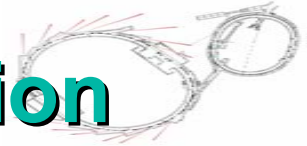
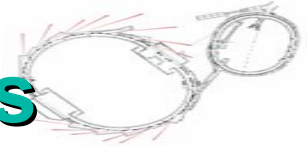


3 GeV Injector and BTS Operation



- **Injector improvements**
 - ↳ **Recent improvements**
 - ↳ **Future improvements**
- **3 GeV injector testing**
- **Radiation issues**
 - ↳ **BTS ACMs (SPEAR3 BSOICs, LIONs)**
 - ↳ **Monitoring of electron losses**
 - ↳ **Running modes – reducing injector radiation**
- **Injector efficiency**
- **BTS optics**
- **BTS final raft rebuild**

Recent injector improvements



○ Power supply upgrades

↳ White circuit bias and pulser

- ↳ H₂O-cooled SCRs
- ↳ New pulser transformer
- ↳ New regulation and interlock circuits

↳ B2-6 supply

- ↳ Cooling fans
- ↳ SCRs reconfigured
- ↳ New regulation and interlock circuits

↳ New booster quad trim supply

↳ New BTS quadrupole and B2-6 trim supplies

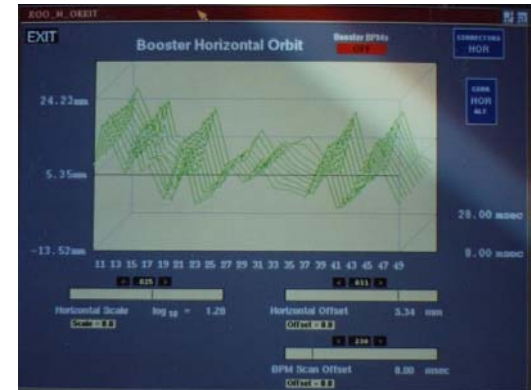
↳ New ejection septum supply

Recent injector improvements, 2



○ Diagnostics

- ↪ LTB BPMs improved
- ↪ Booster BPMs revived
- ↪ Phosphor screens and cameras improved
- ↪ Thermocouple monitoring



