TOP MASS IN DI-LEPTON FINAL STATE USING THE MODIFIED DALITZ-GOLDSTEIN METHOD

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top mass in dilepton channel/ modified Dalitz-Goldstein method

R.H. Dalitz, G.R. Goldstein, Phys.Rev. D45 (1992) 1531; K. Karr and K. Sliwa CDF4393, 1998.

THE FIRST OF NOW MANY “MATRIX ELEMENT” ANALYSES: NO “BLACK BOXES”

- Unknowns are four-momenta of the two neutrinos
- Eight equations of constraint:

$$
\begin{aligned}
(l_1+\nu_1)^2 &= M_W^2 \\
(l_2+\nu_2)^2 &= M_W^2 \\
(t-l_1-b_1)^2 &= M_\nu^2 = 0 \\
(\bar{t}-l_2-b_2)^2 &= M_\nu^2 = 0 \\
(t)^2 &= M_t^2 \\
(\bar{t})^2 &= M_t^2 \\
-P_x^t &\sim P_x^{\bar{t}} \\
-P_y^t &\sim P_y^{\bar{t}}
\end{aligned}
$$

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- Solve geometrically rather than algebraically (Dalitz-Goldstein)

- Don't use any black-boxes, necessary integration performed "by hand" on a fine grid spanning the parameter space with its volume correctly taken into account

- With assumed top quark mass, M_t, first six equations constrain t and tbar three-momentum vectors to point somewhere on respective ellipses in three momentum (lepton, b-quark and assumed M_t suffices to find such an ellipse for each combination)

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• Problem is fully constrained by the last two equations - projection of an ellipse from 3-dim momentum space onto a transverse momentum plane is also an ellipse, to 0-th order (no transverse momenta of incoming partons) the t and tbar transverse momenta are equal and opposite - ellipses should then cross each other, intersection points are the solutions for the t and t-bar momenta satisfying all the constraints

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• Both ellipses are scanned over a fine grid of points. Transverse momentum of the ttbar system, P_{tt}, is calculated for each pair of points

• Each pair of points is assigned relative probability factor, $P(X_{tt})$, where $X_{tt}=P_{tt}/M_t$. This factor downgrades solutions with unlikely values of P_{tt}

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- Each point in the grid is assigned relative probability, $P(x_1,x_2)$, which quantifies level of agreement between Bjorken-x values calculated at the given point and Bjorken-x values expected from structure functions (QCD matrix element calculation for t-tbar production enters here)

$$P_{x_1,x_2} = \frac{\sum_{i=qq,gg} F_i(x_1) F_i(x_2) \frac{d\sigma}{d\hat{t}}(\hat{s},\hat{t})_i}{\sum_{i=qq,gg} \frac{d\sigma}{d\hat{t}}(\hat{s},\hat{t})_i}$$

- Each point in the grid is assigned factor $P(l^+)$ and $P(l^-)$ which quantify level of agreement of two leptons candidate energies as calculated in top quark rest frame, with corresponding energies predicted by V-A matrix element calculations

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• Circumferences of ellipses used to take into account the phase space volume (thanks to Sarka Todorova for stimulating discussions) (NEW)

• Each b jet energy is smeared over a fine grid in 3σ range about its measured value. Each "guess" of b quarks' jet energy is treated as a new COMBINATION of leptons and jets - a single combination with the largest integrated probability is selected rather than taking the weighted average (NEW)

• Thus, method scans a fine grid in four-dimensional parameter space formed by smearing two measured b jet energies and sampling along points along resulting two families of possible ellipses

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- Top quark mass is sampled over wide range of possible values (86-386 GeV/c^2 in CDF analyses)

- Complete likelihood, L, for each point in the grid is defined as:

$$L=\{G(b)xG(bbar)\}xP(X_{tt})xP(x_1,x_2)xP(l^+)xP(l^-)$$

- For given combination of two jets "guesses" and two leptons and assumed top quark mass, M_t, L values for each point are projected onto the top quark mass axis and added together. This is done for entire range of M_t to form a probability distribution as a function of top quark mass for this combination

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- Peak of distribution points to the most likely mass for given combination

- Integral of distribution defines a probability for a given combination, L_{comb}.

