Particle Fluctuations in STAR

Gary D. Westfall
Michigan State University
for the STAR Collaboration

Search for QCD Transitions

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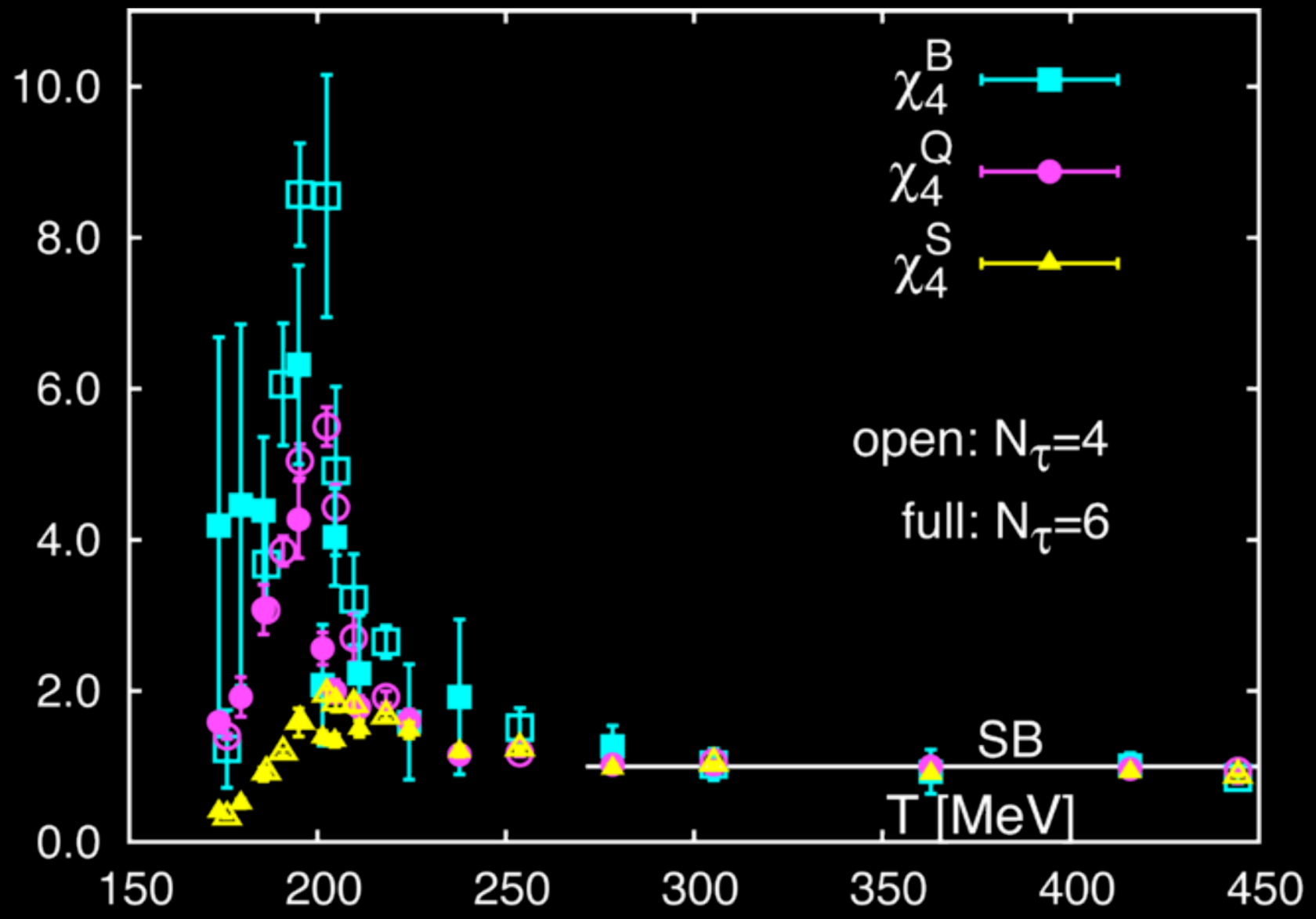
  - Hadronic matter to quark gluon matter
- If we pass near a QCD critical point, we expect an increase in susceptibilities and a corresponding increase in particle number fluctuations
- Look for changes in fluctuations as a function of incident energy

Lattice QCD Calculations

- Cheng et al., arXiv:0811.1006v2 [hep-th], quadratic and quartic fluctuations of baryon number, electric charge and strangeness, all quantities normalized to hadron gas

Lattice QCD Calculations



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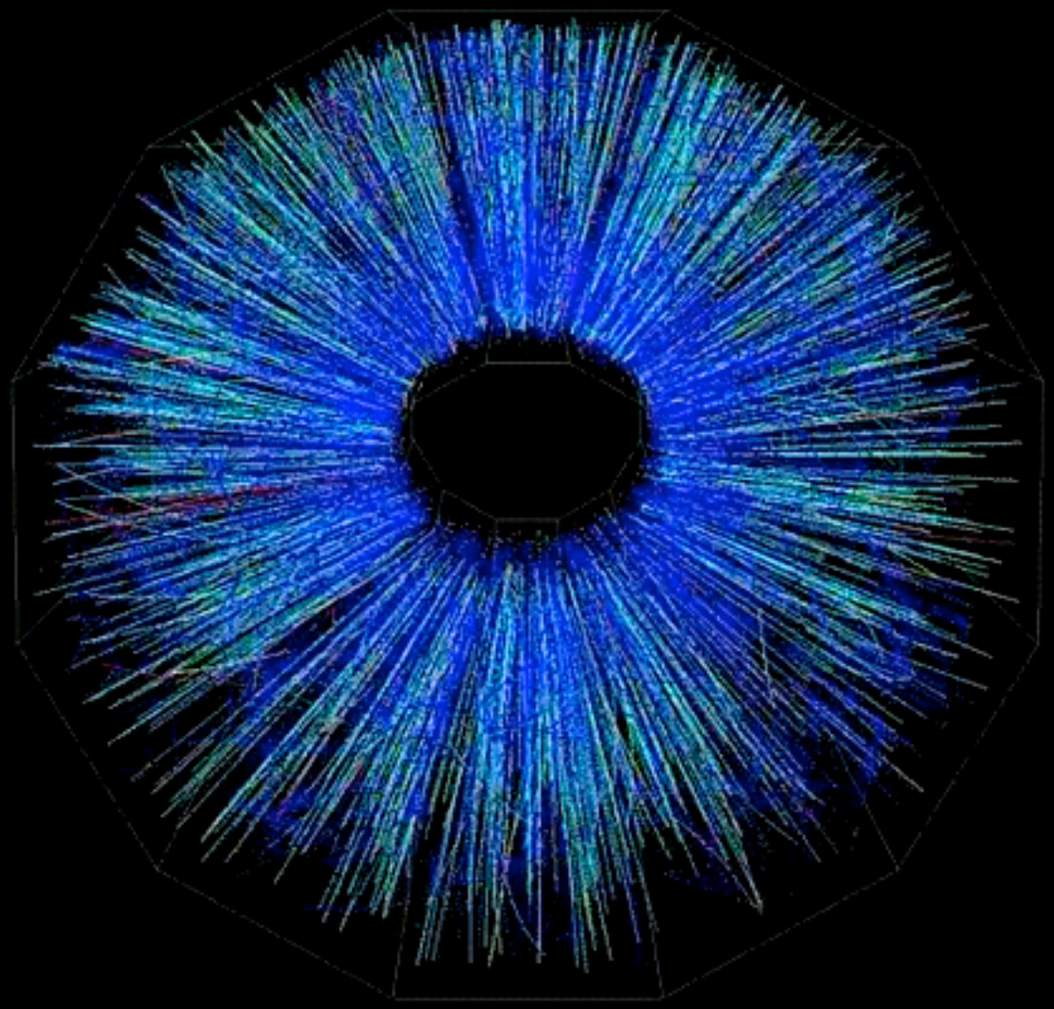
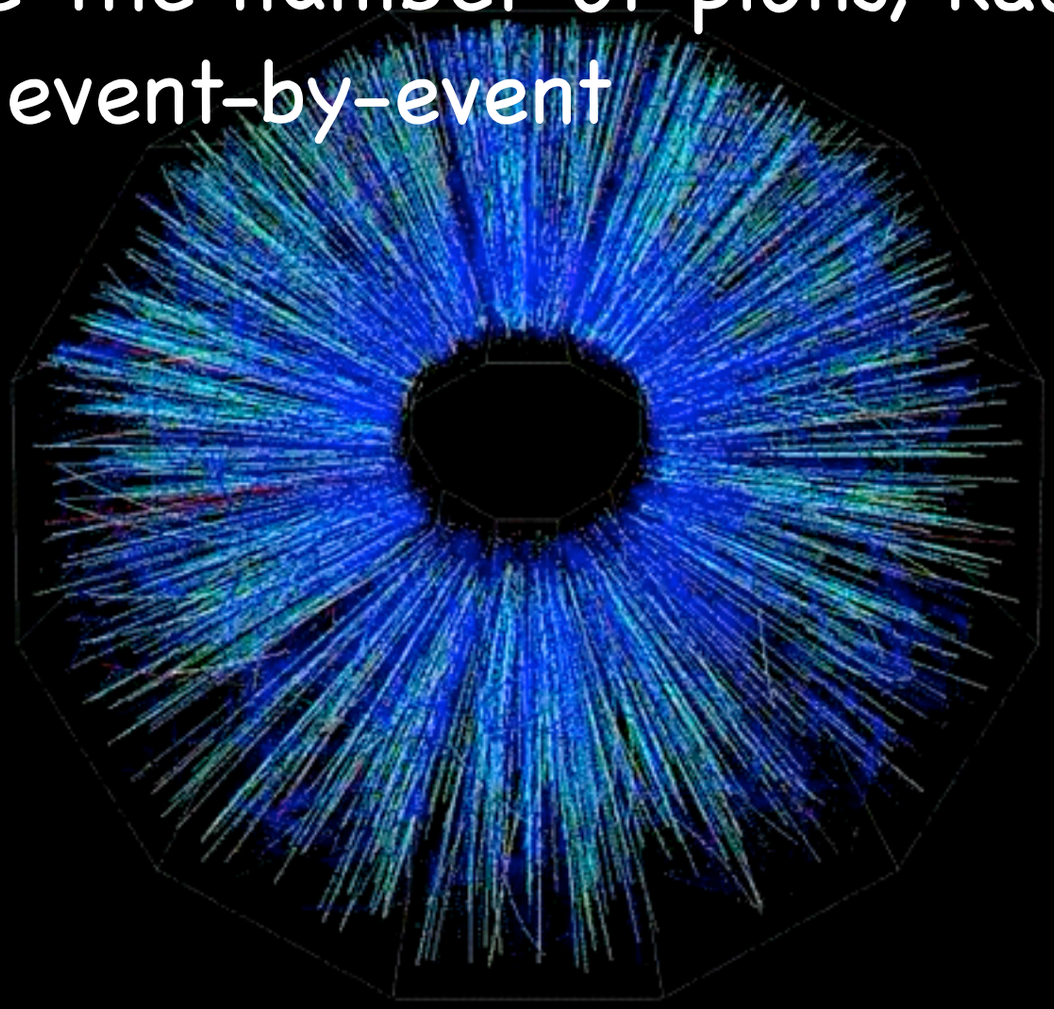


Fluctuations

- Measure the number of pions, kaons, and protons event-by-event



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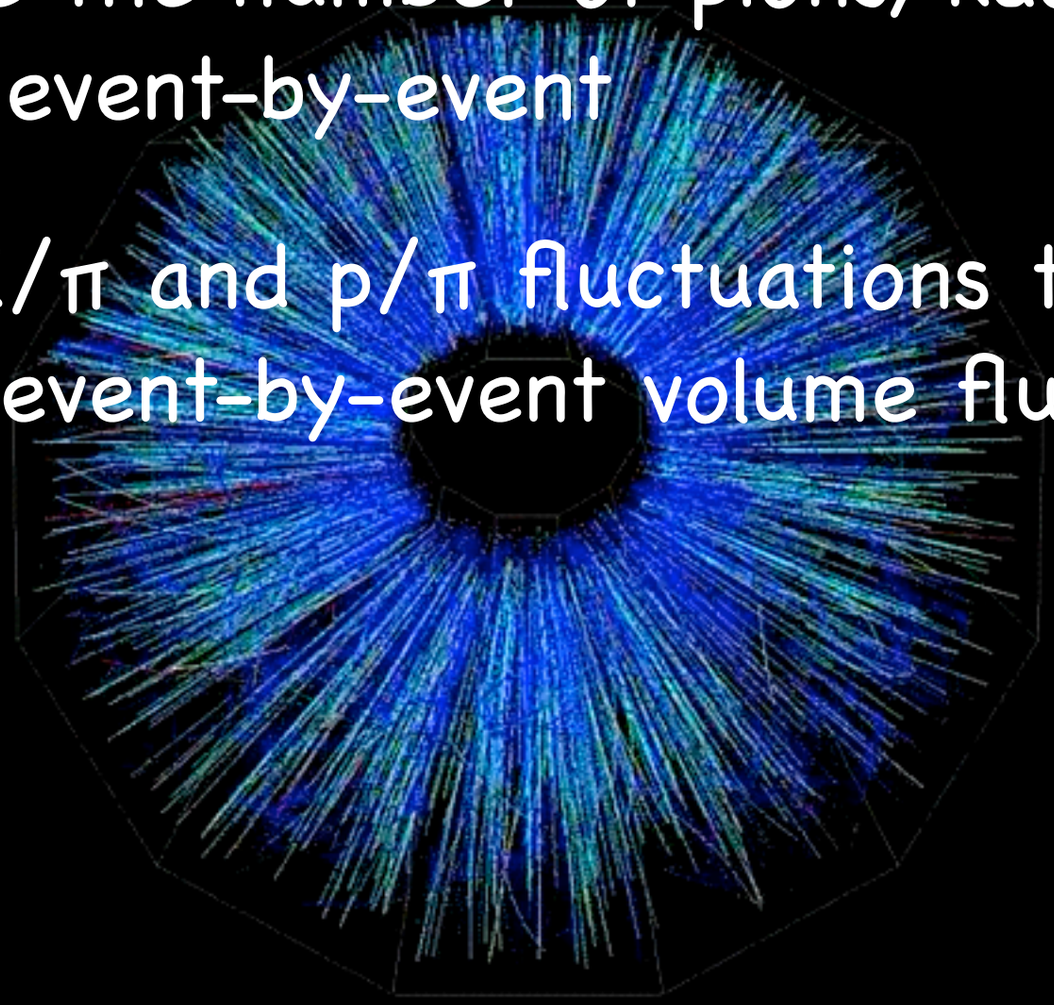

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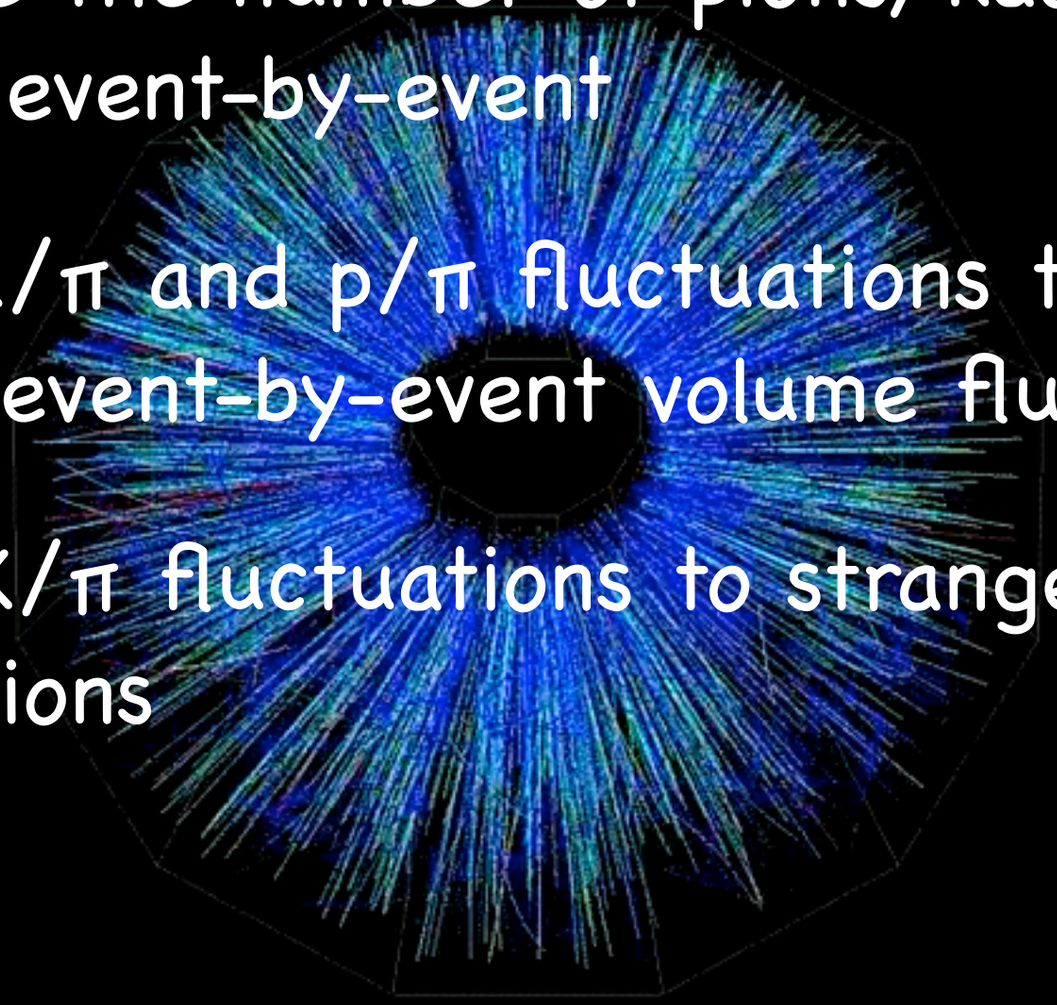

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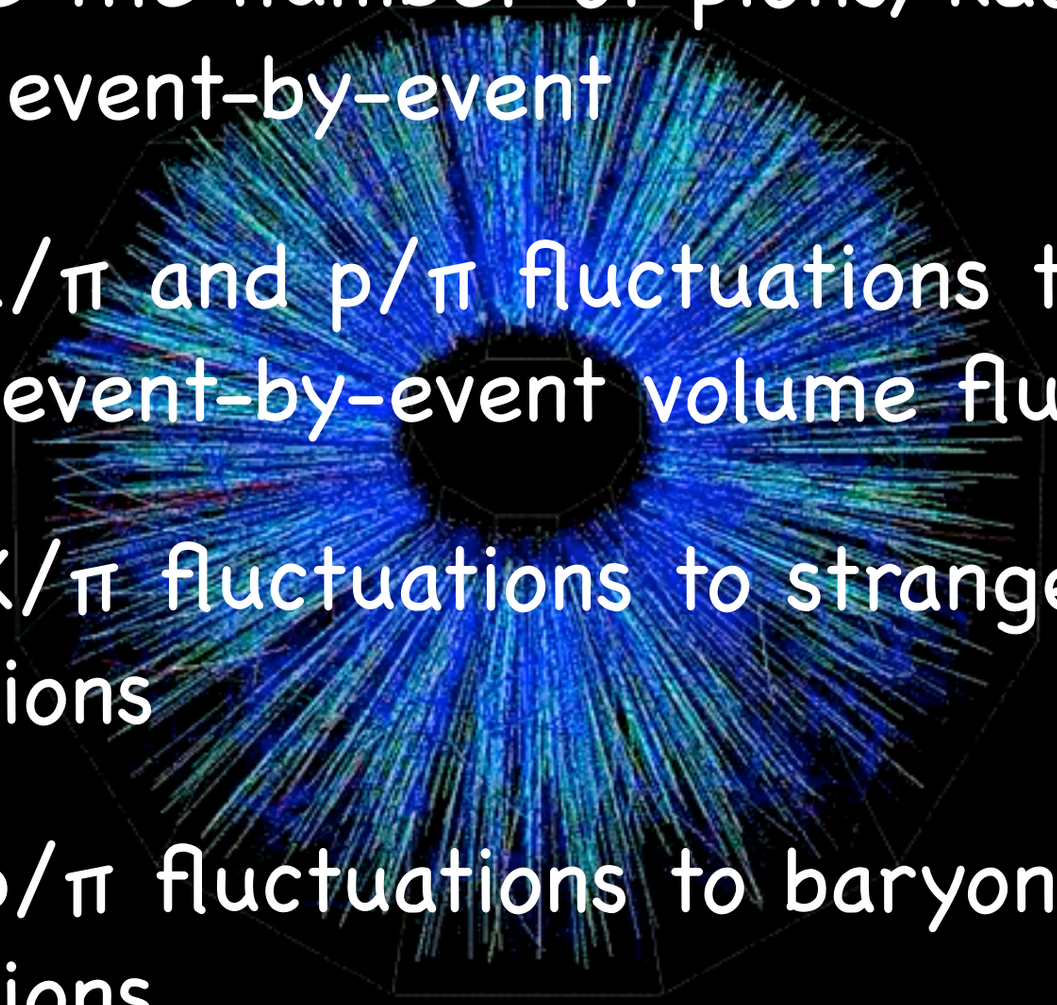

Fluctuation Observables

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$$\sigma_{dyn} = \mathrm{sgn}\left(\sigma^2_{data} - \sigma^2_{mixed}\right)\sqrt{\left|\sigma^2_{data} - \sigma^2_{mixed}\right|}$$

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Measure deviation from Poisson behavior

