Convolution fit

in the $\mathrm{WW} \rightarrow \mathrm{qq}\ell\nu$ channel

at $\sqrt{s} = 189$ GeV

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- Method
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- Bias Correction
- Expected Errors
- Preliminary Results
- Summary

A copy of the transparencies can be found at
/afs/cern.ch/user/d/dubbj/public/ww/ww_070999.ps

Method (1)

The Convolution method tries to use the full information of each WW-event in an Unbinned Maximum Likelihood Fit of an analytical distribution to the data.

- For each event i construct a χ^2**-function** of the **kinematic variables**
  - qqeν, qq$\mu\nu$
    jet energies and -directions
    lepton momentum and -direction
  - qq$\tau\nu$
    jet energies and -directions
    τ-direction from its decay products

  The missing neutrino momentum is calculated from **momentum conservation**. **Energy conservation** and an **equal-mass constraint** are realized by penalty functions.

  Initial State Radiation (ISR) is **not taken into account** in the χ^2-function.

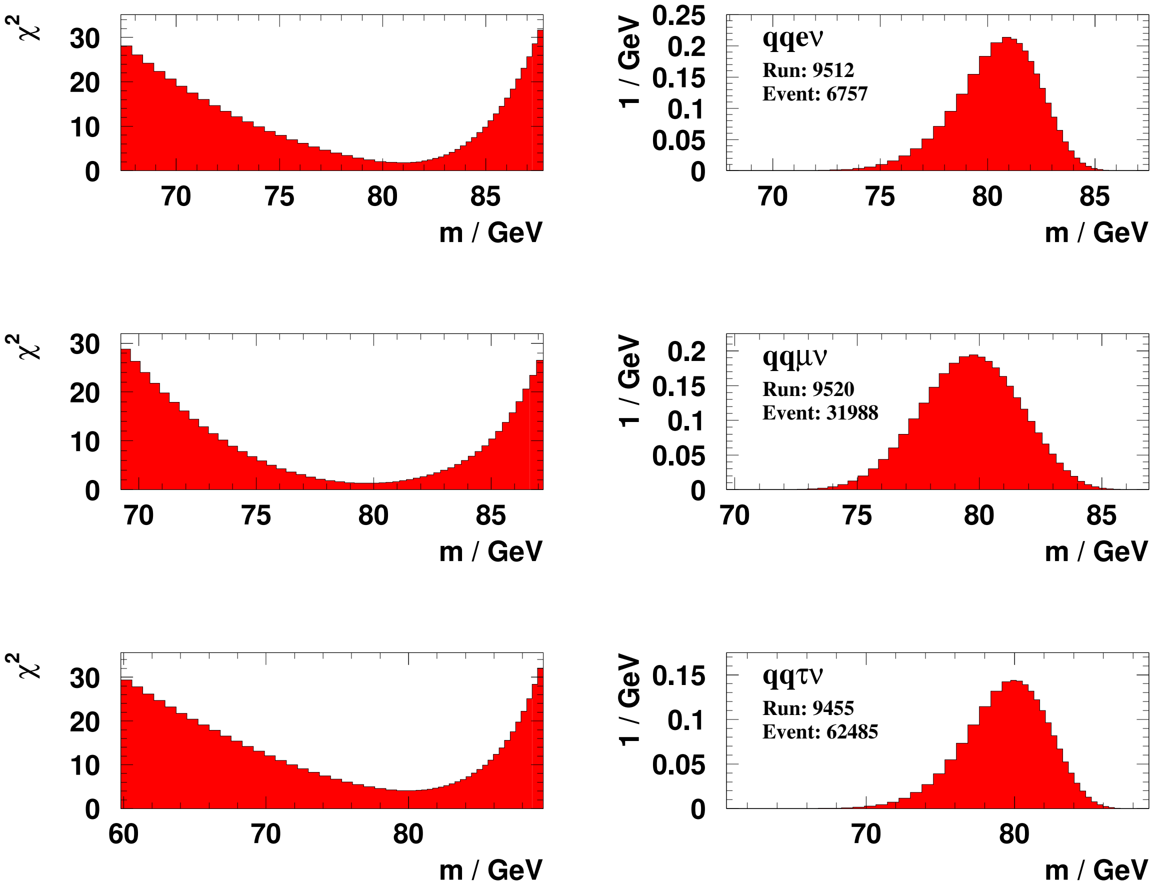
Method (2)

- Determine the **shape** of the χ^2**-function** as a **function of the mean W-mass** m in the event: Minimize χ^2-function with additional mass constraint.

