Roger Cashmore:1965-2015

Oxford to SLAC to Oxford

Frank Close

1964: Higgs; Quarks;
Roger@Oxford

1970: Quarks@Oxford; Partons@SLAC;
Roger@SLAC

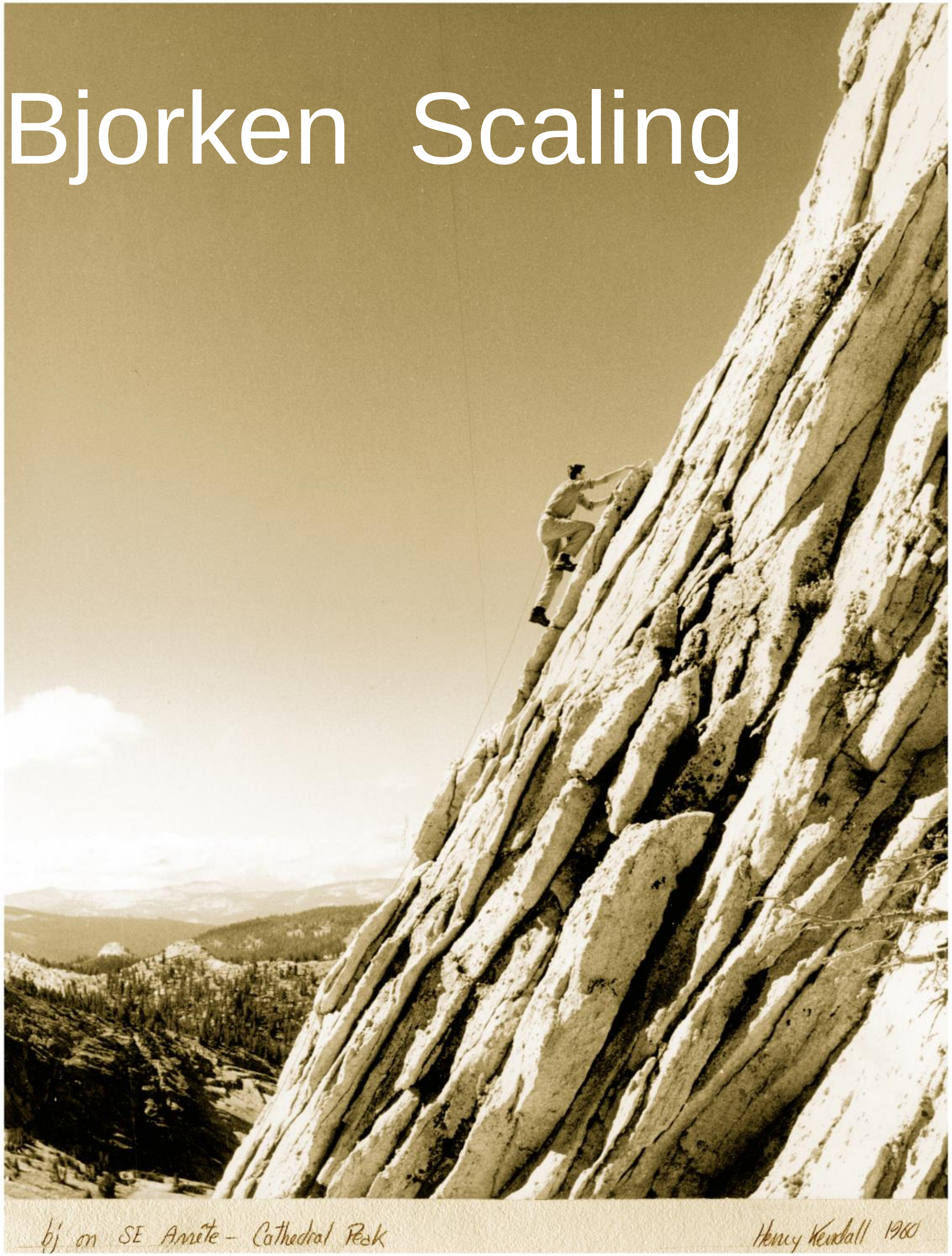
1970

CHLS@SLAC => QCD

FEC@SLAC=> Quarks <=**Roger@SLAC**

Tony Hey@Caltech;

Bjorken Scaling



Oxford@SLAC-PUB

SLAC-PUB-1107
(TH) and (EXP)
September 1972

SPONTANEOUSLY BROKEN GAUGE THEORIES OF WEAK INTERACTIONS AND HEAVY LEPTONS*

J. D. Bjorken and C. H. Llewellyn Smith†
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

Oxford@SLAC-PUB

SLAC-PUB-1007
(TH) and (EXP)
January 1972

HELICITY STRUCTURE OF NUCLEON RESONANCE ELECTROPRODUCTION AND THE SYMMETRIC QUARK MODEL*

F. E. Close† and F. J. Gilman
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

ABSTRACT

SLAC-PUB-923
June 1971
(TH)

INELASTIC LEPTON SCATTERING IN GLUON MODELS*

C. H. Llewellyn Smith
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

ABSTRACT

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SLAC-PUB-
(TH) and (EXP)
December 1971

A DESCRIPTION FOR THE REACTIONS

$a + b \rightarrow c + d + e$*

R. J. Cashmore
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SLAC-PUB-1007
(TH) and (EXP)
January 1972

HELICITY STRUCTURE OF NUCLEON RESONANCE ELECTROPRODUCTION AND THE SYMMETRIC QUARK MODEL*

F. E. Close† and F. J. Gilman

Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

ABSTRACT

SLAC-PUB-1001
(TH) and (EXP)
December 1971

WEAK AND ELECTROPRODUCTION OF NUCLEON RESONANCES IN THE HARMONIC OSCILLATOR QUARK MODEL*

Tariq Abdullah

Department of Theoretical Physics
12 Parks Road, Oxford, England

and

Francis E. Close†

Stanford Linear Accelerator Center
Stanford University, Stanford, California 94305

SLAC-PUB-1000
(TH) and (EXP)
December 1971

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$$a + b \rightarrow c + d + e^{*}$$

