Constrained fits for $t\bar{t}$ event selection and top mass determination in the electron + jets channel

Philipp Weigell

Max-Planck-Institut für Physik
ATLAS-SCT Group
München

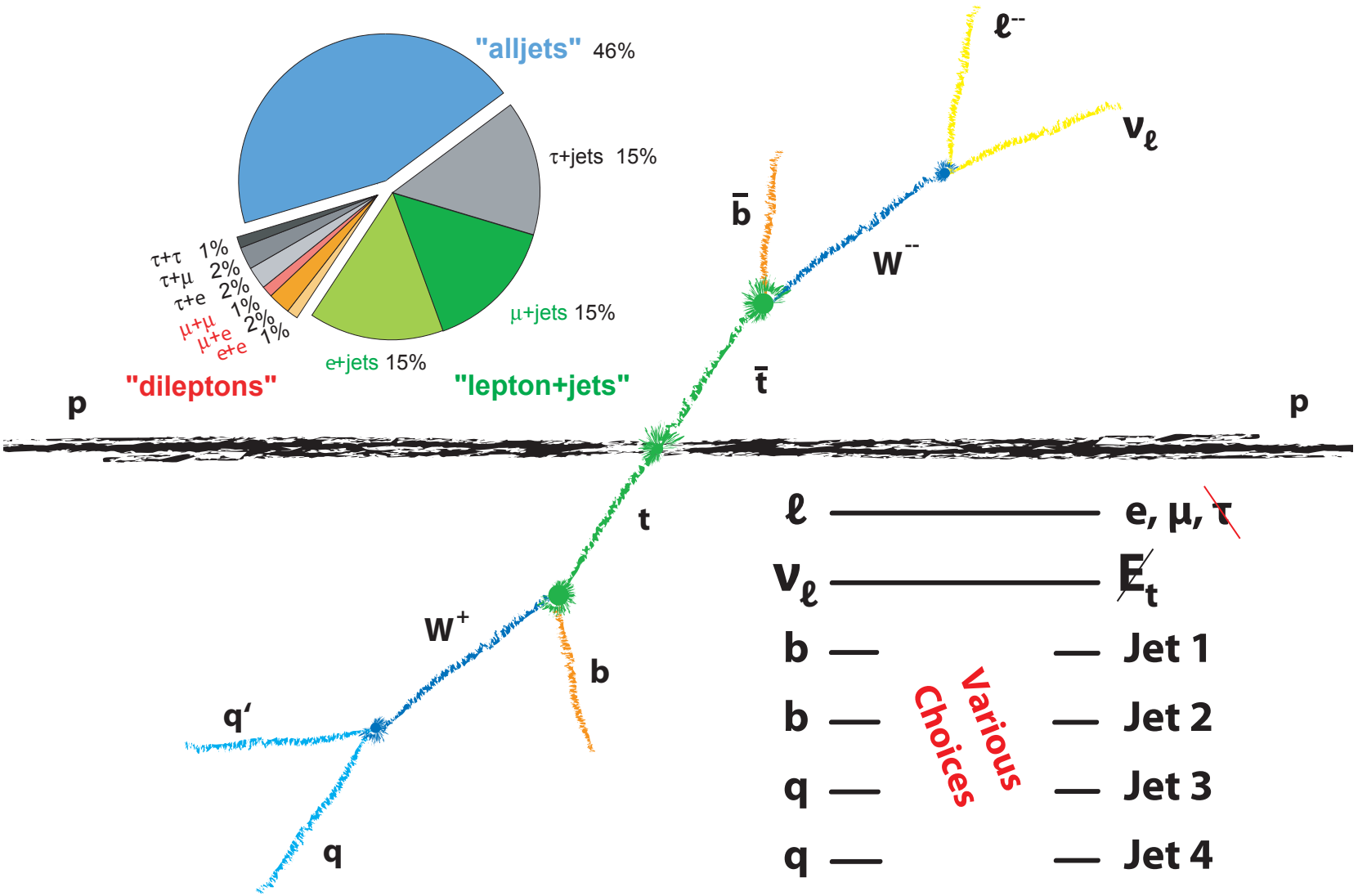
ATLAS-D
Bonn, 24.09.2009

GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung

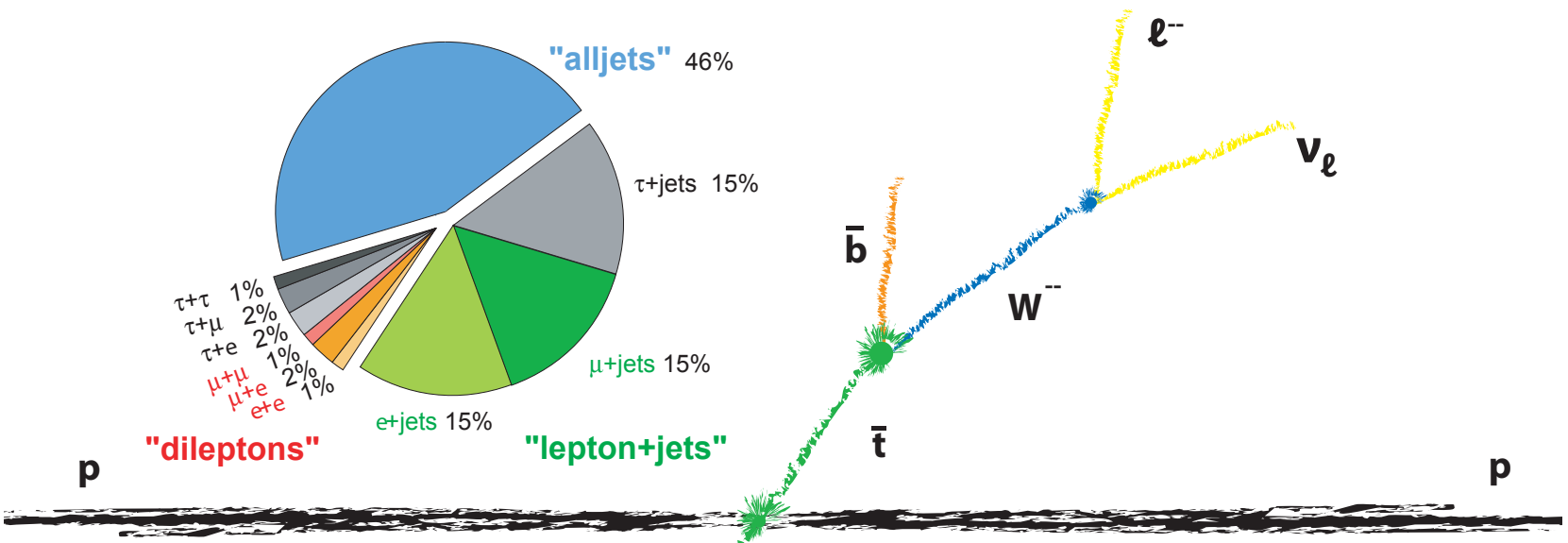
FSP 101
ATLAS

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

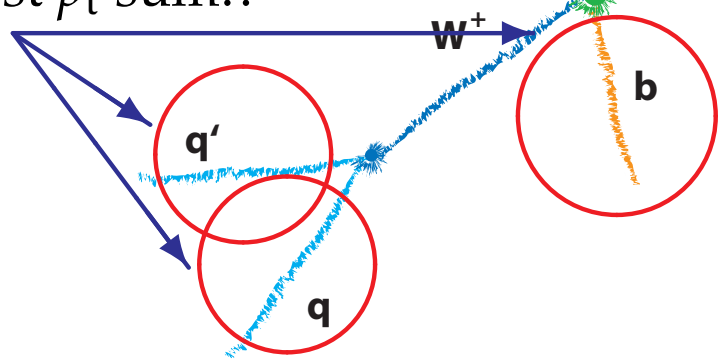
Lepton + jets Channel

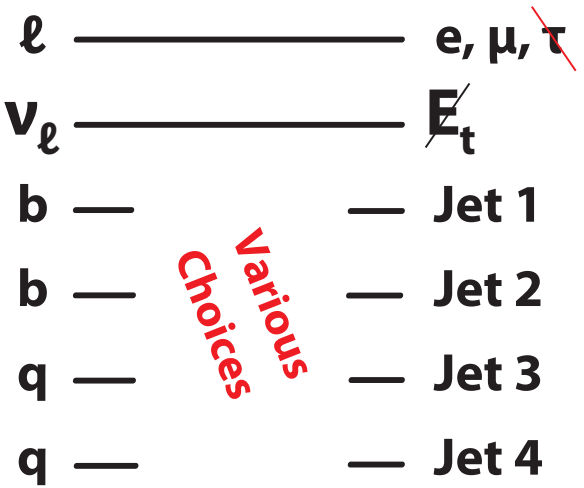


Lepton + jets Channel



