How to subtract underlying event from jets ?

Tancredi Carli, Pavel Starovoitov

CERN, NCPHEP

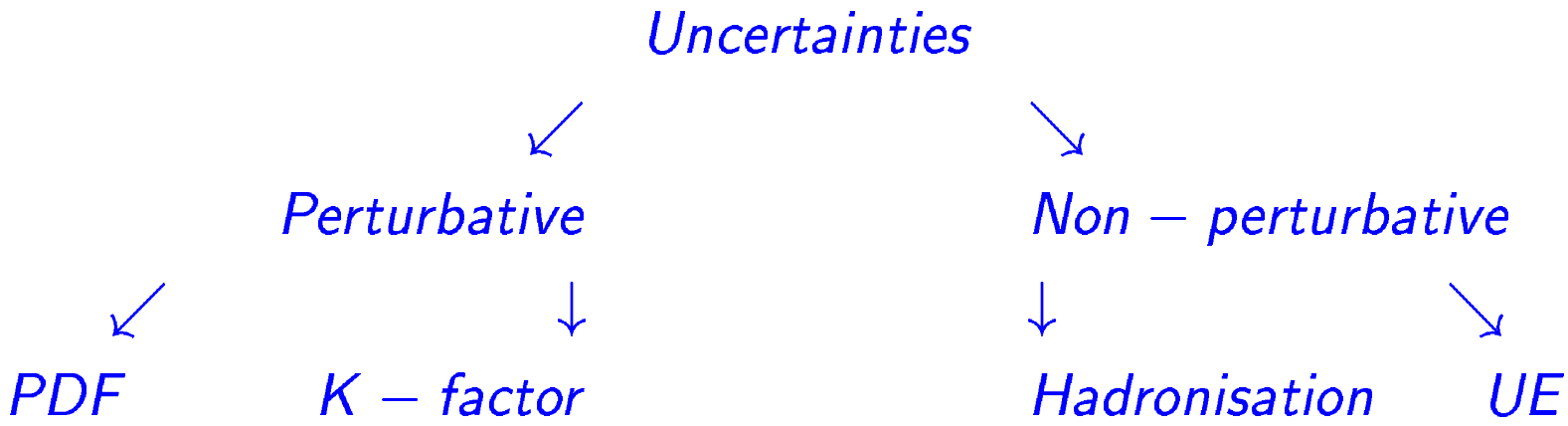
June 6, 2006

Outline

1. Plan
2. How much energy do UE add
3. UE energy map
4. Energy Flows
5. Subtraction
6. Next steps

Plan

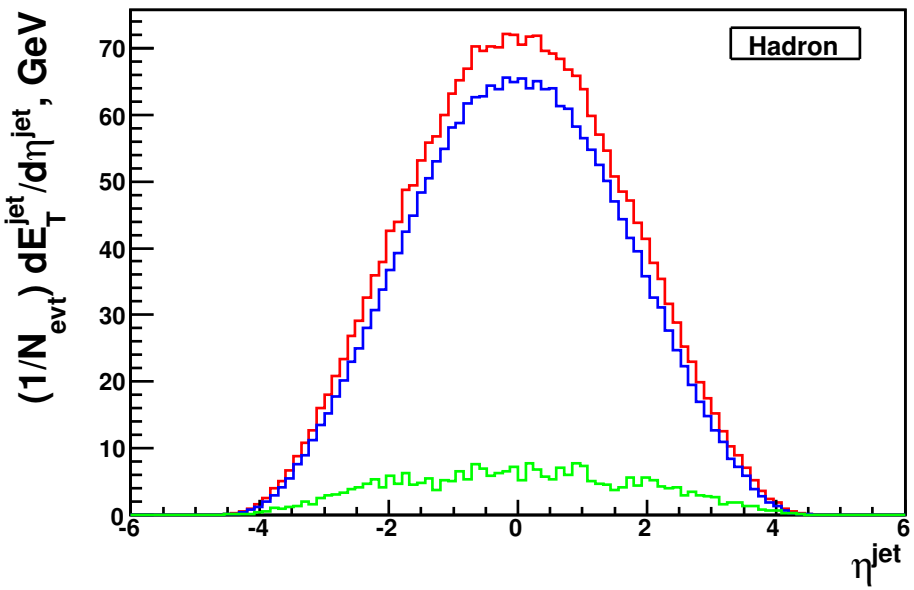
- **Future:** We want to study uncertainties for different Jet Algorithms: Cone & K_T

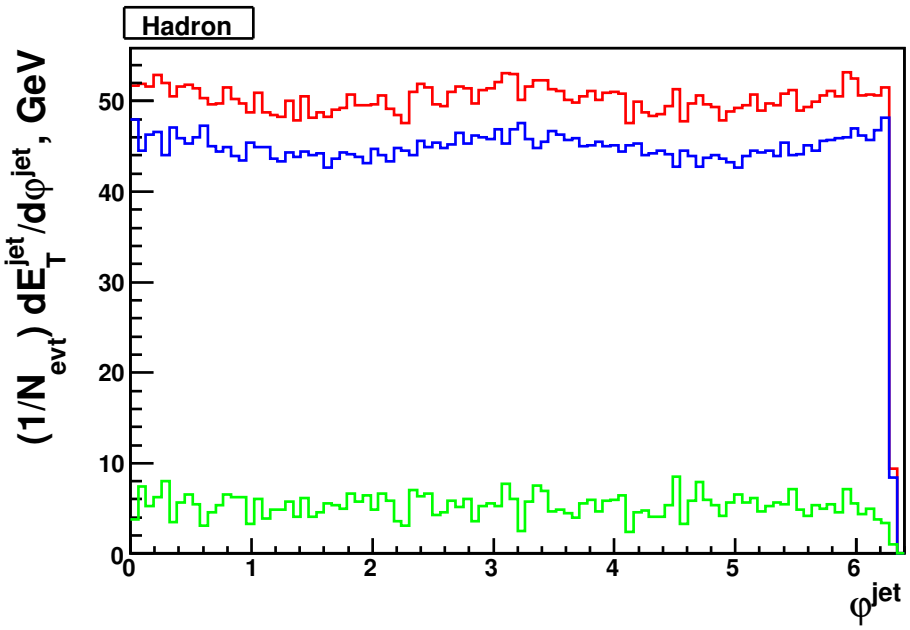


- **Today:** We study Underlying Events
  - Definition
    - ★ UE: collision of beam remnants (subtraction is needed to compare to NLO calculations)
    - ★ MB(Minimal Bias): soft hadron collisions in same bunch crossing (subtraction is needed to measure the cross section)
    - ★ Pile-up: soft hadron collisions from diffrent bunch crossing
  - We use UE as a template for MB since problems are similar

$\frac{1}{N}\frac{dE_T^{jet}}{d\eta^{jet}}$ $\frac{1}{N}\frac{dE_T^{jet}}{d\varphi^{jet}}$

