Design Study for the Interaction Region Push-Pull System for the ILC

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Motivation

The Interaction Region push-pull system represents one of the most technically challenging areas of the ILC, whose performance may determine the success of the entire collider. Challenges range from civil construction to detector sub-system performance. Design of the push-pull system is progressing; however, the complexity of the problem requires enhancement of the current efforts. In particular more support for the engineering design of the components is needed in order to arrive to a mature design before the end of 2012. Besides the clear alignment of the work to the ILC Technical Design Report, it should be noted that synergies are expected to come from close collaboration with similar efforts in the CLIC collaboration.

Current Status of Work

The push-pull arrangement of detectors is not a new idea; however, it was never realised in practice to the extent required for ILC in terms of reliability and efficiency. For ILC, the push-pull arrangement was evaluated on the conceptual level in 2006, and while it has been determined that the technical issues have conceptual solutions, it was deemed that "careful R&D and engineering studies will be needed during the TDP time to validate and optimize the proposed configuration", as stated in the GDE push-pull Configuration Change Request (CCR) to the ILC baseline approved in early 2007.

Interrelation of technical challenges for the push-pull system is best expressed and grasped pictorially as an interrelation diagram (c.f. Figure 1).

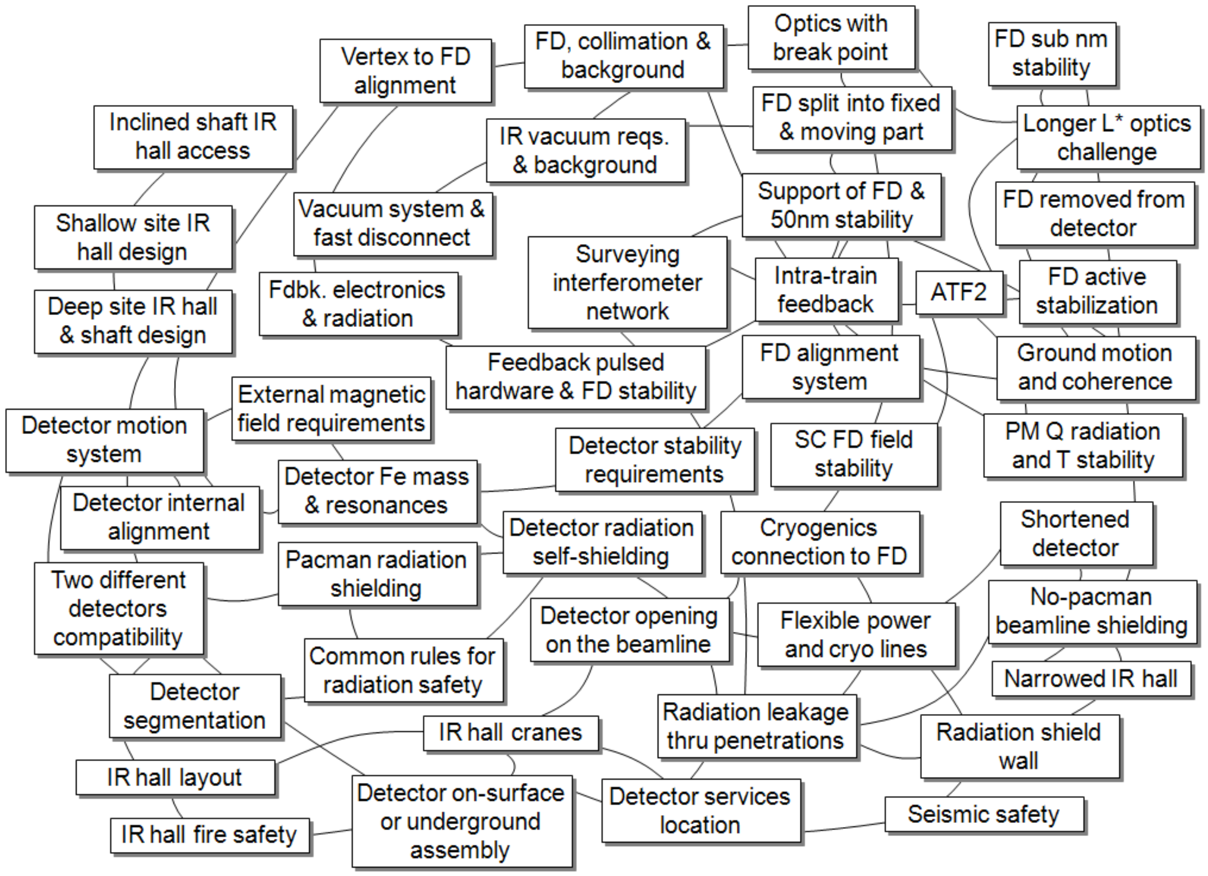

Figure 1: Push-pull Interrelation Diagram

After the approval of the push-pull CCR in early 2007, the technical progress on the push-pull design has been rapidly increasing throughout 2007, with the Interaction Region Engineering Design Workshop IRENG'07 being a noteworthy milestone. The success of the Workshop was by far determined by pro-active preparation, when the Working Groups conducted 23 technical web-conference meetings in preparation for the Workshop in the preceding several months. It is also necessary to note the active participation of CERN engineers in IR design starting from 2007.

