Some first thoughts to substract the underlying event under a jet ?

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Kt-algorithm is conceptually simply and is infra-red und collinear safe
(has been proposed to be used in pp-collisions
by Ellis/Soper and Catani/Seymour)

This algorithm has been successfully used at HERA in gamma-p frame
…but only since recently it has been really used for QCD cross-section at Tevatron

Main difficulty: because of the varying jet area, difficult to subtract
minimum bias (MB) events and the underlying events (UE)

This talk: Study what are the problems in UE subtraction…
See, if jet constituents can be used in case of cone algorithm
Aim: If this works, the same can be done in Kt

Some Definitions

1) Underlying Event (UE): collision of beam remnants
   →Subtraction is needed to compare to NLO calculation
   (non-perturbative correction)

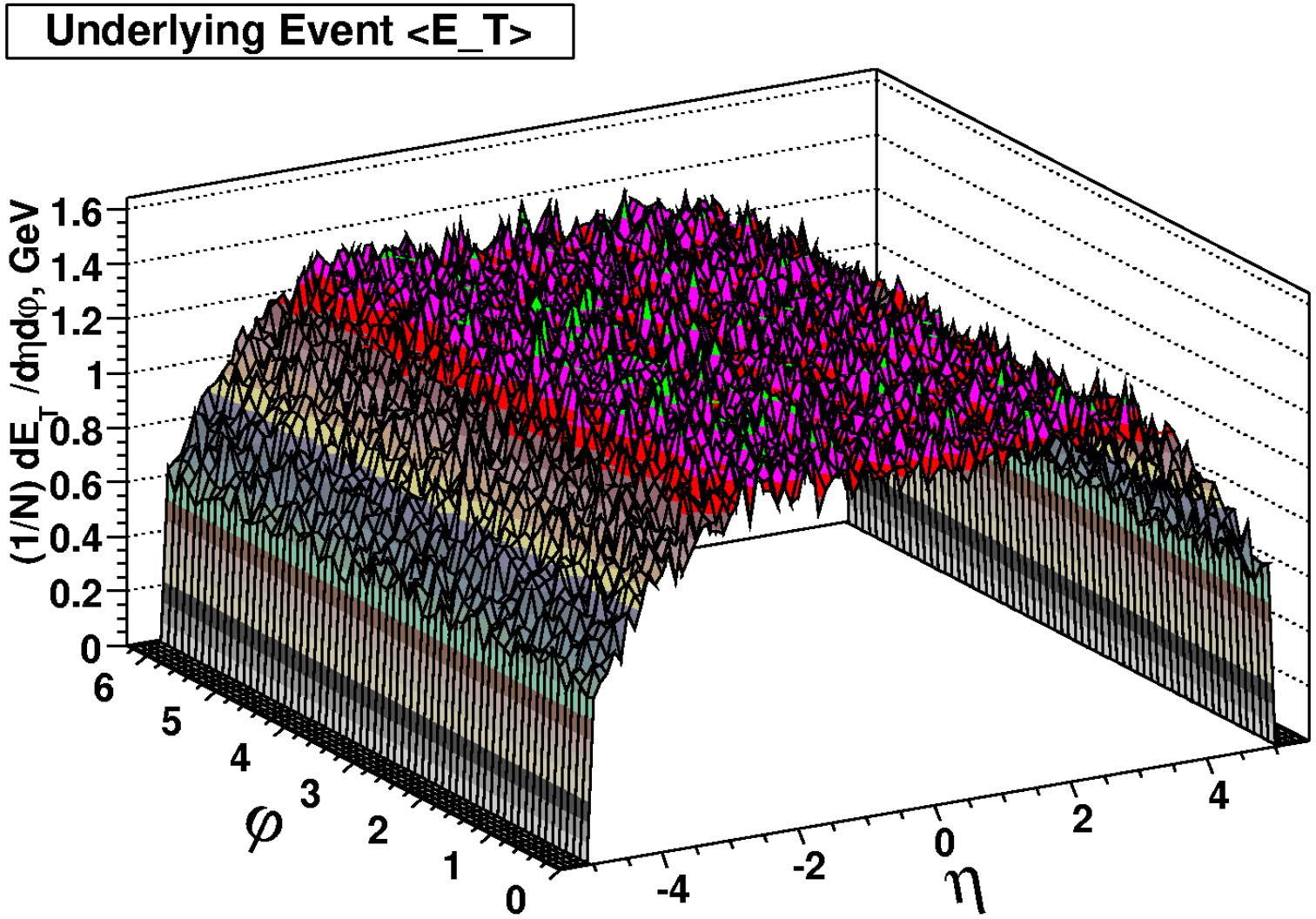
2) Minimum bias event (MBE): soft hadron-hadron collision in same bunch crossing
   → Subtraction needed to measure cross-section (hadron level)
   Can also exploit number of vertices in event

3) Pile-up (PUE): soft hadron-hadron collisions in different bunch crossing
   → Subtraction needed to
   Have to understand E vs time behaviour of detector

