Understanding $q\bar{q}$ Creation

Mac Mestayer

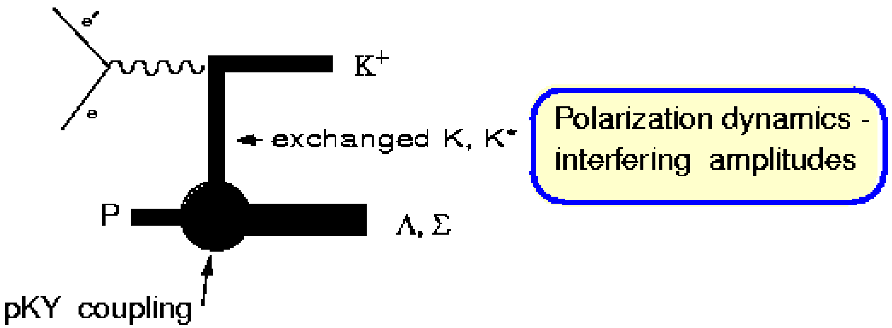
Does the quark model work for exclusive production?
- compared to an hadronic current approach.

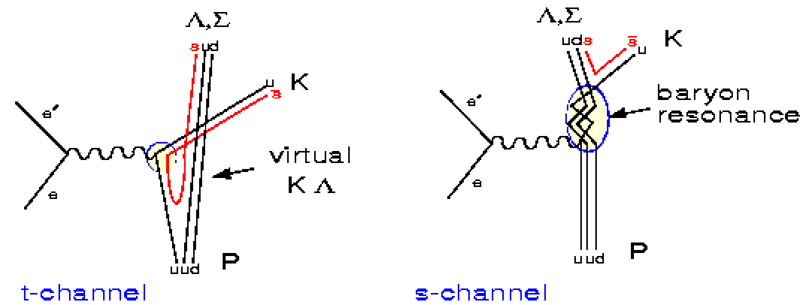
What are ‘constituent quarks’?

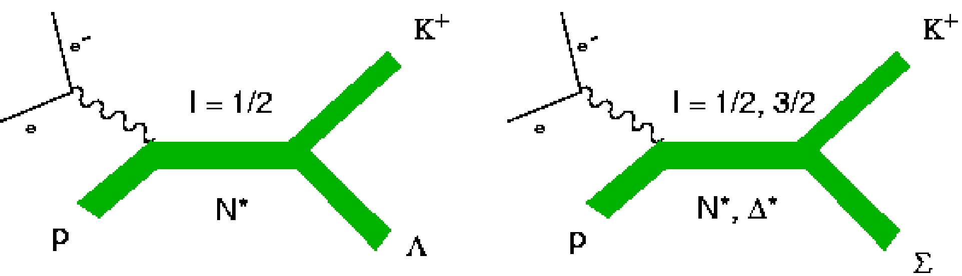
What is the ‘flux-tube’?

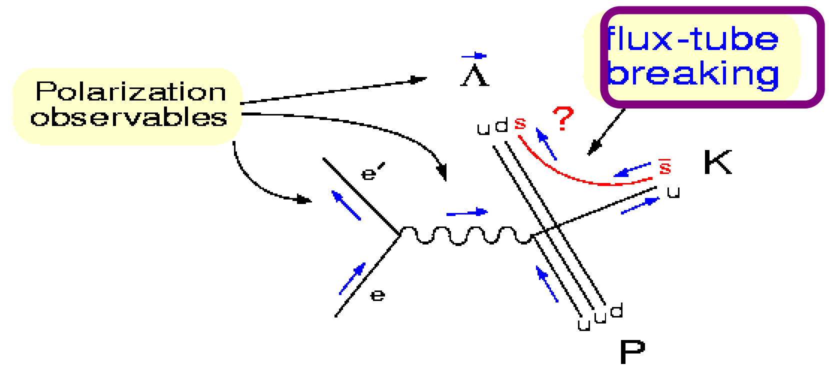
How do $q\bar{q}$ pairs ‘break’ or ‘neutralize’ the color force-field?
What is the flavor dependence?
What is the angular momentum structure?

