ALICE

Properties of the systems created in pp and pA collisions in ALICE at the LHC

6to AVANCE DE TESIS

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AVANCE
De Tesis

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Outline

New from last presentation

- -Some comments about work on publications

Studies about spherocity for pp @ 13 TeV

- The event shape: spherocity
- Spherocity as a tool to look for jets and isotropic events
- Some technical details for this variable

-Optimal cuts for track selection
-Efficiency study as a function of spherocity
-Correction of the particle yield spectra by secondaries and efficiency
-Explanation for efficiency behaviour

Conclusions

New from last presentation

From last thesis report the next work on publication has been done:

A procedding was written:

J.Phys.Conf.Ser. 761 (2016) no.1, 012033

Title: Review of recent results on heavy-ion physics and astroparticle physics in ALICE at the LHC. Héctor Bello, Arturo Fernandez, Antonio Ortiz

http://iopscience.iop.org/article/10.1088/1742-6596/761/1/012033

https://arxiv.org/pdf/1609.00692v1.pdf

1 paper submitted to a journal

Title: Revealing the Source of the Radial Flow Patterns in Proton-Proton Collisions using Hard Probes. Antonio Ortiz, Gyula Bencédi, Héctor Bello

https://arxiv.org/pdf/1608.04784v1.pdf

Spherocity analysis pp @ 13 TeV

Physical Analyisis in ALICE collaboration:

- Transverse Sphericity.

Is defined in terms of the eigenvalues of

$$\mathbf{S}^{\mathbf{L}}_{\mathbf{xy}} = \frac{1}{\sum_i p_{\mathrm{T}i}} \sum_i \frac{1}{p_{\mathrm{T}i}} \begin{pmatrix} p_{\mathrm{x}i}^2 & p_{\mathrm{x}i}\, p_{\mathrm{y}i} \\ p_{\mathrm{y}i}\, p_{\mathrm{x}i} & p_{\mathrm{y}i}^2 \end{pmatrix}$$

as: $$S_{\mathrm{T}} \equiv \frac{2\lambda_2}{\lambda_2 + \lambda_1}.$$

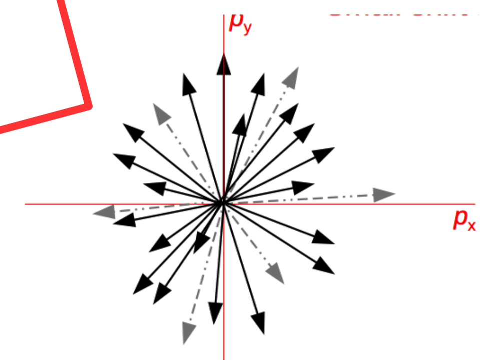
Where $\lambda_1 >= \lambda_2$.

- Transverse Spherocity

Transverse spherocity is

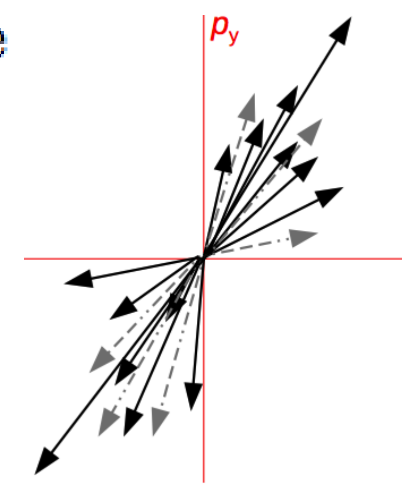
$$S_T^{pherocity} = \frac{\pi^2}{4} \min_{\vec{n}=(n_x,n_y,0)} \left(\frac{\sum_i |\vec{p}_{Ti} \times \vec{n}|}{\sum_i \vec{p}_{Ti}} \right)^2$$

Looking for an ALICE paper with this measurement.



For both cases we have the limits:

$$S_o = S_T^{pherocity} = \begin{cases} 1 \text{ isotropic structure} \\ 0 \text{ dijet structure} \end{cases}$$



Andrea Banfi G. Salam and G. Zanderighi, "Phenomenology of the event shapes at hadron colliders", arXiv:1001.4082

Some technical details for the analysis.

- For the introduction of this variable, some technical details are studied and documented

Event clasification using transverse spherocity and event multiplicity for the analysis of pp data: https://aliceinfo.cern.ch/Notes/node/529

For this study we take some considerations:

DATASET: data: LHC15f pass2 (good runs acroding RCT)

MC: LHC15g3a3 (Pythia8-Monash2013)

EVENT SELECTION: AliVEvent::kINT7, AnalysisUtils::IsSPDClusterVsTrackletBG()

IsPileupFromSPDInMultBins(), IsIncompleteDAQ()

VERTEX: SPD and Track vertices reconstructed, separation along z <5mm

For Spherocity we take more than 2 tracks with pT>0.15 GeV/c and | eta |<0.8

Three set of cuts tested:

STANDAR cuts:GetStandardITSTPCTrackCuts2011(kTRUE,1)

HYBRID:CreateTrackCutsPWGJE(10001008)+CreateTrackCutsPWGJE(10011008)

TPC cuts:GetStandardTPCOnlyTrackCuts+TPCrefit

For Multiplicity: GetReferenceMultiplicity(fESD,AliESDTrackCutsITSTPC,0.8)

Analysis and run selection

Software: Aliroot:`v5-07-20` Aliphysics:`vAN-20160204`
Event shape classes: (PWGLF/SPECTRA/Spherocity)
Analysis macros: `AddTransverseEventShapeTask.C`
`AliAnaTransverseEventShapeTask.cxx`
`AliAnaTransverseEventShapeTask.h`

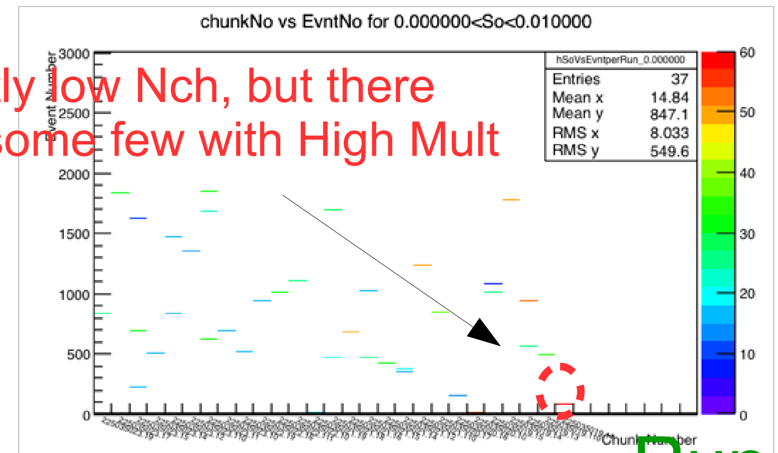
LHC15f pass2: (55 mill of evts) - 54-50
LHC15g3a3 Monash Tune (52 mill of evts)
LHC15g3c3 Perugia 2011 (49 mill of evts)
good runs*:
226500, 226495, 226483, 226476, 226472, 226468, 226466, 226452, 226445, 226444, 226225, 226220, 226170, 226062, 225768, 225766, 225763, 225762, 225757, 225753, 225719, 225717, 225716, 225710, 225709, 225708, 225707, 225705, 225587, 225586, 225579, 225578, 225576, 225322, 225315, 225314, 225313, 225310, 225309, 225307, 225305, 225106, 225052, 225051, 225050, 225043, 225041, 225037, 225035, 225031, 225026

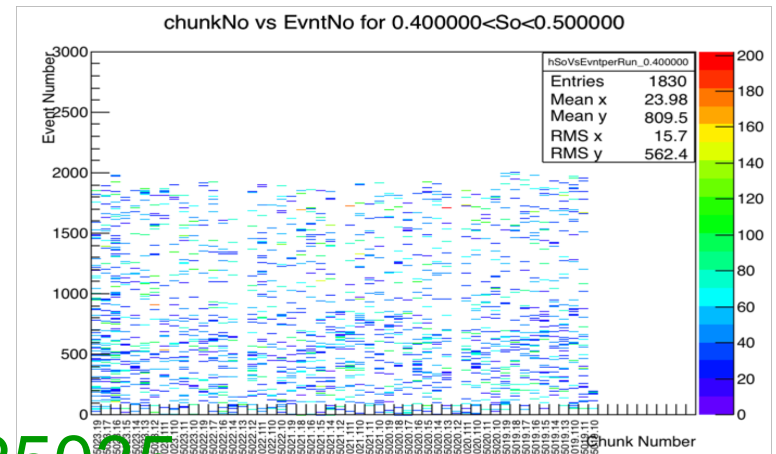
(*) http://twiki.cern.ch/twiki/bin/viewauth/ALICE/PWGLF13TeVanalysis

Spherocity as a tool for searching dijets and isotropic events with high multiplicity.

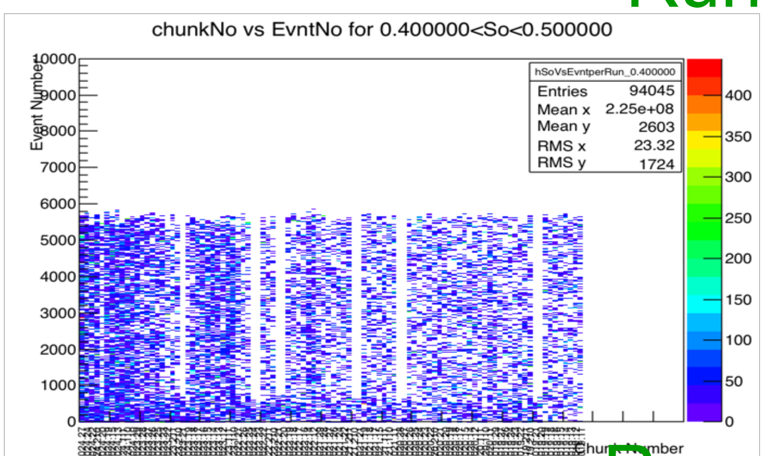
Using So we can find interesting events with specific shape and high multiplicity.

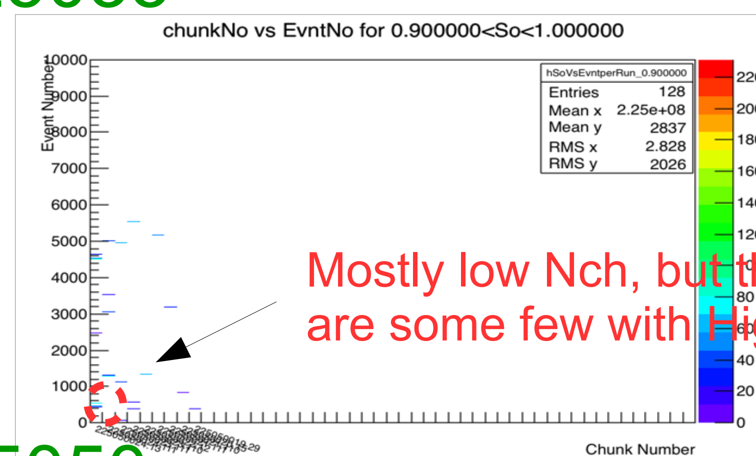
Mostly low Nch, but there are some few with High Mult





Run 225035



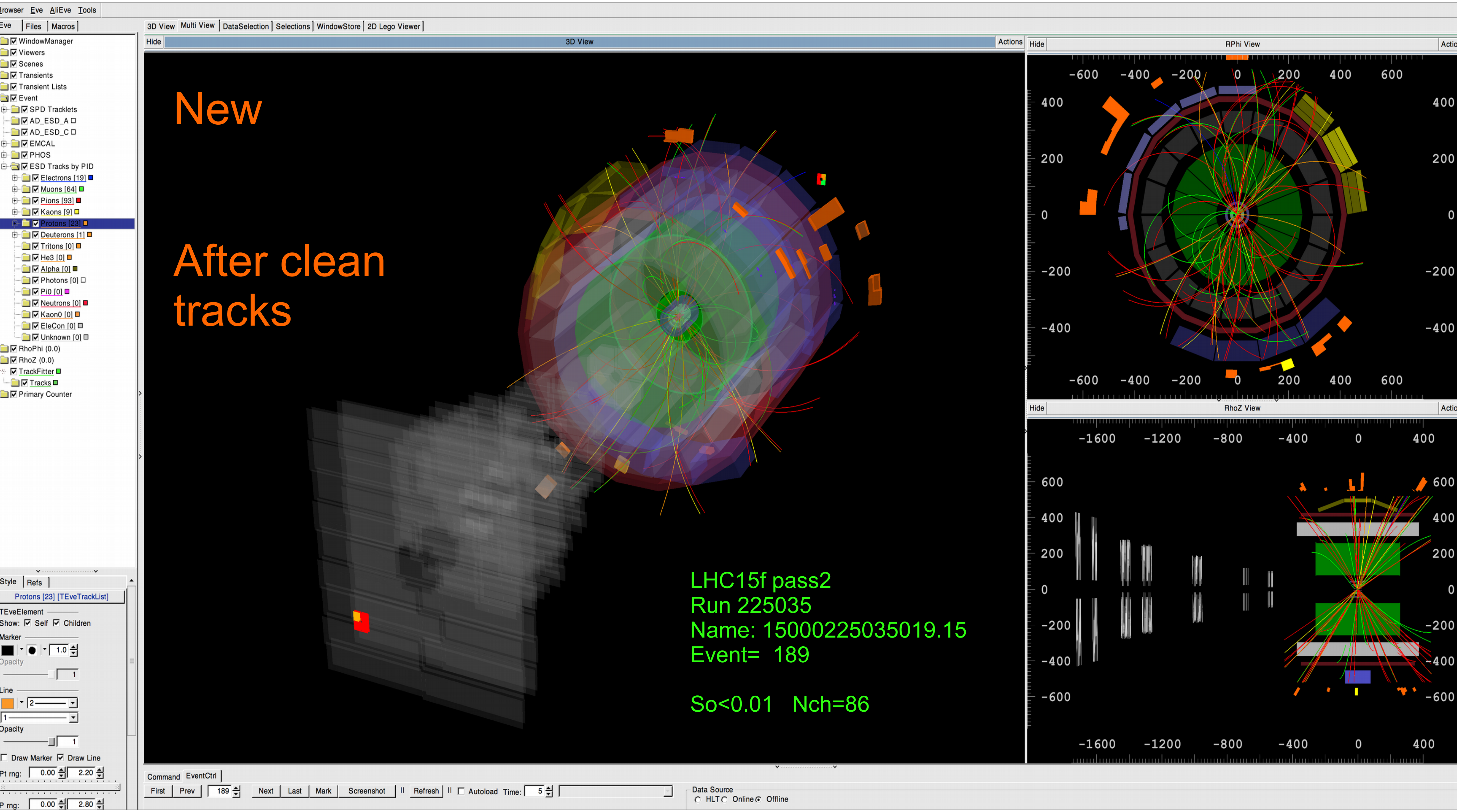


Mostly low Nch, but there are some few with High Mult

Run 225050

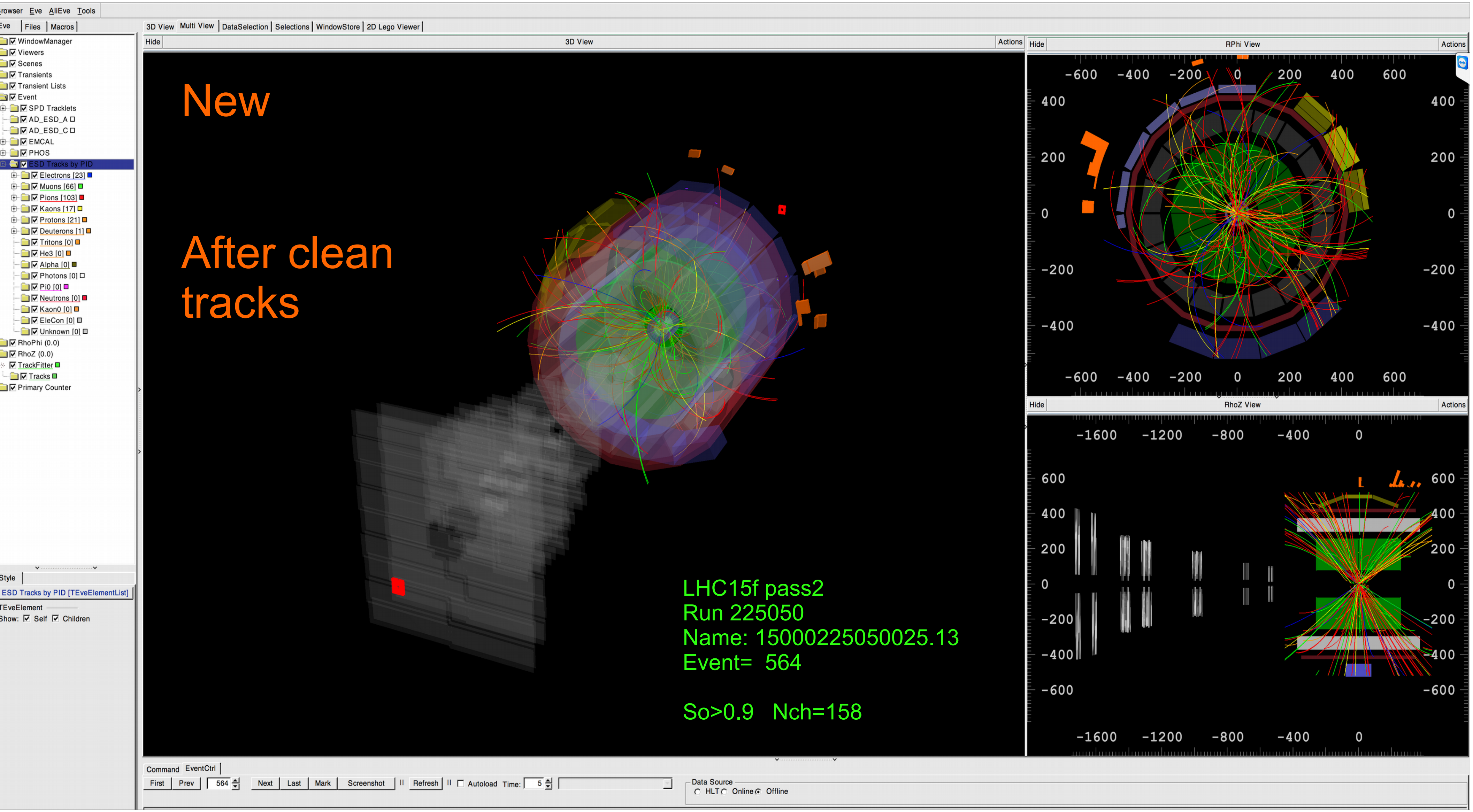
Visualization for events selected with Spherocity R 225035

JETTY EVENT So<0.01 (HM event)



