t-tbar analysis at SiD

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- Flavour tagging for ttbar
- Hadronic ttbar events ID
- Top Mass
- Charge Reconstruction
- t, b forward backward asymmetry

Benchmarking LoI #5

AIM: in the all hadronic channel (**e+e-→tt, t→bW, W→qq'**) calculate:

- Top total cross – section ✓
- Calculate mass of top quark ✓
- Top forwards backwards asymmetry ✓

TOOLS:

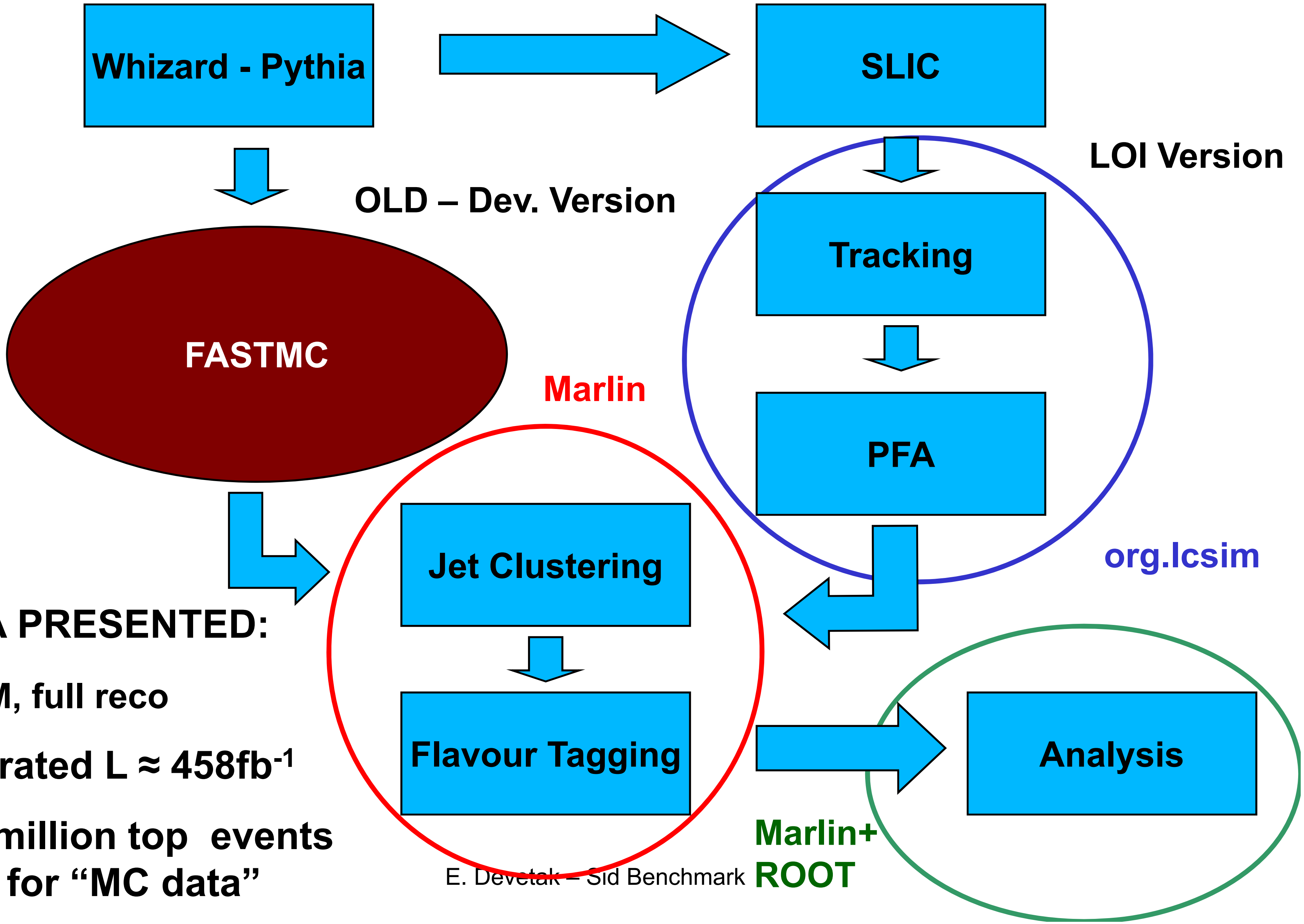
- b tagging (LCFI) ✓
- charge reconstruction (LCFI + ad hoc) ✓
- Kinematic Fitting (MarlinKinfit) ✓

GOOD PROGRESS!

First draft analysis!

Clearly some algorithms need tuning/improvements! (we can do better everywhere)

The simulation process…



DATA PRESENTED:

