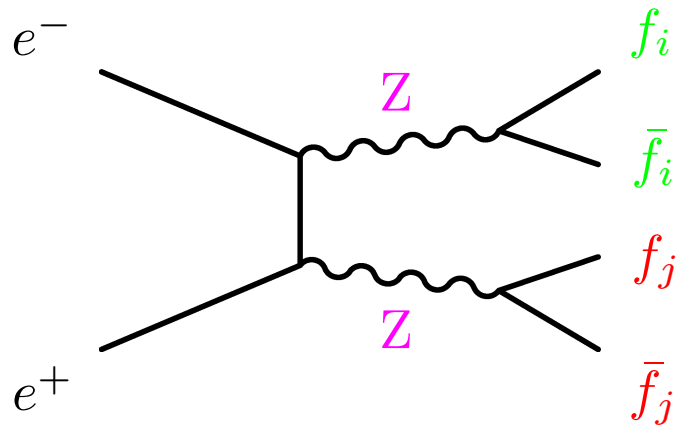


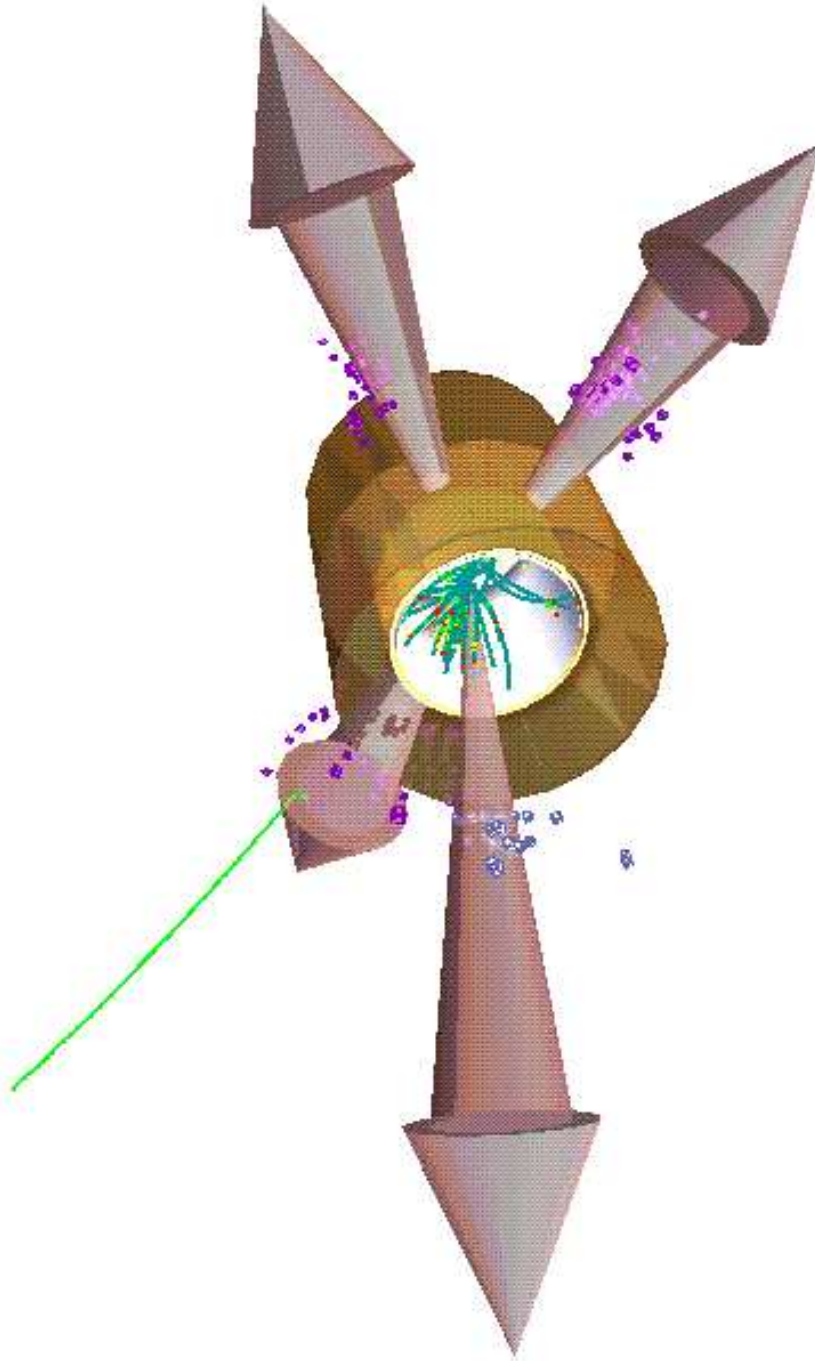
Z-Pair production



Martin Weber reporting on behalf of the ZZ group

16. November 1999

\sqrt{s} / GeV	\mathcal{L} / pb
192	29.7
196	83.7
200	83.0
202	37.0
	233.4

$q\bar{q}q'\bar{q}'$ 

- good statistics (B.R. 49%)
- large background from QCD and WW

$q\bar{q}q'\bar{q}'$, based on neural net

High multiplicity preselection

Force event in four jets,
apply 4C fit

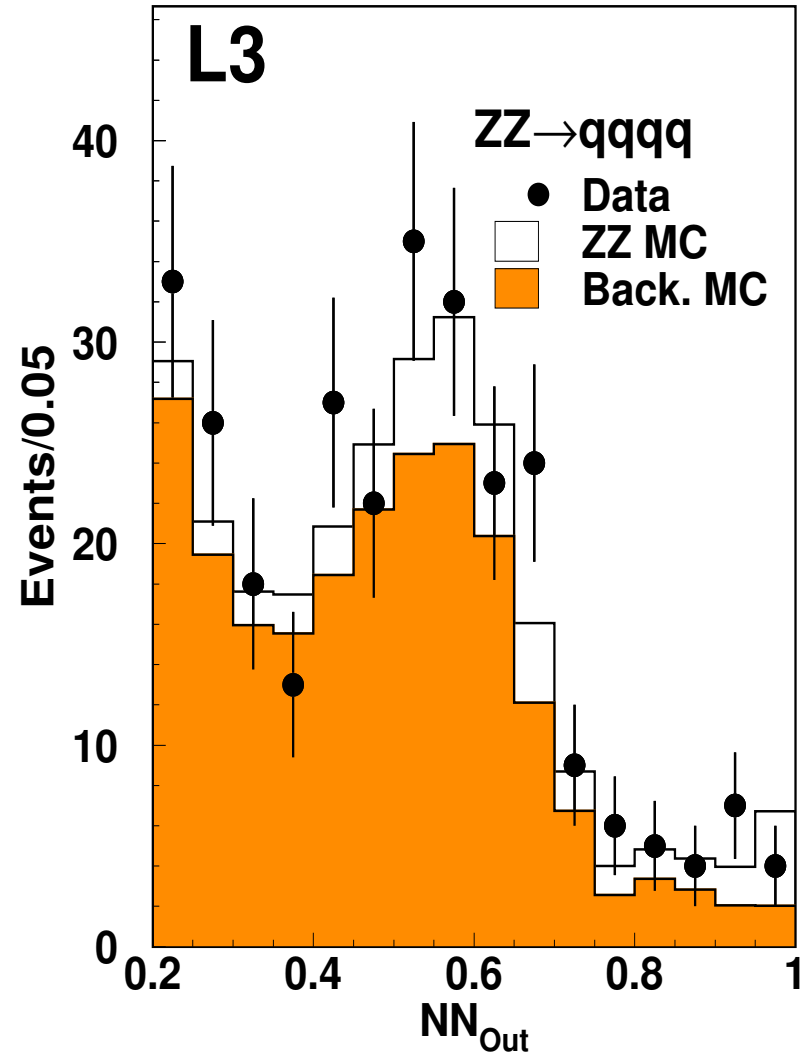
