Correlations & fluctuations

Things I am interested in:

- Correlations (collectivity? v_n?) in small systems?
- (Critical) fluctuations in large systems
- Using correlations to probe particle production mechanisms in pp collisions

How is strangeness produced in p+p?

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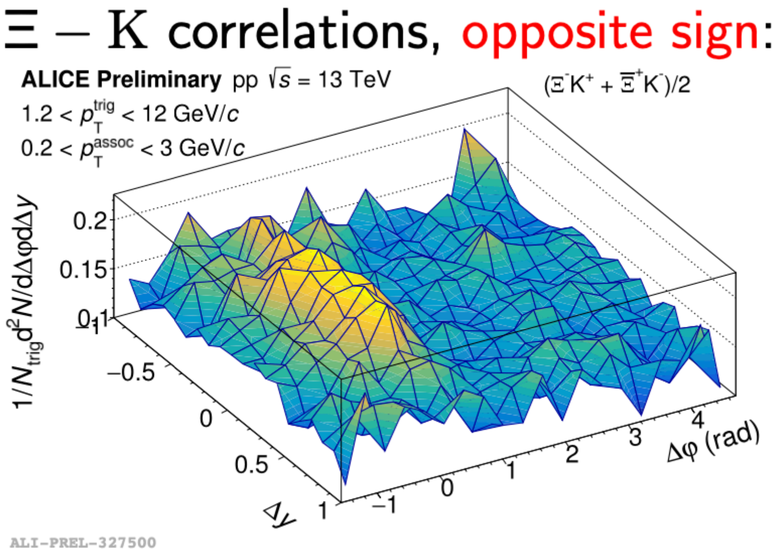
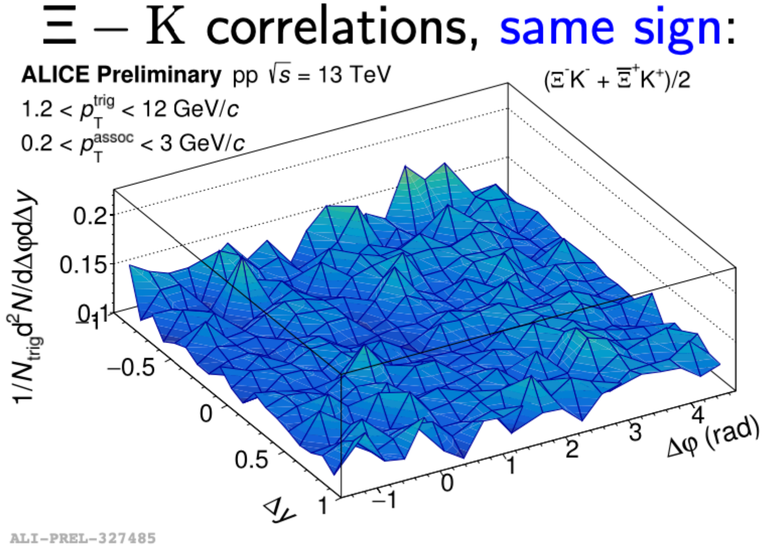
- Balance functions: correlation functions indicate where balancing charges end up in ($\Delta\varphi$, $\Delta\eta$)

- Example: Ξ^-K^+ correlations share a s-sbar pair which could come from the same string breaking
  → but there are also Ξ^-K^+ pairs where the s-sbar is not from the same string, model these with Ξ^-K^- correlations and subtract

- Correlations between Ξ baryon and mesons:
  ΞK → containing a strange quark
  (Ξπ → without a strange quark)

- Correlations between Ξ baryon and baryons:
  ΞΛ → containing a strange quark
  (Ξp → without a strange quark)
  ΞΞ also measured





How is strangeness produced in p+p?

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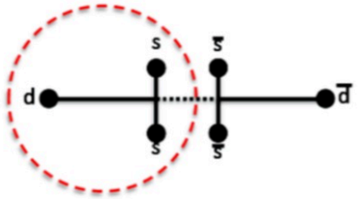
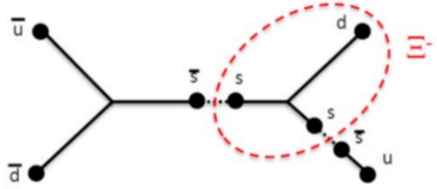
- Balance functions: correlation functions indicate where balancing charges end up in (Δφ, Δη)

Lund string breaking (PYTHIA)

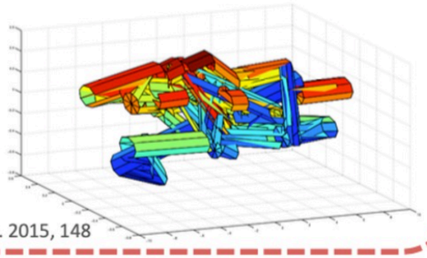
standard:



with junctions:



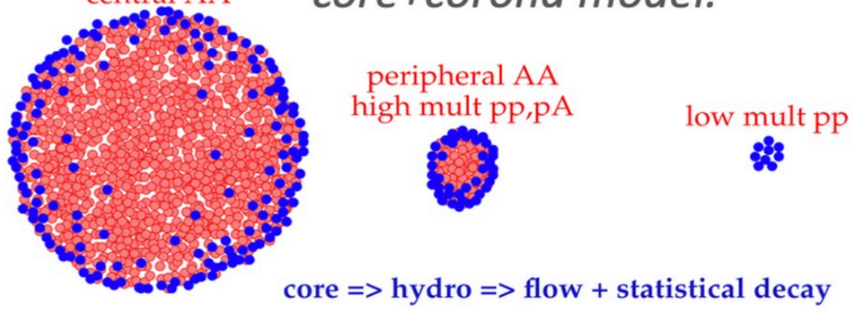
with ropes:



Adolfsson et al. Eur. Phys. J. A 56, 288 (2020), Bierlich et al. J. High Energ. Phys. 2015, 148

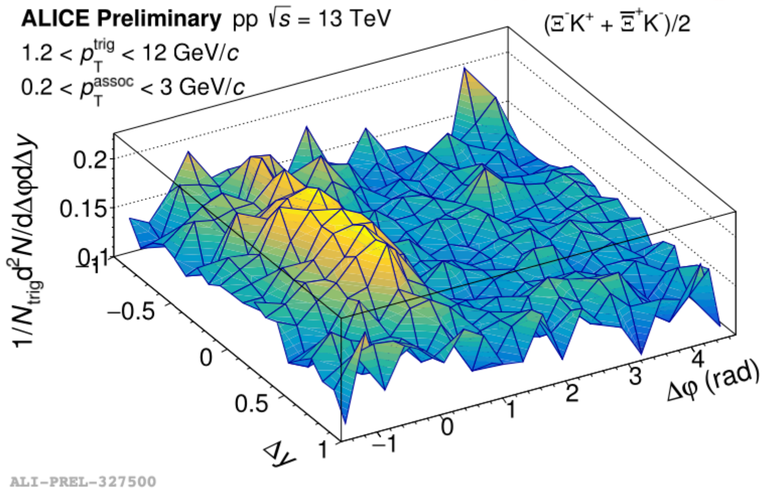
EPOS:

core+corona model:



