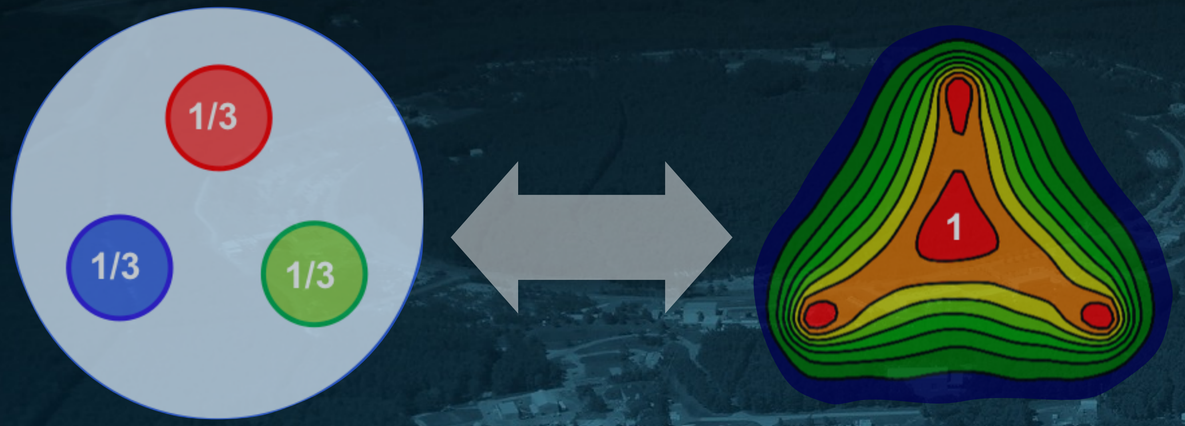


What carries the baryon quantum number ?

Prithwish Tribedy

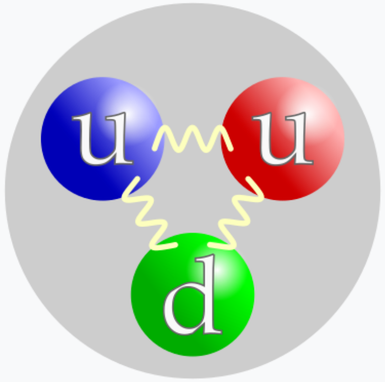
STAR group, Department of Physics

Early Career Scientist retreat (September 9, 2022)

Outline: What carries the baryon quantum number ?

https://en.wikipedia.org/wiki/Proton
https://en.wikipedia.org/wiki/Baryon

Proton



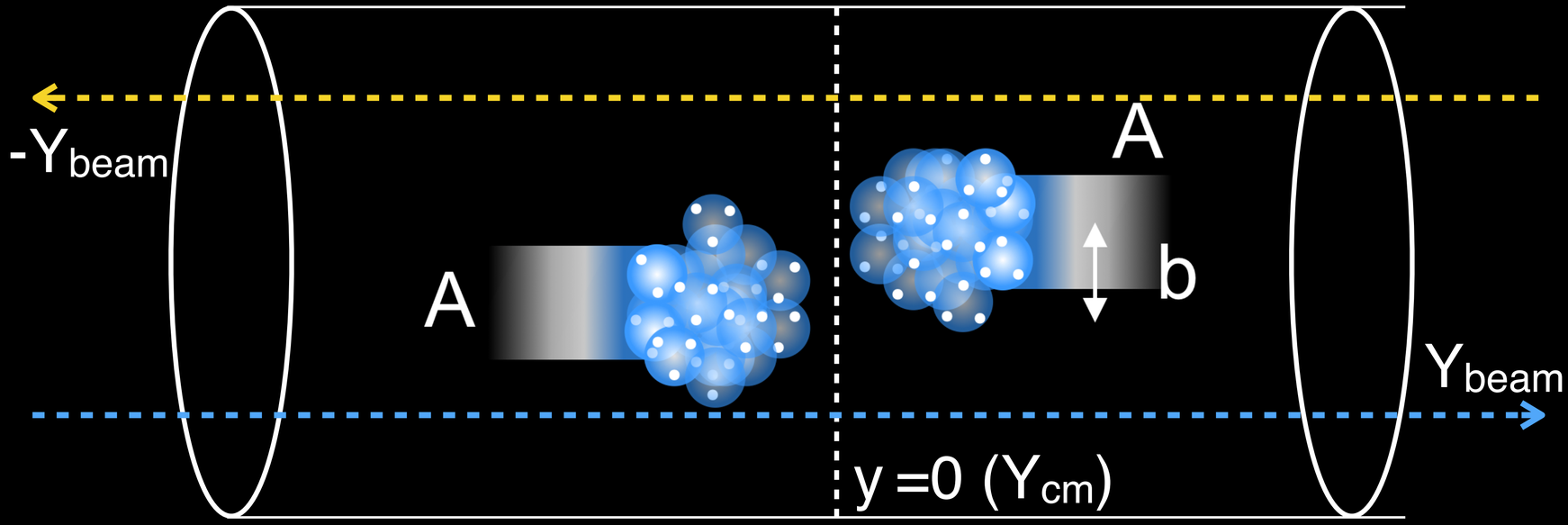
The quark content of a proton. The color assignment of individual quarks is arbitrary, but all three colors must be present. Forces between quarks are mediated by gluons.

