availability & reliability at linear colliders
- historical studies

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PERFORMANCE ISSUES, DOWNTIME RECOVERY AND TUNING IN THE NEXT LINEAR COLLIDER (NLC) *

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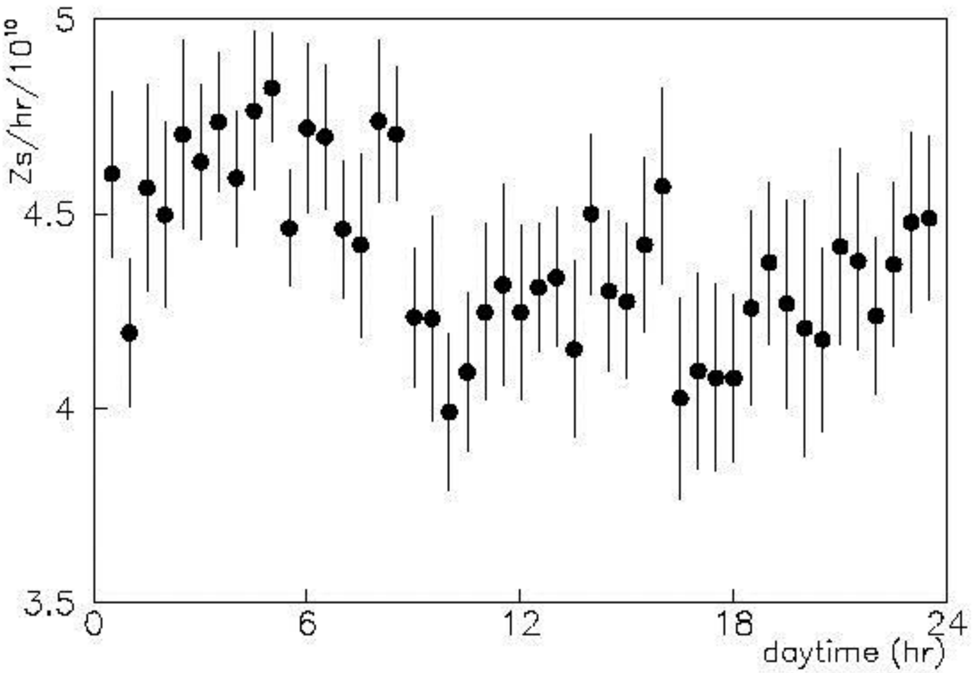
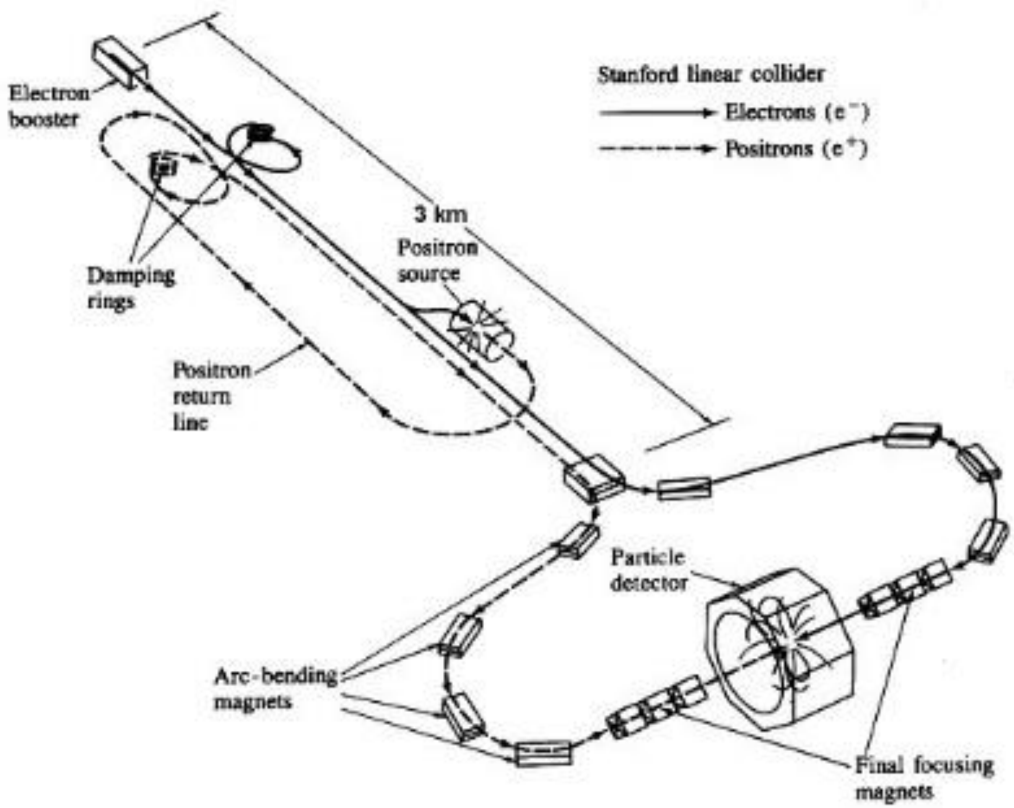


Diurnal luminosity during the 1996 SLC run. Shown is luminosity normalized to 10^{10} particles per bunch. Actual luminosity would be ~12x higher. A rate of 1 Z/hr is equal to ~10^{28} cm^{-2} s^{-1}.

