ALICE India Meeting

Photon Flow in PMD

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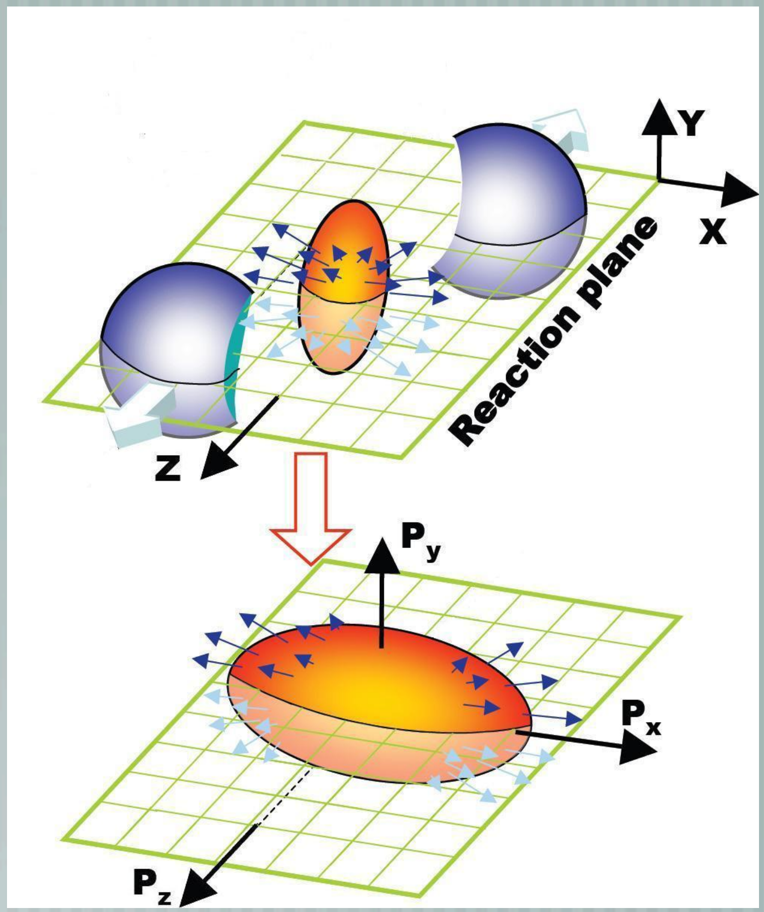
Outline

- To flow or not to flow
- Detector
- Analysis details
  - Data set
  - Cuts
- Integrated flow in Pb-Pb
- Integrated flow in p-Pb

why study flow?

Spatial anisotropy → Momentum anisotropy



Quantified by anisotropic flow

an important probe of the interaction region of collisions

may signal the formation of quark gluon plasma

combining flow and two particle interferometry - 3D picture of the emitting source

Photon Flow

Besides photons from hadron decays, direct photons are emitted at every stage of the system evolution

Since photons interact only weakly with strongly coupled medium - Carry undistorted information of the system

direct-photon production in nucleus-nucleus collisions

prompt photons → hard interactions of partons (quark- antiquark-annihilation and quark-gluon compton scattering)

fragmentation photons → fragmentation of hard scattered quarks or gluons

thermal photons → emitted by the hot thermalized medium through scattering of particles during the QGP phase and hadronic interactions in the hot hadron gas phase

Flow Harmonics

Fourier expansion of azimuthal distribution

$$E\frac{d^3N}{d^3P} = \frac{1}{2\pi}\frac{d^2N}{p_t dp_t dy}\left(1 + \sum_{n=1}^{\infty} 2v_n \cos[n(\phi - \psi_n)]\right)$$