○ Replaced BTS steering magnets

○ Added BTS-C1H steering magnet

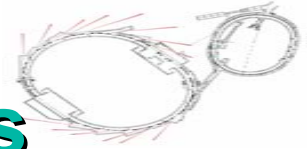
○ RF softstart

○ Reinforced cell chokes, booster quadrupole coils

○ Booster survey



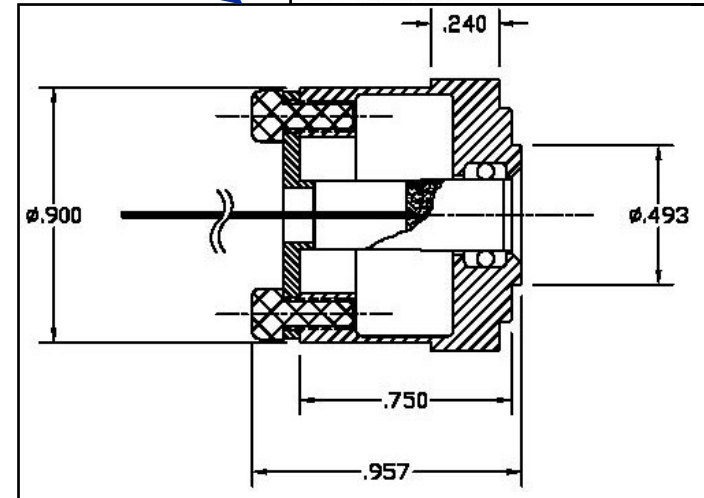
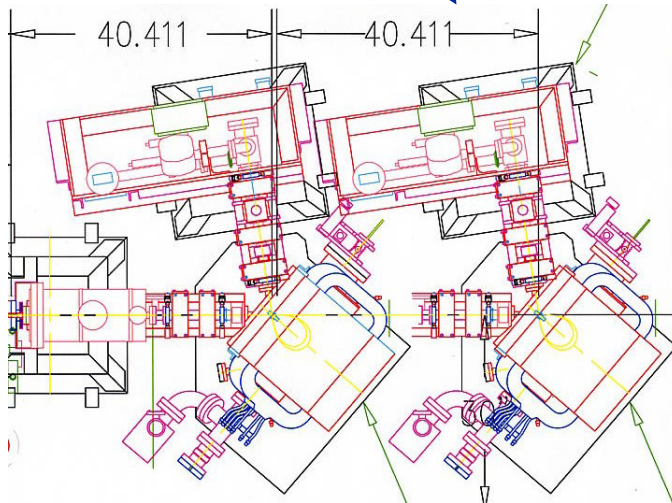
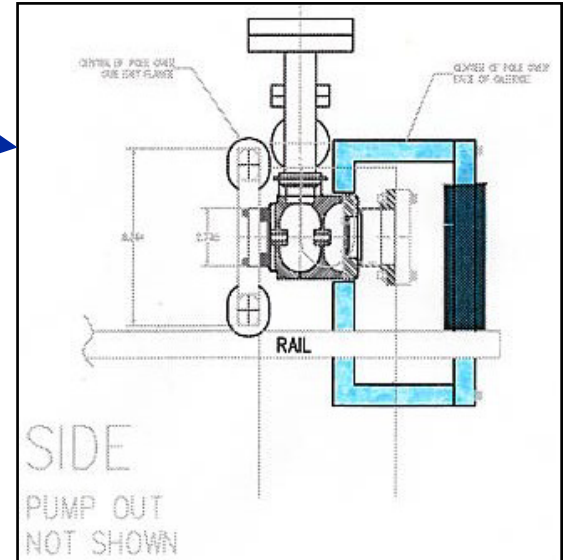
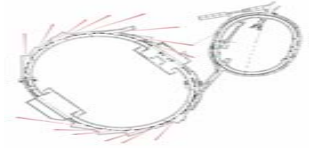
Future injector improvements



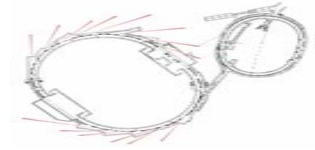
- **New rf frequency**
 - ↳ **358.533 → 358.518, closer to booster optimum frequency**
 - ↳ **Should improve longitudinal capture**
- **New gun cathode and cathode holder**
- **Pulsed signal diagnostics**
- **BTS BPMs, LTB BPM improvements**
- **Transport line standardization & orbit correction**
- **Agreement between setpoints and readbacks**
- **White circuit cell mis-match detector**
- **Injection and extraction kickers**
 - ↳ **New HVPS and control chassis (Sept., 2003)**
 - ↳ **New IGBT pulsers (FY2005)**

Gun cathode fixes

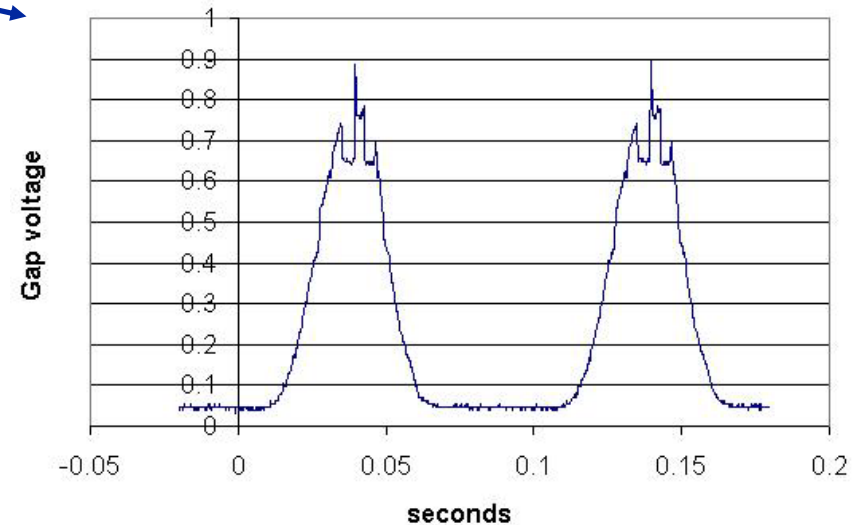
- Back bombardment suppression
- New cathode holder
- New cathode vendor
- 2nd online gun (long term)



