Elastic and Diffractive Scattering 2009:

Summary on theoretical aspects

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Agenda

EDS'09: 13th International Conference on Elastic & Diffractive Scattering
from Monday 29 June 2009 (08:00) to Friday 03 July 2009 (22:50)

: Sessions / : Talks : Breaks

AM

Monday 29 June 2009	
08:30	**Registration** (until 09:30)
09:30	**Introduction session** - David d'Enterria Mario Deile Albert De Roeck Michele Arneodo Monika Grothe Risto Orava Beniamino Di Girolamo Marco Bruschi (until 10:15)
09:30	Welcome - Sergio Bertolucci (*CERN*)
09:45	Startup planning for the LHC and operation scenario for forward physics - Helmut Burkhardt (*CERN*) Slides
10:15	--- Coffee break ---
10:45	**Soft Diffraction I**- Gilvan Alves Aliosha Kaidalov Kenneth Oesterberg Marta Ruspa Rainer Schicker Graeme Watt (until 13:00)
10:45	Theoretical overview on soft diffraction - Alexei Kaidalov Slides
11:15	Description of soft diffraction in the framework of reggeon calculus.

Tuesday 30 June 2009	
08:30	**Elastic Scattering and Total Cross-Section II**- Maurice Haguenauer Munir Islam Laszlo Jenkovszky Alan Krisch Vojtech Kundrat (until 10:35)
08:30	The Froissant Bound for Inelastic Cross Sections - Andre Martin (*CERN*)
08:55	ATLAS CNI Experiment - Total Cross Sections and Luminosity - Matthieu Heller (*Lab. de l'Accelerateur Lineaire (IN2P3) (LAL) - Universite de Paris Sud*) Slides
09:20	Theoretical Aspects of High Energy Elastic Nucleon Scattering - Vojtech Kundrat (*Institute of Physics, AS CR*) Slides
09:45	The Total Cross Sections at the LHC: Models and Experimental Consequences - Jean-Rene Cudell (*Universite de Liege*) Slides
10:10	Proton-Proton Elastic Scattering at LHC and Proton Structure - Richard Luddy (*University of*

Wednesday 01 July 2009	
08:30	**Hard Diffraction I**- Gilvan Alves Aliosha Kaidalov Kenneth Oesterberg Marta Ruspa Rainer Schicker Graeme Watt (until 10:30)
08:30	Analytic properties of DPE amplitudes - Oleg Teryaev (*Joint Inst. for Nuclear Research (JINR)-Unknown-Unknown*) Slides
08:50	Low-x Structure Functions using Discrete BFKL Pomerons - Douglas Ross Slides
09:10	Soft gluon resummation for gaps between jets - Simone Marzani (*University of Manchester*) Slides
09:30	CDF Results on Diffraction - Christina Mesropian (*The Rockefeller University*) Slides
10:00	Inclusive hard diffraction at HERA - Alexander Proskuryakov (*M.V. Lomonosov Moscow State*

Thursday 02 July 2009	
08:30	**Central Production, Higgs**- Valeri Khoze Andrew Denis Pilkington (until 10:35)
08:30	Exclusive high mass di-leptons in CDF - Michael Albrow (*Fermi National Accelerator Laboratory (FNAL)*) Slides
08:50	Exclusive charmonium production at CDF - James Pinfold (*Department of Physics*) Slides
09:10	central exclusive chi-c production - Oleg Teryaev (*Joint Inst. for Nuclear Research (JINR)*) Slides
09:30	Central exclusive production: vector mesons, jets and Higgs - Jean-Rene Cudell (*Universite de Liege*) Slides
09:55	Central Exclusive Higgs Production in the MSSM - Sven Heinemeyer (*CERN*) Slides

Friday 03 July 2009	
08:30	**Forward physics & low-x QCD**- Francois Gelis Hannes Jung (until 10:30)
08:30	HERA results on small x and forward jets - Lev Khein (*MSU*) Slides
08:50	Forward jets physics in ATLAS, CMS and LHCb - David d'Enterria (*CERN*) Slides
09:15	Saturation - Emil Avsar (*CEA/Saclay*) Slides
09:30	Standard dilute BFKL - Florian Schwennsen (*Universite Paris-Sud*) Slides
09:45	Saturation in nuclei - Tuomas Lappi (*CEA/Saclay*) Slides
10:00	Small x related issues - Francesco Hautmann (*Institute of Theoretical Physics*) Slides

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Time	Session / Talk
	Physics Institute) Slides
11:35	Soft Scattering Re-Visited - Uri Maor Slides
12:05	Aspects of Higgs production at the LHC - Errol (Asher) Gotsman Slides
12:25	Color fluctuations and gap survival probability at LHC - Mark Strikman Slides
12:45	One-particle inclusive distribution in the unitarized pomeron models - Evgenij Martynov *(Bogolyubov Institute for Theoretical Physics (ITP))* Slides

Time	Session / Talk
10:35	--- Coffee break, conference photo (1st attempt; weather dependent) ---
11:00	**Elastic Scattering and Total Cross-Section III** (until 13:00)
11:00	TOTEM Experiment: Elastic and Total Cross Sections - Jan Kaspar Slides
11:25	Optical Theorem and Elastic Nucleon Scattering - Milos Lokajicek *(Institute of Physics, AS CR)* Slides
11:45	Pomeron, Duality, Saturation etc. - Chung-I Tan *(Brown)* Slides
12:10	pp Elastic Spin Observables Confront QCD - Dennis Sivers *(Michigan)*
12:35	Reflective Elastic Scattering at LHC - Sergey Troshin *(IHEP, Protvino, Russia)* Slides

Time	Session / Talk
	--- Coffee break ---
11:00	**Hard Diffraction II** (until 12:30)
11:00	Exclusive hard diffraction at HERA - Pierre Marage Slides
11:20	HERMES: New DVCS results - Sergey Yashchenko Slides
11:40	Low x Physics Possibilities at an LHeC - Paul Newman *(Birmingham University)* Slides
12:05	The J/psi way to nuclear structure - Henri Paul Kowalski *(Deutsches Elektronen Synchrotron (DESY))* Slides
12:30	--- Lunch ---

Time	Session / Talk
	Slides
10:35	--- Coffee break ---
11:00	**Central Production, Higgs-** Valeri Khoze Andrew Denis Pilkington (until 11:25)
11:00	Overview of CEP measurements at the LHC - Marek Tasevsky *(Physics Institute Prague)*
11:25	**Heavy Ion Physics-** Francois Arleo David d'Enterria (until 13:05)
11:25	QCD and heavy-ions: RHIC overview - Raphael Granier De Cassagnac *(LLR)* Slides
11:50	QCD and heavy-ions: LHC prospects - Gines Martinez-Garcia *(Laboratoire de Physique Subatomique et des Technologies Associees)* Slides
12:15	QCD and heavy-ions at high-energies: phenomenological aspects - Jean-Yves Ollitrault *(SPhT, Saclay)* Slides
12:40	Medium tomography with jet clustering algorithms - Juan Rojo *(INFN)* Slides

Time	Session / Talk
11:00	**Contributions: forward physics and low-x QCD** (until 12:15)
11:00	Critical phenomena in hadron- and lepton-induced reactions - Laszlo Jenkovszky Slides
11:20	Beauty baryon production in p-p collisions at LHC and b-quark distribution in the proton - Gennady Lykasov *(Joint Institute for Nuclear Research)* Slides
11:35	Higher-twist dynamics in large pT hadron production - Francois Arleo *(CERN)* Slides
11:55	Initial-state interactions in Drell-Yan processes at hadron collisions - Dae Sung Hwang Slides
12:15	**Contributions: cosmic ray physics** (until 12:55)
12:15	HERA, LHC and cosmic rays - Armen Bunyatyan *(DESY)* Slides
12:35	Unusual event alignment topologies in cosmic rays and expectation for the LHC - Alexandre Snigirev *(Moscow State University)* Slides
12:55	--- Lunch ---

Agenda

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Time	Session
13:00	--- Lunch ---
14:30	**Diffraction at the LHC** (until 16:30)
14:30	Diffraction at CMS - Wagner Carvalho (*Instituto de Fisica-Universidade do Estado do Rio De Janeiro (UE)*) Slides
15:00	Diffraction at TOTEM - Simone Giani (*CERN*) Slides
15:30	ATLAS plans on soft and hard diffraction at the early LHC - Vojtech Juranek (*Institute of Physics*) Slides
16:00	Diffraction at ALICE - Rainer Schicker Slides
16:30	--- Coffee break ---
17:00	**Soft Diffraction II** (until 18:00)
17:00	Factorization Breaking in Diffraction - Konstantin Goulianos (*The Rockefeller University*) Slides
17:30	Soft interaction processes at HERA: leading baryons, multi-parton interactions - Armen Bunyatyan (*DESY*) Slides

Time	Session
13:00	--- Lunch ---
14:30	**Past and Future of Forward Physics Experiments I-** Marco Bruschi Beniamino Di Girolamo (until 16:30)
14:30	Fermilab - Konstantin Goulianos (*The Rockefeller University*) Slides
15:00	HERA - Henri Paul Kowalski (*Deutsches Elektronen Synchrotron (DESY)*) Slides
15:30	ATLAS - Antonio Zoccoli (*Bologna*) Slides
16:00	CMS - Krzysztof Piotrzkowski (*Universite Catholique de Louvain*) Slides
16:30	--- Coffee break ---
17:00	**Past and future of forward physics experiments II-** Marco Bruschi (*INFN Bologna, ITALY*) Beniamino DI GIROLAMO (*CERN PH-ADE*) (until 17:30)
17:00	TOTEM - Gennaro Ruggiero (*CERN*) Slides
17:30	**Discussion session: What can we learn/expect from the LHC experiments?-** Karsten Eggert (*CERN*) (until 19:00) Minutes

Time	Session
13:50	**Contributions: photon-induced and heavy-ion physics** (until 14:30)
13:50	Sensitivity to anomalous WWgamma, gamma gamma WW and gamma gamma ZZ couplings in photon induced processes at the LHC - Oldrich Kepka (*Centre d'Etudes de Saclay (CEN Saclay)*) Slides
14:10	Spin correlations in the \Lambda \Lambda and \Lambda \bar {\Lambda} systems generated in relativistic heavy ion collisions - Valery Lyuboshitz Slides
14:30	--- break ---
15:15	--- Excursion ---

Time	Session
	Slides
13:05	--- Lunch ---
14:30	**Cosmic Ray Physics and Related Studies at LHC-** Joerg Hoerandel Gianni Navarra (until 16:35)
14:30	Cosmic Rays and Extensive Air Showers - Todor Stanev
14:54	Current concepts in theory and modelling of high energy hadronic interactions - Klaus Werner Slides
15:18	Test of hadronic interaction models with EAS data - Jörg HöRANDEL Slides
15:42	Proton air cross section measurements with air shower experiments - Gian Carlo Trinchero Slides
16:06	Forward experiments at LHC - Alessia Tricomi (*Dipartimento di Fisica*) Slides
16:30	Conclusions: the interplay of EAS and accelerator experiments - Jörg HöRANDEL
16:35	--- Coffee break ---
17:00	**Photon-Induced Physics-** Jeffrey Gronberg Joakim Nystrand (until 18:50)
17:00	Ultra-peripheral Collisions in

Time	Session
14:30	**Summary Session** (until 16:30)
14:30	Summary on theoretical aspects - Jacques Soffer (*Temple University, Philadelphia*)
15:15	Summary on experimental aspects - John Dainton (*The Cockcroft Institute*)
16:00	Summary of the discussion session - Karsten Eggert (*CERN*)

Outline

1 - Soft Diffraction

- Theoretical overview on soft diffraction Kaidalov
- Reggeon calculus for soft diffraction Poghosyan
- Soft diffraction Re-Visited Maor
- Aspects of Higgs production at the LHC Gotsman
- Color fluctuations and gap survival probability at LHC Strikman
- One particle inclusive and unitarized Pomeron models Martynov

2 - Elastic Scattering and Total Cross-Section

- Amplitudes pp, $\bar{p}p$ in Coulomb interference region Ferreira
- GPD and elastic scattering at LHC Selyugin

Outline (continued)

- Froissart bound for σ_{inel} Martin
- Theoretical aspects of elastic scattering at HE Kundrat
- Total cross section at LHC: Models and Exp. Consequences Cudell
- pp elastic scattering at LHC and proton structure Luddy
- Optical theorem and elastic nucleon scattering Lokajicek
- Pomeron, duality, saturation Chung I Tan
- pp elastic spin observables confront QCD Sivers
- Reflective elastic scattering at LHC Troshin

Outline (continued)

3 - Hard Diffraction

- Analytic properties of DPE amplitudes Teryaev
- Low-x structure functions using discrete BFKL Pomeron Ross
- Soft gluon resummation for gaps between jets Marzani

4 - Central production, Higgs

- Central exclusive χ_c production Teryaev
- Central exclusive Higgs production:vector mesons, jets, Higgs Cudell
- Beyond Standard Model Higgs search Heinemeyer
- Exclusive Higgs production in a triplet scenario Huitu

Soft Diffraction *(Kaidalov)*

Contents.

- Introduction. s- and t-channel points of view for diffraction.
- Unitarity effects in Gribov`s approach.
- Interplay of soft and hard diffraction.
- Large mass diffraction and role of pomeron interactions.
- Conclusions.

Soft Diffraction *(Kaidalov)*

Introduction.

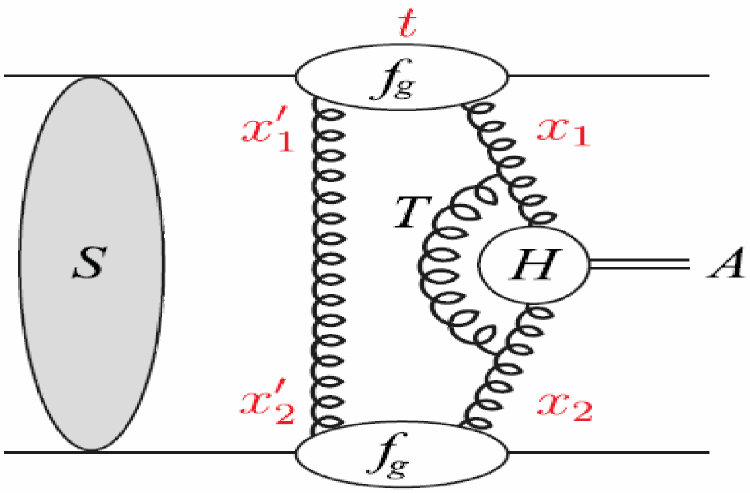
- Diffractive processes constitute ≈ $\frac{1}{2}\sigma^{(tot)}$. Investigation of these processes gives an important information on dynamics of strong interactions at high energies.

