Status of the $\mathrm{WW} \rightarrow \mathrm{qq}\ell\nu$

Convolution fit at $\sqrt{s} = 189$ GeV

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- Method
- Bias Correction + Expected Errors
- Systematics
- Preliminary Results
- Summary and Outlook

A copy of the transparencies can be found at
/afs/cern.ch/user/d/dubbj/public/ww/ww_250899.ps

Method (1)

- For each event i construct 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**

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

- 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 (3)

- $f(m; \mathrm{M_W}, \Gamma_\mathrm{W})$ 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 happened 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)

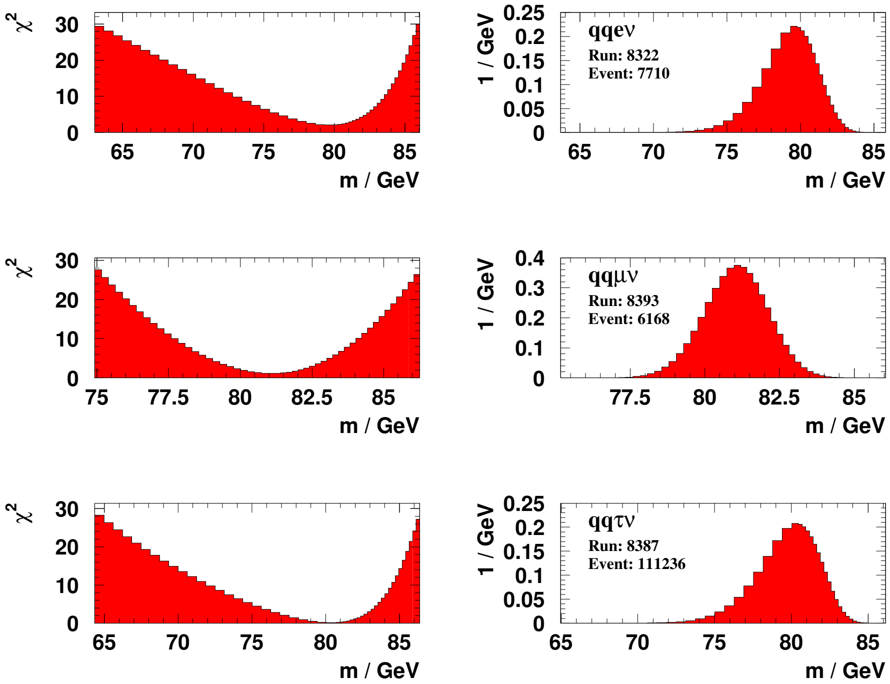
$$f(m; \mathrm{M_W}, \Gamma_\mathrm{W}) = \frac{1}{N} \int bw(m - (\sqrt{s} - \sqrt{s'})/2; \mathrm{M_W}, \Gamma_\mathrm{W}) \times Q(s')\, ds'$$

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

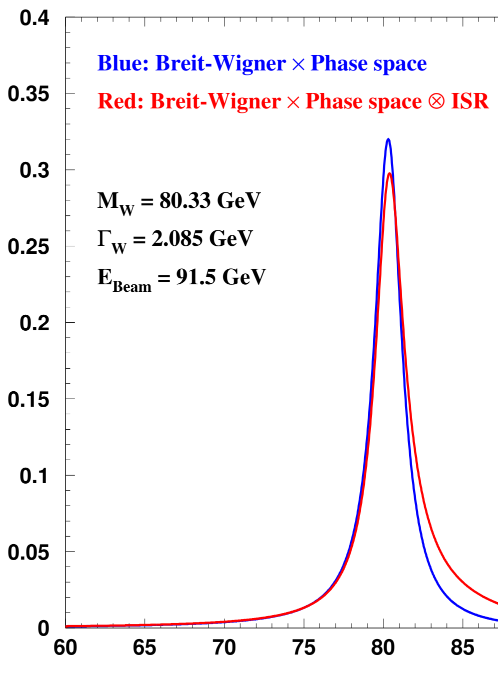
$$\mathcal{L}(\mathrm{M_W}, \Gamma_\mathrm{W}) = \prod_{i=1}^{N_{Sample}} \mathcal{L}_i(\mathrm{M_W}, \Gamma_\mathrm{W}).$$

  This function is maximized to obtain $\mathrm{M_W}$ and Γ_W.

