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$\langle p_T \rangle$ vs N_{ch} with spherocity percentile cuts

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ACO meeting

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Brief summary

Goal: $<p_T>$ vs N_{ch} for charged particles in spherocity bins

- Strategy for corrections
- Analysis update

  MC closure test

  Data LHC15f pass2

Strategy in MC and Data

- Get the p_T spectra for each N_{rec} bin and So bin.
- Make all the corrections: efficiency, secondaries, etc.
- Get the $\langle p_T \rangle$ vs N_{rec} in bins of So.
- Unfold by Spherocity
- Unfold by multiplicity
- Get the closure test and/or the fully corrected $\langle p_T \rangle$ vs N_{ch}. In So bins

Analysis update

- Why a So analysis in N_{ch}bin=1 and So percentil?
- $<p_T>$ in So percentile bins corrected by eff. & sec.

  Pythia Perugia 2011(LHC15g3c3)with EPOS-LHC (LHC16d3)

- Response normalized for So_{med} vs So_{true} for EPOS

  in So bins size = 10% perc and N_{ch} bin size=1.

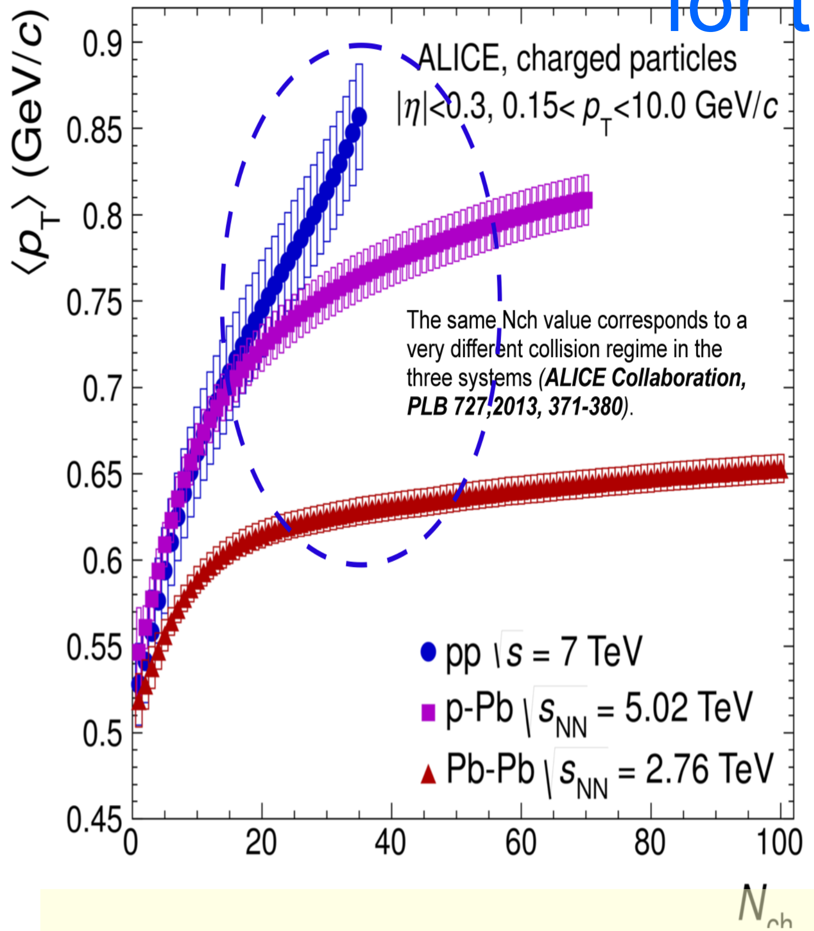
- Spherocity unfolding procedure and closure test

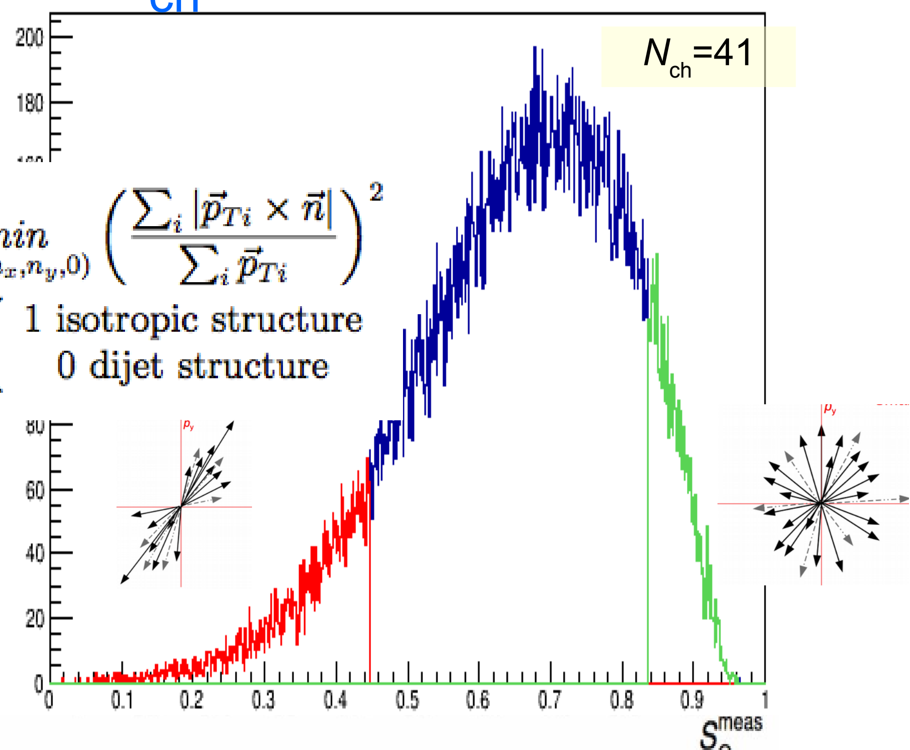
  $<p_T>$ vs N_{ch} in So percentile bins

- $<p_T>$ in So percentile bins unfolded

  Data (LHC15f pass2)

- # Why a So analysis with N_{ch} bin=1 and So percentil for the $\langle p_T \rangle$ vs N_{ch}?





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

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

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/

Analysis details

- **Datasets**

  Pythia Per2011 (LHC15g3c3) (36.1 M events after sel)

  EPOS-LHC (LHC16d3) (39.7 M events after sel)

  Data (LHC15f pass2) (27.2 M events after sel)
- **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. Three set of cuts were tested:

  TPC: GetStandardTPCOnlyTrackCuts()+TPCrefit

  Hybrid: CreateTrackCutsPWGJE(10001008)+CreateTrackCutsPWGJE(10011008)

  Standard: GetStandardITSTPCTrackCuts2011(kTRUE,1)
- At the end we decided to use the TPC track cuts (global tracks wich satisfy 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

  GetReferenceMultiplicity(fESD,AliESDtrackCuts::kTrackletsITSTPC,0.8)
- We use the recommended vertex selection for 13 TeV pp analysis:

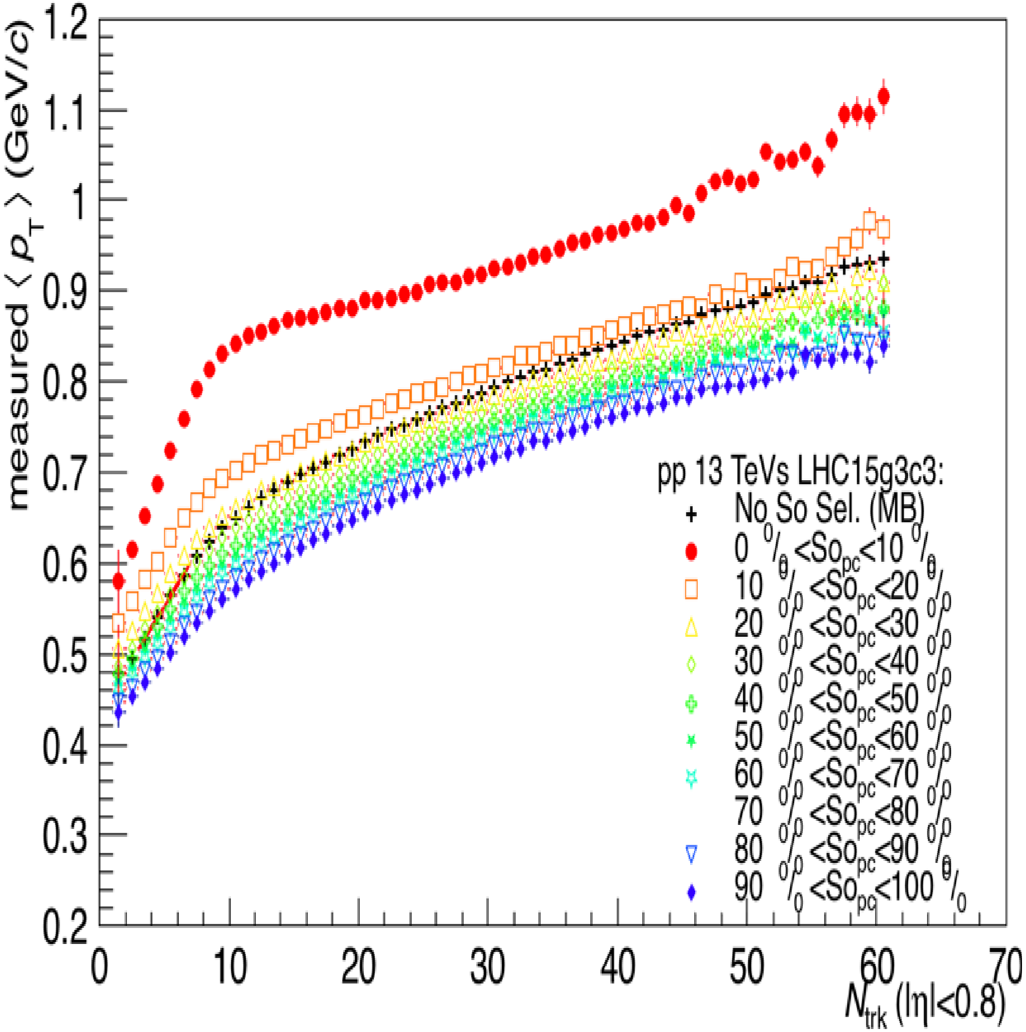
  https://twiki.cern.ch/twiki/bin/view/ALICE/PWGPPEvSelRun2pp

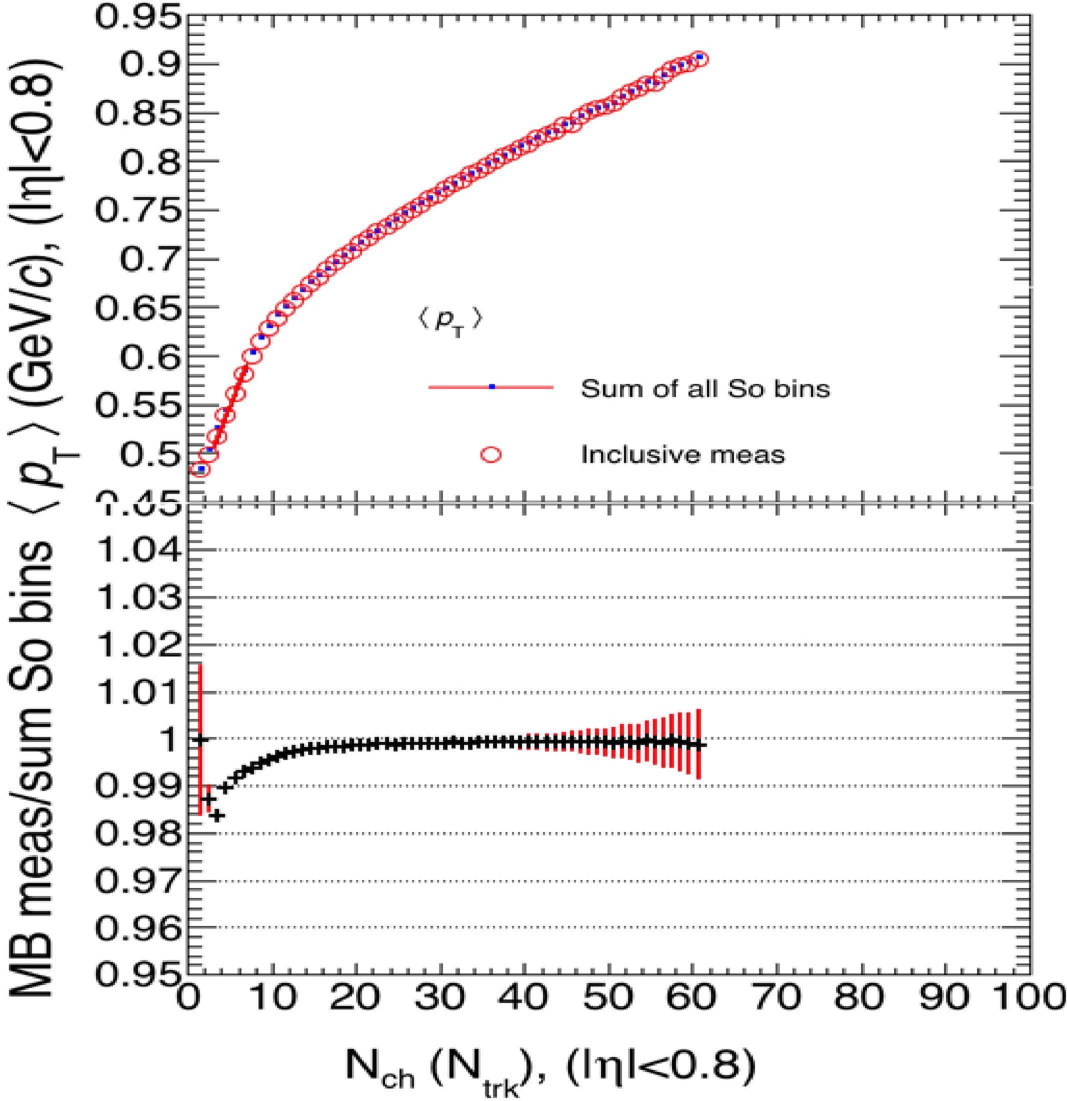
Analysis Update

MC closure test

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

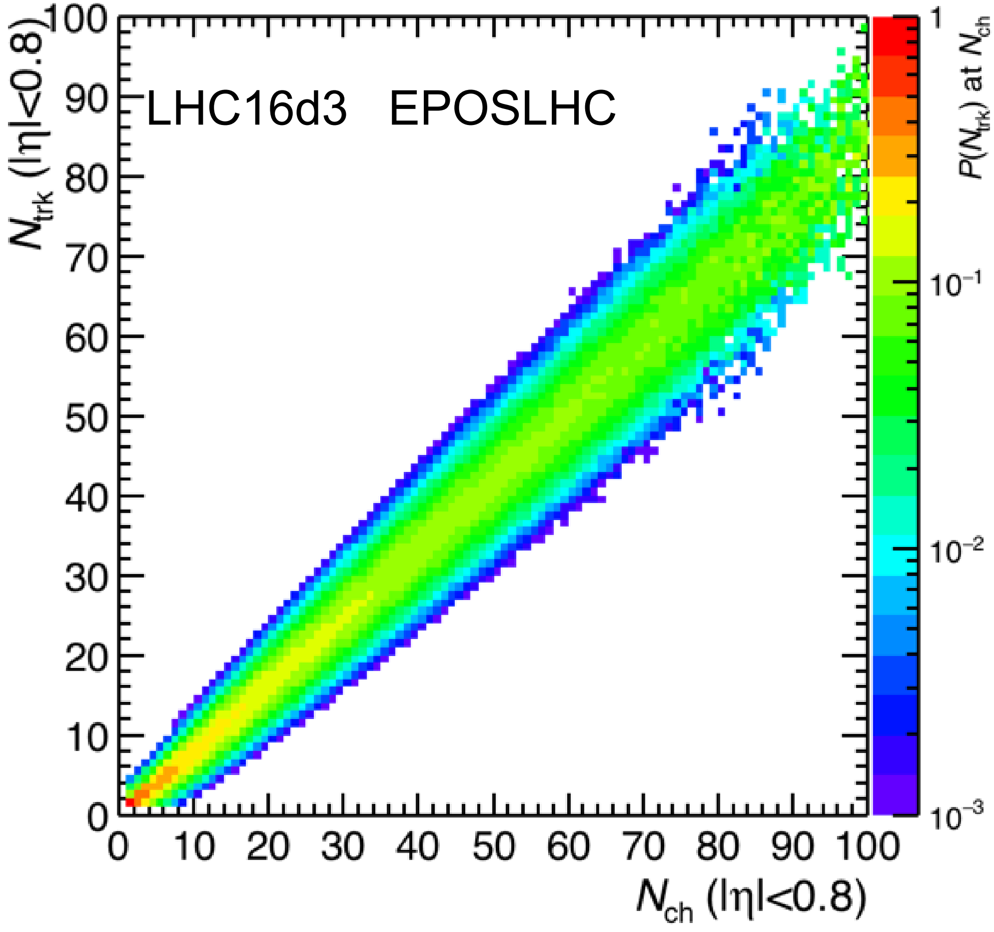
Pythia Per2011 (LHC15g3c3) as data.





- N_{ch} response matrix to correct by Multiplicity

Not extrapolated



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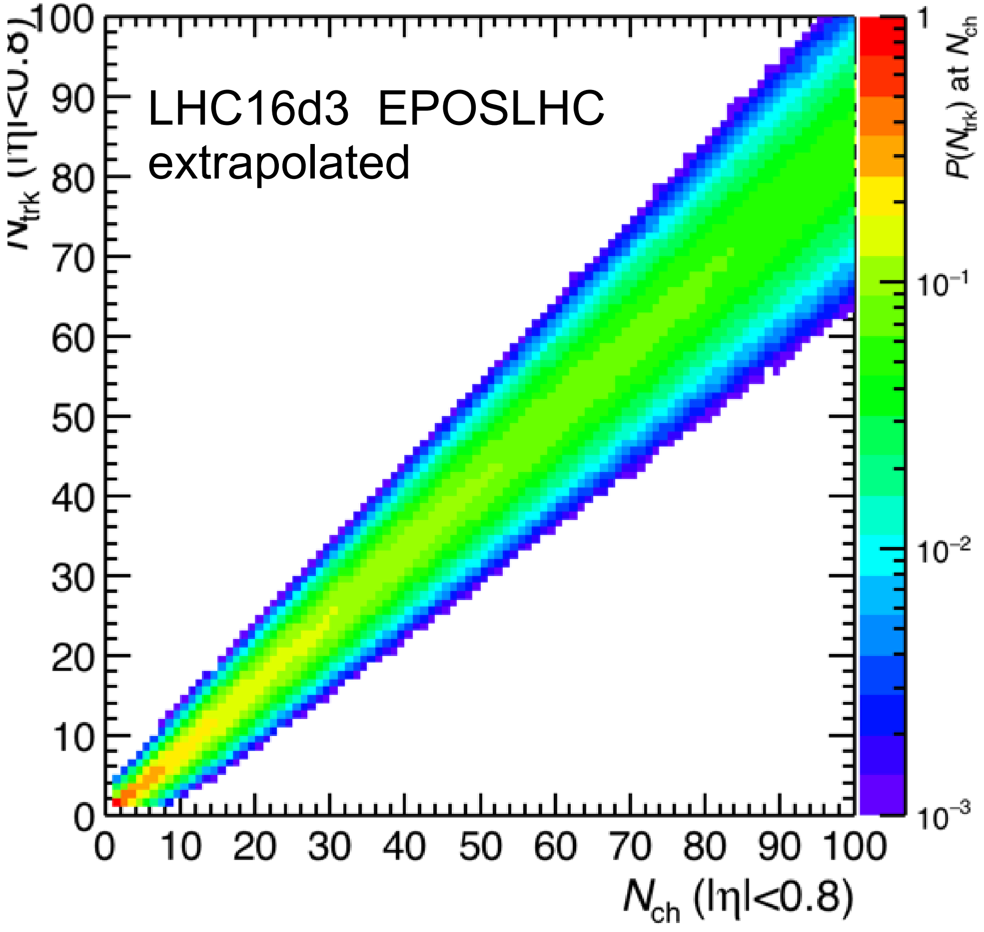
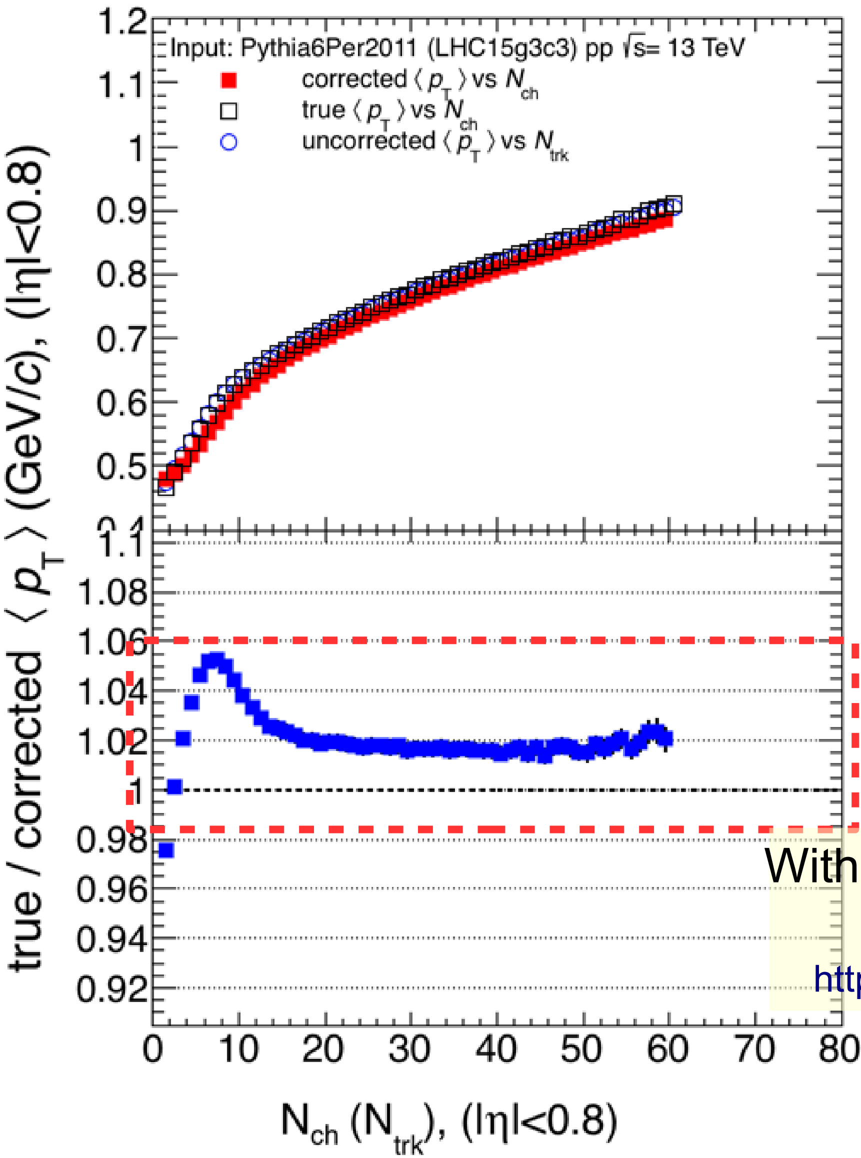


We will use EPOS-LHC fo the correction

Inclusive <p_T> vs N_{ch} Unfolded (corr. by N_{ch})and closure test.

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



For multiplicity correction we based on:

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

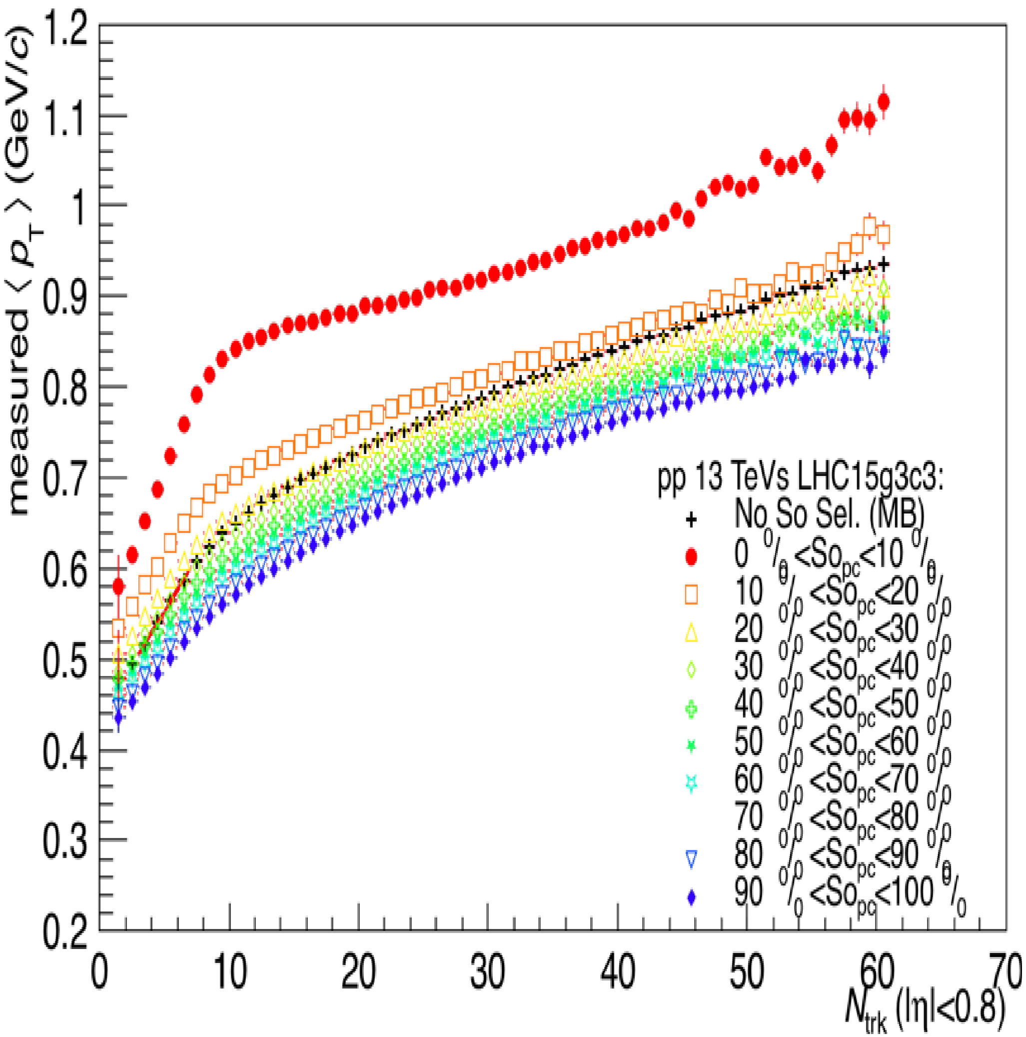
where, R is the multiplicity response matrix.

