1 S2: System Tests Needed for the ILC Linac

The S2 task force was created by the Global R&D board in June 2006 to determine the nature and size of a system test needed to properly test the ILC acceleration technology. Our charge was to set the goals, specifications and a timeline for the system test(s). This section contains our conclusions. There is more detailed information about our deliberations on the S2 Wiki page[1] and the full report is available online[2].

Our major conclusions are summarized in the following bullets.

- The TTF facility at DESY has provided valuable system tests of many elements of the ILC technology. More tests can and should be performed there. Further testing activities for the XFEL, as well as the complete XFEL, will continue to provide valuable experience.
- However several important changes to the TTF design are being planned for the ILC. These include a higher gradient, relocation of the quad to the center of the cryomodule, shortening of the cavity end-group, and a new tuner design. Also under discussion are different modulators, klystrons, and cavity shapes among other developments. These design changes are numerous and major enough that a further system test is warranted.
- The basic building block of the ILC linac is one RF unit containing three cryomodules with full RF power controlled as in the final linac. **The minimum size system test needed to confirm the performance of a new design is a single RF unit with ILC like beam. As many tests are statistical in nature, a longer string test with several RF units or multiple tests with one RF unit would be better.** The primary reason beam is needed is to check that higher order modes (HOMs) are coupled out and absorbed so they do not cause a significant heat load at liquid helium temperature.
- All three regions have expressed a desire for command of basic ILC SCRF technology and are preparing to manufacture cryomodules locally. Local test facilities at the scale of 1 RF unit are under construction in Asia and the Americas. Europe is trying to increase its ILC related efforts with a forthcoming proposal to the European Commission (FP7). The proposal will be based on expanding the usage of existing infrastructures.
- As construction of the project starts, a test facility (or facilities) will be needed to qualify manufactured RF unit components of the final consolidated ILC linac system design. These components may be built at industries in different regions. One of the possible scenarios is to build a test string with contributions of a total of several RF units from the three regional teams. **There are many factors that will influence the choice of the size of the string and whether the goals can be accomplished instead through several smaller tests or one long string. These factors will be coupled to the future industrialization strategy adopted for**

[1] http://www.linearcollider.org/wiki/doku.php?id=rdb:rdb_external:rdb_s2_home
[2] S2 report – proper reference is waiting for submission to ILCDOCS

ILC main linac components. Therefore we cannot at this stage determine the ideal scale of this second phase of system tests.

- Sections 5 and 6 of the full report list reasons for doing tests and give a rough schedule for doing them in a phased approach. Some of the reasons for tests evolved from the R1 – R4 ranked lists of technology demonstrations called for by the Greg Loew TRC report. Our plan is based on a natural schedule for components to be ready. Therefore some low risk items are tested earlier than some high risk items. The phasing of the plan recognizes development times necessary for the final design of components, as well as the need for a few iterations that may be necessary to reach ILC specifications for the full RF unit, especially if these have to be implemented outside the TTF. **There are number of phases to the system tests we propose (starting with 1 cryomodule and ending with several RF units). Phase 1.3 (at least 1 RF unit of near final ILC design) should be successfully tested before more than 1% of the final industrially produced ILC cryomodules are manufactured.** This keeps the risk of having to rebuild a large number of cryomodules low while accepting a moderate risk of a schedule delay and having to rebuild 1% of the cryomodules. This risk is moderate because the successful phase 0 and 0.5 tests were done with cryomodules only slightly different than the final design.

Table 1 describes the phases of the system tests and gives rough completion dates.

Figure 1 gives the schedule in graphical form showing its relation to other parts of the project.

Costs are a bit difficult to define as these system tests are done in stages some of which are already completed.

We estimated that at a lab which had a cryoplant and an empty building but virtually nothing else it would cost $86M not including lab labor to build phase 1.3. This included: infrastructure to process and test cavities and assemble cryomodules; purchasing the parts for non-final versions of cavities and cryomodules along with those for the final versions; beam source, buncher, diagnostics, spectrometer, dump; shielding and PPS system; cryogenic lines; klystrons, modulators, LLRF, and RF distribution.

Fermilab has estimated a cost of $32M not including lab labor to build phase 1.3. This does not include the infrastructure or parts costs for building the cryomodules as this is partly done and is accounted in a different part of their budget proposal. They have an injector which they will be moving hence its cost is reduced.

KEK has estimated a cost of 1,579,220 k-yen or about $13M not including lab labor to build phase 1.3. This assumes they have finished an earlier phase which puts beam through a single cryomodule.

Each group has estimated what is appropriate for it given what they already have (or have planned for the near future). As they are estimating different things, it is no surprise the answers are quite different.

Table 1 Rough technically limited schedule for completing the string tests.

