Comments on jets in Top Monte Carlo

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Jet Energy and Resolution Meeting
August 3, 2005

Jets in HERWIG and PYTHIA

- Monte Carlo generators: partons may become very massive during parton shower development. This requires some adjustment of parton directions to conserve energy-momentum.

- We compare HERWIG and PYTHIA's results.

- b jets deviation from tree level partons (ΔR)
  - The understanding of ΔR is important especially for matrix element analyses as the above physics effects are combined with detector effects, thus influencing jet resolution
  - Effects on jet response
  - Is there a problem with HERWIG V6.504 or what we observe is what is expected?

- Summary and Conclusions

HERWIG MONTE CARLO

HERWIG $t\bar{t}$ event: following the partons. Subscript 0 refers to tree level, subscript 1 to the adjusted parton

line	Part.	Code	stdep	parent	Da1	Da2	mo1	Mo2	Px	Py	Pz	E	M
46	$\bar{t}$	-6	155	94	47	48	20	38	1.9	-110.0	92.7	228.8	177.9
47	W_0	-24	123	-6	49	47	46	47	18.6	-132.8	34.7	164.1	88.0
48	$\bar{b}_0$	-5	124	-6	50	46	46	46	-16.7	22.8	58.0	64.7	4.85
50	$\bar{b}_1$	**94**	144	-5	52	53	48	46	-16.6	16.8	66.5	71.2	**9.45**
Note that the W_0 decay jets are missing!													
49	W_1	-24	195	-24	54	55	47	46	18.4	-126.8	26.2	157.6	87.9
54	q_1	-2	123	-24	56	56	49	55	52.5	-90.9	26.1	108.1	0.3
56	q_2	**94**	143	-2	58	59	54	49	52.3	-90.7	26.0	107.9	**2.15**
55	$\bar{q'}_1$	1	124	-24	60	54	49	54	-34.1	-35.9	0.1	49.5	0.3
60	$\bar{q'}_2$	**94**	144	1	62	64	55	29	-33.9	-36.1	0.2	49.7	**4.2**

W_1 and b_1(ID=94) have been adjusted from W_0 and b_0 to take into account parton shower effects (i.e., large mass of b quark)

PYTHIA MC Top event

PYTHIA $t\bar{t}$ event: following the partons. Subscript 0 refers to tree level, subscript 1 to the adjusted parton

line	Part.	Code	stdep	parent	Da1	Da2	Mo1	Mo2	Px	Py	Pz	E	M
7	$\bar{t}$	-6	3	2	0	0	4	5	27.1	-173.8	-148.5	290.0	176.4
10	W_0	-24	3	-6	0	0	7	0	57.1	-144.5	-167.3	241.8	79.6
11	$\bar{b}_0$	-5	3	-6	44	47	7	0	-30.2	27.2	20.8	45.9	4.85
44	$\bar{b}_1$	-5	2	-5	101	101	11	0	-5.1	-12.6	22.7	26.9	4.85
45	gluon	21	2	-5	101	101	11	0	-0.9	-0.0	-0.1	0.9	0.
46	u	1	2	-5	101	101	11	0	-10.8	-9.4	-12.4	18.9	0.
47	$\bar{u}$	-1	2	-5	108	11	0	108	-6.5	-17.3	-6.2	19.5	0.
W_0 decay jets are missing as in HERWIG													
17	W_1	-24	2	-24	55	60	10	0	50.2	-132.3	-150.6	221.4	79.5
14	q_1	1	3	-24	0	0	10	0	-18.4	-27.0	-53.3	62.5	0.
15	$\bar{q}'_1$	-2	3	-24	0	0	10	0	68.6	-105.3	-97.3	158.9	0.

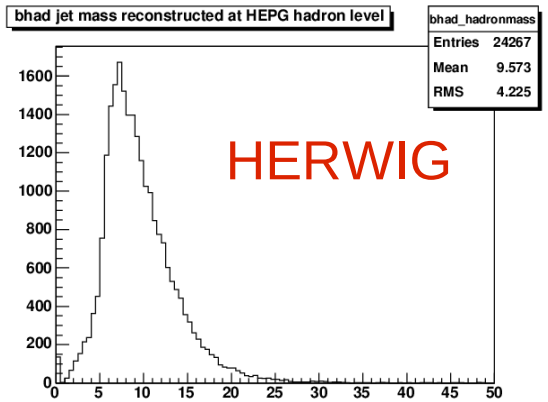
Here partons 44-47 will be added to compare with the b_1 of HERWIG (ID=94 b parton).

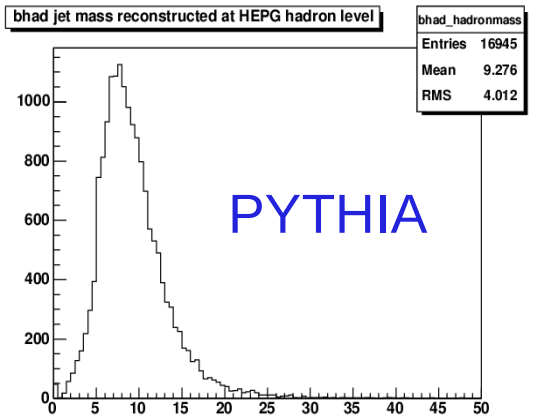
Partons 14-15 will be modified (as in HERWIG) in the next step.