How to describe exclusive production ? hadrons or quarks ?









- Currents are mesons, baryons
- Not “elementary”
- Mature field; but many parameters

- Currents are constituent quarks
- Not “elementary” either !
- Successes in meson decays; not as much work on production

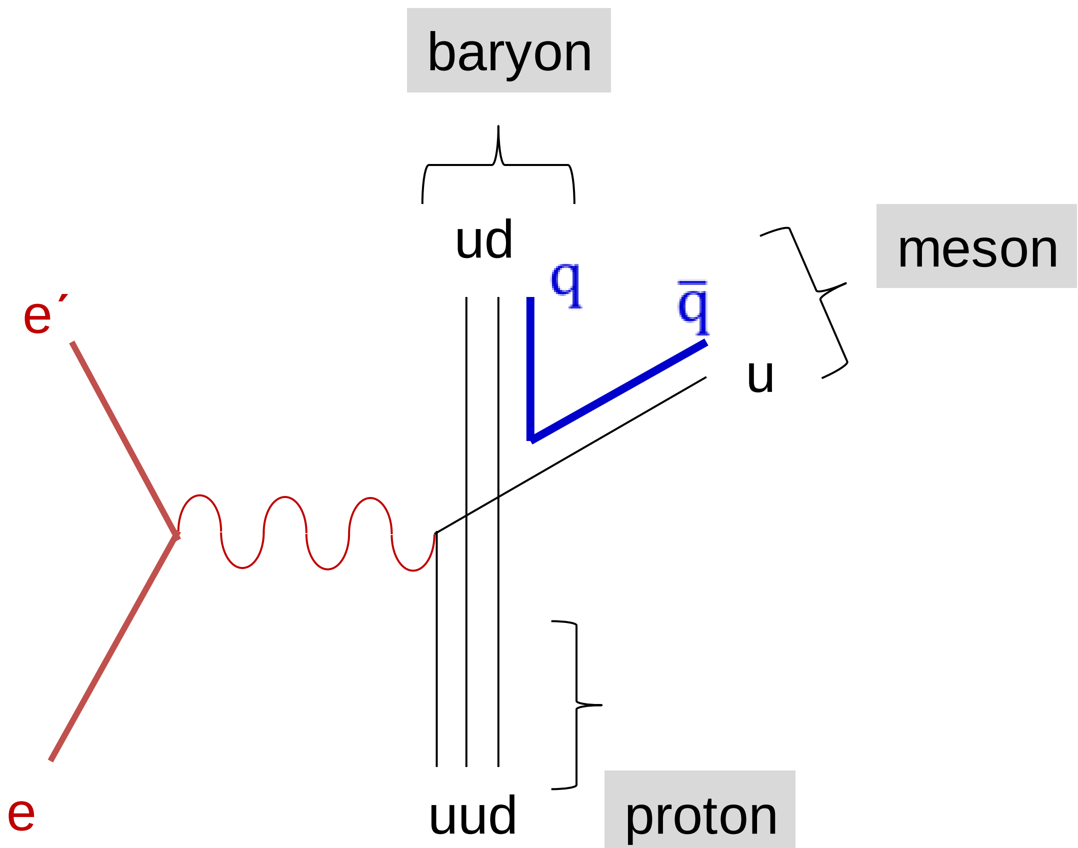
“Strangeness Suppression in $q\bar{q}$ Creation Observed in Exclusive Production” *

Mac Mestayer, Kijun Park & CLAS Collaboration

- What did we measure ?
  - ratio of electro-production cross-sections for 2-body (baryon-meson) final states: $K^+\Lambda$, π^+n and π^0p
  - ratio of processes in which only one $q\bar{q}$ pair is produced
  - in a quark model picture, the ratios are proportional to the relative production rates of $s\bar{s}$, $d\bar{d}$, or $u\bar{u}$
- What was the physics conclusion?
  - that $s\bar{s}$ production is suppressed relative to $d\bar{d}$ and $u\bar{u}$
  - suppression factor may be universal

* accepted for publication in Phys. Rev. Lett.