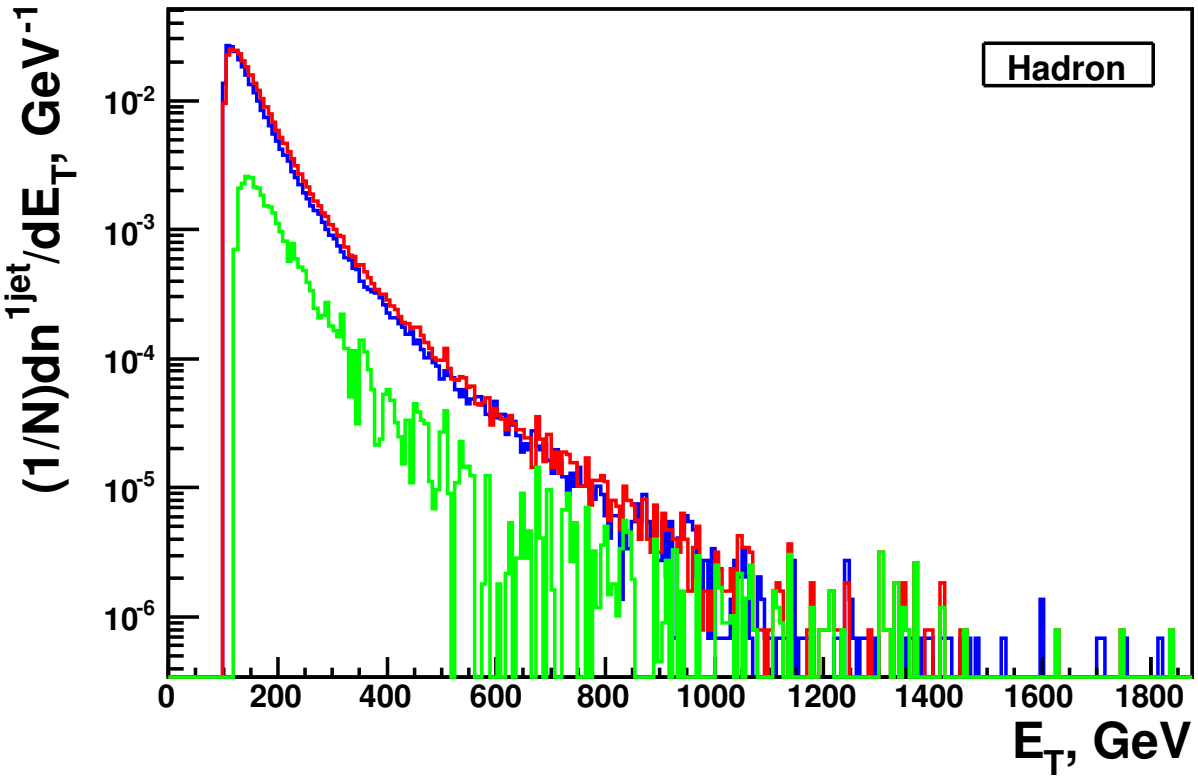
Generator: Sherpa-1.0.8
Jet cut: $E_T^{jet} > 100\ GeV$; $\left|\eta^{jet}\right| \leq 5$
Jet Algorithm: MidPoint





