CMS UE Plans

Livio Fano'

on behalf of the MBUE@CMS group

https://twiki.cern.ch/twiki/bin/view/CMS/MBUE

Institutions and groups participating (present, past, future)

* CERN
    - A. De Roeck
* Cukurova University (Adana)
    - N. Bakirci
* DESY
    - H. Jung, N. Sen, A. Knutsson
* Florida University
    - R. Field, M. Zakaria, Khristian Kotov
* Hamburg University
    - F.Bechtel, P. Schleper
* National Taiwan University
    - P. Bartalini, Min-zu Wang, Yuan Chao, Chang You Hao
* Perugia University
    - G. Bilei, L. Fano', A. Lucaroni
* Trieste University
    - D.Treleani, F.Ambroglini

few words on CMS

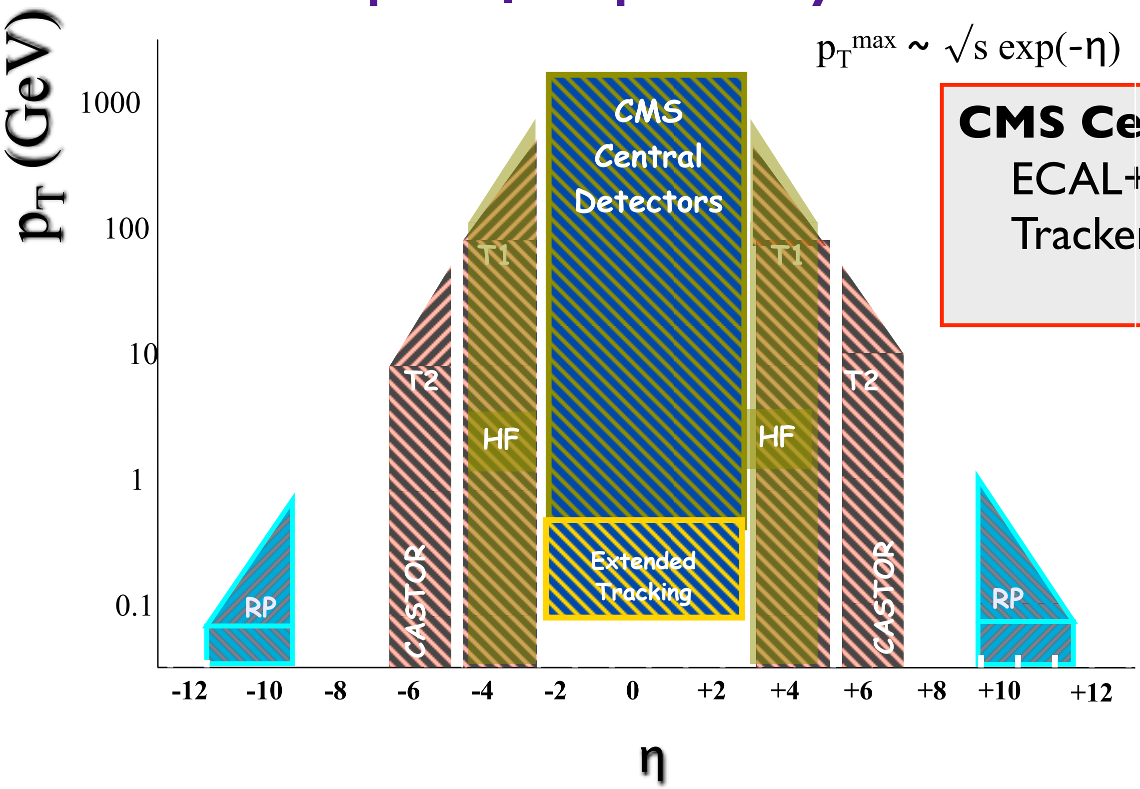
UE in central region

- + jets
- + leading track
- + DY

UE in forward region

MPI specials

CMS pT-η capability



CMS Central detectors:
ECAL+HCAL $|\eta| \leq 3$
Tracker $|\eta| \leq 2.4$
pT> 70 MeV

CMS Forward detectors:
Hadron Forward Calorimeter HF: $3 \leq |\eta| \leq 5$
Castor Calorimeter: $5.2 \leq |\eta| \leq 6.5$
Beam Scintillation counters BSC
Zero-Degree Calorimeter ZDC

TOTEM detectors:
T1 (CSC) in CMS endcaps, T2 (GEM) behind HF
T1 + T2: $3 \leq |\eta| \leq 6.8$
Roman Pots with Si det. up to 220 m

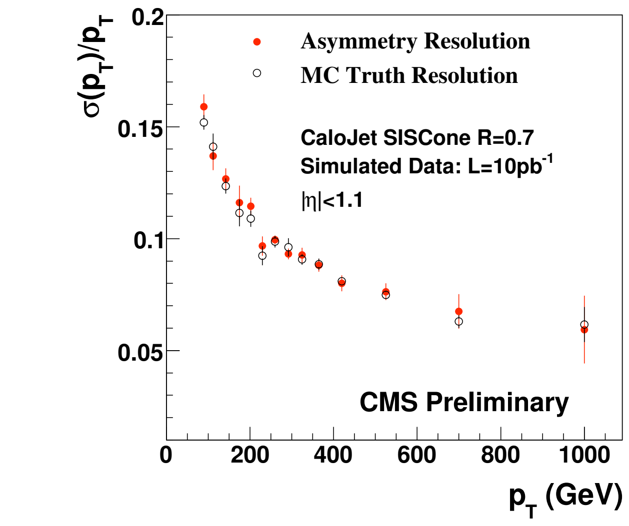
Remember - CMS design choice:

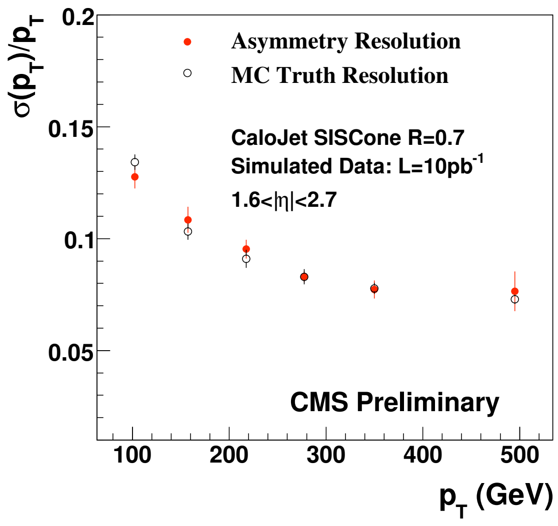
optimize performance for muon/ track momentum resolution and electromagnetic energy resolution....

Now working on: Particle Flow

combine in optimal way information from all subsystems should considerably improve resolution, especially at low jet pT

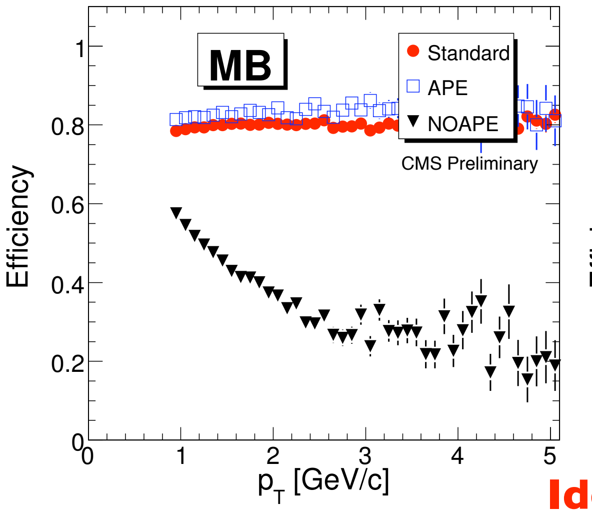
Performances and detectors choice

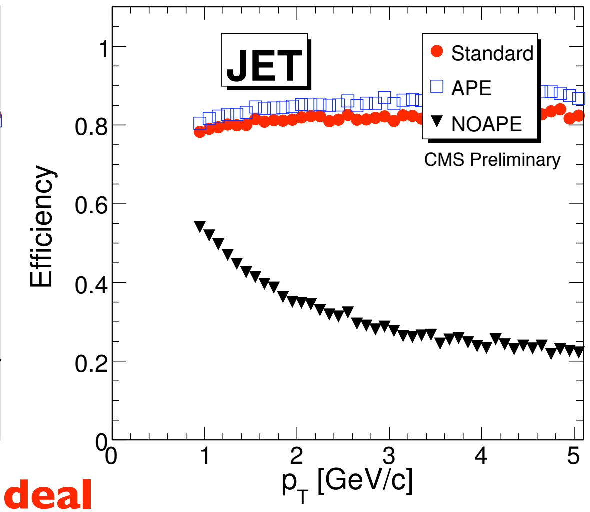


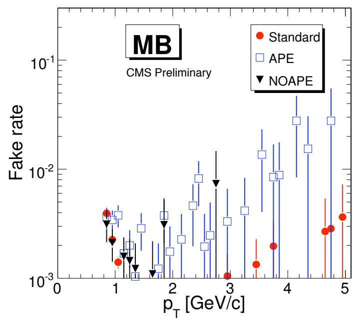


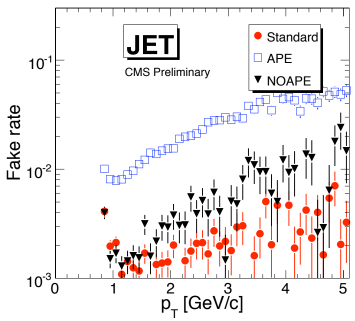
expected jet energy resolution
(in this plot form di-jet balancing)

