Future SiD Benchmarking Studies

Tim Barklow (SLAC)

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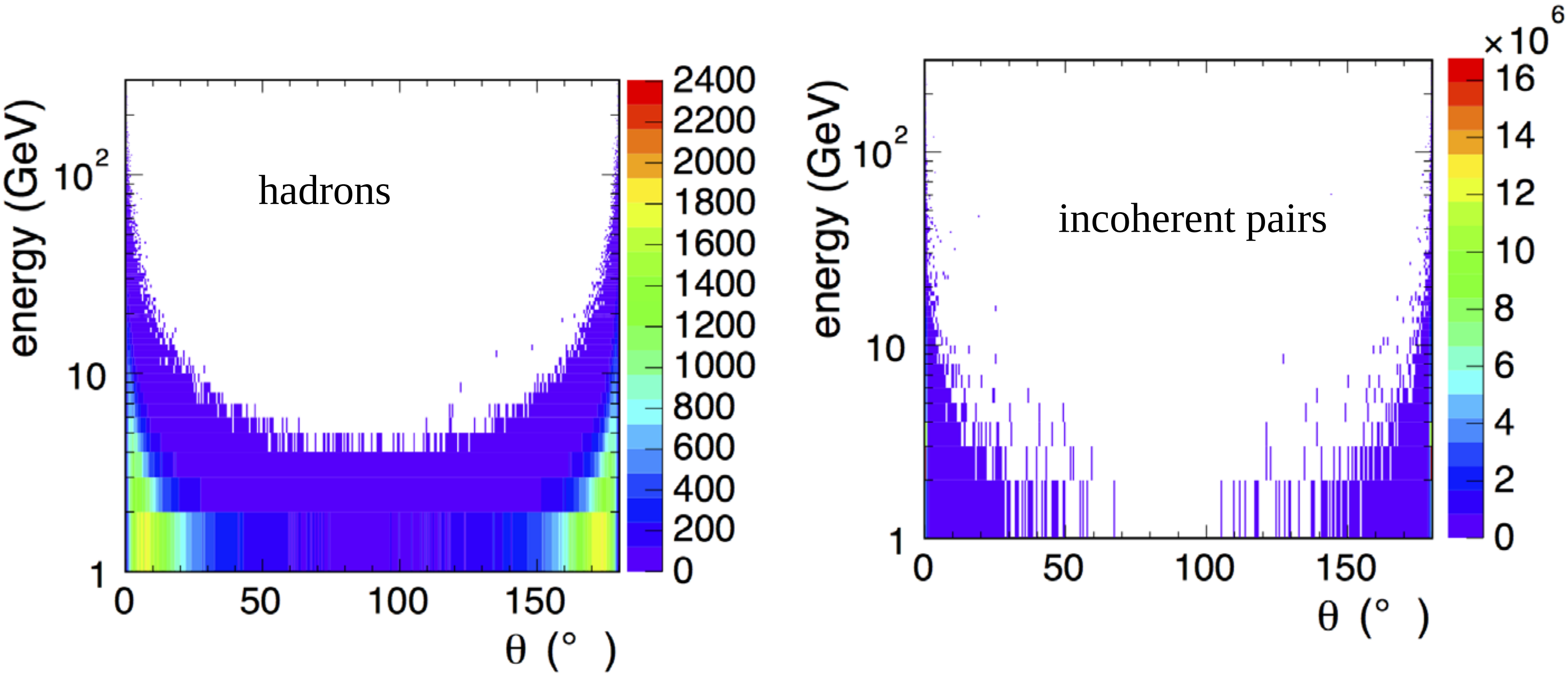
Possible Future SiD Benchmarking Studies

- Low angle electron tagging of $\gamma\gamma$ processes
- Study the possibility of starting the Higgs physics program at $\sqrt{s} = 350$ GeV instead of $\sqrt{s} = 250$ GeV.
- Expand invisible Higgs decay mode analysis to include general BSM Higgs decays, and include the searches for invisible and BSM decays in total width analysis.
- Improve $h \to ZZ^*$ analysis.
- Develop beam energy, luminosity and polarization analyses using extraction line instruments and well understood physics processes.
- Detector optimization benchmarks.

