

Theoretical Framework for Multi-harmonic Correlations in Heavy-ion Collisions

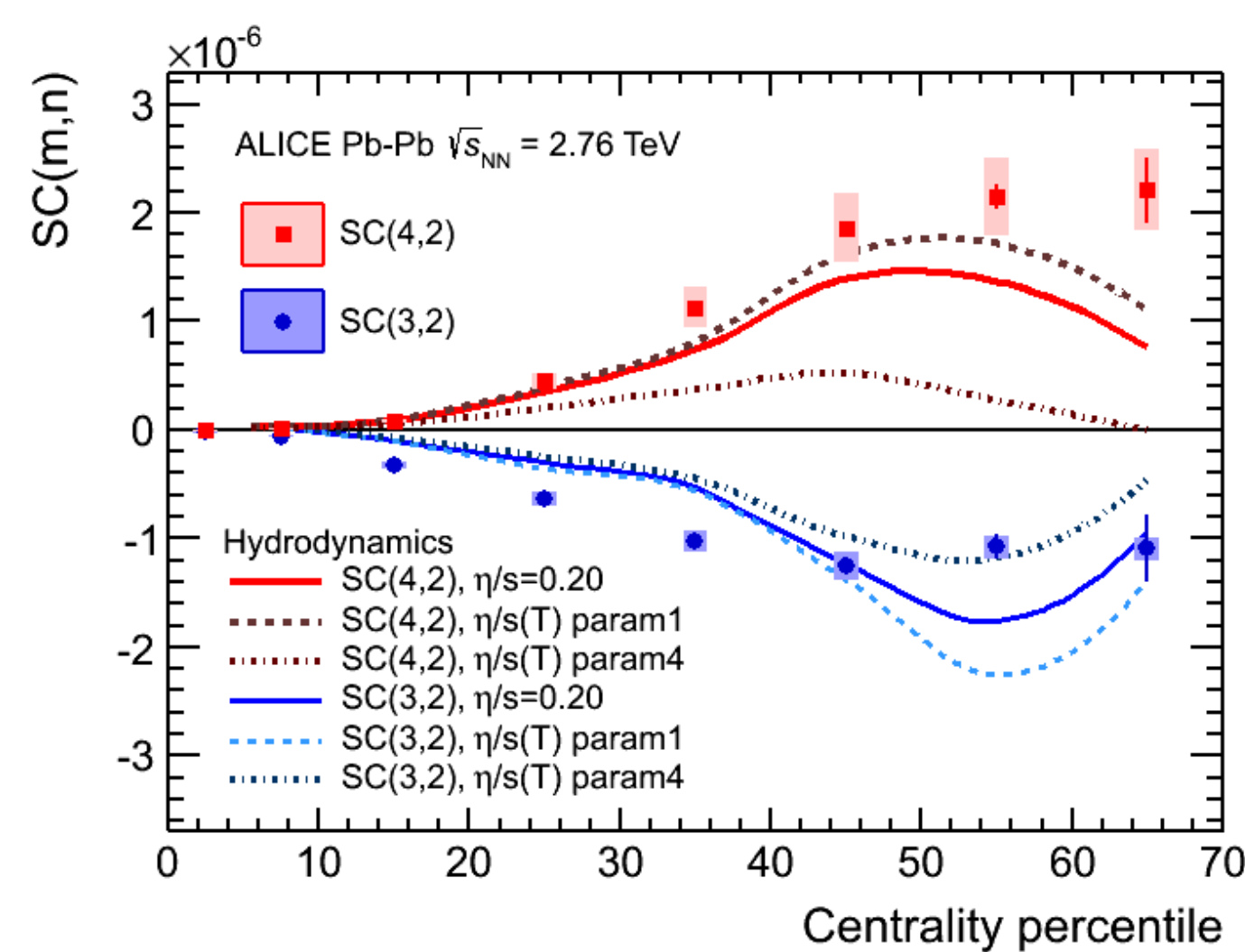
Cindy Mordasini, A. Bilandzic, D. Karakoç, S.F. Taghavi

cindy.mordasini@tum.de, Technical University of Munich

arXiv:1901.06968v2 [nucl-ex]