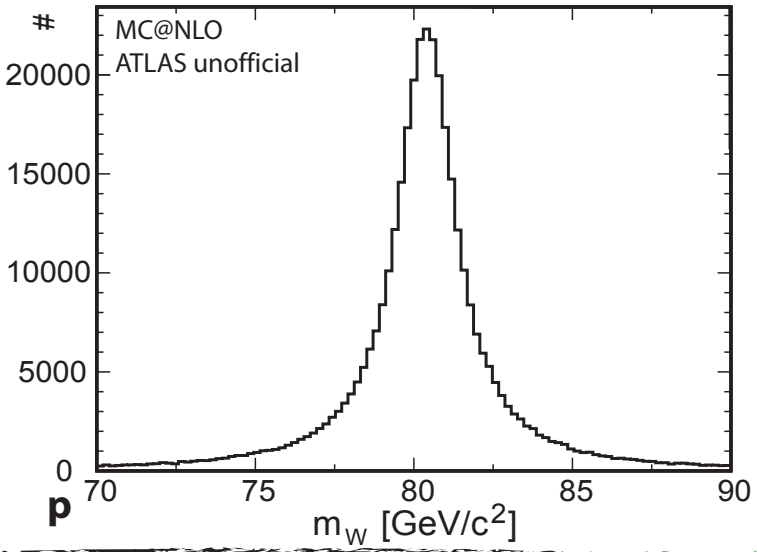
p_t^{max}: Same sphere
$\rightarrow$ highest p_t sum!?





Lepton + jets Channel

World average W mass: 80.398 GeV/c^2



Fit Variables and Constraints

Invariant Masses

- $m_{W,\ell} = \sqrt{(p_\ell + p_\nu)^2} = \sqrt{(E_\ell + E_\nu)^2 - (\vec{p}_\ell + \vec{p}_\nu)^2}$
- $m_{W,\mathrm{h}} = \sqrt{(p_{q_1} + p_{q_2})^2} = \sqrt{(E_{q_1} + E_{q_2})^2 - (\vec{p}_{q_1} + \vec{p}_{q_2})^2}$
- $m_{t,\ell} = \sqrt{(p_\ell + p_\nu + p_{b,\ell})^2} = \sqrt{(E_\ell + E_\nu + E_{b,\ell})^2 - (\vec{p}_\ell + \vec{p}_\nu(p_{\nu,x}, p_{\nu,y}, p_{\nu,z})^T + \vec{p}_{b_\ell})^2}$