$$v_n = \langle \cos(n(\varphi - \Psi_n)) \rangle$$

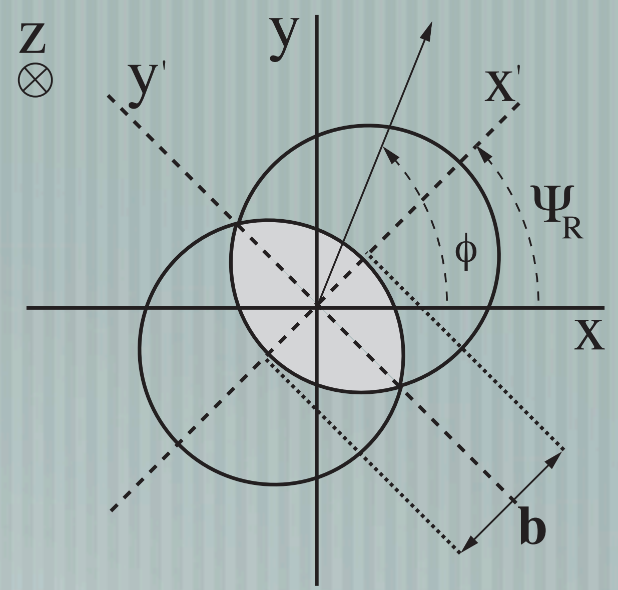
nth order flow harmonic

Methods

Event Plane

Calculate correlation between angle and reaction plane

$$v_n = \langle \cos(n(\varphi - \Psi_n)) \rangle$$



Cumulant Method

Two and Multi-particle correlations

$$\langle e^{in(\phi_1 - \phi_2)} \rangle$$

$$\langle \exp[in(\phi_1 + \phi_2 - \phi_3 - \phi_4)] \rangle$$

$$\langle e^{in(\phi_1 - \phi_2)} \rangle = \langle e^{in\phi_1} \rangle \langle e^{-in\phi_2} \rangle + \langle\langle e^{in(\phi_1 - \phi_2)} \rangle\rangle$$

↓ 2nd order Cumulant

More on Cumulants

Using generating function we build these cumulants

$$G_n(z) = \prod_{j=1}^{M}\left(1 + \frac{z^* e^{in\phi_j} + z e^{-in\phi_j}}{M}\right)$$

Start with Generating function over an event

$$\langle G_n(z)\rangle = 1 + \cdots + \frac{|z|^2}{M}\left\langle \sum_{j\neq k} e^{in(\phi_j-\phi_k)}\right\rangle + \cdots + \frac{|z|^4}{4M^4}\left\langle \sum_{j,k,l,m} e^{in(\phi_j+\phi_k-\phi_l-\phi_m)}\right\rangle + \cdots$$

Average over all events

$$M\left(\langle G_n(z)\rangle^{1/M} - 1\right) = |z|^2 \left\langle\left\langle e^{in(\phi_j-\phi_k)}\right\rangle\right\rangle + \cdots$$

Deduce cumulants

$$M\left(\langle G_n(z)\rangle^{1/M} - 1\right) = \ln I_0(2v_n|z|)$$

Use interpolation formula to deduce flow

$$v_n\{2\}^2 \equiv c_n\{2\},$$
$$v_n\{4\}^4 \equiv -c_n\{4\},$$
$$v_n\{6\}^6 \equiv c_n\{6\}/4.$$

$$c_n\{2k\} \equiv \langle\langle e^{in(\phi_1+\cdots+\phi_k-\phi_{k+1}-\cdots-\phi_{2k})}\rangle\rangle$$

