

# *Imaging Charge Correlations*

*John Bower and Scott Pratt*

MICHIGAN STATE  
UNIVERSITY



Office of  
Science

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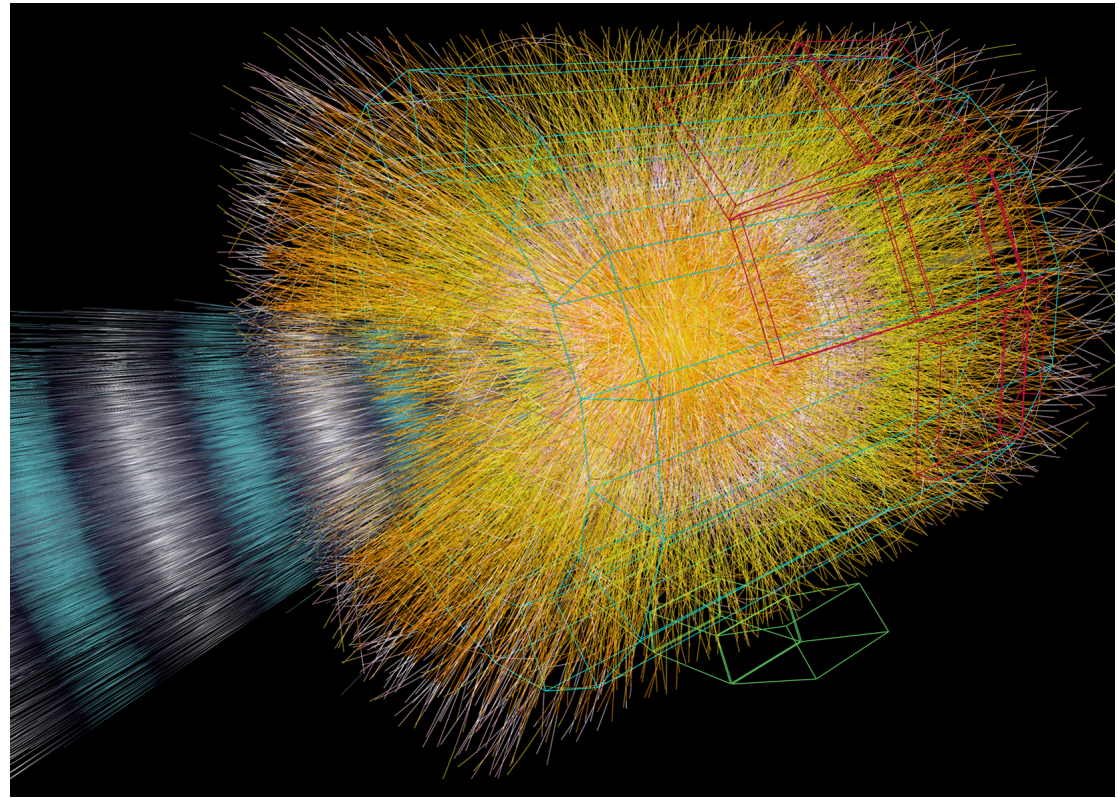
**BEST**  
COLLABORATION

# Relativistic Heavy-Ion Collisions

## RHIC - Brookhaven



## LHC - CERN



**Mission: Determine properties of Quark-Gluon Plasma**

# Goal

From measured correlation in momentum space

$$B_{hh'}(\Delta y) = \frac{\langle (n_h(0) - n_{\bar{h}}(0))(n_{h'}(\Delta y) - n_{\bar{h}'}(\Delta y)) \rangle}{\bar{n}_h + \bar{n}_{\bar{h}}}$$

