Top Mass Systematics: color Reconnection

There are three questions

1. Evaluate Color reconnection systematics

2. Study the differences between the new PYTHIA and the old one (parton shower model, as well as underlying event model). This because we have used PYTHIA V6.2 for the calibration of the method and the systematics

3. To what extend MC and data agree?

Comparison of jet variables MC- Data

Continuing studies on color reconnection systematics require the understanding of jets from PYTHIA V6.4

We have looked at jet variables and compare them to jets in top data. Only b-tagged jets are considered in this comparison.

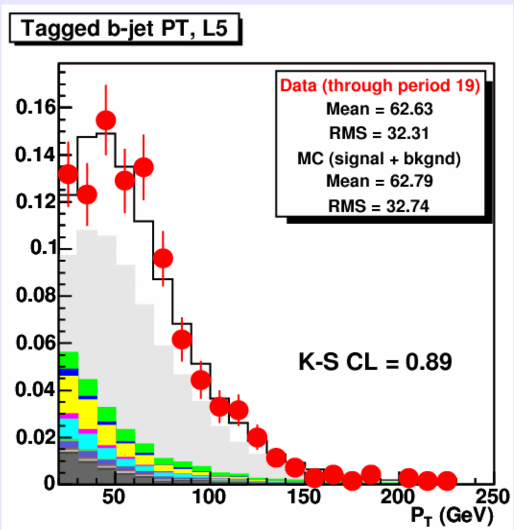
There are 698 jets tagged by our secondary vertex algorithm.
N(events)= 578 with the topology lepton+4 jets (PT>20 GeV) .
N(background)= 134 $\pm$ 34 events.

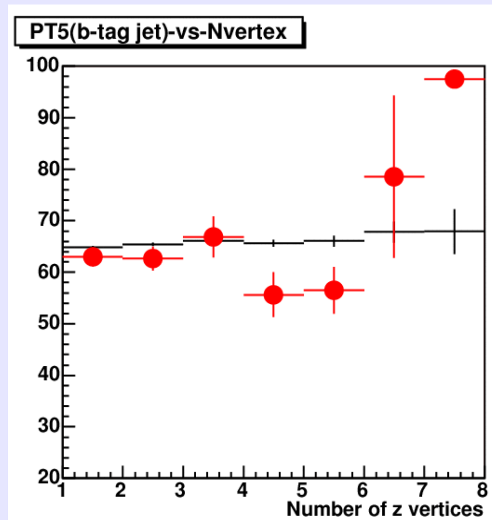
Variables:
- Jet mass
- Number of charged particles
- Eta moments
- Phi moments

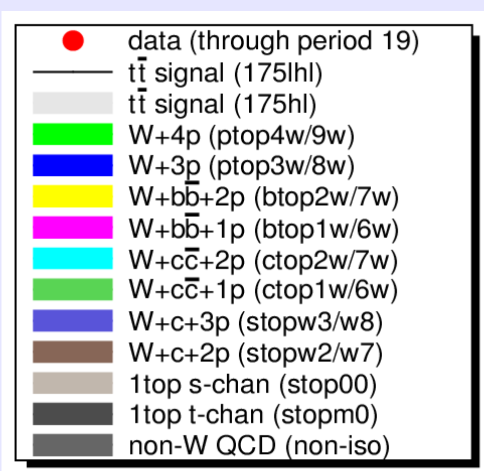
We have many histograms. I only show a few of them.

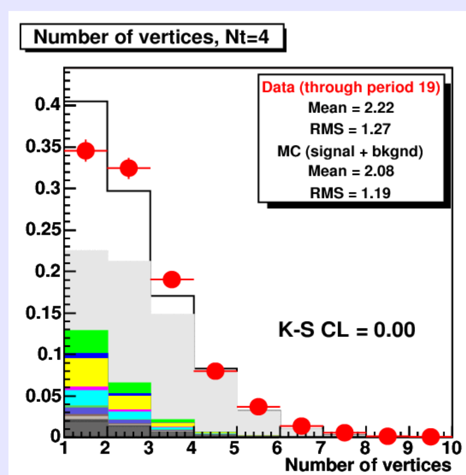
Tagged Jet PT

Comparison of data and MC for the default PYTHIA V6.2.
Only events with N(tight)=4 included (698 jets, of which 13% are non-b)









The measured b-jet P_T agrees with PYTHIA V6.2 tune AV, which is our default.

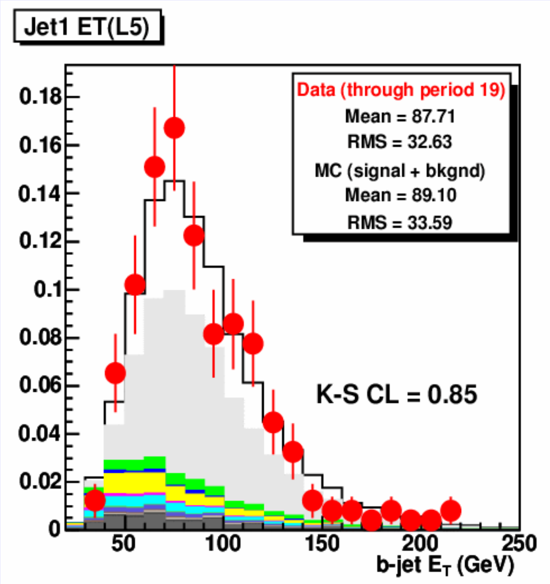
The dependence on Nvtx is minimal which means we are correcting the jets properly.

