NLC - The Next Linear Collider Project

NLC Injector Systems Revised Baseline

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NLC Injector Systems Revised

Baseline, CDR-0.4

NLC Project Milestones

CDR-0.4 Baseline Summary

Injector layouts

C-Band, Techno & Cost

600 MeV X-Band BC2 Linac

(Permanent Magnets, DR Wigglers & RF,
Positron Work, C-Band Pulse Compression,
and Beam Loading Compensation,
LATER this ISG5 in WG2)

NLC CDR Roadmap

FY2000	January	Frame NLC CDR 0.4 Model
	May	MAC Review of CDR 0.4
	September	Release NLC CDR 0.4 Model
FY2001	Oct-Dec	Frame NLC CDR 0.8 Model
	January	New President/Congress New DOE Secretary/SC-1
	July	SNOWMASS '01?
	September	Release NLC CDR 0.8 Model DOE CD-1?
FY2002	Oct-Dec	Frame NLC Two-Site CDR
	March	SLAC-FNAL Request FY04 Start
	September	Release NLC Two-Site CDR
FY2003		[Continued R&D, Site Selection, NEPA, Pre-Construction A&E]
	September	NLC CDR Baseline
FY2004		NLC Title I Start

NLC CDR 0.4 Milestones (Rev. 5 - January 27, 2000)

CDR 0.4 Milestones Issued	January 27
U.S. Collaboration Meeting	Jan. 31 – Feb. 2
CDR 0.4 Planning Process Laid Out	February 10
Cost Estimating Guidelines Issued Cost Contingency Guidelines Issued	February 17
SLAC-KEK ISG 5	February 22 - 25
CDR 0.4 Machine Configuration Finalized	March 2
Project Review[a] (WBS)	March 16 - 17
U.S. NLC Physics and Detectors Workshop (LBNL)	March 29 - 31
SLAC-KEK ISG Report Complete	March 31
Project Review[a] (Technical and Cost)	April 20 - 21
Project Review[a] (Technical and Cost)	May 18 - 19
Collaboration Briefing (@FNAL?)	May 25 - 26
CDR 0.4 Optics and Hardware Finalized	June 8
Project Review[a] (Technical, Cost, and Schedule)	June 22 - 23
Final Cost/Schedule Information to Project Planning	July 14
Project Review[a] (Technical, Cost, and Schedule) Area/Engineering/Facilities Presentation Guidance	July 27 - 28
Dry Run Project Review	August 14 - 18
Dress Rehearsal (If Required)	August 28
Presentation Materials Complete	September 9
Printing of Material for Books	September 12
CDR 0.4 Review/Release	September 19 - 23

