Detailed analysis of p+p elastic scattering $d\sigma/dt$ data

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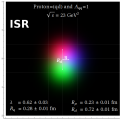
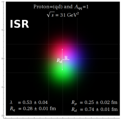
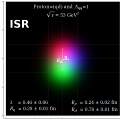
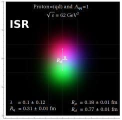
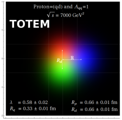
November 28, 2011



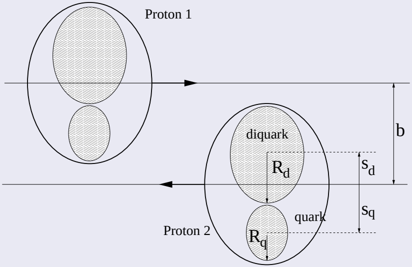








The scattering situation



The cross section

The **inelastic** $p + p$ cross-section for a fixed impact parameter b

$$\sigma\left(b\right) = \int d^2 s_q d^2 s_q' d^2 s_d d^2 s_d' D\left(s_q, s_d\right) D\left(s_q', s_d'\right) \sigma\left(s_q, s_d; s_q', s_d'; b\right) \tag{1}$$

A. Bialas, A. Bzdak, ActaPhys.Polon. B38:159-168,2007

Ingredients...

- Gaussian quark-diquark distribution

$$D\left(s_q, s_d\right) = \frac{1+\lambda^2}{\pi R_p^2} e^{-\left(s_q^2+s_d^2\right)/R_p^2} \delta^2\left(s_d + \lambda s_q\right), \lambda = m_q/m_d \quad (2)$$

- Probability of interaction

$$1 - \sigma\left(s_q, s_d; s_q', s_d'; b\right) = \prod_{a,b\in\{q,d\}} 1 - \sigma_{ab}\left(b + s_a' - s_b'\right) \quad (3)$$

$$\sigma_{ab}\left(s\right) \equiv d^2\sigma_{ab}\left(s\right)/d^2 s = A_{ab} e^{-s^2/\left(R_a+R_b\right)} \quad (4)$$

R. J. Glauber, Lectures in Theoretical Physics, Vol. 1. Interscience, New York 1959.

W. Czyz, L. C. Maximon, Ann. of Phys. 52 (1969) 59.

$d\sigma/dt$

From unitarity the elastic amplitude

$$t_{el}(b) = 1 - \sqrt{1 - \sigma(b)} \tag{5}$$

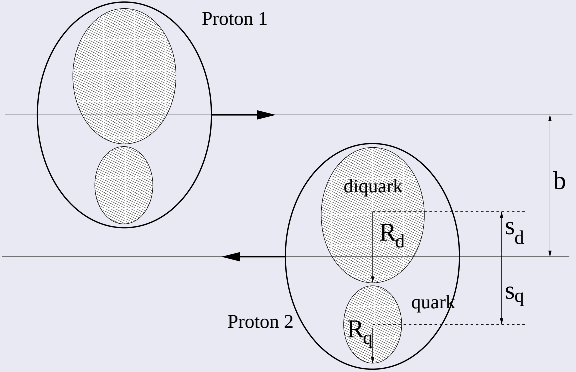
Elastic amplitude in momentum space

$$T(\Delta) = \int t_{el}(b)\, e^{i\vec{\Delta}\cdot\vec{b}} d^2 b = 2\pi \int t_{el}(b)\, J_0(\Delta b)\, b db \tag{6}$$

