pQCD Work

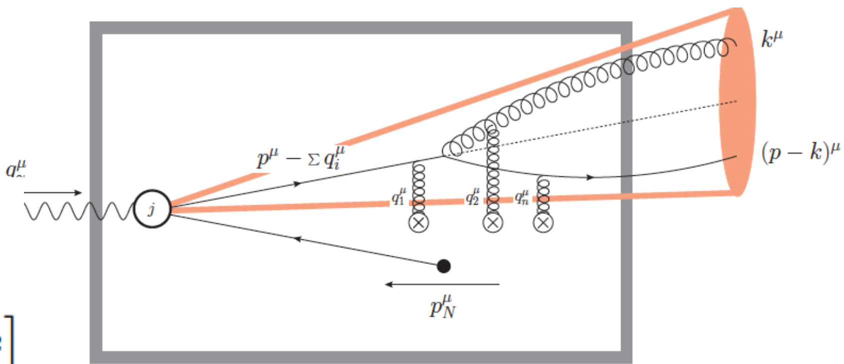
Ivan Vitev (with Sievert, Li, Kang, Reiten)

In-medium parton splitting to any order in opacity

- Automatically get both massive and massless splitting functions

$$xp^+ \frac{dN}{d^2k\,dx\,d^2p\,dp^+}\bigg|_{\mathcal{O}(\chi^0)} = \frac{1}{2(2\pi)^3}\frac{C_F}{1-x}\left|\psi(x,\underline{k}-x\underline{p})\right|^2 \times \left(p^+\frac{dN_0}{d^2p\,dp^+}\right)$$

$$\langle\psi(x,\underline{\kappa})\,\psi^*(x,\underline{\kappa}')\rangle \equiv \sum_{\lambda=\pm1}\frac{1}{2}\mathrm{tr}\left[\psi(x,\underline{\kappa})\,\psi^*(x,\underline{\kappa}')\right]$$
$$= \frac{8\pi\alpha_s(1-x)}{[\kappa_T^2+x^2m^2]\,[\kappa_T'^2+x^2m^2]}\left[(\underline{\kappa}\cdot\underline{\kappa}')\;[1+(1-x)^2]+x^4m^2\right]$$



Obtain recursion relation for all splitting functions

- Same topology, different color algebra

$$\begin{bmatrix} f_{F/F}^{(N)}(\underline{k},\underline{k}',\underline{p};\,x^+,y^+) \\ f_{I/F}^{(N)}(\underline{k}',\underline{p};\,x^+,y^+) \\ f_{F/I}^{(N)}(\underline{k},\underline{p};\,x^+,y^+) \\ f_{I/I}^{(N)}(\underline{p};\,x^+,y^+) \end{bmatrix} = \int_{x_0^+}^{\min[x^+,y^+,R^+]} \frac{dz^+}{\lambda^+}\int \frac{d^2q}{\sigma_{el}}\frac{d\sigma^{el}}{d^2q} \begin{bmatrix} \mathcal{K}_1 & \mathcal{K}_2 & \mathcal{K}_3 & \mathcal{K}_4 \\ 0 & \mathcal{K}_5 & 0 & \mathcal{K}_6 \\ 0 & 0 & \mathcal{K}_7 & \mathcal{K}_8 \\ 0 & 0 & 0 & \mathcal{K}_9 \end{bmatrix} \begin{bmatrix} f_{F/F}^{(N-1)}(\underline{k},\underline{k}',\underline{p};\,x^+,y^+) \\ f_{I/F}^{(N-1)}(\underline{k}',\underline{p};\,x^+,y^+) \\ f_{F/I}^{(N-1)}(\underline{k},\underline{p};\,x^+,y^+) \\ f_{I/I}^{(N-1)}(\underline{p};\,x^+,y^+) \end{bmatrix}$$

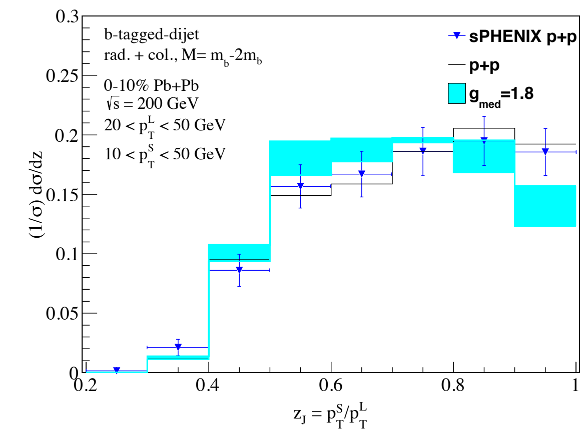
Numerics

- Numerical implementation, see Boram

Di-Bjets and Dijet Mass Distributions

In search of the largest modification

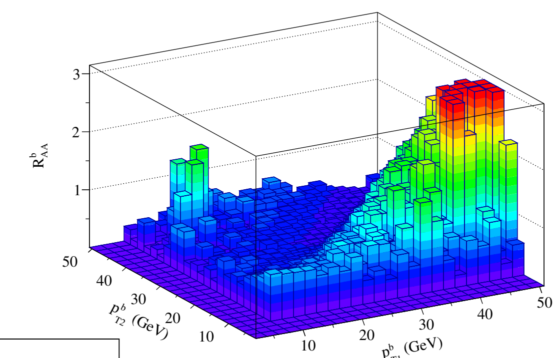
- Dijet asymmetries are small, the mass modification is large
- We have done extensive simulations, PYTHIA



