Study of fermion pair productions at the ILC with center of mass energy of 250 GeV

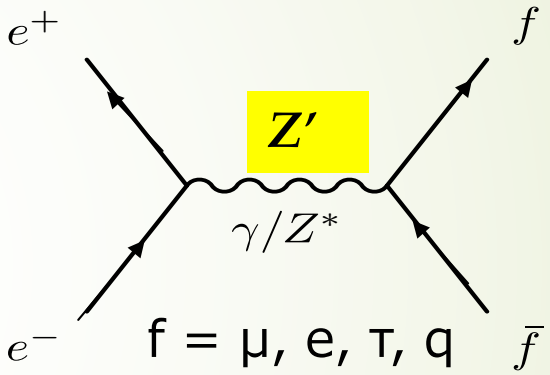
Hiroaki Yamashiro (Kyushu University)

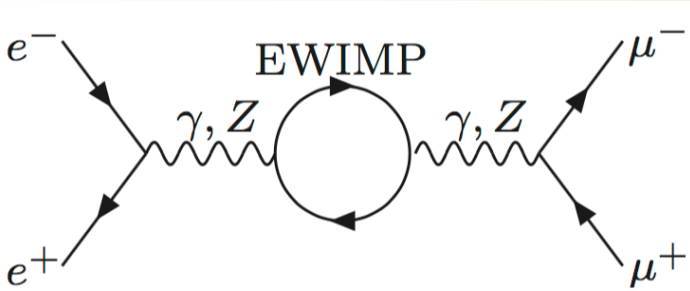
Kiyotomo Kawagoe, Taikan Suehara,Tamaki Yoshioka (Kyushu University)

Keisuke Fujii, Akiya Miyamoto(KEK)

Purpose of 2-fermion process study

- Precise measurements of electroweak processes at the ILC will provide unique opportunities to explore new physics beyond the standard model.
  - (Traditional) Z' models (SSM, ALR, E6)
  - correction by EWIMP (electroweakinos)
  - Z' with gauge Higgs unification

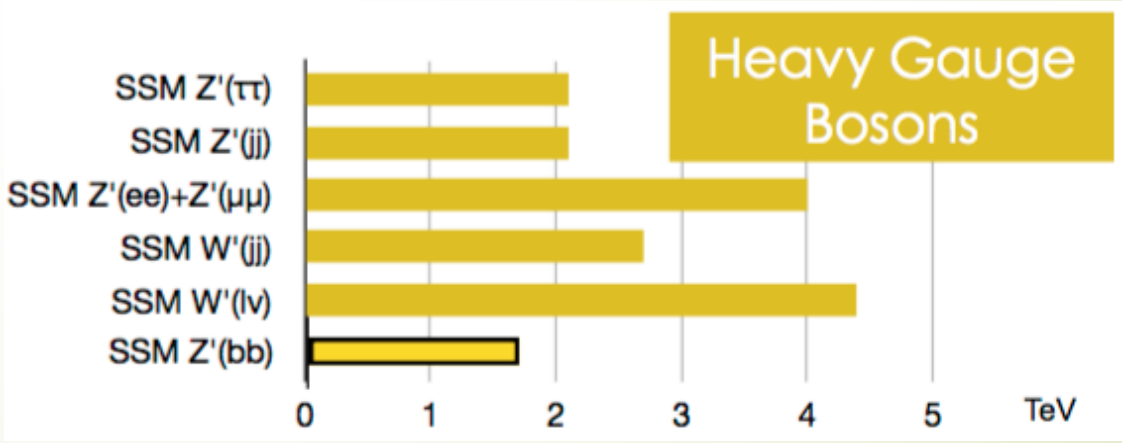




Z' models

- Studies at $\sqrt{s}$ = 500 GeV or more energy exist.
  - The result is made without full simulation.
  - No result at $\sqrt{s}$ = 250 GeV
  - We need to study by **precise simulation and** $\sqrt{s}$ = 250 GeV

- ATLAS
  - Z' →bb: 1,5 TeV
- CMS
  - Z' → bb : 1.7 TeV



Simulation condition

- DBD ILD detector geometry : ild-v1-05
- ILCSoft Version : v01-16-02-p1
- Using H-20 scenario at 250 GeV

