

# 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
- From FastMC to Full reconstruction

# Benchmarking Lol #5

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

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

TOOLS:

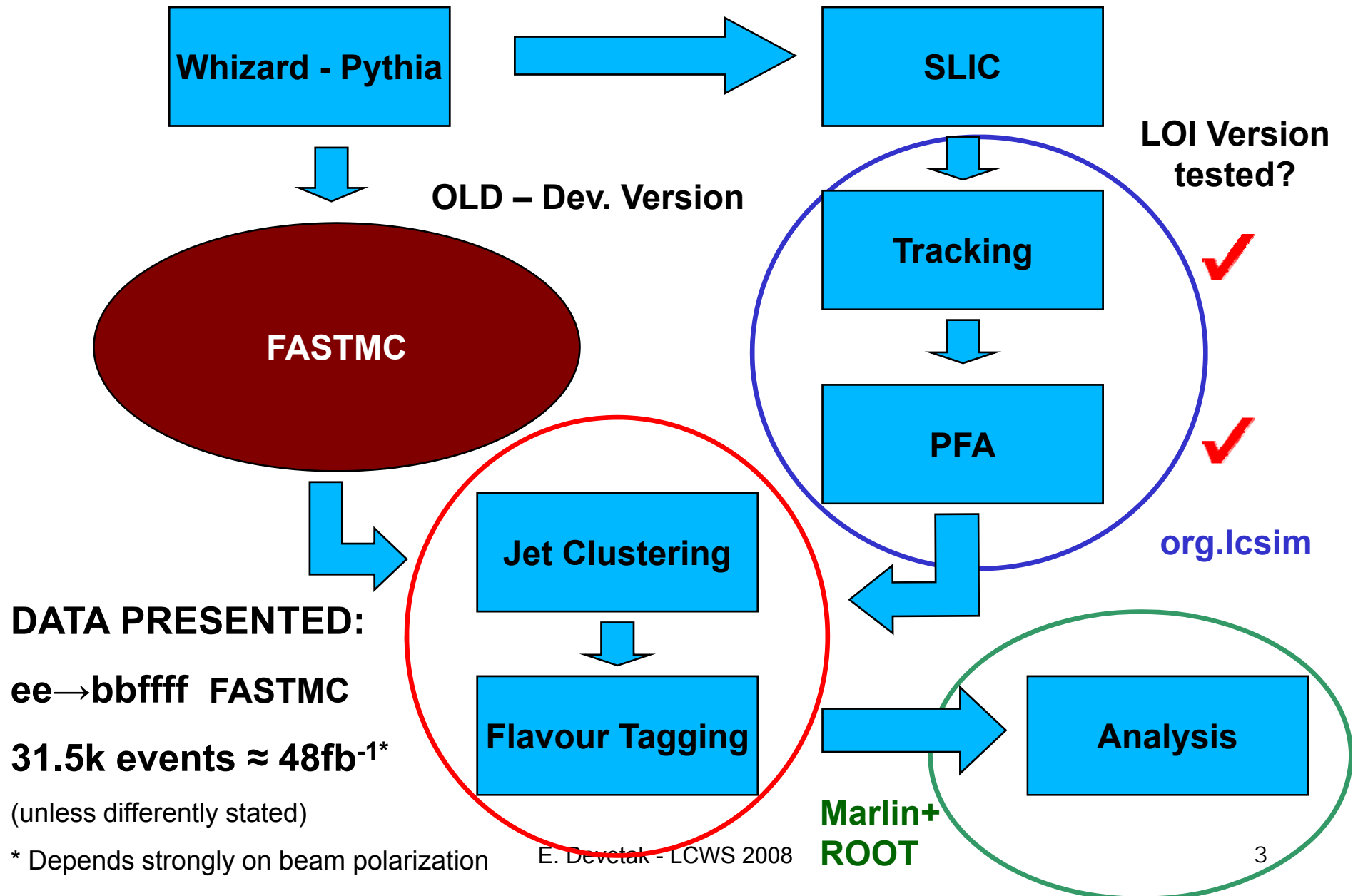
- b tagging (LCFI) ✓
- charge reconstruction (LCFI + ad hoc) ✓
- Kinematic Fitting (MarlinKinfit) ✓