Low angle electron tagging of $\gamma\gamma$ processes

Angular distribution of background



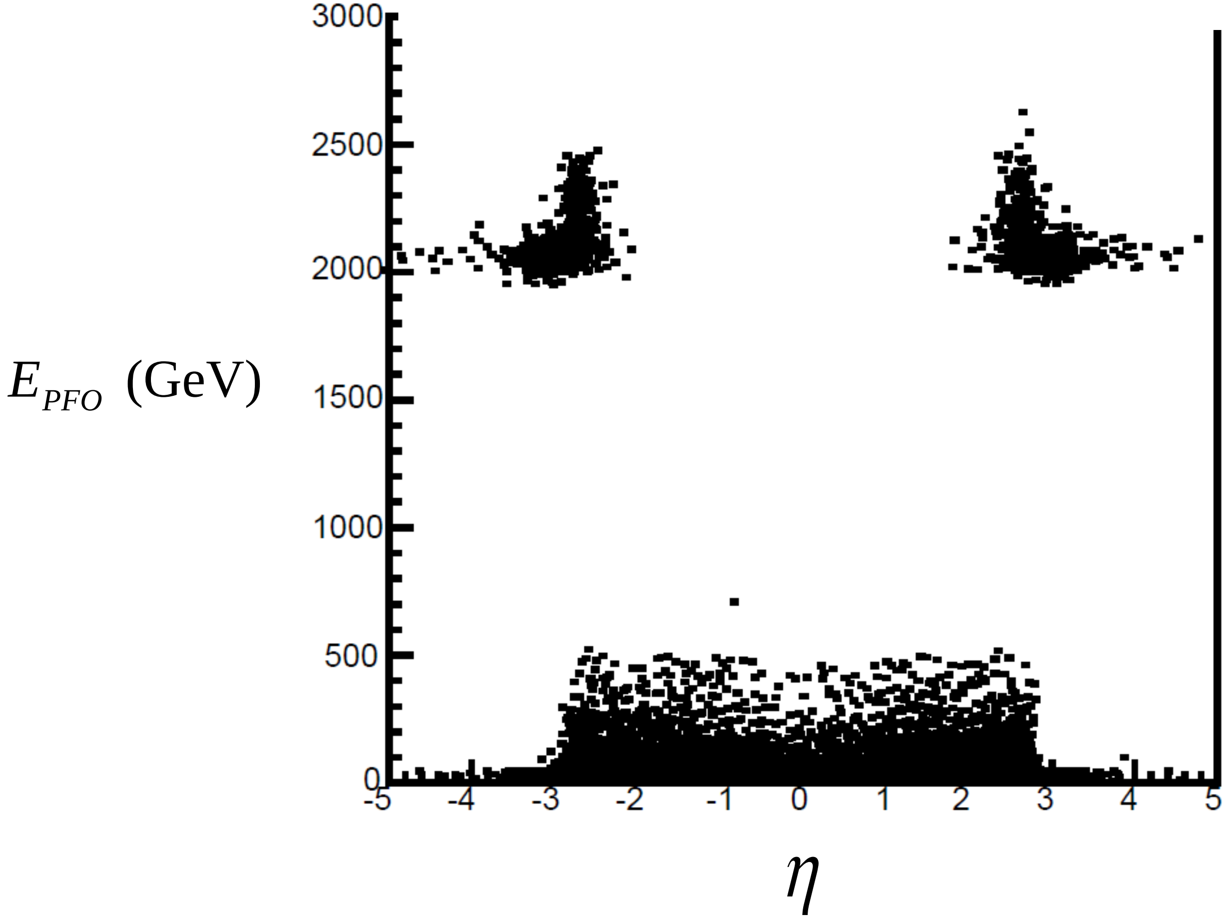
Incoherent pairs affect mostly occupancies and tracking efficiencies

Hadrons have enough energy to reach the calorimeter

Two large energy PFO's at large η

created each event by incoherent $e^{+}e^{-}$ pairs.

