ALICE

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

7º AVANCE DE TESIS

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AVANCE
De Tesis

30 mayo 2017

Outline

New from last presentation

- -Comments about work on publication and Analysis note

Studies about spherocity for pp @ 13 TeV

- Motivation
- Strategy for corrections
- Analysis update
  - MC closure test
  - Implementation in data
- Feed down correction and particle composition

Conclusions

New from last presentation

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

- paper published in a Journal Physics G

IOP Publishing   Journal of Physics G: Nuclear and Particle Physics

J. Phys. G: Nucl. Part. Phys. **44** (2017) 065001 (14pp)   https://doi.org/10.1088/1361-6471/aa6594

Revealing the source of the radial flow patterns in proton–proton collisions using hard probes

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CrossMark

Abstract
In this work, we propose a tool to reveal the origin of the collective-like phenomena observed in proton–proton collisions. We exploit the fundamental difference between the underlying mechanisms, color reconnection and hydrodynamics, which produce radial flow patterns in PYTHIA 8 and EPOS 3, respectively. Specifically, we proceed by examining the strength of the coupling between the soft and hard components which, by construction, is larger in PYTHIA 8 than in EPOS 3. We study the transverse momentum (p_{T}) dis-

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Antonio Ortiz (Mexico U., ICN), Gyula Bencedi (Mexico U., ICN & Wigner RCP, Budapest), Héctor Bello (Mexico U., ICN & Puebla U., Mexico). Aug 16, 2016. 14 p
Published in **J.Phys. G44 (2017) no.6, 065001**
DOI: 10.1088/1361-6471/aa6594
e-Print: **arXiv:1608.04784 [hep-ph] | PDF**

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

- ALICE-Analysis Note is submited and is under discusion with the ARC: Jacek Otwinowski, Oliver Busch.

https://aliceinfo.cern.ch/Notes/node/634

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ALICE-ANA-2014-xxx

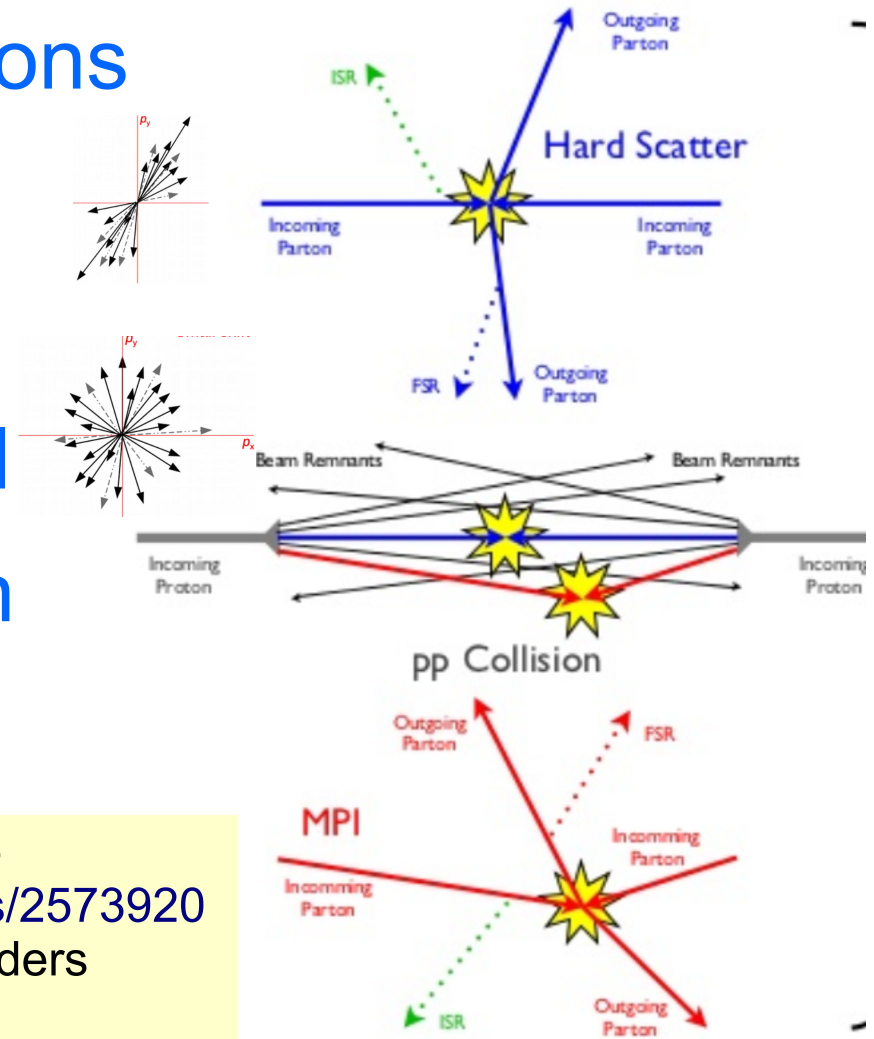
Spherocity analysis for $\langle p_T \rangle$ vs $N_{\mathbf{ch}}$ in pp colisions at $\sqrt{s}$= 13 TeV

Héctor Bello Martínez[1,2], Arturo Fernández Téllez[1], Antonio Ortiz Velasquez[2], Guy Paić[2]

Spherocity analysis pp @ 13 TeV

Motivation

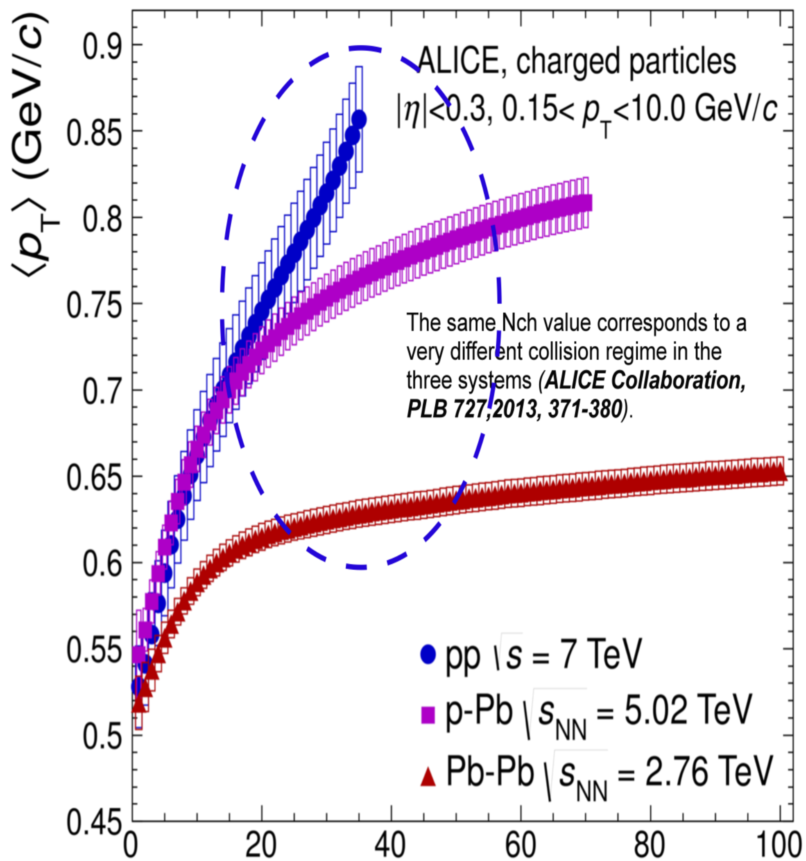
- Study features of HM pp collisions using spherocity will allow soft and hard separation.
- Comparing model and data will help us to get more information about high multiplicity events.



See Antonio’s presentation at high mult worshop
https://indico.cern.ch/event/632298/contributions/2573920
A recent review on event shapes at hadron colliders
arXiv:1705.02056

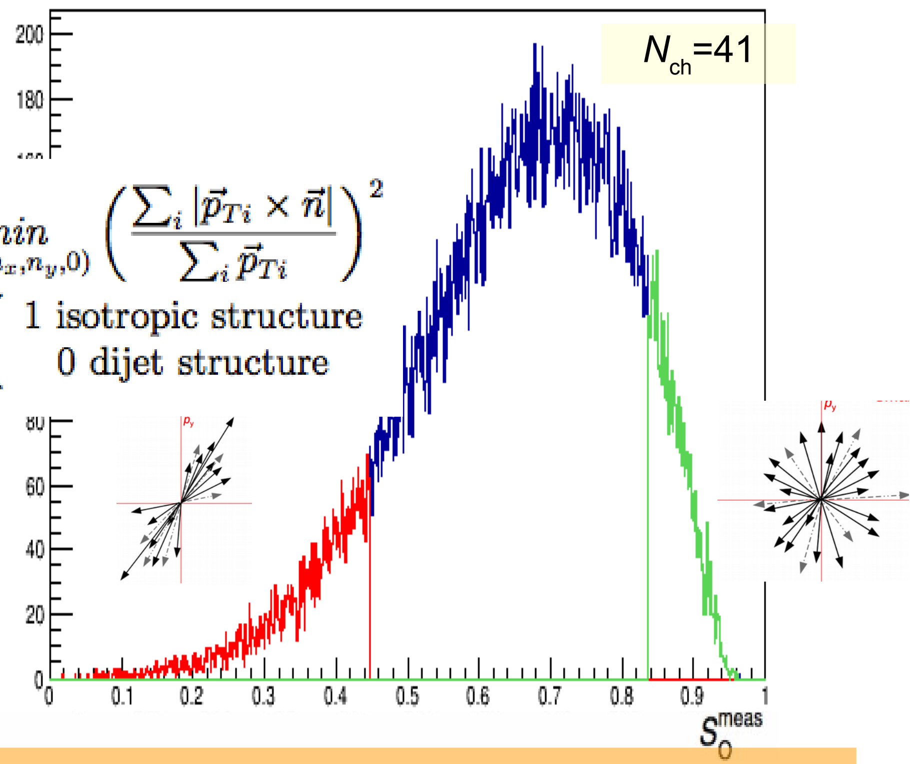
So analysis with N_{ch} bin=1 and So percentile

https://indico.cern.ch/event/637705/



Using N_{ch} bining of size 1 will allow us to see the first and second rise

A study with So could help to understand what kind of process contribute to the behaviour



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

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

Taking So percentile give us better statistics for the event shape selection
These are built in percentages of the P(So) distribution

For 13 TeV results shown in past, no consideration to So percentil binning was done
https://indico.cern.ch/event/477734/
https://indico.cern.ch/event/437981/

Strategy to correct the data

- Get the p_T spectra for a given event class selected cutting on measured spherocity and measured multiplicity N_m
- Correct the p_T spectra by efficiency and secondaries contamination
- Get the $<p_T>$ vs N_m
- Correct by spherocity and multiplicity selection
- Test the correction method using MC reconstructed data (closure test)
- Get fully corrected $<p_T>$ vs N_{ch} in So percentile bins.

Analysis details

- **Datasets**

  Pythia Per2011 (LHC15g3c3)

  EPOS-LHC (LHC16d3)

  Data (LHC15f pass2)

- **Event selection**

  AliVEvent::KINT7, AnalysisUtils::IsSPDClusterVsTrackletBG(), IsPileupFromSPDInMultBins(),IsIncompleteDAQ()

- **Vertex**

  For events with both SPD and reconstructed Track vertices, their separation along the z-axis was required to be smaller than 5 mm

- **Spherocity is reconstructed** using more than two tracks with transverse momentum greater than 0.15 GeV/c and within |eta|<0.8.

  TPC: GetStandardTPCOnlyTrackCuts()+TPCrefit

  More details can be found in:https://aliceinfo.cern.ch/Notes/node/529

- In this presentation, results for the reference estimator are discussed (p_T>0 GeV/c)

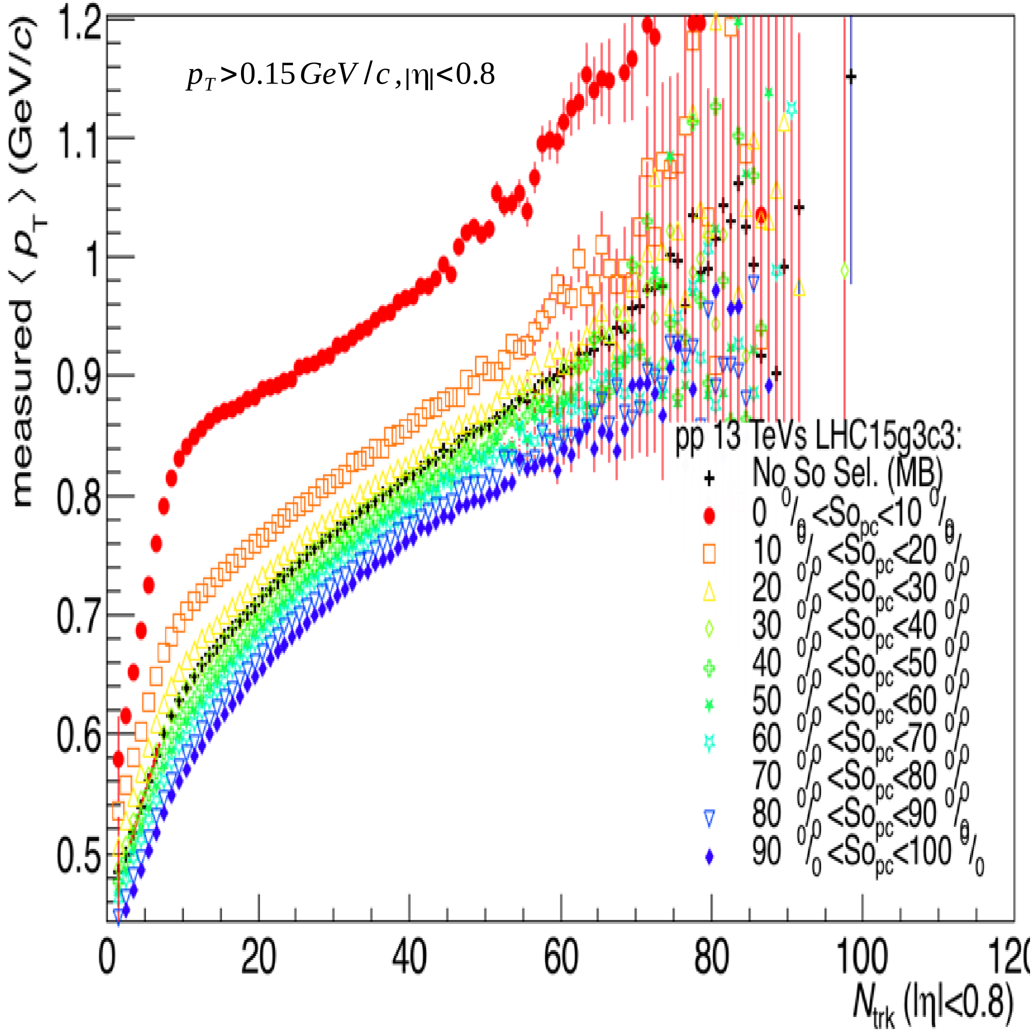
  GetReferenceMultiplicity(fESD,AliESDtrackCuts::kTrackletsITSTPC,0.8)

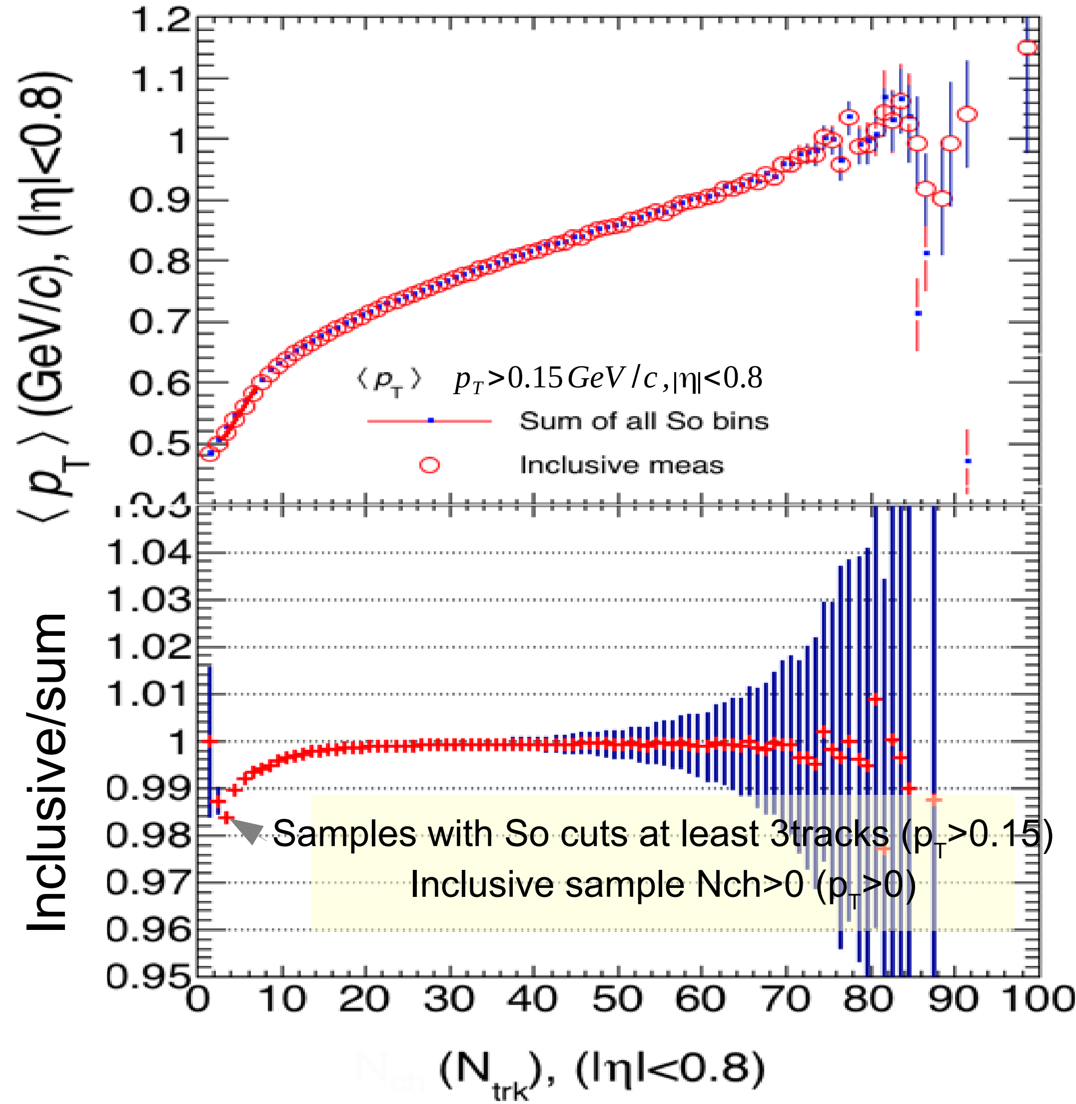
Analysis Update

MC closure test

$\langle p_T \rangle$ for different So_{pc} bins **measured**.

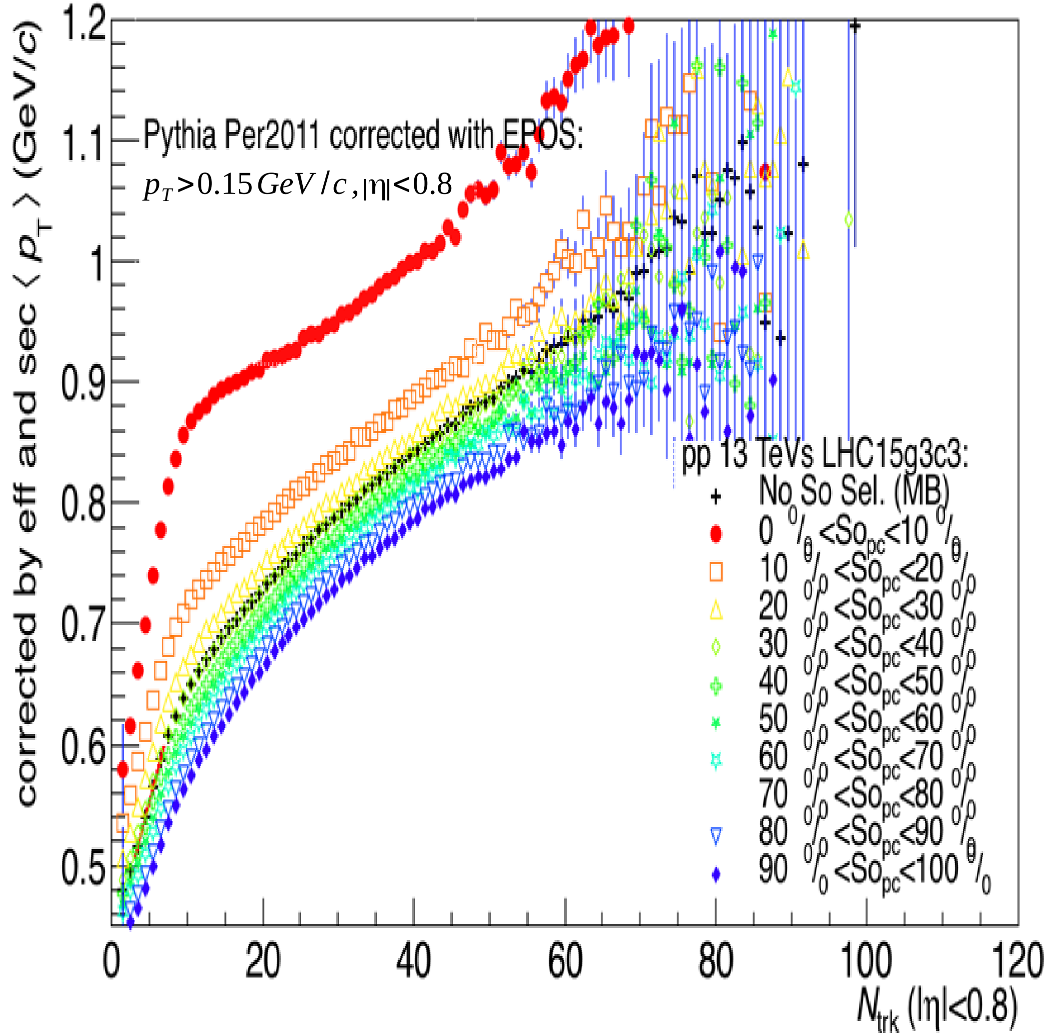
Pythia Per2011 (LHC15g3c3) as data.

