

# CLIC Signals Studies

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CERN

# Basic Physics Channels

- Prior to the full det. sim. for CLIC it seems very important to know what we are looking for.

particle	jets
<ul style="list-style-type: none"><li>• type of particle</li><li>• Momentum distr.</li><li>• Angular distr.</li><li>• Particle charge</li><li>• ...</li></ul>	<p>+</p> <ul style="list-style-type: none"><li>• Jet opening angle</li><li>• Particle distr. inside the jet</li><li>• ...</li></ul>

- Processes Analyzed

$$e^+ e^- \rightarrow \gamma / Z \rightarrow q\bar{q} \quad (q = u, d, s)$$

$$\rightarrow \gamma / Z \rightarrow l^+ l^- \quad (l = e, \mu)$$

$$\rightarrow \gamma / Z \rightarrow t\bar{t}$$

$$e^+ e^- \rightarrow ZZ \quad (Z \rightarrow l^+ l^-, Z \rightarrow 2j, Z \rightarrow \nu\bar{\nu})$$

$$\rightarrow WW \quad (W \rightarrow 2j, W \rightarrow l\nu)$$

$$e^+ e^- \rightarrow \gamma / Z / Z' \rightarrow \mu^+ \mu^- \quad (\text{sequential } Z')$$

$$e^+ e^- \rightarrow \tilde{\mu}_L \tilde{\mu}_L \rightarrow \mu^+ \mu^- \tilde{\chi}_1^0 \tilde{\chi}_1^0$$

$P_T$ , energy & angular distributions are being investigated.

$$e^+ e^- \rightarrow \gamma / Z \rightarrow t\bar{t}$$

t→all & subsequent decays of W

Pythia result @ $\sqrt{s}= 500$  GeV

\*\*\*\*\* PYSTAT: Statistics on Number of Events and Cross-sections \*\*\*\*\*

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=====
I          I          I          I          I
I      Subprocess      I      Number of points      I      Sigma      I
I          I          I          I          I
I-----I-----I      (mb)      I
I          I          I          I          I
I N:o Type      I      Generated      Tried I          I
I          I          I          I          I
=====
I          I          I          I          I
I  0 All included subprocesses      I      10000      122960 I  5.783E-10 I
I  1 f + fbar -> gamma*/Z0-> ttbarI      10000      122960 I  5.783E-10 I
I          I          I          I          I
=====

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$\sqrt{s}= 500$  GeV  $\sigma=0.56$  pb

$\sqrt{s}= 3$  TeV  $\sigma=1.99 \times 10^{-2}$  pb

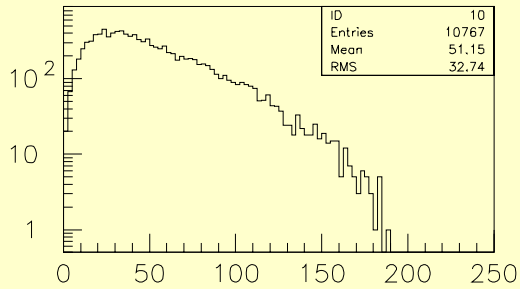
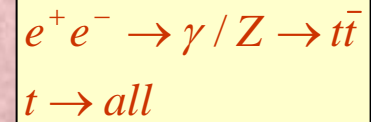
For comparison

Calchep results  
(Calchep2.5.j,  
Pukhov et al.)

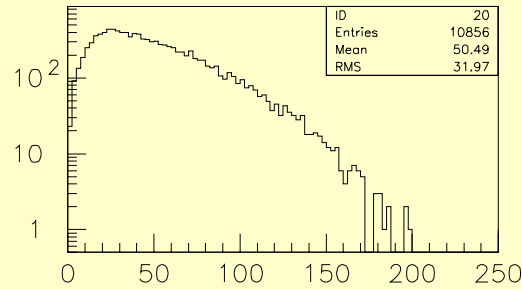
Event listing (summary)

