Encounters with voodoo† QCD

R. L. Jaffe, September 30, 2011

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†I. Hinchliffe, *circa 1980*

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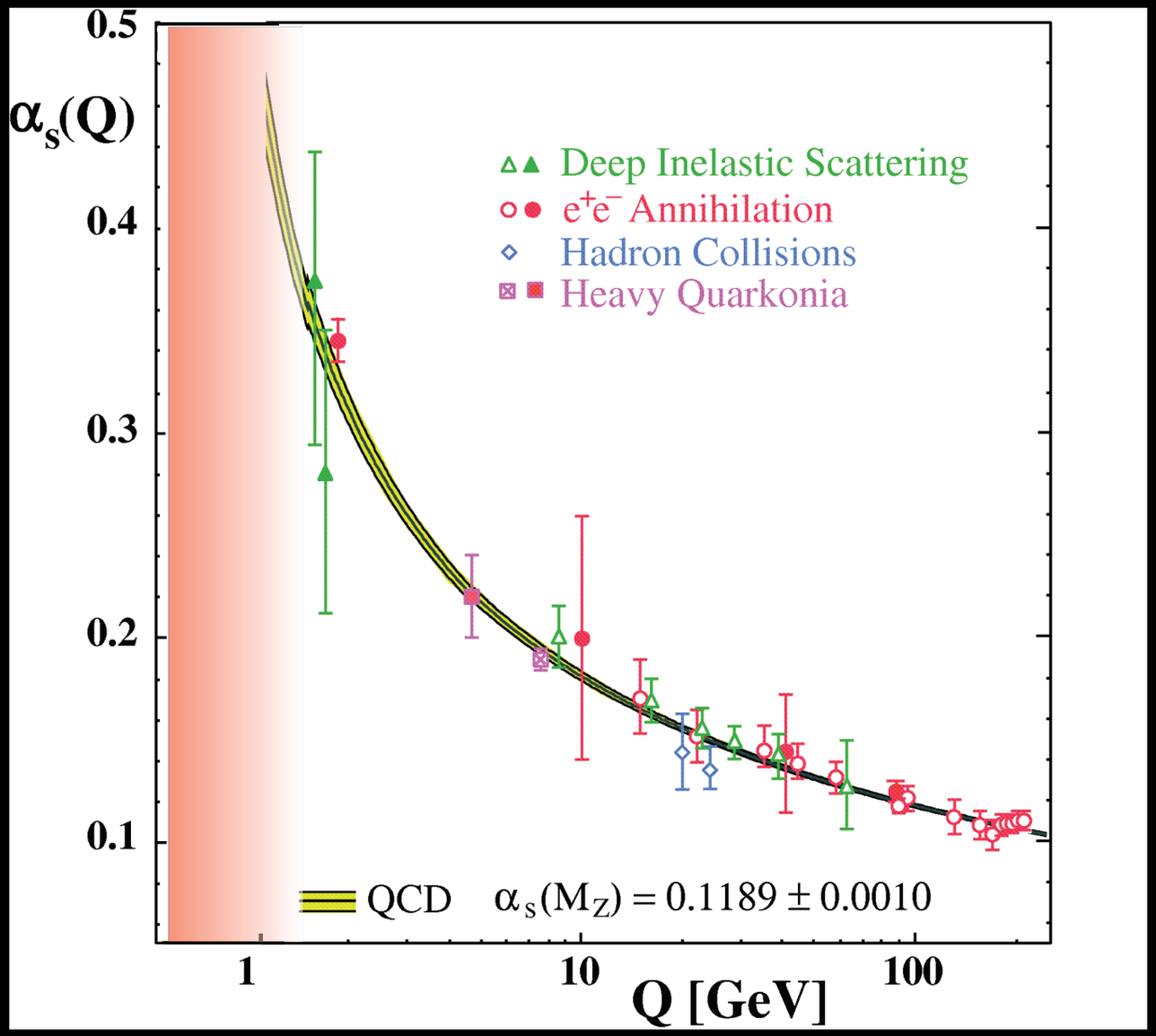
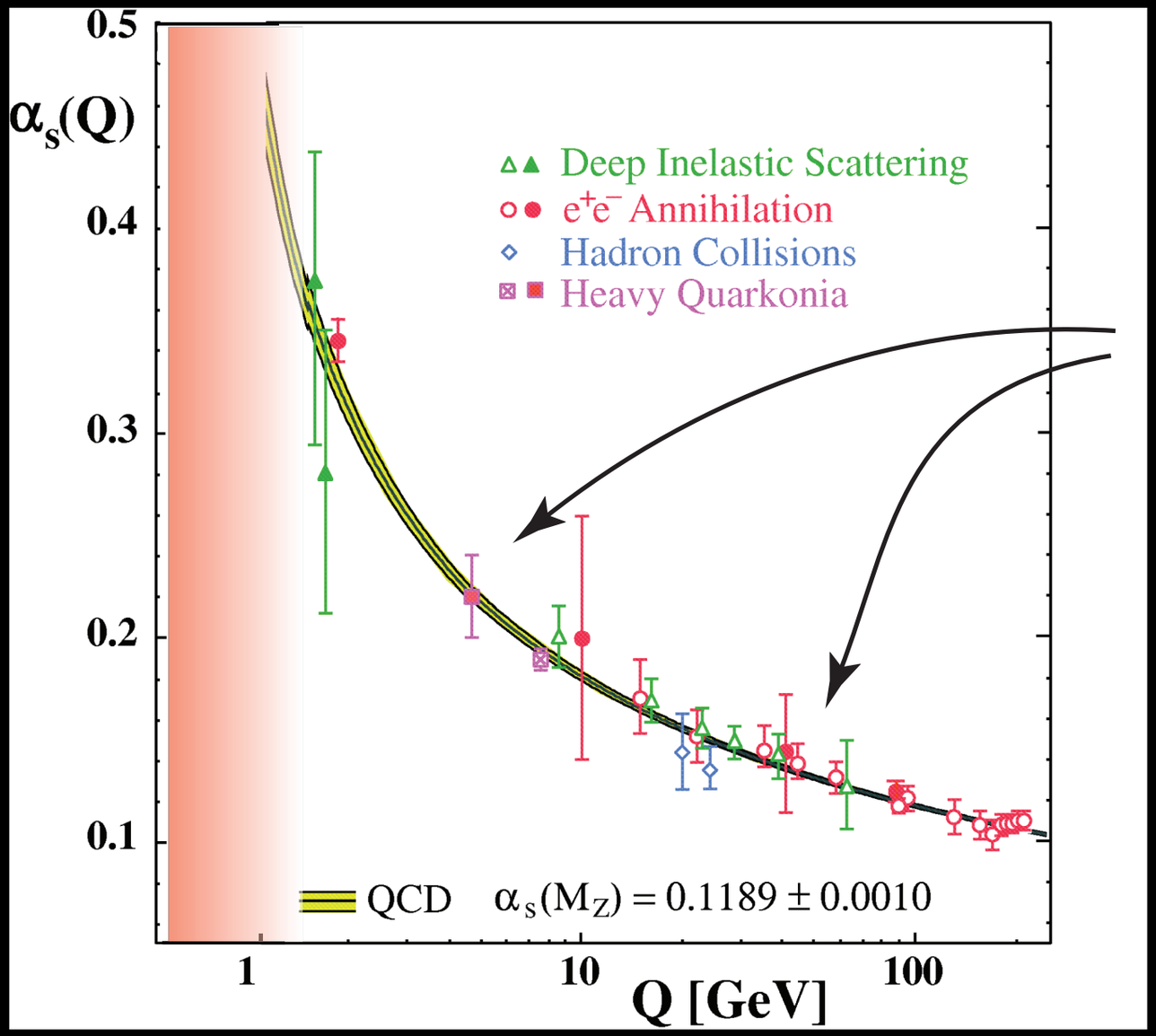