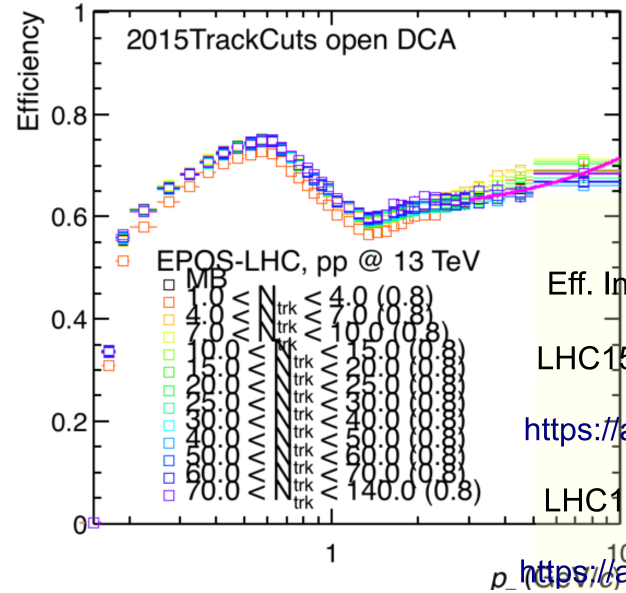




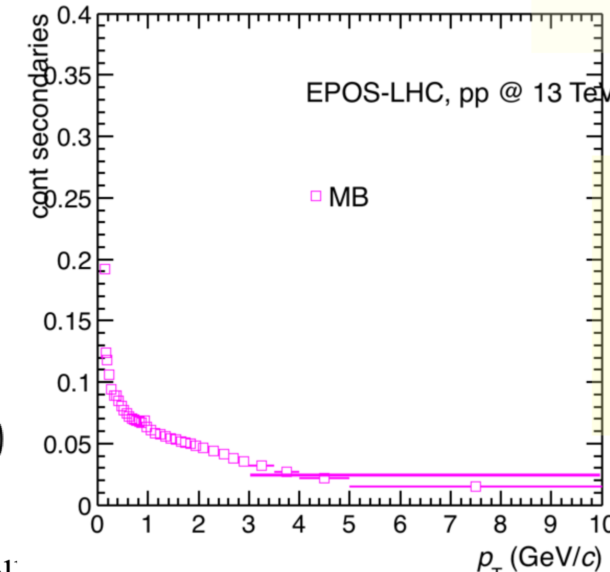
$\langle p_T \rangle$ for different So_{pc} bins **efficiency and secondaries corrected**.

Pythia Per2011 (LHC15g3c3) as data corrected with EPOS-LHC (LHC16d3)





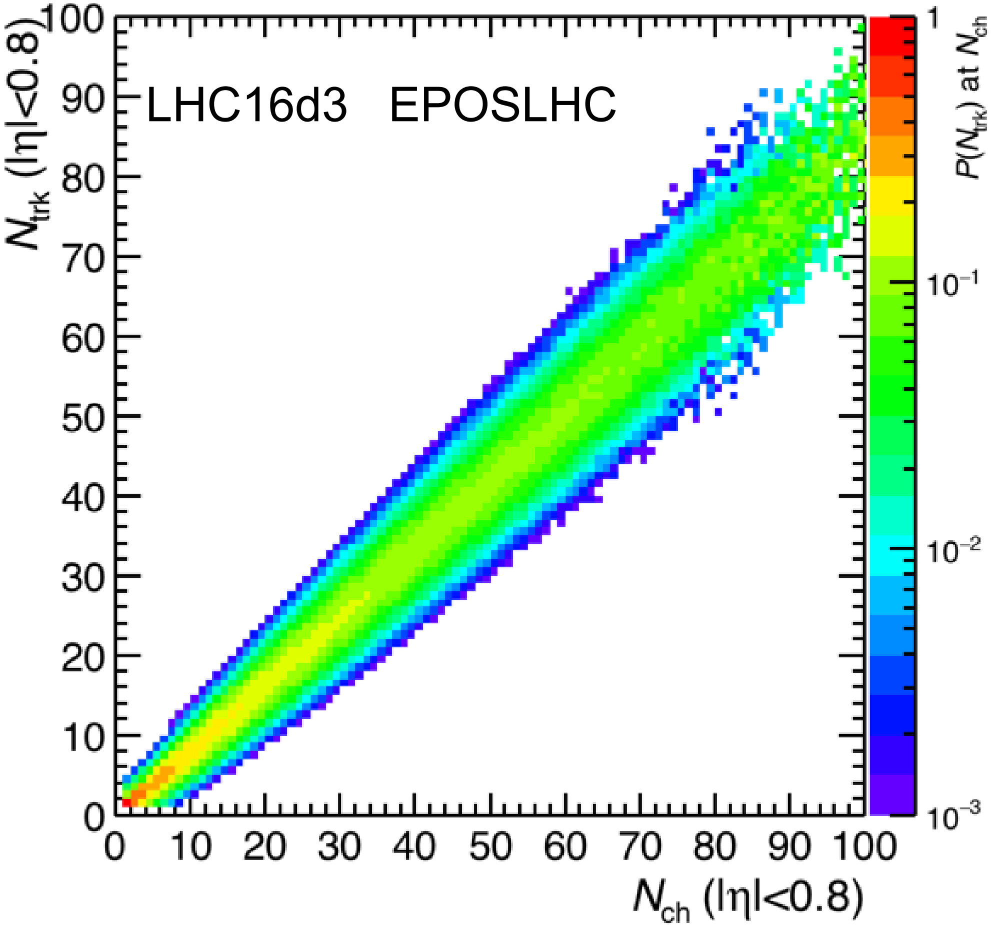
Eff. In Agreement with (See backup):
Sergio´s result
LHC15g3a3 (Monash) pp13 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/564
Edgar´s result
LHC15l1b2 (Per11) pp5.02 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/472



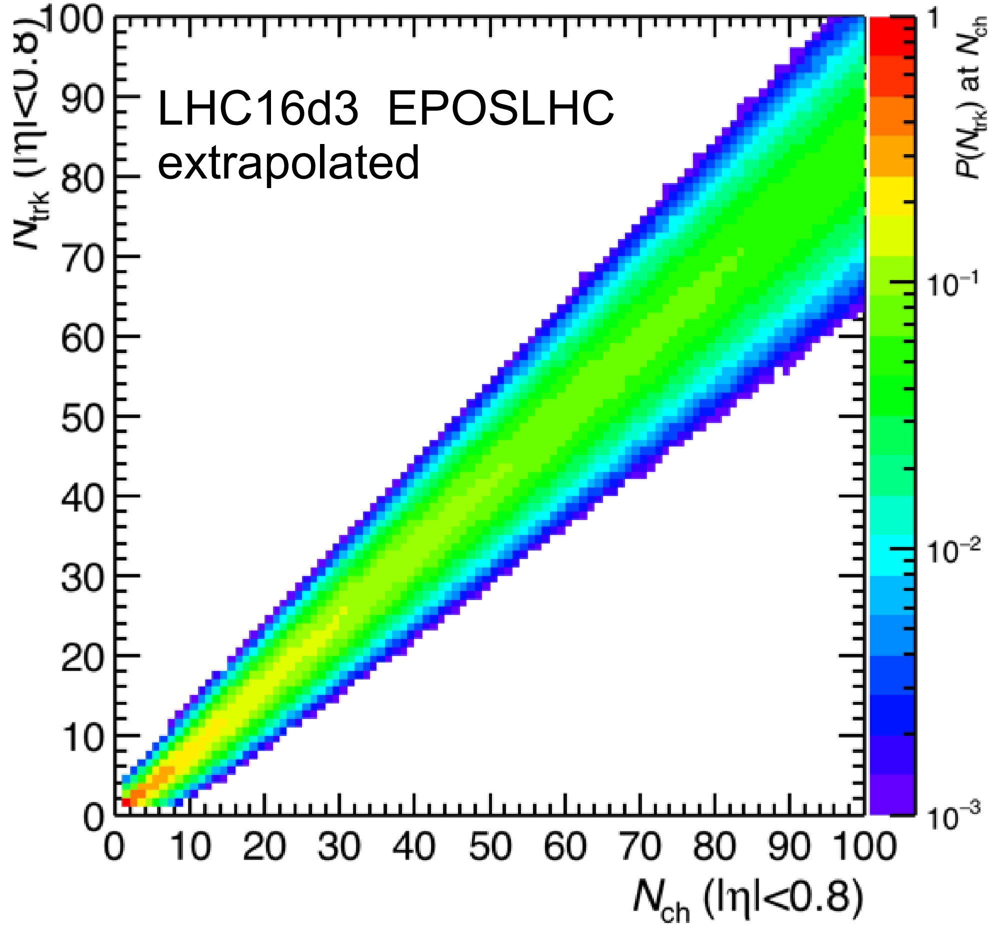
This correction was taken from MC.
For data a more elaborated analisys must be done, albeit, a small effect on $\langle p_T \rangle$ is expected

- N_{ch} response matrix to correct by Multiplicity

Not extrapolated



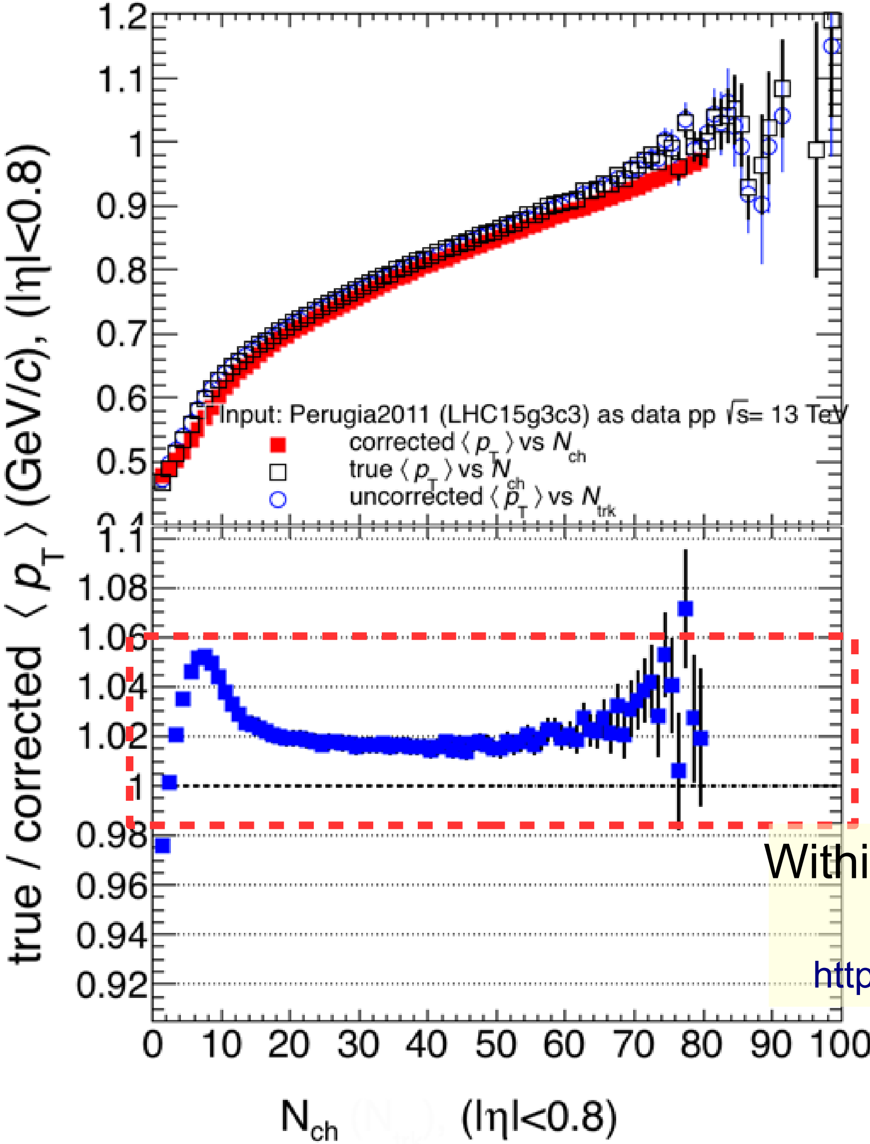
Extrapolated



EPOS-LHC is used for the correction

Multiplicity correction for the inclusive case

Pythia Per2011 (LHC15g3c3) as data corrected with EPOS-LHC (LHC16d3)



For multiplicity correction we based on:

$$\langle p_T\rangle(N_{ch})=\sum_m \langle p_T\rangle(N_m)\times R(N_t,N_m)$$

where, R is the multiplicity response matrix.

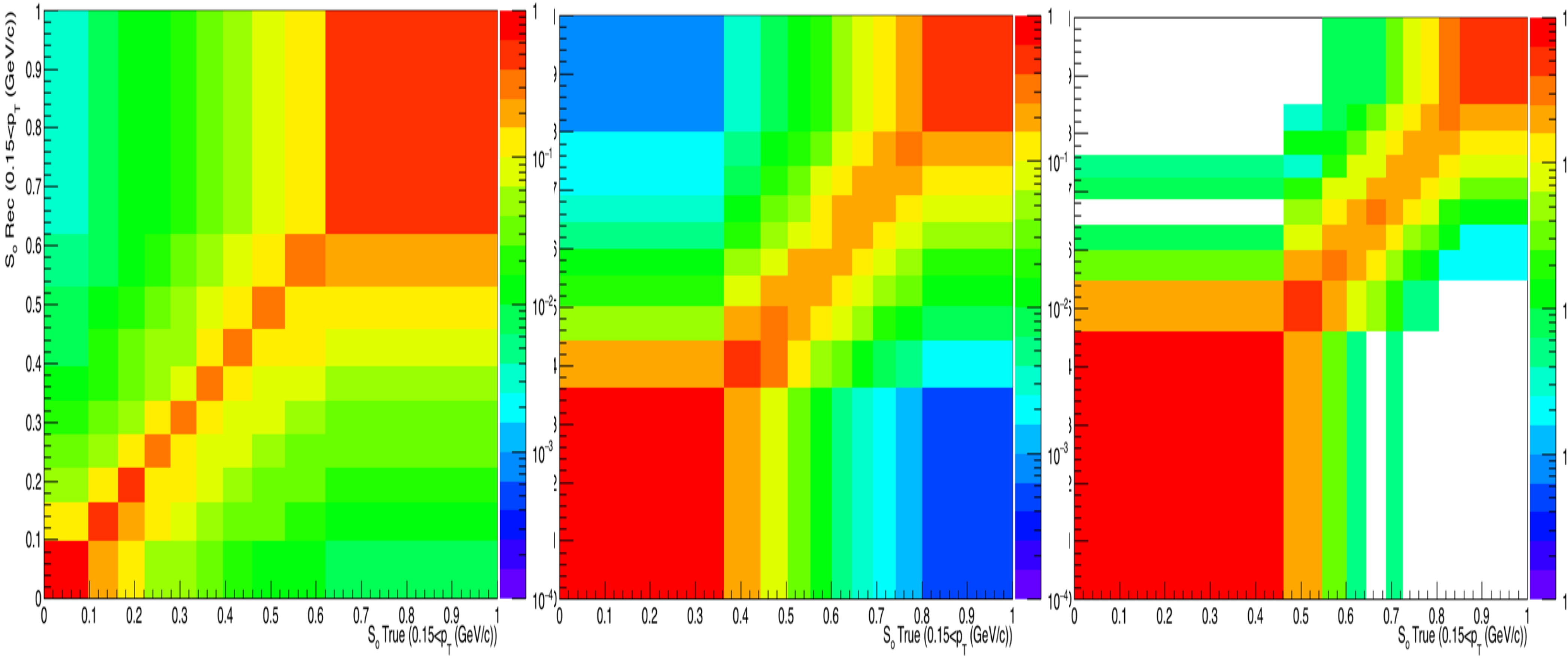
- Correc: Per2011 ESD corr with EPOS-LHC
- True: Per2011 MC
- Unc: Per2011 ESD

Within 6% for low N_{ch} as reported in GSI Analysis Note:
https://aliceinfo.cern.ch/Notes/node/177

Corrections for the So dependent analysis

- This was done with EPOS-LHC, for So correction of Pythia Per2011 as data

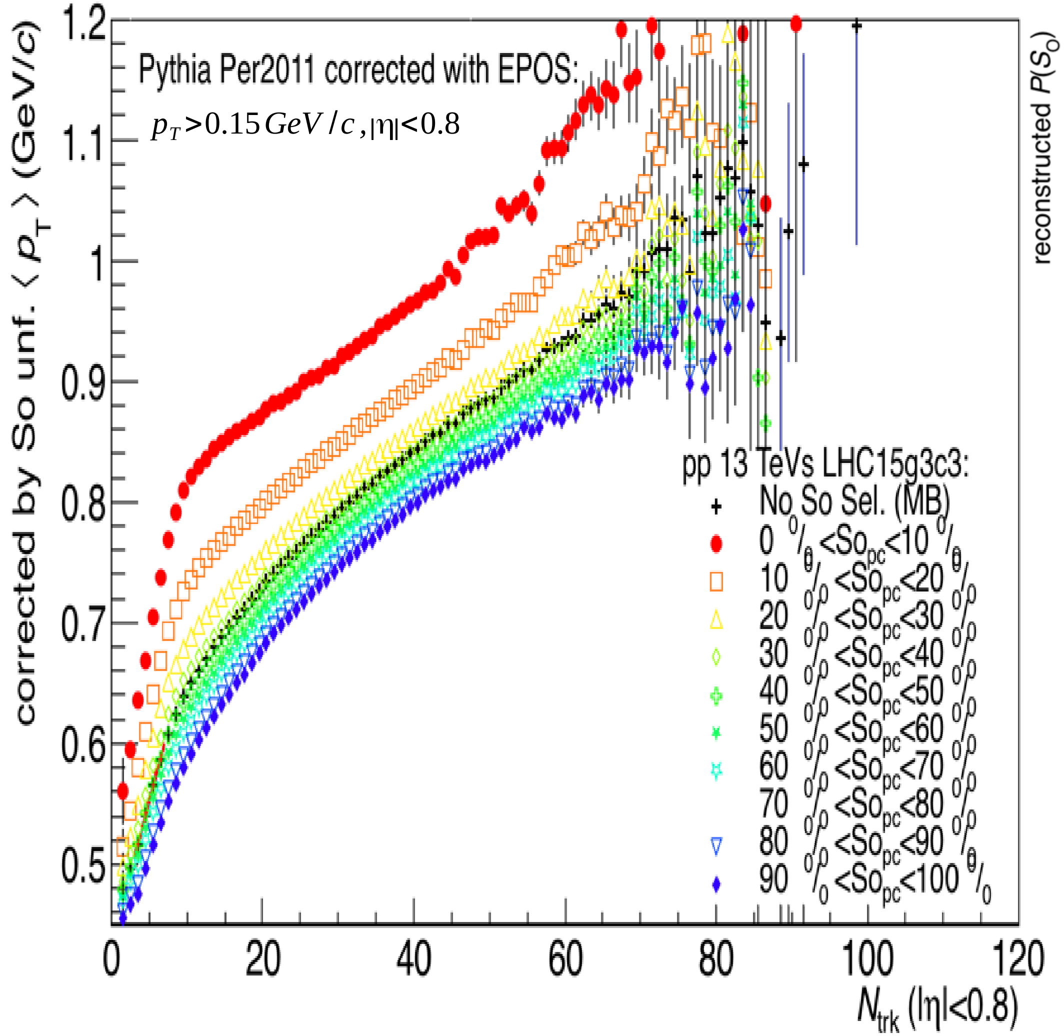
Ntrk=5 Ntrk=25 Ntrk=60

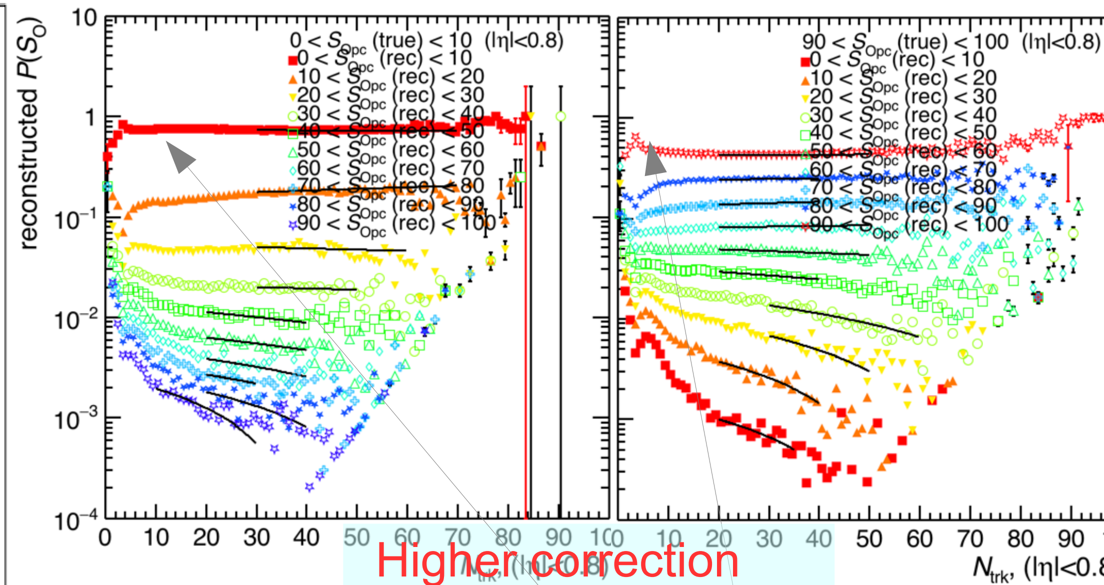


Data should define the So binning used in the sphericity response matrices.

$\langle p_T \rangle$ corrected by Spherocity selection.

