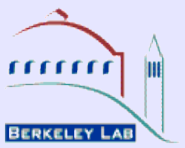




More Studies on Color Reconnection



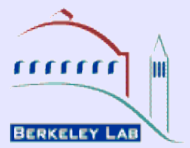
Trying to understand the new tunes

Investigating the new parton shower properties

1. Is there more gluon radiation in the jets?
2. Are the jets different?



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 ($P_T > 20$ GeV) .
N(background)= 134 ± 34 events.

Variables:

Number of charged particles

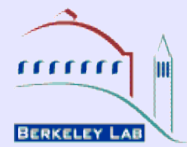
Eta moments

Phi moments

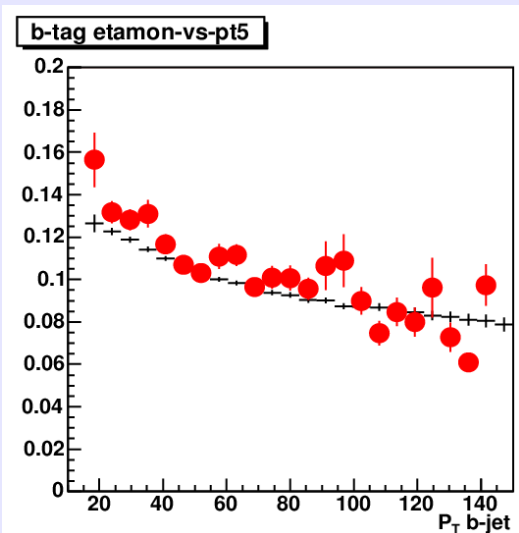
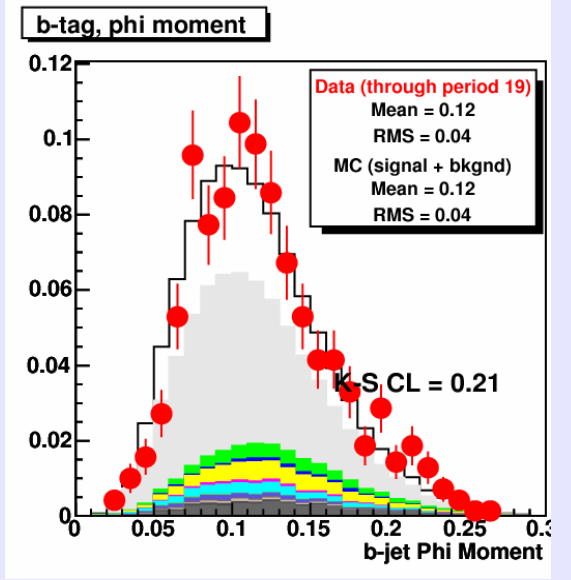
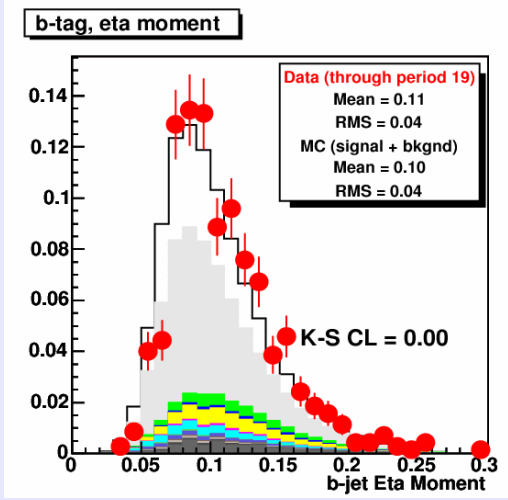
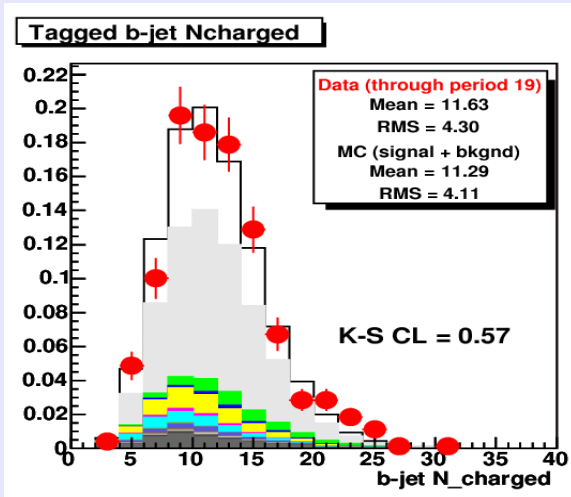
We have many histograms. I only show a few of them.



Jet Shapes Variables in b-jets



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



PYTHIA 6.2 agrees quite well with data for the N(charged) variable.

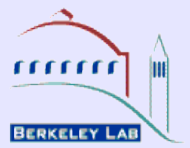
For the moments distributions, we have not normalized to 50 GeV, as the PT distributions for data and MC agree quite well and we are using only one mass point (175 GeV).

The ϕ moments agree 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.

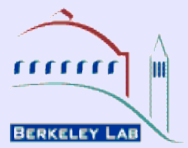
| | V6.2-AV | Apro1h1 | ACR1h1 | S0pro | NOCRPG0 | S0PG0 |
|-------------------|---------|---------|--------|-------|---------|-------|
| b-jet PT | 0.89 | 0.86 | 0.89 | 0.65 | 0.86 | 0.90 |
| ET1 (b-tag) | 0.85 | 0.71 | 0.74 | 0.93 | 0.85 | 0.88 |
| Jet Mass | 0.04 | 0.01 | 0.10 | 0.02 | 0.02 | 0.02 |
| 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.

