Measurement of Mid-rapidity Inclusive Jet Cross Section in pp Collisions at $\sqrt{s} = 200$ GeV

Dmitry Kalinkin
For the STAR Collaboration

[1]Indiana University – Bloomington

[2]Brookhaven National Laboratory

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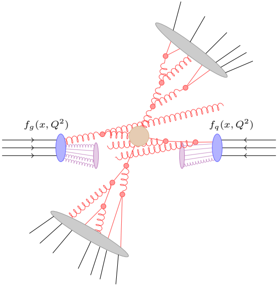
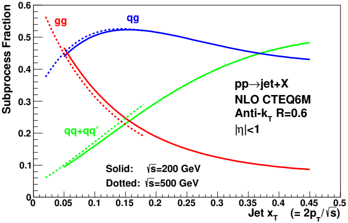
Proton Structure in Hard Interactions

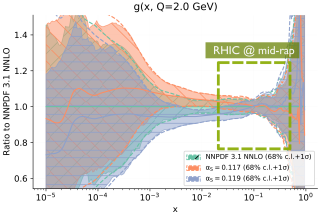


Jet production in high energy collisions of hadrons can be described in terms of following ingredients:

- *Initial state of hadrons*
- *Hard collision of partons*
- *Parton Shower*
- *Underlying Event (UE)*
- *Hadronization*

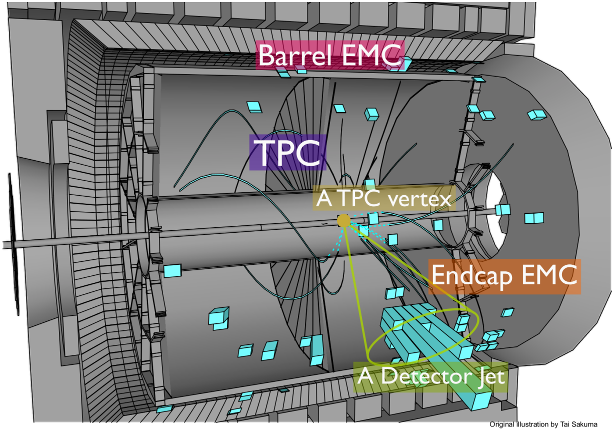
$$d\sigma_{pp\to jet+X}(Q^2) = \sum_{a,b} \int \underbrace{f_a(x_1, Q^2) f_b(x_2, Q^2)}_{\text{proton structure}} \underbrace{d\hat{\sigma}_{a+b\to jet+X}(x_1, x_2, Q^2)}_{\text{hard process+PS+Had.}} dx_1 dx_2$$





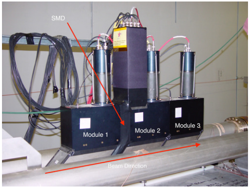
Original plot from NNPDF 3.1 Catalog of plots: α_S variations at NNLO

Jet Measurements using STAR Detector

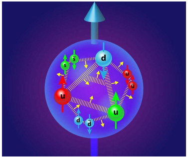


Original illustration by Tai Sakuma

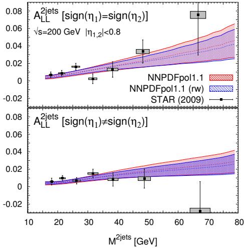
- **TPC**: Interaction vertex and charged particle tracks
- **BEMC** and **EEMC**: Photon energy measurement
- **Trigger condition** on deposited EM energy sum in 1×1 patches in $\eta - \phi$
- East and west **Zero Degree Calorimeter**: Absolute luminosity monitoring



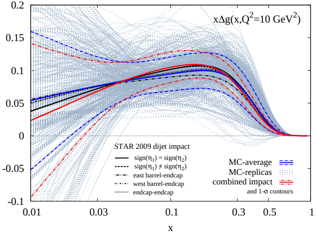
Gluon Polarization using Jets at STAR



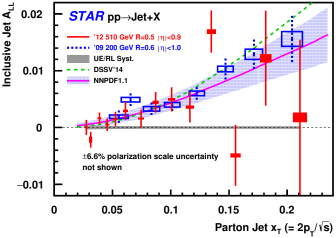
- Measurements using a similar collinear factorization framework $A_{LL} \sim \Delta f_a \otimes \Delta f_b \otimes \Delta\hat{\sigma}$ to determine Δg the helicity distribution of gluons inside the proton
- Detector effects are not unfolded but corrected by adjusting p_T (or M_{jj}) and A_{LL} of independent points
- Run 12 mid-rapidity inclusive jet and di-jet A_{LL} results recently published [PRD 100 (2019) 052005]
- Run 13 and Run 15 publications coming soon



