# Studying non-statistical fluctuation in high multiplicity pp events @ 7 TeV using Scale Factorial Moment (SFM) technique

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**ALICE-India Meeting, 7 Feb, SINP, Kolkata**

# Outline

- Introduction
- Physics Motivation: Dynamical fluctuation using scaled factorial moment (SFM) technique
- Analysis details
- Results
- Summary and outlook

# Introduction

- A characteristic of spatial distribution of charged particles from high energy collision is that it exihibit fluctuation.
- Fluctuation depend on the properties of the system and thus studies on fluctuation may provide information about the dynamics of nuclear collision.
- Two types of fluctuation are there,

(a) Statistical fluctuation (due to finiteness of event size) and

(b) Non-statistical or dynamical fluctation (due to inherent dynamics).

- Out of several methods, the scaled factoial moments (SFM) proposed by Bialas and Peschanski[1] is most significant to extract the dynamical fluctuaiton.
- The power law growth of SFM with decreasing phase space bin size referred as intermittency and indicates the presence of dynamical fluctuation.
- A power law behavior of SFM is also related with self similarity and fractal properties of the emitting source.

[1] A. Bialas, R. Peschanski, Nucl. Phys. B 273 (1986) 703

# SFM techniques

- Scaled factorial moments are of two types:

(i) Horizontally averaged SFM $\langle F_q \rangle_H$ : Characterizes the non-statistical fluctuation in phase space.

(ii) Vertically averaged SFM $\langle F_q \rangle_V$ : Characterizes the non-statistical fluctuation in event space.

- $\langle F_q \rangle_v$ has limitation of losing information about fluctuation in spatial distribtuion in an event.

- $\langle F_q \rangle_H$ has the limitation of its dependence on the shape of the single particle density distribution spectrum.

- The shape dependence of $<F_q>_H$ can be eliminated by converting single particle density distribution from cosθ to X(cosθ) space. Where X(cosθ) is given by,

$$\chi(cos\theta) = \frac{\int_{cos\theta_{min}}^{cos\theta} \rho(cos\theta) dcos\theta}{\int_{cos\theta_{min}}^{cos\theta_{max}} \rho(cos\theta) dcos\theta}$$

- The $<F_q>_H$ is given by,

$$< F_q >= \frac{1}{n} \sum_{i=1}^{N} M^{q-1} \sum_{m=1}^{M} \frac{n_m(n_m - 1).....(n_m - q + 1)}{< n >^q}$$

Where,

$$< n >= \frac{1}{N}\sum_{i=1}^{N} n$$

Here N = total number of event.

$n_m$ = number of particular type of track in $m^{th}$ bin in $i^{th}$ event.

M = number of bin in X(cosθ) space.

- Bialas and Peschanski have shown that for distribution of particles not exhibiting any fluctuation other than the statistical one, $<F_q>_H$ is essentially independent of the bin size.

- For any dynamical fluctuation the SFM should follow a power law of the form,

$$< F_q >_H \propto M_q^{\phi}$$

- Thus a linear plot of $\ln<F_q>_H$ vs lnM with positive slope confirms the existance of intermittency.

- Lipa and Buschbeck[2] have correlated the scaling behavior of factorial moments to the physics of fractal and multifractal objects.

- The intermittency index $\Phi_q$ ,has a special significance from the point of view of anamalous dimension $d_q$ , which is used for description of the fractal objects and is given by,

$$d_q = \frac{\phi_q}{q-1}$$

  - The order independence of $d_q$ may be associated with the formation for QGP.

  - And increse in $d_q$ describes intermittence behaviour.

[2] P. Lipa, B. Buschbeck, Phys. Lett. B 223 (1988) 465.