Some important problems of diffraction:

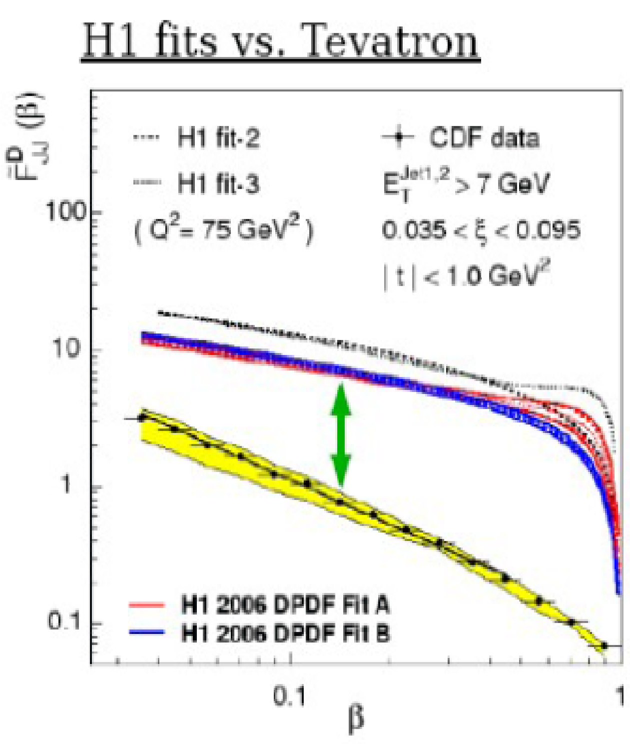
- The nature of the pomeron in QCD.
- Role of s-channel unitarity and multi- pomeron exchanges.
- Small-x problem and "saturation" of partonic densities as $x \to 0$.
- Violation of QCD and Regge factorization in diffractive processes.

DPE Higgs production.

Central exclusive production of a Higgs boson at very high energies. Cross section depends on gap survival probability.



Suppression of diffractive dijets at Tevatron.



Suppression in hadronic interactions is due to multipomeron exchanges.
V.Khoze et al (KKMR)
describe CDF data in multi-channel eikonal model.
Important for Higgs production at LHC.

Reggeon calculus for soft diffraction

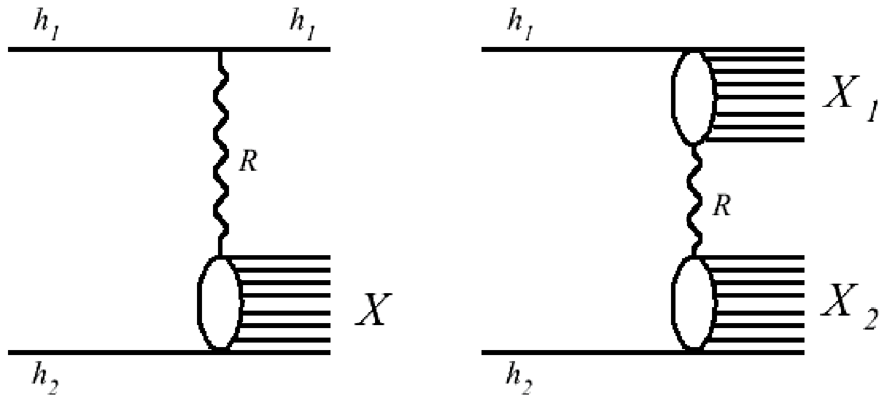
(Poghosyan)

Regge pole exchange diagrams for SD and DD

The process of soft diffraction dissociation is closely related to small angle elastic scattering:

$$h_1 + h_2 \to h_1 + X_2, \quad h_1 + h_2 \to X_1 + h_2, \quad h_1 + h_2 \to X_1 + X_2,$$

where these processes may be considered as binary reactions where each of the incoming hadrons may become a system which will then decay into a number of stable final state particles.



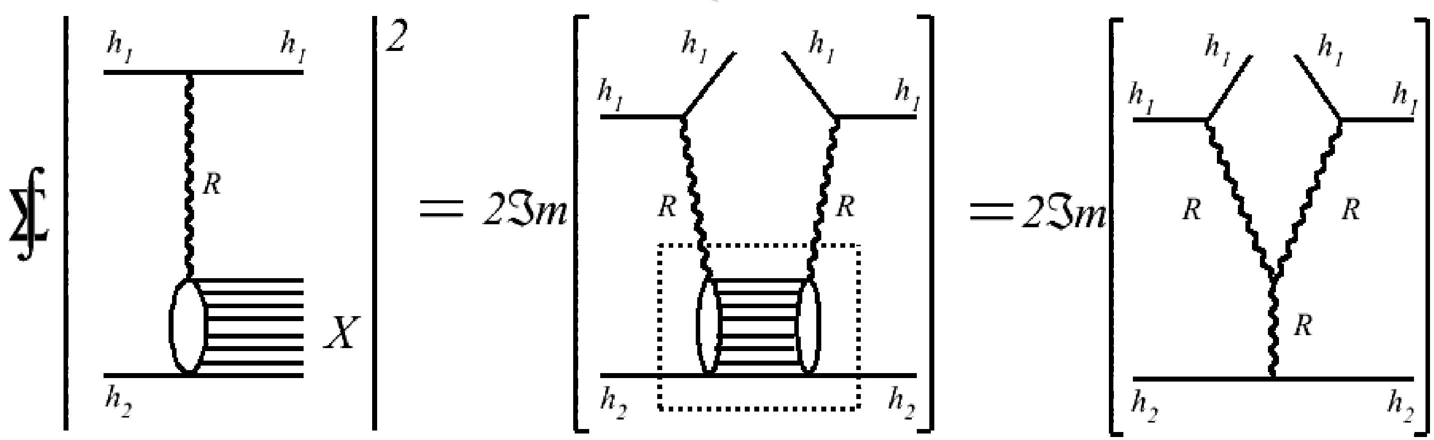
Reggeon calculus for soft diffraction

(Poghosyan)

Triple-Reggeon coupling

Analogous to the optical theorem, Muller's theorem relates the inclusive cross-section for the reaction $h_1+h_2 \rightarrow h_1+X$ to the forward scattering amplitude of the three-body hadronic process $h_1+h_2+h_1 \rightarrow h_1+h_2+h_1$.

$$\sum_c T_{ac} T^*_{ac} = 2\Im m T_{aa}$$



$$\sum_X \left| \cdots \right|^2 = 2\Im m \left[\cdots \right] = 2\Im m \left[\cdots \right]$$

Reggeon calculus for soft diffraction

(Poghosyan)

Conclusion and predictions for LHC.

The model is simple but it gives a good description of data on soft diffraction dissociation.

$\sqrt{s}$ TeV	σ_{tot} mb	σ_{el} mb	B GeV^{-2}	$\sigma_{SD}(M^2/s<0.05)$ mb	$\sigma_{DD}(\Delta\eta>3)$ mb
0.9	66.8	14.6	15.4	8.2	5.7
10	102	27	19.8	12	6.2
14	108	29.5	20.5	13	6.4

Based on the results of KT-MP Pomeron intercept renormalization scheme, we expect to have up to 5% uncertainty due to enhanced diagrams for total and elastic cross-sections and up to 10% for diffractive dissociation cross sections.

Soft Scattering Re-Visited

Uri MAOR

Tel-Aviv University

EDS'09, CERN Genève

Soft Scattering Re- Visited *(Maor)*

1.3

I shall discuss the modelling of the above dynamical observations with special emphesis on:

- The implications of s-channel screening and Pomeron enhancement on soft scattering and its implied gap survival probabilities.
- The approach of the elastic amplitude, at small impact parameter b, toward the black disc bound.
- How much diffraction (soft and hard) do we expect at exceedingly high energies.
- The interplay between theory and data analysis in soft scattering modellings.
- The identification of experimental signatures implied by the above.
- The nature of the Pomeron and its QCD foundations. What is the relation between soft and hard Pomerons?

Soft Scattering Re- Visited *(Maor)*

4.5

1) σ_{tot}, σ_{el}, $\frac{d\sigma_{el}}{dt}$ are compatible.

2) KMR estimates of σ_{sd} are larger than GLMM.

3) The incompatability between GLMM and KMR becomes extreme when comparing σ_{sd}.

4) In early publications KMR had $\sigma_{dd} > \sigma_{sd}$. In the latest set of papers the high mass sector of σ_{dd} is omitted!

	Tevatron			LHC			W=10^5 GeV		
	GLMM	KMR(07)	KMR(08)	GLMM	KMR(07)	KMR(08)	GLMM	KMR(07)	KMR(08)
σ_{tot}(mb)	73.3	74.0	73.7	92.1	88.0	91.7	108.0	98.0	108.0
σ_{el}(mb)	16.3	16.3	16.4	20.9	20.1	21.5	24.0	22.9	26.2
σ_{sd}(mb)	9.8	10.9	13.8	11.8	13.3	19.0	14.4	15.7	24.2
$\sigma_{sd}^{\text{low M}}$	8.6	4.4	4.1	10.5	5.1	4.9	12.2	5.7	5.6
$\sigma_{sd}^{\text{high M}}$	1.2	6.5	9.7	1.3	8.2	14.1	2.2	10.0	18.6
σ_{dd}(mb)	5.4	7.2		6.1	13.4	?	6.3	17.3	
$\frac{\sigma_{el}+\sigma_{diff}}{\sigma_{tot}}$	0.43	0.46		0.42	0.53	?	0,41	0.57	

TABLE III: Comparison of GLMM, KMR(07) and KMR(08) outputs.

5) The extensive LKMR(09) analysis of $\frac{d\sigma_{sd}}{dt\, d\frac{M^2}{s}}$ convincingly demonstrates the need to supplement the 3IP vertex with secondary Regge contributions such as IPIPR and RRIP. LKMR addresses the Pomeron enhanced contribution only at its lowest order. As such this analysis has very limited relevance in our context.

6) KMR (07) and GLMM (08) calculations of $\frac{d\sigma_{sd}}{dt\, d\frac{M^2}{s}}$ are consistency checks as both models need an arbitrary background term so as to reproduce the CDF data.

7) Note that LKMR(09) were able to fit the data at 540 and 1800 GeV only after a relative normalization rescale of 25%.

Soft Scattering Re- Visited *(Maor)*

7.1

7. Concluding Remarks

1) A primary implication of Pomeron enhancement is that σ_{tot} and σ_{el} are reduced at LHC and above. Both GLMM and KMR predictions are 10-20% lower than estimated 2 years ago.

2) A measurement of σ_{sd} and σ_{dd}, in particular high mass, is critical for the understanding of Pomeron enhancement and its decisive verification.

3) I wish to end with a common sense reminder. Obviously, any reasonable model applied to the multi TeV range is required to reasonably reproduce the Sp$\bar{p}$S-Tevatron data. It is also obvious that this is not sufficient.
To remind you, the range of "legitimate" σ_{tot} predictions at the LHC spreads from 90 mb (GLMM, KMR) to 230 mb (Trashin and Tyurin).

Aspects of Higgs production at the LHC

(Gotsman)

ASPECTS OF HIGGS PRODUCTION AT THE LHC

Errol Gotsman
Tel Aviv University

Outline

- GLMM model for high energy soft interactions incorporating multi eikonal scattering plus multi-Pomeron vertices.
- Hard matrix element
- Estimates of Survival Probability for Central Higgs production at LHC.
- Comparison with competing models
- Summary

Aspects of Higgs production at the LHC

(Gotsman)

Survival Probability for exclusive central diffractive production of the Higgs boson

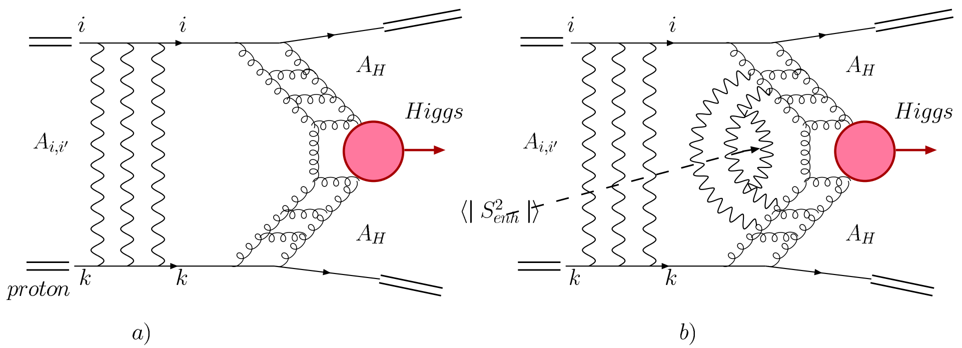


Fig-a shows the contribution to the survival probability in the G-W mechanism
Fig-b illustrates the origin of the additional factor $\langle | S^2_{enh} | \rangle$

Eikonal s-channel corrections give rise to the LRG survival probability of hard diffraction.
Experimental evidence $\rightarrow$ hard dijets with LRG at Tevatron are scaled down by a factor $\langle | S^2 | \rangle \approx 0.1$, compared to dijets at Desy (due to screening).

Aspects of Higgs production at the LHC

(Gotsman)

Survival Probalitity including G-W, Enhanced, and Semi-Enhanced diagrams

(Preliminary)

Survival probability ($S^2\%$)	Tevatron	LHC
G-W + enhanced diagrams	1.51	0.24
G-W + enhanced diagrams + semi-enhanced (perturbative)	1.48	0.23

Color fluctuations and gap survival probability at LHC *(Strikman)*

Strength of the gluon field should depend on the size of the quark configurations - for small configurations the field is strongly screened - gluon density much smaller than average.

How strong are fluctuations of the gluon field in nucleons?

