Nuclear Physics Working Group Report

CLAS Collaboration Meeting
Jefferson Lab

June 18th, 2016

Lamiaa El Fassi
(on behalf of Kawtar Hafidi)

MISSISSIPPI STATE UNIVERSITY

Analyses' Review Update

Deeply Virtual Compton Scattering off ^{4}He

By Mohammad Hattawy et al., IPN Orsay & ANL

Second round

Review committee: Michel Garçon (Chair), Sebastian Kuhn & Zein-Eddine Meziani

Differential cross sections for reactions gamma + d -> pi- p p_spec

N. Pivnyuk, ITEP

Second round

Review committee: S. Strauch (Chair), B. McKinnon and M. Mirazita

Measurements of the Fifth Structure Function of the Deuteron

By G. Gilfoyle, University of Richmond

First round

Review committee: S. Kuhn (Chair), A. El Alaoui and S. Gilad

Analyses' Review Update

Neutral pion electroproduction ratios off C, Fe, and Pb

By T. Mineeva, University of Connecticut

First round

Review committee: L. Weinstein (Chair), Y. Ilieva and M. Wood

Announcement:

- New NPWG chair election will start soon.

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- A nominating committee is formed by:
  - Stepan Stepanyan
  - Hovanes Egiyan
  - Lamiaa El Fassi (Chair)

NPWG Agenda

- No NPWG analysis talks this time (could be due to PAC work!?)

  But

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But

- Had three ALERT run-group proposals talks:

16:05 **Tagged EMC Measurements on Light Nuclei** *25'*
Speaker: Nathan Baltzell (JLab)
Material: **Slides**

16:30 **Tagged Deeply Virtual Compton Scattering Off Light Nuclei** *25'*
Speaker: Whitney Armstrong (Argonne National Laboratory)
Material: **Slides**

16:55 **Partonic Structure of Light Nuclei** *25'*
Speaker: Dr. Mohammad Hattawy (Argonne National Laboratory)
Material: **Slides**

ALERT Run Group

Nuclear Exclusive and Semi-inclusive Measurements with a New CLAS12 Low Energy Recoil Tracker

- Comprehensive suite of studies of ^{4}He nucleus
  - new measurements of SIDIS, DVCS, DVMP reactions
  - to study nuclear models of the EMC effect (including their treaments of off-shellness and FSI), and partonic (including gluonic) structure with GPDs
  - requiring detection of low energy p, ^{3}H, ^{3}He, ^{4}He recoils

- Three PAC-44 Proposals
  - *Tagged EMC Measurements off Light Nuclei*
  - *Tagged DVCS Off Light Nuclei*
  - *Partonic Structure of Light Nuclei*

- Detector System
  - CLAS12 Forward Detectors
  - New ALERT Recoil Detector

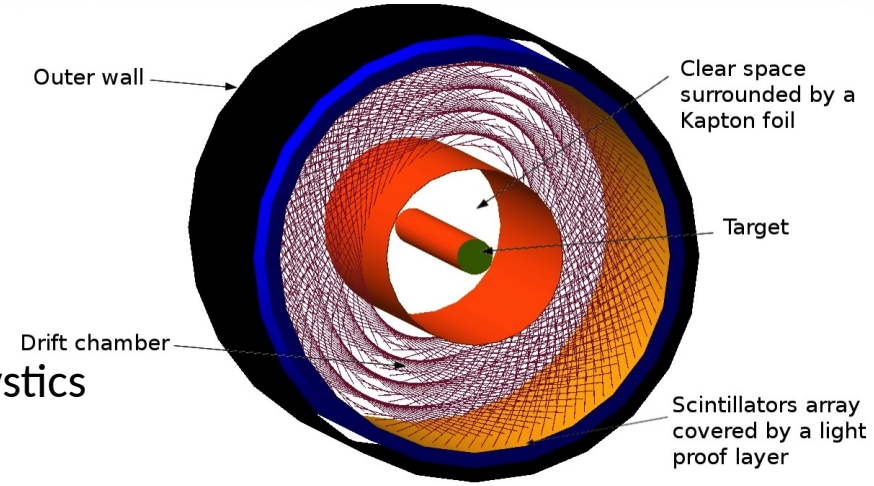
Primary Institutions:

