Benchmarking SiD

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SiD meeting, 23 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: material (amount and distribution)
  - Realities required by reconstruction algorithms: tracking & PFA

Considerations

- Requirements to processes
  - Highlight physics case for ILC
  - Be generic so more physics scenarios are covered → signature oriented
  - Be sensitive to detector parameters
- Reality may decrease sensitivity to physics – need to think about improved analysis techniques to recover

- LoI is a strong time constraint and it will streamline this activity
  - Decide on LoI plots early so work can be focussed on what's needed for LoI
- RD defined a set of 7+1 processes common to different concepts but also allowed to choose processes highlighting our strong features
  - Based on reduced list of Snowmass 2005 benchmarking report
  - Suggested common samples for all concepts
  - Software panel to monitor consistency of beam & physics bkg used by concepts

Benchmarking processes

0. Single $e^{\pm}$, $\mu^{\pm}$, $\pi^{\pm}$, π^0, $K^{\pm}$, K_S^0, 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;

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

reduced list from Snowmass 2005 report hep-ex/0603010

- + ee→ZZ →Zνν

Comments on Processes

- We started to discuss the benchmarking issues with all subsystems
  - Identify additional processes
  - Subsystems may have more than one hardware option. We should 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 within constraints of manpower and tools

Benchmarking Vertexing

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

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

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

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

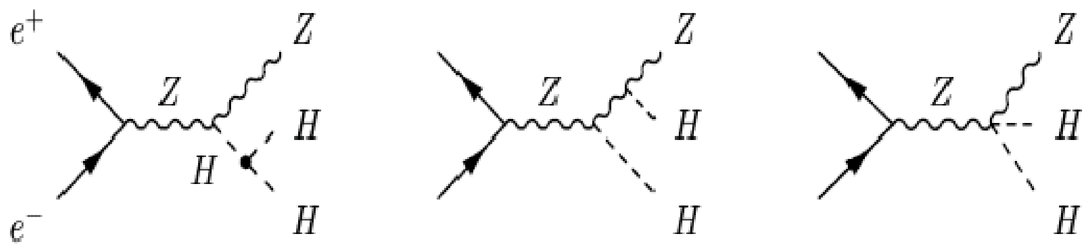
- Main criteria: Highly efficient *b&c* – tagging
- Other possible processes
  - Charm tagging in dominant *b* background
  - Taus: 3-prong vertexing for collimated decays, impact parameter to tag 1-prong decays

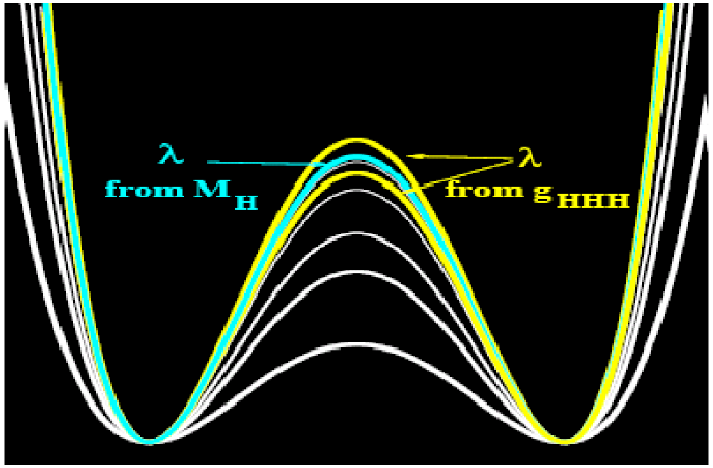
$$ee \rightarrow H^0A^0 \rightarrow b\bar{b}b\bar{b}$$

