Application Program Requirements

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Front End / Linac Applications

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Introduction

Application programs are high level programs that typically incorporate some interaction with the accelerator, i.e. tuning some hardware based on input beam signals. Sometimes the interaction is model based, sometimes empirically based. These applications require input/output from/to the accelerator hardware and instruments via EPICS channel access signals. The hardware includes components such as magnets and RF, as well as instruments such as BPMs, current monitors, etc. Additionally some applications require input from models which themselves need setup information from the accelerator. An additional complication for SNS arises from its pulsed nature – and ensuring that different sorts of signals (e.g. BPM and current monitors) can be reliably received through the control system from the same pulse.

This document serves as a description of the requirements for the application programs. In particular, the different applications envisioned are first briefly described. Then the signals they need to receive and need to send to the accelerator are listed. In particular, synchronization issues associated with these signals are included. Additionally, data-base needs are identified. The data base information includes static data such as the lists of BPMs or magnets in the accelerator element of interest. Another important element in the specifications is the beam pulse type required for this application (e.q. beam intensity and pulse length). Finally, where needed, physics modeling needs are identified. It is hoped that this set of requirements can be used as an interface to the controls and instrument groups, as well as an initial guide to the application developers themselves.

With respect to the synchronization of the data signals coming to these applications, there will be a special pulse mode type for beam "physics" studies (distinct from the other operational mode types). For cases where it is important to correlate data from different sources (i.e. ensure they are from the same pulse), special control system process variables of these signals should be requested to be available for this "physics" mode. These signals can be gathered much slower than 60 Hz, to ensure collection of correlated data. This will allow use of these applications interspersed in normal neutron production mode.

Linac ORBIT Difference Viewer

Description:

This application will be used to display a difference orbit, and compare it to a model predicted orbit. It will be useful in identifying miss-configured elements in a noisy system. Using a short pulse ($\geq$ ~30 μsec) full intensity (36 mA) beam macro-pulse, first acquire, display and store the BPM orbit (i.e. difference signals of BPMs with sum signals exceeding a threshold) over a user prescribed interval of the linac. All BPM signals should be verifiably from the same macro-pulse. Then allow the user to modify a corrector strength within the linac segment. After the modified corrector strength has stabilized, the new BPM orbit should be acquired. Display the difference between the original orbit and the new orbit. Also show the model prescribed orbit over the same interval, calculated using source / magnet / RF strengths read-back from the control system.

Note: This sort of application should be available for all accelerator elements, but is described for the linac first.

Epics Data Get Requirements:

- BPM orbits (sum and difference signals for all BPMs within the linac interval specified)
- Corrector + Quad strengths in the linac
- RF phase and amplitude in the linac
- Ion source intensity, chopper fraction, pulse length
- Time Synchronization of data gets: all magnet, RF, and BPM readbacks should be for the same macro pulse.

Epics Data Put Requirements:

- Pulse mode type
- Corrector strength
- Time Synchronization issues of data puts : none

Model Requirements:

- Provide linac orbit prediction based on input for beam intensity, magnet strengths and RF phase and amplitudes.

Mathematical methods:

- none

Data Base Requirements:

- Provide a list of the names of the BPMs, magnets, and other accelerator elements within the linac
- Magnet strengths (i.e PMQs).

Sequence type

50 mA, 30-50 μ sec macro-pulses (or longer), chopper fraction not important

Profile monitor (MEBT/LINAC)

Description:

This application is used to generate the beam profile by stepping some wires through the beam at some settable intervals. A short pulse beam (20 msec) will be required to avoid melting the wire scanner. It may be necessary to repeat the measurement at a single position for averaging purposes if the signal is too weak. Additionally, a downstream BPM signal will be used to determine if the beam is wandering (jitter) during the pulse. Also a nearby current monitor signal will be provided to ensure the beam is steady during throughout the pulse. If a stable reading is captured for a wire setting, the stepper motor is called to move to the next position. This move is verified, and another pulse is requested. The procedure is repeated until the profile scan is completed.

Note: Profile monitors are used elsewhere, and the linac beamline profile monitors should be similar to that described here. Profile monitors in the ring may have different requirements.

