FACET beam operations readiness with R56=10mm chicane optics in sector 20.

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Goal:

Deliver a "notched" electron beam profile to the E200 experimental interaction point with parameters suitable for E200 "2-bunch" plasma experiments.

Status:

- Sector 20 chicane configured for 10mm R56 to provide correct longitudinal profile. Simulations predict 2 temporally separated bunches with 130um peak-peak separation and bunch populations of approximately 3.5-7 x 10^9 and 1.5-3.5 x 10^9 electrons for the head and trailing bunches respectively. The expected RMS bunch lengths for the 2 bunches are ~25um for the head bunch and 20-35um for the trailing bunch. The ranges indicate the variation depending on how the notch collimator (which removes charge from the central portion of the bunch) and the jaw collimators (which cut charge from the edges) are configured.

- Sector 20 final focus system optics are configured to demagnify the beam at the entrance to the E200 experimental area with a waist set to provide 0.1m x 1m beta functions. With the high energy spread beam at the optimal compression setting (1-1.5%), it is expected from simulations that the horizontal beam size is dominated by uncorrectable high-order aberrations. The expected transverse beam size at E200 is 30-40um x 15-20um assuming typical emittances delivered into sector 20 of ~5-10 x 1-2 x 10^-5 (normalised) and depends on the exact energy spread delivered.

- A procedure was developed to tune the beam up in the sector 20 interaction region to provide the desired beam parameters. Some specific difficulties that arose were:
    - increased background levels in the interaction region due to necessarily higher dispersion in the chicane which made profile measurements on the wire scanner systems difficult. To mitigate this, we tune the transverse properties of the bunch under conditions with lower energy spread by going off-compression using the damping ring phase ramp adjustment facility. We found that tuning under these conditions and then restoring the optimal chirp maintained the tuning and expected transverse properties.

    - increased non-linear dispersion when optimally compressed. This was mitigated as above by performing dispersion correction under reduced energy spread conditions.
    - increased sensitivity to orbit control due to larger beam size through chicane required more careful beam based alignment and tuning.

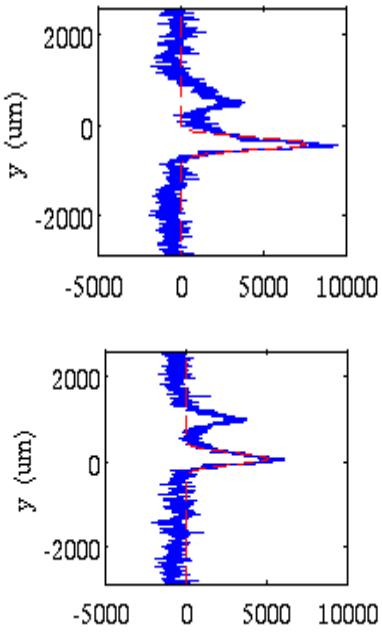
- The transverse properties at the WSIP2 wire scanner in the interaction region of sector 20 were measured with this configuration after tuning at: 17.7um x 17.4um at low energy spread (reduced longitudinal compression) and 41.7um x 17.0um at high energy spread (optimal longitudinal compression). This was in agreement with theoretical expections from the simulation studies and from the measured emittances in sector 18. We thus conclude that we are able to correctly model and experimentally manipulate the transverse phase space with this optical configuration.

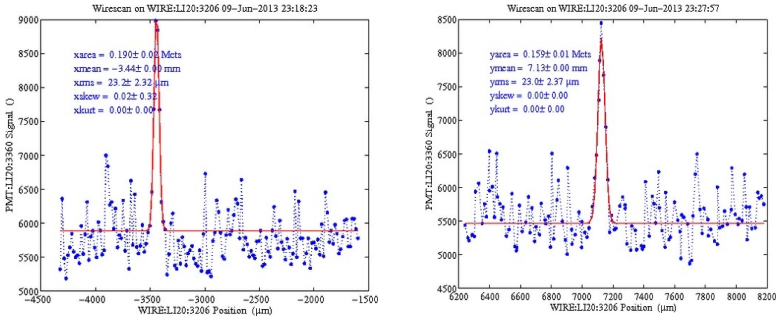
- This configuration is adequate for the initial E200 experimental studies forseen. However, if required in future, it may be possible to reach higher charge densities by:
    - further reducing the vertical beta function at the IP and/or improving the vertical emittances delivered to sector 20
    - finding a longitudinal setup solution that provides a lower energy spread in the bunch
    - finding a more optimal chicane configuration with respect to the generation of non-linear horizontal aberrations

- The procedure for setting up the longitudinal profile (apart from the usual linac setup and RF phasing etc) consists of maximally compressing the beam in sector 18 by using data from the sector 18 bunch length monitor. The sector 18 foil disrupts the beam so the correct compression is maintained by monitoring and maintaining the corresponding signal on the sector 20 bunch length monitor (THz radiation pyrometer) utilizing the dampind ring RF phase ramp knob.

- The longitudinal properties at the sector 20 interaction region were experimentally assesed by utilizing the X-band transverse deflecting RF cavity in the second half of the sector 20 chicane. Using a final focus configuration that produced a high contrast projection of the longitudinal phase space onto one of the interaction region OTR screens, we found the optimal settings for the notch and jaw collimators and measured the 2 bunch notched profile. The measured parameters were: 158,161um peak-peak longitudinal separation; 23.0,23.5 um RMS longitudinal bunch lengths; leading bunch charge of 8.5,5.0 E9; trailing bunch charge of 3.5,3.1 E9. Where the 2 values are with different notch and jaw settings. The second value corresponds to a configuration with cleaner separation of the 2 bunches but with a greater fraction of the beam charge removed.

- The longitudinal setup is in close agreement with expectations from simulations and adequate for the proposed E200 experimental program.





Measured longitudinal and transverse beam profiles. Top, TCAV streaked longitudinal profile observed at IP2B OTR Screen. Bottom, wire scanner profiles of x and y spot sizes at WSIP2.