Di-hadron correlations in pp and pA collisions at STAR

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On behalf of STAR Collaboration

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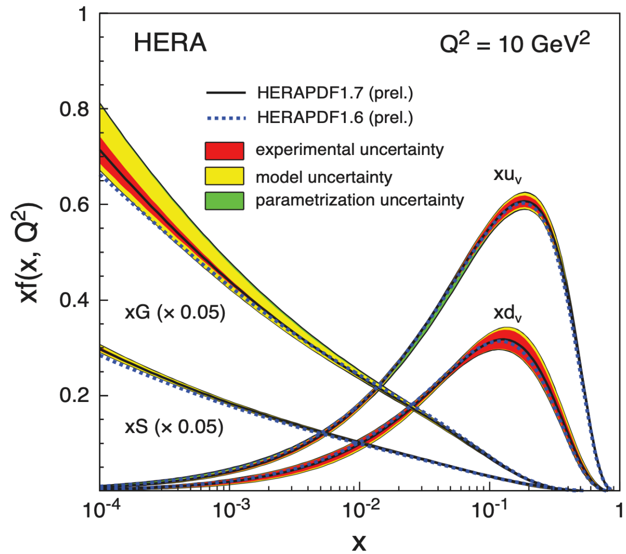
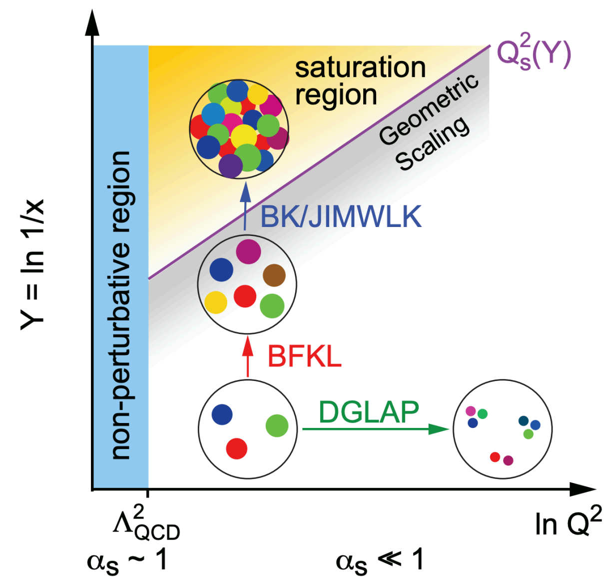
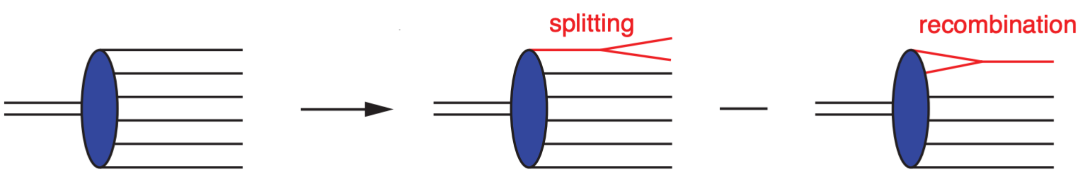
Gluon dynamics at small x

- **P**arton **D**istribution **F**unctions: at small x, the wave function of nucleons is dominated by gluons and gluon density has to be saturated at some point.
- Saturation scale Q_S^2: when $Q^2 << Q_S^2$, gluons start to recombine.
- Gluon dynamics transfer from linear to non-linear: DGLAP/BFKL → BK/JIMWLK.
- Large Q_s: small α_s → perturbative QCD calculations under control.

