Correlation structures from soft and semi-hard components in pp collisions at √s=200 GeV

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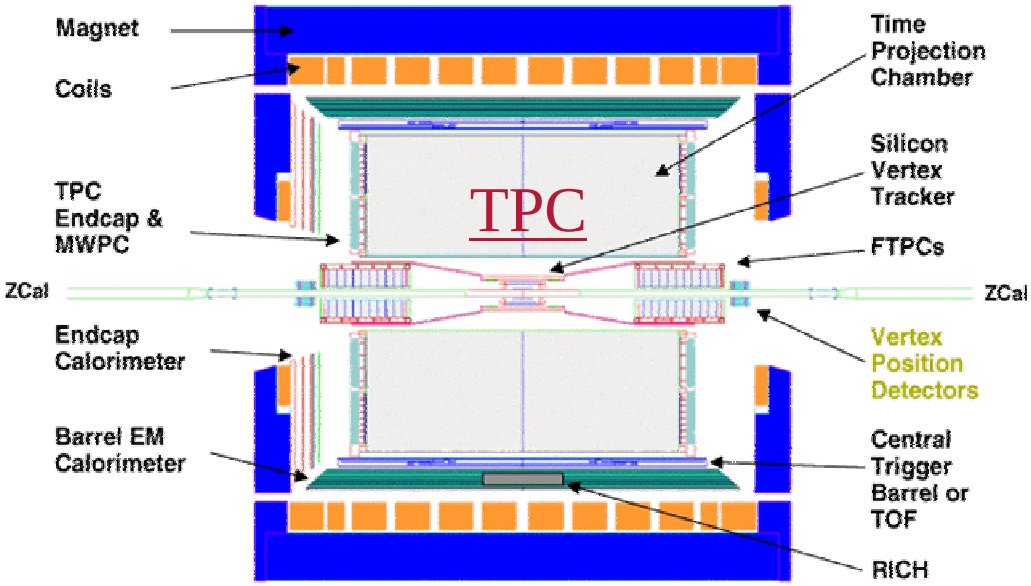
For the STAR collaboration

STAR detector and data set

p-p data sample:
~13x10^6 pp NSD events



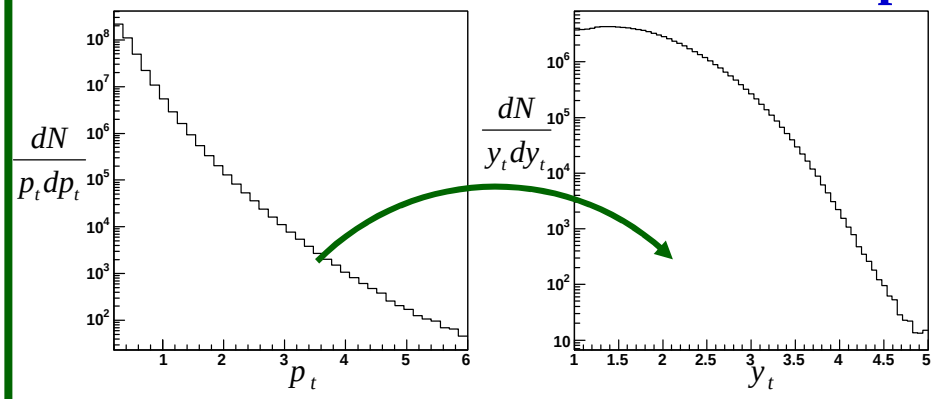
$-\pi \leq \phi \leq \pi$

$-1.0 \leq \eta \leq 1.0$

$0.15\ \text{GeV/c} \leq p_t \leq 6.\ \text{GeV/c}$

$0.9 \leq y_t \leq 4.5$

transverse rapidity



Correlation measures

$$\Delta\rho = \rho_{sib}(x_1,x_2) - \rho_{mix}(x_1,x_2)$$ → # correlated pairs

pairs from same events

pairs from different but similar events

$$\overline{N} \times \frac{\Delta\rho}{\rho_{mix}(x_1,x_2)} = \overline{N} \times (\mathbf{r}_{1,2} - 1)$$ → correlation/hadron

$$\frac{\Delta\rho}{\sqrt{\rho_{mix}(x_1,x_2)}} \rightarrow \frac{\Delta n_{pair}}{\sqrt{n_1 \times n_2}}$$ → correlation/hadron

correlations on x_1,x_2, → η, ϕ, p_t, y_t

autocorrelations on difference vars. $\eta_\Delta \equiv \eta_1 - \eta_2$, $\phi_\Delta \equiv \phi_1 - \phi_2$

4 charge pair-types:

like-sign → LS, unlike-sign →US, CD=LS-US, CI=LS+US

Joint-autocorrelations on η_Δ,ϕ_Δ

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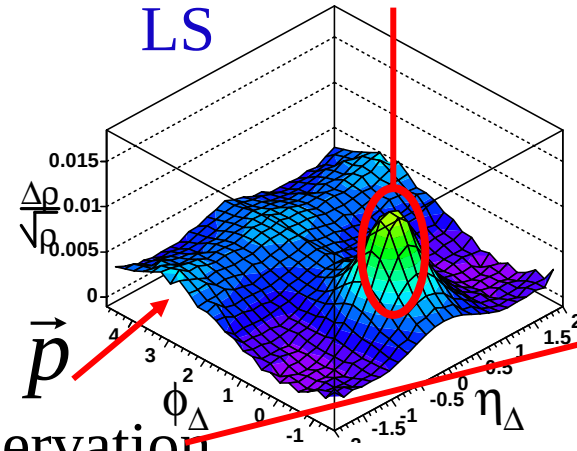
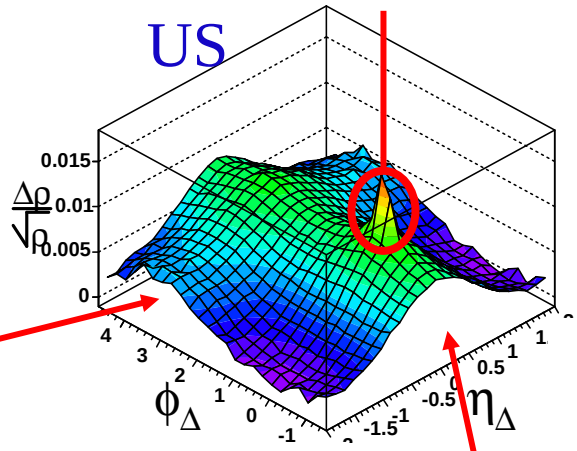
HBT