Total Luminosity	$e^-_L e^+_R$	$e^-_R e^+_L$
2000 fb^{-1}	900 fb^{-1}	900 fb^{-1}

  - Polarization : $|P(e^-)| = 80\%$, $|P(e^+)| = 30\%$
- $e^-_L e^+_R$ and $e^-_R e^+_L$ results are treated independently to investigate the deviation to SM

ee -> bb
Charge ID

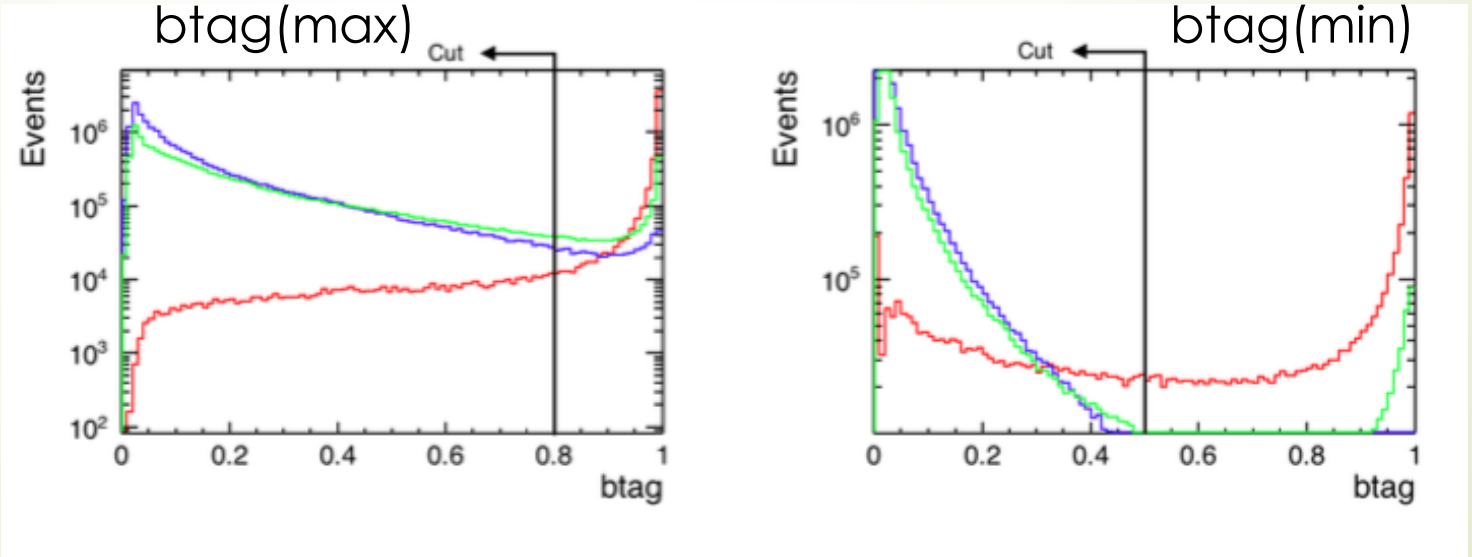
Jet1	Jet2	条件 1	+	0	−	条件 2	+	0	−	条件 3	+	0	−	efficiancy
2	2	B	57042	30046	29545	A	14822	7459	7765	C	3538	1231	2690	64.65%
2	2	A	63328	24894	28411	B	10369	7459	7066	C	3538	1231	2690	66.22%
2	1	B	76748	60794	44257	A	24591	21520	14683	C	10310	3542	7668	61.41%
2	1	A	83417	55611	42771	B	18590	21520	15501	C	10310	3542	7668	61.78%
2	0	B	19239	67602	9065	A	29456	19469	18677	C	9045	3217	7207	60.20%
2	0	A	42781	29199	23926	B	6000	19469	3730	C	9045	3217	7207	60.29%
1	1	B	28157	31528	17870	C	15262	4985	11281	-				55.98%
1	0	B	35064	39606	23072	C	18700	6355	14551	-				55.01%
1	0	C	46805	15357	35580	B	5299	6355	3703	-				53.31%
0	0	C	18113	5532	13611	-				-				48.62%

