Booster and PAR Upgrades and Enhancements

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Priority

- Near Term (2003):
  - Most technical issues solved.
  - Costs may not be known.
- Mid Term (2004)
  - May need to so some R&D, some aspects unknown
  - No budget known
- Long Term (>2004)
  - More difficult projects.

Improvements Not Covered

- Software - i.e. Simulations, scripts required etc.
- Procedure development needed
- Operations modes being commissioned (ie. Direct injection as a backup to PAR)

Information Presented on Improvements

- Benefits.
- What progress as been done so far.
- New components.
- Specifications.
- What still needs to be done.
- What are the unknown aspects

QF and QD Current Transductor Upgrade

- Purpose
  - Measure and correct booster quad supplies for I > 600 A
  - Commission booster low emittance lattices
- Status (near term)
  - Completed
  - Used to commission 109 and 92 nm emittance lattice (standard lattice 132 nm).

New Booster Extraction Septum Spare

- Purpose
  - Have a spare B:ES1 with "core out of vacuum" septum
  - New septum spare is more reliable (replacement is simpler due to out of vacuum design, thermal drift may be smaller)
- Status (near term)
  - Magnet measurements need to be completed
  - Mechanical preparation
  - Evaluate this septum for installation this year if its thermal drift is much better than the existing B:ES1

LTP BESOCM Upgrade

- Purpose
  - Allows averaging over 60 seconds worth of pulses (integration time can be extended this far)
  - Should be much less susceptible to noise (presently hard wired to trip at 1.3 nC/pulse based on PAR SAD)
- Status (near term)
  - Mechanical support needed (Design of new housing and supports for BESOCM transformer T. Pietryla)
  - Plan is to install in April shutdown

Preventative Maintenance

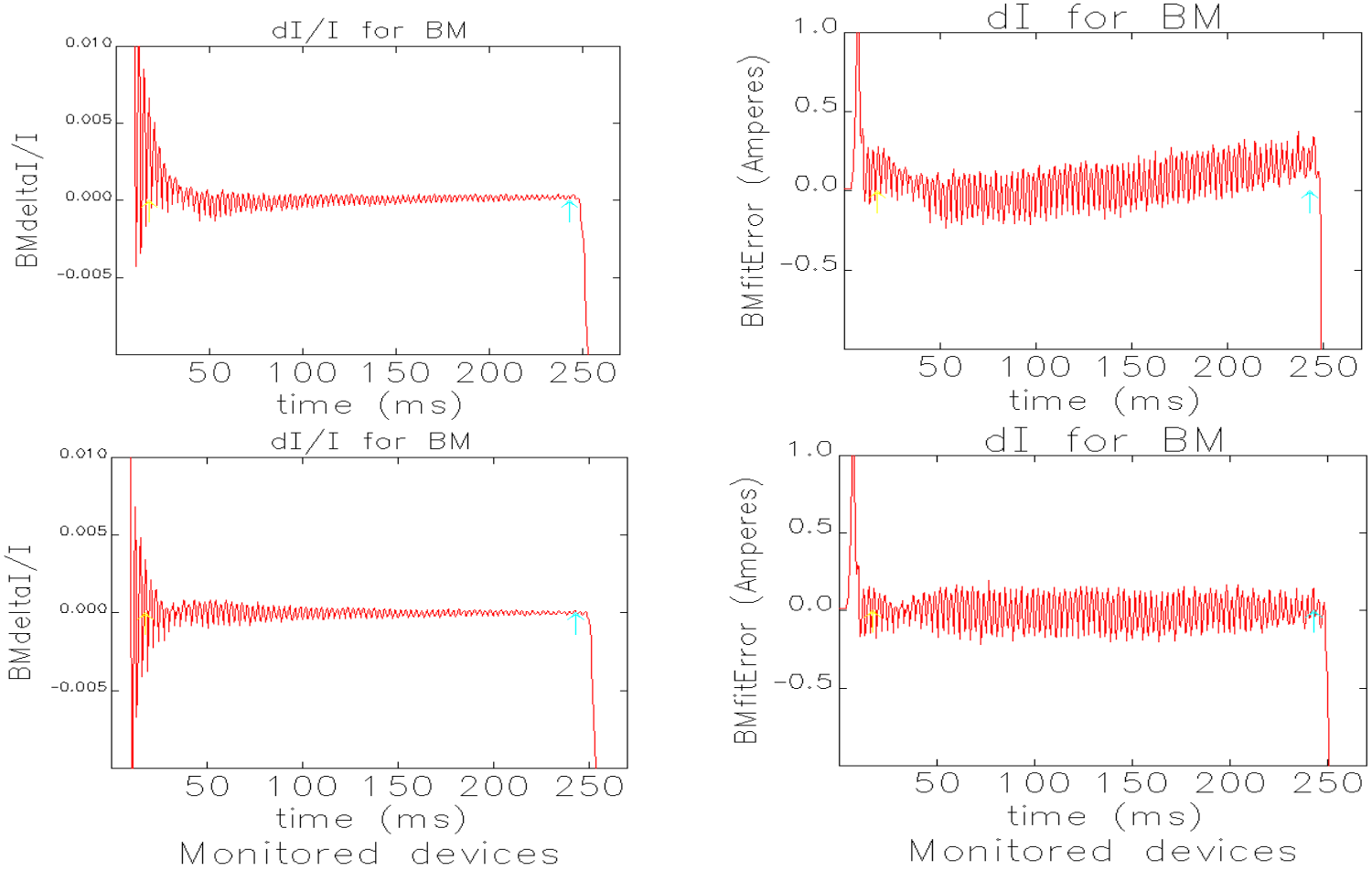
- Purpose: Anticipate minor problems that could crop up due to maintenance
  - Radiation damage to PAR H20 hoses
  - Grounding issues with PAR kickers/LTP Besocm
- Status (near term)
  - Address this during this year's shutdowns