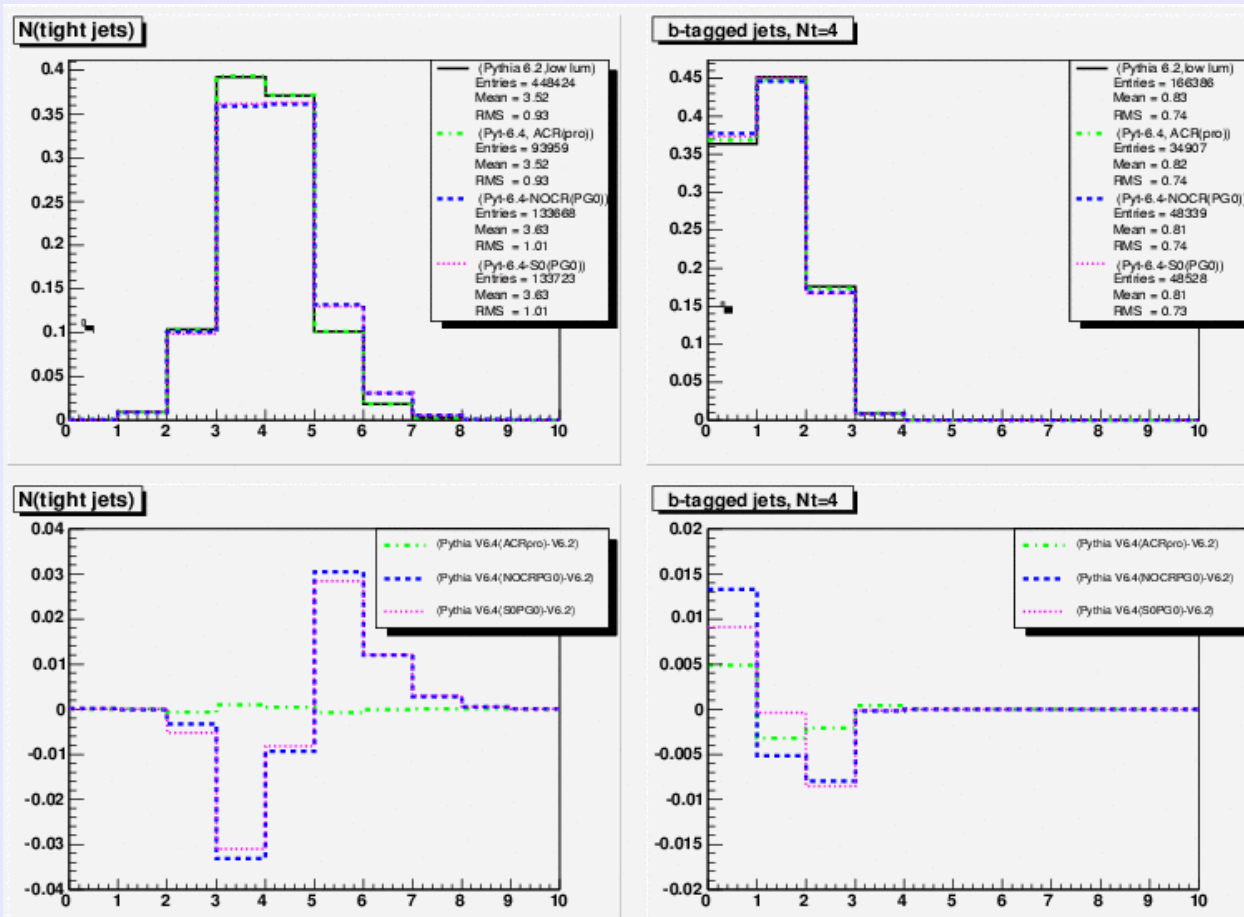
Additional studies are being done and are now **URGENTLY** needed.
quark jet shapes in di-jets events
b-jet studies in di-jet events



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% |

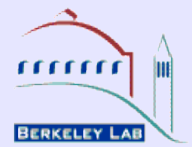
Perugia0 :

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

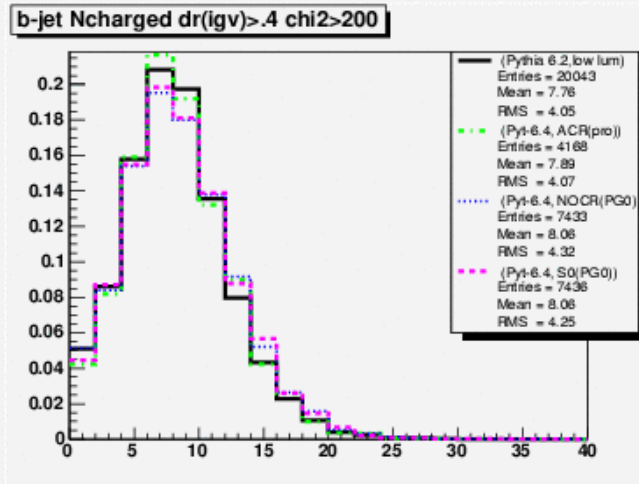
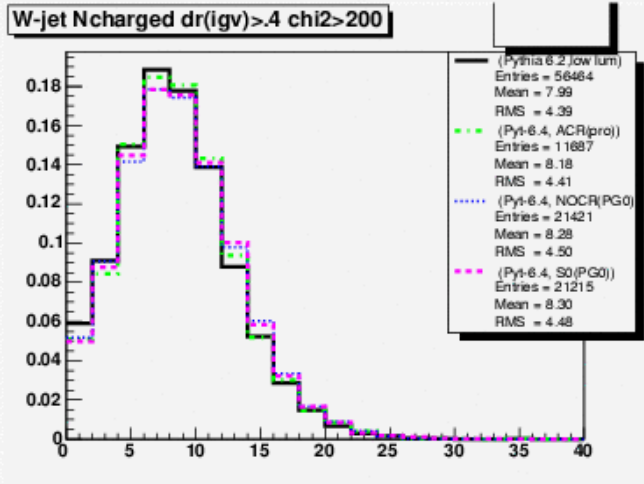
These findings point to more ISR in the S0-Perugia0 samples



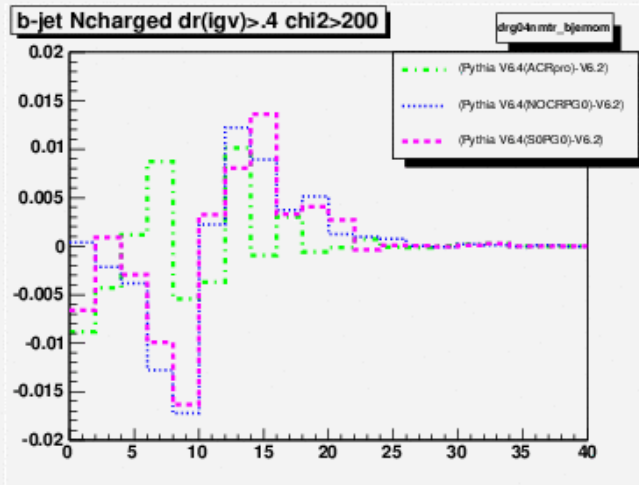
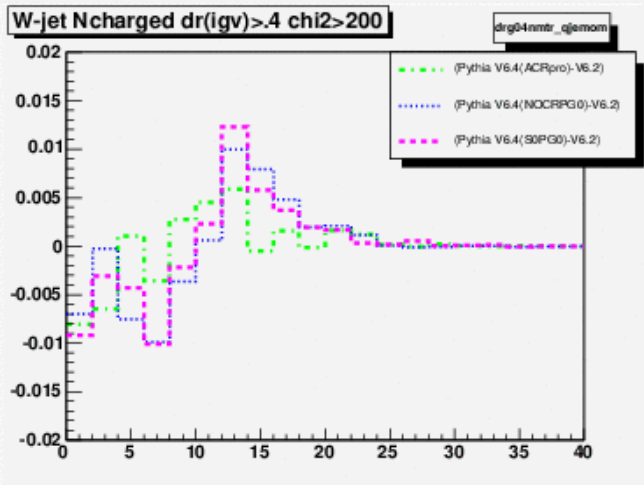
No match-jets properties: N(charged)



