Czech Group in DØ Top Physics

Jiří Kvita

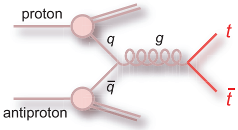
Charles University, Prague

BA Top Meeting, Jan 2007

Outline

- Overview of Czech Group Top Activities at the DØ.
- My Thesis Status and Plans.

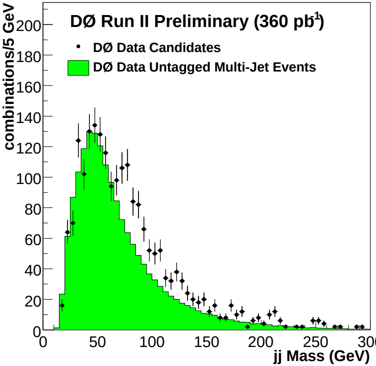
- Disclaimer:
  - I do not attempt to provide an overview of Top Physics at the DØ experiment.
  - I do not aspire on describing all activities we take part in.
  - I would like to share ideas and give some impression on what we study.



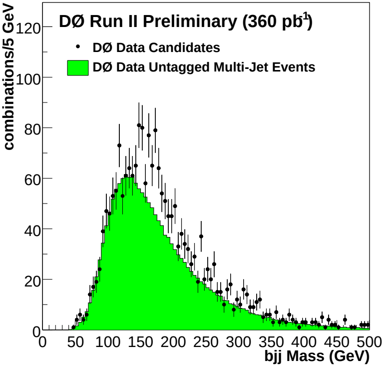
Czech Group at the DØ

- Top quark as the heaviest elementary particle provides a unique window to precision tests of Quantum Chromodynamics.
- Historically, there is a tradition in $t\bar{t}$ multijet channel (K. Soustružník, Run I thesis).
- This is being continued at Run II (with P. Vokáč), in cross section and mass analyses.
- I am interested in kinematics of the $t\bar{t}$ system in l+jets channel.
- Our service work activities for the experiment follow our physics interests: multijet triggers (K.S.), Jet Vertex Confirmation (P.V.), Jet Energy Scale (J.K.).
- DØ works on analyses measuring the cross section, mass, W helicity in $t\bar{t}$, Top charge, Branching ratios...
- Last but not least, there is EW Single Top Production, see public DØ Top page for latest results.

DØ Multijet Analysis (M. Begel)



- The light jets invariant mass distribution m_{jj}.

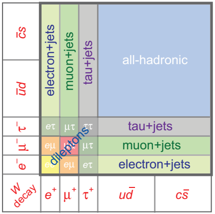


- Invariant mass of a b-jet and two light jets m_{bjj}.

- **Preselected Data** with overlaid expected **Background**.
- All b-jets assignment respecting permutations included.

Kinematics in $t\bar{t}$ l+jets Channel

- The aim is to measure a differential distribution like Top p_{T} or $\Delta\phi$ between the two Top quarks.
- Motivations are several: test top QCD production, its EW decay, look for deviations, compare to theory, measure something differential in $t\bar{t}$, have some fun, make a thesis out of it...
- l+jets channel most suitable: clean, with distinct signature (isolated high-p_T lepton, large missing transverse energy).



Kinematical Fitter

- Objects as seen by the detector have mismeasured properties, calibrated to proper scales only on average.
- Dedicated event-by-event fitting can improve our resolution, account for fluctuations and solve kinematics for unknown variables (neutrinos).
- A simple χ^2-like expression (mass constraints) is used in the minimisation process.

$$\chi^2 \equiv \frac{(M_{W1} - M_W)^2}{\sigma_W^2} + \frac{(M_{W2} - M_W)^2}{\sigma_W^2} + \frac{(M_{t_2} - M_{t_1})^2}{\sigma_t^2}$$

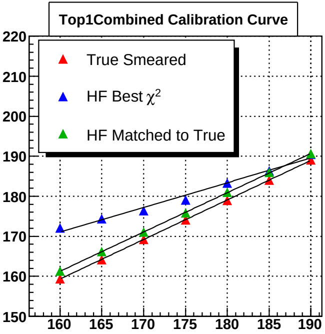
- An iterative kinematical fitter is applied to adjust measured objects' fourmomenta.
- Results are several fitted permutations ordered in their χ^2's.
- Fitter written by Scott Stuart Snyder (Stonybrook).