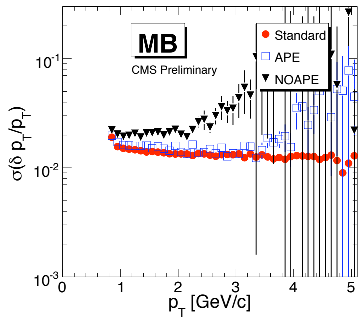
expected tracking performnaces

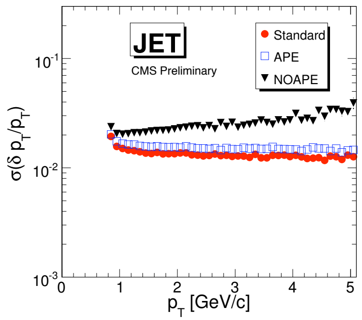












Ideal
startup
startup+APE

MinBias Trigger

Several level 1 (hardware trigger) strategies depending on instantaneous lumi:

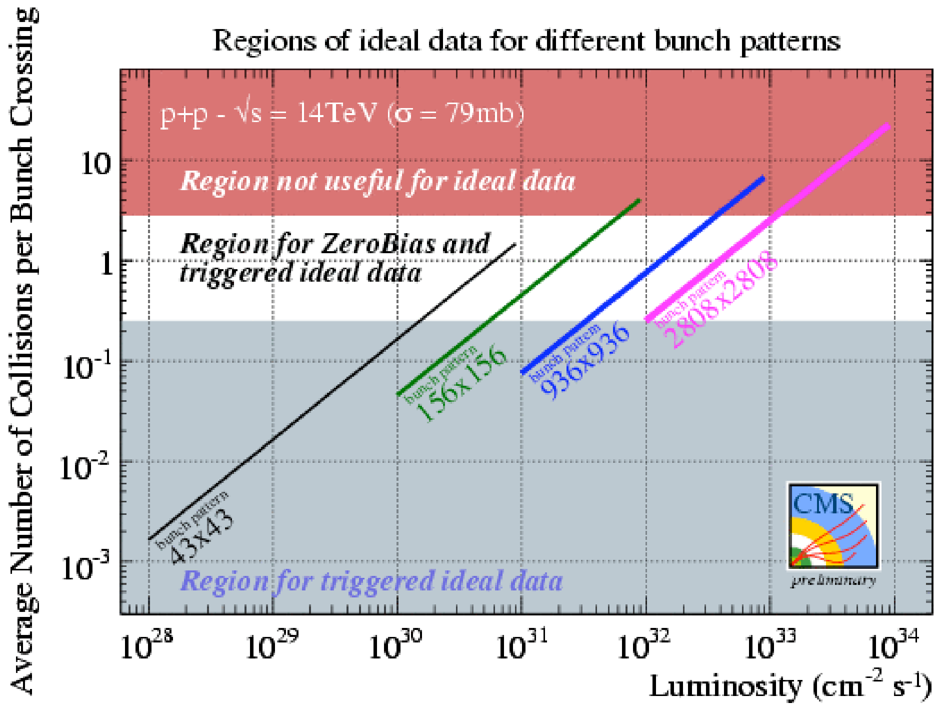
Zero bias: beam bunch crossing time
100% efficient for all data, but not effective at startup conditions

Min bias HF single:single sided forward hadron calorimeter
efficiency: 81% non diffractive
15% diffractive

Min Bias HF double: double sided forward hadroncalorimeter
efficiency: 47.5% non diffractive
0.6% diffractive

Zero bias + 1 Pixel Track: at 900GeV
efficiency: 99% non diffractive
~60% diffractive

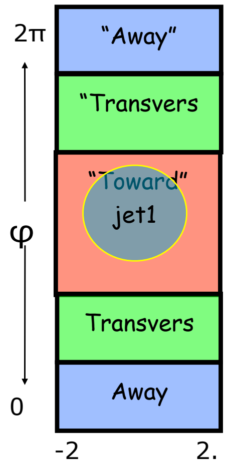
'Ideal data':
One single collision per bunch crossing (no pile-up)

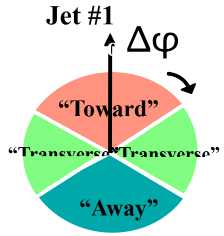


CMS PAS QCD_07_002

UE measurement plan in central region

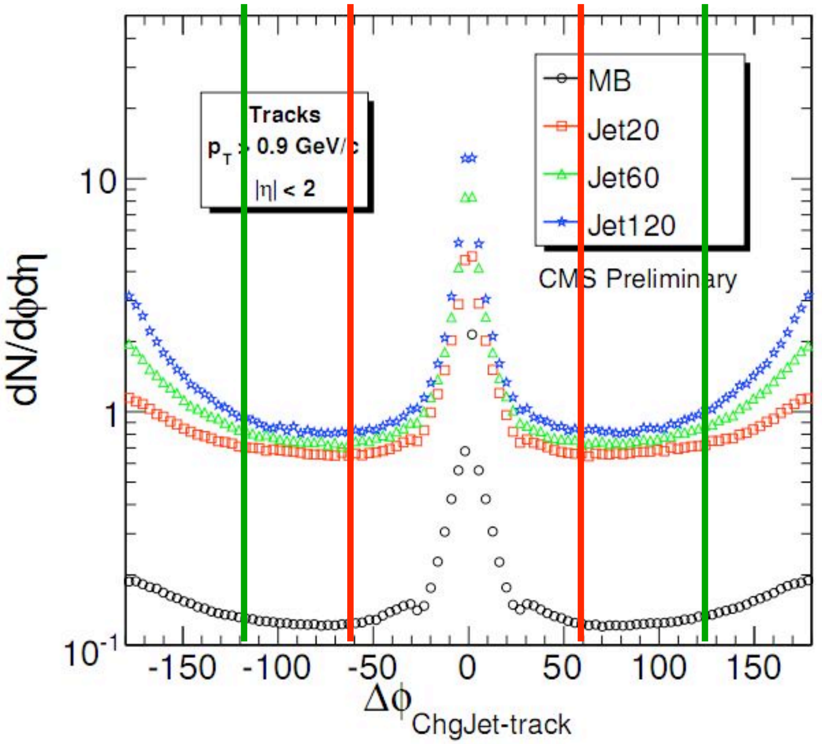
jet topology





Analysis strategy builds on Rick Field experience at Tevatron

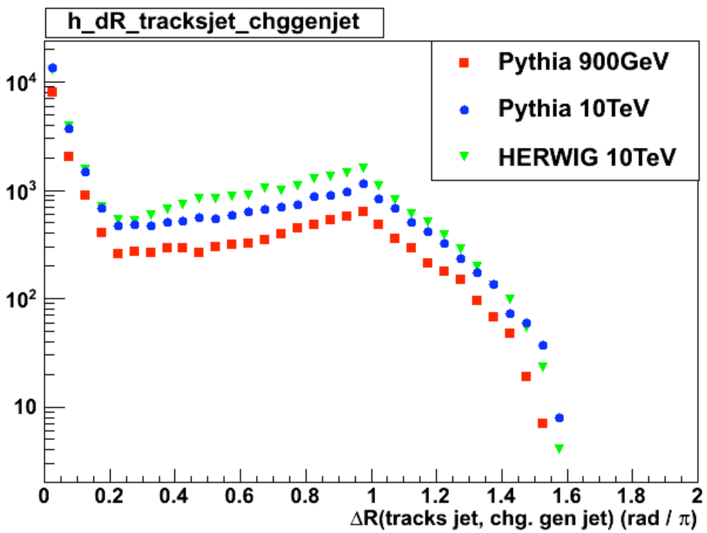
- **Combination of MB and jet triggers based on leading calojet:**
  - PT(calo) > 20, 60, 120 GeV/c
- **Charged jets: SiScone with R=0.5 applied on charged particles with pt >0.5 GeV/c and |η|<2**
  - Standard CMS track reco
  - Startup alignment and calibration
- **3 main regions of interest wrt leading** charged jet: toward, transverse, away
- **2 main density observables in each region**
  - Charged particle density: dN/dηdφ
  - Scalar sum of charged pt: dptsum/dηdφ

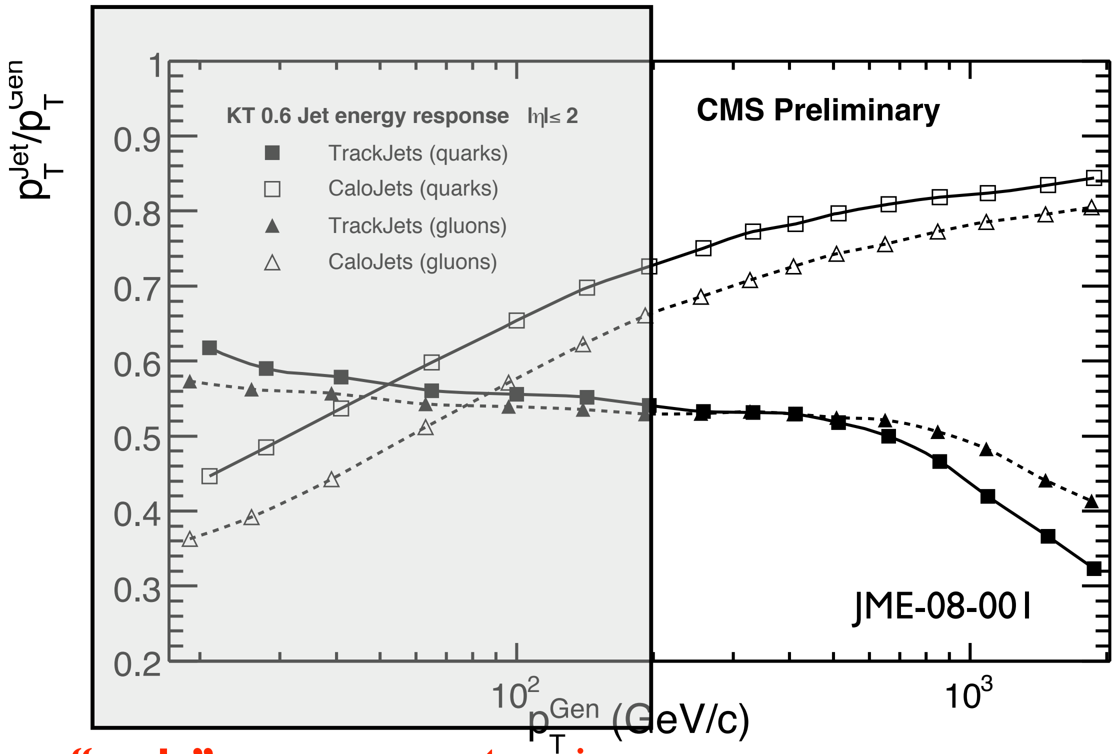


CMS PAS QCD_07_003

UE measurement plan in central region

Why charged jet ?





"early" measurement region

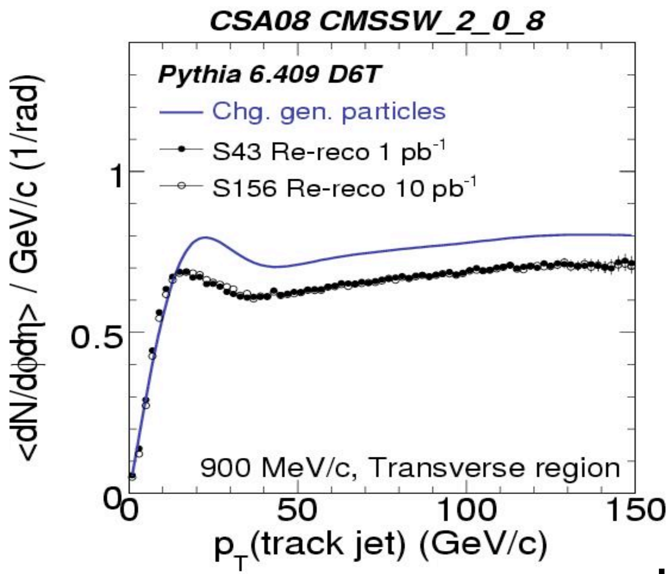
+ well matched in ΔR<0.2 (>~60%)
+ better resolution than calorimetric jet at low pT

in addition:

+ better control of systematics at startup
+ intrinsically free from Pile-up

UE measurement plan in central region

The observables (densities) have to be corrected in order to take properly into account tracking inefficiencies

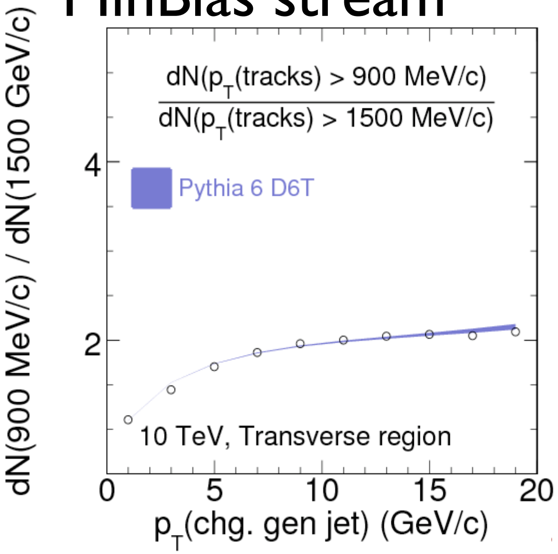


from MC/RECO ratio -> corrections
(warning: old results, tracking not optimized)

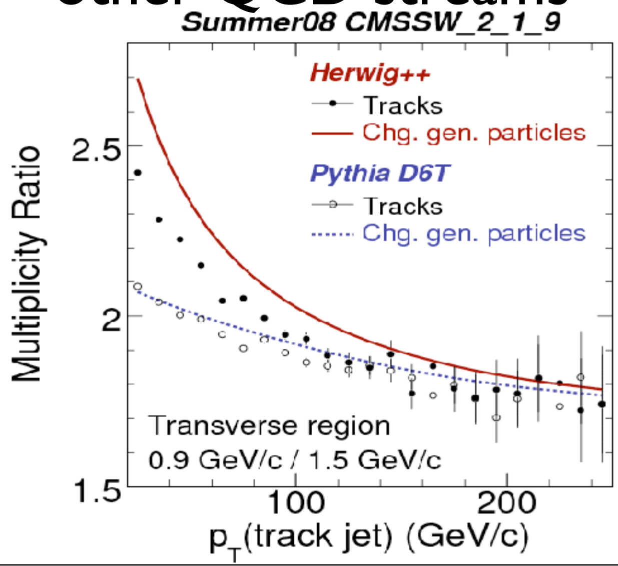
+ low-pT -> efficiency

+ high pT -> fake

MinBias stream

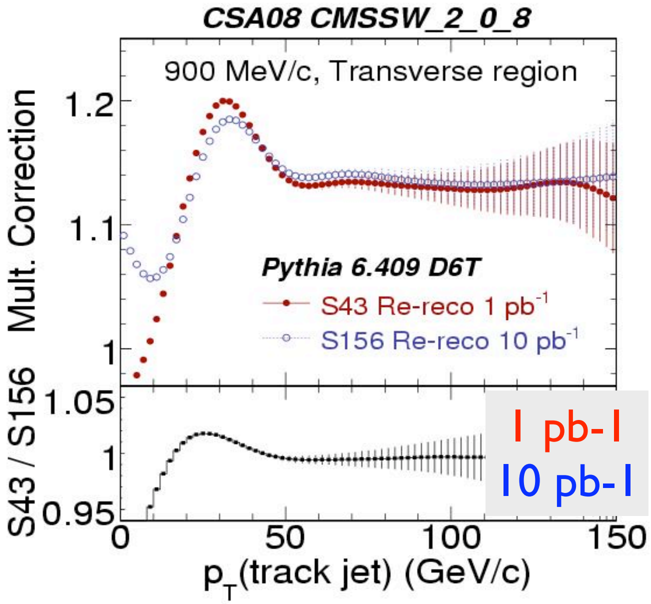


other QCD streams



from the ratio of the observables (builded using different tracking thresholds)
->
inefficiencies from tracking can be mainly reabsorbed

UE measurement plan in central region



1) event based corrections
from MC/RECO ratio -> corrections
(warning: old results, tracking not optimized)

+ low-pT -> fake contribution in MinBias sample (up to 10%)
+ high pT -> 5% from stat
+ systematics from MC model (up to 7% on ptsum, less than 5% on the track density)

2) mix of event and particle based corrections
(work ongoing - following CDF, ATLAS...)