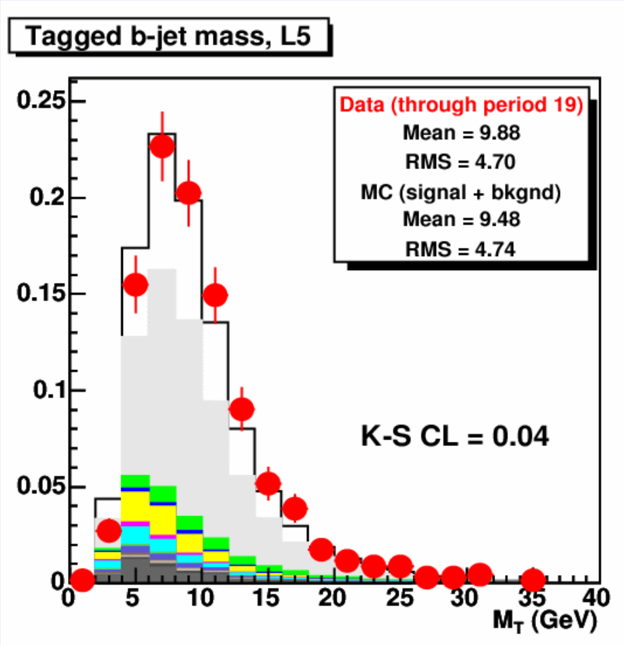
The lumi profile is not very good, as the background luminosity is limited to the first 1/3 of the data.

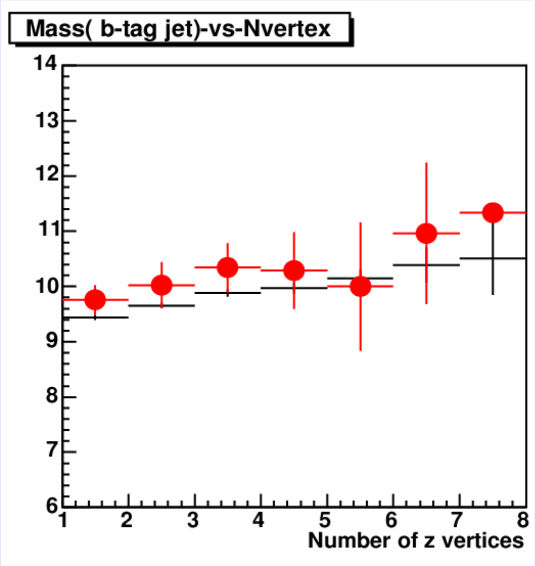
More variables: ET_1 and Jet Mass

ET of jet 1 (the highest ET jet that is also tagged). Good agreement.

Jet mass agrees poorly with MC. Dependence on Nvtx is strong.
Jet corrections are based on PT, do they correct the mass properly?
Can we use these variable to distinguish between different tunes?



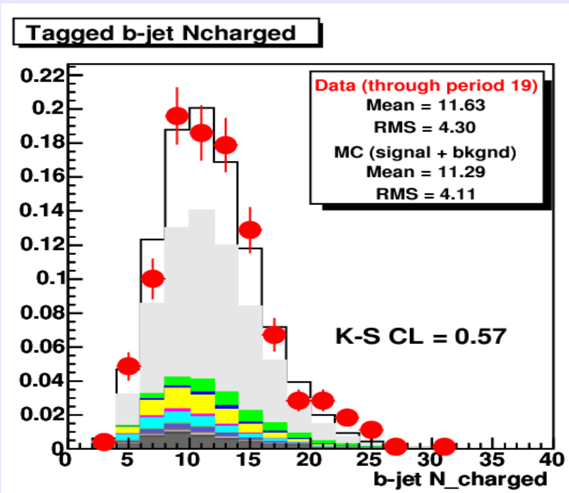


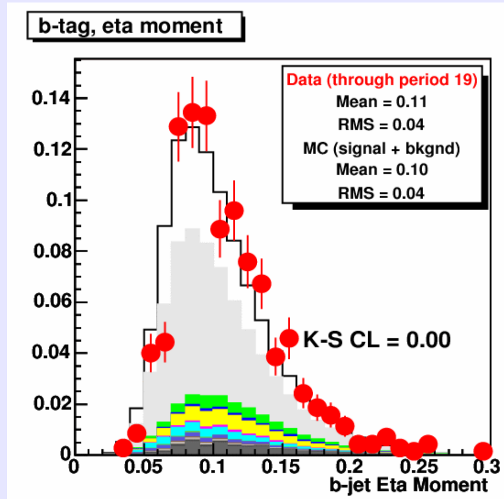


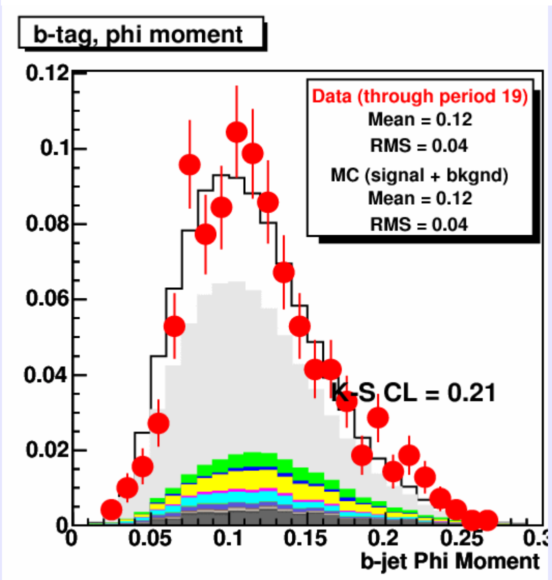
MC expects the average jet mass to vary from 9.6 to 11.0 for 1-7 vertices. We notice, however, that the data is higher than MC for the first three points where there is more data. TO BE UNDERSTOOD

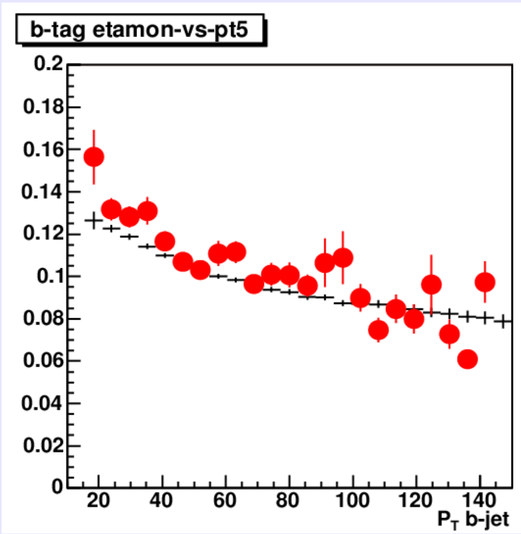
Jet Shapes Variables in b-jets

V6.2 tune AV comparison of N(charged) in cone and φ and η Moments









MC agree quite well for the N(charged) variable.