I	particle/jet	KS	KF	orig	p_x	p_y	p_z	E	m
1	!e+!	21	-11	0	0.000	0.000	250.000	250.000	0.001
2	!e-!	21	11	0	0.000	0.000	-250.000	250.000	0.001
=====									
3	!e+!	21	-11	1	0.000	0.000	250.000	250.000	0.000
4	!e-!	21	11	2	0.000	0.000	-250.000	250.000	0.000
5	!e+!	21	-11	3	-15.939	-10.341	139.809	141.094	0.000
6	!e-!	21	11	4	0.000	0.000	-248.534	248.534	0.000
7	!Z0!	21	23	0	-15.939	-10.341	-108.724	389.628	373.668
8	!t!	21	6	7	-26.690	-39.710	-105.982	211.203	176.311
9	!tbar!	21	-6	7	10.751	29.369	-2.742	178.424	175.640
10	!W+!	21	24	8	-20.646	37.052	-20.707	96.209	83.834
11	!b!	21	5	8	-6.044	-76.762	-85.275	114.995	4.800
12	!W-!	21	-24	9	9.775	38.978	-67.710	112.567	80.449
13	!bbar!	21	-5	9	0.976	-9.609	64.968	65.857	4.800
14	!sbar!	21	-3	10	12.314	7.792	-44.015	46.367	0.500
15	!c!	21	4	10	-32.945	29.188	23.282	49.816	1.500
=====									
16	!e-!	21	11	12	31.319	53.880	-38.151	73.071	0.106
17	!nu_ebar!	21	-12	12	-21.544	-14.902	-29.559	39.496	0.000
=====									
...									

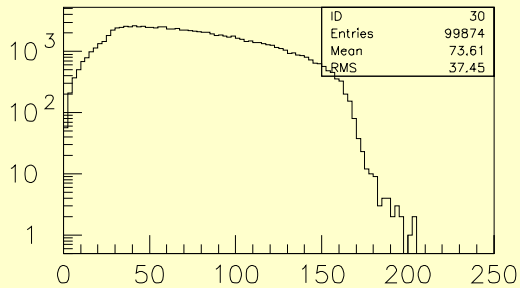
with Pythia 6.4.18  
(T.Jostrand et al.)