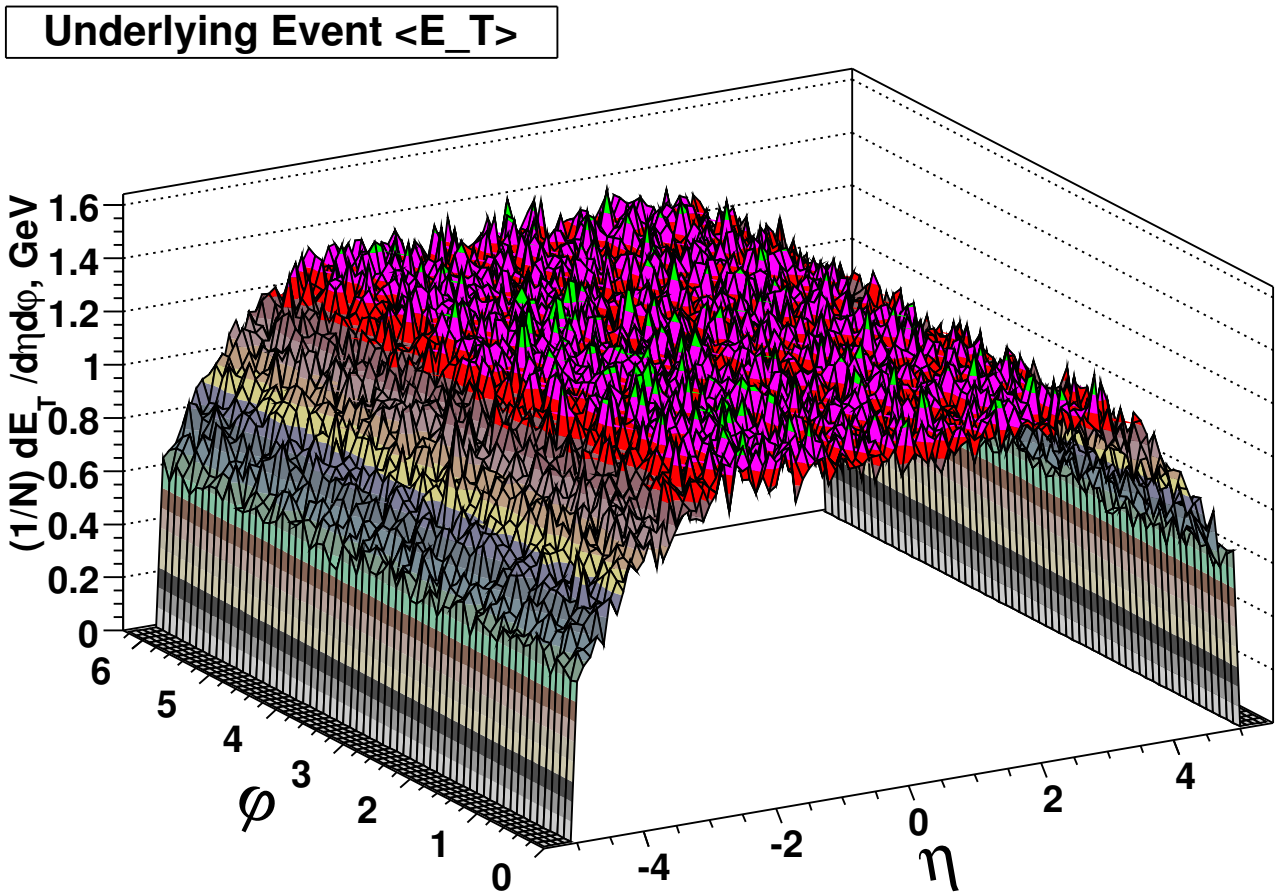
Hard Scale HS+UE Difference

Cross section



Hard Scale HS+UE Difference

$< E_T >$ of Underlying Events in $\eta - \varphi$

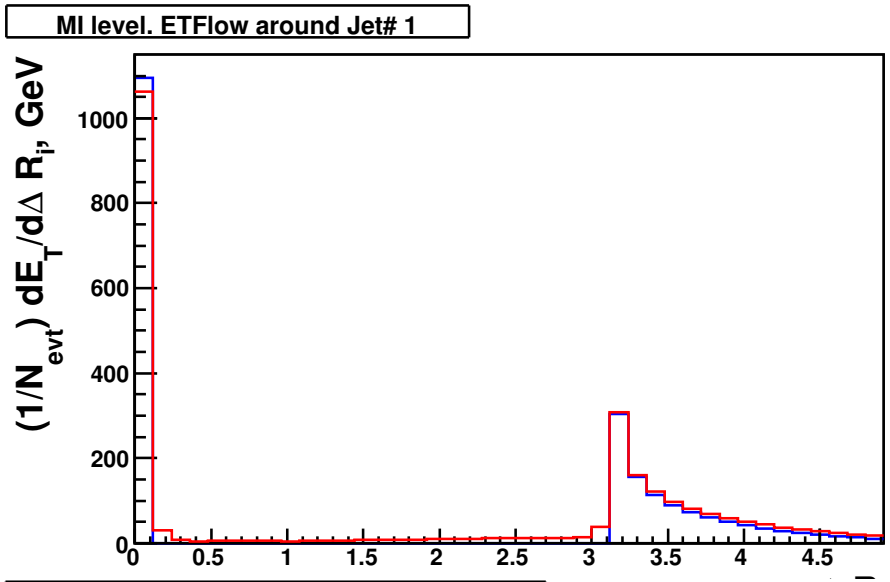


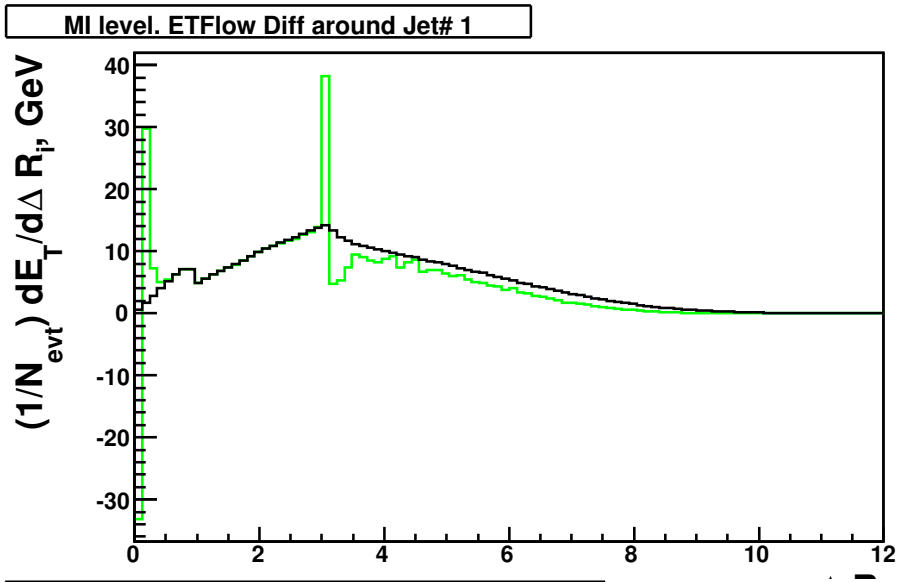
- UE map is flat in φ
- UE map varies in η (phase space)

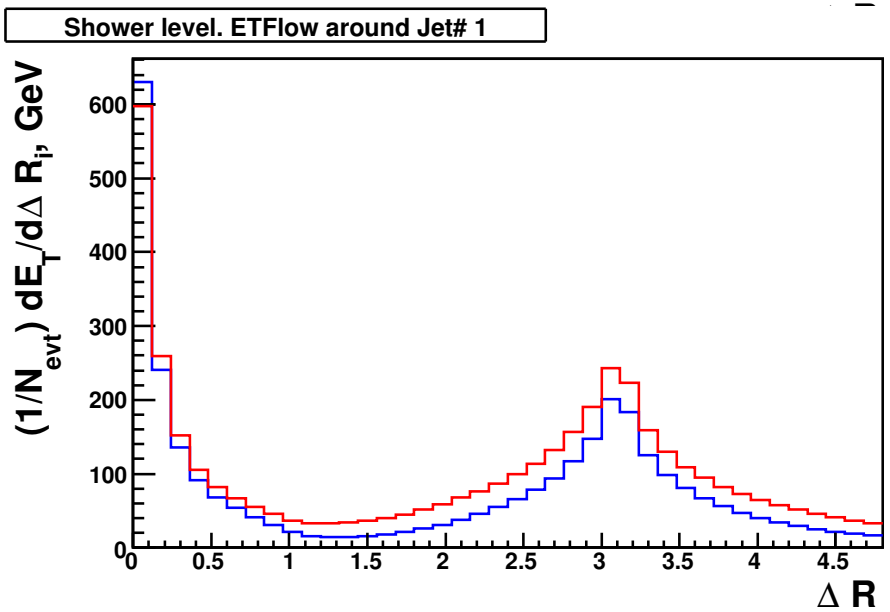
How to deal with UE

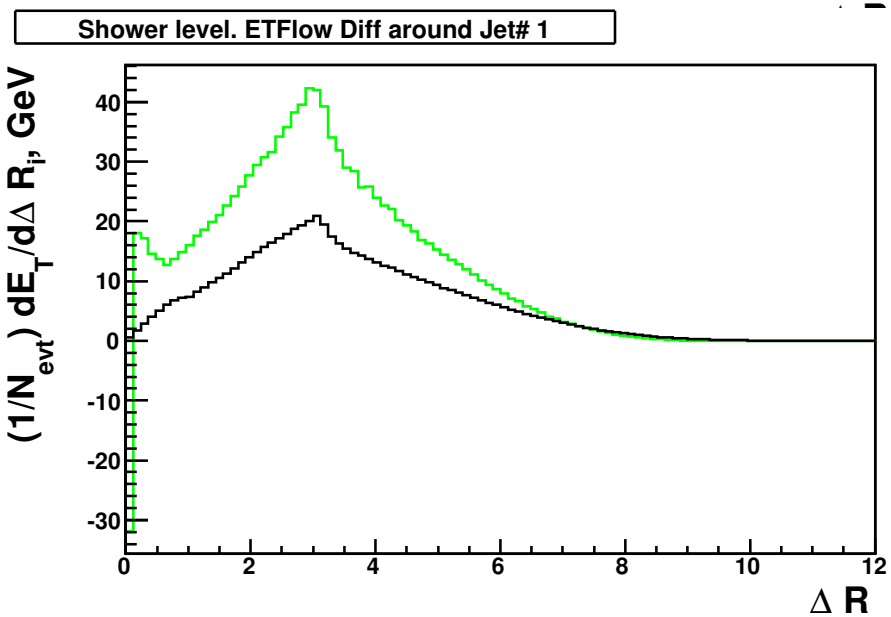
- Assumption: Hard Scale and UE are uncorrelated
- Two possible biases
  - Jet Algorithm sees UE to define a jet
  - UE has structure at event-by-event basis
- Look at Energy Flows
  - $\frac{dE_T}{d\Delta R_i}$ where $\Delta R_i = \sqrt{(\eta_{jet} - \eta_i)^2 - (\varphi_{jet} - \varphi_i)^2}$
  - $\frac{dE_T}{d\Delta\varphi}$ where $\Delta\varphi = |\varphi_{jet} - \varphi_i|$

