



Event shape and multiplicity dependence of ϕ production in pp collisions with ALICE at the LHC

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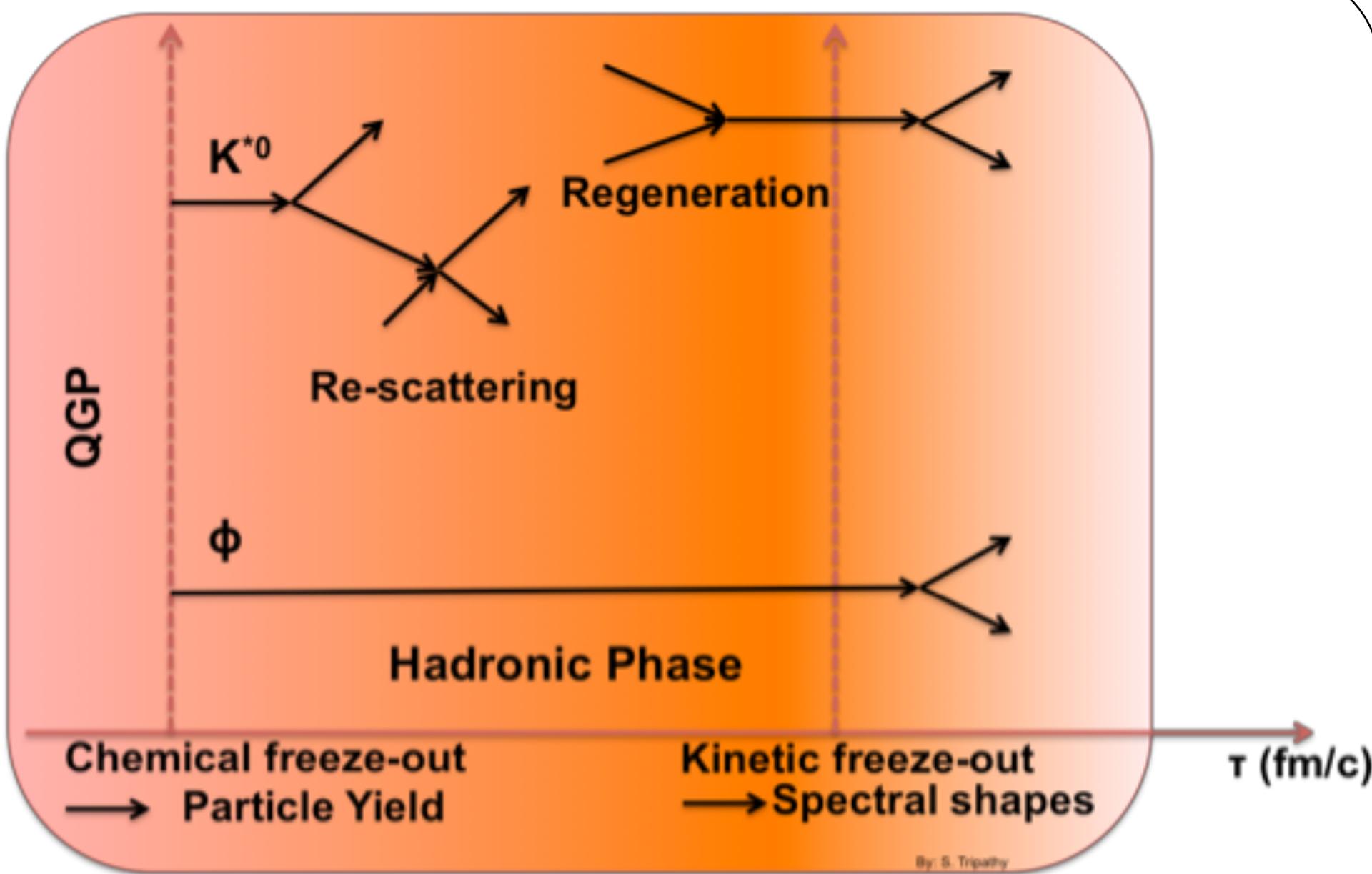
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1. Physics Motivation

- Find whether there is a dependence of the relative $\phi(1020)$ production on the collision energy
- Search for onset of collective effects in small collision systems by a double differential study with multiplicity and event shape (transverse spherocity)
- Investigate whether there is any effect of re-scattering and re-generation for the long-lived ϕ (lifetime: 46.3 fm/c) in high multiplicity pp collisions, where the density and the volume of the system are expected to be larger
- An insight into strangeness using $\phi(1020)$ production in small systems