Upgrade Current Regulation for Booster Main Ramped Supplies

- Purpose: Upgrade is for linear operations ramps
  - Dipole and quadrupole supply current drifts with line voltage (SR standardization, RF system power changes)
  - Injection inefficiency caused mostly by dipole supply
- Status (near term):
  - Current regulators exist
  - Can existing current regulators be used to close the loop with existing magnet ramps?
  - Perhaps easier to put existing software feedback correction in IOC (correction algorithm + Bcontrol)

Dipole Current Errors

- Relative and absolute errors for BM:



Implement Booster Corrector IOC Ramp table Loading

- Purpose: Speed ramp table calculation and loading for faster orbit correction
  - Controllaws operate at a specific ramp time (ie injection/extraction and in between)
  - IOC takes care of updating ramp tables when a current change is sent
- Status: (near term)
  - Controls software changes required
  - Hardware changes?

Booster BPM Timing

- Purpose: Configure booster bpm timing individually instead of in groups of 8 bpms.
- Benefits: Allow configuration of bpms for specific purposes (transverse/longitudinal injection controllaws, extraction bump correction, mid ramp orbit correction)
- Status (mid term)
- Components: Requires new timing card for each bpm

Booster BPM Beam History Upgrade

- Purpose: Most beam histories don't work
  - Two used presently for longitudinal injection controllaw
  - Other applications include betatron tune measurement, instability studies.
- Status (Near to mid term)
  - Planned BH upgrade for SR
  - Can we upgrade booster BH at the same time?

Upgrade PB, PTB Booster Injection Point BPMs for Single Shot

- Purpose: Control beam trajectory for direct injection using RF guns and PC gun
  - Eliminate use of booster injection point bpm SCDU/MS modules for PB and BB (require 4 shots minimum to update x and y readings)
  - Have capability to switch booster injection point bpms (5) between SCDU/MS mode and single shot
- Status: (Mid term)
- Components: Circuit design, booster injection point bpm switch needed

Upgrade PB, PTB Booster Injection Point BPMs for Single Shot cont.

