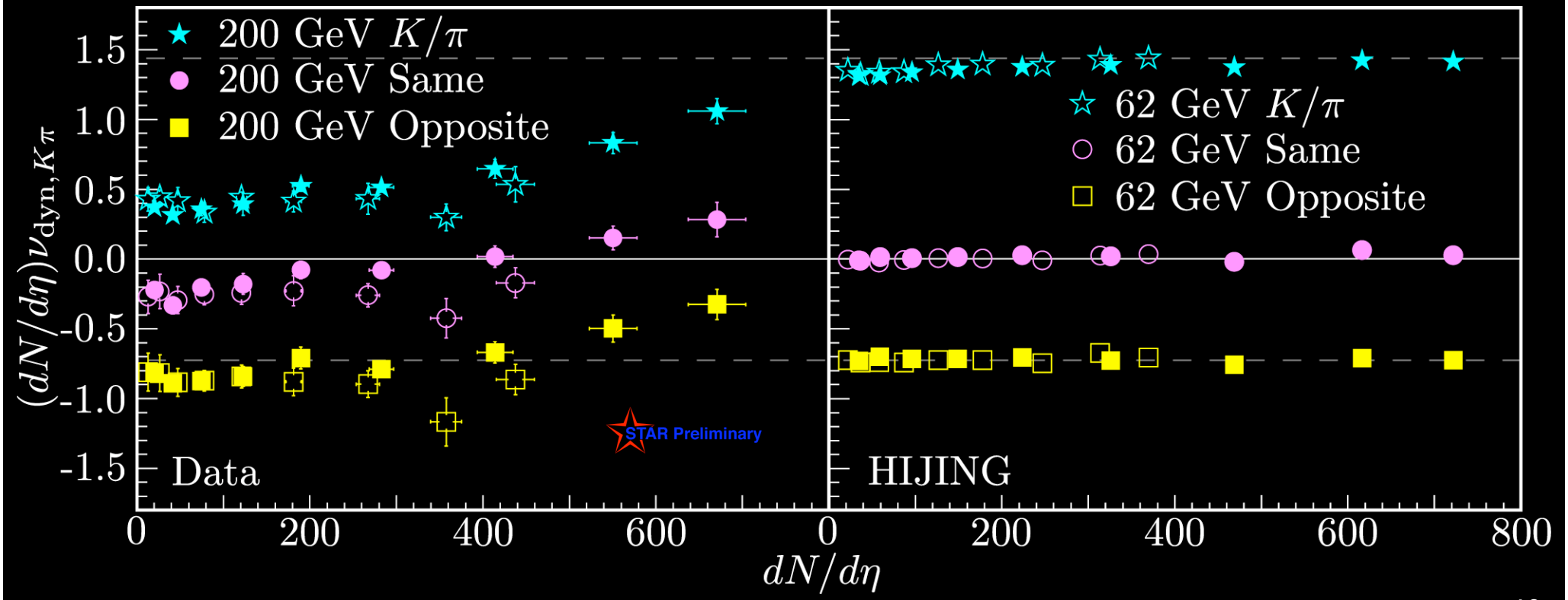
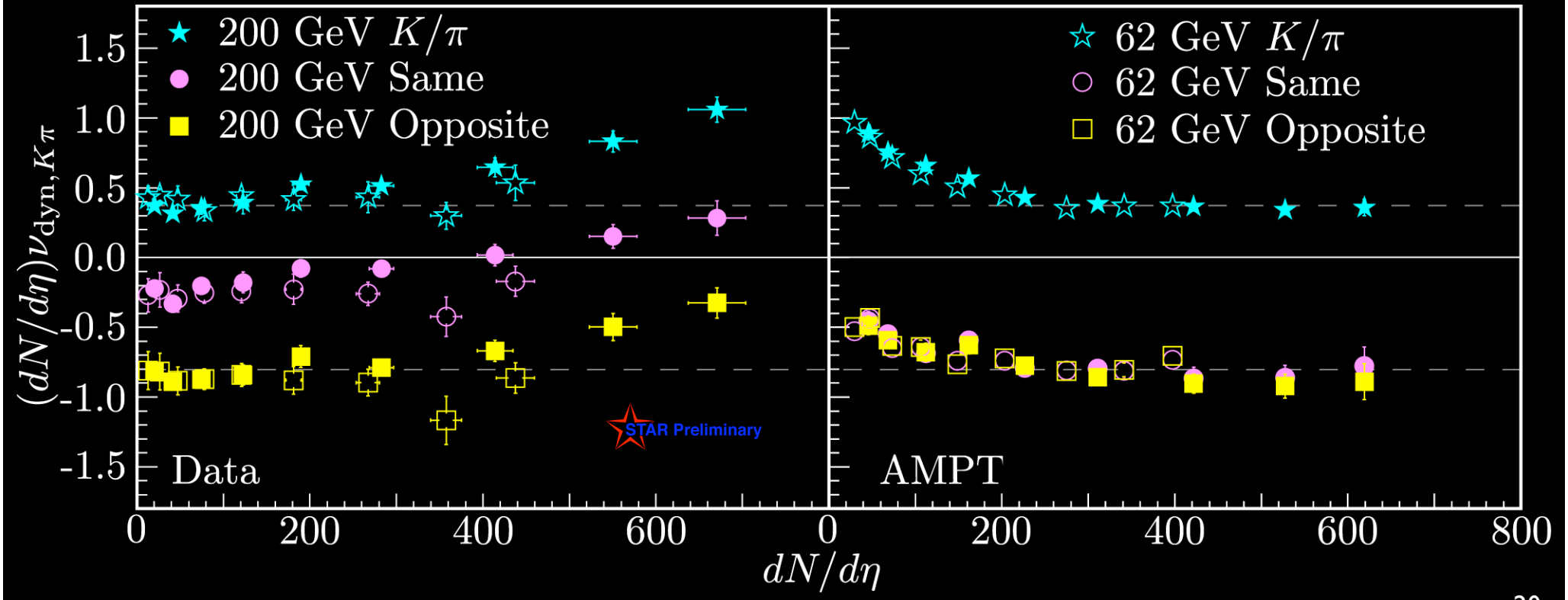
Scale with dN/dη and Compare with HIJING

- Average $v_{dyn,K+/\pi+}$ and $v_{dyn,K-/\pi-}$ to get Same
- Average $v_{dyn,K+/\pi-}$ and $v_{dyn,K-/\pi+}$ to get Opposite



Scale with dN/dη and Compare with AMPT

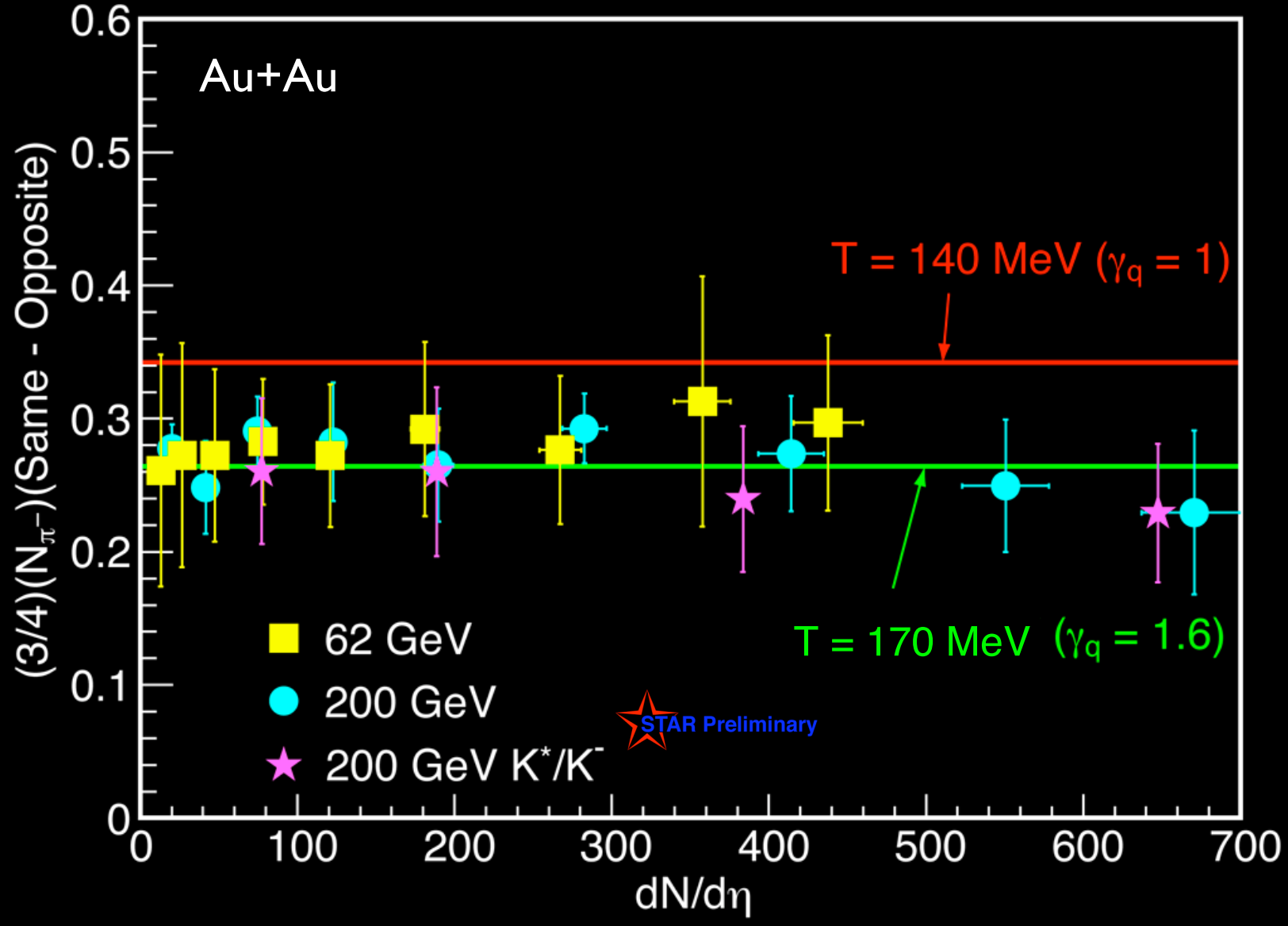
- AMPT (version 1.21, hard scattering) for summed charges is better than HIJING, but centrality dependence is not correct
- No difference between same and opposite



