Update on Matched Data Sets

Is the Devil in the Details?

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New Initial Luminosity Record 76.384E30
6/7/04 1520

Background Material

Matching Matrix Elements with Parton Showers with PYTHIA and HERWIG

⇒ Work with P. Richardson (HERWIG) ⇐

Pythia PS + ME Matching

http://arxiv.org/abs/hep-ph/0312274

CKKW (Catani, Krauss, Kuhn, Webber) developed matching algorithm for e^+e^-

- Extend to hadronic collisions
- Adapt to available PS + hadronization codes
- Pseudoshower method

Pythia as a Development Tool

Basic Problem:

1. PS does not describe energetic, wide-angle emissions very well
2. ME+PS leaves some ambiguity
   - dependence on parton-level cuts
   - feed-up and feed-down of jets

Partial Solution (CKKW):

1. Remember why PS is successful: Sudakov suppession + $\alpha_s(p_\perp)$
2. Use new fast, efficient ME programs
   (a) generate complex topologies at ME level
   $W+0, \cdots W+4$ partons with cutoff
   (b) reweight events to have PS form
   apply Sudakovs and $\alpha_s(p_\perp)$
3. Bootstrap below cutoffs using standard PS tools

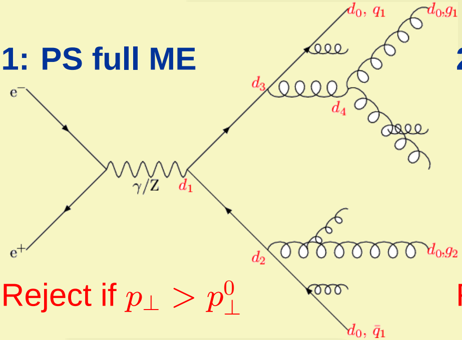
   Need these anyways to connect to hadronization and UE models

Pseudo–Showers and Sudakov Weight

Example: $e^+e^- \to 5$ partons

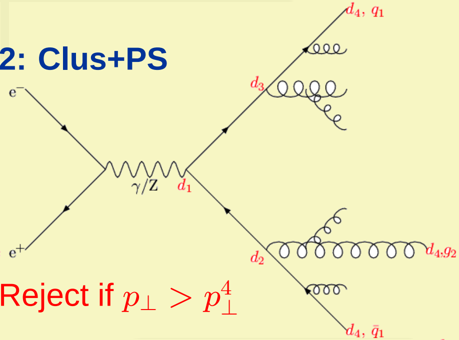
Calculate $p_\perp$-cluster values: $p_\perp^1 > p_\perp^2 > p_\perp^3 > p_\perp^4 > p_\perp^0$ = cutoff

