Start-to-end Transport Optics Design for ILC e- source

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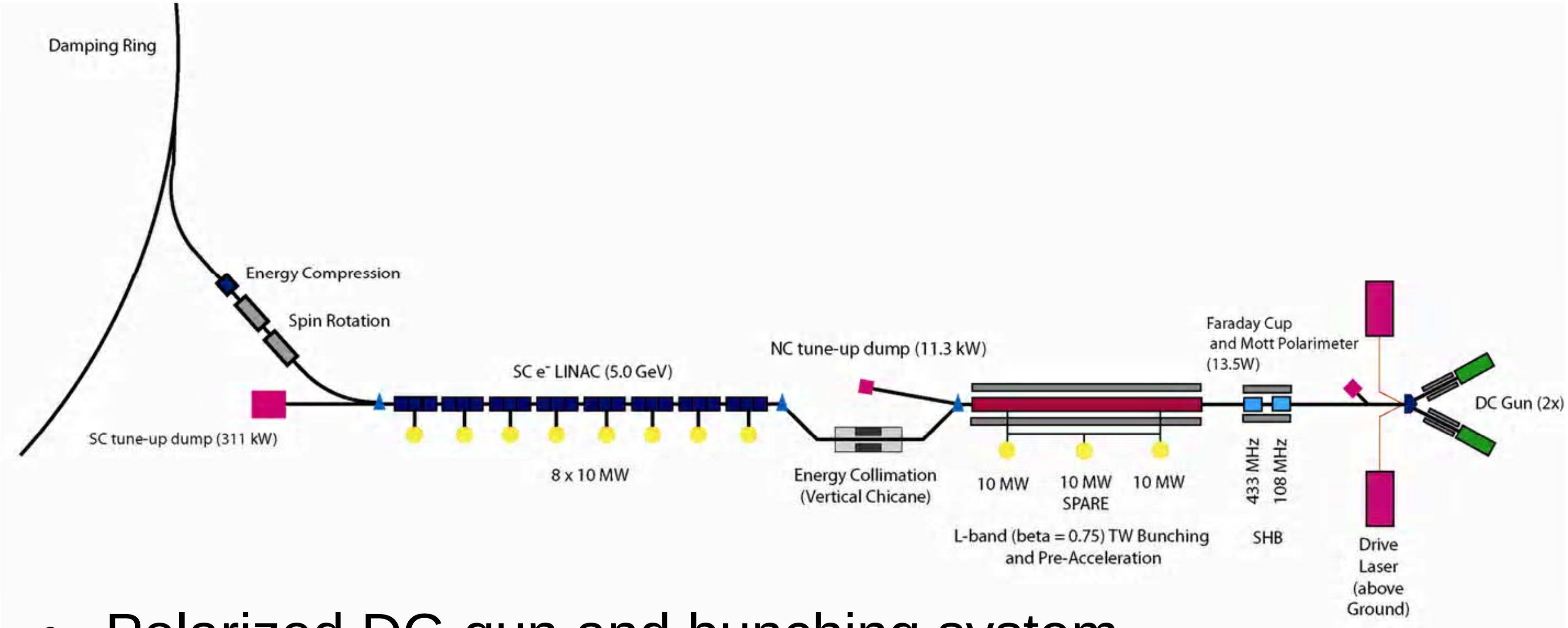
ILC e- source KOM, Sep. 24-25, 2007

Thanks

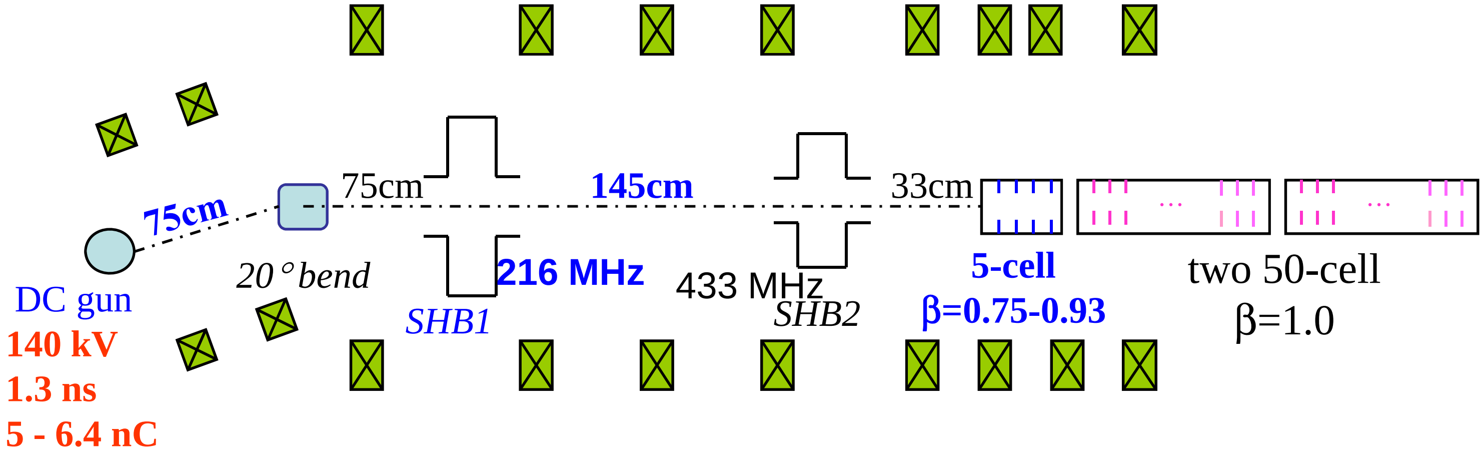
- Contributions from Axel, John, Juwen, Jym, Mark, Roger, …

