First studies to a full 2D mass convolution fit

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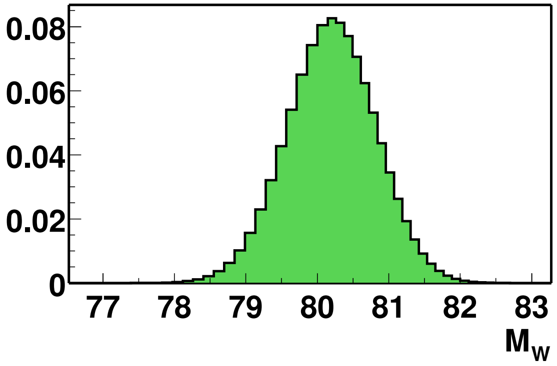
Overview

- The **convolution** method for mass determination
- "1-dimensional" ↔ "2-dimensional" probability functions (equal mass constraint ↔ free masses)
- MC comparisons 2D – 1D - massfits based on 189 GeV data
- Conclusion and to do's



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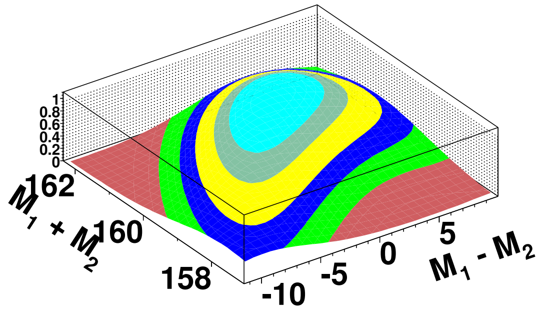


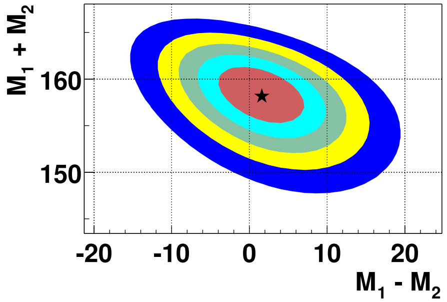
Creating a Likelihood function

$$\mathcal{L}(M_{\mathrm{W}}) = \prod_i \mathcal{L}_i(M_{\mathrm{W}})$$ (Product of event Likelihoods)

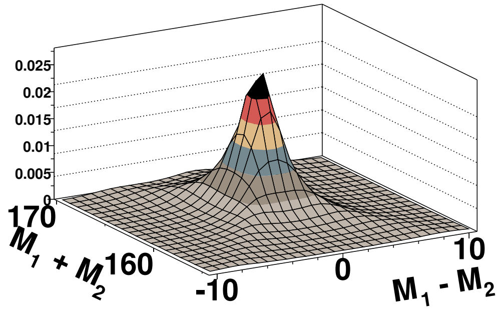
$$\mathcal{L}_i(M_{\mathrm{W}}) = \int\int P_i(m_1, m_2) \cdot f(m_1, m_2; M_{\mathrm{W}}) \cdot dm_1 dm_2$$

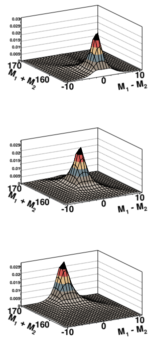
probability-density $\otimes$ physics-function

$P_i(m_1, m_2)$ $f(m_1, m_2; M_{\mathrm{W}})$



$\otimes$





The probability function

kinematic fit $\Rightarrow$ χ^2-**function** $\Rightarrow$ **probability function**

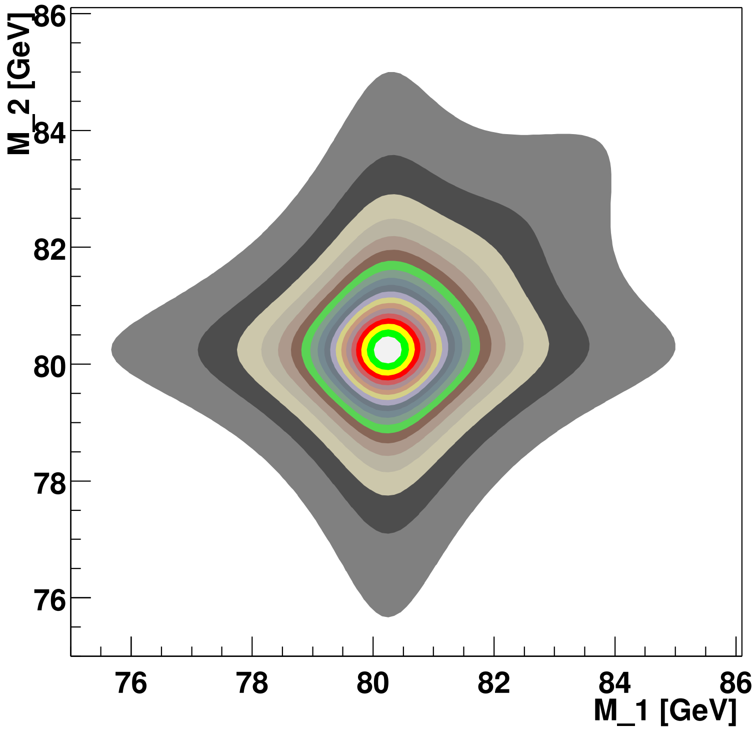
kinematic variables:

- Jet- and lepton energy and momentum
- Neutrino $\Leftarrow$ **momentum conservation**
- constraints: **energy conservation** with penalty function
  - 1D-fit: assume production of equal masses with 2. penalty function
  - 2D-fit: **independent** masses of produced W bosons $\rightarrow$ 1 constraint less

Why independent masses?

finite width of W-boson: equal mass constraint **only approximation**

→ pair of Ws will **not** be produced with exact equal masses



2D χ^2 contour

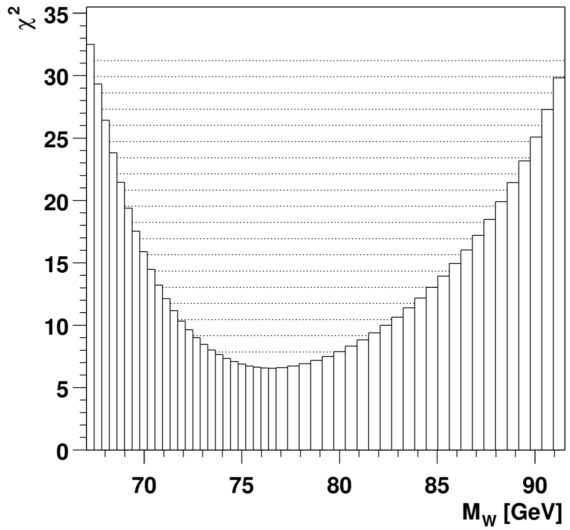
for every event E_i kinematic fit yields:

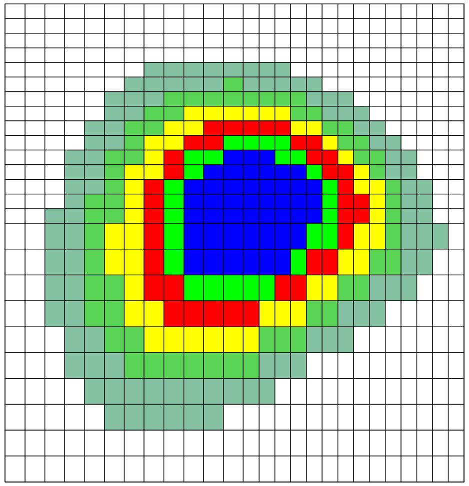
pair of reference masses

$m_{1,i}, m_{2,i}$ at $\chi^2 = \chi^2_{\mathrm{min},i}$

calculate χ^2-function on

appropriate m_1, m_2 grid





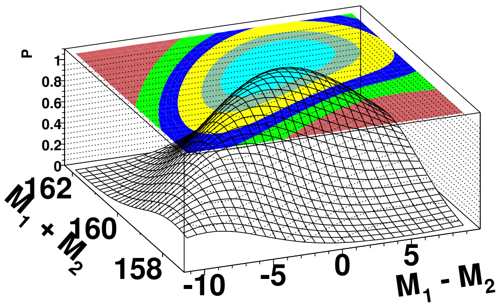
- 1D-Fit (Jörg): $\Delta m_{l/r}$ to m_i with $\Delta\chi^2 > 25 \rightarrow 2$ equidistant grids
- 2D-Fit: use MINUIT - contour to find distances with appropriate $\Delta\chi^2$ and make on all sides equidistant grid