Epics Data Get Requirements:

- Wire signal averaged over the pulse.
- Downstream BPM position (difference signal throughout the pulse (at ~ 1 μsec intervals).
- The current signal from a nearby toroid throughout the pulse.
- Time Synchronization of data gets: all profile, BPM and current readbacks should be for the same macro pulse.

Epics Data Put Requirements:

- Wire position for the profile monitor
- Time Synchronization issues of data puts : none

Model Requirements:

- None.

Mathematical methods:

- none

Data Base Requirements:

- Provide a list of the names of the wire scanners, BPMs, and current monitors within the MEBT and linac

Sequence type

50 mA, 20 μ sec macro-pulses

TOF Energy Monitor

Description:

This application is used to calculate beam energy. It uses the difference between BPM phase signals from 2 BPMs to calculate the time difference between BPM crossings. Knowing the distance between the BPMs gives the energy. Pitfalls to be aware of are that the relative phase signals ae not accurate if the BPMs are on different local oscillators. Also, if the energy is large enough to produce a phase difference > 2p between the two BPMs, this must be known a priori and taken into account (e.g. by using closer spaced BPMs initially). Current signals will also be used as a cross check to be sure the expected beam is actually present. The BPM phase signal is provided throughout so the energy calculation can be averaged over different portions of the macropulse (to provide energy jitter information).

Note: TOF calculations are used in other applications, so this application needs to be encapsulated in an easily callable manner

Epics Data Get Requirements:

- BPM phase signals at specified BPMs, provided at roughly 1 μsec intervals.
- The current signal from a nearby toroid throughout the pulse.
- Time Synchronization of data gets: all profile, BPM and current readbacks should be for the same macro pulse.

Epics Data Put Requirements:

- none

Model Requirements:

- None.

Mathematical methods:

- none

Data Base Requirements:

- Provide a list of the names of the wire scanners, BPMs, and current monitors within the MEBT and linac and transfer lines.
- Provide the local oscillator each BPM is on
- Provide the location of each BPM

Sequence type

50 mA, 20 μ sec – 1 msec macro-pulses

MEBT Quad Tuning

Description:

This application is used to set the quad strengths in the MEBT. Profiles are taken at 4 positions in the MEBT. These are compared to pre-calculated model results, and new focusing strengths are calculated (to provide a matched beam) based on the difference in the profiles. Constraints in calculating the new quad strength settings calculation include keeping the phase advance between choppers 360 (?), …. Revised quad strengths in the MEBT are sent and verified that they have taken effect. Then the profile measurement is repeated and the iteration redone if necessary.

Epics Data Get Requirements:

- MEBT Quad focusing strengths.
- Note: the profile measurement used here requires other EPICS data, but is described elsewhere.
- Time Synchronization issues of data gets : none

Epics Data Put Requirements:

- MEBT Quad focusing strengths
- Time Synchronization issues of data puts : none

Model Requirements:

- None.

Mathematical methods:

- none

Data Base Requirements:

- Provide a list of the names of the quads within the MEBT

Sequence type

50 mA, 20 μ sec macro-pulses (see profile monitor)

MEBT RF Tuning

Description:

This application is used to calibrate the phase and amplitude settings of each RF cavity in the MEBT. The procedure will be needed during commissioning (the calibrations should remain valid unless a cavity is replaced). First the RF phase is calibrated by varying the phase and monitoring the sum signal of the BPM just downstream form the RF cavity. This will be done using repeated short pulses. When the phase is at 90^o, the bunch receives maximum focusing (is compressed longitudinally) and the BPM signal is maximum. This provides the phase calibration. Then the phase is set so $\sim 45^o$, and varied by $\sim \pm 20^o$. During this procedure the beam energy is monitored using a TOF measurement with 2 downstream BPMs. The slope of the Energy(phase) provides the voltage.

Epics Data Get Requirements:

- MEBT BPM sum and phase signals as a function of time during the pulse.
- Time Synchronization issues of data gets : Need to ensure the BPM data is taken after the modification of the RF settings.

Epics Data Put Requirements:

- MEBT RF phase and amplitude settings
- Time Synchronization issues of data puts : none

Model Requirements:

- None.

