Top Physics @ Wuppertal

From DØ to ATLAS

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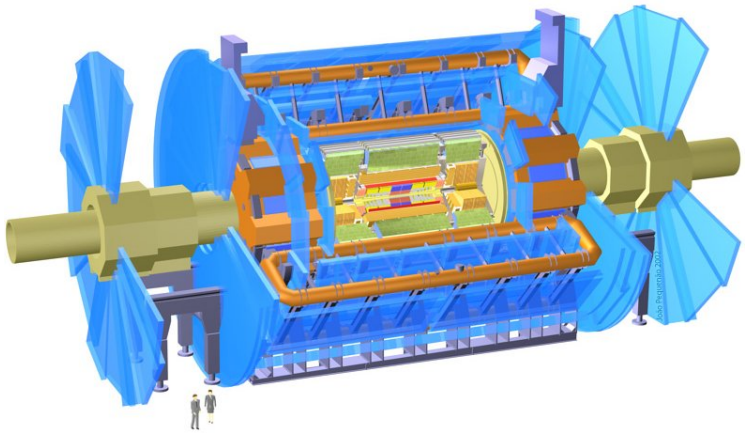
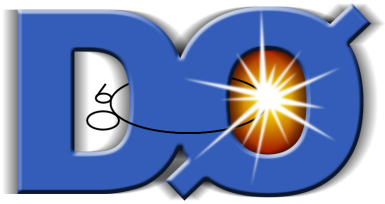
LHC-D Workshop Top-Physik



Outline & Introduction of the Wuppertal top group

- Overview over top analyses in Wuppertal
  - $t\bar{t}$ production cross section
  - Measurement of the $t\bar{t}$ mass spectrum
  - Top decay properties
- Summary



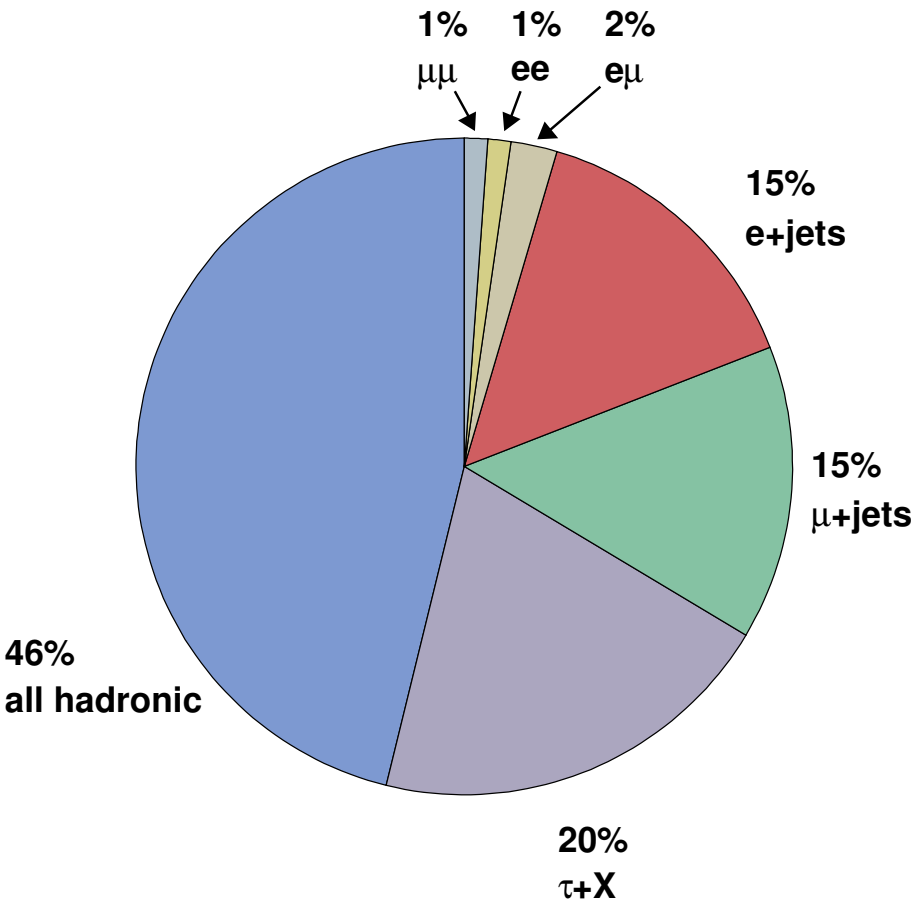
Group members:

G. Gorfine, K. Hamacher, H. Hoeth, P. Mättig, Y. Peters, M. Sandhoff, C. Schmitt, A. Siebel, M. Vaupel, D. Wicke, C. Zeitnitz

Possible discussion points for this workshop marked in red

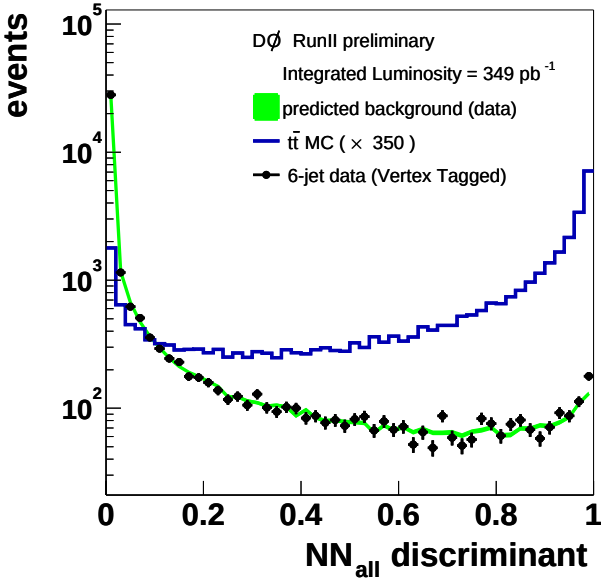
$t\bar{t}$ production in the alljets channel (DØ)

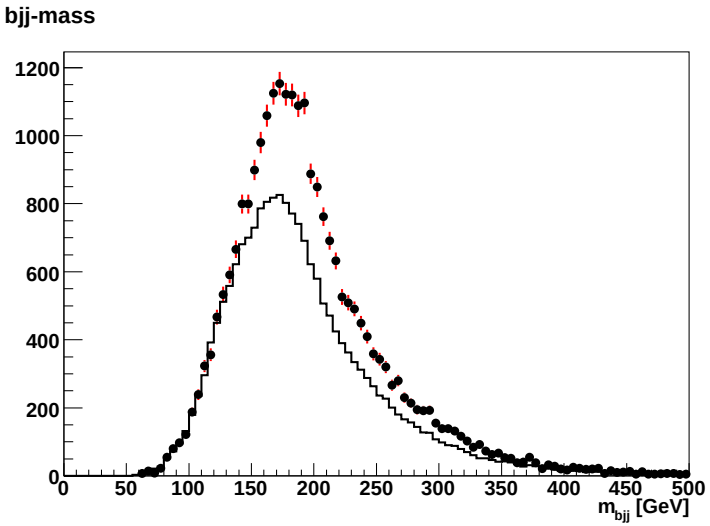
- Highest branching ratio of all decay channels (46%)
- No neutrino in the final state $\longrightarrow$ good mass resolution
- Challenges
  - Huge background from multijet production
  - Discrimination between $t\bar{t}$ and background
  - Background description based on data

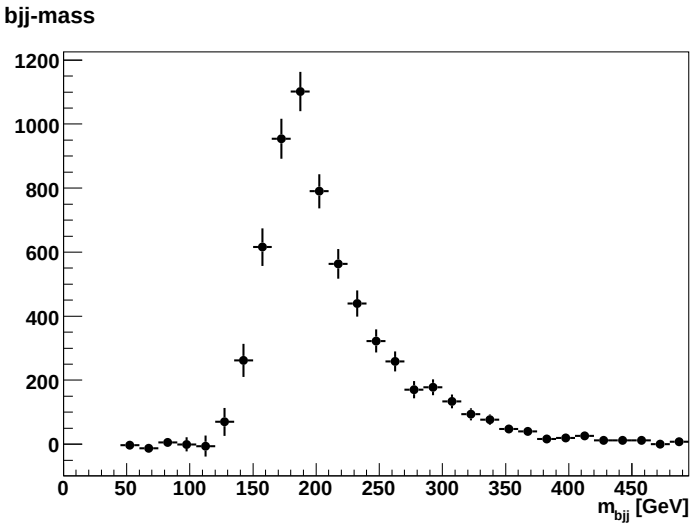


$t\bar{t}$ production in the alljets channel (DØ)

- So far: two different methods
  - Combine many discriminating variables in a NN
  - Hard cuts on the jets (p_T, b-tag) $\longrightarrow$ observe mass peak after background subtraction
- Combine both methods

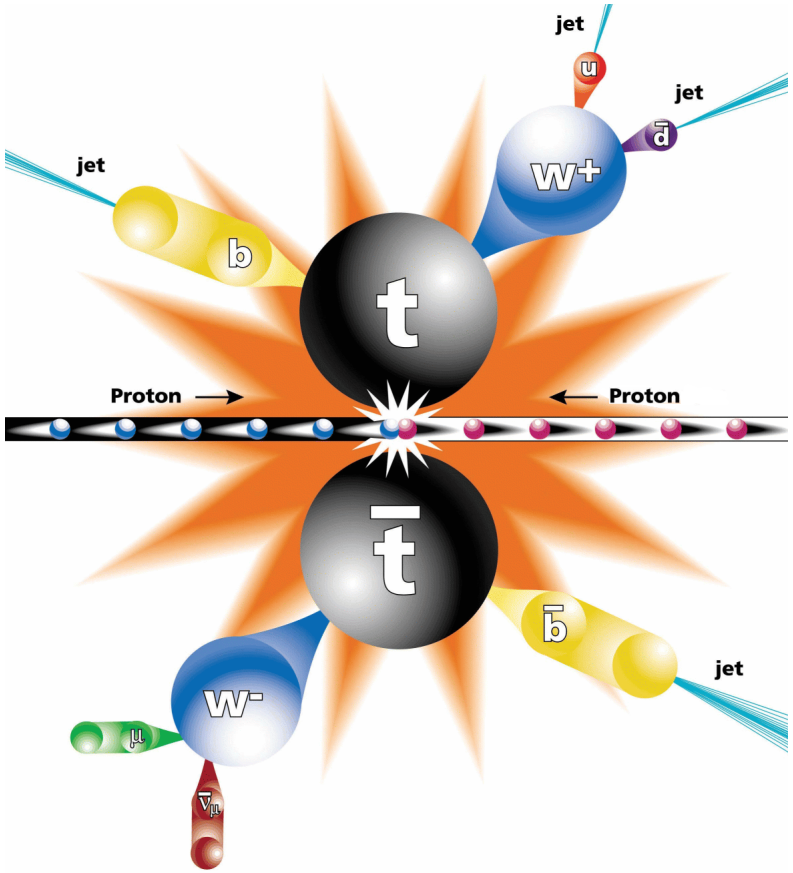






$t\bar{t}$ production cross section (ATLAS)

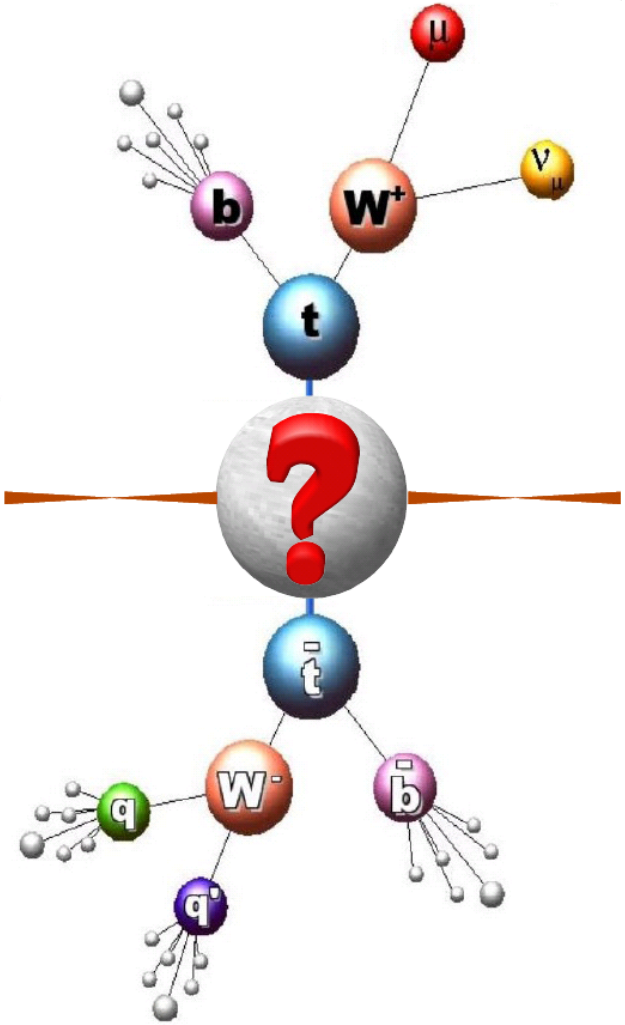
- Plan to measure the $t\bar{t}$ cross section
- Exploit knowledge from DØ analyses
- Start with study of tools
  - Jet algorithm
  - b-tag performance
- Trigger efficiency measurement in data
- Background studies (W+jets, multijet)



Measurement of the $t\bar{t}$ mass spectrum (DØ)

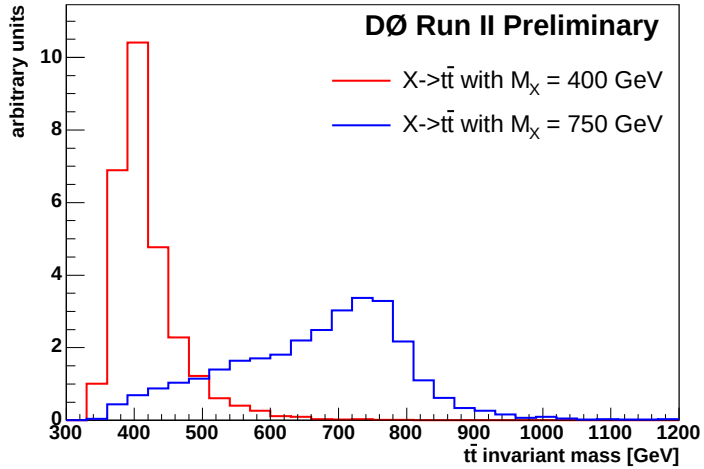
- No resonance production in $t\bar{t}$ system is expected in SM
- Some models predict $t\bar{t}$ bound state
  - E.g. topcolour assisted technicolour predicts leptophobic Z'
- Experimental signature
  - bump in reconstructed $t\bar{t}$ mass spectrum
- Challenges
  - Correct description of the SM background ($t\bar{t}$, W+jets, multijet)

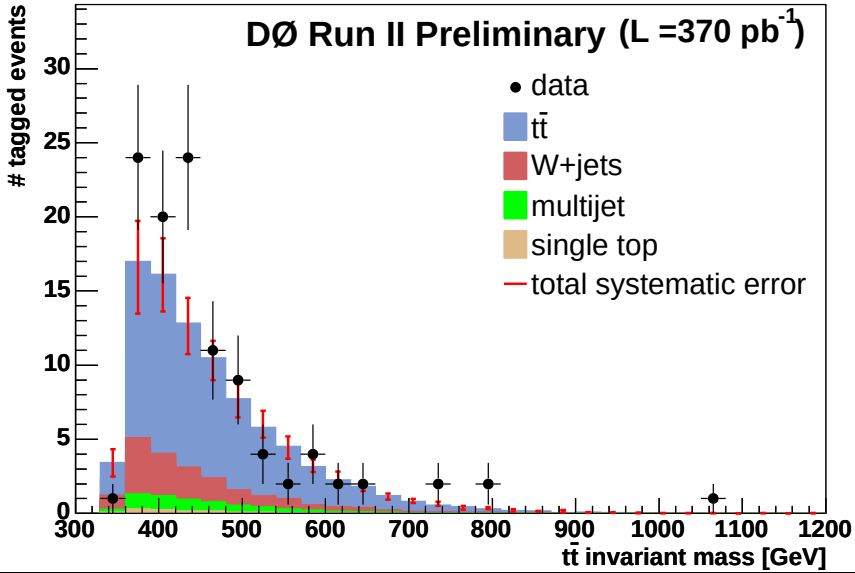
What can we learn from the $t\bar{t}$ mass spectrum?

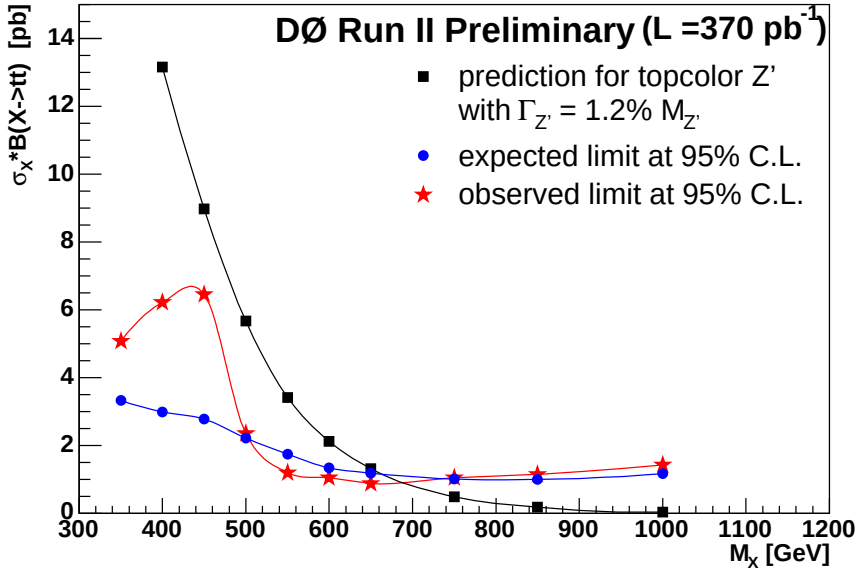


Search for resonant $t\bar{t}$ production (DØ)

- No evidence for $t\bar{t}$ production via intermediate resonance
- Leptophobic Z': $M_{Z'} > 680$ GeV
- Improved analysis for summer conferences ($t\bar{t}$ reconstruction, $\mathcal{L} > 1$ fb^{-1})

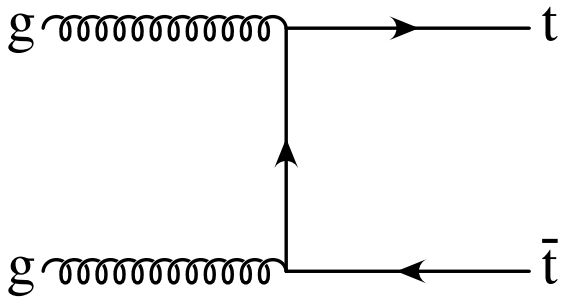


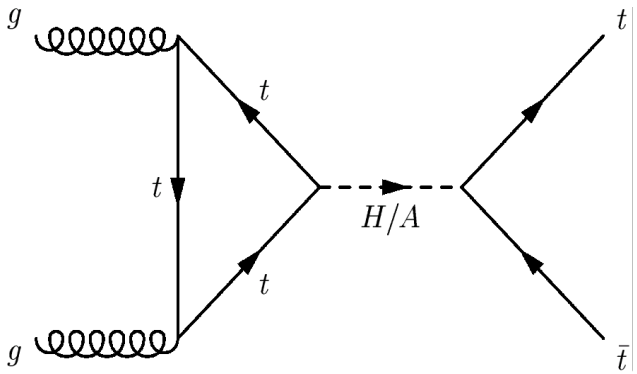




Measurement of the $t\bar{t}$ mass spectrum (ATLAS)

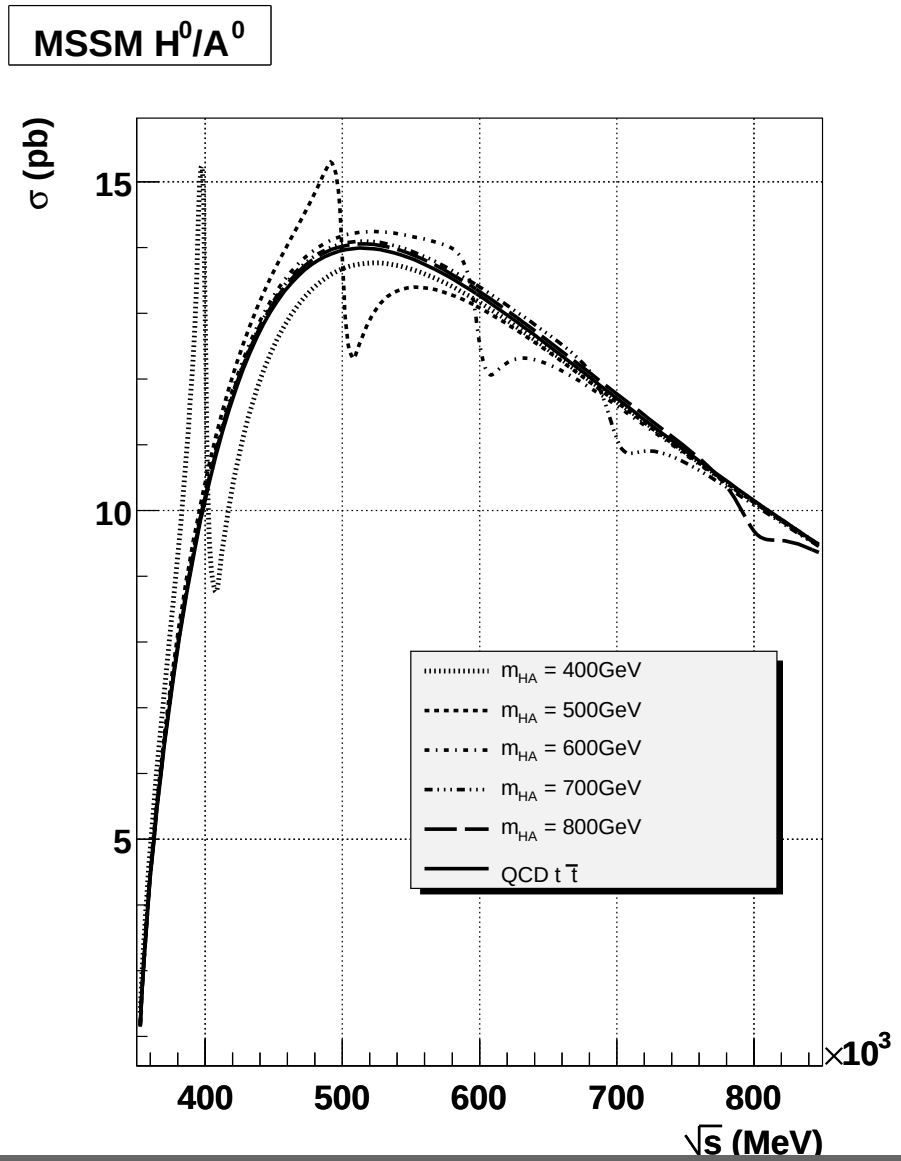
- Alljets channel
  - highest branching ratio
  - no neutrinos in final state
- Main background: multijet production
- $t\bar{t}$ production
  - Standard Model $gg \rightarrow t\bar{t}$
  - Possible resonant production through intermediate Higgs boson
- MSSM:
  - $BR(\mathrm{H}^0/\mathrm{A}^0 \rightarrow t\bar{t}) \approx 100\%$ for $m_{H/A} > 2m_t$ and $\tan\beta \approx 1$



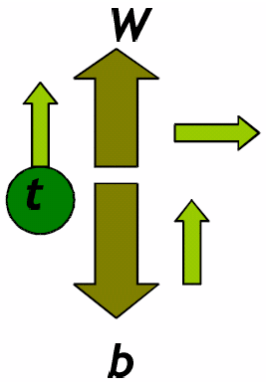


$H \rightarrow t\bar{t}$ (ATLAS)

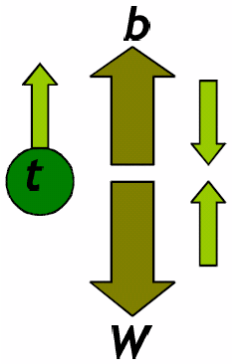
- Additional complication: interference !
  - Interference between $gg \rightarrow t\bar{t}$ and $\mathrm{H}^0/\mathrm{A}^0 \rightarrow t\bar{t}$
  - High $\mathrm{H}^0/\mathrm{A}^0$ masses $\rightarrow$ dip more significant than peak
- Theoretical predictions for interference:
  - K. Gaemers and F. Hoogeveen, Phys.Lett.B146:347 (1984)
  - D. Discus et al, Phys.Lett.B333:126-131 (1994)
  - Any new progress?



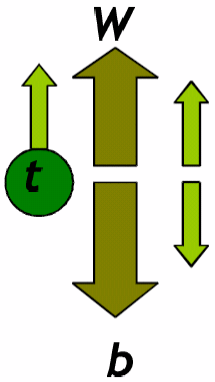
W helicity in top decays (DØ)



Longitudinal fraction f_0



Left handed fraction f_-



Right handed fraction f_+

Test of the SM

Opportunity to look for new physics

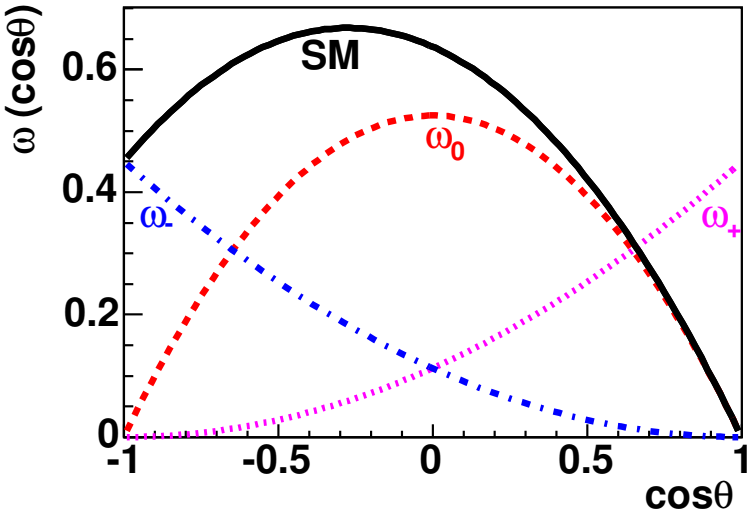
- Longitudinal fraction depends only on kinematics:

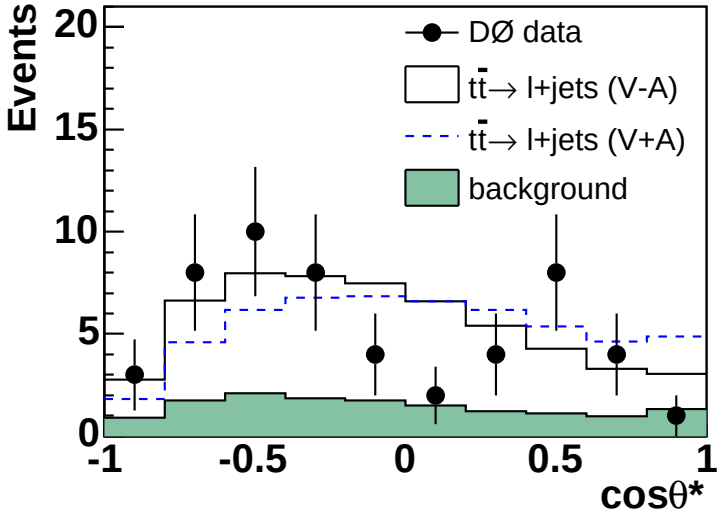
$$f_0 \approx \frac{m_t^2}{2M_W^2 + m_t^2} = (70.1 \pm 1.6)\%$$

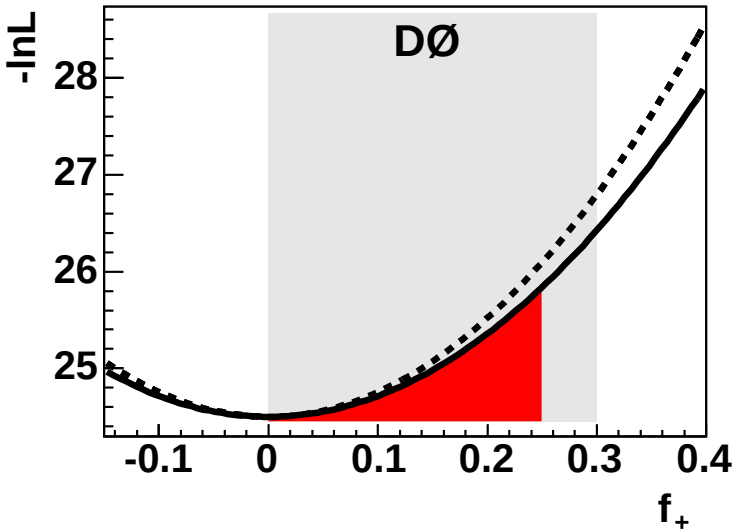
- $V - A$ interaction:
  - f_+ suppressed by factors of order (m_b^2/m_t^2)
  - $f_- \approx 1 - f_0$
- $V + A$ interaction:
  - f_- suppressed by factors of order (m_b^2/m_t^2)
  - $f_+ \approx 1 - f_0$

W helicity in top decays (DØ) — Result

- Result: $f_+ = 0.00 \pm 0.13 \pm 0.07$
- Pure $V + A$ coupling excluded: $f_+ < 0.25$ at 95% C.L.
- Is $\cos\theta$ the optimal variable?
- Sensitivity to BSM effects?