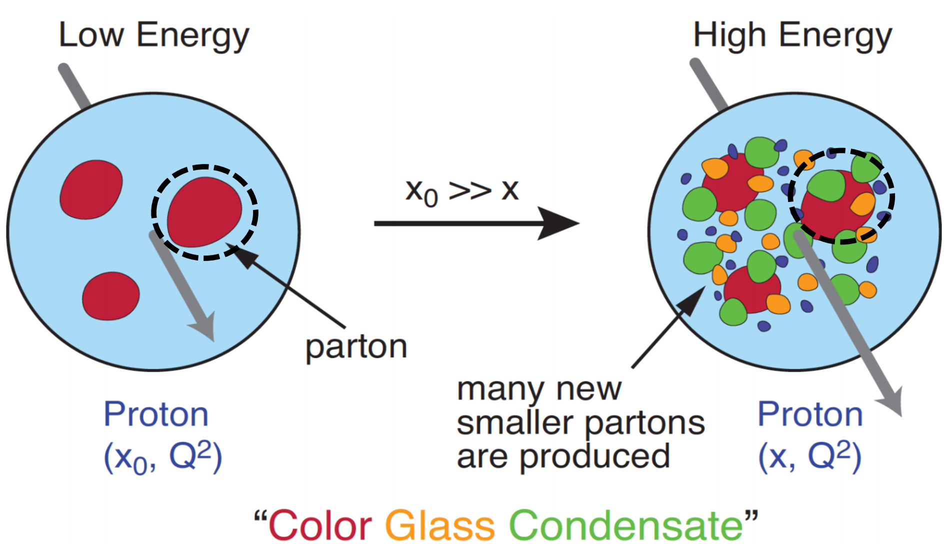


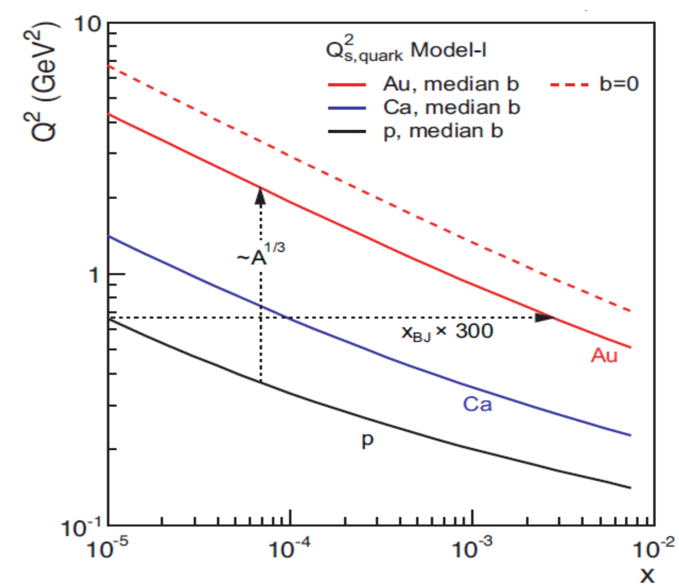




Saturation scale Q_s^2 : x and A dependence

- Parton transverse size decreases as the atomic number A increases and gets smaller at low-x.
- Saturation scale Q_S^2: the inverse of parton transverse size, it grows with A and decreases with x.

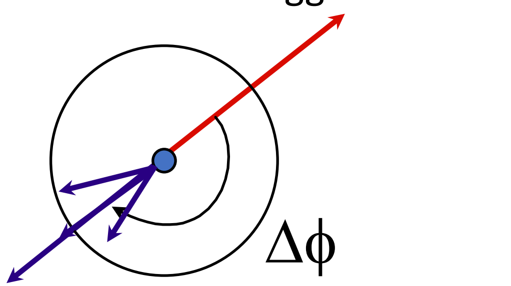




$$Q_s^2(x) \sim A^{1/3}\left(\frac{1}{x}\right)^{\lambda} \sim \left(\frac{A}{x}\right)^{1/3}$$

Di-hadron correlations

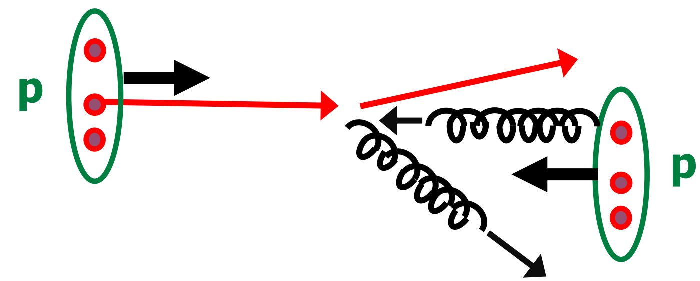
beam-view



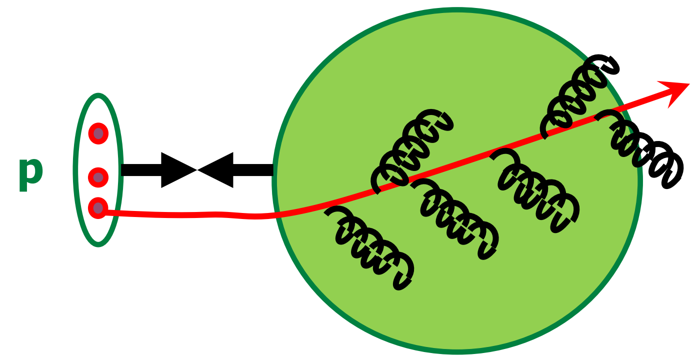
$$C(\Delta\phi) = \frac{N_{pair}(\Delta\phi)}{N_{trig} \times \Delta\phi}$$

- **Why forward**: two final state particles at forward rapidity provide access to small x regime.
- **Method**: measure the azimuthal correlation between two final hadrons in pp and pA.
- **pp**: 2→2 process ⇒ back-to-back di-hadron.
- **pA**: back-to-back configuration is smeared by multiple gluon interactions.