All SM, full reco

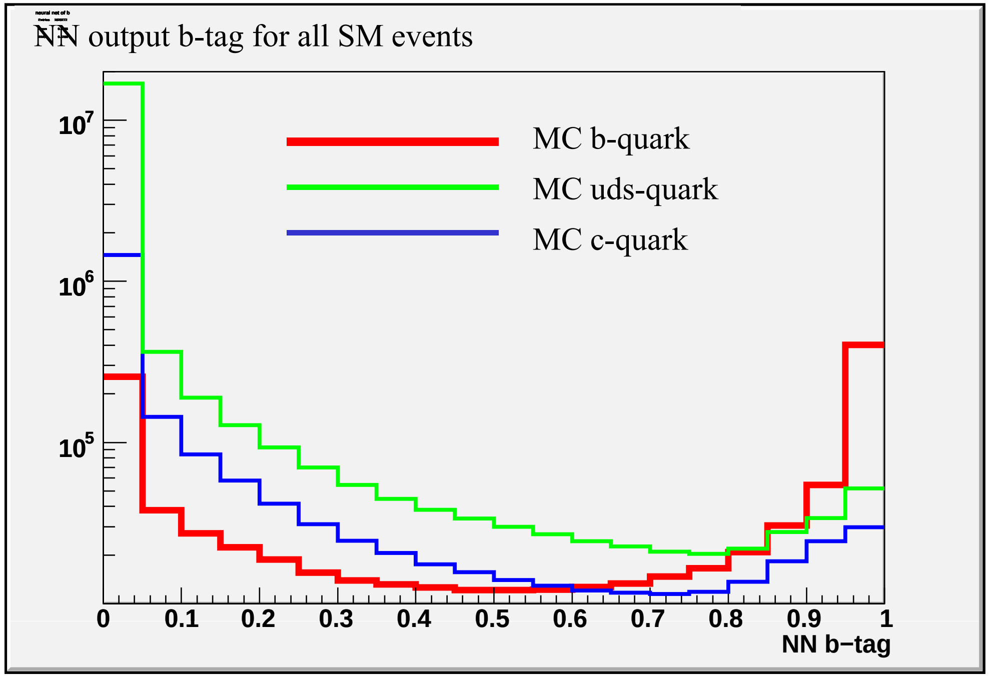
Integrated L ≈ 458fb^{-1}

One million top events used for "MC data"

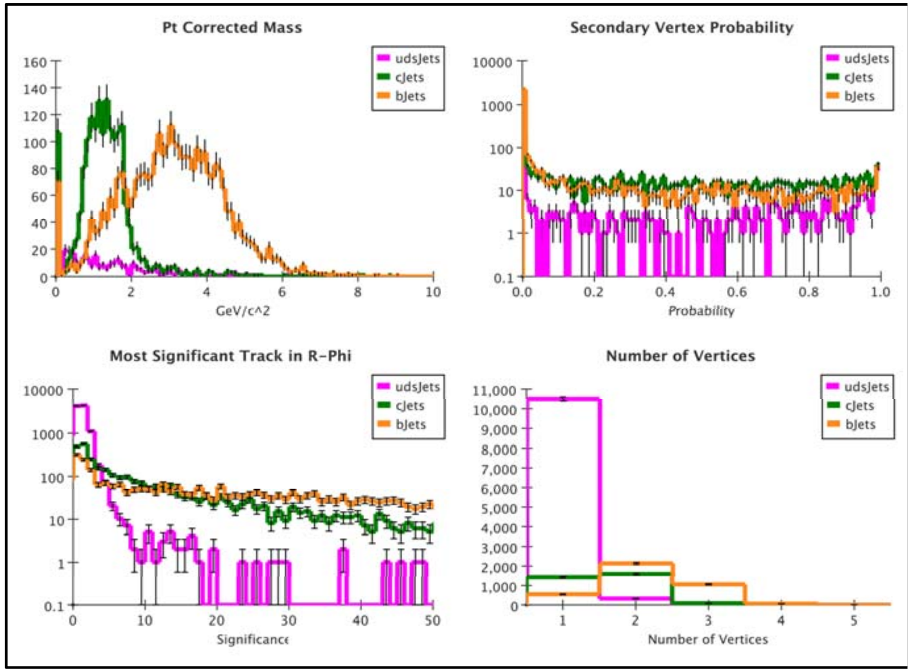
TOOLS 1: Identifying the b quark

Using LCFI Vertex package:

- Defaults tested on di-jet sample
- Need to check b tagging for 6 jets
- Originally developed by LCFI for LDC, check for Sid



All SM events forced to 6jets, hence a lot of jet confusion!