S. Bethke, Prog.Part.Nucl.Phys. 58 (2007) 351-386



Precise QCD: perturbative or non-relativistic

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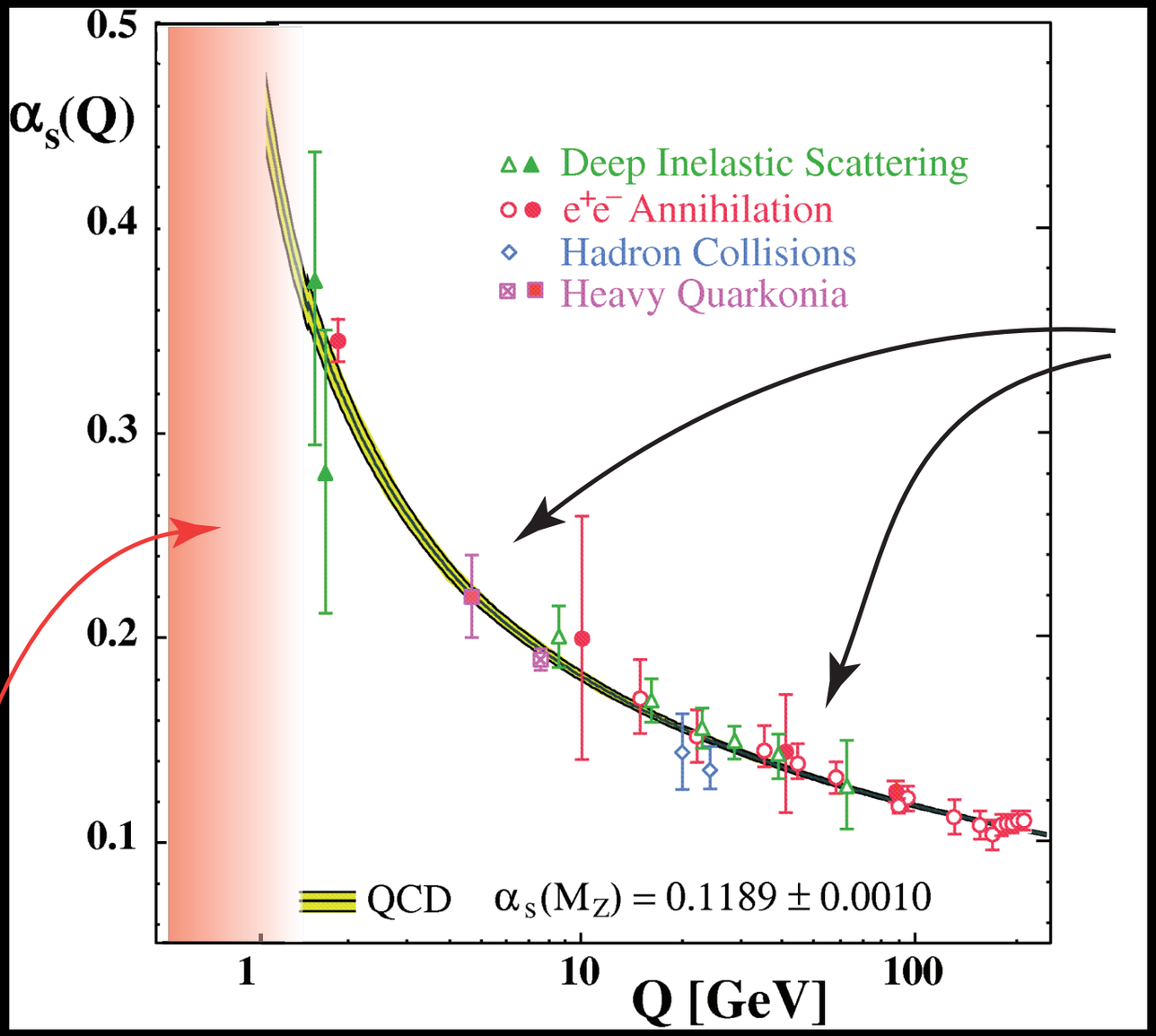

