Transverse Sphericity of minimum bias pp collisions in ALICE at the LHC

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Why study the event shapes?

- The event shapes are observables which measure the geometrical distribution of the final state particles in high energy collisions.
- They are sensitive to perturbative and non-perturbative QCD components of the hadronic interactions (MC tuning).
- In a continuous way they permit the classification of the events according to their hardness.
- They are interesting observables to characterize the high multiplicity events.

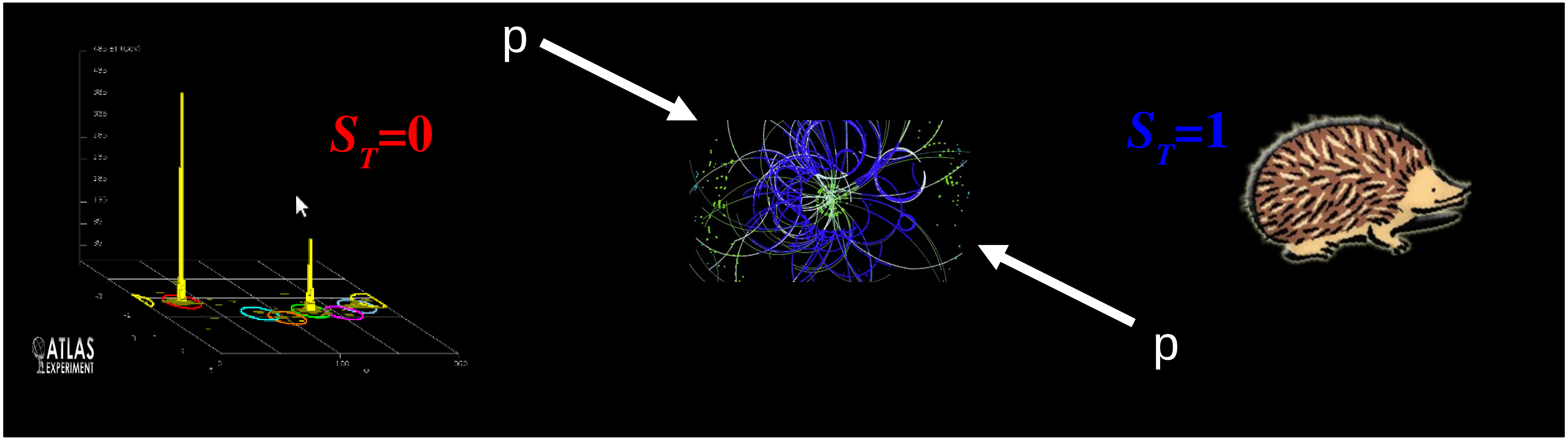
What event shape do we study?

Transverse Sphericity:

$$\mathbf{S^{L}_{xy}} = \frac{1}{\sum_i p_{Ti}} \sum_i \frac{1}{p_{Ti}} \begin{pmatrix} p_{xi}{}^2 & p_{xi}p_{yi} \\ p_{xi}p_{yi} & p_{yi}{}^2 \end{pmatrix}$$