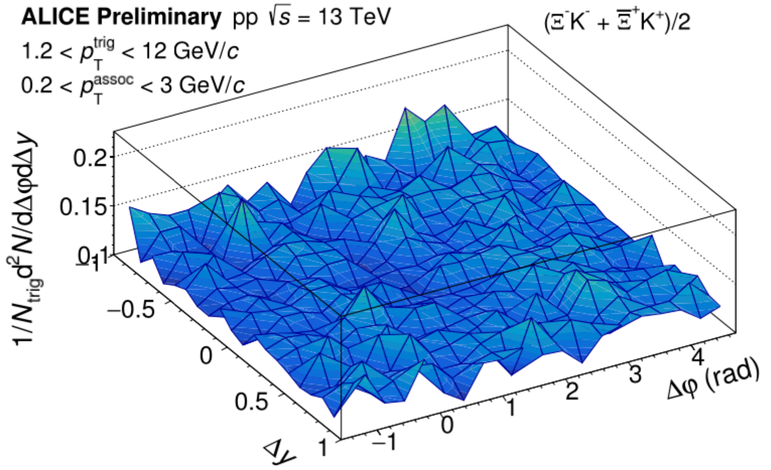
K. Werner. hal-02434245 (2019)

$\Xi - K$ correlations, opposite sign:



ALI-PREL-327500

$\Xi - K$ correlations, same sign:



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Ξπ balance: results

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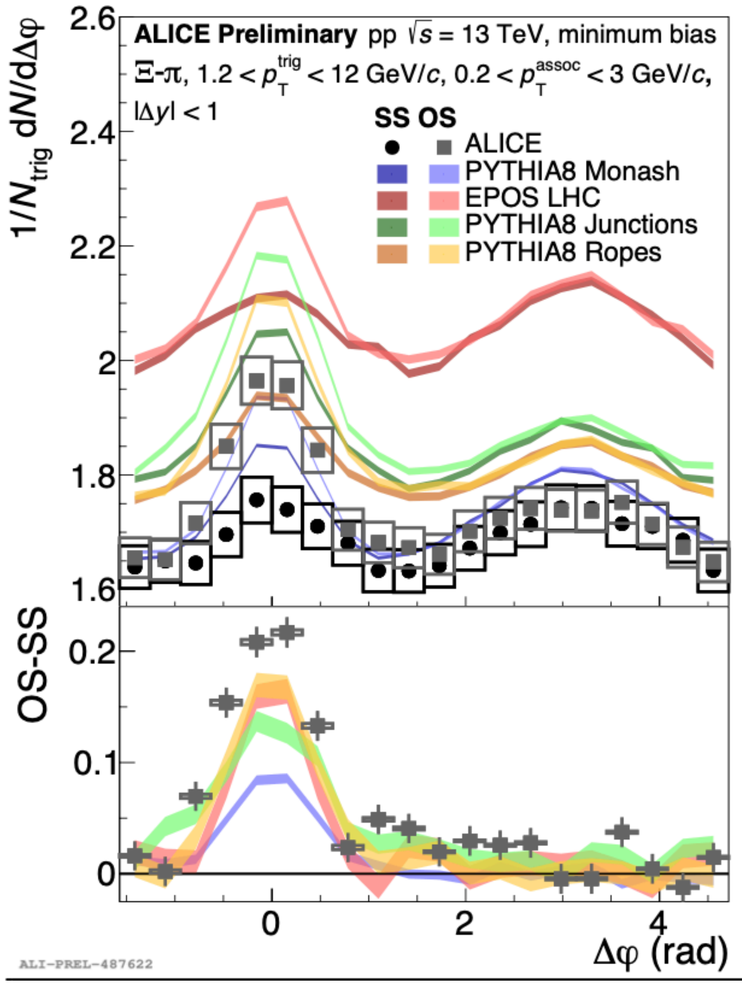
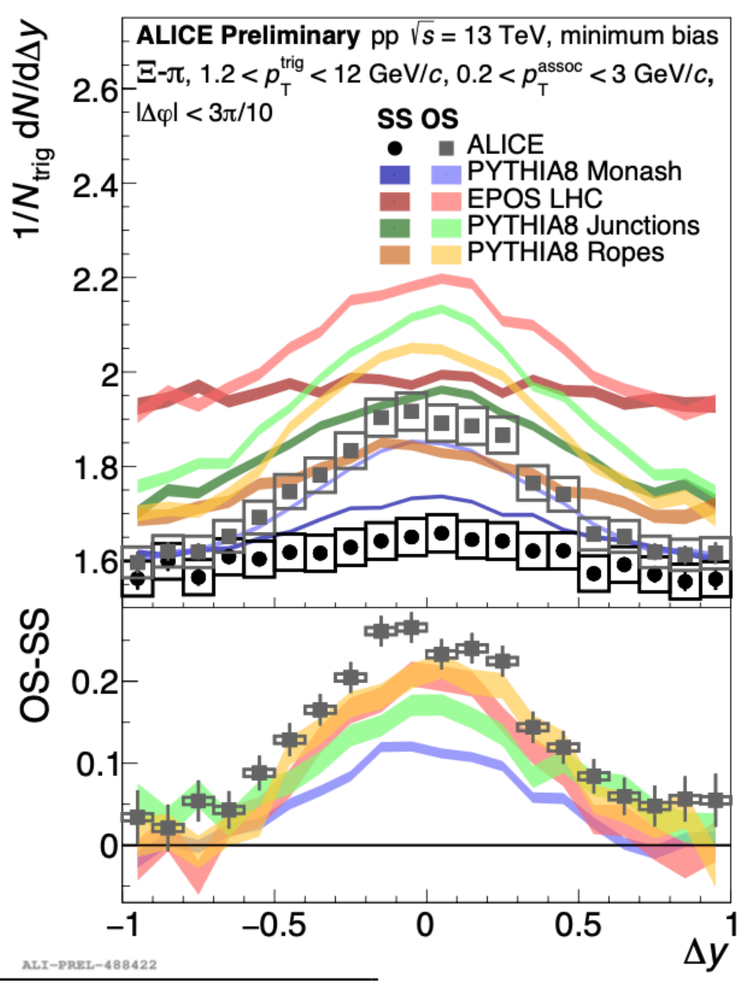
$\Delta\varphi$ projection:



Δy projection, near side:



- Pythia describes overall yields well, tuned to single-particle spectra
- EPOS also gets balance right, as well as Pythia

