ILC Polarized e- source
RDR Overview

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Introduction

- Electron source produces bunch train and transports the electrons to the damping ring
- Treaty point is DR injection device (excluding)
- Source will use a polarized DC gun using photoemission from a GaAs based photocathode
- Source consists of NC RF structures that provide bunching and pre-acceleration to 76 MeV
- ‘Standard’ ILC Linac cryomodules accelerate the beam to 5 GeV
- An additional electron source will provide the drive beam for the positron ‘Keep Alive Source’
- The SLC injector is a good reference point
- Polarization, charge and lifetime of SLC design indicate feasibility of its technology (on a conceptual level) for the ILC
- ILC bunch train parameters provides technical challenges for the ILC source and solutions are not demonstrated

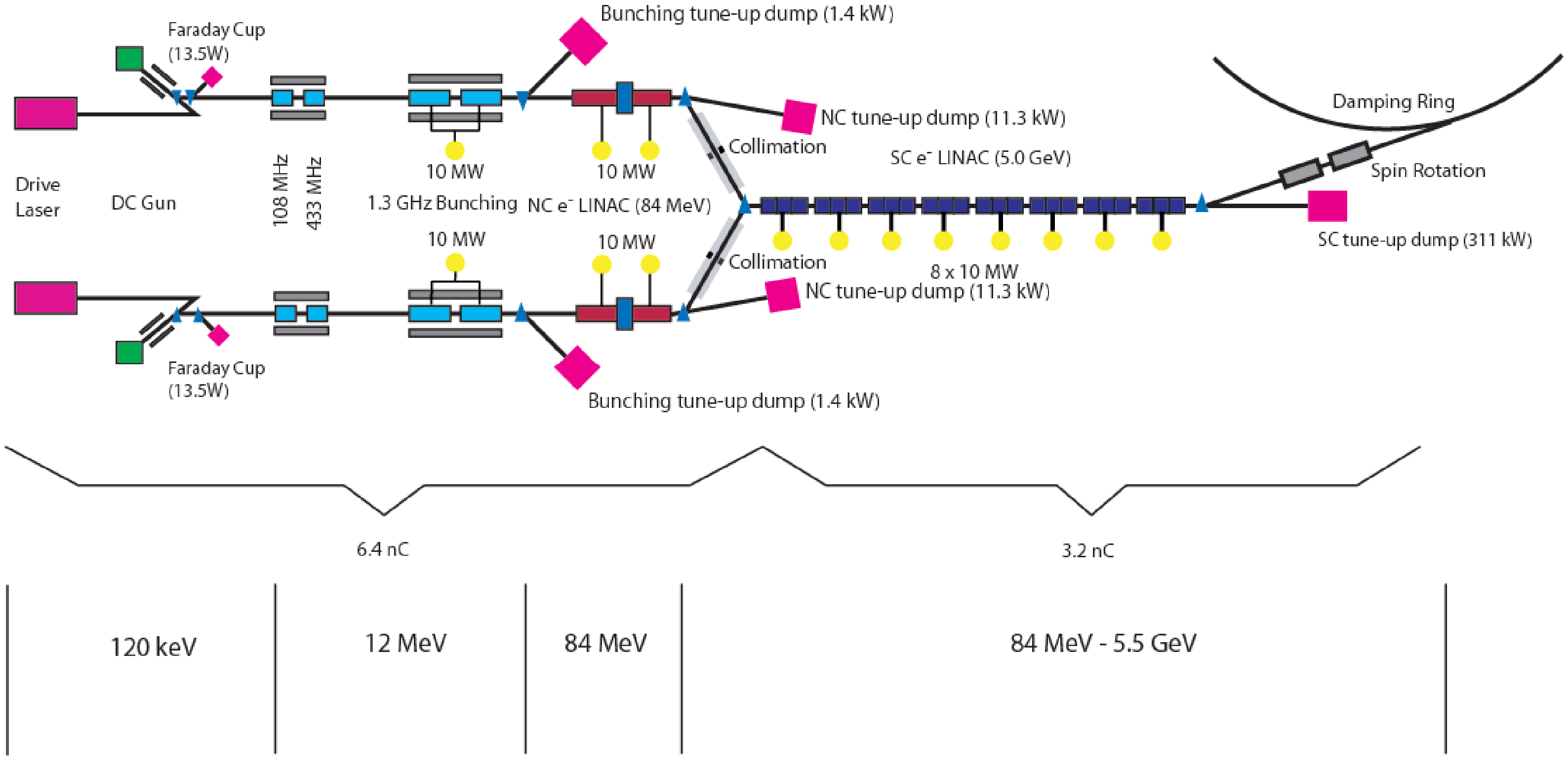
Source Parameters

Parameter	Symbol	Value	Unit
Electrons per bunch (at gun exit)	n_e	3×10^{10}	**Number**
Electrons per bunch (at DR injection)	n_e	2×10^{10}	**Number**
Number of bunches	N_e	**~ 3000**	**Number**
Bunch repetition rate	$F_{\mu b}$	**3**	**MHz**
Bunch train repetition rate	F_{mb}	**5**	**Hz**
Bunch length at source	Δt	**~ 1**	**ns**
Current in bunch at source	I_{avg}	**3.2**	**A**
Energy stability	**S**	**< 5**	**% rms**
Polarization	P_e	**80 (min)**	**%**
Photocathode quantum efficiency	**QE**	**0.5**	**%**
Drive laser wavelength	λ	790 ± 20	**nm**
Single bunch laser energy	**E**	**5**	**μJ**

Principal Subsystems

- Laser System
- DC Gun (Photoemission from GaAs)
- Subharmonic bunching system
- L-band bunching system
- Pre-acceleration
- Booster Linac
- Electron source to damping ring transfer line
  - Spin Rotation
  - RF Energy Compression

