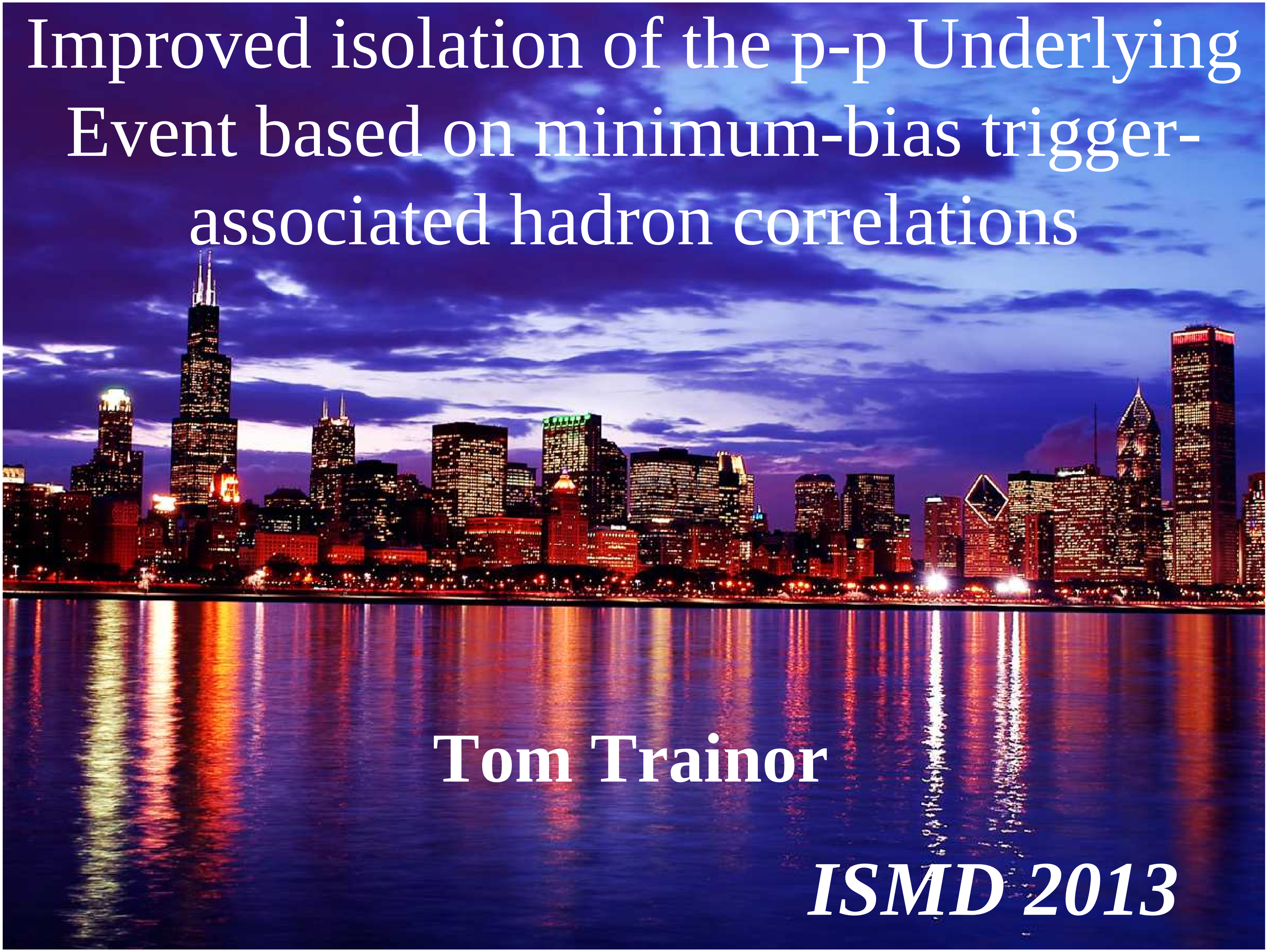
Improved isolation of the p-p Underlying Event based on minimum-bias trigger-associated hadron correlations



Tom Trainor

ISMD 2013

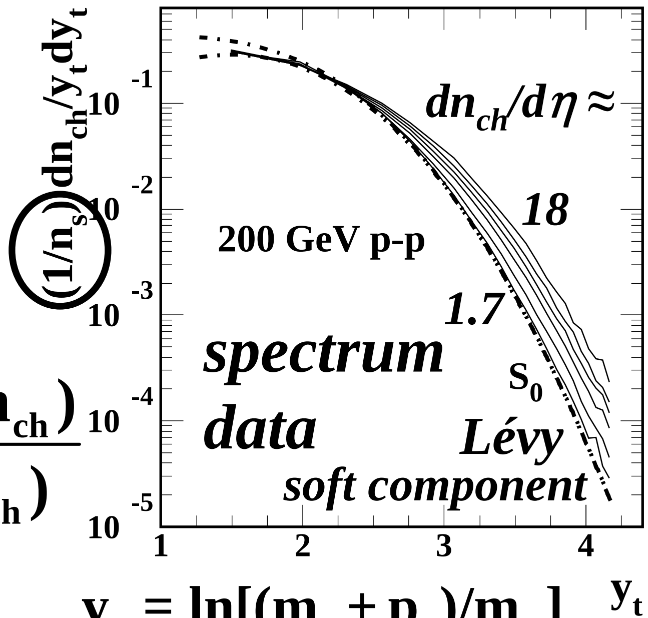
Agenda

trigger-associated (TA) correlations

- ***Measure n_{ch} dependence of p-p p_t or y_t SP <u>spectra</u>***
- ***Define a "Glauber" model for p-p collisions***
- ***Predict n_{ch} systematics for p-p <u>angular correlations</u>***
- ***Develop a two-component TA model (TCM)***
- ***Extract a TA hard component $\rightarrow$ jet fragments***
- ***Make direct comparisons with <u>pQCD and dijets</u>***
- ***Test underlying-event (<u>UE</u>) <u>conjectures re dijets/MPI</u>***
- ***Identify <u>kinematic limits of dijets</u> in p-p collisions***

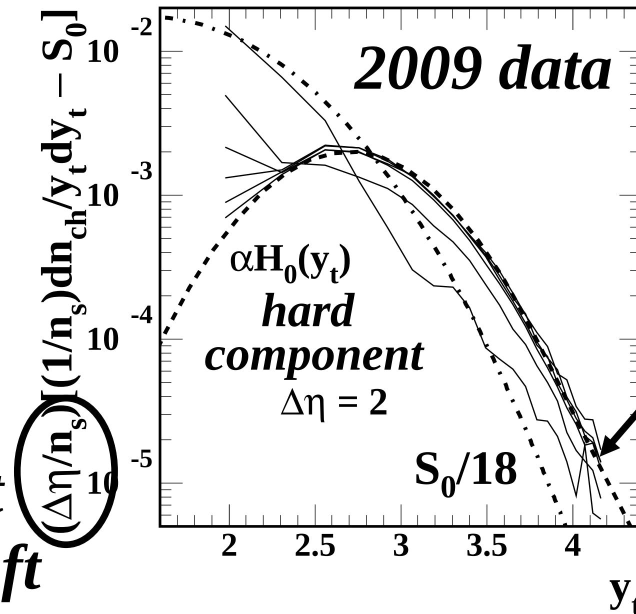
Two-component 1D Spectrum Model

$$\frac{\rho(y_t, n_{ch})}{\rho_s(n_{ch})}$$



$y_t = \ln[(m_t + p_t)/m_\pi]$

subtract TCM soft component



QCD power law

dijet fragment spectra described by pQCD

p-p spectra for seven n_{ch} classes n

nucl-ex/0606028

2006 PRD: $\rho(y_t, n_{ch}) = \rho_s(n_{ch})S_0(y_t) + \rho_h(n_{ch})H_0(y_t)$ ***factorized***

limit $n_{ch} \to 0$

e.g. $\rho_s(n_{ch}) = n_s/\Delta\eta$

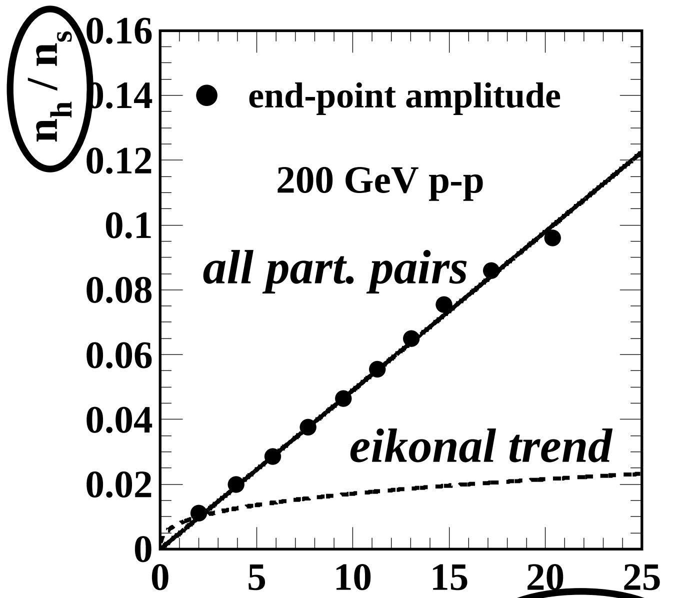
$\rho_h(n_{ch}) / \rho_s(n_{ch}) \propto n_s \approx n_{ch}$