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

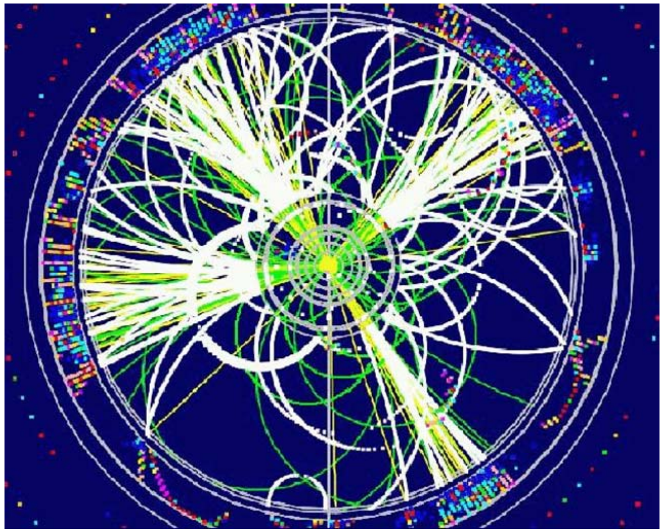
ZHH

Double Higgstrahlung: $e^+e^- \to H^0H^0Z^0$





- Key to understanding of Higgs potential – mechanism of symmetry breaking
- 4 b-jets in final state
- Low xsection/ Large SM backgrounds
- b/c tagging and b/bbar tagging are crucial



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

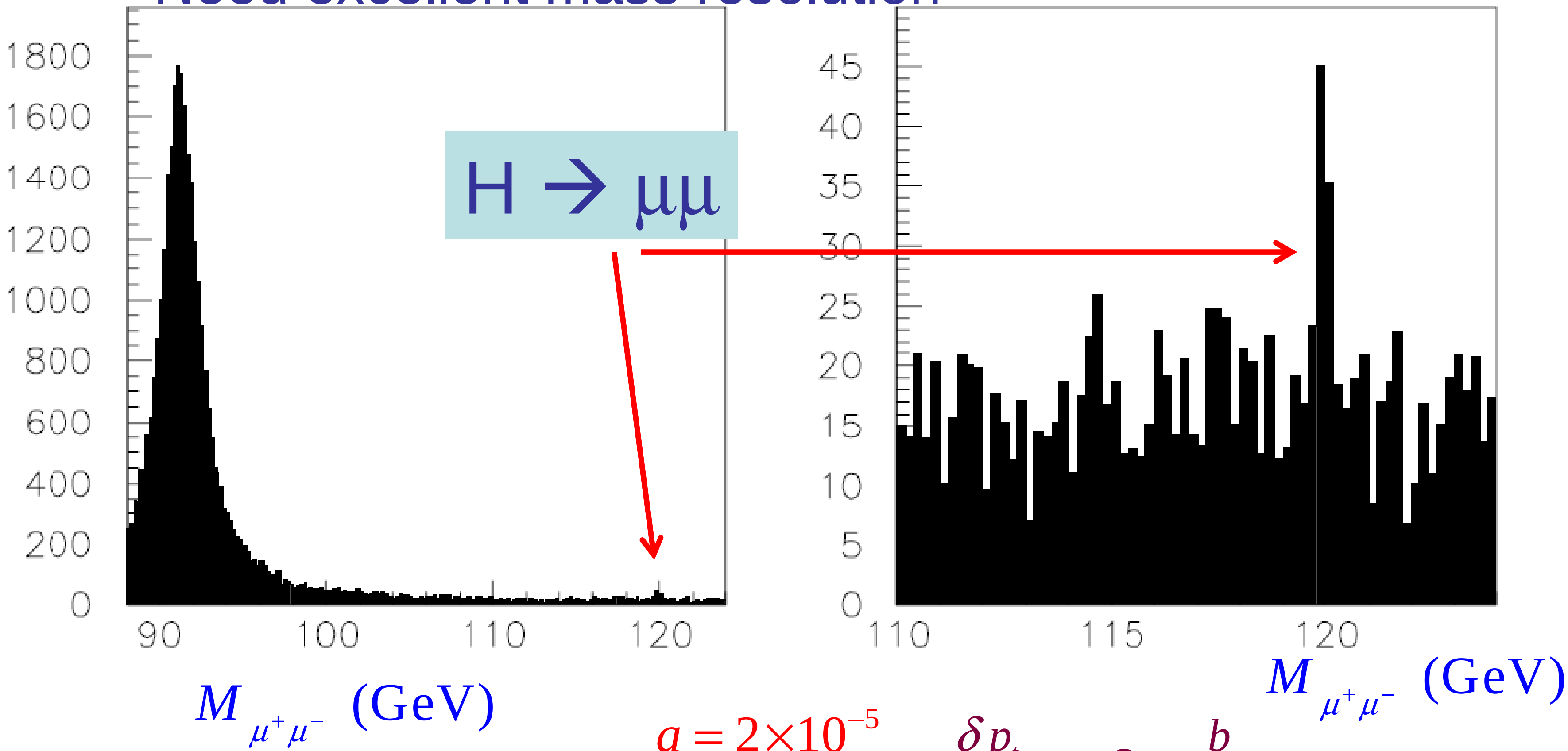
2. $e^+e^- \rightarrow Z^0h^0 \rightarrow \ell^+\ell^-X$, $M_h = 120$ GeV at $\sqrt{s}$=0.35 TeV;

