MONTE CARLO STUDIES OF TOP PRODUCTION AND DECAY

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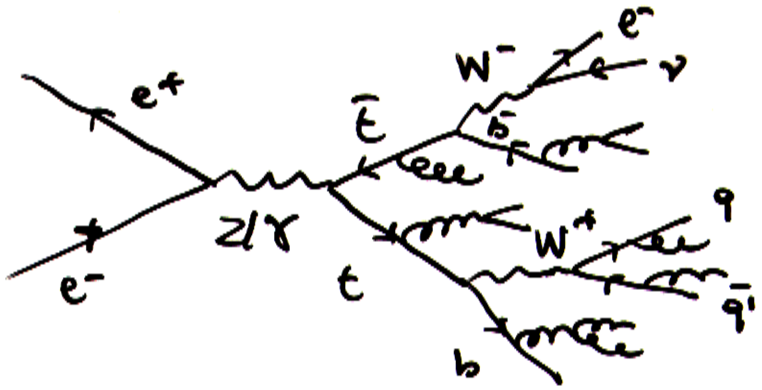
- PARTON SHOWER ALGORITHMS
- NEW FEATURES OF HERWIG
- STUDIES ON THE TOP MASS RECONSTRUCTION
- CONCLUSIONS

COLLABORATORS: M.H. SEYMOUR (RAL)

E.K. IRISH (ROCHESTER)

TOP PRODUCTION AND DECAY

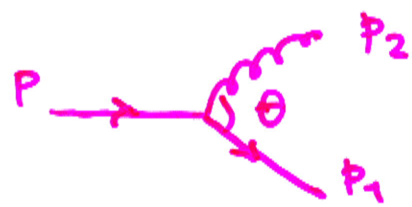


$e^+e^- \to t\bar{t}$

$t \to bW$: EXACT MATRIX ELEMENT

$W \to q\bar{q}'$

GLUON RADIATION IN THE SOFT/COLLINEAR APPROXIMATION



$z = \frac{E_2}{E_1}$

$$dP = \frac{\alpha_s}{2\pi} P(z)\, dz \,\frac{d\cos\theta}{1-\cos\theta}\, \Delta_s(\theta_{max}, \theta) \qquad P(z) = C_F \frac{1+(1-z)^2}{z}$$