Mathematical methods:

- none

Data Base Requirements:

- Provide a list of the names of the BPMs and RF phase/amplitude signals within the MEBT. Also positions of the BPMs and the local oscilator group of each BPM (for TOF calculations).

Sequence type

50 mA, 30 μ sec macro-pulses (is this enough for RF to stabilize?)

DTL / CCL RF Phase Amplitude Set

Description:

This application is used to determine the RF phase and amplitude setpoints. Both the klystron amplitude and phase will be varied and the beam output phase (i.e. energy) monitored. For example, the RF phase may be varied by $\pm$ 15 degrees, parametrically for 6 different amplitude set-points. For each RF phase and amplitude setpoint, a verification needs to be done to ensure that the new settings are active. Then the downstream BPM phase signals will be checked. The quantity to monitor (and plot) will be either the output beam energy or phase. The output energy can be determined by a the TOF application and the output phase provided by the BPM is the difference between a BPM phase signal and an RF reference signal. The klystron RF phase should be set to the point where the downstream output phase signal is insensitive to the input RF amplitude. The RF amplitude can then be set by getting the correct output energy, based on the TOF signals. A short pulse (30-50 μsec) full intensity pulse (50 mA) should be used.

Care should be taken not to use BPM phase measurements from BPMs on different local oscillators (inaccurate relative phase readings). Also, a current signal is useful for cross checking purposes.

Epics Data Get Requirements:

- BPM readbacks: phase and sum signals.
- Toroid current signals
- RF phase and amplitude readbacks
- BPM and current signals to be verifiably from the same micro-pulse (and the same macro-pulse).

Epics Data Get Requirements:

- RF phase and amplitude setpoints
- Time Synchronization issues of data puts. : none
-

Model Requirements:

- none

Mathematical methods:

- None

Data Base Requirements:

- Provide a list of the names of the BPMs and current monitors in the linac
- RF phase and amplitude setpoint names
- Local oscillator each BPM is on.

Sequence type:

30-50 μ-sec pulses (or longer), 50 mA

SCL RF Phase Amplitude Set

Description:

This application is used to determine the RF phase and amplitude setpoints for the SC linac cavities. The concept is to start with a tuned cavity, and use a short beam pulse (integrated current should be ~ 100 μ-sec x 50 mA) to excite the cavity. All downstream cavities of the one being set should be de-tuned. Then the phase and amplitude of the signal from the excited cavity will be gathered. It may take several pulses for the cavity LLRF "feed-forward" to settle down. The excited cavity phase value (relative to the RF reference signal) at the end of this pulse is compared to a table of pre-calculated values, to determine how the input phase and amplitude should be adjusted. The beam current also needs to be known for this comparison to the pre-calculated values.

Epics Data Get Requirements:

- Current signal (either average over the pulse, or every 10 micro sec)
- Cavity amplitude and phase signals (relative to the RF reference signal). These need to be synchronized to ensure they are from the same micro-pulse as the current signal.
- Cavity tune / detune signals (does LLRF do this?)

Epics Data Put Requirements:

- Klystrom phase and amplitude setpoints, pulse length.
- Time Synchronization issues of data puts : none
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Model Requirements:

- None

Mathematical methods:

- None

Data Base Requirements:

- Provide a list of the names of the SCRF cavityies in the linac
- RF phase and amplitude setpoint names
- Precalculated table of RF phase and amplitude readback values for each cavity.

Sequence type:

100 μ-sec pulses (or longer), full intensity. Chopper structure not needed.

Linac Closed Orbit Corrector

Description:

Calculate the dipole corrector strengths to best bring the beam on axis. First calculate the impact of each corrector on the beam positions (i.e. partial derivatives). Start by getting the BPM positions averaged over ~50 μsec. Then modify a single corrector strength, and after verifying the new corrector strength is set, get the BPM positions again. Repeat this for all the BPMs involved. Both sum and difference signals will be needed.

For the case with more correctors than BPMs (e.g. DTL) use least squares to minimize the dipole strengths to correct the orbit. For the single corrector set/BPM pair method solve for the unique solution. For the DTL this may have to be done tank by tank if operational RF overwhelms the BPM signal.

