SSC-SDC-32

# SSC-SDC
## SOLENOIDAL DETECTOR NOTES

PRODUCTION OF TECHNIOMEGA $\rightarrow \gamma Z \rightarrow \gamma \ell^+ \ell^-$

M.L. Mangano

May 1990

SDC Note (1990)

# PRODUCTION OF TECHNIOMEGA $\rightarrow \gamma Z \rightarrow \gamma l^+ l^-$

*Michelangelo L. MANGANO*

Istituto Nazionale di Fisica Nucleare INFN, Pisa
Scuola Normale Superiore and
Dipartimento di Fisica, Pisa, ITALY Pisa U.

(May 1990)

If the electroweak symmetry is broken by technicolor interactions, bound states of the underlying techni-fermions will form, in analogy to the mesons in the spectrum of QCD. Some of these bound states (the so-called technipions) will provide the longitudinal degrees of freedom of the massive $W$ and $Z$ bosons, while others will appear as independent massive particles. The lightest states of the spectrum are vector particles, the equivalent of the $\rho(770)$ and of the $\omega(783)$. We will call them $\rho_T$ and $\omega_T$. The first one is an isotriplet, and will decay into techipions, *i.e.* longitudinal $W$'s and $Z$'s. Since we expect these techivectors to have masses larger than the TeV, the $\rho_T$ will be an extremely broad resonance, very much like a heavy Higgs, and its signal is likely to get washed away. The $\omega_T$, instead, is an isosinglet, and is much narrower. Its properties can be studied using an approach similar to large $N$-QCD. The dynamics of the theory can be parametrized by the mass of the technipions, which we know will have to correspond to the mass of the $W$and $Z$; other parameters, like the $\omega_T$ mass and its couplings, can be obtained by scaling laws extrapolated from QCD and from measured quantities such as $f_\pi$, $m_\omega$ and $\Gamma_{\omega,\rho\rightarrow e^+e^-}$. All of this can be found in Reference 1.

In Reference 1 the following parameters were calculated:

- $M_{\omega_T} \;=\; 2069 GeV(\frac{3}{N_T})^{1/2}$
- $\Gamma(\omega_T \rightarrow WWZ) = 82 GeV(\frac{3}{N_T})^{5/2}$
- $\Gamma(\omega_T \rightarrow Z\gamma) = 2.3 GeV(\frac{3}{N_T})^{1/2}$
- $\Gamma(\omega_T \rightarrow ZZ) = 1.0 GeV(\frac{3}{N_T})^{1/2}$
- $\Gamma(\omega_T \rightarrow WW) = 5.2 GeV(\frac{3}{N_T})^{1/2}$

Here $N_T$ is the number of colors in the technicolor interactions. The couplings of the $\omega_T$ to the standard model fermions (necessary for the fermions to acquire a mass) are four-fermion couplings, like in the Fermi theory. They are inversely proportional to a parameter with the dimensions of a mass squared, which we interpret as the square of the technicolor scale, $\Lambda_{TC}$. Therefore the production cross section for the $\omega_T$ falls with the fourth power of $\Lambda_{TC}$. It is reasonable to expect this scale to be larger than the TeV. Notice that the $\omega_T$ mass is however independent of this scale. The production rates of the $\omega_T$, as a function of $N_T$ and with $\Lambda_{TC} = 1TeV$, are given in the following table, were an integrated luminosity of $10^4\ pb^{-1}$ (1 SSC-year) was assumed:

| $N_T$ | $M_{\omega_T}$ | *Events* |
|---|---|---|
| 2 | $2530GeV$ | 18000 |
| 4 | $1790GeV$ | 49000 |
| 6 | $1460GeV$ | 83000 |

The rates do not include any BR. The rates for different values of $\Lambda_{TC}$ can be obtained by scaling with the inverse of the fourth power.

The dominant decay mode of the $\omega_T$ is to $W^+W^-Z^0$, the same way the leading decay mode of the QCD $\omega$ is to $\pi^+\pi^-\pi^0$. With smaller BR's the $\omega_T$ also decays into vector boson pairs, like $WW$, $ZZ$ and $Z\gamma$, with widths of the order of the GeV, thus giving very sharp peaks.

The $WWZ$ channel might be difficult to observe, because at least two semileptonic BR's are required to hope to separate the signal from the QCD background. The presence of neutrinos, furthermore, smears the sharp peak in the invariant mass, thus reducing the signal even further. The $WW$ suffers from a heavy QCD background. Same for $ZZ$ unless we require the double leptonic decay, which has a too small BR. So we concentrate on the $Z\gamma$ channel, with the $Z$ decaying to e's or $\mu$'s. We used the couplings given in Ref. 1 and wrote a Monte-Carlo which generates $\omega_T$ and standard QCD $Z\gamma$ events, in $pp$ collisions, with the $Z$ decaying into lepton pairs.