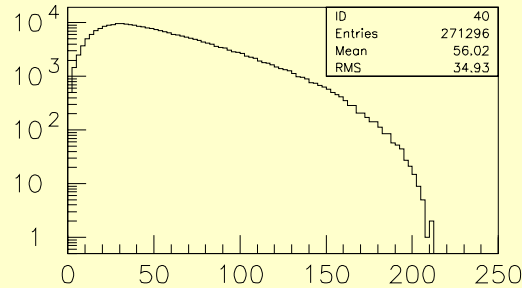
pte distribution



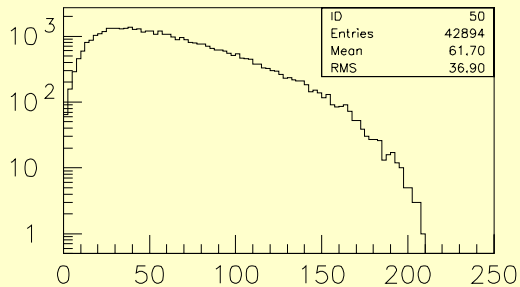
ptm distribution



ptb distribution



ptj distribution



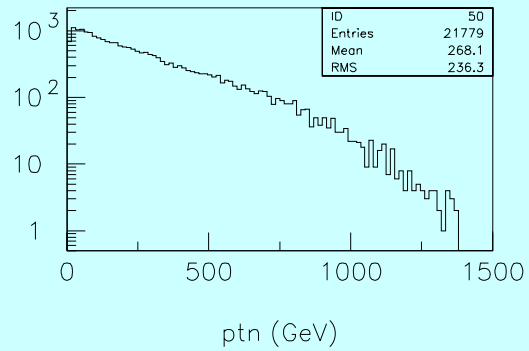
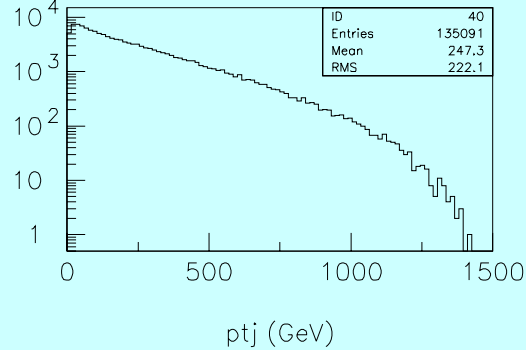
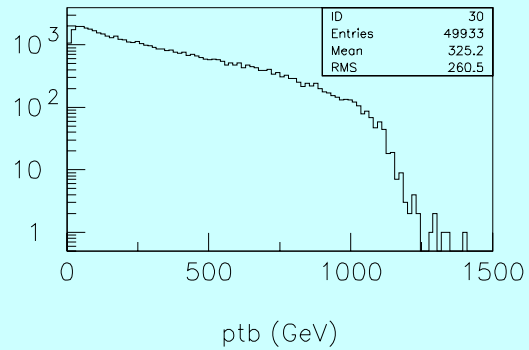
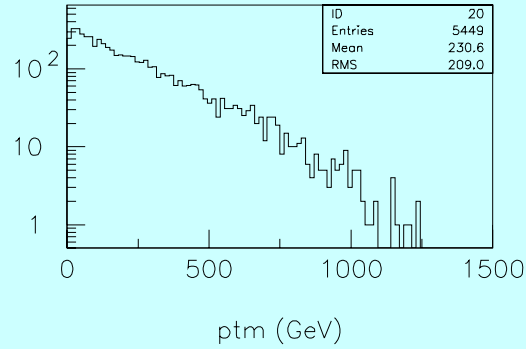
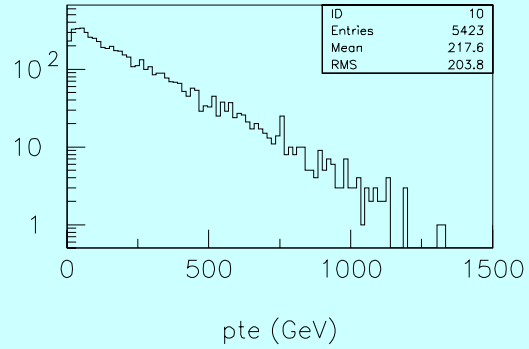
ptn distribution

$p_T$  distributions @  
 $\sqrt{s}=0.5$  TeV

$N_{ev}=10000$

Entries/2.5 GeV



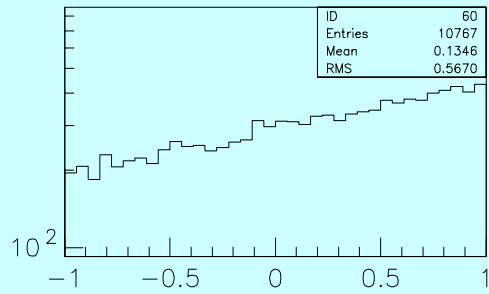


$e^+e^- \rightarrow \gamma/Z \rightarrow t\bar{t}$   
 $t \rightarrow all$

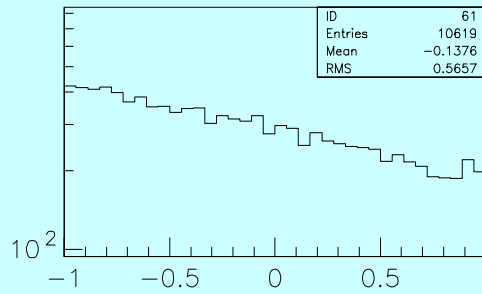
$p_T$  distributions @  
 $\sqrt{s}=3$  TeV

