pQCD and away side correlations in heavy ion collisions

work with Ayala, Magnin,
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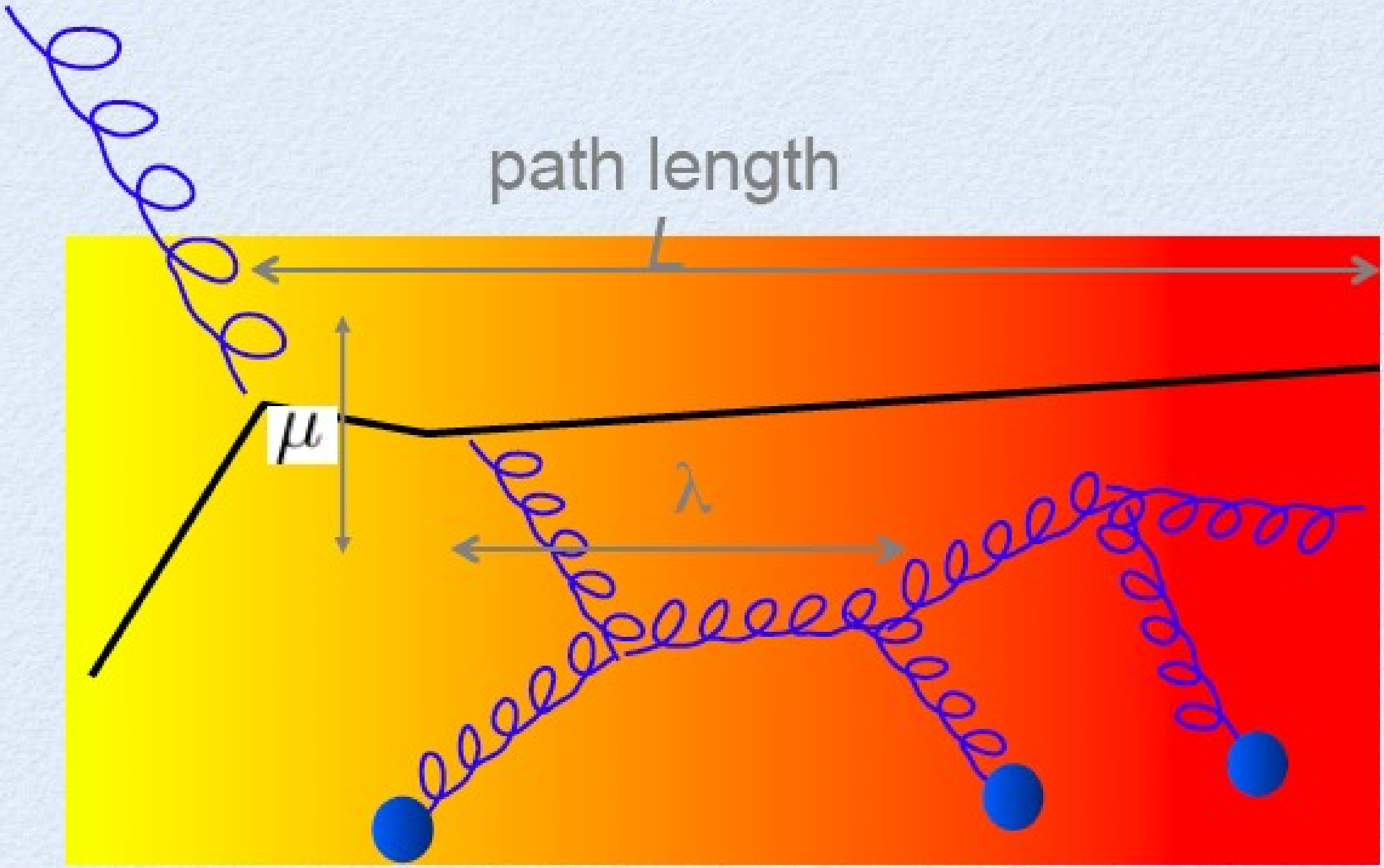
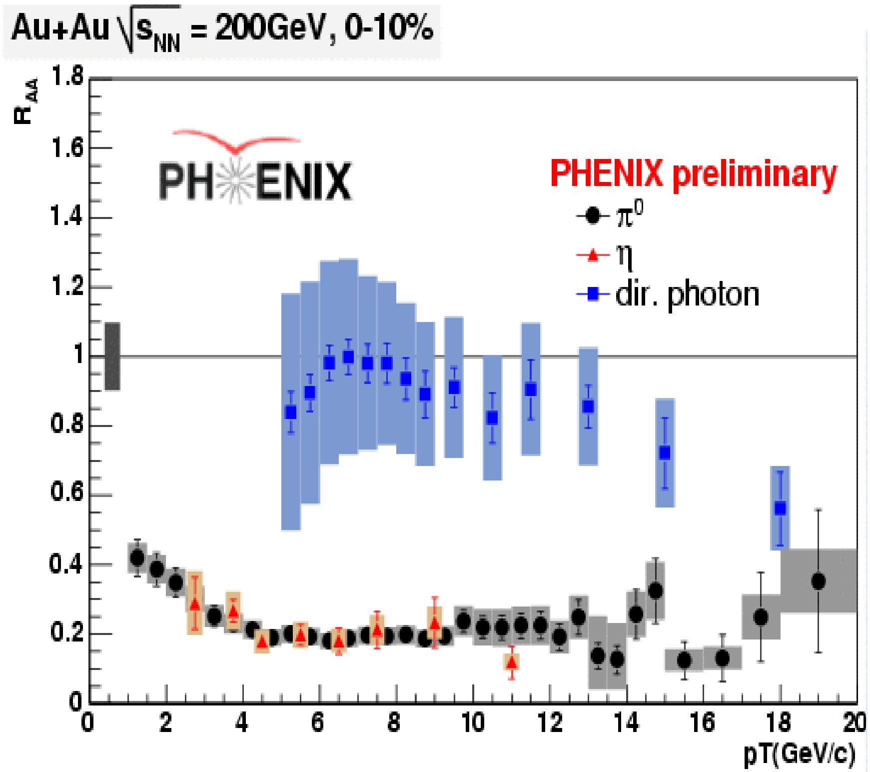
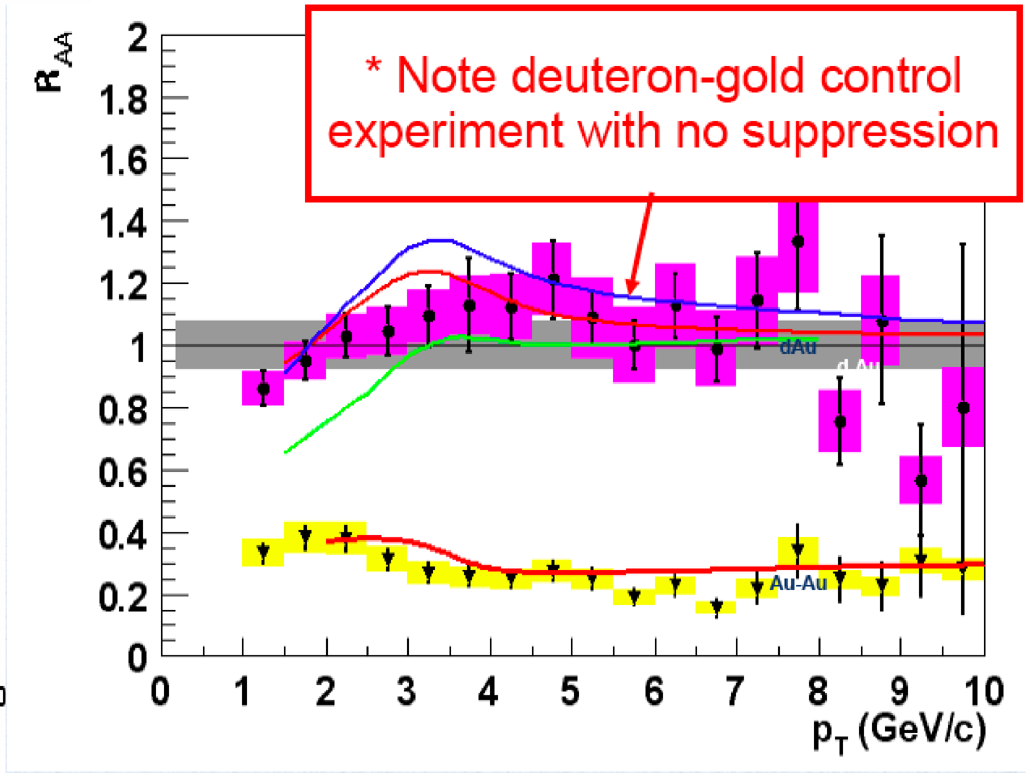
Colliding heavy ions at high energies