side-view



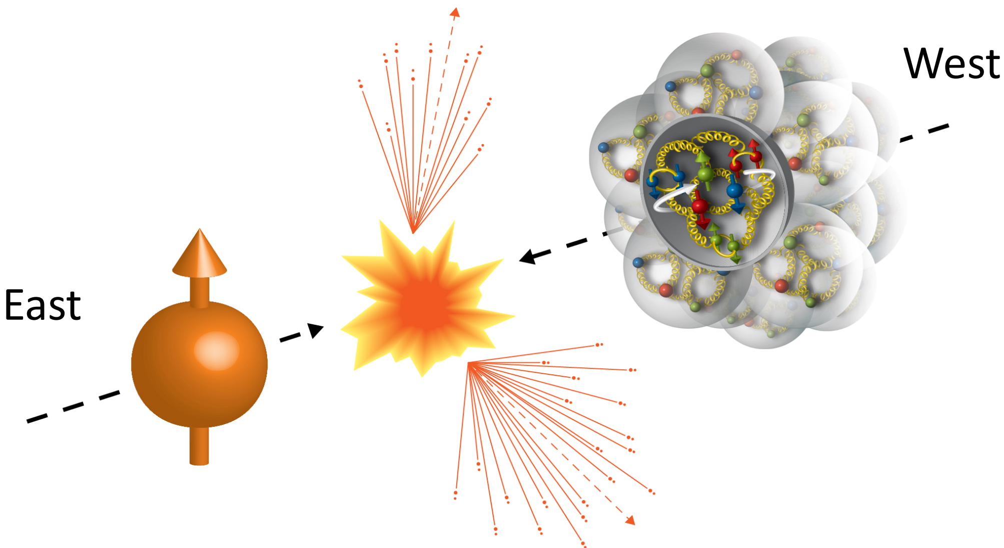
Dense gluon field (Au)

