Two-stage bunch compressor and extraction lines design status

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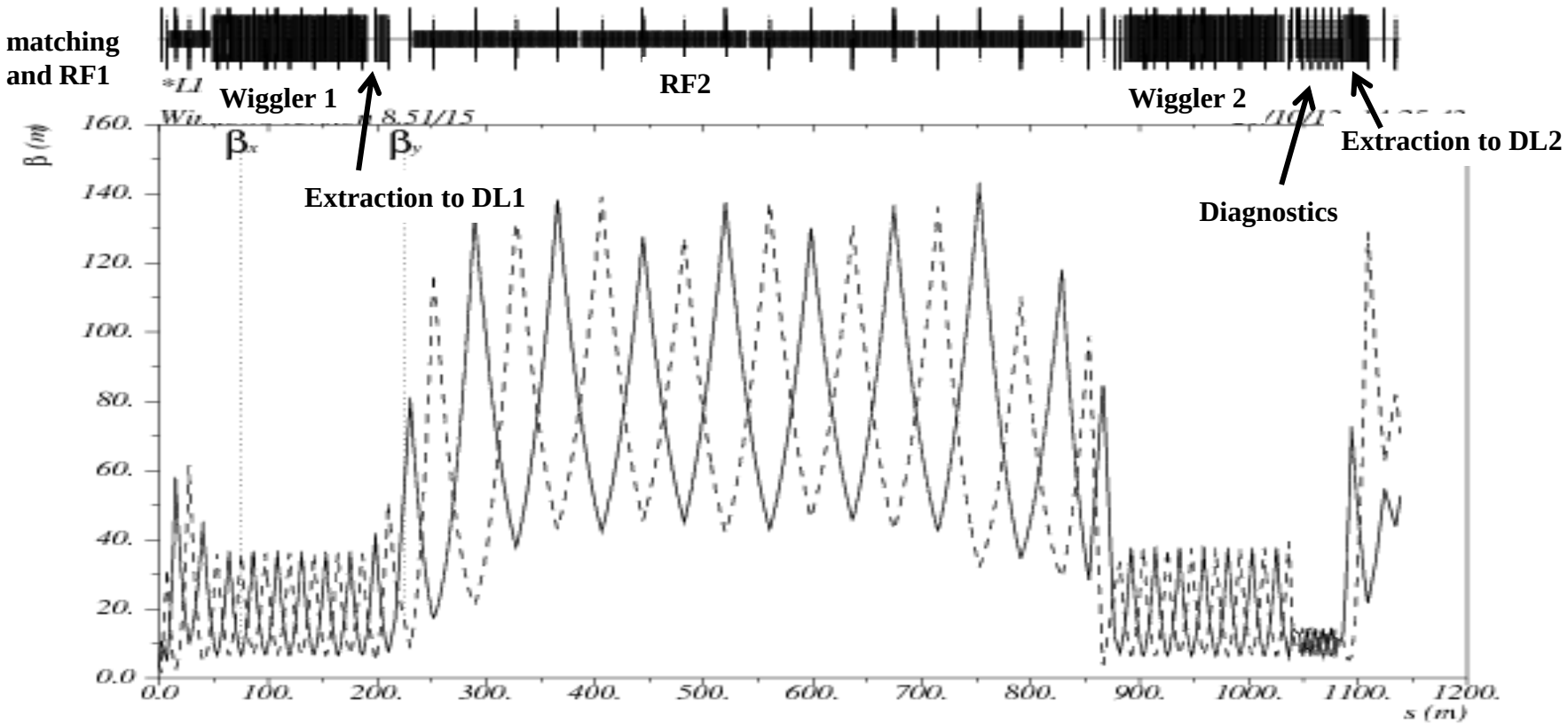
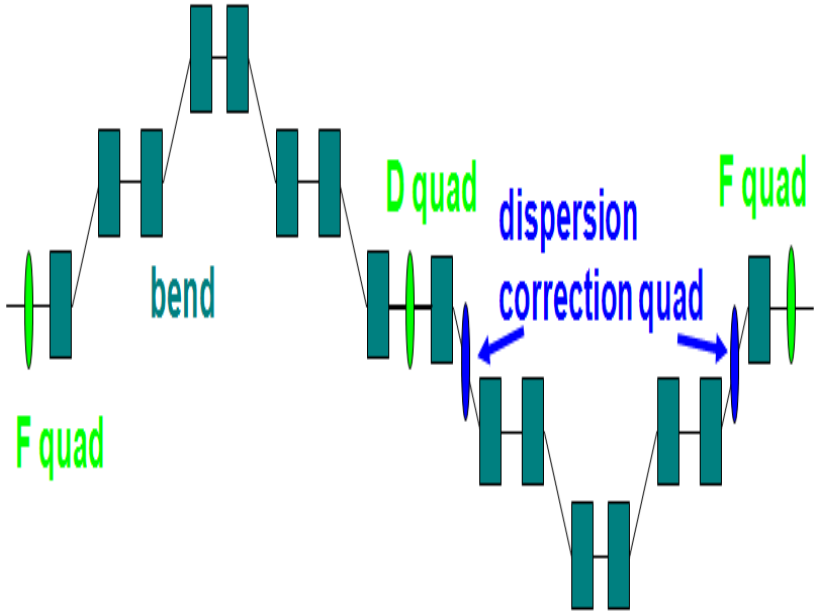
LCWS 12, October 22-26, 2012