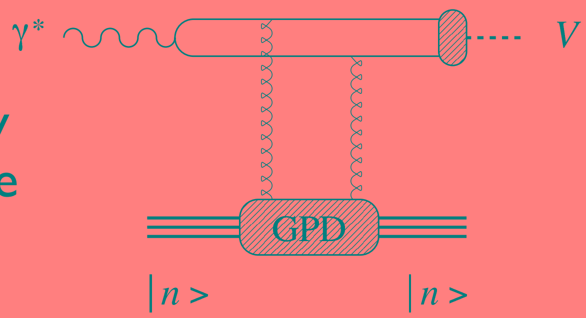
FSTW08

Consider $\gamma_L^* + p \to V + X$ for Q^2 > few GeV^2

In this limit the QCD factorization theorem (BFGMS03, CFS07) for these processes is applicable

Expand initial proton state in a set of partonic states characterized by the number of partons and their transverse positions, summarily labeled as $|n\rangle$

$$|p\rangle = \sum_n a_n |n\rangle$$



Each configuration n has a definite gluon density $G(x, Q^2 | n)$ given by the expectation value of the twist--2 gluon operator in the state $|n\rangle$

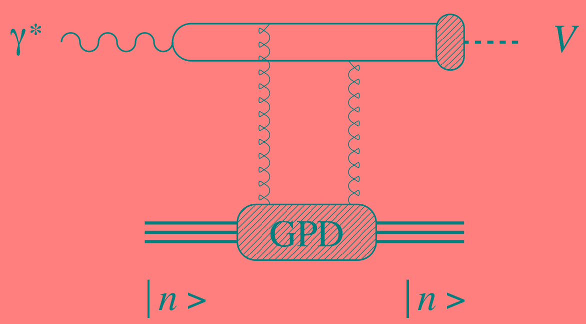
$$G(x,Q^2) \; = \; \sum_n |a_n|^2 G(x,Q^2|n) \; \equiv \; \langle G \rangle$$

Color fluctuations and gap survival probability at LHC *(Strikman)*

Making use of the completeness of partonic states, we find that the elastic($X = p$) and total diffractive (X arbitrary) cross sections are proportional to

$$(d\sigma_{\rm el}/dt)_{t=0} \;\propto\; \left[\sum_n |a_n|^2 G(x,Q^2|n)\right]^2 \equiv \langle G\rangle^2,$$

$$(d\sigma_{\rm diff}/dt)_{t=0} \;\propto\; \sum_n |a_n|^2 \left[G(x,Q^2|n)\right]^2 \equiv \langle G^2\rangle.$$



Hence cross section of inelastic diffraction is

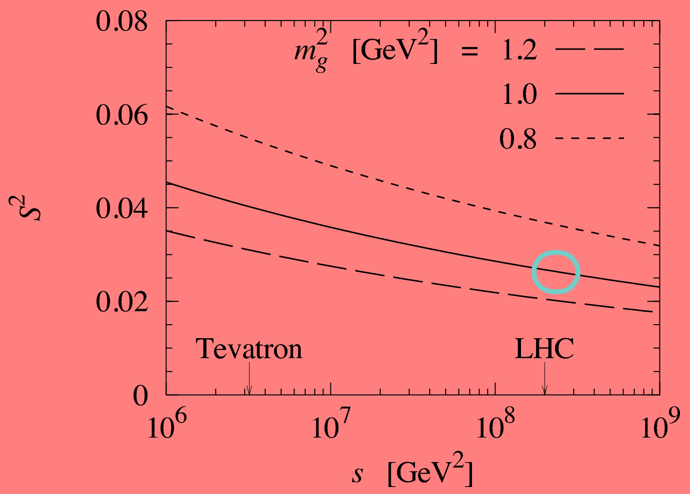
$$\sigma_{\rm inel} = \sigma_{\rm diff} - \sigma_{\rm el}$$

$$\Rightarrow \quad \omega_g \equiv \frac{\langle G^2\rangle - \langle G\rangle^2}{\langle G\rangle^2} = \frac{d\sigma_{\gamma^*+p\to VM+X}}{dt} \Bigg/ \frac{d\sigma_{\gamma^*+p\to VM+p}}{dt}\Bigg|_{t=0}$$

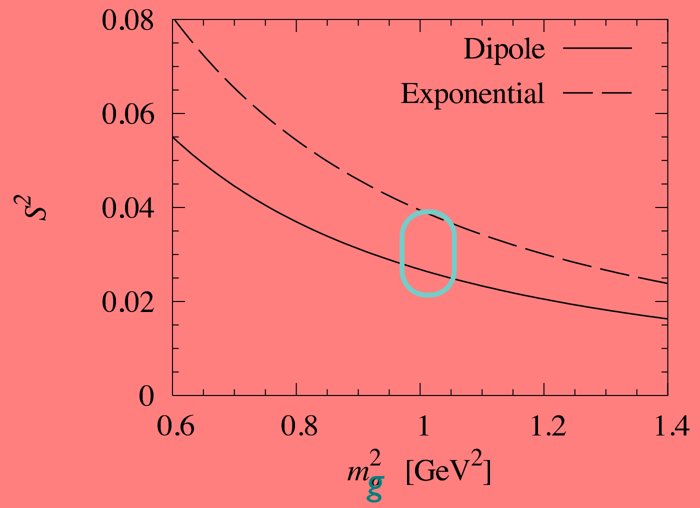
New sum rule!

Color fluctuations and gap survival probability at LHC *(Strikman)*

Sensitivity to GPD input



dipole t dependence of gluon GPD



sensitivity to the shape of gluon GPD

S^2 in the mean field approximation for LHC is 3 - 4 % - close to the result of Khoze et al which however included strong reduction of S^2 due to inelastic diffraction

Color fluctuations and gap survival probability at LHC *(Strikman)*

Is there a chance to get $S^2 \sim 1\%$?

Need mechanism to generate Hard gluons not correlated with other partons

example - Sudakov form factor suppressed contribution

The probability to find a gluon at $x=10^{-2}$ at $Q^2=4\ GeV^2$ which had the same x at a soft scale of Q_0^2 is given by $C\ \delta(x-1)$ in the integral form of the evolution equation times the ratio of gluon pdfs at Q^2 and Q_0^2

$$C = [S_G(Q^2/Q_0^2)]^2 = \exp(-\frac{3\alpha_s}{\pi}\ln^2(Q^2/Q_0^2))$$

the square of the gluon Sudakov form factor - probability not to emit a gluon in the amplitude

Hence suppression factor for this contribution is

$$R = C^2\left[\frac{g_N(x_H,Q^2)}{g_N(x_H,Q_0^2)}\right]^4$$

→ ≤ 0.02 $(Q_0^2 = 1GeV^2)$

→ ≤ 0.3 $(Q_0^2 = 2GeV^2)$ too high Q_0^2??

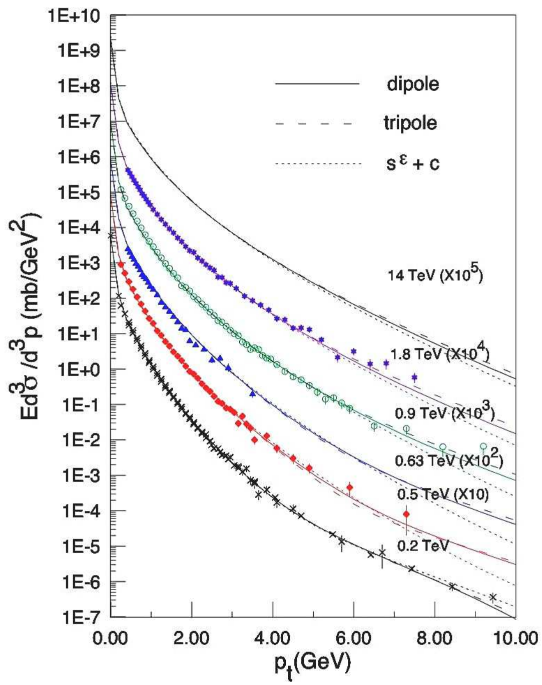
➠ $S^2 < 1\%$ assuming standard pattern of onset of saturation/ black disk regime and no novel parton correlation mechanisms in nucleons

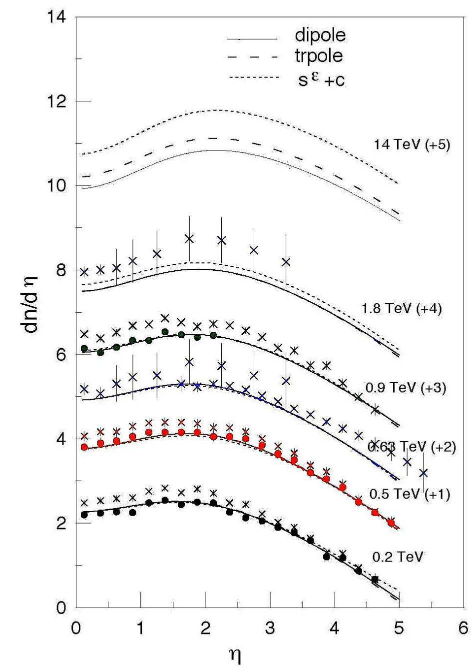
One particle inclusive and unitarized Pomeron models *(Martynov)*

Outline

1. Unitarization of pomeron
   - Elastic scattering
   - Inclusive process
2. One-particle distribution
   - Experimental data
   - Description of the data

One particle inclusive and unitarized Pomeron models *(Martynov)*





$$\bullet - \quad \frac{dn}{d\eta} = \frac{1}{\sigma_{in}} \frac{d\sigma_{in}}{d\eta}, \qquad \times - \quad \frac{dn}{d\eta} = \frac{1}{\sigma_{nsd}} \frac{d\sigma_{nsd}}{d\eta}$$

Amplitudes pp, $\bar{p}p$ in Coulomb interference region *(Ferreira)*

Topics

Near Forward Scattering Amplitude

Coulomb Phase

Analysis of Data

19 - 63 GeV

541-546 GeV

1800-1960 GeV

Amplitudes: slopes and zeros

Derivative Dispersion Relations for Amplitudes

DDR for $t = 0$

Derivative Dispersion Relations for Slopes

A reference: A.K. Kohara, T. Kodama, E.F. : hep-ph 0905.1955

Amplitudes pp, $\bar{p}p$ in Coulomb interference region *(Ferreira)*

Parametrization of Near Forward Scattering Amplitude
For small angles

$$F^N(s,t) \approx F^N_R(s,0)e^{B_R t/2} + iF^N_I(s,0)e^{B_I t/2}$$

Usually B_R and B_I are treated as having equal values. We allow

$$B_R \neq B_I$$

For low $|t|$, the strong differential cross section has approximate form with single exponential slope

$$\frac{d\sigma}{dt} = \left|\frac{d\sigma}{dt}\right|_{t=0} e^{Bt}$$

with

$$B = \frac{\rho^2 B_R + B_I}{1+\rho^2}$$

Amplitudes pp, $\bar{p}p$ in Coulomb interference region *(Ferreira)*

1800 GeV : parameter values and comments

Parameters (with fixed $\rho = 0.14$ and $\rho = 1.0$) are given in the table. Although there are large variation bars, notice that the lowest χ^2 are obtained with B_R larger than B_I, for both experiments.

Table: Forward scattering parameters at 1800 GeV

Exp.	$\sigma(\mathrm{mb})$	ρ	$B_I(\mathrm{GeV}^{-2})$	$B_R(\mathrm{GeV}^{-2})$	χ^2
E710	72.75±0.19	0.14 (fixed)	16.30±0.04	115.57± 164.20	0.6020
E710	71.82±0.18	0.14 (fixed)	16.28±0.04	B_I (fixed)	0.6060
E710	72.65±0.19	1.0 (fixed)	16.28±0.04	167.93± 48.56	0.5961
CDF	80.92±0.44	0.14 (fixed)	17.00±0.09	72.01± 116.15	1.771
CDF	9.98±0.43	0.14 (fixed)	16.98±0.09	B_I (fixed)	1.775
CDF	80.16±0.43	1.0 (fixed)	16.87±0.09	85.73± 16.94	1.705

Observing the large differences in χ^2, we learn that the E710 data are more compatible with the forward scattering basic expression for $d\sigma/dt$ than the CDF data.

GPD and elastic scattering at LHC *(Selyugin)*

Contents

GPD and elastic scattering at LHC *(Selyugin)*

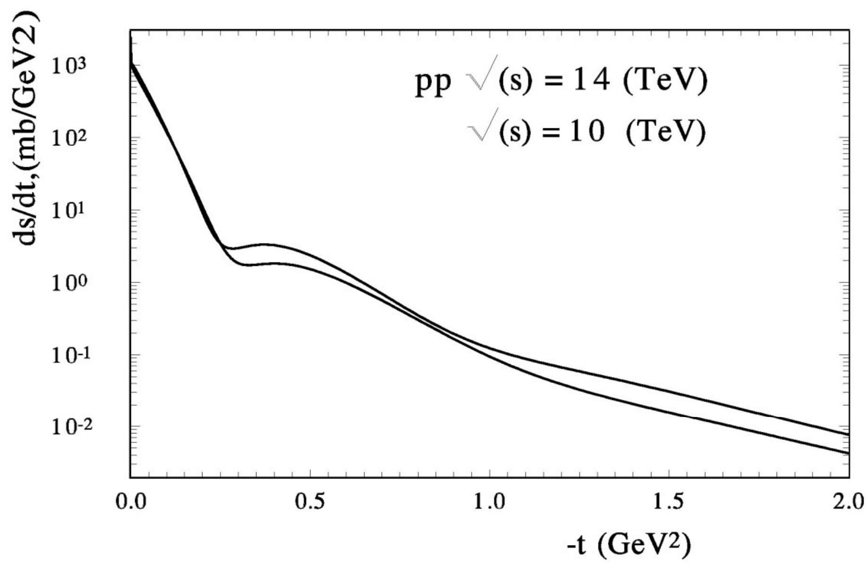
General Parton Distributions -GPDs

Electromagnetic form factors (charge distribution)

Energy momentum tensor form factors (matter distribution)

GPD and elastic scattering at LHC *(Selyugin)*

PREDICTIONS $pp \to pp \quad (\sqrt{s} = 10,\ 14 \quad \text{TeV})$



$\sqrt{s}$ □ 1.8 TeV; $\rho(0) = 0.208;\ \sigma_{tot} = 80.3\,mb;$

$\sqrt{s}$ □ 10 TeV; $\rho(0) = 0.238;\ \sigma_{tot} = 132\,mb;$

$\sqrt{s}$ □ 14 TeV; $\rho(0) = 0.235;\ \sigma_{tot} = 146\,mb;$

The Froissart bound for σ_{inel} *(Martin)*

Improved Froissart bound

$\sigma_{tot}(s) < \pi/m_\pi^2 (lns)^2$ where $\pi/m_\pi^2 = 60mb$

Can improve with average cross section

$\bar{\sigma}_{tot}(s) = 1/s \int_s^{2s} \sigma_{tot}(s')ds' < \pi/m_\pi^2 (lns + C)^2$