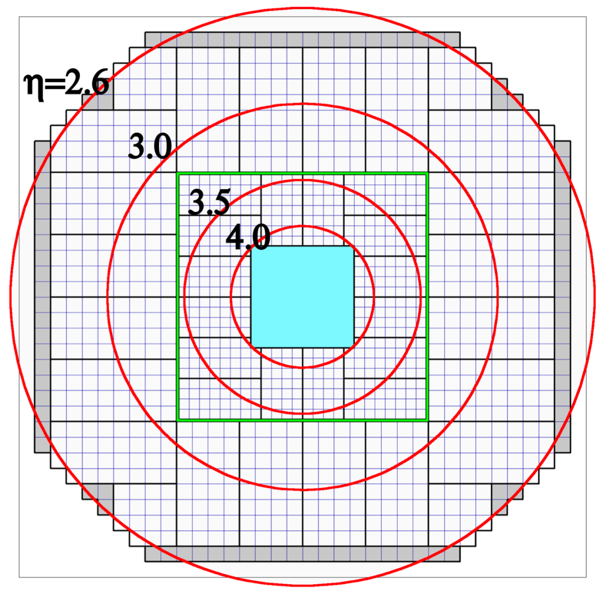


P_T is balanced by many gluons

$$x_A = \frac{p_{T1}e^{-y_1} + p_{T2}e^{-y_2}}{\sqrt{s}} \ll 1$$

STAR forward detector



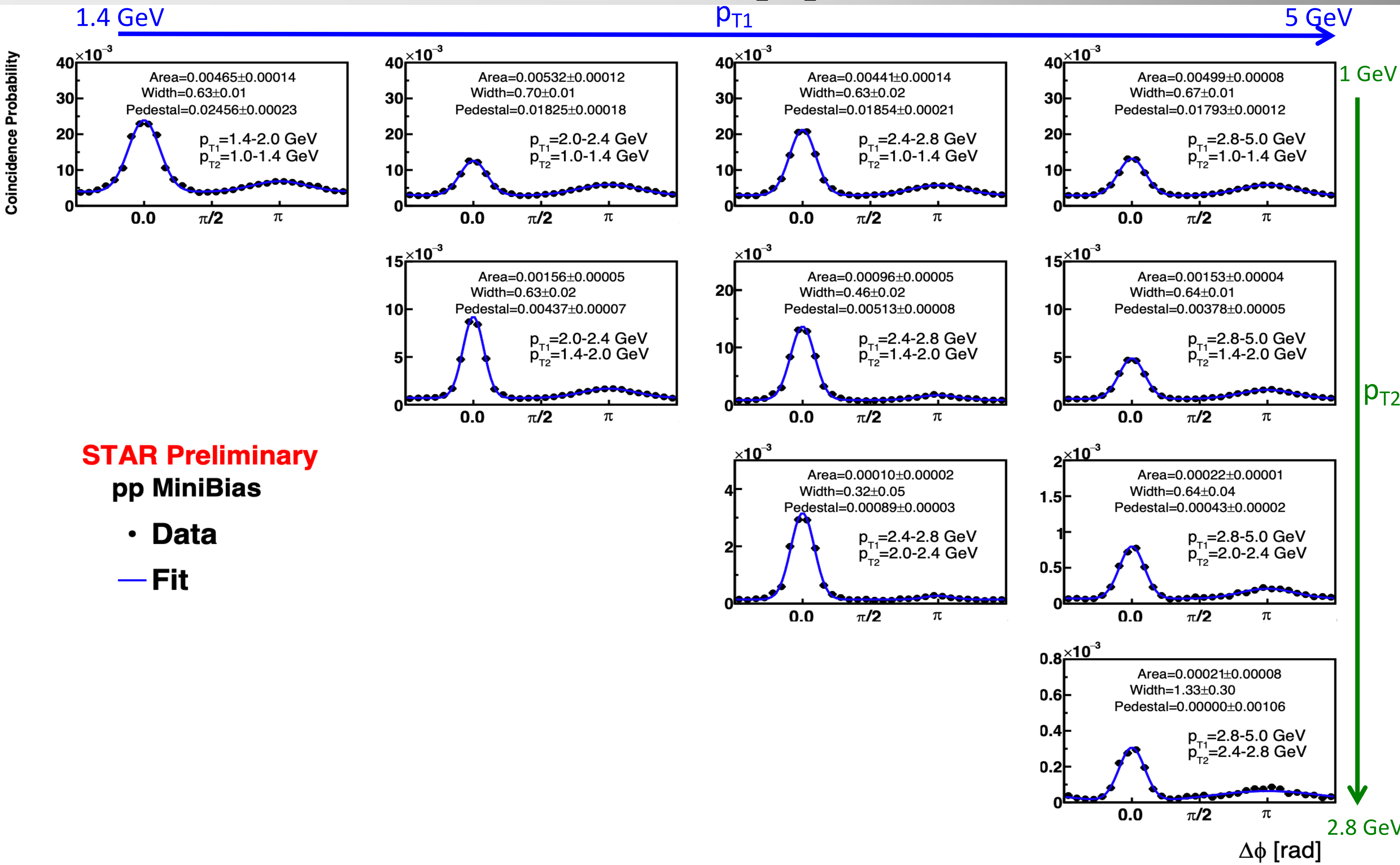


p+p and p+A collisions at $\sqrt{s_{NN}} = 200$ GeV

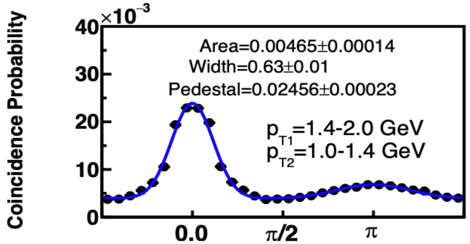
- Au, Al beams → A dependence
