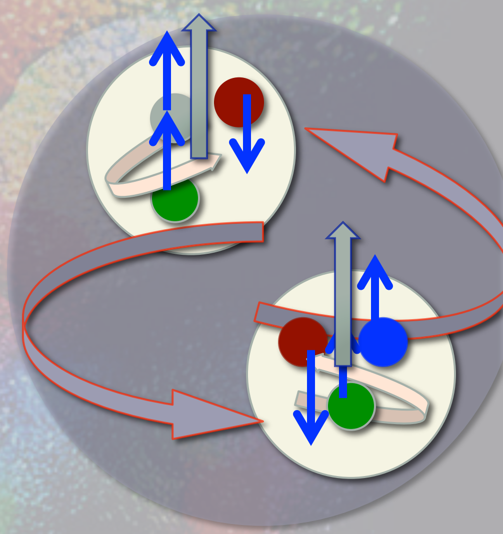
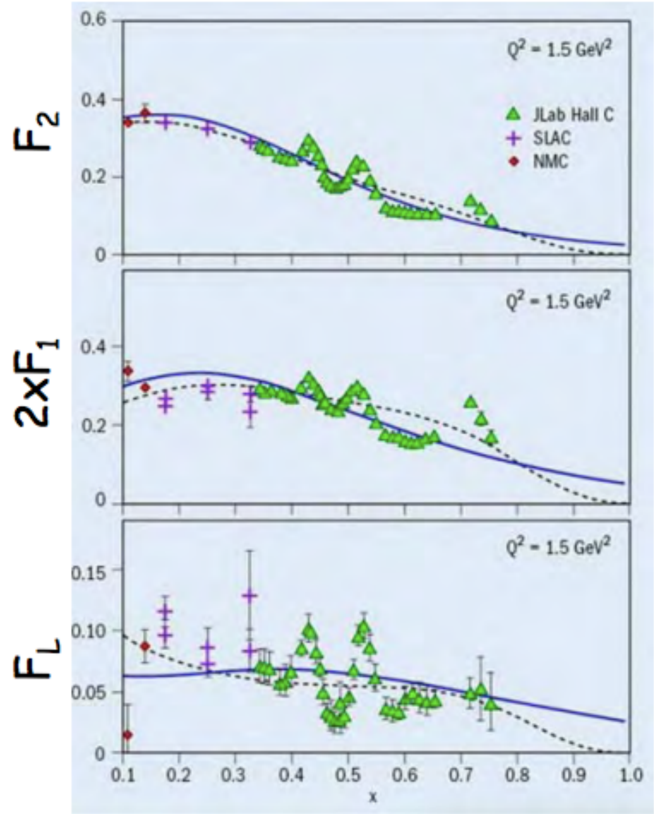
BERNSTEIN POLYNOMIALS BASED PROBABILISTIC INTERPRETATION OF QUARK HADRON DUALITY