For the moments distributions, we have not normalized to 50 GeV, as the PT distributions for data and MC agree quite well and we are using only one mass point (175 GeV).

The φ monents agree very well with the data. The η moments do not agree at all as already observed By Andrea and Hyunsu. The Moment dependence on P_T(jet) is in clear disagreement with the data

Comparison with other tunes

Plots shown are for the default PYTHIA V6.2. The agreement is quantified by the KS value. A summary of the values for many samples is shown below.

	V6.2-AV	Aprolhl	ACRlhl	S0pro	NOCRPg0	S0Pg0
b-jet PT	0.89	0.86	0.89	0.65	0.86	0.90
ET1 (b-tag)	0.85	0.71	0.74	0.93	0.85	0.88
Jet Mass	0.04	0.01	0.10	0.02	0.02	0.02
N(charged)	0.57	0.13	0.84	0.20	0.18	0.30
η moments	0.00	0.00	0.01	0.00	0.00	0.00
φ moments	0.21	0.10	0.47	0.37	0.24	0.26

It is not clear on how to choose between the different tunes as none of the ones considered fair well on all of these variables. We need to do additional work to understand the situation.

Additional studies are being done and are now URGENTLY needed.
- quark jet shapes in di-jets events
- b-jet studies in di-jet events

Procedures

Use the l+jets sample: events with 1 lepton + 4 jets (Et>20 GeV)

A. Given a MC sample, for each event we match the partons from top decays to the observed jets (Ntight = 4). This is match of the 4 partons to the 4 jets in the event.
We then know which jet are light quark jets and which ones are b-jets.
To check the changes between MC's we compare a number of variables for the different tunings, for example:

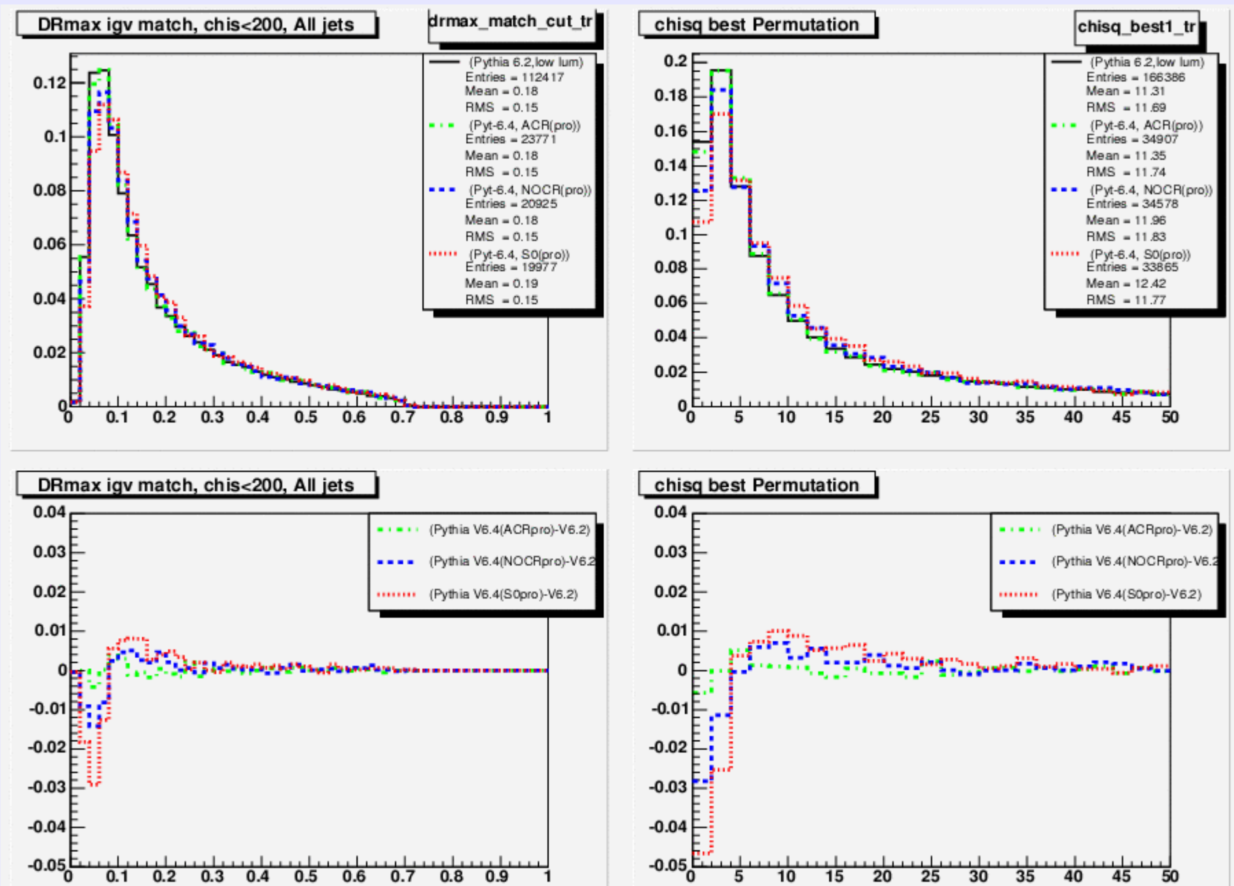
- Compare E(parton) and E(jet) in cone of R=0.4
- Compare M(W) and M(top) using the matched jets

B. We apply to each sample the top mass measurement analysis to obtain a mass and an uncertainty.

- For methods A and B, we compare results obtained for
  V6.2(tune A) old MC (used for CDF measurements)
  V6.4 (tune ACR) only CR added to old shower
  V6.4 (tune NOCR, S0) new shower, wo/w CR

Matching studies: different tunes

The whole event is matched using ΔR for each parton-jet pair. An overall χ^2 is calculated, best $\chi^2 < 200$ are accepted as matched



M=175 GeV

V6.2 (tune A)	68%
V6.4 ACR	68%
V6.4 NOCR	60%
V6.4 S0-pro	59%
V6.4 NCR-Pg0	59%
V6.4 S0-Pg0	59%

