Differential measurement of the common particle-emitting source using p–p and p–Λ correlations in pp collisions at 13.6 TeV with ALICE

Anton Riedel

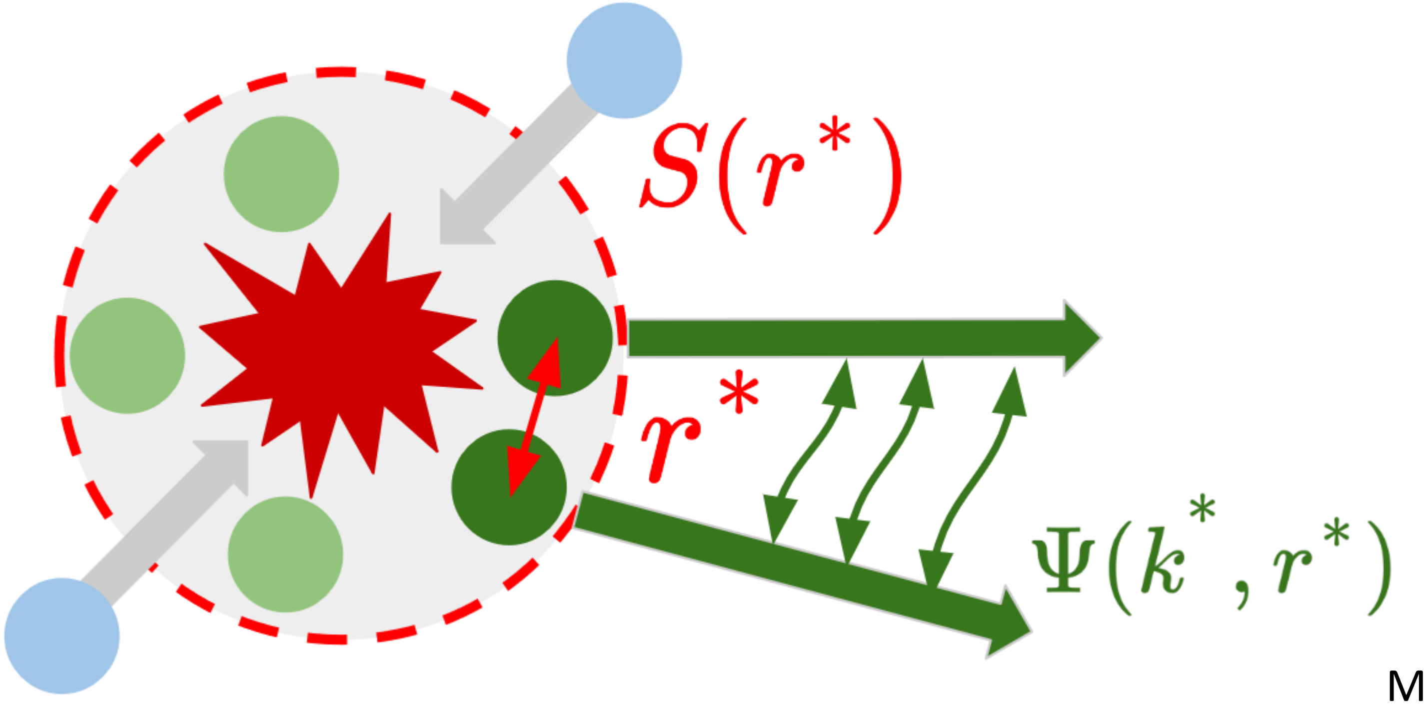
on behalf of the **ALICE Collaboration**

Technical University of Munich

Strange Quark Matter 2024, Strasbourg, France

Accessing hadronic interactions with femtoscopy

$$C(k^*) = \mathcal{N}\frac{N_{\mathrm{SE}}(k^*)}{N_{\mathrm{ME}}(k^*)}$$



M. A. Lisa et al., Ann.Rev.Nucl.Part.Sci.55:357-402, 2005

Accessing hadronic interactions with femtoscopy

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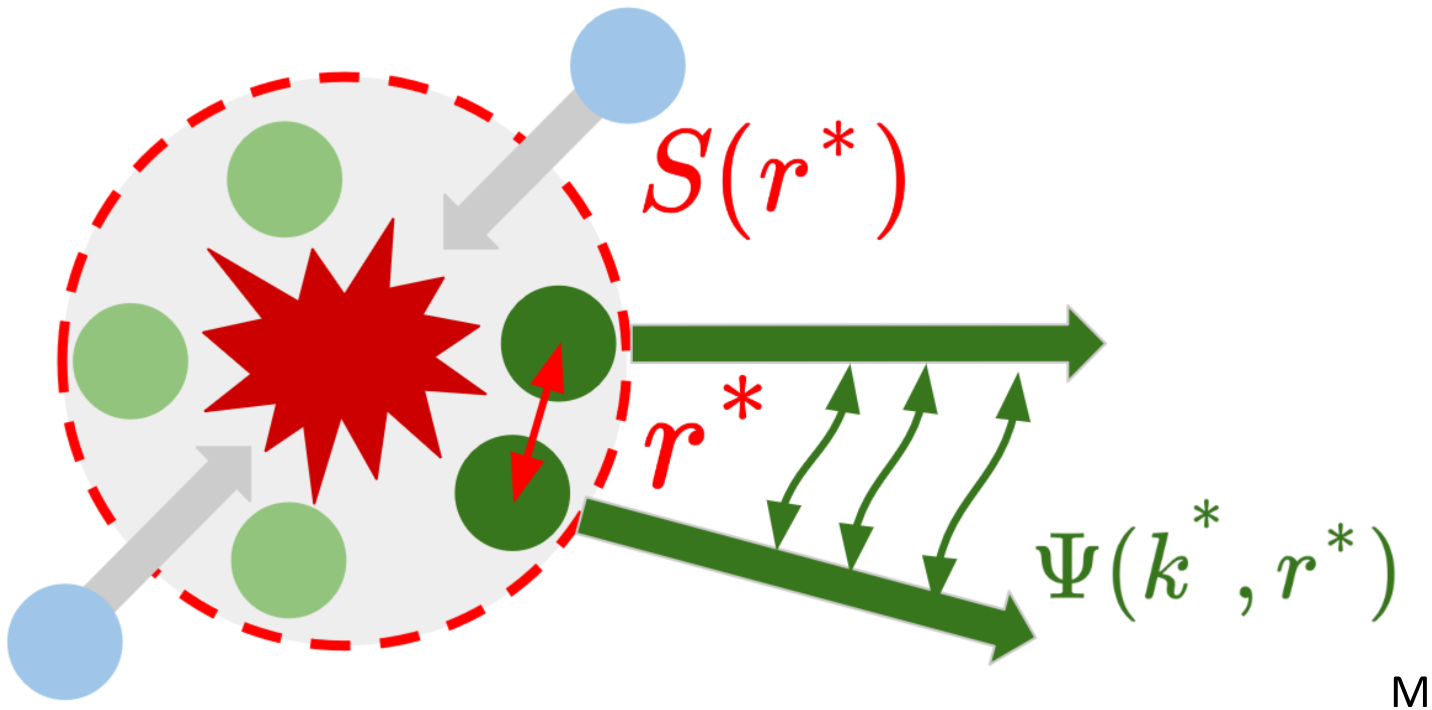

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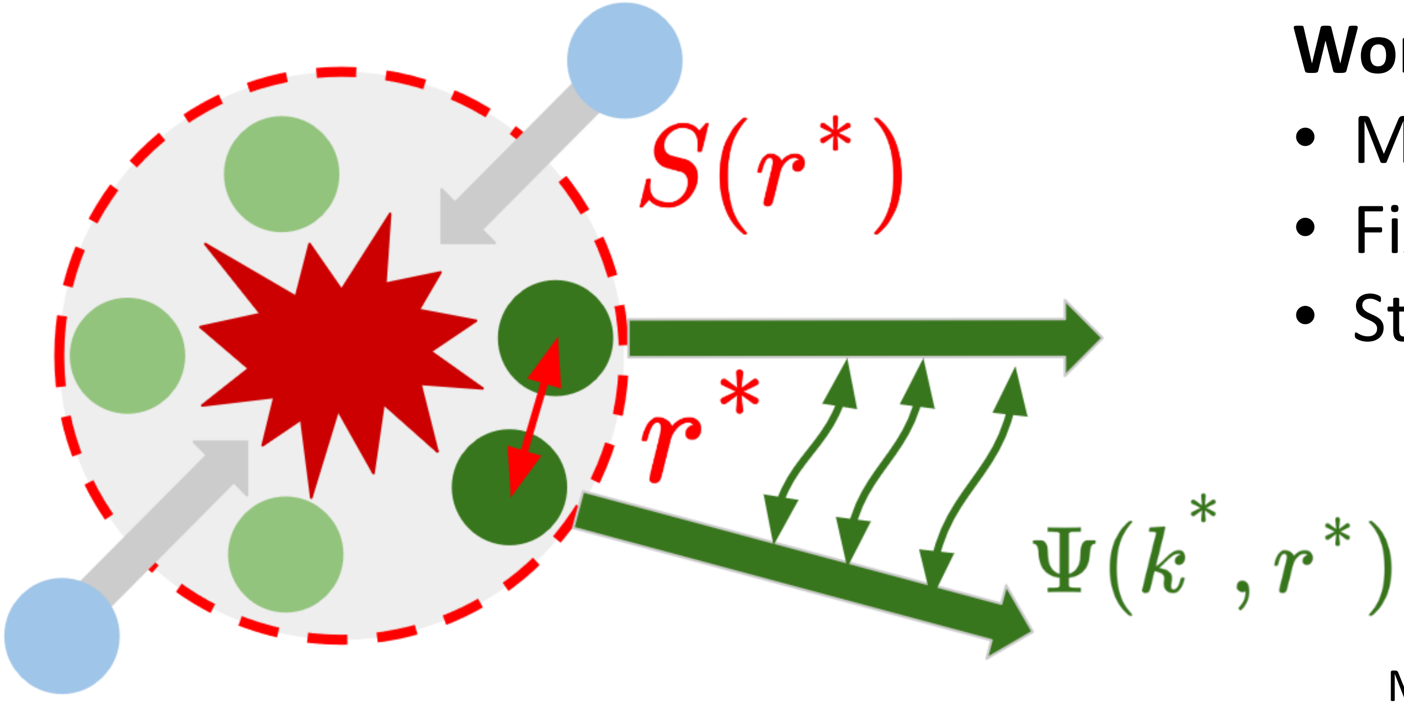

Workflow for accessing interaction:

- Measure correlation function $C(k^*)$
- Fix source $S(r^*)$
- Study interaction $\psi(r^*,k^*)$

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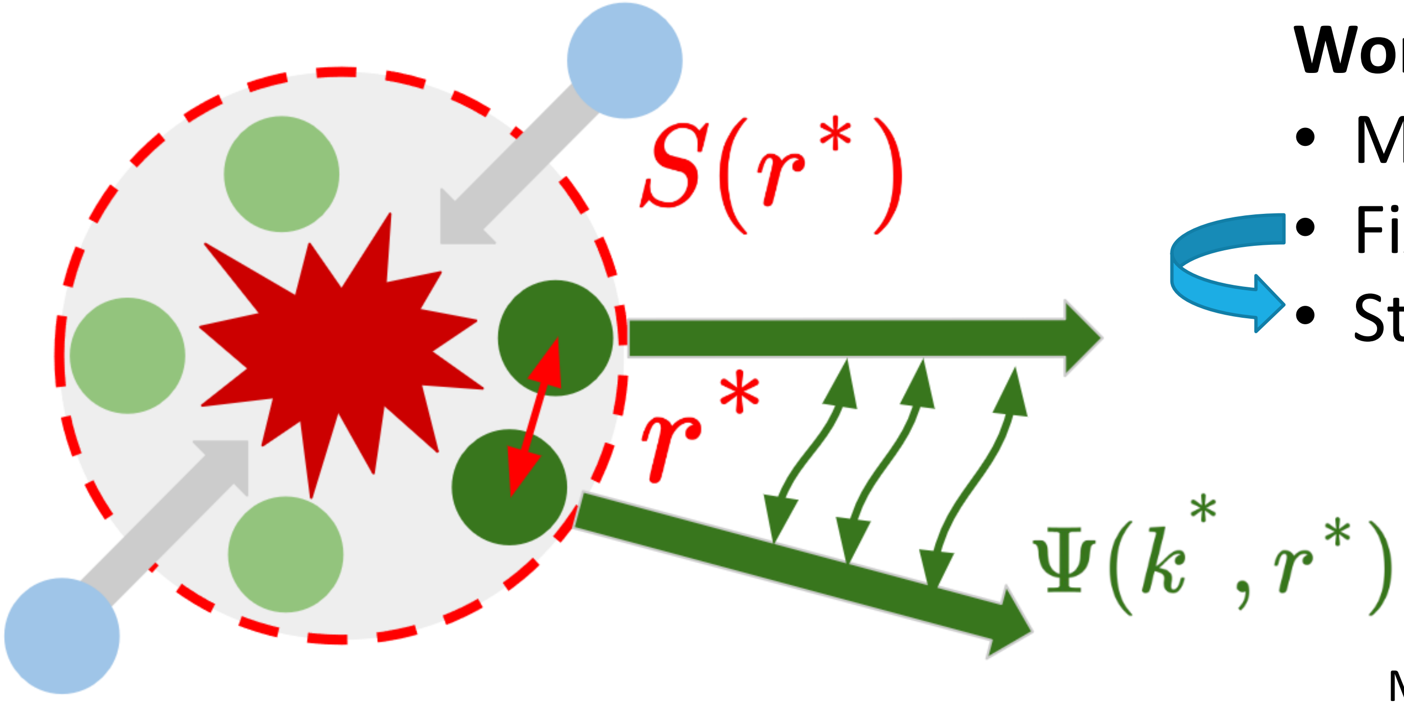