Schematic of ILC e- source



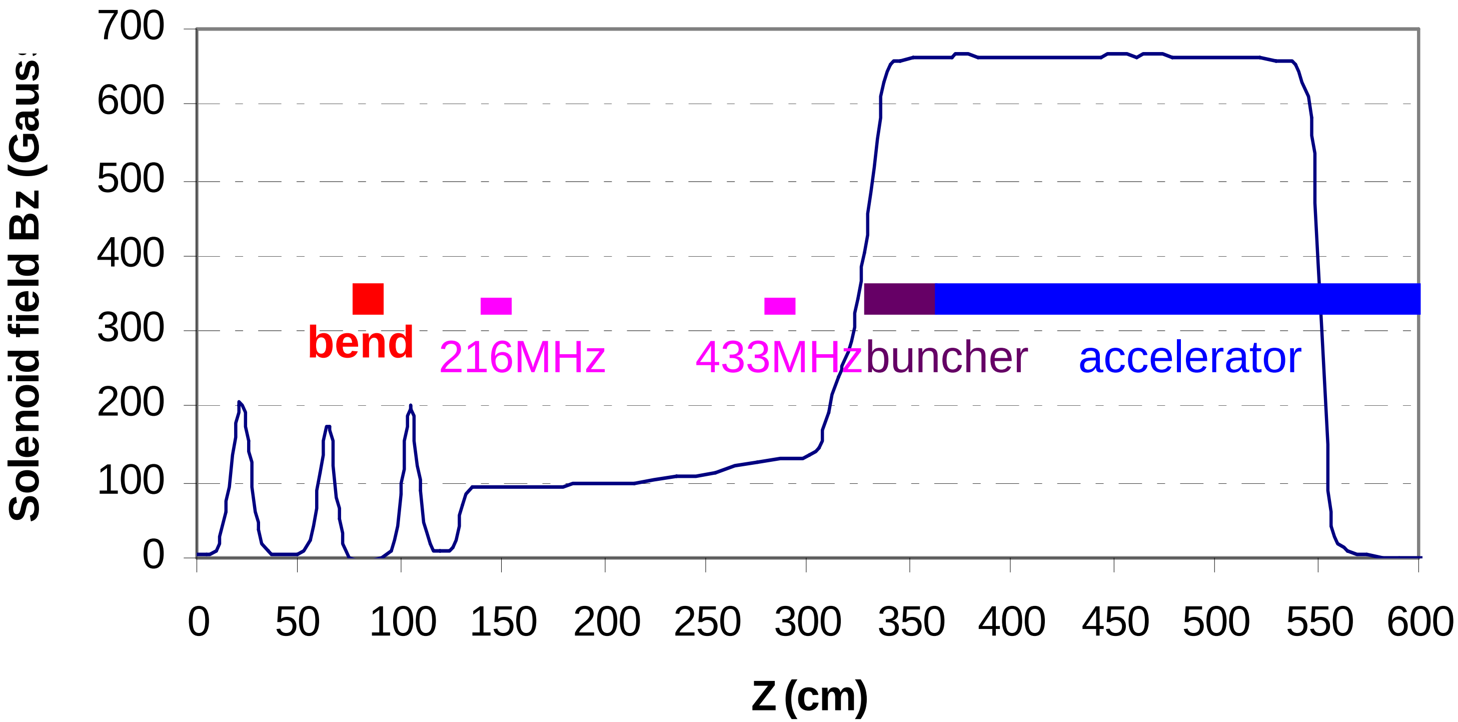
- Polarized DC-gun and bunching system
- Pre-acceleration system
- Vertical chicane, and emittance station
- 5-GeV Booster linac
- LTR: spin rotations and energy compression
- 5-GeV beam dump