basis for all that follows

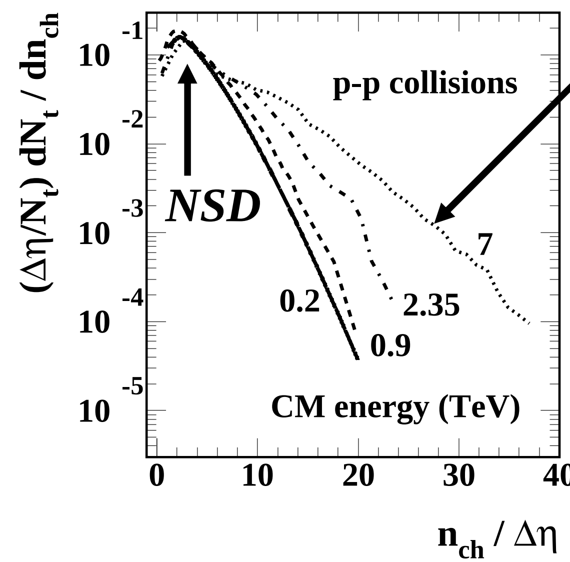
p-p "Glauber" Model

A-A Glauber model: dijets $\propto N_{bin} \propto N_{part}^{4/3} \approx n_{ch}^{4/3}$

exponent 4/3: <u>eikonal signature</u>



$\propto$ ***Npart***



low-x gluon participant fluctuations

$n_{ch} = n_s + n_h \quad n_h \propto n_{ch}^2$

dijets $\propto n_h \propto n_s^2 \propto N_{part}^2$

$\Delta\eta = 2$

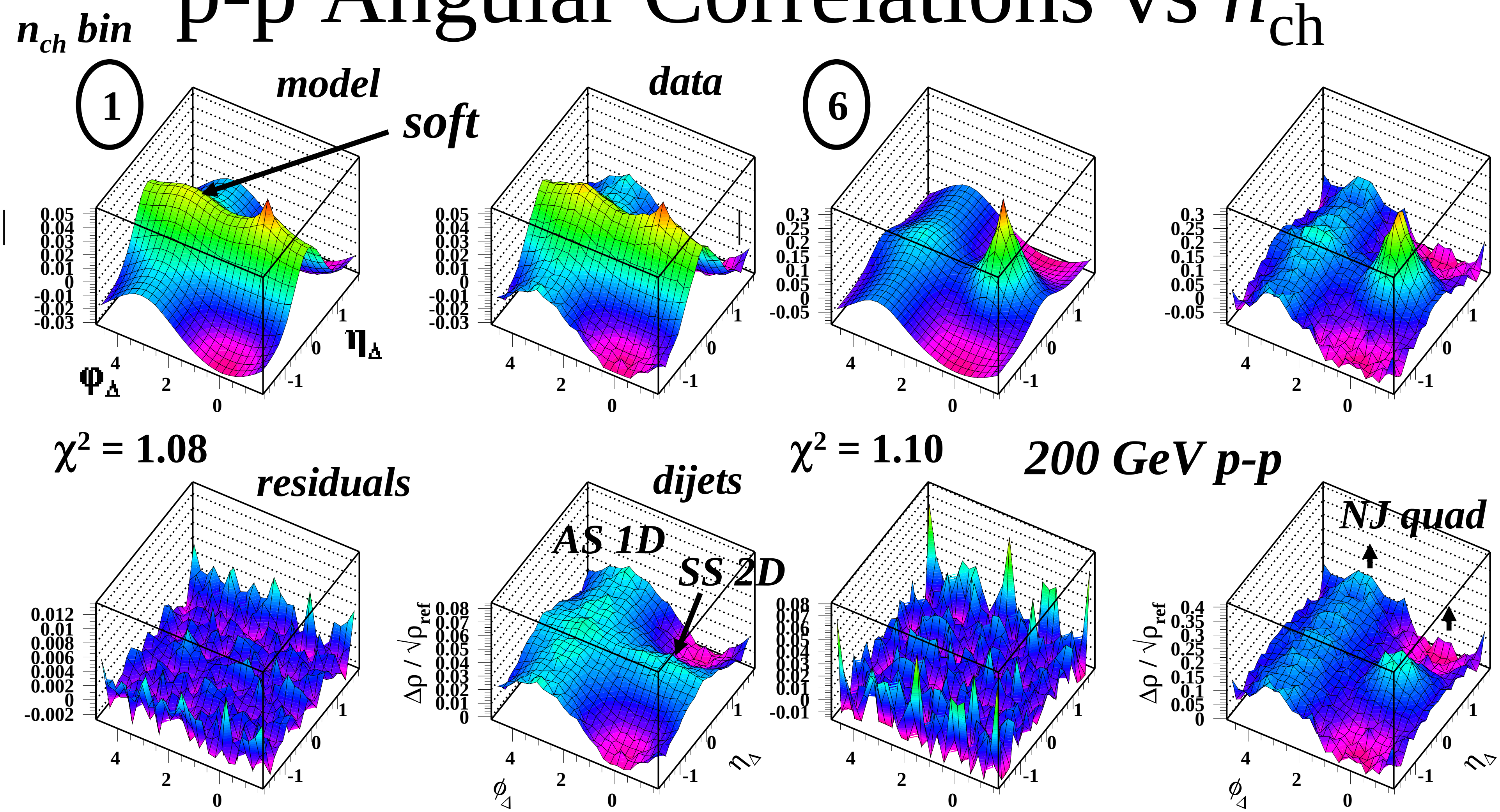
<u>eikonal approximation invalid</u>

no impact parameter

dijet number $n_j = 0.03\,(n_s/2.5\,)^2$

p-p collisions: quantum transitions, $N_{part} \propto n_s \rightarrow$ ***low-x gluons***

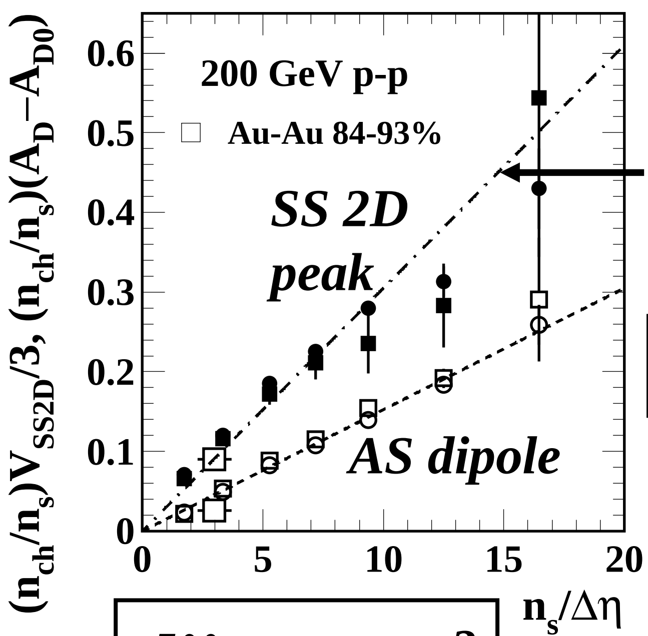
p-p Angular Correlations vs n_{ch}



***per-particle* correlation measure**

three main components: (1) jet-related same-side 2D peak (2) away-side 1D peak (dipole), (3) nonjet quadrupole

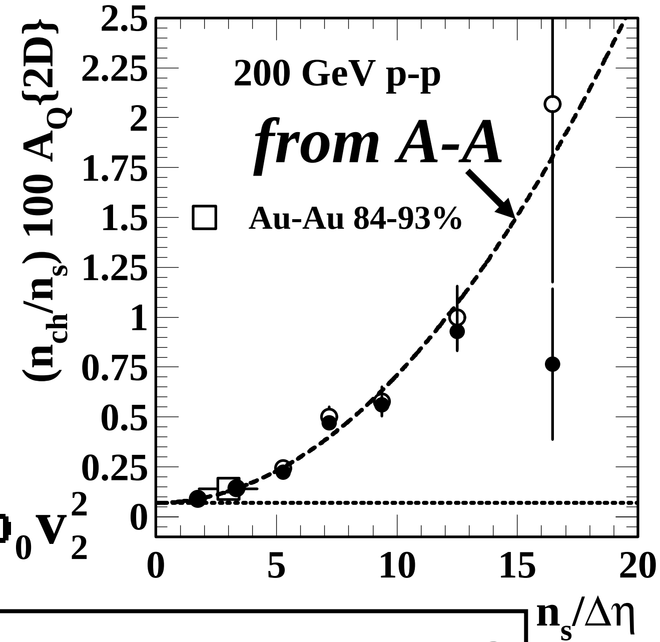
Predictions from pQCD, *p-p* “Glauber”



pQCD 2.5 mb – not a fit

$N_{bin} \propto N_{part}^2$

no eikonal



$A_Q = \rho_0 v_2^2$

dijets $\propto n_s^2$

NJ quadrupole $\propto n_s^3$

minimum-bias (MB) jets – minijets

becomes CMS SS “ridge” in p-p

becomes “elliptic flow” in A-A

in Au-Au collisions: $n_{ch}A_Q \propto N_{part}N_{bin}\varepsilon_{opt}^2$

in p-p collisions: $n_{ch}A_Q \propto N_{part}N_{bin}\left\langle \varepsilon_{opt}^2 \right\rangle$