**GOOD PROGRESS!**

**First draft analysis!**

**Clearly some algorithms need tuning/improvements!**

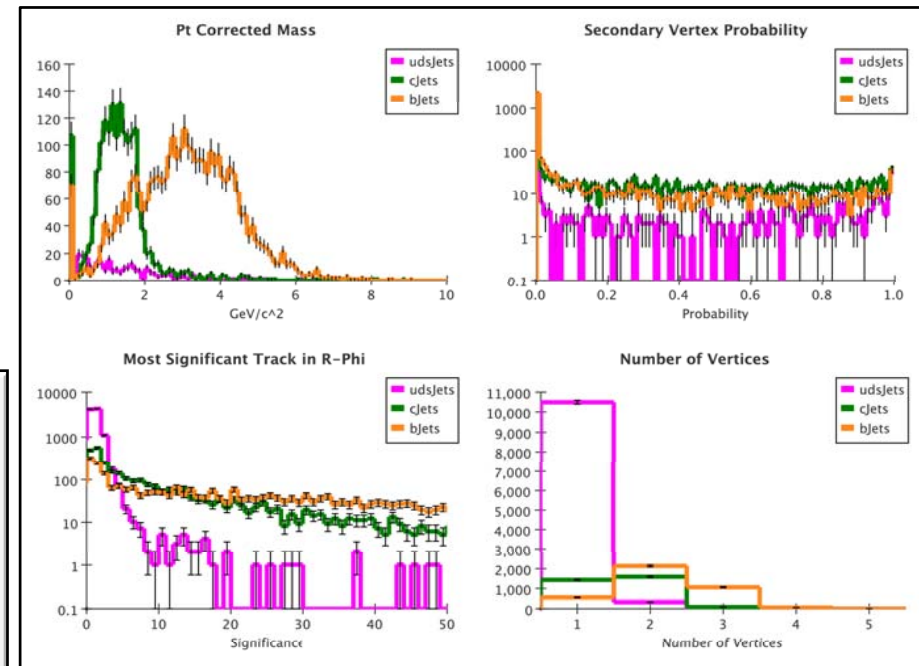
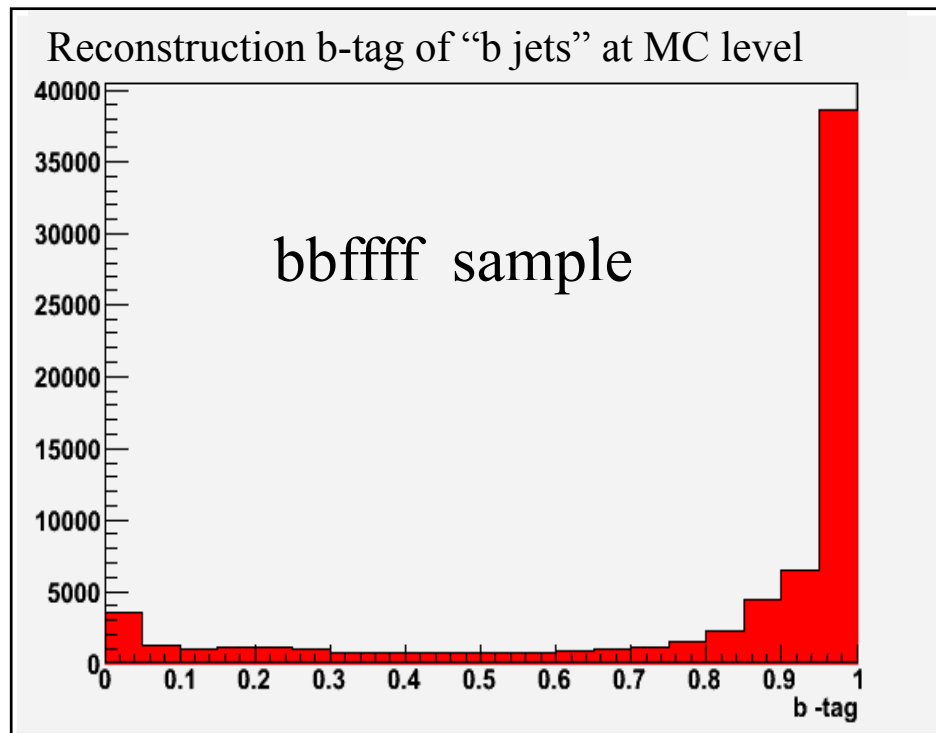
# The simulation process...