Here we just study UE…it is the easiest case

Underlying Event Generation

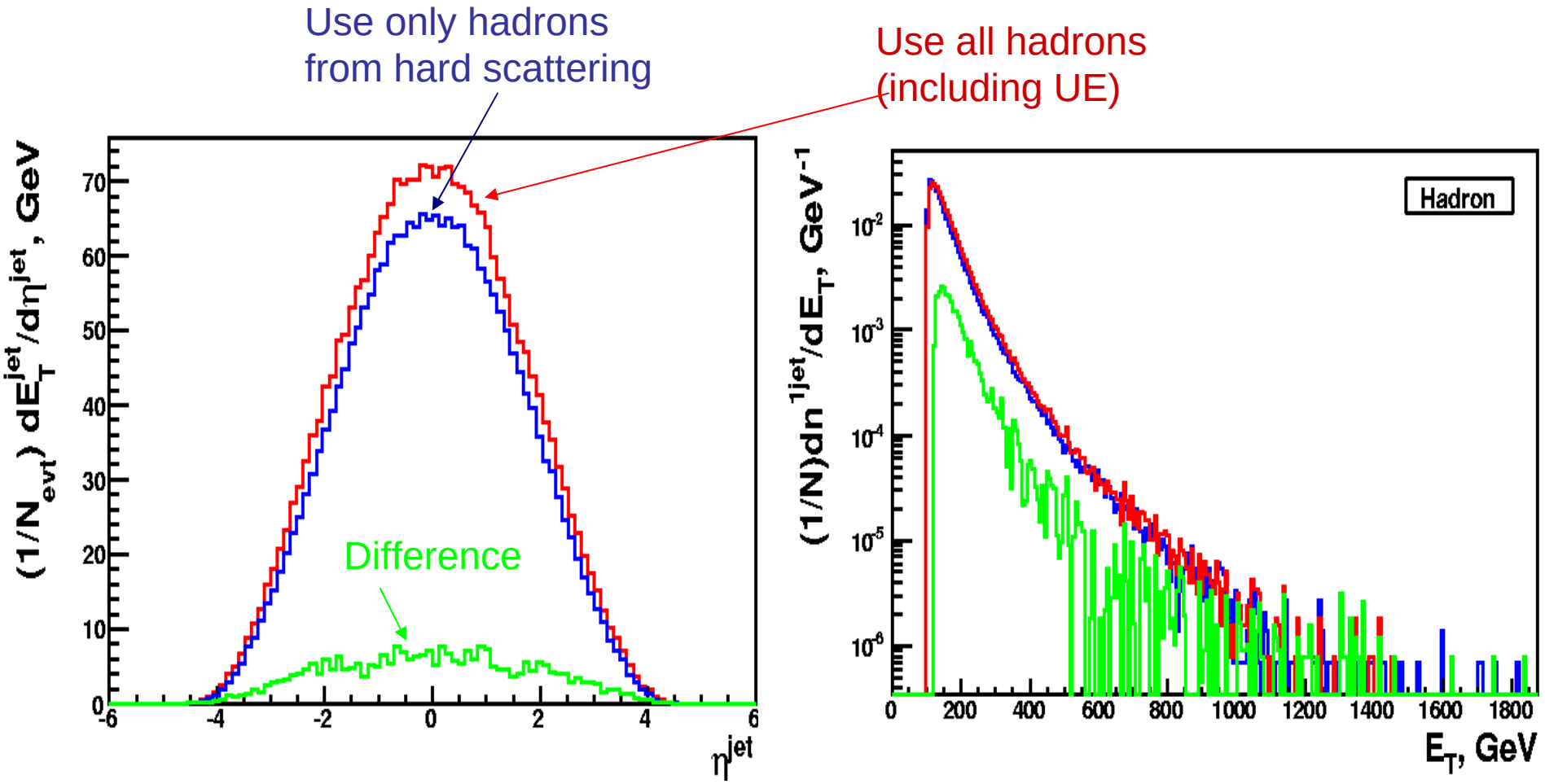
We use SHERPA 1.0.8 to generate UE



UE: flat in ϕ, large η suppressed by phase space

Leading Jet Cross-section

Jet cut: $E_{T,jet} > 100GeV,\ |\eta_{jet}| \leq 5$ use the D0 version of the Midpoint algorithm



→ UE causes sizeable change of jet cross-section

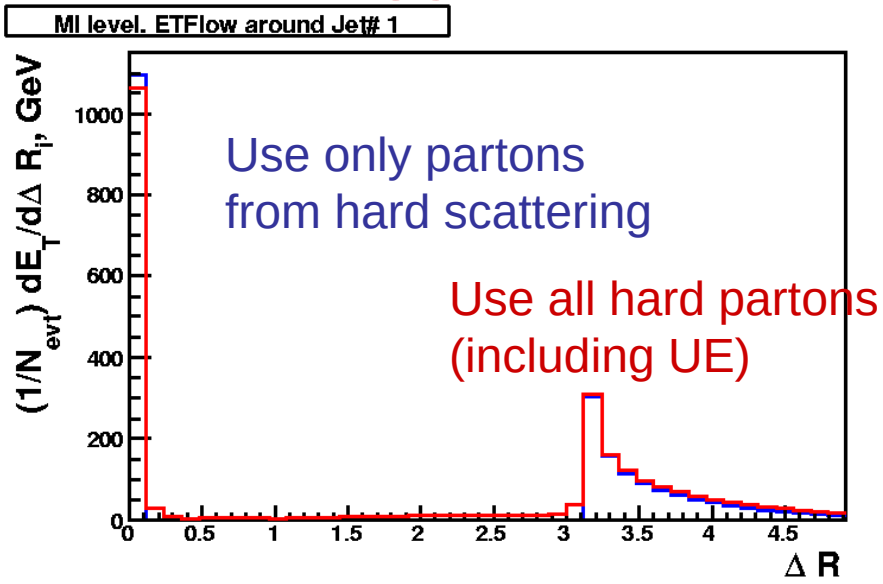
How to deal with UE ?