- Condition(条件)A : Difference of Sum of vertex charge
- Condition (条件)B：Difference of first vertex charge
- Condition (条件)C： Difference of jet charge

Event Selection (ee -> bb)

- Selection 2 jet -> Charge ID
- btag (max) > 0.8 , btag (min) > 0.5
- Select back-to-back event
  - $|\cos\theta_{jet1} + \cos\theta_{jet2}| < 0.2$
- Energy sum > 230 GeV

Red: bb
blue: 2f bkg.
green: 4f bkg.

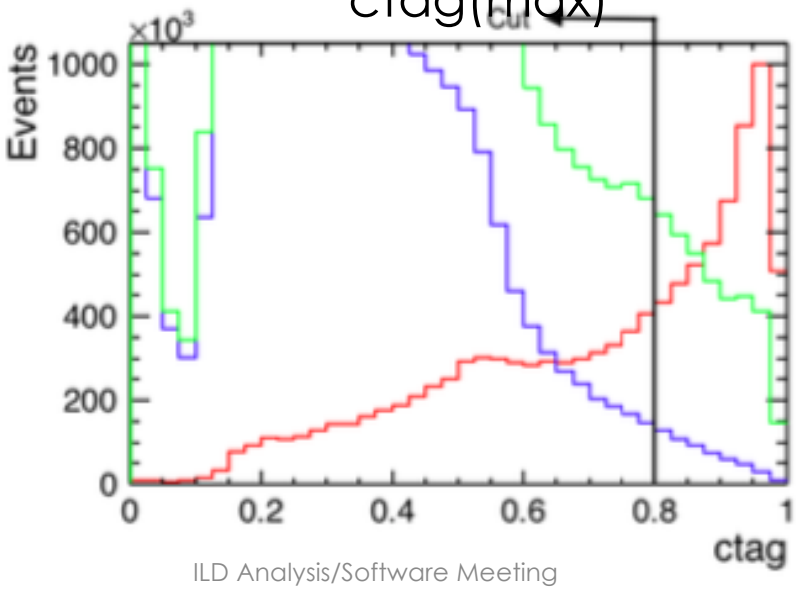


Event Selection (ee -> cc)

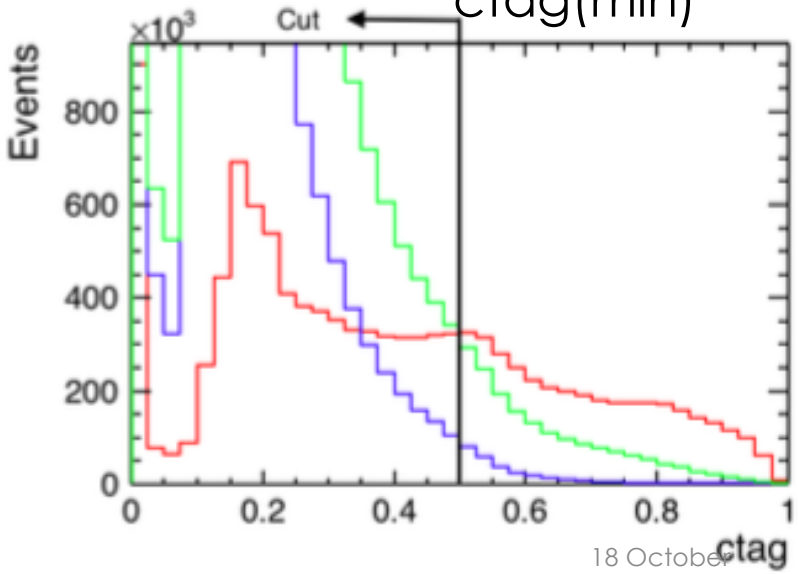
- Selection 2 jet -> Charge ID
- ctag (max) > 0.8 , ctag (min) > 0.5
- Select back-to-back event
  - $|\cos\theta_{jet1} + \cos\theta_{jet2}| < 0.2$
- Energy sum > 230 GeV