In Fig. 1(a) I show the mass spectrum of the $\gamma e^+e^-$ system for a technicolor theory with $N_T = 6$ and with a technicolor scale $\Lambda_{TC} = 1.5TeV$, superimposed onto the standard QCD source of $Z\gamma$ events. These parameters lead to $M_{\omega_T} = 1.46TeV$ and $\Gamma_{\omega_T} = 22GeV$. The energies of the $\gamma$ and of the e's were smeared using the resolution of the EM calorimeter contained in the routine provided by I. Hinchliffe (see his forthcoming note, or see the EoI). Only events with the $\gamma$ and both $e$'s within $|\eta| < 3$ and with the reconstructed mass of the $Z$ within 10 GeV from the $Z$ mass (90 GeV) were kept. The $y$-axis reports the number of events per SSC-year ($10^4\ pb^{-1}$) per 10 $GeV$-bin.

Fig. 1(b) shows the mass spectrum of the $\gamma\mu^+\mu^-$ system, with the same parameters as in Fig. 1(a). The muon momenta were smeared with I. Hinchliffe's routine for the resolution of the muon system. Both muons are within 2.5 units of rapidity, and again only events with the reconstructed $Z$ mass within 10 GeV from the $Z$ mass (90 GeV) were kept.

Figs. 2(a-b) contain the same information as figs. 1(a-b), with the technicolor parameters given by $N_T = 8$ and $\Lambda_{TC} = 1.25TeV$. These parameters lead to $M_{\omega_T} = 1.25TeV$ and $\Gamma_{\omega_T} = 15GeV$.

It is clear from these plots that the resolutions of the EM calorimetry and of the tracking system are sufficient to detect a $\omega_T$ signal within the range of parameters considered here.

Reference 1: *Observing the Techniomega at the SSC*, R.S. Chivukula and M. Golden, Fermilab-Pub-89/256-T (1989).

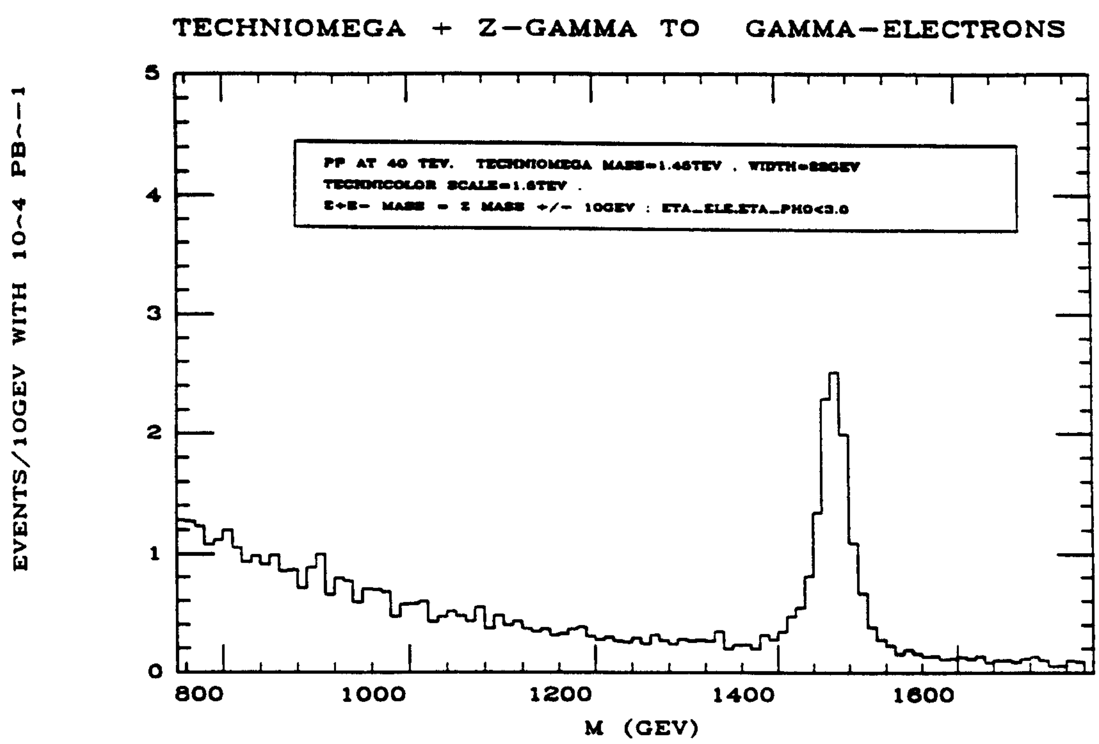



Fig. 1(a)