- $m_{t,\mathrm{h}} = \sqrt{(p_{q_1} + p_{q_2} + p_{b,\mathrm{h}})^2} = \sqrt{(E_{q_1} + E_{q_2} + E_{b,\mathrm{h}})^2 - (\vec{p}_{q_1} + \vec{p}_{q_2} + \vec{p}_{b,\mathrm{h}})^2}$

Constraints (loose)

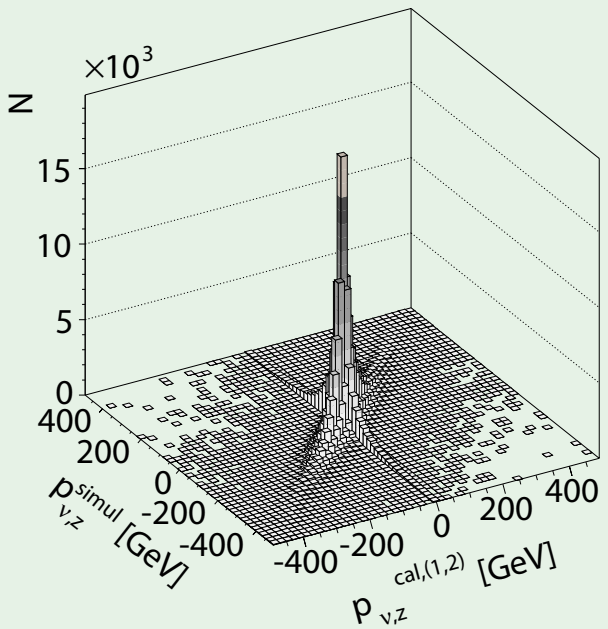
		Initial value	Uncertainty
$m_{W,\ell} - X_1 = 0$	X_1	$80.4\,\mathrm{GeV/c^2}$	$6\,\mathrm{GeV/c^2}$
$m_{W,\mathrm{h}} - X_2 = 0$	X_2	$80.4\,\mathrm{GeV/c^2}$	$6\,\mathrm{GeV/c^2}$
$m_{t,\ell} - m_{t,\mathrm{h}} - X_3 = 0$	X_3	$0\,\mathrm{GeV/c^2}$	$5\,\mathrm{GeV/c^2}$

