Some studies for ALICE

- Motivations for a p-p programme in ALICE
- Special features of the ALICE detector
- Preliminary studies of Physics Performances of ALICE for the measurement of some global properties of Min. Bias events

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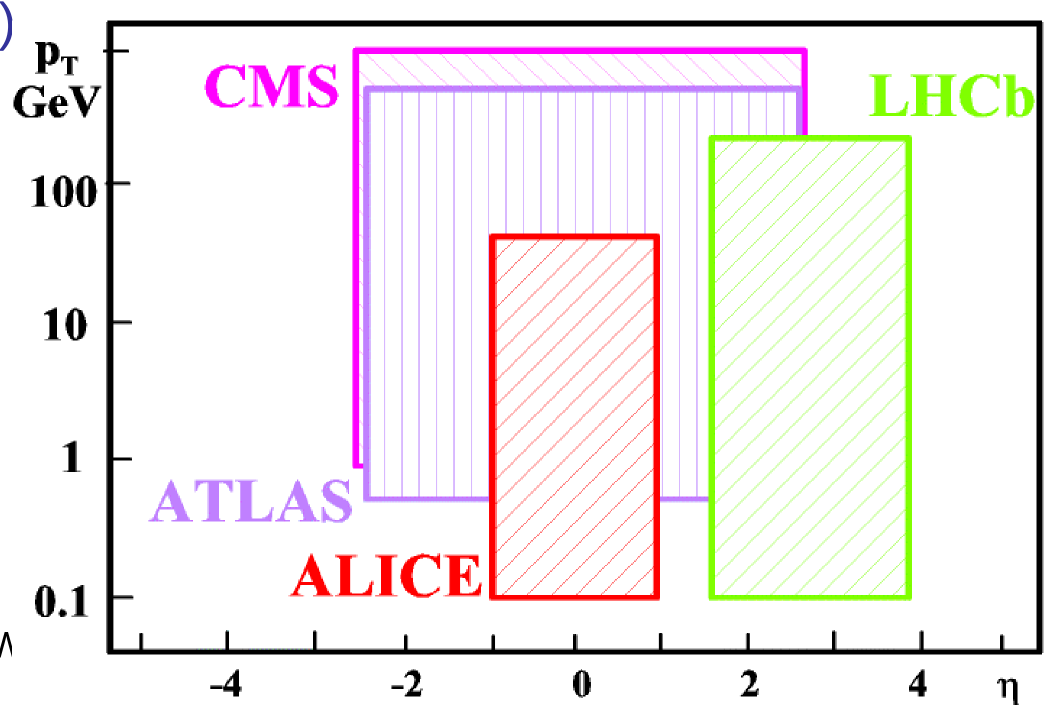
Motivations for the p-p programme in ALICE

- At the startup of LHC, when the luminosity is still relatively low for ATLAS and CMS (10^{33} cm^{-2} s^{-1}), large cross-section phenomena will be investigated. ATLAS, CMS, LHCb and ALICE will study minimum bias events. TOTEM will provide the absolute calibration for the luminosity measurement.
- ATLAS, CMS and LHCb will need the best possible understanding of Minimum Bias and underlying event properties, which contribute to the background to their high P_T signals.
- ALICE is complementary to the other LHC detectors, because it is optimized for Heavy Ions hence for low P_T physics. ALICE should provide useful information to be combined with other LHC experiments.
- The detailed study of low P_T physics with proton collisions is also required for the understanding of heavy ion collisions, by providing "comparison" data (as absolute rates predictions for heavy ions have huge uncertainties, and all signals are studied relative to pp).

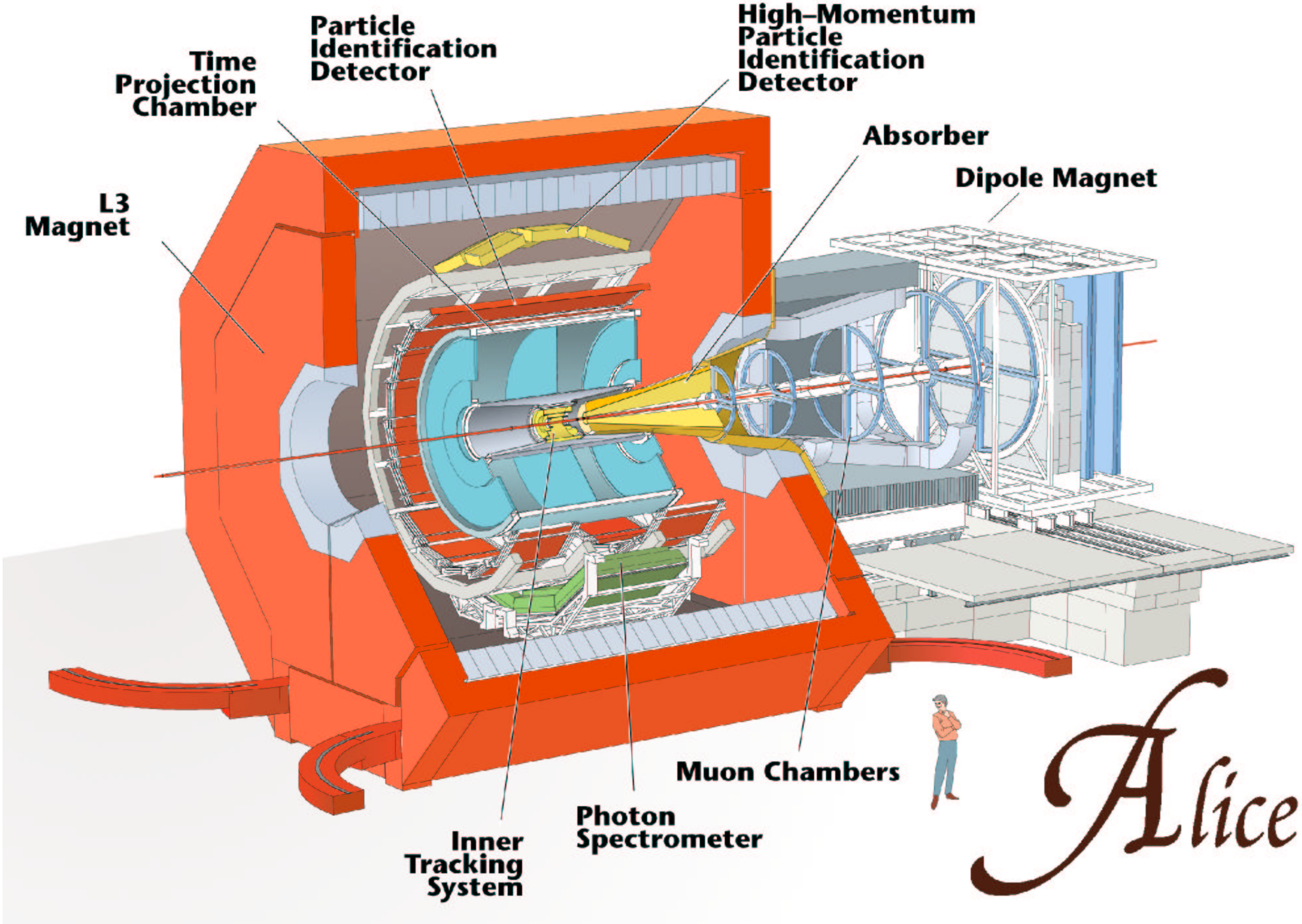
Complementarity of different experiments