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It turns out that

$\sigma^2_{\mathrm{dyn}} \approx \nu_{\mathrm{dyn}}$ for K/π and p/π

Fluctuations Data

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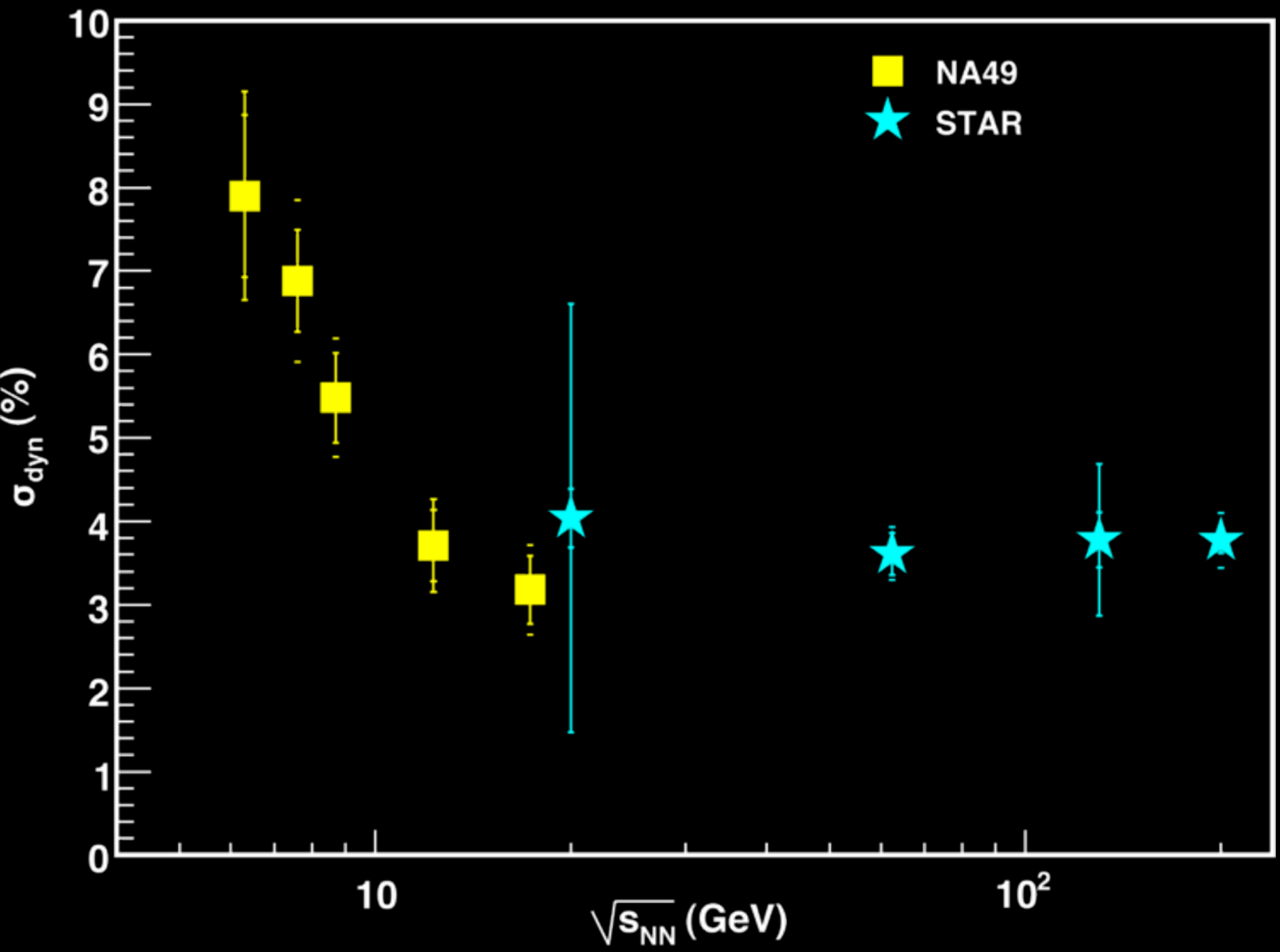

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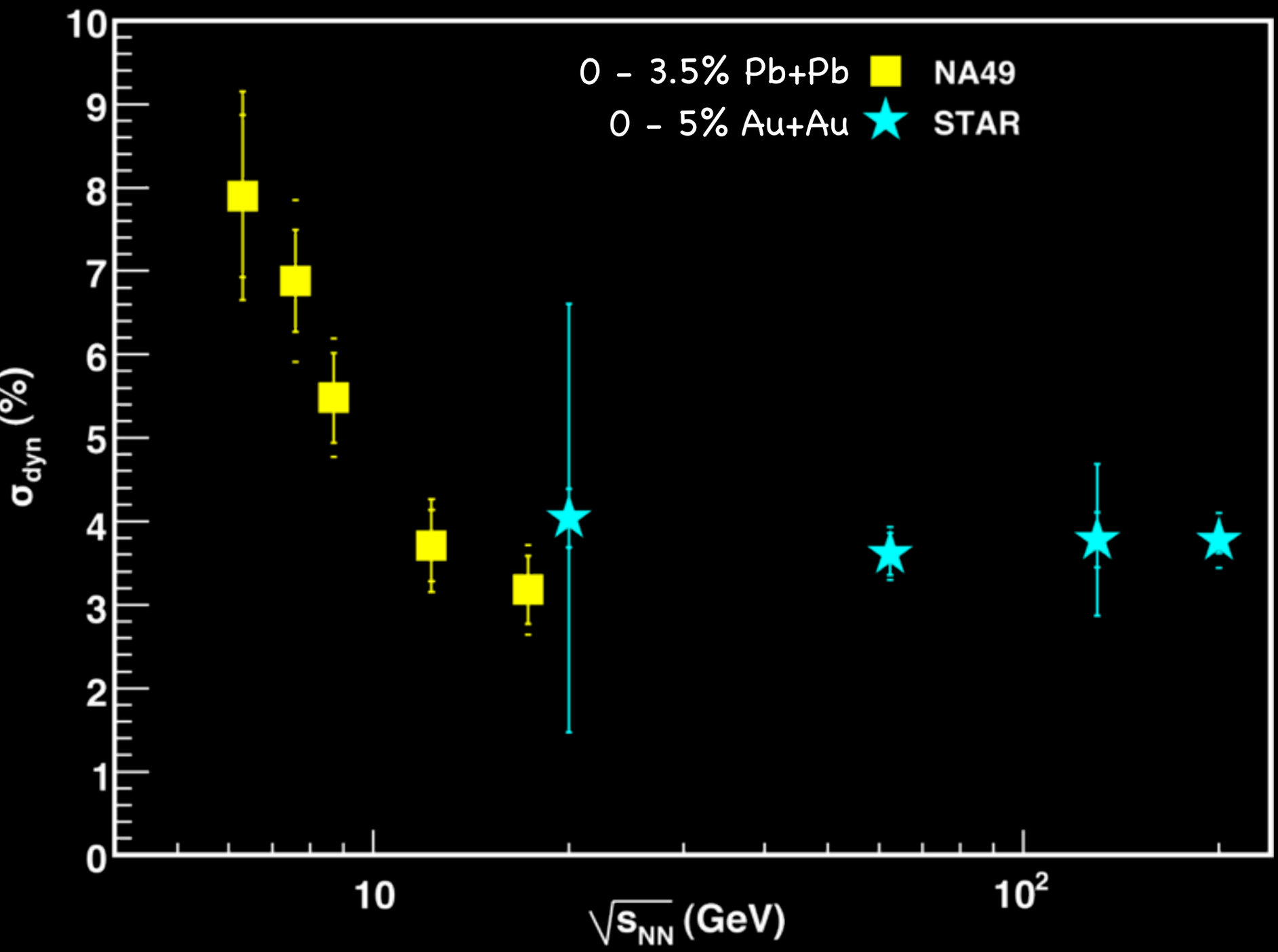

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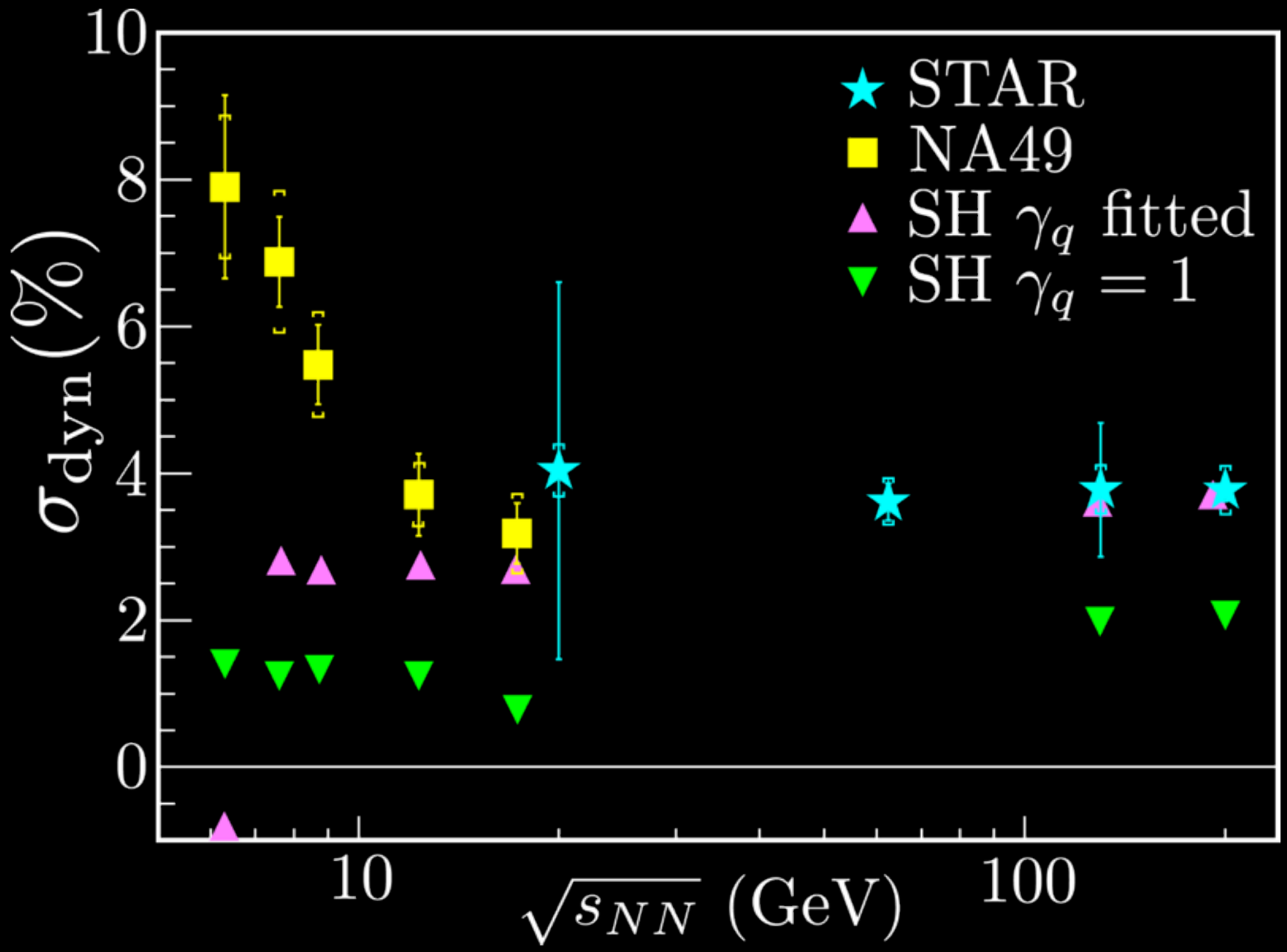

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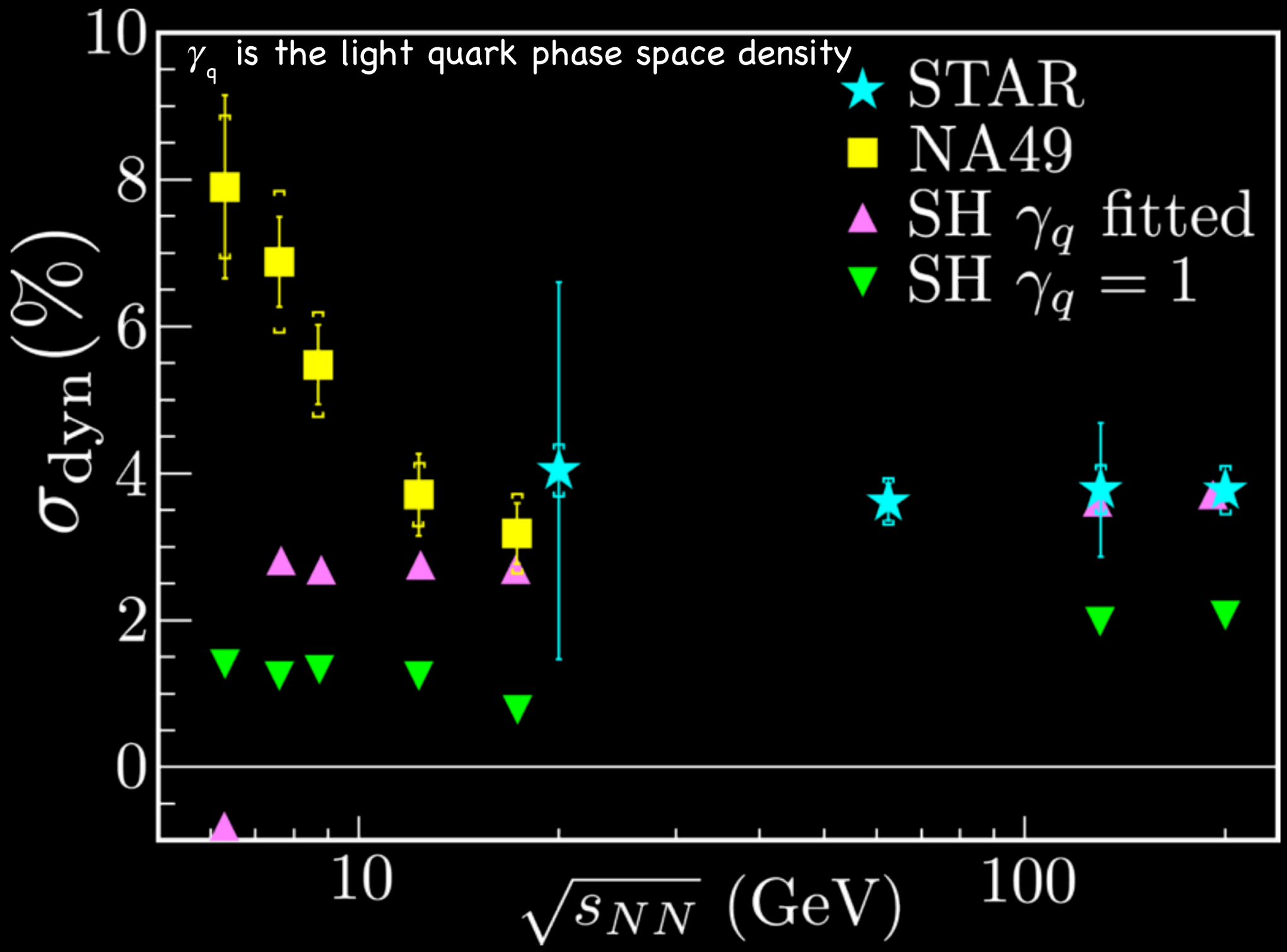

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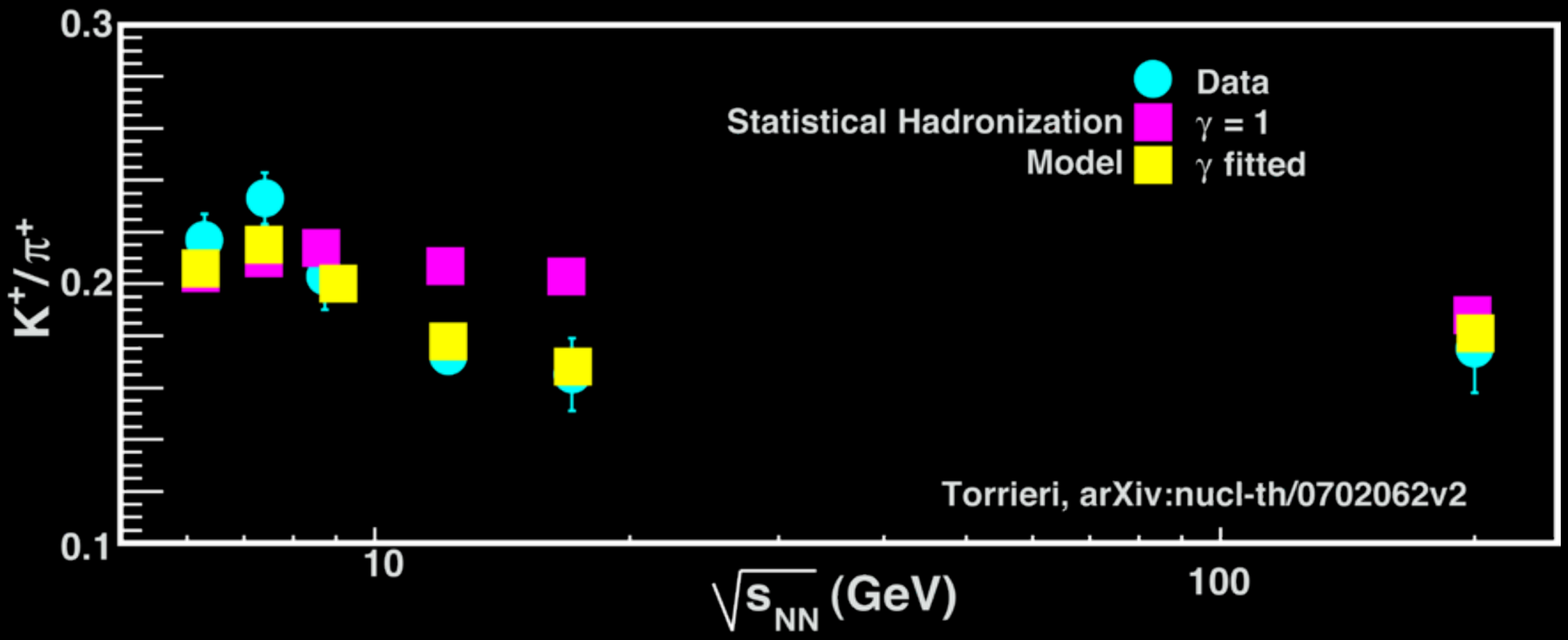

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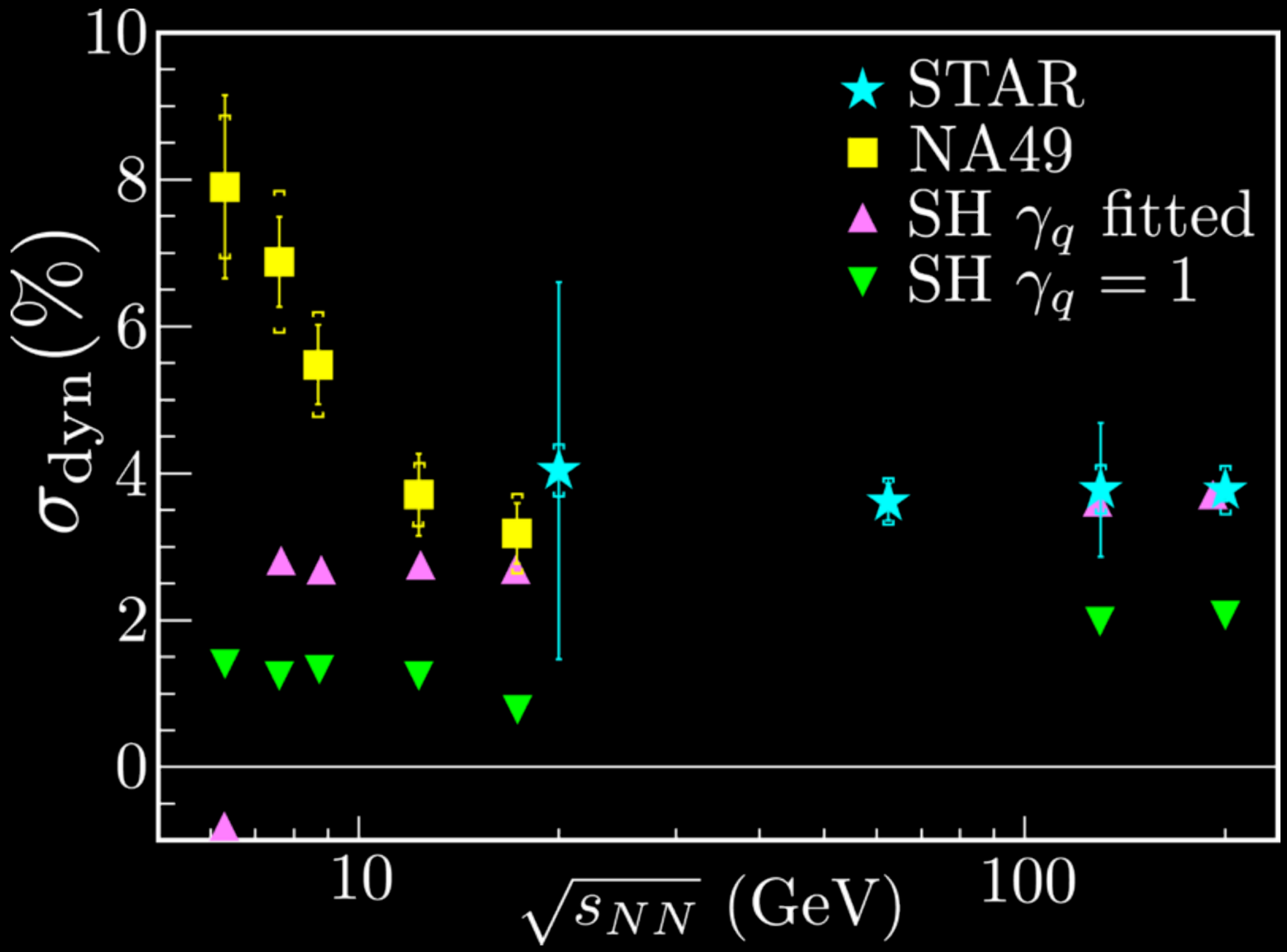

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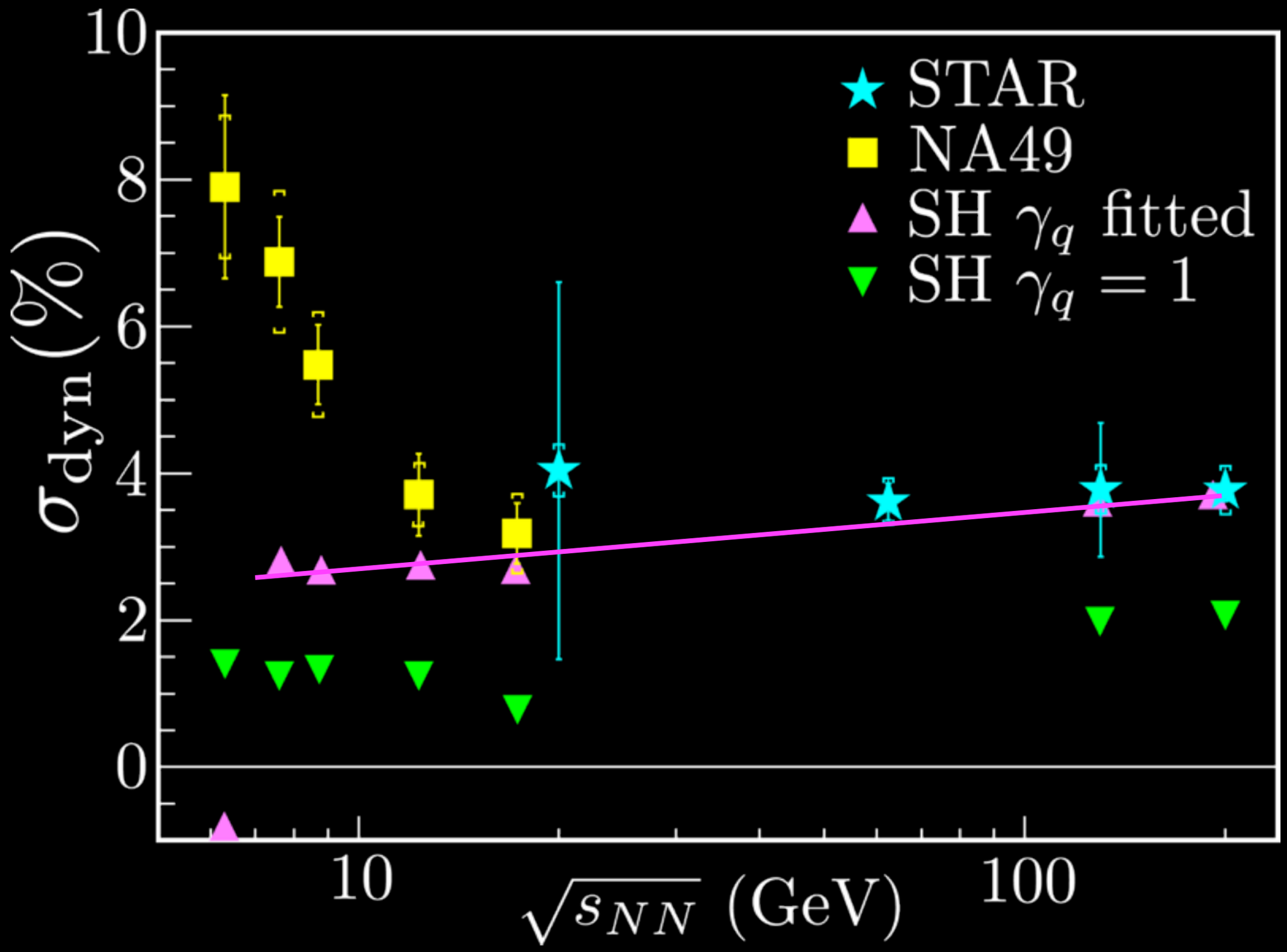

