Universal Behavior of Charged Particle Multiplicities in Heavy-Ion Collisions

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for the PHOBOS Collaboration

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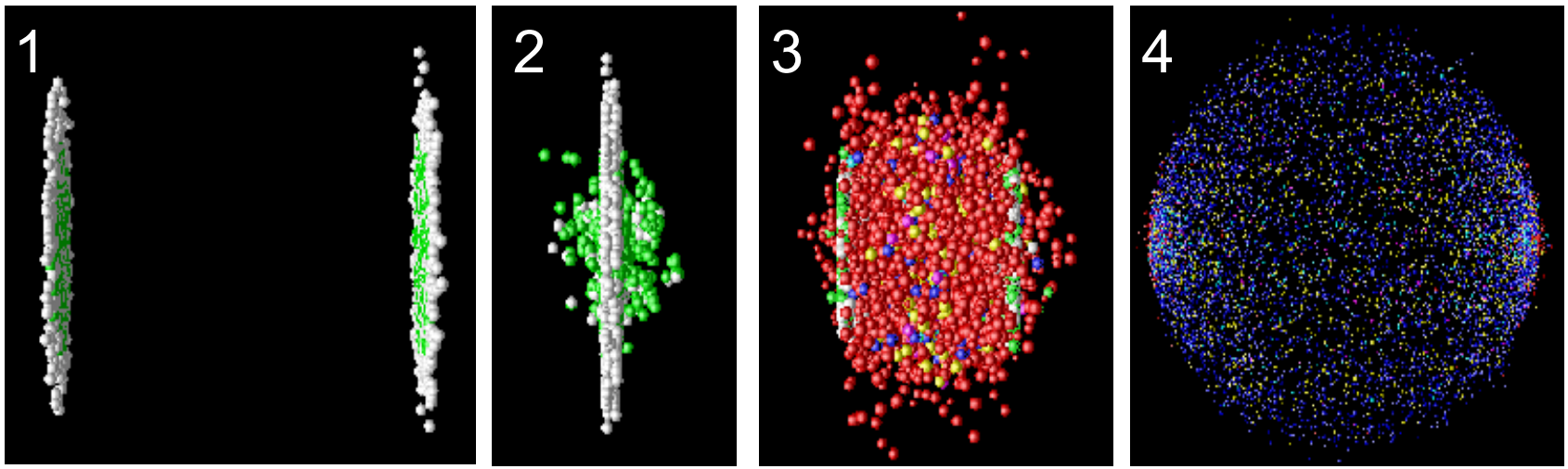
PHOBOS

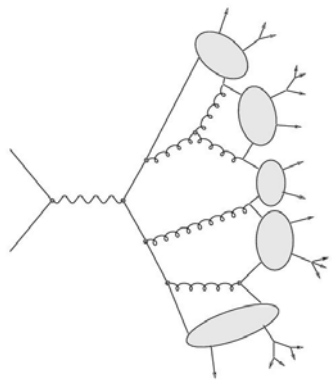
Heavy-Ion Collisions

VNI Simulations: Geiger, Longacre, Srivastava, nucl-th/9806102



Colliding Nuclei | Hard Collisions | Parton Cascade | Hadron Gas & Freeze-out

- Entropy produced as system evolves
  - Where does most of it come from?
  - Initial, partonic or hadronic stage?
  - Can we understand AA with simpler systems?



PHOBOS Collaboration



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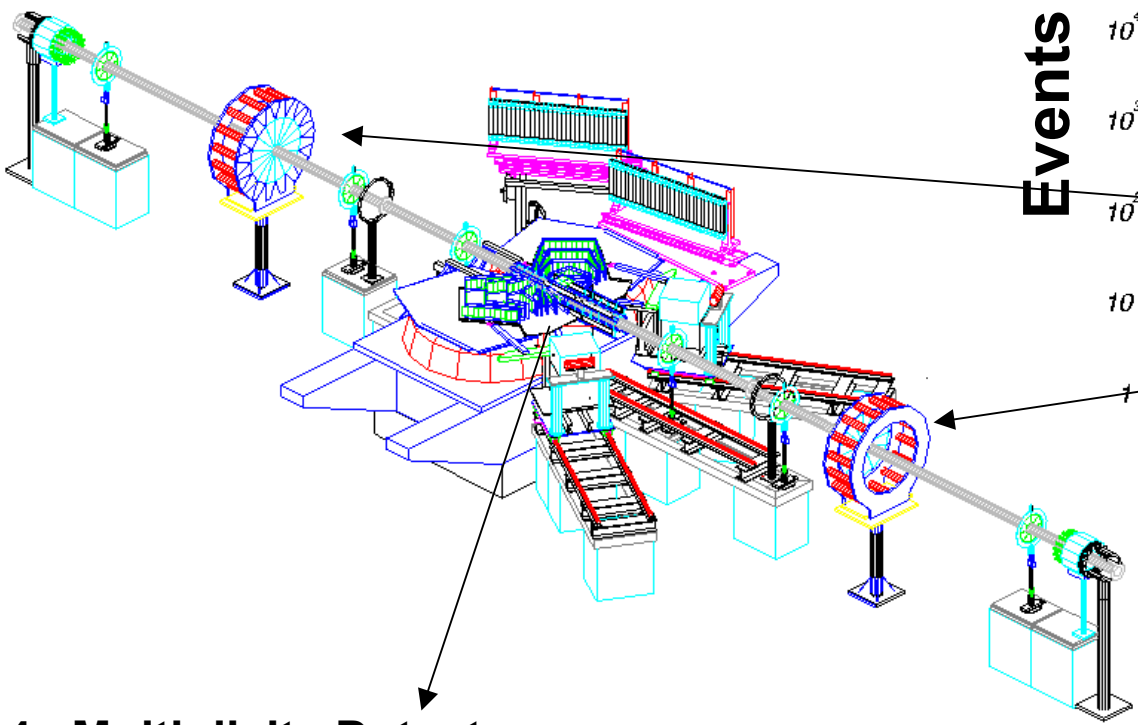
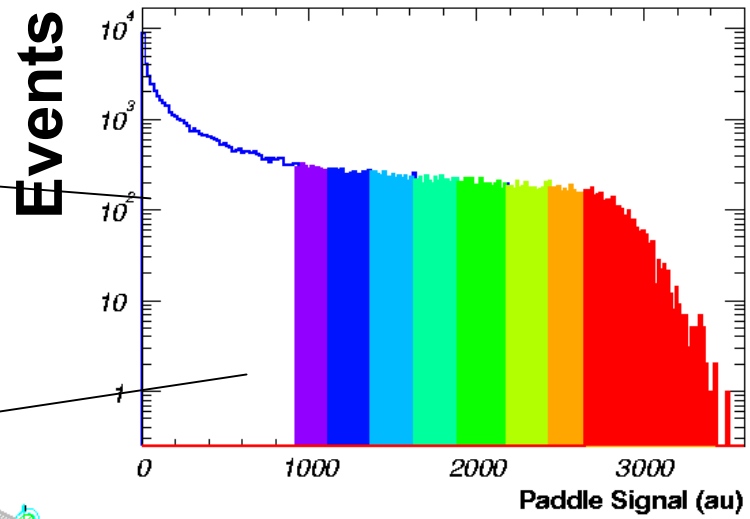
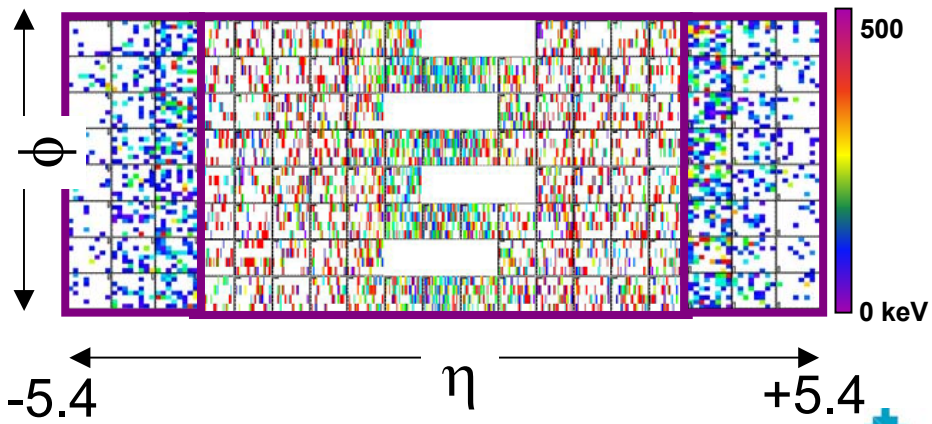
PHOBOS: Centrality & Multiplicity