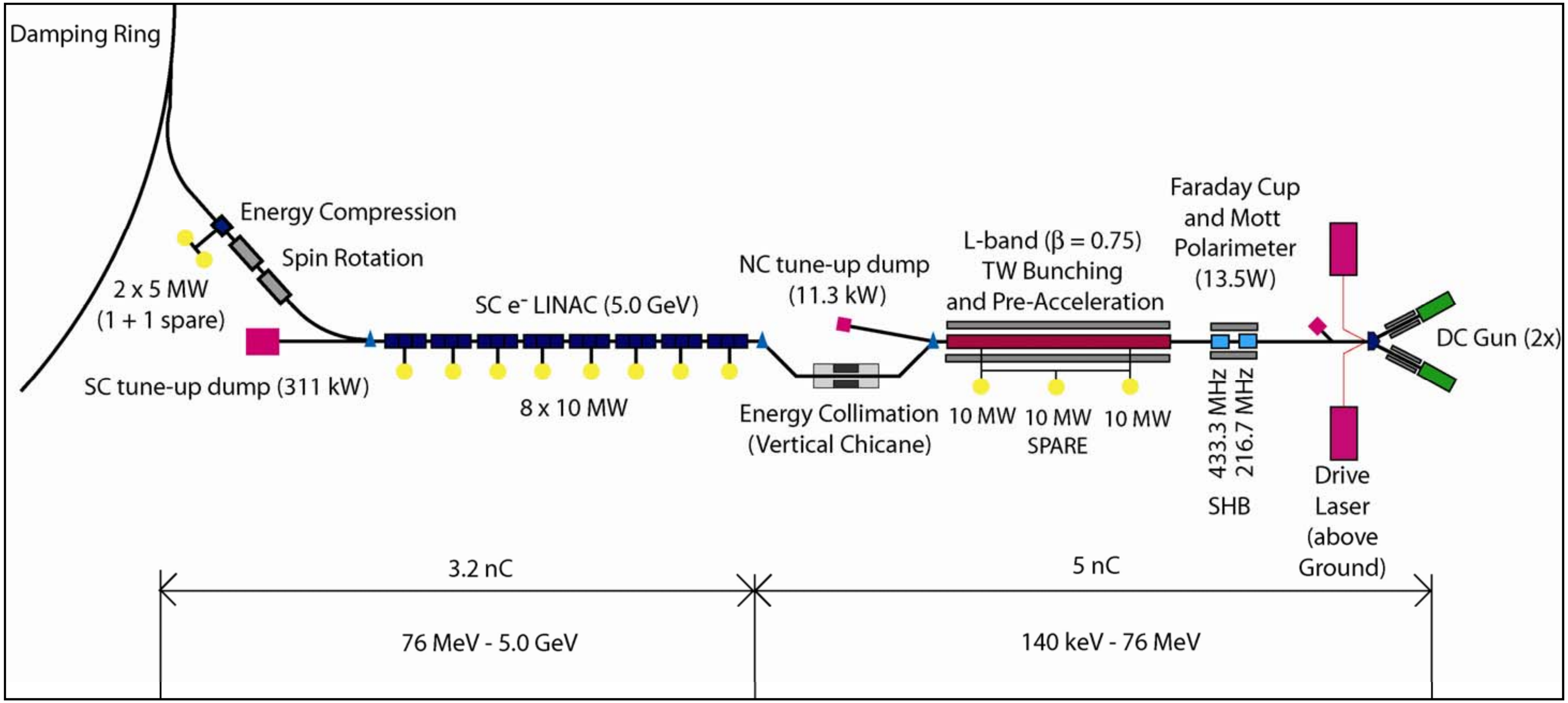
Original Layout



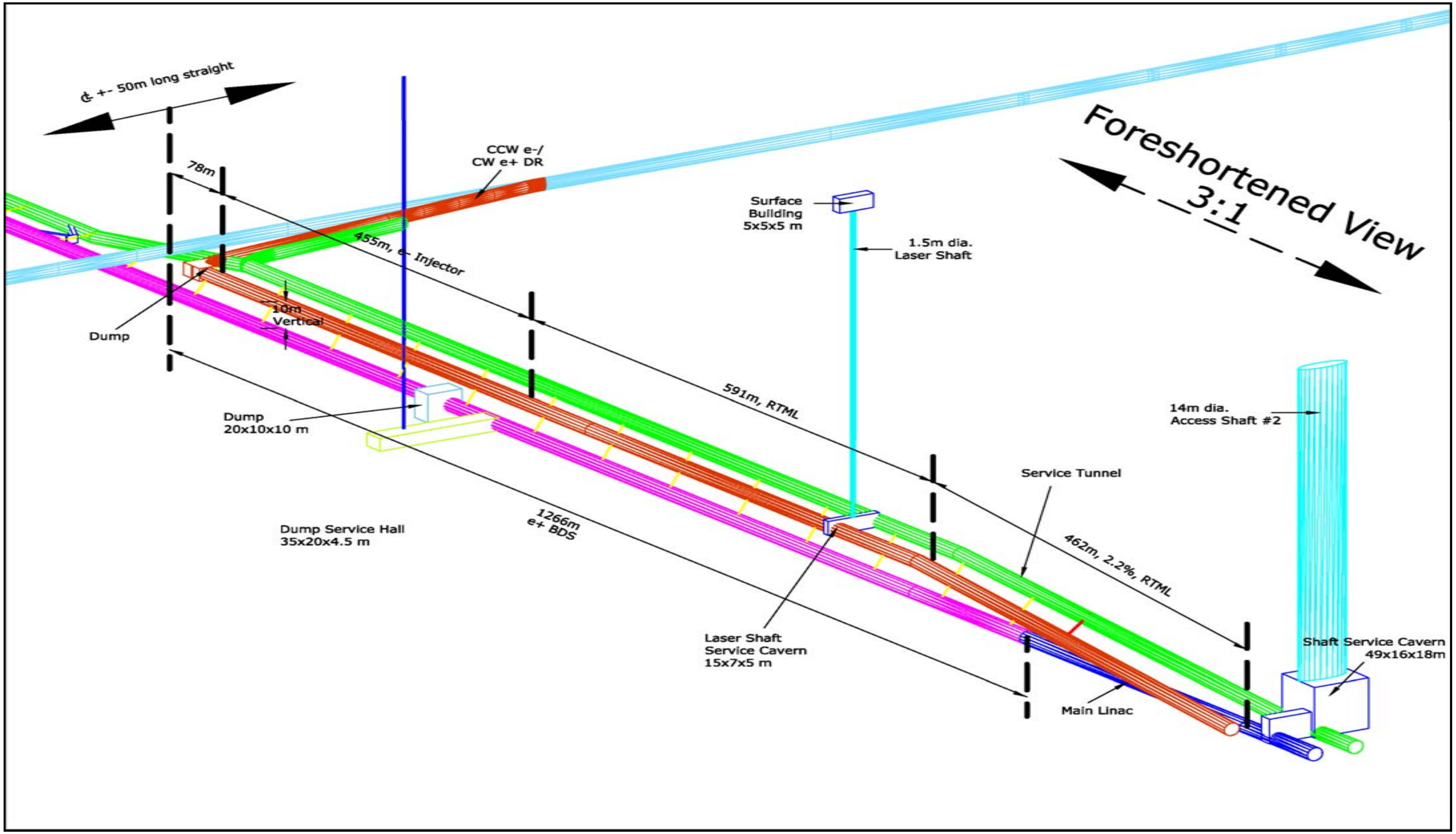
CCR 22

- Driven by cost savings concerns
- Reduced redundancy but seems acceptable solution:
  - Remove one NC beam line
  - Keep 2 laser systems and 2 guns
    - However, no separate access during operation
  - locate laser systems above ground
- Exact coast saving is difficult to express because of convolution of this CCR with move of DR to central location
- Estimated saving is ~ 25 % of total cost

