Impact of ECAL Technologies and Resolution on Higgs Measurements

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Overview

I) Effect of single γ resolution.

II) Comparison SiECAL ScECAL.

(*) Both are analysis are preliminary.

I) Effect of single γ resolution.

Introduction

Target

- Study the effect of the single γ resolution.
- vvH ($\mathrm{H} \rightarrow \gamma\gamma$) at 500 GeV. Main background only (vv$\gamma\gamma$).

Procedure

- Assuming several photon resolutions worst that the observed one.
- For each resolution the significance of the signal over the main background is obtained.
  - Same cut flow as showed in LCWS13.

1	Preselection
2	(coneE_m $<$ 3.76+0.066*E_m) & (coneE_l $<$ 0.0545+0.092*E_l)
3	$\not{E}_T >$ -326 + 1.25*E$_{vis}$
4	$\lvert\cos(\theta^*_\gamma)\rvert < 0.98$
5	$\cos(\theta_\gamma) < 0.98$
6	coneE(γ_1) + coneE(γ_2) $<$ 8
7	$M_{miss} > 140\ \mathrm{GeV/c^2}$
8	BDT

BDT variables

- cosD
- cos(γ)
- pt1 + pt2
- E(H)
- principleThrust
- cosThrustAxis
- oblateness

- Fo is observed single γ E res.
- Generate new γ E (Er) using gaussian.
- Fc is the γ E resolution with those Er.
- Apply same selection cut and extract significance: signal / sqrt(signal + back)

Observed γ E res

```
Fo = ( E - Emc ) / Emc
```

Extracted Er

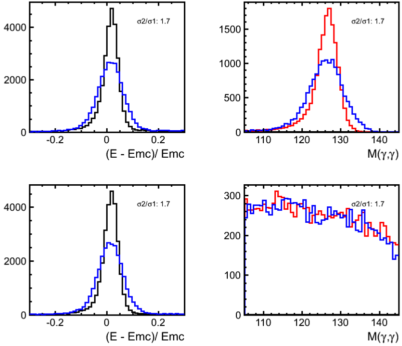
```
Fr = ( Er - E ) / E
frand = Fr(RAND)
Er = frand * E + E
```

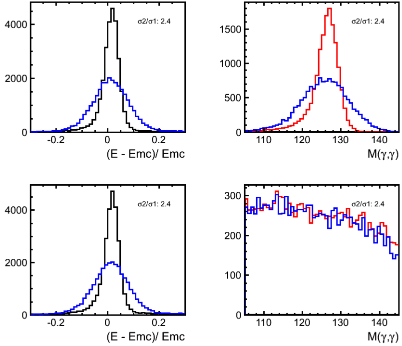
New γ E resolution

```
Fc = ( Er - Emc ) / Emc
```

- The significance is obtained within the signal window [120,132].

Examples

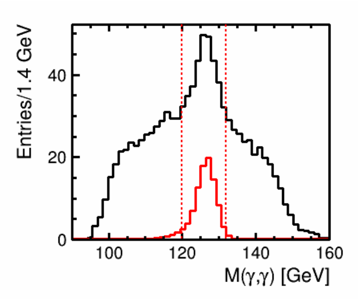




- E res. sigma 1.7 times the observed value.
- vvH(up) vvaa (down)

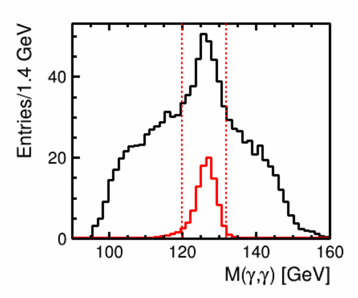
- E res. sigma 2.4 times the observed value.
- vvH(up) vvaa (down)

Default



Process:	signal	mainback	Signf
Cross Section:	0.4	41.6	-
Expected:	193.4	20791.8	-
Generated:	78204	752074	-
Cut1:	178.7	13198.9	1.54
Cut2:	173.9	11347.0	1.62
Cut3:	171.7	10703.5	1.65
Cut4:	168.4	9776.3	1.69
Cut5:	161.5	4754.1	2.30
Cut6:	159.7	4663.3	2.30
Cut7:	140.6	3422.0	2.36
Cut8:	97.9	891.7	3.11
Cut9:	89.4	256.8	4.80