Assumption: Hard scattering and UE are largely uncorrelated
(correlation has been observed, but is weak
Minimum bias event are completely uncorrelated)
Nevertheless:
Any strategy to substract UE energy has to deal with possible biases:

1. Jet algorithm sees UE when defining jet
   e.g. decision to merge to a certain parton configuration into
   2 or 3 jets might depend on the presence of UE, therefore
   the Et of the individual jets can be different

2. UE has structure on an event by event basis
   e.g. probability to see a hadron in a certain eta/phi range is higher
   if there is already a hadron

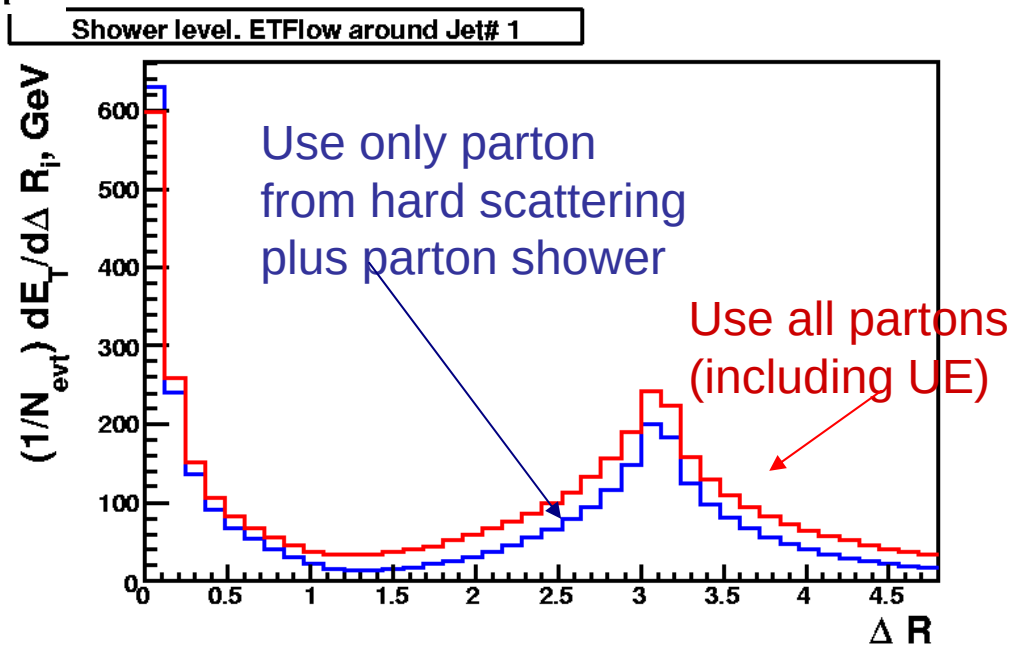
Energy Flow around Leading Jet



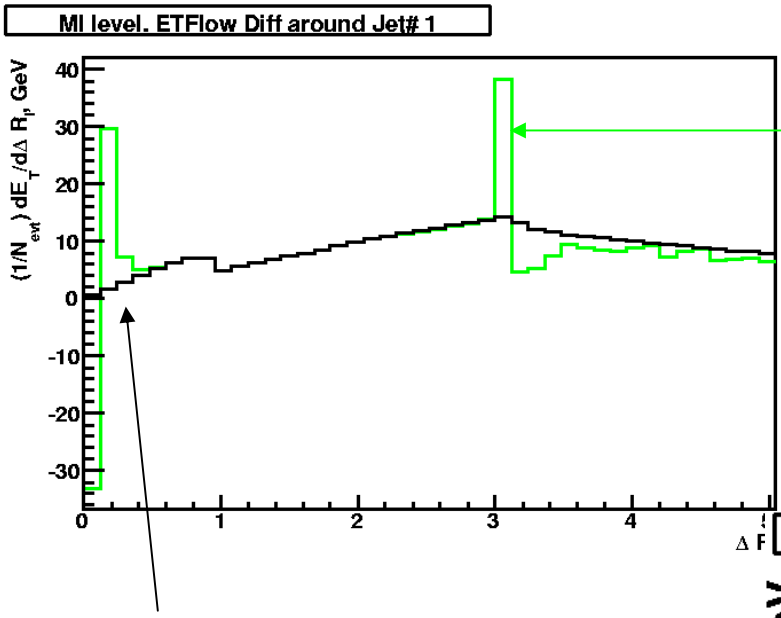
Jets are in most cases back-to-back
(limit deta=0 for LO)

Leading jet is mostly one parton

UE reduces energy in core and widens
(jet axis might be changed a bit..)

