Selection of $p\bar{p} \rightarrow t\bar{t}$ events in the all–hadronic channel

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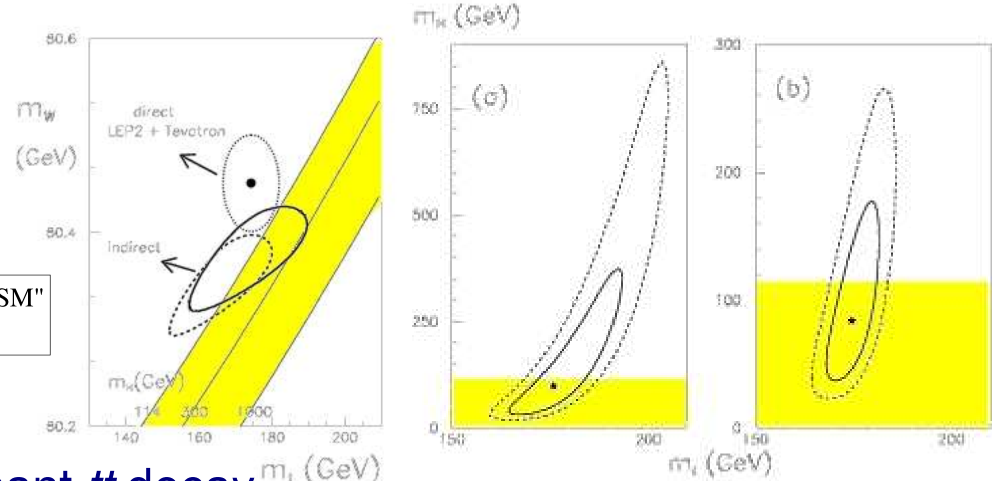
CDF End Of Year Review

Liverpool

16–17 / December / 2002

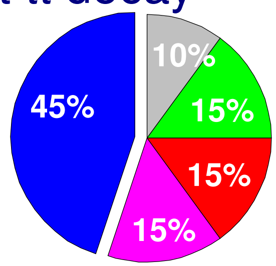
- A more accurate m_t measurement is valuable as input to precision EW analysis

P. Renton "Precision EW tests of the SM"
Rept. Prog.Phys.65:1271–1330,2002

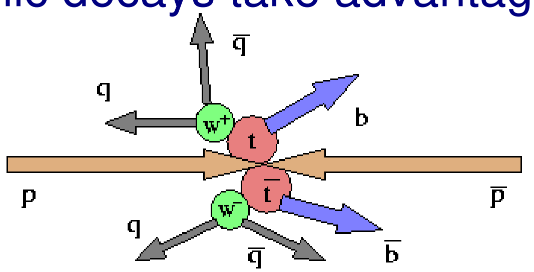


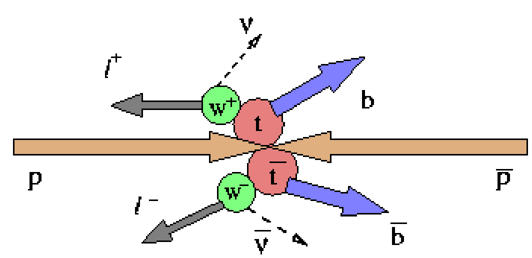
- The all–hadronic is the dominant tt decay

$W \to q\bar{q}$	$W \to q\bar{q}$
$W \to e\nu$	$W \to q\bar{q}$
$W \to \mu\nu$	$W \to q\bar{q}$
$W \to \tau\nu$	$W \to q\bar{q}$
$W \to l\nu$	$W \to l\nu$