Final RDR Layout



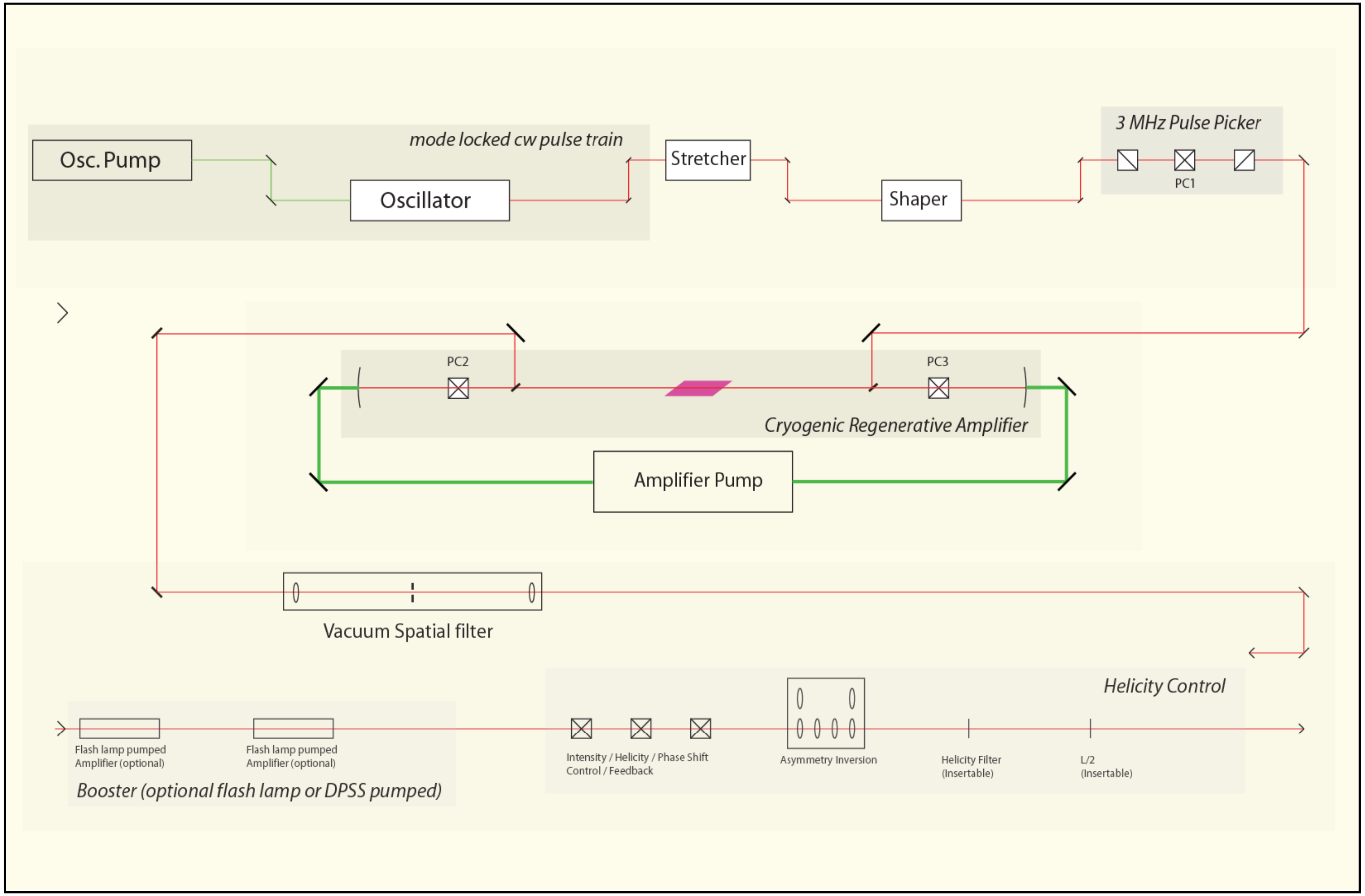
Tunnel concept



Source Laser Parameters

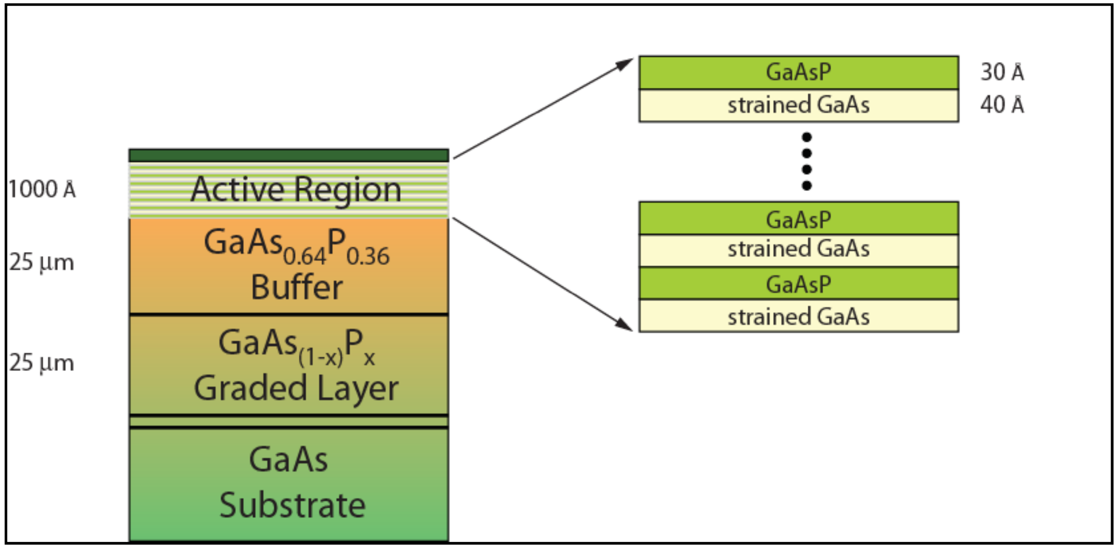
- Central wavelength : ~ 790 nm
- Laser pulse energy is determined by cathode QE
  - ~ 5 μJ mirco pulse energy
- Tunability of ± 20 nm
- Pulse shaping requires bandwidth
- Availability of high power cw pump source to facilitate amplification at 3 MHz
- To tap industrial resources → common lasing medium is required