Classification	Baryon
Composition	2 up quarks (u), 1 down quark (d)
Statistics	Fermionic
Family	Hadron
Interactions	Gravity, electromagnetic, weak, strong

Baryons, along with mesons, are hadrons, particles composed of quarks. Quarks have baryon numbers of $B = \frac{1}{3}$ and antiquarks have baryon numbers of $B = -\frac{1}{3}$. The term "baryon" usually refers to *triquarks*—baryons made of three quarks ($B = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1$).

Baryon number is a strictly conserved quantum number & assumed to be carried by the quarks but never proven

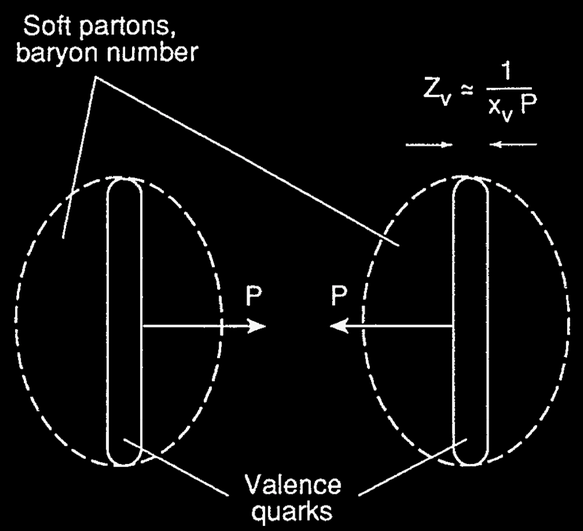
G.C. Rossi and G. Veneziano, Nucl. Phys.B123(1977) 507; Phys. Rep.63(1980) 149
Kharzeev, Phys. Lett. B, 378 (1996) 238-246

