SiD R&D Plan and Opportunities for New Collaborators

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Critical R&D for SiD

1) General
For the overall performance of the SiD detector, we need to demonstrate that the detector can adequately address the full spectrum of the physics at a 500GeV ILC, with extension to 1 TeV. This includes a full simulation of the detector, track reconstruction code, and development of a fully functional Particle Flow Algorithm (PFA). While we have working versions of the simulation, reconstruction, and the PFA, we anticipate significant further developments, which will provide the critical tools to optimize and finalize the detector design.

2) Vertex Detector.
No ILC-ready vertex detector sensor yet exists. The main needs are to develop one or more solutions for the sensors, a demonstrably stable and low mass mechanical support, and pulsed power/cooling solutions. Sensor technologies are being developed, as well as mechanical support materials, designs, pulsed power, and cooling.

3) Tracking Detector.
The priorities for tracking are testing a multi-sensor prototype in the absence of a magnetic field and at 5T, refining the track finding and fitting performance, understanding the optimal forward sensor configuration, and developing more detailed understanding of the mechanical stability and required alignment. Work is underway in all of these areas…

4) Electromagnetic Calorimetry.
For the baseline silicon-tungsten Ecal design, the operability of a fully integrated active layer inside the projected 1.25mm gap between absorber plates must be demonstrated. Sufficient S/N, successful signal extraction, pulse powering, and adequate cooling must be shown as well. Mechanical prototypes with steel rather than tungsten will first be built, followed by a full depth tower appropriate for beam tests. For the alternative MAPS technology being investigated in the U.K., a key need is production of large sensors with sufficient yield.

5) Hadronic Calorimetry.
The priority for hadronic calorimetry is to demonstrate the feasibility of assembling a fully integrated, full-size active layer within a ~8mm gap between absorber plates. Several technologies are being investigated: RPC's, GEM's, Micromegas, and scintillating tiles/SiPM's. All of this work is being carried in conjunction with the CALICE Collaboration, and the results will form a critical component of SiD's future technology selection. An alternative approach, using homogeneous crystal calorimetry with dual readout, is also being studied. This effort needs to demonstrate good hadronic energy linearity and resolution in a test beam, to develop suitable crystals, to produce a realistic conceptual design, and to simulate physics performance.

6) Electronics.

One critical item on electronics is a demonstration of the operation of 1024 channel version of the baseline KPiX chip. Another is to develop power distribution schemes for the vertex detector and tracker with DC-DC conversion or serial powering. **Adapting and testing KPiX readout to the tracker**, calorimeters, and muon systems must also be continued and perfected.

7) Magnet.
For the superconducting solenoid, it is required to demonstrate that a 5T field can be achieved with acceptable reliability and cost, and with acceptable forces. To address cost reduction, a new conductor is being studied. R&D for the Detector Integrated "anti" Dipole coils is also required. Field uniformity studies for the tracker.

8) Engineering Issues.
A credible scheme for push-pull operation is required that achieves acceptable repositioning of the detector, preserving internal alignment, in an acceptably short cycle time. Equally important is achieving the required mechanical stability of the quadrupole focusing lenses.

9) Forward Calorimetry.
A sensor that can survive the radiation environment in the forward region is required, along with suitable readout electronics. Some of this work is collaborative with the FCAL Collaboration.

10) Muon system.
Emphasis is placed on development of reliable, and robust RPCs. SiPMs for scintillator strips are a new technology of interest, also under development.

R&D Priorities for SiD - Selection(2)

Tracking

Tracking uses silicon sensors with hybrid-less readout. Sensors are in hand -> high priority to development of an array of sensors, mounted on support structure -> test in beam.

Also priority to readout through baseline architecture using KPiX chip + reference architecture using LSTFE

Push-pull -> critical role for alignment -> preserve tracker alignment.

Beyond the first year

Tracking

- Emphasis is currently on the development of the double-metal sensor with the associated KPiX readout.

- Demonstrate mechanical robustness, power pulsing, stability/alignment.

- Small scale system consisting of a few sensors with full readout will be tested in a test beam -> test Lorentz forces and mechanical stability. 2010.

- Simulate LOI geometry with individual planar sensors, full digitization.

- Evolve towards technical design by 2012.

Beyond the first year

Forward Calorimetry

The first year outcomes of studies of the two photon backgrounds will be applied to the detector design choices for the forward calorimetry in years 2 and 3. The development of the radiation resistant detectors following year one will be designed to build on the successes and lessons from the first year of effort.