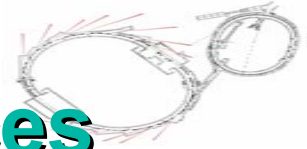
3 GeV injector testing



- **0.6 nA, 3 GeV to BTS Faraday cup (3/13/03)**
- **10 hours steady running (3/20/03)**
- **RF voltage sufficient** →
- **Issues to be addressed**
 - ↪ **Extraction kicker trips**
 - ↪ **Vibration mitigation**
 - ↖ **Pulse choke**
 - ↖ **Resistor banks**
 - ↪ **Charging choke temperature**



New radiation protection devices



○ **BTS ACMs**

- ↖ Trip level 0.5 nA (< 38 mA/min) now, 1.67 nA next year
- ↖ Extraction kicker noise must be reduced

○ **BSOICs**

- ↖ 17 BSOICs distributed outside SPEAR shielding wall
- ↖ Trip level 10 mrad/hr (calculations say 0.33 nA gives 100 mrad/hr)

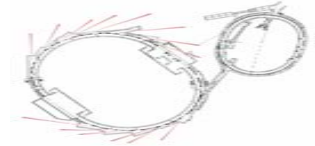
○ **LIONs**

- ↖ 4 cables, each covering ¼ of SPEAR tunnel
- ↖ Must be interlocked before outside users on floor

○ **Loss monitoring**

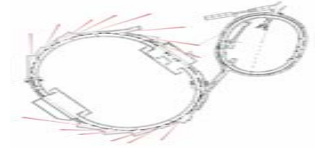
- ↖ Linac ACMs, booster Q-meter or BPMs (by 3/04), BTS ACMs & Faraday cup, and SPEAR injected beam logged in history to determine electron losses.

ALARA



- **Beamline floor will be locked off in December**
 - ↳ **BSOIC trip levels temporarily raised to 100 mrem/hr**
- **New shielding**
 - ↳ **Downstream of LTB-B1 screen**
 - ↳ **BTS septum and loss points along BTS**
 - ↳ **Booster – lead blocks between dipole coils G18, G36-43.**
- **1 Hz or 3 Hz chopper mode**
- **Minimize booster losses toward top of the ramp**
 - ↳ **Keep Copleys tuned**
 - ↳ **Minimize running booster with extraction kicker off**
 - ↳ **Mode used during injector startup with SPEAR in access**
 - ↳ **Promised < 20 hours/year**
- **Insert BTS Faraday cup when not injecting.**

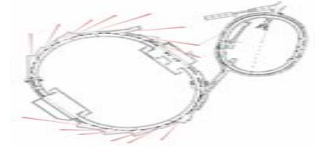
Standard operations



- **4 fills/day (3 top-off, 1 from zero current)**
- **Before injection**
 - ↳ **2 hours on LTB B1 screen**
 - ↳ **5 minutes on BTS Faraday cup**
- **After injection – 5 minutes on LTB B1 screen**
- **Otherwise beam to LTD Faraday cup (or beam off)**

SPEAR 3 3.0 GeV/500mA	120 <u>MeV</u> Beam LTB B1 4 x 2 hr	FARC 4x5 min	Injection 3x10 W-min top-up 1x30 W-min full fill	B1 4 x 5 min
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Injector efficiency



	3/8/2001	11/22/2002
LTD Faraday (mA/min)	230	
LTB BPM AU (mA/min)	212	131
Q-meter inj (mA/min)	183	100
Q-meter ext (mA/min)	100	66
BTS Faraday (mA/min)	46	45
SPEAR rate (mA/min)	20	22

Efficiencies:

booster injection	0.86	0.76
booster ramp	0.55	0.67
booster ejec/BTS	0.46	0.68
SPEAR injection	0.43	0.49

Longitudinal capture losses; difficult to improve.

3 GeV losses;

BTS optics/alignment problems?

