

Proton-Proton collisions at 7 and 13 TeV: Comparison of data in terms of global observables

**By
Samrangy Sadhu
VECC, Kolkata**

High energy pp collisions at LHC

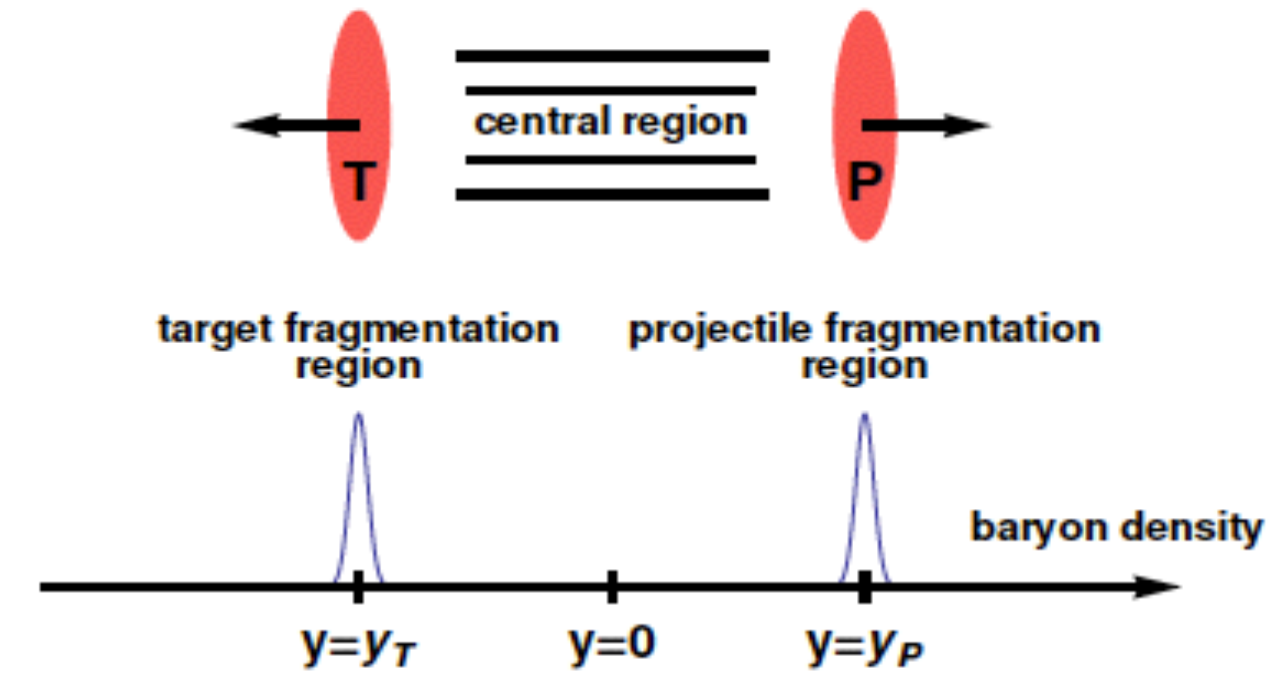
- **Experimental study of High Energy Physics has reached a new height at LHC, the Large Hadron Collider.**
- **Beside the center-of-mass energy per nucleon pair reaching 2.76 TeV in relativistic heavy-ion collisions to study the nuclear matter at extreme condition of high energy-density, the pp collisions (up to 7 TeV) also have shown some unexpected results.**
- **Understanding of pp collisions data is, therefore, not just a requirement for understanding the heavy-ion data, but demands more attention by its own rights.**
- **The experiments at LHC have recorded and analyzed data of pp collisions at center-of-mass energy: 0.9, 2.36, 2.76, 7.0 and 8.0 TeV. New analysis for pp collisions at 13 TeV is on.**
- **With the aim of analyzing high multiplicity pp events, for deciding on high multiplicity trigger estimation, we have started comparing the minimum bias data at 7 and 13 TeV, in terms of **global observables**.**

Global Observable: Multiplicity Distribution

- ◆ **The Multiplicity distribution in high energy collisions refers to the probability distribution $P(n)$ of production of n particle from collisions.**
- ◆ **The Multiplicity distribution has been the premier of basic observables, characterizing the final states of multiparticle production process in high energy physics experiments since the beginning of such studies.**

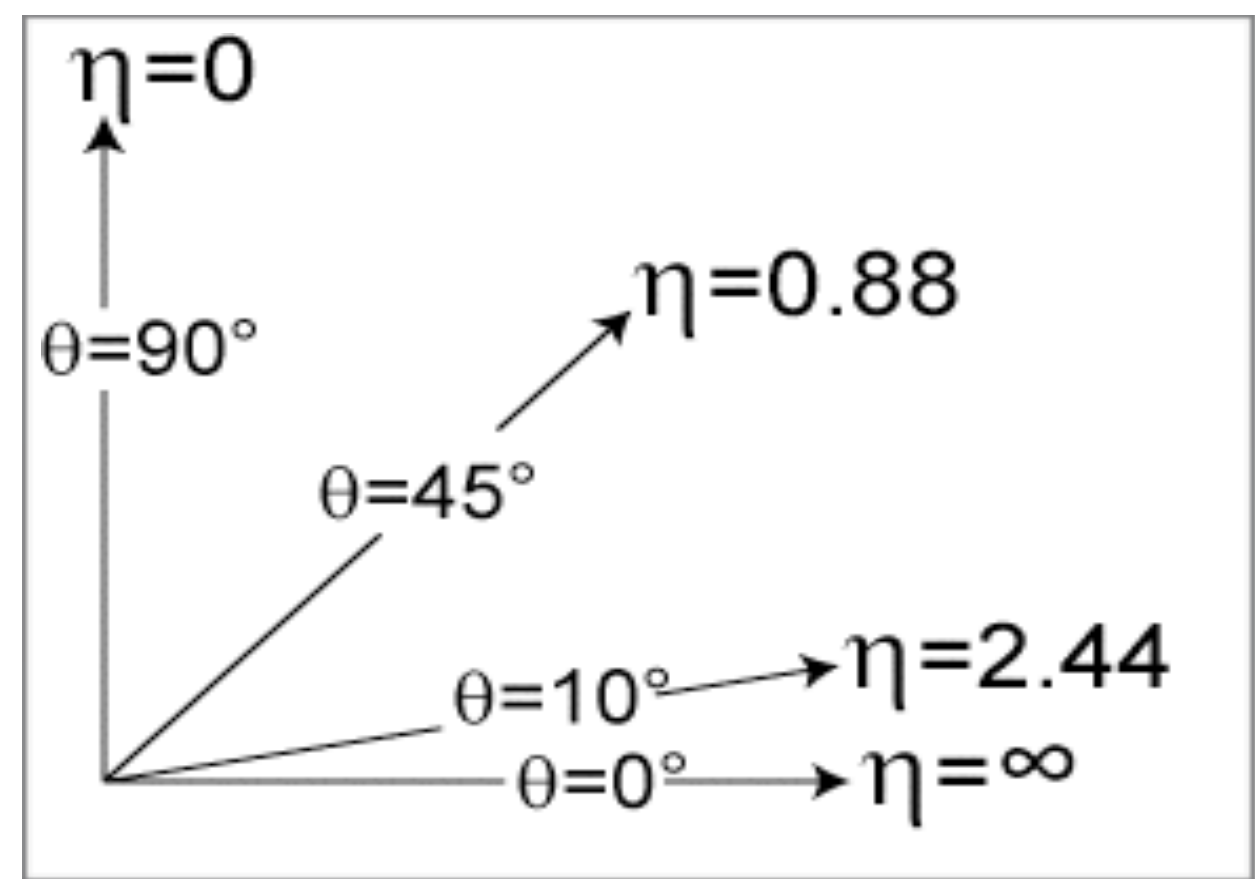
Global Observable: Pseudorapidity Distribution

“rapidity”: $y = 1/2 \ln [(E+p_z)/(E-p_z)]$



pseudorapidity

$$\eta = \frac{1}{2} \cdot \ln \frac{(1+\cos\theta)}{(1-\cos\theta)} = \ln \frac{\cos(\theta/2)}{\sin(\theta/2)} = -\ln \left(\tan \frac{\theta}{2} \right)$$



Global Observable: Invariant Yield

$$E \frac{d^3\sigma}{dp^3} = A \exp(-ap_T)$$

For identified particles, the invariant differential yield in terms of transverse mass can be described by exponential functions:

$$E \frac{d^3N}{dp^3} \propto \frac{1}{e^{m_T/T} - 1}$$

or simply exponential of the form:

$$E \frac{d^3N}{dp^3} \propto e^{-m_T/T}$$

T is called the inverse slope parameter and it is usually connected with the temperature of system formed in heavy-ion or pp collisions.

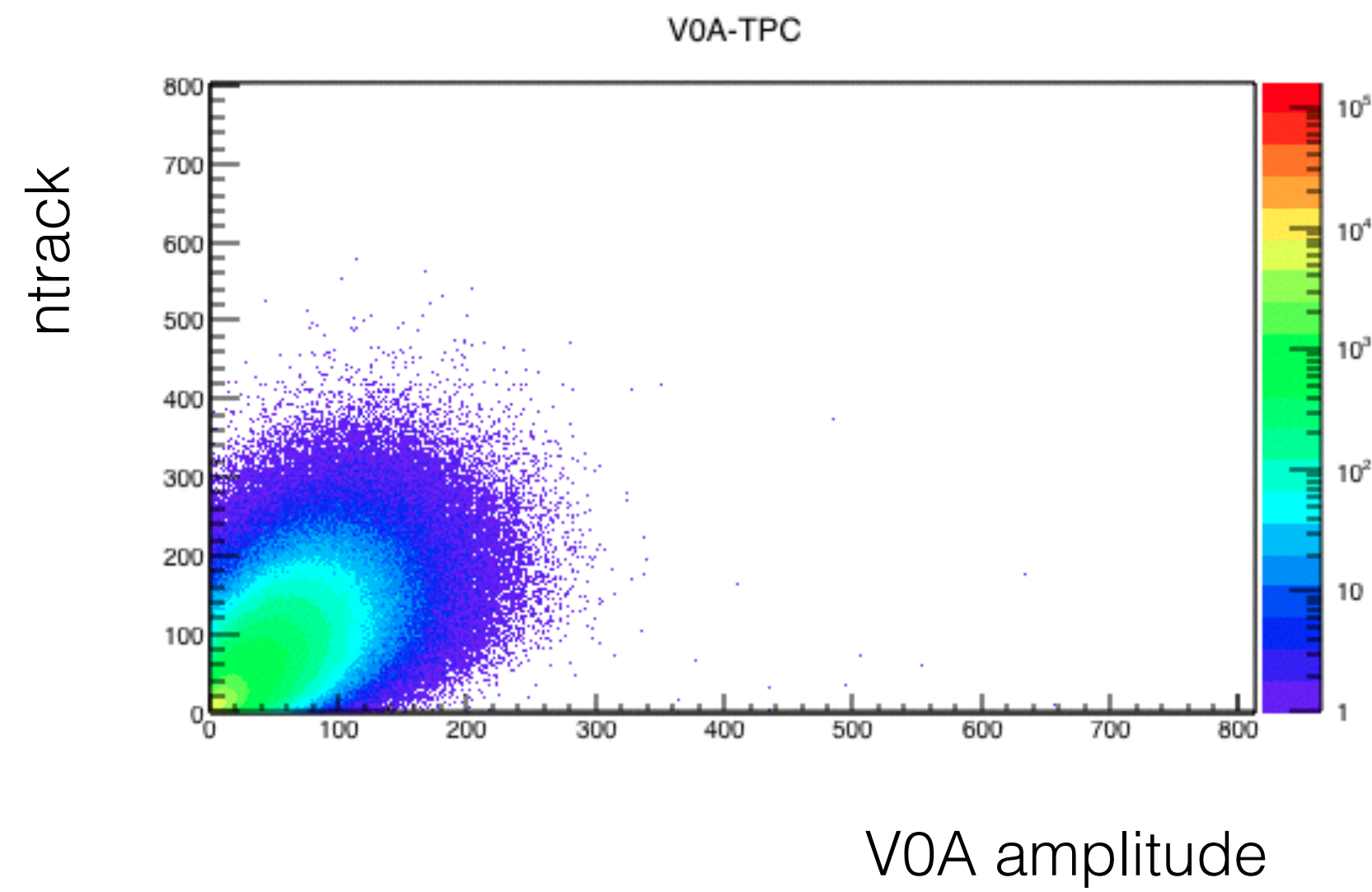
ALICE Setup

- **Several component-detectors of the ALICE setup covers different acceptance and detect different kinds of particles.**
- **The **charged particles** in the mid-rapidity region is mainly detected with the Time Projection Chamber (TPC) and the Internal Tracking System (ITS).**
- **The forward region has several multiplicity detectors including our very own Photon Multiplicity detectors (PMD). The V0 detector in the forward region and the Silicon Pixel Detector (SPD), a part of ITS, are mainly used as **trigger detectors** for minimum bias events.**
- **For my analysis, I have used the data from TPC, SPD and V0**

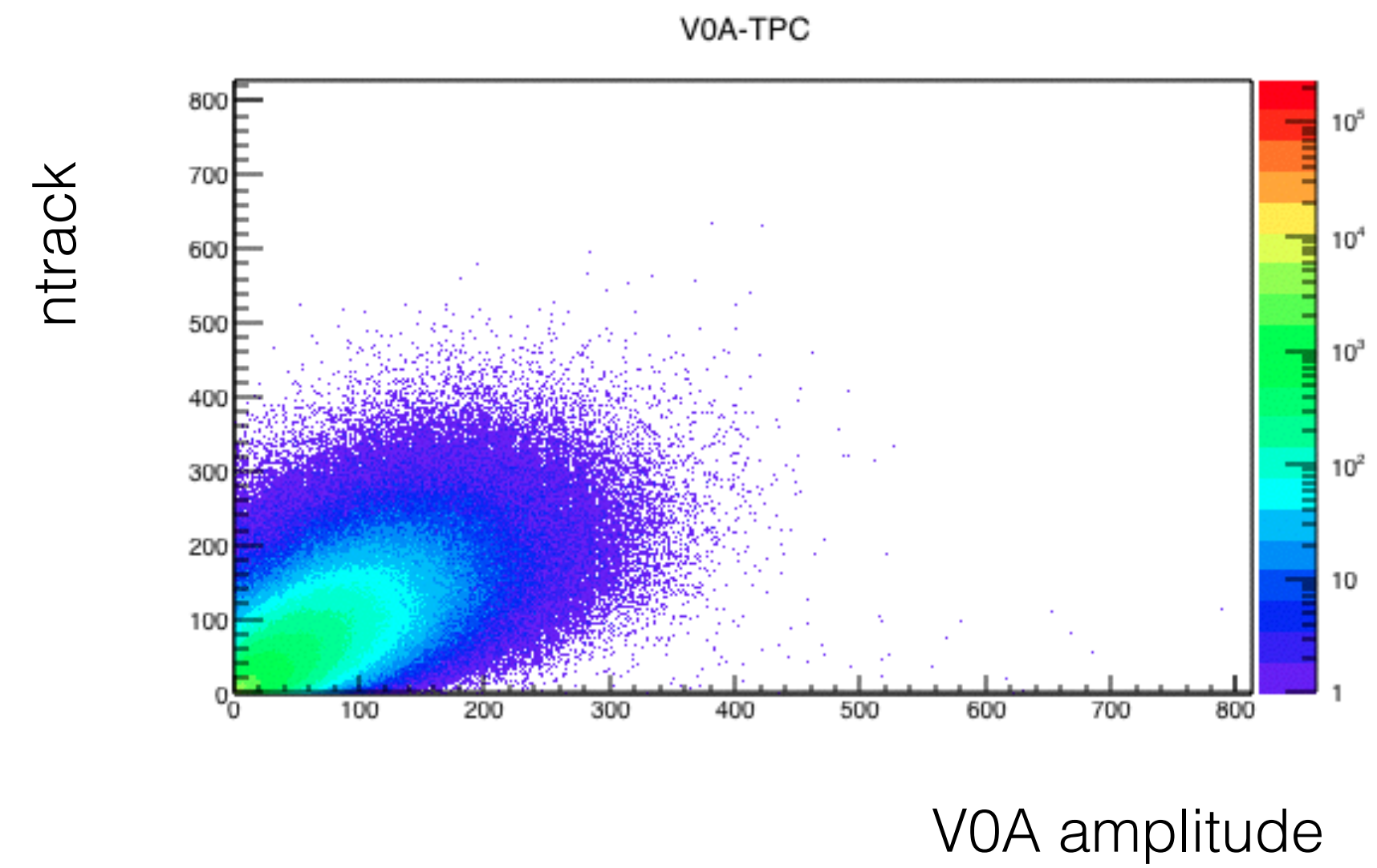
Event selection for this analysis

- **Run numbers for 13 TeV: LHC15f test_pass2 (226062,225106,225717),**
(No. of events = 7187593)
- **Run numbers for 7 TeV: LHC10d pass4 (126007,125085),**
(No. of events = 8724883)
- **Files used: *ESDs.root**
- **Trigger: kMB (Minimum Bias)**
- **Physics selection has been used**
- **rejection of pile up events**
- **inel>0**
- **|vertex z| <= 10 cm**