LS



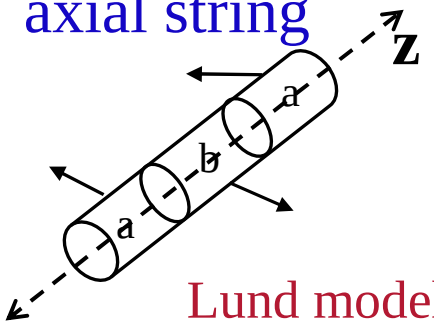
$\vec{p}$ conservation

US



γ-conversion

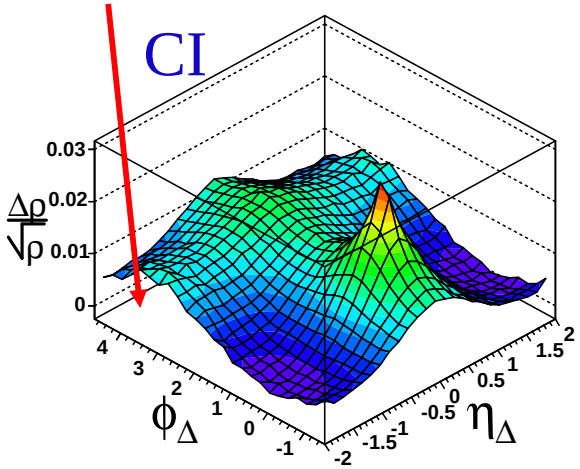
axial string



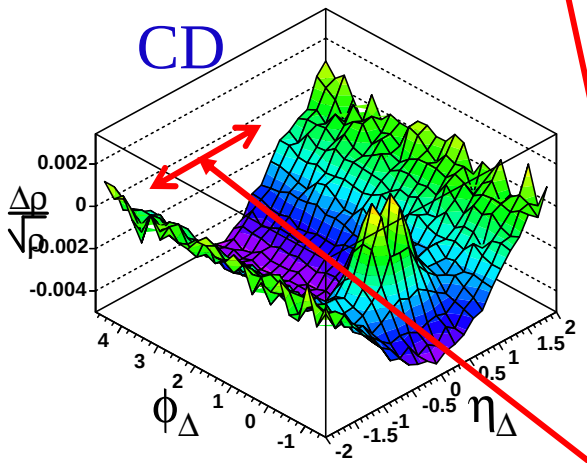
Lund model

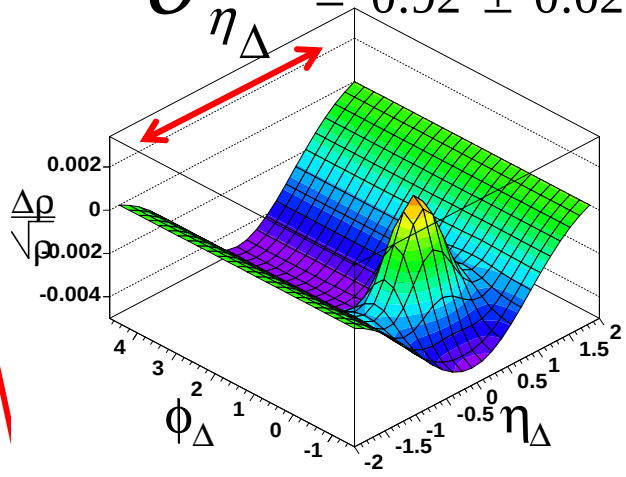
$\sigma_{\eta_\Delta} = 0.92 \pm 0.02$

CI



CD

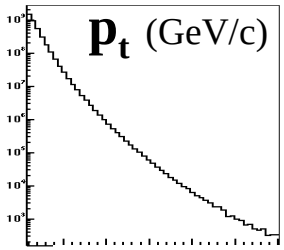


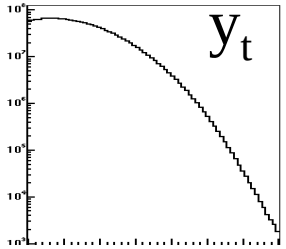


local charge conservation

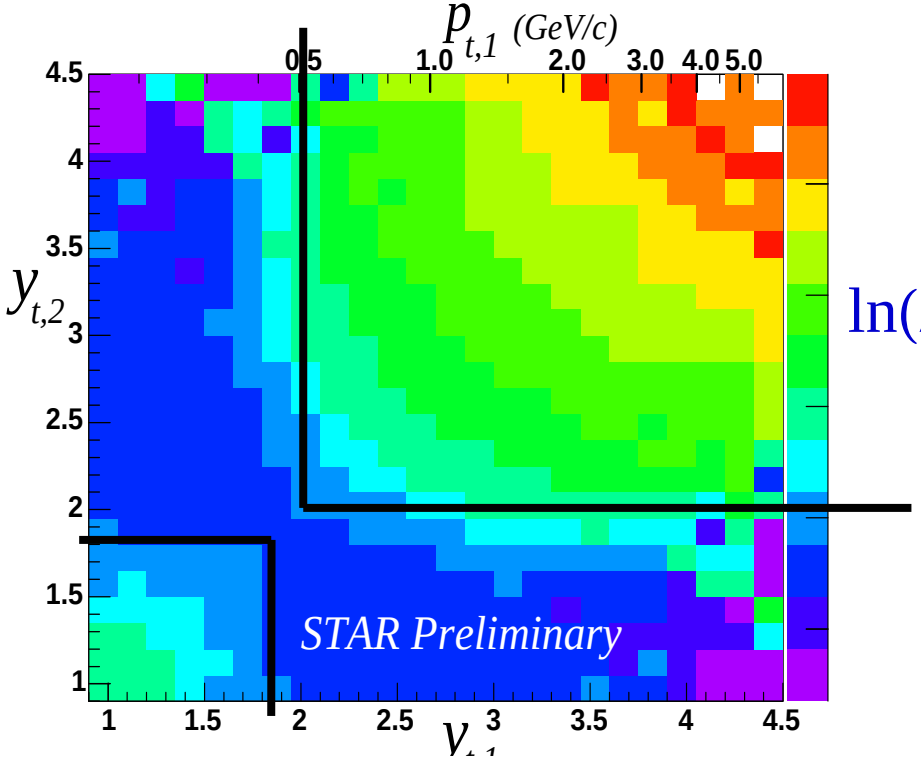
0.15 GeV/c <p_t<6.0 GeV/c

Transverse momentum corr.: y_{t1},y_{t2}



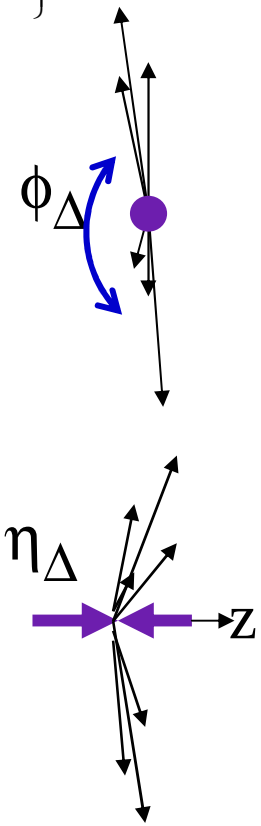


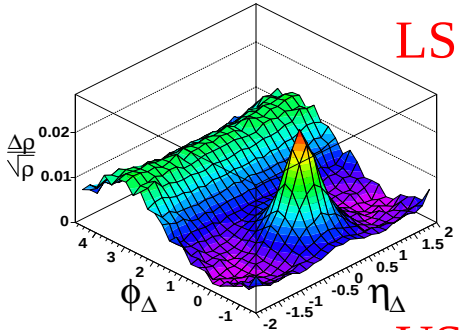
$$y_t = \ln\left\{\sqrt{1+\left(\frac{p_t}{m}\right)^2}+\frac{p_t}{m}\right\} \; ; m = m_\pi$$

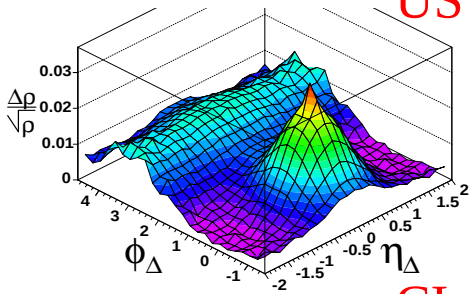


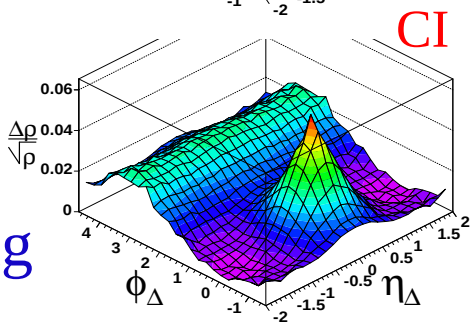
↑

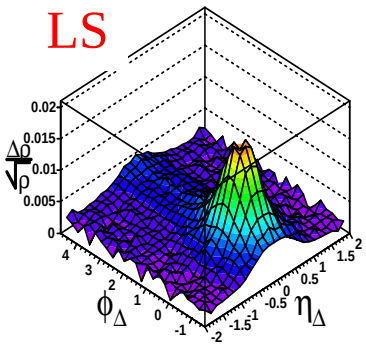
ln(Δρ/ρ)