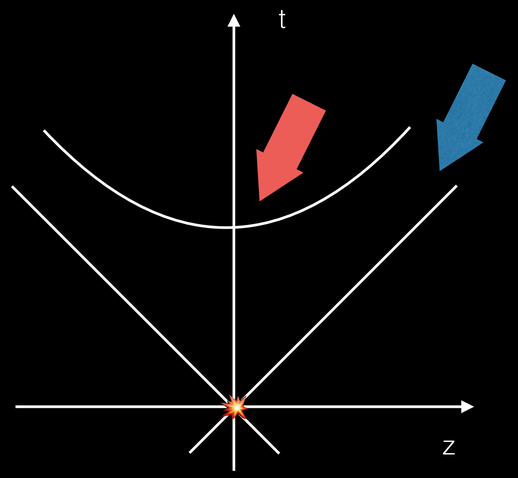


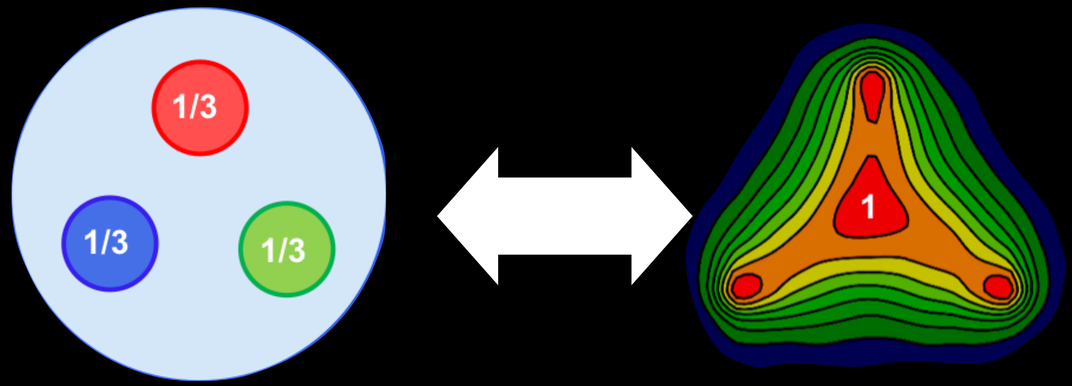
How is it stopped ? How (excess) baryons appear near the central rapidity ?

What carries the baryon number? How is it stopped ?

In the conventional picture valence quarks carry it but this has been never proven



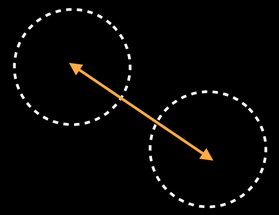




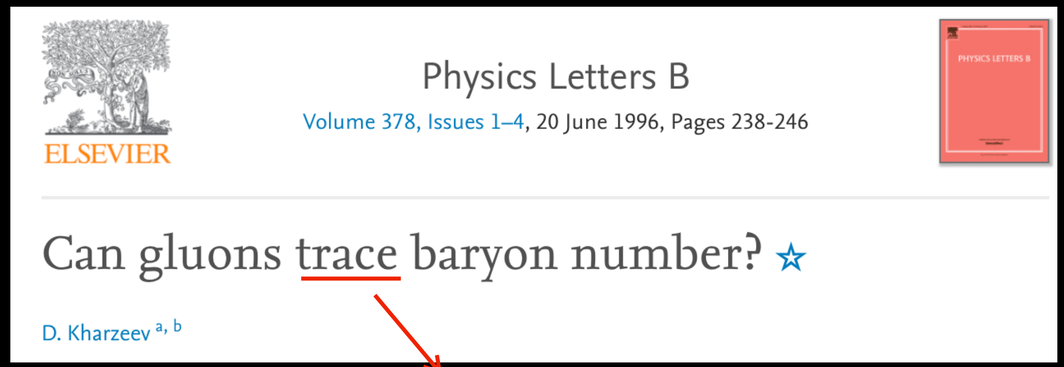
G.C. Rossi and G. Veneziano, Nucl. Phys.B123(1977) 507; Phys. Rep.63(1980) 149
Kharzeev, Phys. Lett. B, 378 (1996) 238-246

$$t_{\rm coll} \sim (x_V P)^{-1} = (1/3 \times 100)^{-1}\ {\rm GeV}^{-1} = 0.006\ {\rm fm}$$