Bunching system

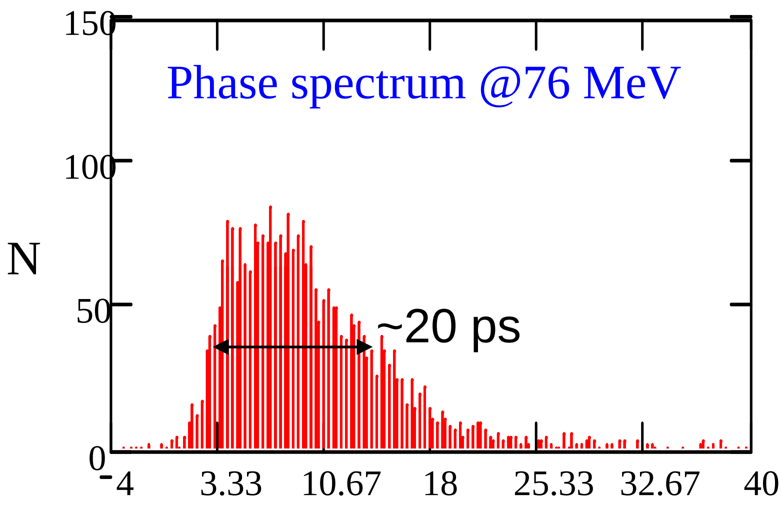


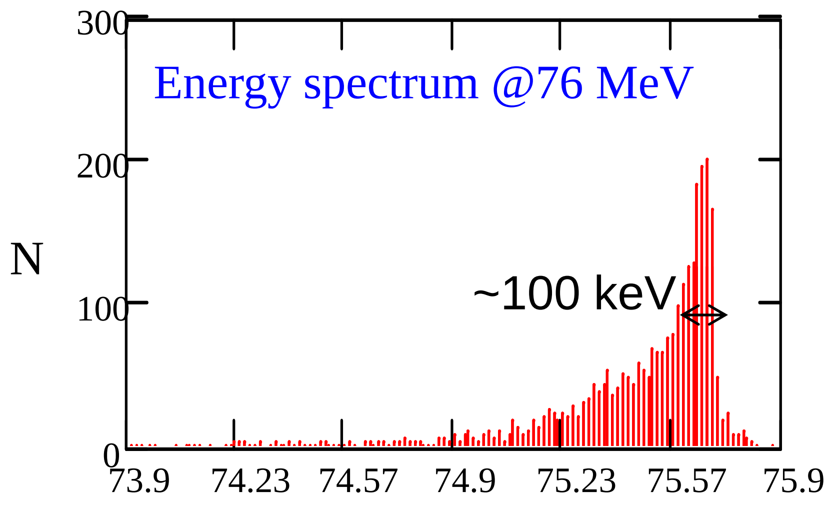
- DC-gun: 140 kV, 1.3 ns
- SHBs: 216.7 and 433 MHz, ~50 kV; bunch is compressed down to 200 ps FWHM.
- One 5-cell tapered-β TW L-band buncher with 5.5 MV/m; bunch is compressed down to 20 ps FWHM.
- Two 50-cell TW structures with 8.5 MV/m of gradient accelerate beam to 76 MeV.