- Forward rapidity hadron production
  - can access low-x gluons
  - with high-x quark probe

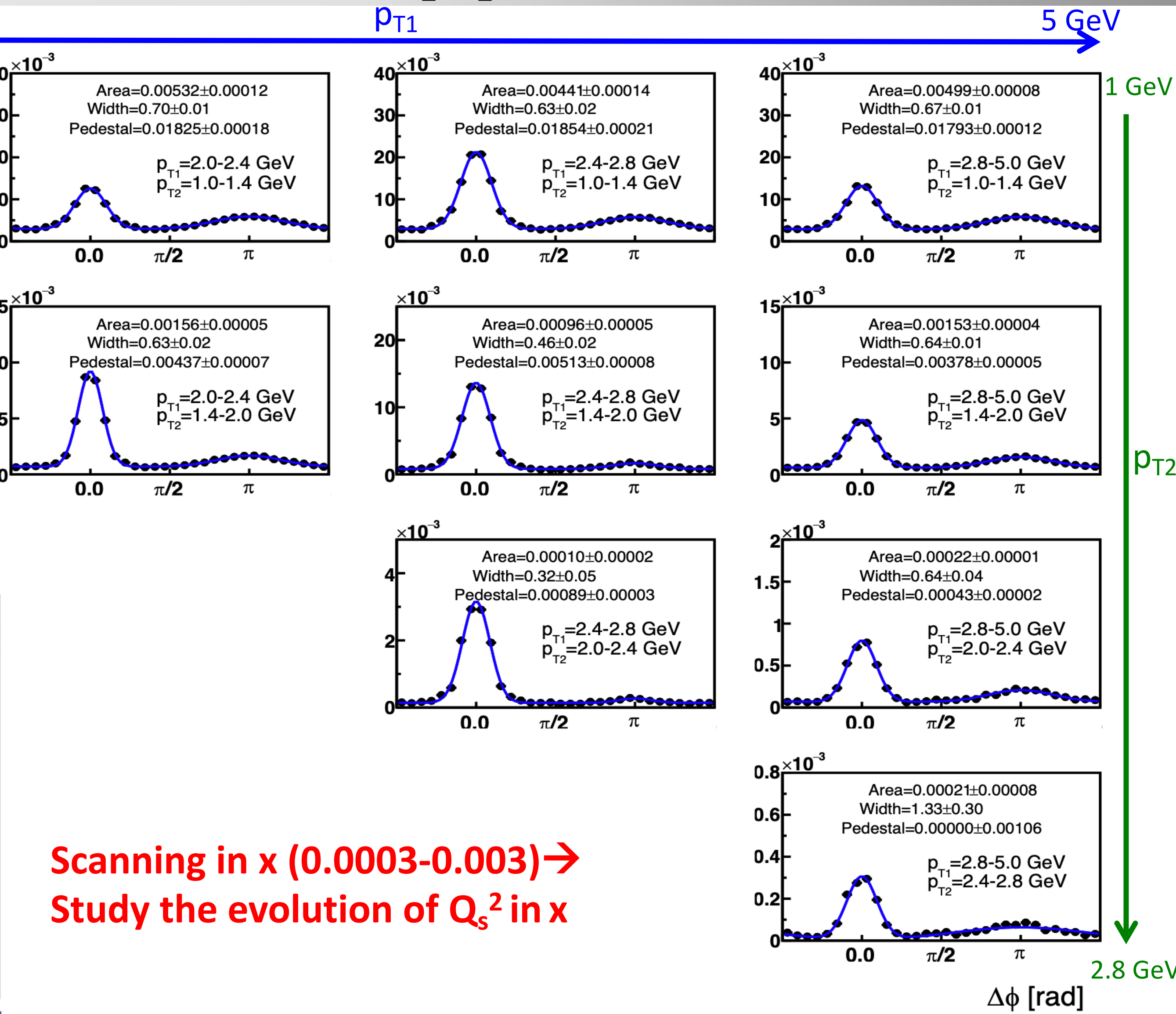
- The high energy photons form shower at FMS, can be reconstructed: cluster finding, shower shape fitting
- π^0 decays into two photons, is constructed from a pair of photon candidates