Epics Data Get Requirements:

- BPM readbacks.
- Corrector + Quad strengths (for EMQ cases)
- Time Synchronization of data gets: All BPM signals should be from the same macro-pulse.

Epics Data Put Requirements:

- Corrector strengths
- Time Synchronization issues of data puts. : none

Model Requirements:

- none

Mathematical methods:

- SVD, least squares, simplex.

Data Base Requirements:

- Provide a list of the names of the BPMs, magnets, and other accelerator elements within the linac
- Magnet strengths (PMQs).

Sequence type:

50 μ-sec pulses (or longer), full intensity beam (50 mA).

Ring Run time machine modeling

Description:

Calculate the ring optics from power supply readbacks. In particular, the transfer matrices, tunes and chromaticities will be calculated.

Epics Data Get Requirements:

- ~ 52 quad + 32 dipole readbacks + ~100 corrector readbacks + 8 bump magnet readbacks, to get the magnet data.
- Time Synchronization of data gets: All magnet readbacks should be at the same time.

Epics Data Put Requirements:

- none

Model Requirements:

- Calculate the R matrix from the input power supply readbacks.
- Calculate the tune and chromaticity
- Existing codes (UAL, MAD, Teapot) can provide the functionality.

Mathematical methods:

- none.

Data Base Requirements:

- Provide a list of the names of the magnets, and other accelerator elements within the ring.

Sequence type:

NA.

Machine Optics Editor

Description:

Calculate the required quadrupole currents needed to provide prescribed tunes.
Additionally the application should preserve the horizontal achromat condition in the ring arcs and prevent excessive beta function size.
Calculate the required sextupole currents to provide the prescribed chromaticity.
This application can be used in conjuction with the Run-time Machine Modeling to verify settings.

Epics Data Get Requirements:

- ~ 48 quad + 32 dipole readbacks + ~100 corrector readbacks + 8 bump magnet readbacks, to get the magnet data for the optics setup.
- Time Synchronization of data gets: All magnet readbacks should be at the same.

Epics Data Put Requirements:

- 5 main quadrupole power supply setpoints. Possibly 1 sextupole power supply setpoint
- Time Synchronization issues of data puts: Ensure all magnet setpoint changes are complete before verifying the updated tune setting.
-

Model Requirements:

- Existing codes (UAL, MAD, Teapot) can provide the functionality.

Mathematical methods:

- Non-linear equation solver such as Simplex method (exists in Mad).

Data Base Requirements:

- Provide a list of the names of the quadrupole, and sextupole power supplies in ring.

Sequence type:

NA

Ring fast beam loss monitor display (Controls group?)

Description:
Display beam loss monitors (BLM) signals in a variety of fashions which can be used to diagnose where and when losses are occurring, and can be used to see the pulse-to-pulse variation of the losses. Some desirable views are:

1) A display of many beam loss monitor signals throughout a pulse (1 signal per turn per BLM).
2) A high frequency (~10 nsec interval) display of a single BLM for a smaller range of turns (~ 10 turns)
3) A continual pulse-to-pulse updated display of specified BLM signals, averaged over the entire turn.
4) A continual pulse-to-pulse updated display of specified BLM signals, at a specified turn.

The BLM information may also be used in conjunction with other applications in presently unforseen ways. So it will be useful to also have the signals described below available for the "instrumentation" mode pulse as well as the normal operational modes, to facilitate correlation with other instrumentation data.

Epics Data Get Requirements:
- Data data gets from the control system
- Average BLM signal per turn for the entire pulse.
- Fast BLM signal at sub-turn intervals (20 nsec)
- Time Synchronization of data gets – BLM data can be verifiably from the same pulse.

Epics Data Put Requirements:
None

Model Requirements:
- None

Mathematical methods:
- None

Data Base Requirements:
- Provide a list of the names of the fast BLMs

Sequence Type
- Nominal operation (50 mA, up to 1500 μsec) and
- Instrumentation mode (50 mA, 20-100 μsec)

Injection, Orbit Bump

Description:

Input the desired closed orbit injection bump trajectory (horizontal and vertical). This requires setting the time dependent field profiles to the injection fast bump (kicker) magnets. These fields need to be calculated based on input specifying the desired closed orbit bump position during the injection period. It is also necessary that the sum of all bends introduced by the kickers be zero.