- ATLAS & CMS optimized for high P_T and high luminosities
- LHCb optimized for the B physics (only in the "forward" kinematic region).
- TOTEM is dedicated to the measurement of the total and elastic cross sections, and of diffractive processes (absolute calibration of the luminosity).
- ALICE is optimized for the study of Heavy Ion collisions, therefore it is ideal for low P_T and high multiplicities (but good also for rather high P_T in some cases)

(Charged particles except muons)



The ALICE detector



ALICE: a soft particle tracker

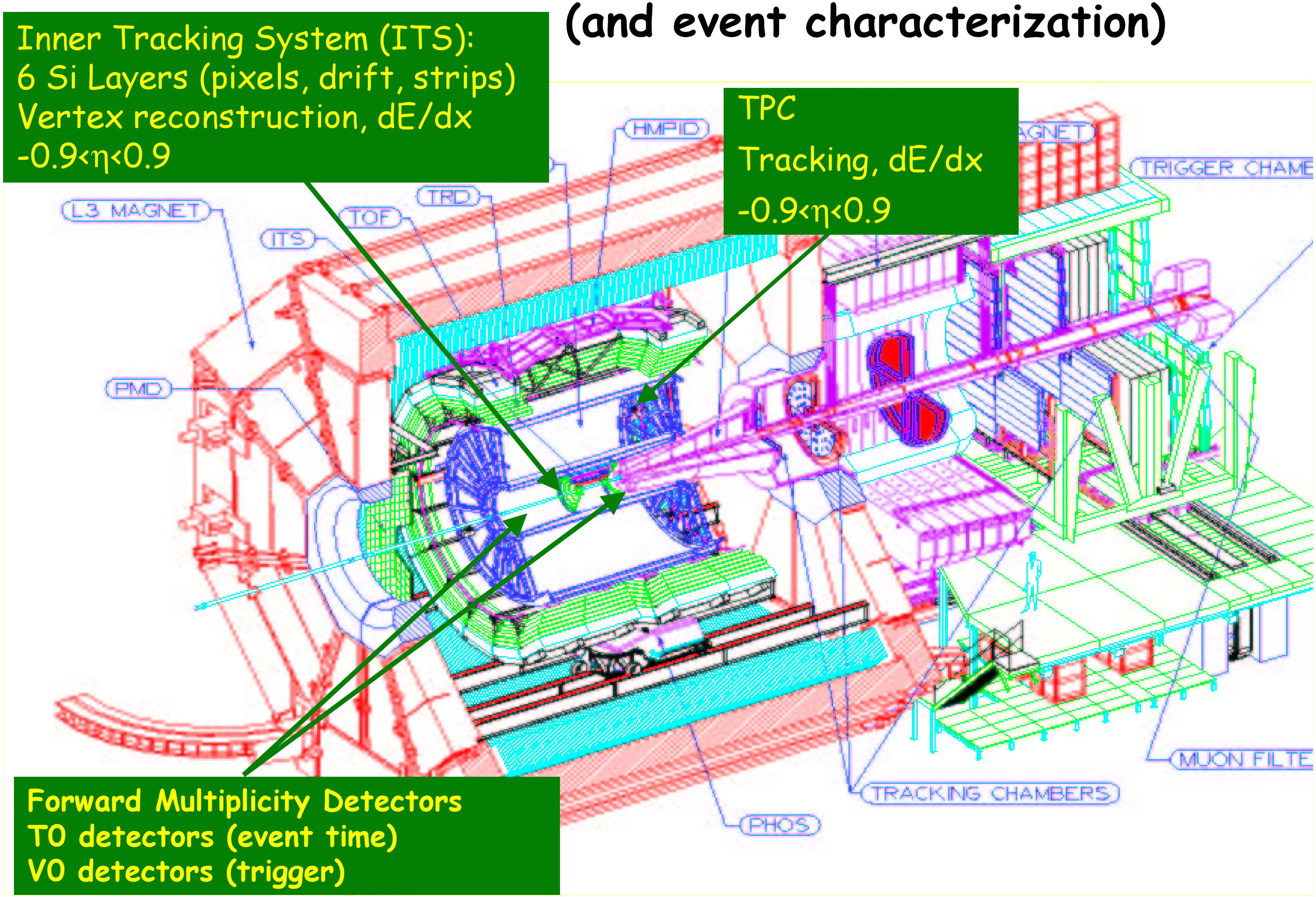
- ALICE is sensitive down to very low P_T

	Magnetic field (T)	P_T cutoff (GeV/c)	Material thickness: X/X0 (%)
ALICE	02.-0.5	0.1–0.25	7
ATLAS	2.0	0.5	30
CMS	4.0	0.75	20
LHCb	4Tm	0.1*	3.2

- Moreover ALICE has remarkable capabilities of particle identification

Particle identification in ALICE

ALICE LAYOUT: TRACKING
(and event characterization)



Acceptance of multiplicity measurements in ALICE

- In ALICE the Minimum Bias trigger is provided by a coincidence between the V0 counters, that cover the pseudorapidity interval $-5<\eta<-3.2$ and $1.6<\eta<4.8$. That corresponds to a visible inelastic cross section of ~60 mb.

- The charged particle multiplicity is measured over 8.8 rapidity units, whereas the momentum is measured in the TPC and in the Inner Tracking System (ITS) over 1.8 rapidity units with optimal resolution, and up to 3 units in total.

Full simulation of pp MB events in ALICE

- A full simulation of 10^5 MB pp events has been done in two steps:
  - Generation of events with PYTHIA 6.150 (properly tuned); GEANT detector simulation and a first level of reconstruction in TPC and ITS.
  - Tracking.
- Multiplicity analysis performed by **T.Virgili,** where the multiplicity N_{ch} was calculated from the number of tracklets in $|\eta|<0.9$ (as measured in the first two Silicon Pixel layers of ITS).
- Preliminary results on:
  - Multiplicity spectrum in $|\eta|<0.9$
  - $<p_T>$ per event
  - $<p_T>$ vs N_{ch}

Tuning of multiple interactions generated by PYTHIA: recent references

- Parameters used for MB event production at LHC (tuning on UA5 MB data, with PYTHIA 6.125 and CTEQ4L) :
  - Model 3 ; $P_{t,min} = 2.47$

    (Ref. CERN Yellow Report : "Workshop on SM at the LHC" CERN 2000-004, pag. 293-298)

LHCb set: USED FOR OUR FULL DETECTOR SIMULATION + RECONSTRUCTION of a big MC sample