Remove with cuts on E_{PFO} and η

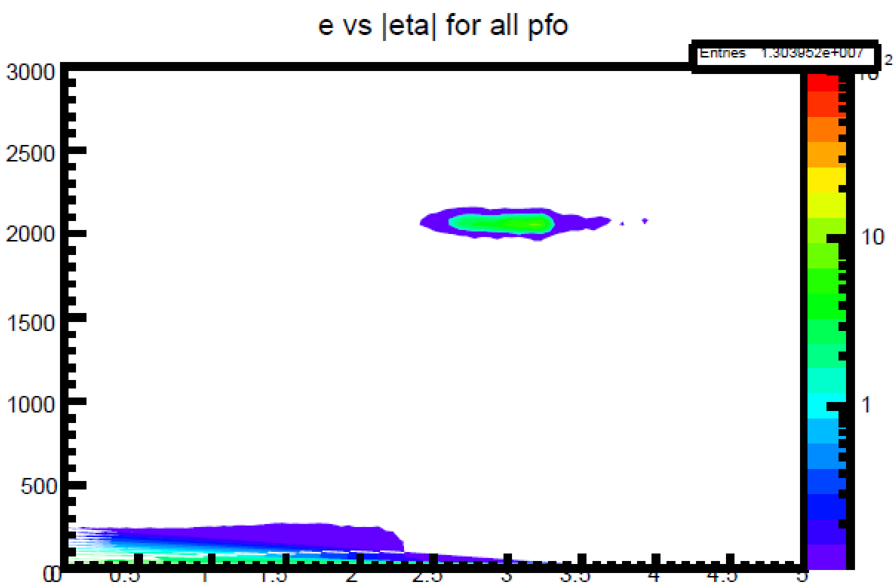


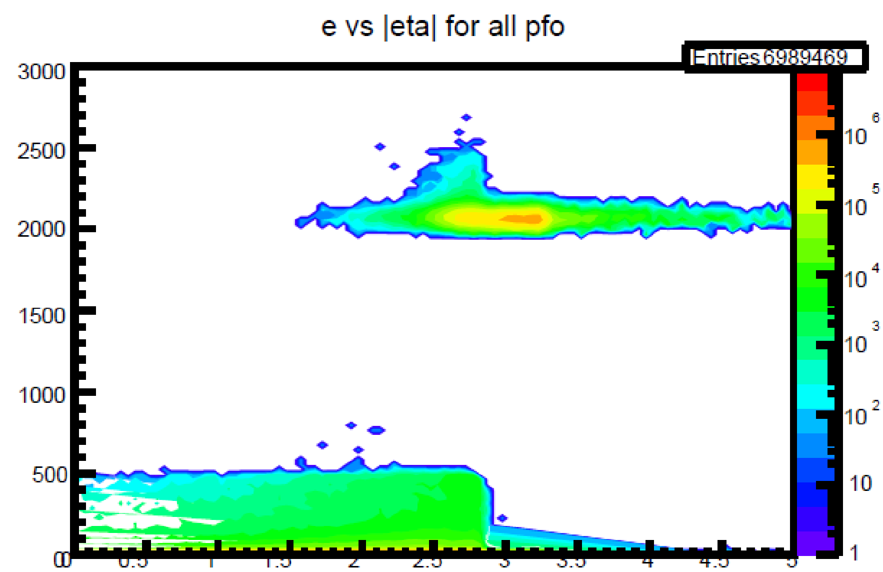
SiD *ffh _ mumu*

$e^+e^- \rightarrow \nu_e\bar{\nu}_e h \rightarrow \nu_e\bar{\nu}_e \mu^+\mu^-$

SiD *4f _ sze _ l*

$e^+e^- \rightarrow e^+e^- \mu^+\mu^-$





E_{pfo} **(GeV)**

η

Goal of new study is to do a proper analysis of the beamcal data and pull forward electrons out of the several TeV energy deposit. Then perform physics benchmark analyses that benefit from $\gamma\gamma$ vetoing such as $e^+e^- \rightarrow \nu_e\bar{\nu}_e h$, $e^+e^- \rightarrow \tilde{\tau}^+\tilde{\tau}^-$, etc.

Study the possibility of starting the Higgs physics program at $\sqrt{s} = 350$ GeV instead of $\sqrt{s} = 250$ GeV.

If you look at the ILC Higgs results following 3 Snowmass years at the baseline luminosity at $\sqrt{s} = 250$ GeV, you don't see a big improvement relative to HL-LHC. It is only after running at $\sqrt{s} = 500$ GeV to get $\sigma \bullet BR(\nu_e \bar{\nu}_e h \to \nu_e \bar{\nu}_e b\bar{b})$ that we see a decent gain. Why not start at $\sqrt{s} = 350$ GeV where we can get all of σ(ZH), $\sigma \bullet BR(Zh \to Zxx)$, and $\sigma \bullet BR(\nu_e \bar{\nu}_e h \to \nu_e \bar{\nu}_e b\bar{b})$? (And measure $t\bar{t}$ threshold)