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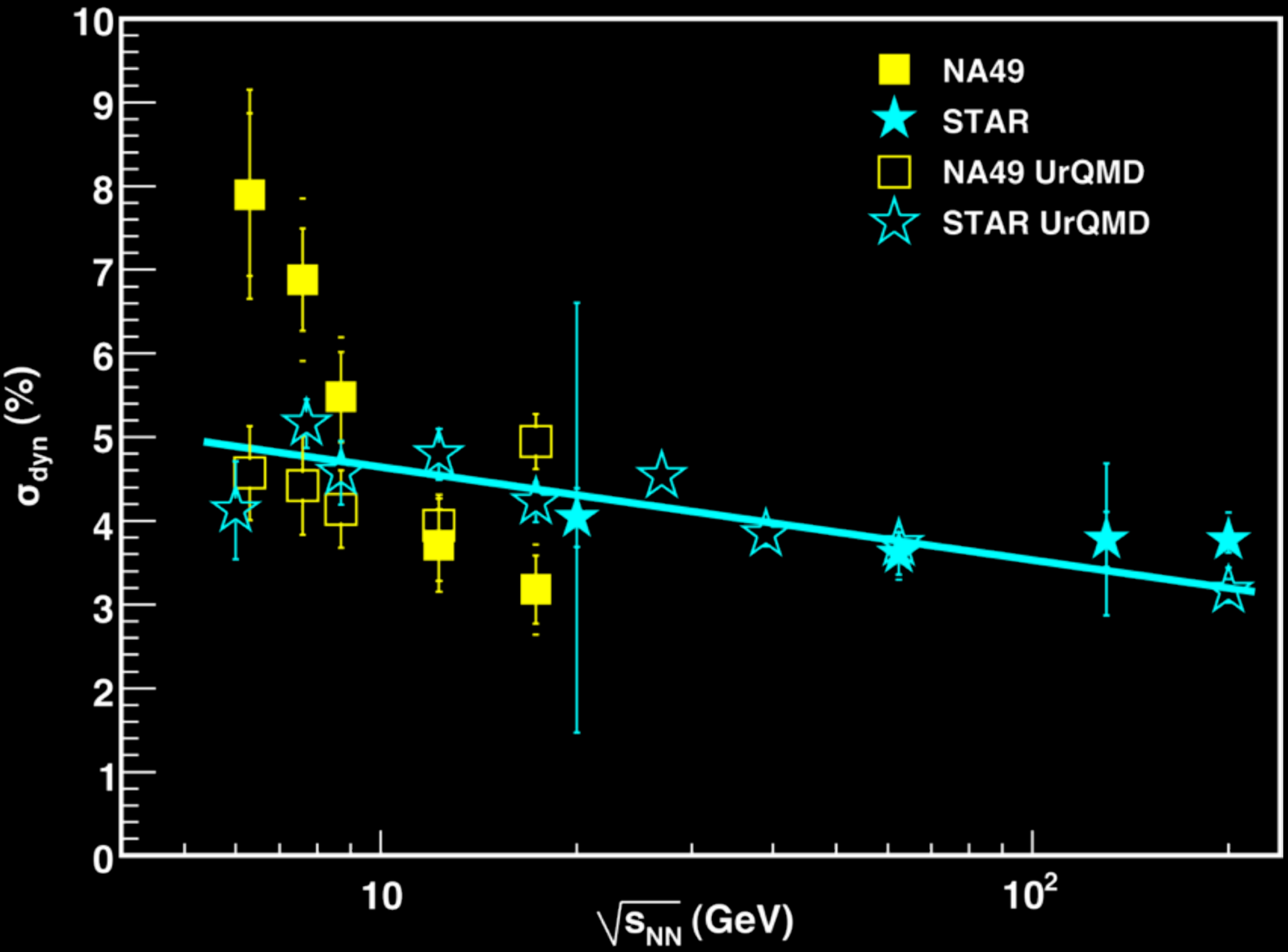
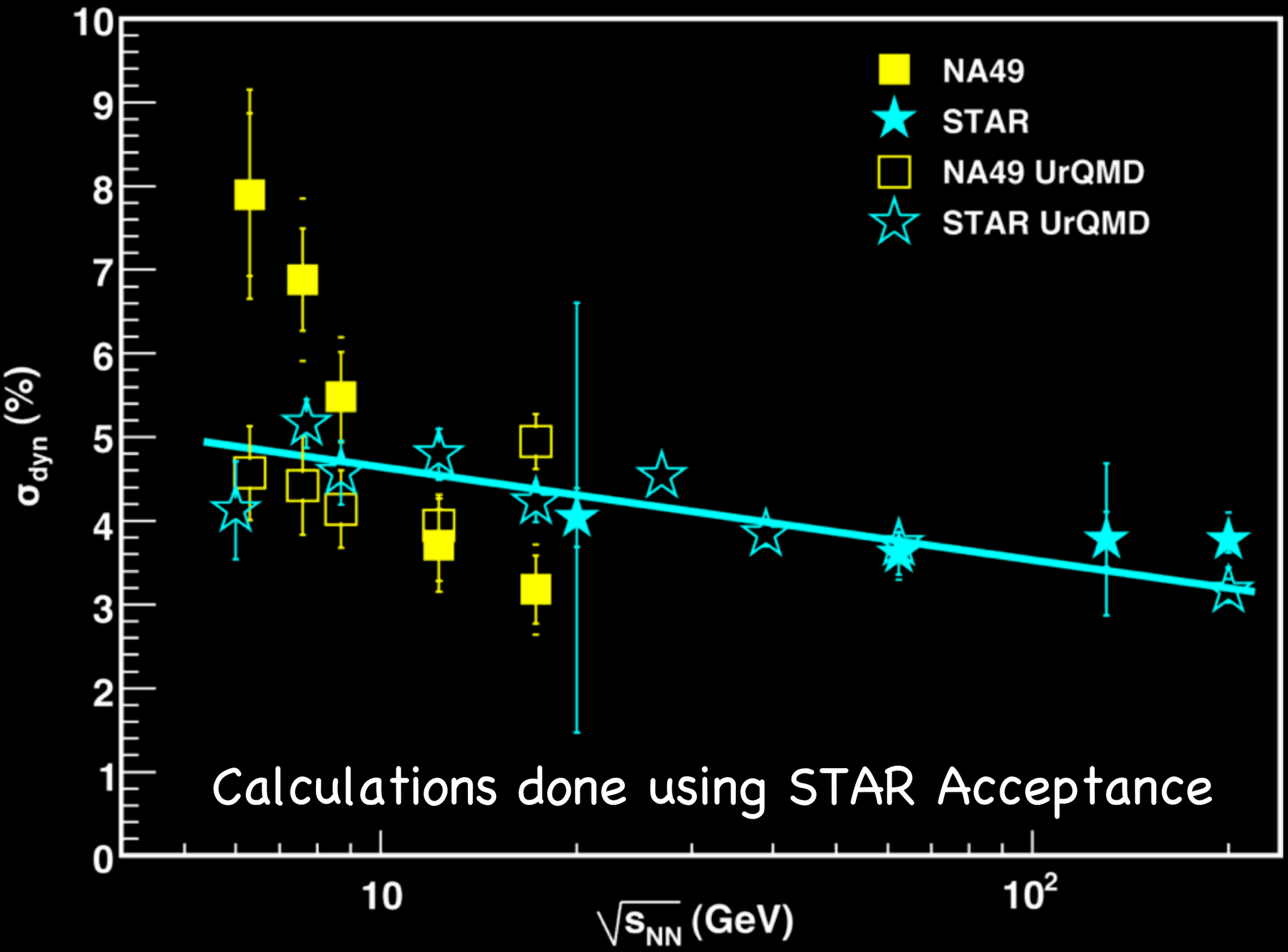

NA49
STAR
NA49 UrQMD
STAR UrQMD
σ_{dyn} (%)
$\sqrt{s_{NN}}$ (GeV)
0
1
2
3
4
5
6
7
8
9
10
10
10^2

UrQMD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Calculations done using STAR Acceptance

HSD

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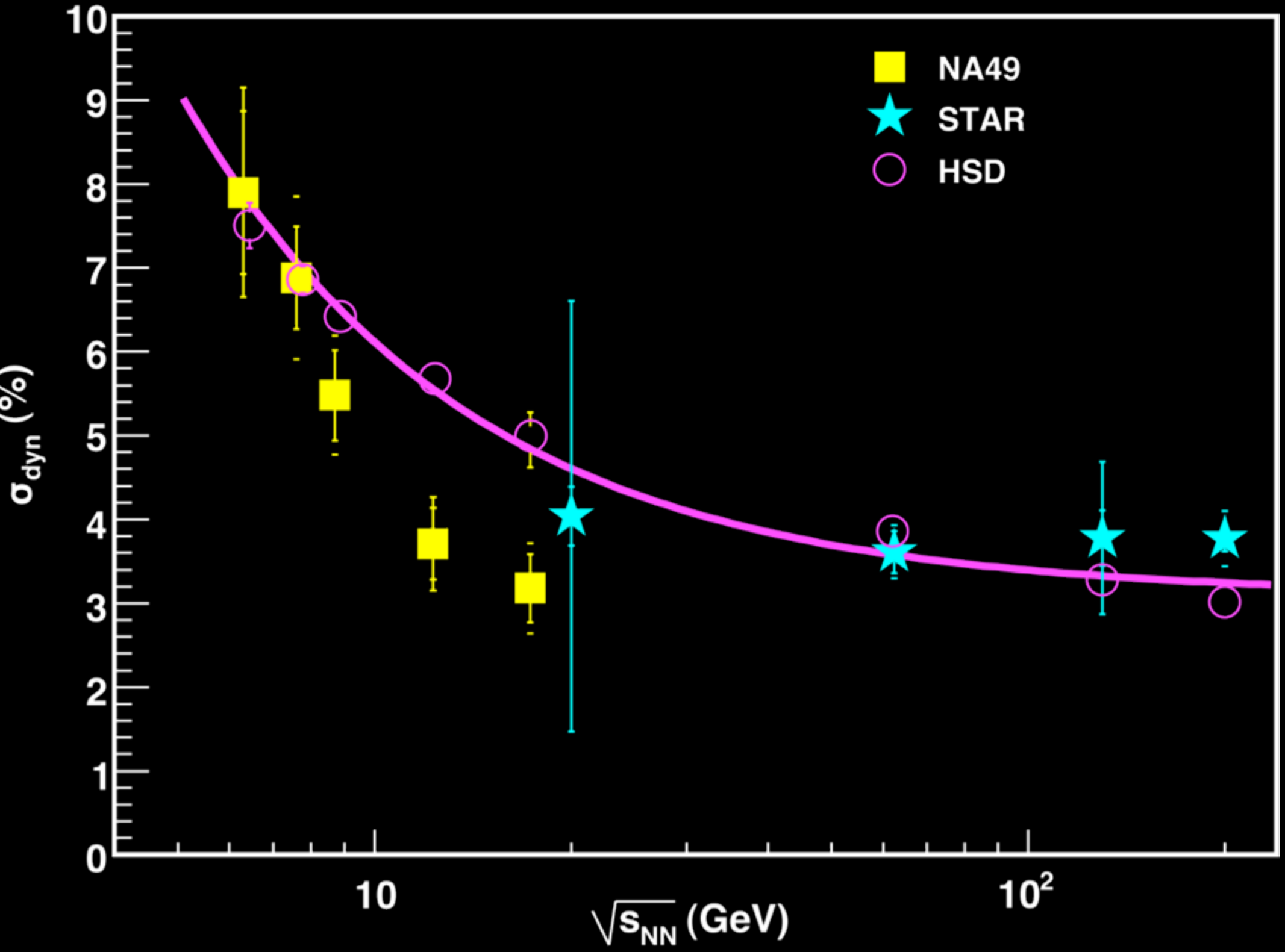

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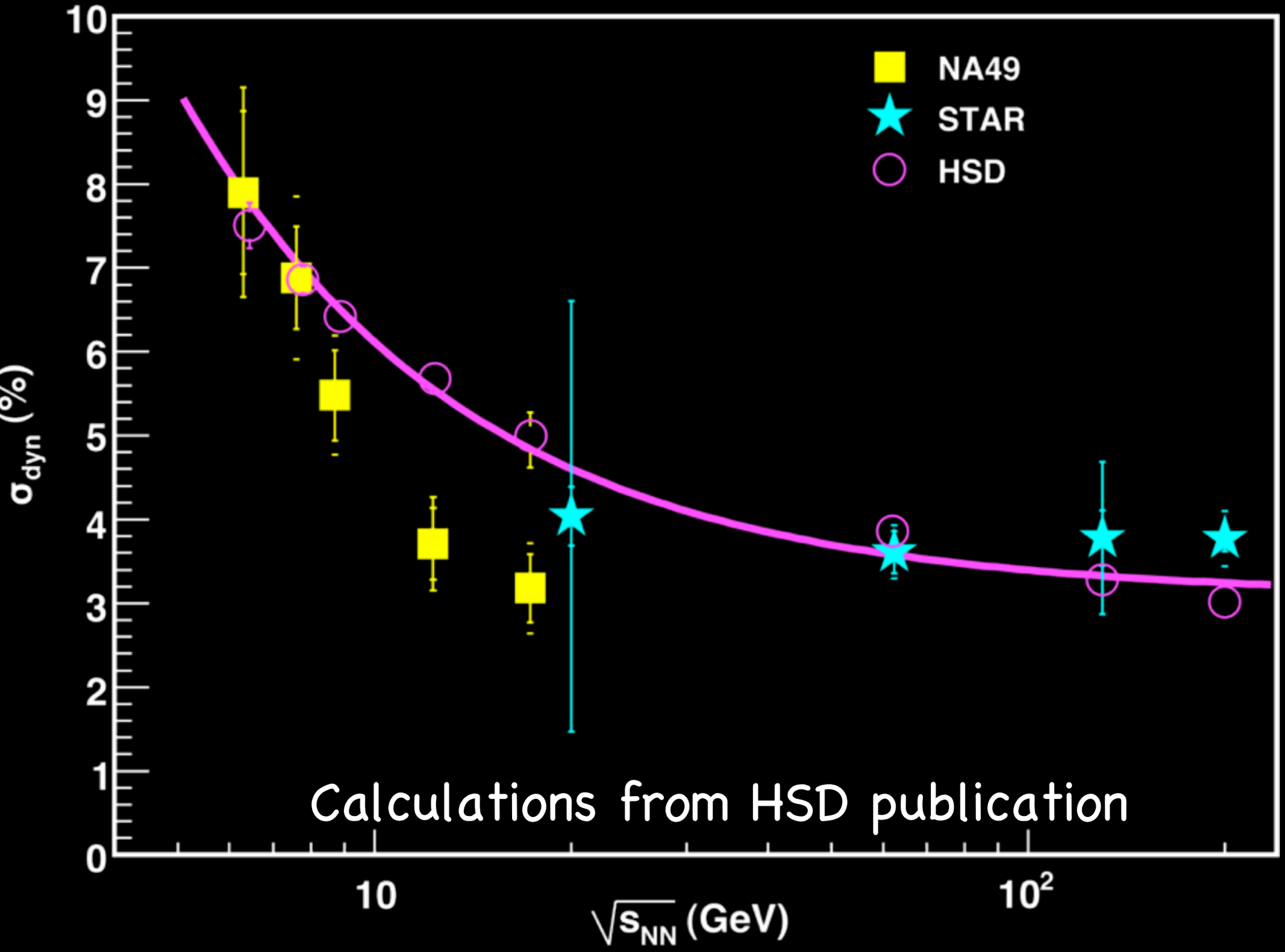
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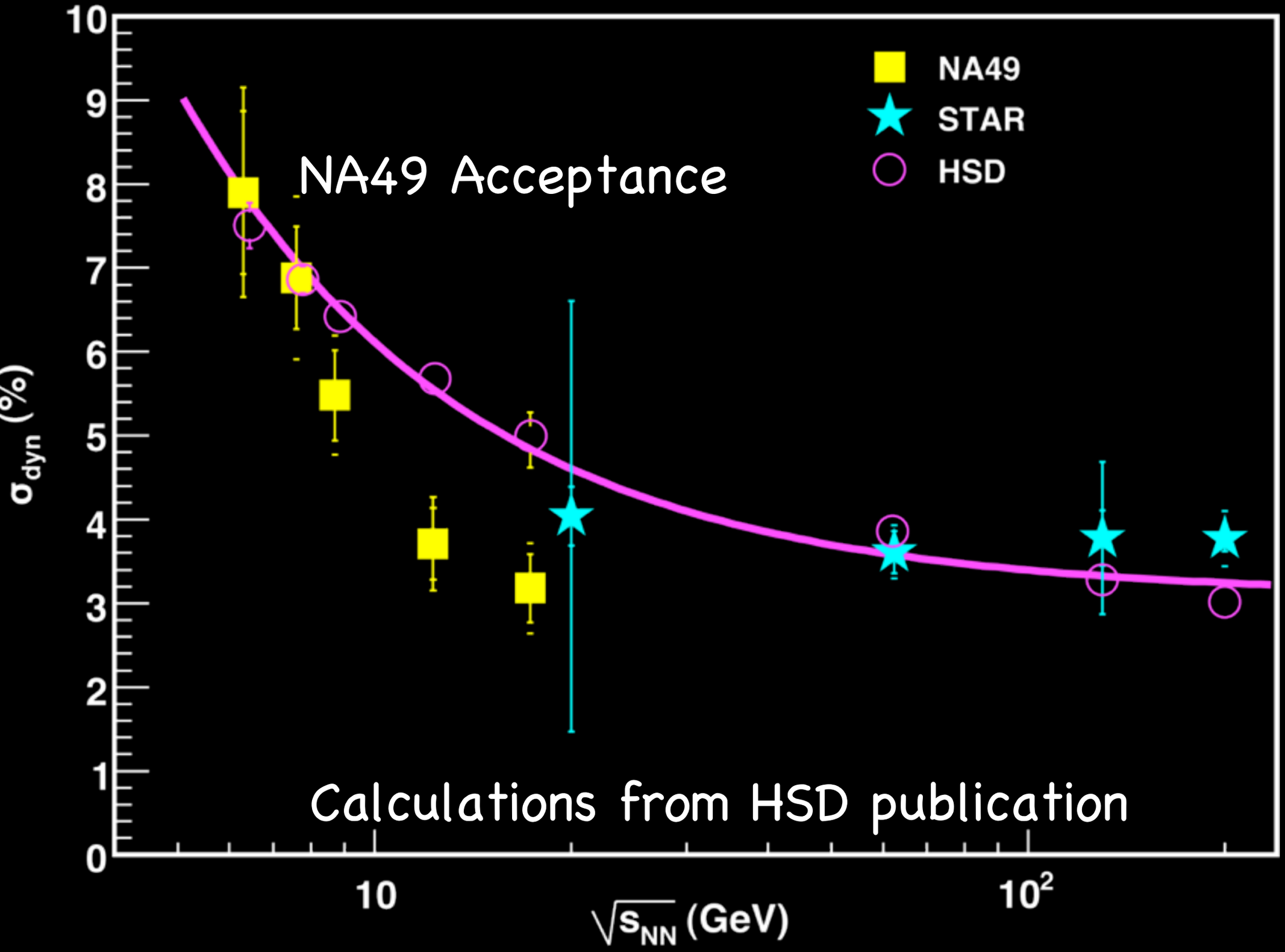
Calculations from HSD publication