- If a sample of candidates contains N events with SMALL background (<20%), one forms a *joint probability* by multiplying the probability distributions for best combinations (with best L_{comb}) found in each event

- study mapping functions ($M_{reconstructed}$ vs M_{true}) for correct combinations of jets and leptons, "flipped","wrong" and those selected by probability (with best L_{comb})

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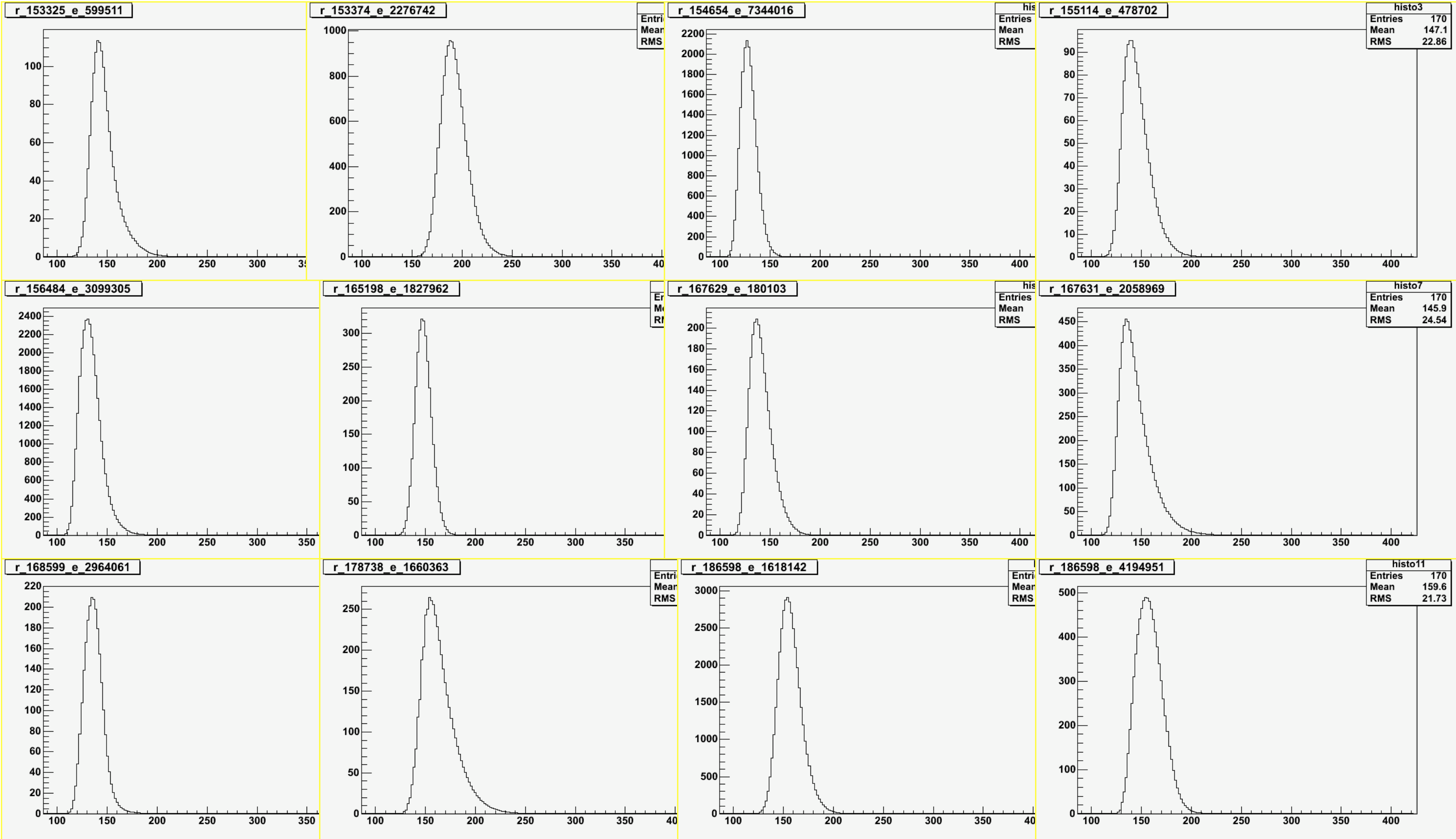
Probability distributions for best combination in each of tight-tight events.