# 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

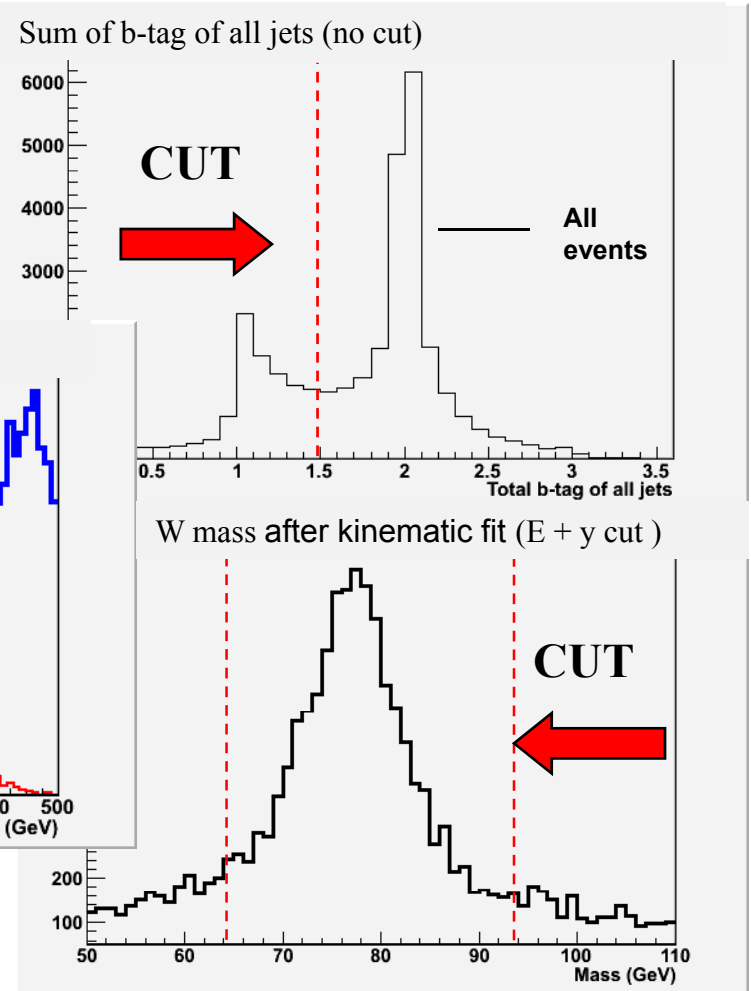
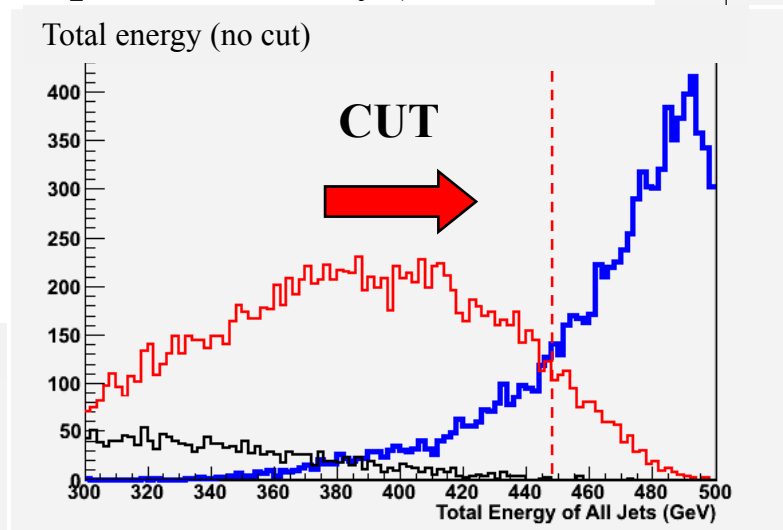
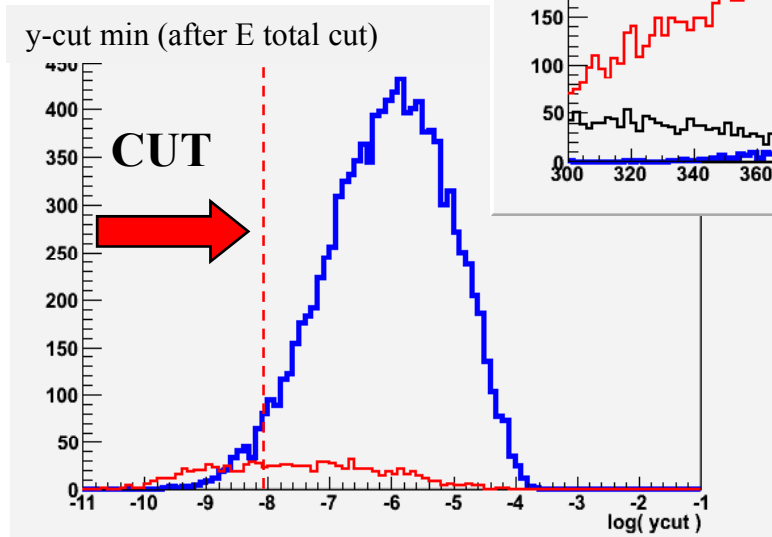


- Good Performance
- So far no parameter optimization for:
  - SiD
  - 6 jet sample
- Not envisaged in LOI timeframe

# $t\bar{t} \rightarrow bbqqqq$ Event Selection

- Perform jet clustering (force to 6 jets)
- Apply quality + background rejection cuts (present background: leptonic and semi-leptonic  $t\bar{t}$  + other  $bbff$  processes only!)

— All Hadronic  
— Semi Leptonic  
— All Leptonic



- Plus other cuts
- At present no e and  $\mu$  identification
- Still some cut optimization needed

# TOOLS 2: Kinematic Fitting

- Kinematic fitter performed after b tagging.
- 2 jets with highest b-tag treated as b jets others as jets from W.