Comparison of Ncharged in no-matching jets for light (left) and b jets



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

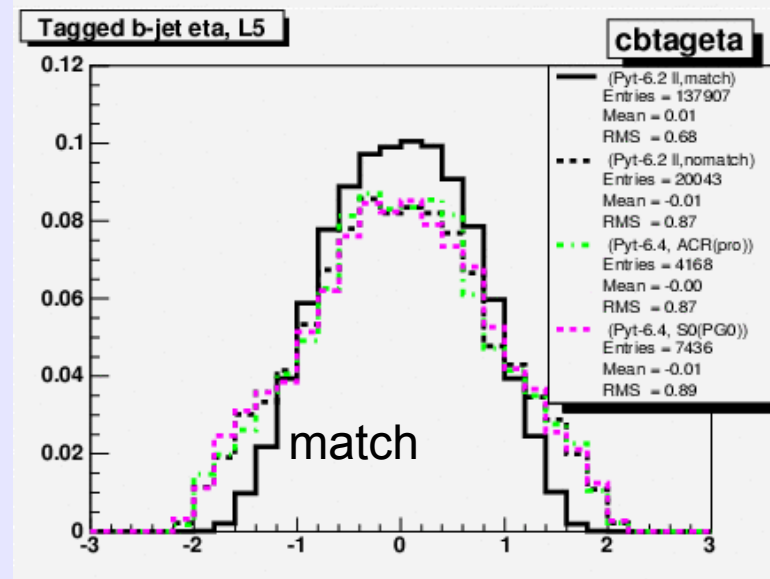
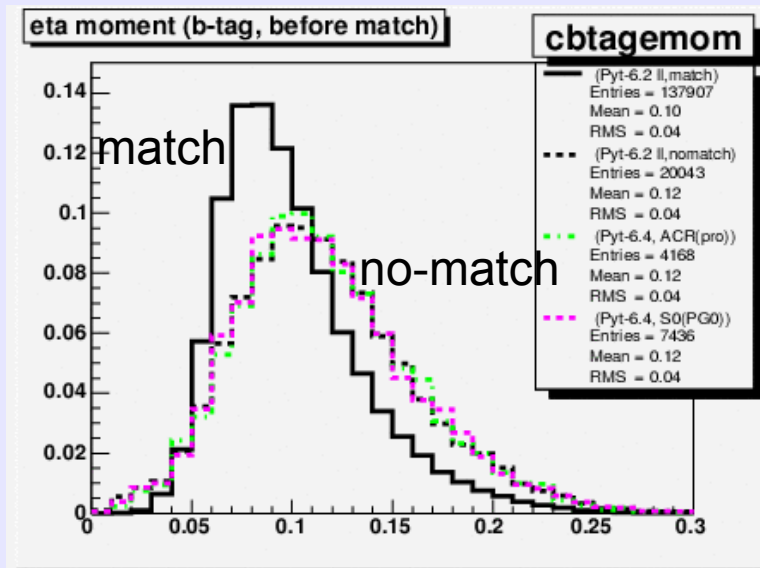


S0-Perugia0:

Non matching jets have more charged particles

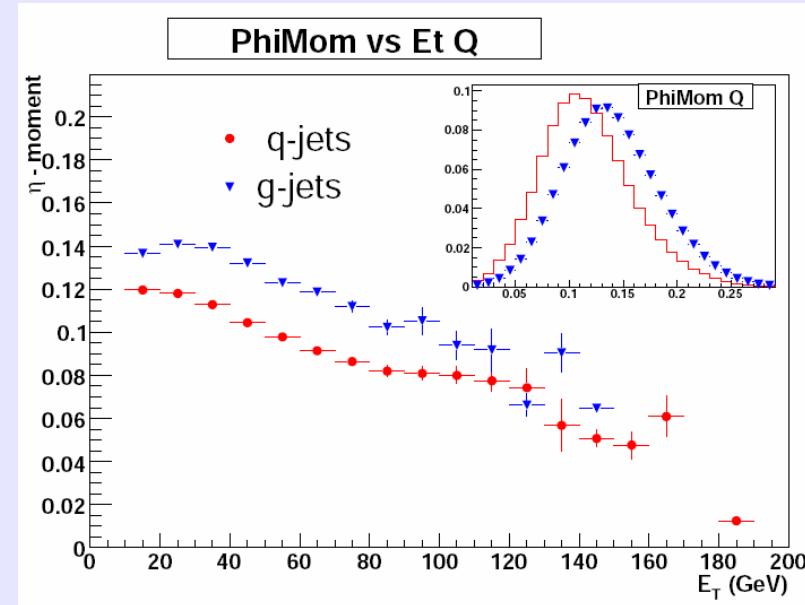
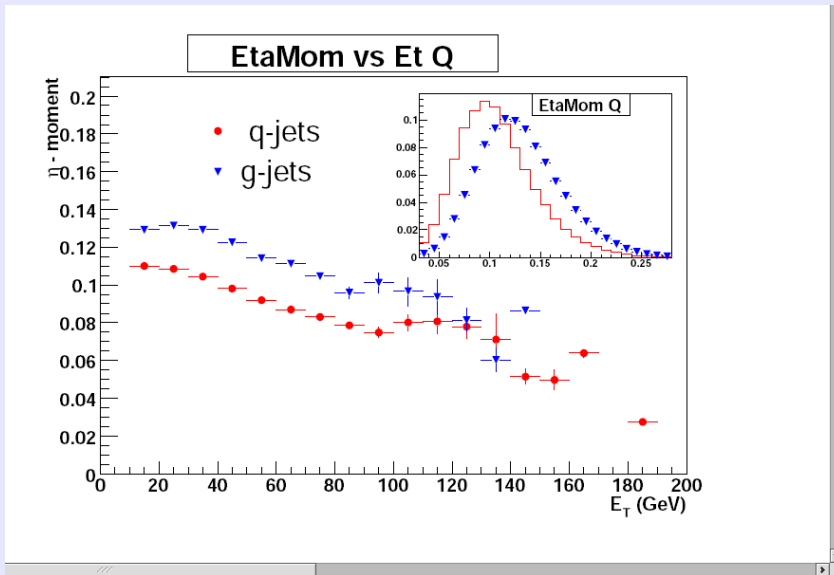
This points to more more gluon jets. That is more ISR/FSR

Compare eta moments and jet eta for matching and no-matching jets. Relative shapes depend on the matching cuts, of course.