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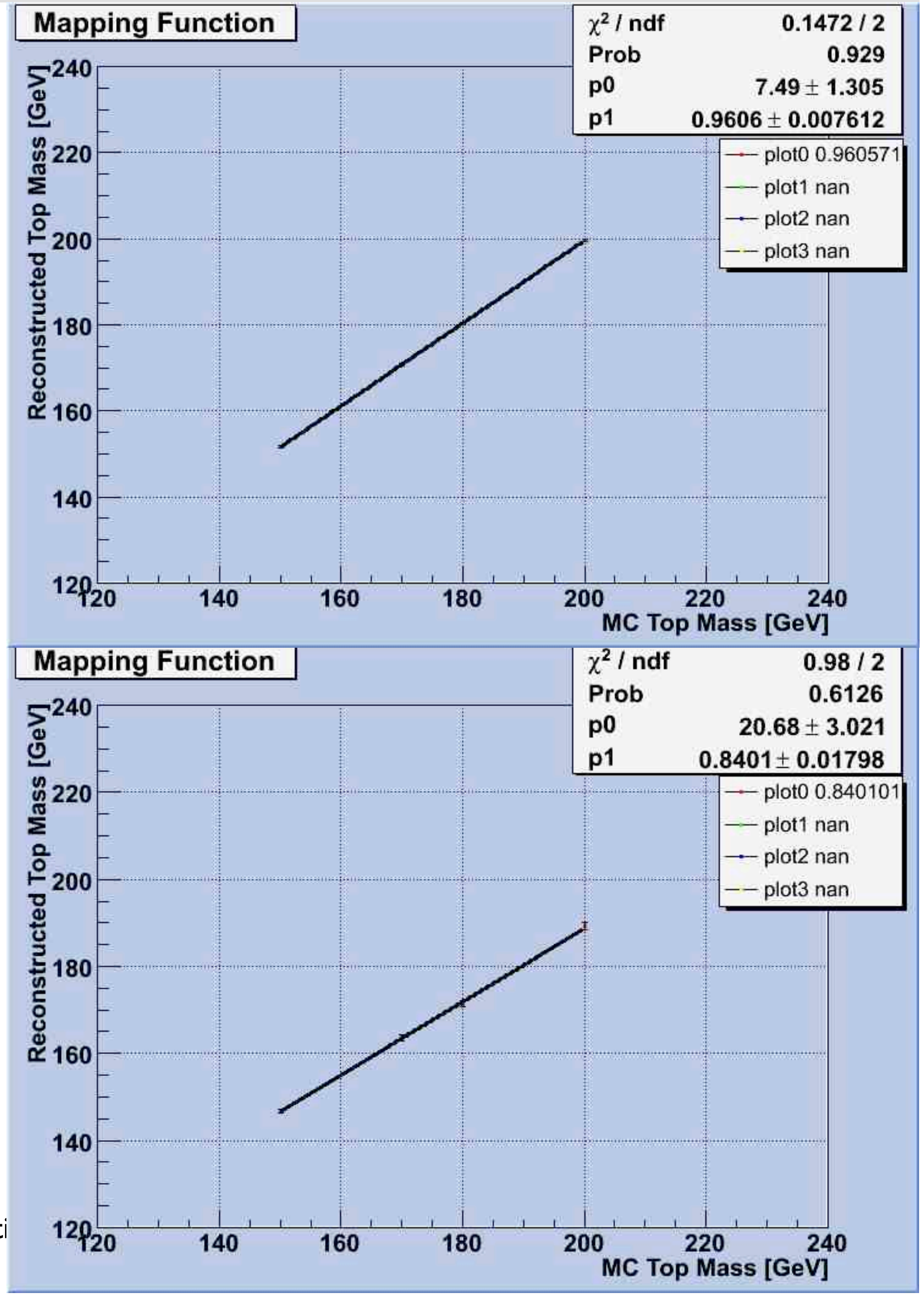
Studies of mapping function, correct combinations for samples of 50 events:

generator level ⇒

fully reconstructed ⇒



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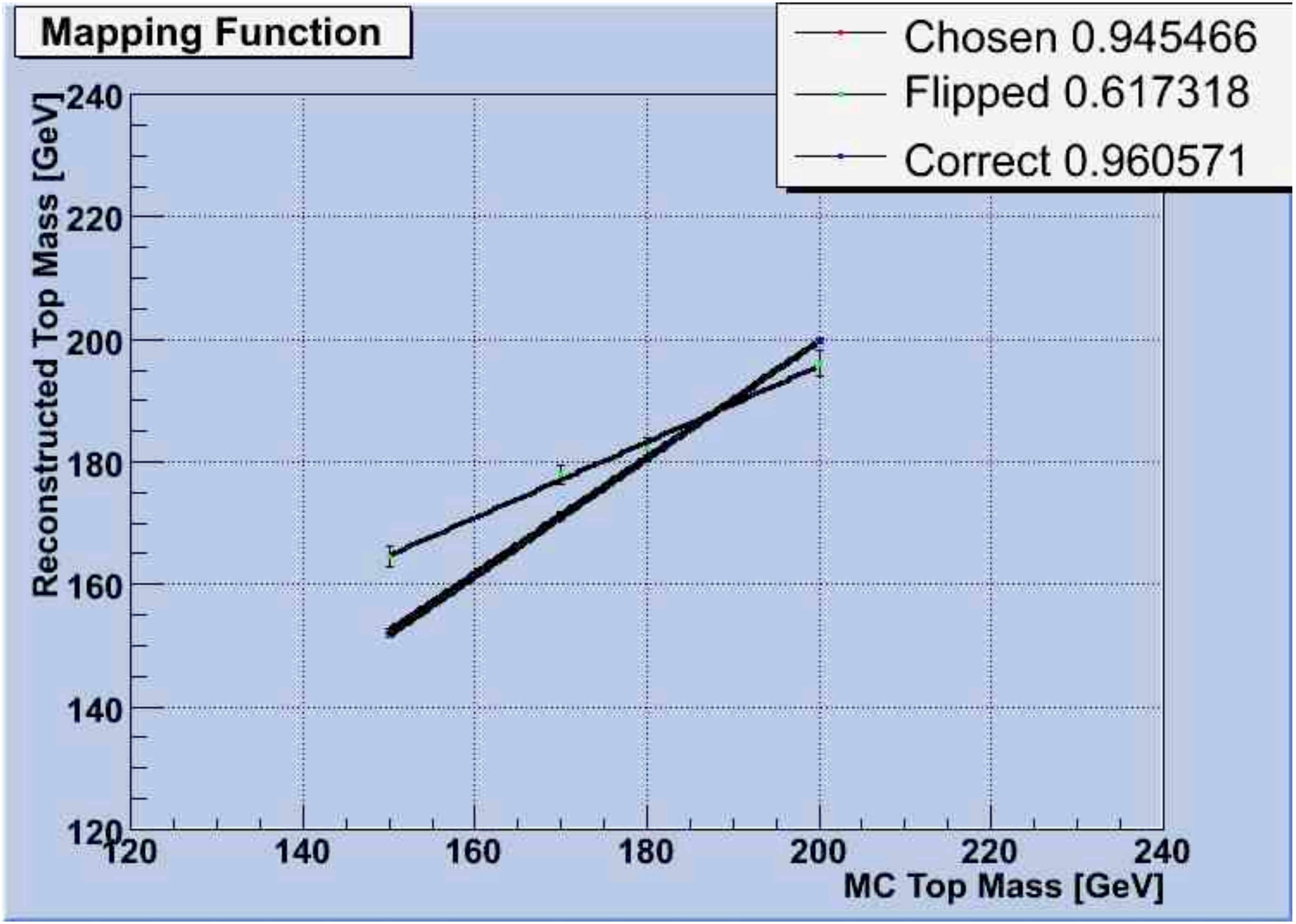
Monte Carlo studies, generator level "OLD ANALYSIS"



