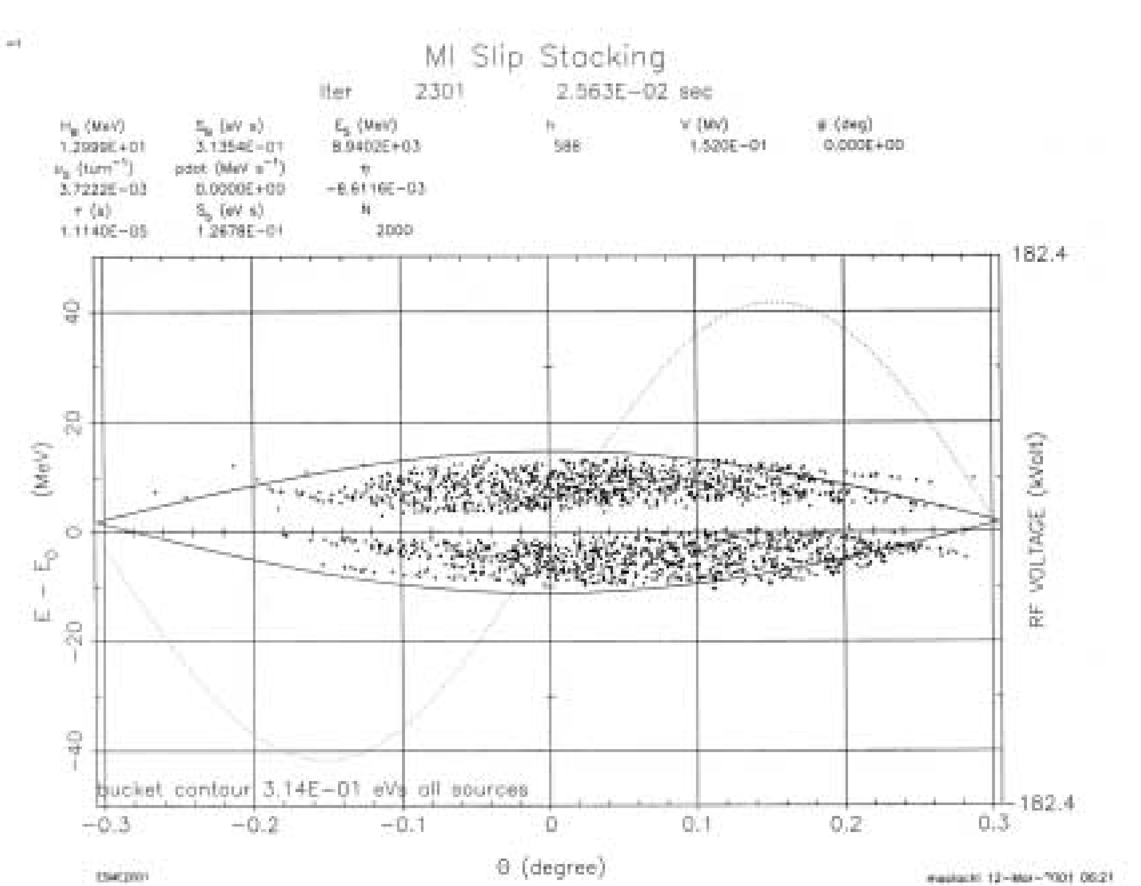
Frequency offset program and RF drive level program for slip stacking. The error signals on the cavity feedback loops are sampled before the cavities are gated off. The first batch is injected and decelerated. The frequency difference between ‘A’ and ‘B’ outputs are kept constant.