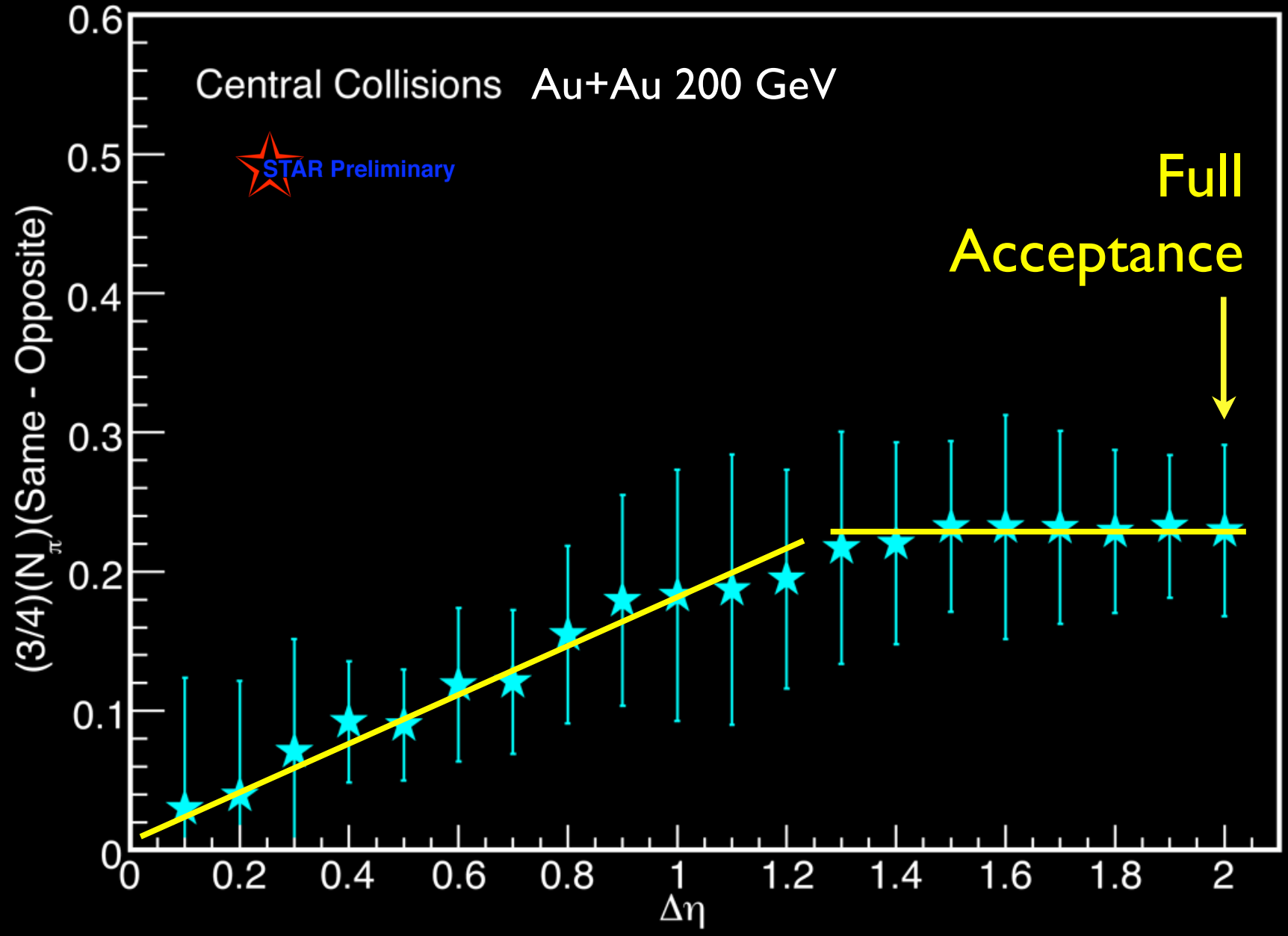
Relation of K/π Fluctuations to Resonance Re-interaction

- Model of Torrieri, Jeon and Rafelski
- Predict K/π fluctuations and resonance production using statistical hadronization model
  - www.gsi.de/documents/DOC-2007-Jul-101-1.pdf
  - Jeon and Koch, PRL 83, 5435 (1999) (π^+/π^-)
- Relate $\nu_{dyn,K+/\pi-}$ and $\nu_{dyn,K-/\pi-}$ to $K^*(892)/K$ ratio
  - $(3/4)\langle N_\pi \rangle(\nu_{dyn,K+/\pi-} - \nu_{dyn,K-/\pi-}) \sim K^*/K$

Resonance Reinteraction Compared with Thermal Model of Torrieri



Dependence on Acceptance



Balance Function

- Balance function represents charge balance of charge/anti-charge pairs
- Balance functions can be expressed in terms of $\Delta\eta$, Δy, q_{inv}, q_{out}, q_{side}, q_{long}, and $\Delta\phi$

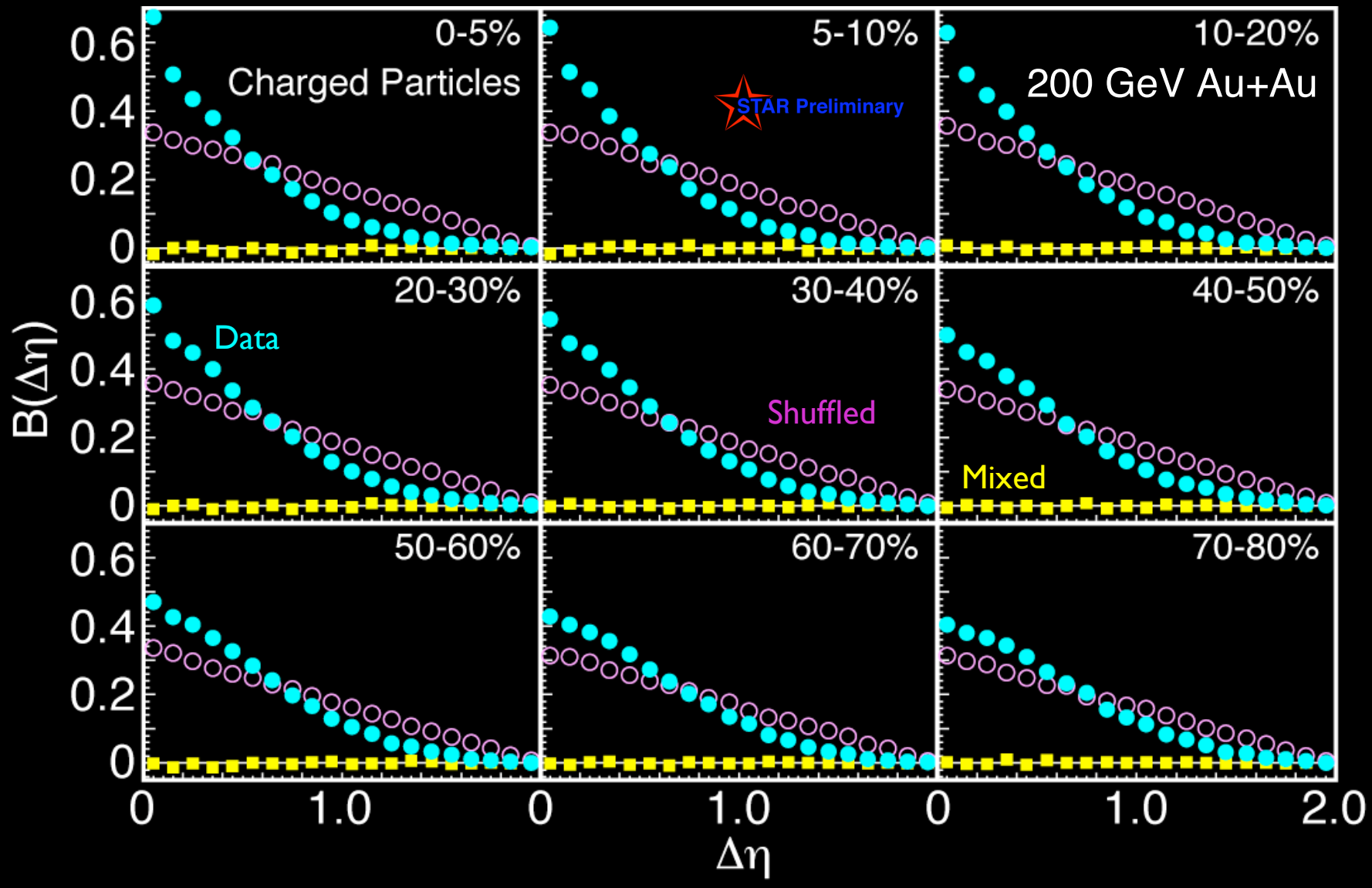
$$B(\Delta\eta) = \frac{1}{2}\left\{\frac{N_{+-}(\Delta\eta) - N_{++}(\Delta\eta)}{N_{+}} + \frac{N_{-+}(\Delta\eta) - N_{--}(\Delta\eta)}{N_{-}}\right\}$$

e.g. $N_{+-}(\Delta\eta)$ is histogram of $\Delta\eta = |\eta_2 - \eta_1|$ for + with -