7 Parameter HXSWG Benchmark

	LHC		ILC(250)	ILC(500)	
			250	250+500	$\sqrt{s}$ (GeV)
Mode	300 fb^{-1}	3000 fb^{-1}	250	250+500	L (fb^{-1})
$\gamma\gamma$	$(5-7)\%$	$(2-5)\%$	17 %	8.3 %	
gg	$(6-8)\%$	$(3-5)\%$	6.1 %	2.0 %	
WW	$(4-5)\%$	$(2-3)\%$	4.7 %	0.4 %	
ZZ	$(4-5)\%$	$(2-3)\%$	0.7 %	0.5 %	
$t\bar{t}$	$(14-15)\%$	$(7-10)\%$	6.4 %	2.5 %	
$b\bar{b}$	$(10-13)\%$	$(4-7)\%$	4.7 %	1.0 %	
$\tau^+\tau^-$	$(6-8)\%$	$(2-5)\%$	5.2 %	1.9 %	

Model independent fit of total Higgs width is based solely on $\sigma \bullet BR$ for SM Higgs decays and does not include limits on direct searches for invisible decays are other non-SM Higgs decays. The total width precision can be improved significantly if the search results are included.

Table 9.1. Summary of expected accuracies $\Delta g_i/g_i$ for model independent determinations of the Higgs boson couplings. The theory errors are $\Delta F_i/F_i = 0.1\%$. For the invisible branching ratio, the numbers quoted are 95% confidence upper limits.

	ILC(250)	ILC(500)	ILC(1000)	ILC(LumUp)
$\sqrt{s}$ (GeV)	250	250+500	250+500+1000	250+500+1000
L (fb^{-1})	250	250+500	250+500+1000	1150+1600+2500
$\gamma\gamma$	18 %	8.4 %	4.0 %	2.4 %
gg	6.4 %	2.3 %	1.6 %	0.9 %
WW	4.8 %	1.1 %	1.1 %	0.6 %
ZZ	1.3 %	1.0 %	1.0 %	0.5 %
$t\bar{t}$	–	14 %	3.1 %	1.9 %
$b\bar{b}$	5.3 %	1.6 %	1.3 %	0.7 %
$\tau^+\tau^-$	5.7 %	2.3 %	1.6 %	0.9 %
$c\bar{c}$	6.8 %	2.8 %	1.8 %	1.0 %
$\mu^+\mu^-$	91%	91%	16 %	10 %
$\Gamma_T(h)$	12 %	4.9 %	4.5 %	2.3 %
hhh	–	83 %	21 %	13 %
BR(invis.)	$<$ 0.9 %	$<$ 0.9 %	$<$ 0.9 %	$<$ 0.4 %

Expand invisible Higgs decay mode analysis to include general BSM Higgs decays, and include the searches for invisible and BSM decays in total width analysis.

From M. Peskin's Higgs parallel session talk Tuesday Nov 12:

The reason for this is that I used a 9-parameter fit constrained to the relation $\sum_i BR_i = 1$.

This constraint is very powerful because determinations of Higgs couplings require constraining the Higgs total width.

$$\sigma(A\overline{A} \to h) \cdot BR(h \to B\overline{B}) \sim \frac{\Gamma(h \to A\overline{A})\Gamma(h \to B\overline{B})}{\Gamma_T}$$

The constraint has a large effect here:

error in Γ_T	unconstrained	$\sum BR = 1$
ILC 500	5.0%	1.6%
ILC 500 up	2.8%	0.75%
ILC 1000	4.6%	1.2%

To get from here to there we need to expand our current suite of Higgs decay mode analyses to include general BSM Higgs decays. This has to be done in a model independent way using both $Zh \to l^+l^-h$ and $Zh \to q\bar{q}h$.

Improve $h \to ZZ^*$ analysis.

Develop beam energy, luminosity and polarization analyses using extraction line instruments and well understood physics processes.