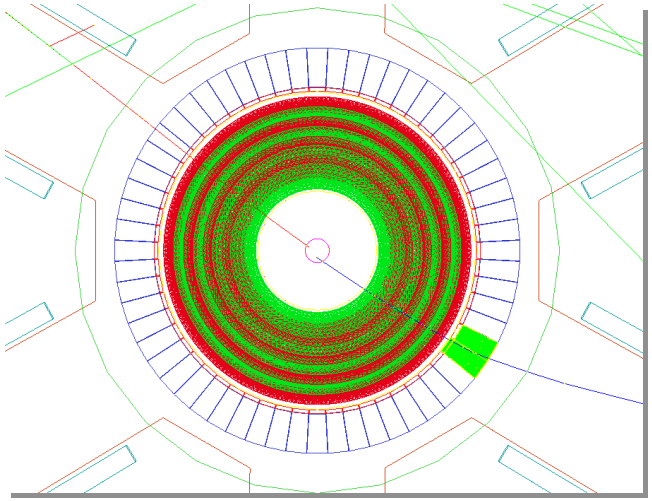
- Argonne National Laboratory
- Institut de Physique Nucléaire d'Orsay
- Temple University
- Jefferson Laboratory

Run Group Contact: K. Hafidi

ALERT Detector

- Gas Target
  - 30 cm effective length, 6 mm radius
  - 3 atm, 25 um Kapton walls
- Hyperbolic drift chamber (32 < R < 85 mm)
  - 30 cm longitudinal wires with 10° stereo
  - 8 ~circular layers of 2 mm hexagonal cells
  - Light gas mixture ~1 atm, insensitive to relativstics
  - 250 ns drift time, included in trigger
- Two Segmented Scintillator Cylinders
  - TOF and total energy measurements
  - Total thickness ~20 mm
  - SiPMs directly attached
  - 150 ps time resolution, can be included in trigger
- Full GEANT 4 Simulation
  - Used to optimize the detector design
  - Evaluate drift chamber occupancies, thresholds, time and tracking resolutions, PID of p, d, ^{3}H, ^{3}He, ^{4}He
- To Do
  - Evaluate/finalize electronics
  - Mechanical integration ongoing