- Use hard constraints:

- Total energy 500GeV
- Total momentum (x,y,z direction) =0
- $W_1\text{mass} = W_2\text{mass} = 80.4$
- $\text{top}_1\text{mass} = \text{top}_2\text{mass}$

*#constraints*

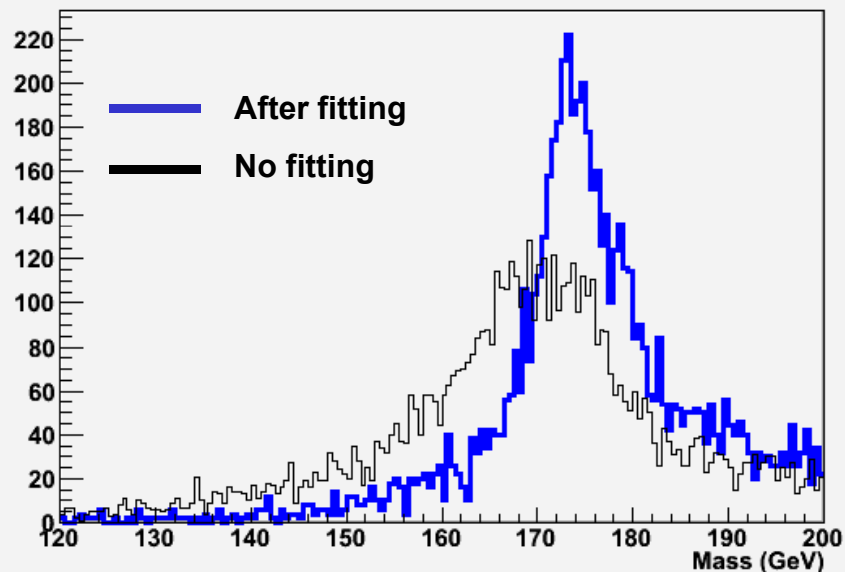
1

3

2

1

Top Mass



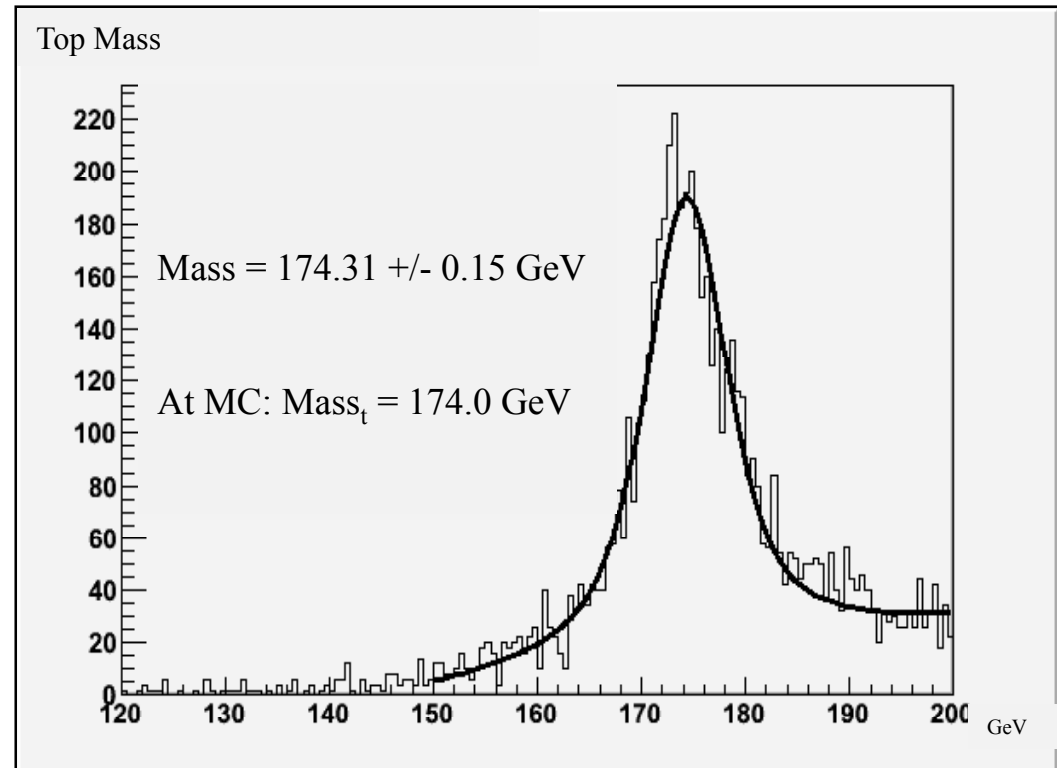
- Attempted also different constrains-combinatorics:

- Not use b tagging
- Not use W mass constrain
- Use only  $W_1\text{mass} = W_2\text{mass}$

- Very useful tool

# Top Mass – Simple fitting

- Function fitted:
  - gauss (detector smearing)
  - convoluted BW (intrinsic width)
  - add tanh (good model for additional background, empirical) from combinatorics?
- Purity: 97%,
- Efficiency: 33%
- Both values can improve:
  - by using  $e, \mu$  ID
  - optimize cuts!