Figure 3.1.2.1.6



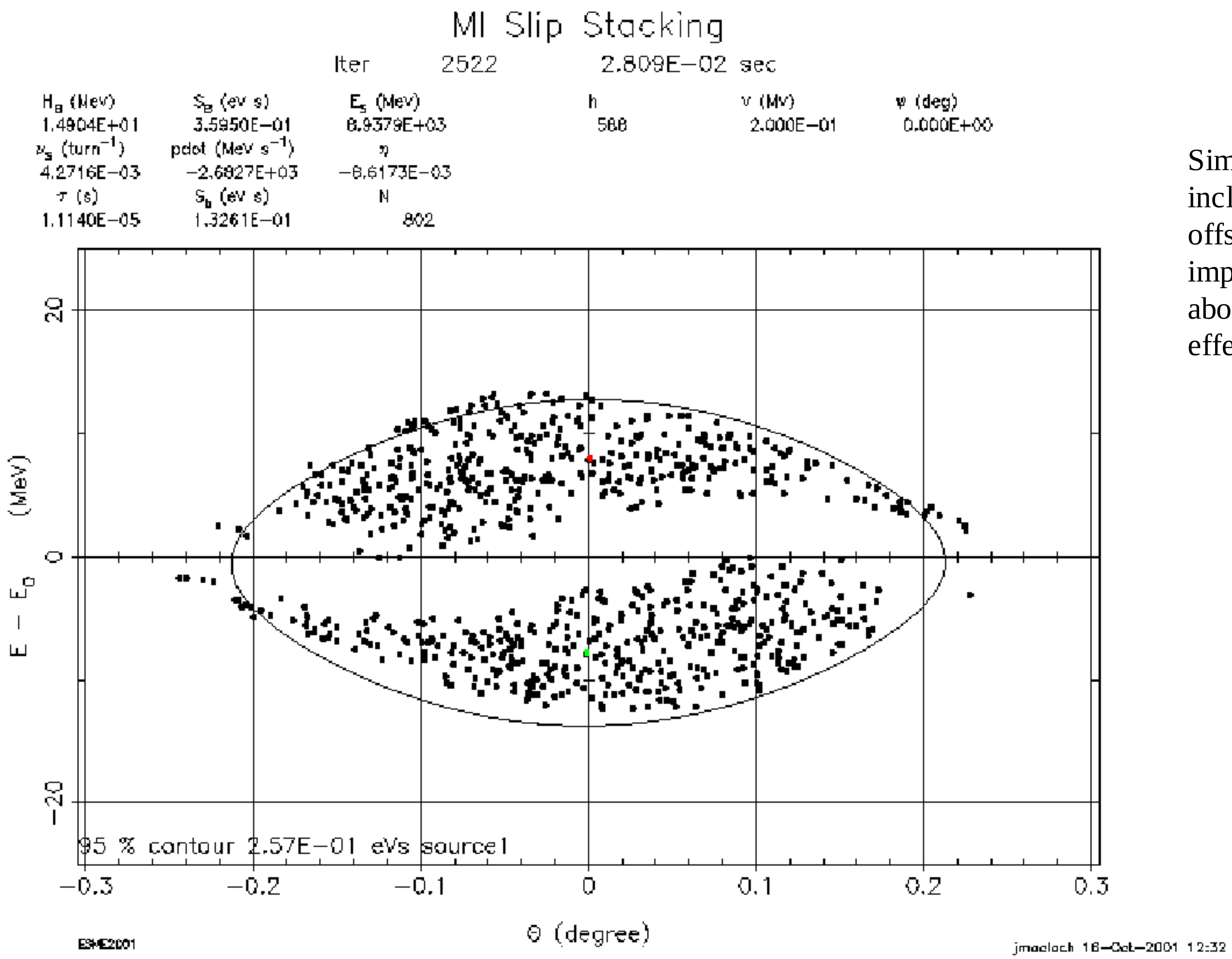
Frequency offset program and RF drive level program for slip stacking. After the second batch is injected, the beam is accelerated so that the energy offsets are symmetric about the nominal orbit. Just before the batches are combined, the energy difference is reduced. The frequency offsets are set to zero, and the RF drive is increased simultaneously to hold both batches at capture.