- All–hadronic decays take advantage of a fully reconstructed final state





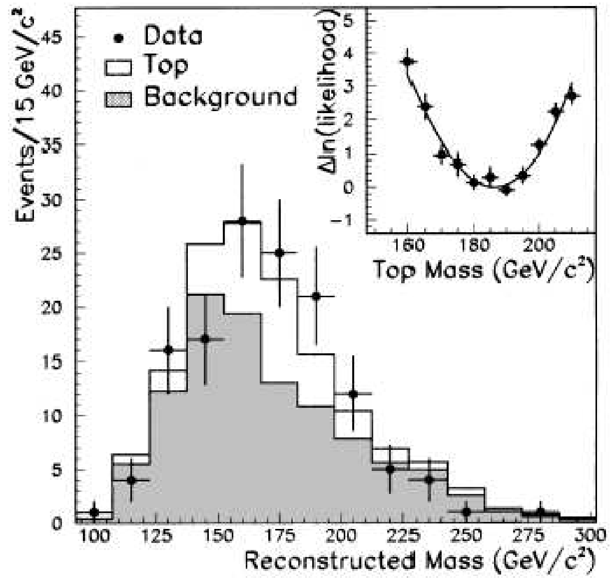
Survey of the current measurements

- CDF top quark mass measurement in the all–hadronic channel

$$m_t = 186 \pm 10\,(stat.) \pm 5.7\,(sist.)\,GeV/c^2$$

CDF Coll. "First Observation of the all hadronic decay of ttbar pairs". Phys. Rev. Lett. 79:1992, 1992

CDF Coll. "Measurement of the top quark mass with CDF at TeVatron" Phys.Rev. D63:03003, 2001



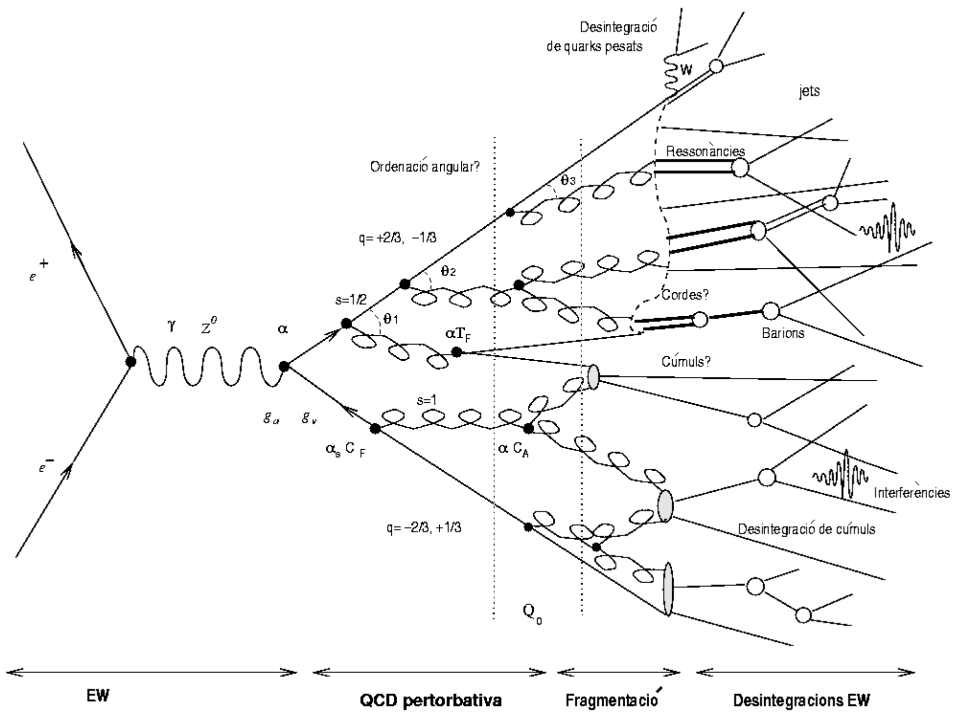
- CDF measurement of m_t (all channels):

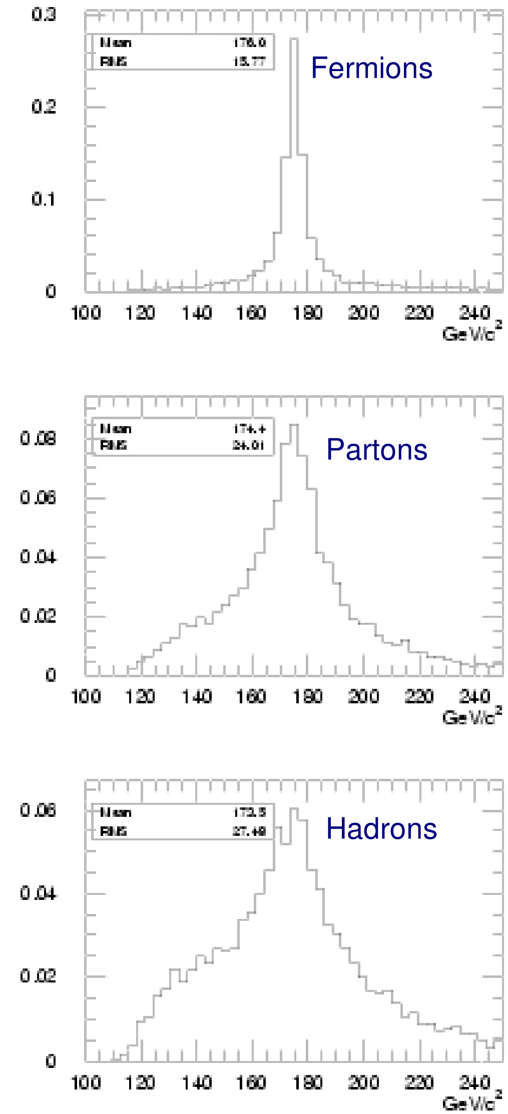
$$m_t = 176.1 \pm 5.1\,(stat.) \pm 5.3\,(sist.)\,GeV/c^2$$