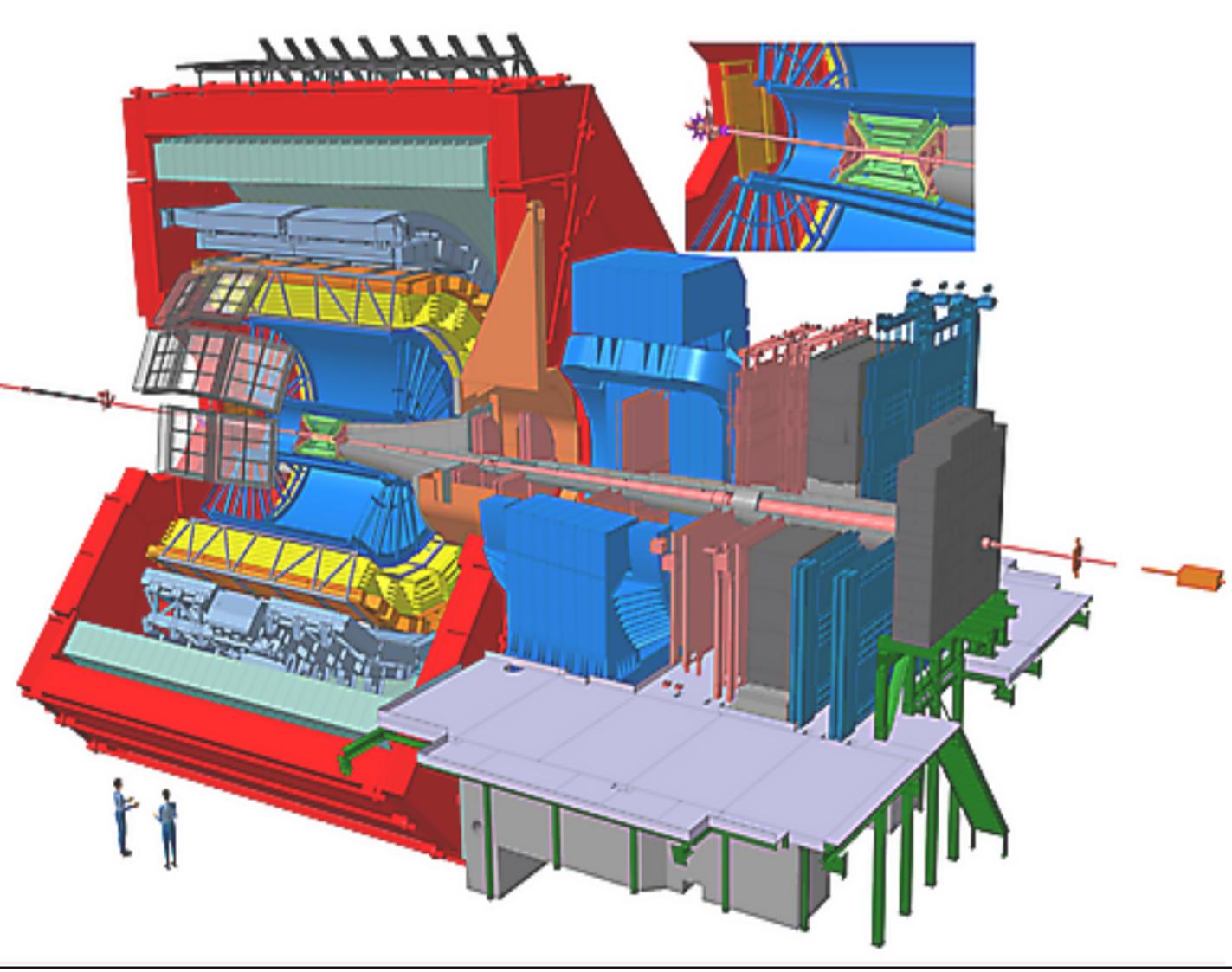


2. A Large Ion Collider Experiment (ALICE)

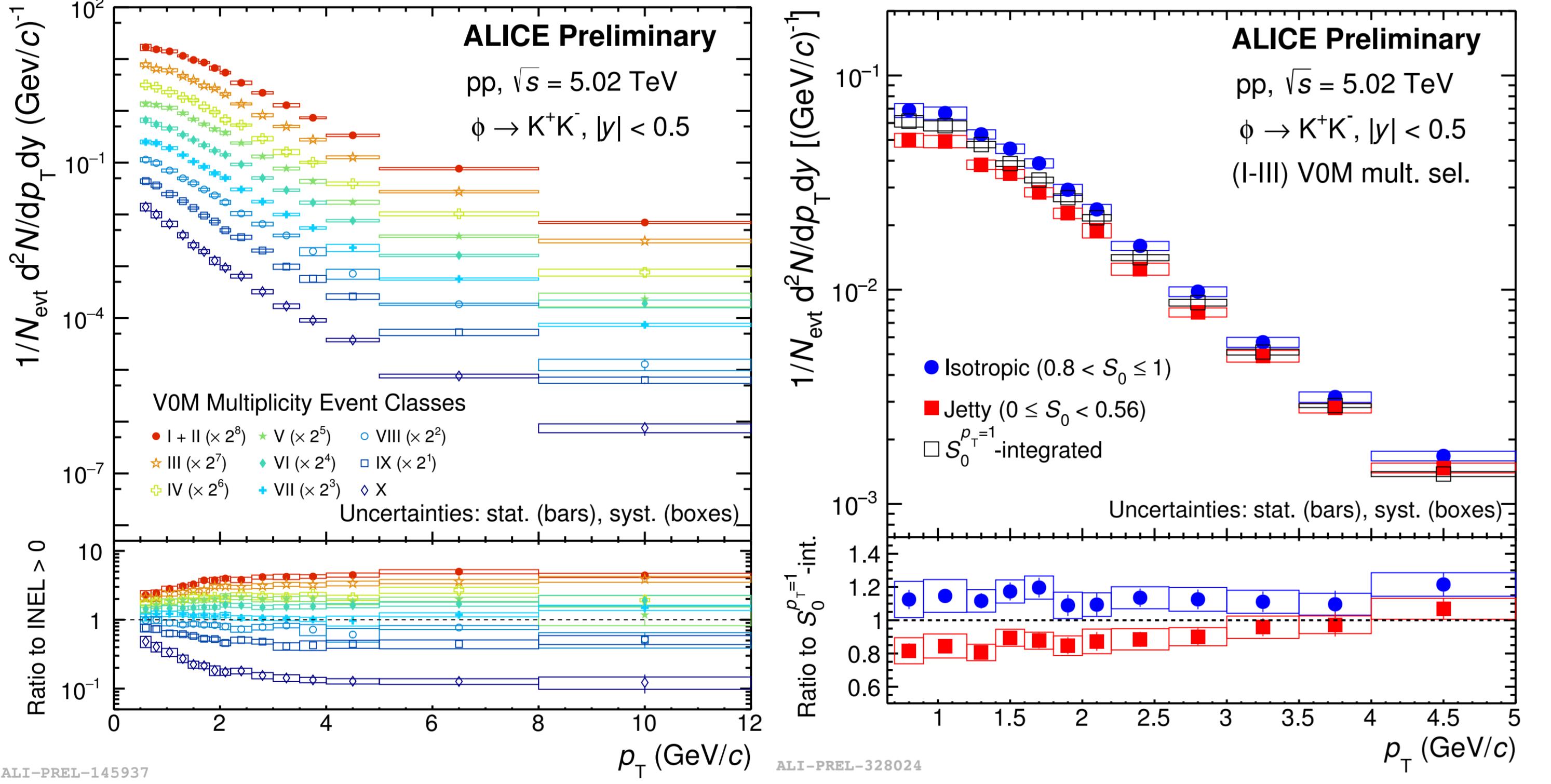
- At the LHC, ALICE has collected data in pp collisions at $\sqrt{s} = 0.9, 2.76, 5.02, 7.0, 8.0$ and 13.0 TeV
- In order to improve the global momentum resolution, tracks are accepted only in the range $|y| < 0.8$ and with $p_T > 0.15 \text{ GeV}/c$