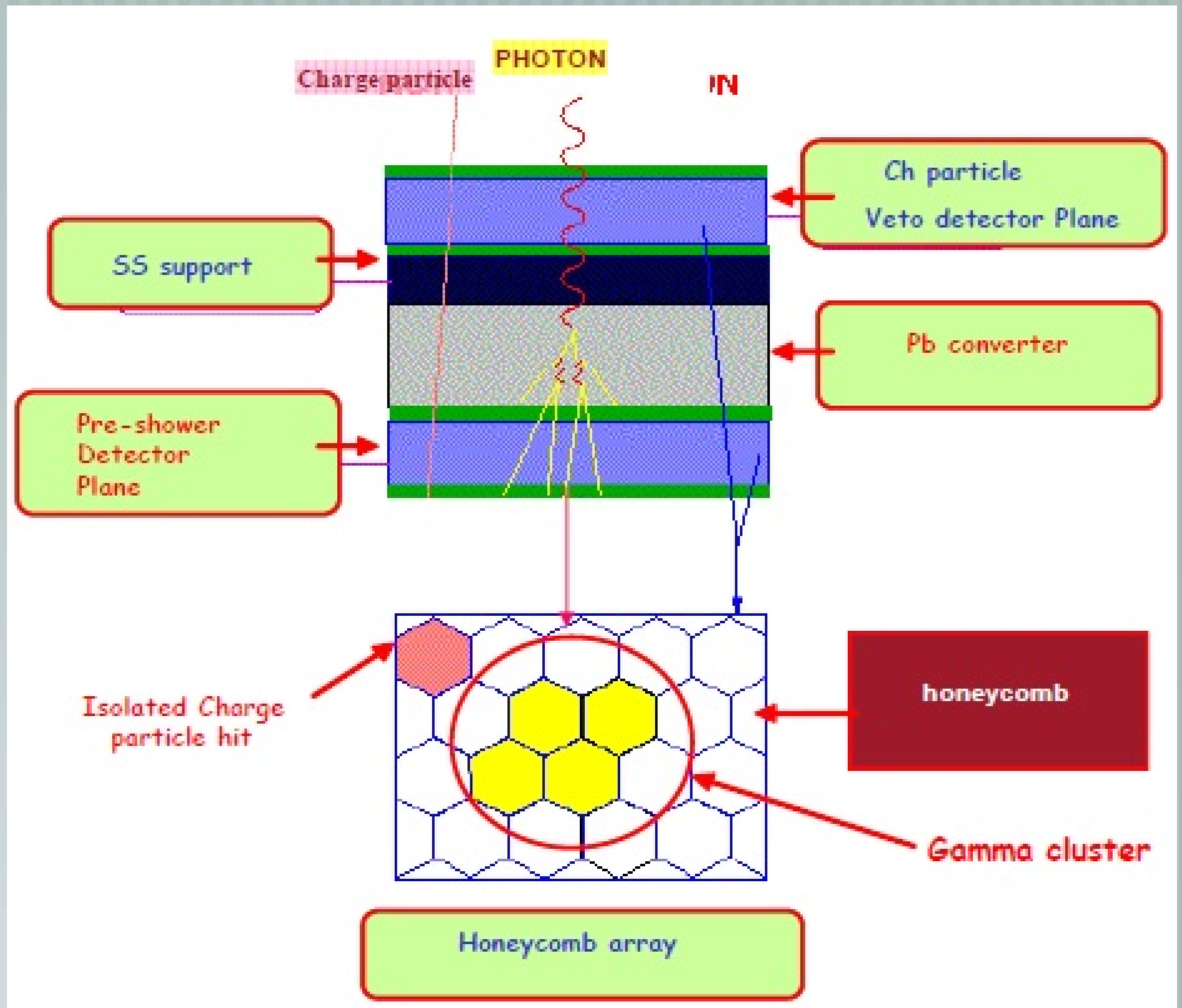
Photon Multiplicity Detector

The charged hadron passing through PMD in general deposits energy like MIP in both planes

Photon do not deposits any energy in CPV but gives large number of hits in the Preshower plane cells

So the cell number and signal strength are used for photon hadron discrimination

Cell depth : 0.5 cm
Cell cross-section : 0.23 cm2
Total no. of cells : 76800×2 (as installed)
Coverage : 2.3 to 3.9 in
Sensitive medium : Gas (Ar+CO2 in the ratio 70:30)