# Analysis Details :

- Detector used : TPC
- ALICE data: p-p at $\sqrt{S_{NN}}$ = 7 TeV

LHC10d, pass2, AOD data

- Run Number : 126088
- Multiplicity cut : V0A multiplicity cut

# Multiplicity distribution :

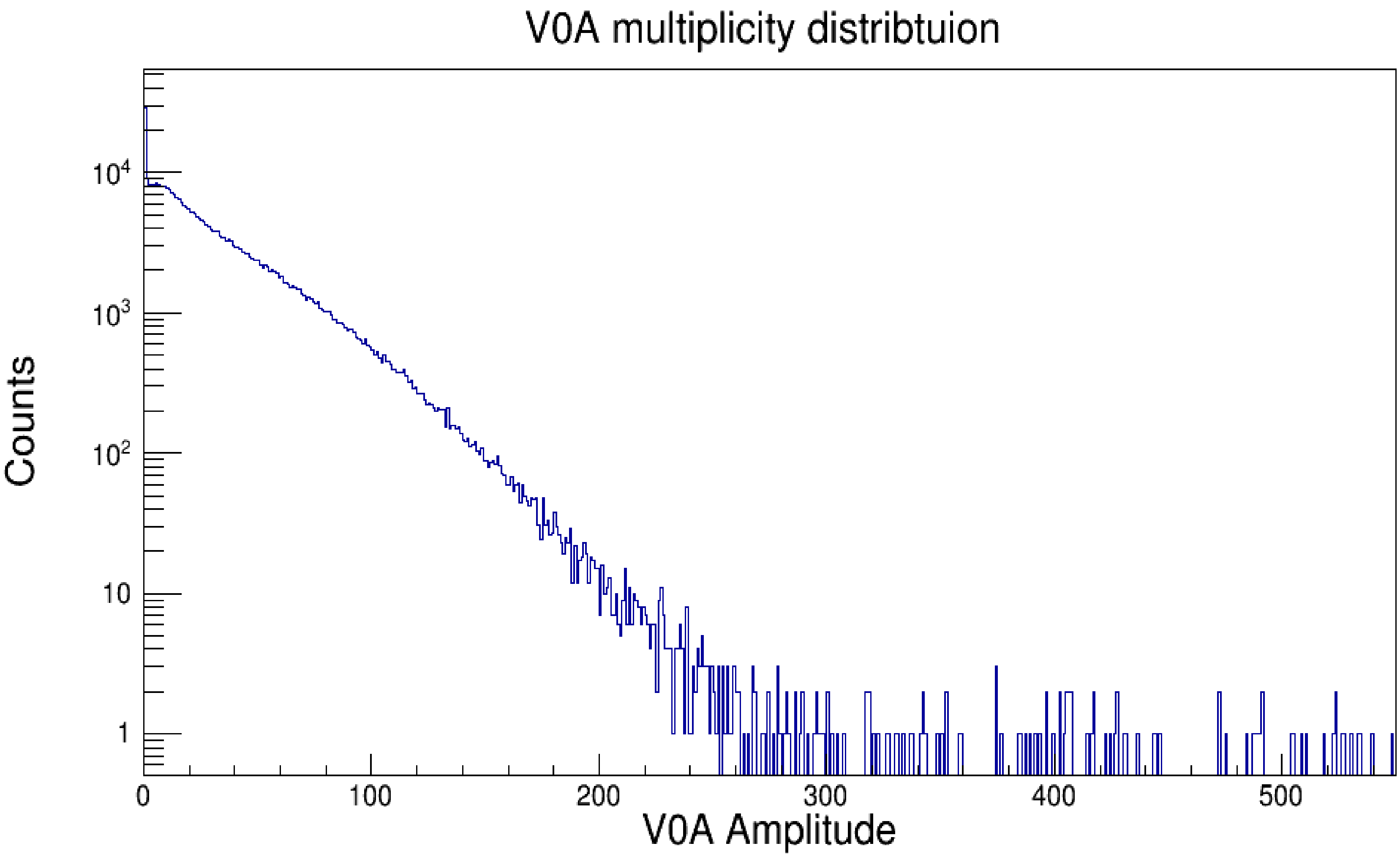


Fig. 1. V0A amplitude distribution

# Particles density distributions in cosθ space

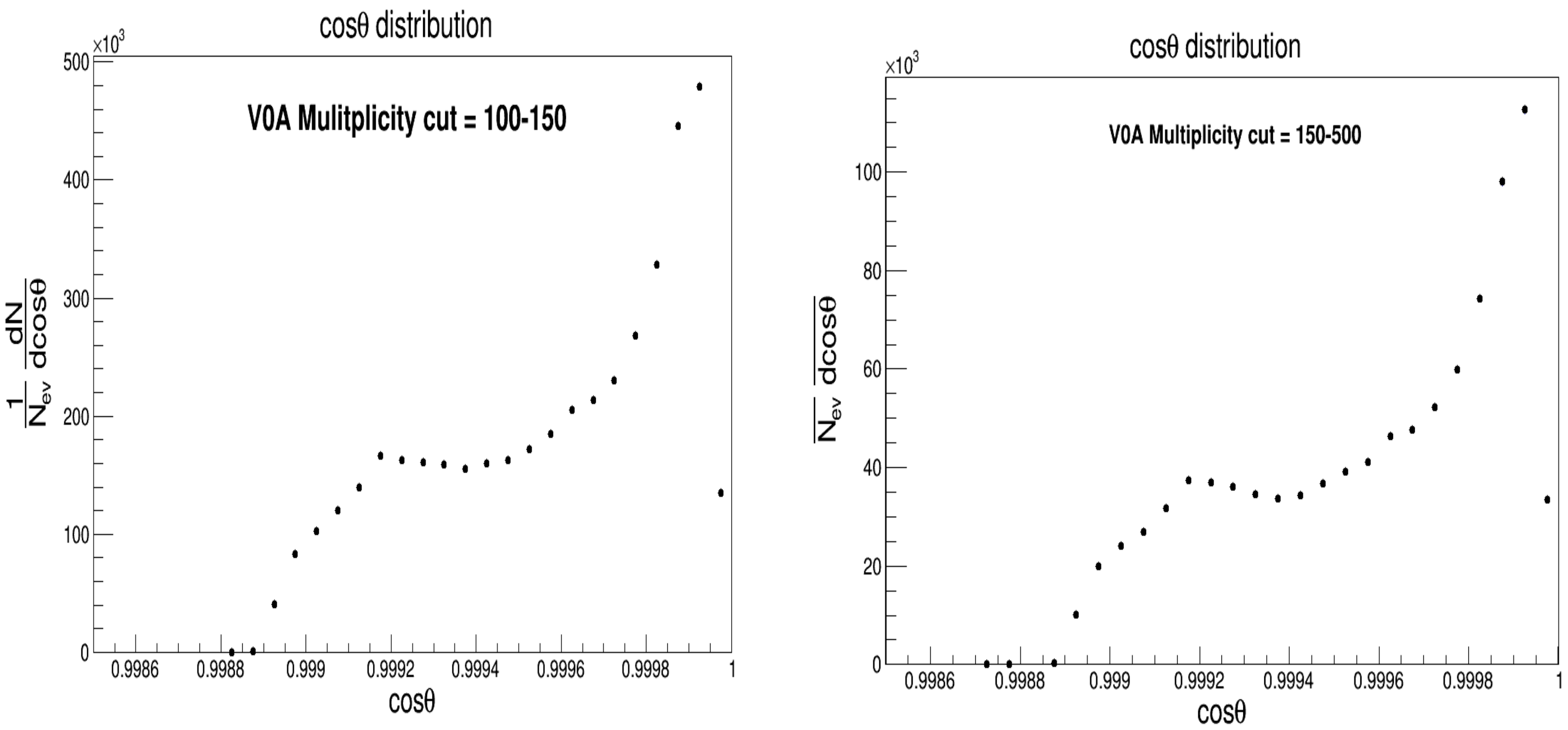