Method (4)



χ^2
1 / GeV
m / GeV
qqeν
Run: 8322
Event: 7710
qqμν
Run: 8393
Event: 6168
qqτν
Run: 8387
Event: 111236



Blue: Breit-Wigner × Phase space
Red: Breit-Wigner × Phase space ⊗ ISR
M_W = 80.33 GeV
Γ_W = 2.085 GeV
E_{Beam} = 91.5 GeV
m / GeV

Background Treatment

- **Included background** in ensemble test/systematic studies:
  - $e^+e^- \to qq$
  - $e^+e^- \to We\nu$
  - $e^+e^- \to ZZ$
- **Mean number of background events** taken from MC subject to the same selections as data:

Channel	qq	Weν	ZZ
$qqe\nu$	5.57	2.07	0.41
$qq\mu\nu$	1.70	0.07	1.25
$qq\tau\nu$	19.02	8.59	8.85
$qq\ell\nu$	26.28	10.73	10.51

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

- **Background shape parameterized as Gaussian** normalized to mean number of background events.

Bias Correction (1)

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

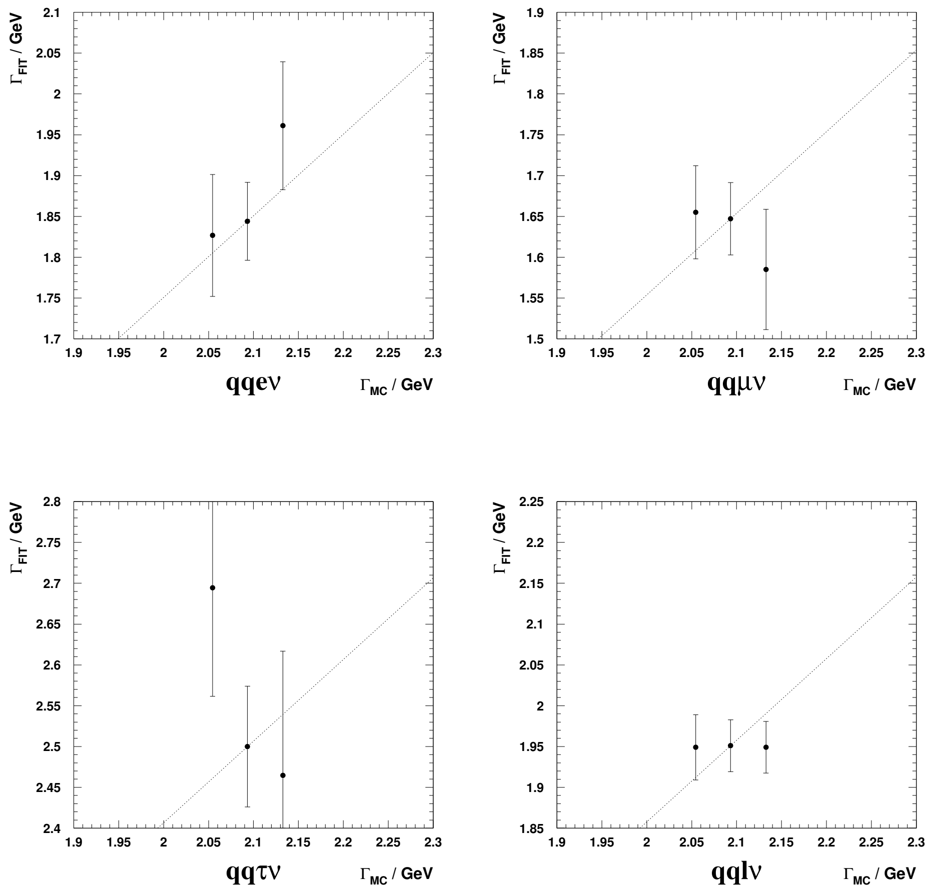
- **Bias correction**: Use inverse of $\mathrm{M_{Fit}}(\mathrm{M_{MC}})$ and $\Gamma_{\mathrm{Fit}}(\Gamma_{\mathrm{MC}})$.