Phase	Completion date	Description
0	2005	TTF/FLASH, not final cavity design, type 3 cryomodule, not full gradient, has beam but work is needed to have regular ILC bunch structure, roughly 2 RF units.
0.5	2008	Extra tests at TTF/FLASH with same type cryomodules as phase 0
1	2008	1 cryomodule, not final cavity design, type 3 cryomodule (and/or) STF type cryomodule, not full gradient, no beam
1.1	2009	1 RF unit, not all final cavity design, not all type 4 cryomodules, not full gradient, beam not needed for tests, but should be built so it and the LLRF are debugged for the next step
1.2	2010	1 RF unit (replacing cryomodules of phase 1.1), final cavity design, full gradient, type 4 cryomodules, with beam
1.3	2011	1 RF unit (replacing cryomodules of phase 1.2), final cavity design, full gradient, type DFM cryomodules, with beam
1.4	2011	Tunnel mockup above or below ground. 1 RF unit perhaps built with parts taken from earlier tests. Includes RTML and e+ transport, no beam
2	2013	Several RF units at one site (of the final ILC?) as a system test of final designs from multiple manufacturers. Need for beam depends on design changes made after phase 1.4.
3	2013	XFEL
4	2018	First 2.5 km of ILC

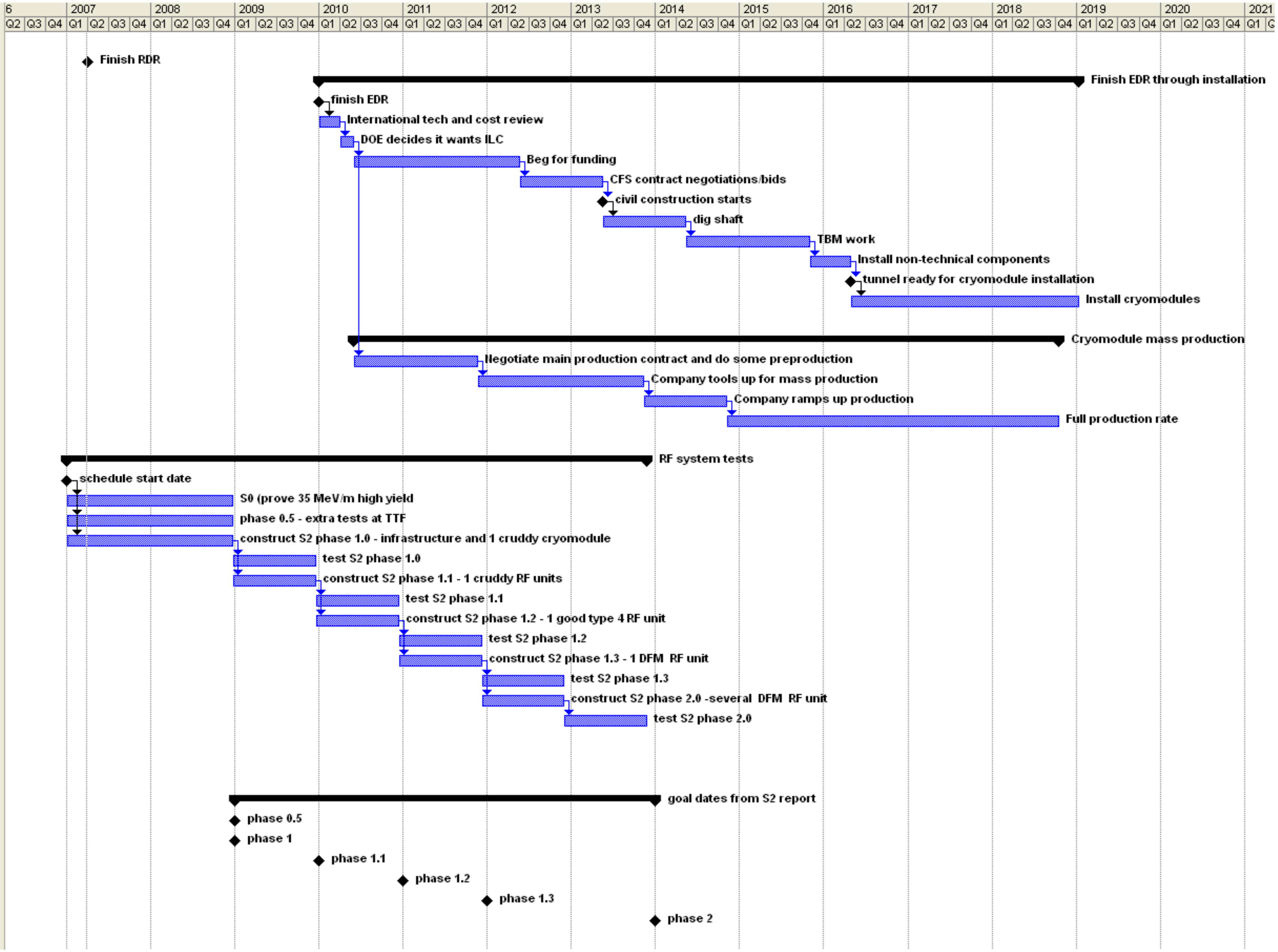

Figure 1. System test schedule in relation to other major project milestones