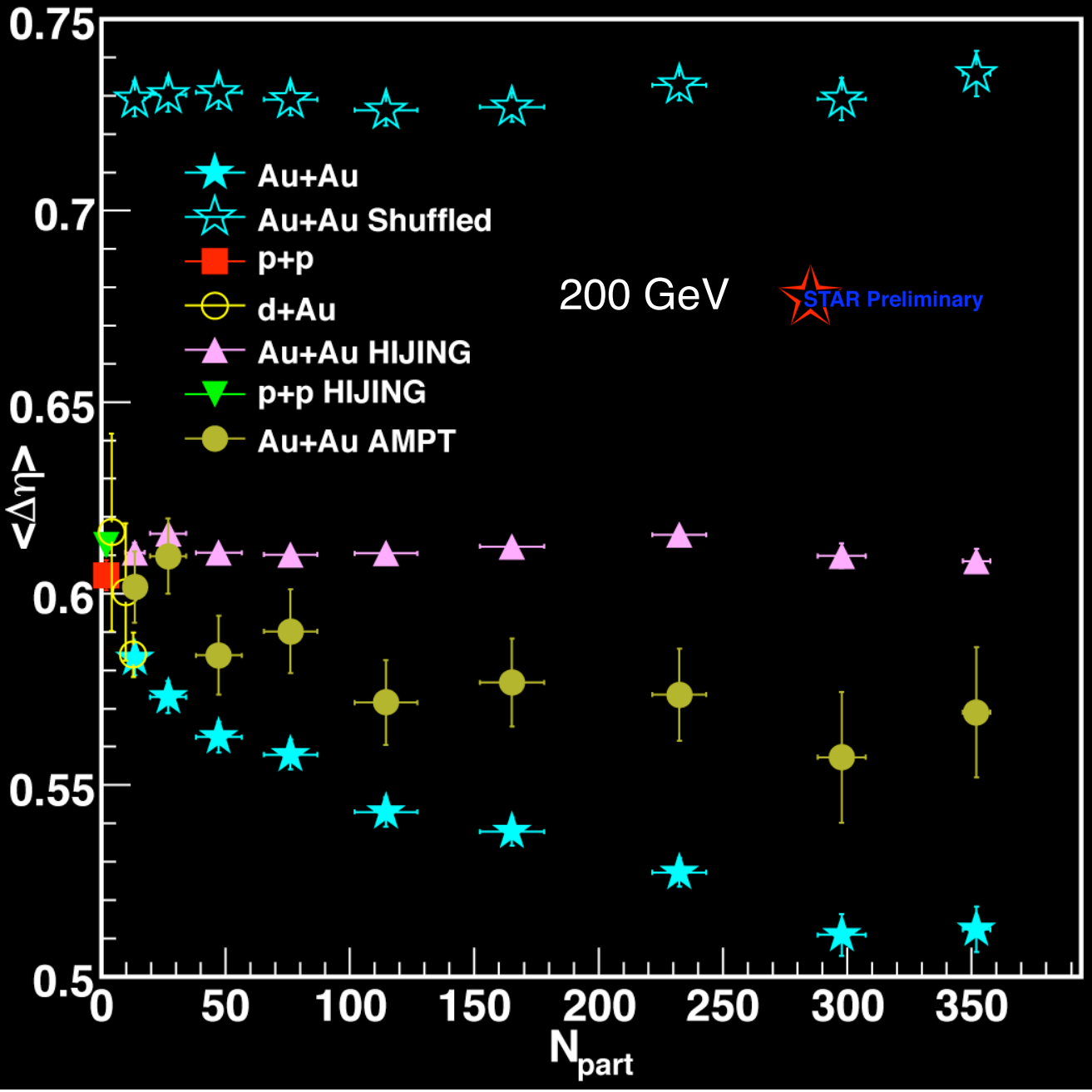
e.g. N_{+} is the number of positive particles

Bass, Danielewicz, Pratt PRL 85 2689 (2000)

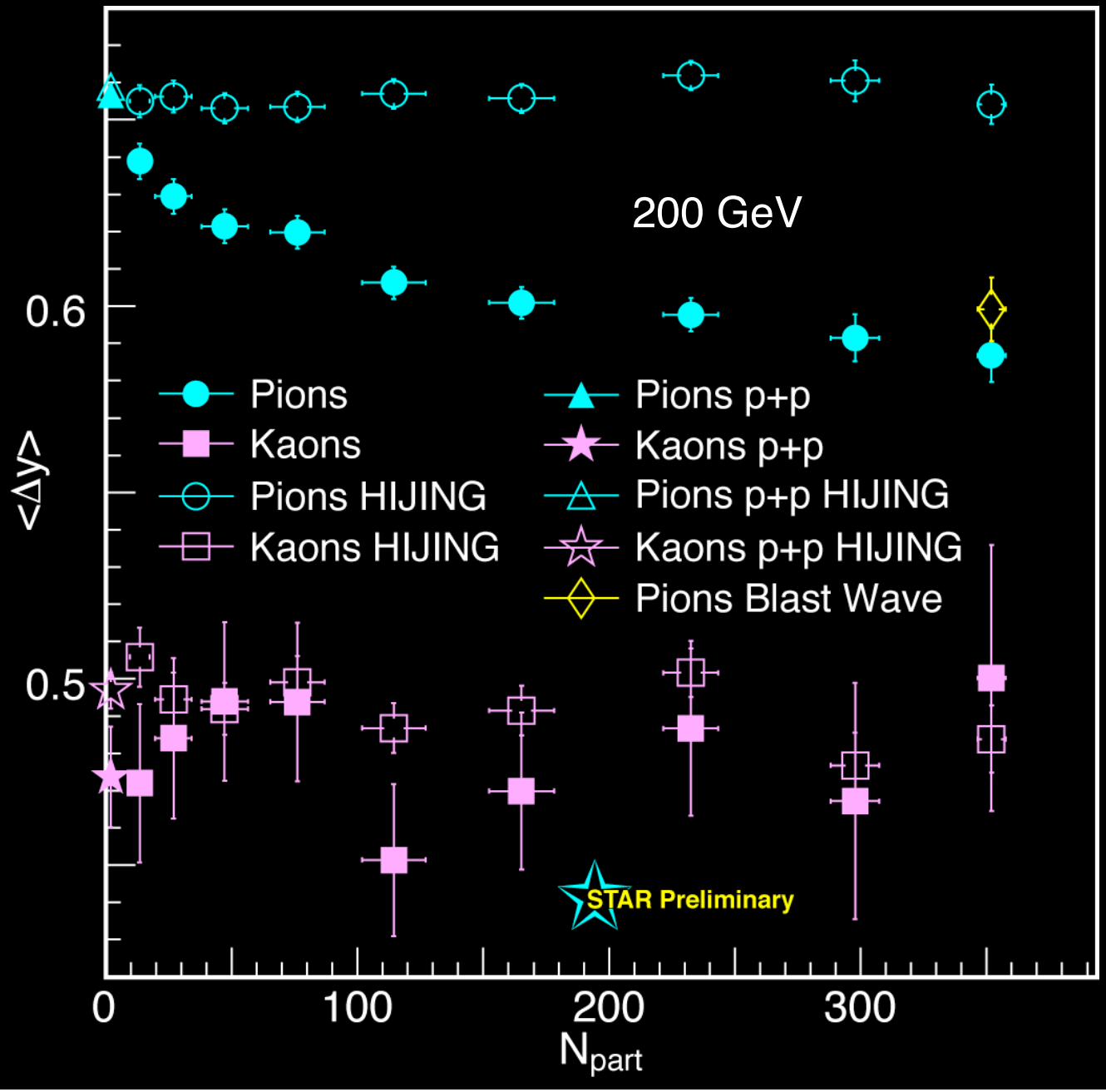
Balance Function



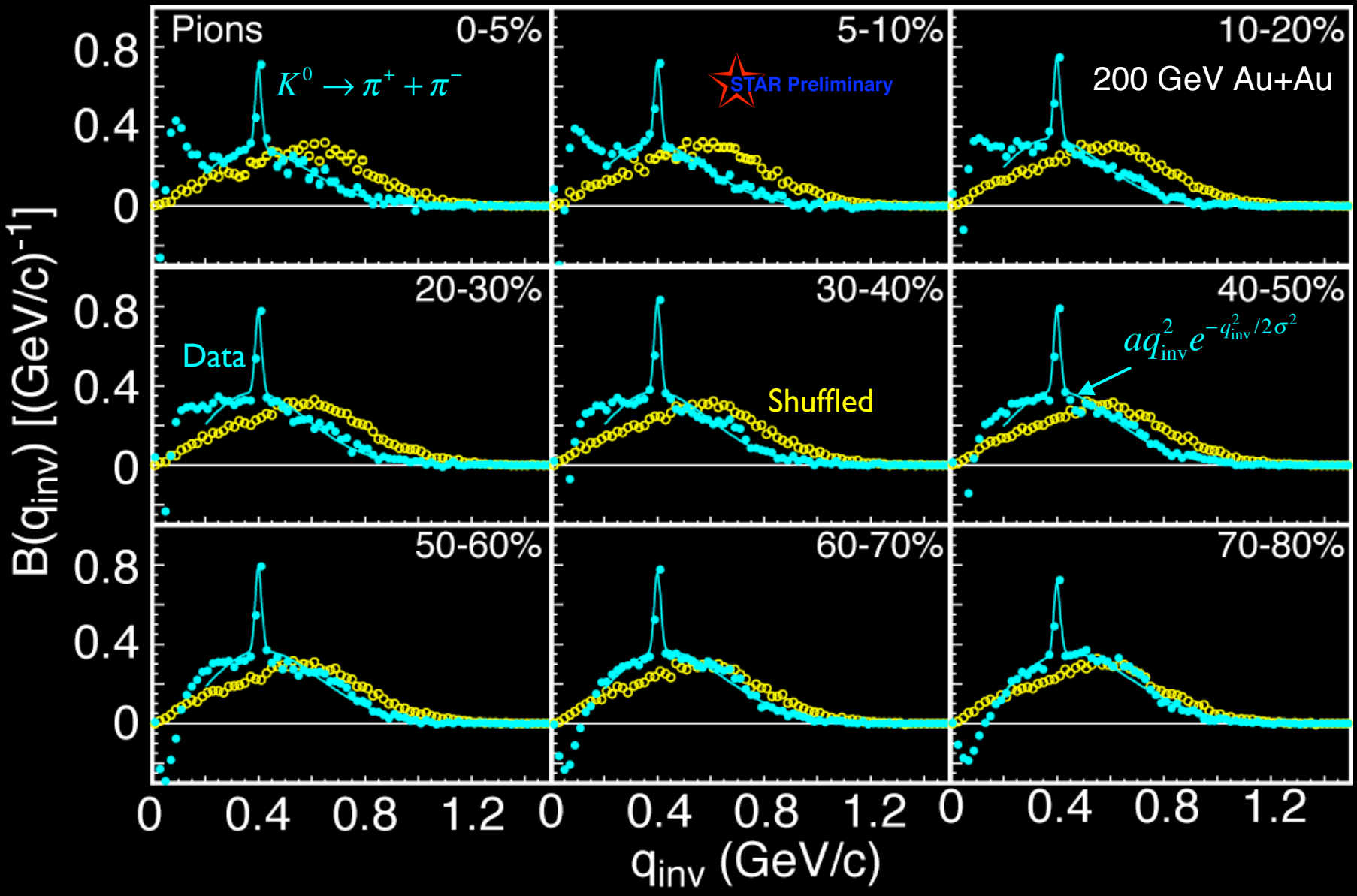
Balance Function Widths - All Charged Particles