- In Run 2 both statistical and systematical errors can be reduced (specially in the all–hadronic channel)
- LHC prospects: achieve a resolution of 1–2 GeV/c^2

QCD effects on the m_t measurement

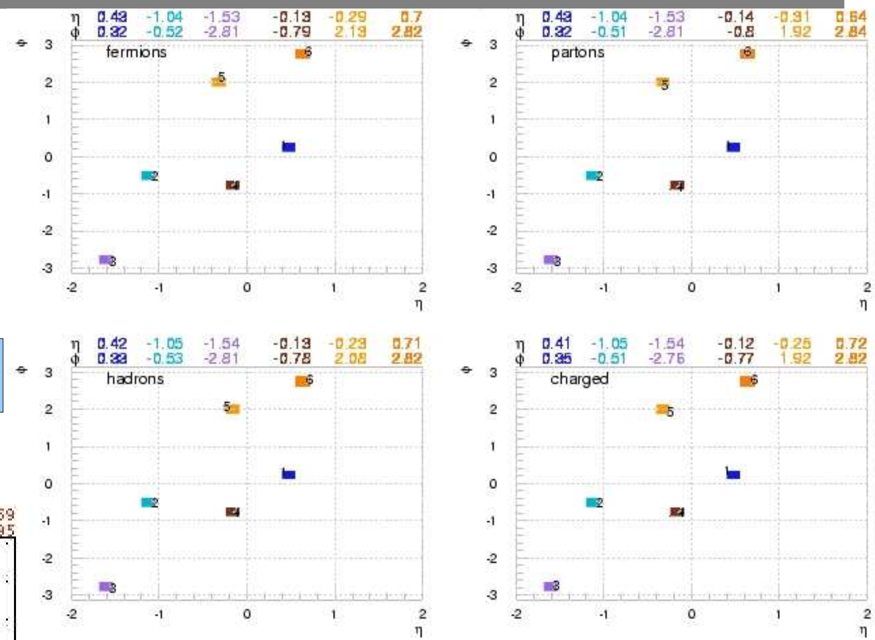
- Academic exercise: generate tt events with PYTHIA and reconstruct the mass of the top at fermion, parton and hadron level (the later two clustering the particles with K_t algorithm)