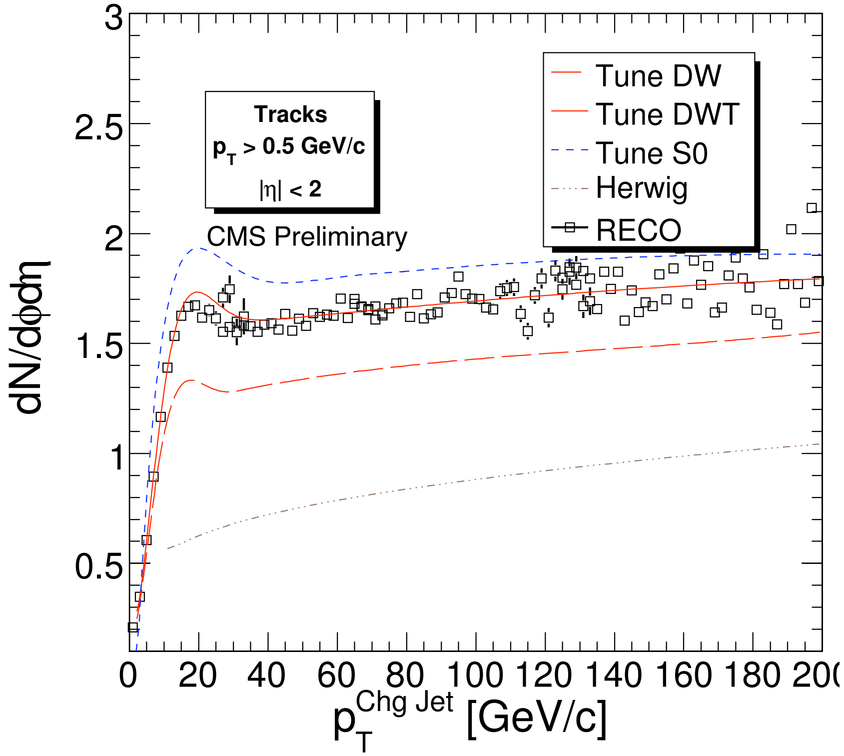
+ efficiency
+ vertexing
+ trigger bias

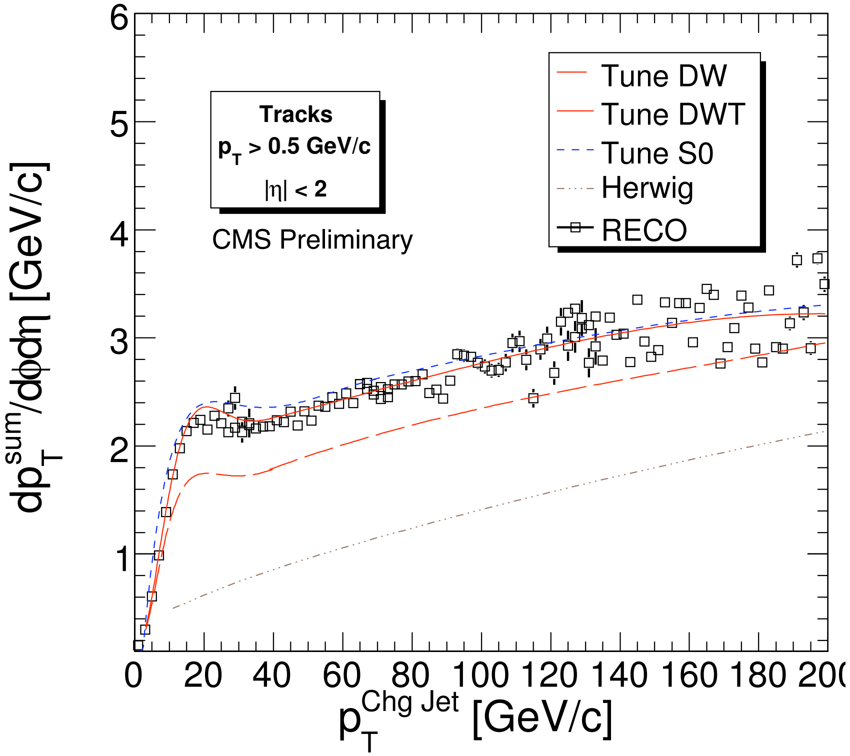
$$P(\eta, v_z, p_T) = \sum_{events} \sum_{tracks} (C_{trk}(\eta, v_z, p_T) \cdot C_{vtx}(\eta, v_z, p_T) \cdot C_{trig}(\eta, v_z, p_T)),$$

$$I(v_z, N) = \sum_{events} (\tilde{C}_{vtx}(v_z, N) \cdot \tilde{C}_{trig}(v_z, N)).$$

Systematics sources (main contribution highlighted)
Track selection, Secondaries, Vertex reconstruction bias (PV_z), **Misalignment**, Beam-gas, particle composition, **Trigger**

UE measurement plan in central region



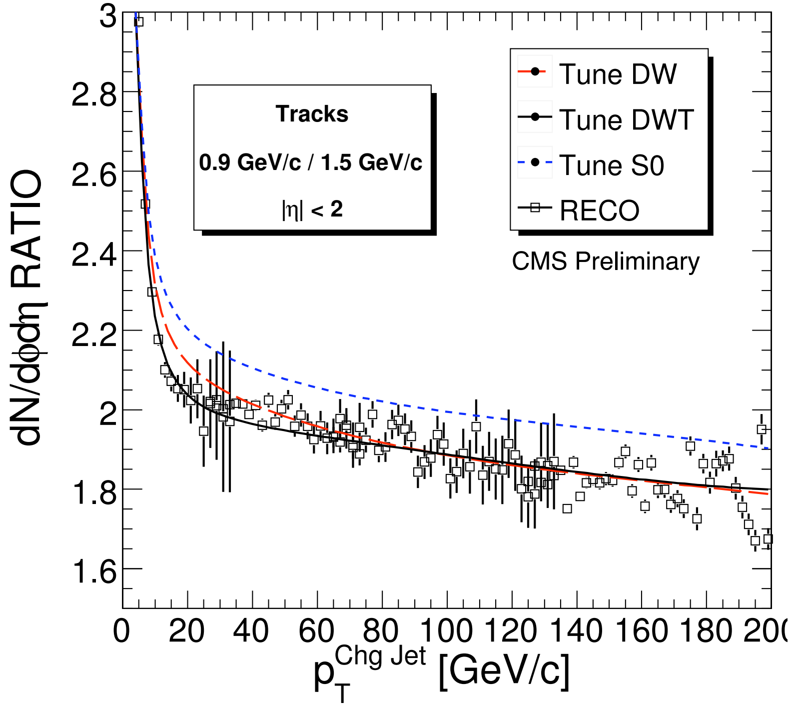


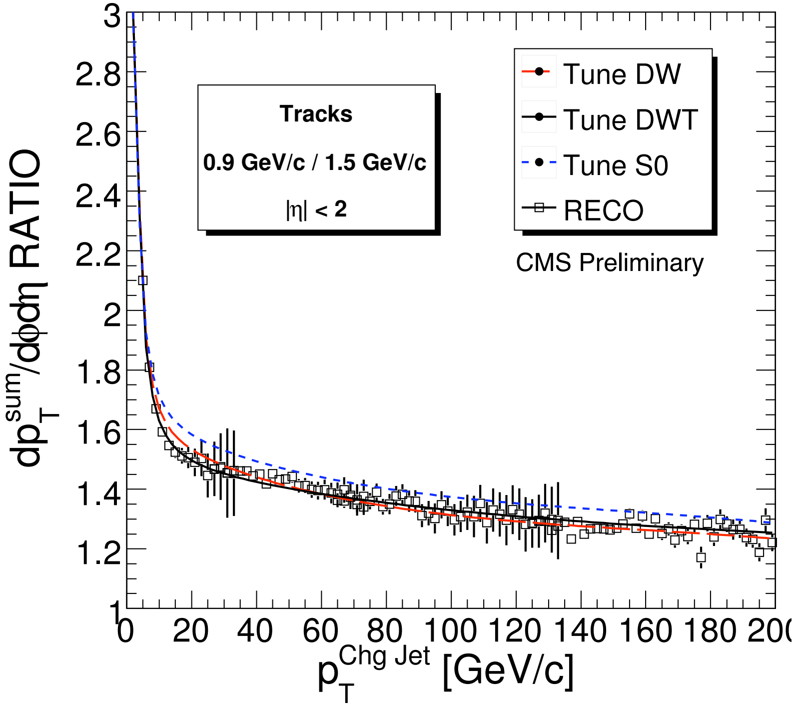
+ difference among the Monte Carlo models can be exploited

+ spread at high pT is mainly due to lack of Monte Carlo event

+ statistical errors are compatible with 10 pb-1 of data-taking

UE measurement plan in central region





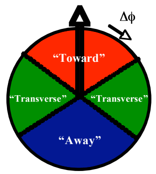
from the ratio of the observables (build using different tracking thresholds)