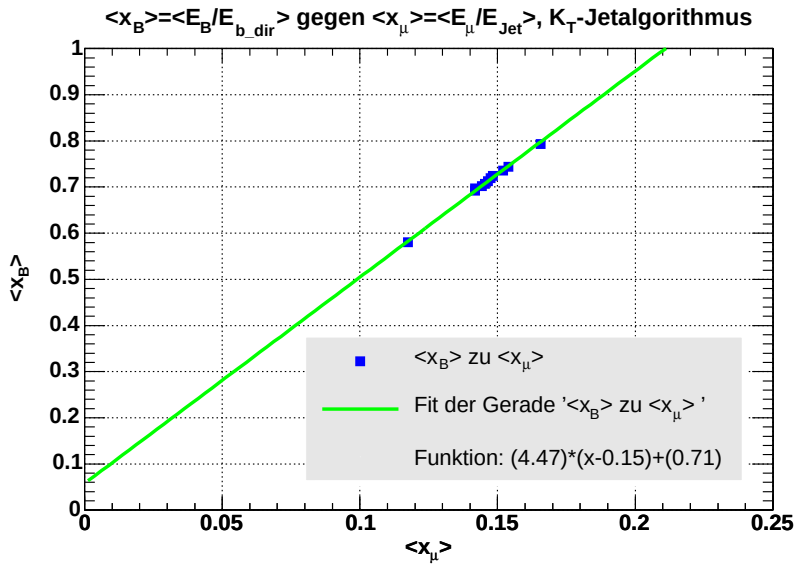


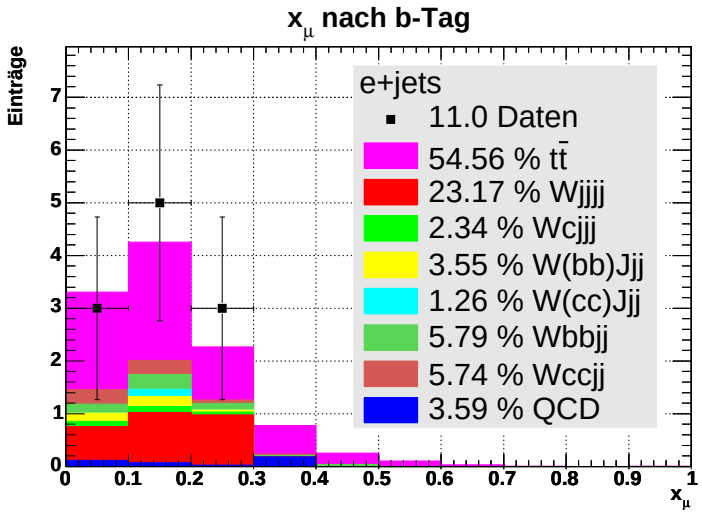


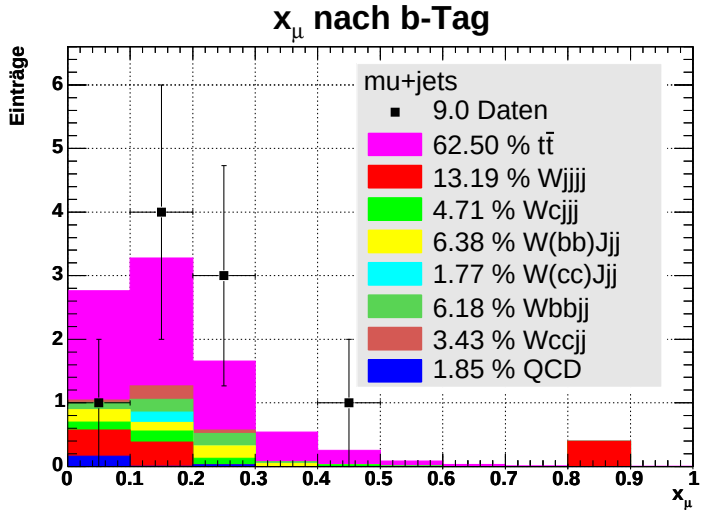


b fragmentation in top decays (DØ)

- Systematic uncertainty for top analyses, e.g. top mass
- First study using semileptonic b decays to infer $\langle X_b \rangle$ from $\langle X_\mu \rangle$
- Can the results from e^+e^- be transfered to pp?
- What is the correct scale?

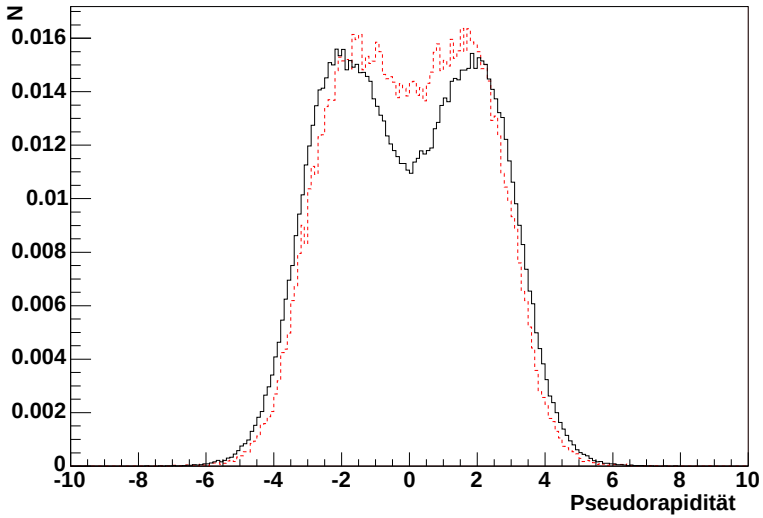






Colour flow in top decays (DØ)

- $t\bar{t}$ system suffers from combinatorial ambiguity (jet $\leftrightarrow$ parton assignment)
- Colour flow might help in identifying jets from W decay
  - Colour connection between jets from W decay
  - No colour connection between b and W decay products
- Difference visible in the η distribution



- Effect very small at the detector level
- Influence of colour-reconnection on e.g. the top mass measurement could be studied using this method

M. Sandhoff, P. Skands: “Colour annealing — a toy model of colour reconnections”, FERMILAB-CONF-05-518-T

Summary

- Extensive top physics program exists in Wuppertal
  - $t\bar{t}$ production
  - Invariant $t\bar{t}$ mass spectrum
  - Top decay properties
  - New techniques (colour flow)
- Main focus shifted to LHC
  - Understand detector
    - Jet identification
    - b-tagging
    - $t\bar{t}$ cross section measurement
  - Top as a window for physics beyond SM