PARTONHADRON DUALITY WORKSHOP
JAMES MADISON UNIVERSITY, SEP. 23-25, 2018

Simonetta Liuti
University of Virginia

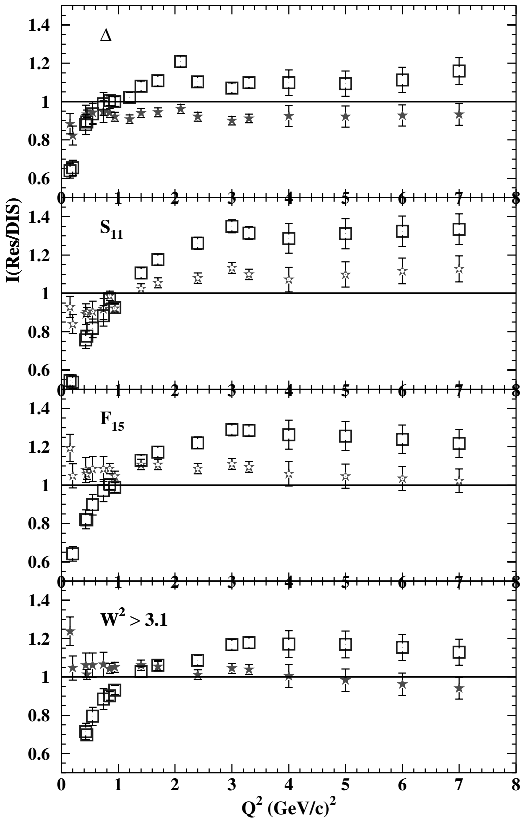


Definition of duality

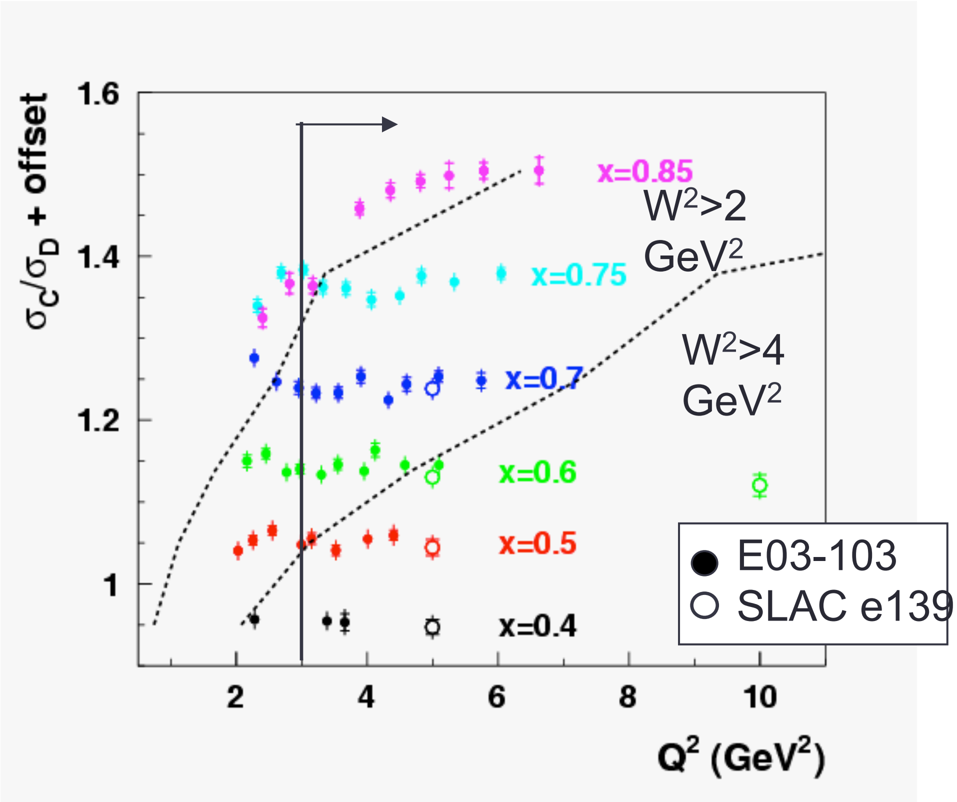


Observation of approximate Q^2 scaling (reminiscent of photon-quark scattering) in the region where the proton resonance structure is clearly detectable

Q^2 dependence
(D. Gaskell's talk)



nucleon



nucleus

Understanding the dynamical origin of this behavior remains one of the unsolved questions in QCD

➔ **monitoring the transition from its perturbative to non-perturbative regimes (including the behavior of α_S in the non-perturbative limit)**

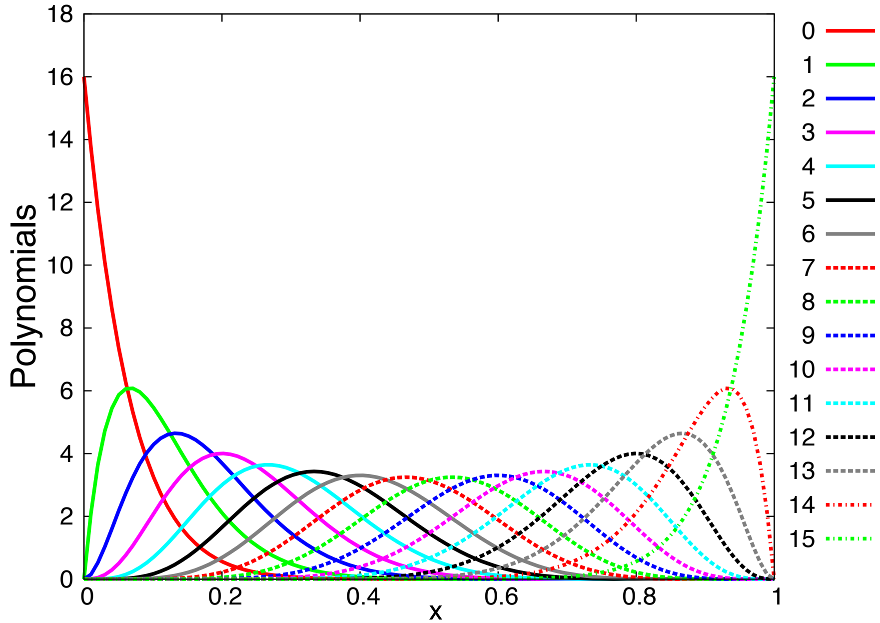
In this talk we ask the question about how to average over the resonances and its physical meaning