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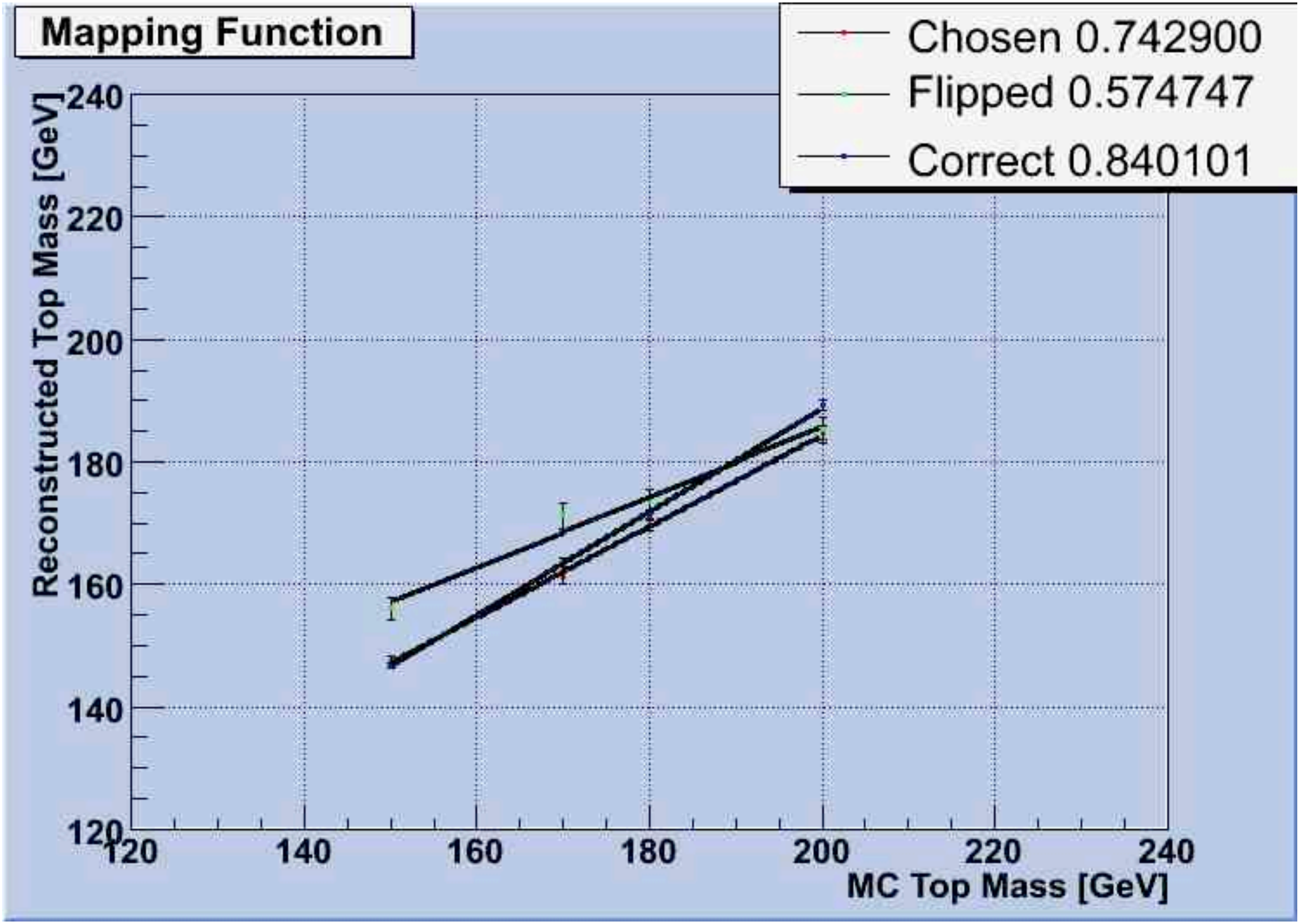
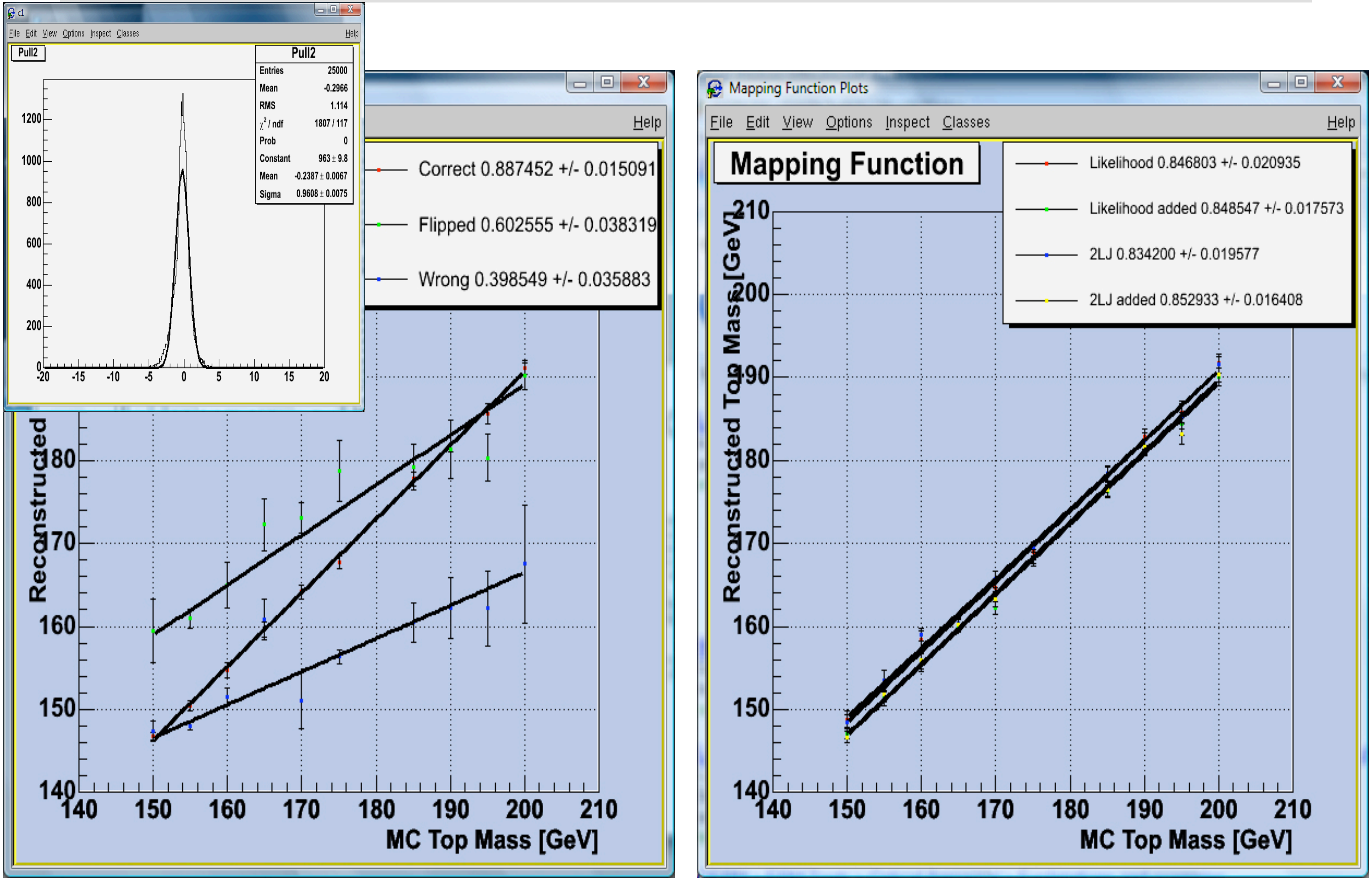
Monte Carlo studies, FULLY RECONSTRUCTED "OLD ANALYSIS"