$$S_T \equiv \frac{2\lambda_2}{\lambda_2 + \lambda_1}$$

Remarks: linearized version, IR&C safe

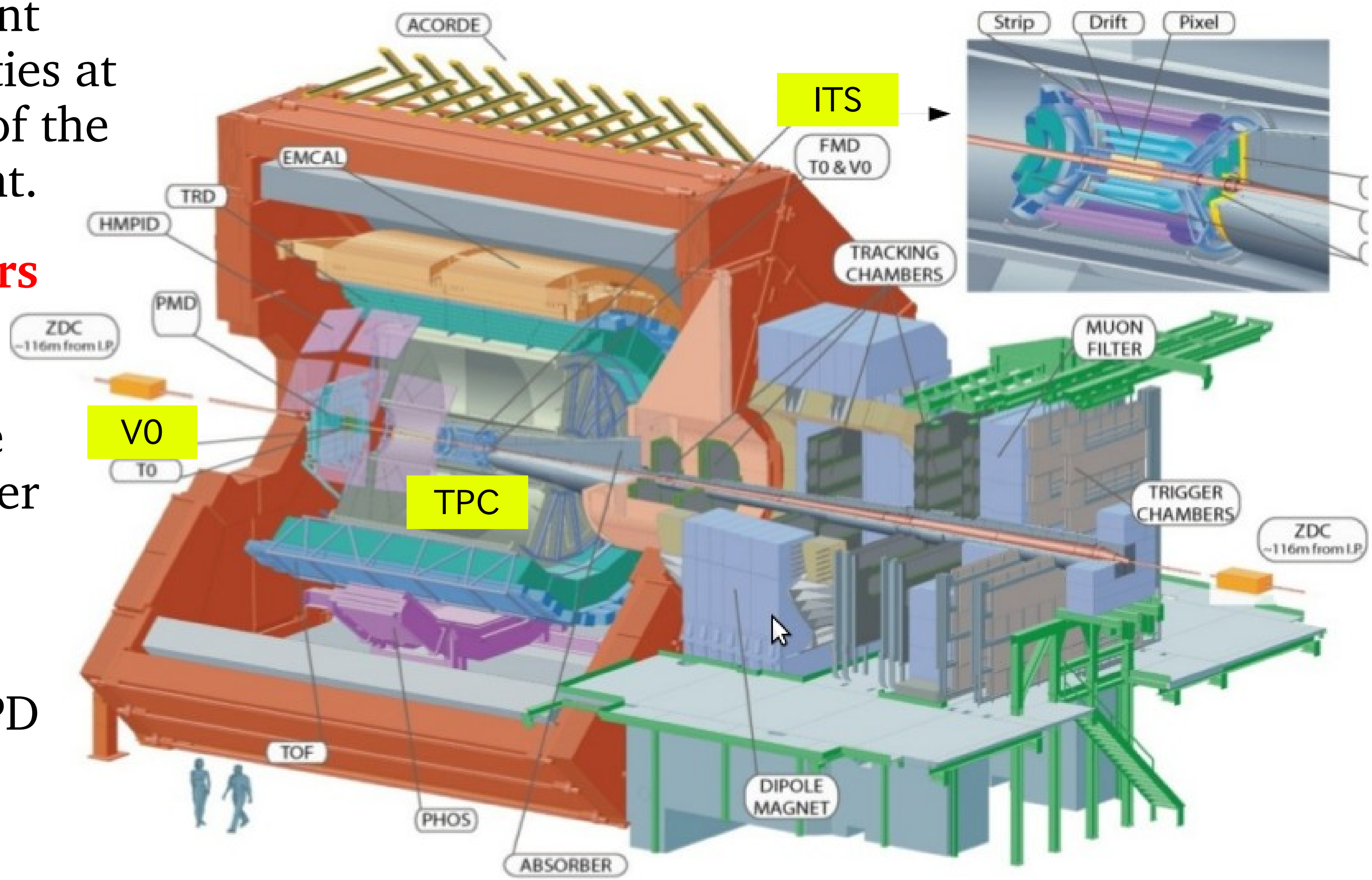


How?

Using the excellent tracking capabilities at low momentum of the **ALICE** experiment.

Relevant detectors for the measurements:

- ✓ **Tracking:** Time Projection Chamber & Inner Tracking System.
- ✓ **Vertex:** SPD.
- ✓ **MB Trigger:** SPD & V0.
- ✓ **Beam Background Rejection:** V0.



the analysis…

The sphericity was computed using primary tracks:

✓ **$|\eta|<0.8$, $p_T>0.5$ GeV/c**

$N_{ch}>2$

The analysis was done at three energies:

- ✓ ***0.9*** **TeV** (3.5 million of MB events).
- ✓ ***2.76*** **TeV** (39.6 million of MB events).
- ✓ ***7*** **TeV** (40 million of MB events).

Event Selection based on the hardness:

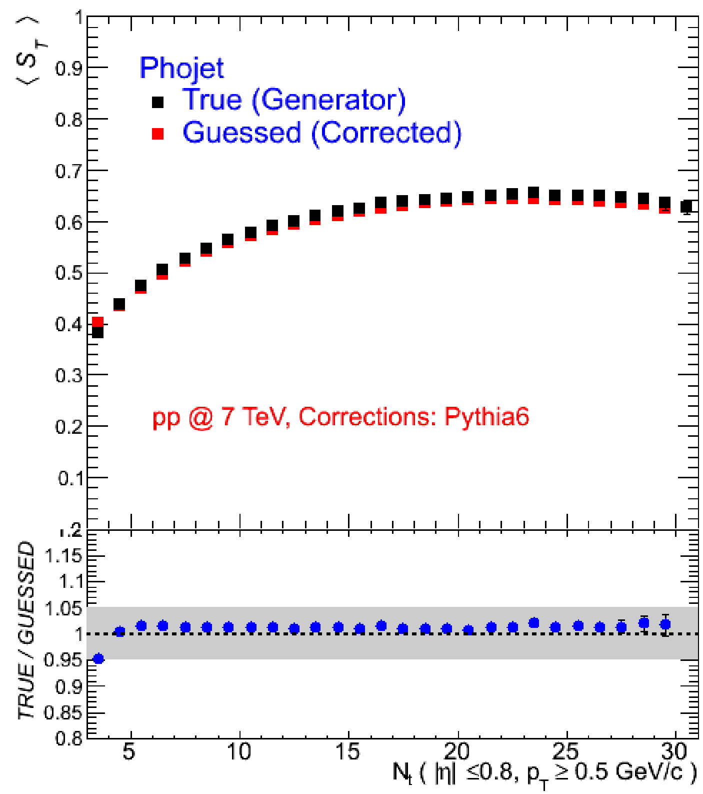
✓ ***Analysis of "Soft" & "Hard" events.*** Defined by a cut on the maximum p_T.

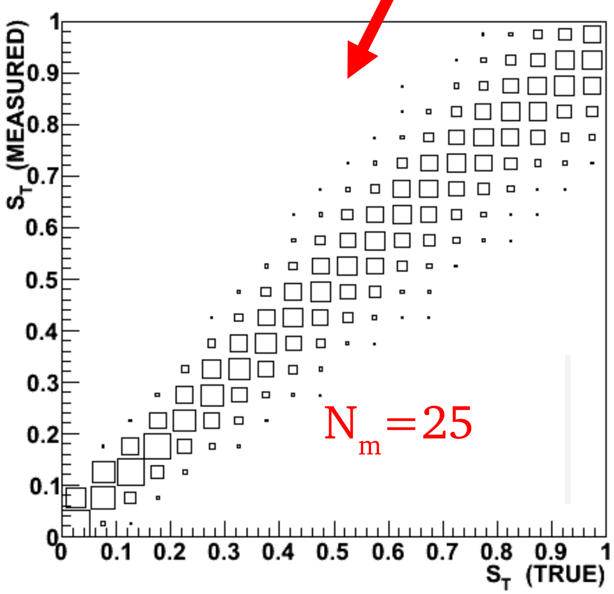
✓ ***Similar studies were done by the CDF and STAR collaborations:*** marked differences between the two regimes were found (*Phys. Rev., D65, 072005, 2002* & Poster presented at *QM2004, nucl-ex/0403038*).