First neural net $QCD \leftrightarrow ZZ$

- topological variables

Second neural net $WW \leftrightarrow ZZ$

- reconstructed dijet mass
- maximum & minimum jet energy
- average number of charged tracks
- dijet mass difference
- b-tag

Signal ($\epsilon = 44\%$)	46.2
Background	219.8
Data	288



$q\bar{q}q'\bar{q}'$, **optimized** cut based analysis

Force event in four jets,
apply 4C fit

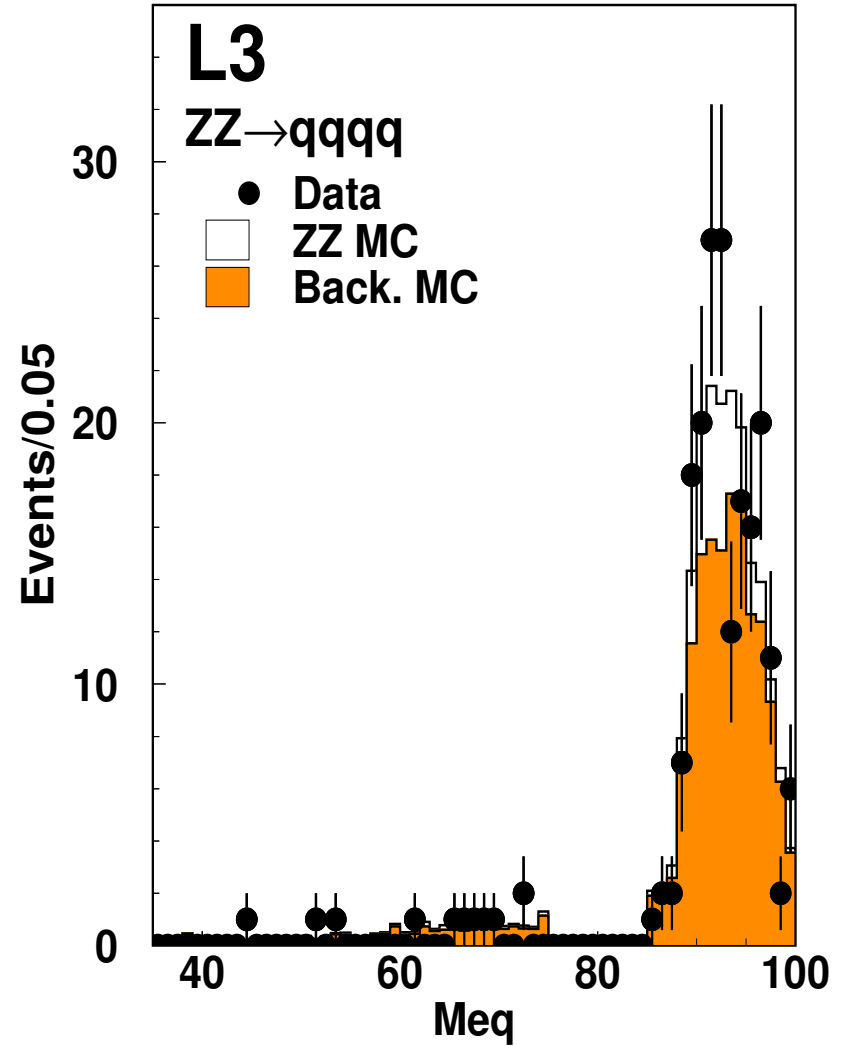
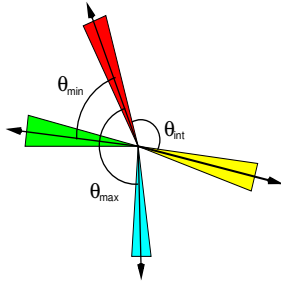
Using boost difference