HERWIG: ANGULAR ORDERING

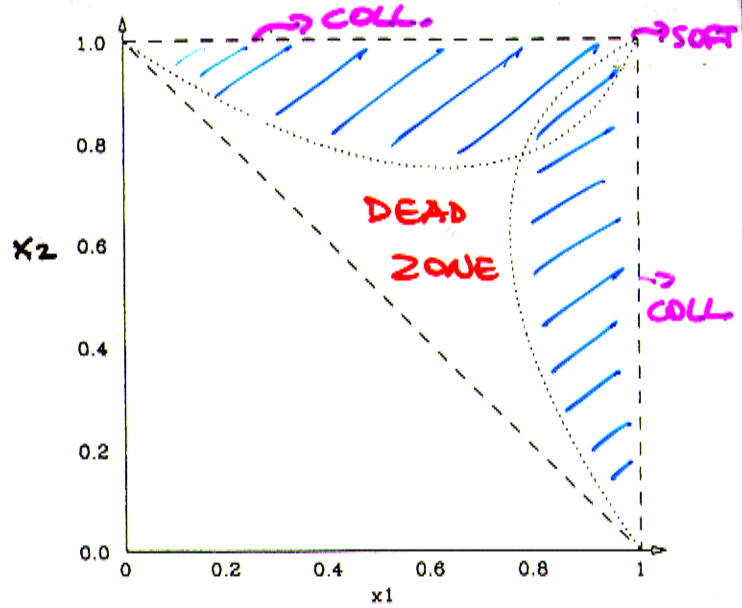
"DEAD ZONES" WITH NO RADIATION

MATRIX-ELEMENT CORRECTIONS TO FILL THE DEAD ZONES

$e^+e^- \to q(p_1)\, \bar{q}(p_2)\, g(p_3)$

$$x_i = \frac{2 p_i \cdot q}{q^2} \qquad q = p_1 + p_2 + p_3$$

M. H. SEYMOUR, ZPC 56 (1992) 161

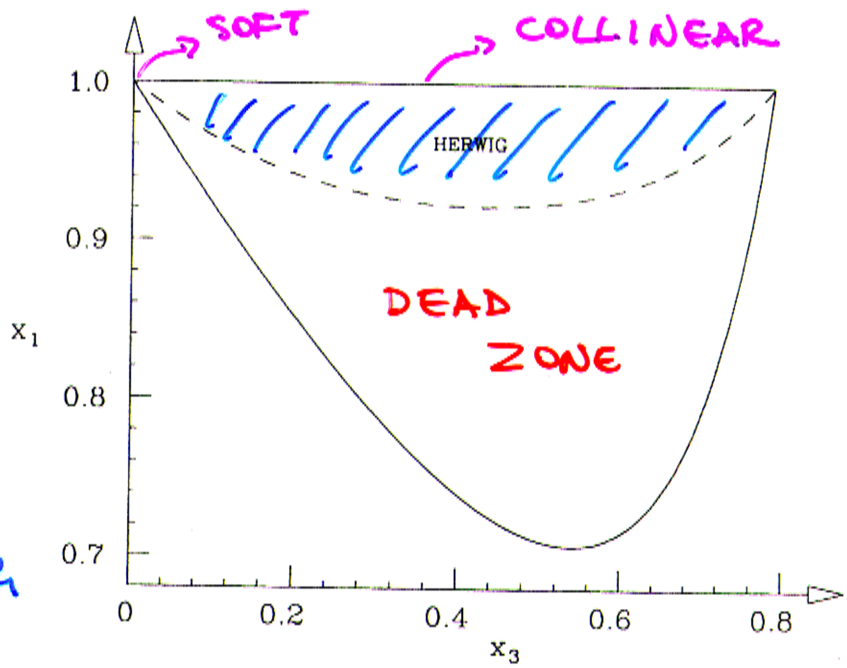


$t(q) \to W(p_1)\, b(p_2)\, g(p_3)$

$$x_1 = \frac{2 p_1 \cdot q}{q^2} - a \qquad a = \frac{m_W^2}{m_t^2}$$

$$x_3 = \frac{2 p_3 \cdot q}{q^2}$$

G. CORCELLA AND M. H. SEYMOUR, PLB 442 (1998) 417



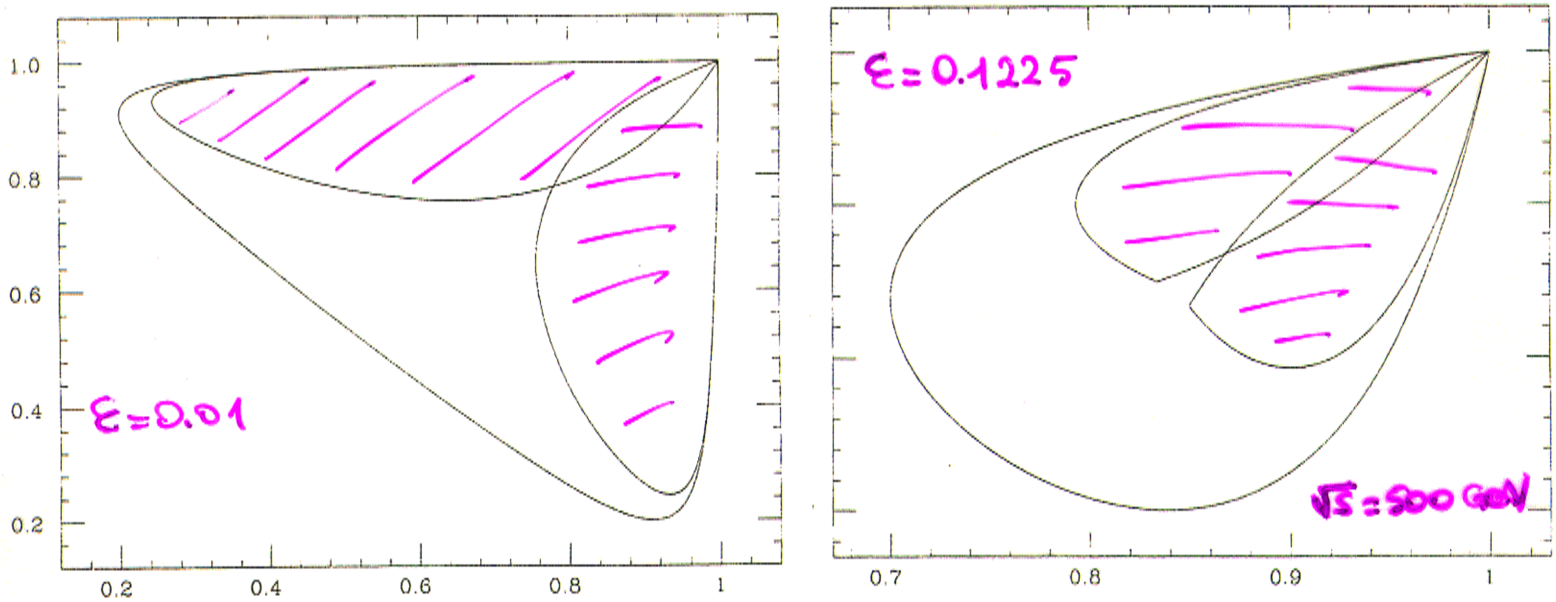
HARD CORRECTIONS: EXACT MATRIX ELEMENT IN THE DEAD ZONE

SOFT CORRECTIONS: EXACT MATRIX ELEMENT IN THE HERWIG REGION FOR EVERY EMISSION BEING THE HARDEST SO FAR

HERWIG 5.9: ONLY CORRECTION TO PRODUCTION

HERWIG 6.1 (hep-ph/9912396): ALSO MATRIX-ELEMENT CORRECTIONS TO TOP DECAYS

SOME MASS EFFECTS ($\varepsilon = m_t^2/s$) STILL MISSING IN THE CORRECTIONS TO THE PRODUCTION (DEAD-ZONE LIMITS AND SOFT CORRECTION)



MASS EFFECTS NOW INCLUDED, BUT NOT YET PUBLIC (HERWIG 6.2).