Pythia Per2011 (LHC15g3c3) as data corrected with EPOS-LHC (LHC16d3)





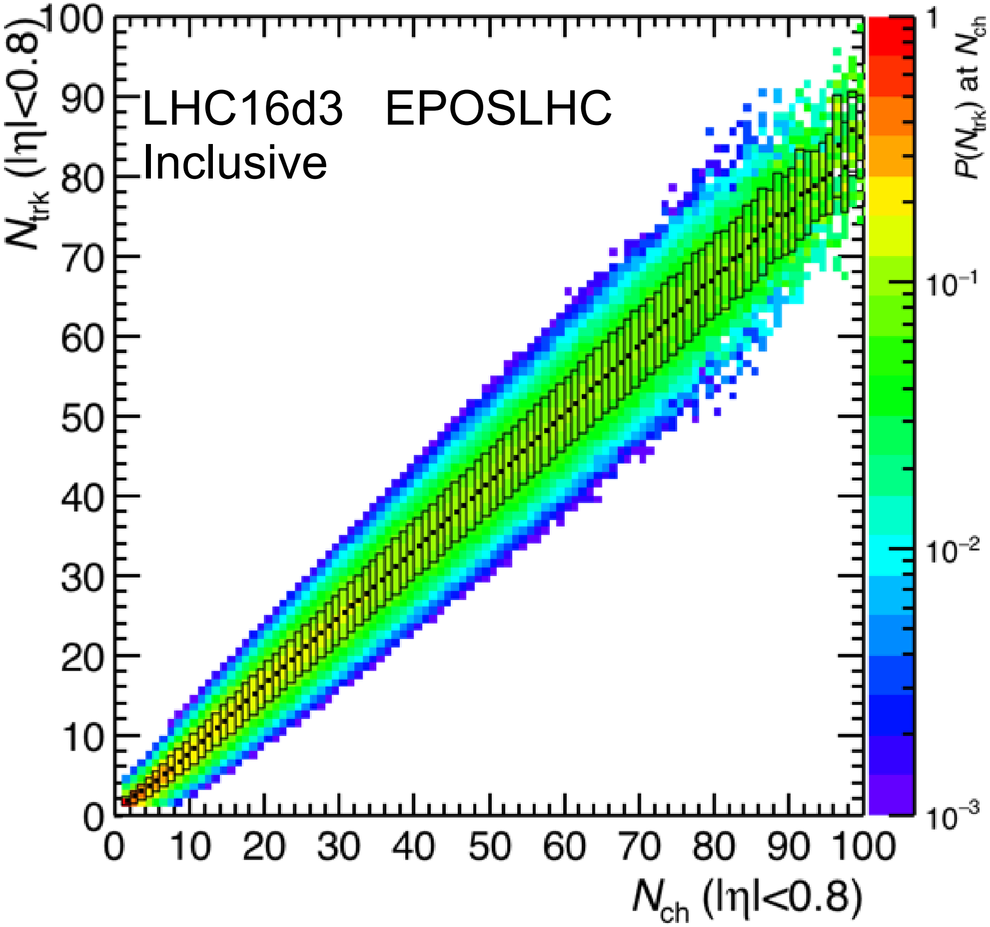
Higher correction for isotropic (~40%) than jetty (~20%)
(Zoomed plots in backup)

$$\langle p_T \rangle (S_O^{corrected_i}) = \sum_{j=1}^{10} \langle p_T \rangle (S_O^{measured_j}) \, P(S_O^{measured_j})_{at\, S_O^{true_i}}$$

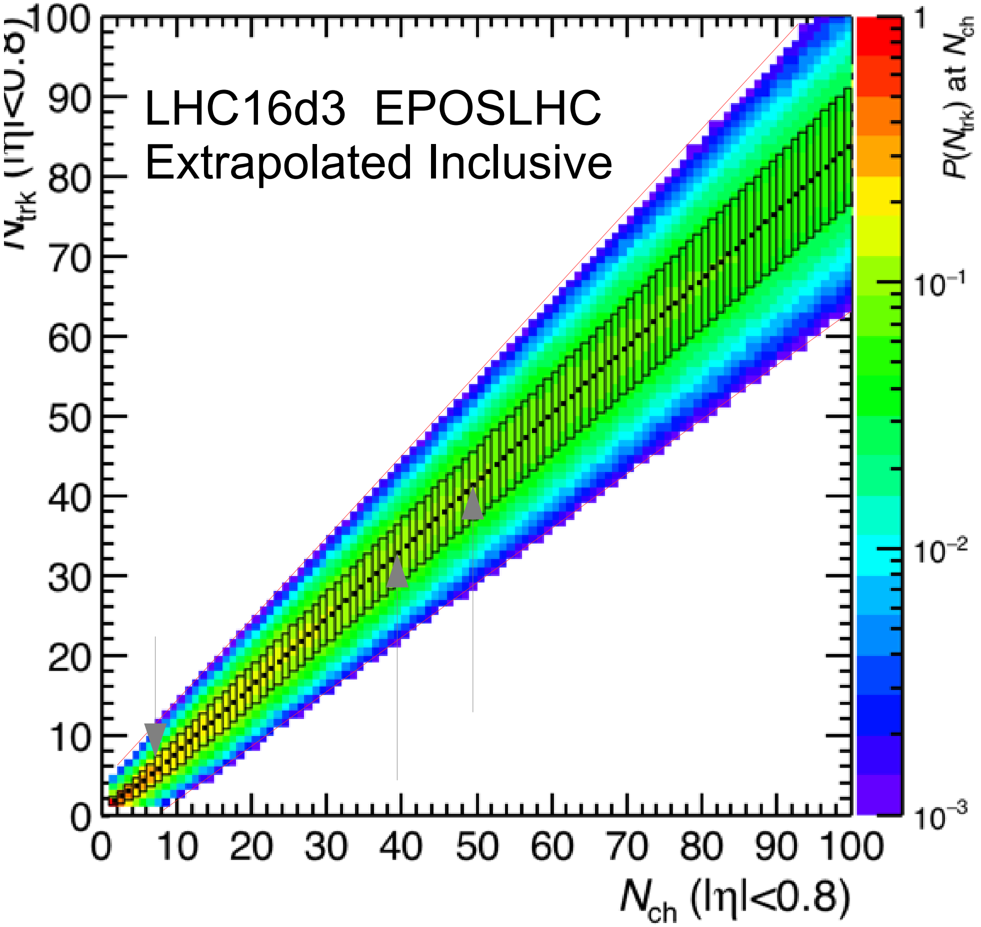
We used a weighting average

- N_{ch} response matrix to correct by Multiplicity

Not extrapolated

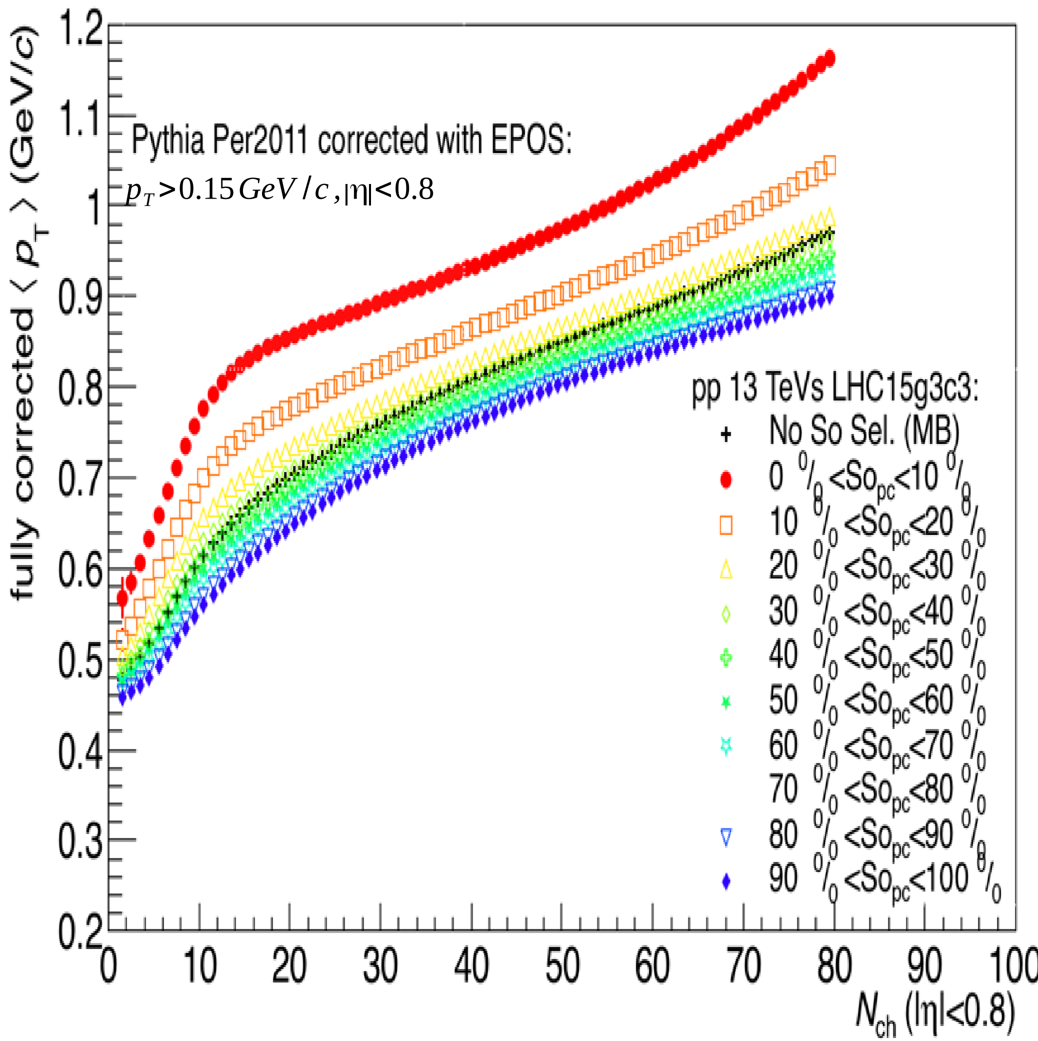


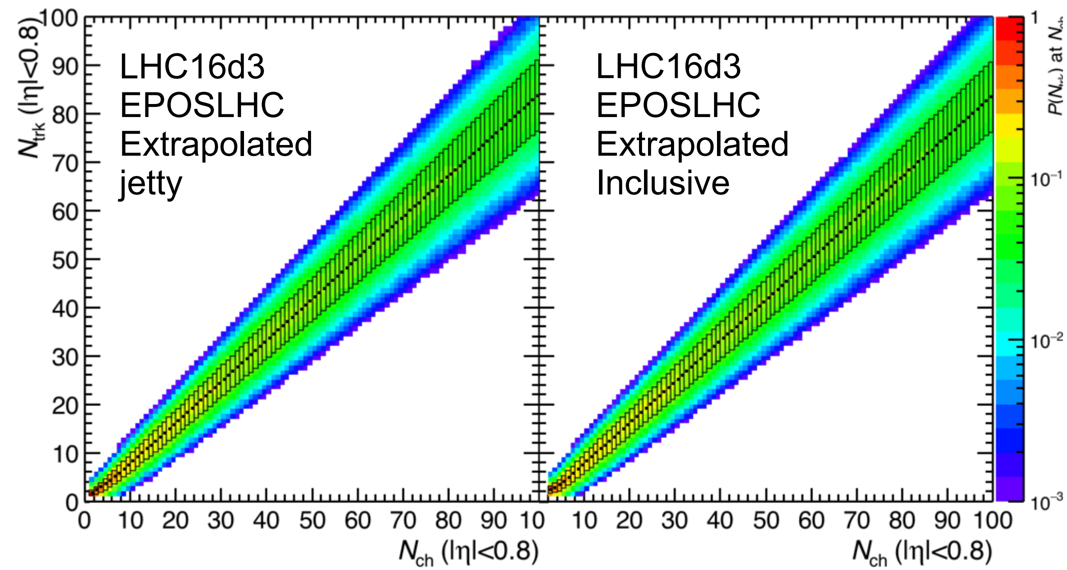
Extrapolated



Spherocity dependent $\langle p_T \rangle$ corrected by multiplicity and Spherocity

Pythia Per2011 (LHC15g3c3) as data corrected with EPOS-LHC (LHC16d3)





We used a weighting average

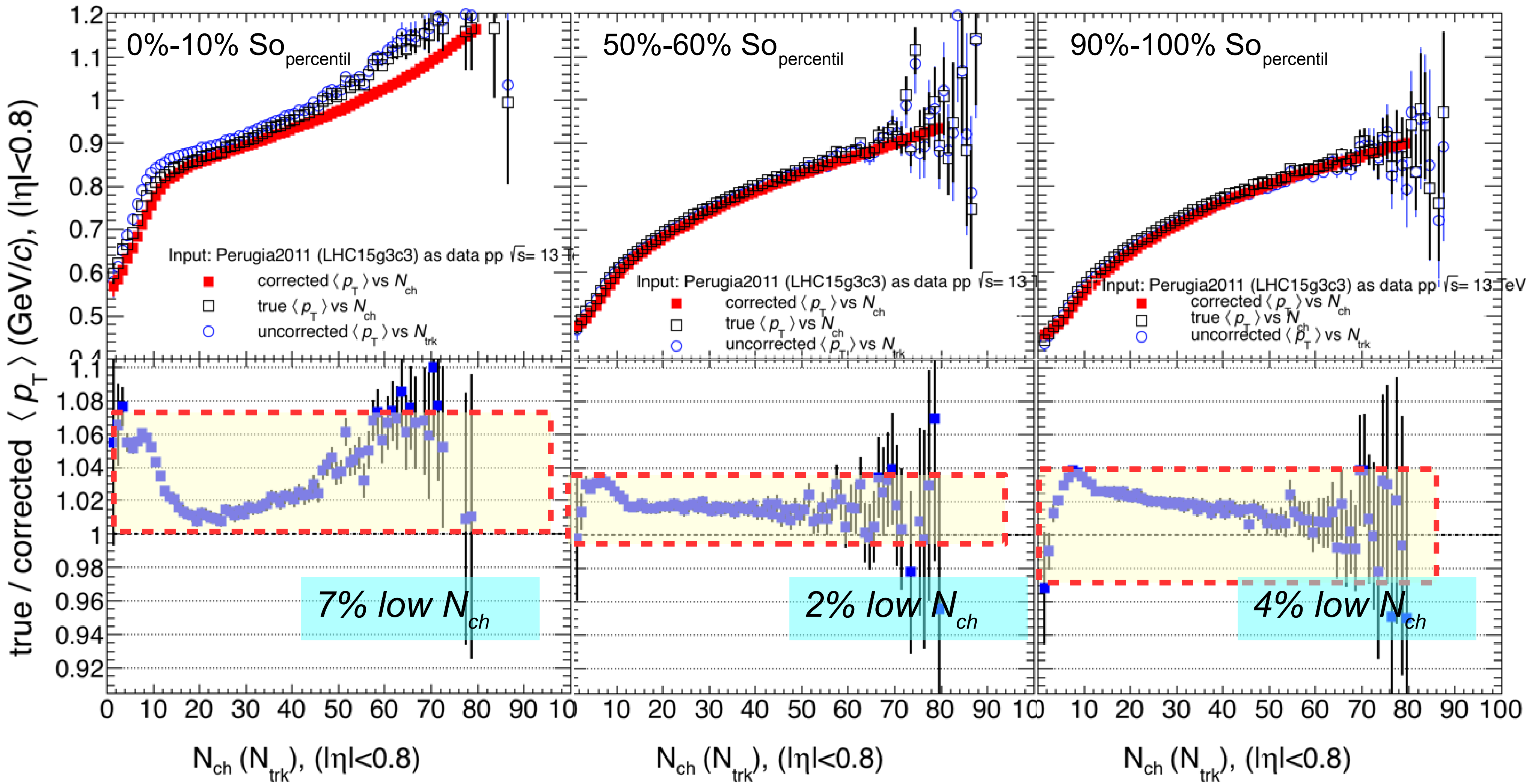
$$\langle p_T\rangle\left(S_O^{corrected_i}\right) = \sum^{10} \langle p_T\rangle\left(S_O^{measured_j}\right) P\left(S_O^{measured_j}\right)_{at\, S_O^{true_i}}$$

$$\langle p_T\rangle\left(N_{ch}, S_O^{corrected_i}\right) = \sum_m \langle p_T\rangle\left(N_m, S_O^{corrected_i}\right) \times R\left(N_t, N_m\right)$$

$<p_T$ (So_{corr},Nch_{corr}) $>$ corrected by N_{ch} CLOSURE TEST

Pythia Per2011 used as data corrected with EPOS-LHC (LHC16d3)

$$\langle p_T\rangle(N_{ch}, S_O^{corrected_i}) = \sum_m \langle p_T\rangle(N_m, S_O^{corrected_i}) \times R(N_t, N_m)$$



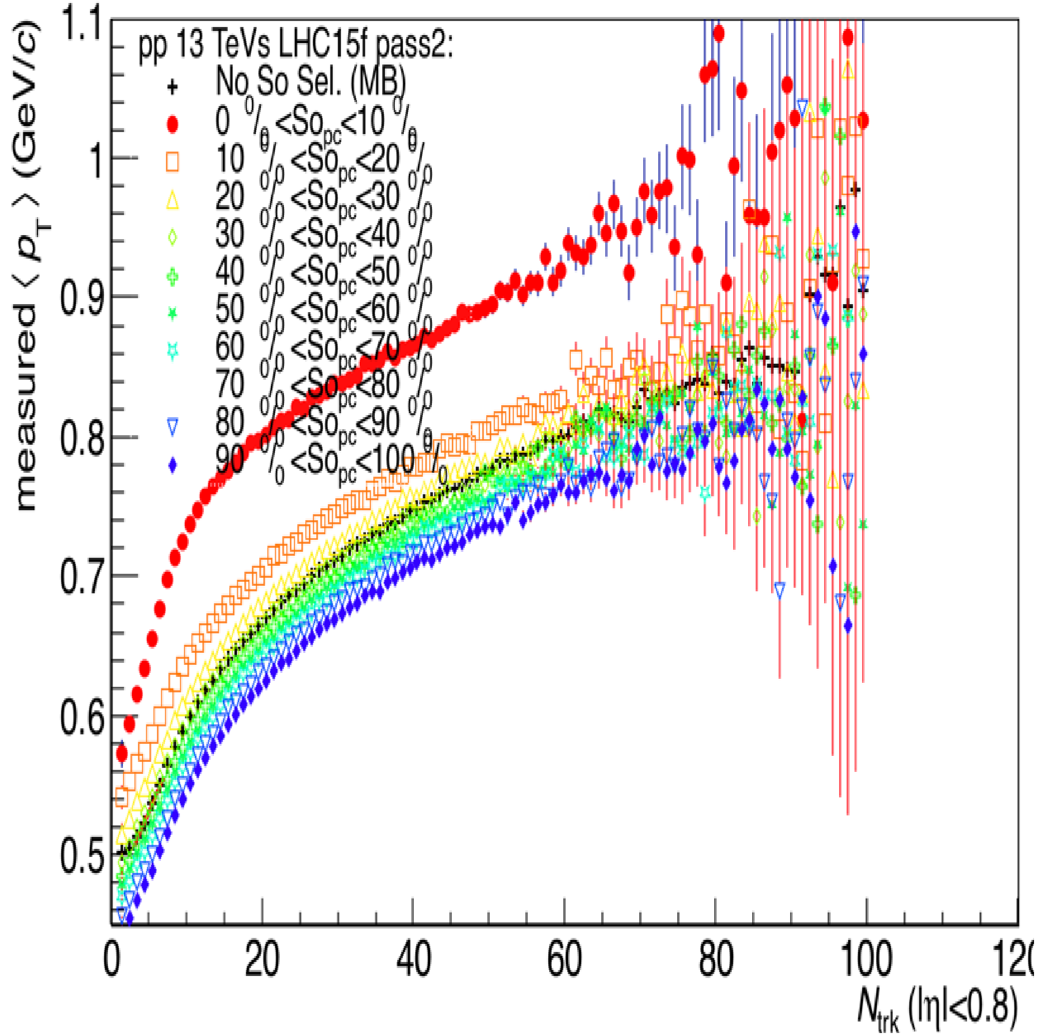
Greater contribution from Multiplicity correction

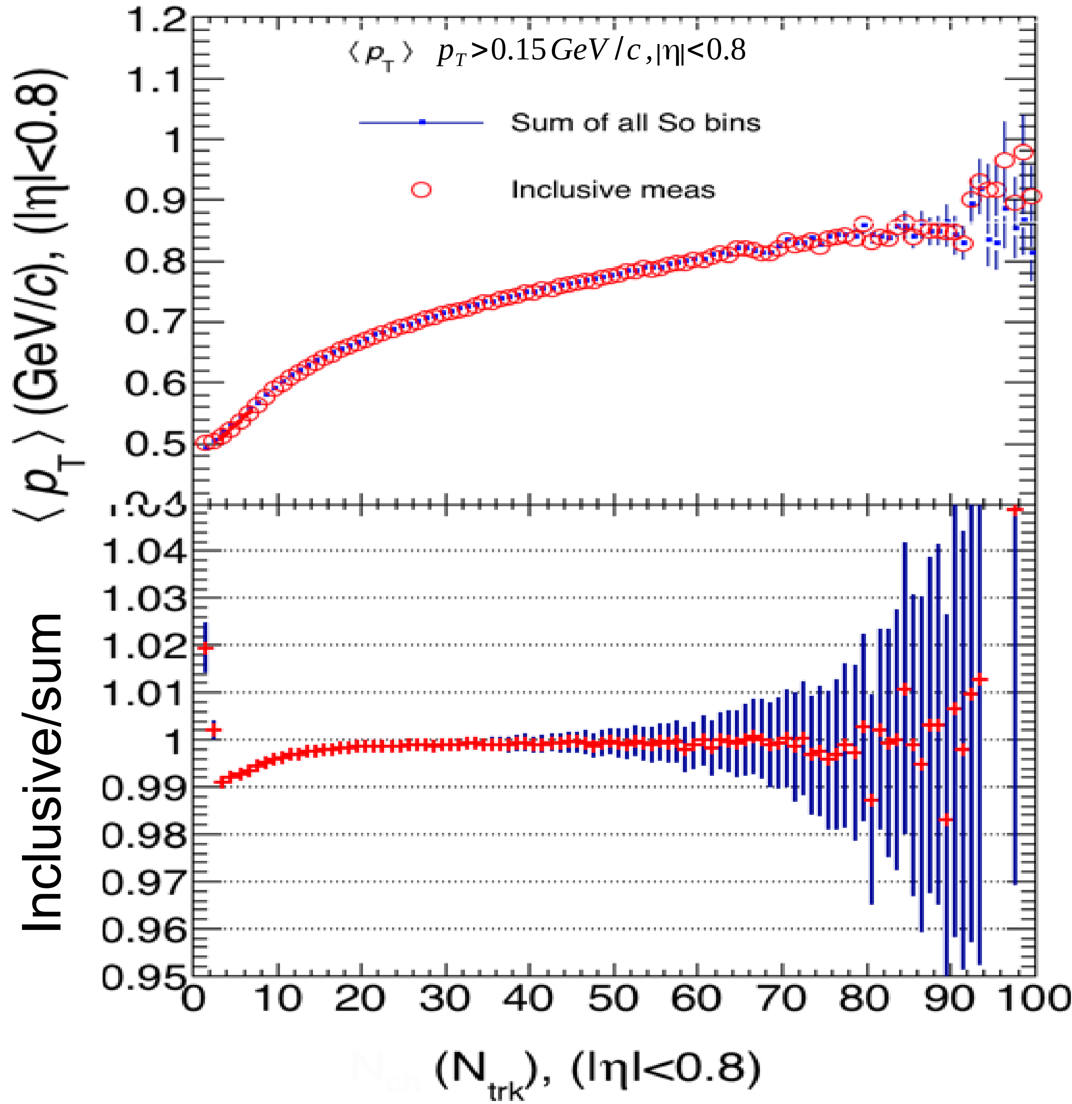
Analysis Update

Data LHC15f pass2

$\langle p_T \rangle$ for different So_{pc} bins **measured**.