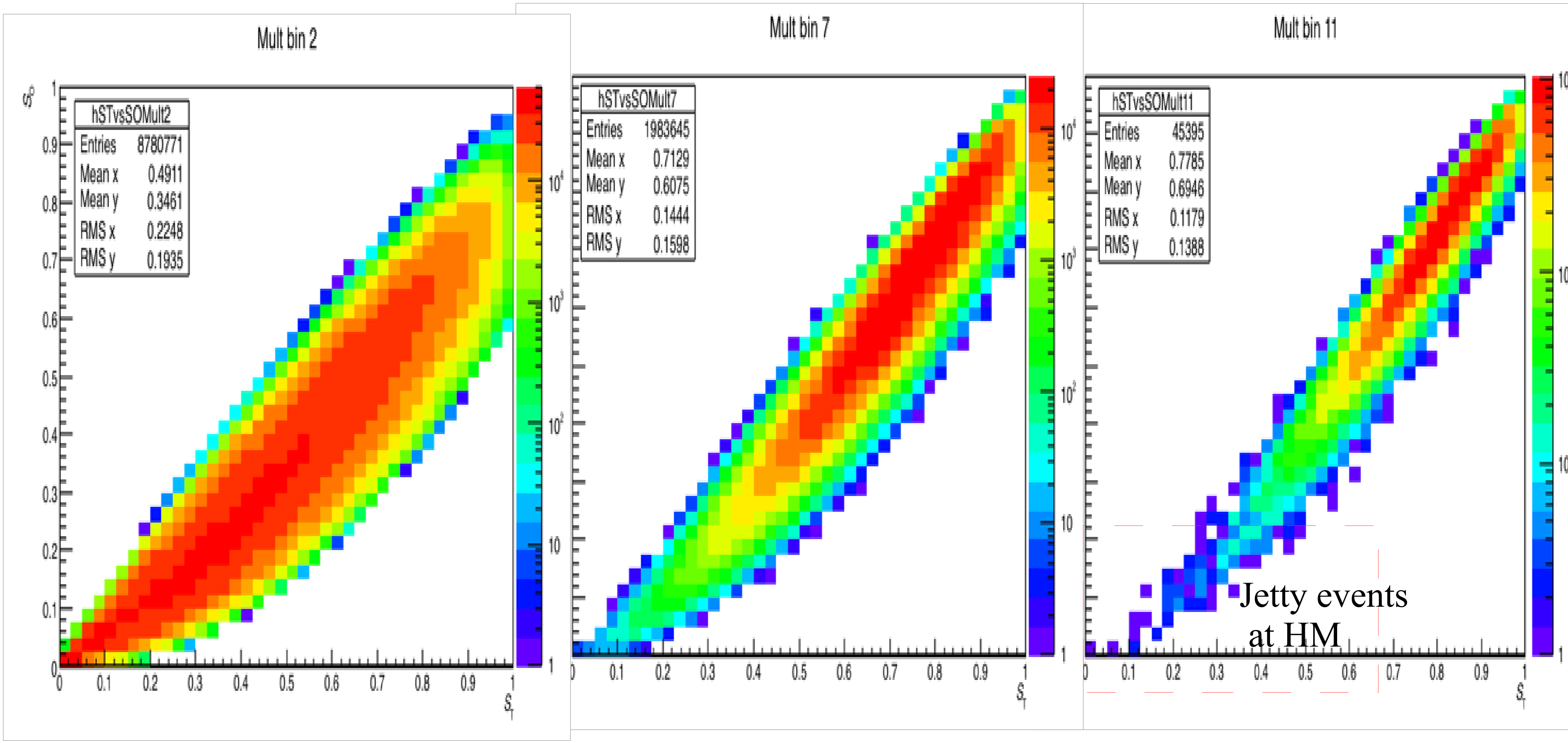
Visualization for events selected with Spherocity R 225050

ISOTROPIC So>0.9 (HM event)



What is the correlation Spherocity vs Sphericity for diff. Nch bins

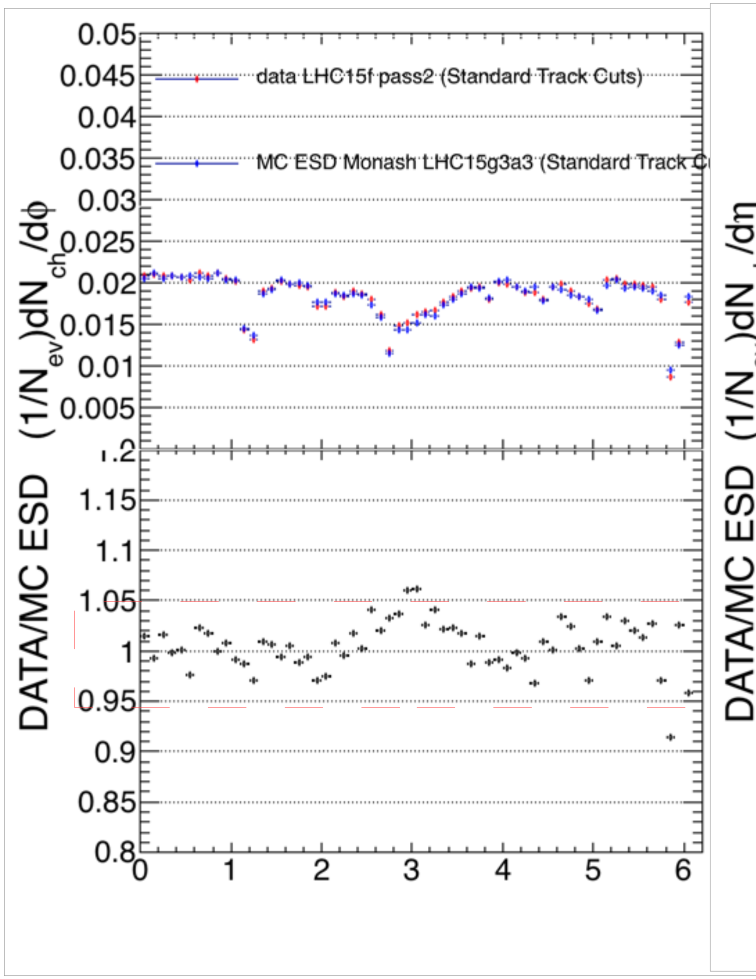
We see the correlation and difference at low and high multiplicity

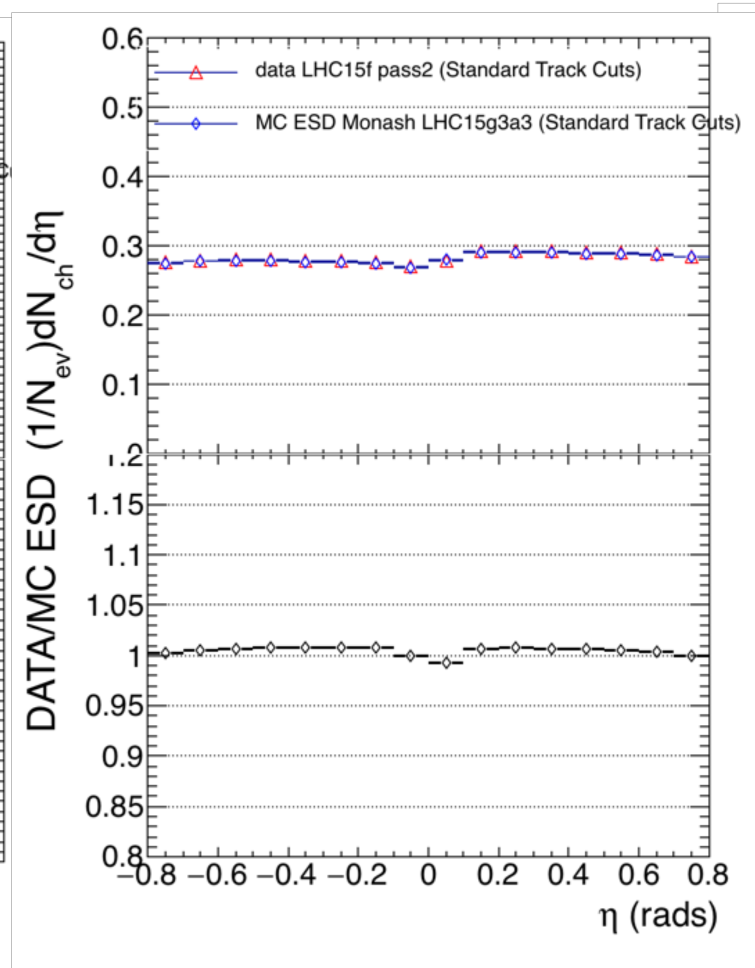


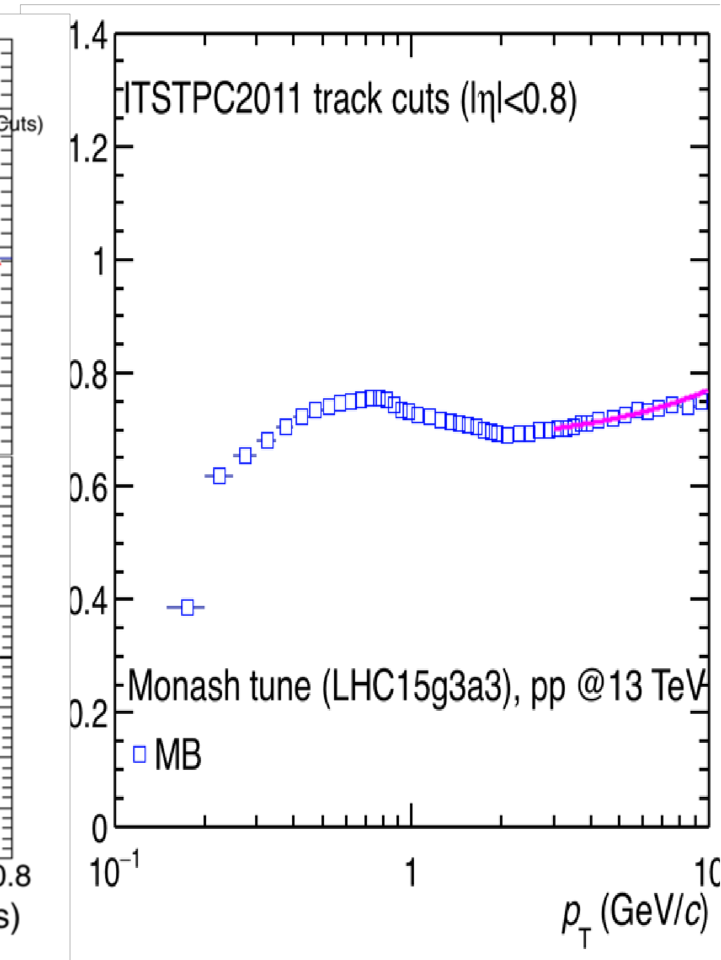
Multbins[14]={0,1, 4, 7,10,15, 20, 25, 30, 40, 50, 60, 70, 140 };

Wich track cuts selection is the optimum?

To study MC/DATA dependence for different cuts:
-ITSTPC2011 golden DATA vs MC

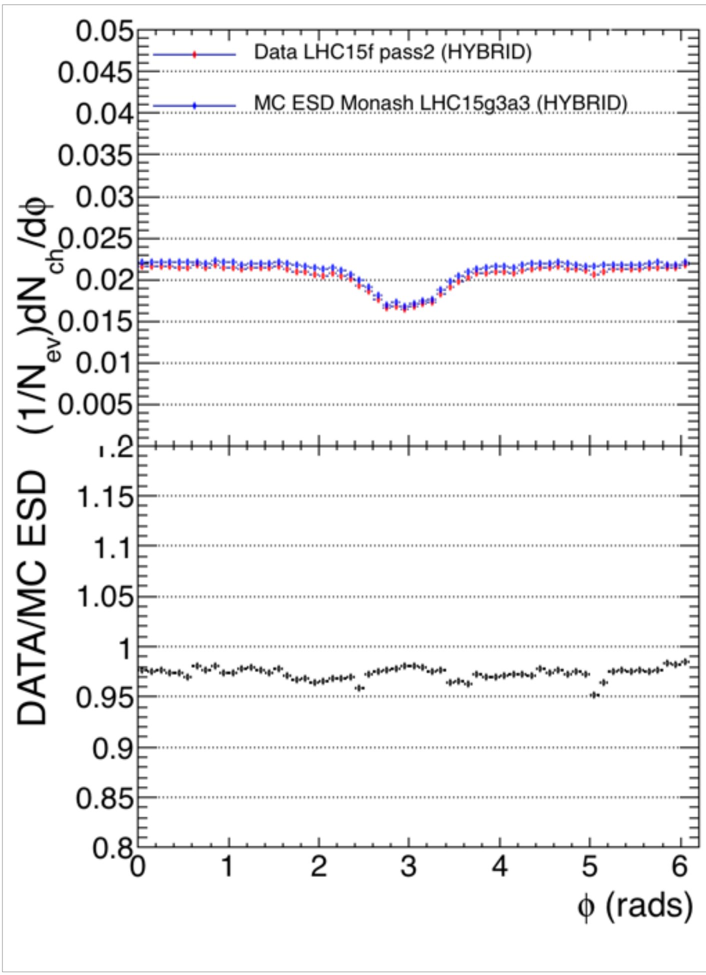


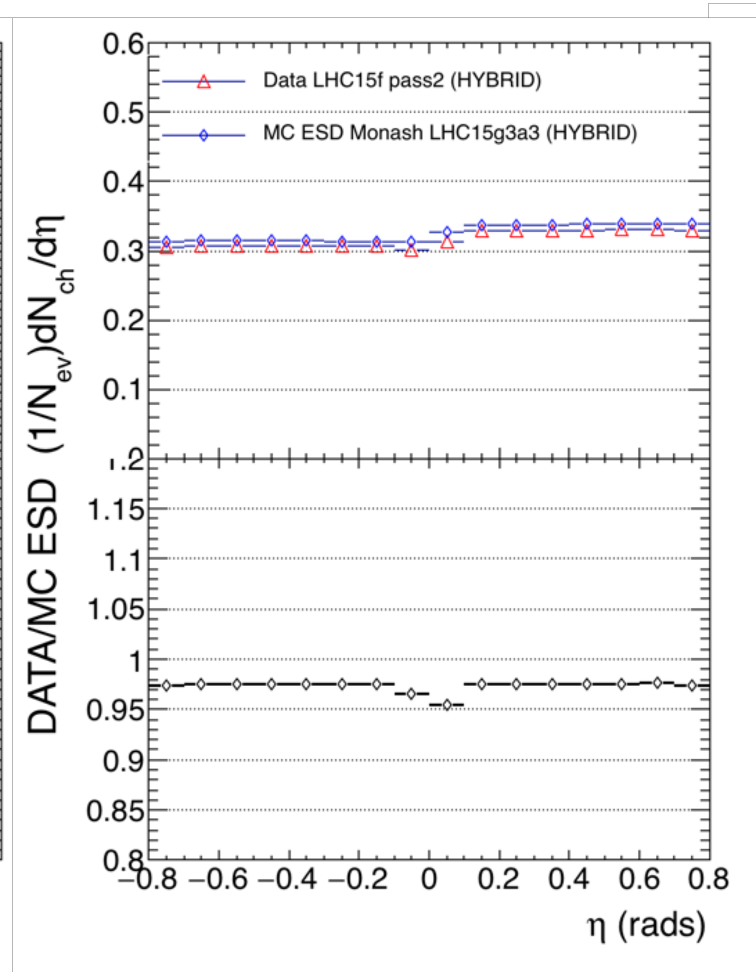


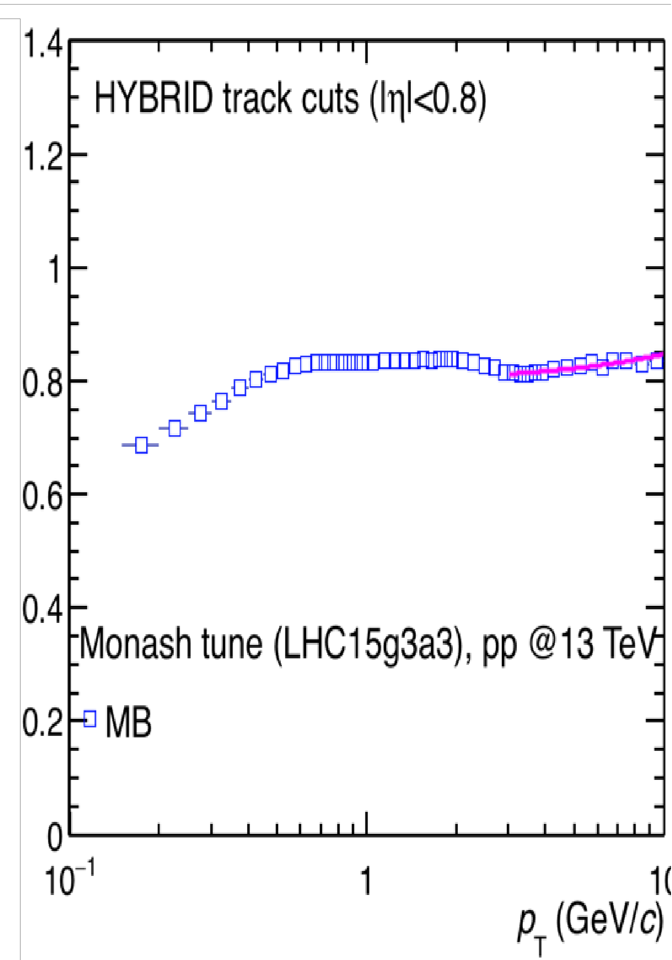


Wich track cuts selection is the optimum?

To study MC/DATA dependence for different cuts: HYBRID track cuts DATA vs MC



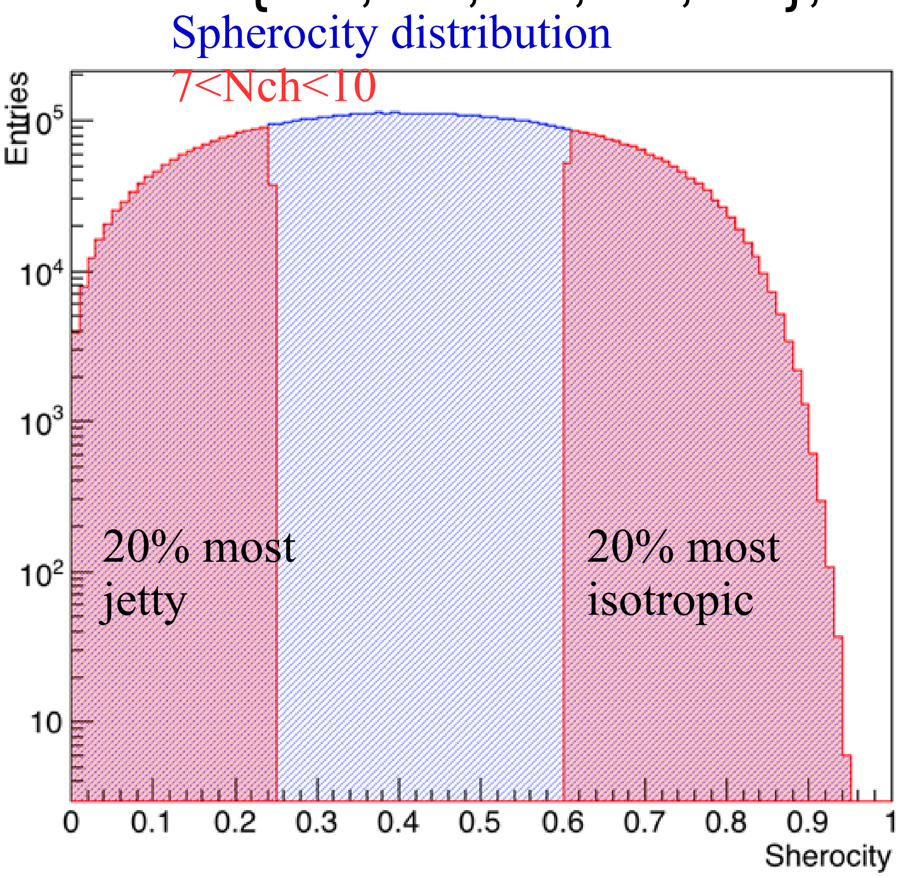


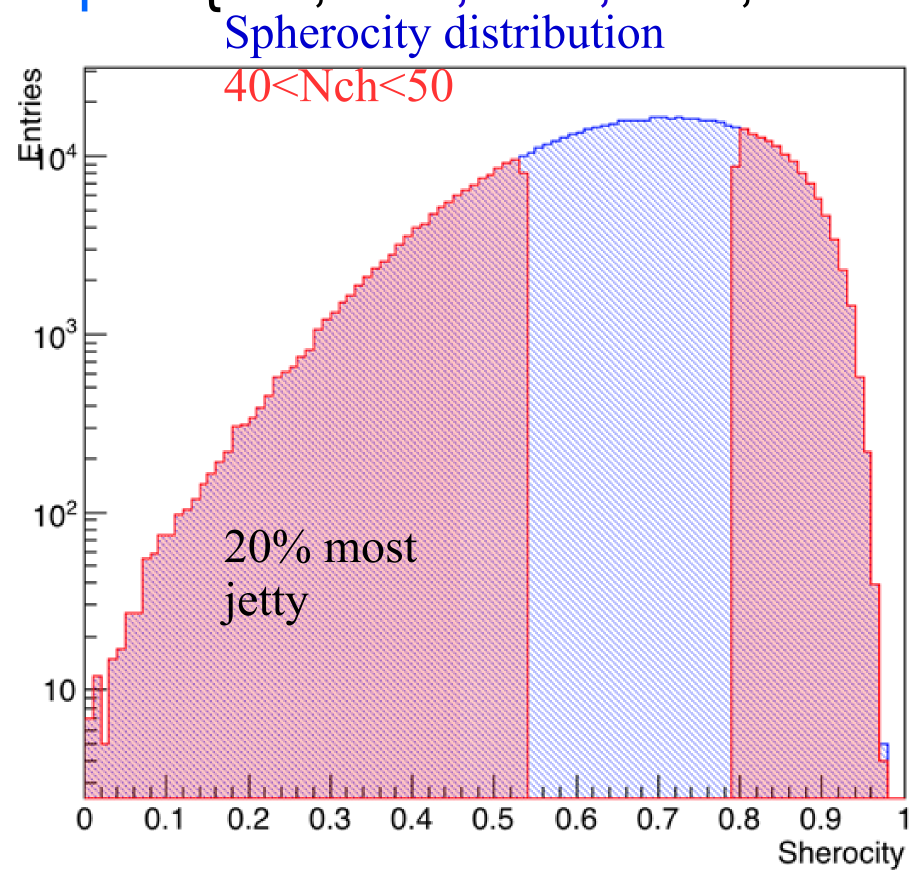


How is affected the efficiency due to the event selection with different topology?