- Convert $\chi_i^2(m)$ into **probability density** $P_i(m)$, which corresponds to the (in general) **asymmetric error**

$$P_i(m) \propto \exp\left(-\frac{\chi_i^2(m) - \chi_i^2(m_{min})}{2}\right)$$

Method (3)



$\chi^2(m)$-curves and corresponding error-densities for some events

- The **event-likelihood** $\mathcal{L}_i(\mathrm{M_W},\Gamma_\mathrm{W})$ is given by the **convolution** of the **error-density** $P_i(m)$ with the **physics function** $f(m;\mathrm{M_W},\Gamma_\mathrm{W})$:

$$\mathcal{L}_i(\mathrm{M_W},\Gamma_\mathrm{W}) = \int f(m';\mathrm{M_W},\Gamma_\mathrm{W})\; P_i(m')\; dm'$$

Method (4)

- $f(m; \mathrm{M_W}, \Gamma_\mathrm{W})$ is a **superposition** of relativistic **Breit-Wigner functions** (with phase-space factor) which are **shifted** by the difference of nominal and actual beam energy, $m \rightarrow m - (\sqrt{s} - \sqrt{s'})/2$, and **weighted** by the probability $Q(s')$ that the event occurred at a center-of-mass energy $\sqrt{s'}$. This takes the **effect of ISR** on the χ^2-function into account (in the statistic mean).

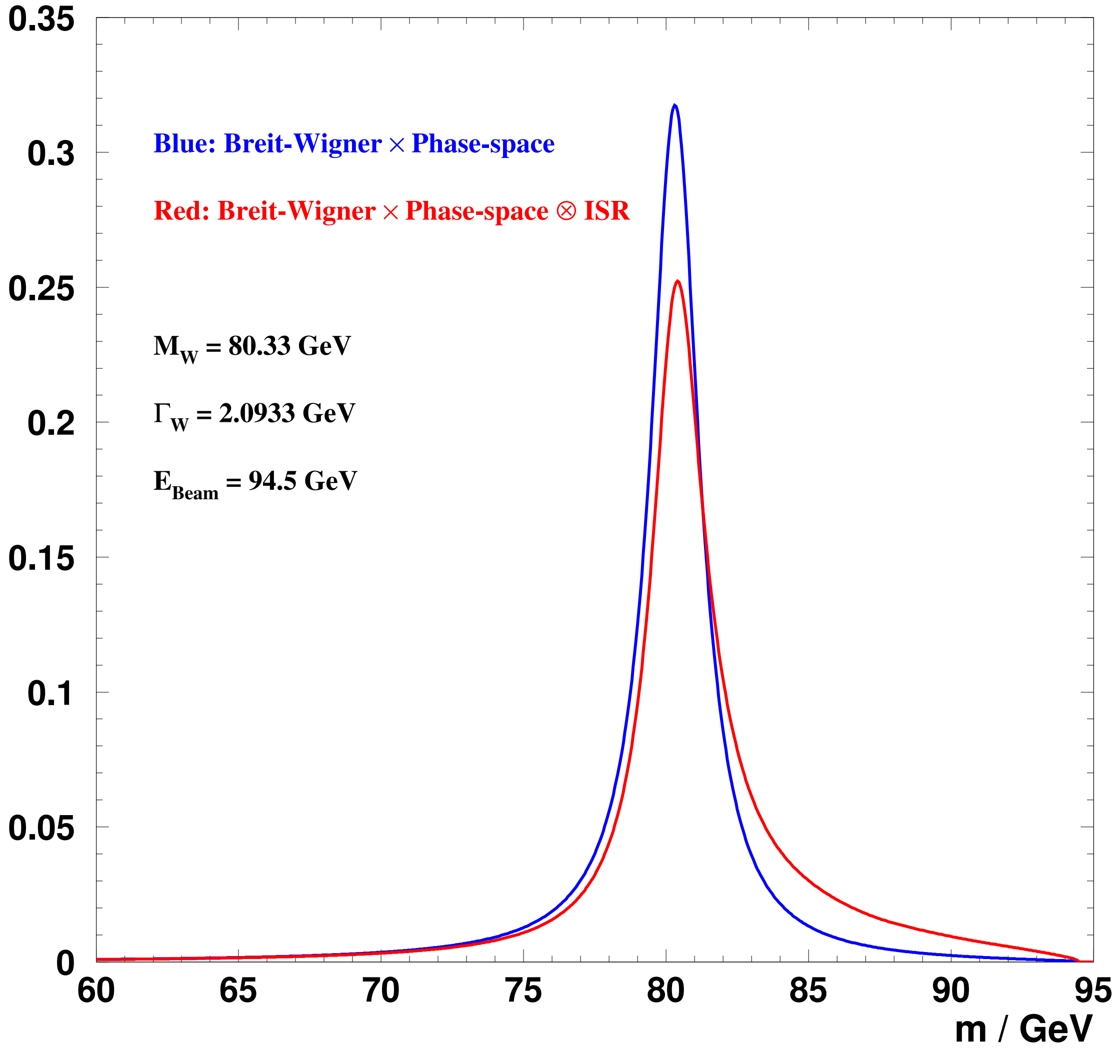
$$f(m; \mathrm{M_W}, \Gamma_\mathrm{W}) \propto \int bw\left(m - \frac{(\sqrt{s} - \sqrt{s'})}{2}; \mathrm{M_W}, \Gamma_\mathrm{W}\right) \times Q(s')\, ds'$$