<u>Bjorken</u>: high p_t partons scatter from the medium and "lose energy" (radiate gluons)



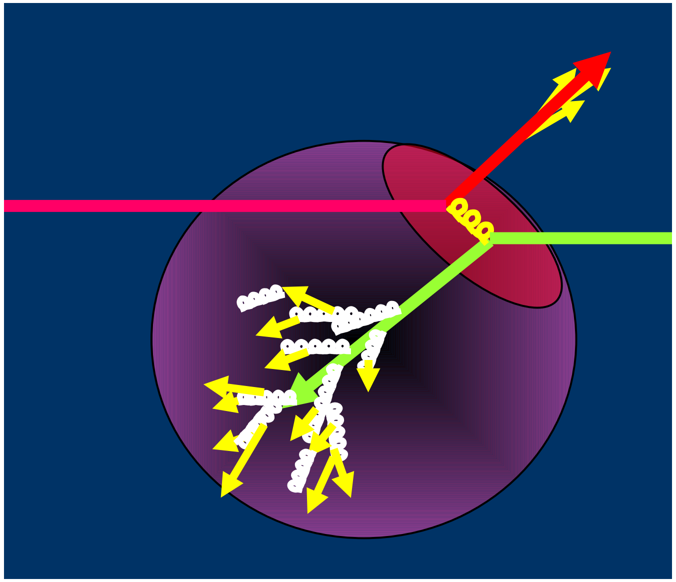
High p_t probes: single inclusive hadron production