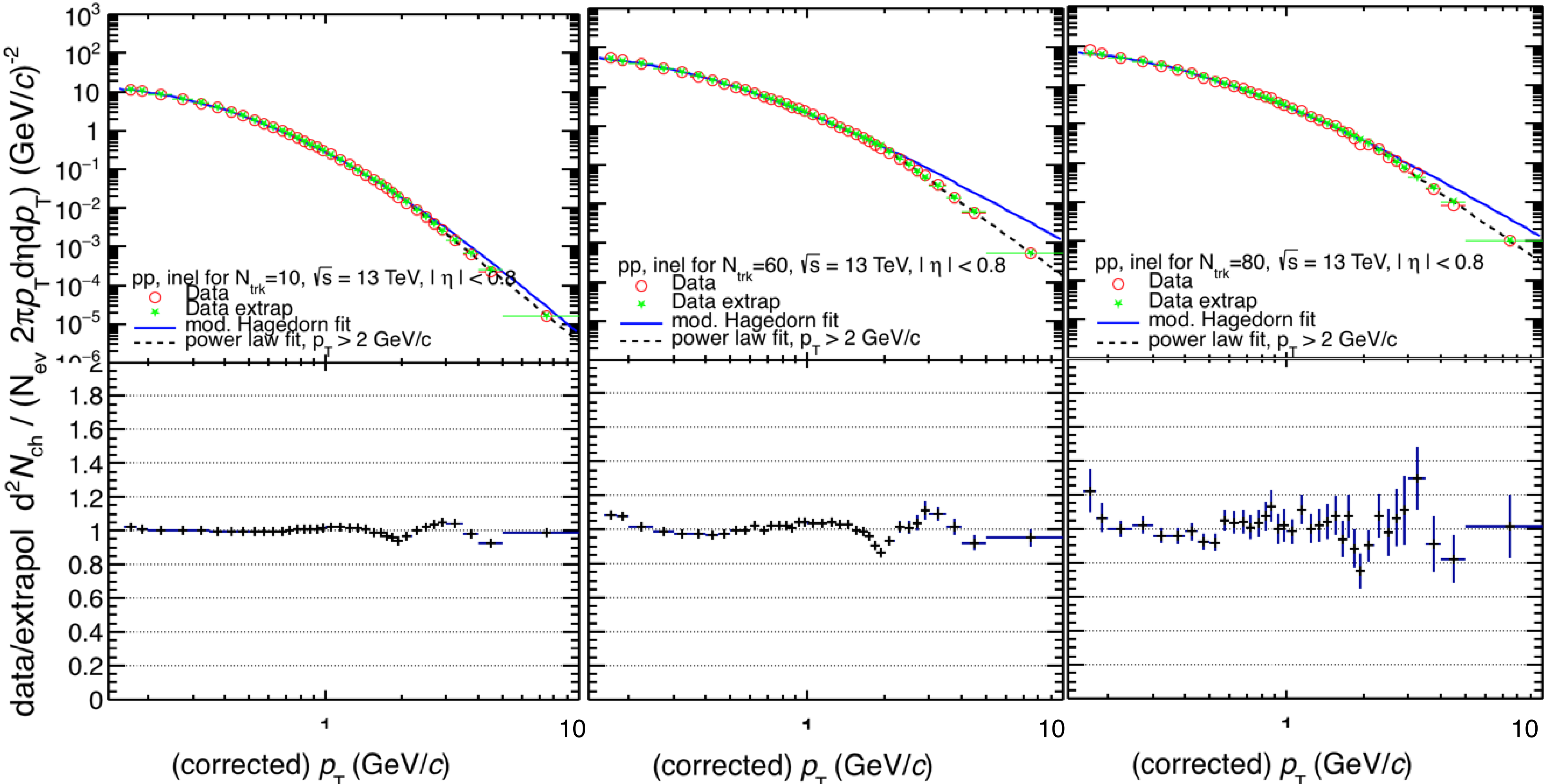
Data (LHC15f pass2).





p_T spectra for inclusive

Data (LHC15f pass2)



Fits based on the following:
Transverse momentum spectra of charged particles in proton-proton collisions at √s=900 GeV with ALICE at the LHC, ALICE Collaboration, arXiv:1007.0719

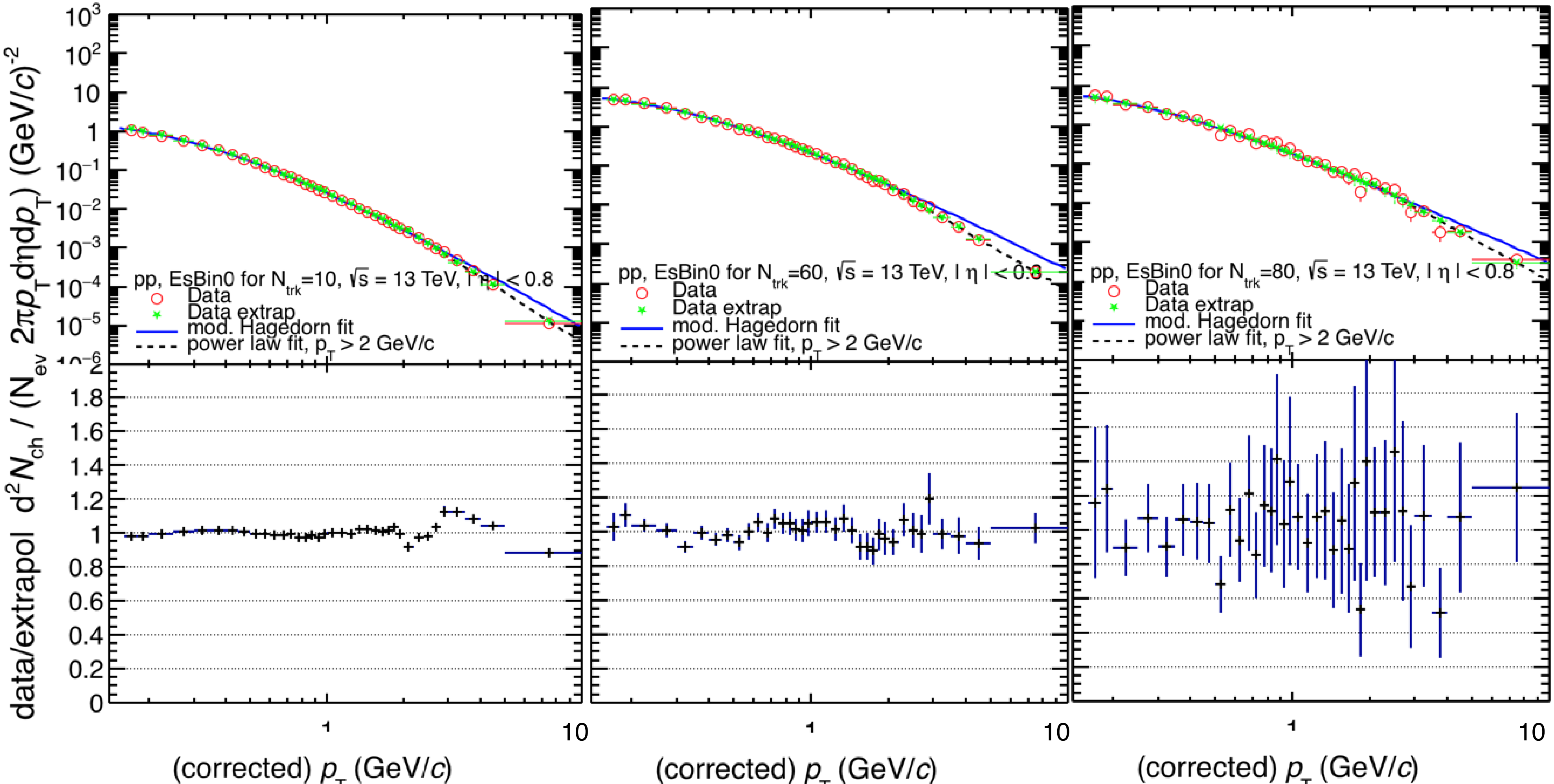
two function were fitted to data in order to avoid statistical fluctuation

$$\frac{1}{2\pi p_T}\frac{d^2N_{ch}}{d\eta\, dp_T} \propto \frac{p_T}{m_T}\left(1+\frac{p_T}{p_{T,0}}\right)^{-b}. \quad (1)$$

$$\frac{1}{2\pi p_T}\frac{d^2N_{ch}}{d\eta\, dp_T} \propto p_T^{-n}, \quad (2)$$

p_T spectra 0%<So_{pc}<10%

Data (LHC15f pass2)



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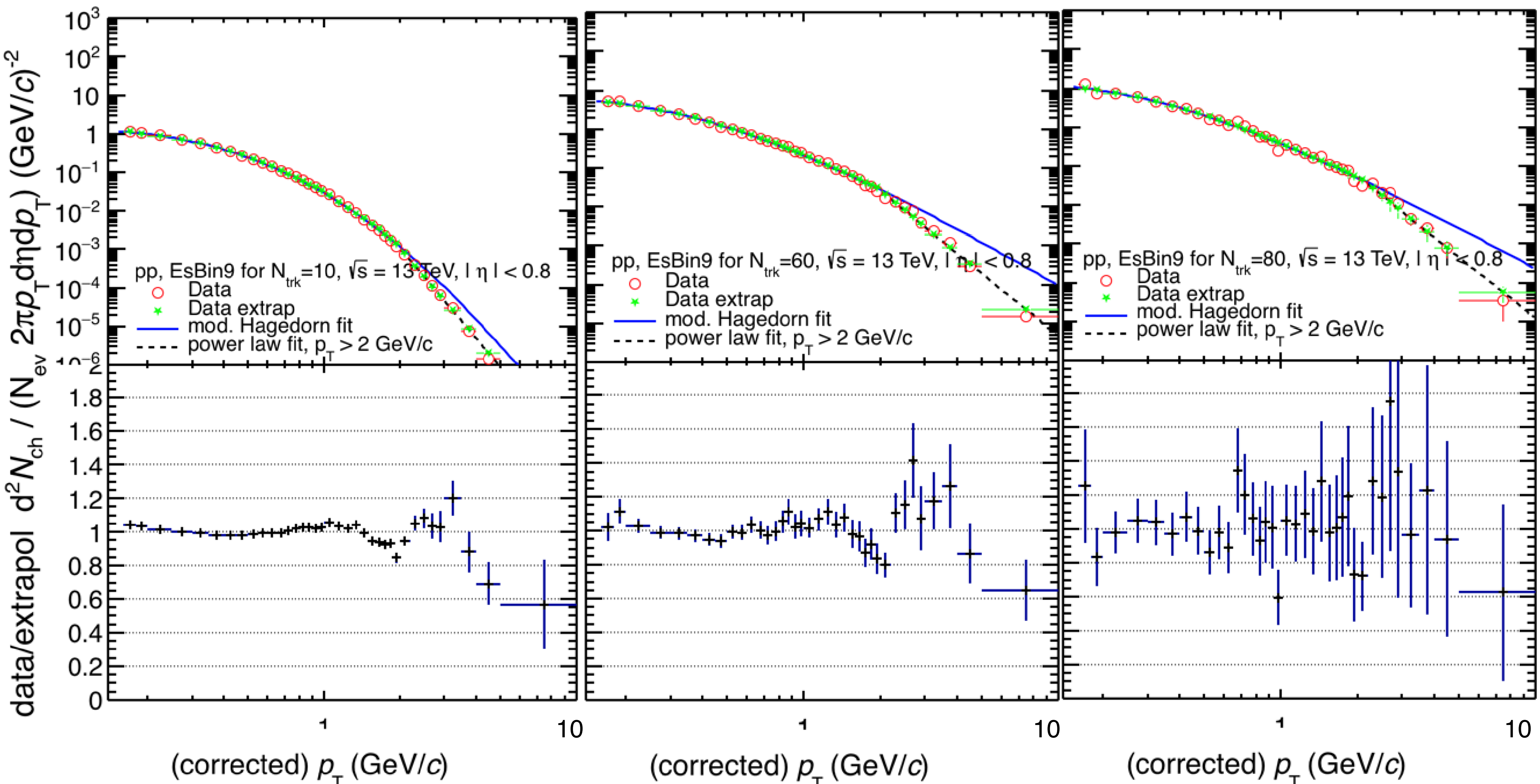
$$\frac{1}{2\pi p_T}\frac{\mathrm{d}^2N_{\mathrm{ch}}}{\mathrm{d}\eta\,\mathrm{d}p_T} \propto p_T^{-n}, \qquad (2)$$

p_T spectra 90%<So$_{pc}$<100%

Data (LHC15f pass2)



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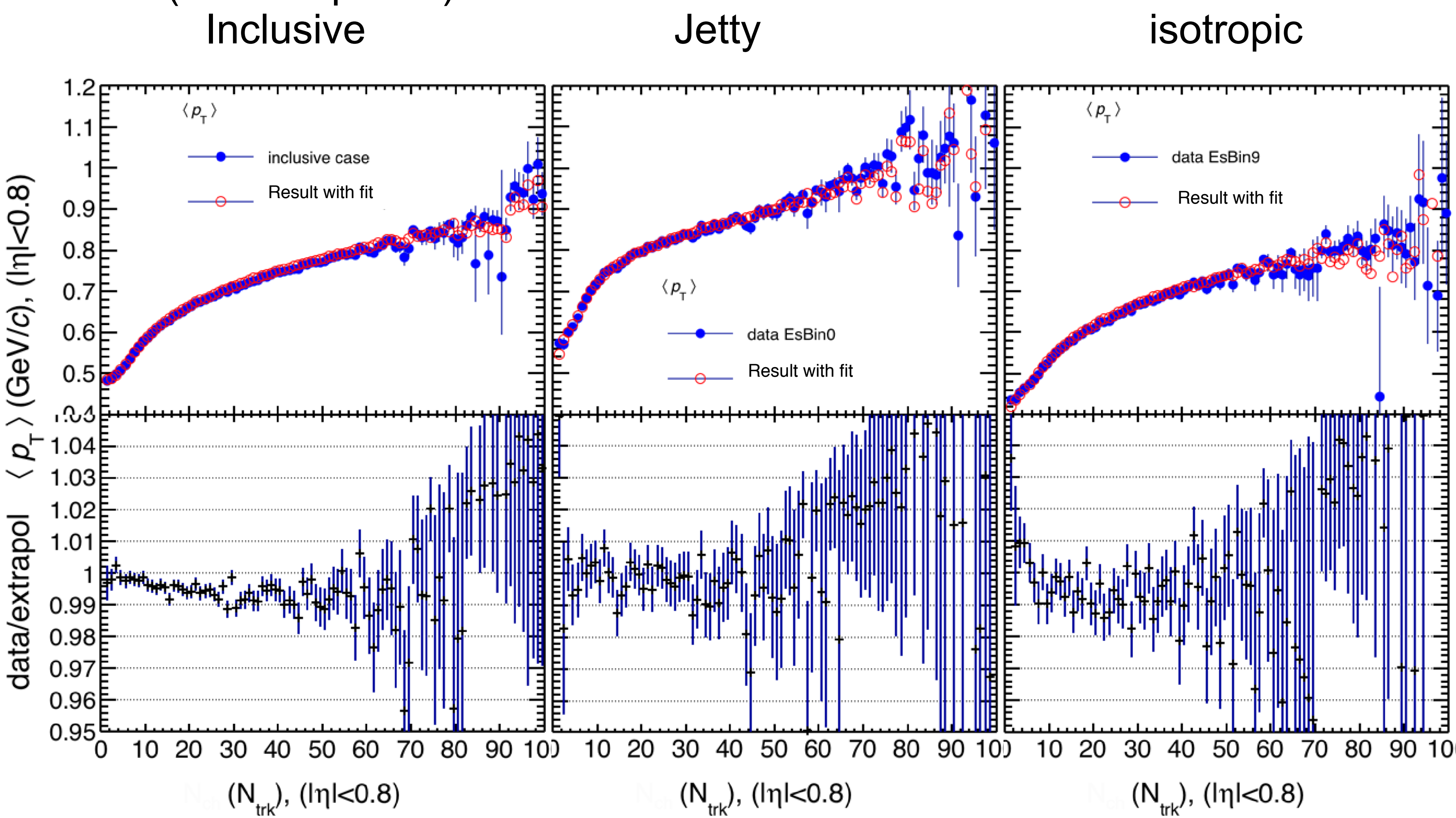
$$\frac{1}{2\pi p_T}\frac{d^2N_{ch}}{d\eta\, dp_T} \propto p_T^{-n}, \qquad (2)$$

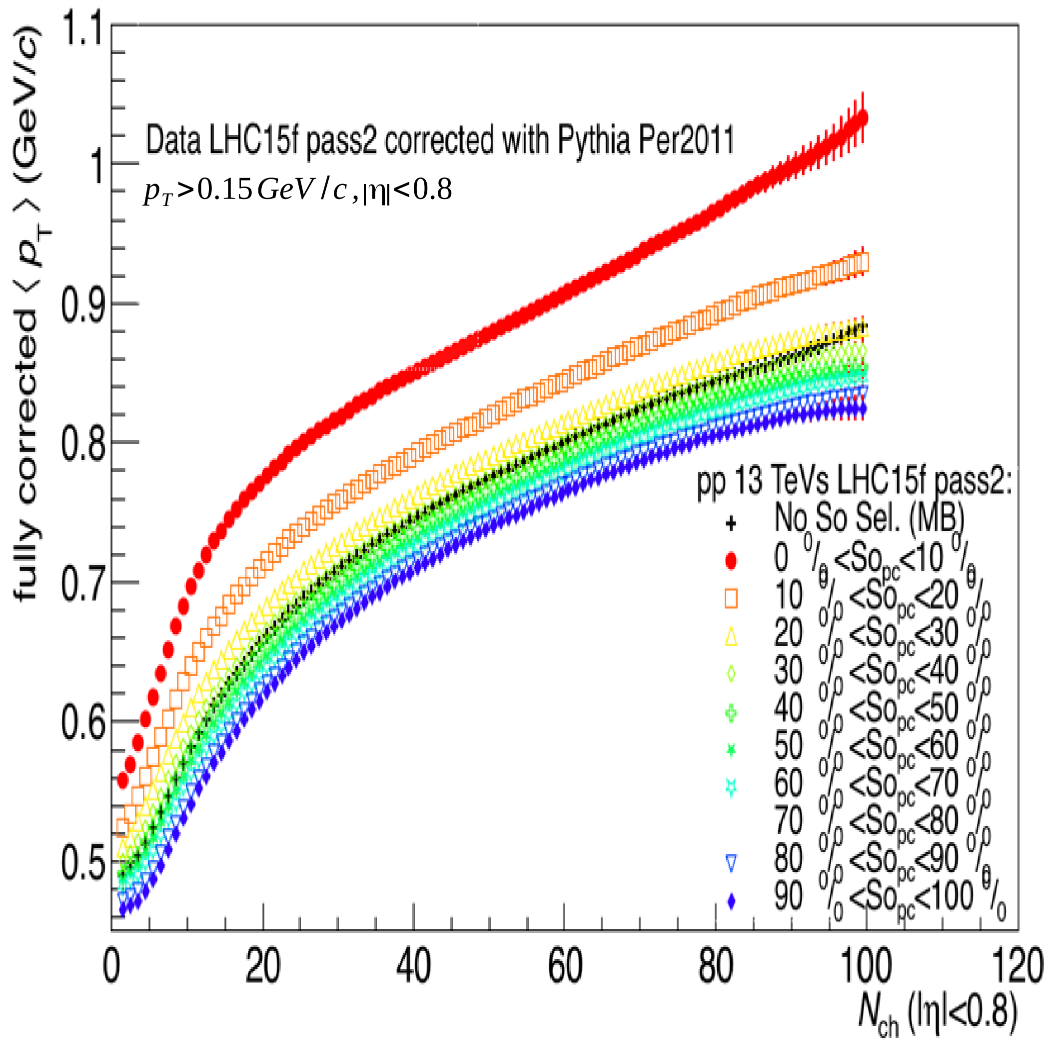
For $<p_T>$ vs N_m , comparison with and without the fit

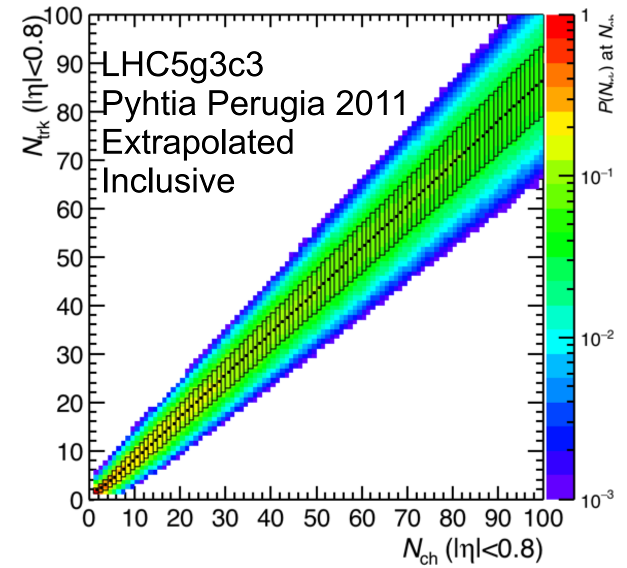
Data (LHC15f pass2)



$\langle p_T \rangle$ for different So_{pc} bins **fully corrected (So Unf + Nch Unf),** following steps as in MC.