- Choice of Ti:Sapphire laser system pumped by solid state
- Nd:YAG (or similar)

Source Drive Laser System Layout



Photocathodes

Baseline design: strained layer superlattice GaAs/GaAsP
- Polarization ~ 85 - 90 % ,QE 1% maximum, 0.3-0.5% routinely



High gradient p-doping increases QE and reduces surface charge limit:

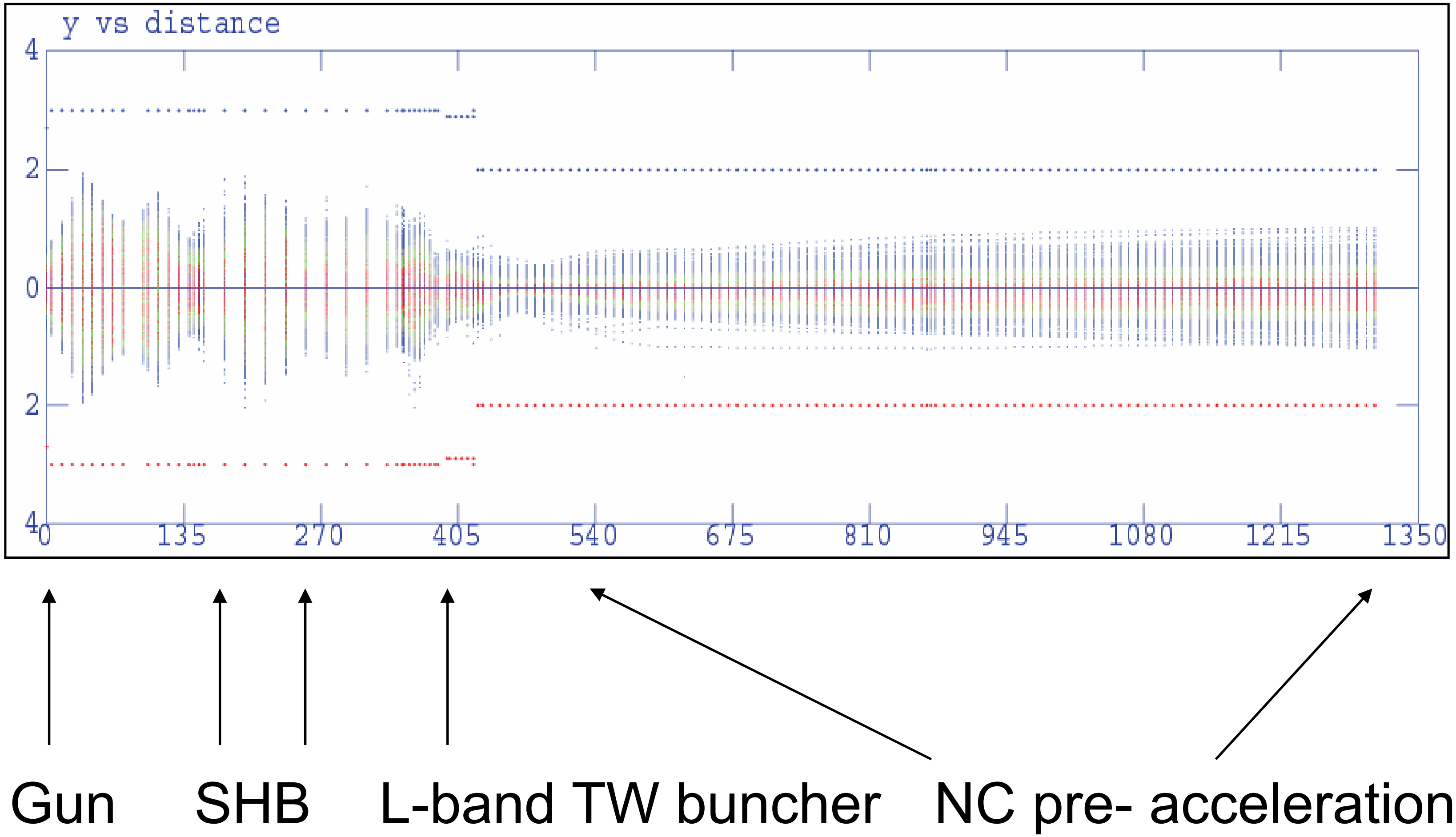
$$5 \times 10^{19}\ \text{cm-3} \rightarrow 5 \times 10^{17}\ \text{cm}^{-3}$$