status of NEW ANALYSIS



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Monte Carlo mapping function studies, generator level

	intercept	slope
best L	10.70+-1.74	0.946+-0.001
best L/2 jets only	8.89+-1.53	0.953+-0.009
correct	7.49+-1.31	0.961+-0.008

Monte Carlo mapping function studies, FULLY RECONSTRUCTED

IMPROVEMENTS BETWEEN “OLD” AND “NEW” RESULTS

	NEW slope	OLD slope
best L	0.849+-0.017	0.743+-0.024
best L/2 jets only	0.853+-0.017	0.746+-0.023
correct	0.887+-0.016	0.840+-0.018

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- PLAN FOR ATLAS STUDIES:

  - Monte Carlo studies with events generated with 10 TeV LHC energy
  - evaluate error on top mass achievable within 1 year, 2 years etc. of low-luminosity running
  - dominant error will be systematic (statistical scales with $\sqrt{N}$), most likely the most important factor will still be jet energy uncertainty
  - backgrounds could be different than in CDF, on the other hand much larger statistics should allow MUCH more stringent selection cuts and most likely in background reduction to less than 10% level, or better
  - use support vector machine (Ben Whitehouse) and tagging information to enrich the sample of top-like events with just the kinematics cuts to bring S/B to 10/1 or better.