Detectors used

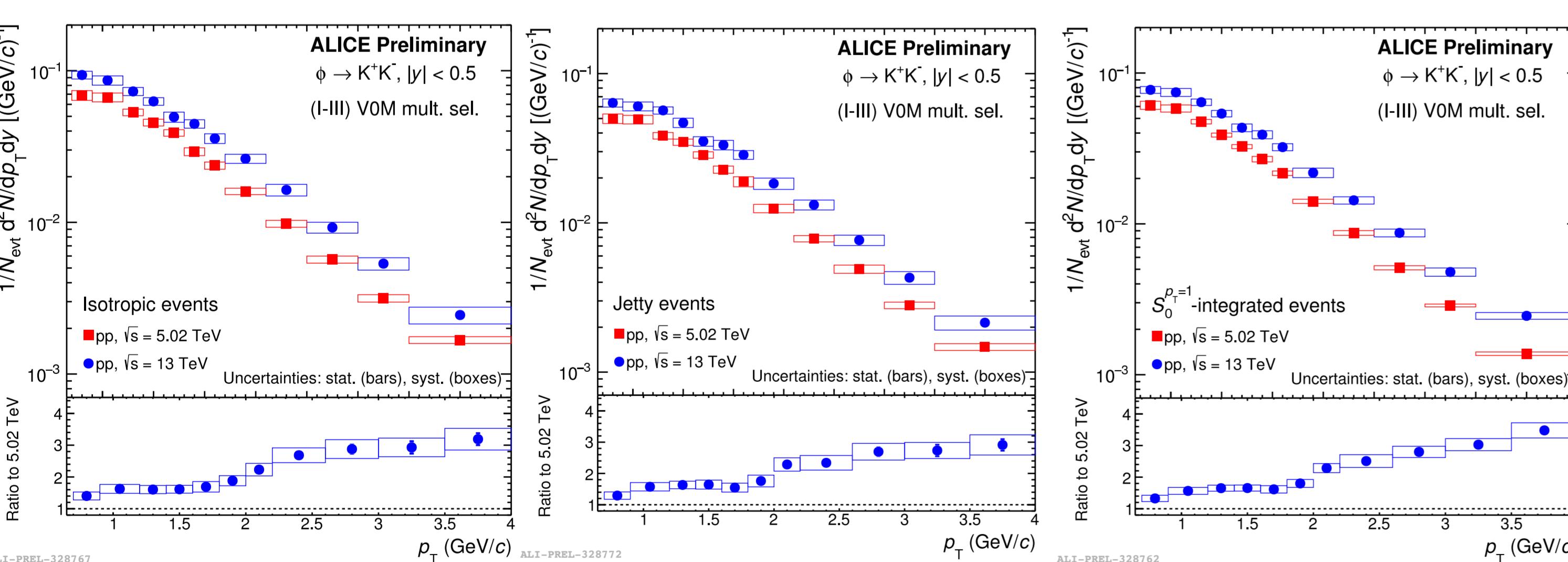
- Inner Tracking system (ITS)**
 - Tracking
 - Vertexing
- Time Projection Chamber (TPC)**
 - Main tracking detector
 - Particle identification (dE/dx)
 - Momentum measurement
- Time of Flight (TOF)**
 - PID via time of flight measurement
- V0**
 - Trigger
 - Multiplicity estimator