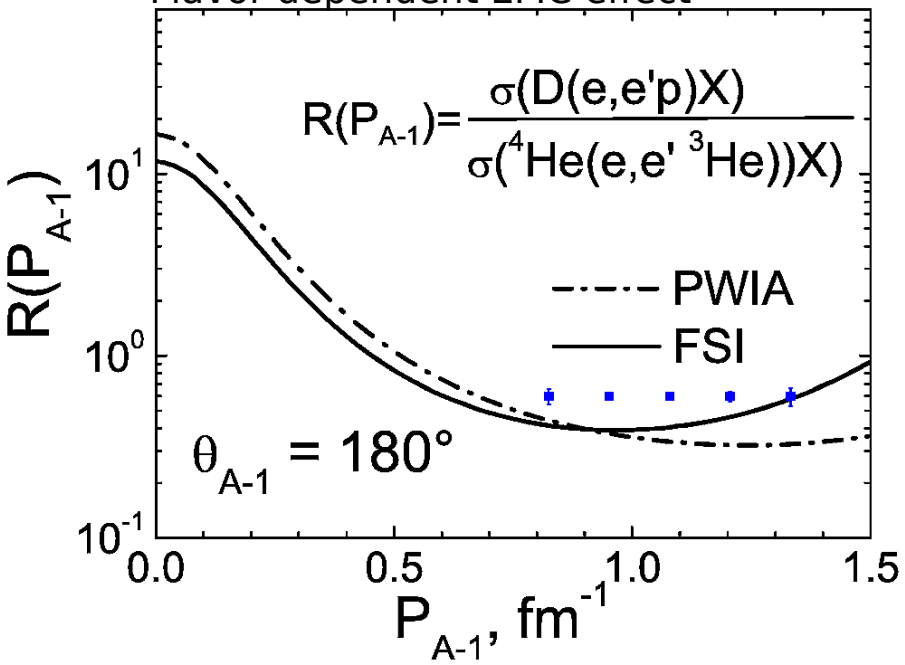


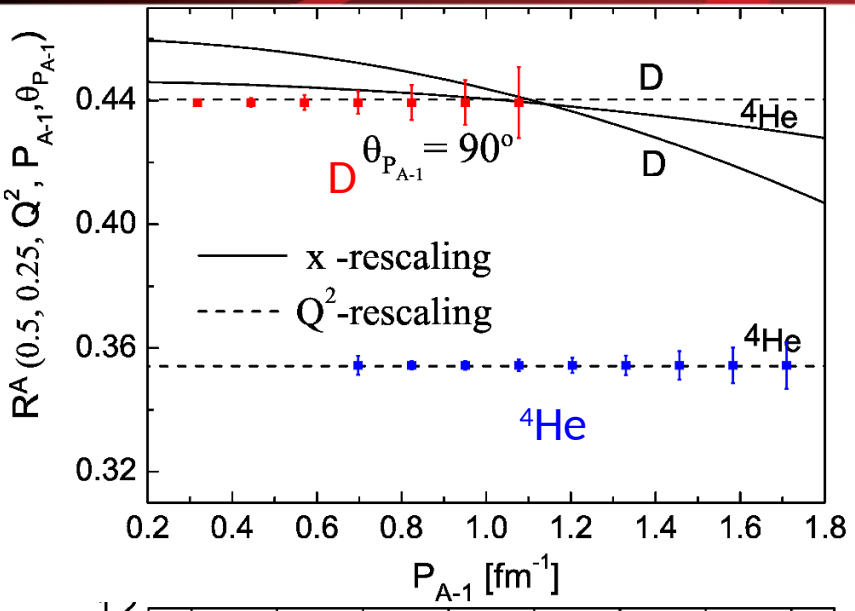


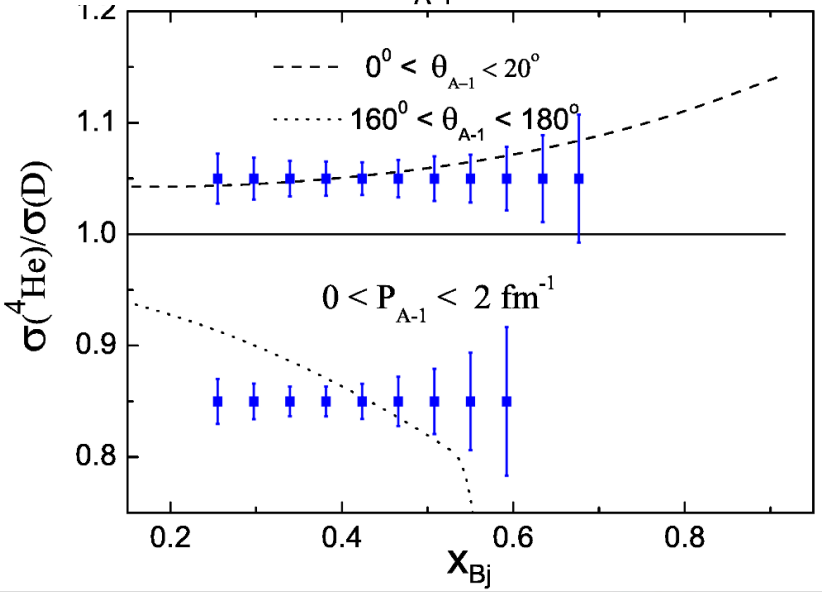
ALERT Tagged-EMC Proposal

Spokespeople: R. Dupré, G. Charles, K. Hafidi, G. Dodge, N. Baltzell

- 20 PAC days at 11 GeV on each of ^{4}He and ^{2}H
  - shared with rest of ALERT Run Group L
- Definitive tests of
  - Spectator model and FSI effects
  - x_B vs Q^2 rescaling of structure functions
  - Local EMC model offshellness
  - Flavor dependent EMC effect







Tagged DVCS Off Light Nuclei

An ALERT Run Group Proposal for JLab PAC 44

Whitney R. Armstrong

Argonne National Laboratory

June 17, 2016

On behalf of spokespersons,
R. Dupré, K. Hafidi, Z.-E. Meziani,
and the ALERT Collaboration