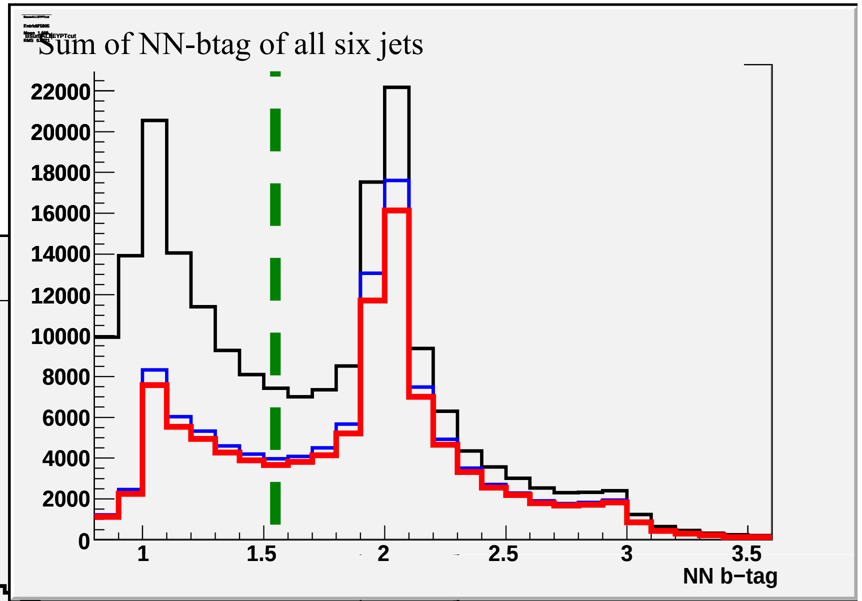


Default on di-jet sample

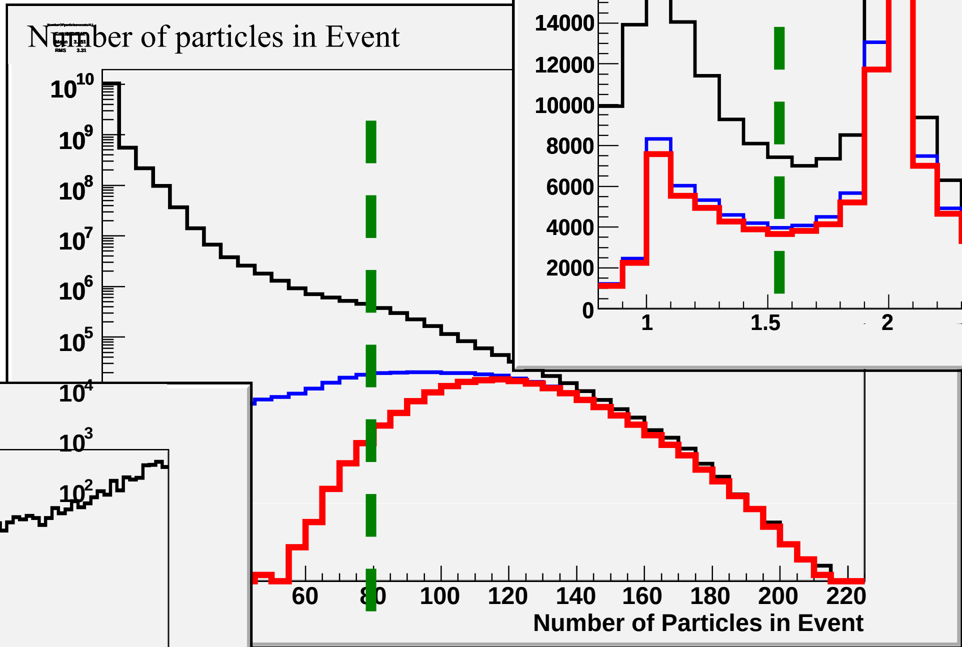
- Good Performance
- So far no parameter optimization for:
  - SiD
  - 6 jet sample
- Not envisaged in LOI timeframe

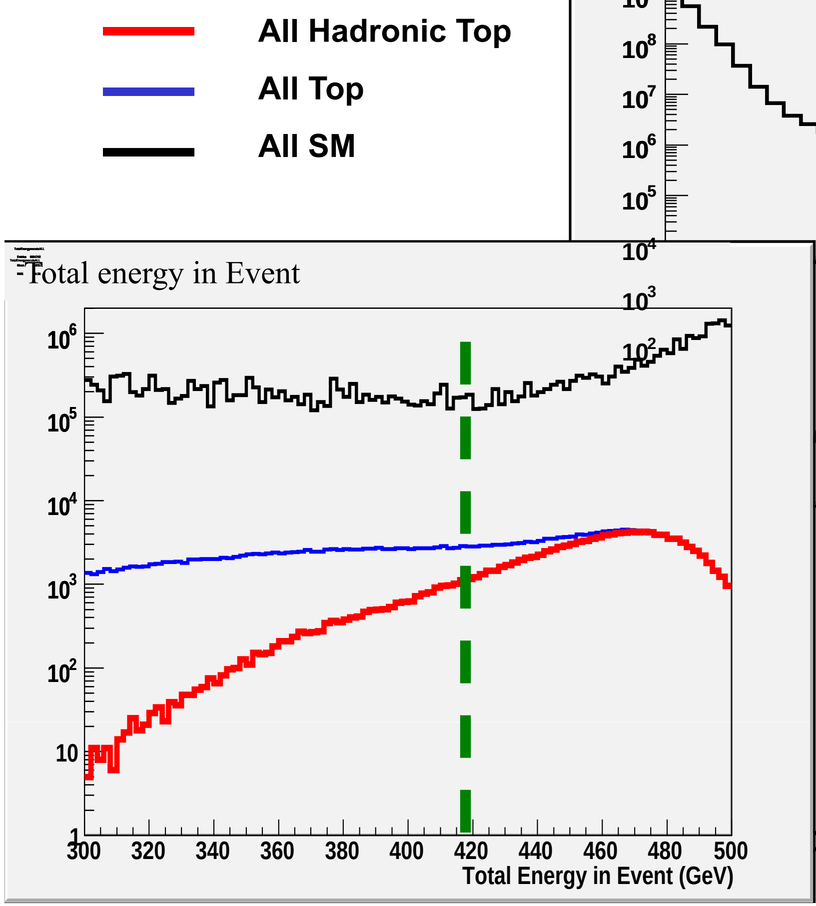
t-t̄ →bbqqqq Event Selection

- Perform jet clustering (force to 6 jets)
- Apply quality + background rejection cuts



After all other cuts





- Apply 6 simple cuts: No Isolated e/μ, Total Energy > 420 GeV , Number Particles > 80, Number Tracks > 30, -log($ycut_{min}$) > -8, b-tagging cut.
- Still some cut optimization possible

Purity –Efficiency – Cross Section

- Started with 132454 hadronic events
- After Cuts 69708 remain
- Efficiency 52.6%
- Background Events 29605
- Total Number of Events 99313
- Purity 70.2%

- Note at present efficiency and backgrounds calculated from the same sample. In future calculate from separate sample (MC sample). This sample contains one million top events. Error on this should be small!
- Assume efficiency has no error.