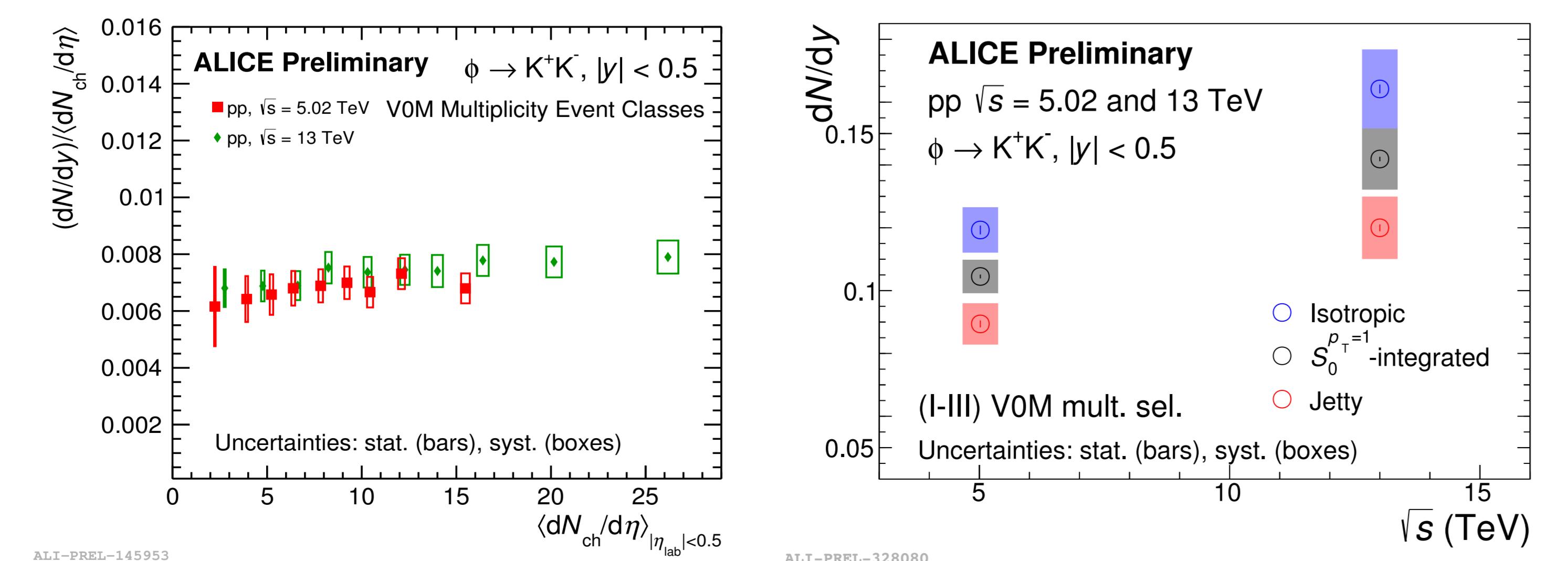
4. p_T spectra, integrated yield and $\langle p_T \rangle$



- Evolution of the spectral shape with increasing multiplicity for $p_T < 5 \text{ GeV}/c$
- Clear separation of ϕ production between isotropic and jetty events in the measured ranges. Low- p_T ϕ production is larger in isotropic events



- p_T spectra get harder with increasing collision energy
- Spectral evolution with collision energy is similar for all spherocity classes



