Understanding the backgrounds to WW->H at the LHC: "the Zeppenfeld plots"

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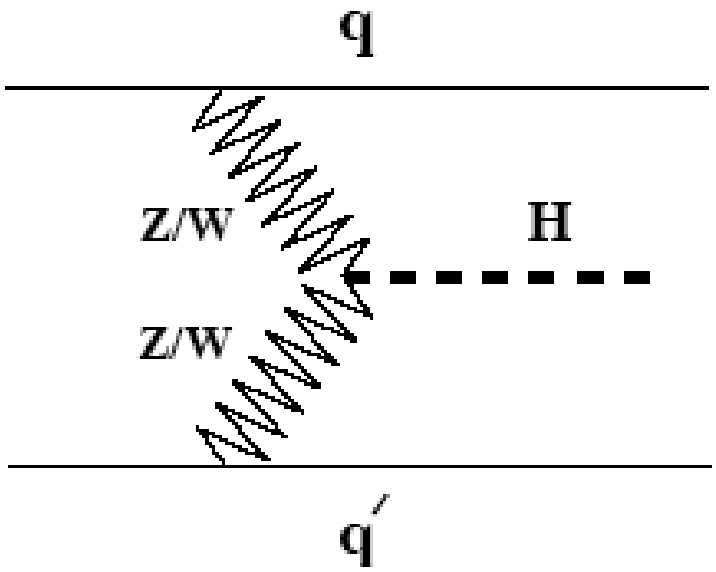
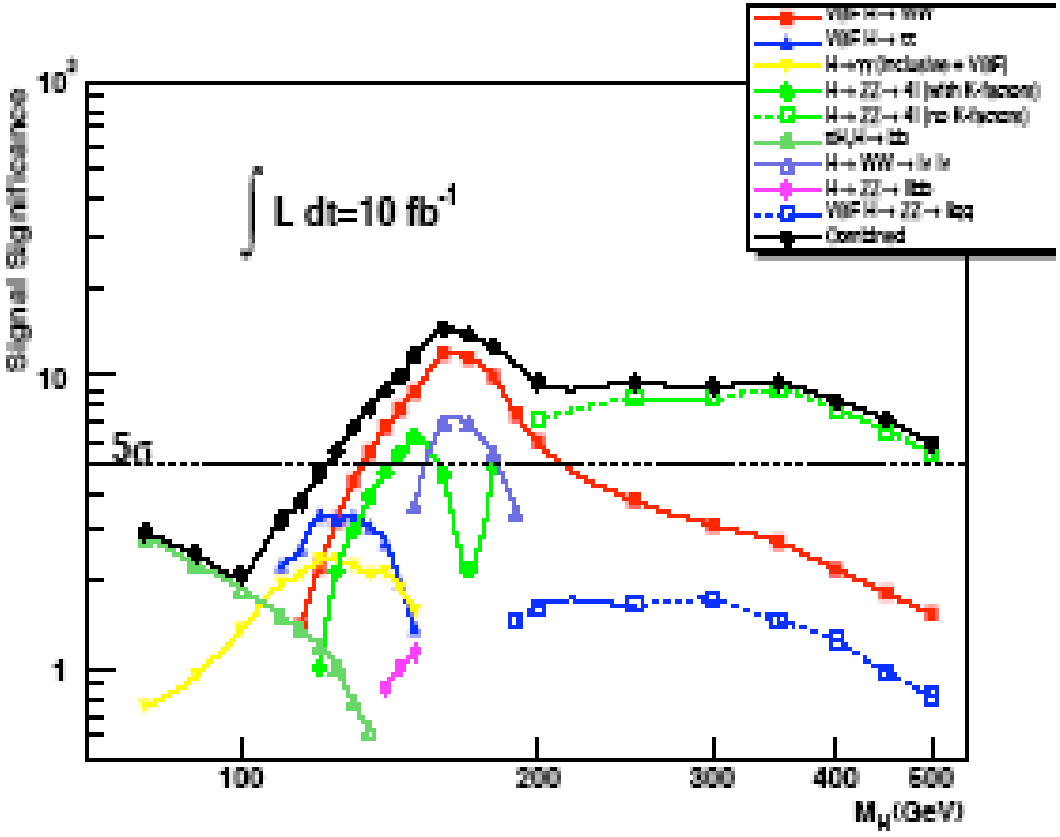
-Monte Carlo studies here
-Comparisons to data next meeting

WW fusion

- Some of the primary search modes for a Higgs discovery at the LHC proceed through the WW fusion process

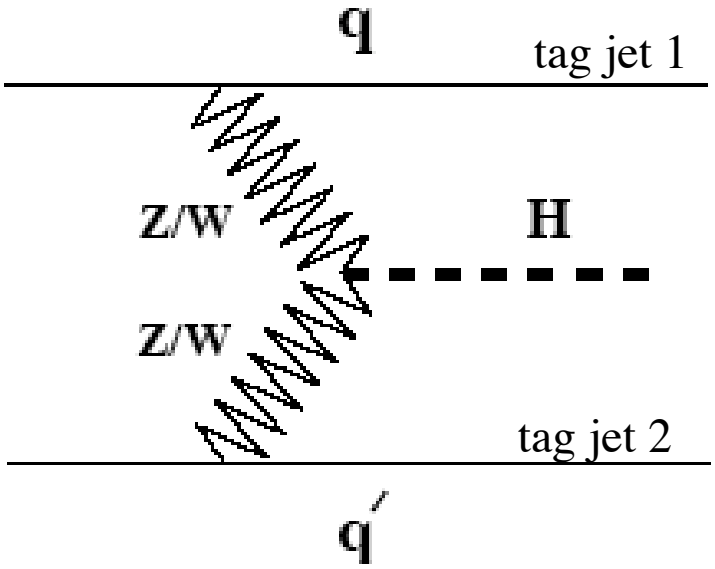




g. 4: Expected significance for ATLAS as a function of Higgs mass for 10 fb^{-1} of integrated luminosi

WW fusion

- Some of the primary search modes for a Higgs discovery at the LHC proceed through the WW fusion process



- Several different decay modes for Higgs accessible
- Two key features of VBF production:
  - presence of forward-backward tagging jets with large rapidity separation
  - suppression of gluon radiation in central rapidity region between the jets due to color singlet exchange

Backgrounds

- There are sizeable backgrounds to this production process due to W + 2 jets/top production
- See, for example, talk of Dieter Zeppenfeld in first meeting of TeV4LHC
- At the Tevatron, Higgs production not accessible through this process, but we can try to understand level of background
  - and in particular effect of a central jet veto

Background studies

- For W+>= 2 jets at the Tevatron
  - look at $|\eta_1-\eta_2|$ as a function of p_T^{min}
  - compare to MCFM, LO and NLO; ALPGEN/MADGRAPH+ Herwig/Pythia (mlm matching and CKKW)
    - CKKW generated by Steve Mrenna using Madgraph+Pythia
- For W+>=3 jets
  - η_3^* distribution as a function of p_T^{min} and $|\eta_1-\eta_2|$
    - $\eta_3^*=\eta_3-(\eta_1+\eta_2)/2$
  - 3 jet fraction as a function of p_T^{jet3}

Dieter Zeppenfeld; talk at TeV4LHC

Expected (LO) cross sections for 2,3 jets in $W^\pm$ production; $B(W\to e\nu,\mu\nu)$ included

$p_{Tj} > 15$ GeV, $|\eta_j| < 3$

	W+2j	W+3j	σ_3/σ_2
$\|\eta_1-\eta_2\|>2$	15 pb	3 pb	19 %
$p_T^{tag}>30$GeV			
$\mu_R=m_W$	3.2 pb	1.4 pb	44 %
$\mu_R=p_{Tj}$	4.2 pb	2.6 pb	62 %
$\|\eta_1-\eta_2\|>3$	0.8 pb	0.37 pb	47 %

- No NLO calculation for W+3j available → substantial scale dependence
- 3 jet fraction is large → fixed order perturbation theory insufficient

More reliable predictions from parton shower programs?

More from Dieter's talk

Get answers from $W+ \geq 2$ jet data

$p_{Tj_1}, p_{Tj_2} \gtrsim 30$ GeV $|\eta_{j_1} - \eta_{j_2}| > 2 \ldots 3$

p_{Tj_3} as soft as possible

- Fraction of events r_{2+n} with $n = 1, 2, 3 \ldots$ additional jets of $p_T > p_{Tmin}$
- p_{Tmin} dependence of r_{2+n}
- rapidity distribution of extra jets $\frac{d\sigma}{d\eta_3^*}$

By how much can a central jet veto reduce the Wjj background ?
i.e. please tell us your jet detection efficiencies .... or provide uncorrected r_{2+n}

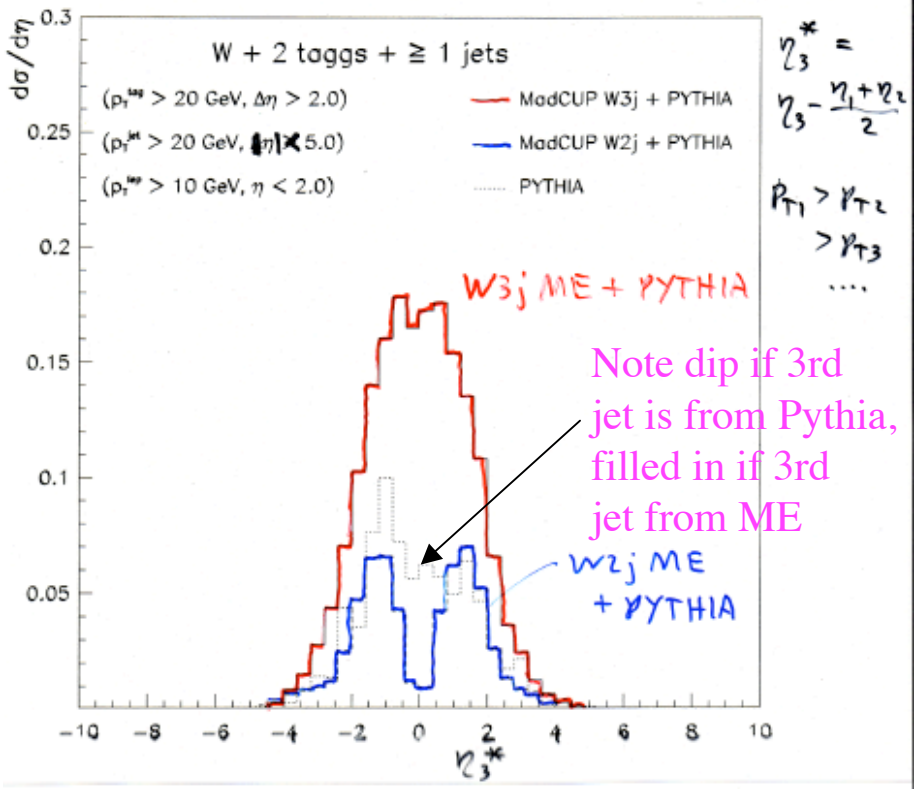
Study by E. Richter-Was

QCD Wjj events @ Tevatron, $W \to \mu\nu$

$B\sigma(\Delta\eta_{tag} > 2, \geq 2 \text{ jets}) \approx 8$ pb

$B\sigma(\quad " \quad, \geq 3 \text{ jets}) \approx 1.3$ pb

for $p_{Tj} > 20$ GeV



More from Dieter

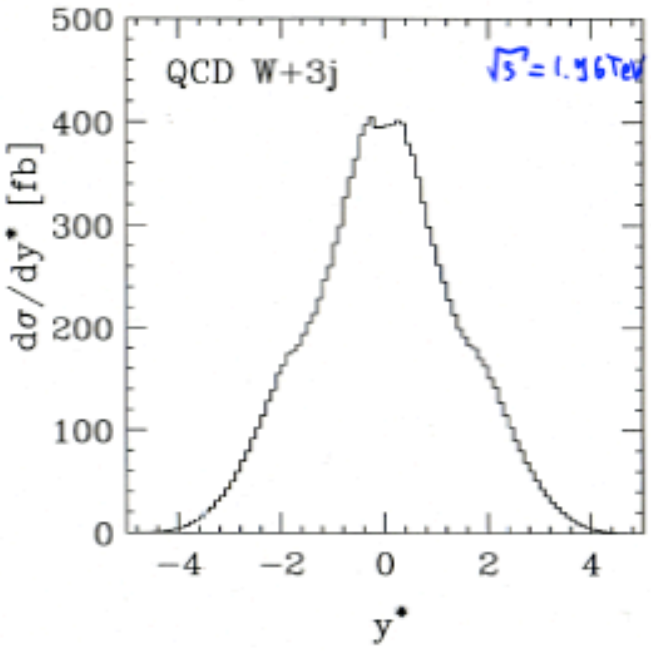
Rapidity distribution of 3rd (softest) jet (LO ME