Neutrino Treatment

ν not measured $\rightarrow$ need to recover

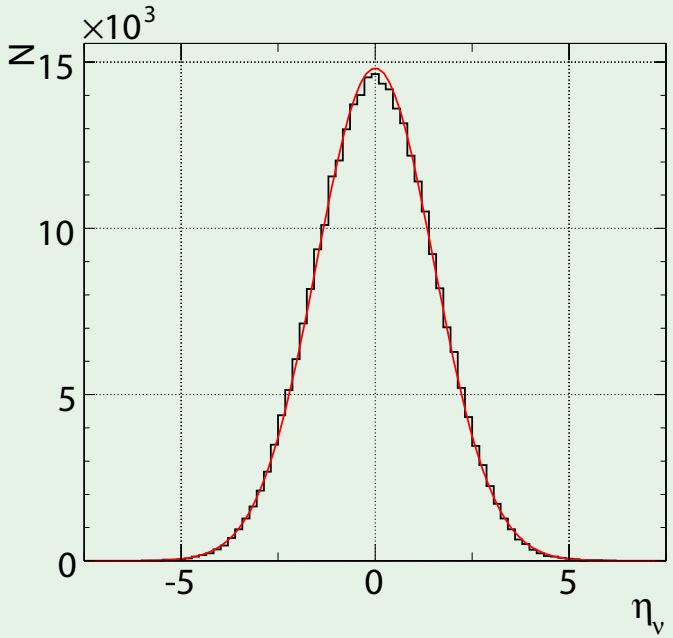
Standard: $p_{\nu,z}$

Idea Calculate $p_{\nu,z}$ from W constraint



Novel: η_ν

Idea Use Pseudorapidity



From Dataset to Selection

Datasets

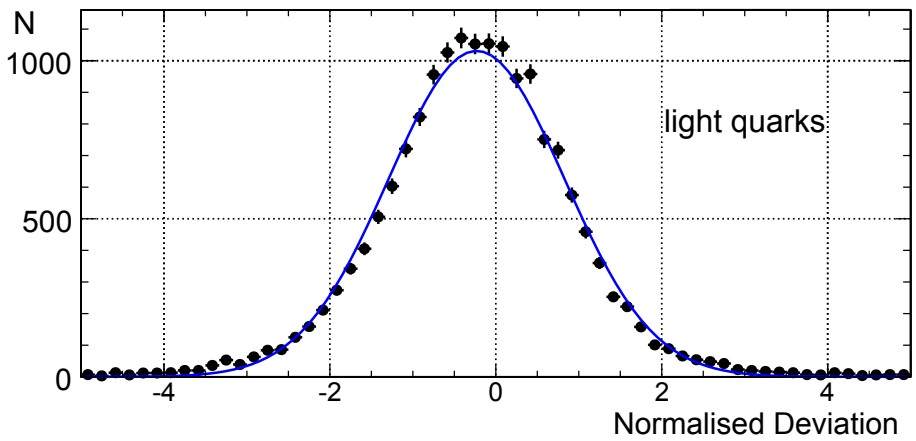
Statistics	11.5k e + jets events
Generator	MC@NLO + Herwig/Jimmy + Geant
Phase Space	Restrictions
Matched	3.5k within $\Delta R < 0.2$

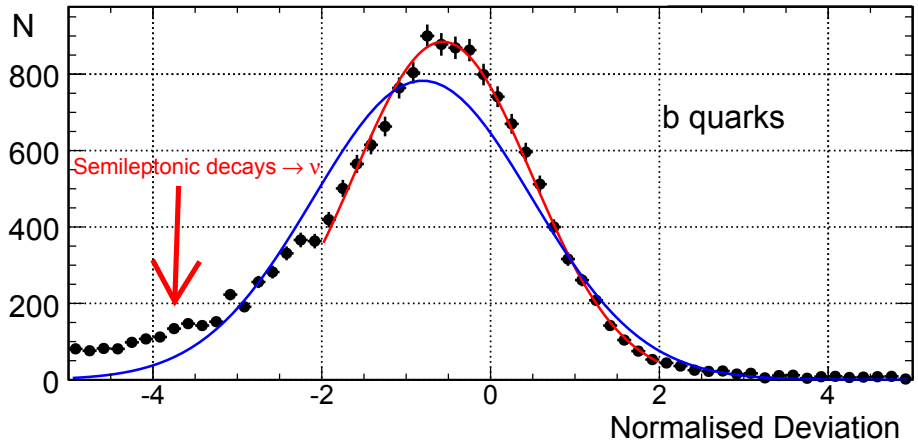
- $N_{jet} = 4$ & $N_e = 1$
- $p_t > 20\,\mathrm{GeV/c}$ & $\|\eta\| < 2.5$