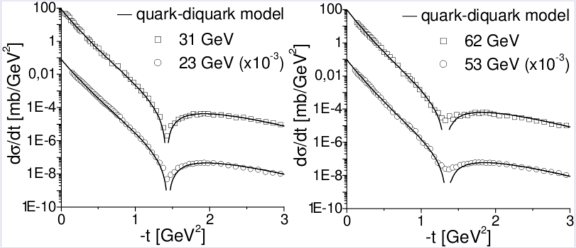
Since $t \simeq -|\Delta|^2$

$$\frac{d\sigma}{dt} = \frac{1}{4\pi} |T(\Delta)|^2 \tag{7}$$

The scattering when the diquark is a single entity



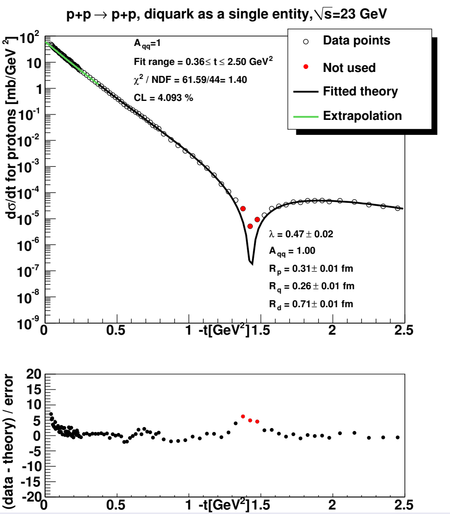
The original fits from A. Bialas and A. Bzdak



Errors, χ^2, CL are not provided !

A. Bialas, A. Bzdak, ActaPhys.Polon. B38:159-168,2007

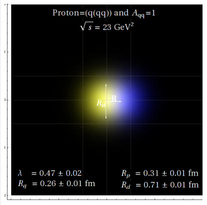
Fitted th. curve at 23 GeV^2 ISR



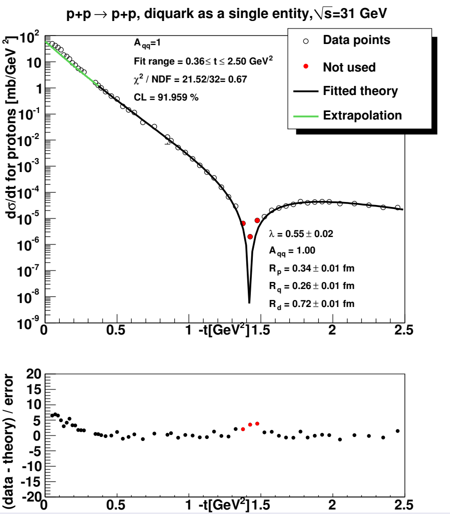
MINUIT parameters

CL	4.0 %
R_{proton}	0.31 ± 0.01 fm
R_{quark}	0.26 ± 0.01 fm
$R_{diquark}$	0.71 ± 0.01 fm
λ	0.47 ± 0.02
A_{qq}	1.00 (fixed)

Visualisation



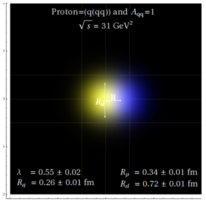
Fitted th. curve at 31 GeV^2 ISR



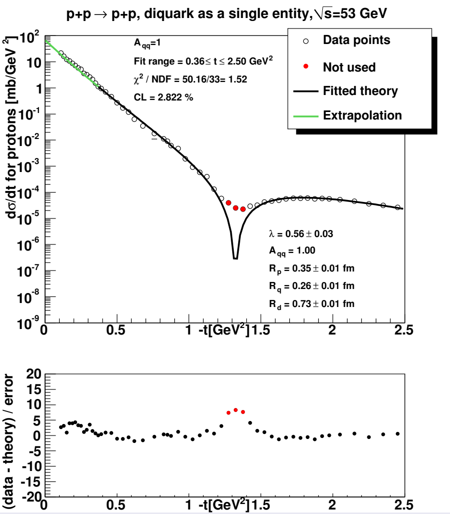
MINUIT parameters

CL	92.0 %
R_{proton}	0.34 ± 0.01 fm
R_{quark}	0.26 ± 0.01 fm
$R_{diquark}$	0.72 ± 0.01 fm
λ	0.55 ± 0.02
A_{qq}	1.00 (fixed)

