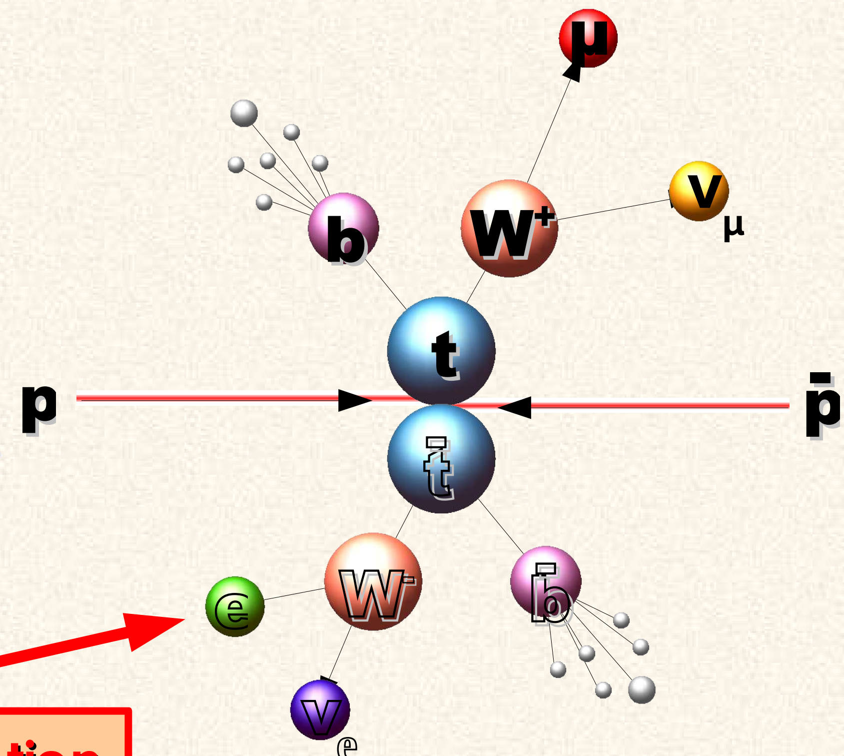
Mesurement of the Top Mass in Dilepton Final States

Christian Schwanenberger

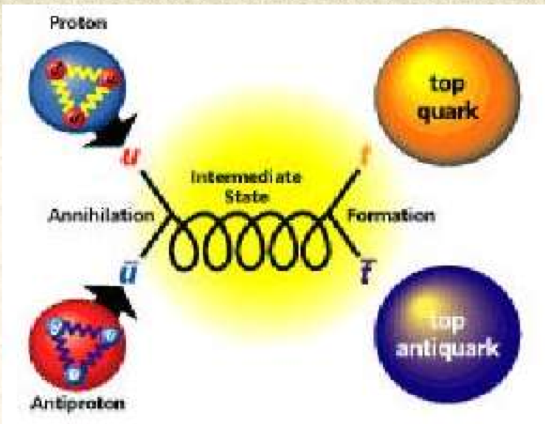


electron identification

Manchester Christmas Meeting , 20-12-2006

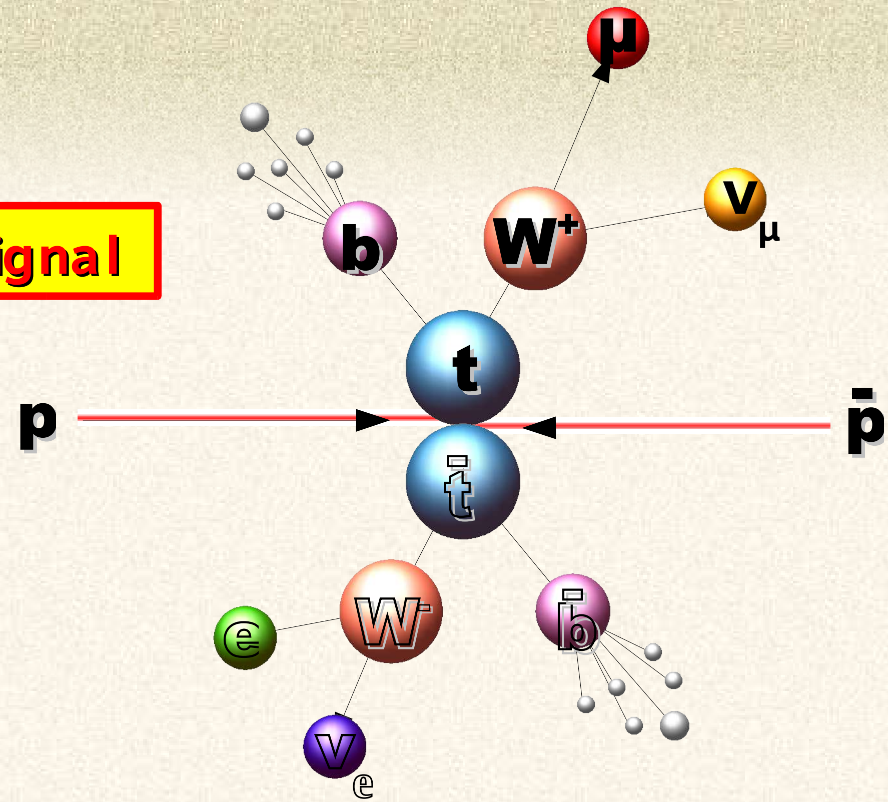
Event Topology in Dilepton Channel

strong production of top pairs

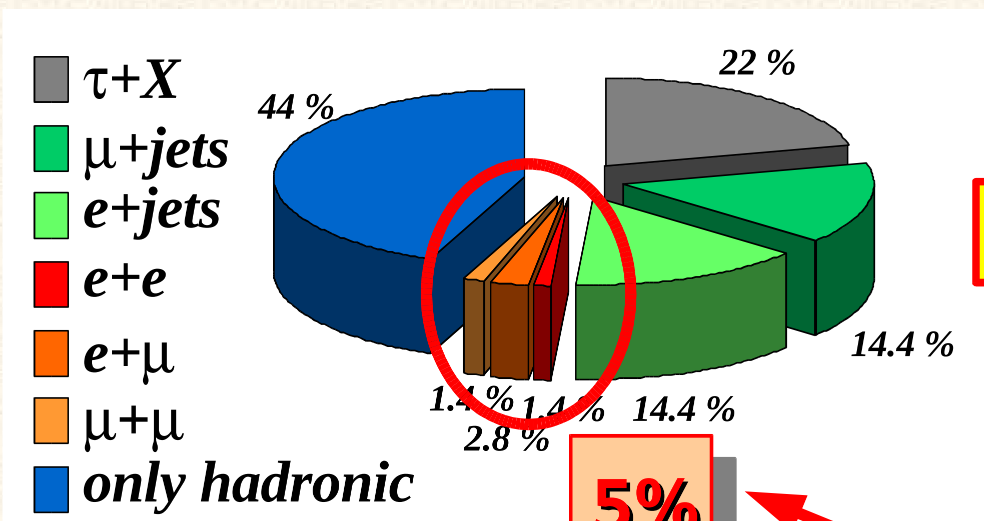


85%

signal

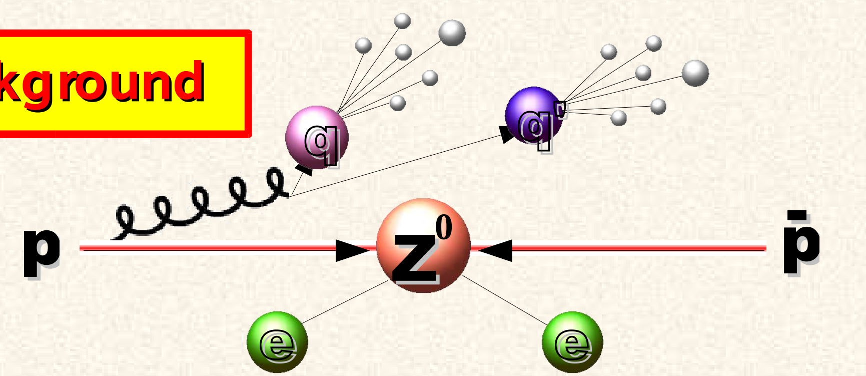


final states



5%

background

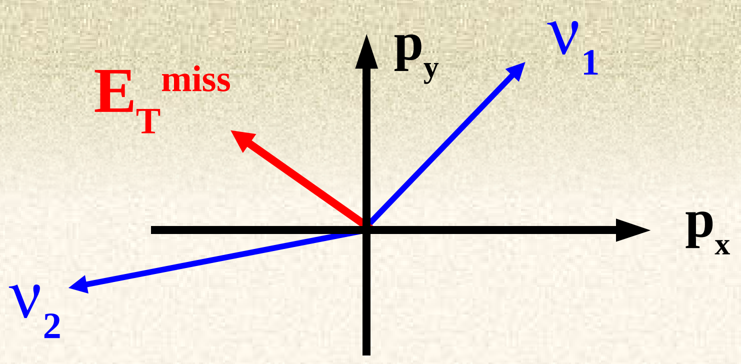


small background ➡ precise measurement in future

Characterisation of Dilepton Events

Problem:

- kinematics is undercontrained due to 2 neutrinos
- multiple solutions: which jet or (l,ν) pair belongs to which top or anti-top quark?

