W-mass determination for

WW $\rightarrow$ qqeν, qq$\mu\nu$ events

using a Convolution method

Jörg Dubbert

Munich University

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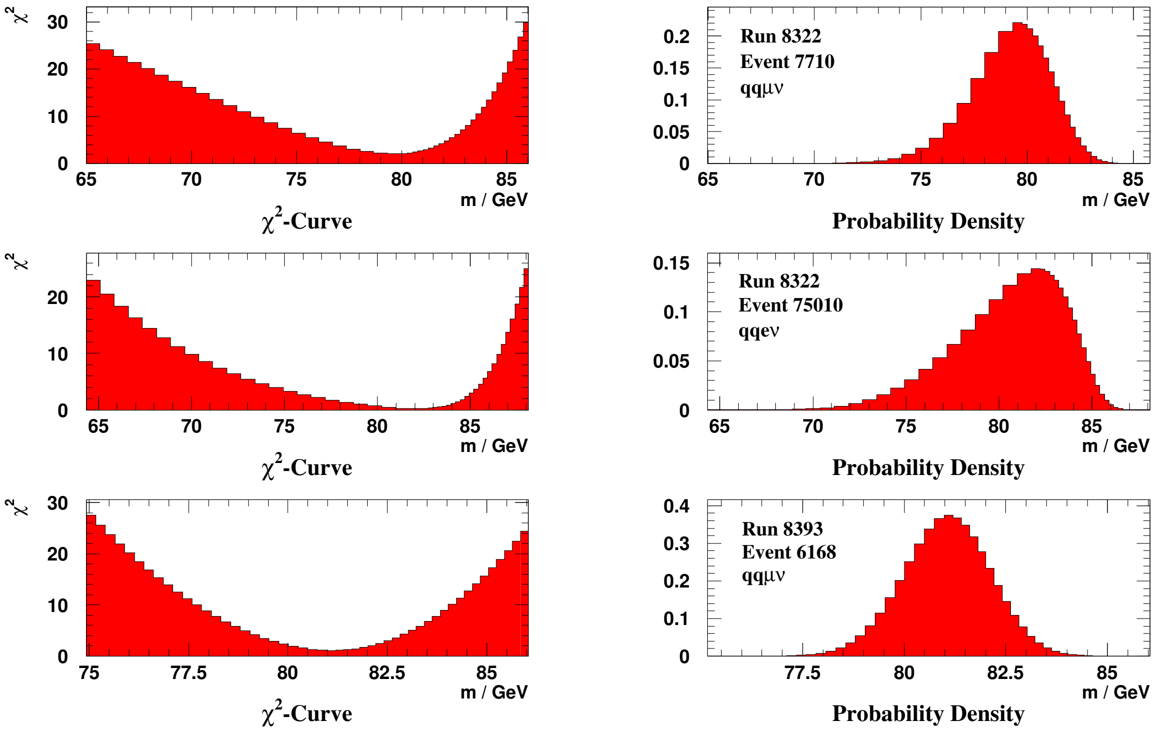
Method

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

- For each event i construct χ^2-function of the jet/lepton energies and momenta with energy/momentum conservation and equal-mass constraint ($m_{\mathrm{W}^-} = m_{\mathrm{W}^+}$)
- Instead of just minimizing the χ^2-function to obtain the mean W-mass m_i of the event, its shape is determined in a certain mass region around the minimum (fix m, minimize χ^2-function $\rightarrow \chi^2(m)$)
- Convert $\chi_i^2(m)$ into probability density $P_i(m)$ ($\rightarrow$ asymmetric errors)

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

Method (cont.)