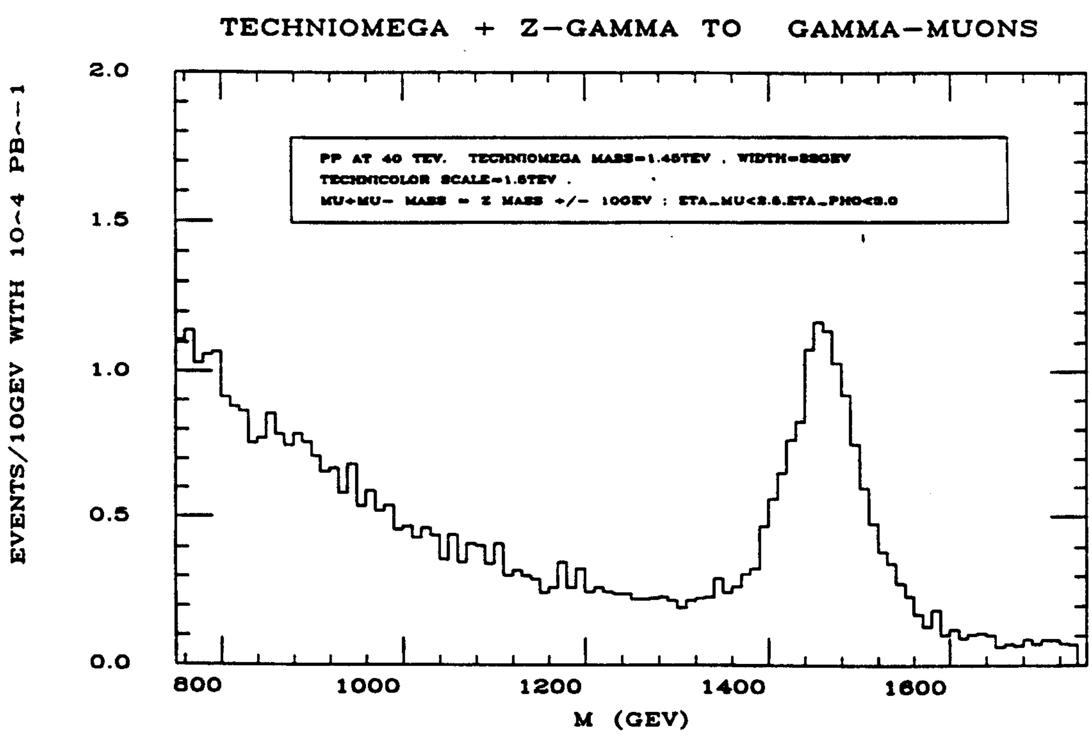
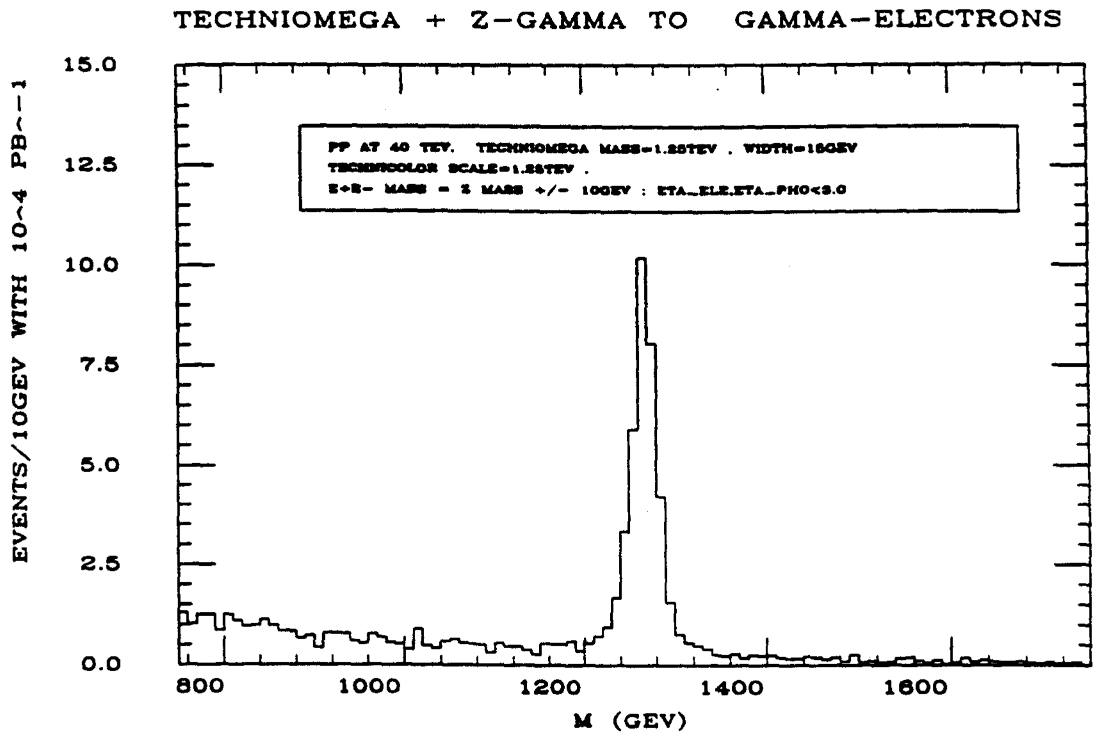
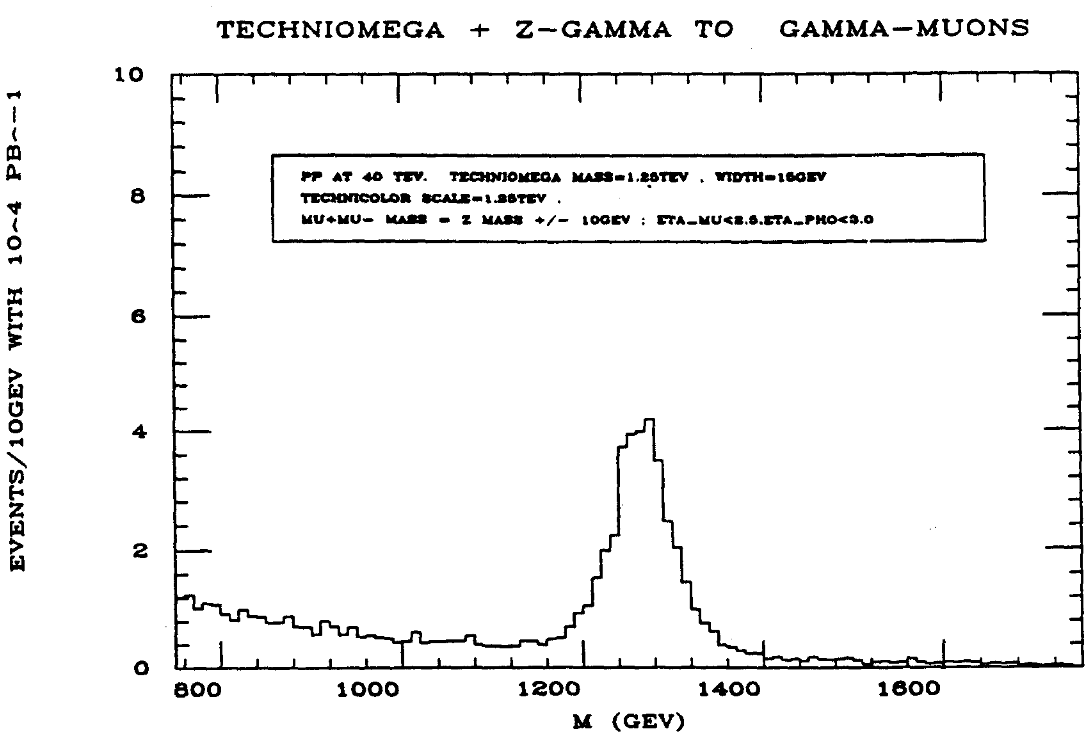



Fig. 1(b)


TECHNIOMEGA + Z−GAMMA TO GAMMA−ELECTRONS
PP AT 40 TEV.
EVENTS/10GEV WITH 10^4 PB^-1
15.0
12.5
10.0
7.5
5.0
2.5
0.0
800
1000
1200
1400
1600
M (GEV)


TECHNIOMEGA + Z−GAMMA TO GAMMA−MUONS
PP AT 40 TEV.
EVENTS/10GEV WITH 10^4 PB^-1
10
8
6
4
2
0
800
1000
1200
1400
1600
M (GEV)

**Figs. 2(a-b)**