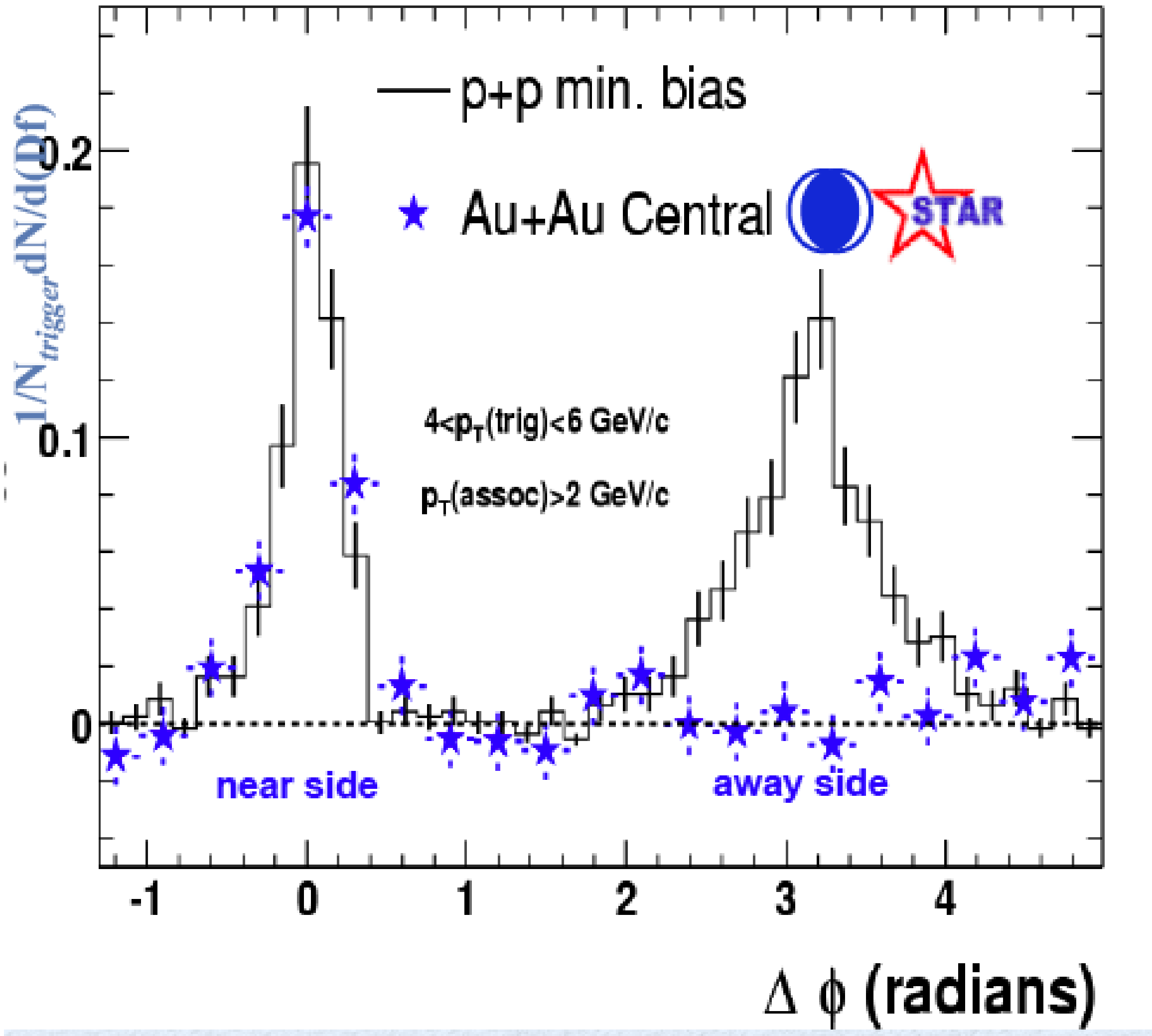




opaque medium

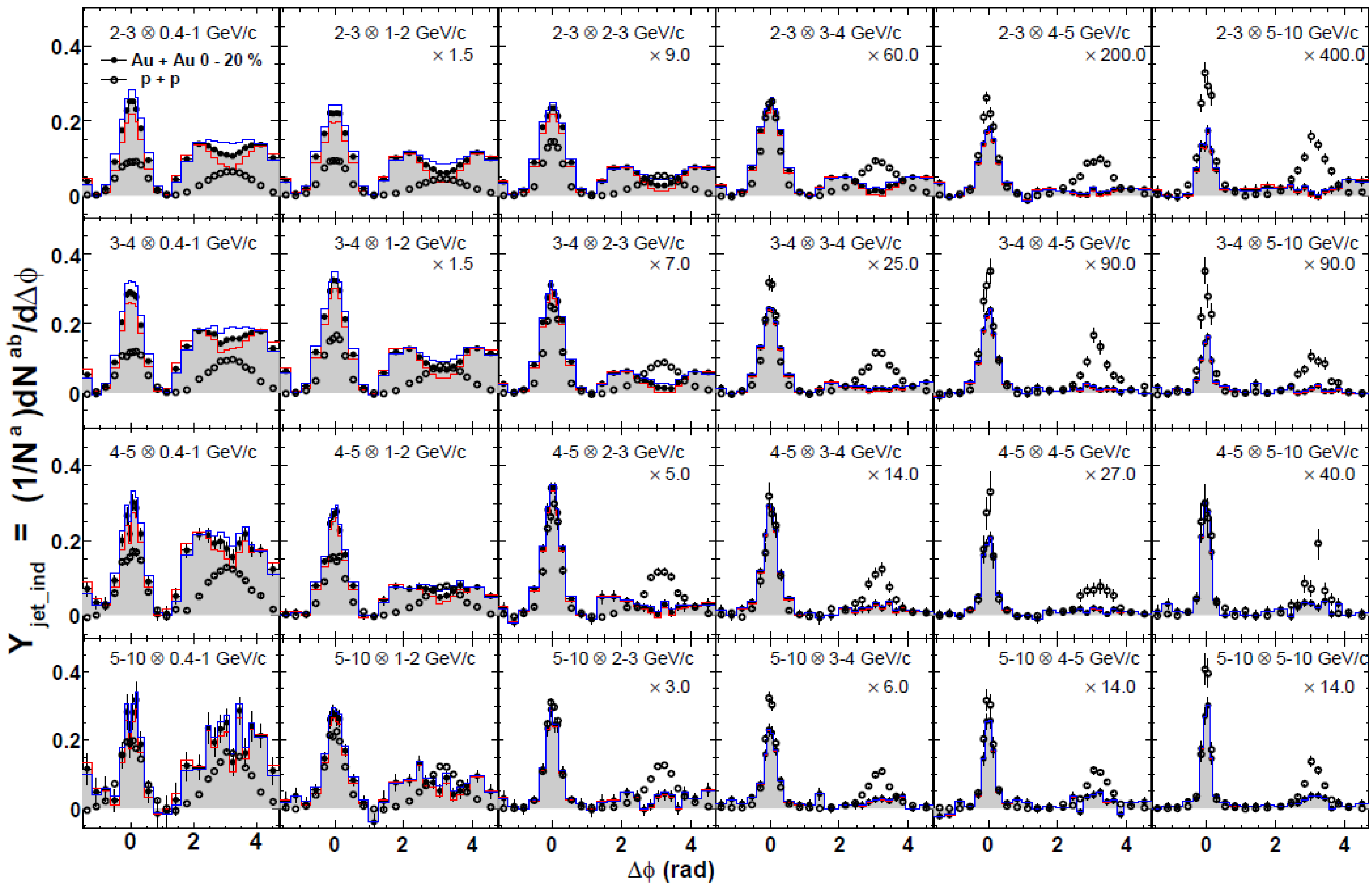
High p_t probes: double inclusive hadron production