Epics Data Get Requirements:

Epics Data Put Requirements:

- Field setpoints at ~ 4 breakpoints during injection for each of the 4 horizontal and 4 vertical kickers.
- Time Synchronization issues of data puts. : none

Model Requirements:

- Calculate the required field per kicker to give the desired closed orbit offset at the foil for each breakpoint, and with no net angle introduced.
- Existing codes (UAL, MAD, Teapot) can provide the functionality.

Mathematical methods:

- none.

Data Base Requirements:

- Provide a list of the names of the magnets, and other accelerator elements within the injection system
- Provide magnet measurement data for the injection magnets.
- Provide positions of all the bump magnets.

Sequence type:

NA

Injection, HEBT-ring optics matching

Description:

The twiss parameters of the HEBT beam at the foil need to be adjustable. It may be desirable to match to the ring twiss parameters, so the ring twiss parameters at the foil should be displayed. The application should accept input twiss parameters for the HEBT beam at the foil, and send appropriate new field setpoints to quads in the HEBT line. In particular, adjustment of the vertical and horizontal alpha and beta twiss parameters are required, while keeping the dispersion at the foil zero. The last eight HEBT quad values are available for this task.

Epics Data Get Requirements:

- Field set points of all magnets in the HEBT, the field setpoints of all magnets in the ring.
- The ion source intensity (bunch intensity is needed).
- Ensure all data is from the same pulse.

Epics Data Put Requirements:

- Field setpoints for the last eight quads in the HEBT
- Time Synchronization issues of data puts - none

Model Requirements:

- Calculate the twiss parameters (with space charge) at the foil the HEBT and ring beamlines.
- Existing codes (UAL, MAD, Teapot) can provide the functionality for the Ring lattice twiss information. T3D can provide the functionality for the HEBT line twiss parameters.

Mathematical methods:

- none.

Data Base Requirements:

- Provide a list of the names of the magnets, and other accelerator elements within the HEBT and Ring lattices.
- Provide magnet measurement data for the HEBT and ring lattices. (Not needed if in the IOC handles this)

Sequence type

NA

Turn-by turn Orbit Report

Description:

Display the beam position for an arbitrary turn range of a given macro pulse. The macro-pulse will be specified by the mode type. A buffer of several pulses should be provided for optional comparison purposes.

Epics Data Get Requirements:

- N turns * 192 BPM signals (48 H and 48 V sum and difference records). N could be up to 1500 turns
- Time Synchronization of data gets: All the BPM gets should be for the same macro-pulse, and identifiable by turn.

Epics Data Put Requirements:

- none

Model Requirements:

- None.

Mathematical methods:

- none

Data Base Requirements:

- Provide a list of the names of the ring BPMs.

Sequence Type

50 mA, 20-1500 μsec

Global Closed Orbit Correction

Description:

Determine the ring closed orbit for a beam injected on axis and calculate the corrector magnet currents needed to minimize closed orbit perturbations. First the injection bump and kicker magnets should be turned off, and the HEBT beam aimed on axis. Then a single turn pulse is injected in the ring, and BPM signals are averaged over several turns (~10) to provide a closed orbit positions. Corrector currents are calculated to minimize the closed orbit perturbations.

Epics Data Get Requirements:

- ~ 48 quad + 32 dipole + ~100 corrector + 11 bump/kicker magnet readbacks, to get the magnet data + BPM signals averaged over 10 turns (48 H and 48 V sum and difference records).
- Time synchronization of data gets: All magnet readbacks should be at the same time, and correspond to the macropulse when the BPM data is taken (esp. need to verify that the bump magnets are off).

Epics Data Put Requirements:

- Number of data puts to the control system: 24 H + 24 V small dipole corrector current setpoints.
- Time Synchronization issues of data puts: Ensure all magnet setpoint changes are complete before verifying the updated closed orbit setting.
-

Model Requirements:

- Model required input from control system: magnet power supply readbacks
- Model output to the application: revised dipole corrector power supply setpoints to minimize the closed orbit distortion.
- Existing codes: MAD, Teapot can provide the required functionality.