Visualisation



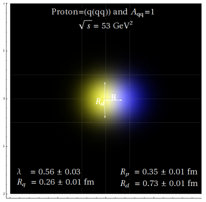
Fitted th. curve at 53 GeV^2 ISR



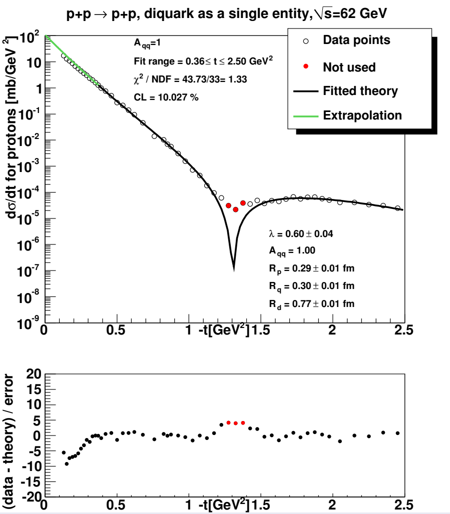
MINUIT parameters

CL	2.8 %
R_{proton}	0.35 ± 0.01 fm
R_{quark}	0.26 ± 0.01 fm
$R_{diquark}$	0.73 ± 0.01 fm
λ	0.56 ± 0.03
A_{qq}	1.00 (fixed)

Visualisation



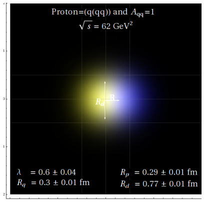
Fitted th. curve at 62 GeV^2 ISR



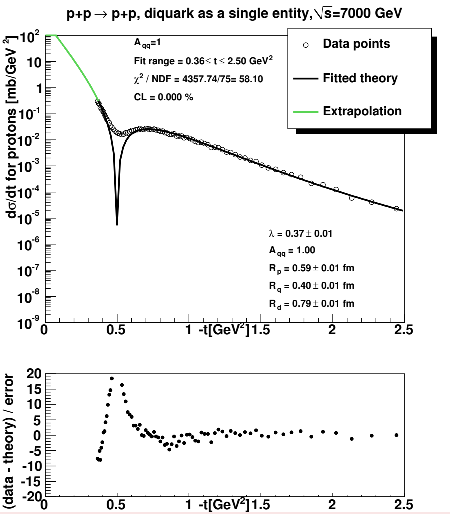
MINUIT parameters

CL	10.0 %
R_{proton}	0.29 ± 0.01 fm
R_{quark}	0.30 ± 0.01 fm
$R_{diquark}$	0.77 ± 0.01 fm
λ	0.60 ± 0.04
A_{qq}	1.00 (fixed)

Visualisation



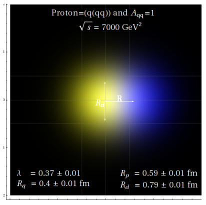
Fitted th. curve at 7k GeV^2 TOTEM



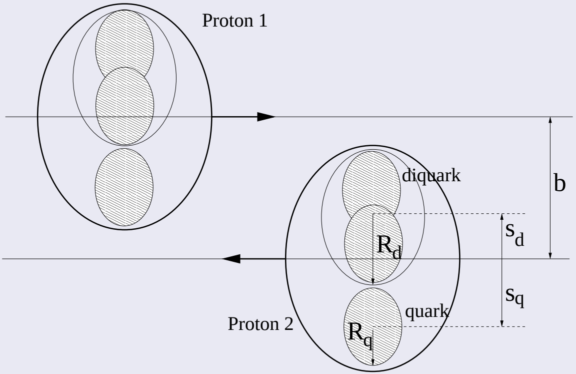
MINUIT parameters

CL	0.0 %
R_{proton}	0.59 ± 0.01 fm
R_{quark}	0.40 ± 0.01 fm
$R_{diquark}$	0.79 ± 0.01 fm
λ	0.37 ± 0.01
A_{qq}	1.00 (fixed)