Samples with new parton shower have:

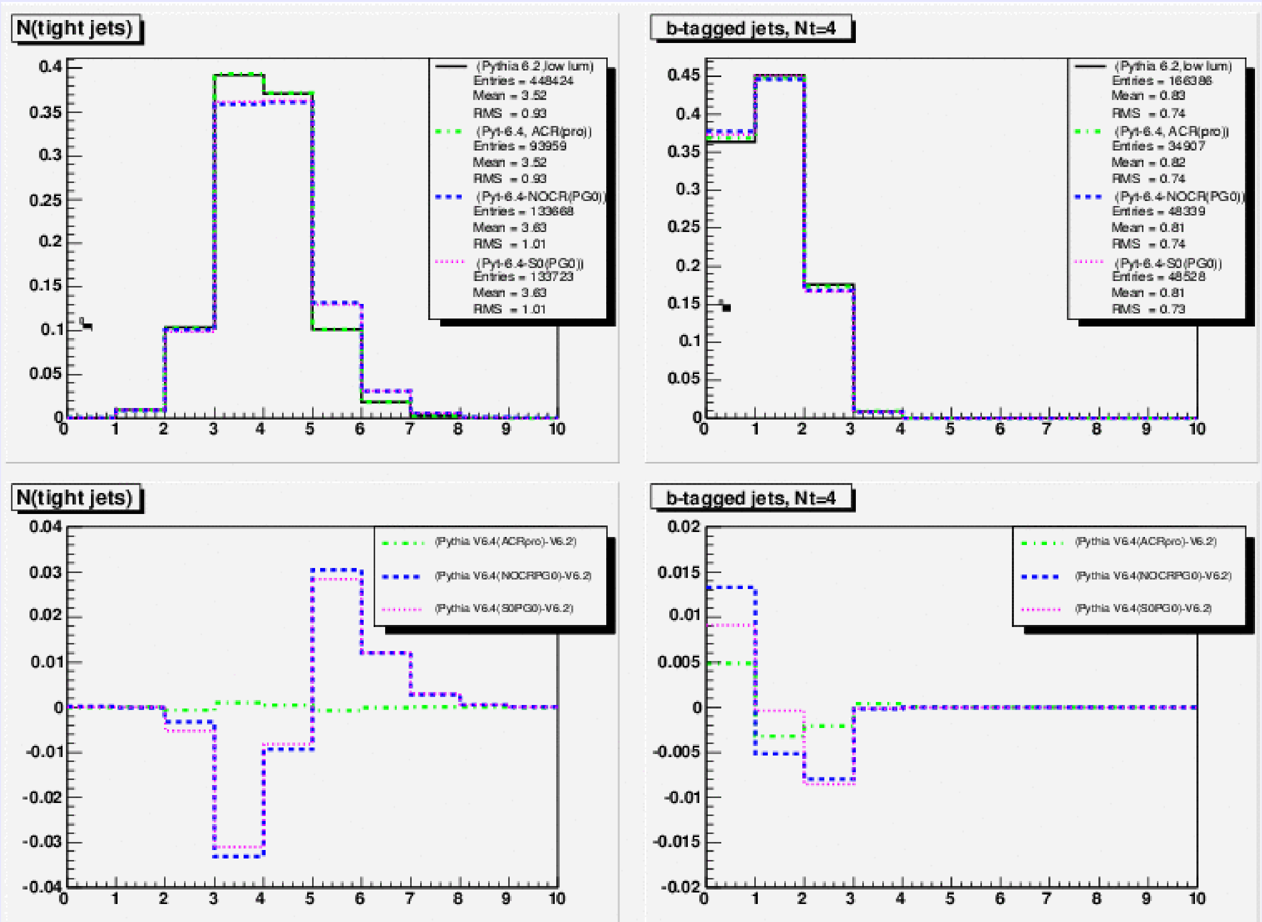
wider χ^2 distributions

wider ΔR "

The new parton shower model gives less matched events .

More matching studies: more ISR?

Comparison of Number of tight jets in the Perugia0 and PYTHIA V6.2.
Also comparison of number of tagged b jets in the N(tight)=4 sample



Matching events:

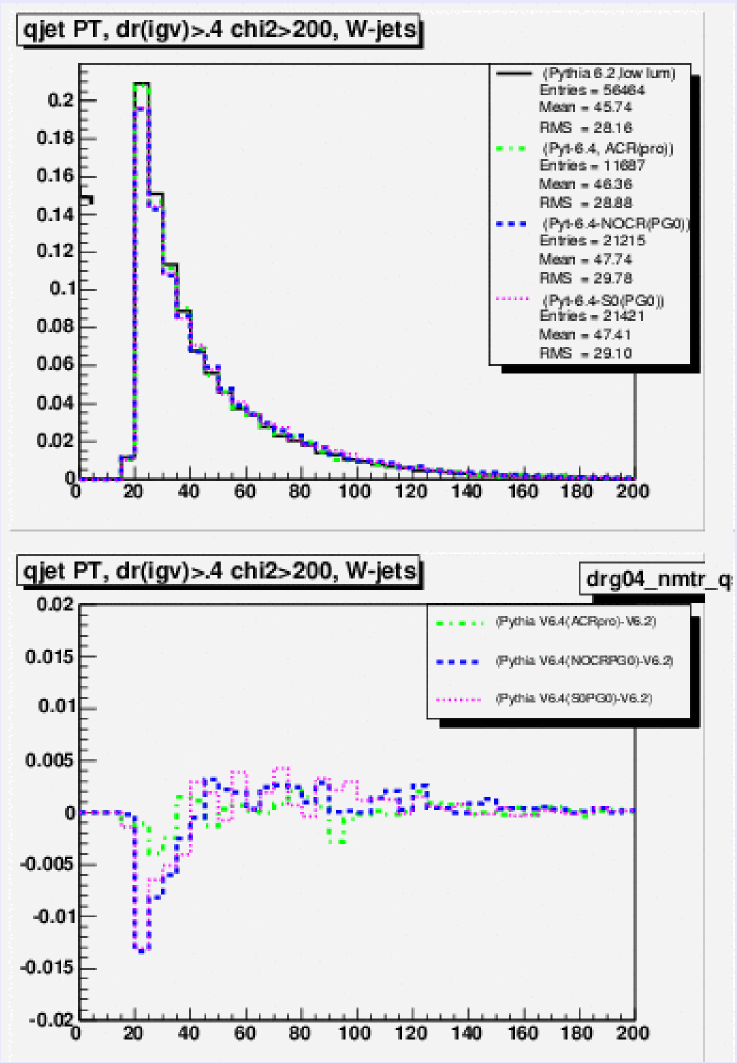
V6.2 (tune A) 68%
V6.4 ACR 68%
V6.4 NCR-Pg0 59%
V6.4 S0-Pg0 59%