Strategy

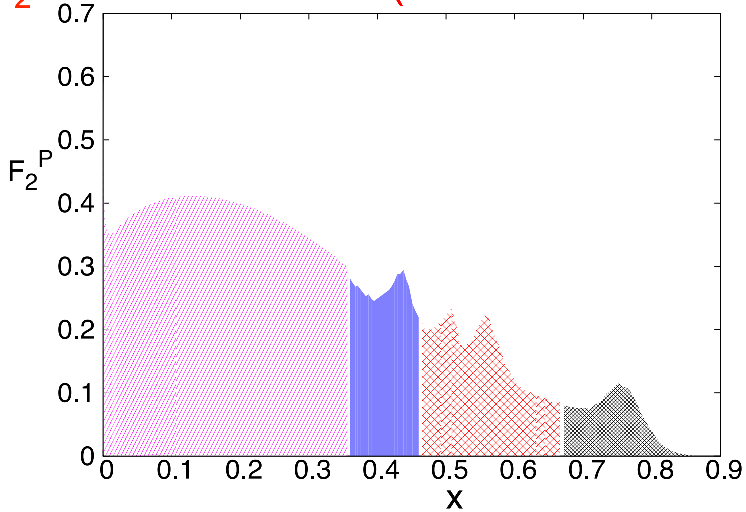
1. Introduce a set of orthogonal polynomials (Bernstein polynomials) and calculate the F_2 moments

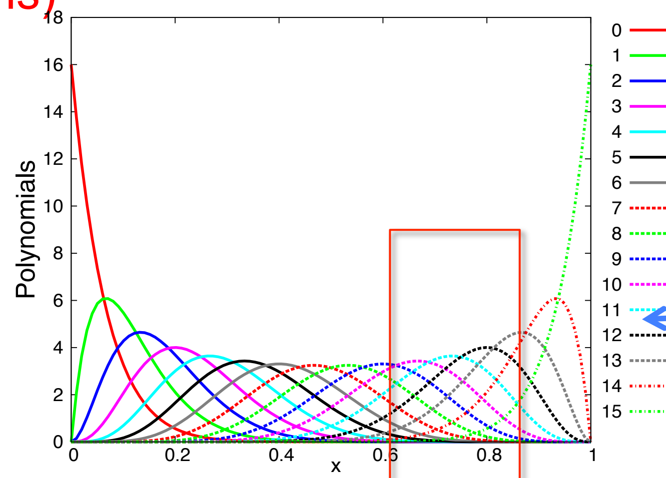
2. Bernstein polynomials select ranges in x that are determined completely independently from those characteristic of resonance structure (the ranges spanned by each B moment do not coincide at any given Q^2 with any of the most prominent resonance ranges)
3. By increasing the number of B moments, restricting their ranges in x, one can define a critical number and interval size after which the smoothness of the curve is disrupted and the characteristic resonance structure starts reappearing.
4. By sampling the structure function with Bernstein polynomials, one, therefore, obtains quantitative clues on the degree of ``locality" of parton-hadron duality.

Bernstein polynomials



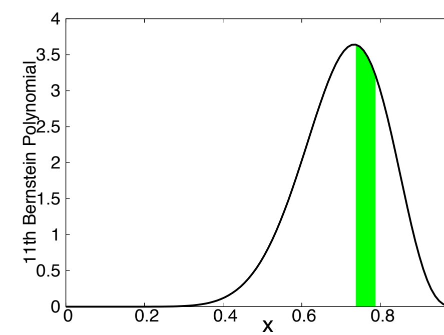
F_2 at Q^2=1.8 GeV^2 (various resonance regions)