Jet masses at hadron level

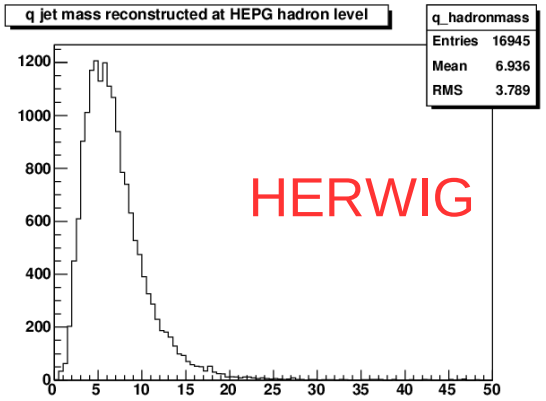
Compare masses at the end of the parton shower, i.e. at particle level.
Use cone algorithm to find jets, compute the mass using jet cone=0.4

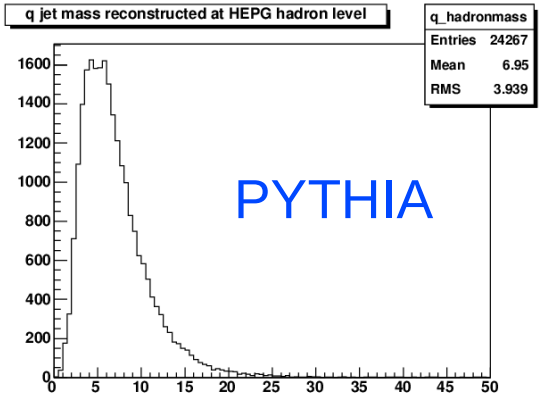
B jet mass Δm=0.3GeV





q jet mass Δm=0.01GeV





b jet mass in HERWIG is larger by 0.3 GeV

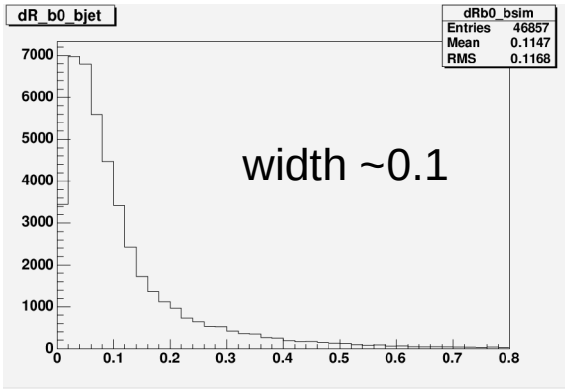
b jet direction changes in MC

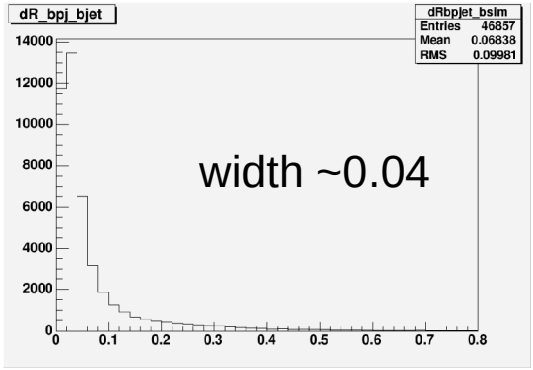
△R(Tree level - Simulation)

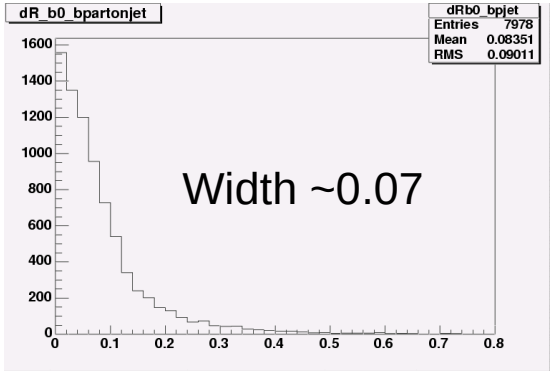
△R(Id=94-Simulation)

△R(Tree level - ID=94)