ΞK balance: results

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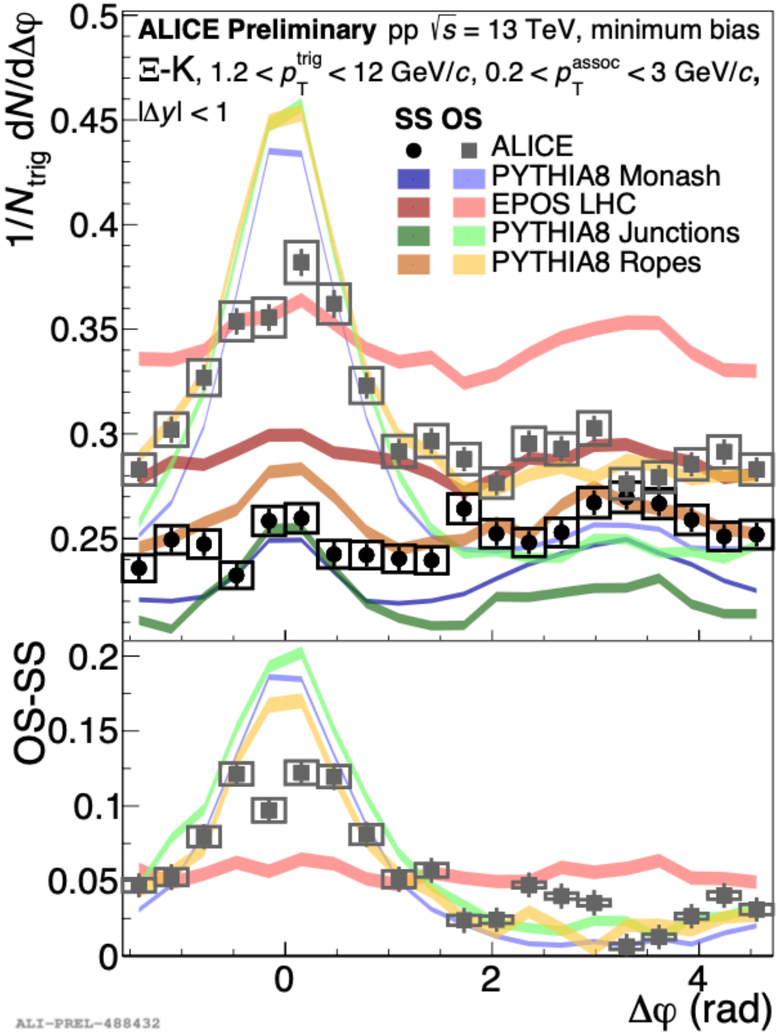
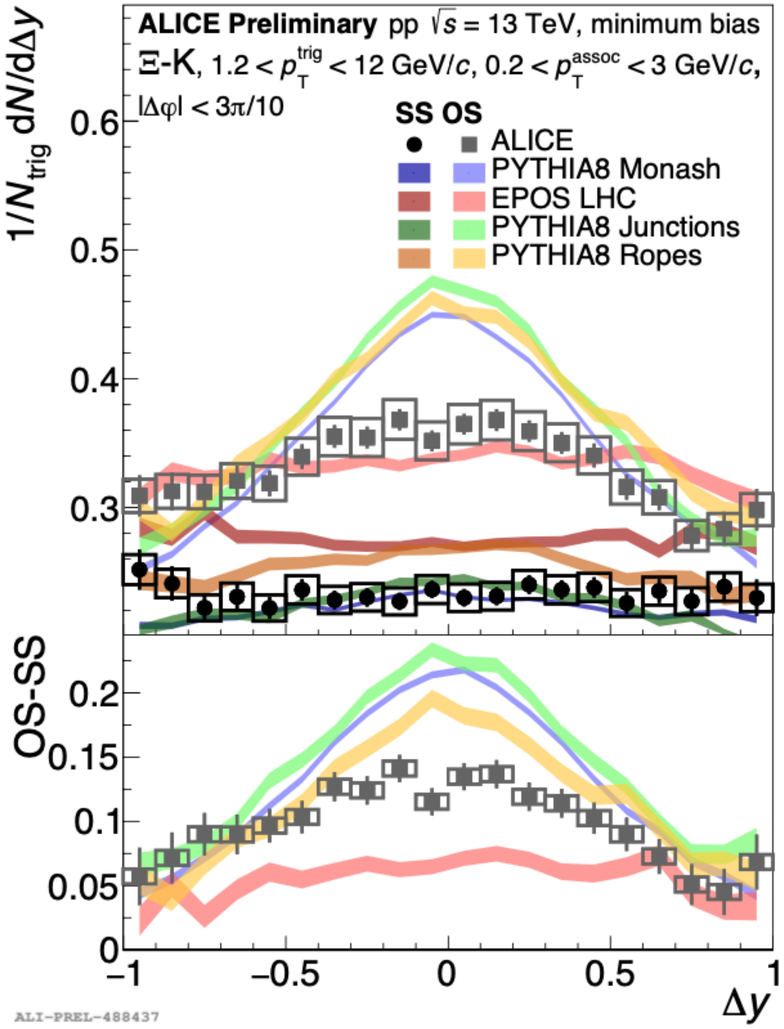
$\Delta\varphi$ projection:



Δy projection, near side:



- Wider NS peak in data than in Pythia → strange quarks produced earlier? more diffusion?
- EPOS has no local conservation of strangeness, predicts flat OS-SS difference, in contradiction to data

