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Diffraction scattering and the parton structure of hadrons

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DIFFRACTION SCATTERING AND THE PARTON STRUCTURE OF HADRONS

Marek Matas
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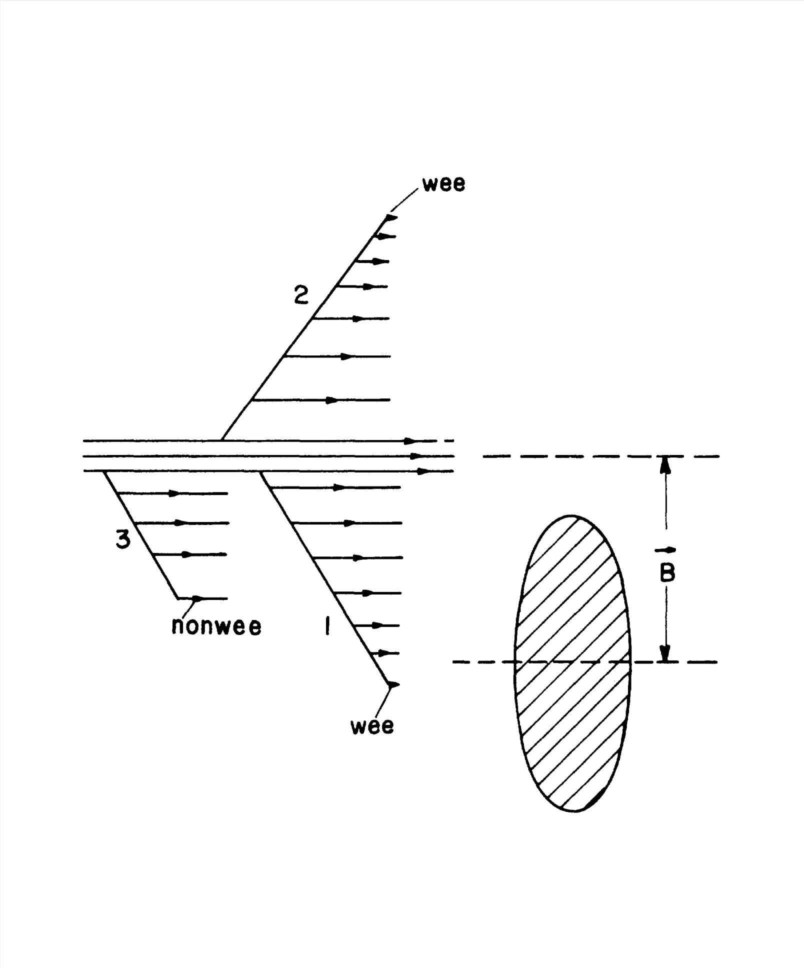
BASICS

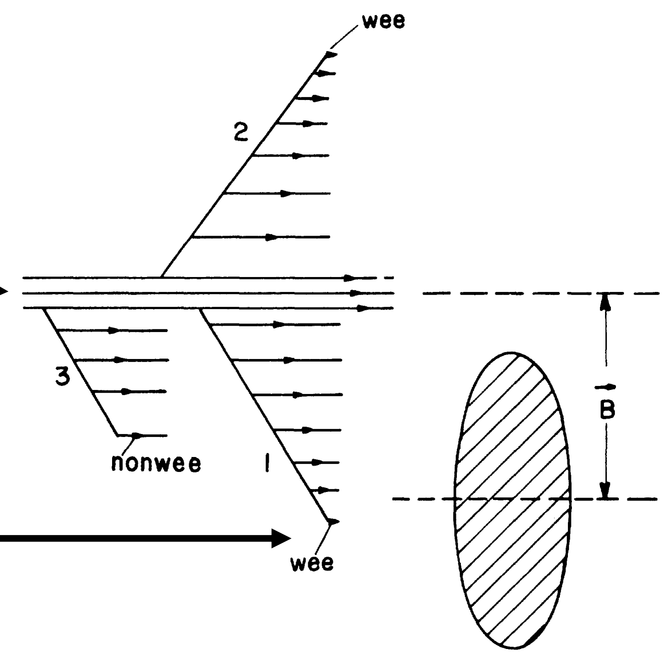
- In this paper, the authors have disregarded QCD-based physics entirely.
- They solely assume a presence of point-like partons inside nucleons.
- One of the nucleons is assumed to be consisted of partons of different energy and the other of an optical potential on which the projectile hadron scatters.