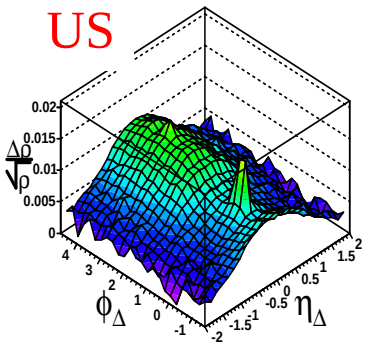


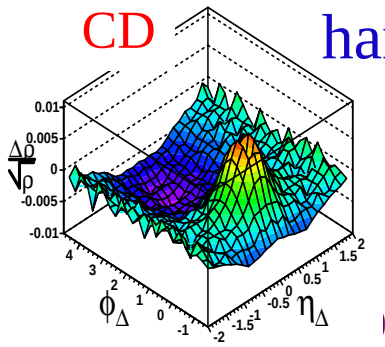












hard scattering

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hard component correlation structure

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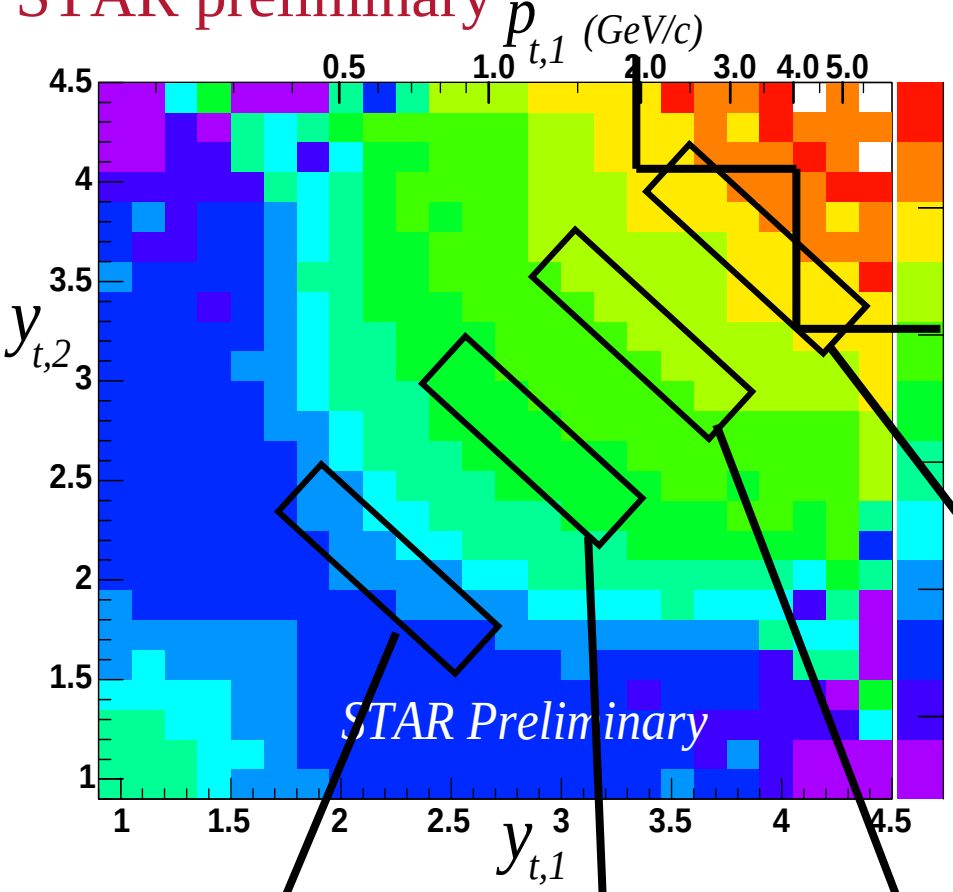
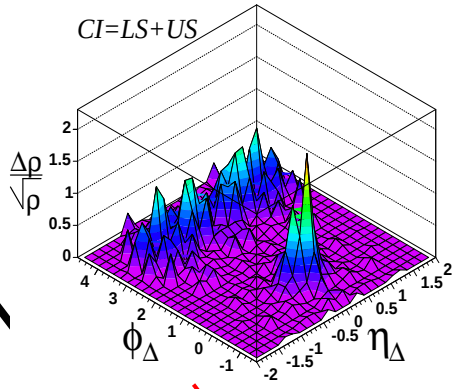
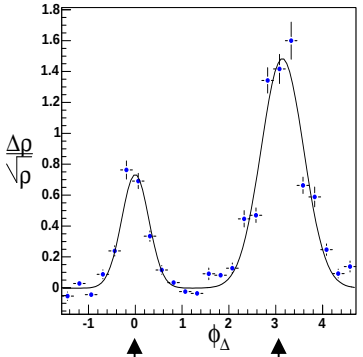


conventional 'jet-finding'