Energy Flow $\frac{dE_T}{d\Delta R_i}$ around jet with maximal E_T



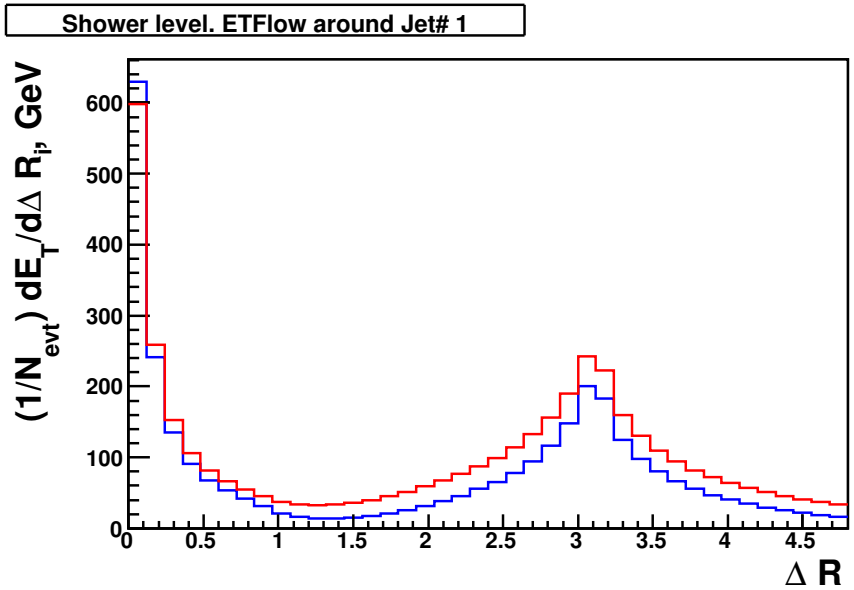


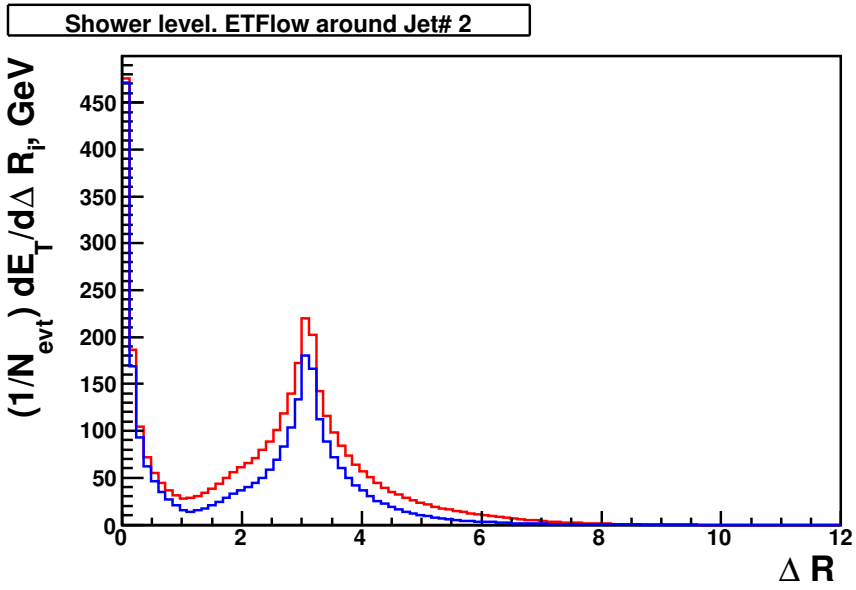


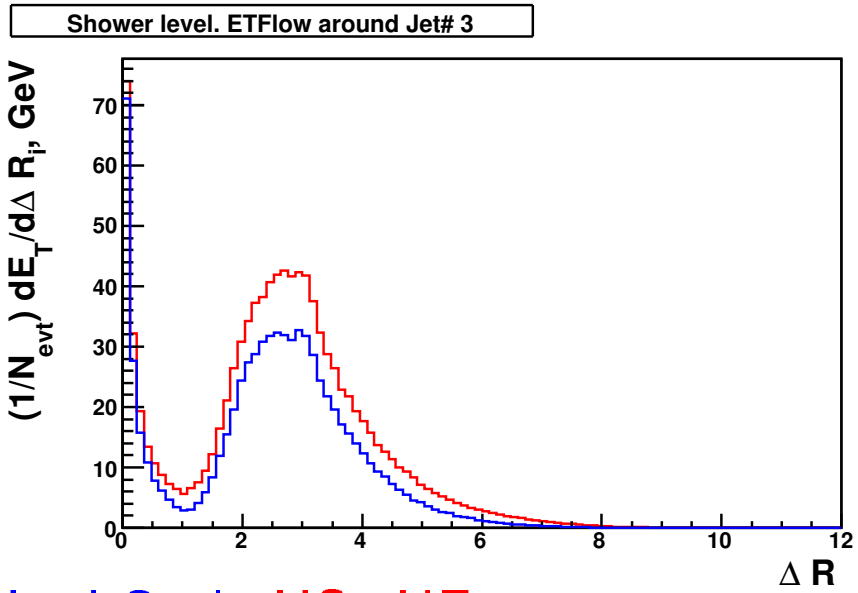


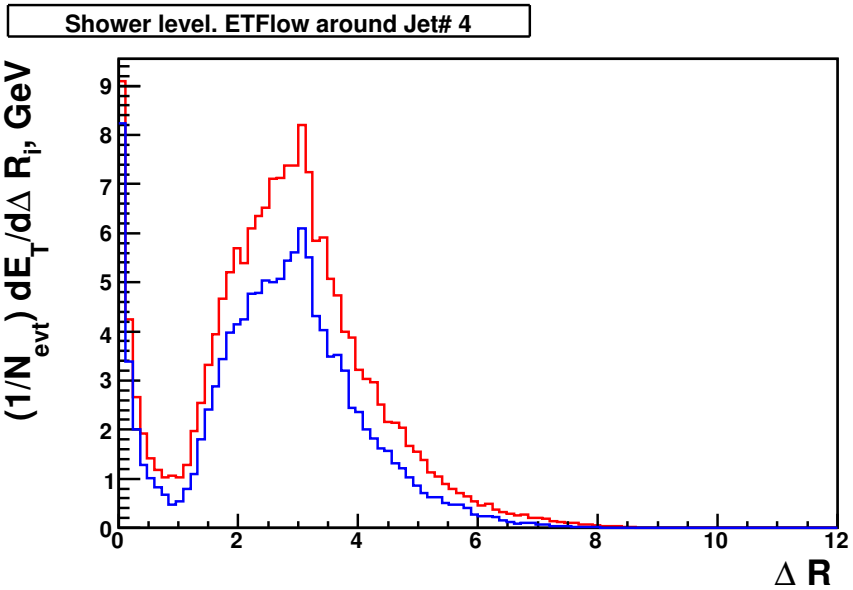
Hard Scale HS+UE Difference UEPartons only