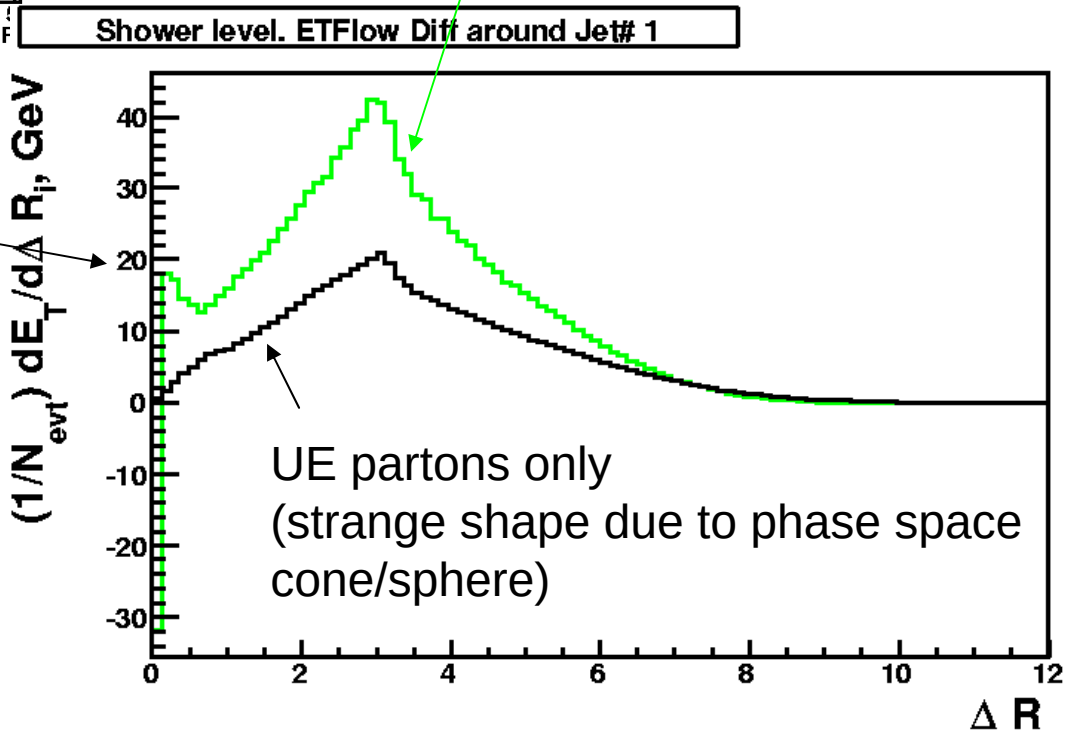


dR Energy Flow around Leading Jet



Difference:
with-without UE

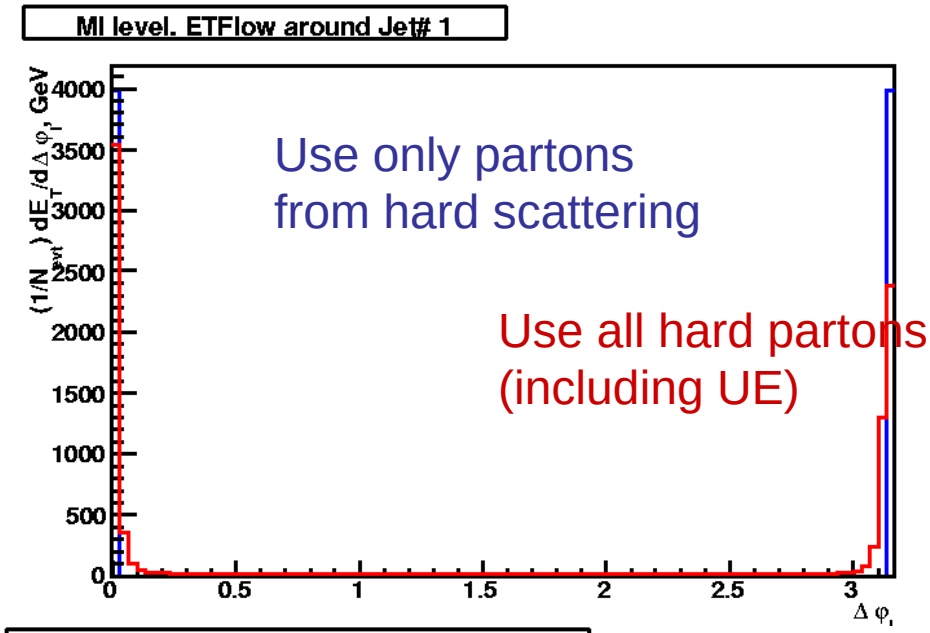
Jet algorithm pulls in UE partons
and changes jet axis