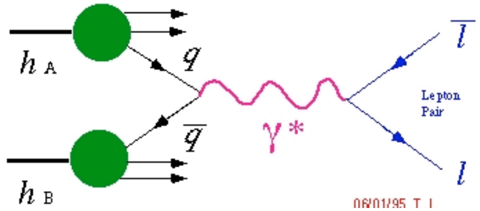
+ lower sensitivity to different Monte Carlo models
BUT
+ inefficiencies from tracking can be mainly reabsorbed (better control of systematics from detector)

UE measurement plan in central region

DY topology

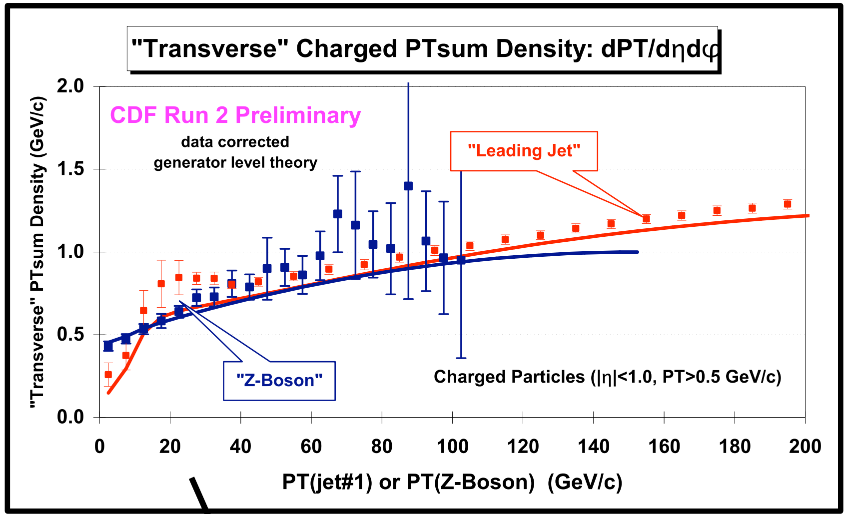
observables are the same

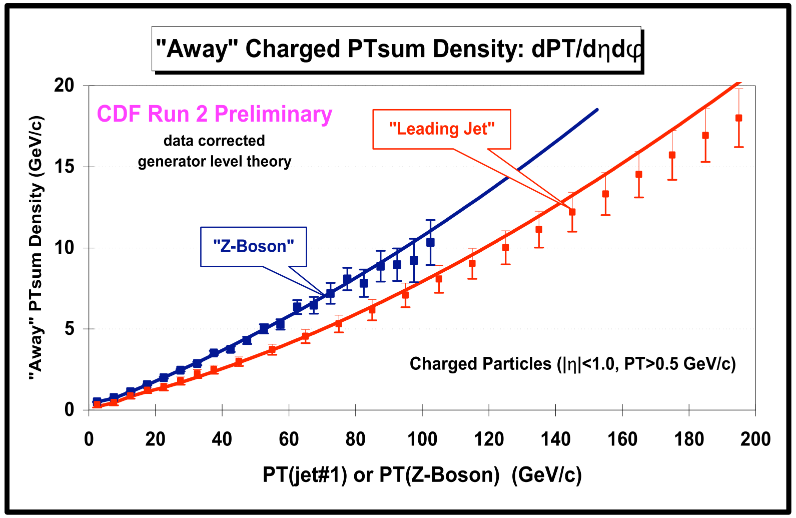




The PT of the boson is used to define a direction

[Rick Field, HERA/LHC]





CDF

Z boson or Jet

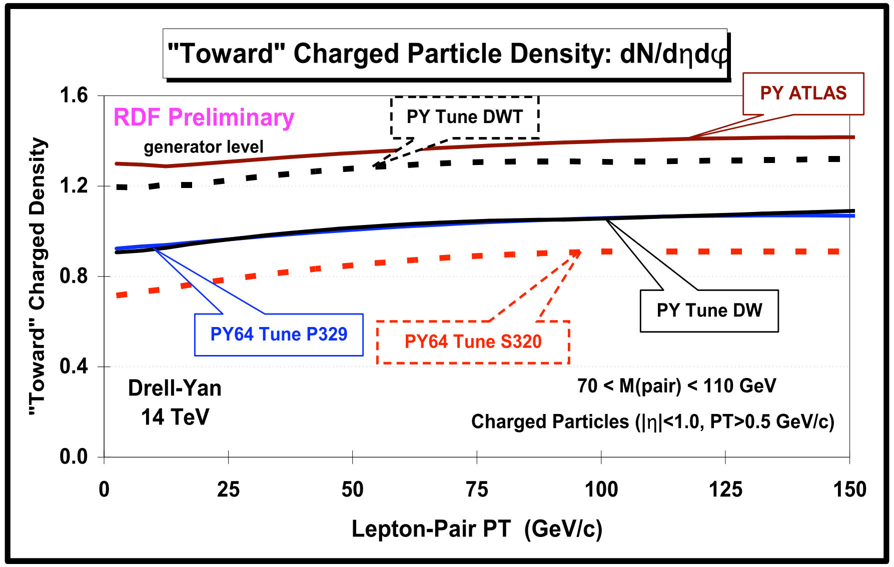
Universality of UE ?

Data at 1.96 TeV on the charged *scalar* PTsum density, dPT/dηdφ, with $p_T > 0.5$ GeV/c and $|\eta| < 1$ for "Z-Boson" and "Leading Jet" events as a function of the leading jet p_T or $P_T(Z)$ for the "transverse" and "away" region.

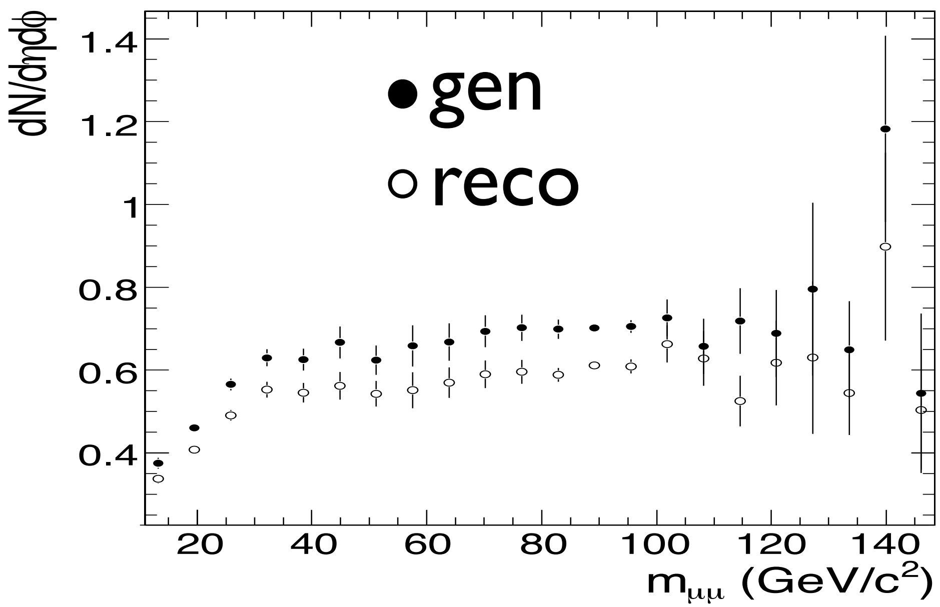
The data are corrected to the particle level (*with errors that include both the statistical error and the systematic uncertainty*) and are compared with PYTHIA Tune AW and Tune A, respectively, at the particle level (*i.e.* generator level).