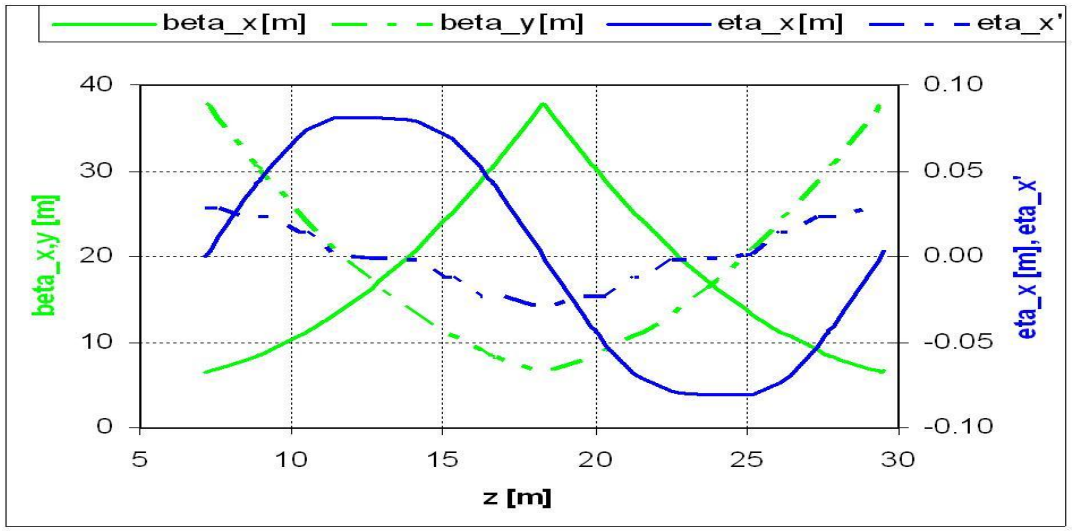
Two stage BC

- It was decided to return to the two stage BC option since it suggests more flexibility (natural upgrade to the 150um long beam) and smaller energy spread throughout the RTML. The disadvantage of this option is a higher price tag due to ~300m longer beamline.
- In the baseline design the BC compresses 6mm 5GeV to 0.3mm at 15GeV beam.