V0A-TPC Correlation

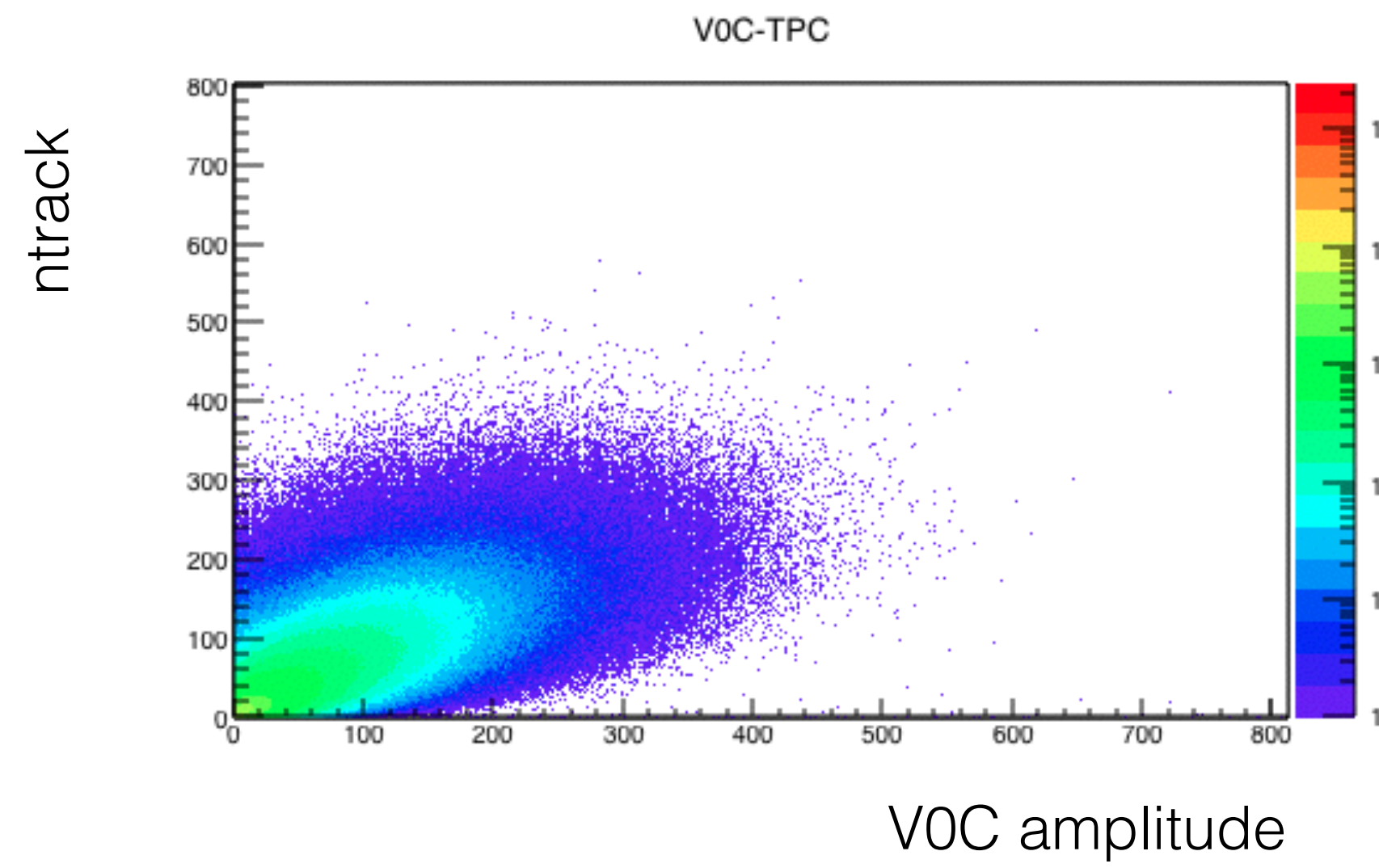


7 TeV

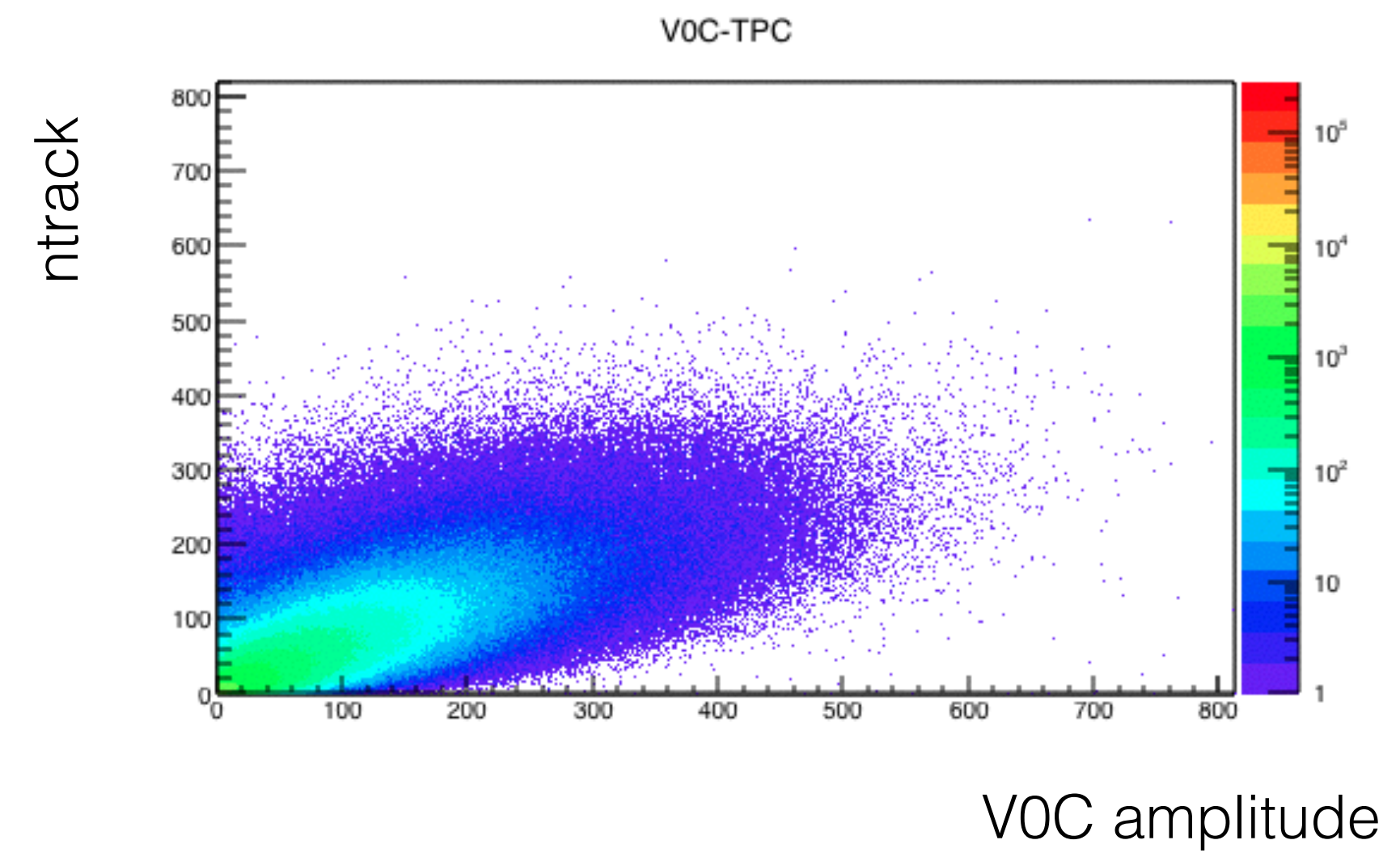


13 TeV

V0C-TPC Correlation

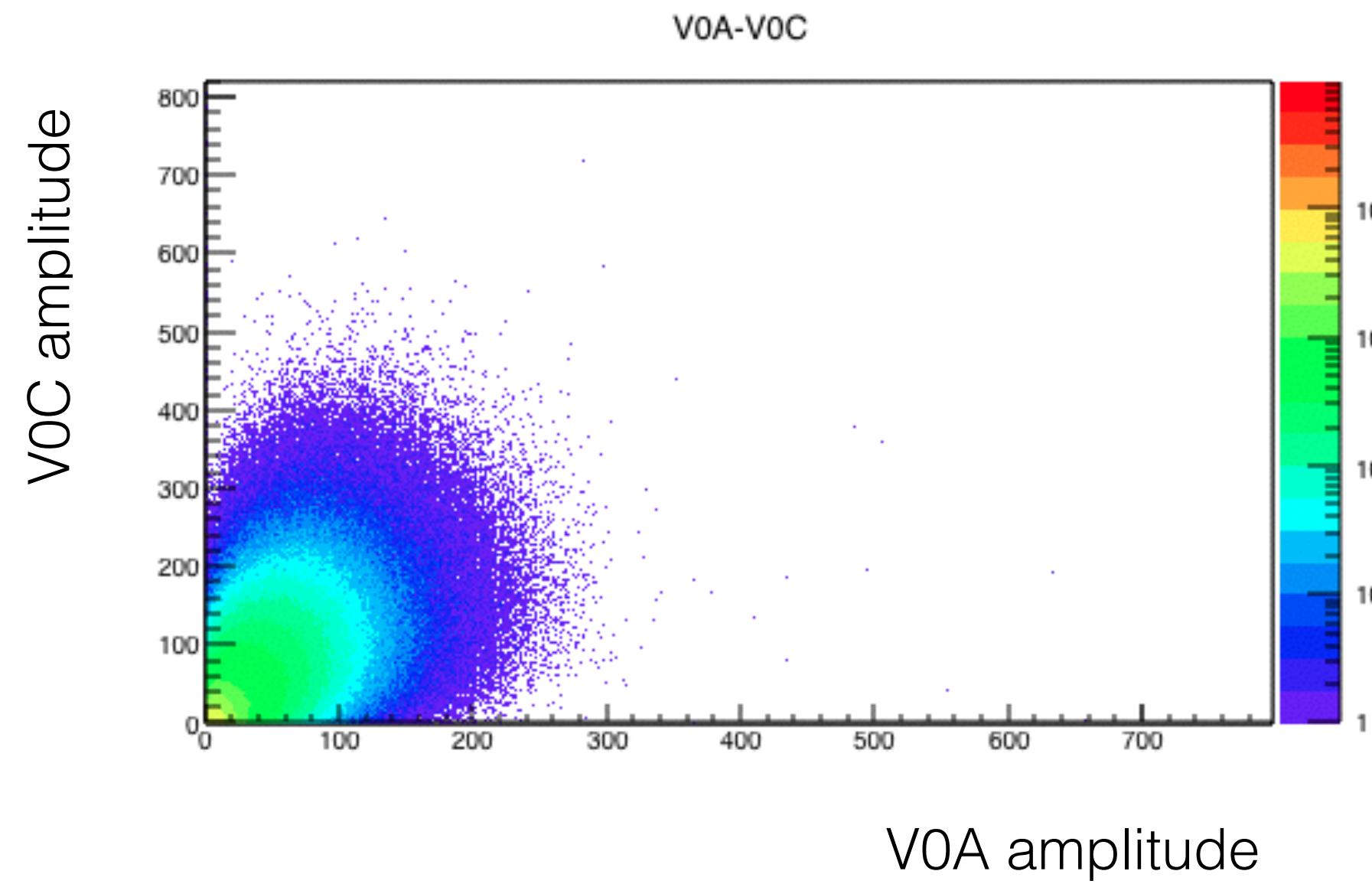


7 TeV

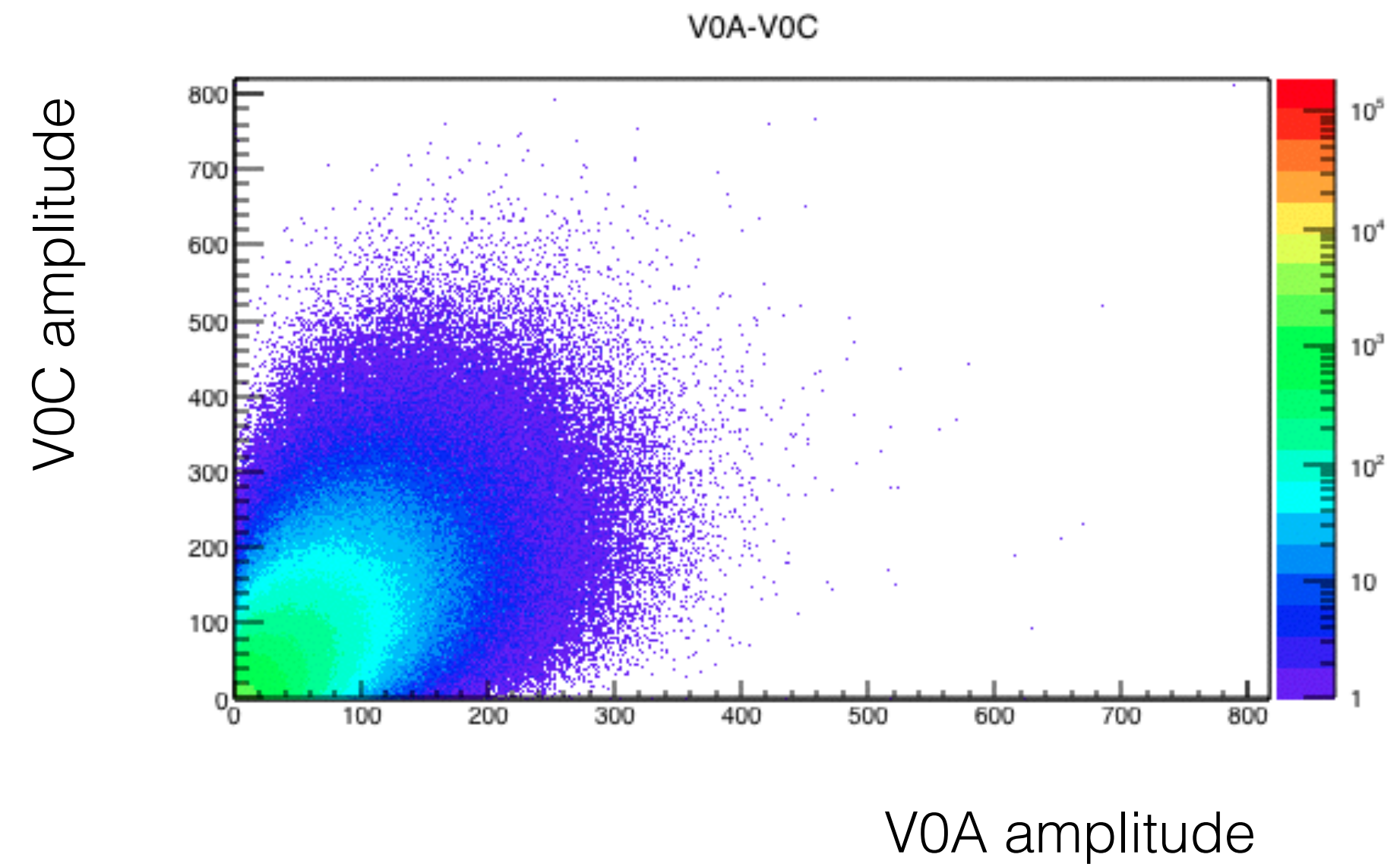


13 TeV

V0A-V0C Correlation

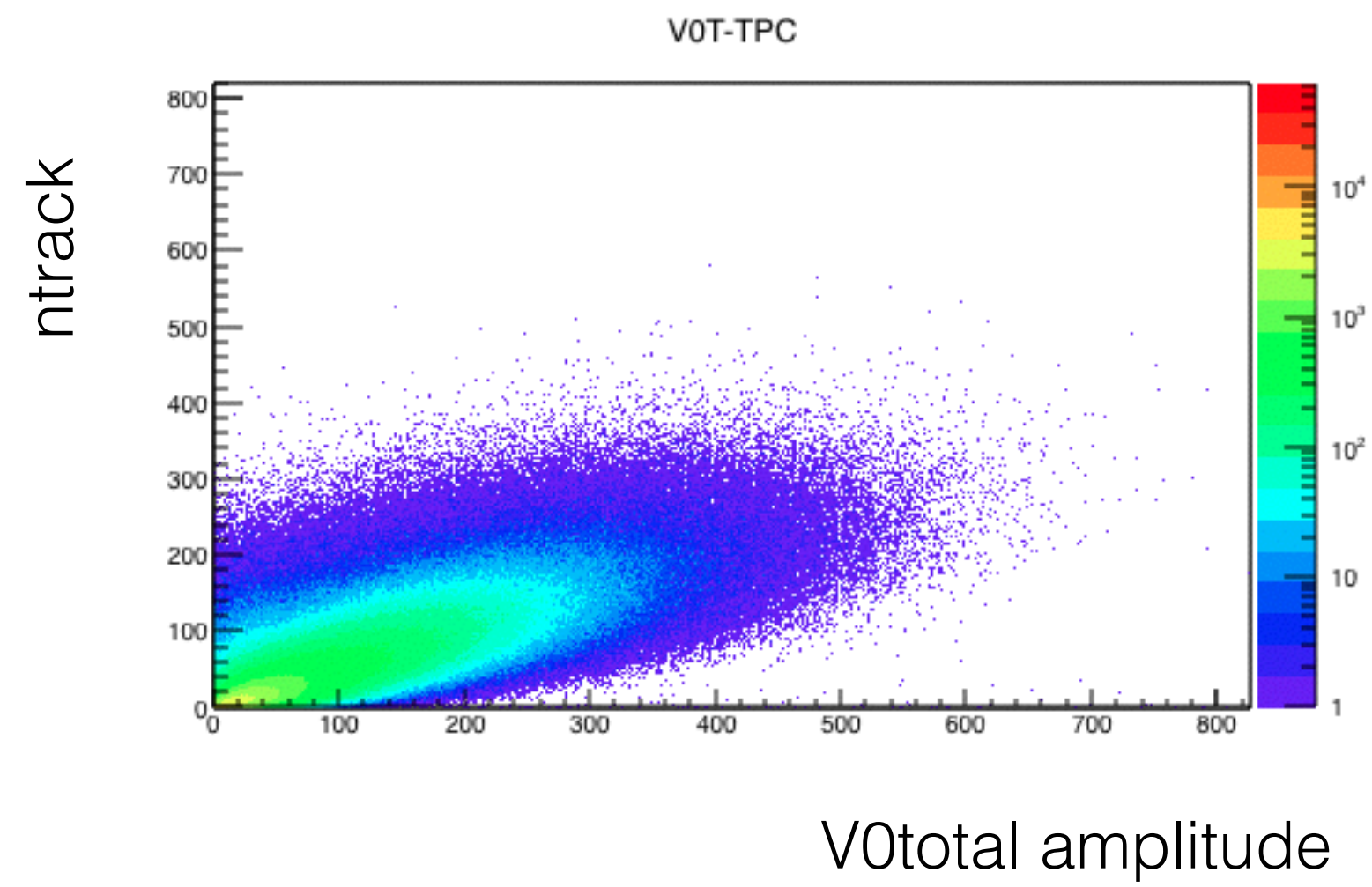


7 TeV

