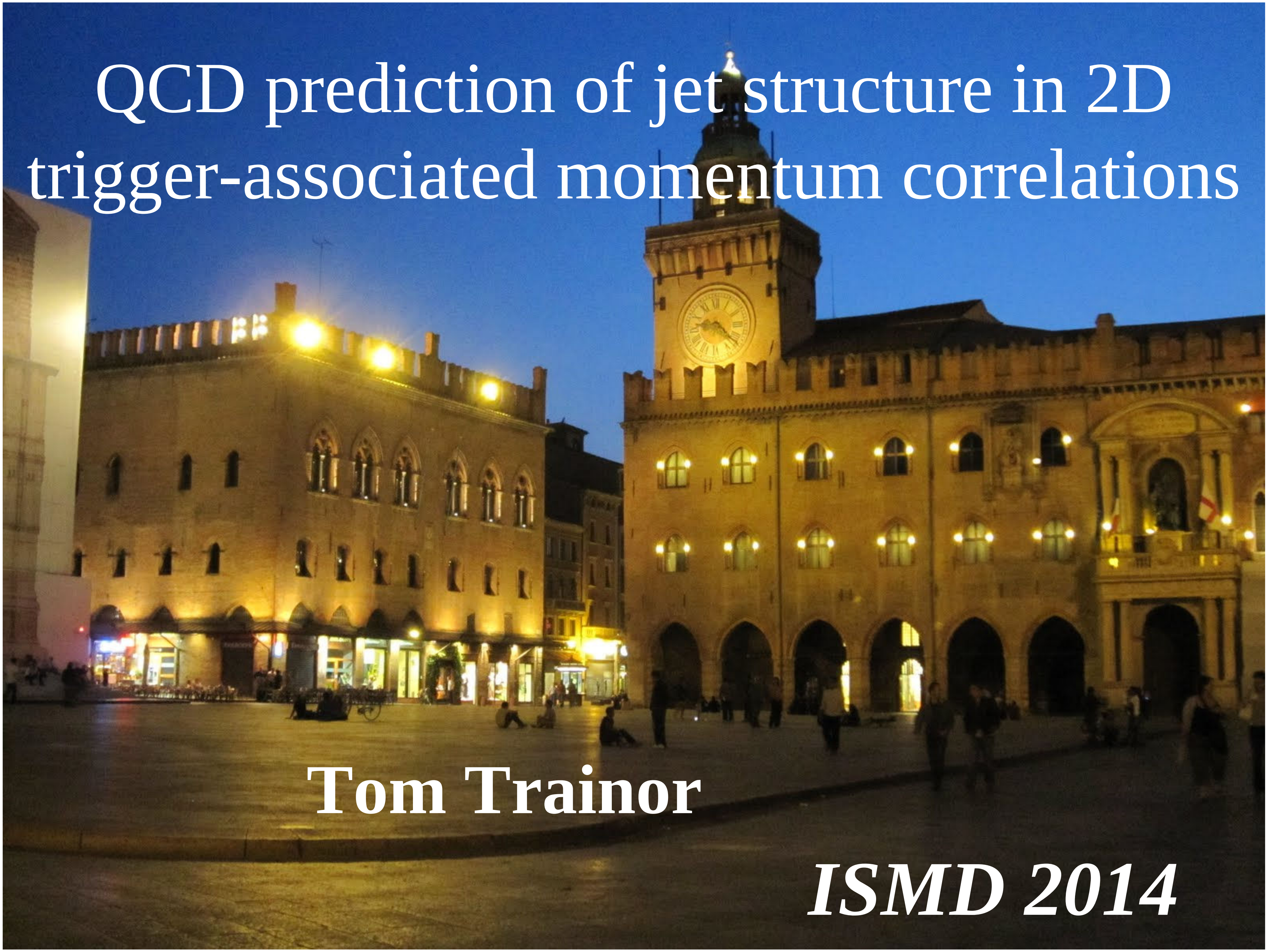
QCD prediction of jet structure in 2D trigger-associated momentum correlations



Tom Trainor

ISMD 2014

Agenda

- ***Define trigger-associated (TA) correlations***
- ***Derive a TA two-component model (TCM)***
- ***Extract a TA hard component (HC) → jet fragments***
- ***Predict the TA HC via pQCD (MB jet spectrum, FFs)***
- ***Identify <u>kinematic limits on dijets</u> in p-p collisions***
- ***Isolate single triggered dijets from secondaries (MPI)***
- ***Test underlying-event (UE) conjectures re dijets/MPI***

Trigger-associated (TA) Correlations

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

- ***the highest-p_t hadron is the "trigger"***
- ***n_{ch}-1 other hadrons are "associated"***
- ***form all trigger-associated pairs (not self pairs)***
- ***subtract calculated TCM TA soft components***
- ***get conditional data hard component $A_{hh}(y_{ta}|y_{tt})$***
- ***determine azimuth dependence relative to trigger***

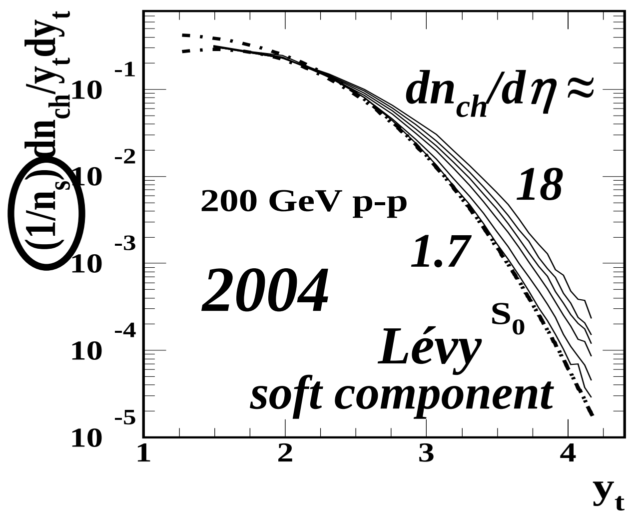
no p_t cuts – all jets, all hadron pairs accepted