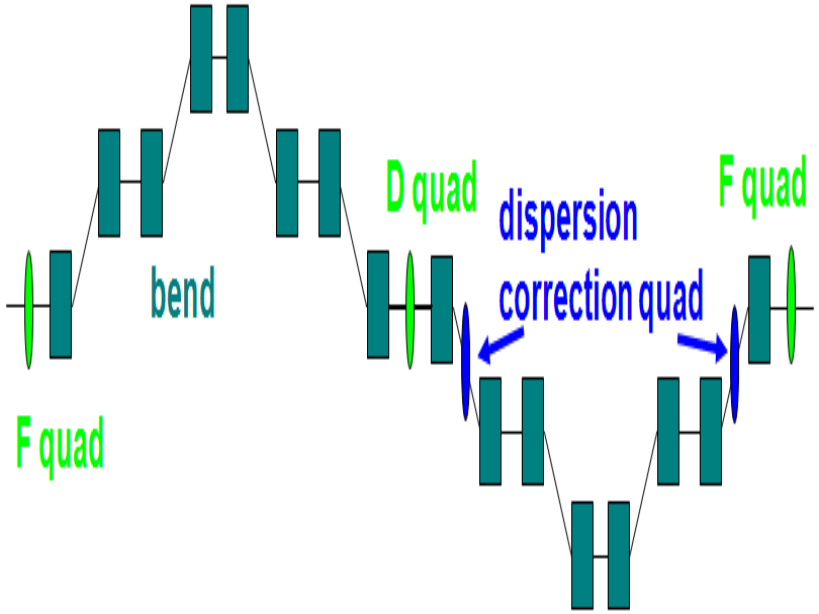
Design of the Wiggler

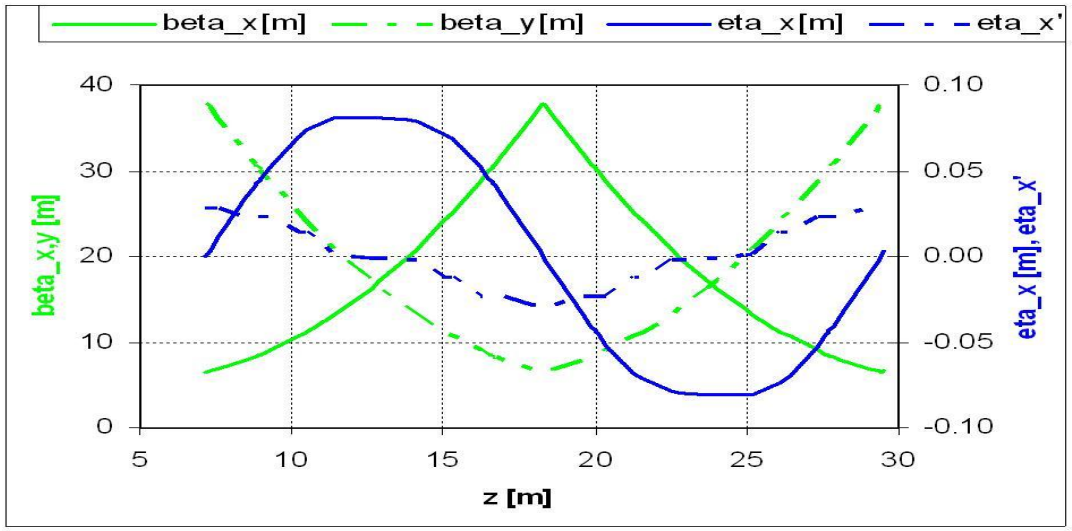




- Each wiggler consists of 6 identical cells
- Nonzero dispersion slope (η') is introduced at the entrance of each cell
- Wiggler cells are contained in FODO structure with 90° phase advance per cell
- Focusing and defocusing quads are placed in the zero dispersion regions
- There are 4 additional normal quads and 4 skew quads per wiggler (in cells 1,3,4 and 6) that are used for possible dispersion correction without introducing betatron coupling or mismatches.
- Sixteen bends allow tuning R56 while preserving beam's trajectory in quads

Design of the Wiggler





- Differences between the current design and the RDR (ILC2007b) lattice are minial.
- Now the tuning quads are located in the second half of the wiggler cell; in the old lattice the tuning quads are located in the first half of the wiggler cell.
- Also the new wiggler has collimators (adjustable energy spoilers at the SQ location and fixed absorbers at the CQ location) in cells #1 and #3.

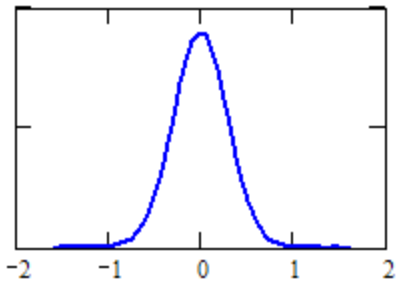
Two stage BC parameters

Initial beam			BC1 parameters		Beam after BC1			BC2 parameters		Final beam		
dp/p, %	σ_z, mm	E, GeV	Grd/-φ, MeV/deg	R_{56}, mm	dp/p, %	σ_z, mm	E, GeV	Grd/-φ, MeV/deg	R_{56}, mm	dp/p, %	σ_z, mm	E, GeV
0.11	6	5	18.67/115	372	1.42	0.9	4.8	25.8/23.9	55	1.13	0.3	15
0.12	6	5	18.67/115	372	1.42	0.9	4.8	26.1/25.2	55	1.19	0.3	15
0.137	6	5	18.67/115	372	1.42	0.9	4.8	26.5/26.9	55	1.26	0.3	15