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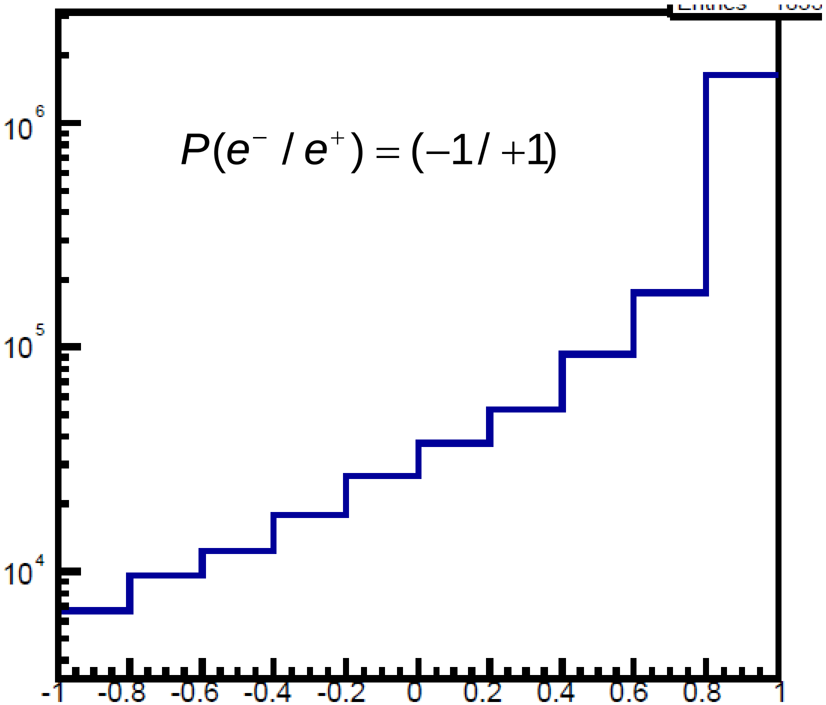
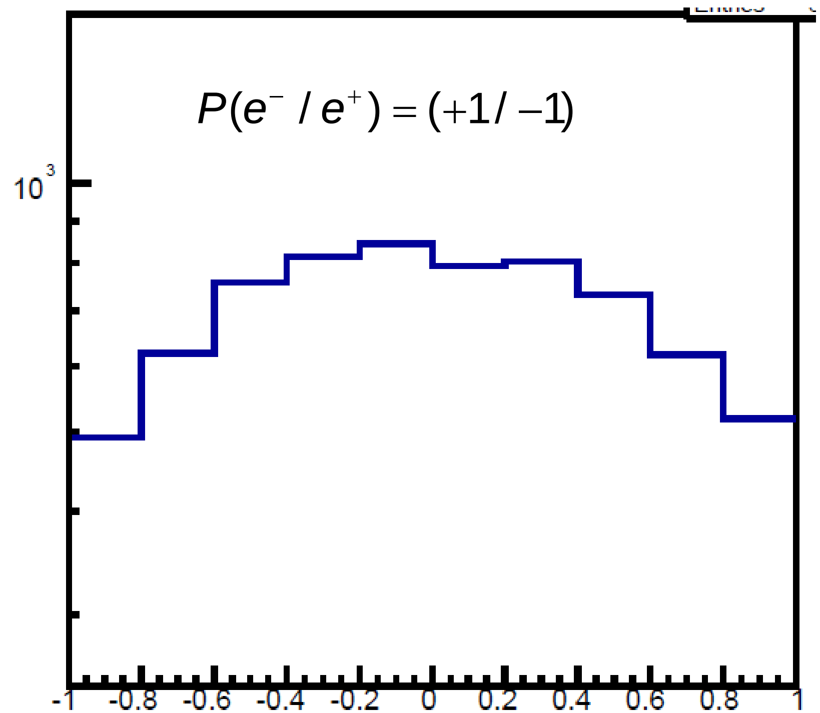
$e^+e^- \to W^+W^- \quad \sqrt{s} = $ **1 TeV**

$\frac{d\sigma}{d\cos\Theta}$



$\cos\Theta$

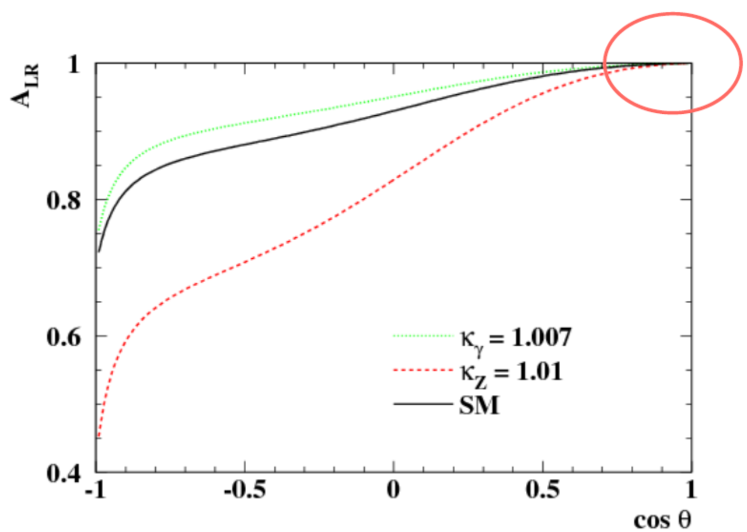


$\cos\Theta$

Either fit over entire $\cos\Theta$ **range and assume SM**

or

restrict fit to $1-\varepsilon < \cos\Theta < 1$



From Graham Wilson's talk at Precision Frontier Colloquium Snowmass 2013: