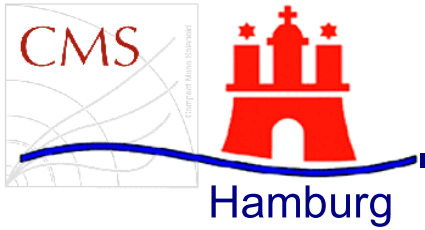


Rediscovery and Early Measurements with Top Quarks at the LHC

Markus Marienfeld (DESY), Jula Draeger, Torben Schum
Roger Wolf (University of Hamburg)

HERA-LHC, Workshop 30.10.2007

Top Production: from 'HERA' to LHC

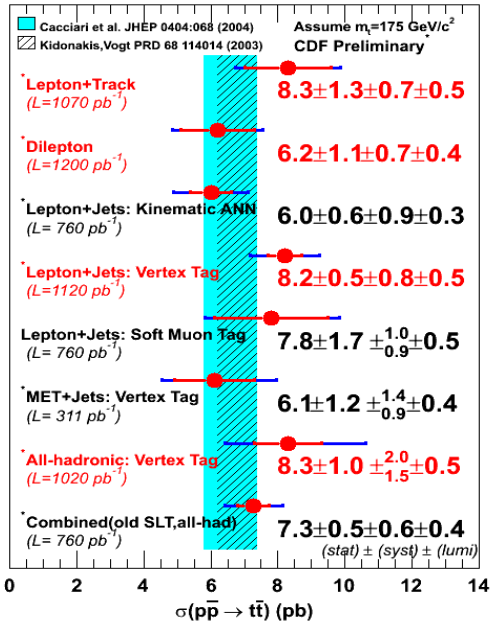
HERA:

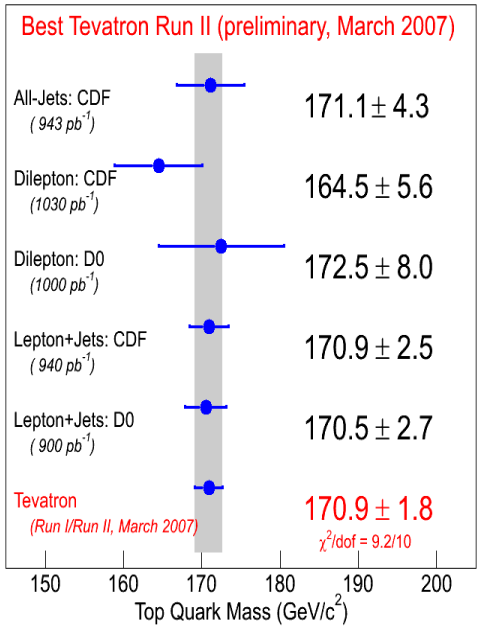
- heaviest Quark is b

D0/CDF:

- σ(ttbar) = 8 pb ±(**7%**) *90% qq*
- M(top) = 172 GeV ±(**1.5-2%**)

  with 2fb^{-1} (RUN II) 16k evts ε~0.05 (~800 reconstructed events)





LHC:

- σ(ttbar) = **833 pb** (NLO) *85% gg*
- L~10^{32}cm^{2}s^{-1} i.e. 16k evts already after 20pb^{-1} (~2d of data taking)
- Aim: δM(top) < ±**1GeV**

Top Production: from 'HERA' to LHC

~~HERA:~~

- ~~heaviest Quark is b~~

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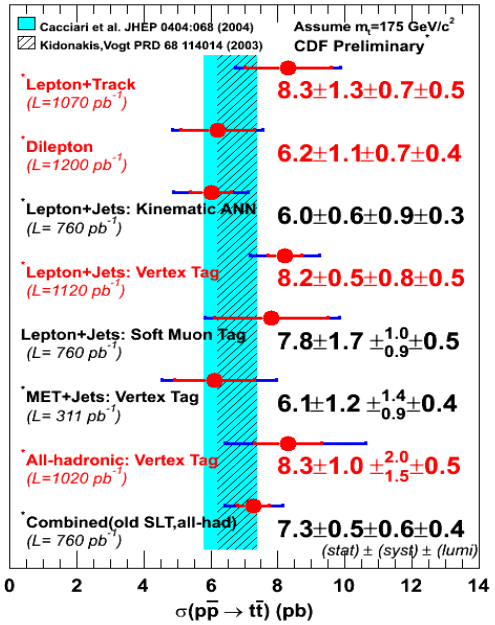

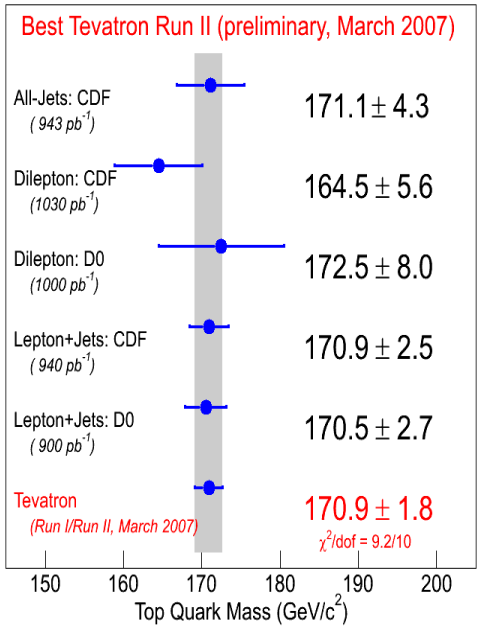

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Top Production: from 'HERA' to LHC

Hamburg

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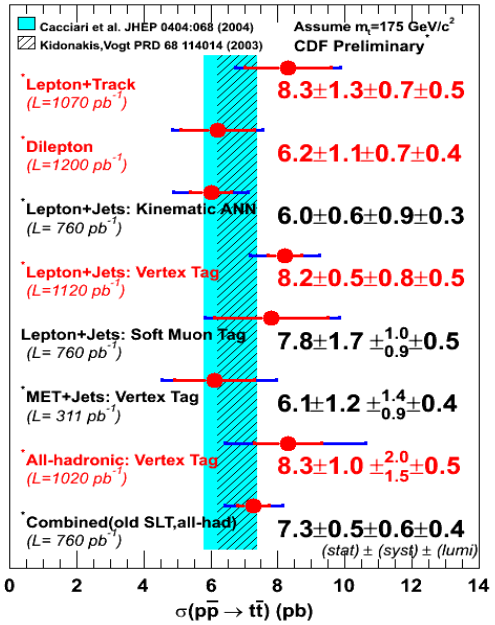

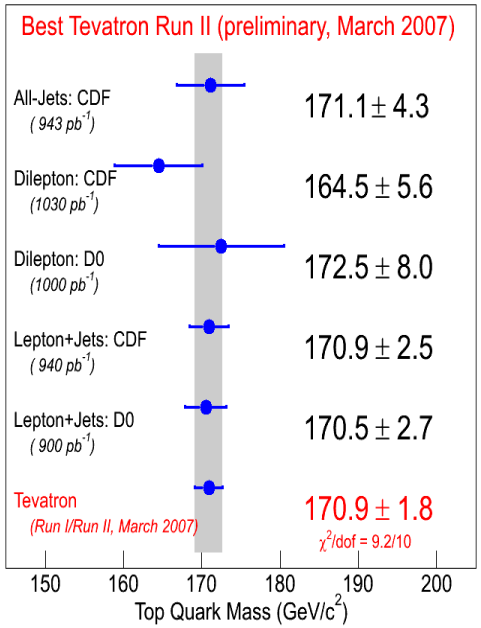

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- Aim: δM(top) < ±**1GeV**

- **Find the Top Quark back at the LHC!**
- **Understand its kinematics**
- **Control systematics**

Outline

- Generator Studies on the kinematics of Top Quarks
  Including PDF dependencies (impact of HERA?)

- Rediscovery of the Top Quark in the first 20pb^{-1} of LHC data
  Using the semileptonic decay channel with a μ in the final state

- Improvement of the Top Quark Mass resolution with constraint fits

Kinematics of Top Quark Production

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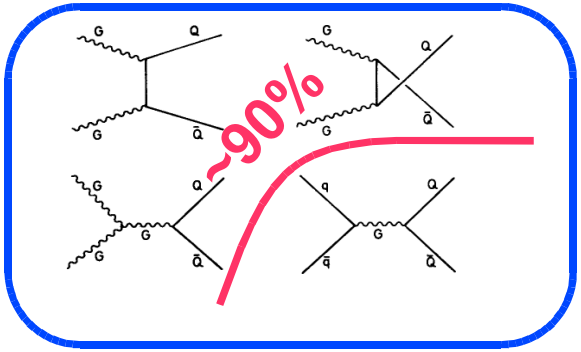
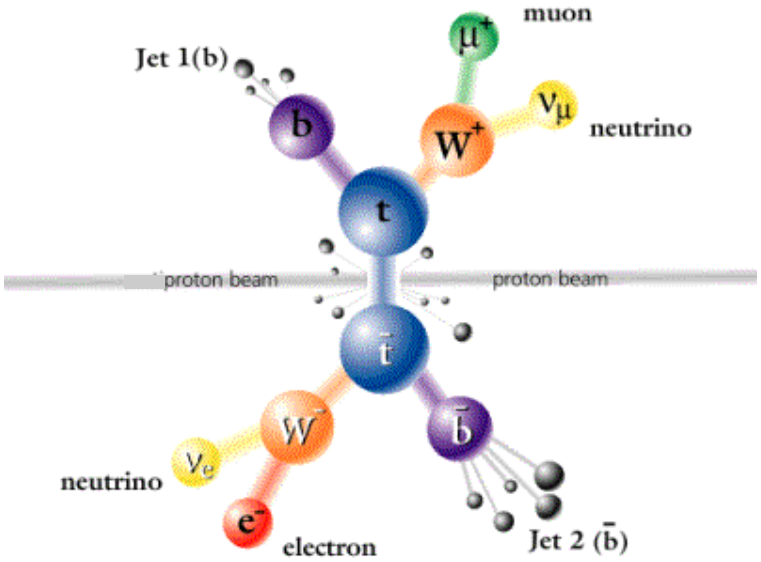
CMS std MC TopRex with interface to Pythia + PS (LO ~450 pb)

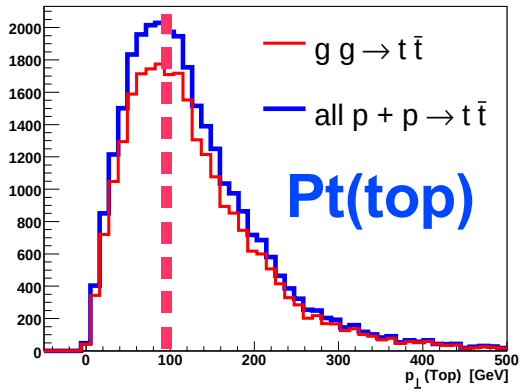
σ(tt)~800 pb (NLO)

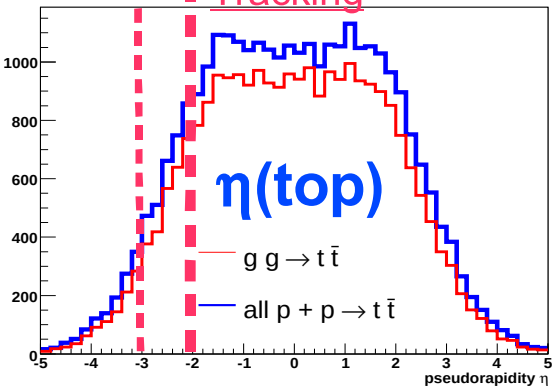


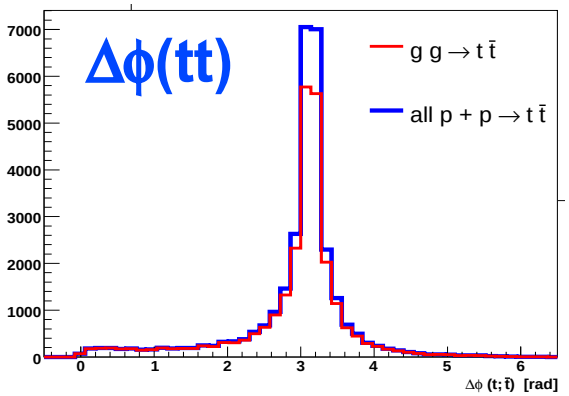


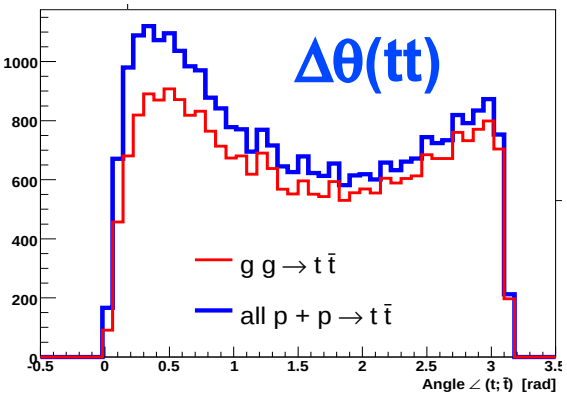
Central Calo

Tracking









Influence of different PDFs

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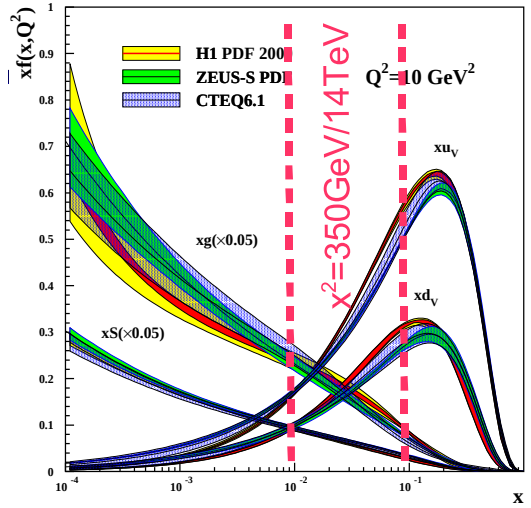
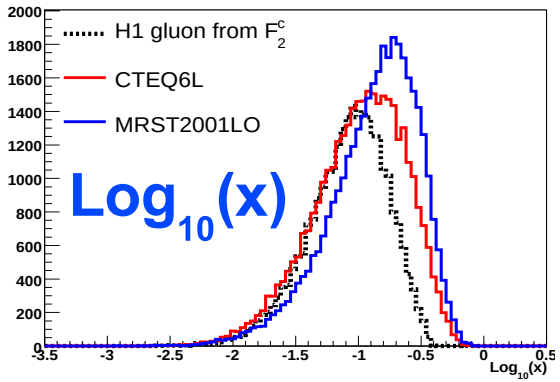
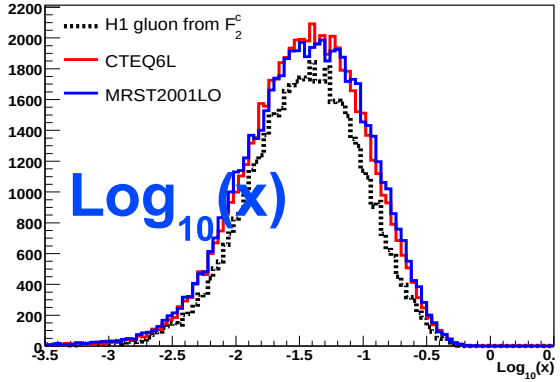


Normalized to Pythia Cross Section

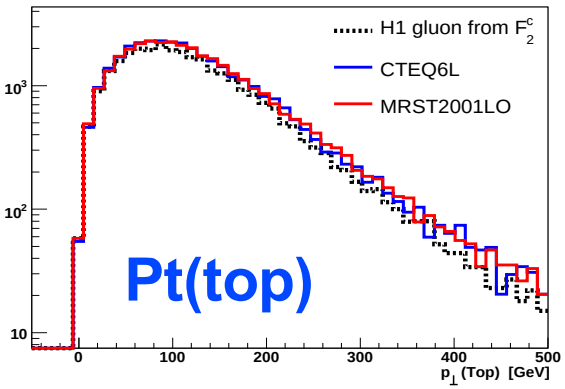


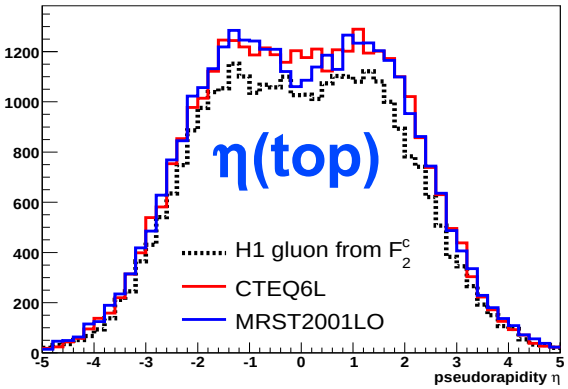
Backward evolution before ISR



At Production Scale after ISR

- Large uncertainties at lower scales wipe out at large scales
- PDFs are mostly probed in the region of $Log_{10}(x)$= -2...-1
- (10-15)% normalization uncertainty remains, shapes are unchanged





Rediscovery of the Top at the LHC

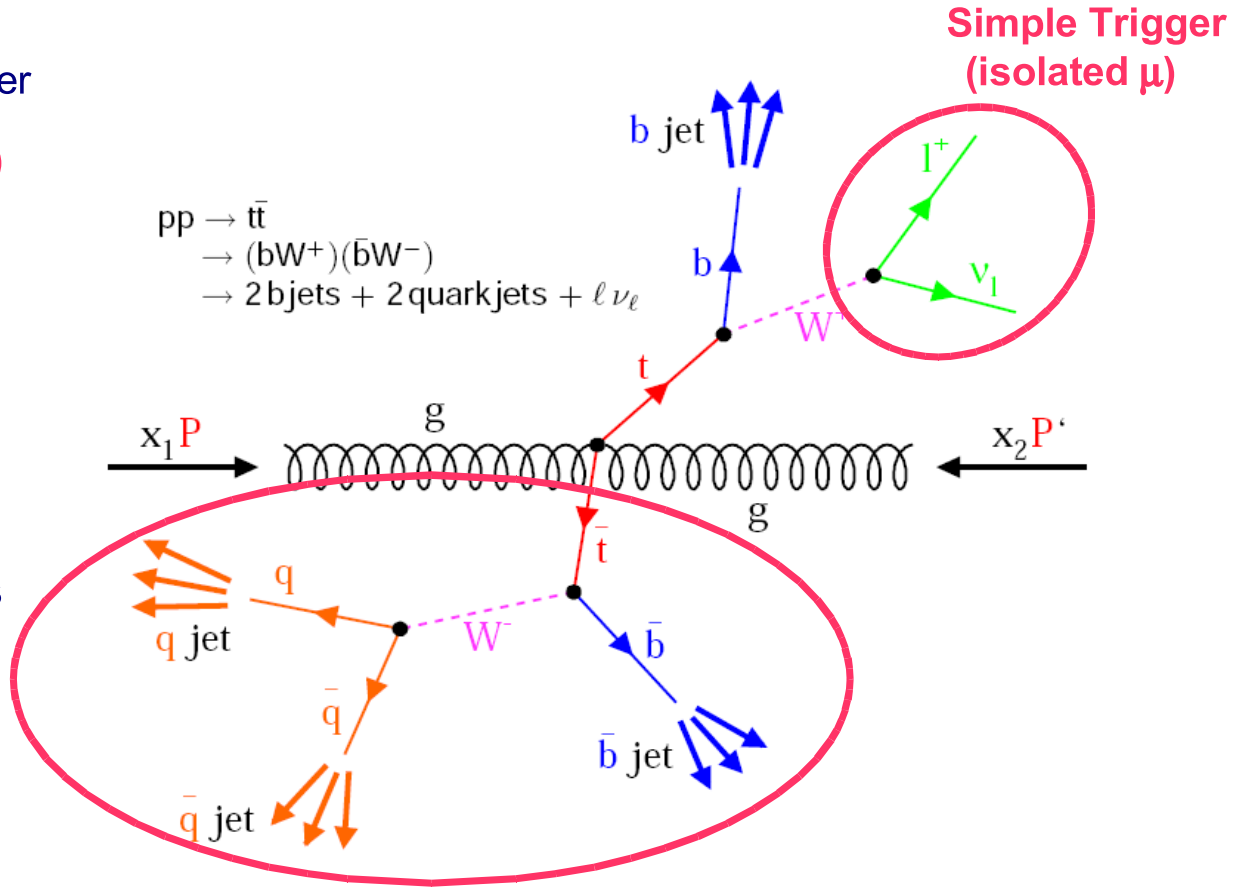
Hamburg

- No issue of statistics but of detector understanding
- Consider Top production as a benchmark process

Scenario (first 20pb^{-1}): Jula Draeger

- Choose semileptonic decay (with μ)
  - 4 high pt jets
  - 2 b jets
  - 1 isolated μ
  - MET
  - reconstructed W
- Don't rely on b tagging
- Don't rely on MET
- Robust & simple cut based analysis

How far do we get in the separation of signal and background?



Unambiguous Top Mass reconstruction with lowest possible combinatorics

Signal & Major Background samples

		Generator:	Statistics (x*20pb^{-1}):	
Signal Top:		TopRex Pythia	*8	
Other Top:	missidentified objects	TopRex Pythia	*8	
W+Jets:	identical topology	Pythia	*3	*500
QCD Jets:	huge cross section	Pythia	*5E-5	*0.9

From official MC mass production in Spring07

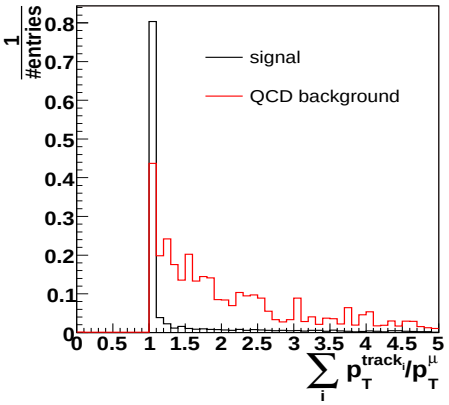
Shortcomings:

- Shapes are NOT known (LO+PS estimates)
- Low statistics esp. for QCD background

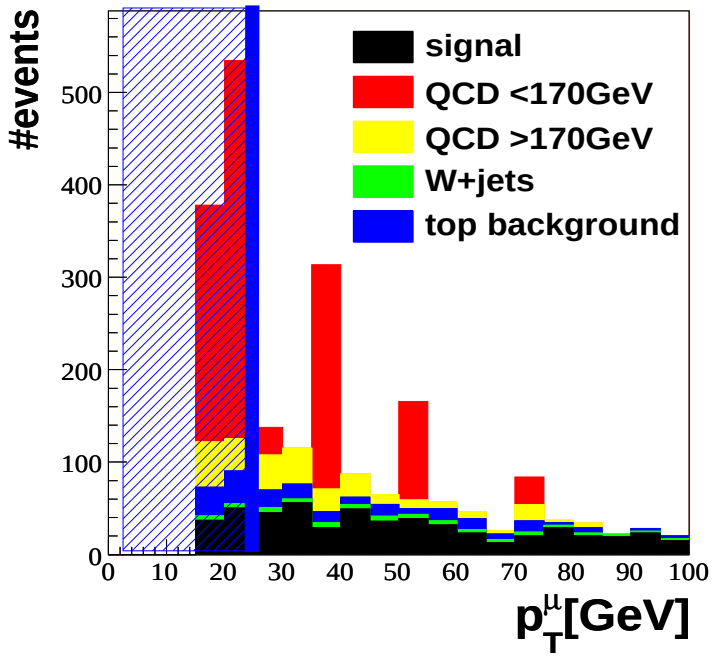
Cut Based Signal Selection

Preselection:

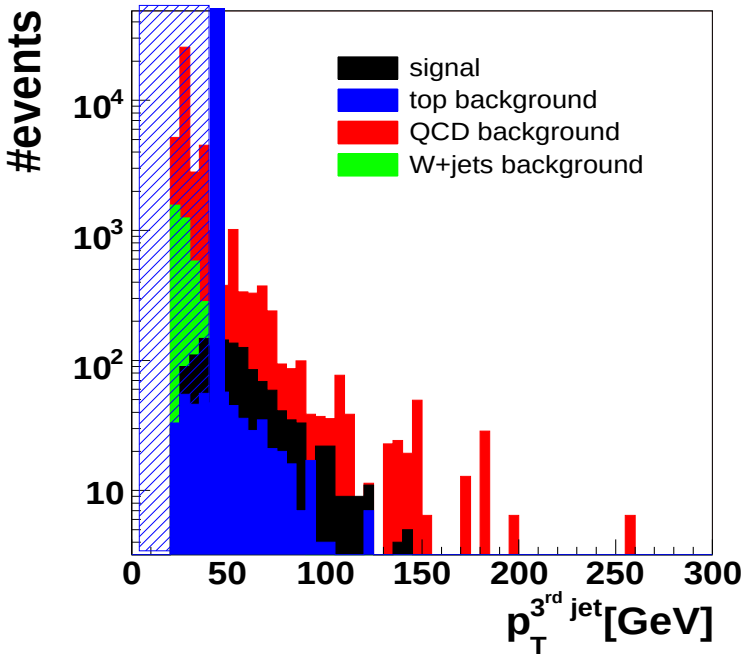
- Assume some Calo calibration
- One isolated μ with $p_t(\mu)>15$ GeV
- Isolation: $\Sigma_{\Delta R<0.3}\{p_t(\mathrm{Trk})\}$ not more then 10% of $p_t(\mu)$
- At least 4 jets with $p_t(\mathrm{calib.})>20$ GeV