χ^2-curves and corresponding probability densities for some events

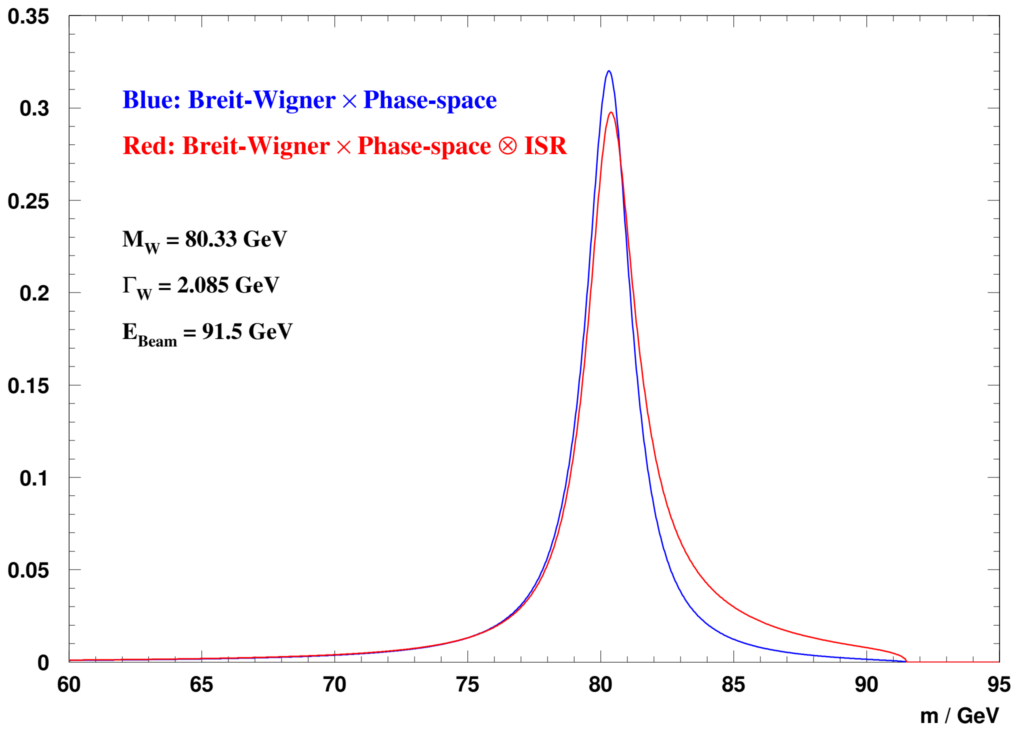
- The Event-Likelihood $L_i(M_\mathrm{W},\Gamma_\mathrm{W})$ is given by the convolution of the physics-function $f(m;M_\mathrm{W},\Gamma_\mathrm{W})$ with $P_i(m)$:

$$L_i(M_\mathrm{W},\Gamma_\mathrm{W}) = \int f(m';M_\mathrm{W},\Gamma_\mathrm{W})\,P_i(m')\,dm'$$

Method (cont.)

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

$$f(m; M_W, \Gamma_W) = \int bw(m, s', s; M_W, \Gamma_W)_{Shifted} \times PS(s', m) \times Q(s')\, ds'$$



Comparison of a relativistic Breit-Wigner function with phase-space factor and the physics-function f

Method (cont.)

- Minimize

$$-\log L(M_{\mathrm{W}},\Gamma_{\mathrm{W}}) = -\log \prod_{i=1}^{N_{Sample}} L_i(m_i; M_{\mathrm{W}},\Gamma_{\mathrm{W}})$$

to get M_{W} and Γ_{W}

Results for 183 GeV data

Integrated luminosity: 57 pb^{-1}

Data events: 260 $qq\ell\nu$ (140 $qqe\nu$, 120 $qq\mu\nu$)

Cuts: Standard WW111 cuts + fit probability > 0.001

Selected events: 237 $qq\ell\nu$ (125 $qqe\nu$, 112 $qq\mu\nu$)

Results:

$$M_\mathrm{W} = 80.37 \pm 0.18 \ \pm 0.09 \pm 0.02 \text{ GeV}$$

$$\Gamma_\mathrm{W} = 2.02\ ^{+0.37}_{-0.32}\ \pm 0.23 \pm 0.02 \text{ GeV}$$

Included Monte-Carlo correction:

M_W : $+0.01$ GeV

Γ_W : $+0.34$ GeV

Expected stat. errors from Monte-Carlo samples:

$\delta M_\mathrm{W} = 0.18$ GeV (Pull: 0.93 ± 0.07)

$\delta\Gamma_\mathrm{W} = 0.33$ GeV (Pull: 1.12 ± 0.08)

Systematics for 183 GeV data

The main MC sample is run 7323 (KoralW at 183 GeV, $M_W = 80.33$ GeV, $\Gamma_W = 2.0933$ GeV)

- **Beam energy**:
  Add 30 MeV to beam energy
- **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
  - **HCAL modeling**:
    Compare results of MC runs 5763 and 6900
- **Fit Procedure**:
  Change convolution range from $\Delta\chi^2 = 25$ to $\Delta\chi^2 = 16$ ("$5\sigma \rightarrow 4\sigma$")
- **MT**:
  Use new MT package instead of GCE

Systematics (cont.)

- **Hadronization**:
  Compare results with HERWIG sample (run 5033)

- **ISR**:
  Compare results from MC runs 7323 and 7667 (only 1. Order ISR effects)

- **4-f Interference**:
  Compare results of two GRC4F samples (run 8056, which includes "all" interfering diagrams, and run 8057, which contains only the CC03 diagrams)

- **Background**:
  Include background events in sample using poisson statistics with a mean value from MC:
  - qq: Select events from $e^-e^+ \to q\bar{q}$ MC-sample (run 5050) and scale to data luminosity: $2.65\ \mathrm{events}/57\ \mathrm{pb}^{-1}$
  - Weν: Select events from $e^-e^+ \to \mathrm{We}\nu$ MC-sample (run 7631) and scale to data luminosity: $0.62\ \mathrm{events}/57\ \mathrm{pb}^{-1}$

