QCD BOLTZMANN EQUATION

BEYOND THE SOFT-SCATTERING APPROXIMATION

JUNE 2018

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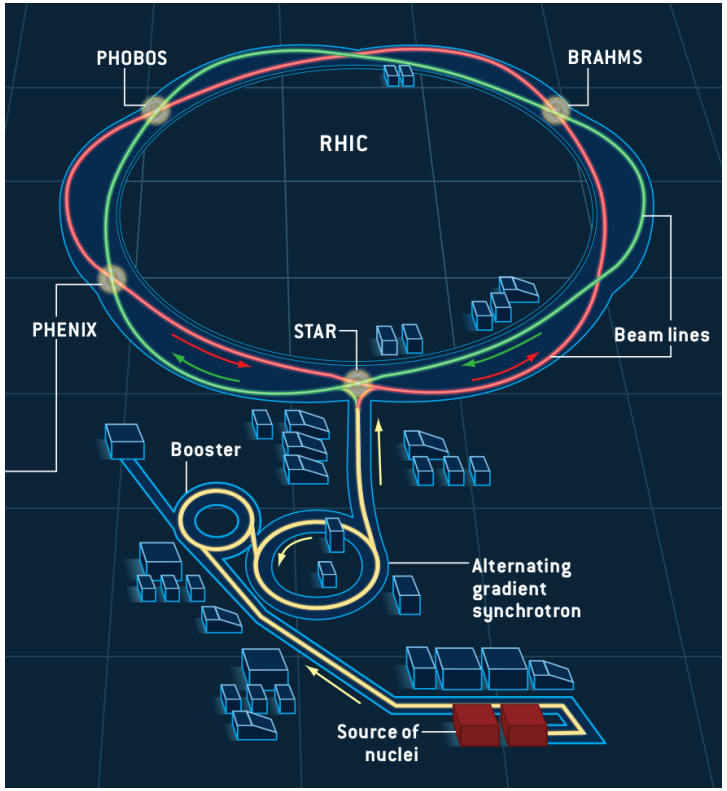
Special thanks:
W Grunow
B Harrison
G Jackson

CONTEXT

What is QGP?