Ξp balance: results

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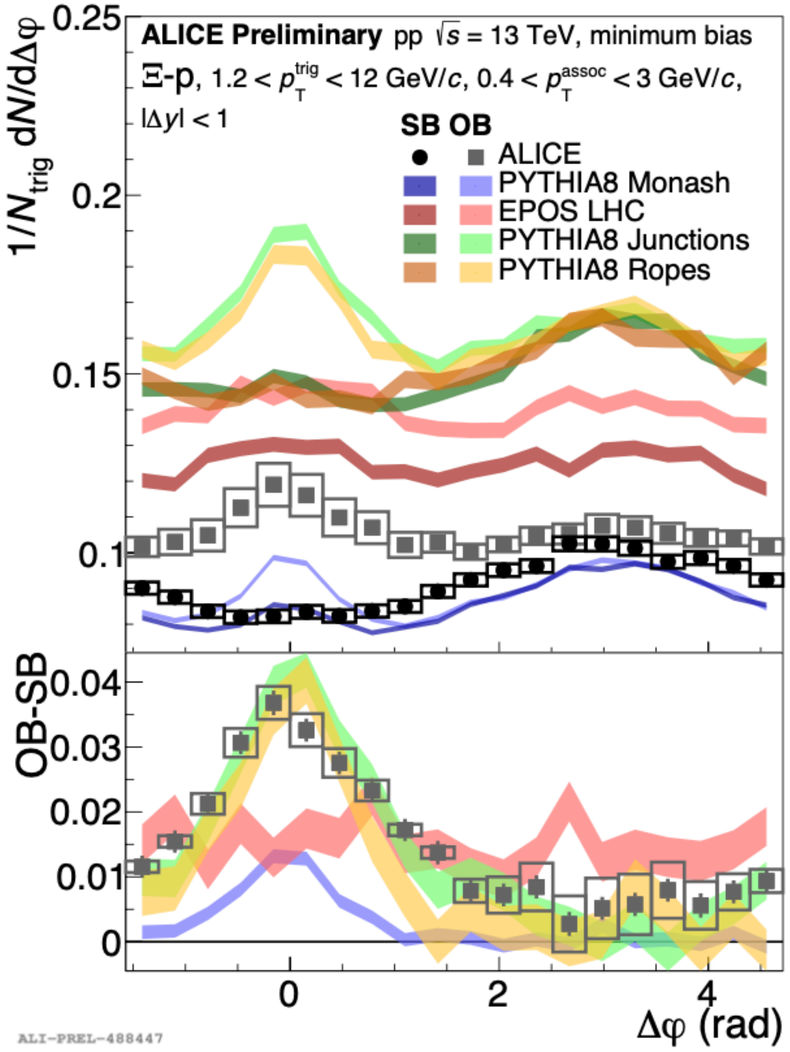
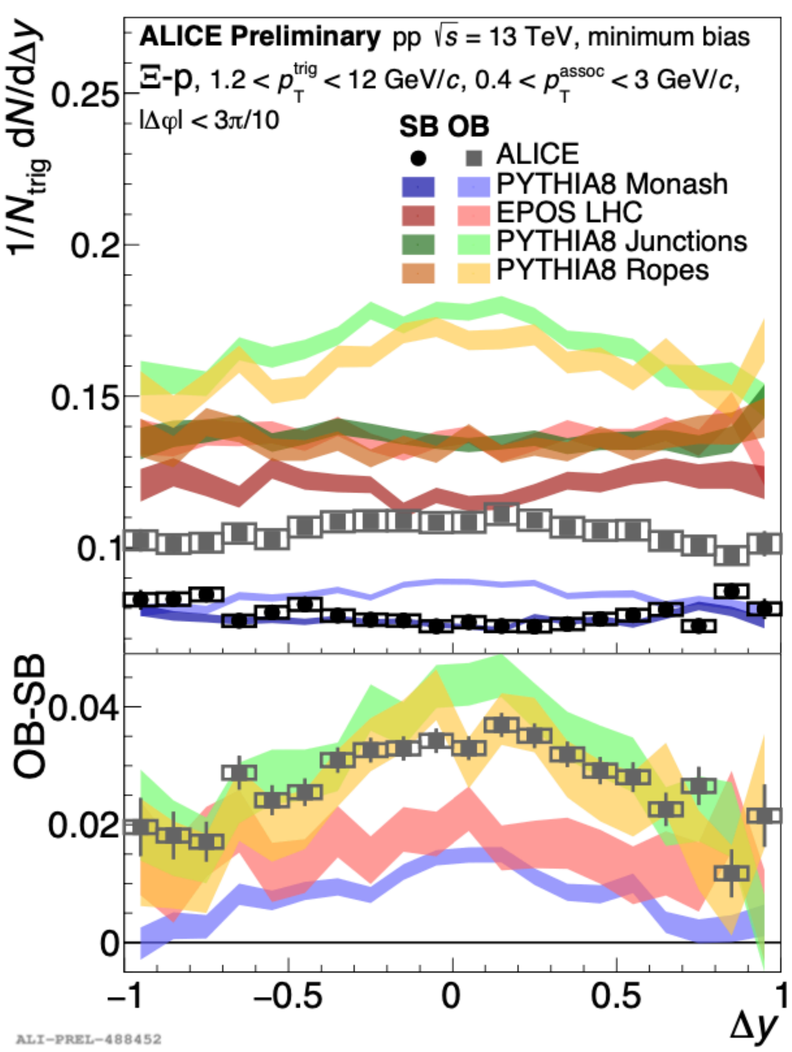
Δφ projection:



Δy projection, near side:



- Junctions and ropes tunes of Pythia are able to get the shape of the OS-SS difference right

ΞΛ balance: results

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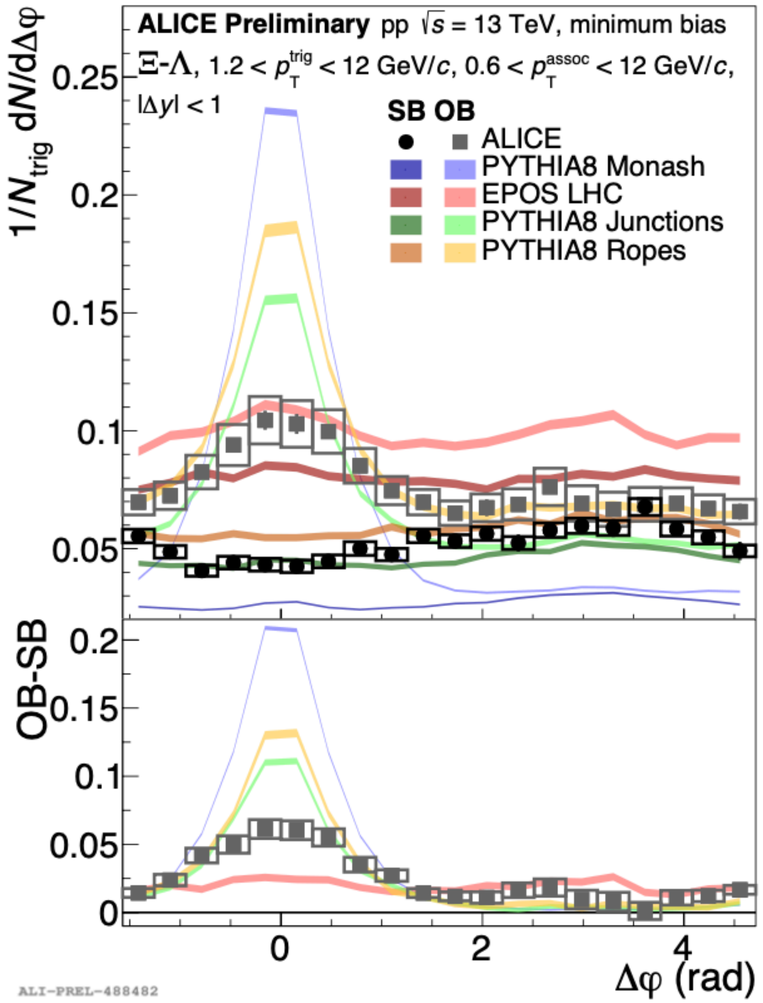
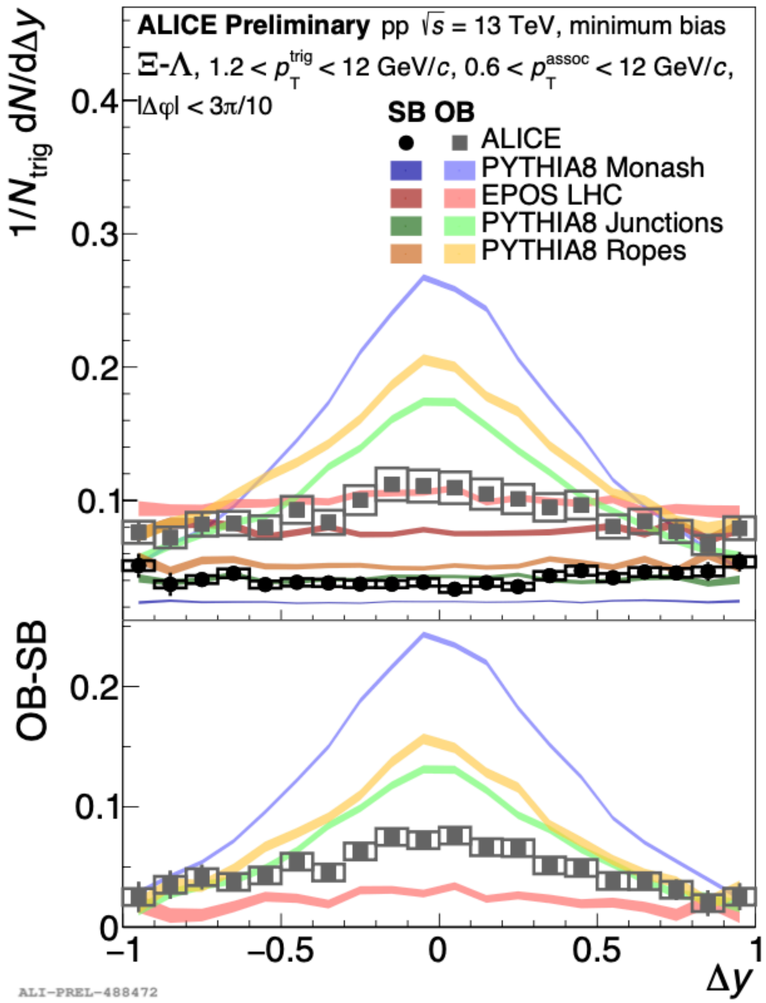
Δφ projection:



Δy projection, near side:



- Similar observations as in ΞK correlations, Pythia predicts a narrower peak than observed in data

Multiplicity dependence

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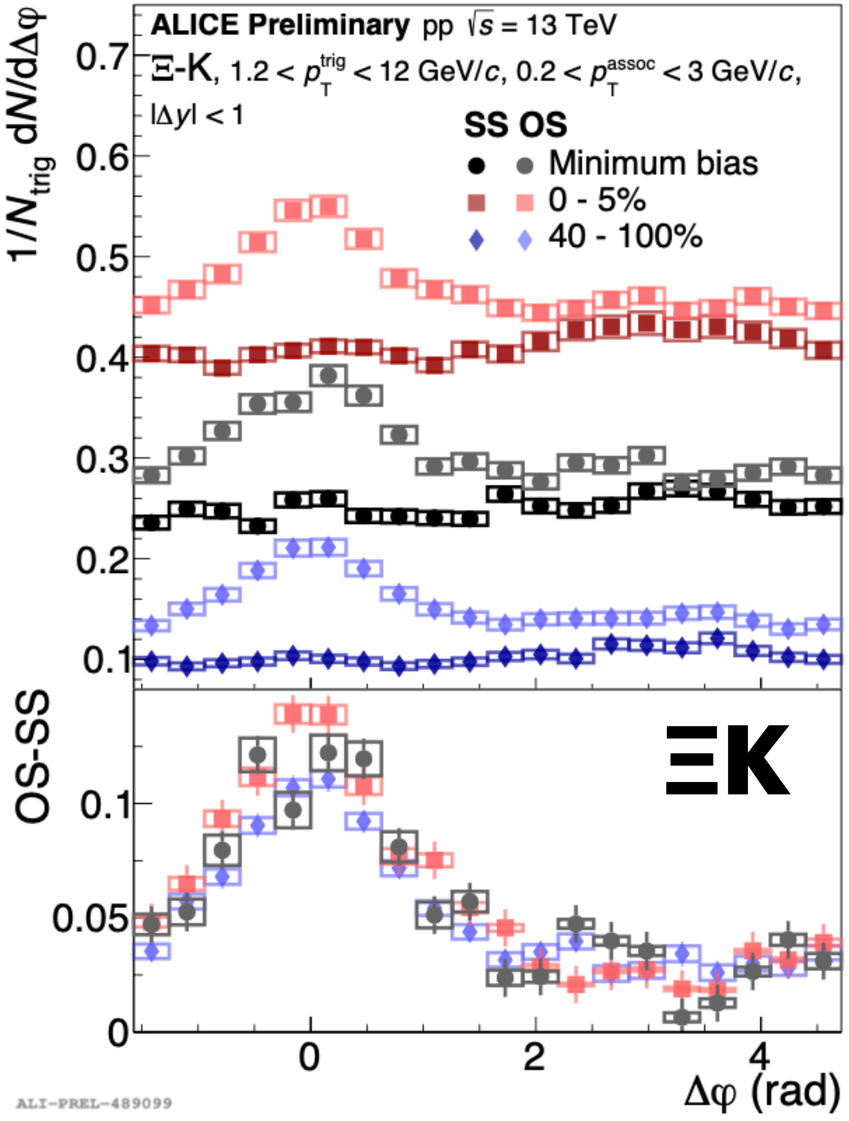
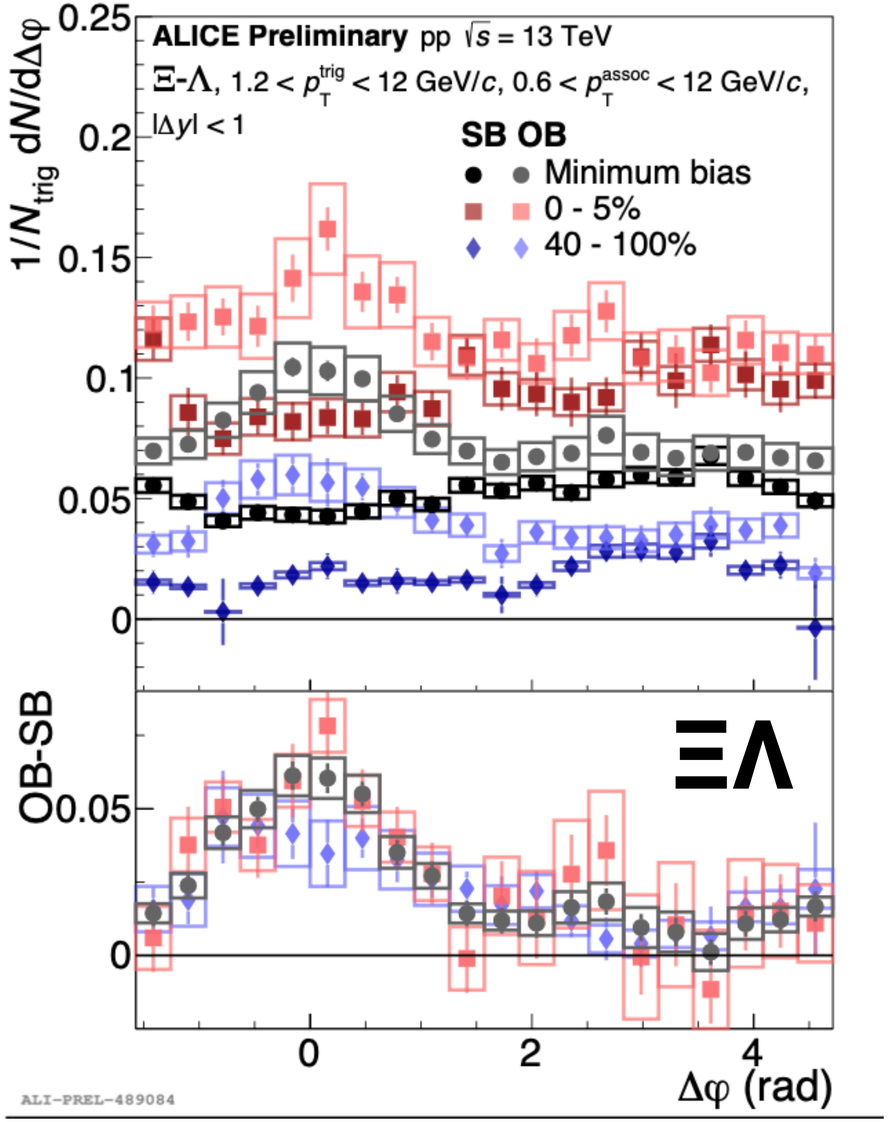
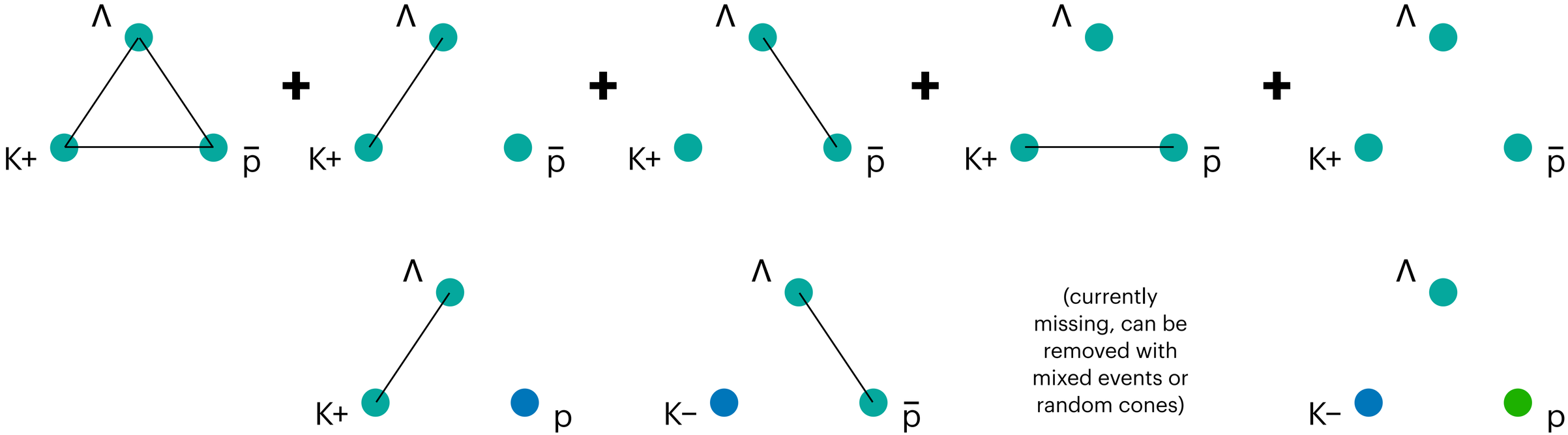