Red: cc
blue: 2f bkg.
green: 4f bkg.

ctag(max)



ctag(min)



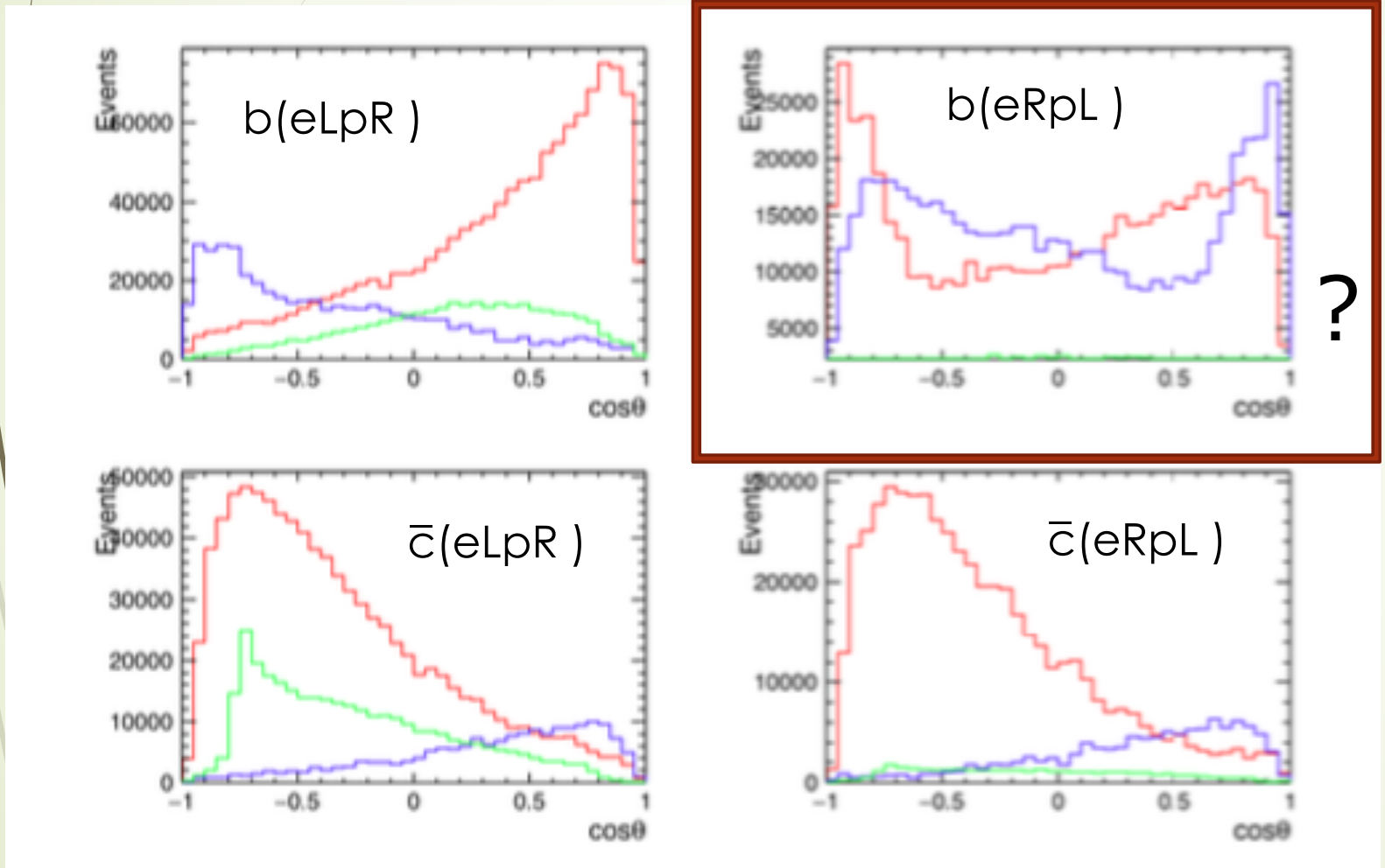
Cut Table (ee -> qq (q= b,c))