MATRIX-ELEMENT CORRECTIONS TO $W \to q\bar{q}'$ STRAIGHTFORWARD (HERWIG 6.2)

SEE, FOR A REVIEW, G.C. AND M.H. SEYMOUR, hep-ph/9911335

FRACTION OF EVENTS IN THE DEAD ZONE

TOP PRODUCTION

$\sqrt{s} = 500$ GeV 2.8 %

$\sqrt{s} = 1$ TeV 2.4 %

TOP DECAY

$\simeq 3$ % INDEPENDENT OF $\sqrt{s}$

W DECAY

$\simeq 7$ % INDEPENDENT OF $\sqrt{s}$

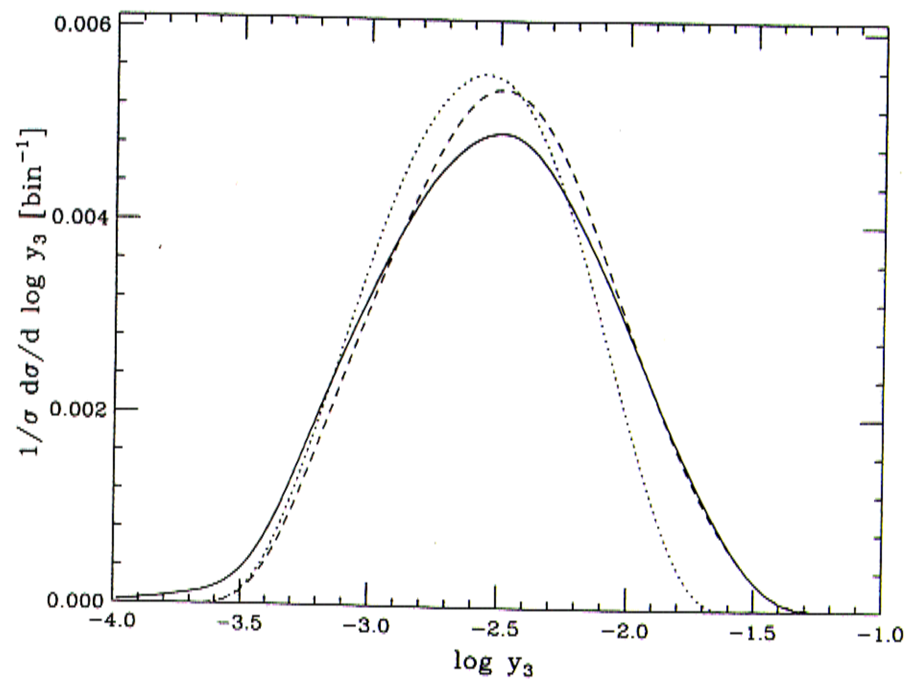
SMALL FRACTIONS : OK $\mathcal{O}(\alpha_s)$ RESULT

TYPICALLY LARGE-ENERGY RESOLVED JETS

$e^+e^- \to t\bar{t}$ $\sqrt{s} = 360$ GeV

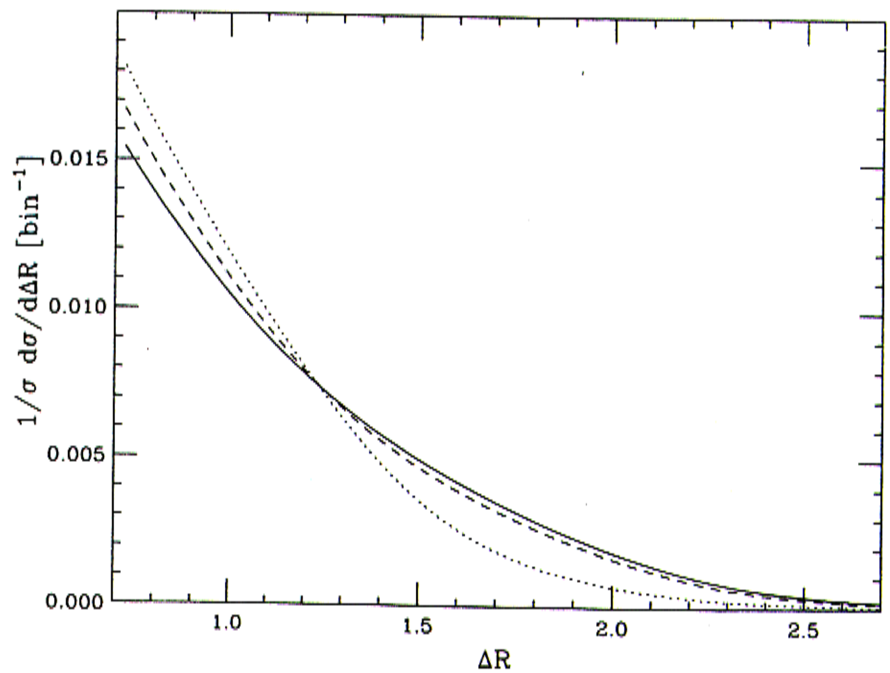
3-JET EVENTS $y_{ij} = \frac{2}{s} \min(E_i^2, E_j^2)(1-\cos\theta_{ij})$