Nev=50000

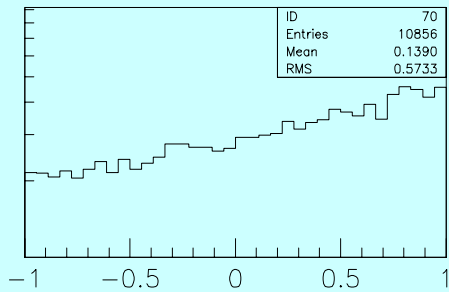
Entries/15 GeV



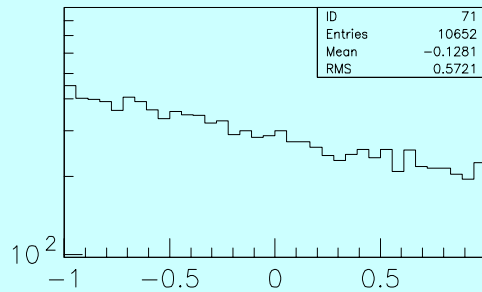
coste distribution



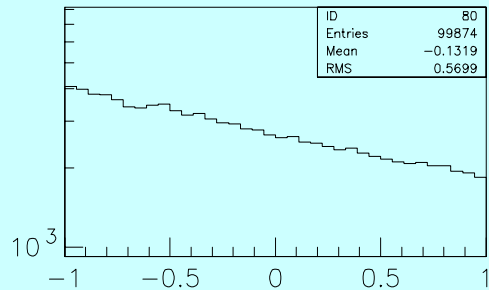
costep distribution



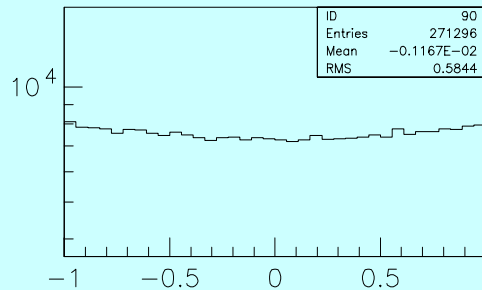
costm distribution



costmp distribution



costb distribution



costj distribution

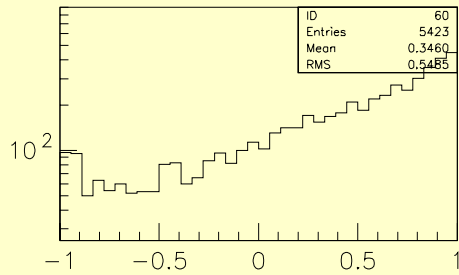
$e^+ e^- \rightarrow \gamma / Z \rightarrow t\bar{t}$   
 $t \rightarrow all$