Visualisation



The scattering when the diquark is a composite object



Diquark is a composite object

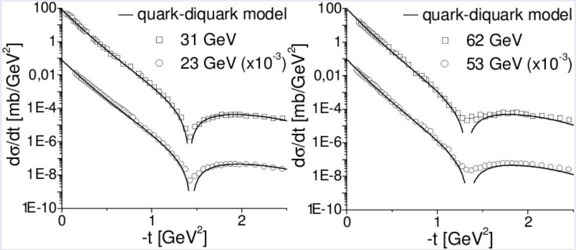
The quark distribution inside the **diquark**

$$D\left(s_{q1},s_{q2}\right)=\frac{1}{\pi d^2}e^{-\left(s_{q1}^2+s_{q2}^2\right)/2d^2}\delta^2\left(s_{q1}+s_{q2}\right) \tag{8}$$

$$\Rightarrow \sigma_{qd}\left(s\right)=\frac{4A_{qq}R_q^2}{R_d^2+R_q^2}e^{-s^2\frac{1}{R_d^2+R_q^2}}-\frac{A_{qq}^2R_q^2}{R_d^2}e^{-s^2/R_q^2} \tag{9}$$

$$\Rightarrow \sigma_{dd} \text{ is similar (not shown)...} \tag{10}$$

The original fits from A. Bialas and A. Bzdak



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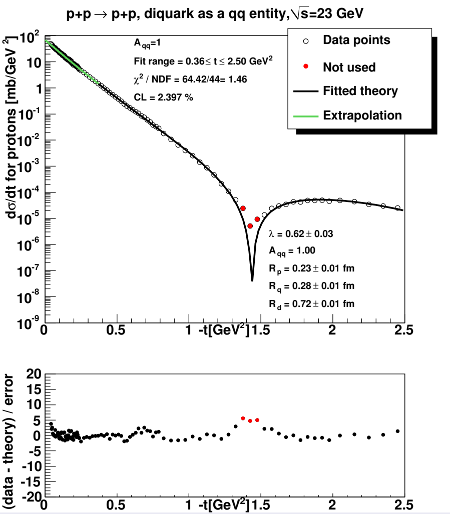
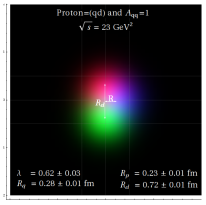


MINUIT parameters

CL	2.40 %
R_{proton}	0.23 ± 0.01 fm
R_{quark}	0.28 ± 0.01 fm
$R_{diquark}$	0.72 ± 0.01 fm
λ	0.62 ± 0.03
A_{qq}	1.00 (fixed)

Visualisation



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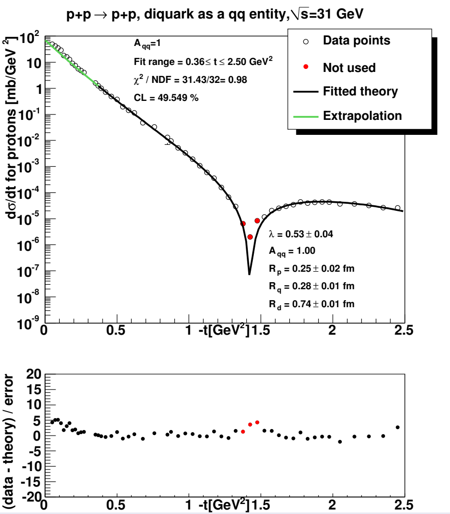
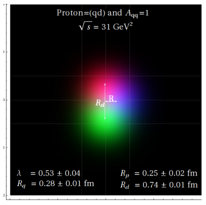


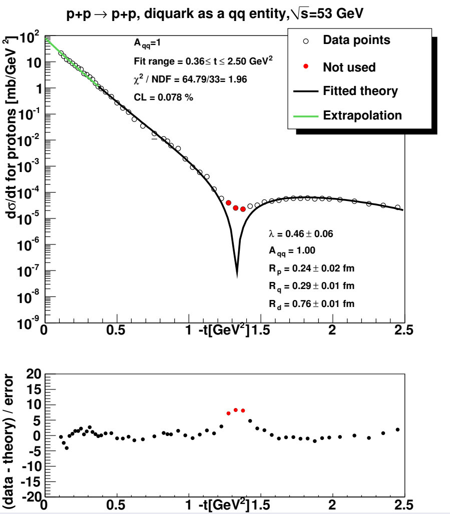
MINUIT parameters

CL	49.5 %
R_{proton}	0.25 ± 0.02 fm
R_{quark}	0.28 ± 0.01 fm
$R_{diquark}$	0.74 ± 0.01 fm
λ	0.53 ± 0.04
A_{qq}	1.00 (fixed)