Data (LHC15f pass2) corrected with Pythia Per2011 (LHC15g3c3)



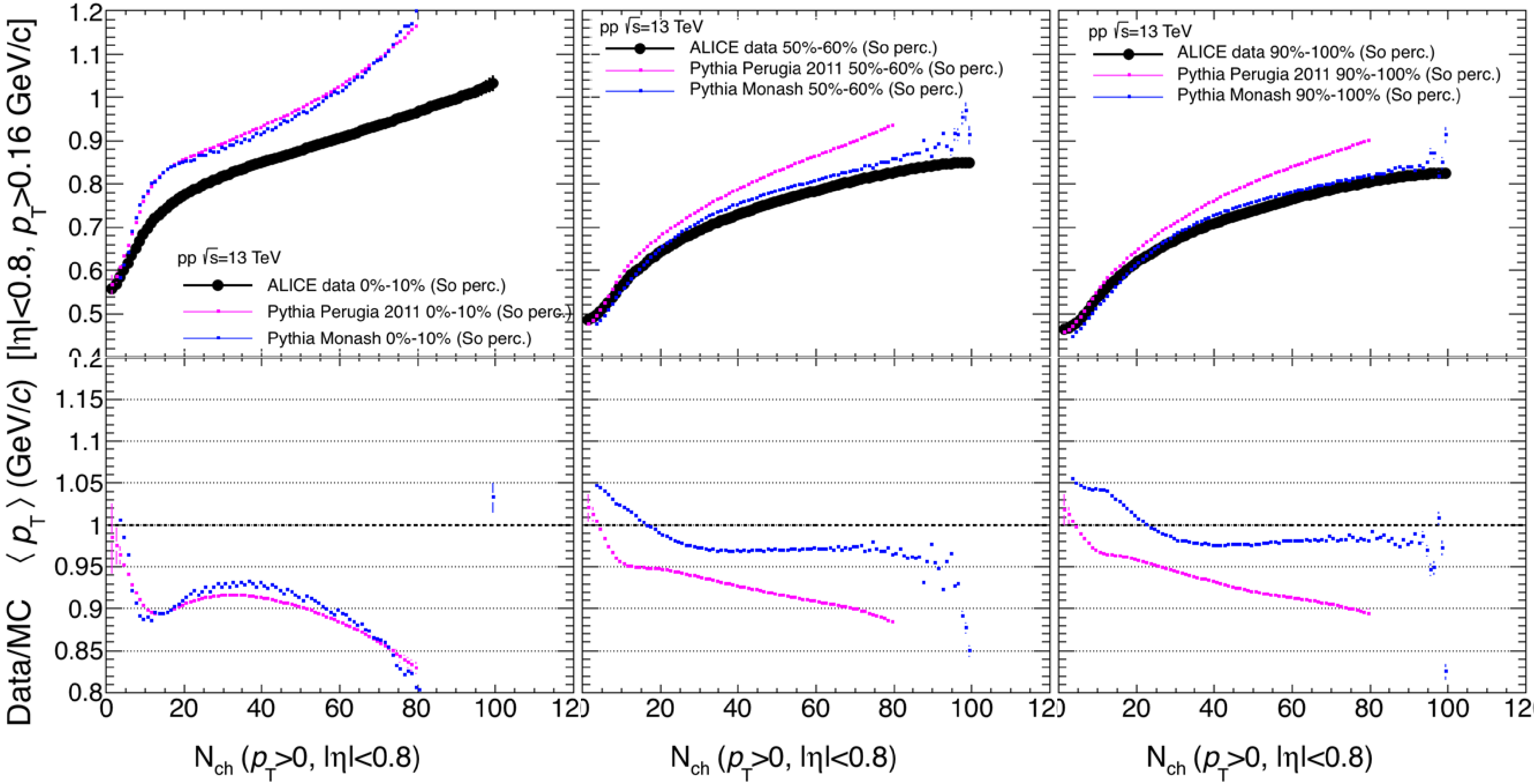


$$\langle p_T \rangle (S_O^{corrected_i}) = \sum^{5} \langle p_T \rangle (S_O^{measured_j}) P(S_O^{measured_j})_{at\, S_O^{true_i}}$$

$$\langle p_T \rangle (N_{ch}, S_O^{corrected_i}) = \sum_{m} \langle p_T \rangle (N_m, S_O^{corrected_i}) \times R(N_t, N_m)$$

<p_T> vs N_{ch} comparison Data(LHC15f pass2) vs MC

Jetty intermediate isotropic



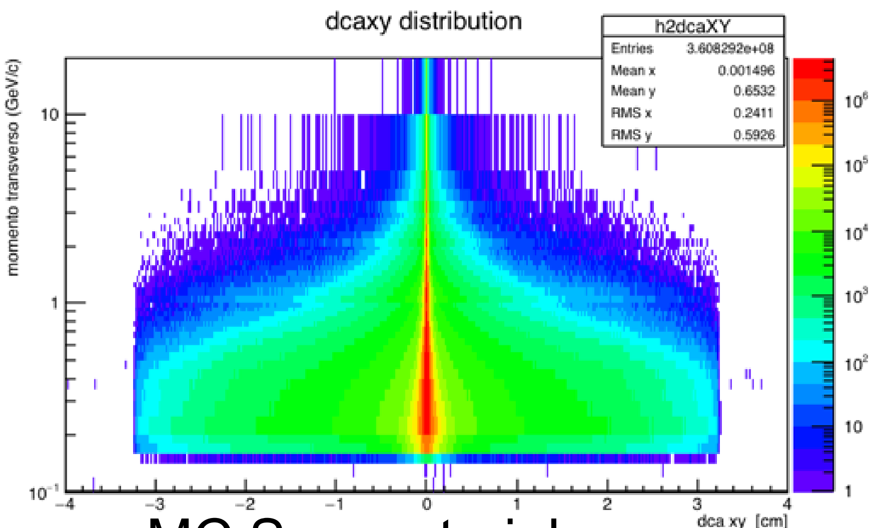
Isotropic samples are well described by Monash,
But for jetty events seems to over-estimate.
Retunning MC?, something its not considered?

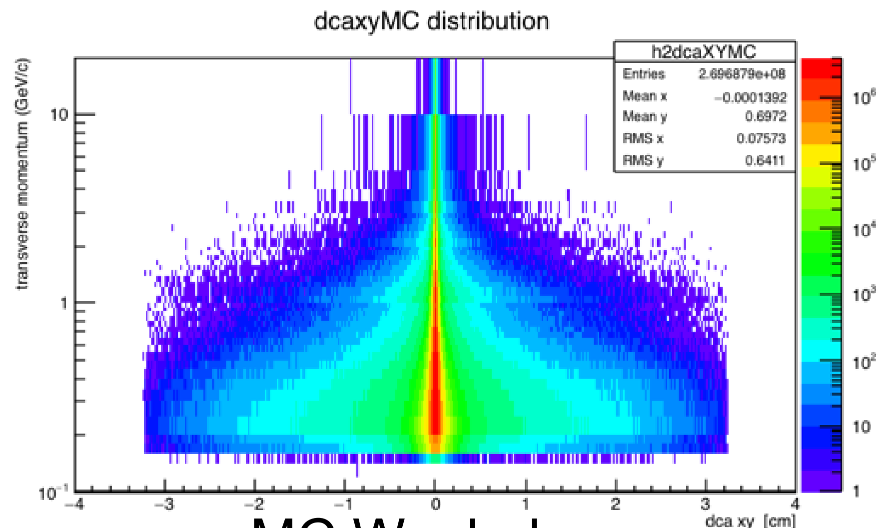
New: feed down correction and particle composition

DCA xy distributions, this was done with Data LHC15fpass2 & MC Pythia Per2011.   Also for each multiplicity and So bins.

All data

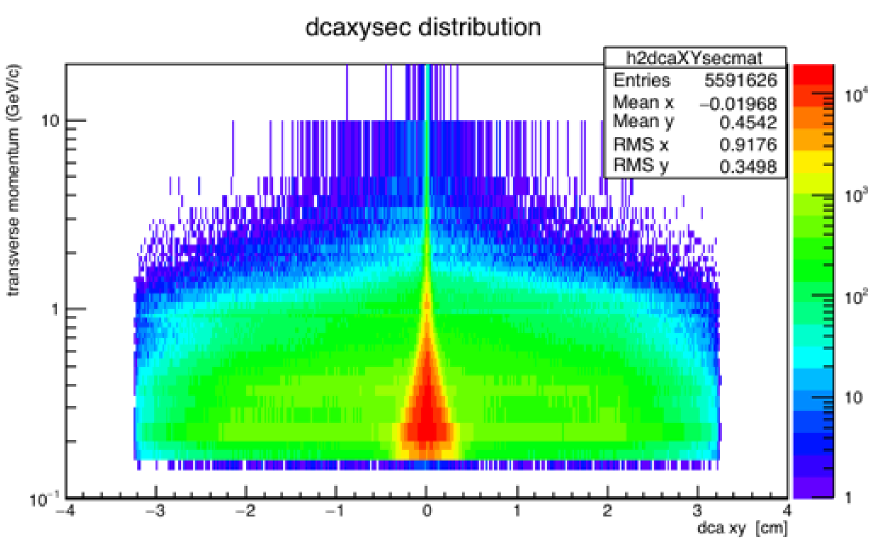
Primaries MC

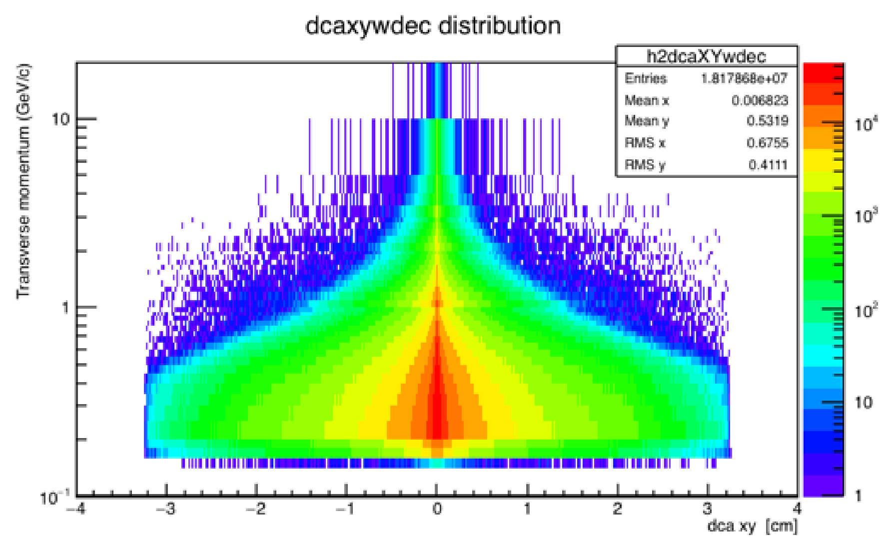




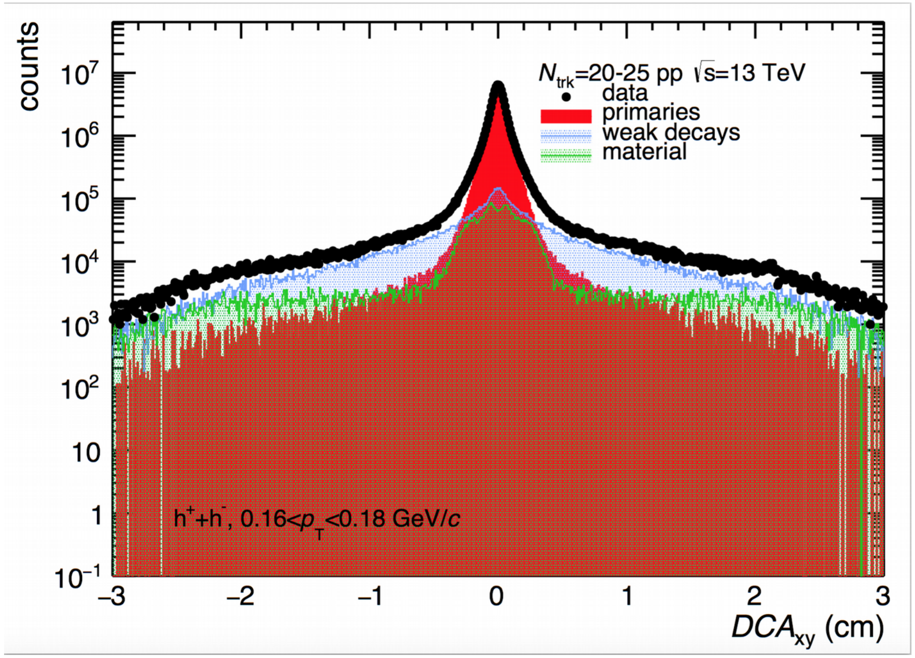
- MC Sec material

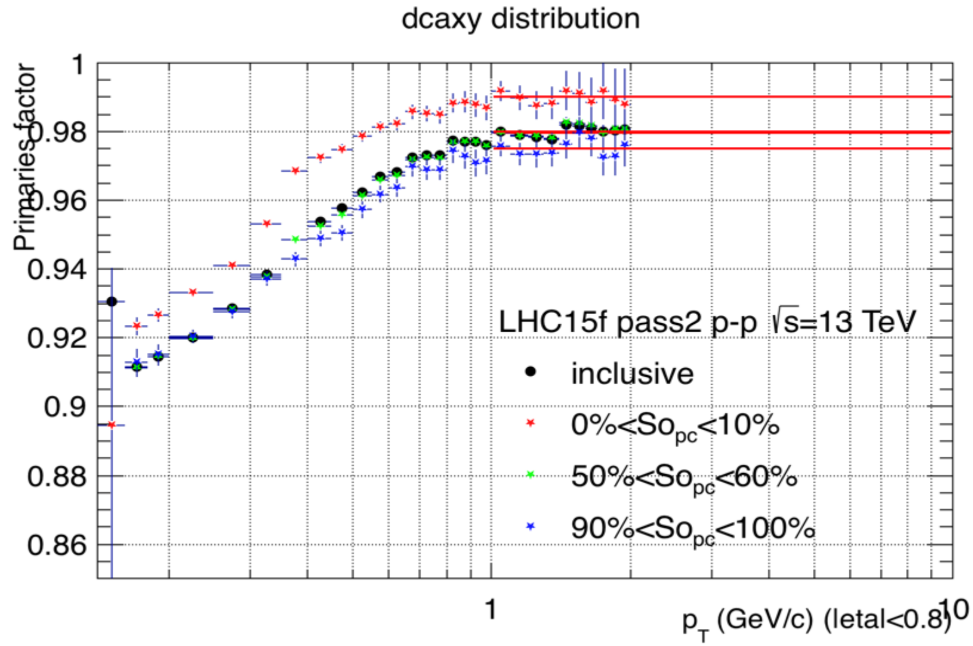
MC Weak decays





- DCA fit and factor of number of primaries

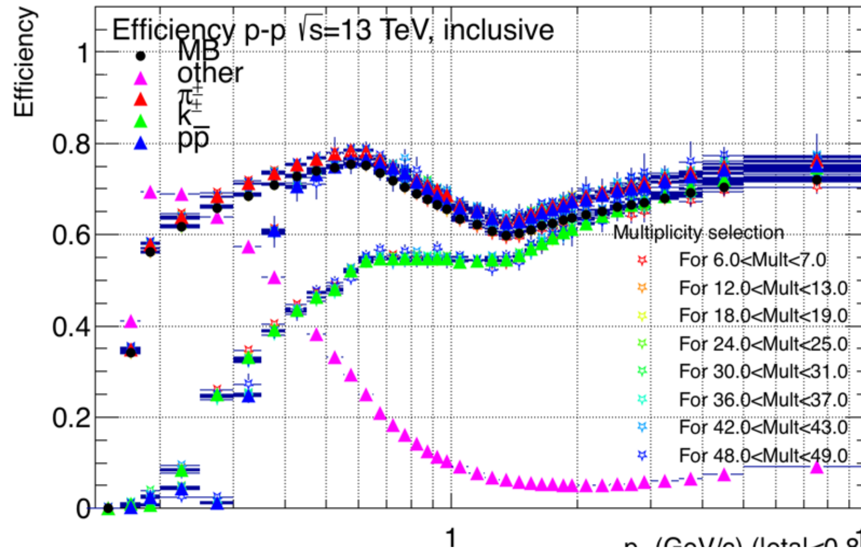




$$DCA_{\mathrm{XY}}^{\mathrm{Data}} = \alpha \cdot DCA_{\mathrm{XYsec-matl}}^{\mathrm{MC}} + \beta \cdot DCA_{\mathrm{XYsec-decays}}^{\mathrm{MC}} + \gamma \cdot DCA_{\mathrm{XYprim}}^{\mathrm{MC}}$$

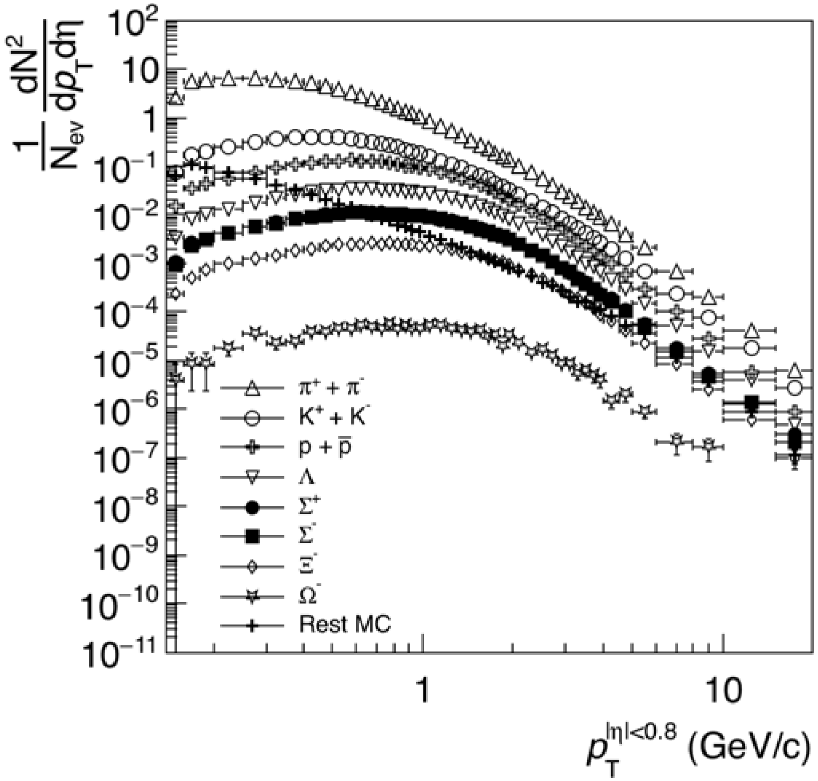
Particle composition

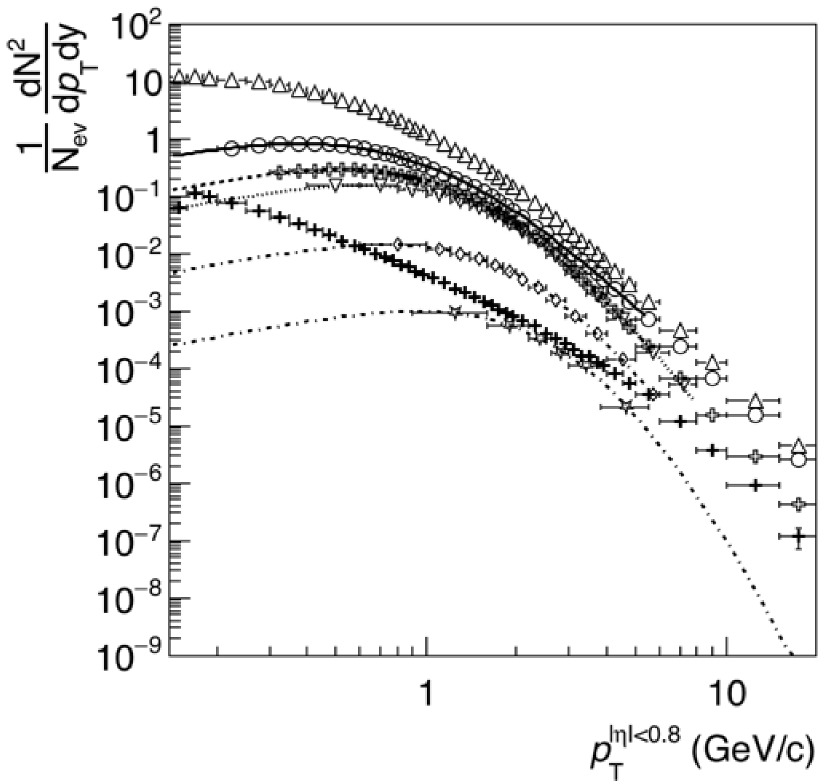
- Efficiency by particle composition



$$\epsilon_{\mathrm{PartComp}} = \frac{\sum_i \epsilon^i_{MC} \cdot (dN/dp_{\mathrm{T}})^i + \epsilon^{RestMC}_{MC} \cdot (dN/dp_{\mathrm{T}})^{RestMC}}{\sum_i (dN/dp_{\mathrm{T}})^i + (dN/dp_{\mathrm{T}})^{RestMC}}$$

- Using spectra MC for 7Tev (left) and data extrapolation at 7TeV(right) (composition not depends on Energy)