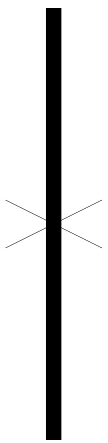


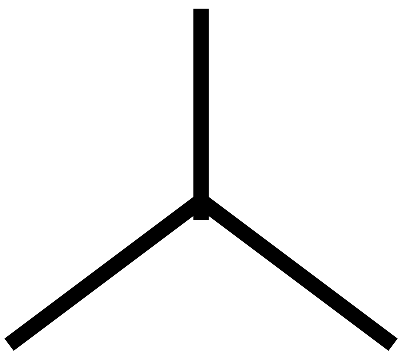
disappearance of back to back jets

rich structure on the away side: Mach cones, ... ?



2 vs. 3 produced partons



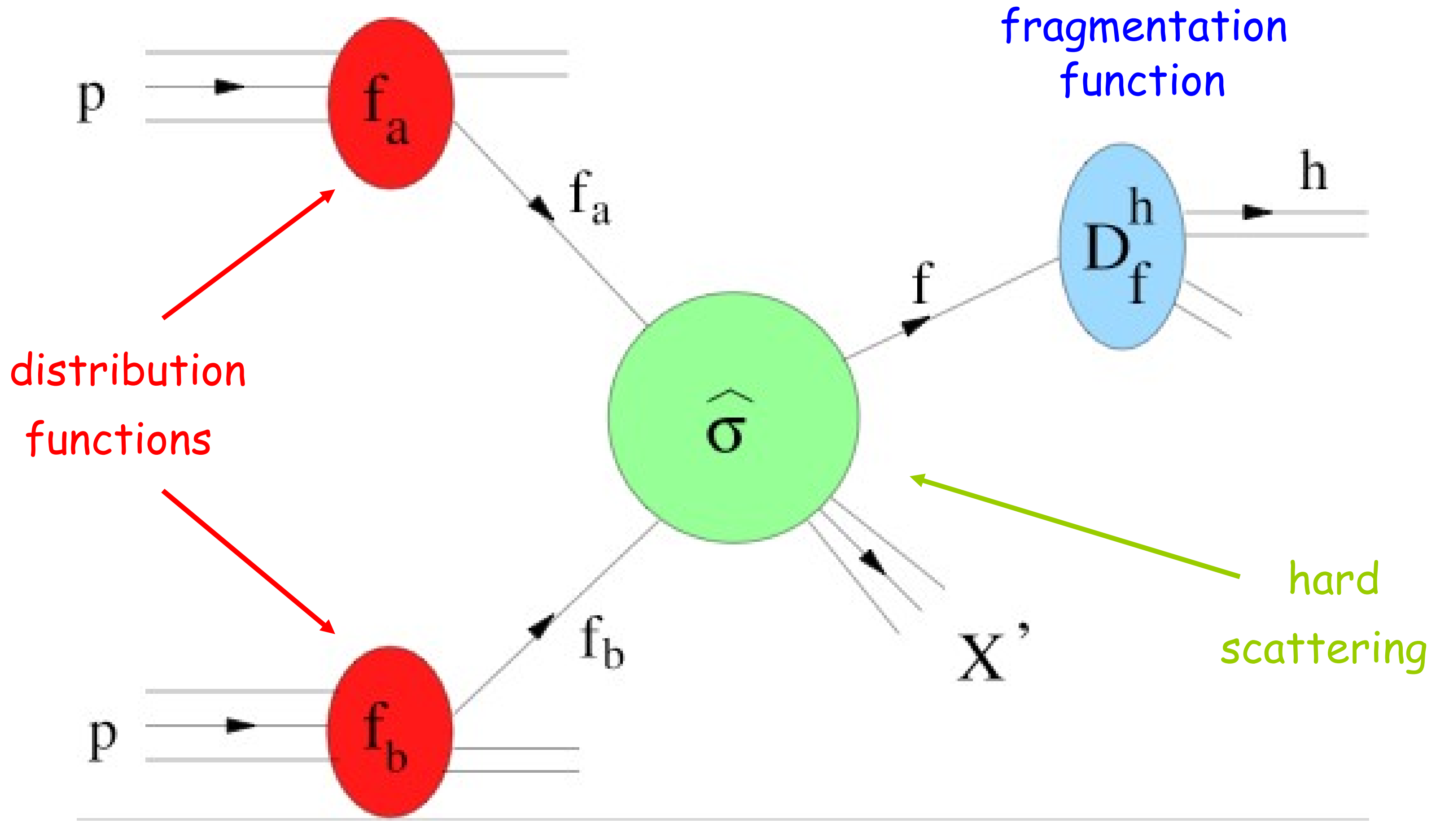


back to back -
away side: one peak

Triangle -
away side: two peaks

Hadron production in pp Collisions

Collinear factorization: separation of long and short distances



partonic cross sections (2 --> 2)