- Physicists smash..
- Exciting realm of QCD



"The First Few Microseconds" - Scientific American

CONTEXT

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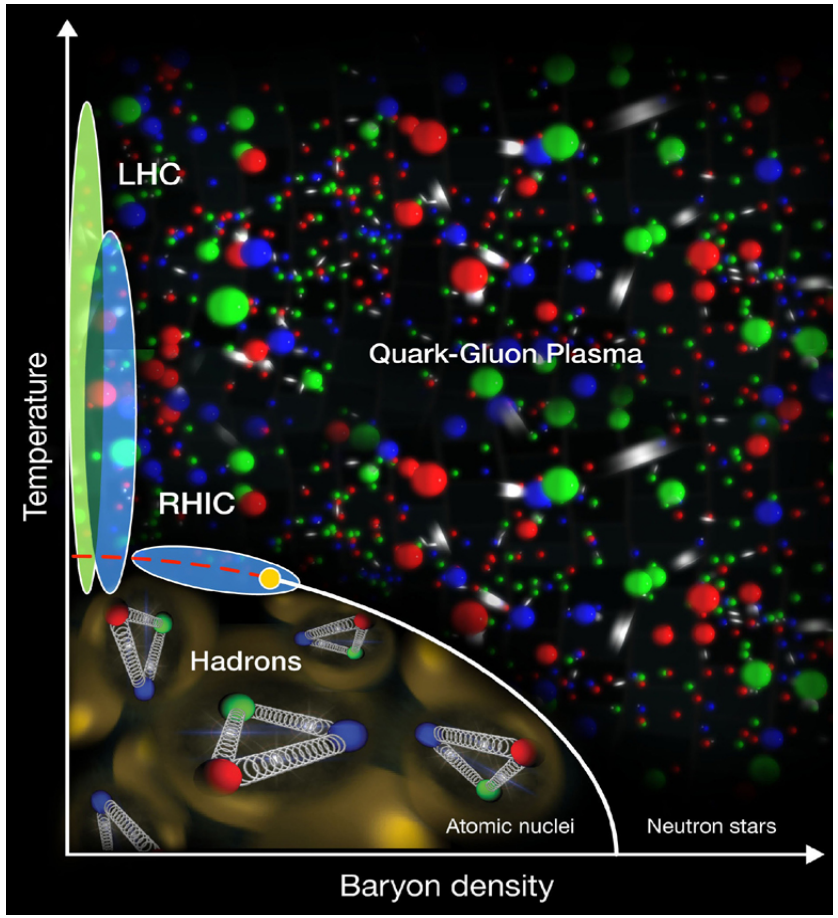
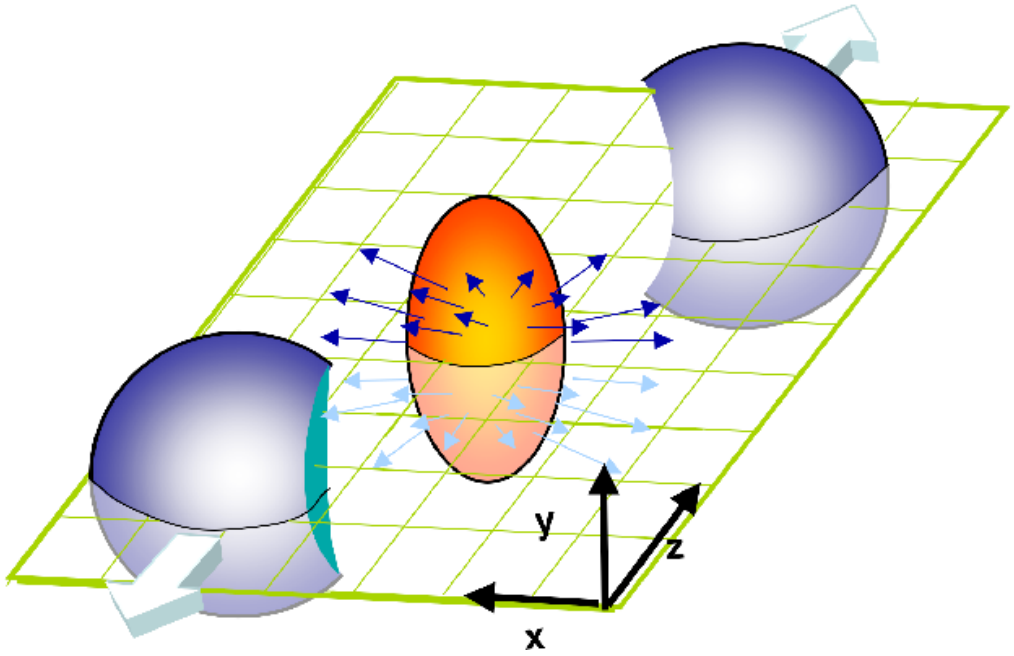


Brook-haven National Labs

CONTEXT

How do we study QGP?

- ‘Strongly coupled’
- Hydrodynamics?
- Kinetic theory!



U Heinz [arXiv:0810.5529]

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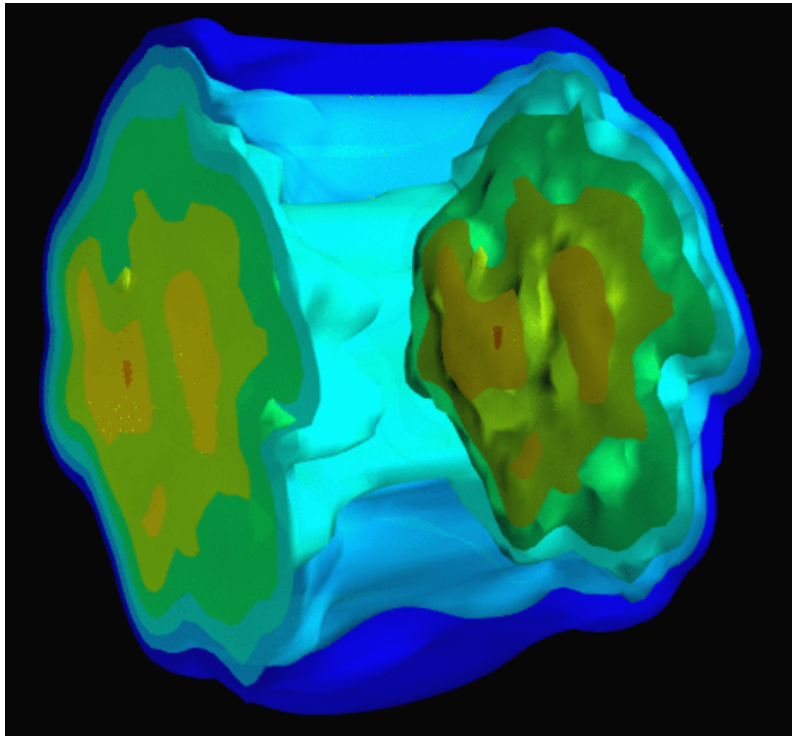