Symmetric Cumulants $SC(m, n)$

- Introduction of the Symmetric Cumulants to probe the genuine correlations between two flow amplitudes v_m and v_n



$$SC(m, n) = \langle v_m^2 v_n^2 \rangle - \langle v_m^2 \rangle \langle v_n^2 \rangle$$

- New and independent set of observables
 - Better sensitivity to η/s of the QGP than what is accessible with the study of only v_n

ALICE Collaboration, PRL **117**, 182301 (2016)

- Are there genuine correlations between more than two flow amplitudes?

- New information which is inaccessible neither with $SC(m, n)$ nor with only one flow amplitude v_n

Generalisation to Higher Orders

- Non trivial generalisation of $SC(m, n)$ to higher orders
- Shift of paradigm**: Cumulant expansion done directly with the **flow amplitudes v_n** and not in the standard way with the azimuthal angles ϕ **as the fundamental degrees of freedom**
- Framework successfully generalised for any number and any combination of different flow amplitudes
- Example: **3-harmonic Symmetric Cumulants $SC(k, l, m)$**
 - For the flow amplitudes v_k, v_l, v_m in the momentum space:

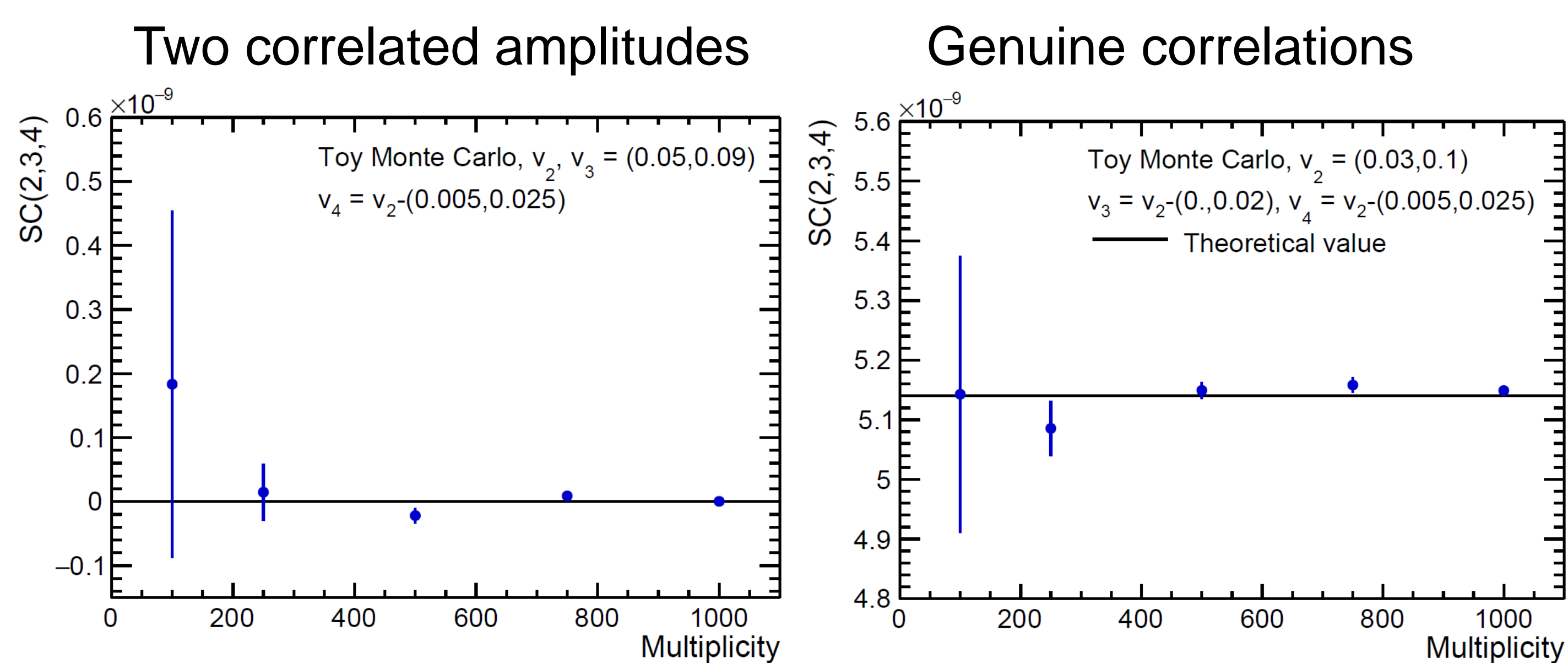
$$SC(k, l, m) = \langle v_k^2 v_l^2 v_m^2 \rangle - \langle v_k^2 v_l^2 \rangle \langle v_m^2 \rangle - \langle v_k^2 v_m^2 \rangle \langle v_l^2 \rangle - \langle v_l^2 v_m^2 \rangle \langle v_k^2 \rangle + 2 \langle v_k^2 \rangle \langle v_l^2 \rangle \langle v_m^2 \rangle$$