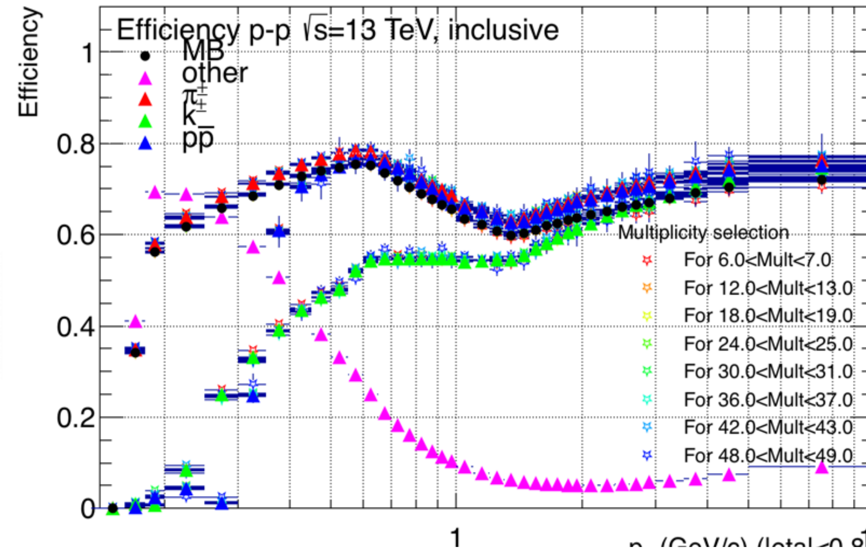




Particle composition

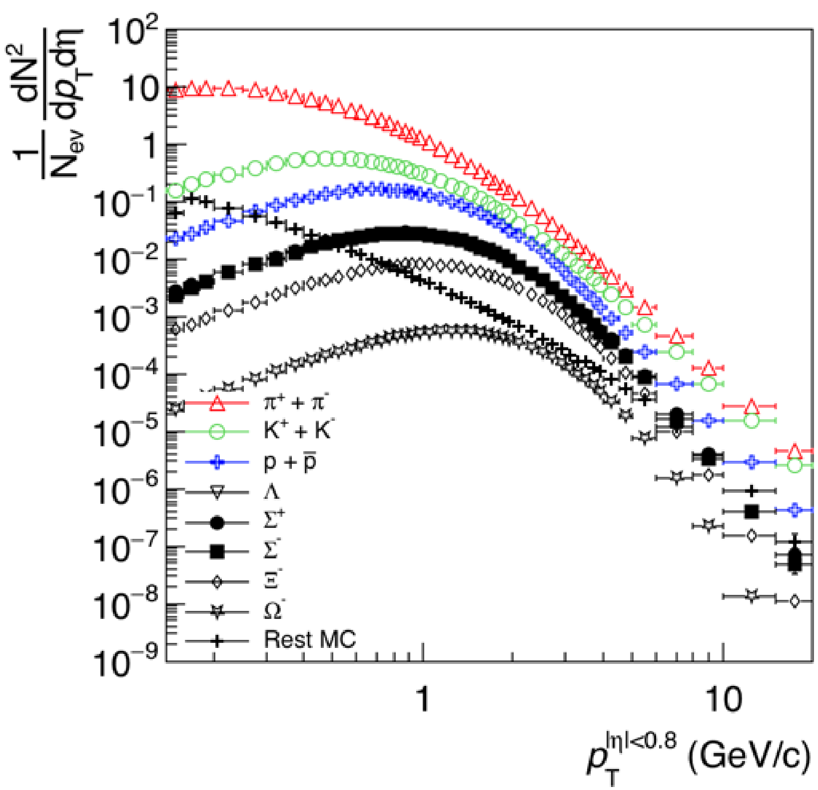
- Efficiency by particle composition
-

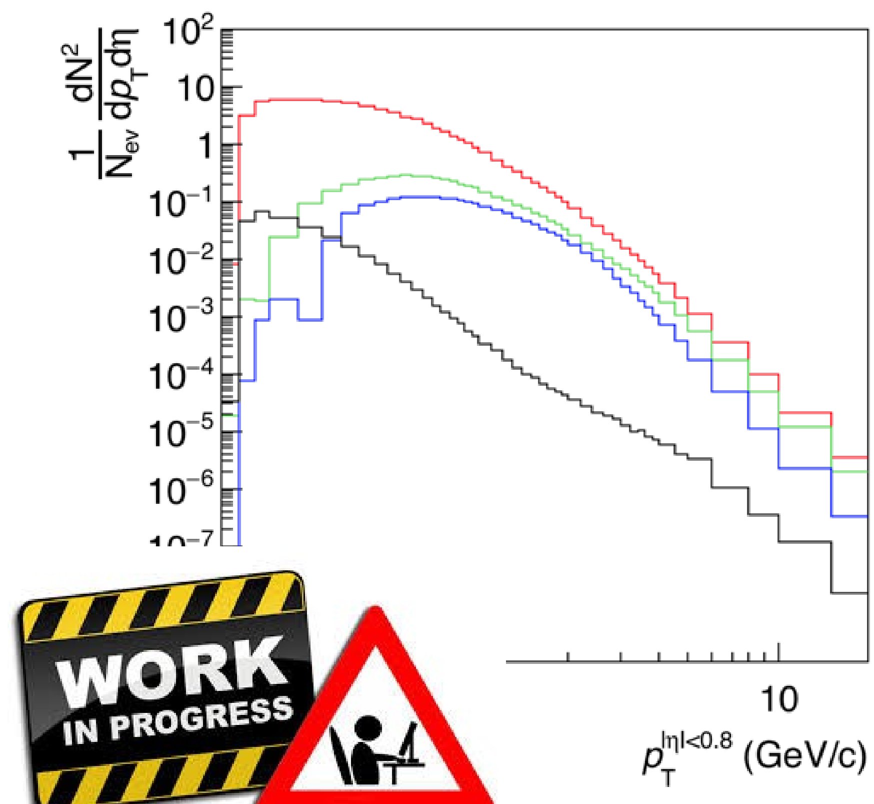
$$\epsilon_{\mathrm{PartComp}} = \frac{\sum_i \epsilon^i_{MC} \cdot (dN/dp_{\mathrm{T}})^i + \epsilon^{RestMC}_{MC} \cdot (dN/dp_{\mathrm{T}})^{RestMC}}{\sum_i (dN/dp_{\mathrm{T}})^i + (dN/dp_{\mathrm{T}})^{RestMC}}$$



- Extrapolated spectra (left)

multiplication by efficiency (right)





Conclusions

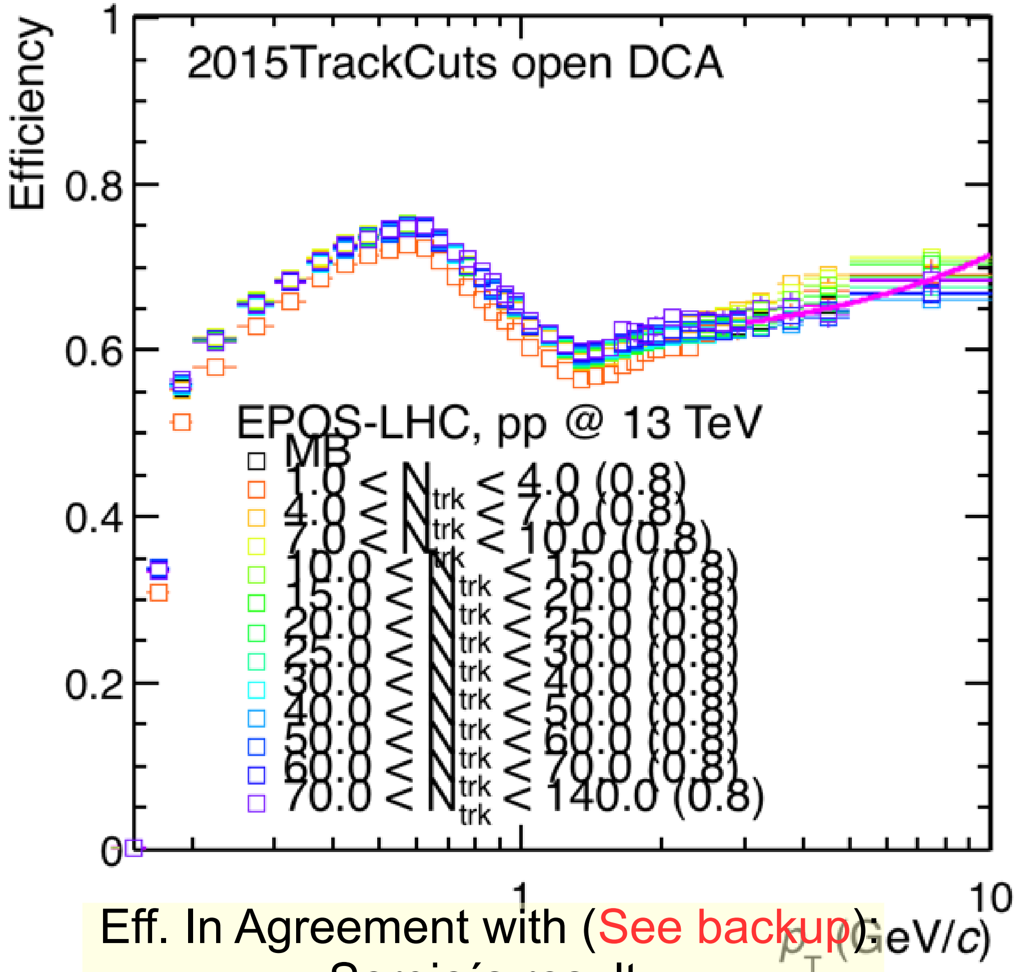
- $\langle p_T \rangle$ vs N_{ch} in spherocity percentile bins is measured and fully corrected
- Closure test within 7% for inclusive and jetty events, 4% for isot.
- For the corrected $\langle p_T \rangle$ vs N_{ch}, deviations from the model (MC) were observed.

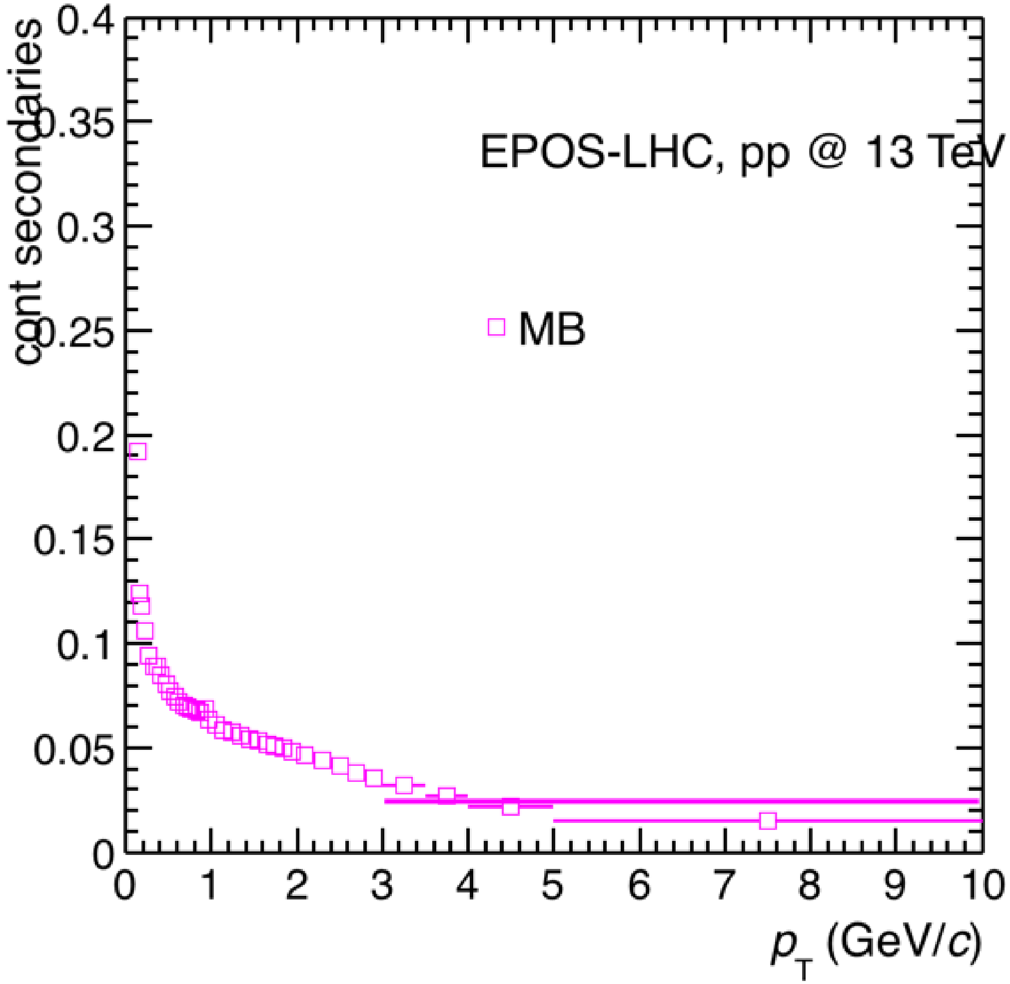
Ongoing

- Apply feed-down correction, using particle composition we spect a very small modification
- Systematic calculation

Backup

- Efficiency & secondaries EPOS-LHC(LHC16d3)

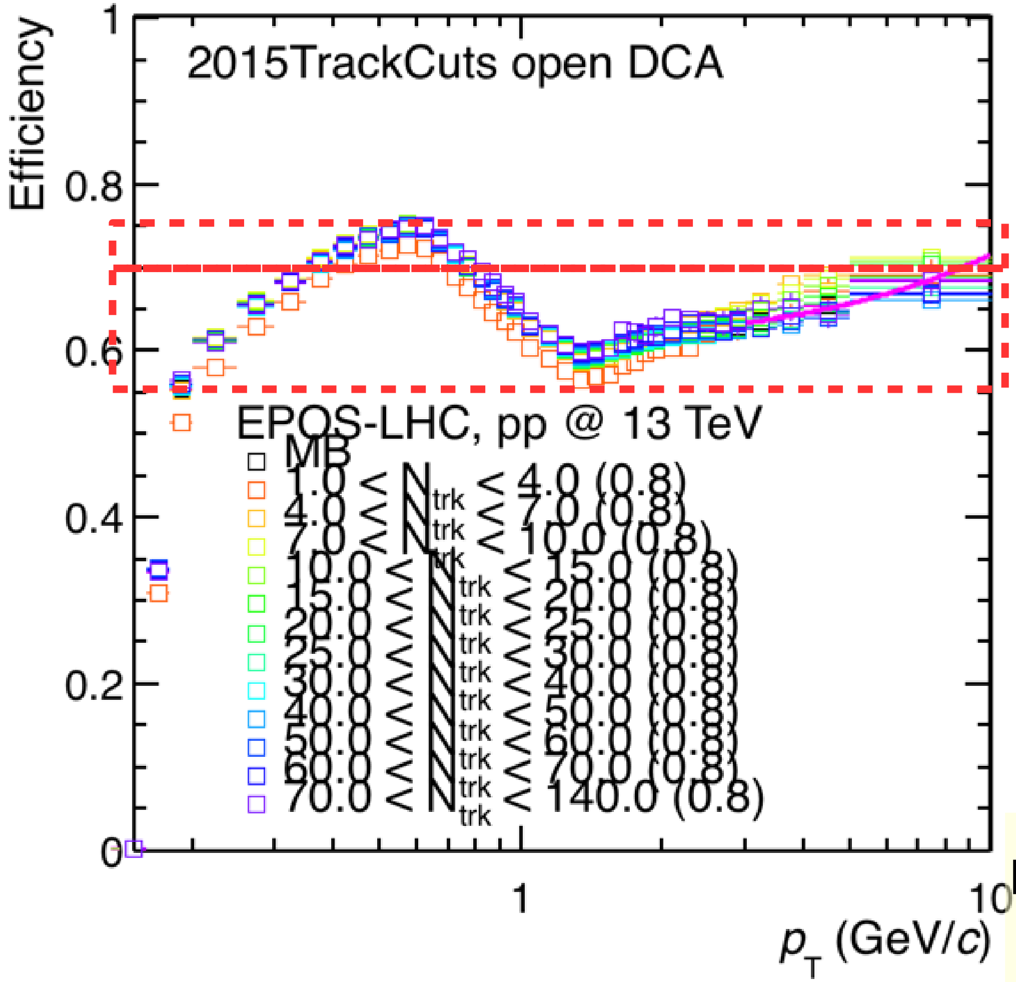


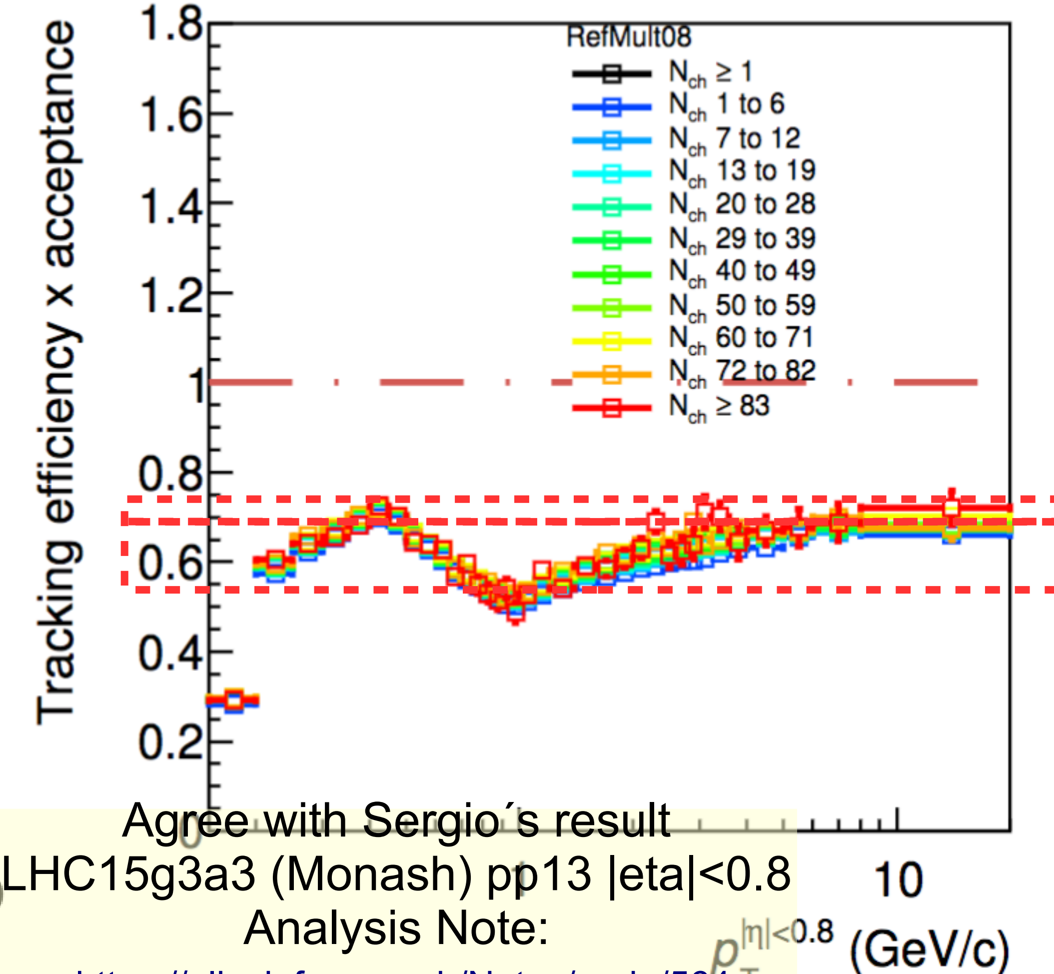


Eff. In Agreement with (See backup):
Sergio´s result
LHC15g3a3 (Monash) pp13 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/564
Edgar´s result
LHC15l1b2 (Per11) pp5.02 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/472

For the secondaries only a test with MC has done
For data a more elaborated analisys must be done
(particle composition, feed-down corrections …)
like GSI analysis for inclusive $<p_T>$ vs N_{ch}

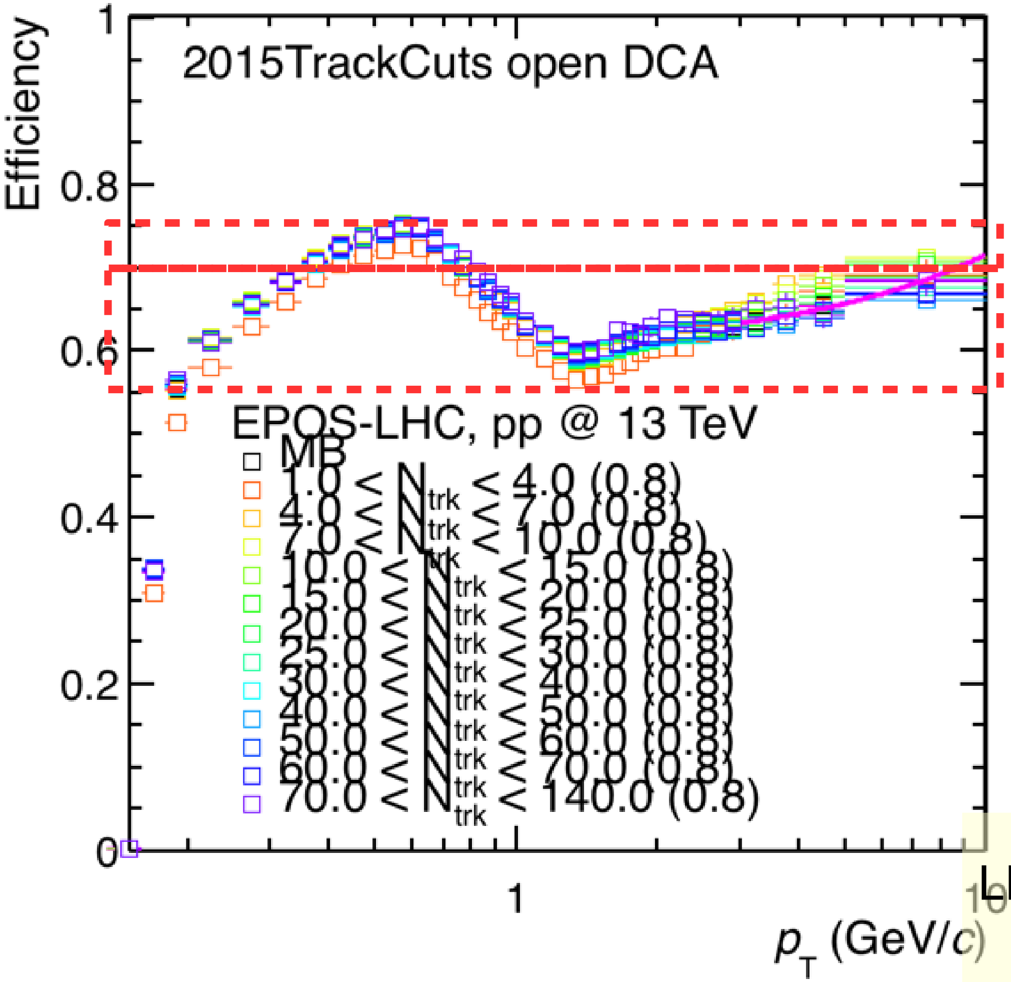
- Efficiency & secondaries EPOS-LHC(LHC16d3)