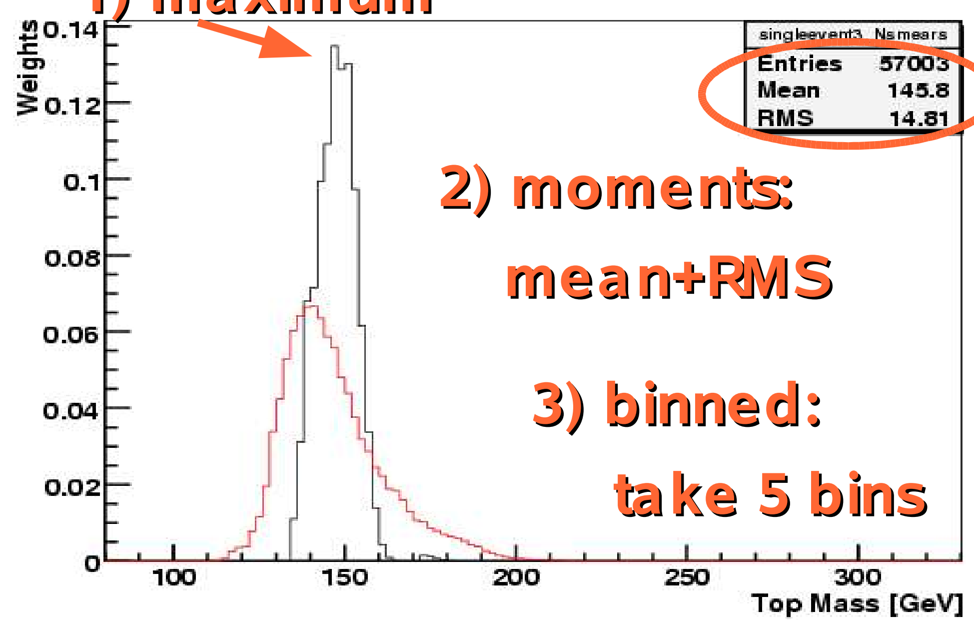


no ν p_z information

➡ apply weight $W(m_t)$ to each event:

neutrino weighting algorithm

1) maximum

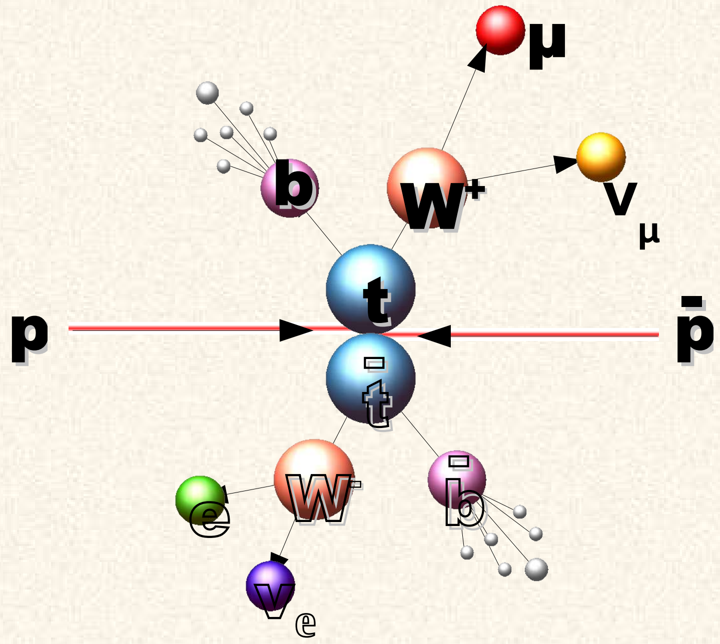


2) moments:

mean+RMS

3) binned:

take 5 bins

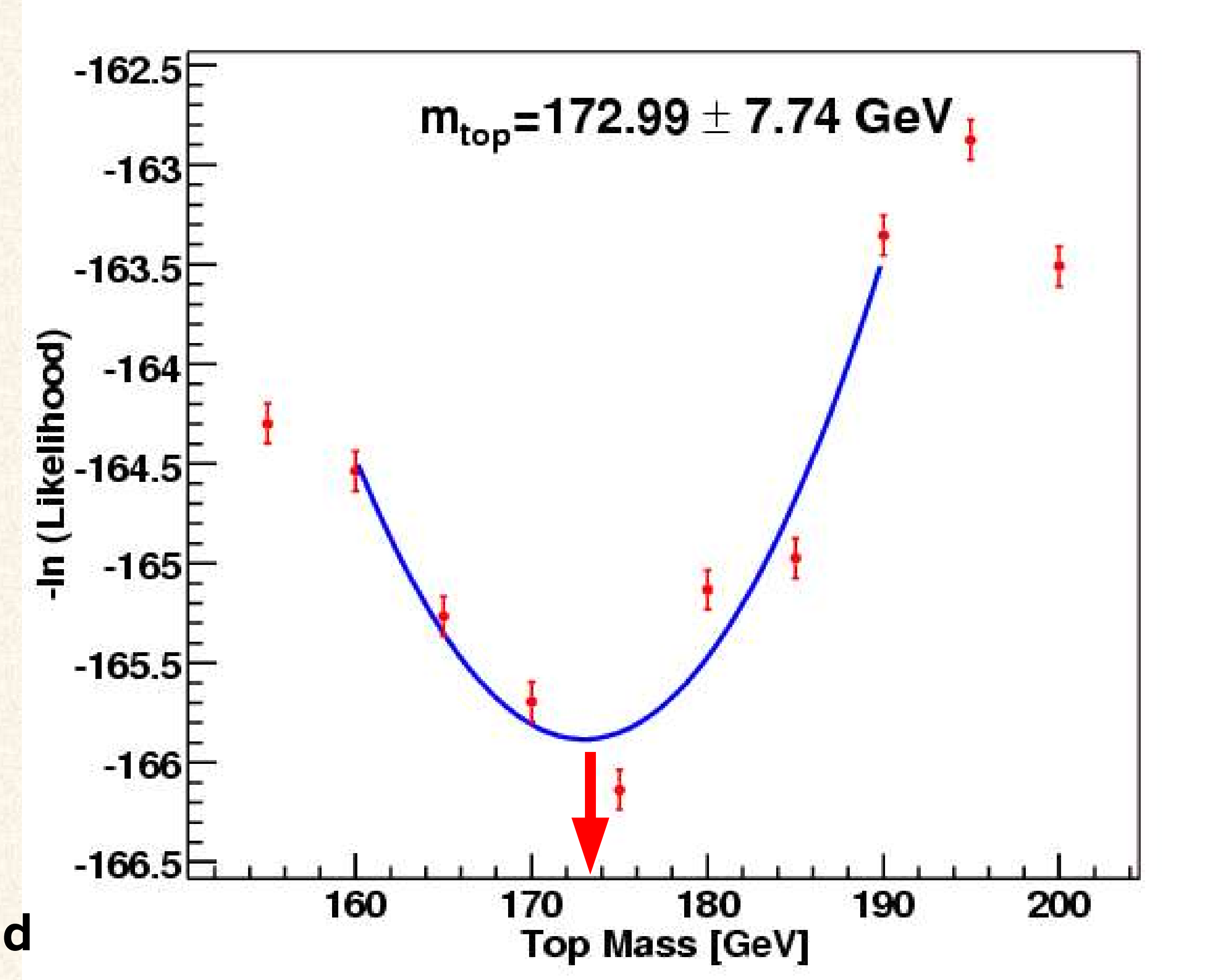


example event

Measurement of Top Mass

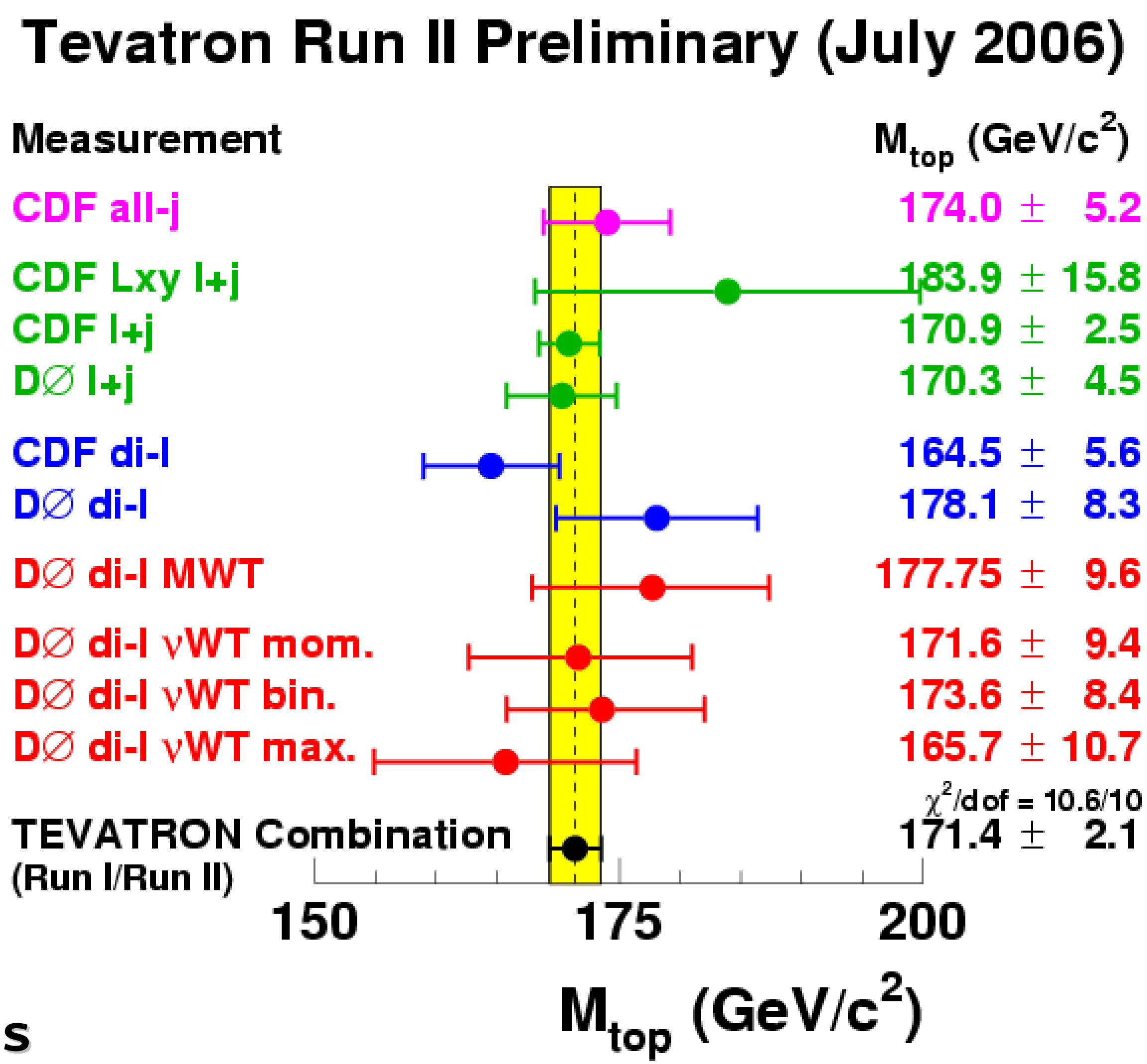
use maximum Likelihood method

$$L(m_{top}) = L_{shape}(m_{top}) \times L_{n_b} \times L_{n_s+n_b}$$



Binned Method

Summary: Top Mass Measurements



combine

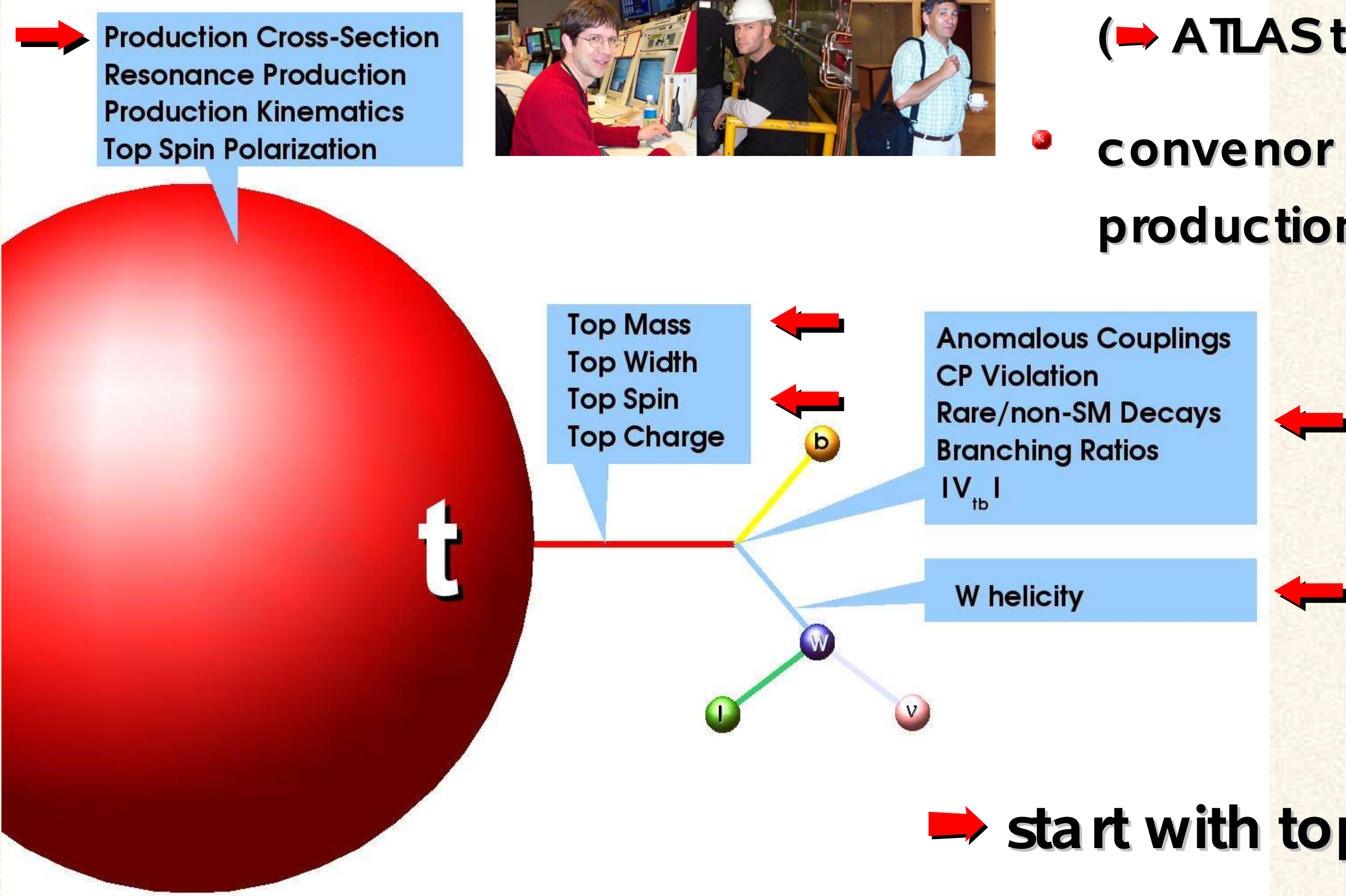
advantages

of all 3 methods

- ➡ improve systematic uncertainties
- ➡ more statistics including more channels

Other Activities

- convenor at DØ for electron identification
- measurement of spin correlations in top pair production (➡ ATLAS talk)
- convenor at DØ for top pair production