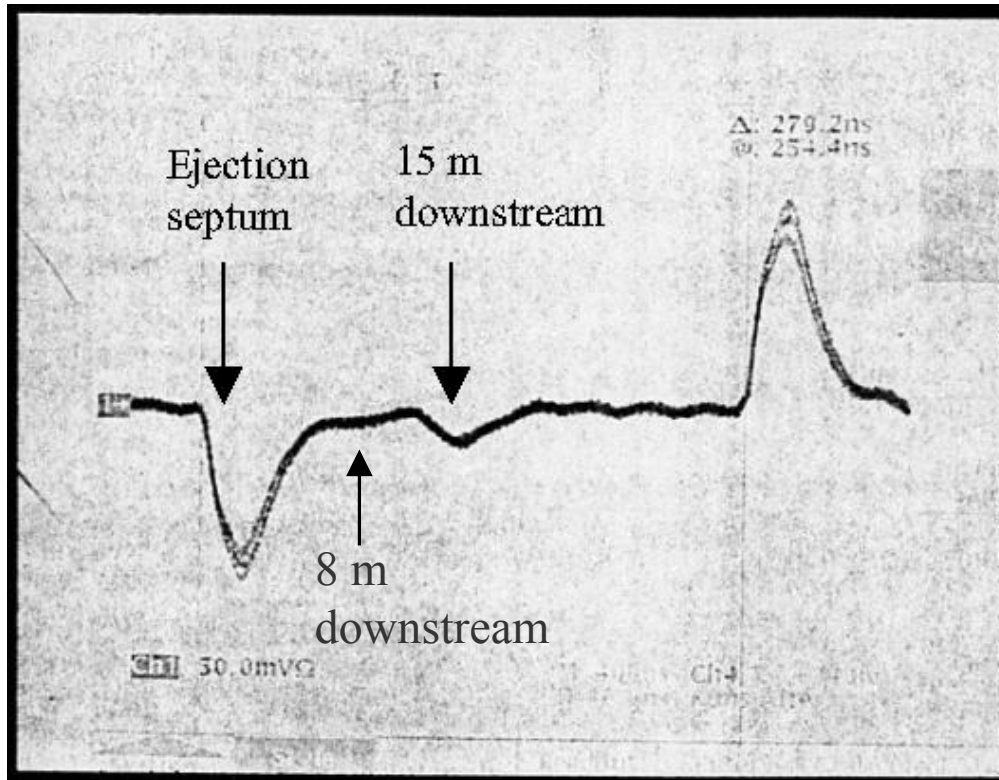
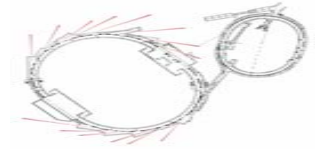
Anticipated beam loss for SPEAR3



Beam from linac	1.03 nA		
LTB/booster injection loss	14%		
First turn in booster	0.89 nA		
Booster capture loss	25%		
Beam ramped in booster	0.67 nA		
Booster extraction/BTS loss	50%		
Beam to SPEAR	0.33 nA	(1 Watt)	
SPEAR injection loss	25%		
SPEAR accumulation	0.25 nA	(19 mA/min)	

- **Table given to radiation physics committee**
- **Factor of 2 less beam in linac**
 - ↳ **BTS ACM limits beam**
 - ↳ **Improved efficiency in booster and SPEAR capture.**

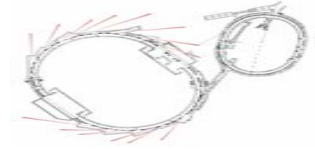
BTS losses



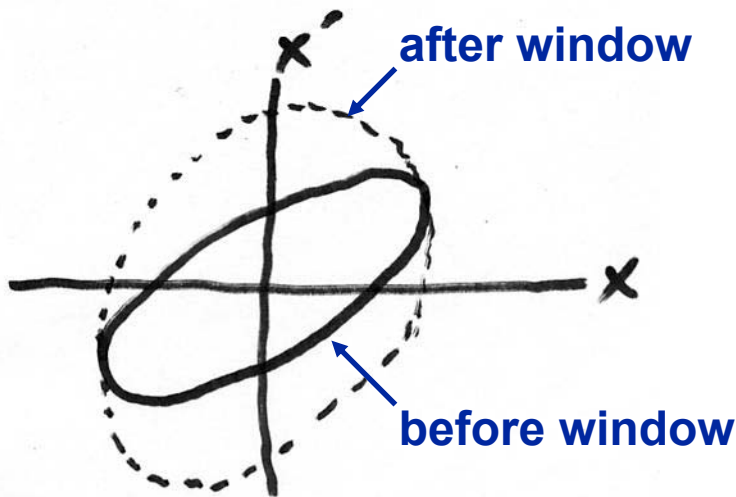
LION measurements of BTS losses.