$p_{t,trig} \geq 4.0$ GeV/c

2.0 GeV/c $\leq p_{t,assoc} \leq p_{t,trig}$

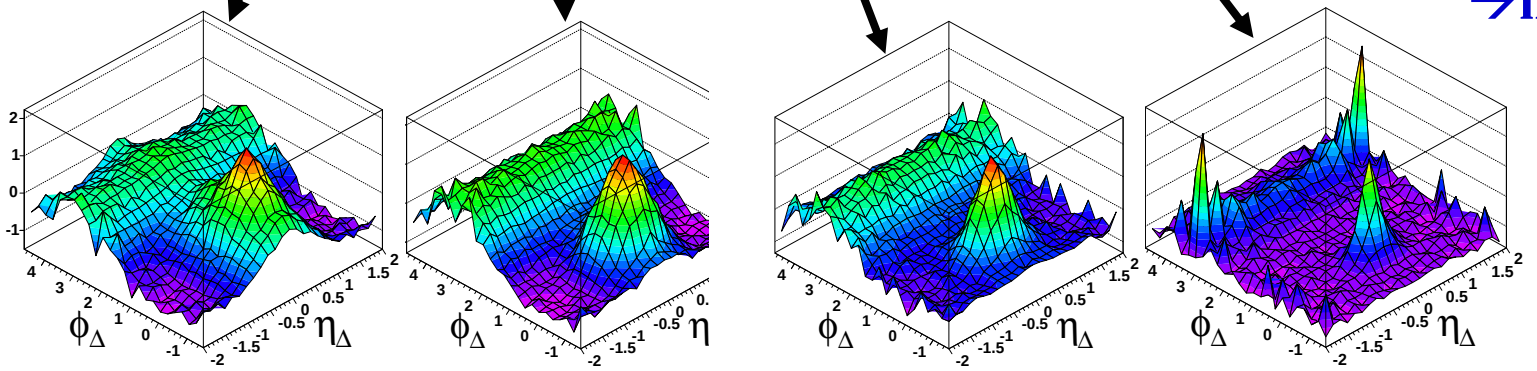




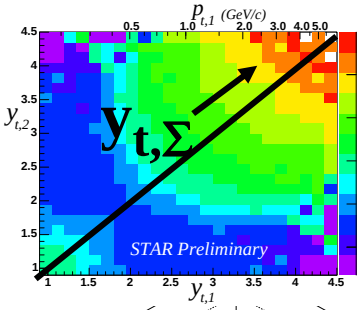
minimum-bias

parton fragmentation

→**minijets**



Model fit to hard component axial structures

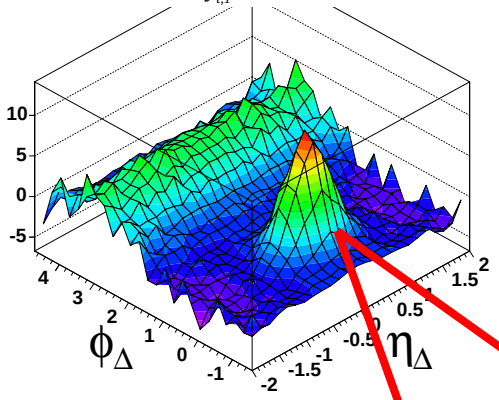


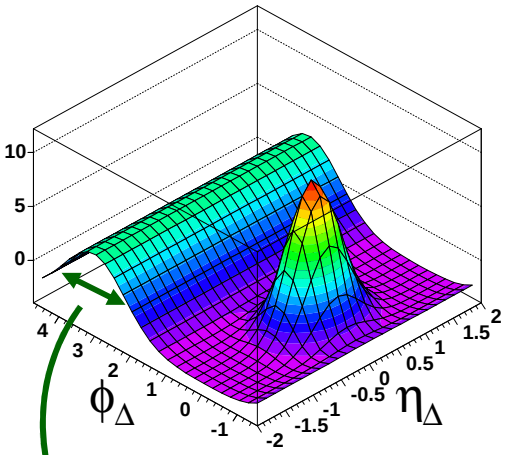
near-side

$$C_{ns} \cdot \exp\left\{-\frac{1}{2}\left(\frac{\eta_\Delta}{\sigma_{\eta_\Delta}}\right)^2 - \frac{1}{2}\left(\frac{\phi_\Delta}{\sigma^{ns}_{\phi_\Delta}}\right)^2\right\}$$

$$+ \; C_{as} \cdot \exp\left\{-\frac{1}{2}\left(\frac{\phi_\Delta - \pi}{\sigma^{as}_{\phi_\Delta}}\right)^2\right\} + C_0$$

away-side

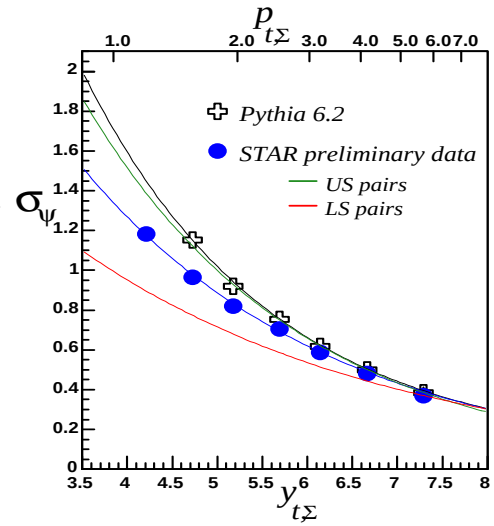


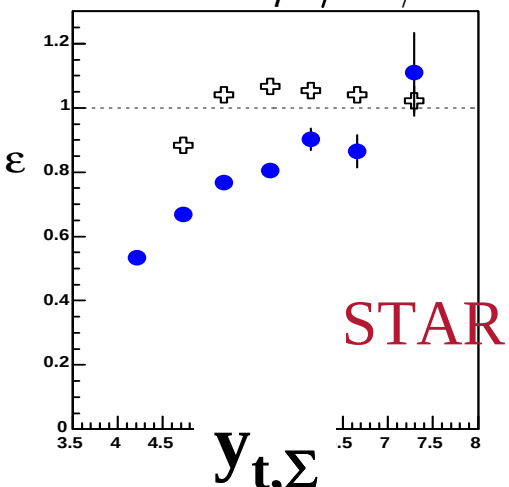


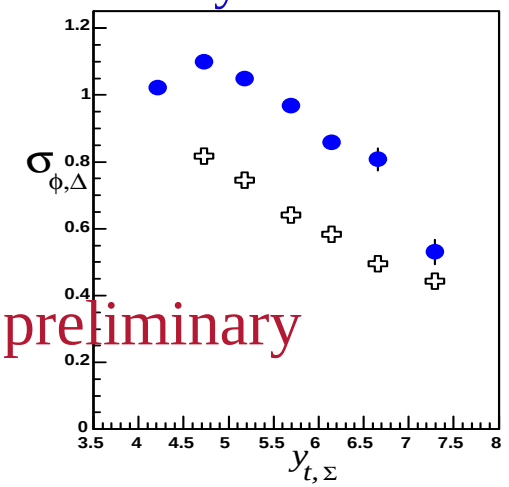
$$\sigma_\psi = \sqrt{\sigma^2_{\eta\Delta} + \sigma^2_{\phi\Delta}}$$

$$\varepsilon = \sigma_{\eta\Delta} / \sigma_{\phi\Delta}$$

away-side width







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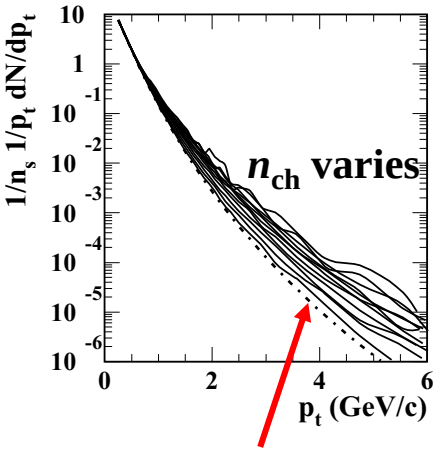
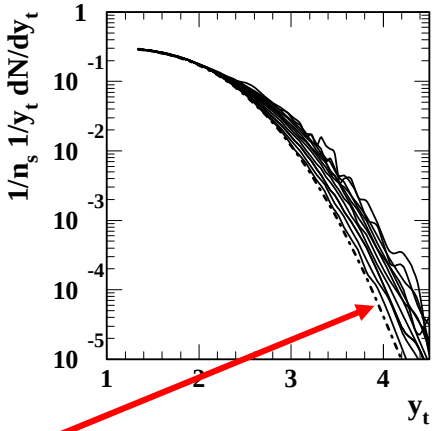
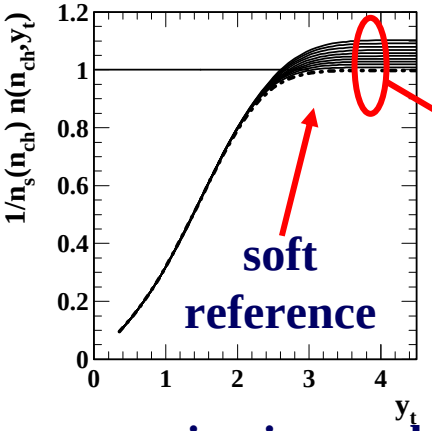
Soft+hard from single particle spectra