(a) Reviews with System Managers and Others as Needed

CDR-0.4, Revised Baseline Summary

6-GeV Prelinacs

C-Band replacement of S-Band in the 6-GeV prelinacs and drive linac

100 m diameter turn-around, no sextupoles
600 MeV BC2 linacs

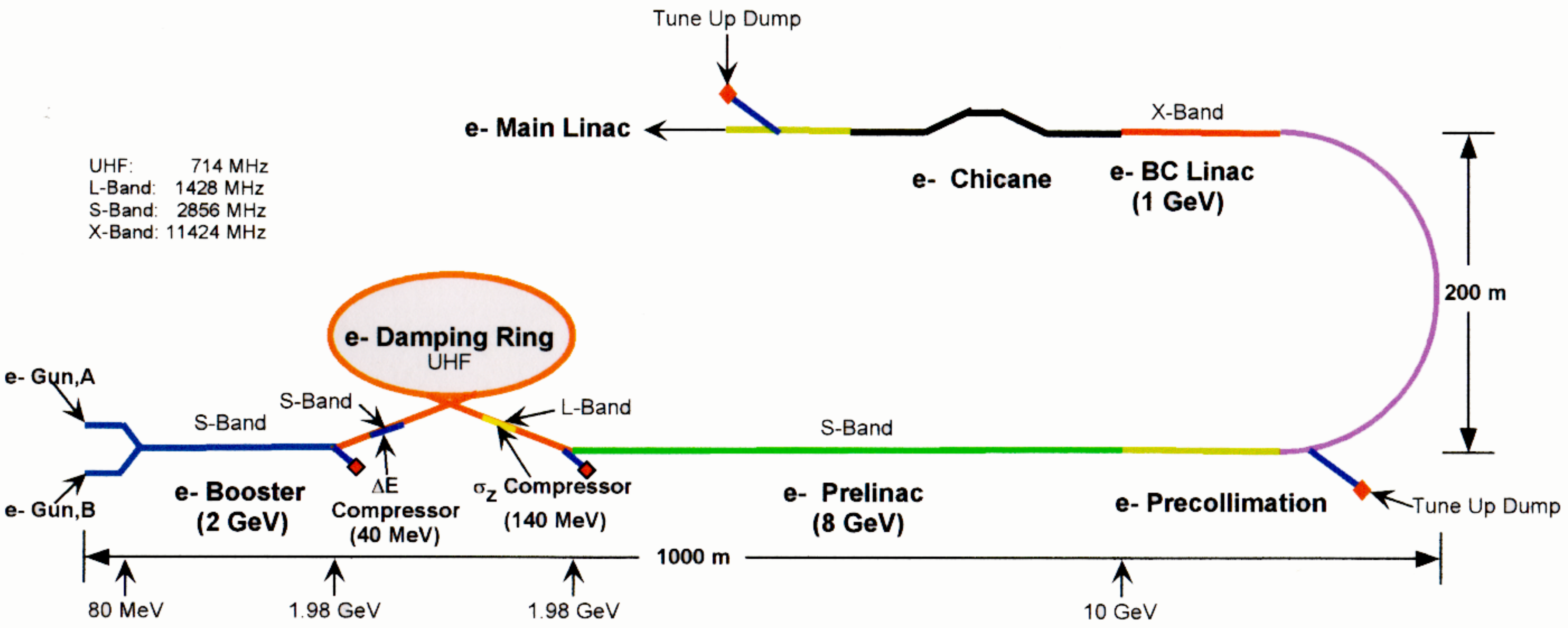
Permanent Magnets, everywhere

Creative Tunnel layouts

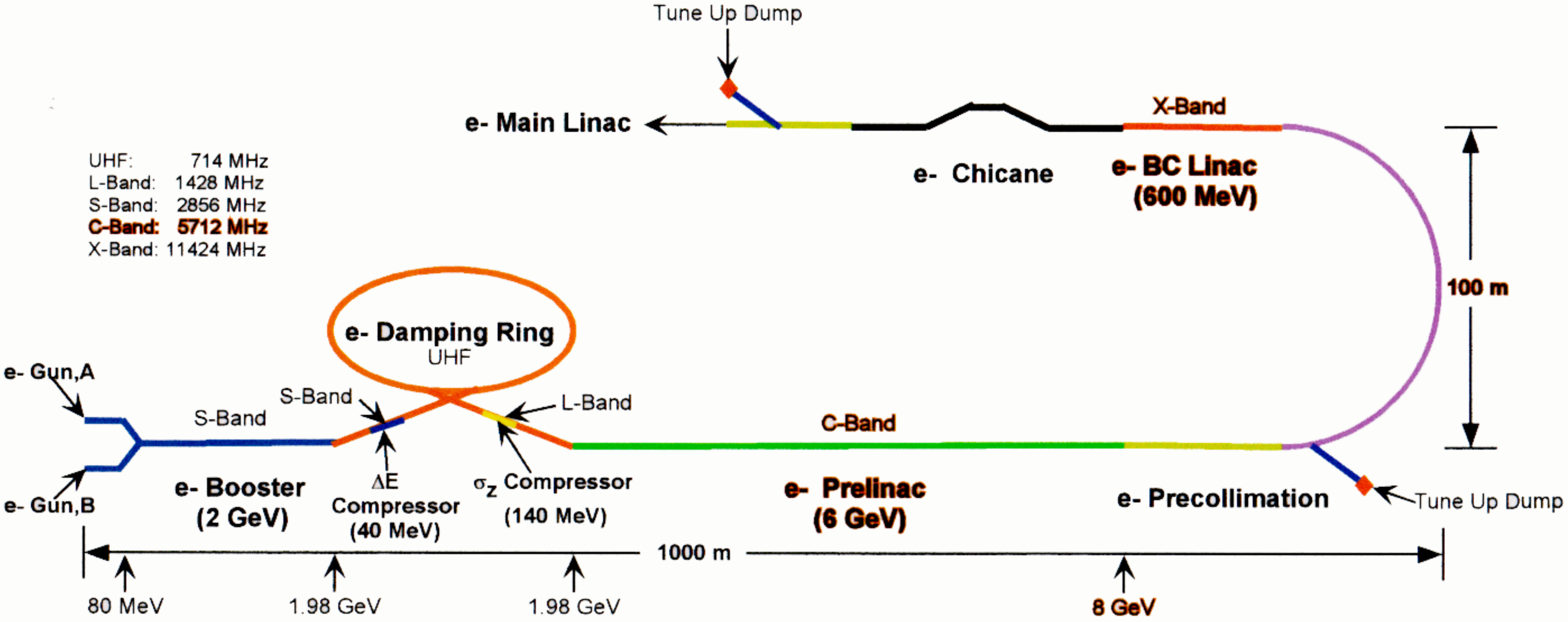
Sources, Damping Rings still well described by the May, 1999 CD-1 Model