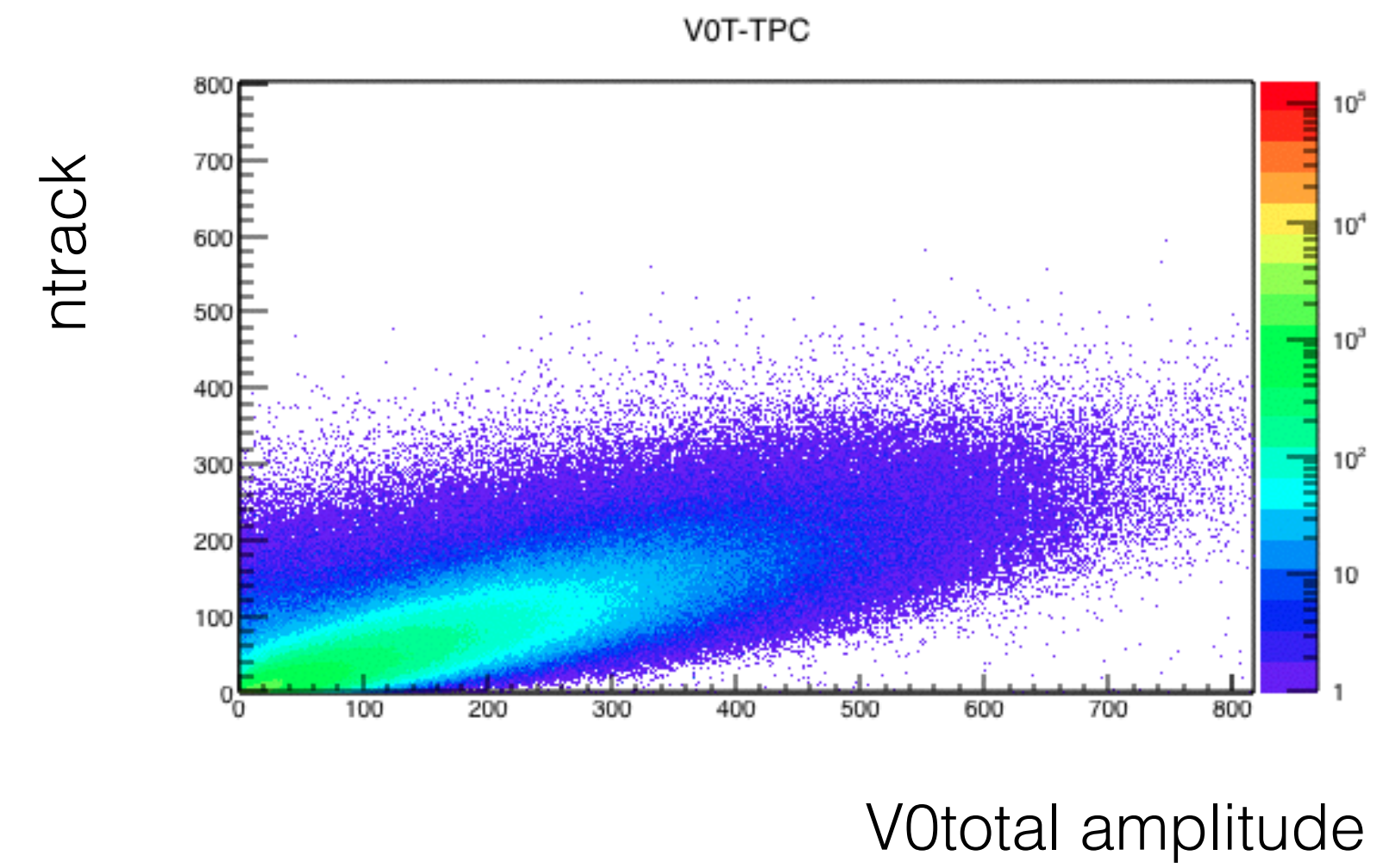


13 TeV

$V0_{\text{total}}$ -TPC Correlation

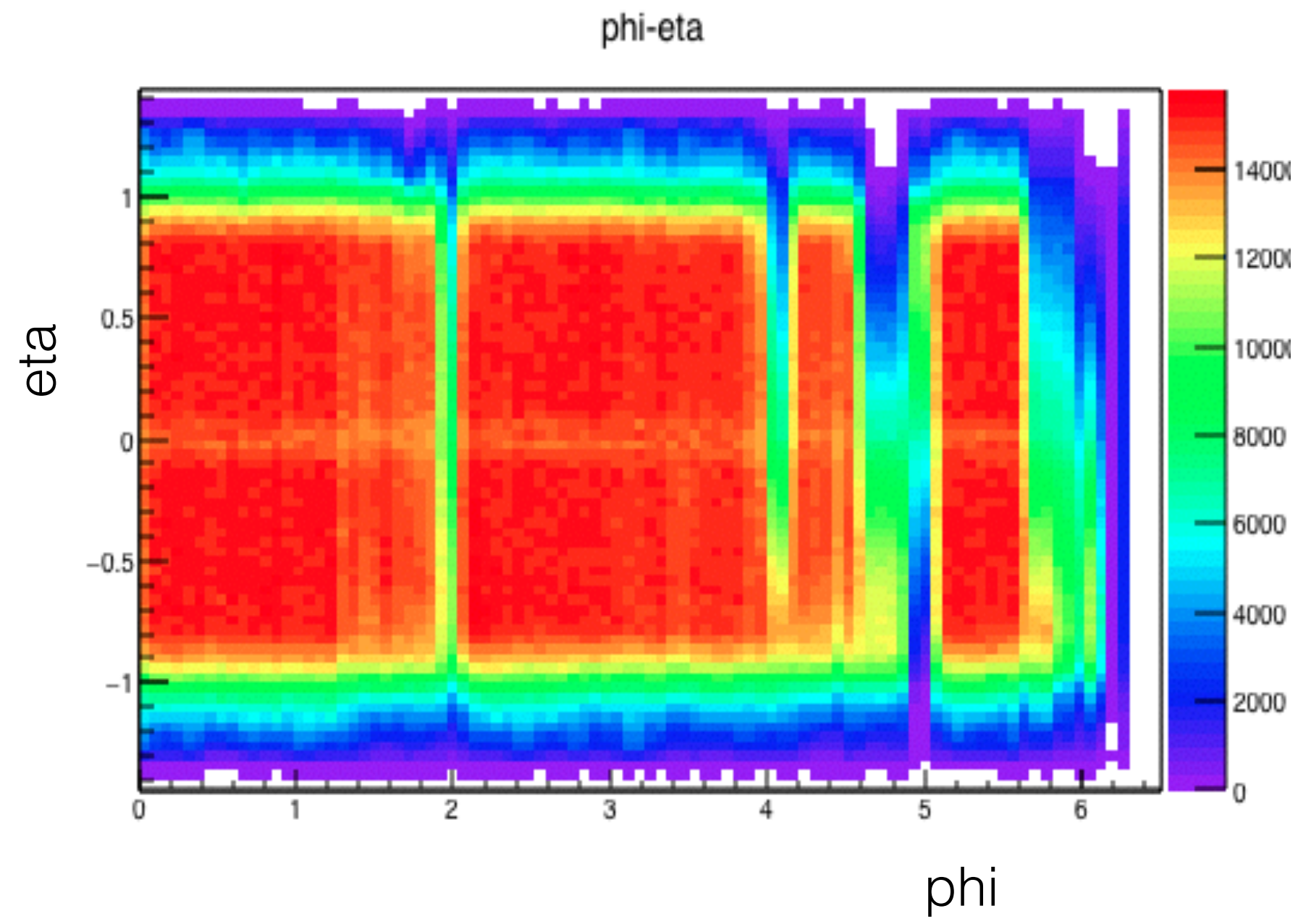


7 TeV

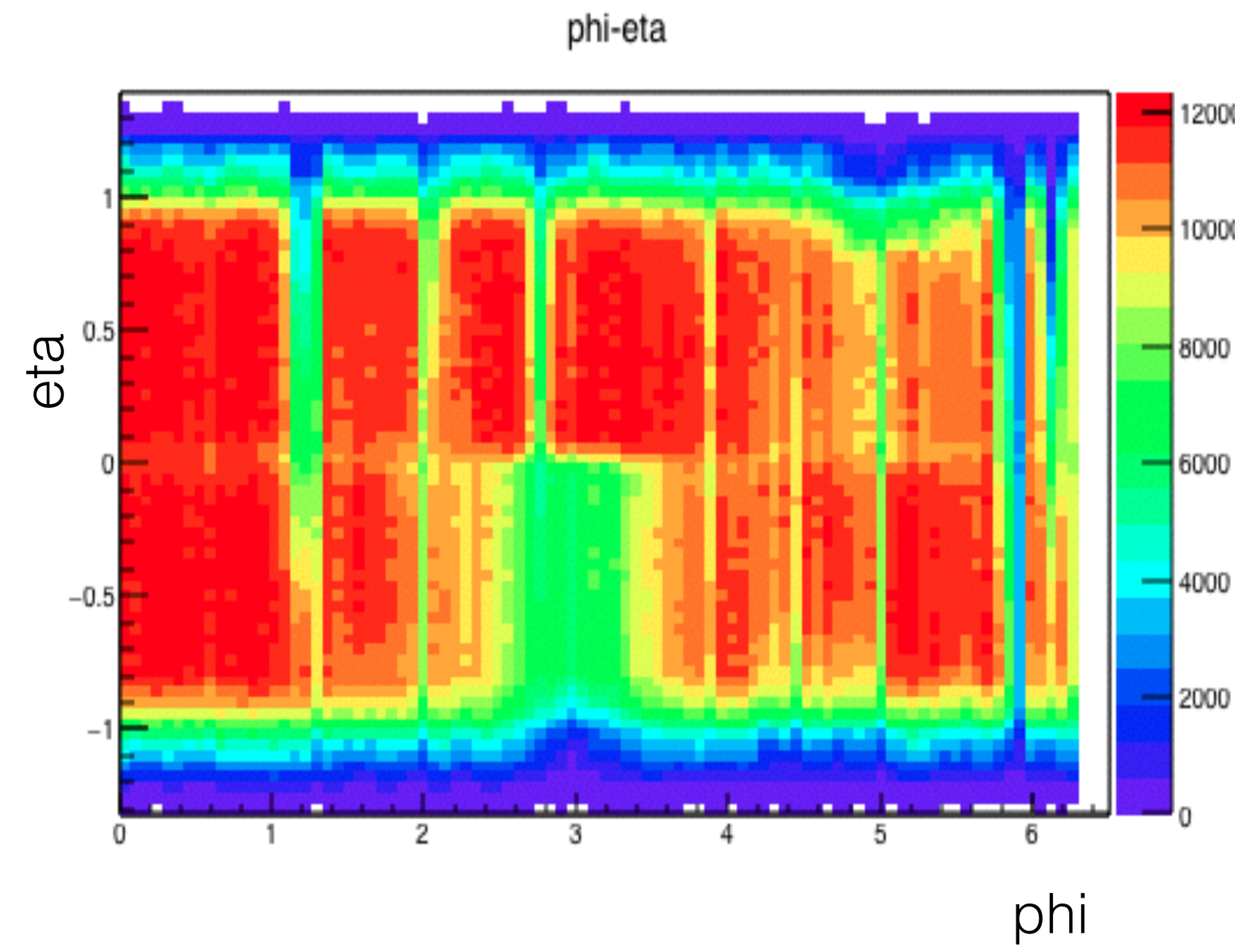


13 TeV

Eta - Phi Correlation for TPC tracks

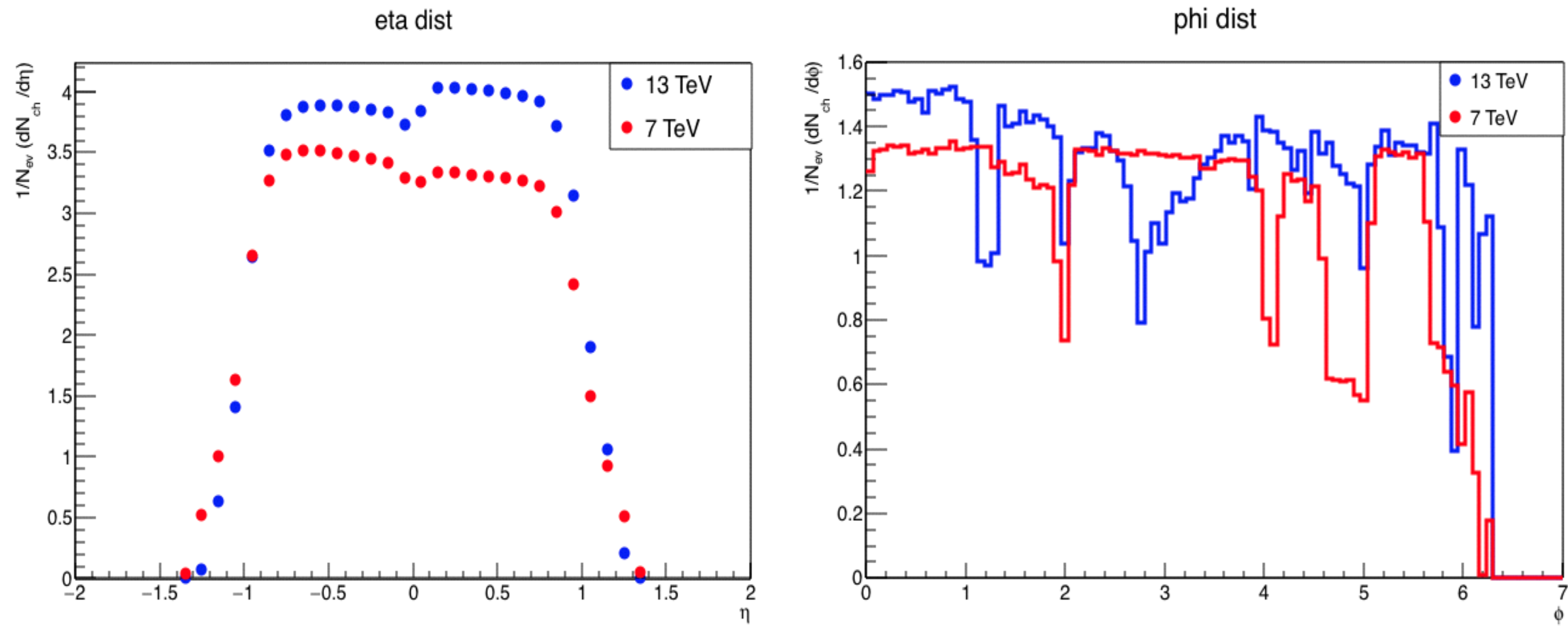


7 TeV



13 TeV

Eta and Phi distribution for TPC tracks