Perugia0 :
More N(tight)
Less b-jets
in 4 jet sample

Both findings point to more ISR in the S0-Perugia0 samples

Matching Studies: no-match PT

Comparison of non-matching light quark jets : PYTHIA V6.2-vs- 6.4 Pg0



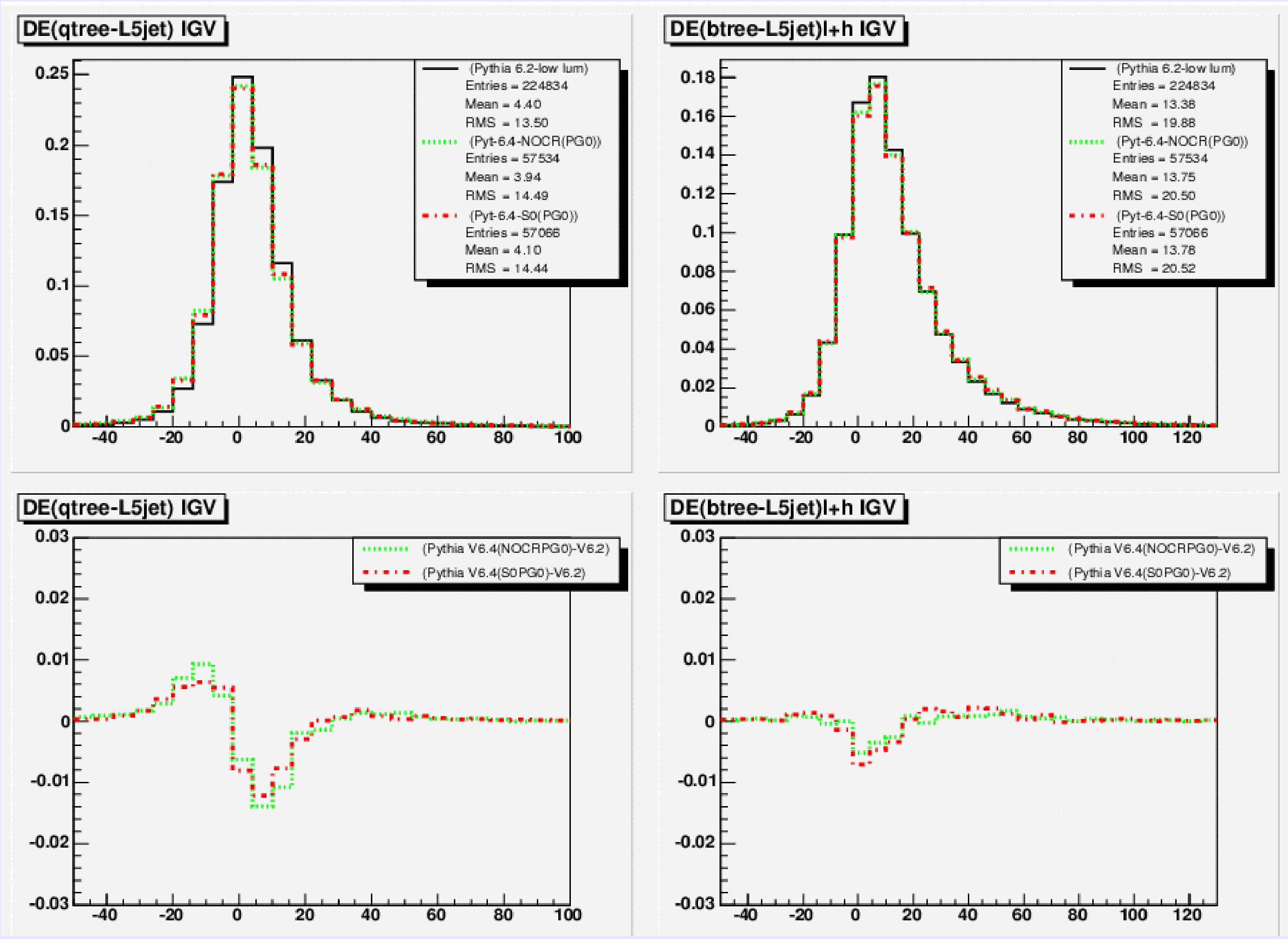
Comparison shows that the P_T of the non-matching jets is higher for the Perugia0 samples: more ISR?

More ISR means that out of the 4 high ET jets is more likely to pick up an ISR jet rather then a jet from top.

This will result in a shifted top mass.

Comparison: E in cone of 0.4

S0Pg0 (S0Perugia0) compared with our default (V6.2 tune A)