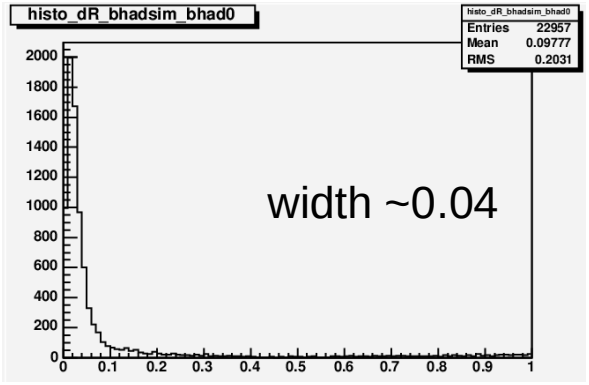
HERWIG

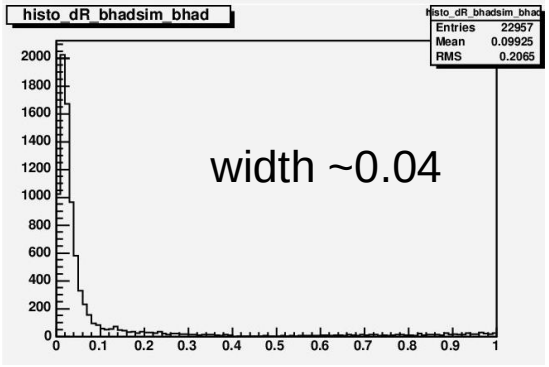


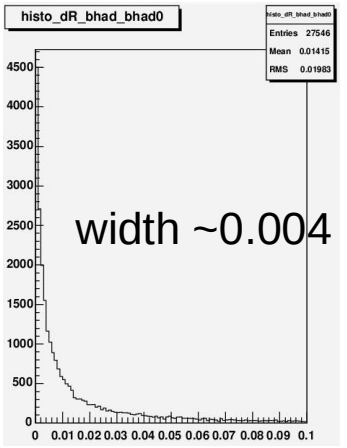




PYTHIA





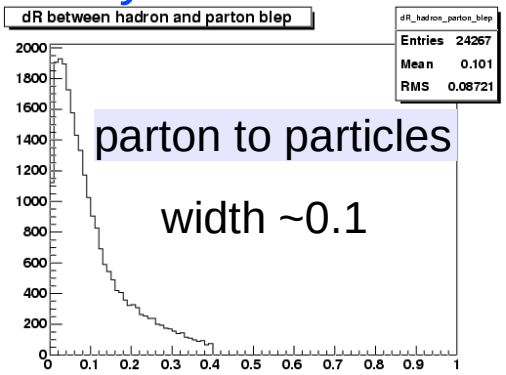


Width here refers to the width at half maximum. Tree level to ID=94 is different in PYTHIA and HERWIG: different physics effects?