Determination of the Resolution

We assume the following detector resolution:

$$\frac{\sigma(E)}{E} = \frac{\alpha_i}{\sqrt{E}} \qquad [E] = \text{GeV}$$





	b quarks	light quarks	leptons
α_i	148 %	114 %	21 %

(Distributions not centered at 0 due to jet energy scale)

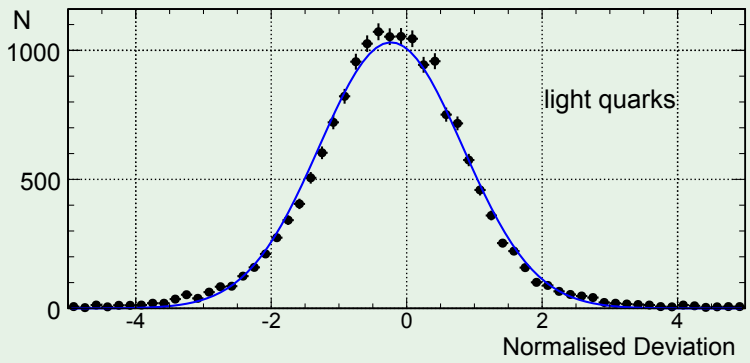
From Dataset to Selection

Datasets

Statistics	11.5k e + jets events
Generator	MC@NLO + Herwig/Jimmy + Geant
Phase Space	Restrictions
	• $N_{jet} = 4$ & $N_e = 1$
	• $p_t > 20\,\mathrm{GeV/c}$ & $\|\eta\| < 2.5$
Matched	3.5k within $\Delta R < 0.2$

+

Resolution



Selection Recipe

1. Take an event
2. Assign each jet to all possible roles $\Rightarrow$ e. g. 12 Permutations for 4 jets
3. Do the fit
4. Select the permutation with the smallest χ^2

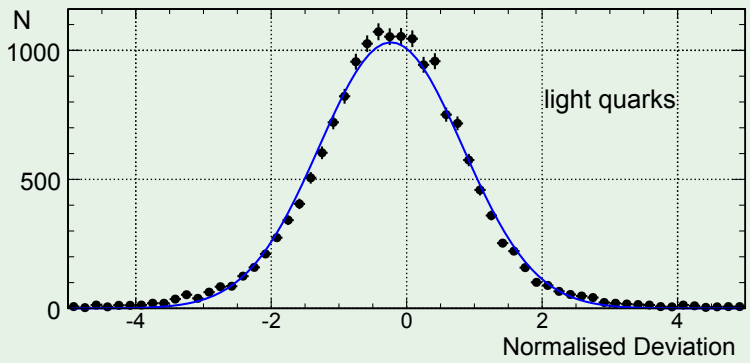
From Dataset to Selection

Datasets

Statistics	11.5k e + jets events
Generator	MC@NLO + Herwig/Jimmy + Geant
Phase Space	Restrictions
	• $N_{jet} = 4$ & $N_e = 1$
	• $p_t > 20\,GeV/c$ & $\|\eta\| < 2.5$
Matched	3.5k within $\Delta R < 0.2$