DC Gun

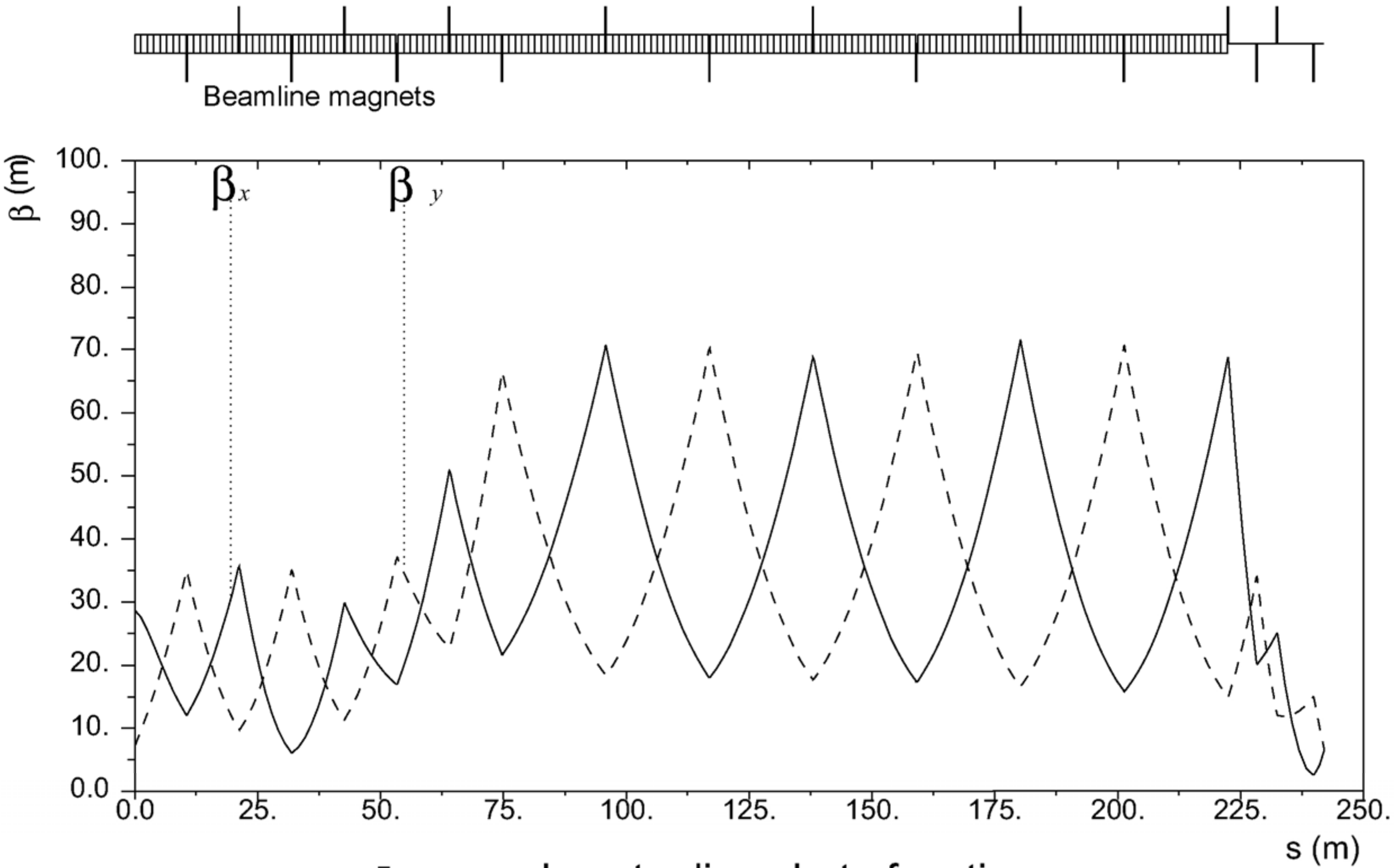
- Baseline is SLC gun (120 kV)
- Higher HV is needed because of 1 ns bunches
- We anticipate Engineering and R&D as part of EDR phase
- See Matt Poelkers talk …