Ensemble Tests using Toy MC

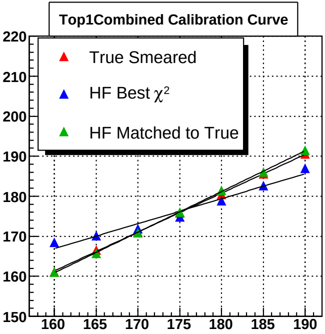
- Unconstrained Top Mass, constrained m_W =80.4 GeV.
- Look at generated mass, then at combined mean from smeared objects.
- Look at HitFit : Use all permutations, best one, weighted by $\exp[-\chi^2/2] > 10^{-3}$, the one matched to generated.
- Study HitFit performance, Study Toy MC performance.
- 40 ensembles per $m_t \in$ 160, 165, 170, 175, 180, 185, 190 GeV.
- Look at:
  - Best χ^2 solution
  - Combine all permutations
  - Weight using fit χ^2: $w = \exp[-\chi^2/2]$.
  - Look at the fit result matched in each object $\Delta\mathcal{R} = 0.1$ to the input.

Mass Calibration Curves, Toy MC

- Look simply at means of mass distributions over ensembles.



e+jets



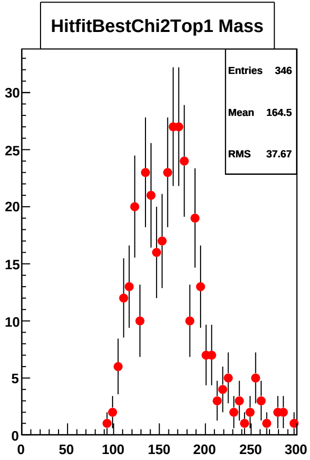
alljets

HitFit Efficiencies and Controls

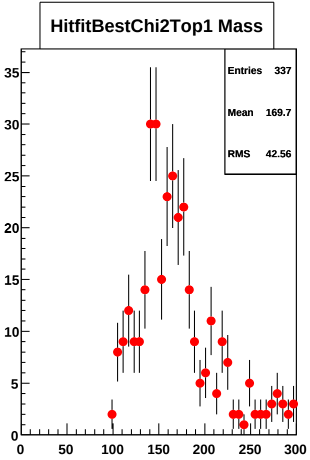
- Study how often HitFit converges
- How often is a fitted permutation matched to the generated one within 0.1 in $\Delta\mathcal{R}$ for every jet/lepton.
- How often is the best χ^2 permutation matched this way.

channel	HF OK	Found Matched	best χ^2 Perm. Matched
e+jets	≈95%	98%	48%
alljets	≈75%	85%	22%

Fitter Check on Top Mass - 1 fb^{-1} Preselected Data



e+jets



μ+jets

Toy Monte Carlo - Purpose and Idea

- The aim is to have a simple, quick, but still realistic tool to investigata basic properties of six objects coming from cascade decays of the original System.
- The $t\bar{t}$ system is very complicated, and one has to look at all possible correlations, like b-jet p_T versus Top p_T, angular correlations ($\Delta\mathcal{R}$ in $\eta \times \phi$ space) etc.
- The goal is to get some feeling of the system, distinguish what features are simple kinematics and cascade decay effects, and what could be signs of new physics.
- Employ momentum conservation and realistic spectra, decay system to top quarks, these to W+b, and finally also decay W's.
- Smear according to resolutions measured in Data.