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Stanford University, Stanford, California 94305

and

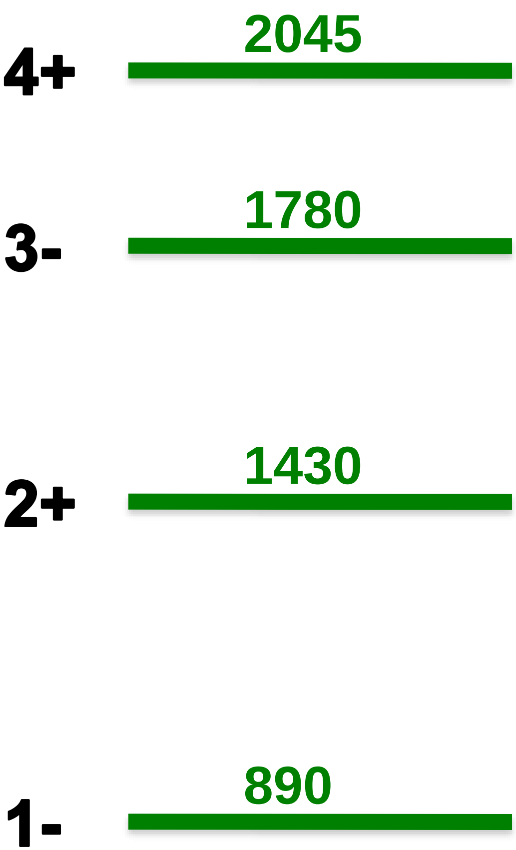
A. J. G. Hey

California Institute of Technology
Pasadena, California 91109

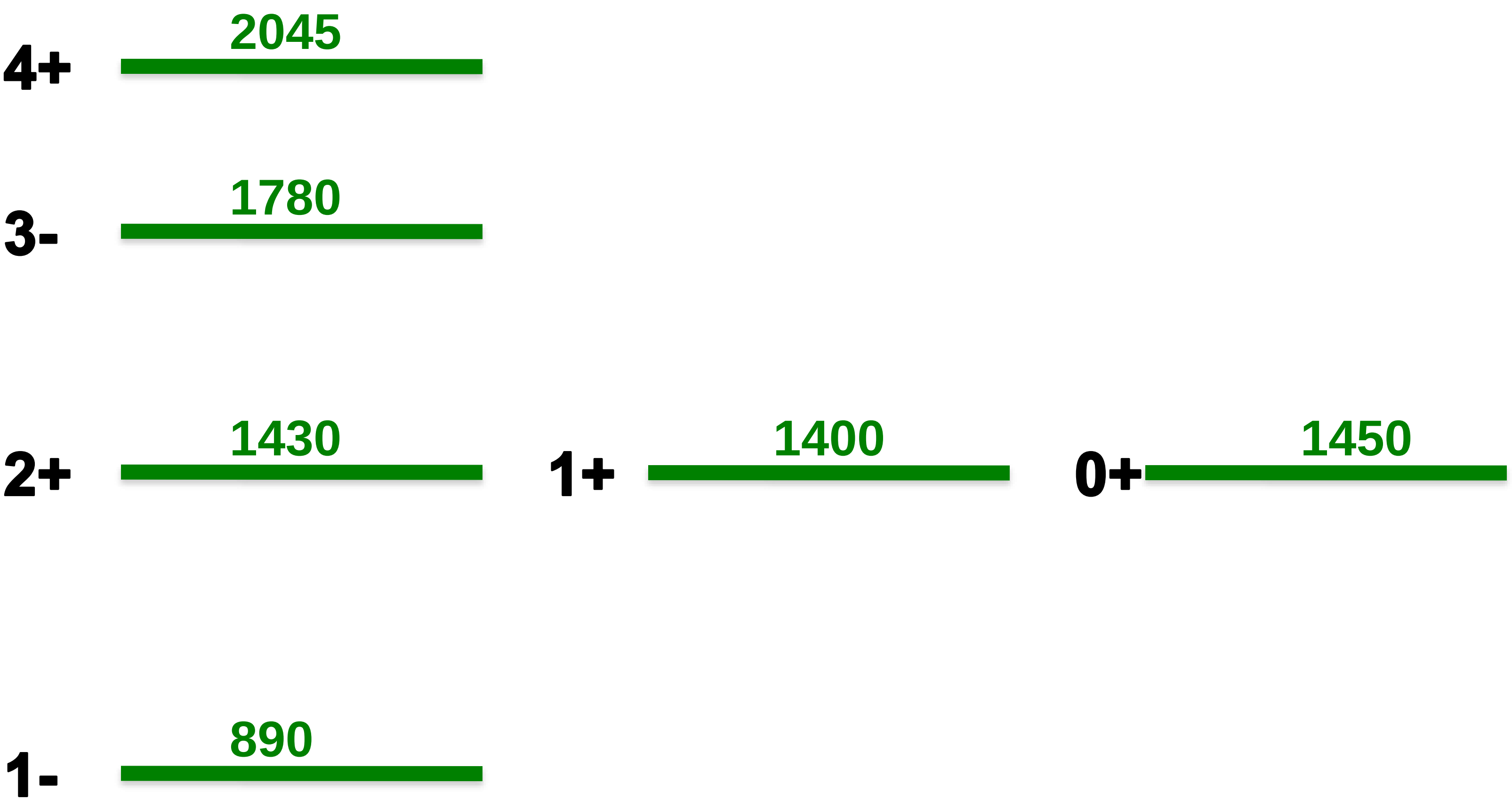
RJC and Quarks@SLAC:1971

- RJC spectroscopy N* and mesons (David Leith's group @SLAC)
- Leith group Strange mesons:
  Textbook Strange linear potential in 1971 !!!
- scalar K(1450)
  sets the scalar scale + fits scalar glueball (later)