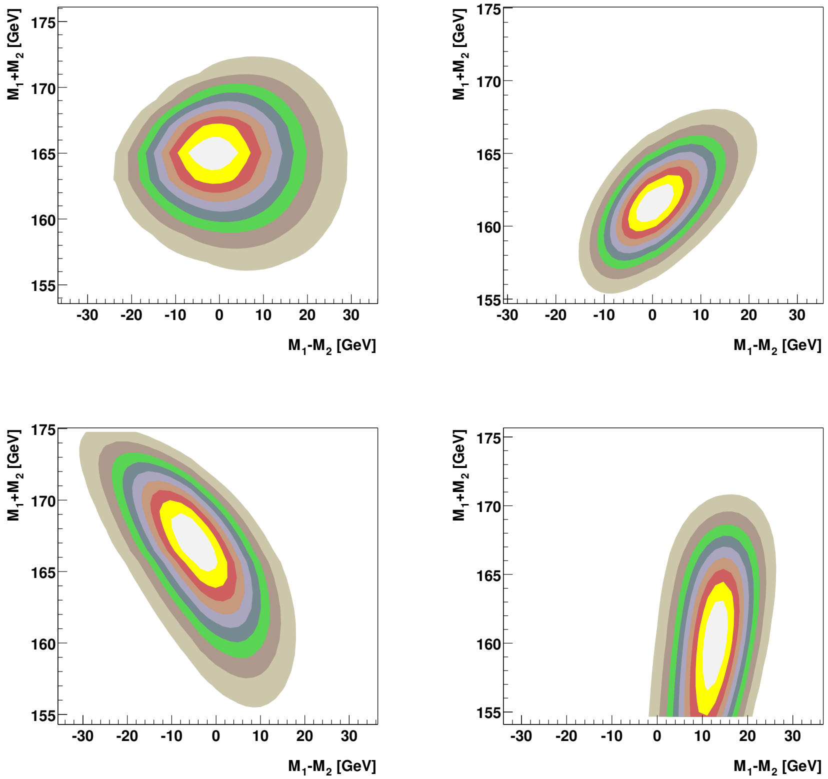
Probabilty function

the $\chi_i^2(m_1, m_2)$-function results in

an **event-probability density** $P_i(m_1, m_2) \propto$

$$\exp\left[-\frac{1}{2}\left(\chi_i^2(m_1, m_2) - \chi^2_{\mathrm{min},i}\right)\right]$$





$\rightarrow$ which contains the generally asymmetric error of the mass-fit

Physics function

probability – by theory – for a certain mass-pair m_1, m_2

under a given mass-hypothesis M_{W} $\Rightarrow$

Superposition of relativistic Breit-Wigner(BW) functions

ISR implementation on statistical way (see Jörg's analysis)

$$f(m_1, m_2; M_{\mathrm{W}}) = \int \mathsf{BW}(\rho \cdot (m_1, m_2), s'; M_{\mathrm{W}}) \times \mathrm{PS}(s', m_1, m_2) \times Q(s')\, ds'$$

$$\mathsf{BW}(\rho \cdot m_1, \rho \cdot m_2) \times Q(s')$$

$\rho = \rho(s')$: mass correction for events with $s = s' \rightarrow \rho = \sqrt{\frac{s'}{s}}$

PS : phase-space factor $\propto \sqrt{s - (m_1 + m_2)^2}$

$Q(s')$: probability for an event with $s = s'$ (from MC)

Mass fit

Making $-\log\mathcal{L} = -\sum\log\mathcal{L}_{\mathrm{i}}$ from complete sample of events
$\rightarrow$ minimizing with MINUIT $\Rightarrow$ **mass** of the W-boson

Sample **selection**:

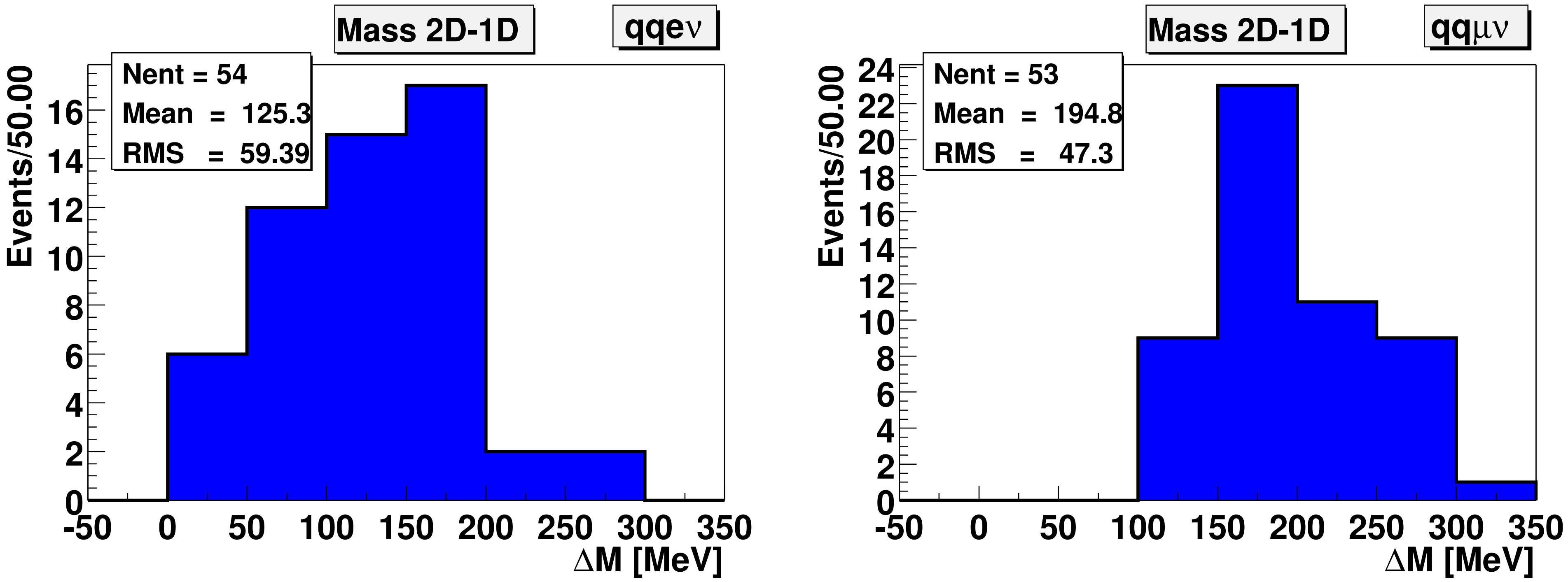
- **189GeV**, semileptonic WW112 selection (compares with Jörg's thesis) (for the moment only $\mathrm{qqe}\nu$ and $\mathrm{qq}\mu\nu$)
- require m_1, m_2 fit probability $P(\chi_i^2) > 0.001$
- require **smooth** χ^2 function (exclude events with "spikes")

Data events after selection cuts

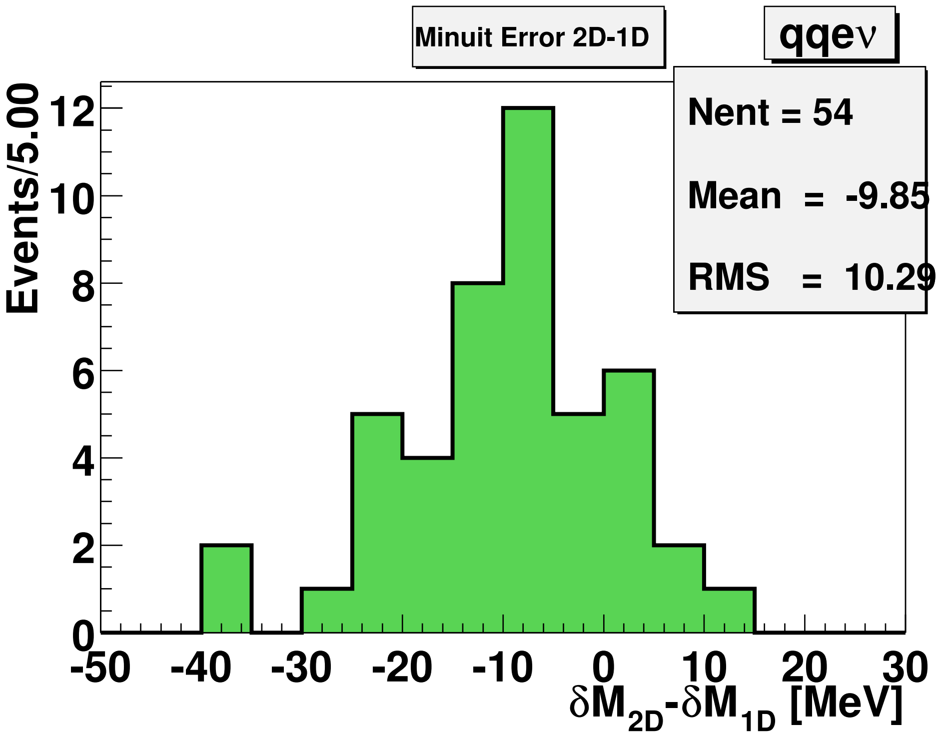
Sel	Channel	Sel. Events	$P > 0.001$	smoothness
1D	$\mathrm{qqe}\nu$	396	367	340
	$\mathrm{qq}\mu\nu$	402	374	355
2D	$\mathrm{qqe}\nu$	396	384	380
	$\mathrm{qq}\mu\nu$	402	381	381
1D	$\mathrm{qqe}\nu$	396	364	335
& 2D	$\mathrm{qq}\mu\nu$	402	366	347