Developing the SiD Work Plan

Schedule and Milestones

<u>2009</u>

- **Simulation/Reconstruction:** PFA improvements; tracking simulation and reconstruction improvements and background studies; simulation of dual readout concept; optimization of SiD design.
- **Electronics:** Full KPiX chip; develop beamcal readout.
- **Tracker:** Sensor test; sensor with readout test; develop alignment concept.
- **ECAL:** Sensor test; sensor with readout test.
- **Beamcal:** Evaluation of beamcal sensor technologies.
- **HCAL:** RPC and GEM with readout tests; GEM slice test; Micromegas slice test; RPC construct 1 m^3; engineering design of HCAL module; dual readout crystal candidate selection and photon detection studies.
- **Vertex:** Develop sensors; continue mechanical and power distribution designs.
- **Muon:** Test RPCs, scintillating fiber, and RPC longevity.

Developing the SiD Work Plan

2010

- **Simulation/Reconstruction:** Update physics studies; dual readout full simulation and physics performance.
- **Electronics:** Test beamcal sensor readout; develop SiPM readout (if needed).
- **Tracker:** Test alignment concept; beam test sensors with readout and support system in B field; test Lorentz forces and mechanical stability with pulsed power.
- **ECAL:** Build and test ECAL tower; build mechanical prototype for ECAL module.
- **HCAL:** Produce engineering design of module with integrated readout; dual readout beam test of concept; continue beam tests and analysis; ready 1 m^2 modules of GEM and Micromegas; continue development of suitable crystals.
- **Vertex:** Develop sensors; continue mechanical and power distribution designs.
- **Muon:** Prototype muon chambers; longevity test; study costs.
- **MDI:** Develop push pull designs; vibration studies; study alignment issues.
- **Magnet:** Develop new conductor jointly with others.
- **Beamcal:** Design sensors.

Developing the SiD Work Plan

2011

- **Technology Selections:** ECAL, HCAL, Muon.
- **Engineering:** Complete engineering designs for ECAL, HCAL and Muons for chosen technologies and forward systems; plan preproduction and detailed design phase.
- **Simulation/Reconstruction:** Complete detector optimization; realistic GEANT4 detector description based on technology choices; generate MC data.
- **Complete beam testing:** SiW ECAL, RPC, GEM, Micromegas, Scint & SiPM HCAL; proof of principle development of suitable crystals and photodetectors.
- **Tracker:** Test large scale system.
- **Vertex:** Test sensors; continue mechanical and power distribution designs.
- **Benchmarking:** Studies with final detector choices and optimized design.
- **Magnet:** Continue new conductor development.

2012

- Complete optimized SiD detector design.
- Begin tests of magnet material.
- Begin full scale prototyping.
- Write SiD proposal.

Beginnings of an overall SiD R&D plan

	2010	2011	2012
Vertex Detector	Continued development of SiD selected technologies + multiple non-SiD		
Tracking	Small scale/few sensor test	Large scale test? →	Technical design
ECal	Si-W 30 sensor stack tests ----------→ Design/build barrel module MAPS – dev of 2nd gen chip -→ stack test ---→		
HCal	RPC 1m3 stack assembly and tests --------→ Tech sel. -→ Tech proto Options 1m2 -> 1m3 assembly/tests ----------→		
FCal	Studies for detector design choices, dev of radiation resistant detectors		
Electronics/DAQ	Completion of KPiX design, creation/operational demo of 1024 ch.		
Muon	Completion of R&D --------→ Tech choice ------→ Large scale prototype		
Magnet	Solenoid/anti-DID studies --- dev of new conductor --- tests?		

Beginnings of an overall SiD R&D plan

What we MUST do:

Major SiD R&D Priorities:

Tracker – array of sensors/support, beam test

ECal – Sensor + KPiX + cables…test + operability in 1.25mm space + plausible design in available space.

Electronics – demonstrate successful operation of 1024-channel KPiX chip.

HCal – Successful operation of large plane(s) of at least one technology with 8-12mm active gap + plausible design in available radial space/supports

FCal - Sensors

MDI – Push-pull, QD0 stability

There are many associated/parallel/alternative/desirable tasks – execution depends on available $$ + people

Opportunities for New SiD Collaborators

Vertex

– Mechanical design of thinned supports and ladders – recently organized "plume" collaboration (Bristol, Strasbourg, DESY and Oxford).
- Need physicists, engineers, techs to develop alignment
– Power Delivery, stability, and infrastructure – need physicists, engineers, techs.

Tracking

– software person to develop track fitting/Kalman filter
- software person to optimize tracking geometry
- study of physics reach of physics benchmarking studies with regard to tracking geometry
- characterization of double-metal sensors
- readout of double-metal sensor with cable and KPiX - test beam studies of above with and without B-field

Opportunities for New SiD Collaborators

Forward Calorimetry

There are engineering opportunities for FCal (including MDI) mechanical design for Lumical and Beamcal.

There are also Postdoc level opportunities for FCal suimulation activities.