

Top Quark Production with an Associated Z Boson

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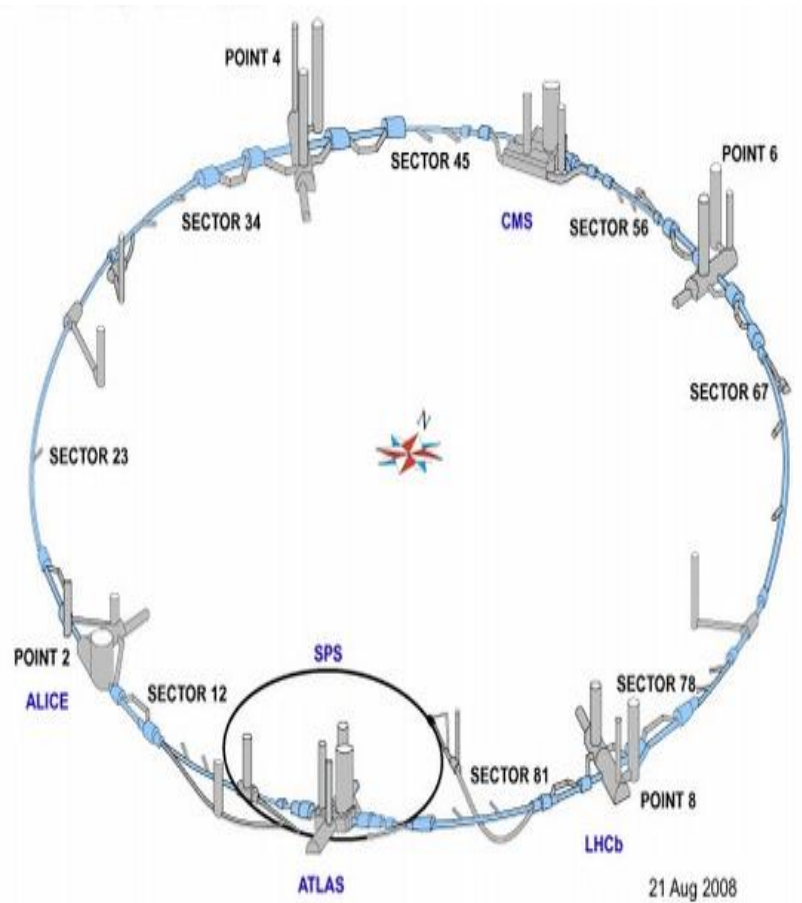


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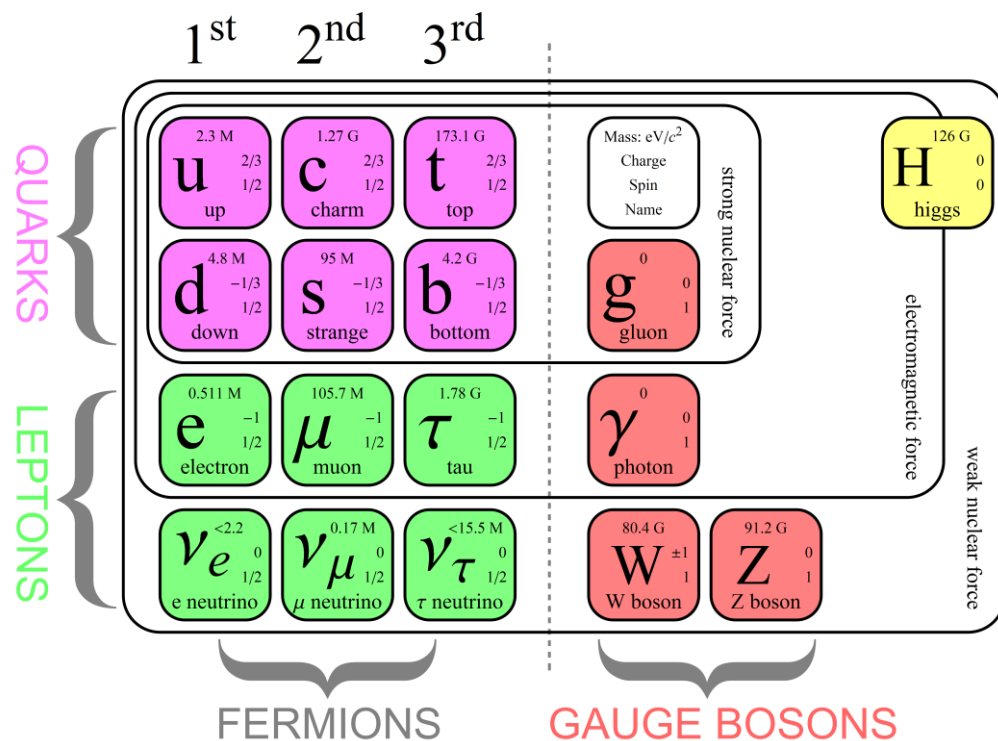
Top quark production with an associated Z boson ($t\bar{t}Z$) is one of only a few possible methods of single t production