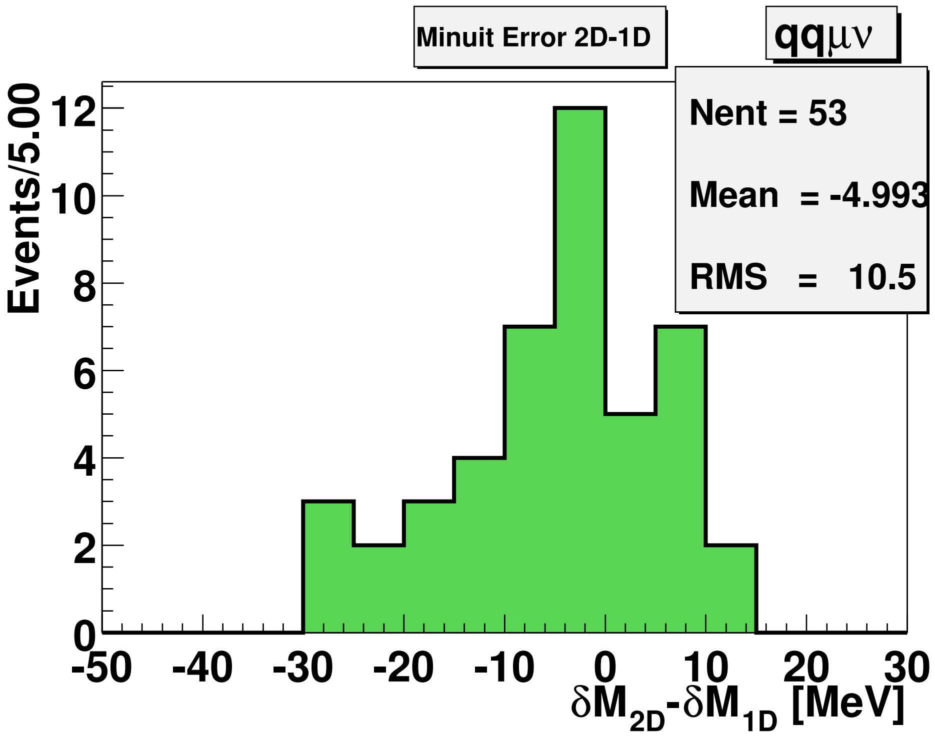
for MC comparisons: only events used which pass both selections