1: PS full ME



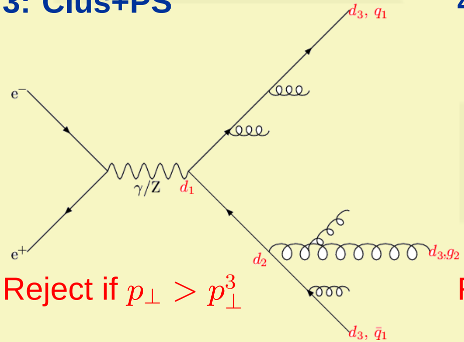
Reject if $p_\perp > p_\perp^0$

2: Clus+PS



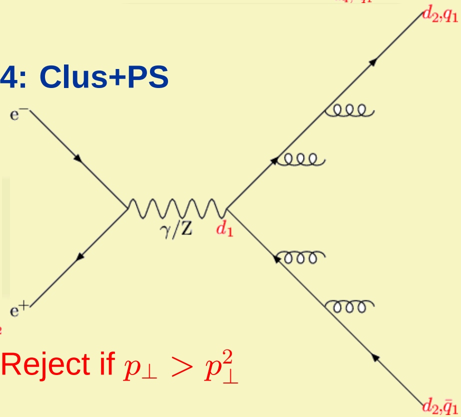
Reject if $p_\perp > p_\perp^4$

3: Clus+PS



Reject if $p_\perp > p_\perp^3$

4: Clus+PS

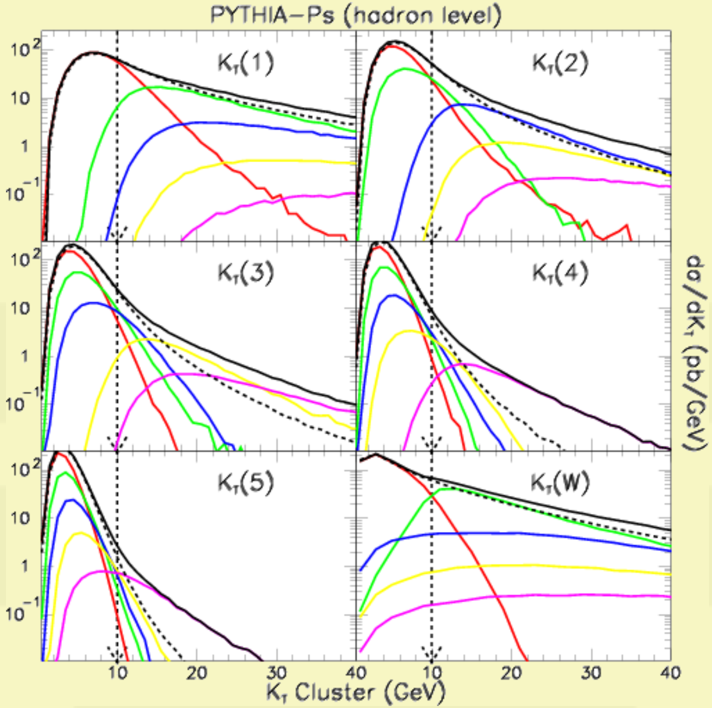


Reject if $p_\perp > p_\perp^2$

mc4 run2

CDF Theatre

W+0 $\oplus \cdots \oplus$ W+4 hard partons



$$k_T^2 = 2\text{min}(E_i, E_j)^2(1 - \cos\theta_{ij}) \sim \text{min}(E_i/E_j, E_j/E_i)m^2$$

Solid is Pseudoshower result

Dashed is PYTHIA with default (ME) correction

Other colors represent different ME contributions (0, 1, 2, 3, 4 partons)

Extension of Datasets

$\surd$ Include RF Underlying Event Tunes and QED Radiation

$\surd$ Muons $\Leftrightarrow$ Electrons

$\times$ $e^+\nu_e \Rightarrow e^-\bar{\nu}_e$

Particle $\Rightarrow$ Antiparticle && $\vec{p} \Rightarrow -\vec{p}$

Location	Leptons	QED	UE
/pnfs/patriot/Z_jets/MEPS/32858/	E	1	A
/pnfs/patriot/Z_jets/MEPS/34895/	E	1	Default
/pnfs/patriot/Z_jets/MEPS/55531/	M	0	Default
/pnfs/patriot/Z_jets/MEPS/49289/	M	1	B
/pnfs/patriot/W_jets/MEPS/34211/	E	1	A
/pnfs/patriot/W_jets/MEPS/34748/	E	1	Default
/pnfs/patriot/W_jets/MEPS/72342/	M	0	Default
/pnfs/patriot/W_jets/MEPS/48623/	M	1	A

Note: The numbers refer to job numbers and are otherwise meaningless

Other Improvements

Automation of Code to Handle (Color Singlet)+QCD radiation

- i.e. $WW + 0, 1, 2, 3, 4$ partons

Tracking down one case of odd behavior in $Wb\bar{b}$+jets generation with `MadEvent`

- As a cross check, would like to be able to get experiments ME datasets for the same

