Event Shape Sorting

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Anisotropic expansion

(only nuclear collisions and assume non-flow effects under control)

- generic effect: blue-shift
  $\Rightarrow$ more particles and higher p_t in direction of stronger transverse flow
- link between the observable spectrum and the expansion of the fireball
- expansion results from the pressure gradients
- anisotropic expansion $\Leftarrow$ anisotropic pressure gradients in initial conditions
- initial conditions evolved into final distribution—nothing added
- some contribution from hard partons depositing momentum during expansion

Mapping of ε_n's and v_n'n

- spatial anisotropy

$$\varepsilon_{m,n} e^{in\Psi_{m,n}} = \int r\, dr\, d\phi\, r^m e^{in\phi}\, \rho(r,\phi)$$

use $\varepsilon_n = \varepsilon_{n,n}$

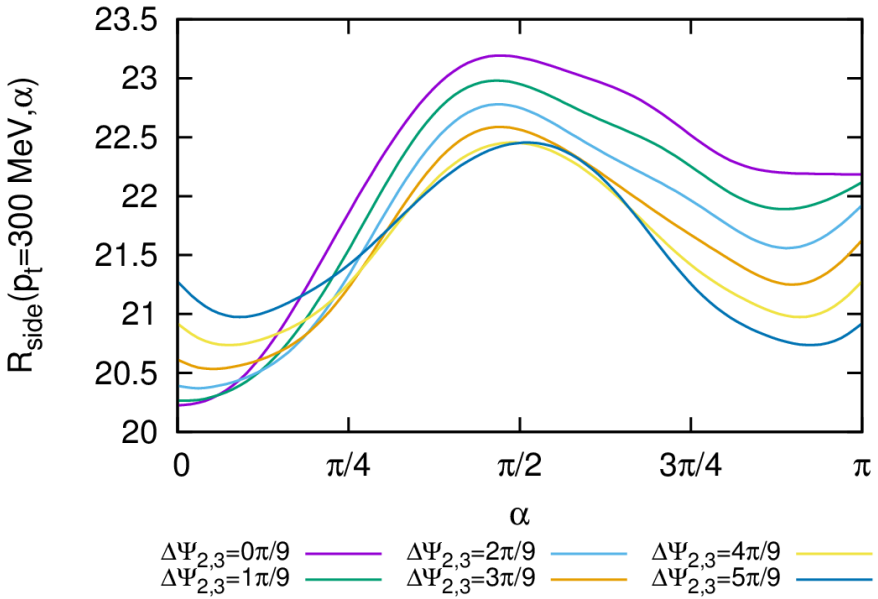
- to a very good extent $\langle v_n \rangle = k \langle \varepsilon_n \rangle$
  [F.G. Gardim *et al.*, Phys. Rev. C **85** (2012) 024908]

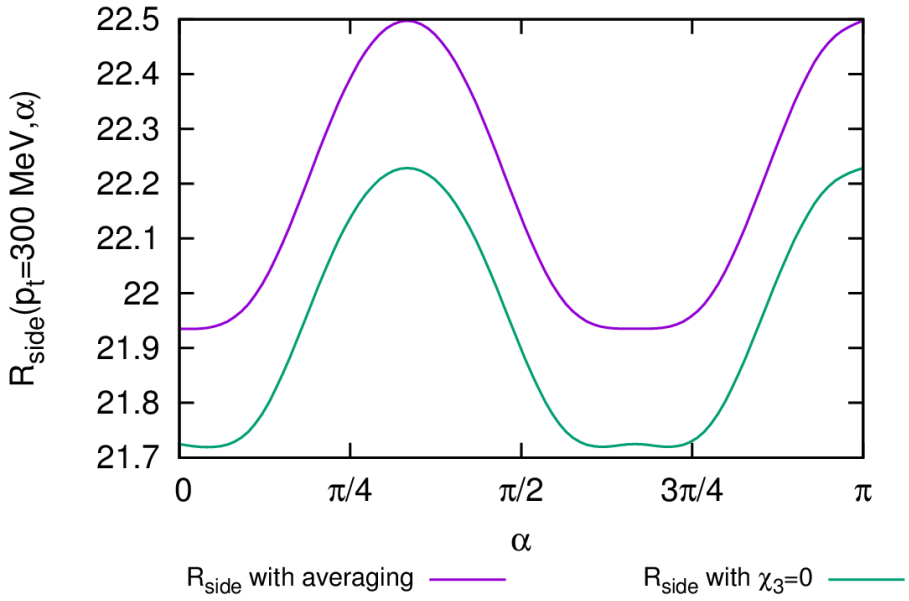
- also mapping between the values in individual events and between probability distributions
  valid for various initial conditions and ideal as well as viscous hydro
  [H. Niemi *et al.*, Phys. Rev. C **87** (2013) 54901]

Each event is different

- each event undergoes different evolution
- it would be great to reproduce each event dynamics individually

Example: $R^2_{\text{side}}(\alpha)$ for different angle difference between 2nd and 3rd order event plane, and averaged over $\Delta\Psi_{23}$.





Figures: Sándor Lökös (see talk on Tuesday afternoon)

Event Shape Engineering

- Two subevents
  - Subevent a: event selection
  - Subevent b: physical analysis
- Helps avoiding nonphysical biases (nonflow effects)
- Information loss
- Event selection according to the magnitude of the **reduced flow vector** q_n

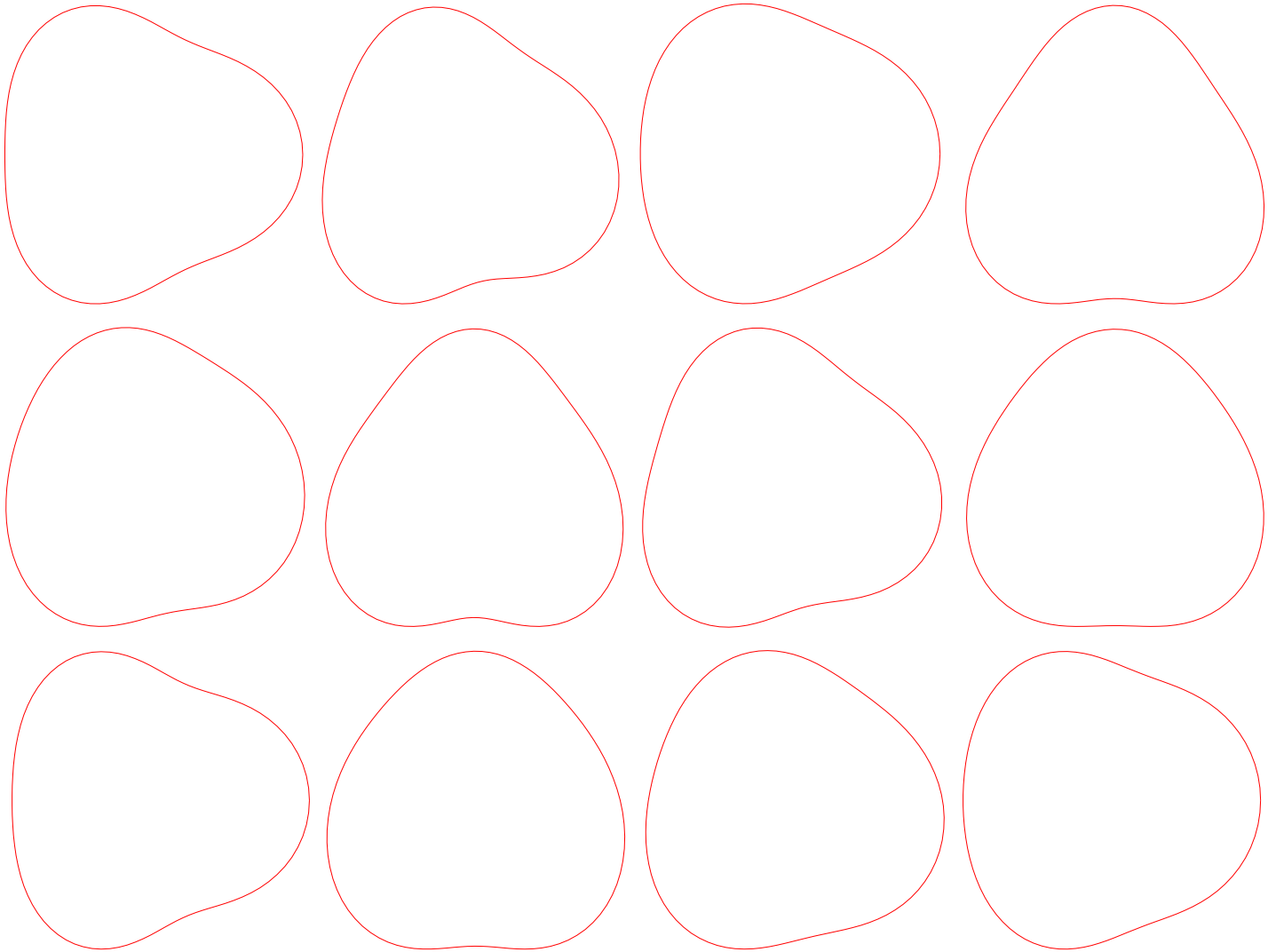
$$\vec{Q}_n = \left(\sum_{i=1}^{M} \cos(n\phi_i) \, , \sum_{i=1}^{M} \sin(n\phi_i) \right) \, ,$$