For three different Event Shape binnings and percentiles

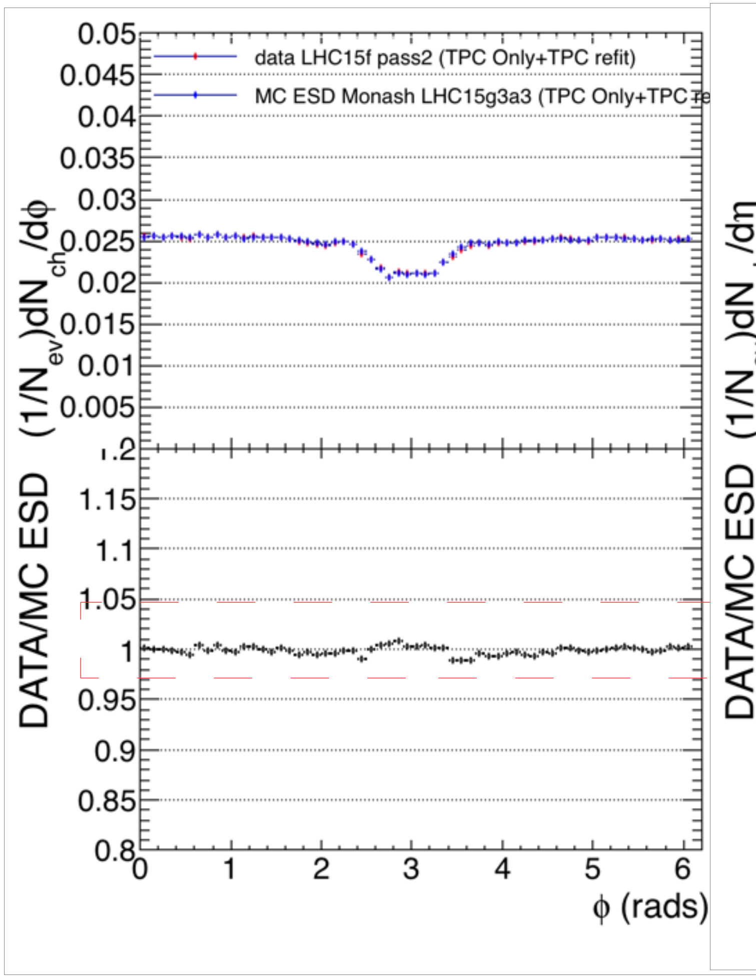
- BinA= {0.0,0.1,0.4,0.9,1.0};   BinApc= {0.0,10.0,40.0,90.0,100.0};
- BinB= {0.0,0.2,0.4,0.8,1.0};   BinBpc= {0.0,20.0,40.0,80.0,100.0};
- BinC= {0.0,0.3,0.4,0.7,1.0};   BinCpc= {0.0,30.0,40.0,70.0,100.0};

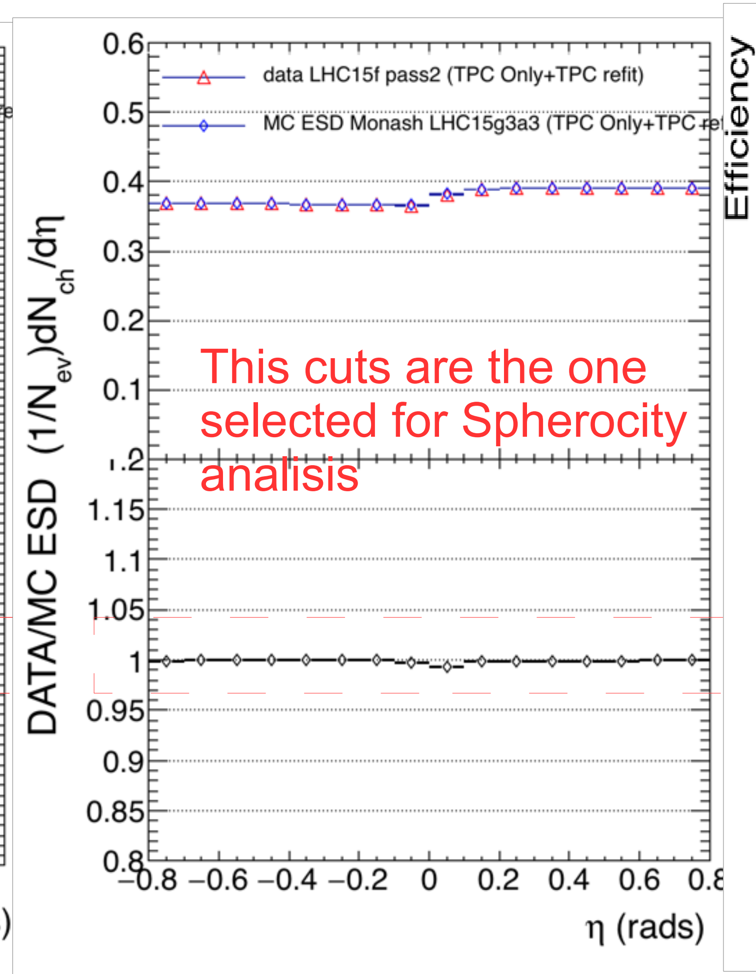




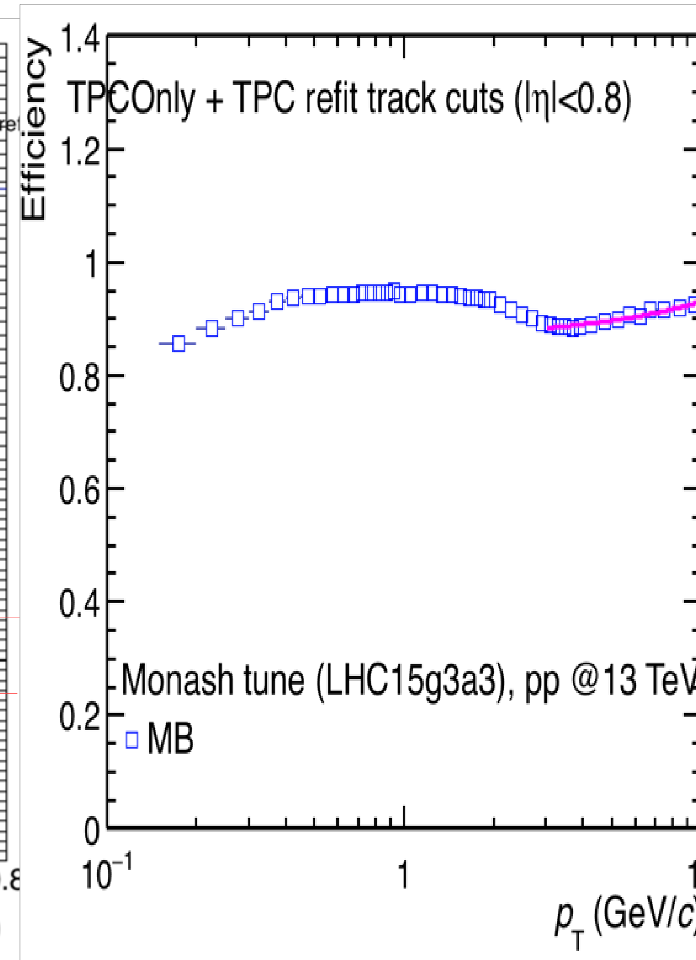
Wich track cuts selection is the optimum?

To study MC/DATA dependence for different cuts: TPC Only+TPC refit DATA vs MC



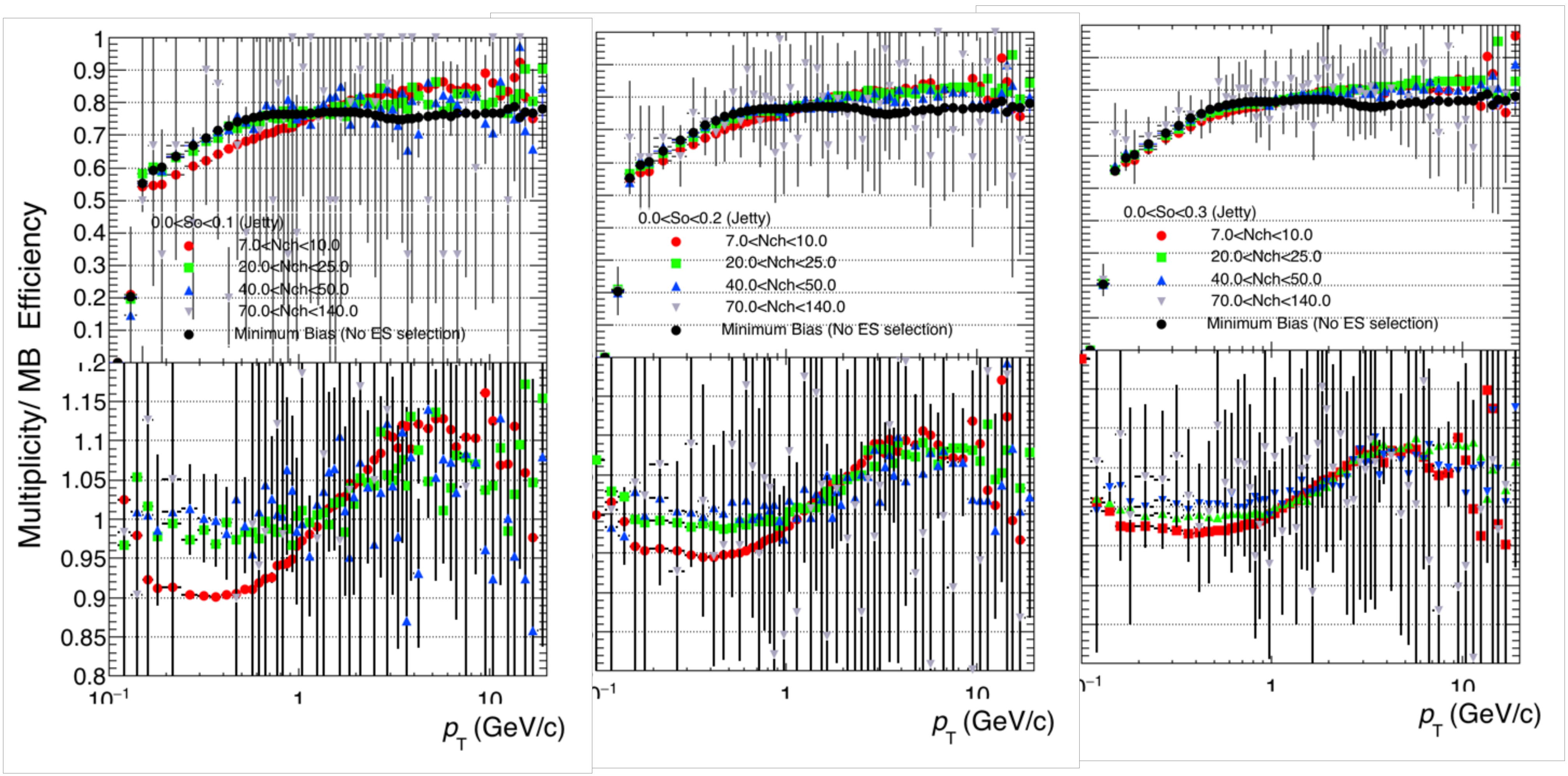


This cuts are the one selected for Spherocity analisis



For three different SPHEROCITY binnings for JETTY events

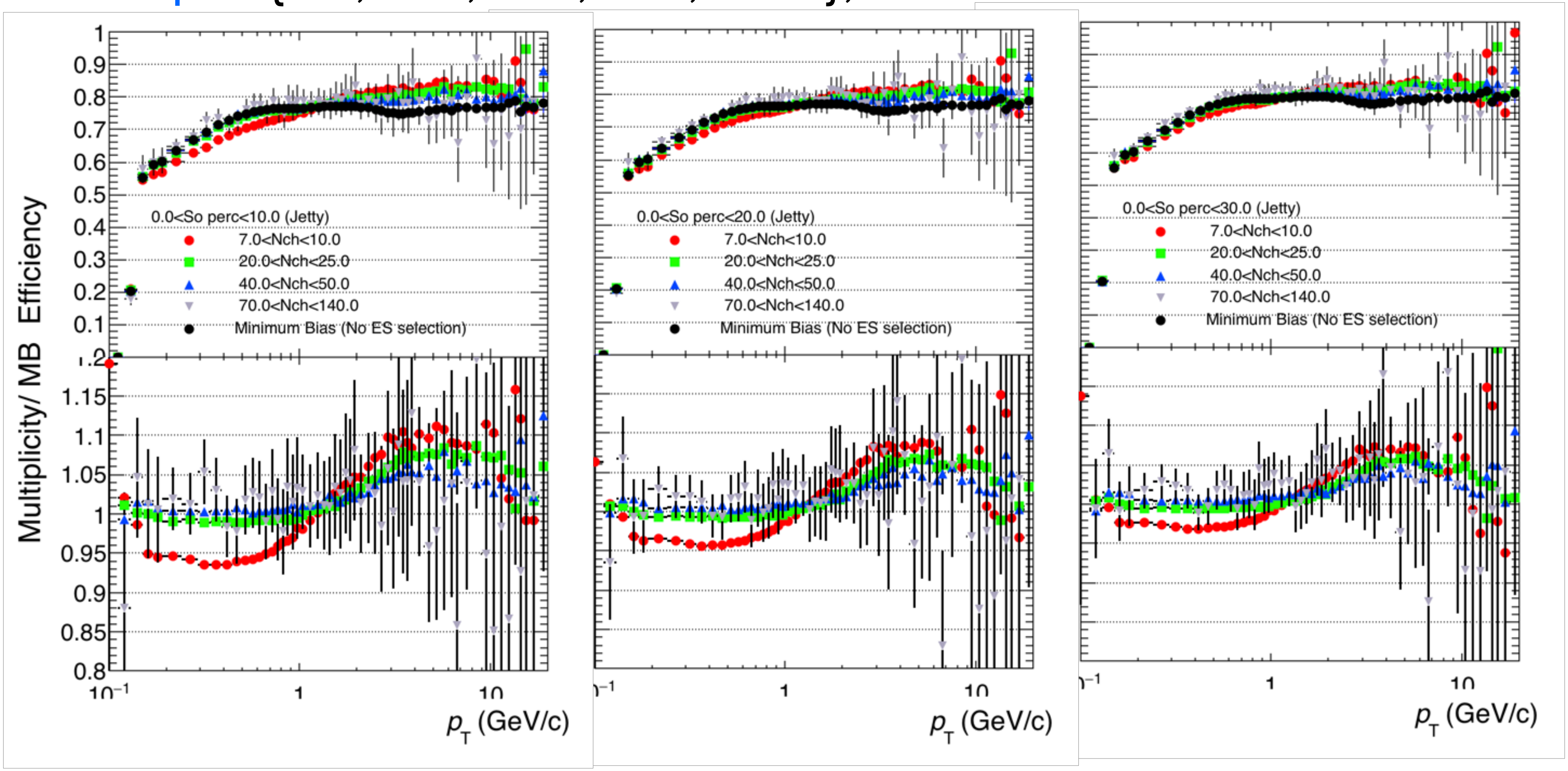
- BinA= {0.0,0.1,0.4,0.9,1.0};
- BinB= {0.0,0.2,0.4,0.8,1.0};
- BinC= {0.0,0.3,0.4,0.7,1.0};



For three different SPHEROCITY percentiles for JETTY events

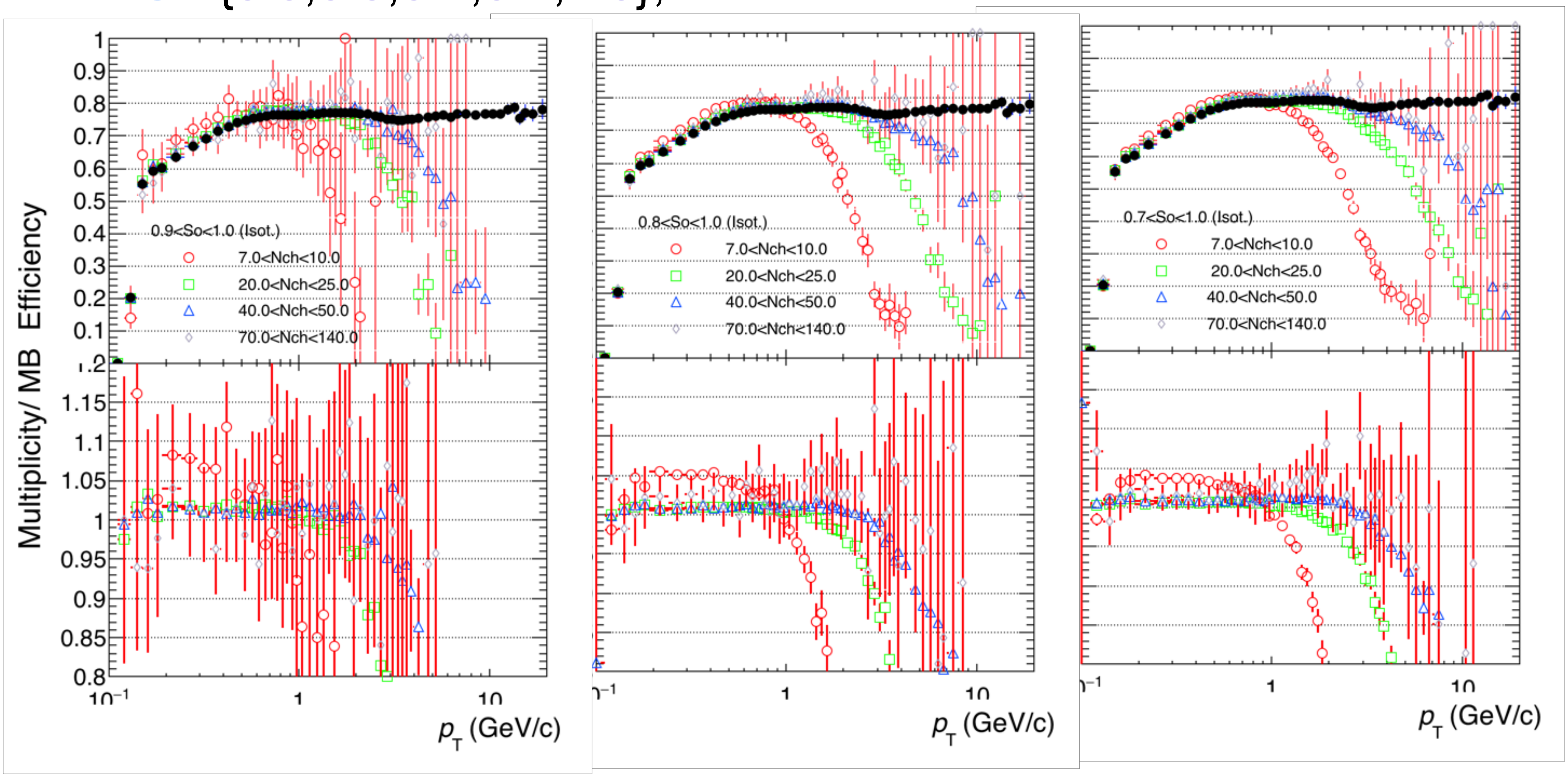
- BinApc= {0.0,10.0,40.0,90.0,100.0};
- BinBpc= {0.0,20.0,40.0,80.0,100.0};
- BinCpc= {0.0,30.0,40.0,70.0,100.0};