Cost Validation expected to Drive Changes

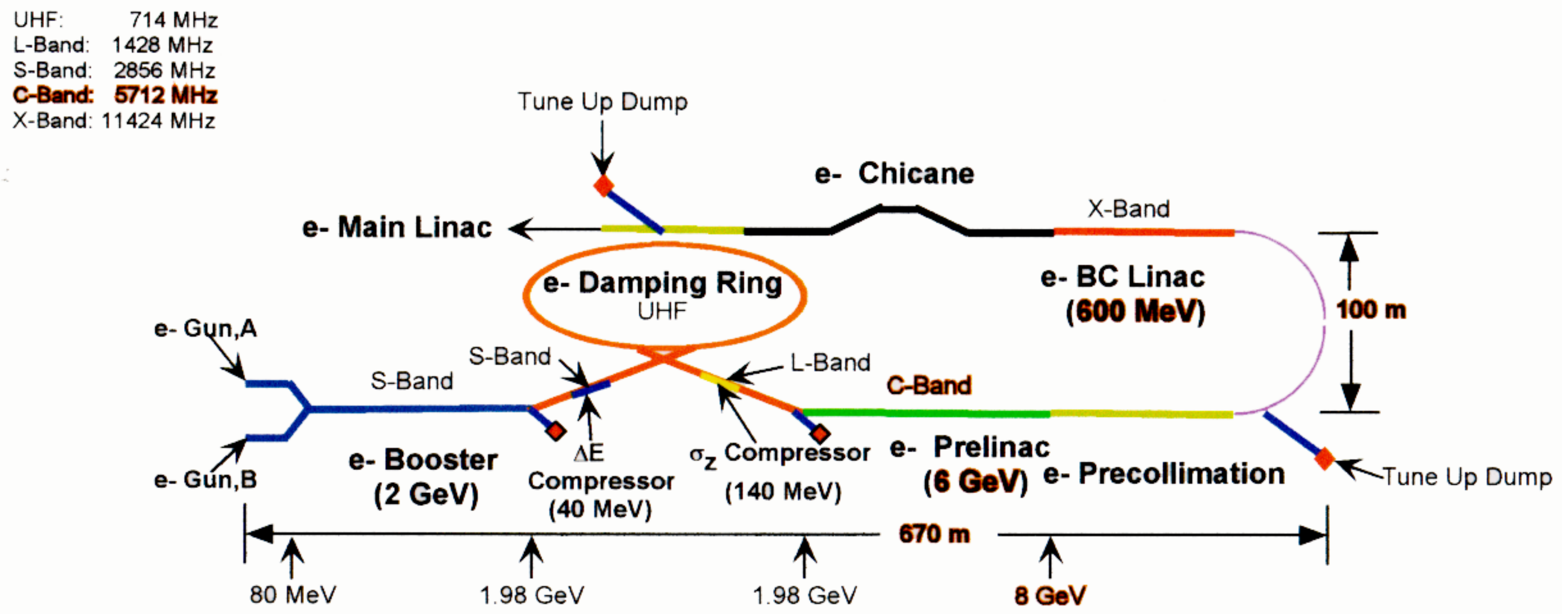
NLC ELECTRON INJECTOR SYSTEM

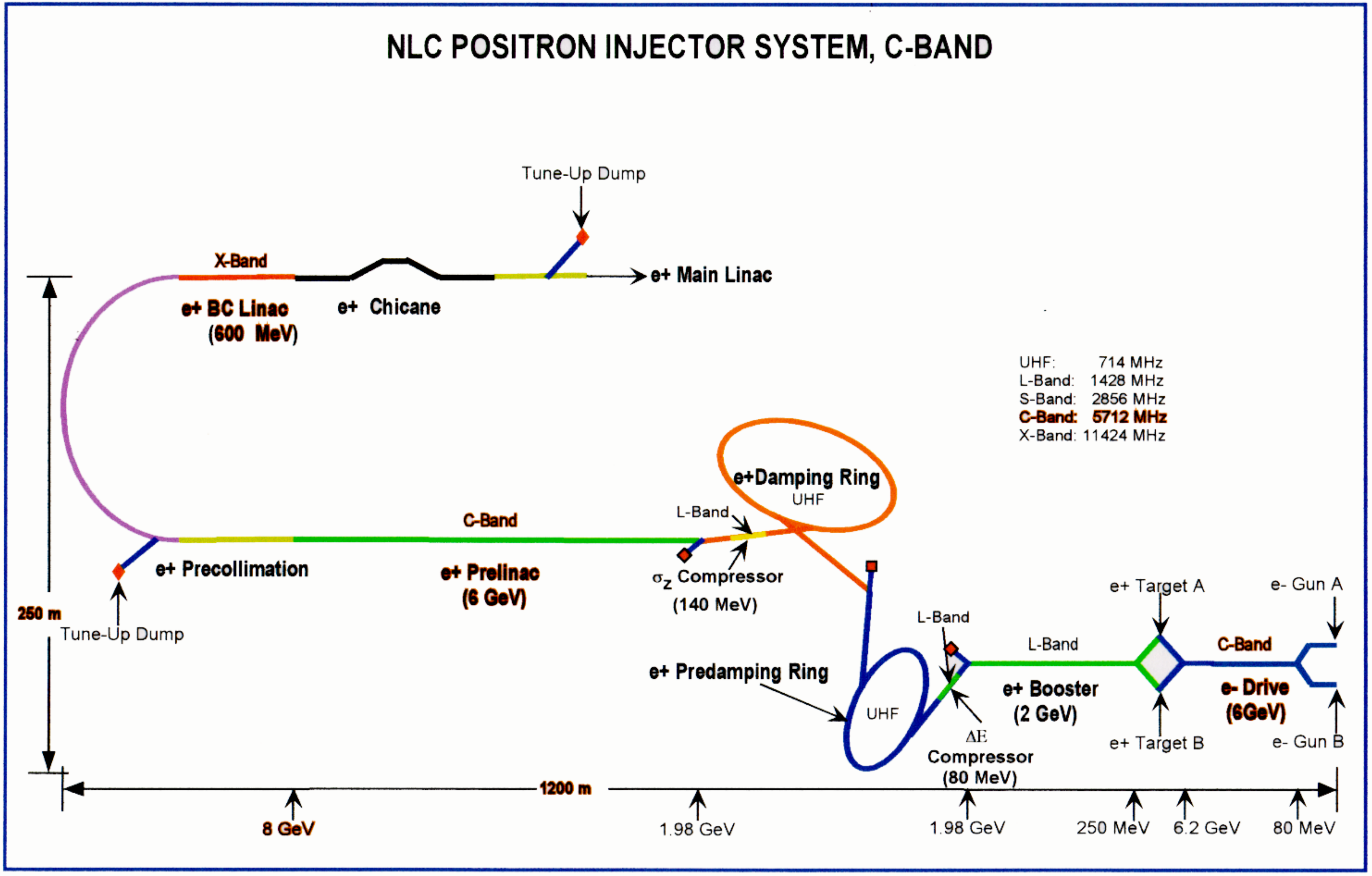


NLC ELECTRON INJECTOR SYSTEM, C-BAND

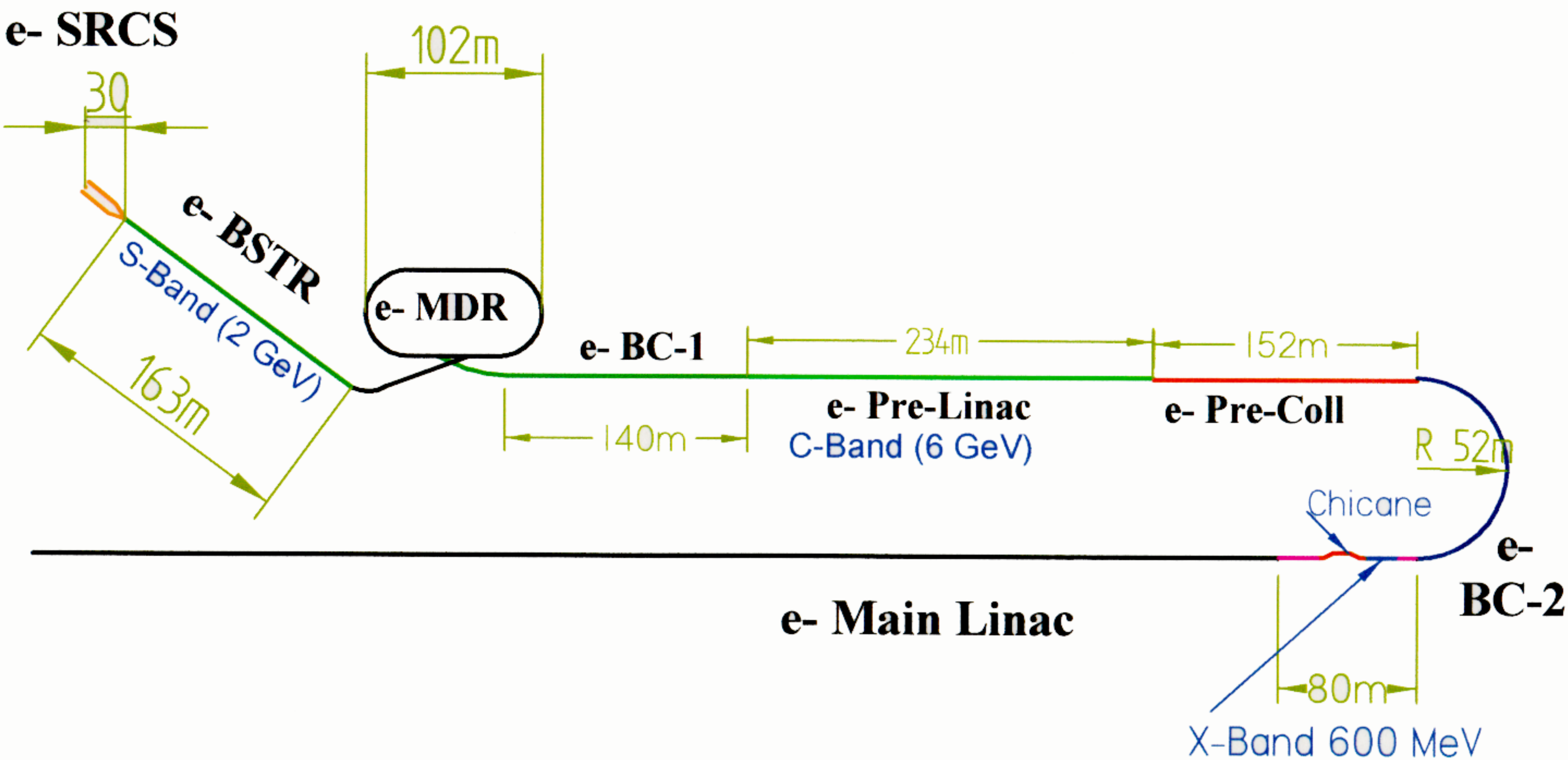


NLC ELECTRON INJECTOR SYSTEM, C-BAND