- Can now extrapolate results to  $500\text{fb}^{-1}$ :  $\sigma_m = 46\text{MeV}$  (statistical error)

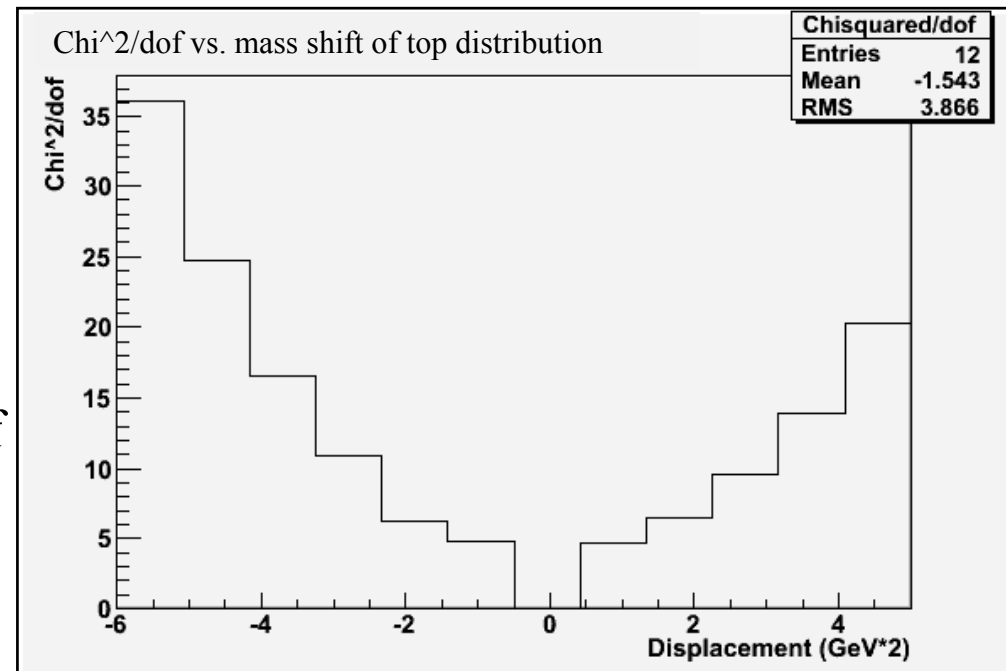
## NOTES

- FastMC study; smaller statistics studies with full reconstruction suggest no significant degradation
- Sample is  $b\bar{b}f\bar{f}$  and not  $t\bar{t}$  – no way of separating the two with the produced sample (so includes  $WWZ, Z \rightarrow b\bar{b} + \dots$ )

# Top Mass – “template fitting”

WITH ONLY ONE SAMPLE:

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



PRELIMINARY RESULTS:

- For  $48 \text{ fb}^{-1}$  get  $\sigma_m = 155 \text{ MeV} \rightarrow$  For  $500 \text{ fb}^{-1}$  get  $\sigma_m = 48 \text{ MeV}$
- Consistent with simple fitting!

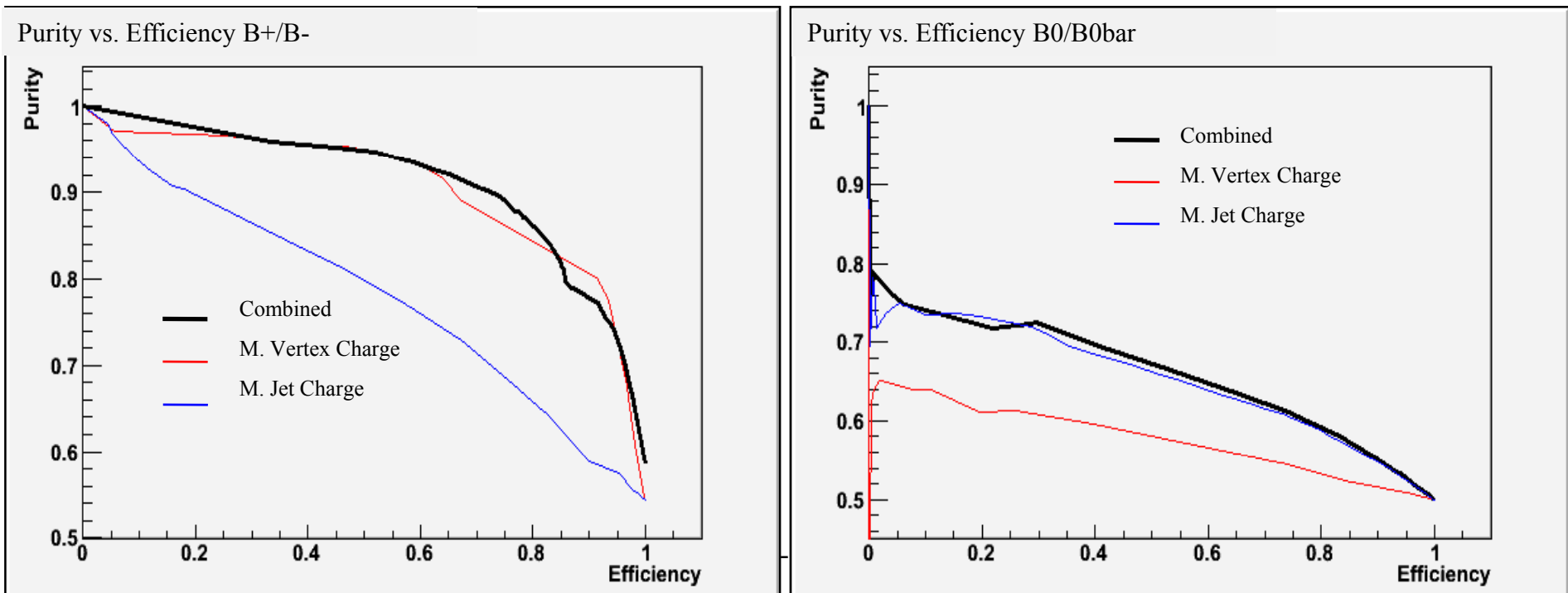
PRELIMINARY RESULT TO BE INTERPRETED AS SANITY CHECK

(but promising way forward...)