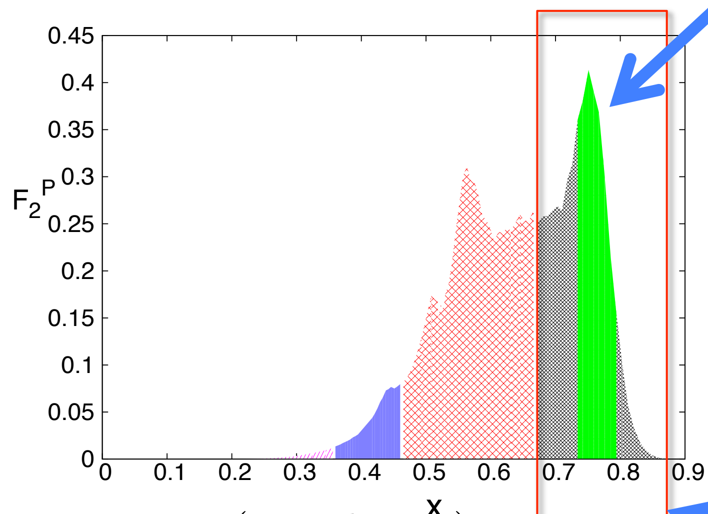




11

11th Bernstein polynomia

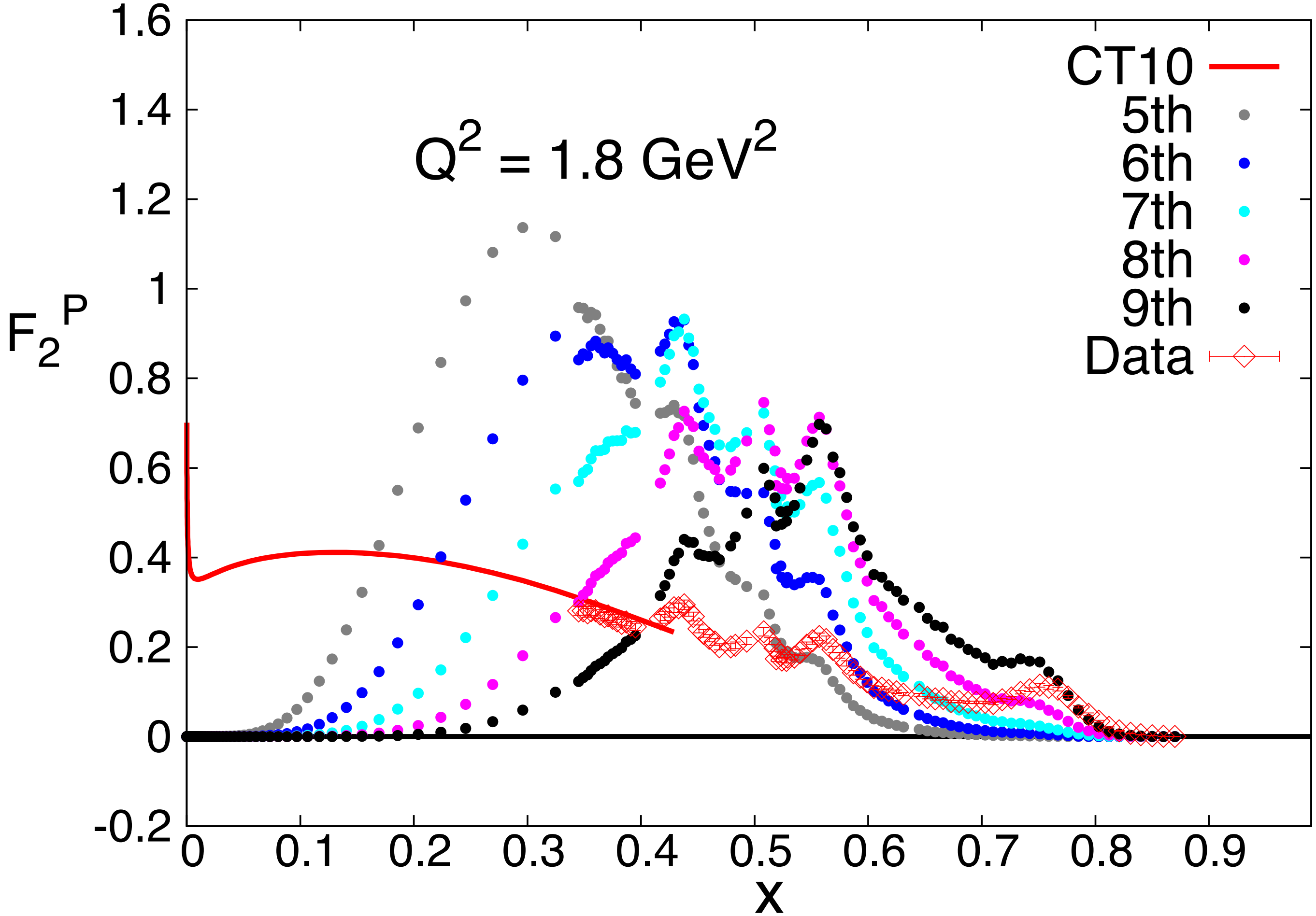




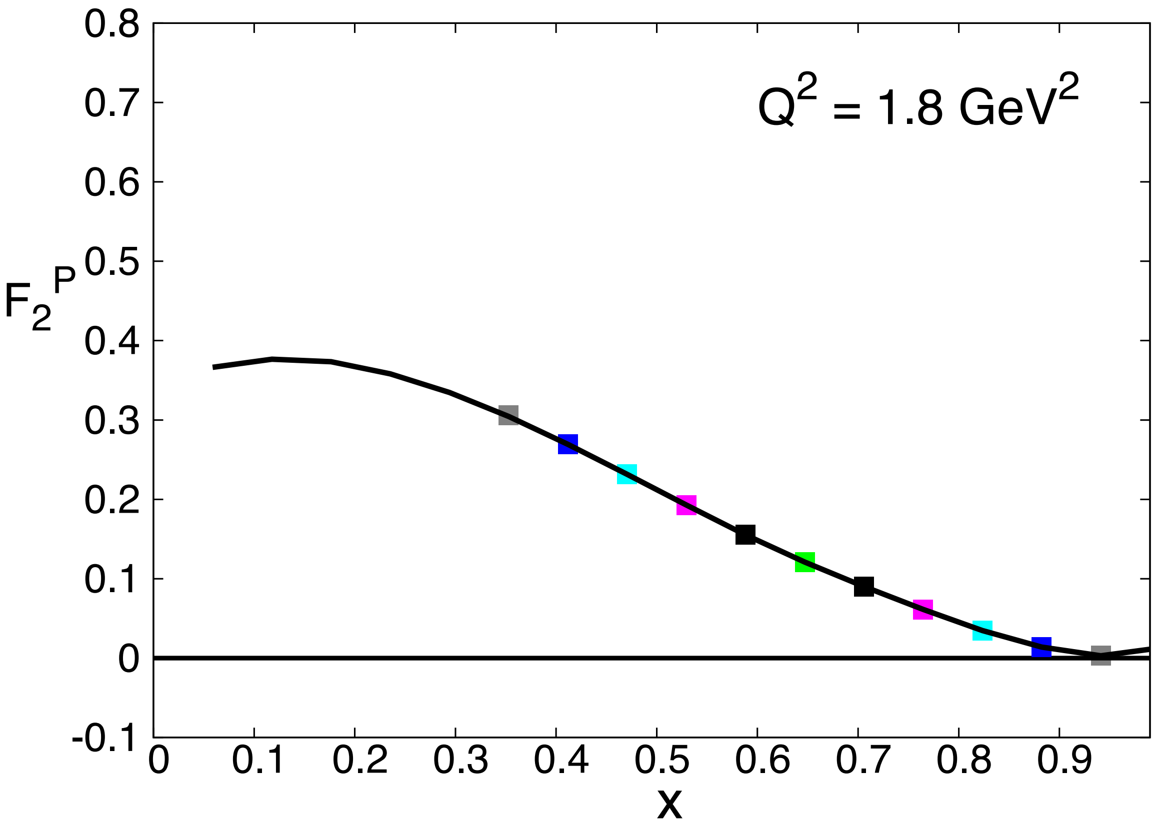
variance