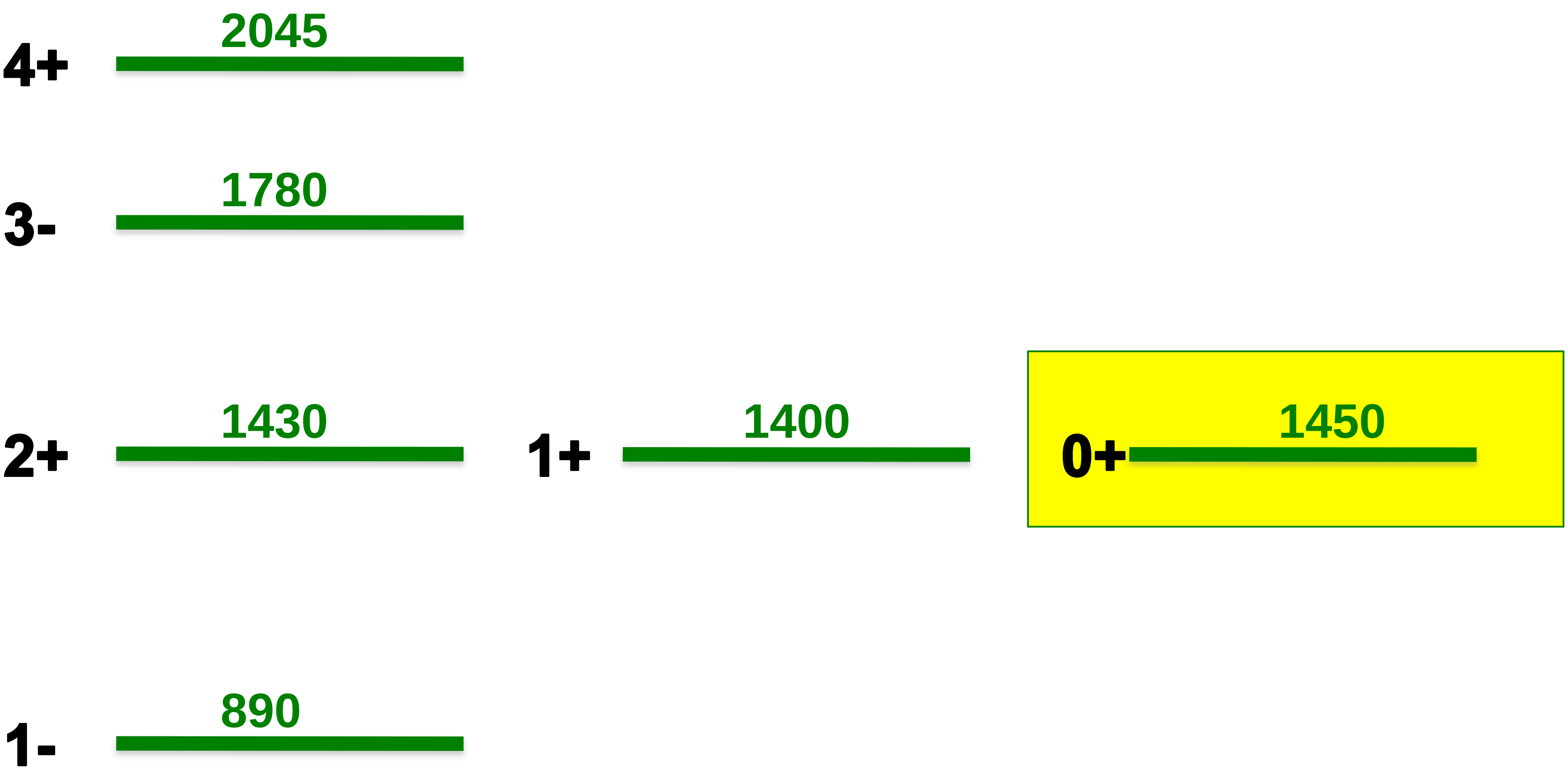
Strange Quark ^3P_J Spectrum: **Leith Group SLAC 1971**



Strange Quark ^3P_J Spectrum: **Leith Group SLAC 1971**



Strange Quark ^3P_J Spectrum: **Leith Group SLAC 1971**



1964 Quarks as constituents: Dalitz

Mass large;
Big binding energy
Non relativistic

1967 Quarks in Deep inelastic: SLAC CERN

Mass small
QCD Lagrangian
What relation?

1969 **Feynman** Kislinger Ravndal Non relativistic Quark Model

But are they “real” or just group theory algebra artefacts?

Volume 38B, number 7 PHYSICS LETTERS 3 April 1972

HELICITY STRUCTURE OF NUCLEON RESONANCE ELECTROPRODUCTION AND THE SYMMETRIC QUARK MODEL *

F. E. CLOSE ** and F. J. GILMAN
Stanford Linear Accelerator Center, Stanford University, Stanford, Calif. 94305, *USA*

Received 18 January 1972

The symmetric quark model with harmonic forces is shown to lead to a rapid change with q^2 of the helicity structure for electroproduction of the second (D_{13}) and third (F_{15}) nucleon resonances. Preliminary results of coincidence measurements of pi-zero electroproduction in the resonance region are found to disagree with this prediction. Some further experimental tests and theoretical consequences of this failure are discussed.

Close Gilman 1972: Photoproduction to electroproduction.

Reveals Quarks are dynamic: “real”