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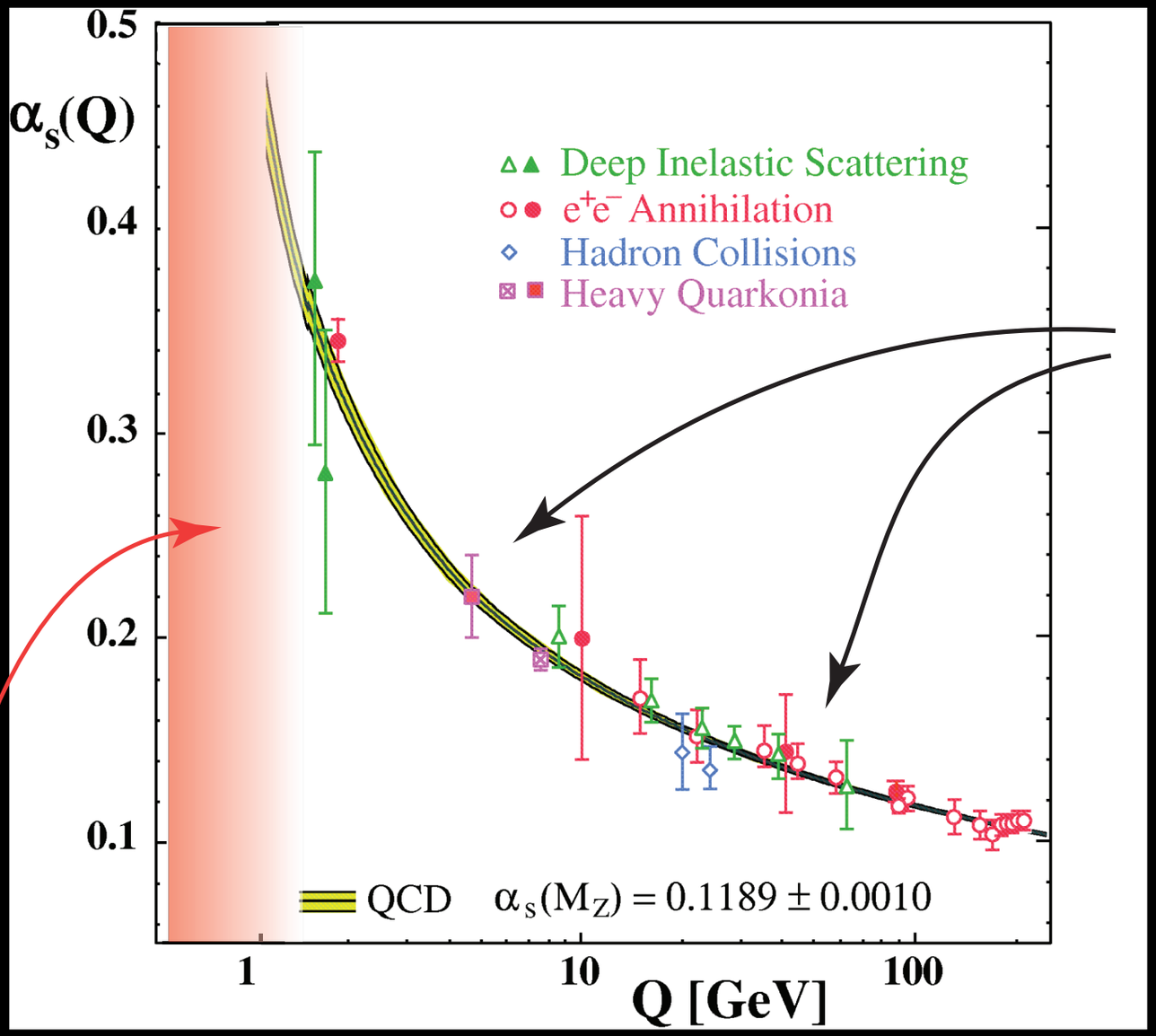
But quarks were first "discovered" in light hadron phenomena, where they are relativistic and strongly coupled