+

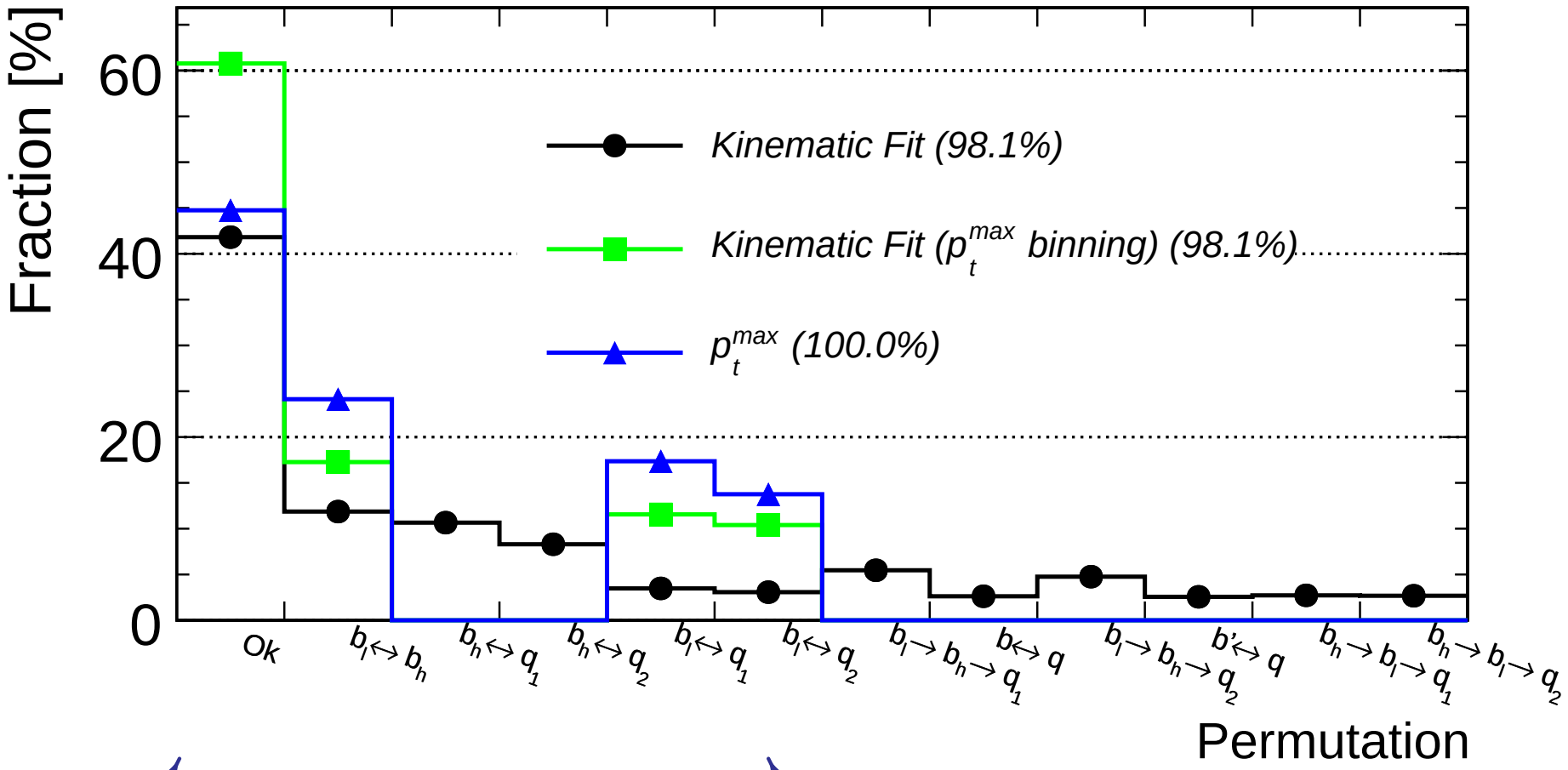
Resolution

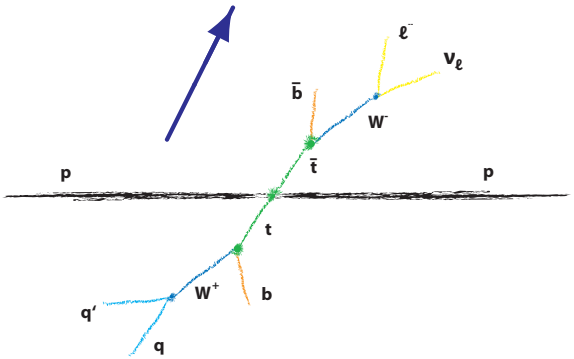


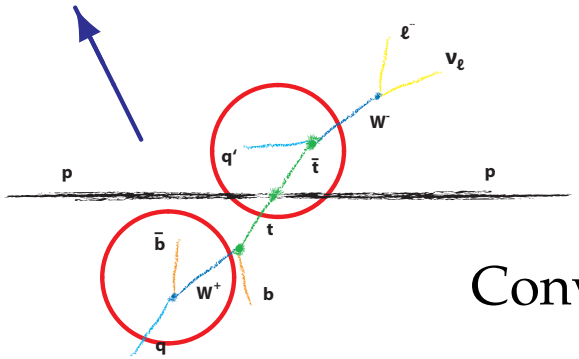
Selection Recipe

1. Take an event
2. Assign each jet to all possible roles $\Rightarrow$ e. g. 12 Permutations for 4 jets
3. Do the fit
4. Select the permutation with the smallest χ^2