$ZZ \leftrightarrow WW$

choose jet-pair with maximum angle

- masses and angles of dijets
- mass difference of the pairs
- jet topologies ($\ln(y_{34}), \ln(y_{45})$)

Maximize signal/background ratio for
discriminating variables



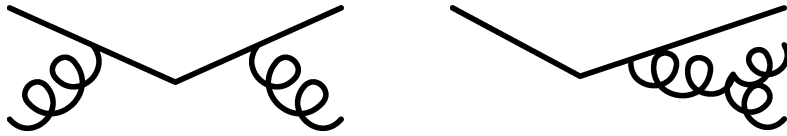
Signal ($\epsilon = 33\%$)	35.8
Background	164.7
Data	199

$q\bar{q}q'\bar{q}'$, different approach

Force event in four jets, **no** 4C fit

Reduce **QCD** background

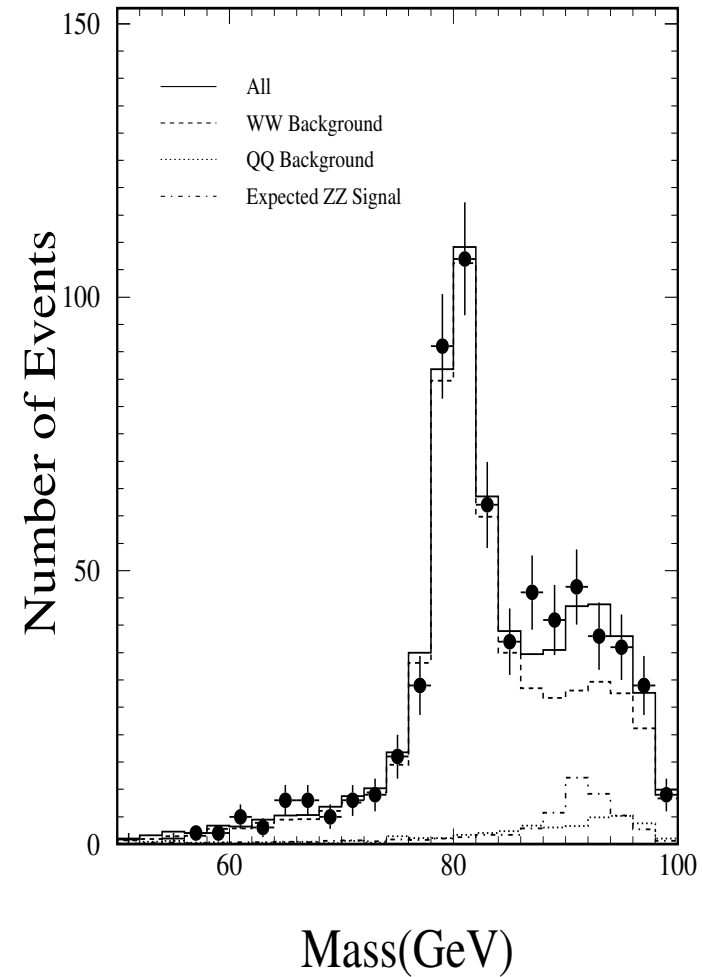
- di-jet boosts $\gamma_{ij} = E_{ij}/M_{ij}$
- boost difference $\Delta\gamma = |\gamma_{ij} - \gamma_{kl}|$
- order $\Delta\gamma_1 \leq \Delta\gamma_2 \leq \Delta\gamma_3$
- cut on $\Delta\gamma_2 + \Delta\gamma_3$