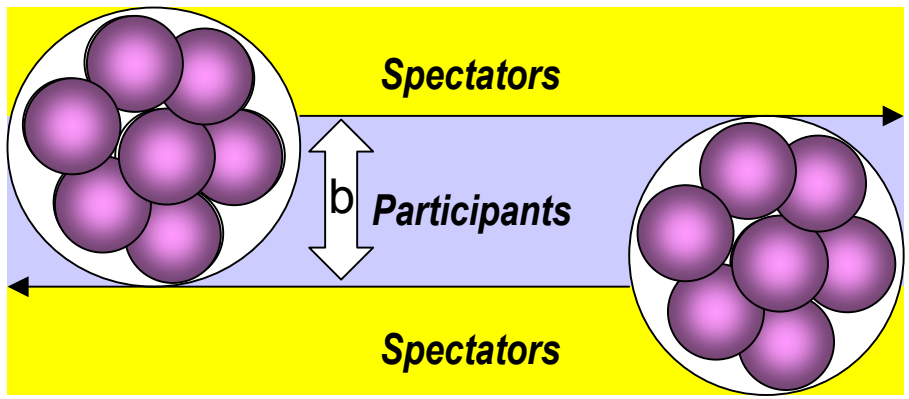




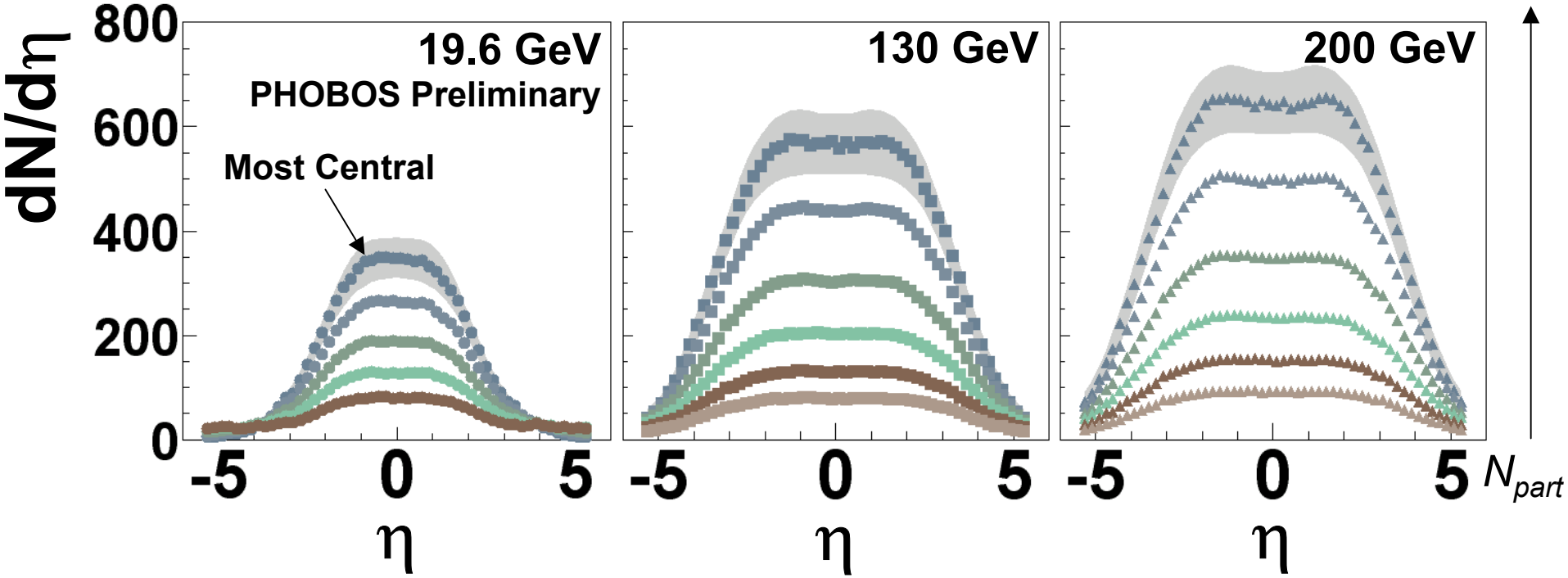
Paddle Signal
(monotonic w/ N_{part})

4π Multiplicity Detector





PHOBOS Data on dN/dη



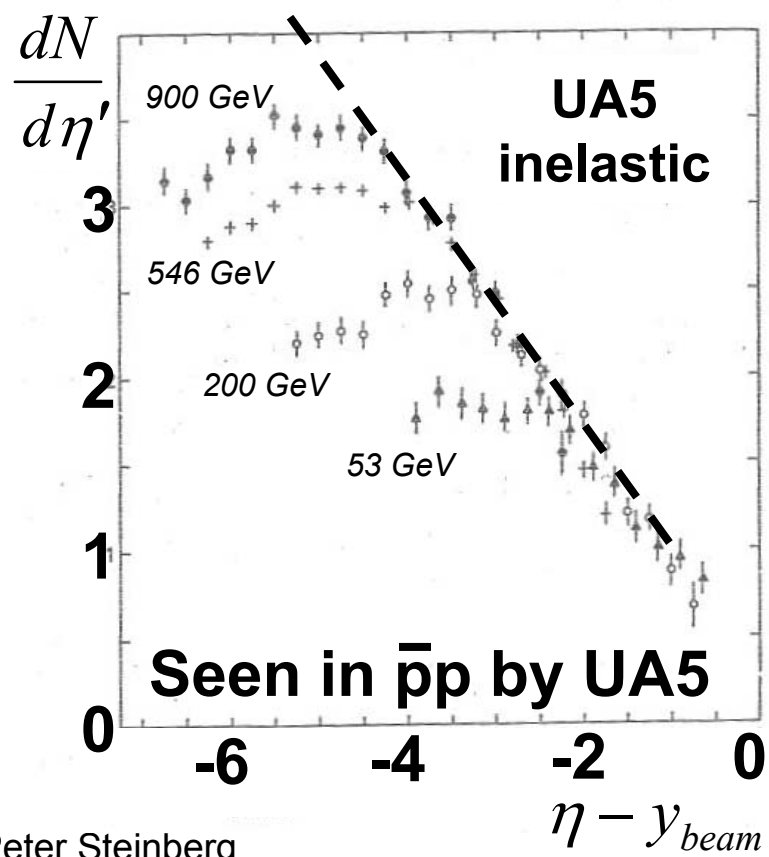
- Au+Au collisions at √s=19.6, 130, 200 GeV
  - dN/dη for |η|<5.4 over full azimuth
  - Centrality from paddles (130/200) & N_{hits} (19.6)
  - Top 50% of total cross section (N_{part}~65-360)