Mathematical methods:

- SVD

Data Base Requirements:

- Provide a list of the names of the magnet power supplies in ring and BPMs.

Sequence Type

Full Current (50 mA), single turn (~ 1 μsec) pulse.

Tune measurement (a)

Description:

The machine tune can be determined by injecting a low intensity beam on axis, pinging it (i.e. give a small dipole kick to a small fraction of the circulating beam), and monitoring the beam postion at a prescribed BPM for several hundred turns. This stream of difference data can be FFT'd to get the tune and spread (i.e. centroid and width of the main FFT signal). The machine should be static during this time (e.g. bump magnets have no time varying fields). The closed orbit should be corrected prior to running this application. A single turn injection is sufficient, provided the BPM's can read this signal. Otherwise several injected turns should be used.

The sequence mode should allow the injection of a few turns, and also be configured to fire the pinger some interval after the injection occurs.

Epics Data Get Requirements:

- Difference and sum signals from a prescribed BPM for several hundred turns, at the minimum interval possible (1/16 turn ?)
- Time Synchronization of data gets: The beam position measurements should be available on a turn by turn basis. Need to verify this is after the pinger fires.
- Signal that indicates that the pinger fired, and tells when it fired relative to the start of the injection.

Epics Data Put Requirements:

- Data puts. : none

Model Requirements:

- None.

Mathematical methods:

- FFT.

Data Base Requirements:

- Provide a list of the names of the magnets within the ring and BPMs in ring.

Sequence type:

- Short pulse (1-10 turns), full intensity (50 mA), with a pinger pulse after injection.

Tune measurement, twiss estimate (b)

Description:

The measured machine tune can also be determined by injecting a single turn beam pulse off axis, monitoring the beam position as it oscillates around the machine for several turns, and fitting to a sine wave. The beam pulse length should only one turn. This application will need several turns of BPM information, and the machine should be static during this time (e.g. bump magnets have no time varying fields). The BPM signals should be available on a turn by turn basis for up to 100 turns. The closed orbit offset from the HEBT beam (at the foil) should be known (from the BPM signal in the quad in the middle of the injection chicane), to check the magnitude of the measured oscillation. This information can be used to check the realtive twiss parameters at the BPM positions (i.e. beta).

The closed orbit correction should be run prior to running this application, to minimize orbit fluctuations.

Epics Data Get Requirements:
- The beam position will be determined from ~ 48 BPMs around the ring, with 2 sum and 2 difference signals per BPM. The signal should be available per turn for ~100 turns.
- The beam position and angle at the foil should also be provided (last 2 BPM signals from the transfer line, before the foil or profile monitor).
- All BPM signals need to be verifiably from the same pulse, and the turn by turn signal is also needed.

Epics Data Put Requirements:
- Number of data puts to the control system: ring injection bump magnet set points.
- Time Synchronization issues of data puts. : none

Model Requirements:
- none

Mathematical methods:
- Trig fit for tune.

Data Base Requirements:
- Provide a list of the names of the magnets within the ring and BPMs in ring and transfer line.

Sequence type:

Short pulse: single turn injection of the ring, single turn, full intensity (50 mA)

Twiss measurement
(with individual quad windings)

Description:

The measured machine beta values can be determined by injecting a low intensity beam on axis, pinging it (i.e. give a small dipole kick to a small fraction of the circulating beam), and monitoring the beam postion at a prescribed BPM for several hundred turns. The stream of BPM difference data can be FFT'd to get the tune and spread (i.e. width of the main FFT signal). The machine should be static during this time (e.g. bump magnets have no time varying fields). The closed orbit should be corrected prior to running this application. A single turn injection is sufficient, provided the BPM's can read this signal. Otherwise several injected turns should be used.

Epics Data Get Requirements:

- The beam position will be determined from a prescribed BPM for several hundred turns.
- Signal from the pinger indicating that it fired (and when)
- Time Synchronization of data gets: The beam position measurements should be available on a turn by turn basis. Need to verify this pulse is the one when the pinger fires and get the turn when the pinger fired.