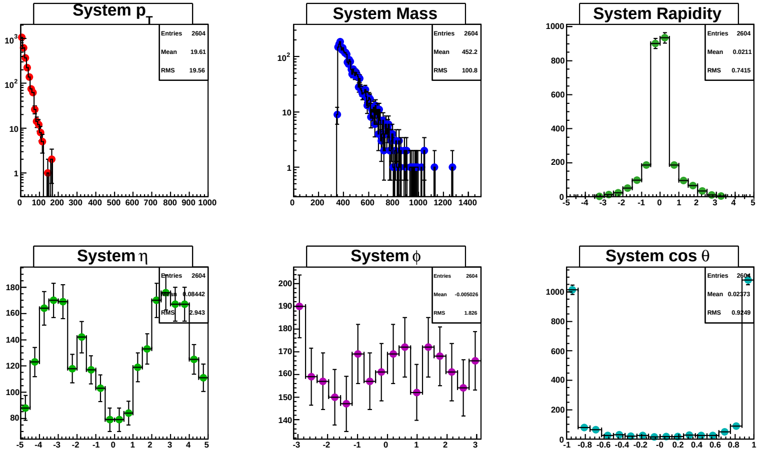
Toy MC Generation Features I

- **Generate $t\bar{t}$ System** with realistic p_{T}, η and Mass spectra, ϕ uniform.
- **Decay it to $t\bar{t}$**, use Breit-Wigner's for Top's: (Γ_t =1.4 GeV), within 10 Γ_t's around pole (generation speed up:).
- **Decay each top to $W + b$**, use Breit-Wigner's for W's (Γ_W =2.12 GeV), within 10 Γ_W's around pole.
- Flavours: 50% : 50% $W^+ \to \bar{u}d : \bar{c}s$ (for future c jet resolutions:-)
- **Generate estimated number of signal l+jets** untagged events, smear requested number of events by a Poisson.
- **Cuts**: p_{T} cuts of Jets, Lepton and MET $> 20\,\mathrm{GeV}$, $|\eta|$ cuts of 2.5 and 2.0 for Jets and Lepton $\Rightarrow$ **Shapes the Phase Space!**
- **Convention:** Top1=Leptonic, Top2=Hadronic.

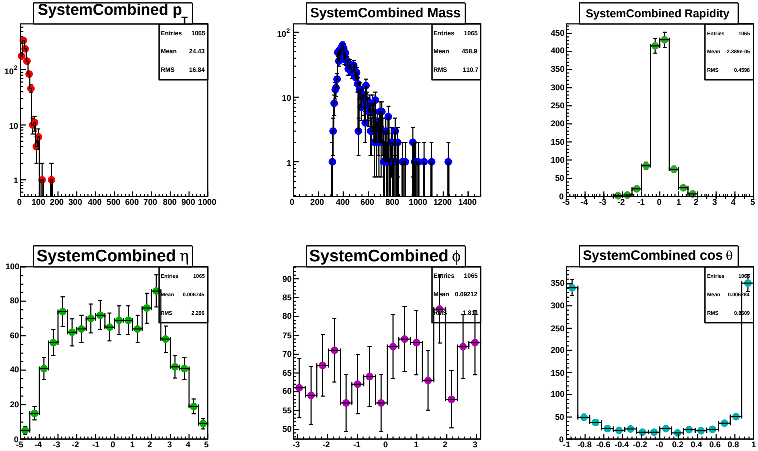
Toy MC Generation Features II

- Isotropic decays except for:
  System $\rightarrow t\bar{t}$ (I take LO $q\bar{q} \rightarrow t\bar{t}$ Matrix element $\cos\theta^*$ spectrum).
  Also, system η spectrum taken loosely from my p14 MC results.
- **Jet, Lepton momentum smearing** Data Resolutions.
- Neutrino (missing energy) smeared as a jet at the moment.
- Smear also jet and lepton angles,
- No b-tagging simulation yet.
- Combine smeared objects and look at Top Mass, p_{T}, $t\bar{t}$ System...
- Plugging-in **finite** $\sigma_\eta = 0.05$ **and** $\sigma_\phi = 0.05$ for jets changed hadronic top mass (correct permutations only) from 15 to 20 GeV!

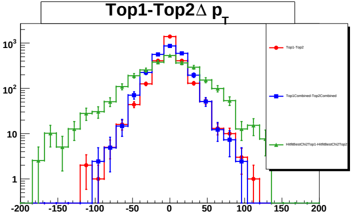
Generated $t\bar{t}$ System, e+jets

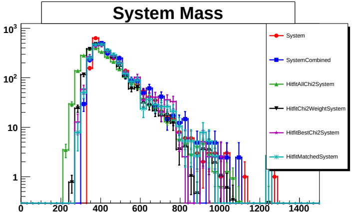


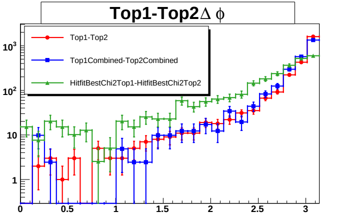
Smeared ($\equiv$ Combined, After Cuts) $t\bar{t}$ System, e+jets

