Introduction to the 1.5 days mini-workshop on

Gluons at RHIC

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The gluons are abundant in the proton. Because of this, gluons play a very important role in the interaction of the protons. The reaction is dominated by gluon related sub processes such as $gg \rightarrow gg$ or $gq \rightarrow gq$. The dominance of gluon contribution is especially true for the higher energy hadron collisions, such as RHIC, Tevatron, and LHC.

The behavior of the gluon in the proton is less known than the quarks in the proton, since a major probe to investigate the internal structure of the proton, the deep inelastic scattering of leptons off the proton target, is not sensitive to the gluon distribution. Therefore, the behavior of the gluons in the protons has been studied in the pp or $pbar\,p$ interactions.

The RHIC at Brookhaven National Laboratory will provide a completely new domain of the gluon study for the following reasons:

1) study of polarized gluons has become possible,
2) pp collision will reach its high energy frontier, and
3) pA and AA collisions will elucidate the gluons in nuclei, which is crucial information for the exotic search in AA collisions.

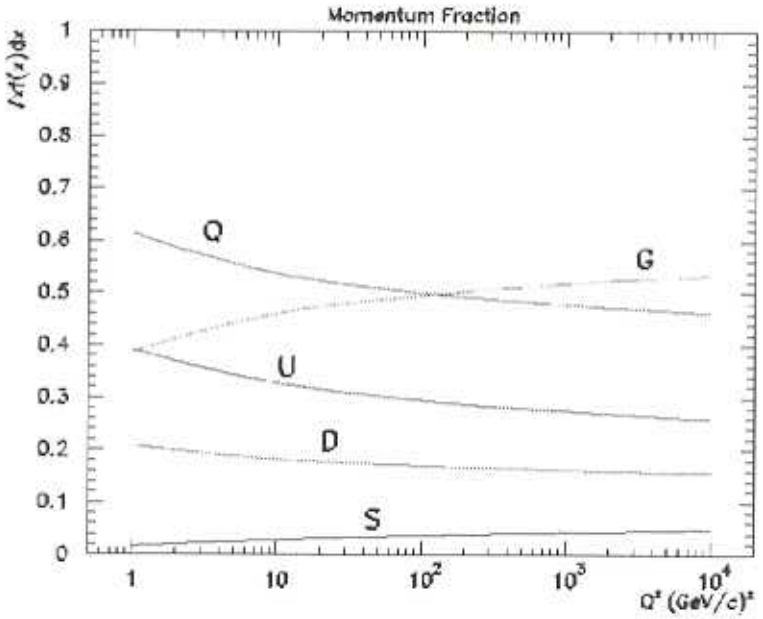
The goal of this workshop is to summarize the current status of the knowledge on the gluons in the unpolarized and the polarized proton and to discuss how we can improve our knowledge using the RHIC. A special emphasis is put on the measurements of gluon polarization in the proton at RHIC from three aspects:

1) theoretical definition of gluon polarization and its gauge-invariance,
2) experimental method to extract the gluon polarization from polarized pp reaction, and
3) theoretical and experimental uncertainties involved in the determination of the gluon polarization.

Finally the sensitivity of the proposed RHIC measurements will be compared with other possible measurements, such as COMPASS and polarized-HERA. The summary table will follow soon.

Gluon Studies in *pp* Collisions

- Gluons are abundant in the proton
  - gluon related processes dominate the reaction
    - $gg \rightarrow gg$, $gq \rightarrow gq$
  - This is true in extremely high energy
    - RHIC, (Tevatron), LHC



- Less known for gluon
  - sensitivity of DIS limited
  - extraction of structure fn's from hadron collisions more complicated than DIS

Gluons at RHIC

- Completely new domain of studies
  - polarized gluon, $\Delta G(x)$
    - one of the major interests in RHIC Spin physics
  - even unpolarized gluon $G(x)$
    - highest energy in *pp* collisions; any energy dependent systematic uncertainty?
  - "*EMC effect*" in gluon
    - *p*A and AA; how gluons behave in nuclei?
    - provide a basis of "exotic search" in AA
      - J/ψ suppression ; open heavy flavor production
      - nuclear shadowing effect