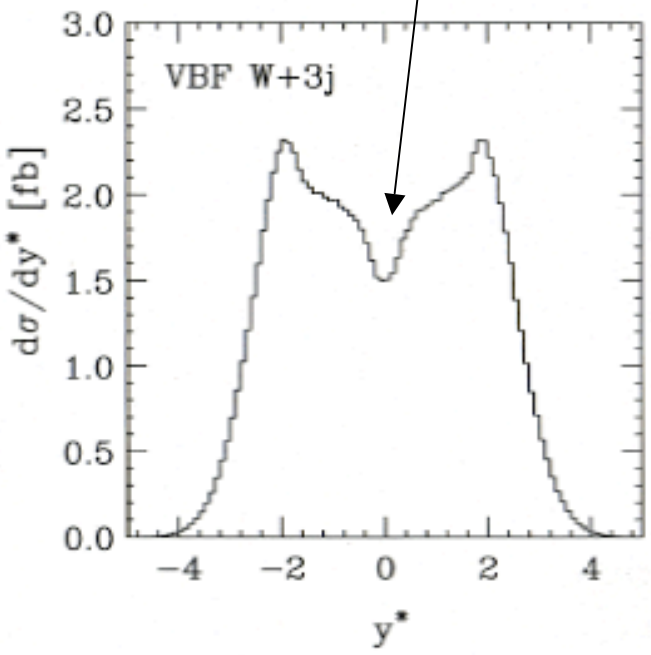
$p_T^{tag} > 30$ GeV

$\Delta\eta_{tag} = |\eta_1 - \eta_2| > 2$

$p_{T3} > 15$ GeV

VBF naturally has a dip at y*=0



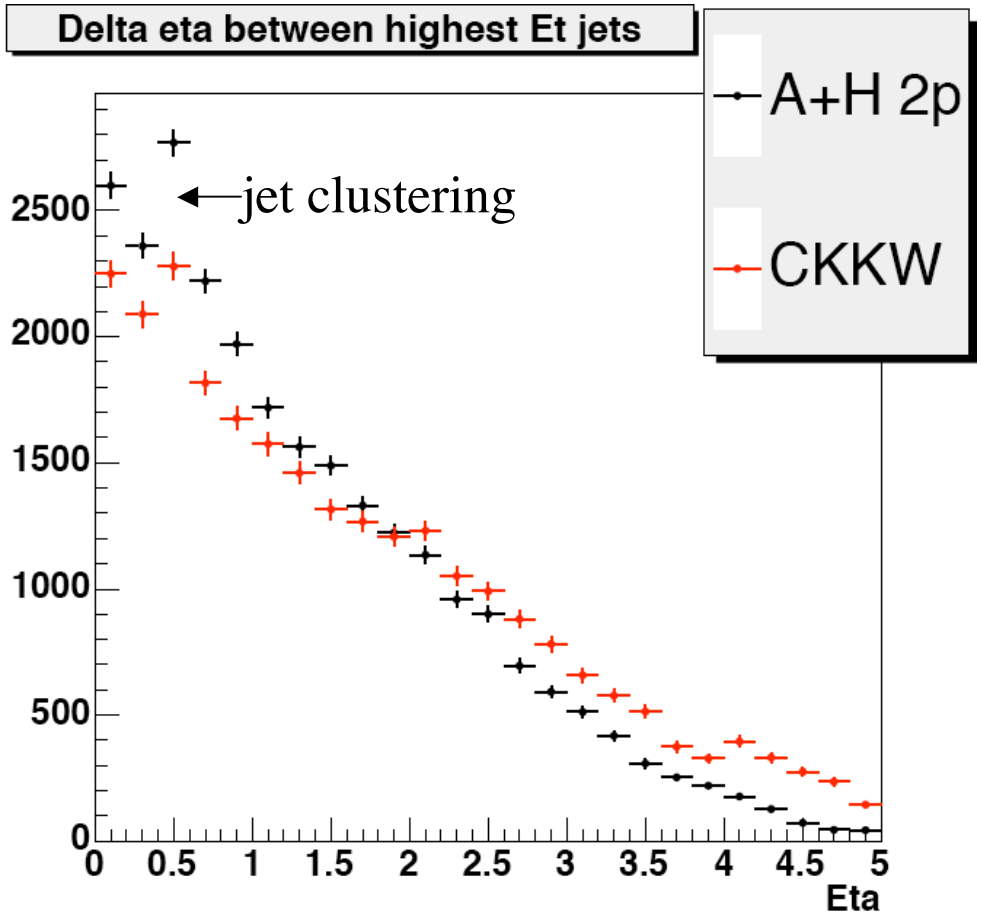


$y^* = y_3 - \frac{y_1 + y_2}{2}$

$\Delta\eta$ of tag jet plots

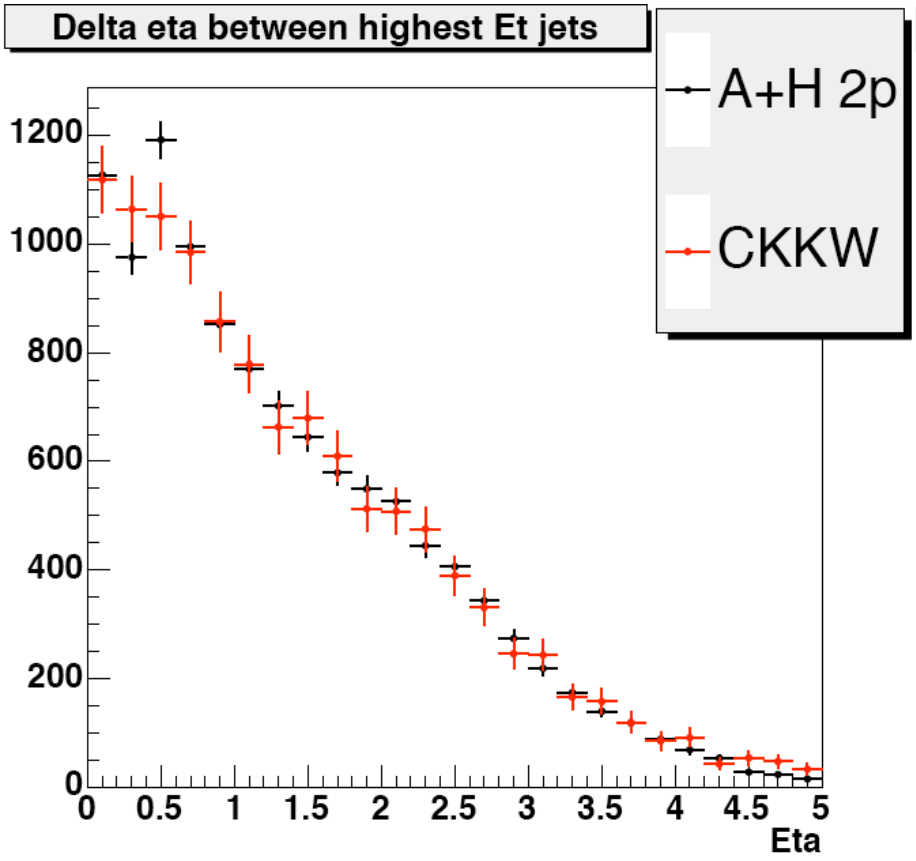
- Look at η difference between tagging jets
- Compare to Alpgen W + 2 partons) interfaced to Herwig for additional parton showering and to CKKW sample (generated with Madgraph interfaced to Pythia)
- 3 different E_T cuts on tagging jets
  - all jets defined using a cone of 0.4