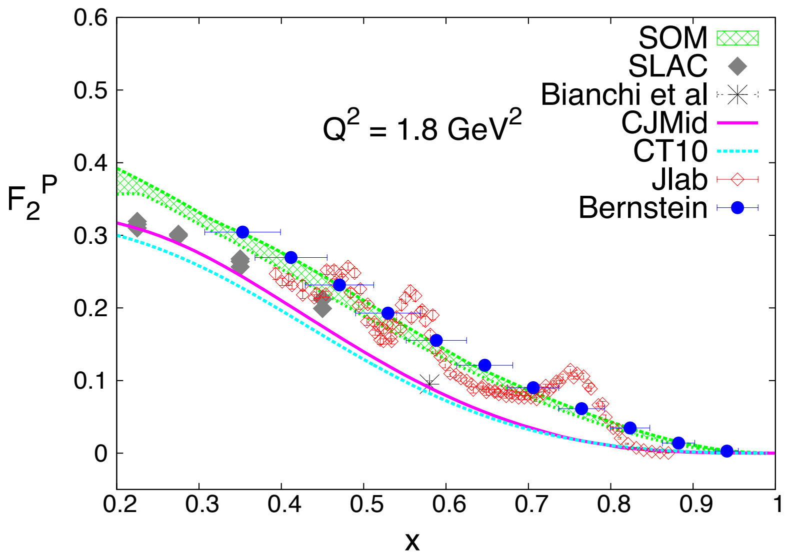
$$(\Delta x)^2_{n,k} = \left|\left\langle x^2\right\rangle_{n,k} - \langle x\rangle^2_{n,k}\right| = \frac{(n-k+1)}{(n+2)^2\,(n+3)}$$