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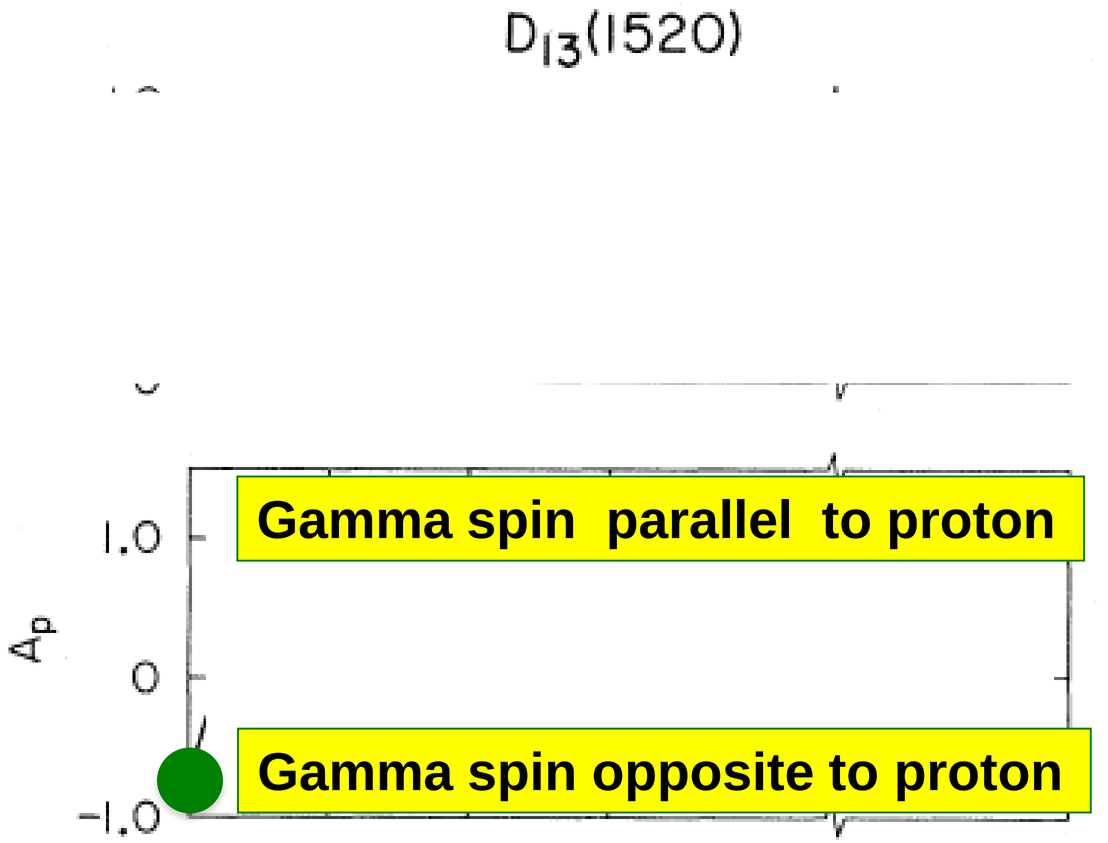
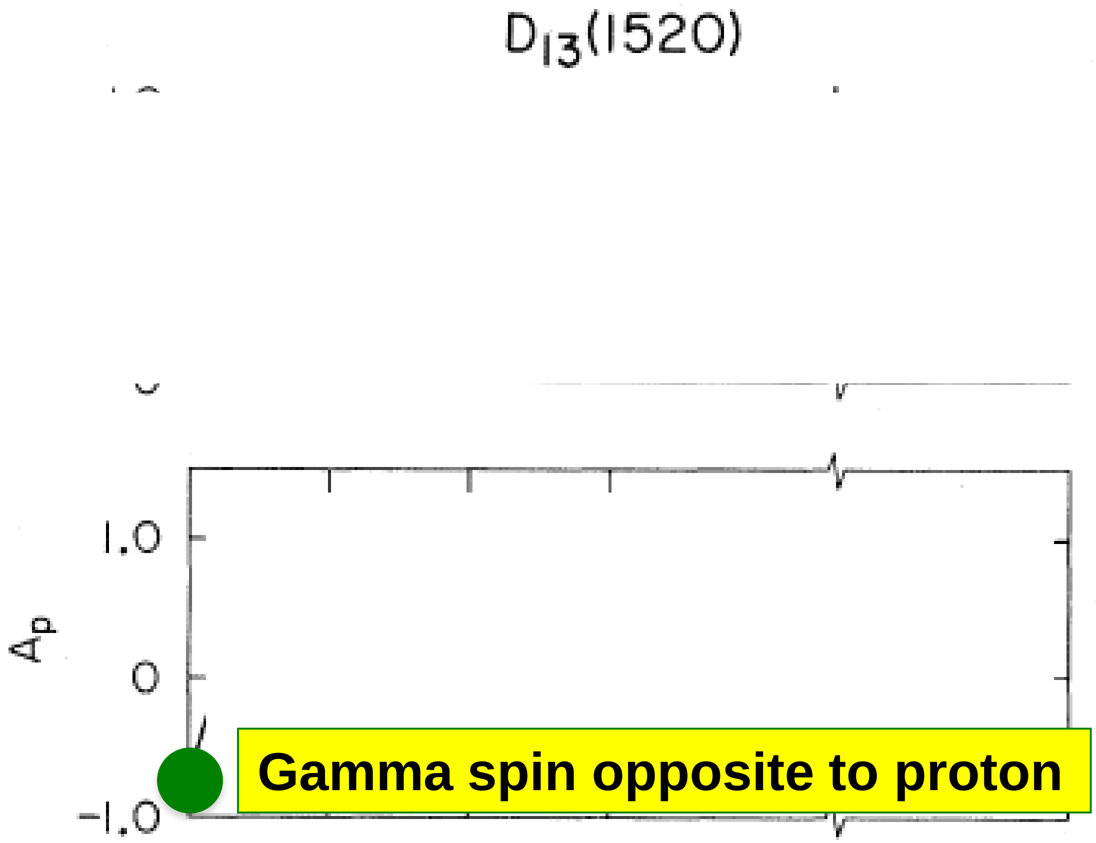
If constituent quarks are physical:

magnetic dominates electric at large q^2

Spin polarisation asymmetry changes sign



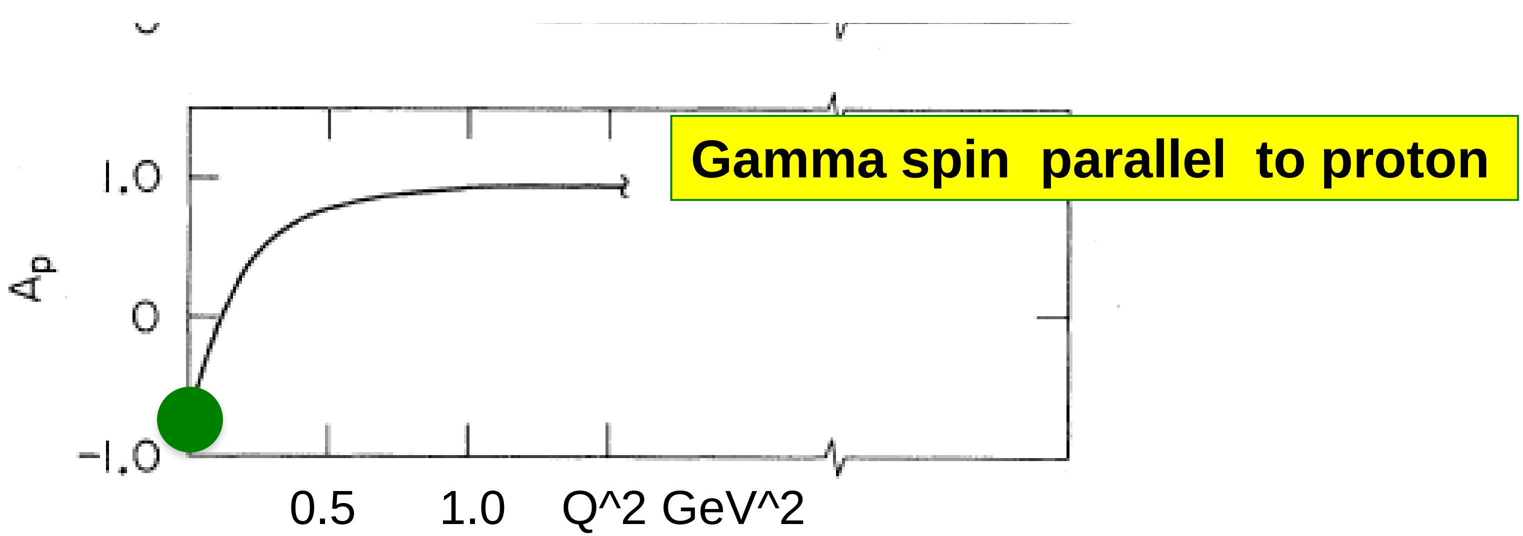
D13(1520)
1.0
0
−1.0
Ap
Gamma spin parallel to proton
Gamma spin opposite to proton