rapidities: $y \equiv \ln[(p+E)/m_\pi]$ $\quad y_t \equiv \ln[(p_t+m_t)/m_\pi]$

p-p Spectrum TCM and Dijets

nucl-ex/0606028

p-p* spectra for ten n_{ch} classes *n

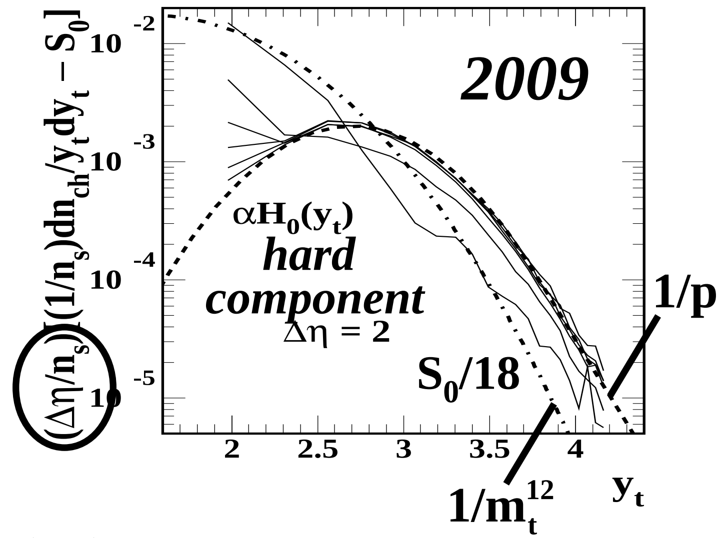


for $\Delta\eta = 1$

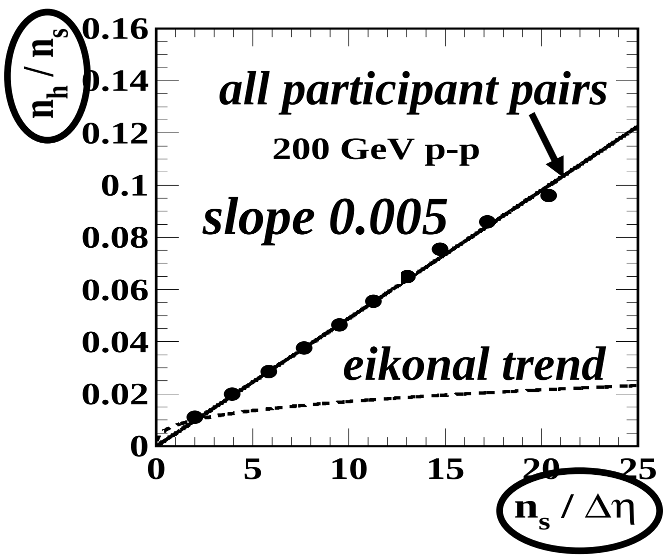
$n_{ch} = n_s + n_h$

$n_h \approx 0.005\, n_s^2$

→ ***subtract*** S_0



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

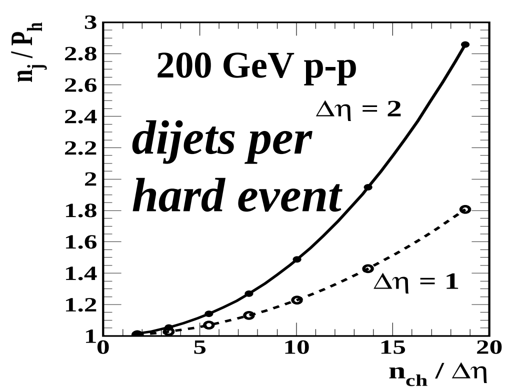


dijet number: $n_j \propto n_h \propto n_s^2 \propto N_{part}$ 2

$$n_j \approx \Delta\eta\ 0.03\ (n_s/2.5)^2$$

$$P_s(n_{ch}) = \exp[-n_j(n_{ch})]$$

$$P_h(n_{ch}) = 1 - P_s(n_{ch})$$



Trigger-associated TCM

within some $\Delta\eta$

arXiv:1307.1819

TCM for SP spectra:

$$F(y_t, n_{ch}) = n_s S_0(y_t) + n_h H_0(y_t)$$

$$n_{ch} = n_s + n_h \qquad n_h = \alpha n_s^2$$

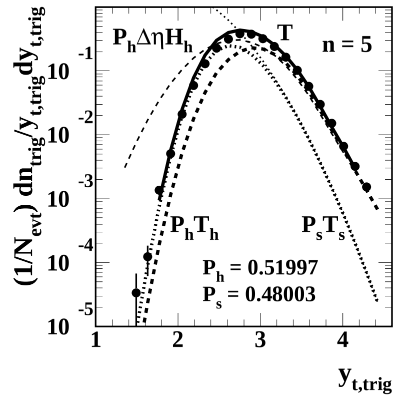
$$n_j \propto n_h$$

trigger spectrum:

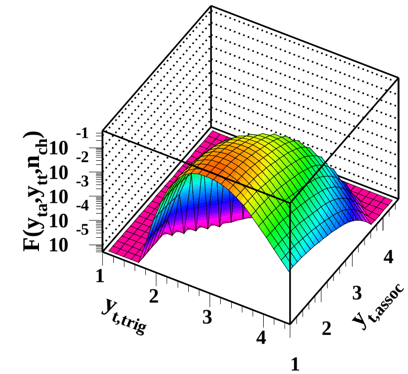
$$T(y_{tt}) = G(y_{tt}) F(y_{tt})$$

void probability: $G(y_{tt}) = \exp[-n_\Sigma(y_{tt})]$

$T(y_{tt})$



$F_{ta}(y_{ta}, y_{tt})$



joint TA distribution:

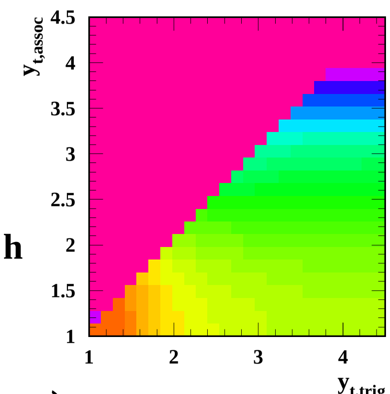
$$F_{ta}(y_{ta}, y_{tt}) = T(y_{tt}) A(y_{ta} \mid y_{tt})$$

soft and hard event types:

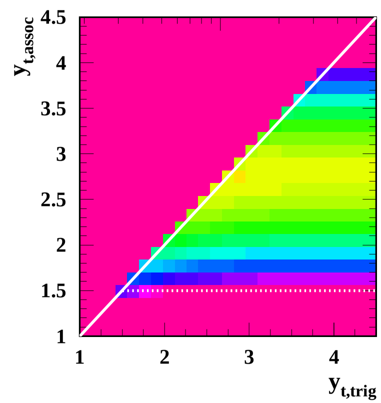
$$A(y_{ta} \mid y_{tt}, n_{ch}) = P_s(n_{ch}) A_s + P_h(n_{ch}) A_h$$