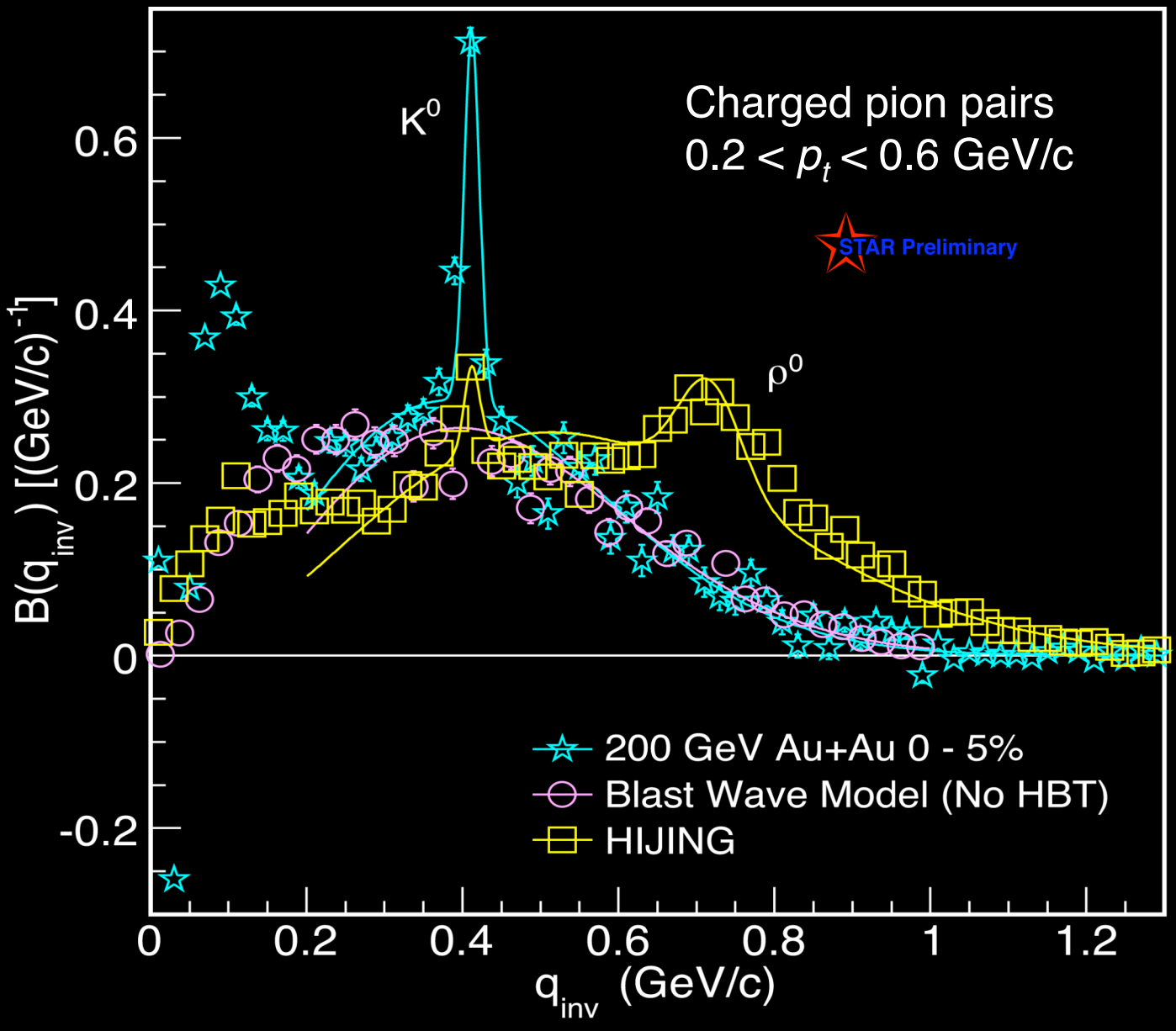
Balance Function Widths - Pions and Kaons