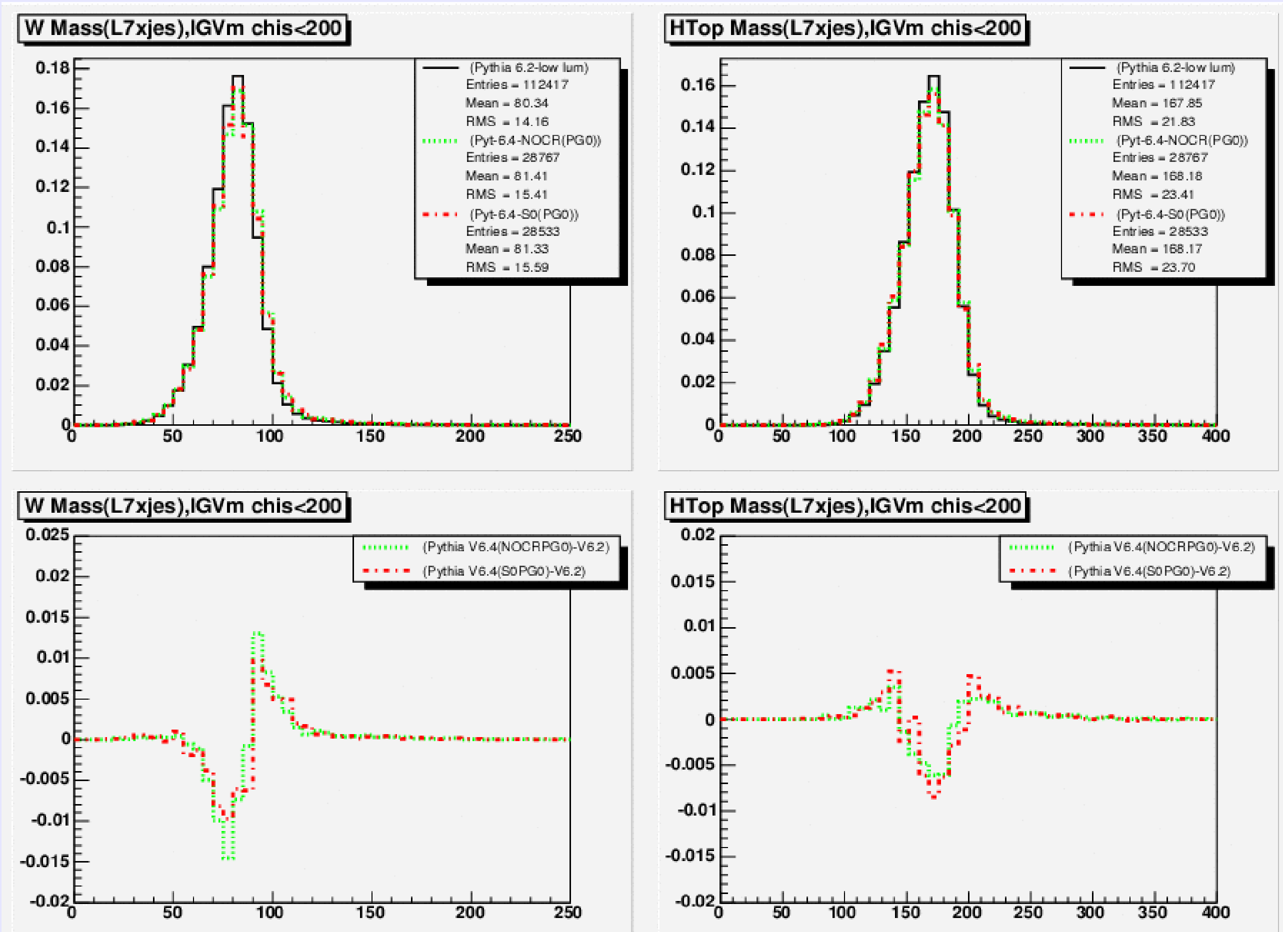


S0Pg0 -Nominal

	Δ E (cone) GeV
W-jets	+0.30 ± 0.15
b-jets	-0.40 ± 0.15

The S0-Perugia0 tune has different behavior for the b-jets

S0-Perugia0 W and Top mass shifts



M=175 GeV ΔMw

V6.4 NCR-Pg0 +1.07
V6.4 S0-Pg0 +1.00

M=175 GeV ΔMtop

V6.4 NCR-Pg0 +0.33
V6.4 S0-Pg0 +0.33

The S0- Perugia0 and corresponding NOCR have a small top mass shift

Summary of studies on M_{top}

Comparison of V6.2 (nominal) to V6.4 (the "pro" files)
Using both methods, i.e., reconstructing top mass with event matching and with our ME method.

Sample	Δm_W (GeV/c^2)	Δm_t (GeV/c^2)	Δm_t (GeV/c^2)	Δ JES σ
	MC event matching		MTM3 Pseudo-Experiments	
V6.2 (nominal) (ttkt75)	–	–	–	0.01±0.05
V6.4 tune A-pro (otop45)	-0.15±0.13	-0.05±0.20	-0.12±0.26	0.04±0.06
V6.4 ACR-pro (otop46)	-0.09±0.12	-0.14±0.20	-0.53±0.26	0.08±0.06
V6.4 NOCR-pro (otop47)	+0.53±0.14	-0.09±0.21	-1.46±0.27	0.22±0.06
V6.4 S0-pro (otop44)	+0.39±0.14	-1.18±0.22	-1.80±0.28	0.11±0.06
V6.4 NOCR-Pg0 (ctops4)	+1.07±0.09	+0.33±0.14	-1.60±0.32	0.34±0.07
V6.4 S0-Pg0 (ctops3)	+1.00±0.09	+0.32±0.14	-1.45±0.33	0.27±0.07

- ACR (old shower+CR) shows little effect from CR = -0.41 ± 0.37 GeV
- NOCR: Event matching finds large ΔM_W, ME fit compensates for this with a large value of ΔJES, resulting in ΔM_{top} = -1.5 GeV .
  For ΔJES= 0 we get ΔM_{top} = -0.7 ± 0.2 GeV

Color Reconnection Systematic

- S0-pro : ΔM_{top} = -1.8 GeV, expected because of -1.3 GeV b-jet shift.
- S0-Perugia0 : the light quark jets are more shifted then the b-jets. This shifts the W mass considerably (~ 1GeV). The top mass goes up for this reason. The ME fit gets a large DJES to recontract the W mass properly, this moves the jets down resulting in a large DMtop
- NOSR-Pg0: same as above .
- Bottom line: what is the CR systematics?

