R&D, Risk, and Reliability

ILC-TRC R1, R2's a reminder

What is considered risky for the linacs

Availability study

IRC-TRC R&D Needed (linac technology)

R1 R&D needed for feasibility demonstration
R2 R&D needed to finalize design choices & ensure reliability

R1 -Build 35MV/m cryomodule, measure quench and dark current
R2 -Test complete RF sub unit with several modules at nominal field
couplers, controls(llrf), alignment, quench, breakdown rates
- tradeoffs between one and two tunnel
- cryo module & quad information on sources/and levels of vibration
- development of most critical instrumentation,
include intra and train to train luminosity monitors and laser wires.
- evaluation of critical sub system reliability(MTBF, MTTR, MTBO)

Risk linacs

Technology	level (arbitary units)
Klystron	5 lifetime
Cavity production	5 prod performance
Coupler production	3 prod perform
Gradient	3
Heatload Dark current	2 data needed
Energy variation	2 rf control
Loss of vacuum	1

Emittance	
Linac emittance tuning	4 ballistic tuning, quads off, centers,pc
Beam jitter	3 vibration quads
Wake fields, production	1,3 cavity posit,tilt stab 300mic,micrad, fab
Diagnostics BPM's	2 resolution 3mic, stability to quad 11mic
Magnet system, production	1, 2 quad centers, persist cur, with excit 360mic
Site noise	2
Intra train feedback	2 hi gain, band width
Dark current wakes	1

Goal Availability Study

25% tot downtime for Hardward problems
Of this only 15% explicitly budgeted to specific devices
Rest (10%) kept in reserve contingency

For the Damping Rings and Linacs
Find MTBF of specific devices and linac energy overhead which along with the
Budgeted nominal down time for other regions (e.g. injector, cryoplant) gives 85% up time for HEP Lumi Integration and Scheduled Machine Development (MD).

There is opportunistic MD that can take place in some regions while others are in access for repair. This means that Scheduled MD is less than the overall desired time.

Availability Study

Machine Development Allocation	%	Lumped systems Down Time% (*1/2 tunnel access)
e- inj	1	.4*
e- damping ring	2	
e- compressor	1	.3*
e- linac	1	
e- beam delivery system	1	.4*
		.4*
e+ source	1	
e+ damping ring	2	.3*
e+ compressor	1	
e+ linac	1	.4*
e+ bds	1	.3*
IP	1	1.0
Cryo plants		.5
site power		.2
global controls		4.2
Total	13	

Tune up recovery time/time without beam

e- inj	.1
e- damping ring	.2
e- compressor	.1
e- linac	.1
e- beam delivery system	.1
e+ source	.1
e+ damping ring	.2
e+ compressor	.1
e+ linac	.1
e+ bds	.1
IP	.2
Cryo plants	
site power	
global controls	

Example- if e- linac fails total time to recover operation is about twice the time for repair. (undulator e+)

Cold Results #2, 2 tunnel, und e+, 3% energy overhead

region	% downtime incl forced MD
sitewide	4.614
e- injector	1.322
e- DR	1.767
e- compressor	0.9338
e- linac	1.288
e- BDS	0.6625
e+ source	0.9052
e+ PDR	0
e+ DR	1.347
e+ compressor	0.5155
e+ linac	1.103
e+ BDS	0.4971
IP	0.5185
% time down incl forced MD	15.5

% time down incl forced MD	15.5
% time fully up integrating lum or sched MD	84.5
% time integrating lum	74.3
% time scheduled MD	10.2
% time actual opportunistic MD	1.78
% time useless down	13.7
number of accesses per month	3.79

Note: linacs are 2.4%
DR's 3.1%
other regions 5.4%
site wide 4.6%
cryo plant 2.6%
power 1.4%
controls global 0.6%