E. R. Nocera at Transversity 2017

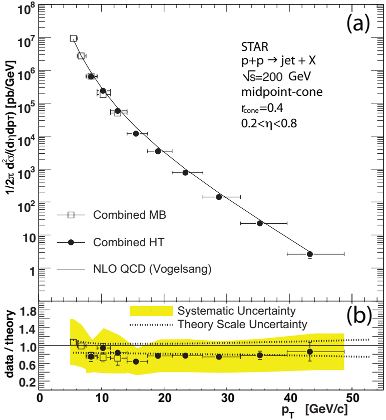


de Florian et al., PRD 100 (2019) 114027

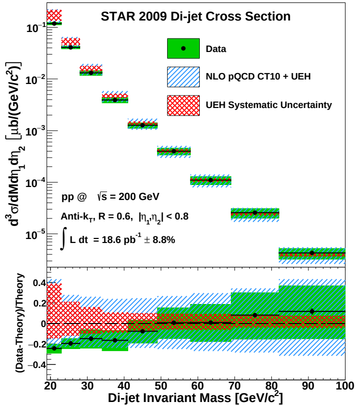


STAR Collaboration, PRD 100 (2019) 052005

Published Jet Cross Sections from STAR



Phys. Rev. Lett. 97 (2006) 252001



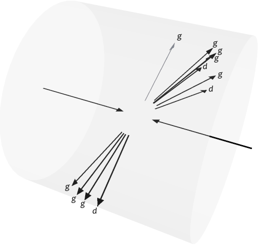
Phys Rev D 95 (2017) 071103

- An inclusive jet cross section
- Mid-point cone algorithm
- Not corrected for UE or hadronization
- Bin-by-bin detector effects correction
- Limited acceptance

- A di-jet cross section
- anti-k_T algorithm
- Detector effects unfolded
- No data-driven UE correction

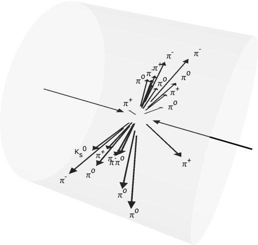
Jets at Three Levels

Parton jets



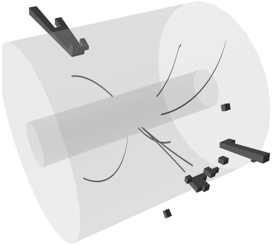
- Made of partons outgoing from the hard interaction
- Definition flexible depending on theoretical needs (e.g. fit using pQCD)

Particle jets



- Made of stable particles (at STAR the π^0 treated as stable)
- Universal – Free from all detector effects
- Includes effects of
  - QCD radiation
  - Hadronization
  - UE (unless subtracted)

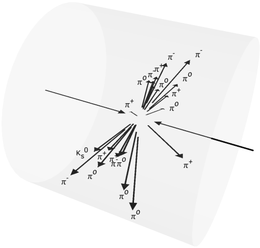
Detector jets



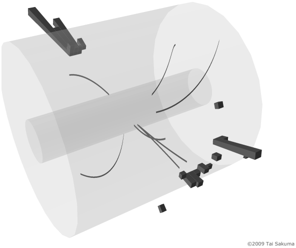
- Made of tracks and discrete calorimeter towers
- Experiment specific

Detector Effects Unfolding

Particle jets

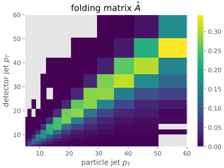


Detector jets



Simulation with Pythia 6 and GEANT3

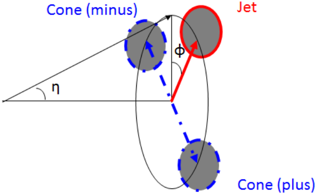
Unfolding of p_T spectrum by inverting the detector response matrix:



- Matrix inversion gives the exact result for the maximum likelihood estimator
- Statistical fluctuations are regularized by choosing sufficiently large bin sizes
- Need to estimate uncertainty due to the choice of prior (in this case, Pythia)

Underlying Event Correction

- Two off-axis cone regions defined as $(\varphi - \varphi_{\text{jet}} \pm \pi/2)^2 + (\eta - \eta_{\text{jet}})^2 \leq {R_{\text{UE}}}^2$ with $R_{\text{UE}} = 0.5$