Hadron species

Determine charge correlations in coordinate space

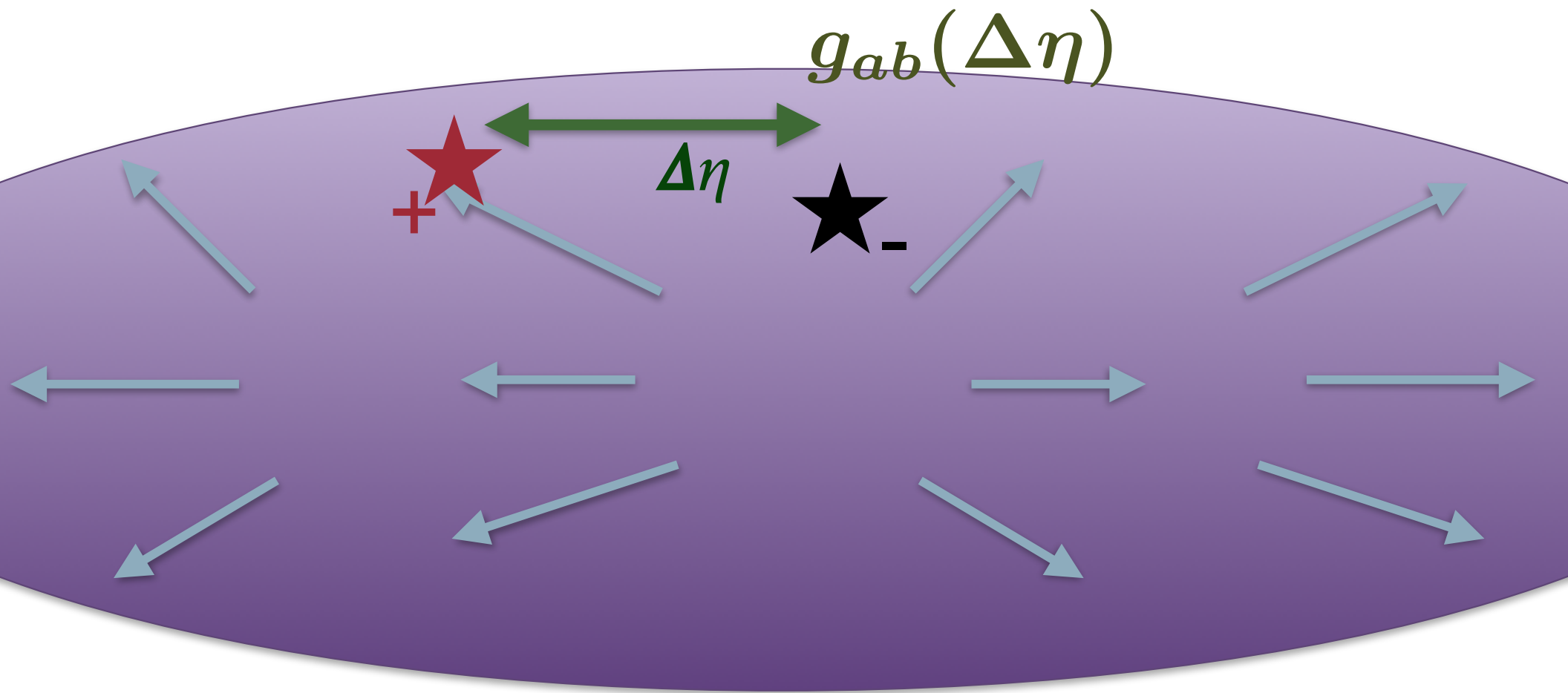
$$g_{ab}(\Delta\eta) = \langle \Delta\rho_a(0)\Delta\rho_b(\Delta\eta) \rangle$$

Charge (uds)