— 6.1 .... 6.0 - - - $e^+e^- \to t\bar{t} \to W^+ b W^- \bar{b} g$



$E_T > 10$ GeV

$\Delta R > 0.7$

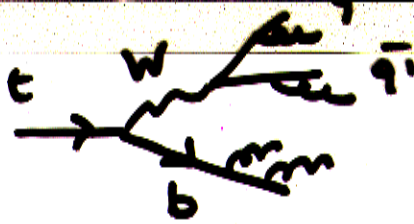


GOOD AGREEMENT AT LARGE y_3 AND ΔR

G.C. AND M.H. SEYMOUR, PLB 442 (1998) 417

HADRON W DECAY

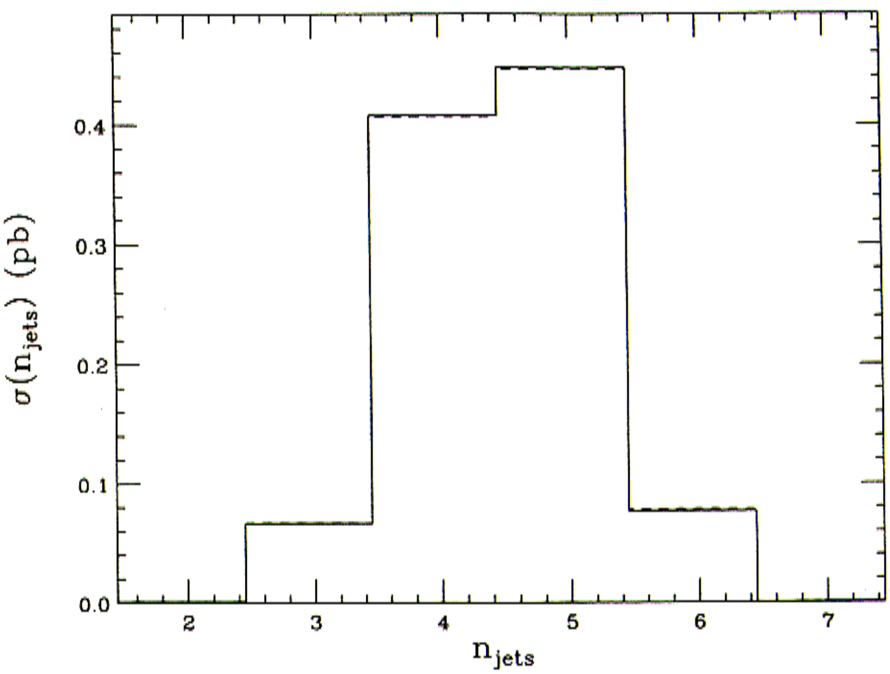
$\sqrt{s} = 370$ GeV



$y_{cut} = 0.01$ $E_T > 10$ GeV

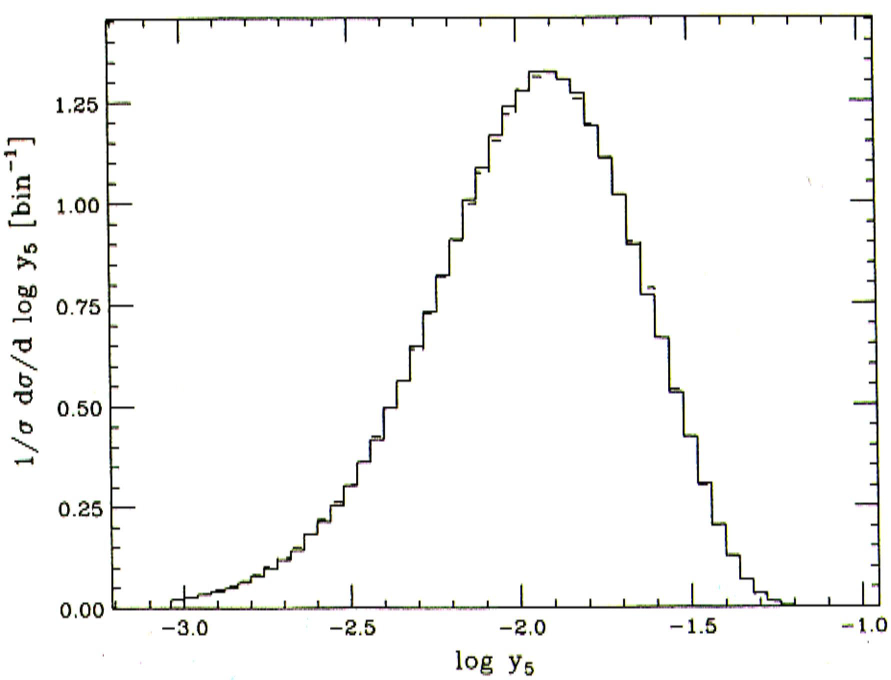
.... 6.1

—— 6.2



SMALL EFFECTS OF CORRECTIONS TO W DECAY

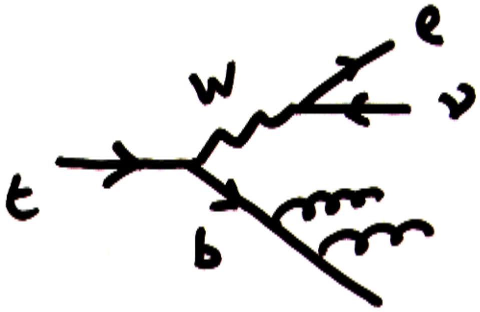
5-JET EVENTS $E_T > 10$ GeV



STUDIES ON THE TOP MASS RECONSTRUCTION AT THE LINEAR COLLIDER

WORK DONE IN COLLABORATION WITH E.K. IRISH

DILEPTON CHANNEL IN THE TOP DECAY



OBSERVABLES RELATED TO THE TOP MASS:

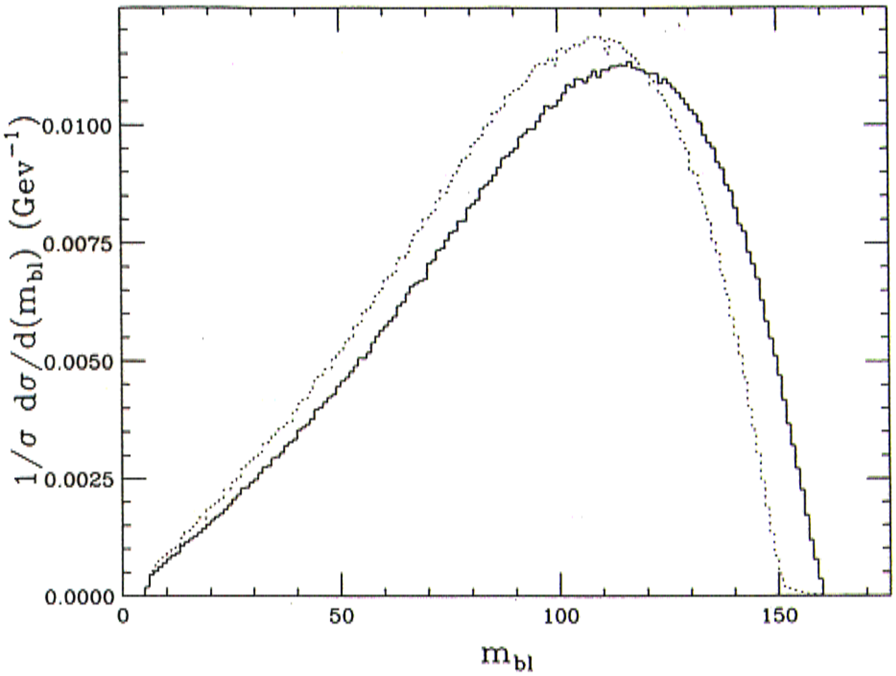
- INVARIANT MASS $m_{be} = (p_b + p_e)^2$