Better statistics for percentiles



For three different SPHEROCITY binnings for ISOTROPIC events

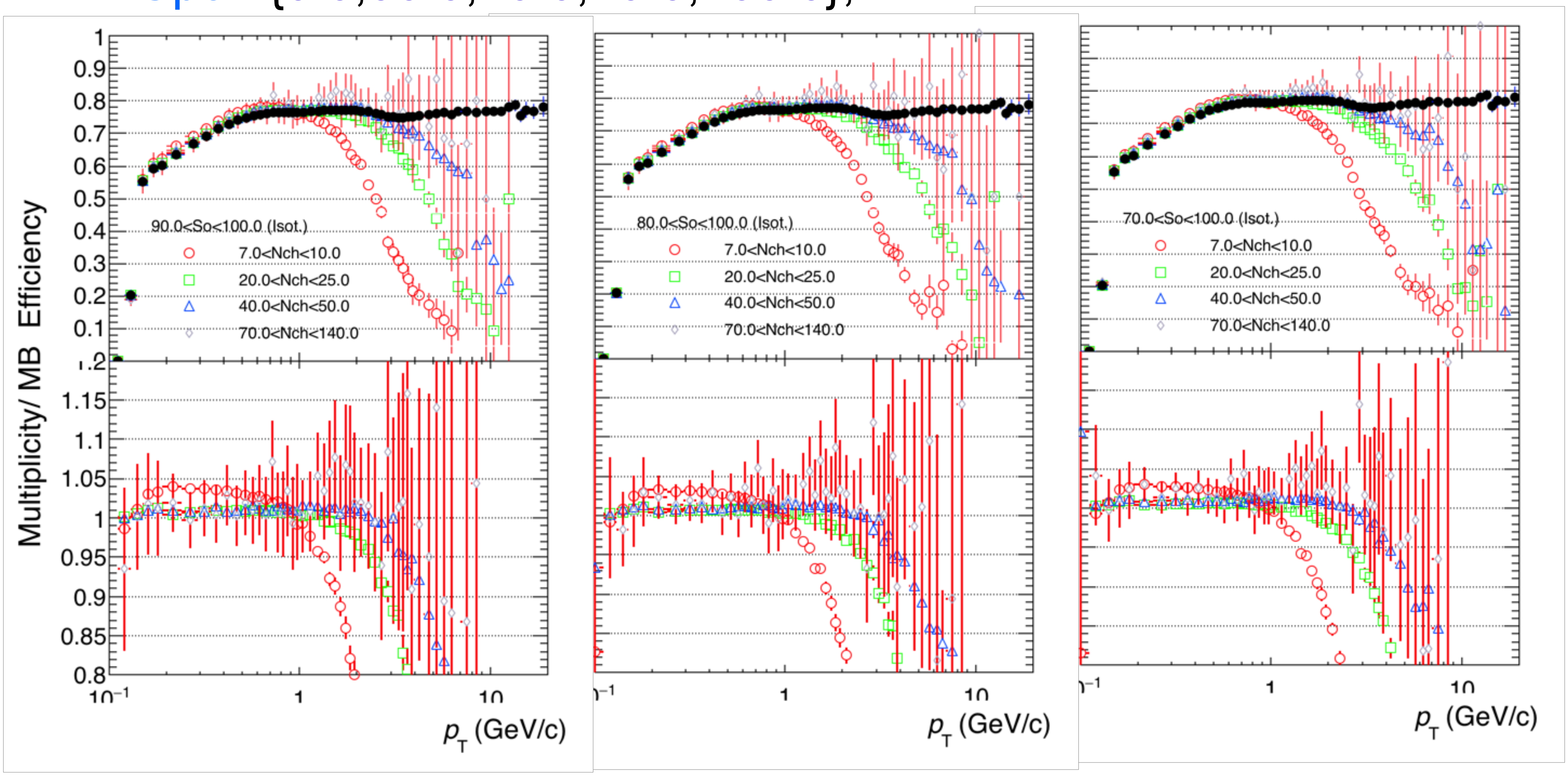
- BinA= {0.0,0.1,0.4,0.9,1.0};
- BinB= {0.0,0.2,0.4,0.8,1.0};
- BinC= {0.0,0.3,0.4,0.7,1.0};



For three different SPHEROCITY percentiles for ISOTROPIC events

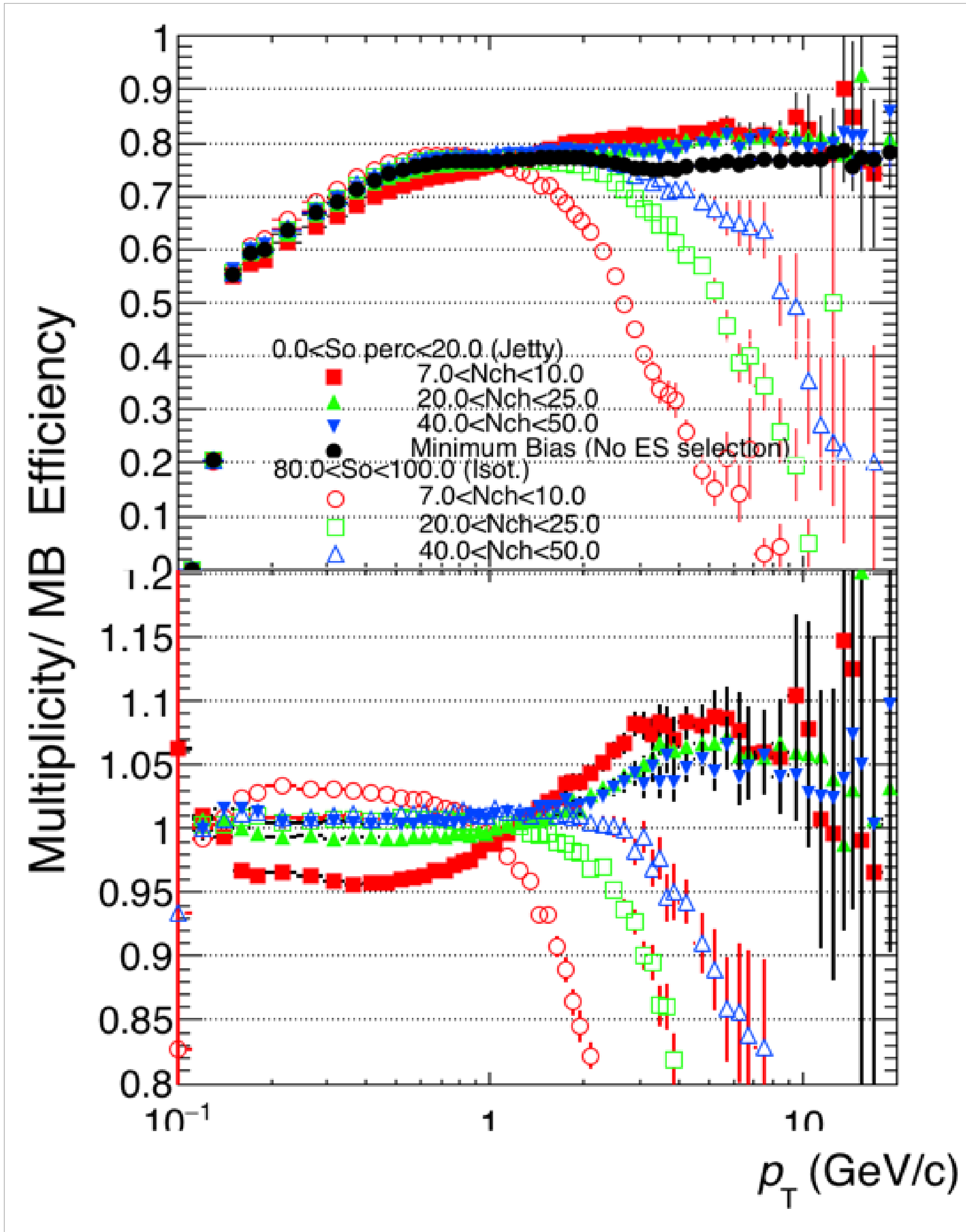
- BinApc= {0.0,10.0,40.0,90.0,100.0};
- BinBpc= {0.0,20.0,40.0,80.0,100.0};
- BinCpc= {0.0,30.0,40.0,70.0,100.0};

Better statistics for percentiles

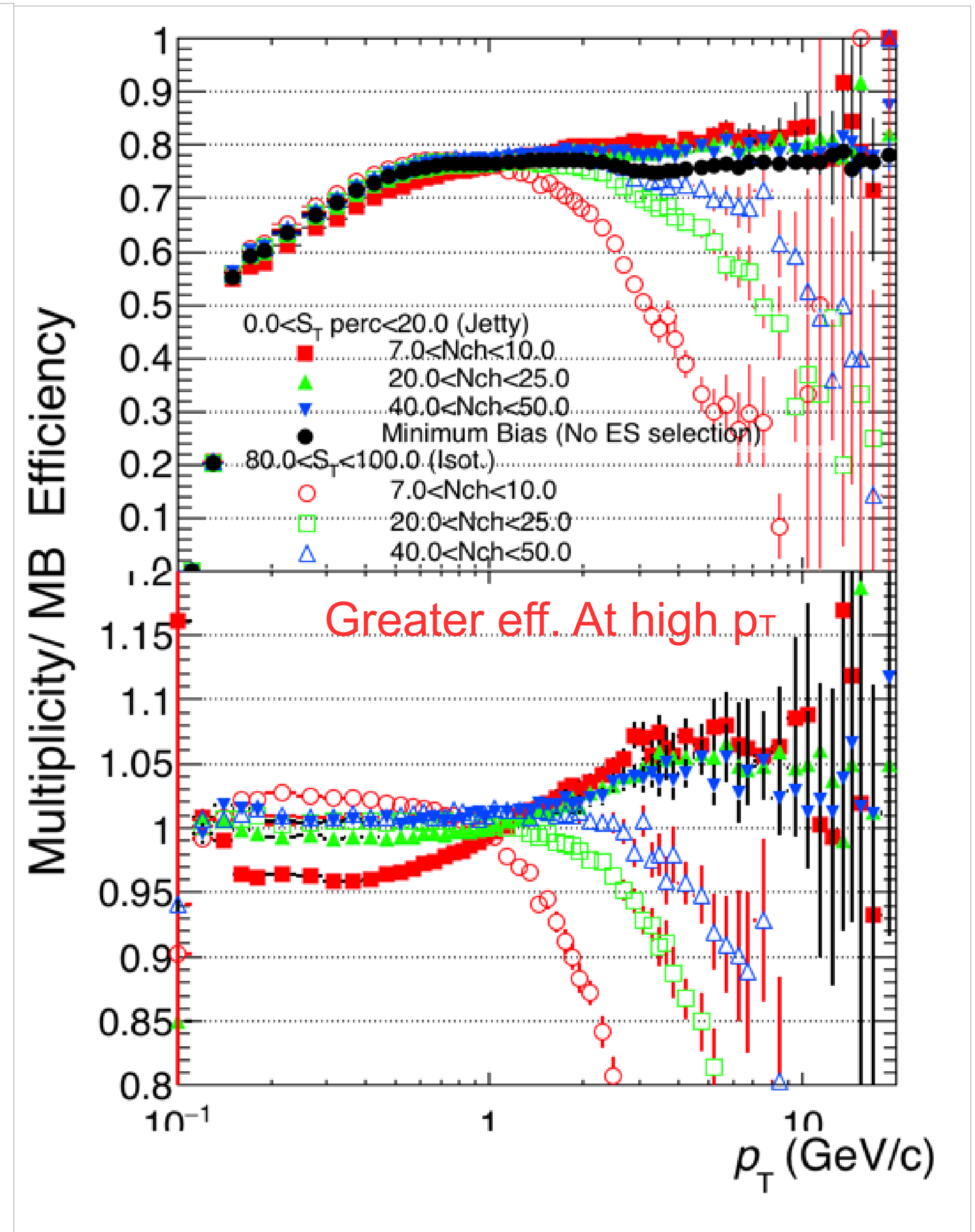


Comparison for percentile bins with best statistics.

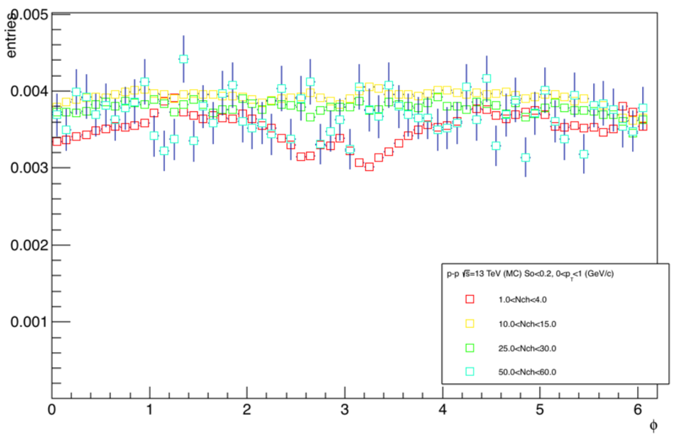
SPHEROCITY

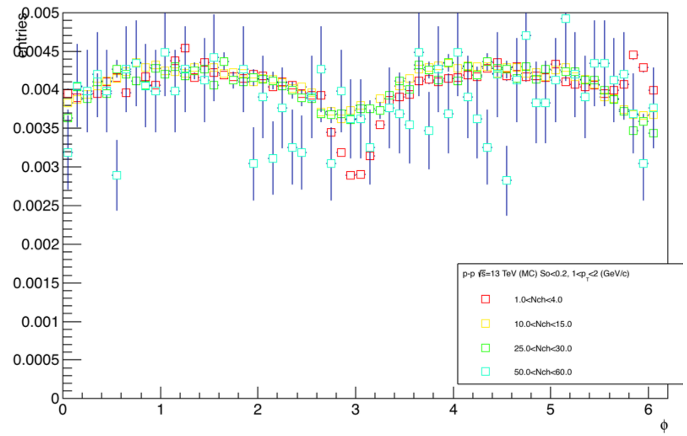


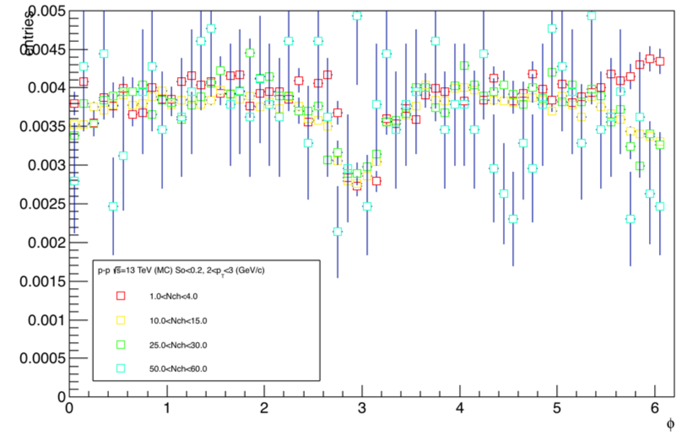
SPHERICITY

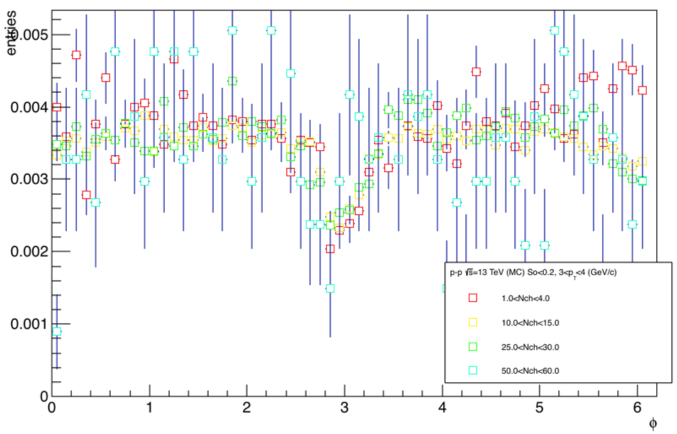


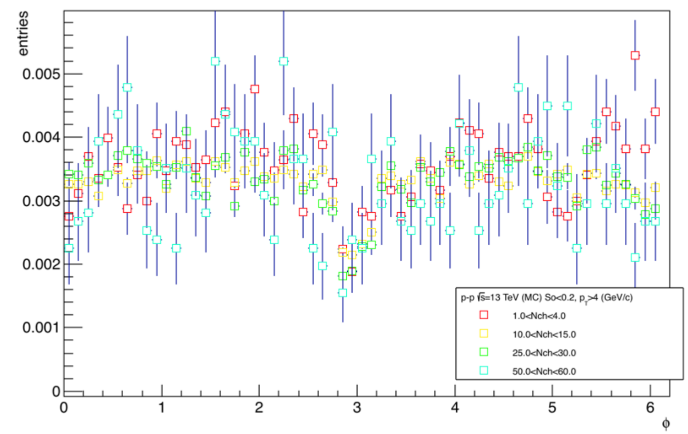
To try to understand the behaviour with respect pT range, and Nch for fixed holes.   Phi distributions for dijets





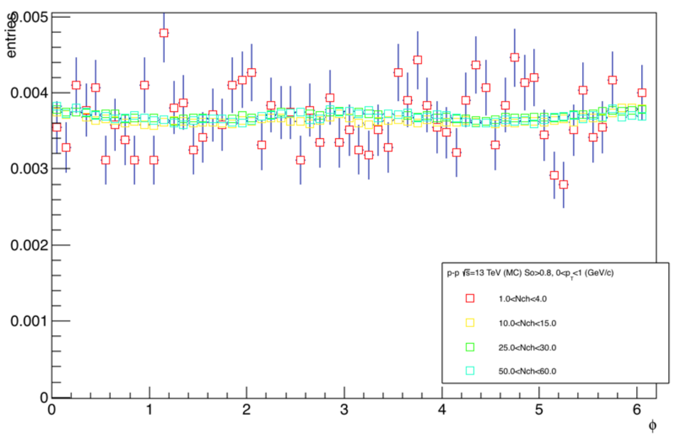


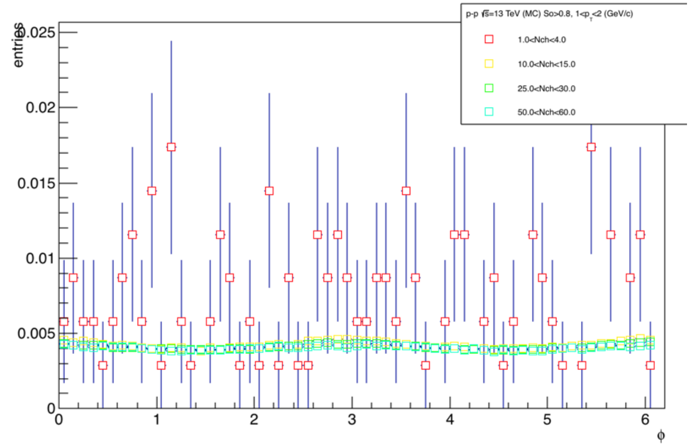


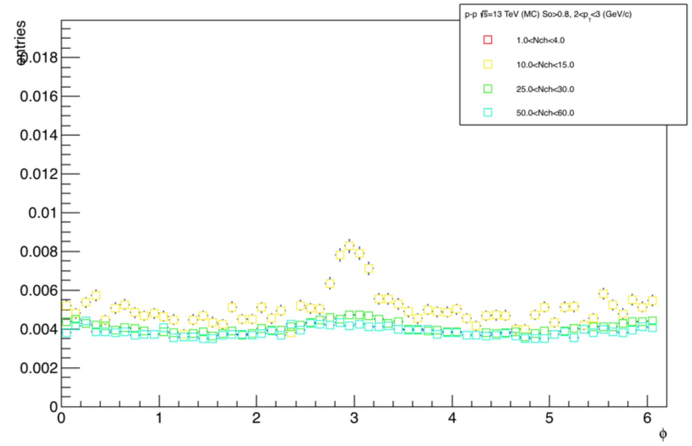


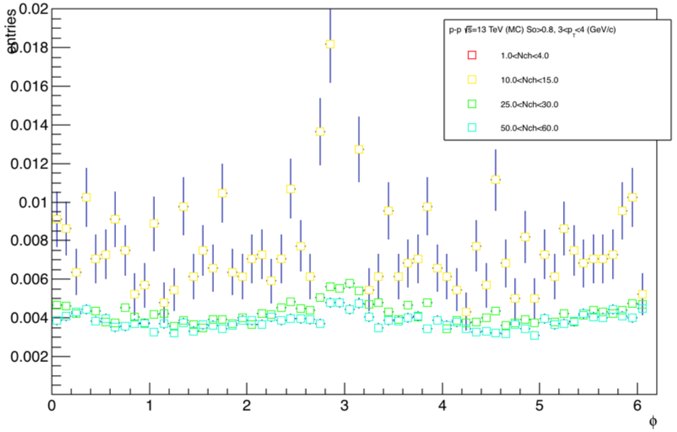
We see that for different samples within diff. p_T ranges, the behaviour of the phi distribution is independent of Nch.