Figure 3.1.3.1.3



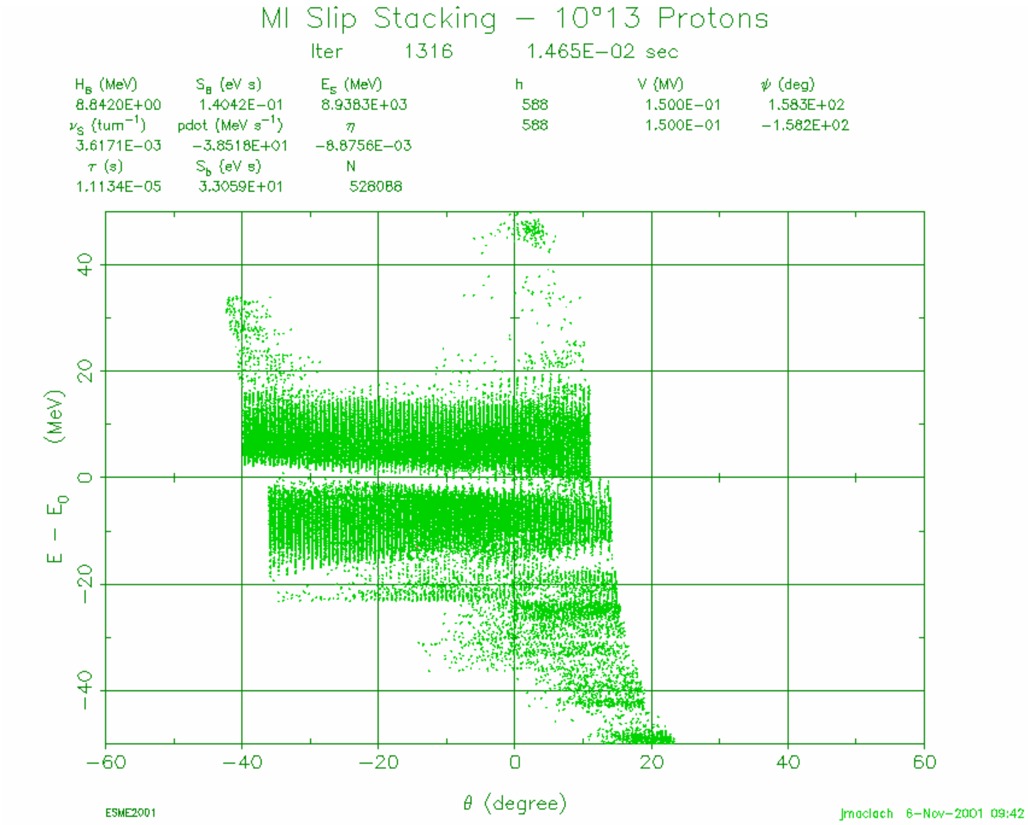
Early attempt at simulating slip stacking. This shows the beam profile at capture time. The longitudinal emmitance of each bunch has not diluted significantly, and the final emmitance is about three times the initial bunch emmitance. These results do not include beam loading.

Figure 3.1.3.1.4



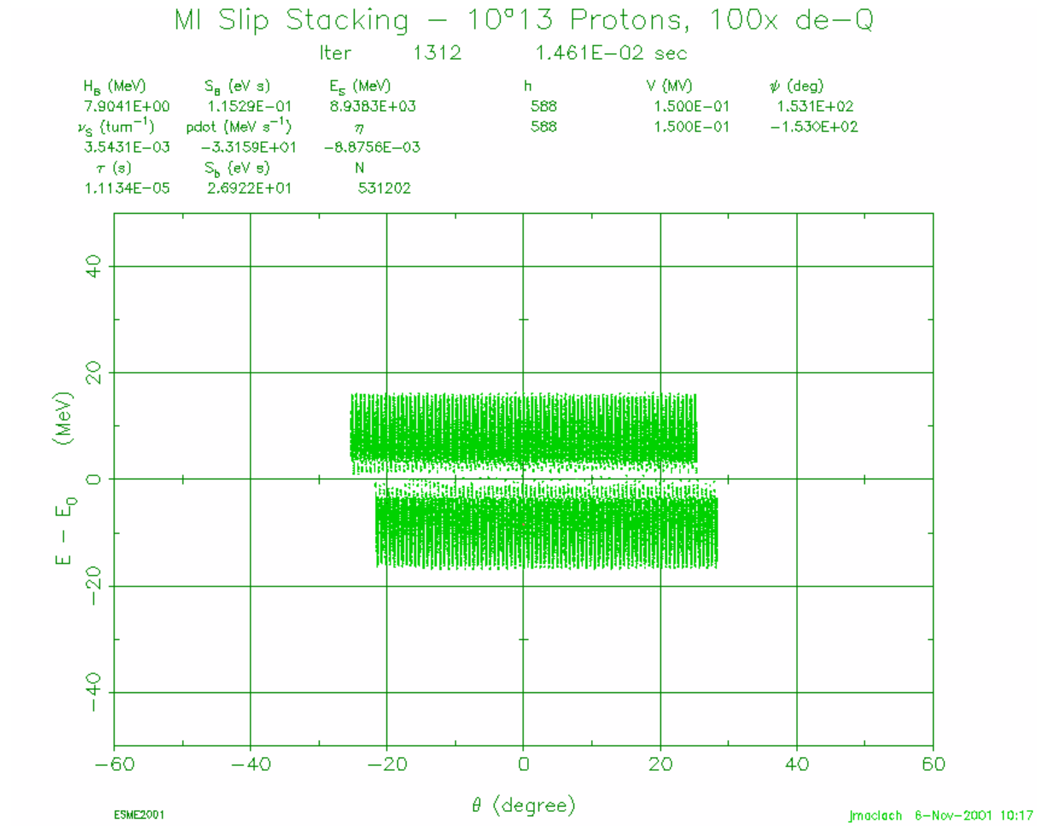
Simulation of capture including reducing energy offset before capture. This improves final emmitance by about 17%. Does not include effects of beam loading.