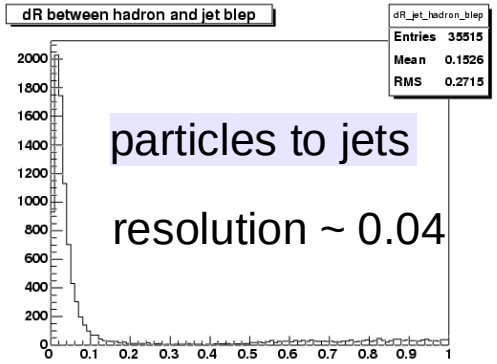
The b jet directions at hadron level

ΔR at hadron level : b0-had level jet and simulation

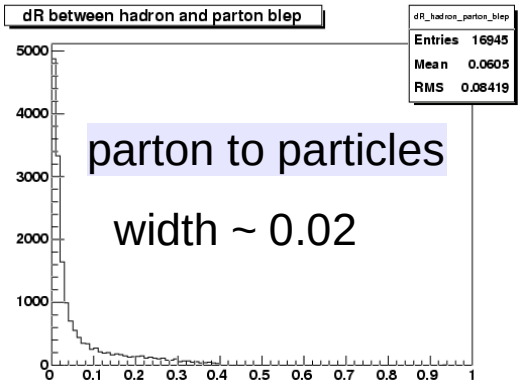
Physics effects

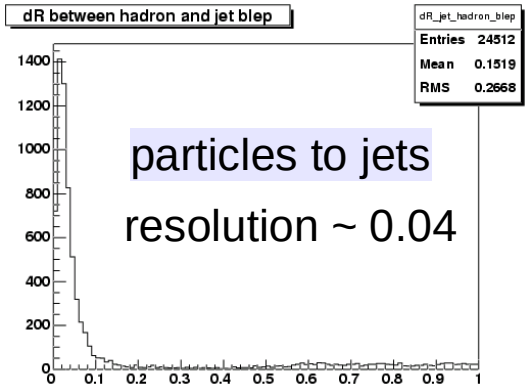


Detector effects



HERWIG





cone of 0.4 used

PYTHIA

Jets in HERWIG get large angle deviations (~0.1) when they acquire a mass

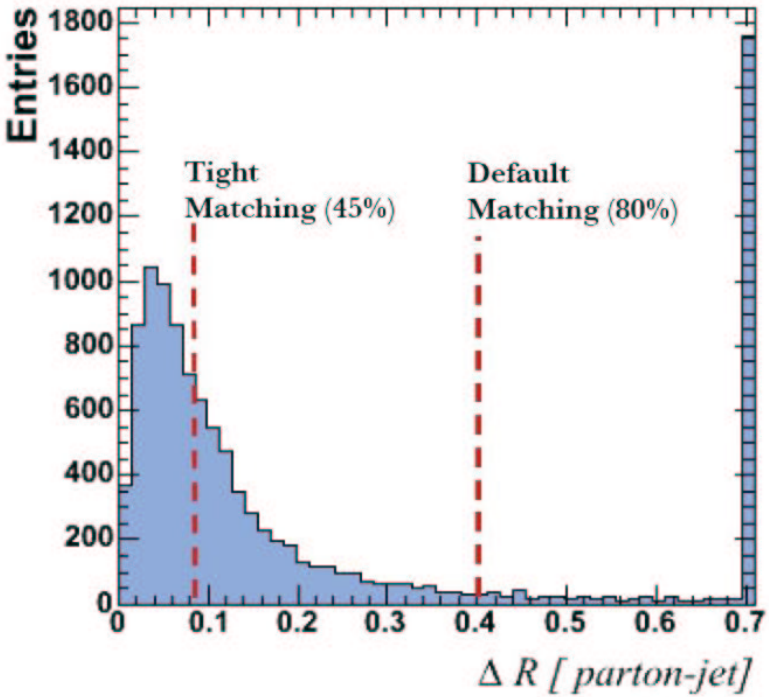
- Effect seen at the parton level as well as the hadron level
- Detector effects (resolution) are a small part of the ΔR we observe.

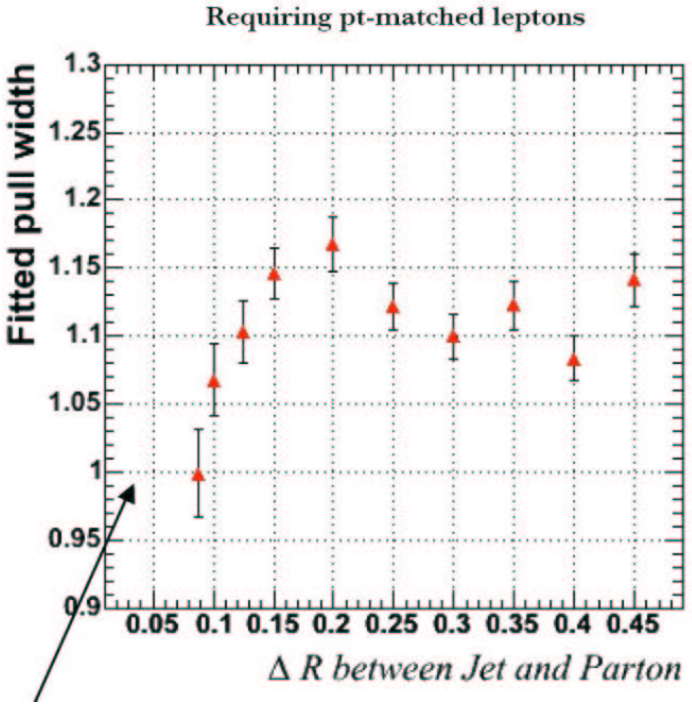
PYTHIA angle deviation is small(~0.02), detector effects same as HERWIG

Why do we care?

Large ΔR gives large pulls

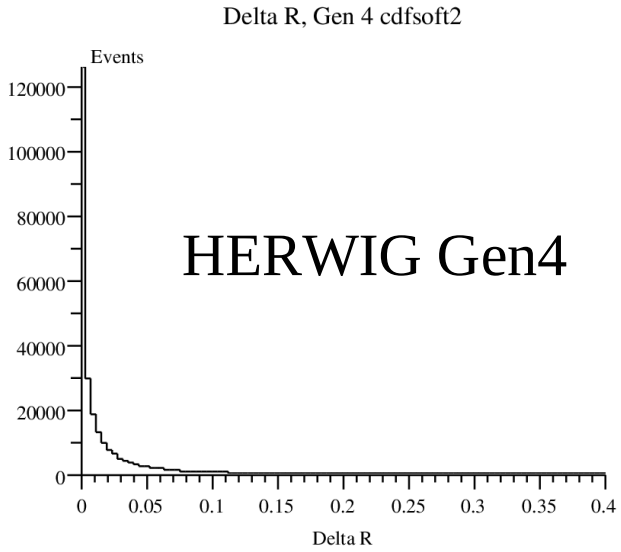
From Daniel Whiteson talk on MADCOW pulls, April 2005





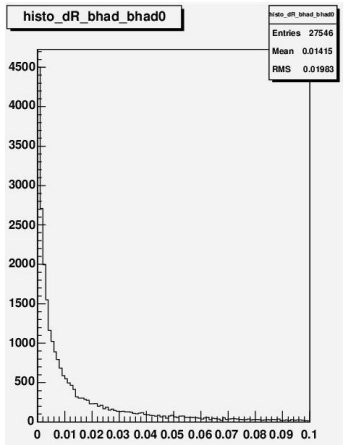
How do Gen4 jets look like?