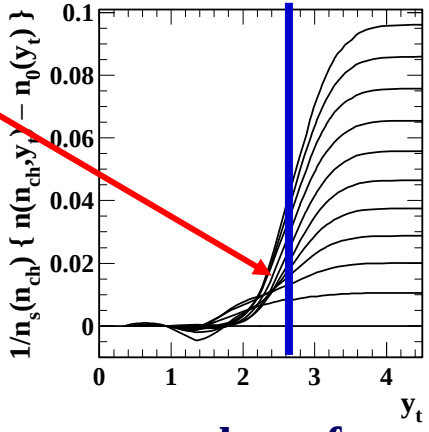
$$\frac{1}{n_s(n_{ch})\cdot p_t}\frac{dN}{dp_t}(n_{ch},p_t)=S_0(p_t)+\frac{H(n_{ch},p_t)}{n_s(n_{ch})}$$







running integrals

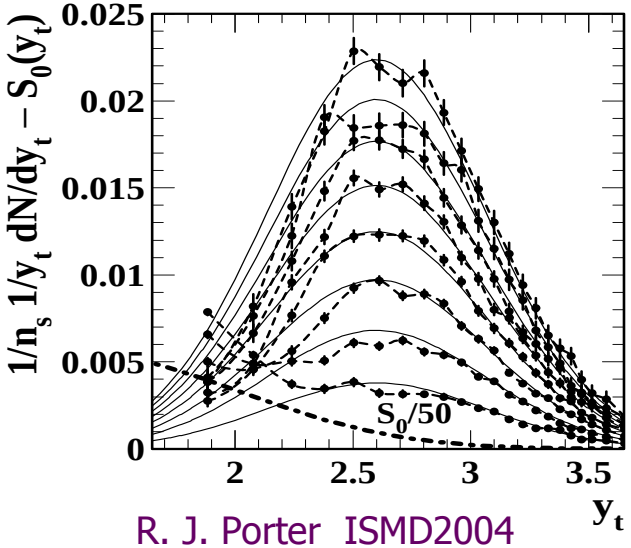


total – soft

soft reference Lévy S_0:

$$A_s/\{1+\beta_0(m_t(p_t)-m_0)/n\}^n$$

total–soft = hard (minijets)→



$H_0=H/n_h$ → gaussian

$$A_h\exp\{(y_t-\bar{y}_t)^2/2\sigma^2_{y_t}\}$$

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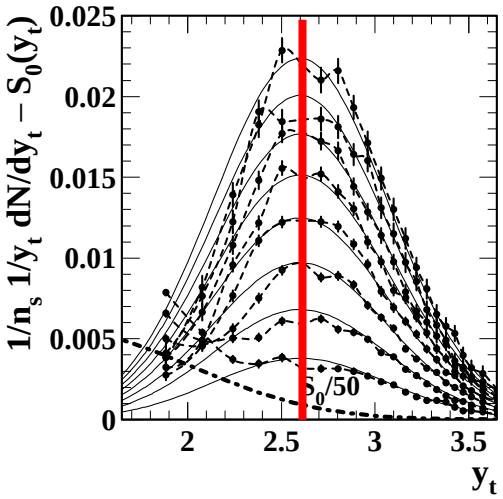

y_{t1},y_{t2} correlations revisited

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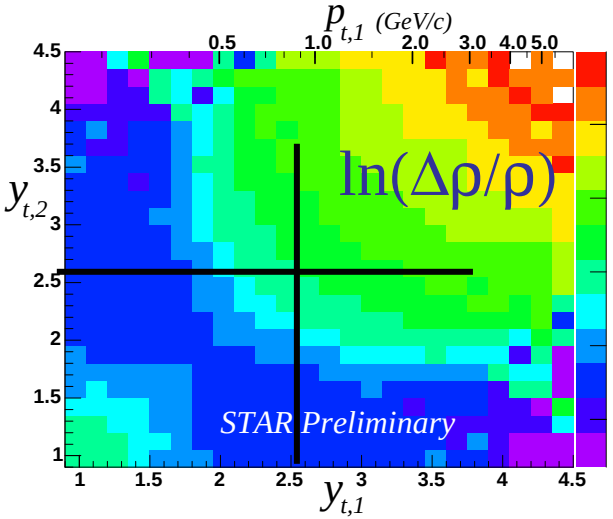
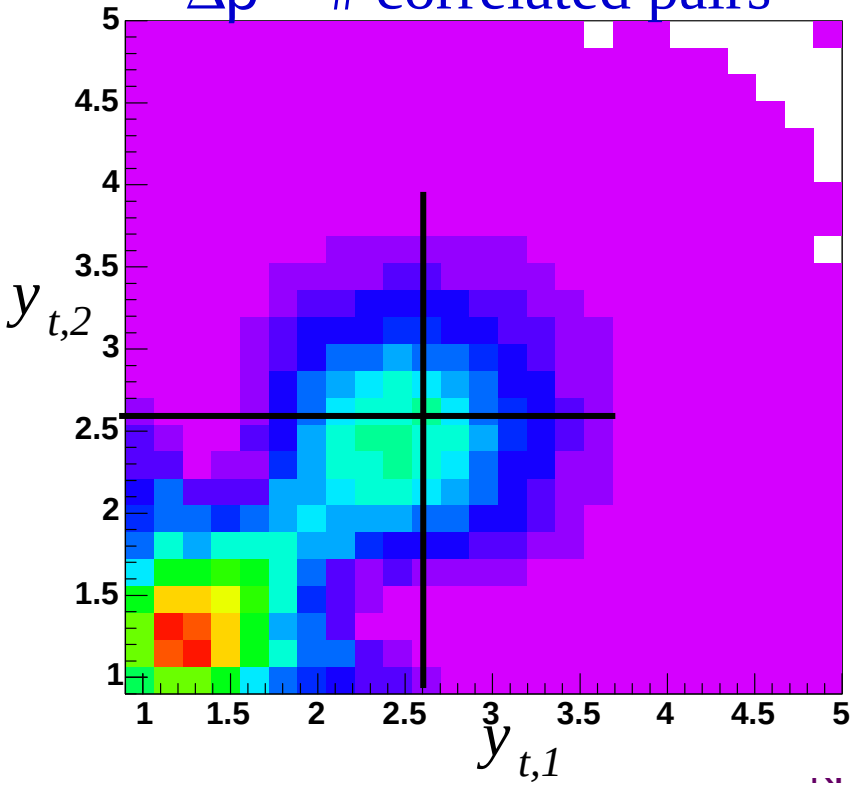
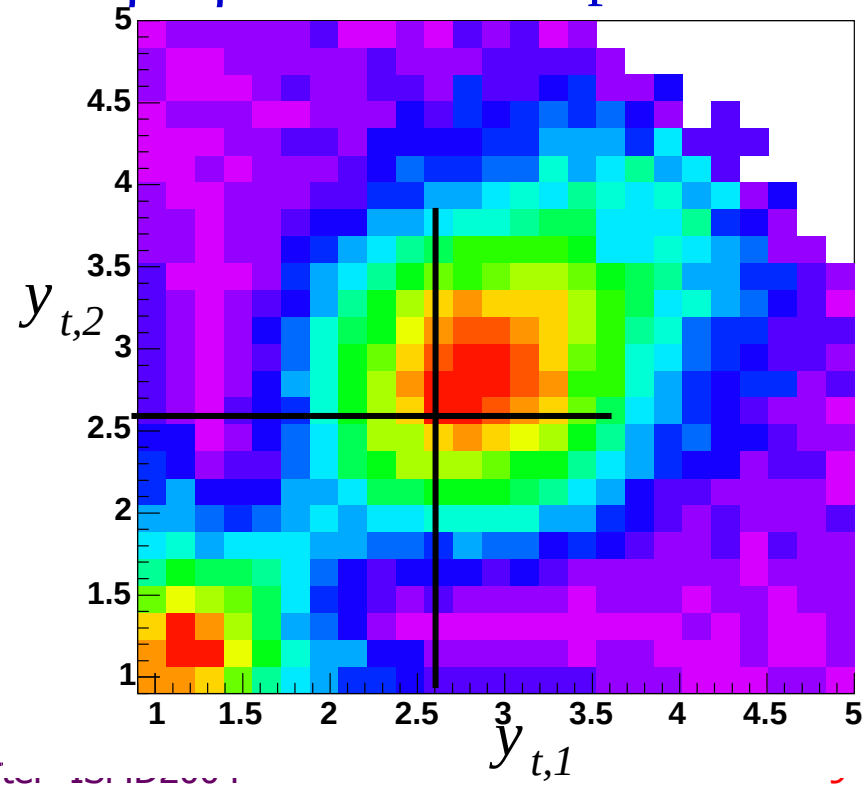