Visualisation



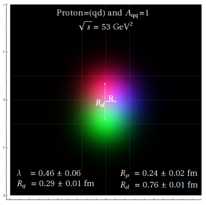
Fitted th. curve at 53 GeV^2 ISR



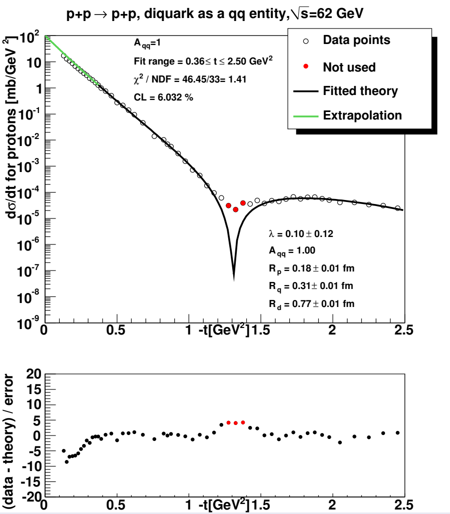
MINUIT parameters

CL	0.1 %
R_{proton}	0.24 ± 0.02 fm
R_{quark}	0.29 ± 0.01 fm
$R_{diquark}$	0.76 ± 0.01 fm
λ	0.46 ± 0.06
A_{qq}	1.00 (fixed)

Visualisation



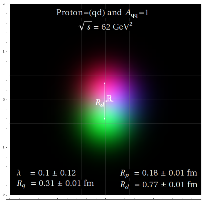
Fitted th. curve at 62 GeV^2 ISR



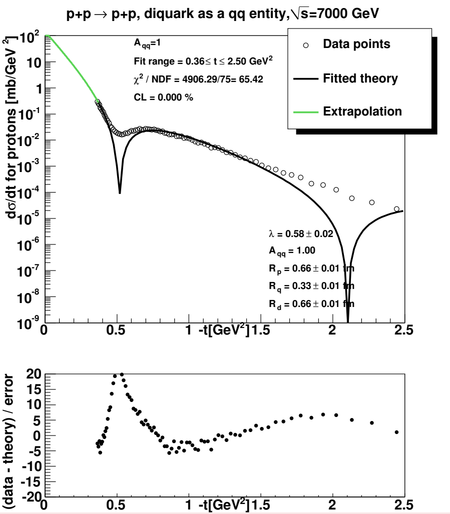
MINUIT parameters

CL	6.0 %
R_{proton}	0.18 ± 0.01 fm
R_{quark}	0.31 ± 0.01 fm
$R_{diquark}$	0.77 ± 0.01 fm
λ	0.10 ± 0.12
A_{qq}	1.00 (fixed)

Visualisation



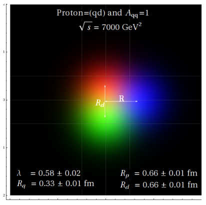
Fitted th. curve at 7k GeV^2 TOTEM



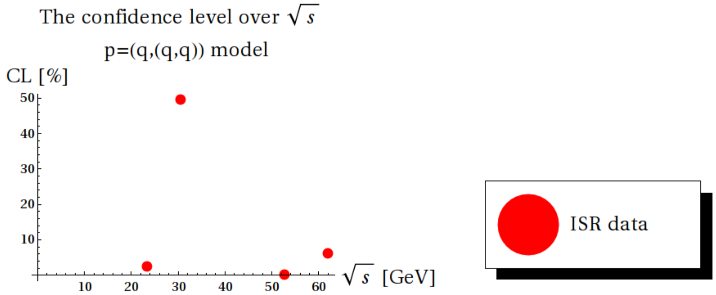
MINUIT parameters

CL	0.0 %
R_{proton}	0.66 ± 0.01 fm
R_{quark}	0.33 ± 0.01 fm
$R_{diquark}$	0.66 ± 0.01 fm
λ	0.58 ± 0.02
A_{qq}	1.00 (fixed)