E_T of tag jets > 8 GeV/c

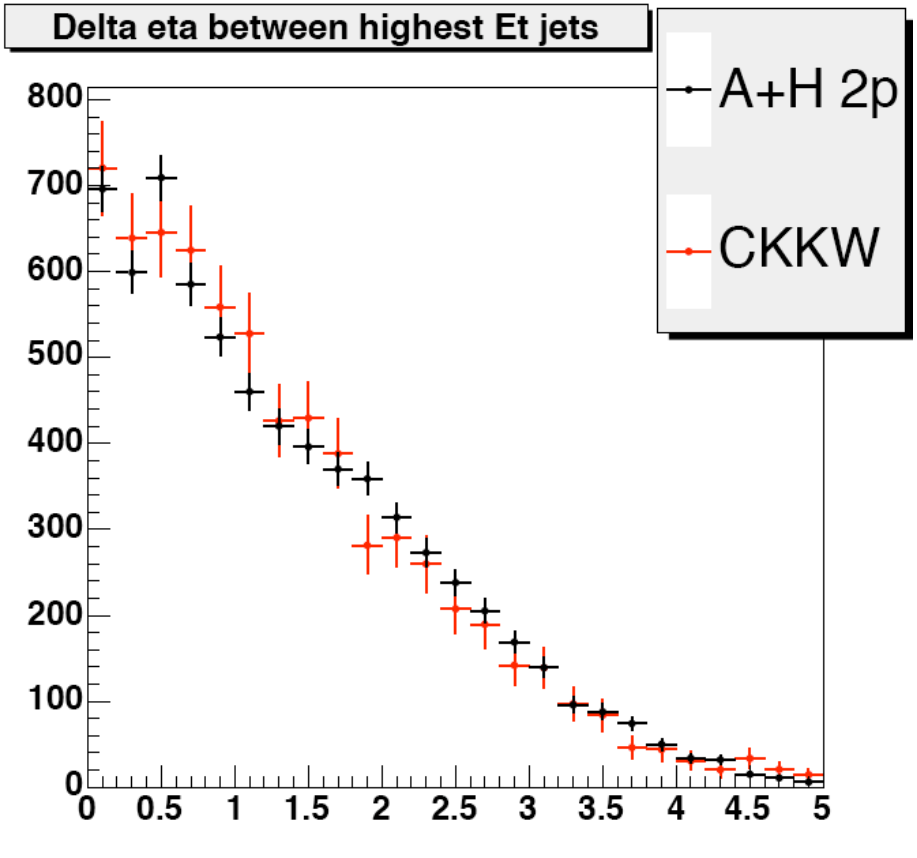


$\Delta\eta$ of tag jet plots

E_T of tag jets > 15 GeV/c



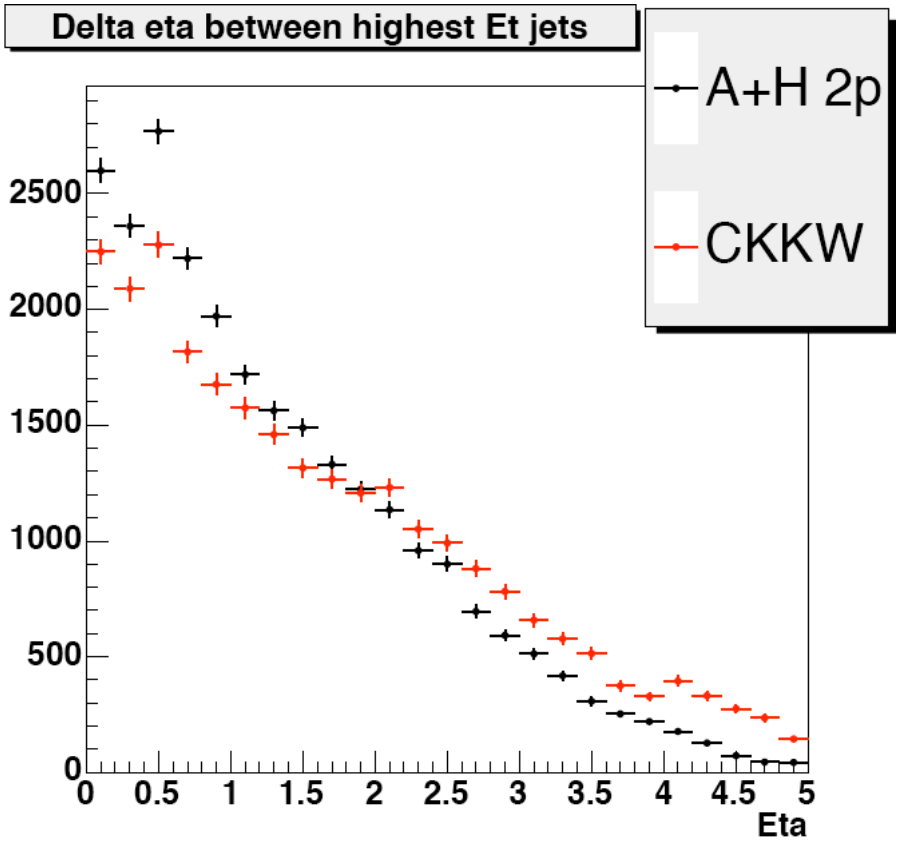
E_T of tag jets > 20 GeV/c

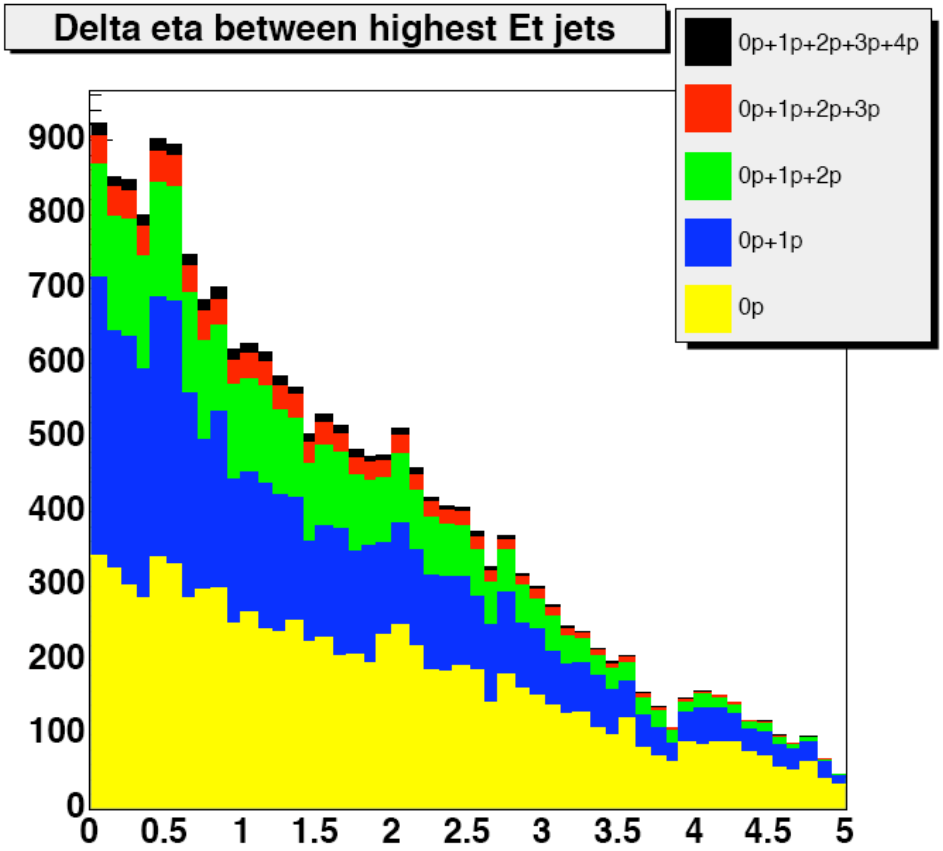


Both A+H and CKKW seem to describe the data reasonably well.