B Schenke
[arXiv:1009.3244]

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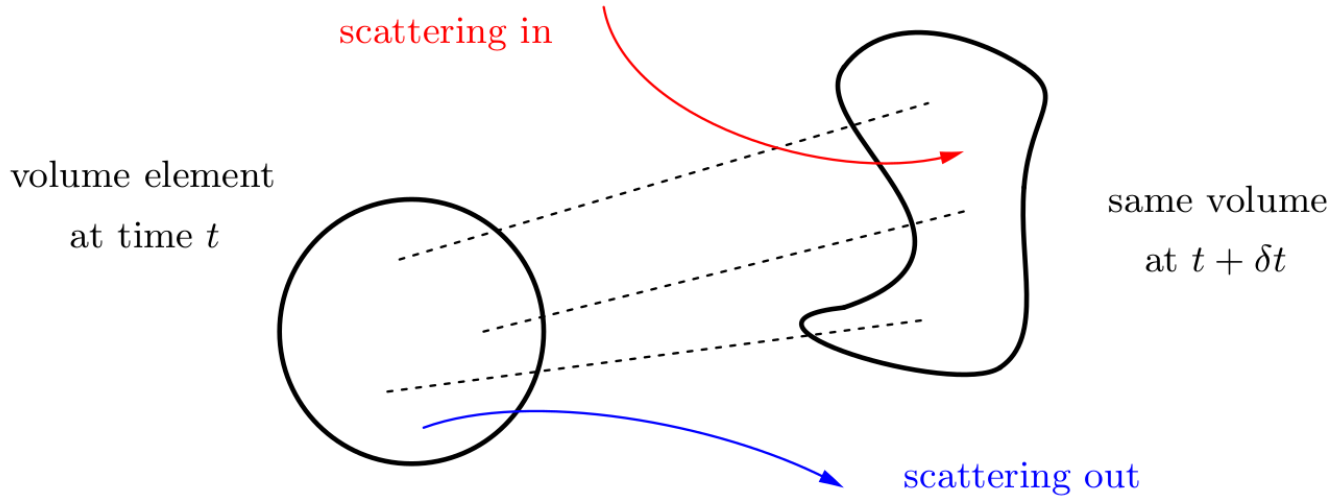


G Jackson [arXiv:1704.06284]

THE BOLTZMANN EQUATION

Simple?

$$\mathcal{D} f = \mathcal{C}_{[f]}(\boldsymbol{k})$$

THE BOLTZMANN EQUATION

Not so simple..

$$\mathcal{D}f = \mathcal{C}_{[f]}(\boldsymbol{k})$$

$$\frac{1}{2E}\int_{234} \mathrm{d}\Gamma\, |\mathcal{M}|^2 \cdot \mathcal{F}_{[f]}$$

Need approximations!

- Gluon-only system
- Only elastic collisions

THE BOLTZMANN EQUATION

Relaxation time approximation

$$\mathcal{D}f = \frac{f_{eq} - f}{\tau}$$

- Powerful!
- Not what we want

THE BOLTZMANN EQUATION

Further approximations

$$\mathcal{D}f = \mathcal{C}_{[f]}(\boldsymbol{k})$$

- Spatially homogeneous distribution

$$\mathcal{D} = \partial_t + \boldsymbol{v} \cdot \boldsymbol{\nabla}$$

- Spherically symmetric in momentum space

THE BOLTZMANN EQUATION

Fokker-Planck approximation

$$\partial_t f = -\nabla \cdot \mathcal{J}$$

- Assume soft-scattering dominates
- Expand in exchanged momenta
- Integro-differential ⟶ differential equation!

THE BOLTZMANN EQUATION

Fokker-Planck approximation

$$\partial_t f = -\nabla \cdot \mathcal{J}$$

- Assume soft-scattering dominates (??)