$$q_n = |\vec{Q}_n| / \sqrt{M} \, .$$

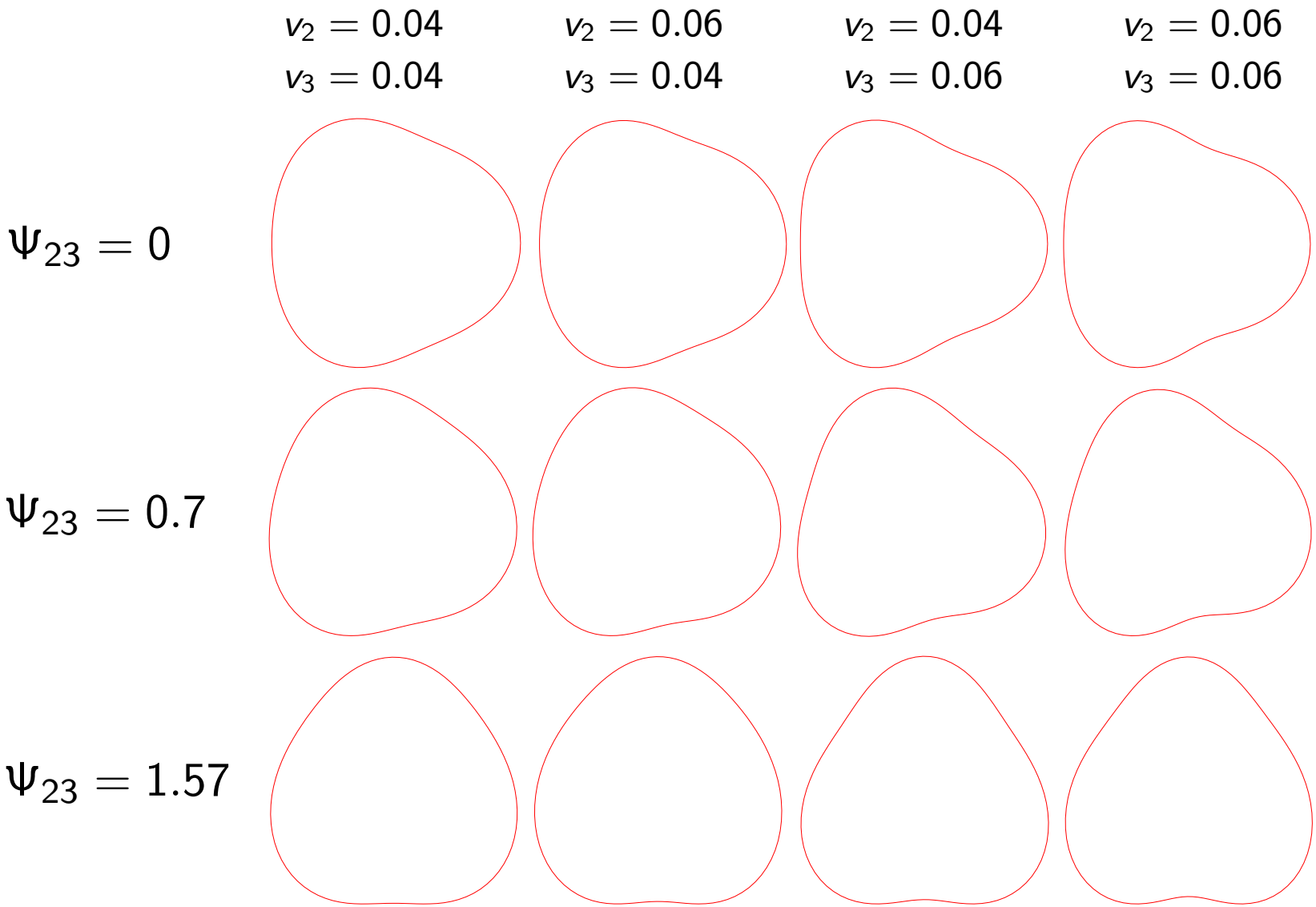
[J. Schukraft, A. Timmins, S. A. Voloshin, Phys. Lett. B 719 (2013) 394-398]

Event shapes

How to do Event Shape Engineering among these shapes. . . ?



. . . ordered


$v_2 = 0.04$
$v_3 = 0.04$
$v_2 = 0.06$
$v_3 = 0.04$
$v_2 = 0.04$
$v_3 = 0.06$
$v_2 = 0.06$
$v_3 = 0.06$
$\Psi_{23} = 0$
$\Psi_{23} = 0.7$
$\Psi_{23} = 1.57$

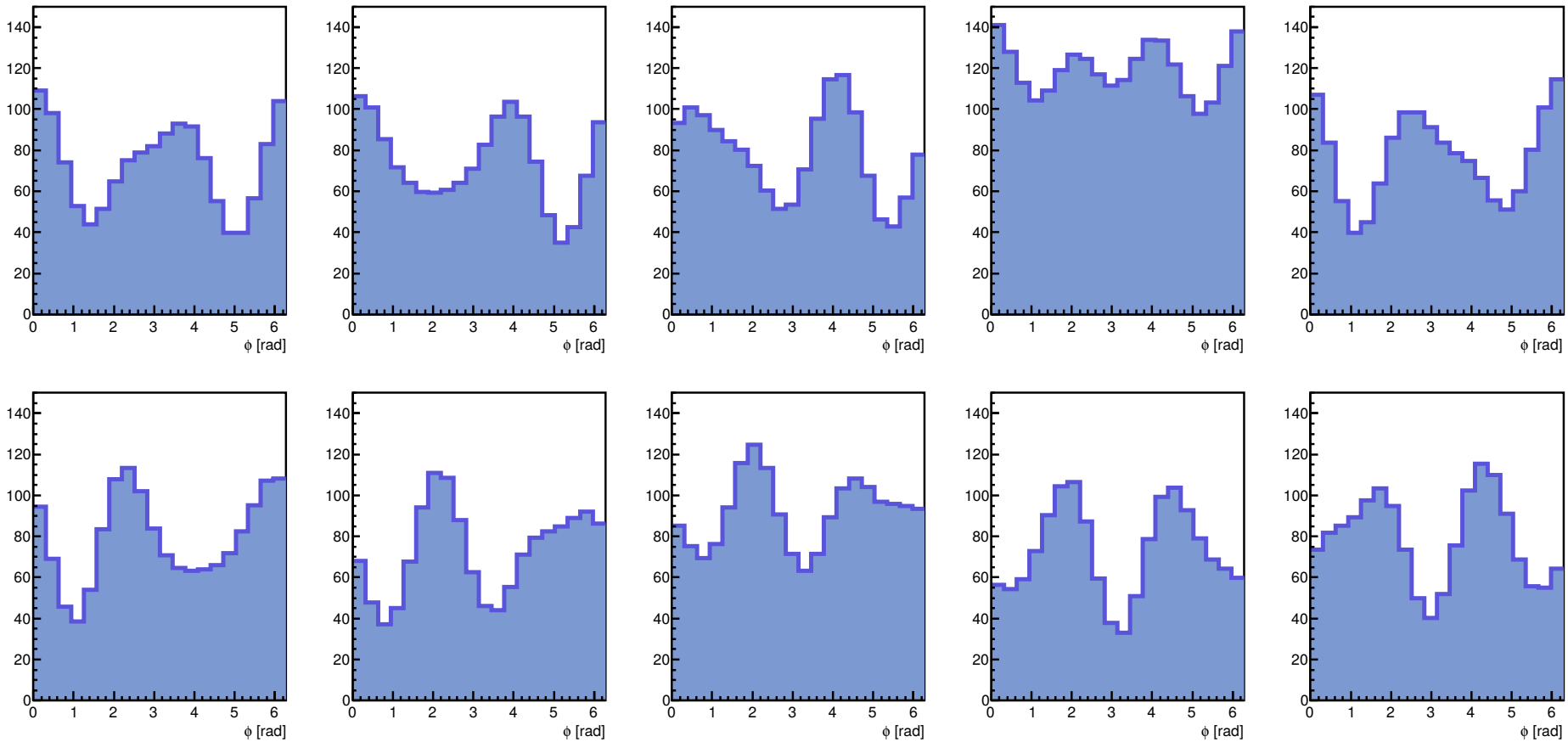
Event Shape Sorting: the algorithm

We will sort events according to their histograms in azimuthal angle.

1. (Rotate the events appropriately)
2. Sort your events as you wish
3. Divide sorted events into quantiles (we'll do deciles)
4. Determine average histograms in each quantiles
5. For each event i calculate Bayesian probability $P(i|\mu)$ that it belongs to quantile μ
6. For each event calculate average $\bar{\mu} = \sum_\mu \mu P(i|\mu)$
7. Sort events according to their values of $\bar{\mu}$
8. If order of events changed, return to 3. Otherwise sorting converged.

S. Lehmann, A.D. Jackson, B. Lautrup, arXiv:physics/0512238
S. Lehmann, A. D. Jackson and B. E. Lautrup, Scientometrics **76** (2008) 369 [physics/0701311 [physics.soc-ph]]

Assigning event to event bin



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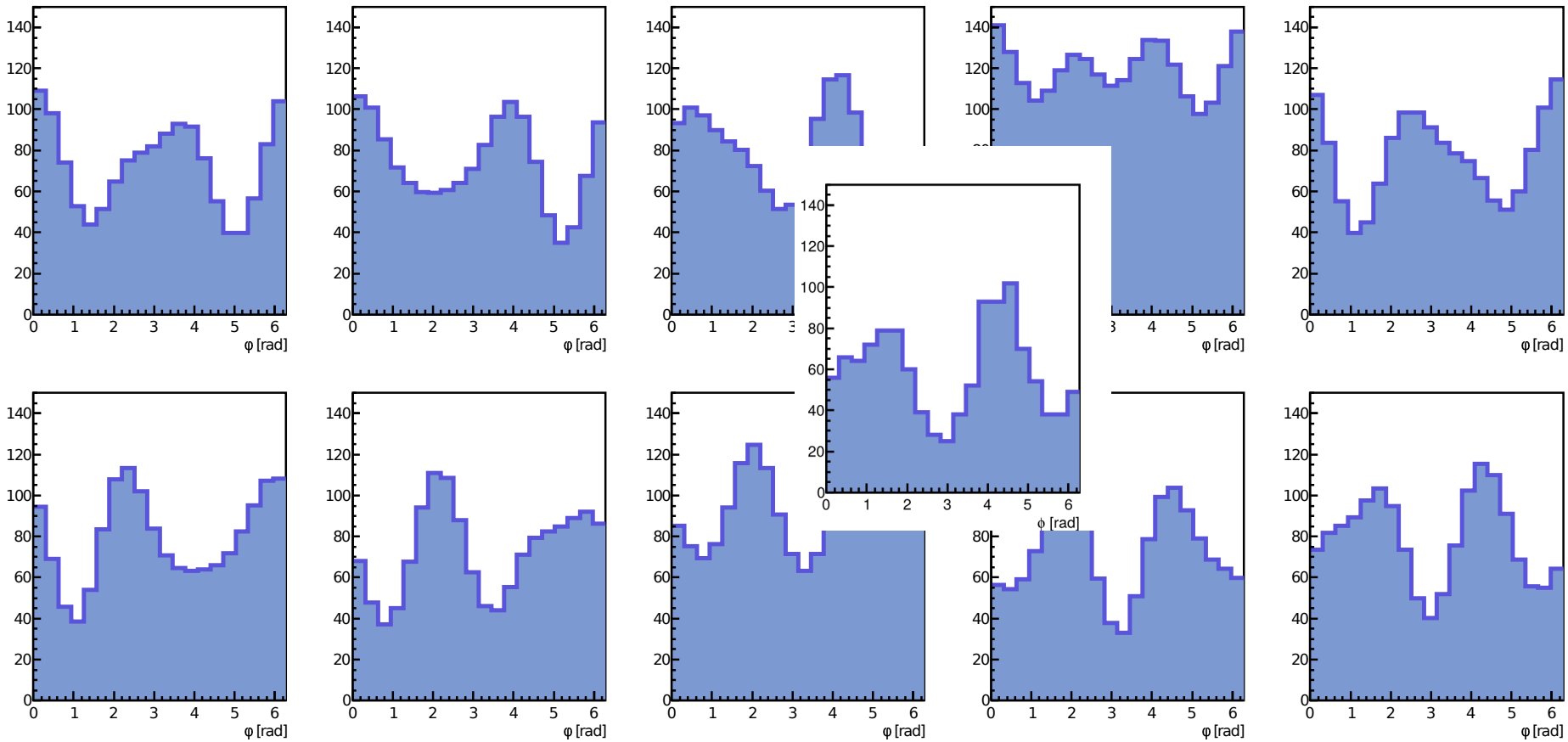