Feynman Quark Model fitted this OK

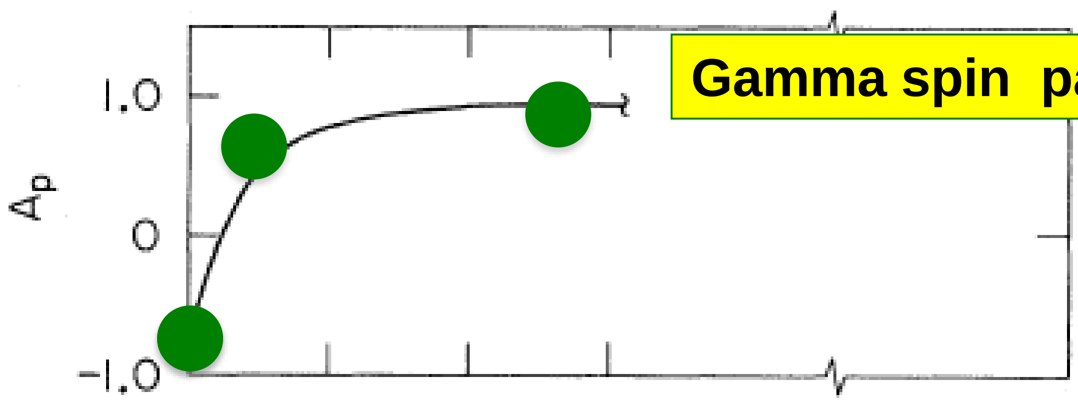
$D_{13}(1520)$

Close Gilman predict dramatic change in sign



$D_{13}(1520)$

Daresbury NINA + Bonn confirm



Gamma spin parallel to proton

0.5 1.0 Q^2 GeV^2

- Constituent quarks are “real” – but what and why?

- ??Constituent glue??

- 1994 Lattice: Scalar glueball ~1500MeV
- 2015 Naïve: Lattice glueballs dont exist

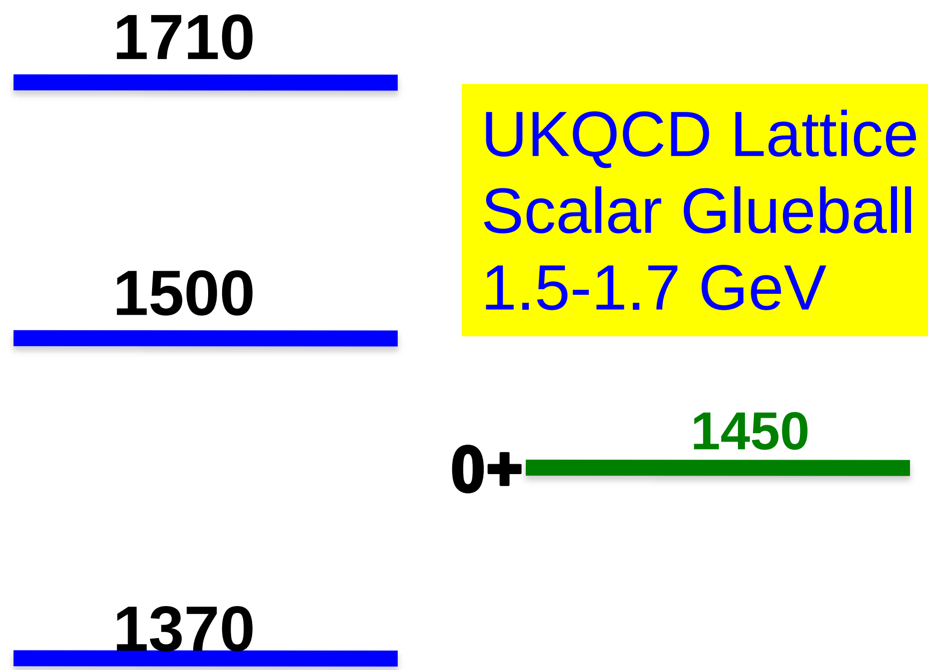
Scalars: Strange Leith + Lattice Glueball ……………