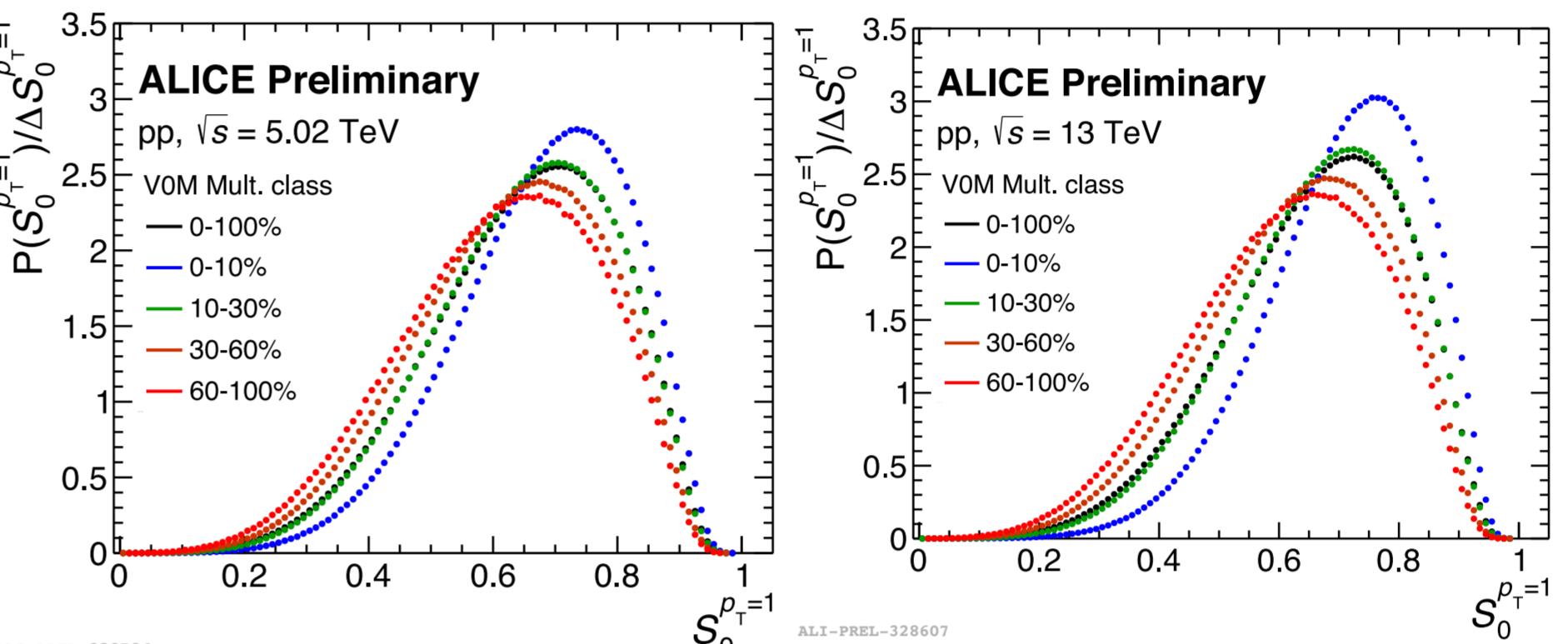
- Event multiplicity drives the particle production irrespective of collision energy for LHC energies
- Integrated yields: Larger for isotropic events in both the collision energies
- Similar trends for pp collisions at both 5.02 and 13 TeV

3. Transverse Spherocity

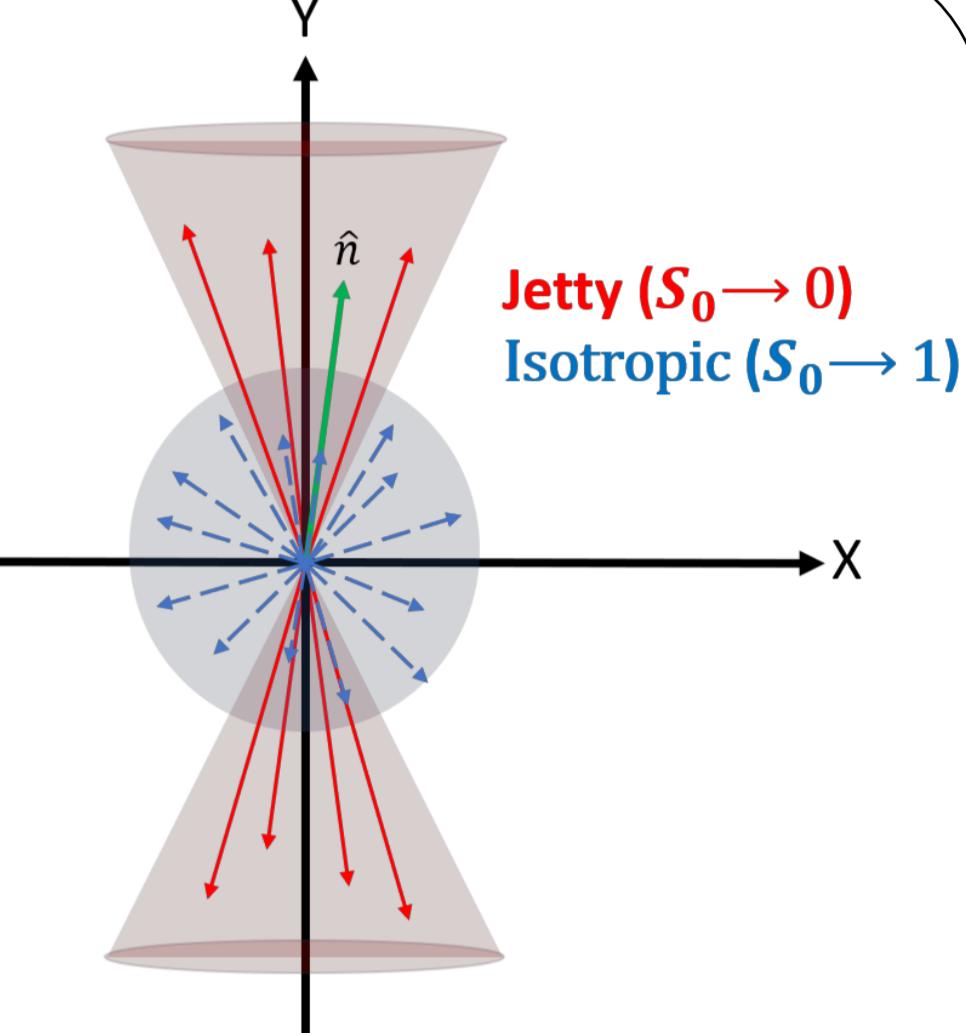
$$S_0^{pT=1} = \frac{\pi^2}{4} \min_{\hat{n}=(n_x, n_y, 0)} \left(\frac{\sum_i |p_{Ti} \times \hat{n}|}{\sum_i p_{Ti}} \right)^2$$