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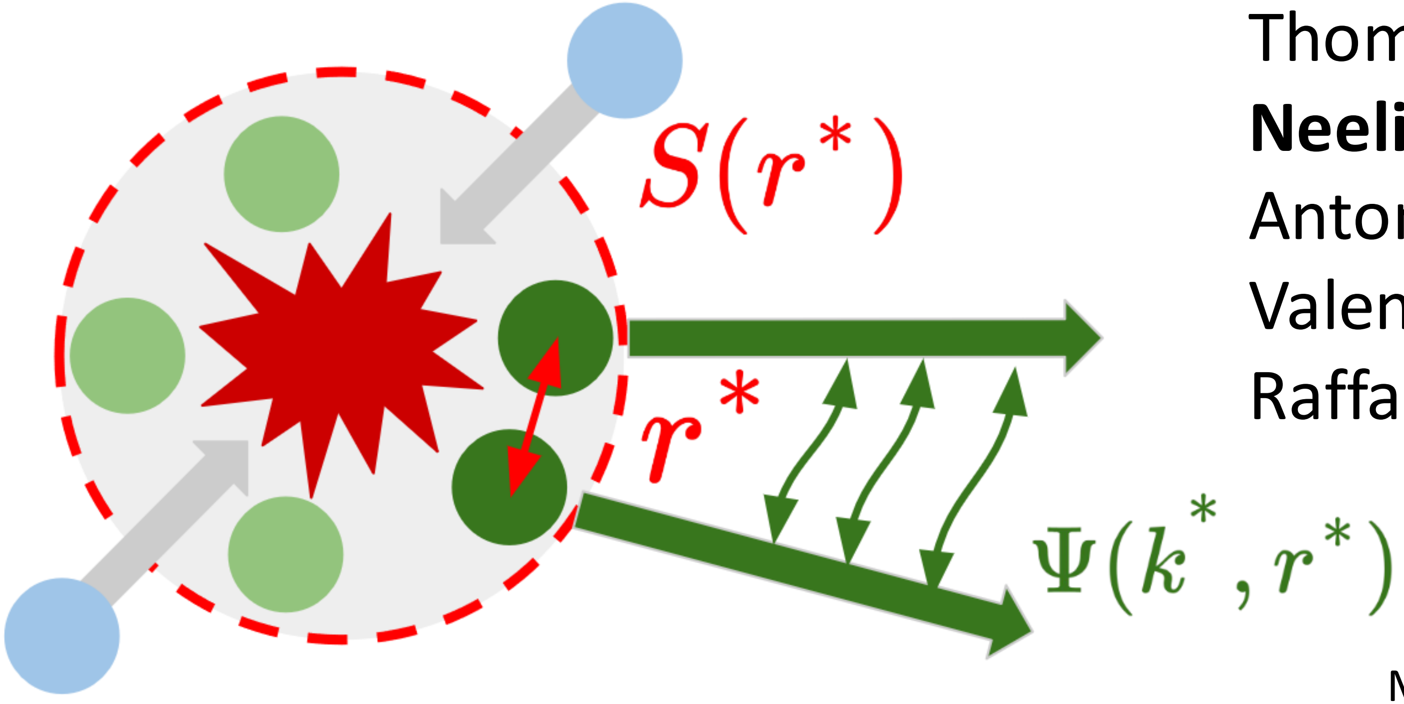


Femtoscopy @ SQM 2024:

Thomas Humanic 4 Jun, 09:10

Neelima Agrawal 4 Jun, 18:30

Anton Riedel 4 Jun, 17:30

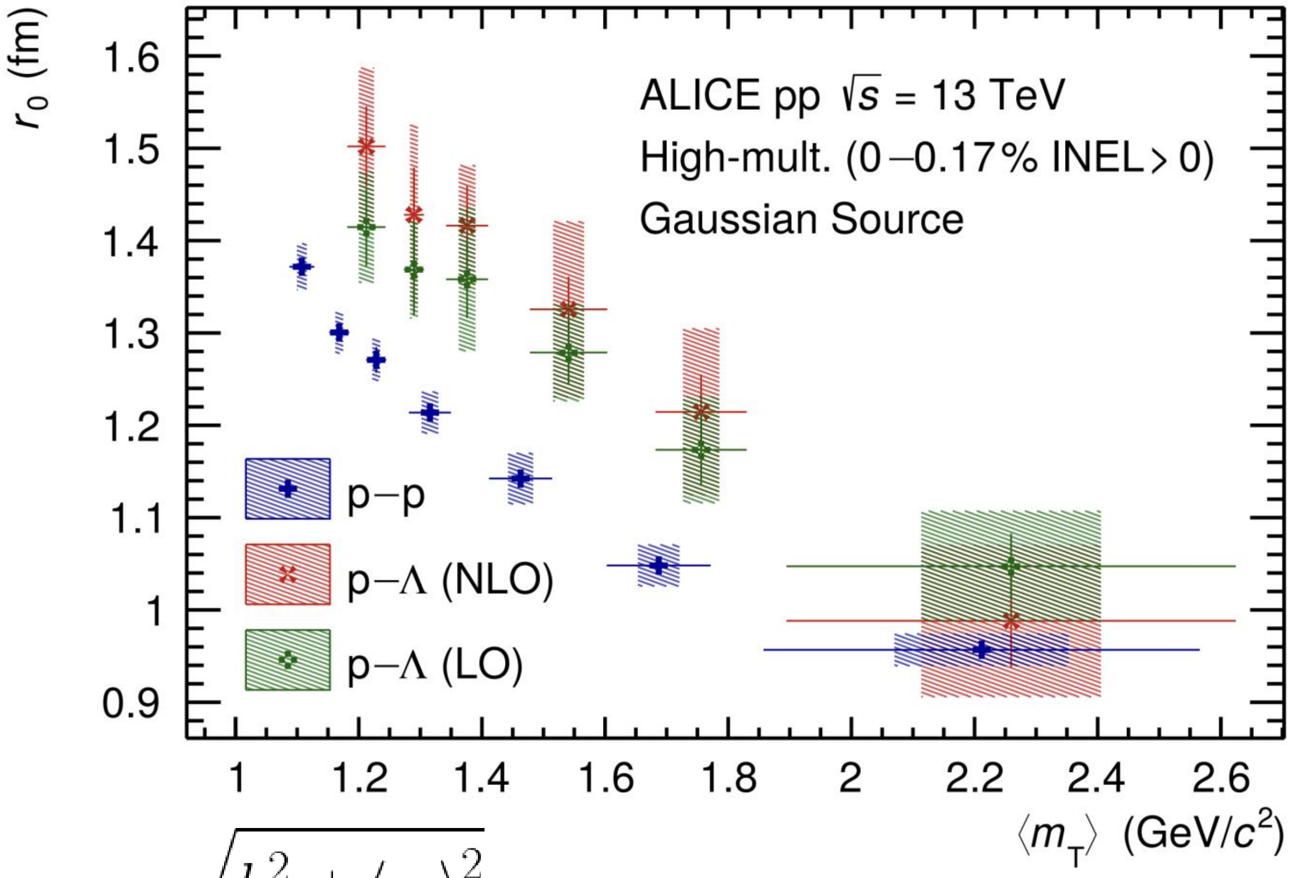
Valentina Mantovani Sarti 5 Jun, 08:30

Raffaele del Grande 6 Jun, 17:30

M. A. Lisa et al., Ann.Rev.Nucl.Part.Sci.55:357-402, 2005

Common baryonic source in pp collisions

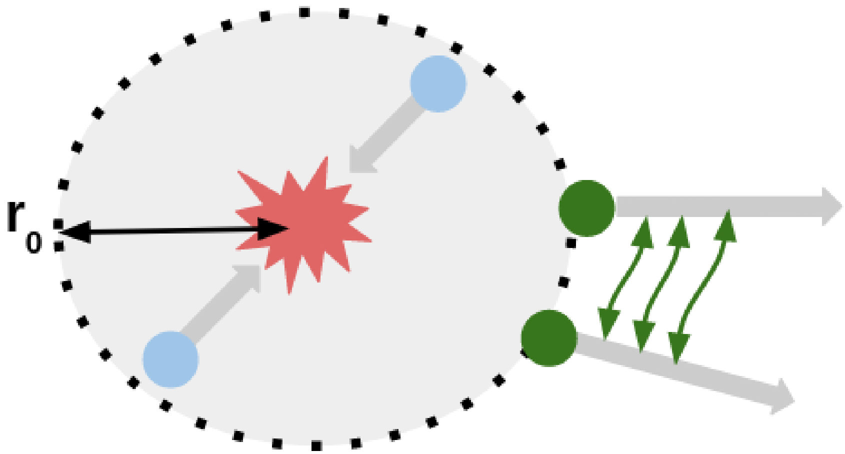
ALICE Coll. PLB 811 (2020)



$$m_{\mathrm{T}} = \sqrt{k_{\mathrm{T}}^2 + \langle m \rangle^2}$$

$$k_{\mathrm{T}} = \frac{1}{2} \left| p_{\mathrm{T},1} + p_{\mathrm{T},2} \right|$$

- Scaling is expected for common radial flow velocity and hadronization time scale
- Effects influencing the scaling include non-Gaussian contributions to the source



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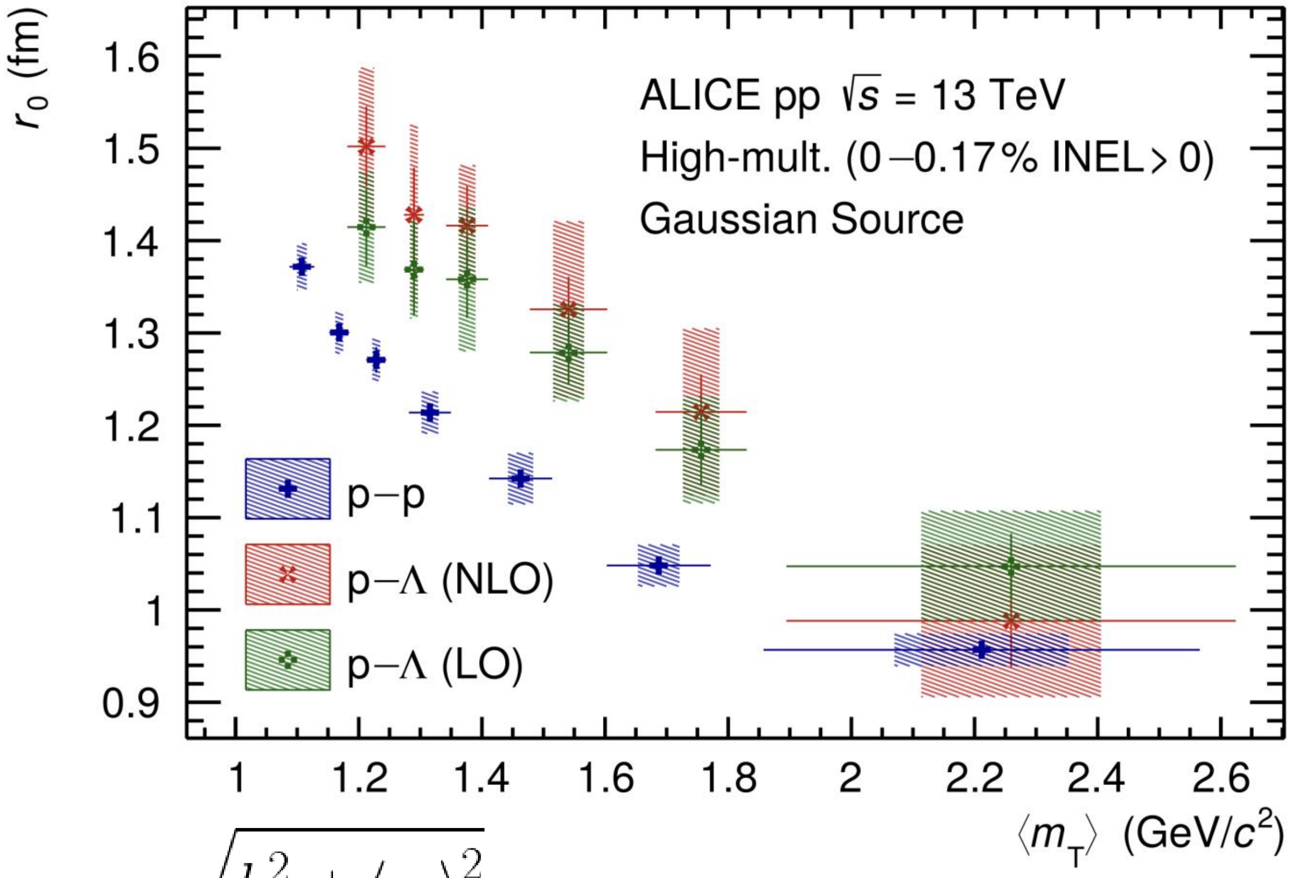
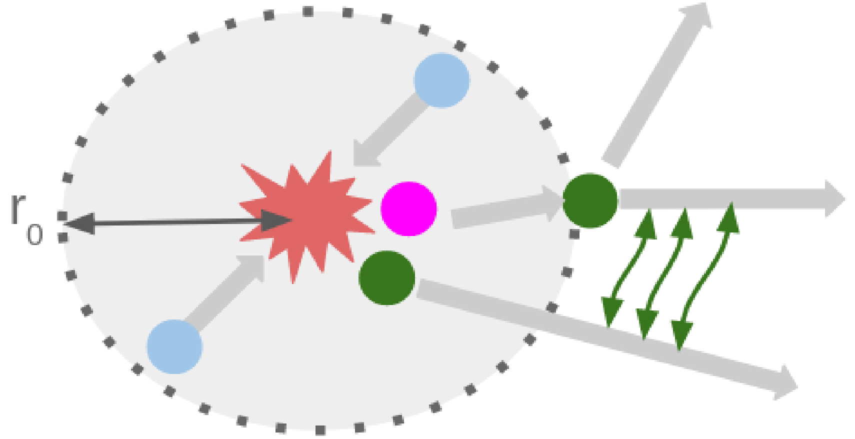


- Scaling is expected for common radial flow velocity and hadronization time scale
- Effects influencing the scaling include non-Gaussian contributions to the source
- **Feed-down from resonances[1,2]**



$$m_T = \sqrt{k_T^2 + \langle m \rangle^2}$$

$$k_T = \frac{1}{2} |p_{T,1} + p_{T,2}|$$

[1] Y. Sinyukov et al. NPA 946 (2016)
[2] A. Widemann et al. PRC 865 56 (1997)