Figure 3.1.4.2.4



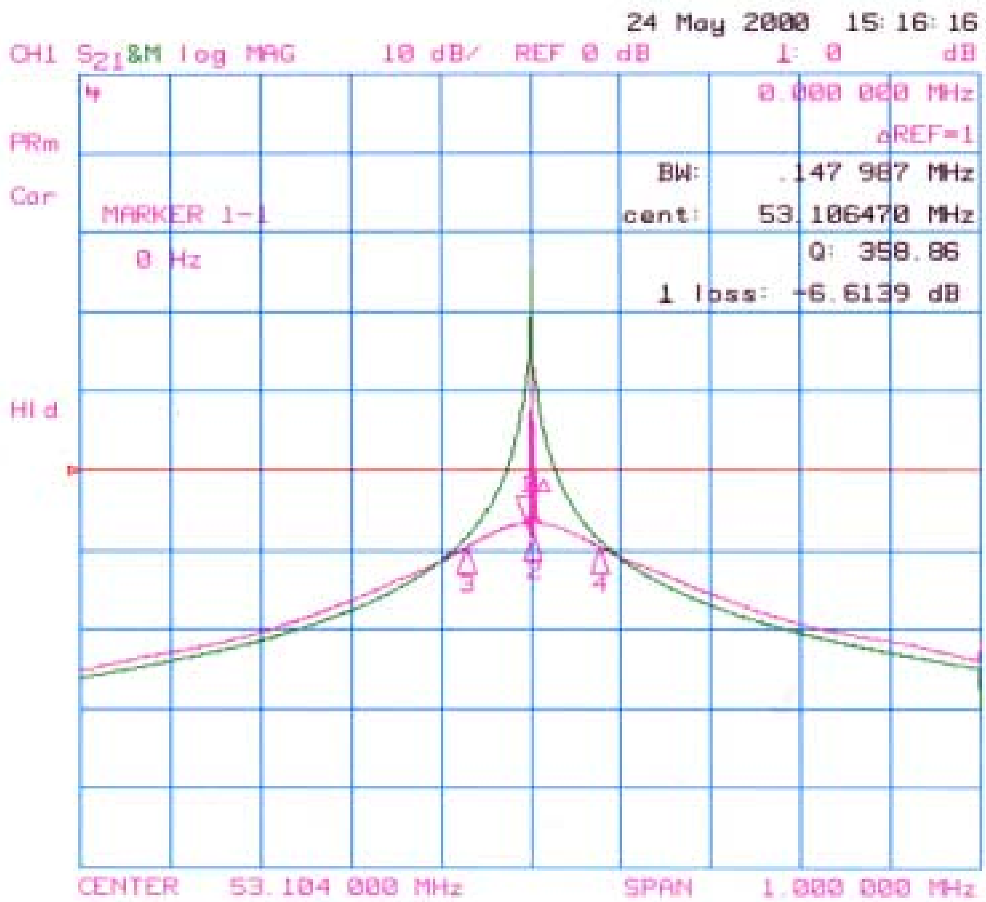
Final profile for captured beam for both batches for slip stacking including beam loading with no compensation. Notice the effect of transient beam loading on the final bunches.