$$P_s(n_{ch}) = \exp[-n_j(n_{ch})]$$

$A(y_{ta} \mid y_{tt})$



$A_{hh}(y_{ta} \mid y_{tt})$

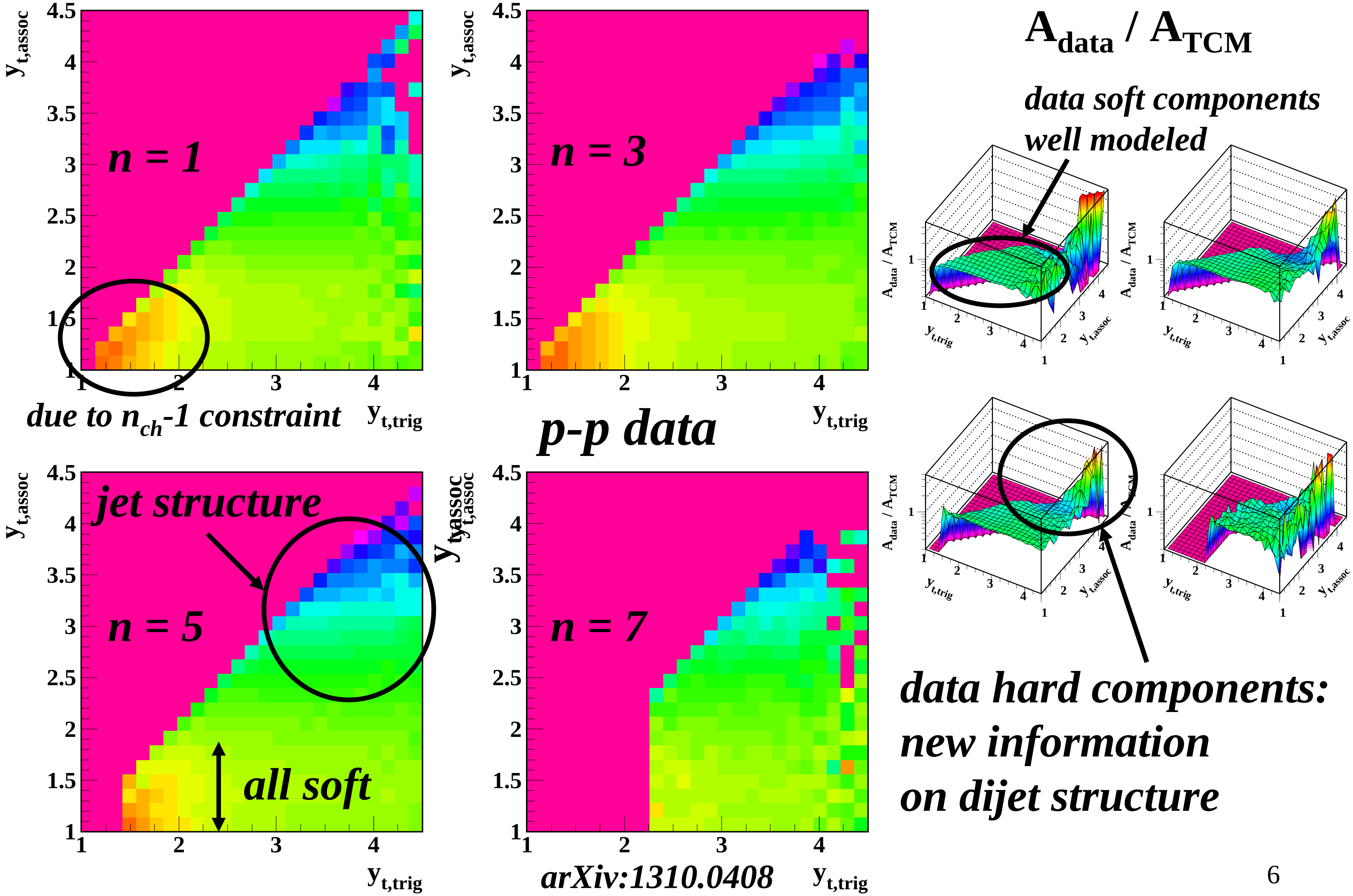


hard component of hard events (TCM or data):

z axis logarithmic

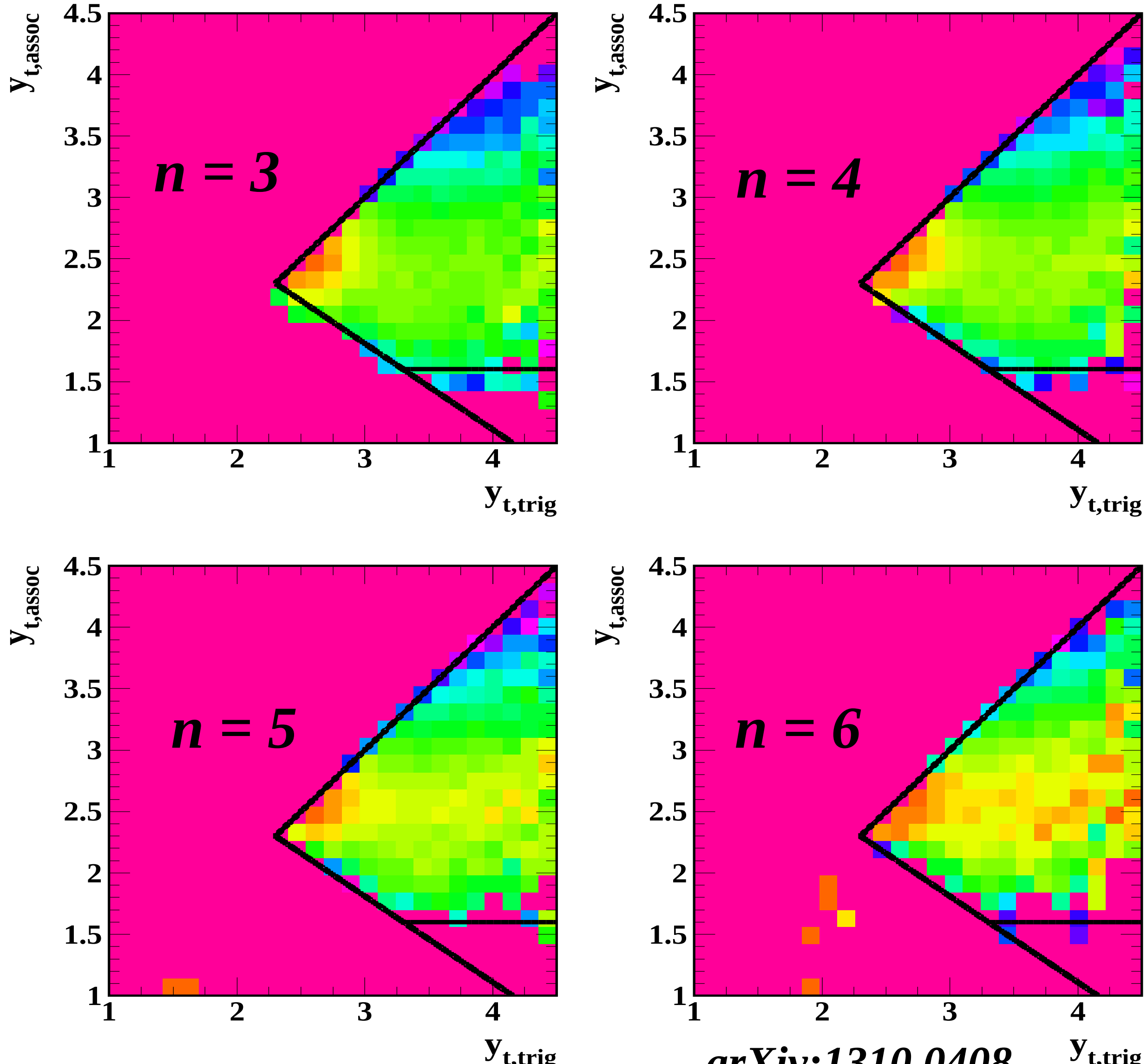
$A_{hh}(y_{ta} \mid y_{tt})$ ***object of study: includes all <u>dijet</u> TA correlations***