BASICS

- They have disregarded the contribution of the high-energy partons to the fluctuations that govern diffraction processes.

- They focus on modelling the behavior of the soft partons and their contribution to the cross section.



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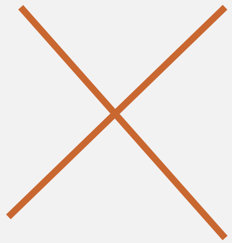
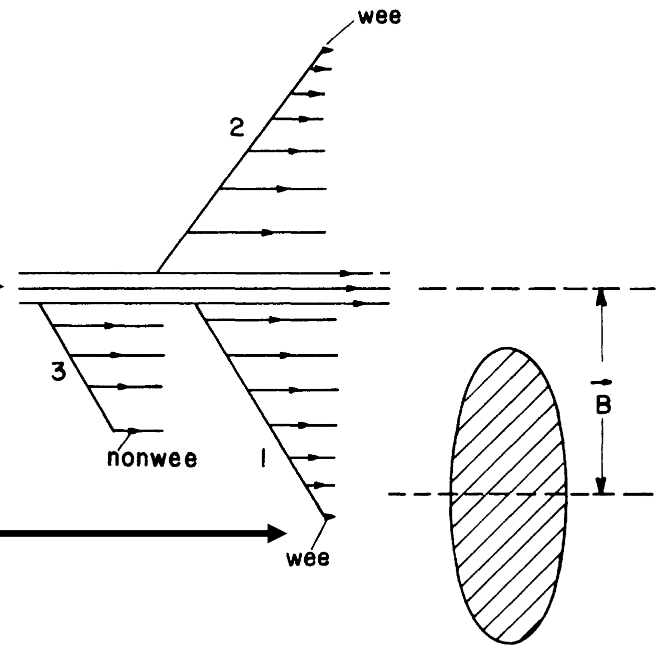


$$|B\rangle = \sum_N \prod_{i=1}^{N} \int d^2\vec{b}_i dy_i C_N(\vec{b}_1, \ldots, \vec{b}_N; y_1, \ldots, y_N) \times |\vec{b}_1, \ldots, \vec{b}_N; y_1, \ldots, y_N\rangle .$$



MODEL

Wee parton model

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Projectile hadron

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Wee parton model

Projectile hadron

Parton rapidities

Parton impact parameters (positions)

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Parton rapidities

Parton impact parameters (positions)

$$|C_N(\vec{b}_1, \ldots, \vec{b}_N; y_1, \ldots, y_N)|^2 = e^{-G^2}(G^{2N}/N!) \prod_{i=1}^{N} |C_i(\vec{b}_i, y_i)|^2$$

Poisson distribution with a mean of G^2 is associated with the probability of existence of N partons.

$$\int d^2\vec{b}_i dy_i |C(\vec{b}_i, y_i)|^2 = 1 .$$

which is normalized

MODEL

Summary of the model:

$|\vec{b}_1, \ldots, \vec{b}_N; y_1, \ldots, y_N\rangle$ Independent wee-parton states

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These interact with probablity

$$t(\vec{b}_1, \ldots, \vec{b}_N; y_1, \ldots, y_N; \vec{b}) = 1 - \prod_{i=1}^{N} (1 - \tau(\vec{b}_i + \vec{b}, y_i)]$$