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Precise QCD: perturbative or non-relativistic

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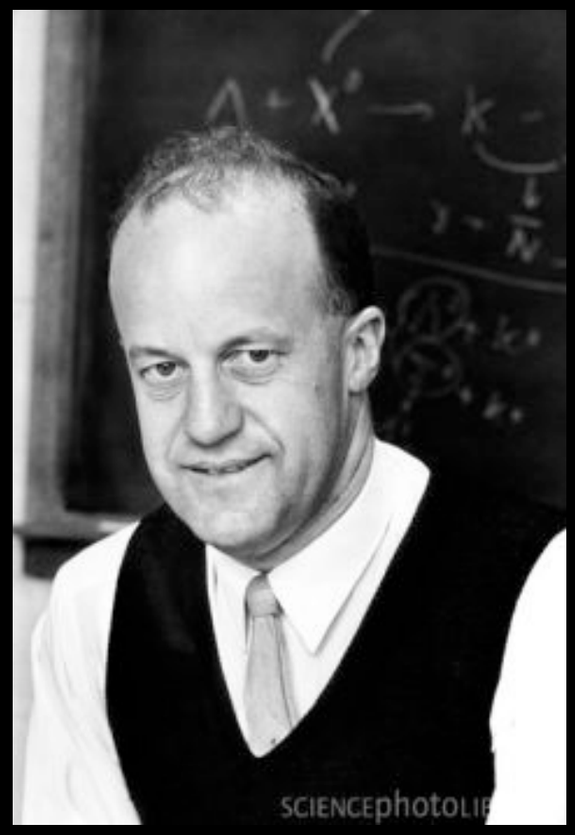

R. H. Dalitz and his students at Oxford 1964 – 1972

Voodoo QCD?

- Constituent quark model
- OZI – rule
- Vector dominance
- QCD sum rules

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A challenge in the first decade of QCD

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A challenge in the first decade of QCD

Why bother?

What is the structure of matter?

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GGR & RLJ:

- *Normalizing the Renormalization Group Analysis of Deep Inelastic Leptoproduction*, Phys Lett 93B, 313 (1980).

- *On the Nuclear Dependence of Electroproduction* (with F. E. Close and R. G. Roberts), Phys Lett 143B, 449 (1984).

- *Change of Confinement Scale in Nuclei: Predictions for Structure Functions Confront Electroproduction Data* (with F. E. Close and R. G. Roberts), Phys Rev D31, 1004 (1985).