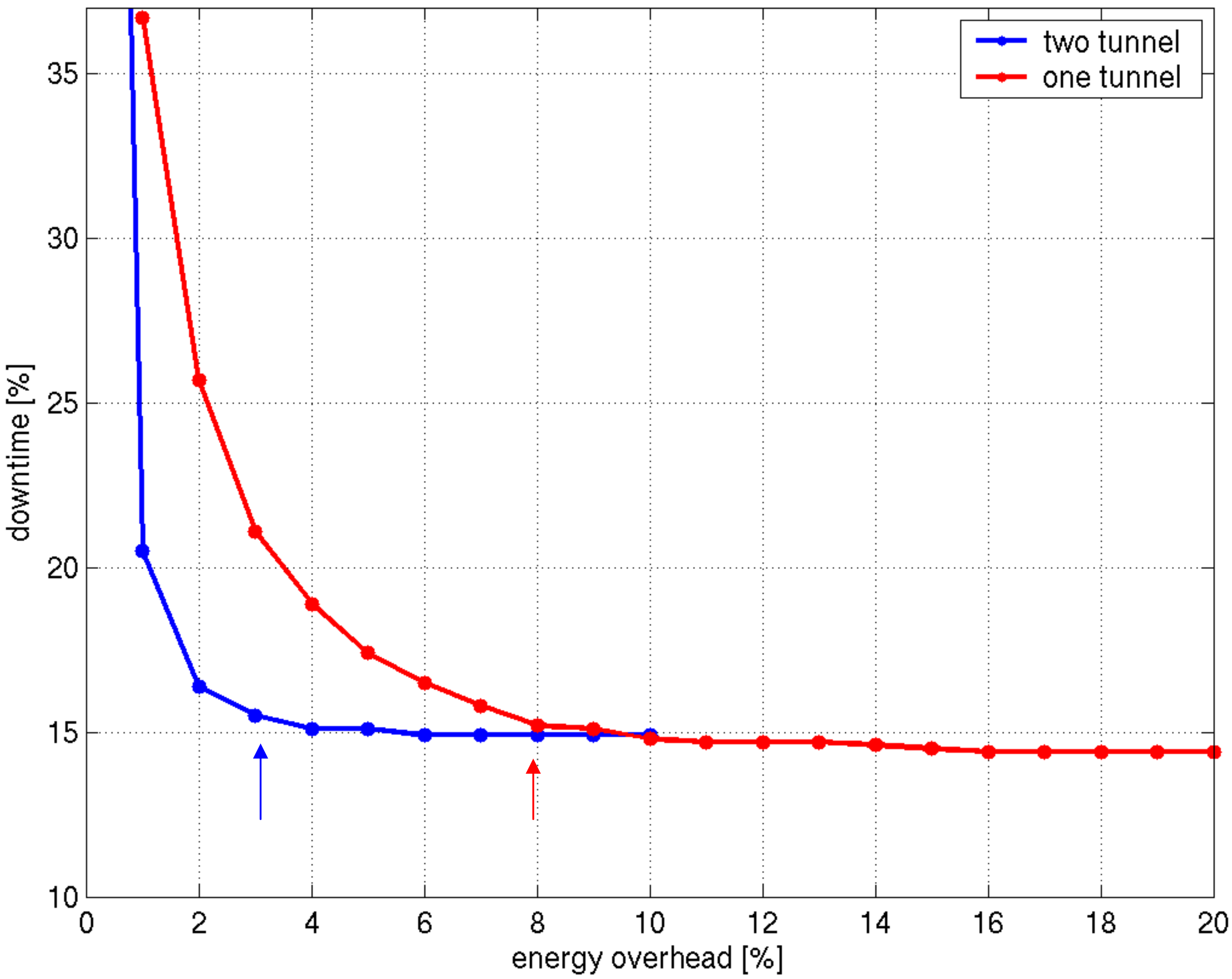
#2Cold- What are DR & Linac MTBF's ? Energy overhead 3% (devices with MTBF increased from nominal)

Device	MTBF (hr)	#device	%Increase DT if 0.1*MTBF
water cooled magnets	10e6	2800	5%
Large PS controllers	4e6	600	1.2%
Large PS	2e6	600	1.9%
electronic modules	0.3e6	25000	3.8%
linac controls local	0.9e6	600	0.8%
vac valve controllers	0.95e6	300	1.3%
flow switch	2.5e6	1700	1.8%
water instrumentation	.09e6	330	1.2%
AC power dist small	3.6e6	700	1.1%
1st 5 kly & hardware	range0.8-100e6	10	0.4%
cavity tuner	50e6	18000	0.1%
insulat vac pumps	0.6e6	150	1.6%