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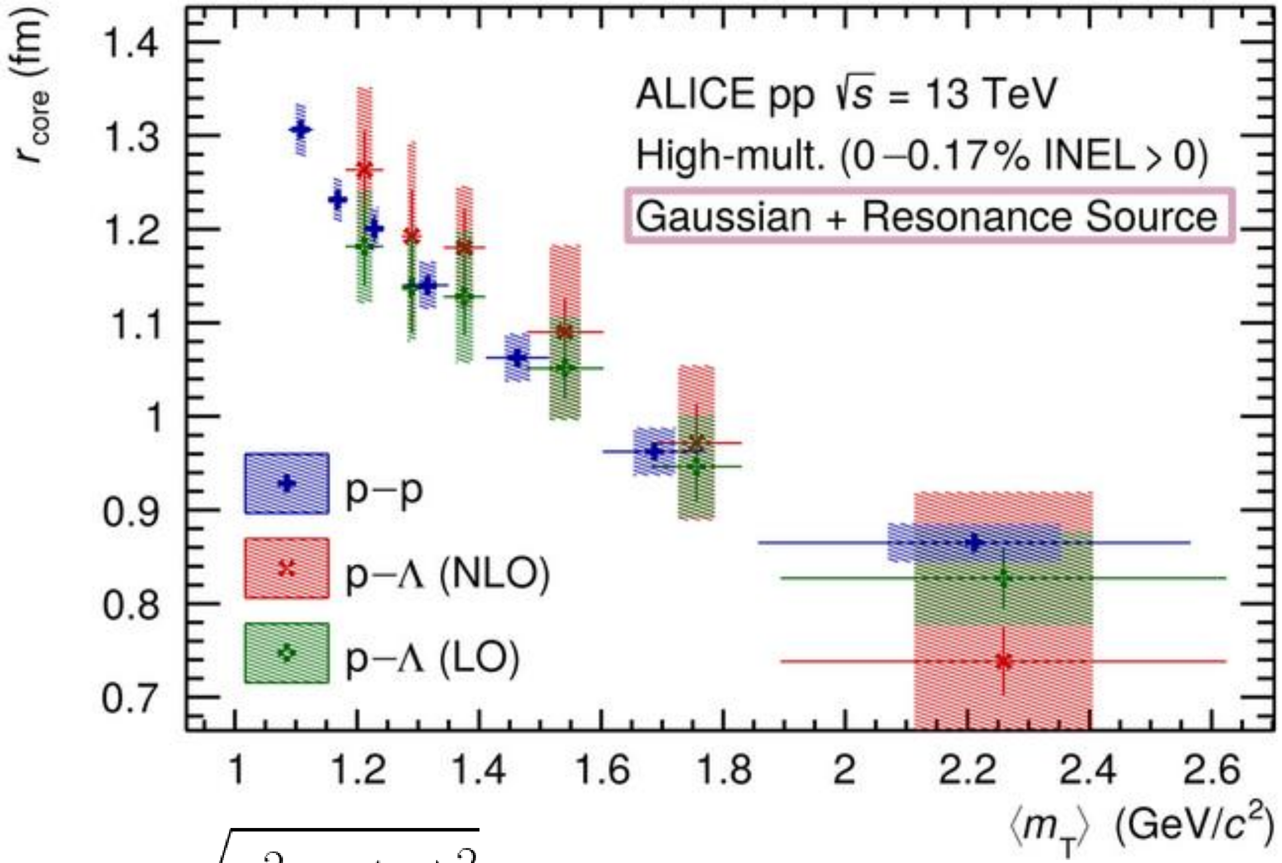

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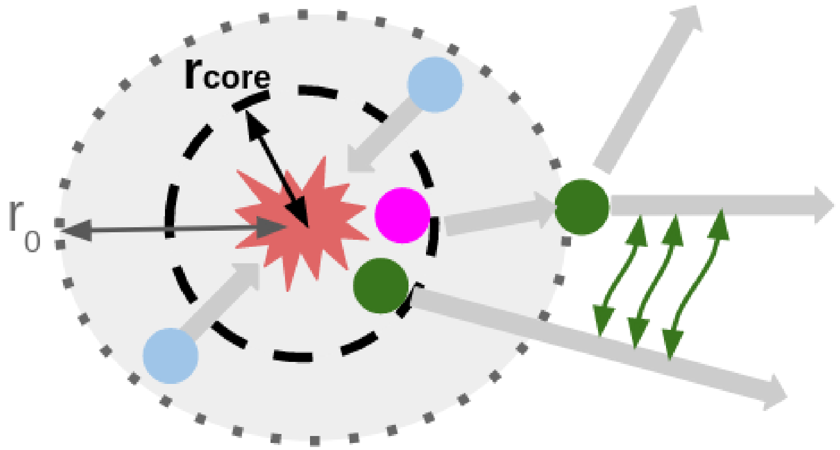
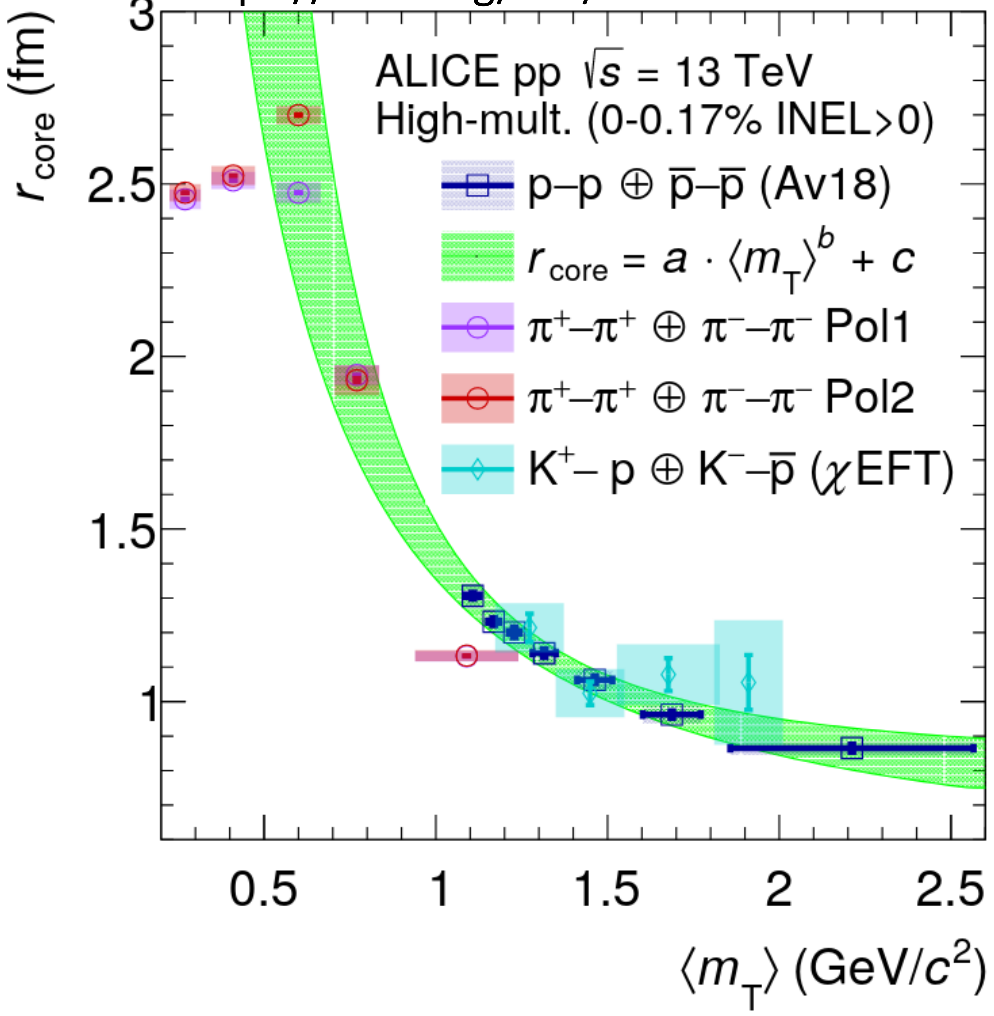
- Common scaling is restored by accounting for non-Gaussian contributions
- Motivates the assumption of a universal particle source for baryons



Common hadron source in pp collisions

ALICE Coll. EPJC in press
https://arxiv.org/abs/2311.14527



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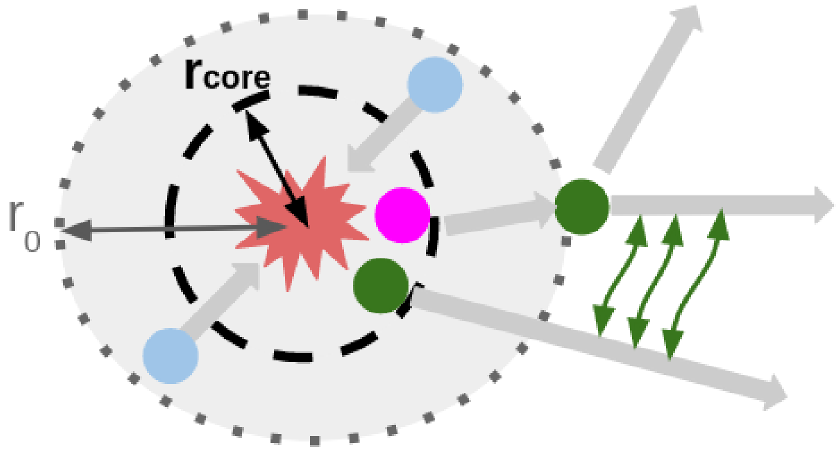

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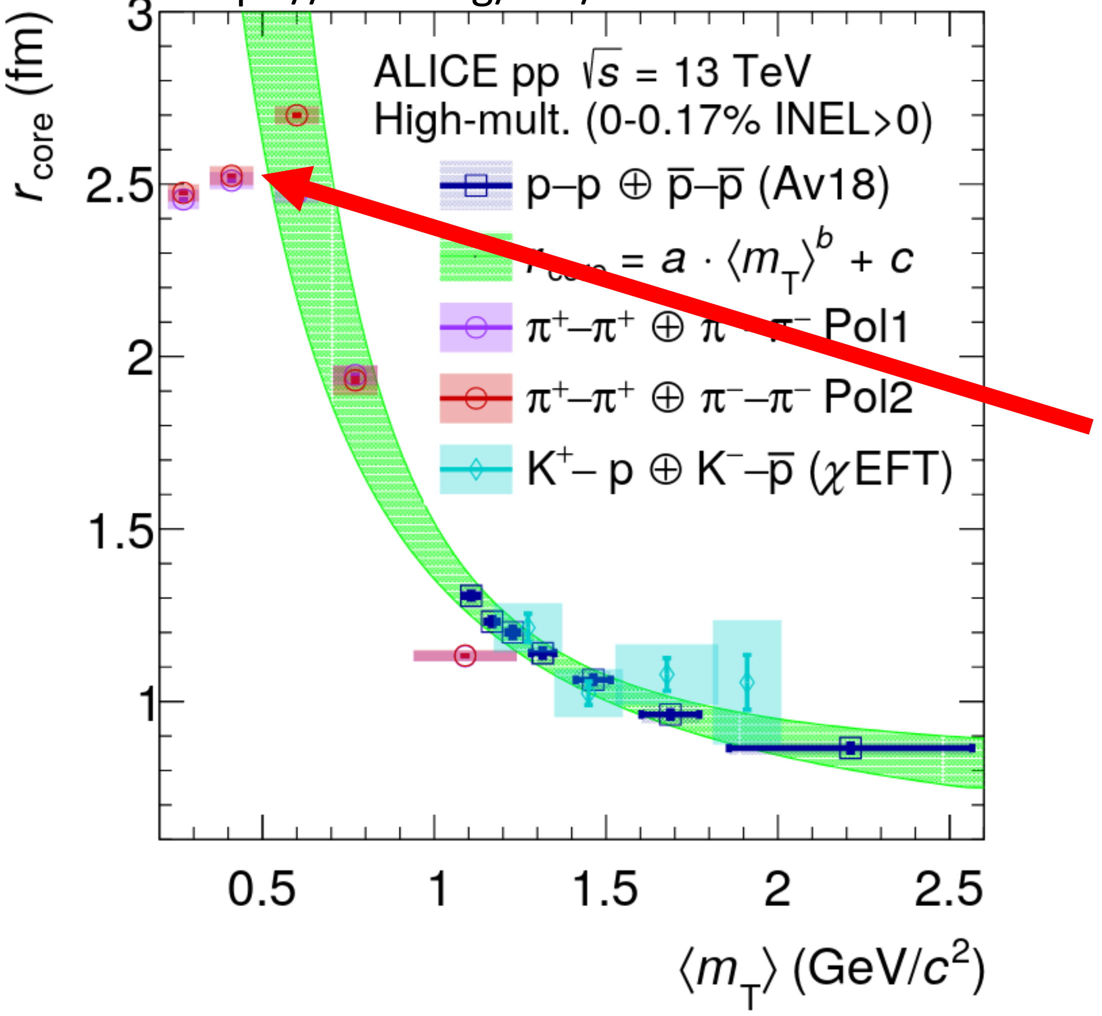
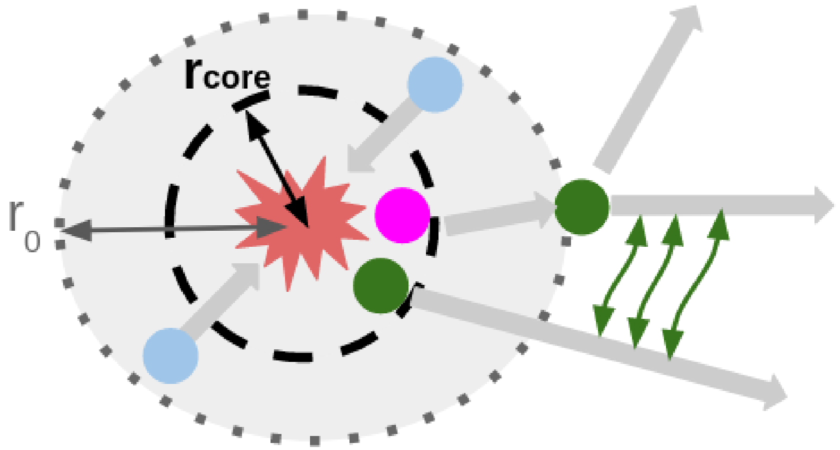


- Common scaling is restored by accounting for non-Gaussian contributions
- Motivates the assumption of a universal particle source for baryons
- Common scaling also holds for meson-baryon and meson-meson pairs
- Saturation observed at low m_T