- The total likelihood-function is the product of the individual event-likelihoods,

$$\mathcal{L}(\mathrm{M_W}) = \prod_{i=1}^{N_{Sample}} \mathcal{L}_i(\mathrm{M_W}, \Gamma_\mathrm{W}(\mathrm{M_W})).$$

This function is maximized to obtain $\mathrm{M_W}$ (the W-width is constraint to its SM value).

Method (5)



Comparison of a relativistic Breit-Wigner function (with phase space factor) and the physics function $f(m; \mathrm{M_W}, \Gamma_\mathrm{W})$

Background Treatment

- **Included background** in ensemble test/systematic studies:
  - $e^+e^- \to qq$
  - $e^+e^- \to We\nu$
  - $e^+e^- \to ZZ$

- The **number of background events** in each sample is **randomly determined** from a **Poisson distribution** with the corresponding mean number of the background events in a data-sized sample.

- The **shape of each background** in each channel is **parameterized as a Gaussian**, normalized to the mean number of background events and **added to the physics function**.

Bias Correction (1)

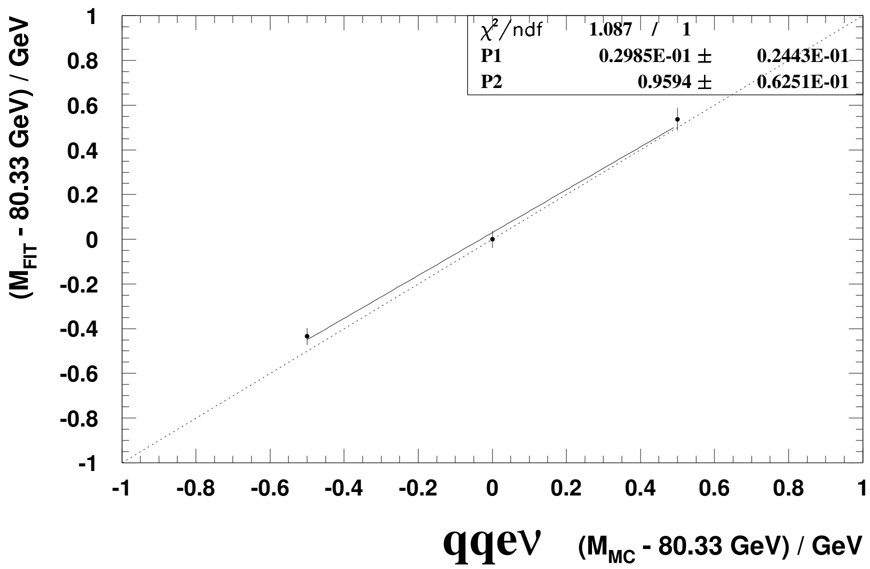
- Fit data sized samples from MC runs with M_{MC} = 79.83, 80.33, 80.83 GeV.
  Straight line fit of the mean values gives $M_{Fit}(M_{MC})$.