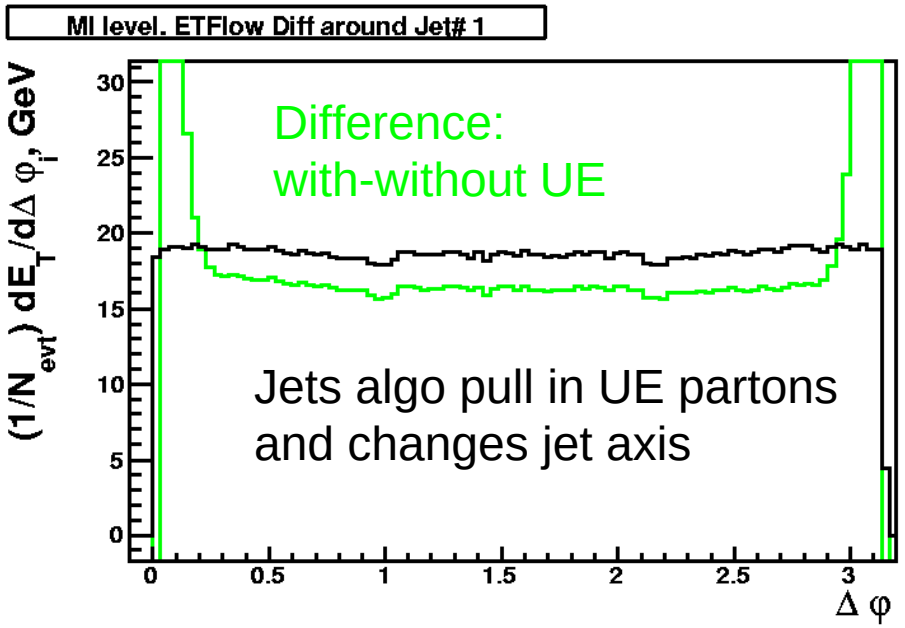


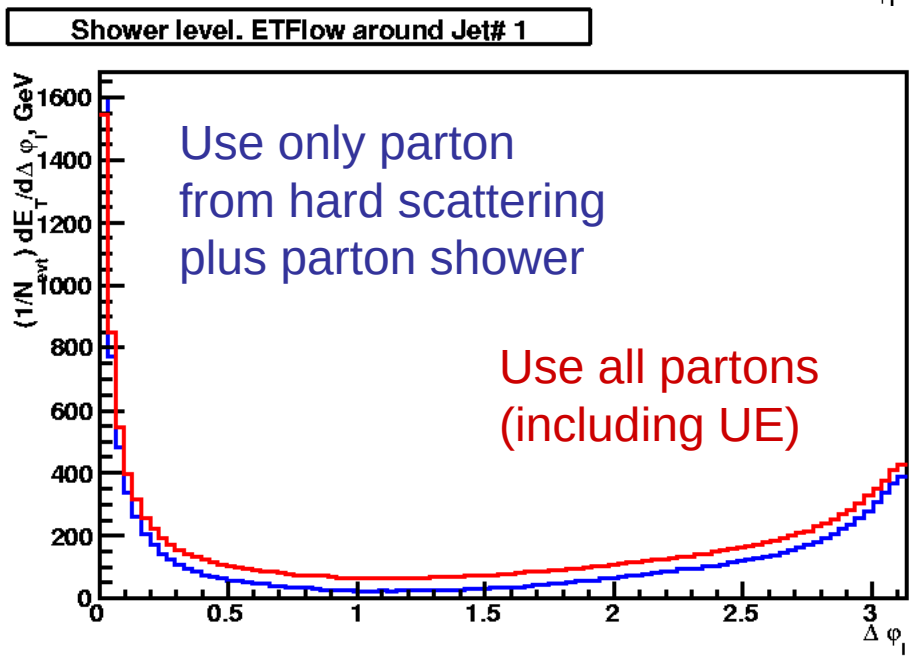
UE partons only
(strange shape due to phase space
cone/sphere)

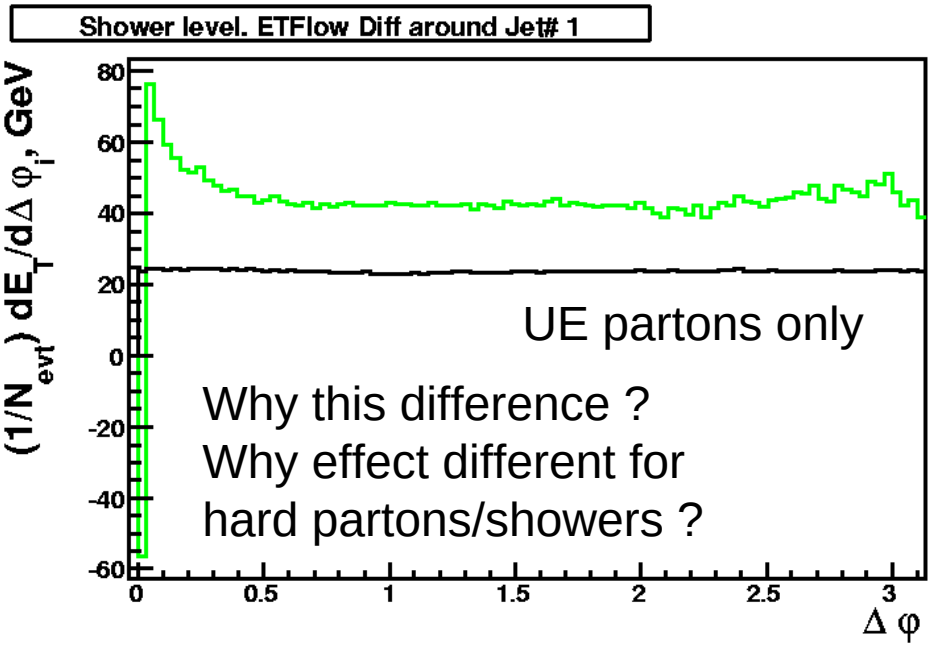
Why cross-section difference
is very different from
mean UE energy ??