Res 00



Process:	signal	mainback	Signf
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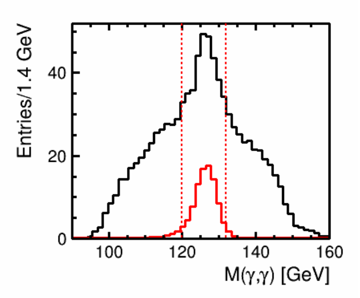
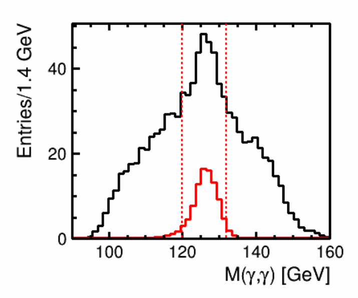
Cut2:	174.0	11347.1	1.62
Cut3:	171.7	10703.7	1.65
Cut4:	168.5	9776.6	1.69
Cut5:	161.5	4754.7	2.30
Cut6:	159.7	4664.1	2.30
Cut7:	140.7	3422.5	2.36
Cut8:	98.6	895.6	3.13
Cut9:	90.3	261.7	4.81

Res 15

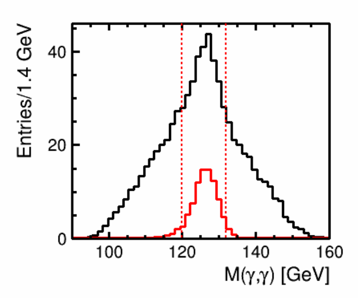


Process:	signal	mainback	Signf
Cross Section:	0.4	41.6	-
Expected:	193.4	20791.8	-
Generated:	78204	752074	-
Cut1:	178.7	13197.9	1.54
Cut2:	173.9	11346.2	1.62
Cut3:	171.6	10702.6	1.65
Cut4:	168.4	9774.9	1.69
Cut5:	161.5	4753.7	2.30
Cut6:	159.7	4662.9	2.30
Cut7:	140.6	3422.1	2.36
Cut8:	97.9	821.9	3.23
Cut9:	88.7	259.3	4.75

Res 20

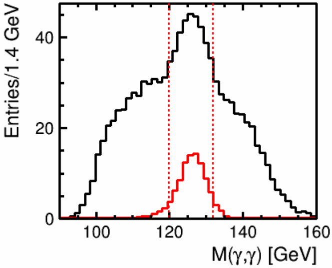


Process:	signal	mainback	Signf
Cross Section:	0.387	41.6	-
Expected:	193.4	20791.8	-
Generated:	78204	752074	-
Cut1:	178.7	13197.2	1.54
Cut2:	173.9	11345.5	1.62
Cut3:	171.7	10701.8	1.65
Cut4:	168.5	9773.0	1.69
Cut5:	161.5	4751.6	2.30
Cut6:	159.7	4661.0	2.30
Cut7:	140.6	3420.4	2.36
Cut8:	96.5	829.6	3.17
Cut9:	86.9	256.0	4.69

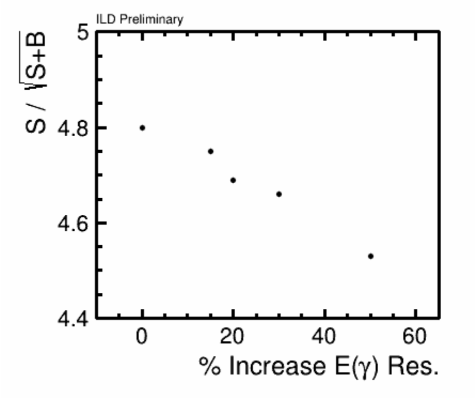


Process:	signal	mainback	Signf
Cross Section:	0.4	41.6	-
Expected:	193.4	20791.8	-
Generated:	78204	752074	-
Cut1:	178.7	13195.3	1.55
Cut2:	173.9	11344.5	1.62
Cut3:	171.6	10699.1	1.65
Cut4:	168.5	9770.7	1.69
Cut5:	161.5	4750.3	2.31
Cut6:	159.8	4659.5	2.30
Cut7:	140.7	3420.4	2.36
Cut8:	90.8	619.5	3.41
Cut9:	81.4	223.3	4.66

Res 50



Process:	signal	mainback	Signf
Cross Section:	0.4	41.6	-
Expected:	193.4	20791.8	-
Generated:	78204	752074	-
Cut1:	178.7	13189.0	1.55
Cut2:	173.9	11338.5	1.62
Cut3:	171.6	10688.7	1.65
Cut4:	168.4	9760.2	1.69
Cut5:	161.4	4747.8	2.30
Cut6:	159.7	4657.3	2.30
Cut7:	140.7	3420.7	2.36
Cut8:	99.3	910.0	3.13
Cut9:	84.6	263.9	4.53



- Significance decreases 5.6 % when single γ reolution is degraded 50%.