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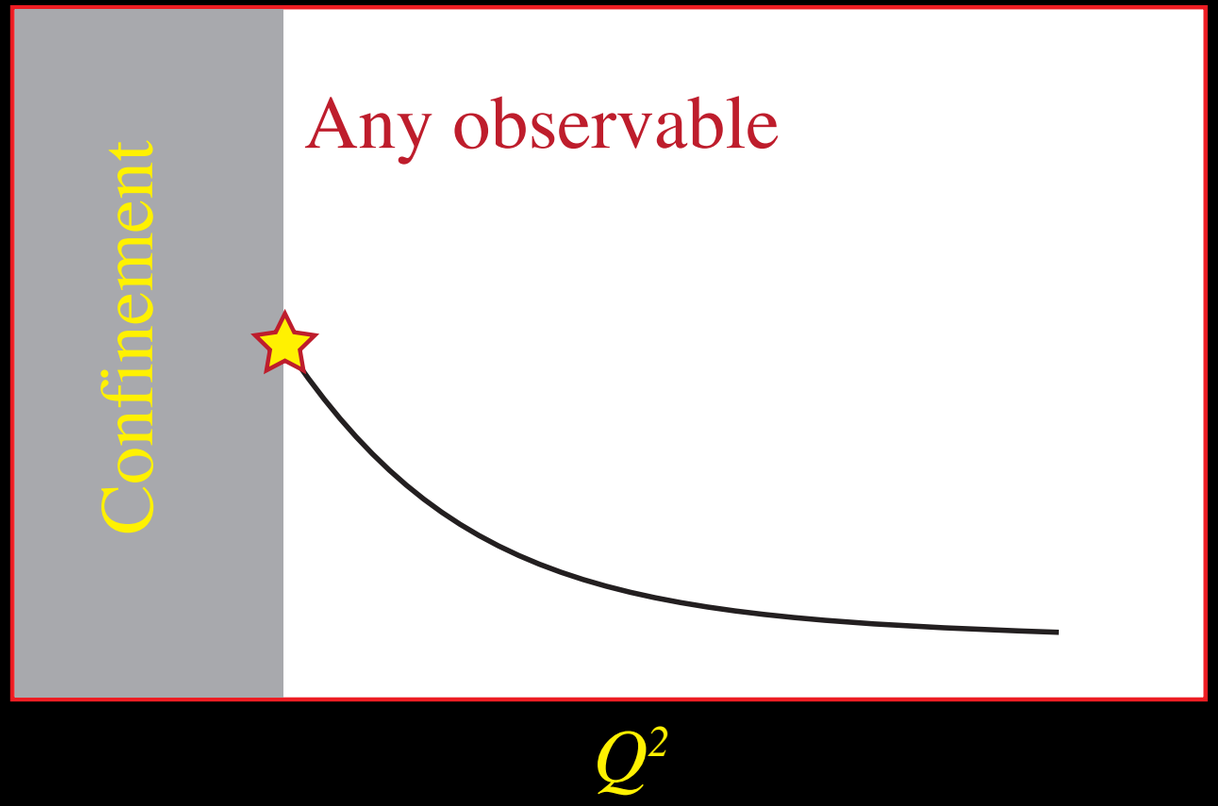
Basic idea?

- Devolution meets the "stone wall" of confinement.

  MIT Bag Model collaboration (Ken Johnson, Thorn, Chodos, Donoghue, Weisskopf, RLJ)

  QCD Sum Rules (Shifman, Vainshteyn, Zakharov)

  Parton structure functions at low Q^2 (Glück & Reya)



Integrate out long range confining interactions into a "mean field" in which quarks and gluons propagate.