Energy Flow $\frac{dE_T}{d\Delta R_i}$ around four leading jets



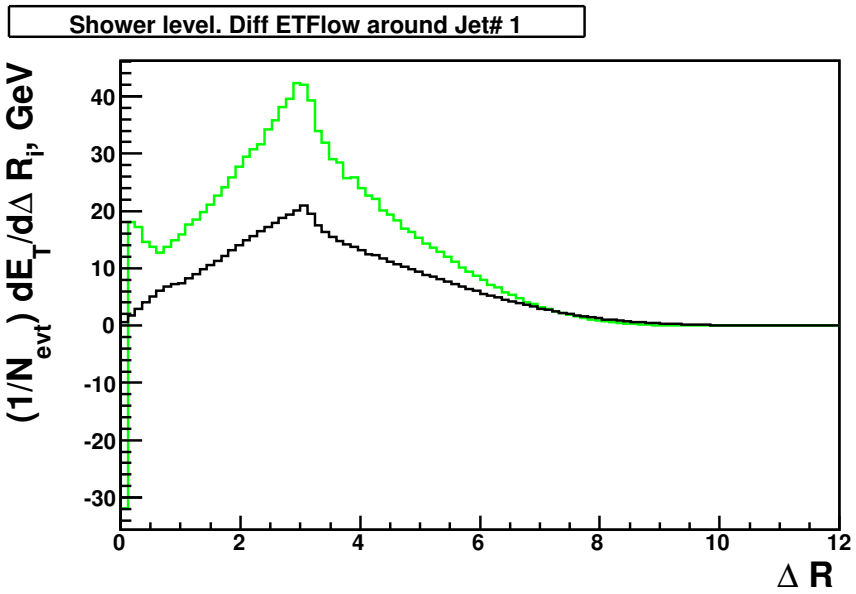


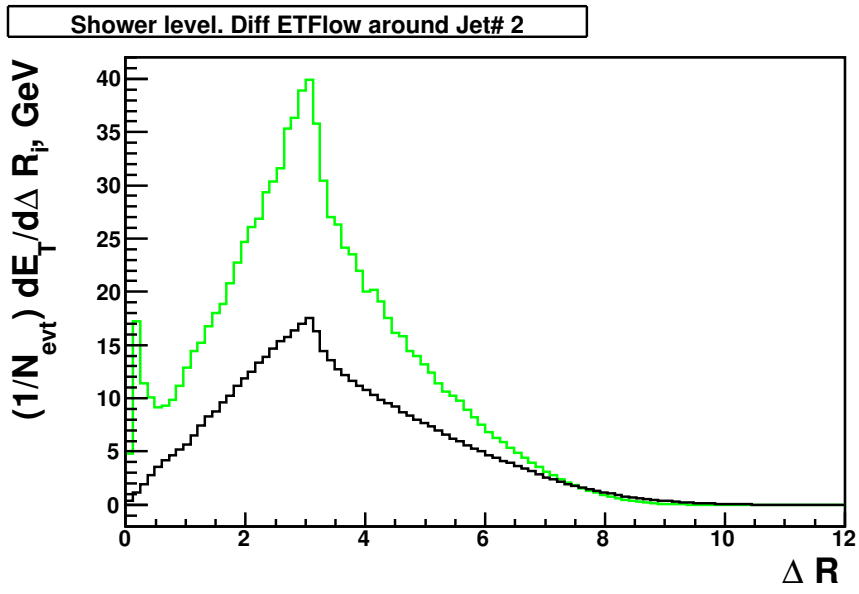


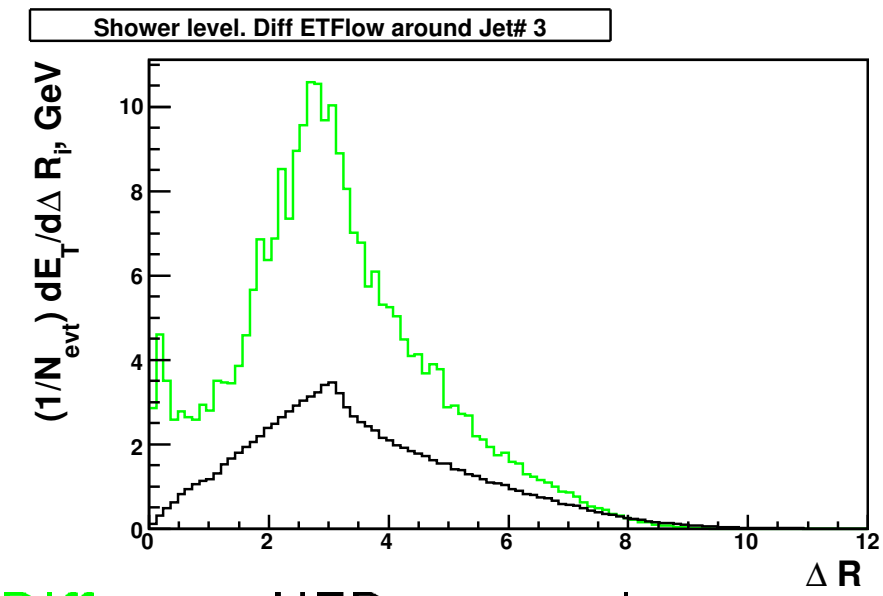


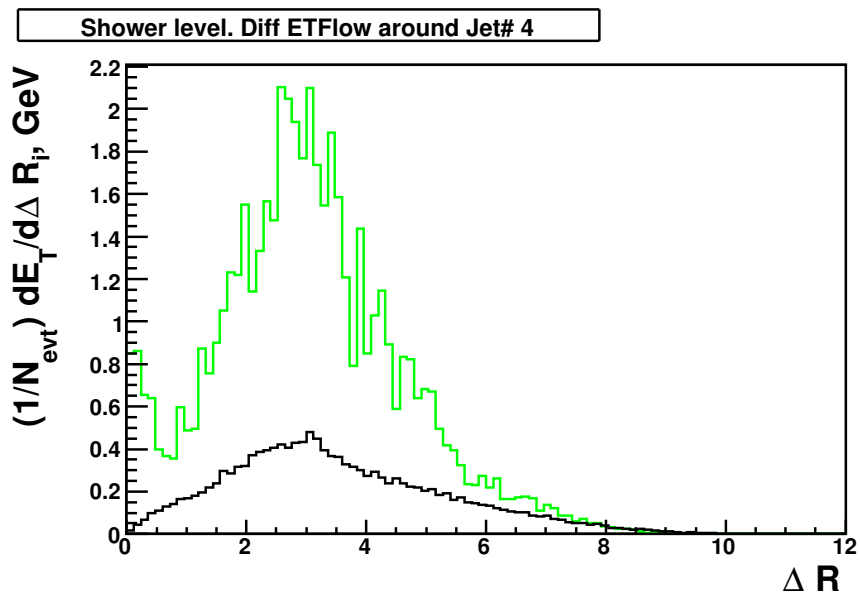
Hard Scale HS+UE