- Unknown: How well do booster button bpms work with single shot 10 ns S-Band pulses from rf guns?

Booster Tune Measurement/Bunch Cleaning System Upgrade

- Purpose :
  - Bunch cleaning at injection (< 3 GeV) needed for direct injection/subharmonic capture to insure bunch purity
  - Dedicated dsp based tune measurement will eliminate the need for VSA/extraction kicker pinger system
- Status (Near to Mid term)
  - Bunch cleaning demonstrated in studies but inefficient (only keep single 352 MHz bucket out of 10 ns rf gun pulse)
  - Integrate tune measurement/bunch cleaning systems

Booster Tune Measurement/Bunch Cleaning System Upgrade

- Components:
  - Low level prototype rf switch and controls exist for bunch cleaning
  - Need two 100 W, 352 MHz cf, 10 MHz BW amplifiers for bunch cleaning
  - Need four 25 -50 W 352 MHz cf, 10 MHz BW amplifiers for tune measurement
  - Need to ramp the drive power for tune measurement amplifiers (use spare AFGs)

Realign Booster

- Purpose: Compensate for rf drive frequency changes
  - Improve horizontal BPM response linearity
  - Eliminate large displacement in sextupoles (improve lattice linearity)
  - Need to shorten circumference by 1.84 cm after all decker distortions are in place
- Status: (Long term)
- Unknown: Can the vacuum chambers be moved the same amount as the magnets?

Implement an Independent RF Source for Booster

- Purpose: Run the booster independent of SR
  - Can do measurements as a function of frequency (chromaticity, dispersion)
  - Useful to have an independent rf source for subharmonic capture commissioning
- Status (Near to mid term)
- Unknown aspects:
  - Timing/controls modification/P0 timing. Need to inject into same SR buckets
  - Switch without dumping beam

Rapid Waveguide Switch for Booster RF

- Purpose: Rapidly switch between RF5 and RF3
- Status (near term)
  - Presently shutter R&D ongoing between rf group and vendor for shutter
  - ACIS modification required (chassis, key switch)
  - Install during a shutdown this year

Finish Booster Subharmonic Capture Design

- Purpose: Efficient direct injection from linac to booster (LS-297)
  - Capture rf gun beams up to 10 nC/pulse 2 Hz (8-10 ns 0.5 % total energy spread)
  - Removes PAR from absolutely required to a backup machine
- Status (Long term to build and fully commission)
  - Short term: Test new elegant RFMODE element that has improved simulation of rf cavity tuning
  - Work with RF group on a design of a 6^{th} Subharmonic capture cavity (58 MHz, 400 kV, LS-26, LS-28)

Commission Fast Ferrite Tuner

- Purpose: Rapidly tune 352 MHz booster rf cavities for subharmonic capture project
  - Improve transient beam loading at injection for top-up operations (presently just detune a constant amount)
  - The exact tuning/voltage ramp for 352 MHz system for subharmonic capture is critical for bunch purity
  - Has SR rf cavity application
- Status: (Near term) Presently being studied by rf group

Commission Fast Ferrite Tuner cont.

- Unknowns:
  - Achievable tuner bandwidth (5 - 10 kHz)
  - Need to test with spare booster 352 MHz cavity and evaluate tuner bandwidth and resonant frequency tuning range

Upgrade PAR Kickers

- Purpose: Allow PAR to operate at its design energy of 450 MeV
  - Booster dipole has much better current regulation when injecting at 450 MeV (factor of ~2 in dI/I)
  - PAR needs to be a robust backup for subharmonic capture/rf guns for at least the next few years
  - Faster damping would allow more flexibility tuning 12^{th} harmonic for bunch purity
  - Future PAR experiments can take advantage of full design energy
  - Allows LEUTL to interleave at up to 450 MeV while not changing PCGun charge (~0.5-1 nC)
- Status: Deferred Nov 2001 (ASD spec 2001-021)