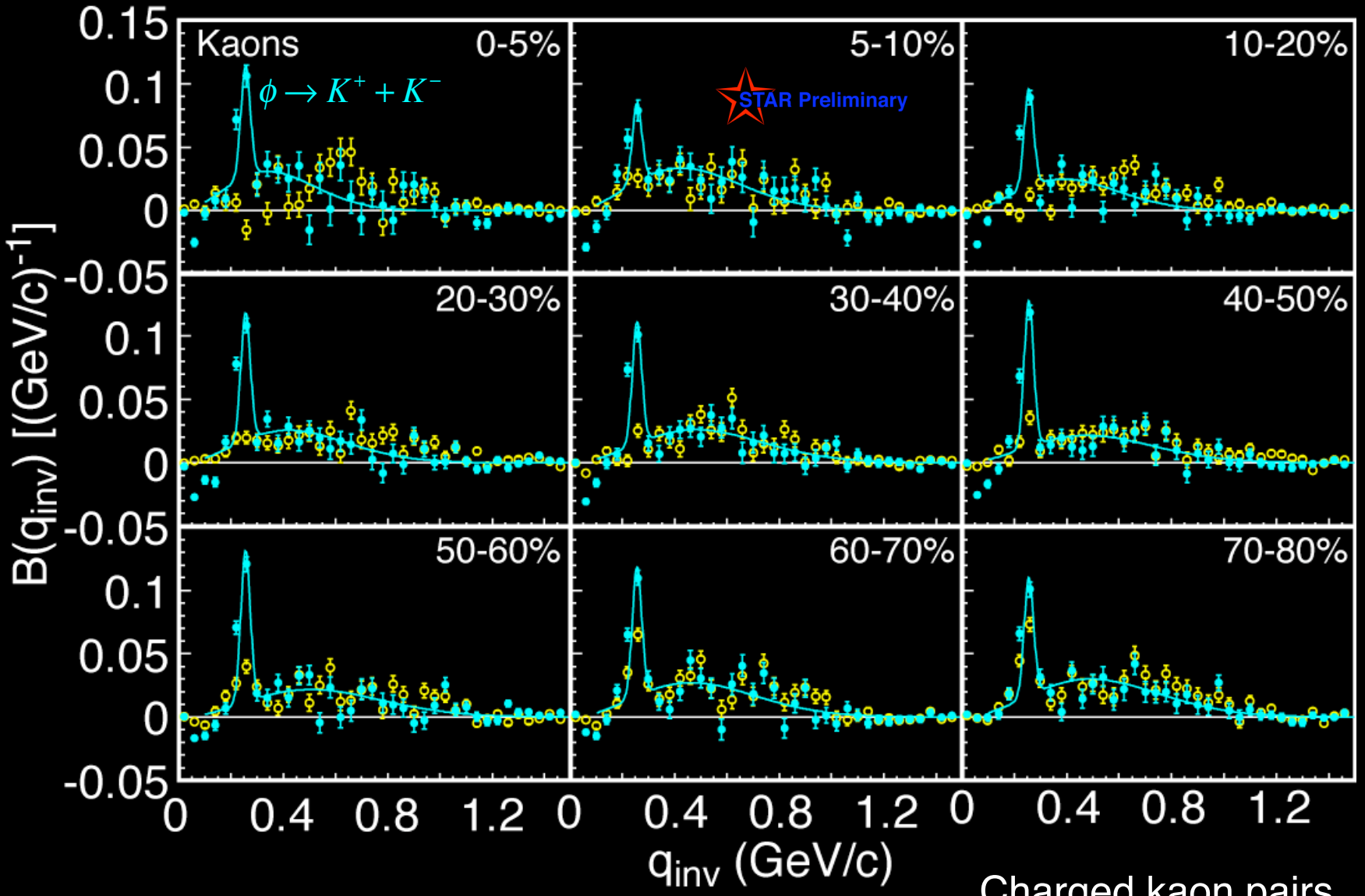
$B(q_{inv})$ for Pions



$B(q_{inv})$ for Pions



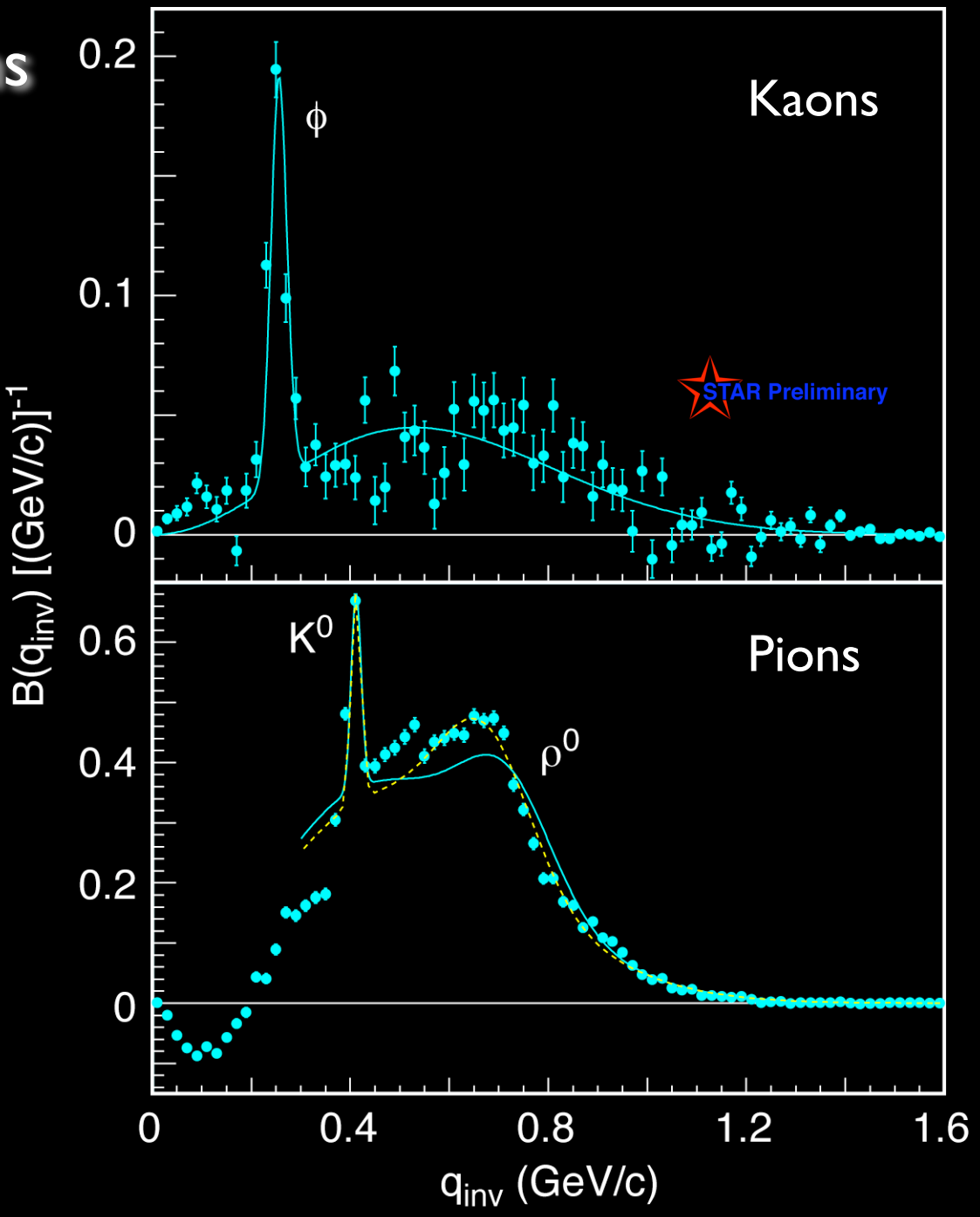
$B(q_{inv})$ for Kaons



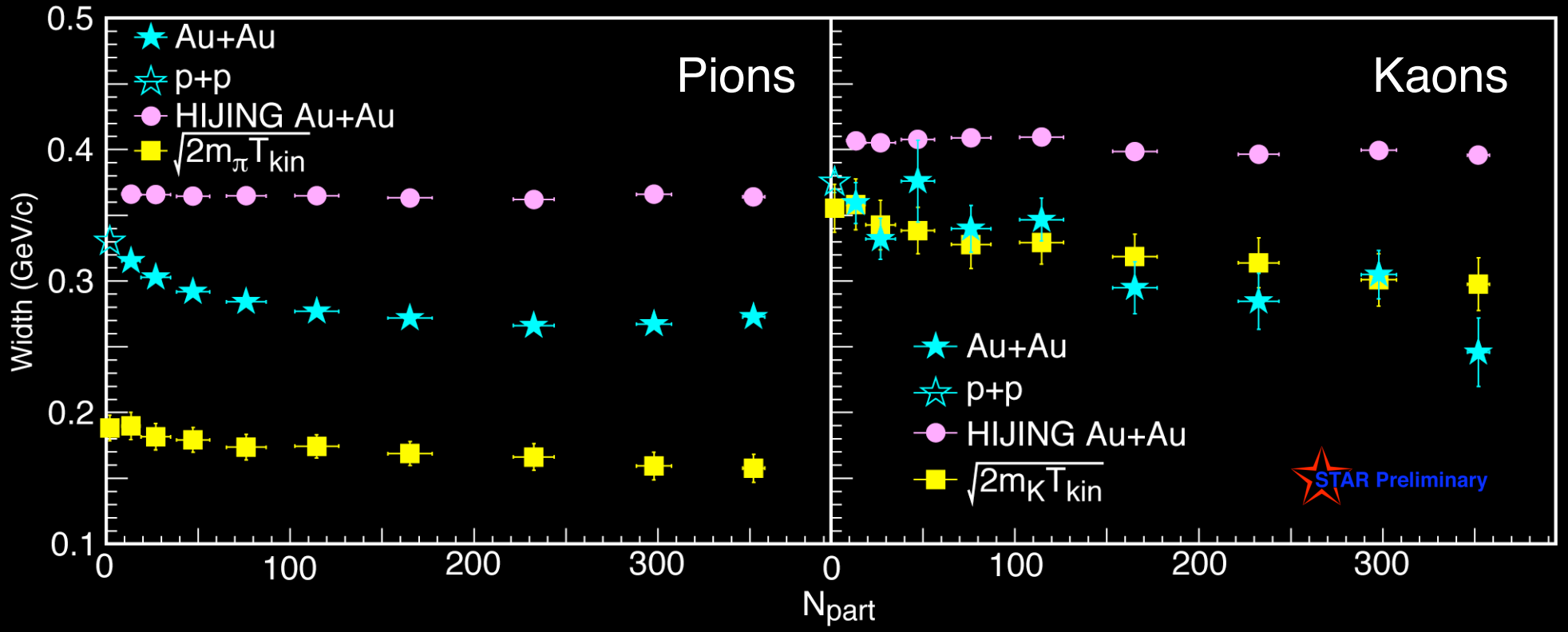
Charged kaon pairs
$0.2 < p_t < 0.6$ GeV/c

$B(q_{inv})$ for Pions and Kaons from p+p at 200 GeV

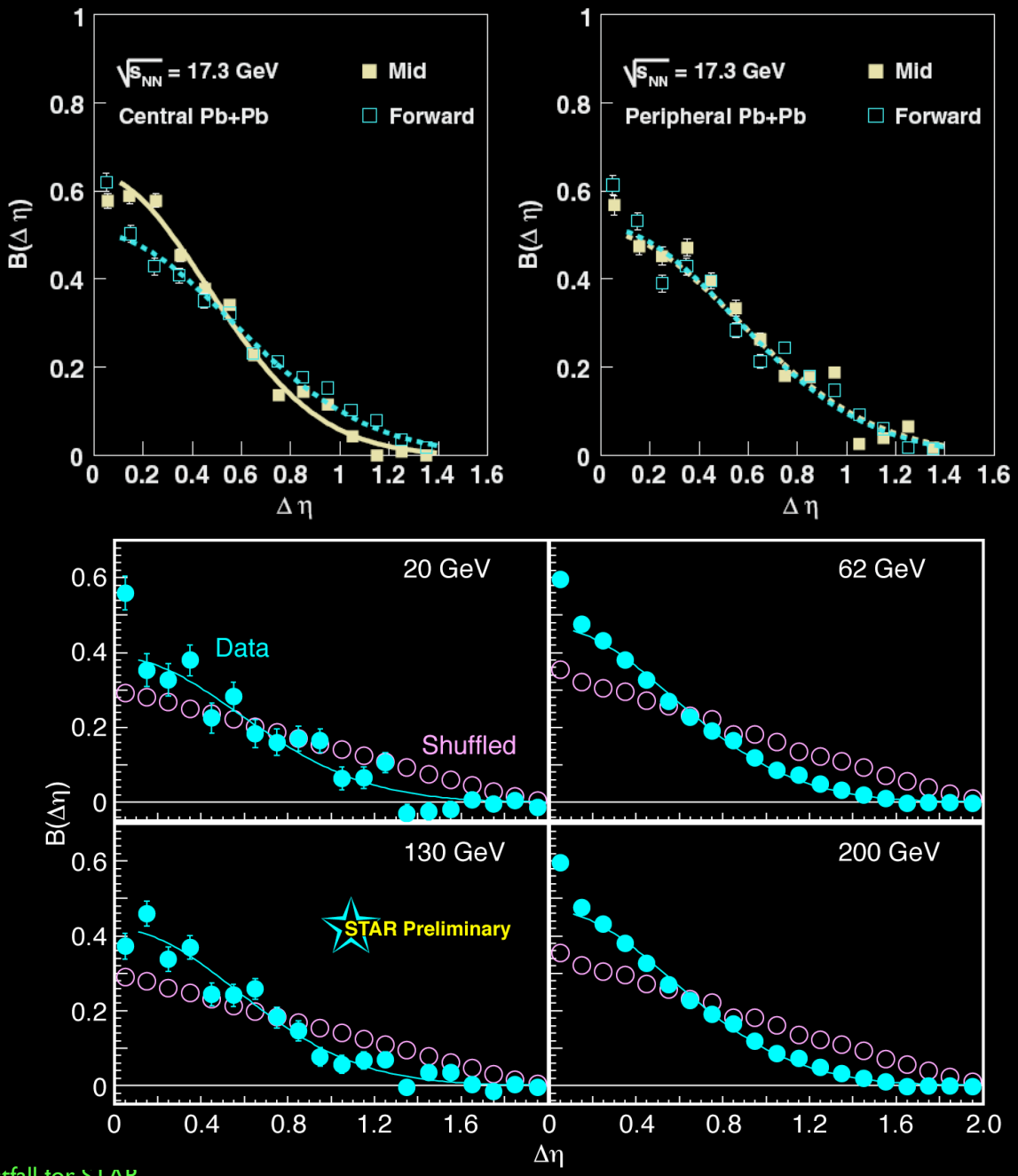
- $B(q_{inv})$ for pions shows K^0 and ρ^0
  - The ρ^0 peak is shifted down as previously observed
- $B(q_{inv})$ for kaons shows ϕ



Balance Function Widths from $B(q_{inv})$



Balance Function - Excitation Function



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Phys. Rev. **C** 76, 024914 2007