5. $e^+e^- \rightarrow \tilde{e}^+_R\tilde{e}^-_R$ 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
  - H→μμ

H→μμ

- One of important Higgs Br
- $M_{\mu\mu}$ distributions for NN>0.95 for signal and background summed
  - – Need excellent mass resolution



$a = 2\times10^{-5}$

$b = 1\times10^{-3}$

$$\frac{\delta p_t}{p_t^2} = a \oplus \frac{b}{p_t \sin\theta}$$

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;

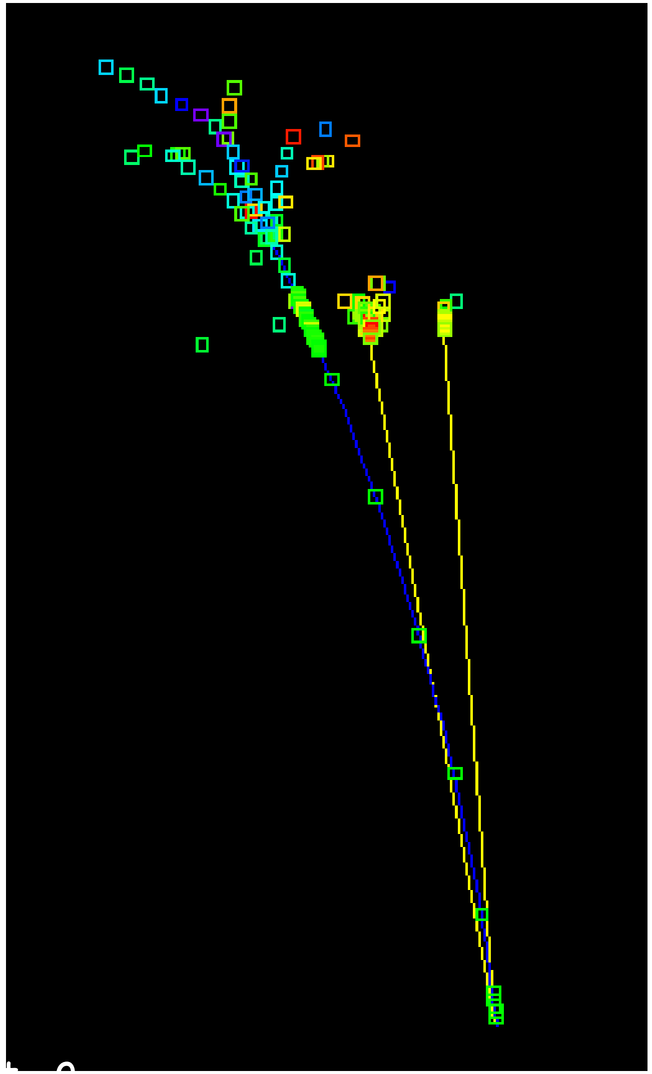
4. $e^+e^- \to Z^0h^0h^0$, $M_h = 120$ GeV at $\sqrt{s}$=0.5 TeV;

7. $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- / \tilde{\chi}_2^0\tilde{\chi}_2^0$ 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→WW$\nu\nu$ (no beam energy constraint)
  - π^0 reconstruction: tau polarization, b-tagging

Importance of π^0

- H→$\tau\tau$ process
- Tau polarization (from $\tau \rightarrow \rho\nu \rightarrow \pi^+\pi^o\nu$) allows to determine CP properties of Higgs
- Separation of clusters and reconstruction of π^o requires excellent segmentation of EMCAL
- Also : using π^0 to constrain the vertex mass → improvements in 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. $e^{+}e^{-} \rightarrow Z^{0}h^{0} \rightarrow \ell^{+}\ell^{-}X$, $M_{h} = 120$ GeV at $\sqrt{s}$=0.35 TeV;