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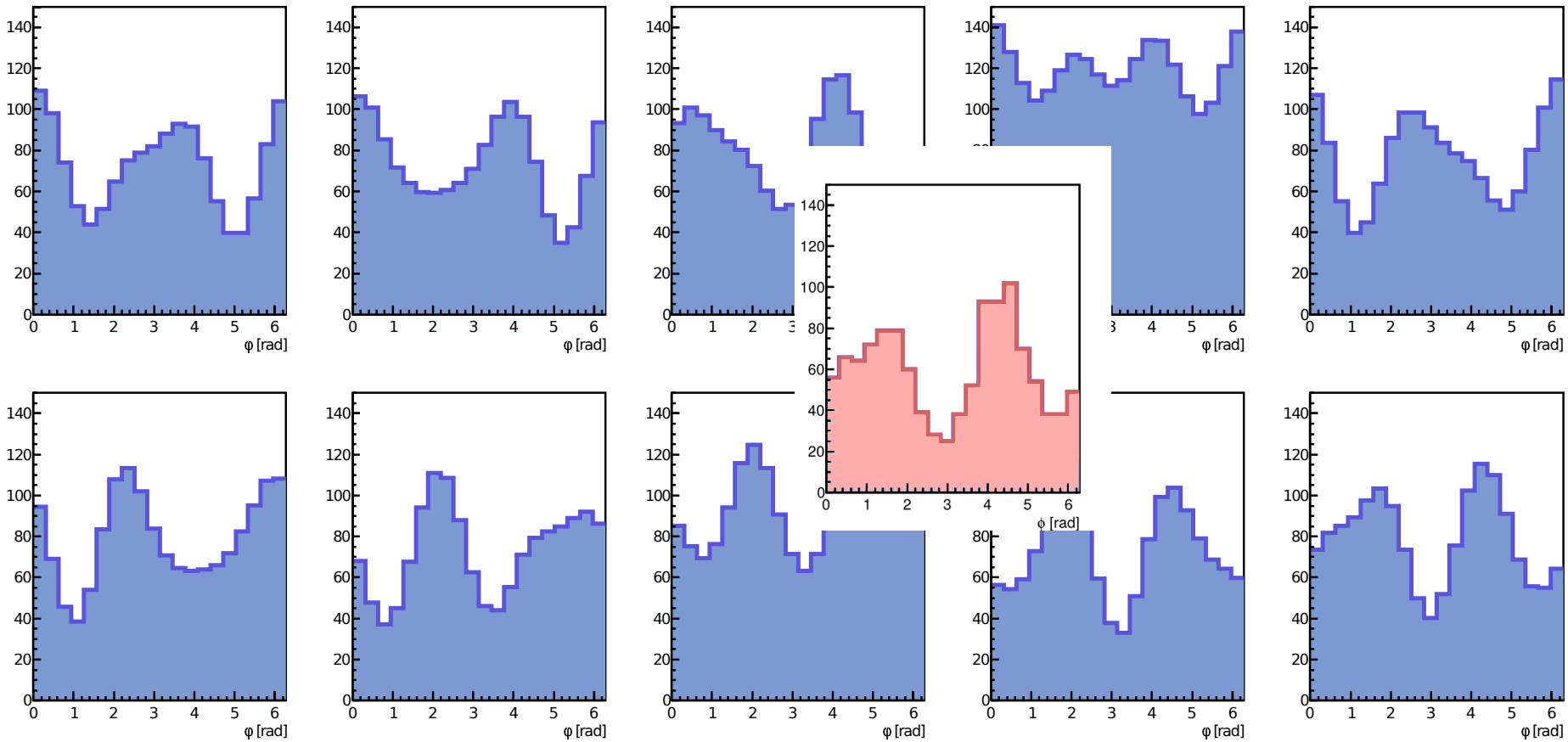

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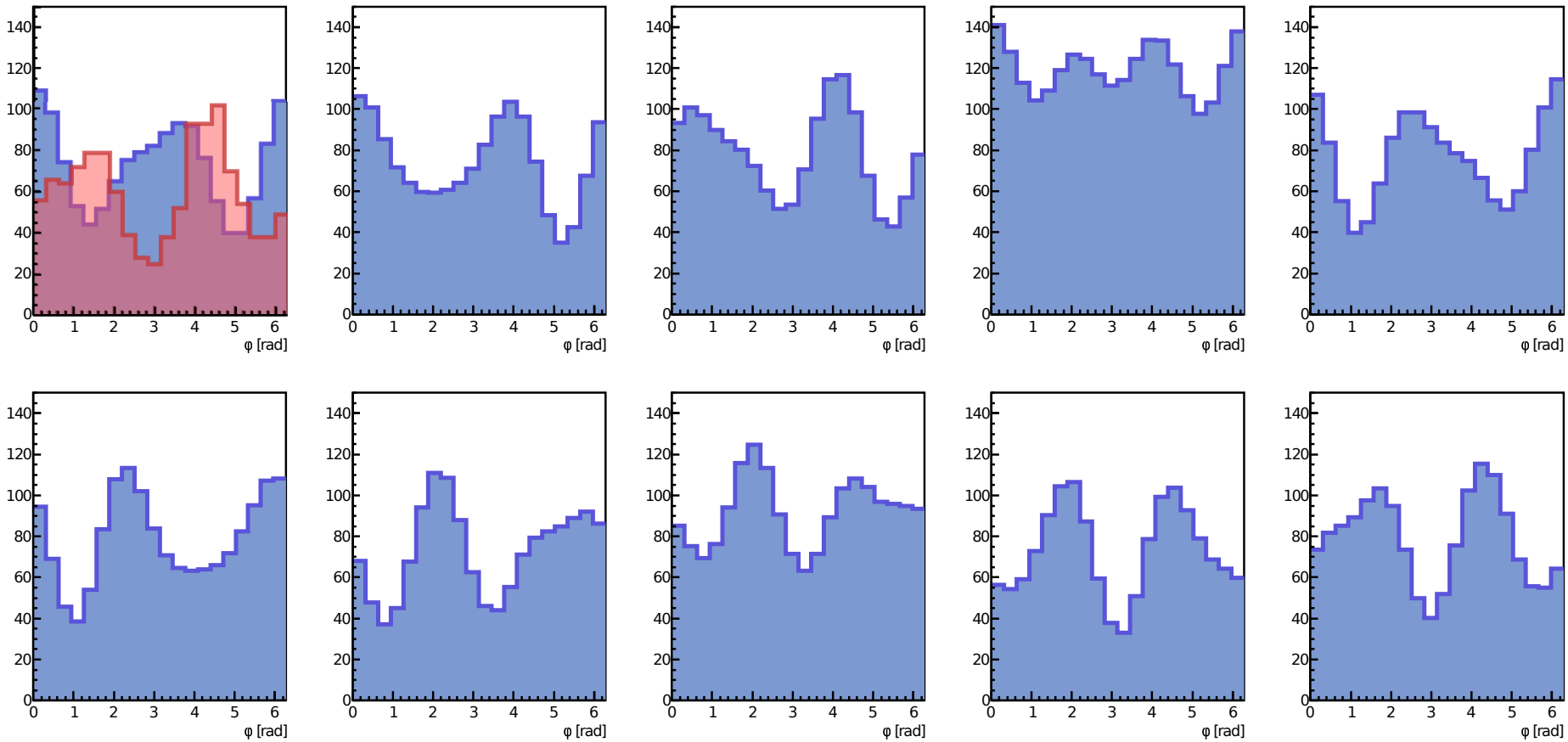

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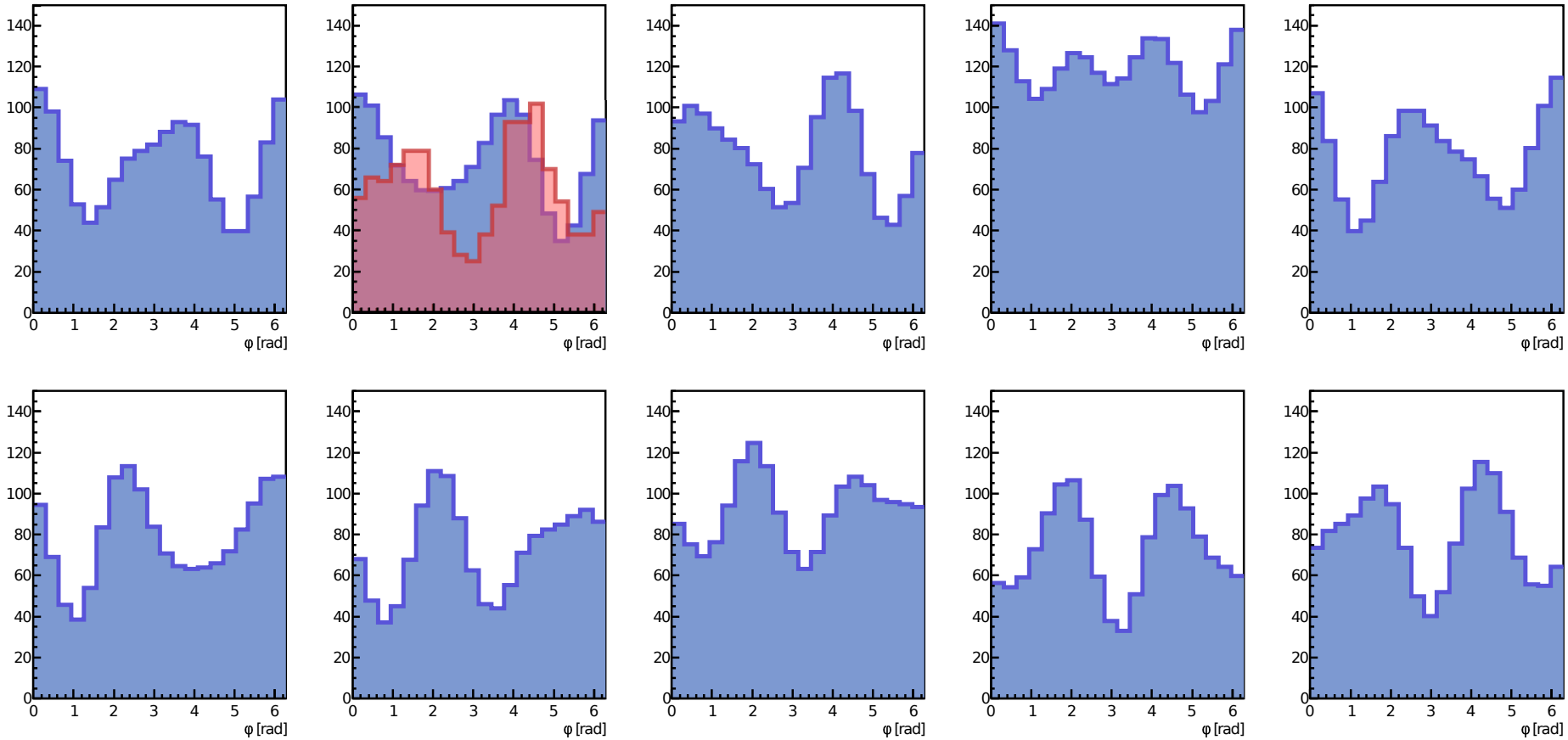