New rigourous result on inelastic cross section

$\sigma_{inel} < \pi/4m_\pi^2 (lns)^2$

Theoretical aspects of elastic scattering at HE *(Kundrat)*

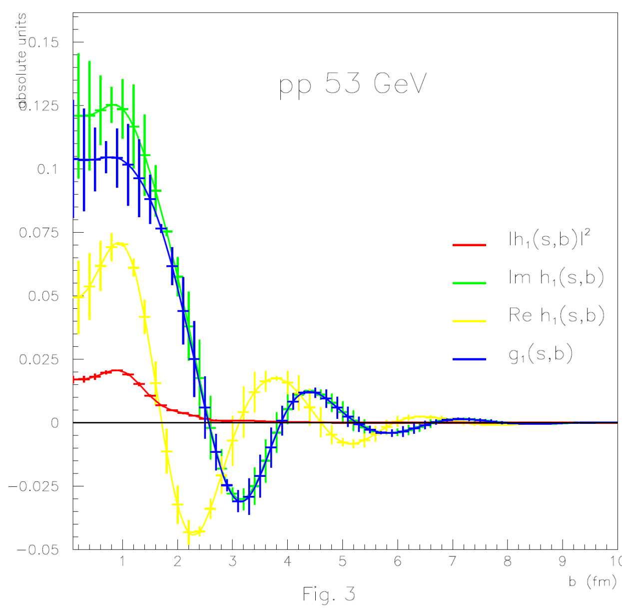
Theoretical aspects of high energy elastic nucleon scattering

V. Kundrát, M. Lokajíček, Institute of Physics AS CR, v.v.i., Prague, CR
J. Kašpar, CERN, Geneva and Institute of Physics AS CR, v.v.i., Prague, CR

1. Introduction
2. General eikonal model approach
3. Elastic hadronic amplitude
4. Profiles for pp at 53 GeV
5. Model predictions for pp elastic scattering at the LHC
6. Luminosity estimation at the LHC
7. Conclusion

Theoretical aspects of elastic scattering at HE *(Kundrat)*

resulting profiles



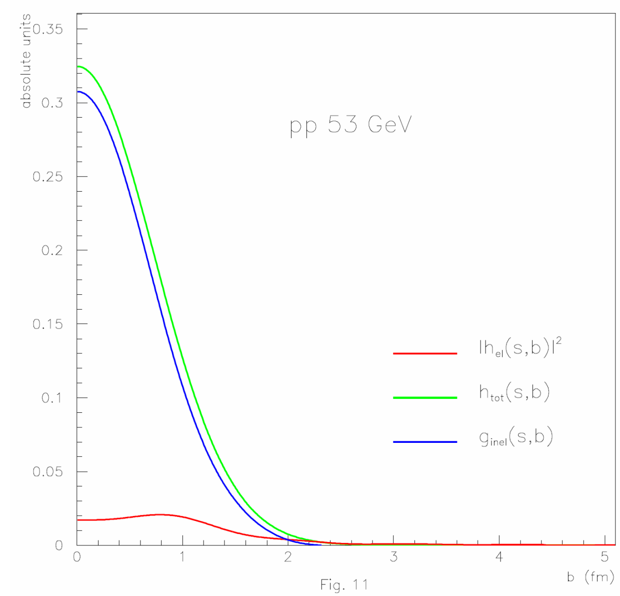


Fig. 3: original oscillating profiles (statistical errors)

Fig. 11: final shape of profiles; full lines:

red … peripheral elastic profile
green … central total profile
yellow … central inelastic profile

“original” values of total, elastic and inelastic rms and of cross sections conserved

Total cross section at LHC: Models and Exp. Consequences *(Cudell)*

The total cross section at the LHC

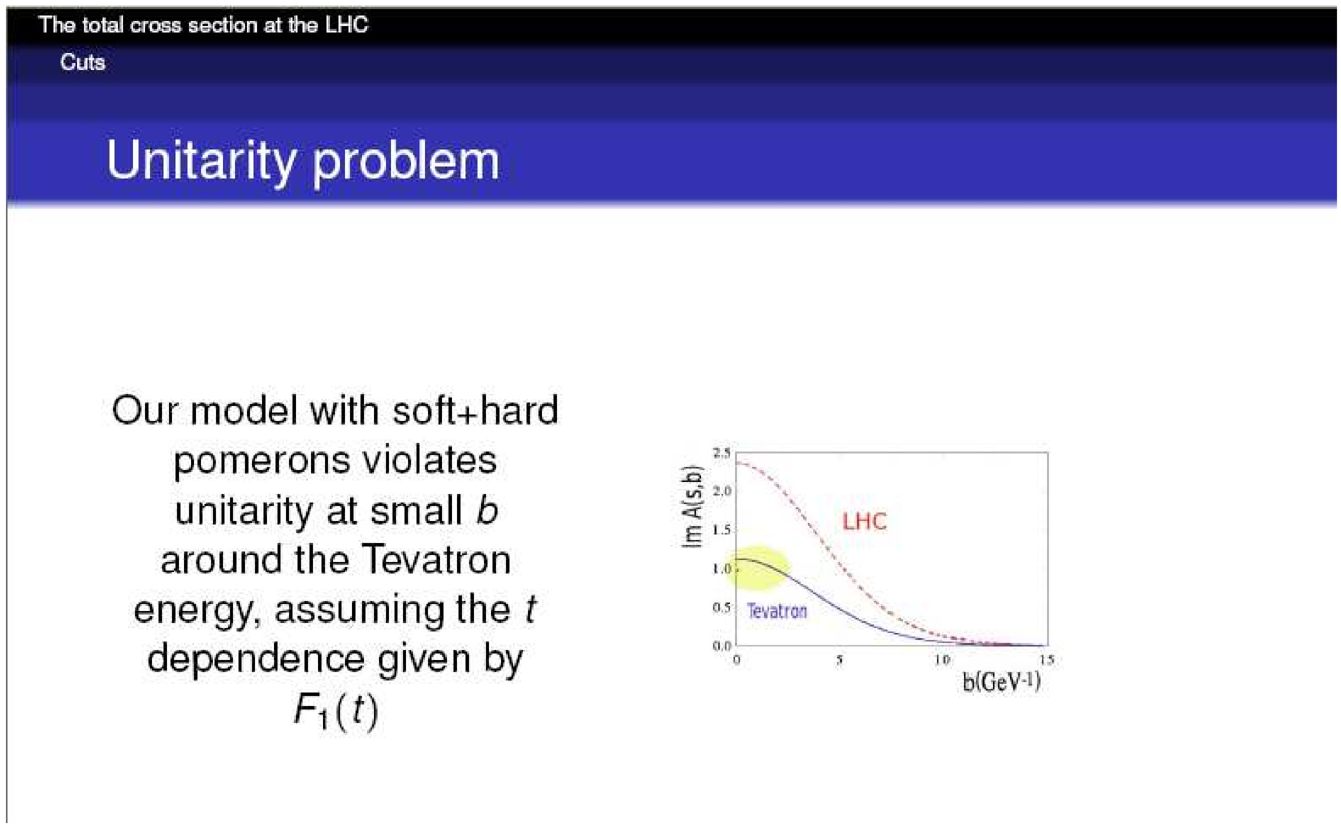
The basic problem

No theory

- General principles:
  - analyticity
  - unitarity of partial waves
- several possibilities:
  - simple or multiple poles
  - cuts (eikonal, U matrix, multi-channel eikonal, KMR,...)
- Phenomenological fits and extrapolation

Total cross section at LHC: Models and Exp.

Consequences *(Cudell)*



Total cross section at LHC: Models and Exp. Consequences *(Cudell)*

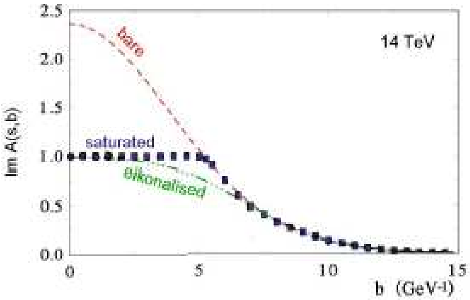
The total cross section at the LHC

Cuts

Unitarised hard+soft pomerons

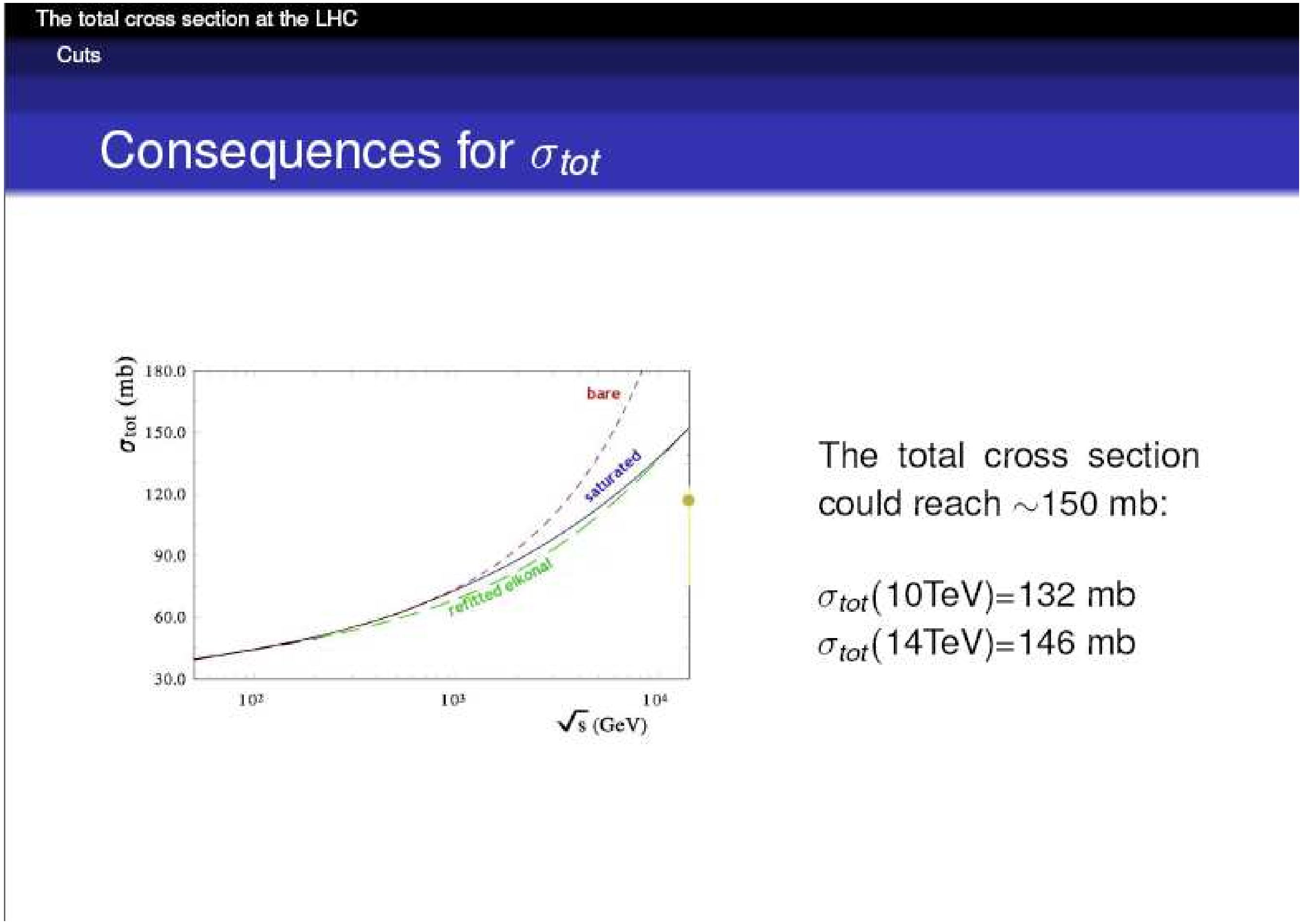
Two simple choices:

- "Saturation": cut $Im\, A(s, b)$ at 1 and add a smoothing function - in some sense minimal unitarisation
- Use a simple eikonal

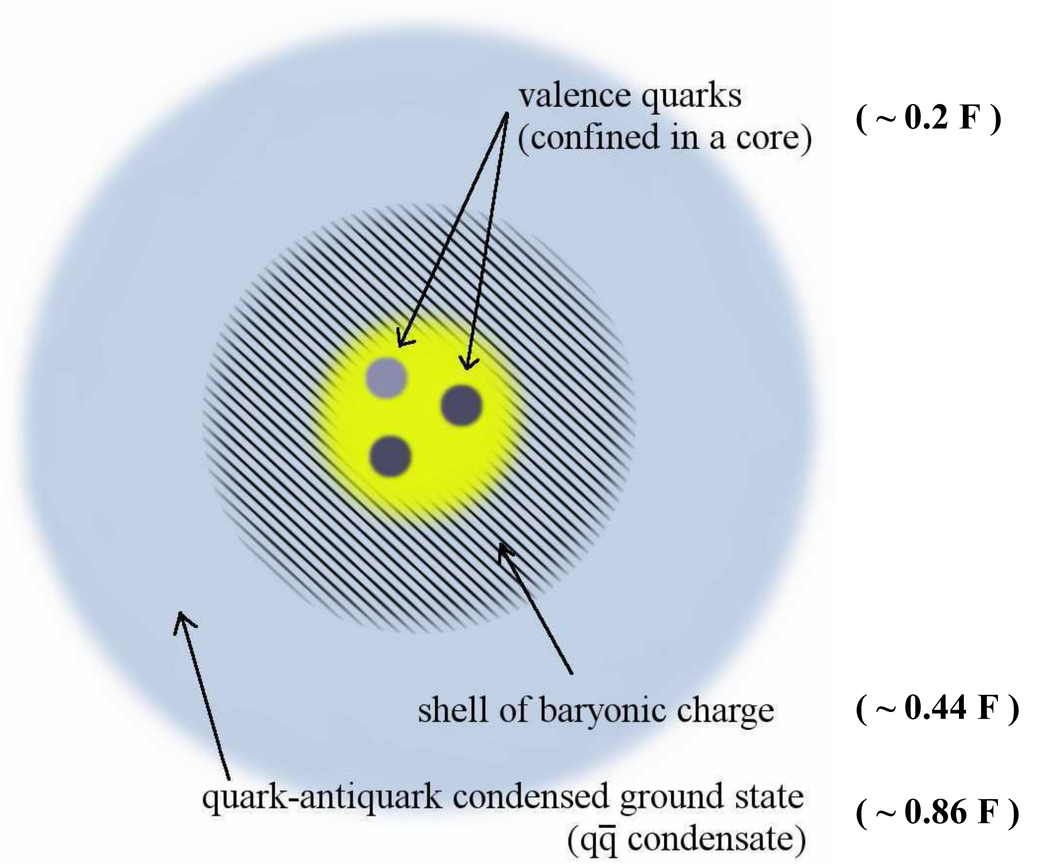


Total cross section at LHC: Models and Exp.