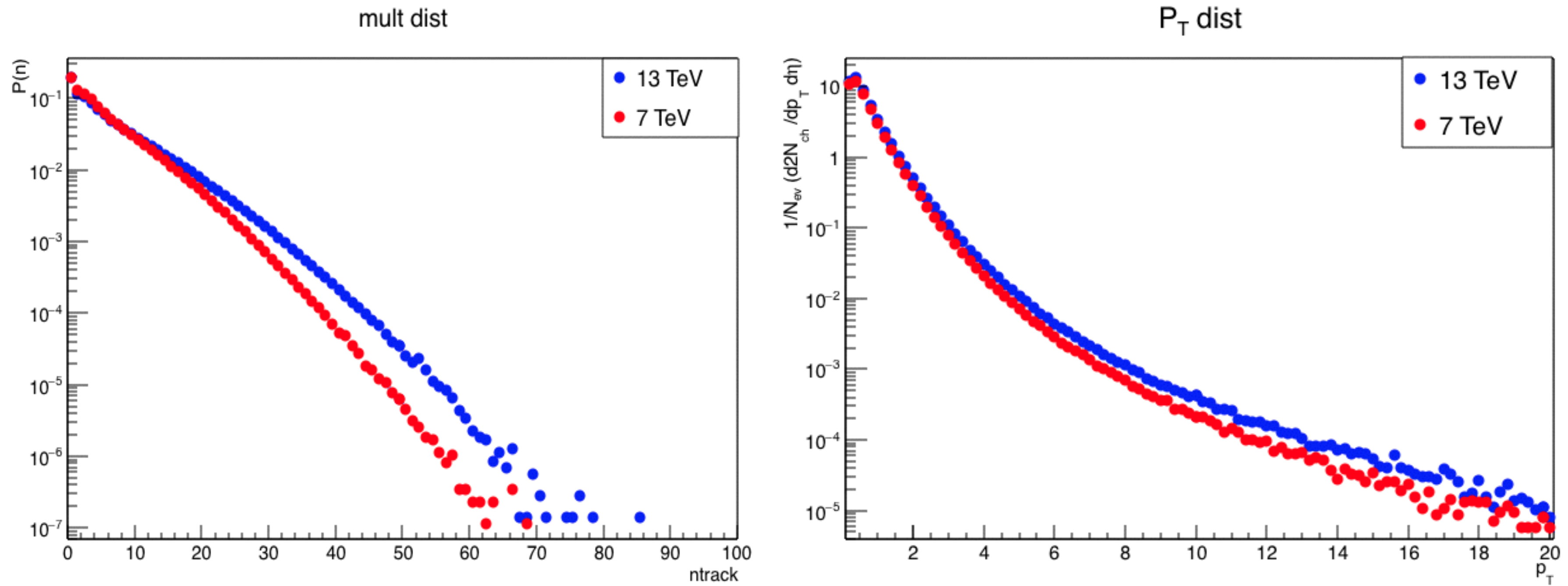


Cuts on TPC tracks

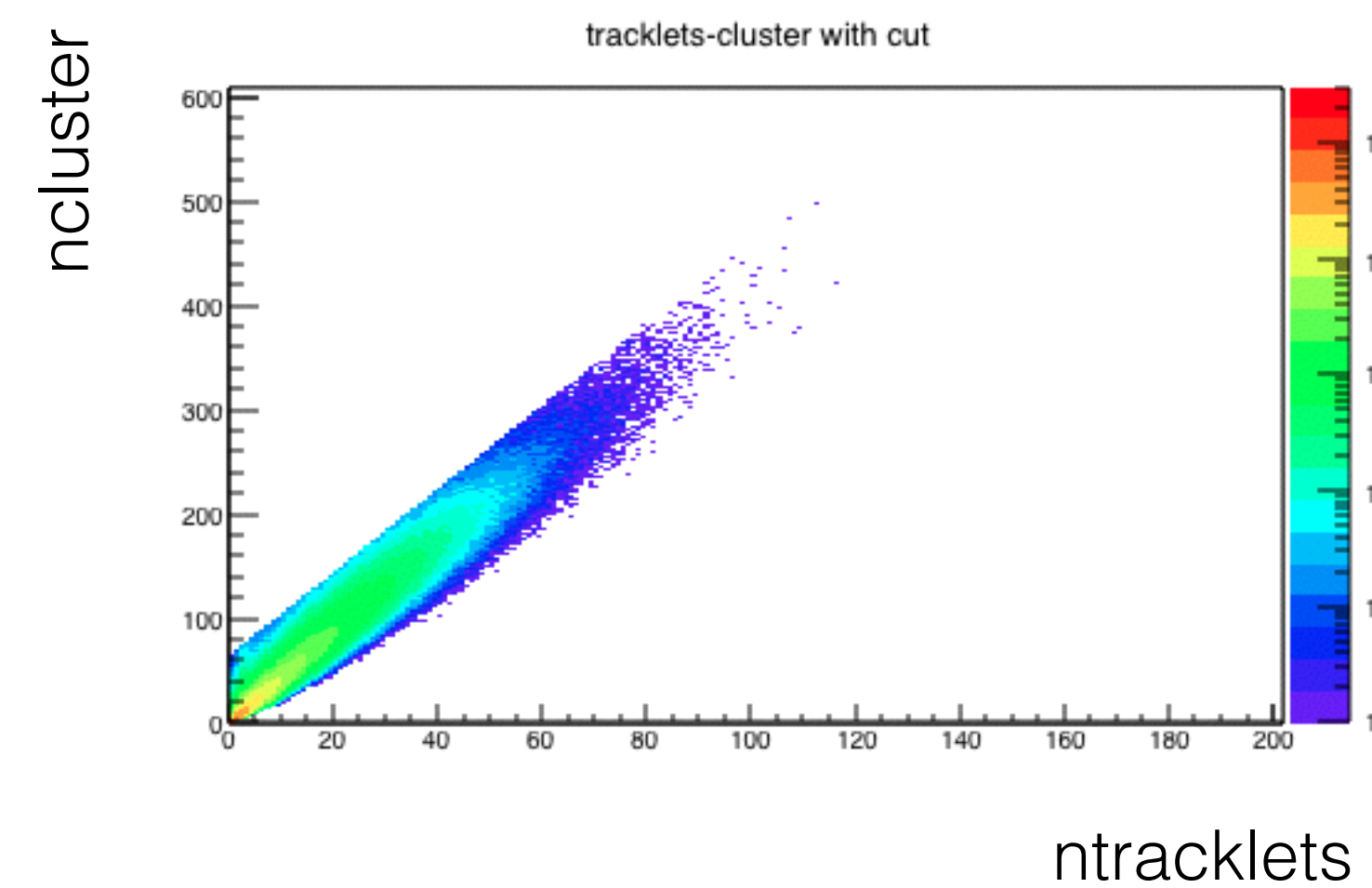
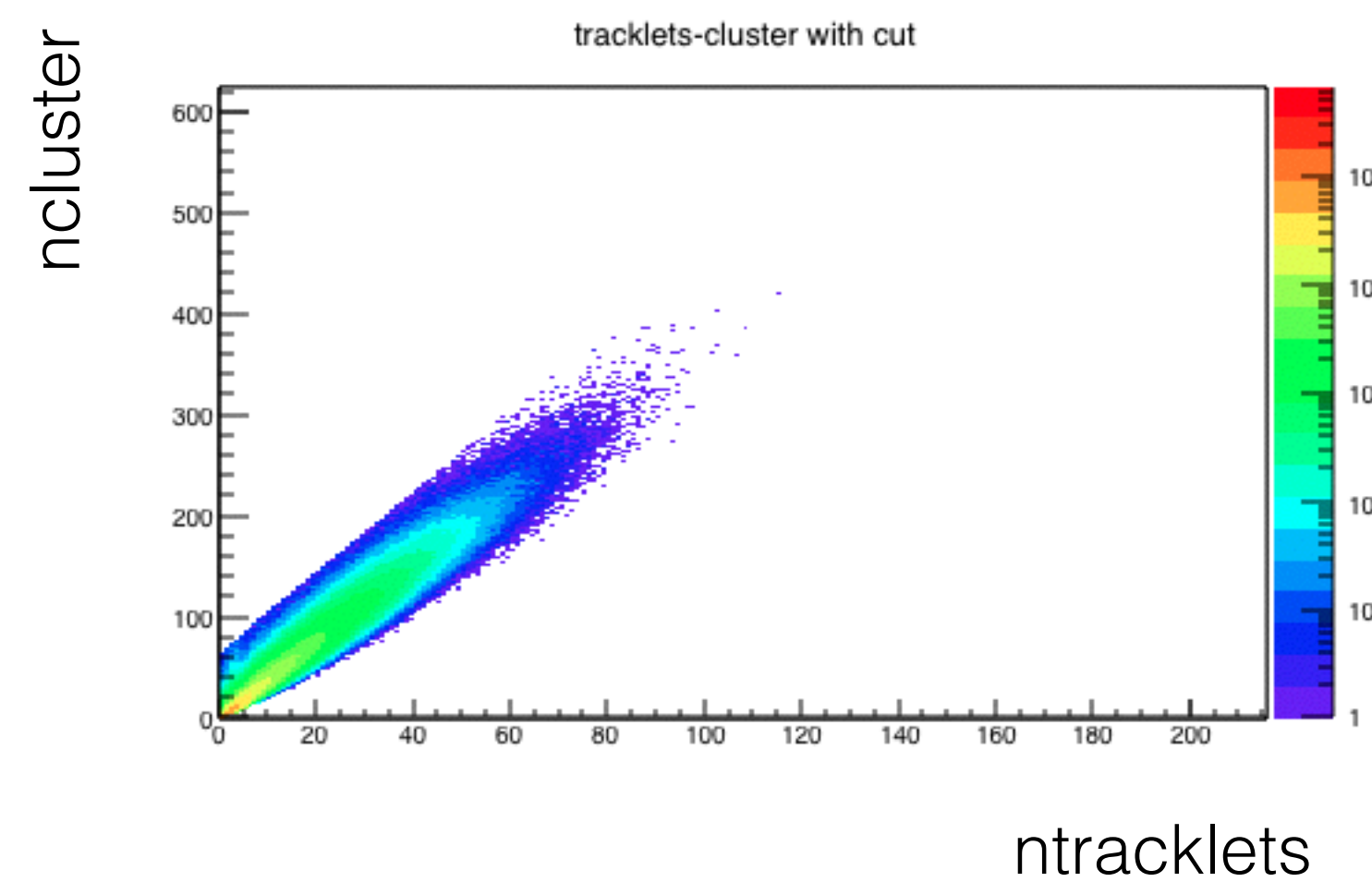
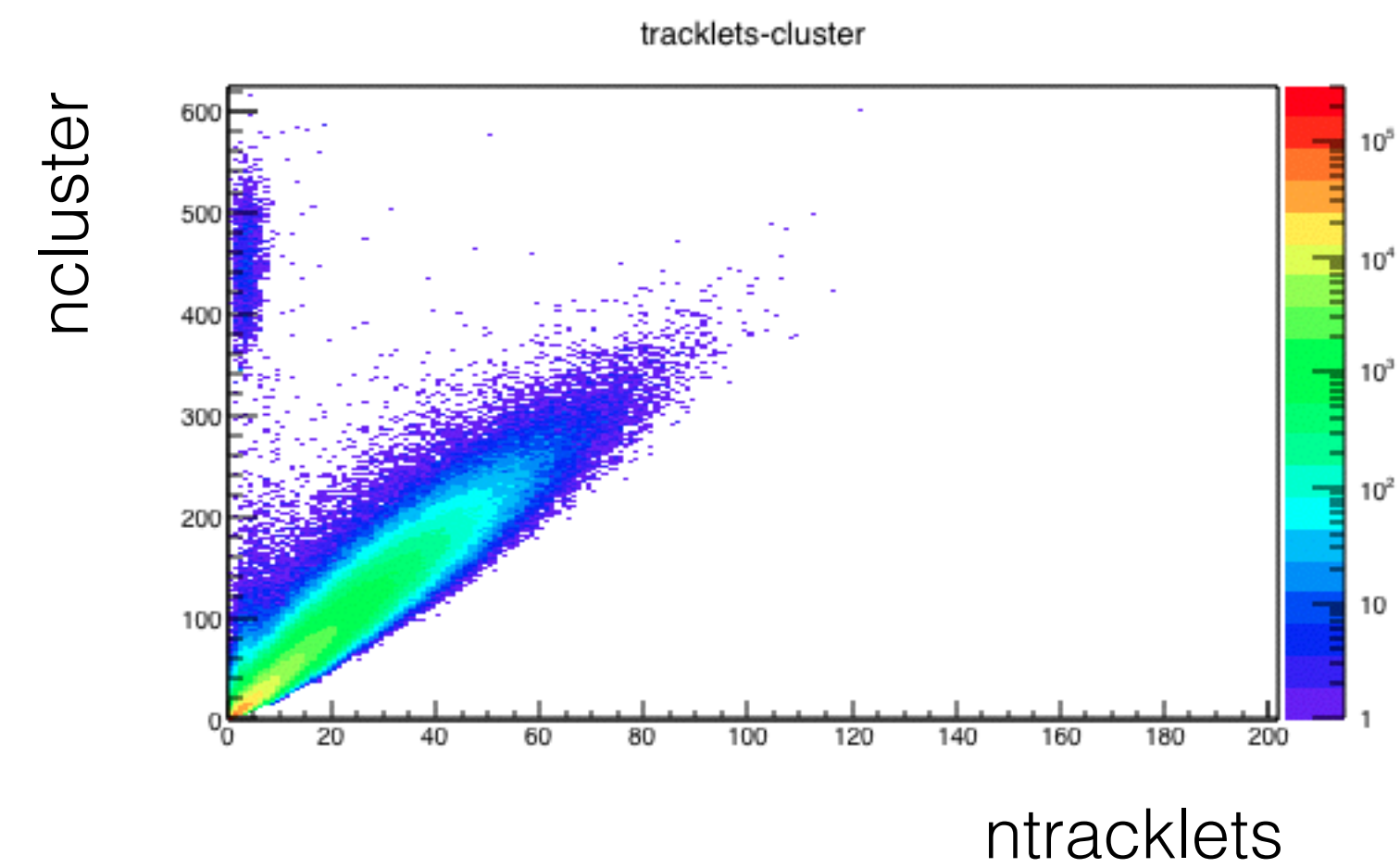
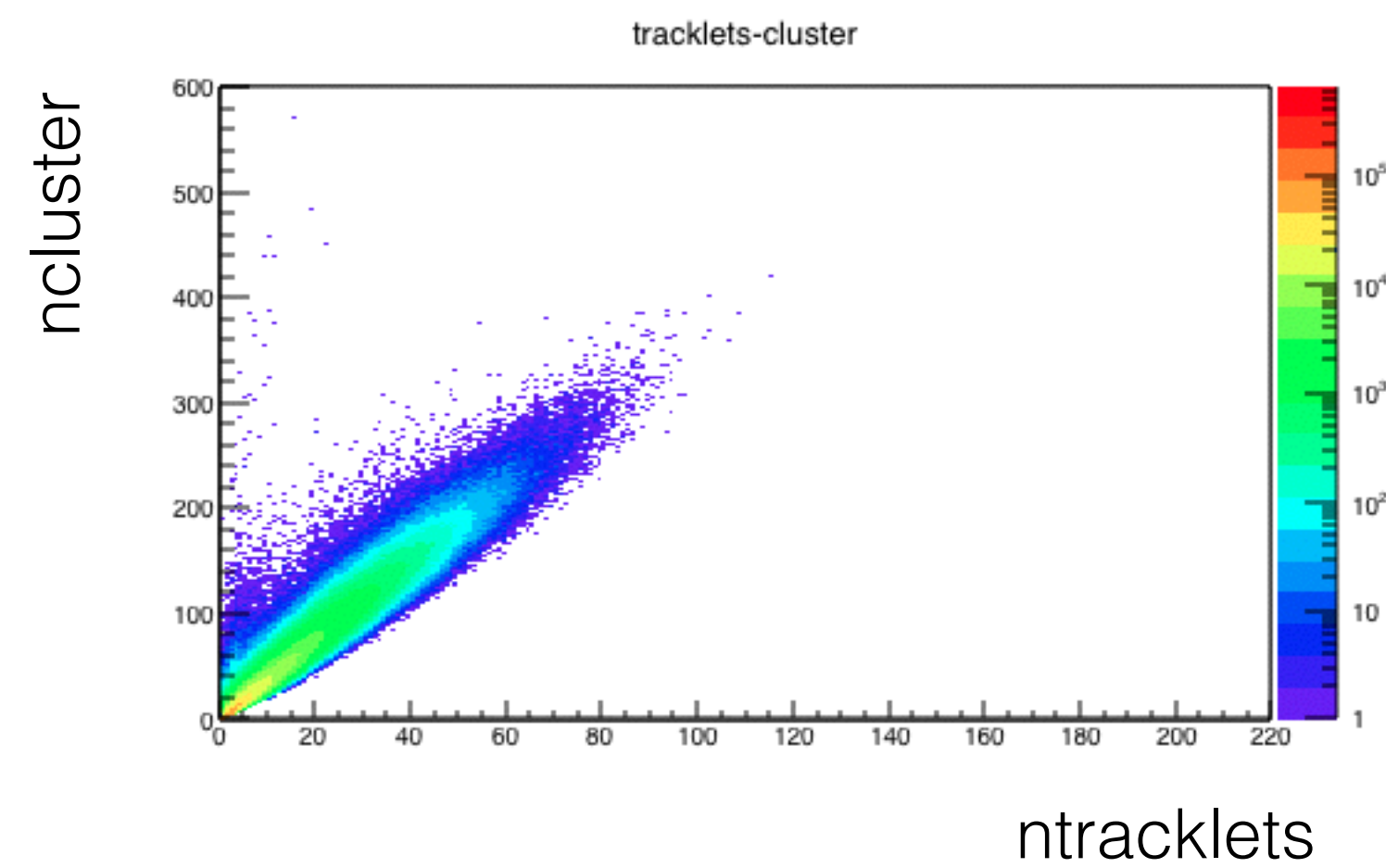
We have used similar track cuts as have been used for analysis of 7 TeV pp data.