HSD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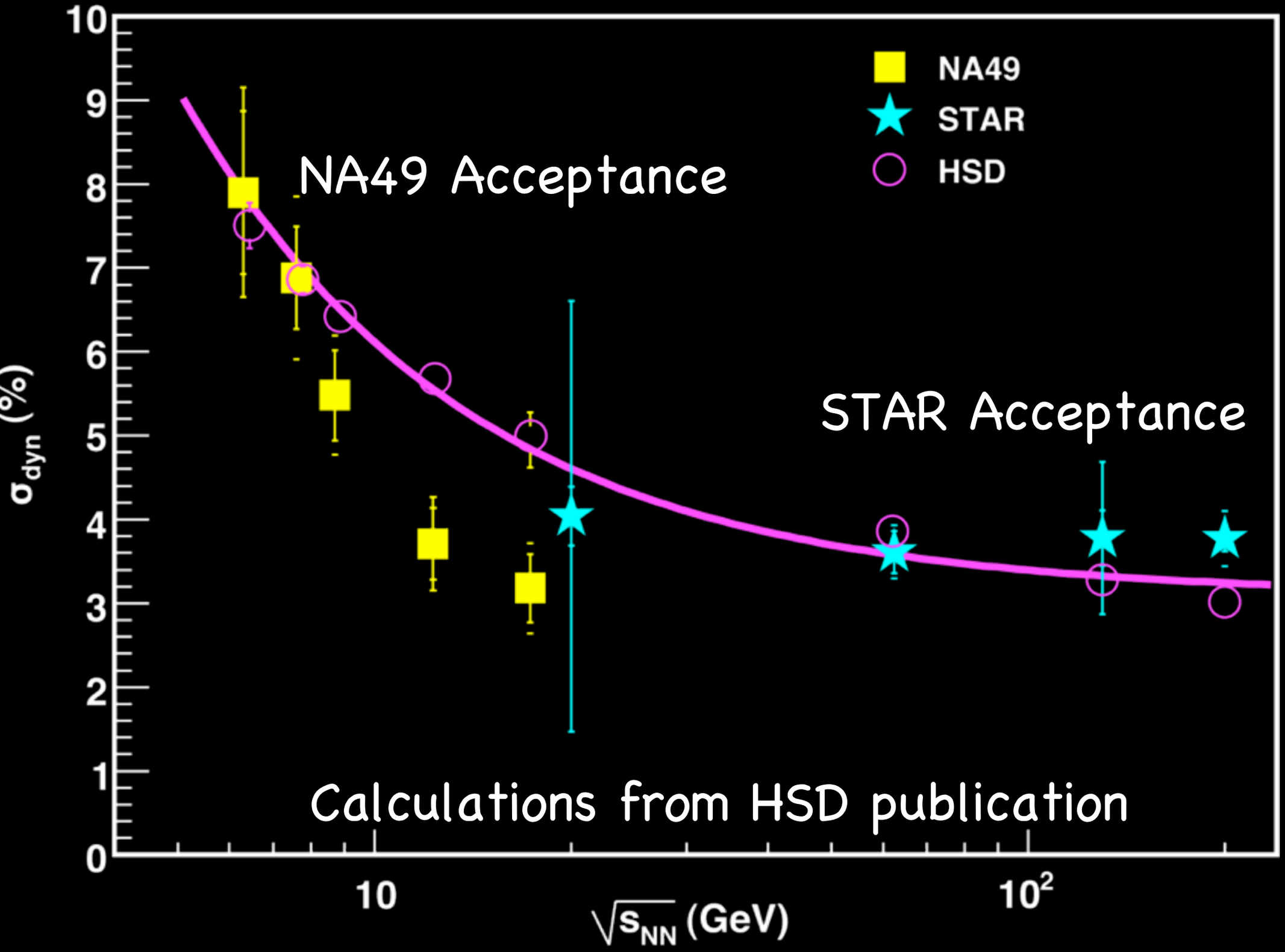
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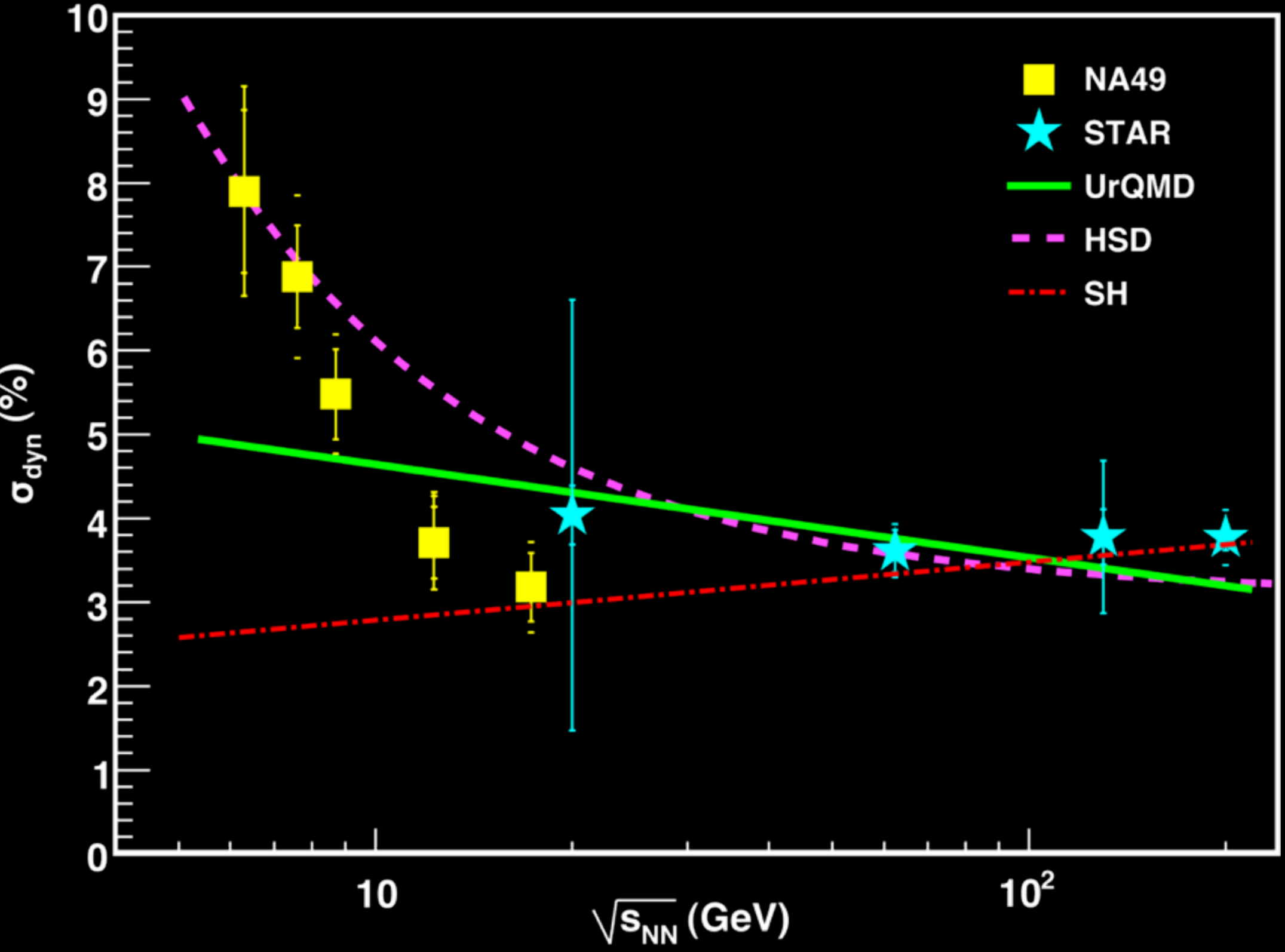

Compare STAR K/π Data with UrQMD and HSD

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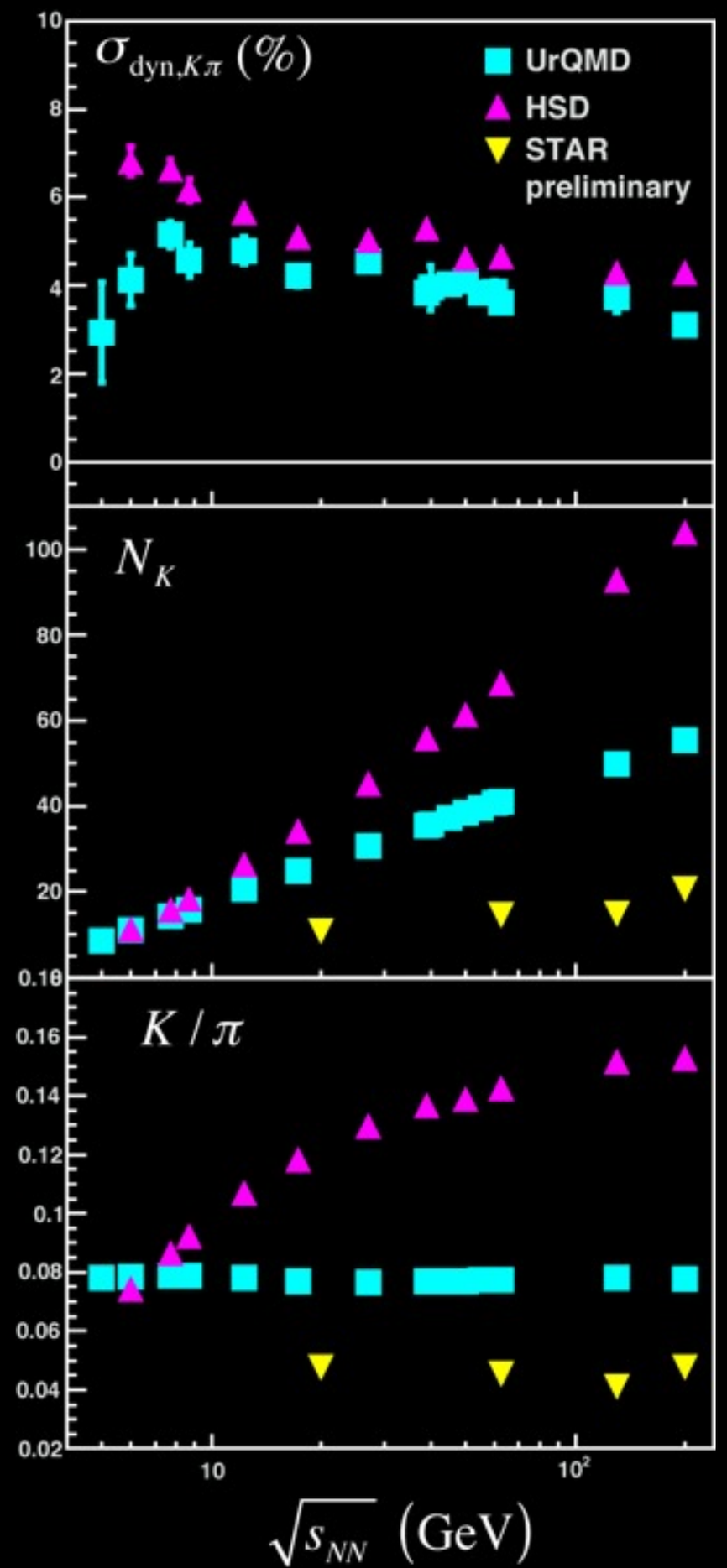

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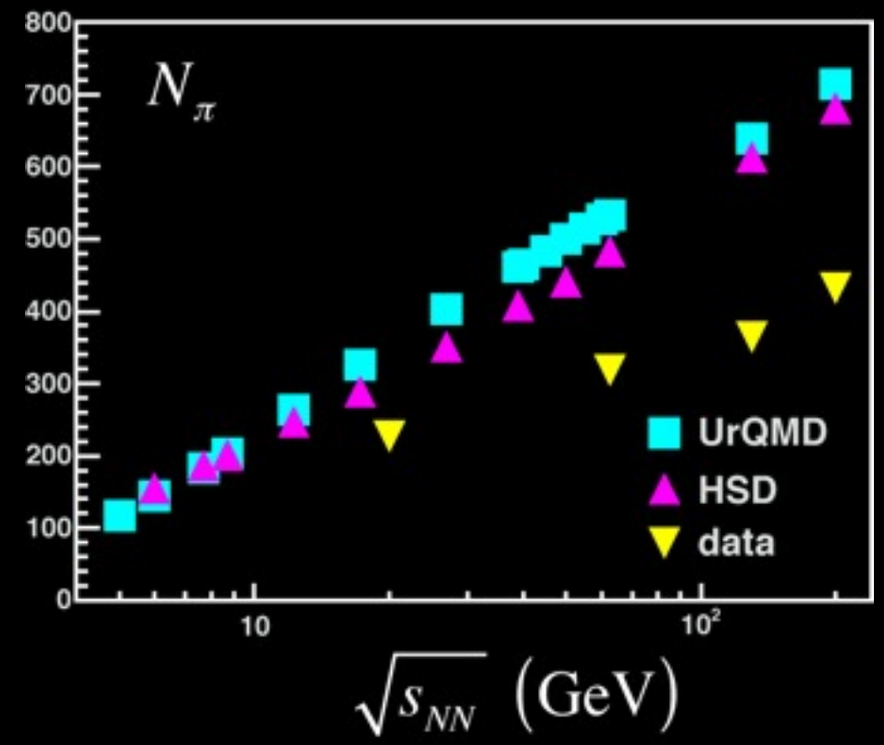

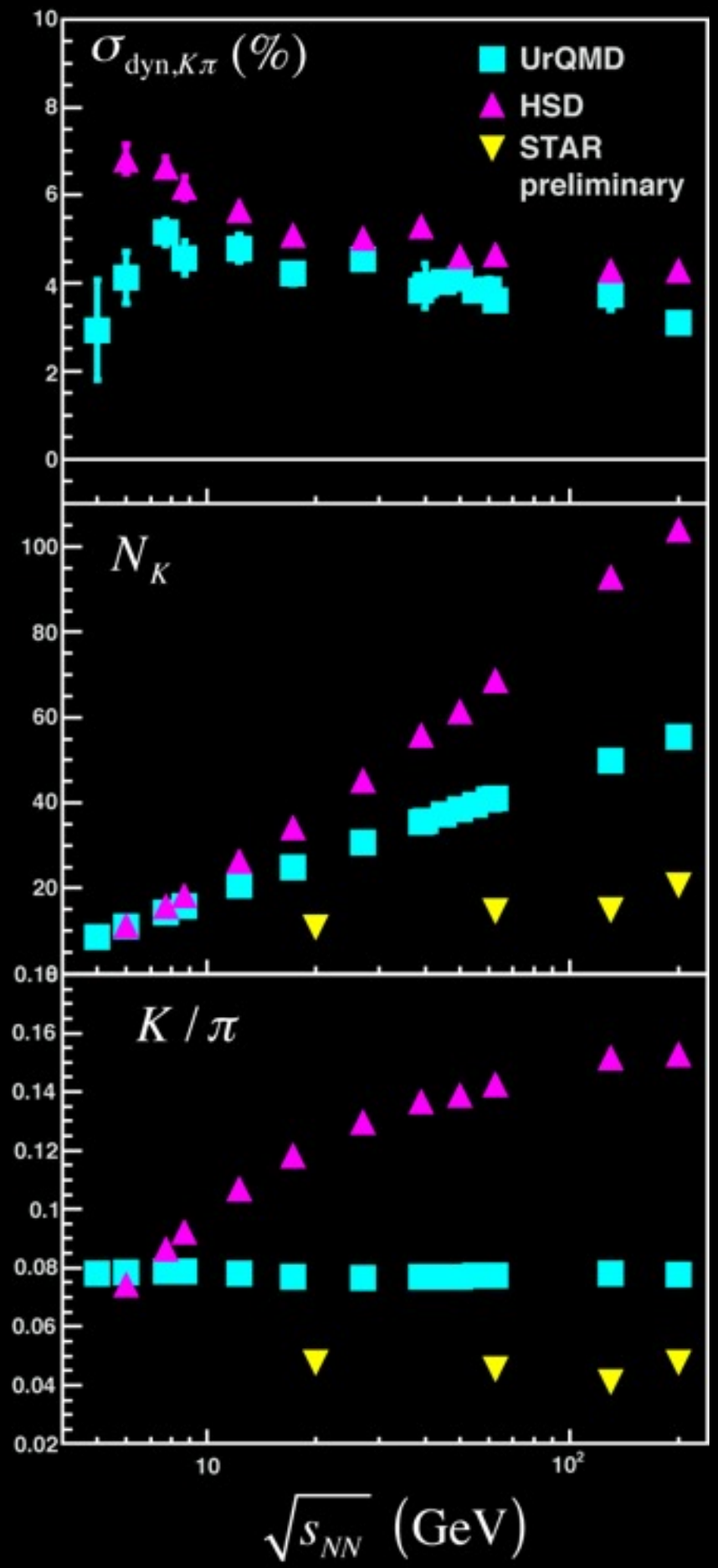

Another Explanation for K/π

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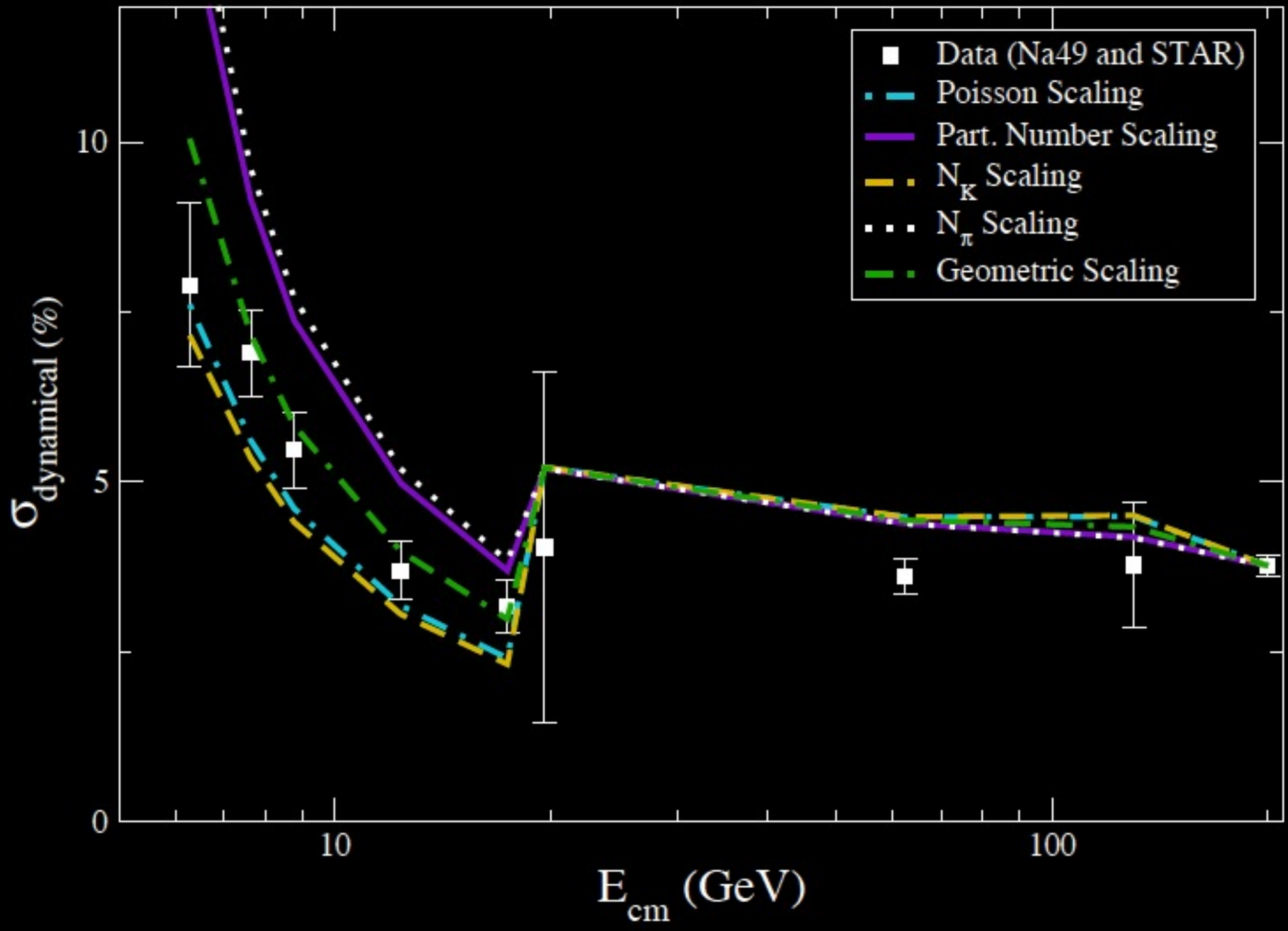

Scaling for K/π Fluctuations

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Poisson: $\sigma_{dyn}\left(\sqrt{s}\right) = \sigma_{dyn}\left(200\ GeV\right)\dfrac{\left[\sqrt{\dfrac{1}{\langle K\rangle}+\dfrac{1}{\langle \pi\rangle}}\right]_{\sqrt{s}}}{\left[\sqrt{\dfrac{1}{\langle K\rangle}+\dfrac{1}{\langle \pi\rangle}}\right]_{200\ GeV}}$

Particle Number: $\sigma_{dyn}\left(\sqrt{s}\right) = \sigma_{dyn}\left(200\ GeV\right)\dfrac{\left[\sqrt{\langle K\rangle+\langle \pi\rangle}\right]_{200\ GeV}}{\left[\sqrt{\langle K\rangle+\langle \pi\rangle}\right]_{\sqrt{s}}}$

N_K : $\sigma_{dyn}\left(\sqrt{s}\right) = \sigma_{dyn}\left(200\ GeV\right)\dfrac{\left[\sqrt{\langle K\rangle}\right]_{200\ GeV}}{\left[\sqrt{\langle K\rangle}\right]_{\sqrt{s}}}$ N_π in a similar way

Geometric: $\sigma_{dyn}\left(\sqrt{s}\right) = \sigma_{dyn}\left(200\ GeV\right)\dfrac{\left[\left(\langle K\rangle\langle \pi\rangle\right)^{1/4}\right]_{200\ GeV}}{\left[\left(\langle K\rangle\langle \pi\rangle\right)^{1/4}\right]_{\sqrt{s}}}$

Centrality Dependence

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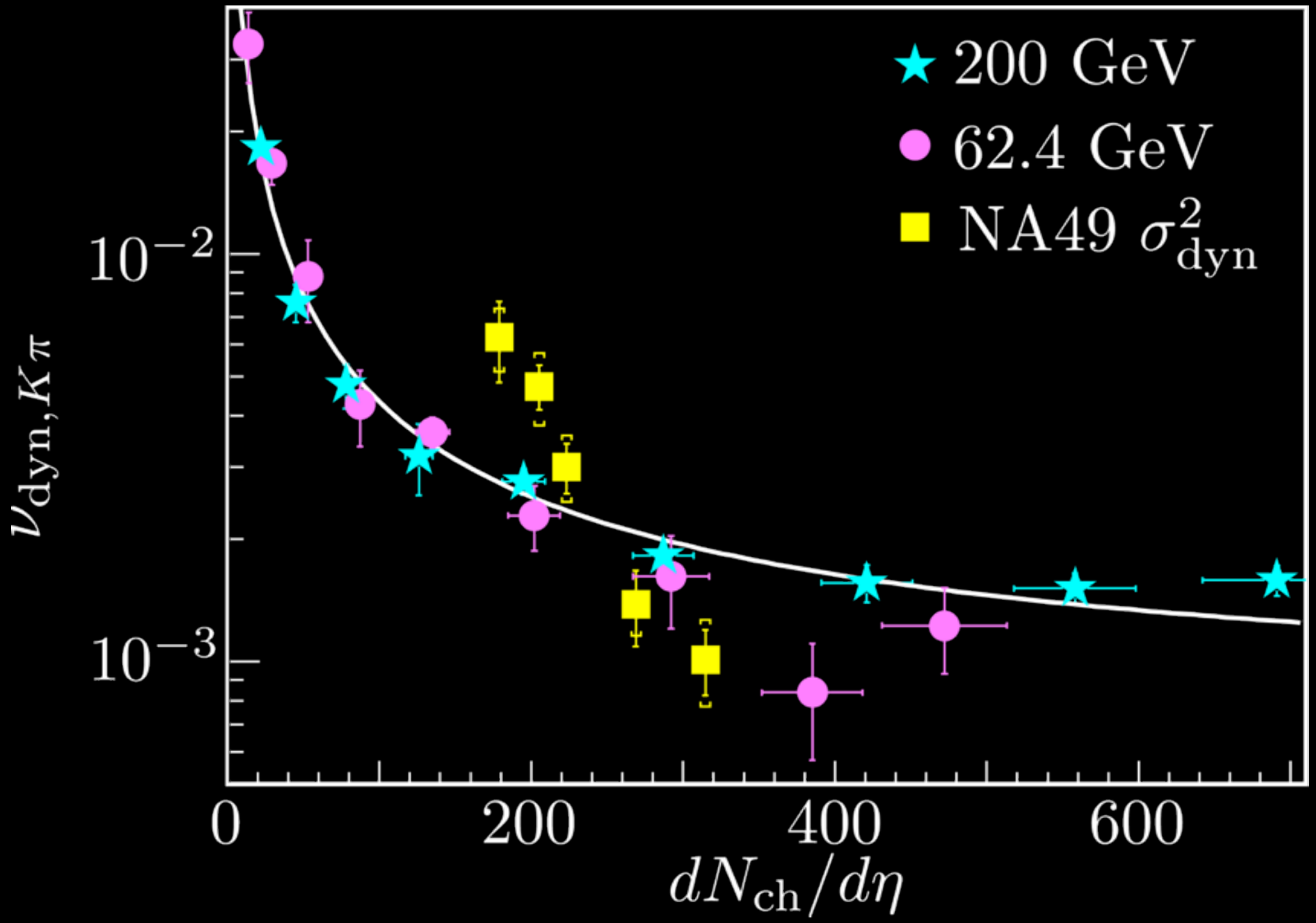