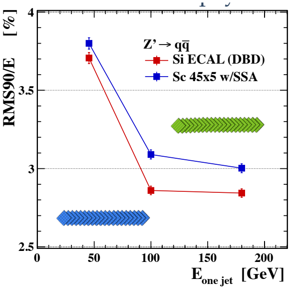
II) Comparison SiECAL ScECAL

Comparison of two ECAL

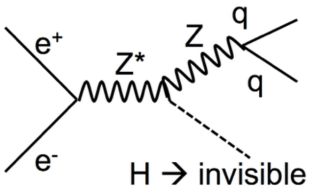
Motivation

- There is two ECAL candidates for the ILD detector.
  - SiECAL
  - ScECAL
- The cost of SiECAL is 2 times the cost of ScECAL.
- JER at 100 GeV jet is 2.5 % better for SiECAL.
  - What about the impact on physic analysis relying on calorimeter?

SiECAL		ScECAL	
Item	Cost [kILCU]	Item	Cost [kILCU]
Tungsten	16310	Tungsten + carbon parts	18500
Carbon fiber structure	2130	Module realisation	1700
Silicon sensors	75000	Scintillators	1030
Readout ASIC	16500	Photo Detectors	10200
Readout Board	21000	Readout ASIC	2500
Materials	1300	Readout Board	25000
Cables, connectors	2220	Readout System	6200
Tooling	9300	Cables, connectors	1000
Assembly	13500	Power supplies	4100
Integration	500	Tooling	3800
Sum SiECAL	157760	Sum ScECAL	74000



Introduction



- ZH, Z→qq, H→invisible is a good option to compare both ECAL.
  - Simple final state two jets
  - The jet reconstruction relies on the calorimeter measurements.

Simulation Conditions

- $\sqrt{(s)} = 250, 350$.
- $\int L = 250\ \mathrm{fb}^{-1}$.
- All processes reconstructed with each of the ECAL.
- Assumed $\frac{\sigma(ZH \to qqH, H \to inv.)}{\sigma(ZH \to qqH)} = 10\%$
- Six background considered.

Process	σ(fb)	$\sigma \cdot L$
ZH $\to$ $qqH_{inv}\nu$	21.2	5.3e+03
ZH $\to$ qqH (SM)	212.2 $-$ 21.2	4.8e+04
ZH $\to$ $\nu\nu$H (SM)	78.3	2.0e+04
ZZ $\to$ qqll	685.4	1.7e+05
Z$\nu\nu$ $\to$ qq$\nu\nu$	272.3	6.8e+04
WW $\to$ qqll	10955	2.7e+06
Weν $\to$ qqeν	5910.1	1.5e+06

Table: $\sqrt{s} = 250 \int L = 250$

Process	σ(fb)	$\sigma \cdot L$
ZH $\to$ $qqH_{inv}\nu$	13.7	3.42e+03
ZH $\to$ qqH (SM)	137.7 $-$ 13.7	3.10e+04
ZH $\to$ $\nu\nu$H (SM)	99.6	2.49e+04
ZZ $\to$ qqll	470.8	1.18e+05
Z$\nu\nu$ $\to$ qq$\nu\nu$	356.4	8.91e+04
WW $\to$ qqll	8090.6	2.02e+06
Weν $\to$ qqeν	4963.8	1.24e+06