Consequences *(Cudell)*

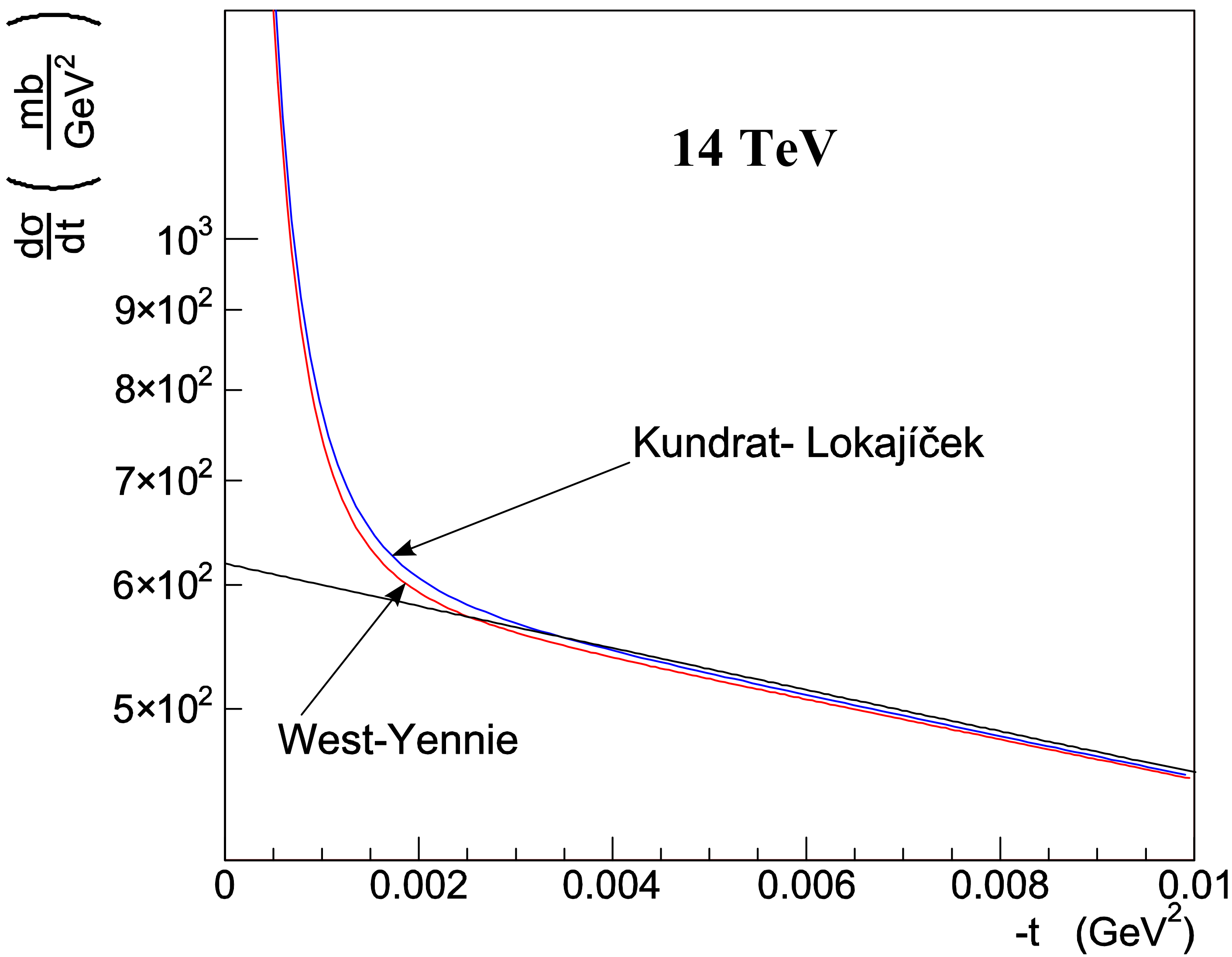


pp elastic scattering at LHC and proton structure *(Luddy)*



Condensate Enclosed Chiral-Bag Model

pp elastic scattering at LHC and proton structure *(Luddy)*

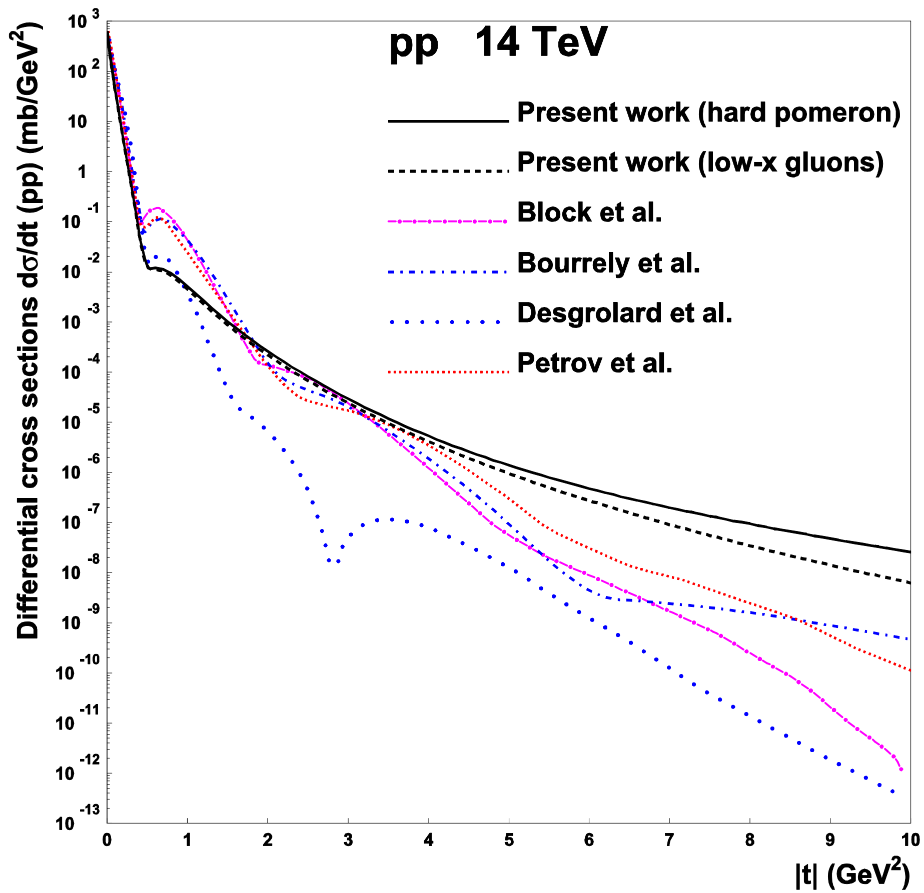


$d\sigma/dt$ when Coulomb interaction is included in our model. Calculation by Jan Kašpar.

pp elastic scattering at LHC and proton structure *(Luddy)*

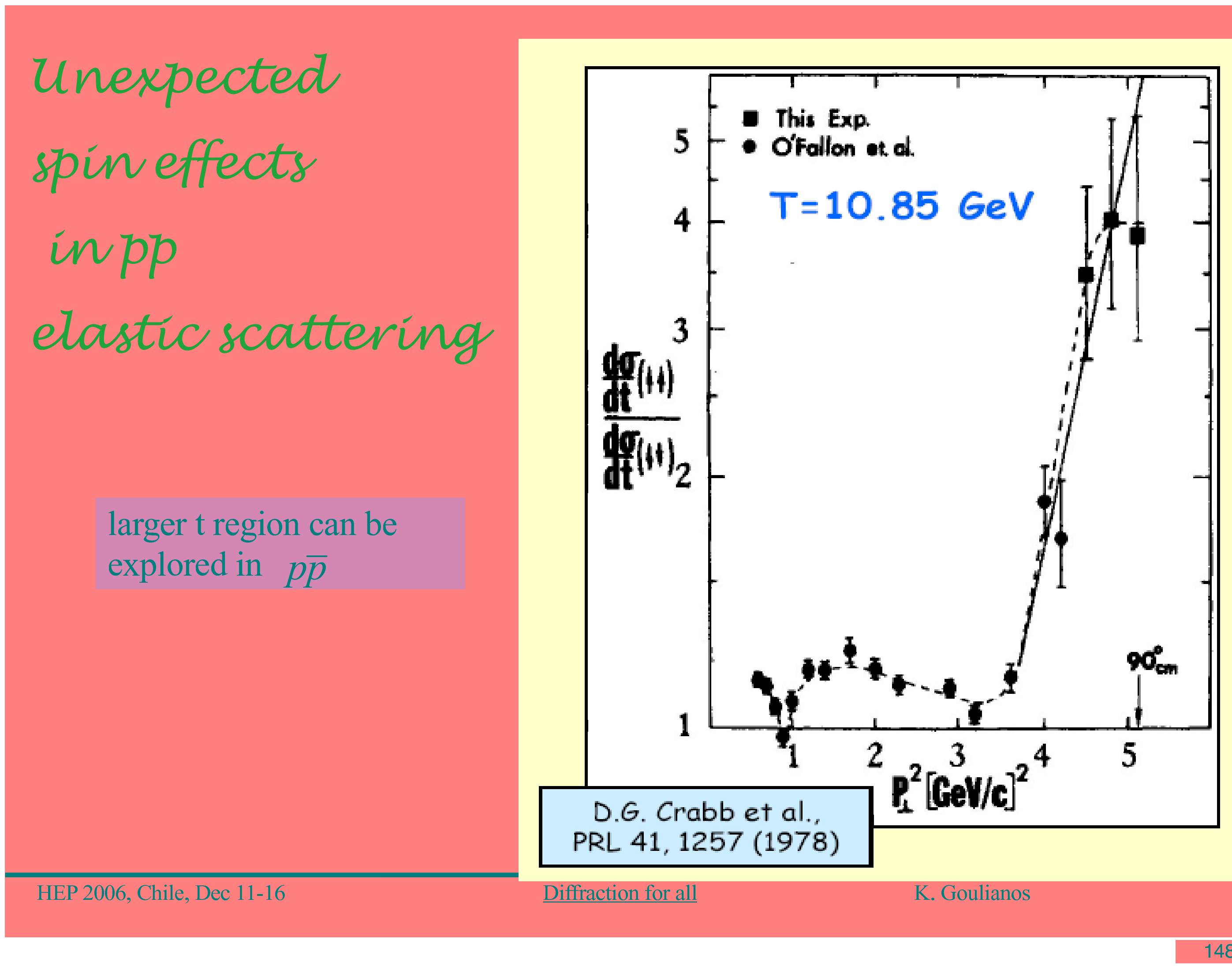
Conclusion

We, therefore, find two distinct classes of models



pp elastic spin observables confront QCD

(Sivers)



pp elastic spin observables confront QCD

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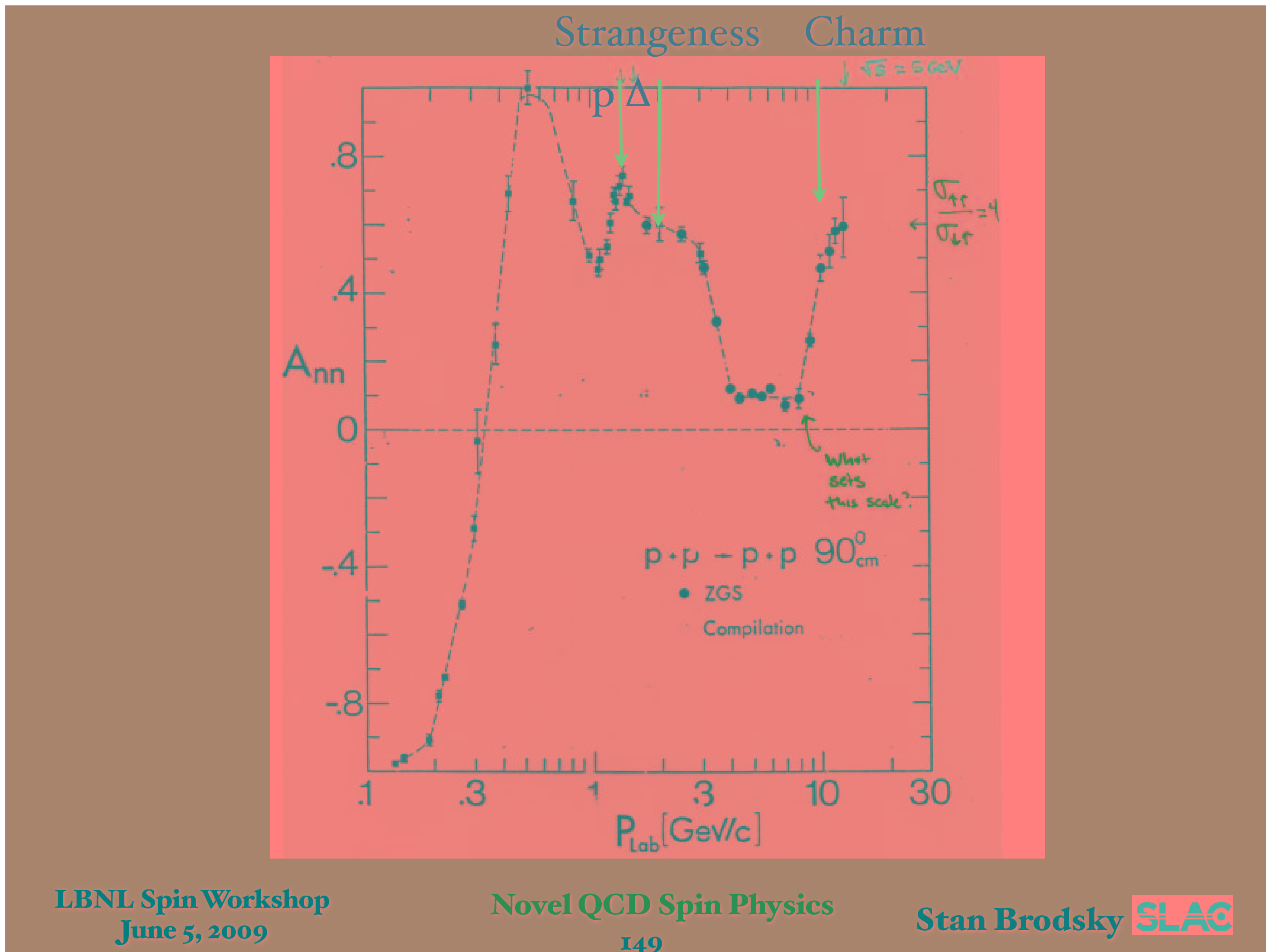