Balance functions for Pb+Pb at $s_{NN}^{½}$ = 6.3 to 17.3 GeV

STAR Preliminary

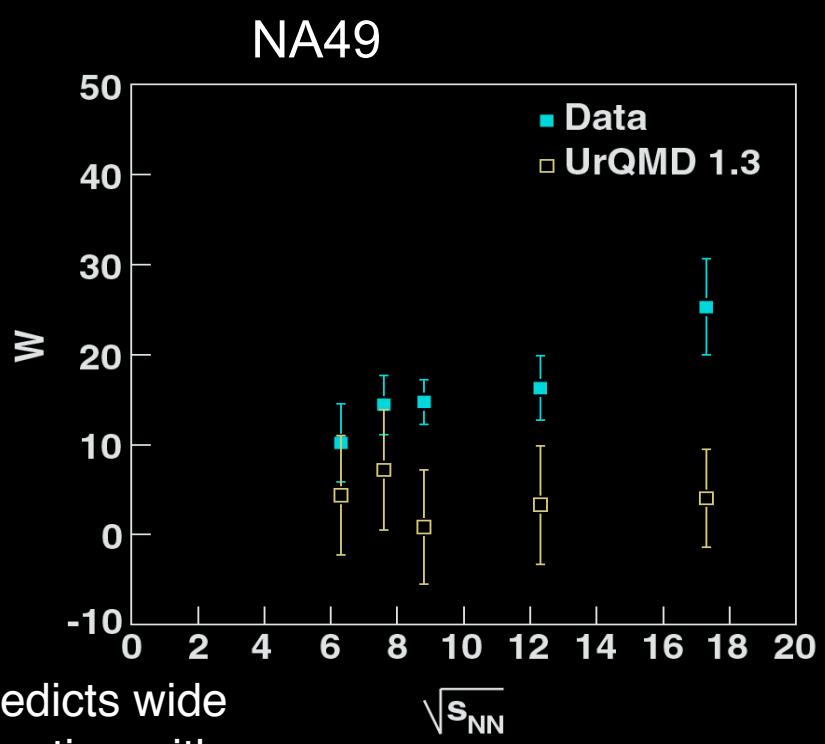
STAR, QM 02, QM 04

Balance functions for Au+Au at $s_{NN}^{½}$ = 20 to 200 GeV

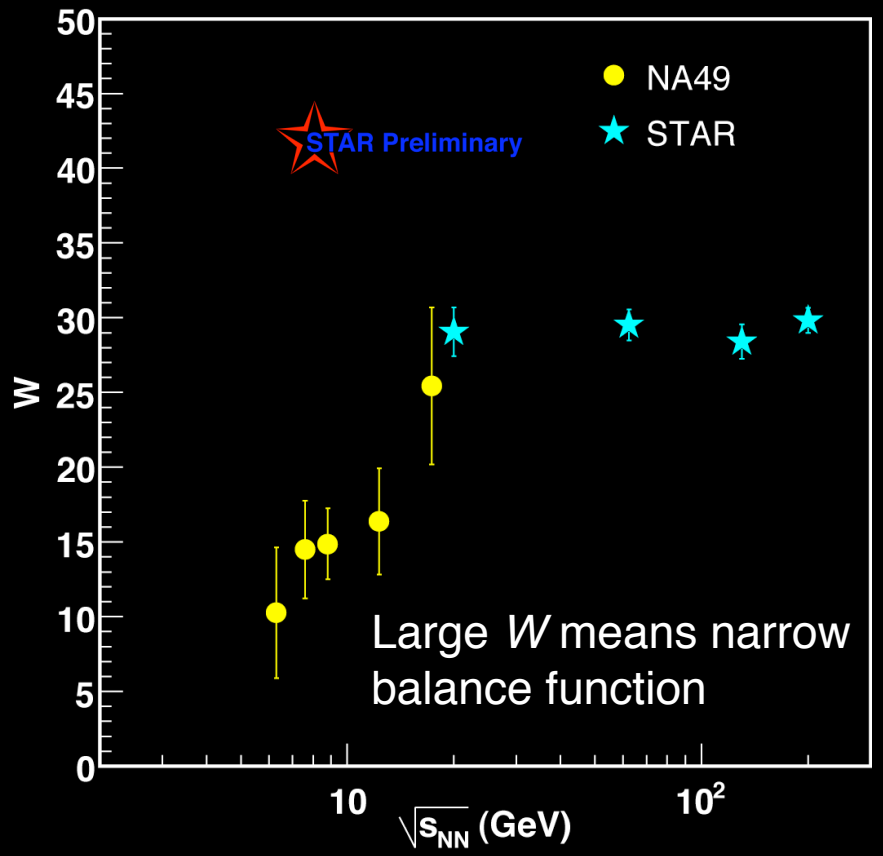
Balance Function Widths - Excitation Function

NA49
Phys. Rev. **C** 76, 024914 2007

$$W = \frac{100 \cdot \left(\langle \Delta\eta \rangle_{\text{shuffled}} - \langle \Delta\eta \rangle_{\text{data}} \right)}{\langle \Delta\eta \rangle_{\text{shuffled}}}$$



UrQMD predicts wide balance function with no centrality dependence



RHIC Low Energy Scan

- For central Au+Au and Pb+Pb collisions, σ_{dyn} for K/π fluctuations may show a deviation from the fluctuations predicted by a statistical hadronization model as a function of incident energy
- The width of the balance function in central Au+Au and Pb+Pb collisions decreases as the energy is increased until around 20 GeV, where it seems to stay constant
- These two observations hint at some kind of phase transition occurring between 7 and 20 GeV
- A comprehensive energy scan from 7 to 60 GeV with STAR and the new TOF will answer many questions

Conclusions - K/π

- Dynamical fluctuations in the K/π ratio in central Au+Au collisions represented by σ_{dyn} show little incident energy dependence at RHIC energies within errors and compare reasonably with SPS results at the top energies
- $\nu_{dyn,K\pi}$ seems to scale with $dN/d\eta$
- $(dN/d\eta)\,\nu_{dyn,K\pi}$ increases slightly with centrality
- $\nu_{dyn,K\pi}$ for same sign particles is close to zero
- $\nu_{dyn,K\pi}$ for opposite sign particles is negative
- HIJING overpredicts $(dN/d\eta)\,\nu_{dyn,K\pi}$ while AMPT seems to get the correct magnitude but not the centrality dependence
- Fluctuations of same and opposite sign particles may give us information about the re-interaction of kaons and pions

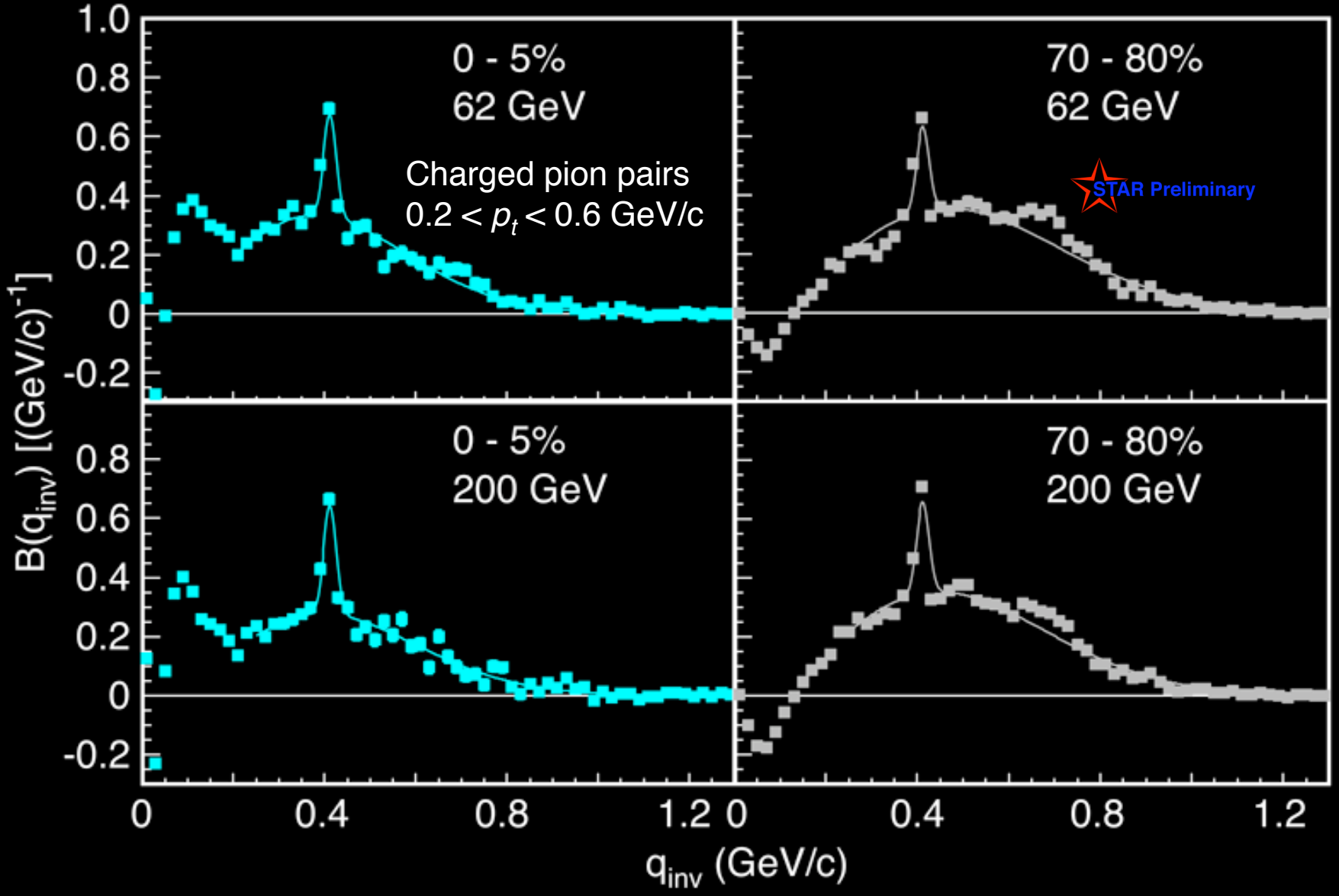
Conclusions - Balance Function

- Balance function $B(\Delta\eta)$ for all charged particles narrows in central Au+Au collisions
  - HIJING shows no centrality dependence
  - AMPT narrows in central collisions, but not as much as the data
- Balance function $B(\Delta y)$ widths for pions and kaons are different
- Balance function $B(q_{inv})$ widths for pions and kaons are the same
- Central Au+Au widths scaled with shuffled events (W) are the same at 20, 62, 130, and 200 GeV
- Balance function $B(q_{inv})$ for pions shows the K^0, but not the ρ^0
- Widths extracted from $B(q_{inv})$ for pions scale with $dN/d\eta$