Shape of  $g_{ab}$  tells us when charges were produced

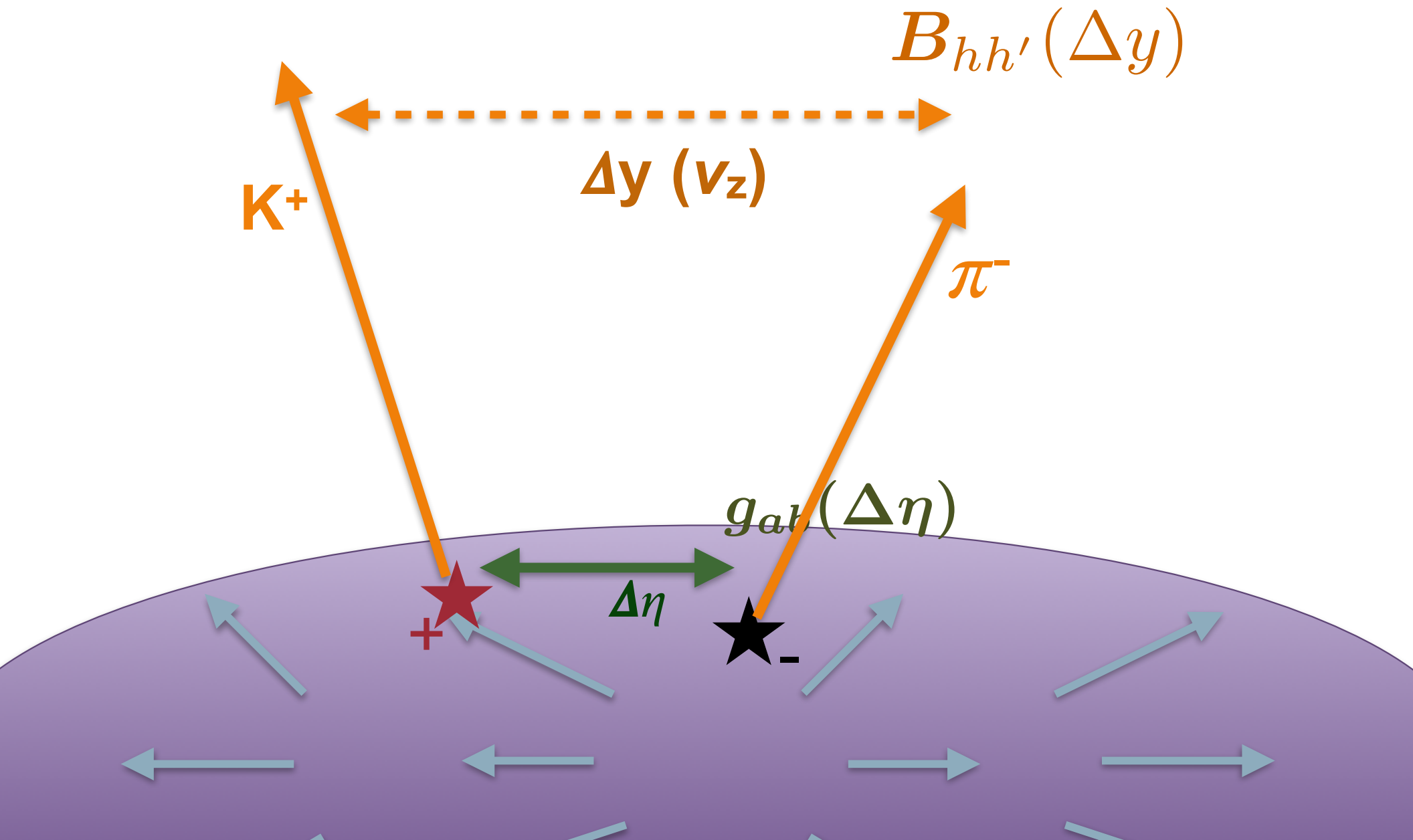
early production  $\rightarrow$  wider spread in  $g_{ab}$