Energy Flow $\frac{dE_T}{d\Delta R_i}$ around four leading jets



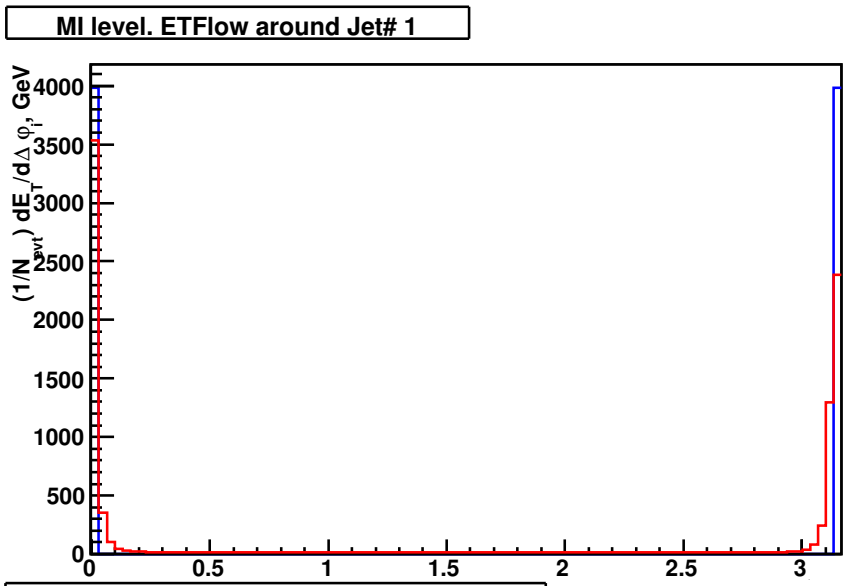


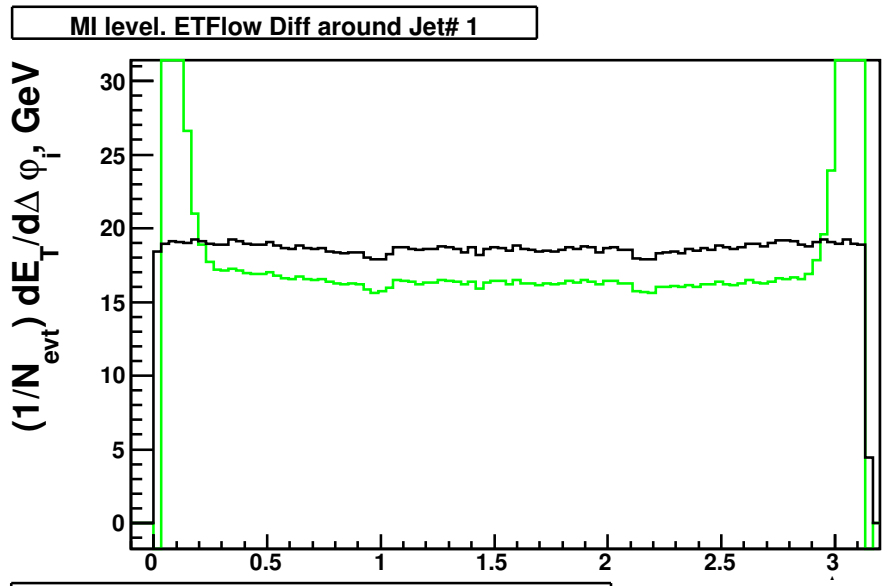


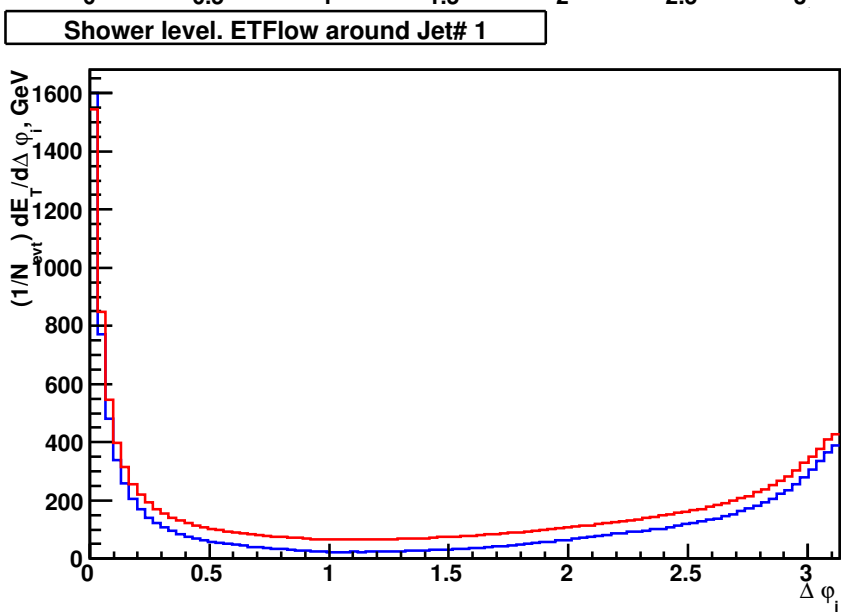


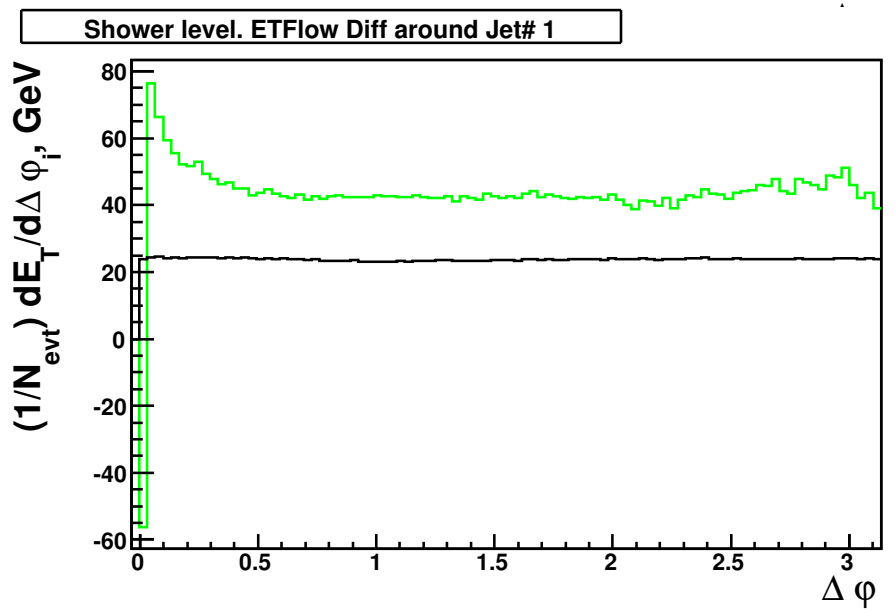
Difference UEPartons only