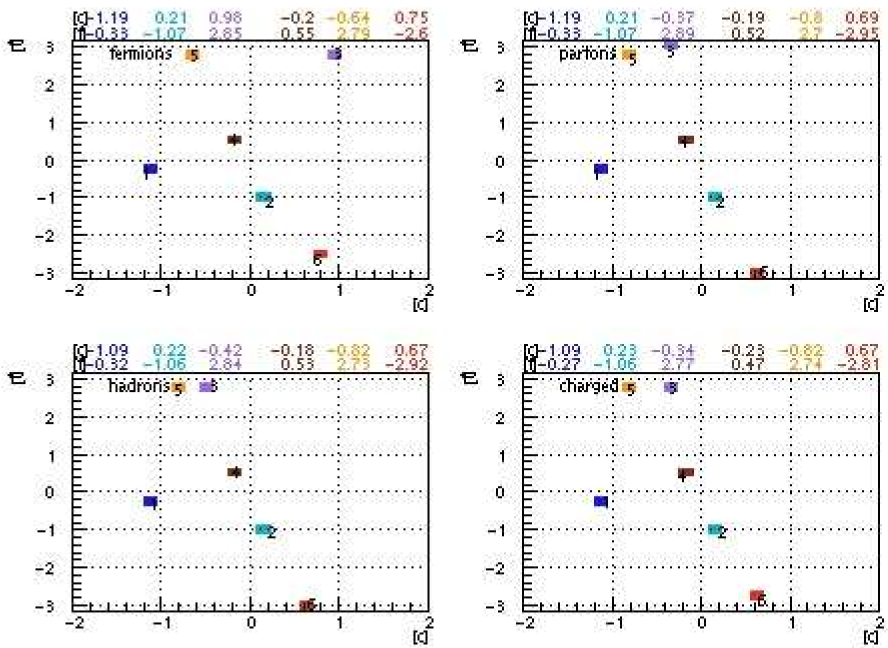


PYTHIA events

- All–hadronic ttbar events. Compare the directions of the 6 quarks with the jets at parton, hadron and charged particle level



Jet directions OK ⟹



⟸ Jet directions shifted

Analysis using MC samples

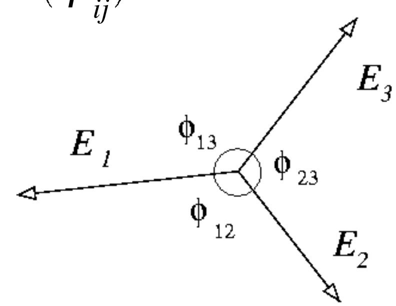
- Use CDF off–line code version 4.9.0 at cdfjif1
- Simulate a tt sample and some background (WW, W+jets and bb)
- Pt cut at generator level of 20 GeV/c
- Force W decays to qq (all–hadronic)

Process	Sim Xsec	Events	Sim Lumin.
T t	3.064 pb	8471	2.77 fb–1
W W	4.105 pb	7000	1.71 fb–1
W + jets	7.744 nb	5000	6.5 E–4 fb–1
B b	0.042 mb	10000	2.4 E–10 fb–1

Analysis of 6–jet events

- Select "*big*" hadronic events
- Use charged tracks and with a K_T–like algortihm force 6 jets
- Group the jets in two triplets (10 possible combinations)
- Compute the jet energies as follows
  - Correct measured energies asking that a pair of each triplet has $m_{jj} = M_W$
  - Second step: take mean invariant mass of both triplets and boost each jet to its triplet CMS frame.
  - Compute the energies in that frame using: $E_i = E_{CM} \frac{|\epsilon_{ijk}| \sin(\phi_{jk})}{\sum \sin(\phi_{ij})}$
  - Test the jet energies and choose that combination that minimizes:

$$\chi^2 = \sum_{j=1}^{6} \left(\frac{E_{meas\ i} - E_{calc\ i}}{\sigma_{E\ i}} \right)^2$$



  - Of course: b–tagging would help

"Hadronic" events selection

- Of course all events are hadronic.
- In this scope "hadronic event" means "multijet"
- Select events according to:

  i. Charged multiplicity ⩾ 50

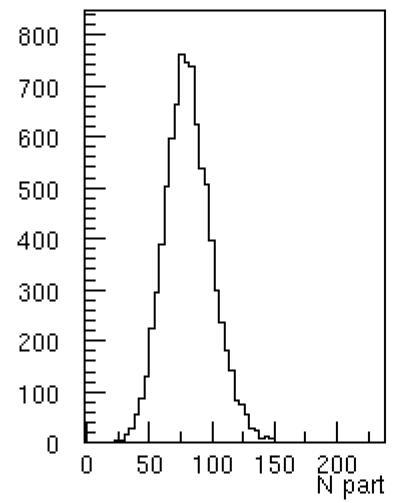
  ii. ΣP_t (of all charged tracks) ⩾ 125 GeV/c