- Cross section = $(N_{\text{Events passing cut}} - N_{\text{BG-Events passing cuts}})/\text{Efficiency}$
- Error = $\sqrt{(N_{\text{Events passing cut}} + N_{\text{BG-Events passing cuts}})}/\text{Efficiency}$

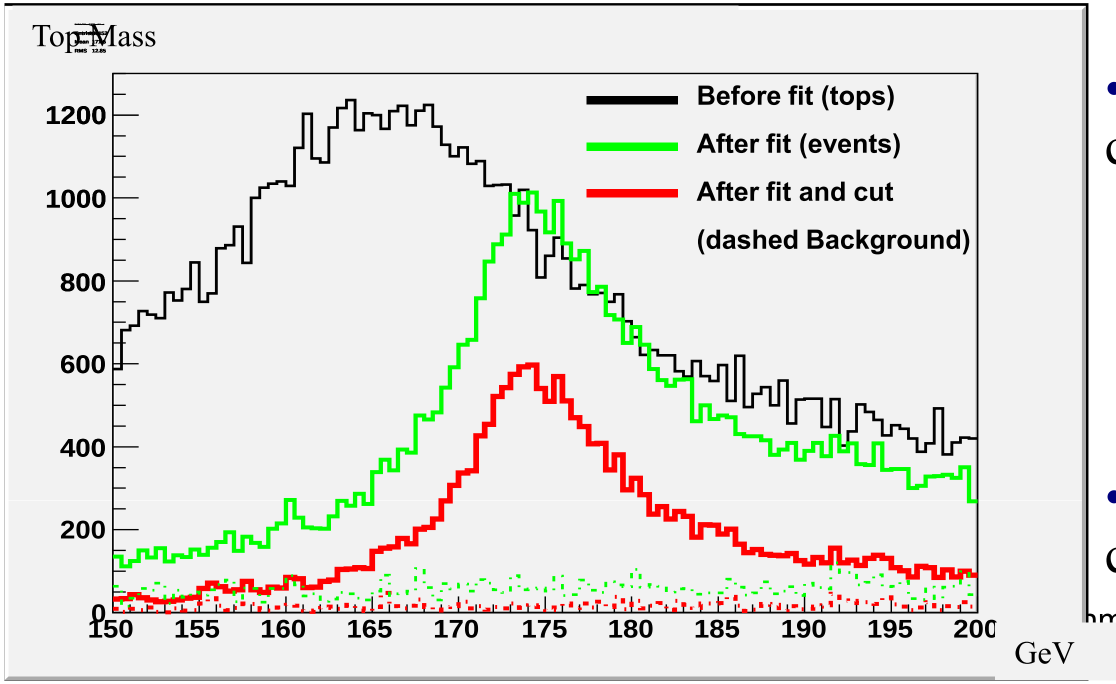
- Cross Section Error ≈ 845 events (or 360 measured events).
- Corresponds to 264.91+/-1.85 fb (purely statistical error)

- Should be able to do better! Possible, do the same after Kinematic Fitting and apply mass cuts.

TOOLS 2: Kinematic Fitting

- Kinematic fitter performed after b tagging.
- 2 jets with highest b-tag treated a b jets others as jets from W. (and b mass assigned)
- Use hard constraints:

Constraint	*#constraints*
Total energy 500GeV	1
Total momentum (x,y,z direction) =0	3
W_1mass = W_2mass = 80.4	2
top_1mass = top_2mass	1



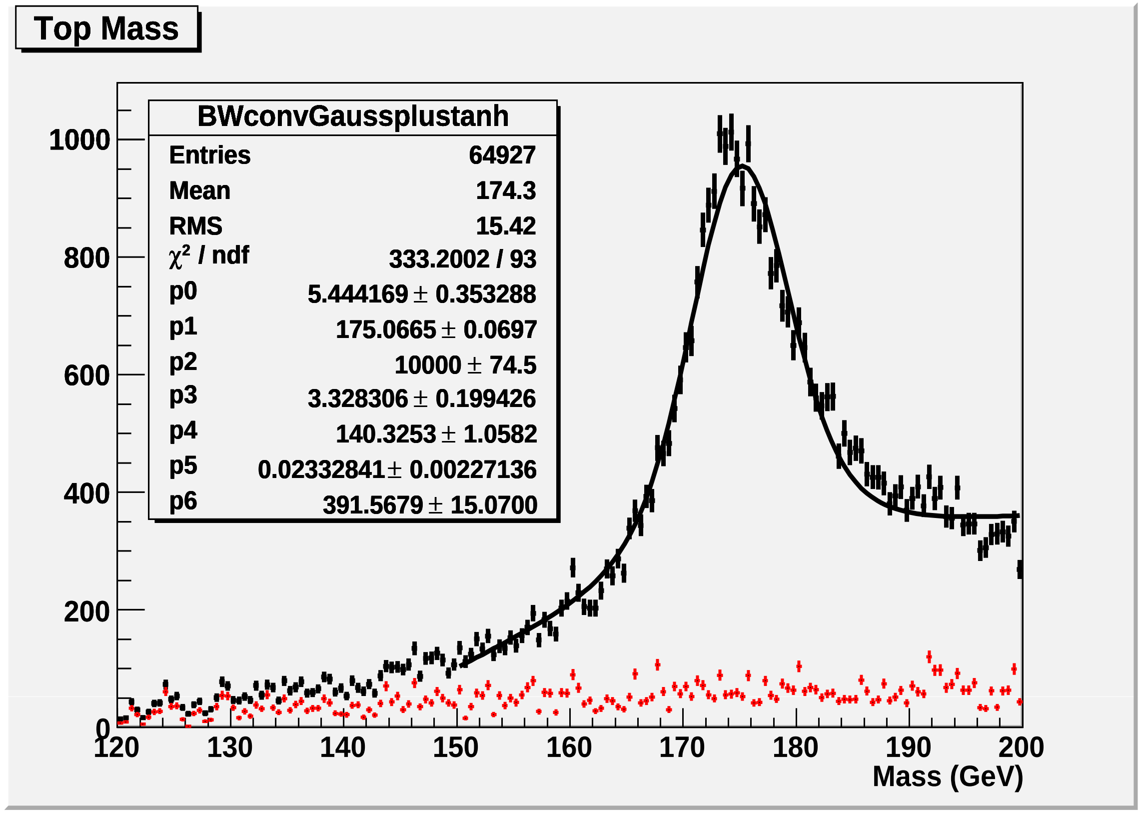
- Attempted also different constrains-combinatorics:
  - Not use b tagging
  - Not use W mass constrain
  - Use only W_1mass =W_2mass