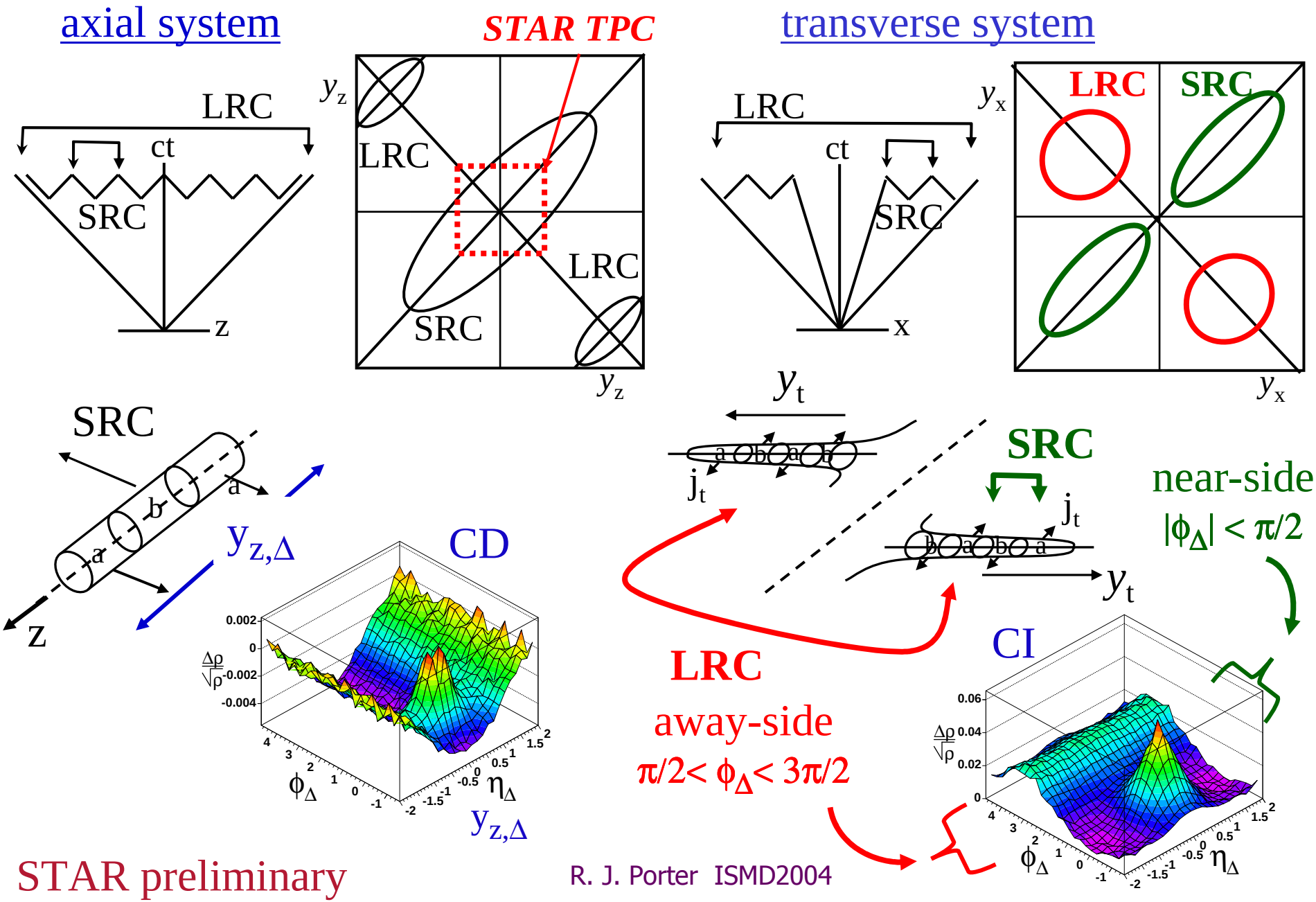
$\Delta\rho$ = # correlated pairs



$\Delta\rho/\sqrt{\rho}$ = correlated pairs/hadron



Short and Long Range Correlations



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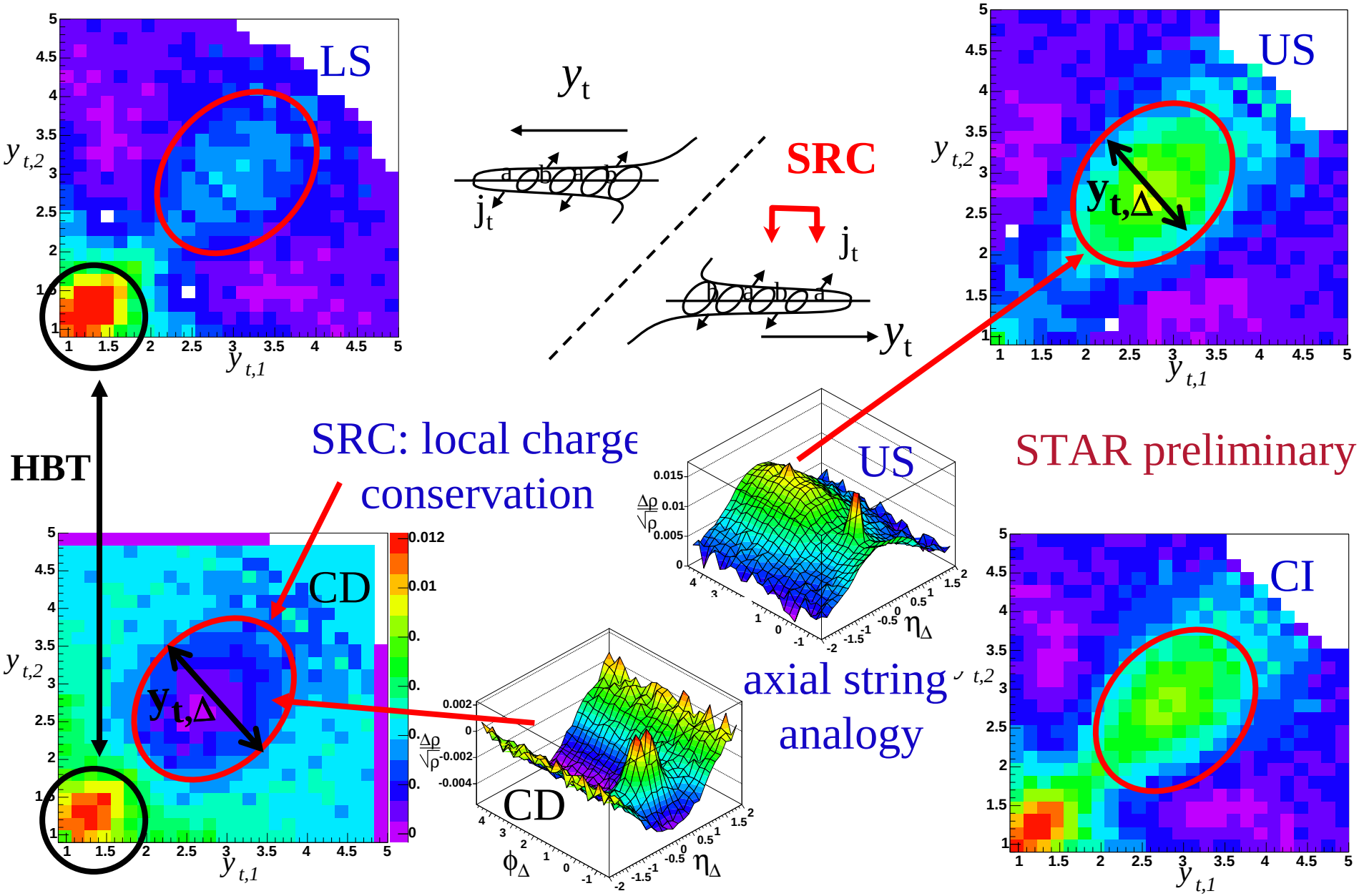
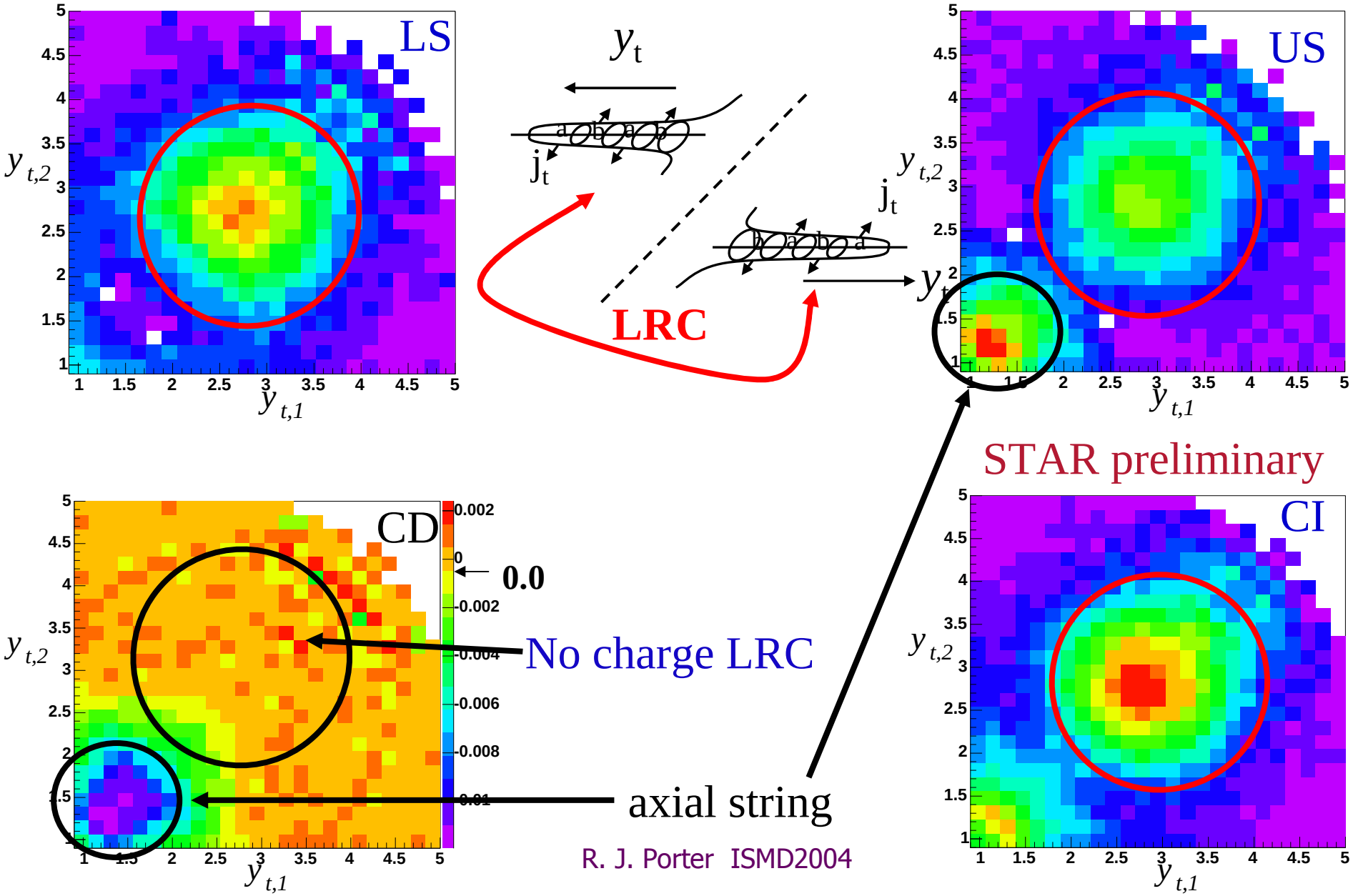