- Further shielding added at loss points
- BTS-C1H added
- BTS realignment
- Improve optics understanding/control
 - ↳ BTS BPMs
 - ↳ Scattering in septa windows
 - ↳ Replace windows?

Scattering in BTS windows



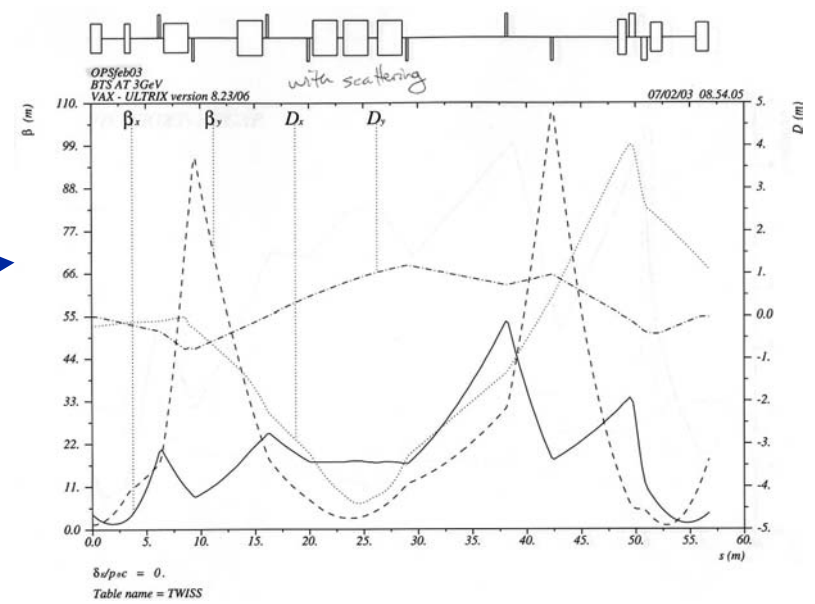
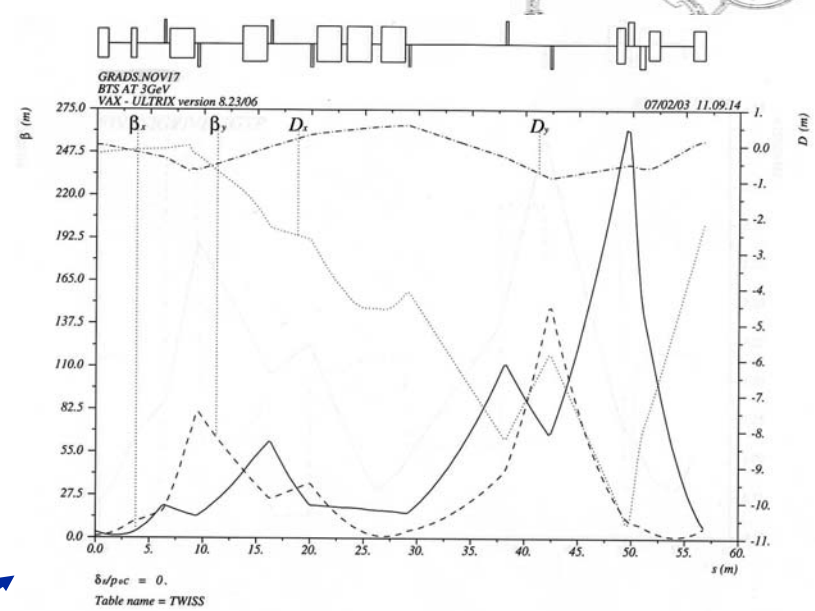
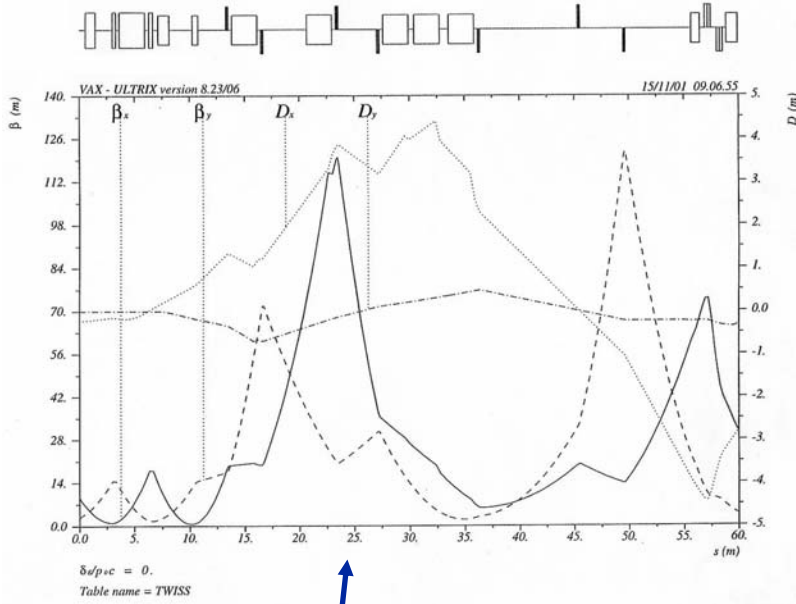
- **Windows add angular spread to beam**
- **Was not considered in original optics design**