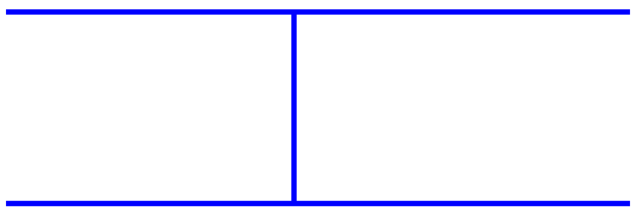
$$q_i + q_j \longrightarrow q_i + q_j \quad (i \neq j)$$

$$q_i + q_i \longrightarrow q_i + q_i$$

$$q_i + \vec{q}_i \longrightarrow g + g$$

$$g + g \longrightarrow g + g$$

and all crossings



partonic cross sections (2 --> 3)

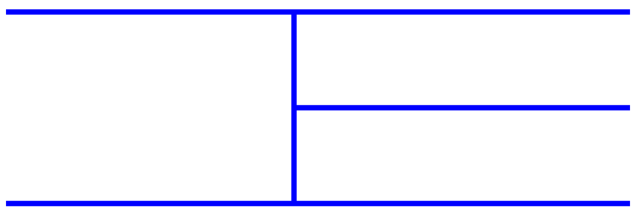
$$q_i + q_j \longrightarrow q_i + q_j + g \quad (i \neq j)$$

$$q_i + q_i \longrightarrow q_i + q_i + g$$

$$q_i + \bar{q}_i \longrightarrow g + g + g$$

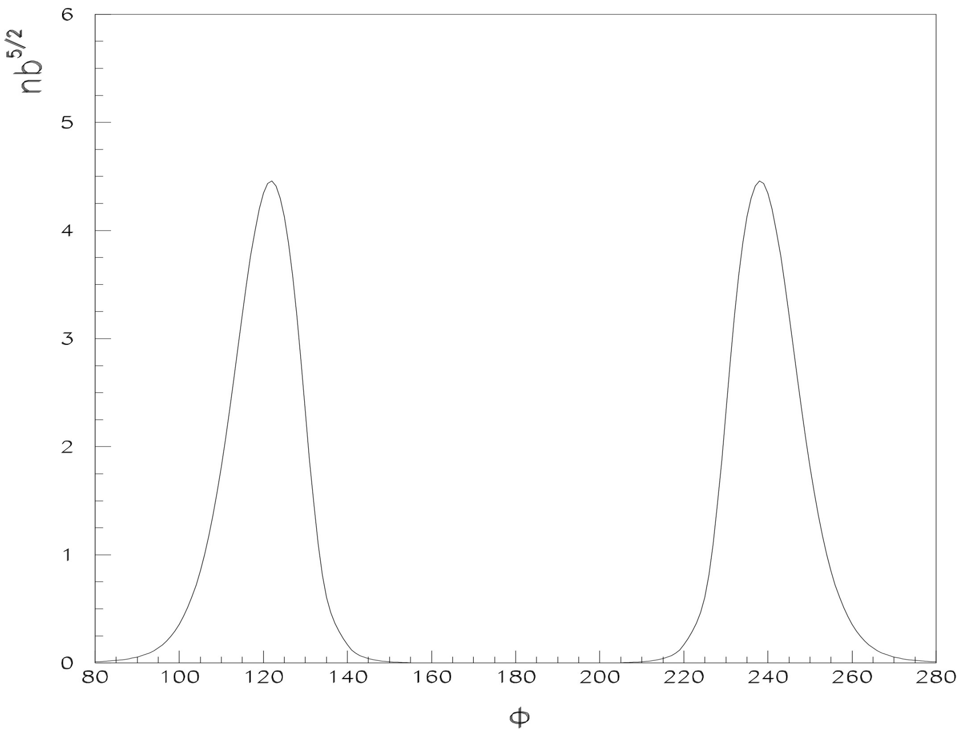
$$g + g \longrightarrow g + g + g$$

and all crossings



Three hadron cross section

$$\frac{d\sigma^{pp\to h1\,h2\,h3\,X}}{d\,y_1 d\,y_2 d\,y_3 d\,h_{1t} d\,h_{2t} d\,h_{3t} d\,\phi_2 d\,\phi_3} = \frac{1}{2^5}\frac{1}{(2\pi)^4}\frac{1}{h_{3t}\,S}\frac{|\sin\phi_2|}{[\sin\phi_2\,\sin^2(\phi_3/2)-\sin\phi_3\,\sin^2(\phi_2/2)]^2}\int dz_3|\mathcal{M}|^2$$
$$\times\; f_{i/p}(x_1,\mu^2) f_{j/p}(x_2,\mu^2) D^0_{h1/k}(z_1,\mu^2) D^0_{h2/m}(z_2,\mu^2) D^0_{h3/n}(z_3,\mu^2),$$