- **$p_T > 0.2$**
- **$|\eta| < 0.8$**
- **standardITSTPCtrackcuts2010**

Multiplicity and p_T distribution from TPC tracks



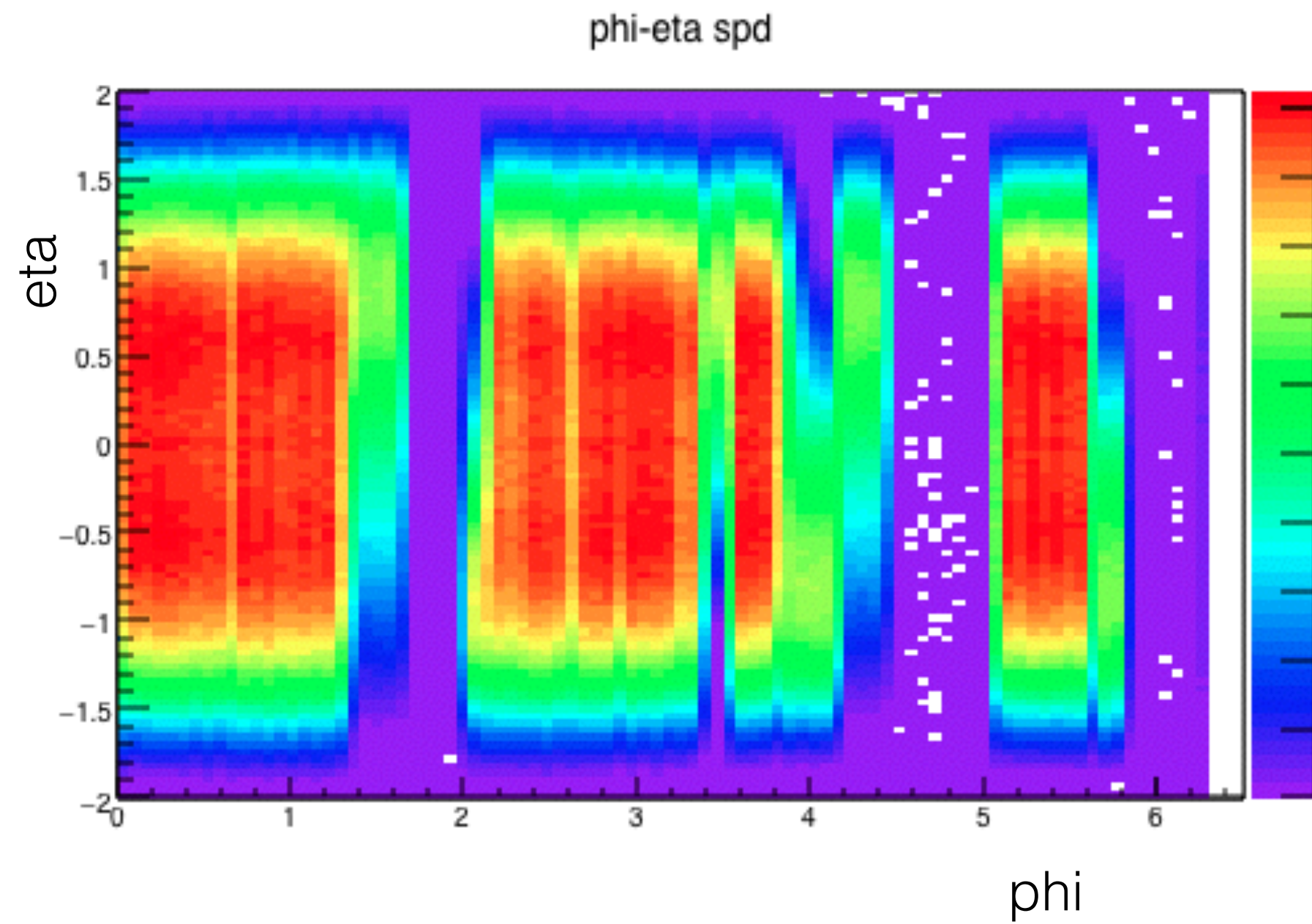
SPD tracklets vs. cluster cut



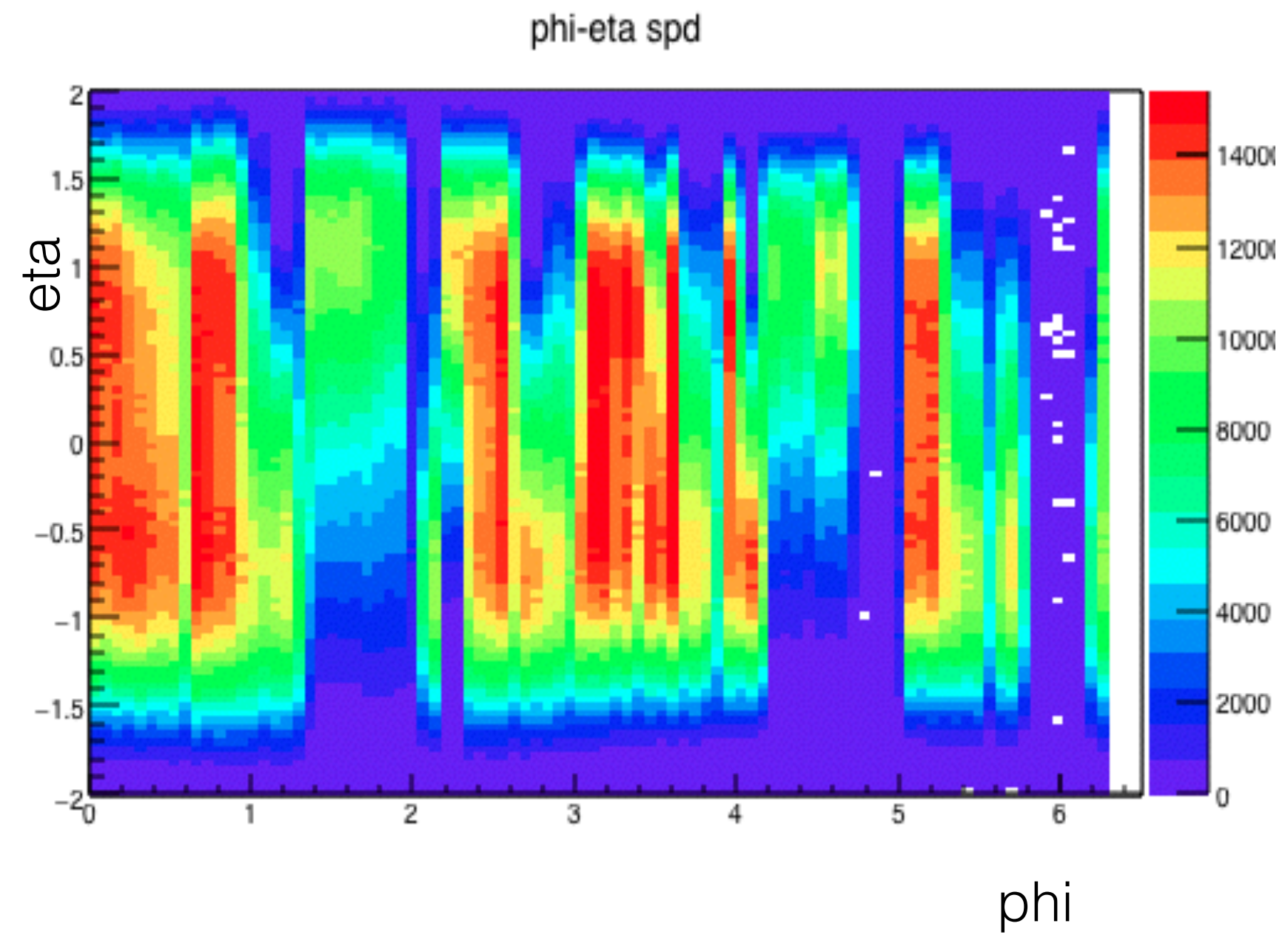
7 TeV

13 TeV

Eta - Phi Correlation for spd tracklets

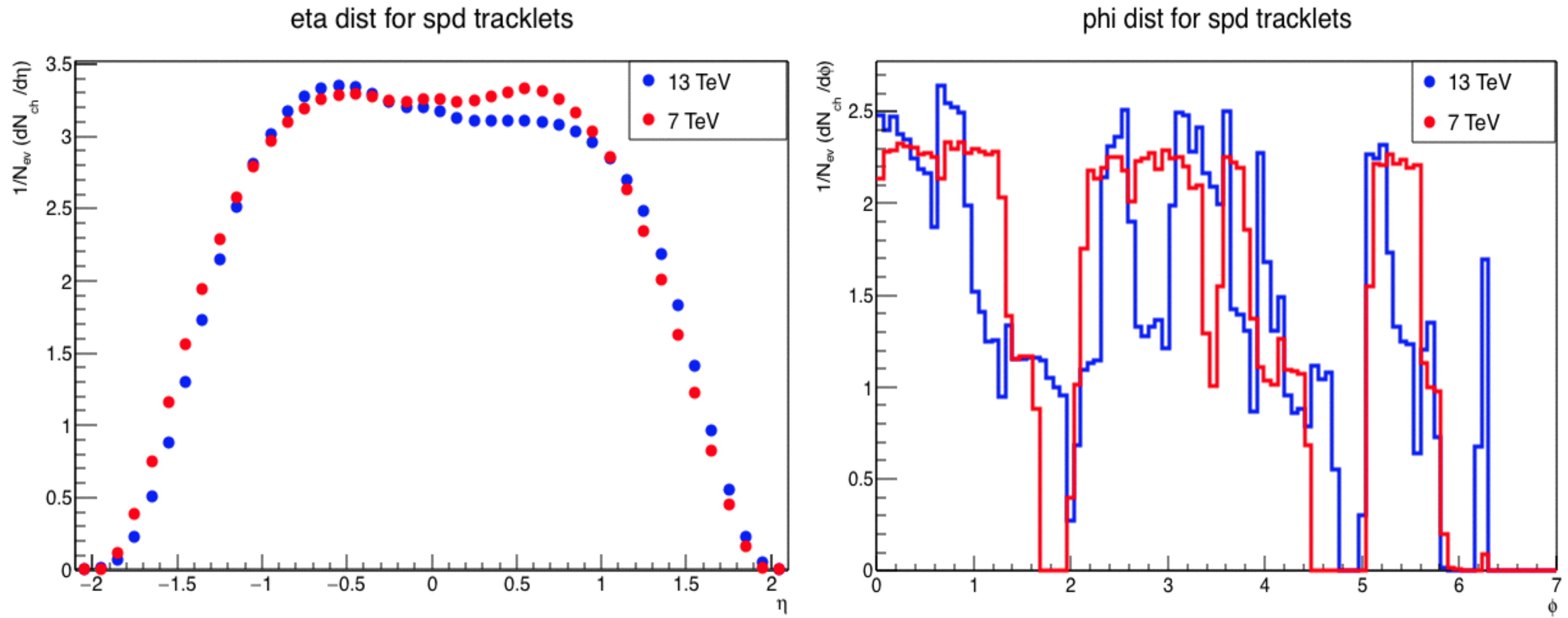


7 TeV

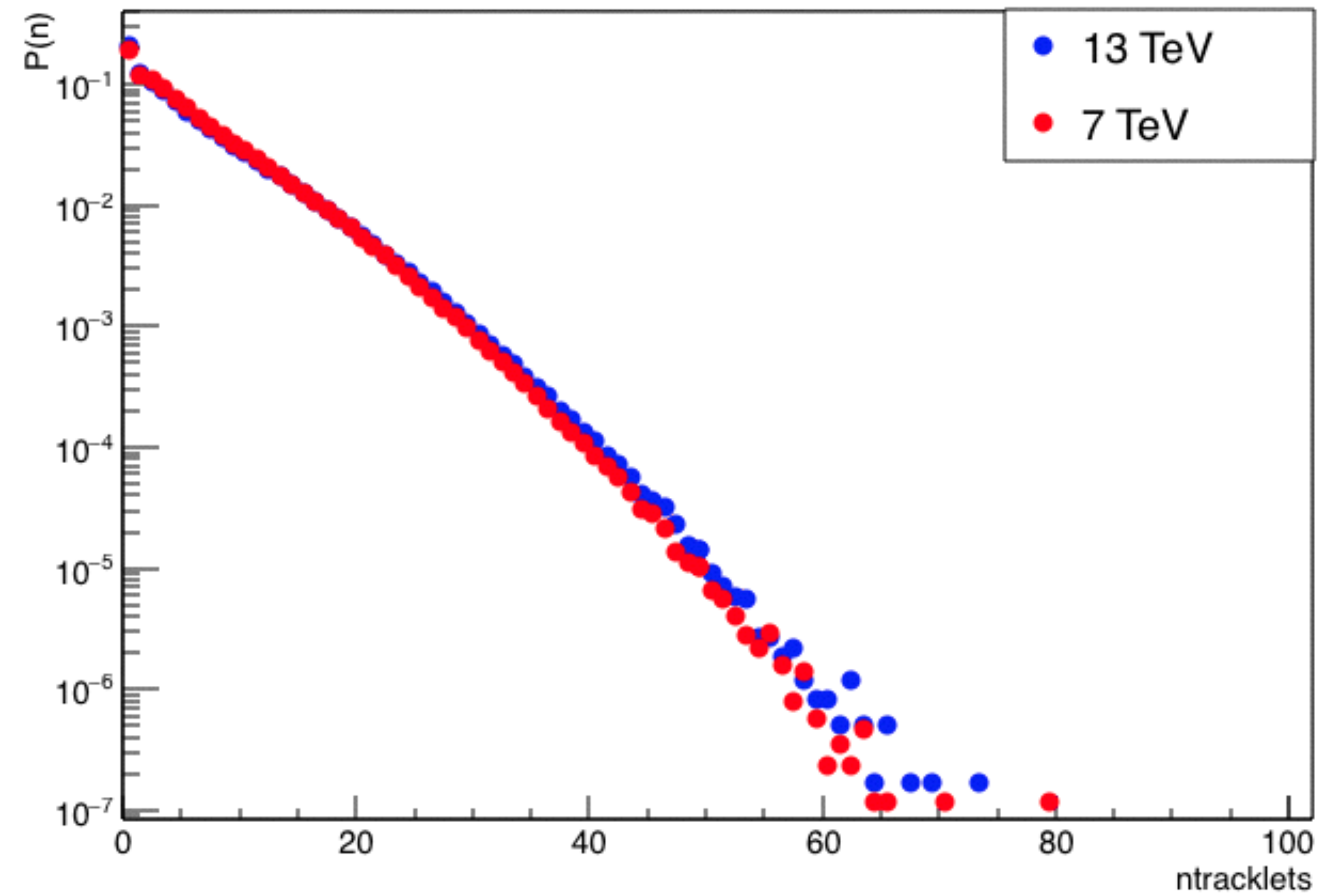


13 TeV

Eta and Phi distribution from spd tracklets



Multiplicity distribution from spd tracklets



Comparison: Data vs MC

Run no. for data: LHC15f_pass2

(226606, 226605, 226603, 226602, 226600, 226596, 226593, 226591,
226573, 226551, 226543, 226532, 226500, 226472, 226468, 226466, 226445,
226444, 226225, 226210, 226183, 226177, 226176, 226175, 226170, 226085,
226062, 225768, 225763, 225717, 225716, 225710, 225709, 225589, 225587,
225586, 225582, 225580, 225579, 225578, 225576, 225322, 225315, 225314,
225313, 225310, 225307, 225305, 225106, 225105, 225052, 225051, 225050,
225043, 225041, 225037, 225035, 225031, 225026, 225016, 225011, 225000)

Total 62 runs

Run no. for MC: LHC15g3c3 (Pythia6, Perugia-2011)

(226500, 226476, 226472, 226468, 226466, 226452, 226445, 226444, 226225, 226170,
226062, 225768, 225766, 225763, 225757, 225753, 225719, 225717, 225716, 225710, 2
25709, 225708, 225707, 225705, 225587, 225586, 225579, 225576, 225315, 225314, 22
5313, 225310, 225309, 225307, 225305, 225052, 225051, 225050, 225043, 225041, 225
037, 225035, 225031, 225026, 225016, 225011, 225000)

Total 47 runs

Event selection:

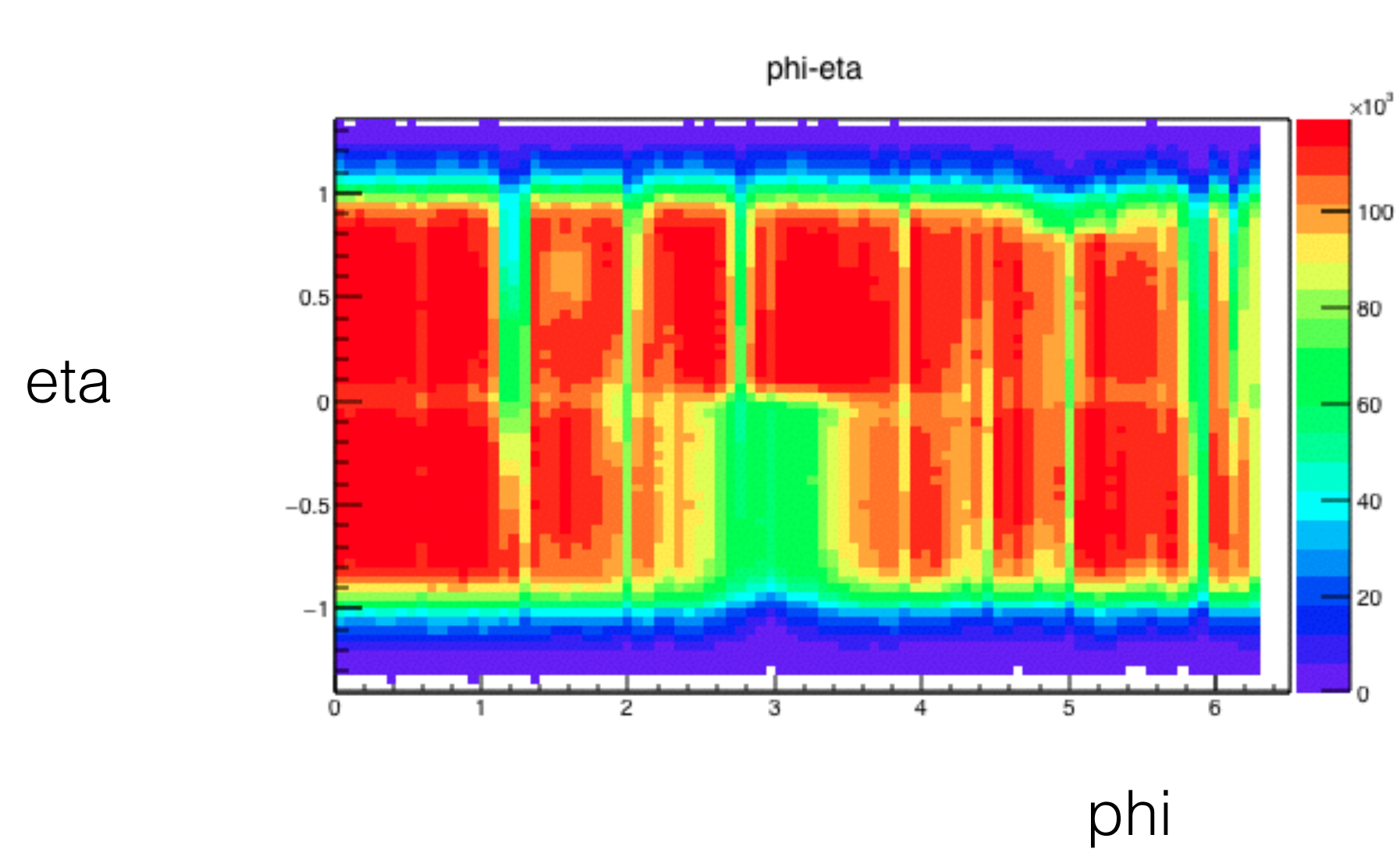
Trigger: kMB

- physics selection has been used
- rejection of pile up events and incomplete events
- $l_{\text{vertex}} z_l > 10 \text{ cm}$
- rejection of events with condition $f_{\text{NofITSClusters0}} + f_{\text{NofITSClusters1}} > 65 + 4 * f_{\text{NofTracklets}}$
- V0A and V0C Decision taken to be 1.
- $\text{inel} > 0$
- no. of events : $4.67e+07(\text{data}), 2.38e+07(\text{MC})$

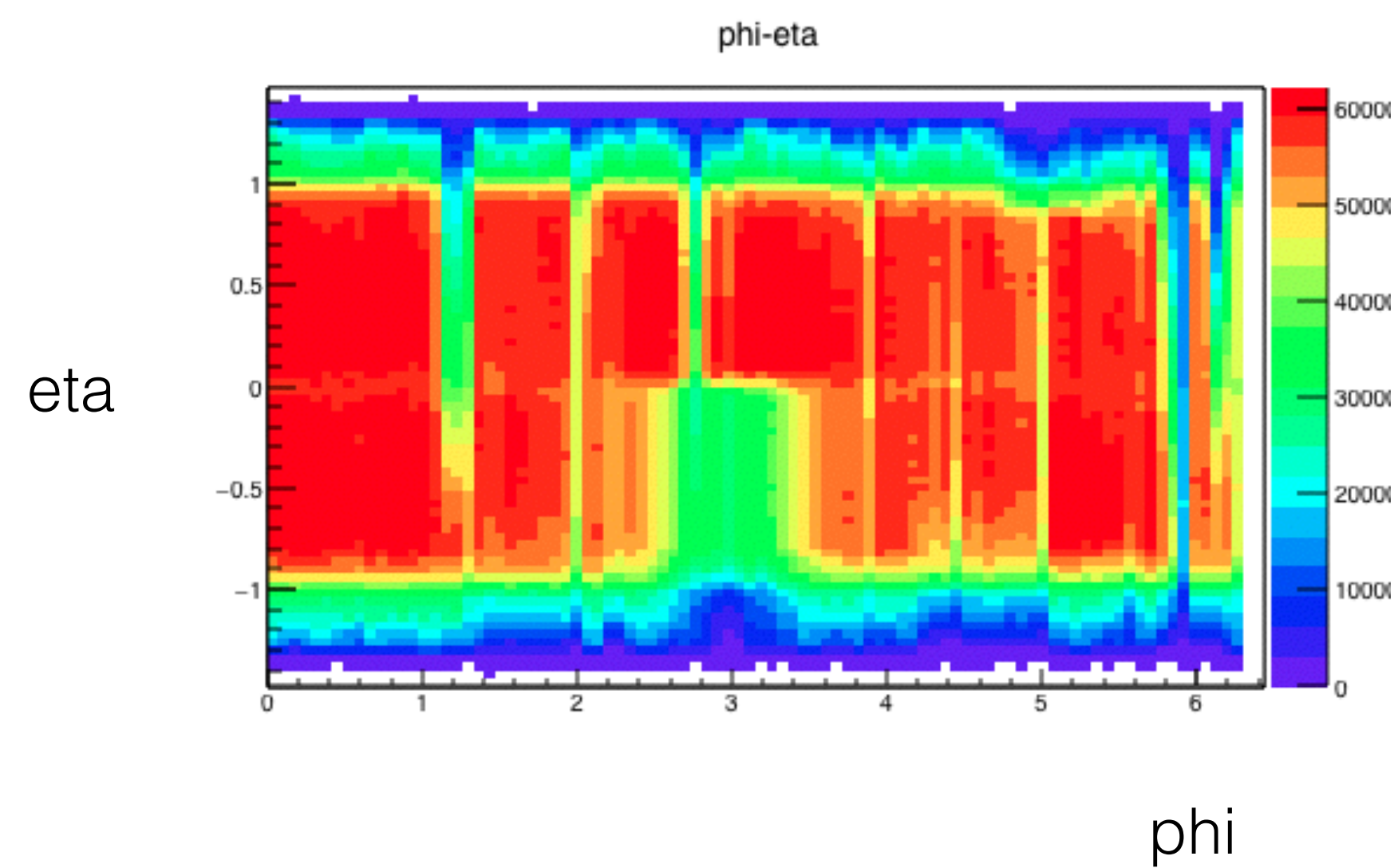
Track cuts:

- StandardITSTPCTrackCuts2010
- $p_T > 0.2$
- $l_{\text{etal}} < 0.8$

Eta - Phi correlation for TPC tracks

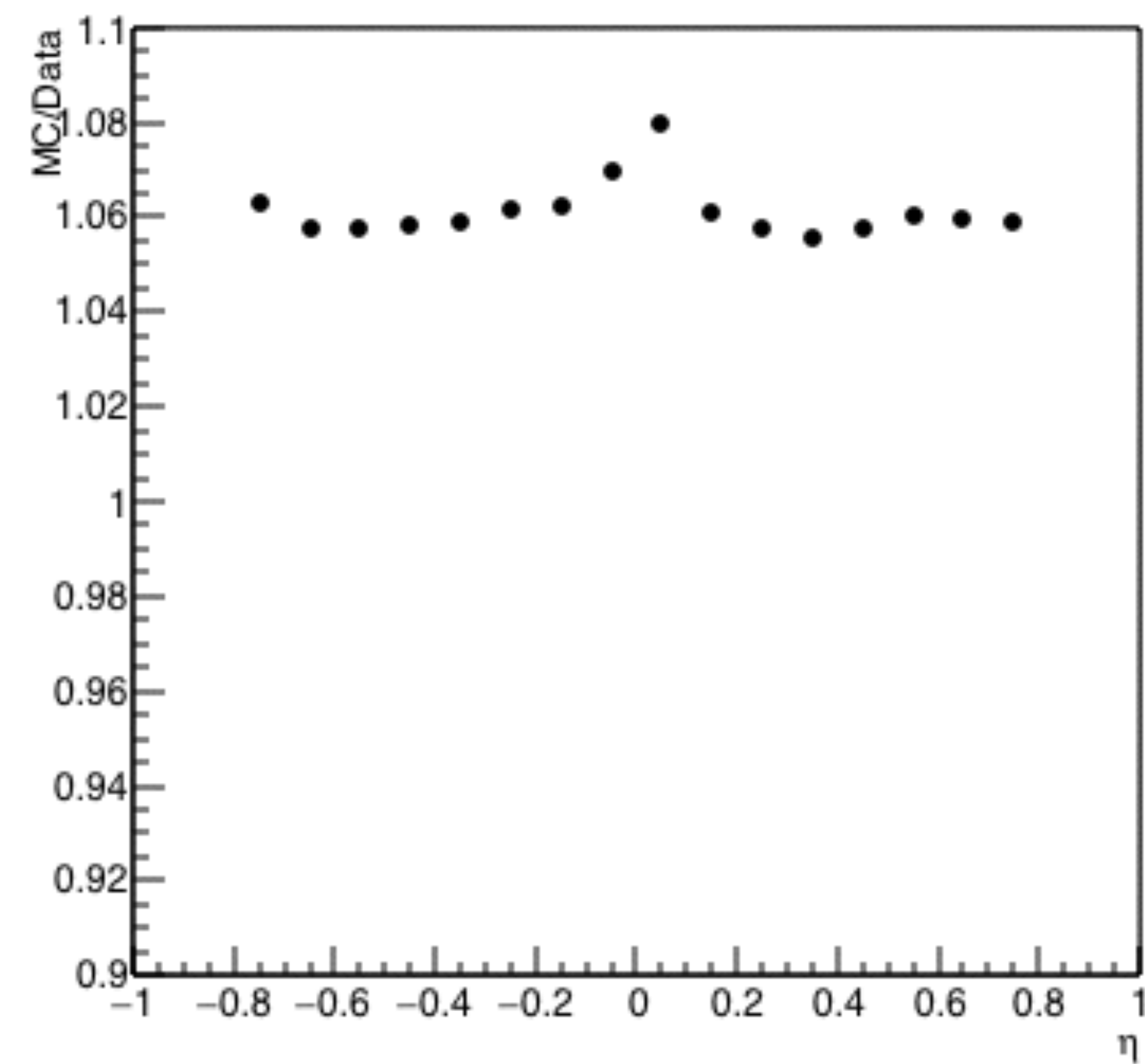
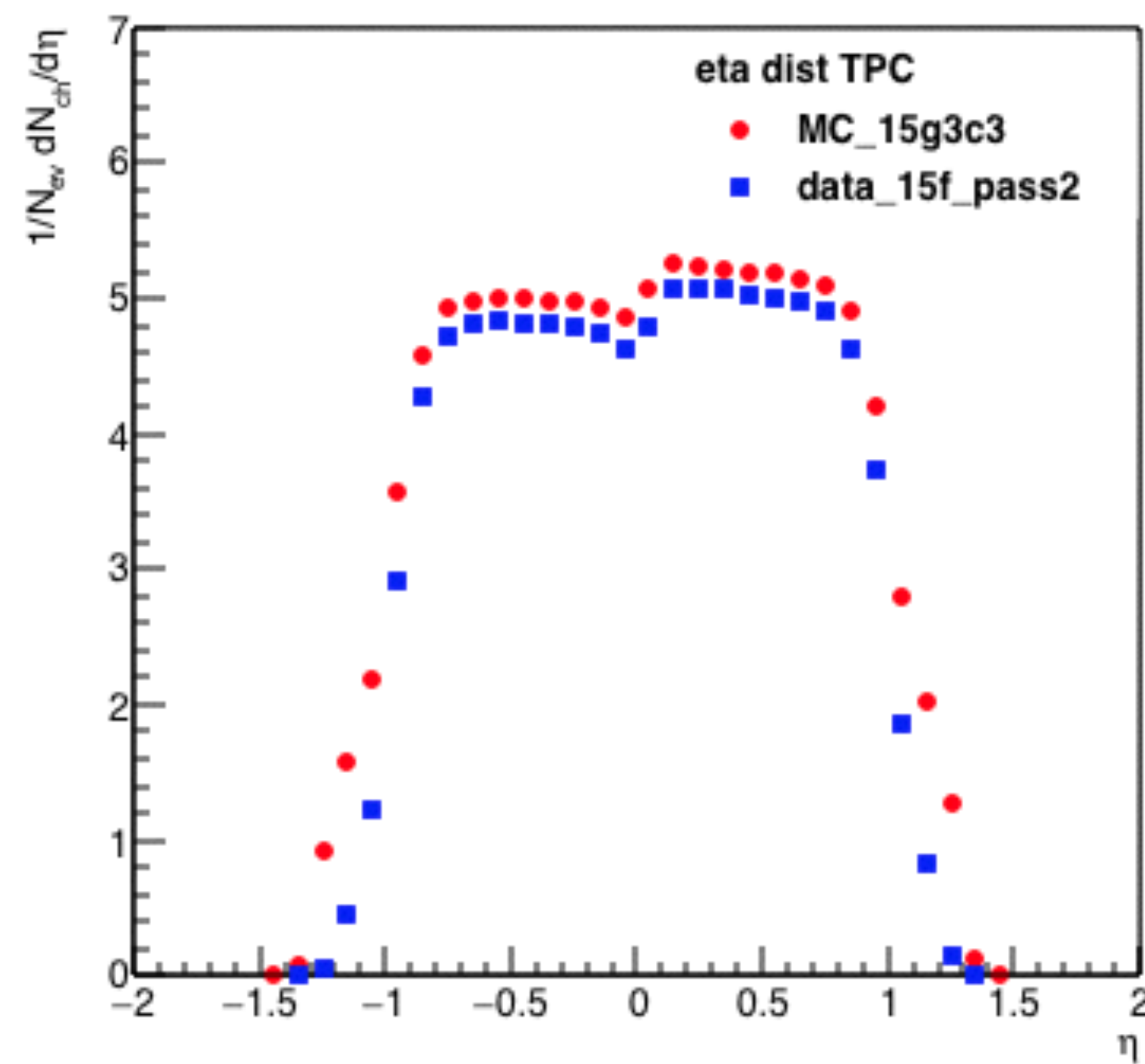


Data



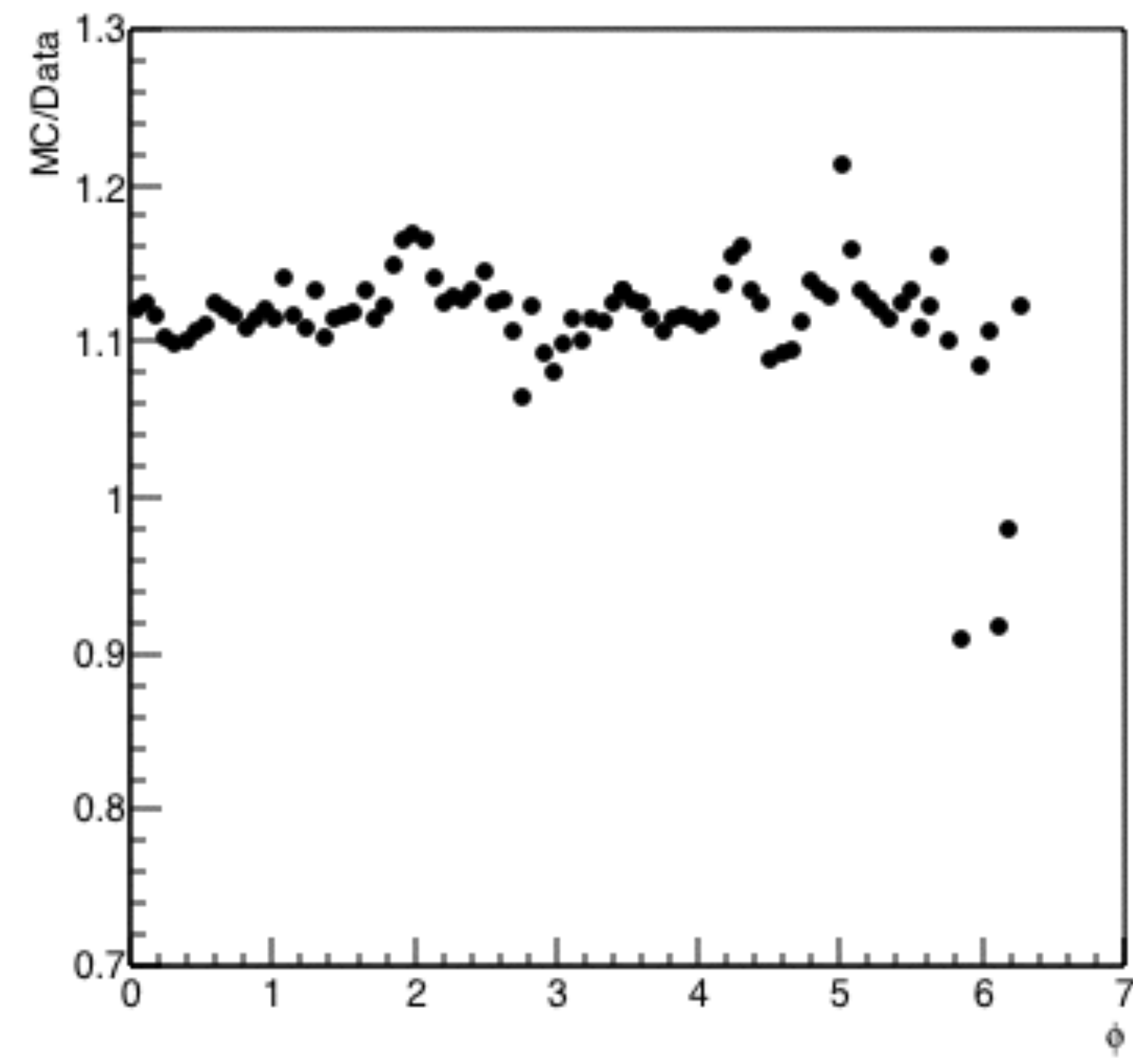
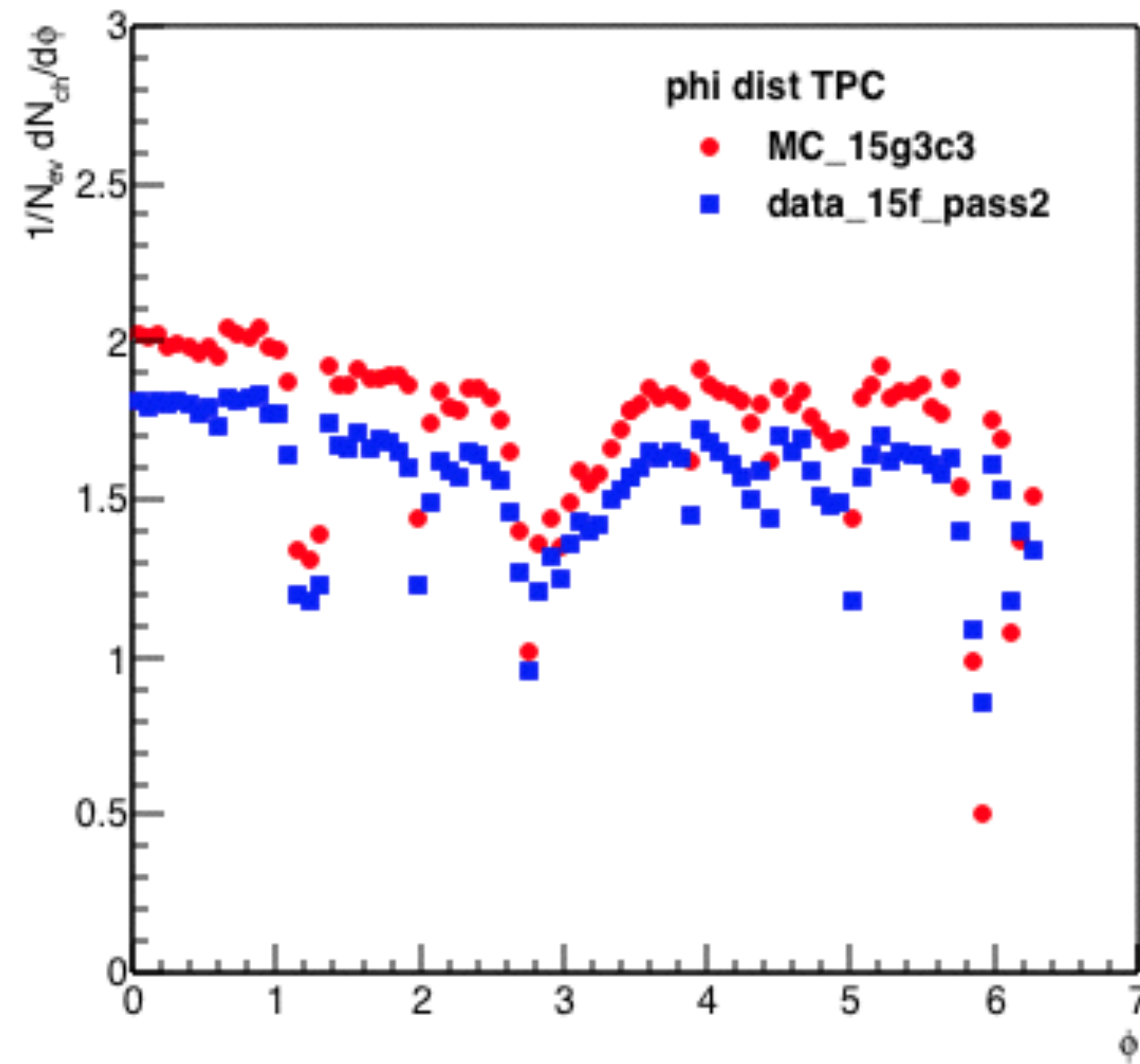
MC