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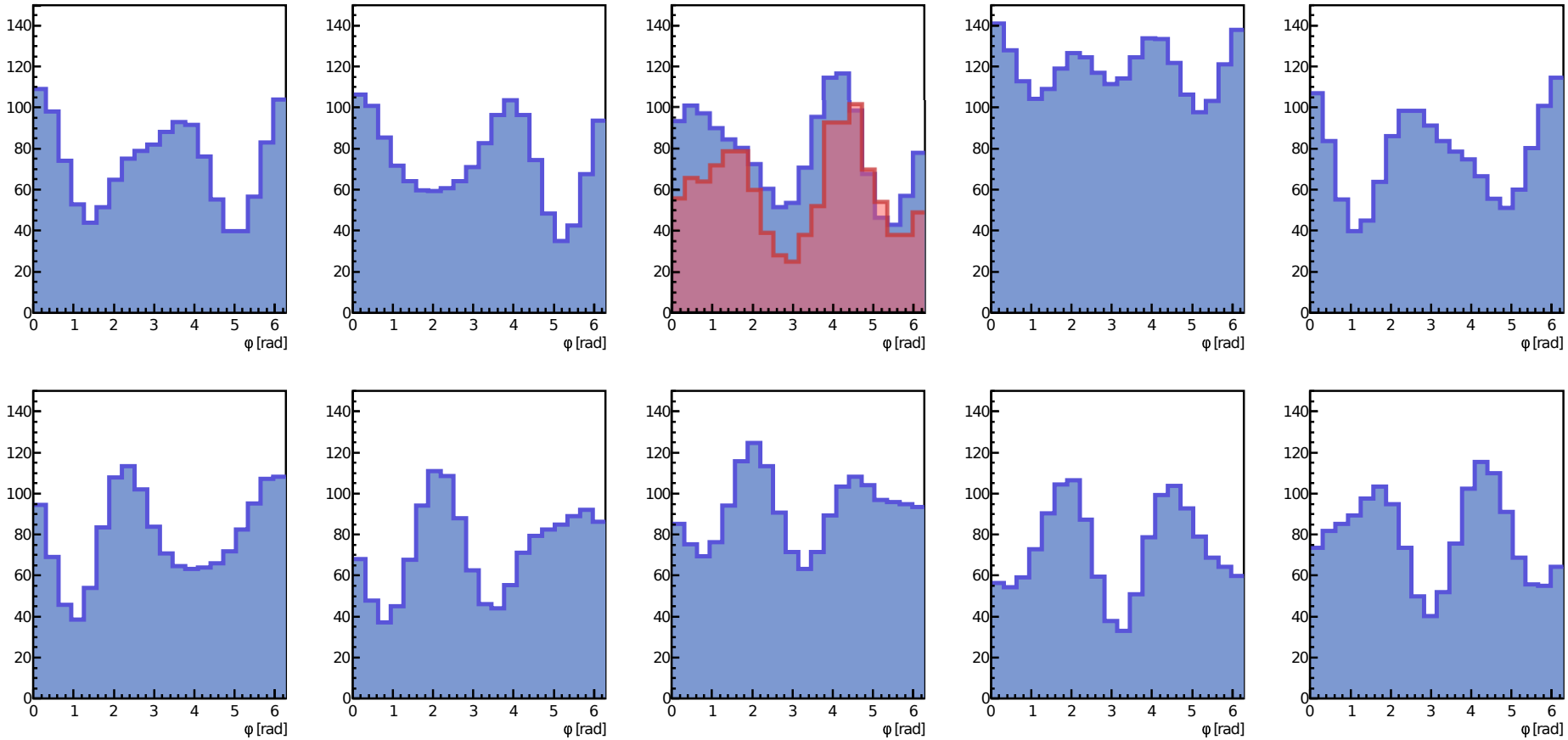

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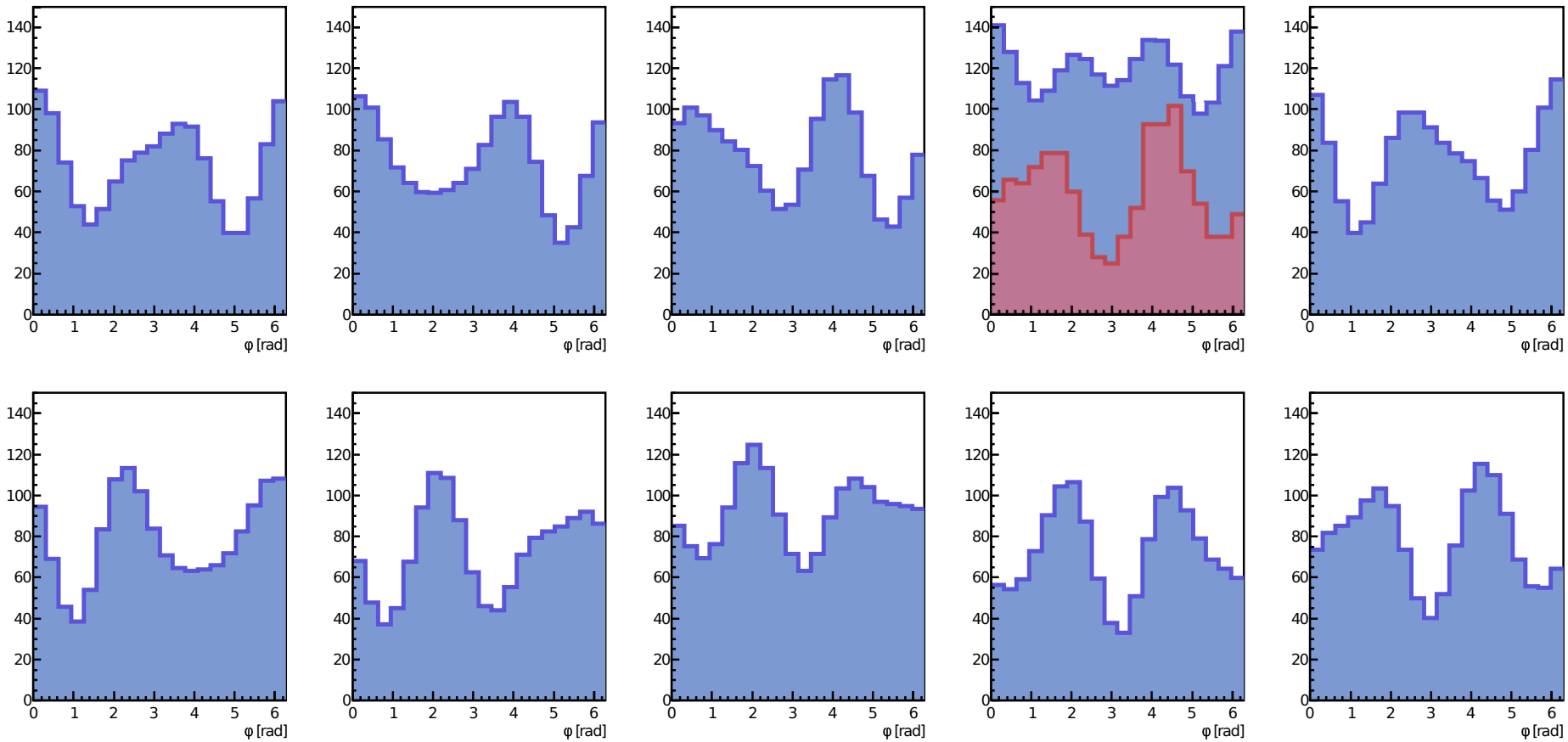

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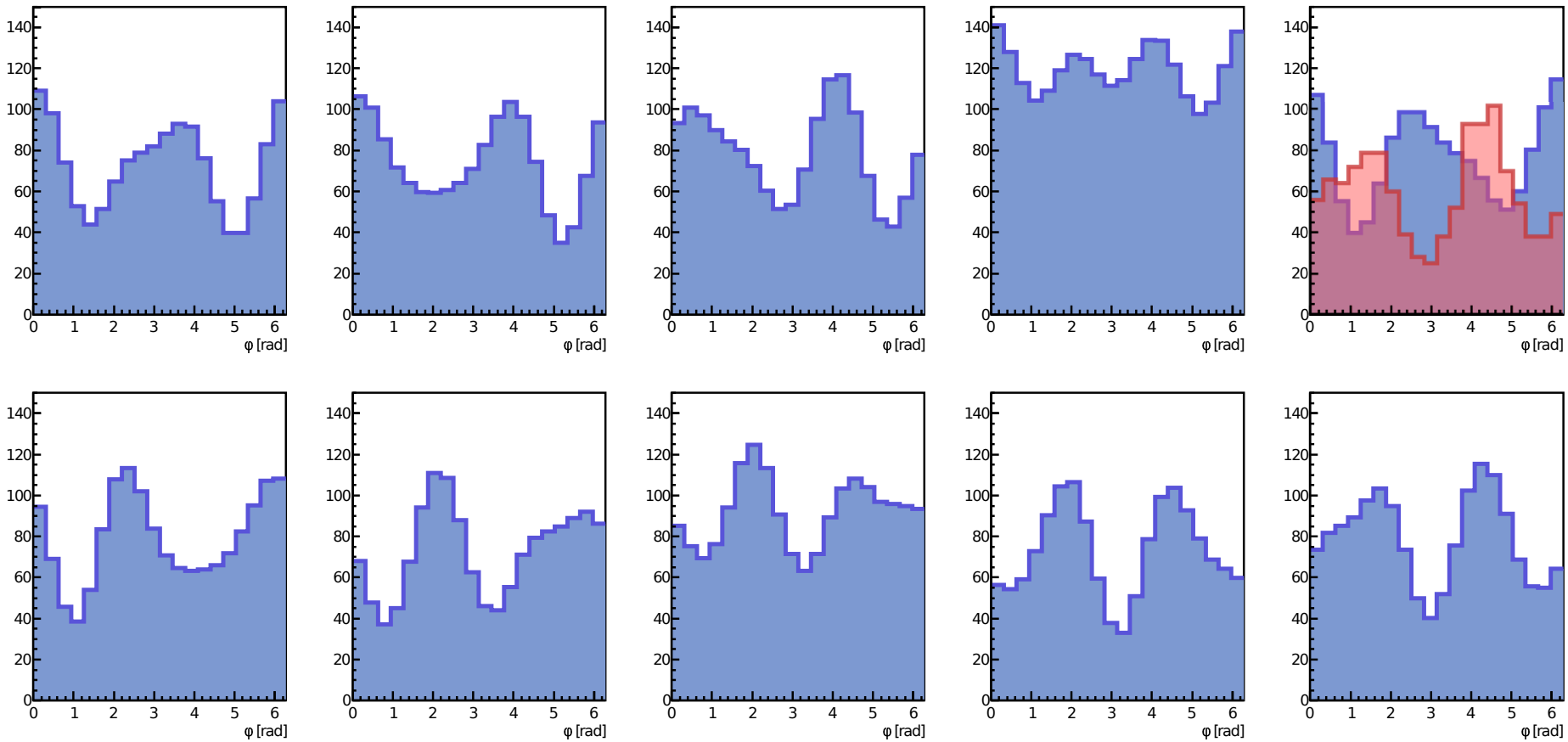