dPhi Energy flow around Leading Jet









UE Subtraction

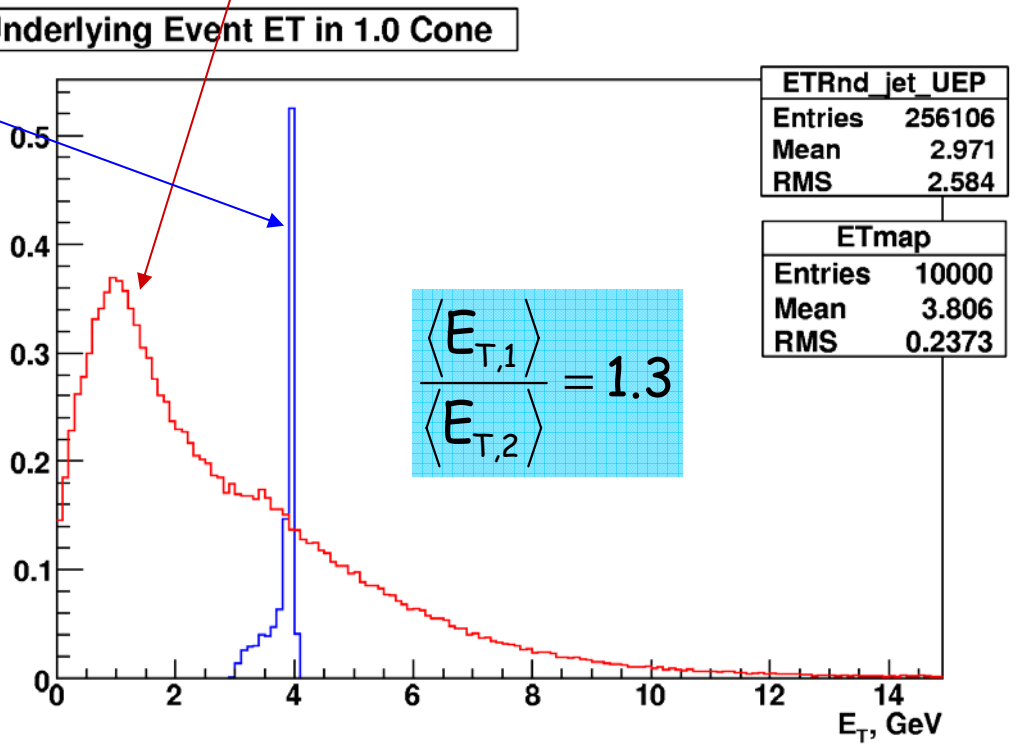
Possible strategies:
Measure minimum bias events:

1) -determine mean Et in cone around random axis
   -subtract this number from each jet
   (not possible for Kt-algorithm, since jet area is not well defined)

2) -Determine mean Et in eta/phi tower,
   -sum of mean Et of jet constituents
   (possible for Kt, if no holes)

Mean Et using method 1 and 2
Is not the same !

Why ?
Correlation event-by-event ?
Need to fold in eta-jet distribution ?



Conclusion

UE subtraction is rather tricky for all algorithms

Jet algorithm see UE during jet clustering
→ cross-section with-without UE not equal mean UE energy

It seems that jet algorithm pulls in UE and changes axis

… effect to be quantified

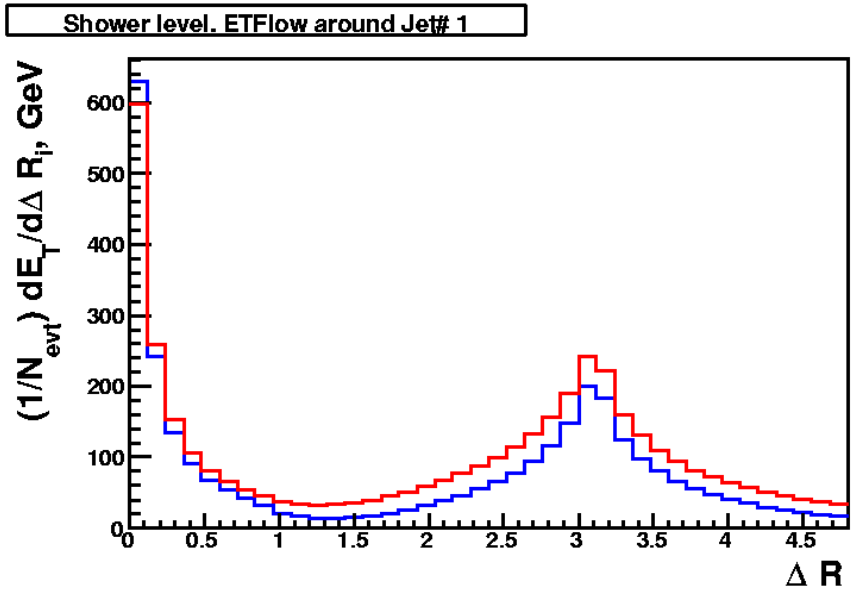
Next step: define a cross-section (or mass of a particle)
and quantify how a give correction method works

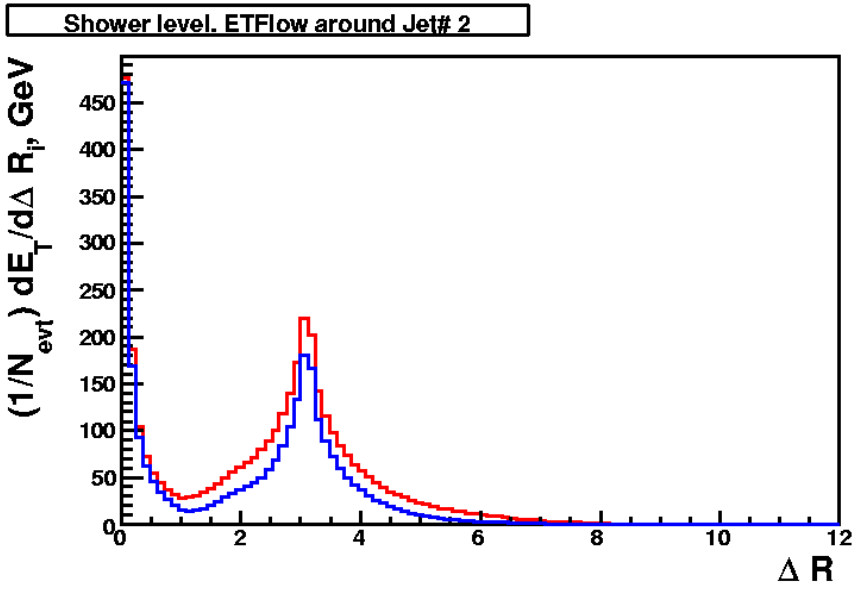
For Kt-need to define area
e.g. via constituents (e.g. calo cells/towsers)
or as proposed by M.Cacciari/G. Salam using large number of soft particles