Figure 3.1.5.2.4



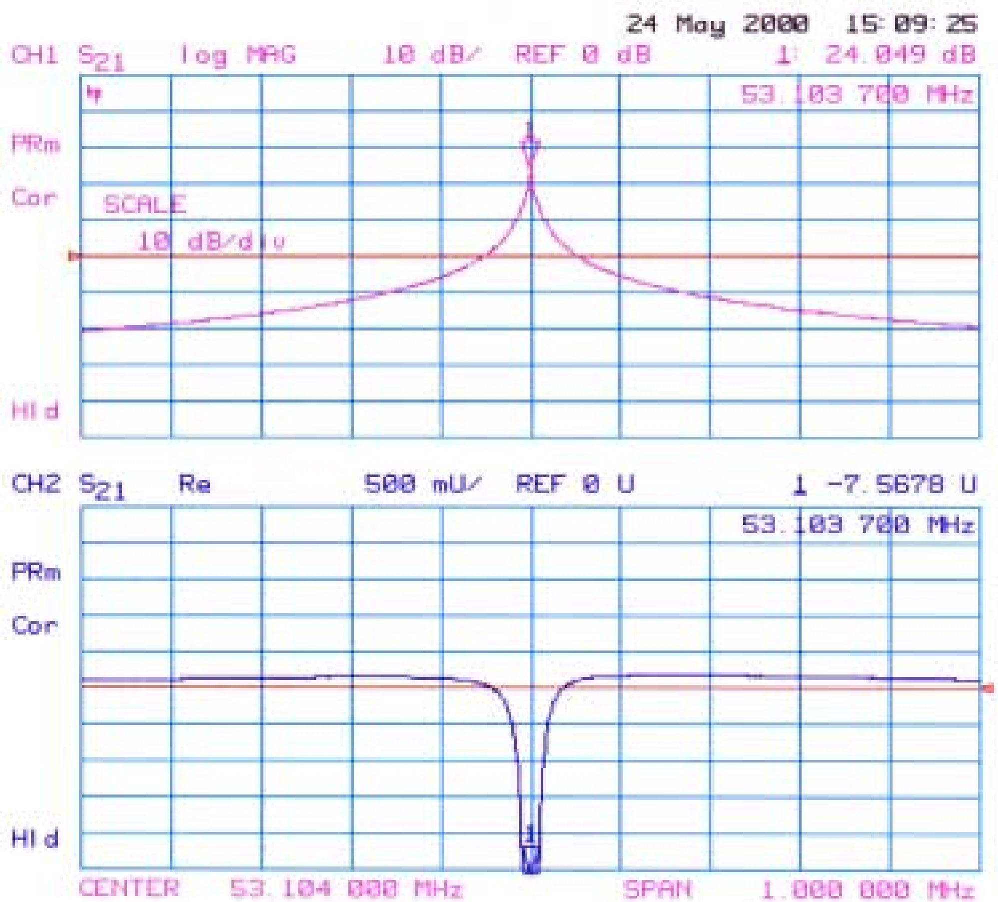
Final profile for captured beam for both batches for slip stacking including beam loading with an ideal direct RF feedback system with 40dB of loop gain.

Figure 3.1.5.3.3



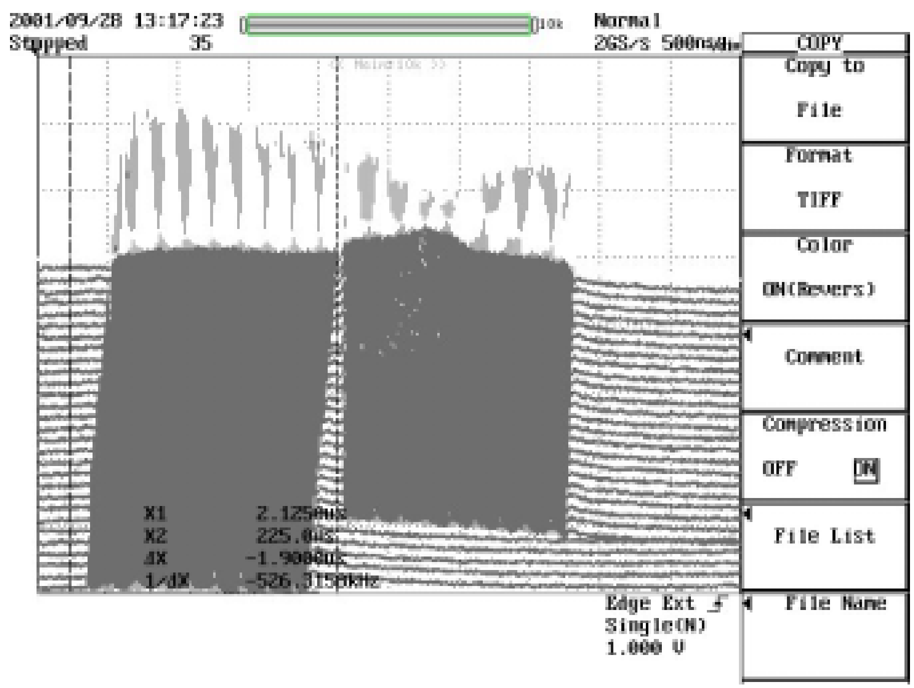
Cavity response with 20dB of direct RF feedback beam loading compensation (pink) and without (green).