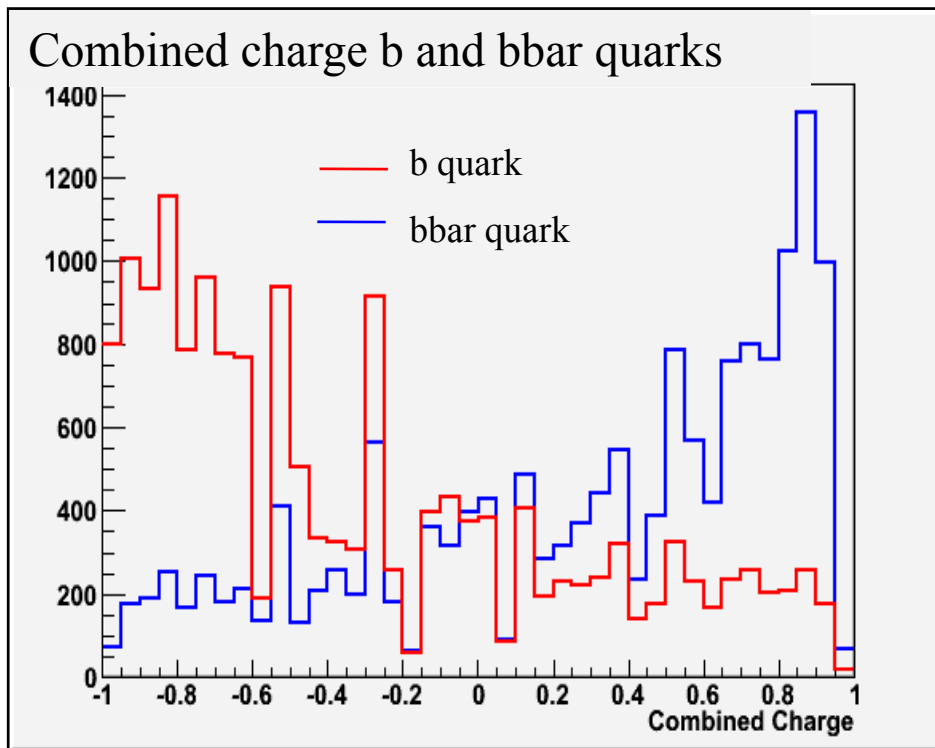
# TOOLS 3: Charge Reconstruction

- 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
  - Momentum weighted Jet charge
- Variables chosen for  $t\bar{t}$  hadronic! (different choices for different analysis?)



# 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.

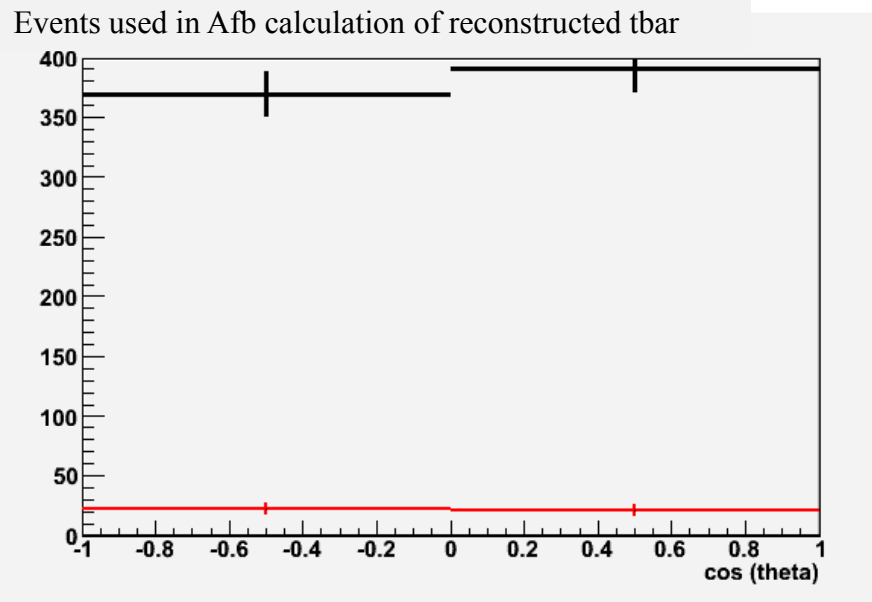
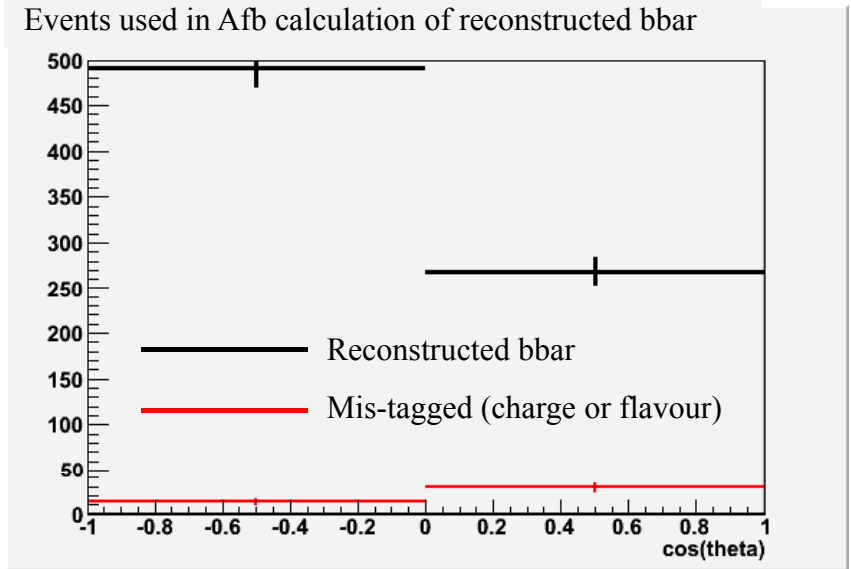