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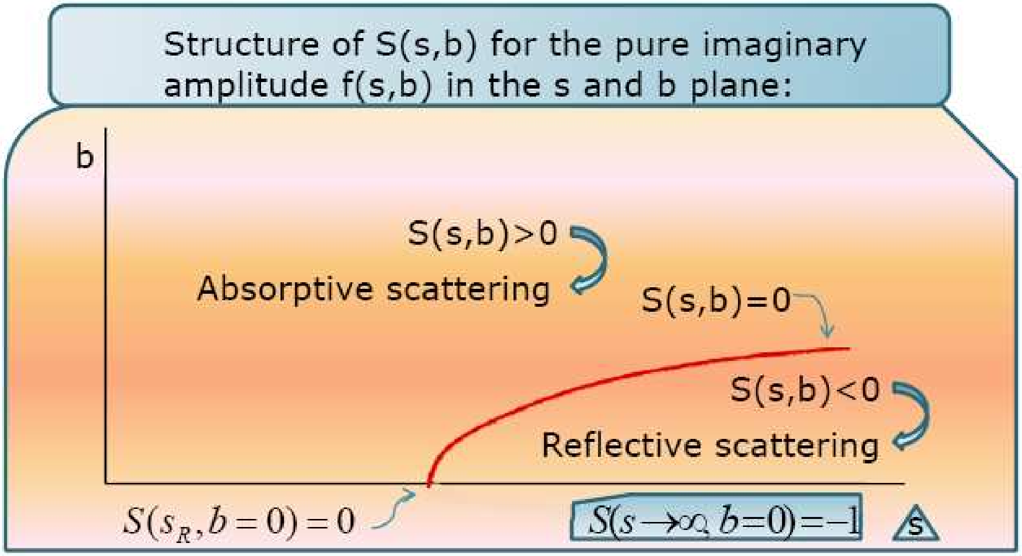
Reflective elastic scattering at LHC *(Troshin)*

Elastic scattering, amplitude and S-matrix of this process:

$$S_l(s) = 1 + 2if_l(s) \Longrightarrow S(s,b) = 1 + 2if(s,b)$$

Impact parameter representation (unitarity):

$$\mathrm{Im} f(s,b) = |f(s,b)|^2 + \eta(s,b)$$



Reflective elastic scattering at LHC *(Troshin)*

Phenomenology (based on chiral quark model for U-matrix)

Total, elastic and inelastic cross-sections;

Differential cross-section;

Knee in cosmic rays energy spectrum and other phenomena in this field;

Estimate for the gap survival probability is 0.2.

Large values of $\sigma_{tot}(s) \cong 230$ mb

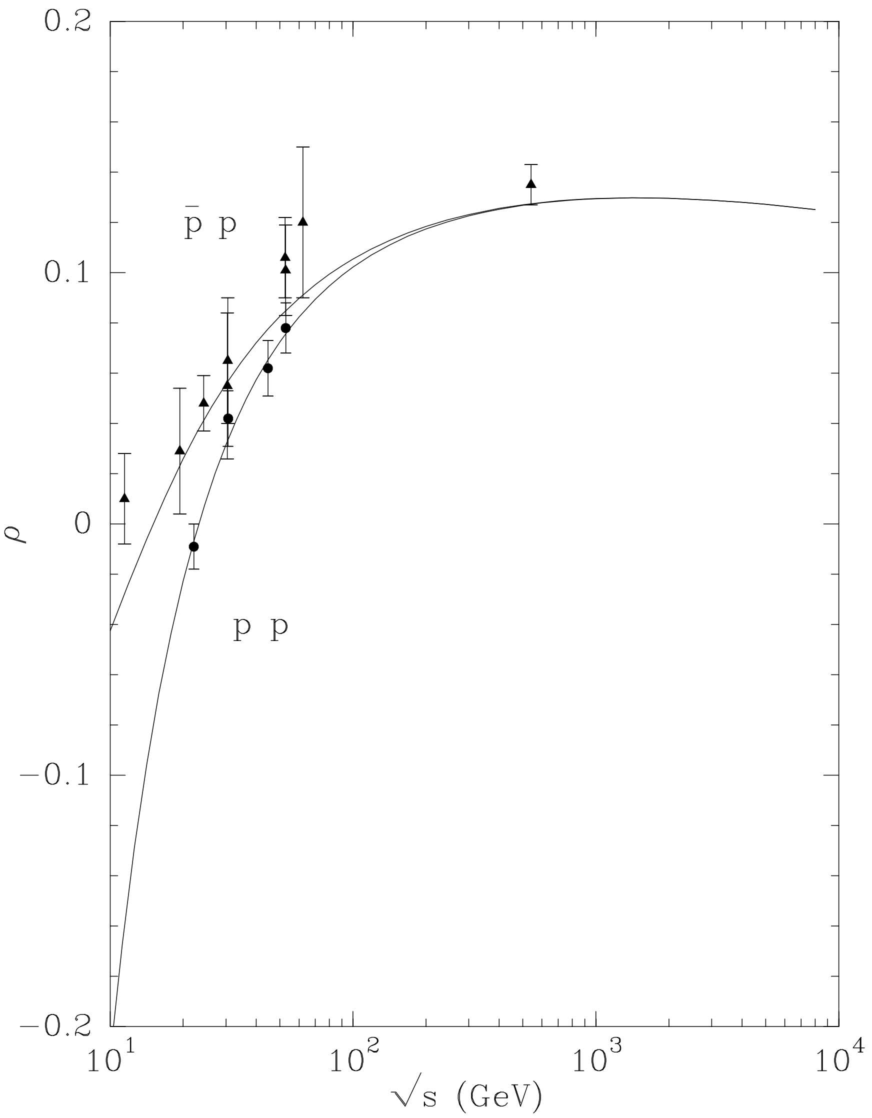
and ratio $\sigma_{el}(s)/\sigma_{tot}(s) \cong 2/3$

at the LHC energies (14 TeV), while $\sigma_{inel}(s) \cong 77$ mb.

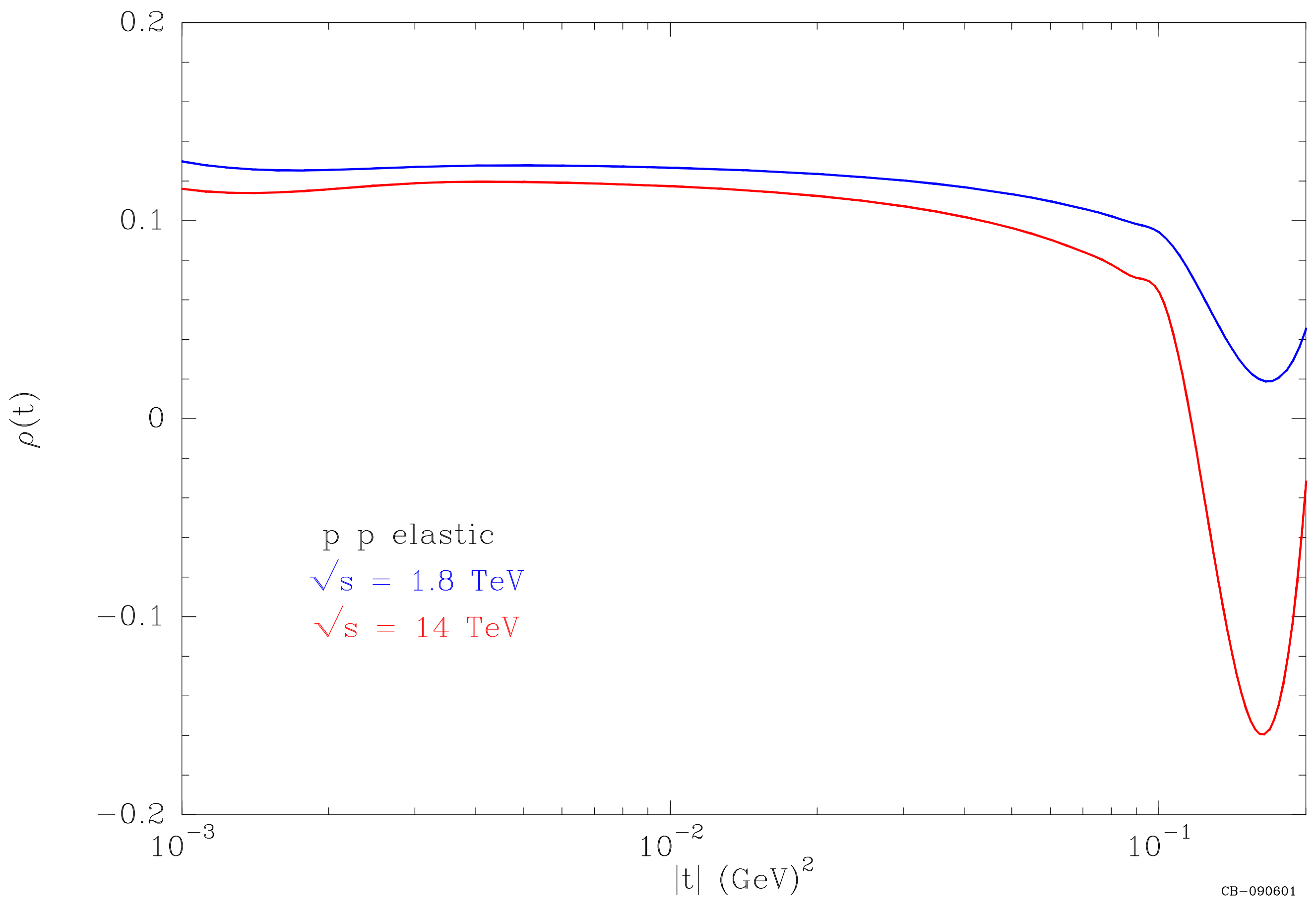
Standard background estimations remain valid.

Note the strong model dependence of numerical estimates.

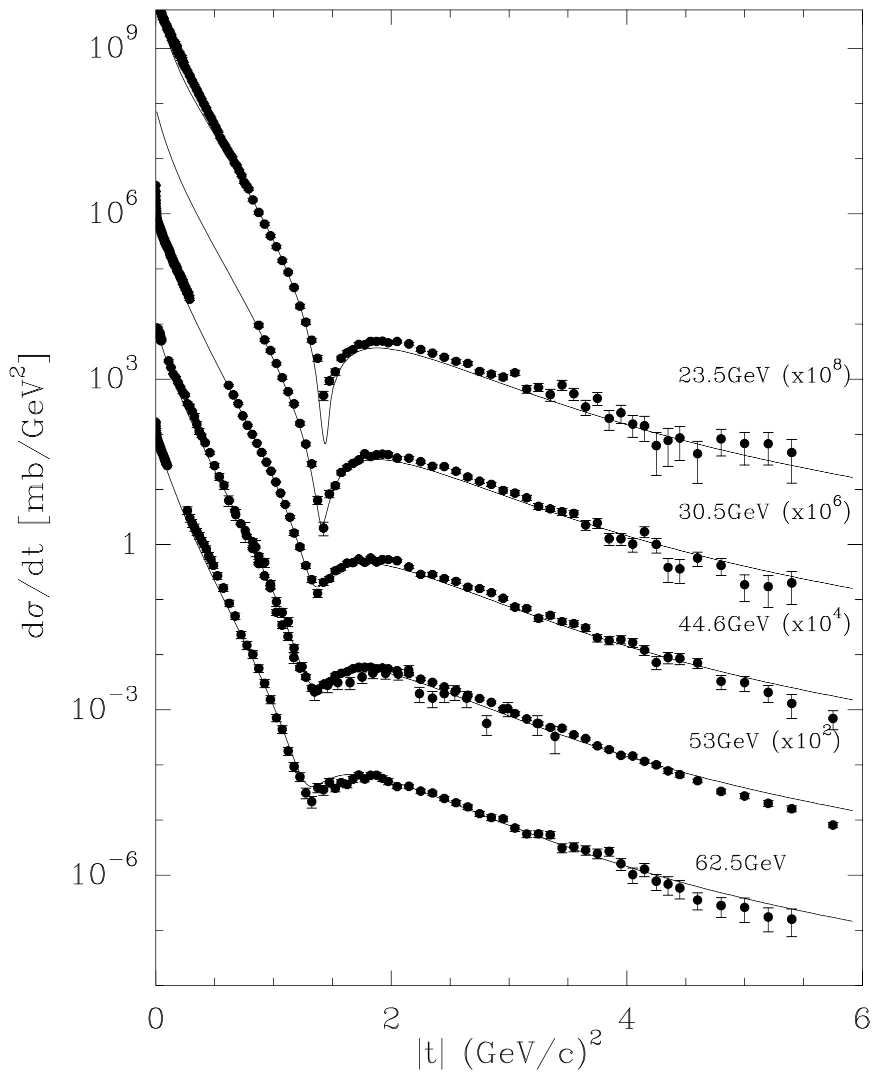
A short digression on the BSW impact picture



A short digression on the BSW impact picture

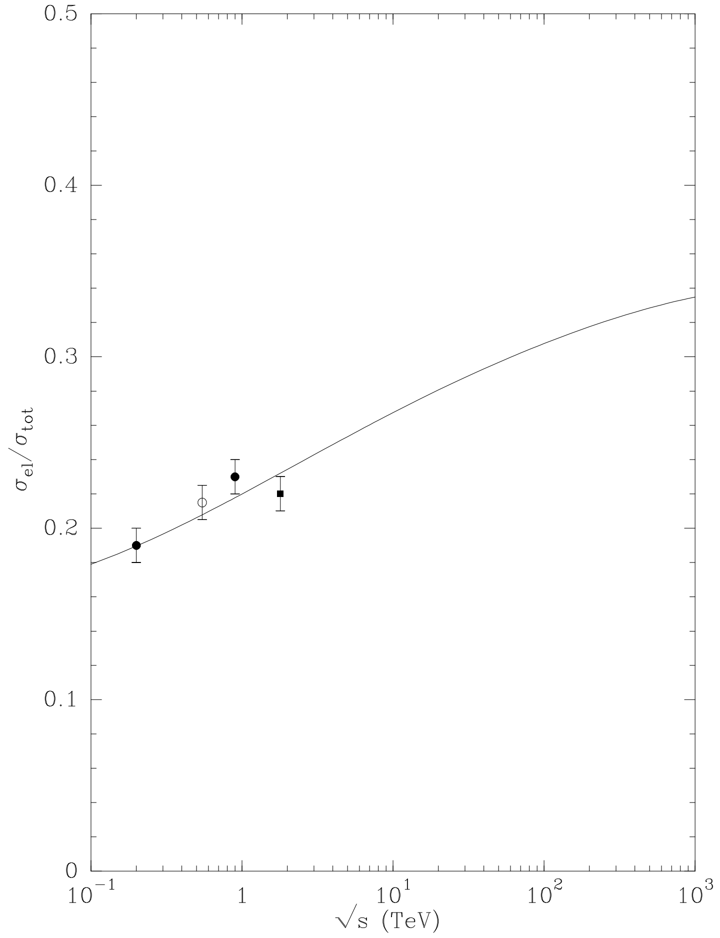


A short digression on the BSW impact picture



A short digression on the BSW impact picture

Neither Tel Aviv nor Durham models have this increasing ratio



Analytic properties of DPE amplitudes

(Teryaev)