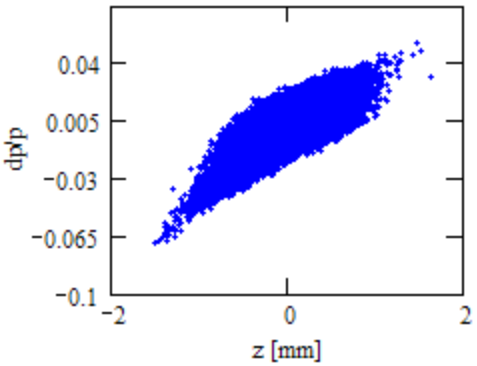
- The three initial energy spreads upstream of the BC correspond to:
  - dp/p = 0.11% 5Hz mode for both electrons and positrons
  - dp/p = 0.12% 10Hz mode for electrons
  - dp/p = 0.137% 10Hz mode for positrons

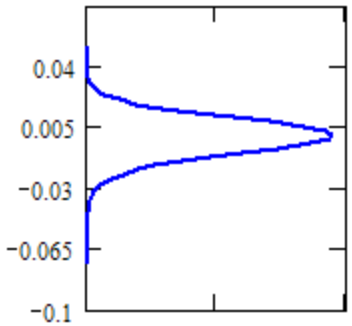
Final 0.3mm long beam

- For the case of initial dp/p=0.11%, final 0.3mm long beam has 1.13% energy spread at 15GeV.
- The beam is not sensitive to 10% drop in RF2 gradient.



Initial beam dp/p, %	Final beam length change (%) for 10% drop in BC2RF gradient
0.11	1.3
0.12	2.3
0.137	3.0



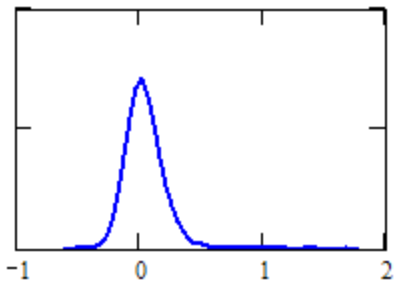


BC parameters for 150 um long final beam

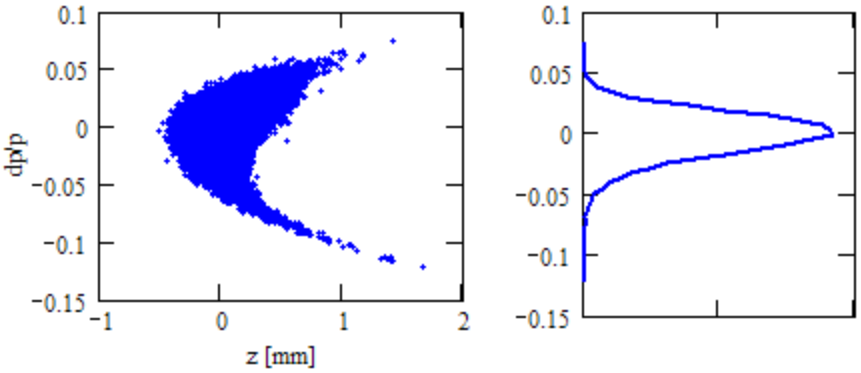
Initial beam			BC1 parameters		Beam after BC1			BC2 parameters		Final beam		
dp/p, %	σ_z, mm	E, GeV	Grd/-φ, MeV/ deg	R_{56}, mm	dp/p, %	σ_z, mm	E, GeV	Grd/-φ, MeV/ deg	R_{56}, mm	dp/p, %	σ_z, mm	E, GeV
0.11	6	5	18.67/ 120	348	1.37	1.36	4.77	27.2/ 29.2	69	1.85	0.15	15
0.12	6	5	18.67/ 120	348	1.37	1.37	4.77	27.5/ 30.4	69	1.93	0.15	15
0.137	6	5	18.67/ 120	348	1.37	1.4	4.77	30.5/ 39	52.4	2.52	0.15	15

- The 150um final length is achievable for all three cases of initial energy spread.
- It requires higher RF2 gradient.
- The maximum final energy spread is 2.5%.

Final 0.15mm long beam



Initial beam dp/p, %	Final beam length change (%) for 10% drop in BC2RF gradient
0.11	7.1
0.12	5.3
0.137	9.0



- The plot shows the final 150um long beam for the case of initial dp/p=0.11%.
- The 10% drop in RF2 gradient noticeably affects the final beam length.