Using p-DVCS to cleanly measure n-DVCS

Bound Nucleon

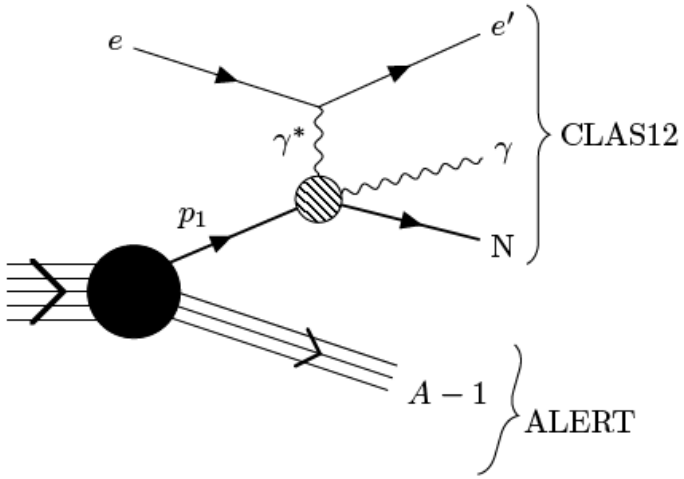
$^4\mathrm{He} + \gamma^* \rightarrow \gamma + p + {}^3\mathrm{H}$ → Test PWIA FSIs

Quasi-Free neutron

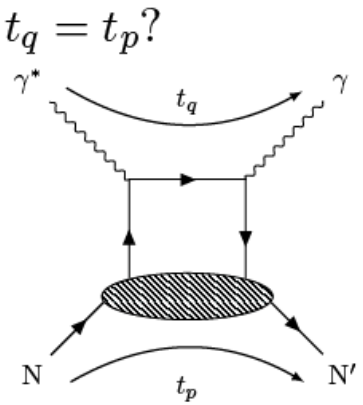
$^4\mathrm{He} + \gamma^* \rightarrow \gamma + (n) + {}^3\mathrm{He}$

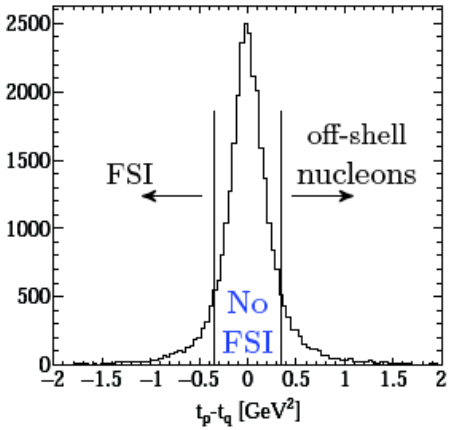
$^2\mathrm{H} + \gamma^* \rightarrow \gamma + (n) + p$

n-DVCS



- Use pDVCS to study FSIs and test the PWIA.
- Identify kinematics without FSIs
- Use charge symmetry → n-DVCS similarly free of FSI