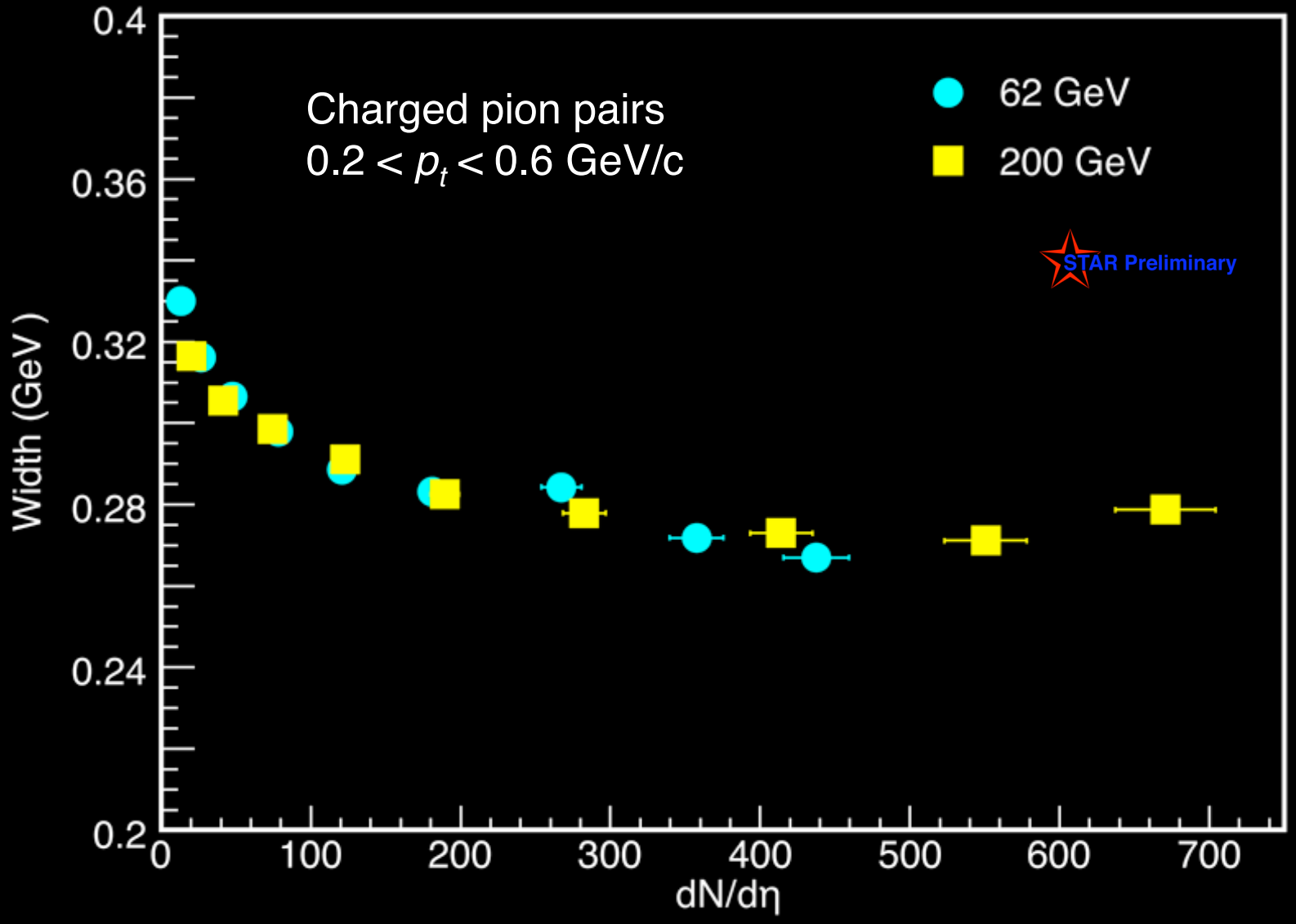
The End

Extra Slides

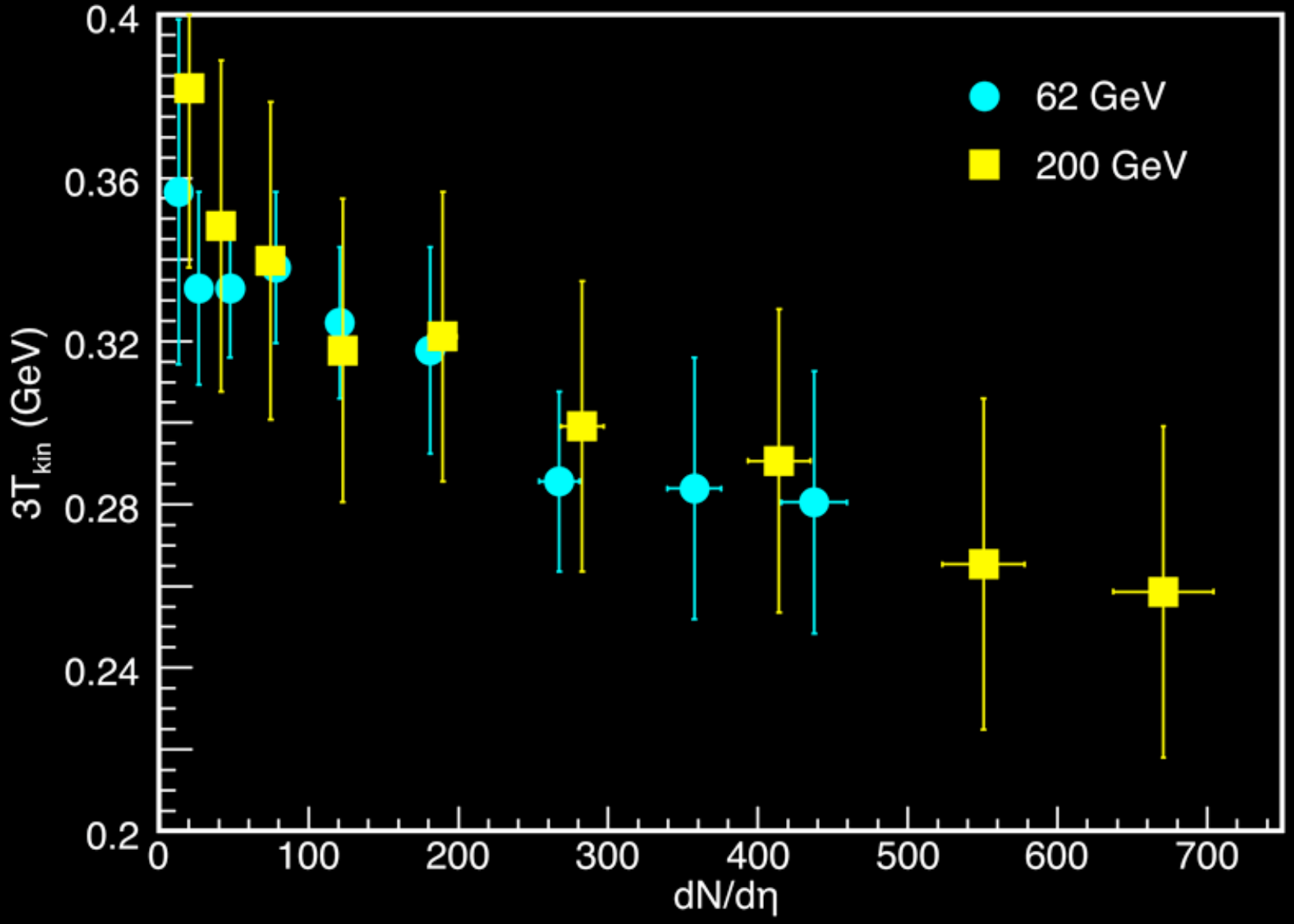
Balance Function with Identified Pions - Excitation Function



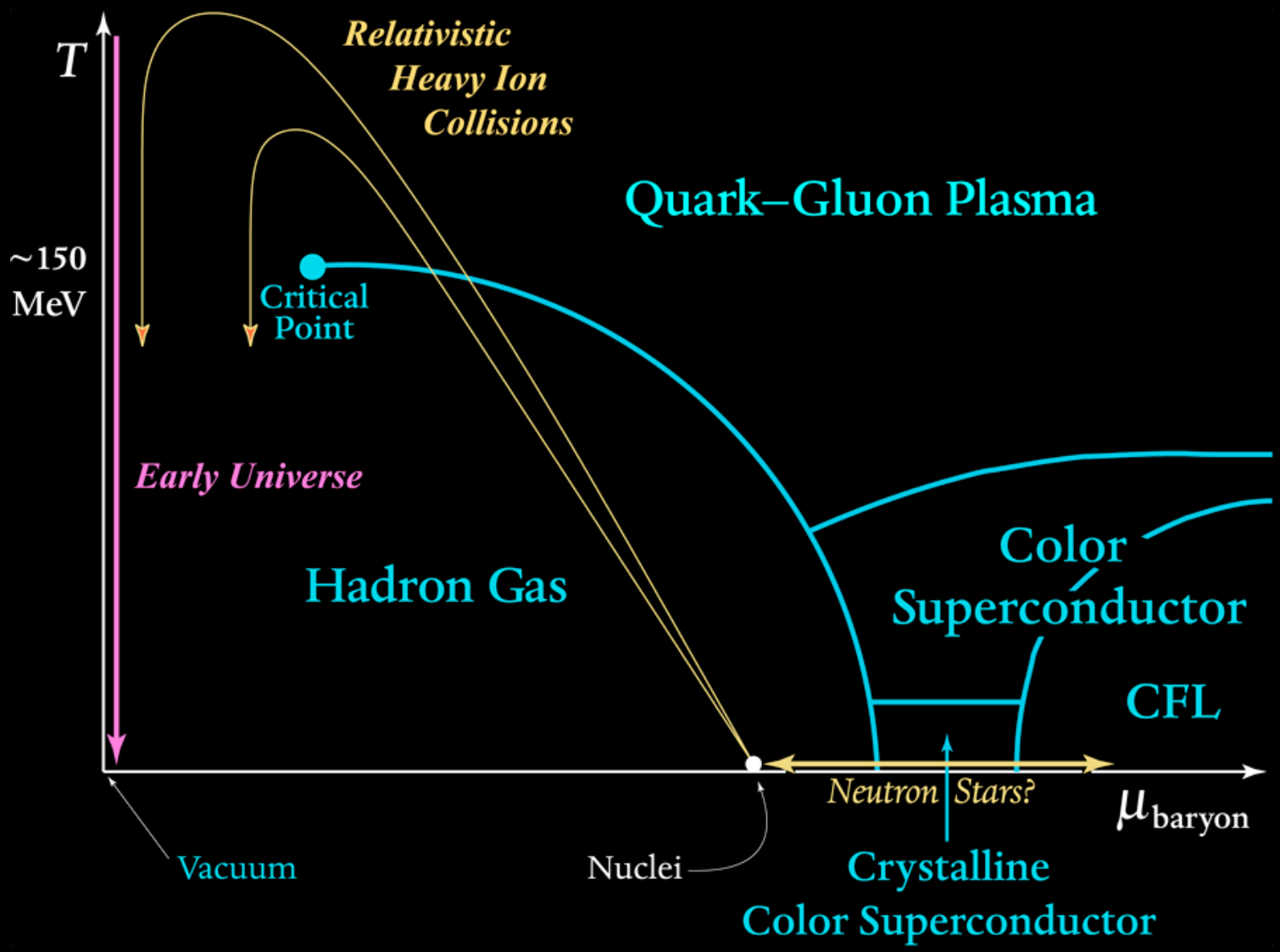
$B(q_{inv})$ Widths using Identified Pions - Excitation Function