Eta distribution for TPC tracks



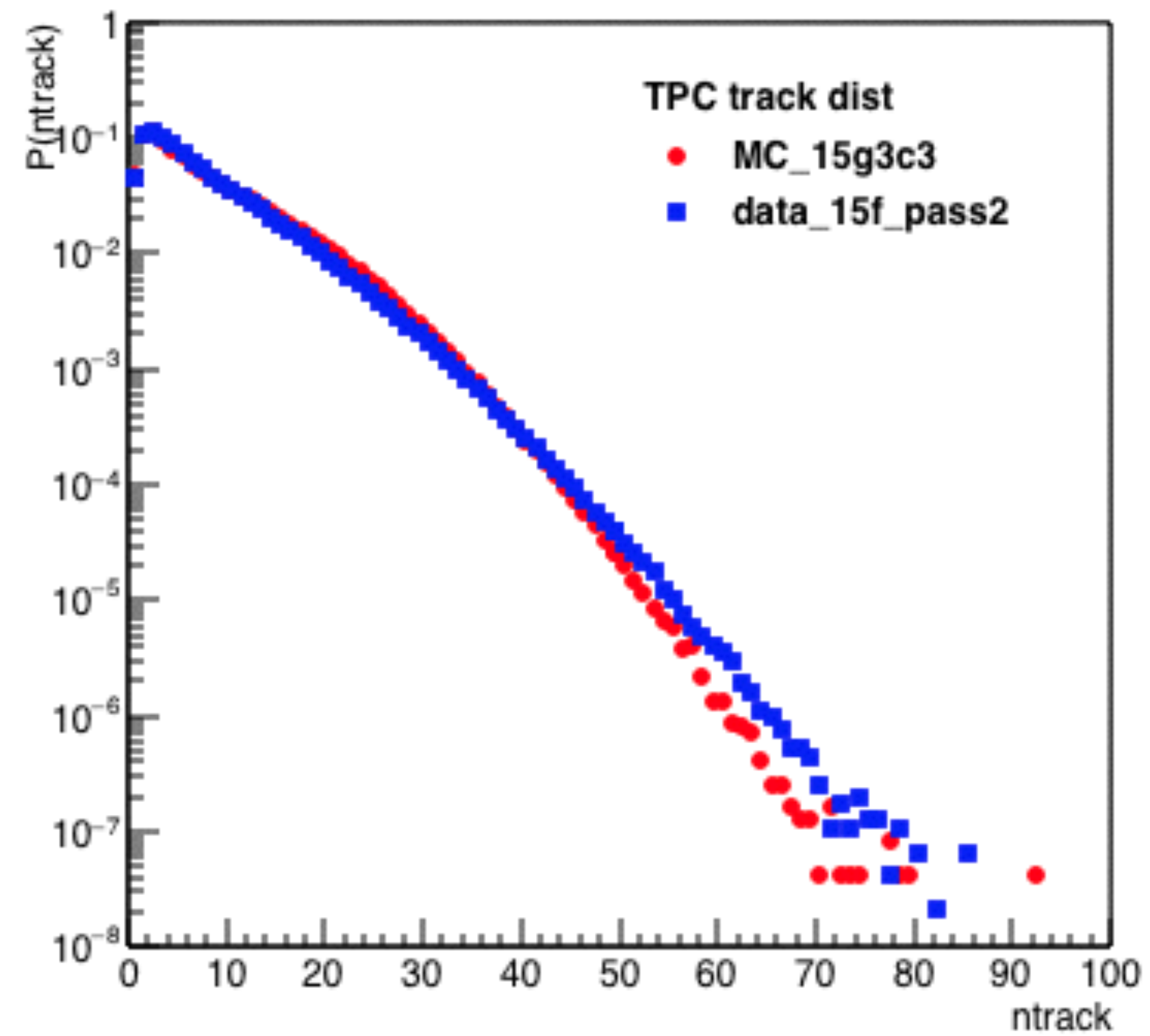
Deviation is 5.5% to 8%

Phi distribution of TPC tracks

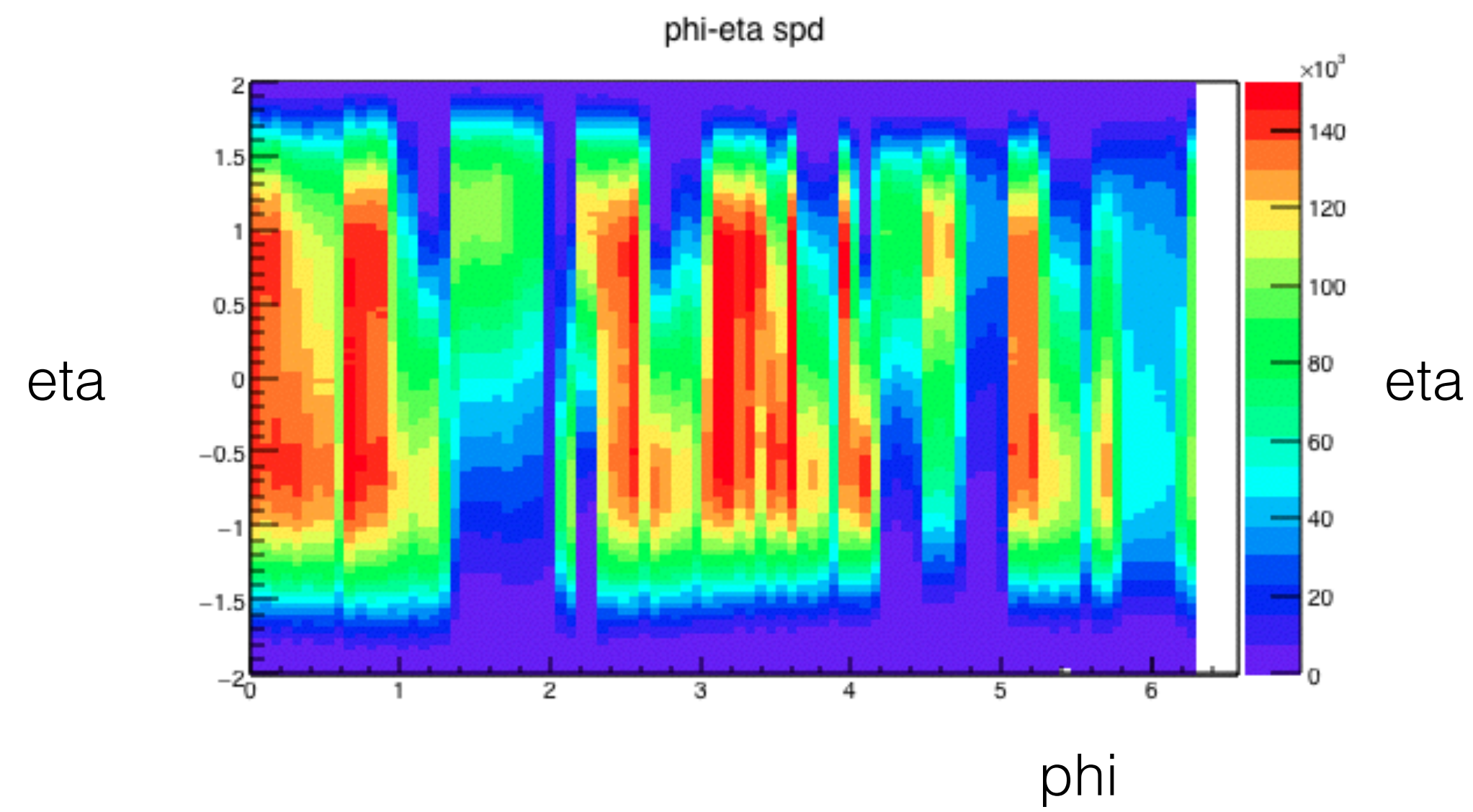


Deviation is nearly about 1% except bad/missing TPC channels

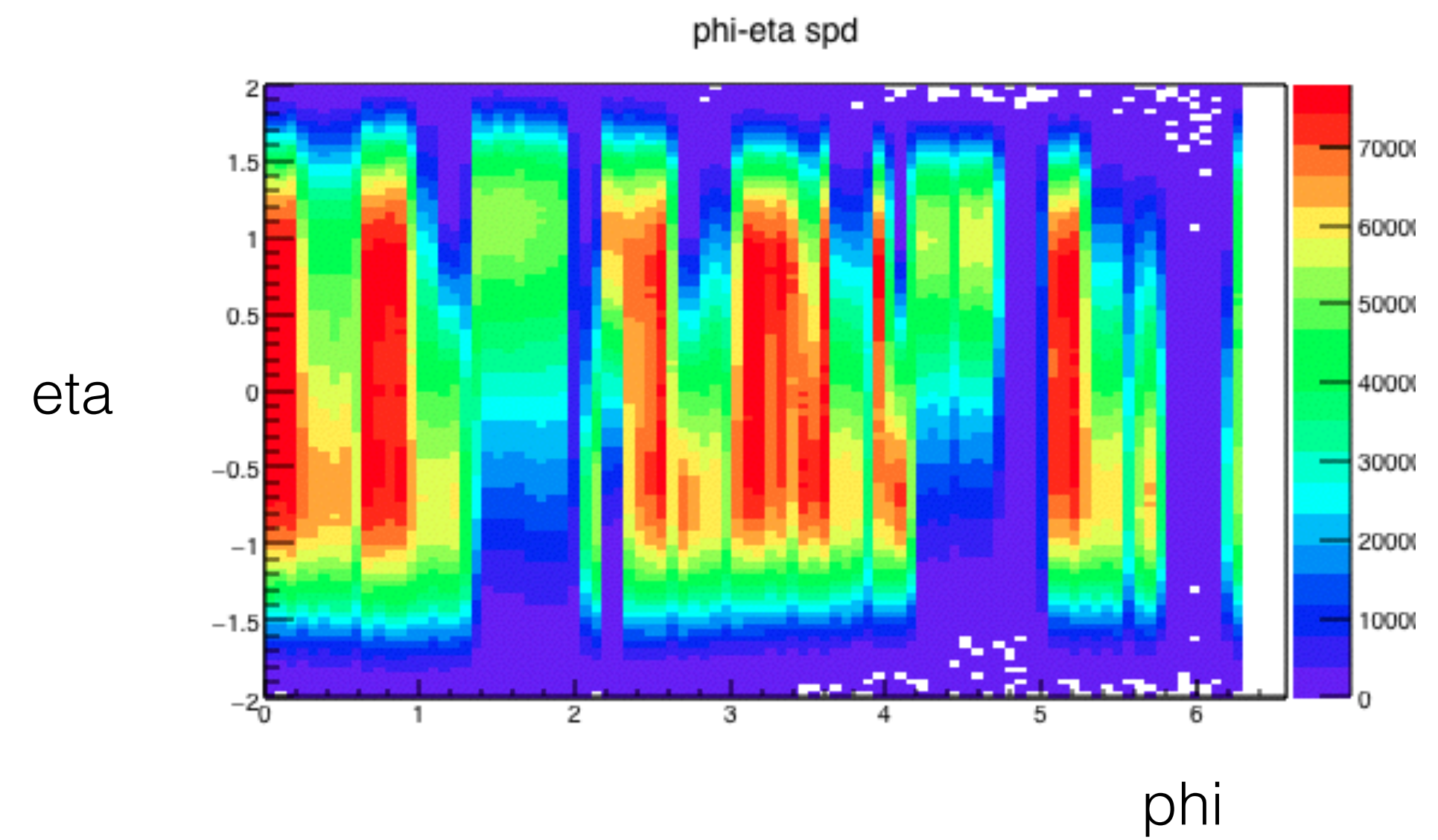
Distribution of TPC tracks



Eta-Phi correlation for spd tracklets

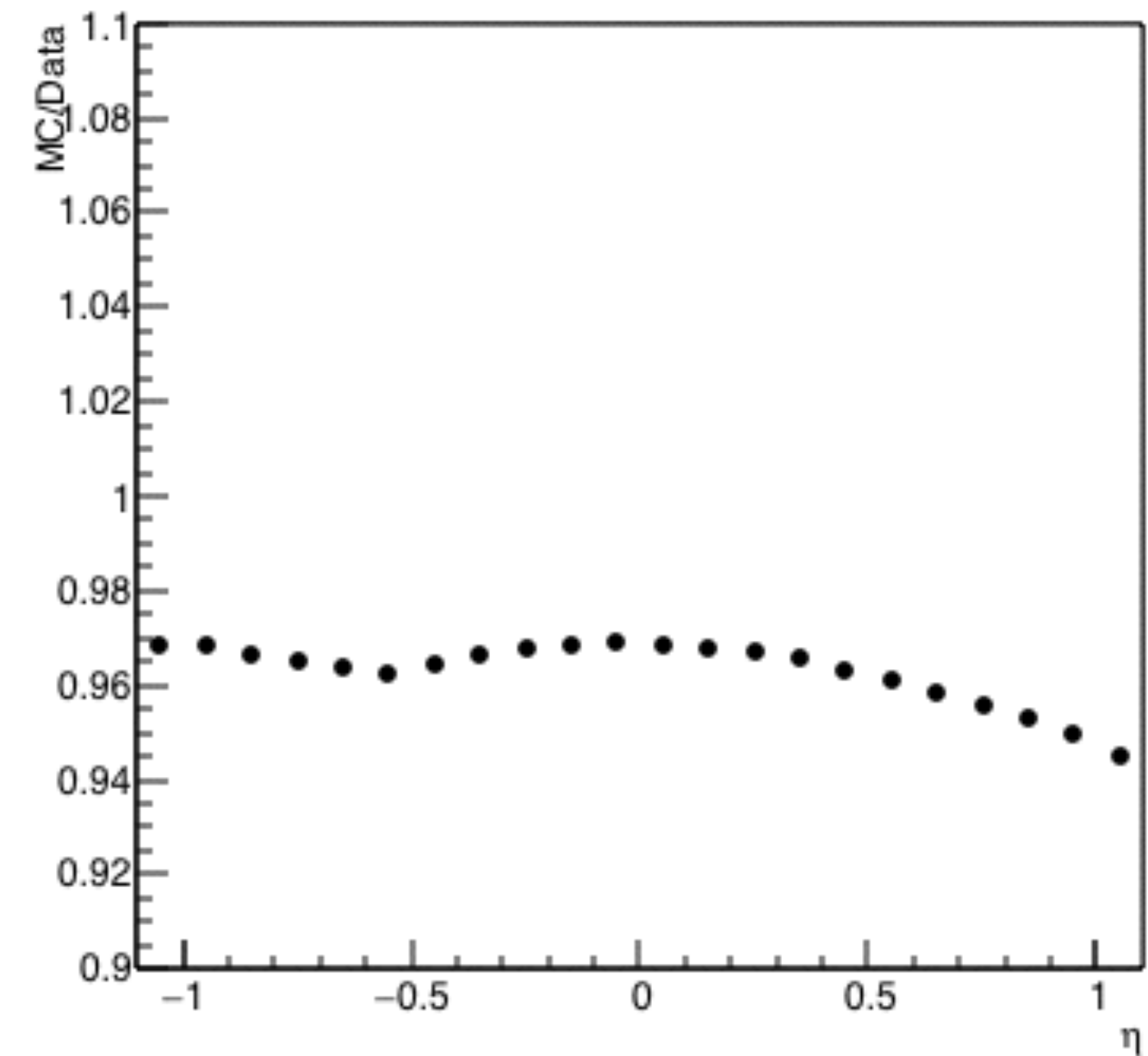
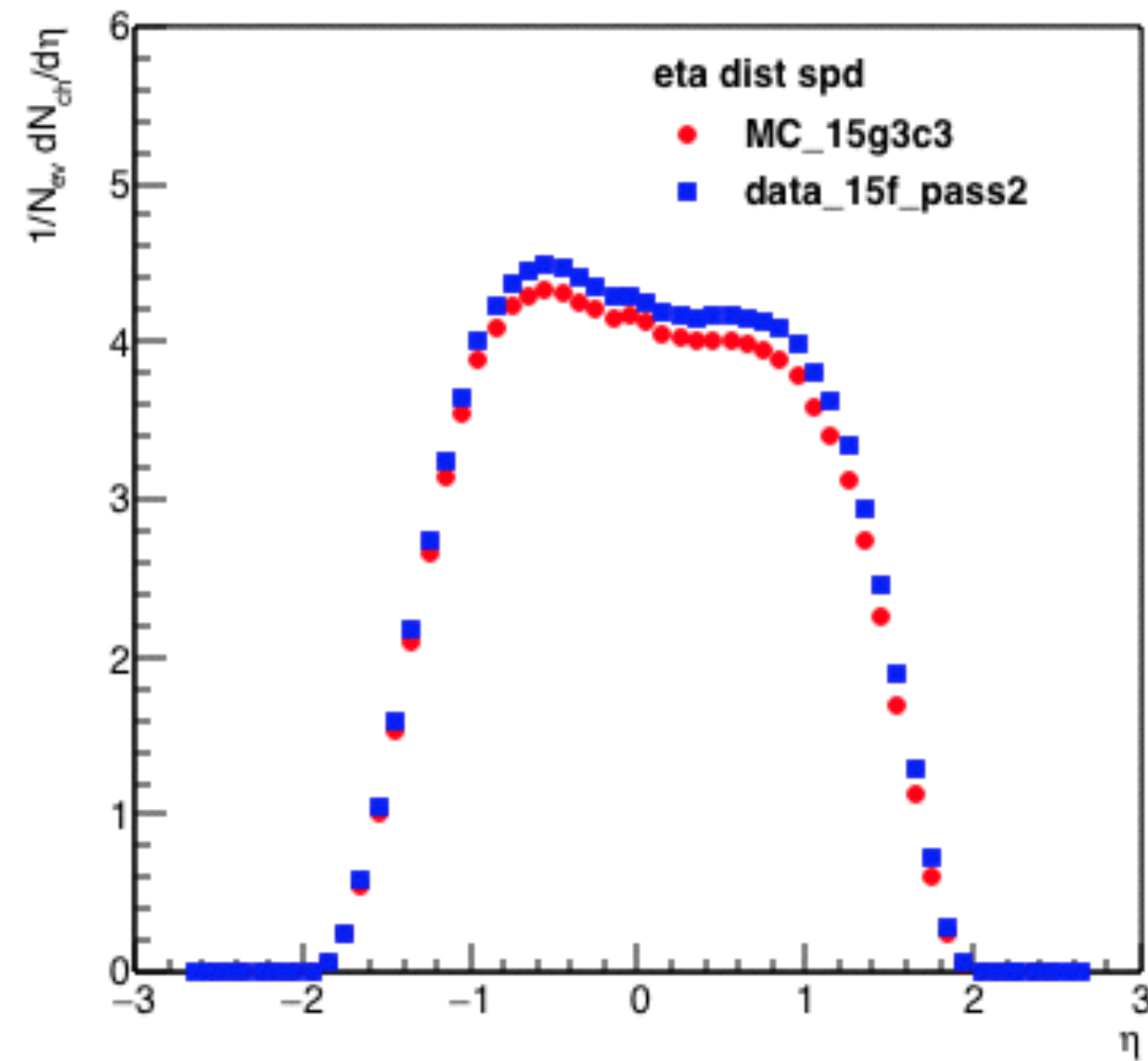


data



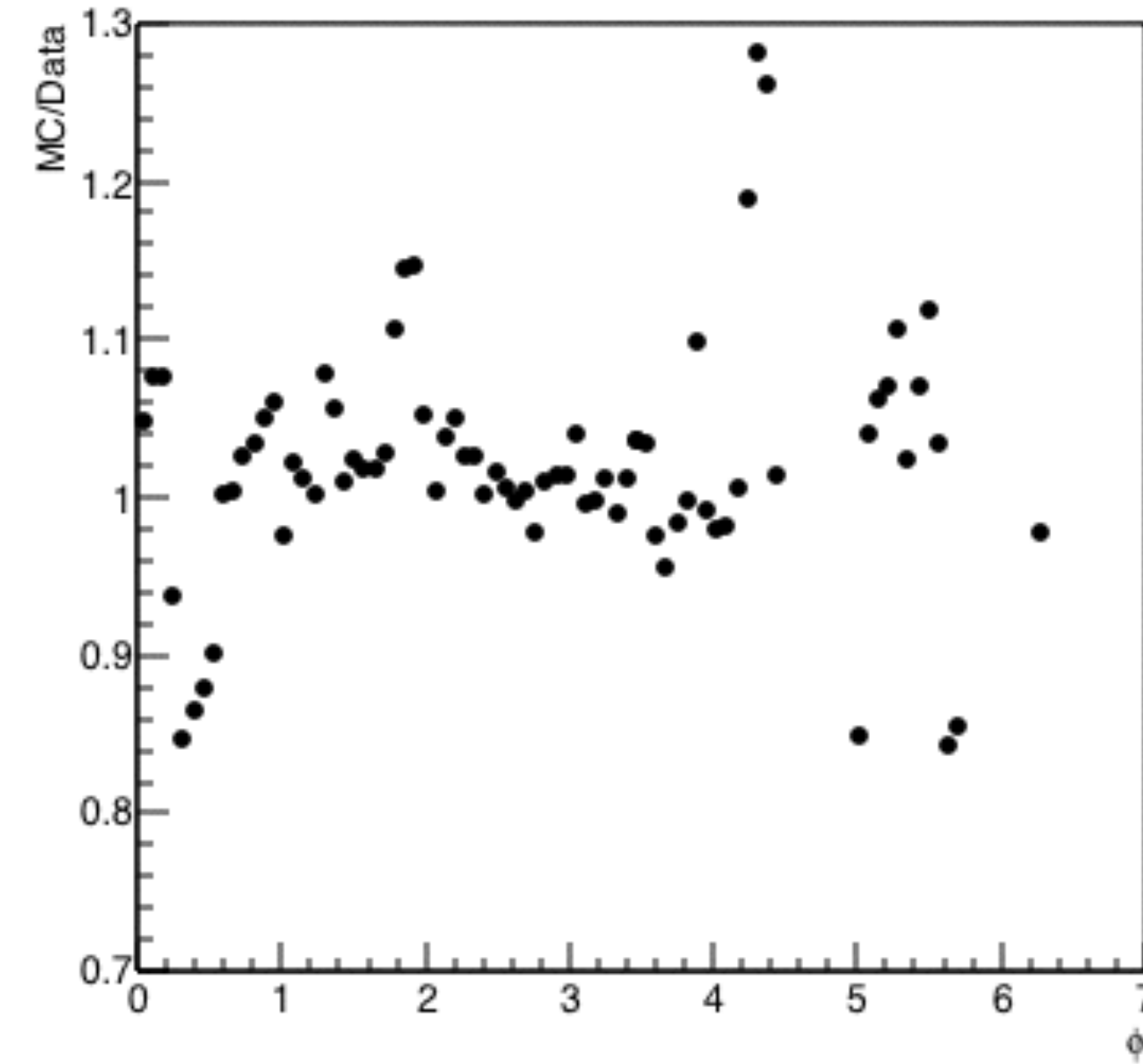
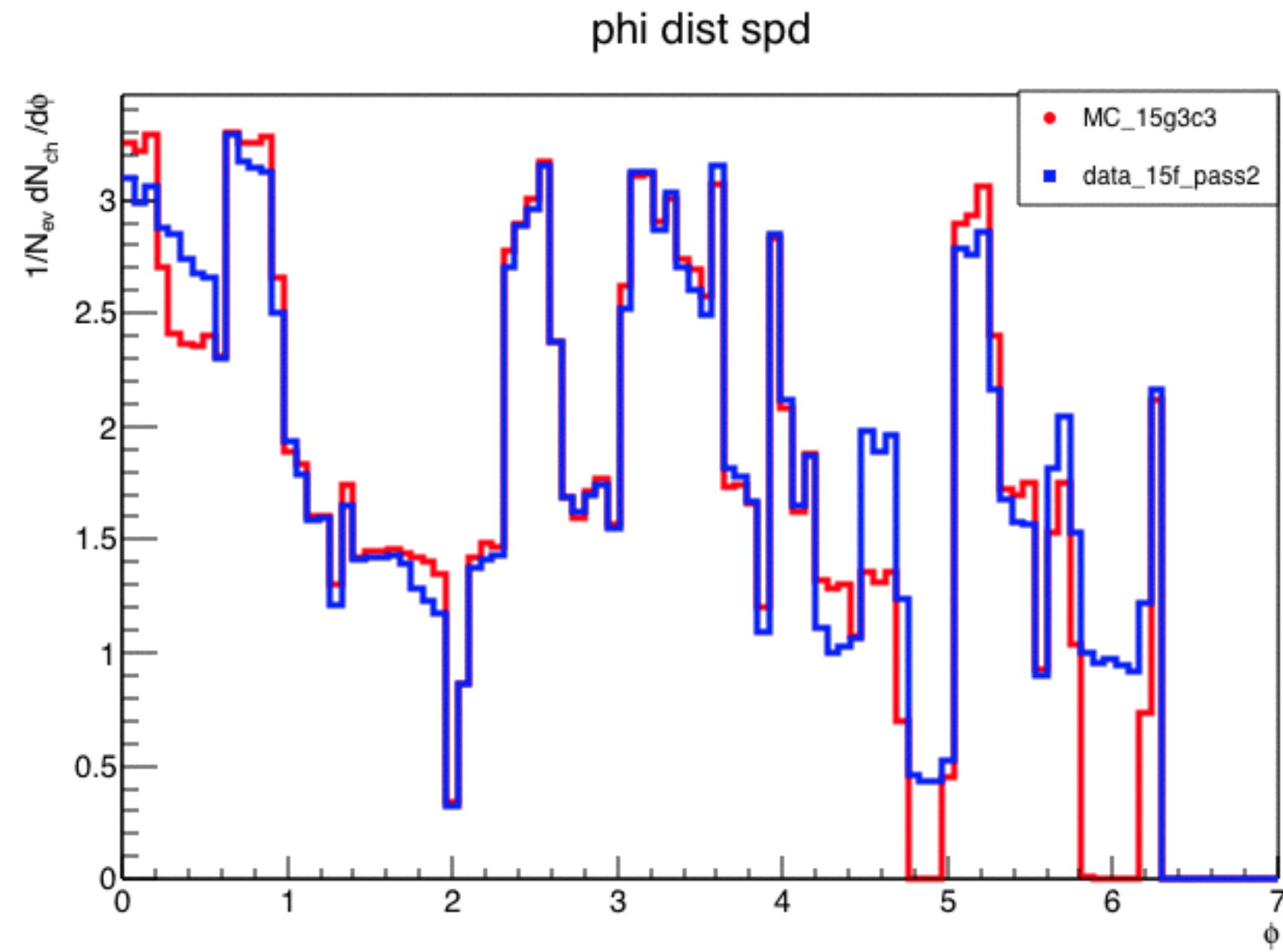
MC

