Availability and reserved tunnel-extension – Some comments on ILC Energy Overhead

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Material largely drawn from J.Carwardine's talk at Oxford AAP meeting

Information based on availsim simulations (T.Himel)

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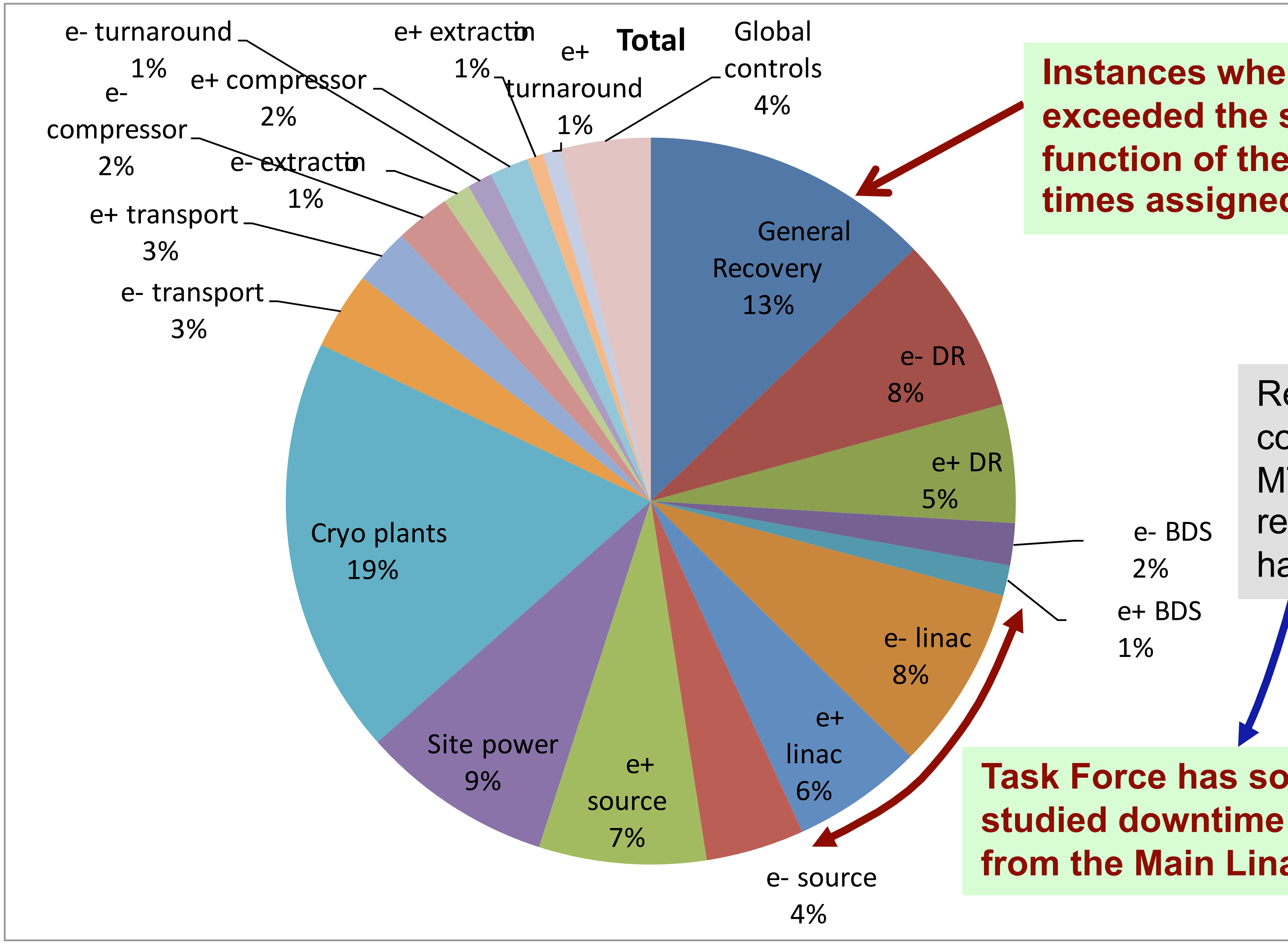
Downtime by accelerator area for KCS simulation (Percentage of the 15% "budget")