soft component $\propto n_s$

NJ quadrupole $\propto N_{part}^3 \propto n_s^3$

proton dissociation to participant partons

prediction: $(n_{ch}/n_s)A_Q \propto n_s^2$

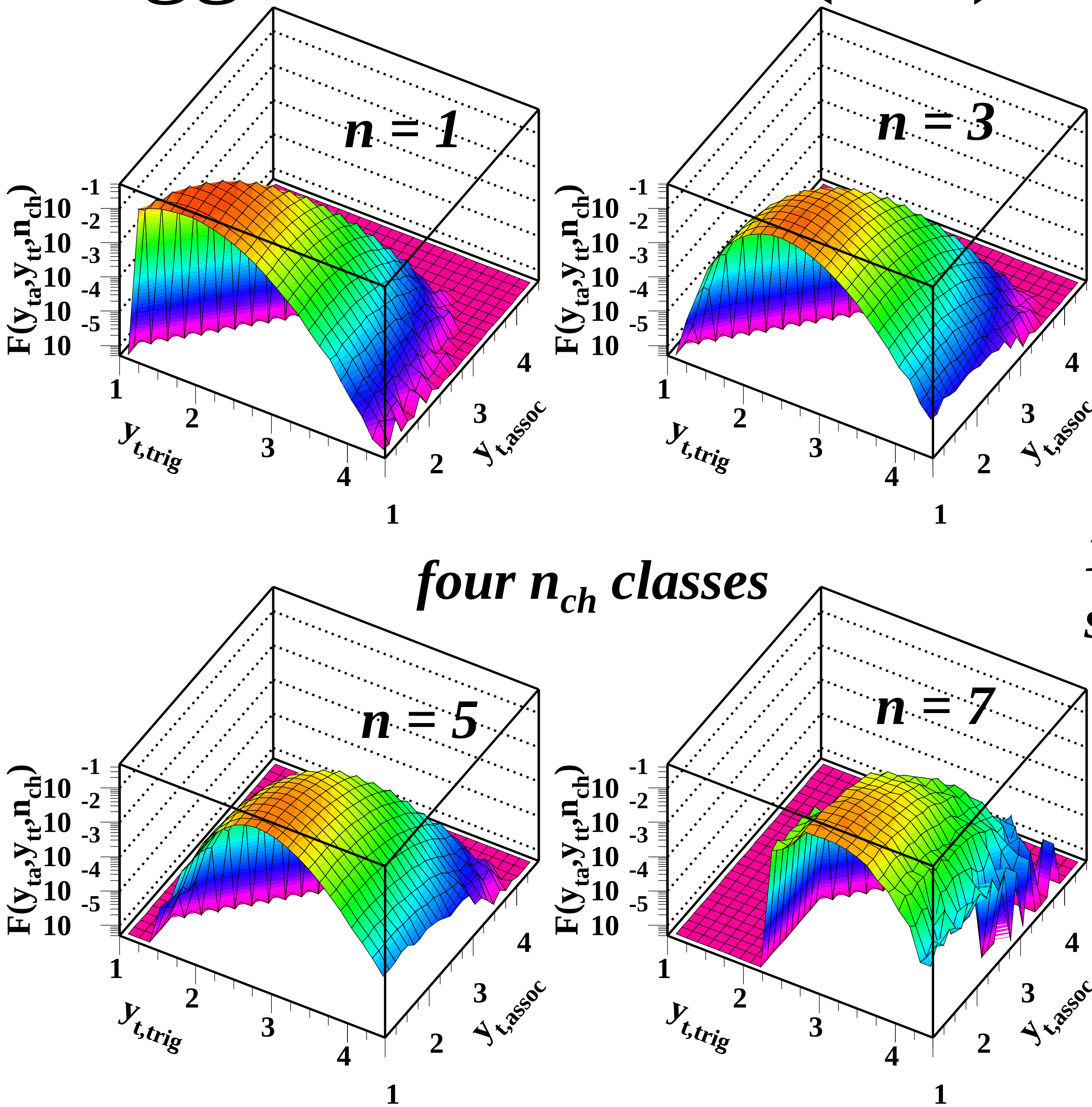
Trigger-associated Correlations

for events with n_{ch} hadrons in $\Delta\eta$

- ***in each event the highest y_t is the "trigger"***
- ***n_{ch}-1 others are "associated"***
- ***form all trigger-associated pairs except self pairs***
- ***subtract calculated TCM soft component(s)***
- ***obtain <u>conditional</u> hard component $H_h(y_{ta}:y_{tt})$***
- ***H_h can be compared with parton-fragment FFs***
- ***determine kinematic limits of jet production***
- ***determine azimuth dependence relative to trigger***

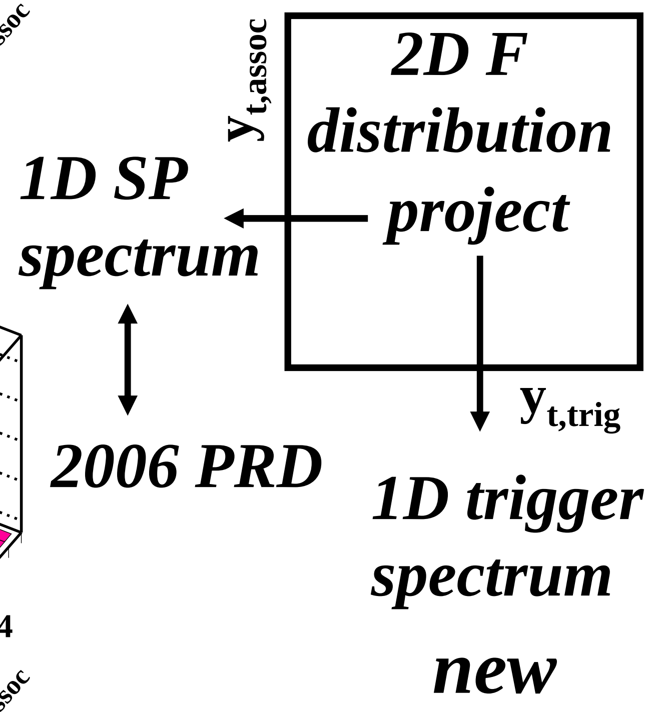
<u>no p_t cuts</u> – all jets, all hadron pairs accepted

Trigger-associated (TA) Distributions F



four n_{ch} classes

marginal projections constrain 2D TCM



TA Two-component Model – TCM

1D *event-type prob* *void prob* *1D SP spectrum TCM*

TCM trigger model

$$\rho_{trig}(y_{tt}, n_{ch}) = P_s(n_{ch})G_s(y_{tt}, n_{ch})S_0(y_{tt}) + P_h(n_{ch})G_h(y_{tt}, n_{ch})F_h(y_{tt}, n_{ch})$$

$$F_h(y_{tt}, n_{ch}) = p_s'(n_{ch})S_0(y_{tt}) + p_h'(n_{ch})H_0(y_{tt})$$

sample-type prob

$P_s = \exp(-n_j)$

$P_h = 1 - P_s$

n_j – dijet number

void probability:

$$G_x(y_{tt}, n_{ch}) = \exp\left[-\kappa\int_{y_{tt}}^{\infty} dy_t n_{ch} F_x(y_t, n_{ch})\right]$$

exercise in compound probabilities

derive 2D two-component TA model based on 1D spectra

1307.1819

derived from 1D SP spectra

$$F(y_{ta}, y_{tt}, n_{ch}) = \frac{1}{N_{evt}(n_{ch})(\hat{n}_{ch} - 1)} \frac{d^2 n_{ch}}{y_{tt} dy_{tt} y_{ta} dy_{ta}}$$
$$= P_s(n_{ch})T_s(y_{tt}, n_{ch})A_s(y_{ta} : y_{tt}, n_{ch})$$
$$+ P_h(n_{ch})T_h(y_{tt}, n_{ch})A_h(y_{ta} : y_{tt}, n_{ch}),$$

where $A_s(y_{ta} : y_{tt}, n_{ch}) = S_0''(y_{ta} : y_{tt}, n_{ch})$ for soft and $A_h(y_{ta} : y_{tt}, n_{ch}) = p_s'(n_{ch})S_0'(y_{ta} : y_{tt}, n_{ch}) + p_h'(n_{ch})H_0'(y_{ta} : y_{tt}, n_{ch})$ for hard event types.