UKQCD Lattice
Scalar Glueball
1.5-1.7 GeV

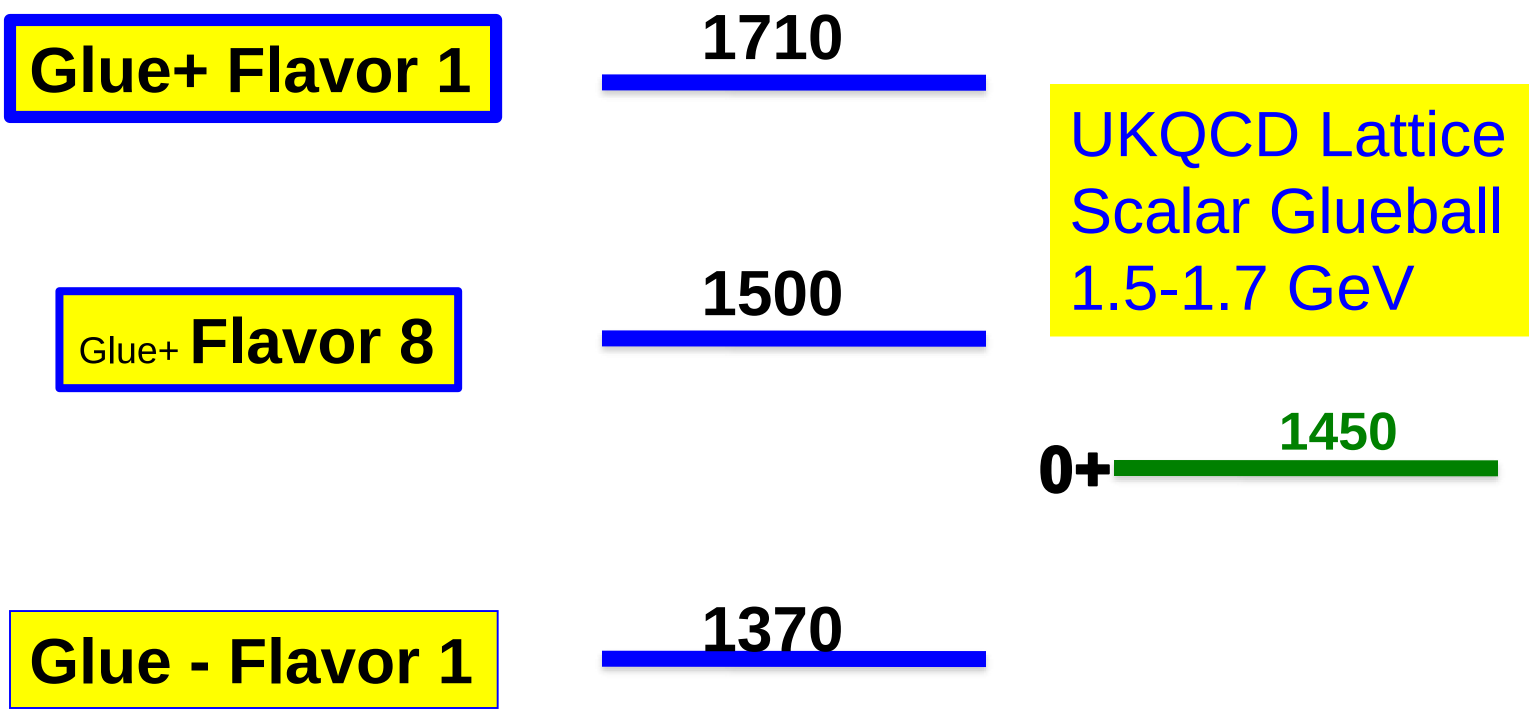
1450

0+

Scalars 2015:



Scalar Glueball Mixed 2015: e.g. LHCb + Close-Kirk

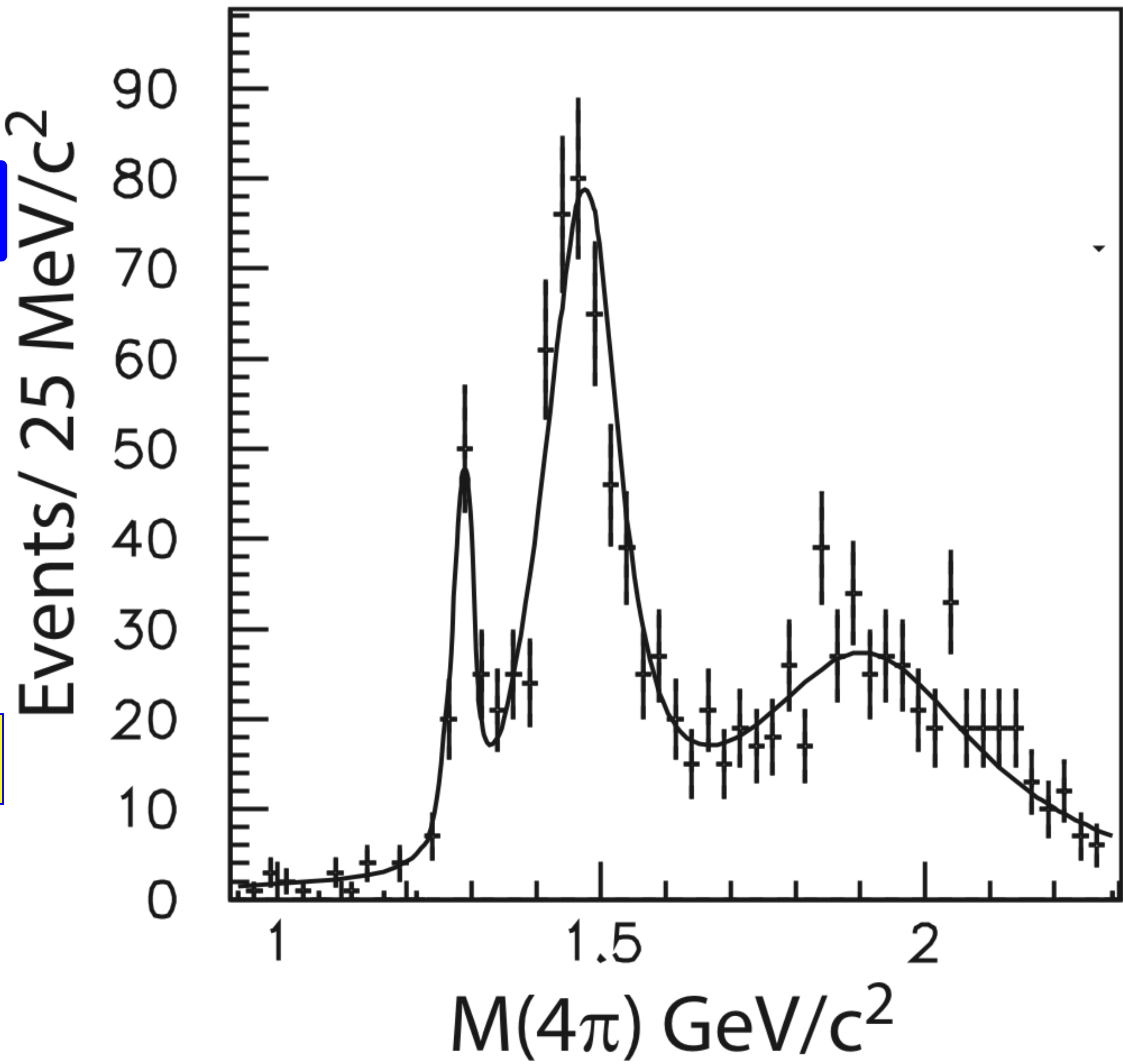


Close-Kirk Phys Rev 91; 114015 June 2015; **LHCb B_s \to \psi + 4\pi**

1710 **Glue+ Flavor 1**

1500 Glue+ **Flavor 8**

1370 **Glue - Flavor 1**

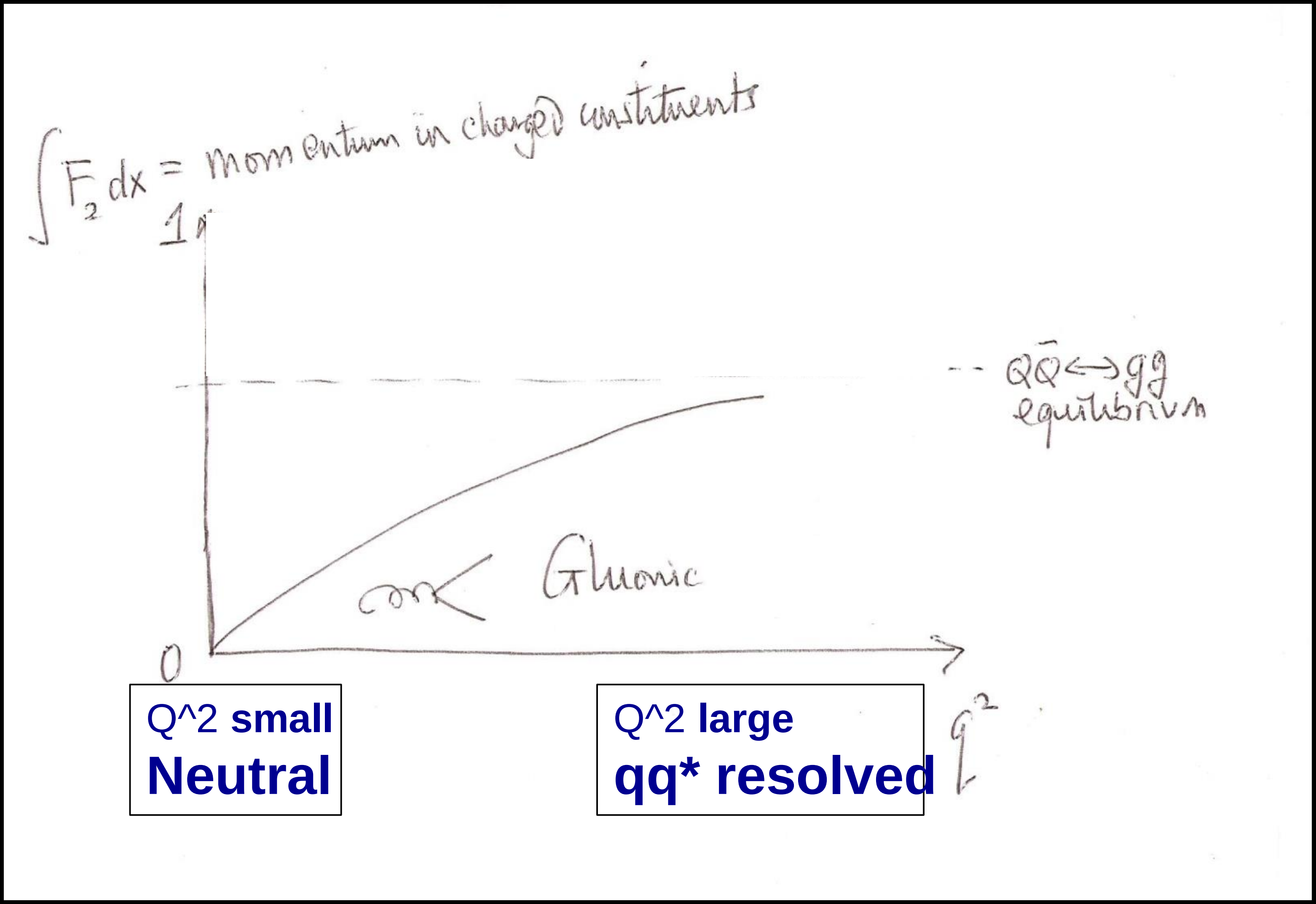


Thought experiment:

Deep Inelastic electron scattering from a glueball

Integral of $F_2 dx$ = momentum sum rule

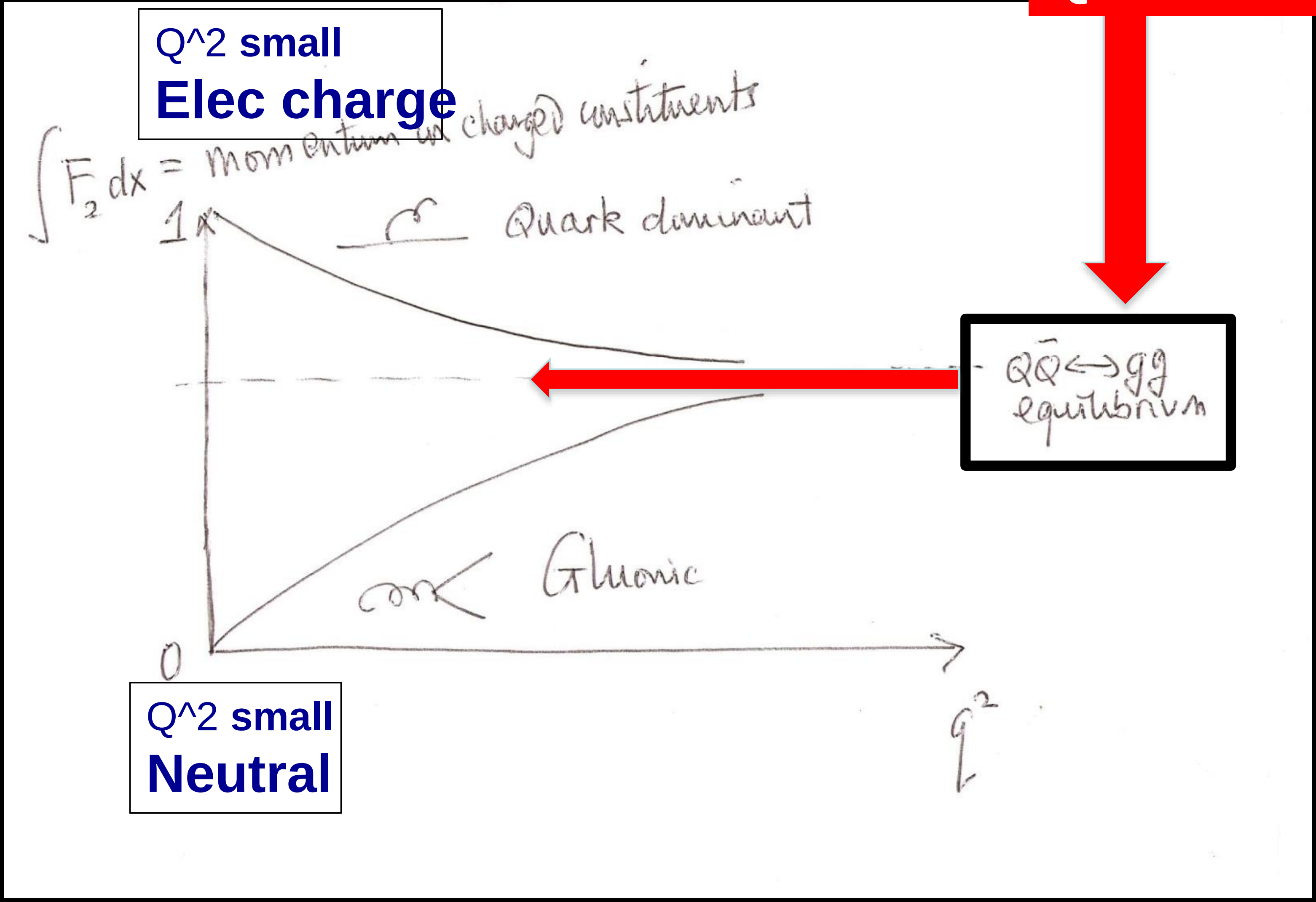
RISES with q^2



QCD m=0 quarks + glue gives

Two classes of hadrons

Q^2 = inf
Q G balanced



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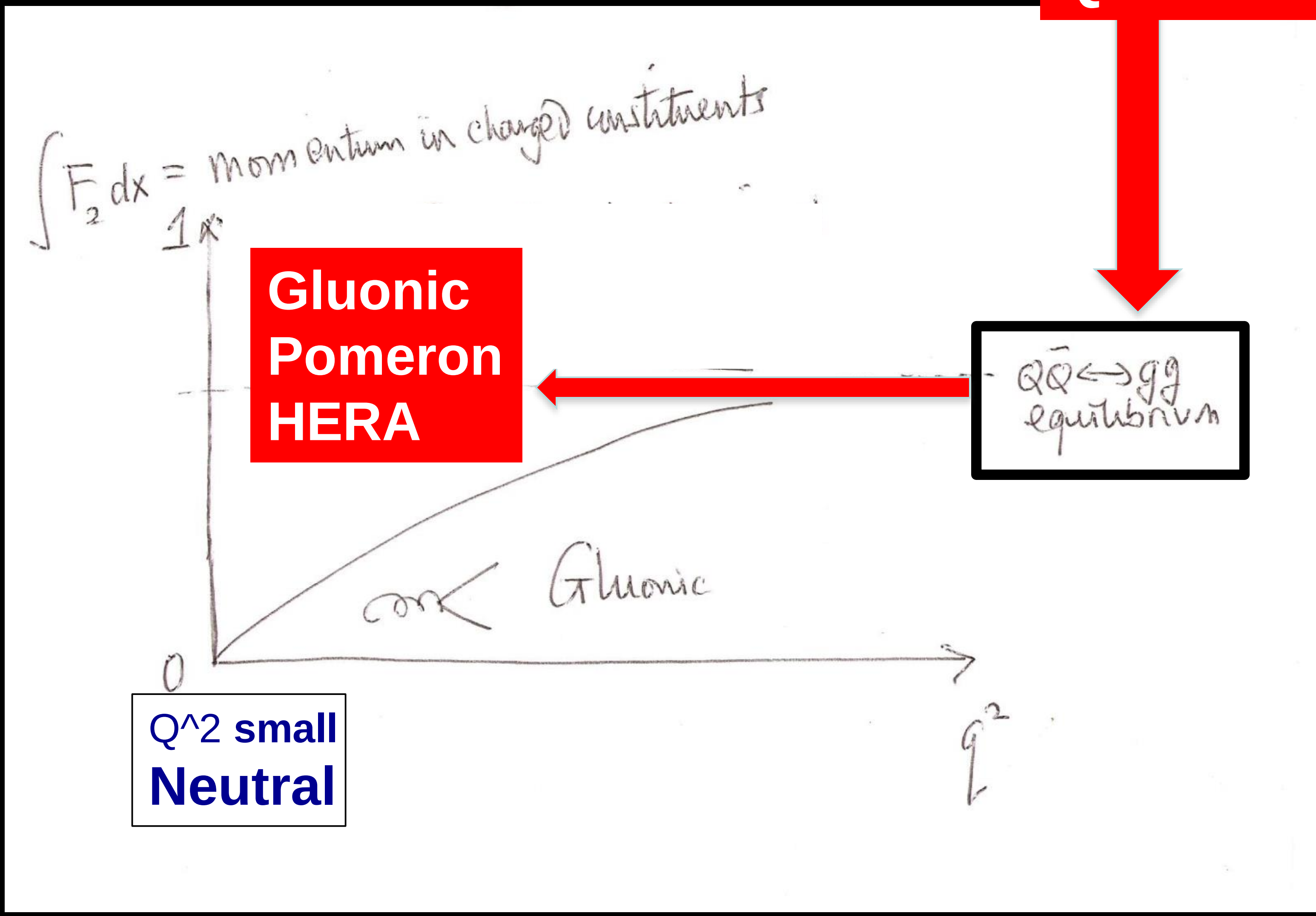

QCD m=0 quarks + glue gives

Two classes of hadrons

Conventional: G momentum <

Asymptotic G/qq* balance

Gluonic: G momentum >

QCD m=0 quarks + glue gives

Two classes of hadrons

Conventional: G momentum <

Gluonic: G momentum >

Asymptotic G/qq* balance

Classification of gluonic/conventional hadrons
Without non-relativistic assumptions.
Applies for “real” QCD quarks

QCD m=0 quarks + glue gives

Two classes of hadrons

Conventional: G momentum <

Gluonic: **G momentum** **>**

Asymptotic G/qq* balance

But **Glueballs; Hybrids**; **Conventional** = **Three** ??

QCD m=0 quarks + glue gives

Two classes of hadrons

Conventional: G momentum <

Asymptotic G/qq* balance

Gluonic: G momentum >

Hybrids/Glueballs not distinct.
Hybrid = Glueball with flavor/ Glueball = Hybrid flavor singlet

QCD m=0 quarks + glue gives

Two classes of hadrons

Conventional: G momentum <

Gluonic: G momentum >

Asymptotic G/qq* balance

Hybrids/Glueballs not distinct.

Hybrid = Glueball with flavor/ Glueball = Hybrid flavor singlet

Lattice Glueball is naïve: doesn't exist in "real" world.

Glueball/Hybrid separation artificial

2015: Don’t pollute the PDG with bad data analyses. Read SLAC-PUB-1000

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With memories of Herceg Novi

Logel Cashmole:1965-2015

Oxfold to SRAC to Oxfold

Flank Crose