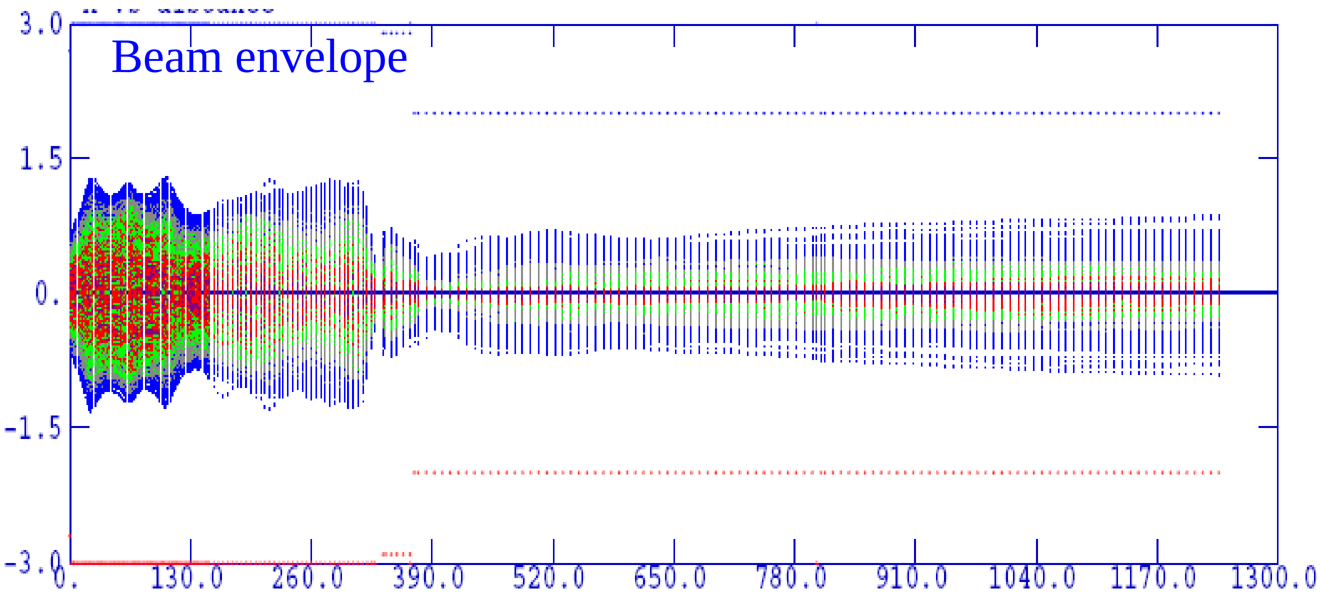
Solenoid field map

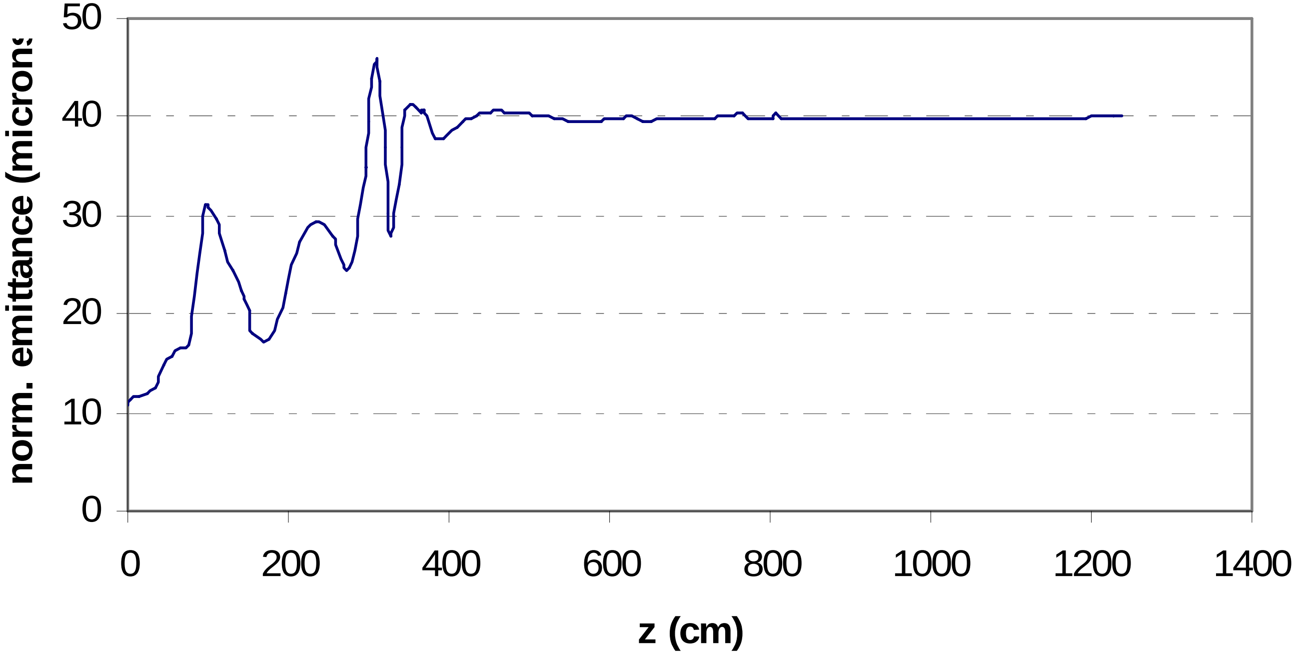


Longitudinal phase spaces






Beam envelope
3.0
1.5
0.
-1.5
-3.0
0.
130.0
260.0
390.0
520.0
650.0
780.0
910.0
1040.0
1170.0
1300.0

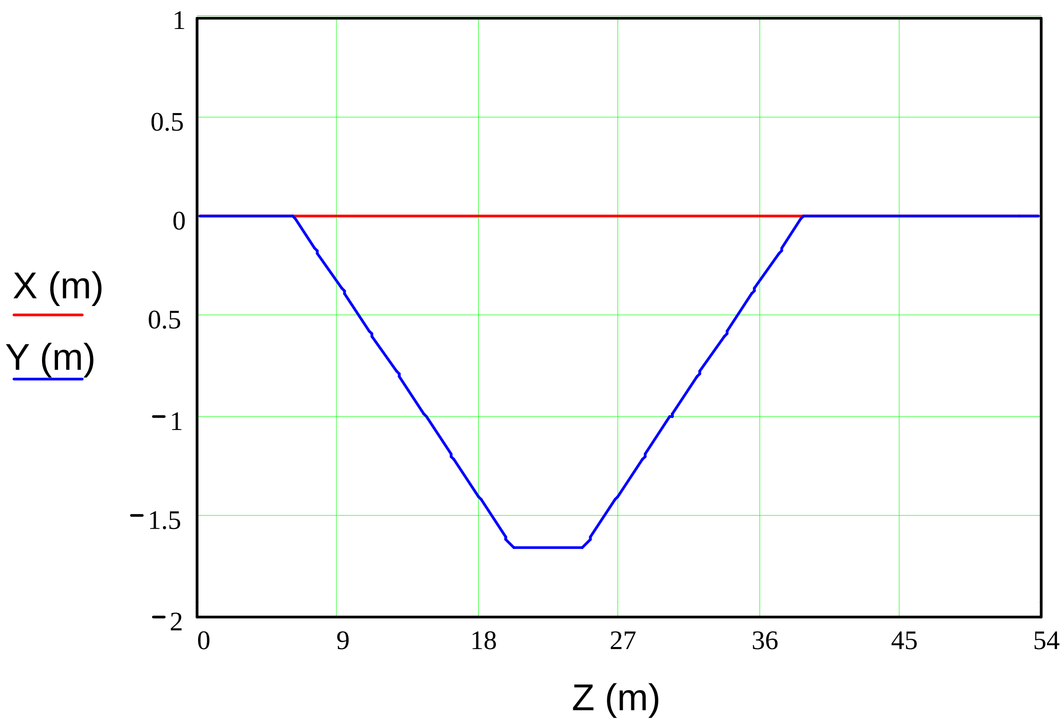

norm. emittance (micron
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
z (cm)

Parameters for bunching system

Gun voltage	140 kV
Initial charge at the gun Transmission throu. injector	5.0 nC (6.4 nC) >99%
Initial bunch length Final Bunch length - FWHM - FW	1.3 ns 20 ps ~45 ps
Energy spread - FWHM - FW	~100 keV <1.5 MeV
Norm. rms emittance	40 μm (50 μm)