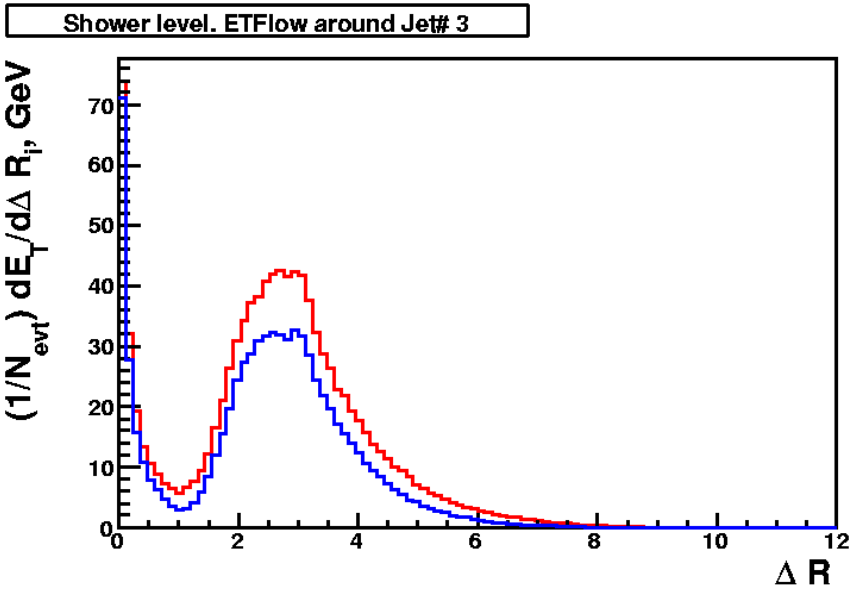
Potenial problem:

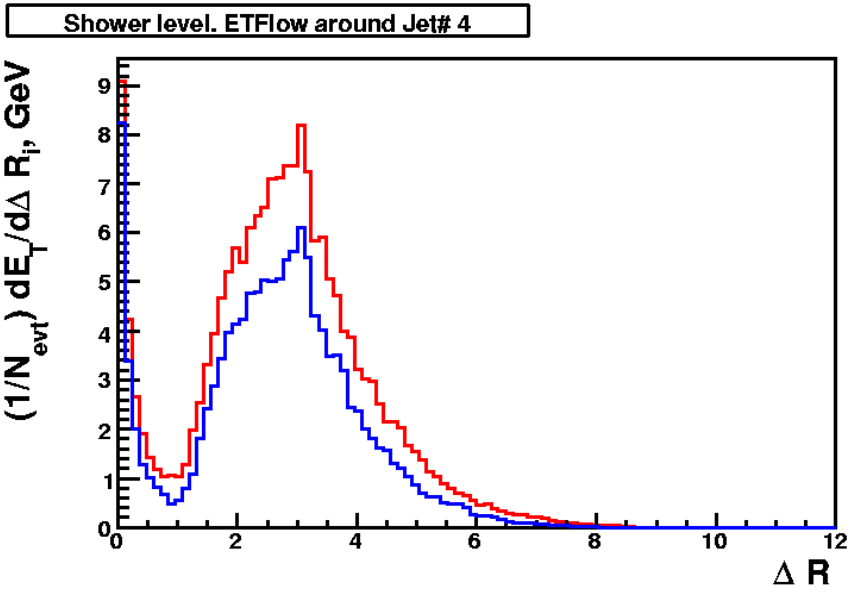
$$\sum_{constituants} \langle E_T \rangle_{events} \neq \left\langle \sum_{constituants} E_T \right\rangle_{events}$$

