Jet-like azimuthal correlations in p+p and p+A collisions at forward rapidity with STAR

Mriganka M. Mondal (*for the STAR Collaboration*)

Institute of Physics, Bhubaneswar, India

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Abstract

At very low Bjorken x, parton densities in a nucleon/nucleus reach a point where the gluon density is expected to transit to a saturation regime. The saturation scale (Q_s) is defined as the inverse of typical transverse inter-partonic distance and can be expressed as $Q_s \sim (A/x)^{1/3}$. So far no clear experimental observation of the onset of gluon saturation has been made. Observables at forward rapidity at STAR probe gluons at very small x (.001< x <.005) in heavy nuclei where parton saturation is expected. Scanning the azimuthal correlations of jets as a function of rapidity and transverse momentum has the potential to yield critical insight into gluon saturation. During the 2015 RHIC run, STAR recorded data in p+p, p+Al and p+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, with mid-rapidity calorimeters and the Forward Meson Spectrometer (FMS), which cover a wide acceptance of -1.0 to 2.0 and 2.5 to 4.0, respectively, in pseudorapidity over the full azimuth. The status of determining jet-like azimuthal correlations from these data sets is reported.

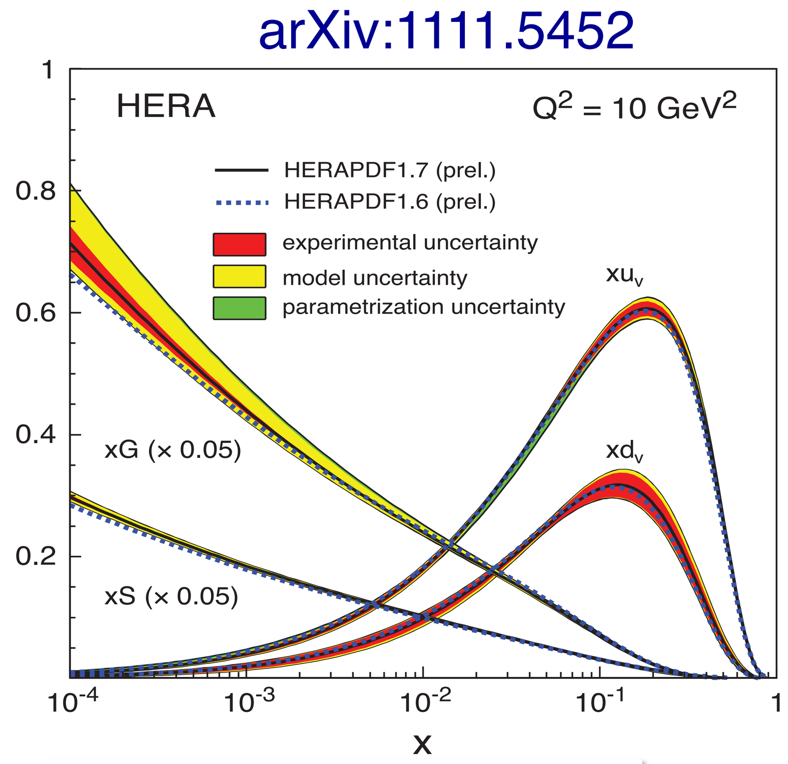
Gluon Saturation

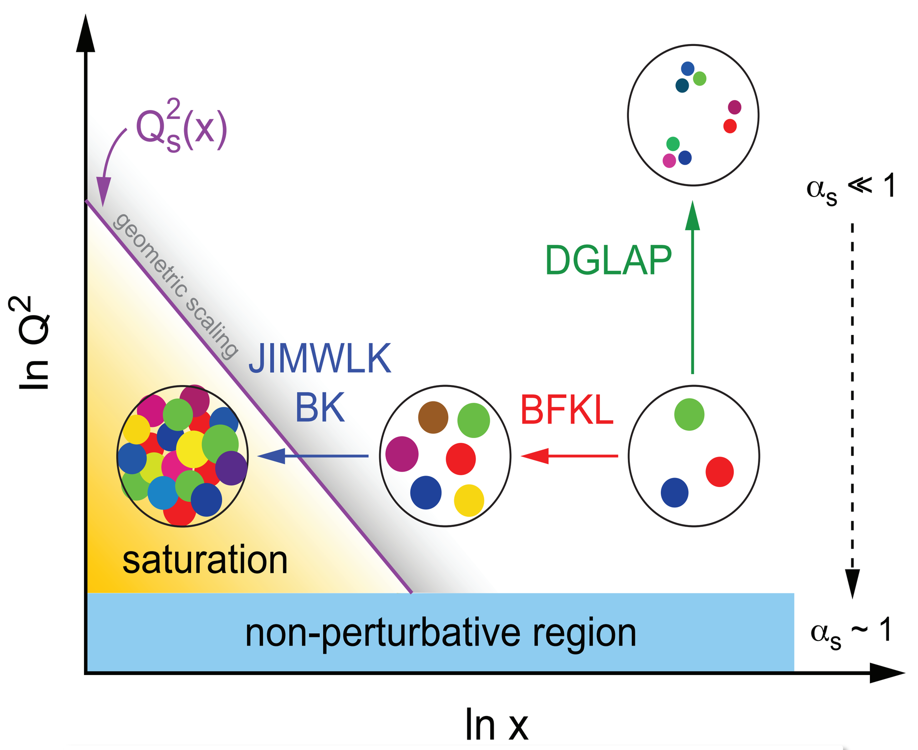
- Densities of gluons and sea quarks are **high at low x.**
- Parton density evolution is linear (BFKL) at low parton density.
- As density grows, gluons start to recombine and the evolution become nonlinear, leading to the **saturation of parton density,** called **C**olor **G**lass **C**ondensate.

Expect to see at RHIC?

small x (.001< x <.005) at STAR

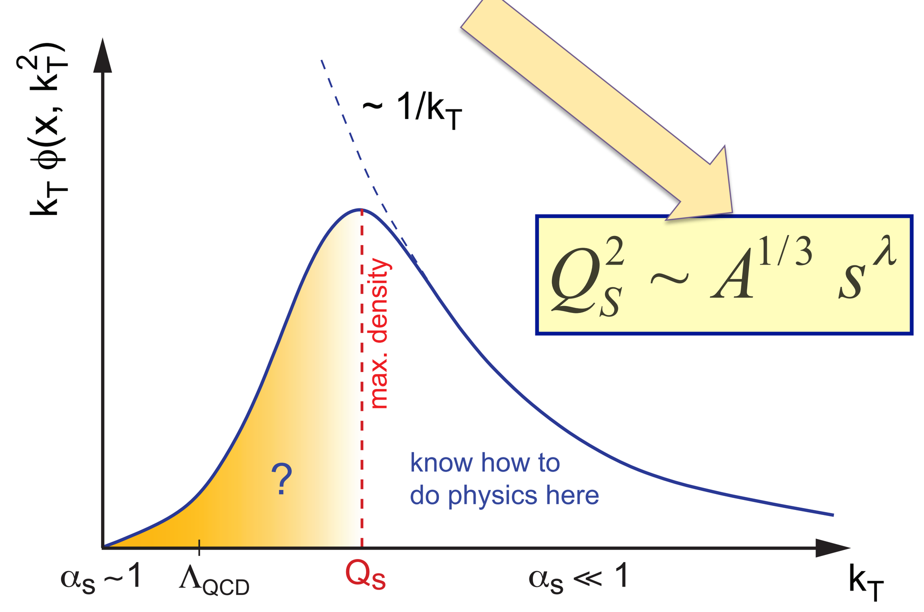
arXiv:1111.5452





forward rapidity <---- midrapidity

p+Au at √s = 200GeV



$$Q_S^2 \sim A^{1/3}\, s^{\lambda}$$

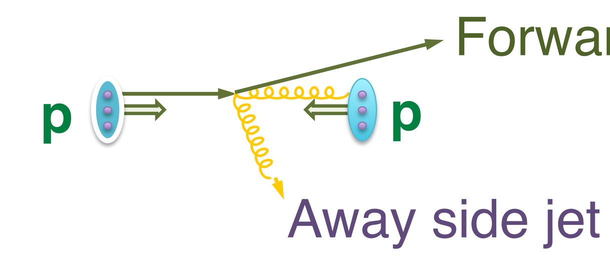
Gluon "size" = 1/transverse momentum = $1/Q_s$