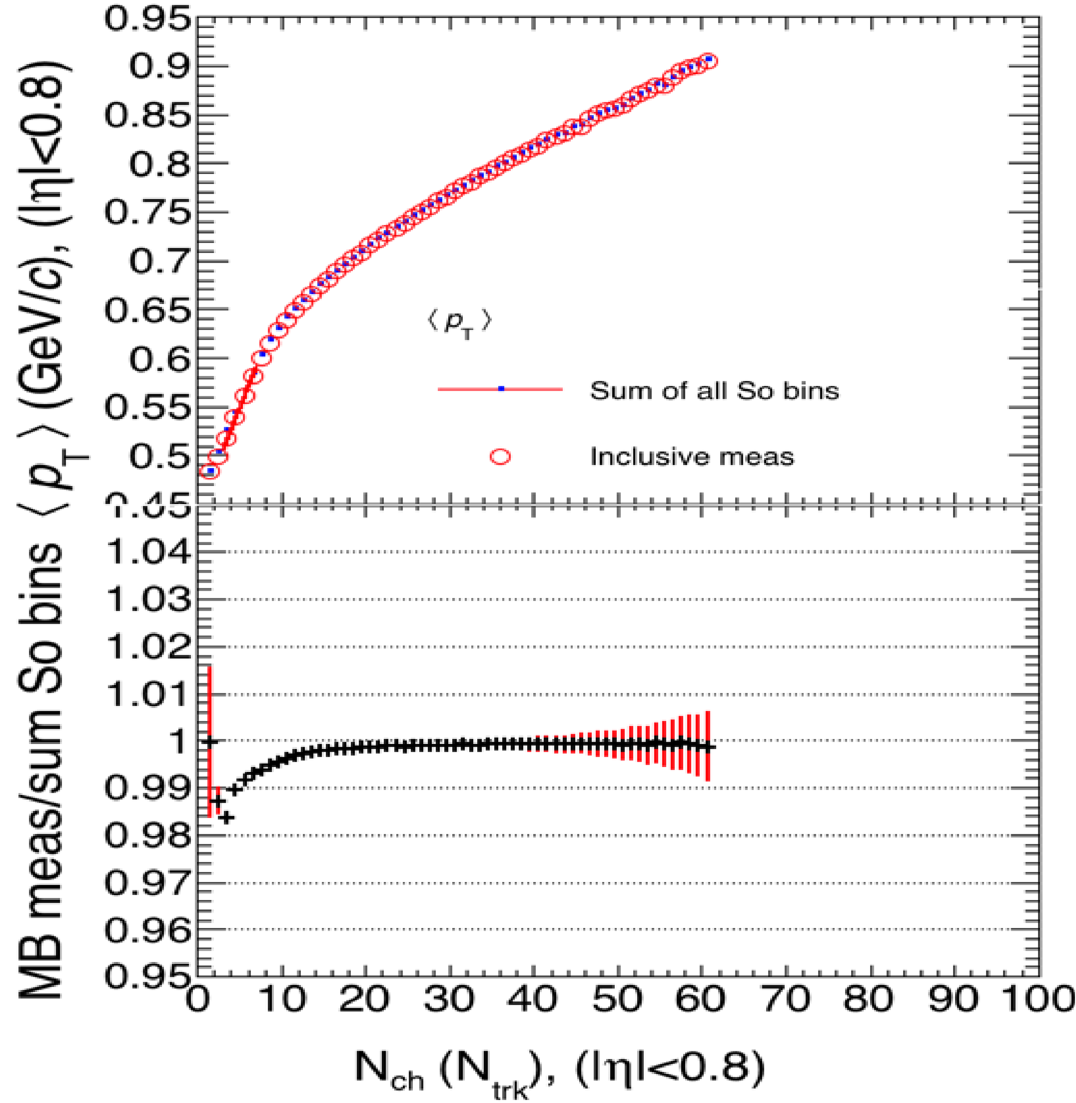
- Correc: Per2011 ESD corr with EPOS-LHC
- True: Per2011 MC
- Unc: Per2011 ESD

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

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

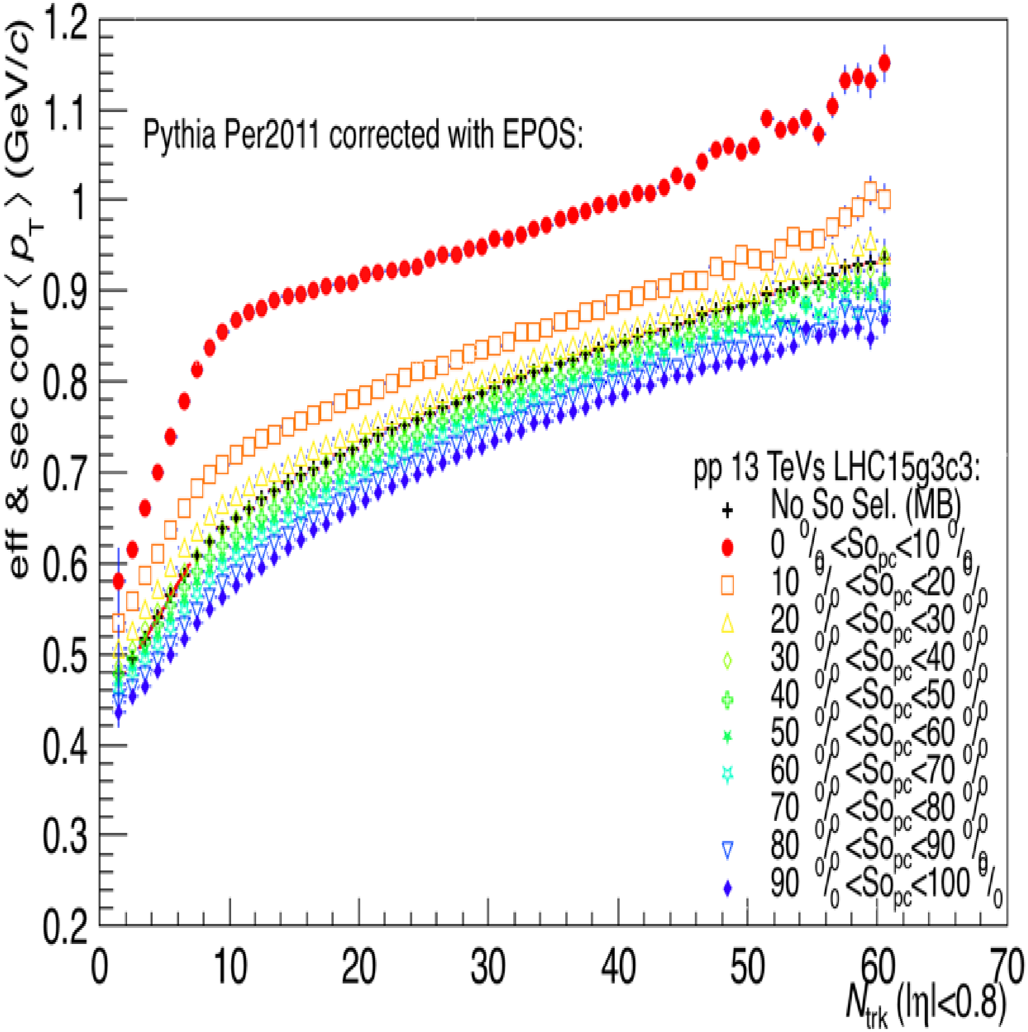
Pythia Per2011 (LHC15g3c3) as data.

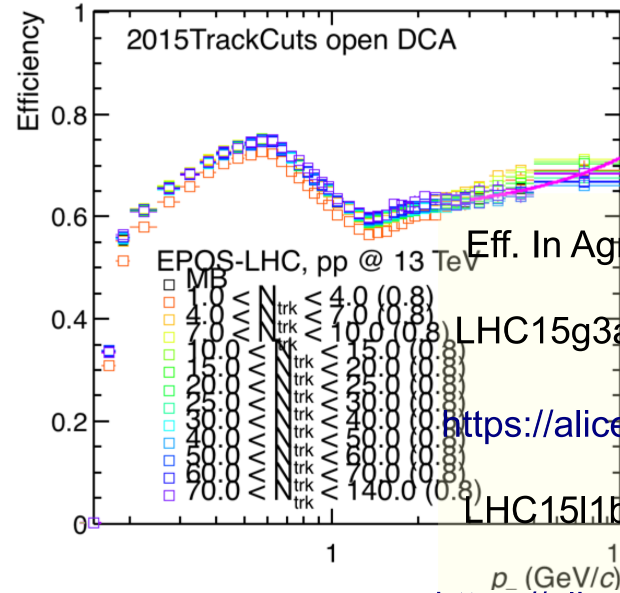




$\langle p_T \rangle$ for different So_{pc} bins **efficiency and secondaries corrected**.

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





Efficiency indep of So
(see Vytautas talk)
(Using V0M the auto correlations are destroyed)

Eff. In Agreement with (See backup):

Sergio´s result
LHC15g3a3 (Monash) pp13 |eta|<0.8
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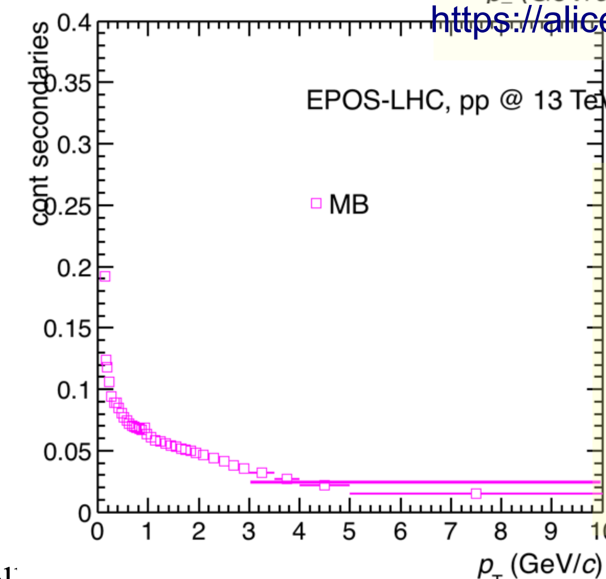
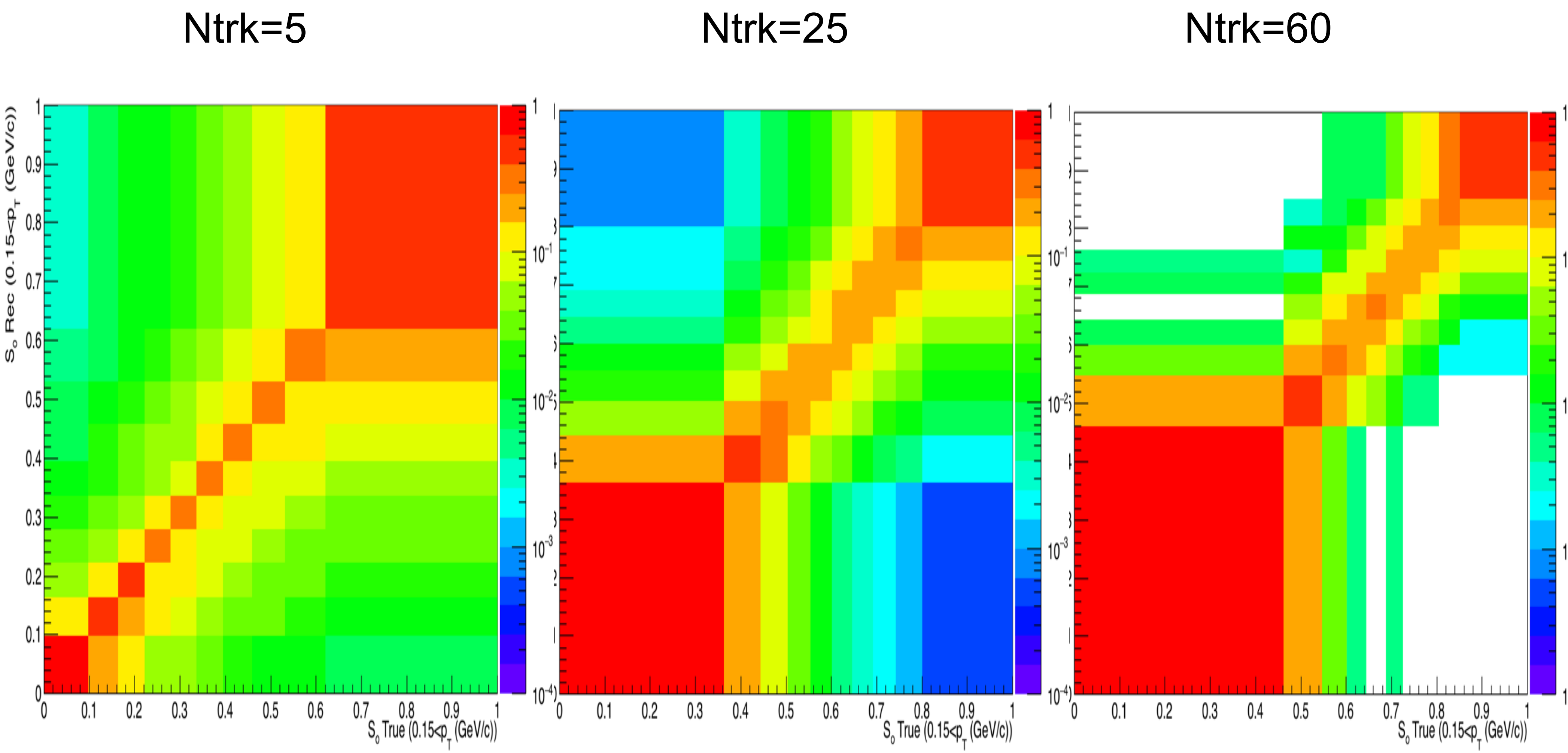


For the secondaries only a test with MC has done
For data a more elaborated analisys must be done (particle composition, feed-down corrections …) like GSI analysis for inclusive $\langle p_T \rangle$ vs N_{ch}

Normalized response matrix ($So_{measured}$ vs So_{true} in bins of 10% So percentil)

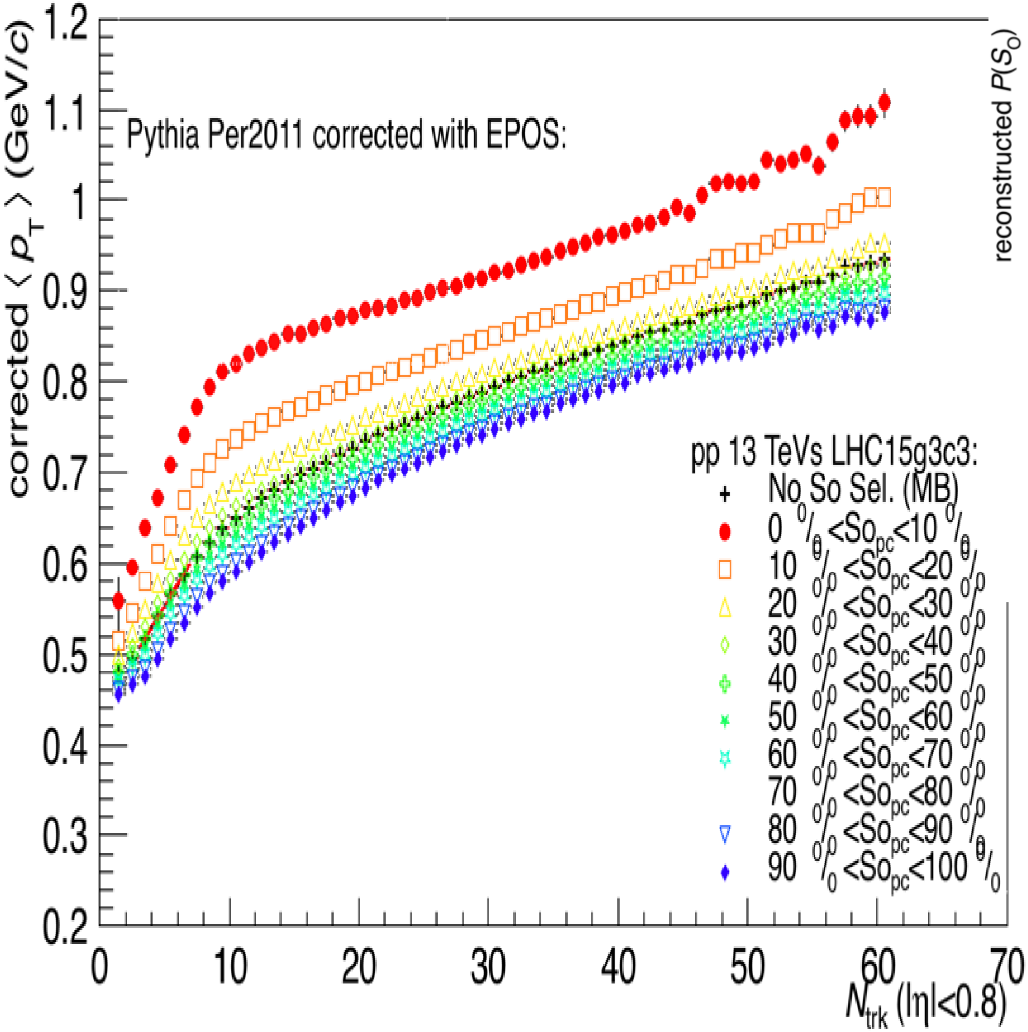
- This was done with EPOS-LHC, to unfold (via So) Pythia Per2011 as data

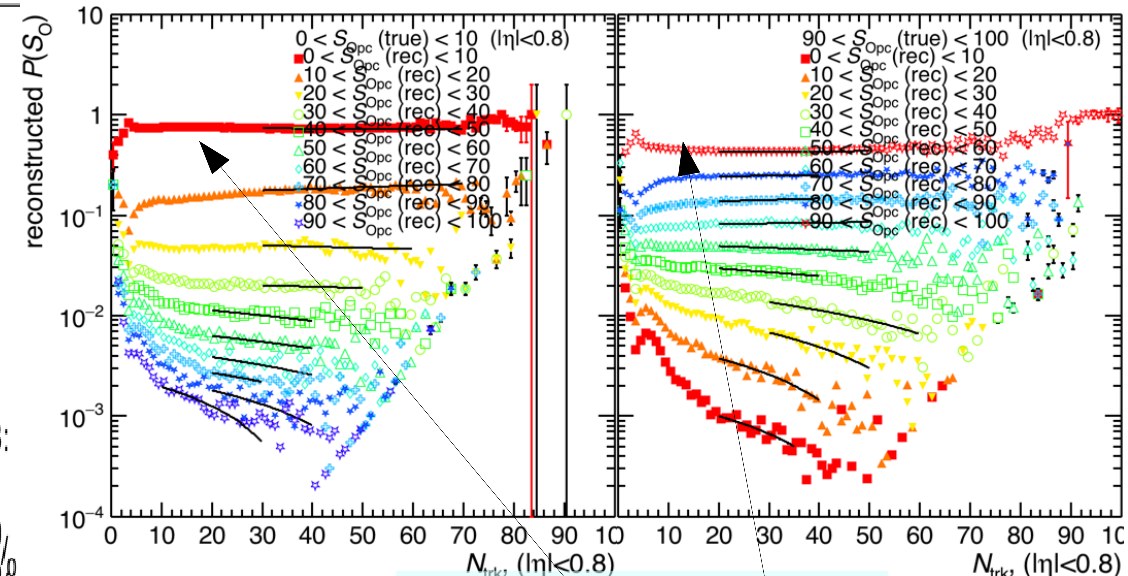


All entries at each column have the 10% of the events.

$\langle p_T \rangle$ for different So_{pc} bins **corrected by Spherocity Unfold .**

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



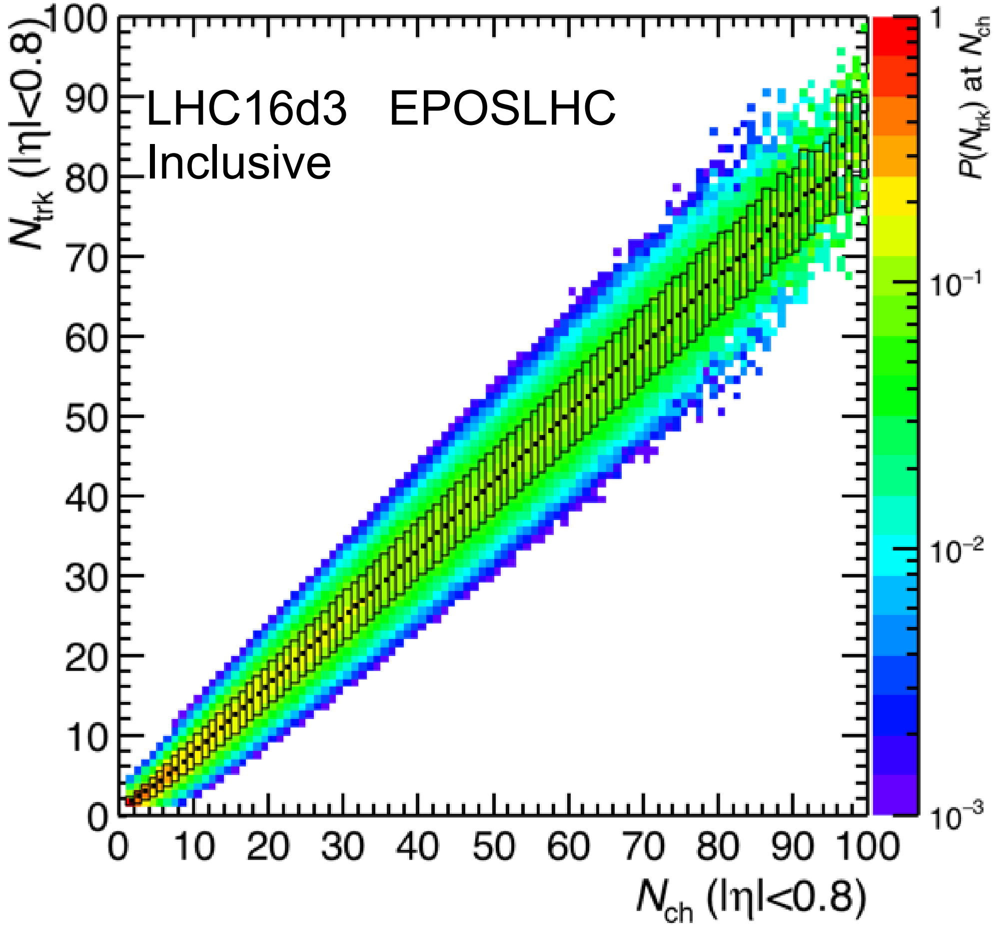


Higher correction
for isotropic (~40%)
than jetty (~20%)
(Big plots in backup)

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

- N_{ch} response matrix to correct by Multiplicity

Not extrapolated



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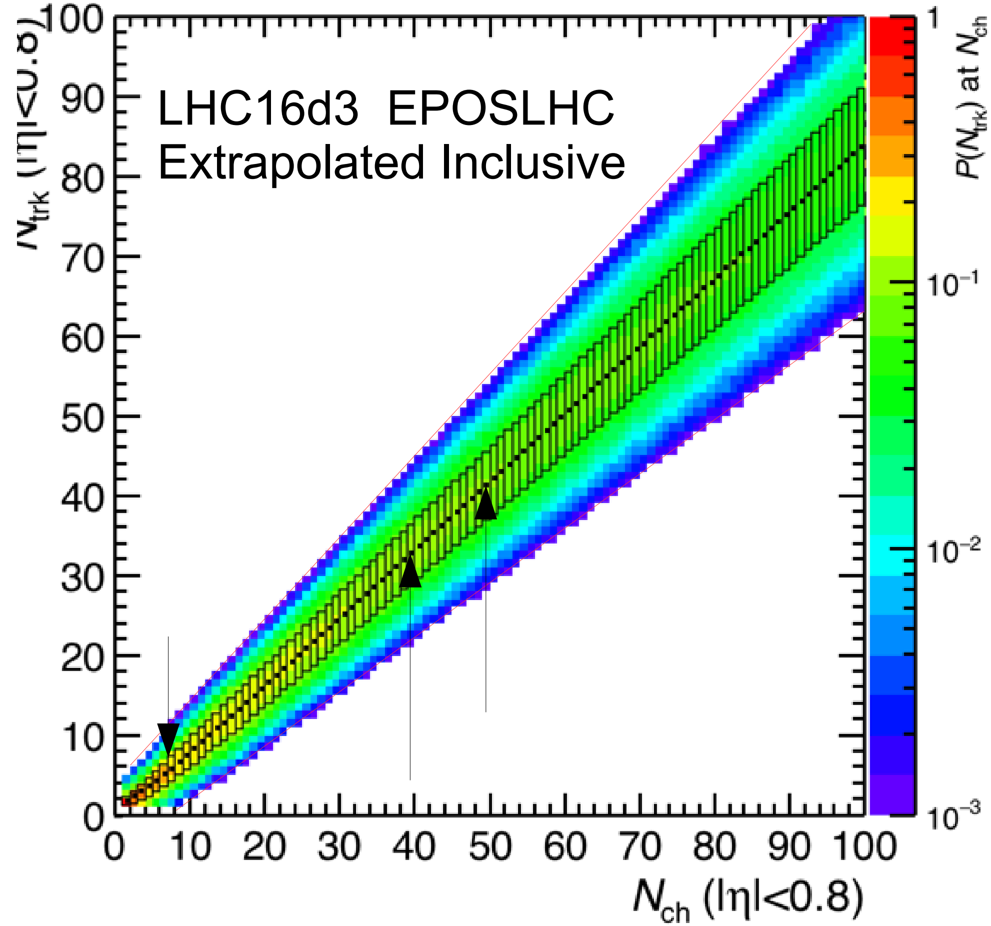