- b-QUARK ENERGY

- LEPTON ENERGY

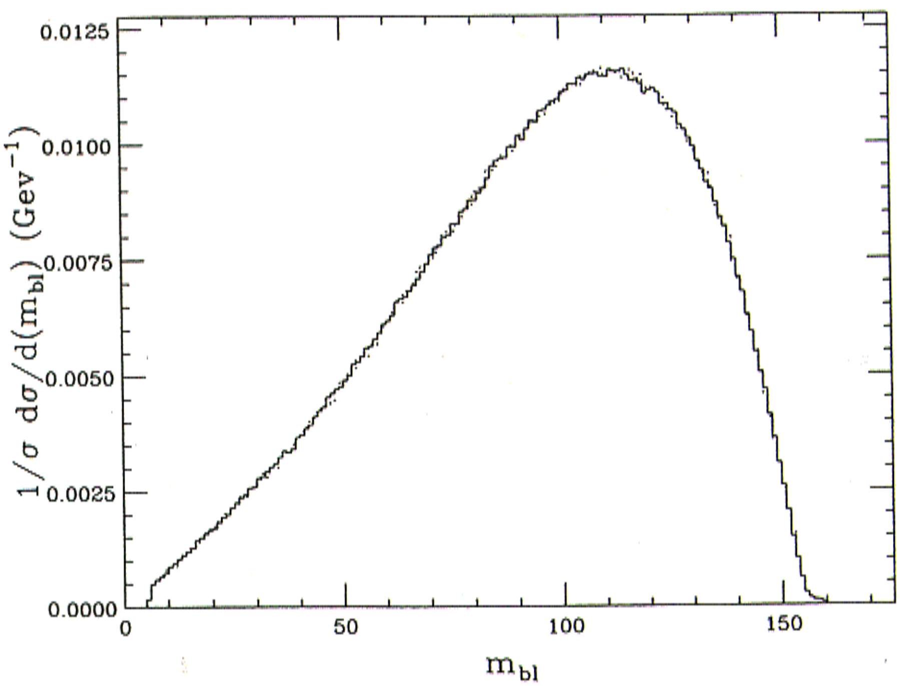
INVARIANT-MASS DISTRIBUTIONS

$\sqrt{s} = 500$ GeV —— 179 GeV .... 171 GeV



HERWIG 6.1

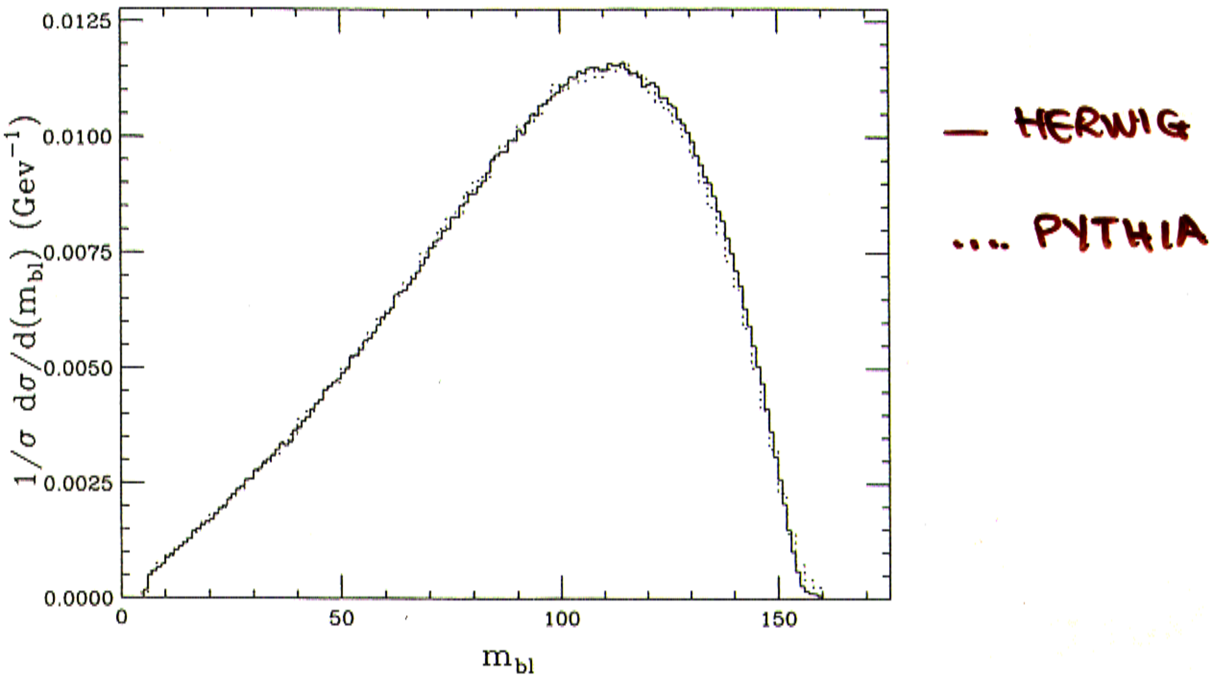
$m_t = 175$ GeV —— $\sqrt{s} = 500$ GeV .... $\sqrt{s} = 1000$ GeV



HERWIG 6.1

$m_{b\ell}$ DISTRIBUTION INDEPENDENT OF $\sqrt{s}$

REASONABLE AGREEMENT HERWIG / PYTHIA



m_t	$\langle m_{b\ell}^{H}\rangle$	$\langle m_{b\ell}^{P}\rangle$
171	91.60	91.01
175	94.63	93.94
179	97.65	96.53

$\Delta(P-H) \simeq 100 - 500$ MeV

LINEAR FITS:

HERWIG: $\langle m_{b\ell}\rangle = 0.756\, m_t - 37.761$ GeV

PYTHIA: $\langle m_{b\ell}\rangle = 0.690\, m_t - 26.816$ GeV

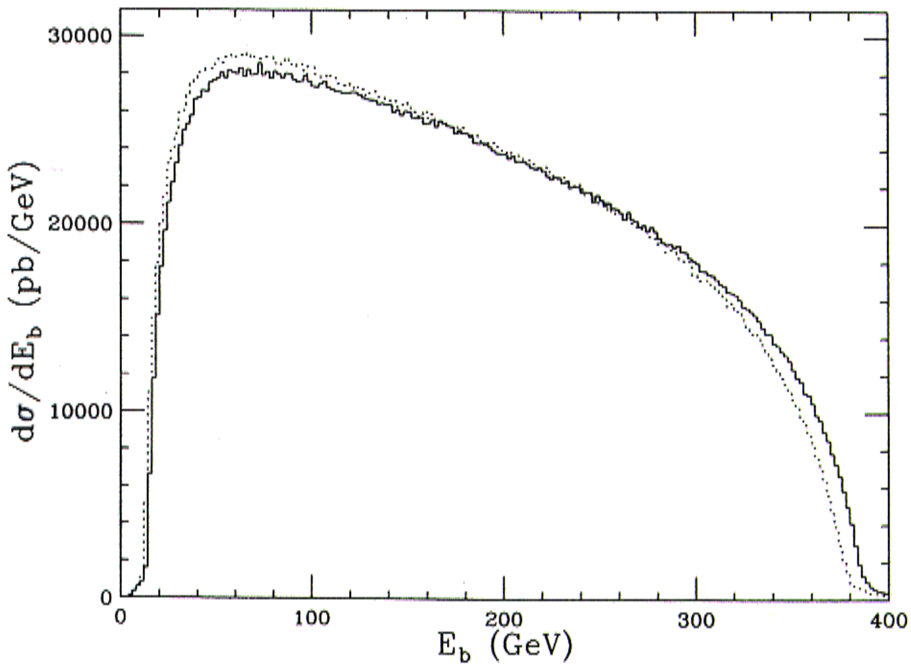
$\varepsilon \sim O(10^{-4}\,\mathrm{GeV})$