Pt(μ)>25 GeV

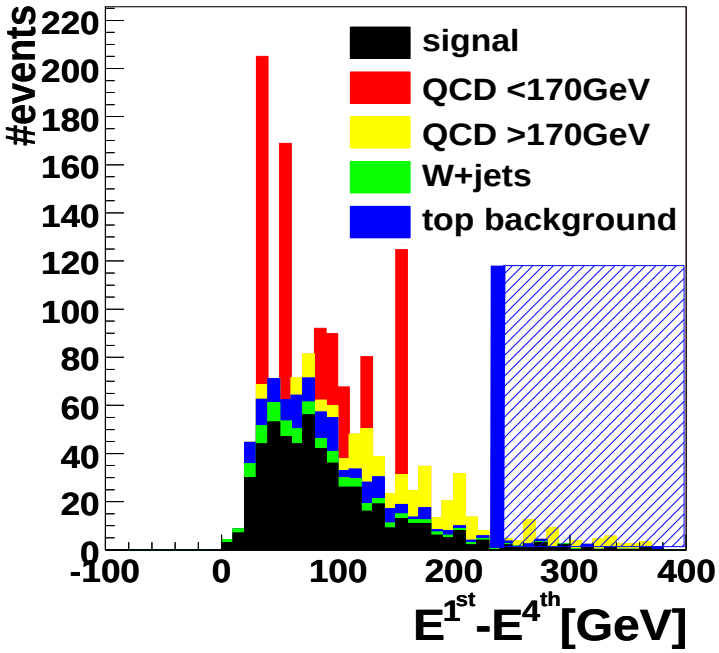


Pt(3. Jet)>45 GeV

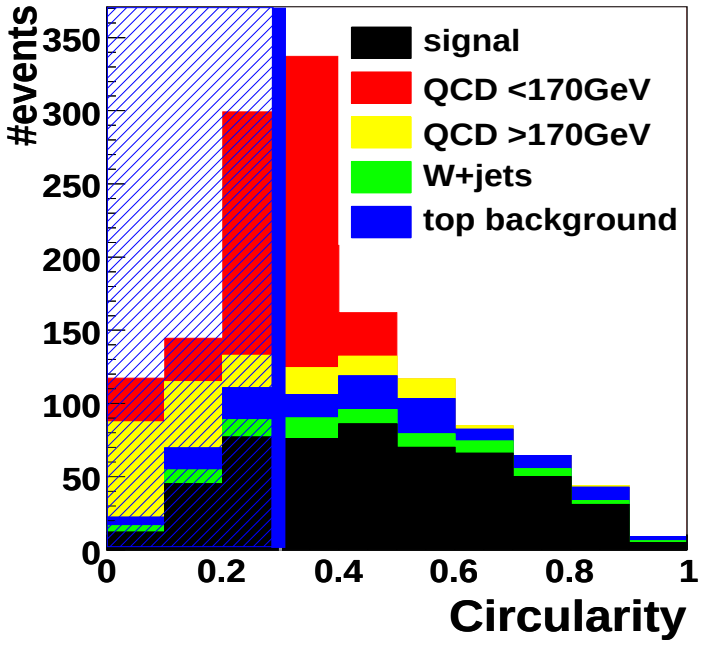


Cut Based Signal Selection

Et(1.Jet)-Et(3.Jet)<230 GeV



Cir>0.3



Reconstruction of the Top Mass

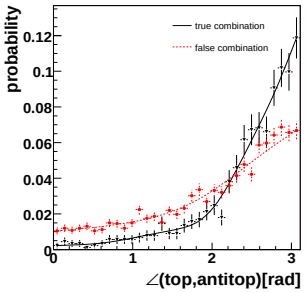
Likelihood Ratio for further signal discrimination:

$$LR = \frac{\Pi L^{true}}{\Pi L^{true} + \Pi L^{false}}$$

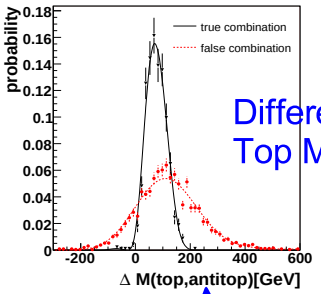
signal events matched to parton level

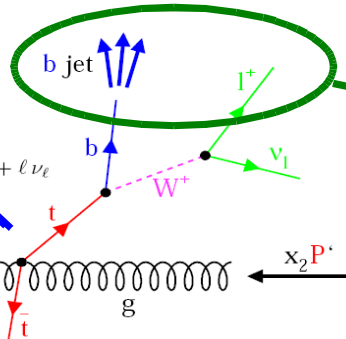
combinatorial + remaining background

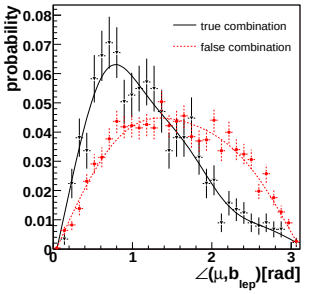
Angle between Top Quarks



Difference in Top Masses

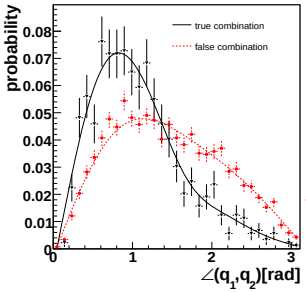


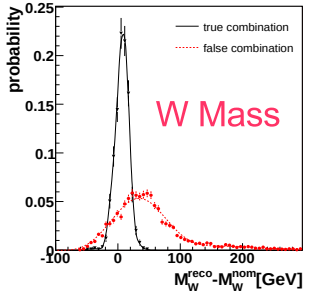




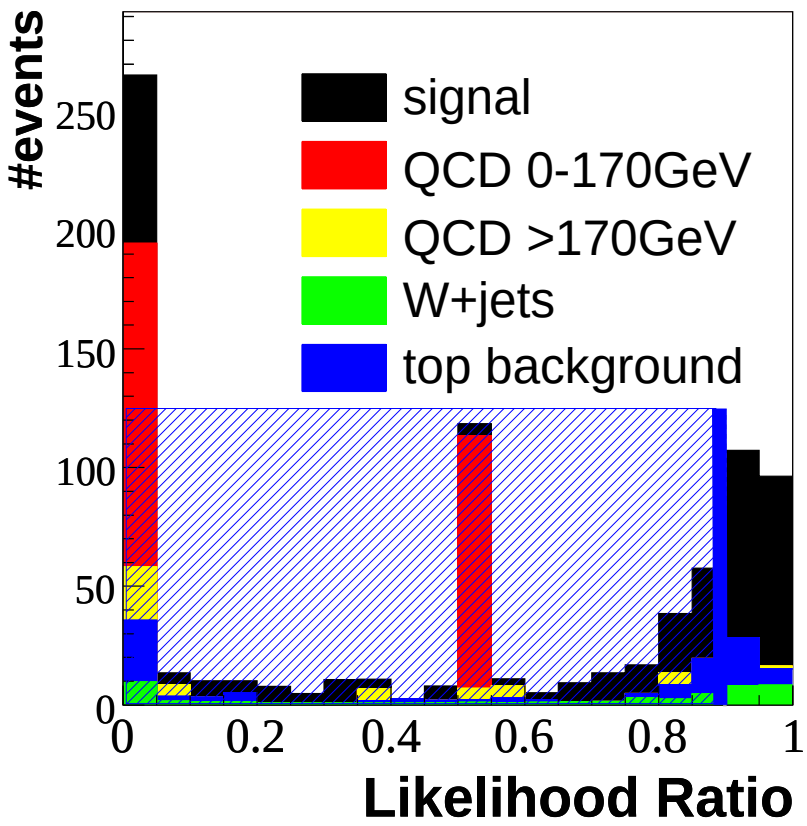
Angle between b and μ

Angle between W Quarks





Reconstruction of the Top Mass



Efficiencies:

Signal:	**6%**	(~155 evts)
Top BG:	0.2%	
W+Jets:	2E-3%	
QCD Jets:	0%	

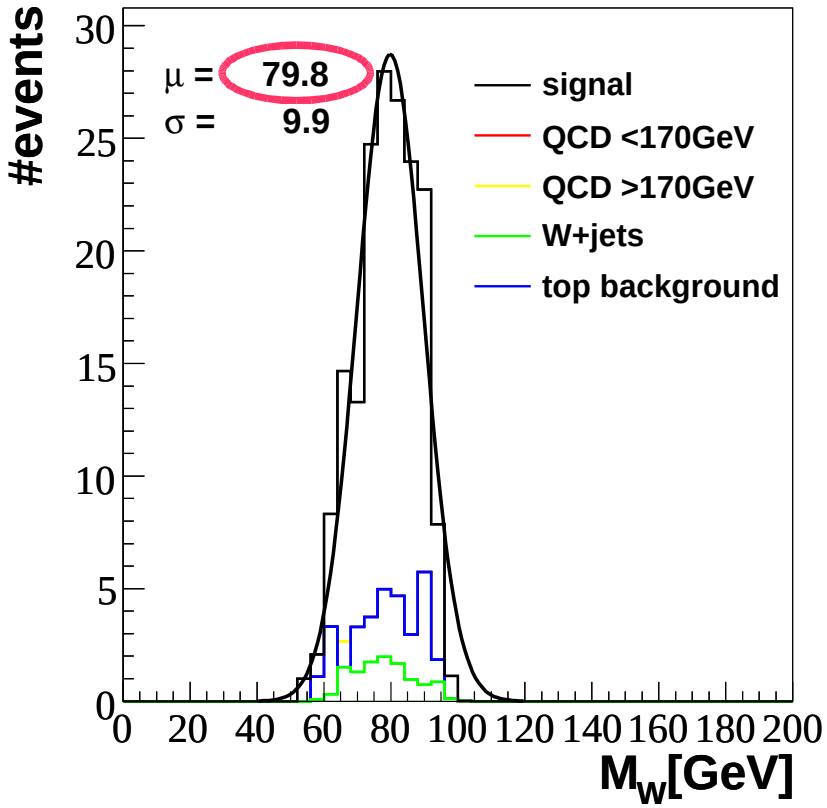
BUT: with large uncertainties!

Signal Purity: ~70%

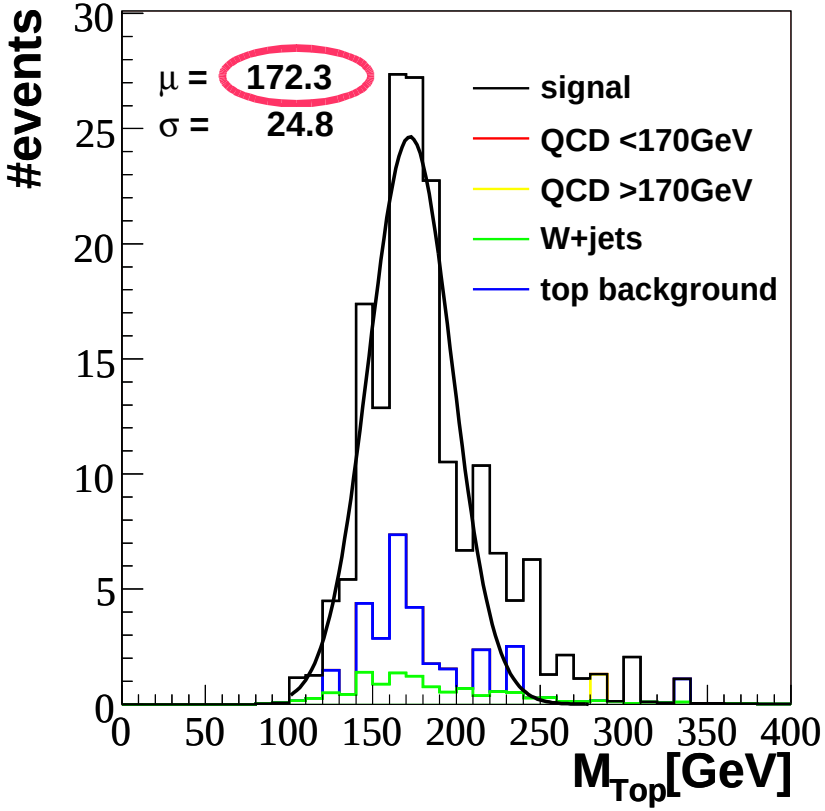
Fraction of events with right combination for Top Mass Plot: ~70%