$e^+e^- \to b\bar{b}$	$e_R^-e_L^+$				$e_L^-e_R^+$			
	シグナル $(b\bar{b})$	$q\bar{q}(q=u,d,s,c)$	$qq\bar{q}\bar{q}$	$q\bar{q}\ell\ell$	シグナル $(b\bar{b})$	$q\bar{q}(q=u,d,s,c)$	$qq\bar{q}\bar{q}$	$q\bar{q}\ell\ell$
全イベント	8848410	27633500	1178364	925953	10713700	36939300	13075310	8813410
btag	5556730	59113	101835.76	45122.37	6707130	86217	563988	103668
$\cos\theta$ の和	1650510	34863	73073.526	8920.4723	2306470	52927	410259	17060
$E_{sum} > 230$ GeV	1103560	24658.7	47593.305	5199.1174	1639500	37929	272439	10338

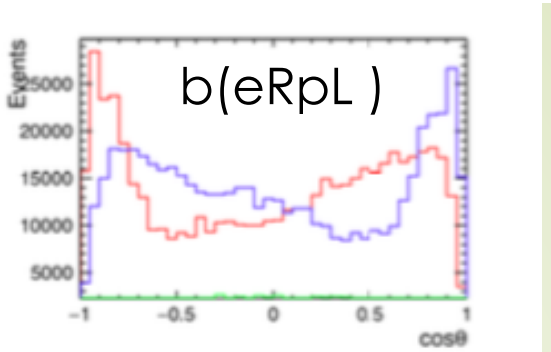
$e^+e^- \to c\bar{c}$	$e_L^-e_R^+$				$e_R^-e_L^+$			
	シグナル $(c\bar{c})$	$q\bar{q}(q=u,d,s,b)$	$qq\bar{q}\bar{q}$	$q\bar{q}\ell\ell$	シグナル $(c\bar{c})$	$q\bar{q}(q=u,d,s,b)$	$qq\bar{q}\bar{q}$	$q\bar{q}\ell\ell$
全イベント	11009600	35854700	13075310	8813410	8317340	26364300	1178364	6005805
ctag	2651620	55892	482204	2532957	1842800	39052	48015	36648
$\cos\theta$ の和	1154900	9052	398059	7477	706146	4815	39517	2742
$E_{sum} > 230$ GeV	1060330	7698	308924	5254	635102	4210	29847	1945