**Angular distributions**  
**@  $\sqrt{s}=0.5$  TeV**

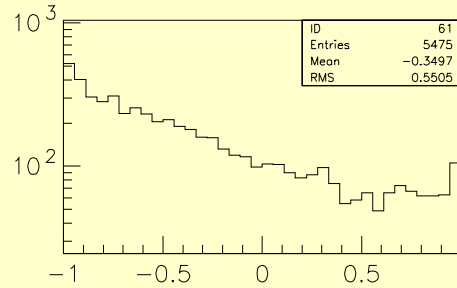
**$N_{ev}=10000$**

**Entries/bin(5 deg)**  
**GeV**

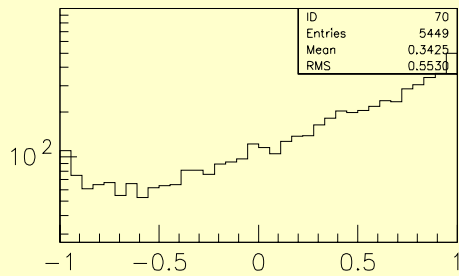




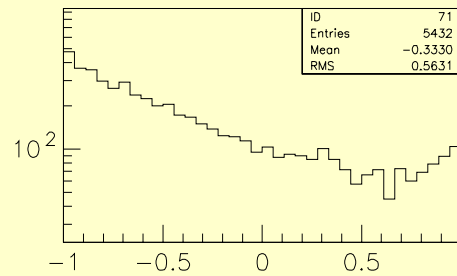
coste



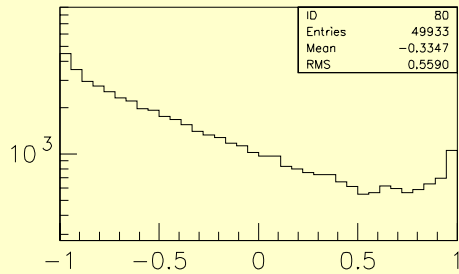
costep



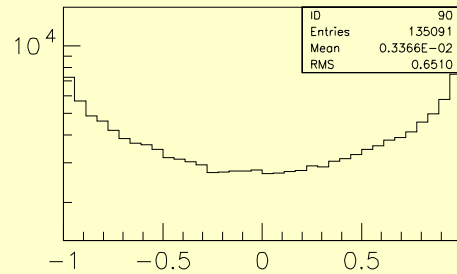
costm



costmp



costb



costj

$e^+e^- \rightarrow \gamma/Z \rightarrow t\bar{t}$   
 $t \rightarrow all$

Angular distributions  
 @  $\sqrt{s}=3$  TeV

$N_{ev}=50000$

Entries/bin(5 deg)  
 GeV

$$e^+ e^- \rightarrow \gamma / Z / Z' \rightarrow \mu^+ \mu^- \quad (\text{sequential } Z') @ \sqrt{s} = 3 \text{ TeV}$$

Parameters:

$$M_{Z'} = 750 \text{ GeV}$$

$$g_{V_d} = -0.693$$

! V coupling of  $Z'$  to down type quarks

$$g_{A_d} = -1.$$

! A coupling of  $Z'$  to down type quarks

$$g_{V_u} = 0.387$$

! V coupling of  $Z'$  to up type quarks

$$g_{A_u} = 1.$$

! A coupling of  $Z'$  to up type quarks

$$g_{V_e} = -.8$$

! V coupling of  $Z'$  to charged leptons

$$g_{A_e} = -1.$$

! A coupling of  $Z'$  to charged leptons

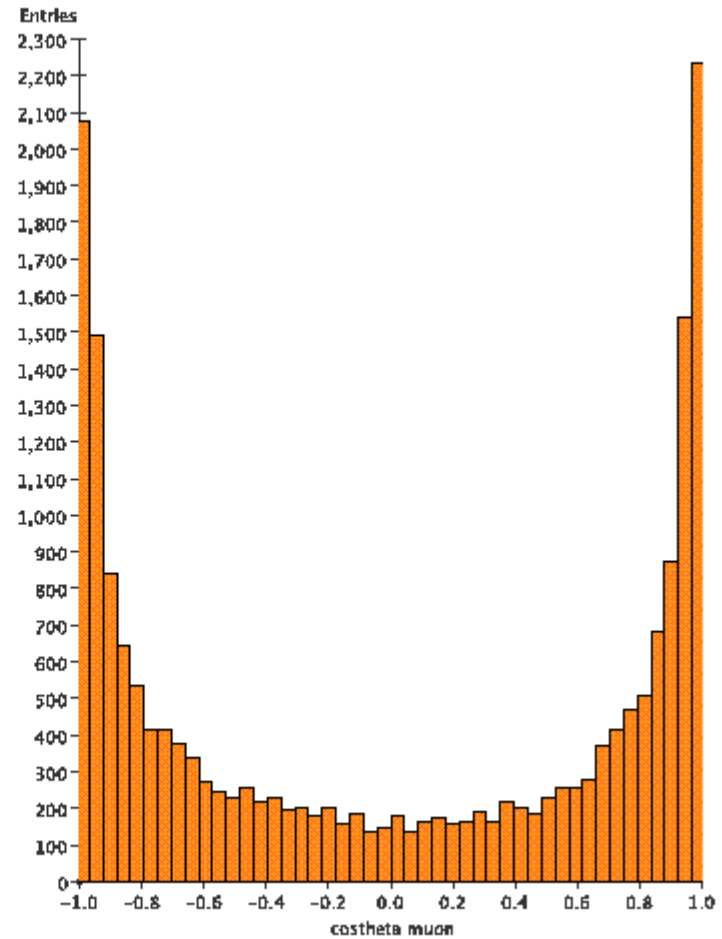
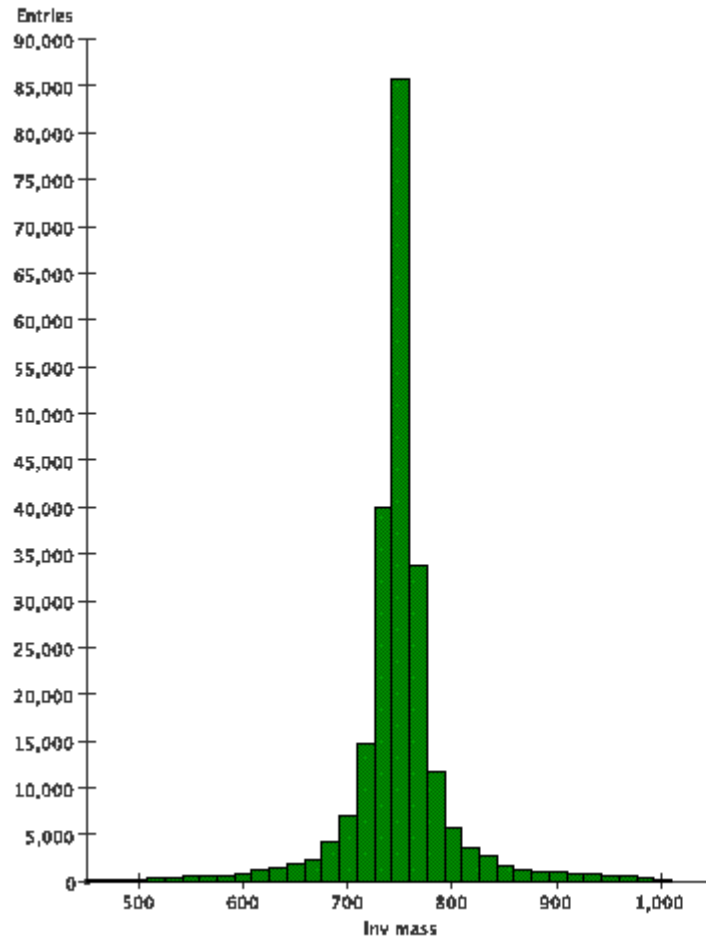
$$g_{V_\nu} = 1.$$