To try to understand the behaviour with respect pT range, and Nch for fixed holes. Phi distributions for isotropic events



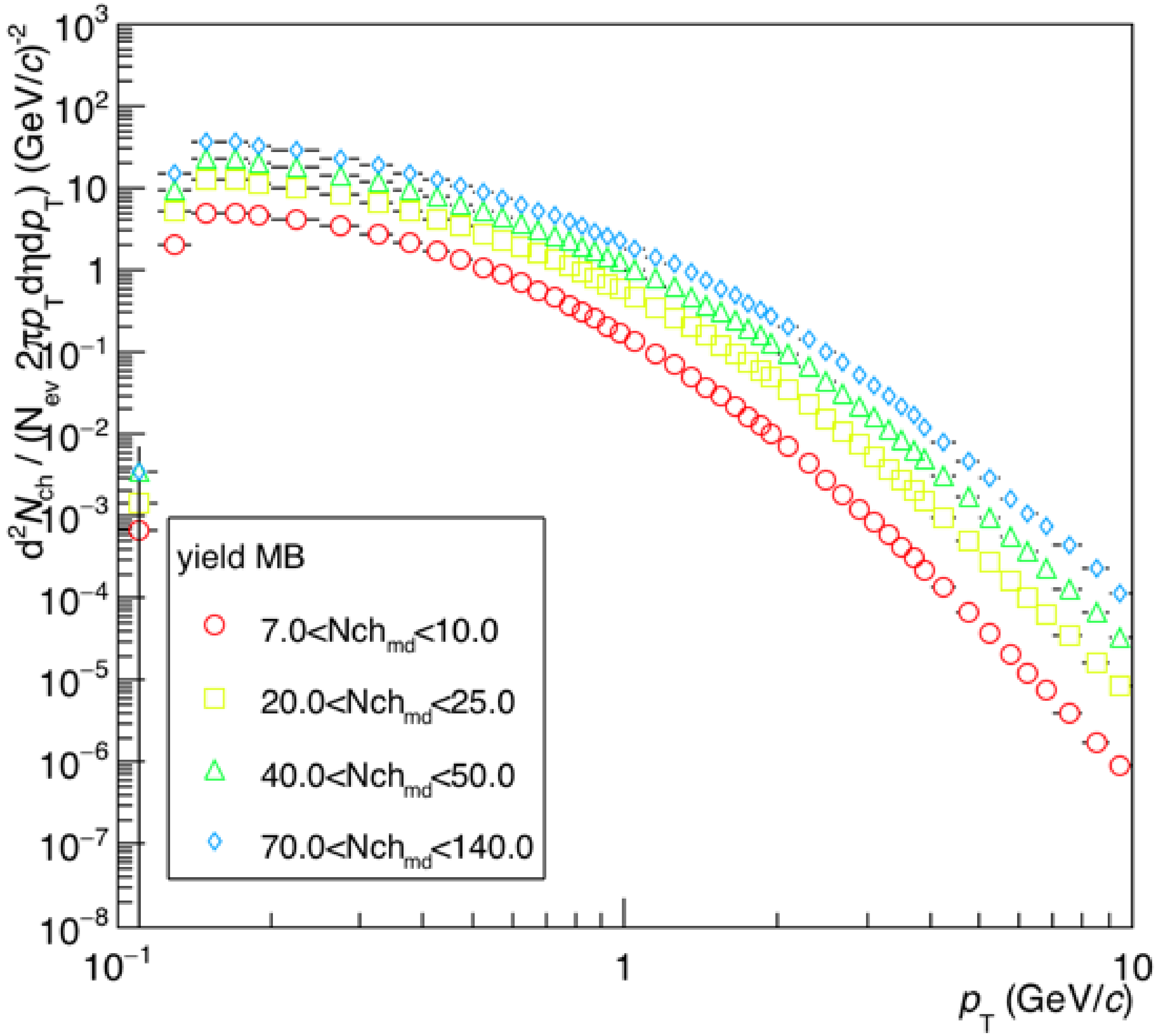




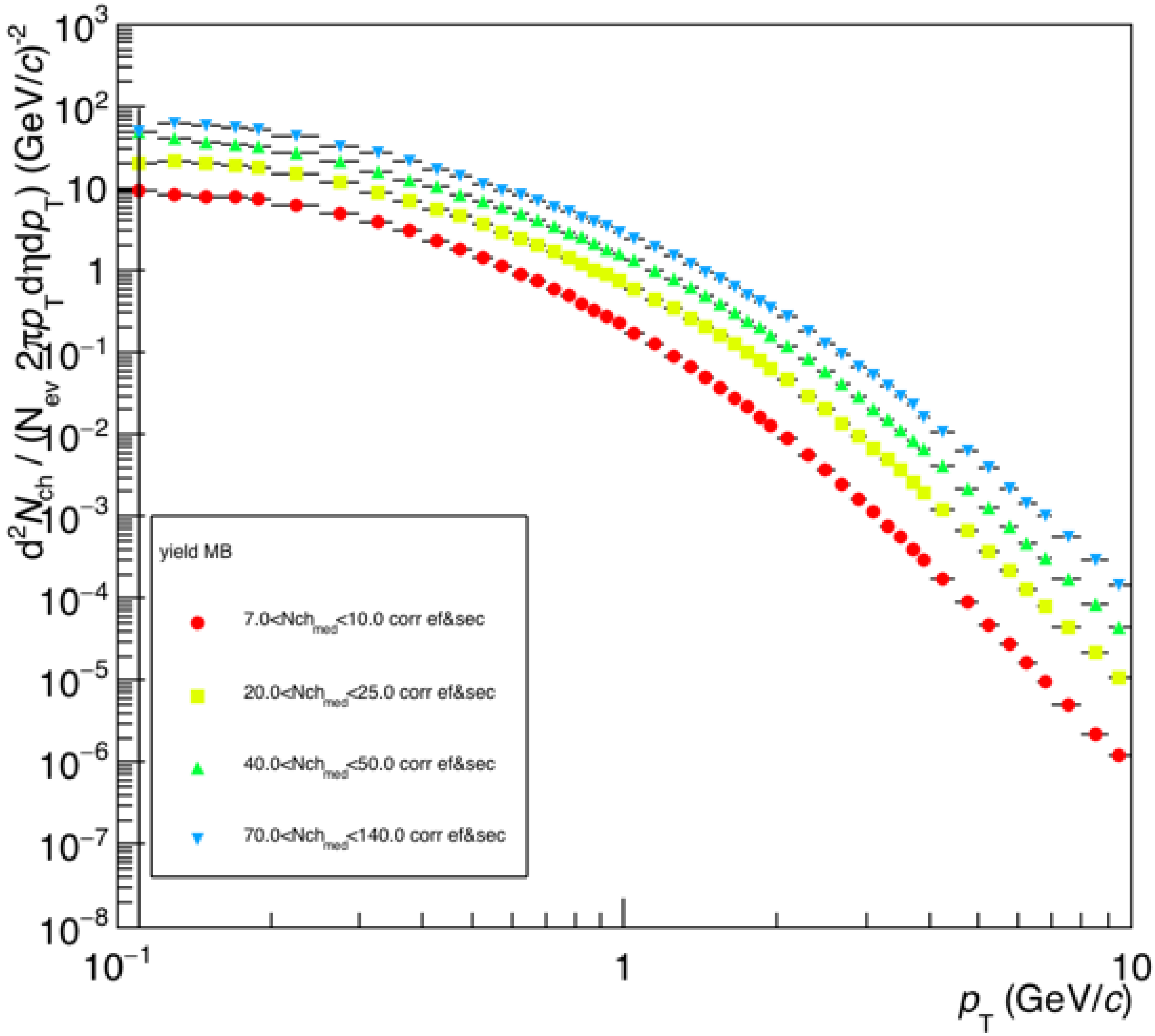


We see that for different samples within diff. pT ranges, is clear the dependence of the multiplicity and also the decreasing of statistics for low Nch when pT range increase

The spectra for the charge particles (MC ESD) for MB.

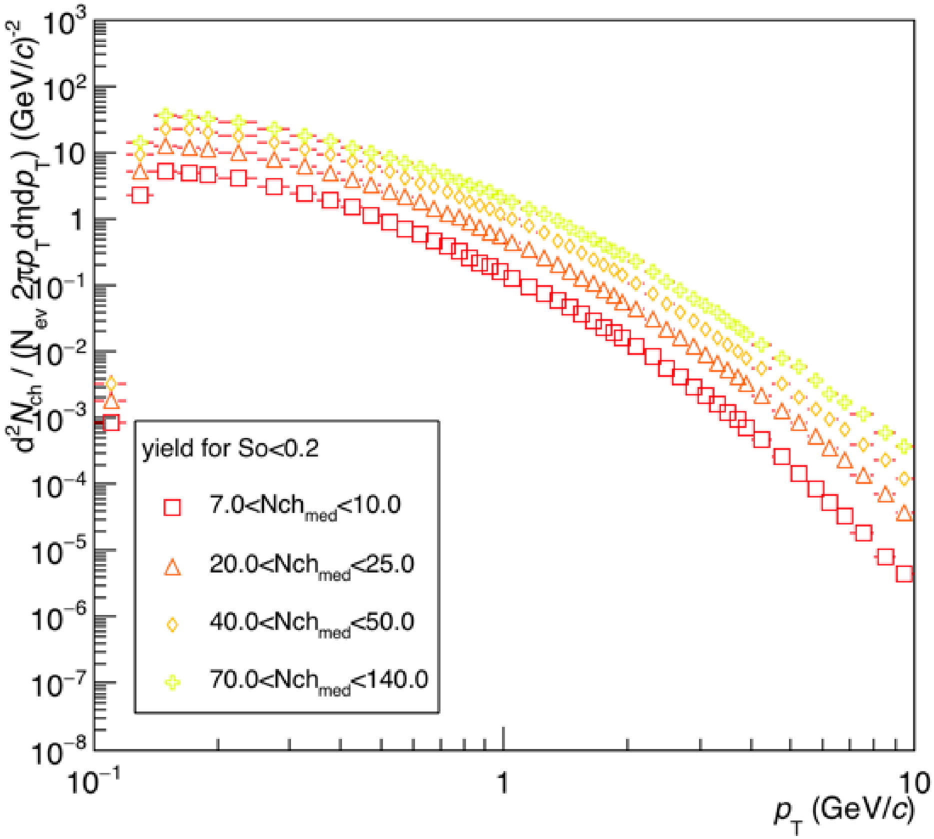


The spectra for the charge particles corrected by efficiency and secondaries for MB.

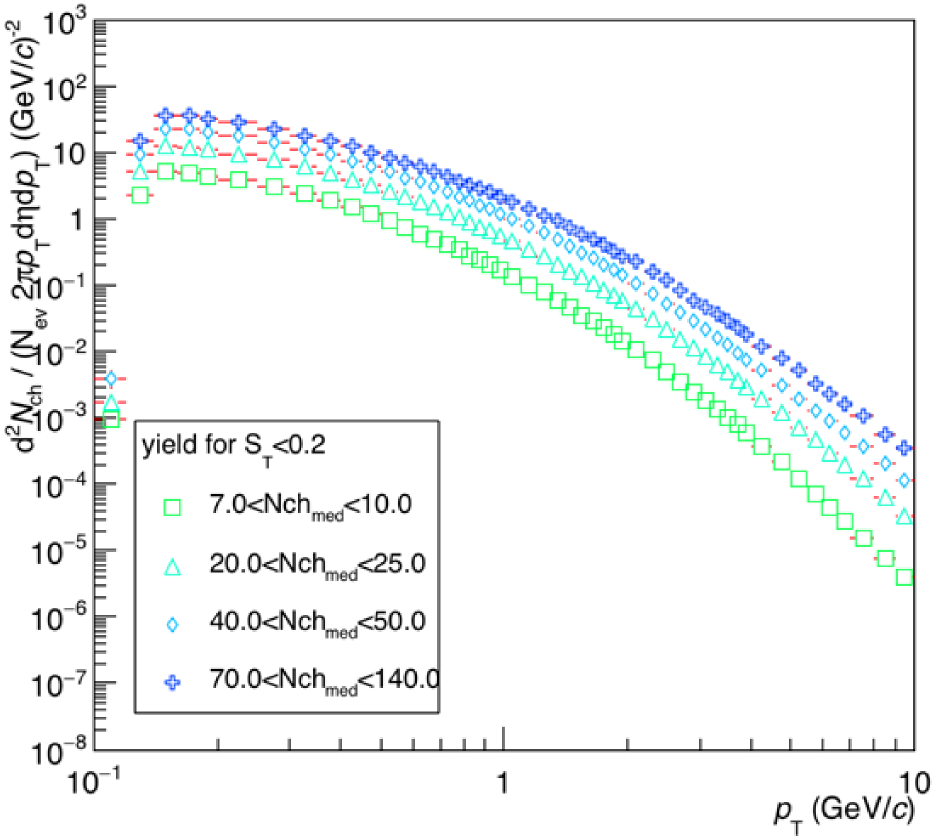


The spectra for jetty charge particles (MC ESD).

- Selected with SPHEROCITY

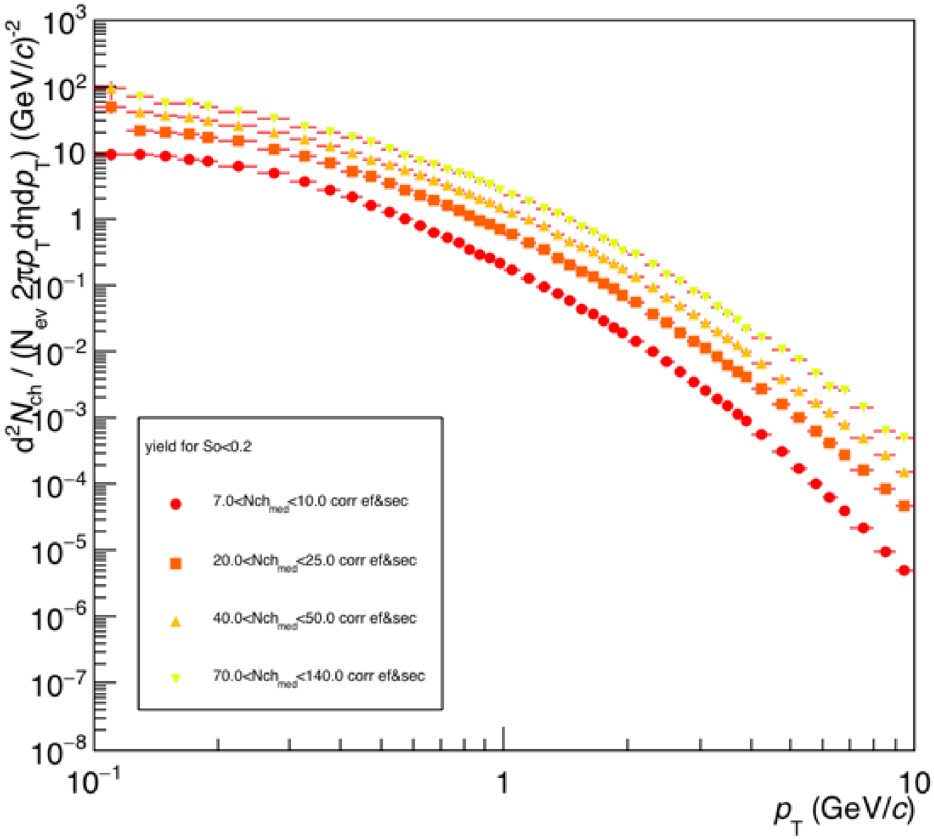


Selected with SPHERICITY

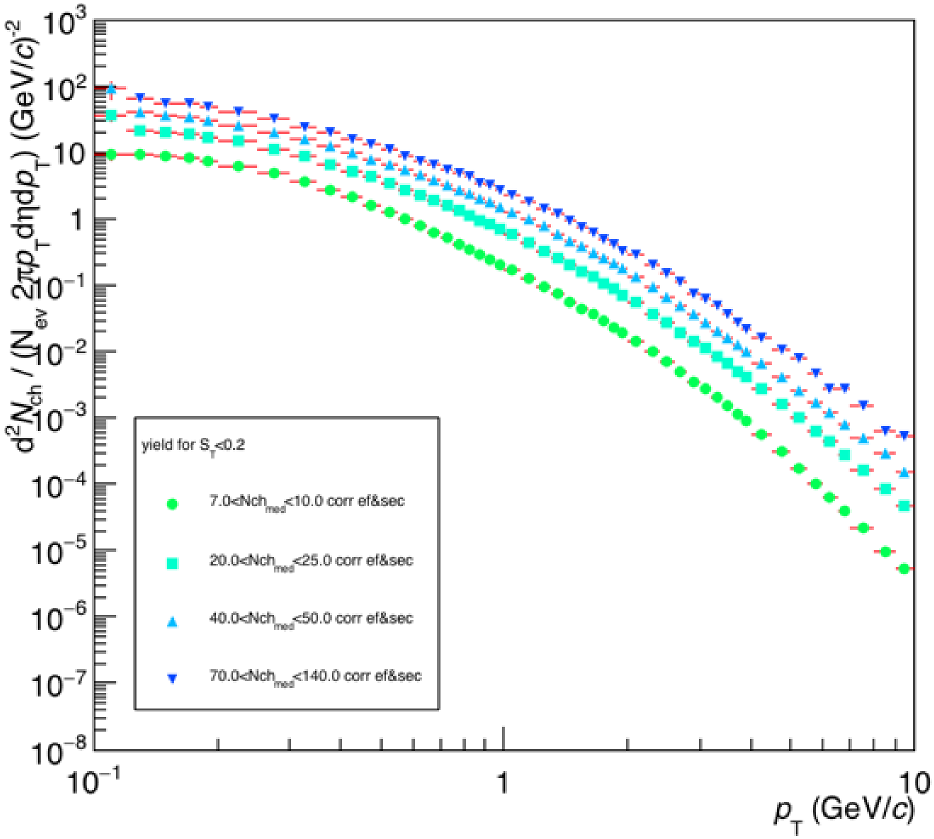


The spectra for jetty charge particles corrected by secondaries and efficiency (jetty efficiency).