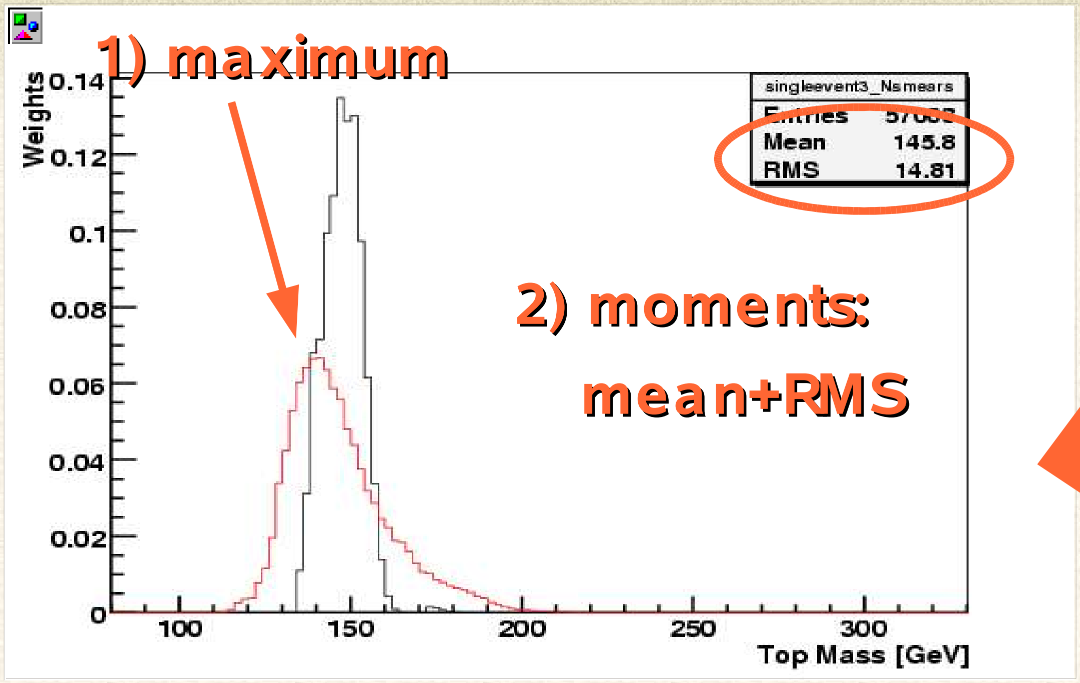


➡ start with top physics at ATLAS

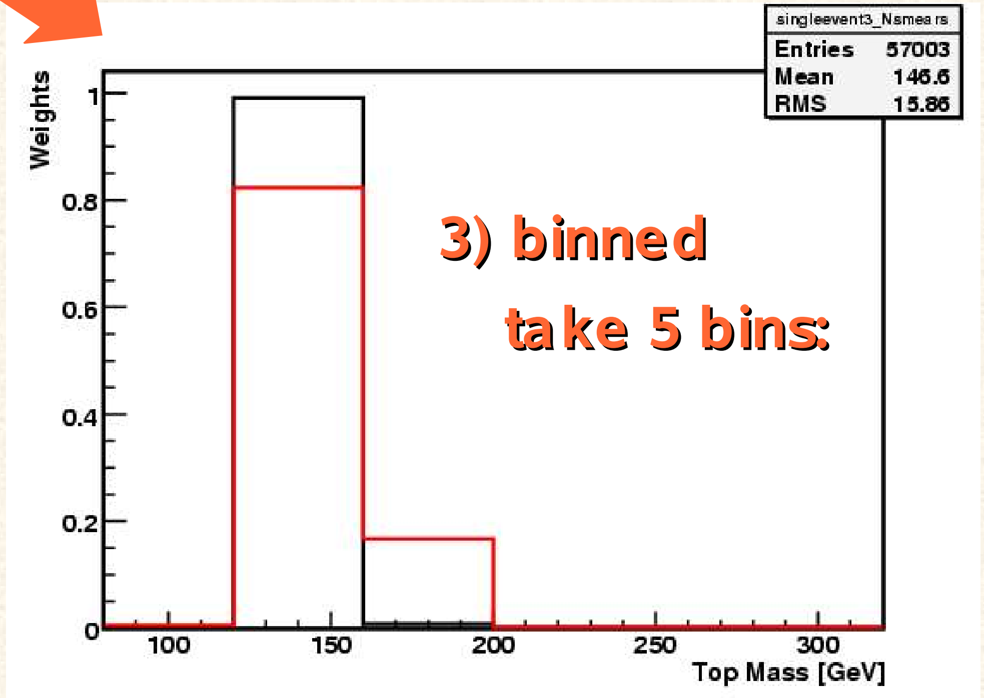
Backup

3 Methods for νWT Methods

Weight as function of reconstructed top



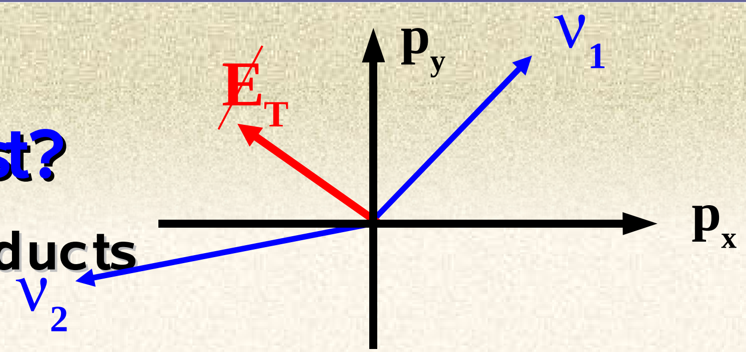
red histograms after 150 times smearing



➡ **combine advantages of all 3 methods**

Characterisation of Dilepton Events (I)

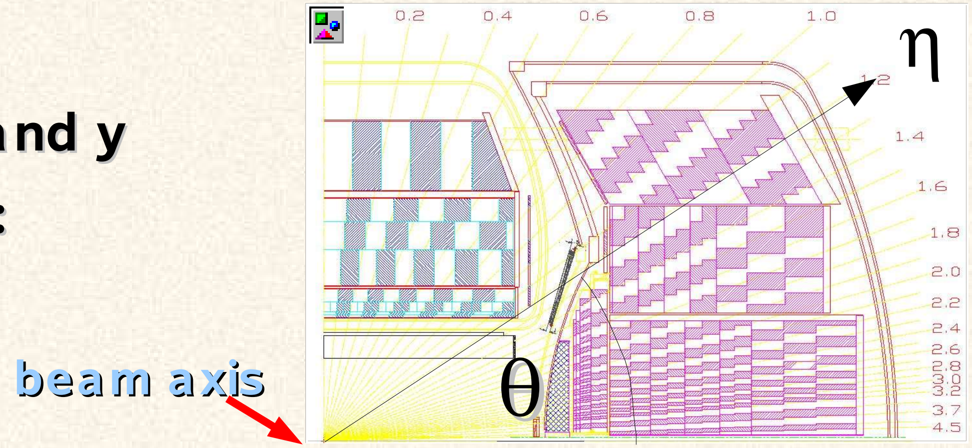
IDEA: to which top mass does kinematics of measured event fit best?

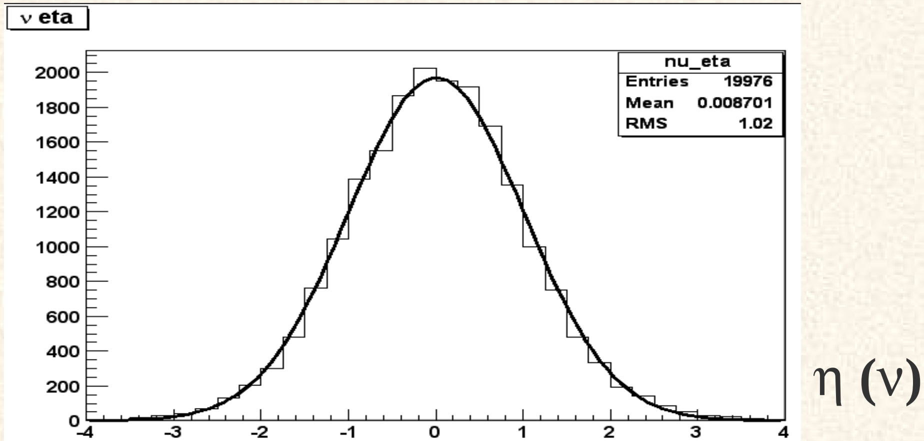


no ν p_z Information

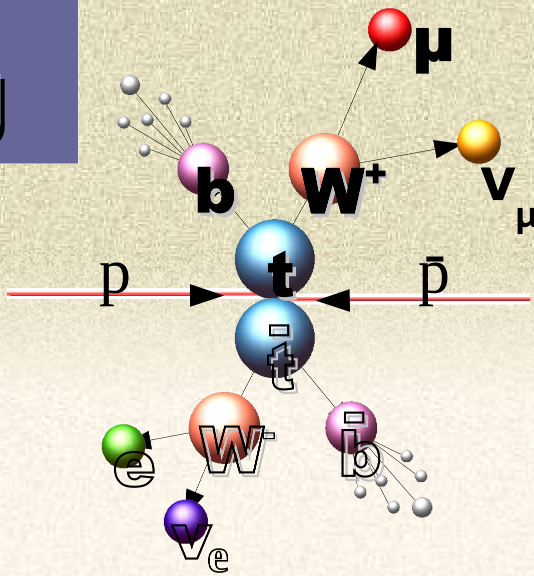
- final state defined by 4 vectors of 6 decay products
- reduces to 24 – 6 masses = 18 independent parameters
- measure lepton, jet momenta and x- and y components of the sum of ν momenta: 14 measures
- invariant masses of (l,ν) pairs are M_W and $m_t=m_{tbar}$: 3 constraints
- still underdetermined: 18 – 14 – 3 = 1