Di-π^0 correlations in pp



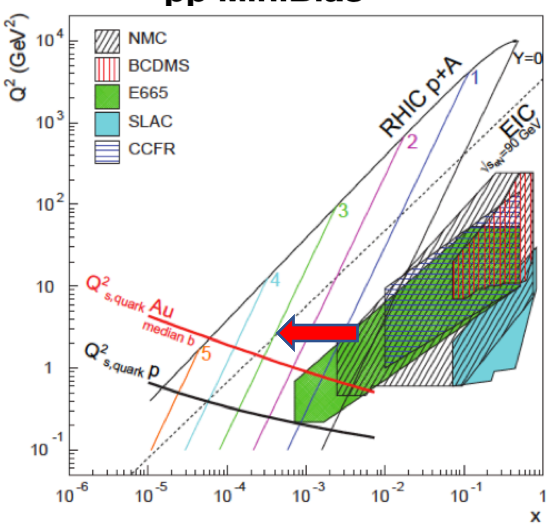
Di-π^0 correlations in pp





STAR Preliminary

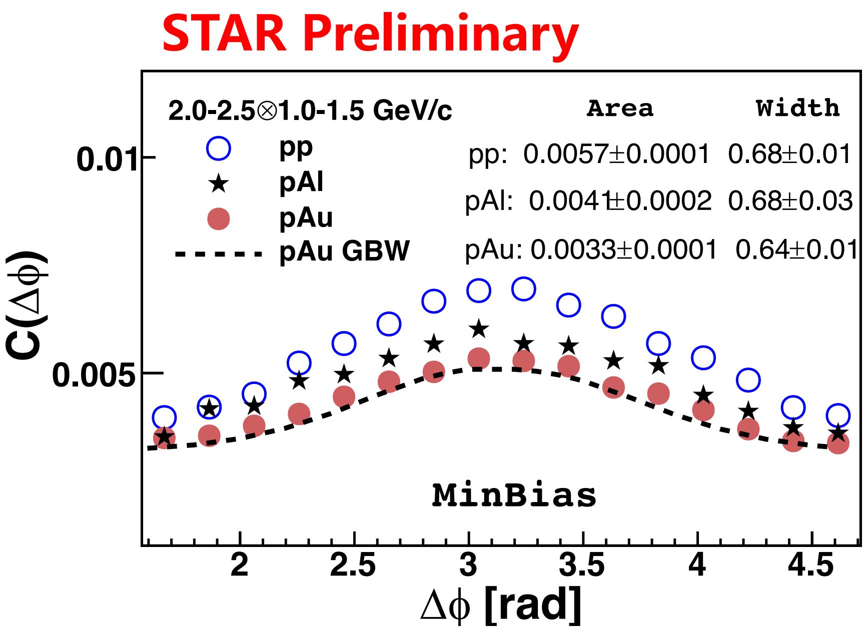
pp MiniBias

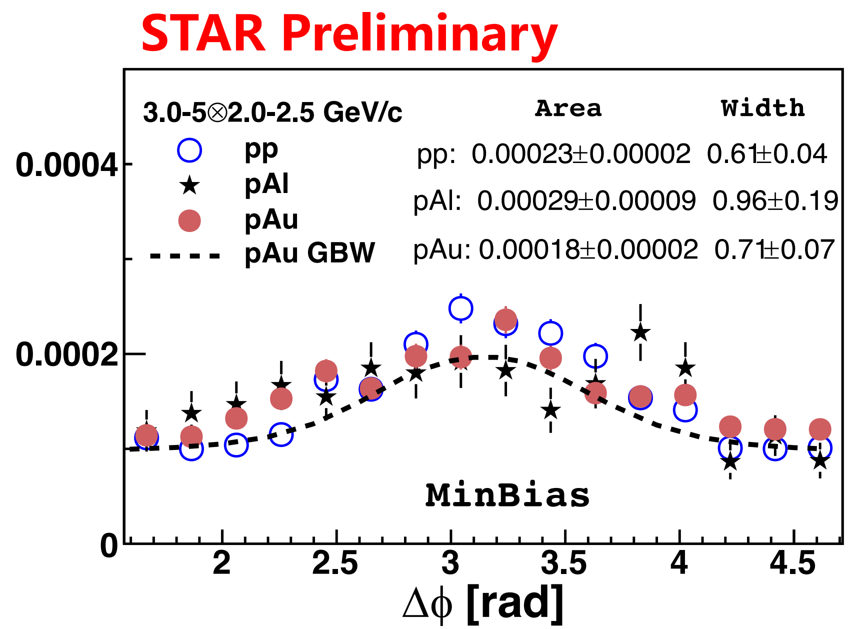


Scanning in x (0.0003-0.003)→

Study the evolution of Q_s^2 in x

Di-π^0 correlations in pp and pA



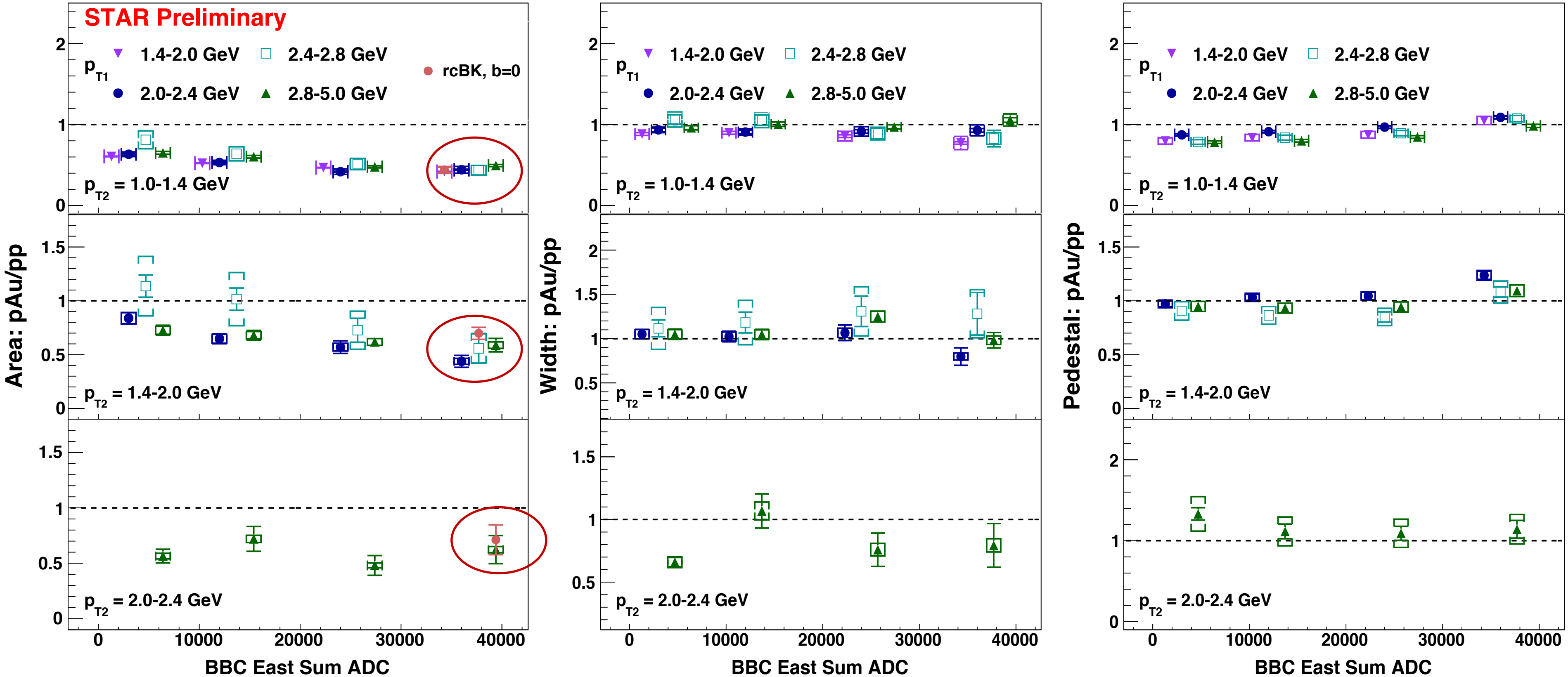


GBW: A. Stasto et al., Phys. Lett. B, 716(2012) 430-434

- A dependence: at low p_T range, more suppression is observed in pAu than pAl in comparison with the reference pp.
- x dependence: no suppression in pA at high p_T range (large x).