- Cut on probability event satisfies constrains (10% cut presented)

mark

Top Mass – Simple fitting, no prob. cut

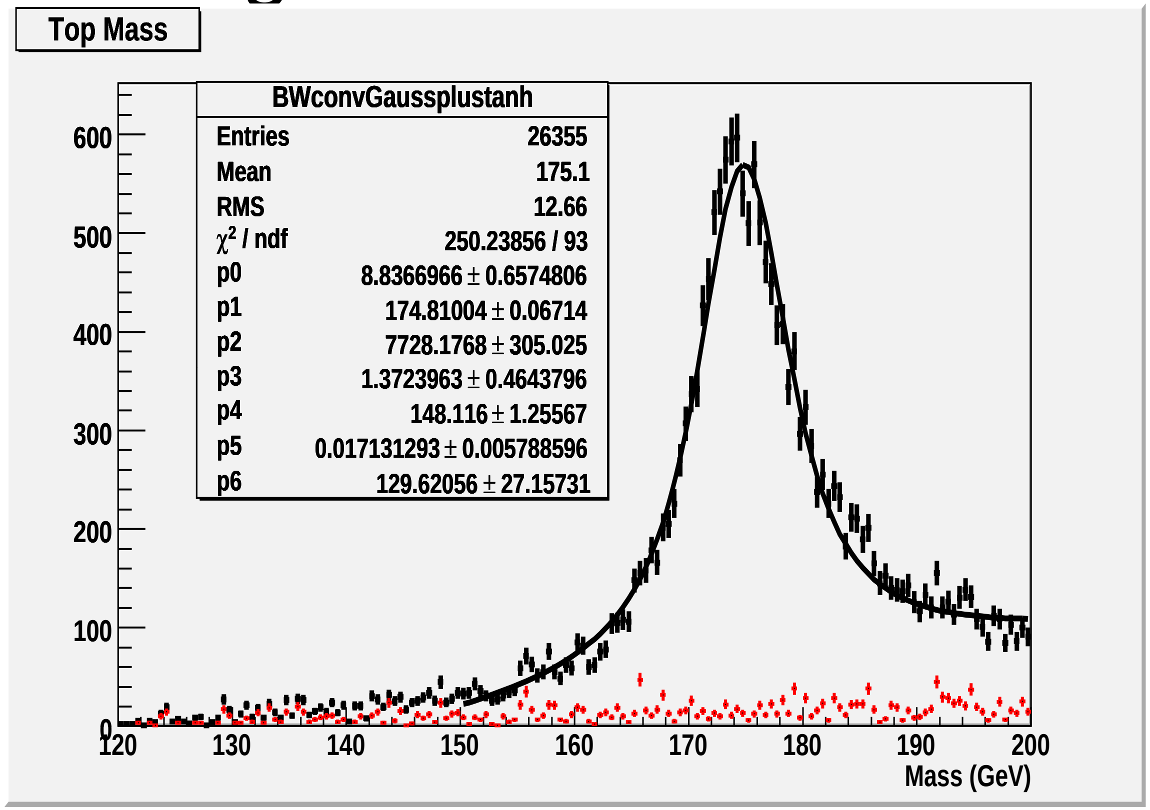
- Function fitted:
  - gauss (detector smearing)
  - convoluted BW (intrinsic width)
  - add tanh (best model found for additional background, empirical) from combinatorics!
- Purity: 91%,
- Efficiency: 43%
- Major issue is combinatorics background.
- Produces fat tails at high Mass!
- Some ideas …



- Results for 458fb^{-1}: σ_m= 70MeV (statistical error)
- Peak displaced. Used 174.0GeV top at MC, fitting value 175.09 GeV. Issue understood tanh not good model. Find combinatorics error and fit separately!
- Lorentz half width > 5GeV.
- Calculate Cross Section error: 1.30 fb (better)

Top Mass – Simple fitting

- Apply 10% probability cut
- Purity: 94%,
- Efficiency: 19%
- Major issue is combinatorics background.
- Produces fat tails at high Mass!
- Much better fit (χ^2/Dof ≈ 2.5), previously higher. (If cut only central region $\chi 2$/Dof < 2).
- Still same issues as before, but more under control.
- tanh not best function. Change!