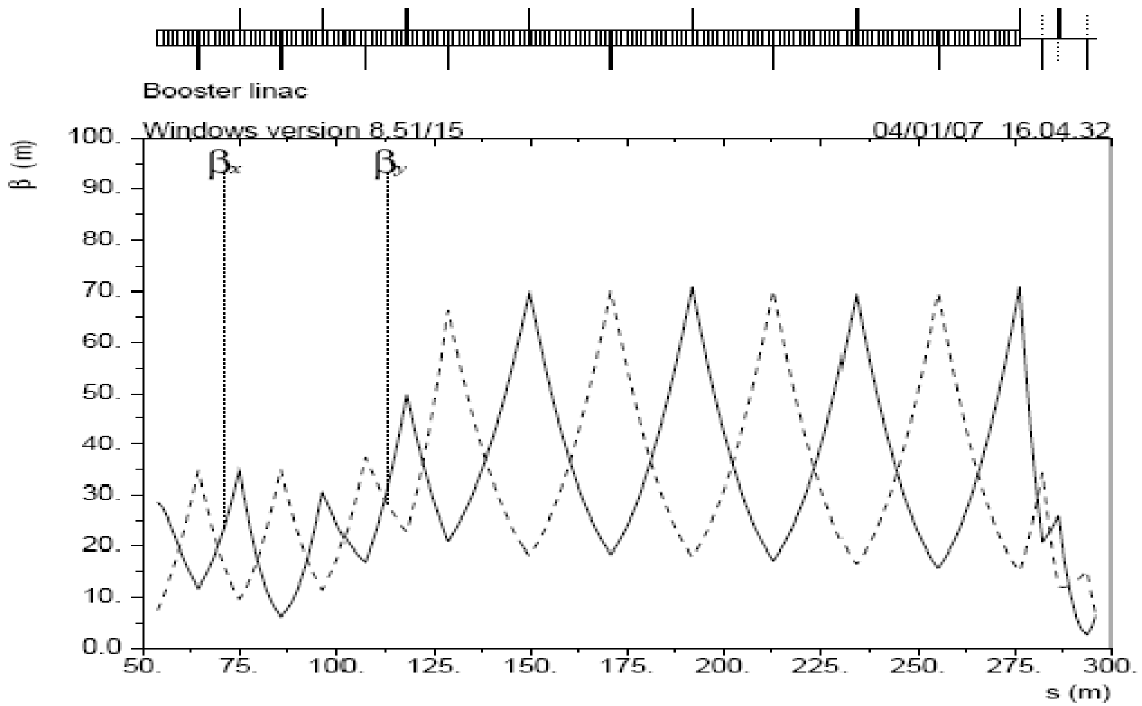
Vertical chicane, emittance

- The vertical chicane is to clip off the low energy tail of bunched beam.
- Emittance station downstream of the chicane: conventional 4-wire scanners.



5-GeV e- booster linac

- Accelerate beam to 5 GeV using 21 standard ILC CMs.
- Have two sections:
  - 76 MeV to 1.717 GeV (7 CMs, 1 Quad/CM)
  - 1.717 GeV to 5 GeV (14 CMs, 1 Quad/2CMs)



LTR – Linac to Ring

- **Spin rotations to preserve polarization in DR:**
  - Bending magnets from longitudinal to horizontal plane

$$\theta_{spin\_bend} = \frac{E(GeV)}{0.44065} \cdot \theta_{bend}$$

θ_{bend} $=n\cdot 7.929°$ at 5-GeV; here n=7 to get R56=86cm.

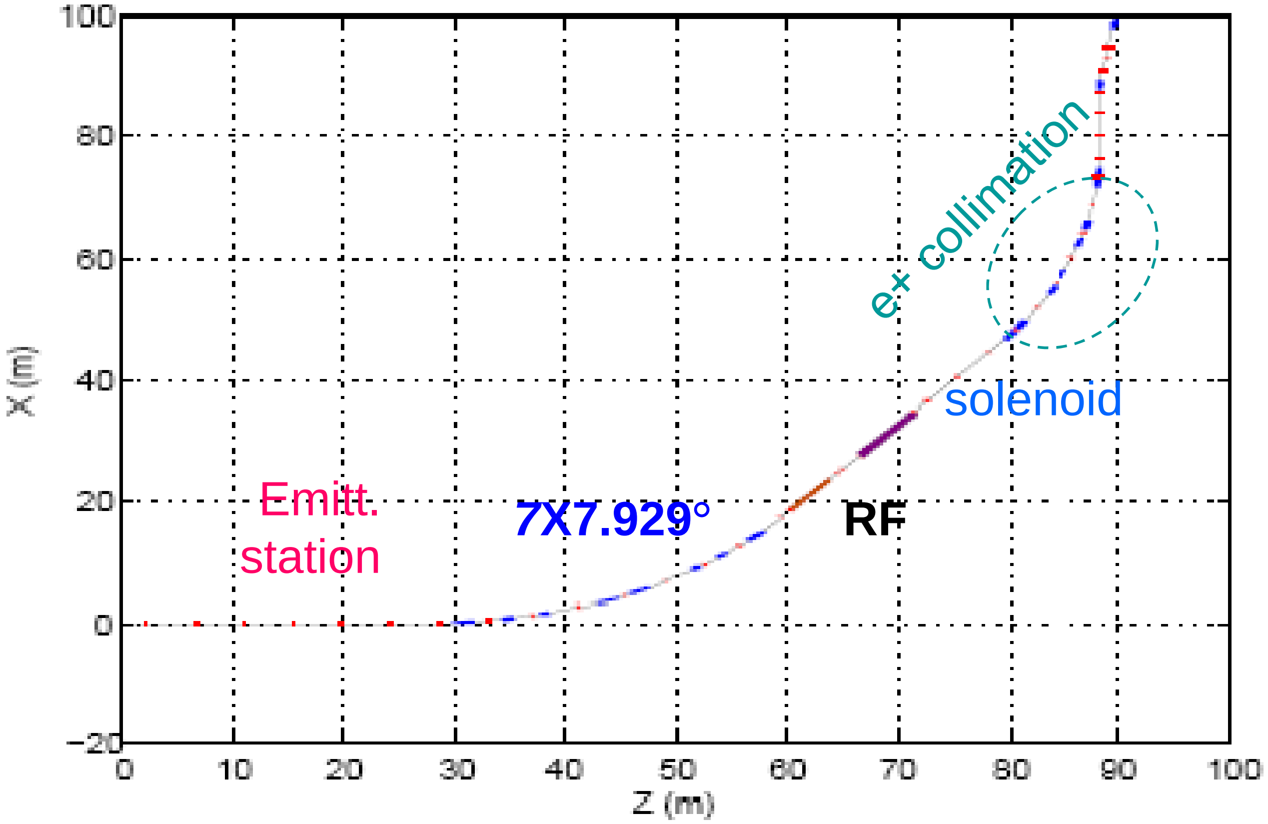
  - Solenoid from horiz. to vert., parallel to the magnetic field in DR.

$$\theta_{spin\_sole} \approx \frac{B_z \cdot L_{sole}}{B\rho}$$

$B_z \times L_{sole}$ = 26.23 T.m at 5-GeV.