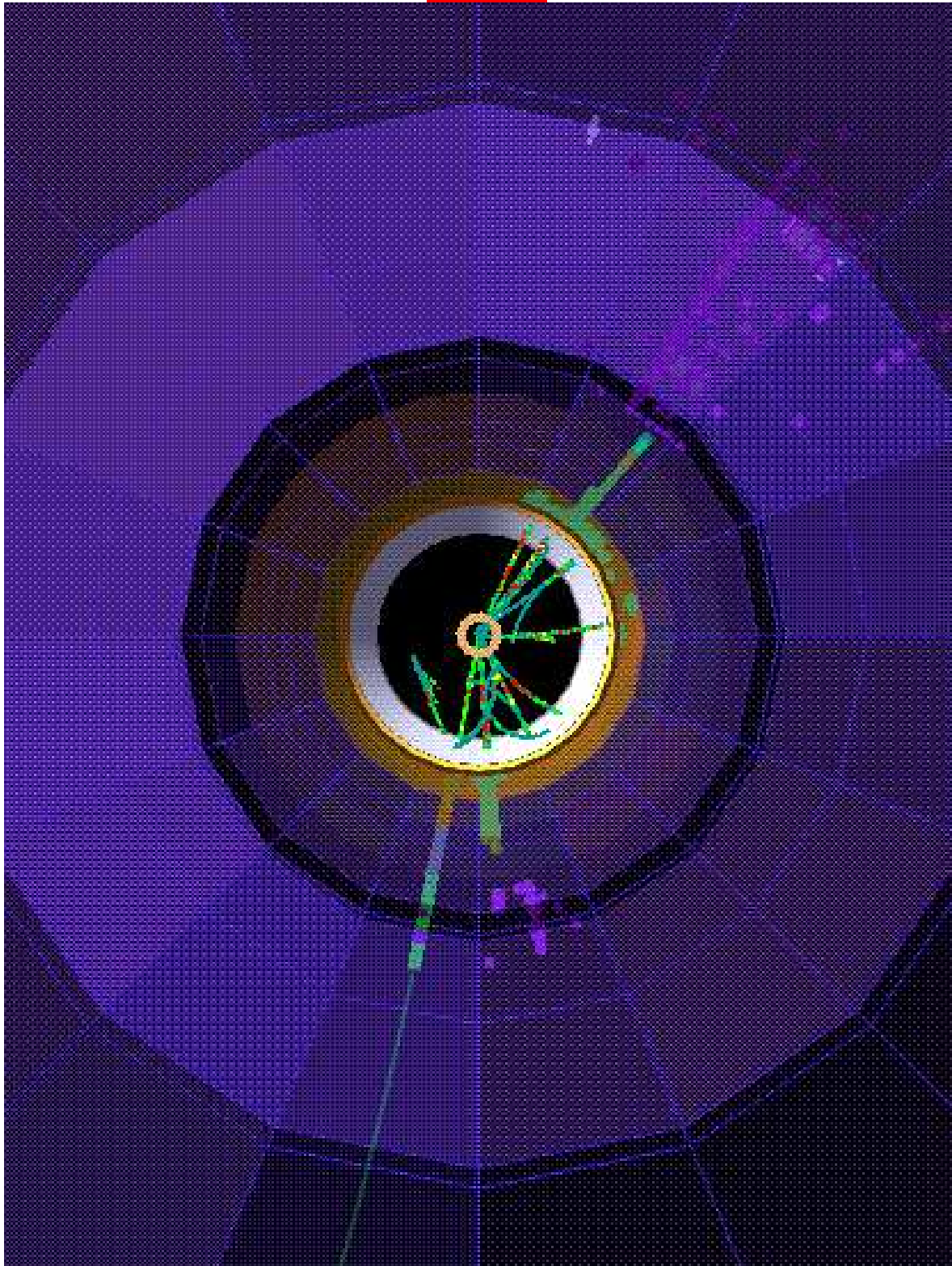


- triple-jet boosts $\gamma_{ijk} = E_{ijk}/M_{ijk}$
- cut on largest γ_{ijk}

Signal ($\epsilon = 45\%$)	50.0
Background	587.5
Data	640

At 192 to 202 GeV



$q\bar{q}\nu\bar{\nu}$ 

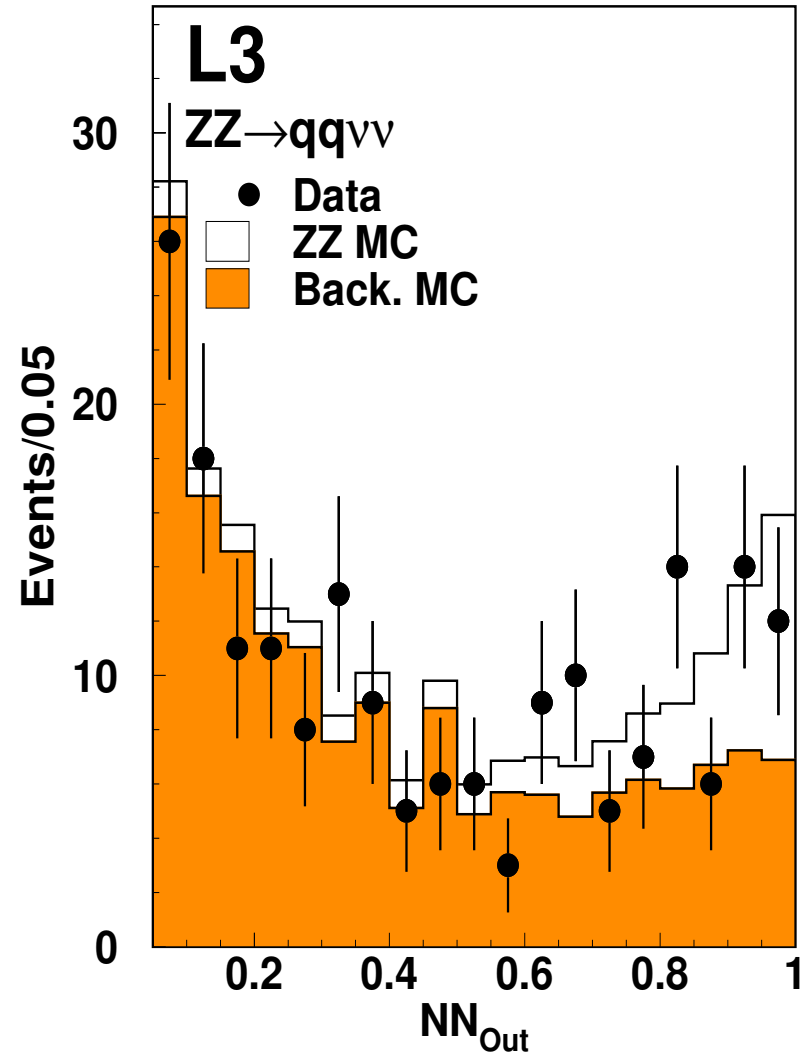
- good statistics (B.R. 28%)
- large background from QCD and $W\nu$