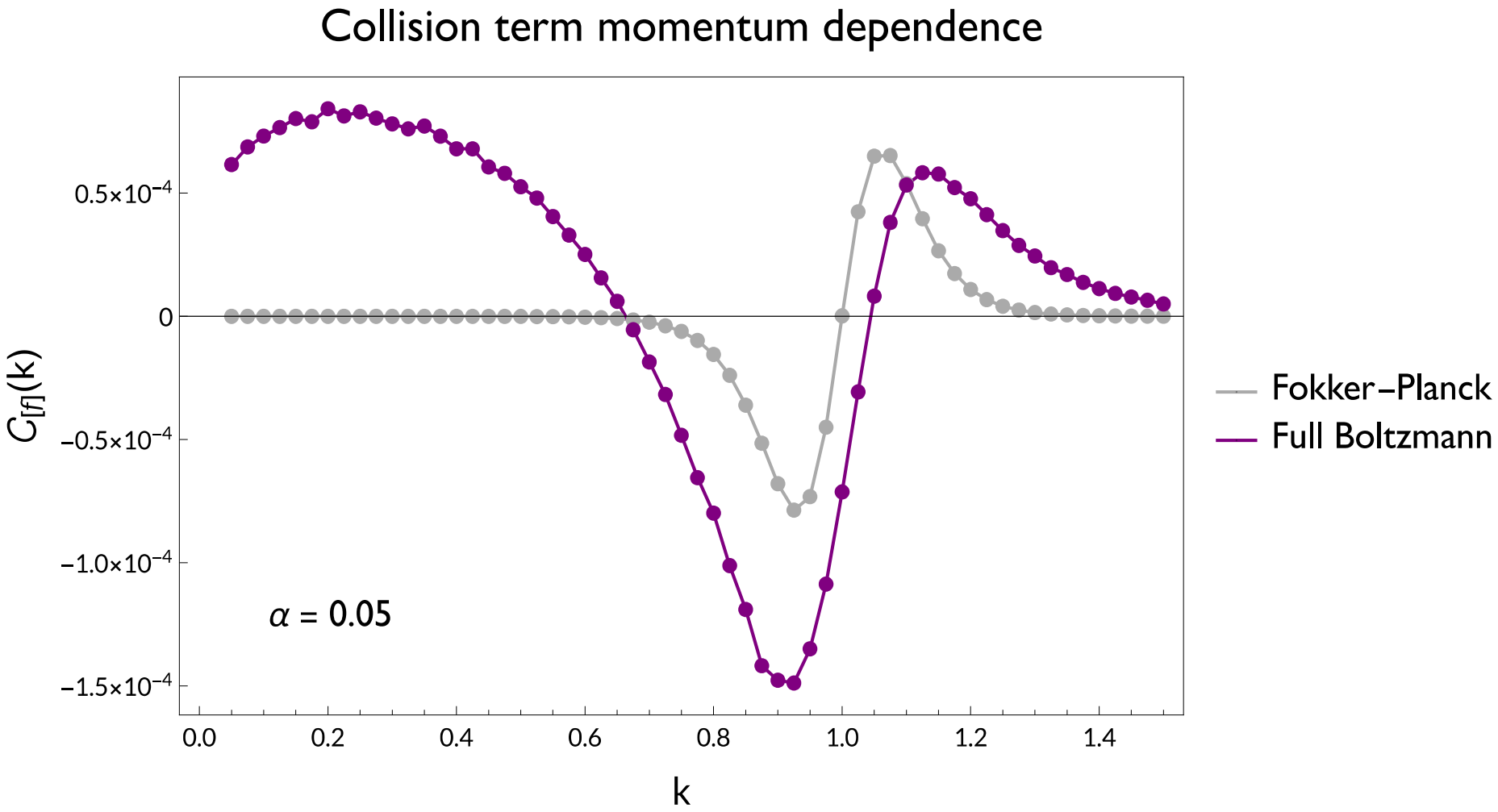
THIS THESIS

Solve the full Boltzmann equation

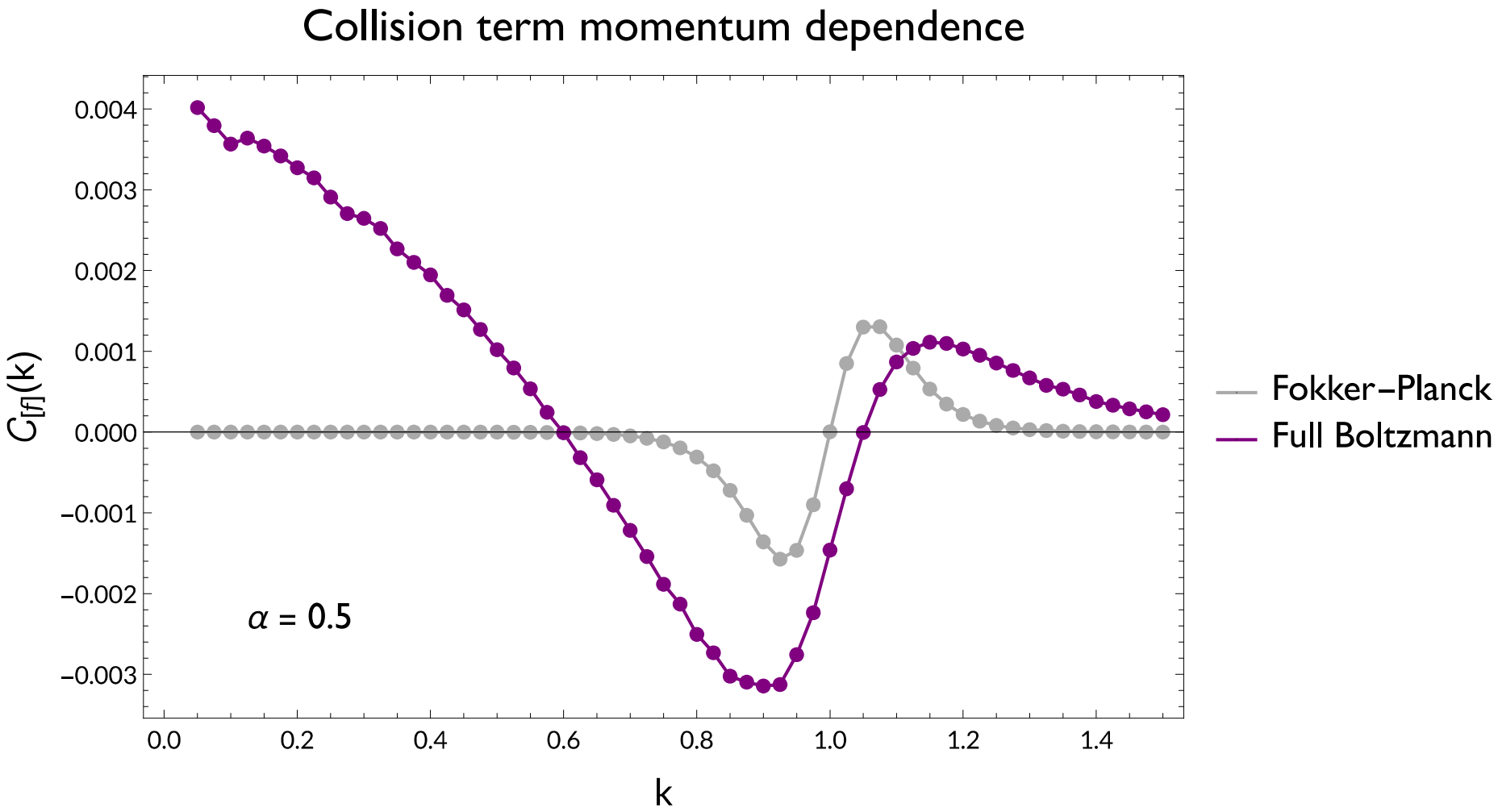
$$\partial_t f = \frac{1}{2E} \int_{234} \mathrm{d}\Gamma \, |\mathcal{M}|^2 \cdot \mathcal{F}_{[f]}$$

- Effects of the soft approximation
  - quantitative
  - qualitative?
- More? :)

EARLY RESULT



EARLY RESULT



CONCLUSION/OUTLOOK

- Full evolution in the works..

Thank you!

BACKUP SLIDES

Our list of assumptions/approximations:

- $2 \to 2$ interacting gluon system
- Distribution is spatially homogenous
- Distribution is spherically symmetric in momentum

BACKUP SLIDES

Our matrix element:

$$|\mathcal{M}|^2 = 72(4\pi\alpha)^2 \left[3 - \frac{tu}{s^2} - \frac{su}{t^2} - \frac{ts}{u^2}\right]$$

$$\frac{su}{(t-\mu^2)^2}$$