near-side structures on y_{t1},y_{t2} : SRC



away-side structures on y_{t1},y_{t2}: LRC



away-side structures : Pythia 6.2

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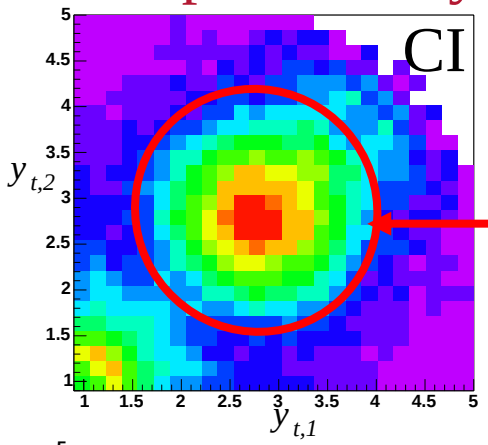
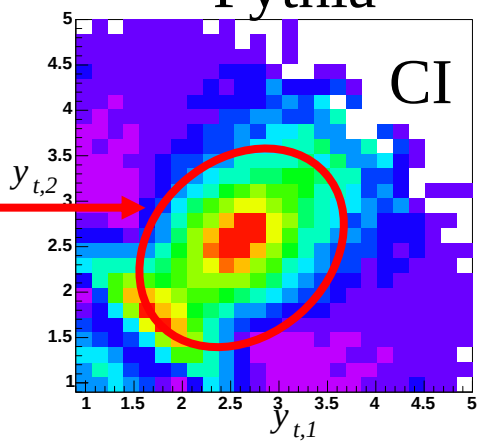
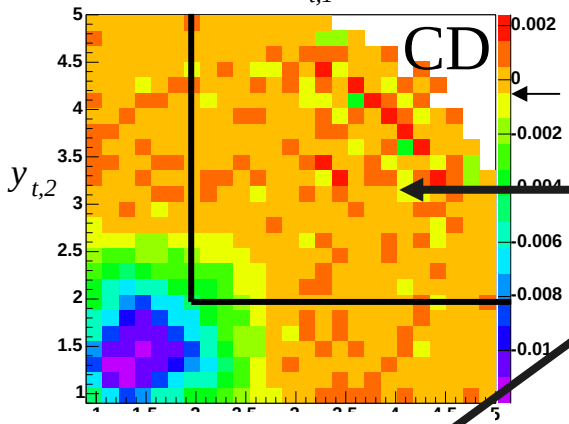
Pythia