Main Topics

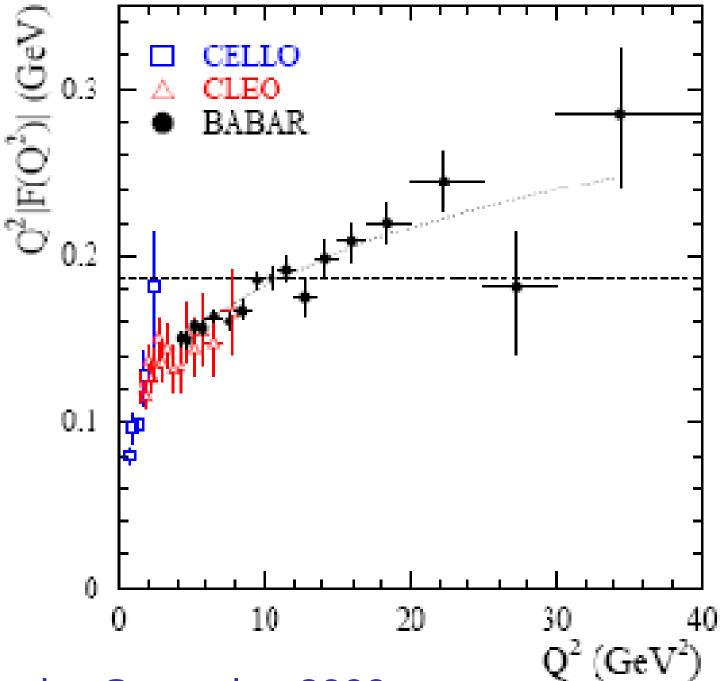
- QCD factorization and its violation
- QCD factorization vs analyticity
- Analyticity and crossing for hard exclusive lepton hadron reactions
- DPE specifics and the role of Steinmann relations
- BABAR data: violation of factorization typical?
- Possible implications for Higgs production
- Conclusions

Analytic properties of DPE amplitudes

(Teryaev)

Hot topic for (p)QCD: BABAR data **0905.4778** [hep-ex]

- Pion-photon transition FF
- Where is attractor?!



Low-x structure functions using discrete BFKL Pomeron *(Ross)*

Goal

- To fit low-x data from HERA to discretized eigenfucntions of BFKL kernel.
  (Discrete eigenfunctions simulate description of data by a Pomeron as a Regge pole),
- Extract low-x gluon distribution for applications to jet production and diffractive events at LHC.

Low-x structure functions using discrete BFKL Pomeron *(Ross)*

Impact Factor:

$$\Phi = Ak^2 e^{-bk^2}, \quad b = 2\ \mathrm{Gev}^{-2}$$

1. Linear Shift:

$$\eta(\omega) = \eta_0 + \eta' \frac{\omega}{\omega_1}$$

$$\eta_0 = -0.74\pi, \quad \eta' = 0.76\pi$$

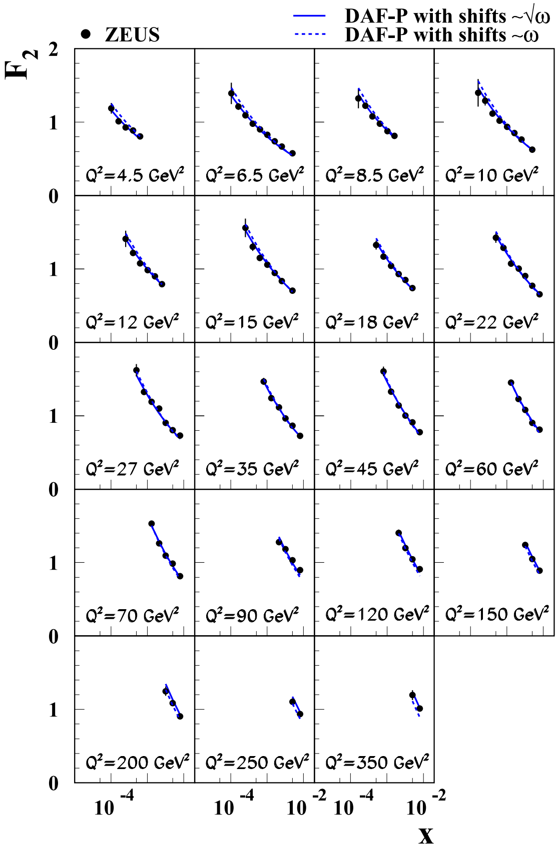
$$\chi^2 \sim 3 \text{ per DOF}$$

2. Non-linear Shift:

$$\eta(\omega) = \eta_0 + \eta' \sqrt{\frac{\omega}{\omega_1}}$$

$$\eta_0 = -0.74\pi, \quad \eta' = 0.76\pi$$

$$\chi^2 \sim 1.1 \text{ per DOF}$$

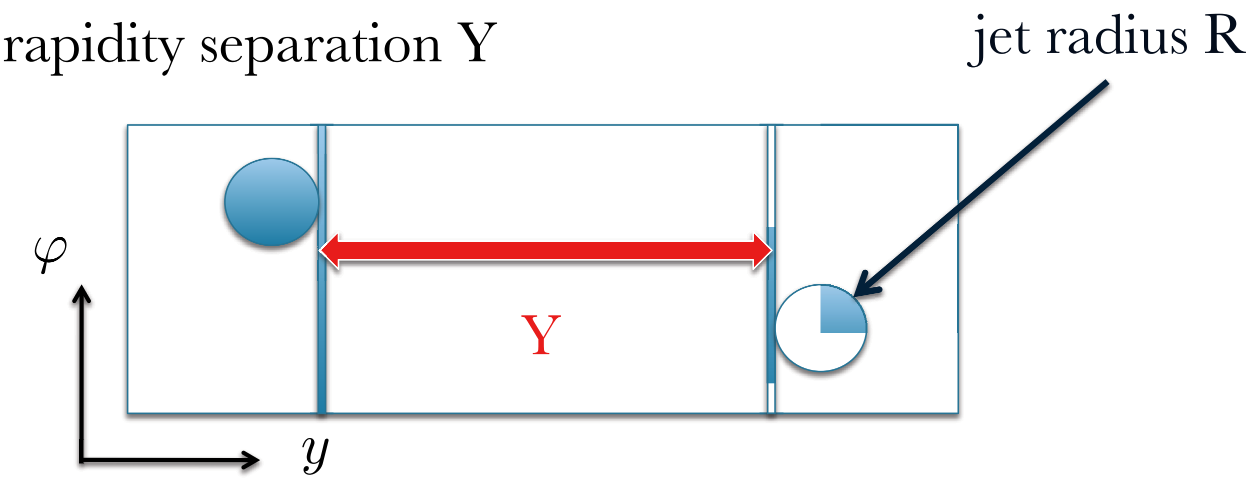


Soft gluon resummation for gaps between jets *(Marzani)*

The observable

Production of two jets with

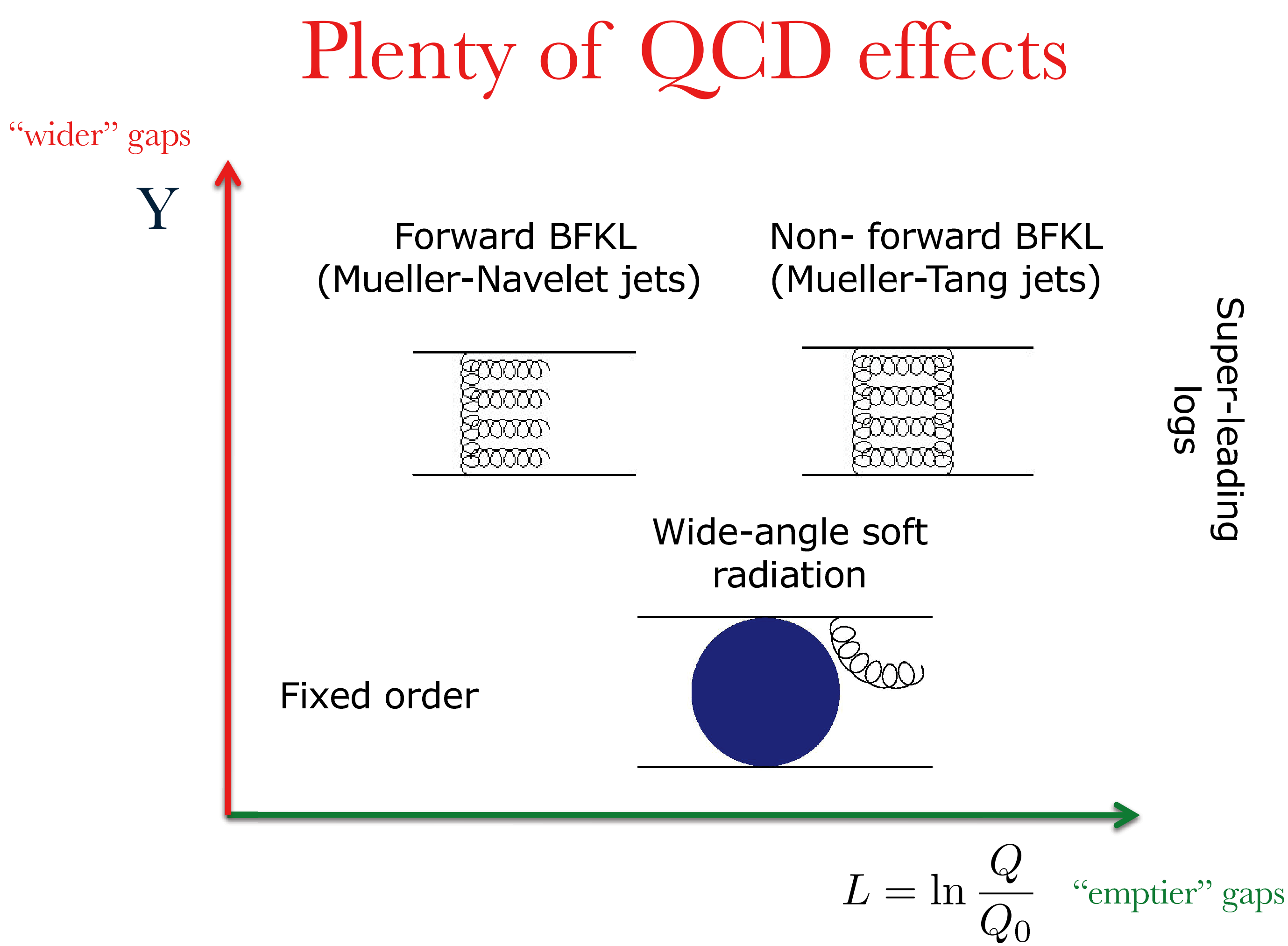
- transverse momentum Q
- rapidity separation Y



- Emission with $k_T > Q_0$ forbidden in the inter-jet region

Q_0 can be rather large: the gap is a region of limited hadronic activity

Soft gluon resummation for gaps between jets *(Marzani)*

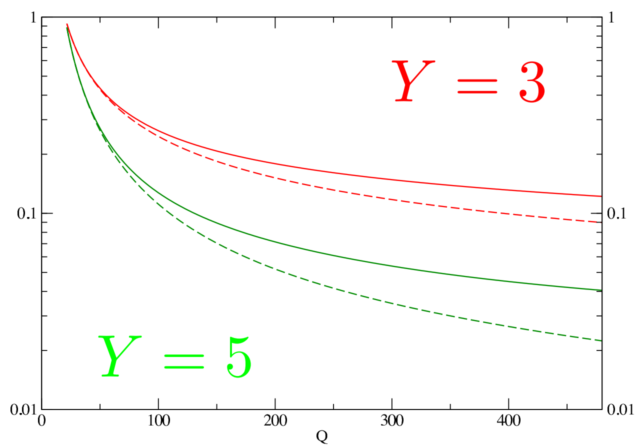


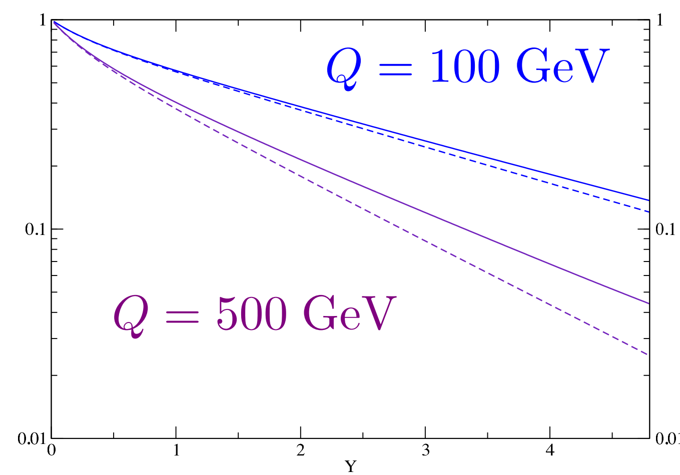
Soft gluon resummation for gaps between jets *(Marzani)*

Global logs and Coulomb gluons (no gluon outside the gap)

$$f^{(0)} = \sigma^{(0)}/\sigma^{\text{born}}$$

$\sqrt{S}$ = 14 TeV
Q_0 = 20 GeV
R = 0.4
η_{cut} = 4.5





- solid lines: full resummation
- dashed lines: ignoring $i\,\pi$'s

Large Coulomb gluon contributions !

Main Topics

- QCD factorization and ‘Durham Model’
- Heavy quarkonia: inclusive and exclusive production
- Generalized (skewed) UGD and positivity
- Relative contributions of spin 0,1,2 for various UGD
- Helicity amplitudes
- Conclusions

Density matrix positivity and GUGD

- General property (counterpart of unitarity) **Phys.Rept.470:1-92,2009**.