➡ take η_ν distribution from MC for assumed m_t and scan over hypothetic top masses





$m_{top}^{Dilepton}$ from Neutrino Weighting



Neutrino Weighting Algorithm:

1) event probability assuming: m_{top} , m_W, η's of neutrinos, correct l+jet pairing from top

$$\omega_i = \exp\left(\frac{-(E_x - p_x^{\nu} - p_x^{\bar{\nu}})^2}{2\sigma_x^2}\right)\cdot\exp\left(\frac{-(E_y - p_y^{\nu} - p_y^{\bar{\nu}})^2}{2\sigma_y^2}\right)$$

2) two solutions for neutrino and antineutrino each:

$$\omega(m_t, \eta_\nu, \eta_{\bar{\nu}}, l-jet) = \sum_{i=1}^{4} \omega_i$$

3) scan neutrino η distribution from -3 to 3:

$$\omega(m_t, l-jet) = \sum_{\eta_\nu, \eta_{\bar{\nu}}} P(\eta_\nu, \eta_{\bar{\nu}}) \cdot \omega(m_t, \eta_\nu, \eta_{\bar{\nu}}, l-jet)$$

4) solve for both l-jets (b and bbar) pairings:

$$W(m_t) = \sum_{l^+ - jet_1}^{l^+ - jet_2} \omega(m_t, l-jet)$$

$m_{top}^{Dilepton}$ from νWT / MWT Methods

ICHEP

Neutrino Weighting: νWT

Matrix Weighting: MWT

1) event probability, assume: m_{top}, m_W, correct l+jet pairing from top

- assume η's of neutrinos
- don't use missing E_x, E_y

- use measured missing E_x, E_y
- as function of lepton energy E (in top quark rest frame) of both leptons

p(m$_t$) =

$$\exp\left(\frac{-(\not{E}_x - p_x^{\nu} - p_x^{\bar{\nu}})^2}{2\sigma_x^2}\right)\cdot\exp\left(\frac{-(\not{E}_y - p_y^{\nu} - p_y^{\bar{\nu}})^2}{2\sigma_y^2}\right)$$

p(E_ℓ^{CM} | m$_t$) =

$$4 m_t E \frac{m_t^2 - m_b^2 - 2 m_t E}{(m_t^2 - m_b^2)^2 + m_W^2 (m_t^2 + m_b^2) - 2 m_W^4}$$

2) sum over all kinematical solutions and l-jets assignments to t, tbar

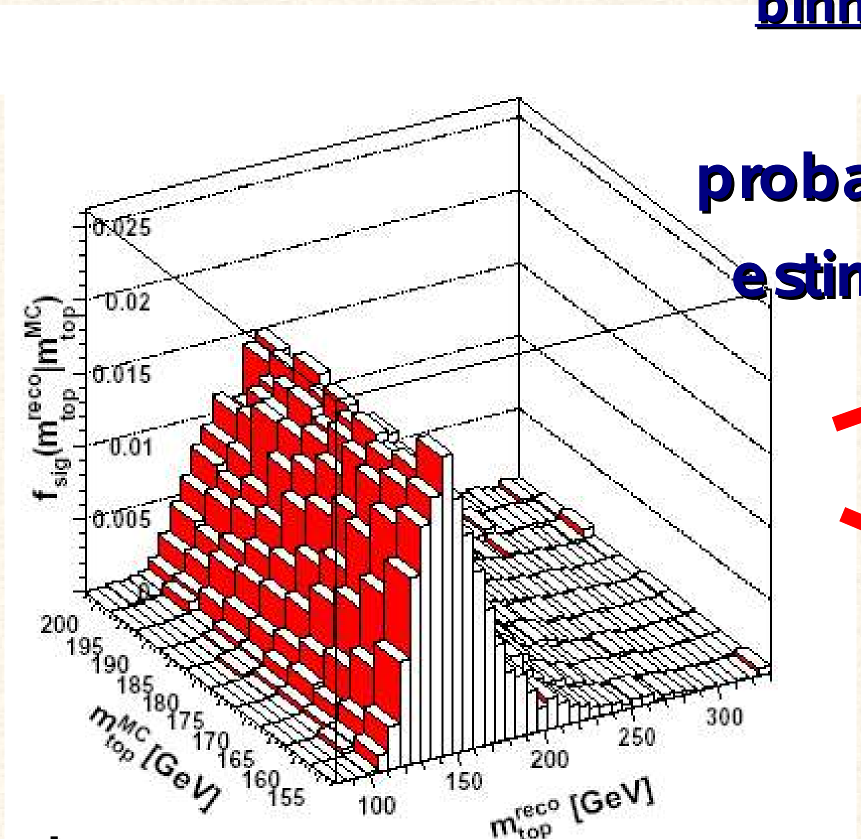
- scan over η distributions

3) use maximum Likelihood method to extract top mass

$$L(m_{top}) = L_{shape}(m_{top}) \times L_{n_b} \times L_{n_s + n_b}$$

Smooth Weight Distributions νWT Methods

Weight Function for different top mass hypotheses

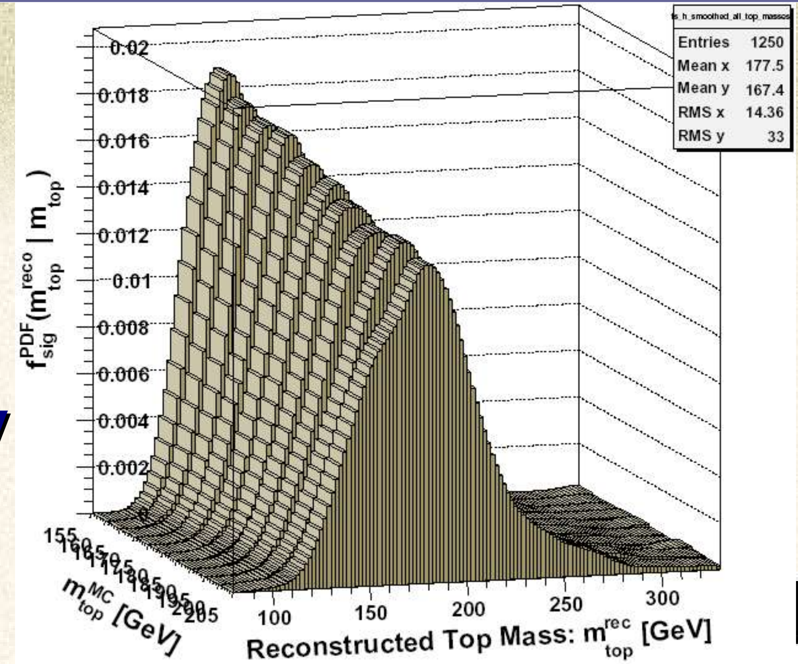


top mass hypothesis

reconstructed top mass

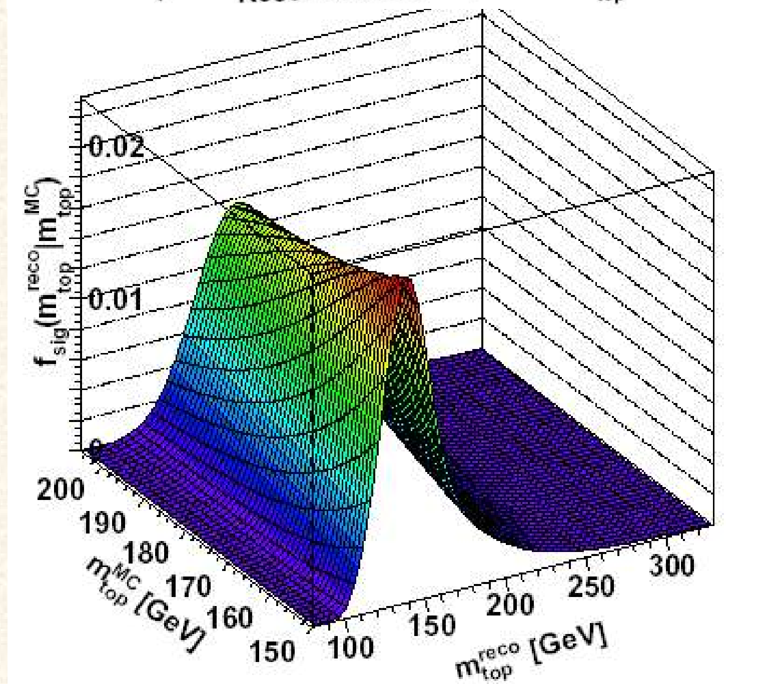
binned, moments method:

probability density estimation (PDE)



maximum method:

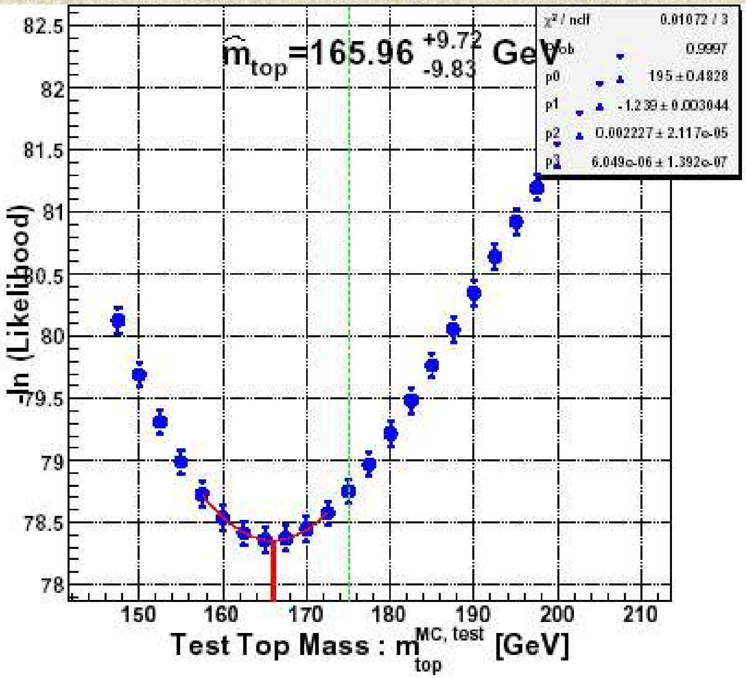
2-dimensional fit



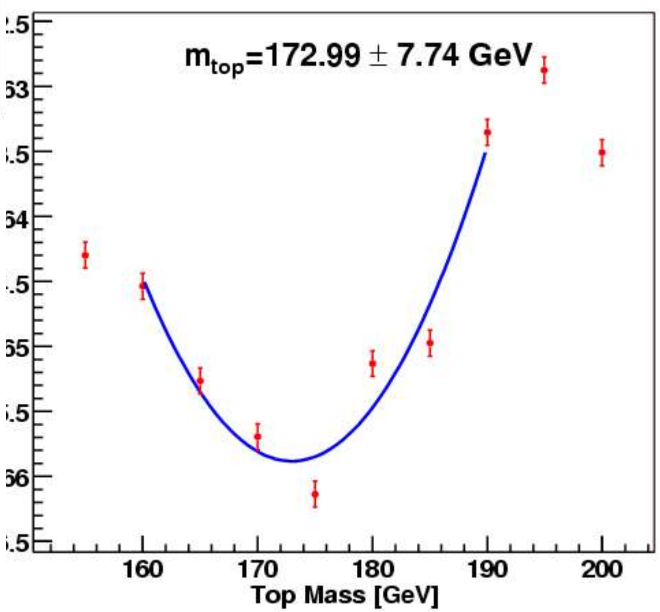
➡ lower systematic uncertainties!

Data Measurement: νWT

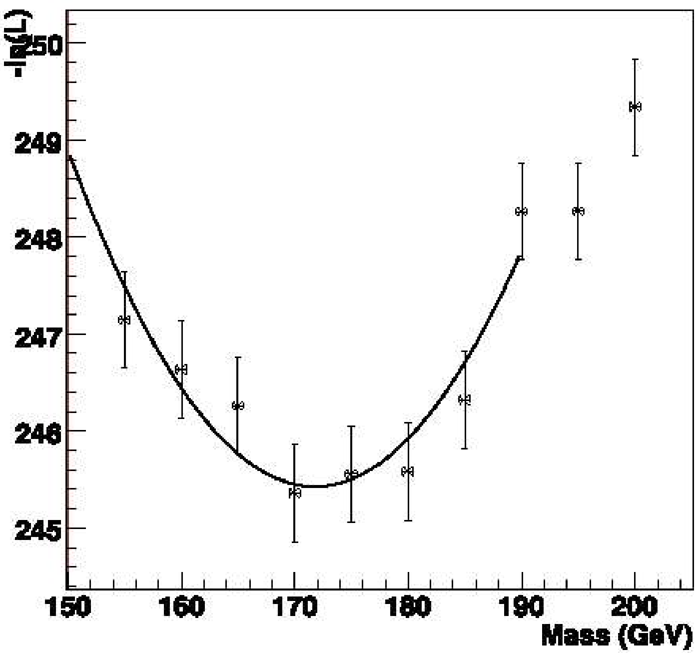
Maximum Method



Binned Method



Moments Method

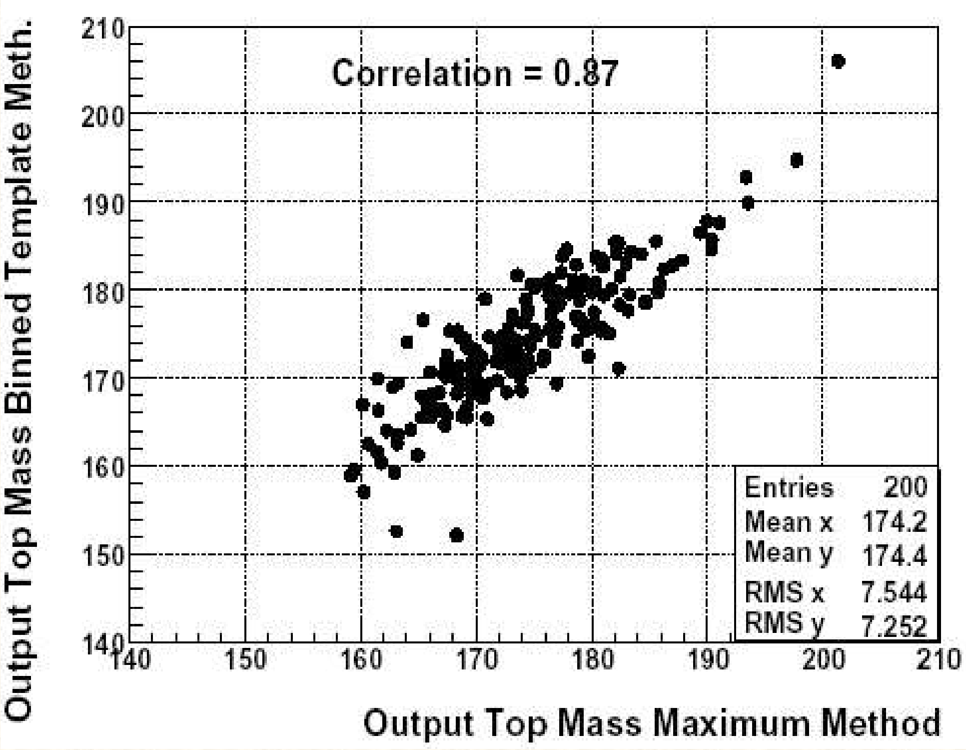


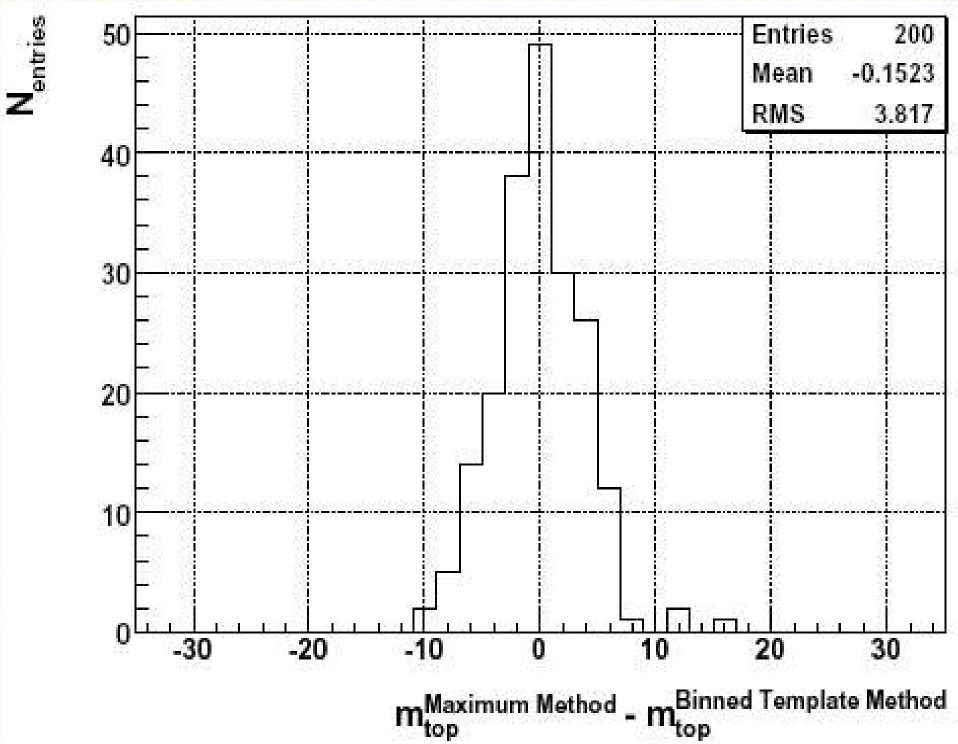
Maximum Method: $m_{top} = 165.7 \pm 9.7\ (stat.)\ ^{+4.4}_{-4.7}\ (syst.)$ GeV