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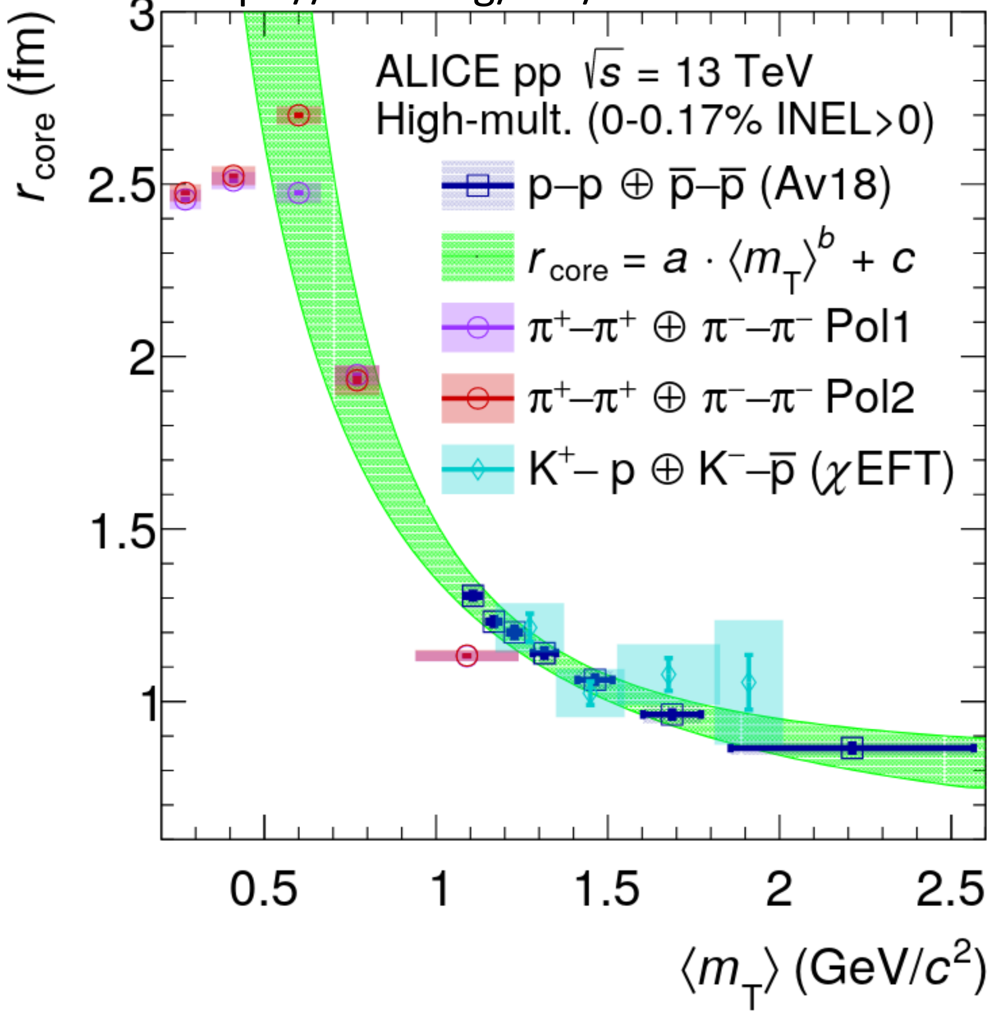
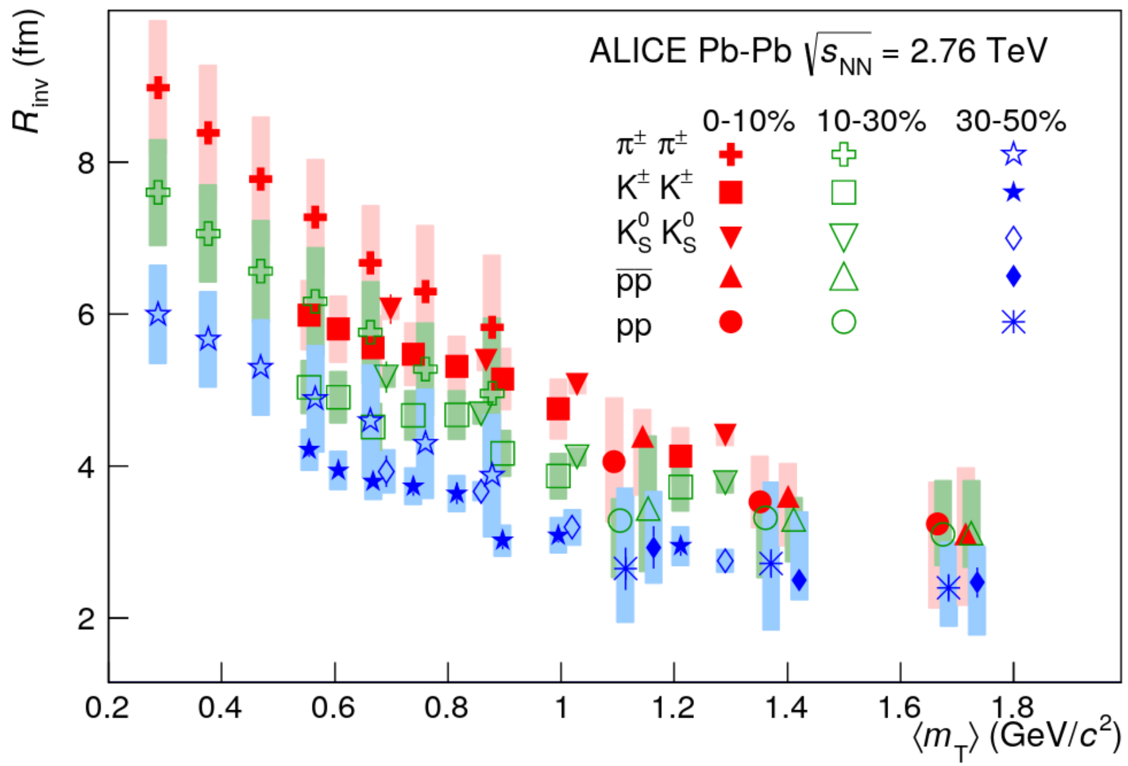
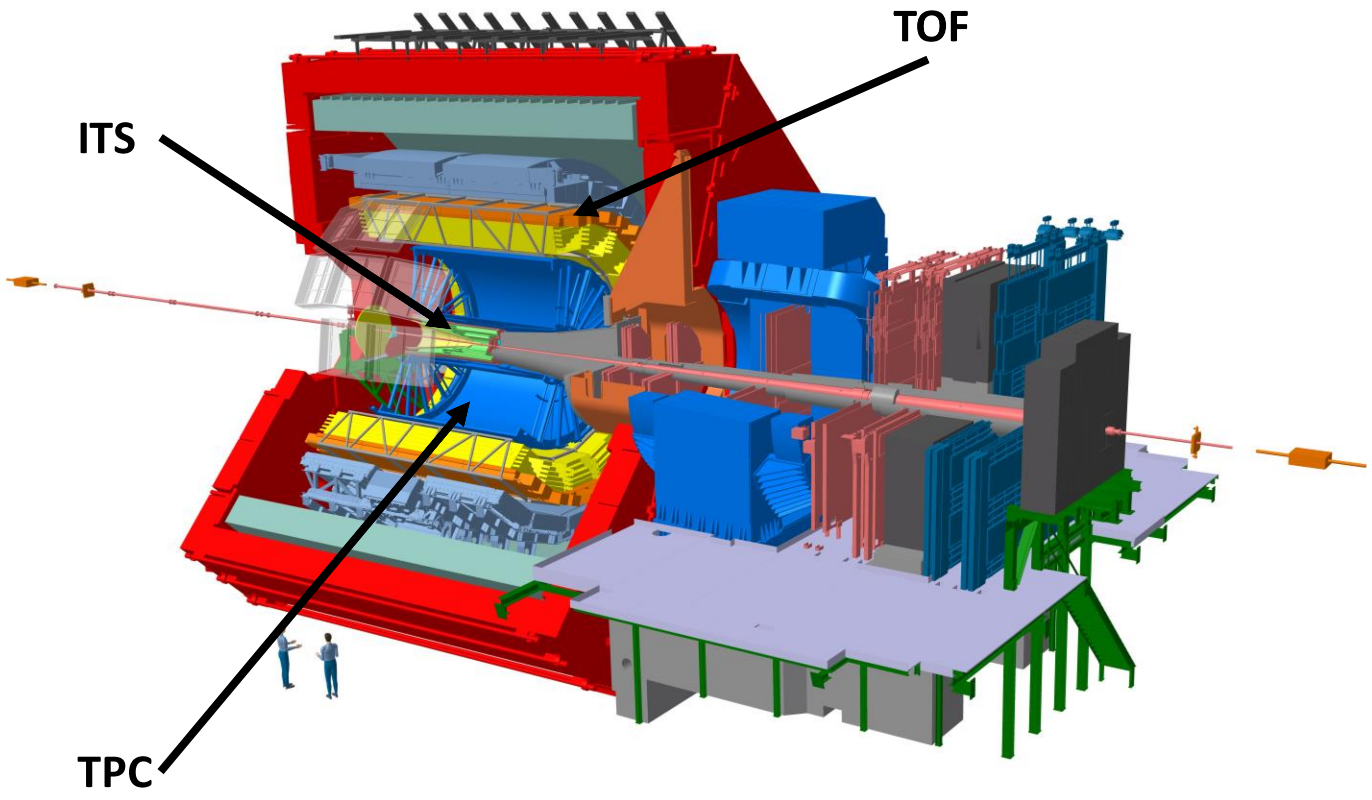


- In Pb–Pb collisions, there is also a scaling with centrality/multiplicity
- **Can this be observed in pp collisions?**

ALICE Coll. Phys. Rev. C 92, 054908

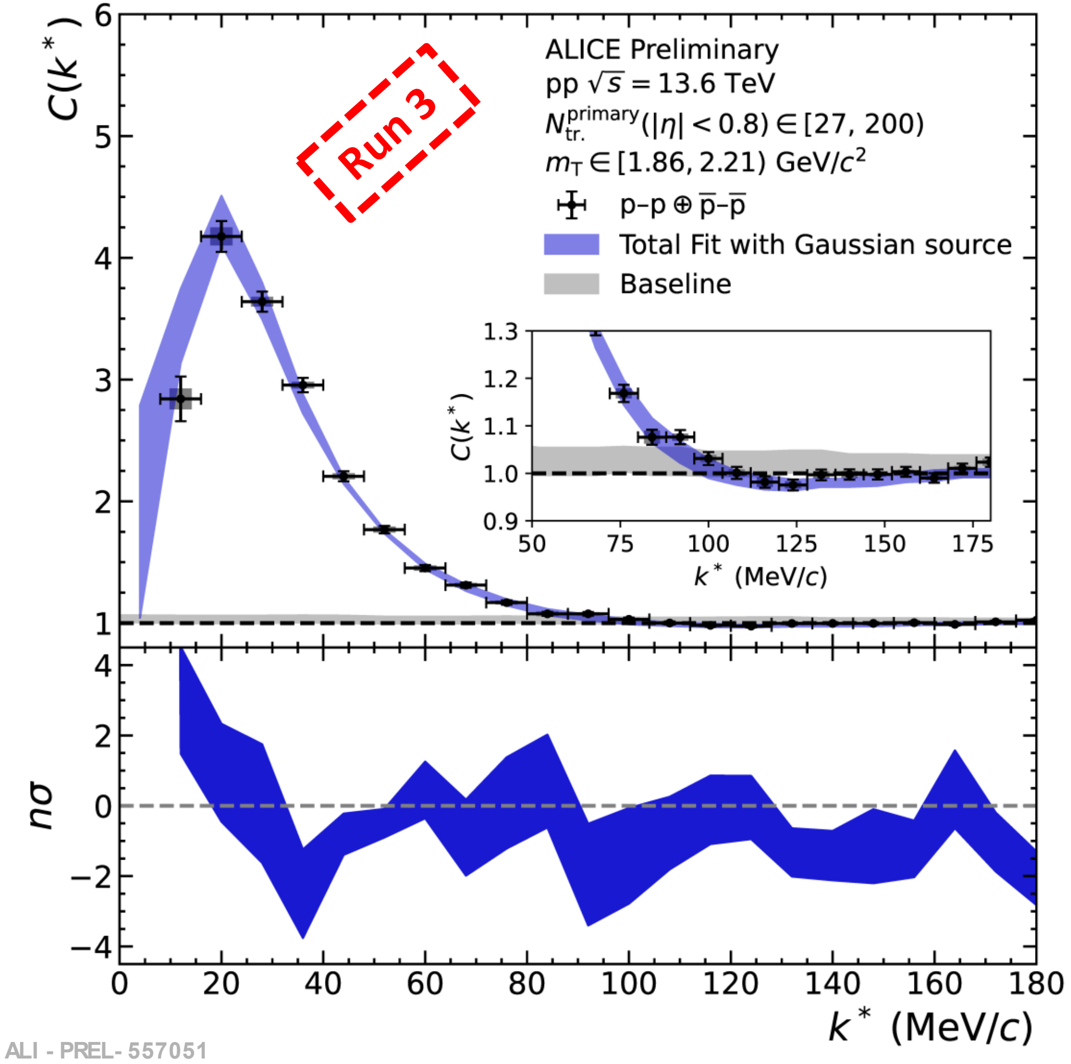


Femtoscopy at ALICE in pp 13.6 TeV

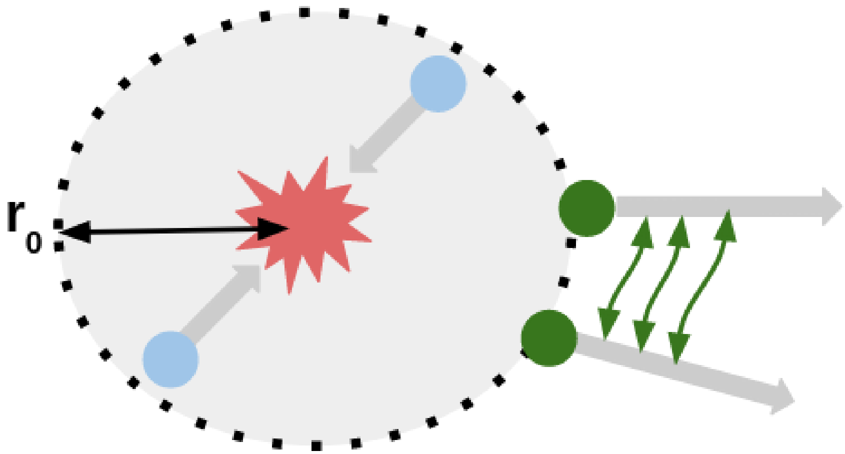


- Upgraded ALICE detector collected roughly **500 billion** pp collisions at 13.6 TeV in 2022 alone
- So far roughly 800x more pp collisions recorded compared to Run 2
- Large minimum bias data sample allows to to study the femtoscopic source **differentially in m_T and multiplicity**
- p–p correlations can be used as standard candle