Energy Flow $\frac{dE_T}{d\Delta\varphi}$ around jet with maximal E_T



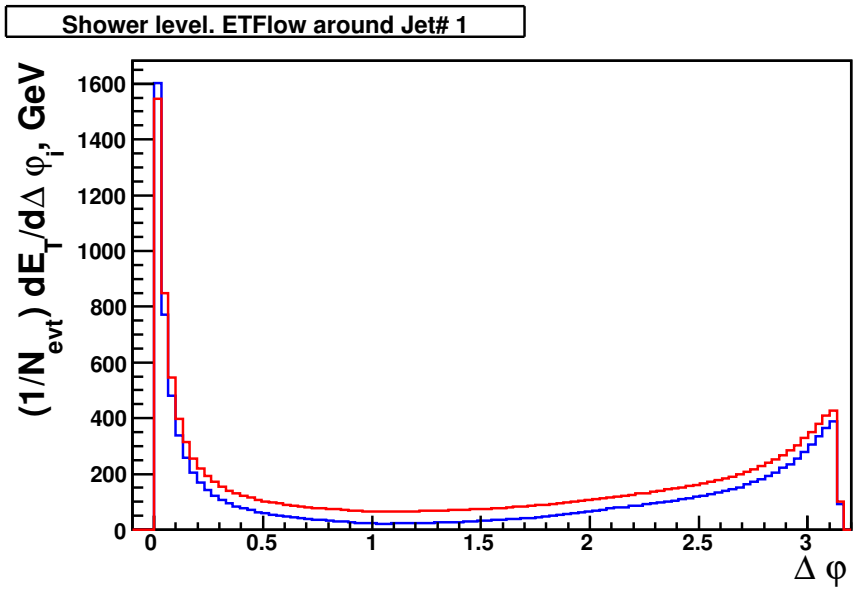


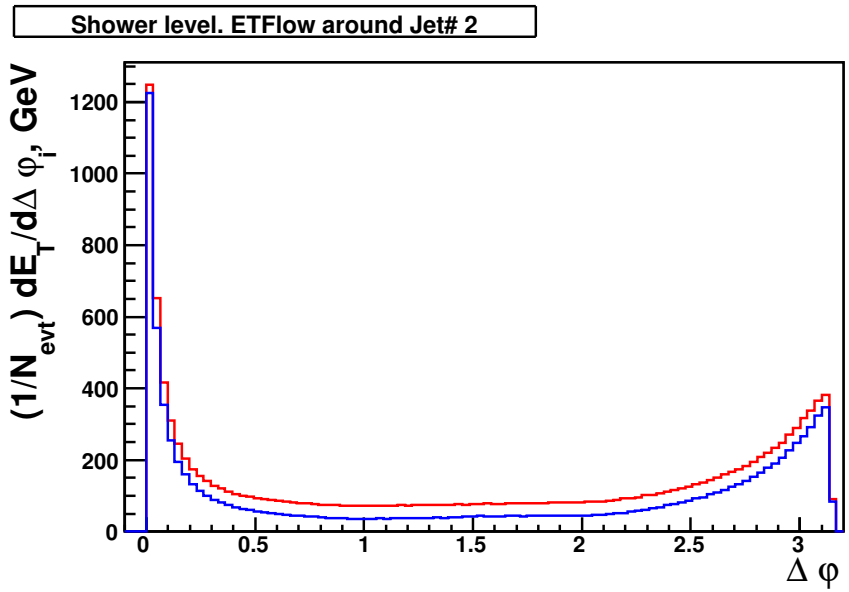


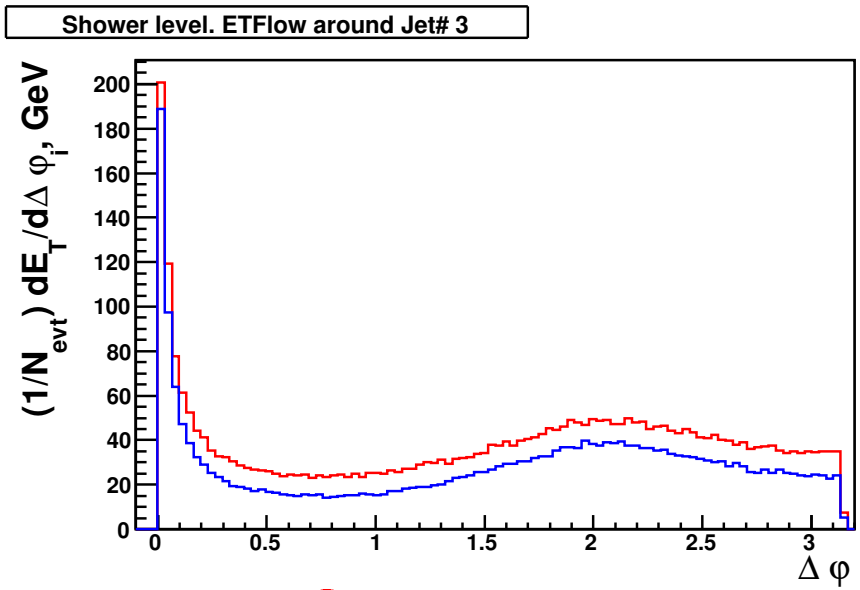


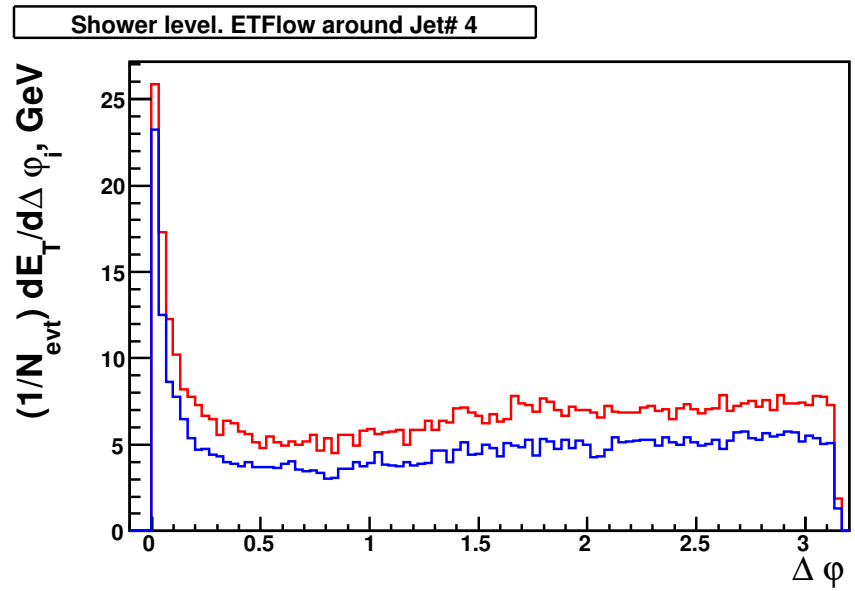
Hard Scale HS+UE Difference UEPartons only