NOTE: “granularity” from binning + “transformation”

- Can use different assumptions of what is signal and what is background
  - $B^+/B^-$  (previous page)
  - $B^0/\overline{B}^0$  (previous page)
  - $b/\overline{b}$
- For asymmetry study:
  - Use assumption  $b/\overline{b}$
  - Multiply Combined Charge for 2 highest b-tag jets
  - Cut: Combined Charge  $< -0.6$

# t and b quark asymmetries

- Most of the error comes from charge reconstruction
- Few events from flavour mis-tagging
- Total mis-reconstructed  $\approx 5\%$
- Asymmetry  $b\bar{b}$  quark:  $0.33 \pm 0.04$
- Combine b and  $b\bar{b}$ :  $0.31 \pm 0.04$
- Consistent with standard model input.
- Note a 80-30 polarized beam has been used!



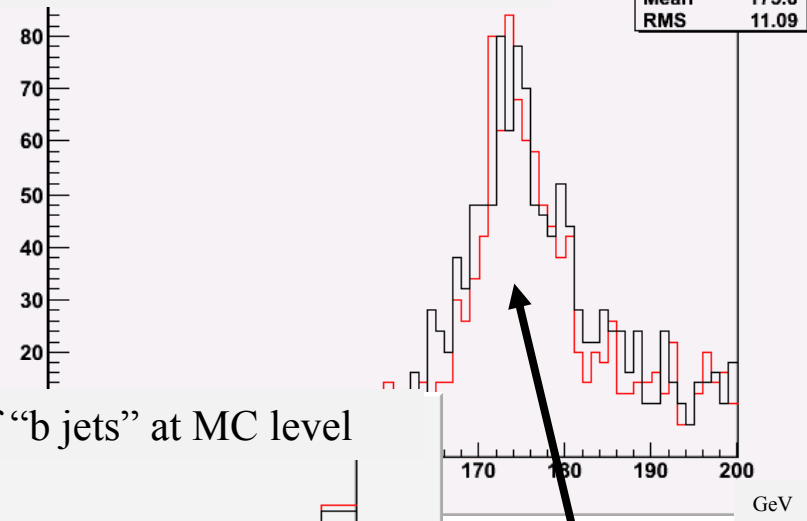
- Preliminary result on t quark
- Asymmetry  $t\bar{t}$  quark:  $0.05 \pm 0.04$
- ... low
- No direct comparison with predictions at the moment.
- Expected in the region of 0.1?
- More statistics needed!

# From fastMC to SiD PFA

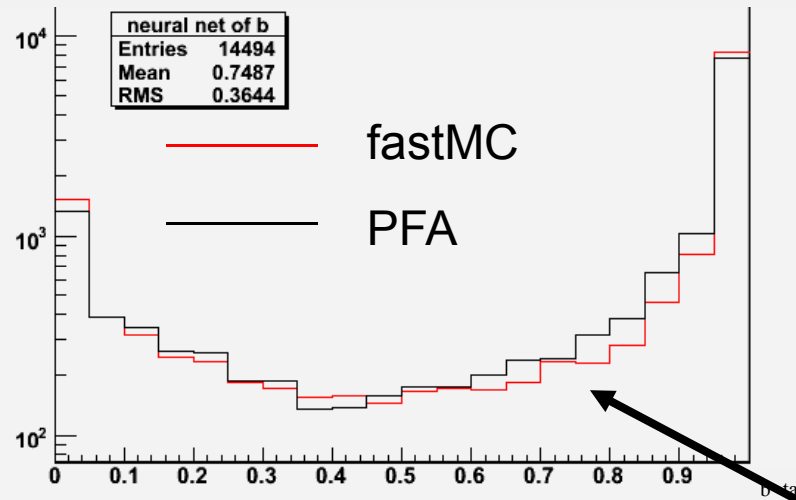
- Started move to more realistic simulation
- Step one move to SiD PFA
- Test performance (at low statistics)