$q\bar{q}\nu\bar{\nu}$, based on neural net

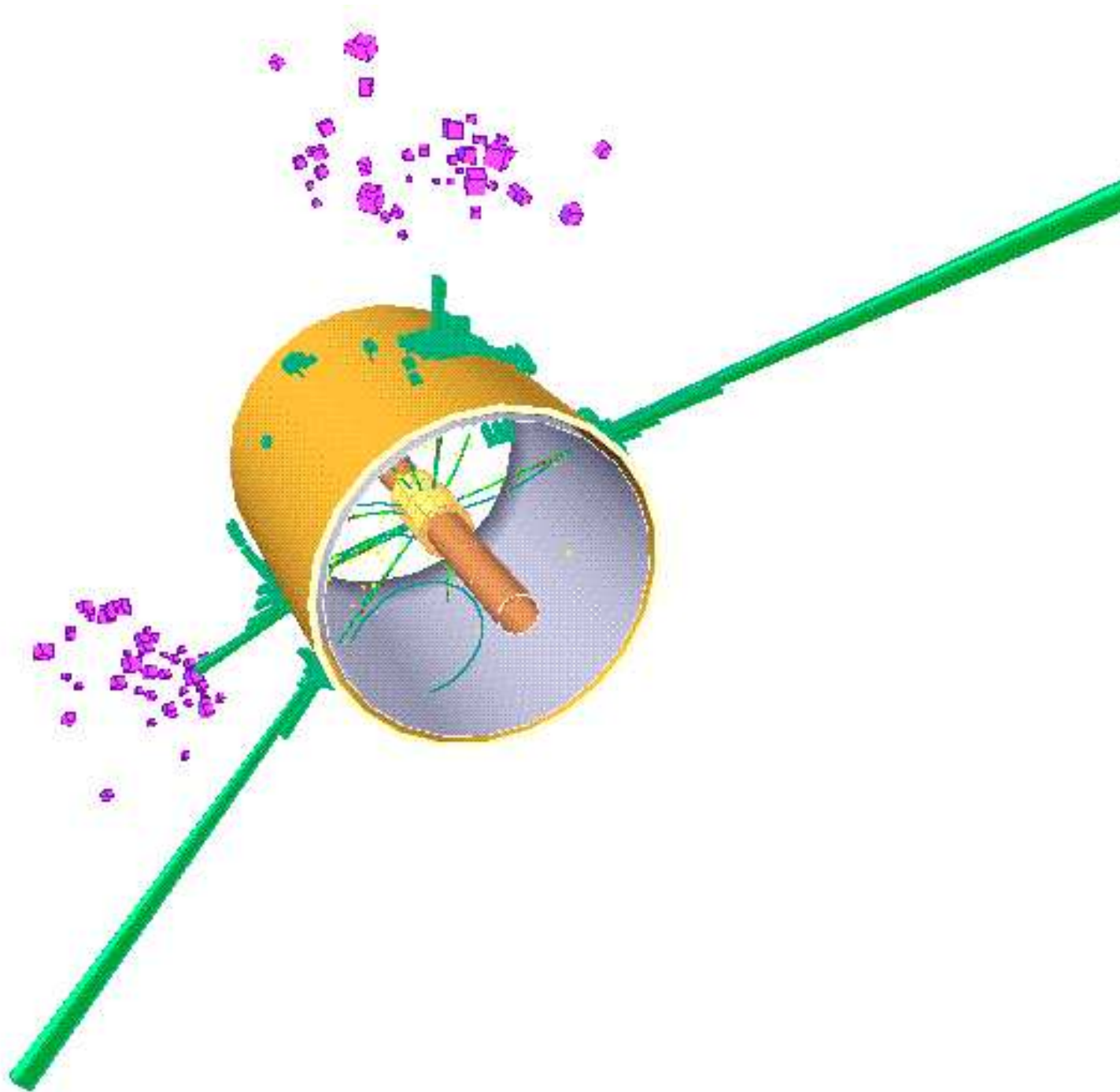
- high multiplicity events
- visible & recoil mass close to M_Z
- p_t , reject high p_l/E_{vis}
- small energy in missing energy direction
- small energy in FB calorimeter
- reject high energetic e, μ, γ
- masses of the two jets
- total missing momentum