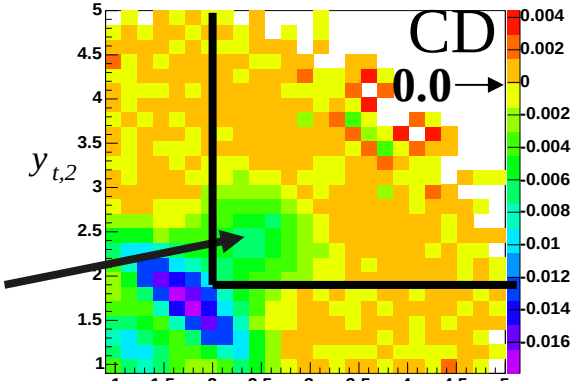


Long range momentum conservation

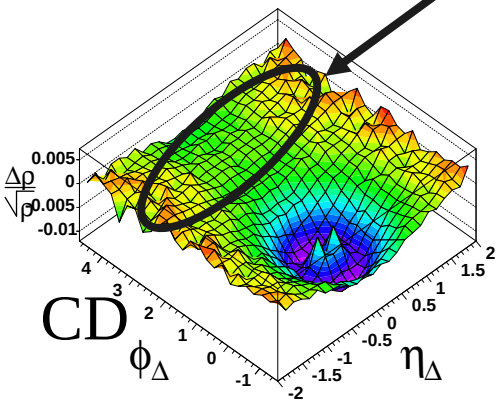




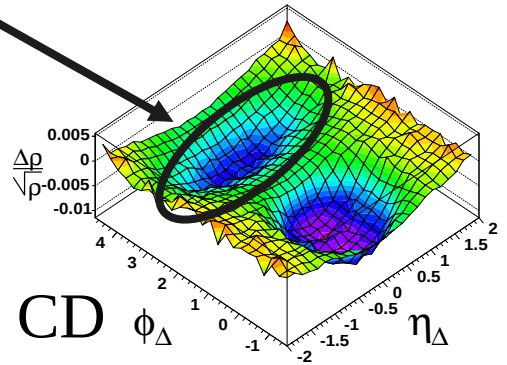
no charge LRC



charge LRC from Pythia

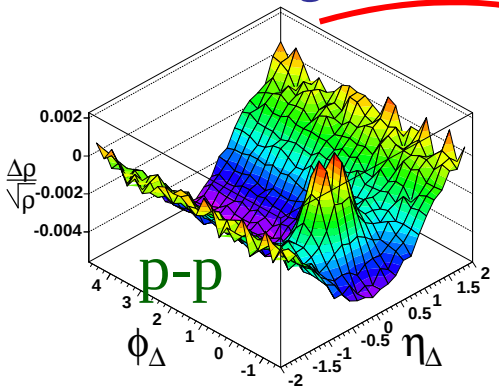


absence of charge LRC was observed previously in p-p: L. Drijard *et al.*, NPB156(1979)309

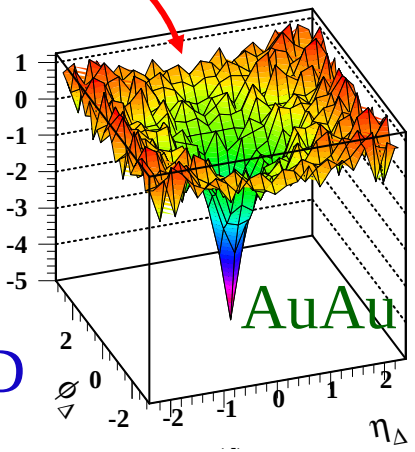


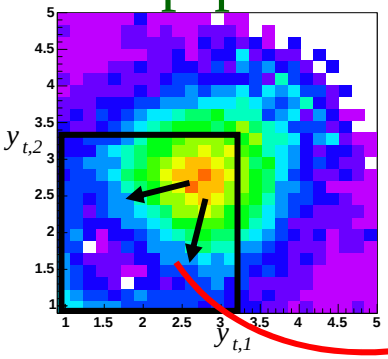
p-p reference for AuAu collisions

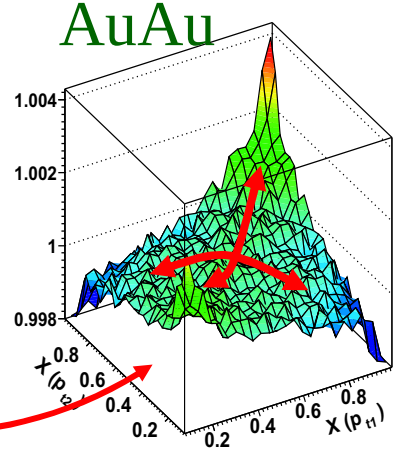
1D gaussian→2D exponential



CD → CD

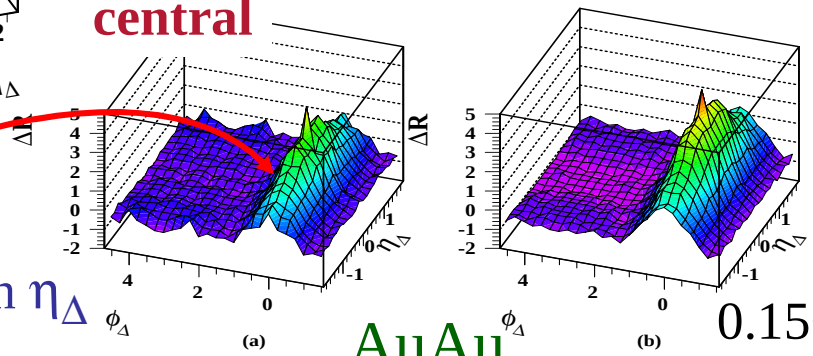






dissipation to lower p_t

central



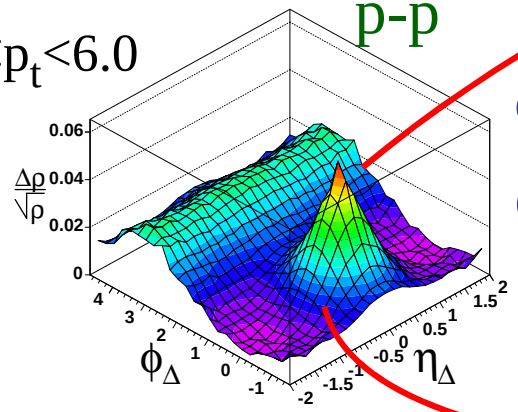
0.15<p_t<2.0

AuAu

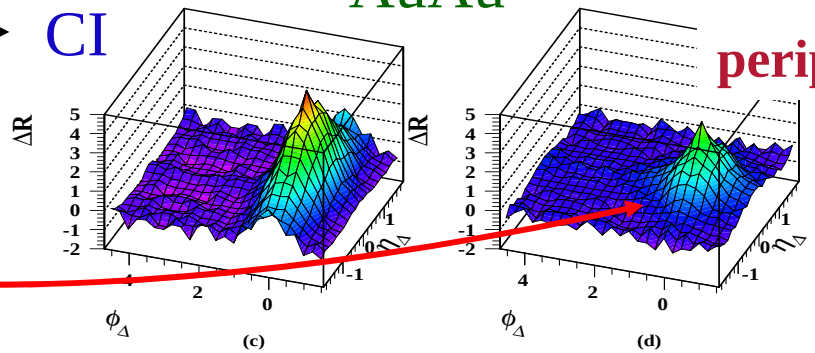
elongation on η_Δ

p-p

0.5<p_t<6.0



CI → CI



peripheral

minijets

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Summary

- correlations on y_{t1},y_{t2} reveal soft and hard components
  - soft (axial string) fragments for $y_t<2$
  - hard (transverse parton) fragments for $y_t>2$
- p-p 1D p_t distributions reveal 2-component system
  - 2-particle correlations confirm hard component
- hard components of y_{t1},y_{t2} correlations explored
  - SRC near-side correlations – charge conservation
  - LRC away-side correlations – momentum, not charge
- correlations in p-p provide essential reference for Au-Au collisions