Associated-per-Trigger Ratios A = F/T



Hard Component of A = F/T

***per hard event*, dependent on n_{ch}**

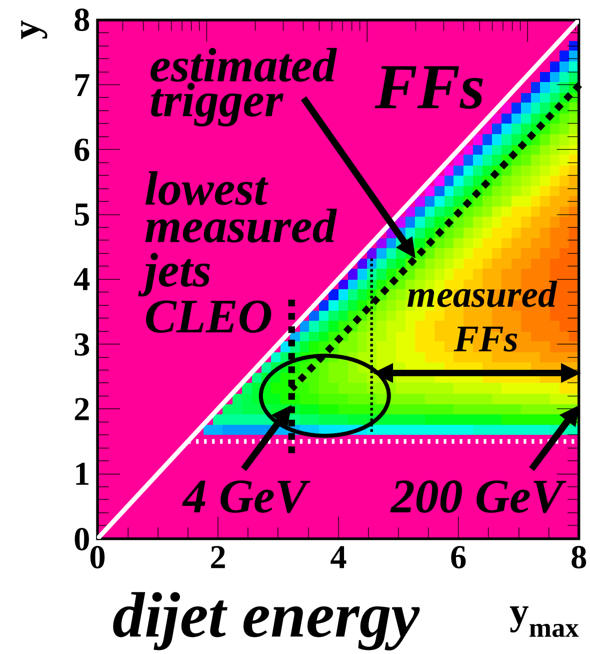


subtract TCM soft components

compare with unbiased jet structure

hep-ph/0606249

measured FFs – 2006



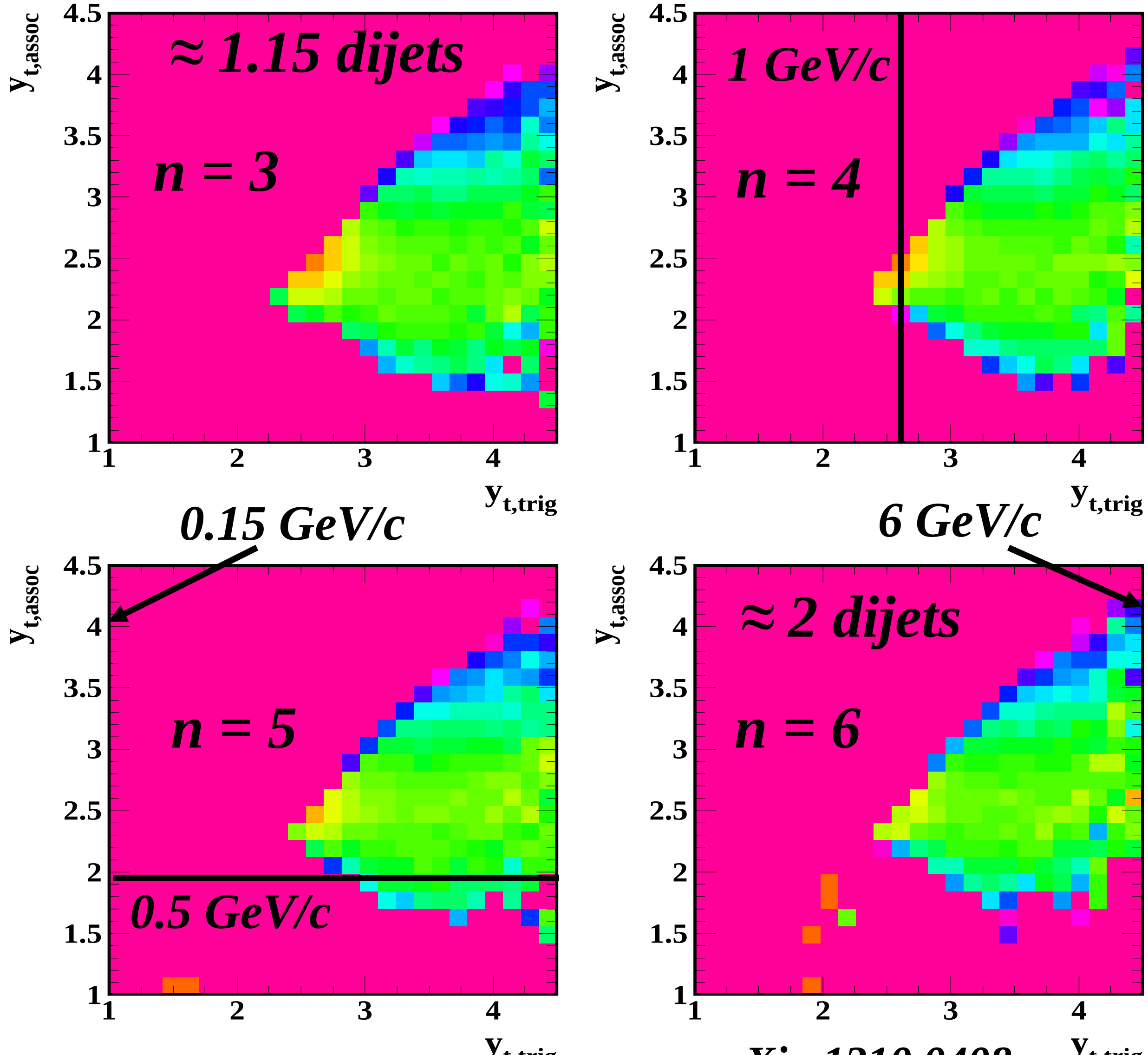
dijet energy

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

arXiv:1310.0408

Hard Component of $A = F/T$

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



arXiv:1310.0408

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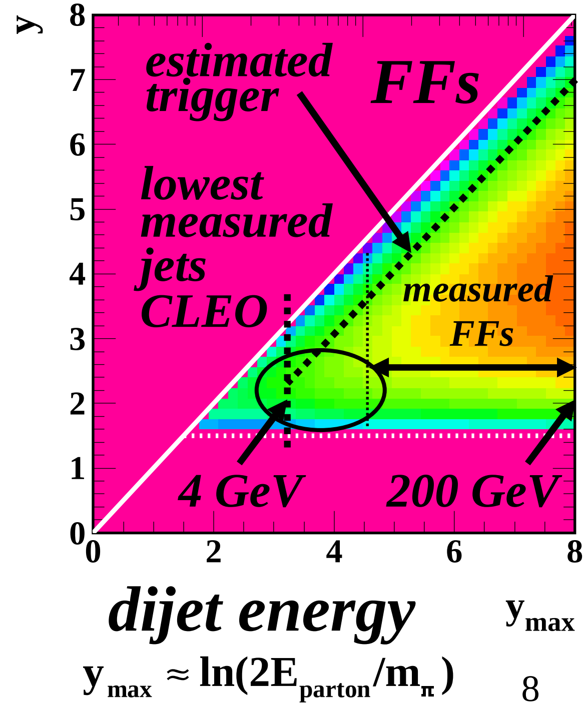
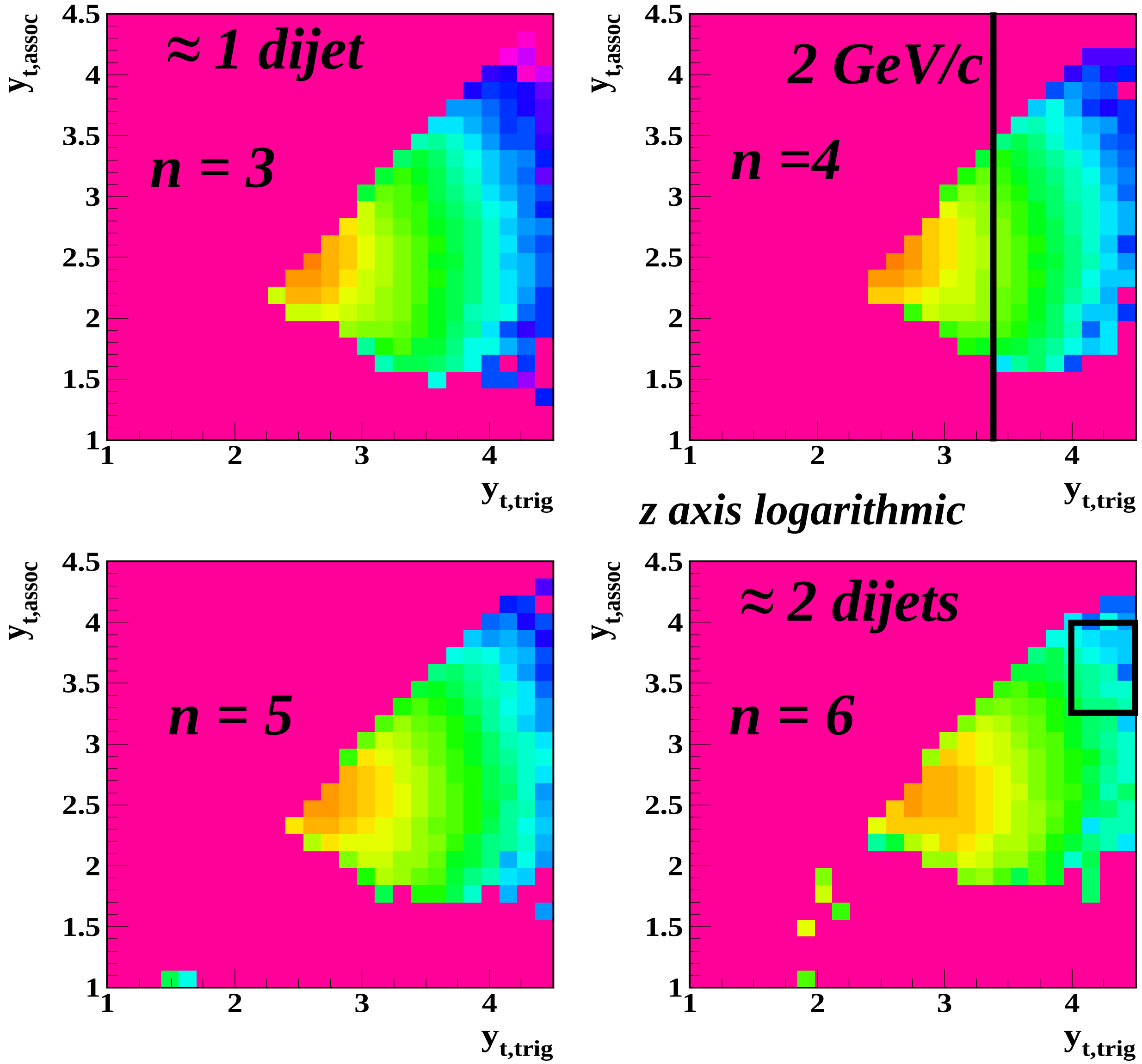
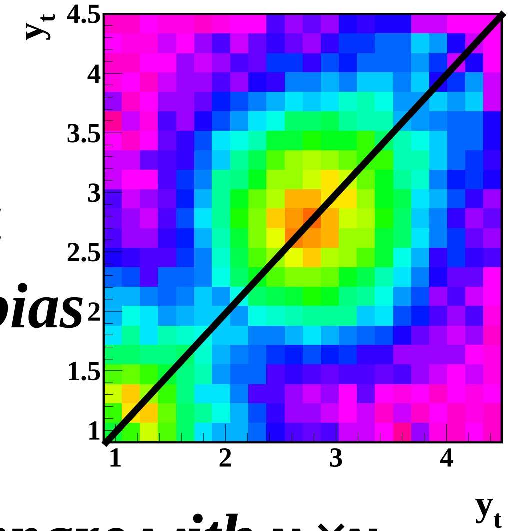