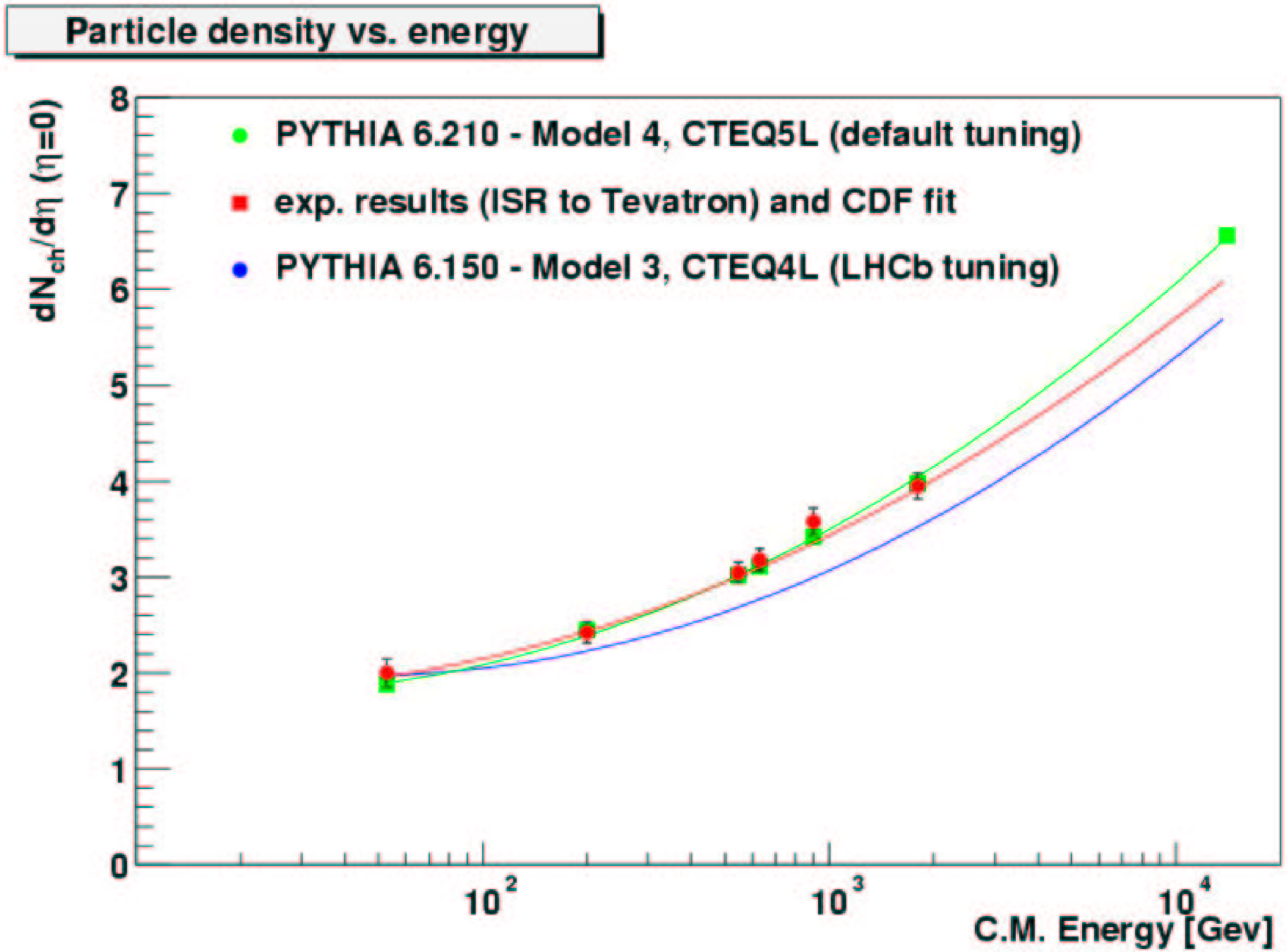
- Updated set of parameters used for MB event production and Underlying Event properties at Run I and II @ Tevatron (CDF) with PYTHIA 6.206 and CTEQ5L

  (Ref. R.Field : "Minimum bias and the Underlying Event at the Tevatron and the LHC" ; talk presented at the Institute for the Fundamental Theory, Univ. of Florida, Oct. 22 2002)

- Other studies by ATLAS group in Sheffield, also from the tuning to SPS and Tevatron data

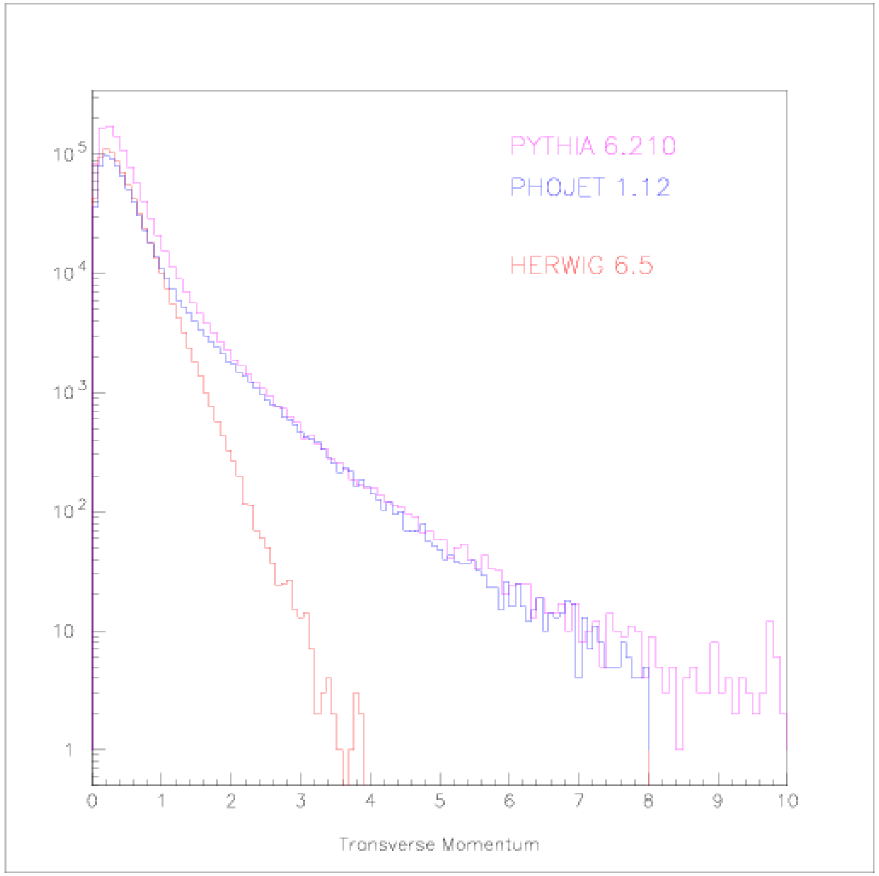
  (Ref. A.Moraes et al. : "Minimum bias interactions and the Underlying Event" ; talk given at the Monte Carlo at Hadron Colliders Workshop, Univ. of Durham, Jan. 14-17 2003)

Studies on best-tuning of PYTHIA parameters



Charged particle P_T spectra at 14 TeV according different models

- Good agreement between PYTHIA 6.2 and PHOJET1.12
- No tracks with p_T> 3-4 GeV generated by HERWIG (that was already remarked in CDF studies of min.bias data at 630 and 1800 GeV)
- Indication of a lack of description of hard and semi-hard physics in the HERWIG model of min.bias events (waiting for JIMMY…)



Primary charged particles: a definition

- Projectiles protons, quarks, gluons, strings, final state hadrons, leptons and photons are stored in kinematic tree; the full chain of particles generated by decays and interactions in the GEANT model of the detector is kept in the event record.
- The ”primary” particles must be properly defined and identified.
- All the particles actually giving hits in the apparatus are in fact secondaries, at some level.
- However, the identification of secondary particle (and the following classification of its parent particle as a primary) depends upon the experimental capability to resolve secondary vertices.