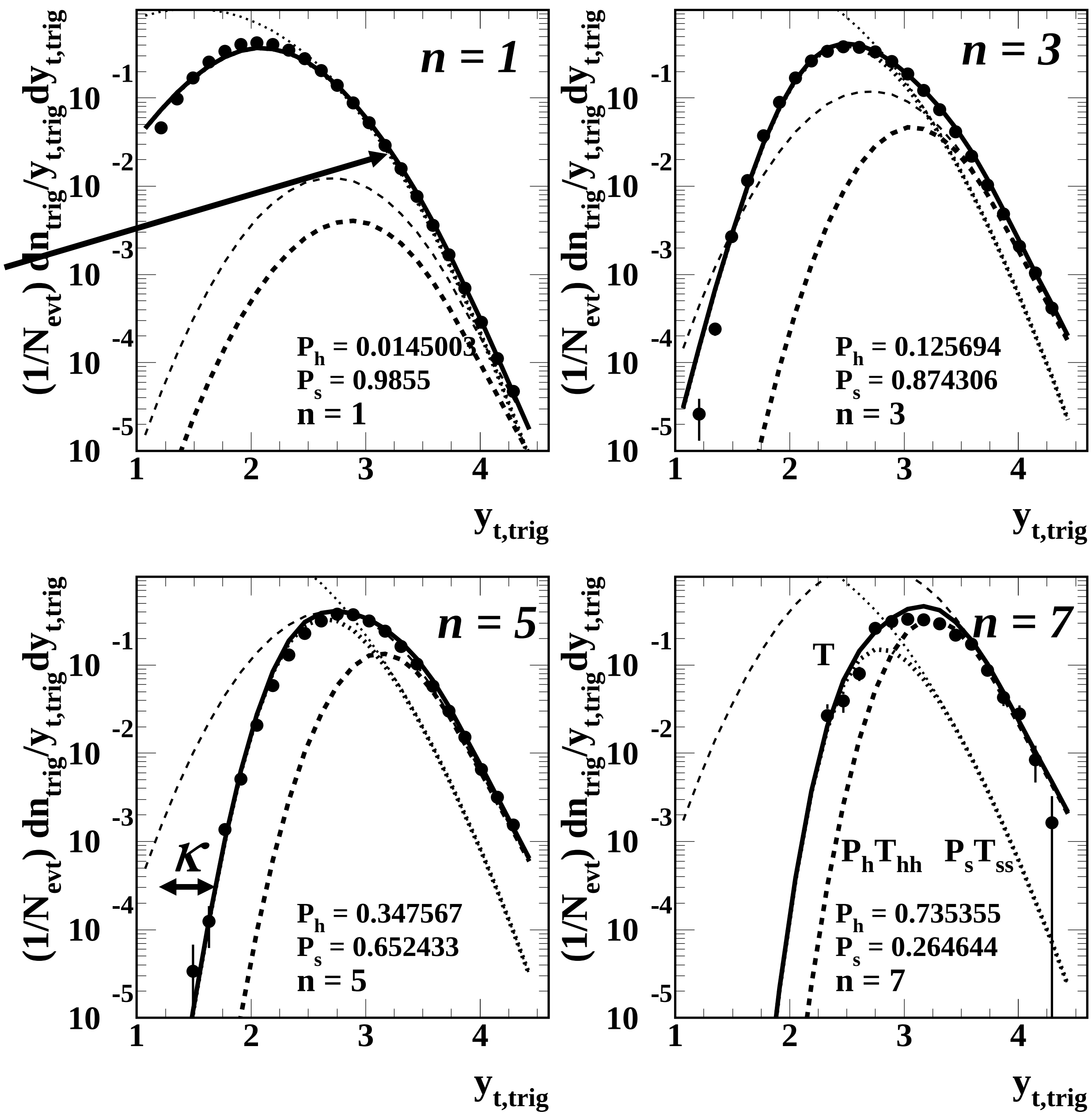
includes factorized hard-component model $H_0'(y_{ta}:y_{tt})$ as place holder

Trigger Spectra T – Four n_{ch} Classes

calculated
$\rho_{trig}(y_{tt}, n_{ch})$
solid curve

Note:
only one adjustment – O(1) parameter κ ***accounts for non-Poisson correlations***