E_T of tag jets > 8 GeV/c

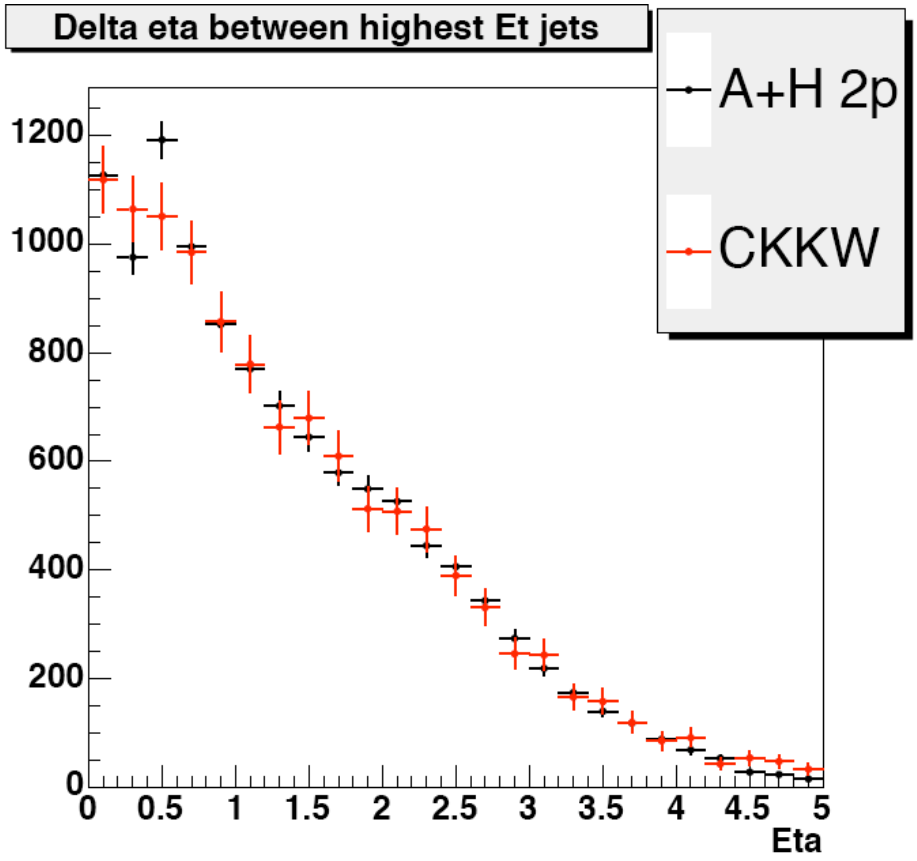
- CKKW decomposition

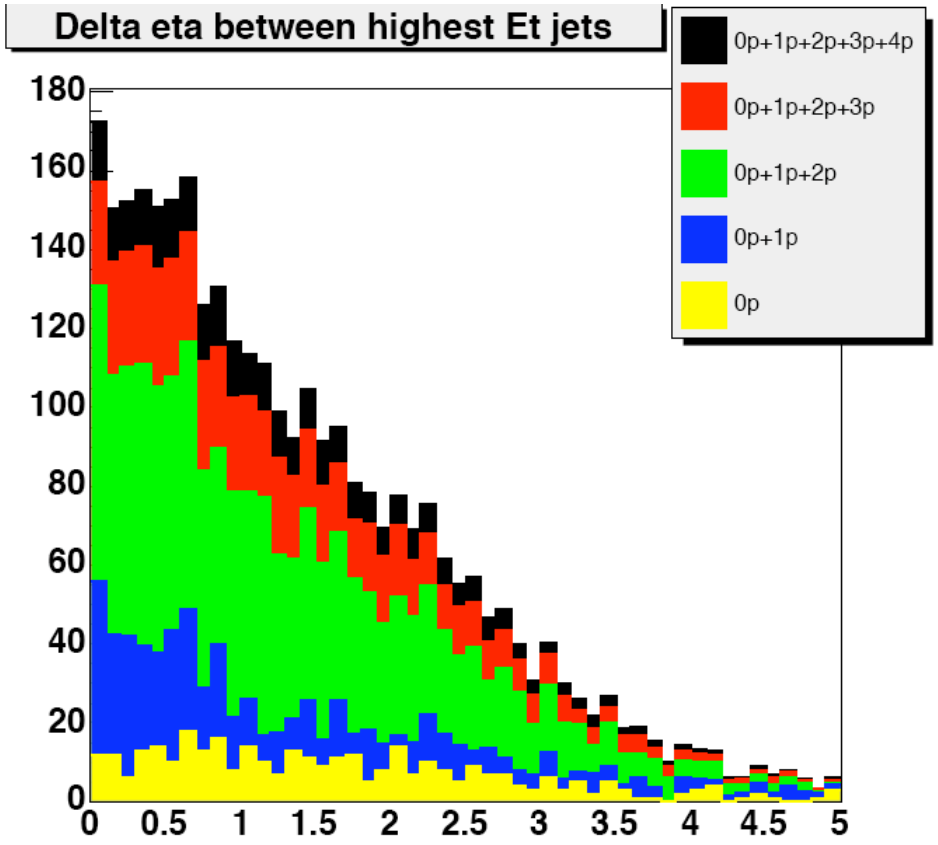




E_T of tag jets > 15 GeV/c

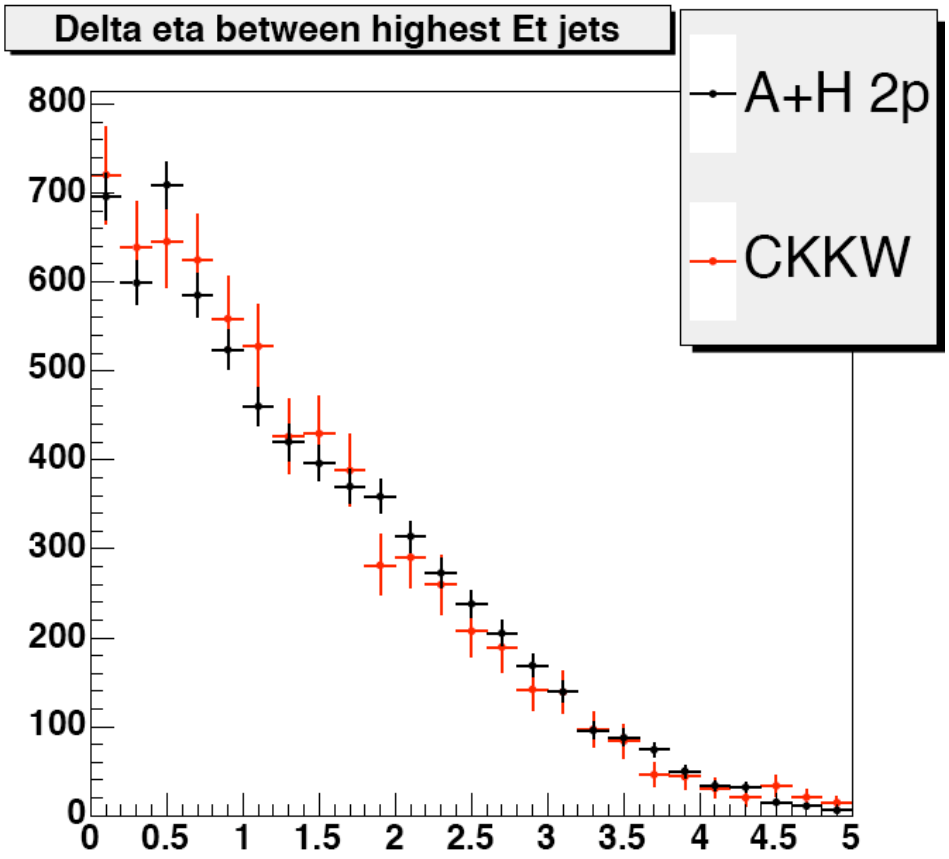
- CKKW decomposition

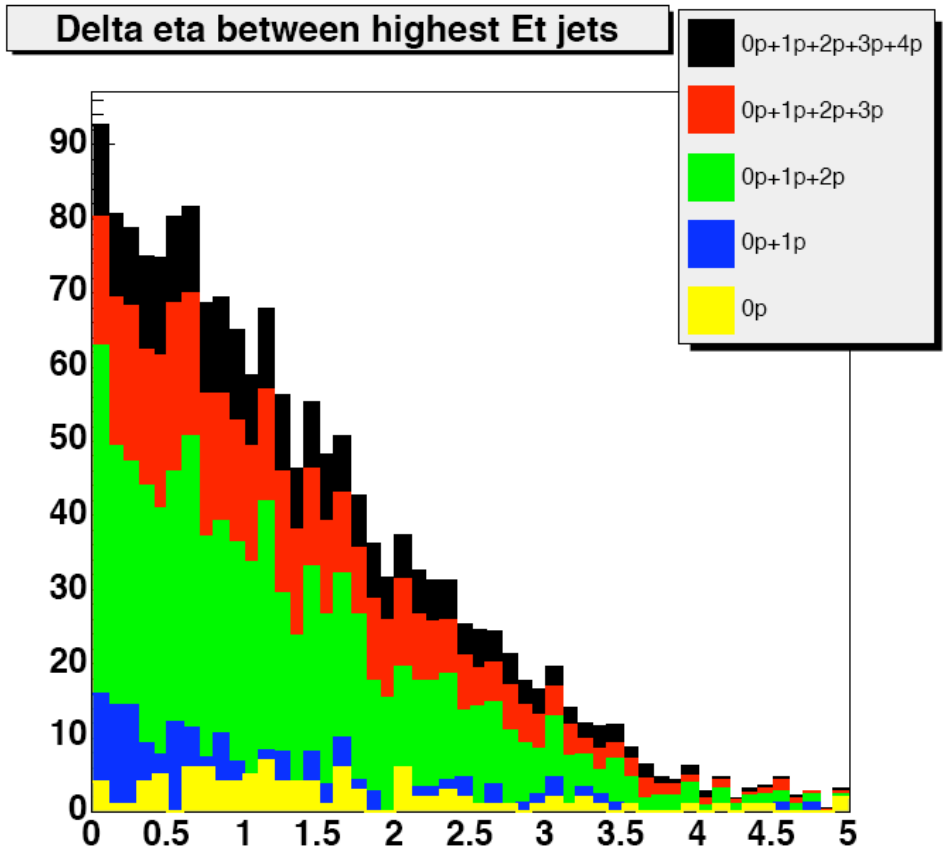




E_T of tag jets > 20 GeV/c

- CKKW decomposition

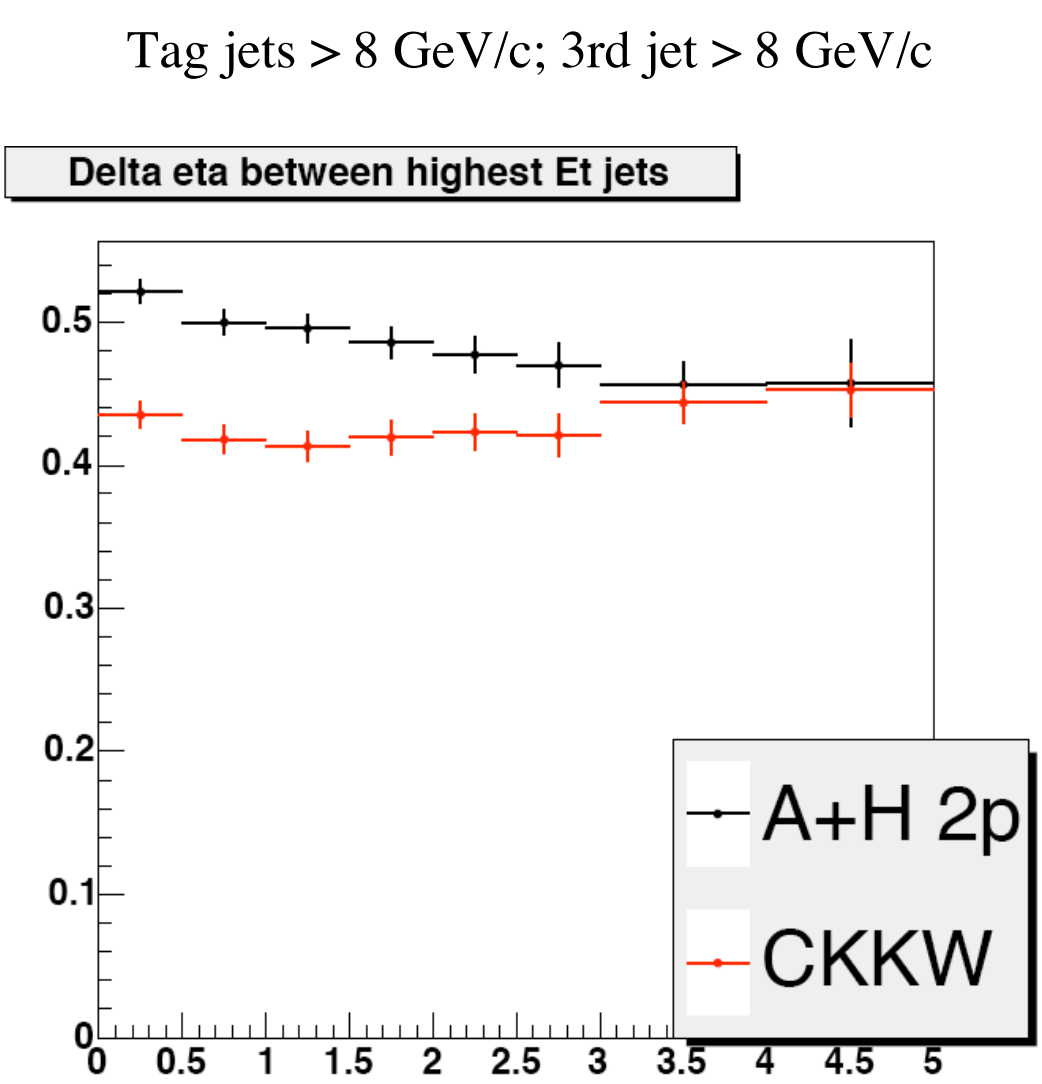




For low E_T tagging jets, W + 0 p relatively important; 2 p required for higher E_T

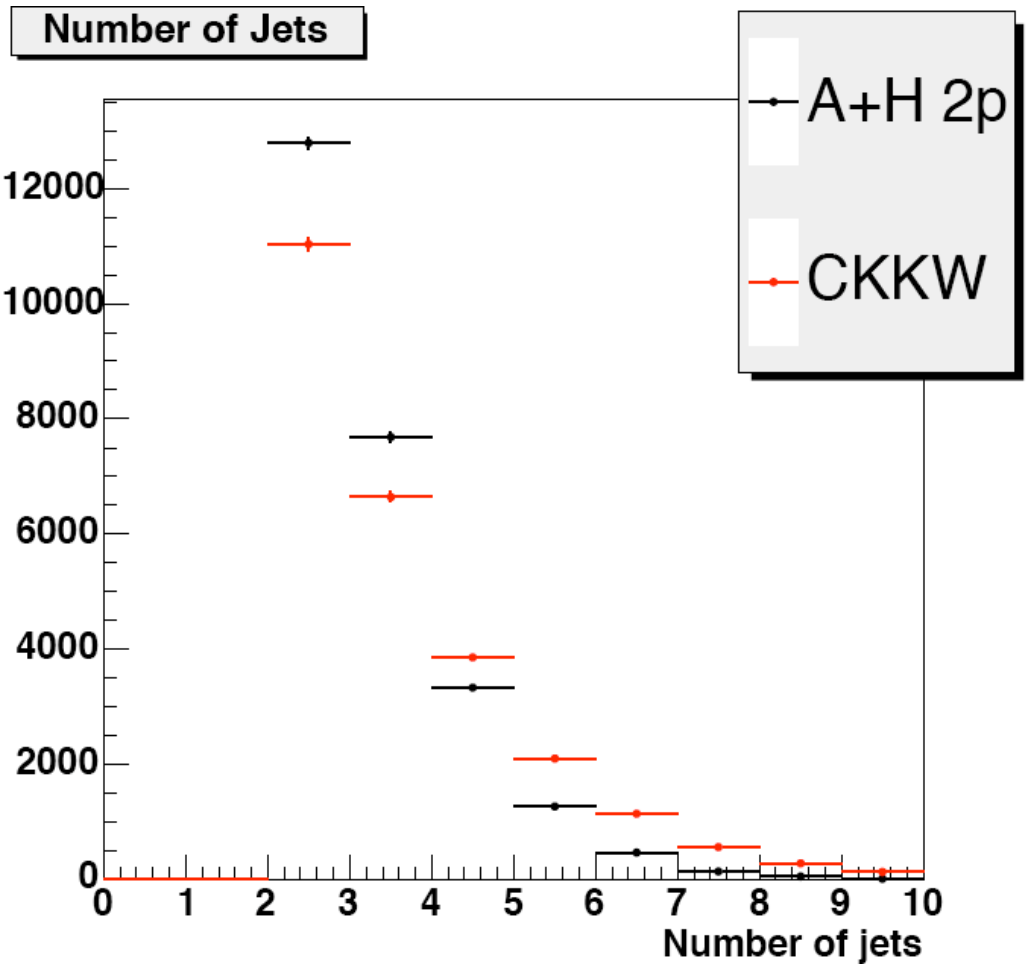
2 jet/>= 2 jet ratio as function of η

- Fraction of >= 2 jet events with only 2 jets
- 3rd jet has cut at 8 GeV/c; 3 different cuts on tagging jets