Figure 3.1.5.3.4



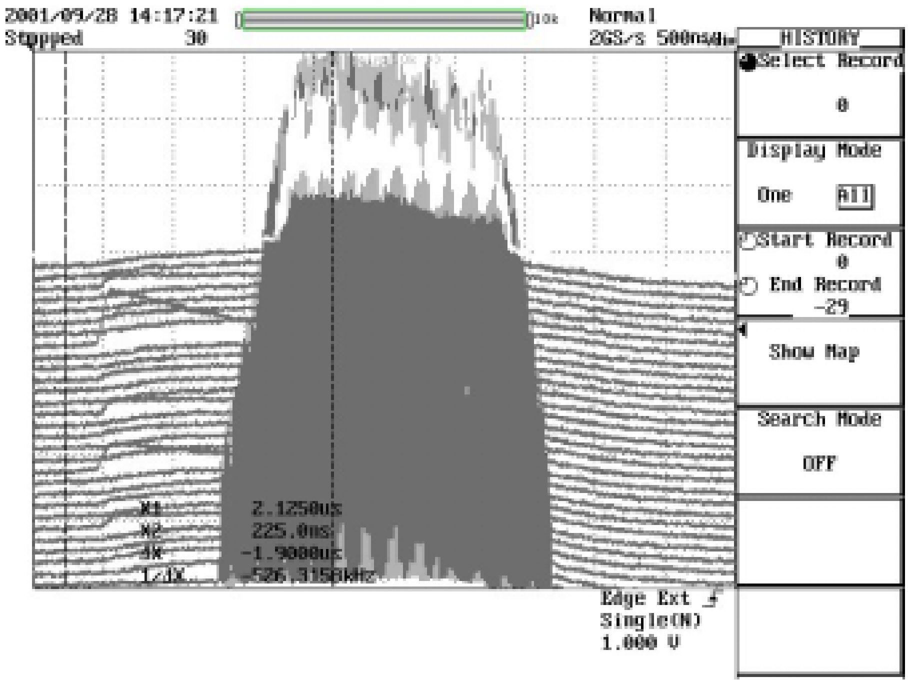
Cavity response with 20dB of direct RF feedback beam loading compensation.
Notice that the real part of the response is well below +1.

Figure 3.1.3.2.9



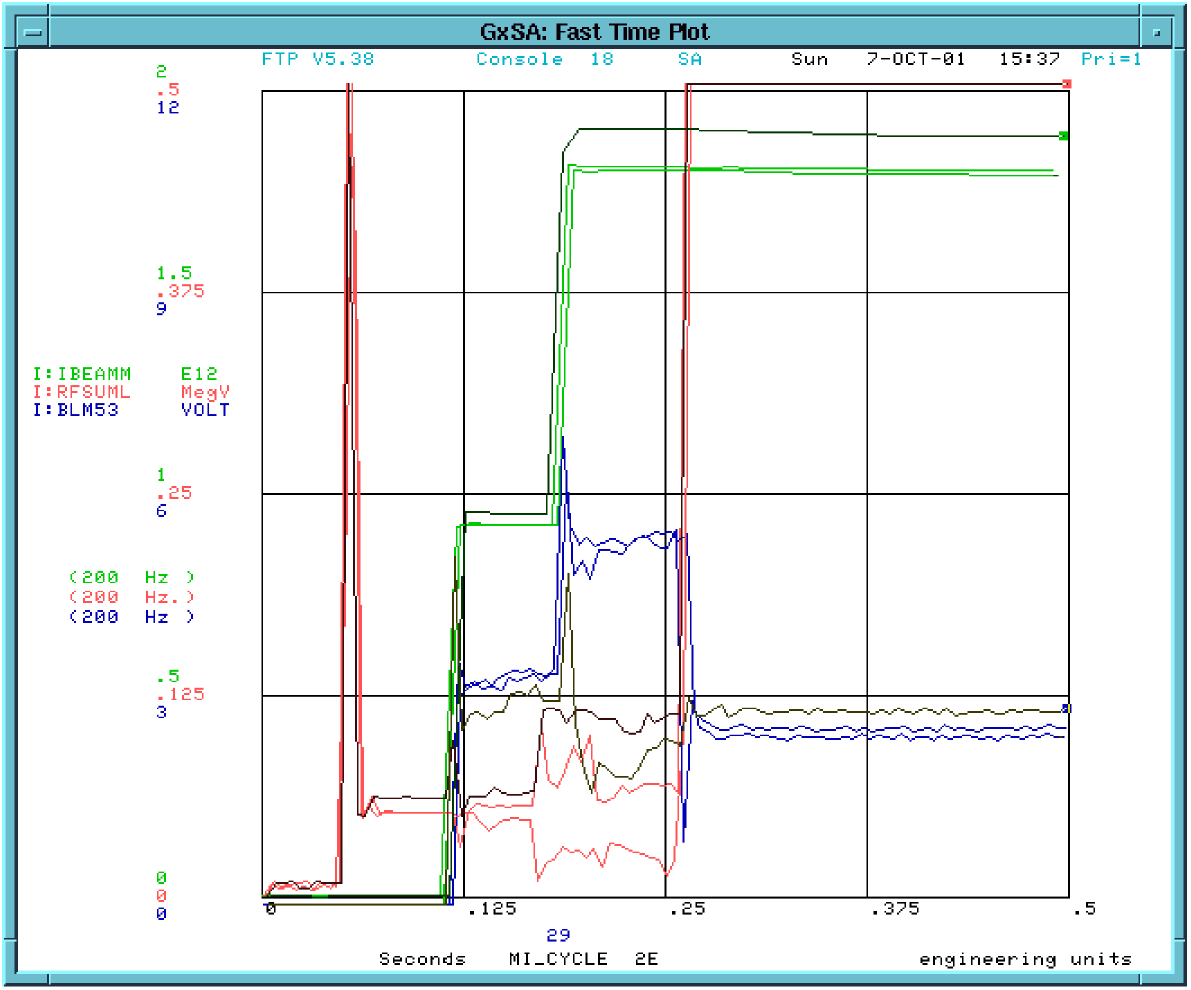
Mountain range plot showing main injector slip stacking just after the second batch is injected.