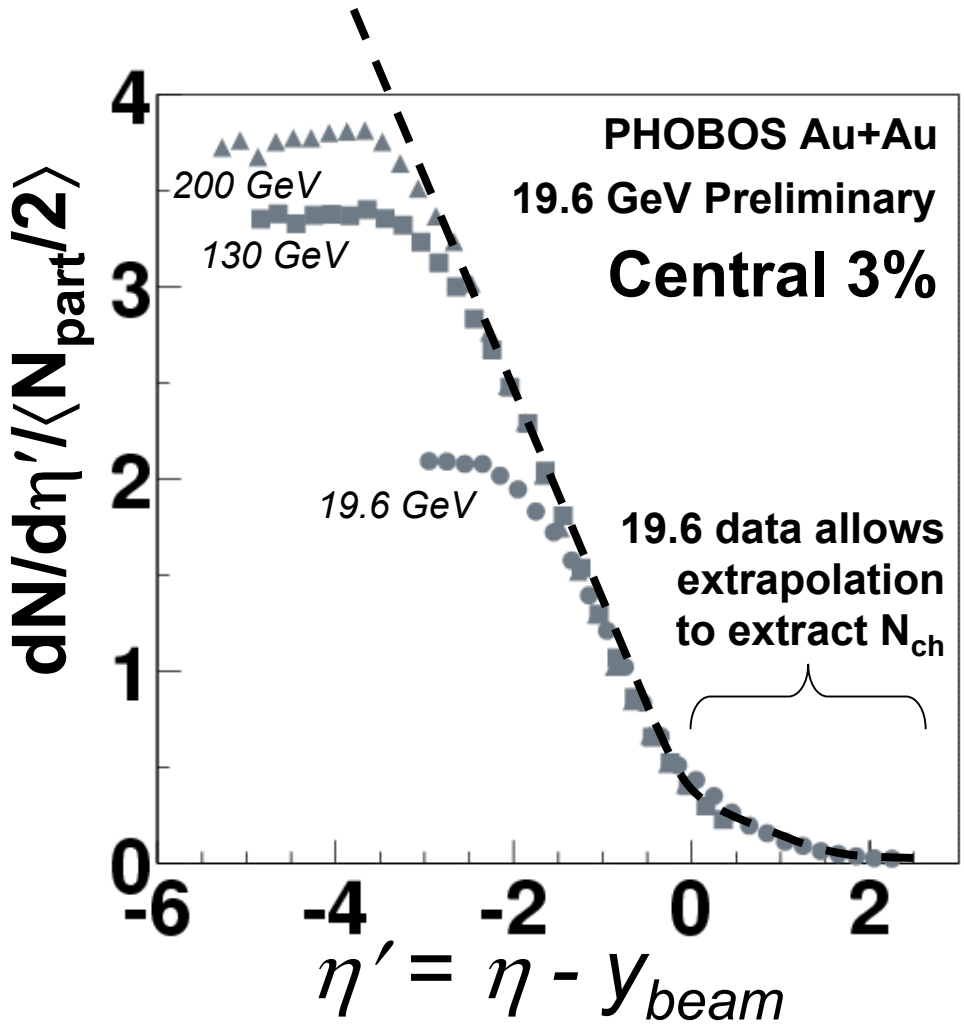
Limiting Fragmentation

Plotting dN/dη vs.

$$\eta' = \eta - y_{beam}$$

shows scaling behavior in the "forward" region→





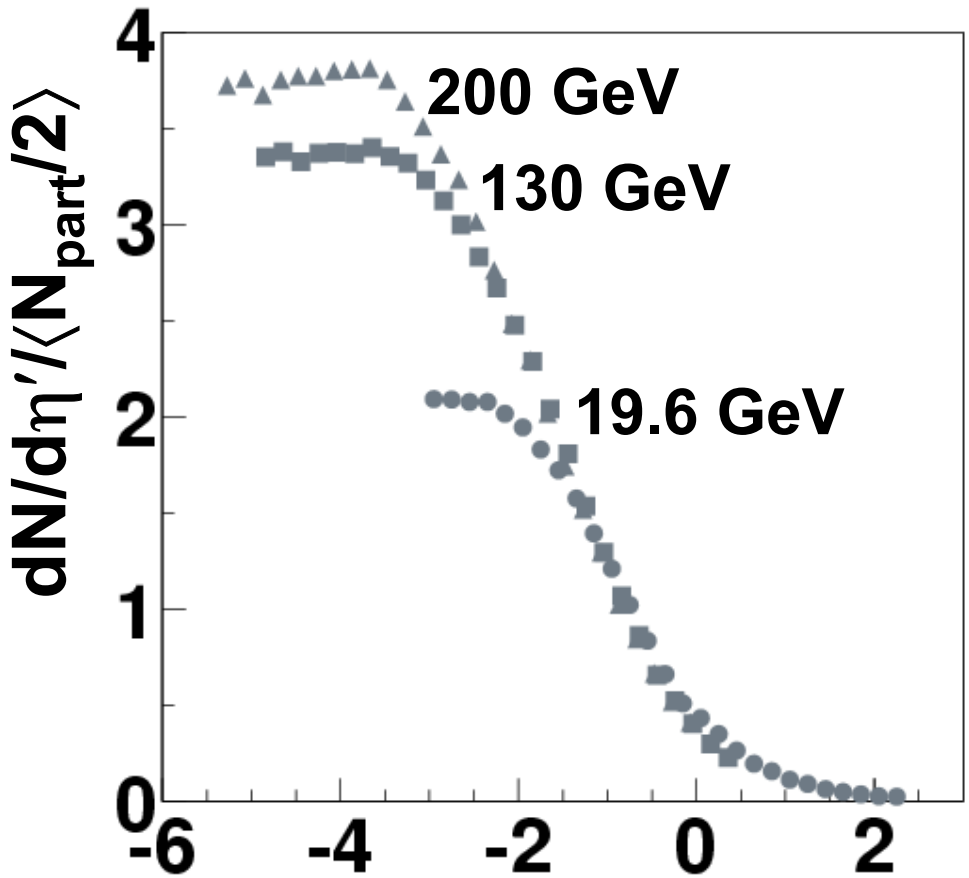
Universal limiting distribution seen in both AA and pp