2*1 mil stainless windows at extraction septum:

- ϵ_x : 96 \longrightarrow 243 nm
- β_x : 9.3 \longrightarrow 3.9 m
- α_y : -0.95 \longrightarrow +.004

BTS optics

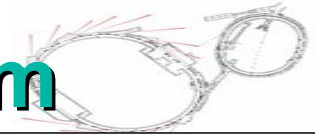


Original BTS design

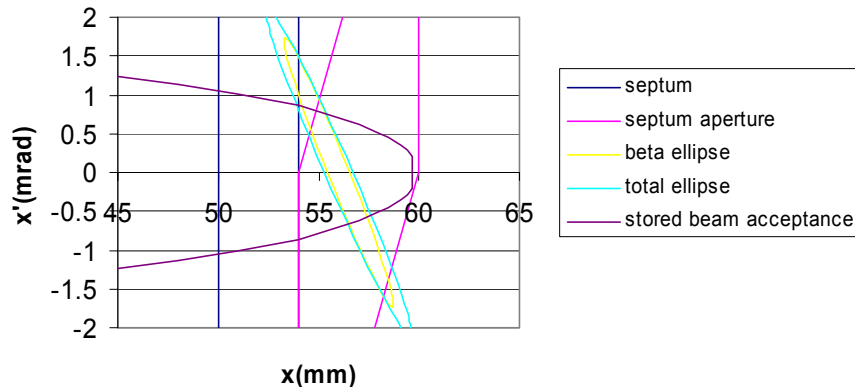
Original BTS design with scattering

What Ops. tweaked to

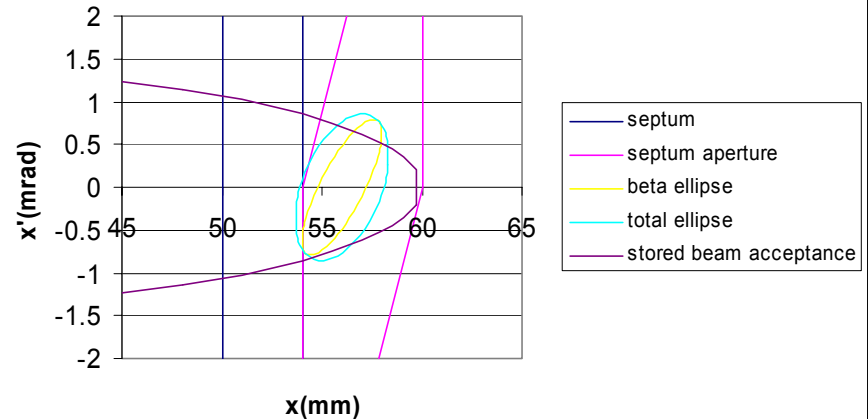
BTS optics at injection septum



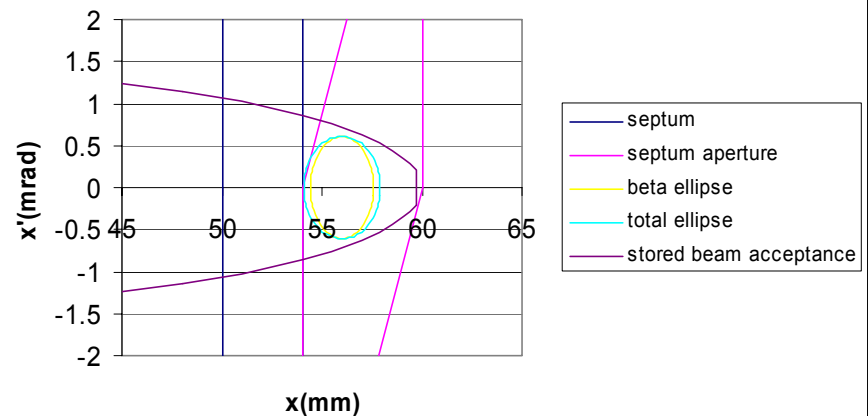
2 sigma ellipses, original design optics, scattering included



2 sigma ellipses, Ops. quad settings, 07feb03

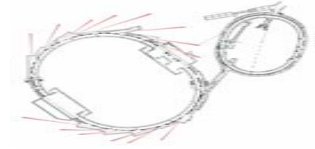


2 sigma ellipses, new design



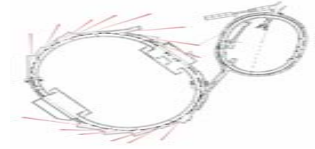
- Original design optics gave bad match at septum