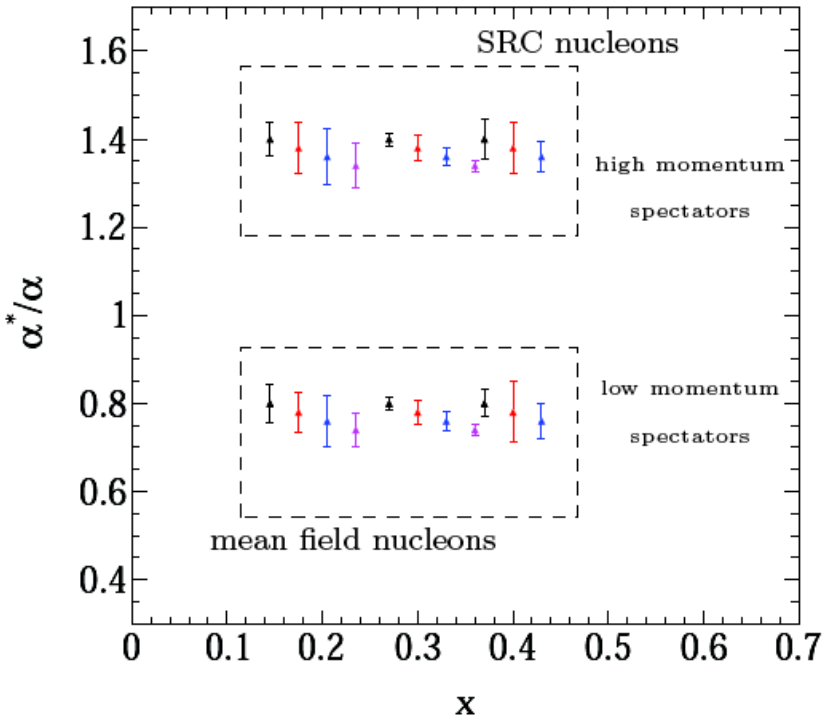


$$A_{LU}^{\sin\phi} = \frac{1}{\pi}\int_{\pi}^{\pi} d\phi \sin\phi = \alpha$$

Off-forward EMC Ratio

$$R_\alpha^n = \alpha_{n^*}^{(^4\mathrm{He})} / \alpha_n^{(^2\mathrm{H})}$$

Tagged DVCS Off Light Nuclei Summary



Colors indicate the different t bins which are shifted horizontally for clarity

Separated mean field nucleon EMC Effect and SRC nucleon EMC Effect

Observed deviations from 1 $\rightarrow$ medium modifications of nucleons at the partonic level

- Tagged DVCS has unique ability to study FSIs in a model independent way
- Determine **unambiguously** if mean field nucleons are modified in nuclei
- ^{4}He is the lightest of nuclei where this could easily be done
- Tagged DVCS BSA and FSI measurements complementary to a wide variety of existing and proposed experiments

Argonne NATIONAL LABORATORY

Jefferson Lab PAC 44

Nuclear Exclusive and Semi-inclusive Measurements with a New CLAS12 Low Energy Recoil Tracker

Partonic Structure of Light Nuclei

M. Hattawy (Argonne National Lab)

(On behalf of : N. Baltzell, R. Dupre, K. Hafidi, Z.-E. Meziani, M. Paolone)

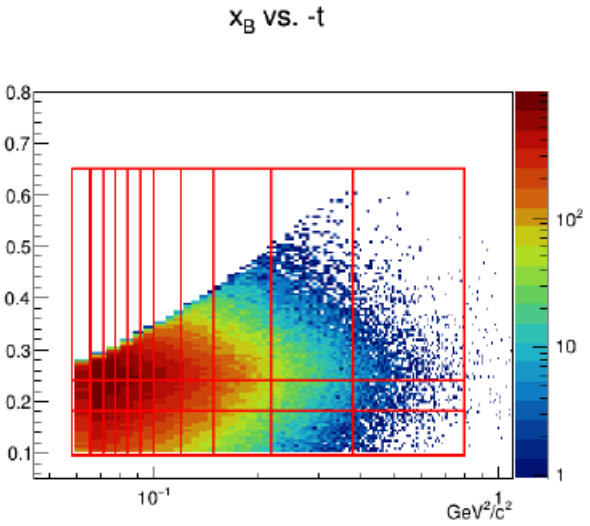
NPWG - CLAS Collaboration Meeting - Friday, 17 June 2016

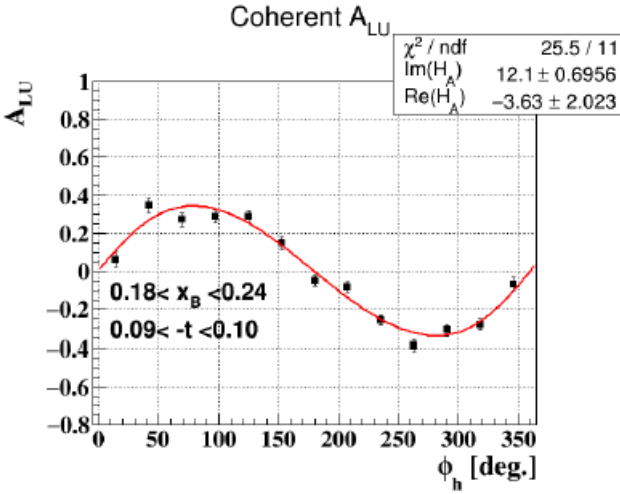
U.S. DEPARTMENT OF ENERGY

DVCS off He-4: Projected precisions

The statistical error bars are calculated for:

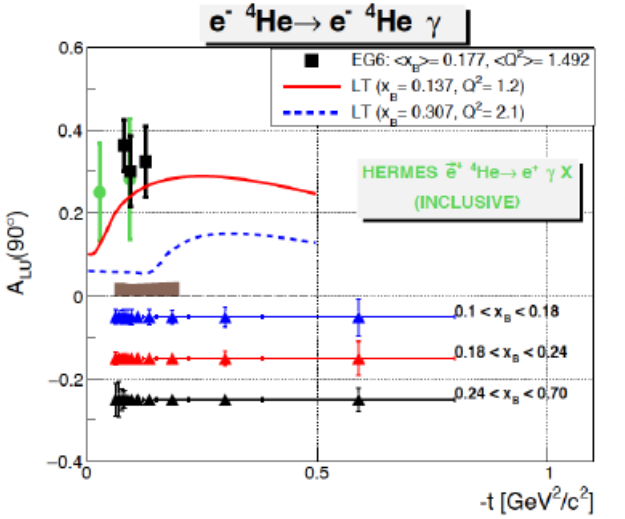
- 20 days at a luminosity of 3.0 X 10^{34} $cm^{-2}s^{-1}$.
- 10 days at a luminosity of 6 X 10^{34} $cm^{-2}s^{-1}$.

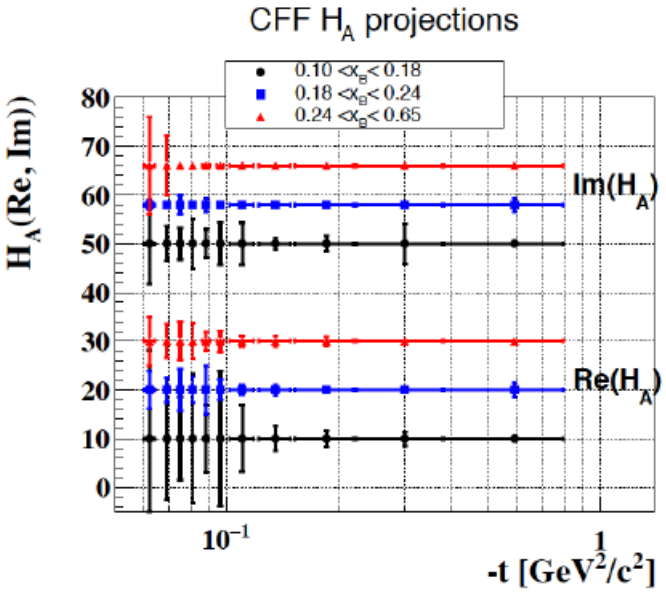


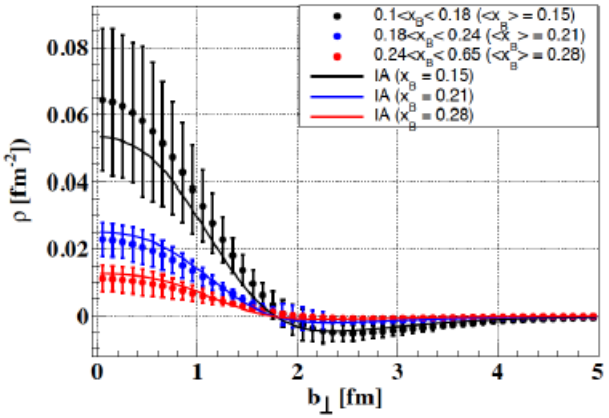


$$\rho(x,0,b_\perp) = \int_0^\infty J_0(b\sqrt{t}) H^A(x,0,t) \frac{\sqrt{t}}{2\pi} d\sqrt{t}$$

Projected charge profile precisions







φ production off He-4: Gluon profiles

$$e + {}^4He \rightarrow e' + {}^4He + \phi(K^+ + K^-) \qquad \frac{d\sigma_L}{dt} = \frac{1}{(\varepsilon + 1/R)\Gamma(Q^2, x_B, E)} \frac{d^3\sigma}{dQ^2 dx_B dt}$$

R can be extracted from the angular distribution of the kaon decay
In the phi helicity frame, assuming s-channel helicity conservation:

$$W(\cos\theta_H) = \frac{3}{4}\left[(1 - r_{00}^{04}) + (3r_{00}^{04} - 1)\cos^2\theta_H\right]$$

Angular distribution amplitude

Spin-density matrix coefficient: $r_{00}^{04} = \frac{\epsilon R}{1 + \epsilon R}$

Angle of kaon decay In phi helicity frame

Gluon density calculation:

$$\rho_g(x, 0, b_\perp) \rightarrow \int_0^\infty J_0(b\sqrt{t}) \sqrt{\frac{d\sigma_L}{dt}} \frac{\sqrt{t}}{2\pi} d\sqrt{t}$$