Analysis Details

Data Analyzed

Pb-Pb	LHC10h 2.76 TeV
p-Pb	LHC12g 5.02 TeV

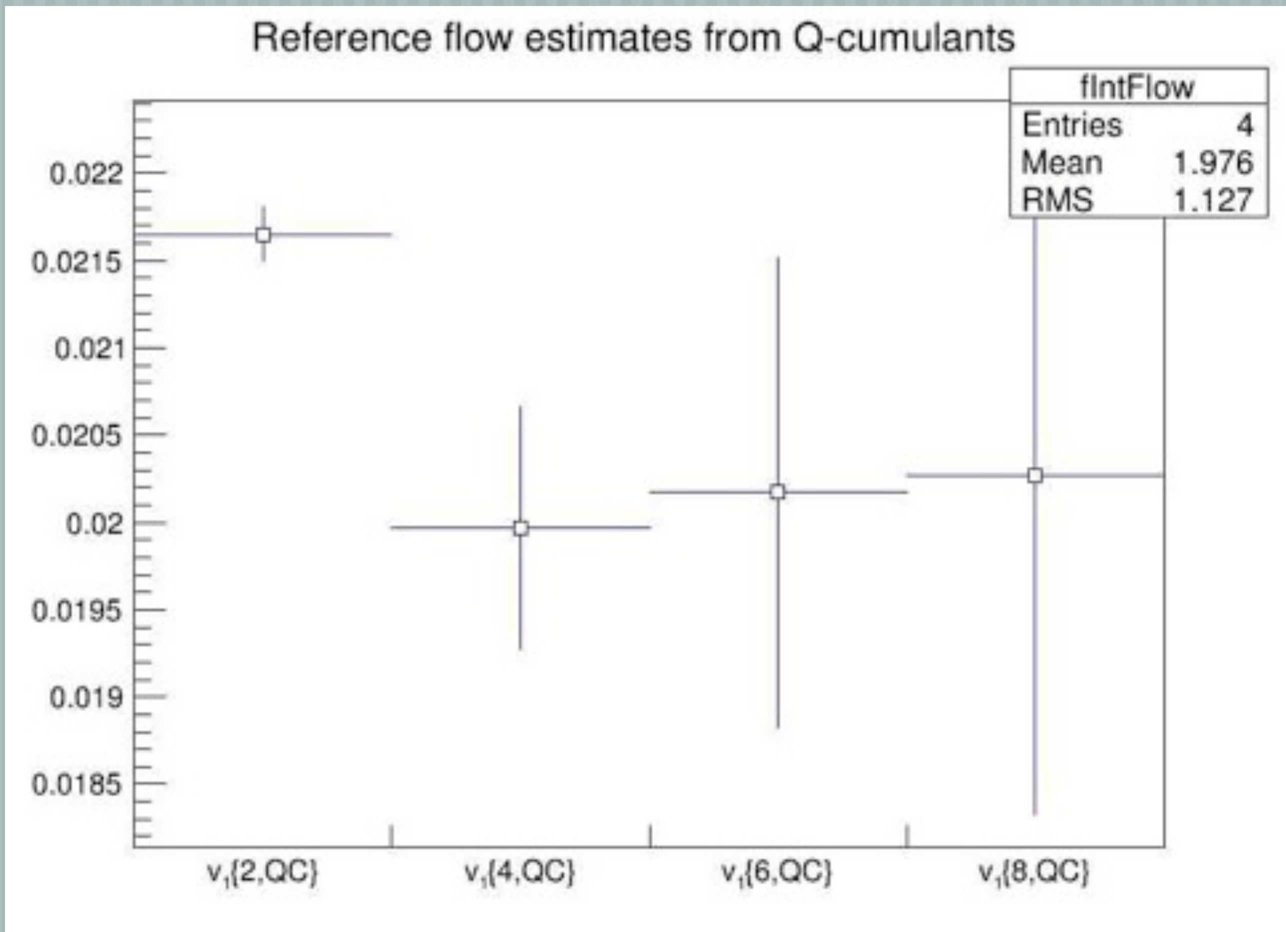