Hard Component of F = TA

actual minbias trigger-associated HC

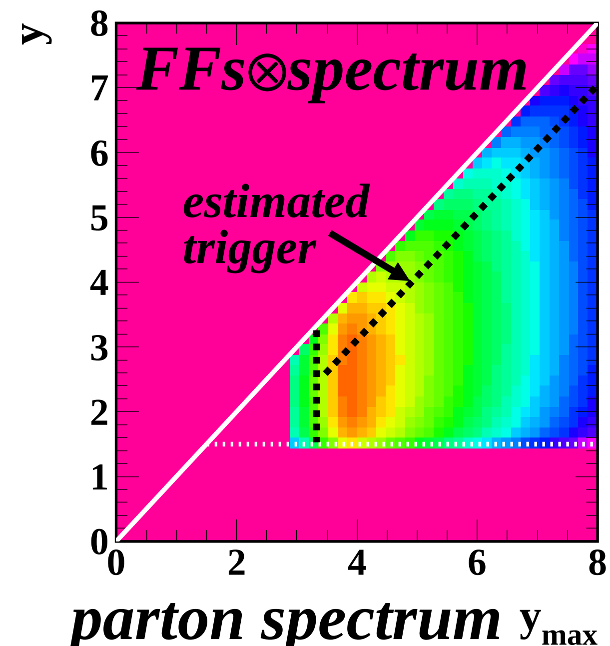


2004 minbias



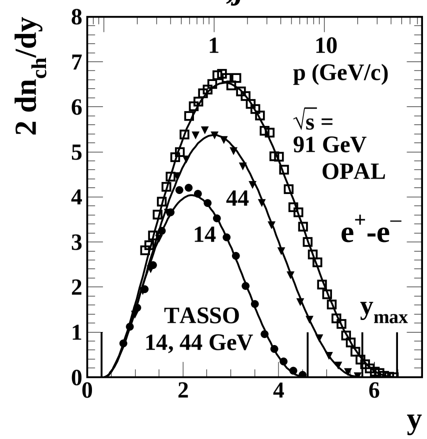
compare with $y_t \times y_t$ correlations and…

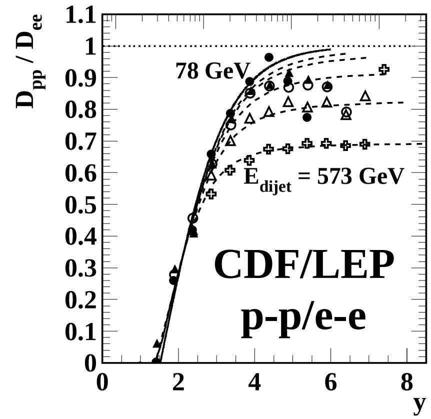
pQCD factorization



Fragmentation Functions – TA Partition

$2dn_{ch,j}/dy$ *arXiv:1407.6422*





FFs for given parton and hadron types:

$$D_\alpha^\beta(y\,|\,y_{max}) \qquad y_{max} = \ln(2E_{jet}/m_\pi)$$

$S_t(y_{trig}\,|\,y_{max})$

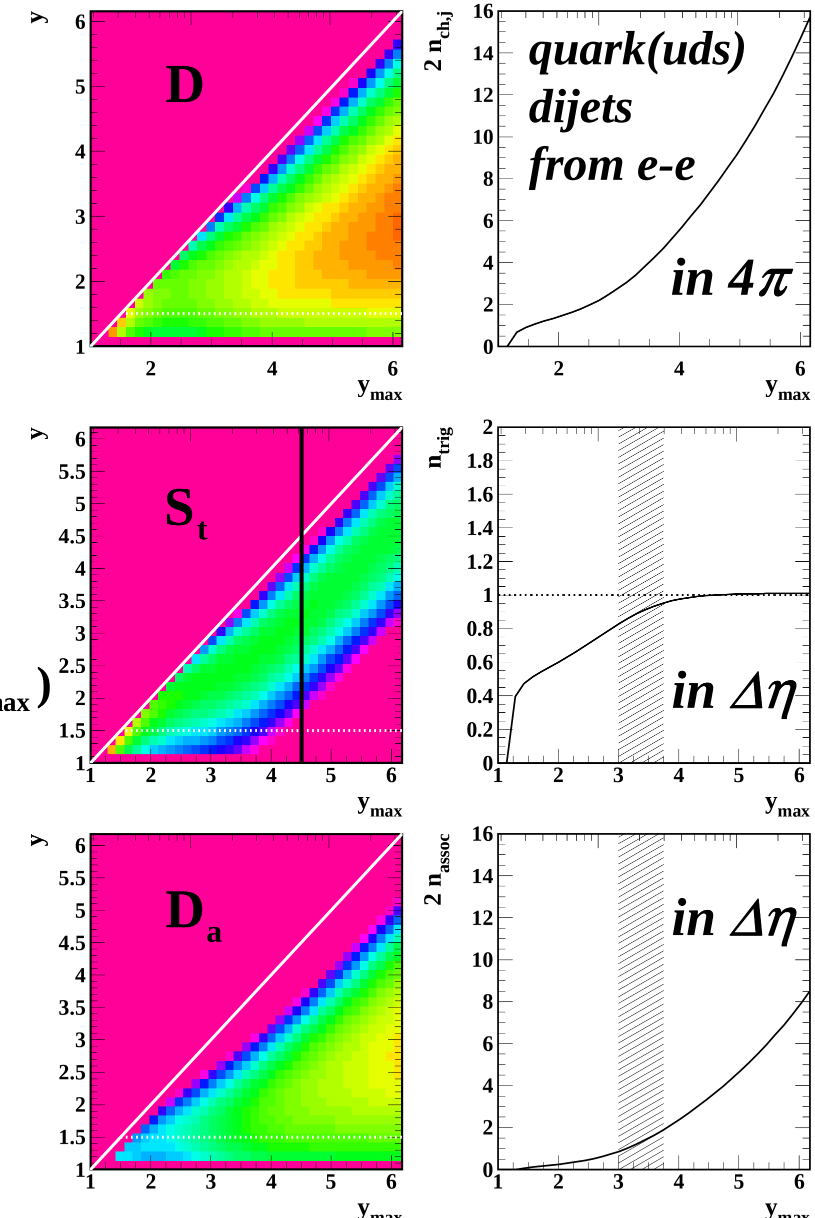
trigger fragment from void probability:

$$S_t(y\,|\,y_{max}) = G(y)\ \varepsilon(\Delta\eta) D(y\,|\,y_{max})$$

complementary associated fragments:

$$D_a(y\,|\,y_{max}) = [1 - G(y)]\ \varepsilon(\Delta\eta) D(y\,|\,y_{max})$$

dijet fraction in $\Delta\eta$

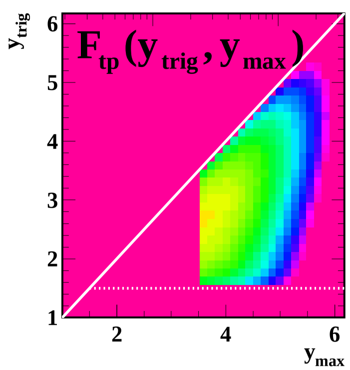


z axis logarithmic

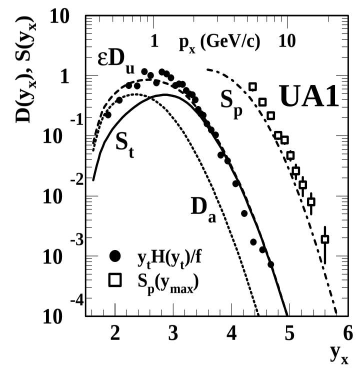
Convolutions and Bayes' Theorem

relate parton-fragment FF system to hadron-hadron TA system

$$F_{tp}(y_{trig}, y_{max}) = S_p(y_{max}) S_t(y_{trig} \mid y_{max})$$



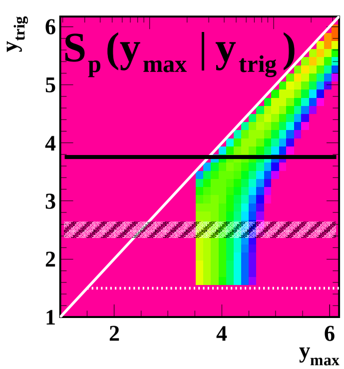
project onto y_{trig}

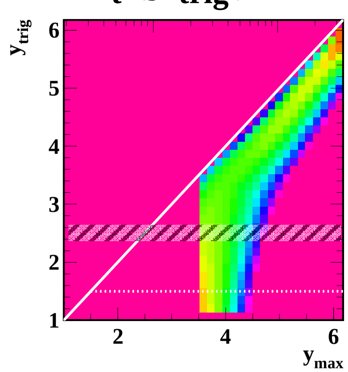


$$S_t(y_{trig}) = \int_{y_{trig}}^{\infty} dy_{max} S_p(y_{max}) S_t(y_{trig} \mid y_{max})$$

Bayes' theorem:

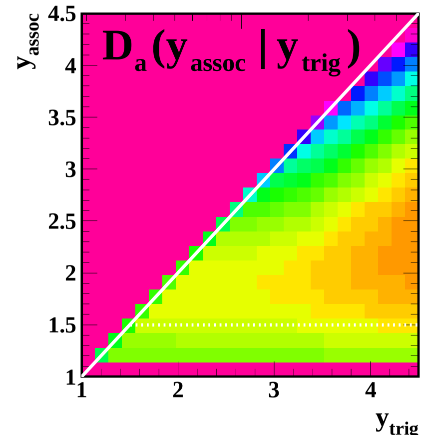
$$S_p(y_{max} \mid y_{trig}) = \frac{S_p(y_{max}) S_t(y_{trig} \mid y_{max})}{S_t(y_{trig})}$$

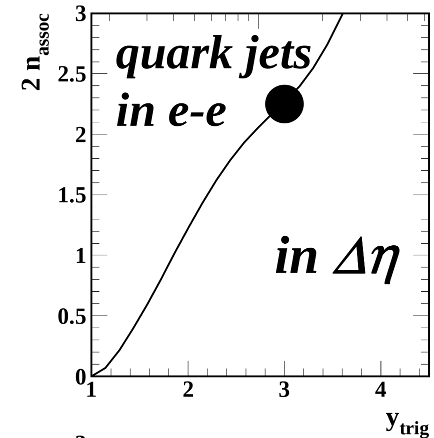


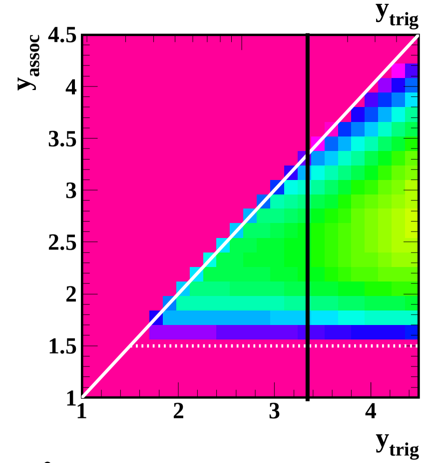


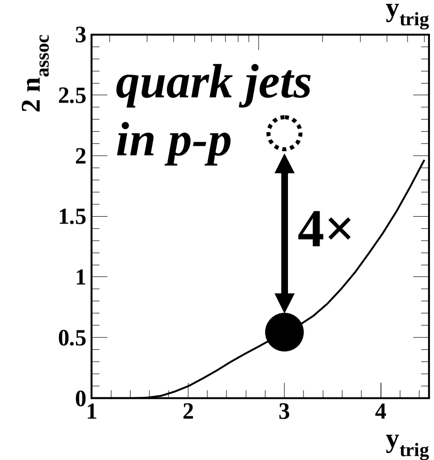
$$D_a(y_{assoc} \mid y_{trig}) = \int_{y_{trig}}^{\infty} dy_{max} S_p(y_{max} \mid y_{trig}) D_a(y_{assoc} \mid y_{max})$$

[*vs* y_{ta} $A_{hh}(y_{ta}|y_{tt})$]









arXiv:1407.6422

Isolating the Triggered Dijet

arXiv:1407.6422

$$\underbrace{P_h R_h A_{hh}}_{\text{data}} = A - \underbrace{P_s R_s A_s - P_h R_h A_{hs}}_{\text{TCM soft components}}$$

