Status report
W-mass determination for
$WW \to qqe\nu,\ qq\mu\nu$ events
using a Convolution method

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- Method
- Results
- Systematics
- Conclusions

A copy of the transparencies can be found under /afs/cern.ch/user/d/dubbj/public/ww/ww_141098.ps

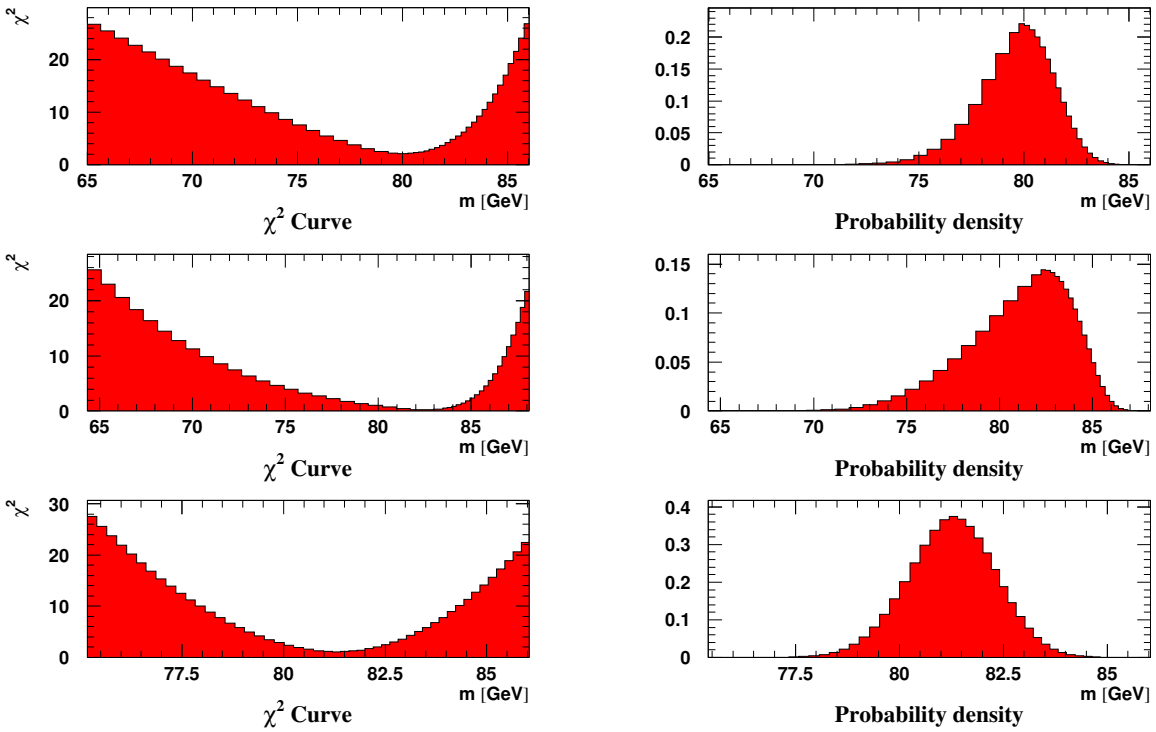
Method

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

- For each event i construct χ^2-function of the jet/lepton energies and momenta with energy/momentum conservation and equal-mass constraint ($m_{W^-} = m_{W^+}$)
- Instead of just minimizing the χ^2-function, 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)

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

Method (cont.)