κ ***= 1.3-1.6***



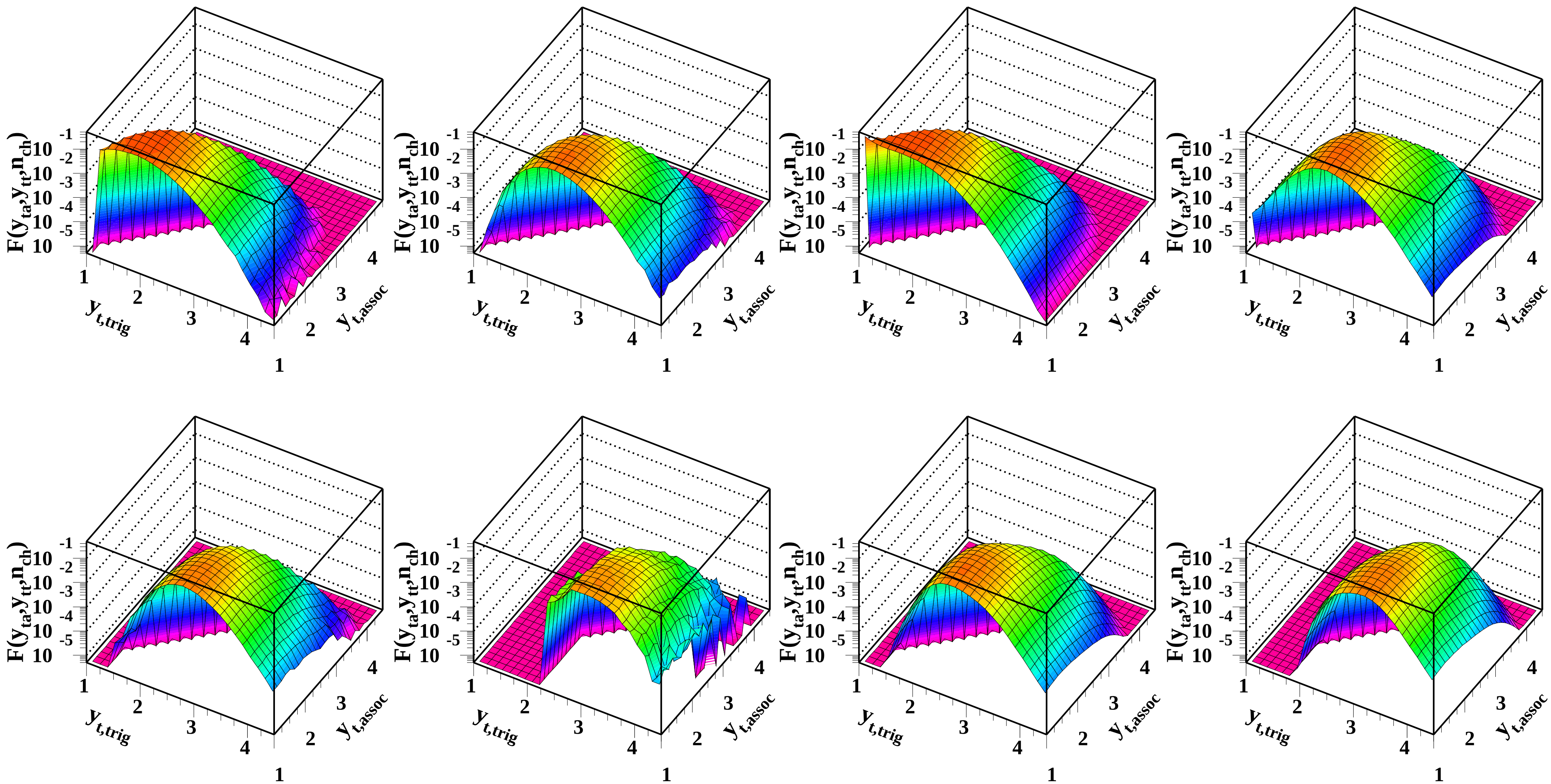
no vertical adjustment

points are measured trigger spectra

trigger spectrum components

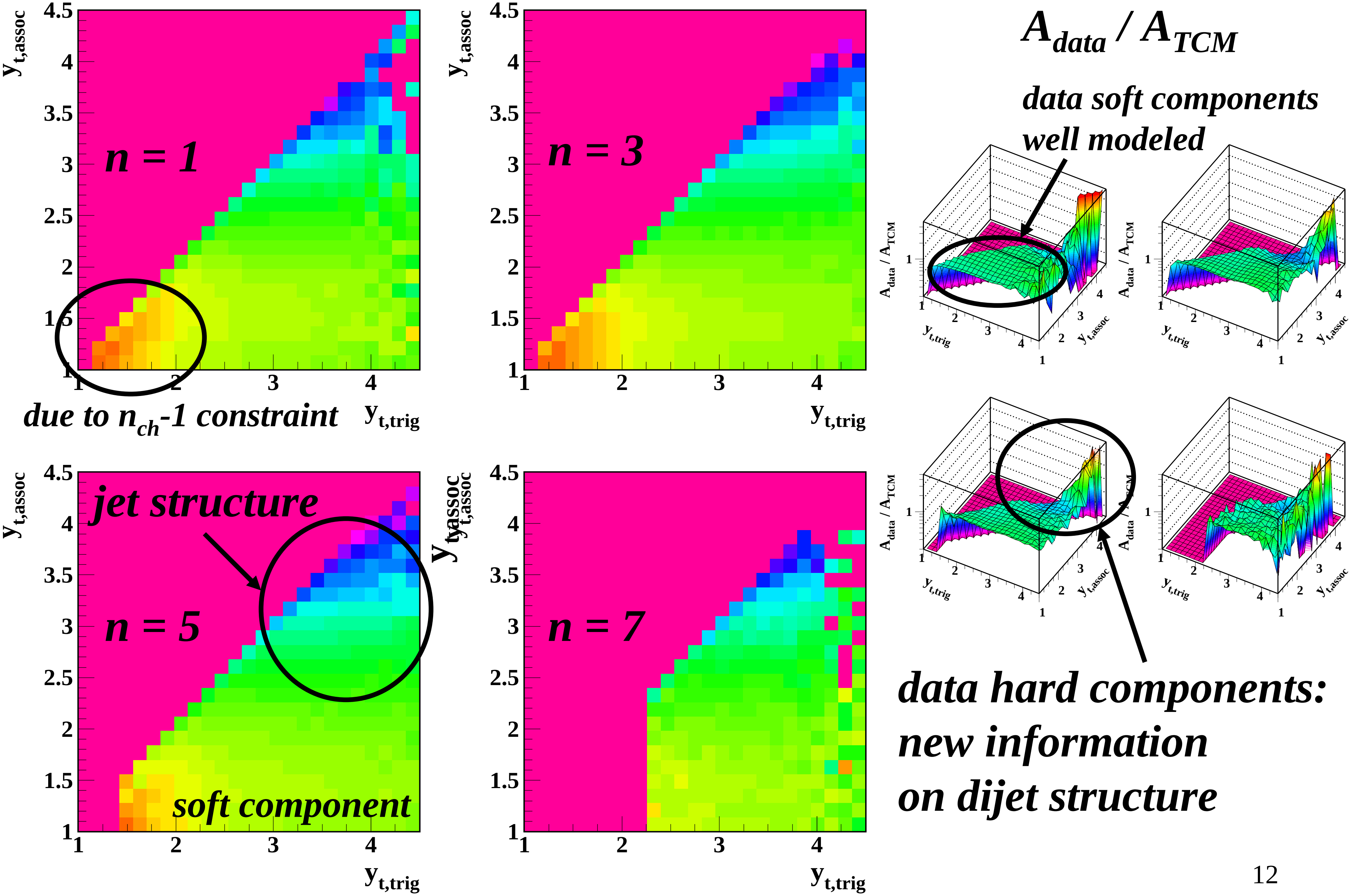
Compare 2D TA Data and TA TCM

F data ***F TCM***



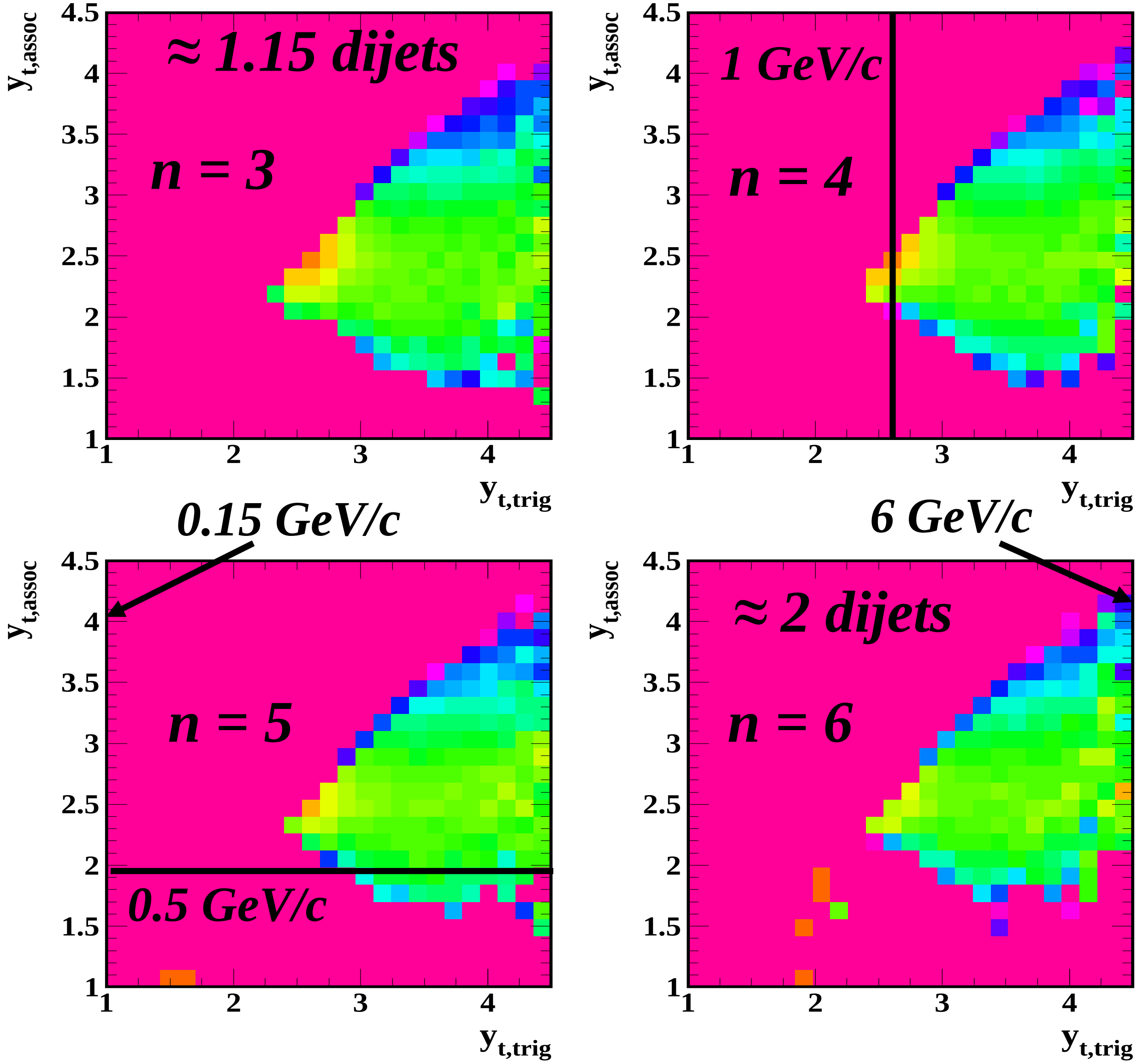
major features agree quantitatively

Associated-per-Trigger Ratios A = F/T



Hard Component of A = F/T per Dijet

per-dijet ***approximately independent of*** n_{ch}***!***

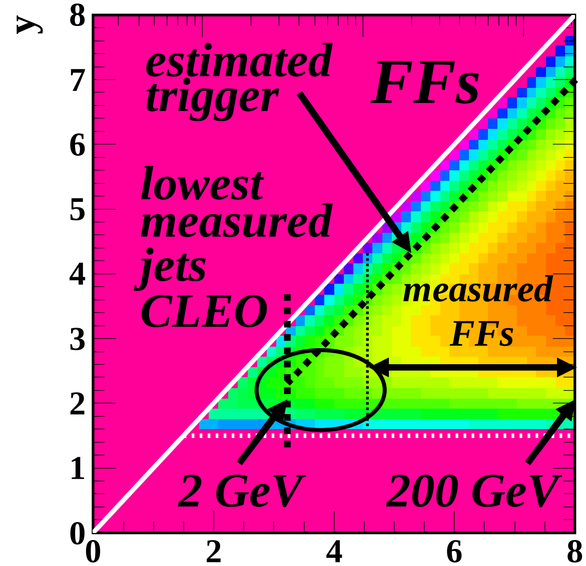


subtract TCM soft components