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$$\langle t \rangle = 1 - e^{-G^2 \langle \tau \rangle},$$
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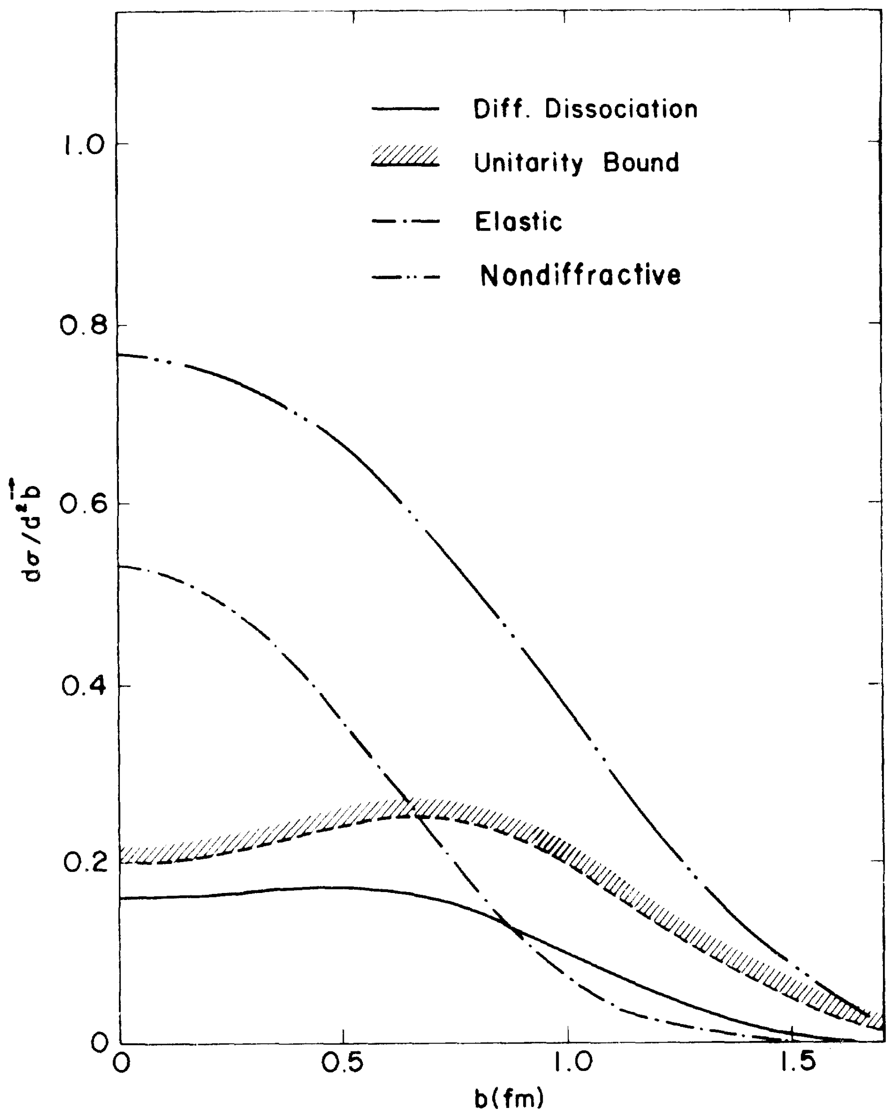
$$d\sigma_{el}/d^2\vec{q} = \frac{1}{4\pi^2} \langle \tilde{t} \rangle^2,$$
$$d\sigma_{diff}/d^2\vec{q} = \frac{1}{4\pi^2} (\langle \tilde{t}^2 \rangle - \langle \tilde{t} \rangle^2),$$

Which translate to the cross sections like this.

HOW THE WORLD LOOKS LIKE WHEN YOU DO THIS

CROSS SECTION DISTRIBUTION



The cross section and its distribution in impact parameter.

The free parameters in this model were fit to describe the integrated total cross section and elastic cross section.

This prediction corresponds with an integrated diffractive cross section of 6.5mb.

CROSS SECTION DISSECTION

Then they tested the dependence of the cross section on the fluctuations in the

1. Impact parameter position

$$\langle \tau^n(b) \rangle \rightarrow \int dy_1 [d^2\vec{b}_1 |C(\vec{b}_1, y_1)|^2 \tau(\vec{b}_1 + \vec{b}, y_1)]^n$$

2. Rapidity of parton

$$\langle \tau^n(b) \rangle \rightarrow \int d^2\vec{b}_i \left[\int dy_1 |C(\vec{b}_1, y_1)|^2 \tau(\vec{b}_1 + \vec{b}, y_1) \right]^n$$