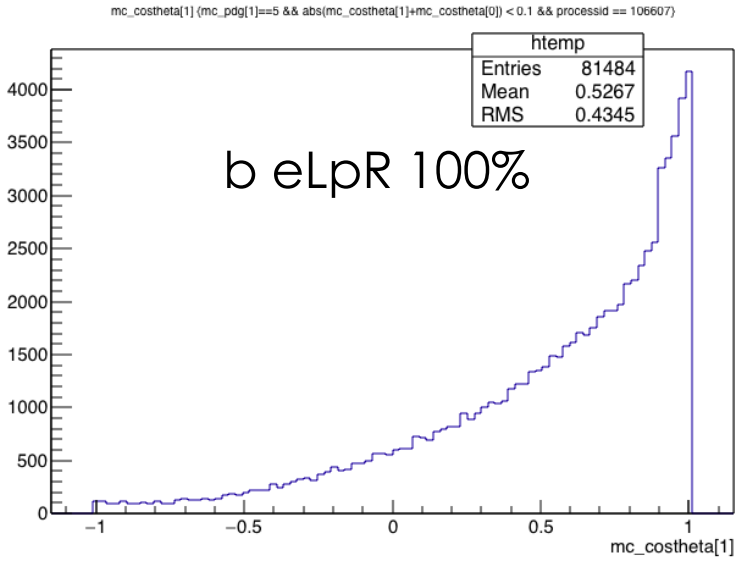
cosθ distribution

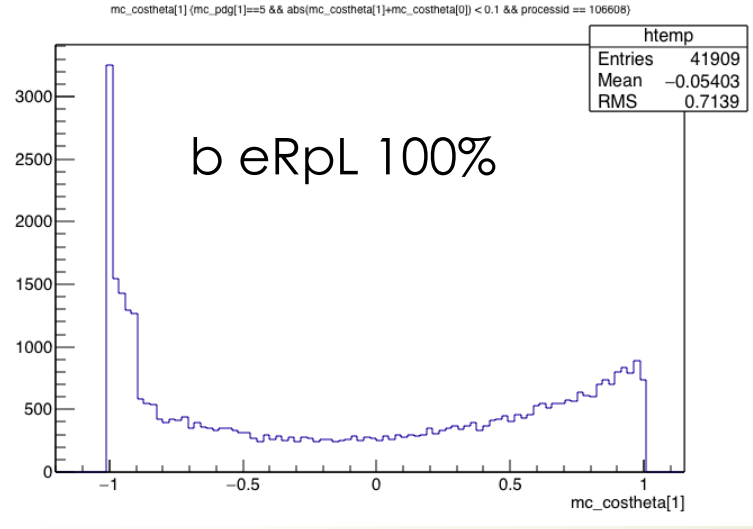
Red: signal
Blue: signal (Charge ID failed)
Green: Back ground

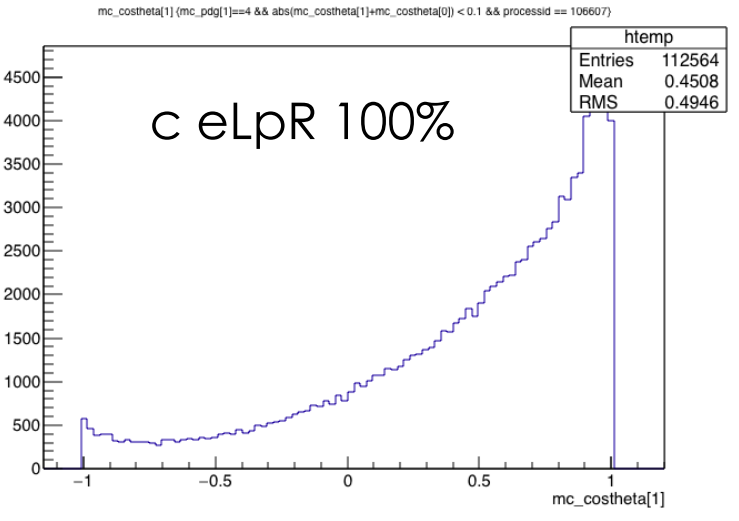


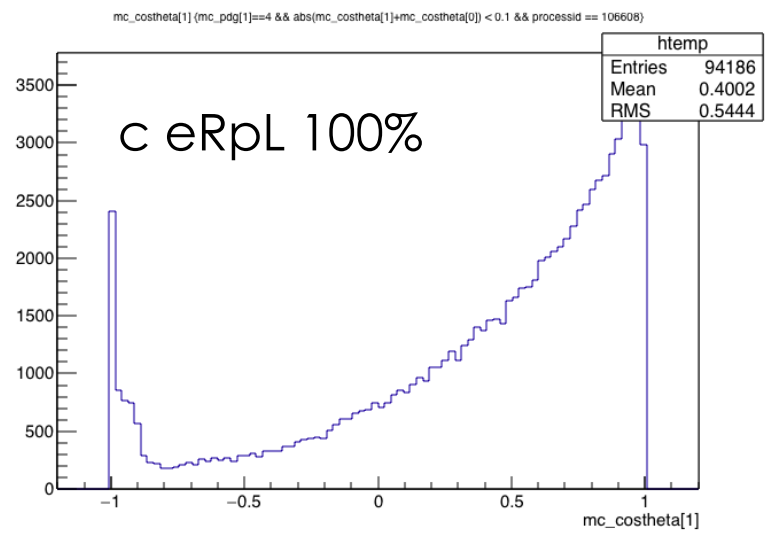
b(eRpL)