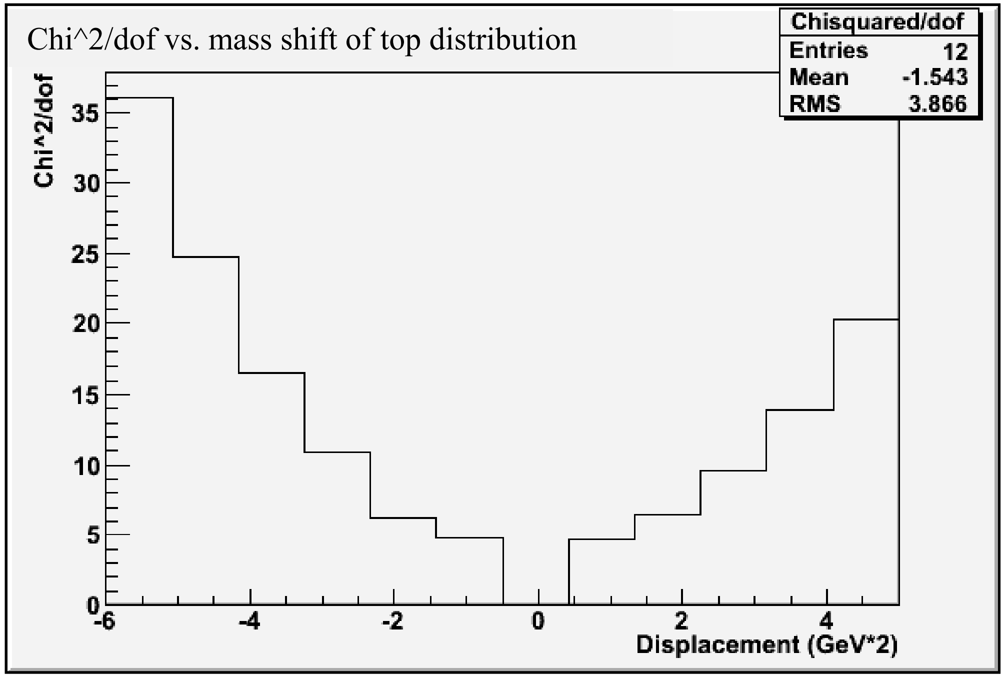


- Results for 458fb^{-1}: σ_m= 67MeV (statistical error)
- Peak displaced. Used 174.0GeV top at MC, fitting value 174.81 GeV. Issue understood tanh not good model. Describe Combinatorics background
- Lorentz half width > 8GeV. Not critical, understood, use double gaussian.
- Calculate Cross Section error: 1.96 fb (worse)

Top Mass Diversion – “template fitting”

WITH ONLY ONE SAMPLE:

- Assume reconstruction and analysis differences minimal for $\Delta m \approx 1$GeV
- Effectively assume infinite sample for MC template
- Take sample and shift it with steps of 0.5GeV
- Calculate χ^2/dof
- Infer σ_{mass} of analysis



Old Plot produced with fast MC

- Currently only experimented with FASTMC and no SM background

PRELIMINARY RESULTS:

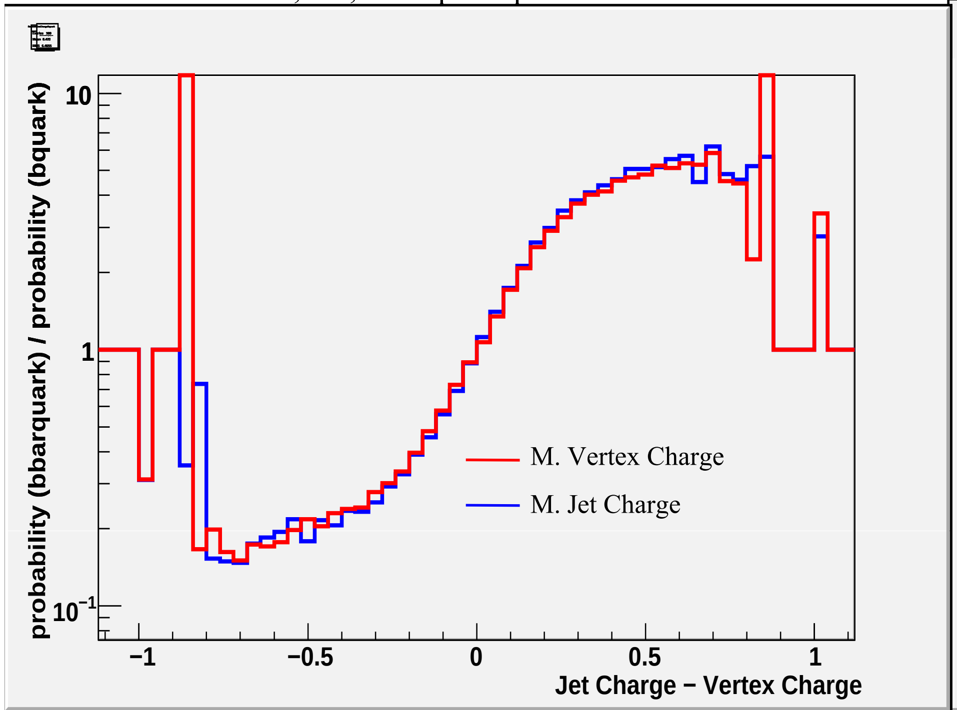
- Results with FastMC 50fb^{-1} show that result consistent with simple fitting
- Method does not suffer from combinatorics background problems!