We work in the energy loss approach

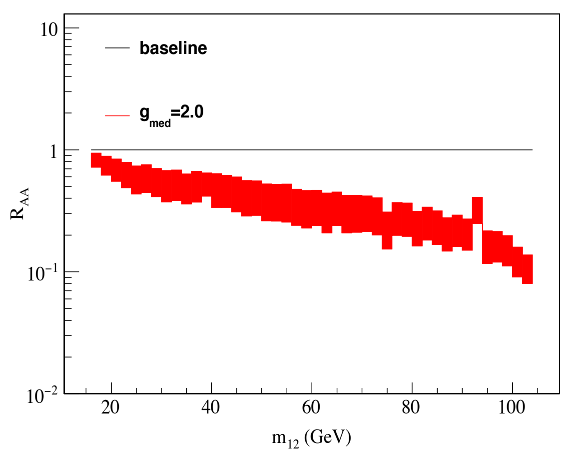
- The modification of individual masses is small
- Most of the information is in the 2D suppression plot

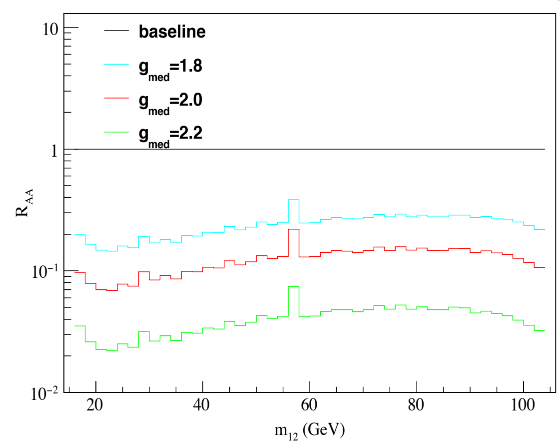
$$\frac{d\sigma}{dm_{12}} = \int dp_{1T} dp_{2T} \frac{d\sigma}{dp_{1T} dp_{2T}} \delta\left(m_{12} - \sqrt{\langle m_1^2 \rangle + \langle m_2^2 \rangle + 2 p_{1T} p_{2T} \langle \cosh(\Delta\eta) - \cos(\Delta\phi) \rangle} \right)$$



Numerics

- Use numerics from the 2+1 D hydro, Boram coded splitting functions/energy loss





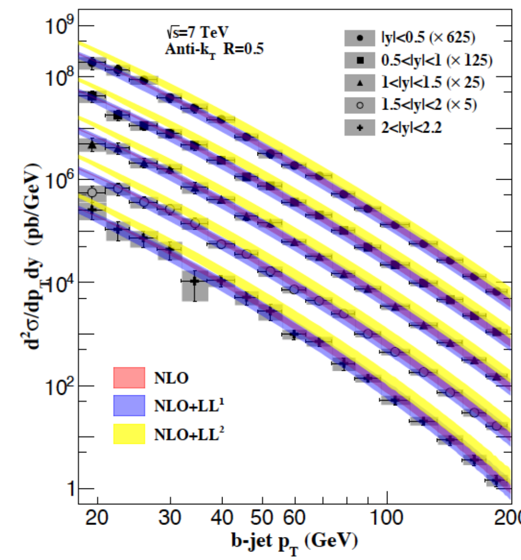
Los Alamos
NATIONAL LABORATORY
EST. 1943

Heavy Flavor Jet Functions, Inclusive b-jets

Go beyond the energy loss approach

- Express results in heavy flavor jet functions modification is large
- Also include DGLAP evolution

$$\frac{d\sigma_{pp\to J_Q+X}}{dp_T d\eta} = \frac{2p_T}{s}\sum_{a,b,c}\int_{x_a^{\min}}^{1}\frac{dx_a}{x_a}f_a(x_a,\mu)\int_{x_b^{\min}}^{1}\frac{dx_b}{x_b}f_b(x_b,\mu)$$
$$\times\int_{z_{\min}}^{1}\frac{dz_c}{z_c^2}\frac{d\hat\sigma_{ab\to c}(\hat s, p_T/z_c,\hat\eta,\mu)}{dvdz}J_{J_Q/c}(z_c,m_Q,w_J,\mu)$$



Medium correction

- Include full splitting functions and sum rules

$$J^{\rm med}_{J_Q/Q}(z,wR,m,\mu) = \left[\int_{z(1-z)w\tan(R/2)}^{\mu} dq_\perp P_{QQ}(z,m,q_\perp)\right]_+$$

$$J^{\rm med}_{J_s/g}(z,wR,m,\mu) = -\,\delta(1-z)\int_0^1 dx\int_{x(1-x)w\tan(R/2)}^{\mu} dq_\perp P_{Qg}(x,m,q_\perp)$$
$$+\int_{z(1-z)w\tan(R/2)}^{\mu} dq_\perp\left(P_{Qg}(z,m,q_\perp)+P_{\bar{Q}g}(z,m,q_\perp)\right)$$

Numerics

- Include cold nuclear matter effects
- Think about the inclusion of collisional energy loss
- Since evolution is now in momentum space, think about medium induced evolution beyond the fixed order correction