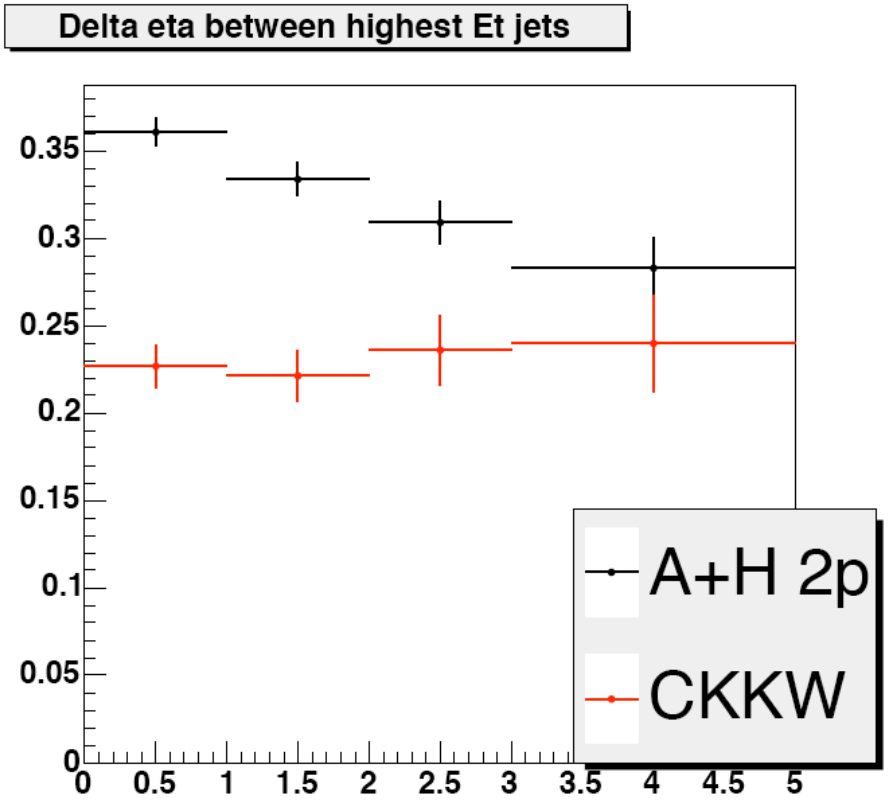
Jet multiplicity

- 8 GeV/c tagging jets (+central jet)
- All η separations

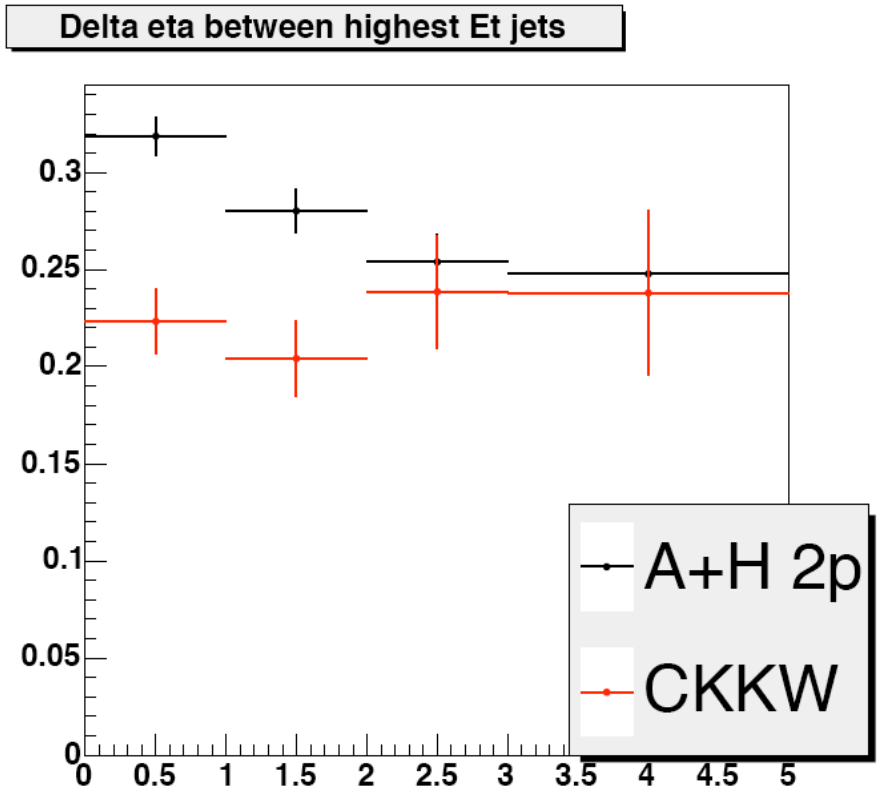


2 jet/>= 2 jet ratio as function of η

Tag jets > 15 GeV/c; 3rd jet > 8 GeV/c



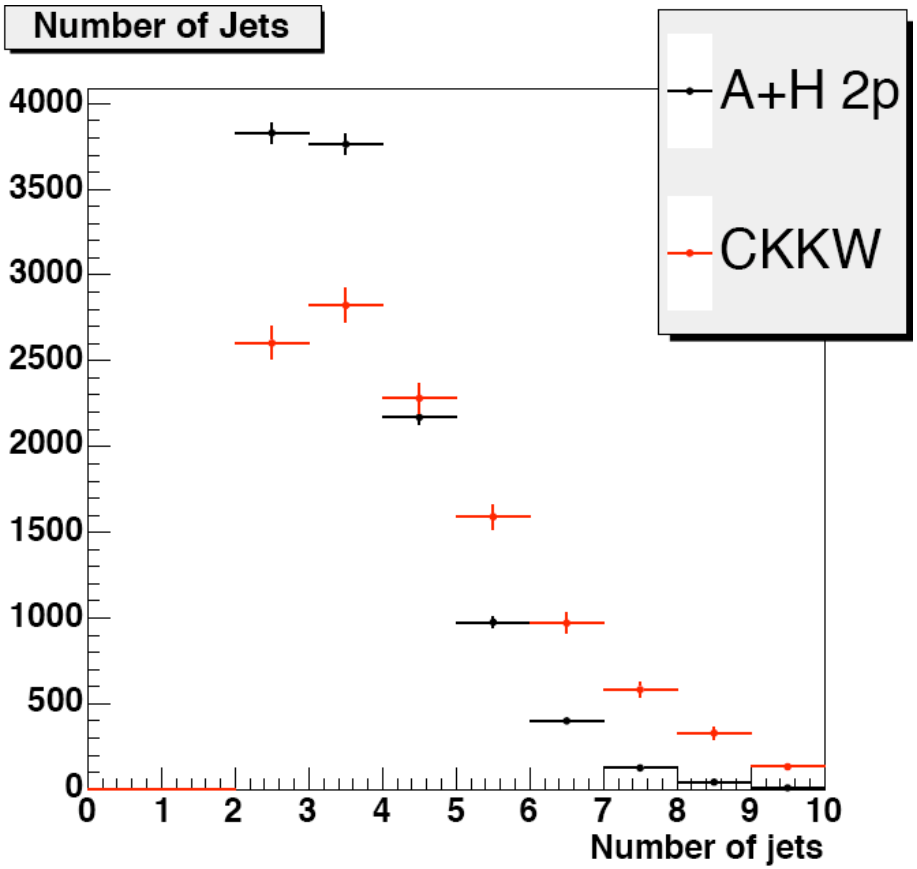
Tag jets > 20 GeV/c; 3rd jet > 8 GeV/c



A+H predicts too high a rate; CKKW agrees well with the data; rate is flat with rapidity separation; note >= 3 jet fraction very high (~80%)

Jet multiplicity

- 15 GeV/c tagging jets (+ 8 GeV/c central jet)
- All η separations



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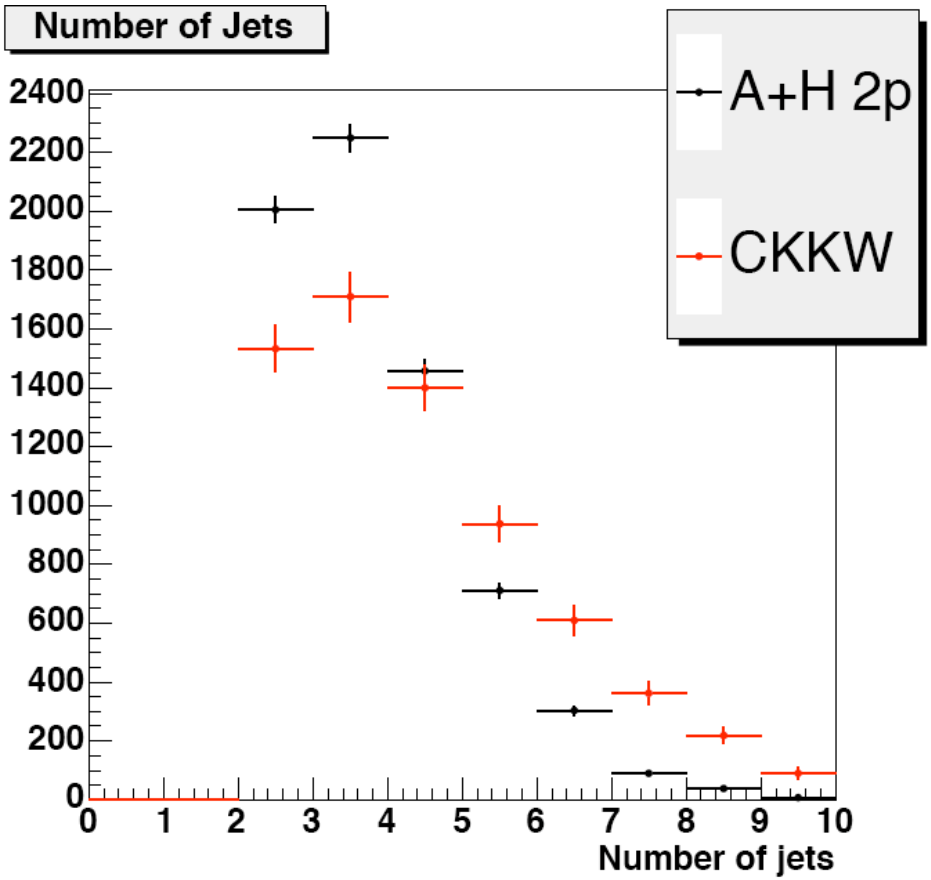
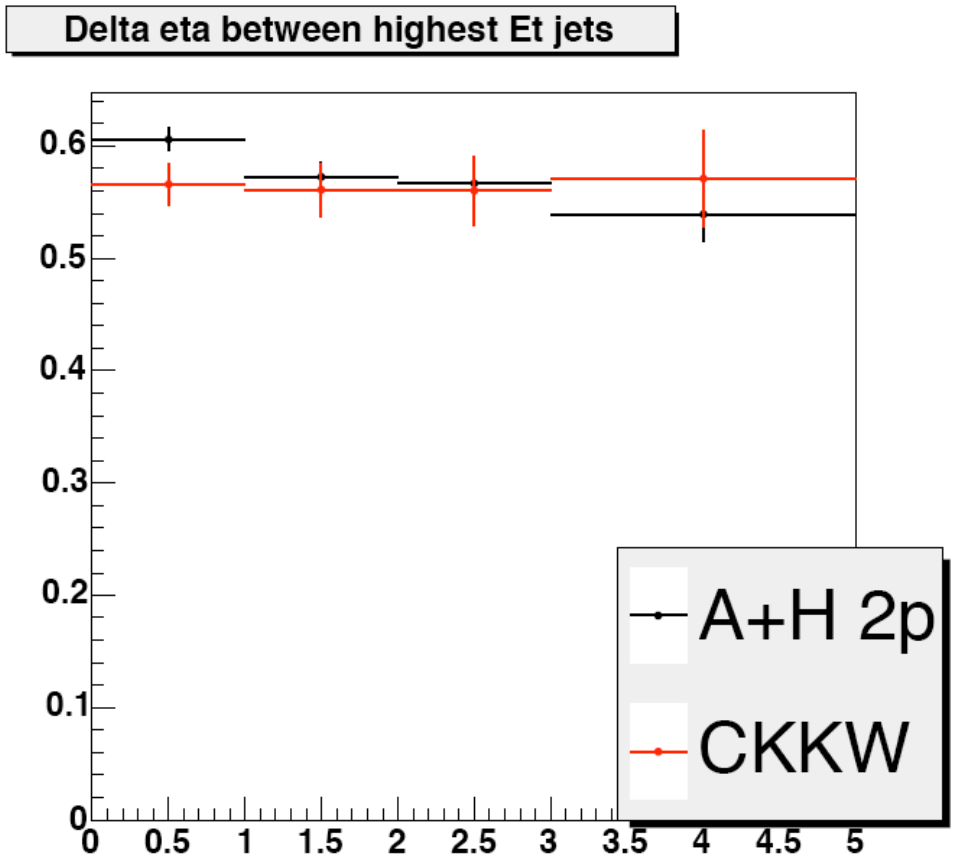