compare with unbiased jet structure

hep-ph/0606249

measured FFs – 2006

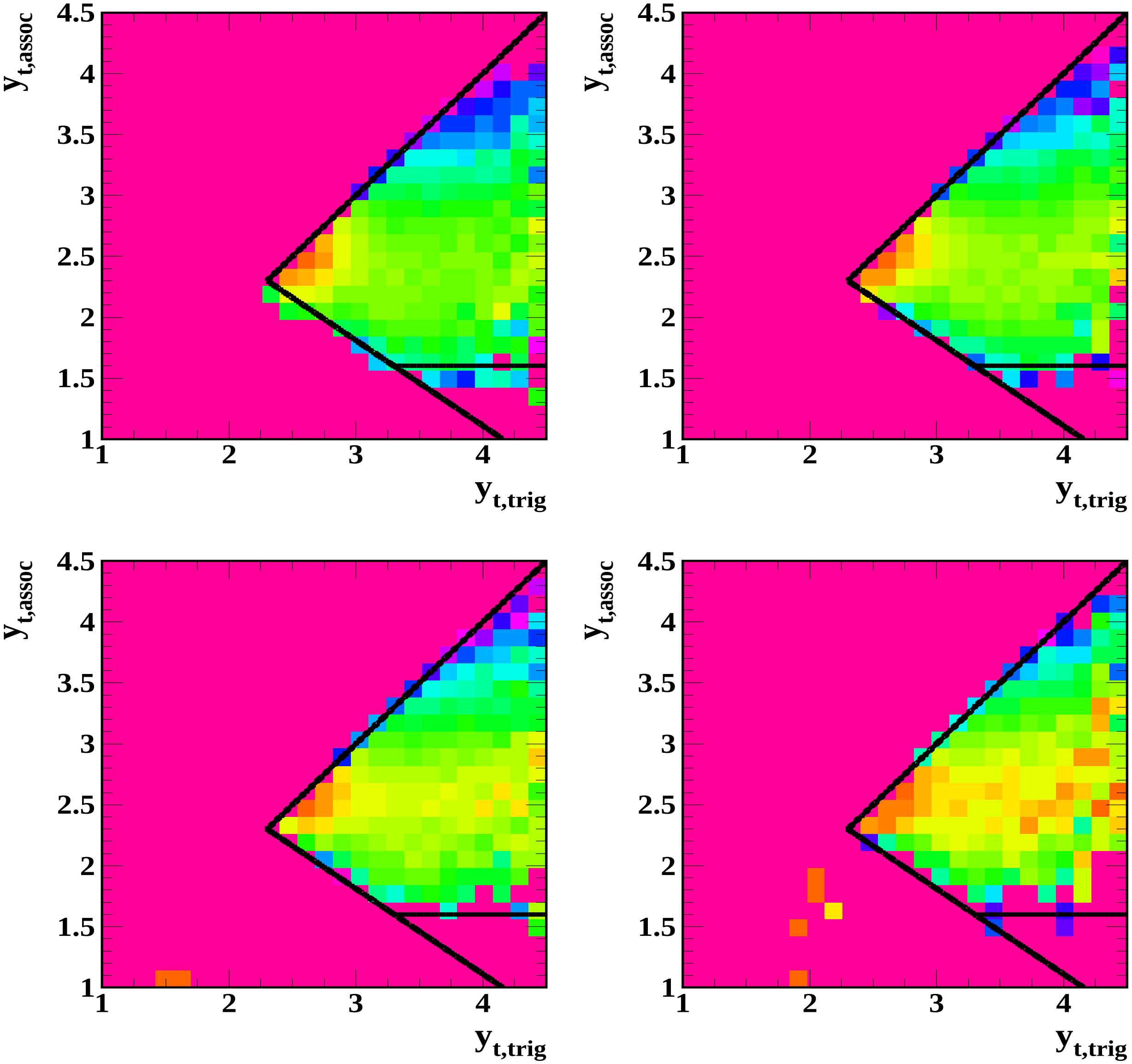


parton energy y_{max}

$y_{max} \approx \ln(2E_{parton}/m_\pi)$

Hard Component of A = F/T <u>per Dijet</u>

per hard event dependent on n_{ch}



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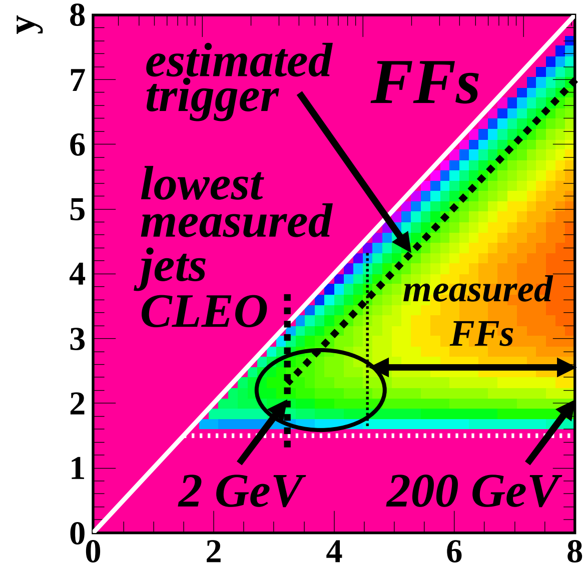
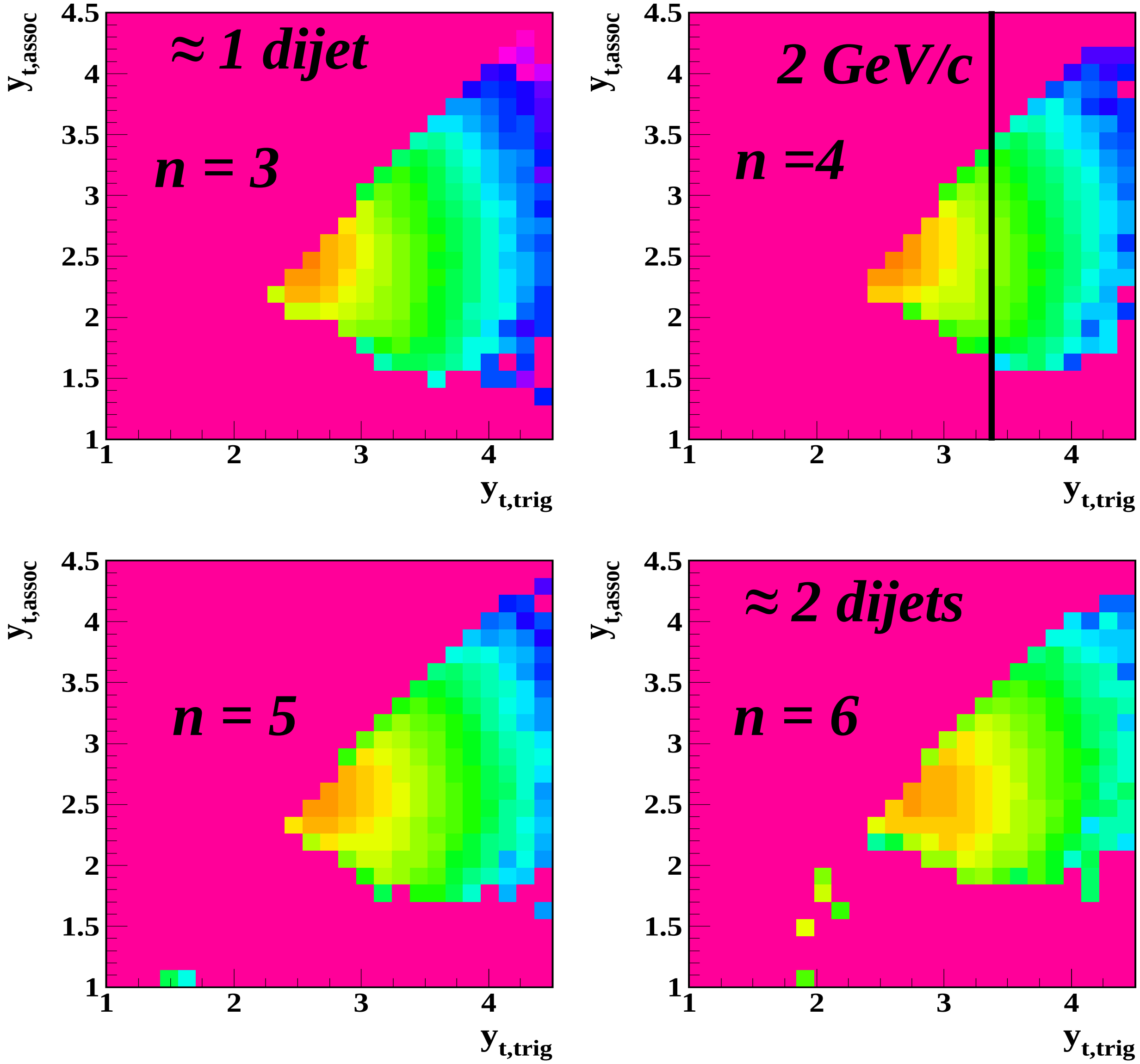


parton energy y_{max}

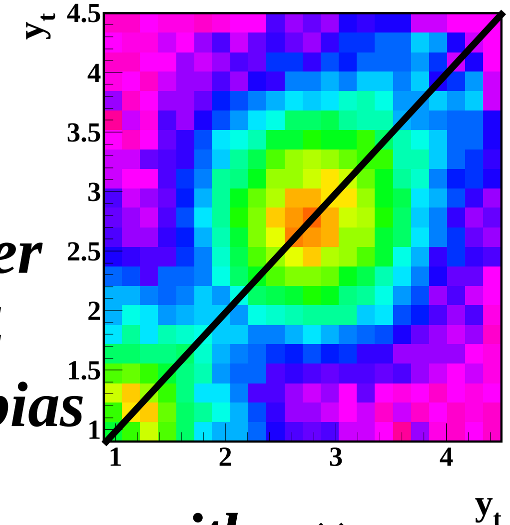
$y_{max} \approx \ln(2E_{parton}/m_{\pi})$