Tree level-to-ID=94 for b-partons

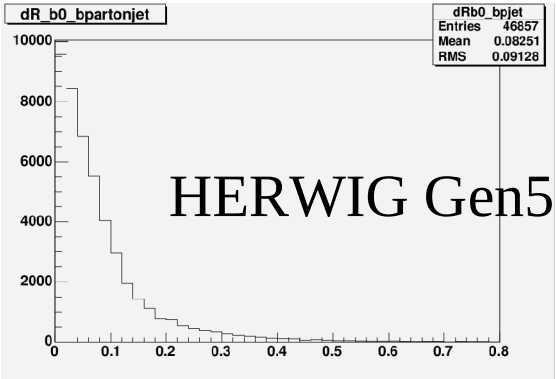


HERWIG Gen4

HERWIG Gen 4 looks the same as PYTHIA Gen5



PYTHIA Gen5



HERWIG Gen5

HERWIG Gen5 looks very different!

Code changes: Gen4 to Gen5

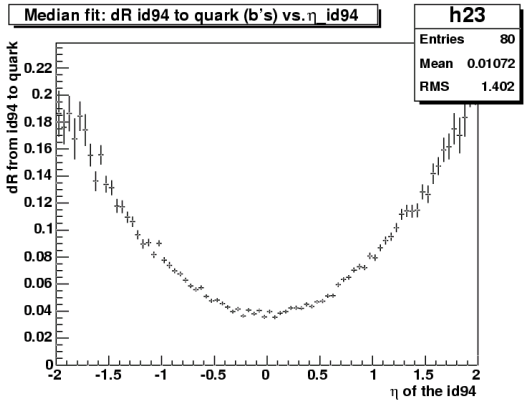
Jeremy Lys looked at the code and found that one routine had changed. HWBJCO was changed to take care of: aligning ISR cones and MC@NLO ("to do boost in 2 stages", not expected to alter top decays) . Jeremy run 3 versions of HERWIG and PYTHIA and got following results (angles are in radians, W0b0/W1b1 is the angle between the two planes).

quantity	HERWIG 6.500	HERWIG 6.504	HERWIG 6.505	PYTHIA
b0•b1	0.018	0.079	0.073	0.016
W0•W1	0.006	0.048	0.048	0.009
d1•d3	0.039	0.036	0.039	
W1d1/d1d3	3.141	3.141	3.141	
W0b0/W1b1	0.000	0.072	0.065	
b0•Bhad	0.070	0.121	0.110	0.077
b1•Bhad	0.070	0.071	0.064	0.078

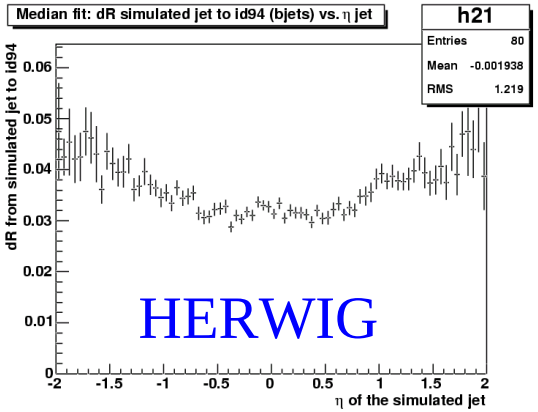
- The "adjustment" of the W and the b's are different in 6.504 and 6.505
- The W-jets are not changed (d1 and d3 are the daughters of W1).
- The direction of the Bhad with respect to b0 has changed.
- HERWIG authors have been asked to comment on these results on July 14

More details on b jets ΔR

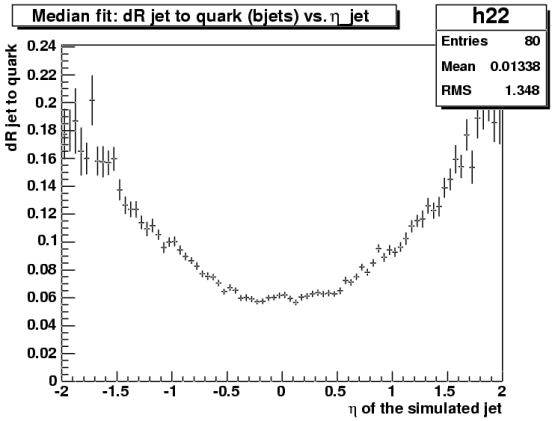
△R(Tree level-Simulation)

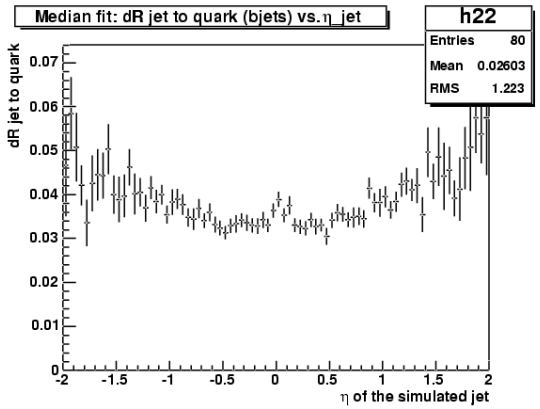


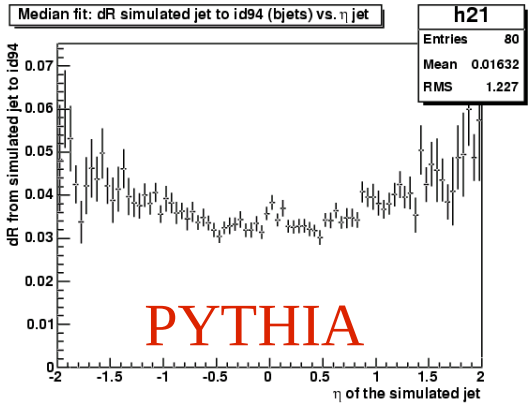
△R(Id=94-Simulation)