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

Channel	Slope of $\mathrm{M_{FIT}}(\mathrm{M_{MC}})$
$qqe\nu$	0.977 ± 0.005
$qq\mu\nu$	0.921 ± 0.005
$qq\tau\nu$	0.854 ± 0.006
$qq\ell\nu$	0.950 ± 0.003

Bias Correction (2)

Problem: Method does not seem very sensitive to Γ_W



- Bias correction for Γ_W estimated from MC at central mass value ($M_W = 80.33$ GeV)
- No scaling factor applied to errors for Γ_W

Expected Errors

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

Channel	Exp. error M_W (MeV)	Exp. error Γ_W (MeV)
$\mathrm{qqe\nu}$	176 ± 2 (192 ± 19)	300 ± 5
$\mathrm{qq\mu\nu}$	193 ± 2 (184 ± 19)	282 ± 5
$\mathrm{qq\tau\nu}$	305 ± 5 (244 ± 25)	520 ± 9
$\mathrm{qq\ell\nu}$	115 ± 2 (108 ± 11)	197 ± 3

- Pull distributions

Channel	Pull width M_W (MeV)	Pull width Γ_W (MeV)
$\mathrm{qqe\nu}$	1.04 ± 0.02	1.04 ± 0.02
$\mathrm{qq\mu\nu}$	1.06 ± 0.02	1.06 ± 0.02
$\mathrm{qq\tau\nu}$	1.02 ± 0.02	0.94 ± 0.02
$\mathrm{qq\ell\nu}$	1.01 ± 0.01	1.01 ± 0.02

Systematics (1)

The main MC sample is run 8058 (KORALW, $M_W = 80.33$ GeV, $\Gamma_W = 2.0933$ GeV)

- **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 $\Delta\chi^2 = 16$ ("$5\sigma \rightarrow 4\sigma$")
- **Hadronization**:
  Compare results with HERWIG sample (run 8099)
- **4-f Interference**:
  Compare results of two GRC4F samples (run 8058 and run 8438)
- **Background**:
  Increase mean number of background events by 5%
- **HCAL modeling and ISR**:
  Taken from $\sqrt{s} = 183$ GeV studies

Systematics (2)

Systematic	MC ΔM_W (MeV)	Data ΔM_W (MeV)	MC $\Delta\Gamma_W$ (MeV)	Data $\Delta\Gamma_W$ (MeV)
Beam energy	14	8 ± 8	2	25 ± 13
$E_{jet} \times 0.99$	13	28 ± 17	5	-12 ± 23
$p_{lep} \times 0.99$	2	-12 ± 14	3	-62 ± 22
$\delta E_{jet} \times 1.03$	-11	-19 ± 14	-14	-18 ± 21
$\delta p_{lep} \times 1.03$	2	6 ± 10	-8	-9 ± 21
$\delta(\theta,\phi)_{jet} \times 1.05$	7	15 ± 12	-14	-36 ± 18
$\delta(\theta,\phi)_{lep} \times 1.03$	2	6 ± 12	3	10 ± 19
HCAL model	3 ± 27		-26 ± 45	
Detector total	43 MeV		95 MeV	
Fit	0	0 ± 1	0	0 ± 3
ISR 1.Order	37 ± 37		38 ± 59	
Hadronization	-20 ± 29		-175 ± 43	
4-f	43 ± 23		84 ± 61	
Background	2 ± 20		4 ± 42	
Total	79 MeV		228 MeV	

Preliminary Results for OPAL data

at $\sqrt{s} = 189$ GeV

Integrated luminosity: $183\ \mathrm{pb}^{-1}$

Dadlist: ww_189.dad

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

Cuts: Standard WW112 cuts + fit probability $>$ 0.001

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

Results:

$$\mathrm{M_W} = 80.47\ \pm 0.12\ \pm 0.08 \pm 0.01\ \mathrm{GeV}$$

$$\Gamma_\mathrm{W} = 2.48\ ^{+0.22}_{-0.21} \pm 0.28 \pm 0.02\ \mathrm{GeV}$$

Results for each channel:

Channel	$\mathrm{M_W}$ (GeV)	Γ_W (GeV)
$qqe\nu$	80.23 ± 0.17 (80.25 ± 0.17)	$2.11^{+0.34}_{-0.31}$
$qq\mu\nu$	80.48 ± 0.20 (80.47 ± 0.18)	$2.53^{+0.36}_{-0.32}$
$qq\tau\nu$	80.44 ± 0.28 (80.41 ± 0.26)	$1.96^{+0.52}_{-0.45}$

(Blue: Results for Reweighting method PN 385)

Summary and Outlook

- Results comparable to Reweighting methods . . .
- . . . but unfortunately not better
- Still some problems

- Improve $qq\tau\nu$ channel
- Try SM fit
- Try MT correction
- . . .