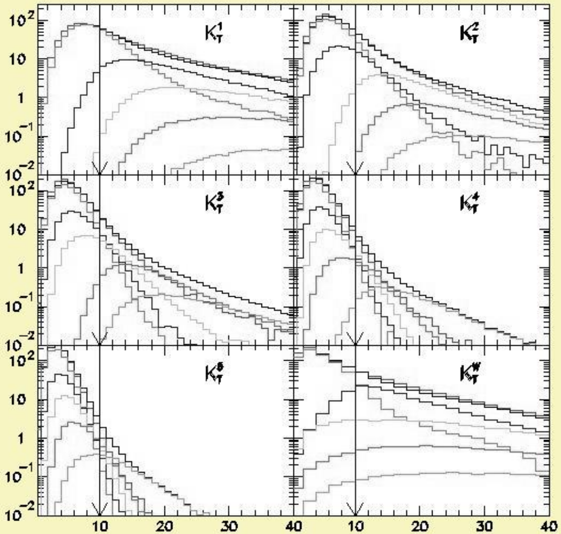
Declaration of Datasets in `SAM`

- Developing duplicate and complementary Database with summer student

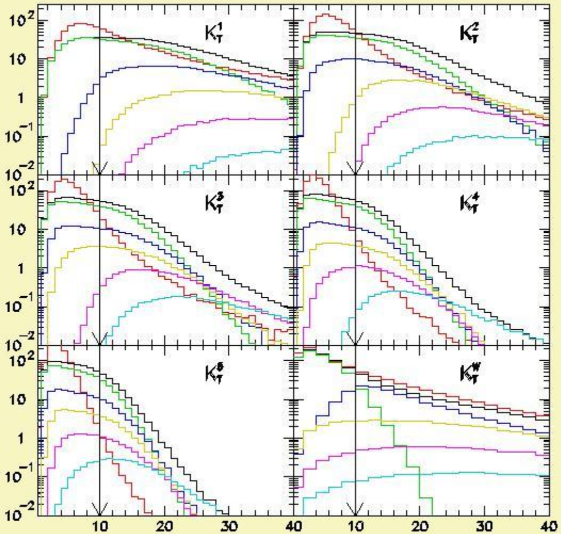
What is the Impact of the UE?

1. Should Tune 0, A-D, Z matter for high-p_T physics?
2. Should it effect Matched Datasets?
   - Only match to shower partons
   - “soft” physics smooths over how/where matching is done

1: Default



2: Tune A



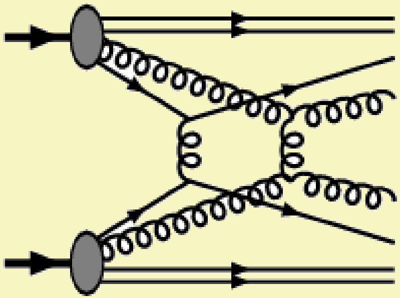
Standard Pythia uses Default UE in both plots

Underlying Event Model

P. Skands & T. Sjöstrand (Lund) JHEP 0403:053,2004

Multiple Interactions

Consequence of composite nature of hadrons!

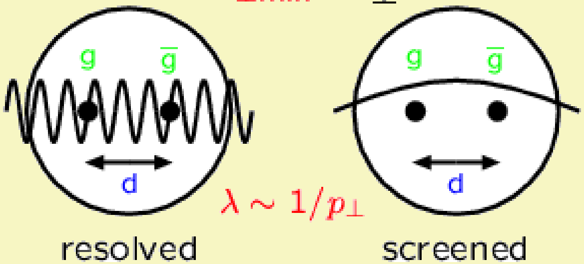


Evidence:

- direct observation: AFS, UA1, CDF
- implied by width of multiplicity distribution + jet universality: UA5
- forward–backward correlations: UA5
- pedestal effect: UA1, H1, CDF

One new free parameter: $p_{\perp\mathrm{min}}$

$$\frac{1}{2}\sigma_{\mathrm{jet}} = \int_{p_{\perp\mathrm{min}}^2}^{s/4} \frac{\mathrm{d}\sigma}{\mathrm{d}p_\perp^2}\,\mathrm{d}p_\perp^2 \quad \Longleftarrow \quad \int_0^{s/4} \frac{\mathrm{d}\sigma}{\mathrm{d}p_\perp^2}\,\frac{p_\perp^4}{(p_{\perp 0}^2 + p_\perp^2)^2}\,\mathrm{d}p_\perp^2$$