Binned Method: $m_{top} = 173.6 \pm 6.7\ (stat.)\ ^{+5.1}_{-4.0}\ (syst.)$ GeV

Moments Method: $m_{top} = 171.6 \pm 7.9\ (stat.)\ ^{+5.1}_{-4.0}\ (syst.)$ GeV

Maximum vs. Binned Method: νWT





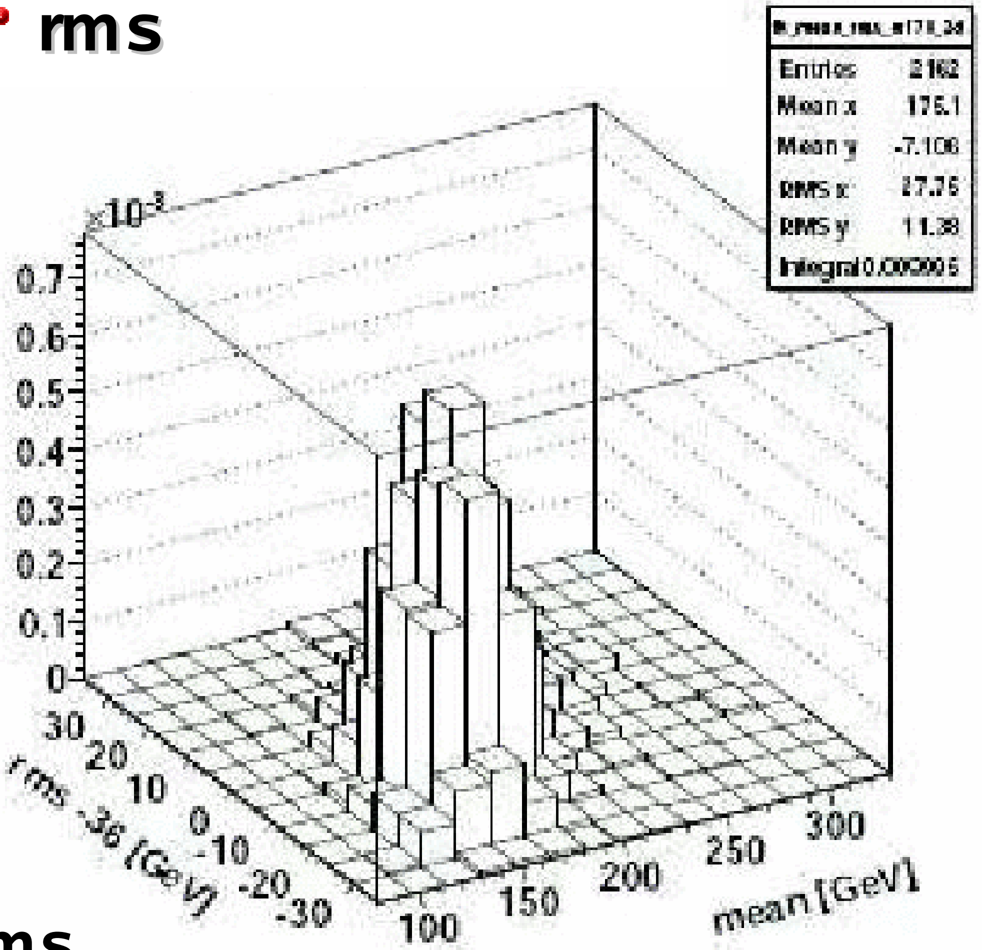
200 ensembles with signal MC

3-dimensional Fit

- generated top mass
- average
- rms

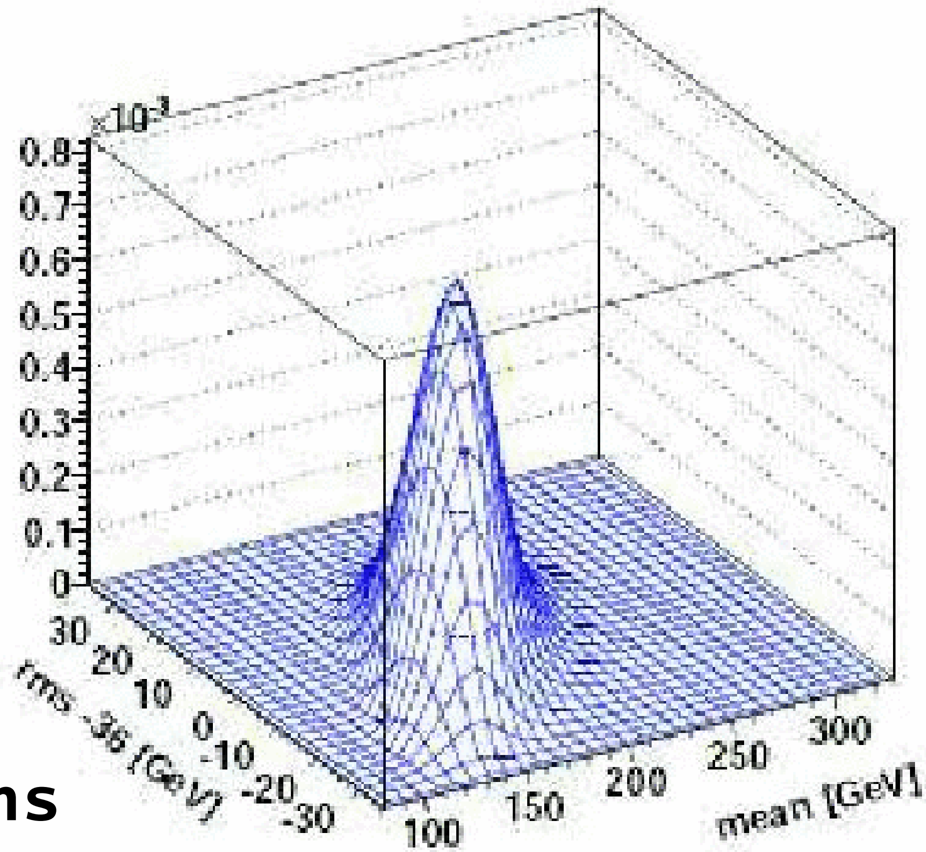
Jörg Meyer

m_{top} = 170 GeV



rms

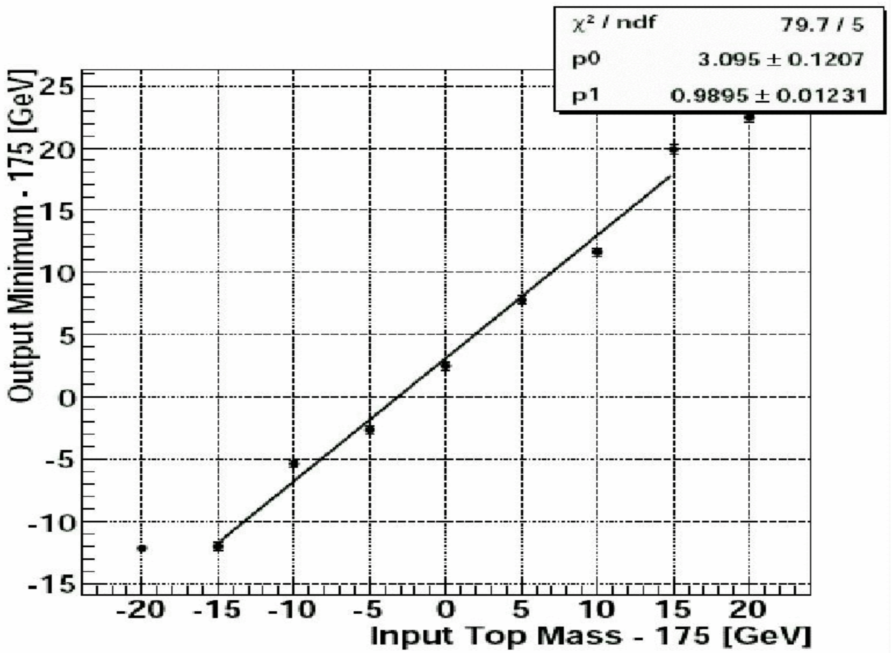
mean

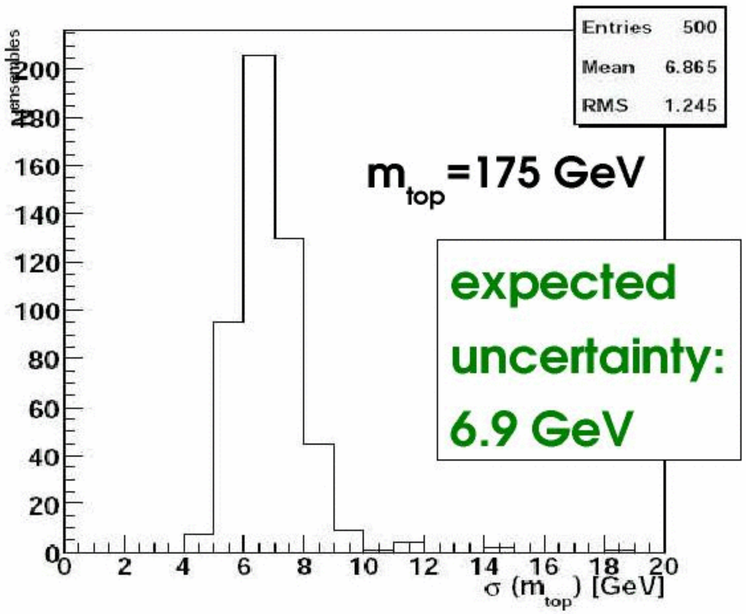


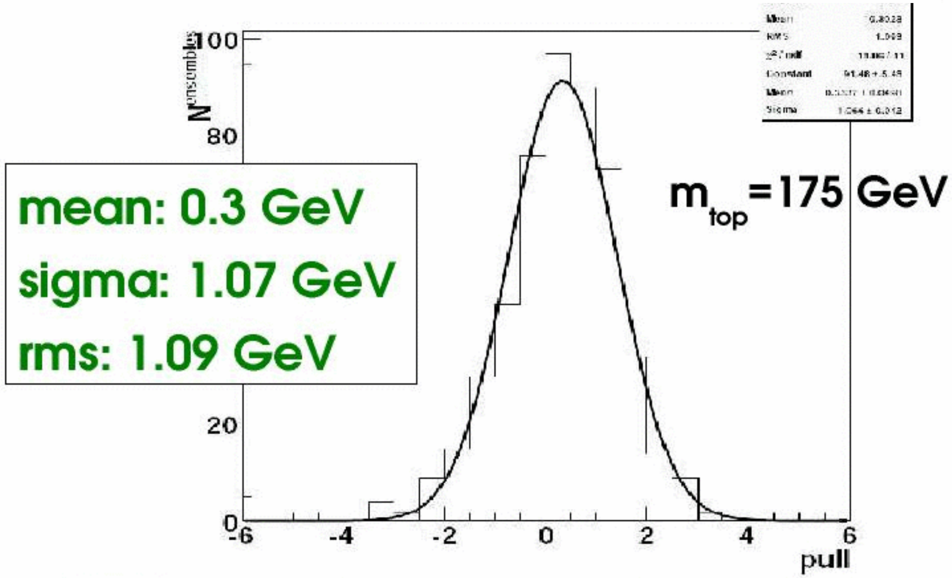