In the following, primary particles are those which:

- are generated at time~0 (strong interaction decays)
- are not decaying within a distance comparable with the sec.vertices resolution of the detector

Example

- π, K (charged) originating from Δ and ρ decays are primary

Interaction vertex at the LHC

- Position of the beam in (x,y) given by the machine with very high precision (stable for a long time)
- "Nominal" size of the beam:

  σ = 15 μm in Pb-Pb

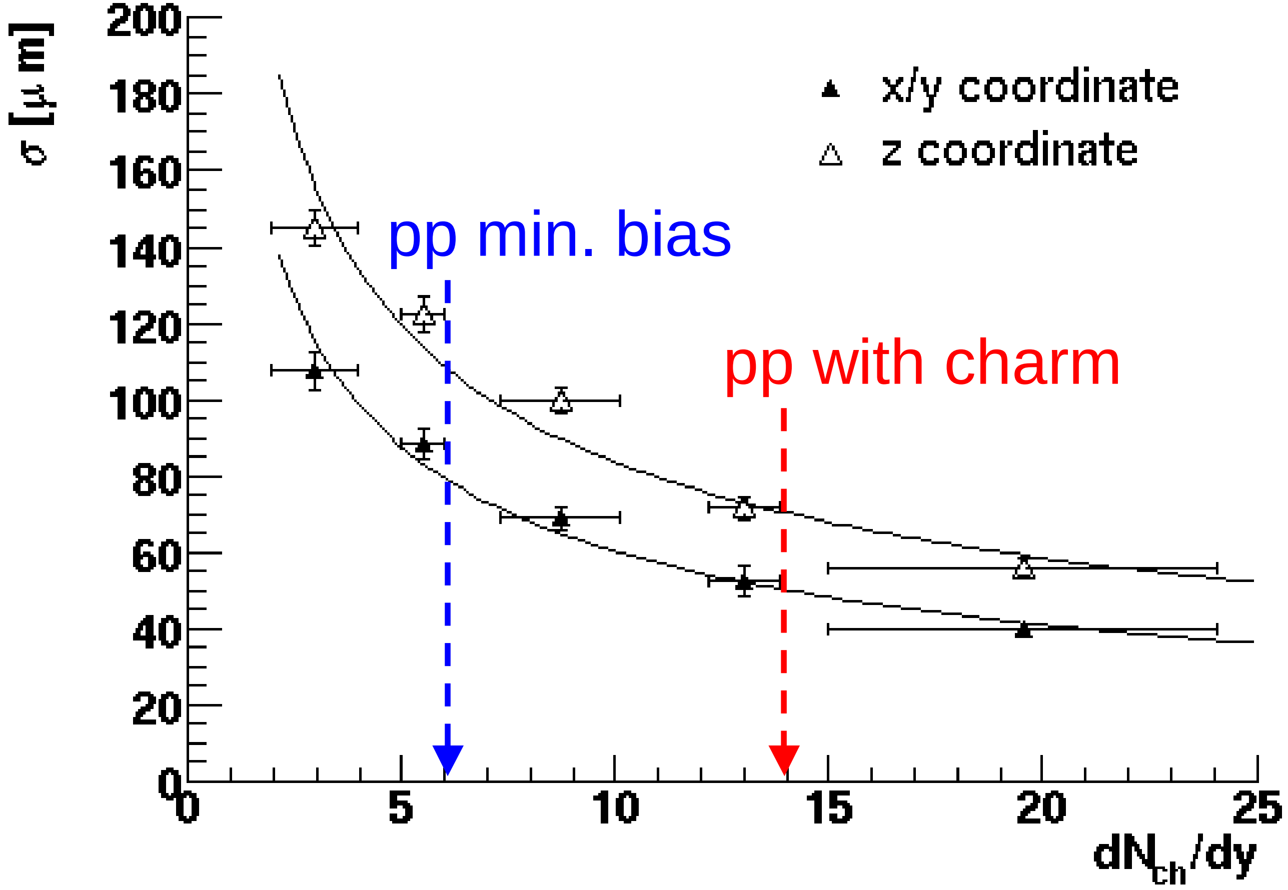
  σ = 15 μm in pp ($\mathcal{L} \sim 10^{31}$ cm^{-2} s^{-1})

  $\sigma \approx$ 150 μm in pp (if $\mathcal{L}$ is reduced at ALICE IP to ~ 10^{29} cm^{-2} s^{-1})
- The vertex position has to be reconstructed in 3D using tracks.

  This is performed in 2 steps:
  - **VERTEX FINDING**: using DCA for track pairs
  - **VERTEX FITTING**: (inspired by CMS and ATLAS methods)
    - give optimal estimate of the position of the vertex
    - give vertex covariance matrix
    - give a χ^2