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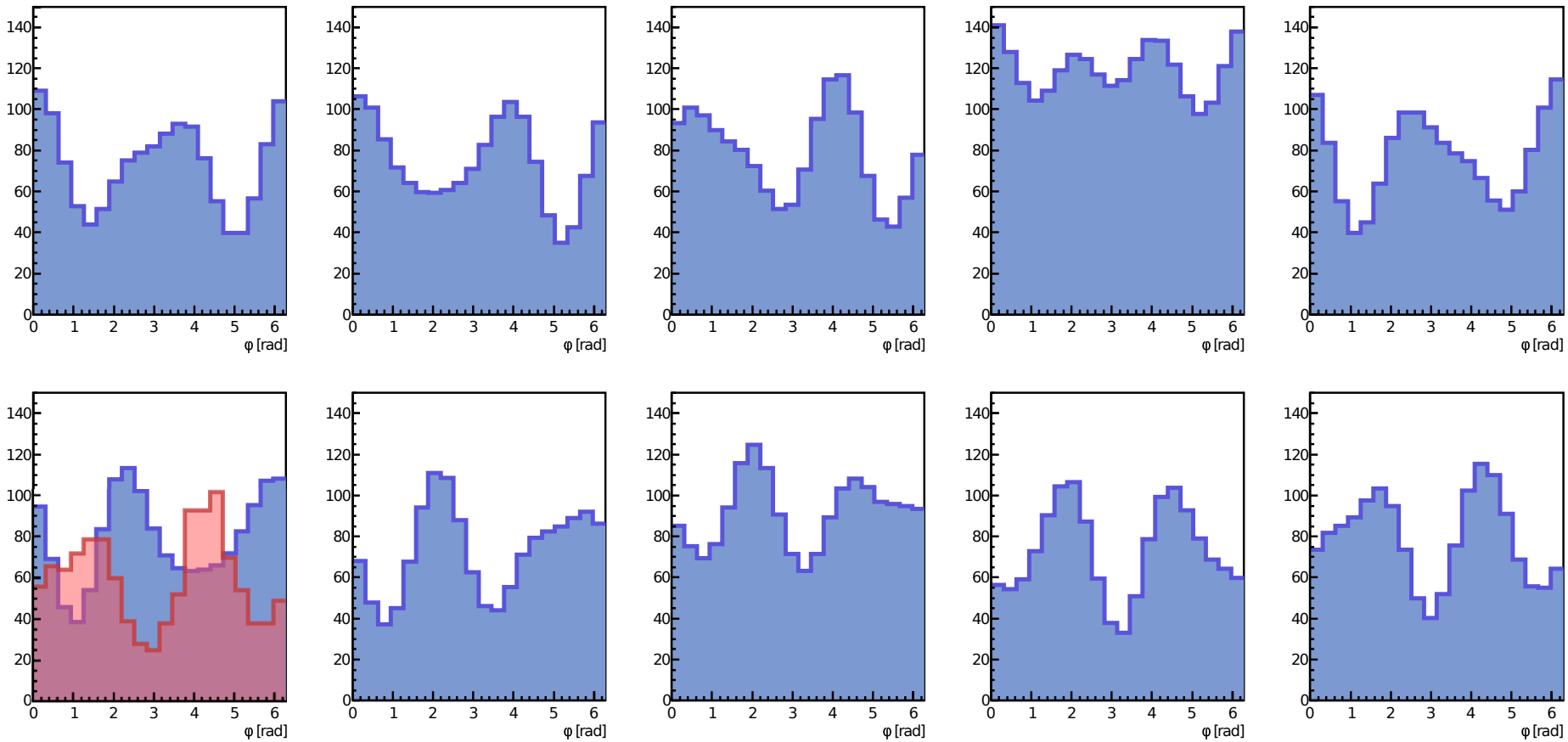

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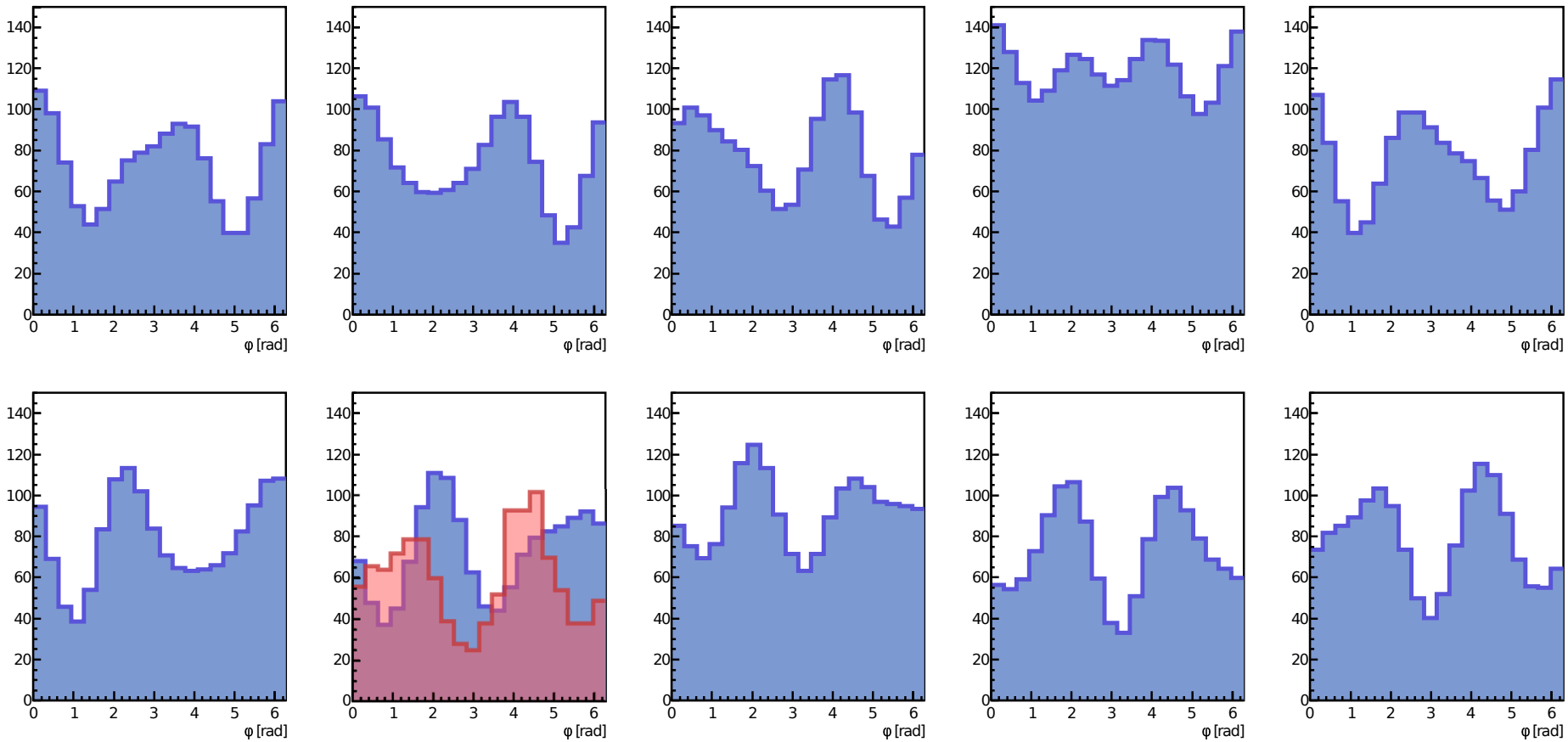

