SiD R&D Priorities

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SiD R&D Priorities

- Where we stand now – priorities developed for the recently submitted LCRD proposal (recall this was for U.S. Universities – more on this from Jim/next talk)

- What is expected in 2nd and 3rd years – needs to be developed!

- Evolution of the SiD R&D plan towards a technical design in 2012.

R&D Priorities

- First defined the areas of Critical R&D for SiD

- Discussion of R&D priorities for SiD – the process

[Applied priorities to first year funding request (LCRD)]

-> These items used as input to LOI R&D chapter

- Funding beyond first year:

-> We anticipate expanding R&D budget – requested $2M - $3M -> $4M for the three years of LCRD.

-> ??Boost from stimulus package in short term (request for needed people and equipment support)– but questions about expanding support of science in longer term.

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, and scintillating tiles/SiPM's. A European project studies micromegas layers. 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.

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 - Process

- Prioritization is complex – many factors/issues:

-> importance of the specific R&D for concept viability

-> expected return on investment

-> facilitating collaboration growth

-> relation to overall collaboration R&D activity

-> mainly focused on the immediate future (one year), R&D is time dependent with different time scales for each project.

These issues were the subject of much review and discussion by a six person *ad hoc* committee.

R&D Priorities for SiD – Selection(1)

(in the order they were given in LCRD)

Jet Energy Resolution -> PFA progess -> establish viability for large scale system -> Calorimetry is critical

Critical alternative technologies:

ECal – fine-grained Si-W (baseline), MAPS

HCal - RPC(baseline), GEM, micromegas, scintillator/SiPM and Homogeneous dual-readout as alternate approach.

☛ Ready the baseline technologies for large scale prototyping as soon as possible + further PFA development. Also strategically important to start R&D on dual-readout.

R&D Priorities for SiD – Selection(2)

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.

R&D Priorities for SiD – Selection(3)

-Vertex detector -> 3-D vertically integrated Si and Chronopixel technologies are a priority.

- Muon detectors -> RPC (baseline) – priority, plus support for scintillator.

Projects will be reviewed and re-assessed for progress and prioritization.

Beyond the first year

Vertex detector

Many technologies being pursued (DEPFET, CCDs, 3D Vertical Integrated Silicon, and MAPS) – current funding can only support development of limited choice.

Technology selection by time of start of ILC construction -> build/test small prototype.

∴ Extended R&D timescale for vertex detector – not strongly tied to TDR.

Beyond the first year

Tracking

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

- Sensors need to work in a high magnetic field, operated with pulsed power while retaining their alignment under these conditions.

- 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?

- ? Larger scale test…2011?

- Request for funding for the tracking detector will increase substantially over the next few years.

Beyond the first year

Calorimetry: ECal

- Si-W ECal: anticipate that the test-beam related data taking and analysis will continue beyond August 2010.

- First the module will be tested in an electron beam (possibly at SLAC), followed later by a beam test with hadrons.

- Completion of this R&D is expected by 2012.

- MAPS ECal: the goal is to make a second generation chip which is sufficiently large to make a ECAL stack to study digital electromagnetic calorimetry in detail.

Beyond the first year

Calorimetry: HCal

- RPC option -> continue with testing the 1m^3 stack. beyond the first year. Calorimeter will be exposed to muons and pions and positrons of various energies. The response and energy resolution will be measured together with characteristics of hadronic showers, for Particle Flow Algorithms. R&D for Technical Prototype – 2010-2012.

- GEM option will test its 1m^2 layers as part of the CALICE hadron calorimeter prototype (2010-2011), and will design and build a complete, integrated layer with minimal thickness and full services. Thick GEM prototypes will also be assembled and tested as large sections of thick GEMs become available. Gas studies for thick GEMs will also continue.

Beyond the first year

- **Calorimetry: HCal**

-Micromegas option -> continued testing of, and analysis of results from, the 1m^3 stack 2010-2011

- Scintillator/SiPM option -> insertion of the integrated readout layer planes fabricated with the CALICE/EUDET electronics into the CALICE absorber stack. This installation will be followed by the commissioning and exposure of this prototype to a test beam. 2010-2011?

- Homogeneous dual-readout calorimetry -> development of suitable crystals, photodetectors, and associated readout electronics, all in preparation for a demonstration of linearity and energy resolution for hadrons in a test beam, while developing a conceptual design for inclusion of this technology into SiD. 2010-2012?

Beyond the first year

Muon

-The 2nd and 3rd year of muon detector effort will work toward a technology choice (RPC/Scintillator) during 2011.

- RPC/KPIX proof of principle -2008-9, Optimize interface board & protection circuitry design 2009-10. CR/beam tests.

- Scintillator SiPMs -> development or acquisition of an SiPM compatible ASIC, possibly a modified KPiX.

- Planning for construction of a larger-scale prototype of the selected technology would begin, with simulation studies of overall detector performance for muons. The simulation model of the muon system would be derived from measurements with prototypes.

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.

How will the R&D priorities evolve – as we approach a Technical Design?

Factors affecting R&D progress/priorities:

- availability of funds
- interest in/continuation of projects
- success or otherwise of specific initial R&D
- evolution of the overall SiD design
- R&D elsewhere (horizontal collaborations)
- evolution of technologies within/outside SiD
- overall ILC timescale – TDR in 2012

Evolution of R&D towards completion for TDR - contributions to LOI R&D Chapter.

Elements of complete SiD R&D plan:

Roles in validation etc:

1) We need a coherent plan to get us to the TDR

2) We need to have the R&D validated for future funding support.

- List of **all** SiD R&D projects

  -> Project, who, when, funded,...

- Deliverables, milestones ?

The phases towards the TDR

Tech design Phase 1 -> 2010 (the current LCRD year 1)

Tech design Phase II -> 2010-2012

In 2011 -> completion of R&D

-> technology selections

-> start TDR

2011 -> 2012…design/start to build/test sections (modules,..) of subsystems with selected technologies

TDR ready 2012, work on subsystem technical prototypes continues.

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?		