Benchmarking for LoI

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SiD Benchmarking meeting, 9 Oct 2007

From Physics Studies to Benchmarking

- Entering a new phase: LoI in 2008 and EDR in 2010
- Emphasis of physics studies will shift towards
  - Evaluation and comparison of detector choices
  - Realities required by engineering (ex material)
  - Realities required by reconstruction algorithms

- New Research Director will define a set of processes common to different concepts but also will allow concepts to choose processes highlighting their strong features

Considerations

- Requirements to processes
  - Highlight physics case for ILC
  - Be generic so more physics scenarios are covered → signature oriented
  - Be sensitive to detector parameters
- What's different from previous studies: matured tools
  - real geometries
  - material effects
  - effects from realistic reconstruction algorithms in Tracker and Calorimeters
- Reality may decrease sensitivity to physics – need to think about improved analysis techniques to recover
- LoI is a strong time constraint and will help to streamline this activity
  - The list reduced after Snowmass 2005 from 27 processes to 8

Benchmarking processes

reduced list from Snowmass 2005 report hep-ex/0603010

0. Single $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, π^0, $K^{\pm}$, K^0_S, γ, $0 < |\cos\theta| < 1$, $0 < p < 500$ GeV

1. $e^+e^- \to f\bar{f}$, $f = e$, τ, u, s, c, b at $\sqrt{s}$=0.091, 0.35, 0.5 and 1.0 TeV;

2. $e^+e^- \to Z^0h^0 \to \ell^+\ell^-X$, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;

3. $e^+e^- \to Z^0h^0$, $h^0 \to c\bar{c}$, $\tau^+\tau^-$, WW^*, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;

4. $e^+e^- \to Z^0h^0h^0$, $M_h = 120$ GeV at $\sqrt{s}$=0.5 TeV;

5. $e^+e^- \to \tilde{e}^+_R\tilde{e}^-_R$ at Point 1 at $\sqrt{s}$=0.5 TeV;

6. $e^+e^- \to \tilde{\tau}^+_1\tilde{\tau}^-_1$, at Point 3 at $\sqrt{s}$=0.5 TeV;

7. $e^+e^- \to \tilde{\chi}^+_1\tilde{\chi}^-_1 / \tilde{\chi}^0_2\tilde{\chi}^0_2$ at Point 5 at $\sqrt{s}$=0.5 TeV;

Comments on Processes

- Reduced list is a good starting point and likely to be used by RD
- We need to decide which other processes we want to consider
- Benchmarking group will discuss this with all subsystems
  - Subsystems may have more than one hardware option. We should try to be positive about it - look for processes emphasizing strong sides of different options.
- We need to be realistic what we can be done in a year

Benchmarking Vertexing

1. $e^+e^- \to f\bar{f}$; $f = e, \tau, u, s, c, b$

3. $e^+e^- \to Z^0h^0$, $h^0 \to c\bar{c}, \tau^+\tau^-, WW^*$, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;

4. $e^+e^- \to Z^0h^0h^0$, $M_h = 120$ GeV at $\sqrt{s}$=0.5 TeV;

6. $e^+e^- \to \tilde{\tau}_1^+\tilde{\tau}_1^-$, at Point 3 at $\sqrt{s}$=0.5 TeV;

- Main criteria: Highly efficient *b&c* – tagging
- Other possible processes
  - Charm tagging in dominant *b* background
  - Taus: 3-prong vertexing for collimated decays, impact parameter to tag 1-prong decays

$$ee \to H^0A^0 \to b\bar{b}b\bar{b}$$

$$ee \to \tilde{t}_1\tilde{t}_1$$

Benchmarking Tracking

0. Single $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, π^0, $K^{\pm}$, K^0_S, γ, $0 < |\cos\theta| < 1$, $0 < p < 500$ GeV

1. $e^+e^- \to f\bar{f}$, $f = e, \tau, u, s, c, b$ at $\sqrt{s}$=0.091, 0.35, 0.5 and 1.0 TeV;

2. $e^+e^- \to Z^0h^0 \to \ell^+\ell^- X$, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;

5. $e^+e^- \to \tilde{e}^+_R\tilde{e}^-_R$ at Point 1 at $\sqrt{s}$=0.5 TeV;

- Main issues
  - Momentum resolution/Pattern recognition
  - V0 reconstruction
  - **ALGORITHMS**
  - Forward tracking
- Other processes
  - Busy multi-jet events
  - Reconstruction of E_{cm} : ee→μμ

Benchmarking Calorimetry

0. Single $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, π^0, $K^{\pm}$, K^0_S, γ, $0 < |\cos\theta| < 1$, $0 < p < 500$ GeV

3. $e^+e^- \to Z^0h^0$, $h^0 \to c\bar{c}$, $\tau^+\tau^-$, WW^*, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;

4. $e^+e^- \to Z^0h^0h^0$, $M_h = 120$ GeV at $\sqrt{s}$=0.5 TeV;

7. $e^+e^- \to \tilde{\chi}^+_1\tilde{\chi}^-_1 / \tilde{\chi}^0_2\tilde{\chi}^0_2$ at Point 5 at $\sqrt{s}$=0.5 TeV;

- Main issues
  - Energy resolution, di-jet mass resolution
  - **Algorithms** are probably even more important than in tracking
  - Compensating CAL?
- Other processes
  - ee→WWνν (no beam energy constraint)
  - π^0 reconstruction: tau polarization, b-tagging

More Benchmarking

- Muons
  - purity: punchthroughs, decays in flight

0. Single $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, π^0, $K^{\pm}$, K^0_S, γ, $0 < |\cos\theta| < 1$, $0 < p < 500$ GeV

2. $e^+e^- \rightarrow Z^0h^0 \rightarrow \ell^+\ell^- X$, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;

- Forward systems
  - Luminosity
  - Electron veto (two-photon bkg)

6. $e^+e^- \rightarrow \tilde{\tau}_1^+\tilde{\tau}_1^-$, at Point 3 at $\sqrt{s}$=0.5 TeV;

- Anything else ?

Strategy of Benchmarking

- SiD is a concept with distinct features
  - compact detector with precise silicon tracking and compact calorimeters inside the magnet which allows for fine segmentation at acceptable cost
- Optimization should be done within these constraints
  - As opposed to a wide open optimization
  - Different from ILD which needs to decide how to average LDC & GLD
- Select a point in detector parameter space and check for an optimum around this point
  - Need to decide how to select the point and how to define the range of parameters

Tools for Benchmarking

- Most of results so far used Fast Monte Carlo
- Full simulation (SLIC) and reconstruction code are available and there are already results that used the full simulation chain

- Important to use uniform tools – org.lcsim, JAS3, WIRED4
- Need a simulation chain which would work out of the box
- Need strong support from simulation group

Random Thoughts

- Decide on LoI plots early so work can be focussed on what’s needed for LoI
- Manpower issues – identify people for key processes
- Clearly the optimization will be much affected by cost factors. Need to disentangle this?
- Suggest common samples for all concepts

Timeline

- Timeline
  - Oct 2008 submit LoI
  - June 2008 Benchmarking studies ready
  - Feb 2008 All key analyses on-going
  - Dec 2008 First sample analysis
  - Oct 2008 Tools ready