From ACR (pro)-A(pro) CR = -0.41 ± 0.37
From S0(pro) and NOCR CR = -0.34 ± 0.38
From the Perugia0 tunes CR = $+0.15 \pm 0.45$

- More statistics will help. At this point it seems that CR ~0.5 GeV

Summary of Matching and ME fits

- We find the following CR values from the “pro” tune files:

  -0.41 $\pm$ 0.37 GeV from ACR (-0.4 $\pm$ 0.3 GeV, Winter Conf)

- CR --> -0.34 $\pm$ 0.38 from S0-NOCR,

  CR --> +0.15 $\pm$ 0.45 from the Perugia0 tunes

- The S0-pro (S0Pg0) tune gives ΔM_{top} = -1.8 GeV (-1.5 GeV)

  this is directly related to different jet shapes, i.e., different p-shower

- Tune S0 tunes include systematics that we are already taking into account ,i.e.

  generator : $\Delta(m_t)$ = 0.51 +- 0.37 GeV

  ISR/FSR : $\Delta(m_t)$ = 0.29 +- 0.26 GeV

  OOC : $\Delta(m_t)$ = 0.52 GeV

  b-jets : $\Delta(m_t)$ = 0.38 GeV

  that is 0.88 GeV, most of the MC related systematics.

- More comparison of the S0 tune with Tevatron data needs to be done URGENTLY. We need to disentangle the various contributions

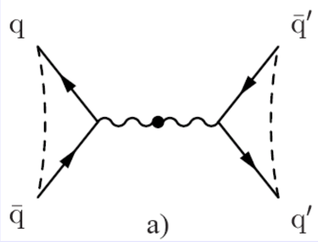
Backup slides

Color Reconnection Systematics

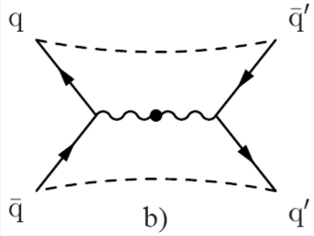
Strong color correlations between the hard process and the underlying event are implied by tune A and similar tunes. These effects may be interpreted as sign for color reconnection.

The issue has been studied at LEP for the W mass measurement

LEP



CR effects on the M_W measurement at LEP contribute to systematics



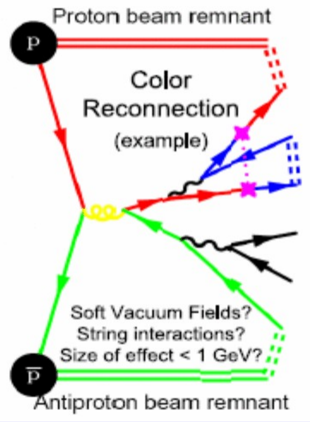
CR(sys) = 8 MeV

out of 22 MeV (total sys)

(LEPEWWG hep-ex/061203)

Tevatron

Preliminary MC studies have indicated possible contributions



to the top mass systematics of order

CR(sys)≈ 0.5 GeV

D. Wicke and P. Skands arXiv:0807.3248V1

Top Mass systematics

For the Winter Conferences Tevatron had delivered 5.8 fb^{-1}, of which 3.2 fb^{-1} were used for the measurement. This will be ~4 fb-1 for Summer '09. Statistical error will get smaller, including the (JES) uncertainties.

Measurement soon will be dominated by systematic uncertainties.

Systematic source	Δm_t (GeV/c^2)
Calibration	0.16
MC generator	0.51
ISR and FSR	0.29
Residual JES	0.52
b-JES	0.38
Lepton P_T	0.18
Permutation weights	0.01
Pileup	0.09
PDFs	0.17
Background: fraction	0.36
Backg: composition	0.33
Backg: average shape	0.03
Backg: Q^2	0.08
Backgrounf:MC statistics	0.05
Color Reconnection	0.41
Total (MC Dependent)	1.13 (0.88)

Systematics dependent on MC used amount to

JES 0.7 GeV
CR 0.4 GeV
Other 0.9 GeV

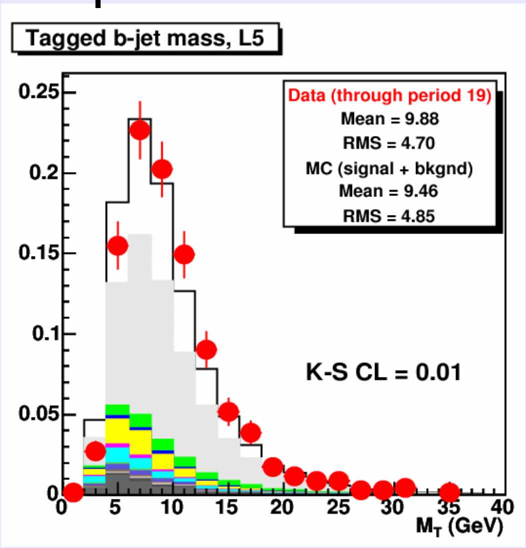
Total 1.2 GeV (of 1.3 GeV)

MC dependent systematics, other the the Color reconnection, are in red.

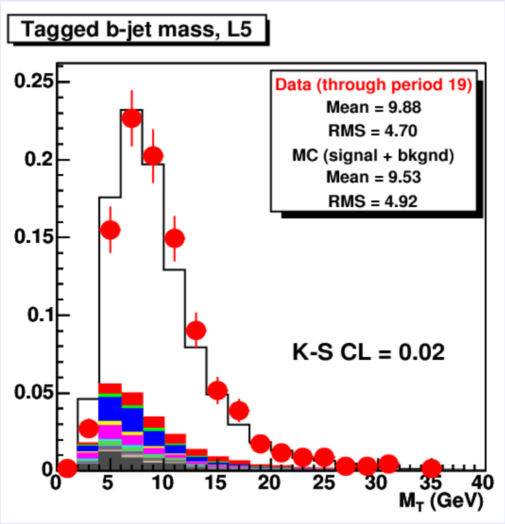
Preliminary studies, which I will be showing today, have evaluated the systematic uncertainty from Color Reconnection to be 0.41 GeV