RESULT WILL BE USED FOR CONSISTENCY/SANITY CHECK

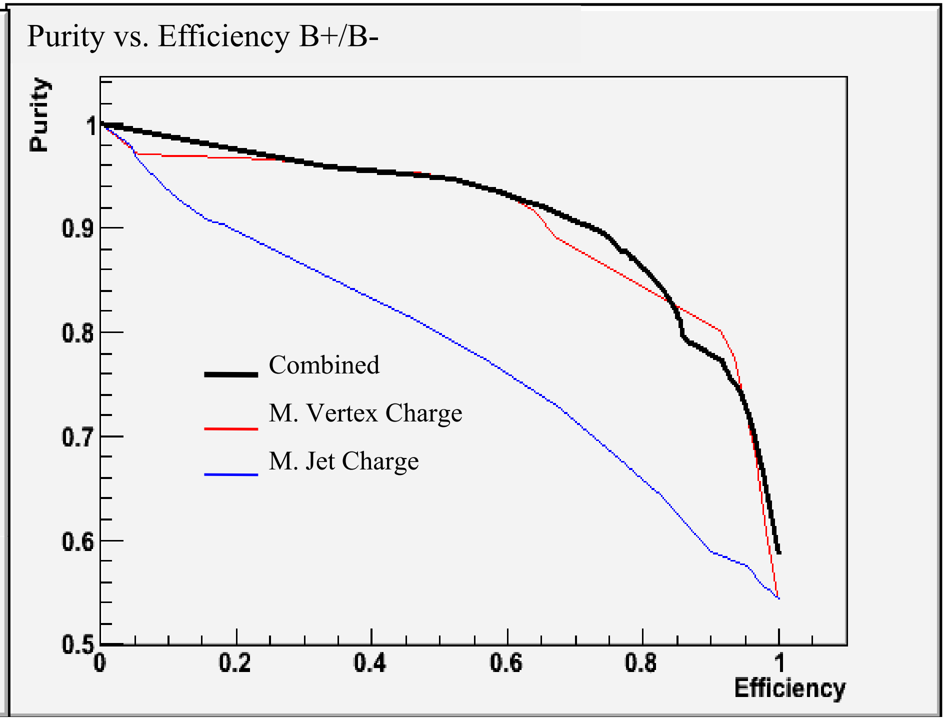
TOOLS 3: Charge Reconstruction

- Idea: develop series of discriminating variables, then recombining them
  - Similar to what it is done in the flavour tagging.
- At present two charge reconstruction algorithms implemented (more can be added!):
  - Momentum weighted secondary vertex charge - good for B+/B- if secondary found
  - Momentum weighted Jet charge – Good for B0s and of no secondary.
- Variables chosen for ttbar hadronic! (different choices for different analysis?)

Plot Produced with 1,000,000 top sample full reconstruction

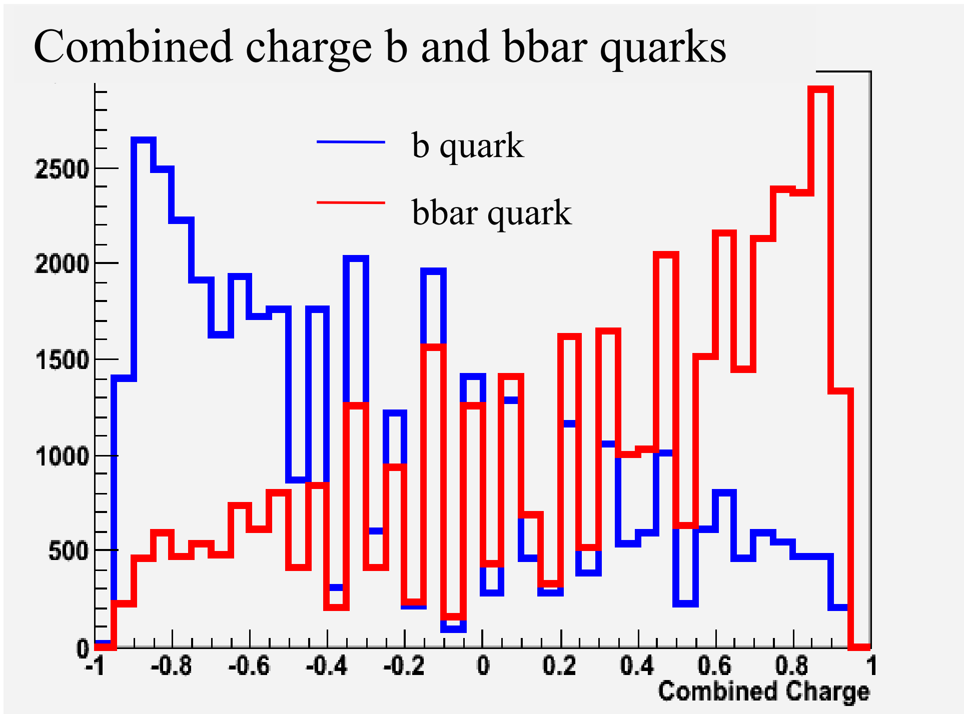


Old Plot produced with fast MC



TOOLS 3: Combining charge variables

- To get Combined Charge variable:
  - Use “MC data” to determine ratio of signal to backgrounds in each bin for each variable.
  - Use this ratio as a discriminating power of each variable for that specific event.
  - Multiplies the ratios of each variable considered.
  - Apply transformation to get a result between -1 and 1.