$| z \text{ vertex} | < 10$ cm

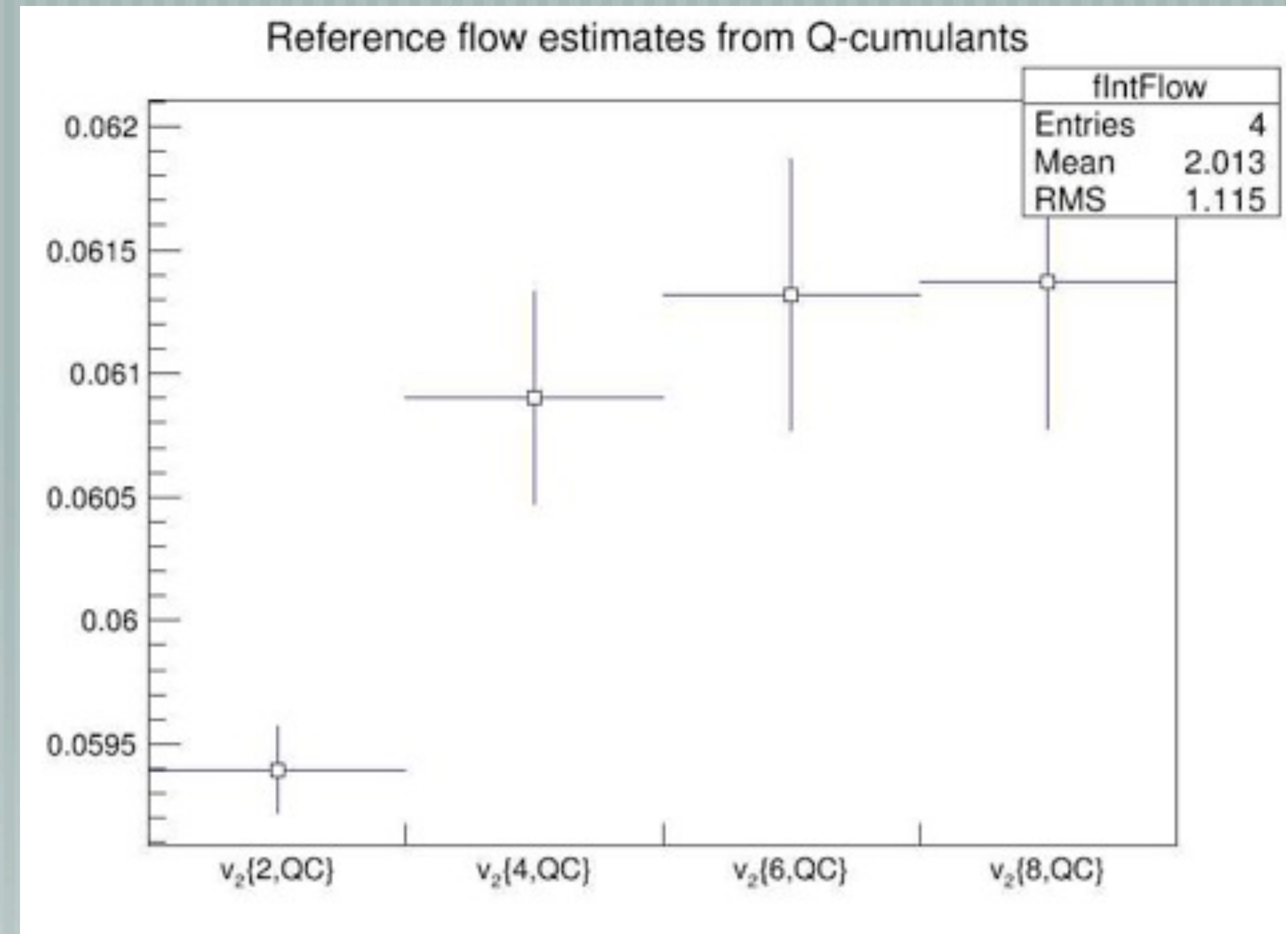
n = (2.3,3.9)