# Visually





# Visually

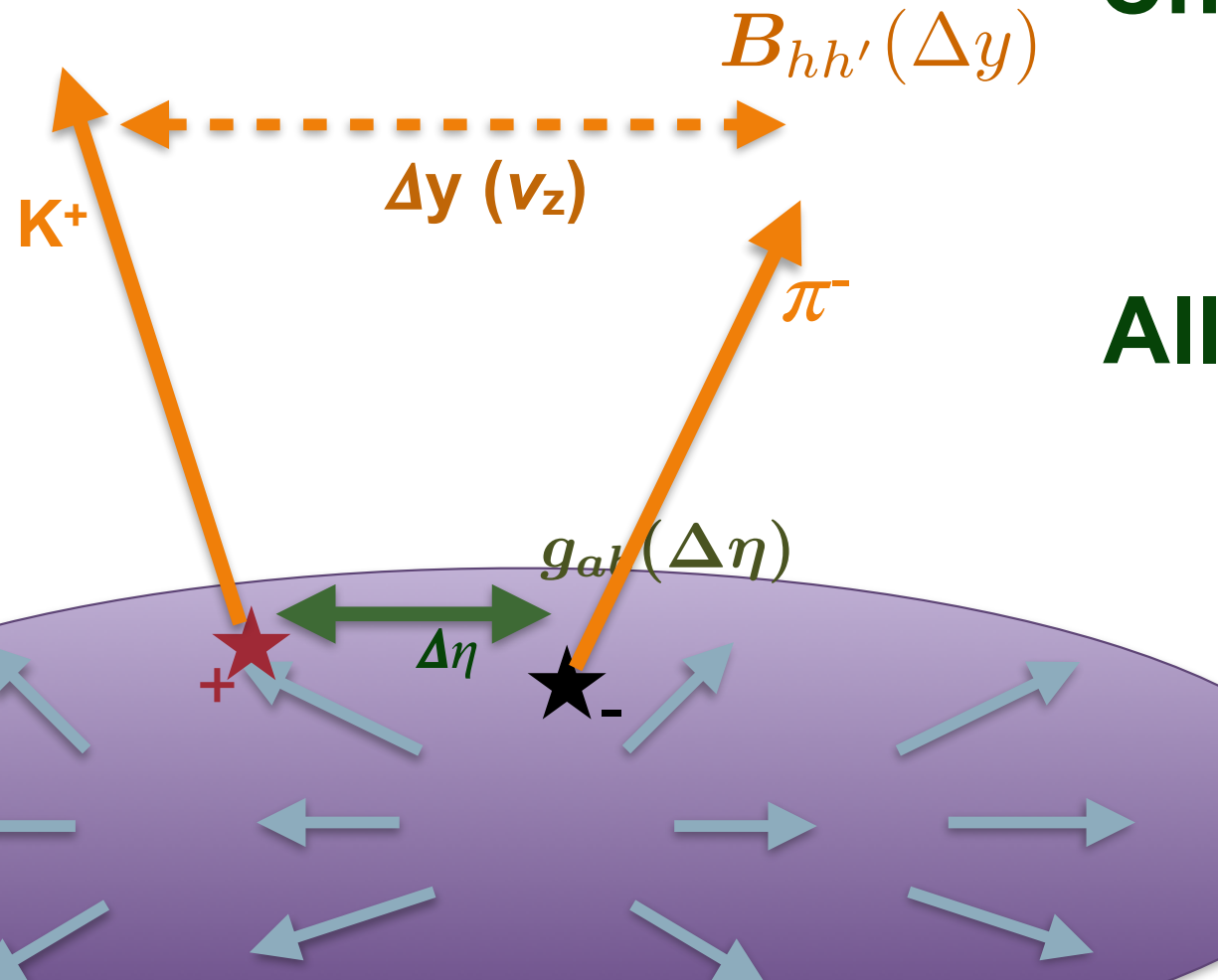


# Mapping *Blast-Wave* Model to $B_{hh'}$

Depends on:

- Temperature
- Collective flow
- Chemical equilibration

All well known (5-10%)