**NO MAJOR DIFFERENCE**

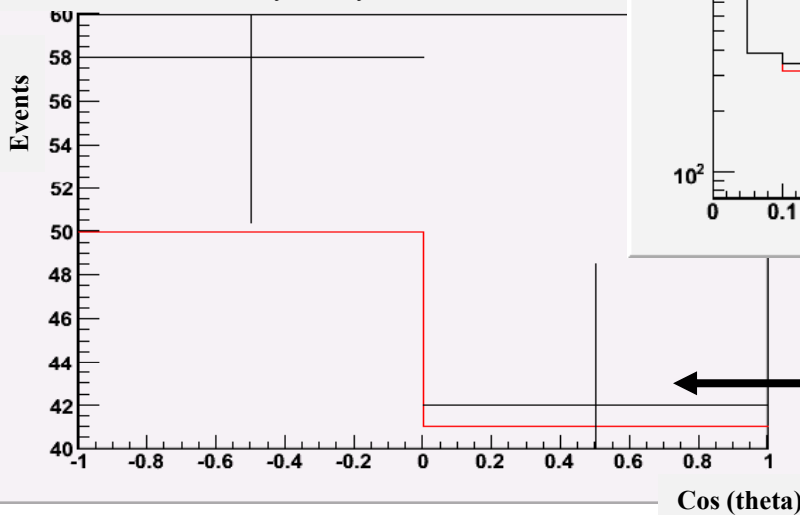
Top Mass after cuts and fitting



Reconstruction b-tag of "b jets" at MC level



Forward - Backward Asymmetry of reconstructed bbar



Increase in  $\sigma$ , very small, expect  $\approx 5\%$

Comparable, some issues from V0s, need finder

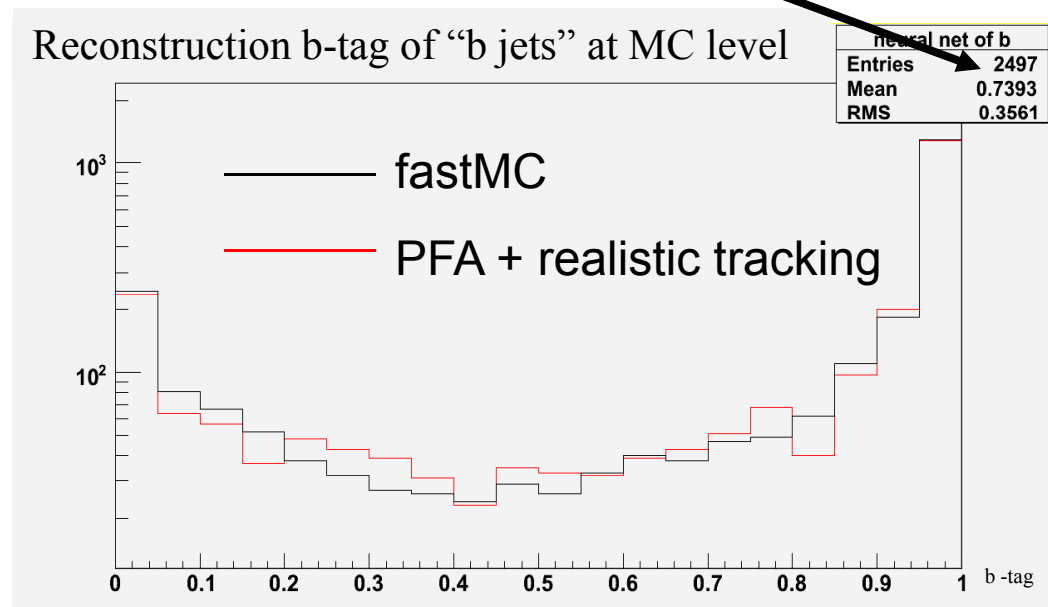
Better statistics with PFA, no difference in mis-tag

## ... + realistic tracking

- Step two move to realistic tracking
- Again test performance (here statistics very very low statistics)
- At first glance...

**NO SURPRISE**

**REPEAT WITH  
MORE STATISTICS  
AND NEW ALGORITHM**



- Additionally algorithm improved substantially since plot...
- Test show: no major difference in results expected from full reconstruction
- Moving very quickly to full reconstruction and to higher statistics!



# Conclusion - Outlook

- Outlined reconstruction framework and analysis.
- First results for top mass (including sanity check), b quark forward backward asymmetry in  $t\bar{t}$  events and t quark asymmetry
- First results with full PFA and with realistic tracking
- Analysis platform almost ready bits to tweak and optimize

## FUTURE PLANS

- Move to full reconstruction
- Higher statistics
- Look at total cross-section measurement
- Optimize

Thanks to: Matt, Ron, Richard, Norman, Tim and Andrei