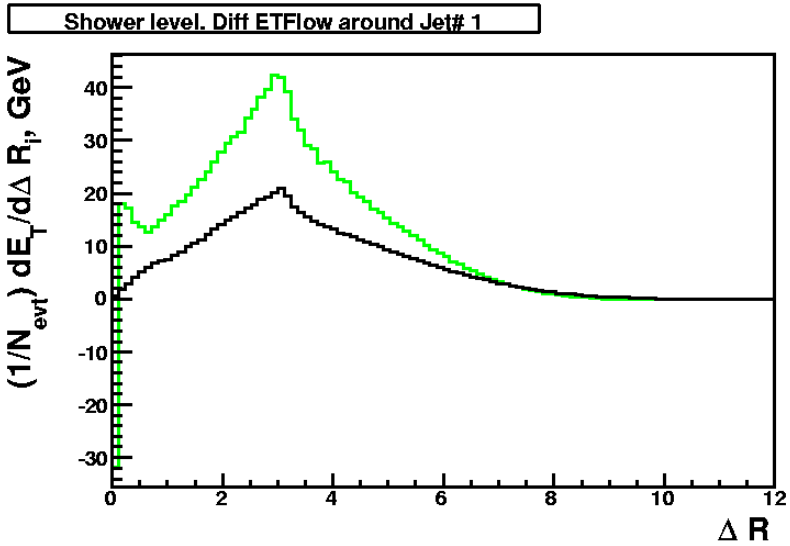
Energy Flows around Jets

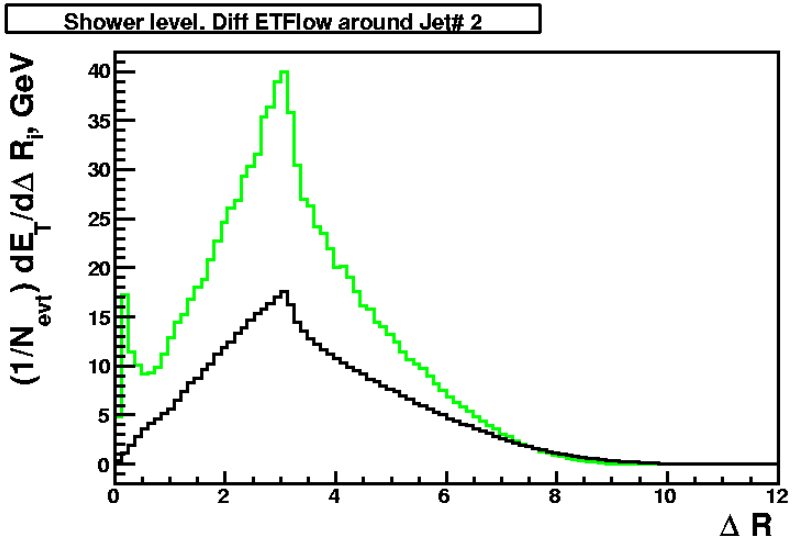


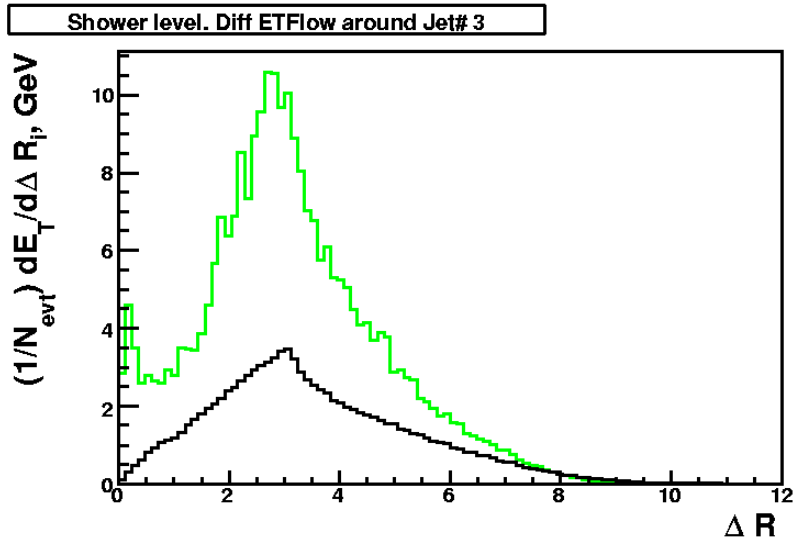


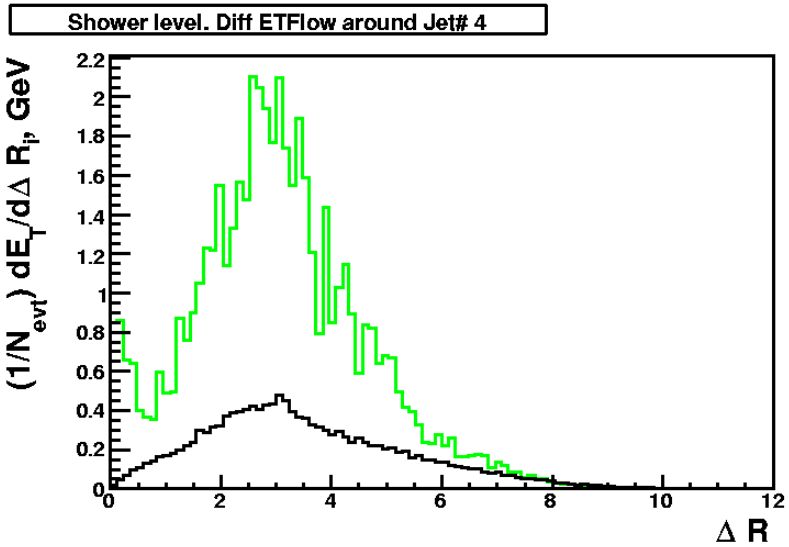





Shower level. Diff ETFlow around Jet# 1
(1/N_evt) dE_T/dΔ R_j, GeV
Δ R


Shower level. Diff ETFlow around Jet# 2
(1/N_evt) dE_T/dΔ R_j, GeV
Δ R


Shower level. Diff ETFlow around Jet# 3
(1/N_evt) dE_T/dΔ R_j, GeV
Δ R


Shower level. Diff ETFlow around Jet# 4
(1/N_evt) dE_T/dΔ R_j, GeV
Δ R