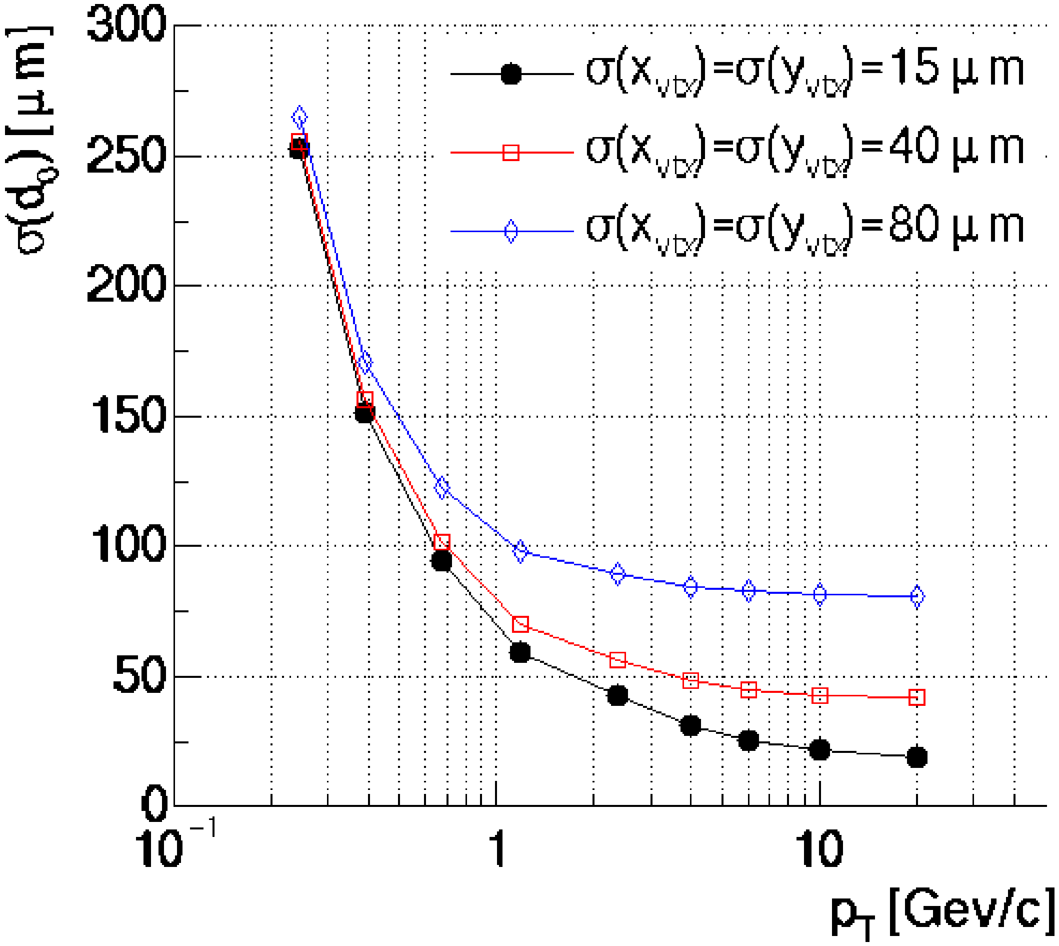
A. Dainese & M. Masera

Resolutions VS multiplicity



A. Dainese

Effect on impact parameter resolution



as in Pb-Pb
pp with charm
pp min. bias

Study performed by A.Dainese, for its Ph.D. thesis on on the D^0 detection

Multiplicity reconstruction

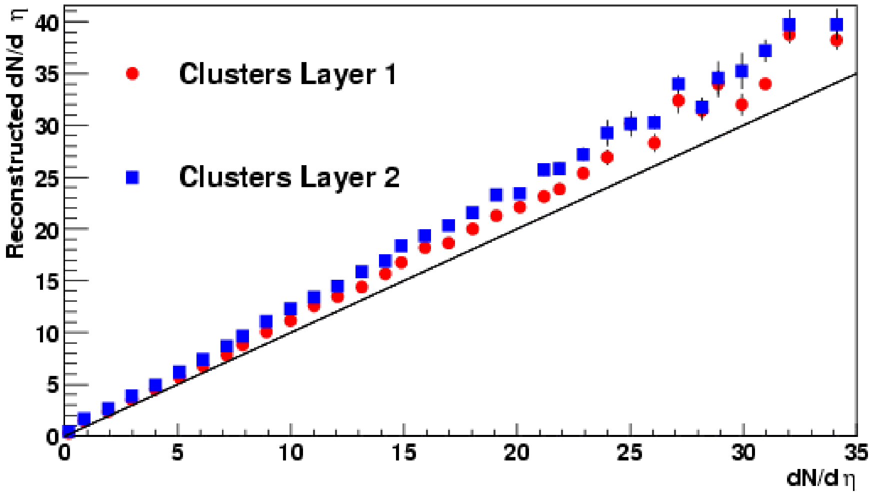
With 1 or 2 layers of ITS Silicon Pixel Detectors

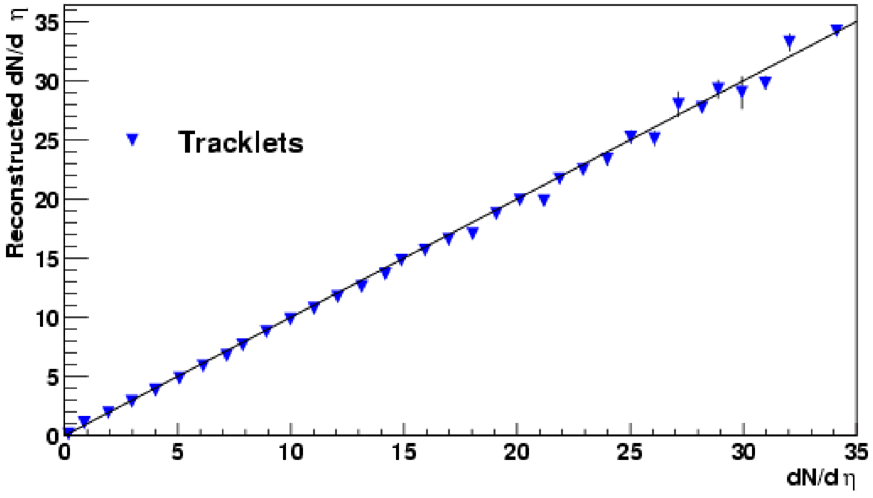
Two methods are compared:

- counting of clusters on one layer

- counting of tracklets

$|\eta| < 0.5$

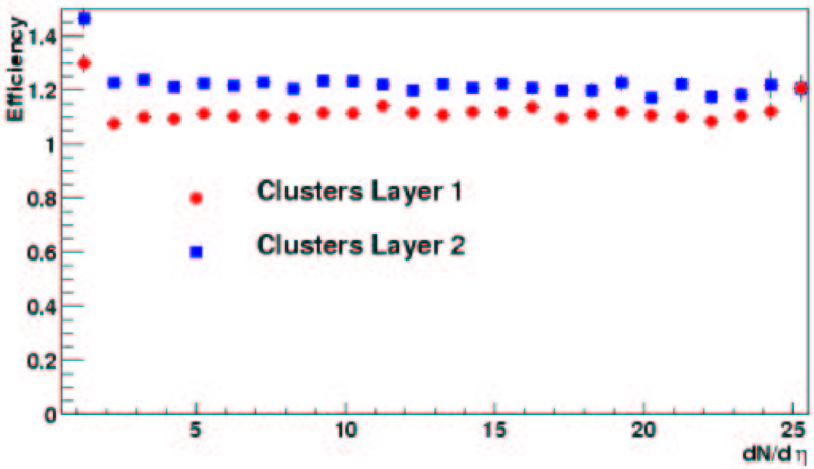




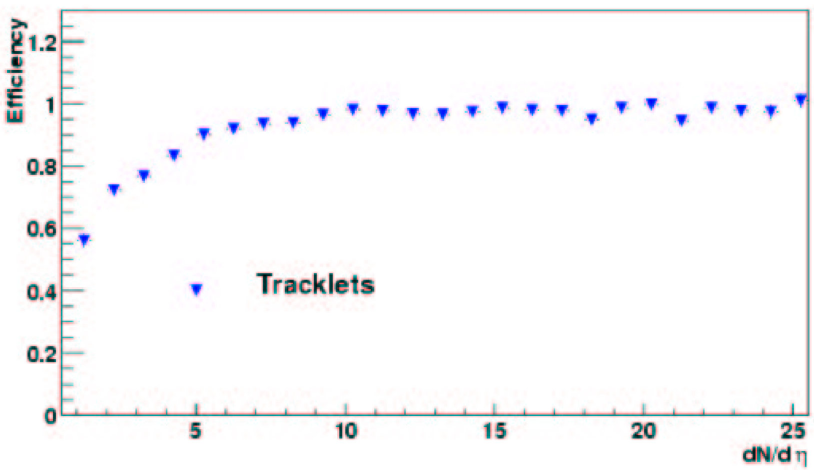
T. Virgili

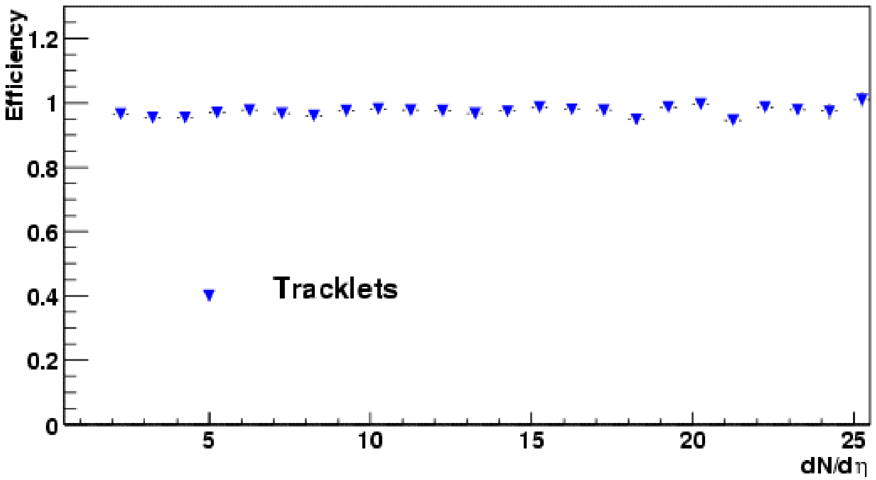
Multiplicity reconstruction: efficiency