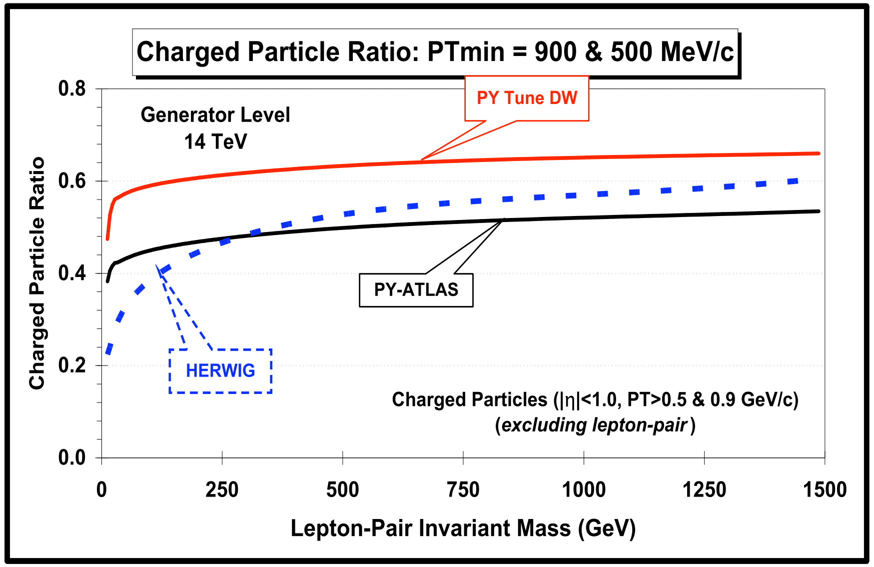
UE measurement plan in central region

LHC expectations (Rick)



CMS “measurement” (cmsnote 2006/067)





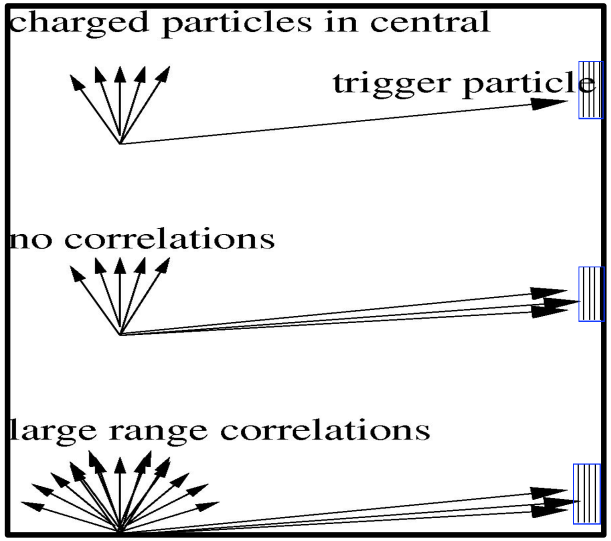
Ratio P_T>0.9GeV/P_T>0.5GeV (P_T tracks threshold)

ratio can be used to reduce systematics from corrections (as for the jet case)

still sensitive to different model

UE measurement plan in the forward region

long range correlation and MI

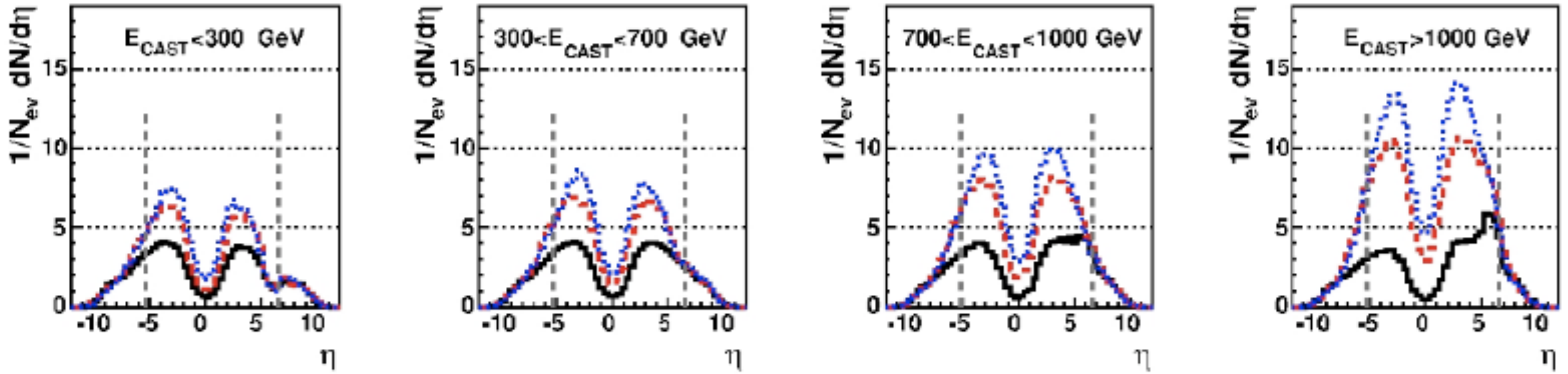


•**With MPI**:
Large energy of trigger in CASTOR, → Higher particle multiplicity in central region

•**Without MPI:**
No, or very small, correlation

PYTHIA:
-Rick-Field's CDF tune A (tune A)
-Sandhoff-Skands tune 0 (tune S0)
-MI switched off

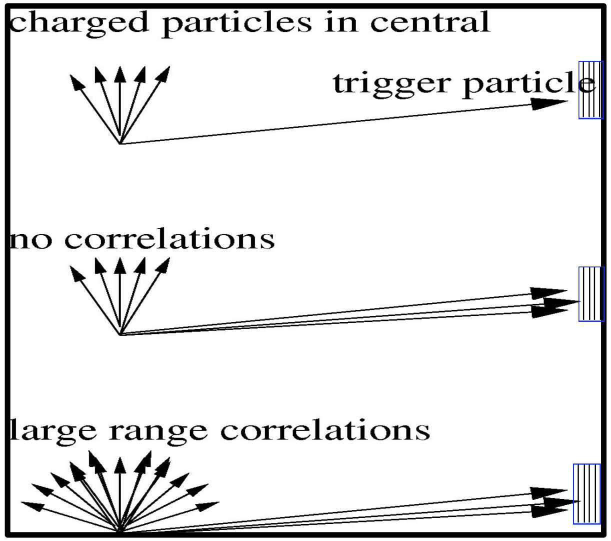
QCD events



(CASTOR particles smeared according to beam test data + 1 GeV noise cut applied.)

UE measurement plan in the forward region

long range correlation and MI



- **With MPI**:
  Large energy of trigger in CASTOR,
  → Higher particle multiplicity in central region

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  No, or very small, correlation

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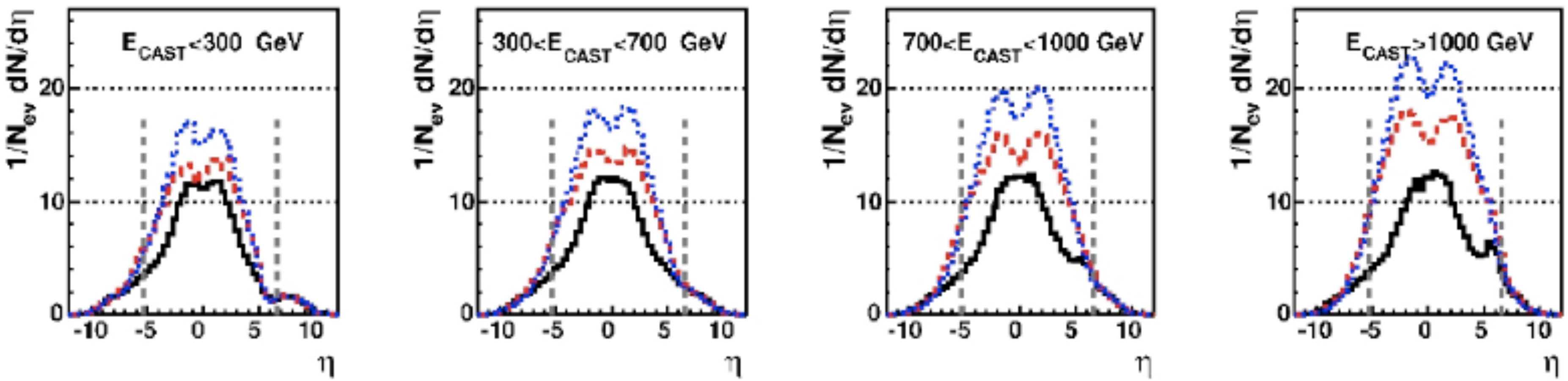
Top events

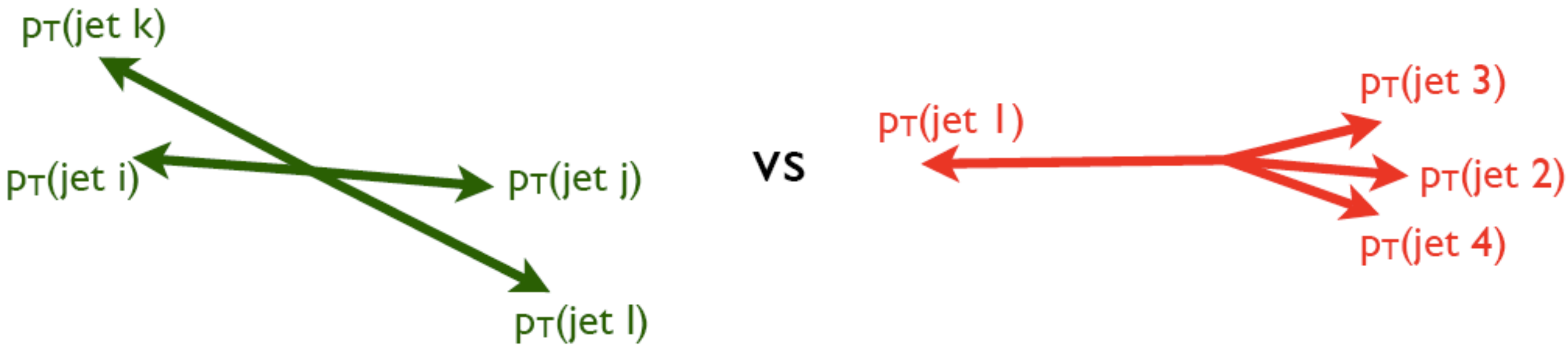


→ **Top events much higher activity in the UE**

(The UE event depends on the hardness of the reaction.)