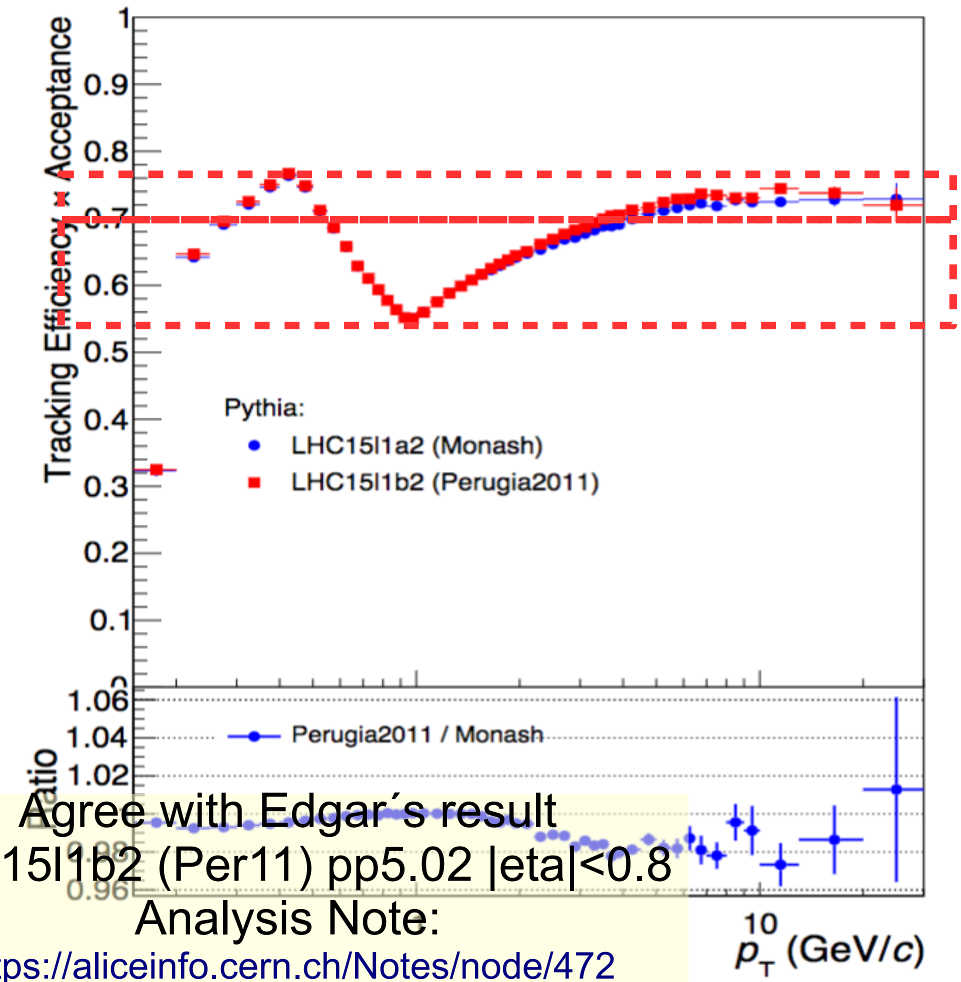




Agree with Sergio´s result
LHC15g3a3 (Monash) pp13 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/564

- Efficiency & secondaries EPOS-LHC(LHC16d3)

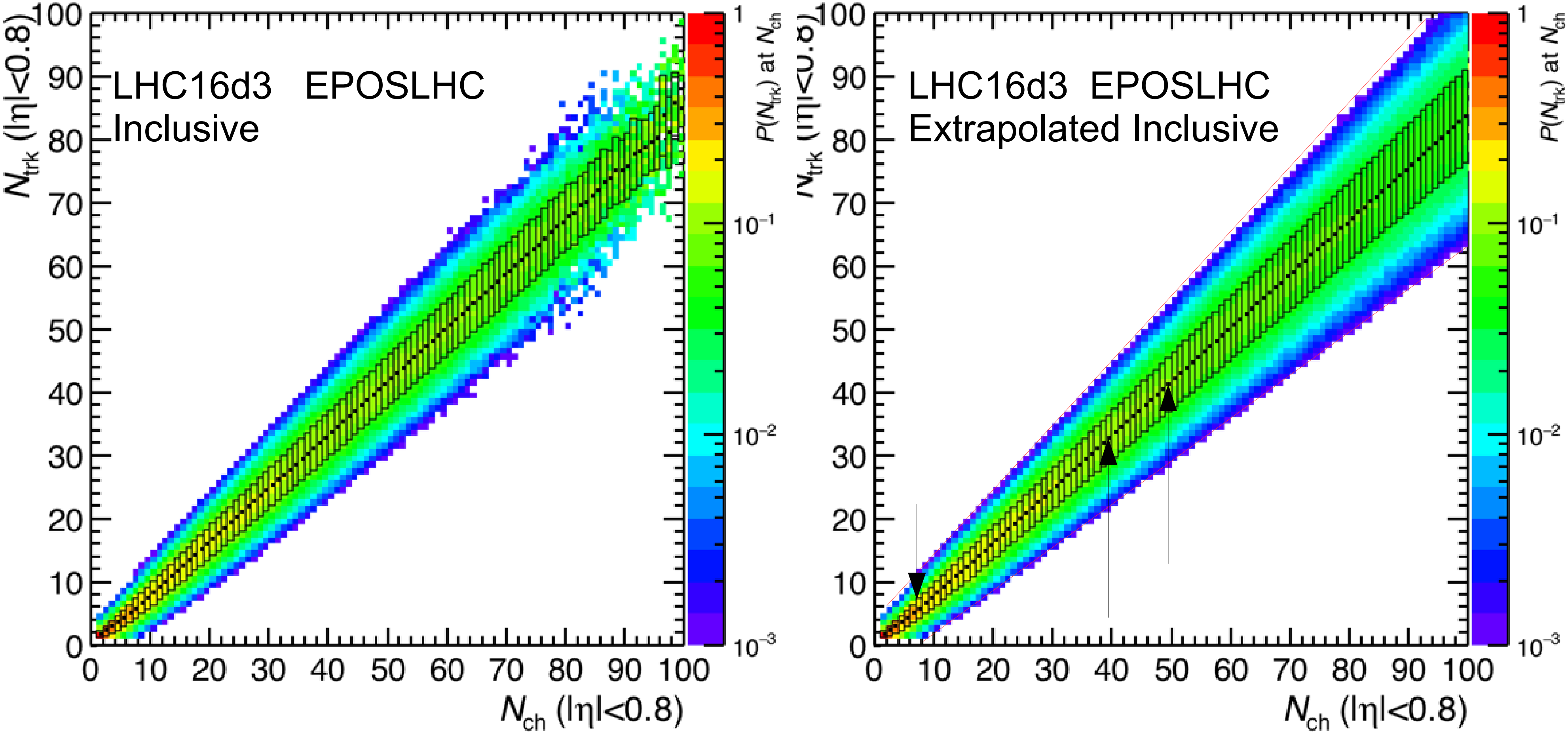




Agree with Edgar´s result
LHC15l1b2 (Per11) pp5.02 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/472

- N_{ch} response matrix to correct by Multiplicity

Not extrapolated | Extrapolated



- N_{ch} response matrix to correct by Multiplicity

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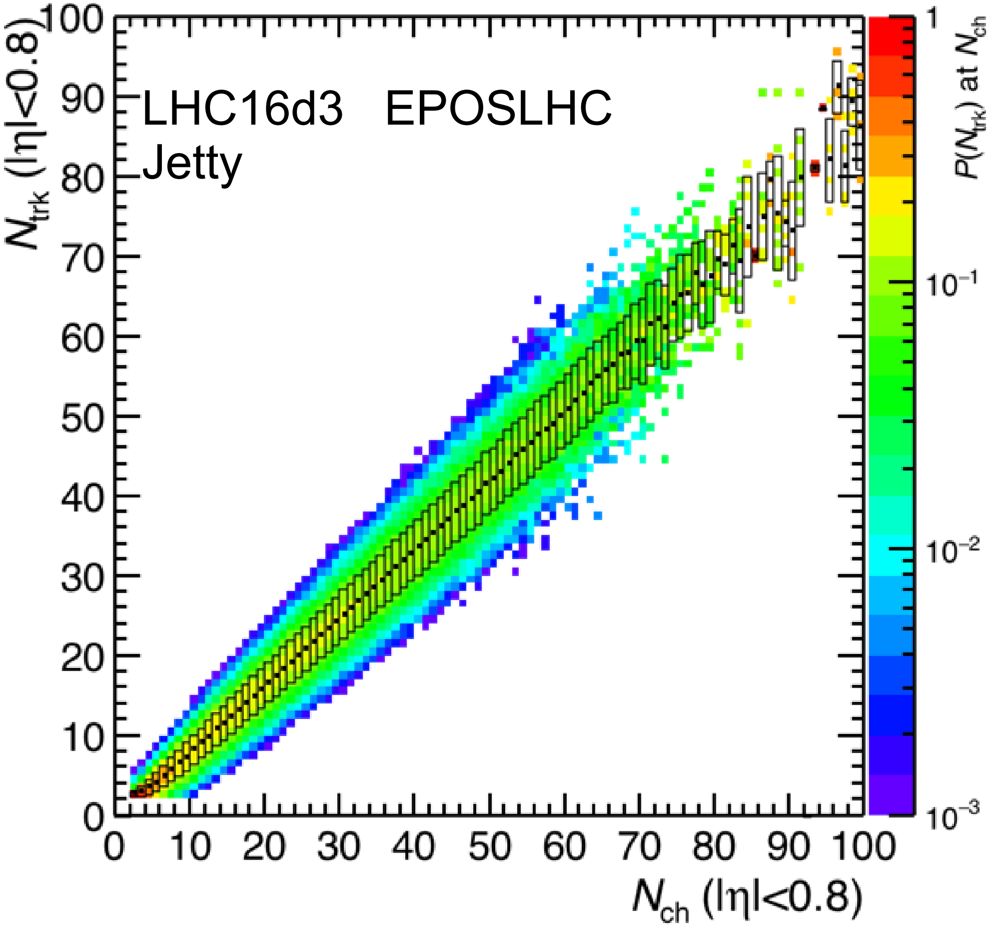
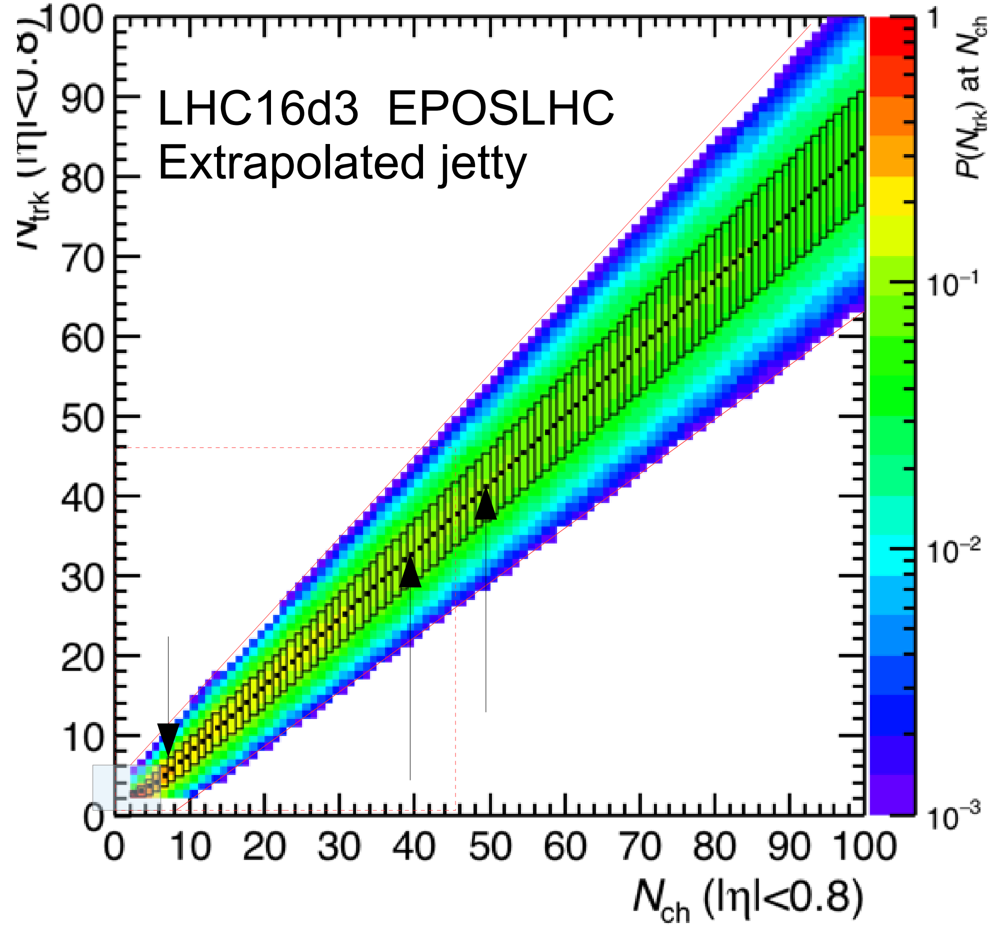
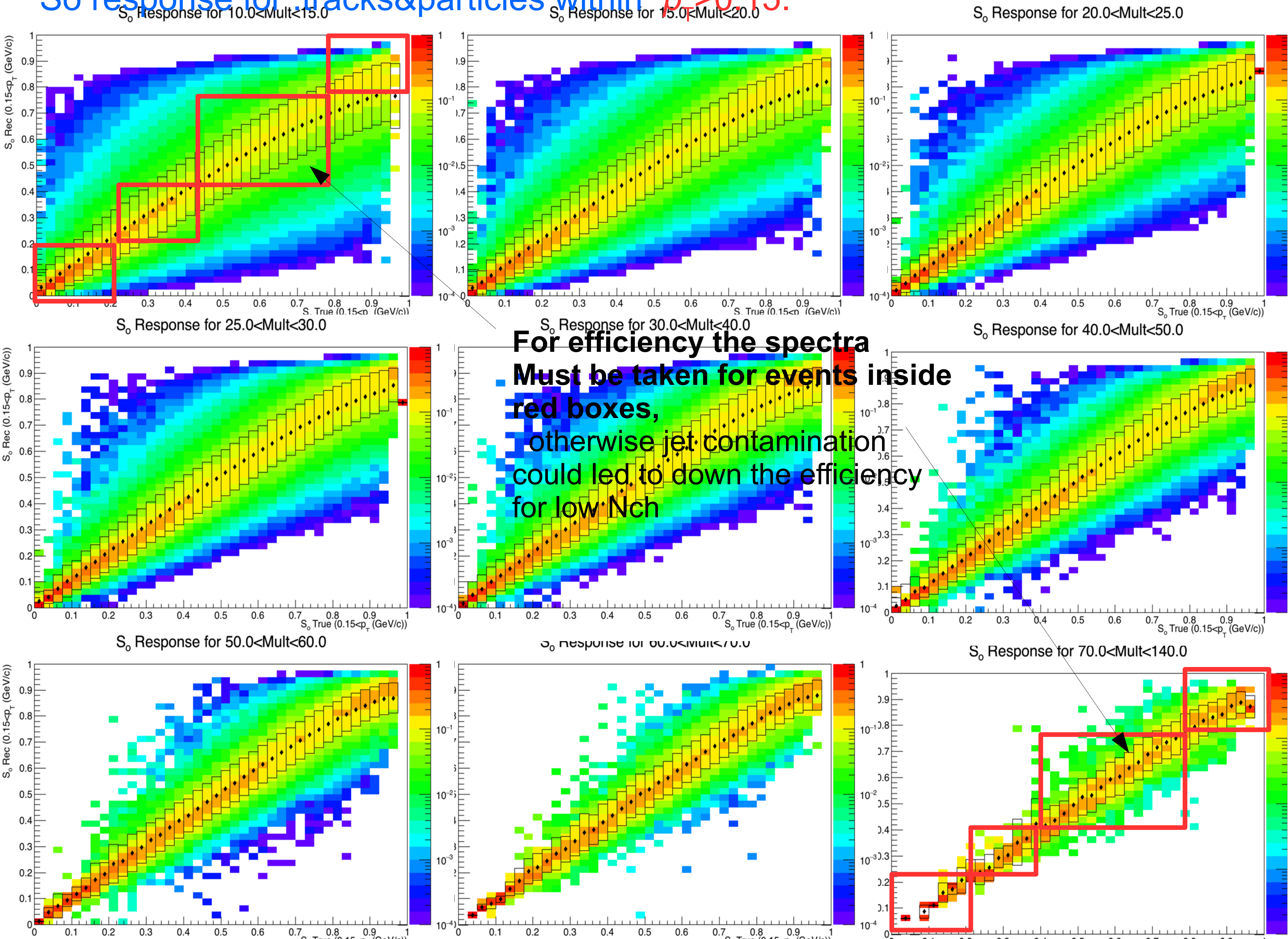


Extrapolated



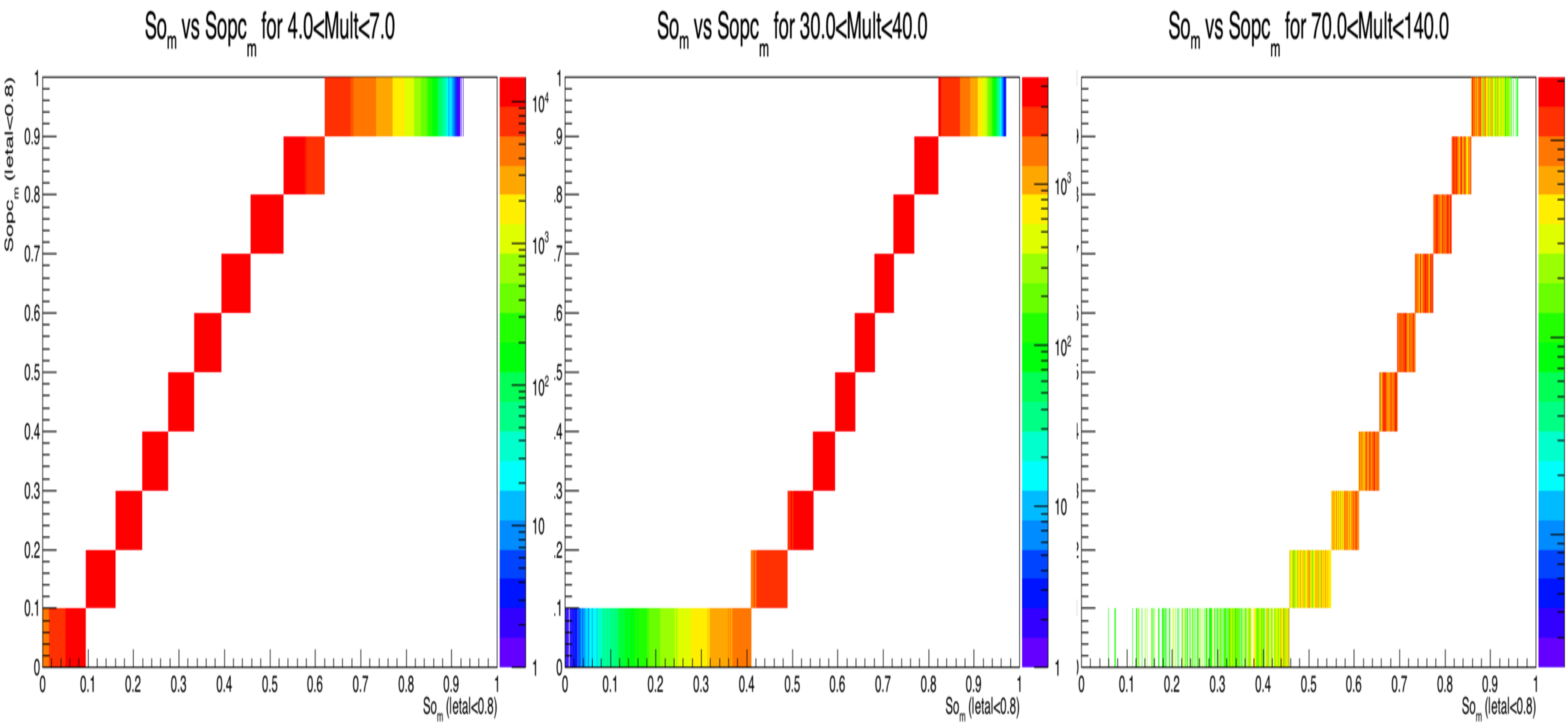
So response for tracks&particles within p_T>0.15.