  iii. P_t (leading particle) ⩾ 12 GeV/c

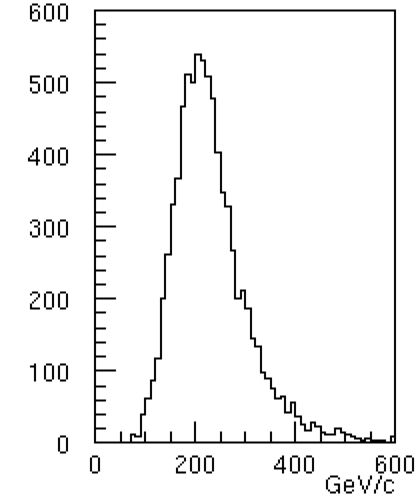
  iv. P_t (second particle) ⩾ 10 GeV/c

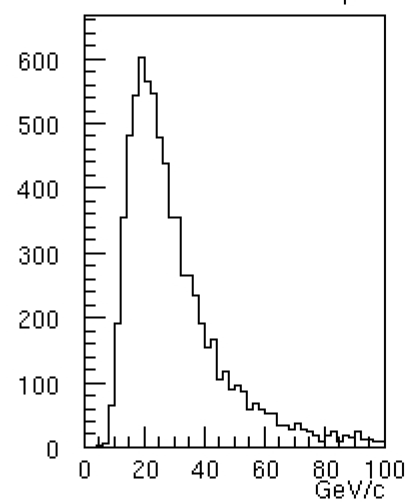
  v. Number of KtClusModule−cone1.0 jets ⩾ 4

- Charged multiplicity

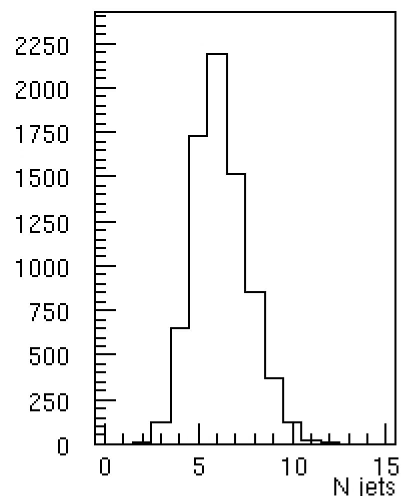


- ΣP_t (of all charged tracks)





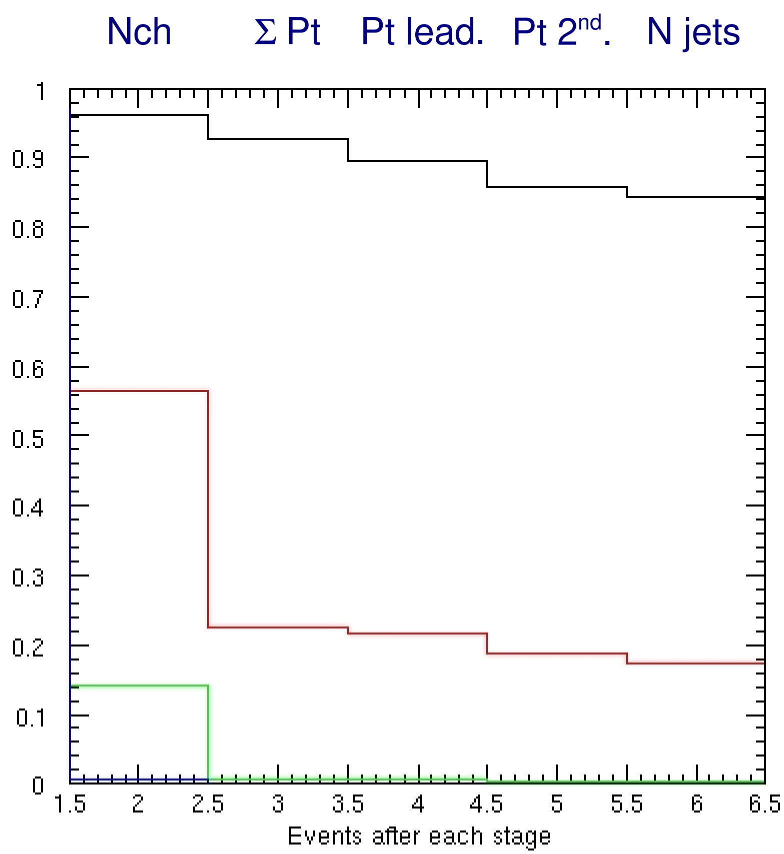
P_t (leading particle)



- KtClusModule−cone1.0

"Hadronic" events selection (2)