- Top quarks generally do not appear alone
- Lone top quarks were theorized to appear with a W boson partner (tW production)
- The next step was the search for lone top quarks with an associated Z boson ($t\bar{t}Z$)



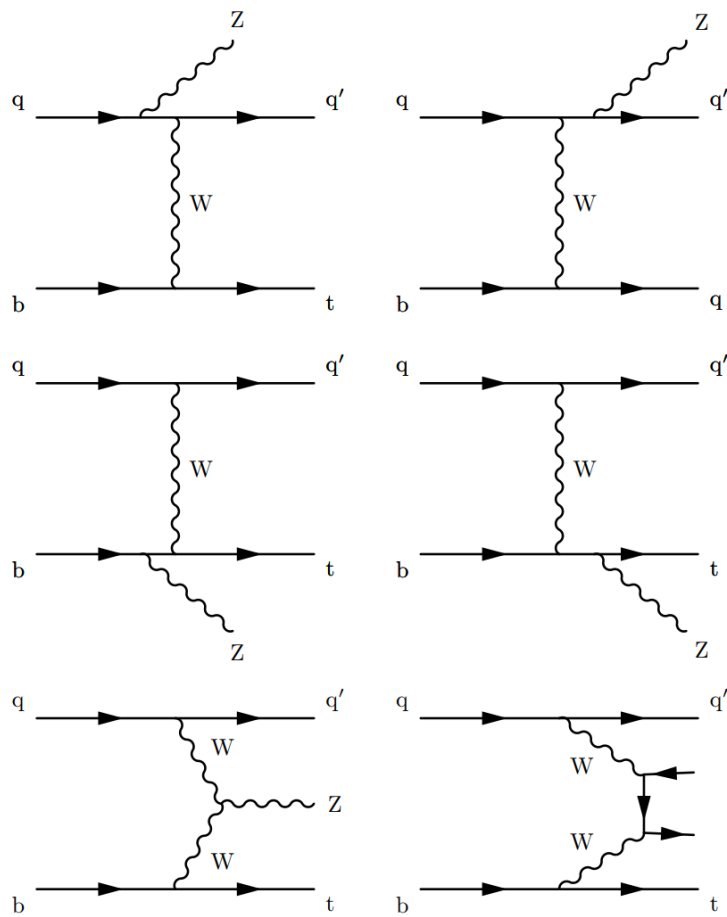
The process of top quark production with an associated Z boson is expected but has not been observed

- Components –
 - Bottom quark
 - Some other quark (q)
- Products –
 - Top quark
 - Resultant quark (q')
 - Z boson
- Detection is done using final decay products
 - The trilepton state of decay is the current signal target



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Analysis is done using a neural network to locate traces of decay products in collision data

Detections occur by searching for specific resulting states

- Hadronic
- Single Lepton
- Dilepton
- Trilepton

leptonic	hadronic	
$W^+ \rightarrow l^+ \nu$	$W^+ \rightarrow q \bar{q}$	
$W^- \rightarrow l^- \bar{\nu}$	$W^- \rightarrow q \bar{q}$	

hadronic	leptonic	
	visible	invisible
	$Z^0 \rightarrow e^+ e^-$	$Z^0 \rightarrow \nu \bar{\nu}$
	$Z^0 \rightarrow \mu^+ \mu^-$	
$Z^0 \rightarrow q \bar{q}$	$Z^0 \rightarrow \tau^+ \tau^-$	



The neural network is trained to use the trilepton signal to discriminate from background readings

Network Training

- Take only cases with trilepton products of eee , $\mu\mu\mu$, $e\mu\mu$, or $ee\mu$
- NN observes correlation between variables and occurrence of trilepton state
- NN can recognize probability of a tZq interaction within a dataset