The pace of the push-pull design work was somewhat affected by the events at the end of 2007; however, the work continued, although at a reduced rate. Among the noteworthy accomplishments of 2008 one needs to mention the work of the machine and detector teams of all existing detector concepts on the so-called Interface Document, which describes minimal functional requirements of the push-pull system and the interaction region. The IR Interface Document was developed in iterations and published in early 2009[1].

Following the selection of the two concepts, more detailed engineering considerations proceeded in 2009, focusing in particular on attempts to find common solutions to critical subsystems, in particular for the detector shielding and detector moving system. While the common solution for the shielding of SiD and ILC was quickly found, it was realized that making further progress on the design of the detector motion system required detailed computational and experimental studies of detector stability. Such studies were launched, experimentally at KEK and CERN, and computationally at several

[1] B. Parker et al.,"Functional Requirements on the Design of the Detectors and the Interaction Region of an e+e- Linear Collider with a Push-Pull Arrangement of Detectors", ILC-Note-2009-050.

places. One should again highlight the fruitful cross-fertilization between ILC and CLIC designs – considerations of an optics with an increased distance from IP to the final doublet resulted in modification of the entire approach to CLIC interaction region, where a shortened detector housed in a narrow tunnel centred on the beamline allowed the removal of the Final Doublet from the detector and its placement on a more stable floor. And vice versa, stability measurements at the CMS detector were proven useful for crosschecks of vibration computations done for ILC detectors.

Noting this steady progress, one should stress the large amount of technical design work remaining to be performed to confirm the feasibility of the push-pull system and to develop a design suitable for further engineering realization.

Organisation

The development of a realistic push-pull system is an ongoing collaborative approach between the ILC machine groups, here mainly the Beam Delivery System technical area group, and the ILC detector concepts. The work is organised and monitored jointly between the BDS technical area leaders of the GDE and the Machine Detector Common Task Group of the Research Director's detector organisation. The progress of the work is reported to the GDE Executive Committee and to the Physics and Experiment Board.

Tasks

The following list summarises the major tasks of the working plan.

1. Design of the detector motion system; study of its vibration properties in simulation and experiment.
2. Design of the IR underground hall for push-pull, including facilities and services for the operation of the detectors, radiation shields, seismic issues, impact of safety rules.
3. Optimisation of the detector integration and its impact on assembly procedures, magnetic and radiation shielding, vibration sources.
4. Design of detector services supplies for push-pull (data and HV cables, cryogenics).
5. Design and prototype of the final doublet quadrupoles and verification of their stability.
6. Design of alignment system for the final doublet magnets and the inner detector components, including the design of a laser interferometer system.
7. Study on IR vacuum design, including vacuum requirements and design of quick connection valves.
8. Study of intra-train feedback systems in a push-pull system.

The relations of the tasks are shown in the work plan diagram (c.f. Figure 2)

Milestones

The work described in this proposal will be aligned to the ongoing efforts in the ILC project. The oncoming Linear Collider workshops will serve as major milestones where the design study team will meet to review the progress, and assess the work plan and the achievement of deliverables.

Detailed deliverables and a prioritised work plan will be developed, based on the actual level of resources.

Date	**Milestone**
Summer 2010	Finalisation of work plan, implementation of additional resources
October 2010	Linear Collider Workshop at CERN
March 2011	Linear Collider Workshop, Eugene
Spring 2011	First draft of IR engineering specifications
Fall 2012	Finalisation of IR engineering specifications
End of 2012	Finalisation of ILC Technical Design Report and the Detailed Baseline Description

Table 1: Milestones

Participants and Resources

This table summarises the main participants and the engineering resources, which are committed and requested for the implementation of this proposal.

Participant	**Task Nos.**	**Description of work**	**Commitment (FTE)**	**Additional Request (FTE)**
CERN	1,2,3,4	Hall design, detector services, push-pull motion system, movable detector services supplies	0.0	2.0
ETH Zurich	1,2,3,4	Hall design, detector services, push-pull motion system, movable detector services supplies	1.0	0.0
DESY	1,2,3	Hall design, push-pull motion system, radiation shields, magnetic shielding	1.0	0.0
KEK	1,2,3	Vibration studies, detector integration, radiation shielding	0.4	0.2
LAL	3,7	Detector integration, vacuum studies	1.0	0,0
LLR	3,7	Detector integration, beam pipe design	0.25	0.5
JAI	6,8	Laser interferometer studies, intra-train feedback system, design	1	2

		integration		
SLAC	1,2,3,6	Beam pipe and VTX support, push-pull motion system, alignment, rad. physics	0.4	1.5
FNAL	2	Push-pull IR CFS integration	1.5	1.5
BARC	2	Push-pull IR to extraction and dump line interface	1.0	1.0
CI & ASTEC	7	Vacuum design for push-pull IR	0.5	1.0
JINR	2	Push-pull IR at shallow site	0.5	1.5
BNL	5,6	Magnet design integration for push-pull IR	1.0	1.0
LAPP	2,3,6	FD & Detector stability	0.3	1.0