- Selected with SPHEROCITY

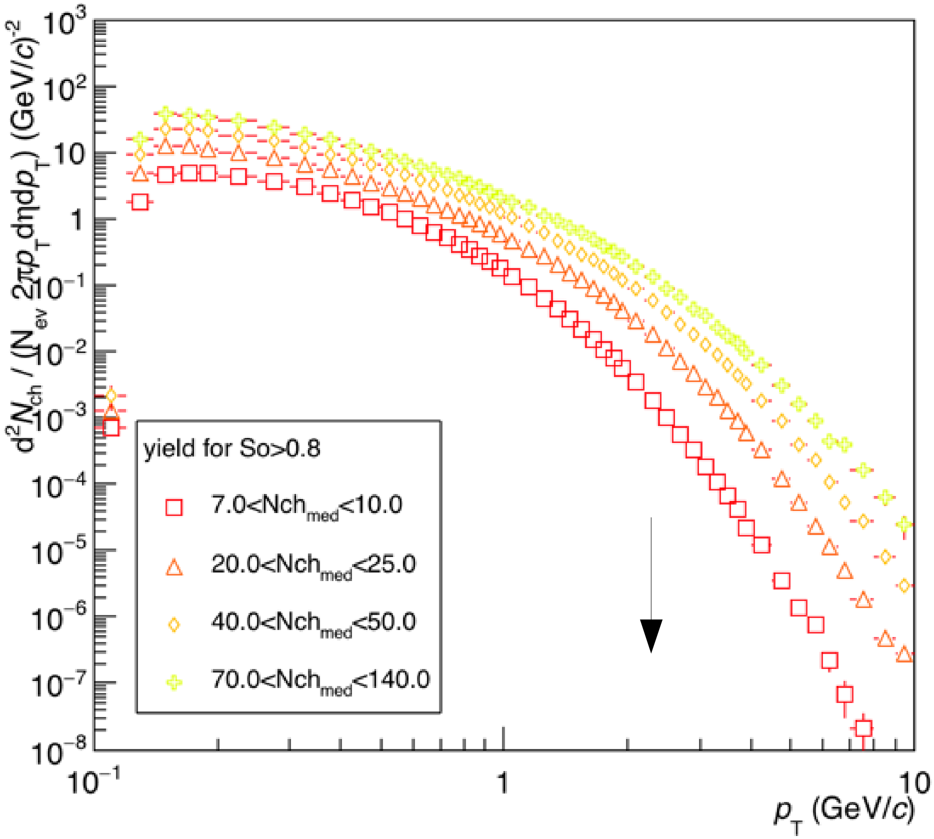


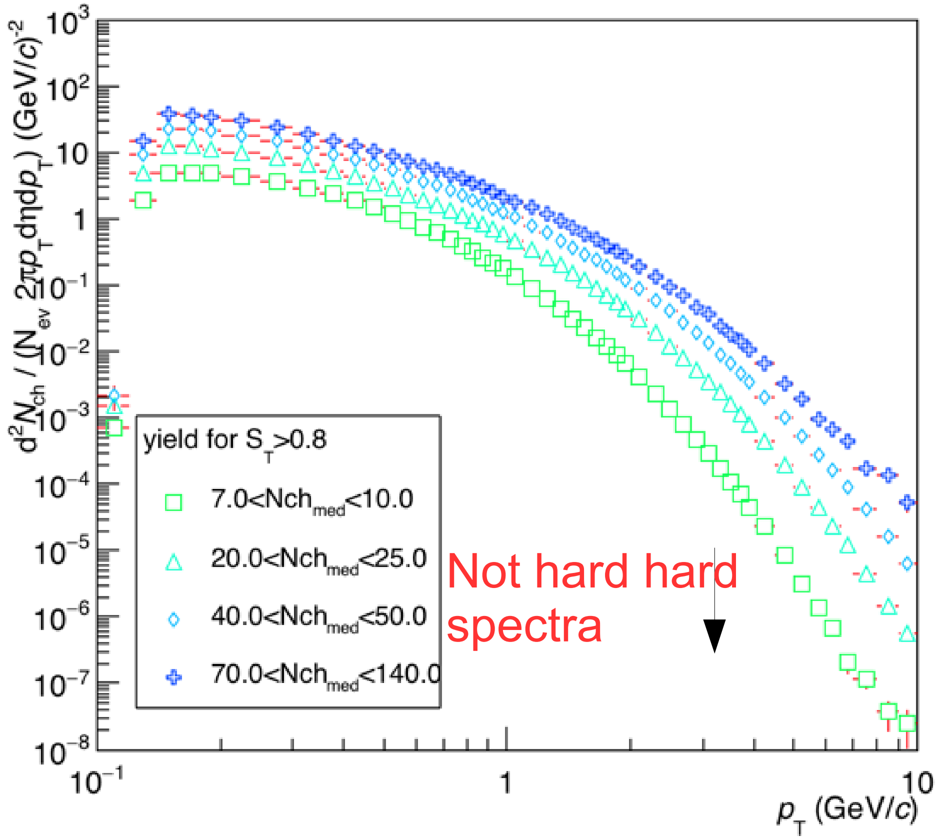
Selected with SPHERICITY



The spectra for isotropic charge particles (MC ESD)

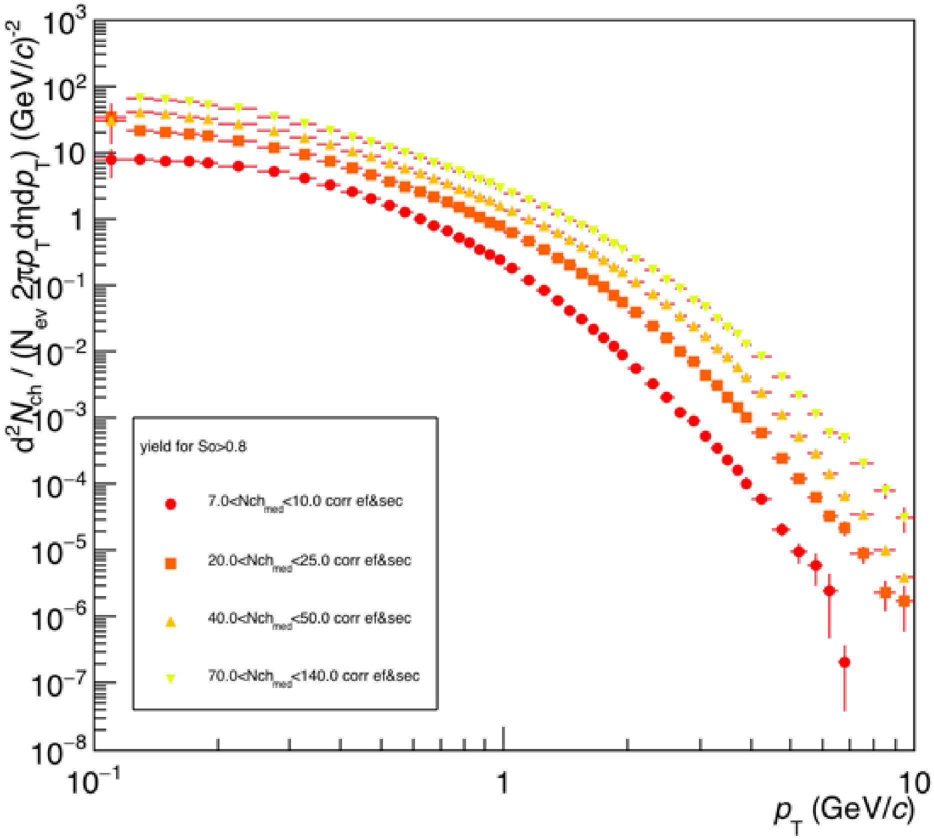
- Selected with SPHEROCITY — Selected with SPHERICITY

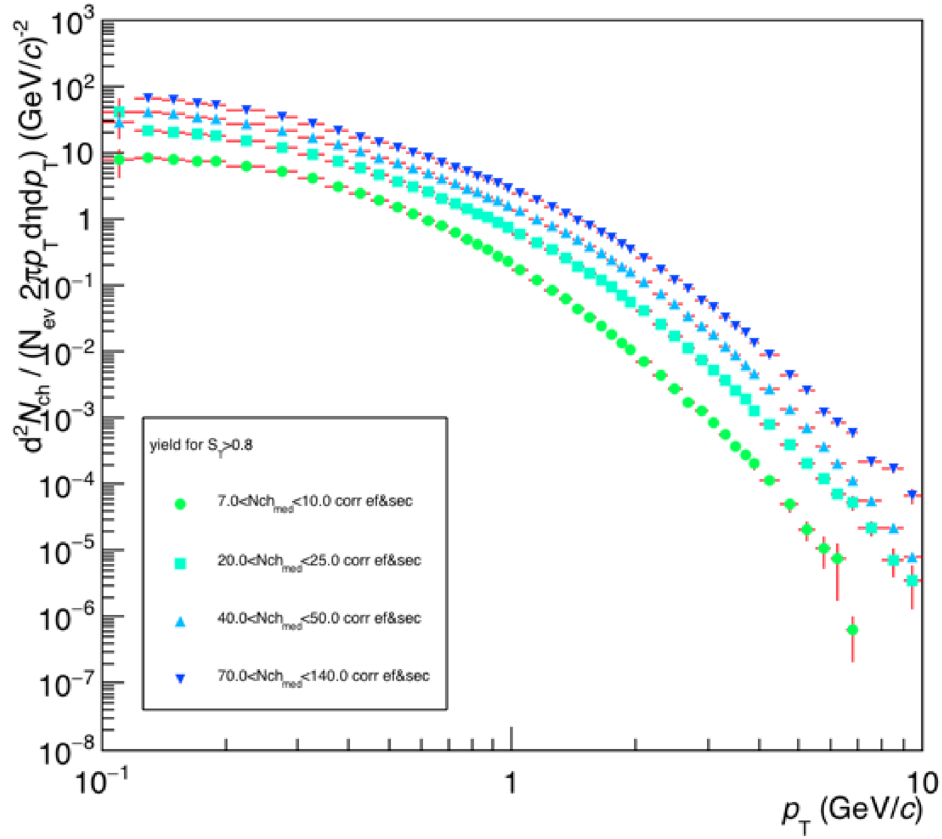




The spectra for isotropic charge particles corrected by secondaries and efficiency (for isotropic cut applied to low dN/deta<25).

- Selected with SPHEROCITY Selected with SPHERICITY





Conclusions

- Spherocity is a tool for selecting different event shape, we are introducing this analysis at ALICE

  --Some technical considerations are needed:

- TPC+TPCrefit are the selected track cuts.
- Efficiency for jetty events is better than for isotropic ones.
- Jetty events efficiency different than MB sample, but no mult dependence.
- For Isotropic and dN/deta >31 and pt<3 GeVs there' s no multiplicity dependence.
- selecting in percentage is less noisy by statistics.

  To do:

- Obtain TH2D phi vs pt vs entries using the trees at xook cluster (tlapoa)

Back up

About the paper submited

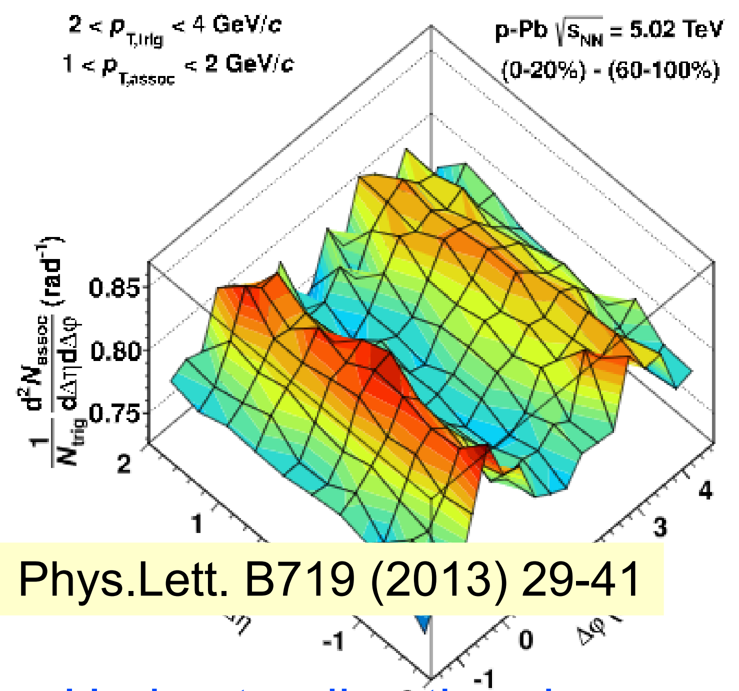
- presented at the seminar and a poster in the Mexican School of DPyC

Introduction

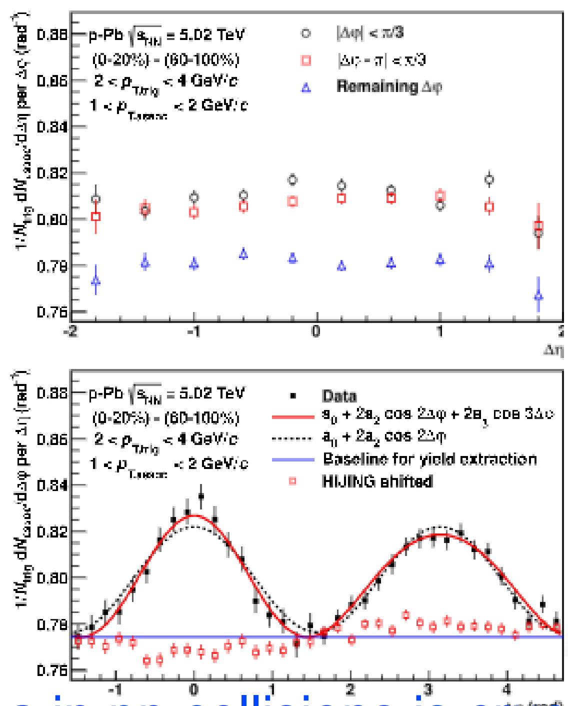
The study of particle production in HM events in small collision systems at the LHC has revealed unexpected new collective-like phenomena. For HM pp and p-Pb collisions we have:

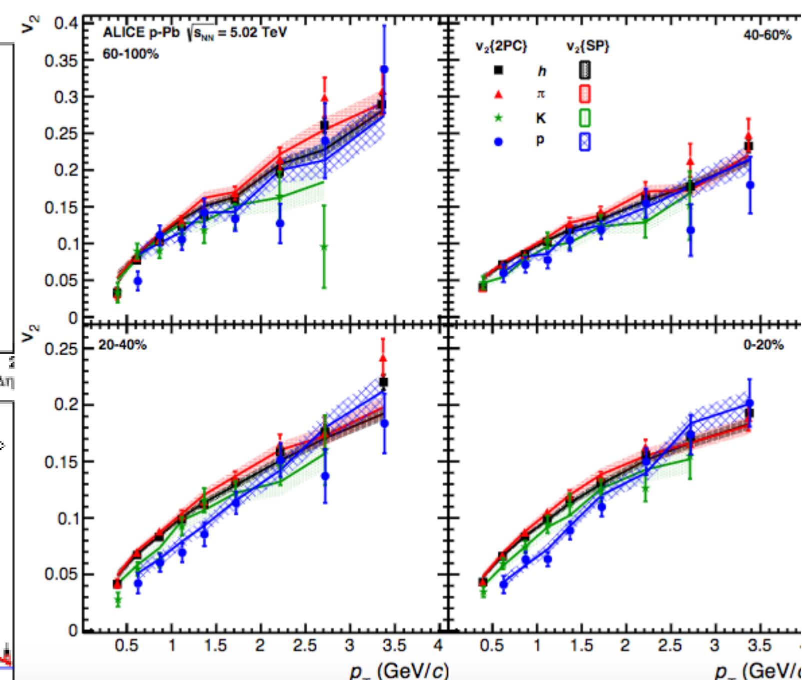
- Radial Flow signals
- Long-range angular correlations
- Strangeness enhacement

Phys. Lett. B 726 (2013) 164-177



Phys.Lett. B719 (2013) 29-41



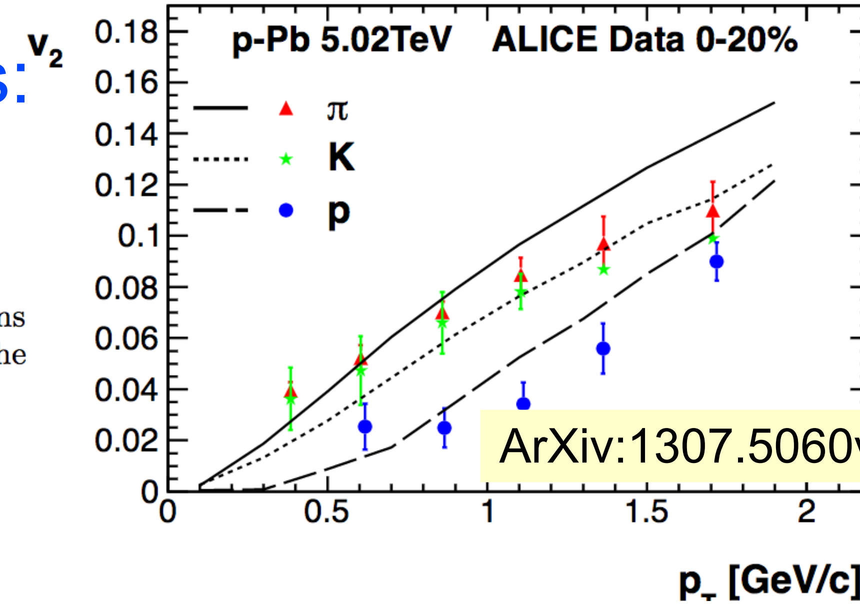


- Understanding the phenomena in pp collisions is crucial for HI physics, Because pp and p-Pb collisions (our “vacuum") is used to extract the QGP effects. However, no jet quenching effects have been found so far in p-Pb collisions, suggesting that other mechanisms could play a role in producing collective-like behaviour in small collision systems

Introduction Some mechanisms:

Hydrodynamic calculations reproduce:

FIG. 4. $v_2\{2\}$ for pions, kaons and protons in p-Pb collisions calculated with the hydrodynamic model, as a function of the transverse momentum. The data come from Ref. [7].



ArXiv:1307.5060v2

However, it has also been found that, multi-parton interactions (MPI) and color reconnection (CR)

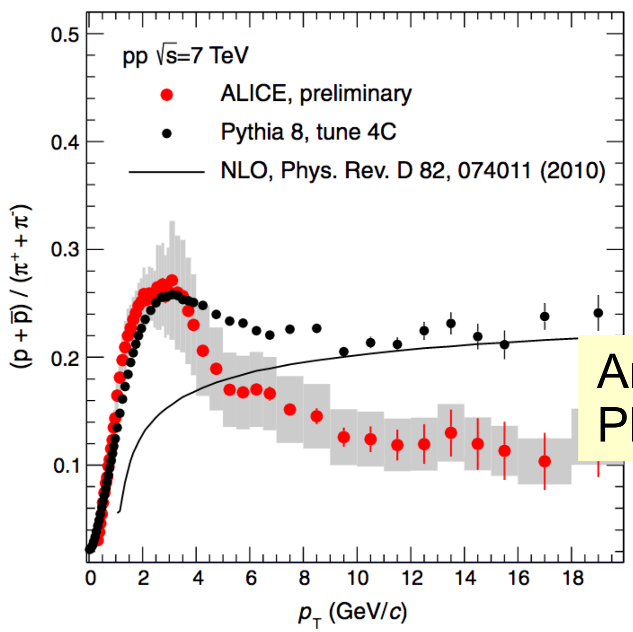


FIG. 1 (color online). Proton to pion ratio from pp collisions at $\sqrt{s} = 7$ TeV. ALICE data are compared to results from PYTHIA 8 tune 4C, as well as next-to-leading order (NLO) QCD calculation [7].