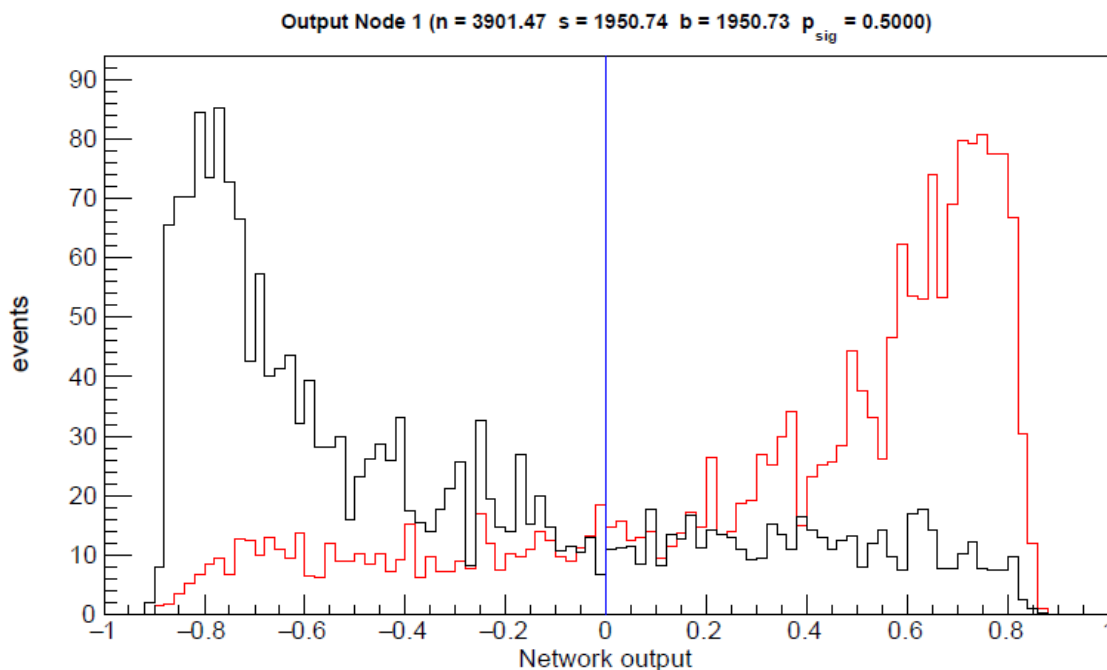
Variable	Significance(σ)	Definition
$\eta(j)$	18.9	Untagged jet η
$p_T(j)$	18.6	Untagged jet p_T
m_t	15.2	Reconstructed top-quark mass
$p_T(tZt)$	10.9	The tZq system p_T
$p_T(\ell^W)$	7.0	p_T of the lepton coming from the W boson decay
$\Delta R(j, Z)$	6.3	ΔR between untagged jet and Z boson
$m_T(\ell, E_T^{\text{miss}})$	4.6	Transverse mass of W -boson
$\eta(\ell^W)$	3.5	η of the lepton coming from the W -boson decay
$p_T(t)$	3.3	Reconstructed top quark p_T
$p_T(b)$	3.1	Tagged jet p_T
$\Delta\phi(t, Z)$	2.5	ΔR between the reconstructed top quark and Z boson
$m(\ell\ell)$	2.5	Reconstructed Z -boson mass
$\eta(Z)$	2.0	Reconstructed Z -boson η



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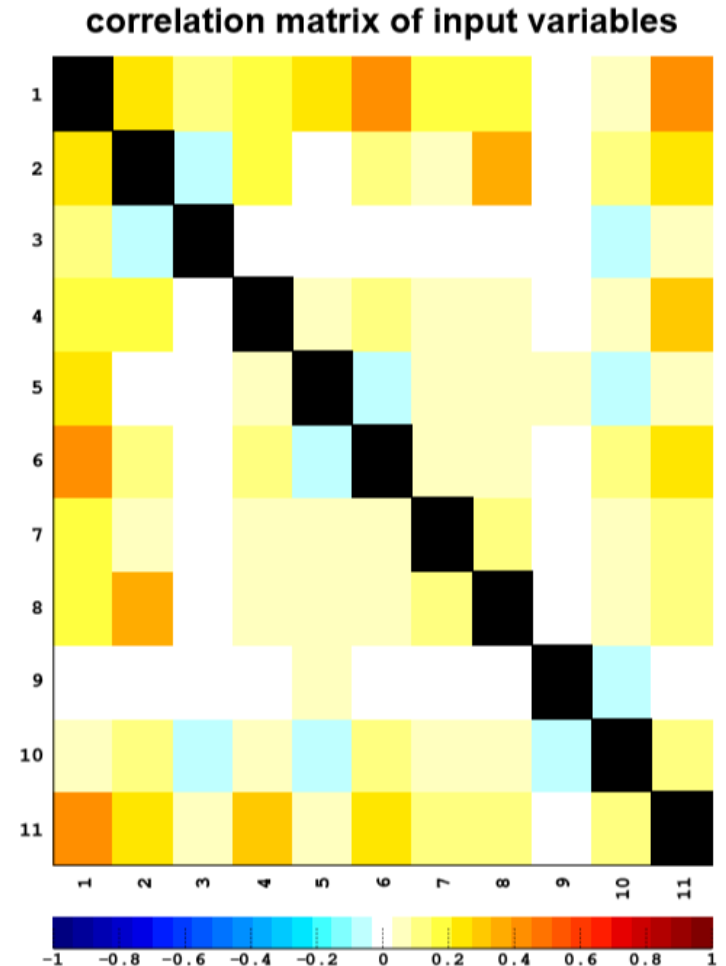


Going forward, the retrained neural net will add linear combinations of successful variables and analyze data

The training of the neural net and BDT have been redone using more monte carlo simulations and different variables

Different combinations of variables and discrimination techniques can yield more accurate trainings

An optimized machine learning structure can better analyze data and produce less uncertainty



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