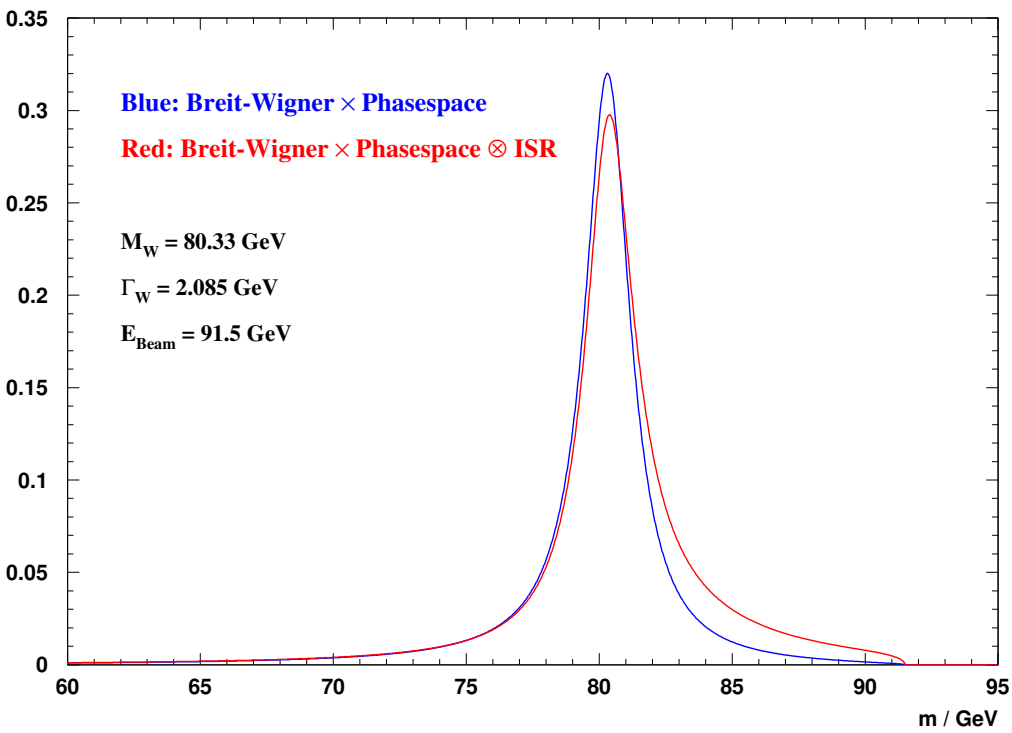
- The Event-Likelihood $L_i(M_W, \Gamma_W)$ is given by the convolution of the physics-function $f(m; M_W, \Gamma_W)$ with $P_i(m)$:

$$L_i(M_W, \Gamma_W) = \int f(m'; M_W, \Gamma_W)\, P_i(m')\, dm'$$

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 $P_{ISR}(s')$ that an ISR photon of energy $E_{ISR}=(s-s')/2\sqrt{s}$ is emitted.
  This takes the effect of ISR on the χ^2-function into account (in the statistic mean)

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



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

Method (cont.)

- Minimize

$$-\log L(M_W, \Gamma_W) = -\log \prod_{i=1}^{N_{Sample}} L_i(m_i; M_W, \Gamma_W)$$

to get M_W and Γ_W

Results for OPAL 183 GeV data

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

Results:

$$M_W = 80.36 \pm 0.18 \ \pm 0.10 \pm 0.03 \text{ GeV}$$

$$\Gamma_W = 2.01 \ ^{+0.37}_{-0.32} \ \pm 0.26 \pm 0.02 \text{ GeV}$$

N.B. Systematic errors not complete

Included Monte-Carlo correction:

M_W : +0.03 GeV

Γ_W : +0.34 GeV

Expected stat. errors from Monte-Carlo Samples:

$\delta M_W = 0.2$ GeV (Pull: 1.07 ± 0.08)

$\delta\Gamma_W = 0.36$ GeV (Pull: 1.09 ± 0.08)

Systematics

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
- **MT**: Use new MT package instead of GCE
- **Hadronization**: Compare results with HERWIG sample (run 5033)
- **ISR**:
  - Redo fits with ISR coefficients taken from Pythia sample (run 5763)
  - Compare results from MC runs 7323 and 7667 (only 1. Order ISR effects)

Systematic	MC ΔM_W (MeV)	Data ΔM_W (MeV)	MC Γ_W (MeV)	Data Γ_W (MeV)
Beam energy	25	24 ± 8	2	2 ± 15
$E_{jet} \times 0.99$	-7	-11 ± 14	2	2 ± 22
$p_{lep} \times 0.99$	4	-5 ± 35	9	18 ± 56
$\delta E_{jet} \times 1.03$	-7	3 ± 14	-1	-6 ± 21
$\delta p_{lep} \times 1.03$	0	3 ± 9	9	18 ± 56
$\delta(\theta,\phi)_{jet} \times 1.05$	5	15 ± 10	-12	-7 ± 20
$\delta(\theta,\phi)_{lep} \times 1.03$	0	0 ± 7	1	-2 ± 11
HCAL model	5 ± 27		20 ± 42	
MT	-105	-36 ± 90	-10	-74 ± 169
Hadronization	36 ± 32		-33 ± 66	
ISR Pythia coeff.	171	167 ± 24	145	167 ± 50
ISR 1.Order	72 ± 39		231 ± 62	
Total	95 (142) MeV		259 (309) MeV	

Systematics (cont.)

Conclusions

- Nice cross-check for other methods
- Good agreement between MC and data
- But still some problems
  - Γ_W too small
  - big effect of ISR modeling
- And much to do
  - 4f systematics
  - background systematics
  - qq$\tau\nu$ channel is missing
  - ...