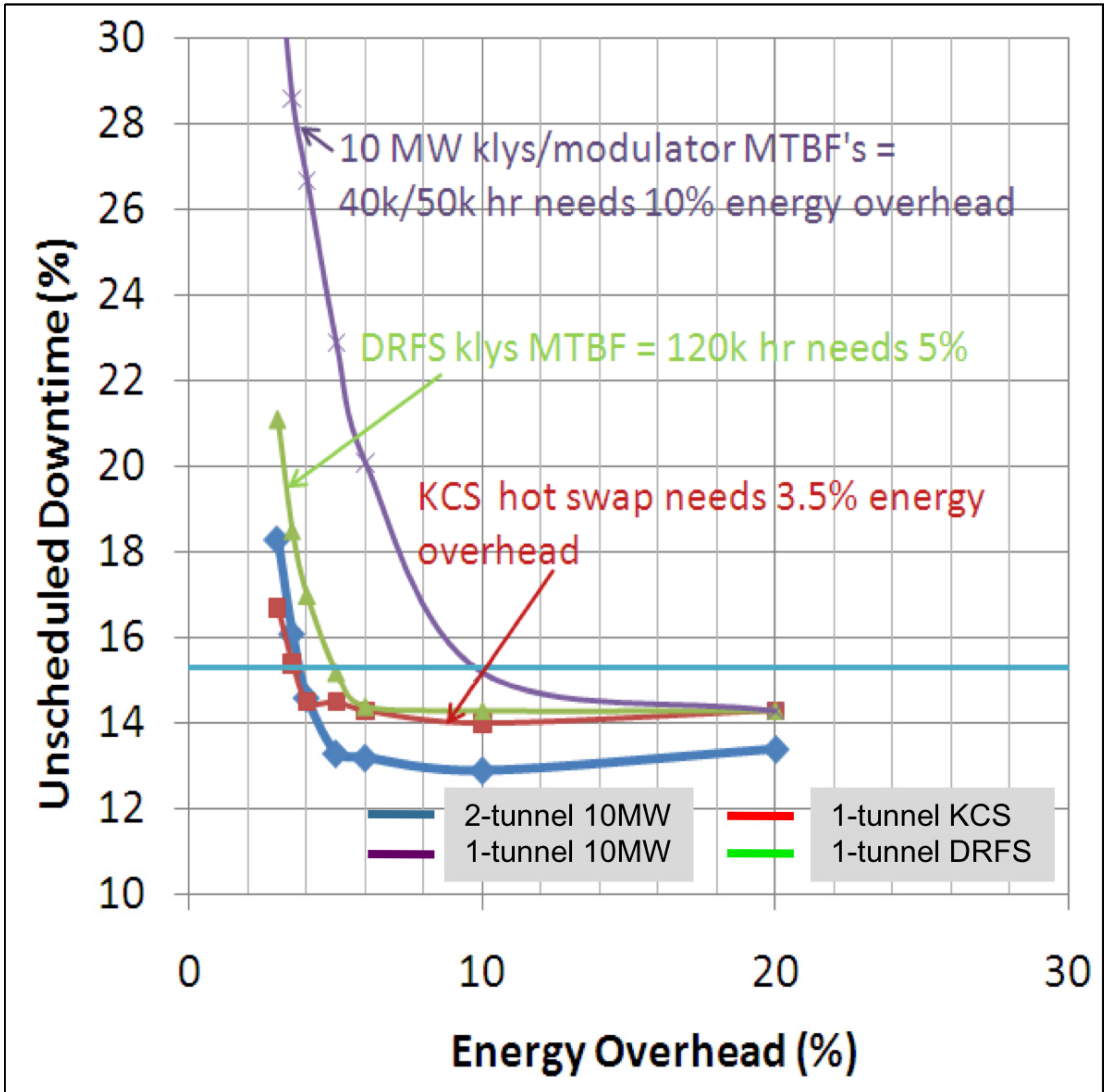


Instances when recovery times exceeded the scheduled 9hrs (a function of the variance in recovery times assigned to Availsim model)

Reducing recovery times could allow Main Linac MTBF requirements to be relaxed (such optimizations have not yet studied)

Task Force has so far only studied downtime contributions from the Main Linac

Total unscheduled downtime vs energy overhead



Notes

- Chart shows **total** unscheduled downtime for all technical systems
- Failures that require energy overhead fall into two groups
  - **Components such as couplers, piezos, tuner motors, etc**
  - **HLRF failures (subject of study)**
- Vertical asymptote: downtime from couplers, piezos, tuner motors, etc
- Horizontal asymptote: downtime from all non-RF systems (overhead-independent)

Observations

- KCS and DRFS require similar overhead
- 1-tunnel RDR RF unit needs more overhead (but note the lower klystron/ modulator MTBF compared with DRFS)
- KCS model assumes there are no common-mode failures (all hot-swap)