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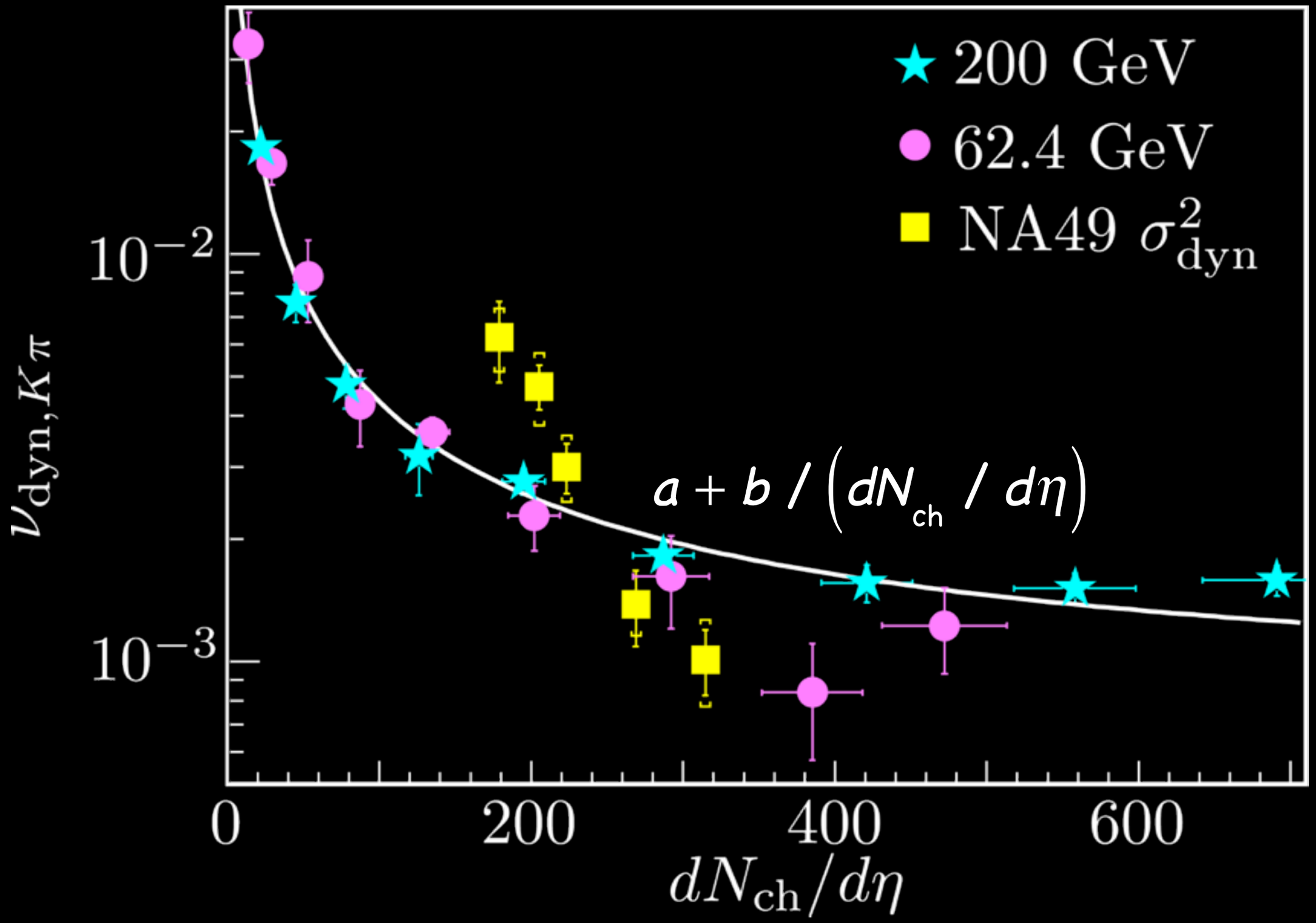

Relate Centrality Dependence to Energy Dependence

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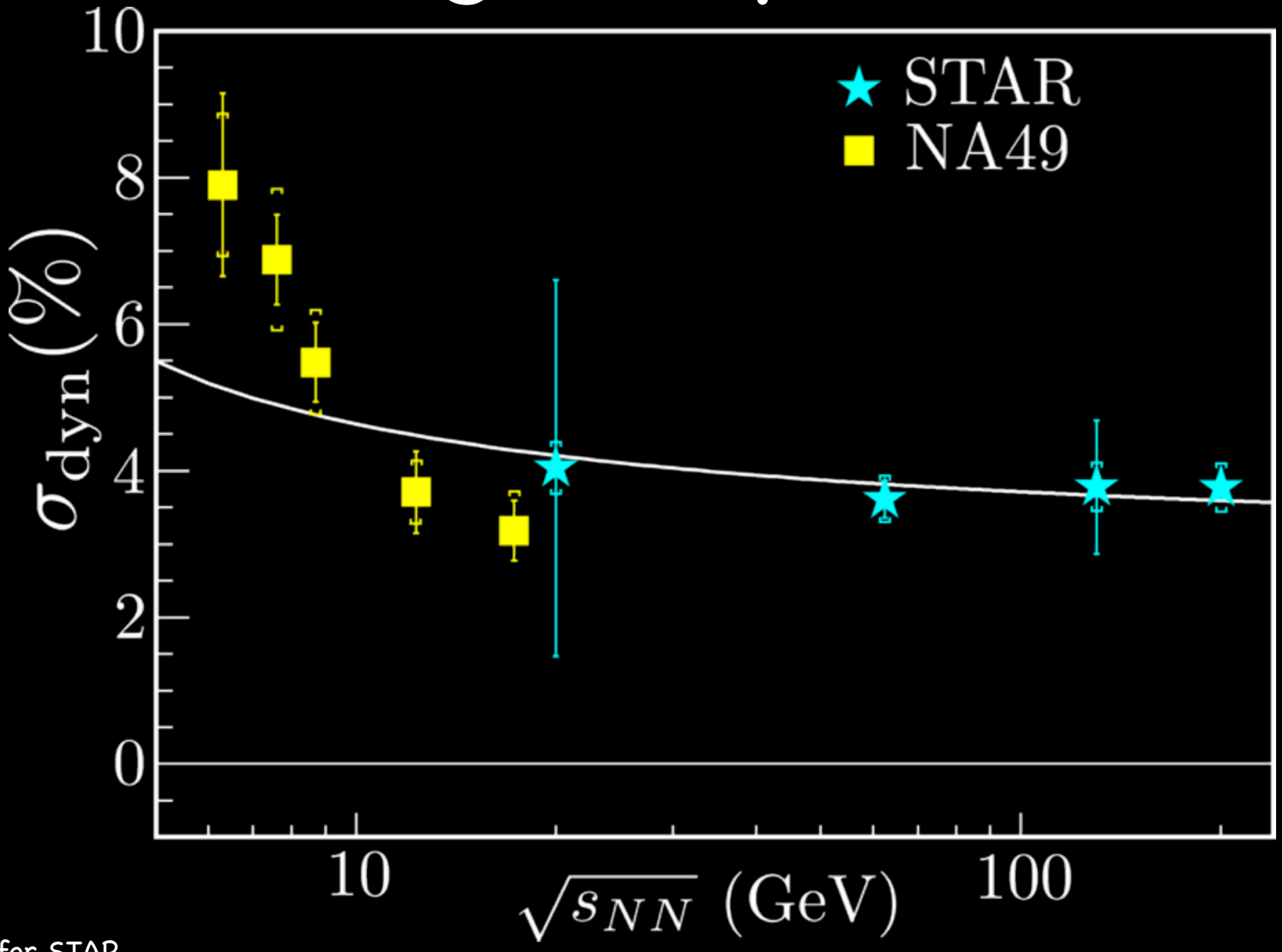

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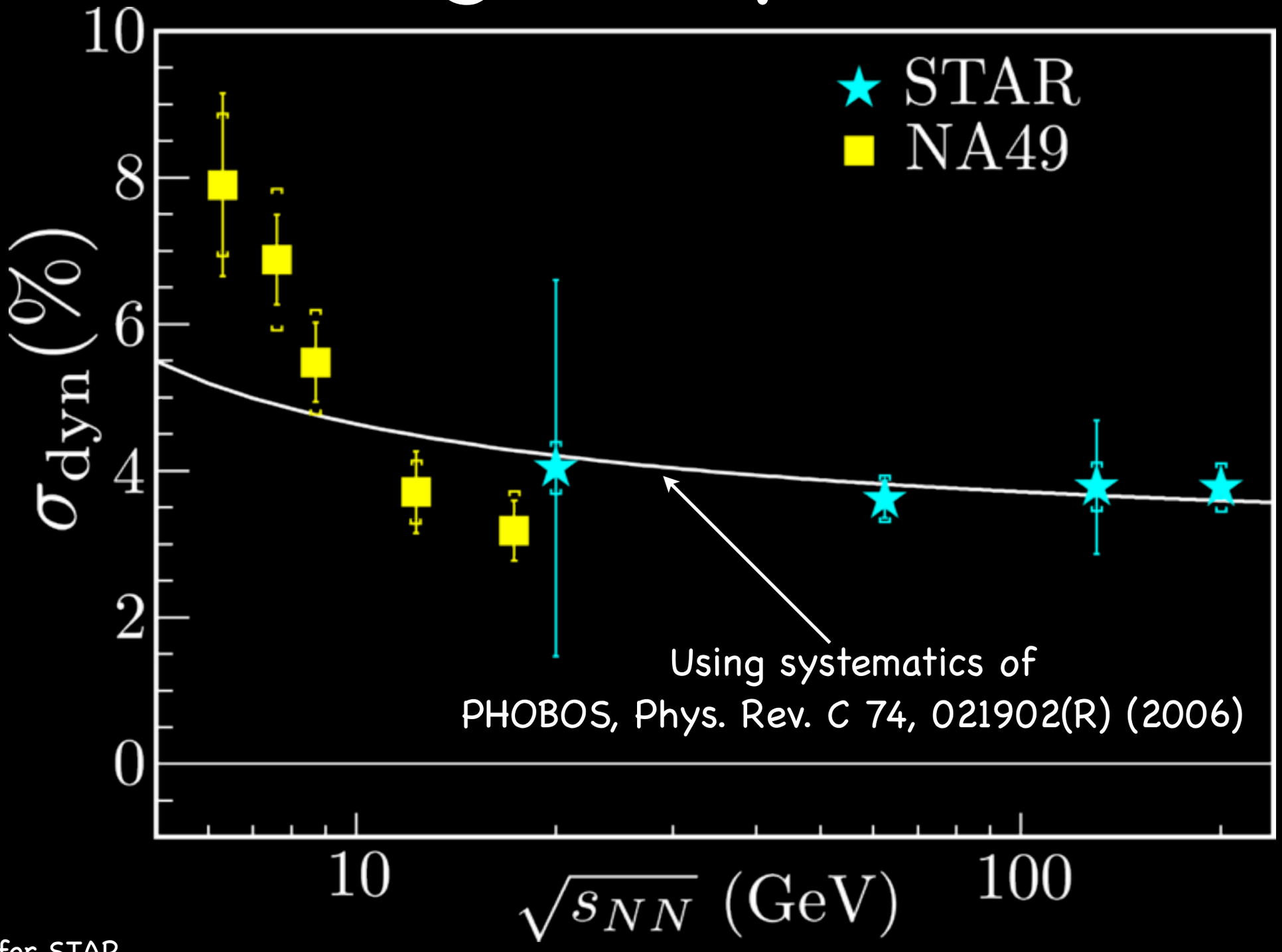

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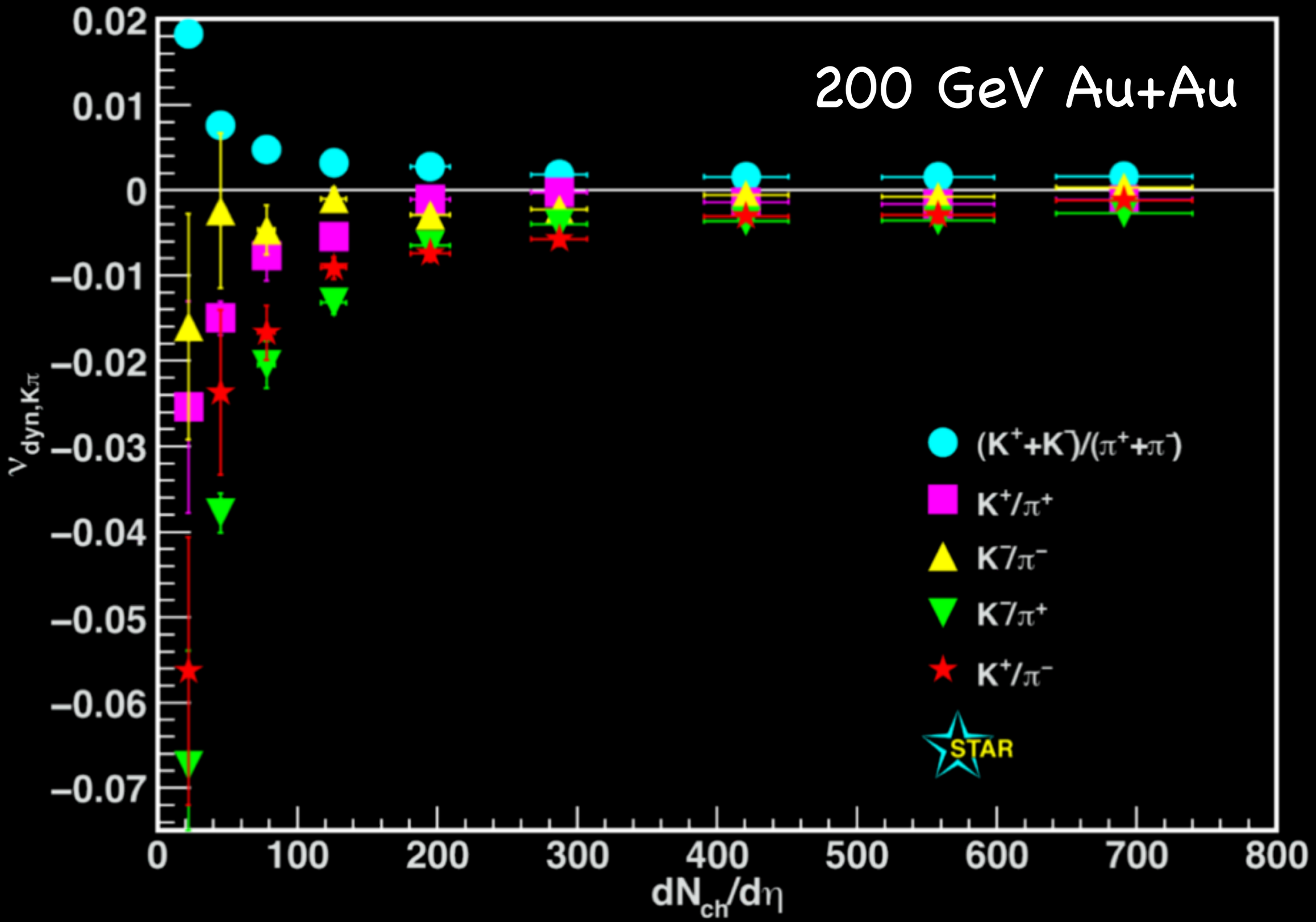

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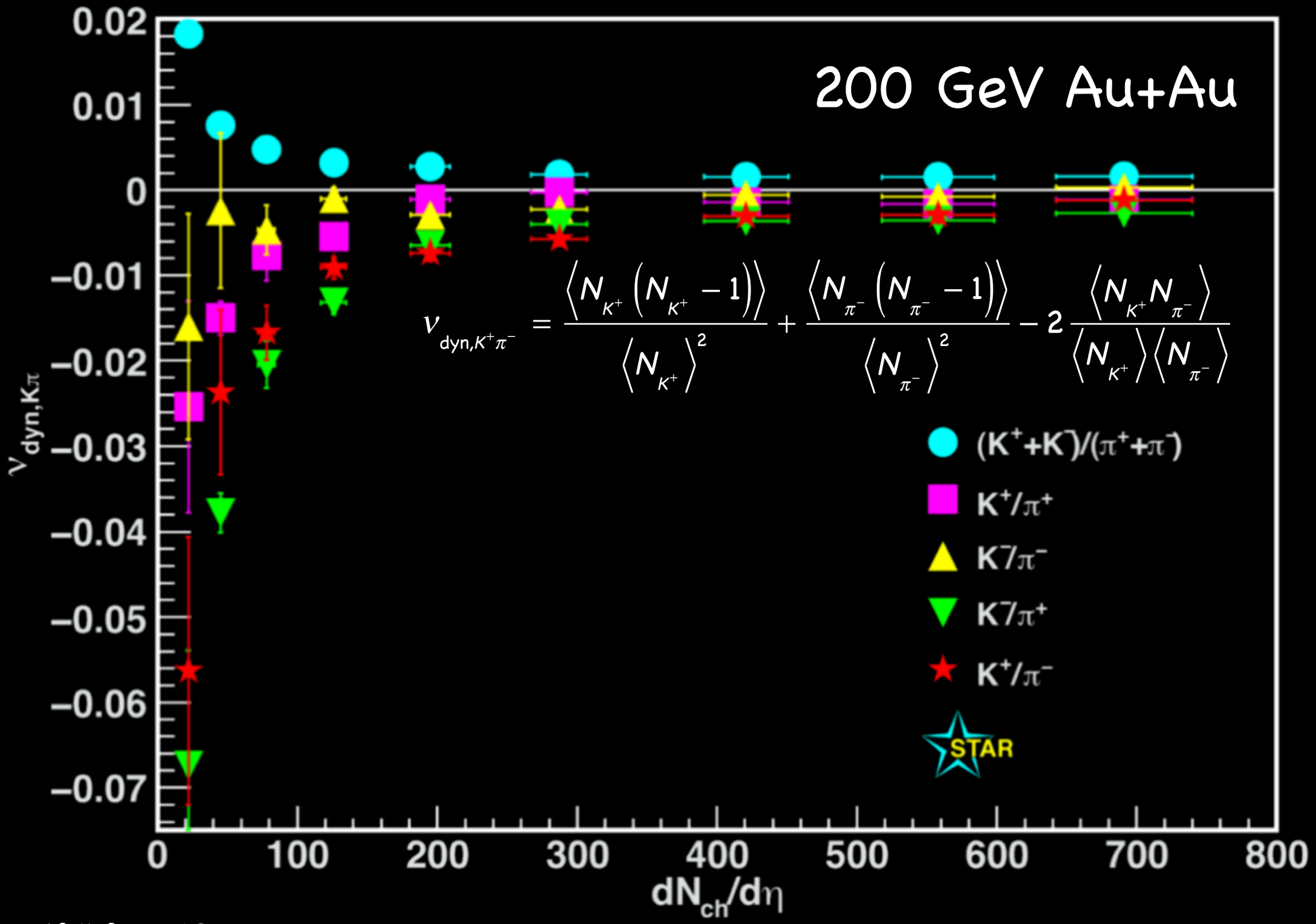

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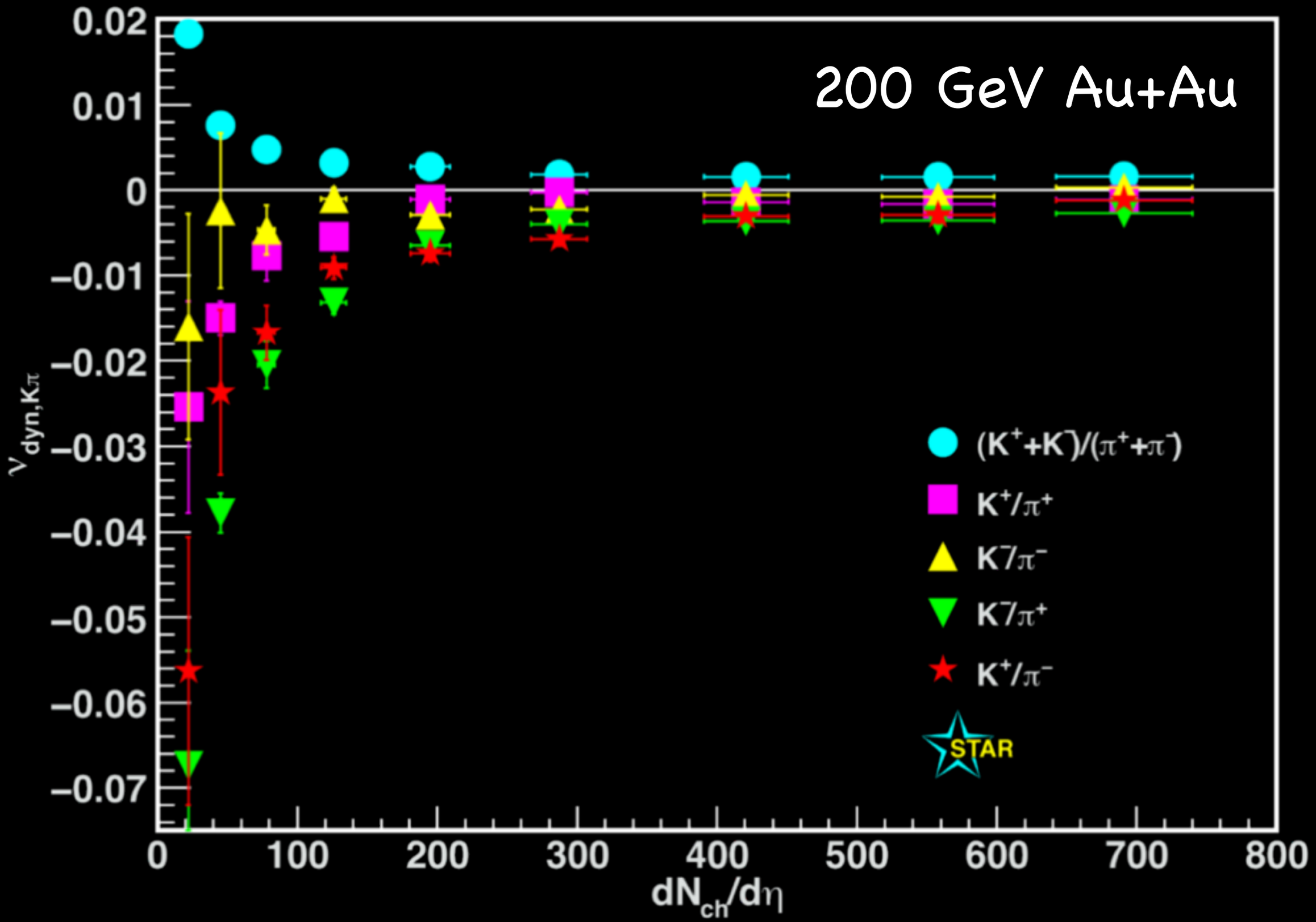