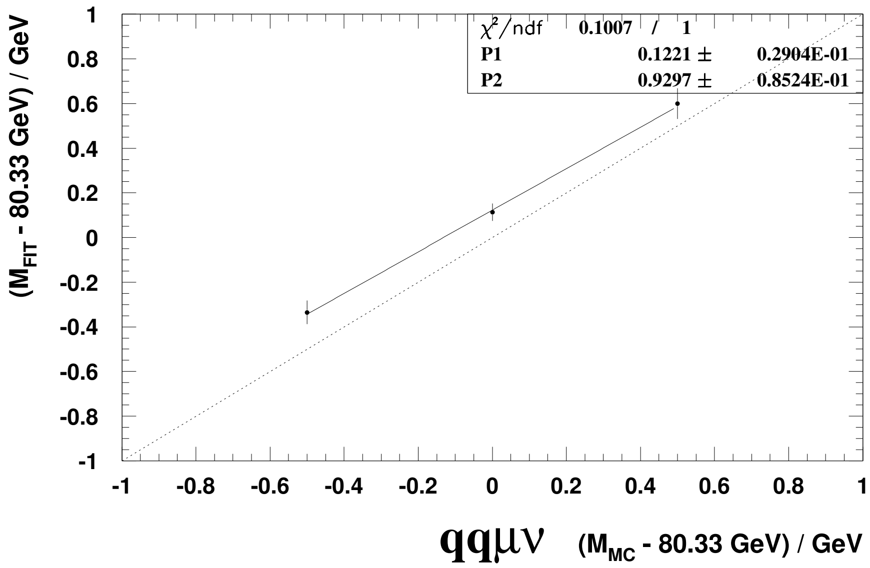
- **Bias correction**: Use inverse of $M_{Fit}(M_{MC})$.

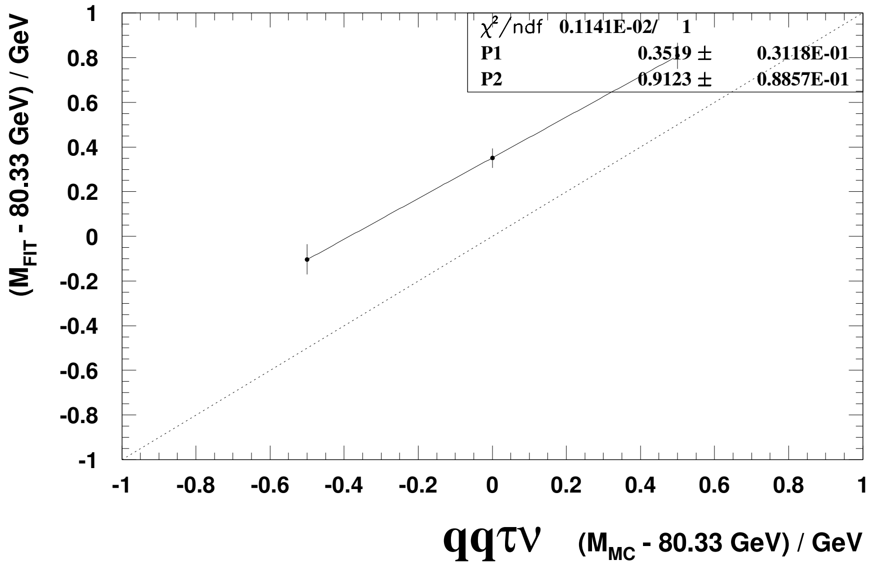
- **Scaling factor** for errors is given by the inverse slope of the fit.

