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Deliverable:

ILCRep: ILC readiness report including: preparation of high-gradient cavity production, a plan for the international approach to engineering documentation, and a detector deployment study.

Executive summary:

Due to the unexpected delay of the ILC in Japan, several tasks related to the machine are significantly shifted in time. This affects the site-specific planning and – even more so – construction work, the production plans for the machine components, the setup of management and documentation strategies and structures, and the plans towards construction of the ILC detector(s).

This report summarises the status of the above-mentioned tasks and objectives.

1. INTRODUCTION

The International Linear Collider (ILC), once construction starts, will be a very large construction project, thus requiring sophisticated management structures and tools to facilitate smooth cooperation of hundreds to thousands of globally distributed scientists and engineers.[1]

A major building block of the ILC machine are the superconducting (SC) radio-frequency (RF) accelerator cavities. A high-quality and reliable industrialised production of close to 1000 cavities is a prerequisite for the overall planning. Much relevant experience has been gained during the recent construction of the European XFEL at DESY, Hamburg (Germany), and Section 2 of this report summarises the status of these experiences and gives an outlook on SC RF cavity production for the ILC.

The electronic documentation of a large project like the ILC is also mandatory. The setup of an EDMS (electronic document management system) for the ILC, however, is hampered by the lack of a well-defined and funded ILC project. Section 3 summarises the situation and sketches the necessary conditions for an EDMS system to be put in place.

Finally, the detectors of an ILC (currently the two detector concepts ILD and SiD) are major construction endeavours that have to be planned with the same scrutiny as the ILC machine itself. Therefore, detailed construction and assembly plans have to be developed that take into account the local and site-specific conditions and the overall schedule of the project. Section 4 sketches the status of the planning of the two concept groups.

2. TOWARDS INDUSTRIALISED HIGH-GRADIENT CAVITY PRODUCTION

The European XFEL project is a SCRF-based free-electron laser currently being completed at DESY. With its size (for the main linac) of approx. 1.7 km, and since it uses the acceleration technology that is also foreseen for the ILC and also very similar cryo-modules, it can be regarded as a 1/10 prototype of the ILC. With 100 ILC-style cryo-modules, the European XFEL will reach a peak energy of 17 GeV. The beam is then used to seed a free-electron laser, thus providing an ultra-bright and coherent X-ray source.

[1] Note that recently, the Japanese laboratory for particle physics, KEK, has published an "ILC Action Plan" [3], which sketches the path towards the development of an ILC project.

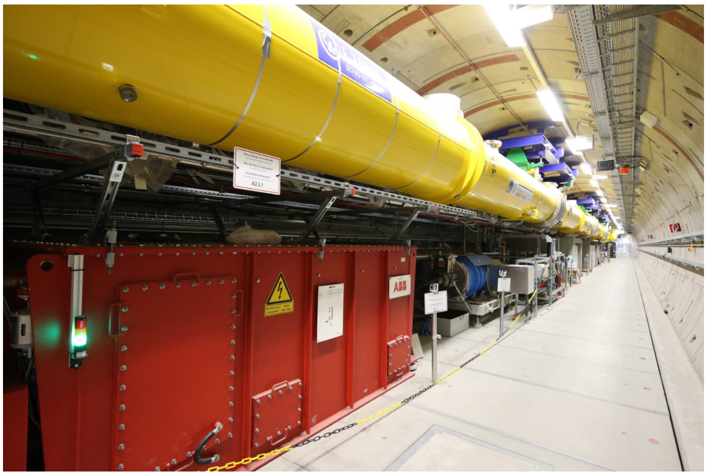

Figure 1: A view of the European XFEL, with the main linac suspended from the ceiling of the tunnel.

A key for the success of the European XFEL project was to involve industry in the construction and assembly of several accelerator components. The XFEL has thus become the first project which has successfully established the production of superconducting cavities in industry. Almost 800 cavities were made and successfully tested. The average maximum gradient achieved is 31.4 MV/ m, with an average useable gradient of 27.9 MV/m (Fig. 2). This exceeds the XFEL requirements of 20 MV/m by far.