We will use EPOS-LHC fo the correction 4corr

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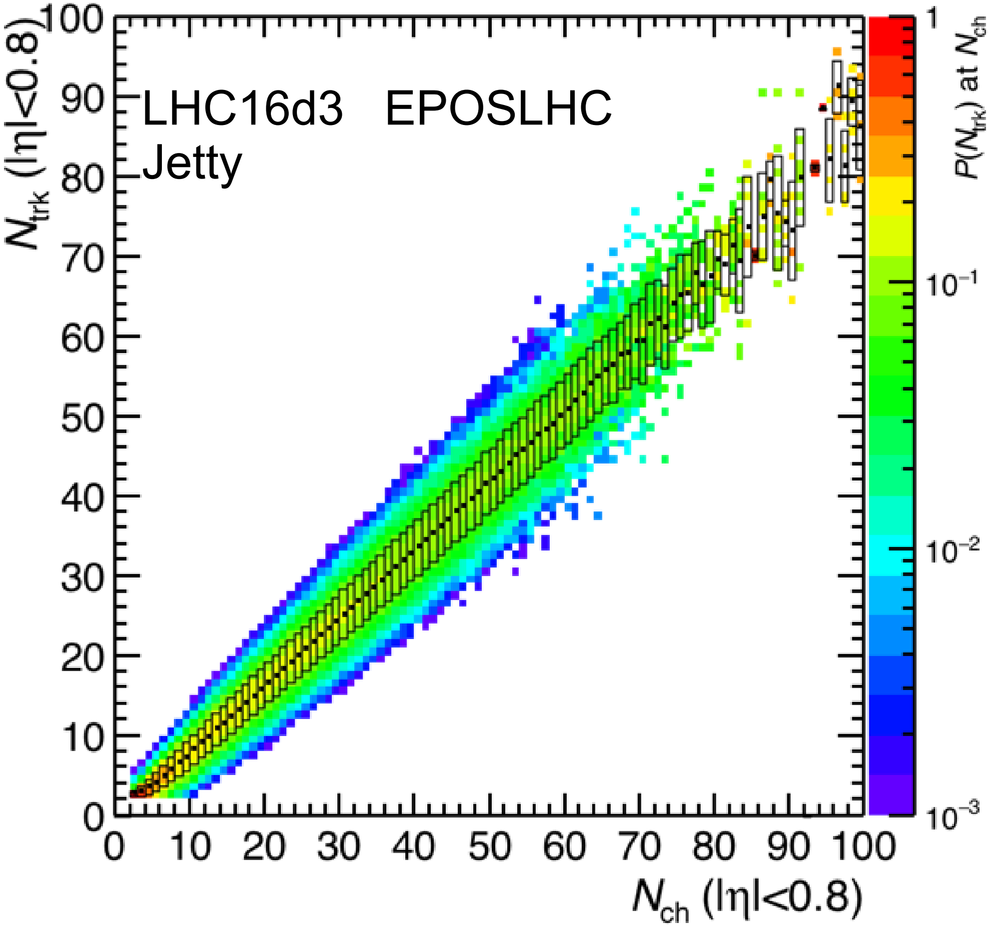

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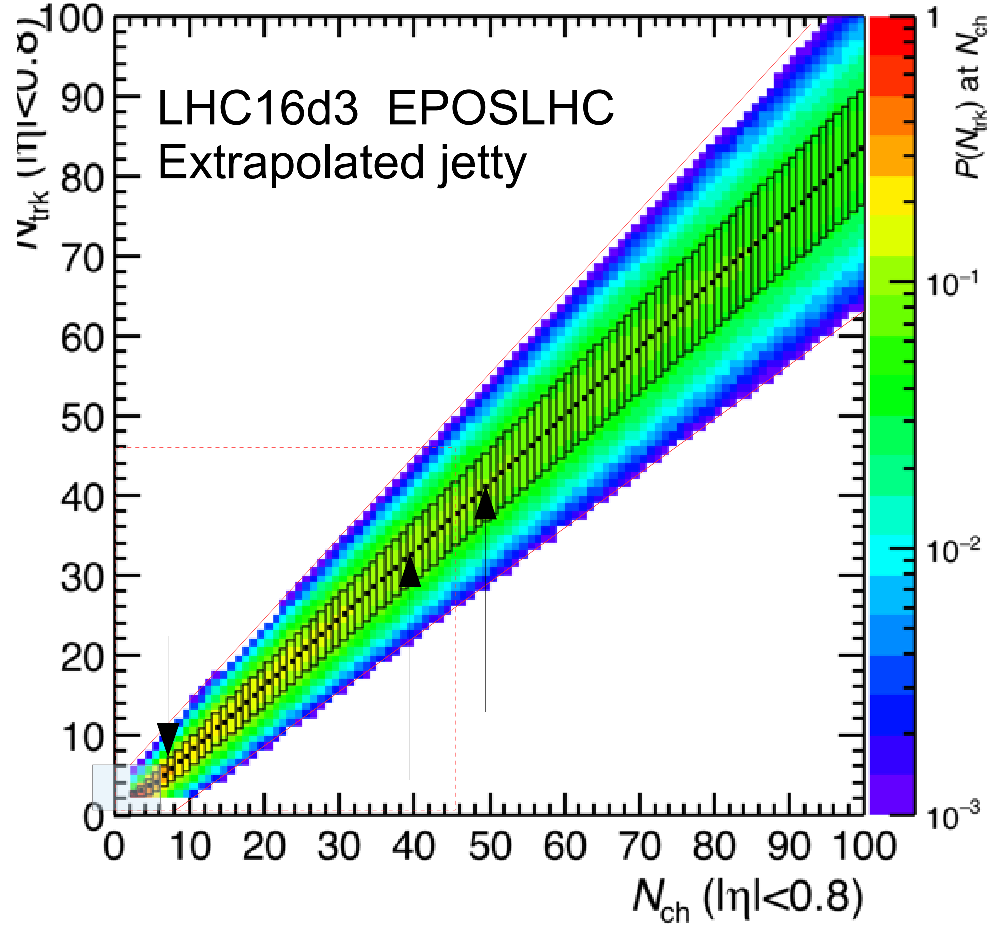

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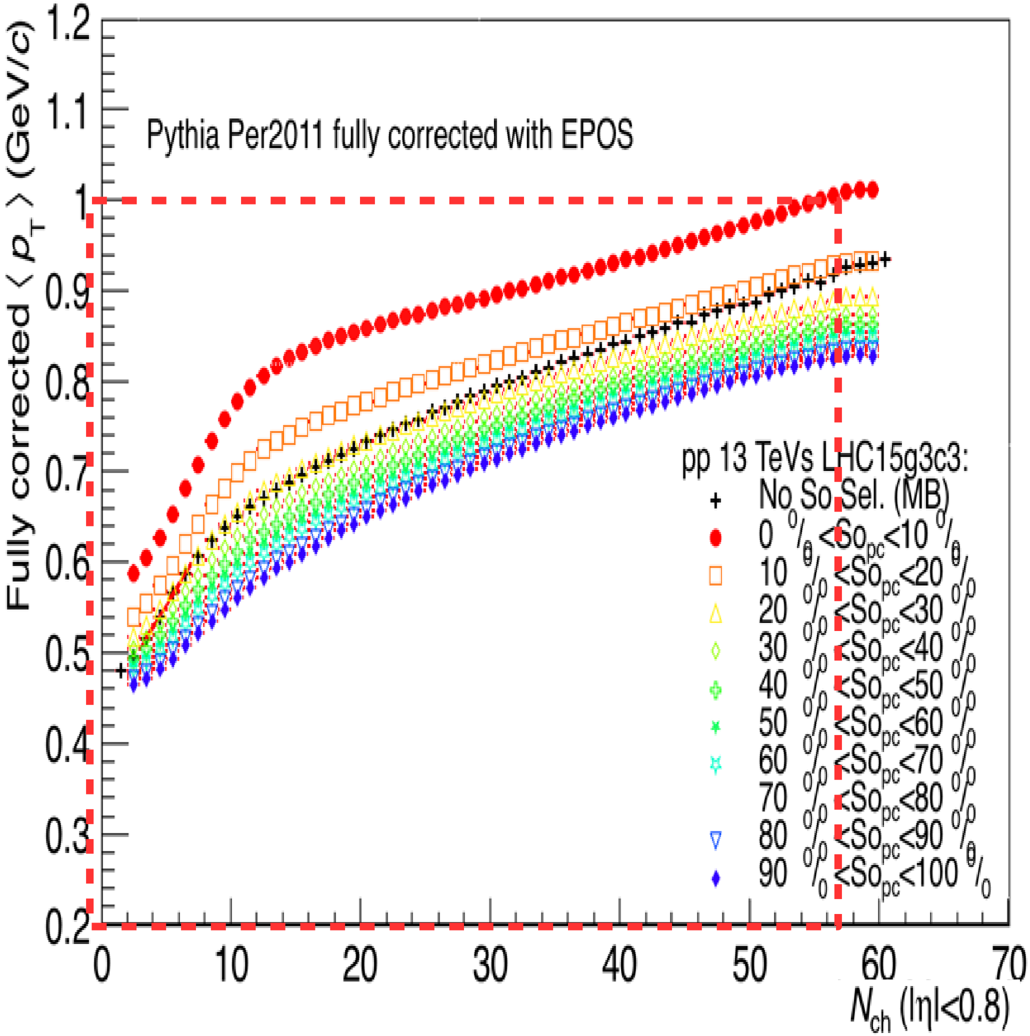
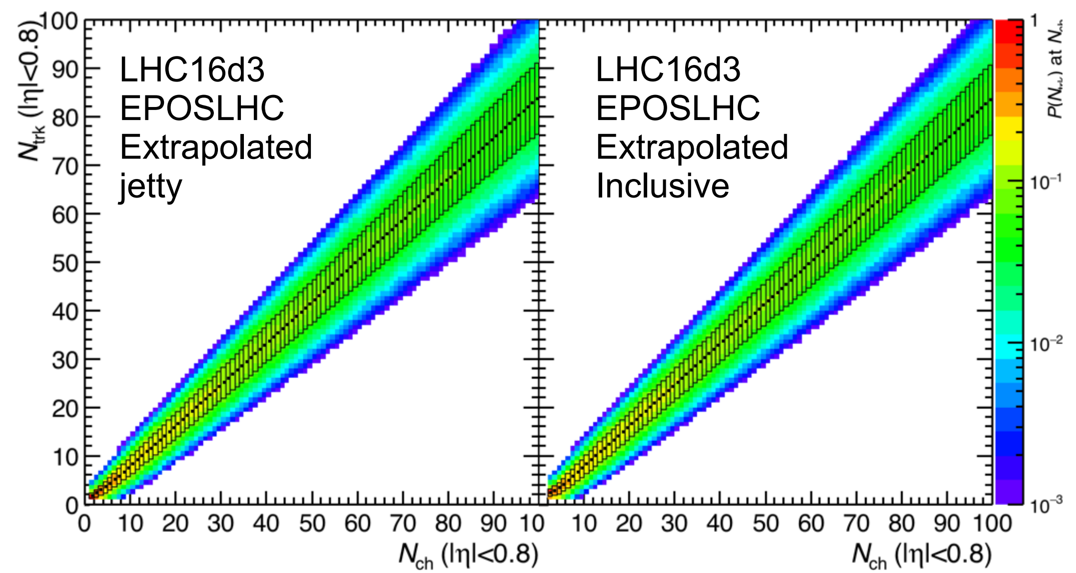
$\langle p_T \rangle$ for different So_{pc} bins **fully corrected (So Unf + Nch Unf)**.

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





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

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

<p_T> for different So_{pc} bins **fully corrected (So Unf + Nch Unf).**

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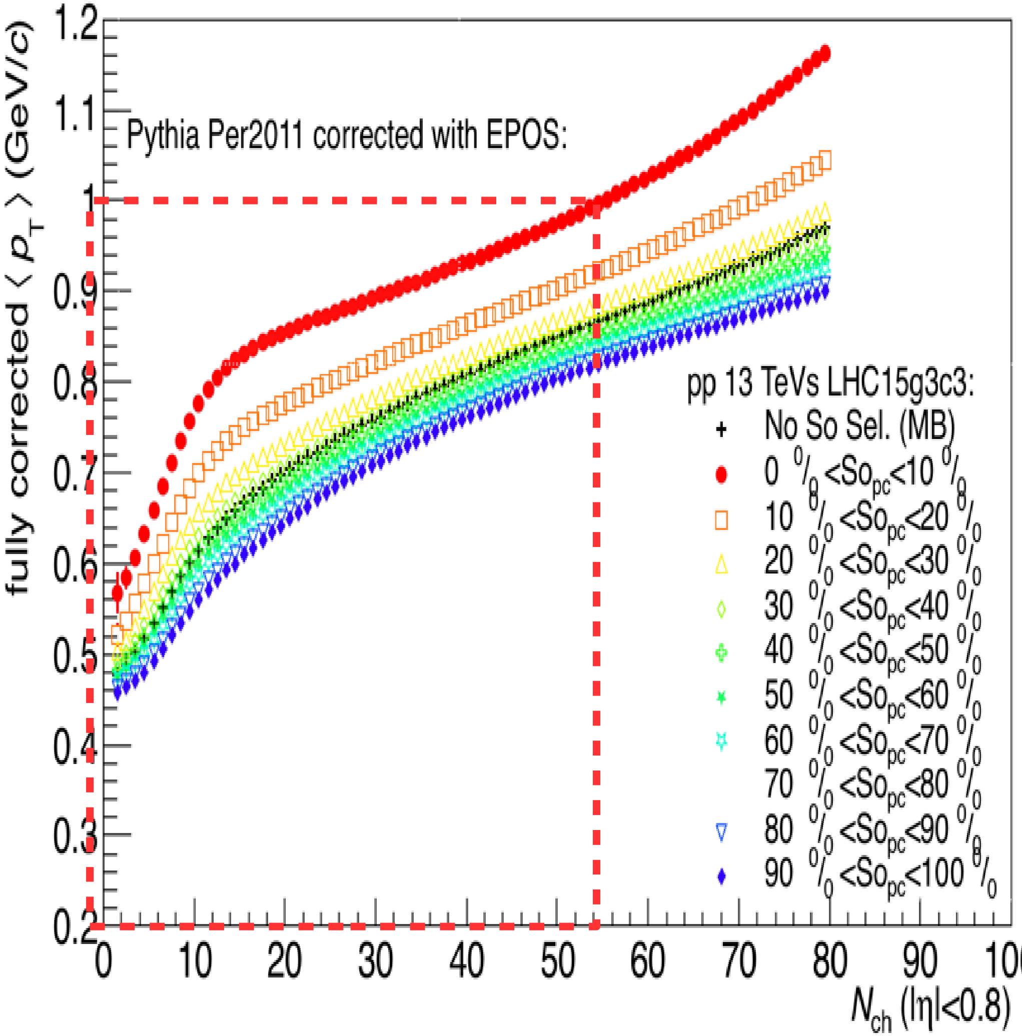

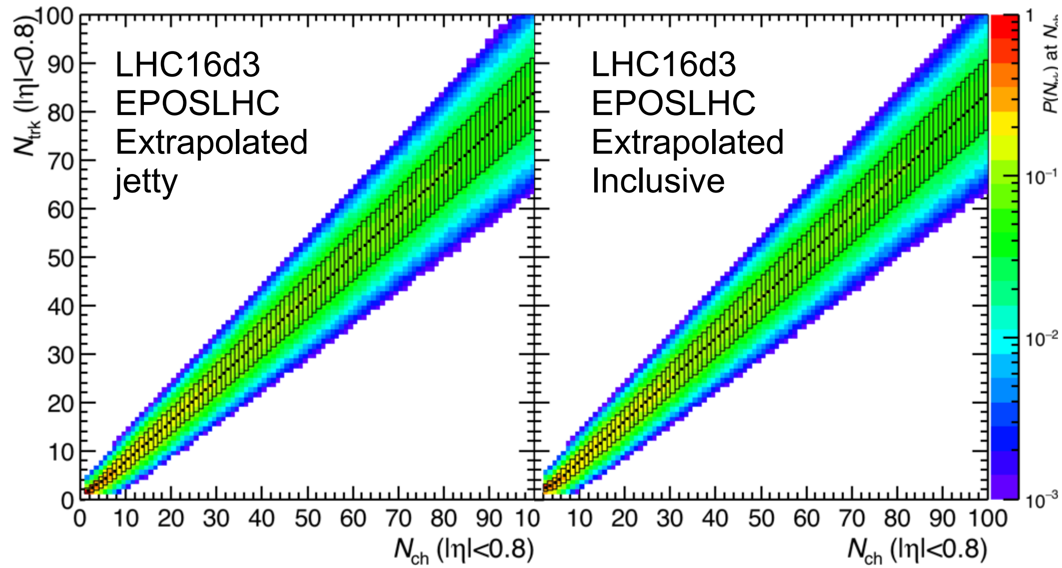

$$\langle p_T\rangle\left(S_O^{corrected_i}\right)=\sum^{5}\langle p_T\rangle\left(S_O^{measured_j}\right)P\left(S_O^{measured_j}\right)_{at\, S_O^{true_i}}$$

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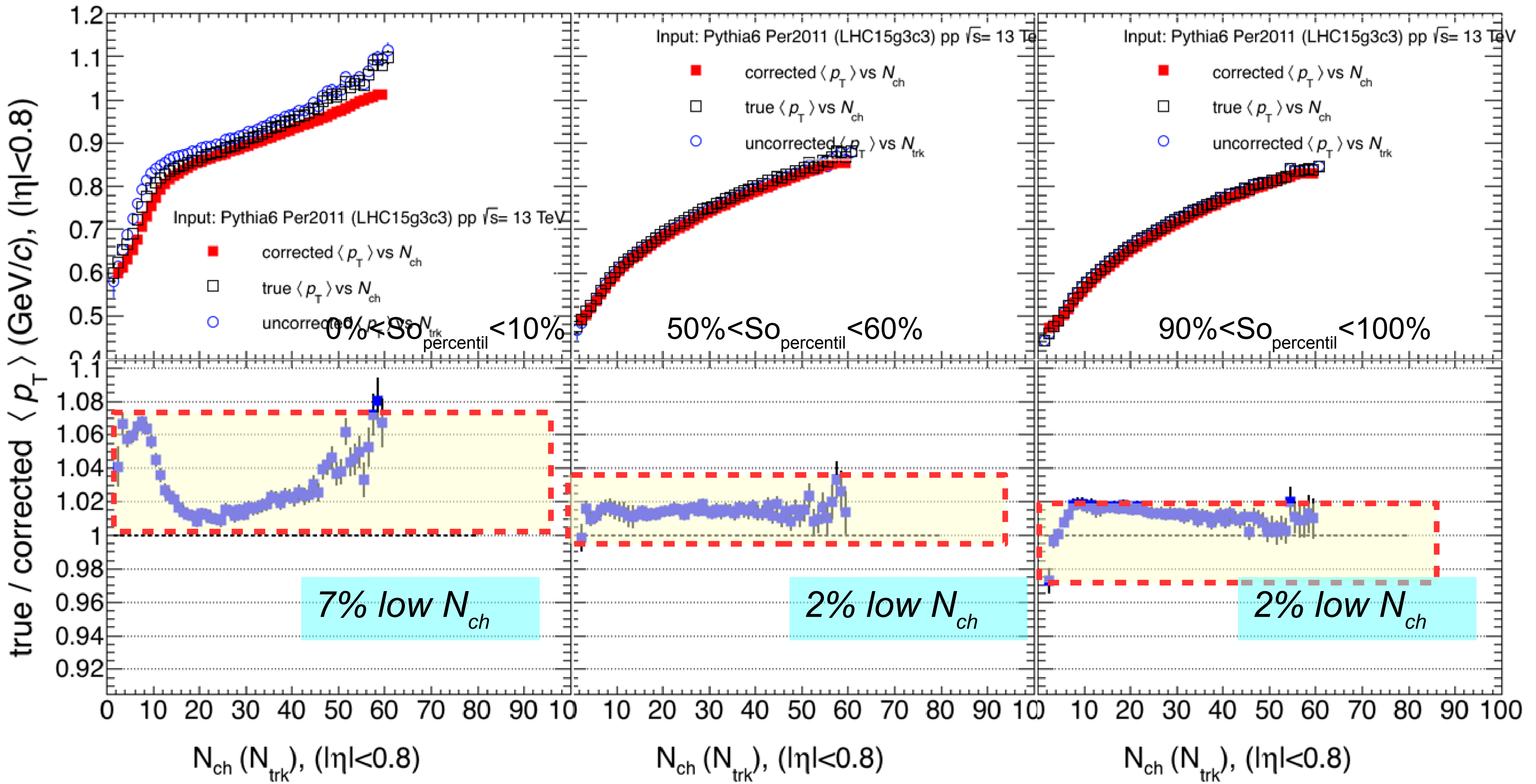
<p_T (So_{corr},Nch_{corr}) > UNFOLDED by N_{ch} CLOSURE TEST

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

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

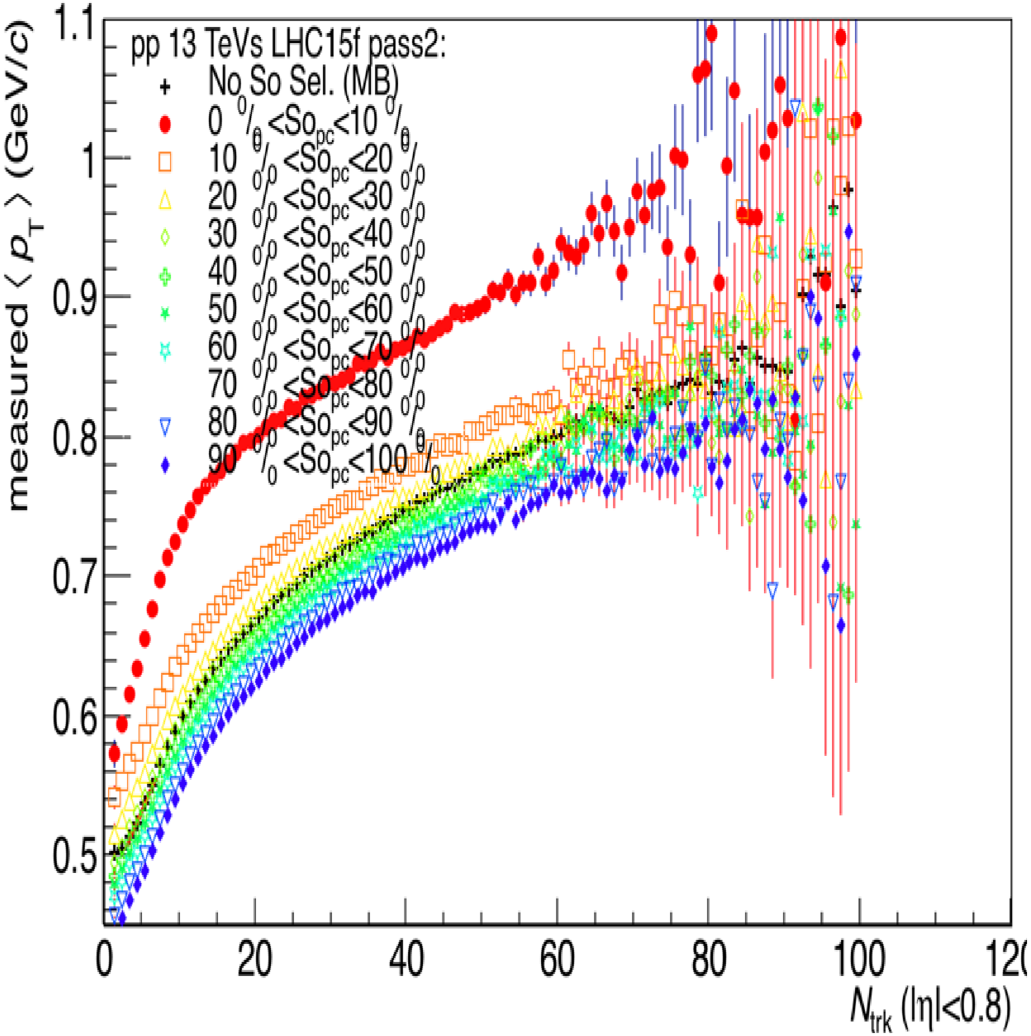


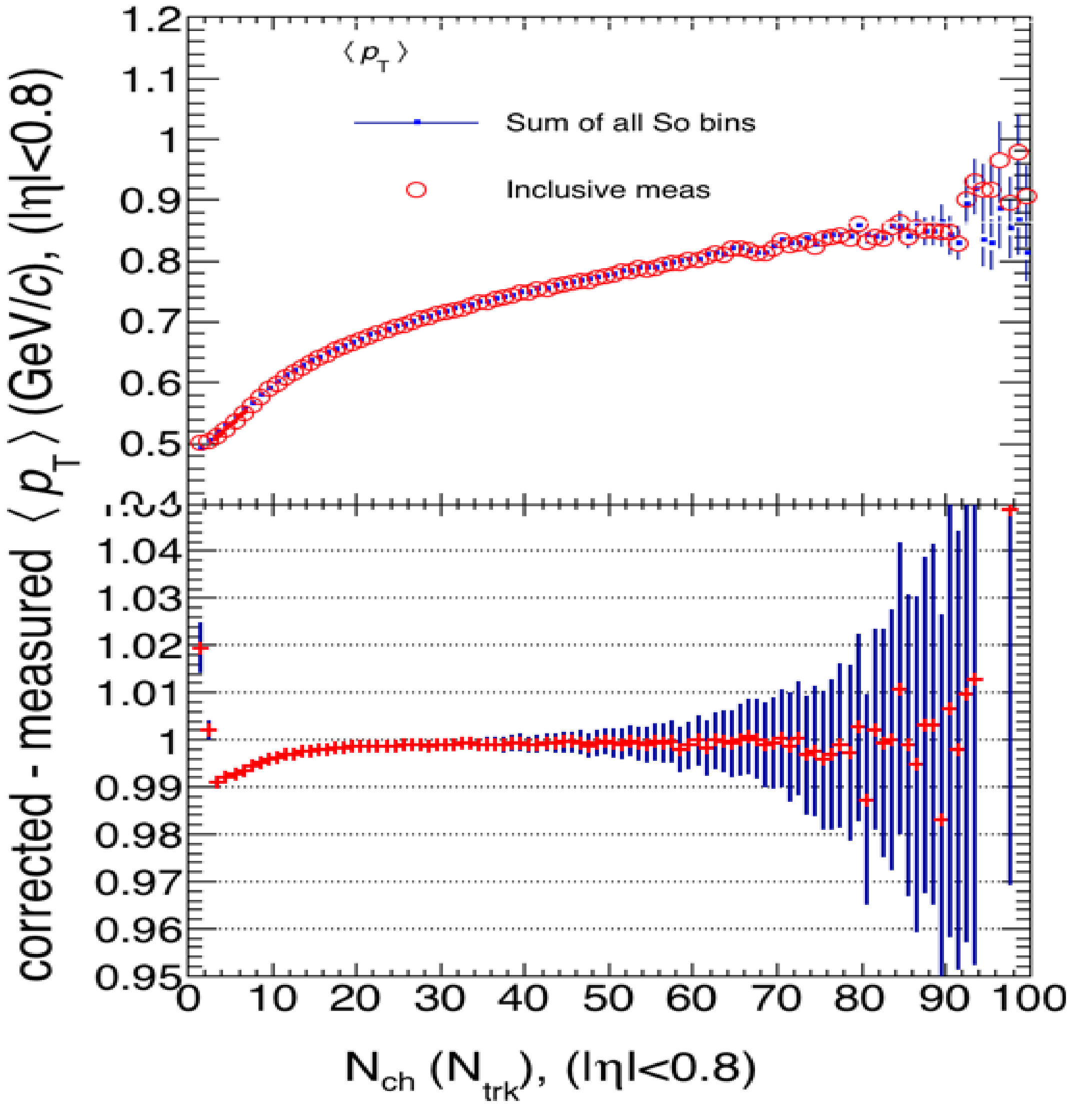
Analysis Update

Data LHC15f pass2

$<p_T>$ for different So_{pc} bins **measured**.