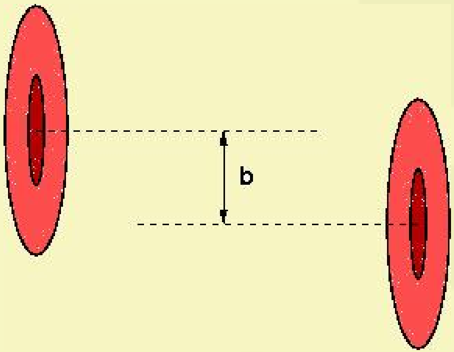


Measure of colour screening length d in hadron:

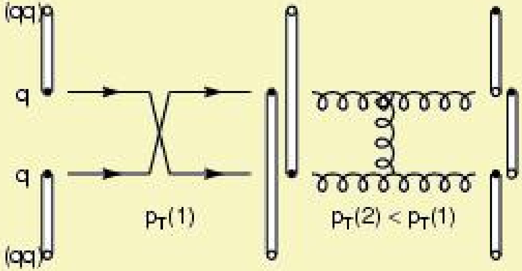
$p_{\perp\mathrm{min}} \langle d \rangle \approx 1 (= \hbar)$

Features of Old Model: Tunes A-D

- Matter distribution in hadrons → overlap $O(b)$
- $\langle \mathrm{N_{int}} \rangle \sim \mathrm{k}O(b)$
- $\dfrac{d\mathcal{P}}{dp_{\perp}i} = \dfrac{1}{\sigma}\dfrac{d\sigma}{dp_{\perp}} \exp[-\int_{p_{\perp}}^{p_{\perp}i-1} \dfrac{1}{\sigma}\dfrac{d\sigma}{dp'_{\perp}} dp'_{\perp}]$



- Strings carry color information
- MIs mainly reconnect to pre-existing strings
- Minimizes string length



MSTP(82) :
(D=1) structure of multiple interactions. For QCD processes, used down to values below , it also affects the choice of structure for the one hard/semi-hard interaction.

= 0 :
simple two-string model without any hard interactions. Toy model only!

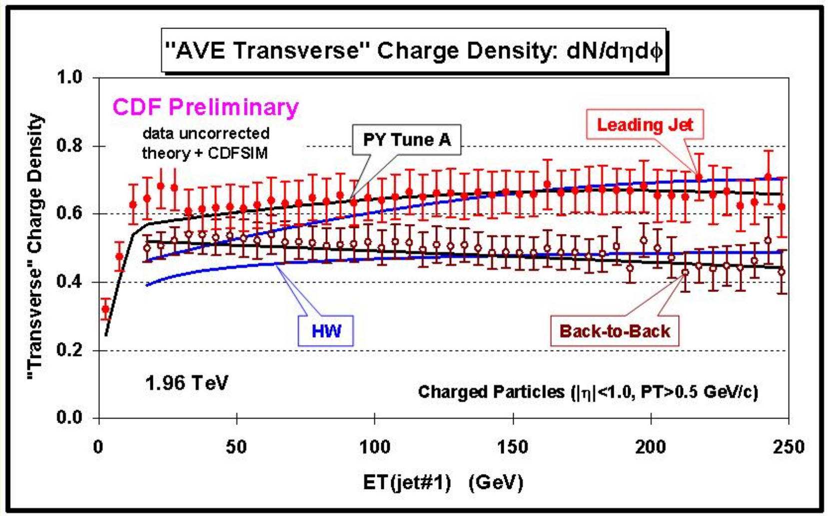
= 1 :
multiple interactions assuming the same probability in all events, with an abrupt cut-off at PARP(81). (With a slow energy dependence given by PARP(89) and PARP(90).)