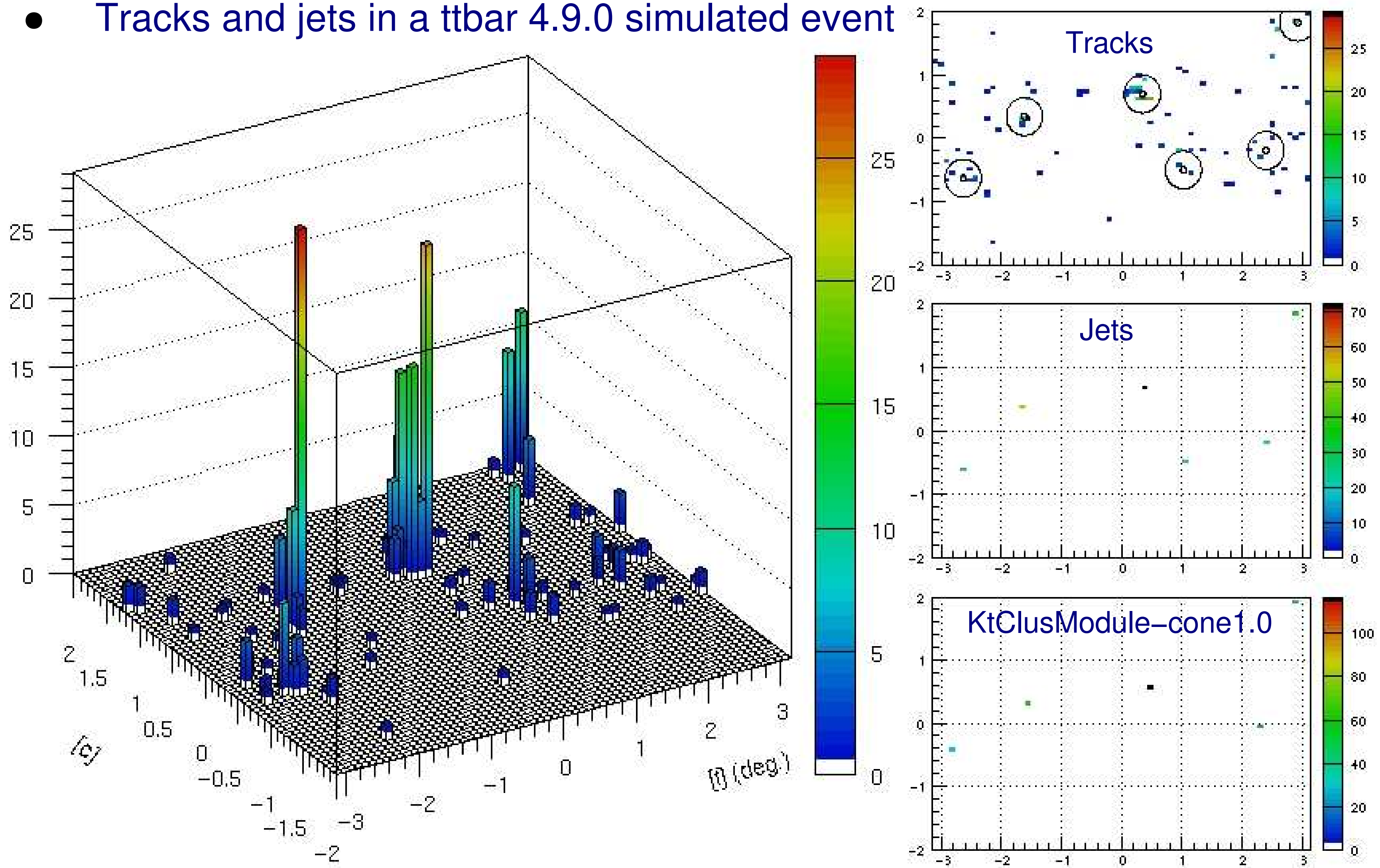
- Efficiency of the selection



Process	Starting	Passing	Eff. (%)
T t	8471	7154	84.5
W W	7000	1211	17.3
W+jets	5000	18	0.4
B b	10000	0	0