Antonio Ortiz et all.
PhysRevLett.111.042001

Hect

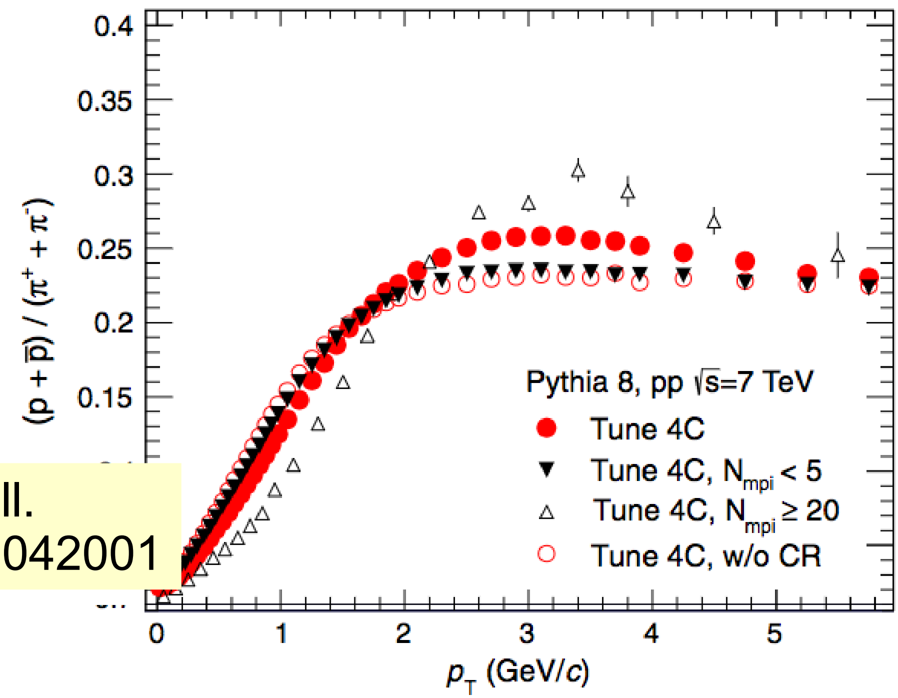


FIG. 3 (color online). Top panel: $(p + \bar{p})/(\pi^+ + \pi^-)$ as a function of p_T in pp collisions simulated with PYTHIA 8 (solid circles), the ratio for events with low (solid triangles) and high (empty triangles) numbers of multiparton interactions are overlaid. Results without color reconnection (RR = 0.0) are also

Introduction Some mechanisms:

Moreover, in color glass condensate, the physics of fluctuating color fields can generate azimuthal multi-particle correlations

ArXiv:1509.03499v2

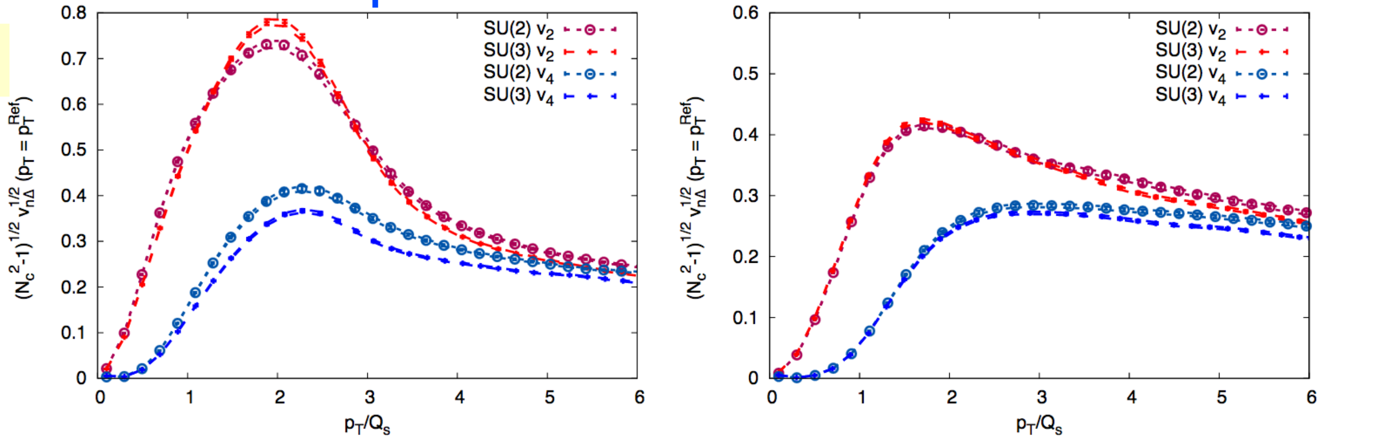
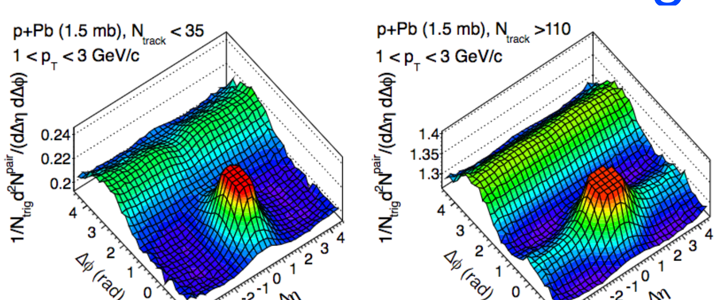


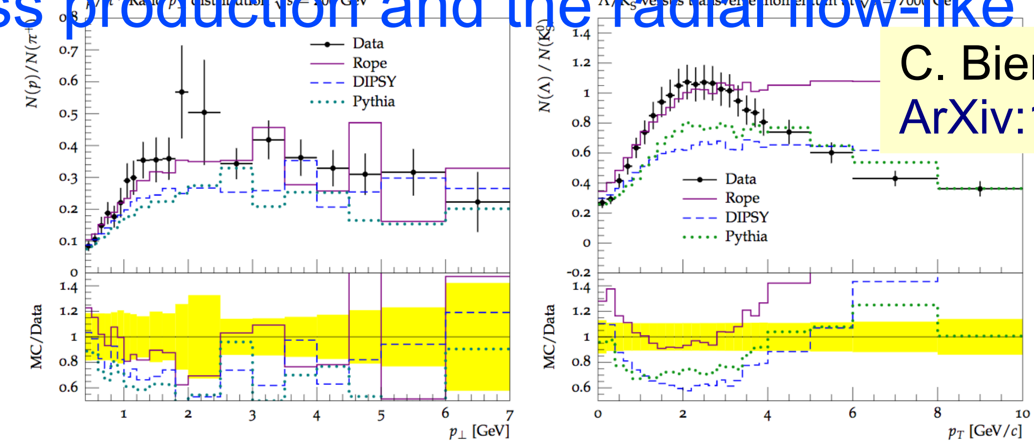
FIG. 5: (Color online) N_c dependence of the azimuthal correlations v_n, scaled by the color factor $\sqrt{N_c{}^2-1}$ for SU(2) and SU(3) gauge theory. The results are computed using the numerical lattice calculation for the MV model (left) and after JIMWLK rapidity evolution (right).

Also, long range angular correlations has been reproduced using the AMPT using the string melting mechanism. Other mechanisms like “color ropes", which are formed by the fusion of color strings close in space, can increase both the strangeness production and the radial flow-like effects



ArXiv:1404.4129v2

Figure 3: The AMPT two-particle density function in p+Pb collisions at $\sqrt{s}$ = 5.02 TeV for low- (left) and high- (right) multiplicity events. The long-range near-side structure in pseudorapidity is clearly visible for high-multiplicity events.



C. Bierlich et all.
ArXiv:1412.6259v

Figure 8: The proton to pion ratio in bins of $p_\perp$ as measured by STAR at $\sqrt{s}$ = 200 GeV (left) and Λ/K_s^0 at 7000 GeV as measured by CMS (right). Both results are compared to DIPSY with and without rope, as well as with PYTHIA8.

What will be shown?

In this work, we study how jets affect the low pT region (pT<2 GeV/c) of the transverse momentum spectra.

- The event-by-event partonic scatterings are mostly associated with low-pT interactions, albeit the probability of having a hard scattering increases with the number of MPI. An interplay between soft and hard scatterings mediated by color strings is therefore expected to provide a strong correlation between the radial flow-like patterns and the hard component of the collision.
- On the contrary, in the scenario where the hydrodynamical evolution is the prime mechanism, jets are not expected to strongly modify the radial flow patterns. In the paper we argue that by exploiting such a fundamental difference between both models, one might say whether or not the observed effects are driven by hydrodynamics.
- A systematic study was proposed by analysing the mid-rapidity (|y|<1) inclusive pT spectra of identified charged hadrons as a function of the mid-pseudorapidity (|eta|<1) event multiplicity (Nch) and transverse momentum of the leading jet (pTjet). This using Pythia 8.212 and Epos3.117.

Simulation Setup

Pythia 8.212 Generator

- Monash 2013,
- 900M events

P. Skands, EPJC74 (2014) 8, 3024

EPOS 3.117, Generator

- 1000M events

K. Werner et al., PRC89 (2014) 6, 064903
K. Werner et al., PRC 82 (2010) 044904
H.J. Drescher et al., PR 350 (2001) 93-289

FastJet 3.1.3, Jet Finder

M. Cacciari et al., EPJC72(2012)1896

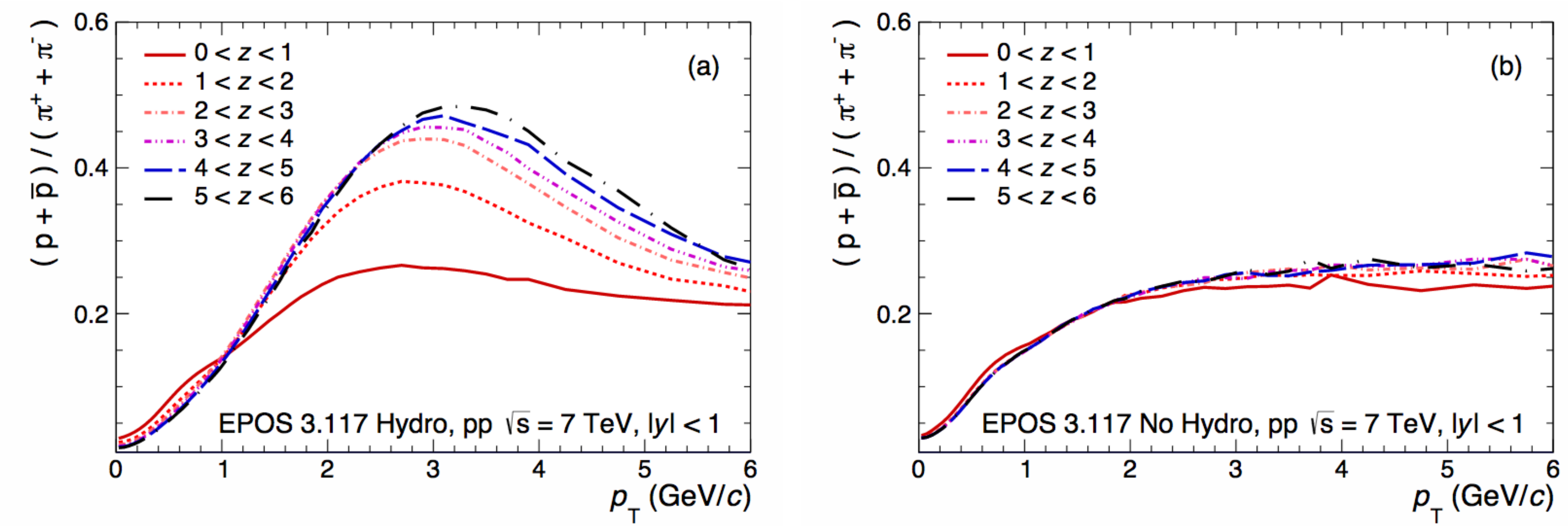
- Anti-*k*T Algoríthm
- R=0.4
- *p*Tmin = 5 GeV
- Maximum pT of the partonic scatterings 25 GeV

Stable and primary particles were considered for the jet reconstruction.

Simulation Setup and Monte Carlo Models

Epos3 and hydrodynamics:

EPOS is a generator of soft and hard events.Its behaviour is based on terms of string densities. If energy density from string segments is high enough they fuse into the so-called “core" region, which evolves hydrodynamically. On the other hand, the low energy density region forms the “corona" which hadronizes using the unmodfied string fragmentation. To illustrate the effect of hydrodynamics we shows the proton-to-pion ratio as a function of pT for different multiplicity classes.



$$z = \frac{\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta}{\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle}$$

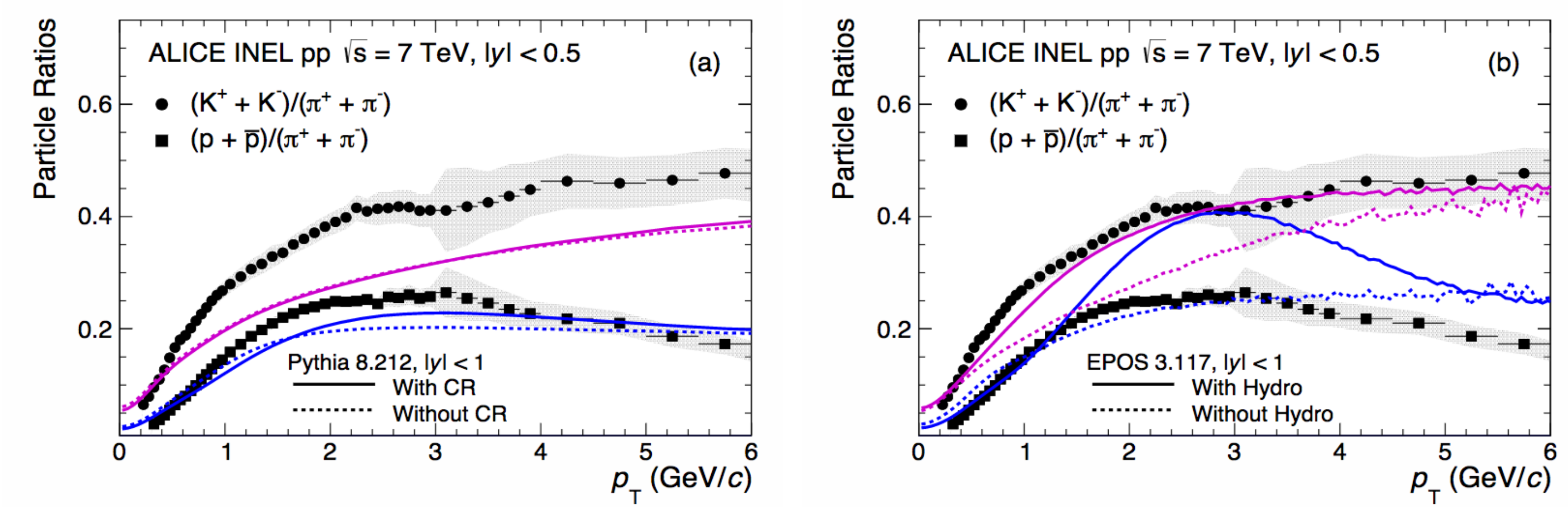
(a) (b)

Fig. 1: (Color online) Proton-to-pion ratio as a function of p_T for different multiplicity event classes. Results for pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ generated with EPOS 3 are presented. The ratios are displayed for simulations (a) with and (b) without the hydrodynamical evolution of the system.

Simulation Setup and Monte Carlo Models

Pythia8 and color reconnection

Pythia8 is a full event generator for pp collisions. For inelastic collisions, which is the main interest here, each collision is modelled via one or more parton-parton interactions. The full calculation involves leading-order (LO) pQCD 2->2 matrix elements, complemented with initial and final-state parton radiation, multiple particle interactions, beam remnants and the Lund string fragmentation model.
Pythia8 also has strong final-state parton interactions (implemented through the CR)

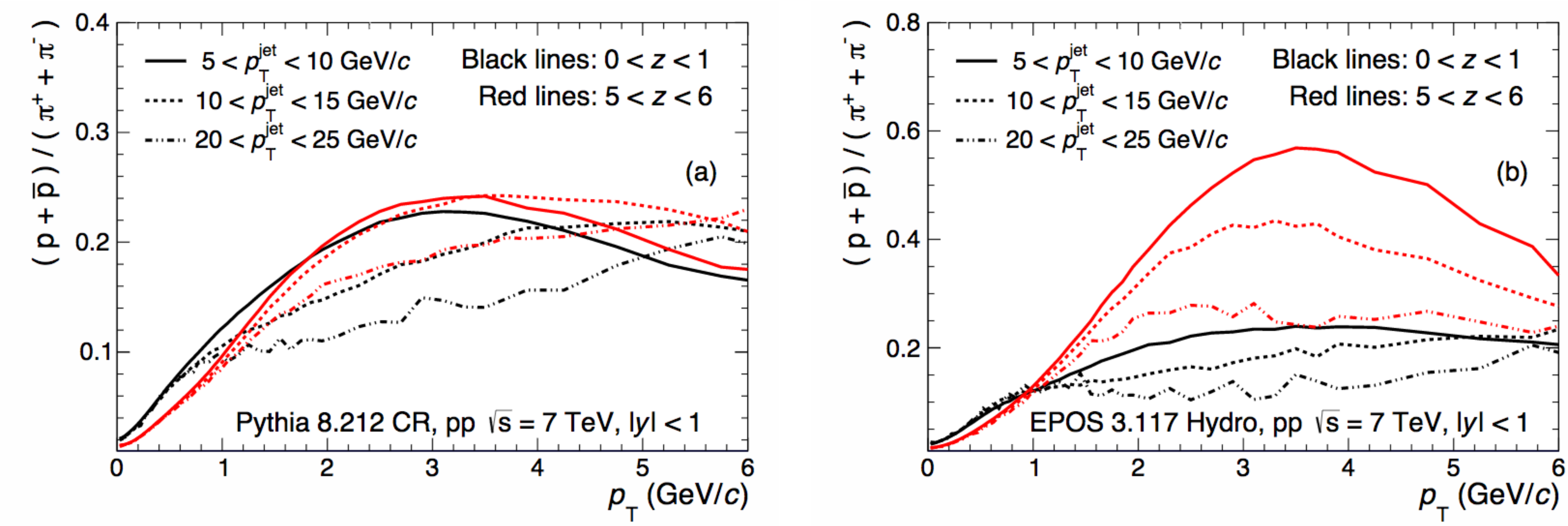


(a) (b)

Fig. 2: (Color online) Proton-to-pion ratio as a function of p_T for inelastic pp collisions at $\sqrt{s} = 7$ TeV measured by the ALICE Collaboration [2]. Results are compared to models carried out (a) with PYTHIA 8 and (b) EPOS 3 event generators. Cases with and without the effect of color reconnection and hydrodynamics are plotted as solid and dashed lines, respectively.

Results and discussion

Proton to pion ratio



(a) (b)

Fig. 4: (Color online) Inclusive proton-to-pion ratio as a function of p_T for two multiplicity classes, $0 < z < 1$ (black lines) and $5 < z < 6$ (red lines); and for different p_T^{jet} intervals. Results are shown for both (a) PYTHIA 8 and (b) EPOS 3.