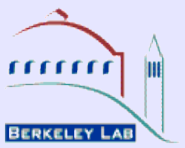
Wider distributions for eta moments and jet eta, point to the non matching jets to be gluon jets

From Brigliadori, Castro, Margaroli's work we have the Expected moments for light quarks and gluons.



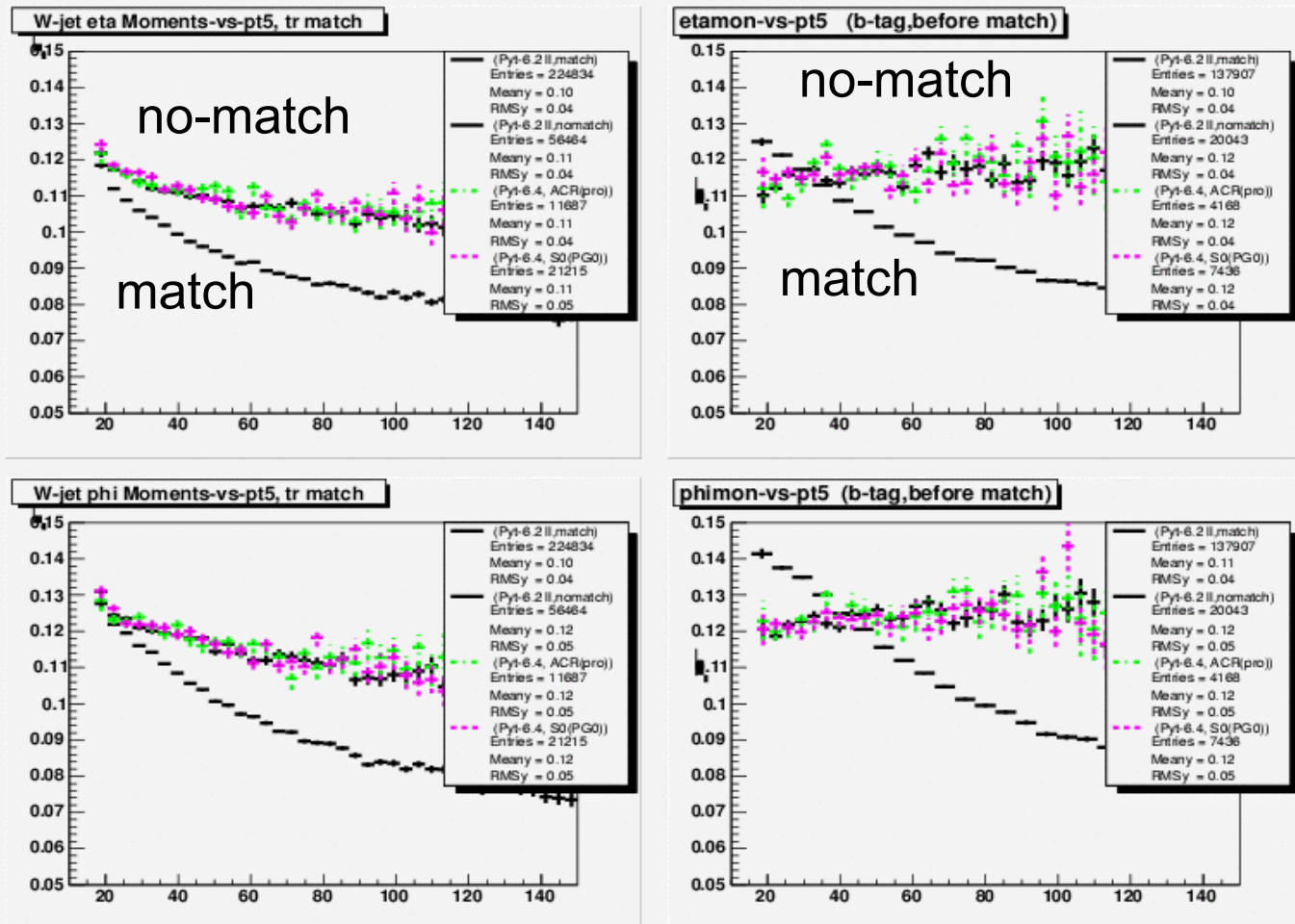


η and ϕ Moments in no-match jets



Moments-vs- PT(jet)

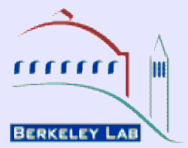
The no-match jets look more like gluon than quark jets



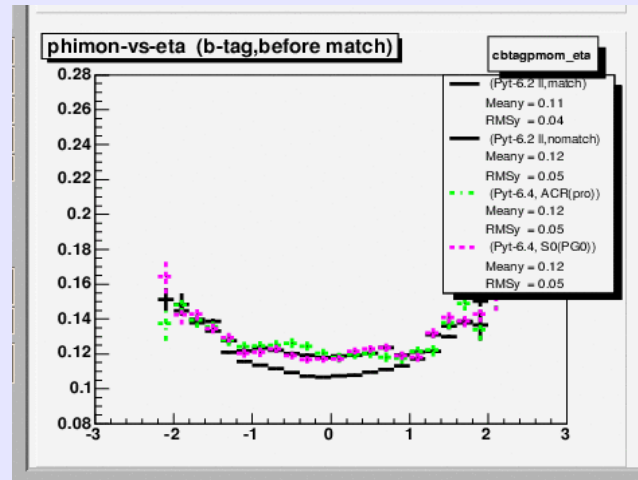
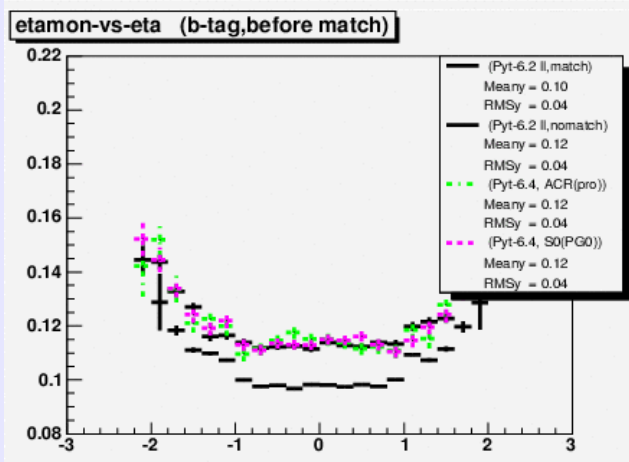
The Perugia0 tunes have more gluon jets (more no-match jets)