Centrality Dependence of dN/dη′

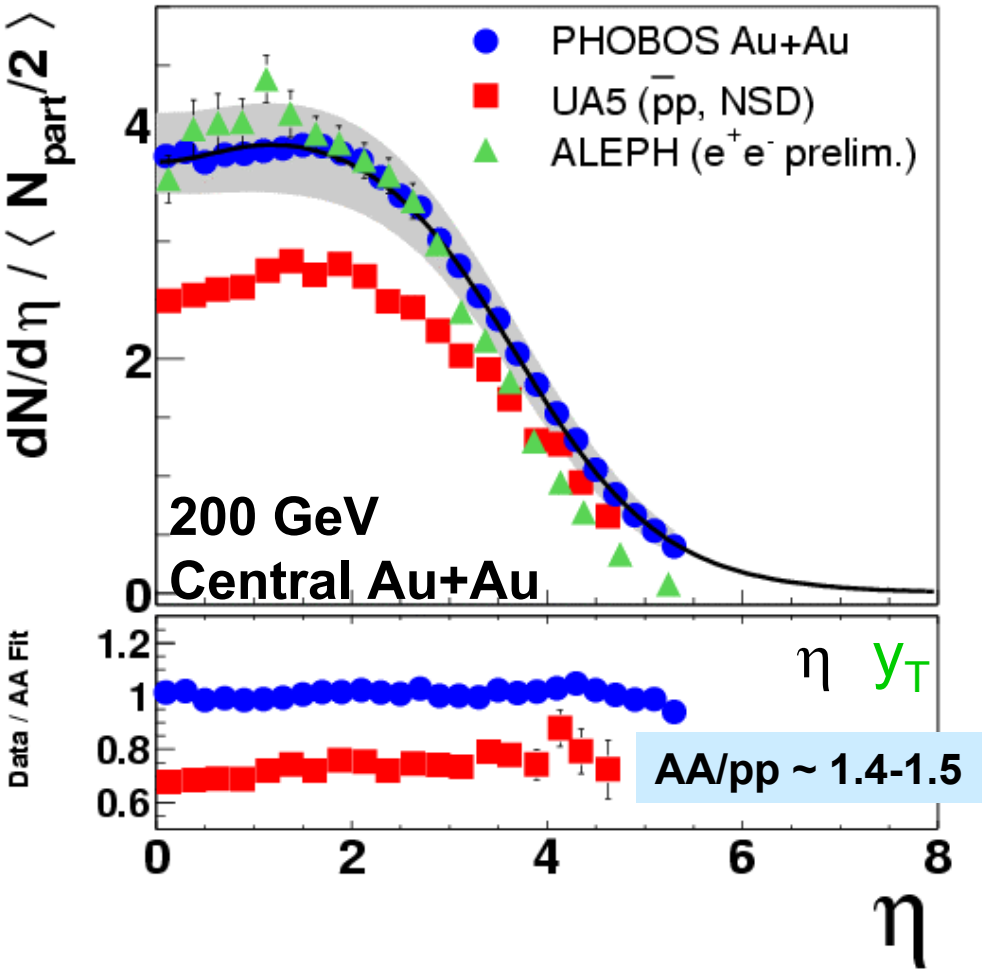
$$\frac{2}{N_{part}}\frac{dN}{d\eta'}(\eta') \quad vs. \quad N_{part}$$

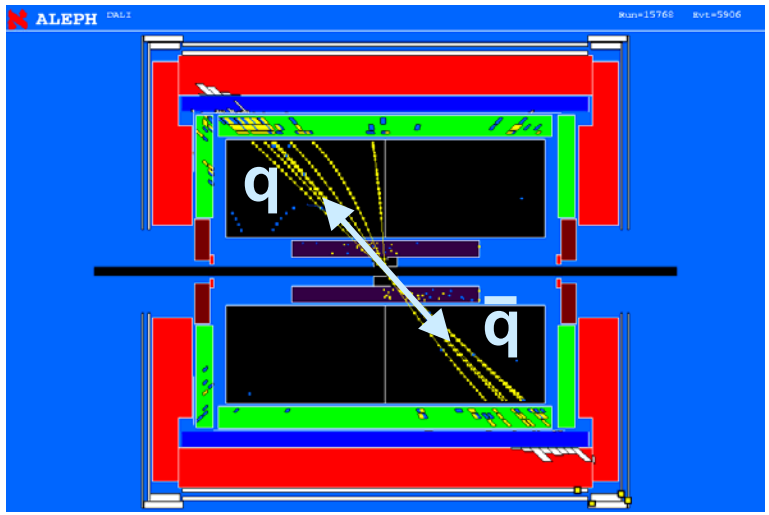
Location	Centrality Dependence	Interpretation
η' ~ -5	Rises	Saturation? 2-component?
η' ~ -1.5	Stable	Scaling
η'~ 1.5	Falls	Cascading in spectators?

- Are these effects related?
  - Long-range correlations?
  - Energy conservation?
  - Stopping?
- Other collision systems?