Residual interactions controlled in the infrared

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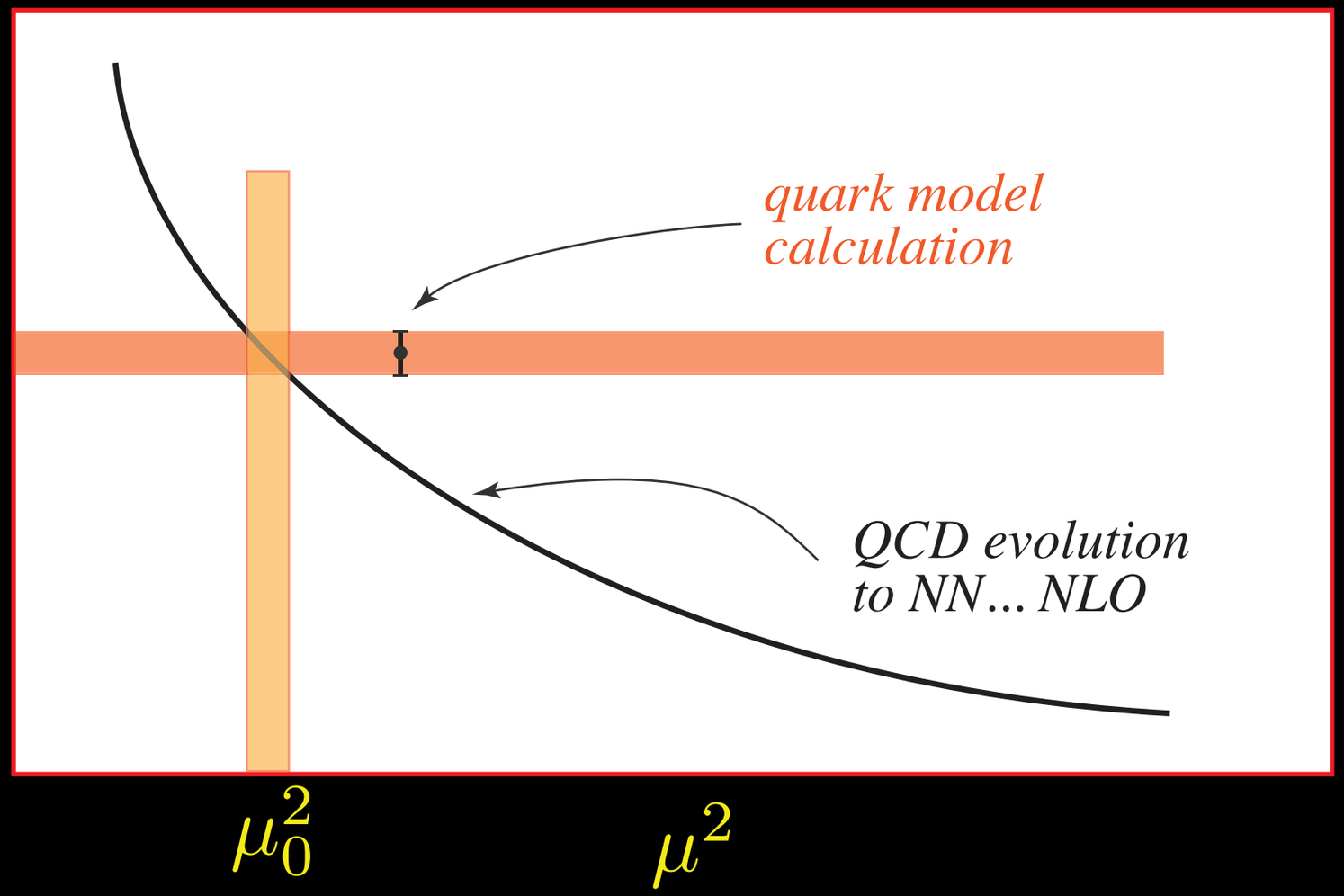
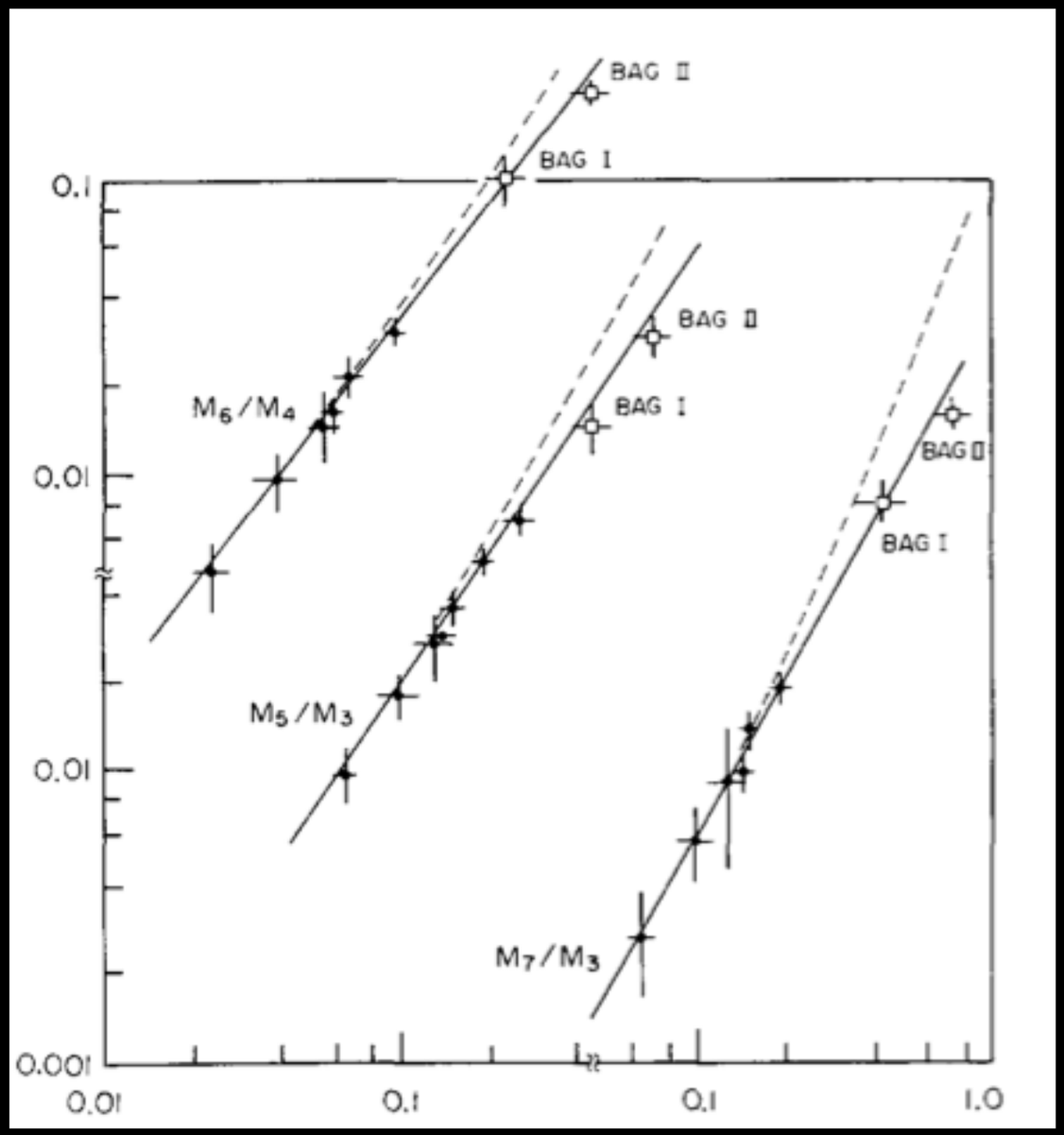
Quark models give hadron matrix elements of scale-dependent operators at an intrinsic, hadronic scale...