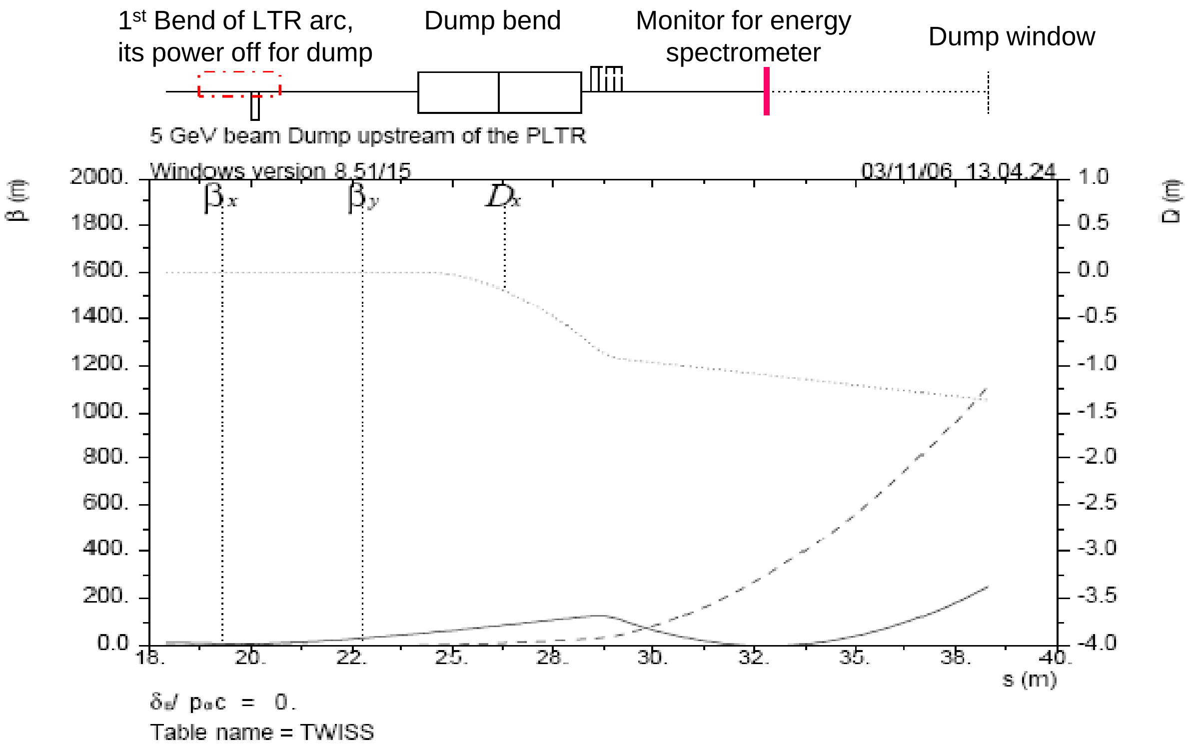
- **Energy compression:** R56 and RF section
- Same LTR as in e+ system: keep e+ collimation
- Emittance measurement, and 3 PPS stoppers
- Matching section

LTR geometry (for e- and e+)