Low x → forward rapidity

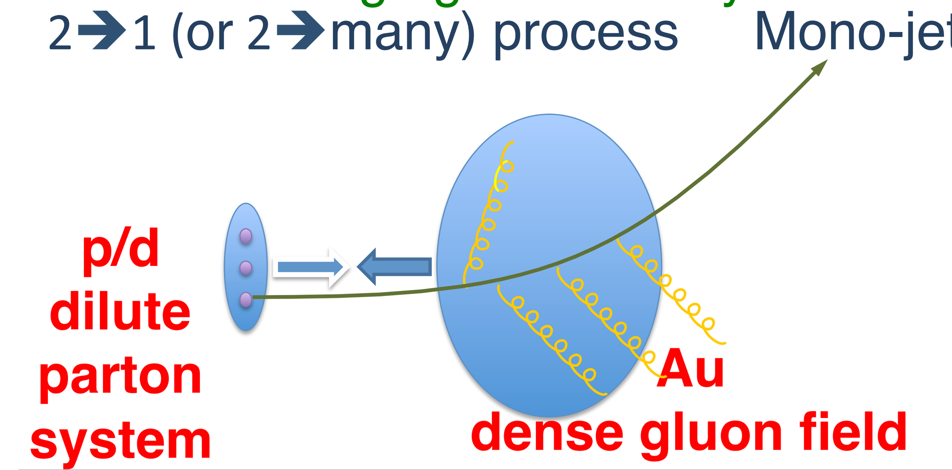
$$x \sim \frac{2p_T}{\sqrt{s}} e^{-y}$$

- The saturation region may be reachable **at forward rapidity** in p+A collisions at RHIC
- Scan in p_T, rapidity and nucleus size (A) may allow to cross saturation scale $Q^2_s(x)$