Linac component systems 2.4% DT

Devices	DT	# 1 linac	MTBF hr e6	MTTR hr	
1)Magnets	.03%	632	10	0.5-8	
2)Power Supplies & controllers	.52%	1270	0.4-4	0.5-2	
3)Vac pump and supply,valves	.55%	1664	0.1-10	1-8	
4)Water pump sys	.11%	12	0.1-2.5	1-4	
5)Cavity, coupler, interlocks, tuners, coupler vac	.12%	~7*9150	0.3-100	1-672	energy overhead
6)cryostat vac sys, JTs	.10%	152	0.3-0.6	2-8	energy overhead
7)1st 5 Mod, kly sys	.06%	67	0.8-70	1-8	
8)Mod, kly systems	.41%	~12*300	.04-10	1-8	energy overhead
9)elect utility	.10%	150	3.6	2	
10)controls & MPS	.38%	410	.005-0.9	1	

Energy Overhead, 1 & 2 tunnel   Huening



Cavity Systems

Devices	DT %	# 1 linac	MTBF hr e6	MTTR hr	del E MeV
cavity-degrade	0	9150	100	672	-8
cavity-broken	0	"	100	672	-29
cavity tuner	0	"	50	672	-29
piezo tuner	0	"	0.5	672	-5
llrf	0.02	"	0.3	1	-29
power coupler-degrade	0	"	10	2	-240
power coupler-broken	0.02	"	10	2	-872
power coupler-disconnect	0	"			-29
coupler interlock sensors	0.06	"	1	1	-872
coupler interlock electro	0.02	"	1	1	-872
coup vac pump	0	762	100	4	-872
coupler vac pump elect	0	762	1	1	-872

Modulator/klystron system

Devices	DT %	# 1 linac	MTBF hr e6	MTTR hr	del E MeV
Modulator	0.14	300	.05	4	-872
pulse transformer	0.0	300	.2	4	"
klystrons	0.12	300	.04	8	"
klystron pre amps	0.01	300	.1	1	"
klystron vac guage/cont	0.01	300	.1	1	"
vac pump	0.03	300	10	8	"
vac pump power supply	0.03	300	.1	1	"
controls timing	0	300	.3	1	"
controls other	0.01	900	.3	1	"
water pump	0.02	150	.12	4	-1744
water instr	0.02	150	.09	2	"
water flow switch(interlock)	0	450	2.5	1	-872
ac power >0.5	0.02	150	.36	4	-1744
ac power .05 to .5	0	150	3.6	2	-1744
Tot	0.41				

Configuration	UT inc forced MD w/o 10% conting	Lumi time with 10%contigency
Two tunnel, e+undulator,	84.5%	64.3%
Two tunnel, e+ conv*	88.2%	74.5%
One tunnel, e+undulator	74.9%	54.3%

*Shows better use of down time for opportunistic MD

Comments

1) Large quantity devices in the cryostat like tuners,tuner motors, piezo tuners, instrumentation, that would require warming up or module removal to fix must either be redundant, be able to be changed in place upon warmup, or be brought out of cryostat. Even if there is enough energy overhead so they do not impact operation, if too many fail during a year of operation warm up repairs during the long shutdown will become excessive.

Example: 20,000 cavities, tuners, etc

if tuner MTBF e6 hr , then in 5000 hr operation 100 will need repair in a long shutdn.

2) Where MTBF are e6 or greater, often this implies redundant systems. eg power supplies.
3) The 1st 5 kly/modulator linac systems are assumed redundant because they disrupt the beam so much that they need to be fixed rather than retune the beam.

Risk

Technology	level (arbitary units)
Klystron	54
Cavity production	54
Coupler production	36
Gradient	36
Heatload Dark current	24
Energy variation	24
Loss of vacuum	18

Emittance	
Linac emittance tuning	48
Beam jitter	36
Wake fields production	36
Diagnostics BPM's	24
Magnet system, production	16, 24
Site noise	24
Intra train feedback	24
Dark current wakes	18

A Tuned Result 8 not what i want

region	% downtime incl forced MD
sitewide	4.601
e- injector	1.322
e- DR	1.758
e- compressor	0.8368
e- linac	1.152
e- BDS	0.6581
e+ source	0.9172
e+ PDR	0
e+ DR	1.308
e+ compressor	0.4746
e+ linac	0.9903
e+ BDS	0.5044
IP	0.5071
% time down incl forced MD	15

% time down incl forced MD	15
% time fully up integrating lum or sched MD	85
% time integrating lum	75.4
% time scheduled MD	9.56
% time actual opportunistic MD	2.44
% time useless down	12.6
number of accesses per month	3.83