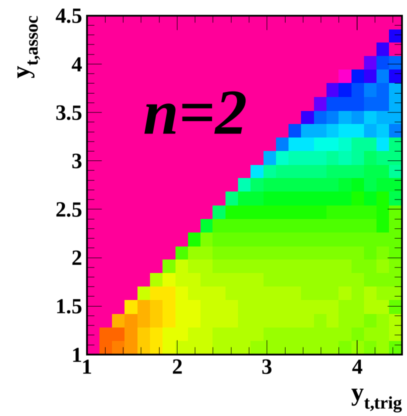
$R_x = T_x/T$

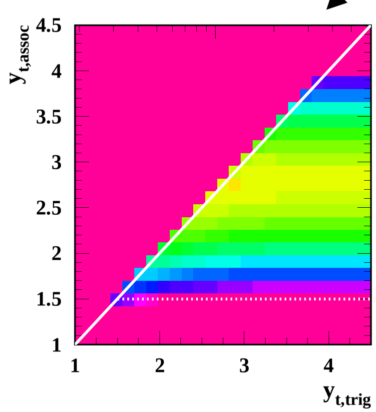
$n_j = 1 + \Delta n_j$

$$T_h A_{hh} = \underbrace{G_{hh} T_{hs} \overset{1+\Delta n_j}{A'_{hh}} + G_{hs} T_{hh} \left(\overset{\Delta n_j}{A''_{hh}}\right.}_{\text{untriggered dijets}} + \left.\overset{1}{A^*_{hh}} \right)$$

triggered

data A = F/T





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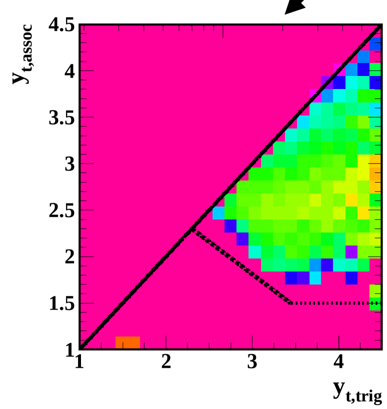

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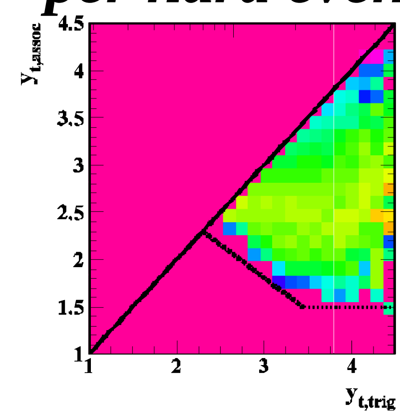
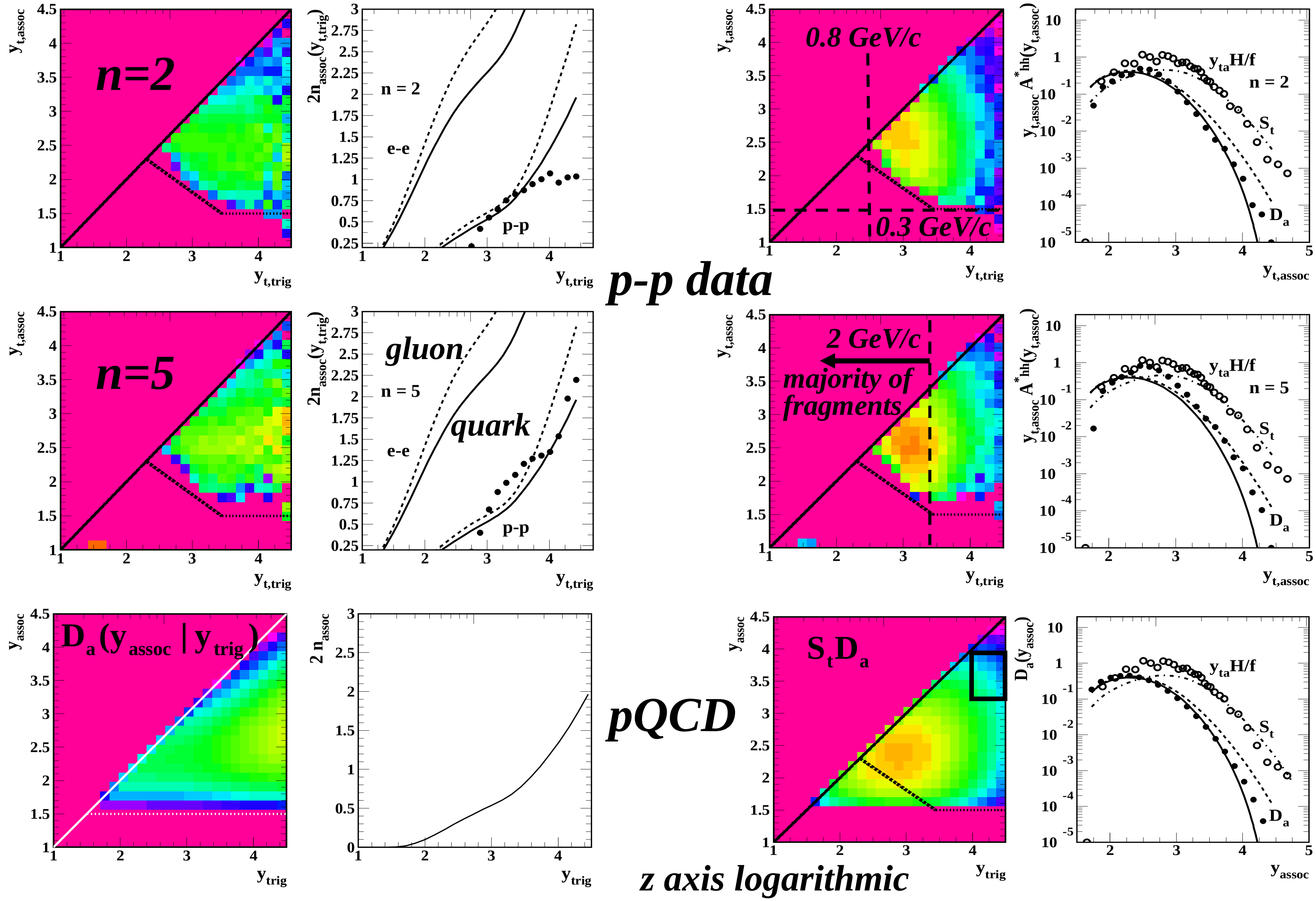
all dijets per hard event



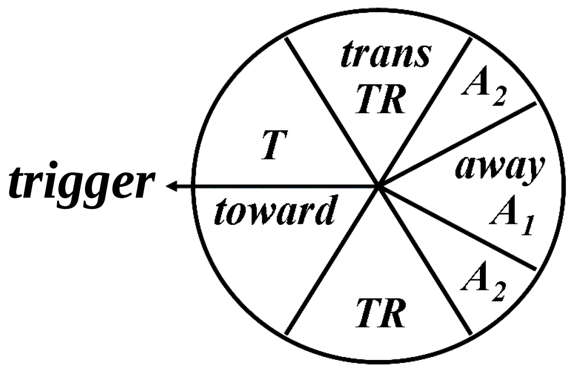
TCM: A'_{hh}, A''_{hh} *data:* A^*_{hh} *single triggered dijet comparable to FFs*

TA Comparisons: FFs vs p-p Data

$y_{ta} A^*_{hh}(y_{ta} \mid y_{tt})$ $\qquad$ $y_{ta} F^*_{hh}(y_{ta}, y_{tt}) = T_h(y_{tt}) y_{ta} A^*_{hh}(y_{ta} \mid y_{tt})$