Azimuthal Correlations

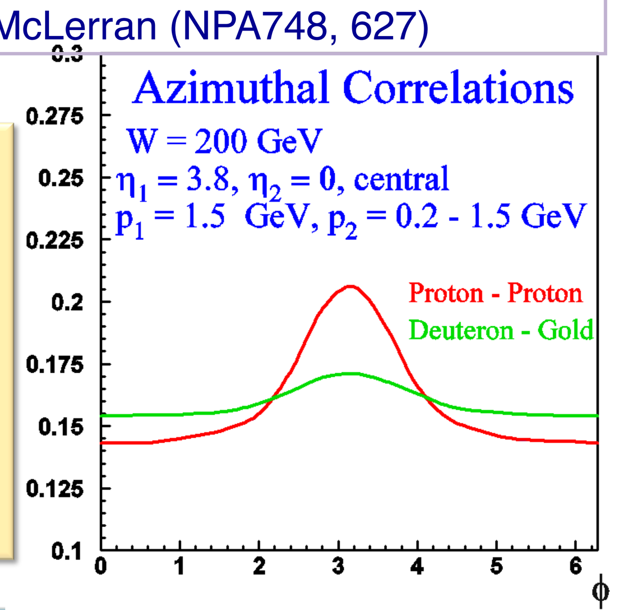


With high gluon density
2→1 (or 2→many) process Mono-jet

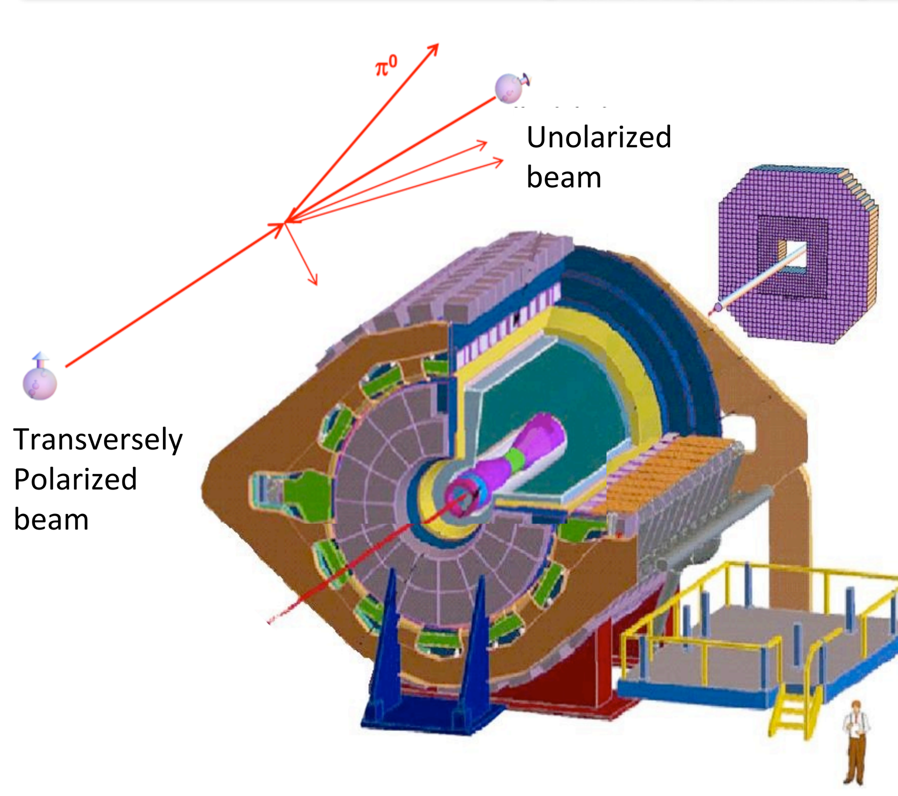


Kharzeev, Levin, McLerran (NPA748, 627)

Jets : access hard scattered paton kinematic, minimize hadronization influence



STAR at RHIC



Forward Meson Spectrometer (FMS)

Midrapidity calorimeters : BEMC : η (-1.0, 1.0) & EEMC : η (1.0, 2.0)

FMS : η (2.5,4.0), π⁰/η -->γγ, direct photons, Drell-Yan

Pre-shower detector installed in 2015

Post-shower detector installed in 2017

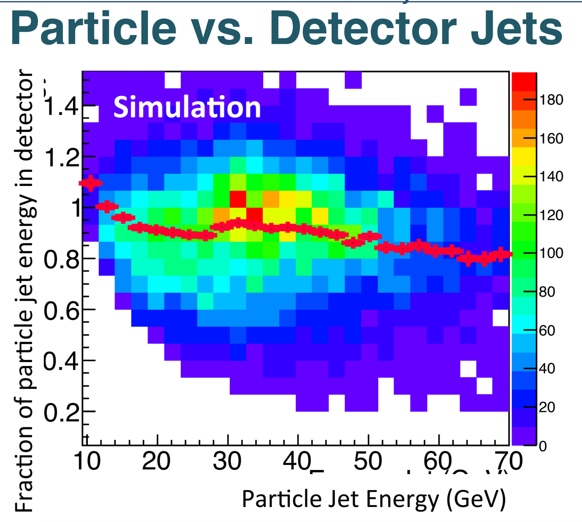
Jet Recontruction

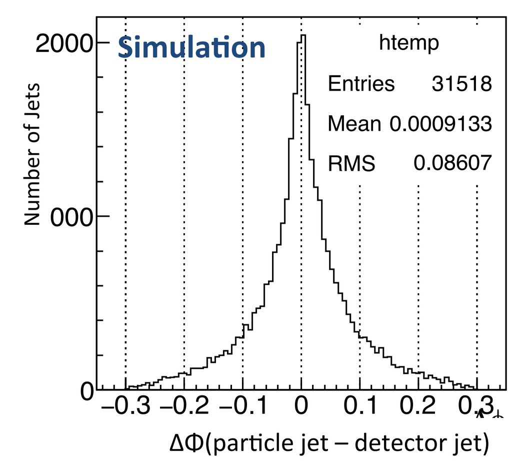
Jets reconstruction (**"FastJet"** package): Forward jets : reconstructed photons (photon candidates) from FMS; Midrapidity jets : towers in BEMC and EEMC; Anti-kt : R = 0.6 for FMS and R=0.5 for B/EEMC; Off-Axis cone radius = 0.5