The results indicate that for 5< pTjet<10 GeV/c the ratios exhibit a bump at pT=3 GeV/c. Whereas, for higher pTjet the position of the peak is shifted to higher pT. This observation suggests that the bump is not an exclusive effect of radial flow, but also a feature of the fragmentation. The maximum of the proton-to-pion ratio increases with increasing multiplicity,

Results and discussion

Blast Wave model fits

The blast-wave model describes a locally thermalised medium which experiences a collective expansion with a common velocity field and undergoing an instantaneous common freeze-out

$$\frac{1}{p_T}\frac{dN}{dp_T} \propto \int_0^R r\,dr\,m_T I_0\left(\frac{p_T \sinh\rho}{T_{kin}}\right) K_1\left(\frac{m_T \cosh\rho}{T_{kin}}\right) \qquad \rho = \tanh^{-1}\beta_T = \tanh^{-1}\left(\left(\frac{r}{R}\right)^n \beta_S\right)$$

From the simultaneous fit of the blast-wave model to the pT spectra of different particle species we extract two parameters, the temperature at the kinetic freeze-out, (T_{kin}), and the average transverse expansion velocity (β_T). To fit the pT distributions we use:

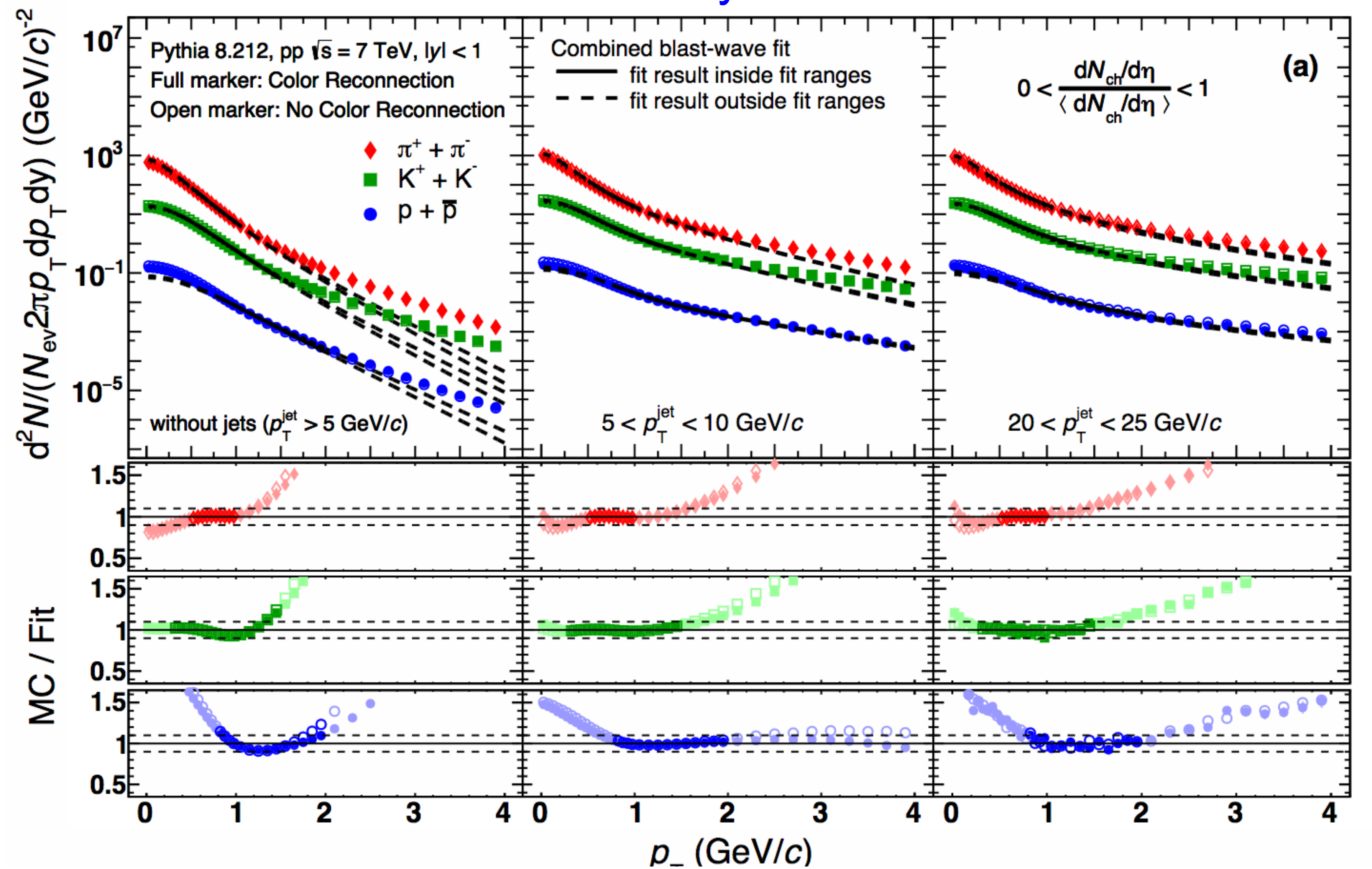
π	K	p
0.5-1.0	0.3-1.5	0.8-2.0

p_T ranges (GeV/c)

For this ranges the spectra is described by the BW fit within 10%

Results and discussion

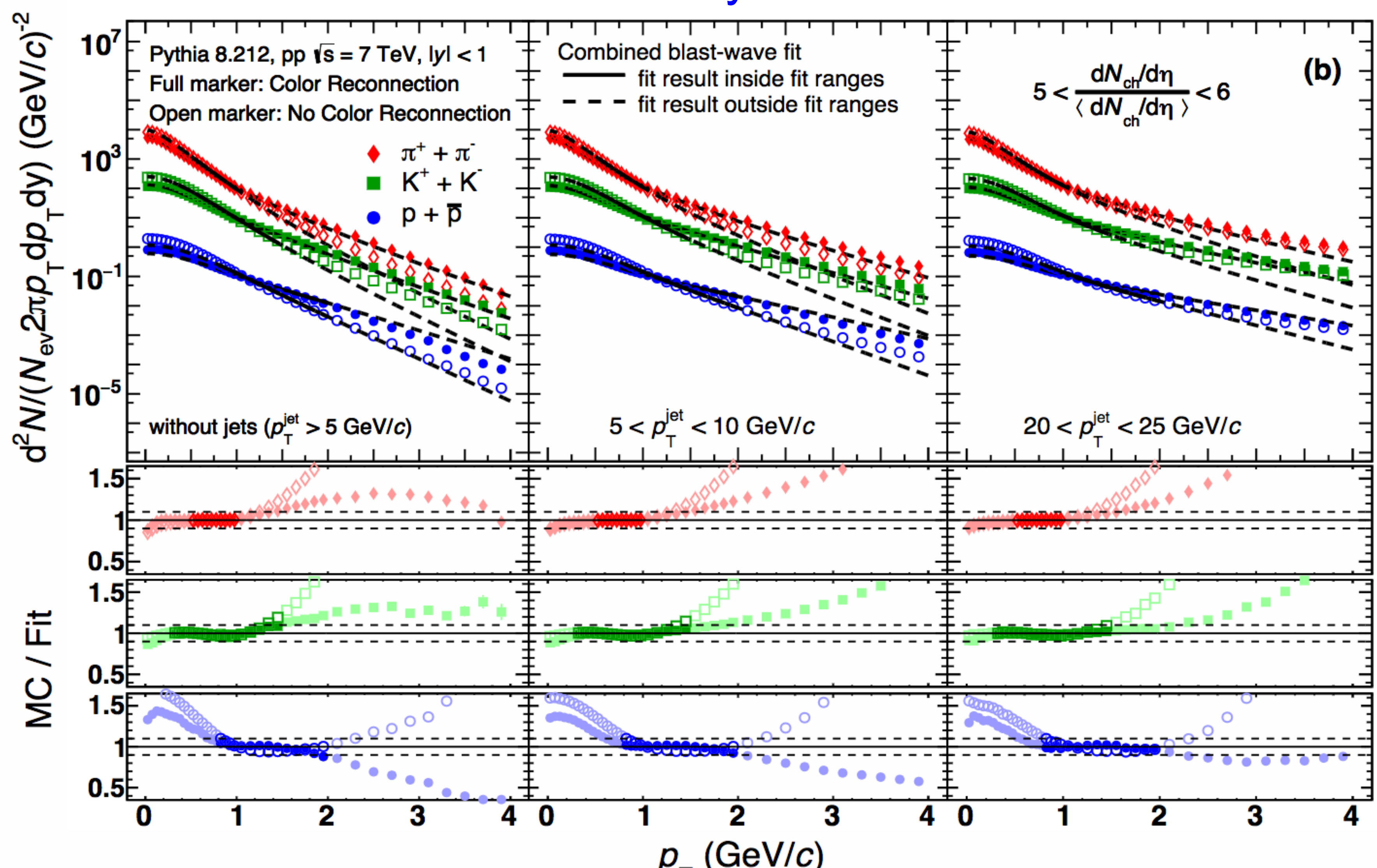
Blast-wave model fits to invariant yield PYTHIA



At low multiplicity where color reconnection effects are negligible, it is possible to find an event class where the radial flow-like patters pop up. Especially, in events having pTjet>5 GeV/c the pT distributions of identified hadrons are better described by the blast-wave model than in those without jets.

Results and discussion

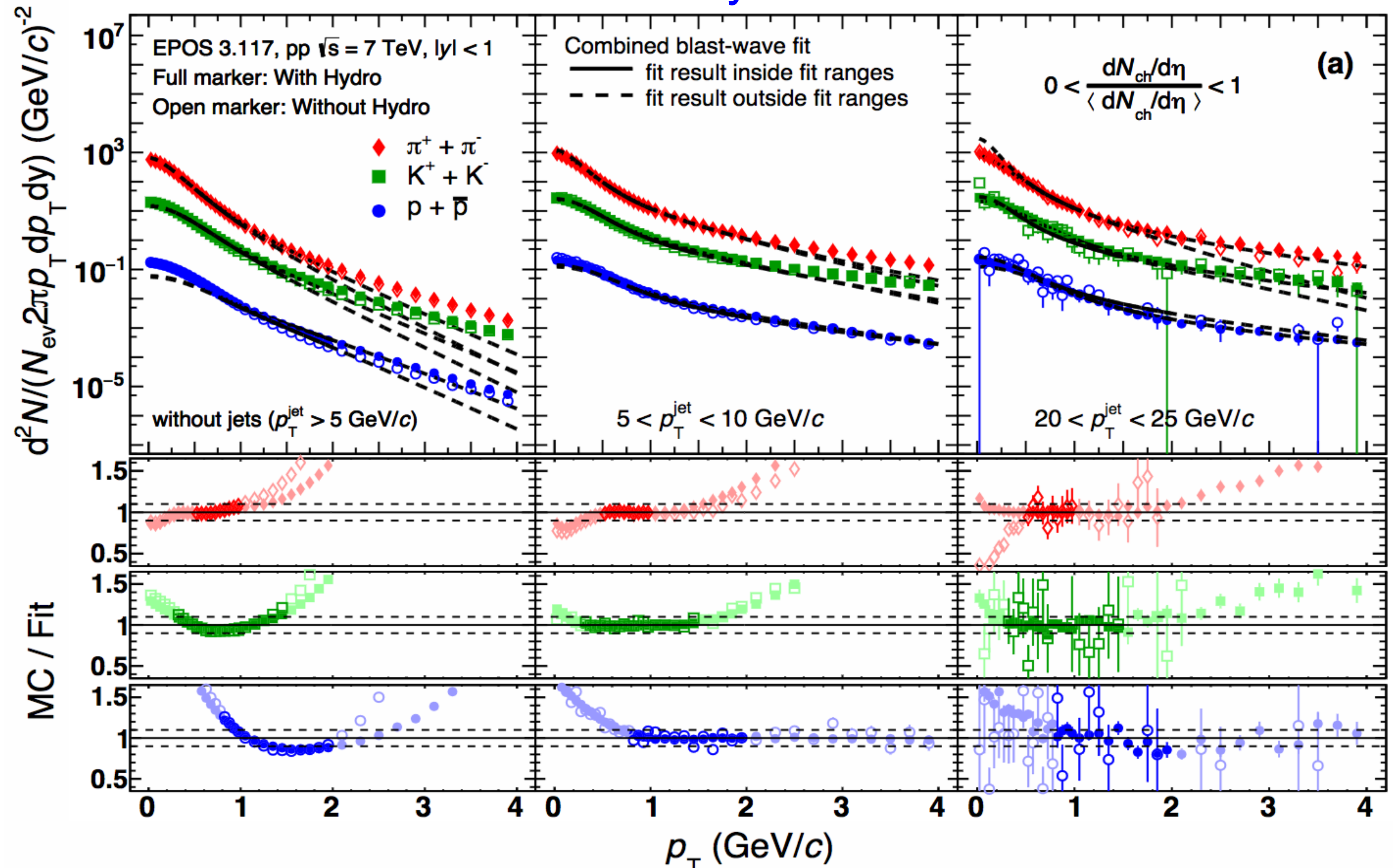
Blast-wave model fits to invariant yield PYTHIA



At high multiplicity, the BW model fails to describe the pT spectra when CR is not included, this behaviour is also observed even if a jet with pTjet>5 GeV/c is produced. On the other hand, with CR the agreement between the BW parametrization and the pT spectra improves with increasing pTjet. This reflects that in Pythia8 the interaction between jets and the underlying event is crucial for generating a collective-like behaviour.

Results and discussion

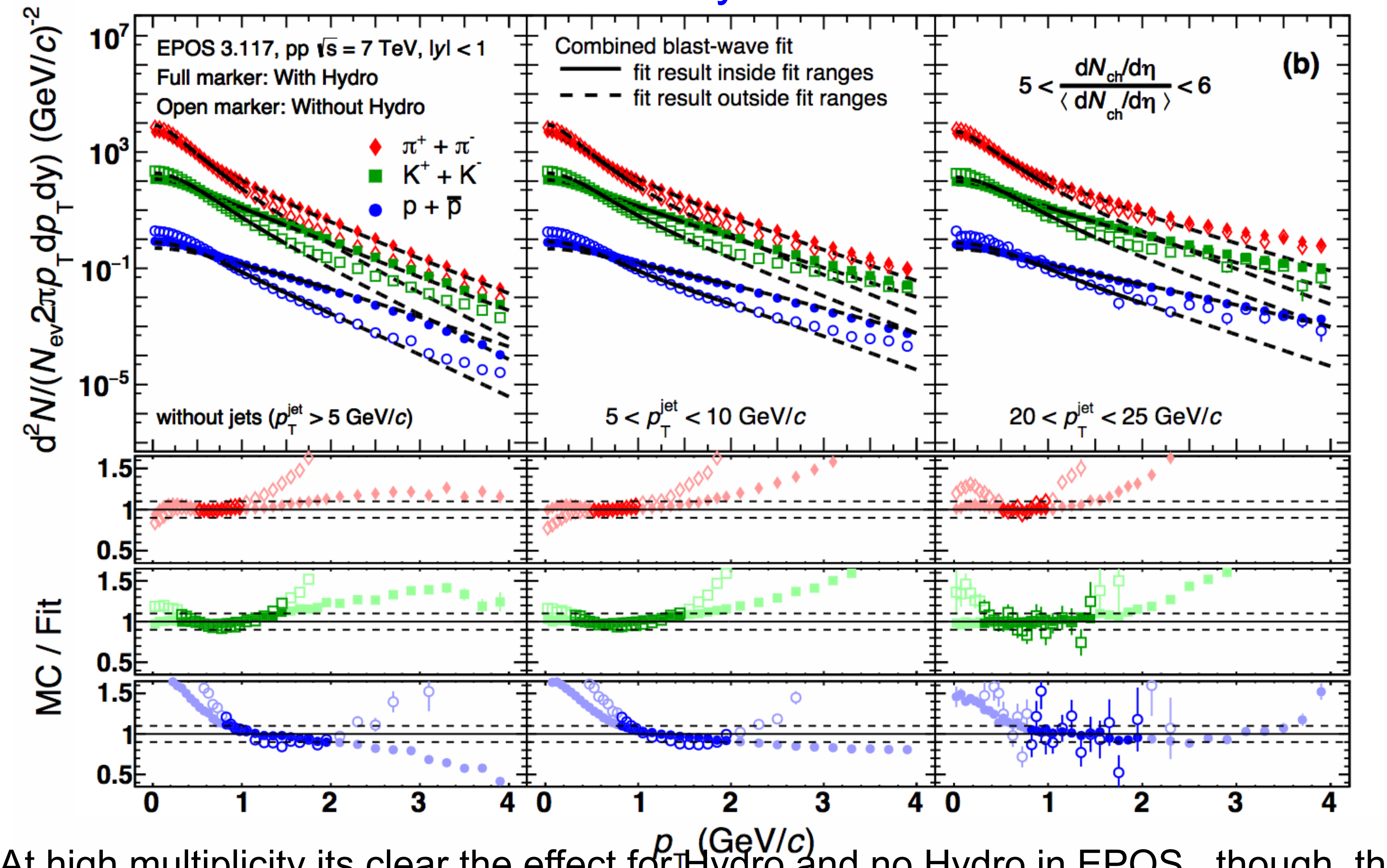
Blast-wave model fits to invariant yield EPOS



At low multiplicity no difference when we impose Hydro and no Hydro in EPOS, though the jet contribution to the radial flow patterns is smaller than in Pythia8.

Results and discussion

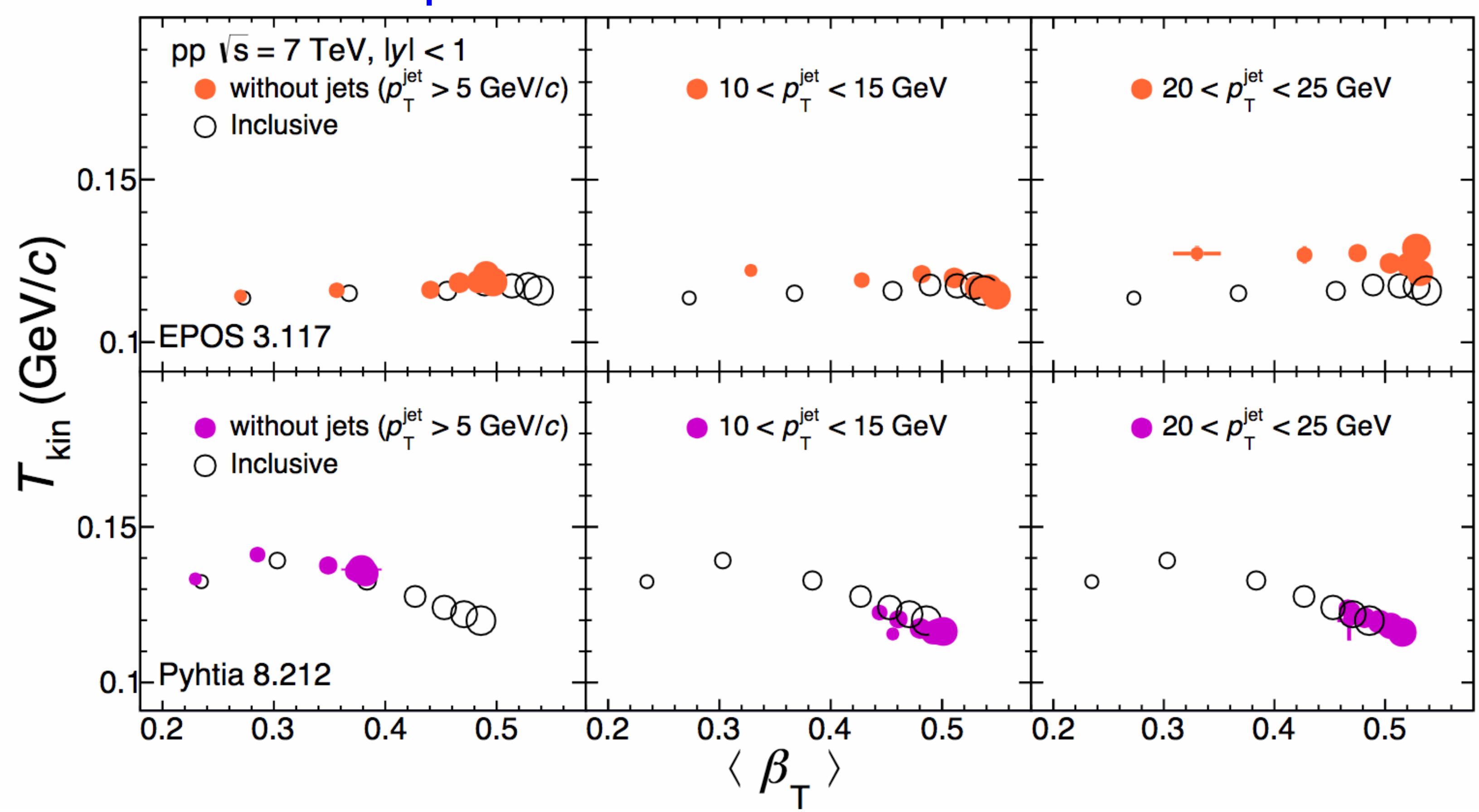
Blast-wave model fits to invariant yield EPOS



At high multiplicity its clear the effect for Hydro and no Hydro in EPOS, though the jet contribution to the radial flow patterns is smaller than in Pythia8.

Results and discussion

Blast-wave model parameters EPOS vs PYTHIA



-For events having jets and being in the same multiplicity class (same marker size), $<\beta_T>$ increases with respect to the case without any selection on the hardness (inclusive case). By looking at, for example, the case of jets with 20< pTjet<25 GeV/c and the highest multiplicity class (5< z <6), the effect is weaker in Epos3 (0.6%) than in Pythia8 (6.8%). This is also illustrated in the larger multiplicity dependence of $<\beta_T>$ obtained in Epos3 than in Pythia8.

-For events without jets, the multiplicity dependence of $<\beta_T>$ is weaker in Epos3 than In Pythia8. In Pythia8 the $<\beta_T>$ reach is much smaller than in Epos3.

Conclusions

- We have studied using Epos3 and Pythia8, exploring an observable which is aimed for ruling out or validating the underlying physics mechanism (hydro or CR) generating radial flow patterns in pp collisions
- In extremely low multiplicity events, where hydrodynamics definitely can not be applied and where color reconnection effects are small, we observe a flow-like peak in the proton-to-pion ratio.The analysis of the spectral shapes using the BW model gives a better description of the pT spectra when a jet (pTjet>5 GeV/c) is produced within the acceptance.This tells us that the so-called flow peak is not an exclusive feature of QGP, because it pops up even in hard events.
- For high-multiplicity events, the particle composition is very different in Pythia8 and Epos3. In Epos3 the size of the proton-to-pion peak increases with decreasing pTjet and its maximum always stays at around pT= 3 GeV/c. On the contrary, in Pythia8 the size of the peak does not change with pTjet, instead the position of the maximum is shifted to higher pT.
- The multiplicity dependence of the average transverse expansion velocity is found to be more affected by jets in Pythia8 than in Epos3