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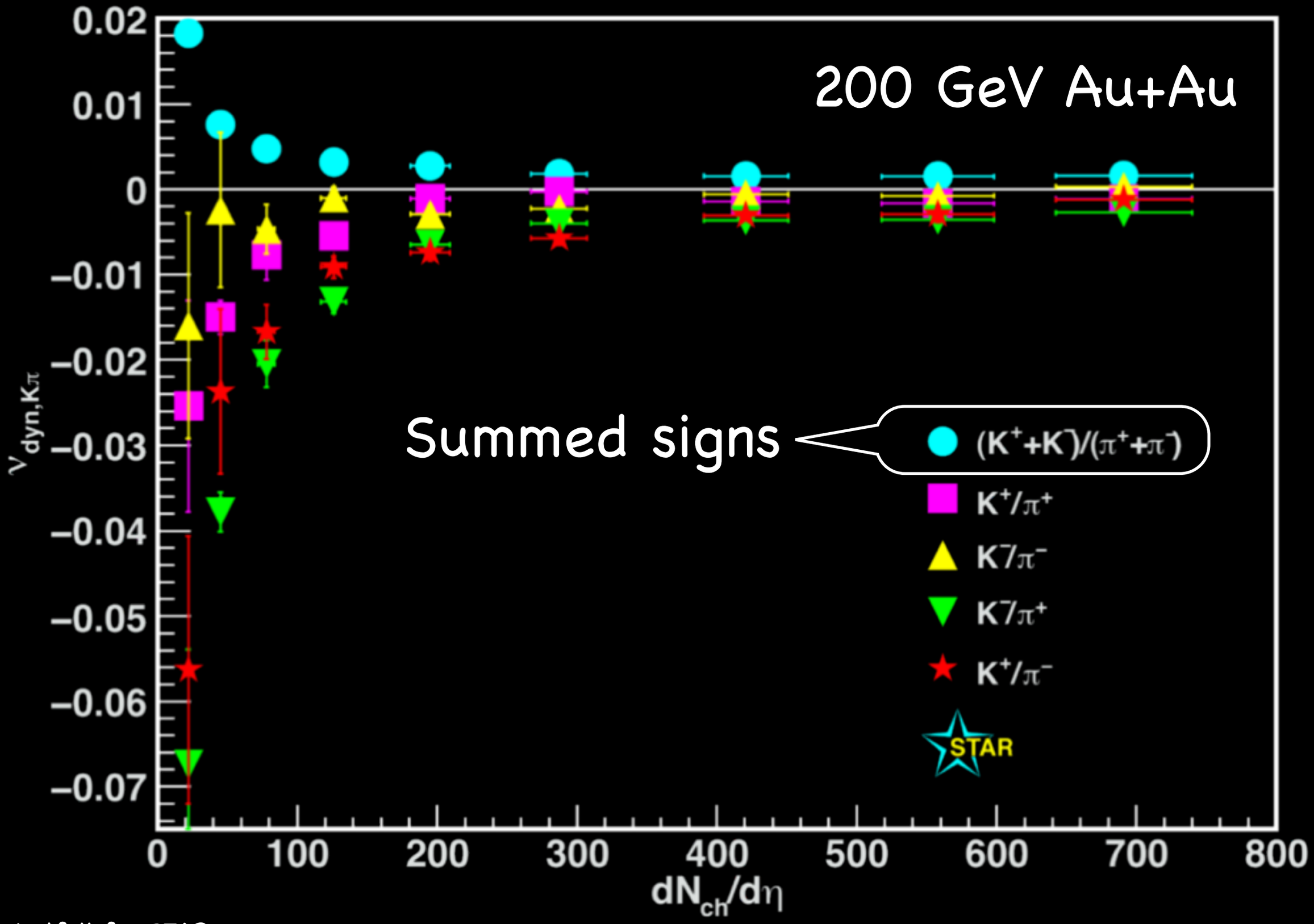

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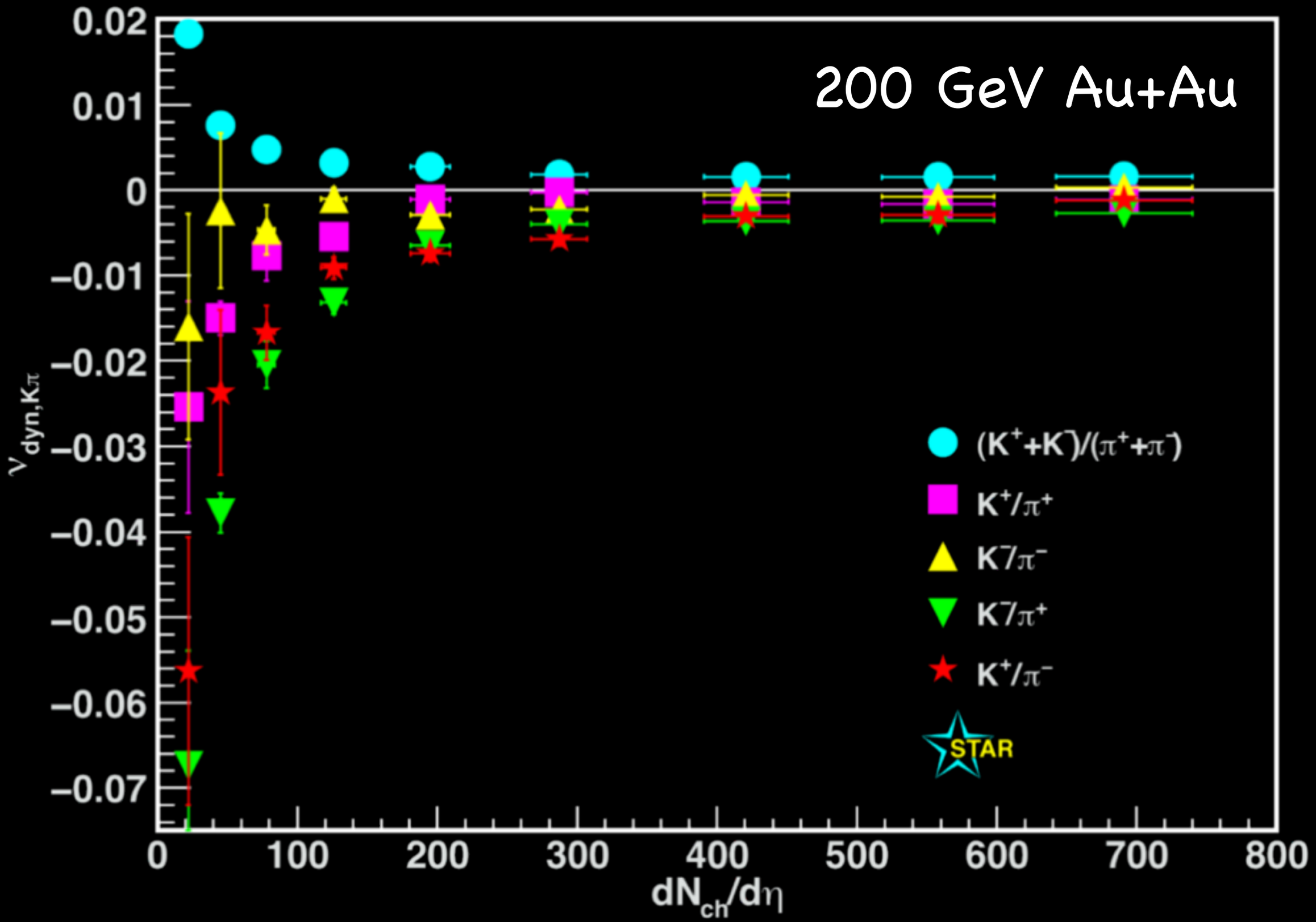

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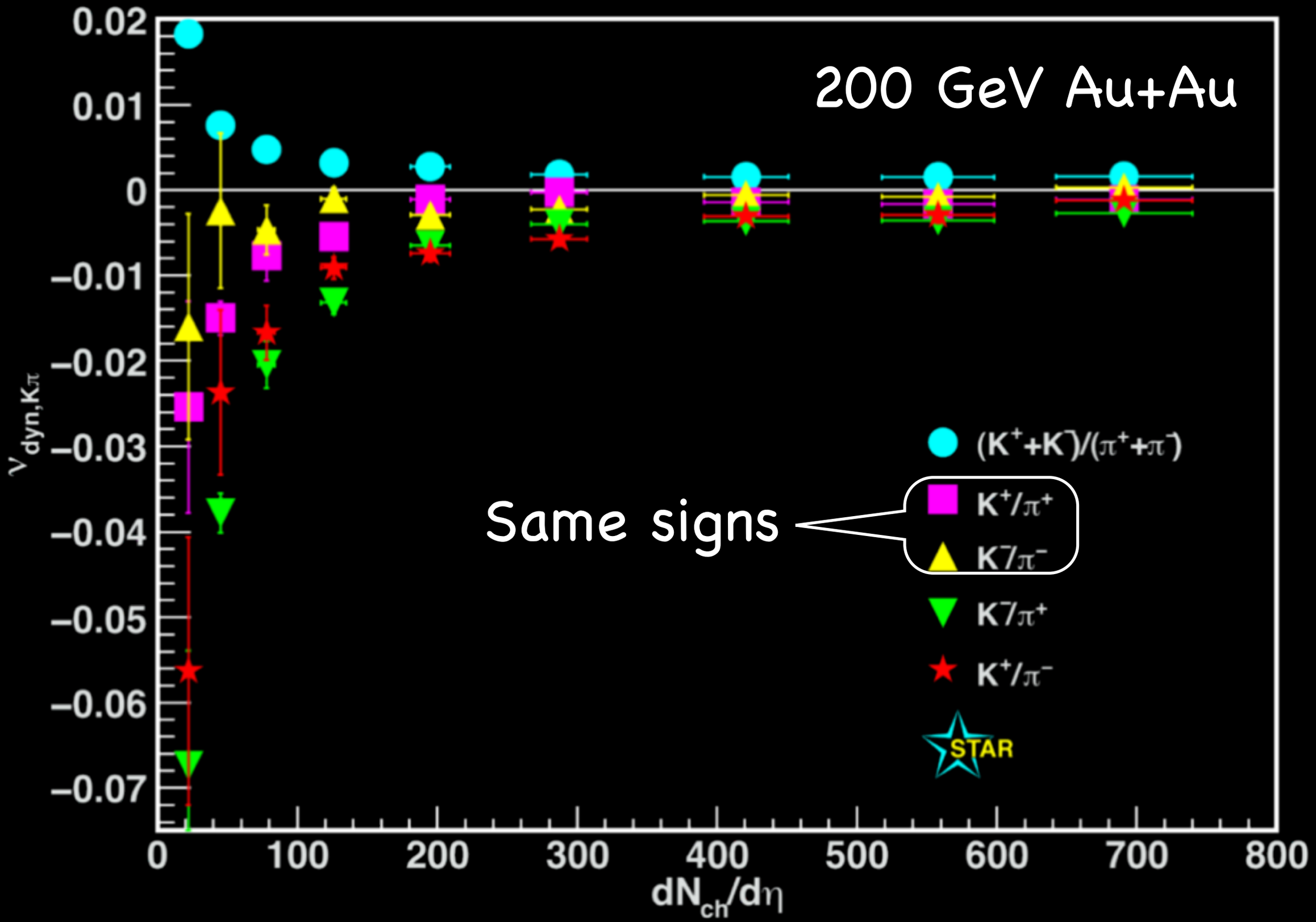

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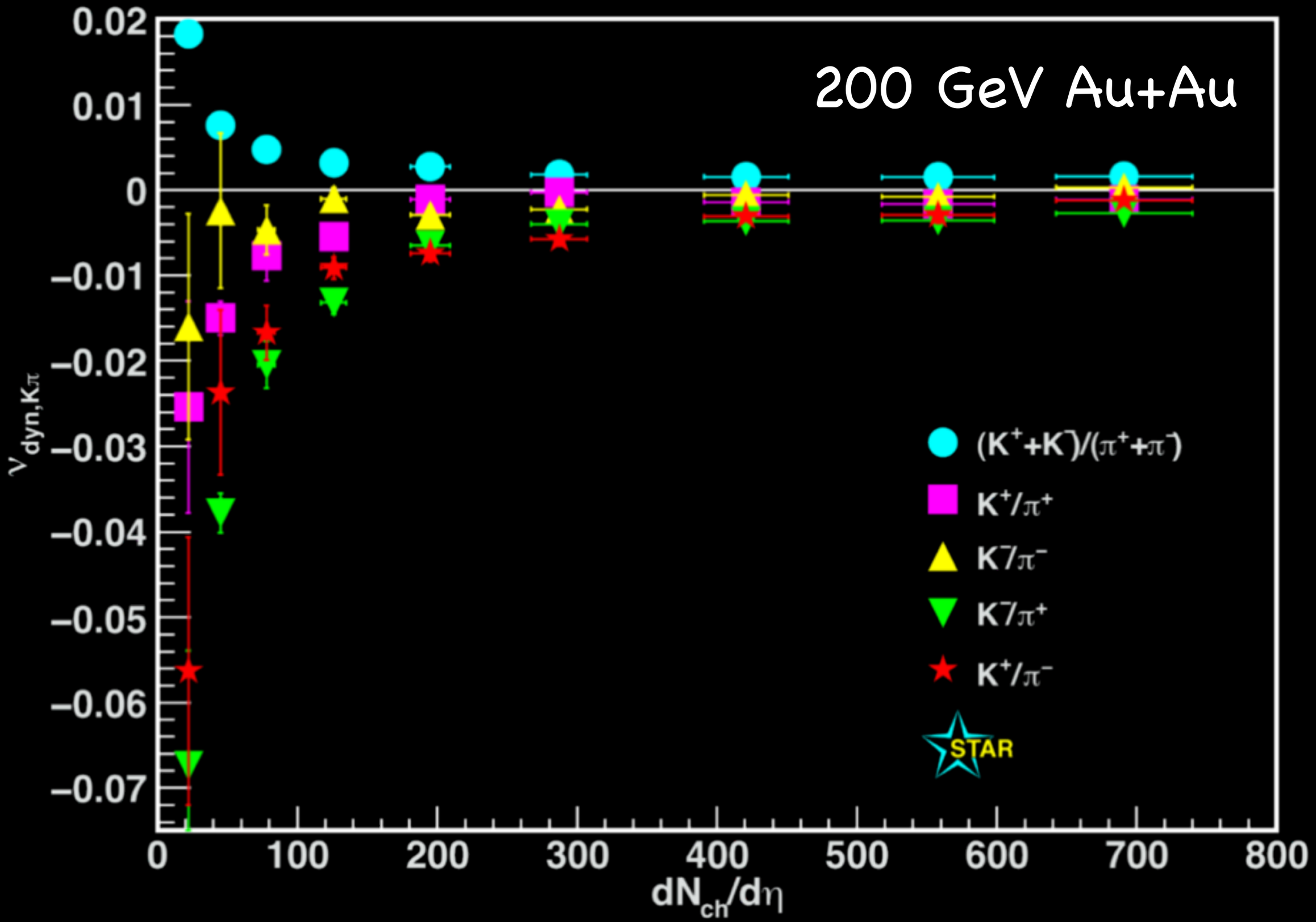

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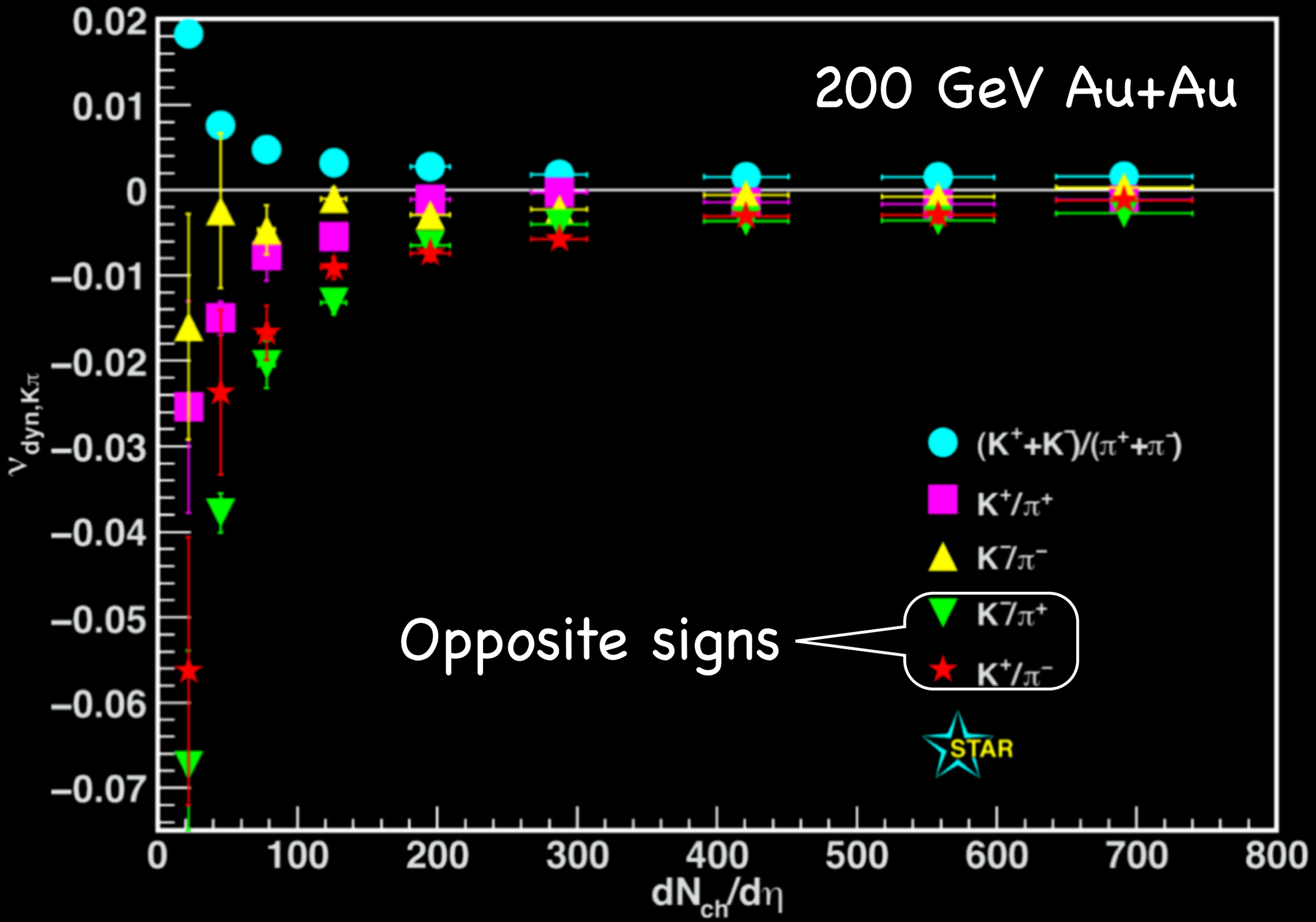

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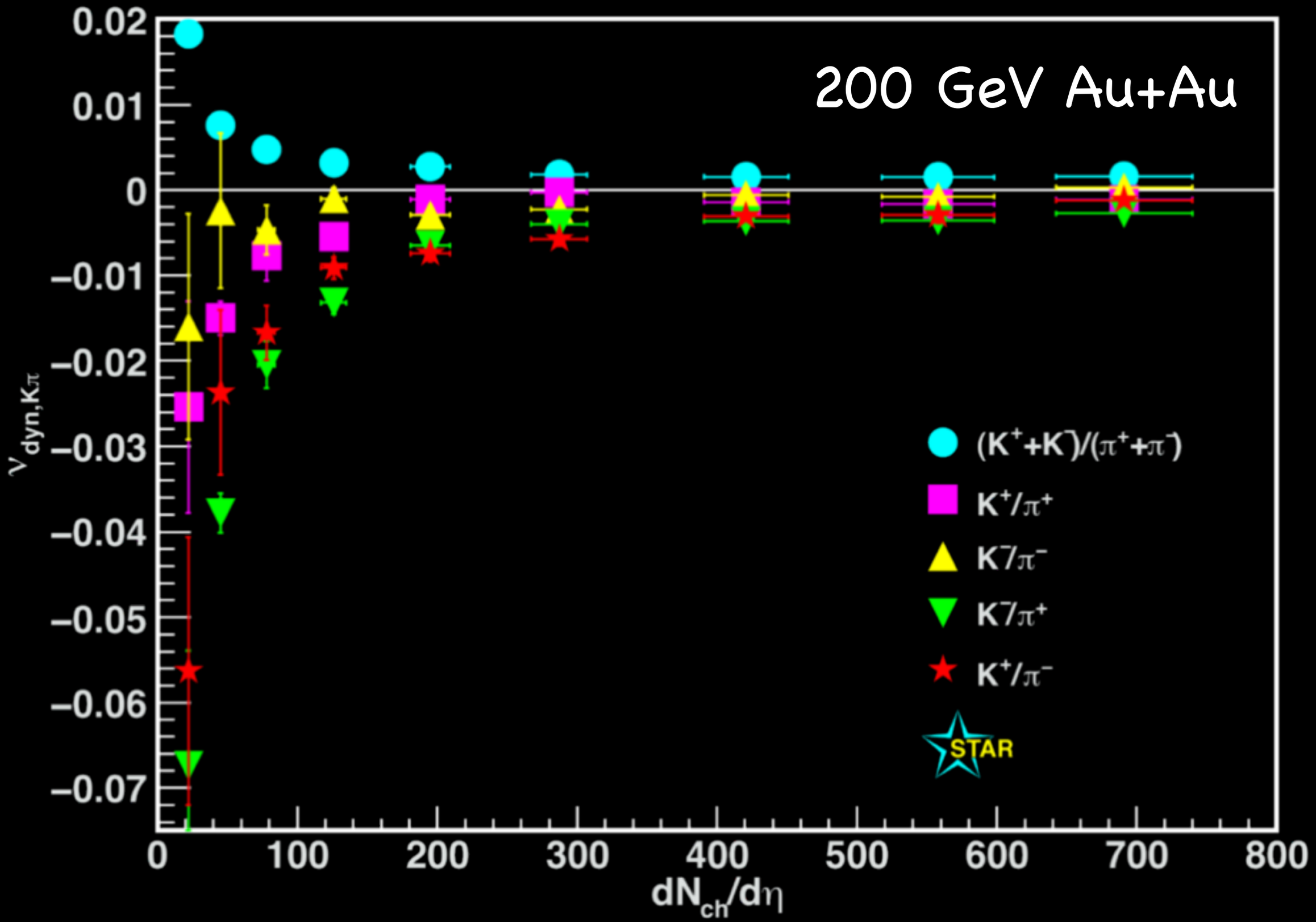