Rapidity Distributions at 200 GeV

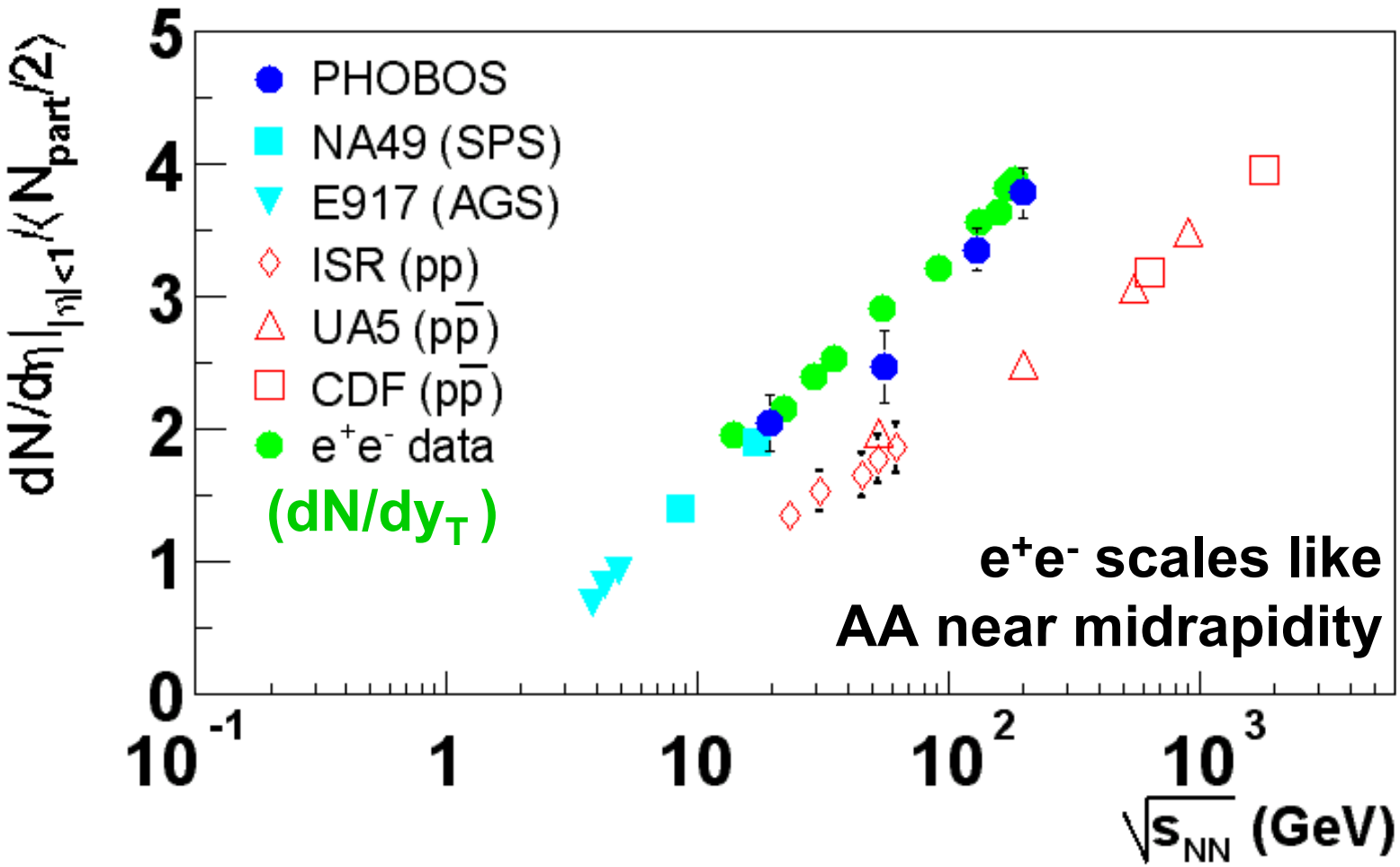




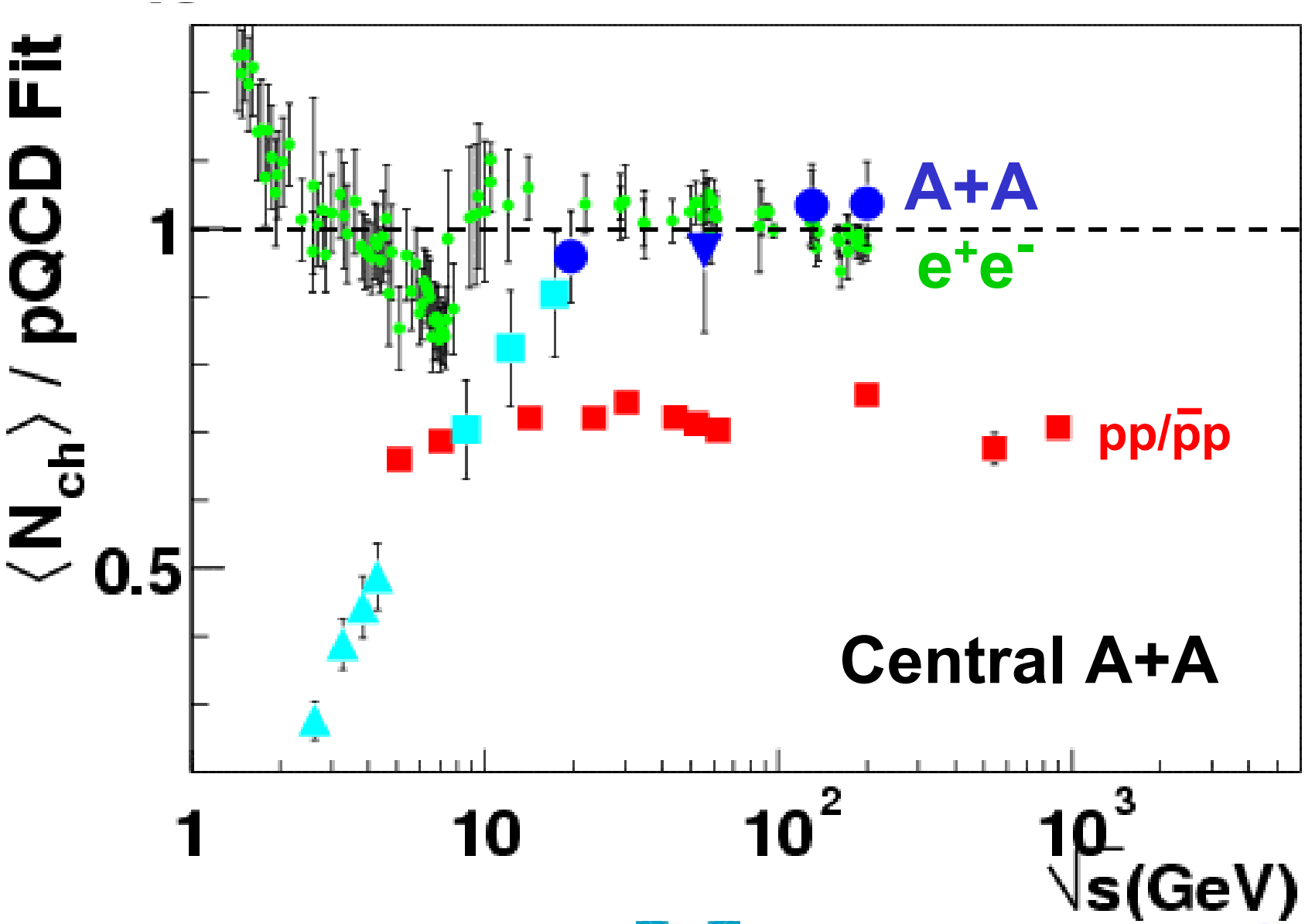
e^+e^- measures dN/dy_T (rapidity relative to "thrust" axis)