- Underlying event contributions in jets for p+p in STAR is well studied
- For p+Au collisions the underlying event background is expected to be larger.
- Off-axis cone correction done for p+p and p+Au

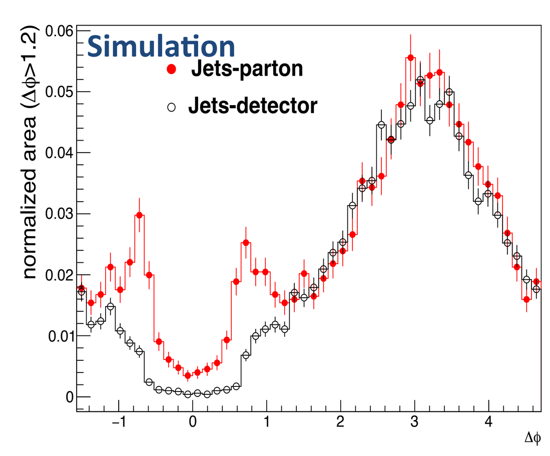
Off-axis correction : Jet p_T correction from p_T density calculated for fixed cone at the same η and Δϕ =π/2 away from ϕ_{jet}

Particle vs. Detector Jets comparisons - PYTHIA





Jet-like Δϕ correlations (parton vs. detector)



PYTHIA events after GEANT simulation of STAR: Good performance for forward jet-jet correlations!

- Jets from FMS (mostly electromagnetic) retain the directional information significantly
- With FMS triggers : Detector Jets retain substantial fraction of jet energies