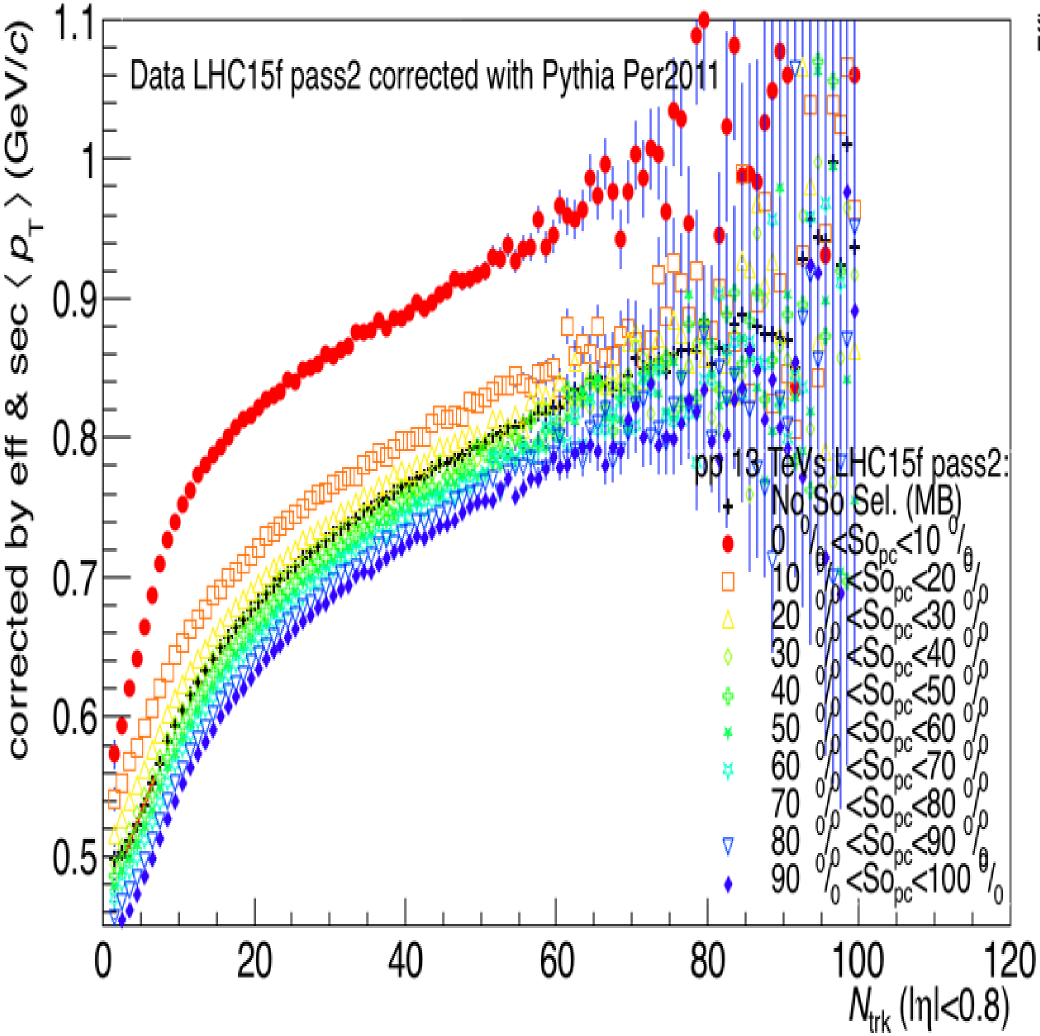
Data (LHC15f pass2).

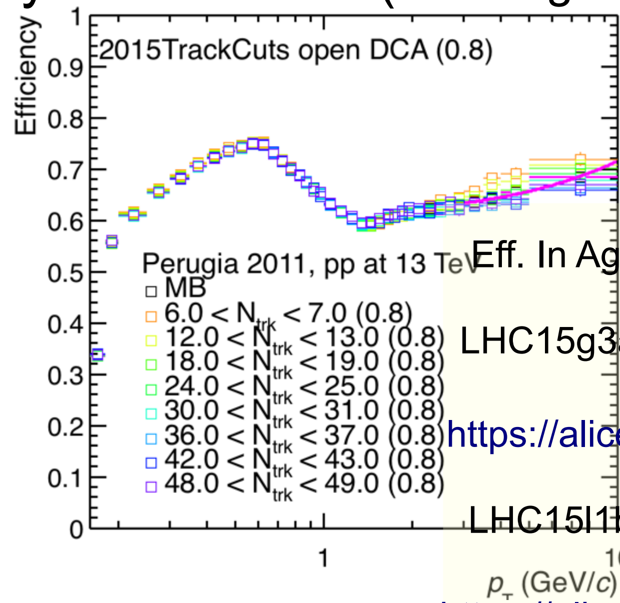




$\langle p_T \rangle$ for different So_{pc} bins **efficiency and secondaries corrected**.

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





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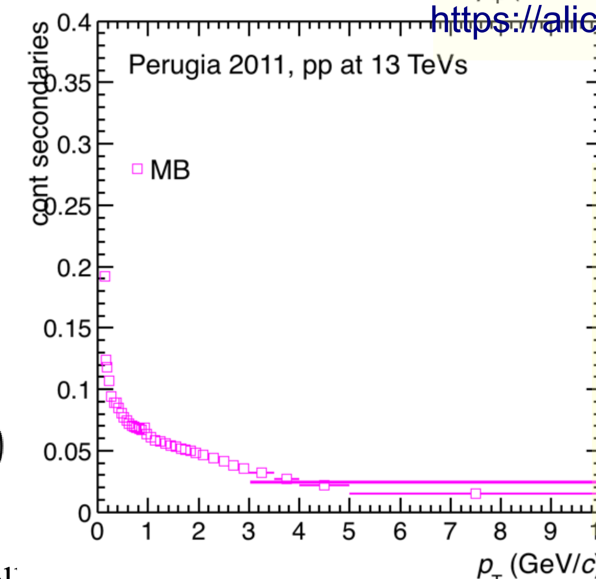

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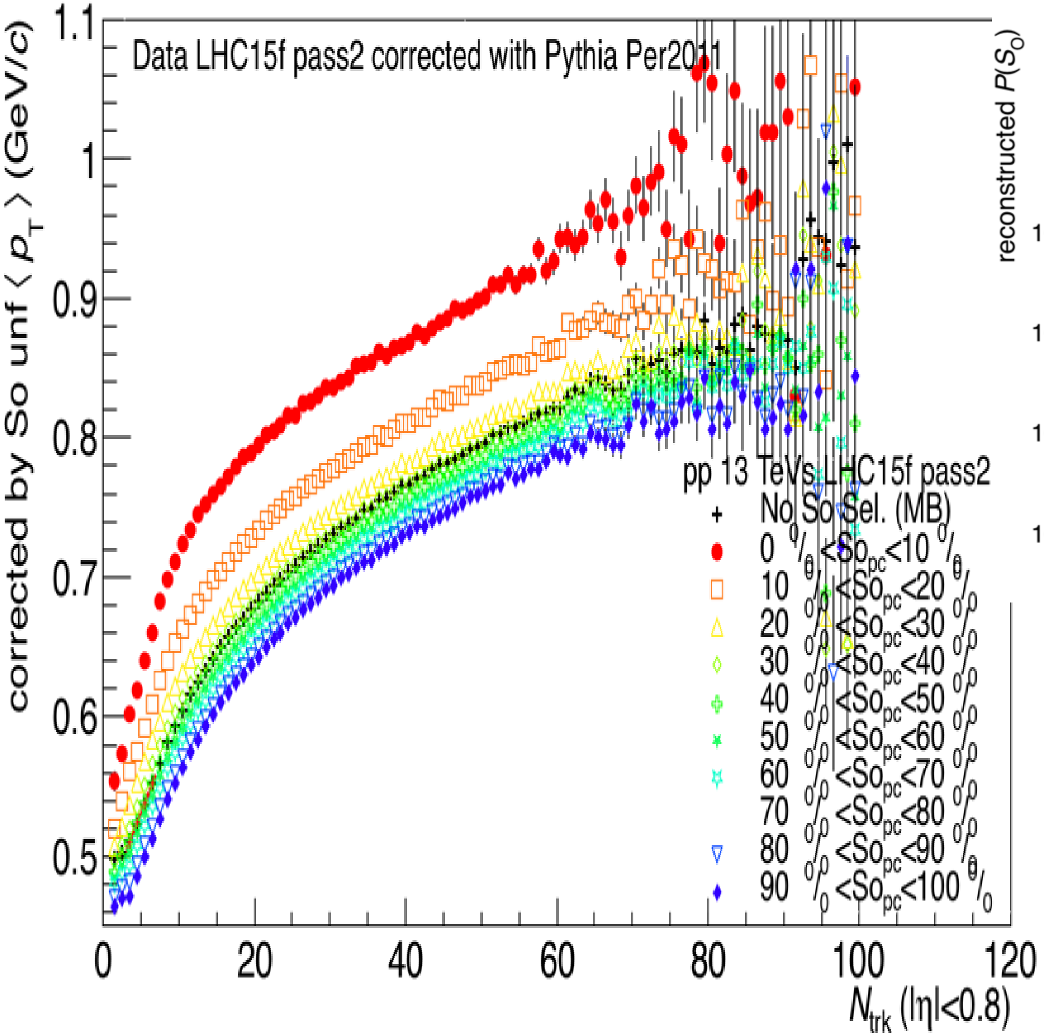
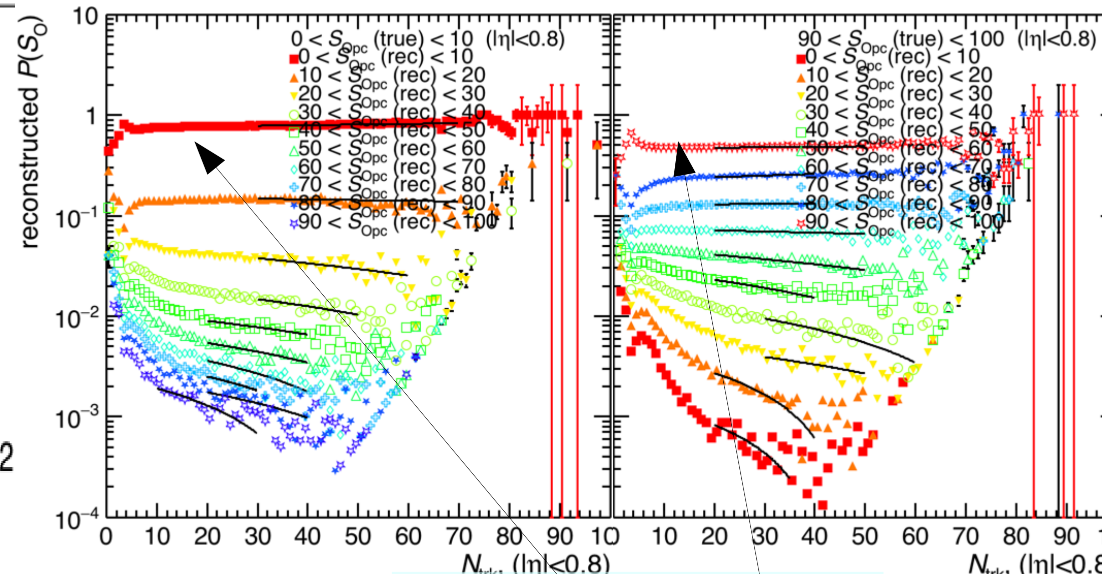
For data a more elaborated analisys must be done (particle composition, feed-down corrections …) like GSI analysis for inclusive $\langle p_T \rangle$ vs N_{ch}

$\langle p_T \rangle$ for different So_{pc} bins **corrected by Spherocity Unfold .**

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





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$\langle p_T \rangle$ for different So$_{pc}$ bins **fully corrected (So Unf + Nch Unf).**

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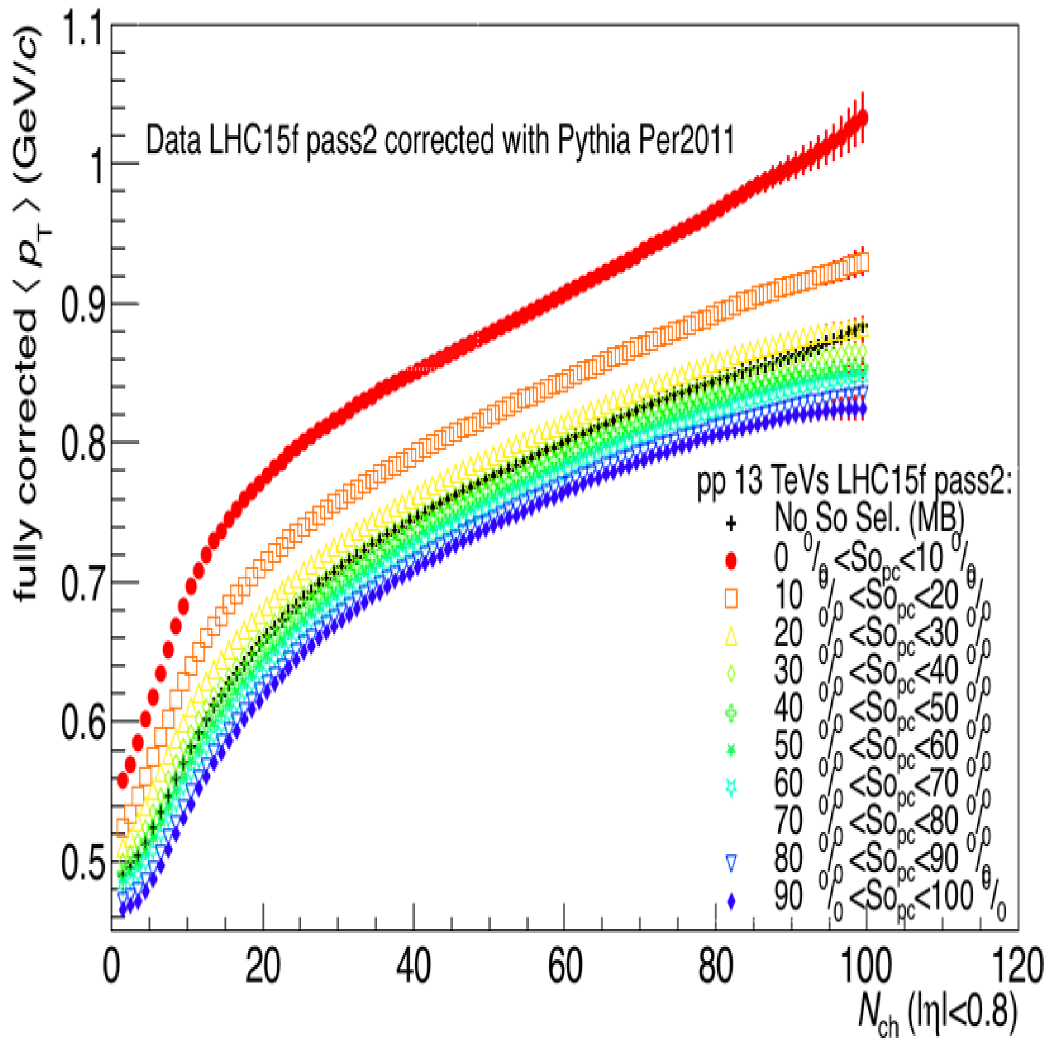

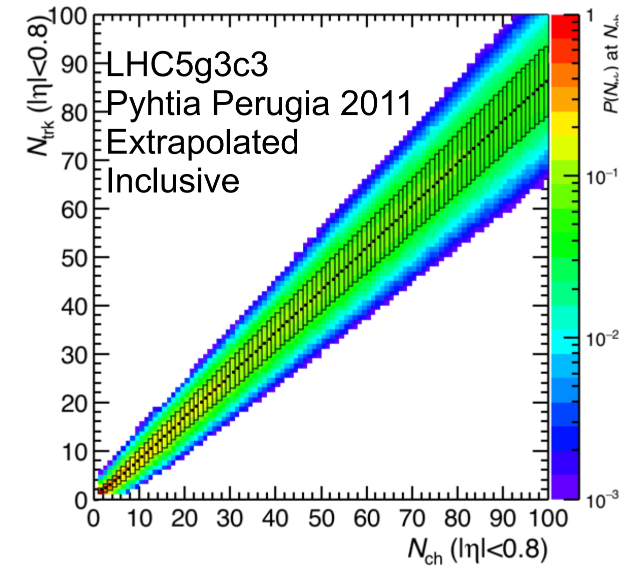

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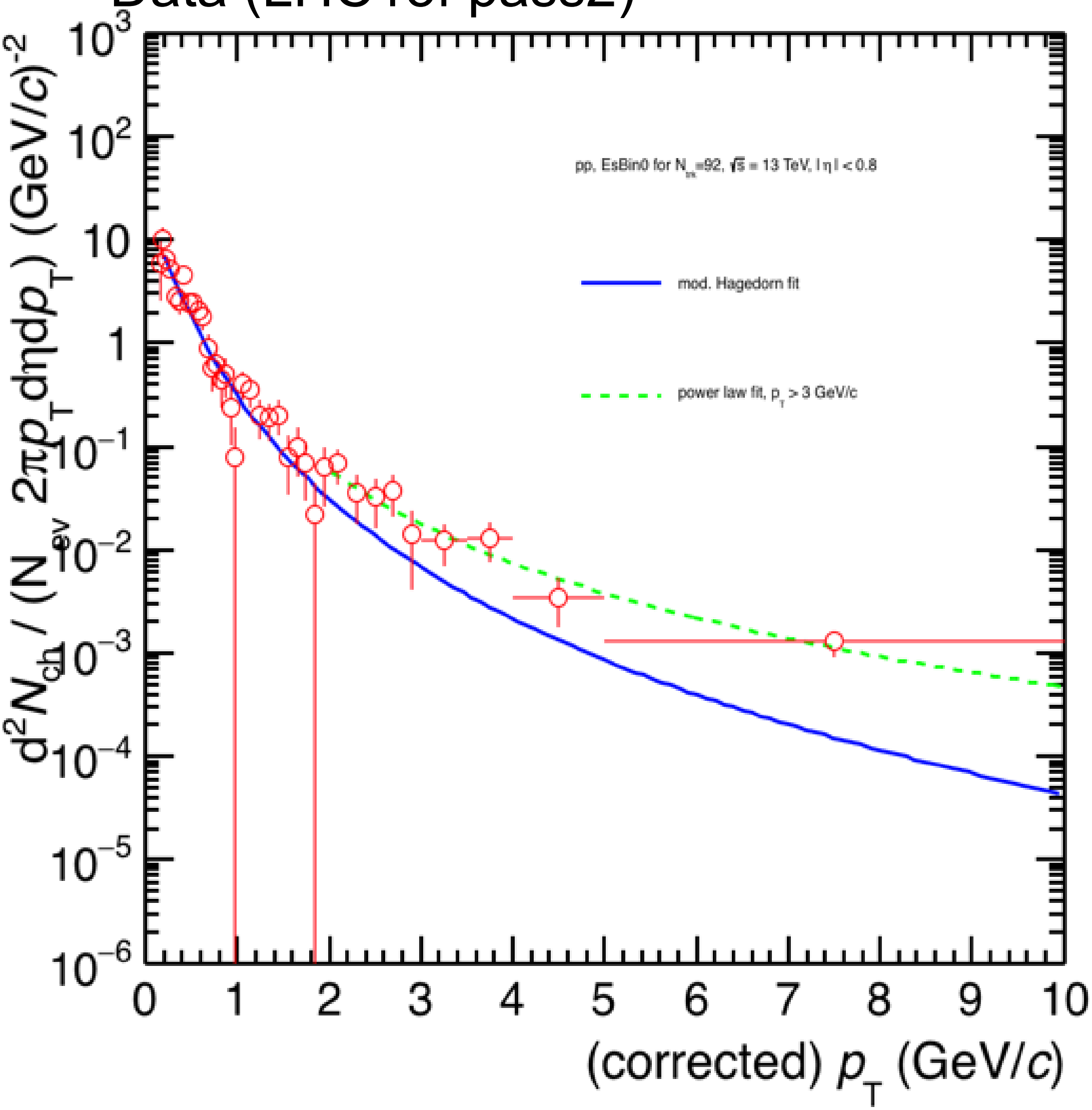
$<p_T>$ for different So_{pc} bins.