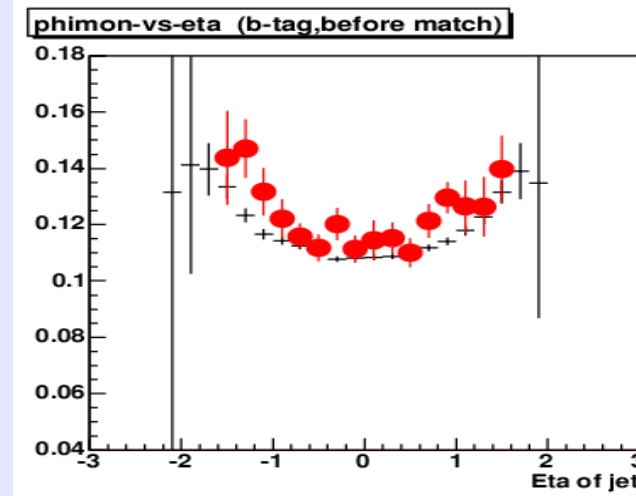
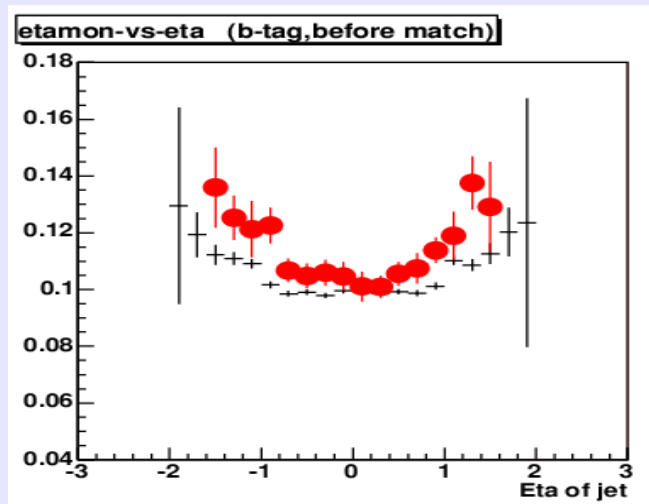
Eta Dependence of eta moments



Moments (η and ϕ) versus jet eta for MC samples (top) and data-MC comparison (bottom).



MC: matching and no-matching comparison for eta and phi moments. phi moments agree better

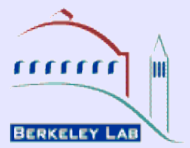


S0Perugia0 comparison with tagged jet data: the phi moments seem to have a better agreement

Expect better agreement with data for phi moments



What we have learned



The S0-Perugia 0 events differ from the PYTHIA V6.2 events in a number of ways:

- Events have more tight jets
- About 58% of the events have non-matching jets (compared with 68%)
- Events have less b-tagged jets in the $N(\text{tight})=4$ sample

Jet Properties:

- The matching jets (light quarks and b quarks) have different energy in the cone of 0.4 than PYTHIA V6.2. This is at the origin of a large top mass shift
- The no-matching jets have more $N(\text{charged})$ particles in the jet
 - The eta moments and phi moments of the non-matching jets point to more radiation in the events

Eta Moments in PYTHIA V6.2

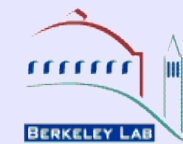
There are a number of holes in eta, larger than the holes in phi.

We see that the moments are smaller in eta than in phi for this

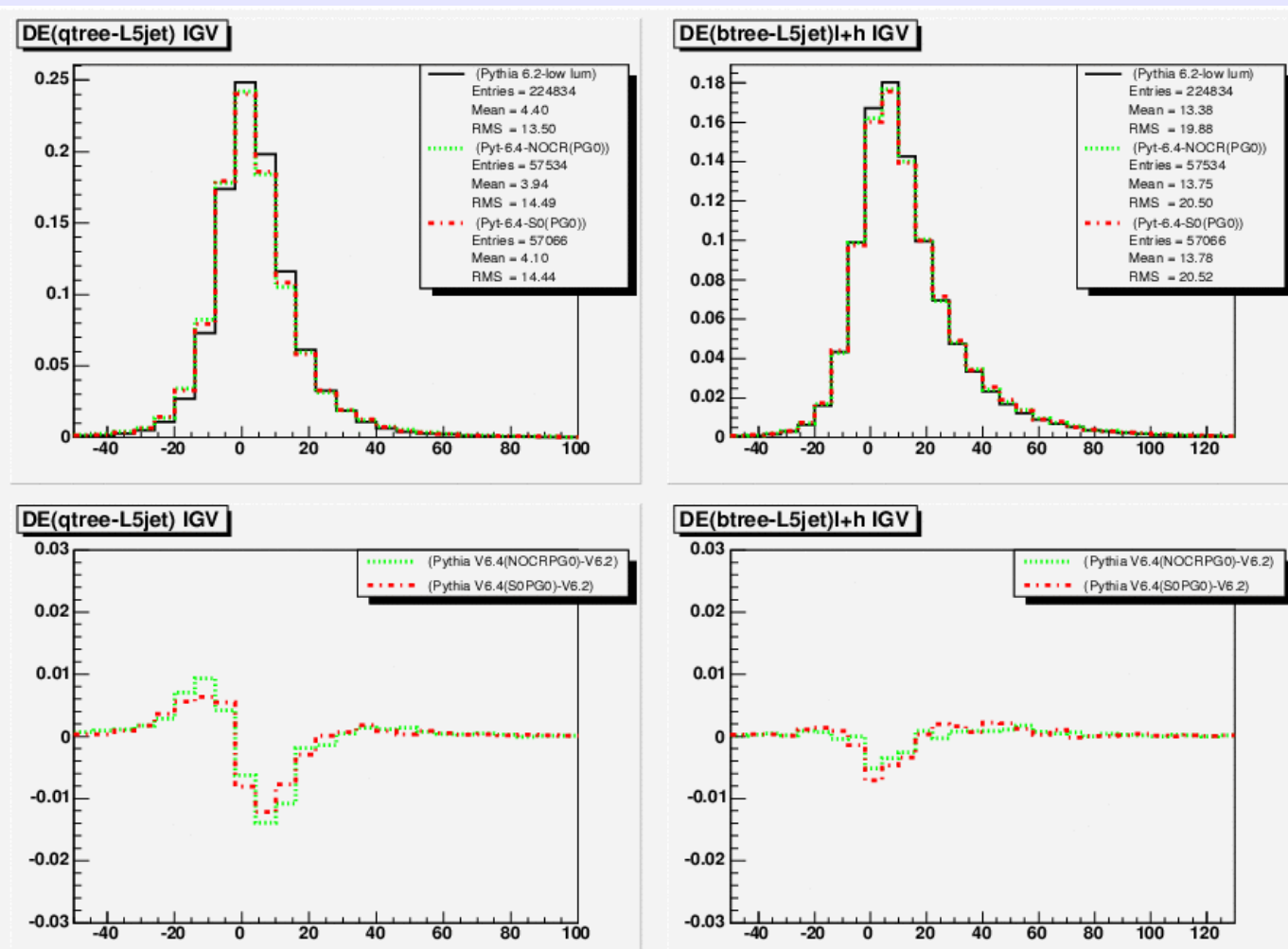
reason. Maybe the MC does not have all the holes properly reproduced