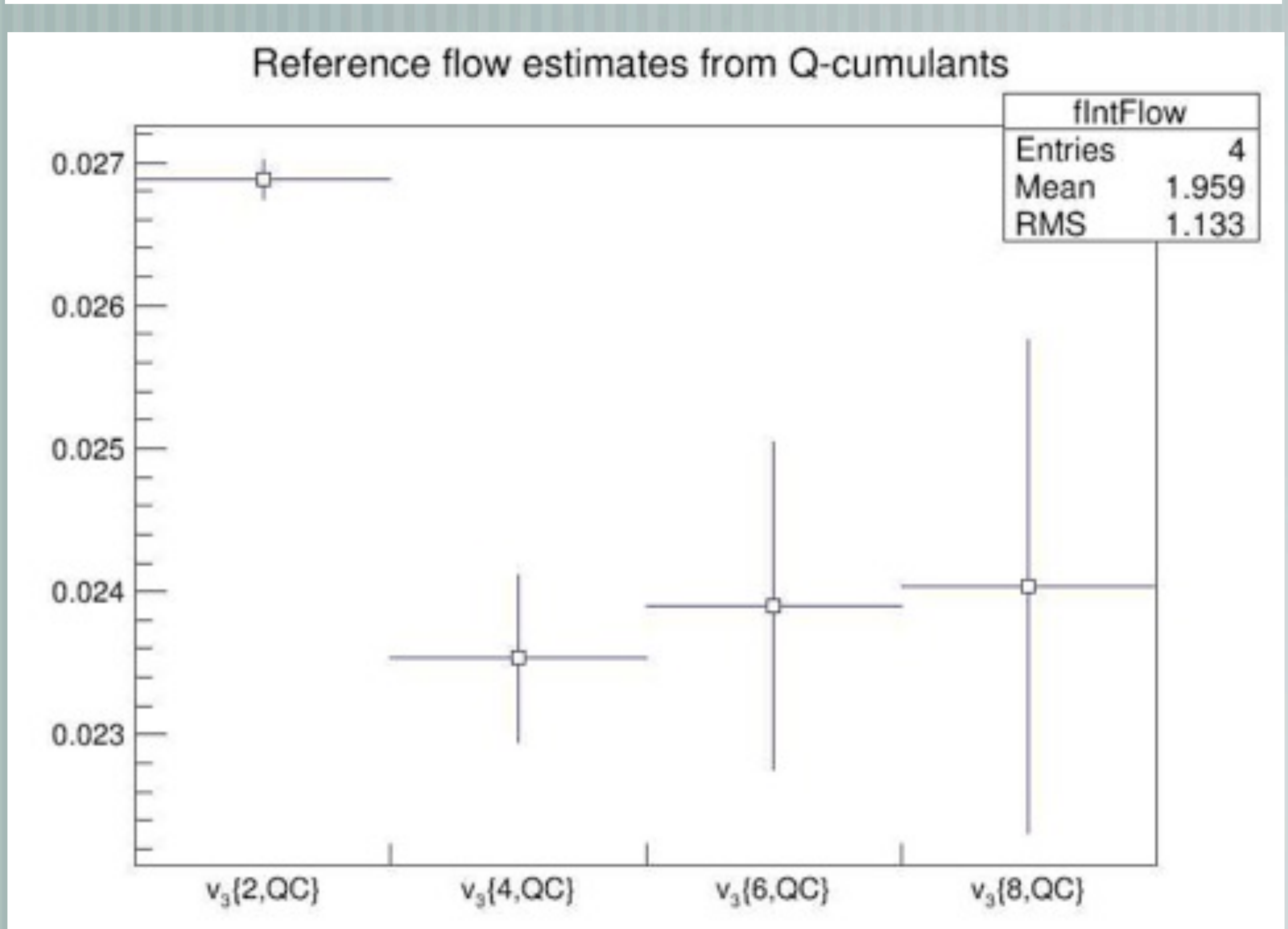
PMDncell > 2

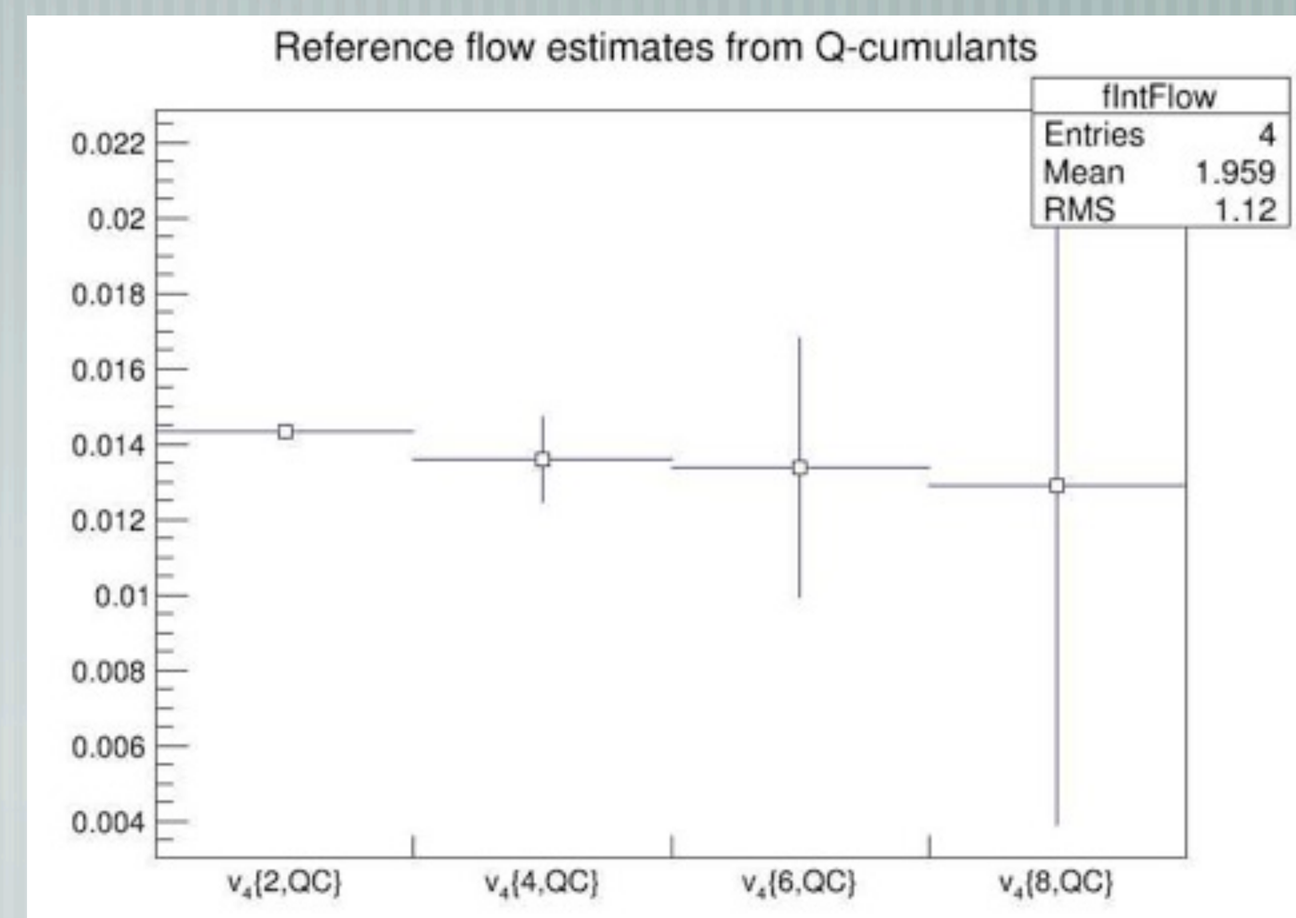
PMDAdc = 472

Integrate flow for PbPb

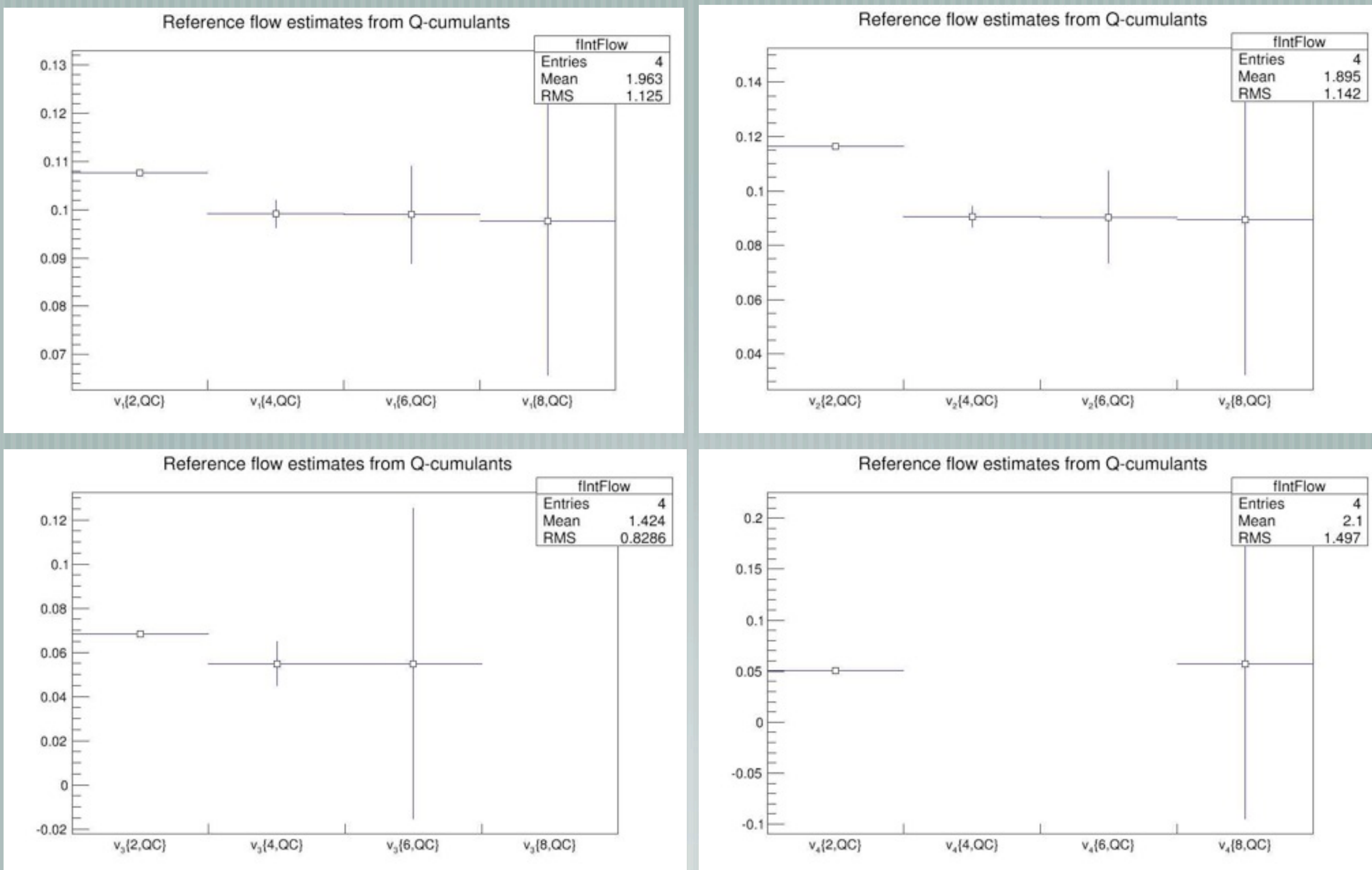