T. Virgili



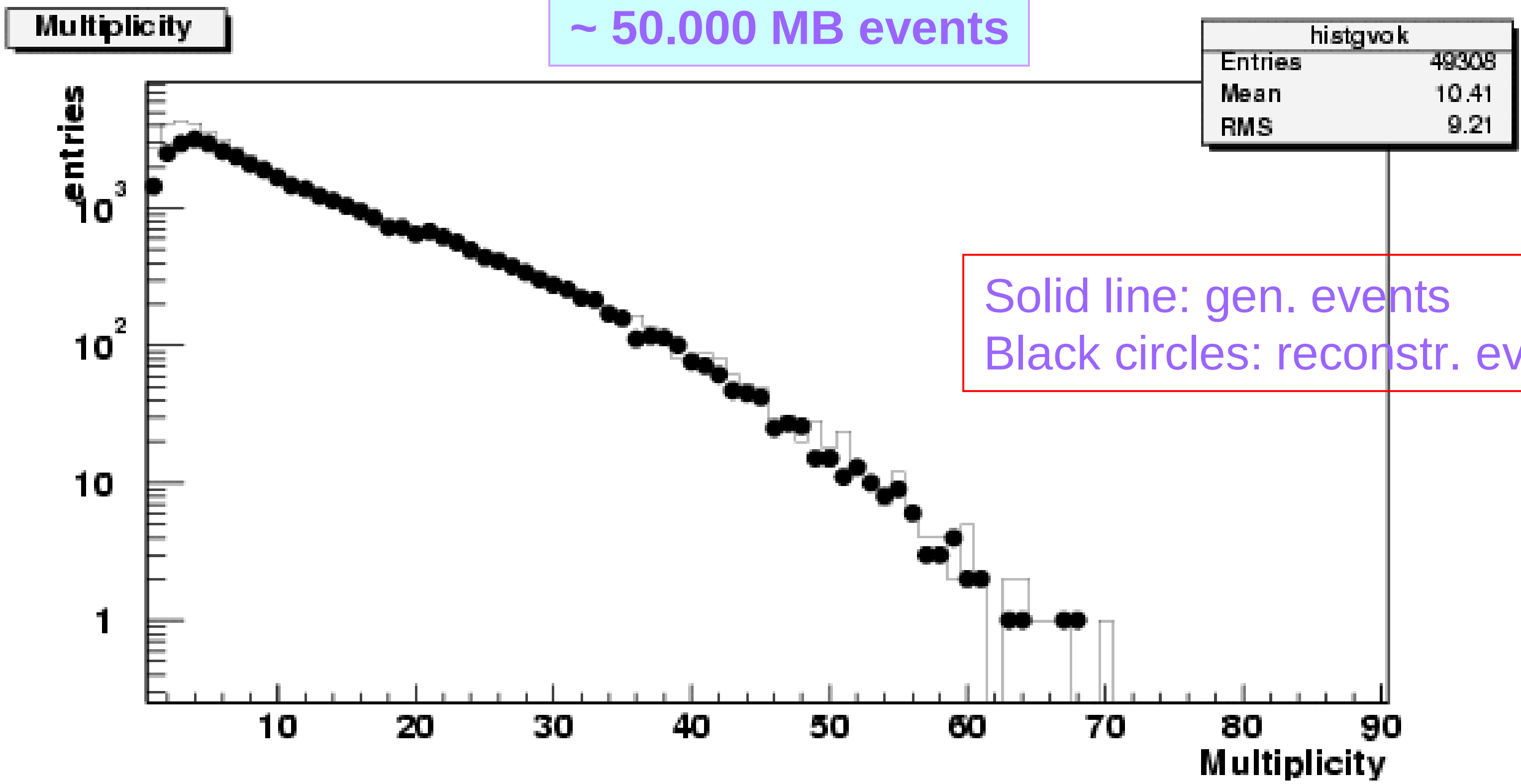
$|\eta| < 0.5$





Multiplicity spectrum

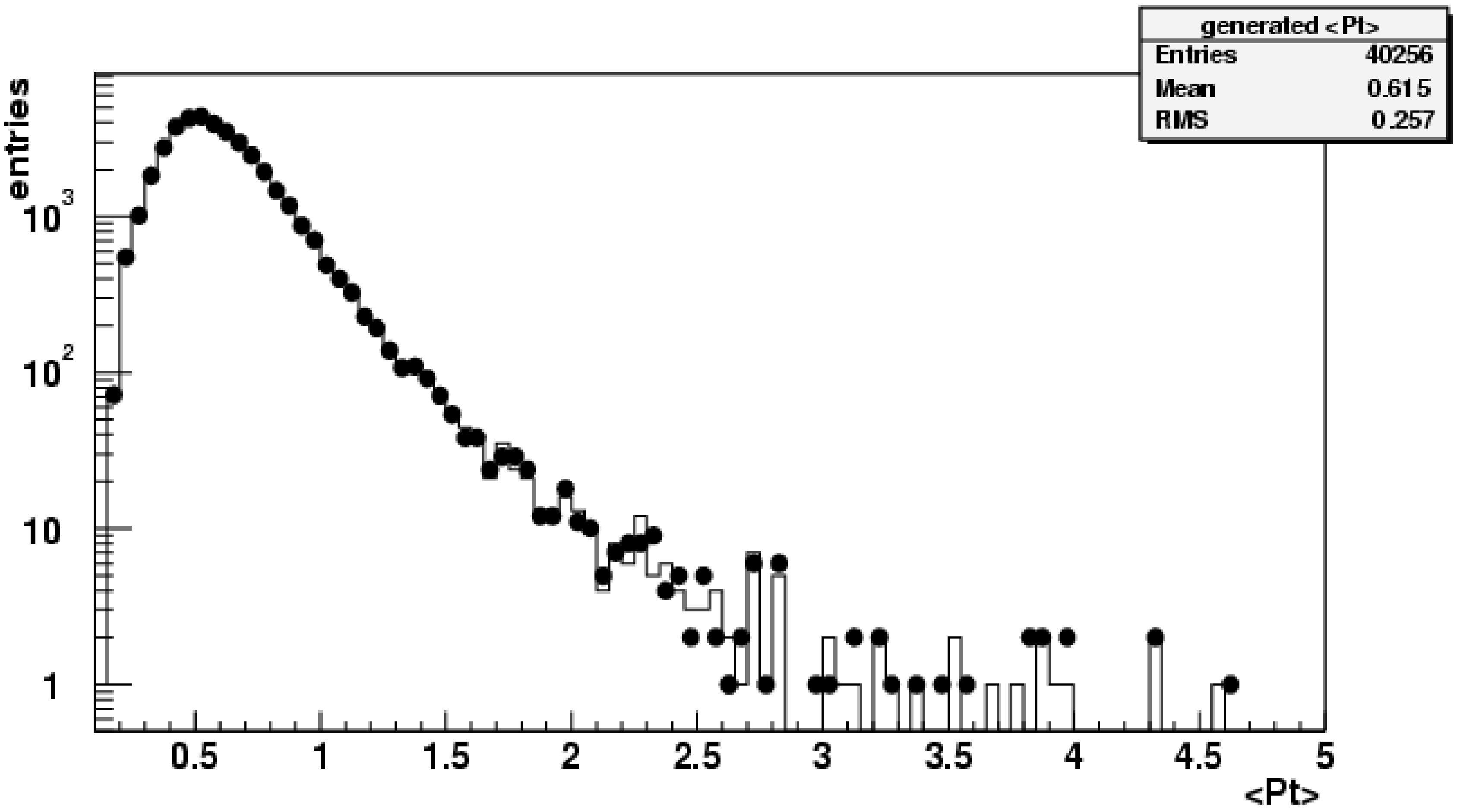
~ 50.000 MB events



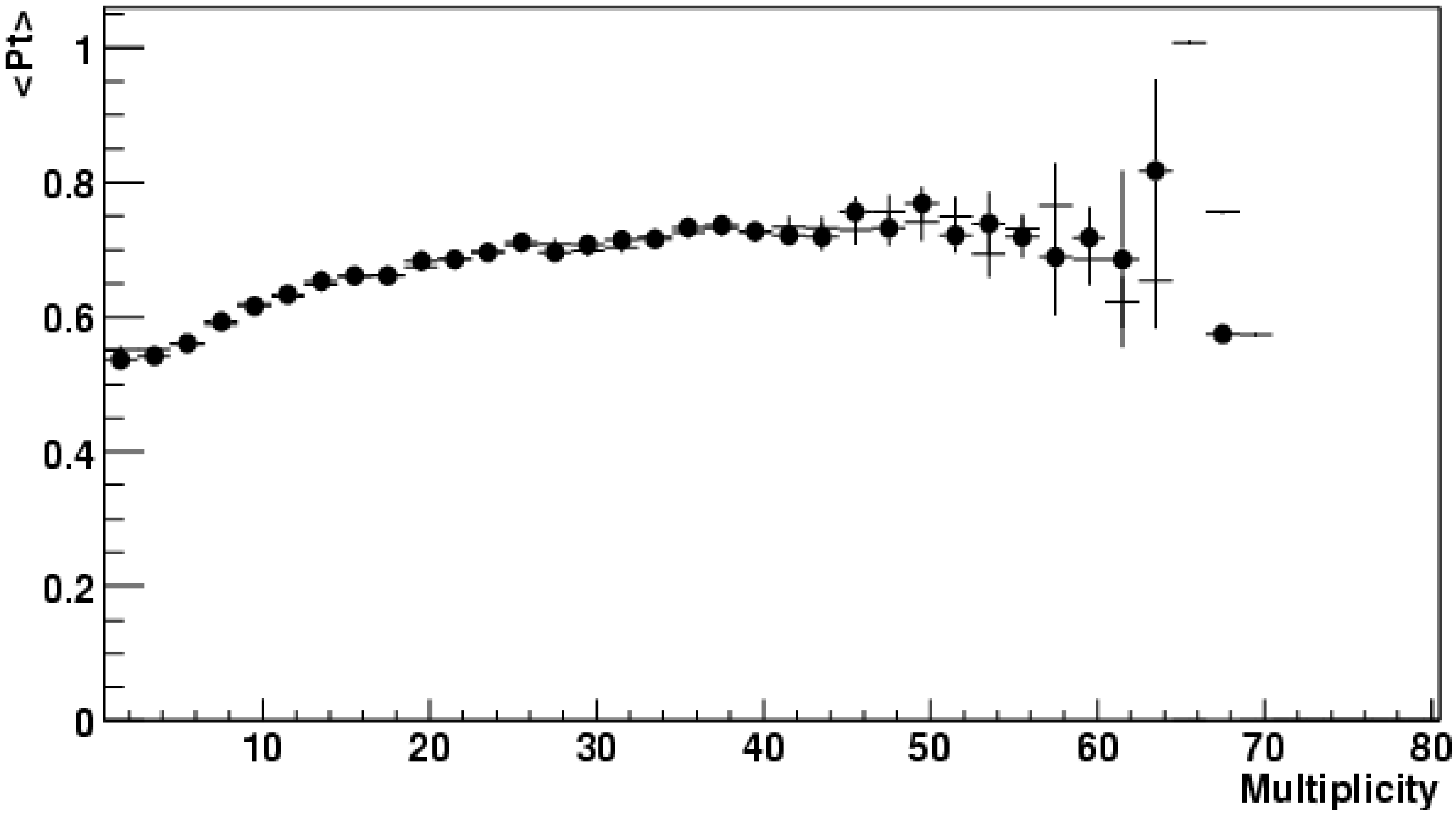
Solid line: gen. events
Black circles: reconstr. events