2D - 1D mass per sample

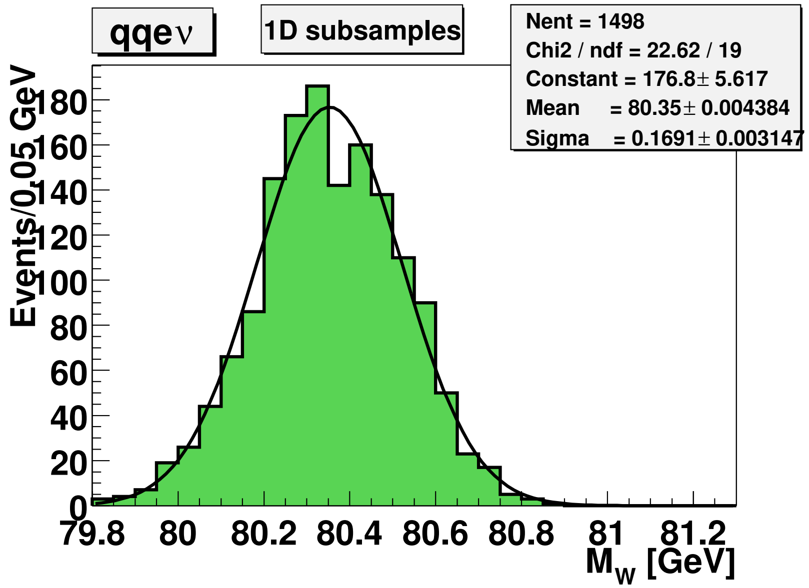


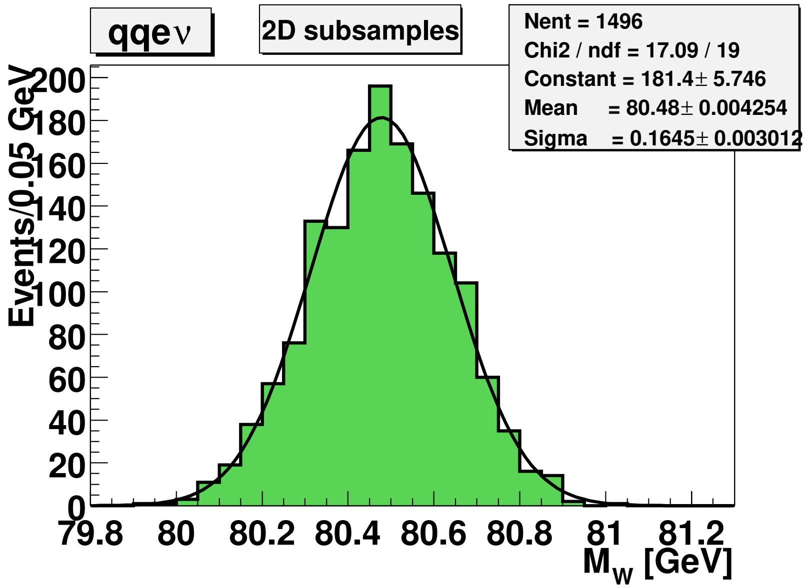
2D - 1D error per sample





Sample tests (1500 Samples)





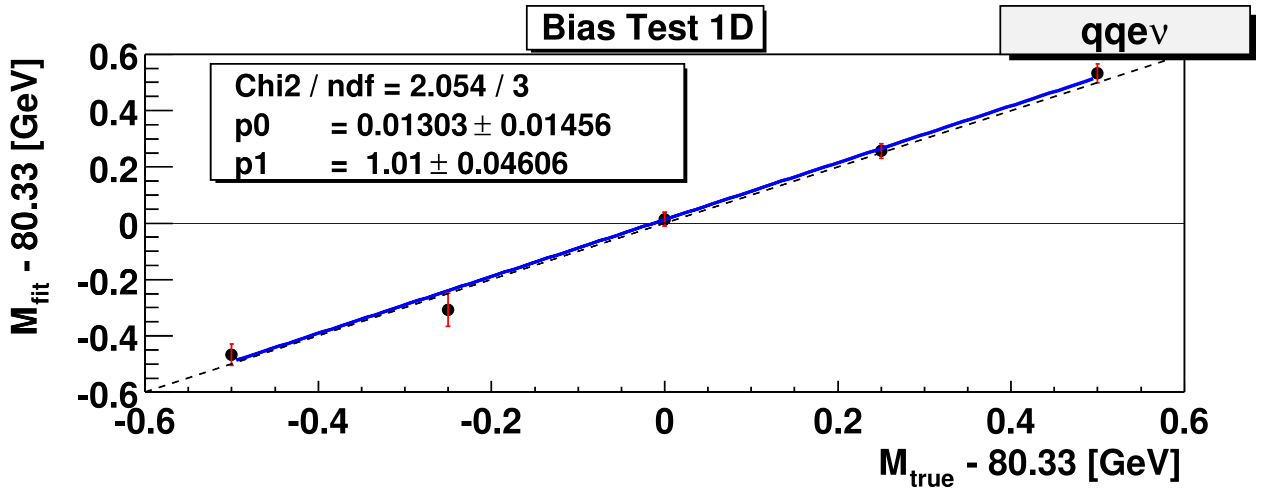
1D - Fit:

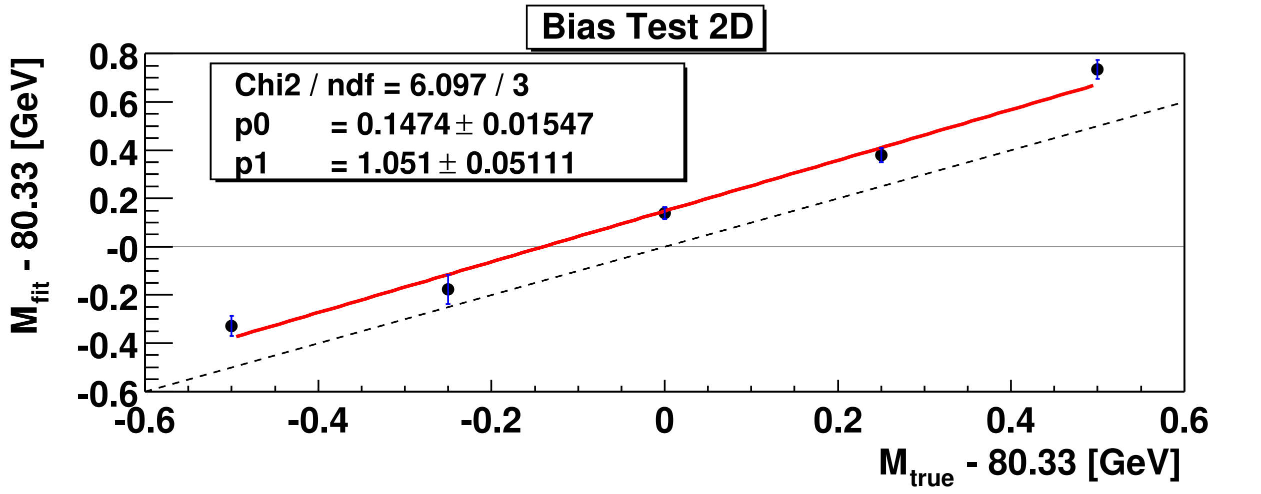
$$M_{\mathrm{W}} = 80.35\,\mathrm{GeV}$$
$$\sigma = 169\,\mathrm{MeV}$$