Hard Component of F = TA

actual minbias trigger-associated pairs

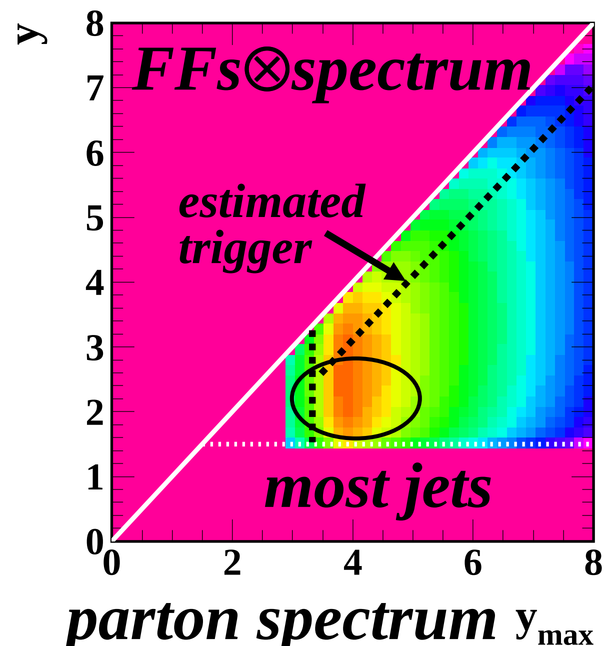


Porter 2004 minbias

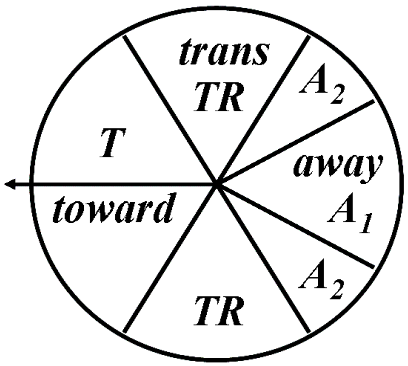


compare with $y_t \times y_t$ correlations and…

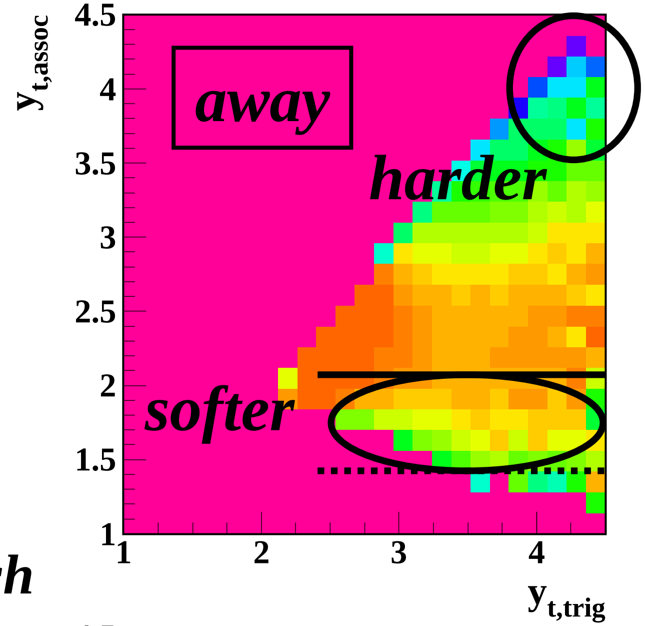
pQCD factorization

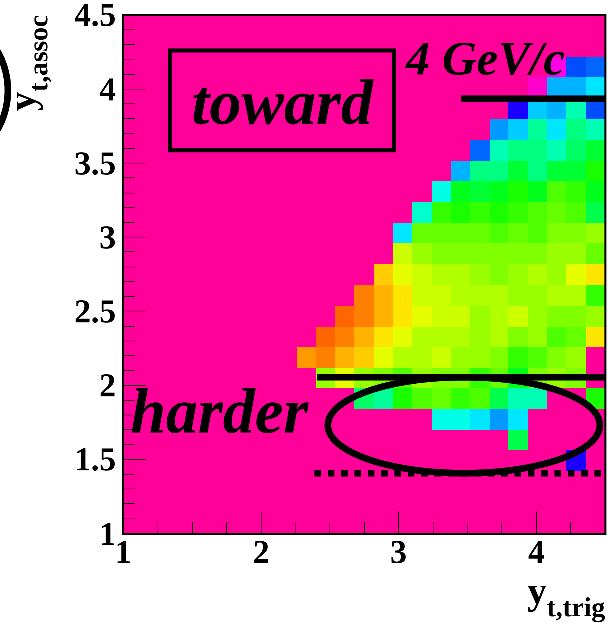


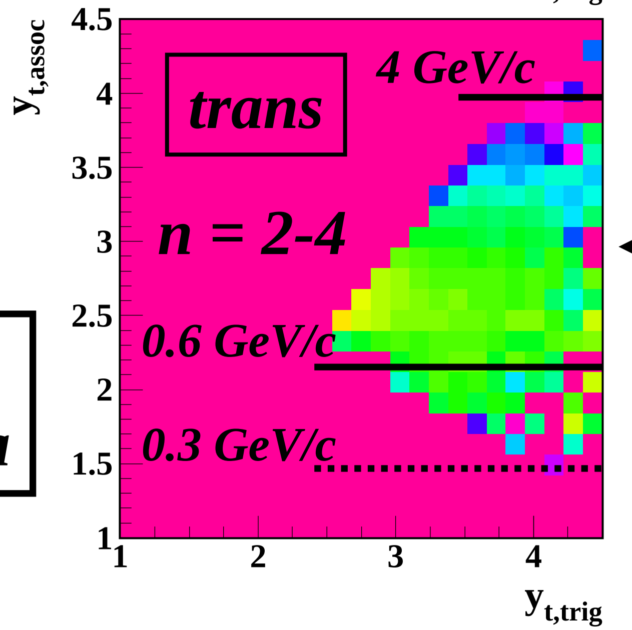
A = F/T vs Azimuth Intervals



sum three low-n_{ch} bins: ***<u>MPI < 15%</u>***





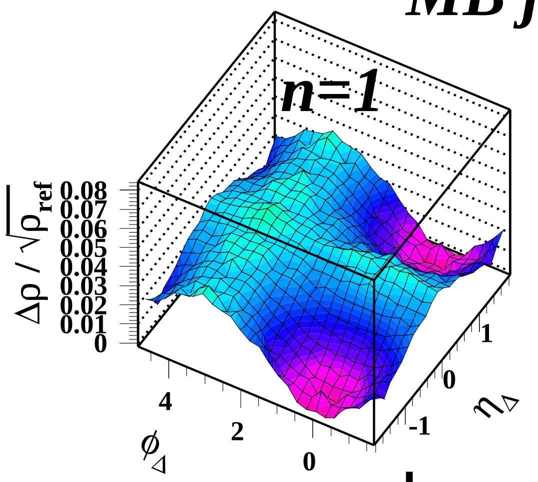


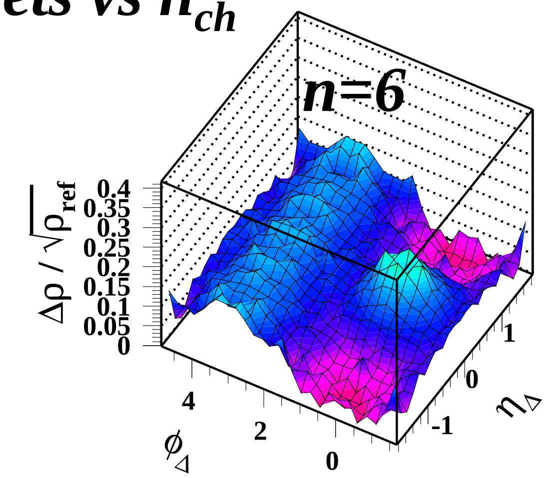
jets in TR!
part of triggered dijet

UE MPI conjecture inconsistent with data

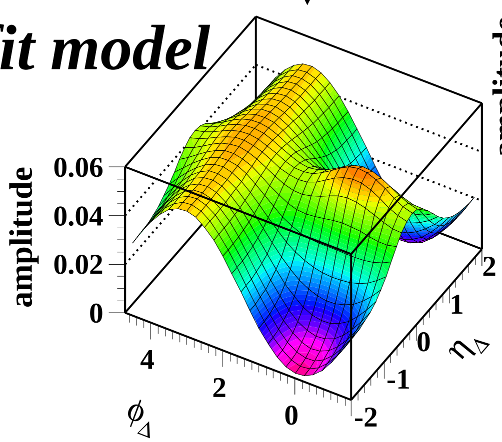
Dijet Structure in the “Trans” Region

MB jets vs n_{ch}

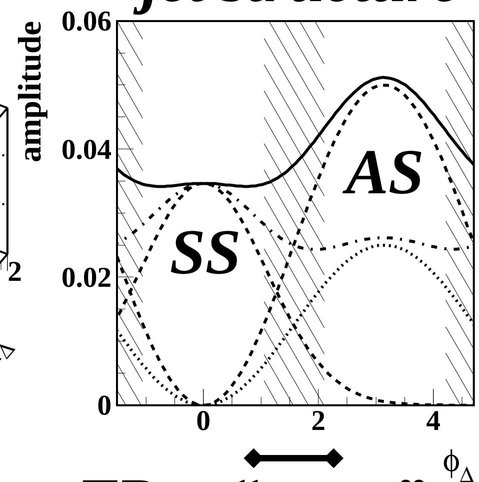




2D fit model



jet structure



TR = “trans”

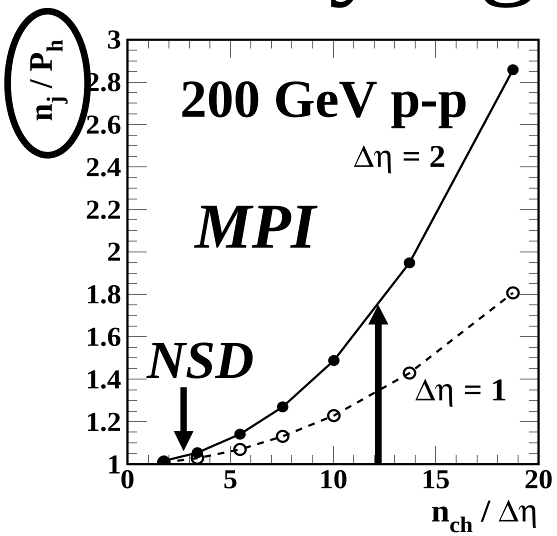
MB jets provide a base for higher-energy dijets

relative to MB jets:

for higher jet energies hadrons added nearer the jet axis do not contribute to the TR