Energy Flow $\frac{dE_T}{d\Delta\varphi}$ around four leading jets



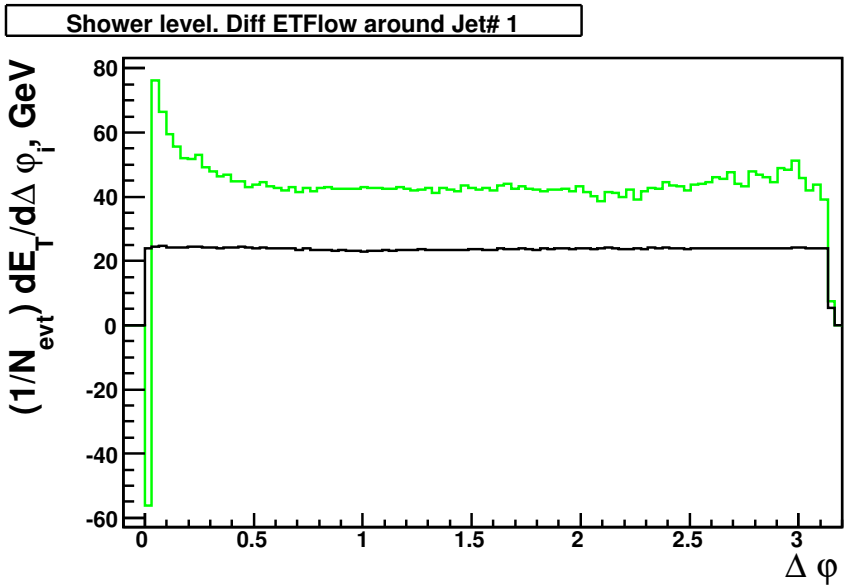


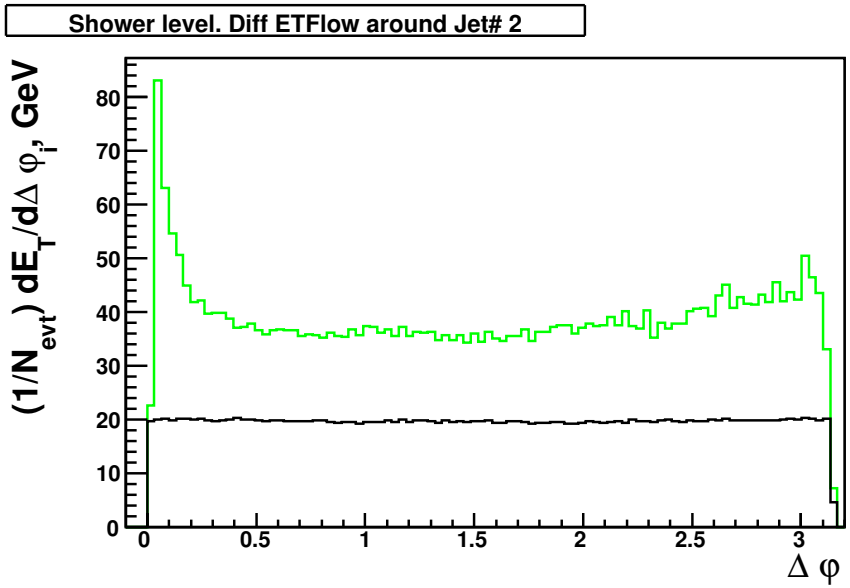


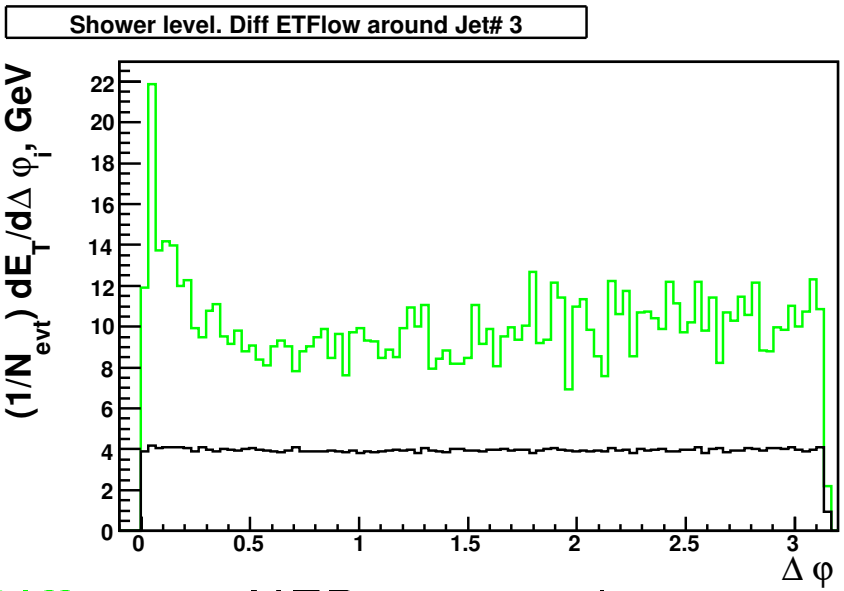


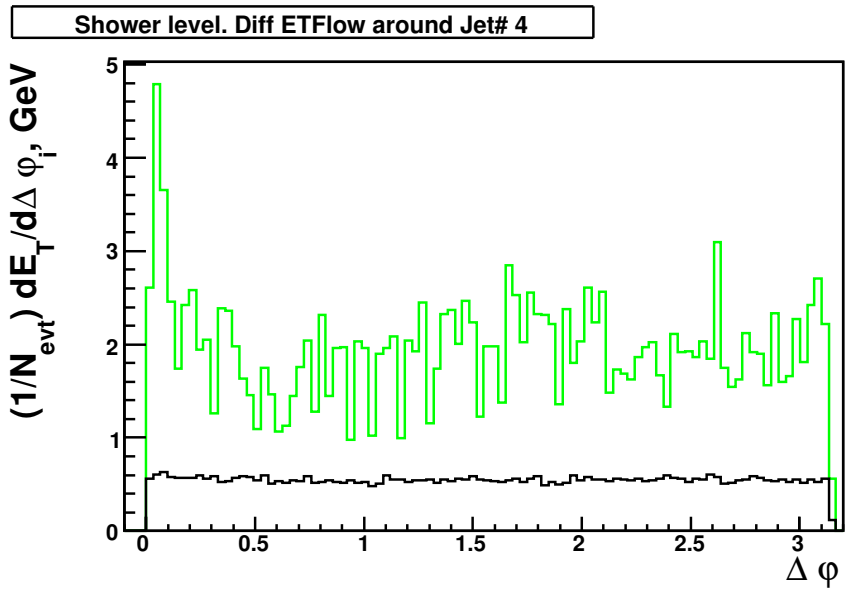
Hard Scale HS+UE

Energy Flow $\frac{dE_T}{d\Delta\varphi}$ around four leading jets









Difference UEPartons only

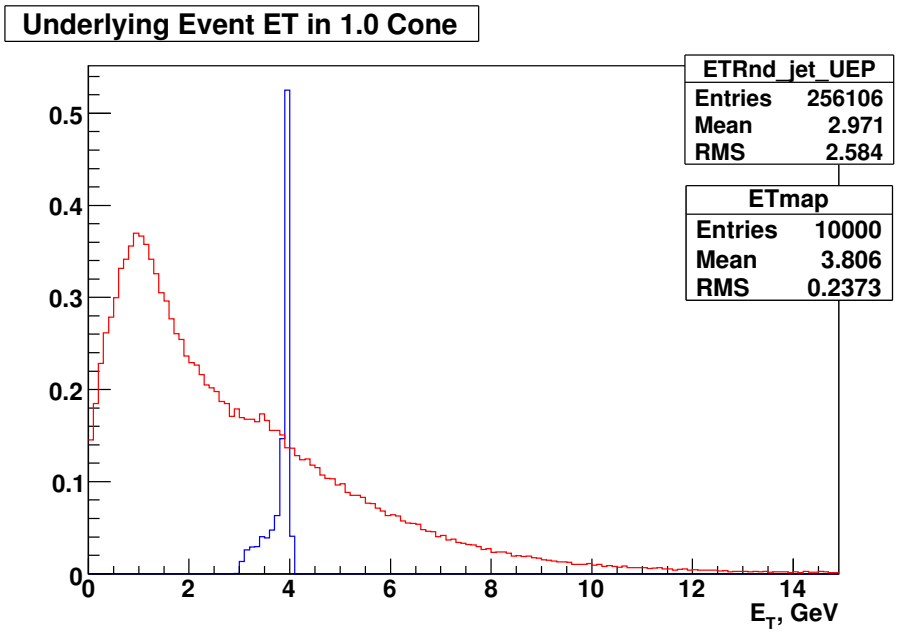
Subtraction

Possible strategy to subtract UE:

- measure MB and determine the average E_T in a cone around a random jet axis and subtract this from each jet
- However, this is not possible for K_T algorithm
  - Use sum of the constituents (to be studied)

Subtraction II

Map: $< E_T >$ in GeV of UE partons at Shower level



E_T in a Cone using UEMap E_T in a Cone on event-by-event basis

$$\frac{<E_T>}{<E_T>} \approx 1.28$$

- correlation on event-by-event basis important?
- need to fold in true η_{jet} distribution?

Conclusions & Next Steps

- Jets at HS+UE becomes broader
- Jet axis in HS+UE is not the same as in HS.
- UE changes the response of the jet algorithm
  - UE produce a bias to the Jet Algorithms