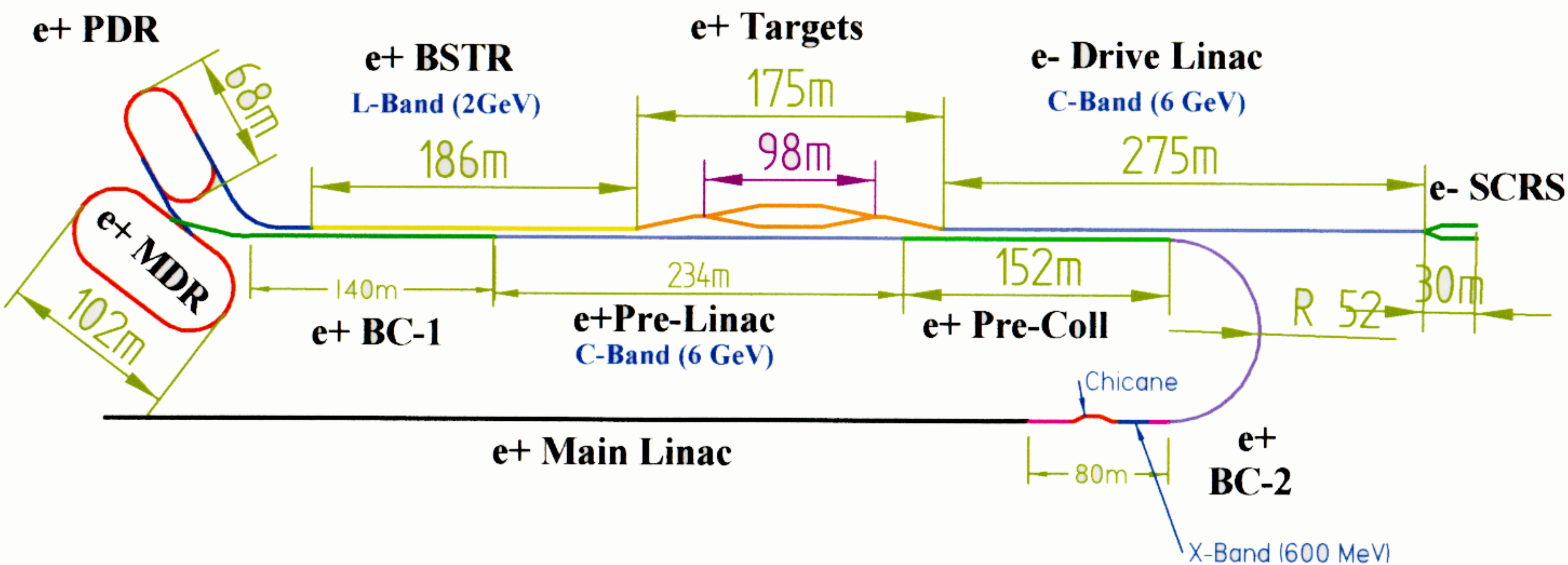



NLC POSITRON INJECTOR SYSTEM, C-BAND
Tune-Up Dump
X-Band
e+ Main Linac
e+ BC Linac
(600 MeV)
e+ Chicane
UHF: 714 MHz
L-Band: 1428 MHz
S-Band: 2856 MHz
C-Band: 5712 MHz
X-Band: 11424 MHz
e+Damping Ring
UHF
L-Band
C-Band
e+ Precollimation
e+ Prelinac
(6 GeV)
σ_z Compressor
(140 MeV)
250 m
Tune-Up Dump
e+ Target A
e- Gun A
L-Band
L-Band
C-Band
e+ Predamping Ring
e+ Booster
(2 GeV)
e- Drive
(6GeV)
UHF
ΔE
Compressor
(80 MeV)
e+ Target B
e- Gun B
1200 m
8 GeV
1.98 GeV
1.98 GeV
250 MeV
6.2 GeV
80 MeV