p–p correlation function in Run 3

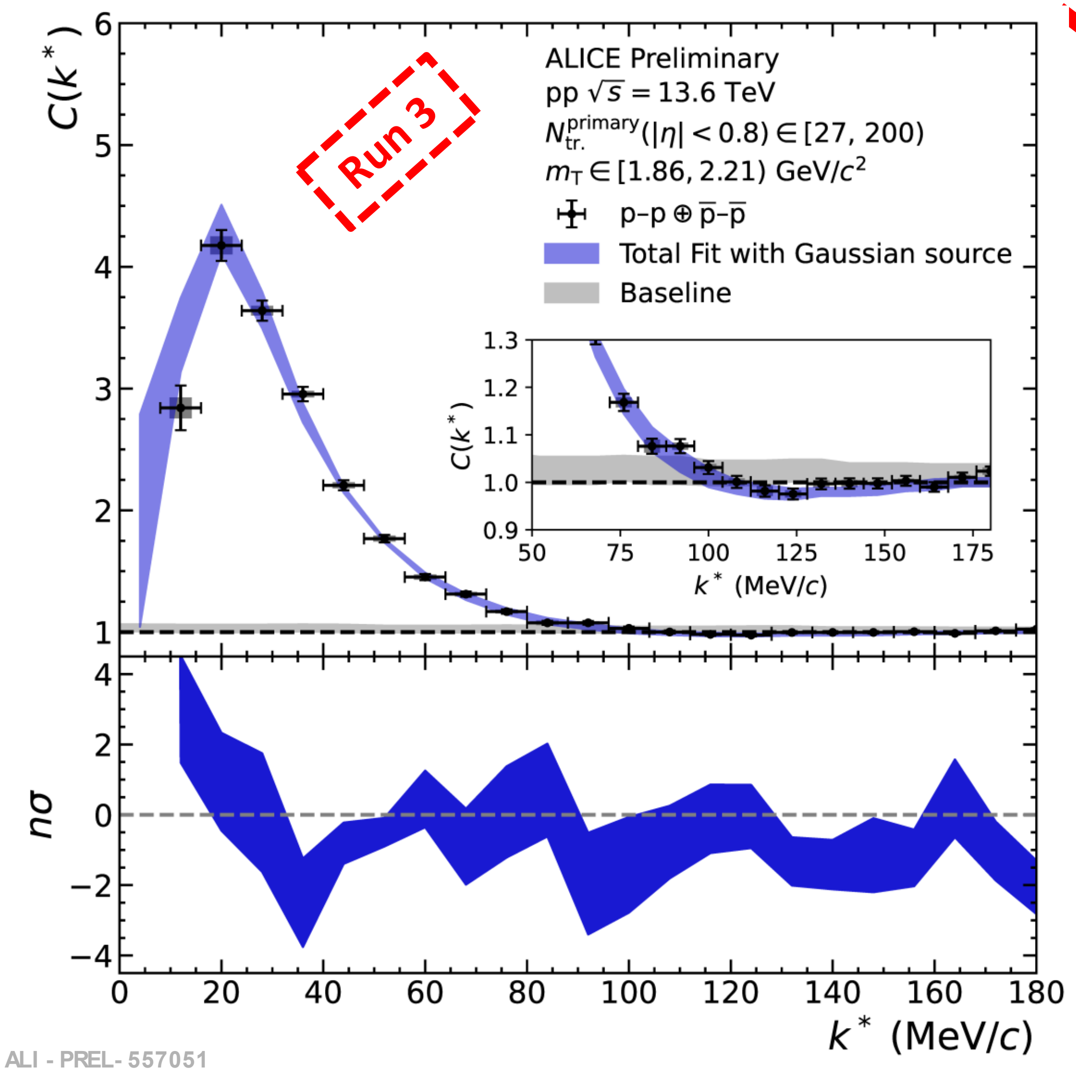


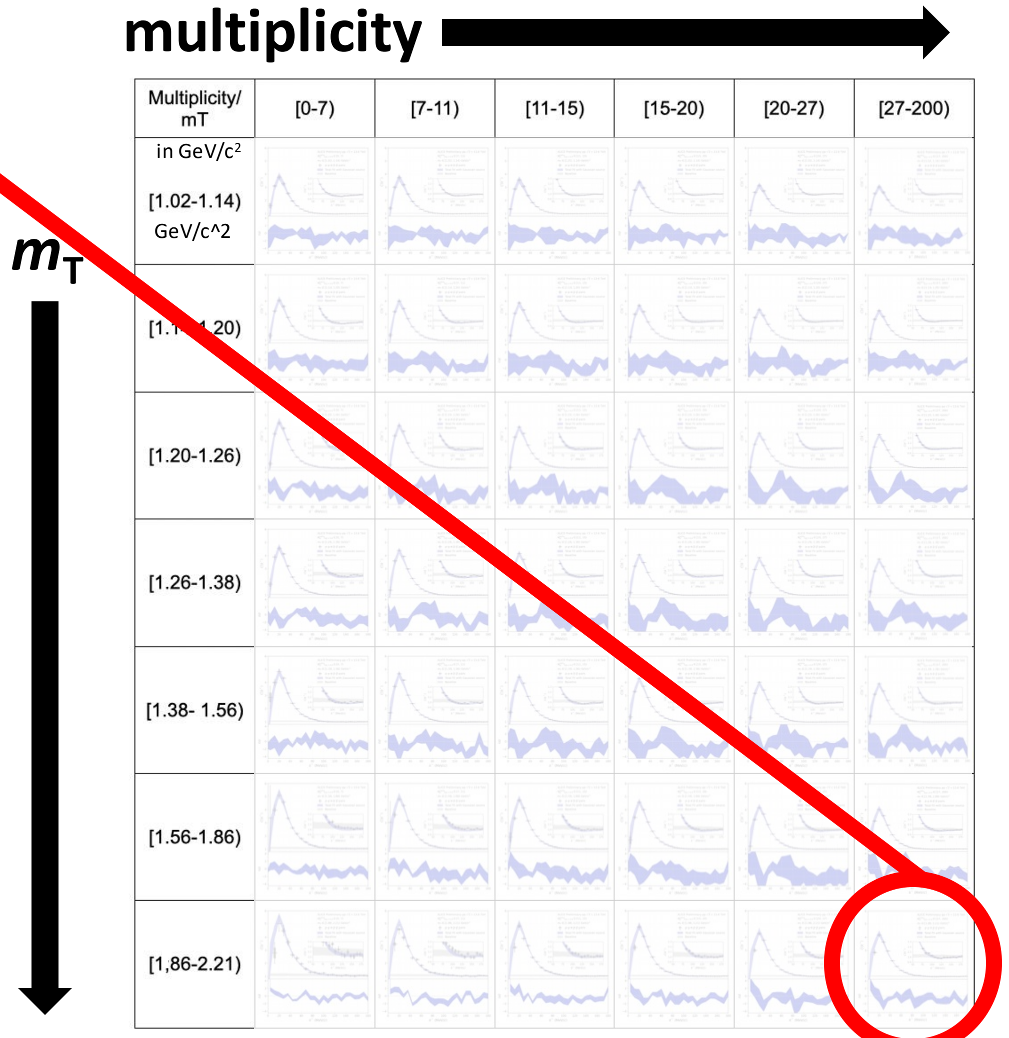
- p–p correlation function is measured in bins of m_T and charged track multiplicity
- Modeling of the interaction: Coulomb, quantum statistics and strong interaction with Argonne v18 potential
- Source modelled effectively with Gaussian profile



p–p correlation function in Run 3

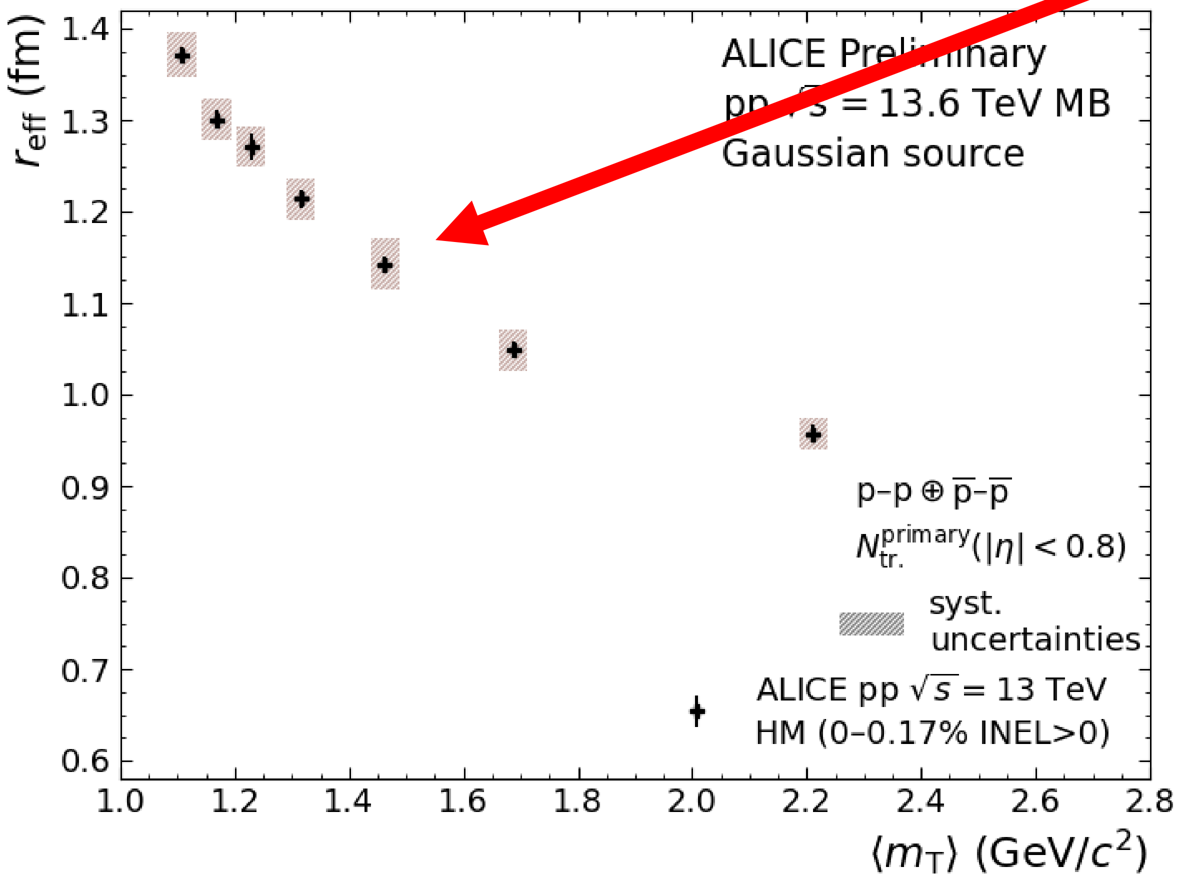
42 correlation functions





p–p correlation function in Run 3

Run 2 data points measured in high multiplicity collisions



Observations:

- Source size decreases with m_T in high multiplicity collisions

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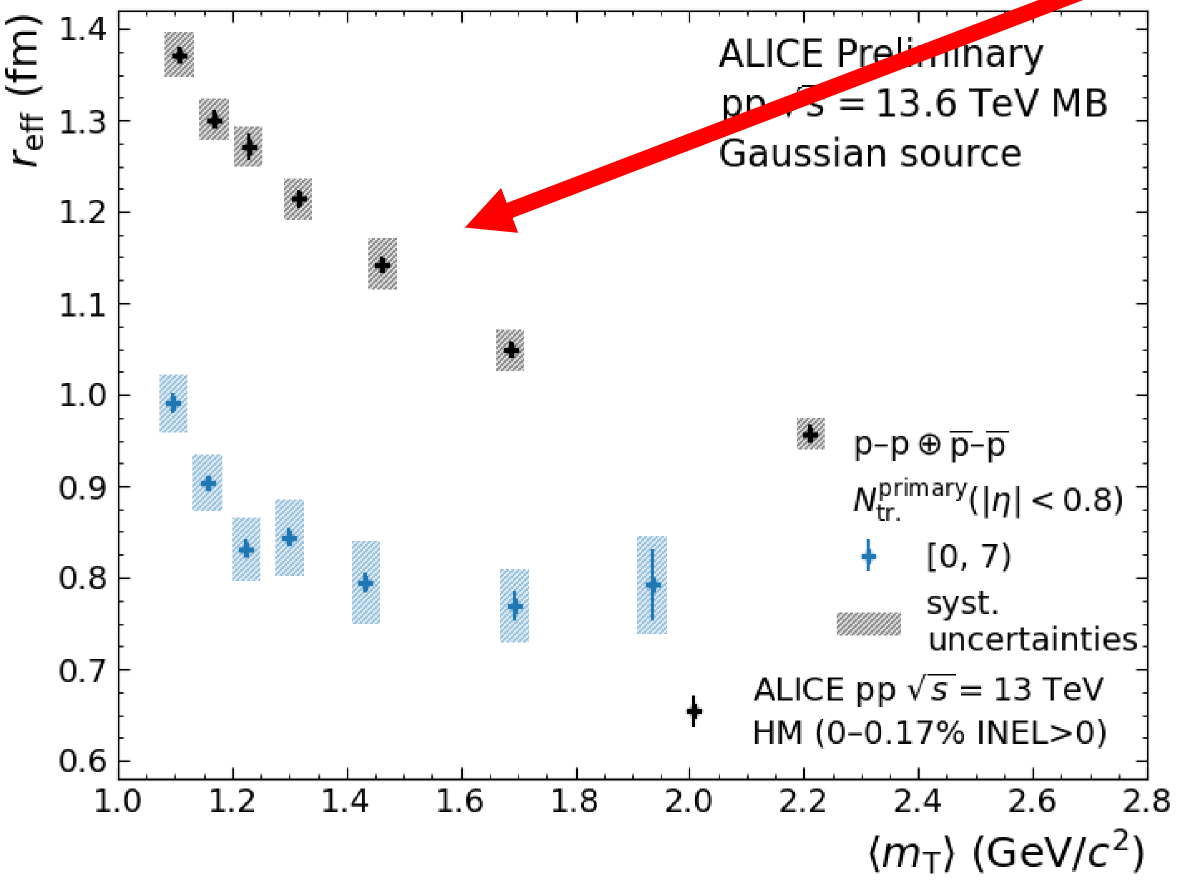