Predictions?

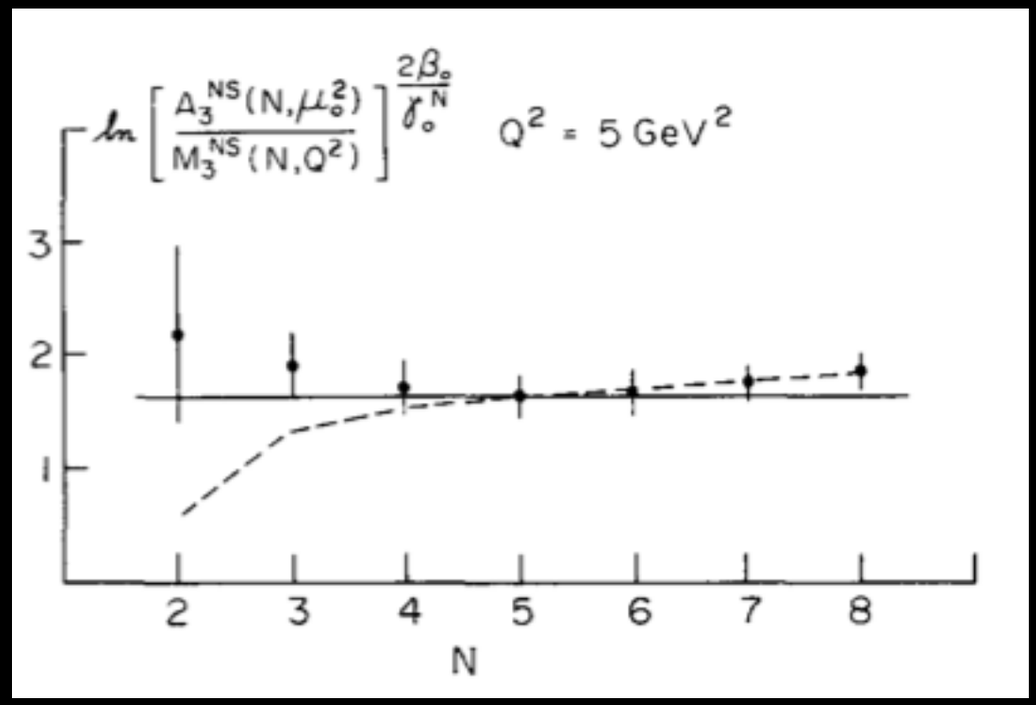


Quark model scale should be single parameter.

From GGR & RLJ, Phys Lett 93B, 313 (1980)



Moments of non-singlet DIS structure functions as twist-two quark matrix elements.



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30 years later

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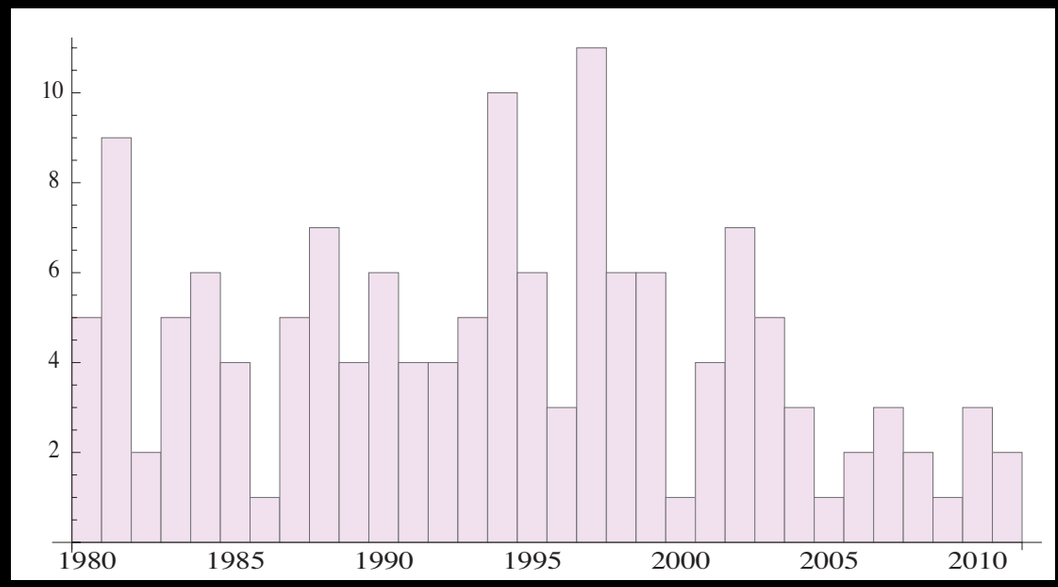