$$t_{\rm int} \sim \mathcal{O}(1)\ {\rm fm}$$



The time available for valence quarks is too short to be stopped in collisions



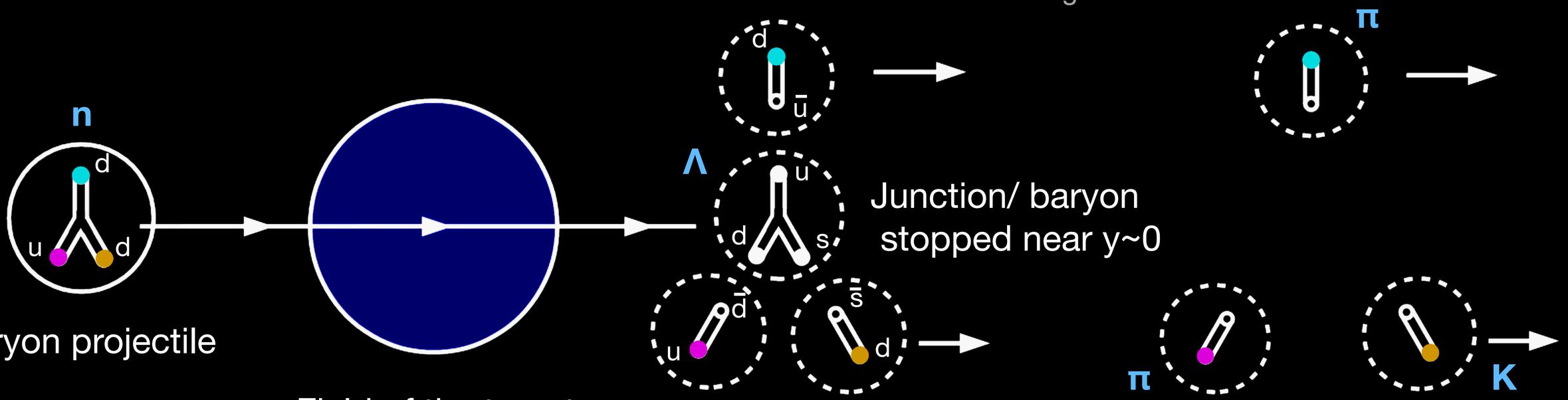
carry

How a baryon junction can be stopped?

Kharzeev, Phys. Lett. B, 378 (1996) 238-246

A string-junction from a projectile can be stopped by the soft parton field of the target and vice versa

fig: Navarra



Quarks fragment as mesons at large y

Features:

The momentum of the stopped baryon will be small (low p_T)

The process with lead to production of meson (pions)

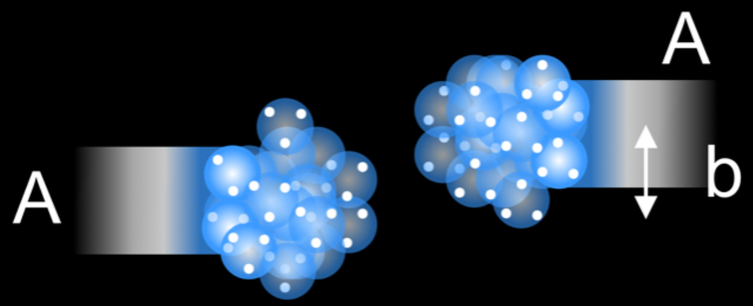
The flavor of the stopped baryon may be different from the incoming baryon

Isobars collisions: most controlled HIC systems

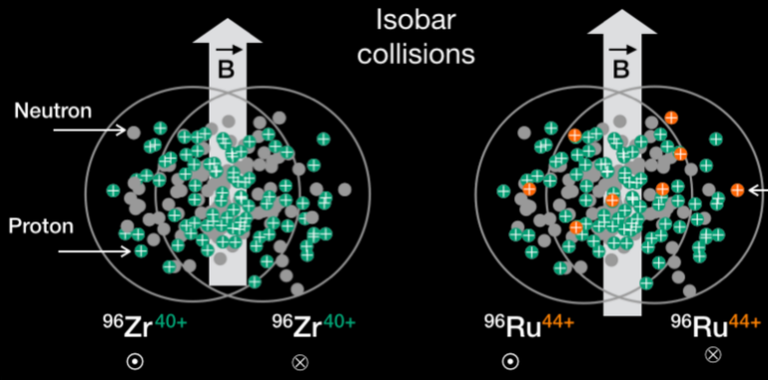
Brandenburg, Lewis,Tribedy, Xu, arXiv:2205.05685

A=Mass number = Baryon number
Z=Atomic number = Electric charge

Scenario 1: Valence quarks carry electric charge & baryon number



$$\text{Charge stopping} \simeq \frac{Z}{A} \times \text{Baryon stopping}$$



Zirconium:
A=96 (Total baryon)
Z=40 (Total charge)

Ruthenium:
A=96 (Total baryon)
Z=44 (Total charge)