2 jet/>= 2 jet ratio as function of η

- 3rd jet probability decreases with increasing 3rd jet E_T cut

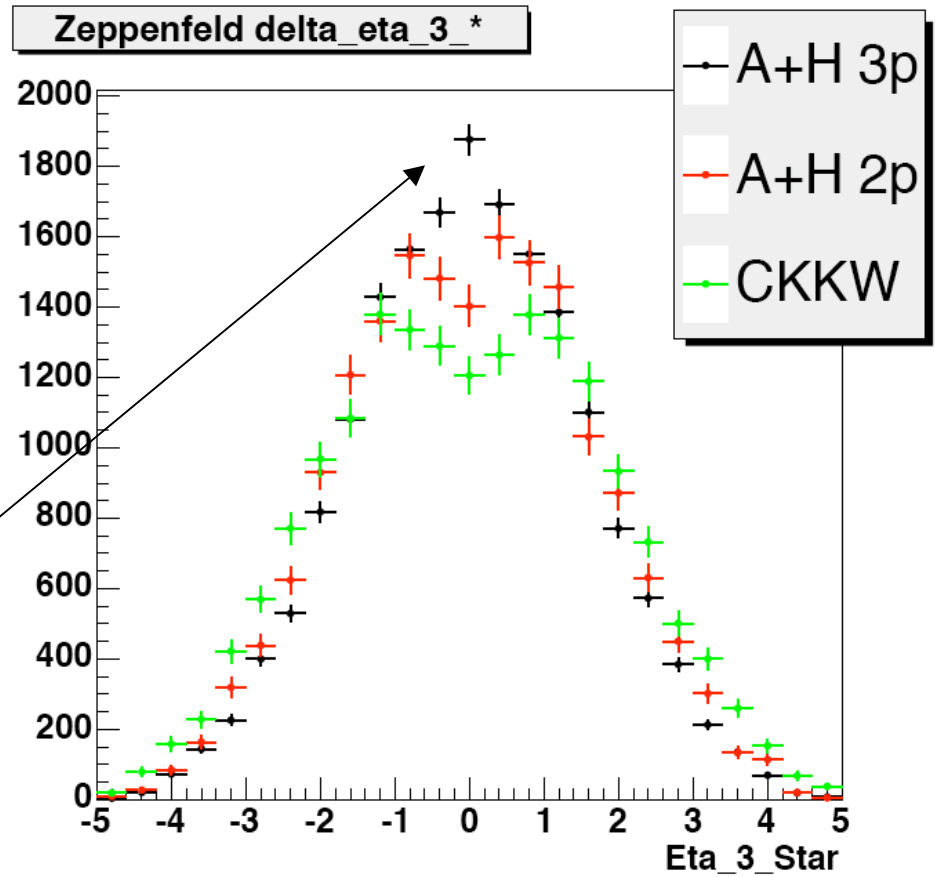
Tag jets > 15 GeV/c; 3rd jet > 12 GeV/c



η_3^* for $\Delta\eta>1$

- Look at η_3^* distribution (as defined by Dieter in his talk) for 3 different tagging jet cuts and for 3 different tagging jet $\Delta\eta$ cuts

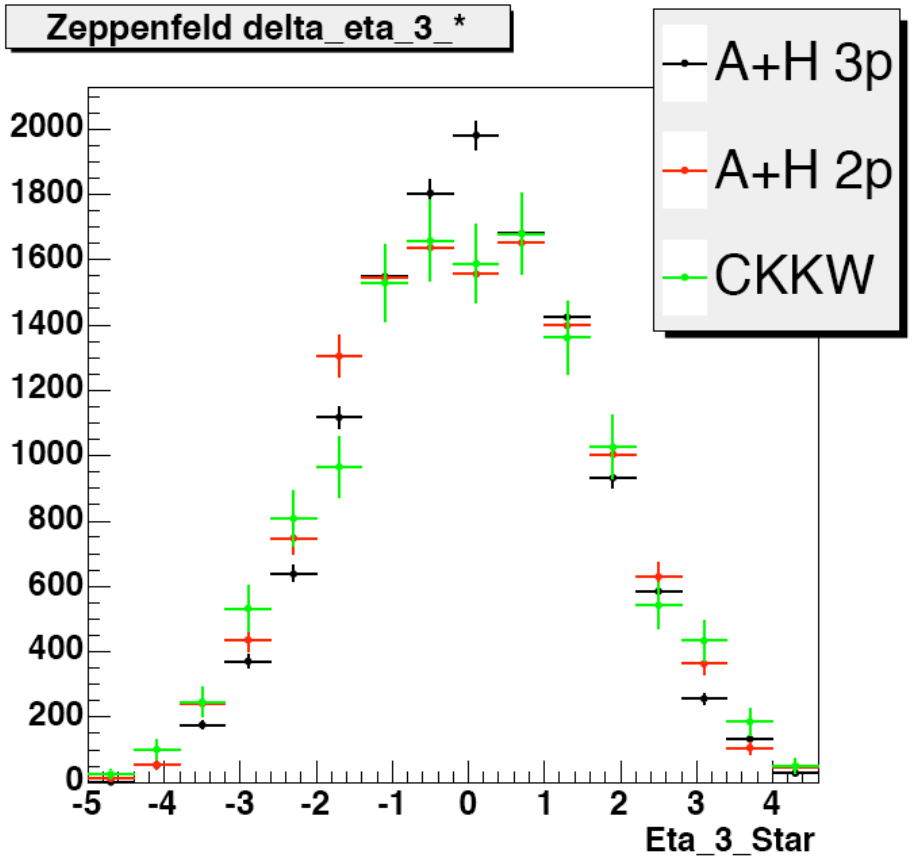
Tag jets > 8 GeV/c; 3rd jet > 8 GeV/c



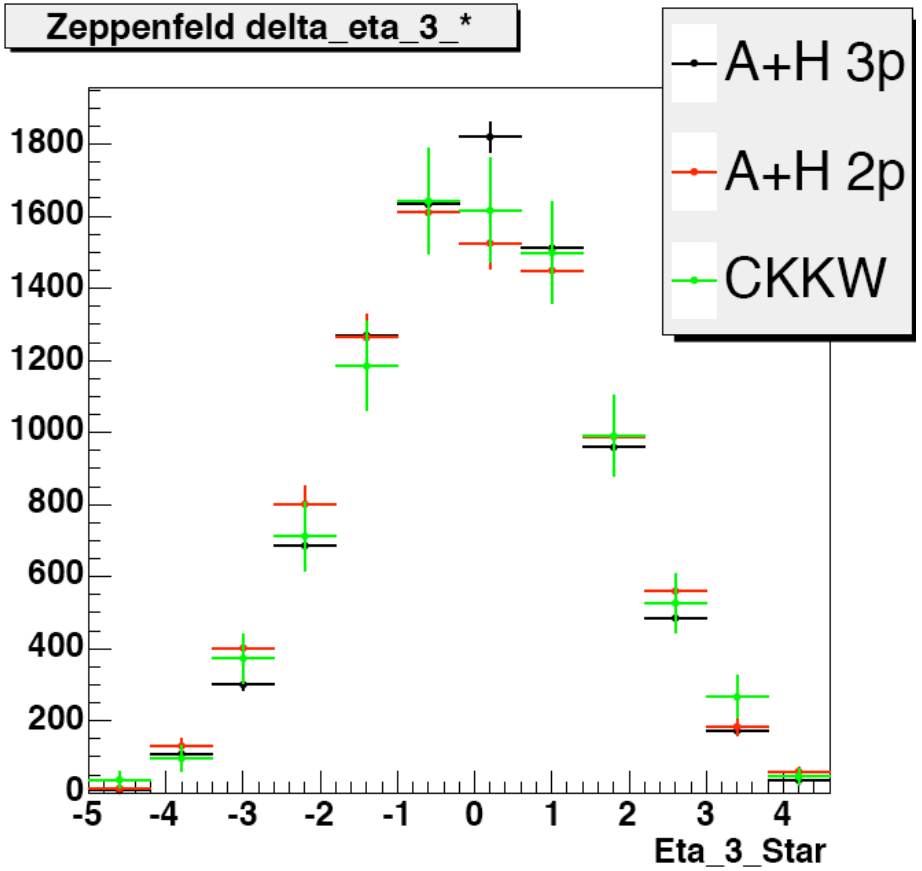
note peak for A+H 3p
…or dip for other distributions

η_3^* for $\Delta\eta>1$

Tag jets > 15 GeV/c; 3rd jet > 8 GeV/c



Tag jets > 20 GeV/c; 3rd jet > 8 GeV/c

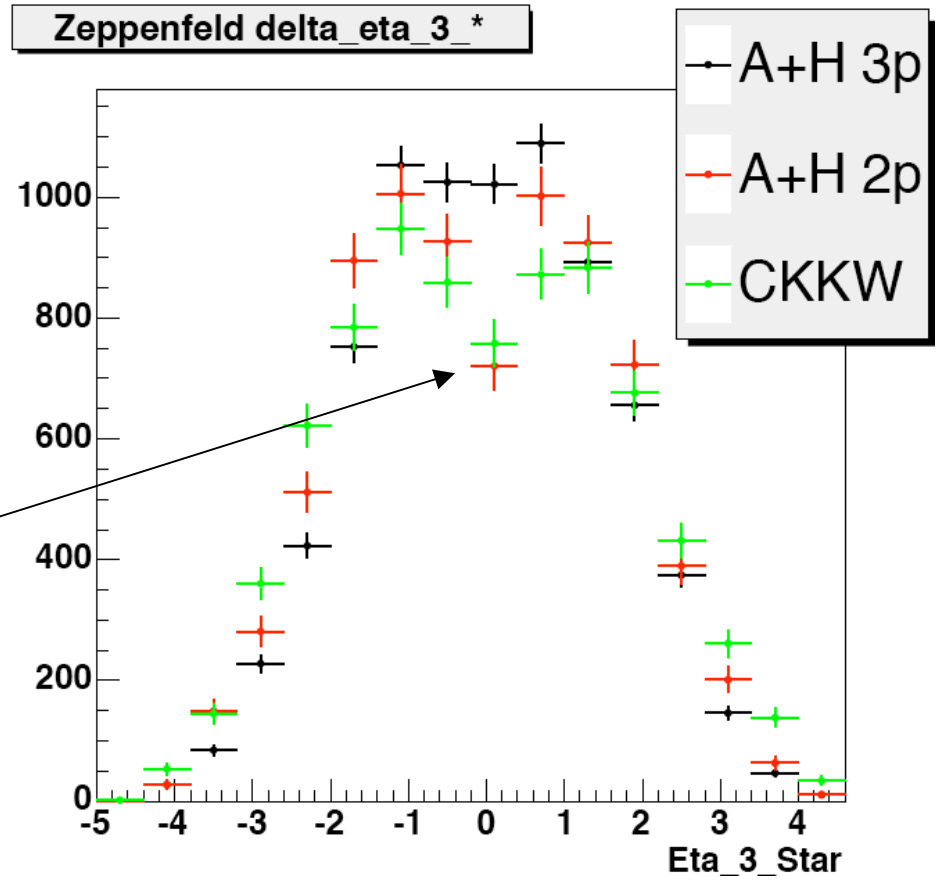


Dip fills in as tag jet E_T increases

η_3^* for $\Delta\eta>2$

- Look at η_3^* distribution (as defined by Dieter in his talk) for 3 different tagging jet cuts and for 3 different tagging jet $\Delta\eta$ cuts