Current Status for 2015 STAR data

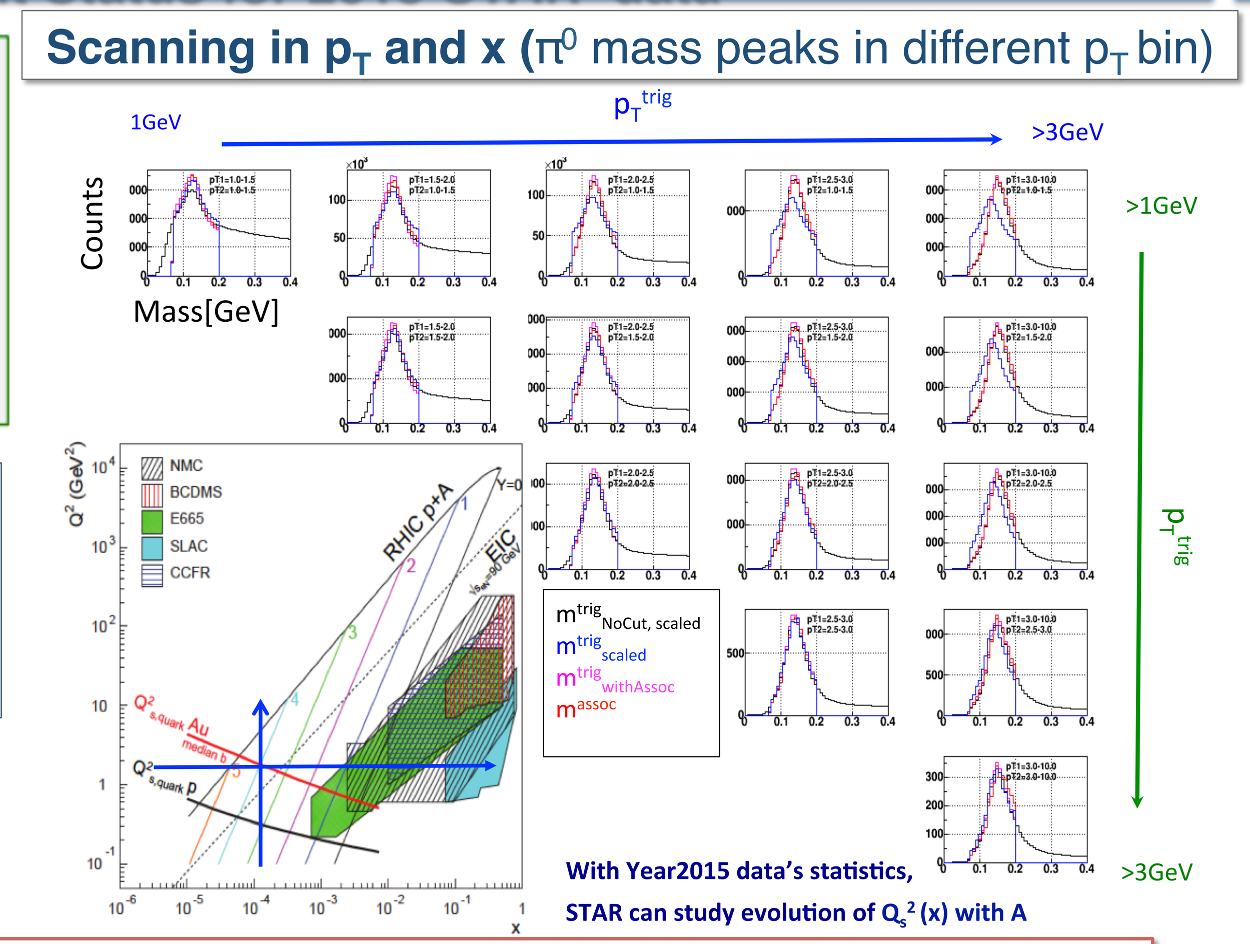
RHIC 2015

- $\vec{p}+p, L_{int} = 40+50\ \mathrm{pb}^{-1}$
- $\vec{p}+Al, L_{int} = 1.0\ \mathrm{pb}^{-1}$
- $\vec{p}+Au, L_{int} = 0.45\ \mathrm{pb}^{-1}$

STAR year 2015 data being analyzed for π⁰-π⁰ and EM jet-EM jet correlation p+p, p+Al, p+Au (d+Au in 2016)

Working on FMS gain uniformity

Scanning in p_T and x (π⁰ mass peaks in different p_T bin)



Akio Ogawa: QM2017 : https://indico.cern.ch/event/433345/contributions/2358413/

RHIC Cold QCD Plan and STAR forward Upgrade

Upgrades Completed

2015

- ❑FMS-Preshower
- ❑RP Phase-II*

Run:

- ❑p+p 200 GeV longitudinal & transverse
- ❑p↑ +Au/Al 200 GeV transverse

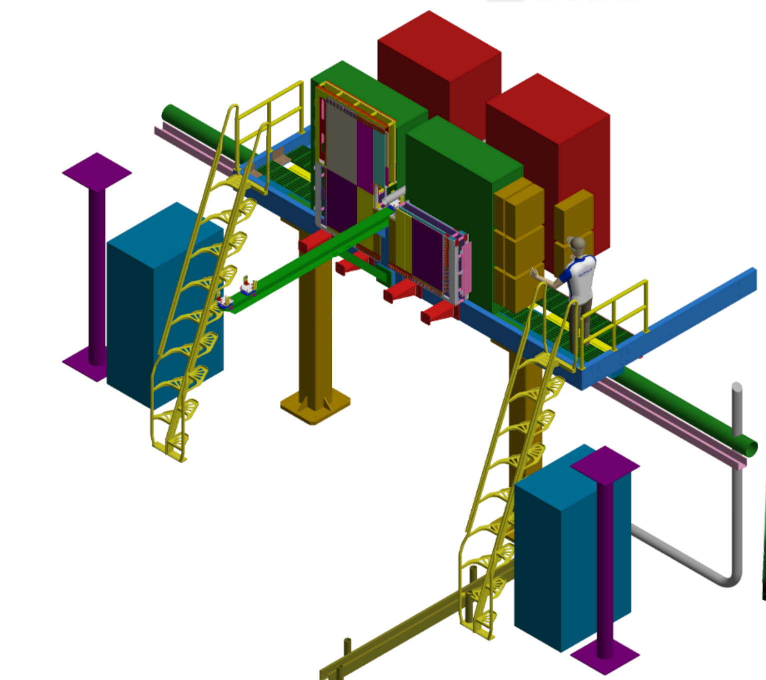
2017

- ❑FMS-Postshower

Run:

- ❑p+p 510 GeV transverse

≧2021



2.5<η<4.0 tracking+EM calorimeter (PHENIX PbSc) + Hadronic calometer

arXiv:1602.03922 [nucl-ex]