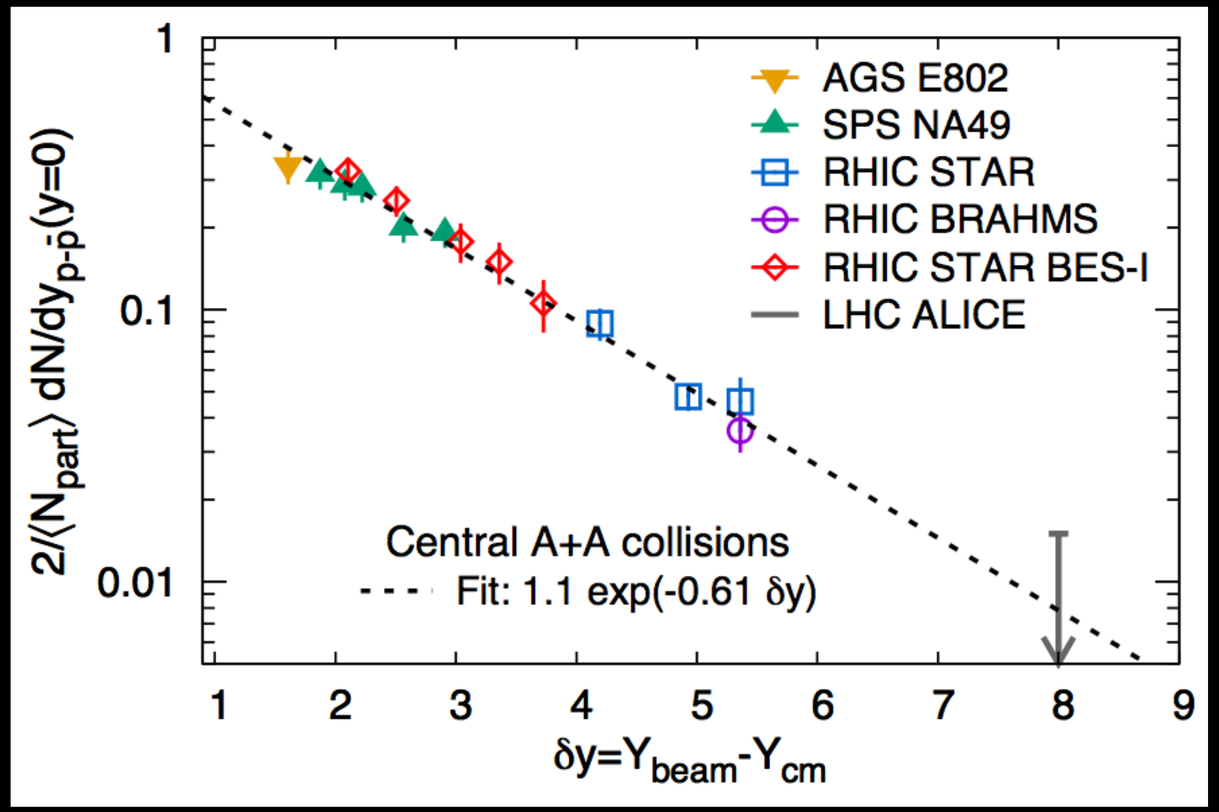
Scenario 2: Valence quarks carry electric charge & junctions cary baryon number

$$\text{Charge stopping} < \frac{Z}{A} \times \text{Baryon stopping}$$

$$\Delta Q \leftrightarrow \frac{\Delta Z}{A} \times B$$

Midrapidity baryon production in A+A collisions

Brandenburg, Lewis, Tribedy, Xu, arXiv:2205.05685



Kharzeev, Phys. Lett. B, 378 (1996) 238-246

Fit to global data on central A+A:

$$\frac{2}{N_{\rm part}} \left.\frac{dN_{\rm p-\bar{p}}}{dy}\right|_{A+A} = N_B\, e^{-\alpha_B (Y_{\rm beam} - Y_{\rm cm})}$$