Comparison: E in cone of 0.4



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



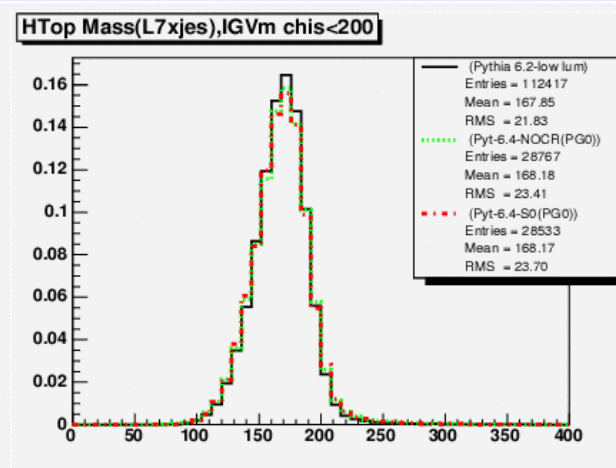
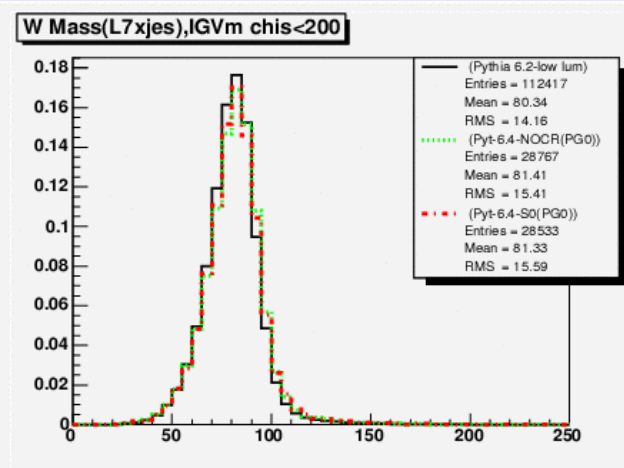
S0Pg0 -Nominal

ΔE (cone) GeV

W-jets $+0.30 \pm 0.15$

b-jets -0.40 ± 0.15

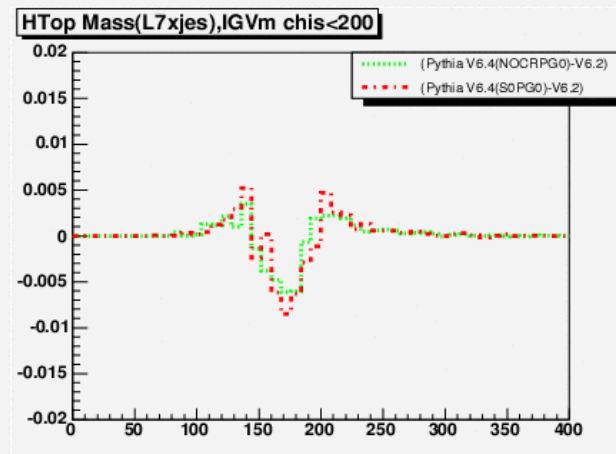
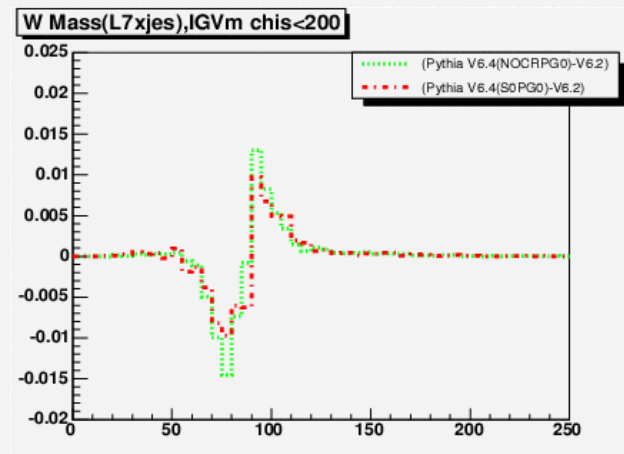
The S0-Perugia0 tune has different behavior for the b-jets



M=175 GeV ΔM_w

V6.4 NCR-Pg0 +1.07

V6.4 S0-Pg0 +1.00



M=175 GeV ΔM_{top}

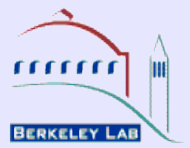
V6.4 NCR-Pg0 +0.33

V6.4 S0-Pg0 +0.33

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



Summary of Matching and ME fits



- We find the following CR values from the “pro” tune files:
 - CR--> -0.41 ± 0.37 GeV from ACR (-0.4 ± 0.3 GeV, Winter Conf)
 - CR --> -0.34 ± 0.38 from S0-NOCR,
 - CR --> $+0.15 \pm 0.45$ from the Perugia0 tunes
- The S0-pro (S0Pg0) tune gives $\Delta M_{\text{top}} = -1.8$ GeV (-1.5 GeV)
this is directly related to different jet and events shapes, due to a different p-shower
- Tune S0 tunes include systematics that we are already taking into account ,i.e.
 - generator : $\Delta(m_t) = 0.51 \pm 0.37$ GeV
 - ISR/FSR : $\Delta(m_t) = 0.29 \pm 0.26$ 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



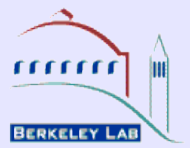
Top Mass Measurement and CR



Backup slides



Procedures



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

A. Given a MC sample, for each event we match the partons from top decays to the observed jets ($N_{\text{tight}} = 4$). 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.