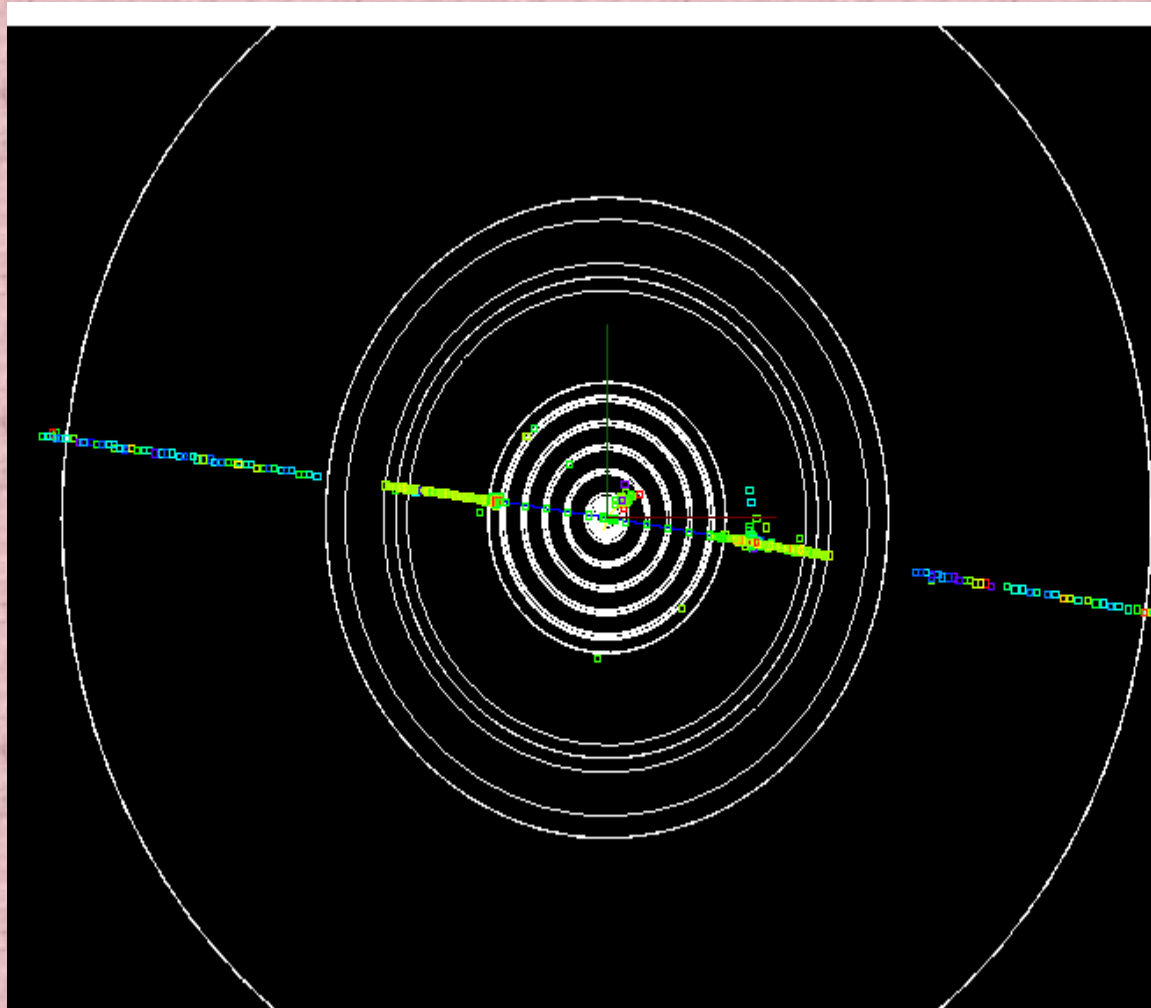
! V coupling of  $Z'$  to neutrinos

$$g_{A_\nu} = 1.$$

! A coupling of  $Z'$  to neutrinos

# With lumi. Spectrum (SPECTRUM 1, CLIC01 , D. Schulte)





$Z' \rightarrow \mu\mu$  event as seen at CLIC000

# Conclusion

Results for  $\sqrt{s}= 0.5$  TeV

process	$P_T$ (GeV)	$\cos\theta$	E distr. (GeV)
ttbar	e, $\mu$ :30 b,j:40 v:30	e, $\mu$ :-1,1 b:-1 j:-1,1	e, $\mu$ :30 b:40-180 j:40 v:40
ZZ	e, $\mu$ :30 b,j:40 v:30	e, $\mu$ :-1,1 b,j:-1,1	e, $\mu$ :30, 220 b:30, 220 j:30, 220 v:30, 220
WW	e, $\mu$ :40 j:40 v:30	e, $\mu$ :-1 j:-1,1	e, $\mu$ :200 j:30,230 v:30

# Results for $\sqrt{s} = 3 \text{ TeV}$

process	$P_T$ (GeV)	$\cos\theta$	E distr. (GeV)
ttbar	e, $\mu$ ,b: 1250 j:1500 v:1500	e, $\mu$ :-1,1 b:-1 j:-1,1	e, $\mu$ :1250 b:1250 j:1500 v:1500
ZZ	e, $\mu$ :1500 b,j:1500 v:1500	e, $\mu$ :-1,1 b,j:-1,1	e, $\mu$ :1500 b:1500 j:1500 v:1500
WW	e, $\mu$ : 1250 j:1500 v:1500	e, $\mu$ :-1 j:-1,1	e, $\mu$ :1500 j: 1500 v: 1500