Table: $\sqrt{s} = 350 \int L = 250$

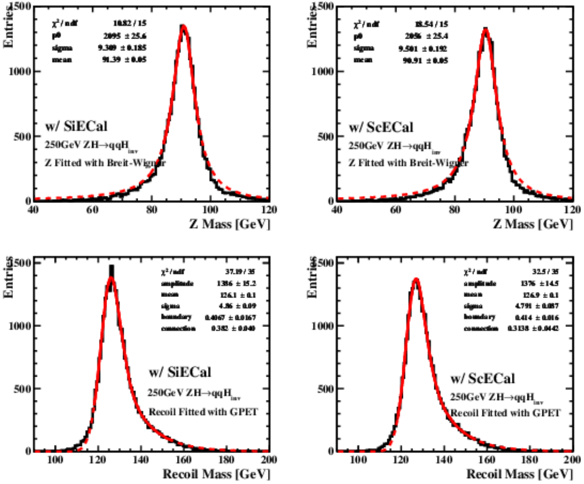
Strategy

Cut Variables

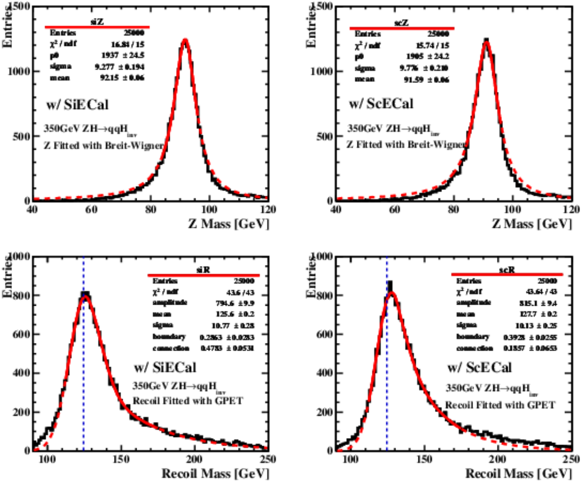
lepton veto
$1.5 < -log(Y_{23}) < 10$
$100 < E(Z) < 144$
$87 < M(Z) < 96$
$50 < p_T(j_1, j_2) < 115$
$|cos\theta(j_1)| < 0.94$
$|cos\theta(j_2)| < 0.94$
$-0.95 < cos(\theta(j_1) - \theta(j_2)) < -0.3$
$|cos\theta(Z)| < 0.94$
$120 < E_{vis} < 280$

- After background reduction use background distribution to perform toy MC.
- From the toy MC extract upper limit of H→invisible.
- Compare those upper limits for both ECAL.

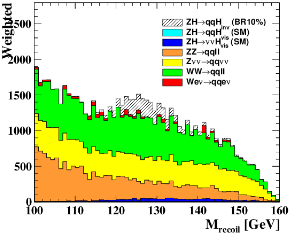
Only Signal ECM =250



Only Signal ECM =350

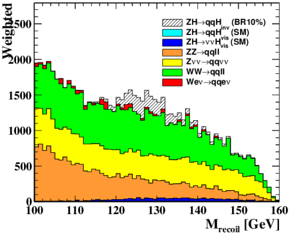


250 SiEcal



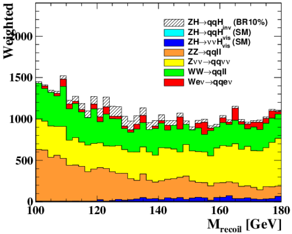
cut/process	qqh_inv	zh_qqh	zh_vvh	zz_sl	zvv_sl	ww_sl	wev_sl
ngen	2.5e+04	2.5e+04	2.5e+04	6.0e+04	6.0e+04	6.0e+05	6.0e+04
xsec	21.2	212.2	78.3	685.4	272.3	10954.8	5910.1
lepveto	99.796	92.10	92.25	80.00	99.82	54.81	29.60
logy23	98.67	60.62	82.32	73.43	97.72	50.15	27.91
zenergy	94.54	0.36	17.99	31.94	64.04	3.29	0.24
zmass	89.15	0.24	9.62	28.02	57.92	2.75	0.16
ptdijet	87.24	0.22	9.11	25.34	53.81	2.48	0.15
costhetaj0	82.08	0.22	8.67	23.14	50.19	2.16	0.13
costhetaj1	75.69	0.20	8.17	21.90	47.69	2.04	0.12
costhetaj01	74.04	0.19	8.04	15.26	38.12	1.31	0.09
costhetaZ	70.52	0.18	7.60	13.37	33.98	1.13	0.08
visenergy	70.46	0.18	7.42	13.35	33.95	1.13	0.08
Remaining	3734	95	1445	16193	19294	26003	1034

250 ScEcal



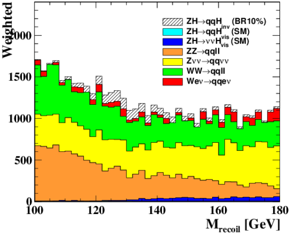
cut/process	qqh_inv	zh_qqh	zh_vvh	zz_sl	zvv_sl	ww_sl	wev_sl
ngen	2.5e+04	2.5e+04	2.5e+04	6.0e+04	6.0e+04	6.0e+05	6.0e+04
xsec	21.2	212.2	78.3	685.4	272.3	10954.8	5910.1
lepveto	99.81	92.00	92.18	79.97	99.83	54.55	30.59
logy23	99.33	57.44	84.89	74.09	98.75	49.98	28.86
zenergy	94.93	0.38	19.85	34.61	68.21	3.73	0.23
zmass	89.48	0.23	10.30	30.52	61.73	3.13	0.16
ptdijet	87.59	0.22	9.76	27.71	57.24	2.81	0.15
costhetaj0	82.66	0.21	9.33	25.35	53.41	2.45	0.13
costhetaj1	76.16	0.19	8.70	23.99	50.83	2.31	0.12
costhetaj01	74.54	0.19	8.56	16.60	40.18	1.44	0.08
costhetaZ	71.14	0.17	8.07	14.54	35.78	1.24	0.07
visenergy	71.04	0.17	7.92	14.53	35.73	1.24	0.07
Remaining	3764	91	1544	17661	20447	27892	1083