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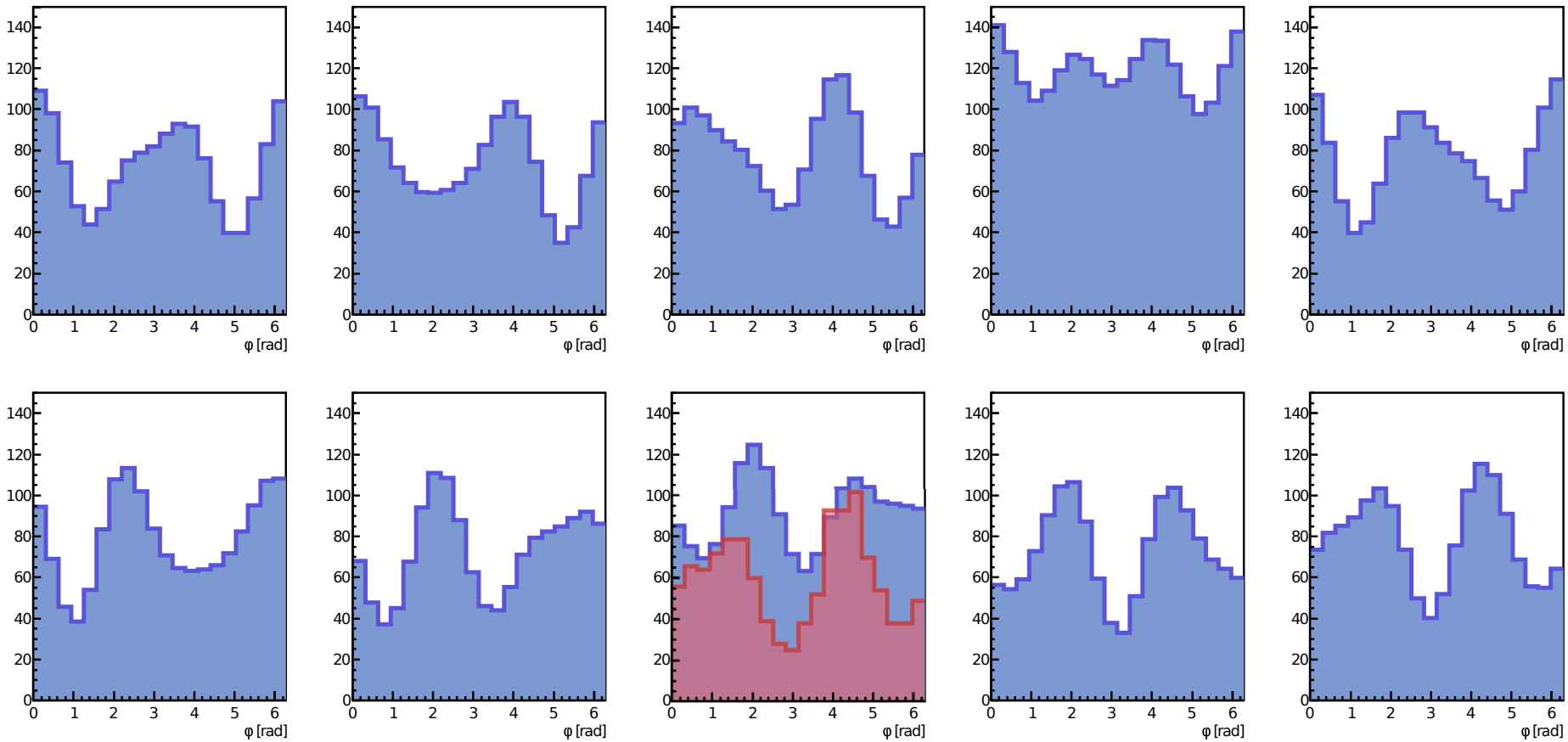

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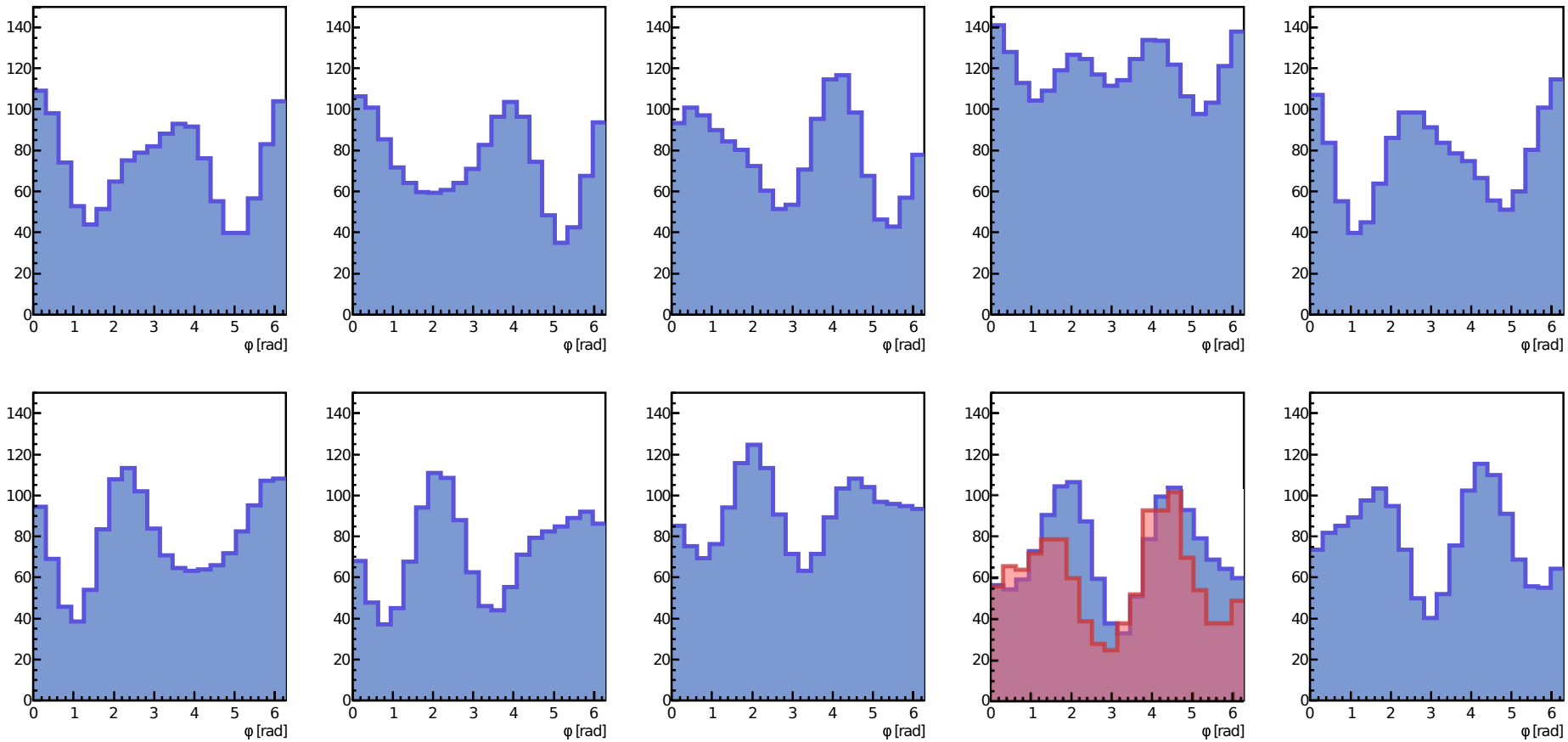