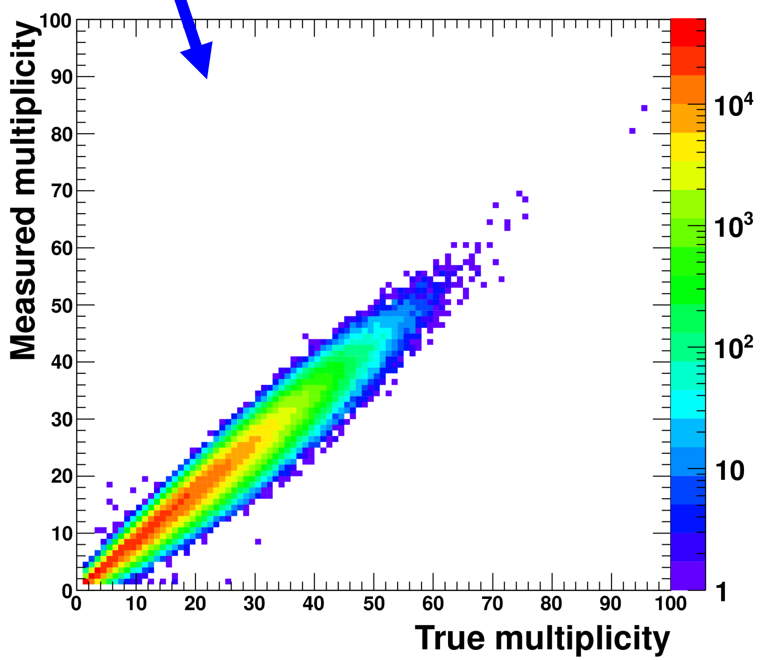
The goal is to measure the average sphericity as a function of multiplicity...

Correction procedure:

$$\langle S_T \rangle (N_t) = \sum_m \langle S_T^{unfolded} \rangle (N_m) \, R(N_t, N_m)$$







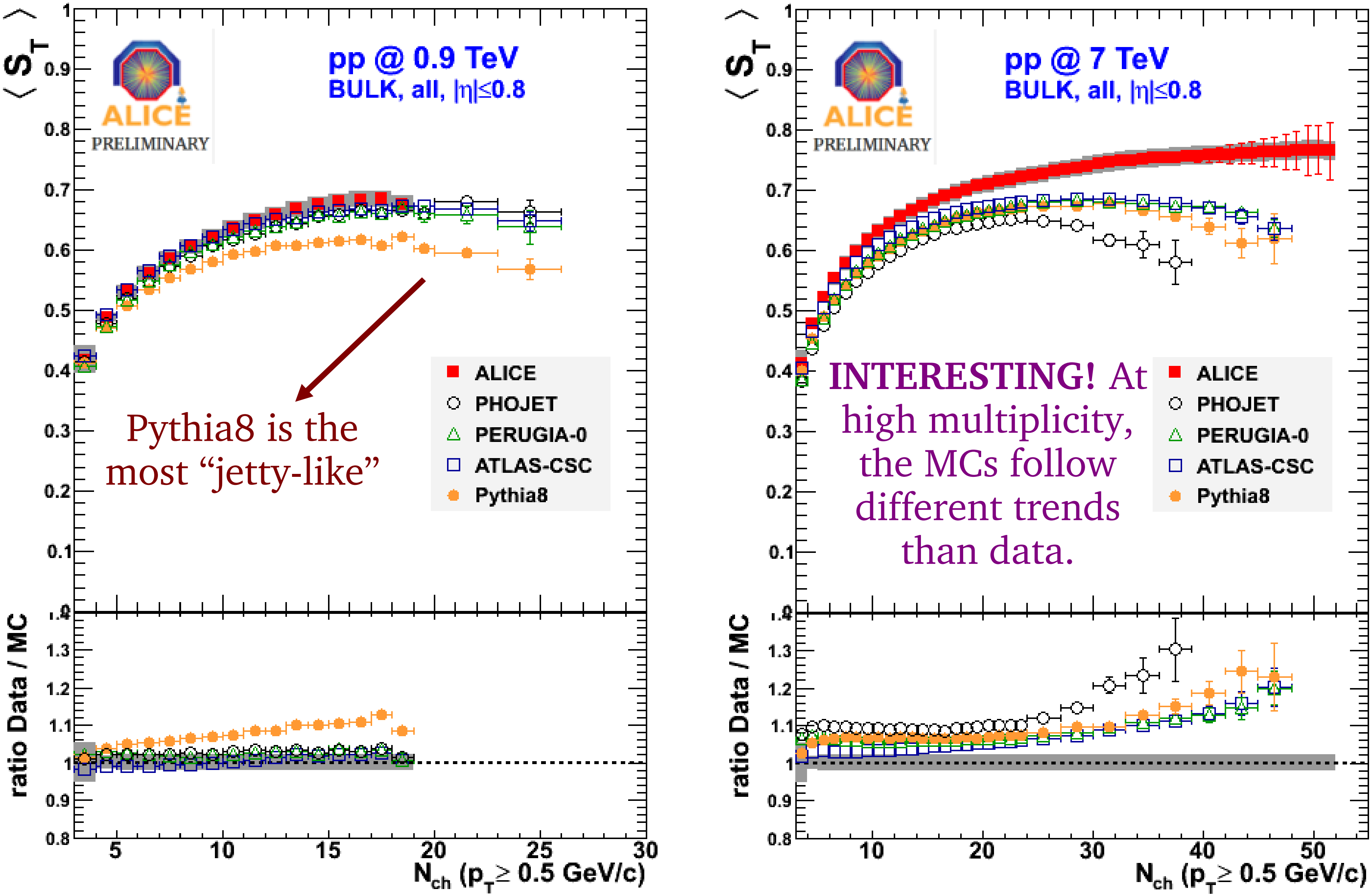
1. Unfolding of S_T spectra.