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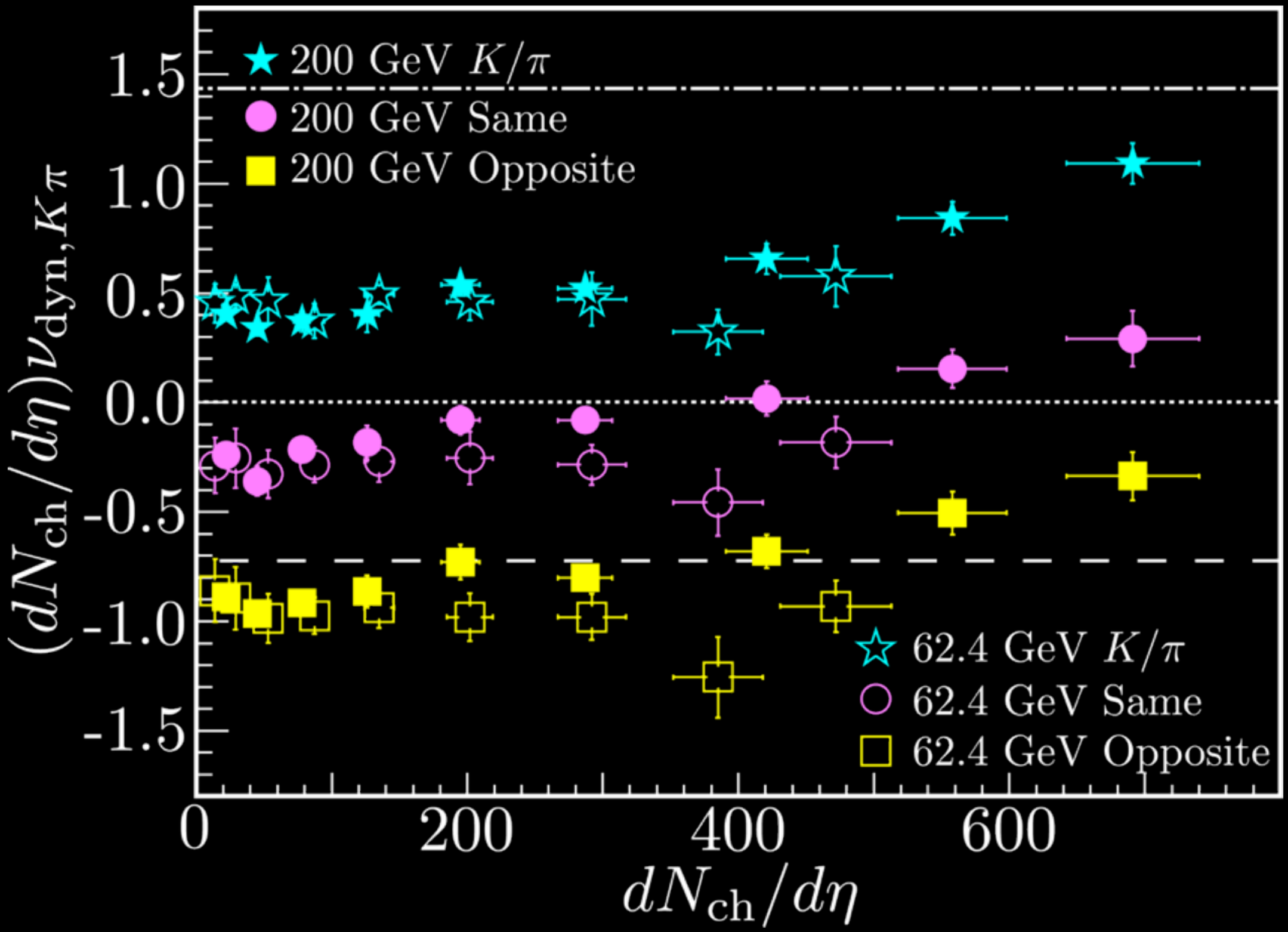

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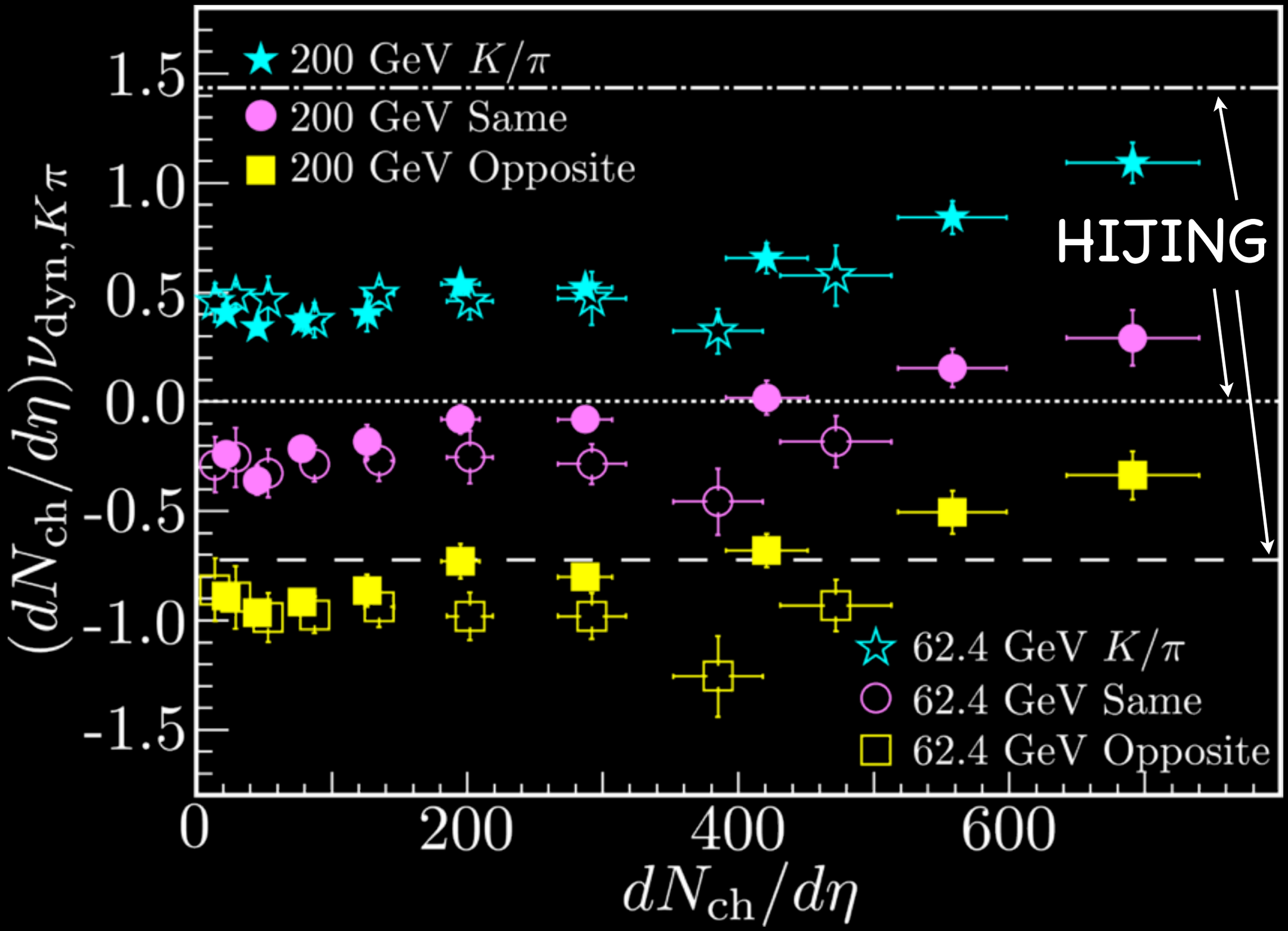

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SH Predictions

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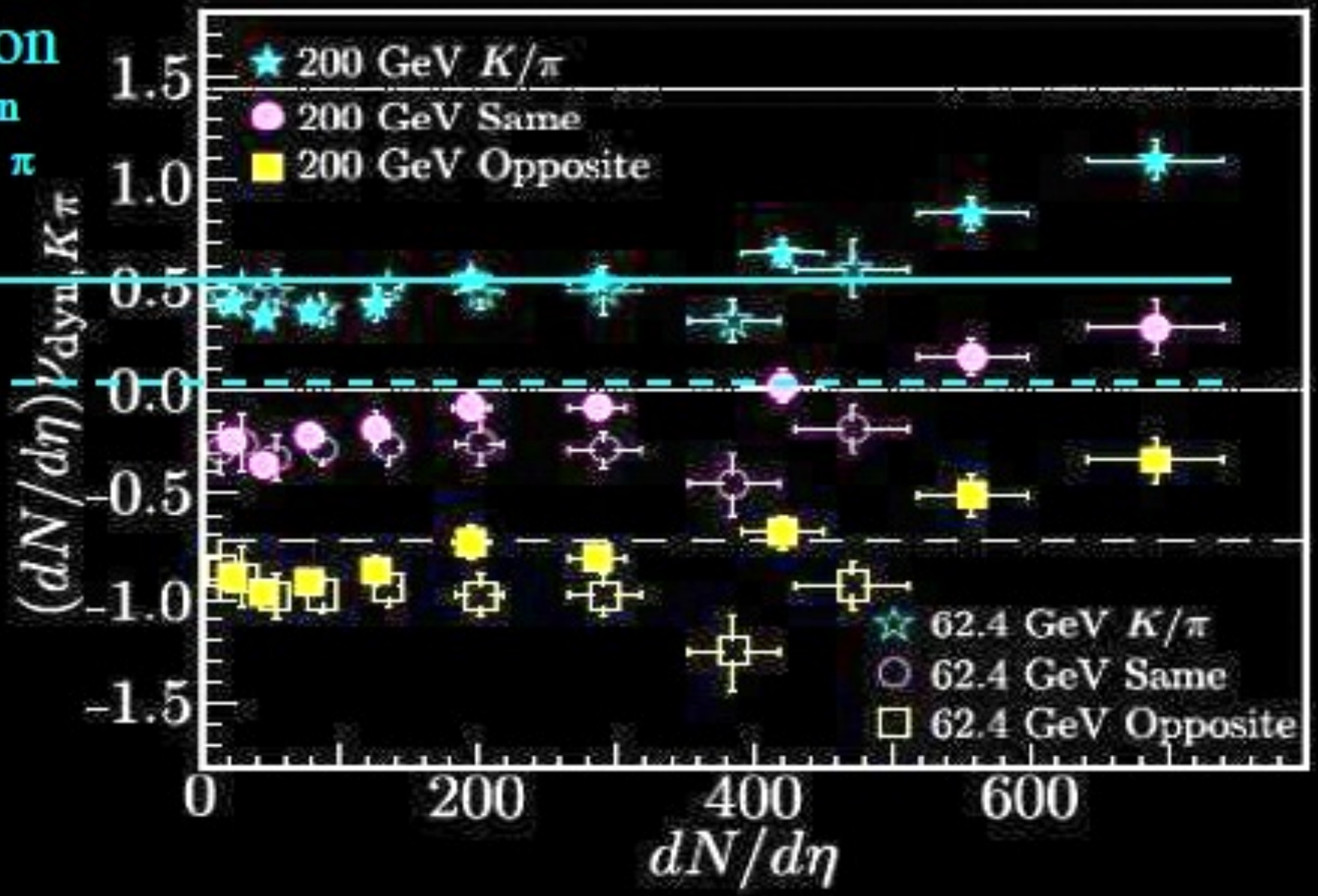
SHM expectation for $(dN/dy)\ \sigma^{dyn}_{K/\pi}$

T=170 $\gamma_{q,s}=1$

T=140 $\gamma_{q,s}>1$



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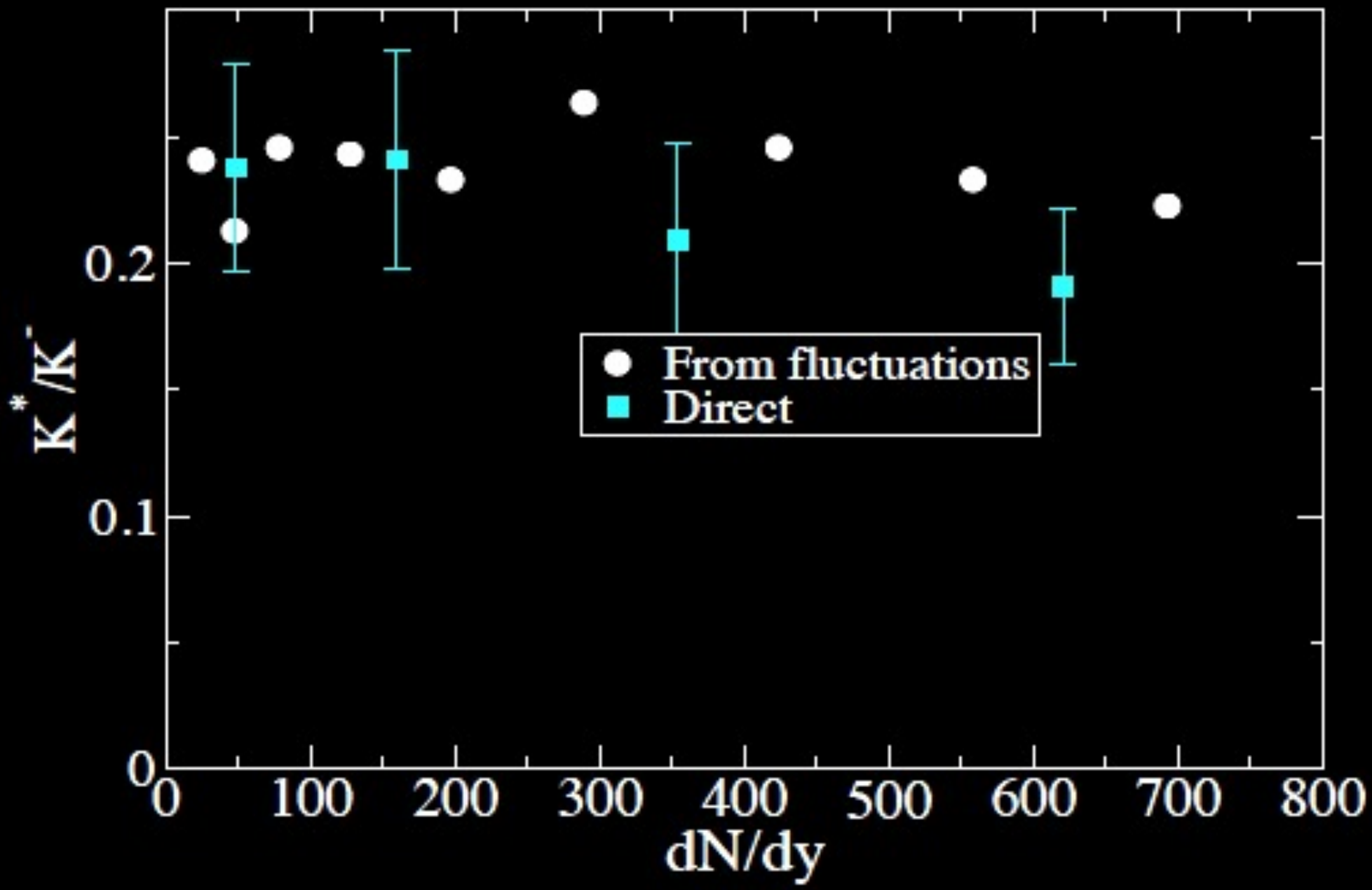

p/π Fluctuations in Central Collisions

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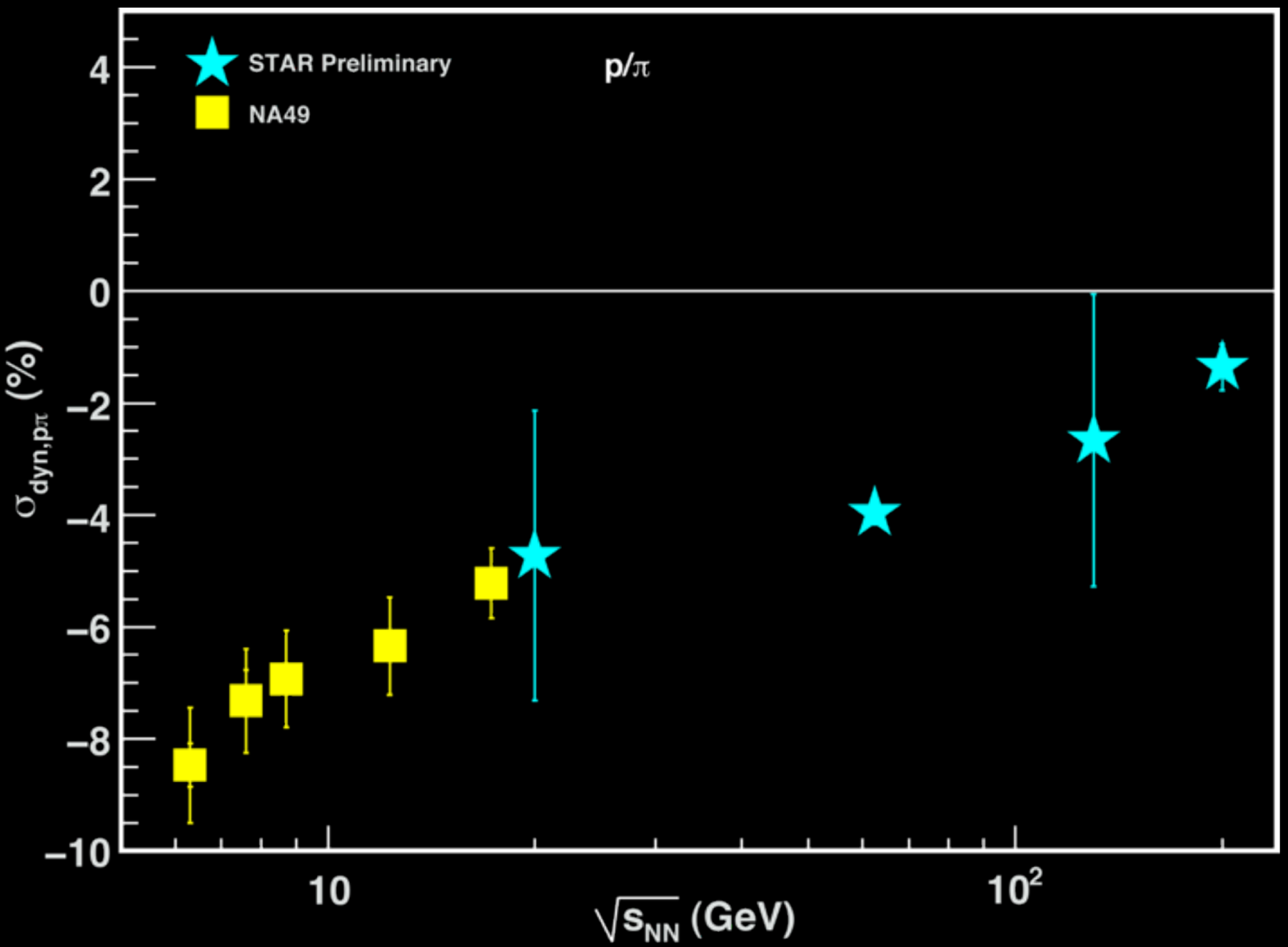

UrQMD and HSD

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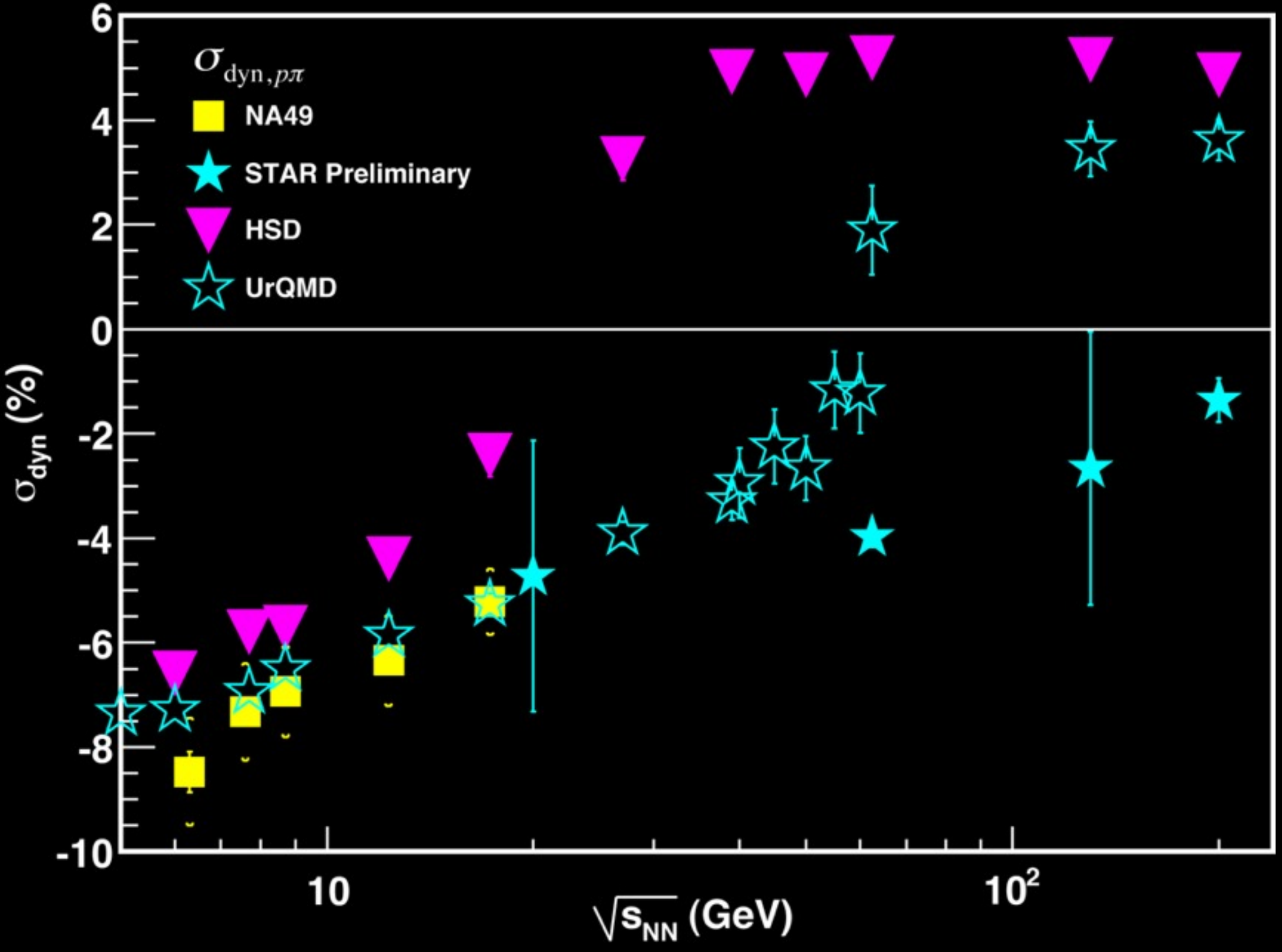