$\Delta m_t \simeq 1.4\, \Delta\langle m_{b\ell}\rangle$

b-JET ENERGY

NON LORENTZ-INVARIANT OBSERVABLE

$\sqrt{s} = 1$ TeV

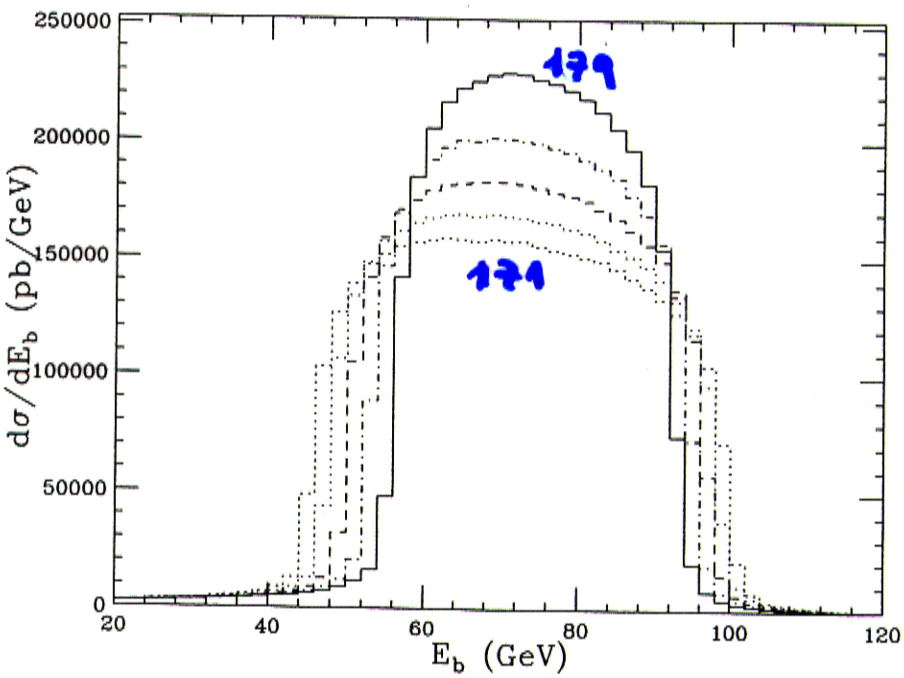


— 179 GeV

.... 171 GeV

HERWIG 6.1

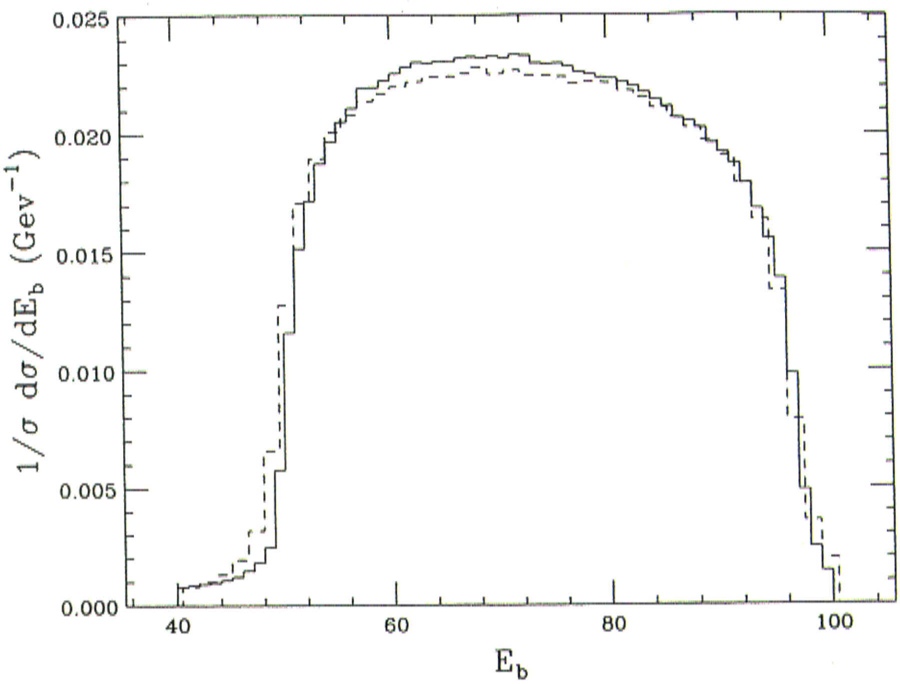
$\sqrt{s} = 370$ GeV



HERWIG 6.1

BIG EFFECT OF THE TOP MASS AT THRESHOLD

COMPARISON HERWIG/PYTHIA



$\sqrt{s} = 370$ GeV

$m_t = 175$ GeV

— HERWIG

--- PYTHIA

$\sqrt{s} = 370$ GeV

HERWIG: $\langle E_b \rangle = 0.257\, m_t + 27.311$ GeV

PYTHIA: $\langle E_b \rangle = 0.239\, m_t + 30.550$ GeV

HERWIG: $\sigma = -2.220\, m_t + 433.760$ GeV

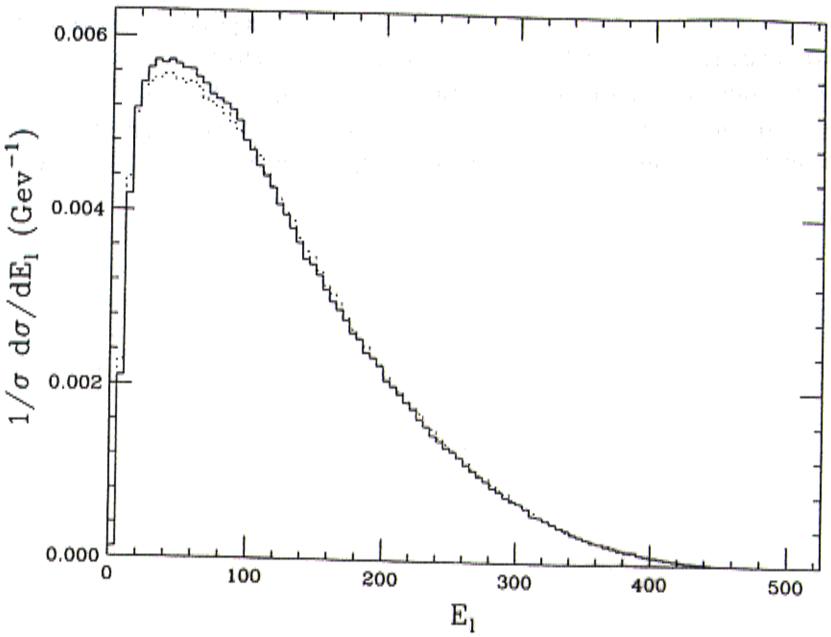
PYTHIA: $\sigma = -2.175\, m_t + 426.220$ GeV

$\Delta m_t \simeq 4 \cdot \Delta \langle E_b \rangle$; $\Delta m_t \simeq 0.45\, \Delta \sigma$

NEGLIGIBLE DEPENDENCE ON THE b MASS

4 GeV $< m_b <$ 5 GeV , $72.796 < \langle E_b \rangle < 72.807$ (GeV)

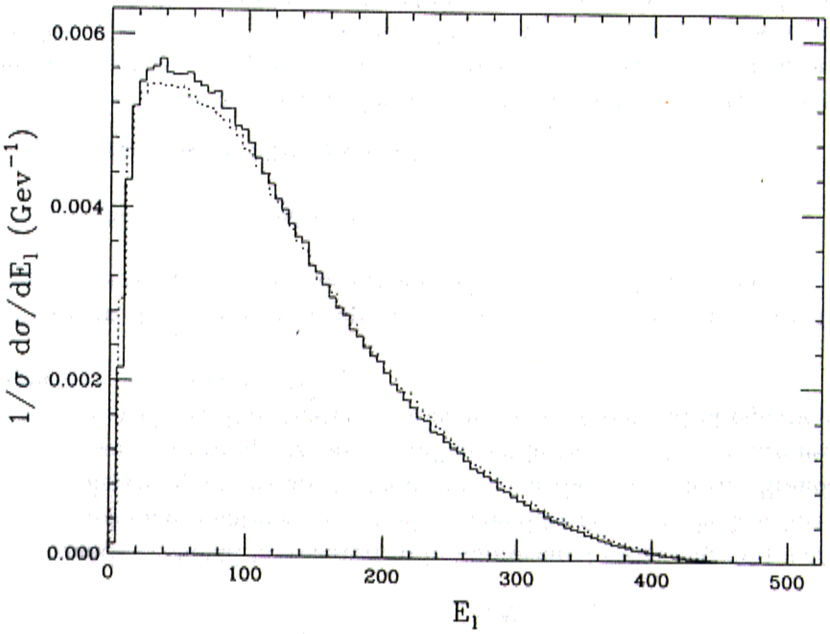