- For the eccentricities $\epsilon_k, \epsilon_l, \epsilon_m$ in the coordinate space:

$$SC_\epsilon(k, l, m) = \langle \epsilon_k^2 \epsilon_l^2 \epsilon_m^2 \rangle - \langle \epsilon_k^2 \epsilon_l^2 \rangle \langle \epsilon_m^2 \rangle - \langle \epsilon_k^2 \epsilon_m^2 \rangle \langle \epsilon_l^2 \rangle - \langle \epsilon_l^2 \epsilon_m^2 \rangle \langle \epsilon_k^2 \rangle + 2 \langle \epsilon_k^2 \rangle \langle \epsilon_l^2 \rangle \langle \epsilon_m^2 \rangle$$

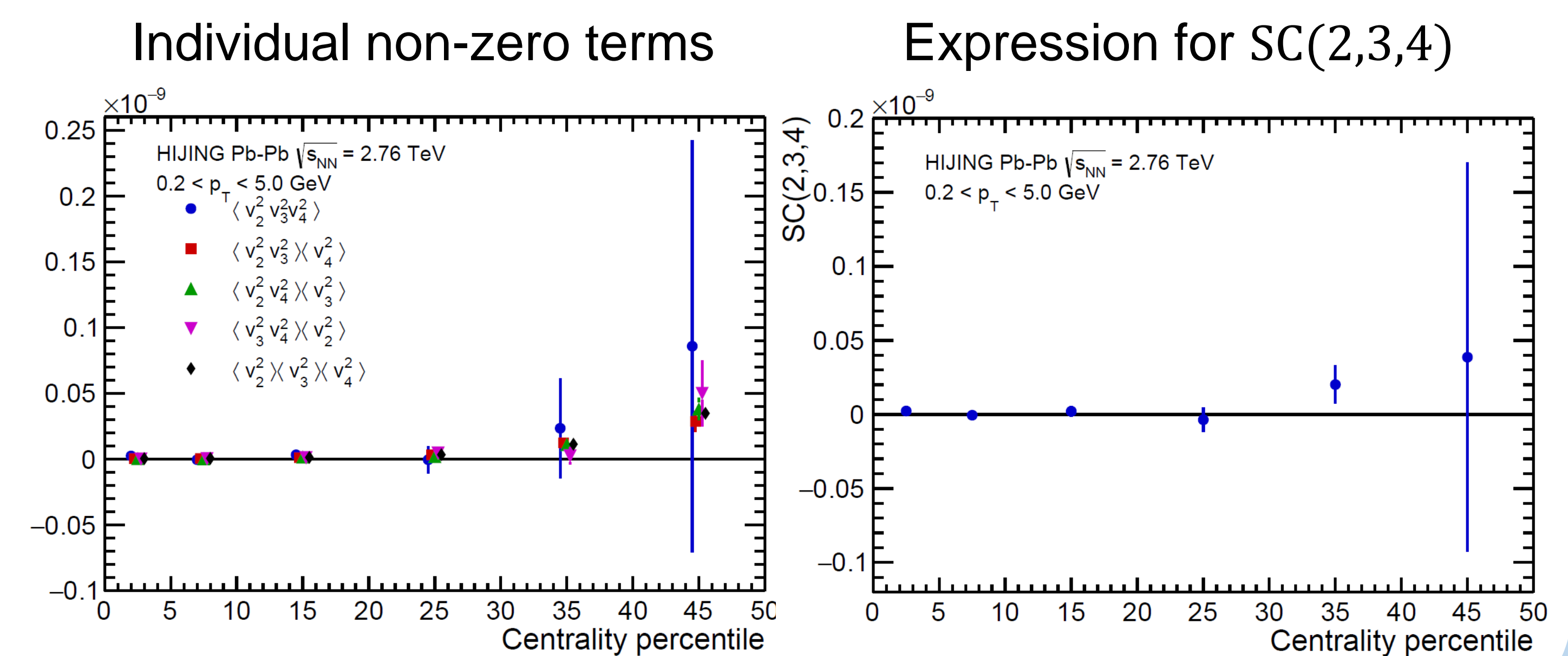
Toy Monte Carlo Simulations

- Framework validated in a controlled environment



Cross-check with HIJING*

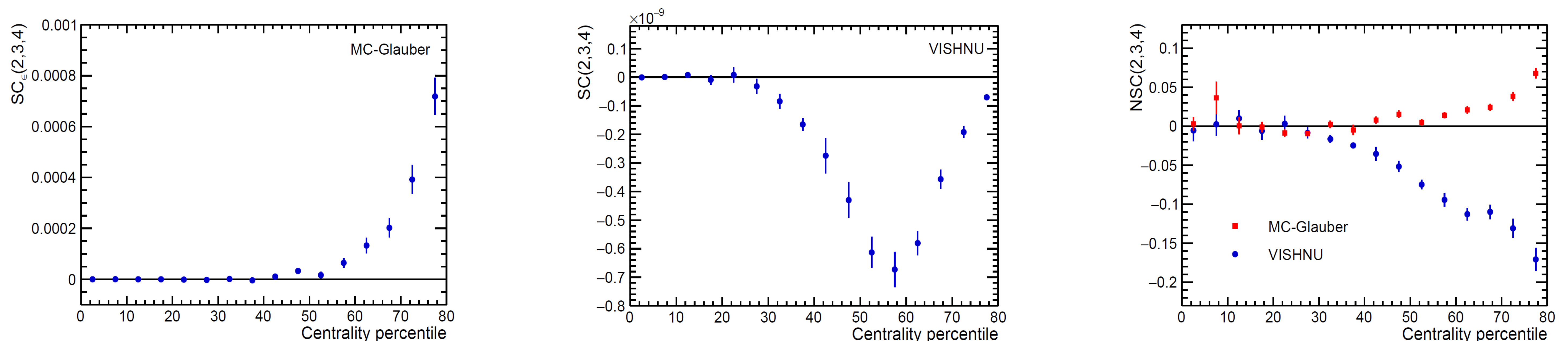
- Higher order Symmetric Cumulants **robust against nonflow**



* M. Guzlowski, X.N. Wang, Comput. Phys. Commun. **83**, 307 (1994)

Predictions from MC-Glauber and iEBE-VISHNU†

- Predictions for Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV at LHC
- System smaller for peripheral collisions \rightarrow **More difficult to thermalize and to transfer the initial anisotropy into the final state**
- Comparison between initial and final states with NSC(2,3,4) \rightarrow **Correlations in the final state dominated by collective evolution**



† C. Shen, Z. Qiu, H. Song, J. Bernhard, S. Bass, U. Heinz, Comput. Phys. Commun. **199**, 61 (2016)