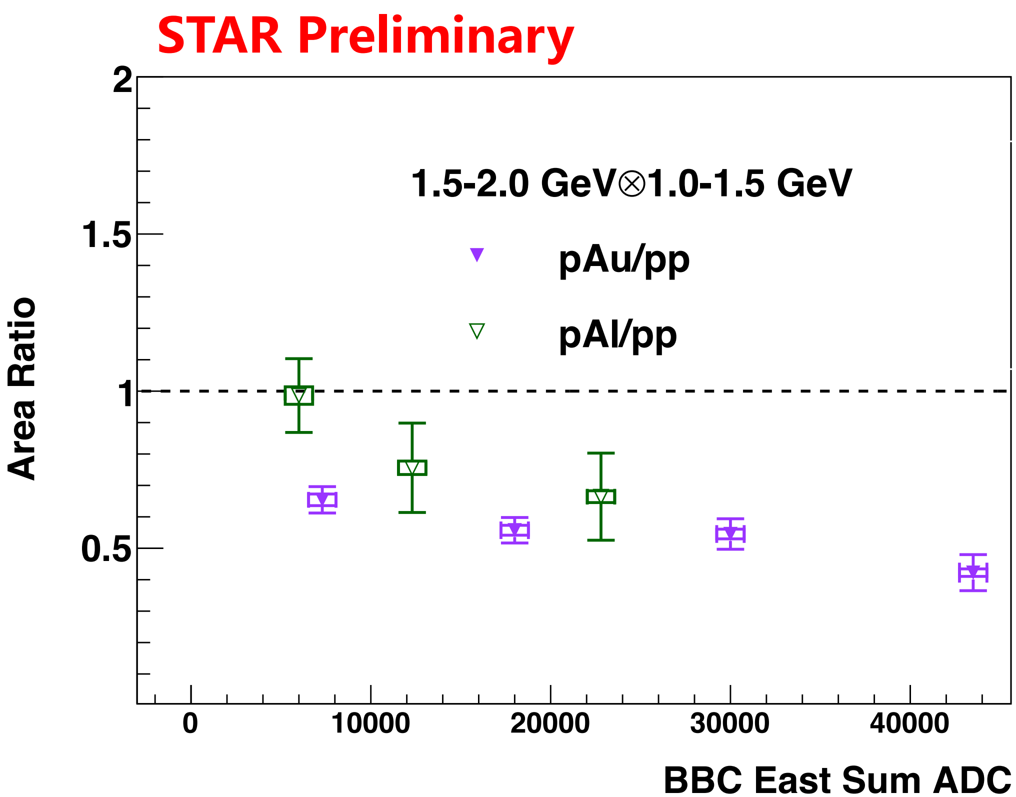
Event activity dependence in pAu

rcBK: Javier L. Albacete et al., Phys. Rev. D 99, 014002]



- Energy deposited at East Beam Beam Counter detector quantifies "event activity": at Au beam side, high energy refers to "high activity" events.
- Suppression is enhanced in "high activity" events.
- Width and pedestal are stable in pp and pAu.

Event activity dependence in pAl

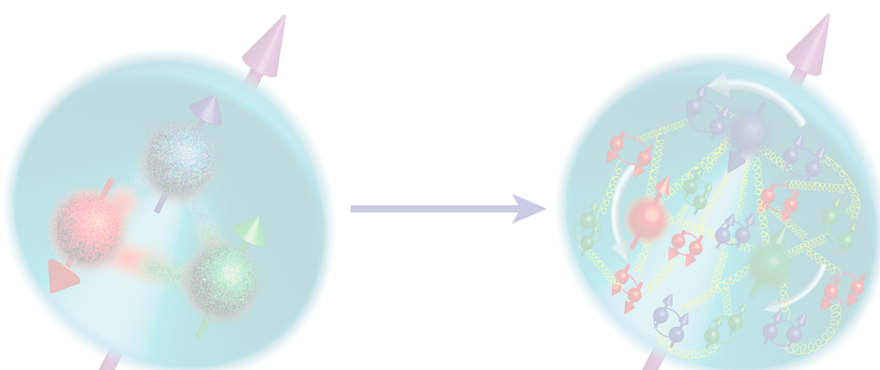


- Less suppression in pAl compared with pAu.
- pAu: suppression depends on BBCE and is enhanced in “high activity” events.
- pAl: indication of enhanced suppression in “high activity” events.

Summary

- The evidence of a novel universal regime of non-linear dynamics in nuclei is very important to help us understand QCD processes in Cold Nuclear Matter:
    - Understand the collective dynamics of gluons
    - Investigate inner landscape of nuclei: initial state input to eA/pA/AA

- Di-hadron correlation is a key measurement in the p+A physics program at STAR
    - A clear signature of non-linear gluon dynamics shown at STAR with di-hadron correlation measurement
    - First measurement of saturation scale dependence on A: more suppression in pAu than pAl
    - Event activity dependence: suppression enhanced in “high activity” collisions