Eta distribution for spd tracklets



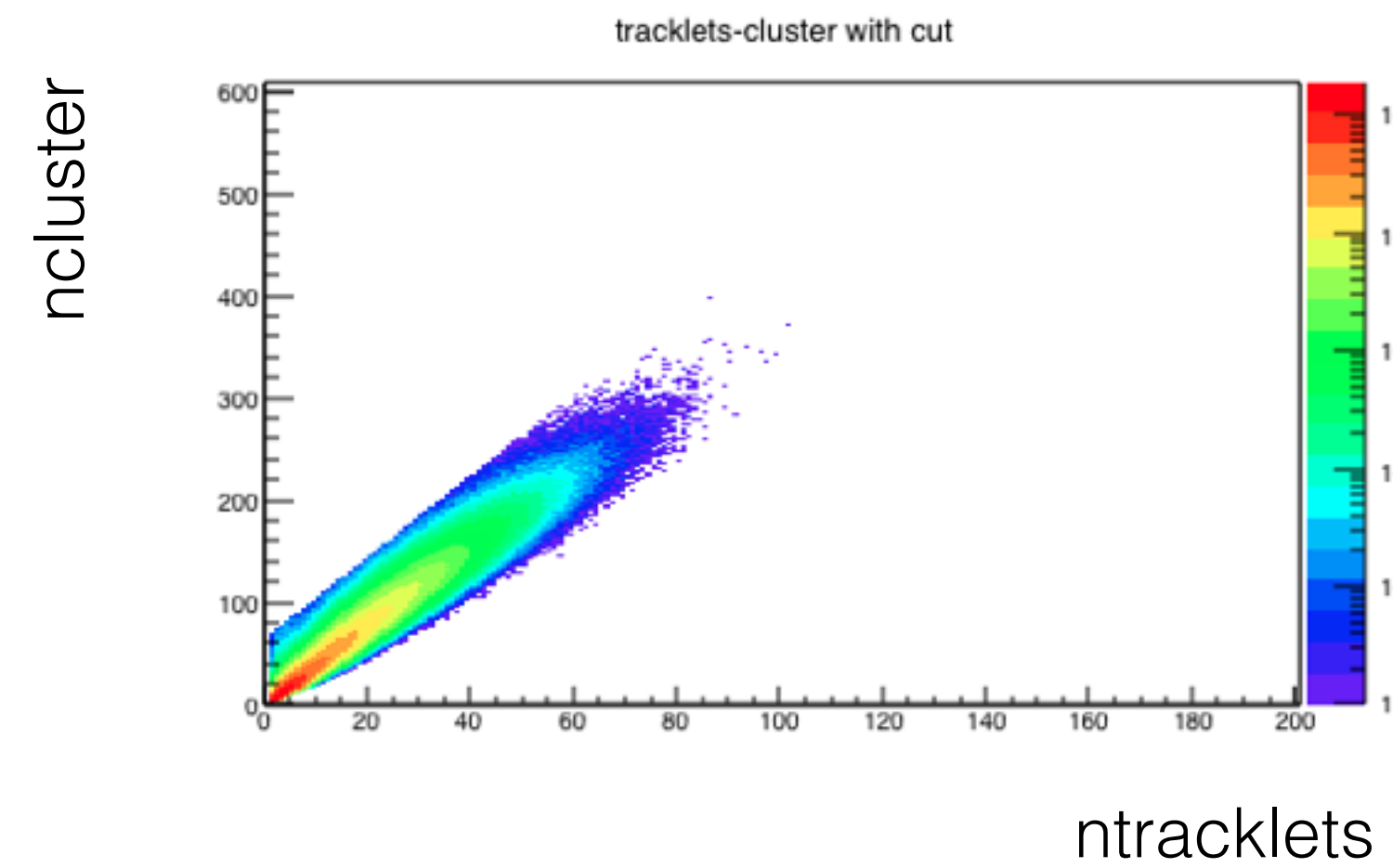
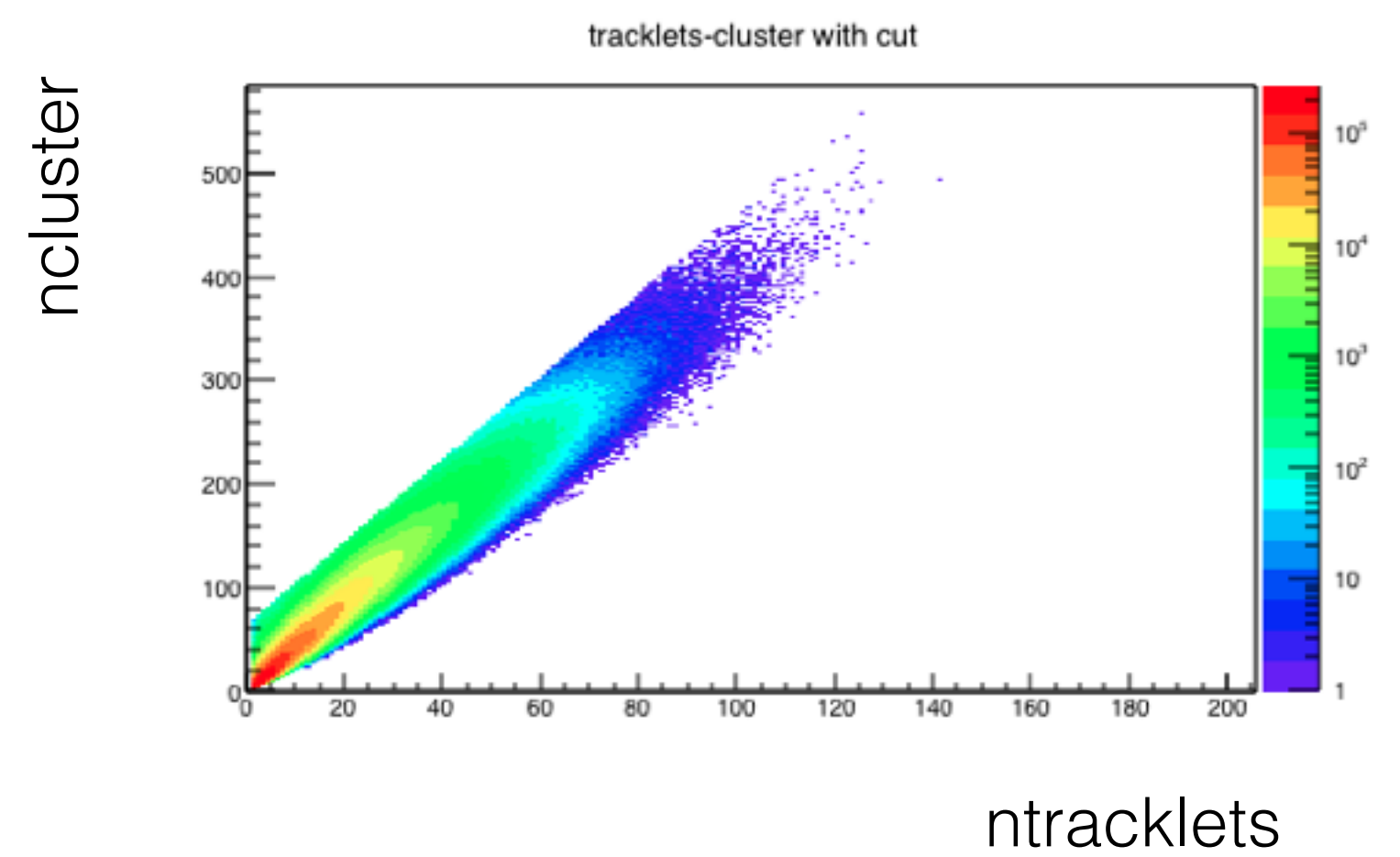
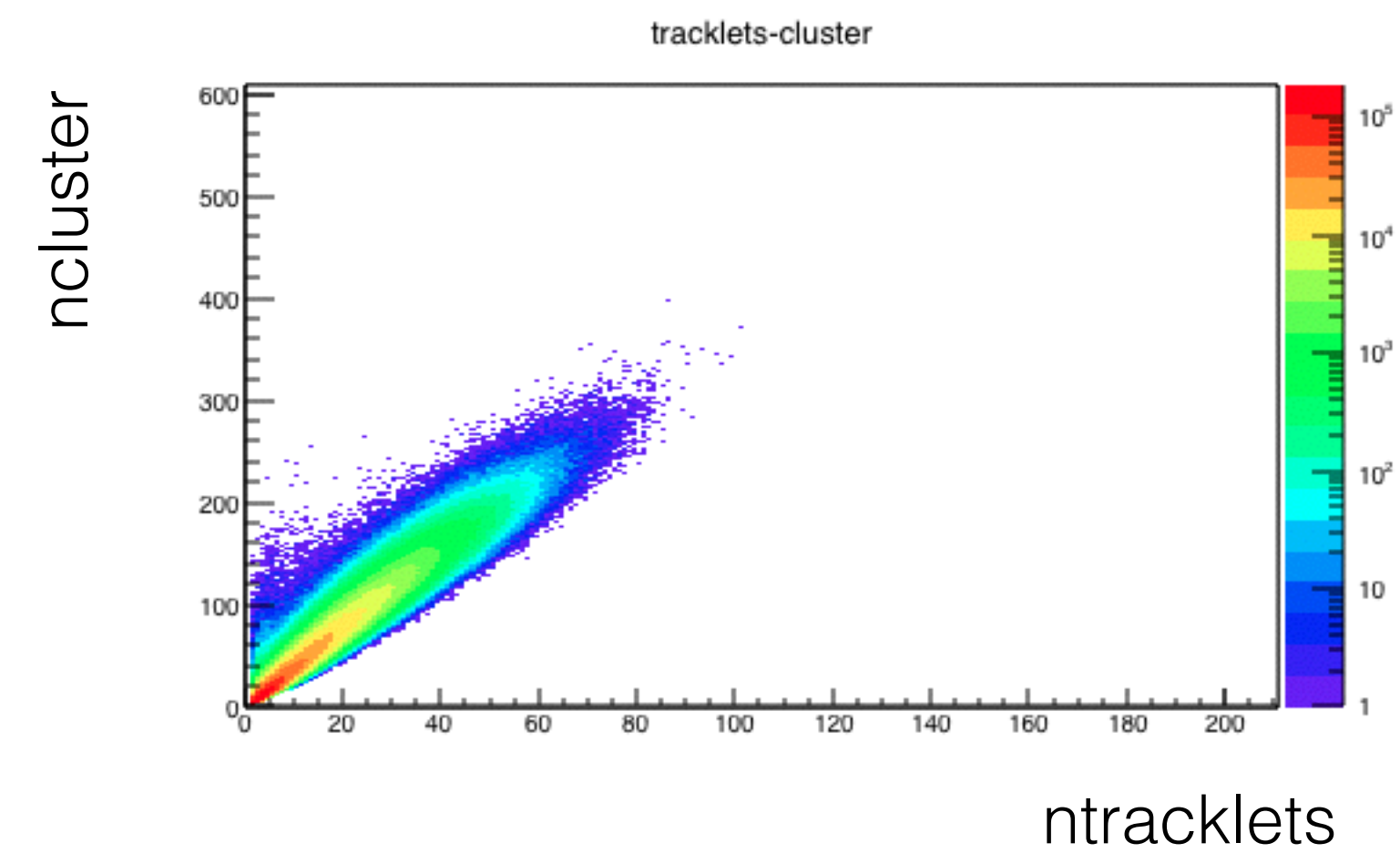
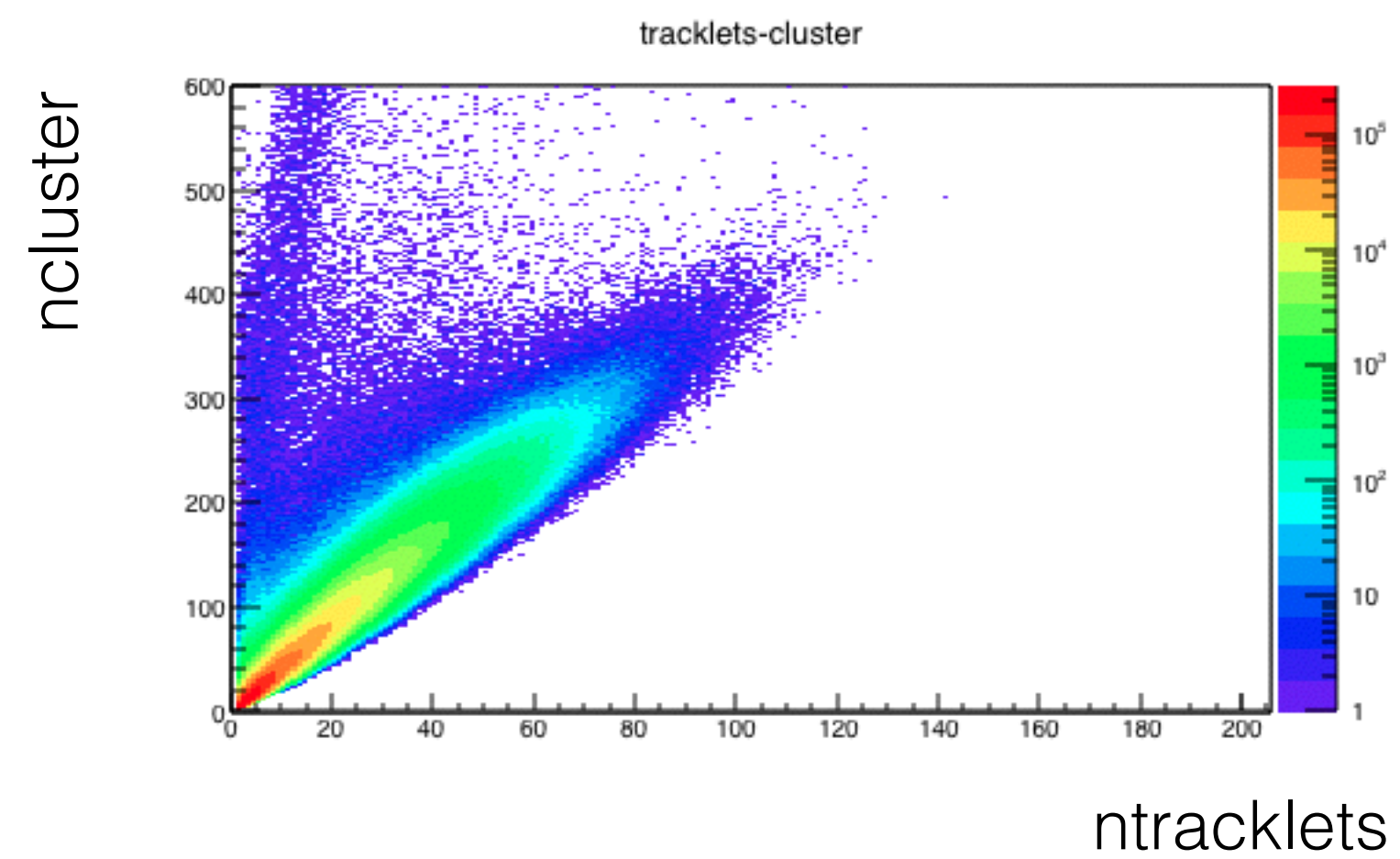
Deviation is 3% to 5.5% in mid rapidity region

Phi distribution of spd tracklets



Deviation is -1% to 1% except bad/missing chanel

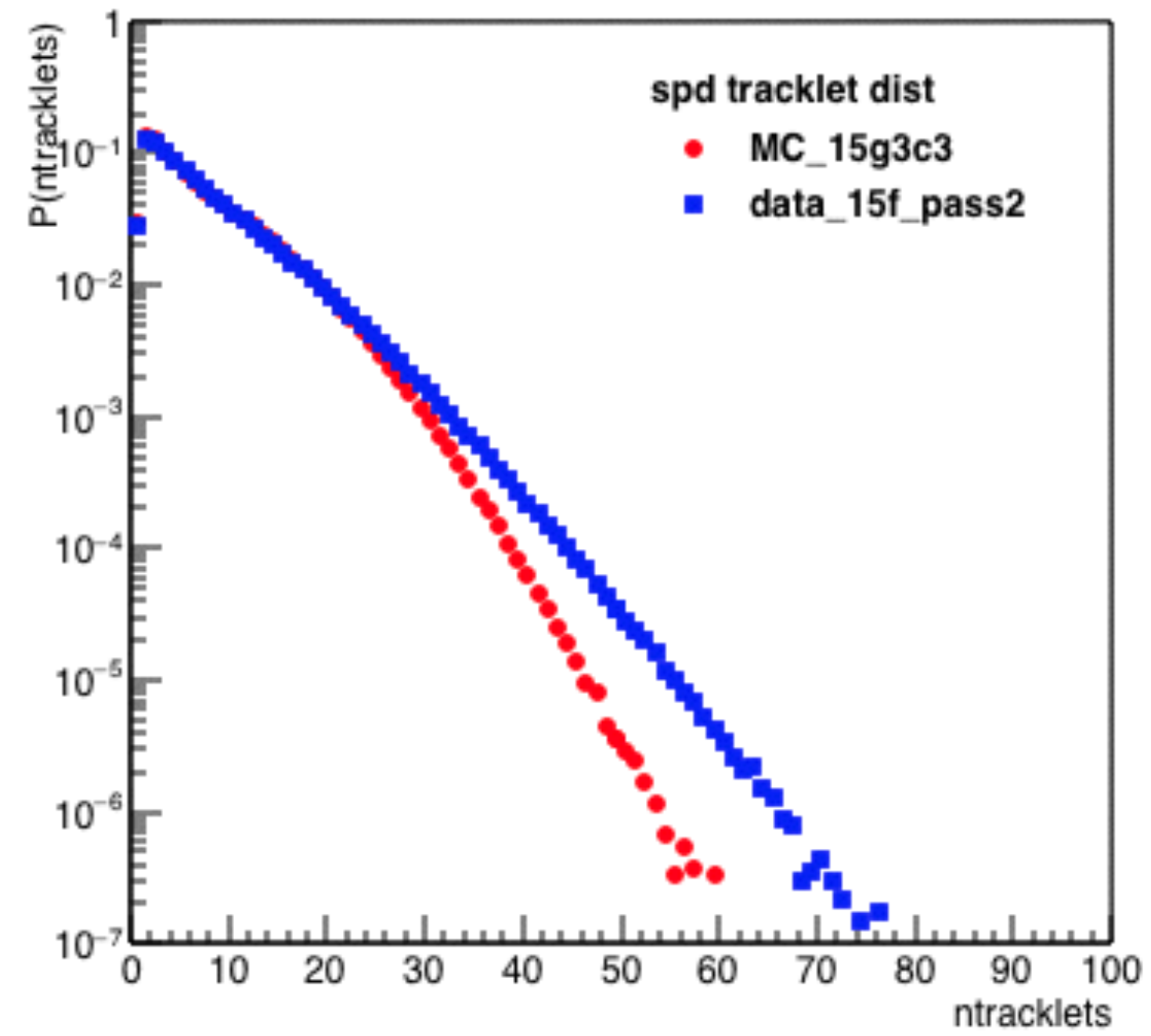
SPD tracklets vs. cluster cut



Data

MC

Distribution of spd tracklets



Summary

- Comparison of raw pp data for 7 and 13 TeV in terms of global observables.
- Comparison of data and MC to find the deviation in eta and phi distribution
- Next plan is to analyze high multiplicity pp events by using HM trigger.
- Error calculations are to be included.

Thank you