Jet Mass

A-pro

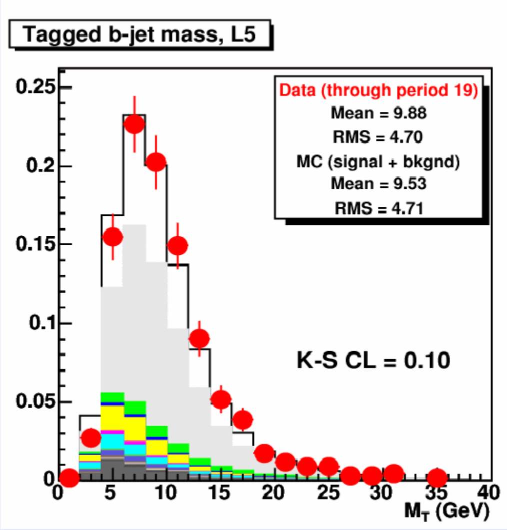


S0-pro

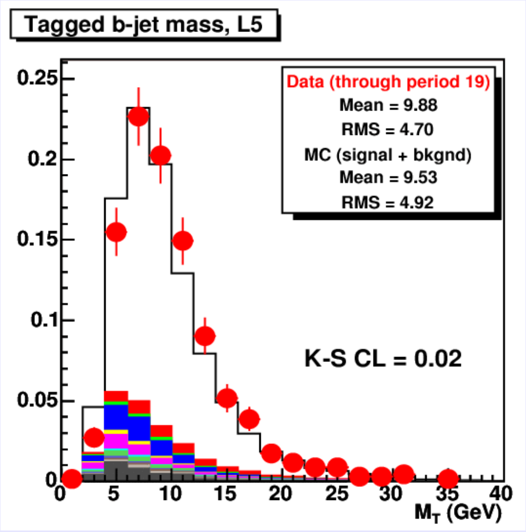


Comment:
Luminosity profile for the S0 files is not correct

ACR-pro

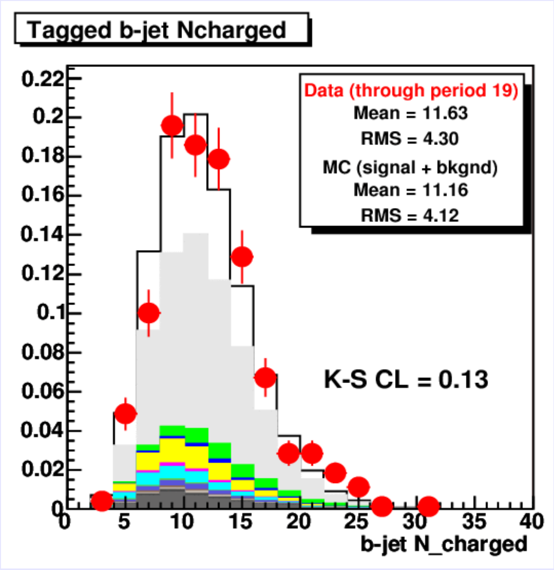


S0-Perugia0

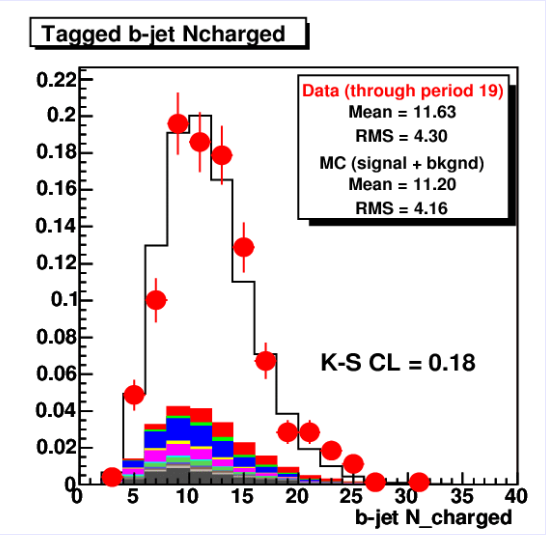


N charged Particles

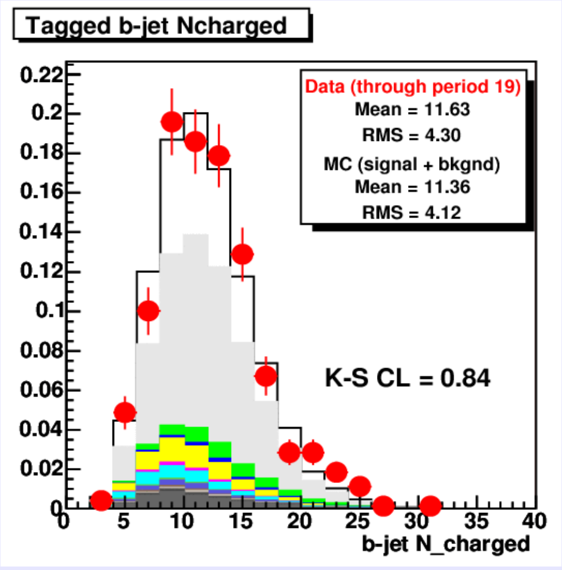
A-pro



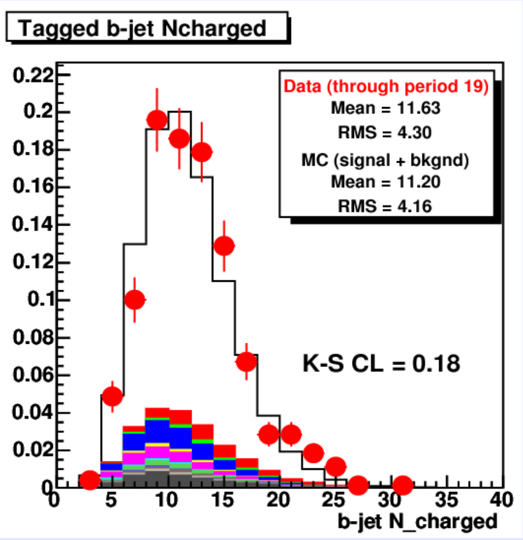
S0-pro



ACR-pro



S0-Perugia0



Comment: Luminosity profile for the S0 files is not correct

Jet Shapes:moments

The eta and phi moments are sensitive to the width of the parton shower. We use calorimeter (both electromagnetic and hadronic components) information to evaluate the moments

We sum over all towers:

$$M_\eta \equiv \sqrt{\sum_{towers} \frac{E_T^{tower}}{E_T^{jet}} \eta^2_{tower} - \eta^2_{jet}}$$

And similar expression for the phi moments,

Used in CDF to distinguish quark jets from gluon jets in ttbar production in the 6 jets topology