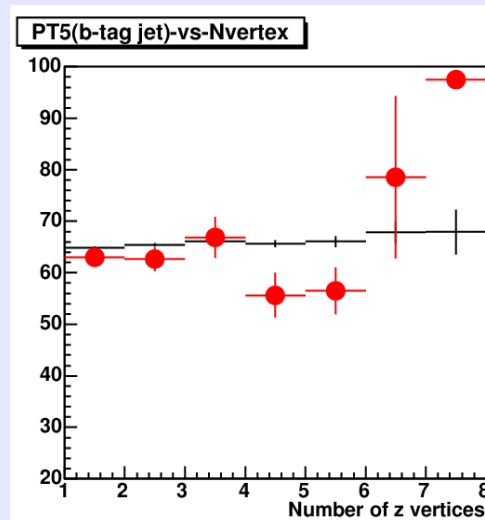
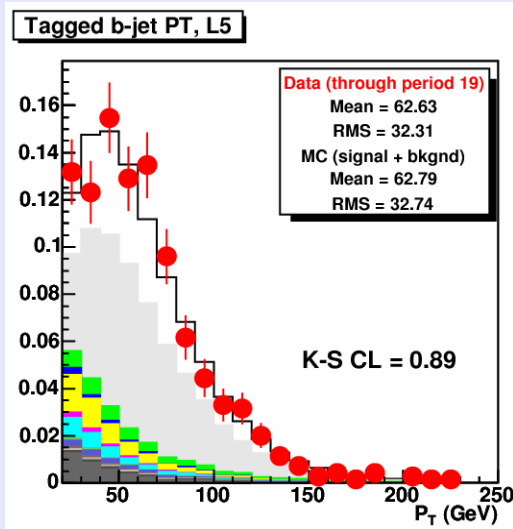
To check the changes between MC's we compare a number of variables for the different tunings, for example:

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

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

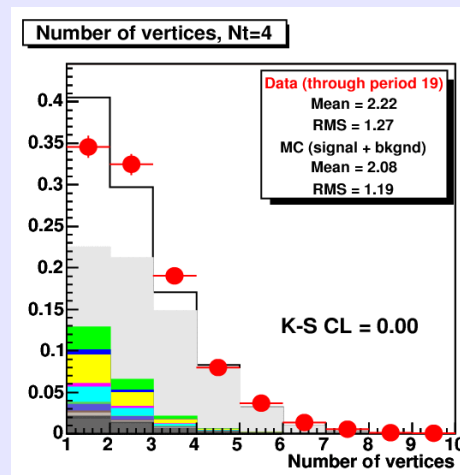
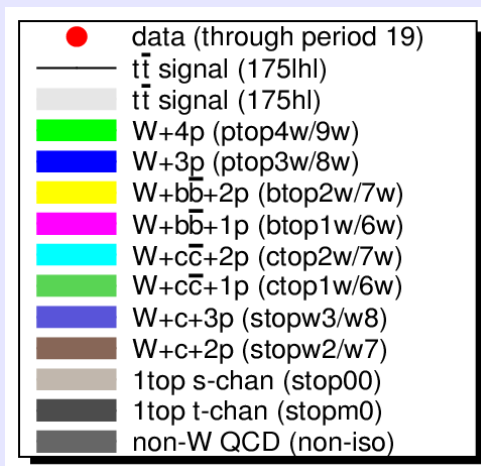
- For methods A and B, we compare results obtained for
 - V6.2(tune A) old MC (used for CDF measurements)
 - V6.4 (tune ACR) only CR added to old shower
 - V6.4 (tune NOCR, S0) new shower, wo/w CR

Comparison of data and MC for the default PYTHIA V6.2.
 Only events with $N(\text{tight})=4$ 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.

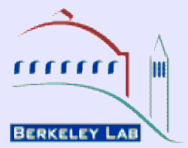
The dependence on N_{vtx} is minimal which means we are correcting the jets properly.



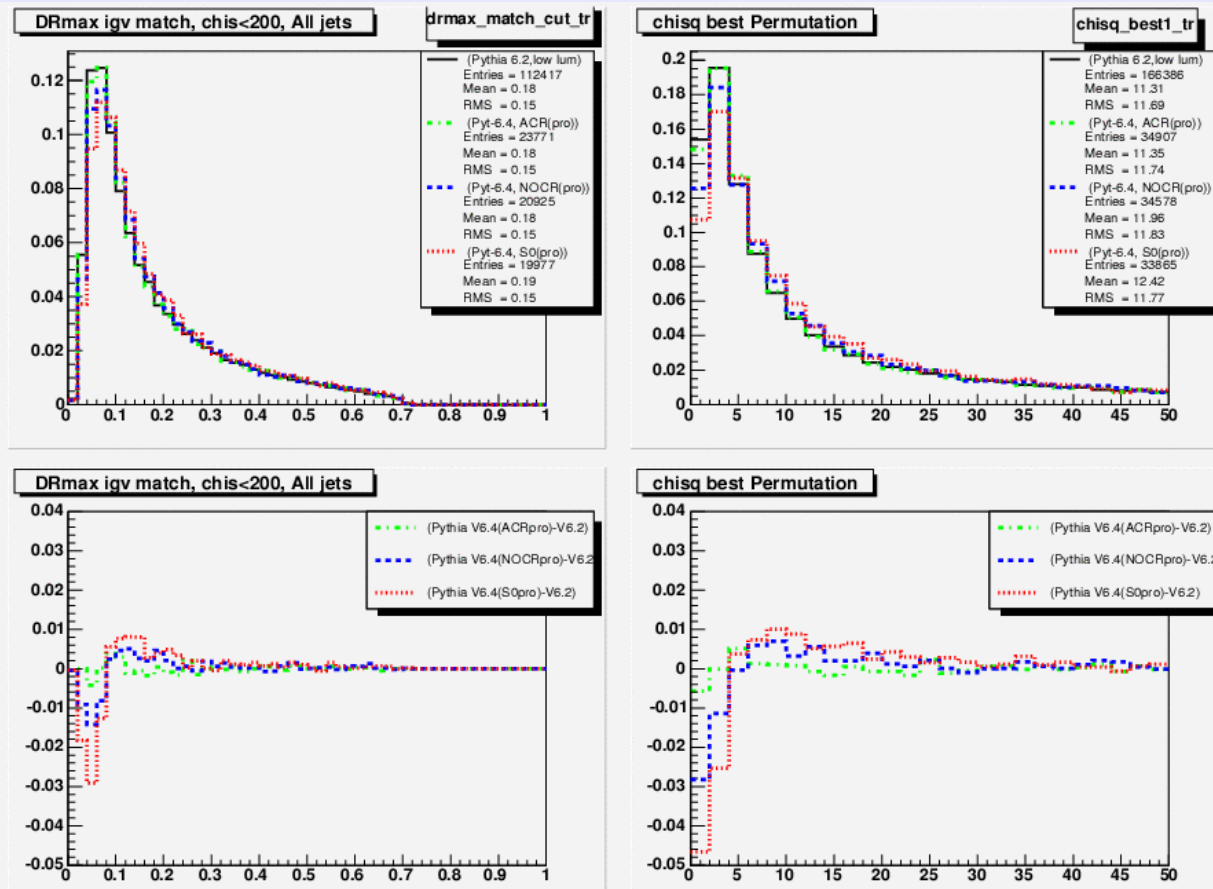
The lumi profile is not very good, as the background luminosity is limited to the first 1/3 of the data.