E- Injector System CDR 0.4



E+ Injector System CDR 0.4



NLC C-Band Injector Tolerances[1]

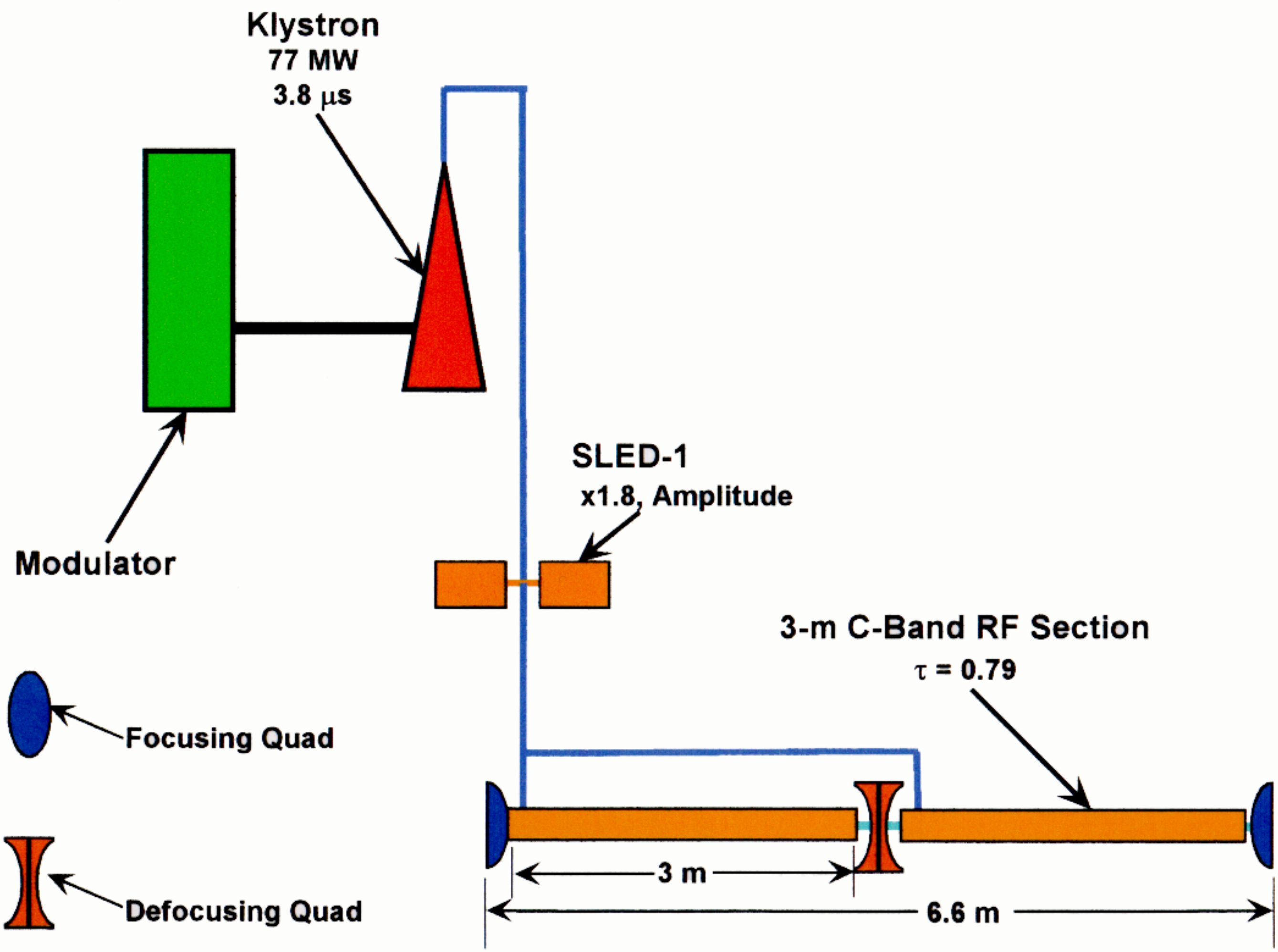
RF Frequency (MHz)	Linac Cost ($M/GeV)	DLWG Alignment[2] (μm)	Quad. Alignment (μm)	Cell-to-Cell Alignment (μm)
1428	25	500	200	?
2856	12	45	10	10
5712	6.5-7.5[3]	7-10	3-2	10?
11424	4	15	2	10

1. TR personal communication and Z. Li, et al., "Parameter Optimization for the Low Frequency Linacs in the NLC," PAC'99.
2. Structure-to-structure alignment tolerance.
3. See Cost Worksheet