3. Number of partons

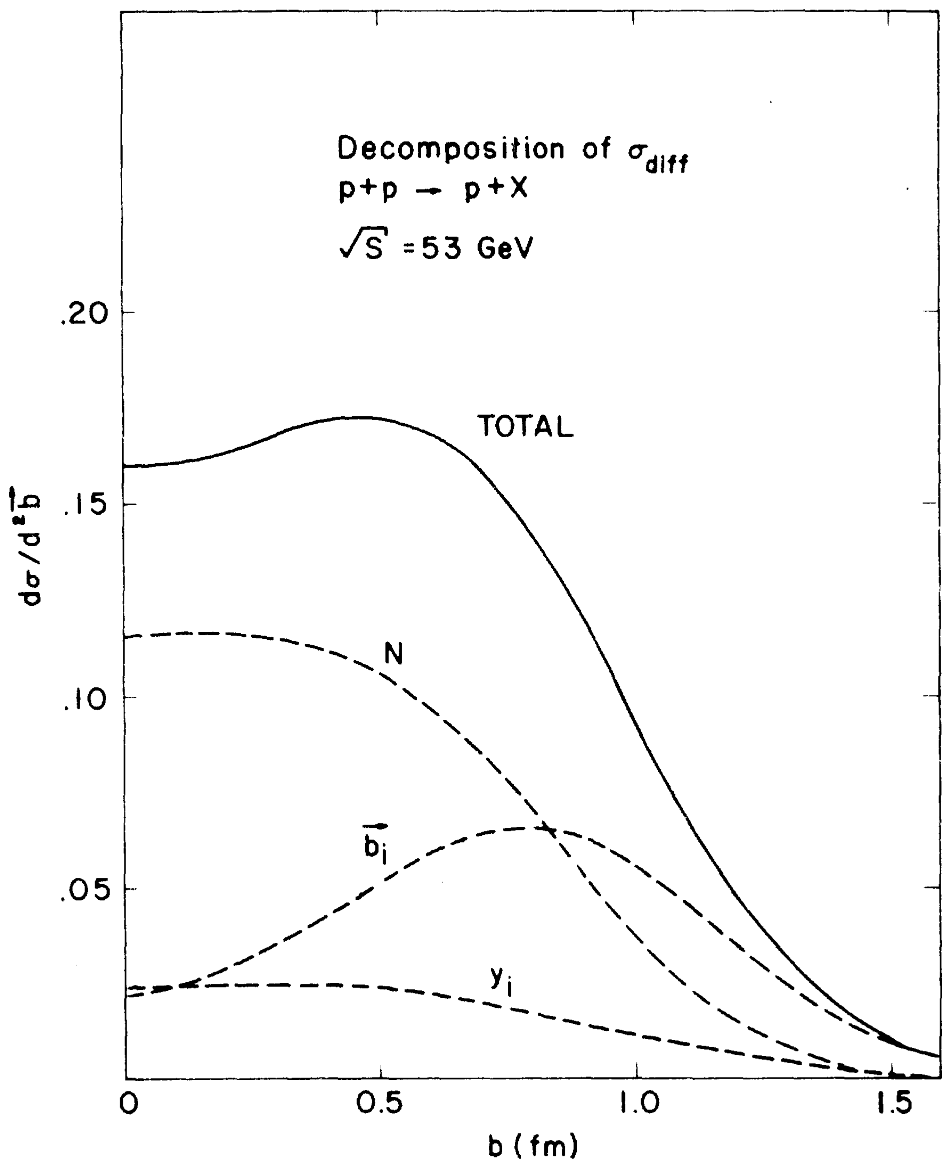
$$\langle \tau^n(b) \rangle \rightarrow \int d^2\vec{b}_i \left[\int dy_1 |C(\vec{b}_1, y_1)|^2 \tau(\vec{b}_1 + \vec{b}, y_1) \right]^n$$

+

$$\langle \tau^n(b) \rangle \rightarrow \int dy_1 [d^2\vec{b}_1 |C(\vec{b}_1, y_1)|^2 \tau(\vec{b}_1 + \vec{b}, y_1)]^n$$

They averaged over the inconsidered fluctuations to study the independent contribution.