Back up

Event activity

Energy deposited at BBC EAST (BBCE)
Nuclei beam goes to east

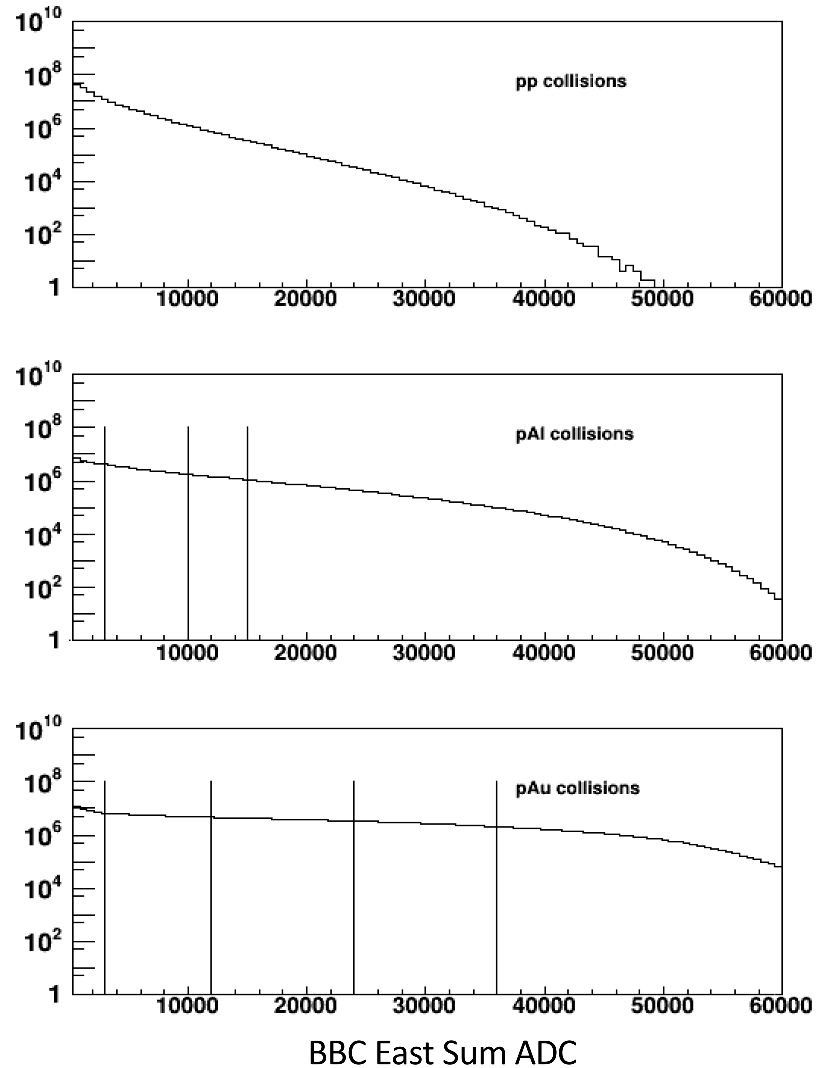
MinBias: No BBCE selection

Low activity pAl: 3000<BBCE<10000
High activity pAl: BBCE>15000

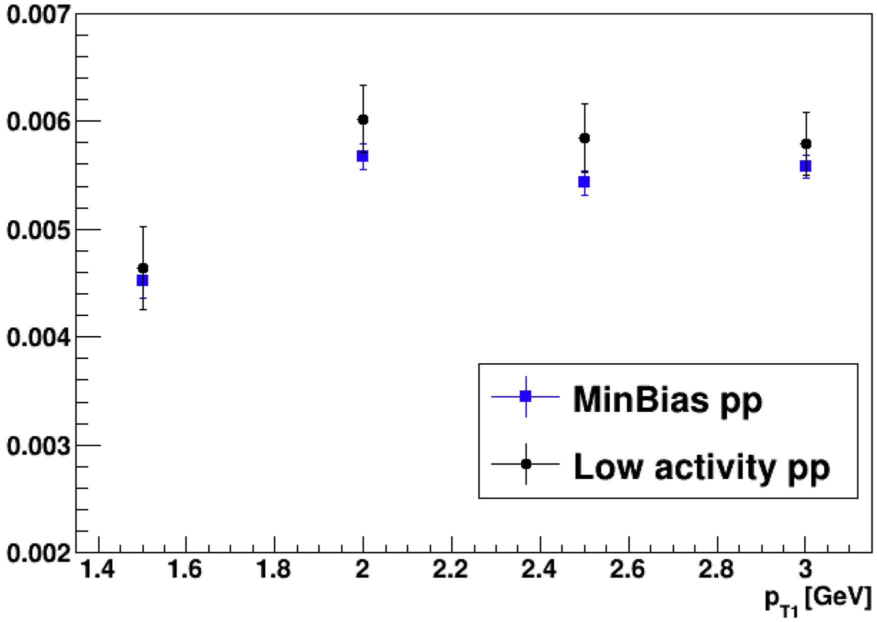
Low activity pAu: 3000<BBCE<12000
High activity pAu: BBCE>36000

What we did:
Correlations in MinBias in pp, pAl and pAu
Correlation in 3 BBCE bins in pAl, 4 BBCE bins in pAu

1. Compare MB pAu pAl with MB pp
2. Compare pAu pAl (from low to high) with MB pp



Event activity dependence in pp



Low Activity pp:3000<BBCE<6000

Area is not dependent on BBCE in pp.