MPI specials - 3 jets+gamma

One has to distinguish between the two topologies :

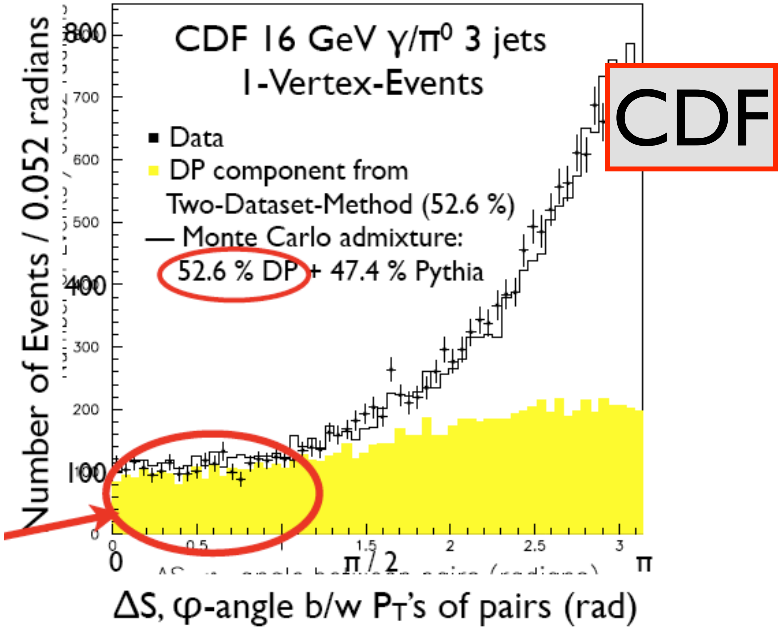


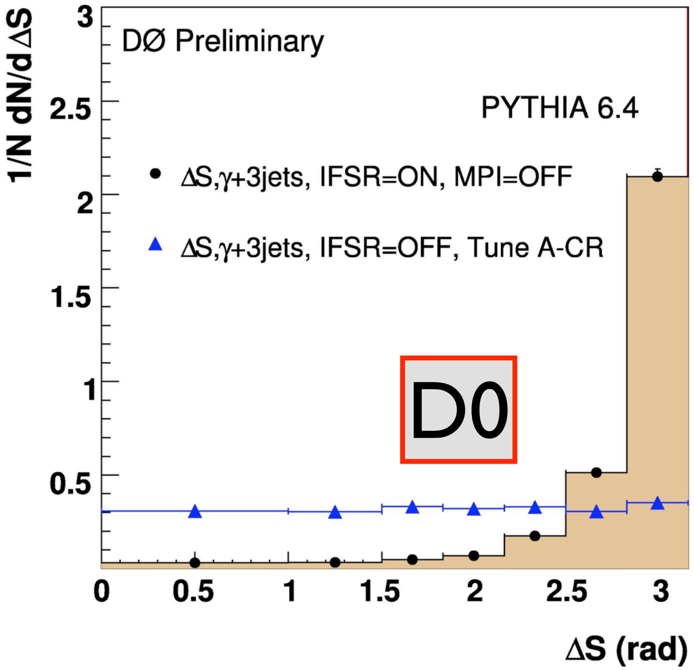
The pairs can be isolated using the variable:

$$\min\left(\frac{|\vec{p}_{Ti}+\vec{p}_{Tj}|^2}{|\vec{p}_{Ti}|+|\vec{p}_{Tj}|}+\frac{|\vec{p}_{Tk}+\vec{p}_{Tl}|^2}{|\vec{p}_{Tk}|+|\vec{p}_{Tl}|}\right)$$

& considering the $\Delta\Phi^{(+)}$ between $\mathbf{p}_{T1}+\mathbf{p}_{T2}$ e $\mathbf{p}_{T3}+\mathbf{p}_{T4}$

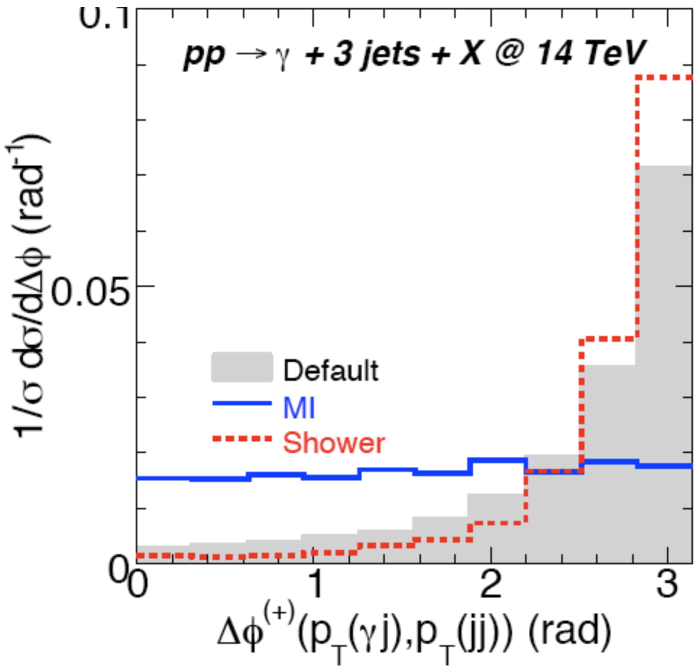
MPI specials - 3 jets+gamma





Tevatron:

σ_{eff} ~12 mb



→ CMS plans the same analysis to estimate σ_{eff}

MPI specials - direct measurement

The basice idea consists in studying the rate N of minijet pairs as a functione of a pT.threshonld of the pair leading jet (Infrared Safe)

$$< N > \sigma_{hard} = \sigma_S$$

$$\sigma_{\rm DP} \equiv m \frac{\sigma_A \sigma_B}{2\sigma_{\rm eff}}.$$

$$\frac{1}{2} < N(N-1) > \sigma_{hard} = \sigma_D$$

$$\langle \mathbf{N(N-1)} \rangle = \langle \mathbf{N} \rangle^{\mathbf{2}} \frac{\sigma_{\mathbf{hard}}}{\sigma_{\mathbf{eff}}}$$

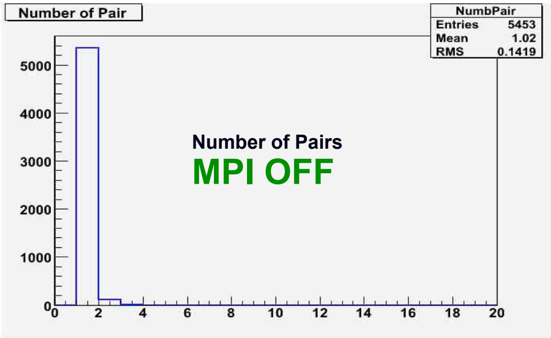
Where $\sigma_{\text{inel}} = \sigma_{\text{soft}} + \sigma_{\text{Hard}}$

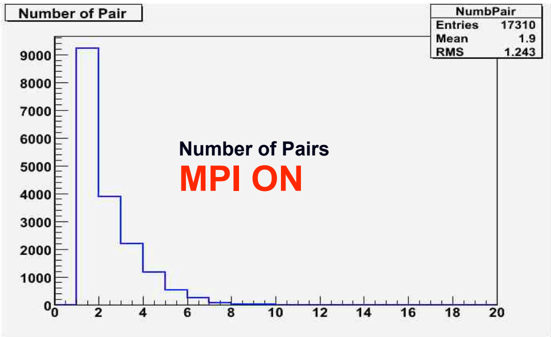
"S" = Single Interactions, "D" = Double Interactions, "Hard" = Inclusive