Visualisation



The confidence level over $\sqrt{s}$



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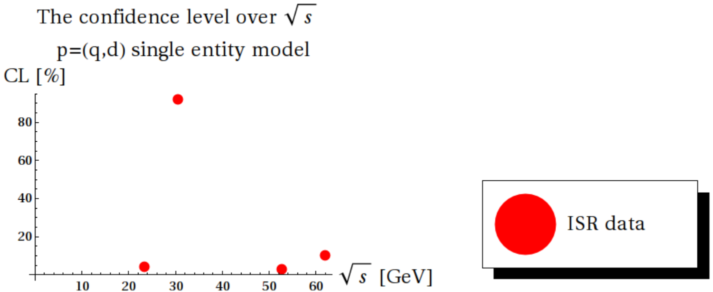
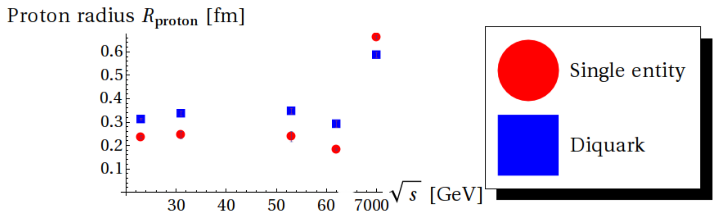
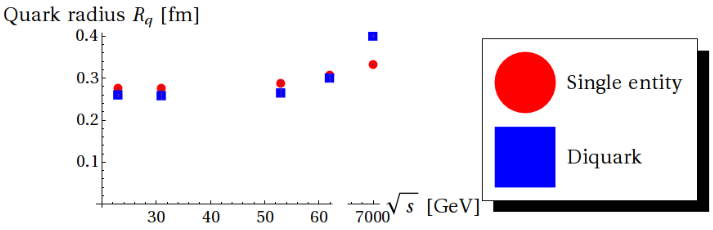


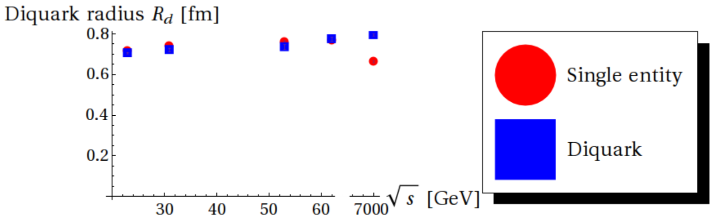
The proton radius over $\sqrt{s}$



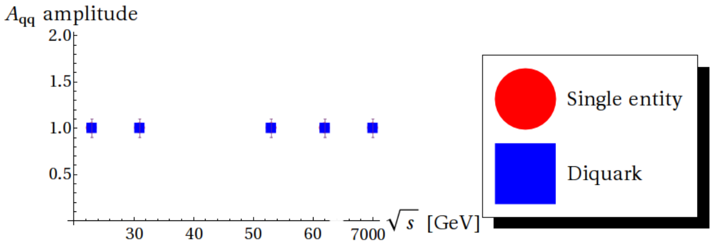
The quark radius over $\sqrt{s}$



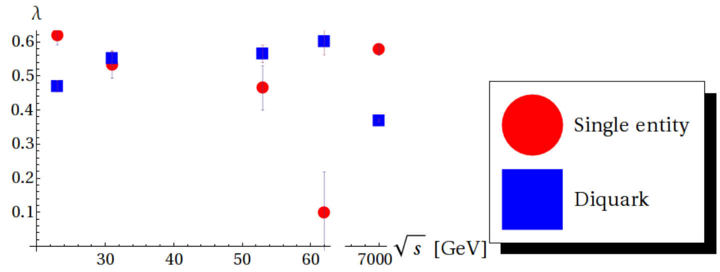
The diquark radius over $\sqrt{s}$



The A_{qq} parameter over $\sqrt{s}$



The λ parameter over $\sqrt{s}$



Conclusions...

Systematic study of fit quality as well as the fit parameters under similar circumstances has been performed for the Bialas - Bzdak model in a wide energy range from ISR to LHC energies.

- Partial description of the data.
- Proton seems to grow with energy but CL is bad at 7 TeV.
- Best result was obtained if the A_{qq} amplitude is fixed to 1.

Acknowledgement

Thank you for your attention !