Hadron production in AA Collisions

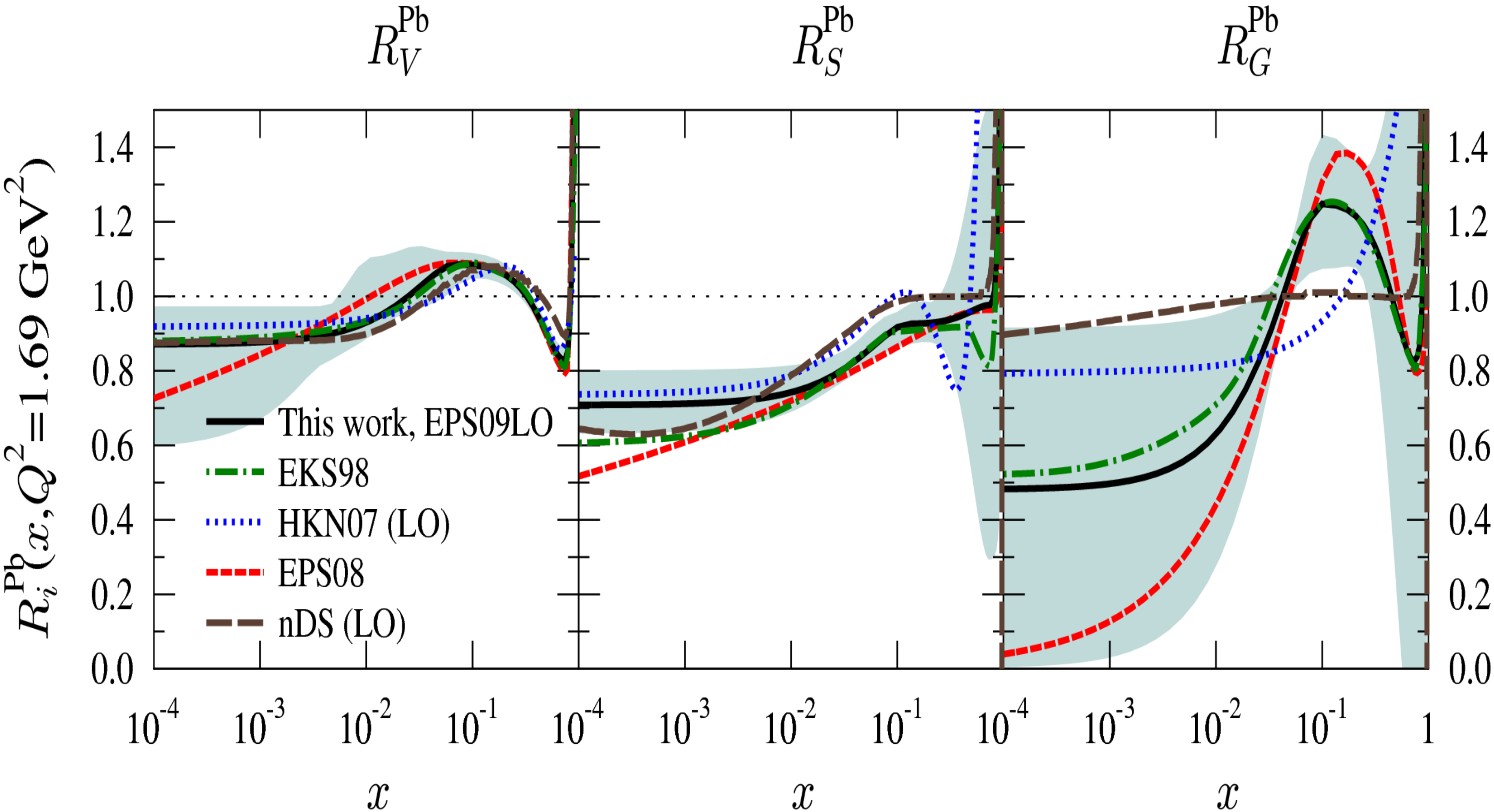
Nuclear modifications:

1) initial state distribution functions

2) hard scattering

3) final state fragmentation functions

Nuclear structure functions: shadowing



from Salgado et al.

Medium-induced energy loss

modified fragmentation functions

Zhang,Owens,Wang,Wang PRL98, 212301,2007

$$D_{h/i}(z_i,\mu^2) = (1-e^{-\langle\frac{L}{\lambda}\rangle})\left[\frac{z_i'}{z_i}D^0_{h/i}(z_i',\mu^2)+\langle\frac{L}{\lambda}\rangle\frac{z_g'}{z_i}\right.$$
$$\left.\times\ D^0_{h/g}(z_g',\mu^2)\right]+e^{-\langle\frac{L}{\lambda}\rangle}D^0_{h/i}(z_i,\mu^2), \quad (2)$$