Example: ttbar event

- Tracks and jets in a ttbar 4.9.0 simulated event



Charged–particle jet selection

- The aim is to select those events with *nice–looking* charged–particle jets

- Selection works as follows

i. ∀ jet: #part in jet ⩾3 & #part in core⩾1

ii. ∀ jet: $E_{core} > E_{outer}$

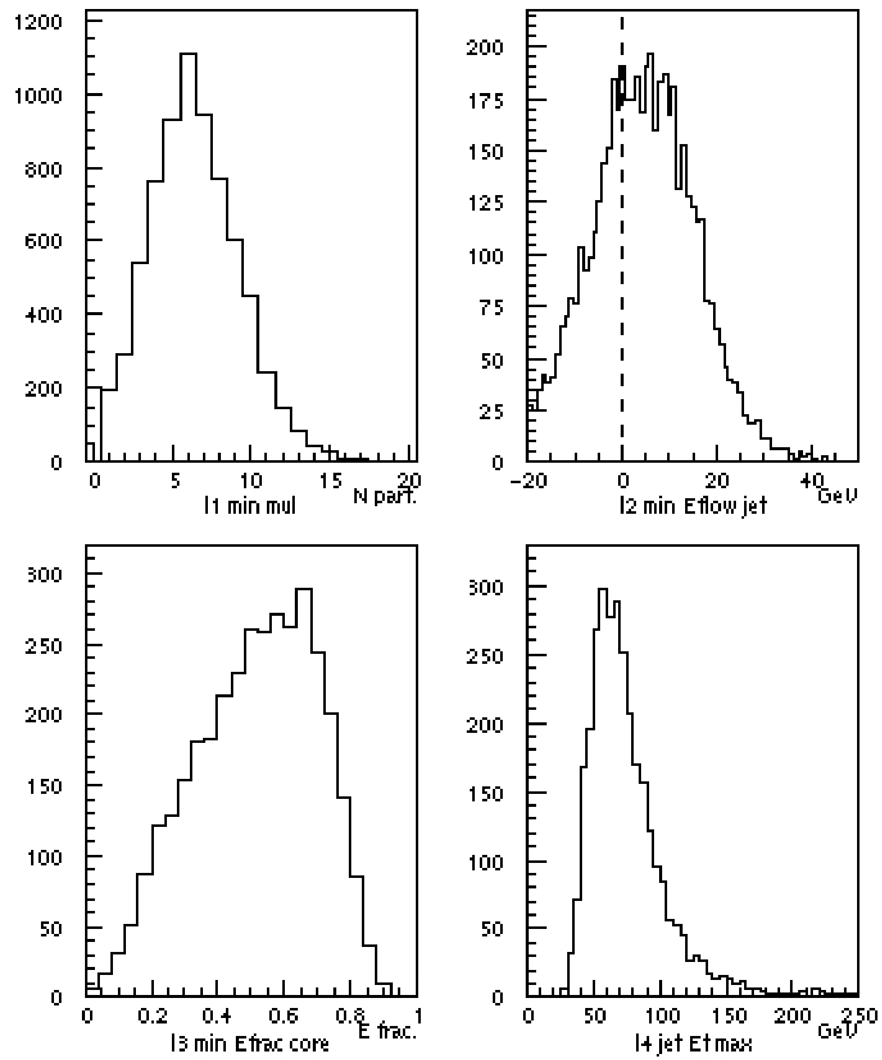
iii. ∀ jet: $E_{core} > 0.2 \times E_{jet}$

iv. E_T (leading jet) ⩾ 40 GeV/c

v. ∀ jet: $E_T > 5$ GeV

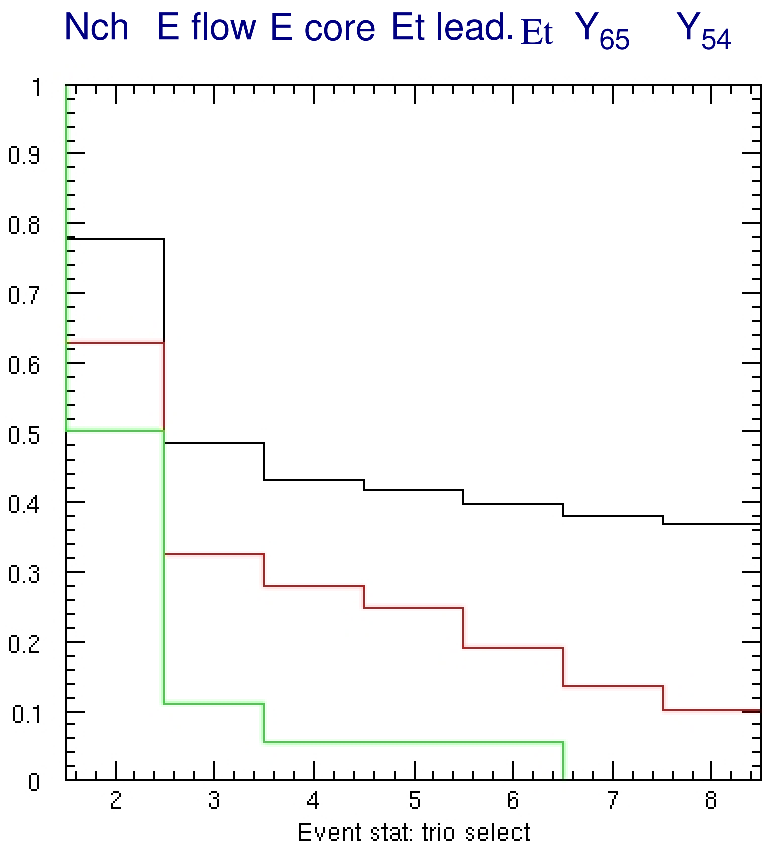
vi. Y_{cut} (6→5) ⩾ 30 GeV^2

vii. Y_{cut} (5→4) ⩾ 100 GeV^2



Charged–particle jet selection (2)