Variables for NN after applying cuts

Signal ($\epsilon = 49\%$)	33.2
Background	68.3
Data	92



$$q\bar{q}l^+l^-$$



- medium statistics (B.R. 14%)
- medium background

$q\bar{q}l^+l^-$, cut based analysis

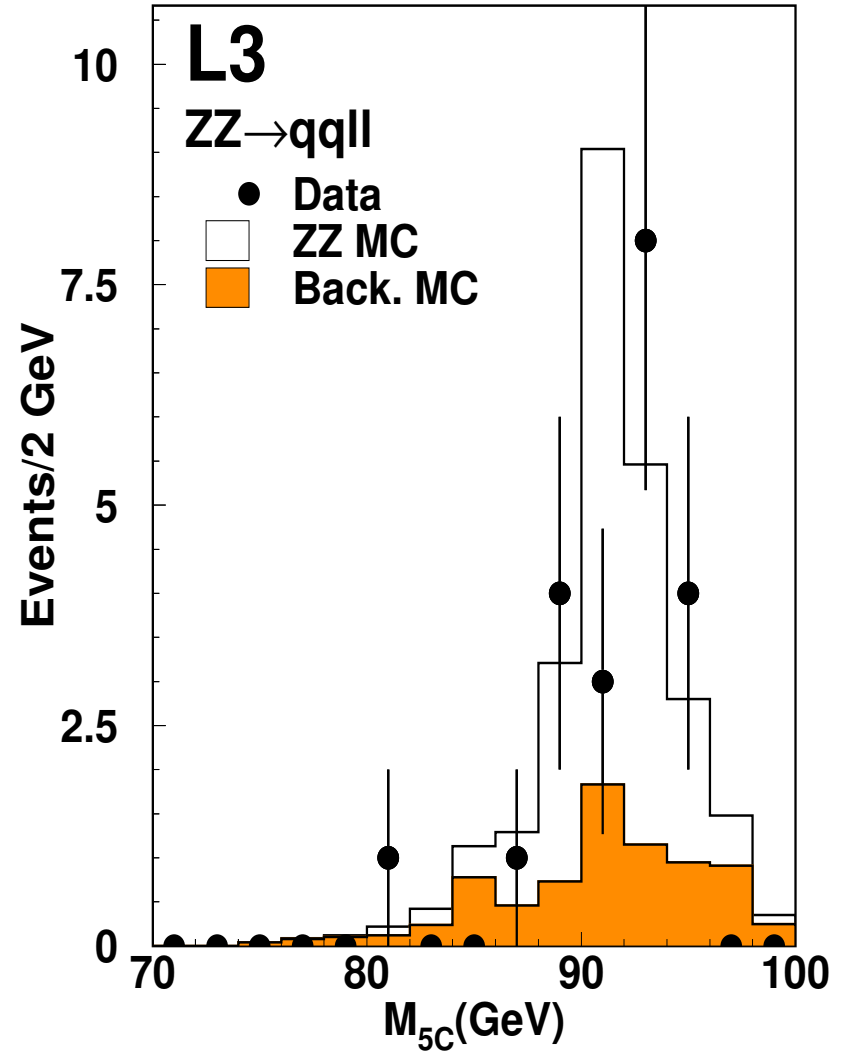
Lepton ID:

- e 1st good separated e , 2nd e or γ
- μ two μ in MUCH (one MIP)
- τ_p two $\tau \rightarrow e, \mu$, low multiplicity jet
- τ_j force 4 jets, 2 jets ≤ 3 tracks

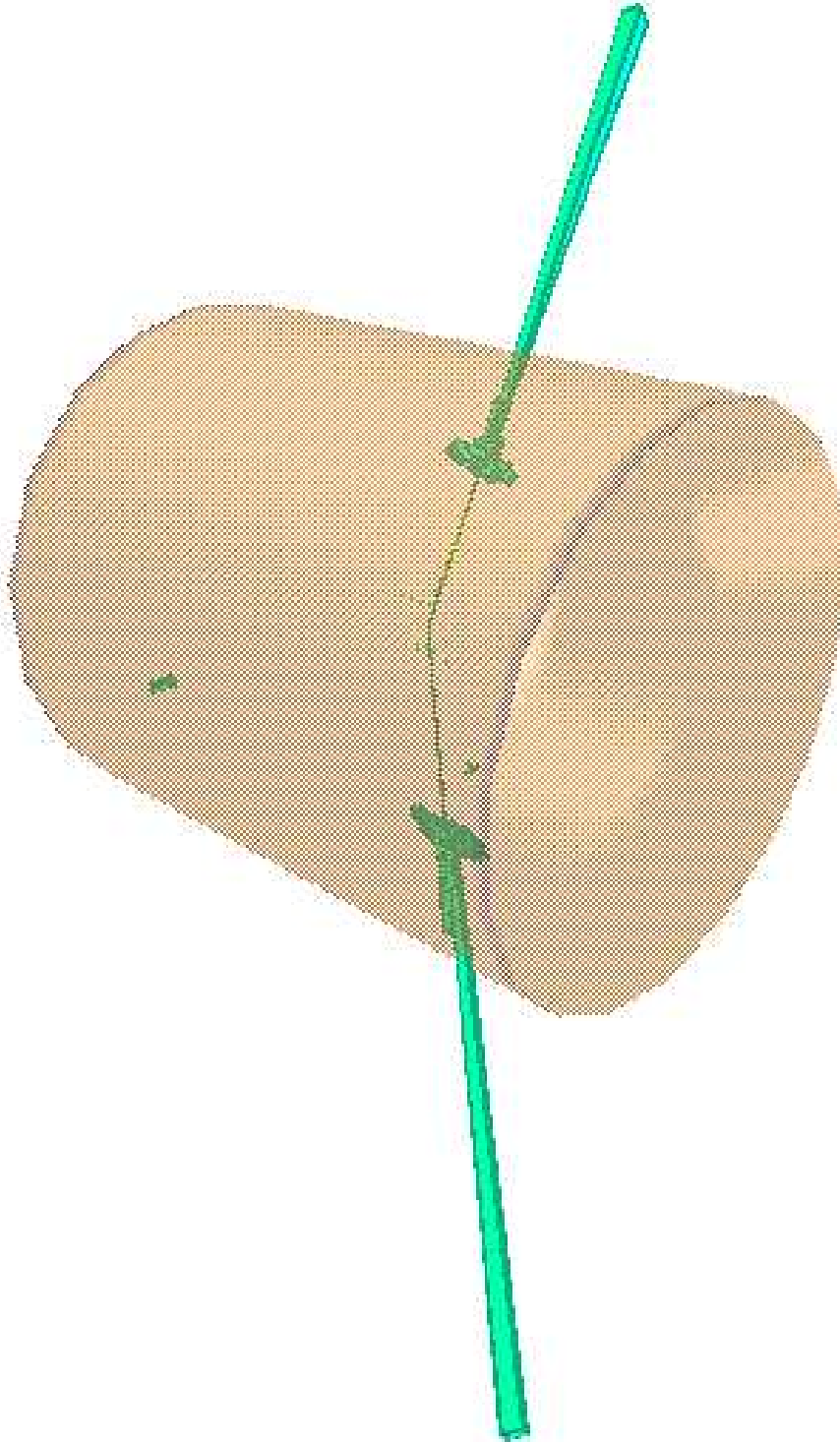
remaining event forced in 2 jets, 4C fit