Accelerator Physics – NC injector

Parmela simulations for low energy beam (to 76 MeV)

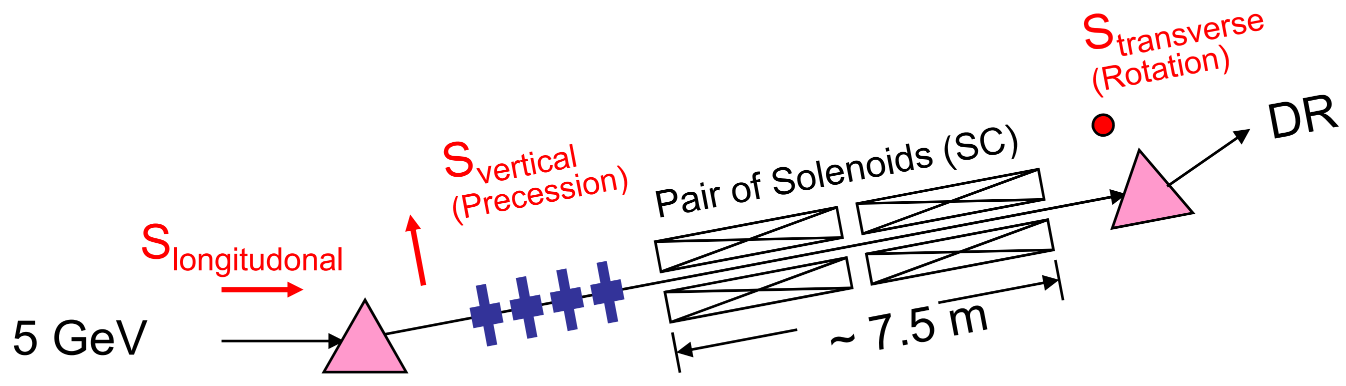


Accelerator Physics – Main SC beam line



e⁻ source booster linac beta functions

Accelerator Physics – Spin Rotation



Bend of n * 7.9312°

Odd Integer

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

$$\theta_{spin} = \frac{\int B_z dl}{B_0 * \rho}$$

Dipole: 7.9312°
→ ~ 2 kG
Solenoid: 26.2 T
→ 2x3.5 m; 38.5 kG

Dipole and solenoid strength are set by spin manipulation requirements, lattice design remains to be done

[1] Moffeit et al., SLAC-TN-05-045

Identical designs are used for e-/e+ sources and RTML

Accelerator Physics – RF compression

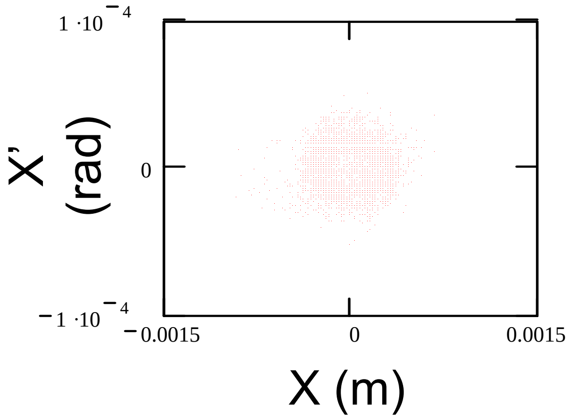
- Hardware is one standard Linac Cryomodule w/o magnets
- Power source is one 5 MW klystron (+spare)
- Accomplishes energy spread specification for injection into DR
- 95% of electrons produce by the DC gun are captured within 6-D damping ring acceptance.

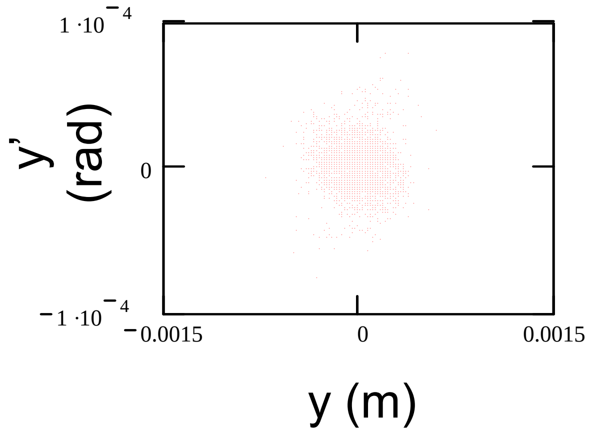
  $\gamma(A_x+A_y) \leq 0.09\text{m}$ and $\Delta E \times \Delta z \leq (\pm 25\ \text{MeV}) \times (\pm 3.46\ \text{cm})$