2. Correction by multiplicity.

The systematic uncertainties…

Contribution	Bulk	Soft	Hard
Track selection cuts	0.3%	0.3%	0.3%
Event generator dependence	0.5%	0.5%	2%
Different run conditions	1.0%	1.0%	1.0%
Secondary track rejection	< 0.8%	< 0.8%	< 0.8%
Pile-up events	0.2%	0.2%	0.2%
Method (Nt < 5)	< 5.0%	< 5.0%	< 11.0%
Method (Nt ≥ 5)	< 1.5%	< 1.5%	< 1.5%
Detector misalignment	negl.	negl.	negl.
ITS efficiency	negl.	negl.	negl.
TPC efficiency	negl.	negl.	negl.
Beam-gas events	negl.	negl.	negl.
Total (Nt < 5)	< 6.0%	< 6.0%	< 12.0%
Total (Nt ≥ 5)	< 2.2%	< 2.2%	< 3.0%

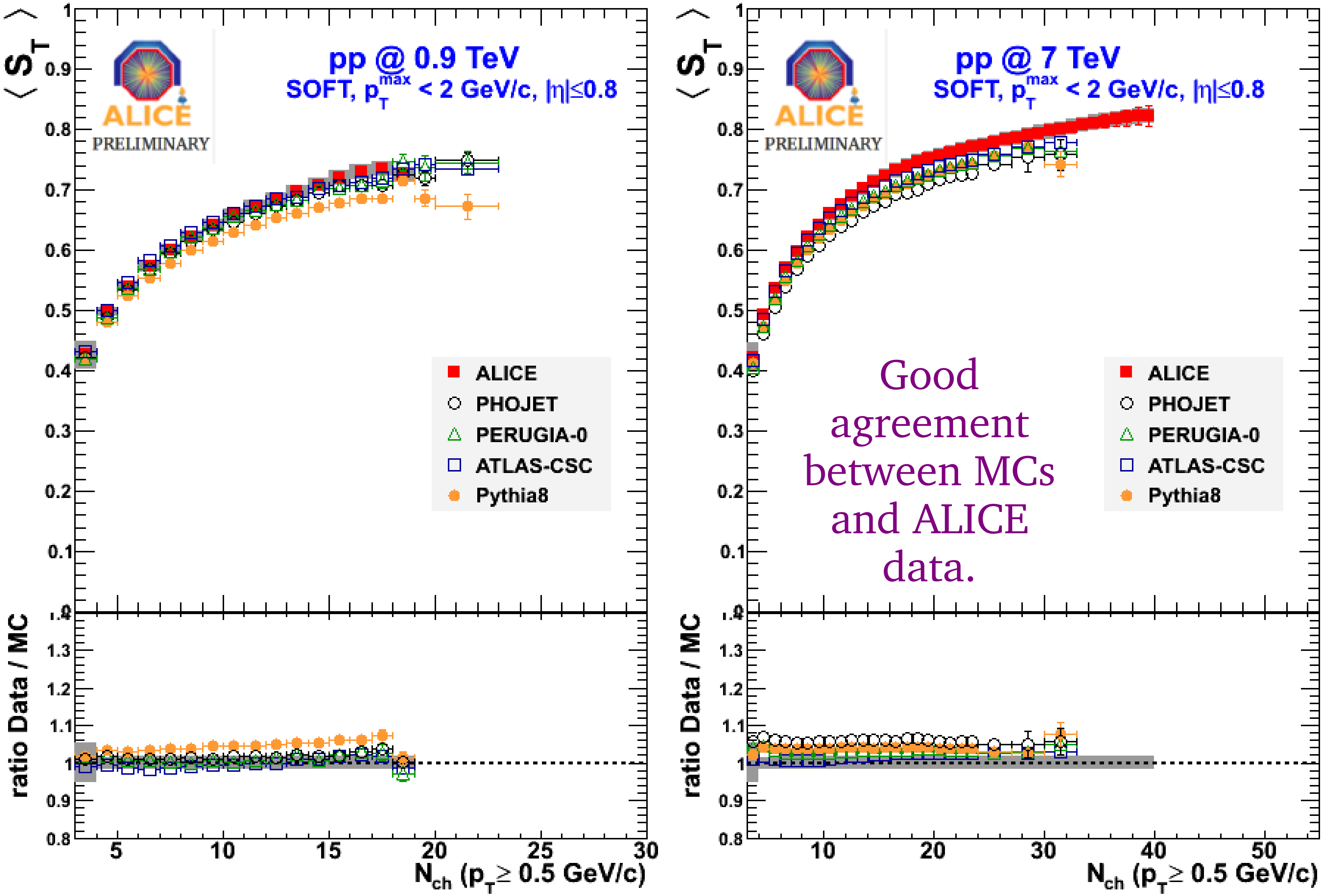
Evolution of $<S_T>$ with the multiplicity



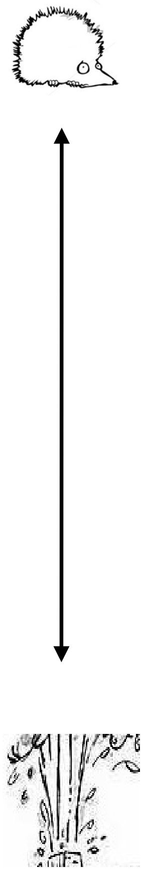
Pythia8 is the most "jetty-like"

INTERESTING! At high multiplicity, the MCs follow different trends than data.