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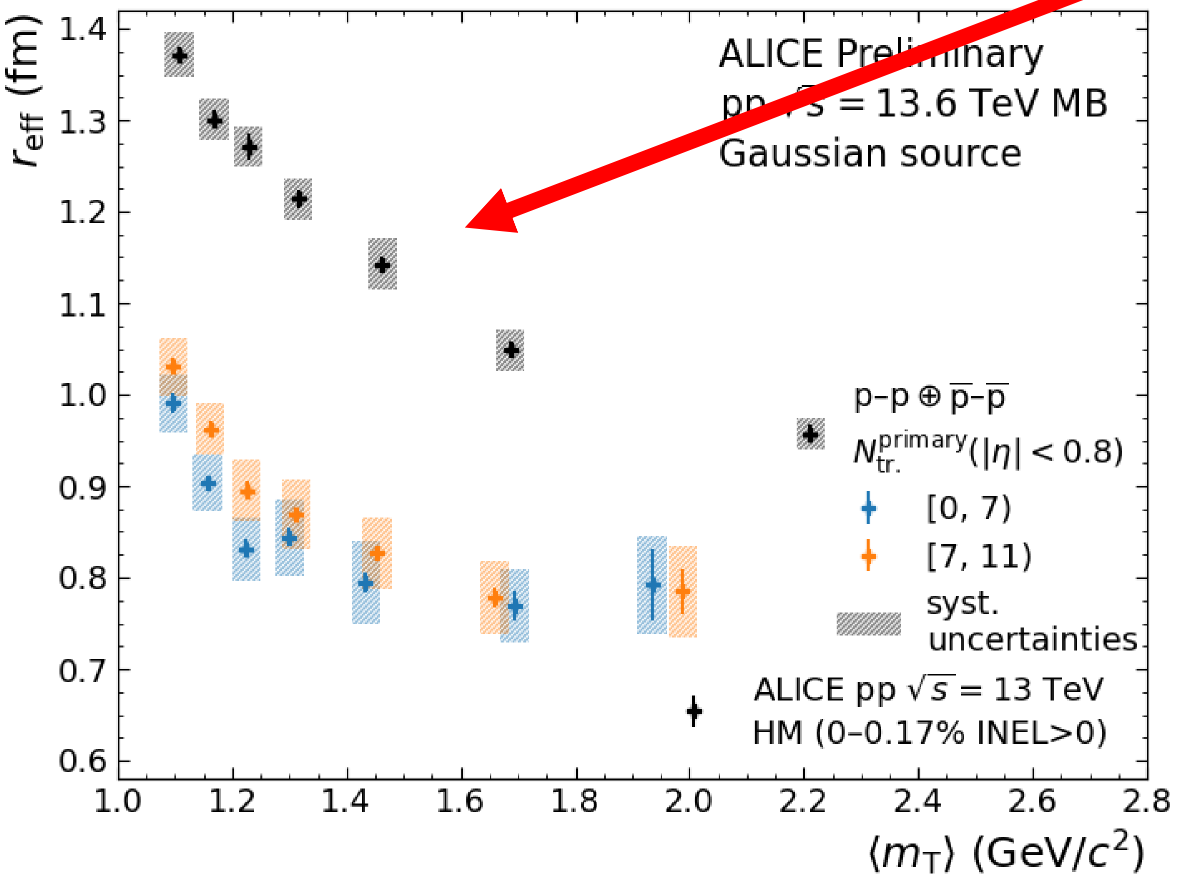

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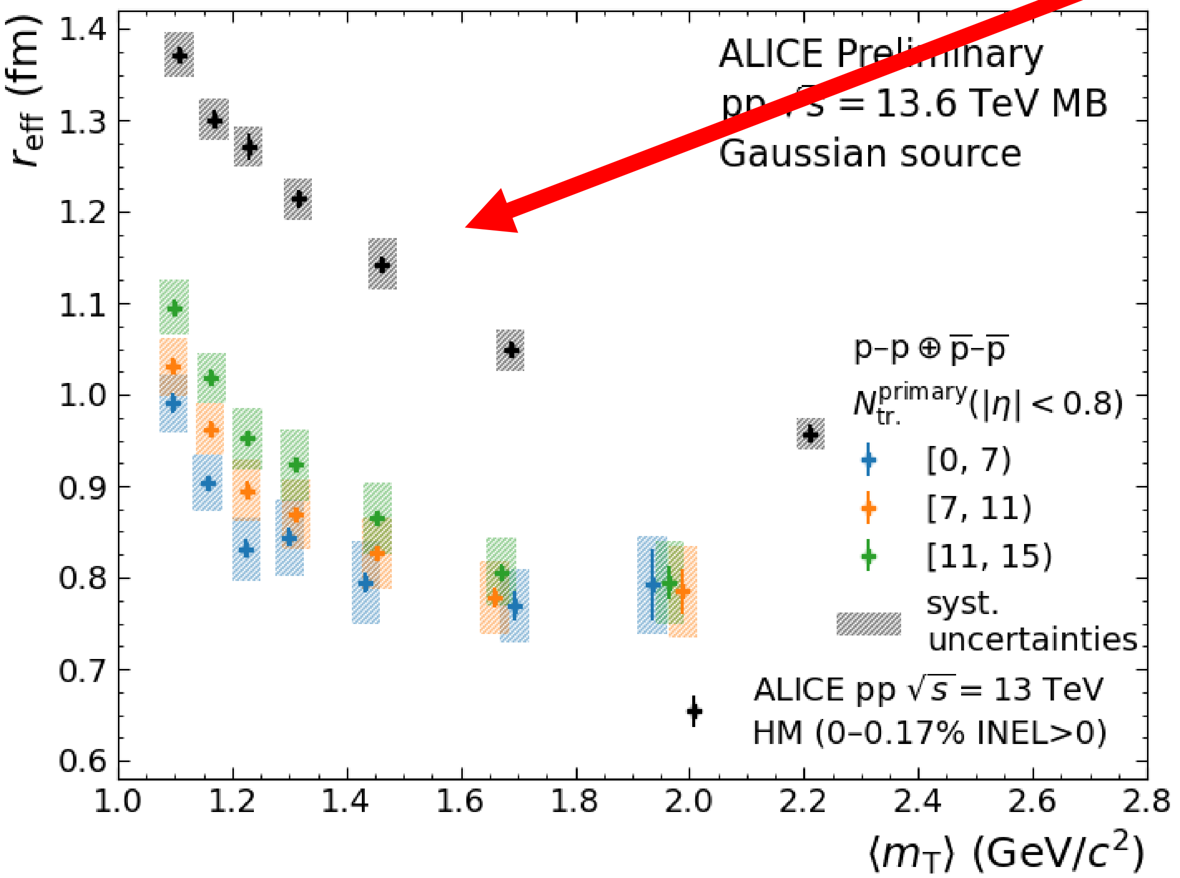

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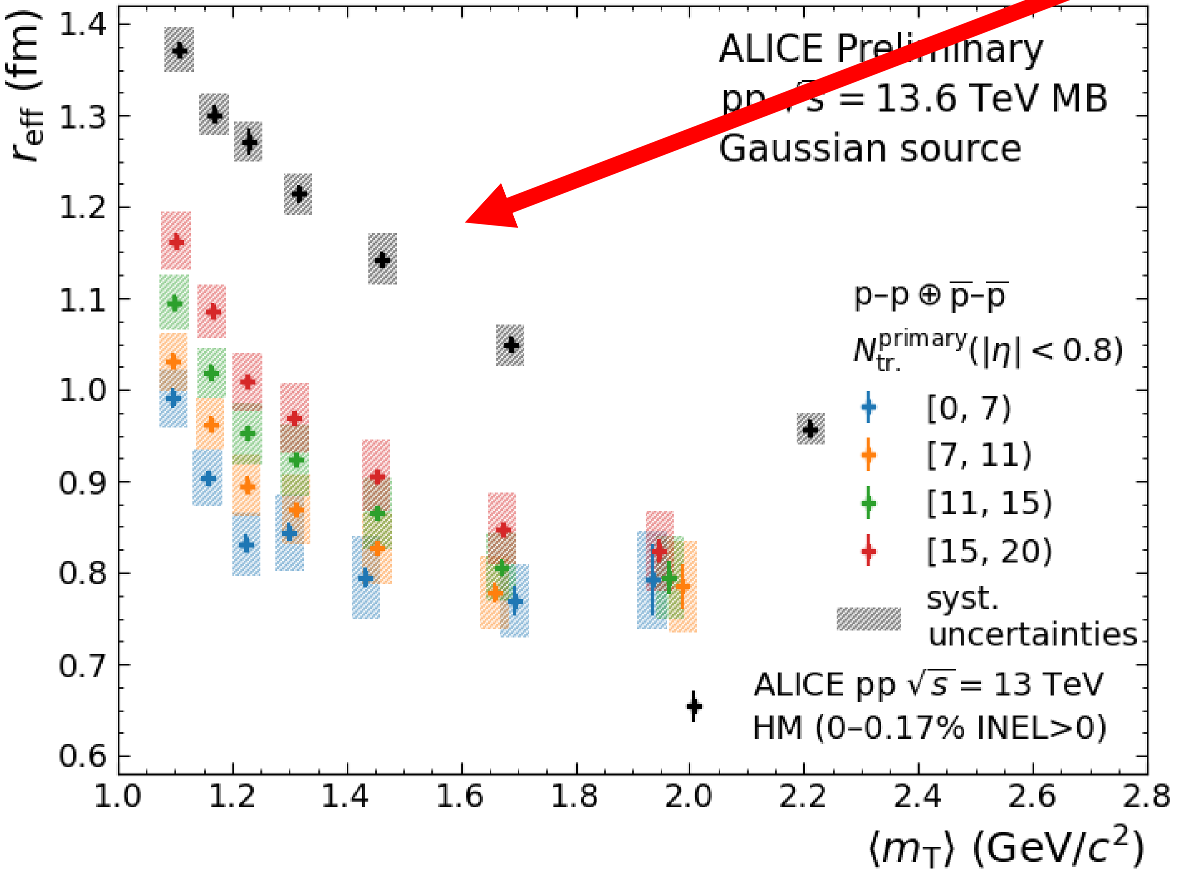

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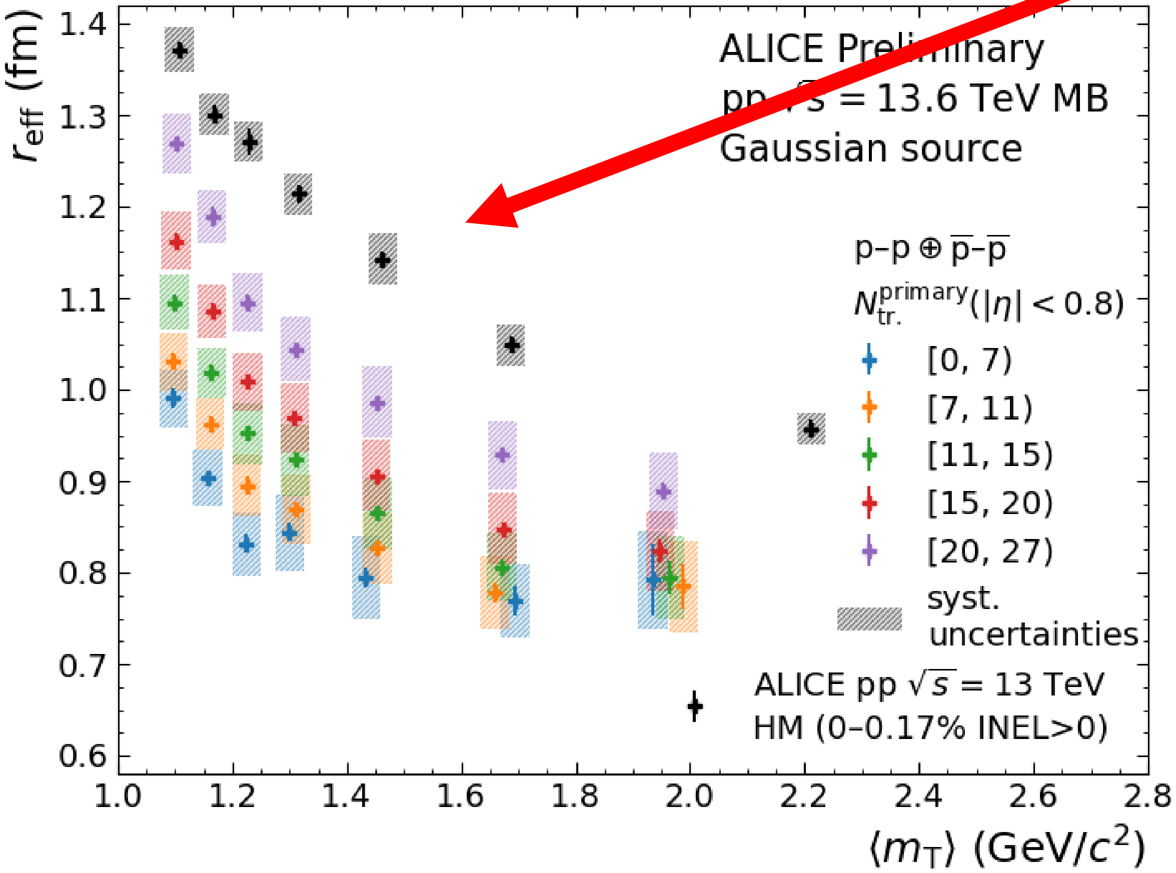

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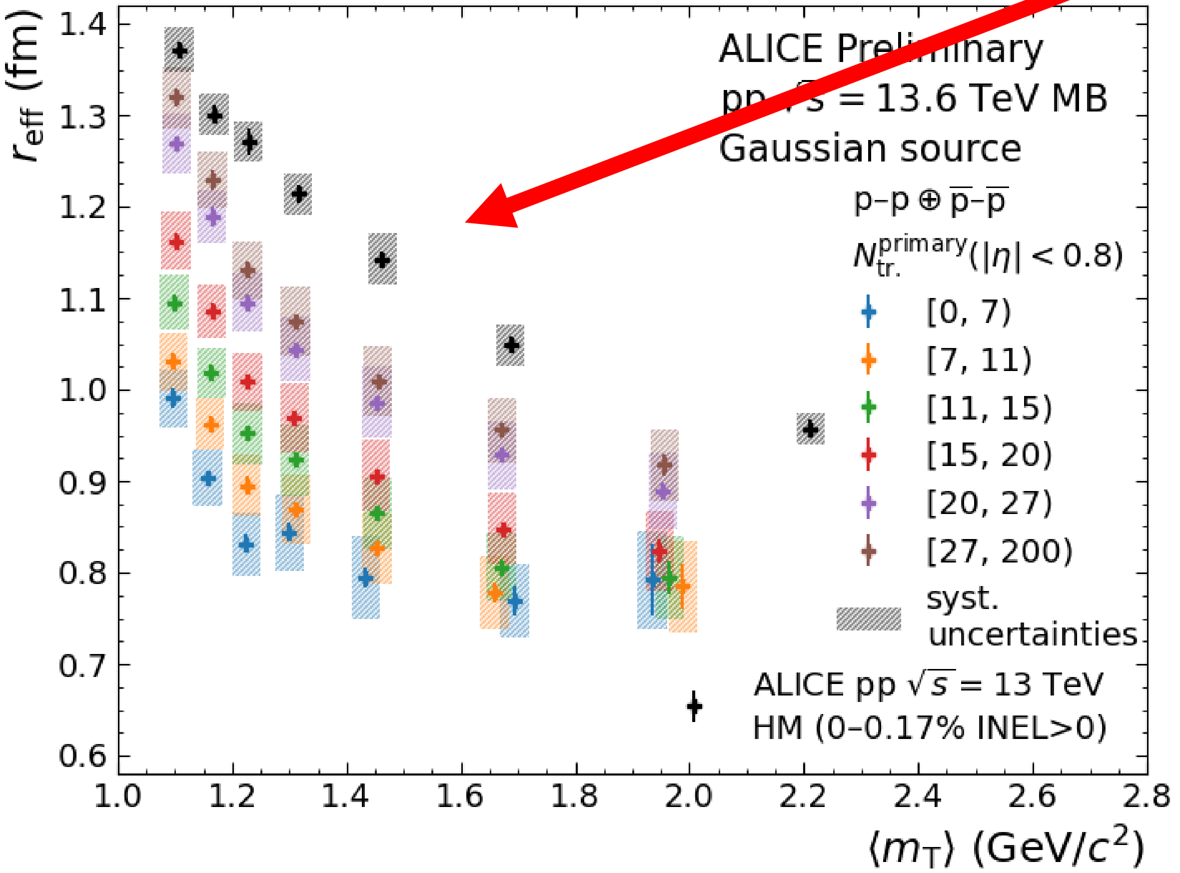