2D - Fit:

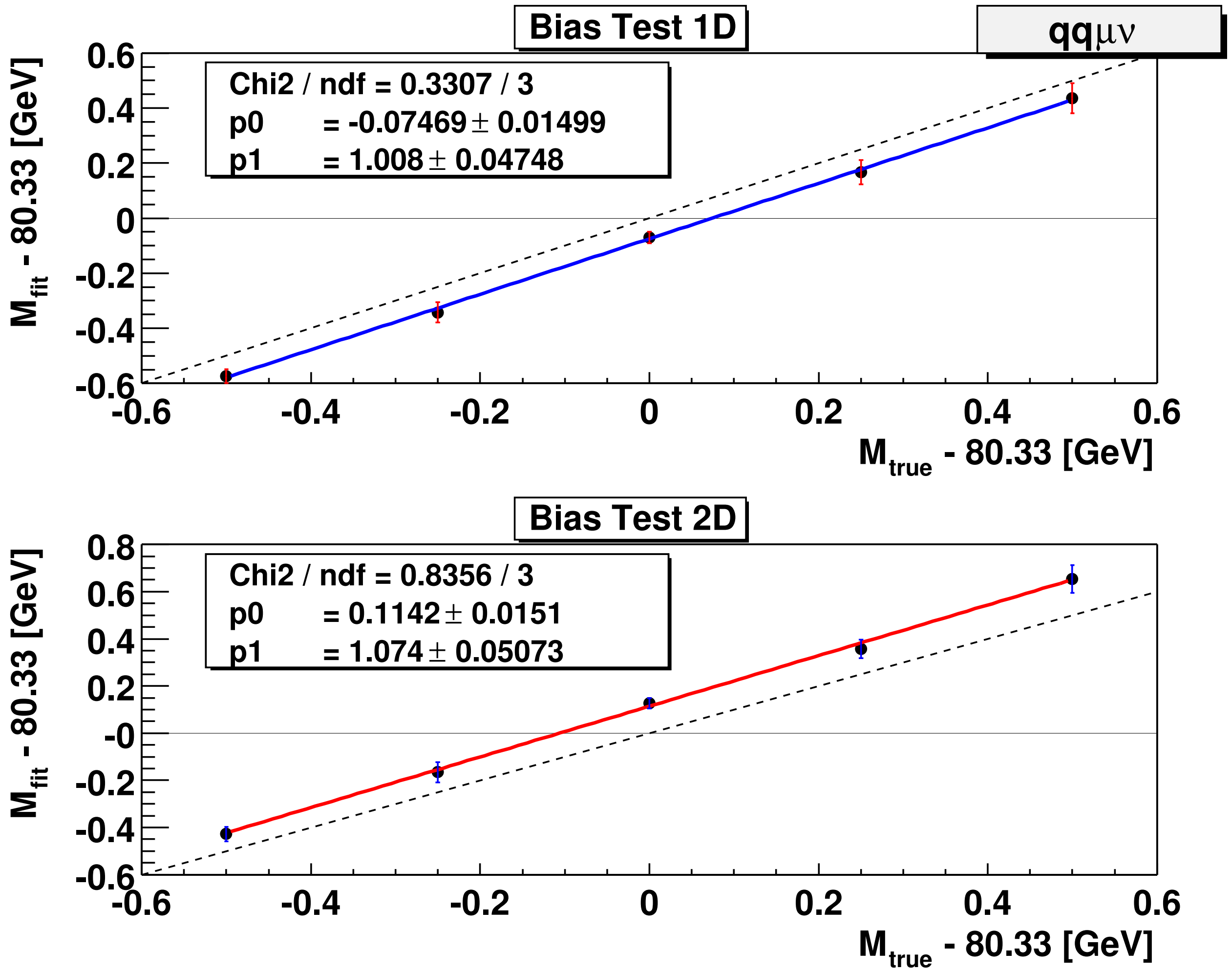
$$M_{\mathrm{W}} = 80.48\,\mathrm{GeV}$$
$$\sigma = 165\,\mathrm{MeV}$$