C-Band Standard RF Module

G = 35 MV/m

ΔE = 210 MeV



Initial NLC Injector System C-Band Design
jcs October 26, 1999
rev.2.2 December 1, 1999
rev.2.3 March 14, 2000

Klystron

Frequency	5712 MHz
Peak RF Power, P_k	77 MW[1] (75 MW)[3]
RF Pulse Width, Δt_k	3.8 μs (4.0 μs)[3]
Repetition Rate	120 Hz
Total Number	87-107[2]

1. Does not account for power loss in the distribution network; this is estimated to be in the range of 7%-15% (power required is then 82-89MW).
2. Depends on whether or not can use C-band for 2-GeV electron booster linac.
3. Working values of 75 MW at 4 μs given to klystron/modulator team

Modulator

Chosen to match klystron design	
Repetition Rate	120 Hz
Total Number	87-107

Accelerator Sections

Section Type	CG, RDDS[1]
Length	3 m
Attenuation Parameter, τ	0.79
Fill Time, T_{fill}	405 ns
Group Velocity, v_g/c	0.0492-0.0103
Average v_g/c	0.025
Iris radii, a	8.9-5.9 mm
a/λ	0.17–0.12
Average iris, a	7.4 mm
Average a/λ	0.14
Average Shunt Impedance, R_s	76.4 MΩ/m
Number of cells	171
Number Sections	174-214
Fabrication Tolerances	Same as X-Band RDDS
Unloaded Gradient	48 MV/m
Loaded Gradient	35 MV/m

1. Chose Zenghai Li S-Band RDS, Rs for 4 m long structure, scaled Q down by sqrt(2), L down by a factor of 2. Increased τ by a factor of 1.7, length by a factor of 1.5. The iris sizes are extrapolated from the SLAC DLWG taking the mean of 3rd and 4th order fits of vg/c to 2a, scaled down by a factor of 2 for C-Band and augmented by the ratio of 14mm/13 mm which is Z. Li's radius increase for RDS with respect to DLWG. The value of a needs to be properly calculated.

Pulse Compression

Pulse Compression Method	SLED-I
Compression Type	KEK, Dual Side-Wall Coupling Irises[1]
Frequency	5712 MHz
β-Coupling	2.5
Q_0	71000
Cavity Fill Time, T_c	1.13 μs
Input Power, P_k	77 MW
RF Pulse Width, Δt_k	3.8 μs
SLED Multiplier, Amplitude	1.809
Total Number	87-107

1. H. Matsumoto, et al., "High power test of a SLED system with dual side-wall coupling irises for linear colliders," NIM A330 (1993), 1-11.

Focusing Lattice

Lattice Type	FODO
Phase Shift per Cell	90^0
Quadrupole Spacing	3 m (or 6 m)
Quad Strength, ∫gdl	30-120 kG (15-60 kG)
Effective Length	15 cm.
Aperture	2 cm.
Max. Pole Tip Field	16 kG
Number of Quads	198-225 (99-113)
Alignment Tolerances[1]	2-3 μm
Correction Actuators[1]	X-Y movers
Drive Linac Alignment	75 μm
Drive Linac Correctors	X-Y Steering Dipoles

1. X-Y movers are required for 2/3 of the total number of quadrupoles (for the 2 6-GeV Prelinacs). 1/3 of the quadrupoles (in the 6-GeV Drive Linac) are set on fixed magnet supports.

Beam Position Monitors

Number of Structure BPMs	348-428[1]
Number of Quadrupole BPMs	198-225 (99-113)
SBPM Resolution	2 μm

QBPM Resolution	<1 µm

1. 2 Structure BPMs (SBPM) per section of DLWG per hds 3/14/00

RF Distribution Waveguide

Rectangular, 1	
Material	Copper
Waveguide Dimension **a**	3.61 cm
Waveguide Dimension **b**	1.70 cm
f_c, TE_{10}	4156 MHz
Field Attenuation TE_{10}	0.0067 nepers/m
Power Loss, 20 m	24%
Rectangular, 2	
Material	Copper
Waveguide Dimension **a**	6.00 cm
Waveguide Dimension **b**	2.82 cm
f_c, TE_{10}	2504 MHz
Field Attenuation TE_{10}	0.0024 nepers/m
Power Loss, 20 m	9.2%
Circular, 1	
Material	Copper
Waveguide Diameter	12.1 cm (4.75 in.)
f_c, TE_{11}	1453 MHz
Field Attenuation TE_{01}	0.00028 nepers/m
Power Loss, 20 m	1%
Circular, 2	
Material	Copper
Waveguide Diameter	7.5 cm (2.95 in.)
f_c, TE_{11}	2344 MHz
Field Attenuation TE_{01}	0.002 nepers/m
Power Loss, 20 m	7.7%

Vacuum Requirements

Vacuum Specification	$<10^{-8}$ torr

Work Needed to be Done in regards to C-Band

Investigation into Pulse Compression

SLED-1,3, BPC, RBPC, DLDS, SWIRL

sets klystron/modulator parameters (P_{peak}, T_{rf})

sets structure parameters (τ, $L_{structure}$, 2a)

sets beam beam loading algorithm

Select Structure Parameters

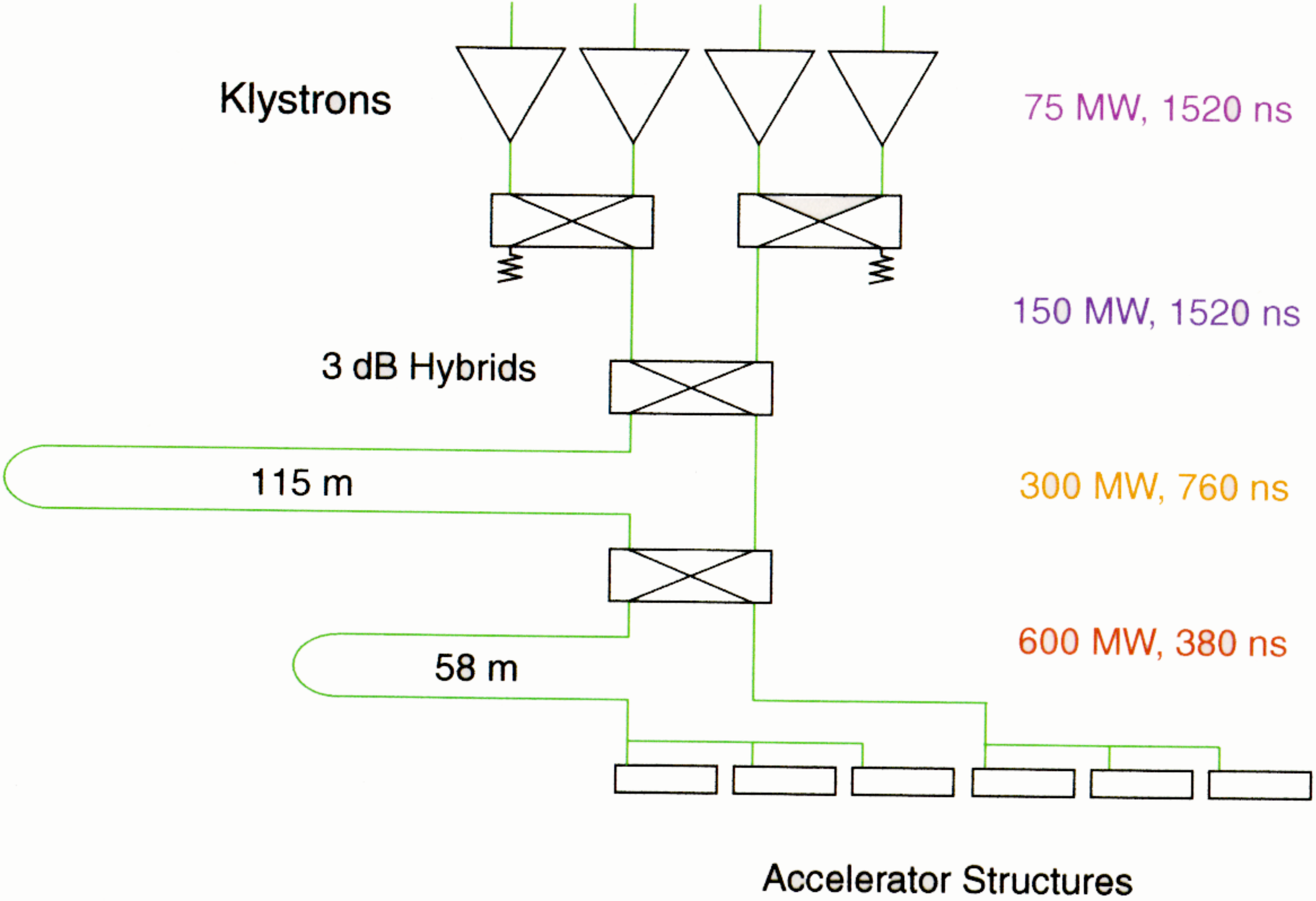
τ, $L_{structure}$, 2a, damping, detuning

Figure out Tolerances, reset NLC Tolerance Budget

BPM resolution, damping requirements, bunch compression scenario (σ_z in the prelinacs)

In the meantime, Starting Cost Estimation using December, 1999 Layout

X-Band Acceleration Section in BC2



600 MeV X-Band BC2 Linac Summary

600 MeV Acceleration, loaded

55 MV/m Gradient, loaded

Six 1.8 m NLC X-Band Accelerator Structures

Binary RF Pulse Compression

Four 75 MW, 1520 ns Klystrons

Extensive use of Main Linac Technologies