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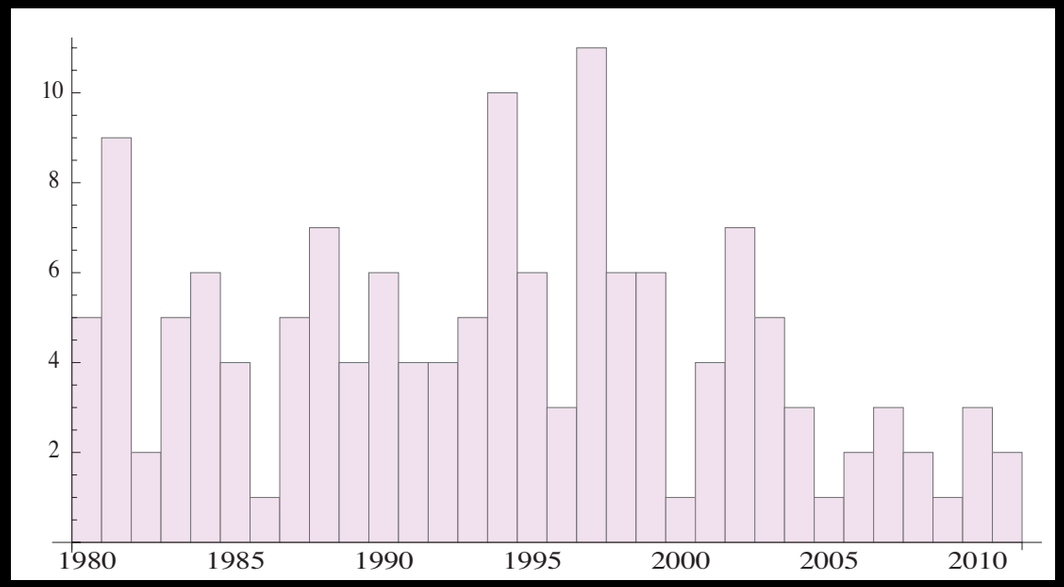
30 years later

- Lattice QCD has displaced heuristic models as the source of information about hadronic bound states.
- But puzzles of voodoo QCD still remain.



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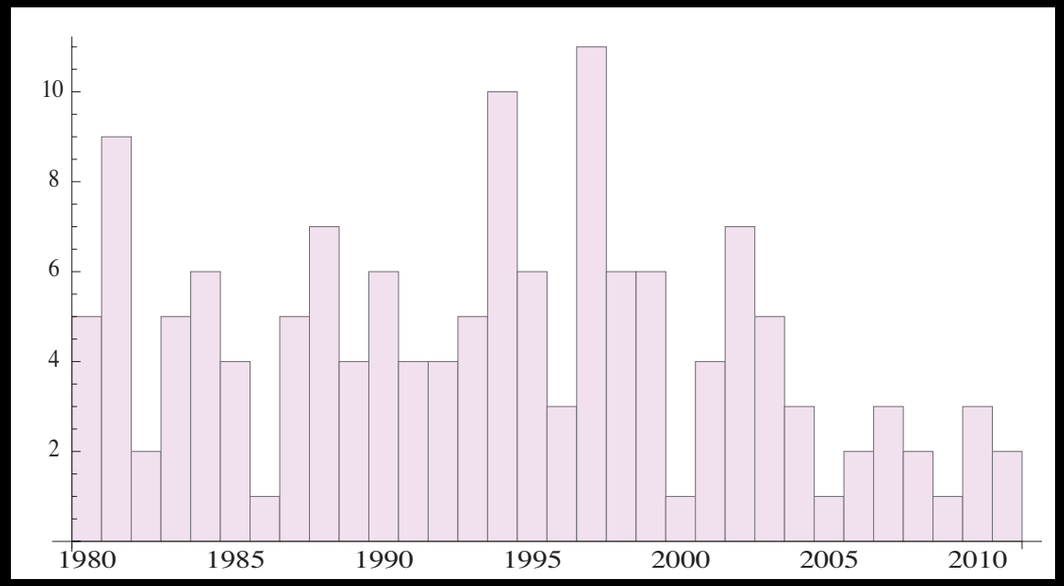

- For example: Quark model classification of baryons relies on OZI rule and SU(6)xO(3), and contradict DIS measurements and lattice calculations of spin and flavor content of nucleon.
- And we still have no successful, systematic description of hadron dynamics at the confinement scale!

- Meanwhile, Graham and I moved on to other problems...