Bias correction $qqe\nu$

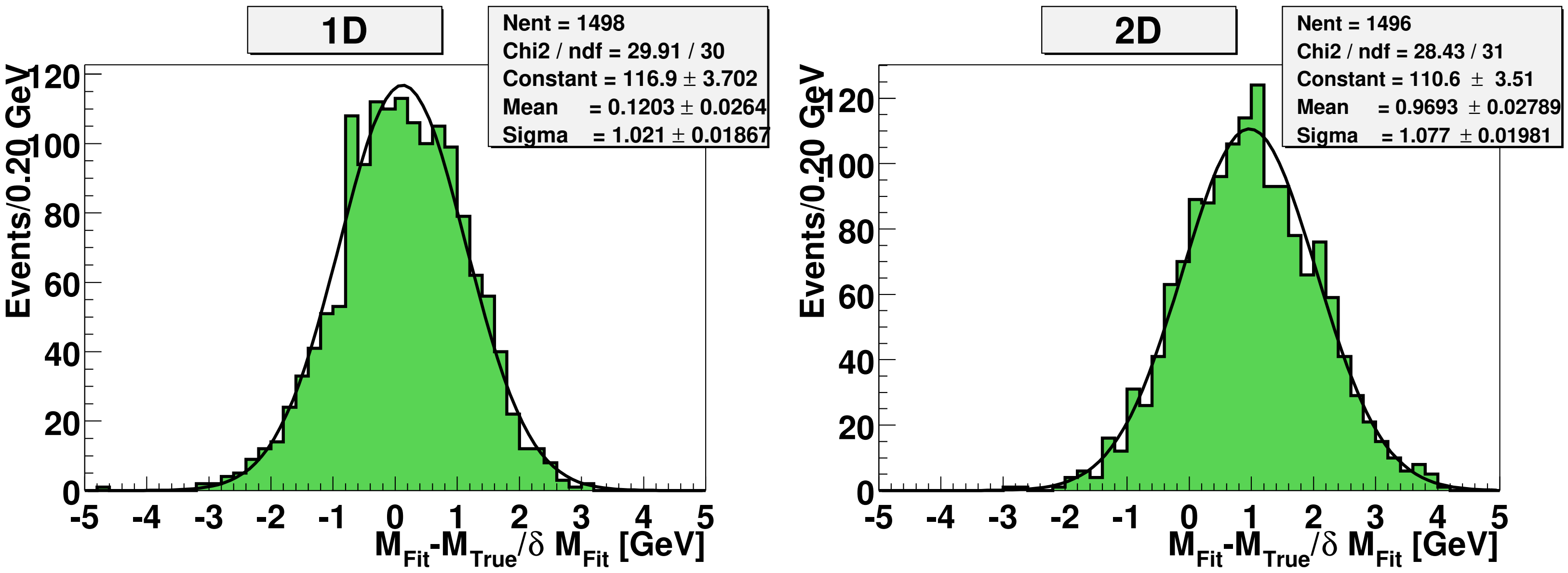




Bias correction $qq\mu\nu$



pull distribution



1D Sigma $= 1.02$ 2D Sigma $= 1.08$

$\sigma/\alpha = 1.01$ $\sigma/\alpha = 1.02$

Conclusions so far

comparison 2D – 1D shows consistent results

2D fit seems slightly better

Error per sample 4-9 MeV **lower** (uncorrected)

spread of samples shows improvement of 4 MeV

Program quite **slow** and memory consuming

χ^2 curves calculation 1D+2D: 38 s / selected event

$\Rightarrow$ **65h** for 6200 $\mathrm{q\bar{q}}\ell\bar{\ell}$-events

21kB/event $\Rightarrow$**128MB**/6200 $\mathrm{q\bar{q}}\ell\bar{\ell}$-events

Still a lot to do

Fit quality cuts:
checking and improving

Background implementation

Results for $qq\tau\nu$-events

Further grid-optimising (MC-grid?)

Faster calculations by avoiding
MINUIT?