Data (LHC15f pass2)



The fully corrected p_T spectra are fitted by the modified Hagedorn function [16]

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

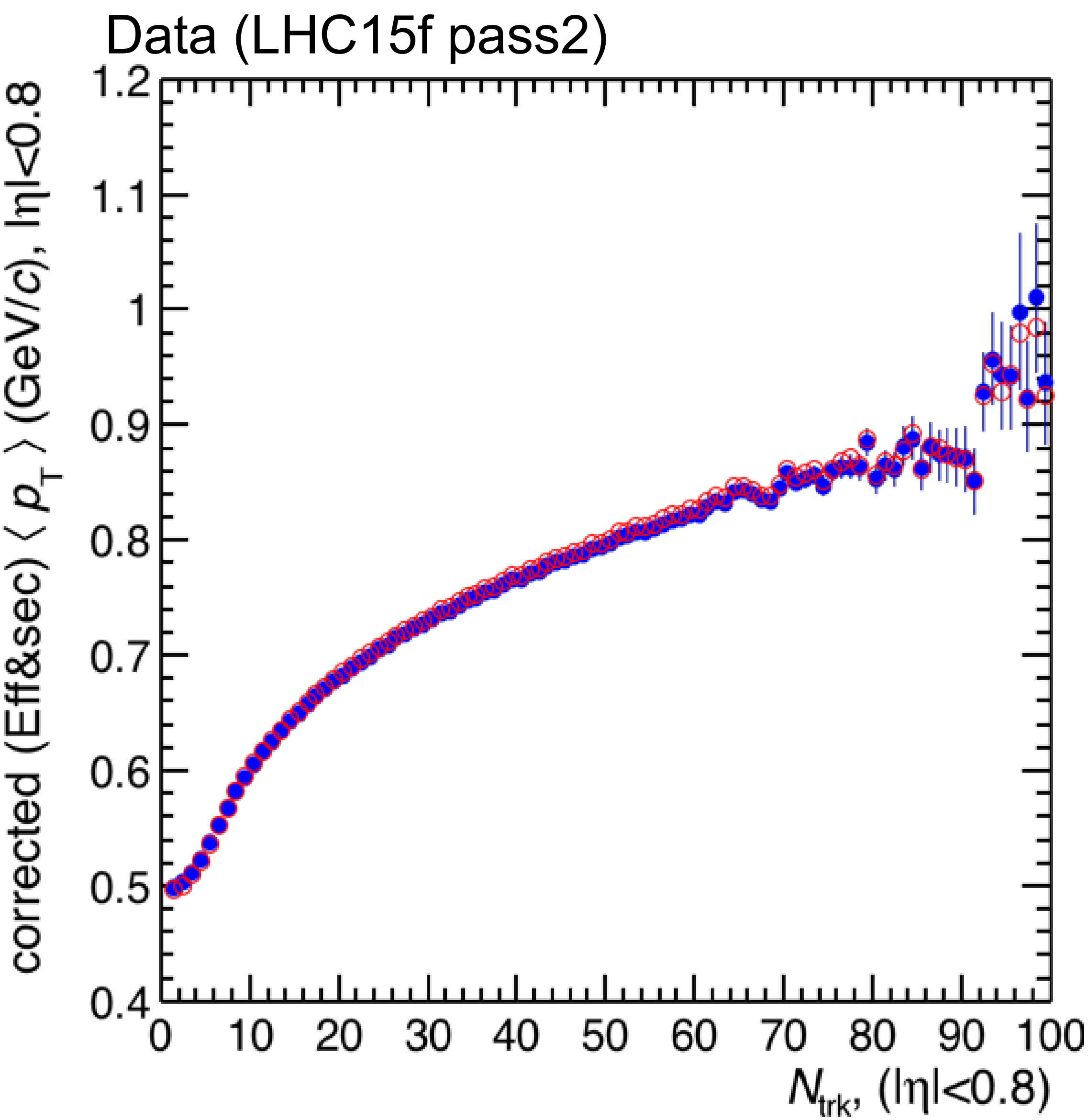
For the transverse mass $m_T = \sqrt{m_\pi^2 + p_T^2}$, the pion mass is assumed for all tracks. At small p_T, the term $\left(1+\frac{p_T}{p_{T,0}}\right)^{-b}$ behaves like an exponential in p_T with inverse slope parameter $p_{T,0}/b$. This provides a good description of the soft part of the spectrum, allowing for an extrapolation of the measured data to $p_T = 0$. To assess the tail of the spectrum at $p_T > 3$ GeV/c, a power law fit is performed

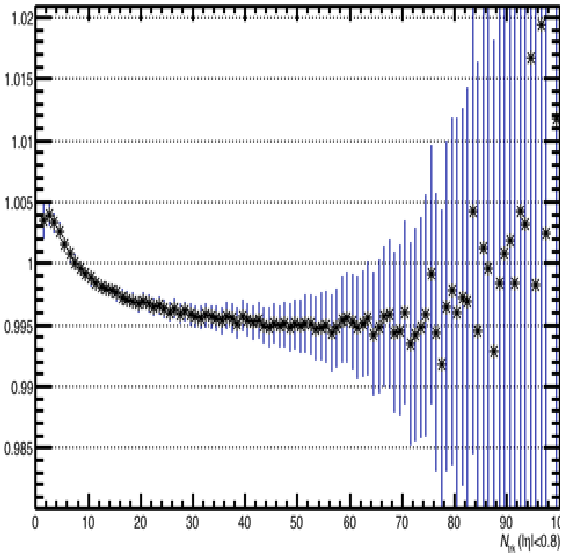
$$\frac{1}{2\pi p_T}\frac{\mathrm{d}^2 N_{\mathrm{ch}}}{\mathrm{d}\eta\,\mathrm{d}p_T} \propto p_T^{-n}, \quad (2)$$

yielding a very good description of the hard part of the spectrum characterized by the power n.

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

$<p_T>$ for different So_{pc} bins.





Conclusions

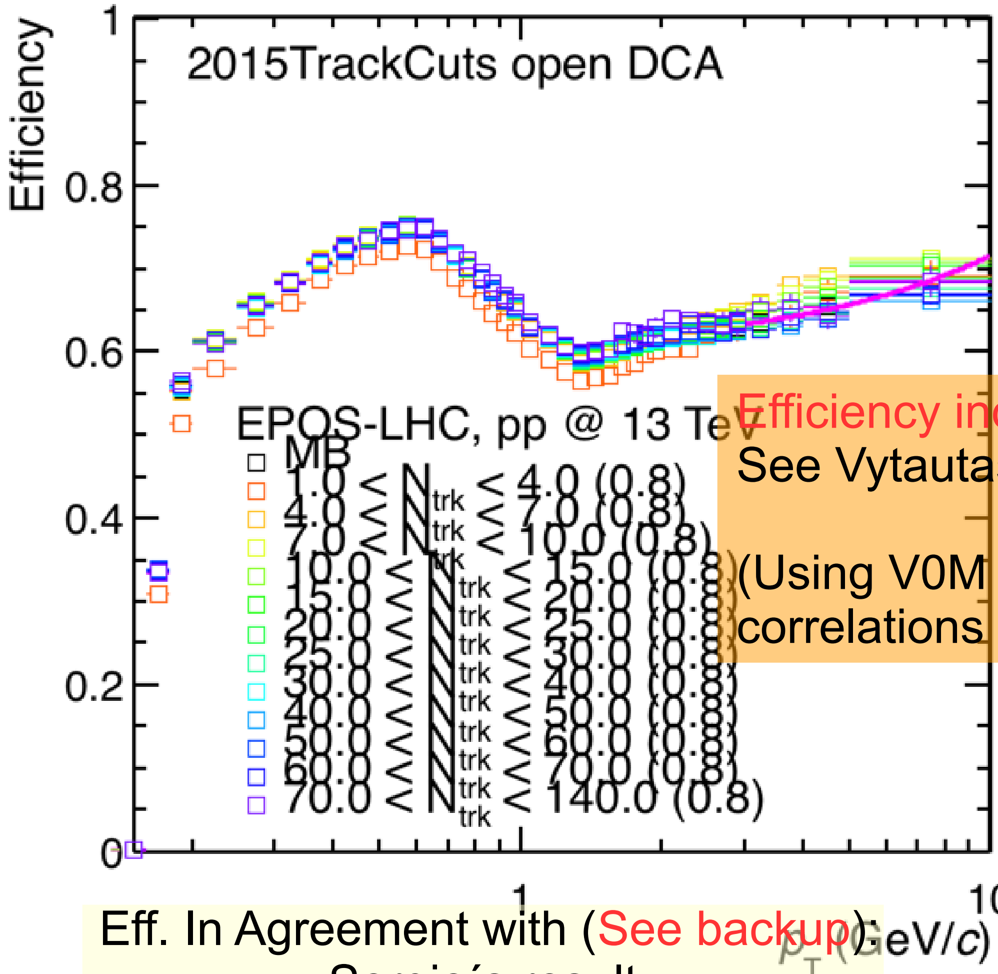
- Spherocity response matrix and proyection for EPOS-LHC in every bin of Nch and in spherocity bins corresponding to the 10% So perc ready for corrections
- Closure test has been made for inclusive charge particles
- Closure test also done for Spherocity intervals
- Mean transverse momentum in So bins corrected for Data

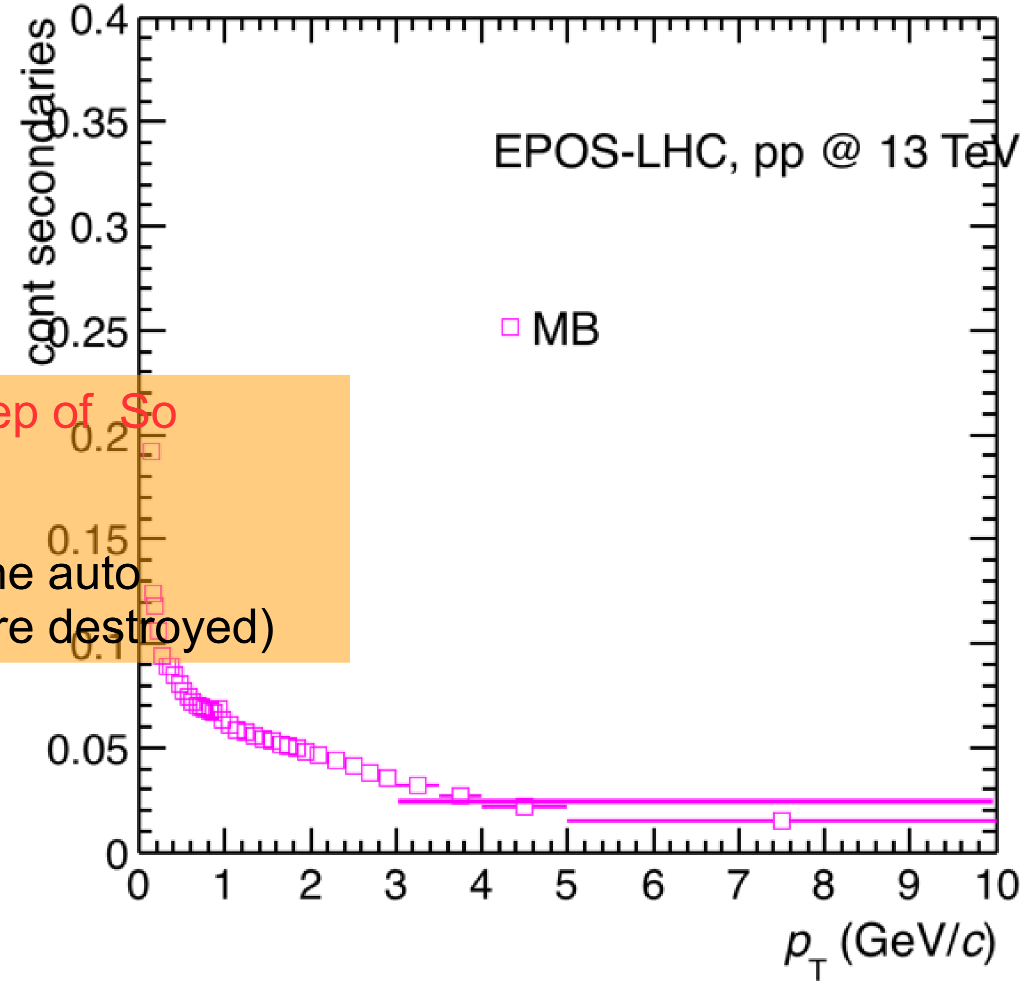
To do

- To make the extrapolation for Sobins
- Make feed-down correction.
- Calculate systematics

Backup

- Efficiency & secondaries EPOS-LHC(LHC16d3)





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See Vytautas

(Using V0M the auto correlations are destroyed)

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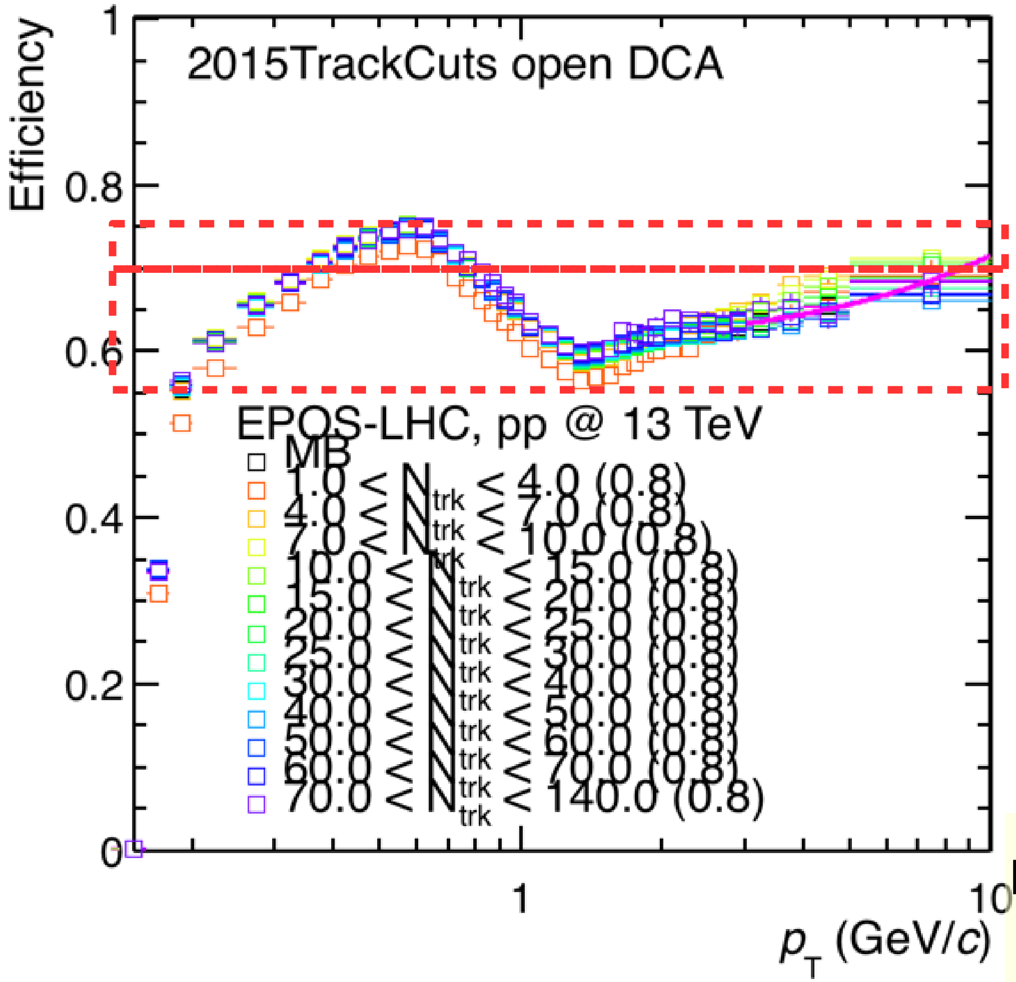
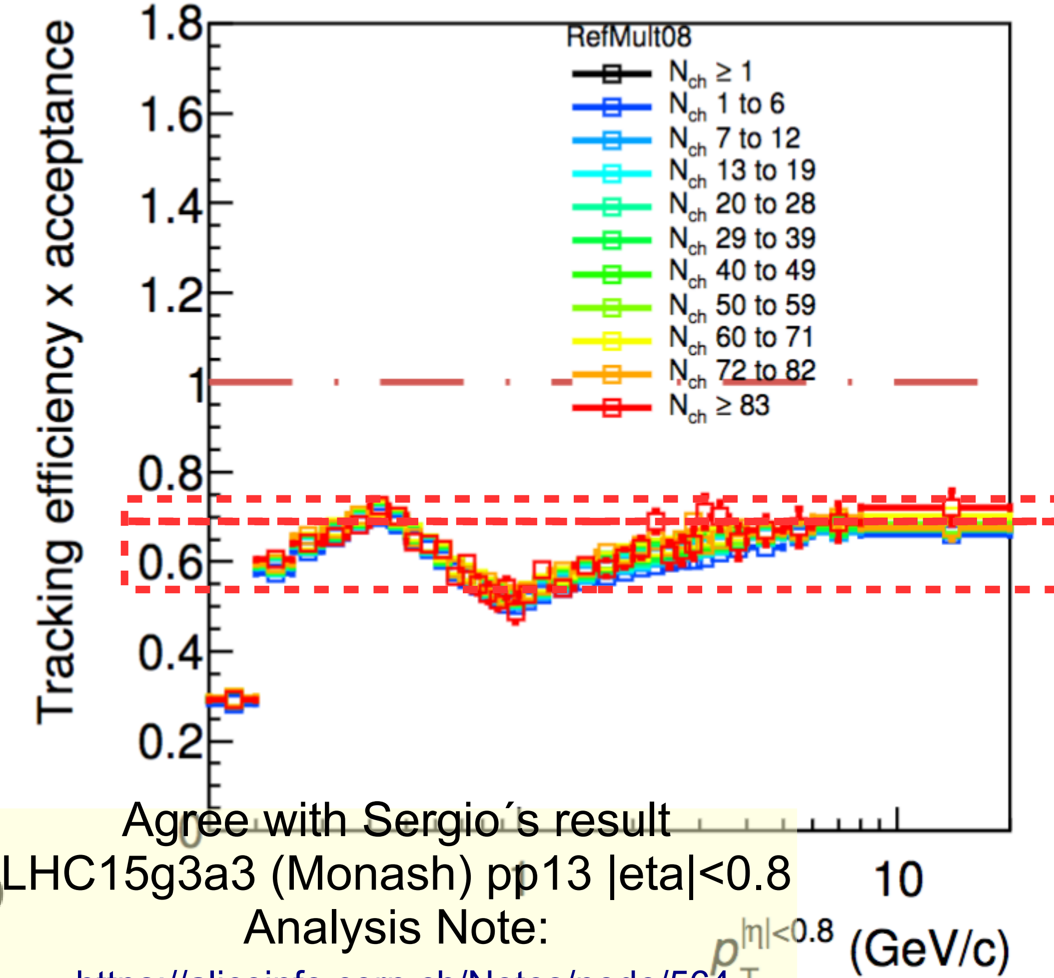
- Efficiency & secondaries EPOS-LHC(LHC16d3)





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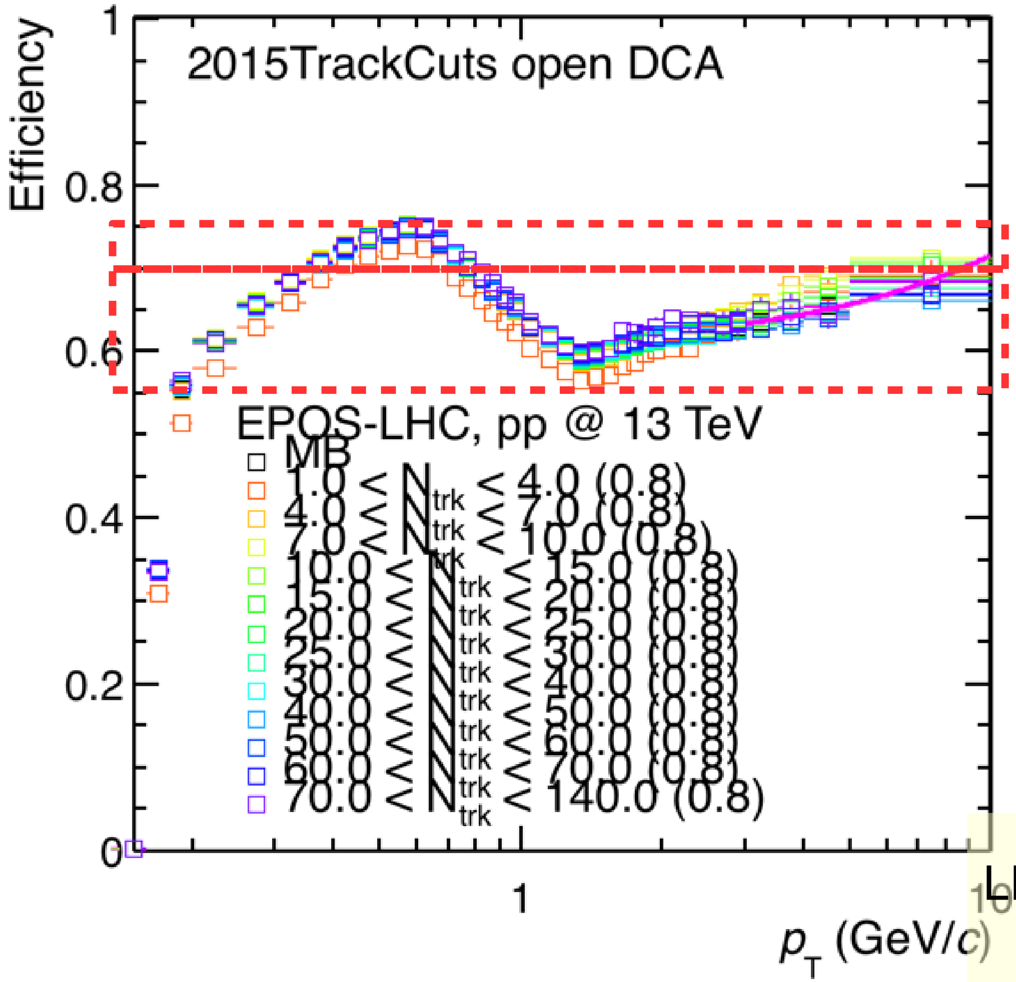
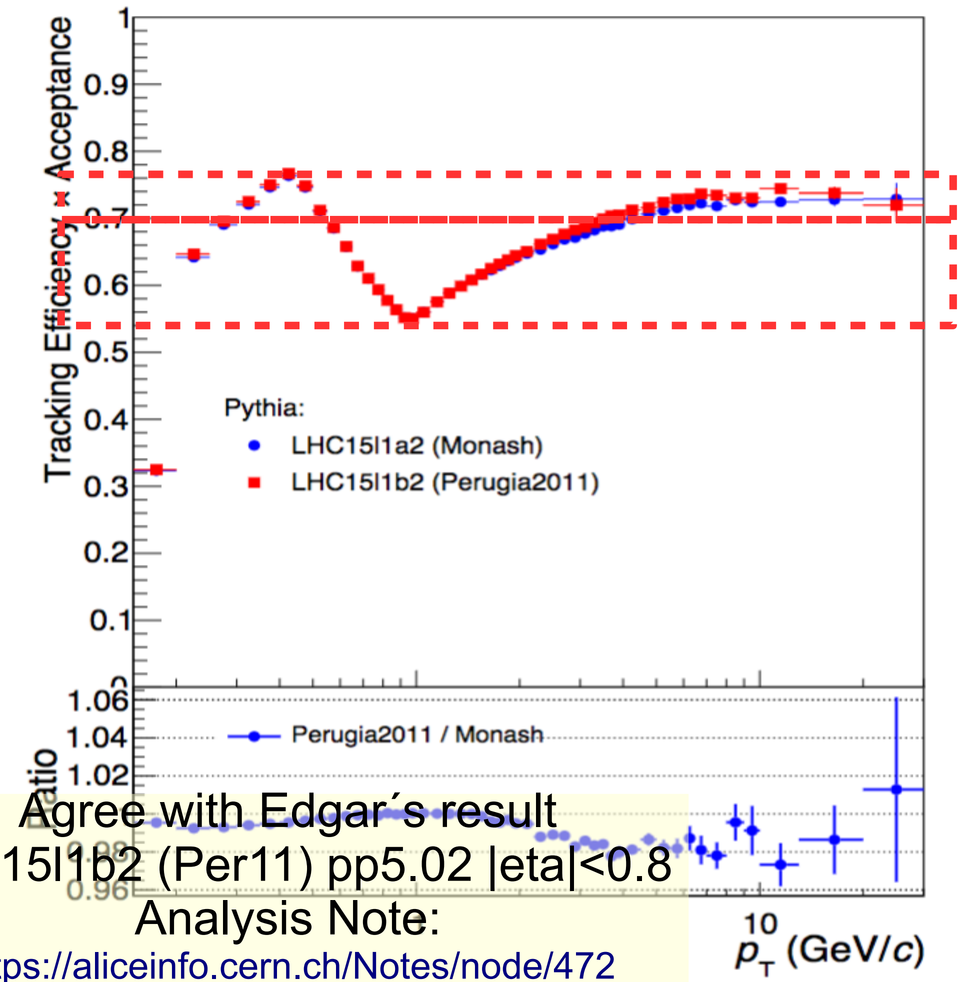
https://aliceinfo.cern.ch/Notes/node/564

• Efficiency & secondaries EPOS-LHC(LHC16d3)