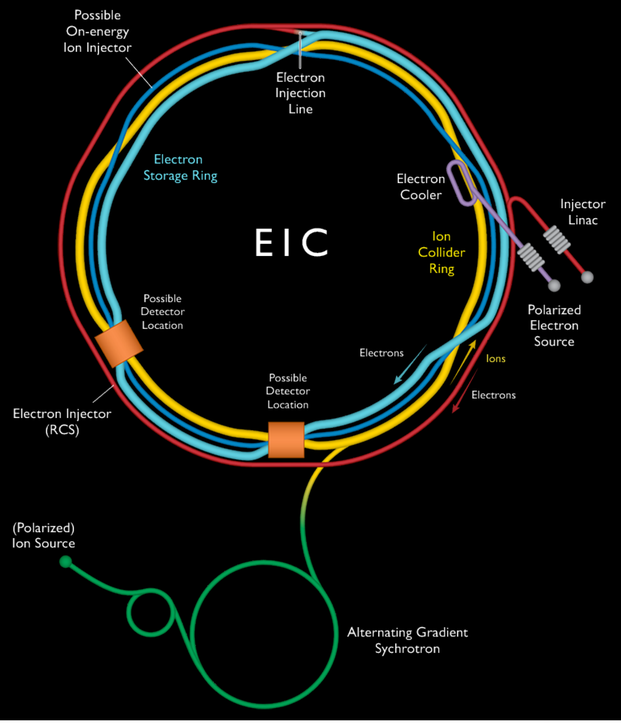
$$\boxed{\alpha_B = 0.61 \pm 0.03}$$

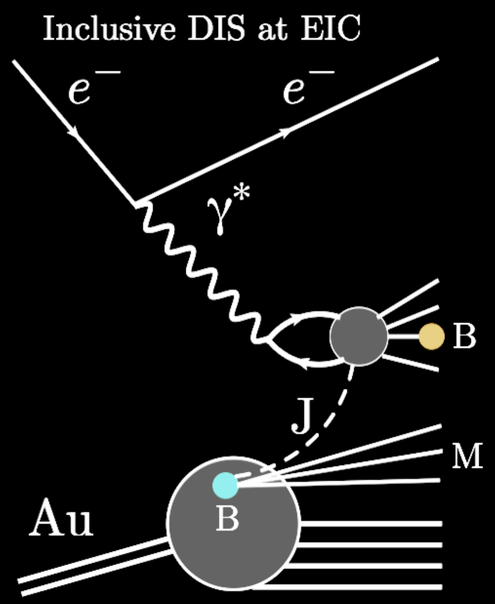
Predictions form Regge theory & baryon junction picture:

$$\boxed{0.42 \leq \alpha_B \leq 1}$$

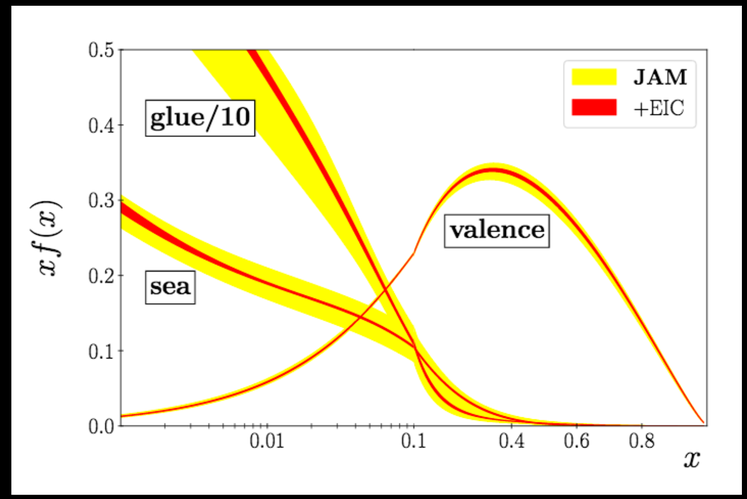
Consistent but more tests are needed

Baryon Distributions in x & Q^2: cleaner environment at EIC

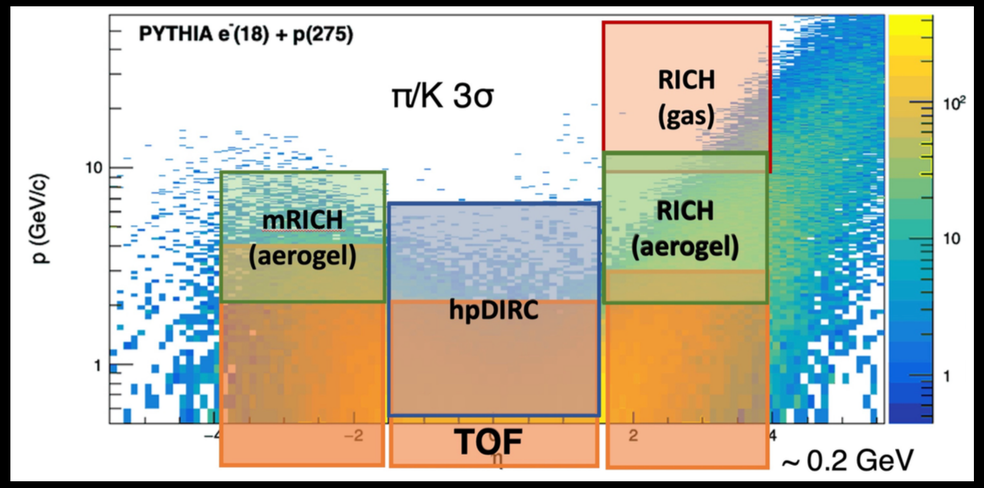


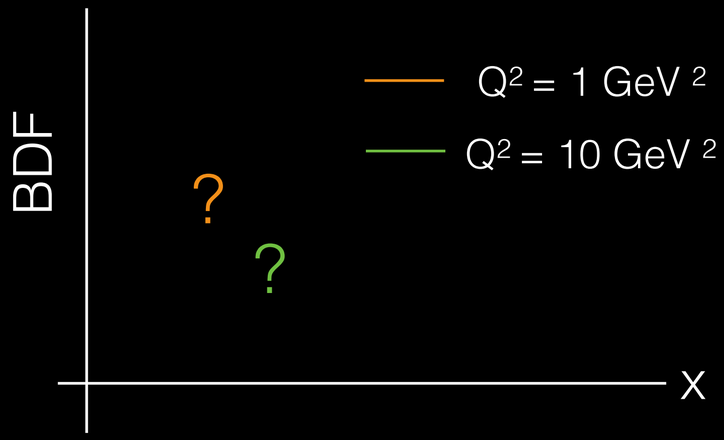


EIC yellow report, arXiv:2103.05419



What is the PDF equivalent of baryons ?