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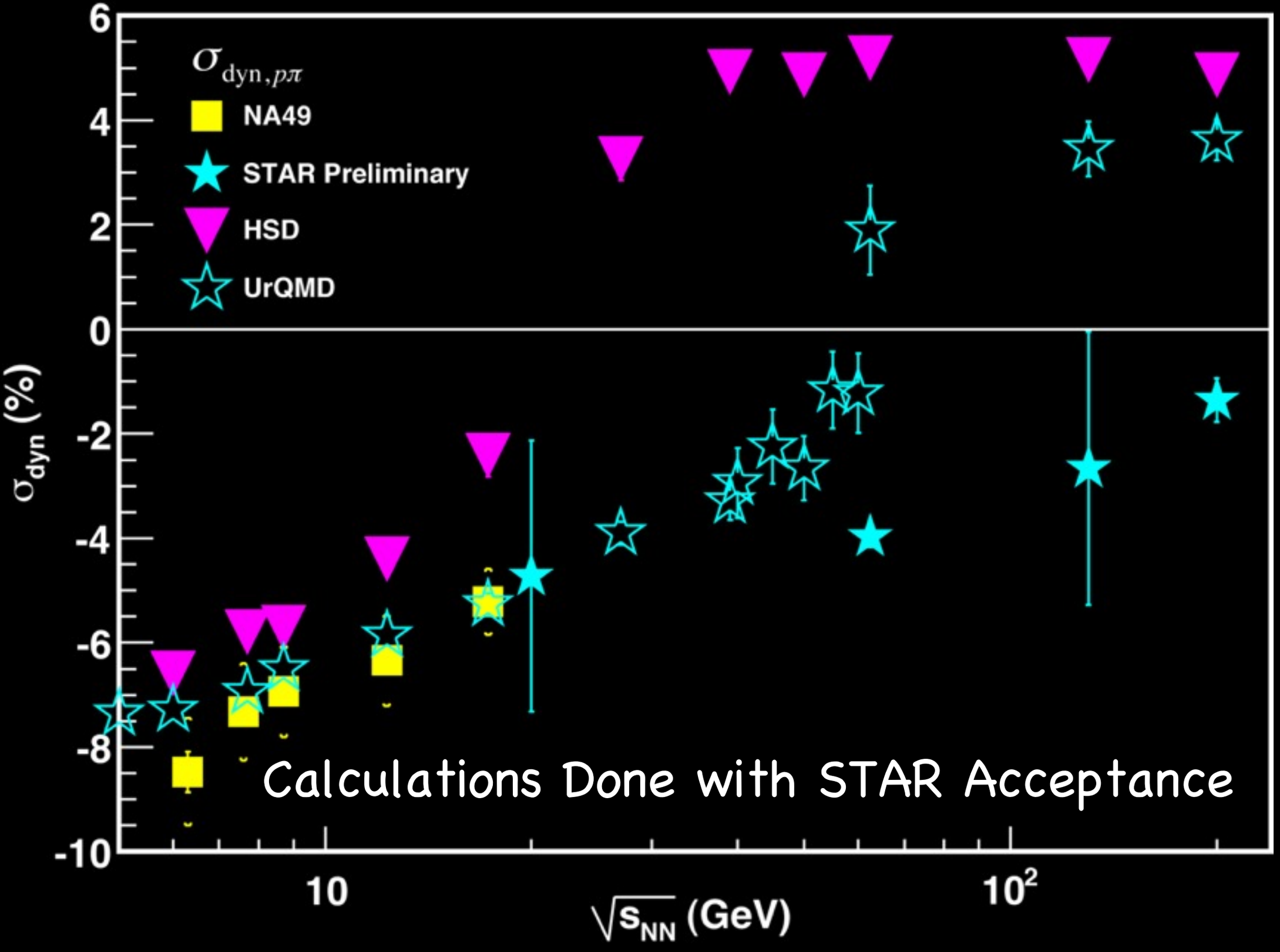

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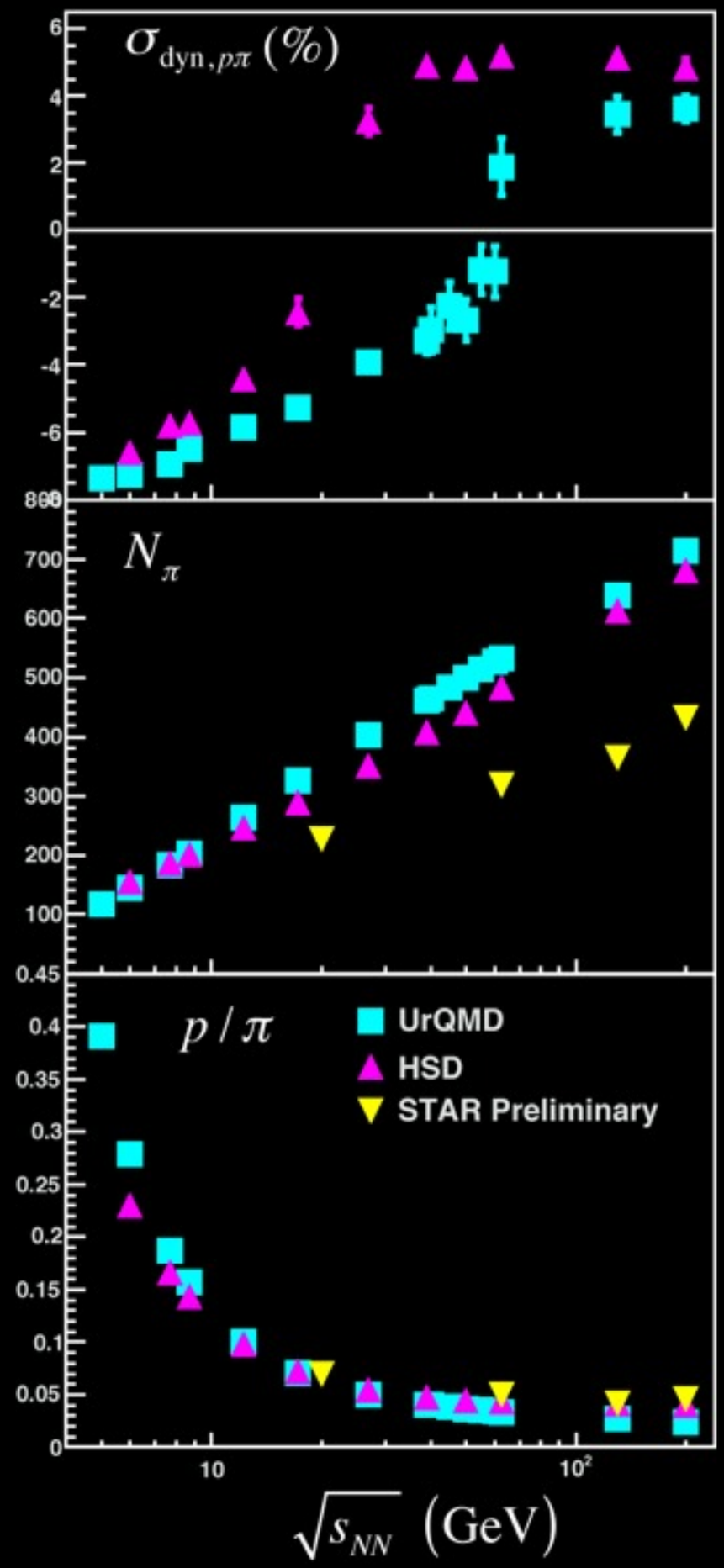

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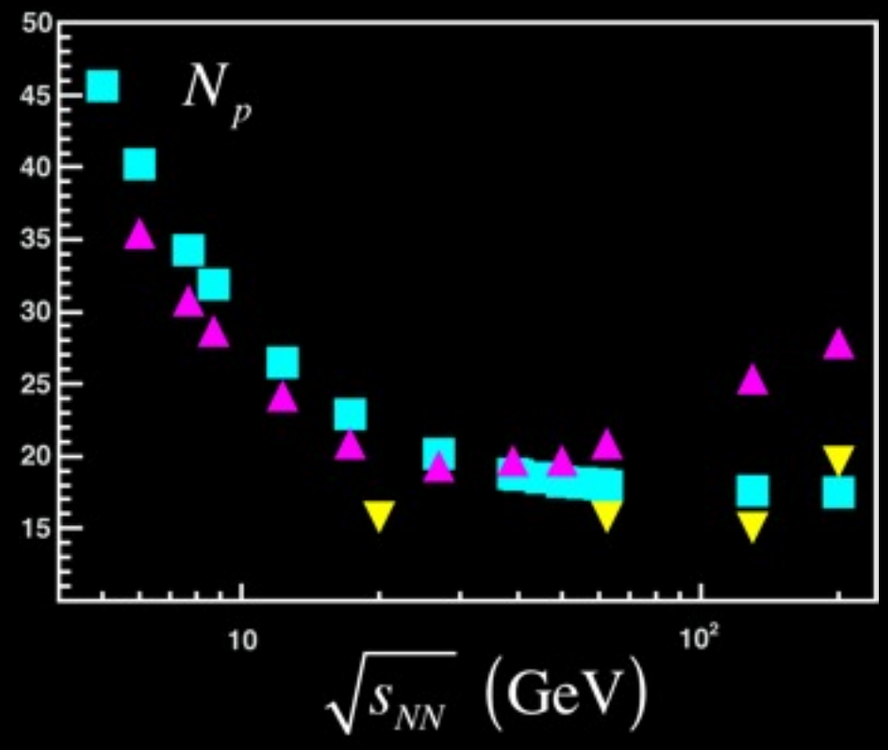

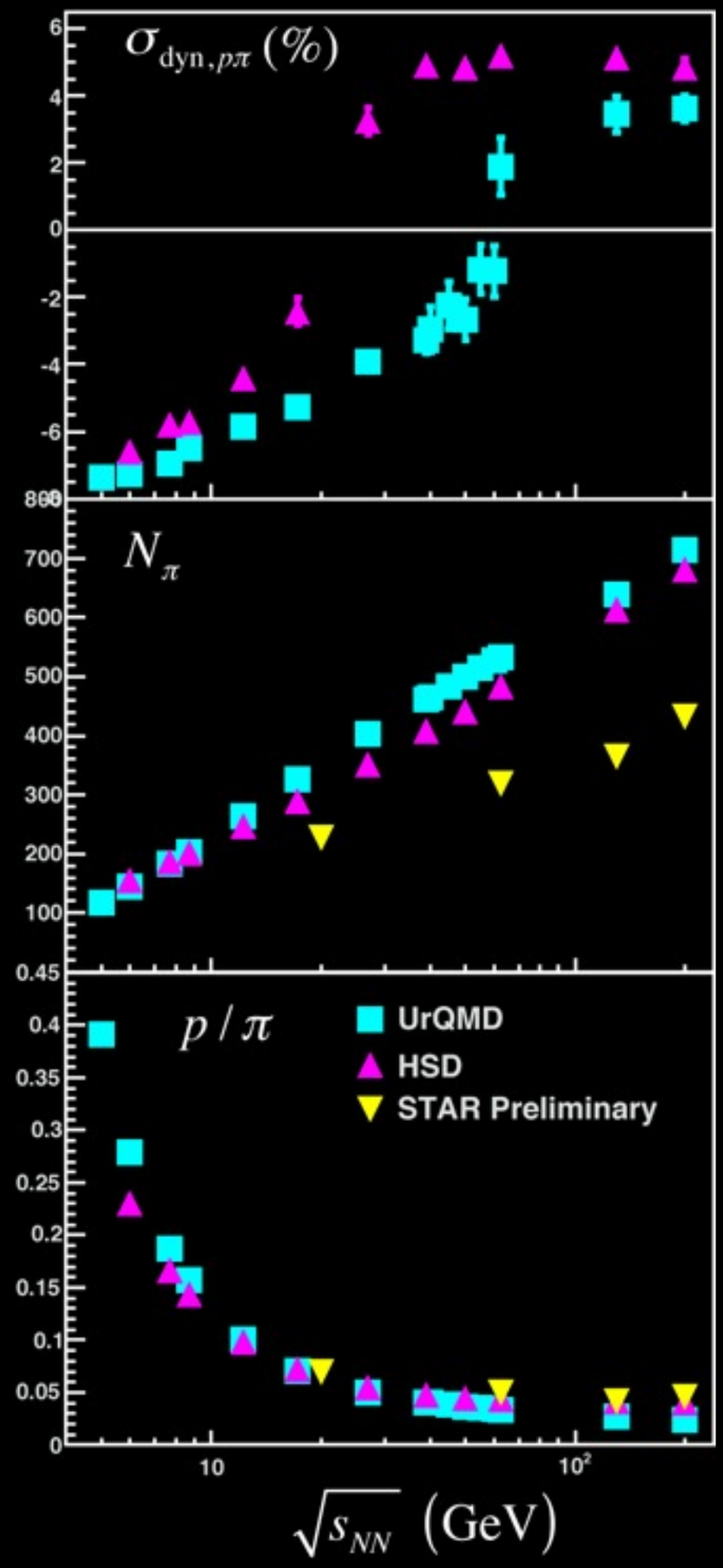

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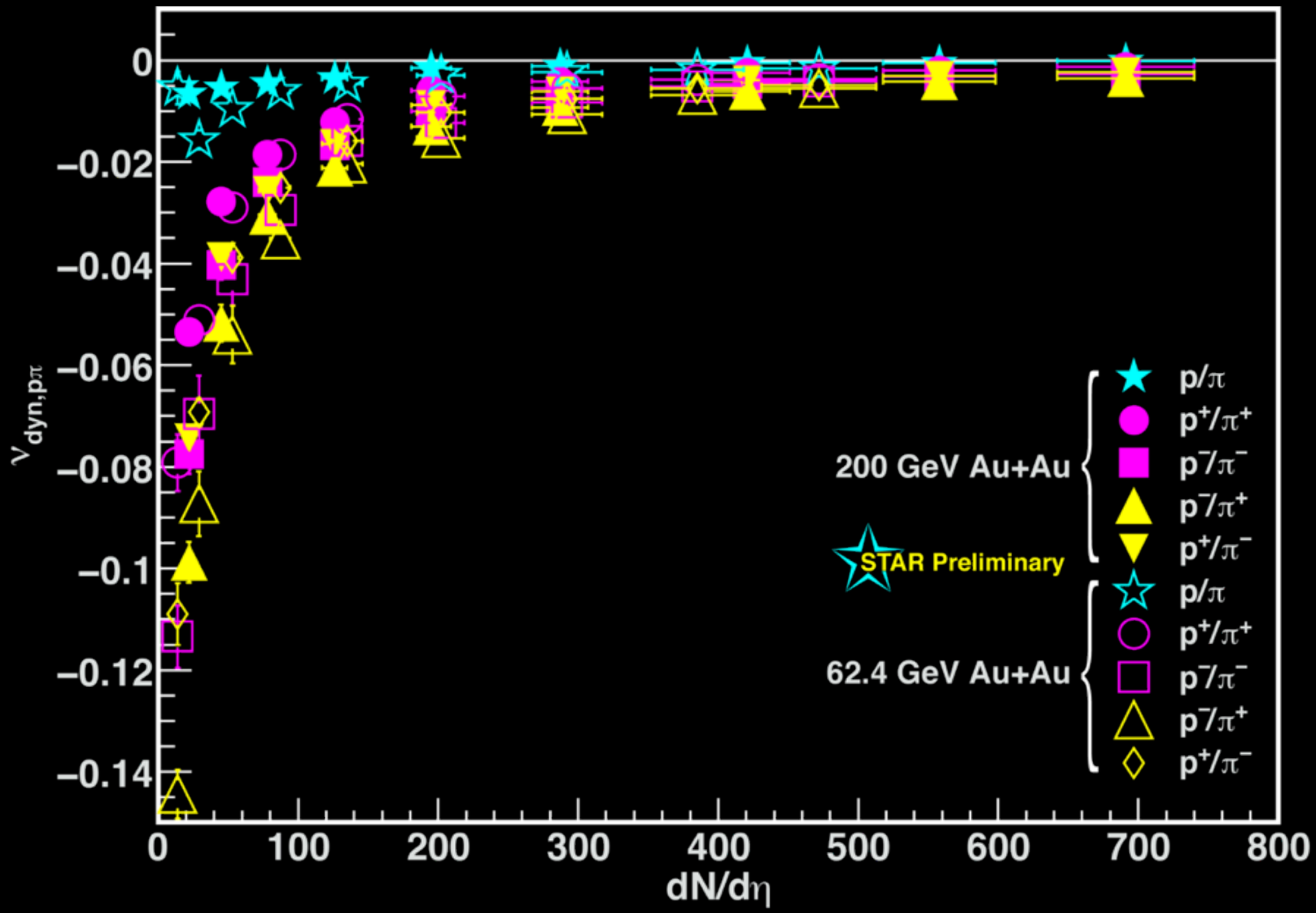

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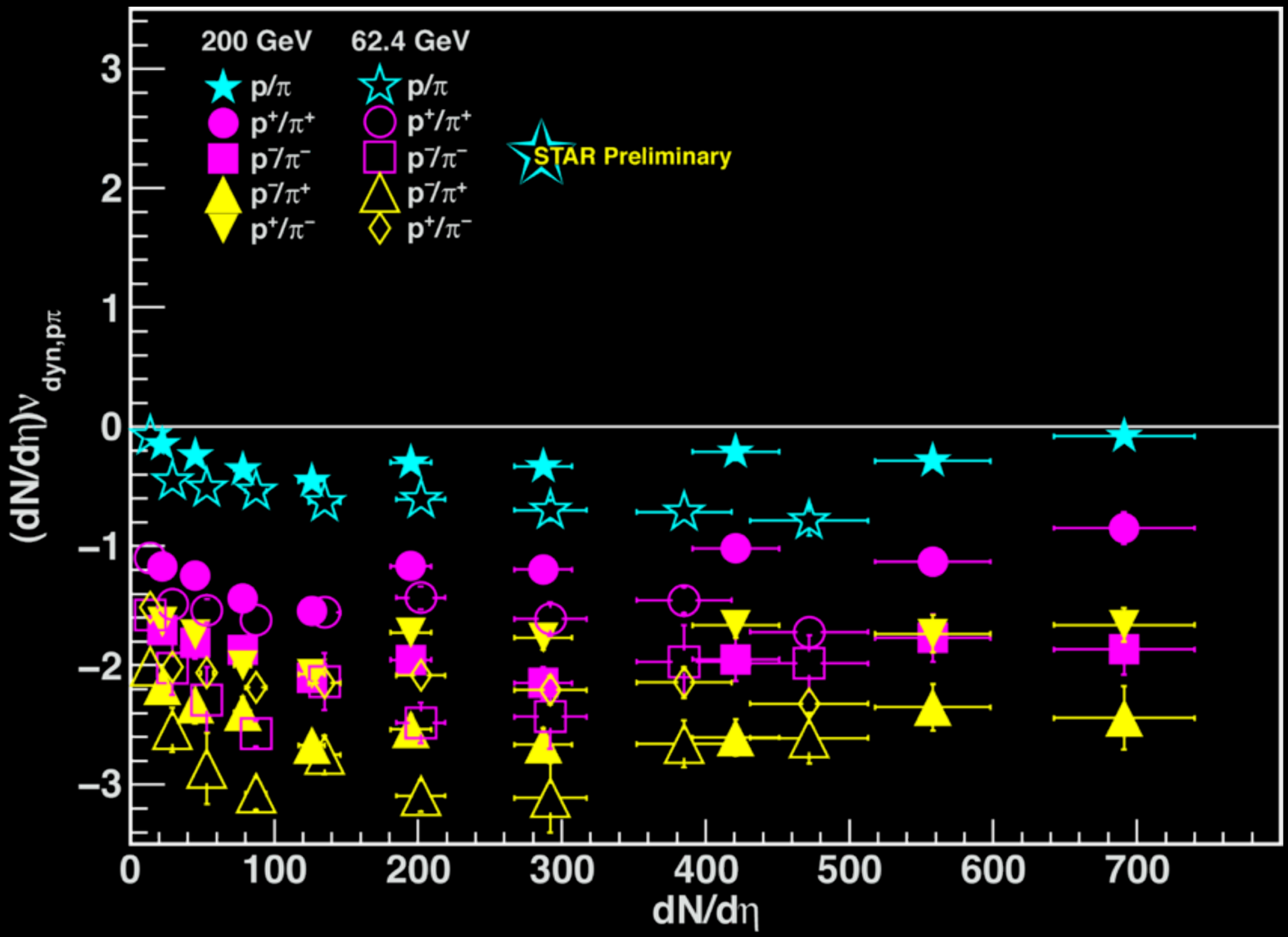

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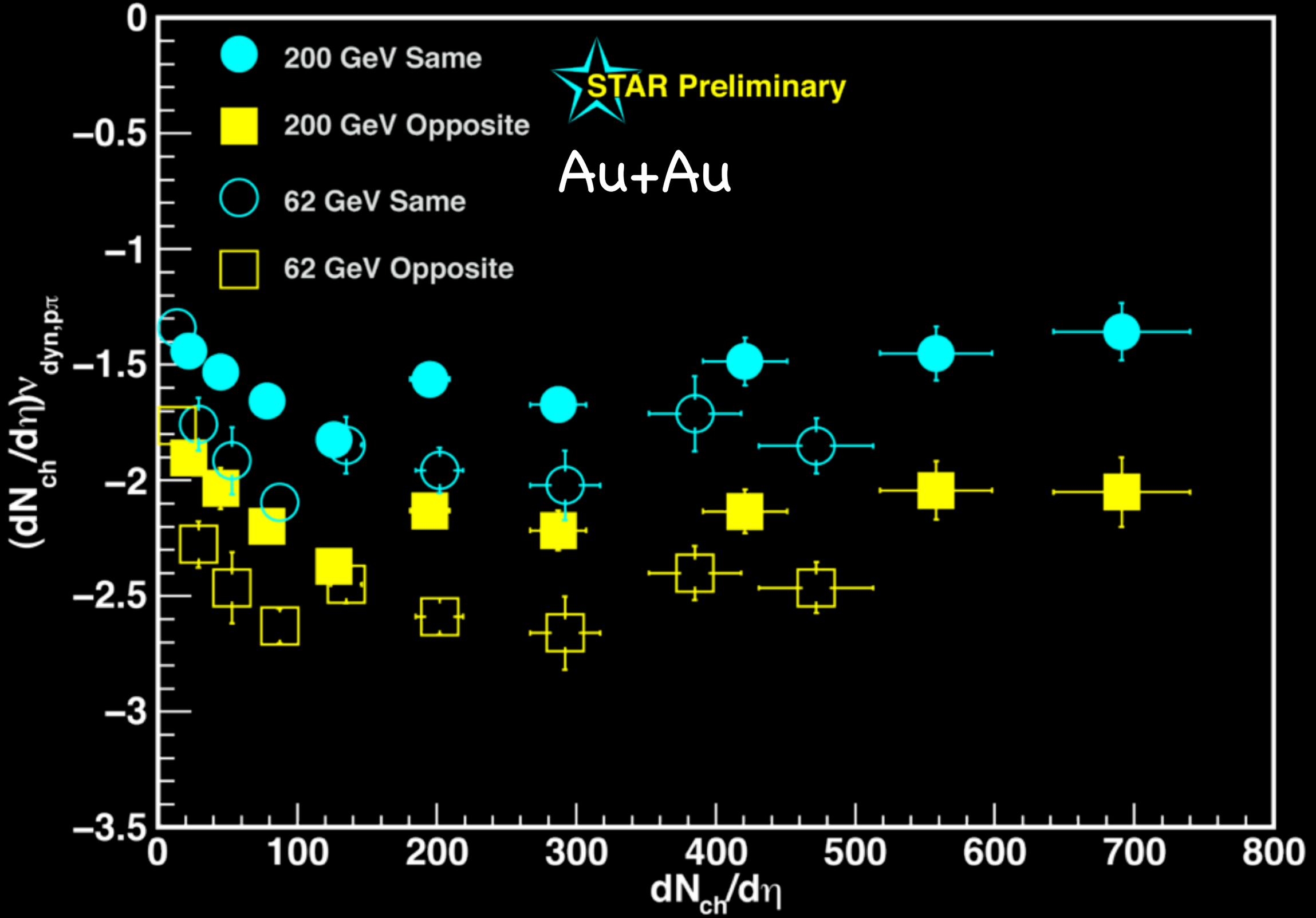

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Extra Slides

Comparison Between UrQMD and HSD