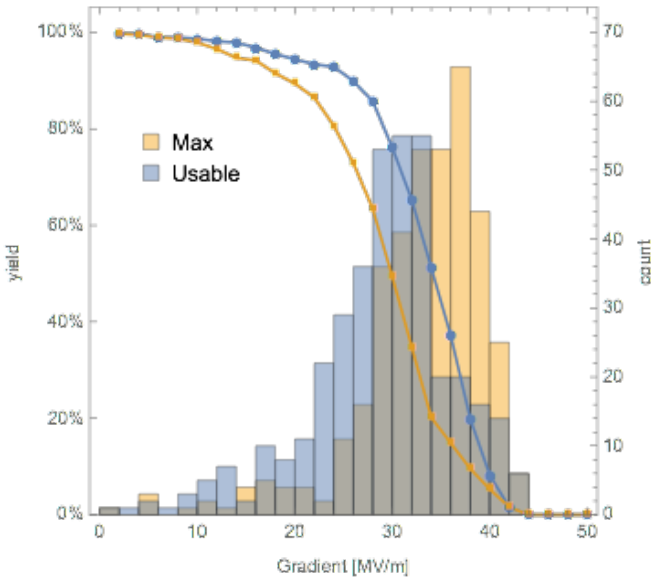

Figure 2: Maximum and usable gradient of the XFEL SCRF cavities.

For a subset of the XFEL cavities, the impact of the re-treatment was studied and compared to the requirements of the ILC TDR (table 1).

		ILC TDR (assumed)	XFEL max	XFEL usable
First-pass	Yield >28 MV/m	75%	85%	63%
	Average >28 MV/m	35 MV/m	35.2 MV/m	33.5 MV/m
First+Second pass	Yield >28 MV/m	90%	94%	82%
	Average >28 MV/m	35 MV/m	35.0 MV/m	33.4 MV/m
First+Second+third pass	Yield >28 MV/m	-		91%
	Average >28 MV/m	-		33.4 MV/m

Table 1: The numbers assumed in the ILC TDR for SCRF cavity performance, compared to the actual numbers achieved during cavity production for the European XFEL.

The ILC assumed an acceptance threshold in the vertical test stand of greater than 28 MV/m. In the ILC TDR, two sets of cavity treatments are foreseen to reach an acceptance of greater than 90%. For the XFEL the numbers in table 1 indicate that the industrial production of SCRF cavities is getting very close to ILC requirements, but that still additional re-work and also additional R&D (as carried out e.g. at DESY and FNAL) is required to match the specifications. The XFEL experience is invaluable in the preparation of industrialised cavity production, and further investigations of production data are ongoing.

3. AN EDMS FOR THE ILC

The situation for the EDMs has been summarized in D17 [1] in detail. With the lack of an approved ILC project and therefore the obvious lack of clearly defined stakeholders, it is very hard to define the requirements for an EDMS and to make real progress in this area. However discussions are still ongoing and the groups are preparing ideas for a future EDMS, which can then be quickly pursued and implemented once the ILC becomes a project.

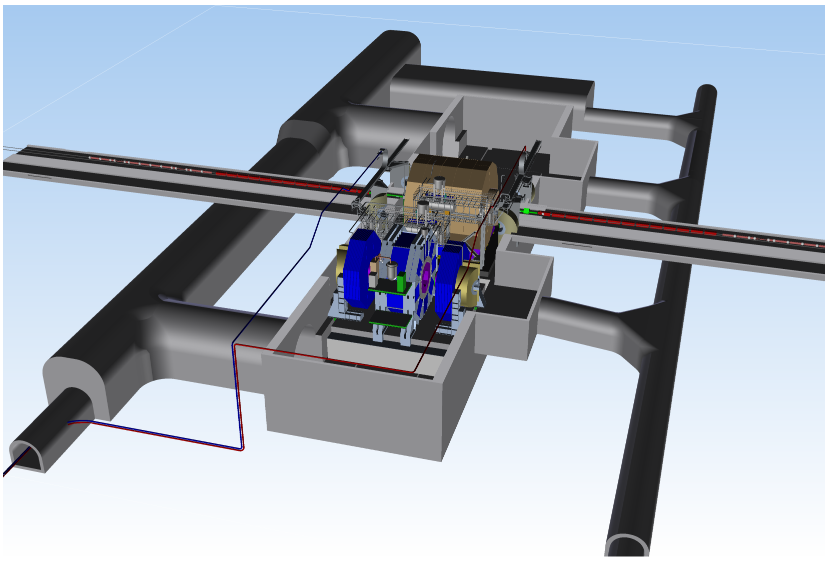

Figure 3: The ILD and SiD experiments in the experimental cavern with some relevant infrastructure.

4. DETECTOR DEPLOYMENT PLANS

Experience e.g. from the experiments at CERN's Large Hadron Collider (LHC) tells that the construction of a complex experiment the size of the ILC detectors easily takes many years and resembles a giant jigsaw puzzle that has to be very carefully planned in terms of timing and resources (person power, local facilities like cranes, interference with other construction work, etc.).