Renovated extraction lines

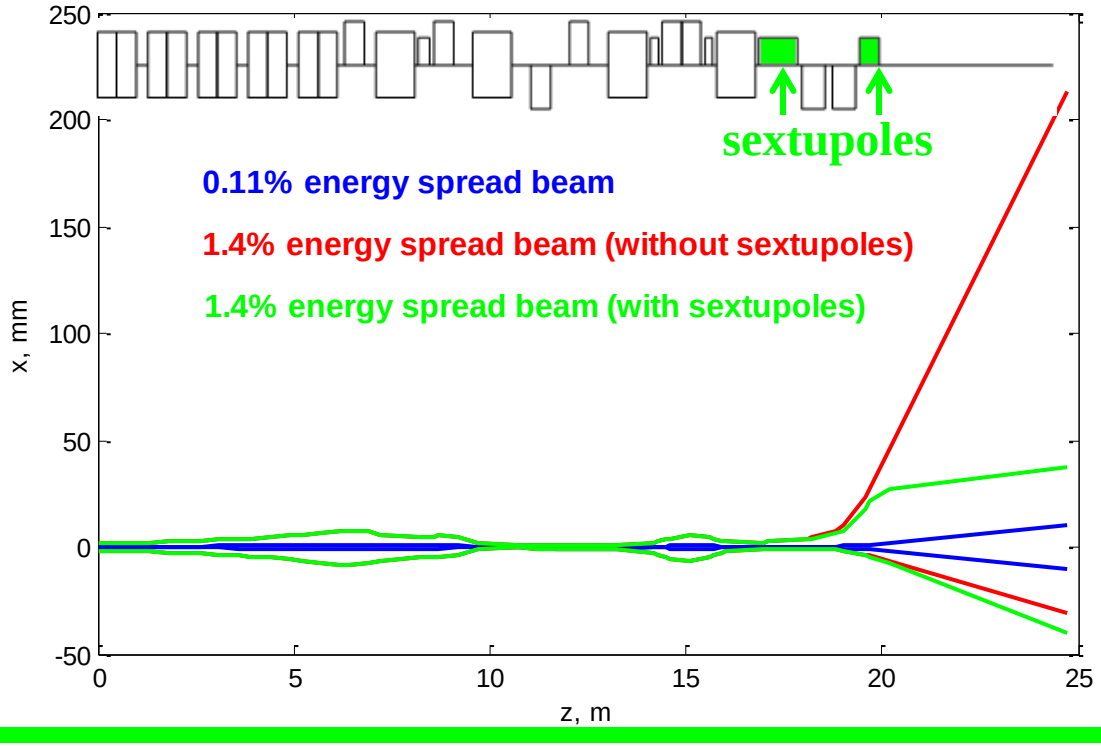
- The previous design of the compact extraction lines for the two stage bunch compressor was based on the bending blocks built of double bend achromats. This allowed (in the linear approximation) decoupling the dispersive effects from the beam focusing.
- The problem of a blown up size (due to the nonlinear dispersion) of the high energy spread beam was resolved with the aid of collimators.
- Such extraction lines are capable of accepting and transmitting up to 220kW of beam power. The ELs can be used for both fast intra-train and continual extraction, and are capable of accepting both low and high energy spread beams.

- On the other hand, for the single stage BC there was found an extraction line solution that uses five sextupoles for containing the nonlinear beam halo and doesn't require any additional beam collimation.

- For the renovated extraction lines we are combining the best features of both designs.