Epics Data Put Requirements:

- Signal to fire the pinger near the start of the injection.
- Time Synchronization issues of data puts. : none

Model Requirements:

- None.

Mathematical methods:

- FFT.

Data Base Requirements:

- Provide a list of the names of the magnets within the ring and BPMs in ring. Also need the pinger signal name.

Sequence Type

- Short pulse (1-10 turns as described above). High intensity (50 mA).

Twiss measurement
(with individual correctors)

Description:

The measured machine beta values can be determined by injecting a low intensity beam on axis and noting the change in the closed orbit at a BPM, by the introduction of an additional kick from the adjacent corrector. The change in the closed orbit position is proportional to the kick strength, the beta and cot(ν), where ν is the phase advance/turn. It is assumed that the closed orbit correction has been previously run, as well as the tune measurement (or else these are repeated in this application). The initial beam position at the BPM is found by averaging a single turn injected beam (on axis), over a few hundred turns. This position is stored. Then the corrector strength is changed and verified. Then the position at the BPM is found again (as described above). The difference in position is used (with the tune and prescribed corrector strength) to calculate the beta value.

Epics Data Get Requirements:

- The beam position will be determined from a prescribed BPM for several hundred turns.
- The corrector strengths need to be provided.
- The beam position measurements should be available on a turn by turn basis (or averaged over the prescribed number of turns) .
- Time synchronization: Need to verify that all the BPM signals are from the same pulse. Also need to verify the second set of BPM data is from a time after the corrector was changed.

Epics Data Put Requirements:

- Input the corrector strength
- Time Synchronization issues of data puts. : none

Model Requirements:

- None.

Mathematical methods:

- none

Data Base Requirements:

- Provide a list of the names of the magnets within the ring and BPMs in ring.

Sequence type

- Single turn, full intensity beam (~50 mA).

Extraction, RTBT-ring optics matching

Description:

The twiss parameters of the RTBT beam at the Lambertson septum need to be matched to the ring twiss parameters, so the ring twiss parameters at the start of the RTBT should be displayed. The application should accept input twiss parameters for the RTBT at the septum, and send appropriate new current setpoints to quads in the RTBT line. There are 8 adjustable quad power supplies between the RTBT start and the 16.8^o bend. There are 6 adjustable quad power supplies between the 16.8^o bend and the end of the RTBT, and there are 3 adjustable quad power supplies at the end of the RTBT. Constraints in setting quad levels are: (a) keep the horizontal phase advance between the septum and 16.8^o bend = 540^o (achromat), (b) keep the phase advance from kicker to target a multiple of 180^o (kicker failure protection) and (c) keep the beam on target (beta) and approaching parallel (alpha = 0). The target beam size should have an input capability incase this needs to be iterated (using loss monitors). The changes introduced in the field setpoints should be verified before proceeding with additional beam pulses.

This program will be run during machine setup (short pulse), but it may also be desirable to be used during operation (full 1000 turn pulse) . So the beam intensity seen by the BPMs may be different.

Epics Data Get Requirements:

- BPM difference signals along the RTBT
- Profile monitor ???
- Time Synchronization issues of data gets: BPM data should be from the same macro-pulse, and verifiable that this pulse is after the RTBT magnet settings are modified.

Epics Data Put Requirements:

- Field set points of all magnets in the RTBT, the current setpoints of all magnets in the ring. (need to be more specific)
- Input the ion source intensity (bunch intensity is needed).
- Time Synchronization issues of data puts. : none

Model Requirements:

- Calculate the ring twiss parameters (with space charge) at the RTBT septum (RTBT line and ring). Existing codes (UAL, MAD, Teapot) can provide the functionality for the Ring lattice twiss information. .
- Calculate the phase advance and twiss parameters throughout the RTBT. Trace-3D can provide the functionality for the RTBT line twiss parameters.
- Window scattering effects may also be needed to calculate the beam on target.

Mathematical methods:

- none.

Data Base Requirements:

- Provide a list of the names of the magnets, and other accelerator elements within the RTBT and Ring lattices..
- Provide the target position and size.

Sequence Type:

- Full intensity (50 mA), short pulse (20-100 μsec) , and
- Nominal operation (50 mA, 1000 μsec).