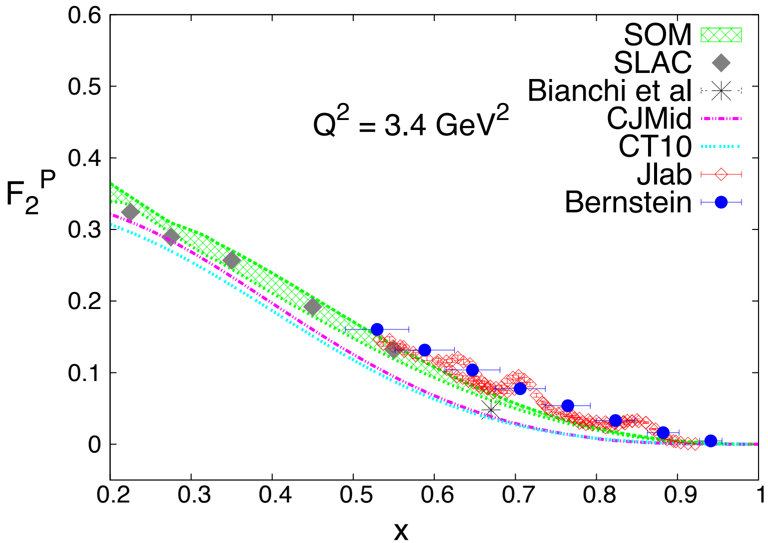
Different polynomials select different regions

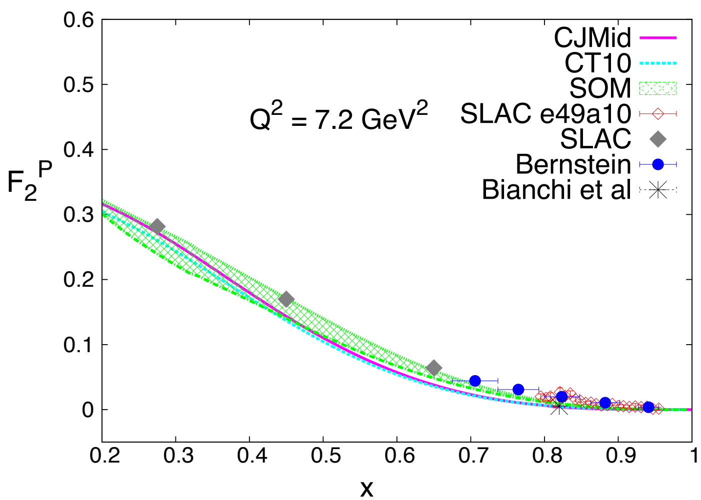


Result of averaging….