Fig. 1. cosθ distribution

# Particles density distributions in X(cosθ) space

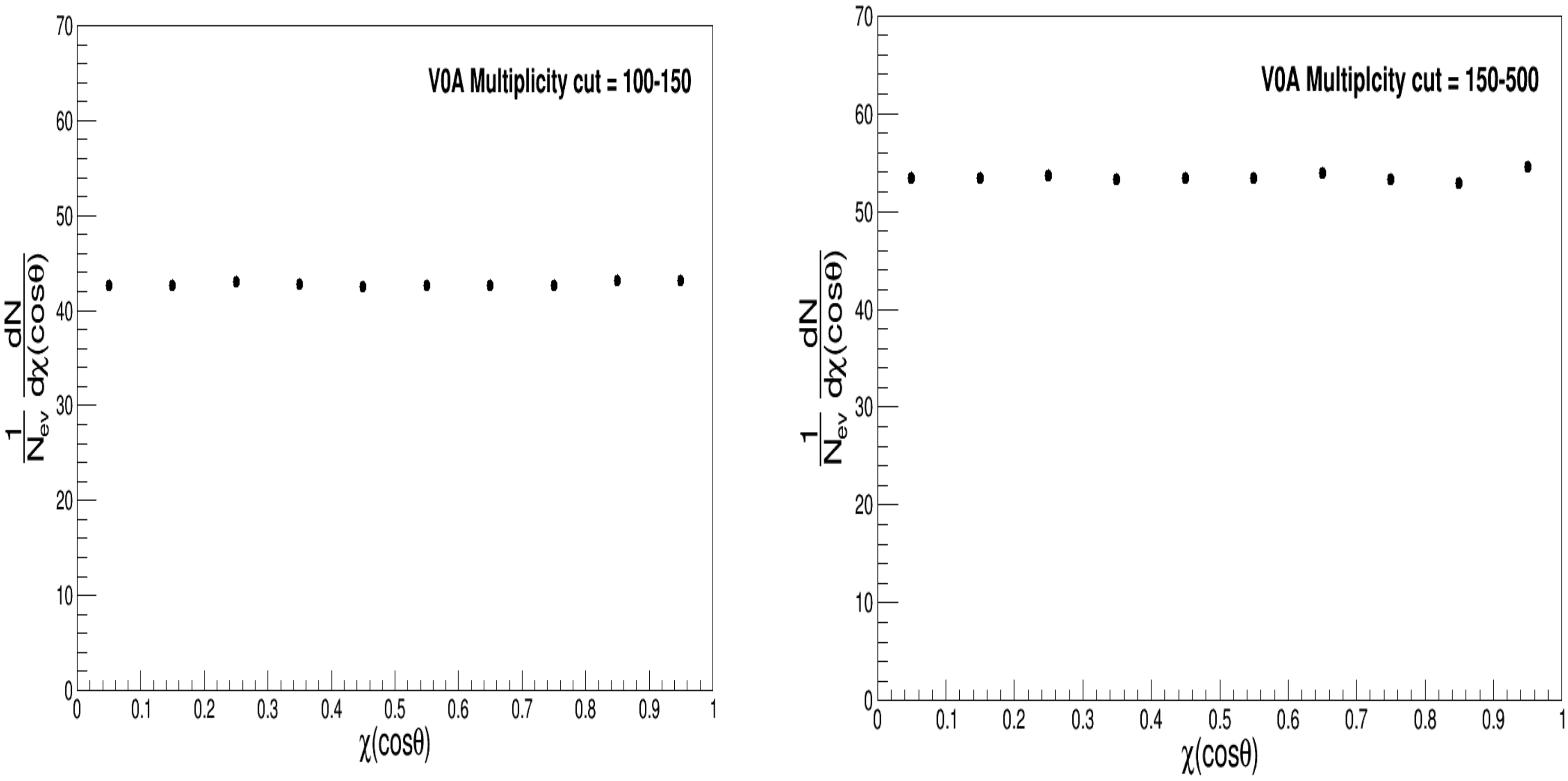


Fig. 2. Single particle density distributions of scaled variable X(cosθ)