Unpolarized Gluon Distribution

→ Steve Kuhlmann's Talk

- Comparison of the most recent analysis

  normalized to MRST central

  – MRST distribution
    - hep-ph/9803445
    - 3 versions of $g(x)$

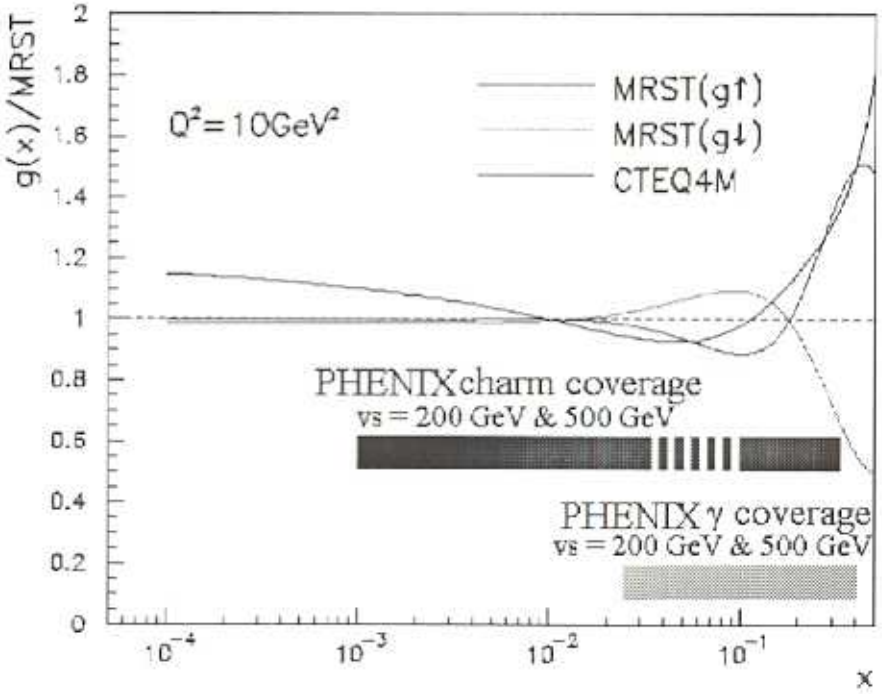
    $\langle k_T \rangle$ = 0.0, 0.4, 0.64 GeV

    – MRST(g ↑) high gluon

    – MRST central

    – MRST(g ↓) low gluon

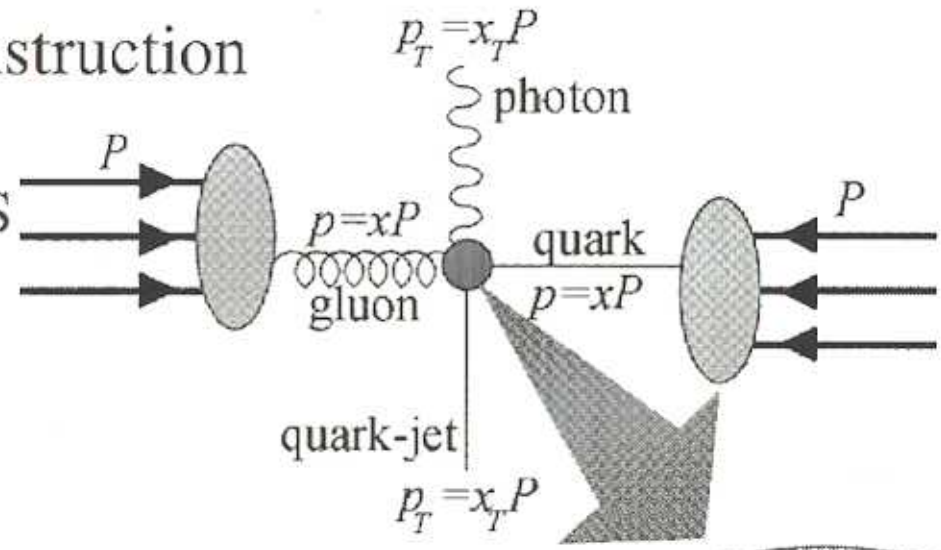
  – CTEQ4M
    - PR **D55** (97) 1280



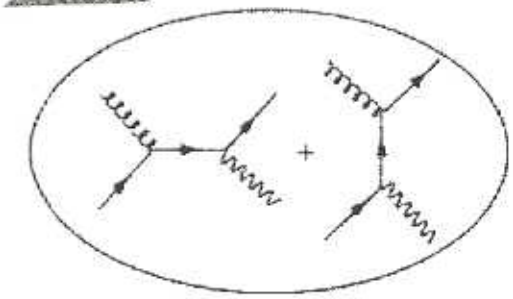
Partonic Kinematics

prompt photon example

- Simple minded reconstruction of partonic kinematics
  - pp CMS = parton CMS
- What is Q^2 ?
  - $Q^2 = p_T^2$?
  - $Q^2 = (p_T/2)^2$?
  - $Q^2 = (2\,p_T)^2$?
- How NLO changes this view?



$$\begin{cases} p_T = p \\ x_T = x \end{cases}$$



温故知新

- 温故知新

  revisit the past to learn something new

  —温(*vt.*) (1) to warm up (2) to revisit or even reincarnate

- 温糊知新

  —糊(*n*) (1) glue

  —温糊知新 = RHIC Spin and HI!

  (1) revisit gluon to learn something new

  (2) warm up gluon to learn something new