# Inverse/Imaging Problem

## 1. MODEL

$$g'_{ab}(\Delta\eta) \rightarrow B_{hh'}(\Delta y)$$

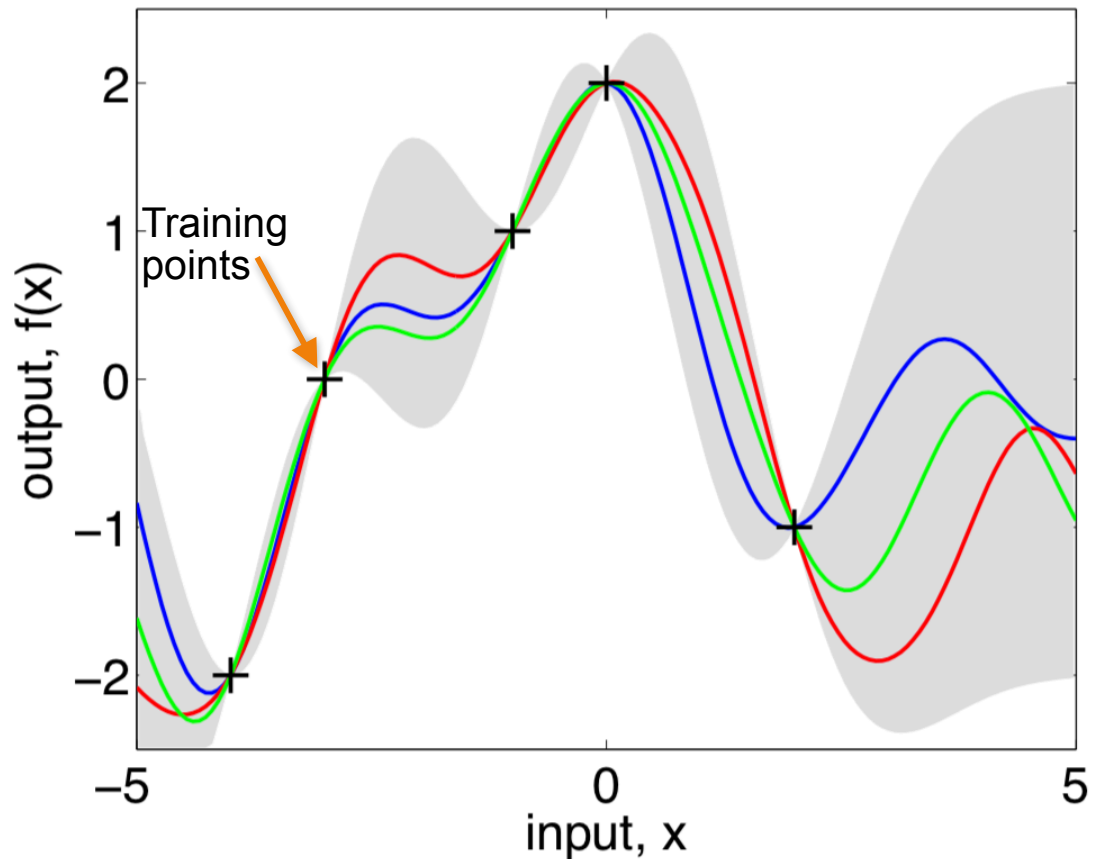
## 2. Parameterize

$$g_{ab}(\Delta\eta) = \frac{A_0}{\cosh(\Delta\eta/\Gamma)} + \frac{A_1}{\cosh^2(\Delta\eta/\Gamma)} \\ + \frac{A_2}{\cosh^3(\Delta\eta/\Gamma)} + \frac{A_3}{\cosh^4(\Delta\eta/\Gamma)} + \frac{A_4}{\cosh^5(\Delta\eta/\Gamma)}$$