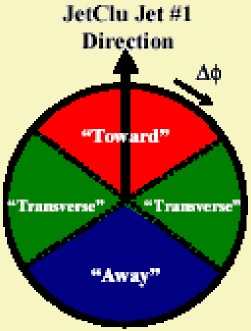
= 2 :
multiple interactions assuming the same probability in all events, with a continuous turn-off of the cross section at PARP(82). (With a slow energy dependence given by PARP(89) and PARP(90).)

= 3 :
multiple interactions assuming a varying impact parameter and a hadronic matter overlap consistent with a Gaussian matter distribution, with a continuous turn-off of the cross section at PARP(82). (With a slow energy dependence given by PARP(89) and PARP(90).)

= 4 :
multiple interactions assuming a varying impact parameter and a hadronic matter overlap consistent with a double Gaussian matter distribution given by PARP(83) and PARP(84), with a continuous turn-off of the cross section at PARP(82). (With a slow energy dependence given by PARP(89) and PARP(90).)

Pythia at Run2: Underlying Event

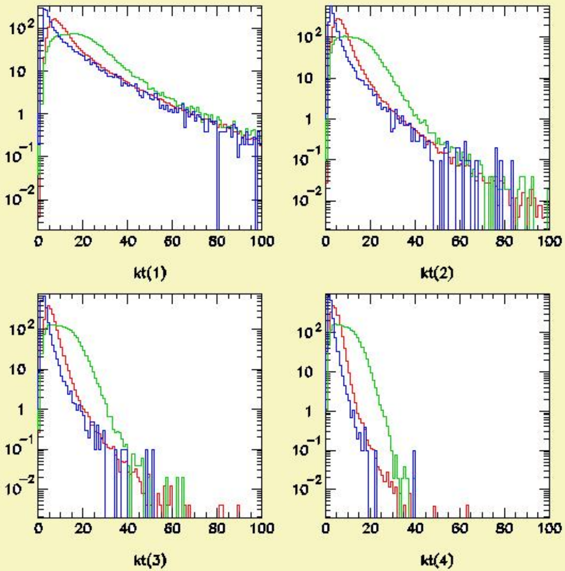




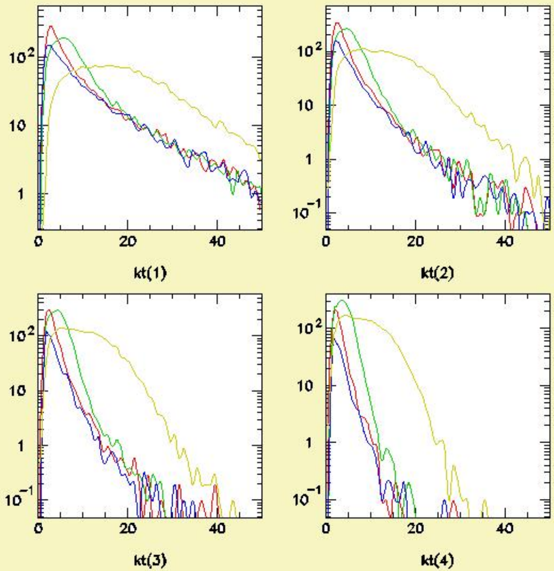
PYTHIA 6.206 and CDF Tune A (CTEQ5L)			
Parameter	Default	Tune	Description
PARP(67)	1.0	4.0	Scale factor for ISR
MSTP(82)	1.0	4	Double Gaussian matter distribution
PARP(82)	1.9	2.0	Cutoff (GeV) for MPIs
PARP(83)	0.5	0.5	Warm Core with % of matter
PARP(84)	0.2	0.4	within a given radius
PARP(85)	0.33	0.9	Prob. that two gluons have NNC
PARP(86)	0.66	0.95	gg versus $q\bar{q}$
PARP(89)	1000.0	1800.0	Reference energy (GeV)
PARP(90)	0.16	0.25	Power of Energy scaling for cutoff