Upgrade PAR Kickers cont

- Unknowns:
  - Fundamental and 12 harmonic system performance needs to be benchmarked and re-evaluated for 400 - 450 MeV operation (design peak gap voltage is 40 kV for fundamental and 30 kV for 12^{th} harmonic rf)
  - At < 400 MeV lose linac redundancy where injectors can fill SR without L4 or L5. Exact energy depends on L2, L4 and L5 performance and bunching chicane position

BTS Transport Line Upgrade

- Purpose: Modify BTS line, and add three screens in order to make emittance/beta function measurement and do optics matching
  - Fewer systematic errors compared to quad scan method
  - Matching will be more important due to reduced SR vertical acceptance from long straight sections
  - Matching will be important for future SR low emittance lattices <1 nm
  - Will allow experimental matching into SR lattices when using different booster lattices

BTS Transport Line Upgrade cont.

  - Idea has been implemented in the linac after the bunch compressor and in the PAR bypass line

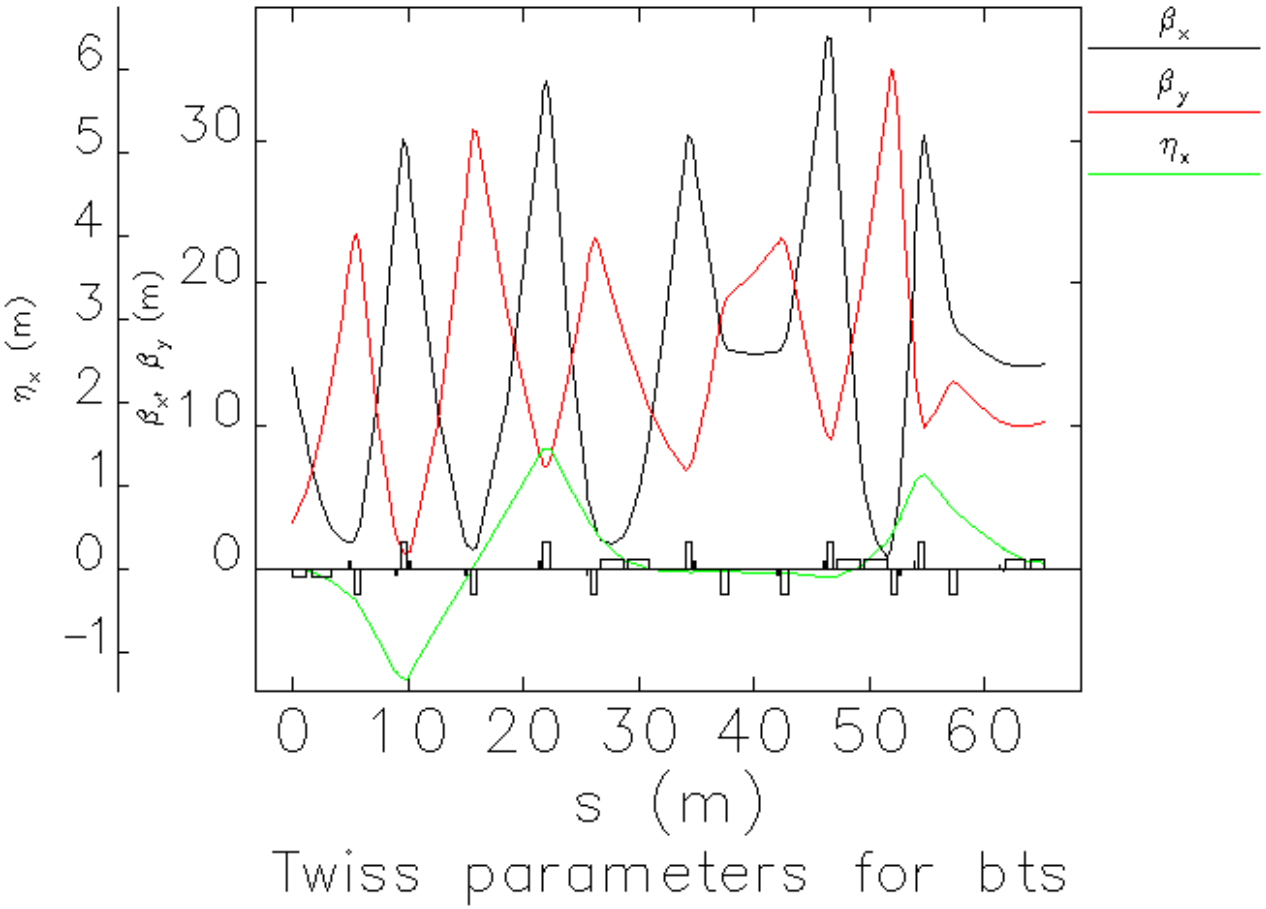
- Status: (Mid to Long term) Presently in the design phase