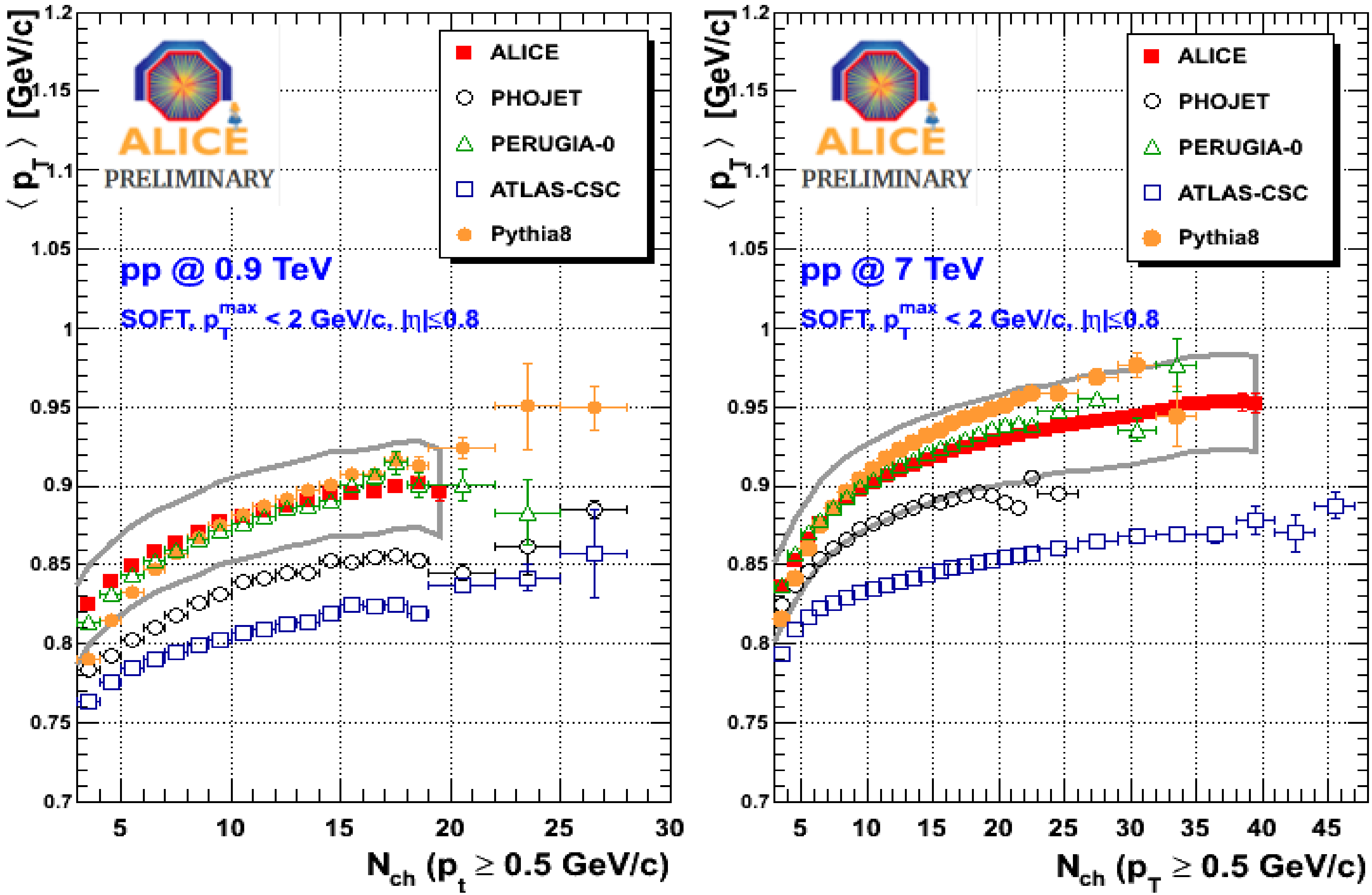
Results in soft events ($\langle S_T \rangle$)



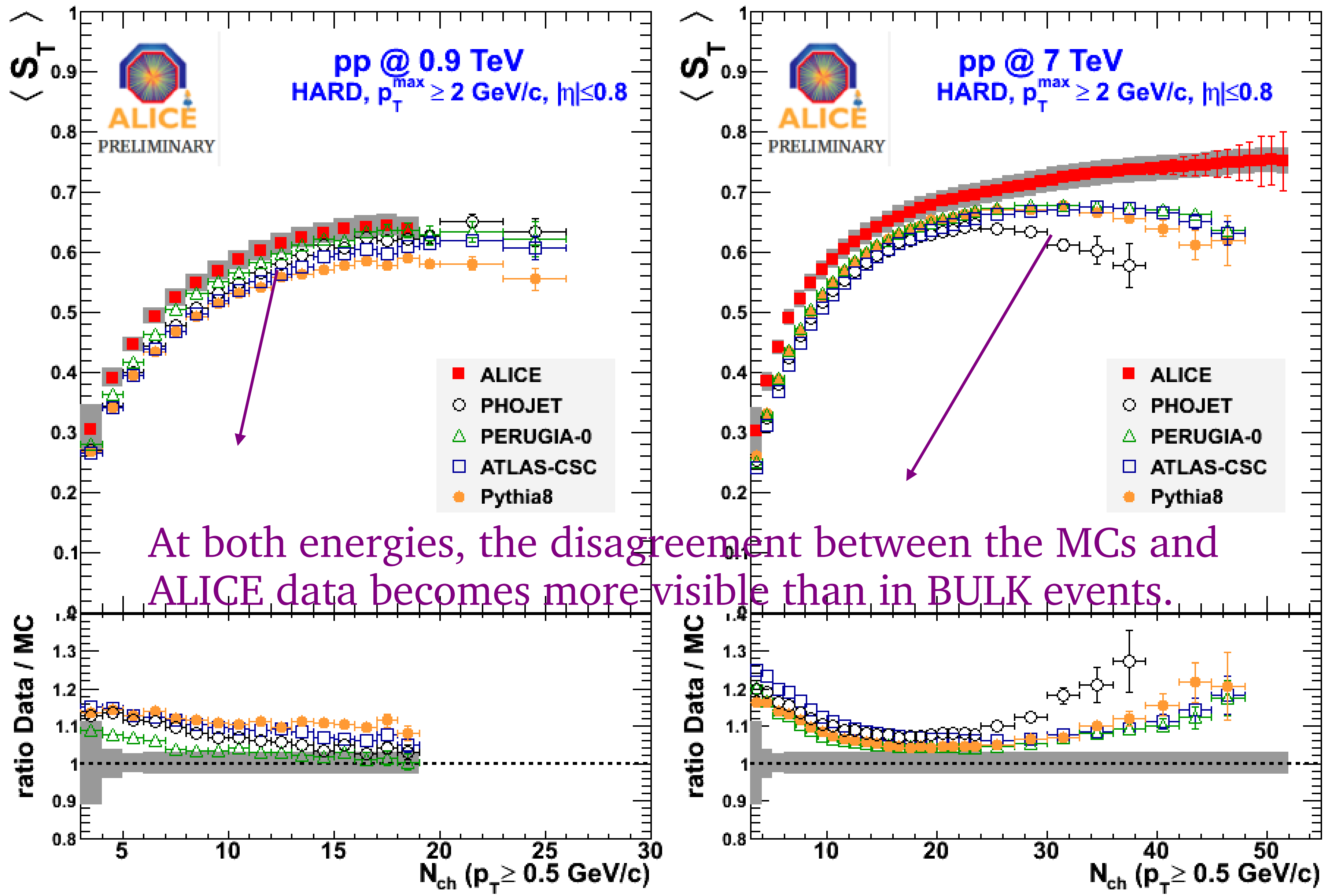
Good agreement between MCs and ALICE data.