- Operations tweaked to a better match
- The new design is better still

BTS optics, continued

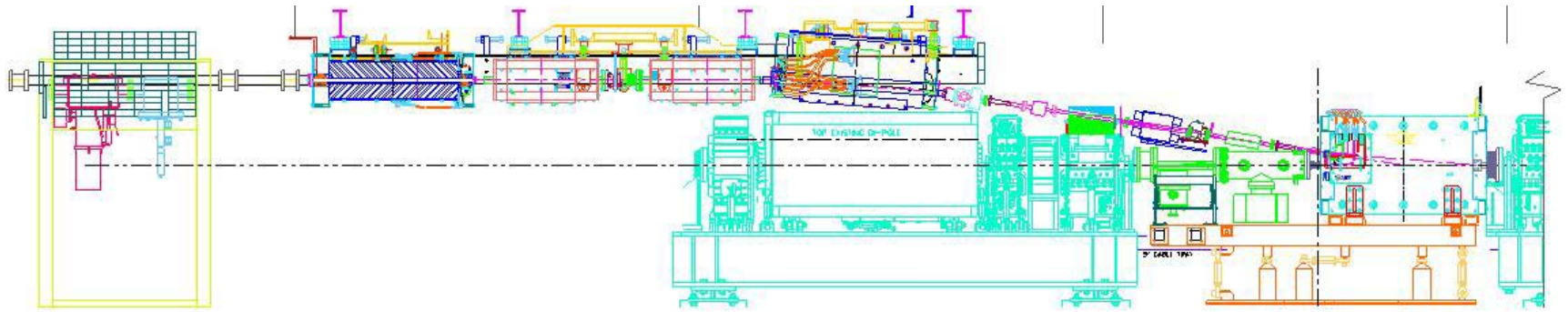


- **Original BTS optics design had errors.**
- **Operations found better solution by tweaking quads to minimize spot size on screens.**
- **Minimizing spot size on screens improved optics from initial erroneous design, but it does not give the best optics.**
- **Now that the BTS optics errors are understood, we can implement an improved design.**
- **Henceforth, when tuning the BTS, focus on steering and minimize quadrupole tweaking.**

Final BTS raft rebuild



- 3 GeV compatible
- New injection location (32 mm offset, was 58 mm)



STRAIGHT SECTION