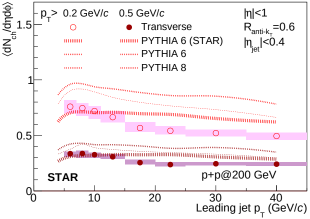


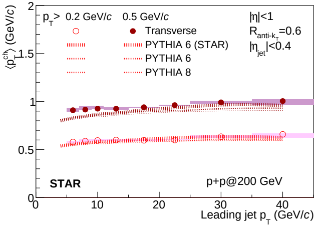
- For each jet calculate a jet area A and a p_T-density of constituents ρ_{UE}
- Correction implemented via a jet p_T shift:

$$\text{jet } p_T \to \text{jet } p_T - A \cdot \rho_{\text{UE}}$$

- Applied to data before unfolding and to simulation in definition of the detector response

Charged UE measured at STAR:

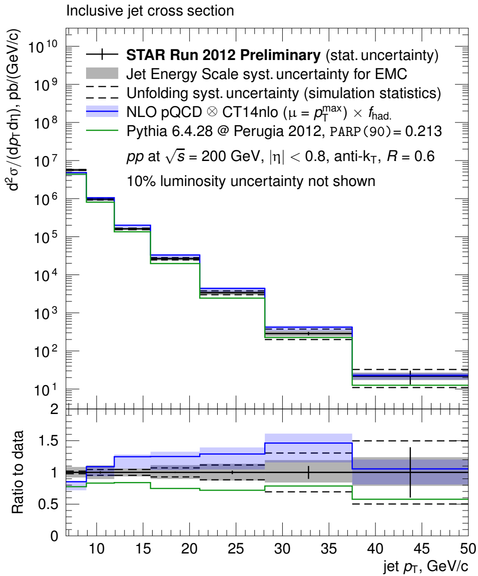




Phys Rev D 101 (2020) 052004

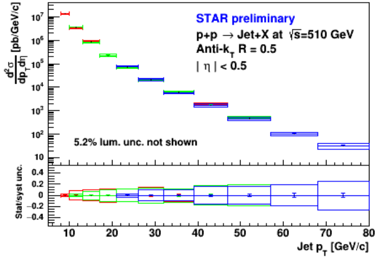
A different set of regions defined as $|\varphi - \varphi_{\text{jet}} \pm \pi/2| < \pi/6$

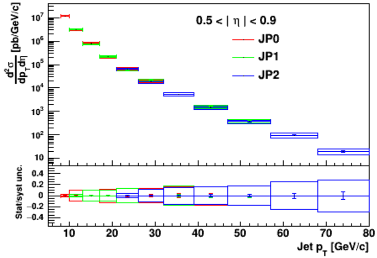
Inclusive Jet Cross Section at $\sqrt{s} = 200$ GeV, Particle Level



- **New preliminary result!**
- $0.067 < x_T = \frac{2p_T}{\sqrt{s}} < 0.5$
- Simulation sample statistics limits unfolding in finer binning
  – **to be improved for final results**
- Jet Energy Scale uncertainty from the EM calorimeter response
  – **leading inherent uncertainty**

Inclusive Jet Cross Section at $\sqrt{s} = 510$ GeV, Particle Level





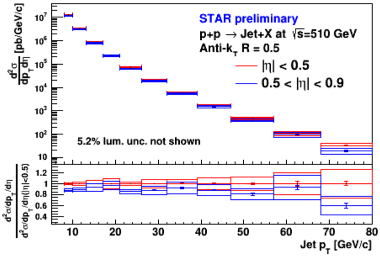
- $0.021 < x_T = \frac{2p_T}{\sqrt{s}} < 0.32$

Different triggers:

- JP0: $E \geq 5.4$ GeV
- JP1: $E \geq 7.3$ GeV
- JP2: $E \geq 14.4$ GeV

Measured in two η-ranges:

- $0 < |\eta| < 0.5$
- $0.5 < |\eta| < 0.9$



Conclusions

- Jet measurements at STAR are extended to the unpolarized case, now with new result for pp at $\sqrt{s} = 200$ GeV
- Inclusive jet measurements at RHIC will allow to better constrain high-x behaviour of the gluon PDF
- …and serve as a normalization for other possible measurements like measurement of hadron fragmentation inside jets
$$\left(\frac{d^2\sigma}{dp_{T;\mathrm{jet}}dz_h}\right) / \left(\frac{d\sigma}{dp_{T;\mathrm{jet}}}\right)$$
- Measurements at two values of $\sqrt{s}$, at 200 GeV and 510 GeV, provide insights into energy dependence of various MC tune parameters