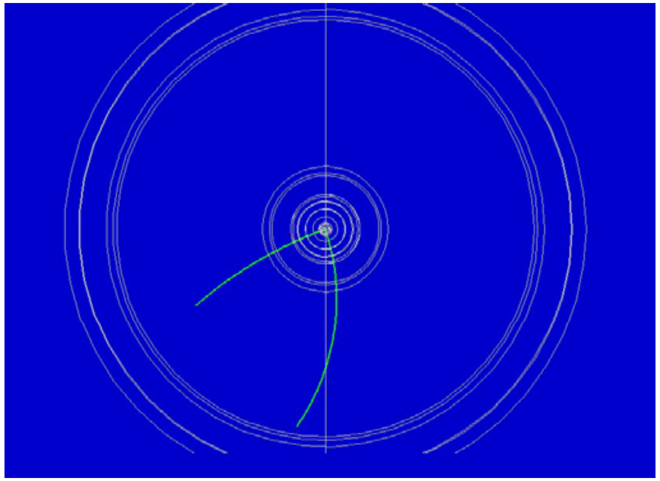
- Forward systems
  - Luminosity
  - Electron veto (two-photon bkg)

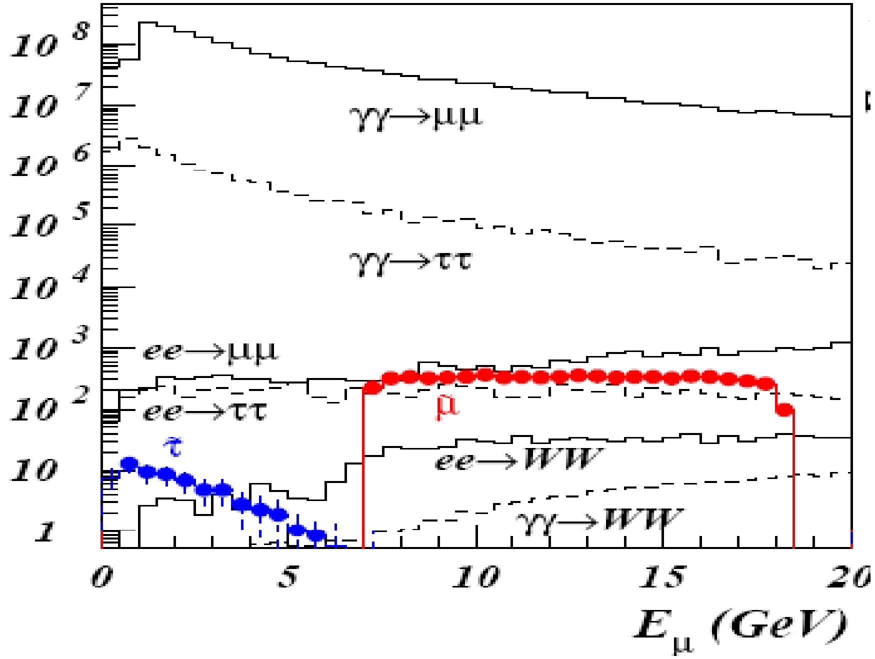
6. $e^{+}e^{-} \rightarrow \tilde{\tau}_{1}^{+}\tilde{\tau}_{1}^{-}$, at Point 3 at $\sqrt{s}$=0.5 TeV;

- Anything else ?

Cosmology Motivated Scenarios

- Dark Matter is 25% of Universe – how to explain?
- In SUSY : small mass split between LSP and NLSP = small visible energy in the detector
  - ee → staus or stops/sbottoms
- Large two –photon backgrounds
  - Need to veto electron/positron in forward systems





Strategy of Benchmarking

- SiD is a concept with distinct features
- Optimization should be done within these distinct features
  - 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

Fast vs Full MC

Many questions can be addressed only with full MC

Two reasons to still use fast MC

- Some questions can be addressed with Fast MC
  - Ex. Optimization of Tracker and VD geometry
- Fast MC is adequate to develop analysis techniques
  - Replaced by full MC at later stage

- Valid question: will data structure change for fast-to-full MC transition?

Timeline

- Oct 2008 submit LoI
- July 2008 Benchmarking studies ready
- Feb 2008 All key analyses on-going
- Dec 2007 First sample analysis
- Oct 2007 Decide what’s needed for LoI

Summary

- New phase of physics studies
- Need to cover 7-8 “obligatory” processes

- Resumed benchmarking meetings: biweekly on Tuesday 9 am SLAC/ 11 am Fermilab/ 5 pm UK
- Talking to subsystem to identify additional processes
- Physics studies are ideal for newcomers, fast track way to contribute to LoI

- Talk to us about your favourite physics process or how you’d like to benchmark your favourite detector system!