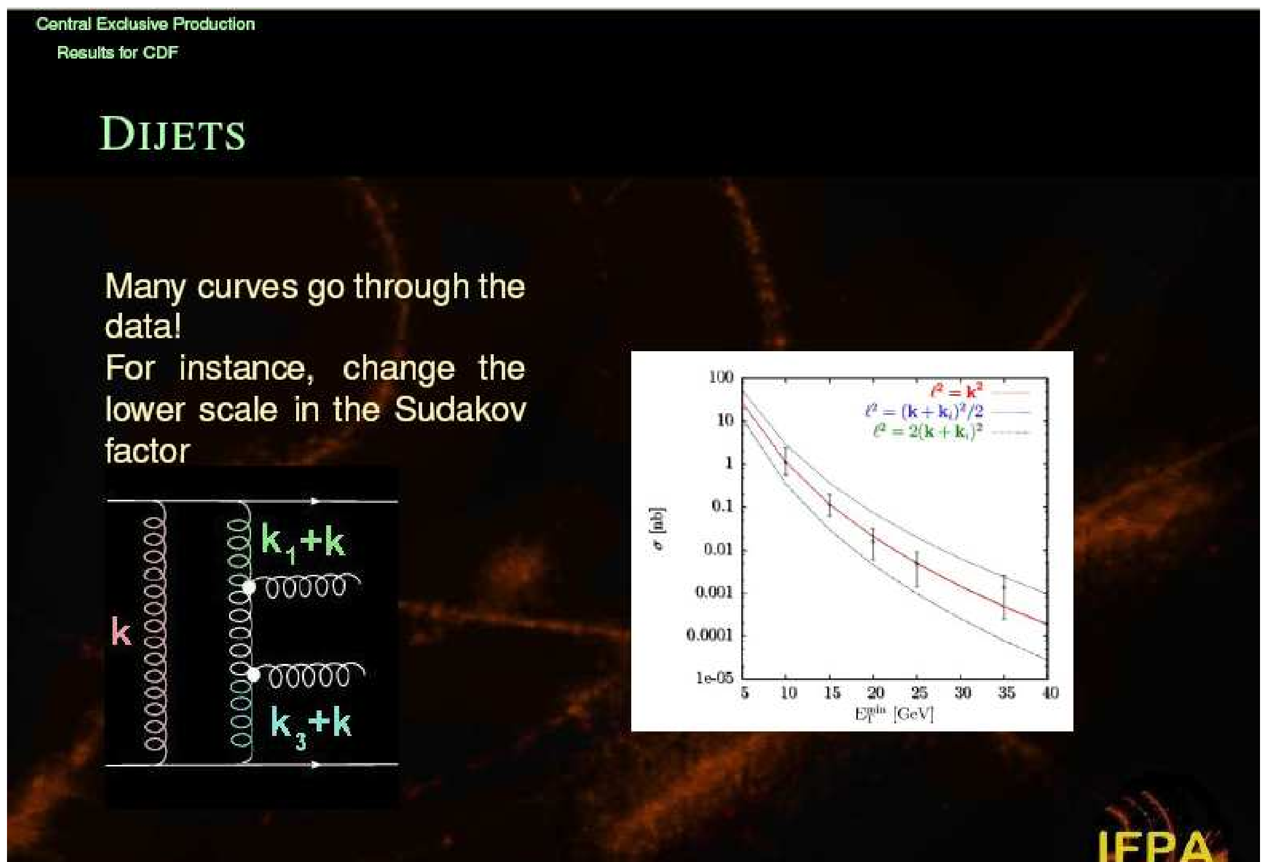
- NP matrix elements (and impact factors)

-parton (-hadron) density matrices
– Cauchy–Schwarz–Bunyakovsky - type inequalities
$|\langle A|B\rangle|^2 < \langle A|A\rangle\langle B|B\rangle$
Collinear GPD – Ryskin; Pire,Soffer,OT; Radyushkin; Pobylitsa
GUGD:

$$f^{\rm off}_{g,1}(x_1, x_1', k^2_{0,t}, k^2_{1,t}, t_1) \;=\; \sqrt{f^{(1)}_g(x_1', k^2_{0,t}, \mu_0^2) \cdot f^{(1)}_g(x_1, k^2_{1,t}, \mu^2)} \cdot F_1(t_1)$$

Saturation – for limited number (or correlation between) intermediate states (= effective dimension of vector space)

Central exclusive Higgs production: vector mesons, jets, Higgs *(Cudell)*



Central exclusive Higgs production:vector mesons, jets, Higgs *(Cudell)*

Central Exclusive Production

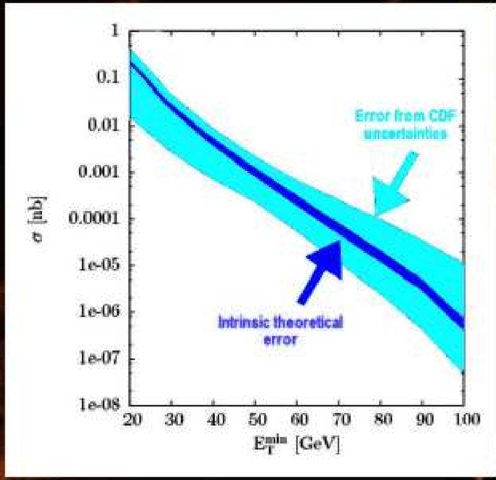
Results for LHC

LHC DIJETS

One can predict the jet LHC cross section using the CDF result to calibrate it

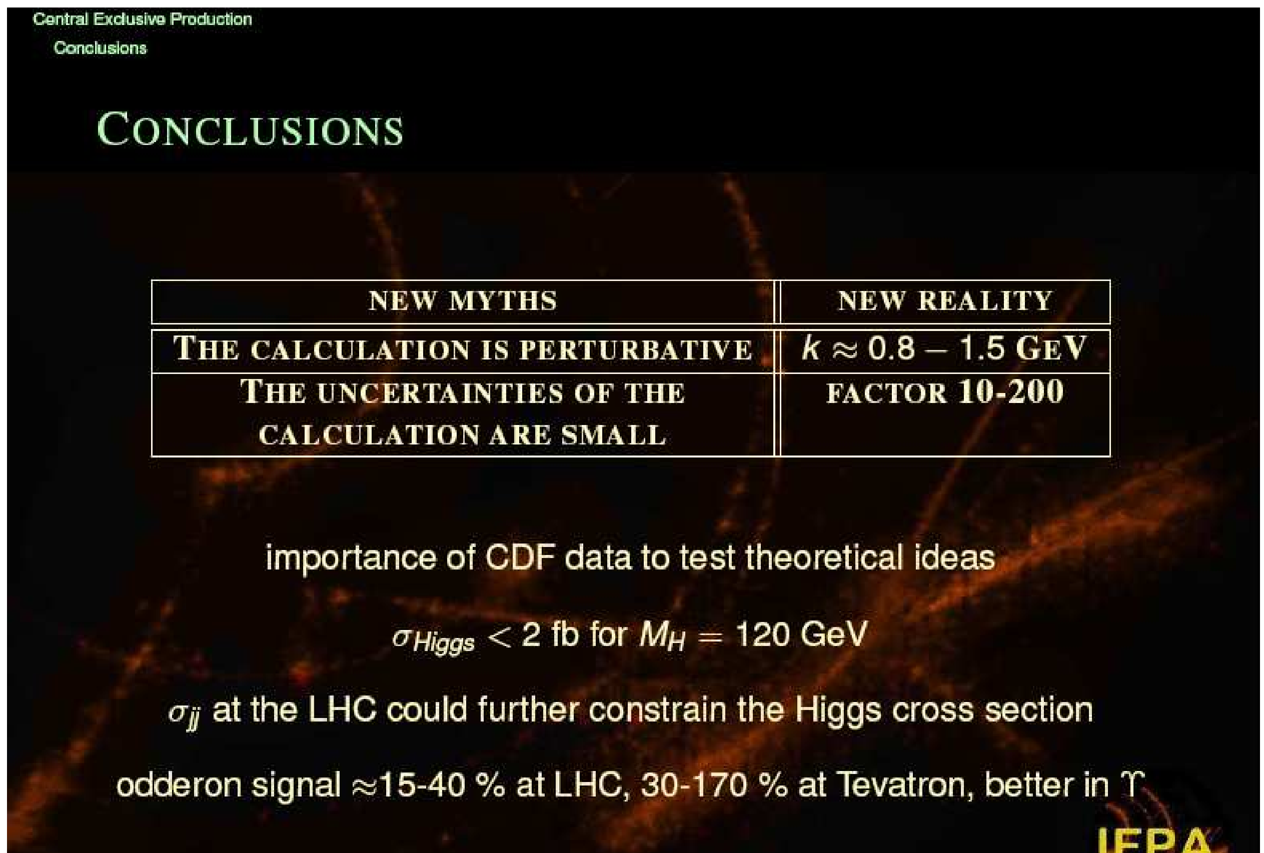
- For typical cuts of FP420

parameter	value
proton fractional momentum loss	0.002-0.02
jet rapidity	<1
mass of jet system	>50 GeV



IFPA

Central exclusive Higgs production:vector mesons, jets, Higgs *(Cudell)*

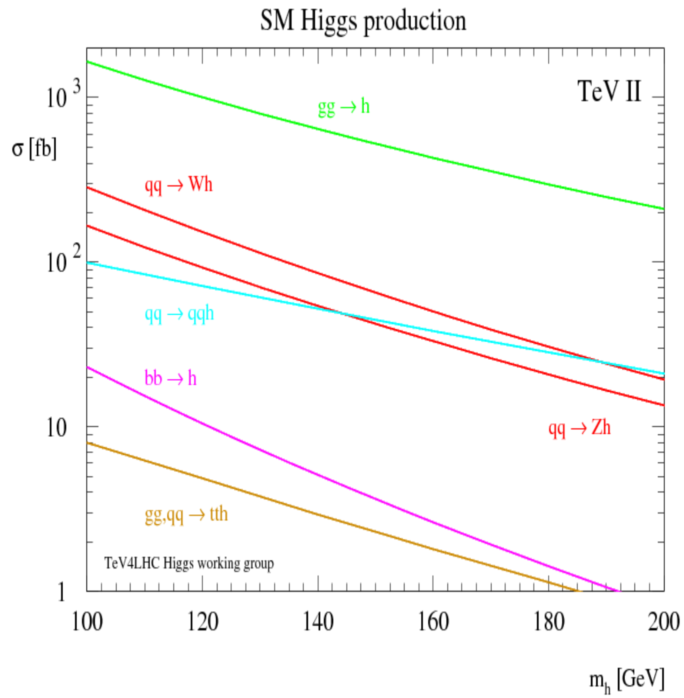


Beyond Standard Model Higgs search

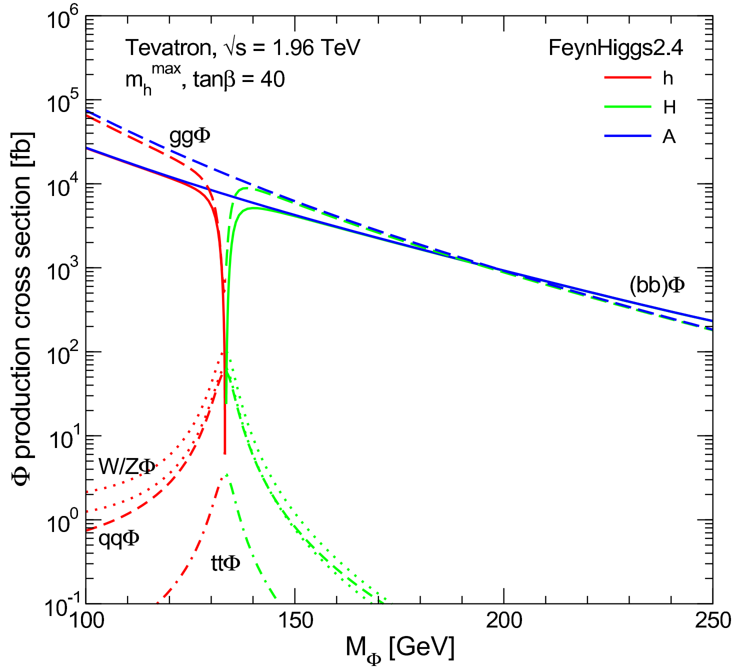
(Heinemeyer)

Higgs production cross sections at the Tevatron:

SM



MSSM



MSSM: possibly enhanced rates at high tan β

Beyond Standard Model Higgs search

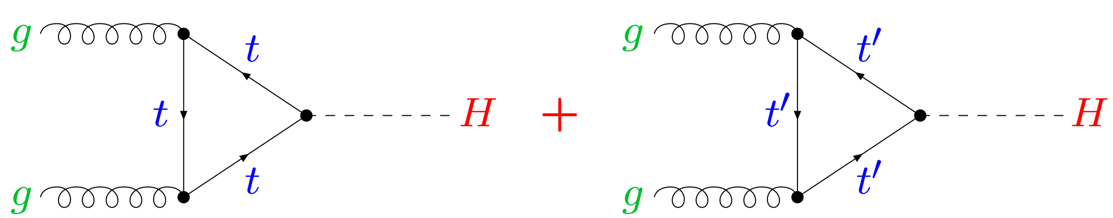
(Heinemeyer)

3. 4th generation model

Assume the SM with a 4th generation of heavy fermions

Relevant changes:

1. additional contribution to $gg \to H$:



   $\Rightarrow$ factor of ~ 9 in Higgs production cross section

2. $\Rightarrow$ factor of ~ 9 in $\Gamma(H \to gg)$

   $\Rightarrow$ reduced BR$(H \to b\bar{b})$, BR$(H \to \tau^+\tau^-)$

Evaluation of SM quantities with FeynHiggs
subsequent application of reduction and enhancement factors

Exclusive Higgs production in a triplet scenario *(Huitu)*

Conclusions

- ***For higher Higgs representations the doublet couplings are enhanced***
  ➡ With forward processes possible to study the representation using the neutral Higgses
- **The forward production complementary to the usual one**
- **In the triplet model with $\rho = 1$:**
  $c_H < 0.5$, 120 GeV $< m_H <$ 150 GeV
  ➡ **H_1^0 observed with 4σ or better,**
  m_H measurement better than 2 GeV for low luminosity

Outlook

Many interesting topics were presented here:

* Soft diffraction

* Elastic scattering and total cross sections

* Hard diffraction

*Central production, Higgs

* etc............

I apologize for not been able to cover more for lack of time and due to my ignorance

Outlook

Many interesting topics were presented here:

* Soft diffraction

* Elastic scattering and total cross sections

* Hard diffraction

*Central production, Higgs

* etc............

I apologize for not been able to cover more for lack of time and due to my ignorance

They reveal new progress in this broad field

We all look forward to new exciting data in particular here from LHC !!

THANK YOU