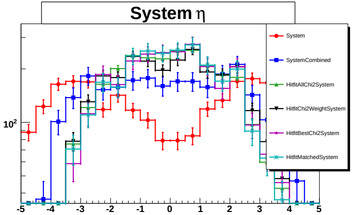
- 

$t\bar{t}$ System Studies



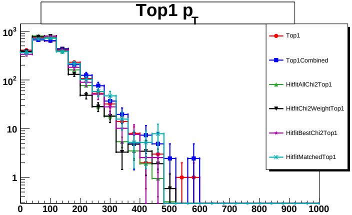


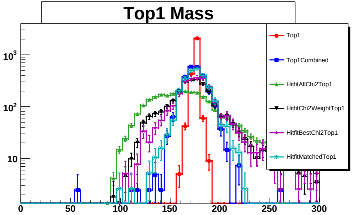




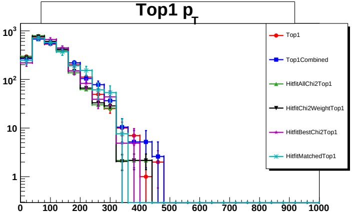
Toy MC, Fitted Leptonic Top

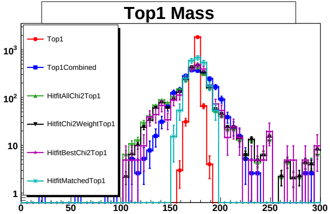
e+jets:





alljets:





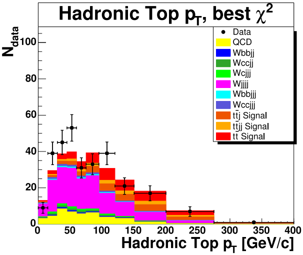
Measuring Some Spectrum

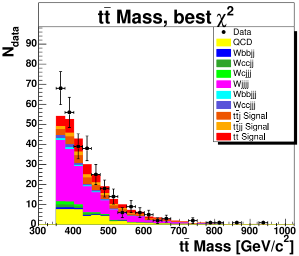
- Apply preselection, use the kinematical fitter, plot the differential distribution (need to decide how to use b-tagging for the fitter).
- This contains several backgrounds: Physics and Combinatorial.
- Use Matrix Method to subtract QCD shape, use measured/theory cross section to get number of $W+$jets and subtract their shape (matched `Alpgen`, for each flavour). Thus we will depend on MC modelling via BG templates.
- Next, we have to subtract Combinatorial BG in the signal only distribution. Again, Signal MC inevitable:
  - Look at distribution of HitFit permutation not matched to MC Reco).
  - Use `MC@NLO` (better description), smear by toy MC, compare to data.
  - In fact, before any subtraction we should first simply add standard BG's and signal MC and compare to data.
- We should be left with Signal, correct combination distribution.

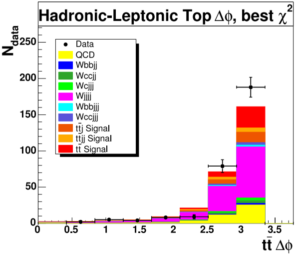
Corrections to the Raw Spectrum

- Next step is to correct for the differential acceptance (effect of preselection cuts).
  - Kinematical cuts (p_{T}, η, ...)
  - b-tagging efficiency.
  - More complicated ($\Delta\phi$).
- There is also effect of HitFit: what is the topology of events for which it does not converge? (efficiency is about 95%)
- We may or may not constrain the Top Mass (resolution on other quantities reportedly better with constrained).
- To compare to theory, one has to unsmear:
  - Use `d0gstar` MC, determine the correction between particle-Reco levels.
  - Use toy MC with arbitrary (parametrised) injected spestrum, use measured resolutions to smear, compare to measured spectrum, iterate.
  - Use e.g. `MC@NLO` input for toy, smear it, determine the correction.
  - Derive an effective top p_{T} resolution in MC (like dijet JER).

300pb Data, Old Results

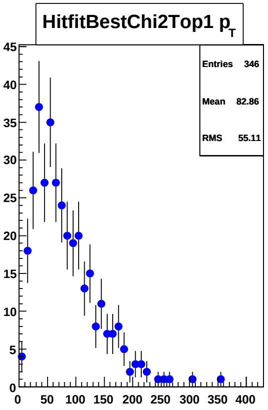




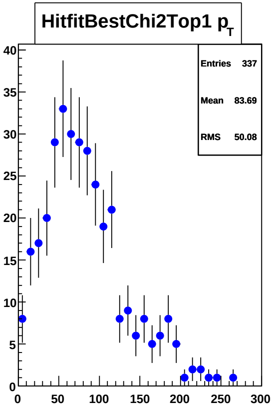


Outlook

- $t\bar{t}$ Physics is a Landscape to Explore (Preselected Data).



e+jets



μ+jets