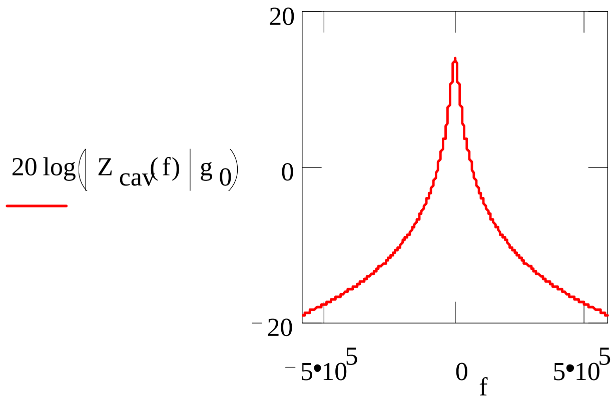
Figure 3.1.3.2.10



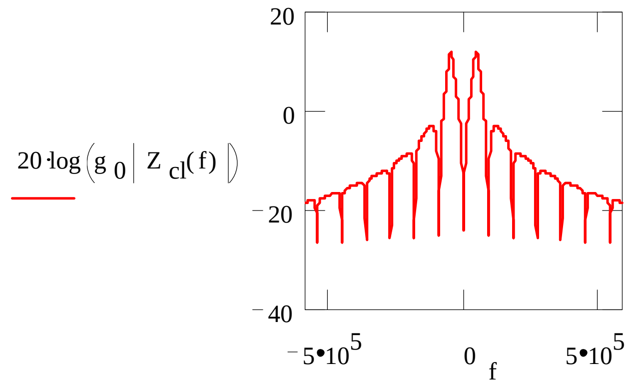
Mountain range plot showing main injector slip stacking when the two batches are captured into a single batch.

Plot of main injector slip stacking cycle. I:RFSUML is the total RF voltage seen by the beam. I:IBEAMM is the total beam intensity in the main ring. I:BLM53 represents the 53 MHz component of beam current. This gives an indication of the amount of beam still left in the bucket.