## 3. Determine parameters by MCMC fit to data

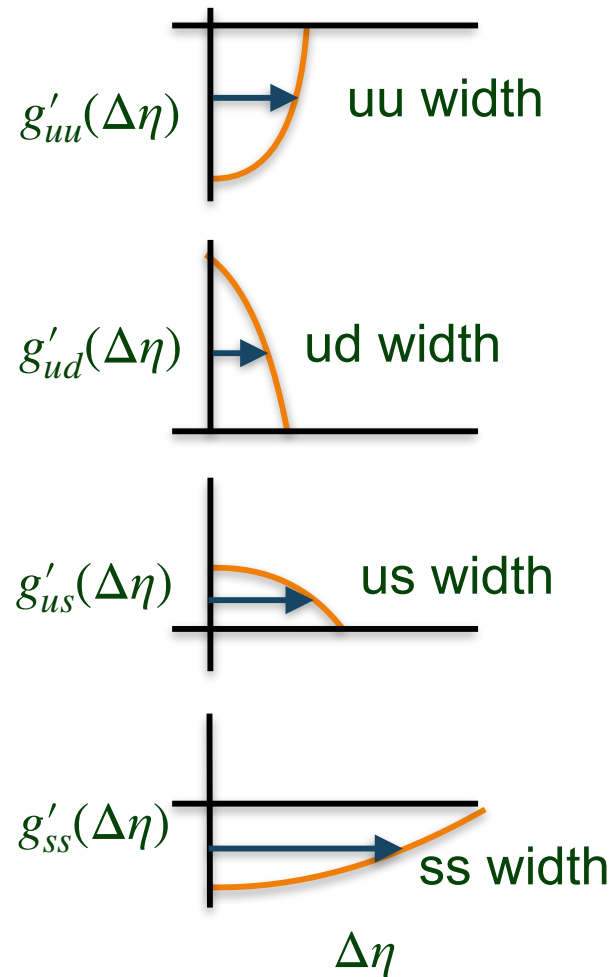
# Gaussian Process Emulator

- Increases speed
- Few days → few hours
- Enables more thorough investigation