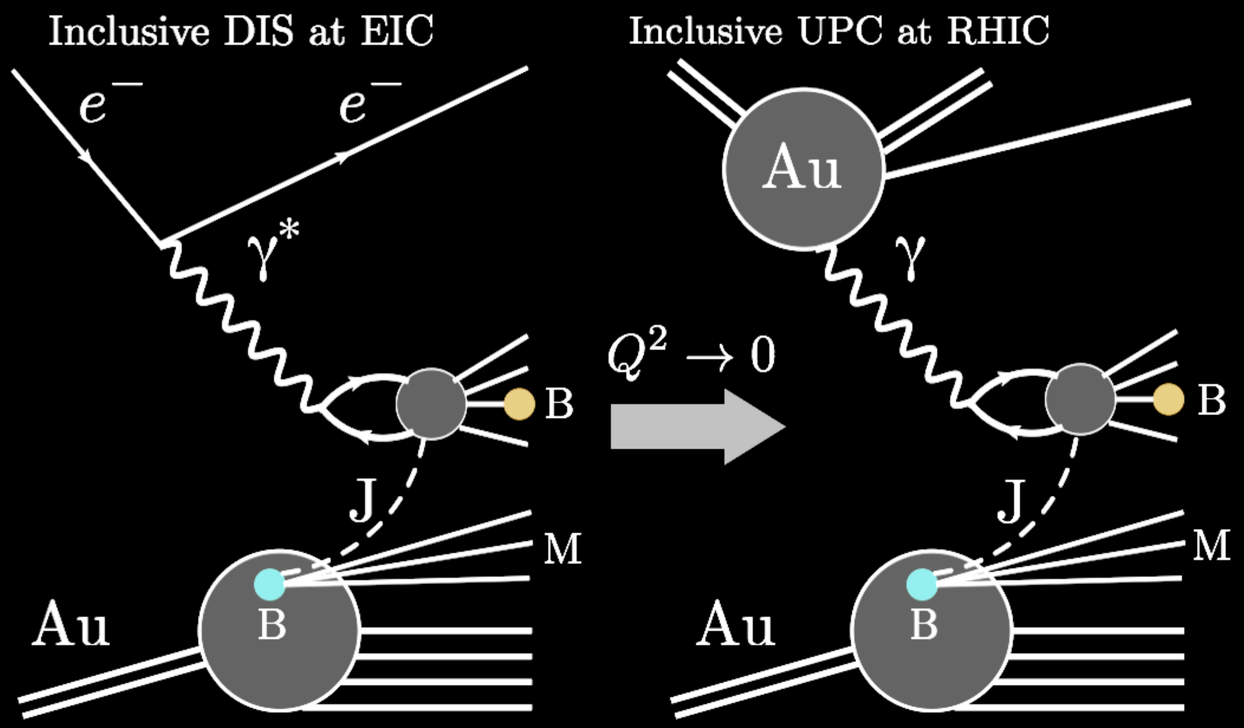




Low momentum PID capable detectors (TOF) at EIC will provide unique opportunity

Baryon free projectile: photon-induced processes

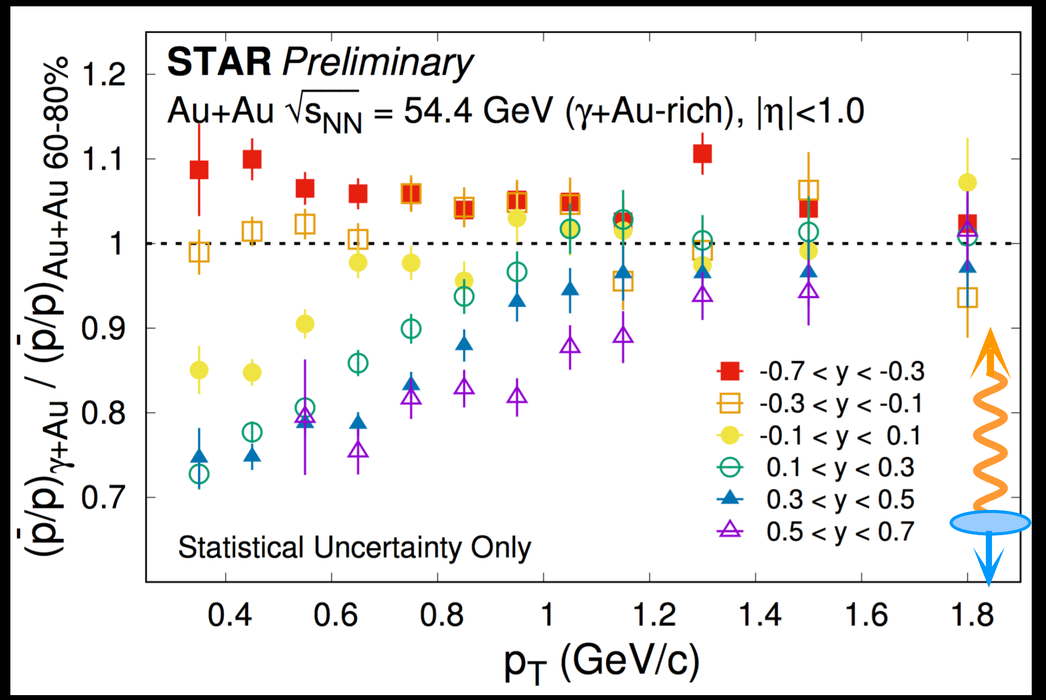
Brandenburg, Lewis,Tribedy, Xu, arXiv:2205.05685



Triggering photonuclear processes using Au+Au UPCs

Nicole Lewis (STAR collaboration), QM 2022

First look at photonuclear events: stronger rapidity dependent stopping in γ+Au » Au+Au



Interesting rapidity dependence of soft baryon stopping observed in RHIC photonuclear events