Surprising agreement in shape between AA/e^+e^-/pp

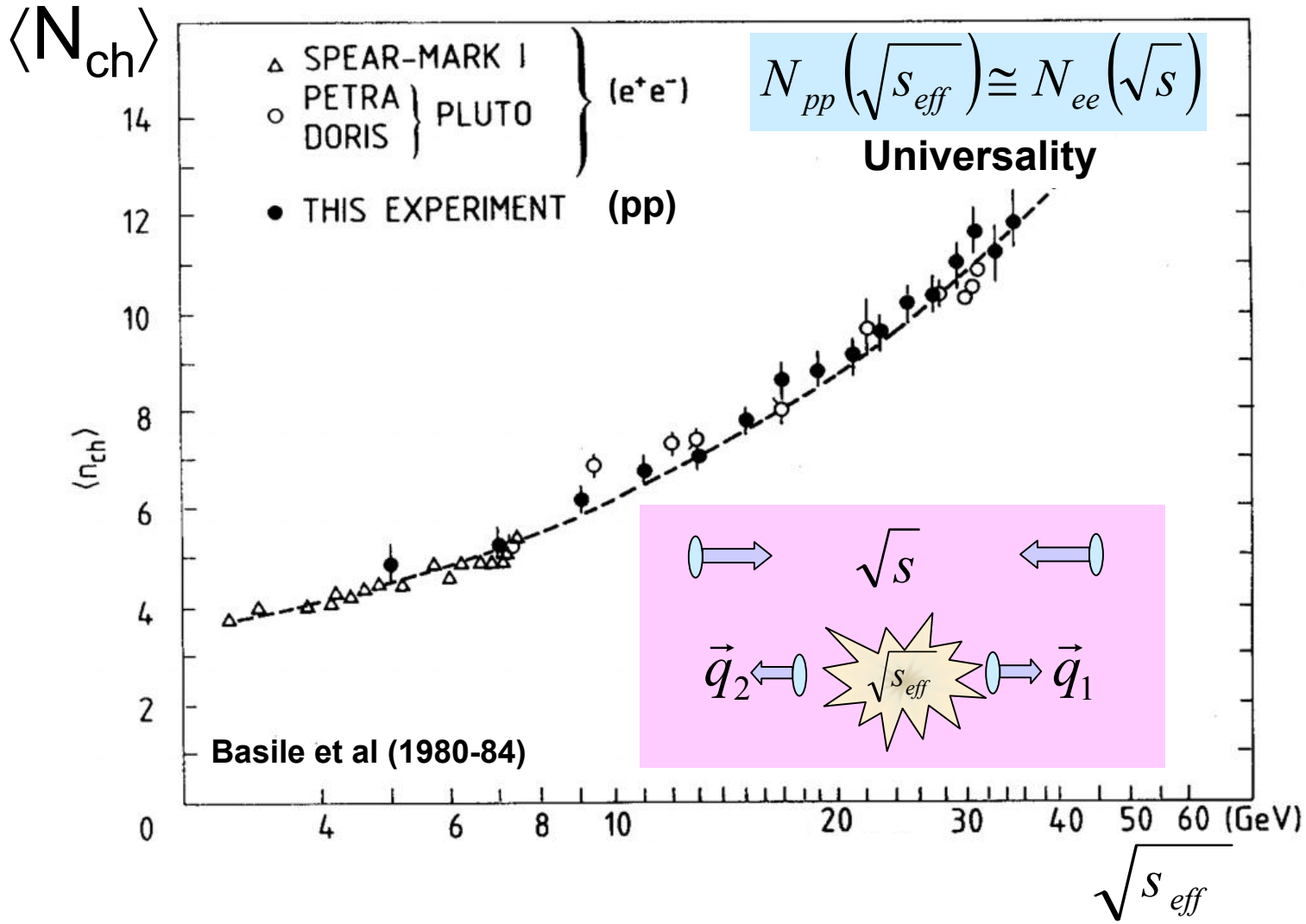
Particle density near midrapidity



Total Multiplicity vs. Beam Energy

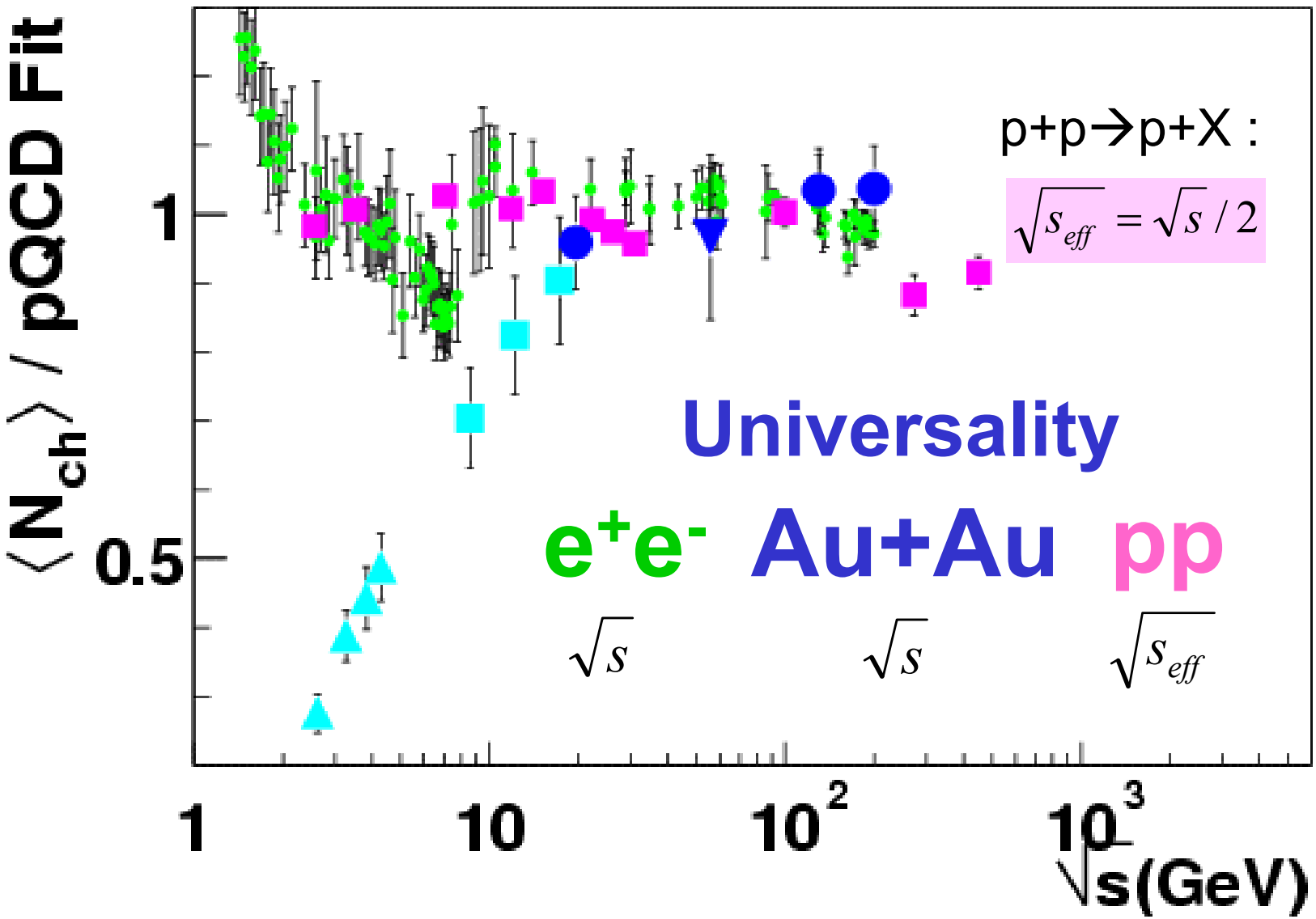


Leading Particle Effect



Subtract energy of leading protons to define effective energy

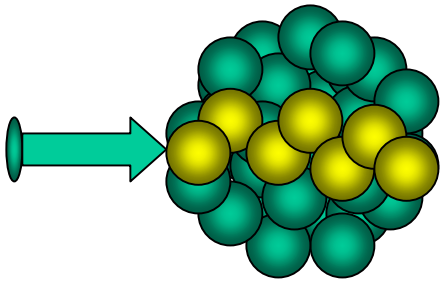
Approach to Universality



How can AA scale like e^+e^-?

pA collisions

E910
NA49



ν counts
collisions
$N_{part}=\nu+1$

- With increasing ν
  - Proton "stops" (i.e. deposits energy)
  - Pion yield ***saturates***