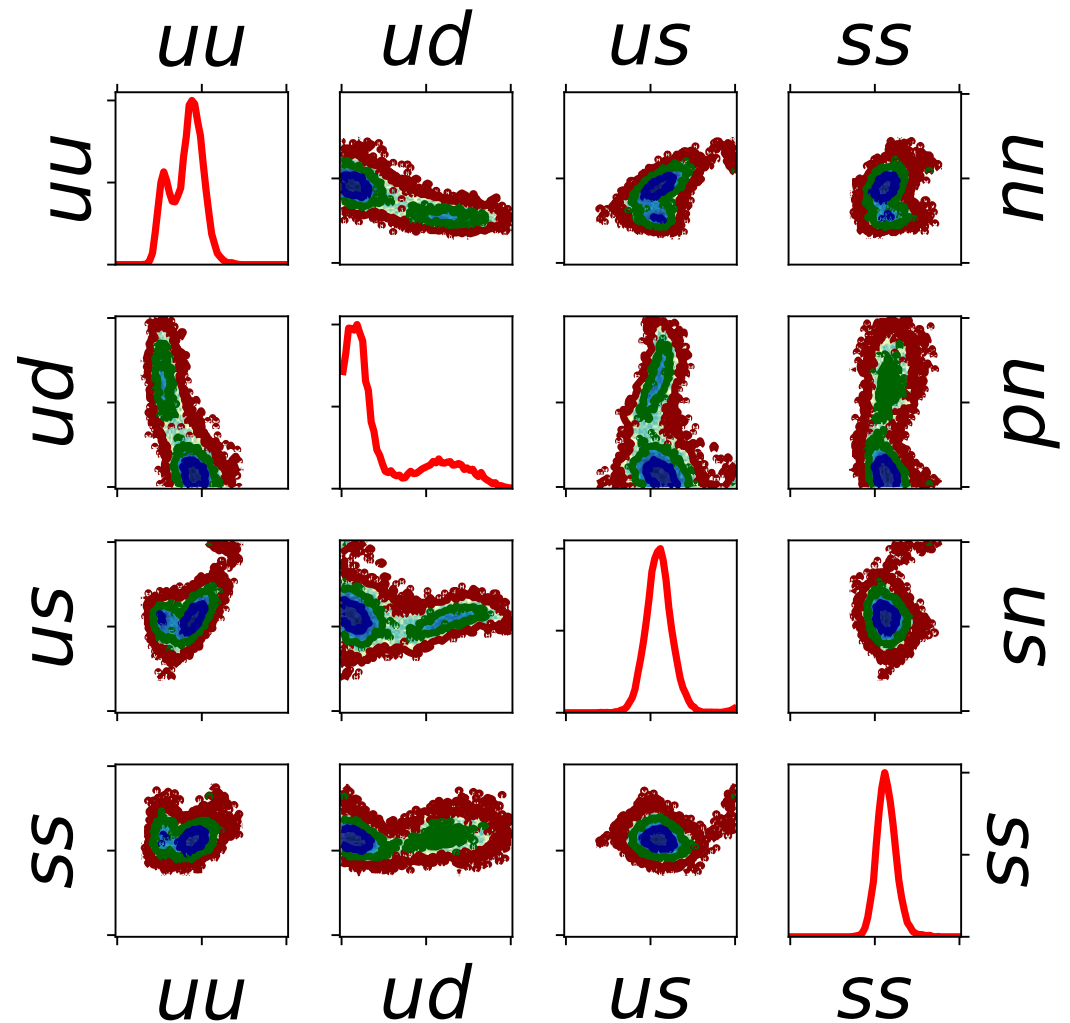




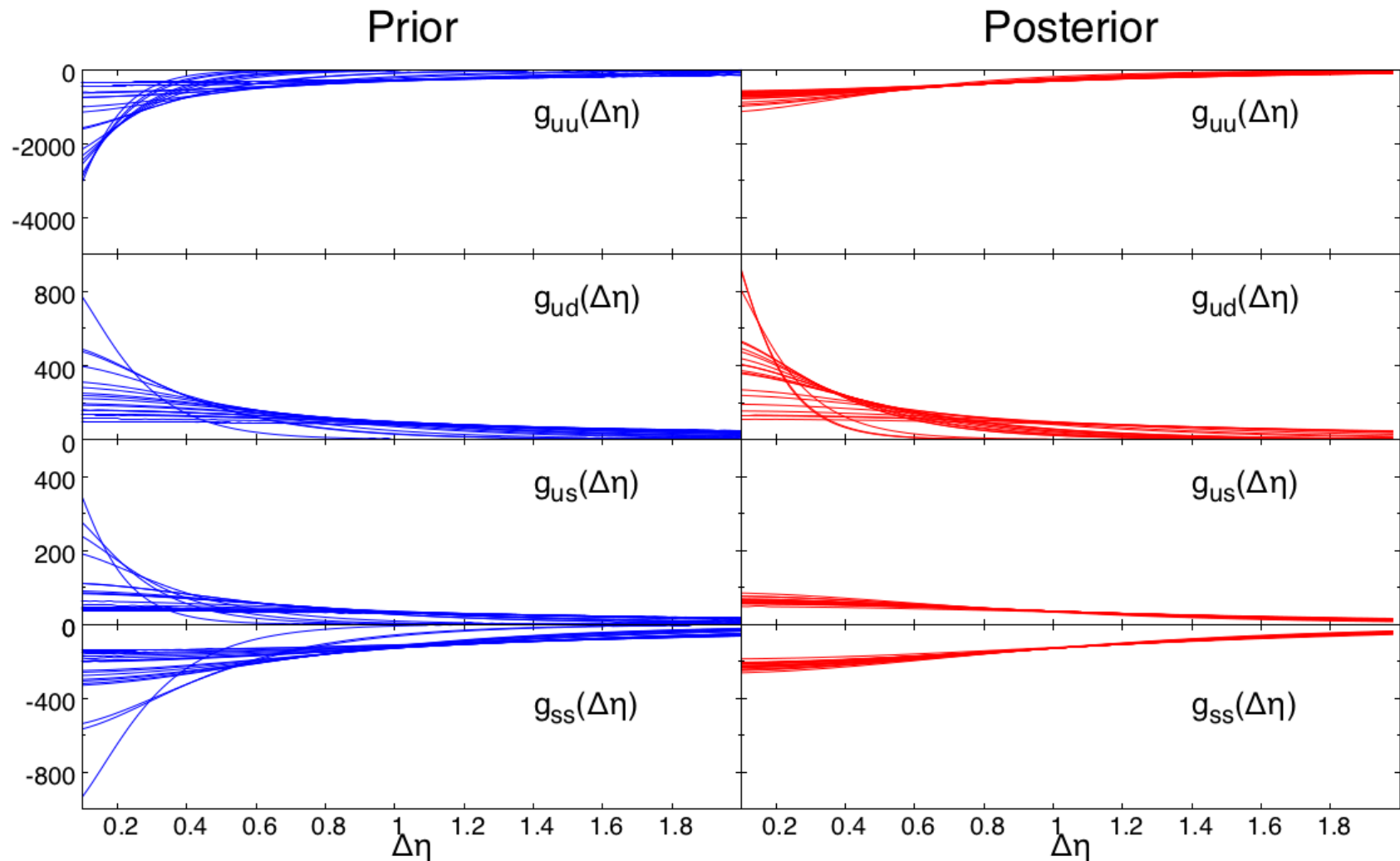
# Preliminary Results (4 parameters)- MCMC



$g_{ab}(\Delta\eta)$  widths: (0.1-1.5  $\Delta\eta$ )