b(eRpL)
Events
cosθ

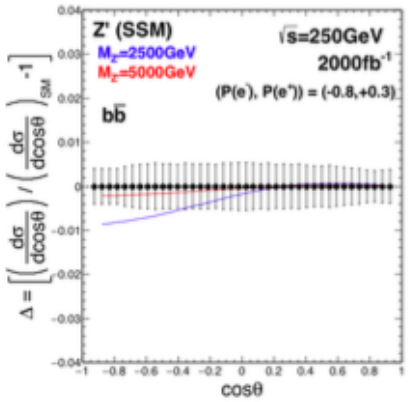

mc_costheta[1] (mc_pdg[1]==5 && abs(mc_costheta[1]+mc_costheta[0]) < 0.1 && processid == 106607)
htemp
Entries 81484
Mean 0.5267
RMS 0.4345
b eLpR 100%
mc_costheta[1]

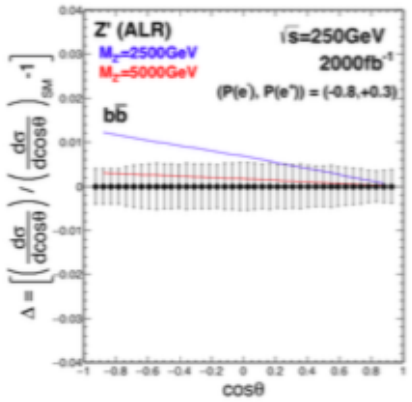

mc_costheta[1] (mc_pdg[1]==5 && abs(mc_costheta[1]+mc_costheta[0]) < 0.1 && processid == 106608)
htemp
Entries 41909
Mean −0.05403
RMS 0.7139
b eRpL 100%
mc_costheta[1]

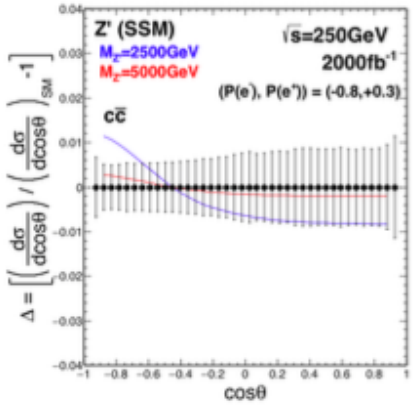

mc_costheta[1] (mc_pdg[1]==4 && abs(mc_costheta[1]+mc_costheta[0]) < 0.1 && processid == 106607)
htemp
Entries 112564
Mean 0.4508
RMS 0.4946
c eLpR 100%
mc_costheta[1]

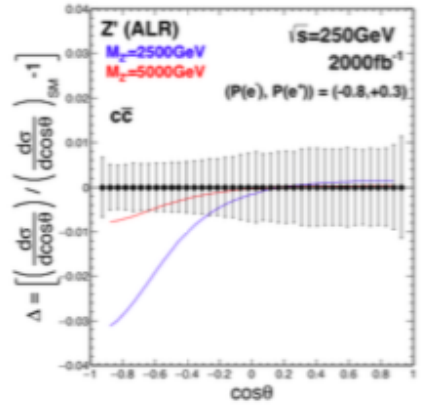

mc_costheta[1] (mc_pdg[1]==4 && abs(mc_costheta[1]+mc_costheta[0]) < 0.1 && processid == 106608)
htemp
Entries 94186
Mean 0.4002
RMS 0.5444
c eRpL 100%
mc_costheta[1]

Z' model (SSM,E6)









considered :
Charge ID effciency

Z' model	ℓ	$\ell+b$	$\ell+b+c$
SSM	2.8 TeV	3.6 TeV	3.4 TeV
ALR	4.0 TeV	4.0 TeV	3.6 TeV
χ	2.9 TeV	2.8 TeV	2.5 TeV
ψ	1.4 TeV	1.8 TeV	1.6 TeV
η	1.8 TeV	1.9 TeV	1.8 TeV

Summary

- Fermion pair productions are sensitive to new contact interactions or a new heavy gauge boson.
- We use e+ e- -> qq process in 250 GeV to investigate the possibility to find the Z' models.
- Z' models bigger than LHC limit can be discovered in the cosθ distributuon.

Plan

- Improve Charge ID effciency