- acolinearity (l^+, l^-), (jet, jet)
- mass (l^+, l^-), (jet, jet) close to M_Z
- four jet topology ($\ln(y_{34})$)
- τ_j : max. l^\pm energy, visible energy

Signal ($\epsilon = 56\%$)	18.0
Background	7.6
Data	21



$$\ell^+ \ell^- \nu \bar{\nu}$$



- low statistics (B.R. 4%)
- low background

$$\ell^+ \ell^- \nu \bar{\nu}$$

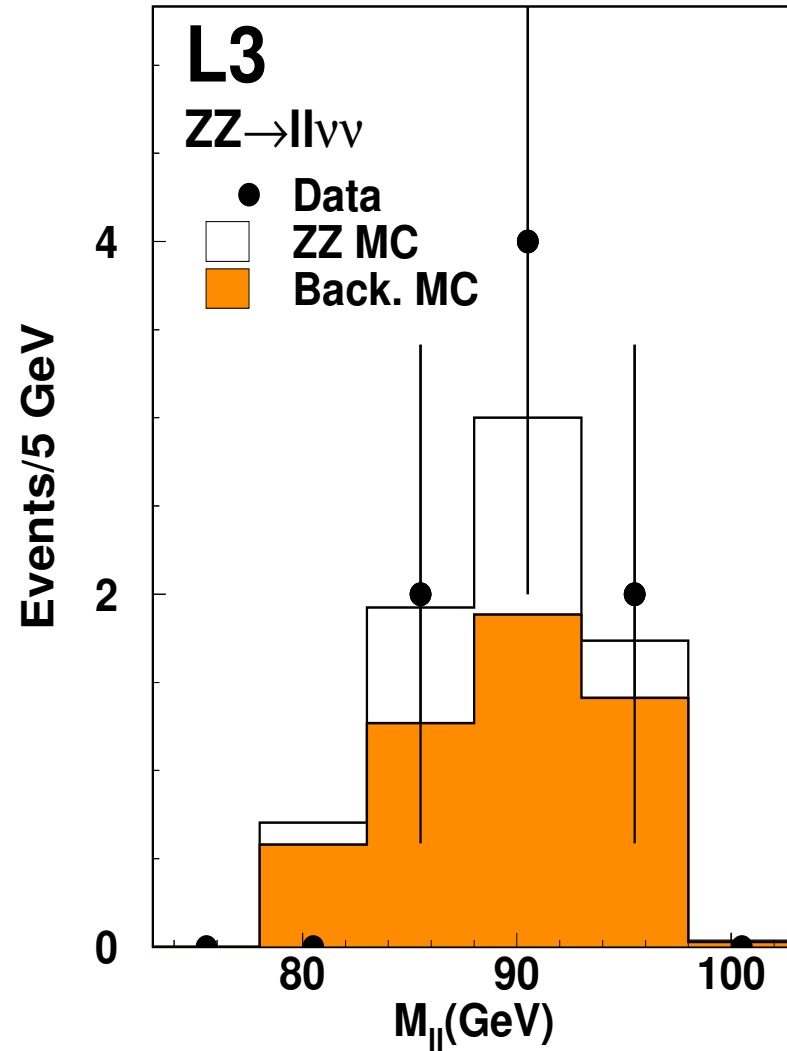
Lepton ID:

- e two e or γ
- μ two μ in MUCH
- τ no dedicated selection

Further steps:

- visible energy in range of M_Z
- acolinearity (Z-Boost)
- acoplanarity (bhabhas)
- constrained fit $M_{\ell^+\ell^-} = M_Z$
- recoil mass close to M_Z

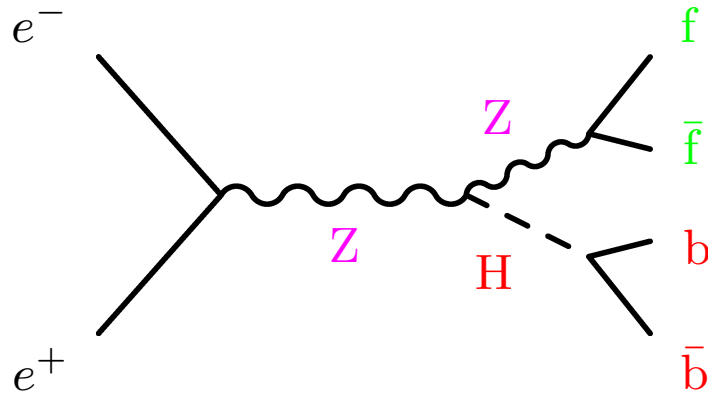
Signal ($\epsilon = 22\%$)	2.5
Background	5.2
Data	8



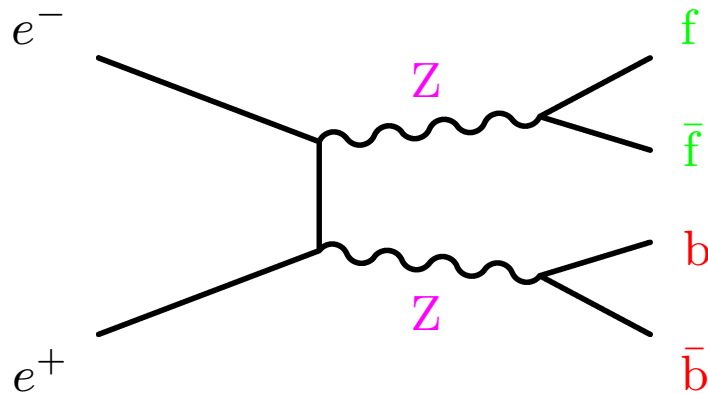
b quark content in ZZ events

Question: Are we sensitive to Higgs production?