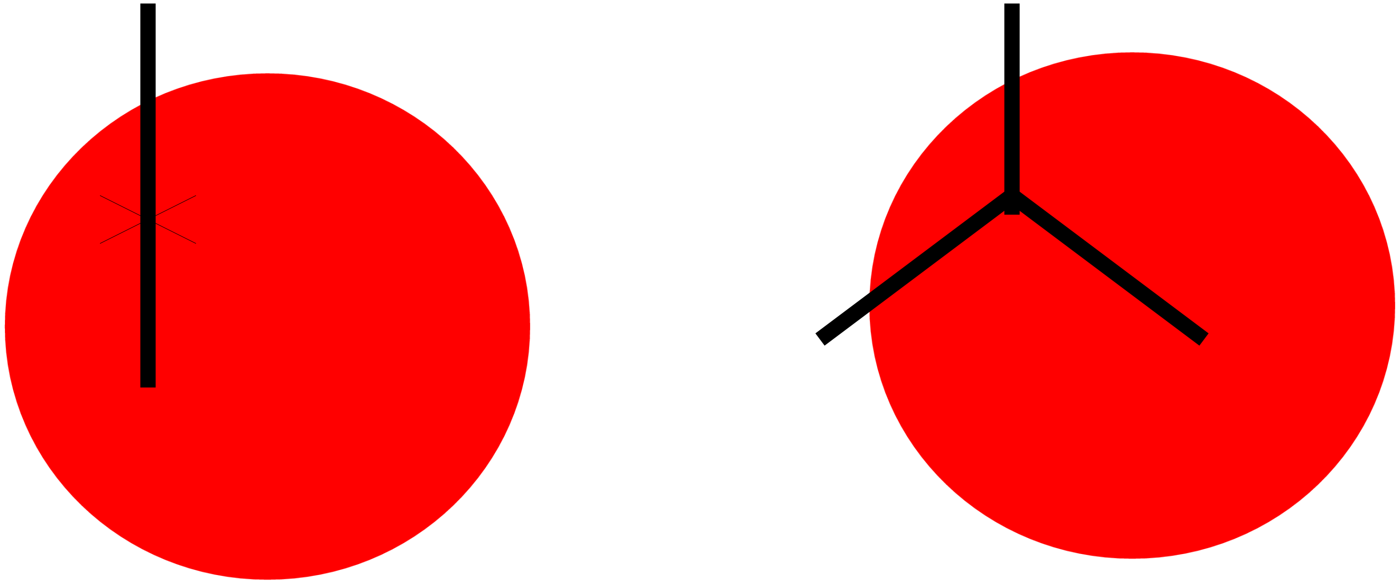
$$z_i' = \frac{h_t}{(b_{ti}-\Delta E_i)} \qquad z_g' = \langle\frac{L}{\lambda}\rangle\frac{b_t}{\Delta E_i}$$

$$\Delta E = \langle\frac{dE}{dL}\rangle_{1d}\int_{\tau_0}^{\infty}d\tau\frac{\tau-\tau_0}{\tau_0\,\rho_0}\,\rho_g(\tau,\vec{b}_\perp,\vec{r}_t+\vec{n}\tau)$$

$$\langle\frac{L}{\lambda}\rangle = \int_{\tau_0}^{\infty}d\tau\frac{1}{\lambda_0\,\rho_0}\,\rho_g(\tau,\vec{b}_\perp,\vec{r}_t+\vec{n}\tau)$$

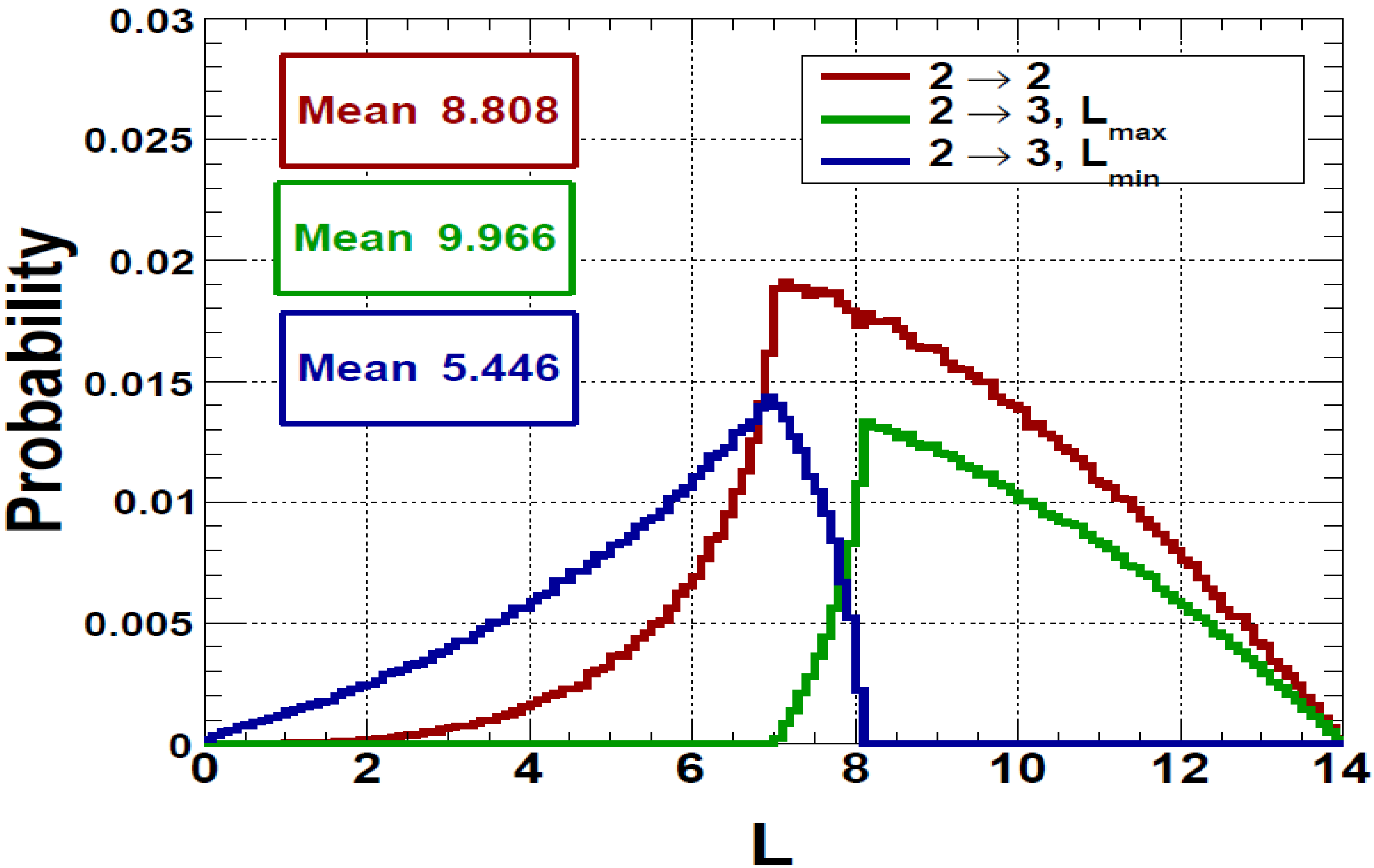
$$\rho_g(\tau,\vec{b}_\perp,\vec{r}_t+\vec{n}\tau) = \frac{\tau_0\,\rho_0}{\tau}\,\frac{\pi R_A^2}{2A}\left[t_A(\vec{r}_t+\vec{n}\tau)+t_A(\vec{b}_\perp-\vec{r}_t-\vec{n}\tau)\right]$$