- No major multiplicity dependence observed → we don't see the "turn-on" of different particle production mechanisms at high multiplicity, for example

Extending the idea further: 3 particles!

- I want to know whether the balancing strangeness and balancing baryon number are correlated
- Example: $\Lambda K^{+}\bar{p}$ correlations

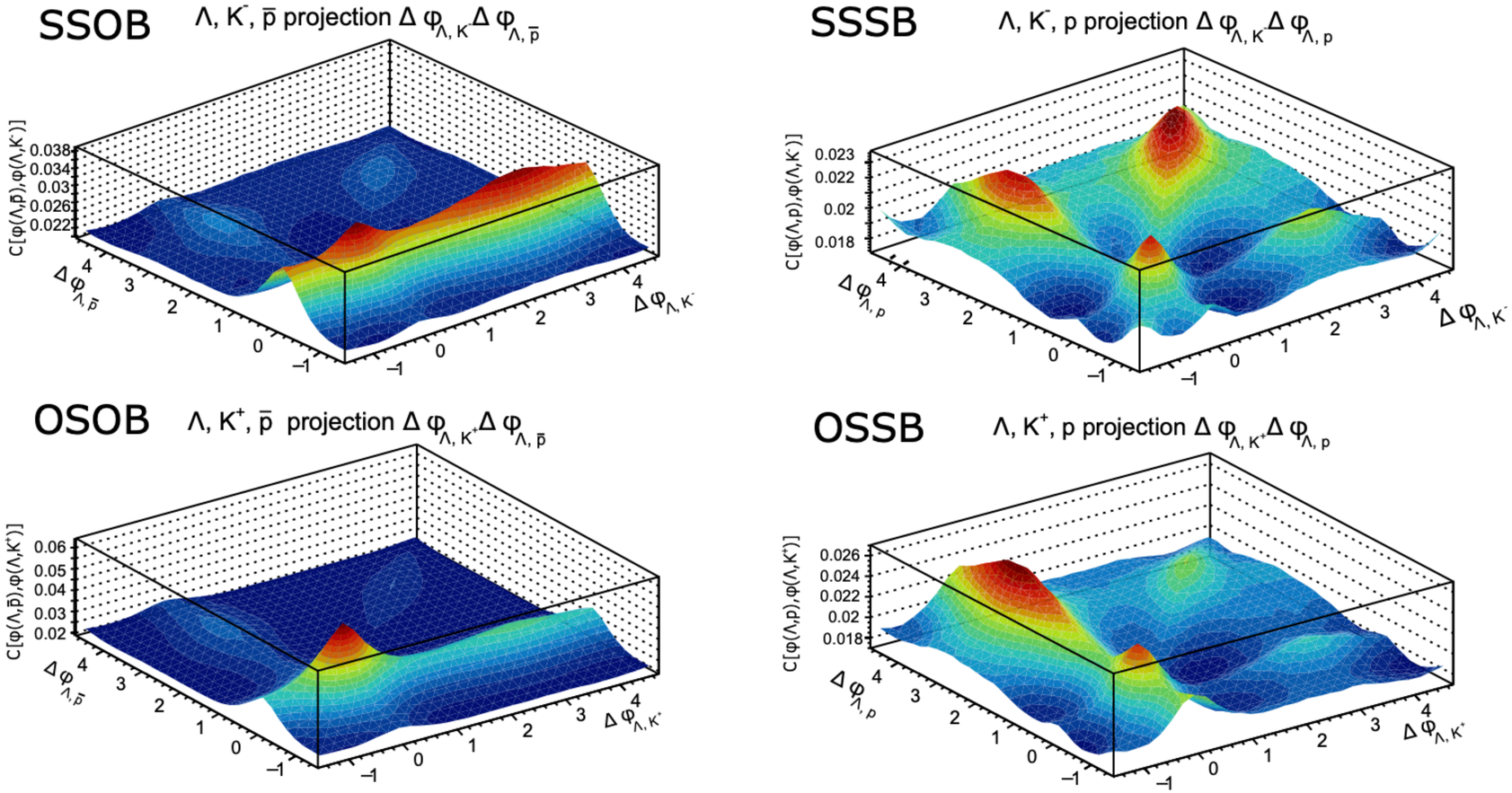


(currently missing, can be removed with mixed events or random cones)

true s-sbar and B-antiB correlation will come from OSOB – OSSB – SSOB + SSSB

Extending the idea further: 3 particles!

- Example: $\Lambda K^{+}\bar{p}$ correlations
- Study performed in Pythia by Mel Petricean (bachelors student in Lund)



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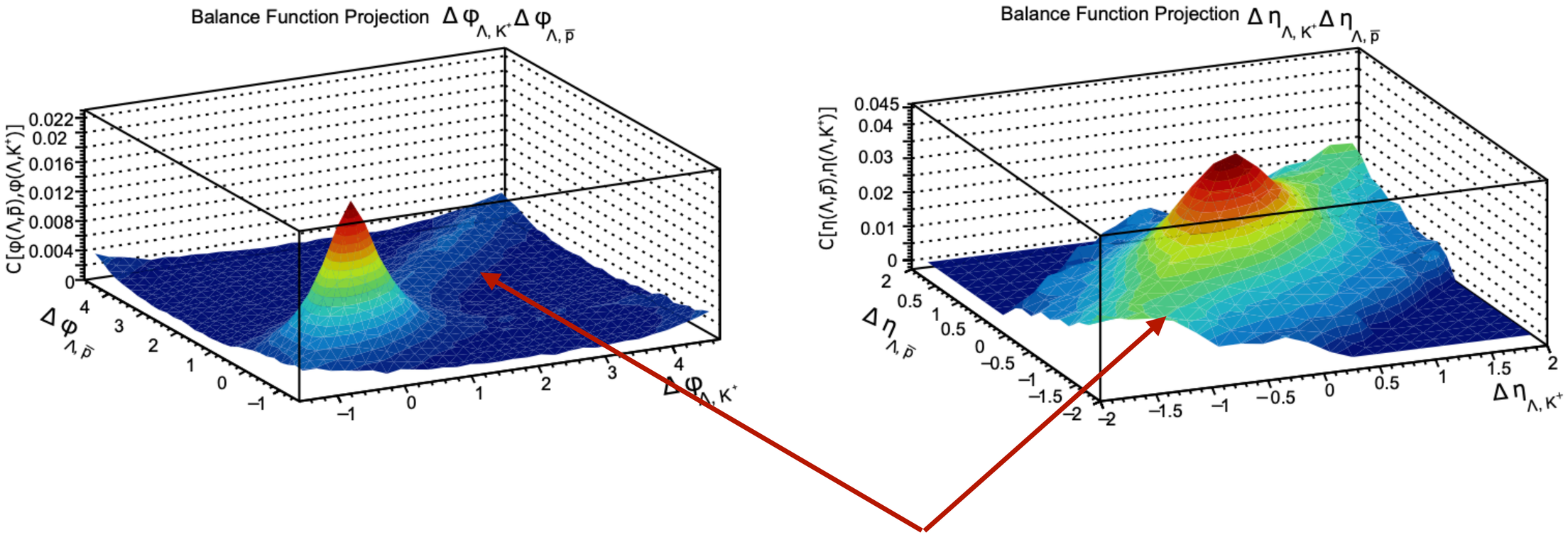
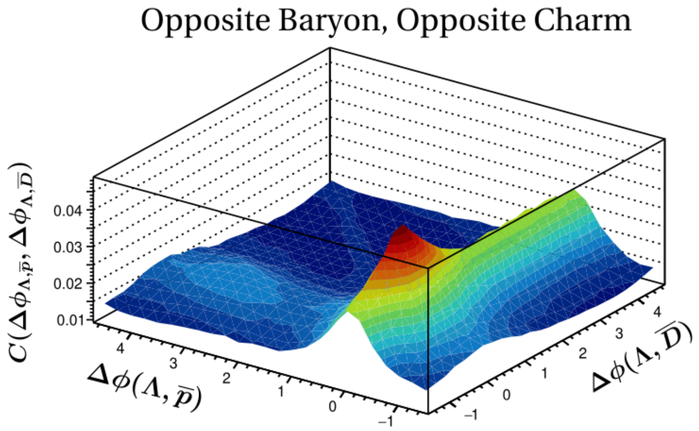
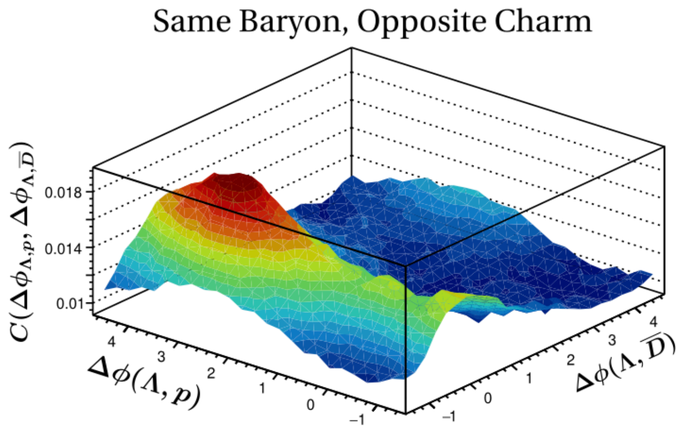