SOM
SLAC
Bianchi et al
CJMid
CT10
Jlab
Bernstein
Q^2 = 1.8 GeV^2
F_2^P
x

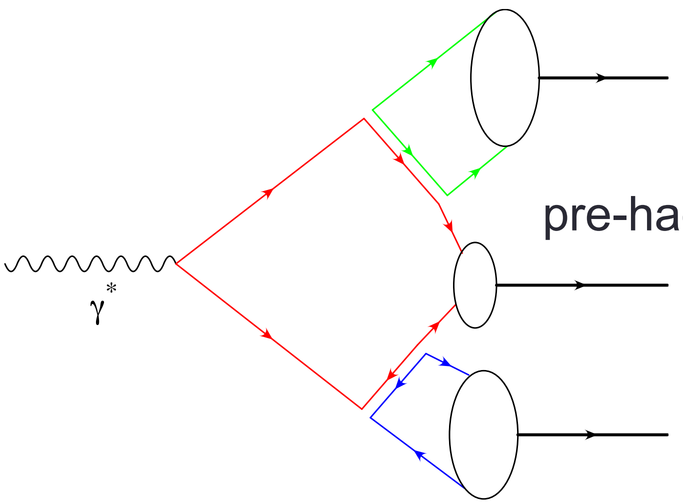

SOM
SLAC
Bianchi et al
CJMid
CT10
Jlab
Bernstein
Q^2 = 3.4 GeV^2
F_2^P
x


CJMid
CT10
SOM
SLAC e49a10
SLAC
Bernstein
Bianchi et al
Q^2 = 7.2 GeV^2
F_2^P
x

Physics ideas: the space-time structure of hadronization

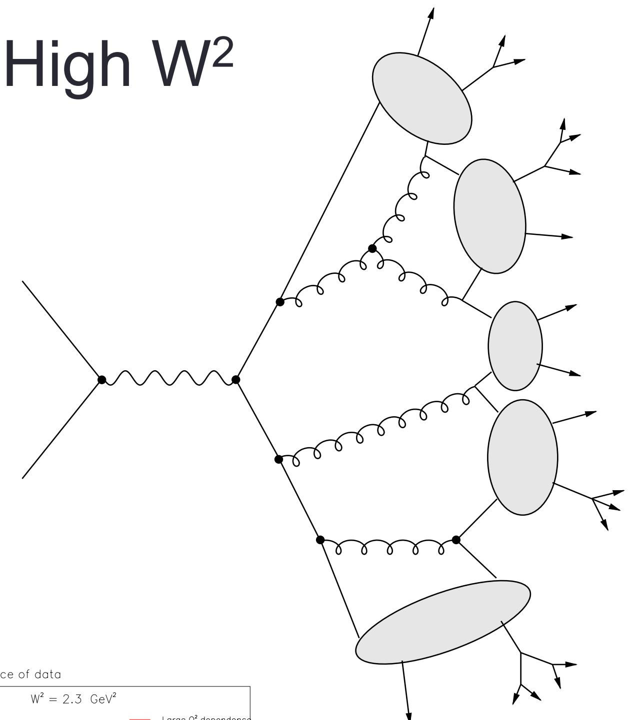
(see also talk by J. Collins)