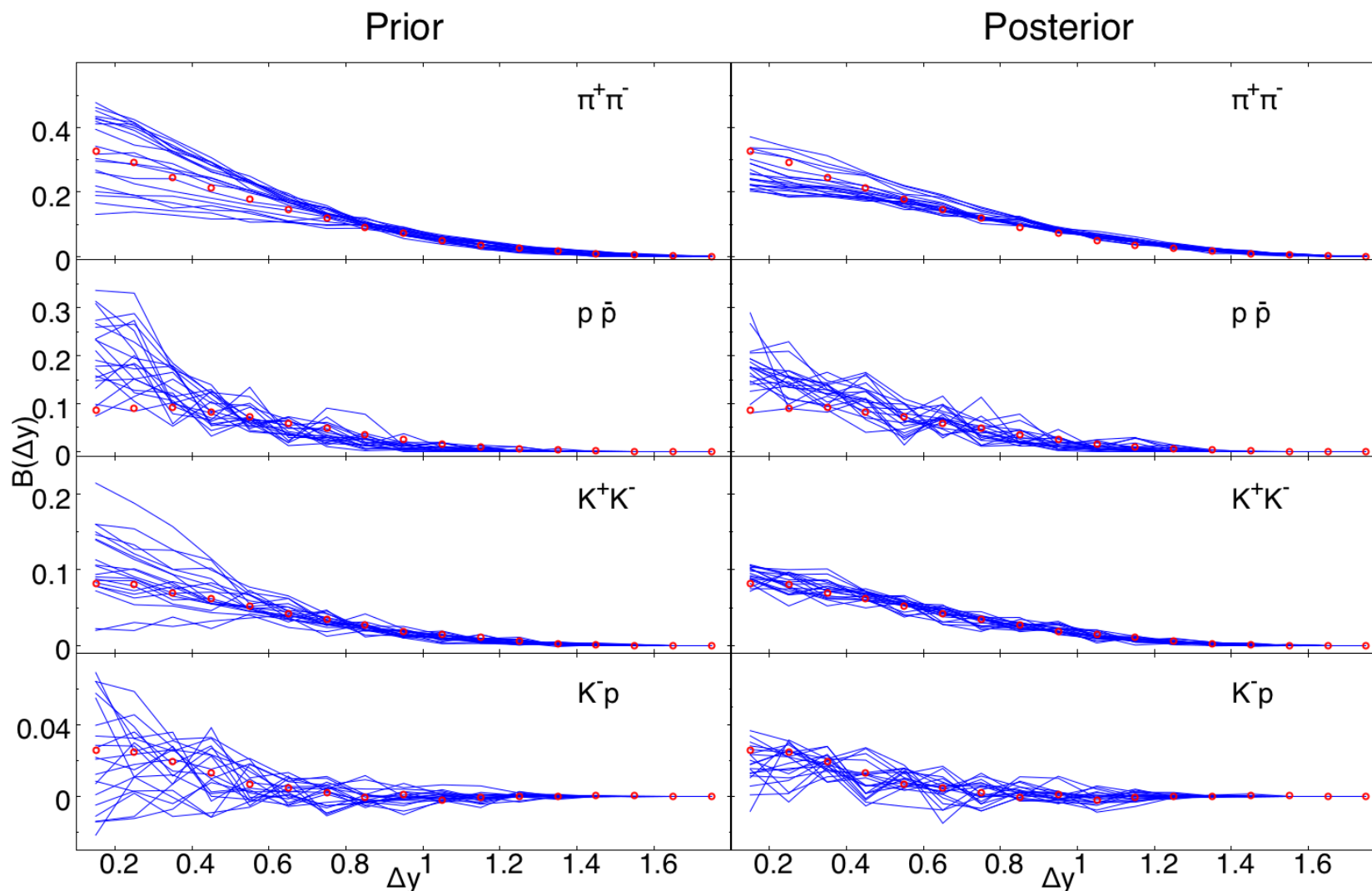


# Preliminary Results - Charge Correlation



**Suggests strangeness produced early,  
up/down produced continuously**

# Preliminary Results (4 parameters)



Model runs represented by blue lines, STAR data by red circles (G. Westfall, MSU).  
0-5% Au+Au 100 GeV

# Where we are headed

- **Increase parameters**  
(Currently trying 16)
- **Understand uncertainties**
  - correlated errors
  - sensitivity to representation  
(Hermite polynomials....)
  - model uncertainties
- **Analyze RHIC and LHC data**
- **Compare to detailed model based on chemical equilibrium**