BTS Transport Line Upgrade cont.

- New components: 5 quadrupoles, 3 high-resolution screens, perhaps OTR screens, more steering magnets (1 spare BTS quad exists, possibly 3 spare coil sets for 3 BTS magnets, 3 spare booster quadrupoles)
- Be able to compensate for loss of a single (or more) quadrupoles

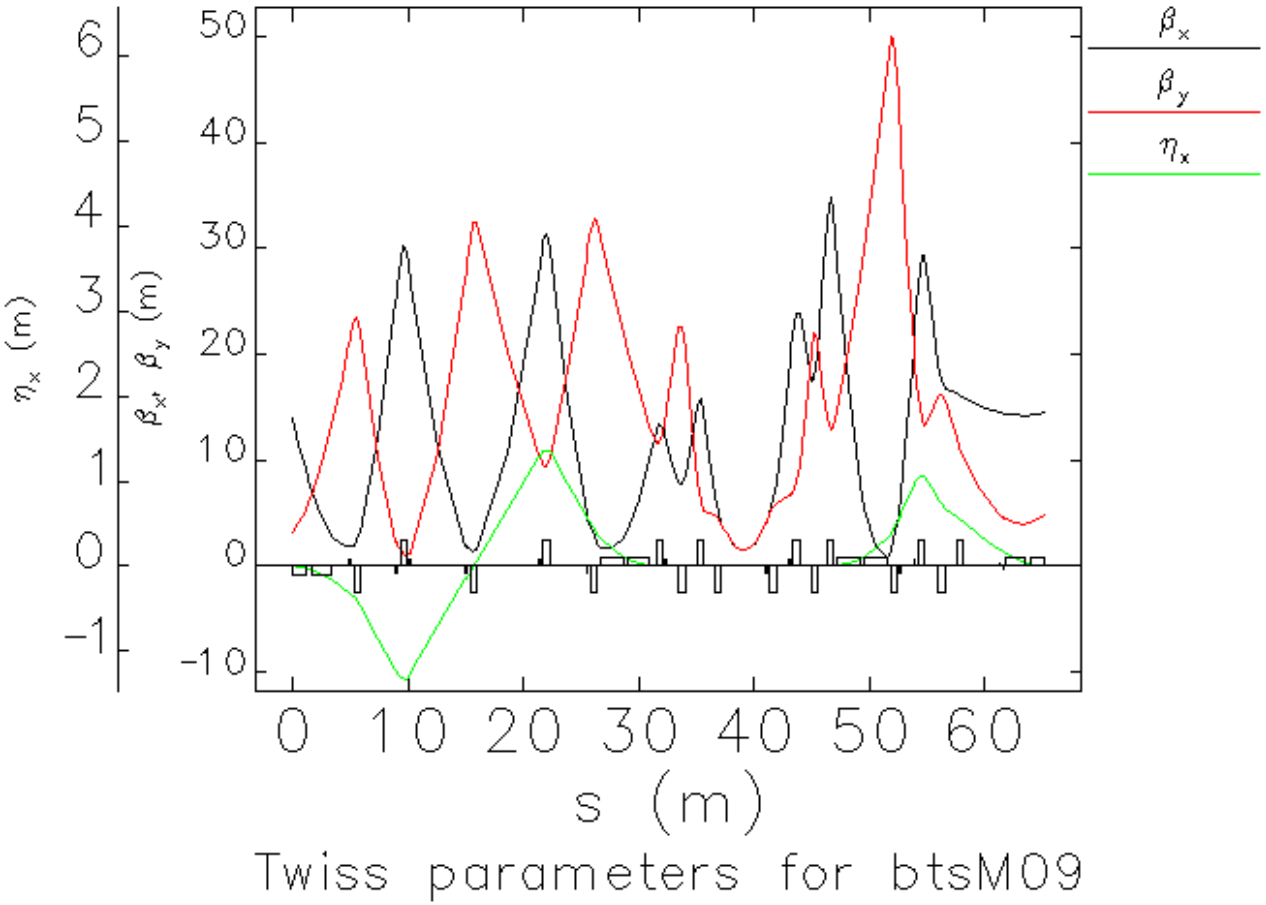
Three-Screen Diagnostics System in BTS (standard BTS lattice)