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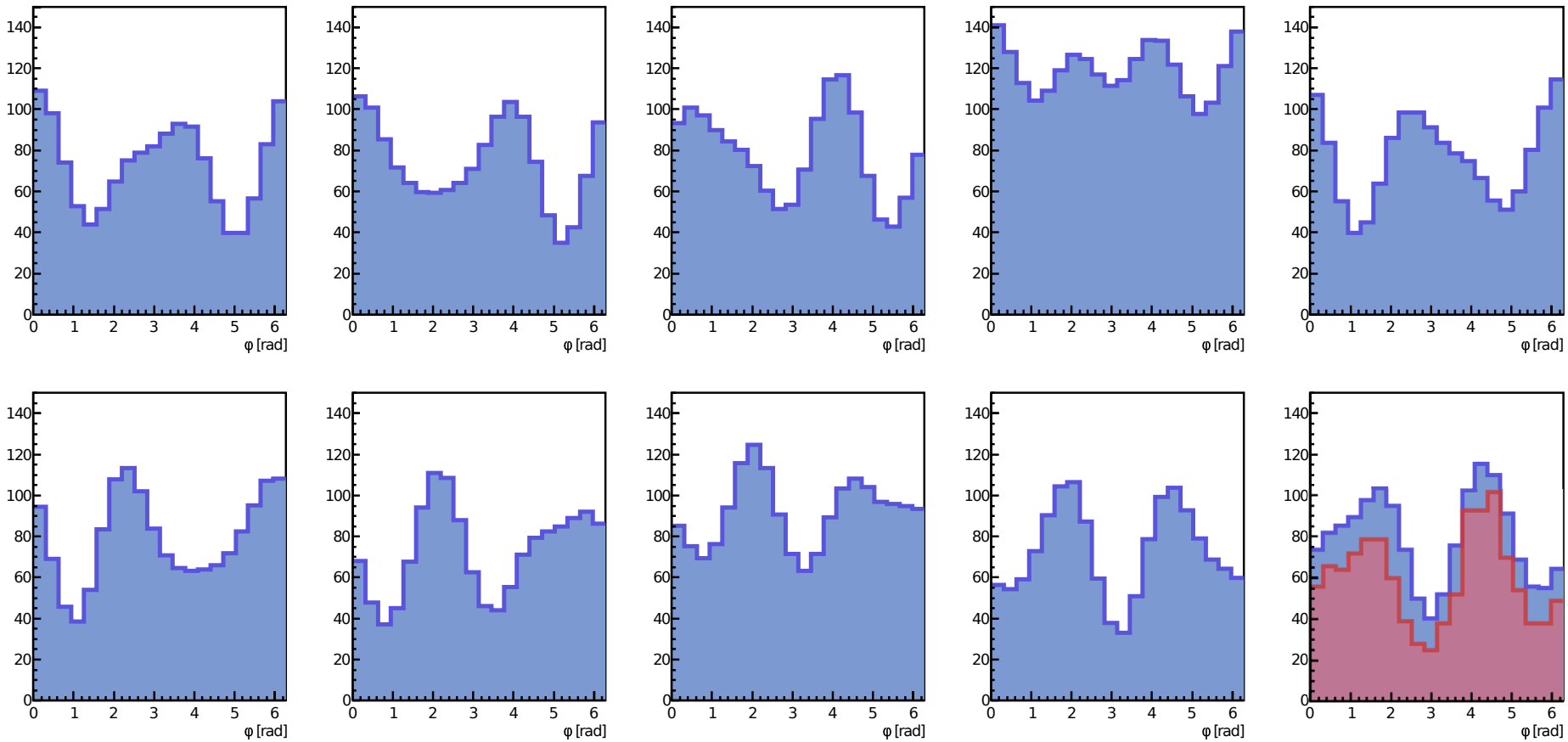
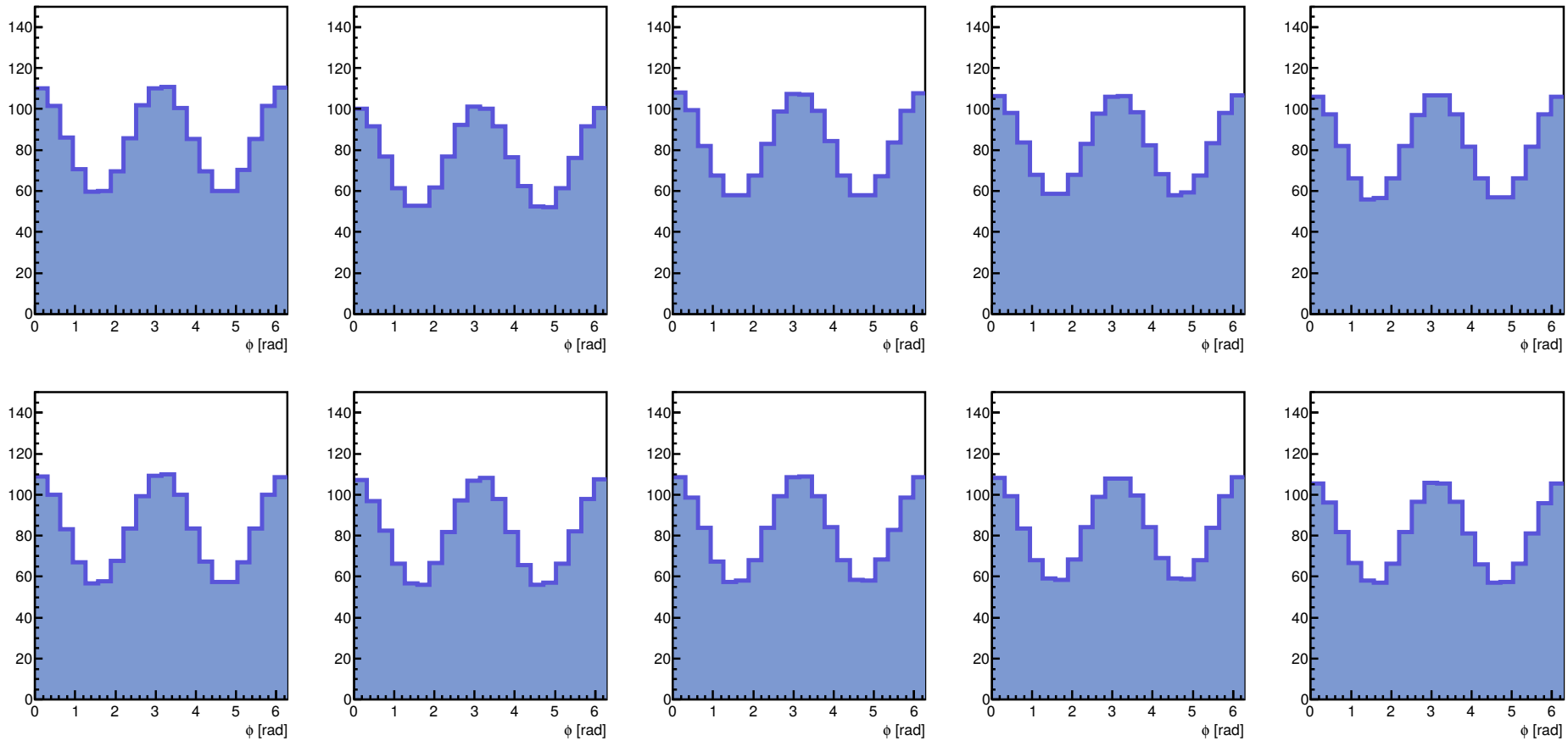
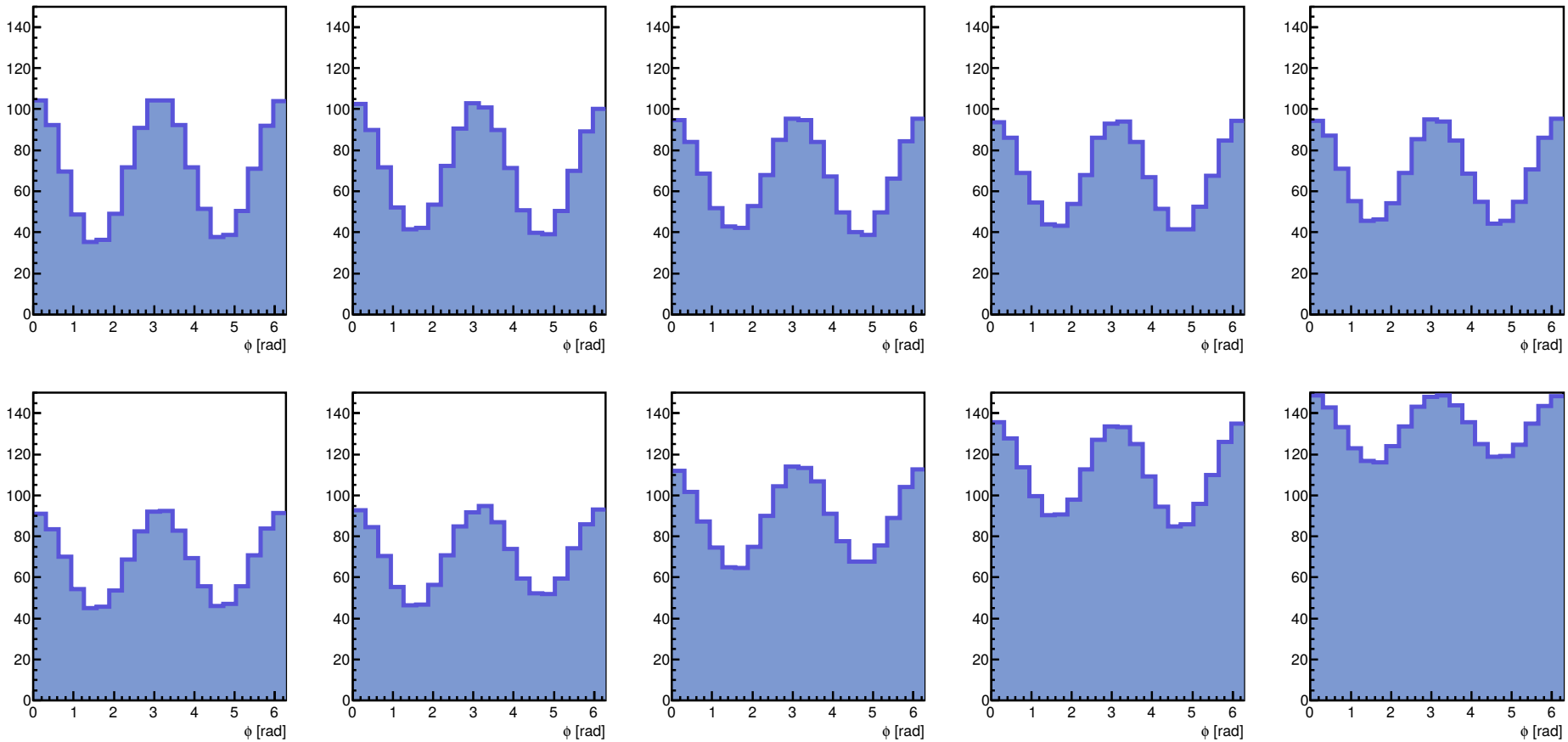