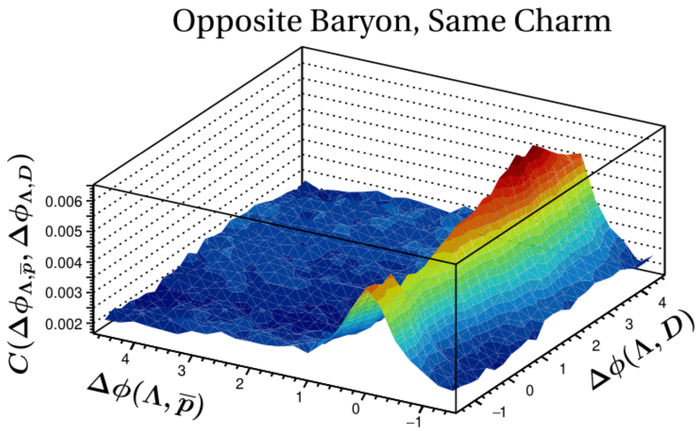
This ridge is the Λ(Kp) correlation which has not been removed

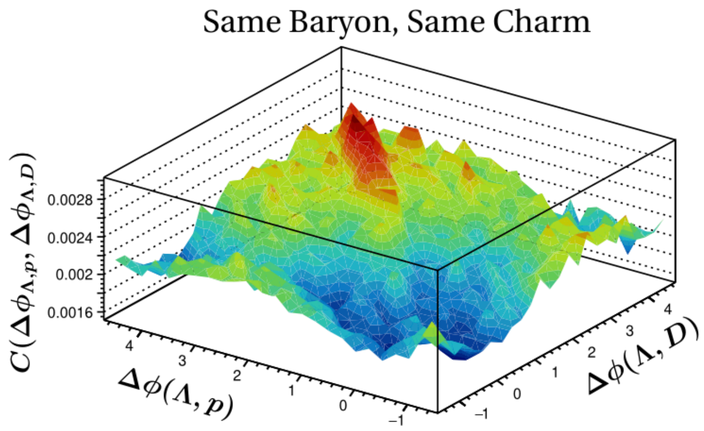
Extending the idea further: 3 particles with charm!

- Example: $\Lambda_c D^- \overline{p}$ correlations
- Study performed in Pythia by Kim Haupt (bachelors student in Lund)









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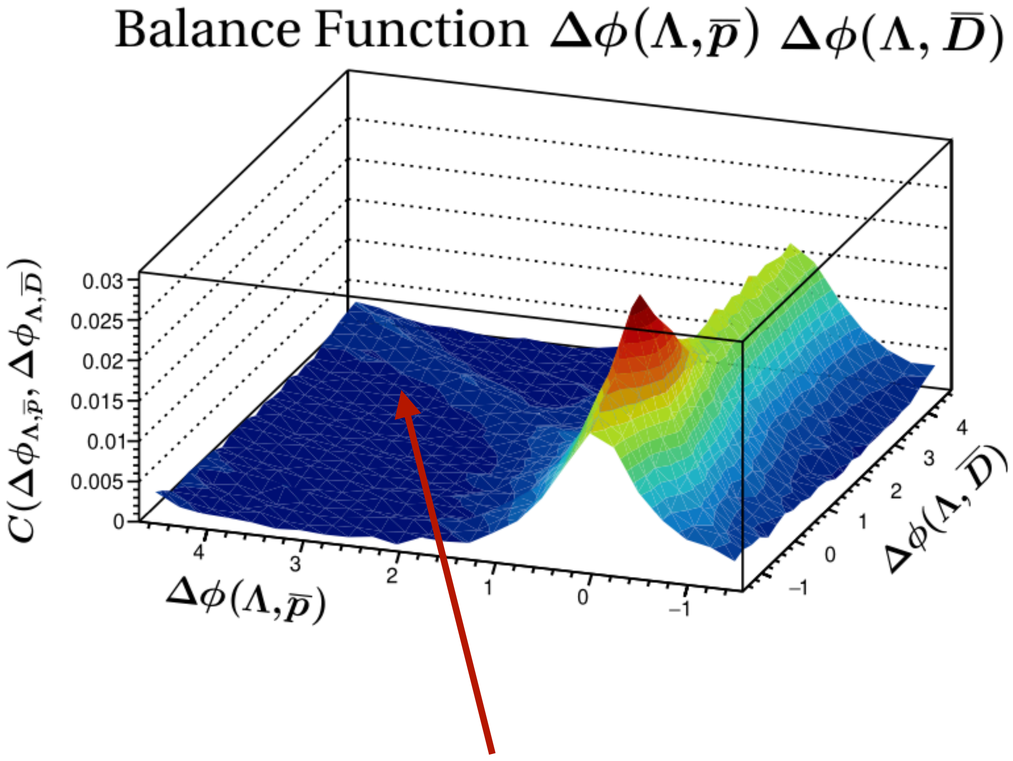

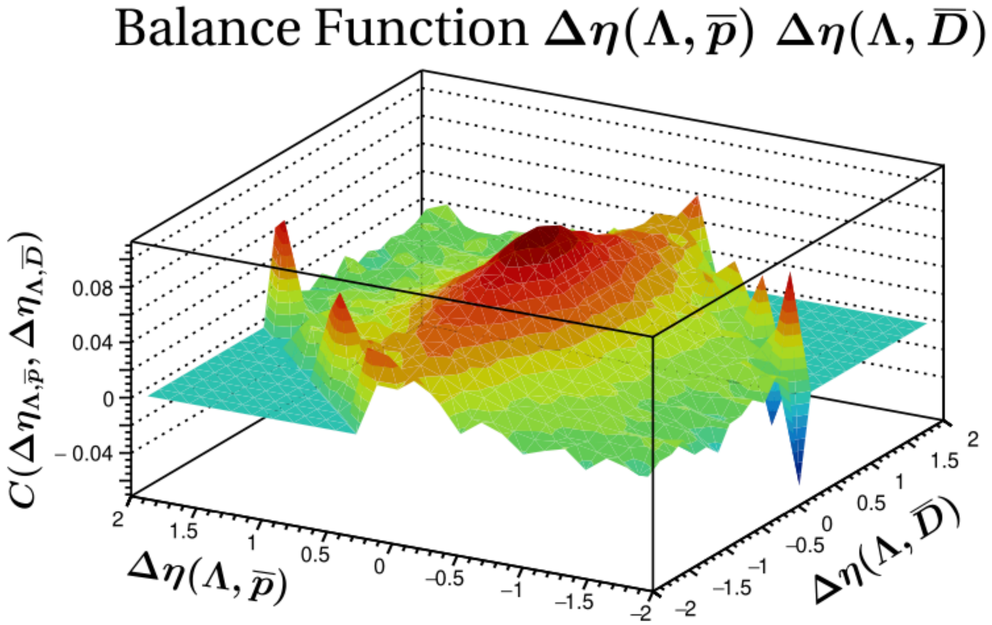

This ridge is the Λ(Kp) correlation which has not been removed

Three-particle balance functions

- An interesting technique that can be used to study several other questions
- Examples: ϕK+K– → is the ϕ strange or S=0?
  ΞK+K+ → does the Ξ always need to be produced with another strange baryon, as the string-breaking picture would suggest?
- Plan is to write up this three-particle idea with Mel and Kim this summer :)