350 SiEcal

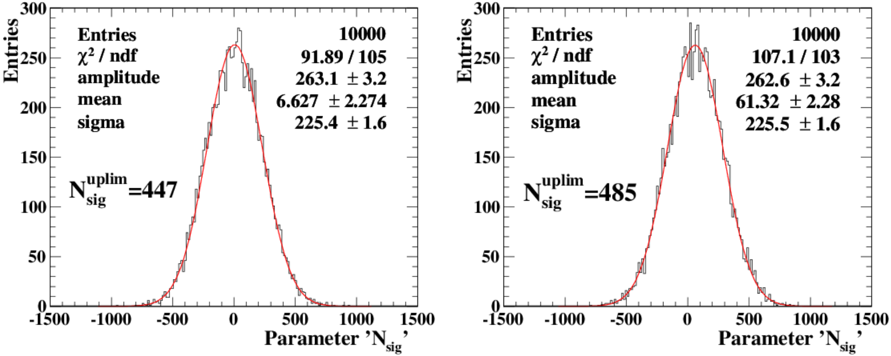


cut/proces	qqh_inv	zh_qqh	zh_vvh	zz_sl	zvv_sl	ww_sl	wev_sl
ngen	2.5e+04	2.5e+04	2.5e+04	6.0e+04	6.0e+04	6.0e+05	6.0e+04
xsec	13.7	137.7	99.6	470.8	356.4	8090.6	4963.8
lepveto	99.87	91.95	92.63	80.53	99.83	59.11	38.68
logy23	98.82	72.86	85.34	77.53	98.69	58.48	38.27
zenergy	94.62	0.80	72.35	49.53	73.38	11.51	3.15
zmass	86.40	0.16	12.47	42.23	65.69	6.07	1.75
ptdijet	84.82	0.16	11.97	38.89	62.48	5.14	1.54
costhetaj0	80.79	0.16	11.28	32.63	55.65	3.81	1.07
costhetaj1	76.29	0.16	10.53	30.57	52.47	3.52	0.90
costhetaj01	54.48	0.11	8.81	17.95	39.12	1.56	0.43
costhetaZ	53.32	0.11	8.22	14.94	33.43	1.20	0.34
visenergy	53.20	0.11	7.81	14.90	33.35	1.20	0.34
Remaining	2193	38	1123	11504	15028	12331	1853

350 ScEcal



cut/process	qqh_inv	zh_qqh	zh_vvh	zz_sl	zvv_sl	ww_sl	wev_sl
ngen	2.5e+04	2.5e+04	2.5e+04	6.0e+04	6.0e+04	6.0e+05	6.0e+04
xsec	13.7	137.7	99.6	470.8	356.4	8090.6	4963.8
lepveto	99.84	92.01	92.30	80.51	99.83	58.88	40.10
logy23	99.52	79.70	86.93	78.83	99.27	58.31	39.72
zenergy	95.32	0.88	74.92	50.50	73.58	12.30	3.54
zmass	86.86	0.18	13.66	42.69	65.71	6.27	1.94
ptdijet	85.44	0.18	13.05	39.35	62.45	5.29	1.70
costhetaj0	81.40	0.17	12.28	33.16	55.65	3.97	1.20
costhetaj1	76.92	0.16	11.35	31.06	52.50	3.65	1.02
costhetaj01	55.14	0.12	9.33	18.29	39.19	1.63	0.48
costhetaZ	53.96	0.11	8.71	15.25	33.49	1.25	0.39
visenergy	53.82	0.11	8.18	15.18	33.38	1.25	0.39
Remaining	2234	40	1158	13344	15709	14114	1969



- The σ is same for both ECAL.
- We are studying the origing of the bias in the ScECAL toy.

Conclusion / Plan

- Cost is an important factor when doing ILD optimization studies.
- The reduction in cost should not compromise very much the detector performance.

- We have studied the impact of the γ single photon resolution in a physics analysis (precision of Br($H \to \gamma\gamma$)
- We found that a degradation of 50% in the single γ energy resolution cause a decrease on the sensitivity of H$\to \gamma\gamma$ of < 6%.

Plan

- Comparison of SiECAL and ScECAL on benchamark analysis is another important study.
- We plan to summarize our study comparing the performance on these two ECALs
  - Estimate the difference in sensitivity on H$\to$invisible for both ECALs.

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