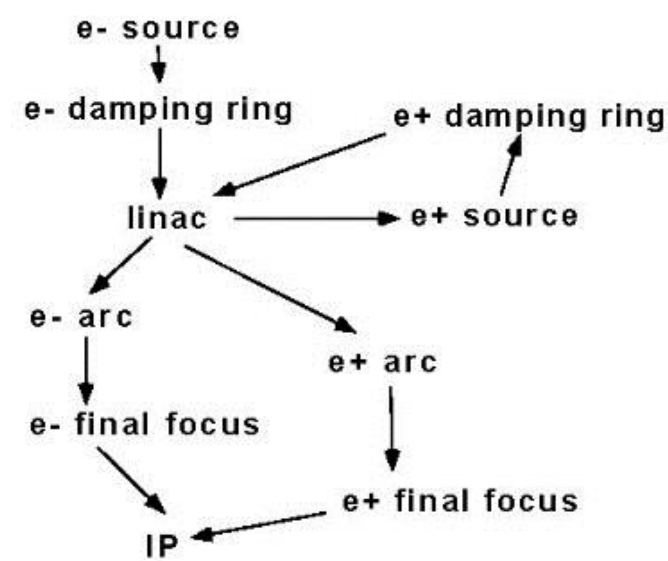
Luminosity	1994/95	1996
$L > 10$ Zs/hr	56 %	57 %
$L > 30$ Zs/hr	42 %	50 %
$L > 40$ Zs/hr	27 %	34 %
$L > 50$ Zs/hr	15 %	18 %

Fraction of time (not including overall down-time) during which a certain luminosity was exceeded in the 1994/95 and 1996 SLC runs.

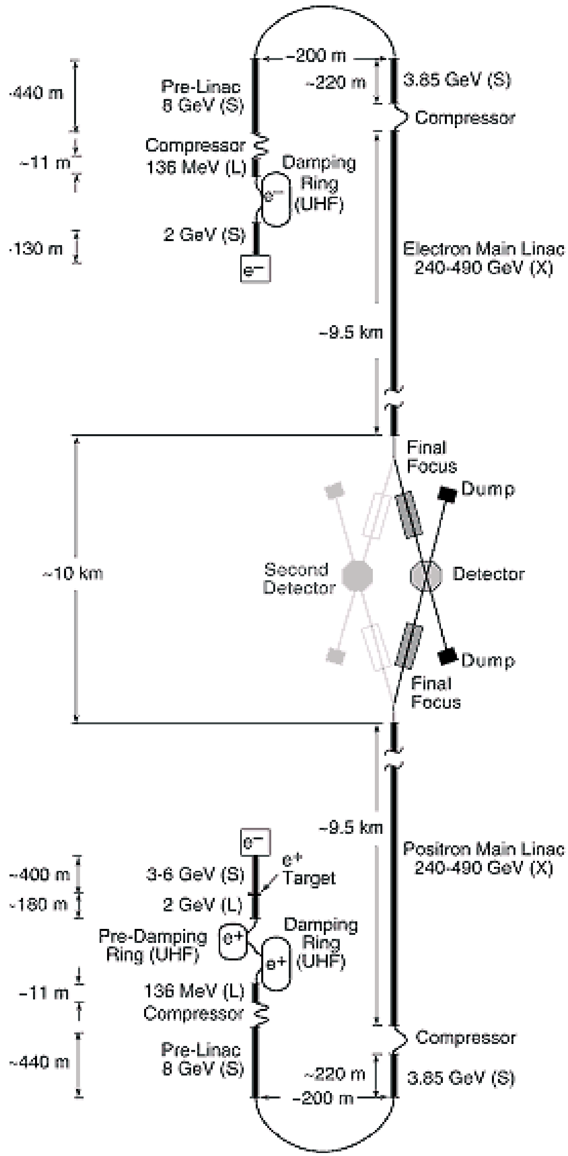
Stanford Linear Collider (SLC)
1987-1998



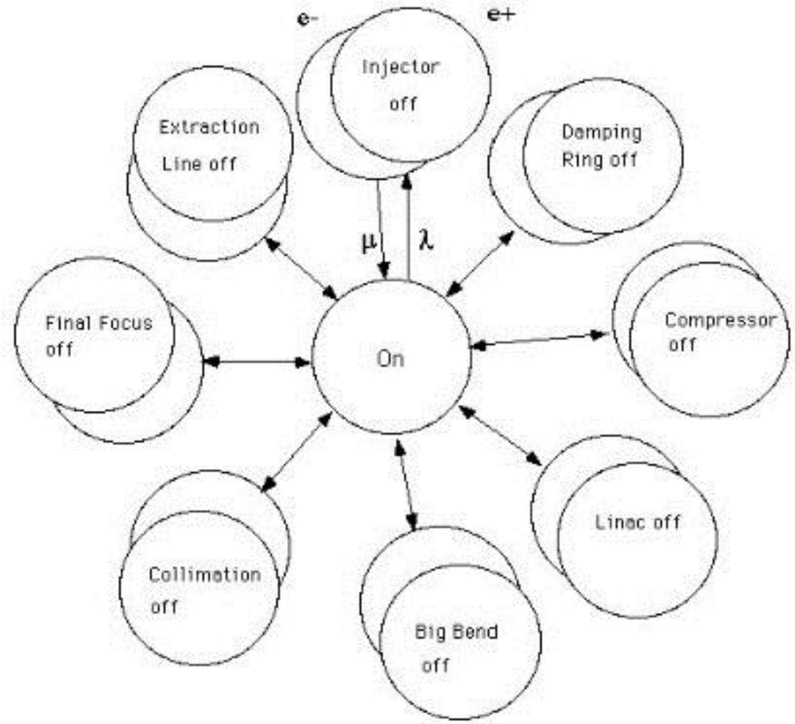
Markov model of the SLC.



Design of the Next Linear Collider (NLC) as of ~1996



Markov model of the NLC



'OFF' indicates a failure of the respective subsystem

example equations for the Markov models

system state

$$\frac{dA_i}{dt} = \lambda_i A_0 - \mu_i A_i$$

failure rate

recovery rate

$$\mu_i = \frac{1}{\sum_{j \le i} \tau_j + \varepsilon_i}$$

tuning recovery time

average repair time

$$1 = A_0 + \sum_{i=1}^{8} A_i$$

total failure rate

$$\bar{\lambda} = \sum_{i \ge 1} \lambda_i$$

availability of e+ or e- system

$$A_0 = \frac{1}{1 + \bar{\lambda}\bar{\tau}}$$

$\bar{\tau}$: effective recovery time

in general: $A_0 = A_0\left(\vec{\lambda}, \vec{\tau}, \vec{\varepsilon}\right)$

various assumptions possible -
e.g. for equal subsystem failure rate, equal repair and recovery times

$$A_0 = \frac{1}{1 + 36\lambda\tau + 8\lambda\varepsilon}$$

another scenario: equal luminosity impact …

performance recovery time - example

recovery from	t_{DT} [min]	t_{ROD} [min]
check BPM polarity & offset	NA	5
activate orbit feedbacks	5	5
close FF collimators	0	0
feedb. & orbit for 90 bunches	5	5
match incoming dispersion	NA	5
measure FF emittances	5	5
coupling corr. & beta-match	0	0
turn on & phase crab cavity	NA	5
establish collisions	2	2
turn on detector	NA	5
correct IP aberrations	5	5
total	22	42

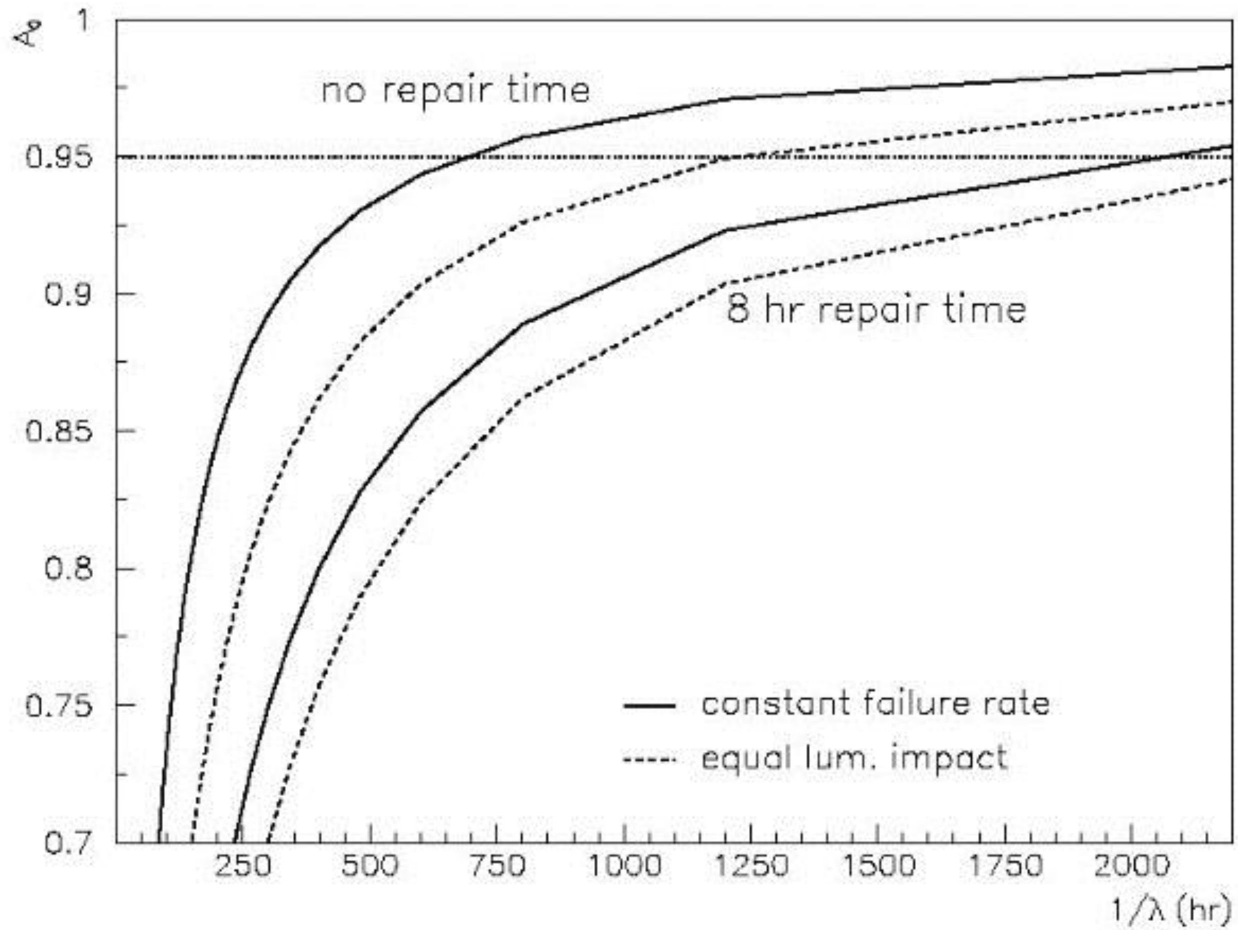
Performance recovery time ε of the NLC final focus after a 1-hr down time (DT) and after a 24-hr repair day (ROD).

procedure	t [min]	T [hr]	$\Delta L/L$ [%]
multi-bunch steering	0.5	0.08	0
dispersion (x&y)	0.12	0.25	0.8
waist (x&y)	0.12	0.25	0.8
skew1 (x'y')	0.06	0.25	0.4
IP divergence	0.017	1	0
skew sexts. (x'^2y', y'^3)	0.12	1	0.2
skew2 (xy')	0.06	1	0.1
skew3 (x'y)	0.06	1	0.1
multi-bunch y-disp.	0.06	8	0.03
multi-bunch waist x& y	0.12	8	0.03
adjust FF main collimators	5	24	0.35
orbit resteering	60	100	0.25
BPM align. & offsets	30	170	0.1
sext. (x'^3, $x'y'^2$)	0.12	170	0
chrom. x& y	0.12	170	0
chrom. skew ($x'y'\delta$)	5	170	0.05
2nd order y-disp.	0.6	170	0.01
crab angle (xz')	—	170	0
match inc. dispersion	5	170	0.05
total			3.27

Continual tunings procedures in the NLC final focus: required time *t*, tuning period *T*, and **estimated luminosity impact ΔL/L**

Recovery times and luminosity reduction due to continual tuning for all NLC subsystems

subsystem	t_{DT} [min]	t_{ROD} [min]	$\Delta L/L$ [%]
systemwide	—	15	—
injectors	4	45	2.5
damping rings	16	64	2.4
compressors	15	70	3.2
main linac	17	45	4.6
collimation	25	25	4.3
IP switch/b. bend	10	15	0.9
final focus	22	42	3.3
extraction line	9	21	0
total	118	342	21.2



Availability $A_{e\pm}$ versus MTBF (=inverse failure rate $1/\lambda$), for an individual recovery time τ =1hr, two different repair times ε and two different assumptions on failure rate scaling.

subsystem	May 96	model I	model II
e− damping ring	0.94	0.90	0.93
e+ damping ring	0.82	0.76	0.82
e− arc	0.89	0.78	0.83
'IP'	0.57	0.57	0.57

Comparison of actual beam availability for various SLC subsystems with that predicted by two different models; the recovery-time was adjusted to give equal IP availability.

While the **data appear to favour models with a longer recovery time for the last subsystems** (model II), they would also be consistent with upstream systems being tuned over extended periods of time.