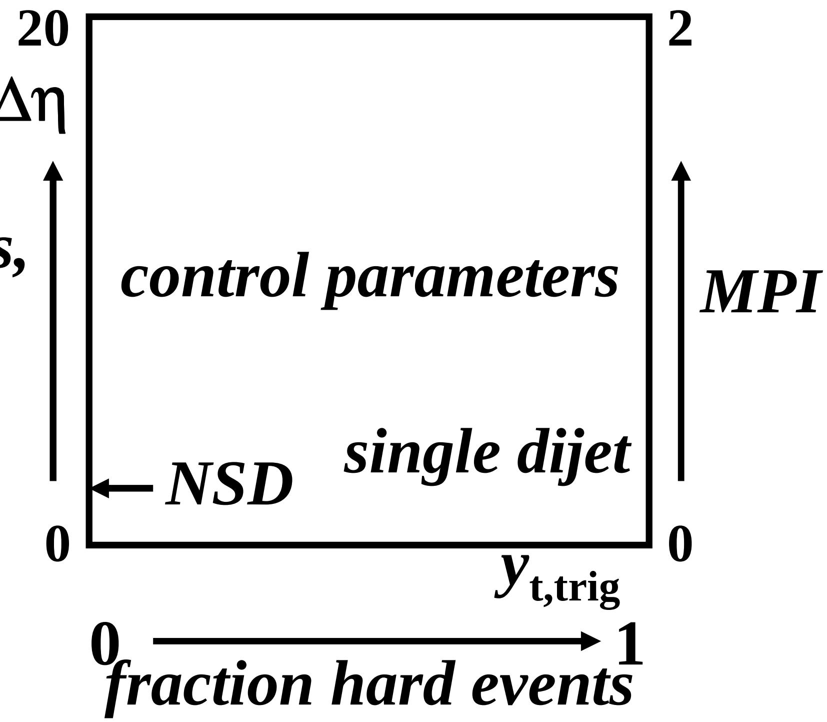
substantial overlap: same-side SS vs away-side AS

Underlying-Event Trends and the TR



number of dijets in hard events

more dijets,
$\propto n_{ch}^2$



real UE = soft component plus MPI described above

jet contribution to TR comes from MB jet structure common to all dijets

hard component in TR

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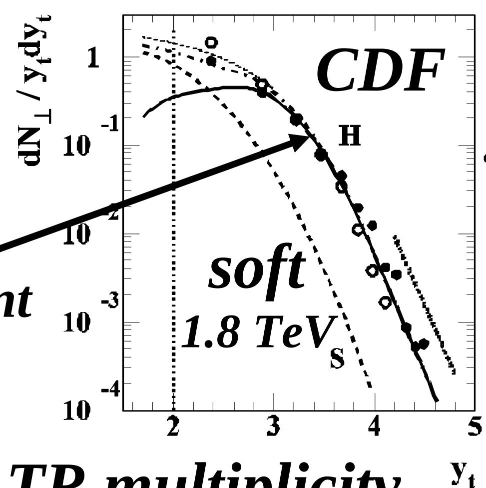
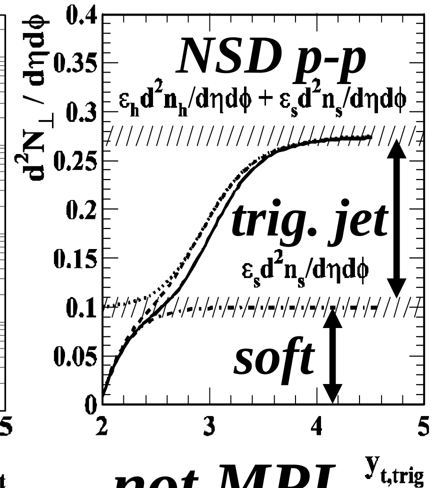
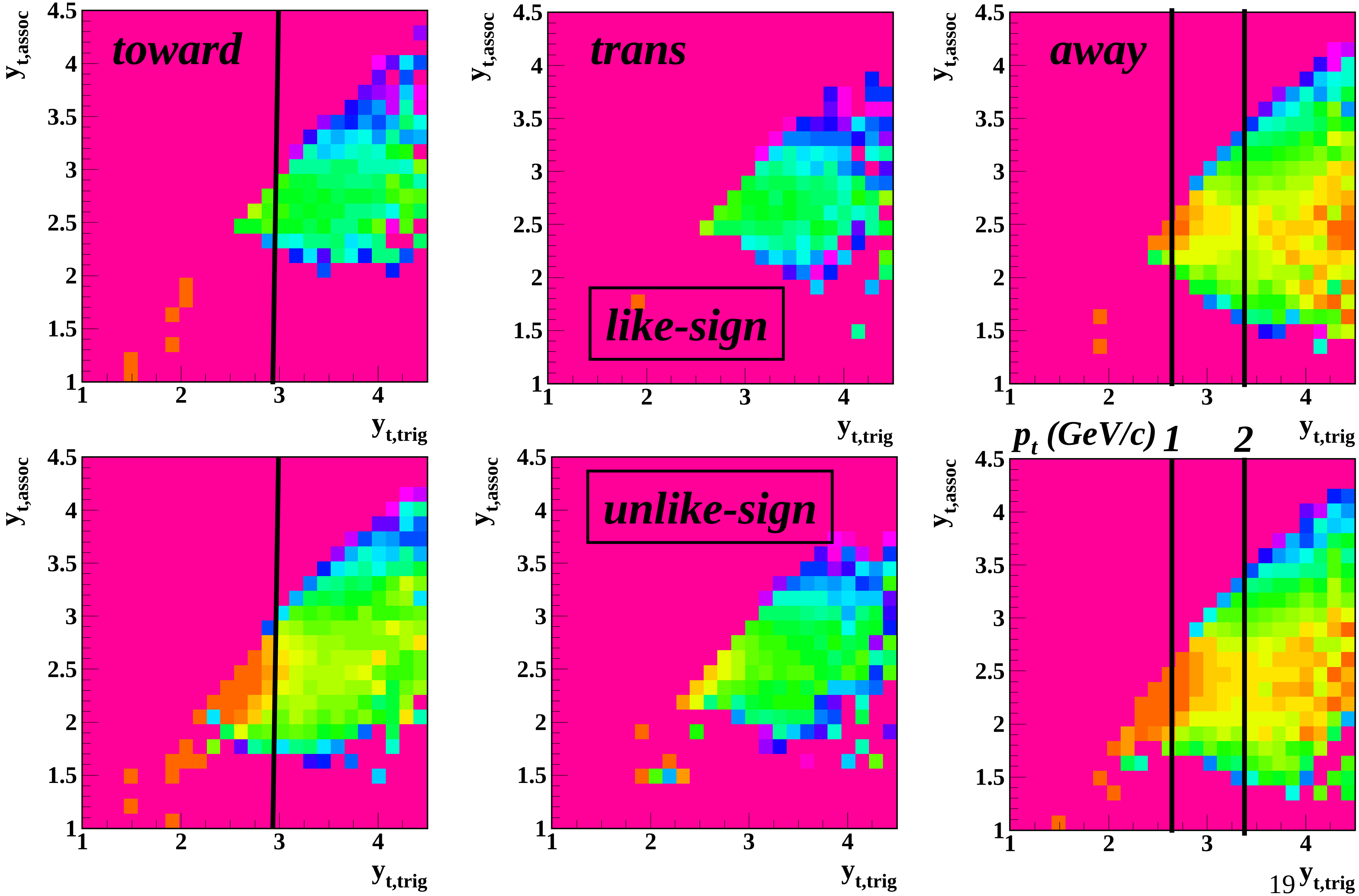


TR multiplicity



not MPI

Charge-pair Type Dependence



Kinematic Space for Jets & Fragments

effective boundaries for jet formation

- ***Trigger** hadrons extend down to 1 GeV/c*
- ***Associated** hadrons extend down to 0.4 GeV/c (AS) or 0.8 GeV/c (SS)*
- ***TA results consistent with measured FFs from LEP, HERA and CDF and with a pQCD parton spectrum that predicts measured dijet production***
- ***Conventional trigger-associated p_t cuts accept a tiny fraction of the actual jet number and jet fragments, produce a deceptive picture of jets in HE collisions***

Summary

- ***"Glauber" model for p-p collisions, <u>no eikonal</u>***
- ***"Soft" component represents <u>participant partons</u>***
- ***Predict trends for dijet, <u>nonjet-quadrupole</u> correlations***
- ***MPI trend with n_{ch}, <u>jet contributions to "trans" region</u>***
- ***Develop TCM for trigger-associated TA correlations***
- ***1D T spectrum, 2D F = TA two-component models***
- ***<u>Hard components of F, A</u> by subtraction → MB jets***
- ***Direct link to measured fragmentation functions and underlying pQCD parton spectrum***
- ***TA results confirm trigger contribution to "trans" region***