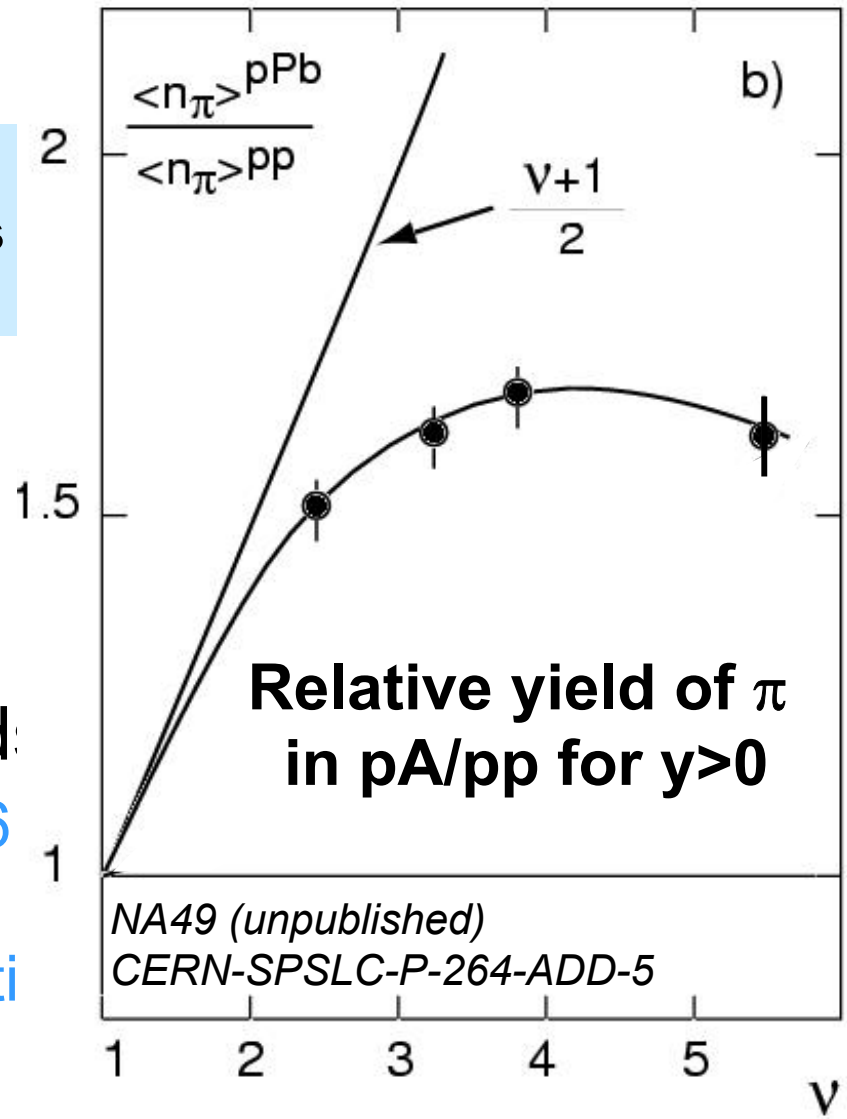
➢ Above ν~3, pion yield

  ➢ Central AA has ν~5-6

    ➢ Scaling with N_{part}

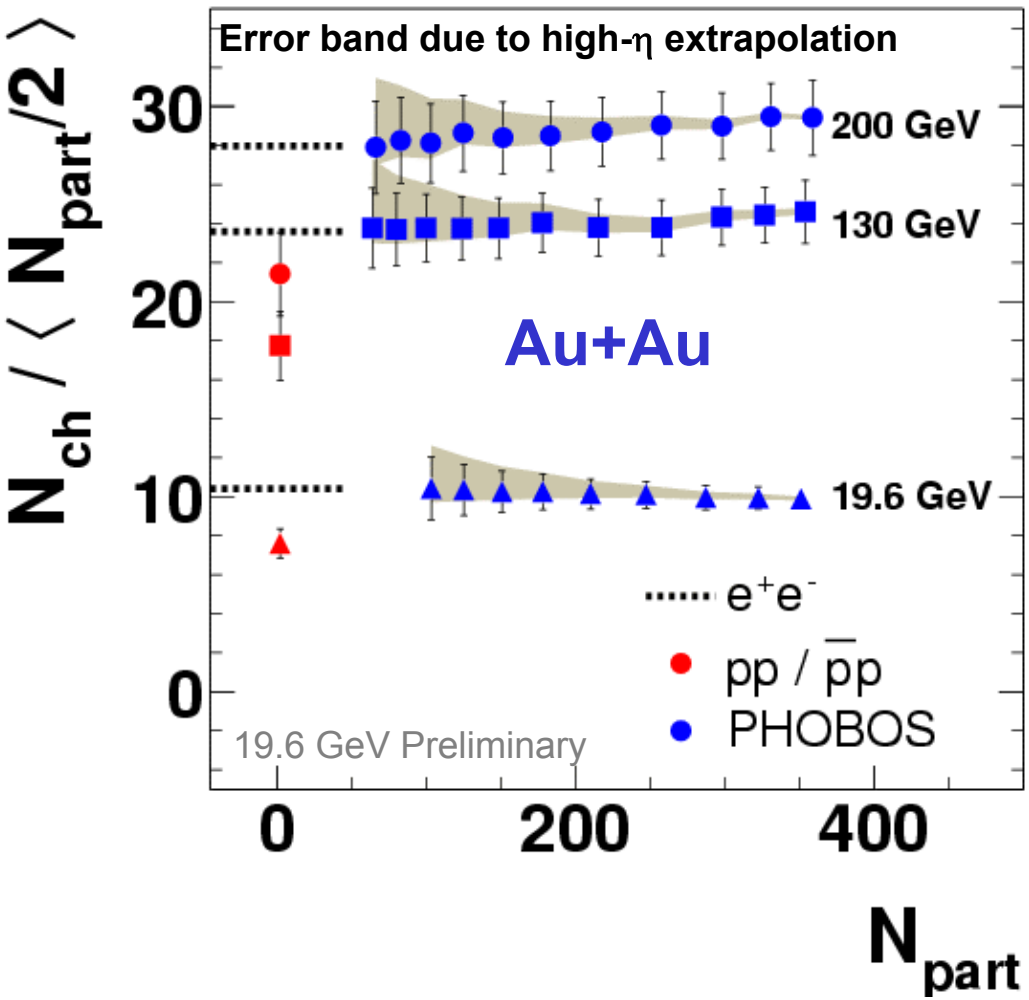
  ➢ Reduces leading parti

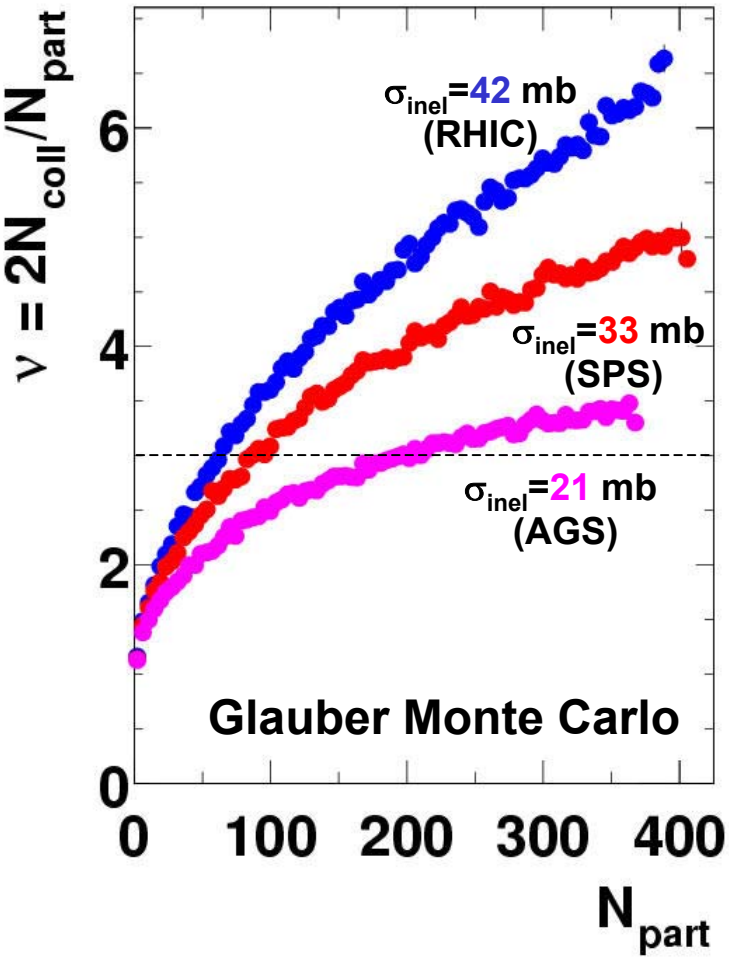
    ➢ Scaling with $\sqrt{s}$



NA49 SPS

Centrality Dependence of $\langle N_{ch} \rangle$





The Return of the Wounded Nucleon Model…

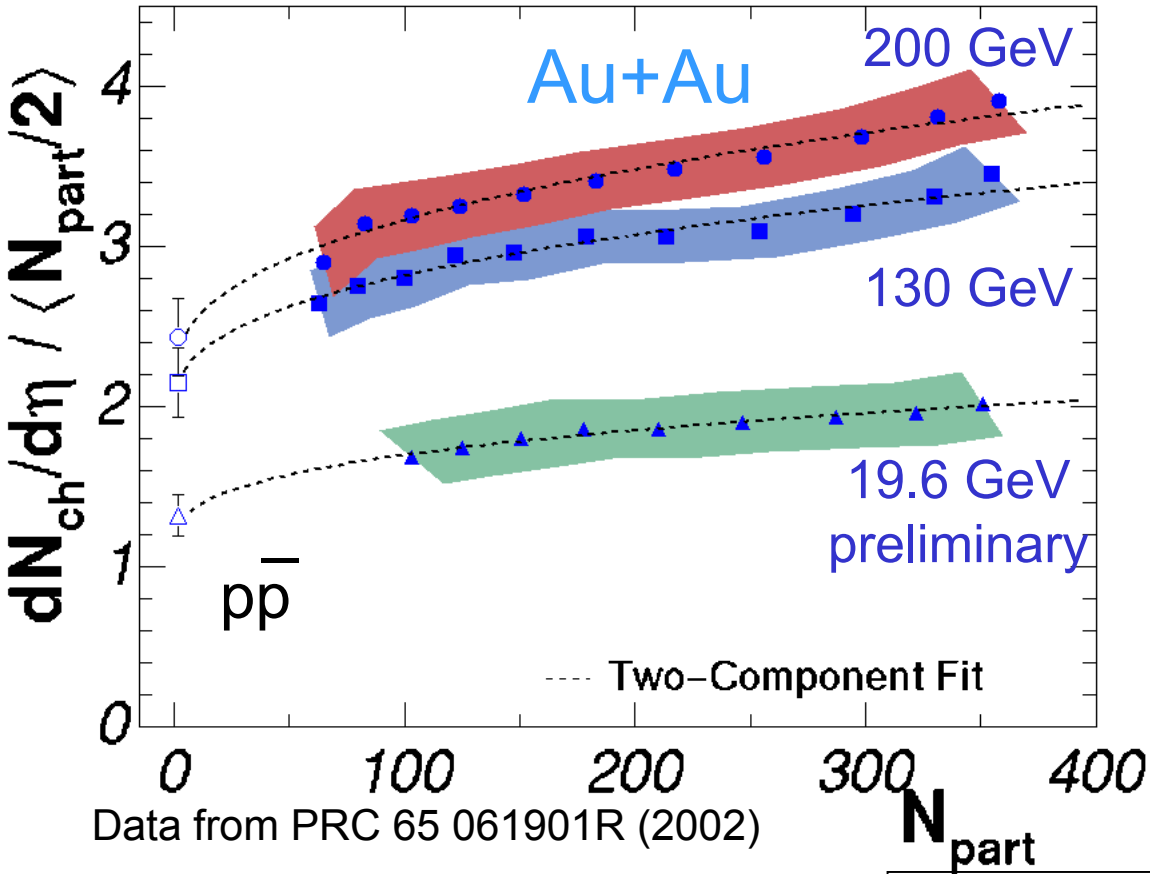
Bialas & Czyz 1976, Elias et al 1978

Two Kinds of Universality

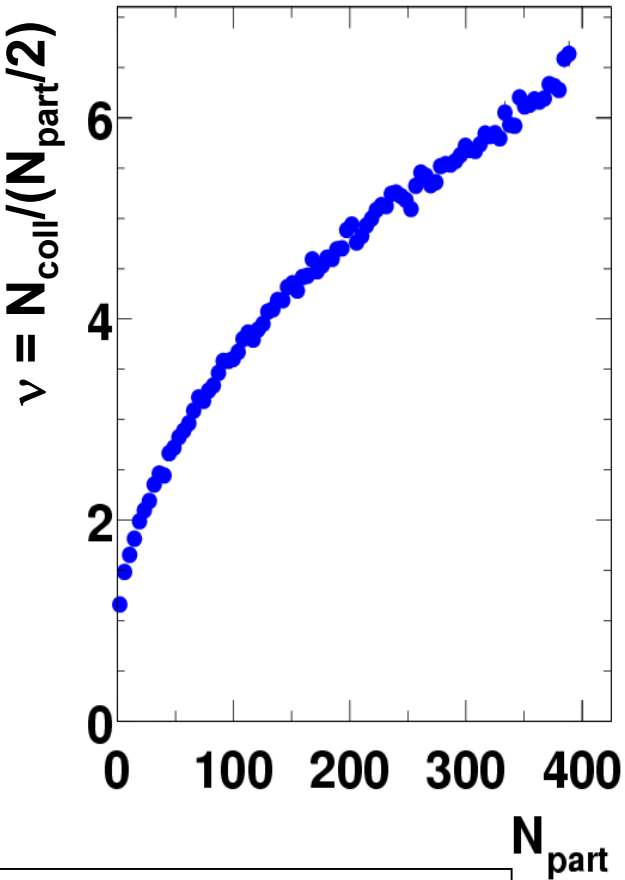
- **Universality in the forward region**
  - Data follow "limiting" distribution in η'
- **Universality of total multiplicity**
  - Same for all systems at same $\sqrt{s}$ ($\sqrt{s_{eff}}$ for pp)
  - "Startling" connection between Au+Au & e^+e^-
- Yields in AA scale primarily with N_{part}
  - Even at transverse momentum up to 5 GeV
  - Gerrit van Nieuwenhuizen's talk
- New perspective on hadron production?

Charged Particle Production

Central Density



Data from PRC 65 061901R (2002)



Two Component Model:

$$\frac{dN}{d\eta} = (1-x)n_{pp}N_{part} + xn_{pp}N_{coll}$$