Low W^2

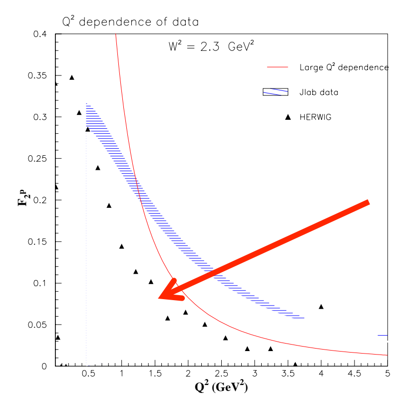


pre-hadron clusters

High W^2



Hadronization procedure based on HERWIG



cluster distribution

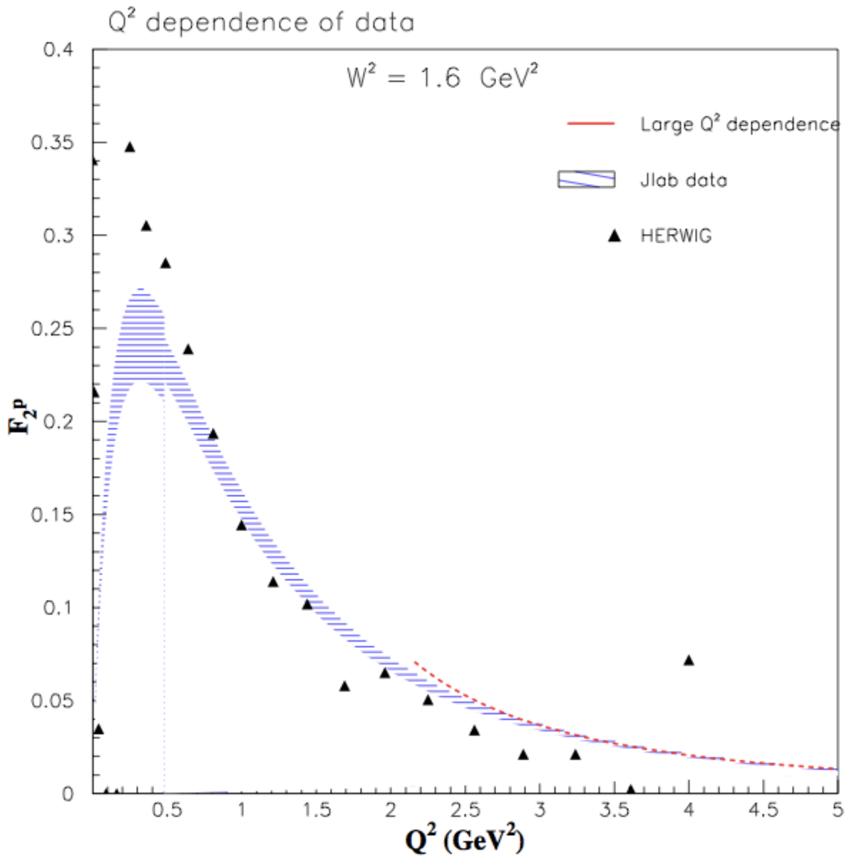
The two pictures

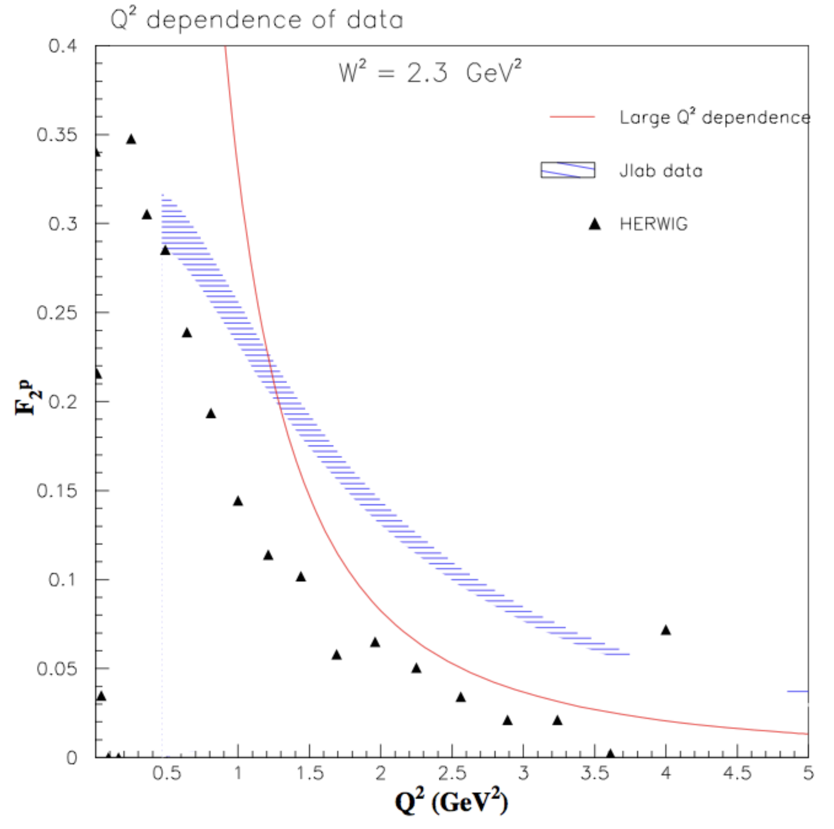
If we broadly attribute the resonance peak formation to an effect of confinement, we can study its emergence by making a one to one correspondence between the number of Bernstein moments used to reproduce the function's behavior in the resonance region and the number of partonic configurations generated from a probabilistic point of view
(➔comparing resolutions)

Large W^2 ➔ large number of different final hadronic configurations, each with low probability

Low W^2 ➔ final configurations with similar hadronic content are formed with a high probability

Similar to parton shower Monte Carlos (MC's) approaches (Lai et al. 2009, Frixione et al, 2002)


Q² dependence of data
W² = 1.6 GeV²
Large Q² dependence
Jlab data
HERWIG
F₂ᵖ
Q² (GeV²)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


Q² dependence of data
W² = 2.3 GeV²
Large Q² dependence
Jlab data
HERWIG
F₂ᵖ
Q² (GeV²)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Conclusions

Parton hadron duality is fascinating because it is at the core of our understanding of the mechanisms defining the space-time structure of QCD reactions

Need to define observables to test quantitatively this idea