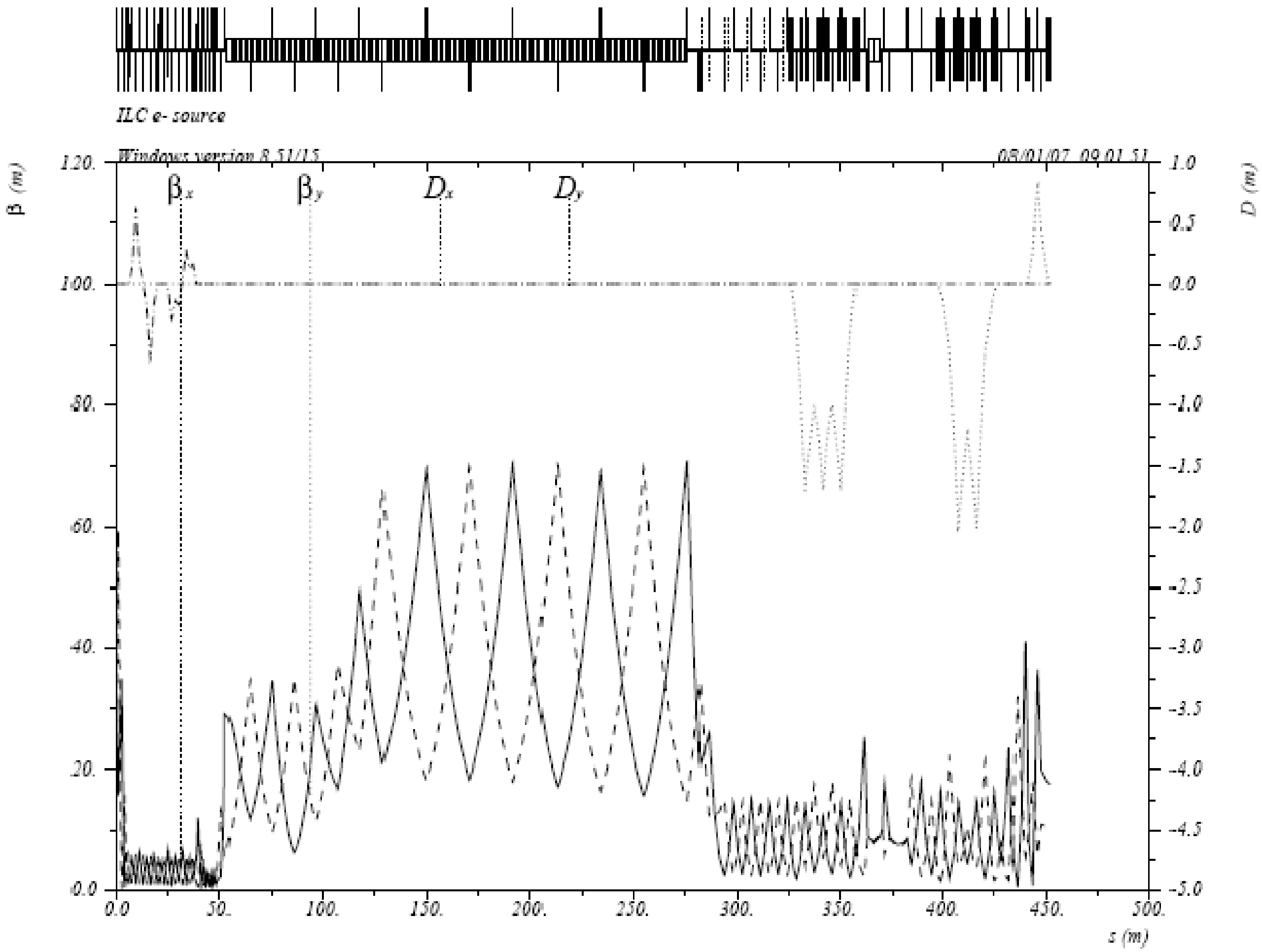


5-GeV beam dump

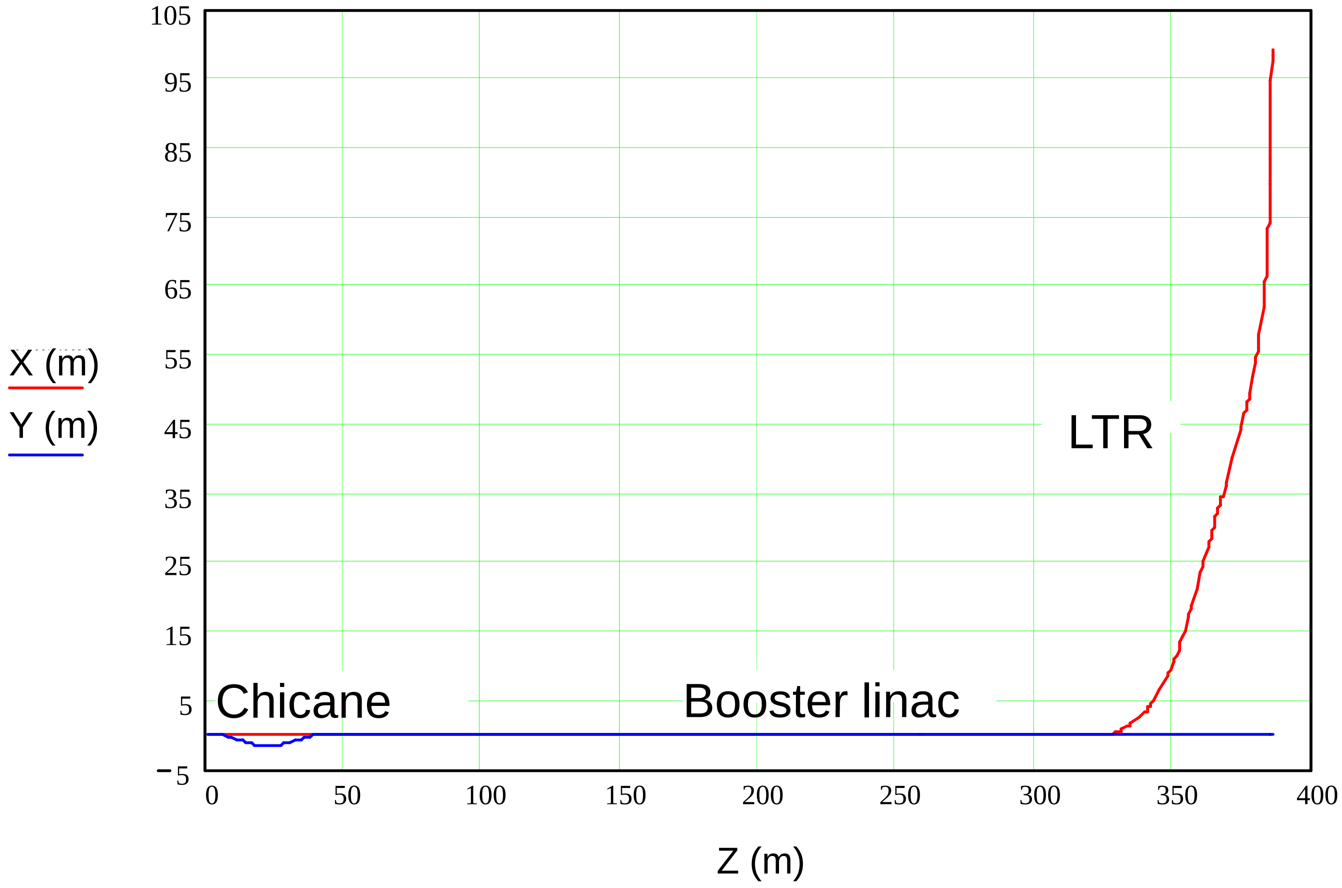
- Beam dump: for ±0.1% and ±10% of δE, half beam sizes in x and y are 0.52cm/1.1cm and 13.7cm/1.1cm, respectively, which meet the dump window specifications.
- Energy spectrometer: 0.1% of resolution.