BC1 extraction line

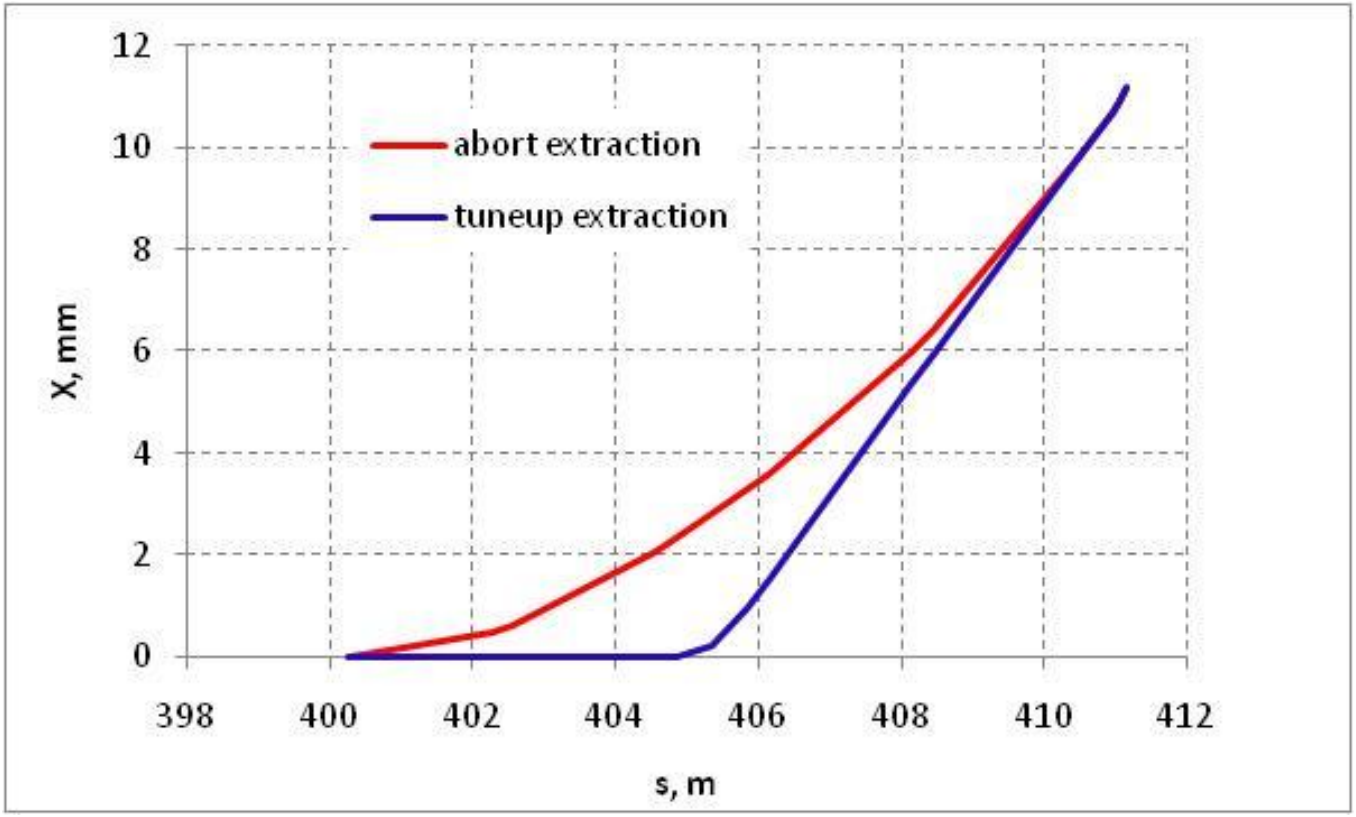
- Since for 2 stage BC the energy spread of compressed beam is small the nonlinear effects are weak and the beam can be contained with only two sextupoles.
- Beam size on the dump window is 19.5mm² in low energy spread case and the high energy spread beam is contained within the borders of and centered on a dump window of 12.5cm diameter.
- The Extraction Line is 24.7m long and the dump is separated from the main beamline by 5.1m.



Conclusion

- The renovated two stage bunch compressor has been finalized for both the nominal final beam length of300 um and the optional 150um long final beam.
- The extraction line downstream of the first stage of the BC has been redesigned. It does not require collimators and need only two sextupoles to contain the high energy spread beam.
- The renovation of the BC2 extraction line is in progress.

Bonus material: Extraction System Design



- Extraction system is common for all beamlines and consists of four 2m long fast abort kickers, and a single 1m long tune-up extraction bend placed in between two central kickers.
- The abort kickers can be charged to 35G each in 100ns. The tune-up bend is powered to 280G.

Bonus material: Beam Dump

- We are utilizing 220kW aluminum ball dump. It is capable of absorbing the full beam power at 5GeV, while at 15GeV it can absorb only about 1/3 of the nominal beam power. Full trains can be run to ELBC2 dump at reduced repetition rate.
- A dump window diameter of 12.5cm is considered to be a basic choice.
- An aluminum window using a 1mm thick hemispherical design is feasible for a suggested aluminum sphere dump.
- It has the promise of long term safe operation, even for the 0.11% $\Delta p/p$ optics with beam spot area on the dump window equal to or larger than $12mm^2$.
- There are no steady state heat transfer issues to reject the energy deposited by the beam to the cooling water.
- Larger diameter (up to 1m) dump window can be made.
- The dumps can be used at 10Hz pulse repetition rate in case the number of bunches is <1400.