Top & W Mass Plots

W Mass



Top Mass

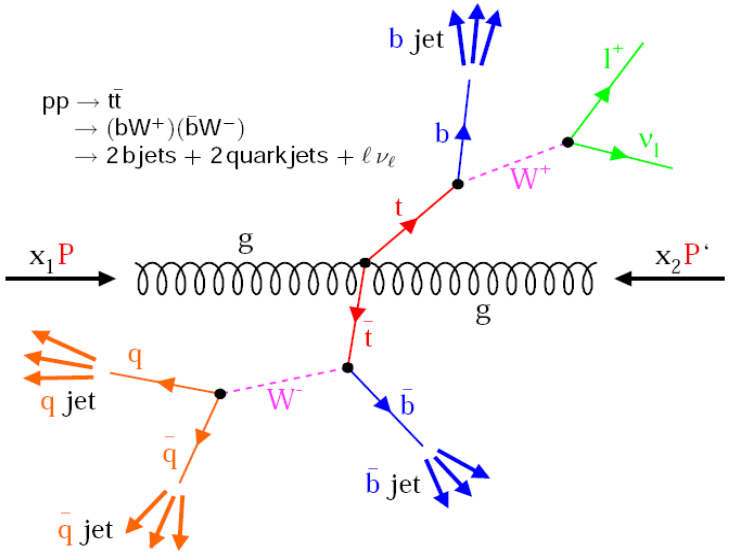


- Made use of the W mass to recalibrate jets
- Work on method to estimate QCD BG from data

Top Mass from a Constraint Fit

Determine the Top Mass from a constraint fit:

- Hypothesis: event topology of semileptonic ttbar event
- 3dof from 5 measured final state objetcts (15 measured parameters)
- ν remains unmeasured (3 free parameters)



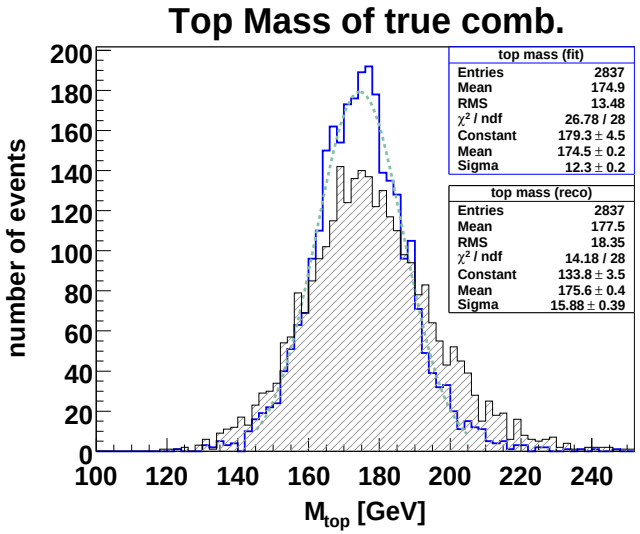
Constraints:

- W Masses (+2 constraints)
- Momentum conservation in the transverse plane (+2 constraints)
- Difference in the two Top Masses (+1 constraint)

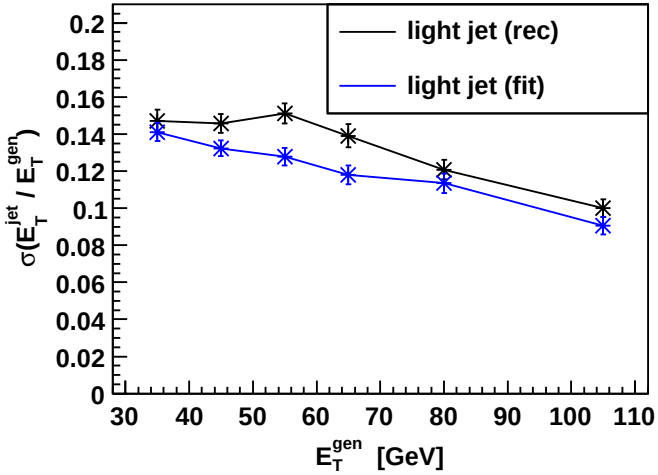
5 constraints fit to determine 4 free parameters (3 from the ν + the Top Mass)

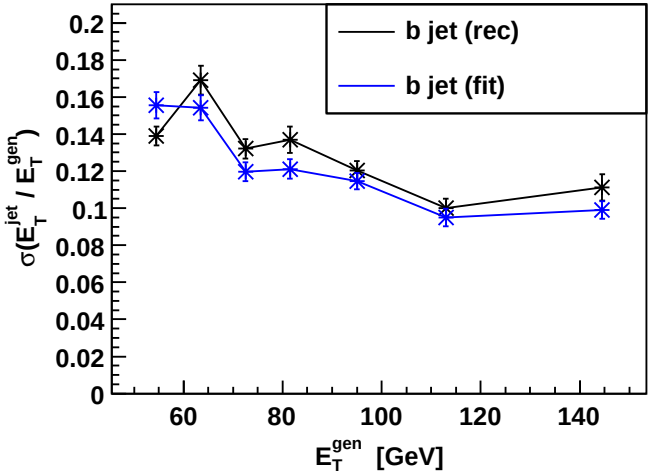
Includes in situ jet calibration via W mass constraint!

Improvement of Resolutions



- Apply constraint fit top signal events after std selection
- Top Mass resolution improves by 30%
- Also jet energy resolution improves





Conclusions

- A rediscovery of the Top Quark should be feasible with the first 20pb^{-1} of good data at LHC
- S/BG~1-3 may be achieved (but based on low statistics on QCD BG)
- Top Mass estimate with ~155 evts (W Mass can be exploited for a recalibration of the jet energy scale)
- Need method(s) to constrain massive backgrounds (like QCD) from data
- In later measurements the use of constraint fits can further improve the Top Mass and jet energy resolution