Spherocity helps to distinguish hard and soft processes.

- Jetty: back-to-back structure, indication of hard QCD
- Isotropic: enhanced underlying events, soft QCD

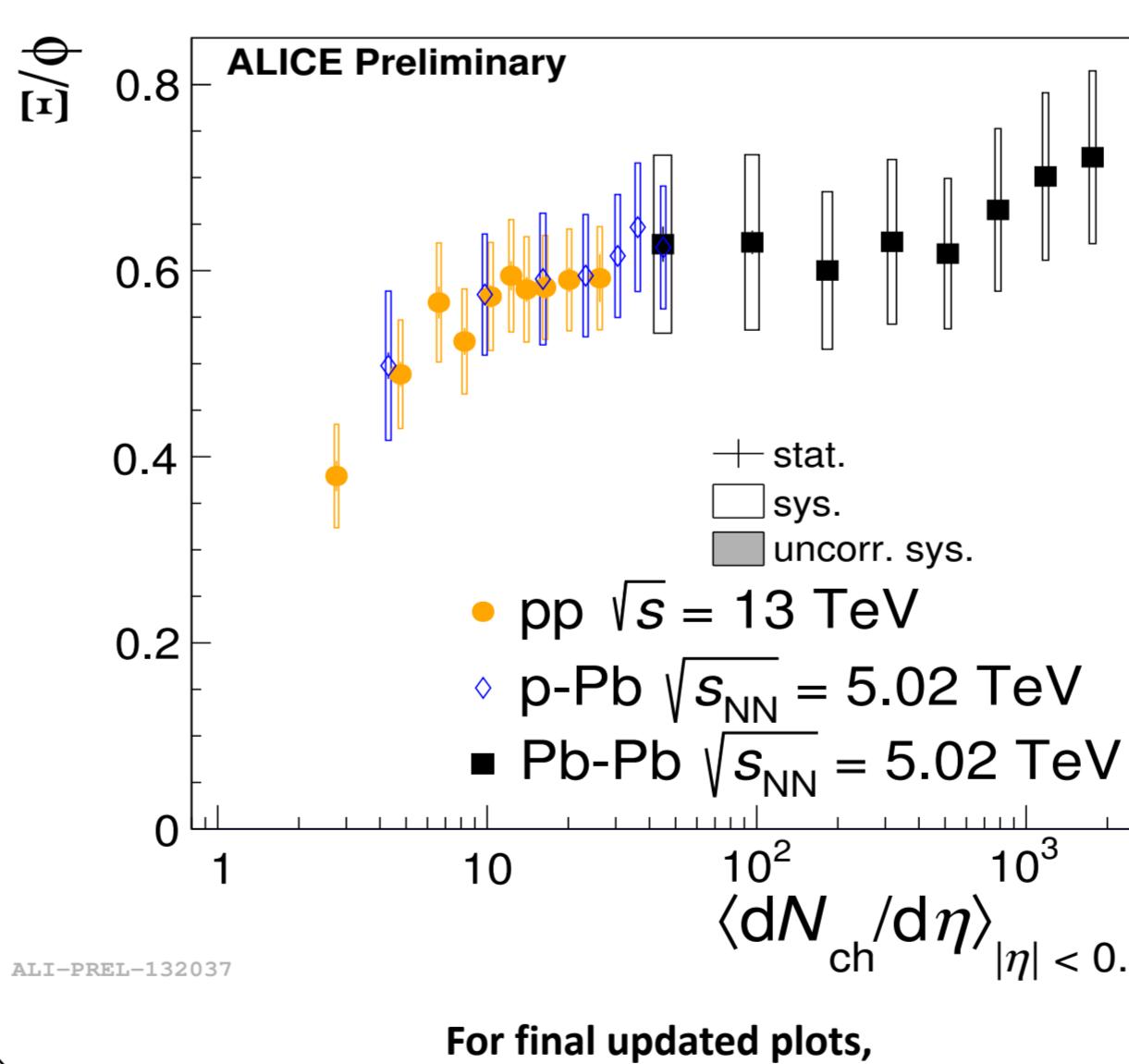
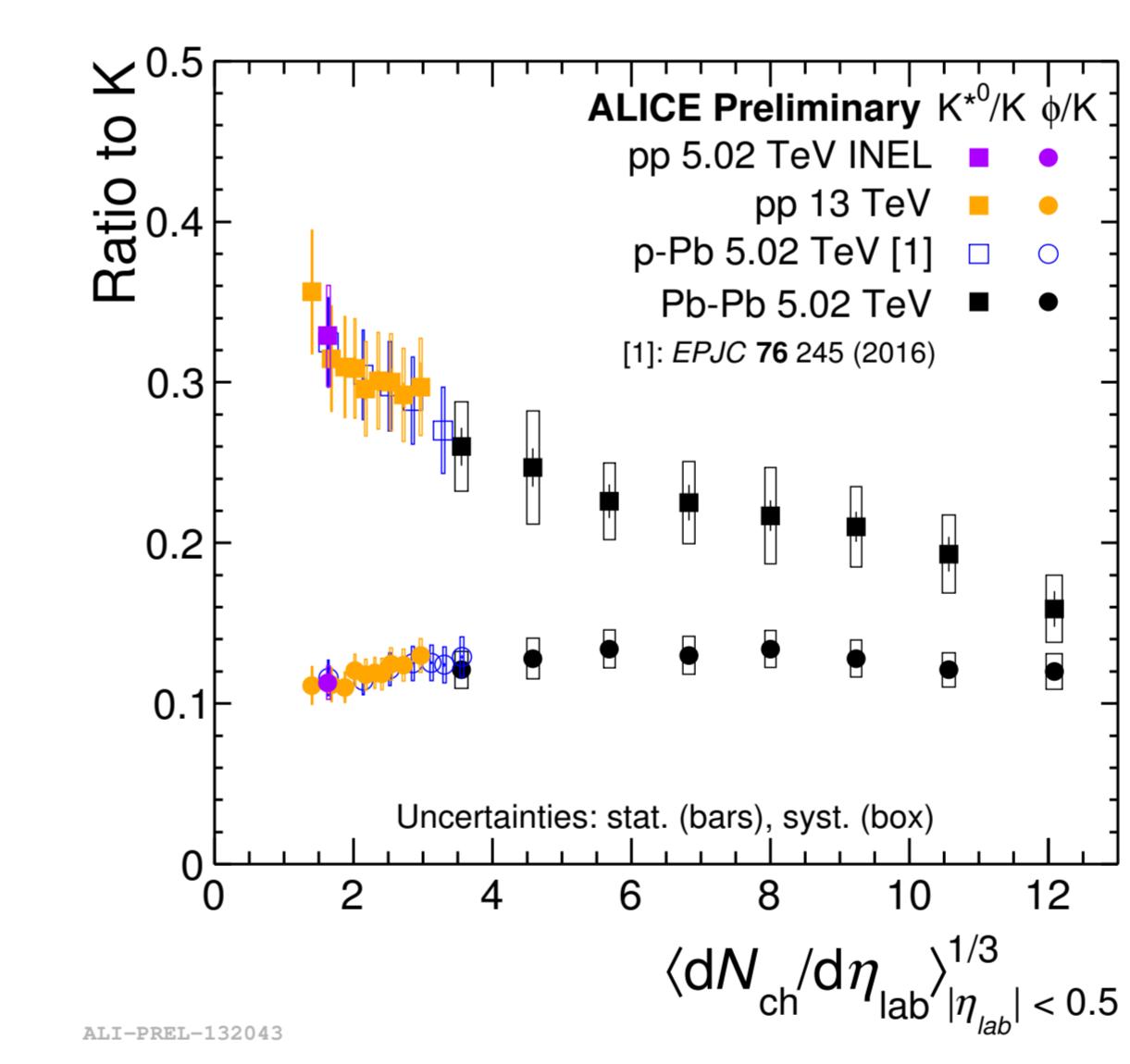
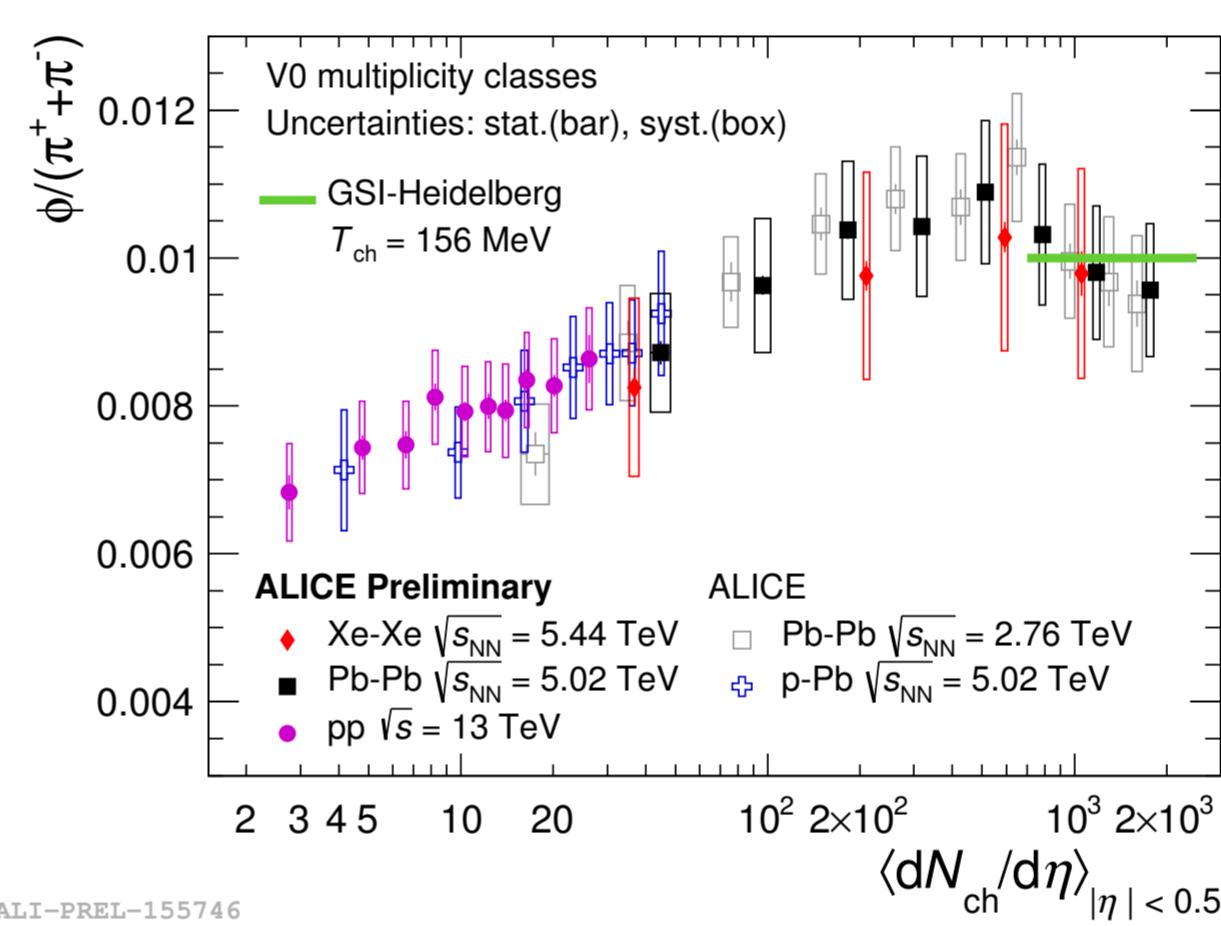