For efficiency the spectra Must be taken for events inside red boxes,
otherwise jet contamination could led to down the efficiency for low Nch

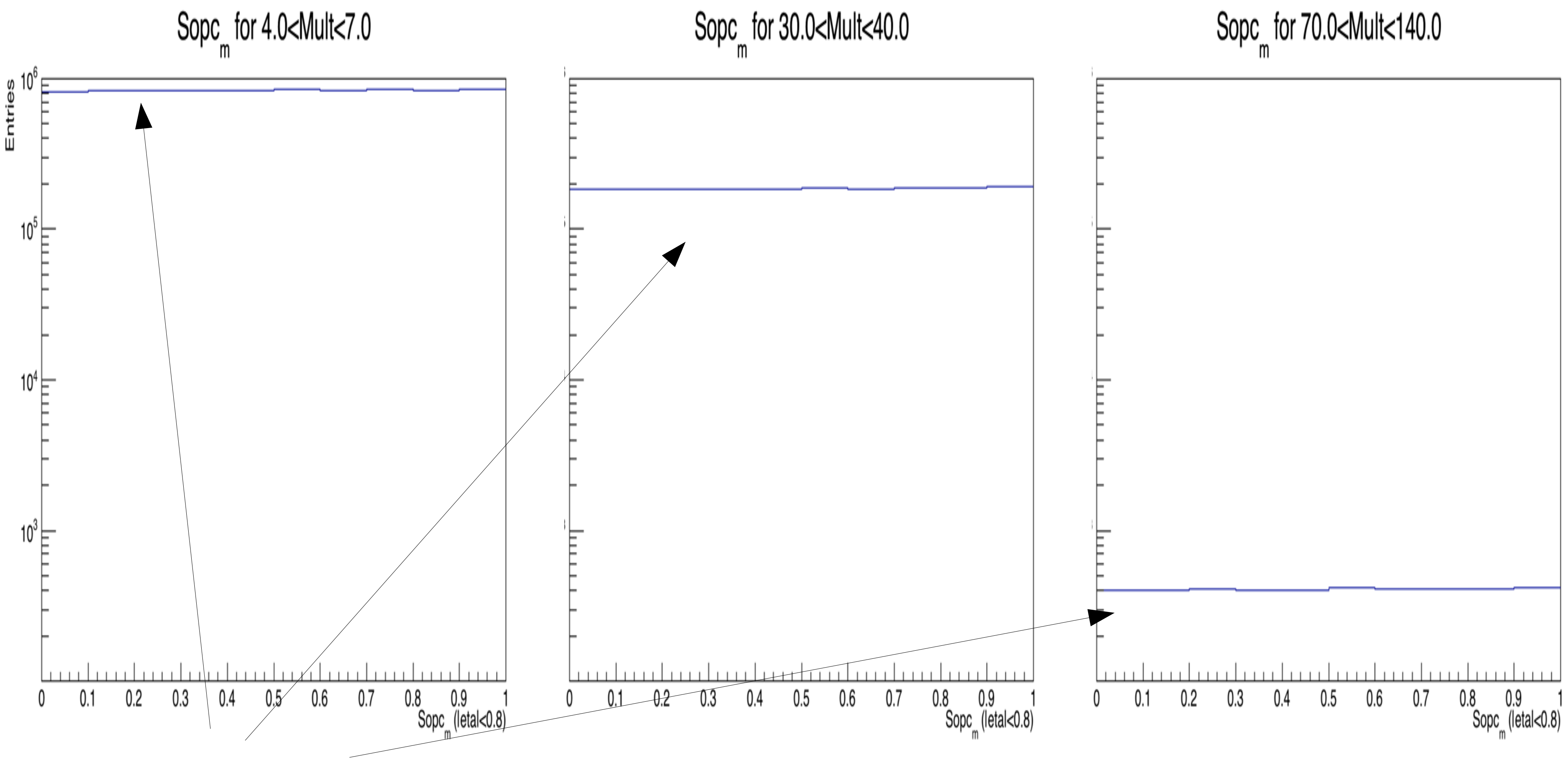
So response (som vs somperc) To GET the Intervals in data for percentiles

- The idea: to get Soperc response matrix (Sopc_t vs Sopc_m)



So response (som vs somperc)

- The idea: to get Soperc response matrix (Sopc_t vs Sopc_m)

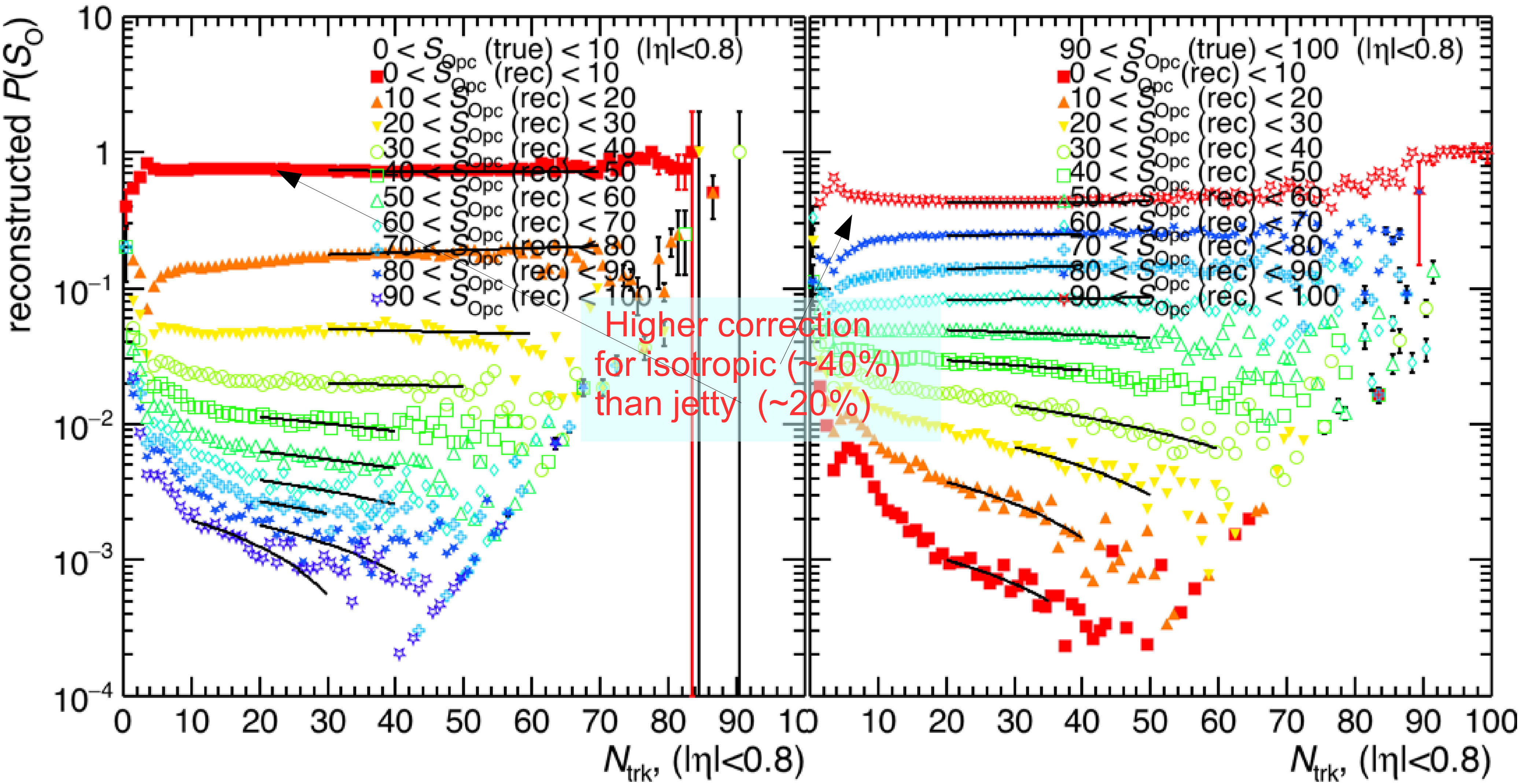


All entries to 10% of Sopc are of the same order

For So UNFOLD Probability of rec So vs Nch_measured for true So percentiles

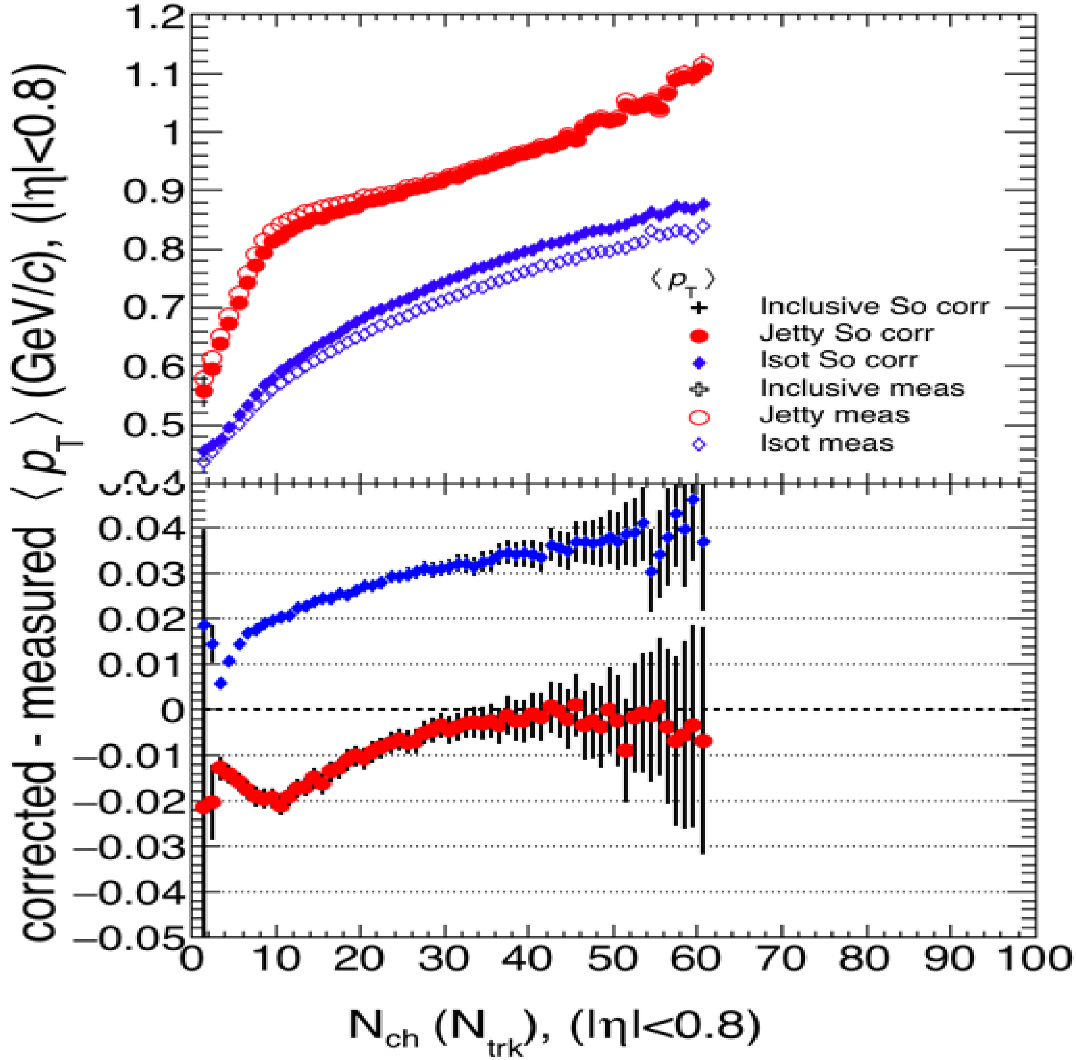
Using EPOS-LHC

$$\langle p_T \rangle (S_O^{corrected_i}) = \sum_{j=1}^{5} \langle p_T \rangle (S_O^{measured_j}) P(S_O^{measured_j})_{at\, S_O^{true_i}}$$

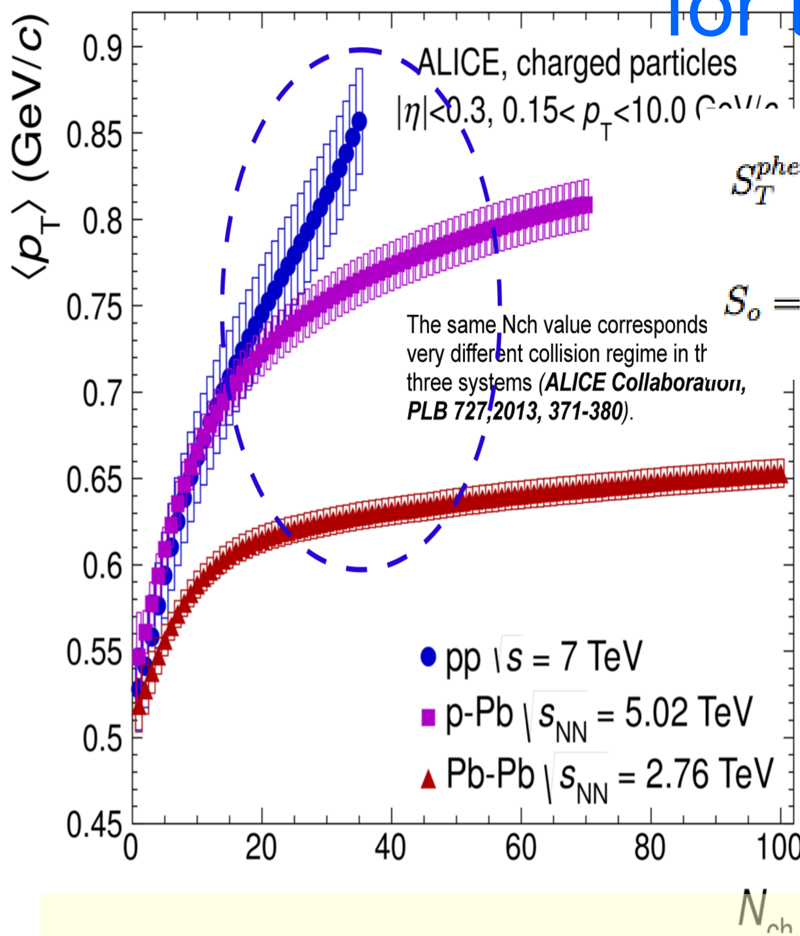


For So UNFOLD Probability of rec So vs Nch_measured for true So percentiles Using EPOS-LHC

$$\langle p_T \rangle (S_O^{corrected_i}) = \sum_{j=1}^{5} \boxed{\langle p_T \rangle (S_O^{measured_j})} P(S_O^{measured_j})_{at\, S_O^{true_i}}$$



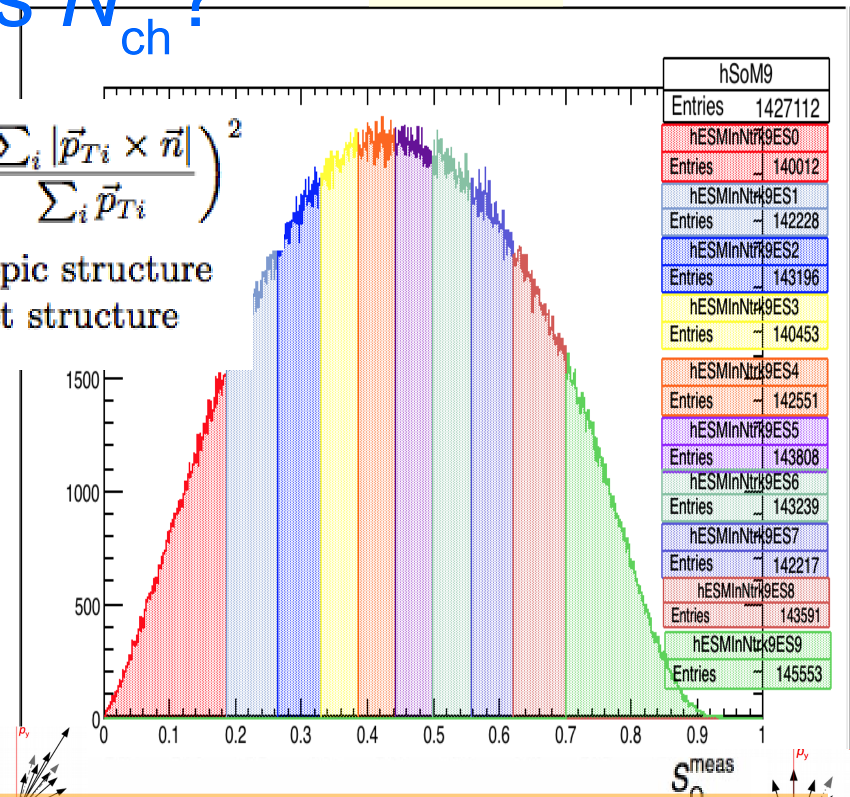
- Why a So analysis with N_{ch} bin=1 and So percentil for the $<p_T>$ vs N_{ch}?

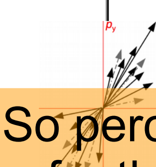


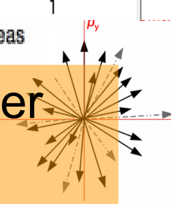
$$S_T^{pherocity} = \frac{\pi^2}{4} \min_{\vec{n}=(n_x,n_y,0)} \left(\frac{\sum_i |\vec{p}_{Ti} \times \vec{n}|}{\sum_i \vec{p}_{Ti}} \right)^2$$

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

N_{ch}=9







Using N_{ch} bining of size 1 will allow us to see the first and second rise

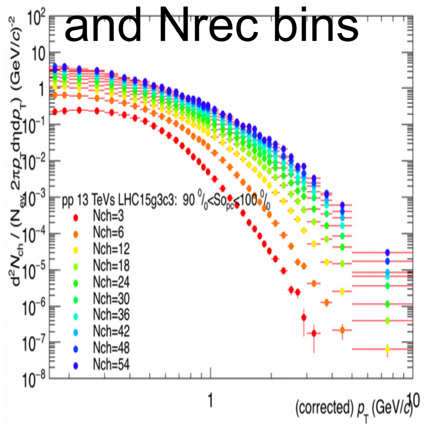
A study with So could help to understand this behaviour

Taking So percentiles as binning give us better statistics for the event shape selection
These are build in percentages of the P(So) distribution

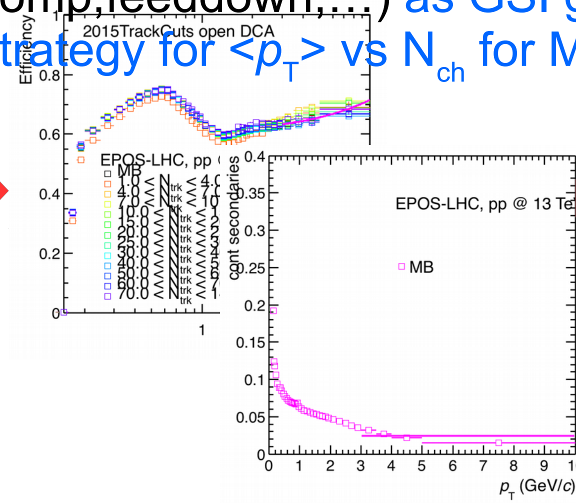
For 13 TeV some results shown don't consider the So percentil binning
https://indico.cern.ch/event/477734/
https://indico.cern.ch/event/437981/

Strategy in MC and data

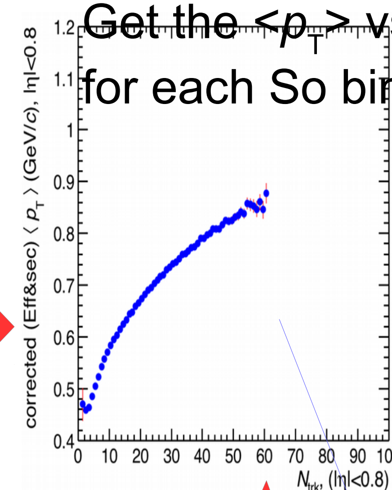
Get spectra in So and Nrec bins



Make corrections to spectra: efficiency, secondaries (particle comp,feeddown,…) as GSI group strategy for $\langle p_T \rangle$ vs N_{ch} for MB

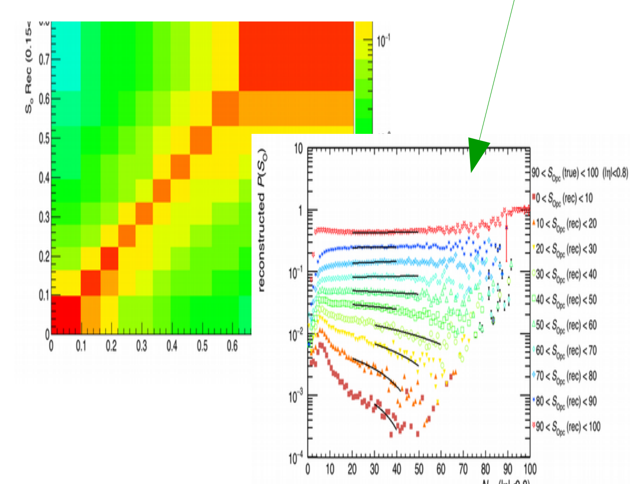


Get the $\langle p_T \rangle$ vs N_{rec} for each So bin



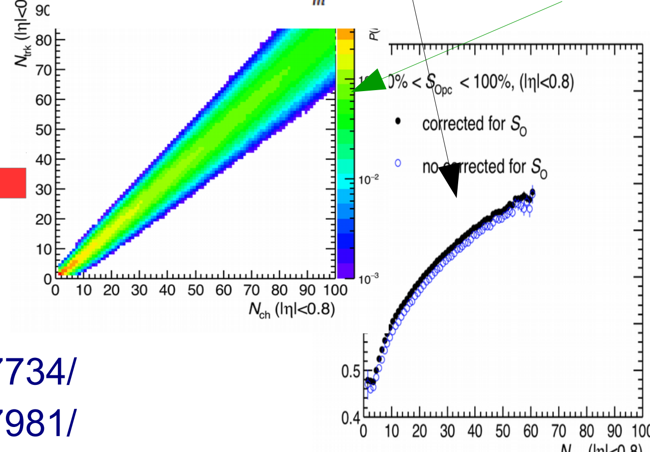
Unfold by Spherocity

$$\langle p_T\rangle(S_O^{corrected_i})=\sum_{j=1}^{5}\langle p_T\rangle(S_O^{measured_j})\,P(S_O^{measured_j})_{at\,S_O^{true_i}}$$

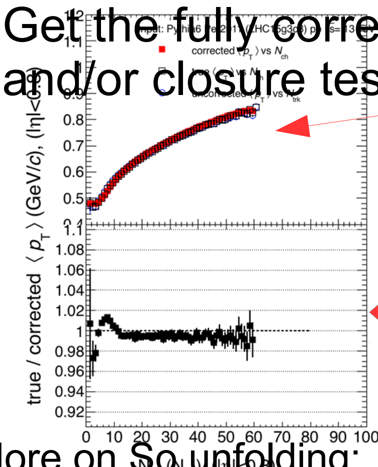


Unfold by Multiplicity

$$\langle p_T\rangle(N_{ch},S_O^{corrected_i})=\sum_{m}\langle p_T\rangle(N_m,S_O^{corrected_i})\times R(N_t,N_m)$$



Get the fully corrected and/or closure test



More on So unfolding:

- https://indico.cern.ch/event/477734/
- https://indico.cern.ch/event/437981/
- https://indico.cern.ch/event/339550
- https://indico.cern.ch/event/325445
- https://indico.cern.ch/event/356335/

Hèctor Bello Martinez

Back Up