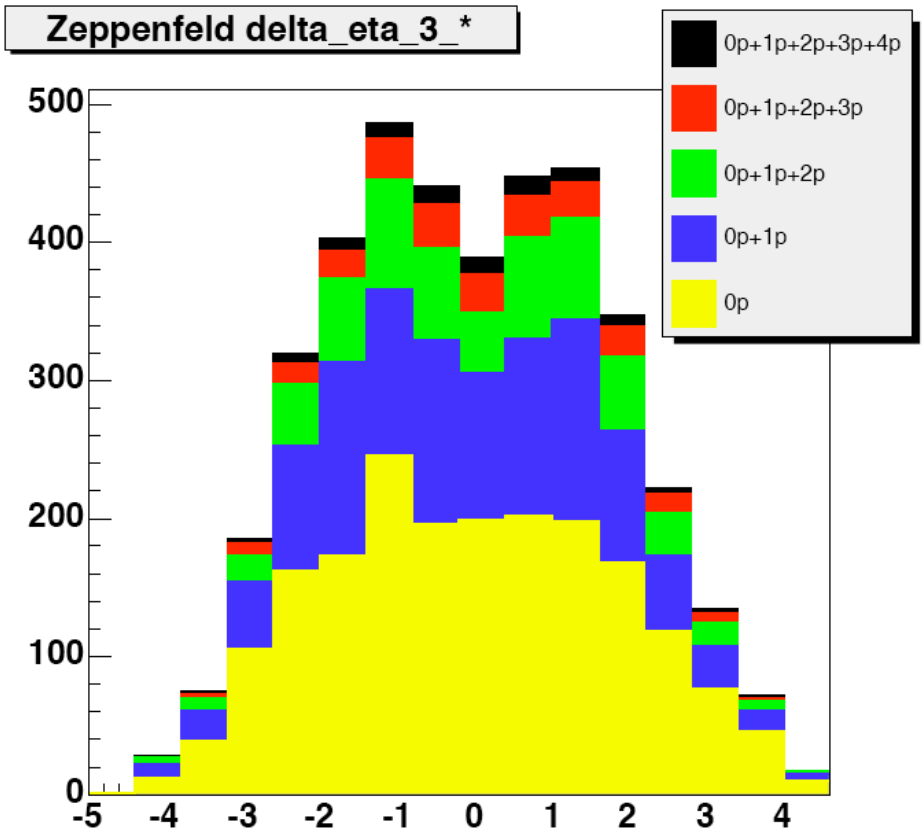
Tag jets > 8 GeV/c; 3rd jet > 8 GeV/c

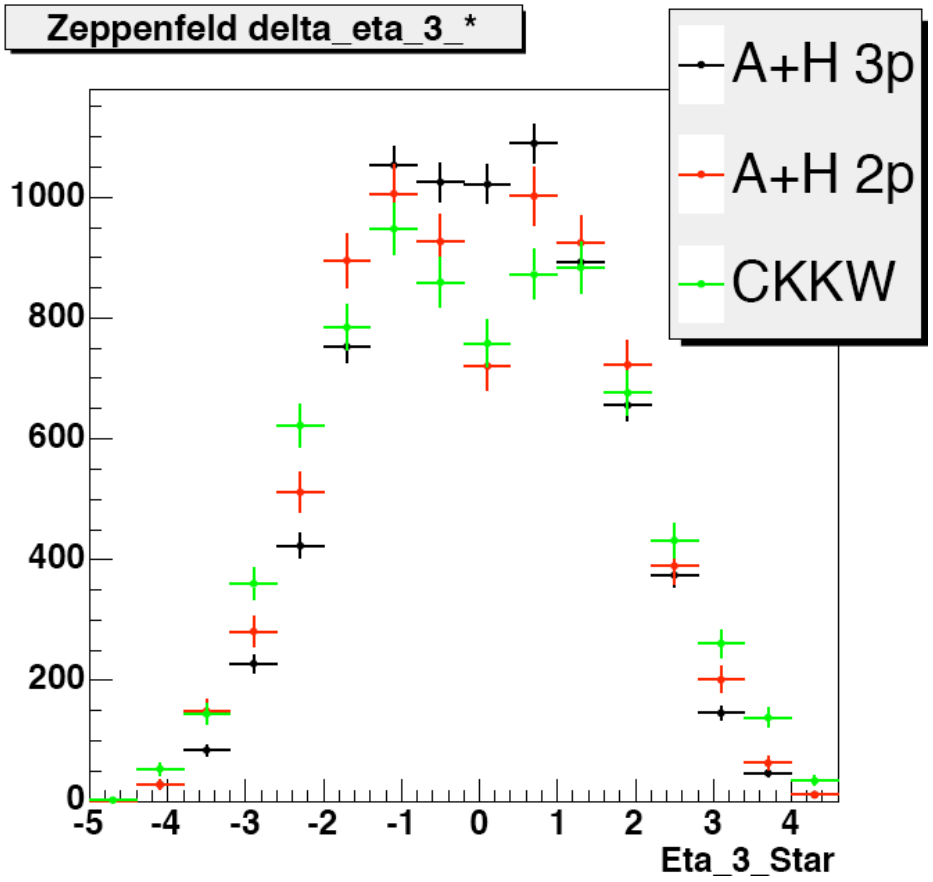


now dip is very noticeable

η_3^* for $\Delta\eta$>2: CKKW decomposition

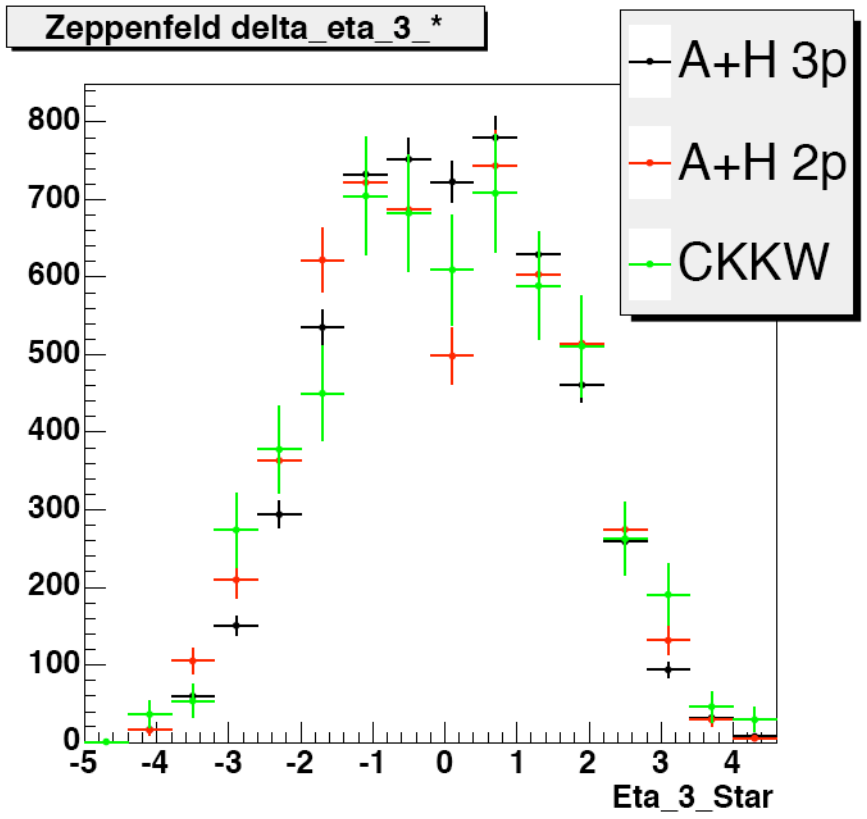
Tag jets > 8 GeV/c; 3rd jet > 8 GeV/c



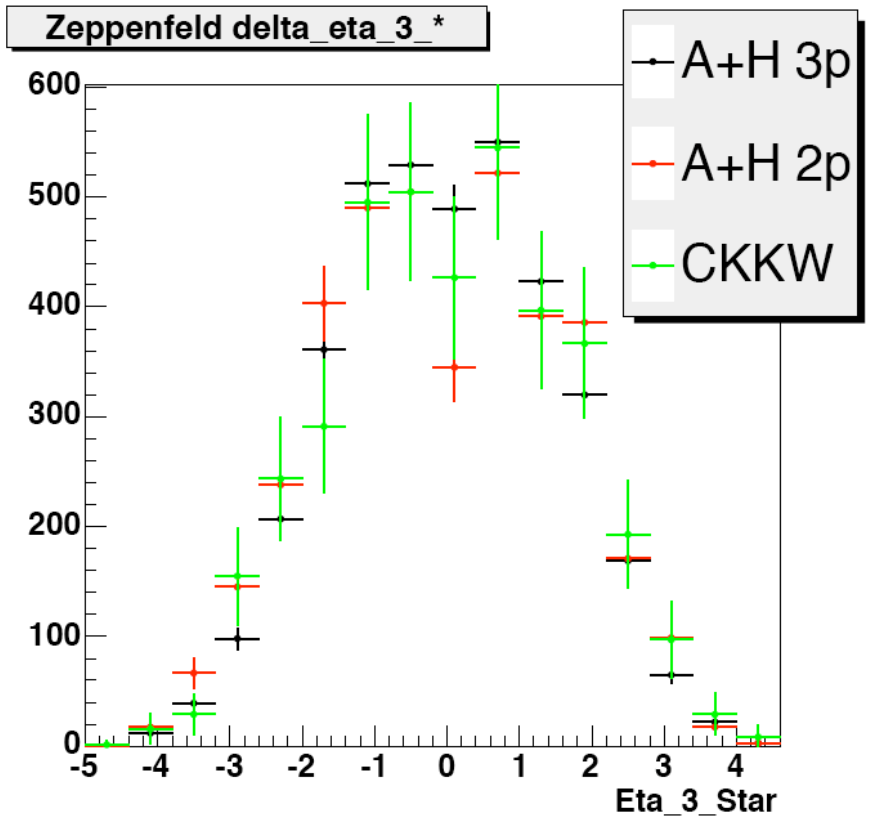


η_3^* for $\Delta\eta>2$

Tag jets > 15 GeV/c; 3rd jet > 8 GeV/c

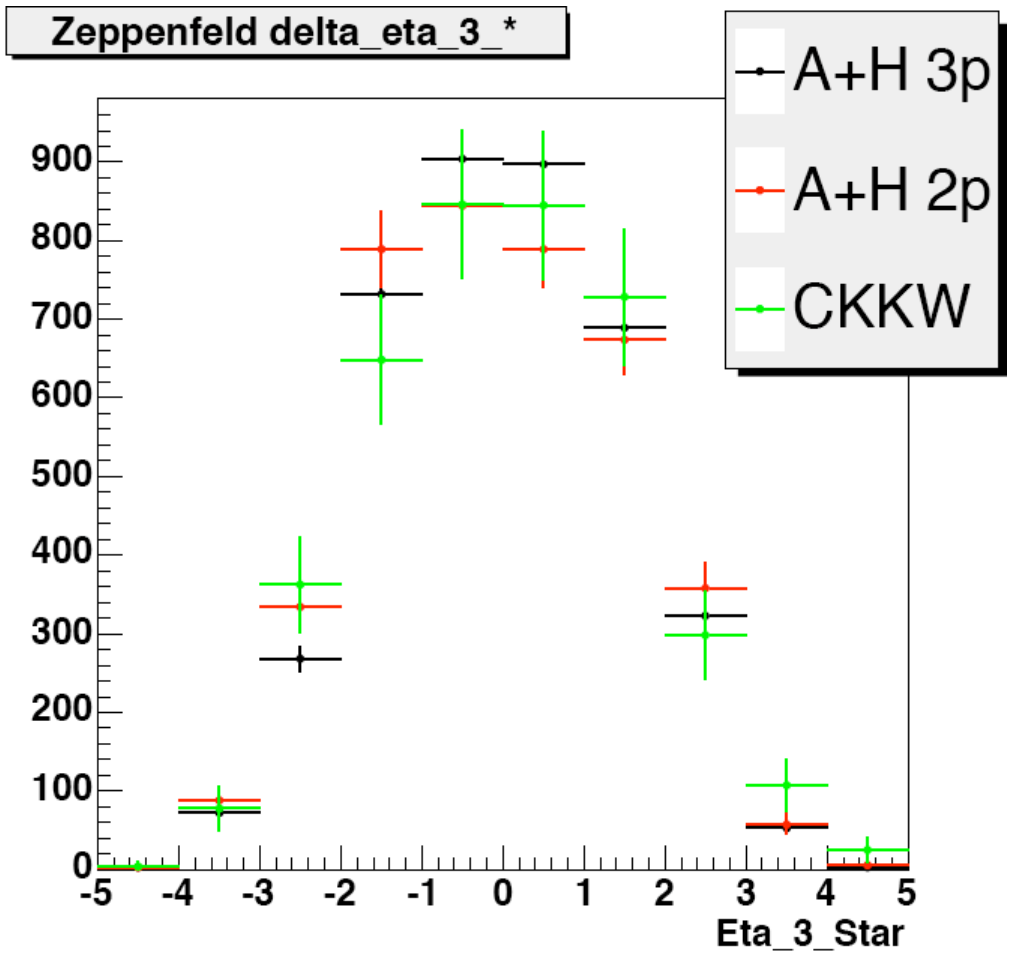


Tag jets > 20 GeV/c; 3rd jet > 8 GeV/c



η_3^* for $\Delta\eta>2$

Tag jets > 15 GeV/c; 3rd jet > 12 GeV/c



η_3^* for $\Delta\eta>3$

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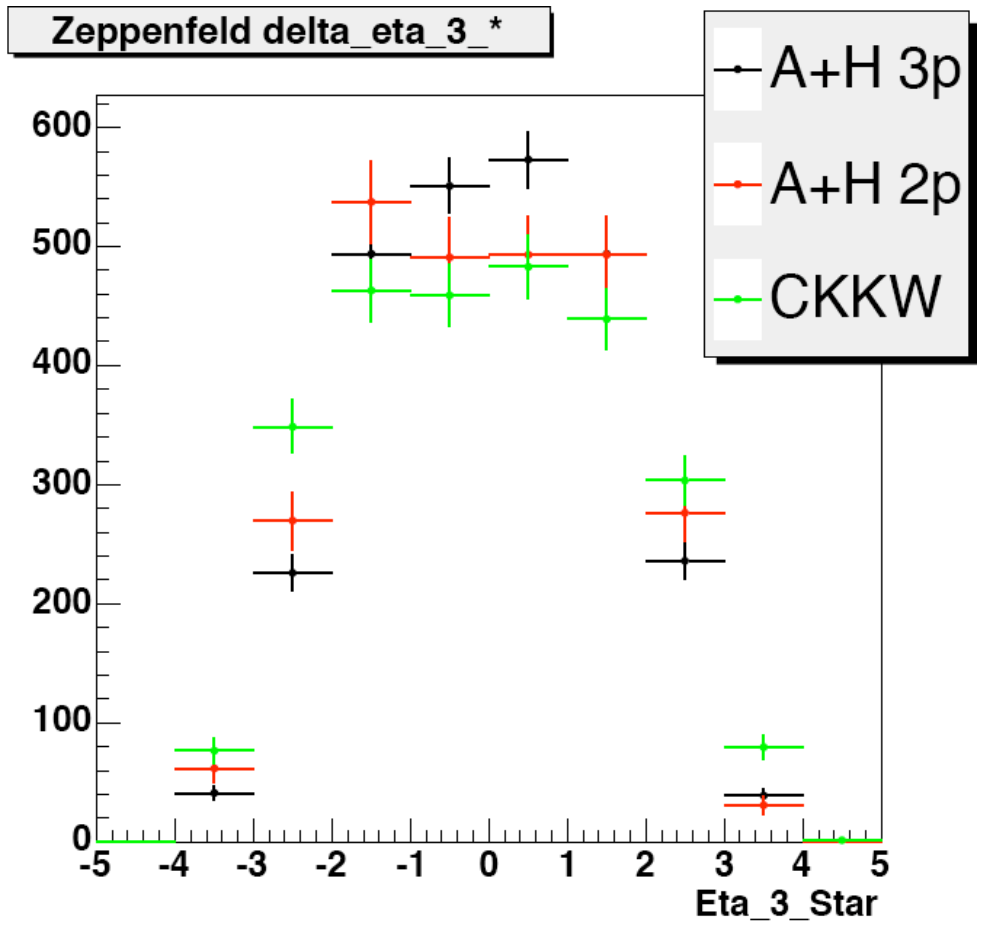
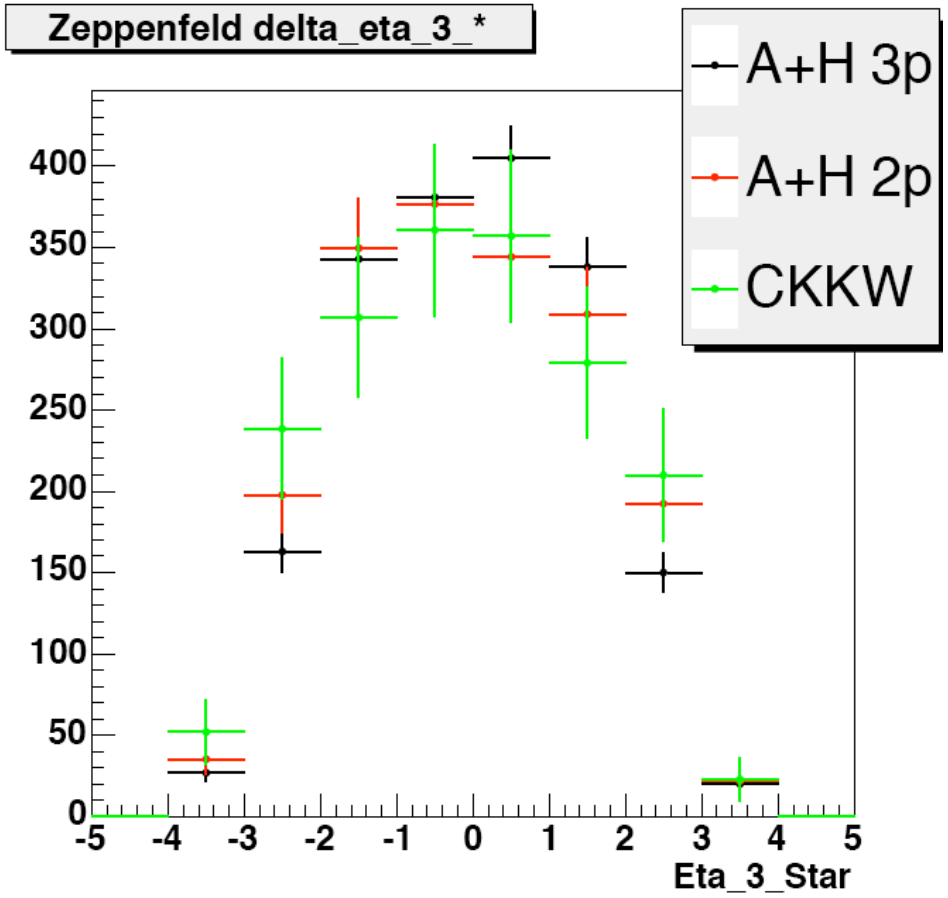
Tag jets > 8 GeV/c; 3rd jet > 8 GeV/c