Kinetic Temperatures as a Reference

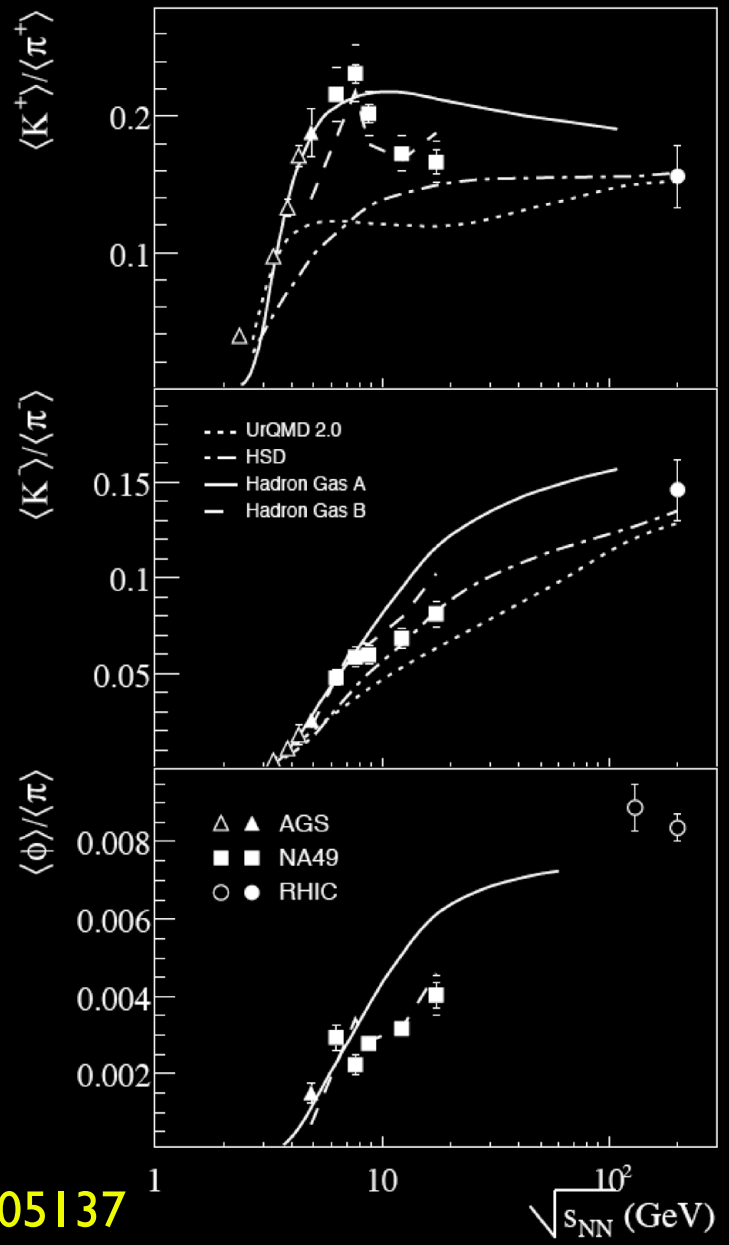


The QCD Phase Diagram



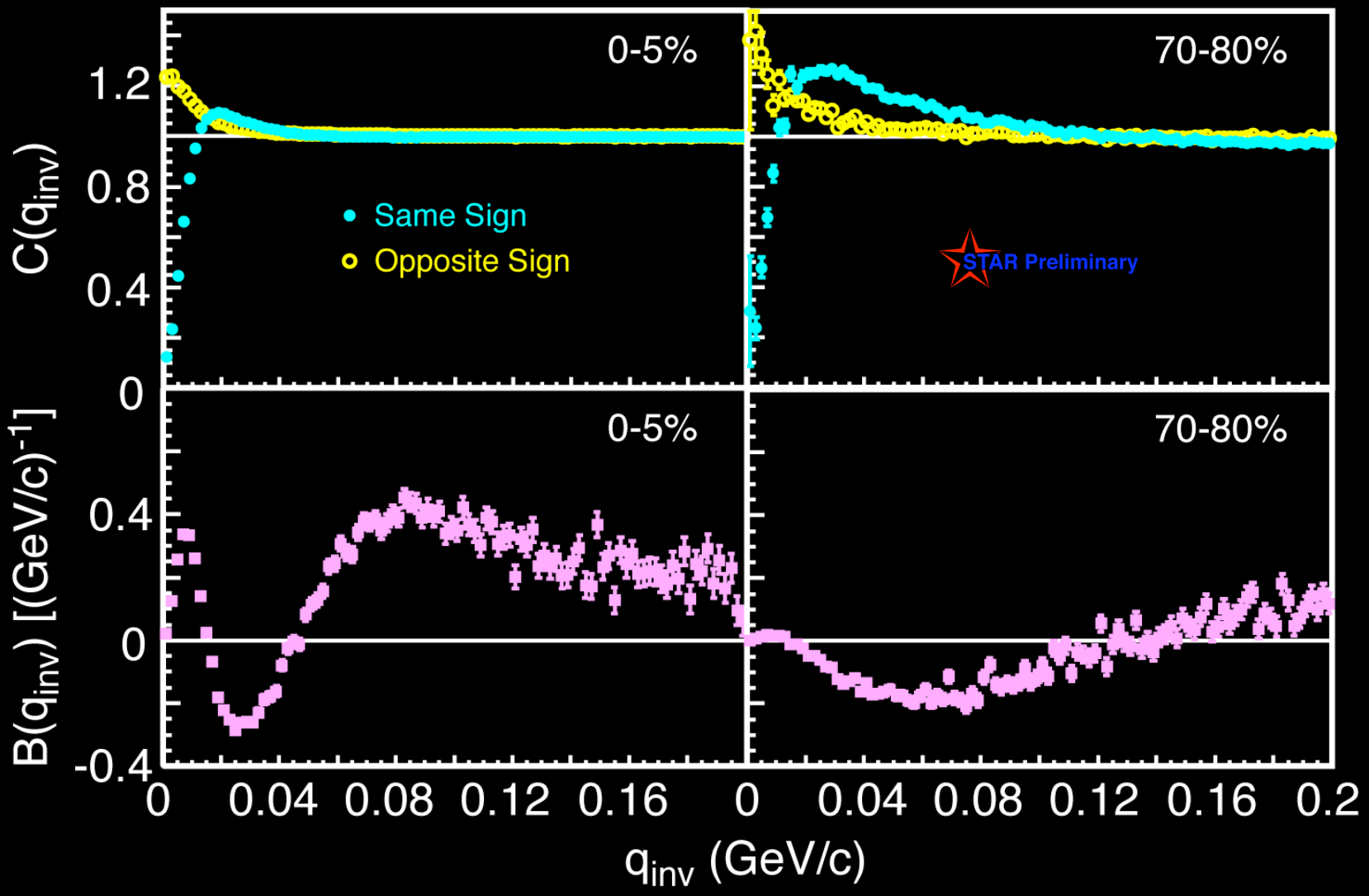
The Search for the QCD Phase Transition

- The production of strangeness may be related to the onset of deconfinement
- Excitation function of $\langle K^+\rangle/\langle \pi^+\rangle$ shows "horn" around $s_{NN}^{1/2}$ = 7 GeV
- The excitation function of $\langle K^-\rangle/\langle \pi^-\rangle$ is smooth



C. Blume (NA49), hep-ph/0505137

HBT-Coulomb Effects for $B(q_{inv})$



- Expanded scale in q_{inv}
- Compare correlation function to $B(q_{inv})$

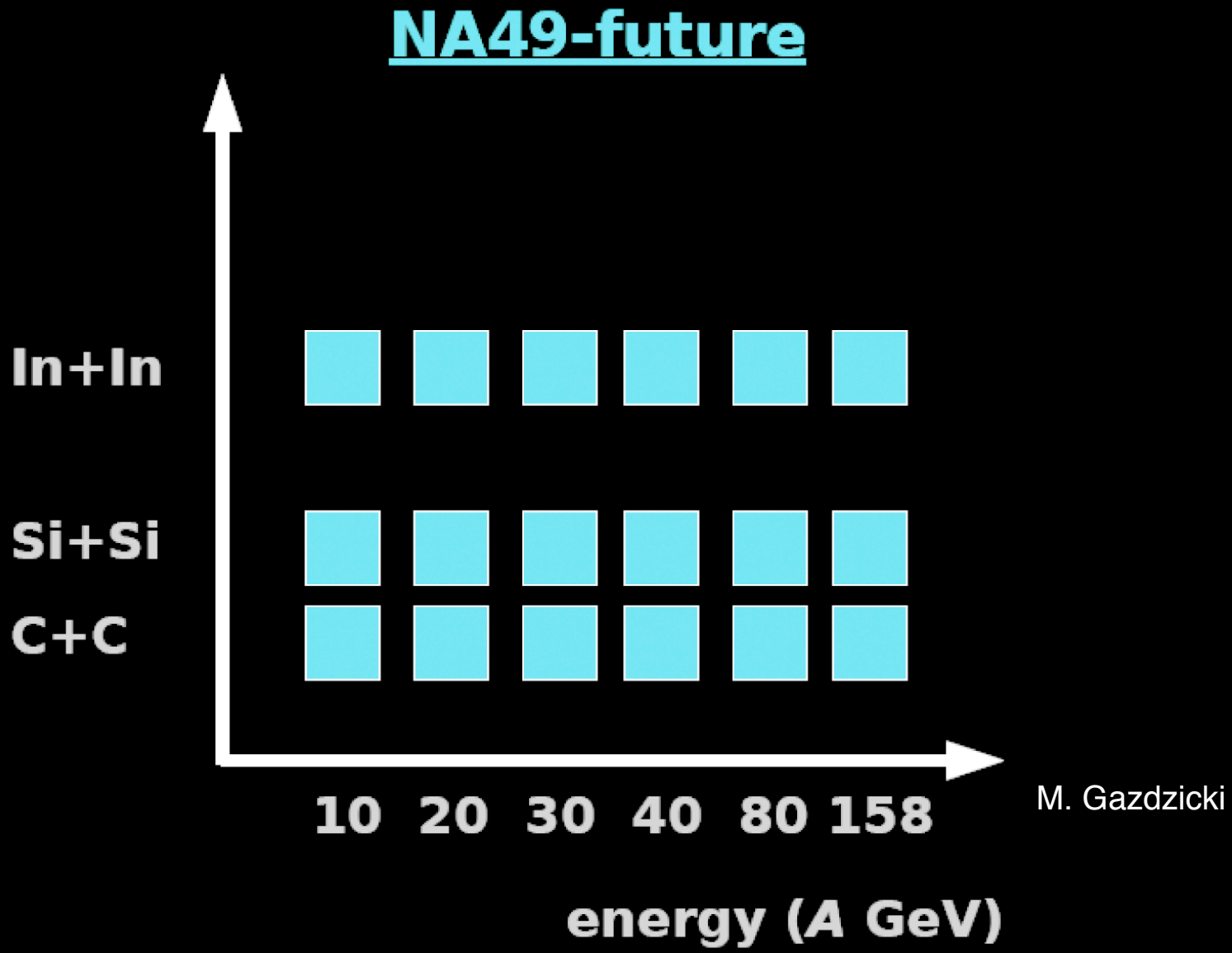
RHIC Energy Scan

- Energies as low as $s_{NN}^{1/2}$ = 4.5 GeV (10 AGeV fixed target)

$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	Min Bias BBC Rate (Hz)	Days/ Mevents	Number Of Events 10^6	Number of beam days
4.6	570	5(5)	9(4.6)	5	45(23+2)
6.3	470	7(50)	4(0.5)	5	20(3+1)
7.6	410	13(150)	2(0.2)	5	10(1+1)
8.8	380	20(300)	1.5(<1)	5(>5)	7.5(1+1)
12	300	54(1000)	0.5(<1)	5(>50)	2.5(1+1)
18	220	>100(>1000)	0.25(<1)	5(>50)	1.5(1+1)
28	150	>100(>1000)	0.25(<1)	5(>50)	1.5(1+2)

T. Satogota, RHIC

NA 49/61 Future Program



M. Gazdzicki

Proposed Energy and Mass Scans