Distribution of Selected Permutation



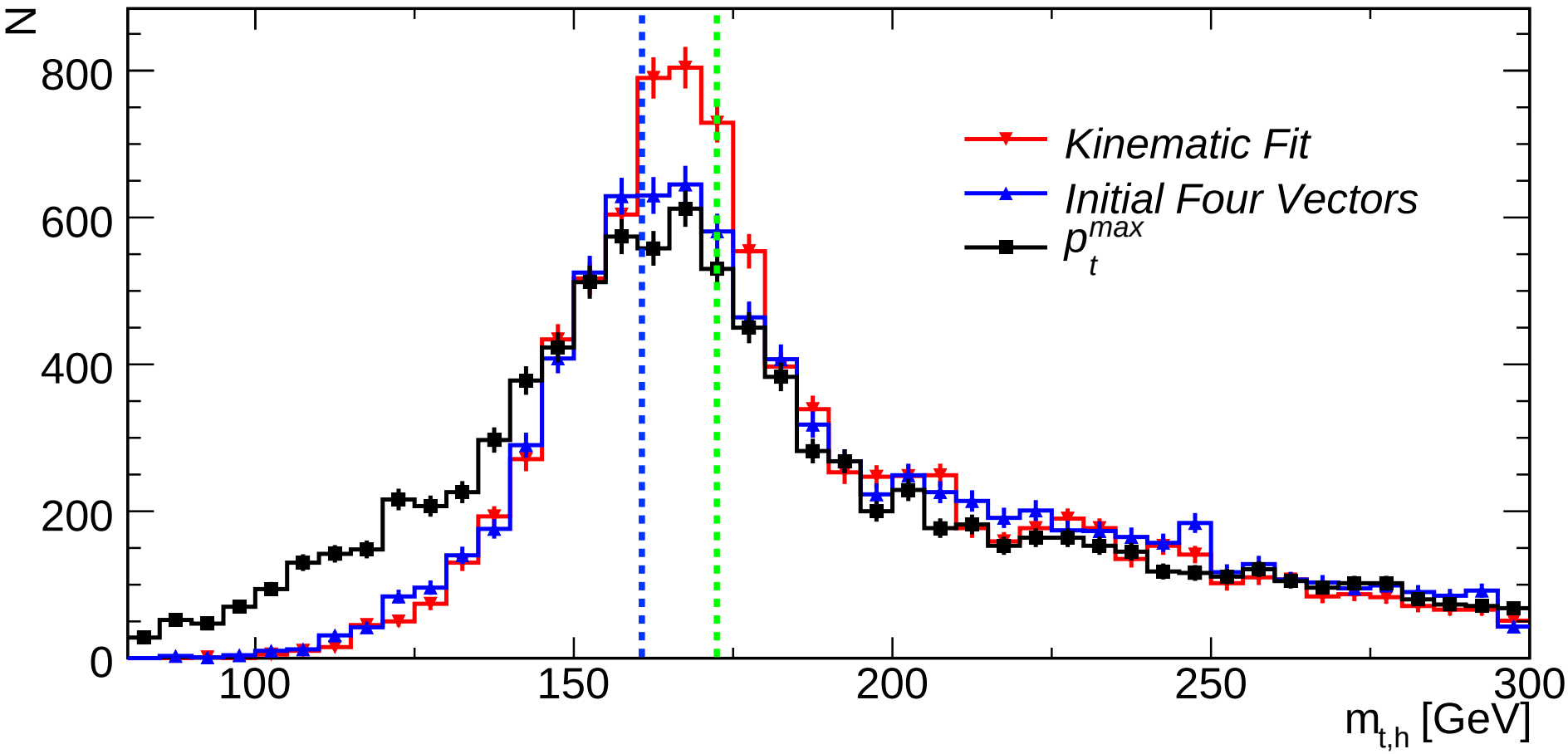




Convergence rate: 98.1 %

Mass Resolution Improvement

Fitting process → Improved four vectors → Resolution



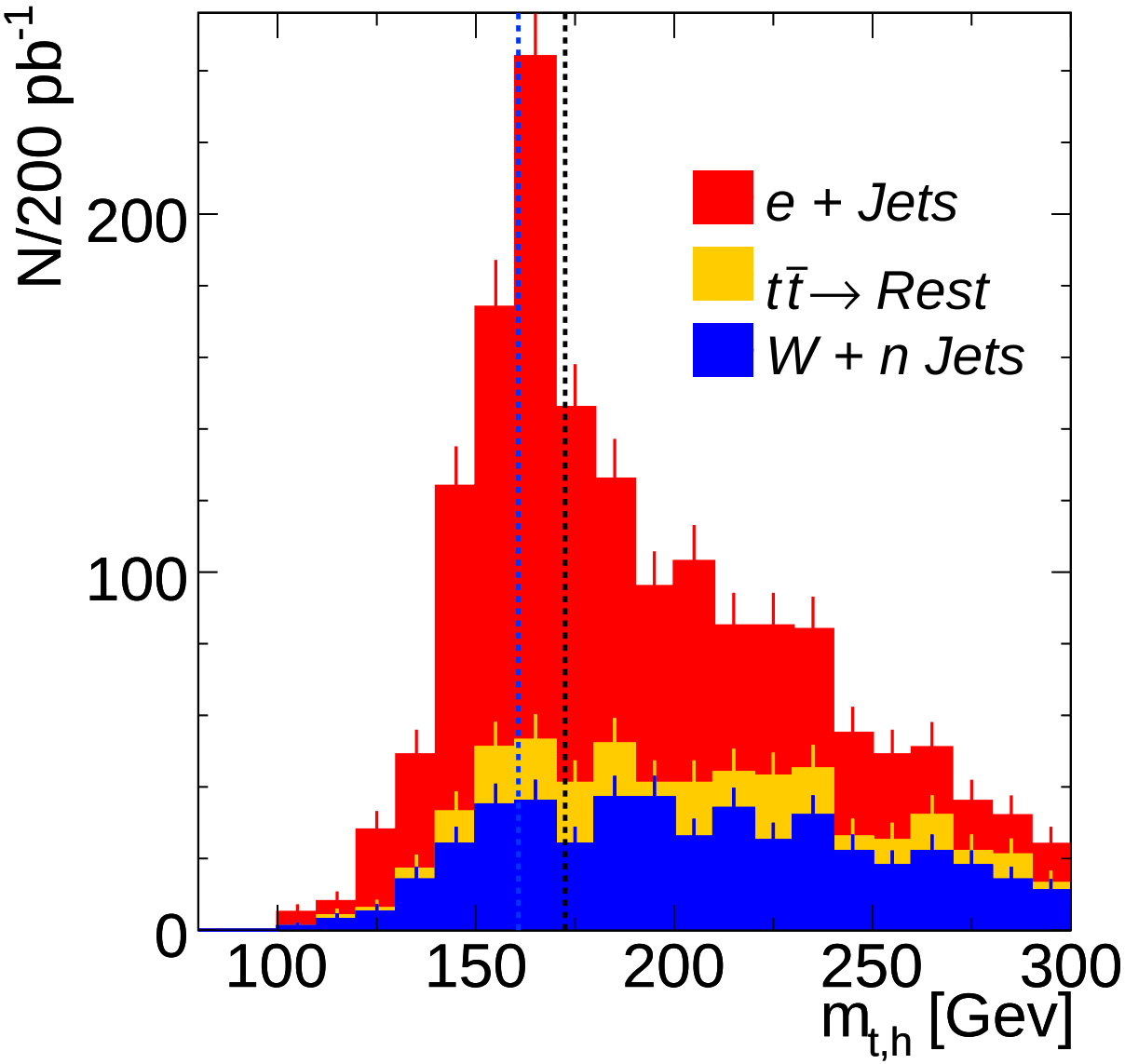
Convergence Rates

Fit converges more often for signal than background ...

T	$t\bar{t}$(e + jets)	$t\bar{t}$(rest)	W + 4 jets	W + 5 jets
$p_{\nu,z}$	87.2	70.8	76.9	73.7
η_ν	87.5	70.0	76.0	72.4

... and the novel approach for the ν performs better

Mass Reconstruction



Conclusions and Outlook

Conclusions

- Constrained χ^2-fit + loosening for widths
- Fit selects correct jets in about $\approx$65 % ($p_{t,max}$: $\approx$40 %)
- Neutrino recoverment better with η_ν
- Backgrounds can be suppressed
- Constraints (m_W, ...) improve resolution