CROSS SECTION DISSECTION

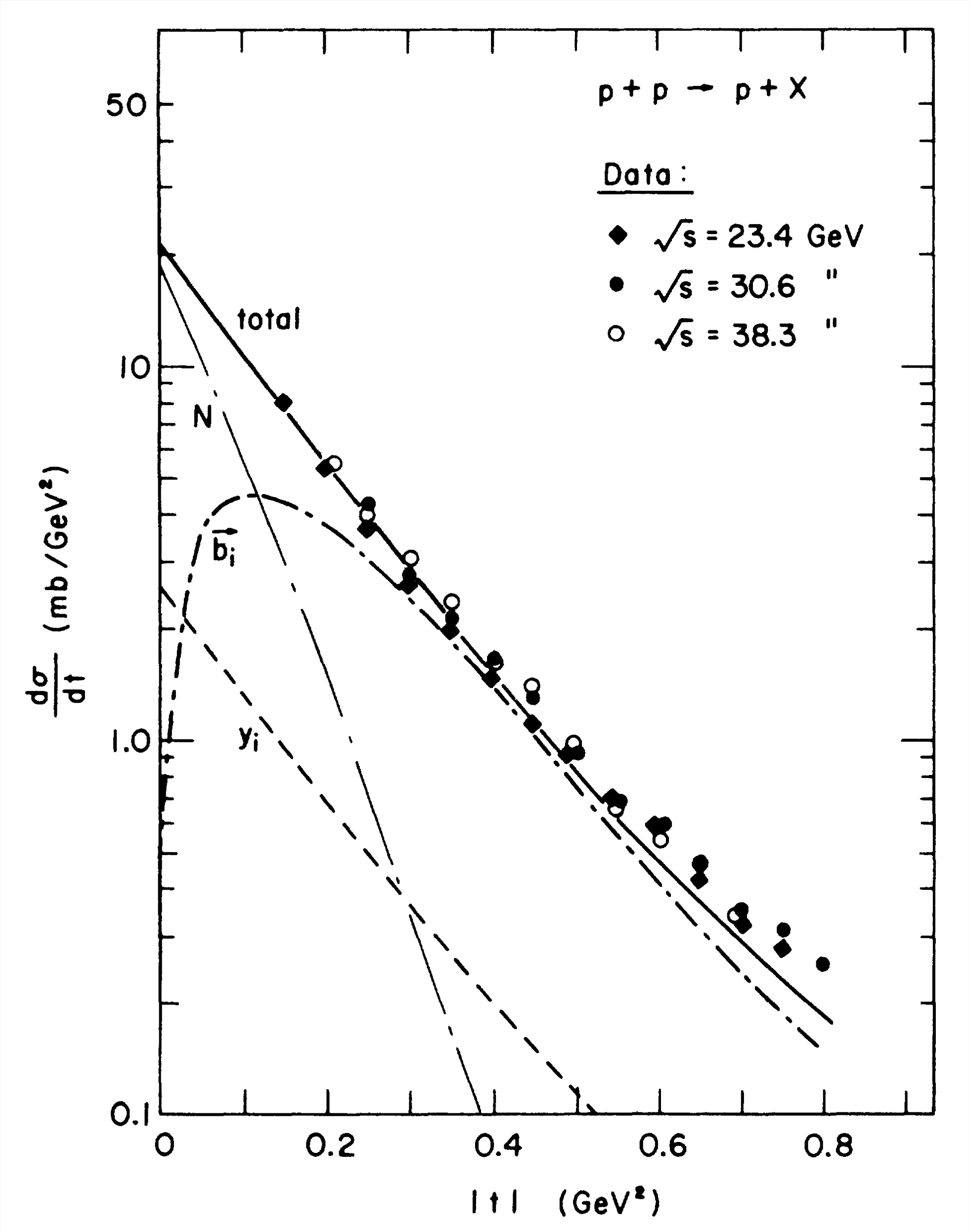


The contribution to the total cross section from fluctuations in impact parameter space, rapidity and number of partons.

12% - rapidity fluctuations
46% - impact parameter fluctuations
47% - number fluctuations

Assumption of independence of fluctuations of partons is almost valid – 105% ~ 100%