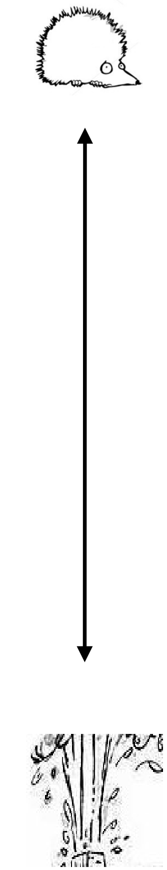
Results in soft events ($<p_T>$)



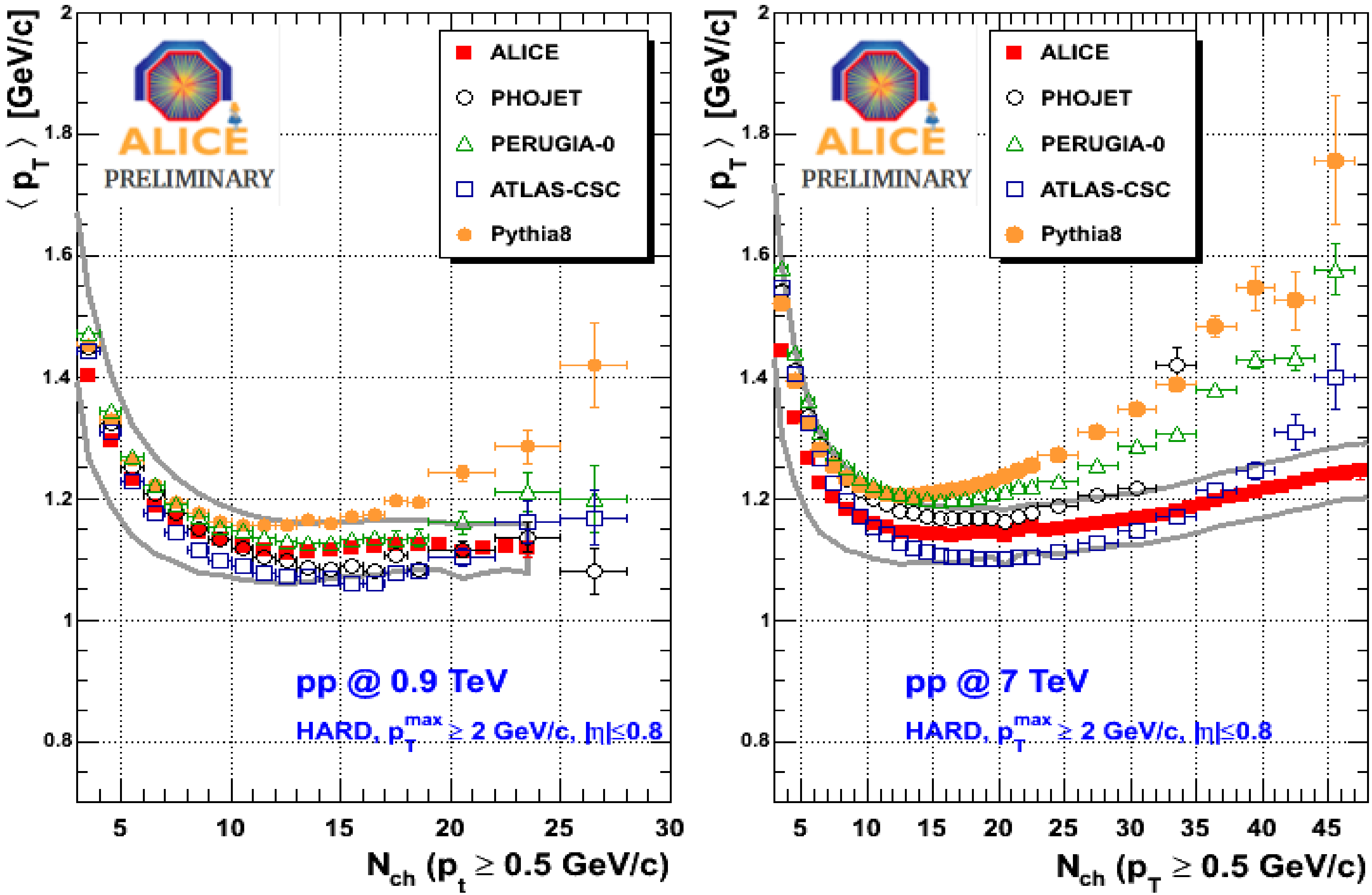
Results in hard events ($<S_T>$)



At both energies, the disagreement between the MCs and ALICE data becomes more visible than in BULK events.