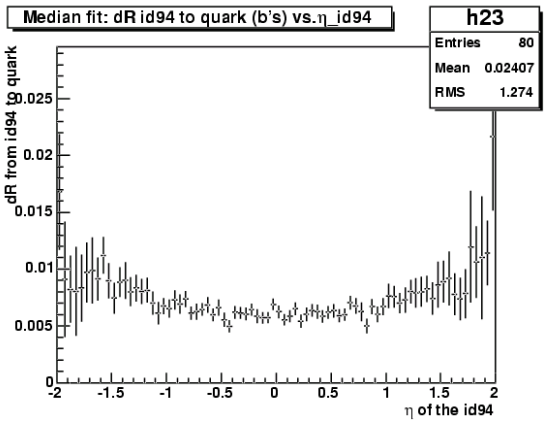


△R(Tree level - ID=94)





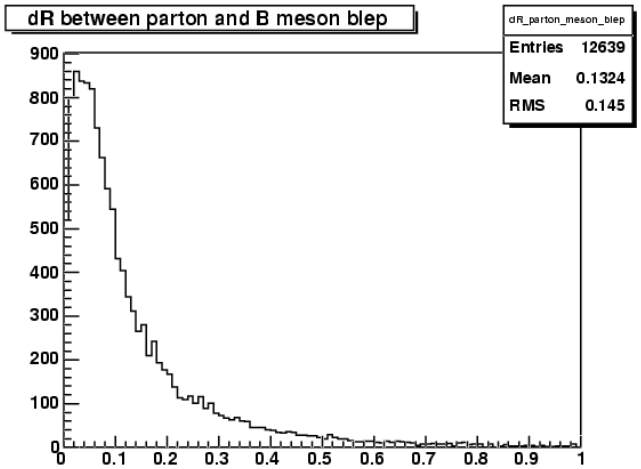




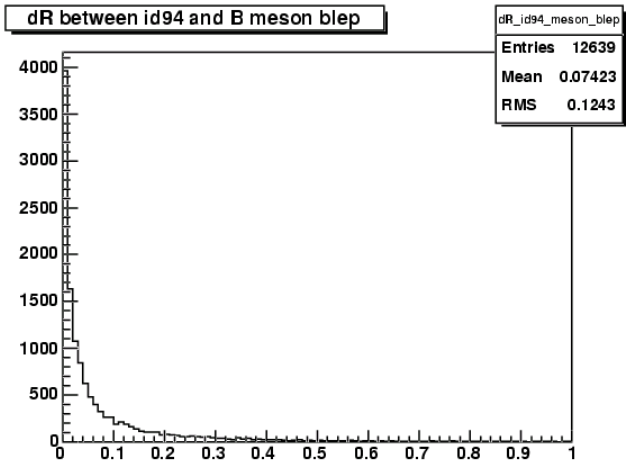
HERWIG shows a large eta dependence originating from tree-ID=94

ΔR of b0 and the B meson

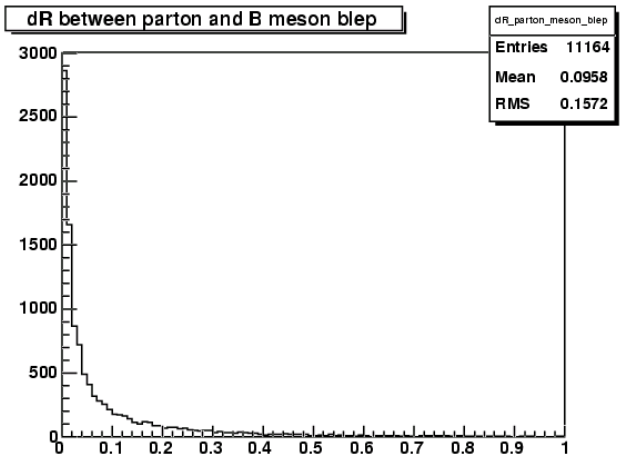
△R(Tree level-B meson)



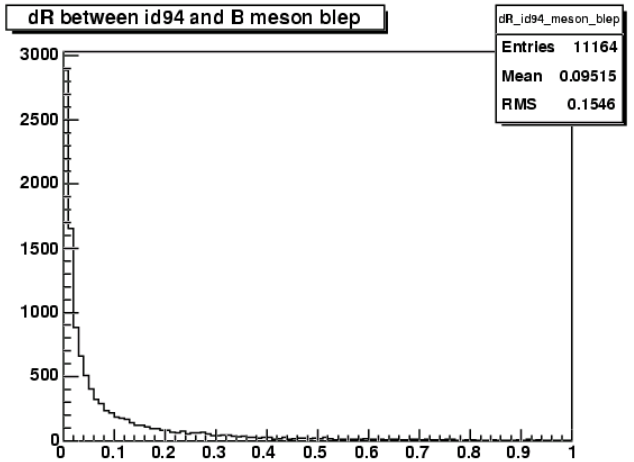
△R(ID=94-B meson)