DIFFERENTIAL CROSS SECTION



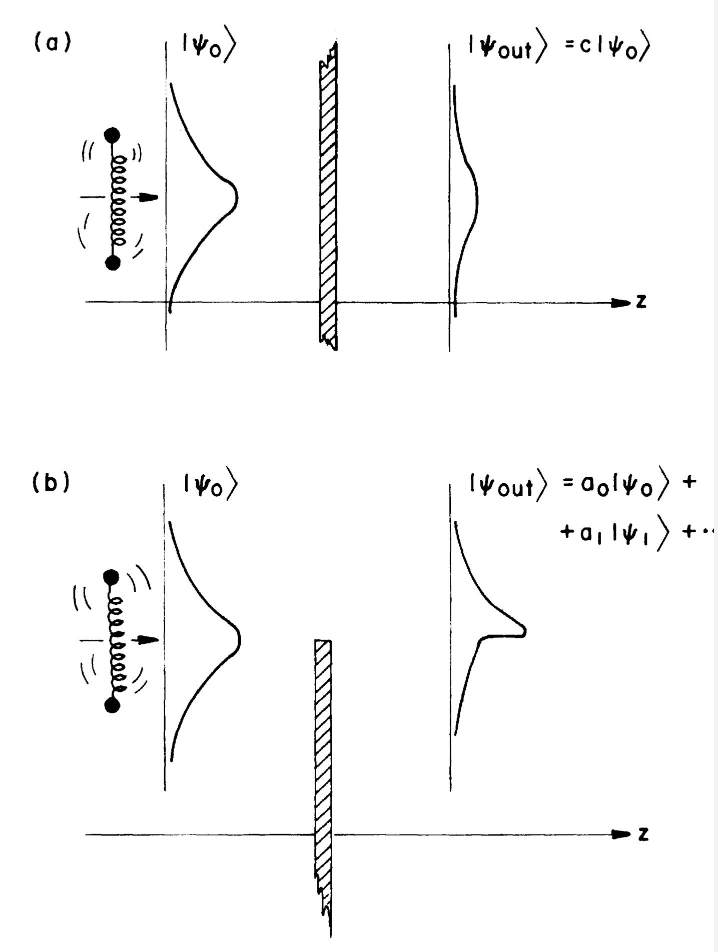
The prediction of this model confronted with data measured at CERN ISR experiment.

Resulting slope of 6.9 GeV^{-2} fits the measured data well.

The decomposition of the cross section into its constituent parts is also shown.

Furthermore, a variation of parameters was carried out, to verify the "rigidness" of the model – a huge variation of parameters resulted into a small variation in results.

PERIPHERALITY



Origin of the diffractive cross section has been shown to be peripheral – large impact parameters contributing more to it.

This is illustrated qualitatively in the following gedanken experiment.

Head on collisions do not deform the wave-function to produce other eigen states.

The peripheral collision then distorts the wave such that other eigen-states are produced in its Fourier decomposition.

COMPARISON TO ADDITIVE QUARK MODEL

$$\sigma_{tot} \underset{BA}{=} \int d^2\vec{b}\,\sigma_{tot}(|\vec{b}_1 - \vec{b}|, \ldots) = 3\sigma^q_{tot}$$

In additive quark model, the total cross section would be equal to the sum of the independent cross sections of the contributing quarks.

In the Born approximation the quark wave function does not depend on impact parameter and quarks are equal in number.

$$d\sigma_{diff}/d^2\vec{q}\,\Big|_{|\vec{q}|=0} = \langle\sigma^2\rangle - \langle\sigma\rangle^2$$

Since $\sigma = 3\sigma^q_{tot}$. is not a distribution, its variance vanishes. So does the cross section, which is in contrary to what we observe in nature.

CONCLUSIONS

Firstly, it was seen that *the global properties of diffraction depended on the distribution and interactions of the very slow "wee" partons only.* Thus,