Starting MTBFs and (final) adjusted MTBFs for SB2009 configurations

Device #	Device	New starting MTBF	New MTBF factor	New ending MTBF	SLC MTBF	FNAL Tevatron MTBF	FNAL Main Injector MTBF	APS MTBF	other MTBF
1	mttf_electronic_module	1.00E+05	3	**3.0E+05**	1.0E+05				
2	mttf_PS_controller	1.10E+06	3	**3.3E+06**	8.0E+04	1.8E+05	1.1E+05	1.1E+06	
3	mttf_controls_local_backbone	1.00E+05	10	**1.0E+06**					
4	mttf_magnet	2.00E+06	10	**2.0E+07**	5.0E+05		2.0E+06		
5	mttf_sc_magnet	3.00E+07	1	3.0E+07		1.6E+06			
6	mttf_small_magnet	3.40E+07	1	3.4E+07	3.4E+07				
7	mttf_PS_corrector	1.10E+06	1	1.1E+06	4.3E+05	1.8E+05	1.1E+05	1.1E+06	
8	mttf_PS	1.10E+06	3	**3.3E+06**	4.3E+05	1.8E+05	1.1E+05	1.1E+06	4.0E+04
9	mttf_kicker	1.00E+05	1	1.0E+05	1.0E+05				
10	mttf_kickpulser	7.00E+03	5	**3.5E+04**	6.6E+03				
11	mttf_modulator	5.00E+04	1	5.0E+04	6.4E+04				
12	mttf_dr_klystron	3.00E+04	1	3.0E+04					
13	mttf_mb_klystron	4.00E+04	1	4.0E+04	5.0E+04				
14	mttf_DRFS_klystron	1.20E+05	1	1.2E+05					1.7E+05
15	mttf_cavity	1.00E+08	1	1.0E+08					
16	mttf_coupler_intlk	1.00E+06	5	**5.0E+06**	9.6E+04				
17	mttf_coupler_intlk_electronics	1.00E+06	1	1.0E+06	9.6E+04				
18	mttf_mover	5.00E+05	1	5.0E+05	5.1E+05				
19	mttf_VacP	1.00E+07	1	1.0E+07	3.8E+06				
20	mttf_VacP_power_supply	1.00E+05	1	1.0E+05					
21	mttf_valve	1.00E+06	5	**5.0E+06**	1.0E+06				
22	mttf_vac_valve_controller	1.90E+05	5	**9.5E+05**	1.9E+05				
23	mttf_fs	2.50E+05	30	**7.5E+06**	2.2E+05				
24	mttf_xfrmr	2.00E+05	1	2.0E+05					
25	mttf_waterpump	1.20E+05	1	1.2E+05	1.2E+05	1.3E+05			
26	mttf_water_instr	1.30E+05	3	**3.9E+05**	3.0E+04	1.3E+05			
27	mttf_elec_small	1.60E+06	1	1.6E+06	3.6E+05				1.6E+06
28	mttf_elec_big	1.60E+06	1	1.6E+06	3.6E+05			6.7E+05	1.6E+06
29	mttf_vac_mech_device	1.00E+05	5	**5.0E+05**					
30	mttf_laser_wire	2.00E+04	1	2.0E+04					
31	mttf_wire_scanner	1.00E+05	1	1.0E+05					
32	mttf_klys_preamp	1.00E+05	1	1.0E+05					
33	mttf_vacG_controller	4.70E+05	1	4.7E+05	4.7E+05				
34	mttf_cavity_tuner	1.00E+06	1	1.0E+06	5.1E+05				
35	mttf_cavity_piezo_tuner	5.00E+05	1	5.0E+05					
36	mttf_power_coupler	1.00E+07	1	1.0E+07					
37	mttf_cryo_leak	1.00E+05	10	**1.0E+06**					
38	mttf_JT_valve	3.00E+05	1	3.0E+05					
39	mttf_cryo_big_prob	1.00E+07	1	1.0E+07					
40	mttf_target	4.4E+04	1	4.4E+04					
41	mttf_MPS_region	3.00E+04	1	3.0E+04	5.0E+03			3.0E+04	

- **Bold**: had to improve MTBF above start value:
- Improve>10
- Improve>3
- Improve>1
- Improve<=1
- White: no data

The Improvement Factors can be considered an indication of technical risk

Energy Overhead in KCS

- Extra klystrons can easily be accommodated in a klystron cluster
  - used as needed
- However mind the details
  - RTML
  - 5 GeV accelerators for the sources use a different partitioning of klystrons

Reasons for Cryomodule failures

- Assumed mean time between failure MTBF
    - Tuner and piezo have the largest impact
        - little practical experience from operating ILC tuners (several variants)
        - R&D necessary to add confidence to operation

	MTBF [h]
Coupler	1×10^{7}
Tuner	1×10^{6}
piezo	5×10^{5}

Repair of tuner requires access to cryomodule. Warm-up cycle of accelerator section is time consuming and expensive.

MTBF for tuner area has to be put on firm grounds

Operational implications

- Tuner failure affects operation of cavity
  - maximum energy
  - integrated luminosity
- Detailed overall effect unknown: 1%, 2%, 3% ?
  - Compensate risk?
    - Better study / design of tuner needed (R&D) — best solution
    - longer tunnel
    - higher-gradient cavities — "golden" cavities, natural solution?

Longer tunnel

- How much longer?
  - 3% entirely arbitrary — *cannot be defended*
- A fully equipped 3% longer tunnel would essentially provide the capability of a 515 GeV machine — *seems odd*
- An empty 3% longer tunnel would emphasize a small staging plan. There is no physics argument to justify such a small increment at this time (rather build an additional 500 GeV empty tunnel). — *not attractive*

Personal comment

- Plan for a 500 GeV at the canonical length
- Better understand the failure for tuners and possibly improve
  - various options
- Invest in higher-gradient cavities