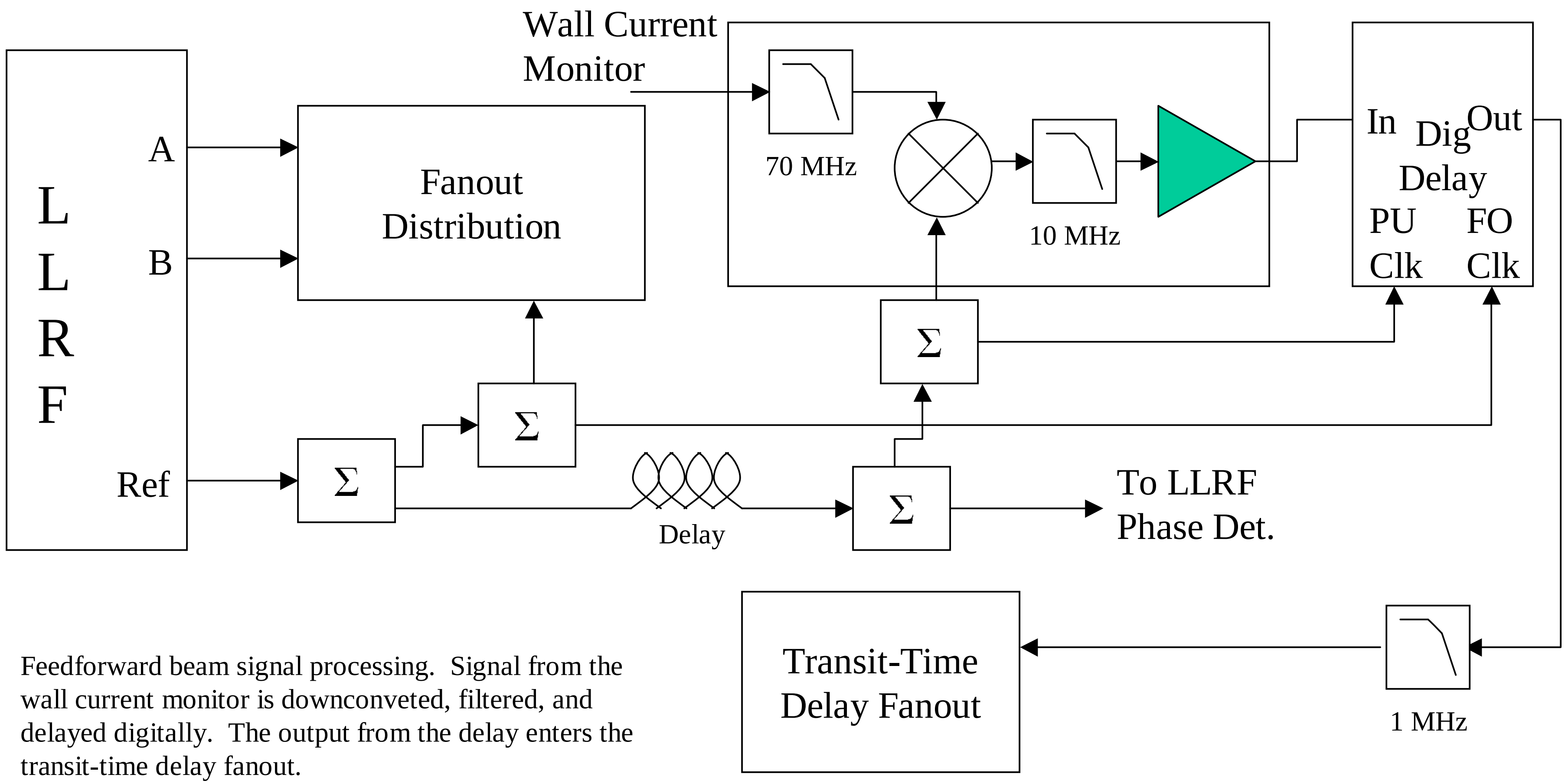


Sample of cavity response without beamloading compensation.



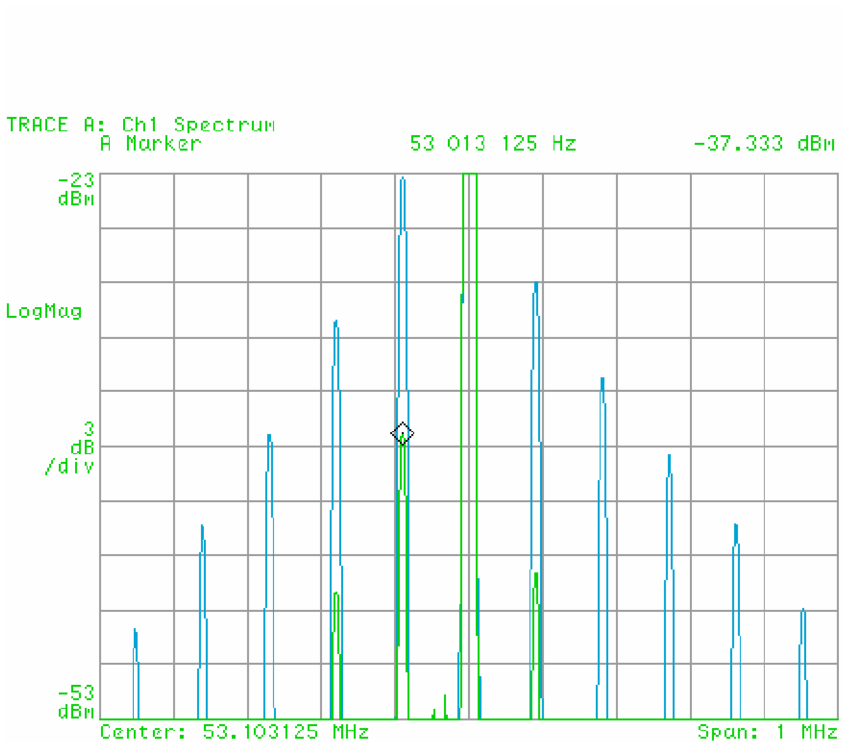
Sample of cavity response with digital direct RF feedback.

Figure 3.1.5.4.1



Feedforward beam signal processing. Signal from the wall current monitor is downconveted, filtered, and delayed digitally. The output from the delay enters the transit-time delay fanout.

Figure 3.1.5.4.3



Results of feedforward compensation on a single cavity during a normal stacking cycle at high field. The blue trace is the spectrum of the cavity gap without compensation, and the green trace is with compensation.