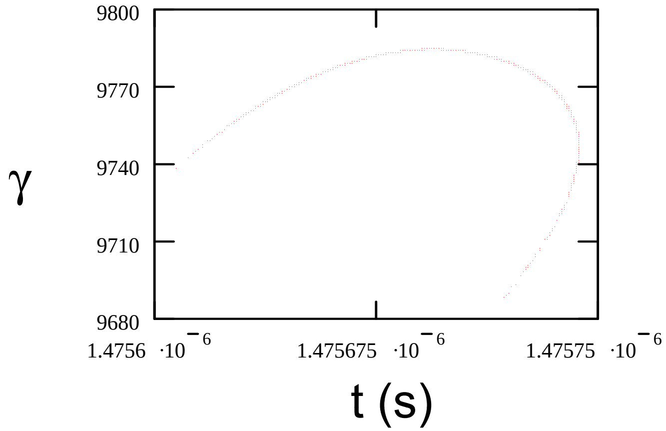
RF compression – Simulation Results

6D Damping ring acceptance √

γ(Ax+Ay)≤0.09m and ΔE x Δz ≤ (±25 MeV) x (±3.46 cm)







Cryomodules

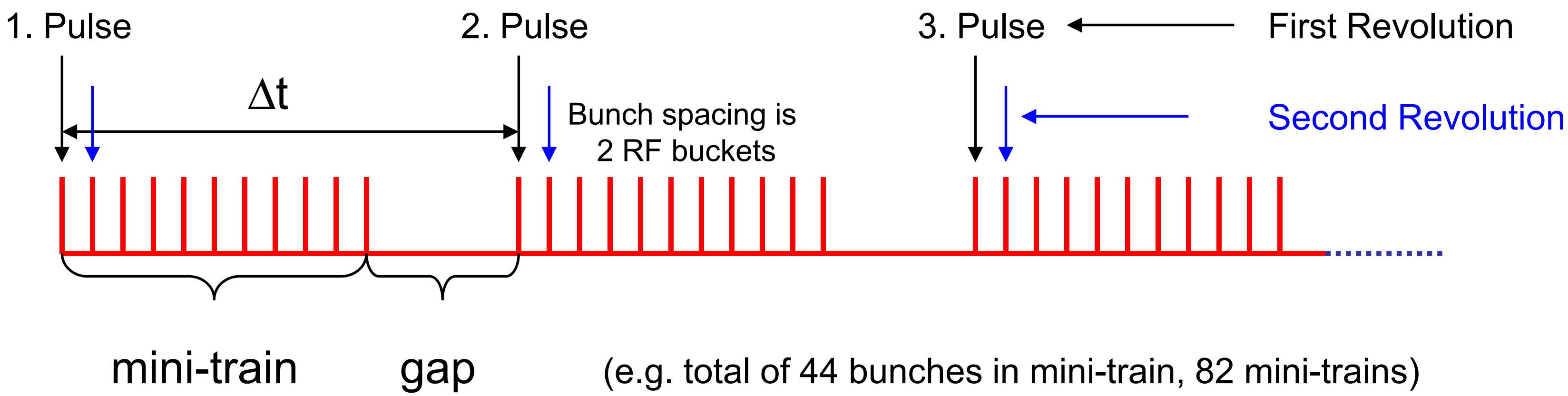
- Total number of CM's: 25
- Use of standard Linac CM's and RF system
- First three strings (of 3 CM) 1 Quad per CM
- Remaining 5 strings 1 Quad per 2 CM's
- 21 CM's needed to accelerate to 5 GeV
- One string provides redundancy
- One CM (w/o magnets) in eLTR used for energy compression

System Inventory

Magnets		Instrumentation		RF System	
Bends	25	BPM's	100	216.7 SHB Cavity	1
Quads (NC)	76	Wirescanners	4	433.3 SHB Cavity	1
Quads (SC)	16	Laser wires	1	5 cell L-band buncher	1
Solenoids (NC)	12	BLMs	5	L-band TW structure	2
Solenoids (SC)	2	OTRs	2	1.3 GHz CMs	25
Correctors (SC)	32	Phase Mon.	2	L-band klystrons/modulators	13

DR – Source RF System Compatibility

DR fundamental RF : 650 MHz
DR fill patterns provides clearing gaps for electron and ion clod



Δt must be an integer multiple of SHB periods, most critical for SHB I

Example:

Δt = 177 DR RF buckets = 272.31 ns → SHB frequency of 216.67 MHz