HERWIG



PYTHIA



The B meson is at large ΔR from the b parton in HERWIG

Jet response comparison:light jets

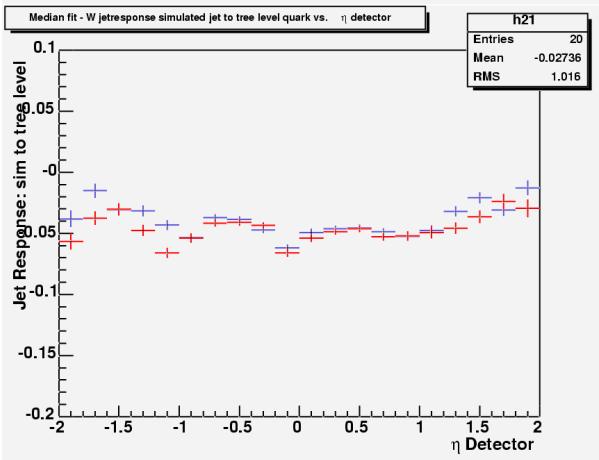
$$\text{Jet response} = \Delta f = \frac{P_T(\text{jet}) - P_T(\text{quark})}{P_T(\text{quark})}$$

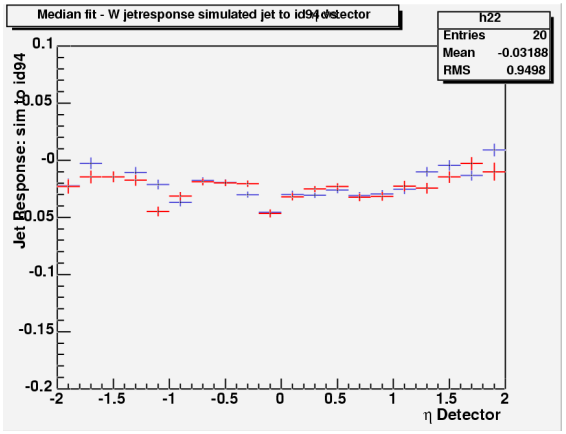
(jet corrected at L5)

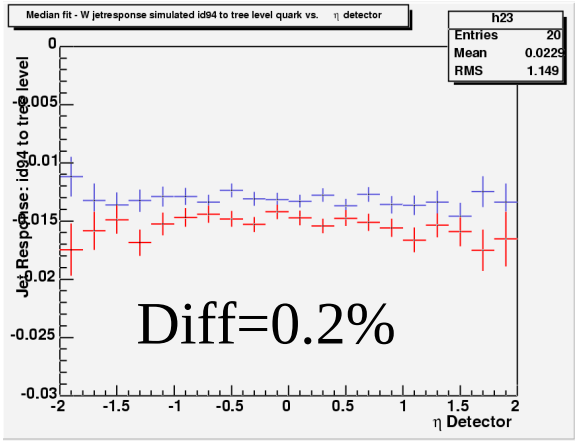
Δf(Simulation-Tree level)

Δ f(Id=94-Simulation)

Δ f(ID=94-Tree level)





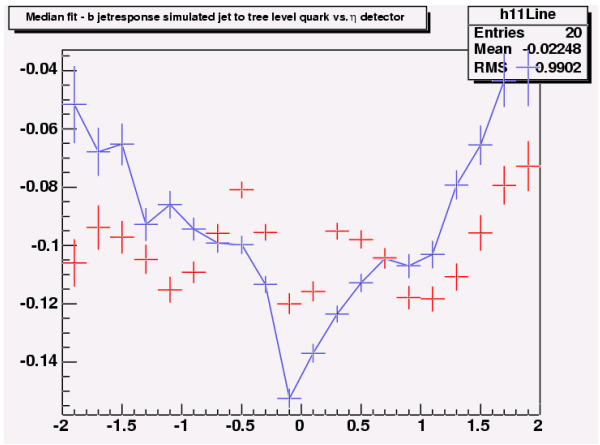


HERWIG (bleu) and PYTHIA (red) response have no eta dependence
They agree very well