Table 2: Engineering Resources[2]

[2] Disclaimer: The Commitment numbers in this table represent the current best estimations of the participants and do not necessarily reflect a formal commitment for the entire duration of the planned efforts. Distribution of efforts among the listed laboratories takes into account established collaborative connections however it represents just one possible scenario.

Work Plan Diagram

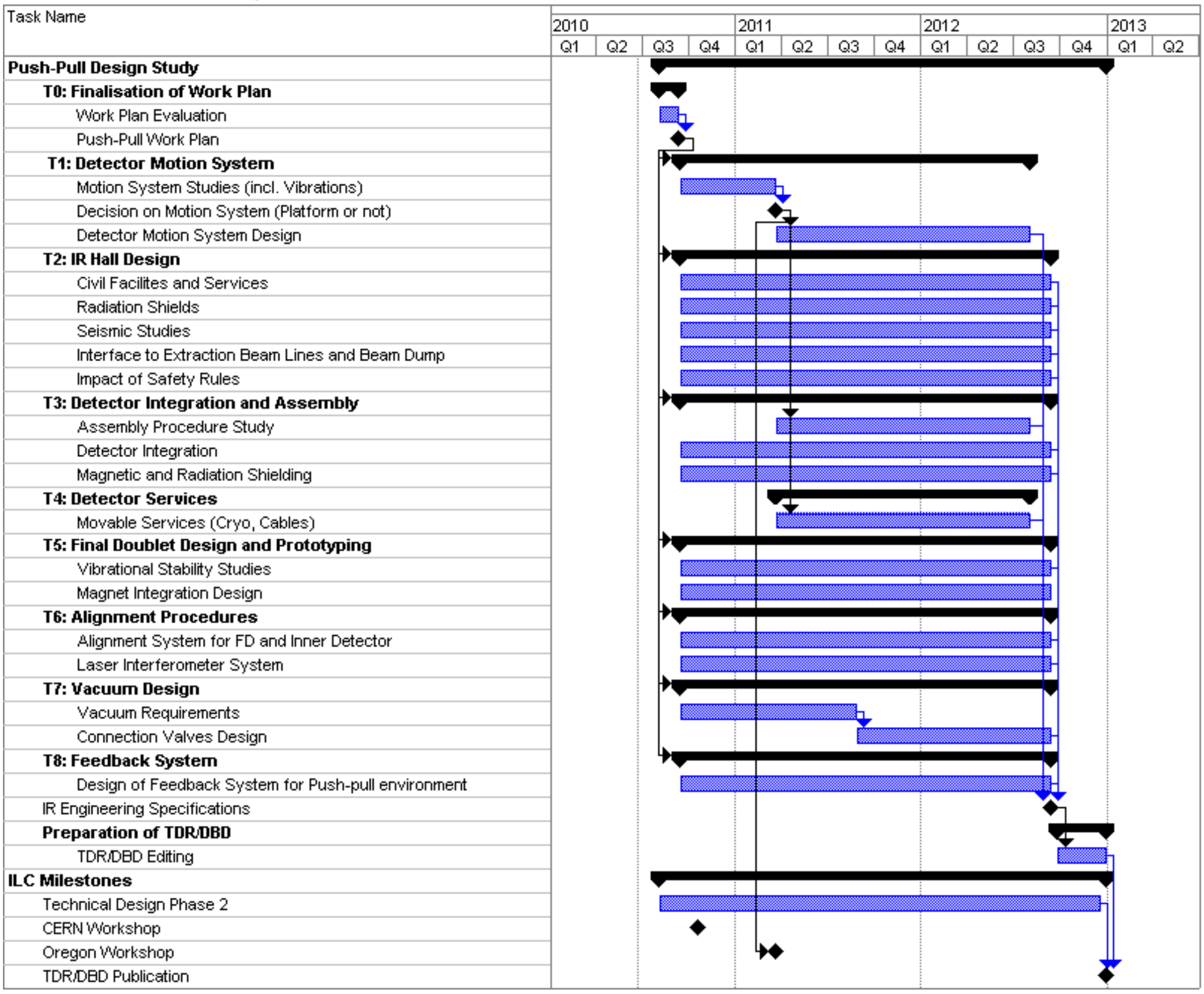

Figure 2: Work Plan Diagram

Summary of Additional Resources

In total, 13.20 additional FTEs of engineering resources are needed over two years for the implementation of this proposal.