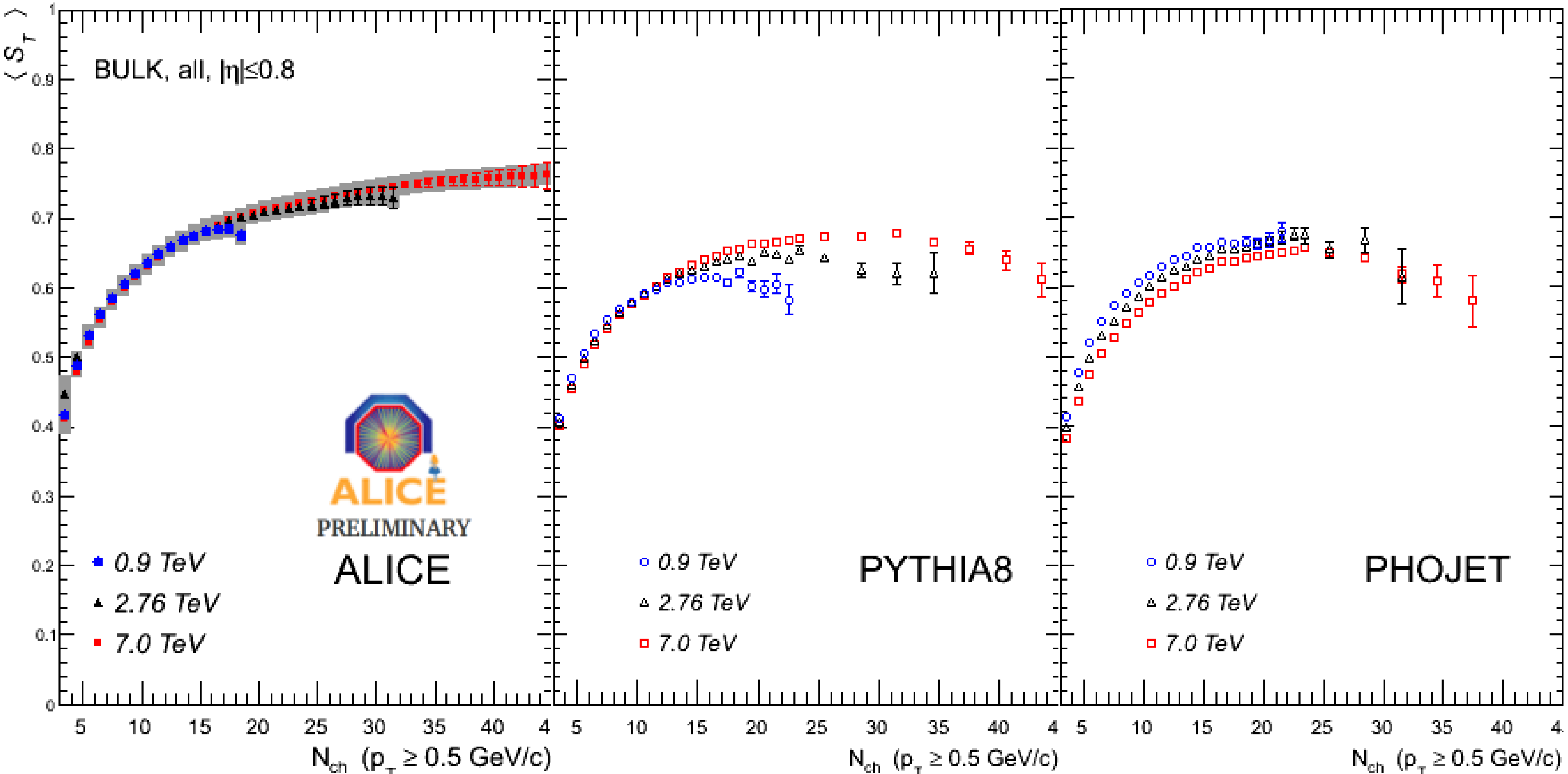


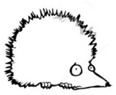
Results in hard events ($<p_T>$)

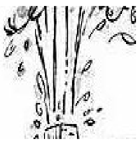


Evolution of $<S_T>(N_{ch})$ with $\sqrt{s}$

Scaling law for the average sphericity??