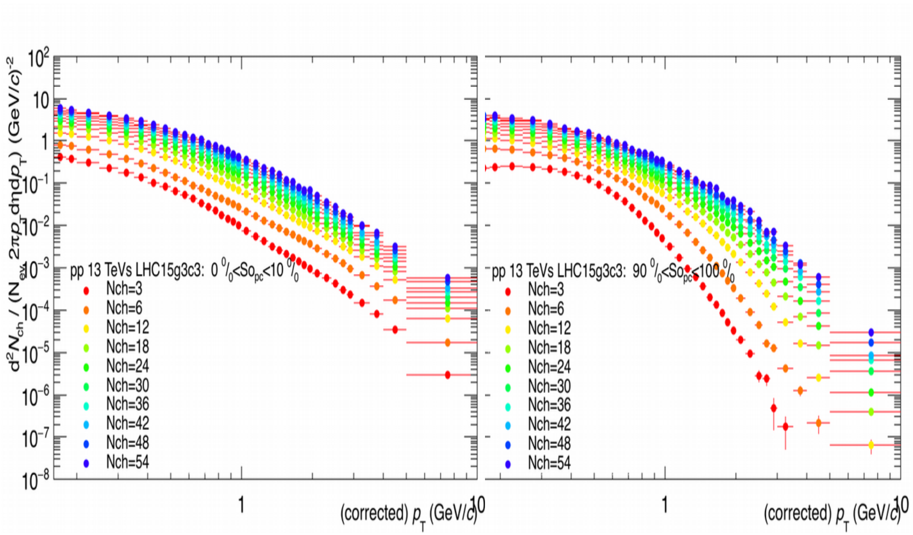


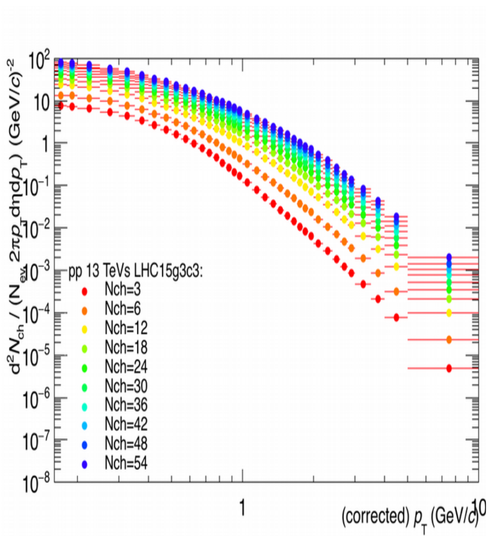


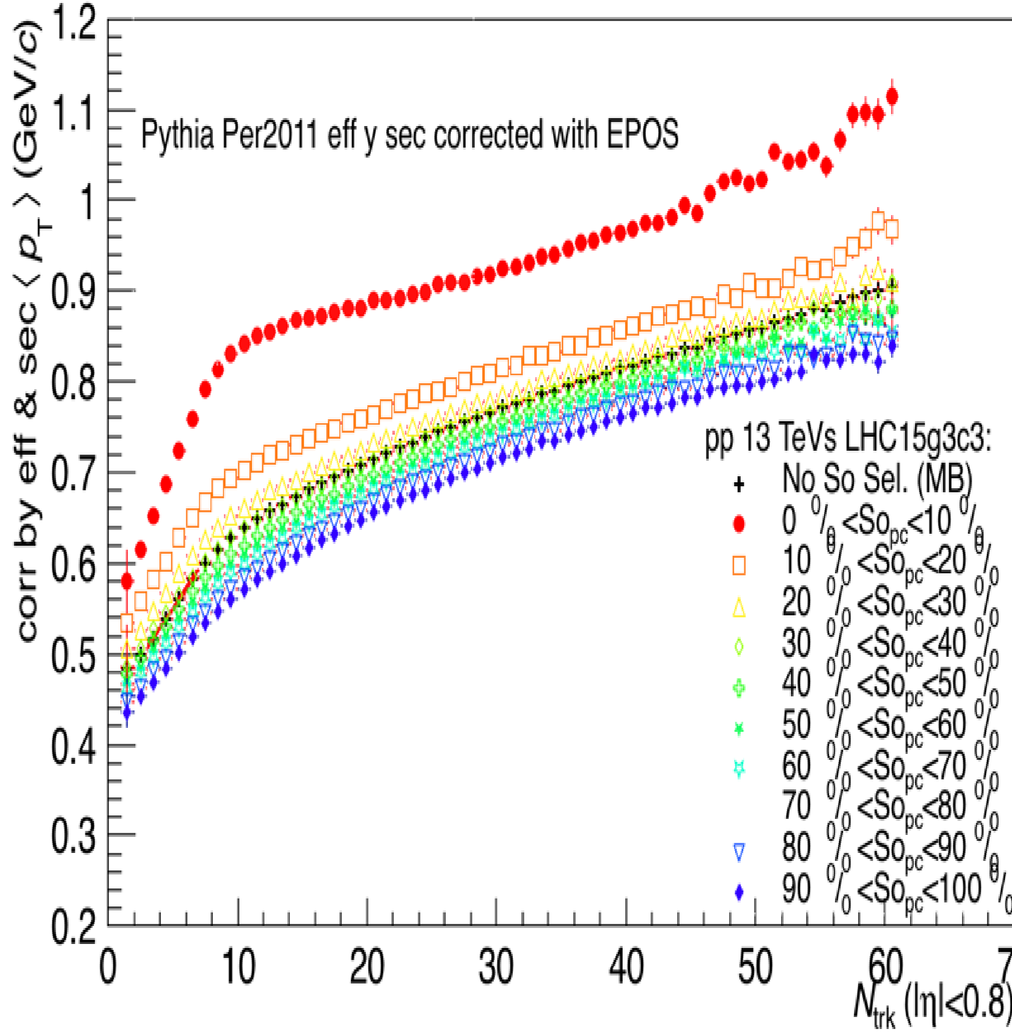
Agree with Edgar´s result
LHC15l1b2 (Per11) pp5.02 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/472

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

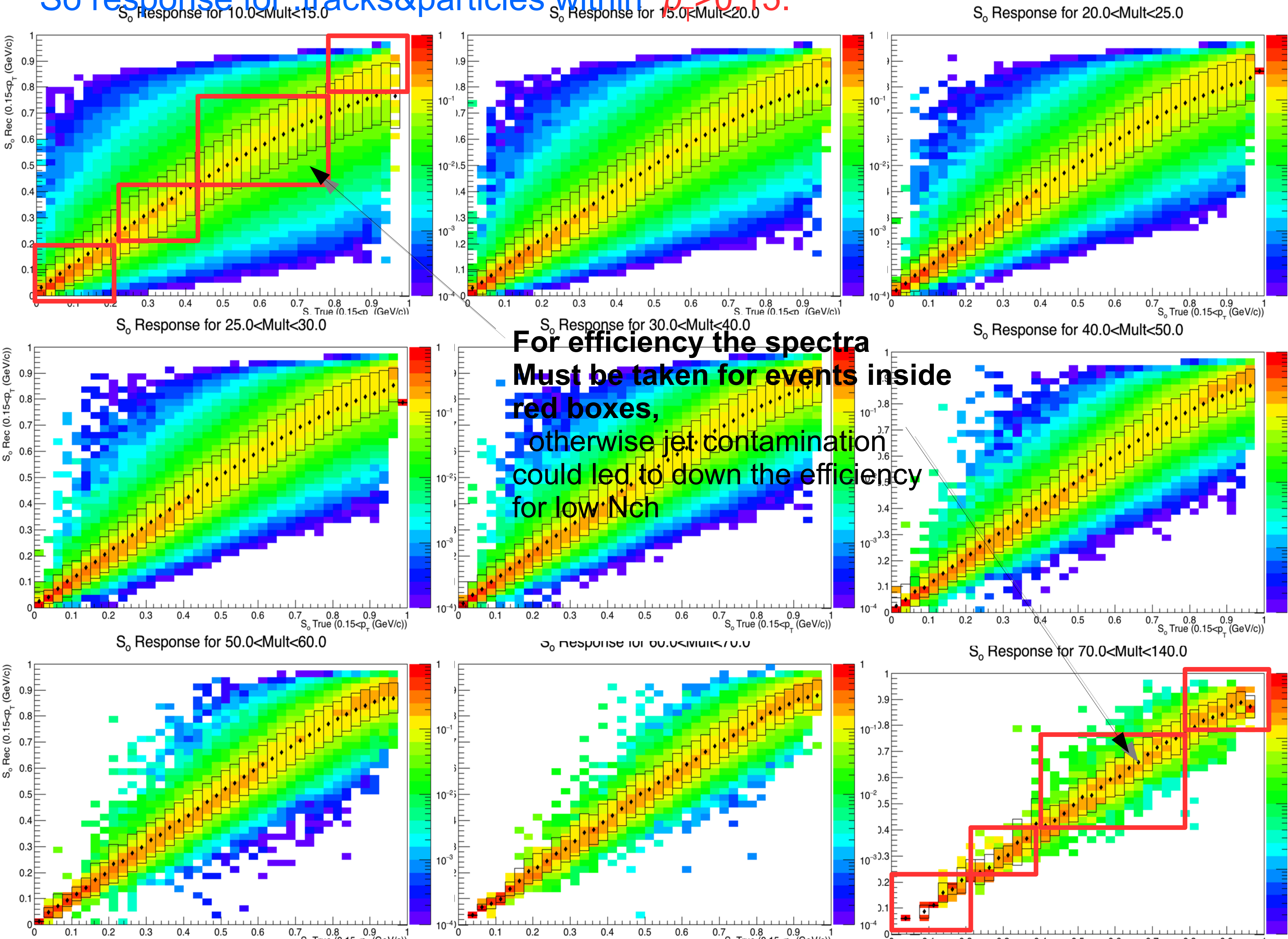
Pythia Per2011 (LHC15g3c3) as data corrected with EPOS-LHC (LHC16d3)







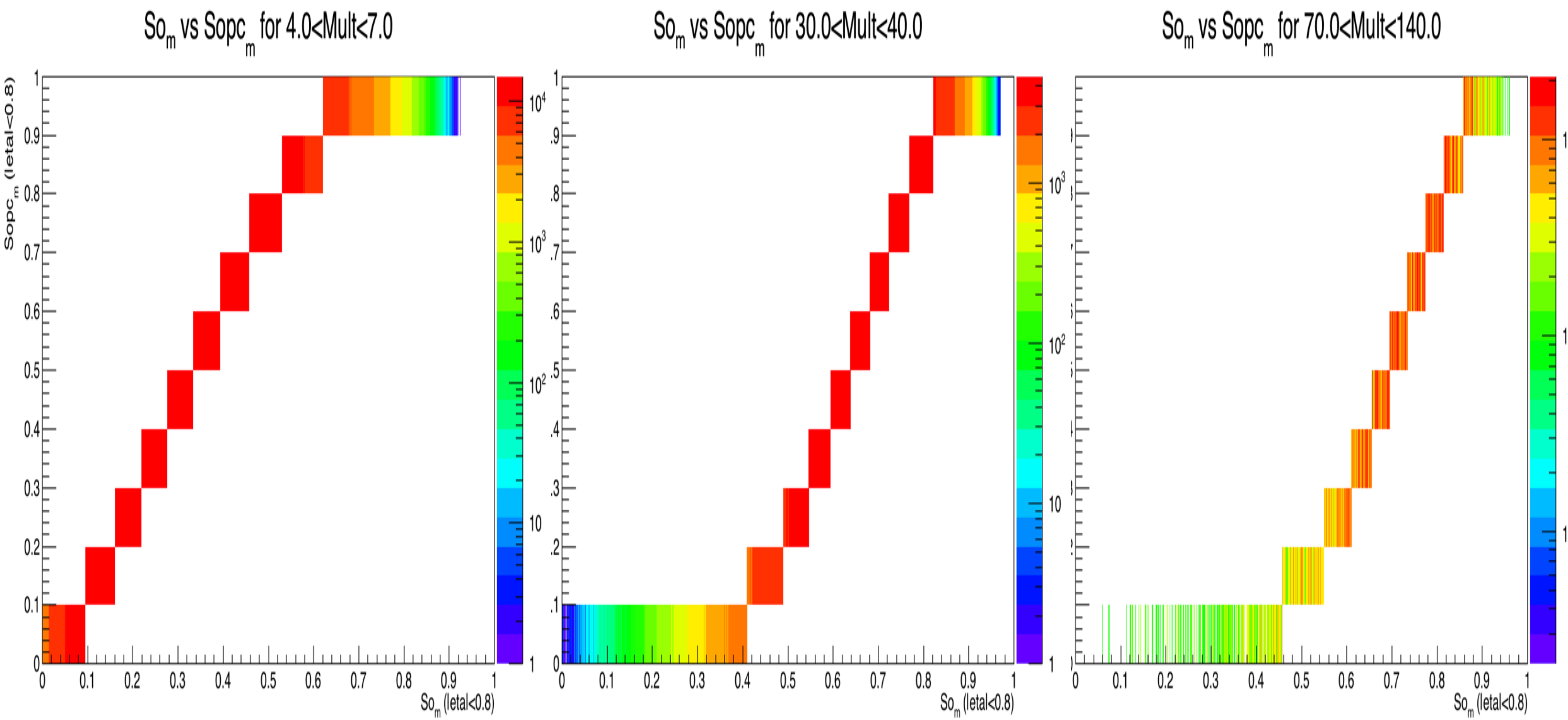
So response for tracks&particles within p_T>0.15.



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

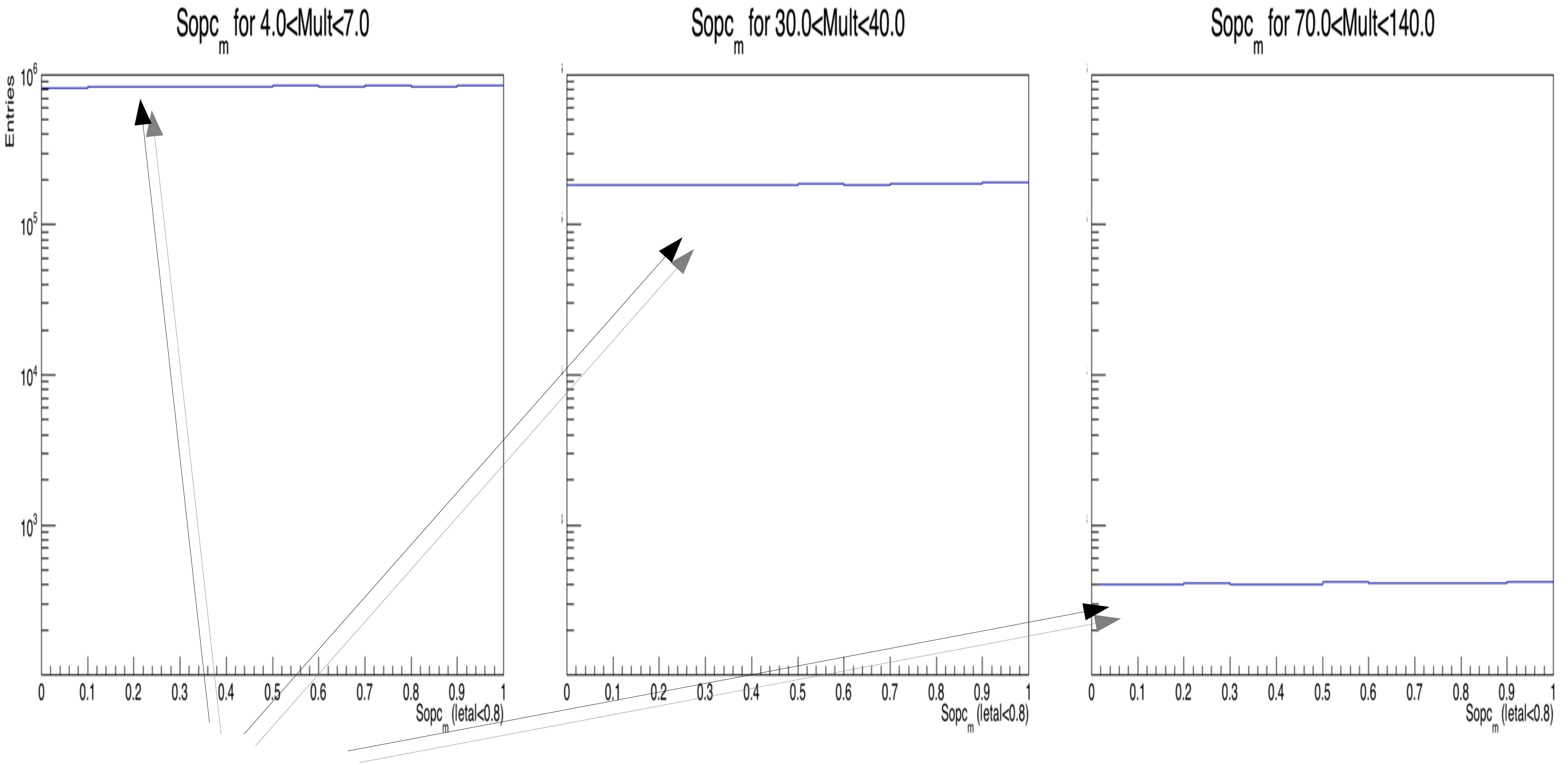
So response (som vs somperc) To GET the Intervals in data for percentiles

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



So response (som vs somperc)

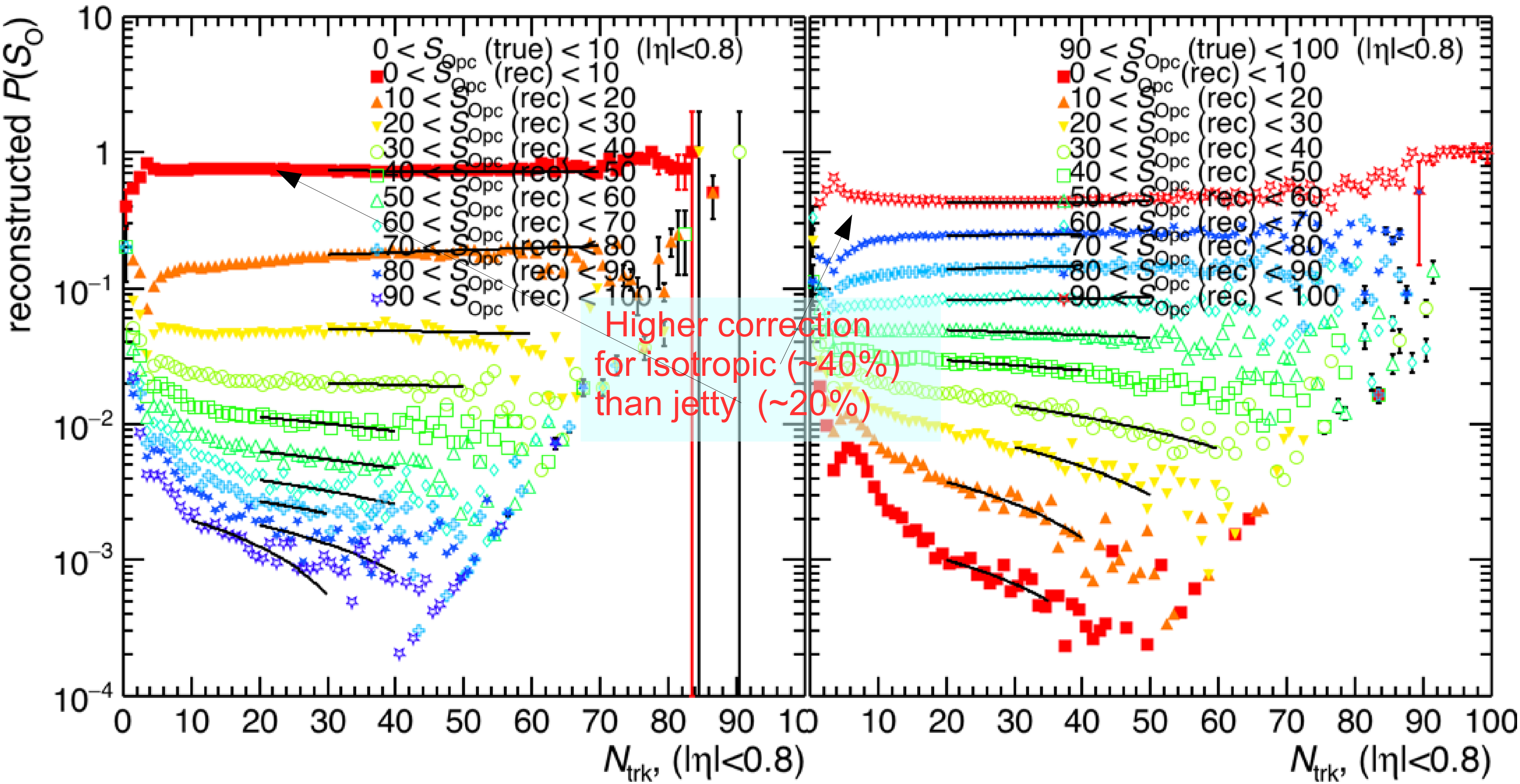
- The idea: to get Soperc response matrix (Sopc_t vs Sopc_m)



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

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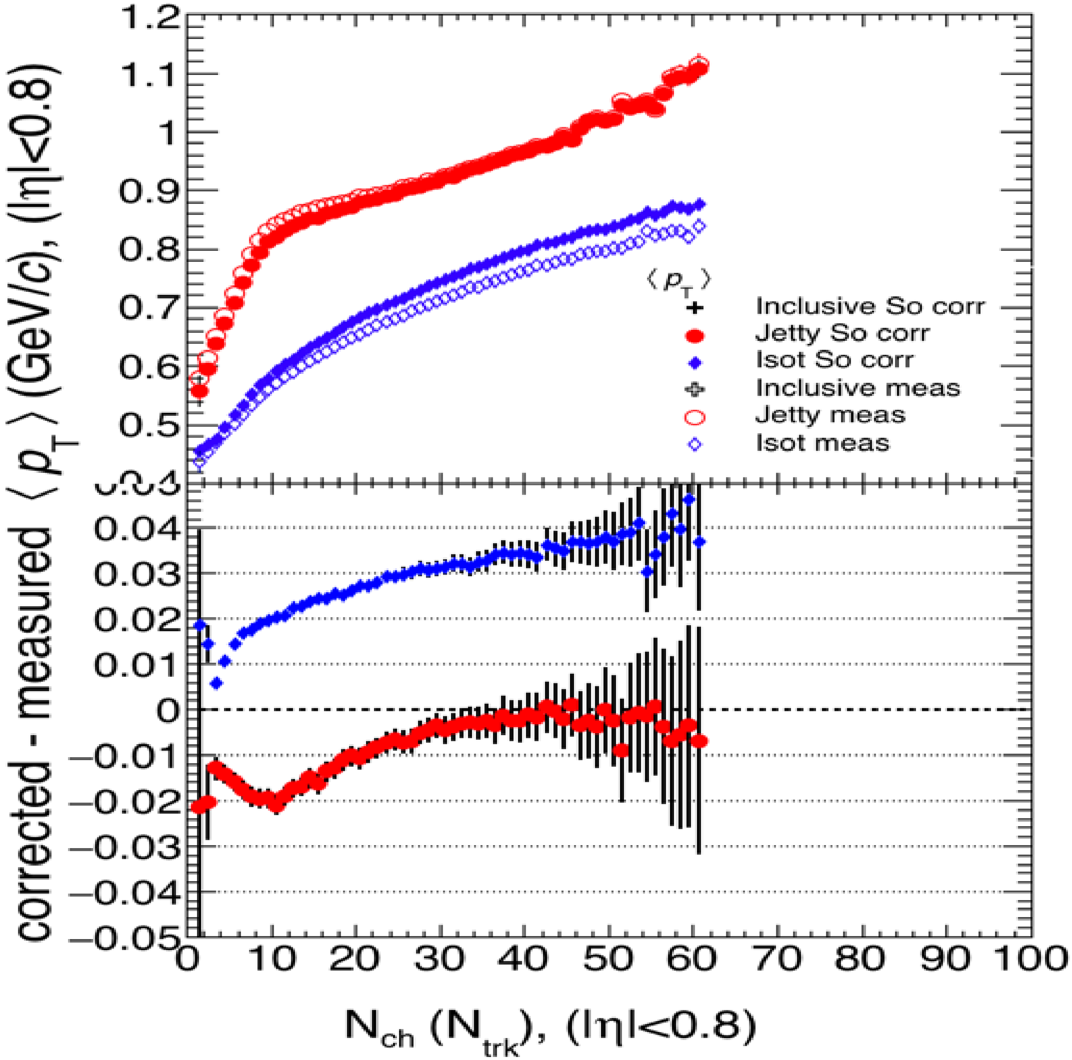
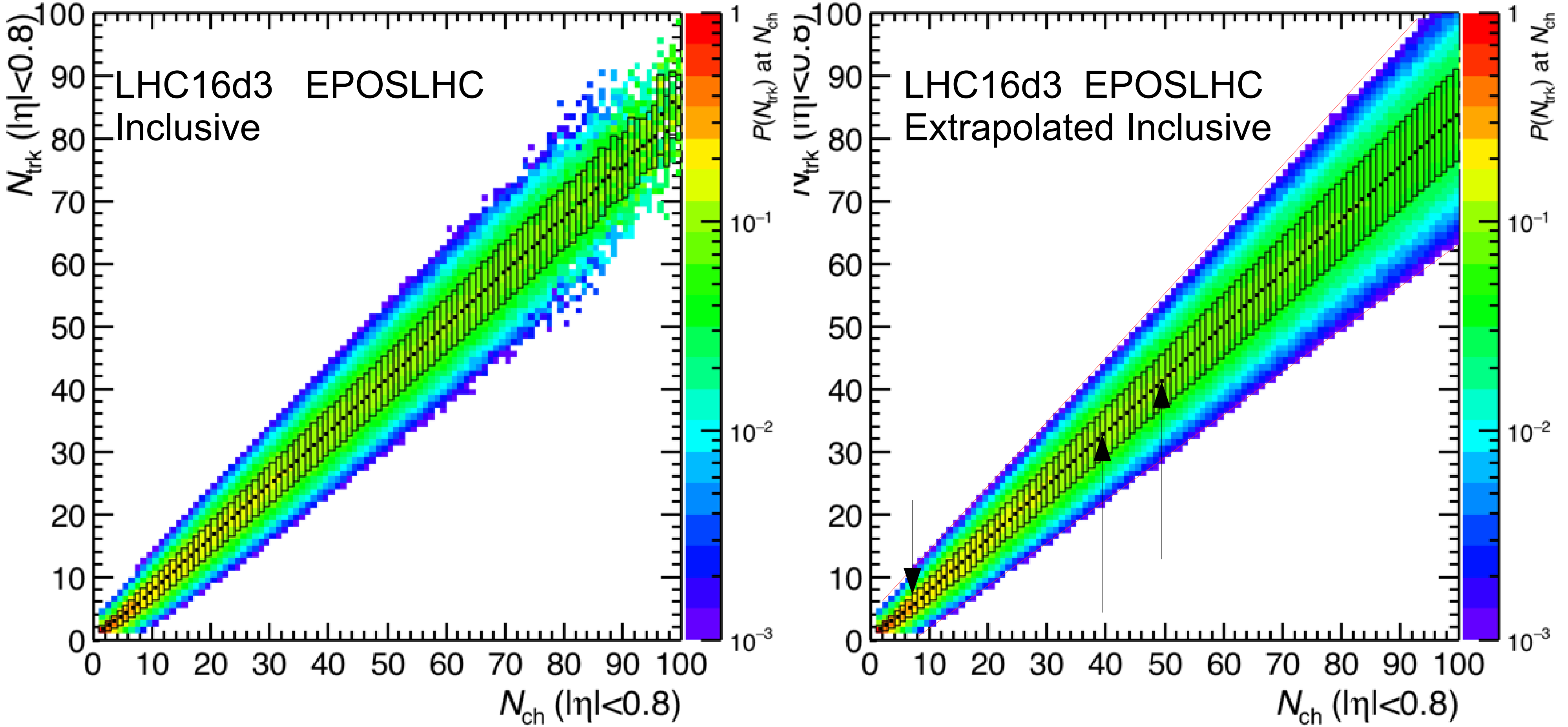