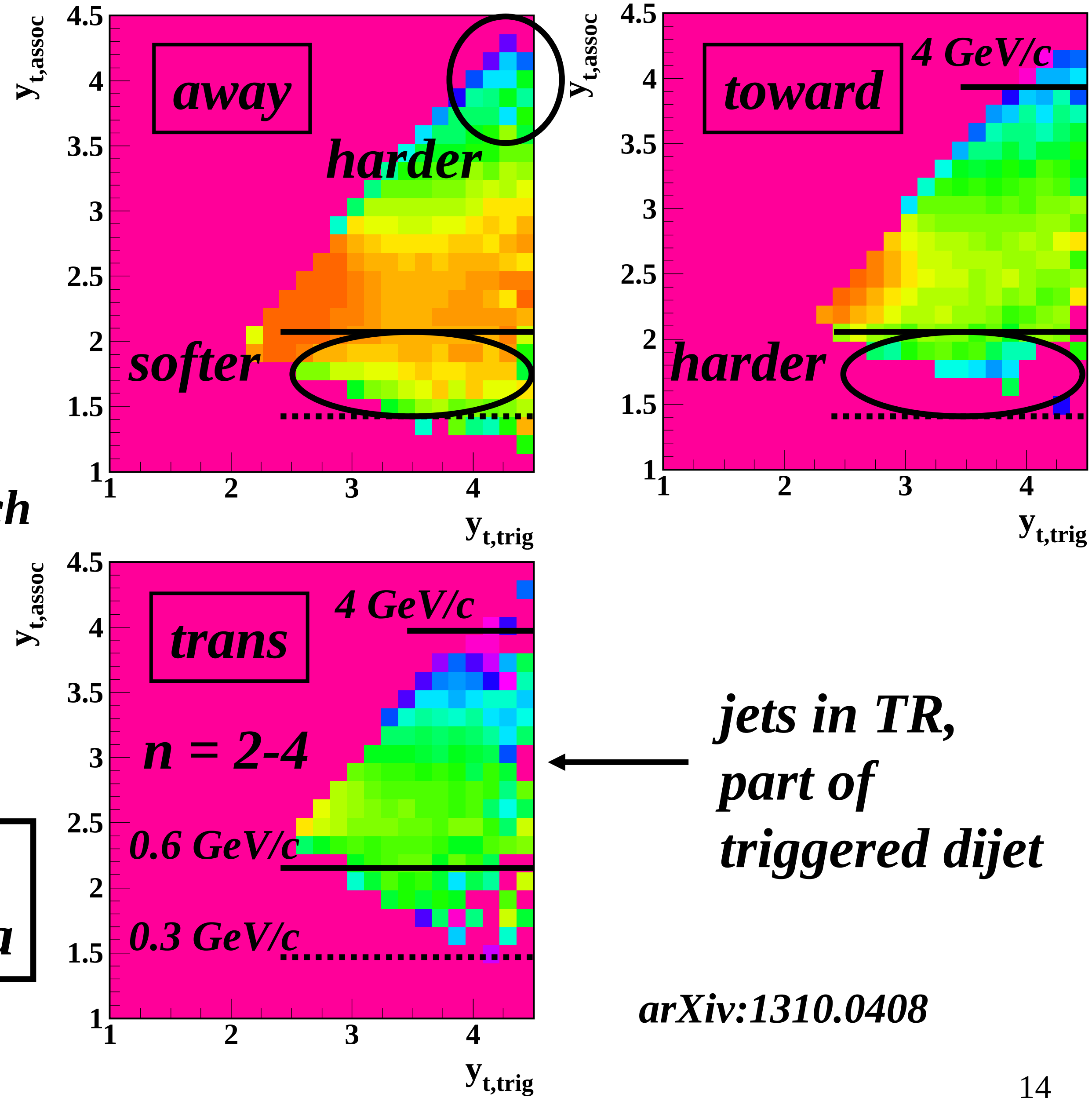


A = F/T vs Azimuth Intervals



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

$\Delta n_j < 0.15$



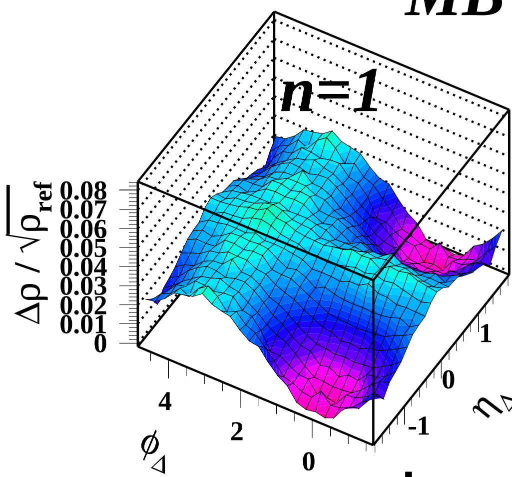
jets in TR, part of triggered dijet

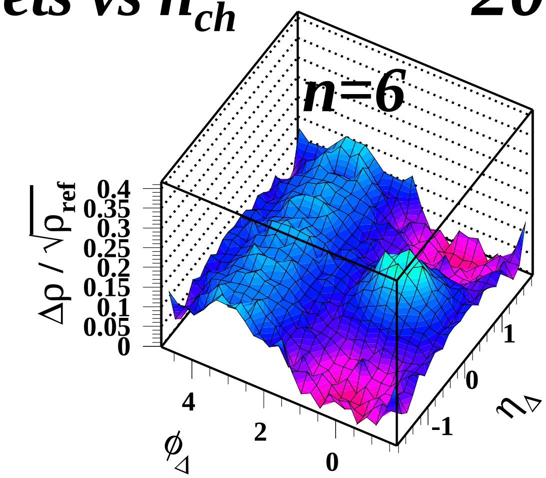
UE MPI conjecture inconsistent with data

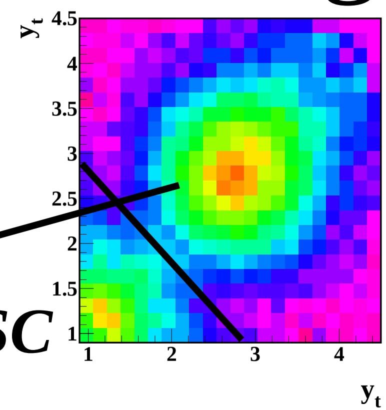
arXiv:1310.0408

Dijet Structure in the “Trans” Region

MB jets vs n_{ch} ***2004***



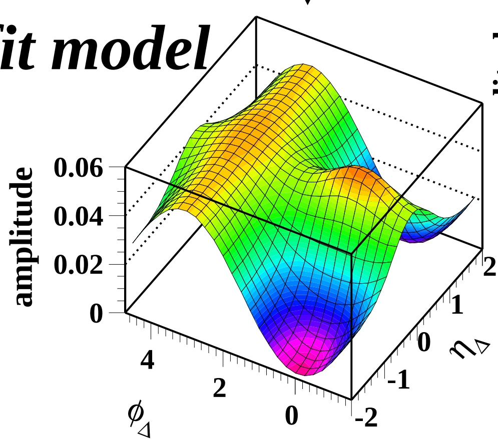




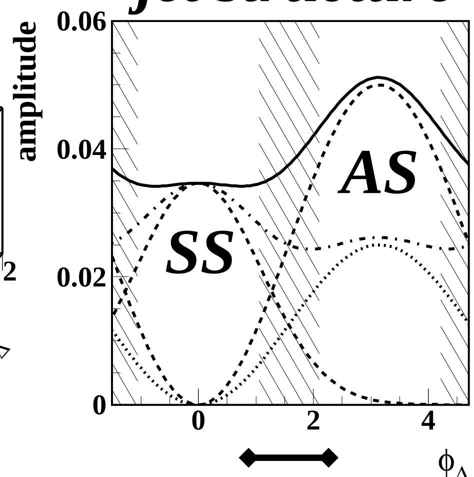
SC ***HC*** ***z axis linear***

MB jets provide a base for higher-energy dijets

2D fit model



jet structure



TR = “trans”

relative to MB jets:

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

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

Summary

- ***Define TCM for 1D T (trigger spectrum), 2D F = TA***
- ***<u>Hard components of F, A</u> → MB dijets***
- ***Distinguish single triggered dijets, secondaries = MPI***
- ***Quantitative link: TA vs FFs + pQCD jet spectrum***
- ***Establish kinematic lower bounds on MB dijets***
- ***TA data confirm trigger dijet contributes to azimuth TR***
- ***MB dijets make a <u>large</u> contribution to p-p, p-A, A-A***