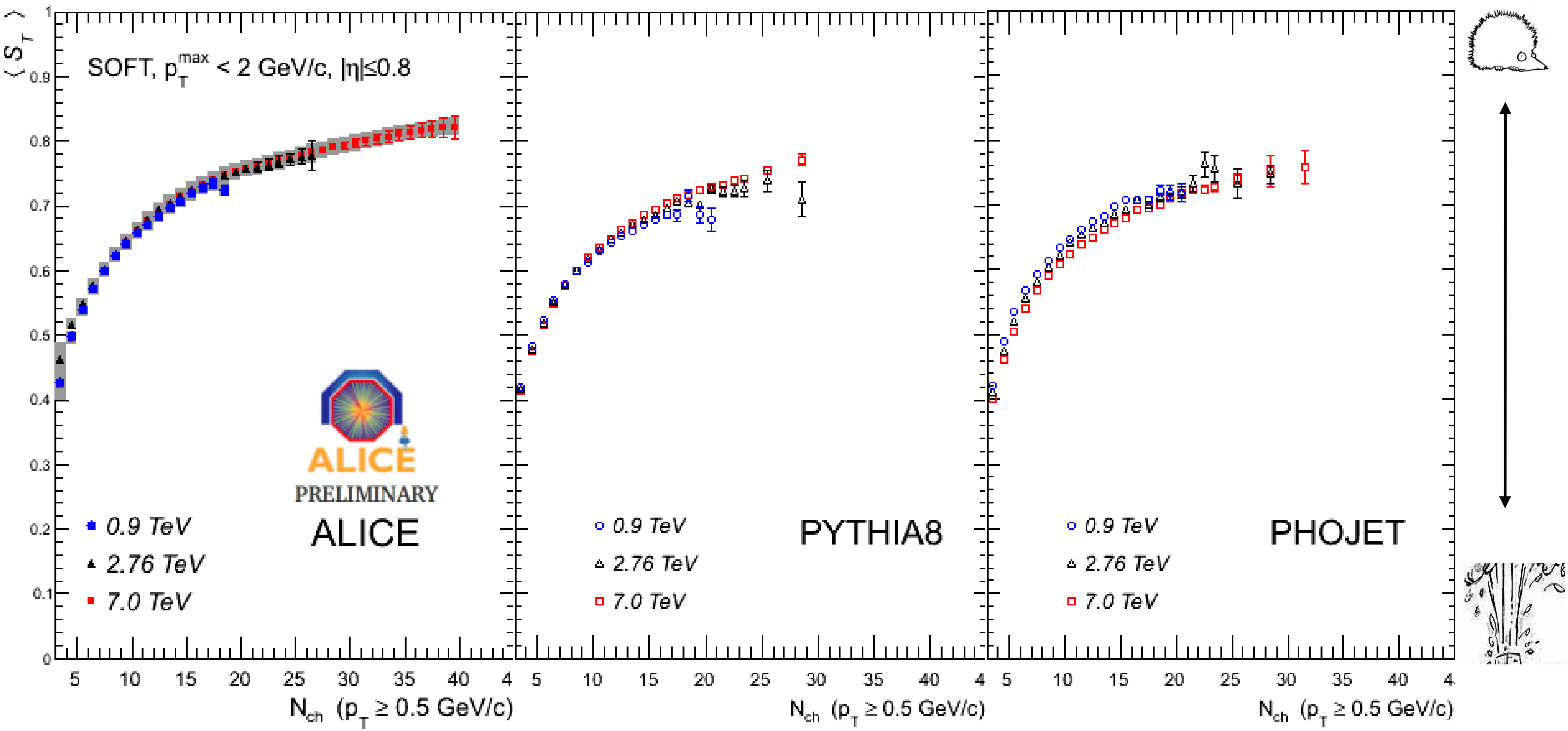






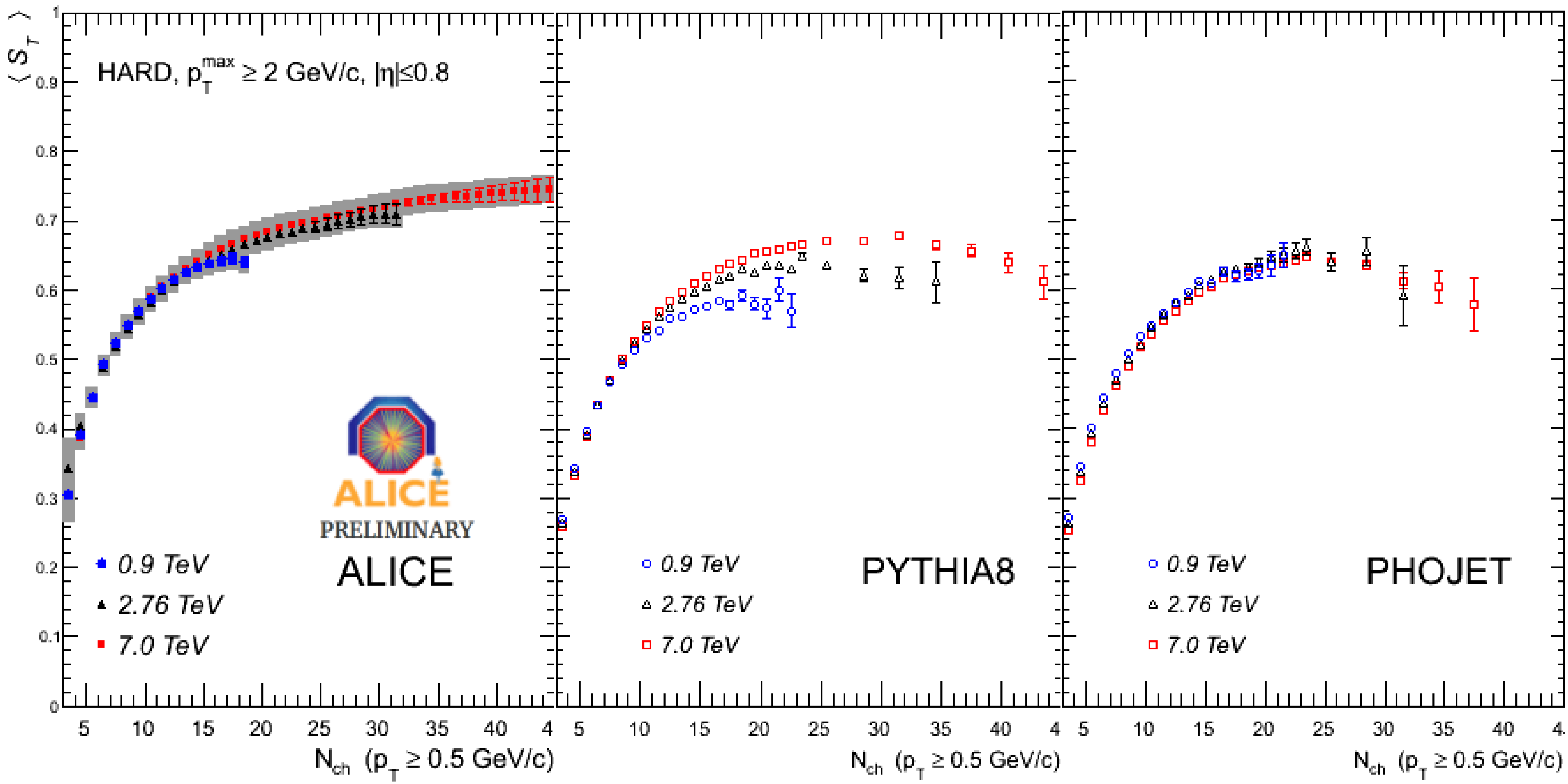
In MC, the trends are different as $\sqrt{s}$ is increased.

Evolution of $\langle S_T \rangle (N_{ch})$ with $\sqrt{s}$
"soft" events



In soft events, the generators follows similar trends than ALICE data.

Evolution of $<S_T>(N_{ch})$ with $\sqrt{s}$ *"hard" events*



Conclusions

- We show an event shape analysis applied to minimum bias interactions.
- The analysis was done at $\sqrt{s}$=0.9, 2.76 and 7 TeV. The events were split in different categories according with their hardness.
- Important differences between the most popular MC generators (PYTHIA6 tunes ATLAS-CSC and PERUGIA0, PYTHIA8 and PHOJET) and data were found.
- In ALICE we found that $<S_T>(N_{ch})$ is independent of $\sqrt{s}$, while the generators show different trends.
- At 0.9 TeV, the majority of the observables which we explored are in good agreement with the MCs, but at 7 TeV the most interesting feature is that the average sphericity at multiplicity above 40 is ~13% larger than the predicted by the generators.