ILC e- source optics



ILC e- source geometry



Tracking from the DC-gun to DR injection

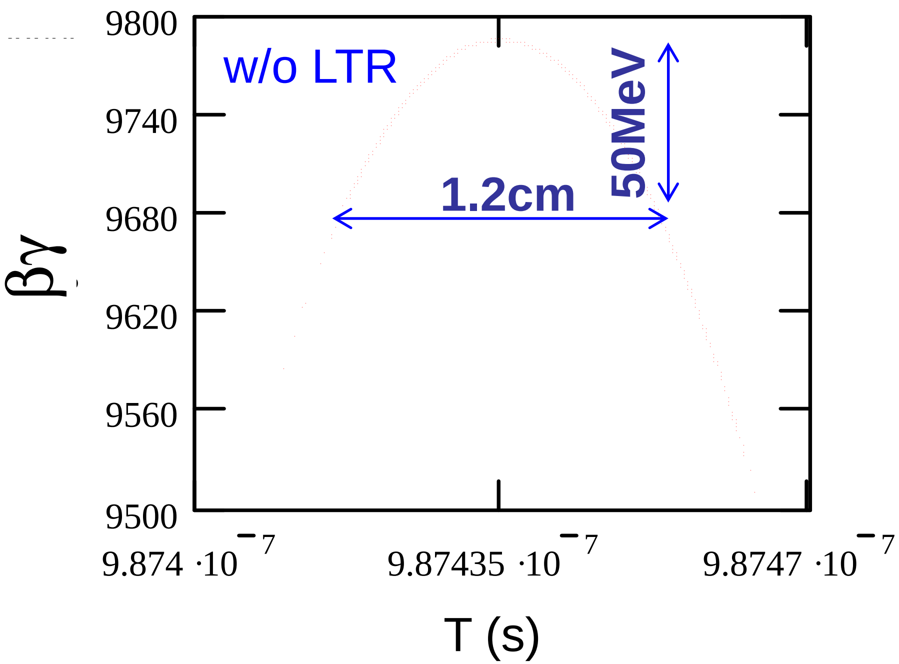
- Tracking from the DC-gun to 76-MeV injector exit using PARMELA.
- Elegant code is used to track the e- beam through the rest of the beamline including: chicane, emittance station, booster linac, and the LTR.
- Energy compression is optimized to accommodate more e- within the DR 6-D acceptance:

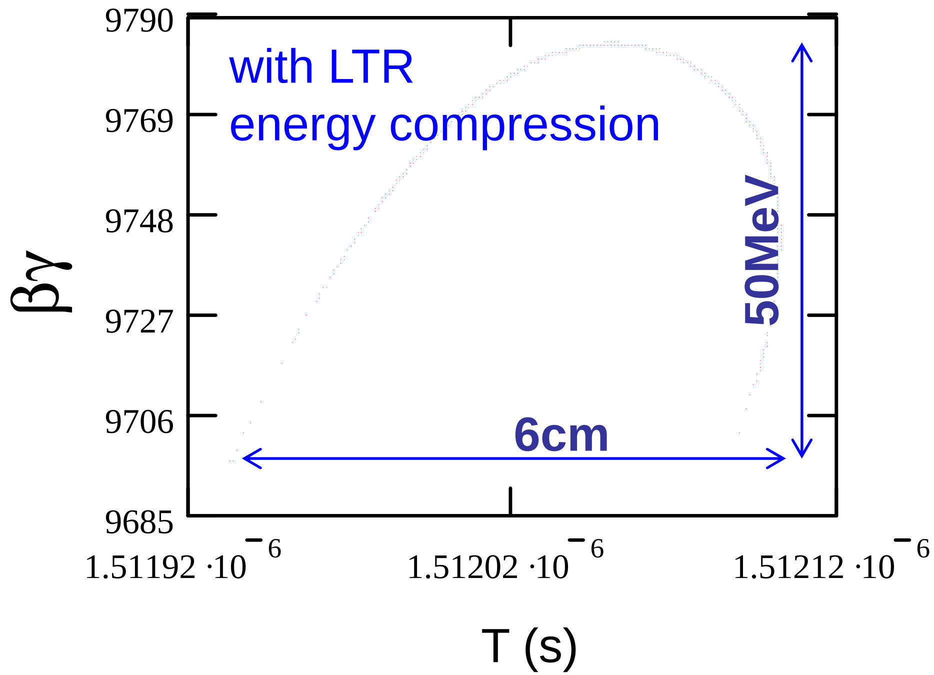
$$A_x + A_y \leq 0.09\text{m, and}$$
$$\Delta E \times \Delta z \leq (\pm 25\text{MeV}) \times (\pm 3.46\text{cm})$$

ILC e- source physical apertures

Components	Half aperture in x/y (cm)
Bunching system	
SHBs	2.5/2.5
L-band buncher	2.5/2.5
Pre-Accelerator	2.0/2.0
Chicane	1.5/1.5
Emittance station	1.5/1.5
Booster linac	3.7/3.7
LTR	
RF section	3.7/3.7
Solenoid	2.0/2.0
Others	5.5/3.0

Longitudinal phase space at e- source end





88% of e- from the gun are captured

94% of e- from the gun are captured

RMS values of magnet errors

	Misalignment in x and y plane	Field error	Rotation error
Quad	$\Delta x = 200\ \mu m$ $\Delta y = 200\ \mu m$	0.1%	
Sextupole	$\Delta x = 200\ \mu m$ $\Delta y = 200\ \mu m$	0.1%	
Bend	$\Delta x = 200\ \mu m$ $\Delta y = 200\ \mu m$	0.1%	0.3 mrad

- Preliminary tracking with errors
- Orbit correction well using correctors (1 corrector/quad)
- May add tilt in the quads later

Summary and Future Work

- Finished the conceptual optics design:
  - A bunching system with extremely high bunching efficiency to compress the bunch length down to 20 ps FWHM is designed.
  - Complete optics to transport e- beam to the DR injection line is developed.
  - Full tracking from the DC-gun to the DR injection shows 94% of e- are captured within DR 6-D acceptance after energy compression.
  - Field and alignment errors and orbit correction are initially analyzed.
- Toward EDR:
  - Bunching system design and optimizations to be more practical to meet with engineering: enough space, real RF structures, real solenoids, etc; expect big changes for the layout.
  - Optics and physical aperture optimizations
  - LTR optimization
  - Detailed complete definition of tolerances
  - Detail complete definition of beam tuning requirements.
  - Beam dumps at 76 MeV and 5 GeV, (and at few MeV?)