rms

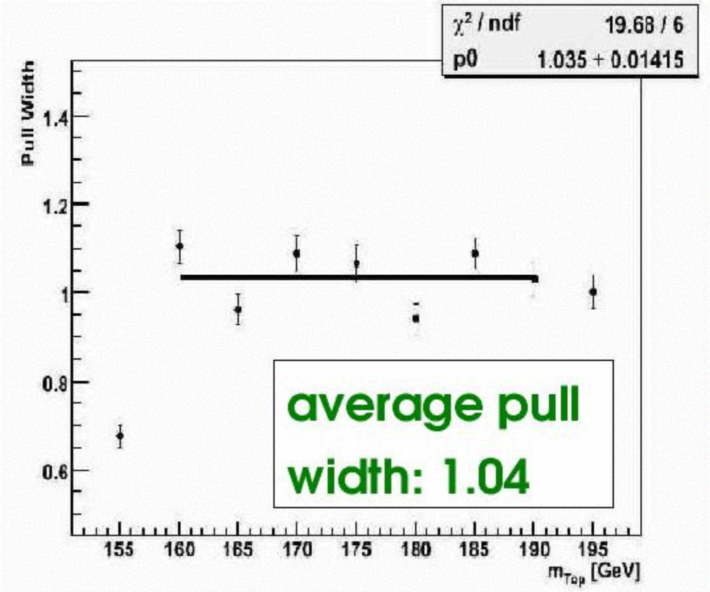
mean

Ensemble Testing





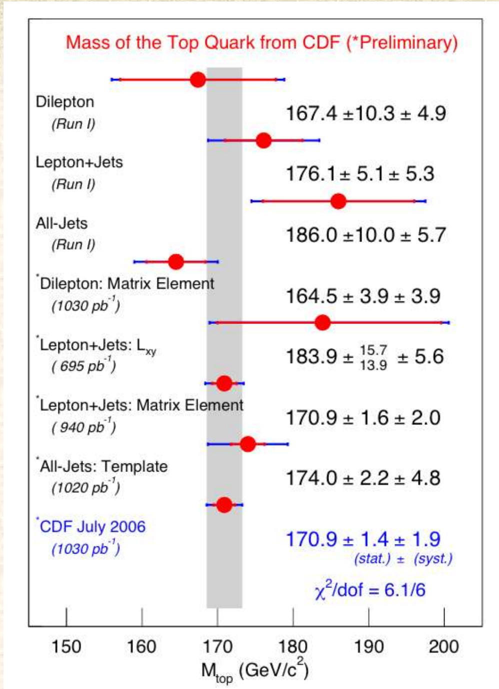


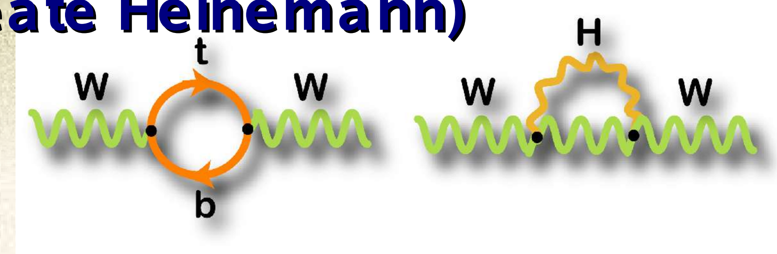


➡ **looks promising!**

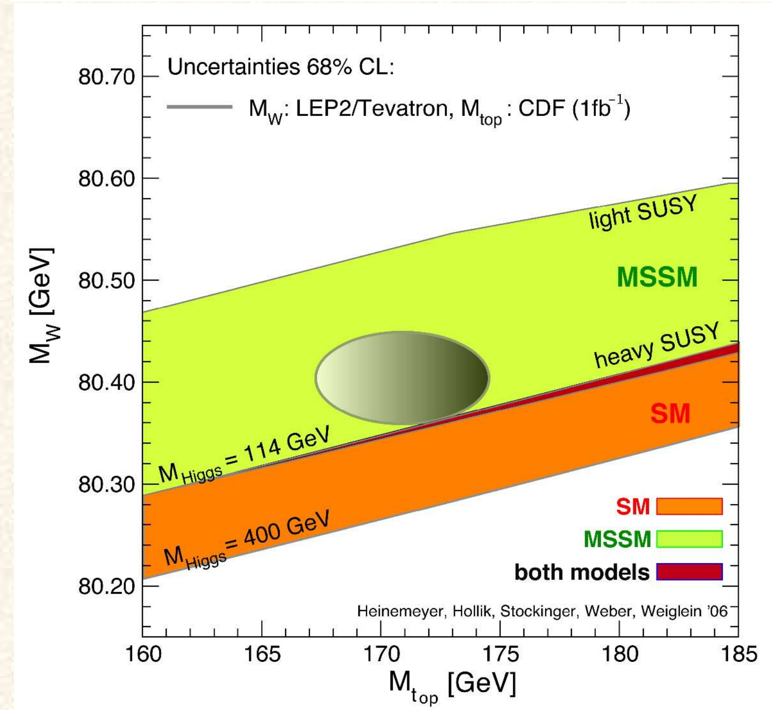
Summary: Top Mass Measurements for Winter

CDF combined Result for ICHEP: (from Beate Heinemann)





$L=1\ fb^{-1}$



- m_{top}=170.9 ± 2.4 GeV
- Standard Model excluded at 68% CL
    - Perfectly allowed at 95% CL though

➡ **DØ should join attacking the Standard Model!**