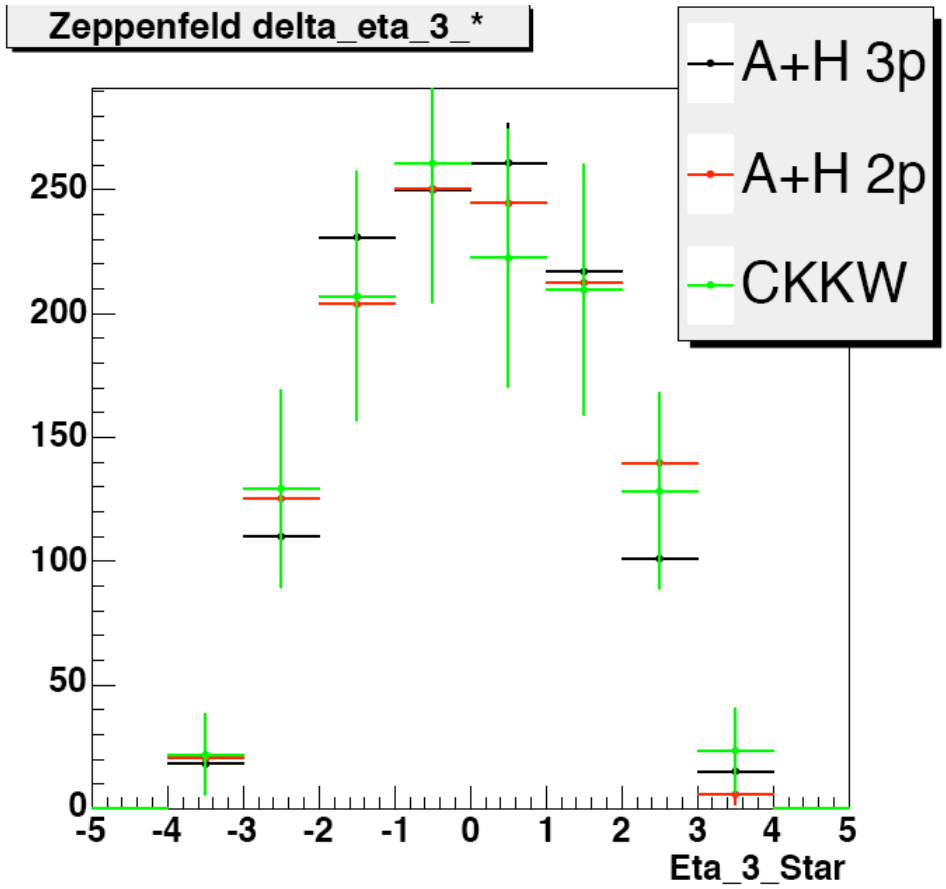


η_3^* for $\Delta\eta>3$

Tag jets > 15 GeV/c; 3rd jet > 8 GeV/c



Tag jets > 20 GeV/c; 3rd jet > 8 GeV/c



η_3^* for $\Delta\eta>3$

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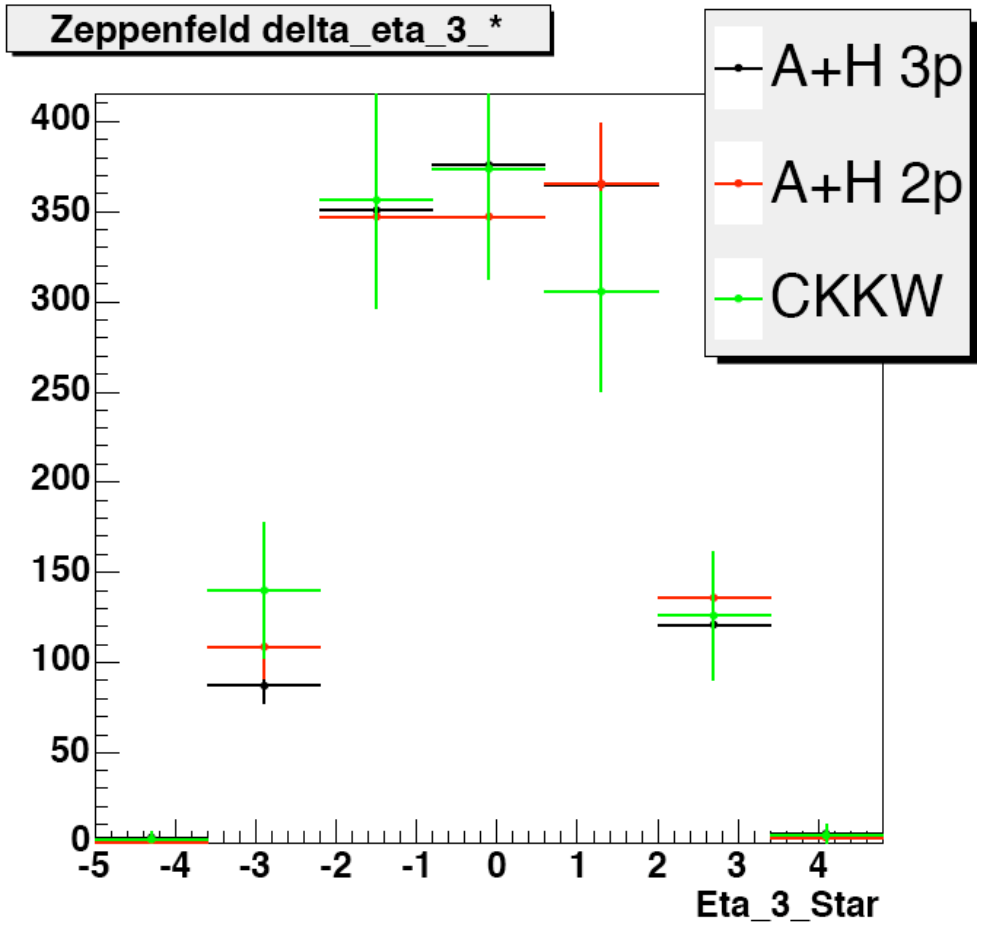

Summary

- Monte Carlo predicts large central jet activity for W + 2 jets widely separated in rapidity
  - good news for LHC if Tevatron data confirms
- Proceeding with data blessing as well as comparisons to MCFM
  - ultimate goal is to publish all cross sections for easy comparison to anyone's theory prediction
- Steve's CKKW sample seems to work very well at Tevatron
  - may try to have Steve generate CKKW events for ATLAS study