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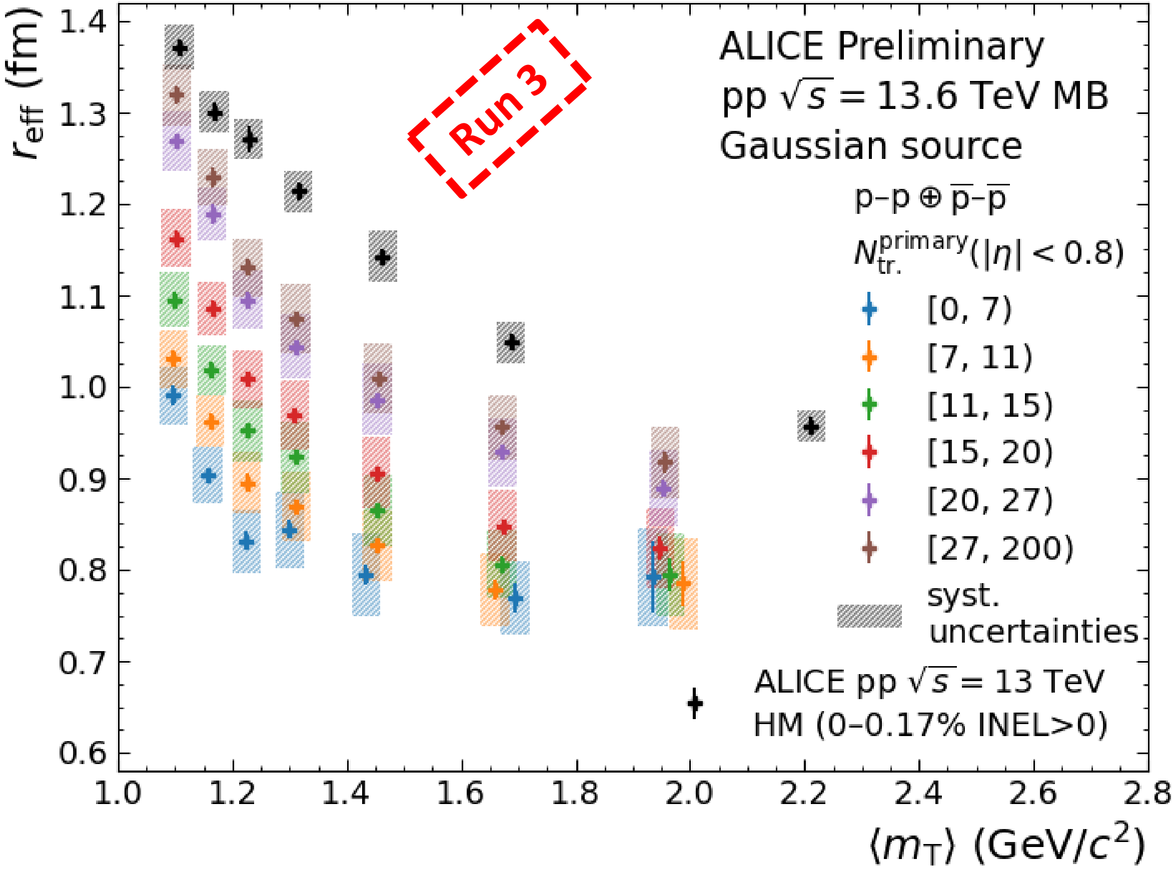

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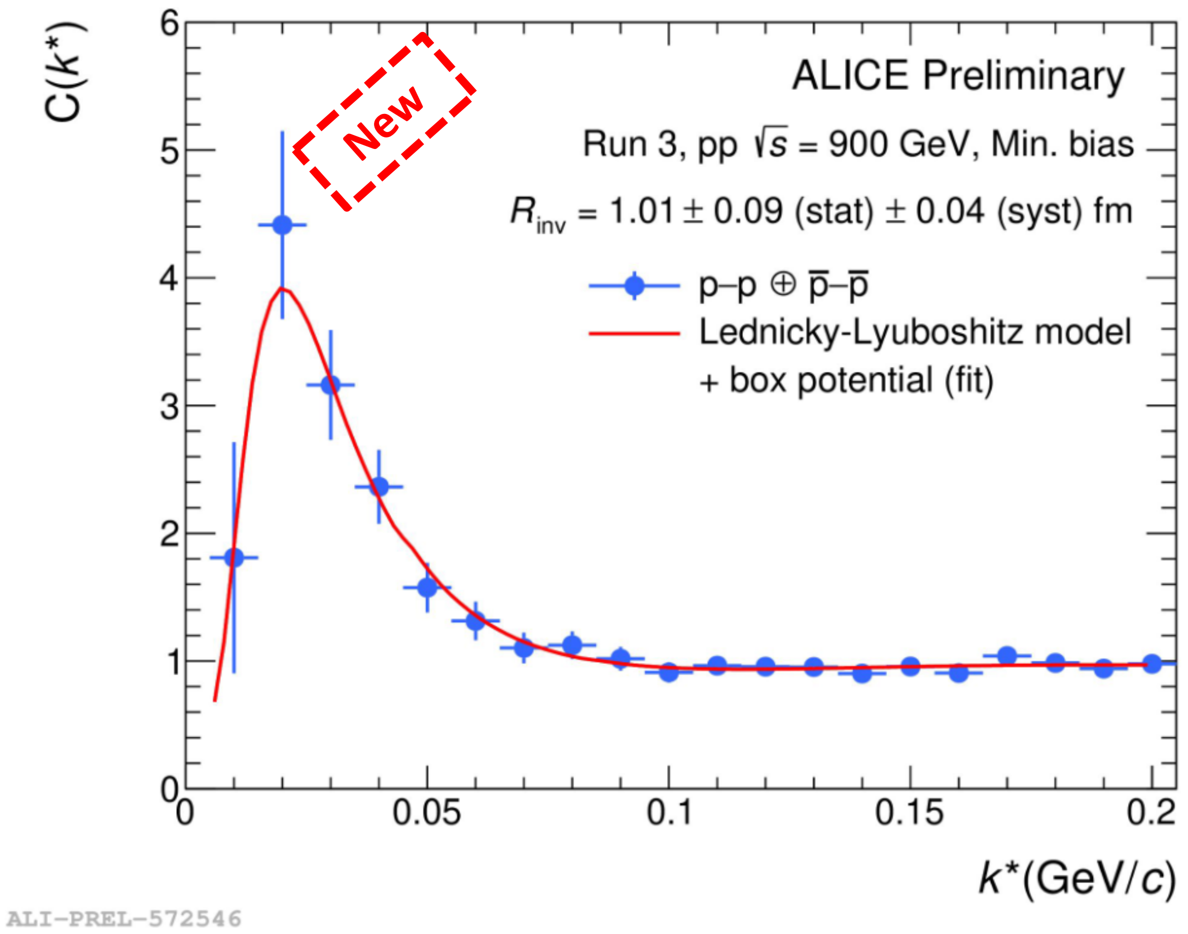
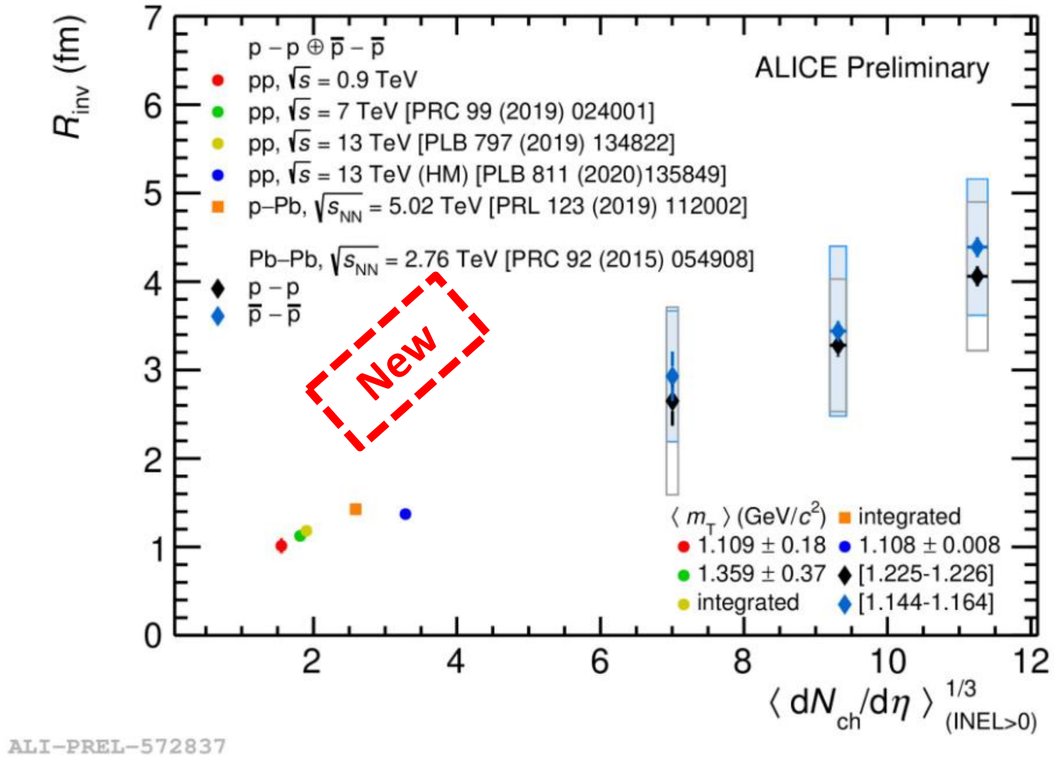
Caveats:

- Multiplicity estimators are not the same in Run 2 and Run 3 (yet)
- Multiplicity percentile in Run 2 is not identical with multiplicity bin [27,200)

p–p correlation function in Run 3 @ 900 GeV

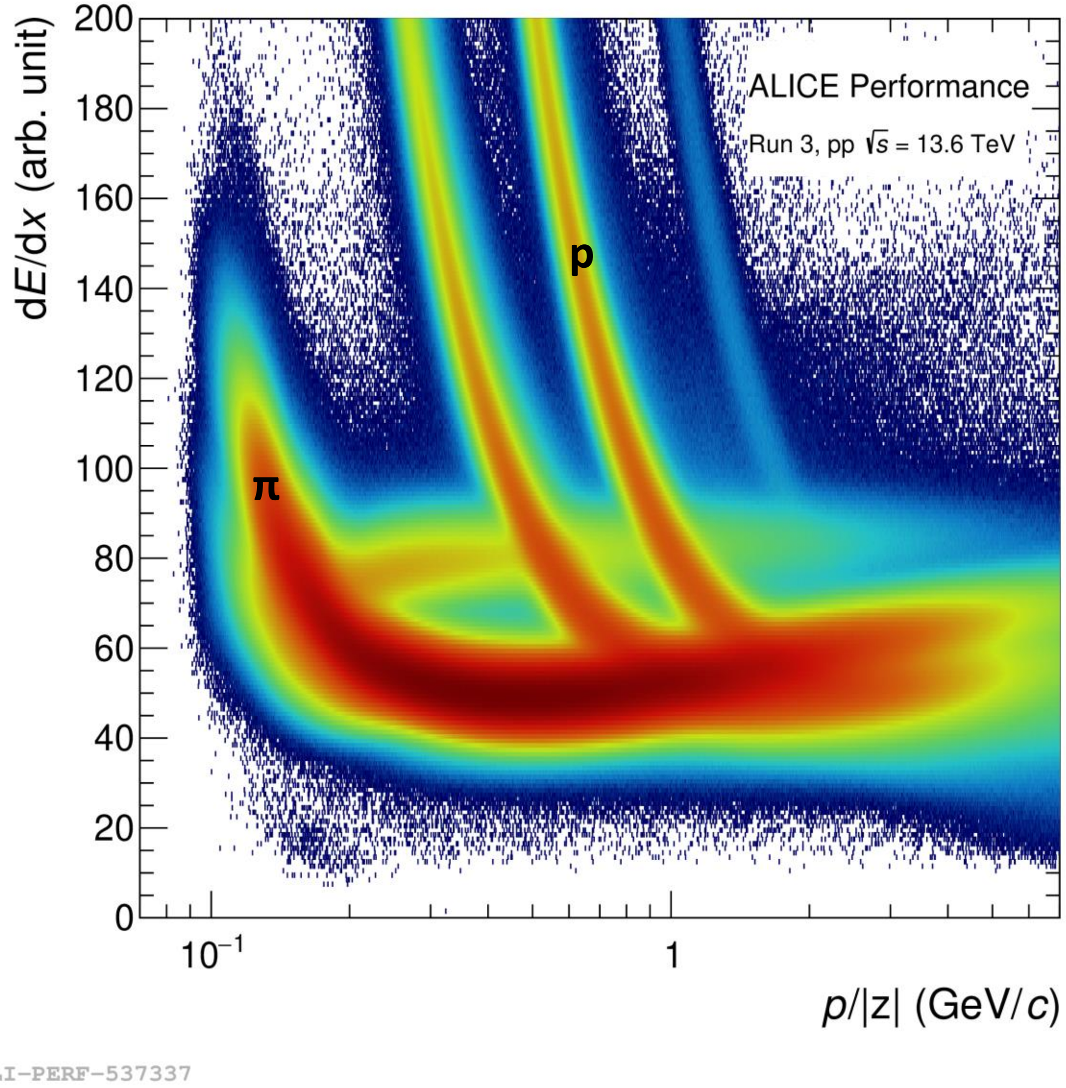
Accessing lower multiplicities with lower center of mass energies