In the above figures, different spherocity distributions are for different multiplicity classes.



Top 20% of the spherocity distribution defines the jetty events while 80-100% of the spherocity distributions defines the isotropic events

5. Particle Ratios



For final updated plots, see: arXiv:1910.14419 [nucl-ex], arXiv:1910.14397 [nucl-ex]

ϕ/π ($|ISI|=0/|ISI|=0$)

- No sign of energy dependence for small colliding systems
- Large systems:** Consistent with predictions from thermal models
- Small systems:** Increase with multiplicity, in contrast to the canonical suppression of strangeness

ϕ/K ($|ISI|=0/|ISI|=1$)

- No sign of re-scattering effects on ϕ .
- Fairly flat or slight increase across wide multiplicity range, which hints that ϕ behaves like a particle with $|ISI| \approx 1$ unit

ϕ/ϕ ($|ISI|=2/|ISI|=0$)

- Fairly flat or slight increase across wide multiplicity range, indicating ϕ behaves like a particle with $|ISI| \approx 1$ or 2 units
- ϕ behaving as if it has 1-2 units of open strangeness may be consistent with expectation from rope-hadronization models (e.g. DIPSY)

6. Summary

- ALICE has measured ϕ in different collision energies and colliding systems
- Event shape analysis shows clear separation of ϕ production between isotropic and jetty events in the measured ranges. Low- p_T ϕ production is larger in isotropic events
- Spectral evolution with collision energy is similar for all spherocity classes
- ϕ behaves like a particle with strangeness ≈ 1 or 2 units