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%

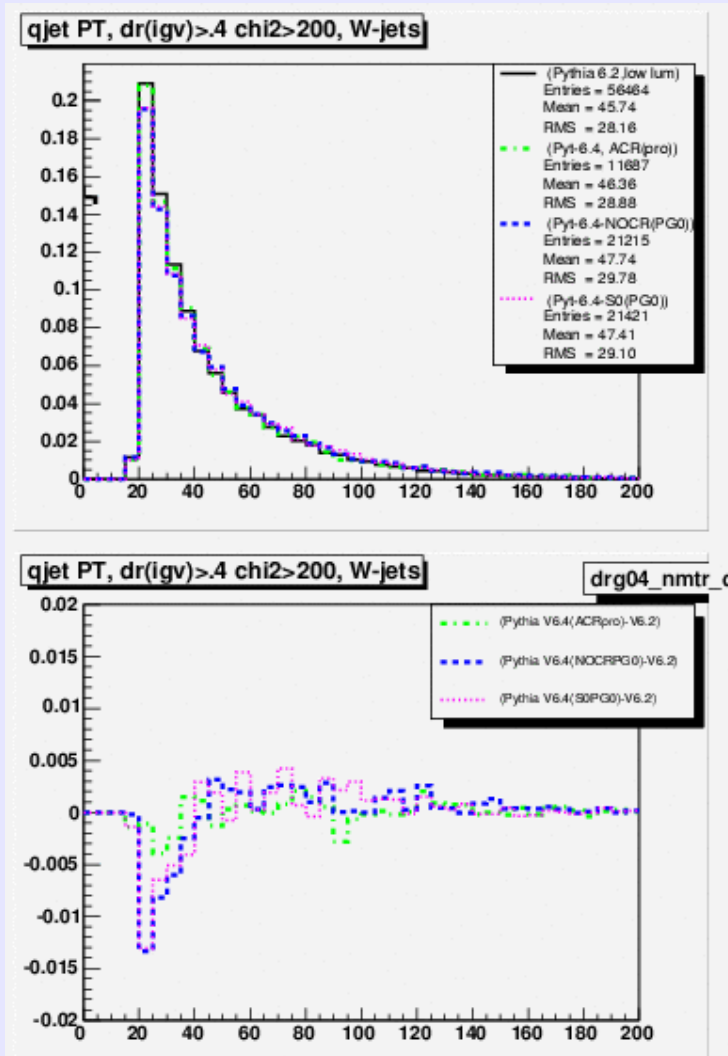
V6.4 NCR-Pg0 59%
 V6.4 S0-Pg0 59%

Samples with new parton shower have:

wider χ^2 distributions
wider ΔR “

The new parton shower model gives less matched events .

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



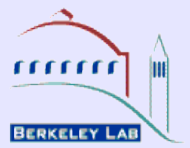
Comparison shows that the P_T of the non-matching jets is higher for the Perugia0 samples: more ISR?

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

This will result in a shifted top mass.



Summary of studies on M_{top}



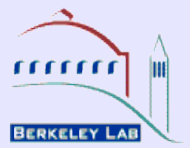
Comparison of V6.2 (nominal) to V6.4 (the “pro” files)
 Using both methods, i.e., reconstructing top mass with event matching
 and with our ME method.

| Sample | Δm_W (GeV/ c^2) | Δm_t (GeV/ c^2) | Δm_t (GeV/ c^2) | ΔJES 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) | $+0.53 \pm 0.14$ | -0.09 ± 0.21 | -1.46 ± 0.27 | 0.22 ± 0.06 |
| V6.4 S0-pro (otop44) | $+0.39 \pm 0.14$ | -1.18 ± 0.22 | -1.80 ± 0.28 | 0.11 ± 0.06 |
| V6.4 NOCR-Pg0 (ctops4) | $+1.07 \pm 0.09$ | $+0.33 \pm 0.14$ | -1.60 ± 0.32 | 0.34 ± 0.07 |
| V6.4 S0-Pg0 (ctops3) | $+1.00 \pm 0.09$ | $+0.32 \pm 0.14$ | -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 $\Delta M_{\text{top}} = -1.5$ GeV .
 For $\Delta \text{JES} = 0$ we get $\Delta M_{\text{top}} = -0.7 \pm 0.2$ GeV



Color Reconnection Systematic



- S0-pro : $\Delta M_{\text{top}} = -1.8 \text{ GeV}$, expected because of -1.3 GeV b-jet shift.
- S0-Perugia0 : the light quark jets are more shifted than the b-jets. This shifts the W mass considerably ($\sim 1 \text{ GeV}$). The top mass goes up for this reason. The ME fit gets a large DJES to reconstruct the W mass properly, this moves the jets down resulting in a large ΔM_{top}
- 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

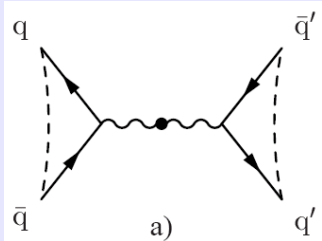
From the Perugia0 tunes CR = $+0.15 \pm 0.45$

- More statistics will help. At this point it seems that CR $\sim 0.5 \text{ GeV}$

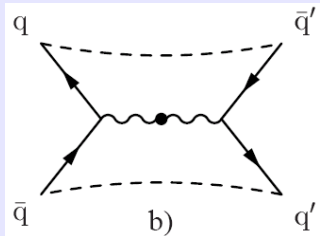
Strong color correlations between the hard process and the underlying event are implied by tune A and similar tunes. These effects may be interpreted as sign for color reconnection.

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

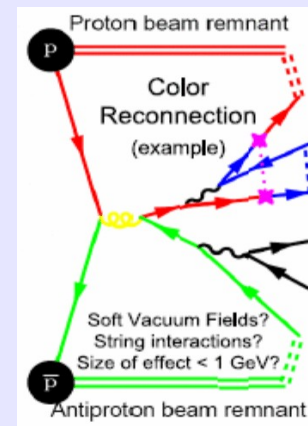


CR(sys) = 8 MeV
out of 22 MeV (total sys)

(LEPEWWG hep-ex/061203)

Tevatron

Preliminary MC studies have indicated possible contributions



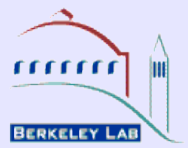
to the top mass systematics of order

CR(sys) \approx 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 $\sim 4 \text{ fb}^{-1}$ 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 |
| Background:MC statistics | 0.05 |
| Color Reconnection | 0.41 |
| Total (MC Dependent) | 1.13 (0.88) |

MC dependent systematics, other than 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

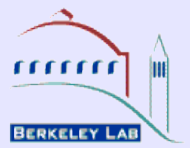
Systematics dependent on MC used amount to

JES 0.7 GeV
 CR 0.4 GeV
 Other 0.9 GeV

Total 1.2 GeV (of 1.3 GeV)



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:

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

And similar expression for the phi moments,

Used in CDF to distinguish quark jets from gluon jets in $t\bar{t}$ production in the 6 jets topology