CONCLUSIONS

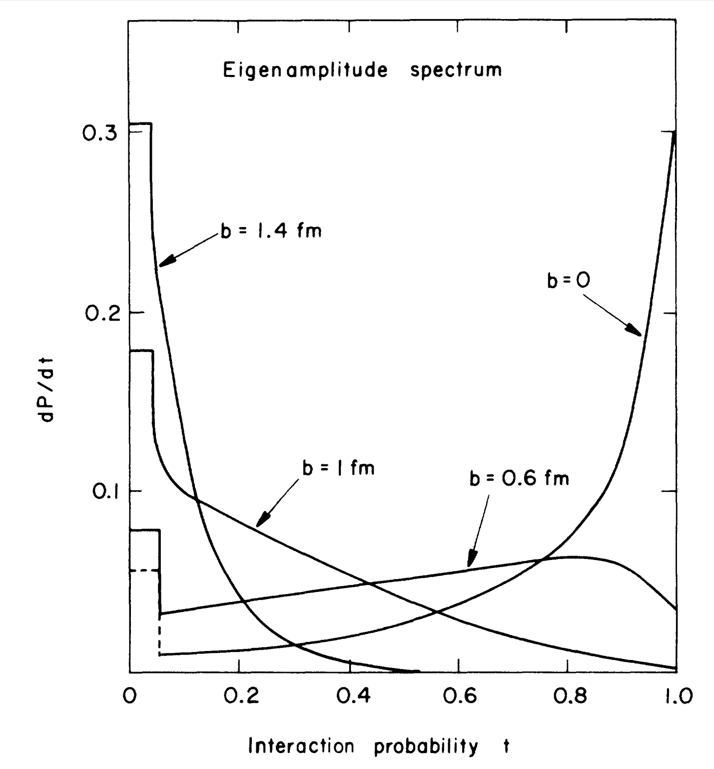
- The model describes elastic scattering as well as dissociative cross section in proton-proton collisions.
- Diffractive collisions have shown to be more peripheral then elastic scattering, which has been qualitatively explained.
- Inelastic cross section has been dissected into its components which contribute ~10%-y, 45%-b and 45%-N.
- Correct forward value of differential diffractive cross section as well as its slope is produced by this model.
- Additive quark model fails to describe such phenomena due to the lack of fluctuations in N, which then results into incorrect data description.

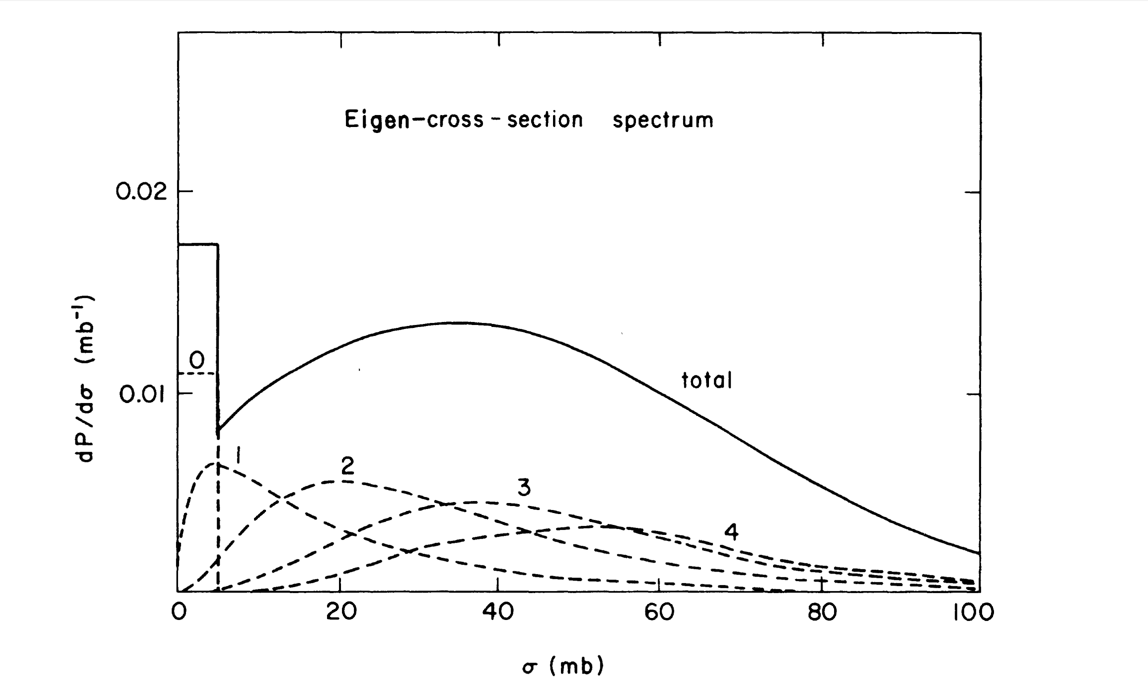
THANK YOU FOR YOUR ATTENTION

No matter what, don’t lose hope. We are all bombastic.

- Dan Nekonečný

CROSS SECTION DISTRIBUTION





$$d\sigma_{\mathrm{diff}}/d^2\vec{q}\,\Big|_{|\vec{q}|=0} = \langle\sigma^2\rangle - \langle\sigma\rangle^2$$

They also studied the distribution of the cross section of the eigen states of the scattering.