- Efficiency of the jet selection

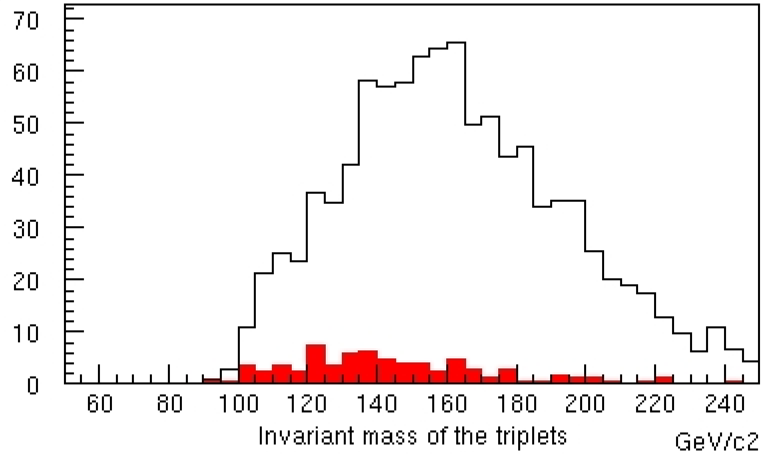


Process	Starting	Passing	Eff. (%)
Tt	7154	2845	39.8
WW	1211	230	19.0
W+jets	18	0	0
Bb	0		

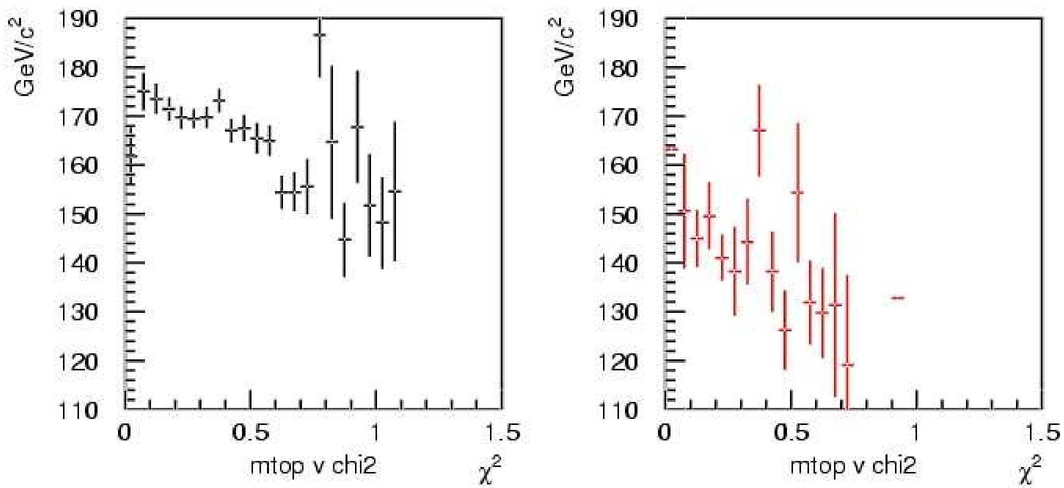
Results

- Invariant mass of the triplets for **ttbar** signal and **WW** background

  (normalized to $1 fb^{-1}$)



- χ^2 dependence.



Summary

- Analysis of ttbar events in the all–hadronic decay channel
- Fully reconstructed final state $\Rightarrow$ kinematics study
- It is necessary a study of the QCD effects on the top mass
- Kinematical Analysis: counts on nice reconstructed jets
- Jet energy correction: assumes $M_{jj}=M_W$
- B tagging would be of tremendous help !
- MC study was performed with ttbar signal and some backgrounds and very preliminary results are promising.
- My plan for 2003:
  - QCD effects
  - Jet clustering algorithms
  - Include B tagging
- Real data analysis