NOTE: “granularity” from binning + “transformation”

458fb^{-1} top-topbar events passing cuts.

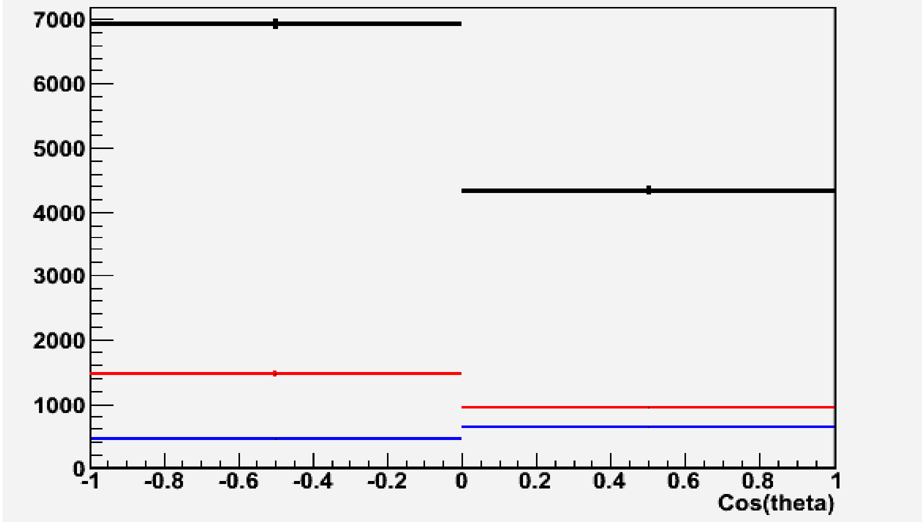
- Can use different assumptions of what is signal and what is background
  - B+/B- (previous page)
  - $B0/\overline{B0}$
  - $b/\bar{b}$ (previous page)

- For asymmetry study:
  - Use assumption $b/\bar{b}$
  - Multiply Combined Charge for 2 highest b-tag jets
- Cut: Combined Charge < -0.6

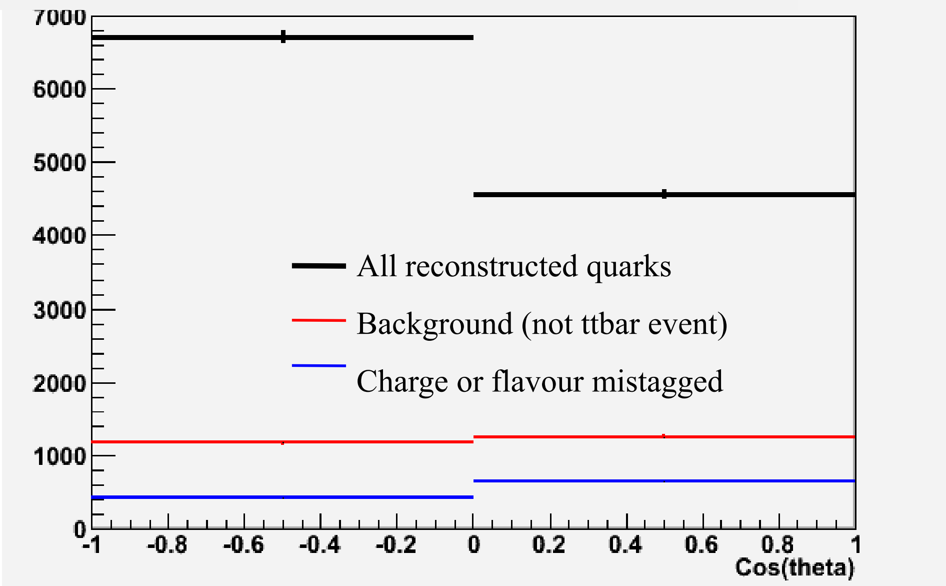
t and b quark asymmetries

- b quark asymmetry
- Background 21%
- Total charge/flavour mis-tagging = 9%
- Asymmetry b quark: 0.29 +/- 0.02
- Hence Purity 70%, Efficiency 5.9%
- Consistent with standard model input.
- At MC level 0.28

Events used for b quark asymmetry



Events used for t quark asymmetry



- t quark asymmetry
- Same data as for b.
- Asymmetry t quark: 0.32+/- 0.02
- At MC level 0.35 – consistent
- Need to recalculate error. Now using simple poisson error. (need binomial, no major change, can quote precision to next significant figure!)

Summary – Results (e+e-→tt, t→bW, W→qq')

All needed results available. If we were to finish this today we could quote:

- Cross section = 264.91+/- 1.30 fb
- Top Mass Error = 174.810+/- 0.067 GeV
- A_{fb} b quark = 0.29 +/-0.02 (0.015)
- A_{fb} t quark = 0.32 +/-0.02 (0.015)

- Given we have one month left:
  - Use MC values from 1million top sample for efficiency calculation
  - Deal with fat tail at high Mass of top mass and hence displaced peak
  - Recalculate Template fitter for full reconstruction (no prob with displaced peak)
  - Recalculate error on asymmetry (so we can quote 1 more sig. figure)
  - Try to increase efficiency of A_{fb}