Original



Three-Screen Diagnostics System in BTS (upgrade lattice)

Three screens



Three-Screen Diagnostics System in BTS (cont'd)

- Specifications:
  - Resolution for screens is around 10 μm and possibly lower for the center screen (Driven by small vertical spot sizes ~50 μm)
  - Remeasure new quads as well as all quads downstream of second dipole since these will be used for matching
  - High charge (YAG vs OTR ? depends on charge)

Accumulate Beam in Booster

- Purpose: Achieve more uniform top-up by filling many SR bunches at once (5 - 10)
- Status (Long term)
- New Components:
  - Kicker bump at B:IS
  - Redesign of booster lattice at B:IS as well as PTB lattice to make room for new kickers
  - Need to redesign booster ramped PS to allow current control for arbitrary ramps with porches (within limits).

Accumulate Beam in Booster cont.

- Other considerations:
  - Reduce requirements on main ramped supply current regulation by going to 1 Hz (or lower) operation
  - As an example, with 58 MHz (6^{th} subharmonic) capture, the booster could be filled every 9^{th} bucket and fill 8 bunches and still preserve 153 ns bucket separation required for timing experiments
  - With PAR and only 352 MHz booster rf system any of 432 booster buckets could be filled
  - SR injection kickers and booster extraction kicker would need a longer ~ 1.2 μs flattop

Low Emittance Booster Lattice

- Purpose: Reduce the emittance to ~10 nm at 7 GeV
  - Ultra clean injection into future < 1 nm low emittance SR lattices with small dynamic aperture
  - Source of beam for testing undulators at high energy
  - Make the booster a light source in its own right (J. Lewellen)
- Status (Long Term)

Booster Low Emittance Lattice cont.

- New Components: Dipoles with gradients
  - New dipole design or modify existing dipoles (10 nm for improved SR injection.)
  - Skew quads to control coupling
  - Need completely new lattice for booster as a light source

Radiation Effects Facility in BTX Line

- Purpose: Study radiation damage effects on various materials using the 7 GeV booster beam
- Status (Long Term)
  - Completed basic physics design of new BTX transport line positioned immediately upstream of the booster beam dump
- New Components required:
  - 3 BTS quadrupoles
  - 2 new pulsed dipoles 0.5 T, 0.1 m
  - 2 bpms 2 flags
  - 1 BTS type current monitor