Exclusive Baryon Meson Production
- quark model picture



$q\bar{q}$	Final State
$u\bar{u}$	π^0 p
$d\bar{d}$	π^+ n
$s\bar{s}$	$K^+ \Lambda$

Strangeness Suppression Results

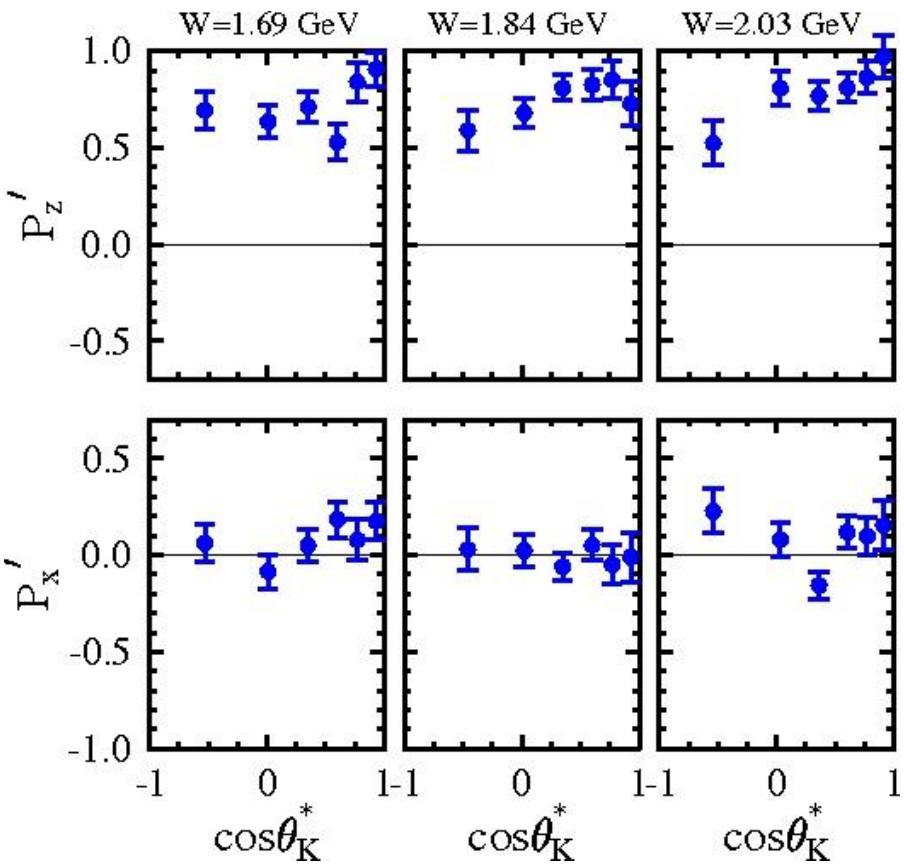
Experimental Ratio Used	$s\bar{s}/d\bar{d}$
$\Lambda K^+/n\pi^+$	0.19 +/- 0.03
$\Lambda K^+/p\pi^0$ "a"	0.22 +/- 0.07
$\Lambda K^+/p\pi^0$ "b"	0.28 +/- 0.07

"a" → assume $u\bar{u}/d\bar{d} = 0.74$ "b" → assume $u\bar{u}/d\bar{d} = 1$

Strangeness suppression is ~same in the exclusive limit as it is at the Z mass → suggests that it is a **universal phenomenon** ?

- what are the dynamics ?