Systematic	MC ΔM_W (MeV)	Data ΔM_W (MeV)	MC $\Delta\Gamma_W$ (MeV)	Data $\Delta\Gamma_W$ (MeV)
Beam energy	24	23 ± 6	2	4 ± 15
$E_{jet} \times 0.99$	-9	-18 ± 9	0	0 ± 20
$p_{lep} \times 0.99$	1	5 ± 30	8	26 ± 58
$\delta E_{jet} \times 1.03$	-7	-7 ± 11	-4	-13 ± 18
$\delta p_{lep} \times 1.03$	0	1 ± 7	8	-10 ± 13
$\delta(\theta,\phi)_{jet} \times 1.05$	4	7 ± 7	-14	-18 ± 18
$\delta(\theta,\phi)_{lep} \times 1.03$	0	1 ± 6	1	-2 ± 10
HCAL model	-3 ± 27		-29 ± 41	
Detector total	47 MeV		80 MeV	
Fit	0	0 ± 2	1	3 ± 7
MT	-117	-46 ± 80	-24	-75 ± 170
ISR 1.Order	50 ± 34		109 ± 67	
Hadronization	21 ± 37		-167 ± 72	
4-f	-1 ± 42		-15 ± 78	
Background	6 ± 16		83 ± 26	
Total	88 MeV		229 MeV	

Systematics (cont.)

Comparison with Reweighting method

Results for the Reweighting method are taken from the OPAL 183 GeV W-Mass paper (CERN-EP/98-197)

Expected error on W-Mass (Pull), including background contribution:

Channel	Reweighting method (GeV)	Convolution method (GeV)
$qqe\nu$	0.31	0.26 ± 0.02 (1.02 ± 0.07) 0.24 ± 0.02 (0.95 ± 0.07)
$qq\mu\nu$	0.30	0.27 ± 0.02 (1.07 ± 0.07) 0.26 ± 0.02 (0.95 ± 0.07)

Red: 125 $qqe\nu$, 112 $qq\mu\nu$ events, prob > 0.001

Blue: 119 $qqe\nu$, 107 $qq\mu\nu$ events, prob > 0.001, $m > 65$ GeV, $\delta m > 0.5$ GeV

First look at 189 GeV data

Integrated luminosity: 180 pb^{-1}

Data events: 780 $qq\ell\nu$ (381 $qqe\nu$, 399 $qq\mu\nu$)

Cuts: Standard WW112 + fit probability > 0.001

Selected events: 718 $qq\ell\nu$ (350 $qqe\nu$, 368 $qq\mu\nu$)

Results:

$$M_{\mathrm{W}} = 80.37 \pm 0.13 \ \pm 0.03(det.) \pm 0.02 \text{ GeV}$$

$$\Gamma_{\mathrm{W}} = 2.65 \pm 0.25 \ \pm 0.05(det.) \pm 0.01 \text{ GeV}$$

Included Monte-Carlo correction:

M_{W} : -0.11 GeV

Γ_{W} : $+0.34$ GeV

Expected stat. errors from Monte-Carlo samples:

$\delta M_{\mathrm{W}} = 0.12$ GeV (Pull: 1.05 ± 0.11)

$\delta\Gamma_{\mathrm{W}} = 0.22$ GeV (Pull: 1.06 ± 0.11)

Systematics for 189 GeV data

The main MC sample is run 8058 (KoralW at 189 GeV, $M_W = 80.33$ GeV, $\Gamma_W = 2.0933$ GeV)

Systematic	MC ΔM_W (MeV)	Data ΔM_W (MeV)	MC $\Delta\Gamma_W$ (MeV)	Data $\Delta\Gamma_W$ (MeV)
Beam energy	22	21 ± 5	2	4 ± 10
$E_{jet} \times 0.99$	-10	-11 ± 8	3	-2 ± 15
$p_{lep} \times 0.99$	2	7 ± 22	4	2 ± 34
$\delta E_{jet} \times 1.03$	-8	-12 ± 9	-5	-10 ± 15
$\delta p_{lep} \times 1.03$	-1	-4 ± 6	-7	-25 ± 8
$\delta(\theta,\phi)_{jet} \times 1.05$	3	4 ± 5	-21	-11 ± 12
$\delta(\theta,\phi)_{lep} \times 1.03$	-2	-2 ± 3	2	1 ± 6
HCAL model				
Detector total	29 MeV		52 MeV	
Fit	0	0 ± 2	1	0 ± 7
MT	-141	-209 ± 34	-45	-18 ± 125

Conclusions

- Might be better than Reweighting by 10-15%
- Good agreement between MC and data for systematics
- But still some problems
  - Γ_W too small
  - big effect of ISR modeling
  - large bias on W-mass ($\approx$ 100 MeV) at 189 GeV

Combining asym. errors with the Reweighting method

- Reweighting method only uses W-mass from fit
- Why not use (asym.) errors from χ^2-curves?
  — so, instead of central mass value fill error distributions in histogram, reweight these.
- First crude try showed reasonable results
- Unfortunately a more sophisticated approach led to worse results (larger expected error and wrong pull). Bugs???
- Worth following it up?