Comparison of Standard Pythia

1: True k_T



2: R=0.4



No UE Default UE Tune A

Tune A k_T compared to R

R vs k_T Again

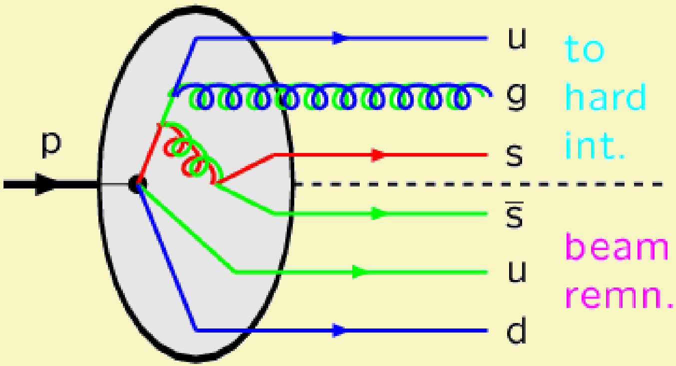
$R = 0.4$ jets converge about $E_T > 20$ GeV

- Limited reach of cone
- What fixes 20 GeV?

k_T jets sensitive to UE model

- "No" limit to reach
- Can this be turned into a way to measure UE?
- How **universal** is the UE model?

Model Correlations in flavor, x_i, Color



Need to assign:

- correlated flavours
- correlated $x_i = p_{zi}/p_{z\text{tot}}$
- correlated primordial $k_{\perp i}$
- correlated colours

for initiators and remnants

+ showers (intertwined?)

Example: parton densities after first interaction:

- valence: scale by #remaining/#original
- sea: bookkeep 'companion' by

$$\bar{s}(x'; x) \quad \propto \quad \frac{g(x+x')}{x+x'} P_{g \to s\bar{s}} \left(\frac{x}{x+x'} \right)$$

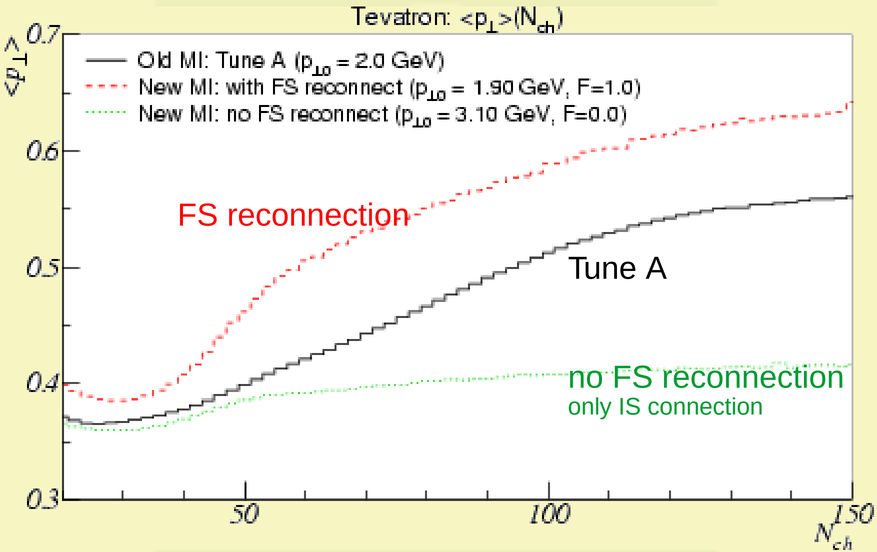
- gluon and normal sea: rescale for momentum conservation

Baryon number topology: junction fragmentation
(nontrivial when ≥ 2 valence quarks kicked out)

Developed for R-parity violation

Testing Color Correlations

- Model describes well multiplicity and charged particle spectra (good as Tune A)
- One difficult observable is $\langle p_\perp \rangle (n_{\mathrm{ch}})$
  - transverse momentum (per charged particle) as a function of n_{ch}
- At present, cannot describe it but color connections are the key



$\downarrow$ str. len
$\uparrow$ n_{int}
$\uparrow$ $\langle p_\perp \rangle$

- Necessity of intertwined (ISR $\longrightarrow$ MI) showers and/or FS reconnections?
- Color connections are the crudest part of the model and there is probably interesting physics behind it (what is the mechanism?)