# ln <$F_q$> vs ln M distribution

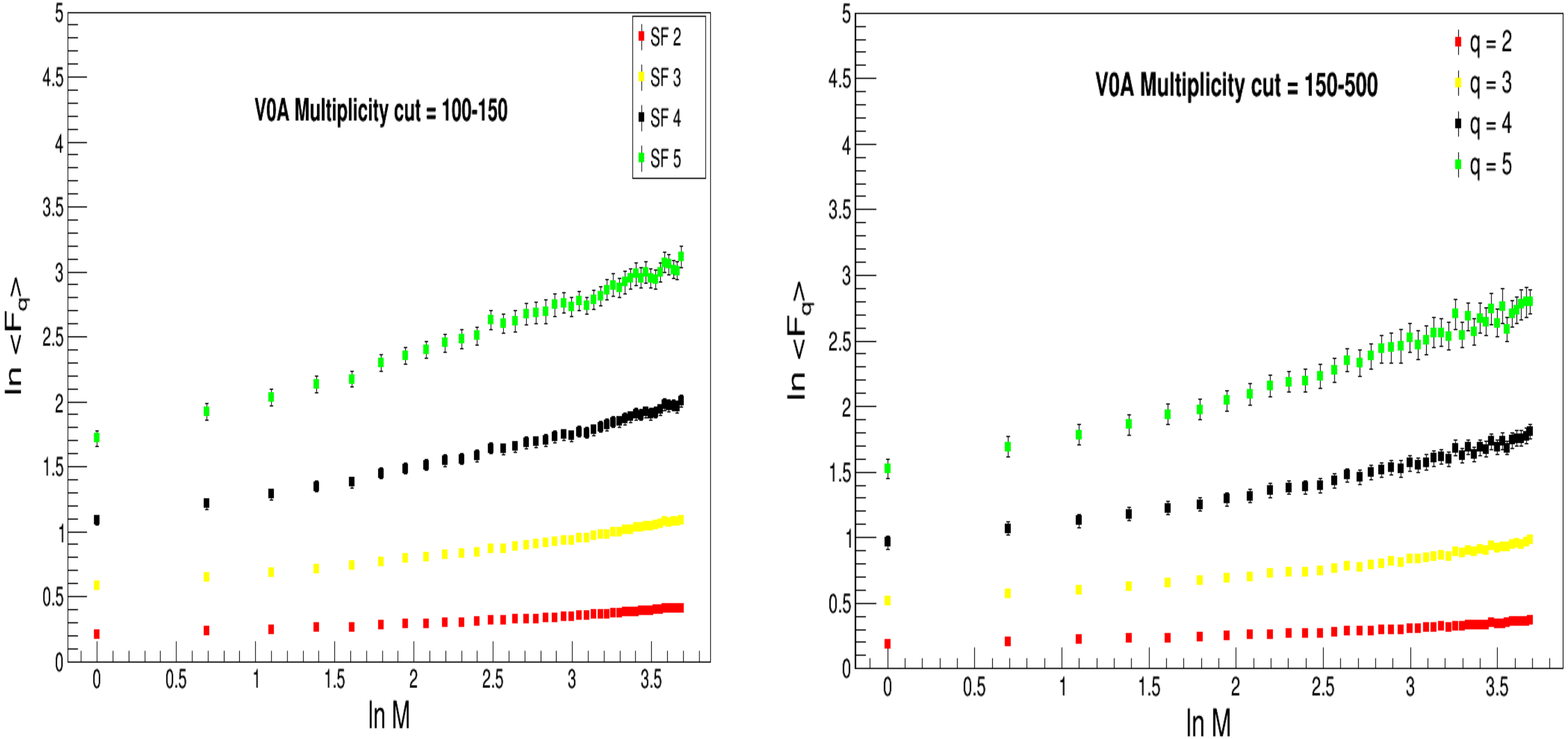


Fig. 3: Variation of ln <$F_q$> as a function of ln M

# Varitaion of $d_q$ distribution with bin size

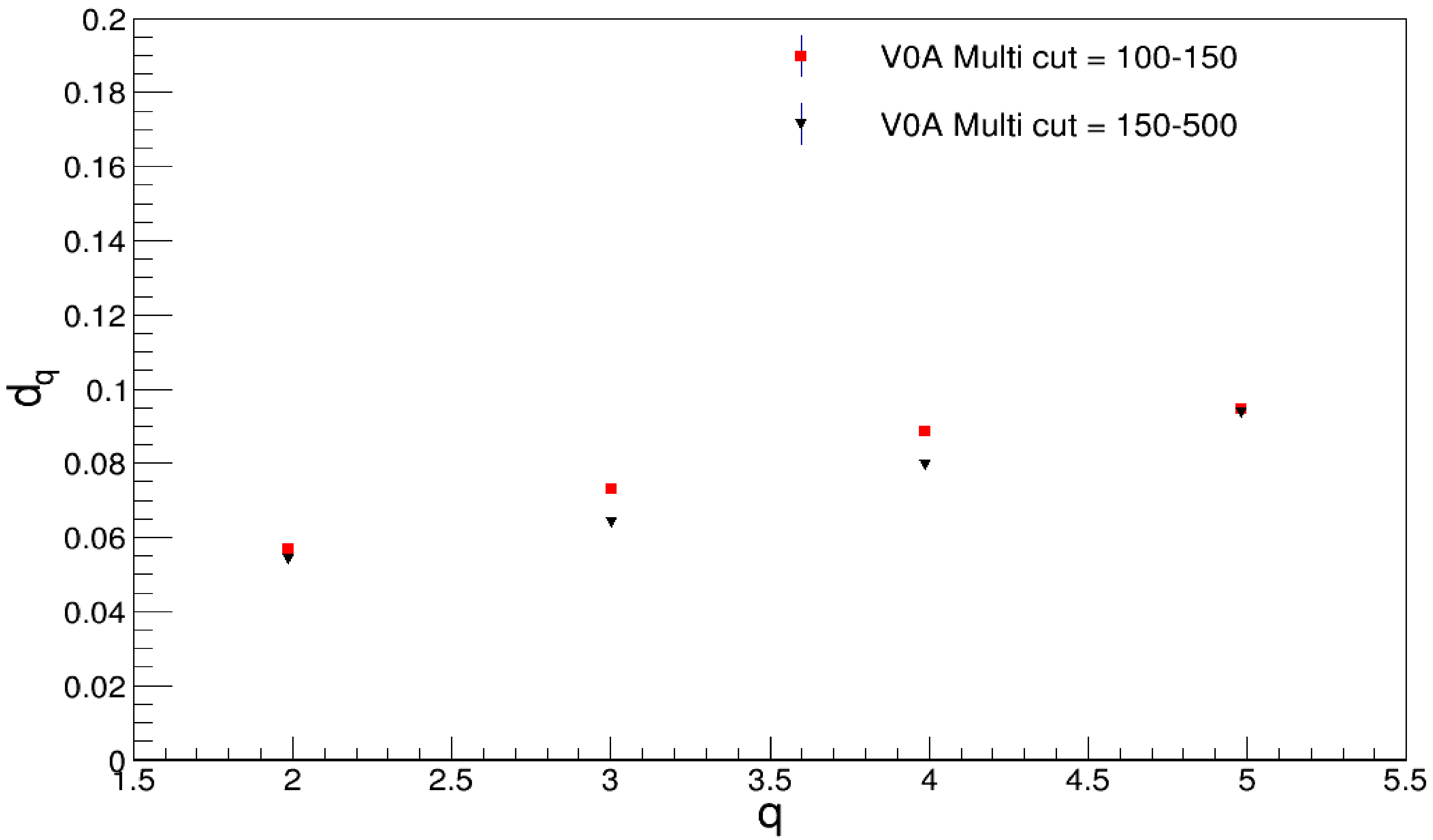


Fig. 6: Dependence of anomalous fractal dimension, $d_q$ on q

# Summary

- The high multiplicity data shows a power law confirming intermittency.
- The $d_q$ plot also gives information about the intermittence behaviour in the high multiplicity event.

# Outlook

- These results are preliminary results which needs to be further analysed with more event.

- Analyze more high multiplicity data at different energies.


Thank You!