Both the ILD and the SiD concept groups have developed, over the past years, detailed concepts for the detectors that very precisely define the experiments in terms of size, components, technologies, necessary infrastructure, etc. (see e.g. Figure for a sketch of the structure of the ILD and SiD detectors in their experimental cavern). The construction of the individual small components of the experiments will largely take place at laboratories all over the world. The pre-assembly into the large detector subsystems, however, (ECAL, HCAL, TPC, inner tracker, FCAL etc.) will take place in a surface assembly hall at the interaction point of the ILC or even, transport possibilities permitting, at other laboratories or companies in Japan or elsewhere. The large detector parts will finally be lowered underground prior to their insertion into the overall experiment.

The overall assembly process and its dependencies have been studied by both concept groups, assembly plans and timelines have been developed, and the critical paths have been analysed.

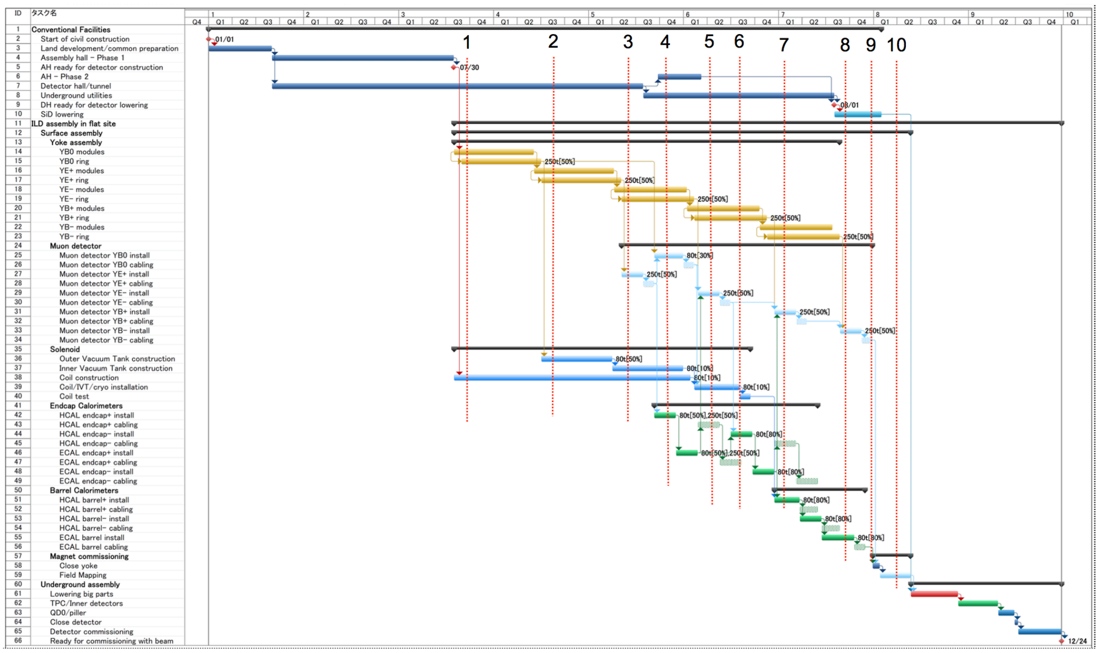

Figure 4: ILD assembly plan.

Figure gives, as an example, the assembly plan of the ILD experiment as seen today. It turns out that the limiting factor in the assembly of the experiment is the R&D and construction of the solenoid coil, for which according to current estimates up to twelve years might be needed. It is thus clear that more investigations are needed, and contacts with the relevant companies in Japan have been made and will be extended using also E-JADE funding.

The role of E-JADE in these planning endeavours was quite significant, as the participation of numerous ILC scientists in a series of mini-workshops related to machine-detector integration issues was only made possible by the available E-JADE funding. The next of these workshops, from which we expect further progress especially in the collaboration with our Japanese colleagues, is scheduled for September 2016.

5. CONCLUSIONS

The ILC has currently not yet been approved and developped into a mature and funded project. This has been quite unexpected and of course has a major impact on the entire work plan of E-JADE WP3. For the SCRF work the focus is on the exploitation of the XFEL experience for a future ILC mass production of the cavities. The EDMS has been significantly delayed due to the absence of a project, which is necessary for the definition of such a system between all the future stakeholders. The assembly plans of the experiments ILD and SiD are quite advanced, and the community has by now a clear picture of how (and on which timescales) the experiments can be built. Overall some progress has been made, but without the ILC going ahead in Japan, it is impossible to proceed in many areas.

REFERENCES

[1] B. List et al. (2016), EDMS User Requirements List, E-JADE Deliverable Report 17.
[2] T. Behnke et al. (2013), The International Linear Collider – Technical Design Report, arXiv:1306.6327
[3] KEK-ILC Action Plan Working Group (2016), KEK-ILC Action Plan, https://www.kek.jp/en/NewsRoom/Release/KEK-ILC_ActionPlan_160106-EN.pdf