Dominant contribution from



Same final state also in ZZ

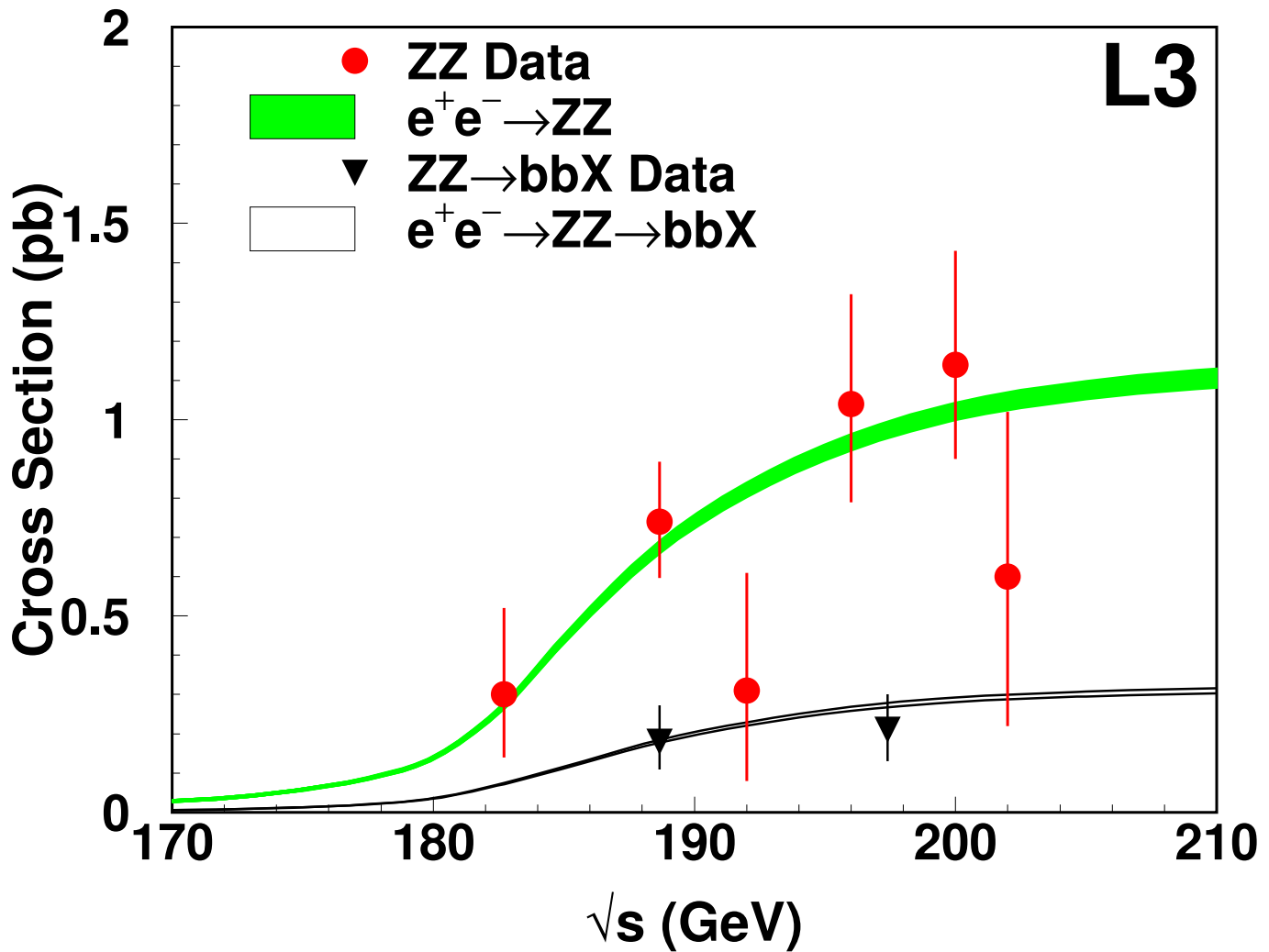


Take previously described analyses and

- make new discriminant by including b-tag
- evaluate cross-section with this distribution

Energy/GeV	$\sigma_{ZZ \rightarrow b\bar{b}f\bar{f}}/\text{pb}$	$\sigma_{\text{SM}}/\text{pb}$
197.5	$0.21^{+0.09}_{-0.08}$	0.27

Cross-section measurement



Energy/GeV	σ_{ZZ}/pb	$\sigma_{\text{SM}}/\text{pb}$
192	$0.31^{+0.30}_{-0.23}$	0.81
196	$1.04^{+0.28}_{-0.25}$	0.93
200	$1.15^{+0.29}_{-0.27}$	1.01
202	$0.59^{+0.42}_{-0.37}$	1.04