Selected events are those with the vertex reconstructed

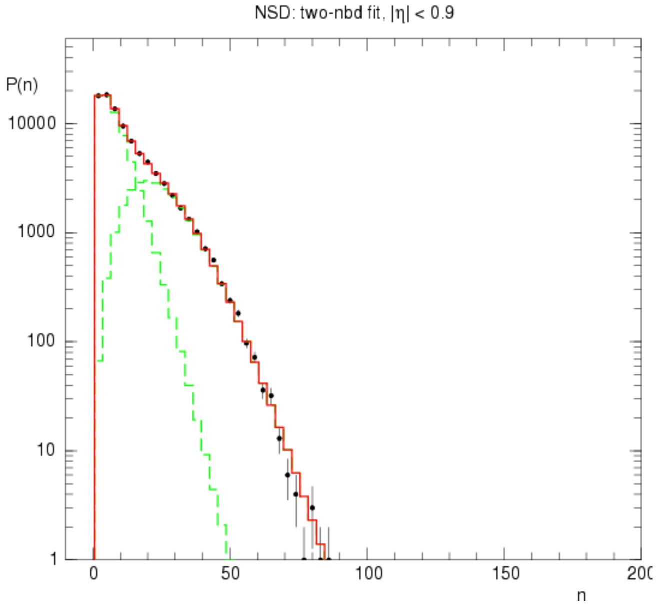
Average p_T (per event)



Average p_T versus multiplicity



Fits of multiplicity distributions with a sum of Negative Binomials

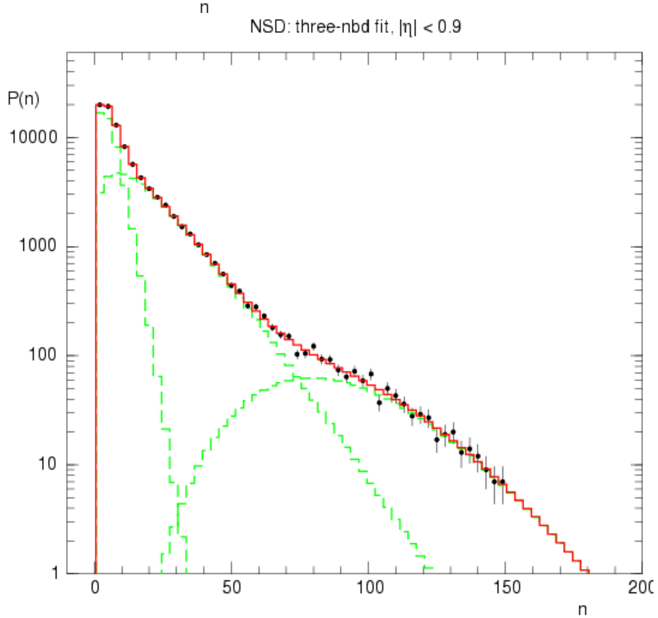


100.000 NSD PYTHIA events

Pythia 6.150
Model 3, CTEQ4L
LHCb tuning

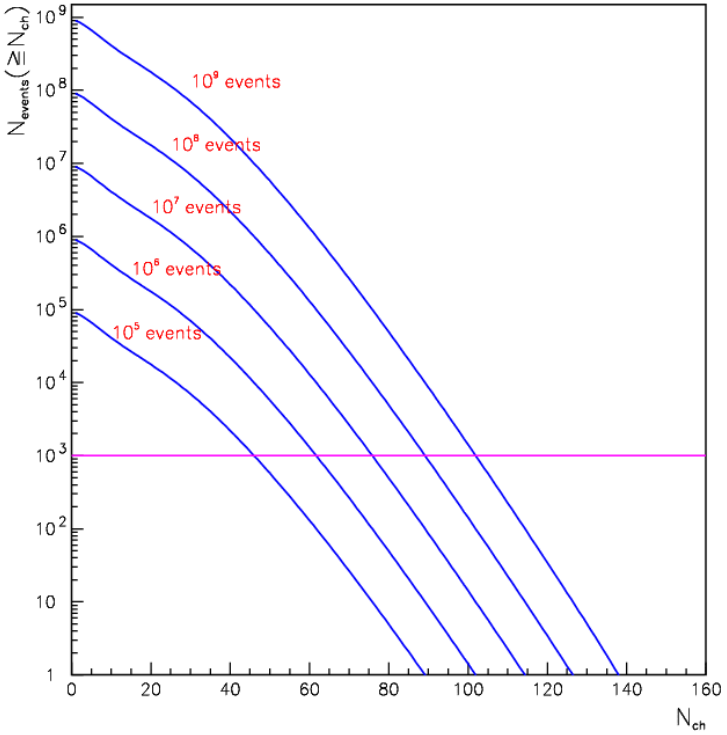
R. Ugoccioni
A. Giovannini
(Dip. Fisica Teorica and INFN, Torino)

Pythia 6.210
Model 4, CTEQ5L
Default param.



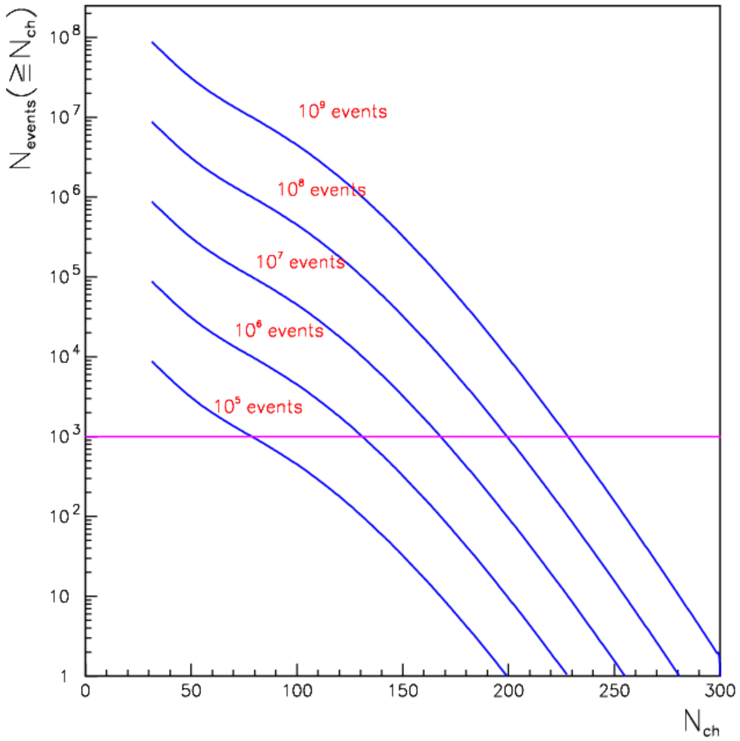
Shoulders can be interpreted as effect of the superposition of different classes of events: soft, semi-hard, hard…
Or, as indication of multi-parton scatterings

Extrapolations to higher statistics of data samples (up to 10^9 events)



Pythia 6.150
Model 3, CTEQ4L
LHCb tuning

Pythia 6.210
Model 4, CTEQ5L
Default param.



Concluding remarks

- The ALICE Physics Performance Report is going to be published at the end of this year. Emphasis will be given to the capabilities to measure given observables, their systematics, etc.
- However also a definition of a more or less stable set of PYTHIA parameters, reproducing Tevatron data would be welcome.
- Ongoing analysis will be updated and finalized after the summer.