Channel	Slope of $M_{FIT}(M_{MC})$	
	GCE	MT
$qqe\nu$	0.97	0.97
$qq\mu\nu$	0.93	0.96
$qq\tau\nu$	0.91	0.88

Bias Correction (2)







Expected Errors

- **Ensemble test** with 2500 MC experiments
  - Same number of $qqe\nu$, $qq\mu\nu$ and $qq\tau\nu$ events as selected data events
  - $e^+e^- \to qq,\ We\nu,\ ZZ$ background included
  - Events are randomly selected from run 8058
- RMS of W-mass distributions (Results for Reweighting from PN 385)

Channel	Exp. error M_W (MeV)		
	GCE	MT	Reweighting
$qqe\nu$	176 ± 4	169 ± 3	(192 ± 19)
$qq\mu\nu$	185 ± 4	170 ± 3	(184 ± 19)
$qq\tau\nu$	269 ± 5	256 ± 5	(244 ± 25)

- Pull distributions

Channel	Pull width M_W	
	GCE	MT
$qqe\nu$	1.02 ± 0.01	0.99 ± 0.01
$qq\mu\nu$	1.00 ± 0.01	0.98 ± 0.01
$qq\tau\nu$	1.06 ± 0.02	1.05 ± 0.02

Systematics

The main MC sample is run 8058

- **Beam energy**:

  Add 30 MeV to beam energy, scale result to LEP error of 20 MeV

- **Detector effects**:

  - **Energy/momentum measurement**:

    Scale jet energy/lepton momentum by 0.99

  - **Energy/momentum errors**:

    Scale errors by 1.03

  - **Angular errors**:

    Scale errors by 1.05

- **Fit Procedure**:

  Change convolution range from $\Delta\chi^2 = 25$ to $\Delta\chi^2 = 16$ ("$5\sigma \to 4\sigma$")

- **Hadronization**:

  Compare results with HERWIG sample (run 8099)

- **4-f Interference**:

  Compare results of two GRC4F samples (run 8055 and run 8438)

- **Background**:

  Increase mean number of background events by 5%

- **HCAL modeling and ISR**:

  Taken from $\sqrt{s} = 183$ GeV studies

Preliminary Results for OPAL data at $\sqrt{s} = 189$ GeV (1)

Integrated luminosity: 183 pb^{-1}

Dadlist: ww_189.dad

Data events: 1216 $\mathrm{qq}\ell\nu$ (378 $\mathrm{qqe}\nu$,
402 $\mathrm{qq}\mu\nu$,
436 $\mathrm{qq}\tau\nu$)

Cuts: Standard WW112 cuts + fit probability $>$ 0.001
+ χ^2-curve smoothness and -limits

Selected events (GCE): 1055 $\mathrm{qq}\ell\nu$ (348 $\mathrm{qqe}\nu$,
361 $\mathrm{qq}\mu\nu$,
346 $\mathrm{qq}\tau\nu$)

Selected events (MT): 1104 $\mathrm{qq}\ell\nu$ (345 $\mathrm{qqe}\nu$,
372 $\mathrm{qq}\mu\nu$,
387 $\mathrm{qq}\tau\nu$)

Preliminary Results for OPAL data

at $\sqrt{s} = 189$ GeV (2)

Channel	M_W (GeV)		
	GCE	MT	Reweighting (PN 385)
$qqe\nu$	$80.244 \pm 0.172 \pm 0.098 \pm 0.009$	80.243 ± 0.174	(80.248 ± 0.172)
$qq\mu\nu$	$80.442 \pm 0.193 \pm 0.139 \pm 0.007$	80.442 ± 0.181	(80.473 ± 0.178)
$qq\tau\nu$	$80.481 \pm 0.250 \pm 0.178 \pm 0.021$	80.612 ± 0.251	(80.410 ± 0.261)
$qq\ell\nu$	$80.363 \pm 0.114 \pm 0.078 \pm 0.008$	80.393 ± 0.112	(80.366 ± 0.111)

Summary and Outlook

- Results look quite good . . .
- but some problems if width not constraint to SM
  (see talk at WW Meeting 25.08.99,
  /afs/cern.ch/user/d/dubbj/public/ww/ww_250899.ps)

- Recheck everything (was done in a hurry)
- Improve $qq\tau\nu$ channel
- Systematics for MT