- N_{ch} response matrix to correct by Multiplicity

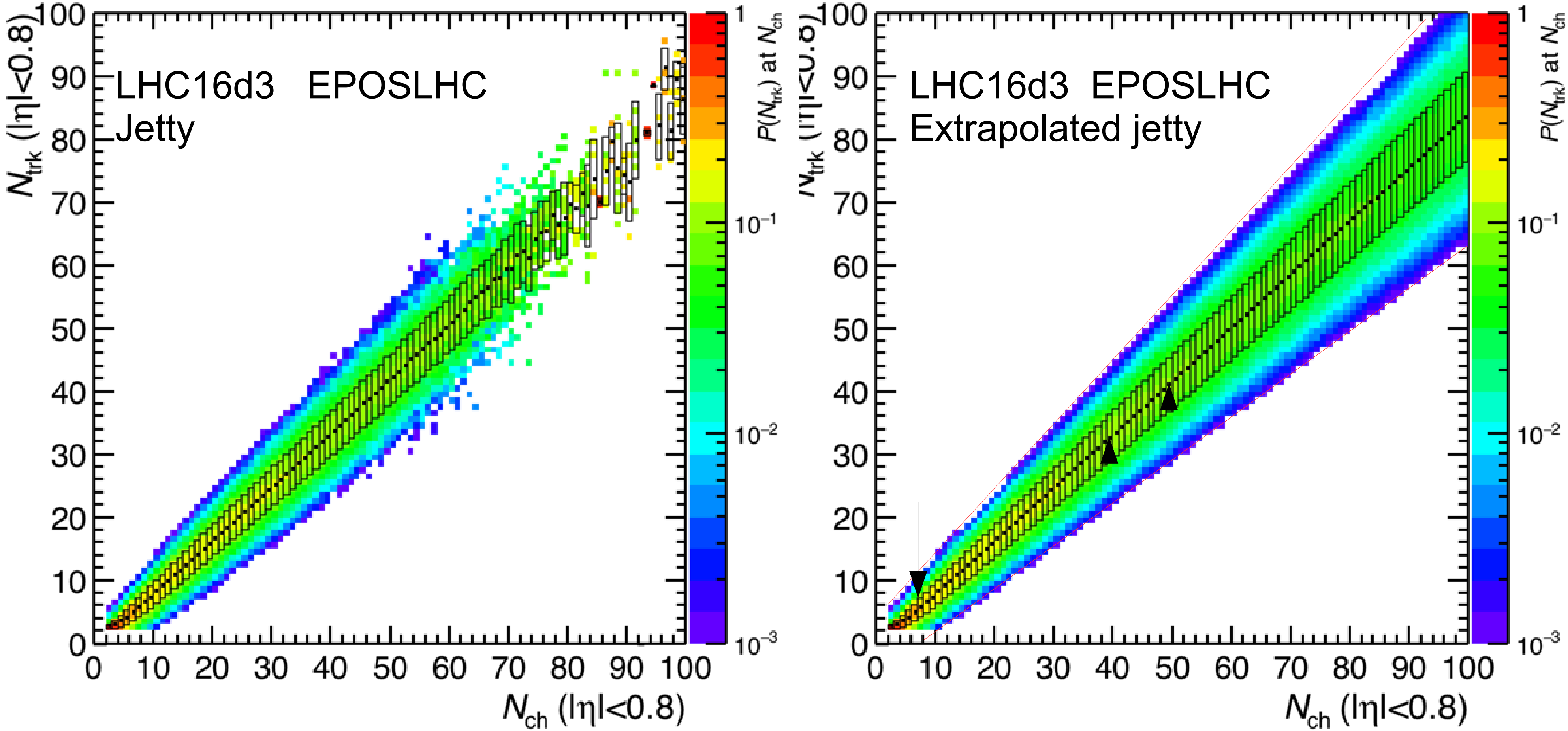
Not extrapolated | Extrapolated



We will use EPOS-LHC fo the correction 4corr

- N_{ch} response matrix to correct by Multiplicity

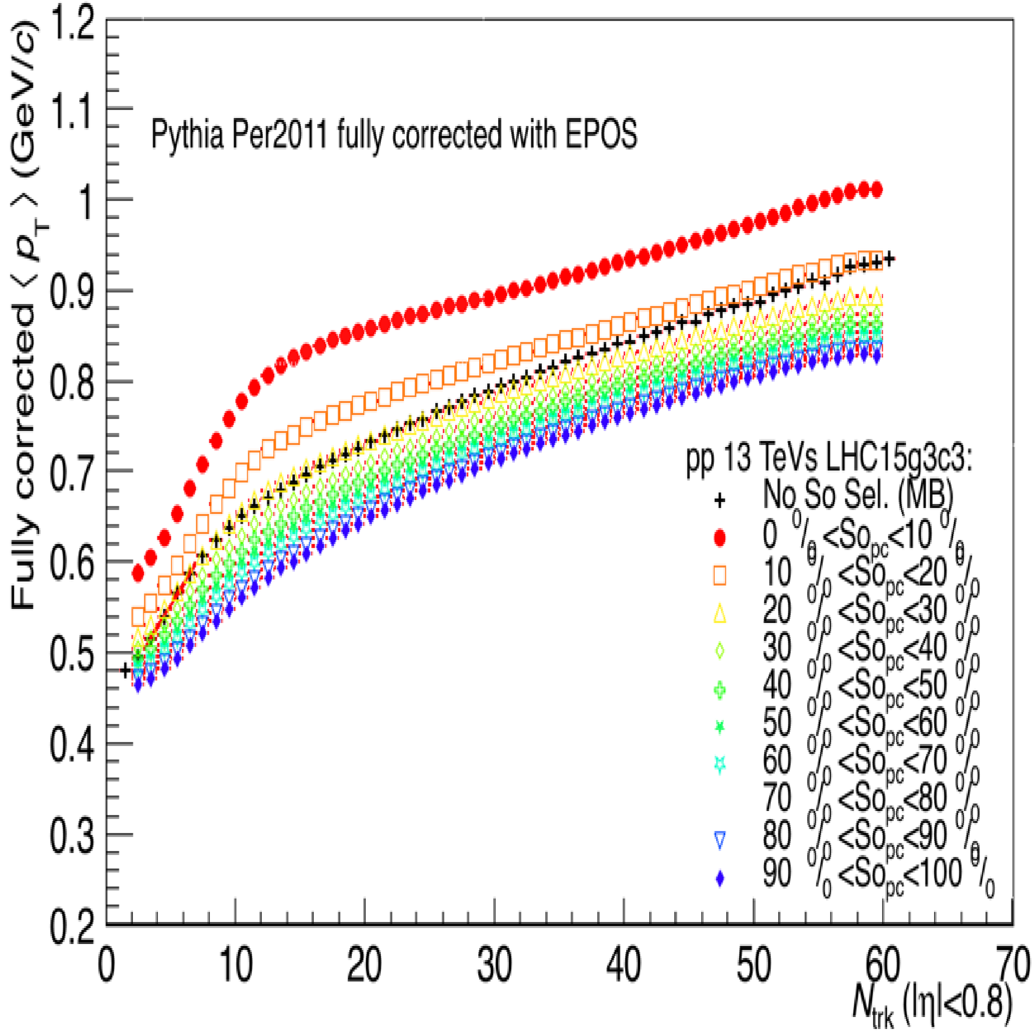
Not extrapolated | Extrapolated



We will use EPOS-LHC fo the correction 4corr

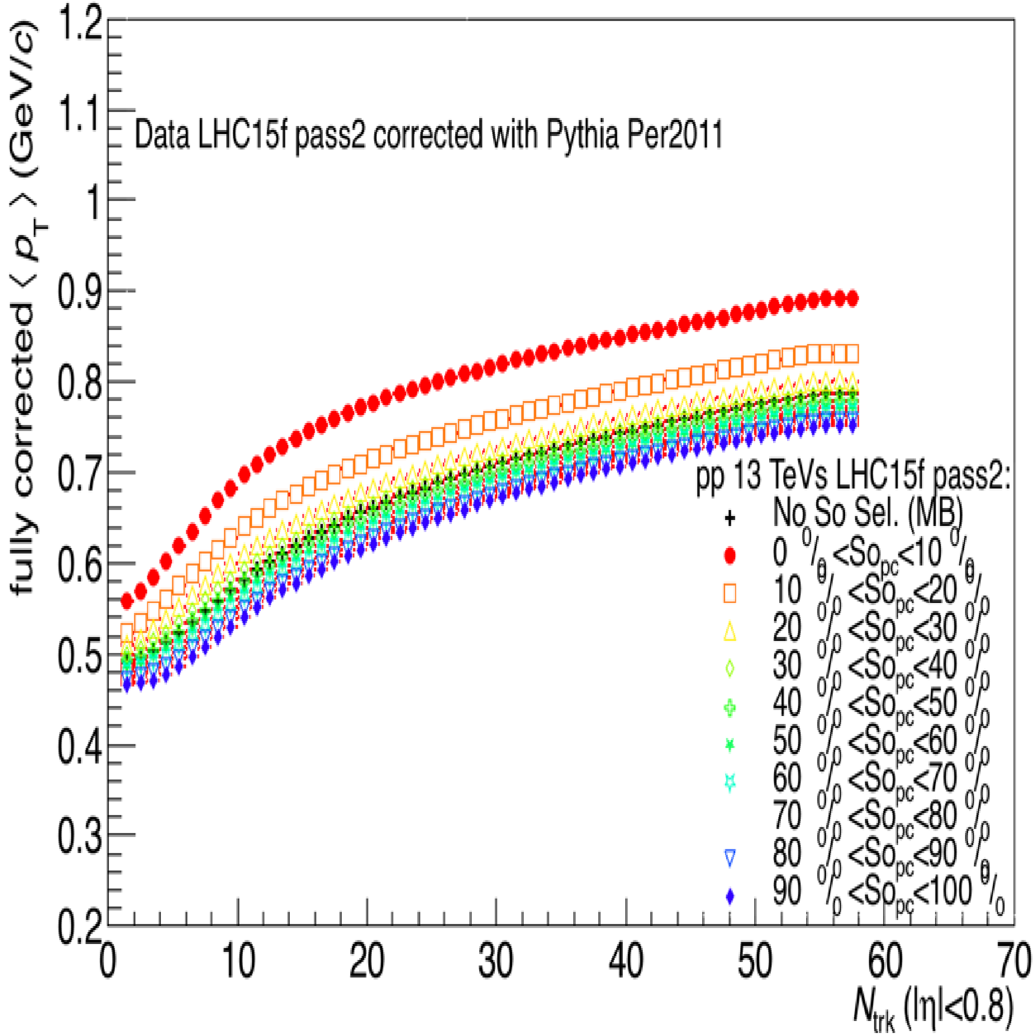
<p_T> vs N_{ch} in different So_{pc} bins for

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

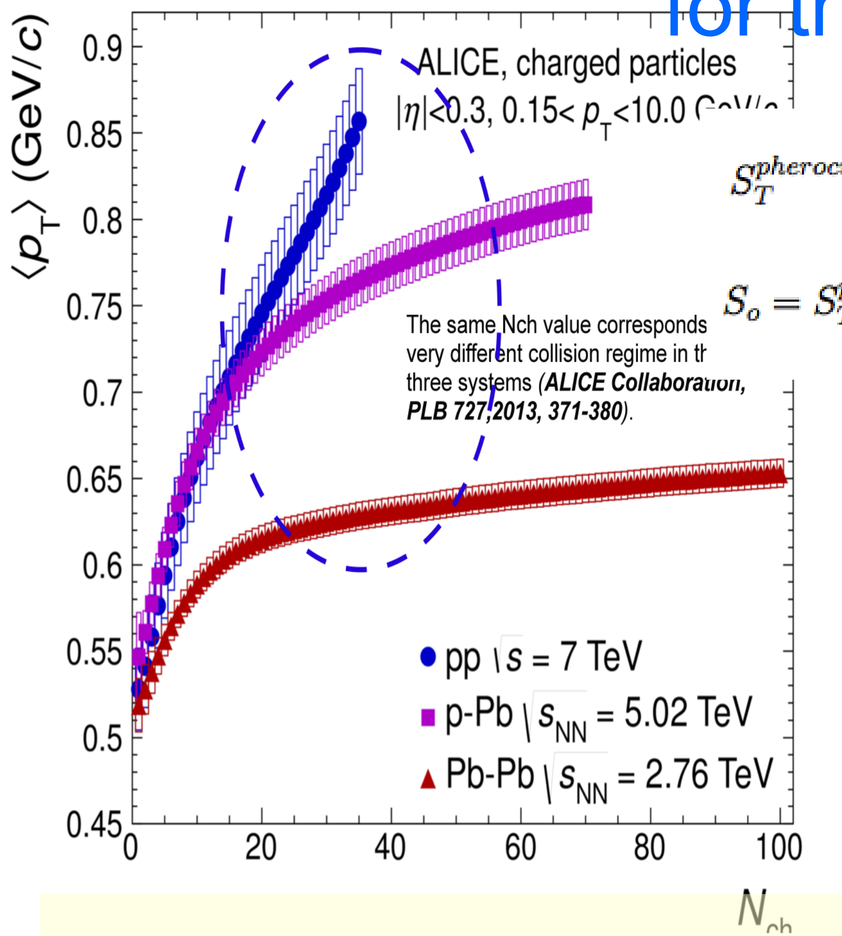


$\langle p_T \rangle$ vs N_{ch} in different So_{pc} bins for

Data (LHC15f pass 2) fully corrected using Pythia Per2011 (LHC15g3c3)



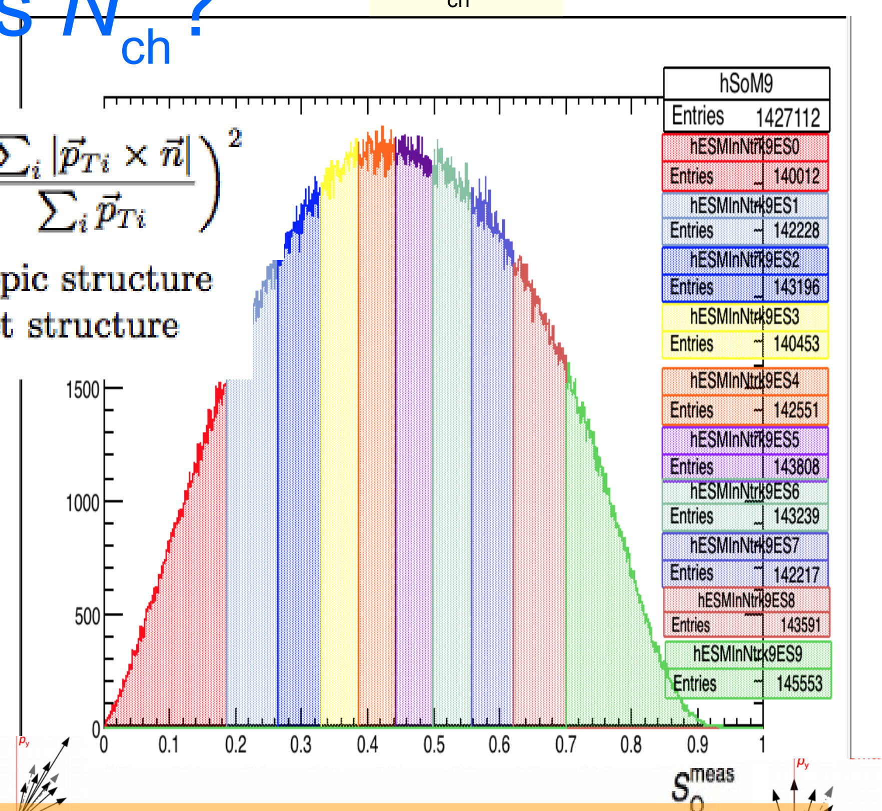
- Why a So analysis with N_{ch} bin=1 and So percentil for the $<p_T>$ vs N_{ch}?



N_{ch}=9

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

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



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

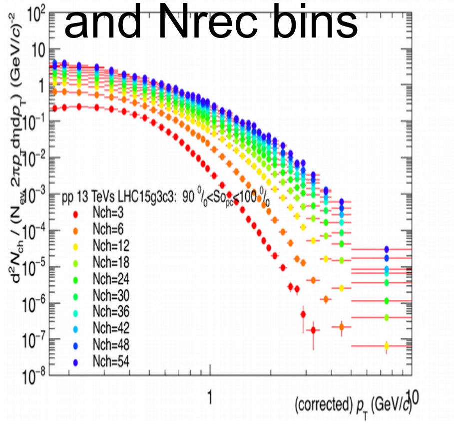
A study with So could help to understand this behaviour

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

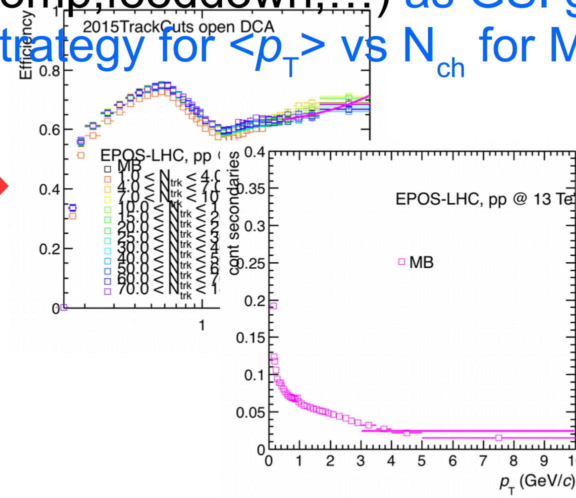
For 13 TeV some results shown don't consider the So percentil binning
https://indico.cern.ch/event/477734/
https://indico.cern.ch/event/437981/

Strategy in MC and data

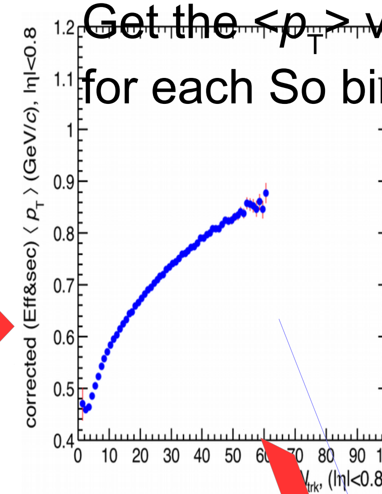
Get spectra in So and Nrec bins



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

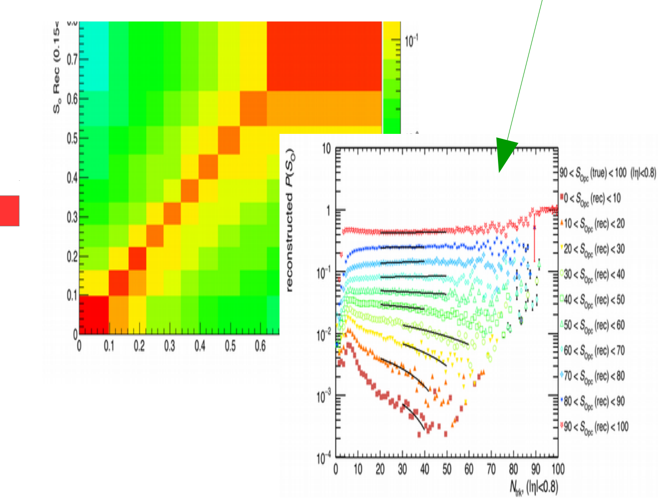


Get the $\langle p_T \rangle$ vs N_{rec} for each So bin



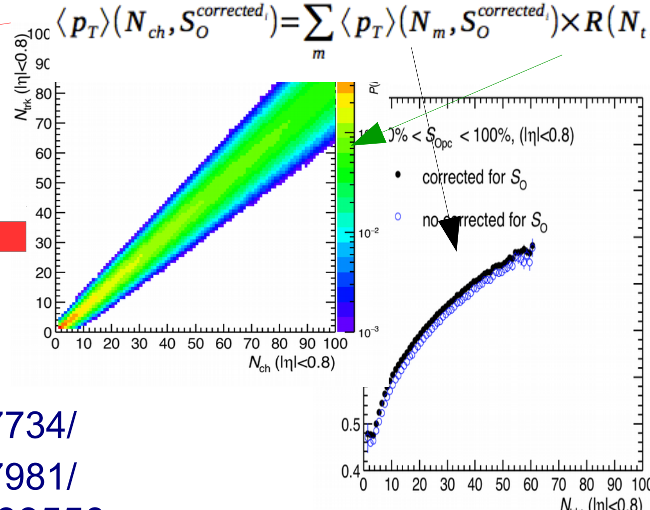
Unfold by Spherocity

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

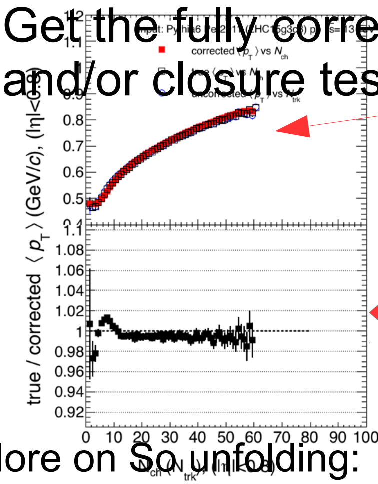


Unfold by Multiplicity

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



Get the fully corrected and/or closure test



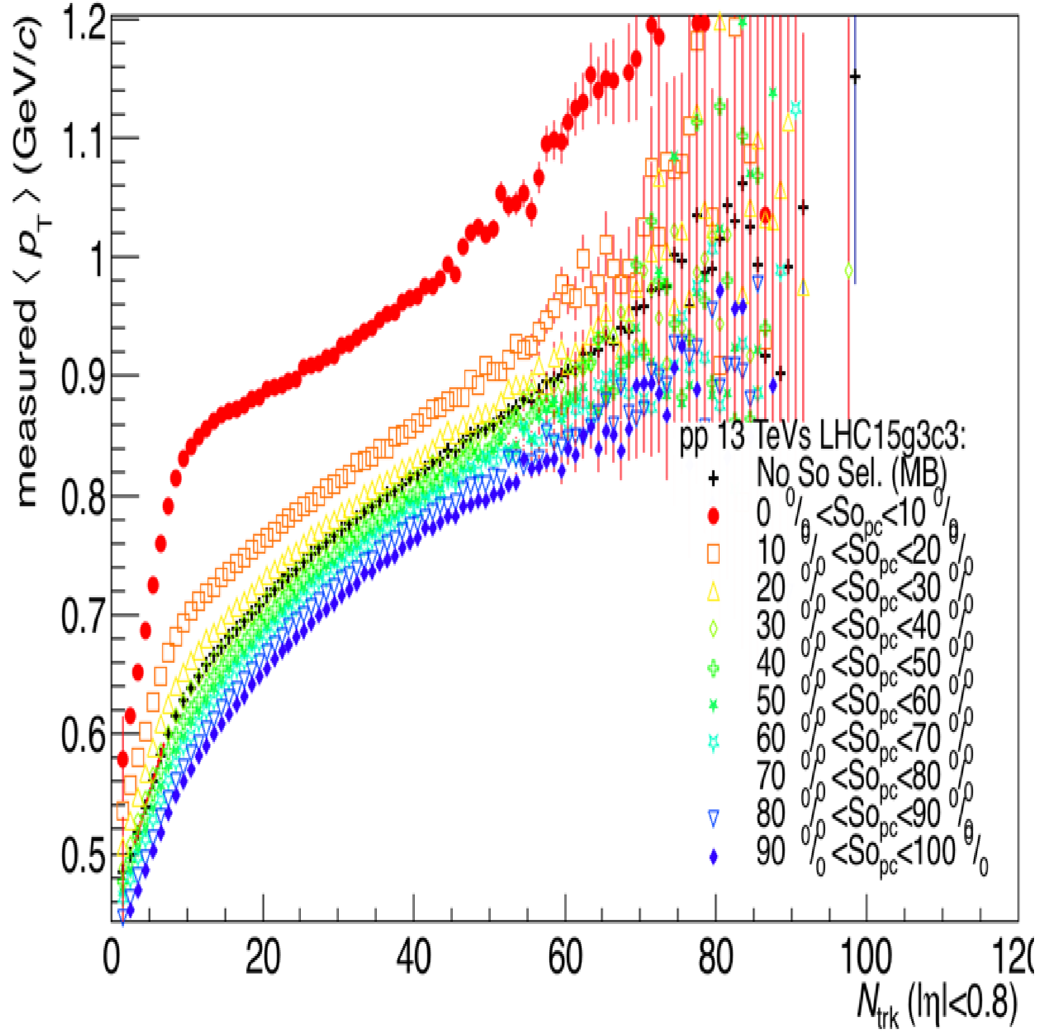
More on So unfolding:

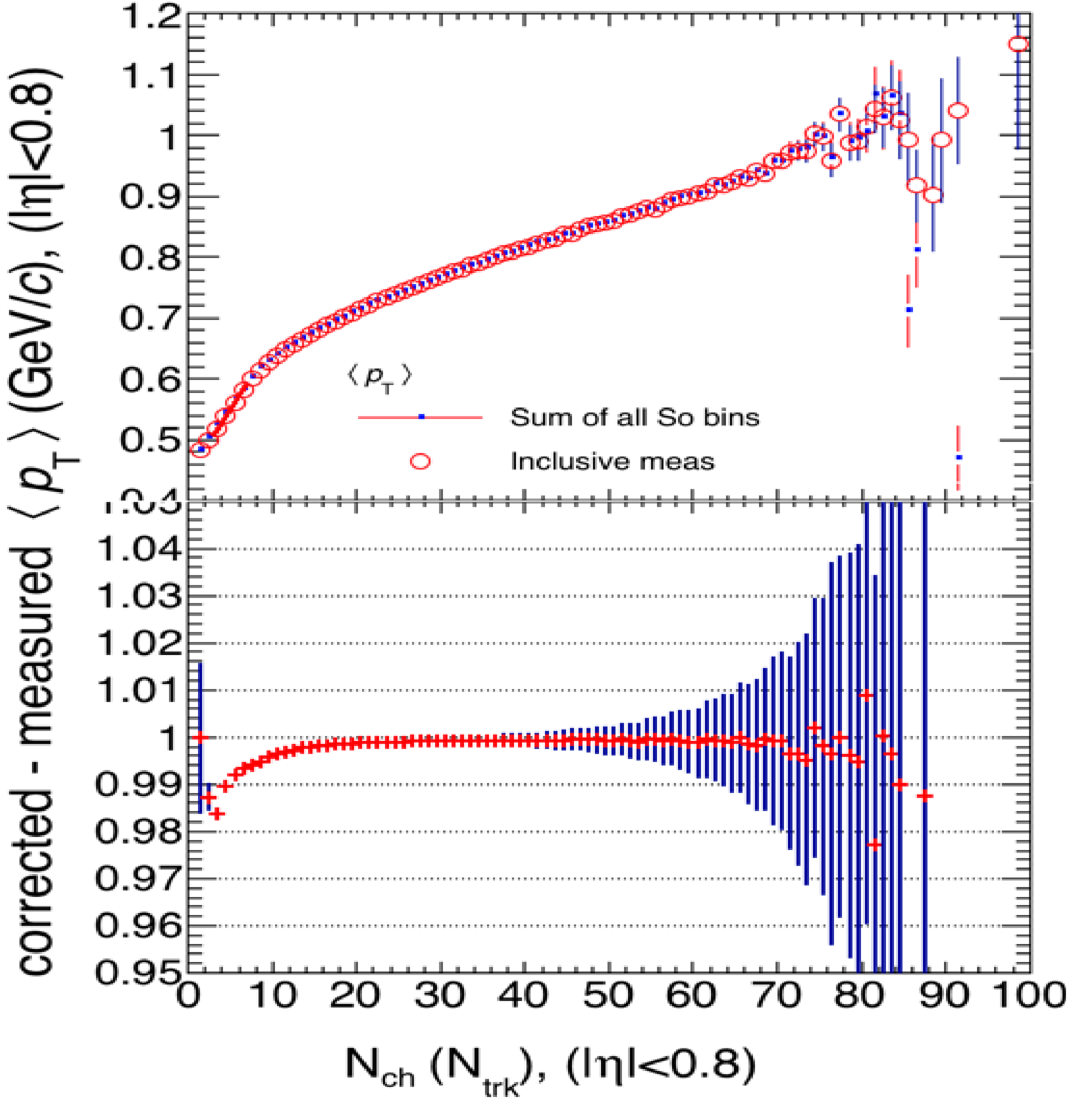
- https://indico.cern.ch/event/477734/
- https://indico.cern.ch/event/437981/
- https://indico.cern.ch/event/339550
- https://indico.cern.ch/event/325445
- https://indico.cern.ch/event/356335/

Hèctor Bello Martinez

<p_T> for different So$_{pc}$ bins **measured**.

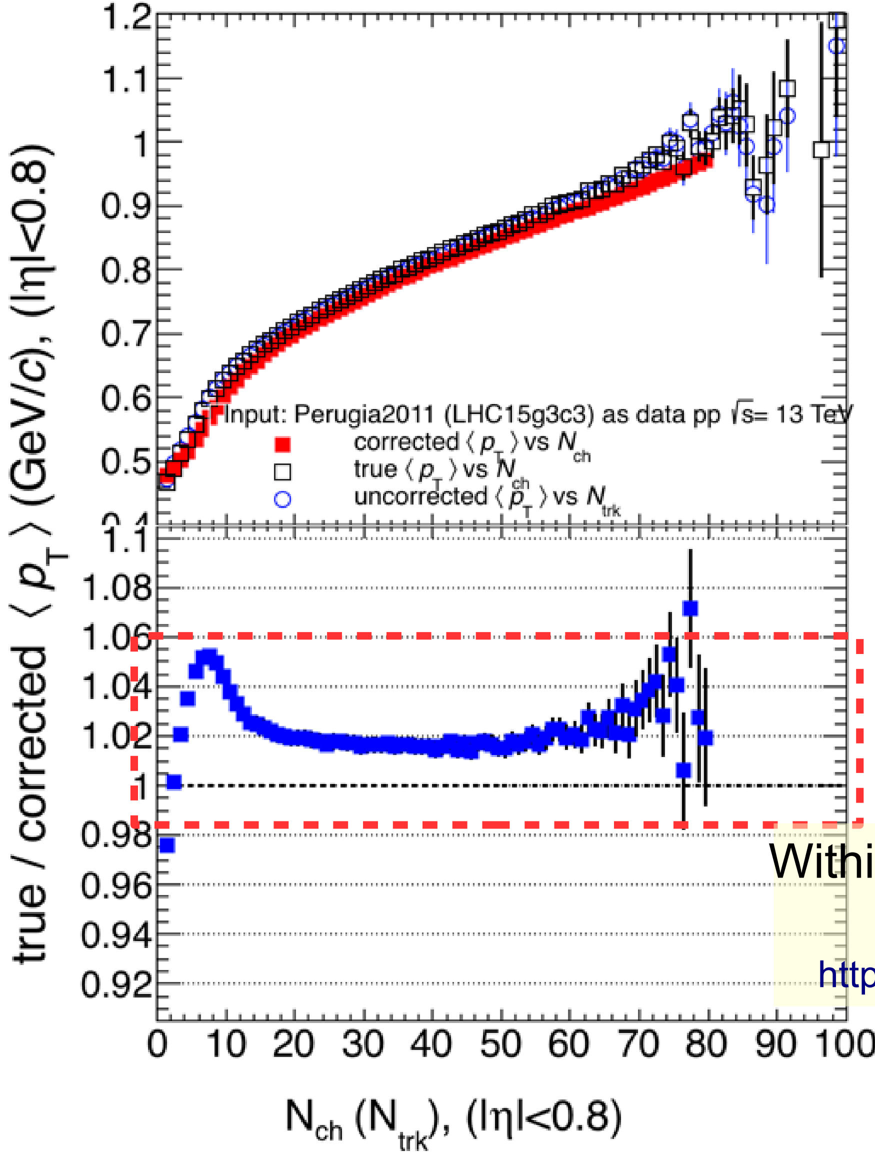
Pythia Per2011 (LHC15g3c3) as data.





Inclusive <p_T> vs N_{ch} Unfolded (corr. by N_{ch})and closure test.

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



For multiplicity correction we based on:

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

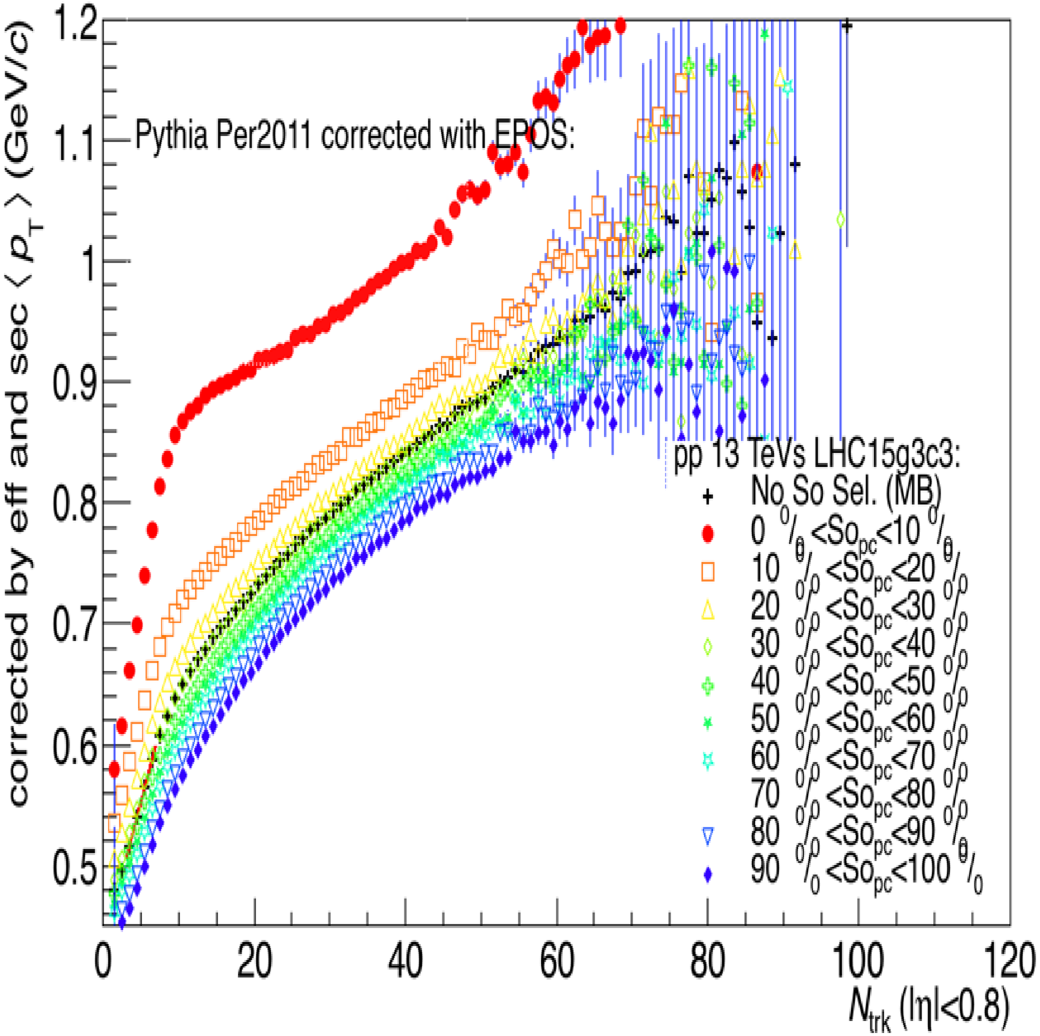
where, R is the multiplicity response matrix.

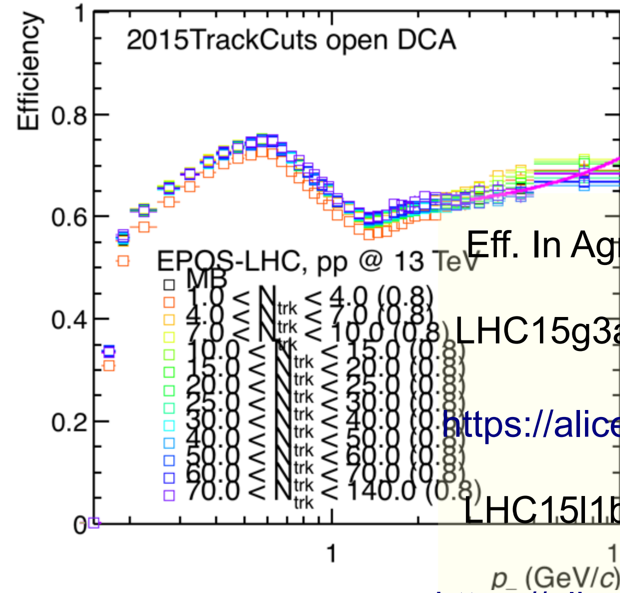
- Correc: Per2011 ESD corr with EPOS-LHC
- True: Per2011 MC
- Unc: Per2011 ESD

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

$<p_T>$ for different So_{pc} bins **efficiency and secondaries corrected**.

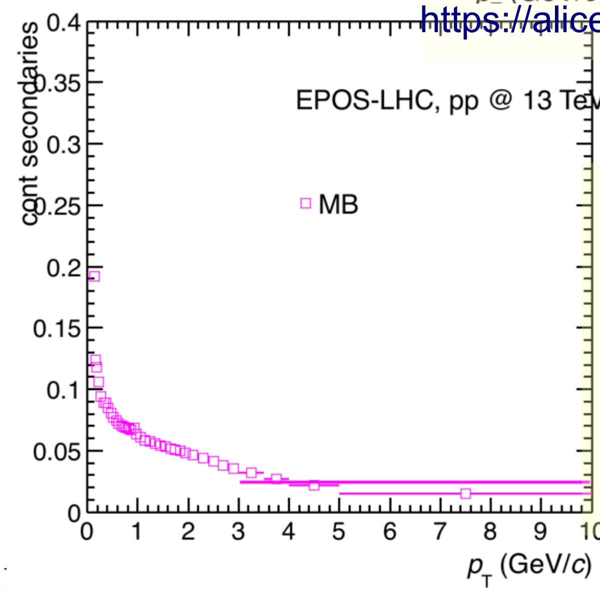
Pythia Per2011 (LHC15g3c3) as data corrected with EPOS-LHC (LHC16d3)





Efficiency indep of So
(see Vytautas talk)
(Using V0M the auto correlations are destroyed)

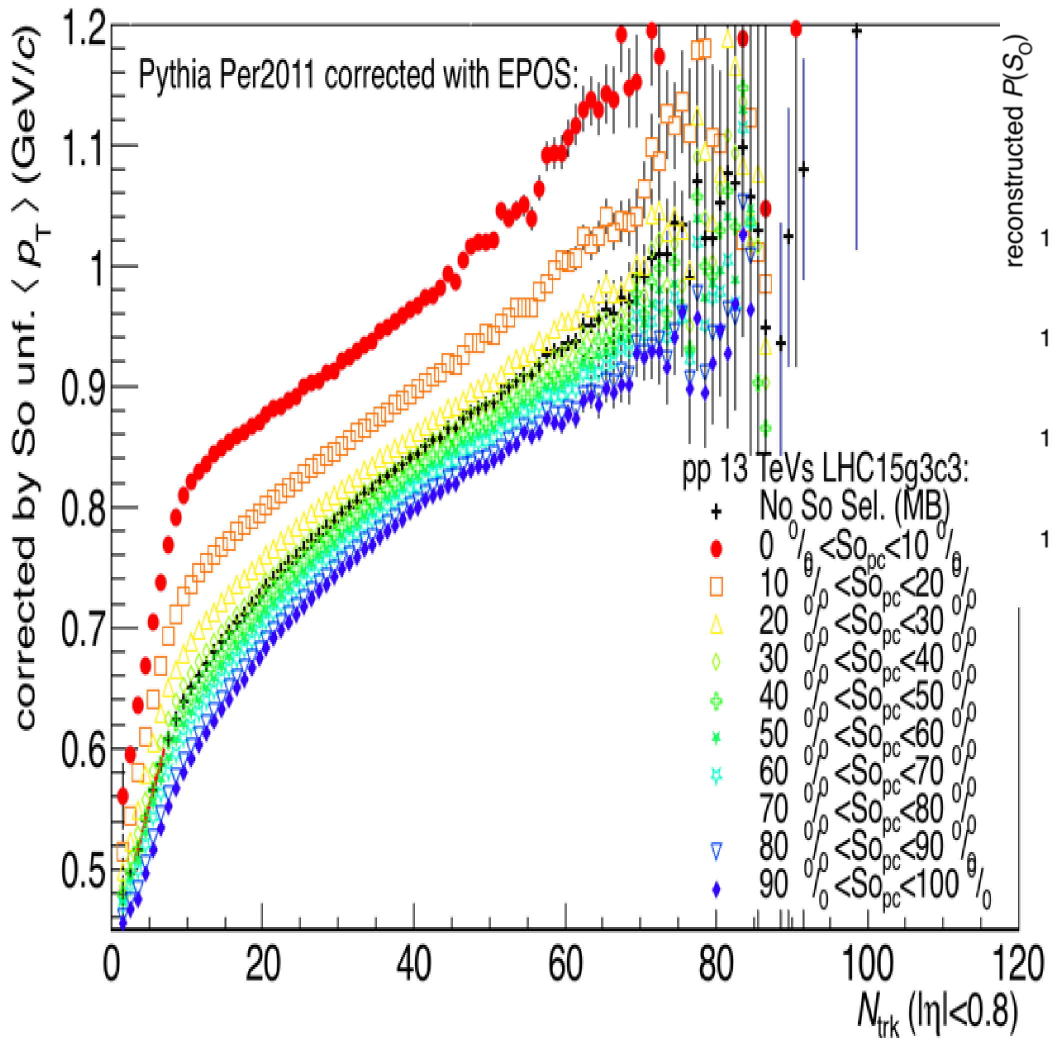
Eff. In Agreement with (See backup):
Sergio´s result
LHC15g3a3 (Monash) pp13 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/56
Edgar´s result
LHC15l1b2 (Per11) pp5.02 |eta|<0.8
Analysis Note:
https://aliceinfo.cern.ch/Notes/node/472

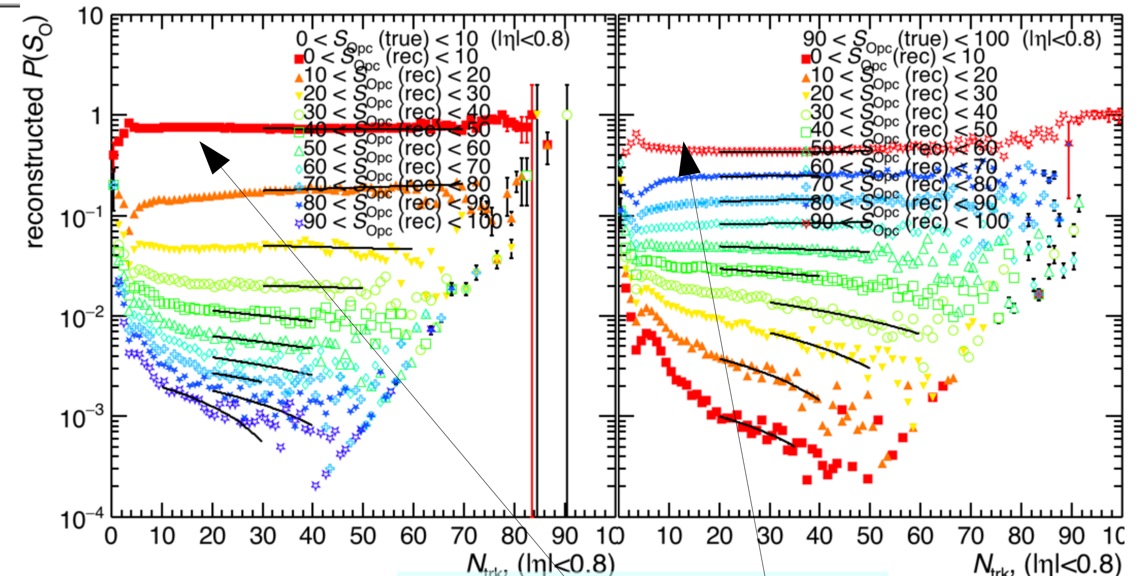


For the secondaries only a test with MC has done
For data a more elaborated analisys must be done (particle composition, feed-down corrections …) like GSI analysis for inclusive $<p_T>$ vs N_{ch}

$\langle p_T \rangle$ for different So_{pc} bins **corrected by Spherocity Unfold .**

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



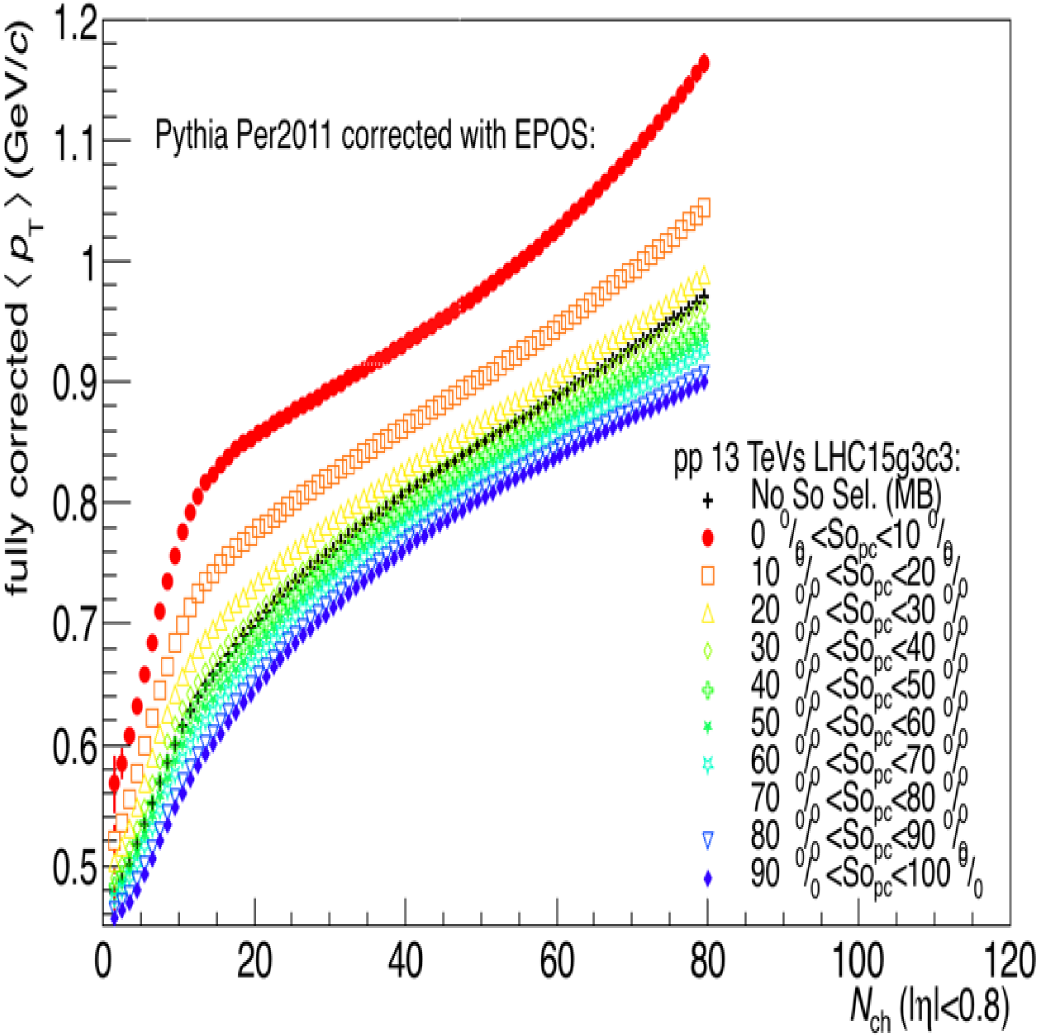


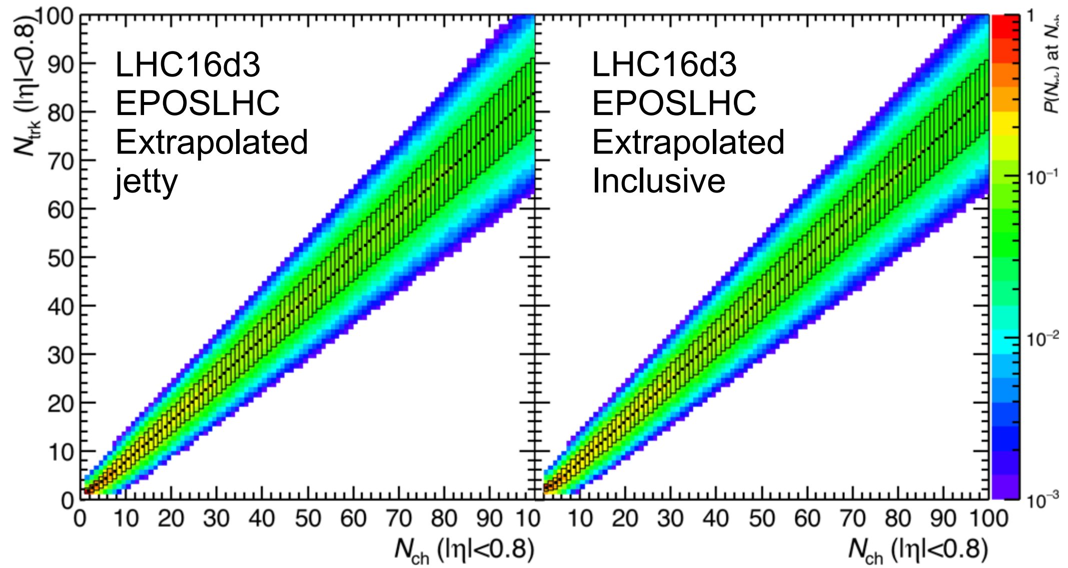
Higher correction
for isotropic (~40%)
than jetty (~20%)
(Big plots in backup)

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

$\langle p_T \rangle$ for different So_{pc} bins **fully corrected (So Unf + Nch Unf)**.

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





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

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

<pT (Socorr,Nchcorr) > UNFOLDED by Nch CLOSURE TEST

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

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