Integrated flow for p-Pb

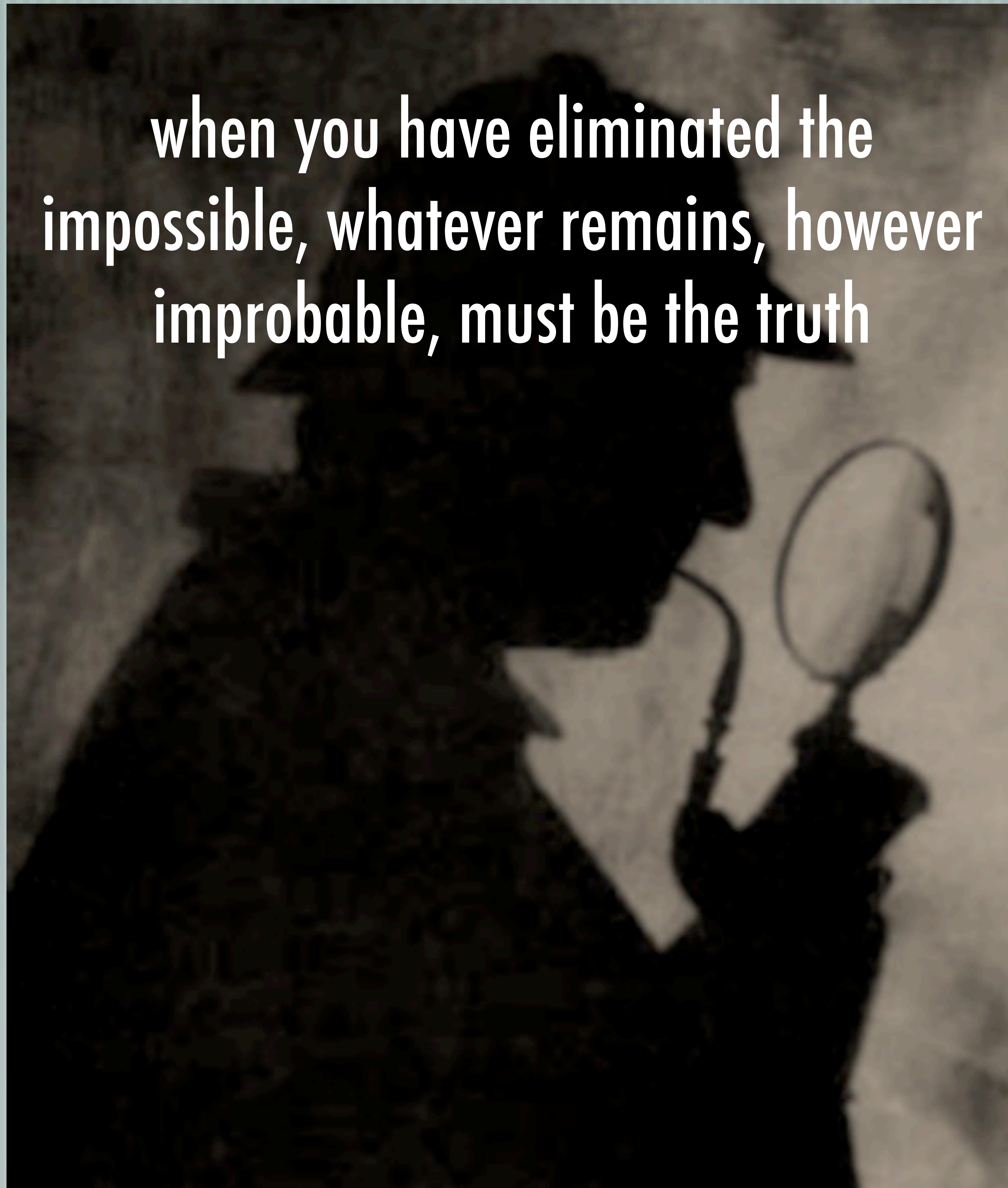


Summary and action items

Integrated flow by cumulants in Pb-Pb and p-Pb to be calculated with higher statistics

Compare results with event plane method result for same data set

Compare with MC production data


when you have eliminated the
impossible, whatever remains, however
improbable, must be the truth