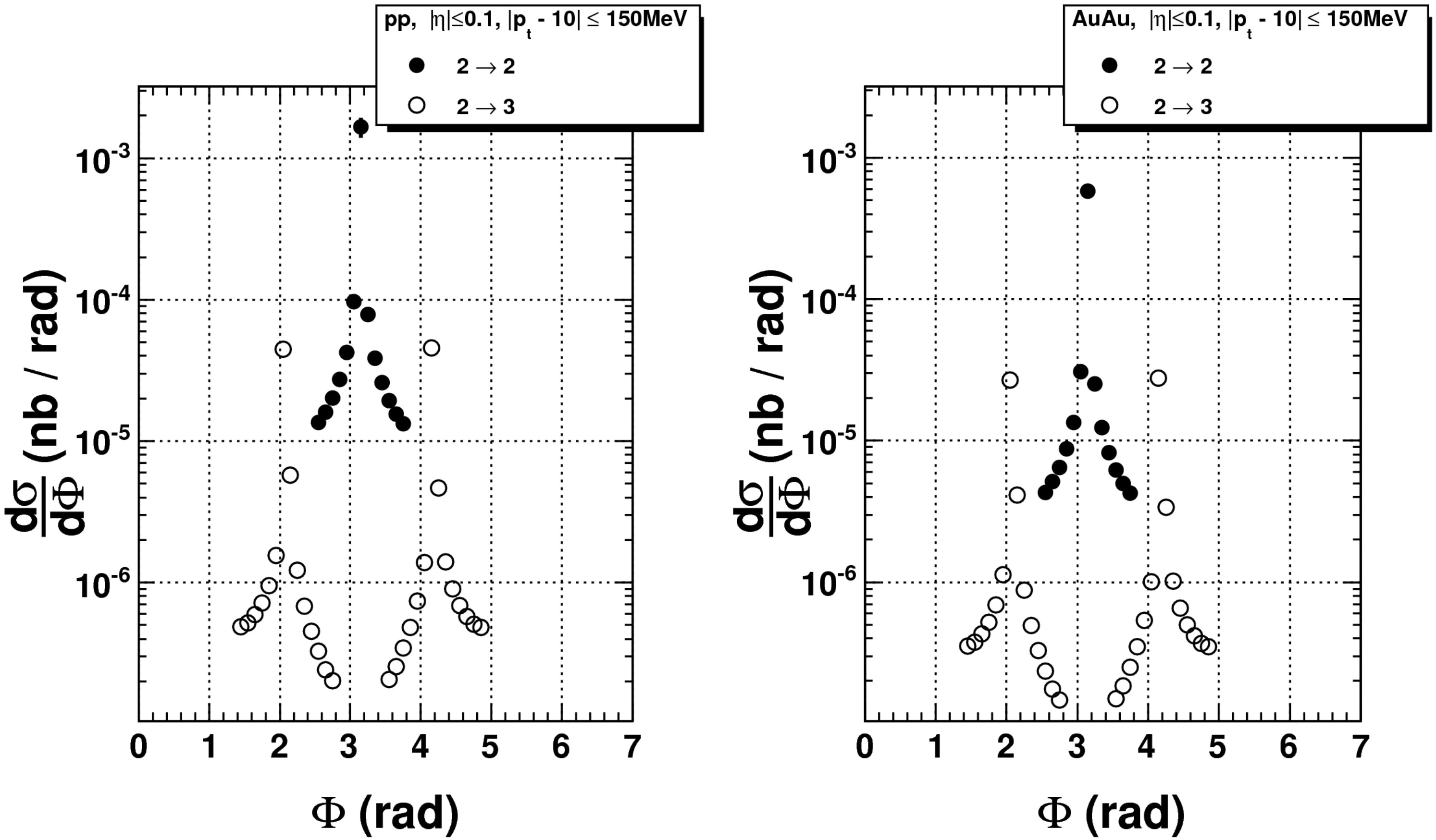
2 vs. 3 produced partons



different path lengths traveled

path length dependence: 2--> 2 vs. 2 --> 3





2 --> 3 are less suppressed compared to 2 -->2

Summary

Three partons produced in a hard collision are less suppressed by the medium compared with two produced partons due to smaller path length traveled

Can the away side angular correlations be understood as a hard process ? (in progress)