Poster by Neelima Agrawal 4 Jun, 18:30

Outlook: p–Λ correlations in Run 3



Λ reconstruction: Λ → pπ

- Excellent PID and vertex finding of ALICE allows for efficient identification of Λ daughter tracks
- V0 algorithm is used to reconstruct Λ candidates

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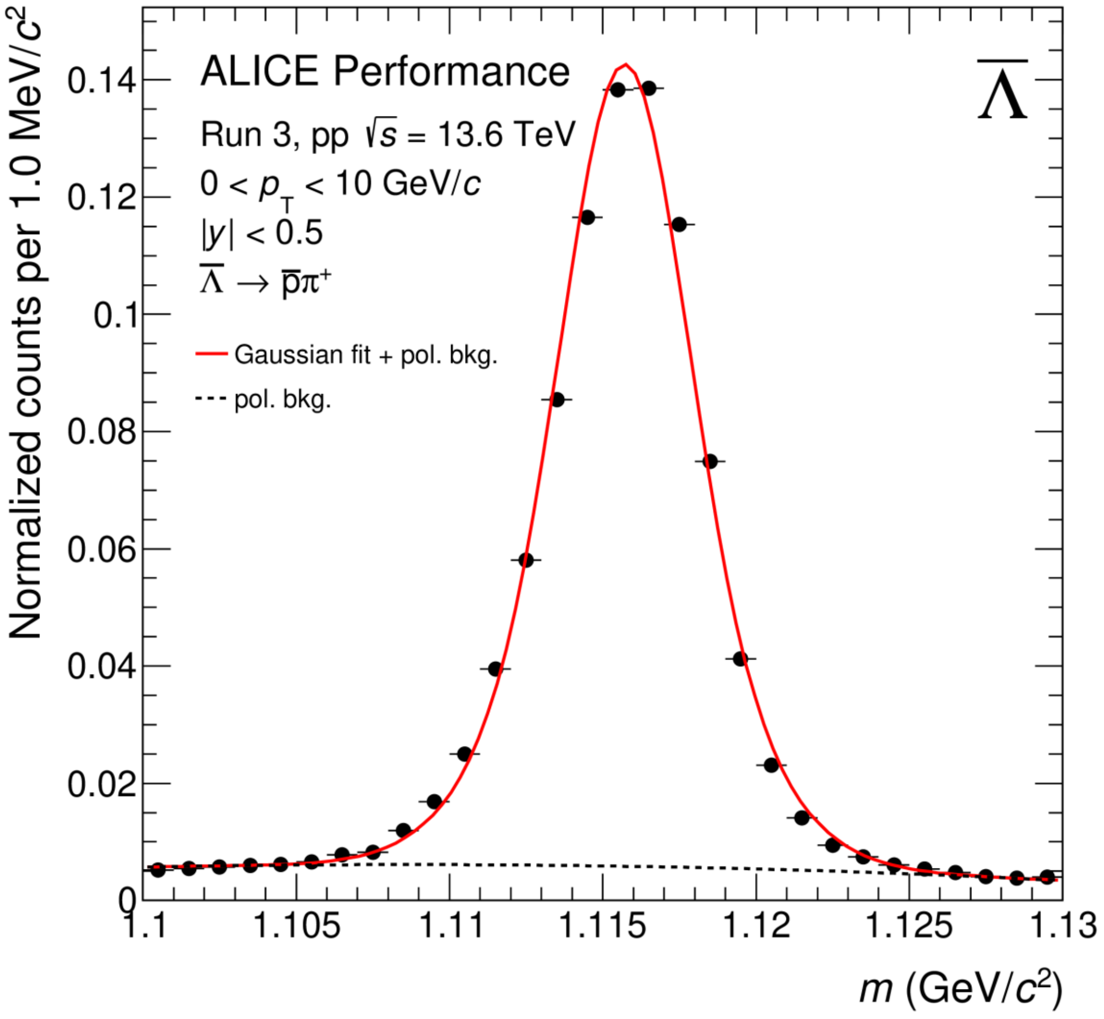

ALI-PERF-529185

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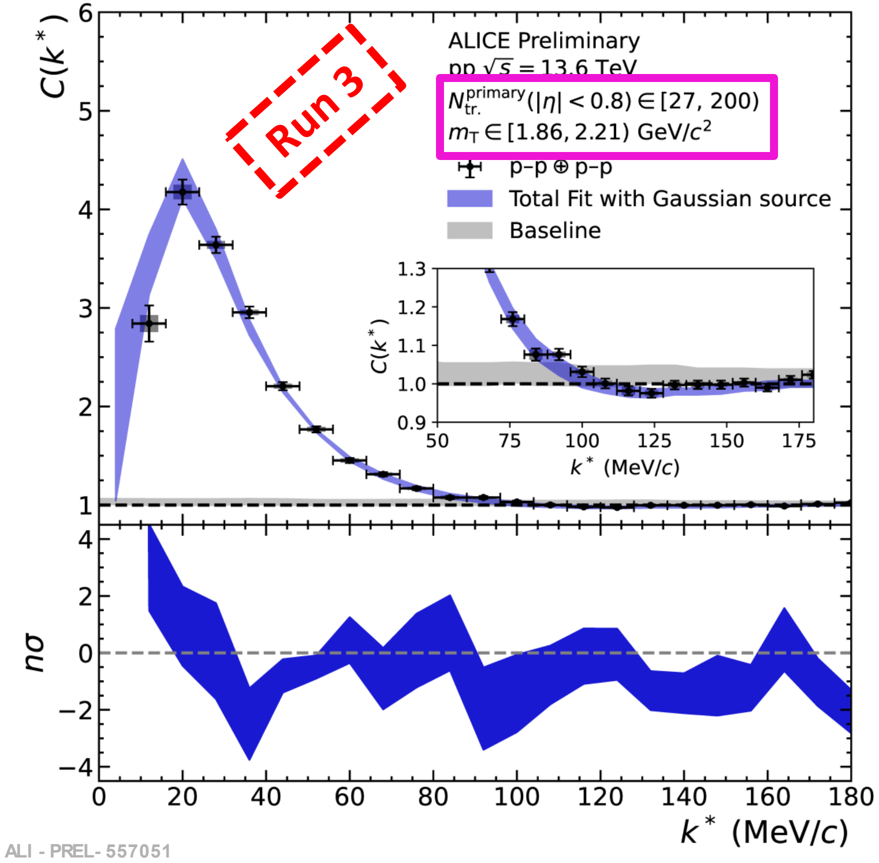
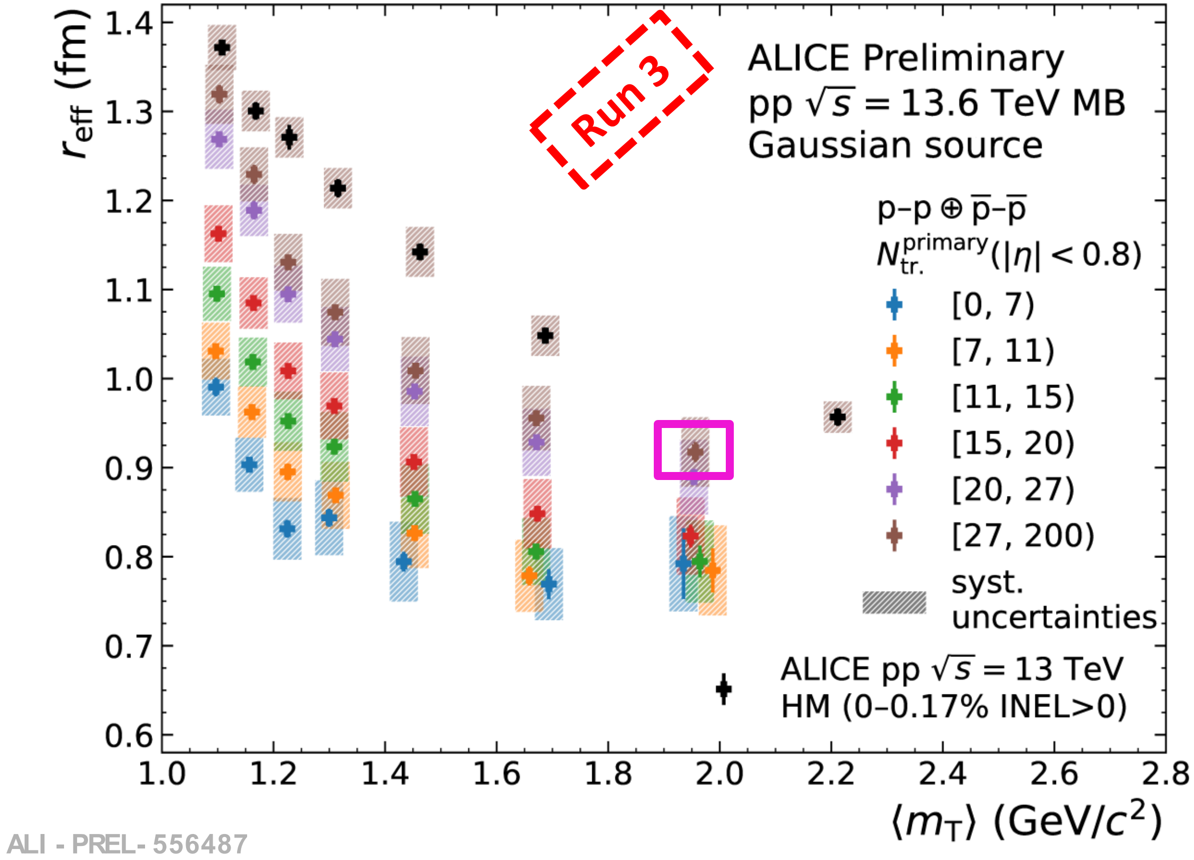
- V0 algorithm is used to construct Λ candidates

p–Λ correlation measurement:

- High purity sample necessary to extract femto signal
- Need good distinction between protons from primary collisions and Λ decays to avoid autocorrelation

Summary:
Differential measurement of p–p correlations in Run 3





Stay tuned for

- Measurement of the p–p and of p–Λ in similar multiplicity class to Run 2 to benchmark Run 3 results
- Extend the common source model with multiplicity scaling of the source

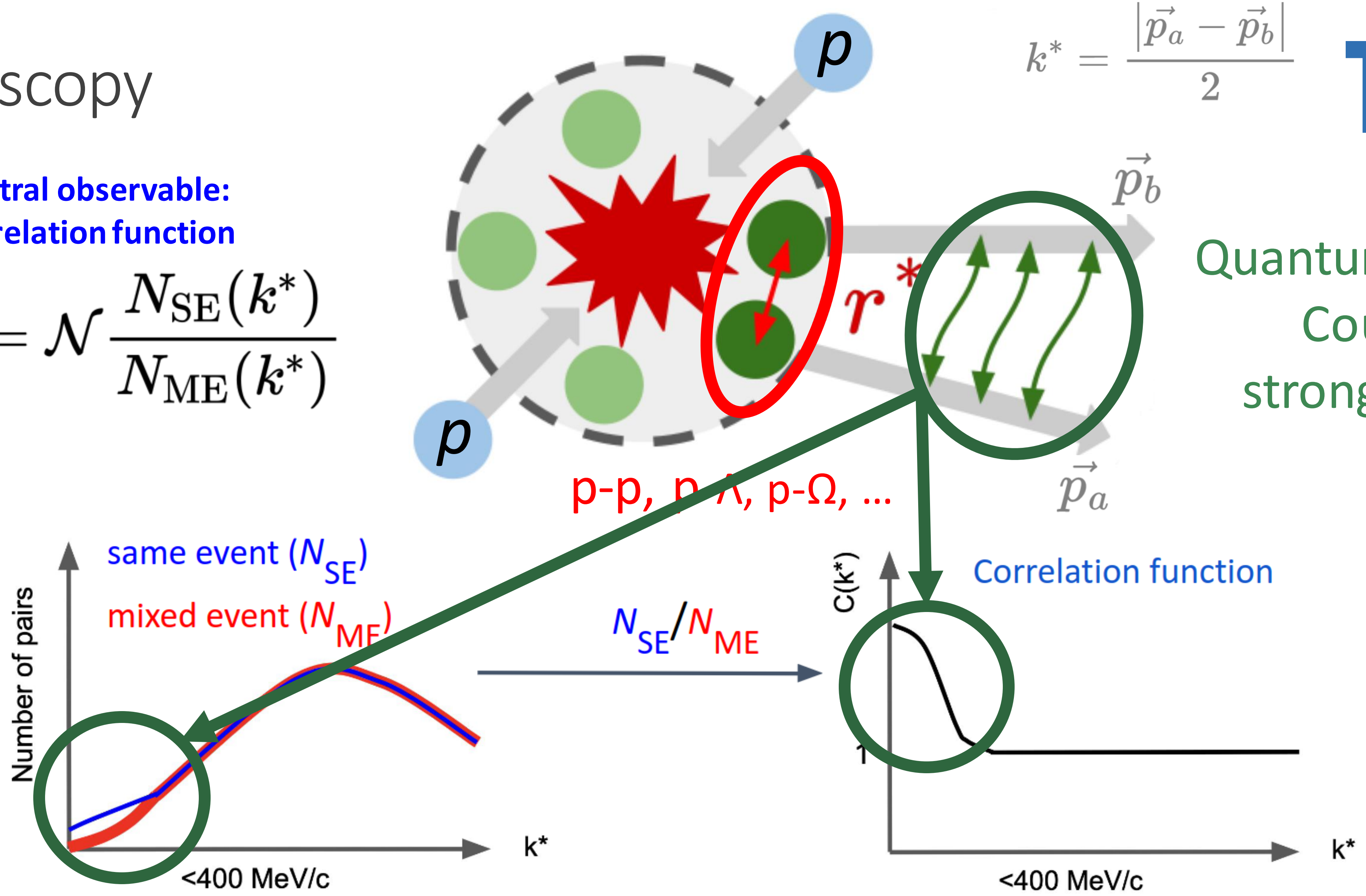
=> Source constrained for future femtoscopic measurements in Run 3 with ALICE

Backup

Femtoscopy

Central observable:
Correlation function

$$C(k^*) = \mathcal{N}\frac{N_{\mathrm{SE}}(k^*)}{N_{\mathrm{ME}}(k^*)}$$



Quantum statistics,
Coulomb,
strong force, …

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