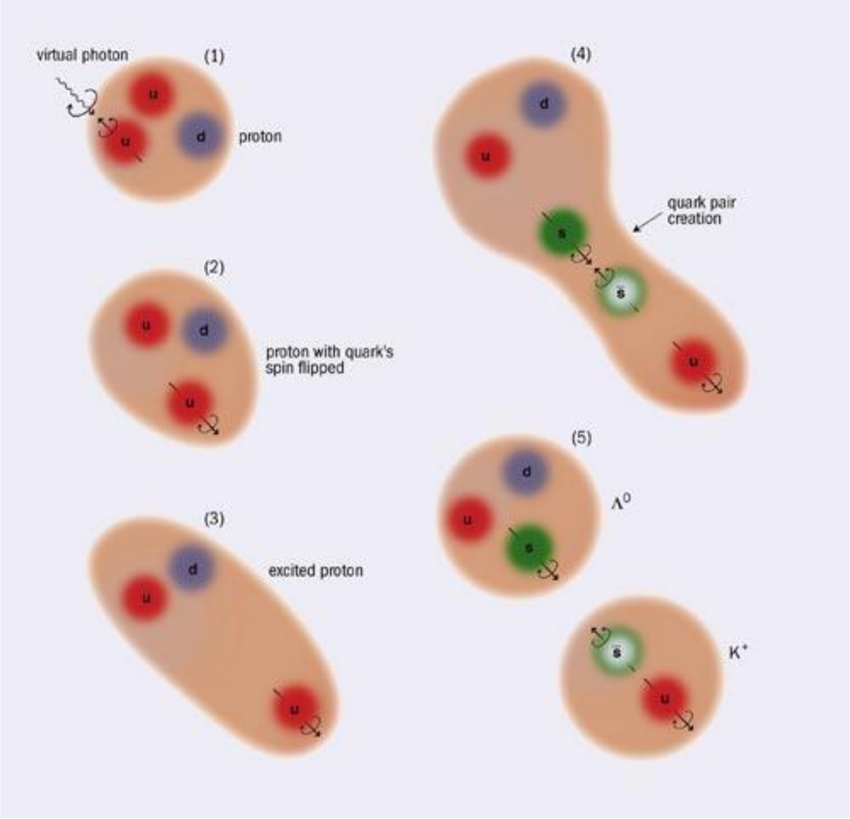
Polarization Transfer in $\vec{e}p \rightarrow K^+\vec{\Lambda}$ *



Polarization transfer to Λ is **very large**

* Phys.Rev.Lett. 90 (2003) 131804

Λ – polarization and $q\bar{q}$ Spin State



CERN Cour. June, 2003 *
CERN Cour. September, 2007 **

Simple quark reaction process:
Two-step process
- polarized γ → polarized u-quark
- scalar K^+ → polarized $\bar{s}$ quark
- observed Λ polarization → $s\bar{s}$ in spin-0 state

Not consistent with $^3P_0$??

* “Jlab results put new spin on the vacuum”
** “Polarized hyperons probe dynamics of quark spin”

Conclusions and Future Studies

- Can simple quark dynamics explain low-energy phenomena ?
  is $q\bar{q}$ creation a universal phenomenon ?
  - early evidence says yes to both
- Is $u\bar{u} = d\bar{d}$? (our data show 0.74 +/- 0.18)
  - study ratio of $\pi^0 p / \pi^+ n$ from D_2 target
- Can theory explain the dynamics of $q\bar{q}$ creation?
  - what role does angular momentum play ? *
  - study Λ transferred polarization in K*Λ final states
- What other experiments can we do ?

* "On the Mechanism of Open-Flavor Strong Decays", E.S. Ackleh, T. Barnes, E.S. Swanson, Phys.Rev.D54 (1996) 6811-6829

Analysis in brief:

- Detect electron and charged hadron (π^+, p, or K^+)
- Bin: Q^2, W, $\cos\theta$, ϕ
- Identify neutral hadron (n, π^0 or Λ) by missing mass
  - fit (sig. + bkgd.), subtract bkgd., count within cuts
- Corrections to yield
  - efficiency/acceptance, phase-space
- Fit corrected ϕ distribution: ($a + b\cos\phi + c\cos2\phi$)
- Ratio of constant terms: $K^+\Lambda/\pi^+n$, π^0p/π^+n, $K^+\Lambda/\pi^0p$

LUND Model of Hadronization (for electro-production)

- Virtual photon ‘knocks’ a quark out of the proton
- Quark recoils from the remainder di-quark;
- stretching a ‘flux-tube’ between them
  - energy density ~ 1 GeV/fermi
- A $q\bar{q}$ pair tunnels out of the potential energy well
- Probability $\approx e^{-\pi m^2 / k}$
  - m is the quark mass; k is the flux-tube energy density
- Ratio of $s\bar{s} : d\bar{d} : u\bar{u} \approx 0.3 : 1 : 1$