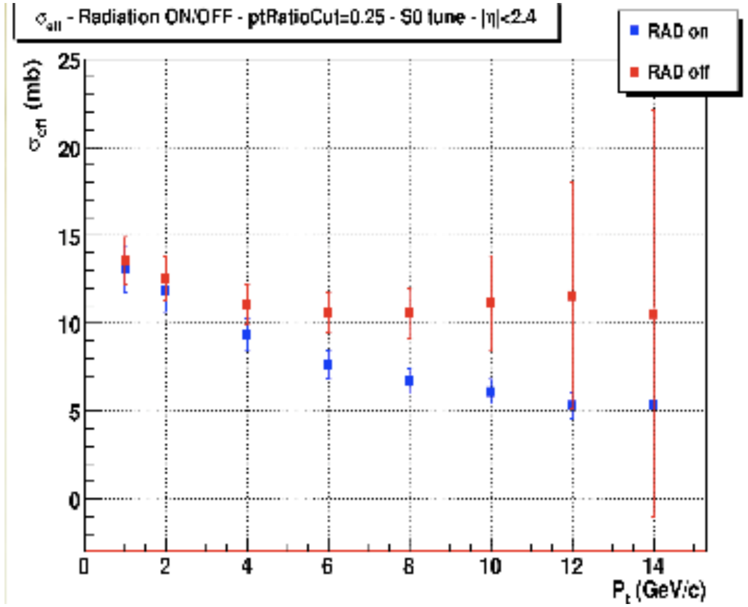
D. Treleani [Phys.Rev.D76:076006,2007]

MPI specials - direct measurement

+ Minijets are reconstructed by tracks clustering and are characterized by a very low pT threshold
+ The minijets are paired in $\Delta\phi$ & pT balancing
+ Number of pairs <-> number of interactions







misura di σ_{eff}(pT)

+ the measurement is independent from the geometric acceptance
+ yet high dependence from radiation

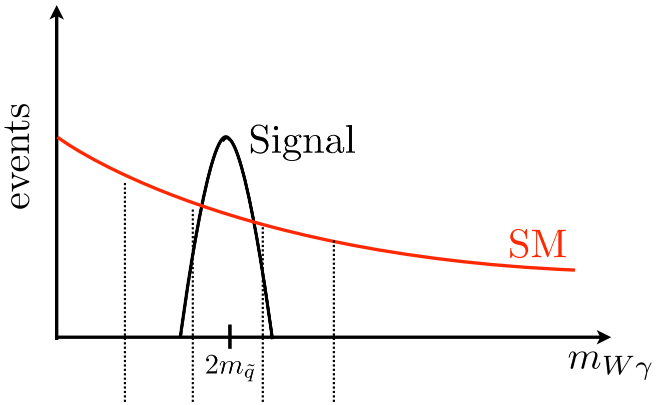
New physics in Underlying Event

Quirks and Signals of New Physics in the Underlying Event

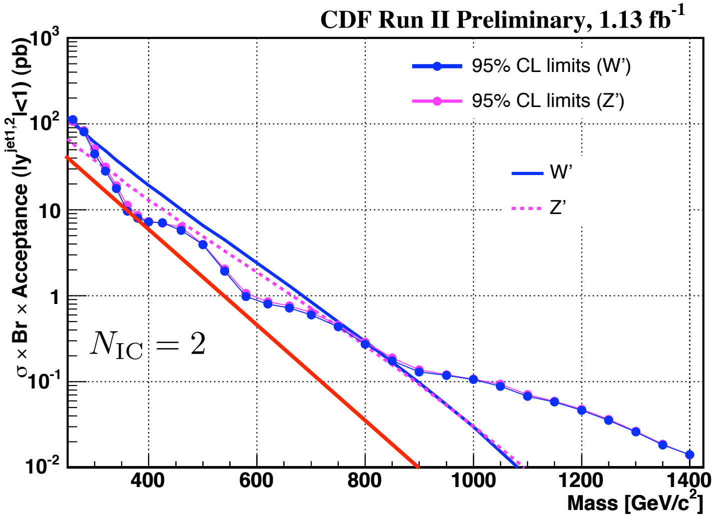
Roni Harnik (Stanford U., ITP & SLAC) ,Tommer Wizansky (SLAC)
arXiv:0810.3948 [hep-ph]

Why in Soft Signal ?

+ Searches for new physics focus on hard objects.
+ Every event in a hadron machine has an additional soft component - underlying event
+ New strong dynamics may lead to a large amount of energy going to many soft objects - an **“anomalous underlying event”**



Case I - a hard signal was discovered
We want to learn more about NP.

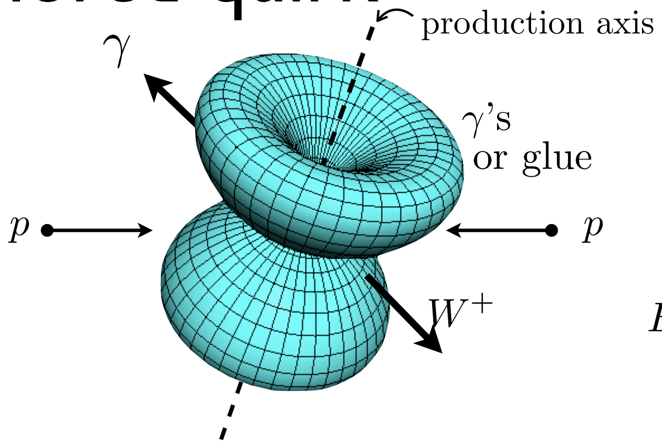


Case II - The hard search is background dominated
Dijet Resonance Search

New physics in Underlying Event

new strong force: SU(3)xSU(2)xU(1)x*SU(N)*
matter: q'=(SM quantum numbers, N)
if $\lambda_{QCD'}$ < q', q' is a squirk

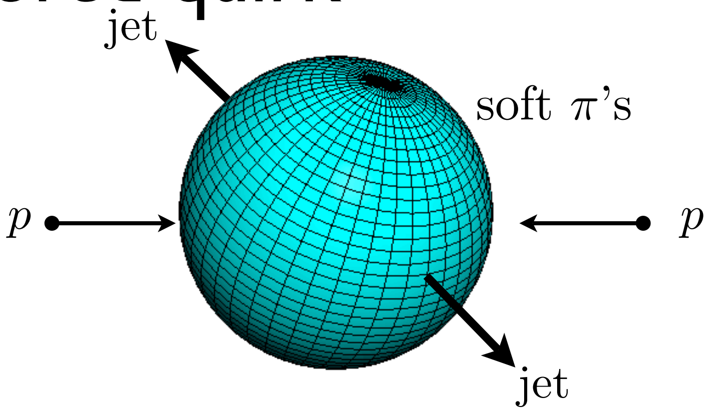
uncolored quirk



$$\omega_\gamma \sim \frac{\Lambda^2}{m_{\tilde{q}}} \sim 0.1\text{ - }1\text{ GeV}$$

$$E_\gamma / E_{\text{glue}} \sim 10 - 100\%$$

colored quirk



Spherical distribution

$$E_\pi \sim \text{sub-GeV}$$

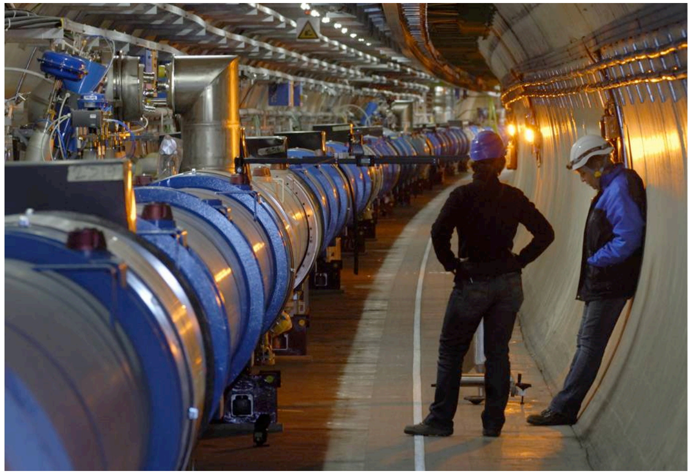
expected signals:

+ high track multiplicity

+ Calorimetric signals

how to make things working

+ having a working accelerator
+ understand signals
+ reconstruct tracks
+ build observables
+ compare and tune
+ publish



Correctly estimate tracking performances is needed to build corrections and reduce systematics, how ?

+ using Monte Carlo
  starting from charged spectra reconstruction using pixel hits (see Krisztian talk)
  -> first tune for LHC -> extract tracking performances ->
  refined tune for LHC with UE observables
+ using data
  MinBias are pions, extract pion reconstruction performances from B0->D*lv, D*->D0pi
+ relative performances (sub-detector tracking)
  SiStrip only, pixel only, SiStrip+pixel

next

CMS setup a rich (and complete) plan to measure UE activity. In addition some specific MI analysis is studied

The idea is to focus on tracking system, at startup. In this way one should simplify:

+ uncertainties coming from JES and calorimeter calibration
+ enlarge the sensitivity to soft interactions, more interesting energy scale to tune non perturbative processes at LHC

My opinion is that this kind of meeting are useful/needed:

+ the 2 detectors are complementary, from some point of view
+ all communities should have an interest in reaching soon the best QCD dynamic understanding at TeV scale
+ it's an interesting synthesis between experimentalists and theorists
+ A not so large but active group is already existing and cooperative working, often transversally to detectors membership (see MPI@LHC "permanent" workshop)