LEPTON ENERGY $\sqrt{s} = 1$ TeV



HERWIG 6.1

— $m_t = 180$ GeV

.... $m_t = 170$ GeV



$m_t = 175$ GeV

— HERWIG

.... PYTHIA

HERWIG : $\langle E_\ell \rangle = -0.138\, m_t + 143.87$ GeV $\varepsilon = 0.05$ GeV

PYTHIA : $\langle E_\ell \rangle = -0.125\, m_t + 144.41$ GeV $\varepsilon = 0.06$ GeV

$$\Delta m_t \simeq 7.5\, \Delta \langle E_\ell \rangle$$

CONCLUSIONS

- PARTON SHOWER ALGORITHMS NEED MATRIX-ELEMENT CORRECTIONS
- HERWIG 6.2 WILL HAVE MATRIX-ELEMENT CORRECTIONS TO TOP PRODUCTION AND DECAY, AND W DECAY, WITH MASS EFFECTS
- STUDIES ON m_t RECONSTRUCTION:

$\Delta m_t \simeq 1.4\, \Delta \langle m_{b\ell} \rangle$ $\Delta m_t \simeq 4 \Delta \langle E_b \rangle$

$\Delta m_t \simeq 0.45\, \Delta \sigma_b$ (THRESHOLD)

$\Delta m_t \simeq 7.5\, \Delta \langle E_\ell \rangle$

IN PROGRESS:

- BEAMSSTRAHLUNG IN HERWIG (CIRCE)
- SPIN CORRELATIONS
- MORE STATISTICAL ANALYSES: KS TEST, LIKELIHOOD FIT, END-POINT ANALYSIS, ETC.