Average histograms, simple example with v_1 and v_2 only

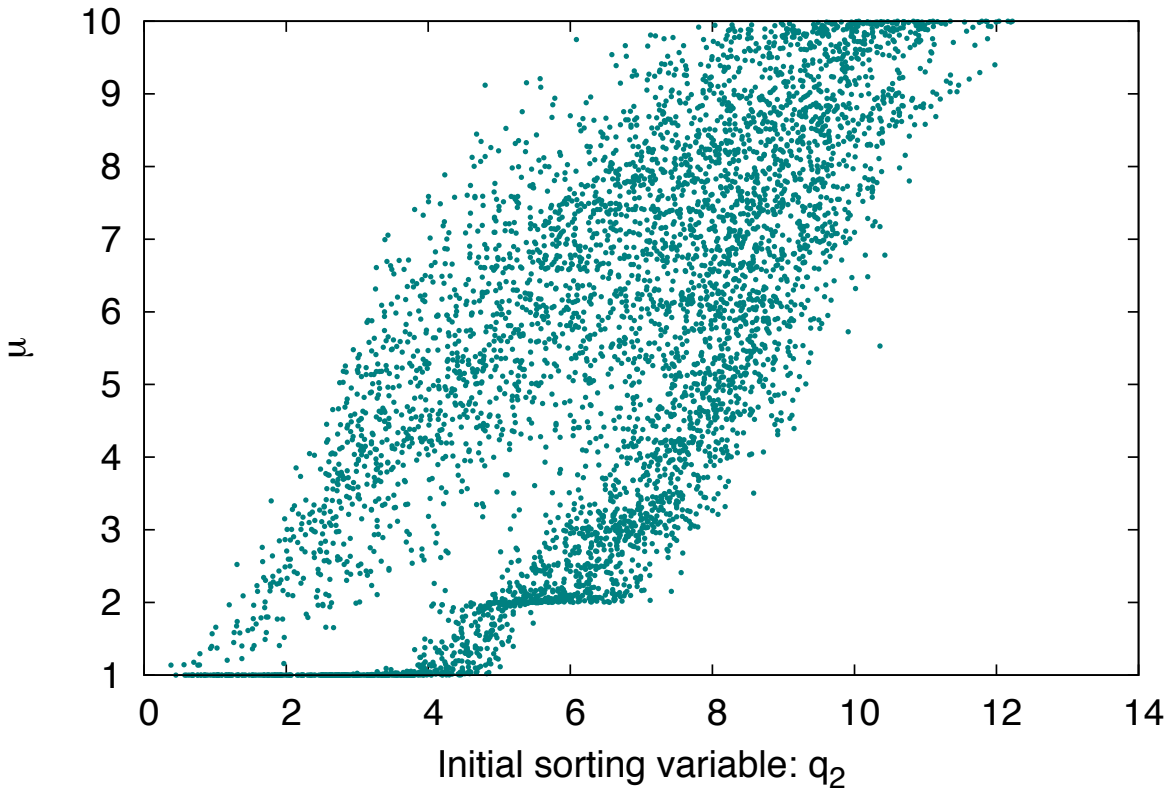


Average histograms, simple example after sorting



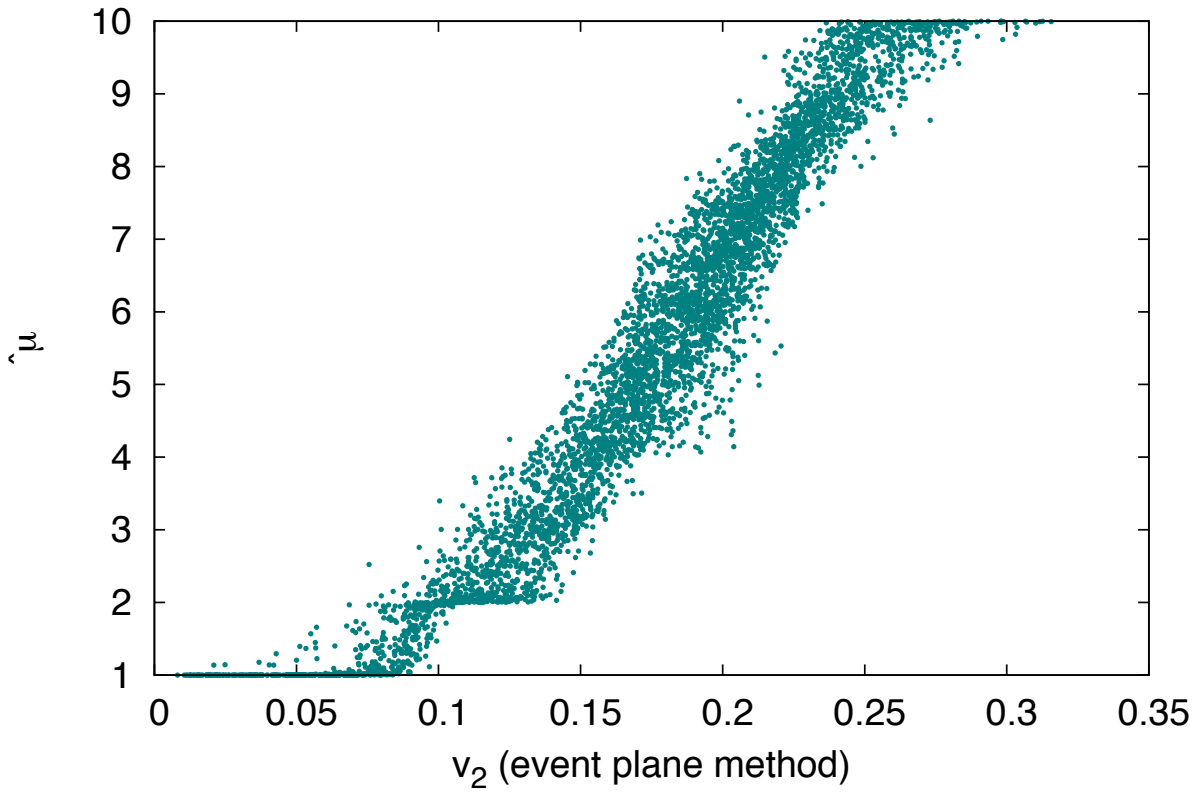
Toy Model: q_2 sorting

- Generated 5000 events up to v_2,
  $v_2 = aM^2 + bM + c$
- $M \in (300, 3000)$
- Initial rotation: Ψ_2
- Sort: q_2



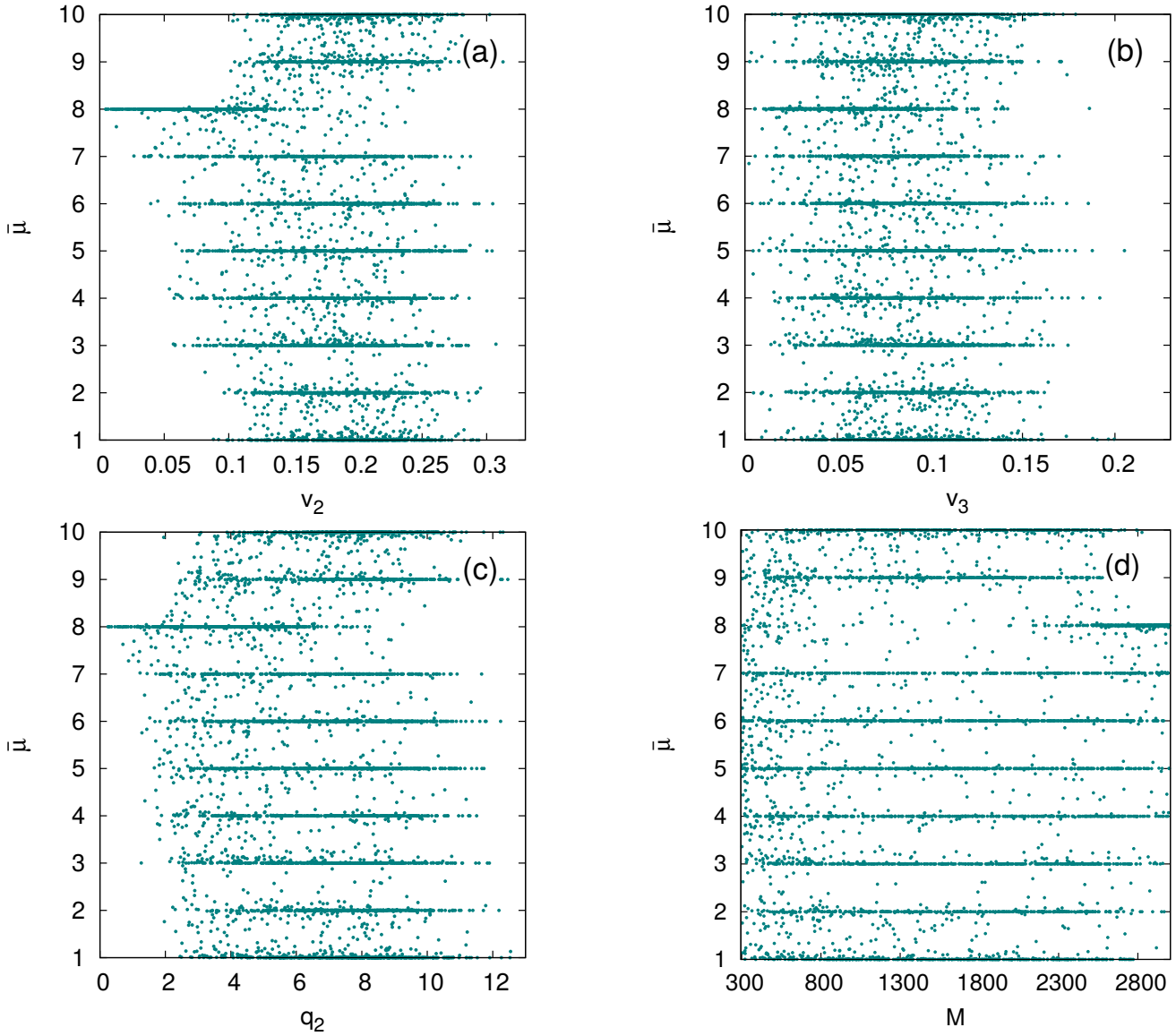
Elliptic flow for q_2 sorting

- Correlation v_2 and μ: 0.959
- Obvious linear dependence
- v_2 might be a better measure than q_2

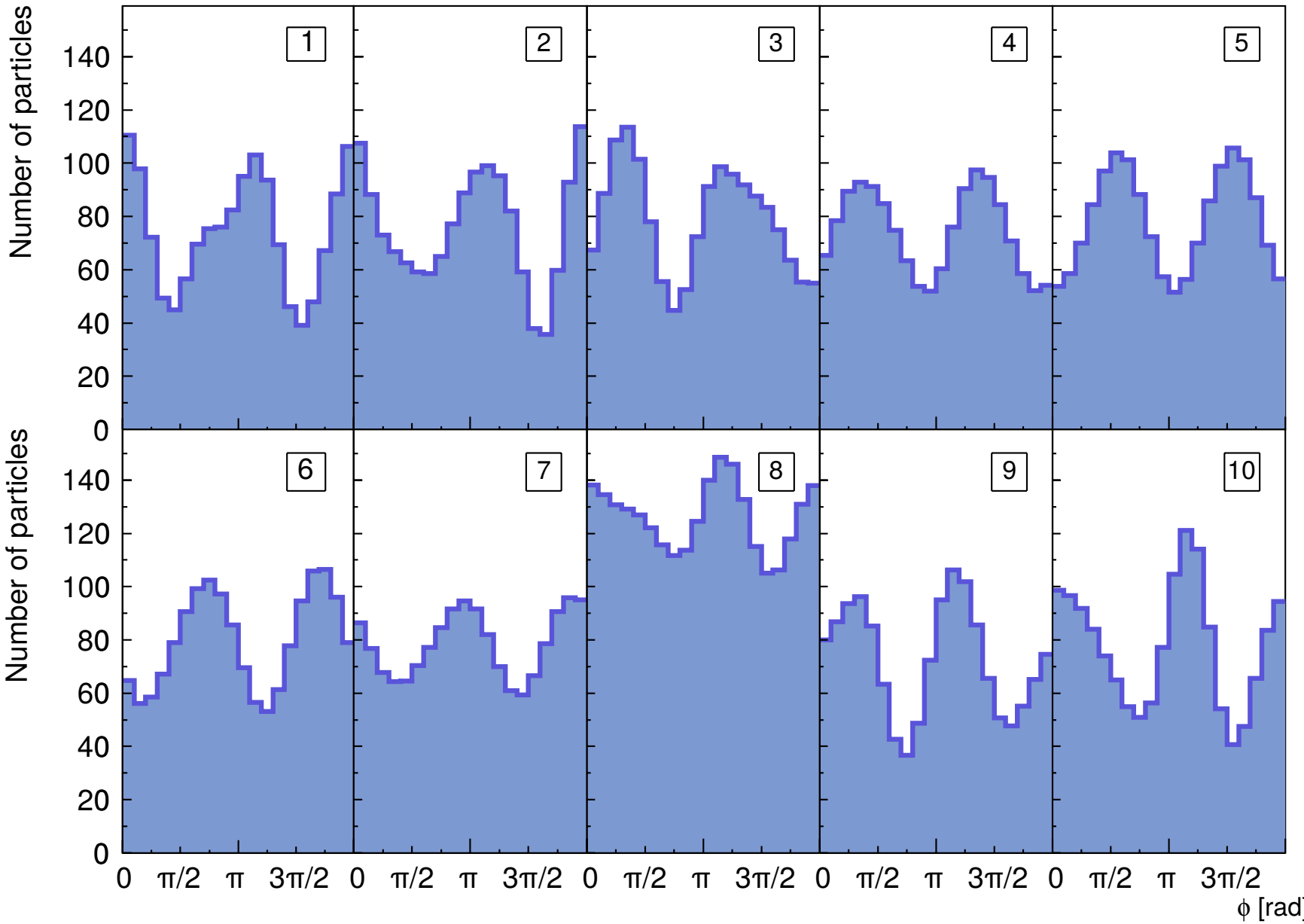


More realistic: all orders of anisotropy

No correlation with any of the conventional measures



More realistic anisotropy: sorting



Conclusions

- The sorting algorithm orders the events according to their similarity.
- This allows to select events which underwent similar evolution

Next steps:

- Test the algorithm with a realistic event generator (we now use AMPT)
- Optimize the performance of the algorithm

What can this be good for:

- exclusive selection of events with specific final state for the comparison with simulations
- single event femtoscopy (choice of ensemble for the mixed events correlations)
- study of non-symmetric systems (e.g. He+Au, U+U)

[Renata Kopečná, Boris Tomášik: arXiv: 1506.06776]