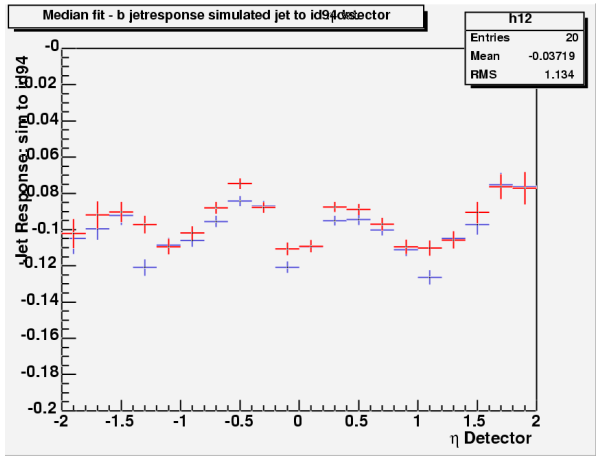
HERWIG-PYTHIA b jets

Eta dependence of response

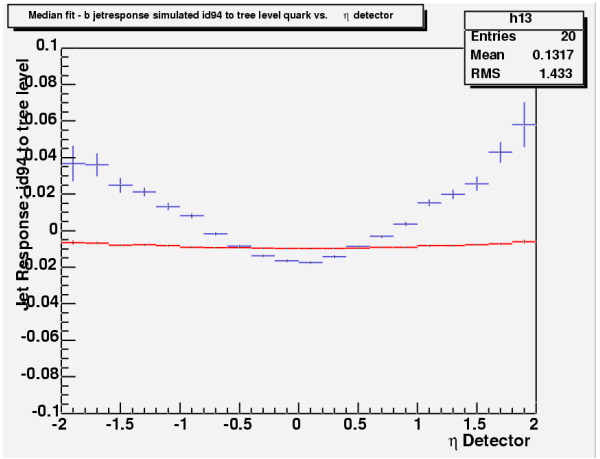
Δf(Simulation-Tree level)



△f(Id=94-Simulation)



△f(ID=94-Tree level)



Large eta dependence of response in HERWIG , especially seen between ID=94 and tree level, same place where we observed a large ΔR

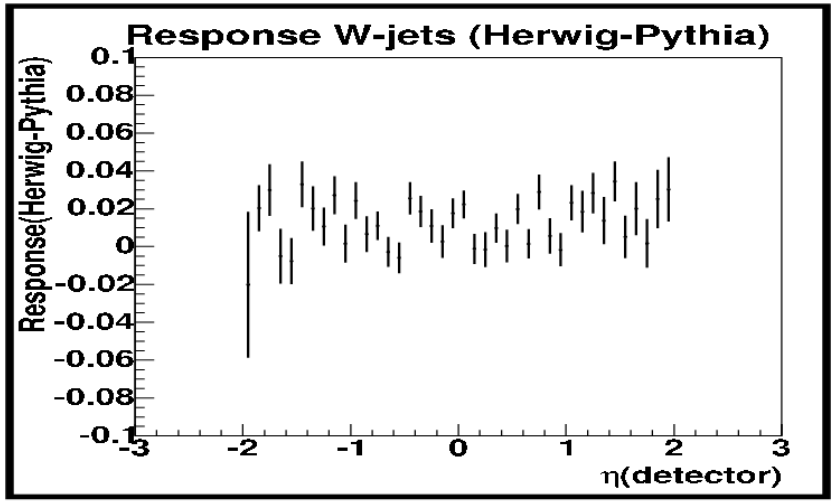
HERWIG-PYTHIA comparison

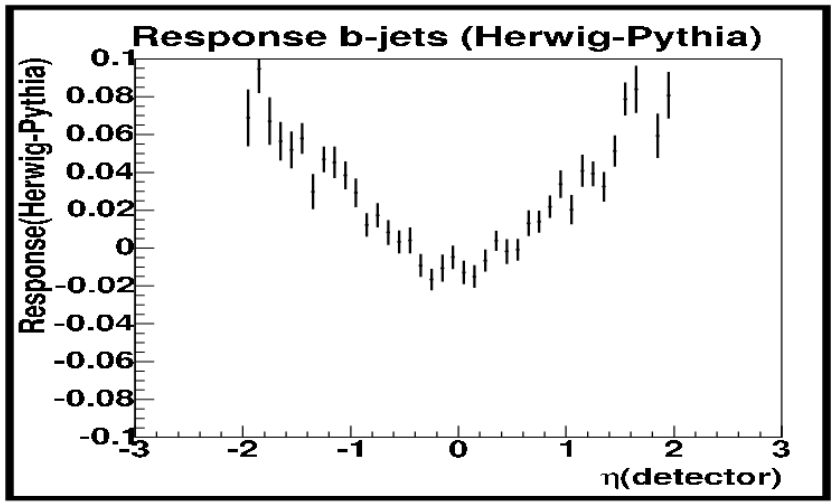
J.F. Arguin, March 2005

Difference between HERWIG and PYTHIA observed by J-F Arguin.

He found that response for b jets was not eta dependent when using ID=94 jets.
Behavior not explained

Now we know why





Summary and Conclusions

- HERWIG V6.504 shows some peculiarities with respect to PYTHIA and HERWIG V5.000
  - Large ΔR between parton and parton jet (ID=94)
  - Eta dependence of this ΔR
  - Direction of B meson is displaced with respect to the tree level b parton
  - Jet response is eta dependent

- These effects affect the resolution with which we measure (in the MC) the b-jet direction as well as the jet response (large pulls).

- HERWIG authors have been informed. Waiting for answers.

- Need to check other processes to see if these effects are present elsewhere.