Description of high-mass diffraction in the framework of reggeon calculus

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Diffraction Day
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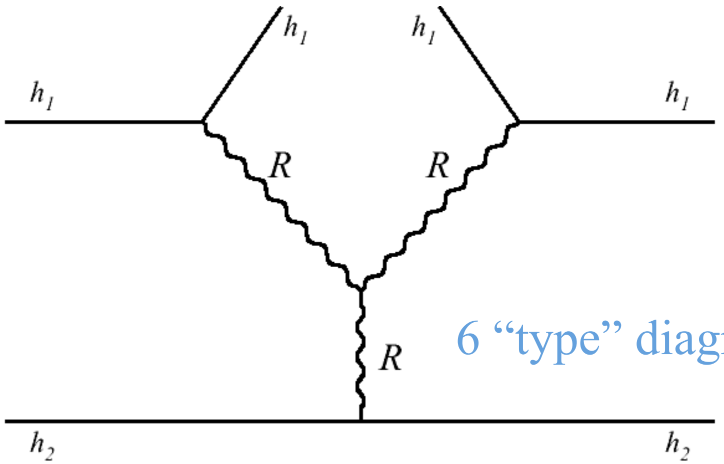
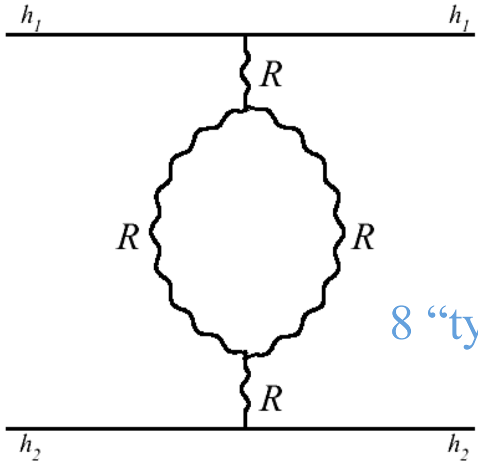
“Elastic” amplitudes for large-mass SD and DD



6 “type” diagrams



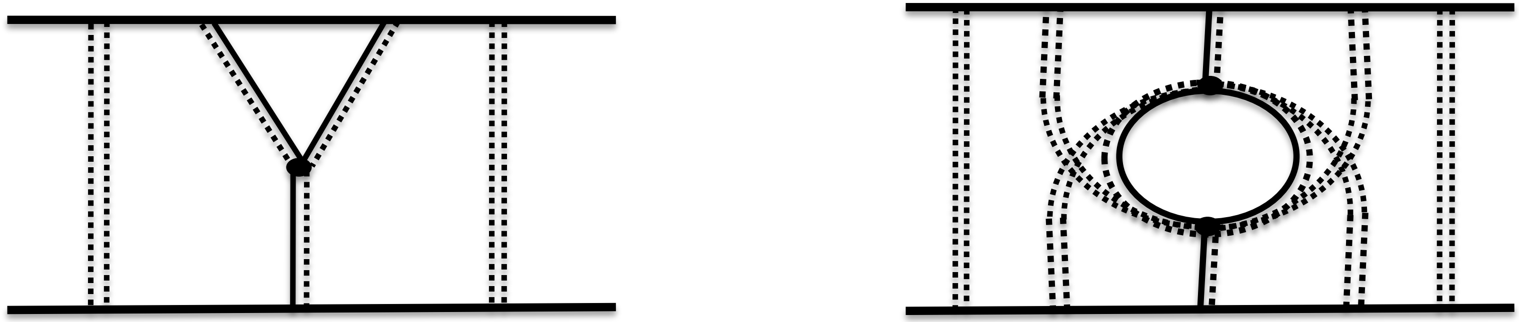
8 “type” diagrams

Triple-Regge description is in good agreement with the FNAL and ISR data for soft diffraction dissociation. However,

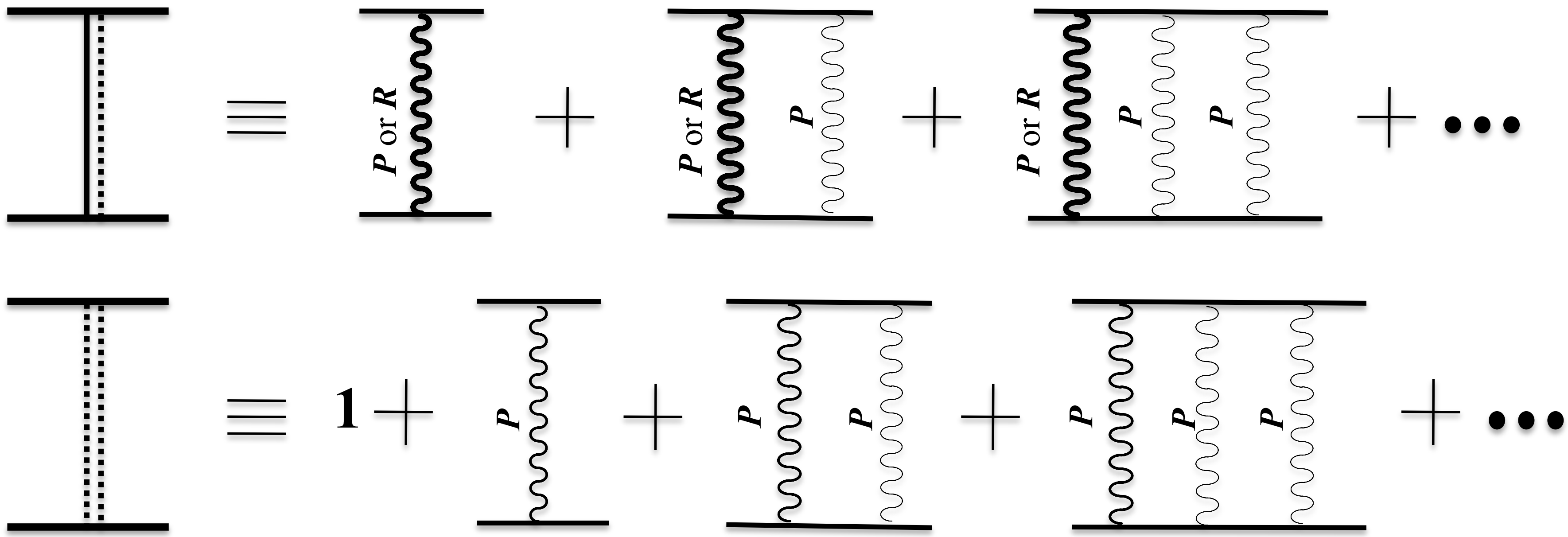
1. higher-energy data from SPS and Tevatron do not show a fast increase of the cross-section with energy as expected from the fits. As far as Tevatron energy is concerned, the predicted value for the single diffraction cross-section is larger than the measured total cross-section.
2. It is not possible to have a unified description of SD and DD data.
3. Triple-pomeron diagram violates unitarity which requires that the total cross section at very high energies should not grow faster than $\ln^2 s$ (Froissart bound).

A model for describing high-mass diffractive dissociation.

Dressed triple-Reggeon and loop diagrams



where

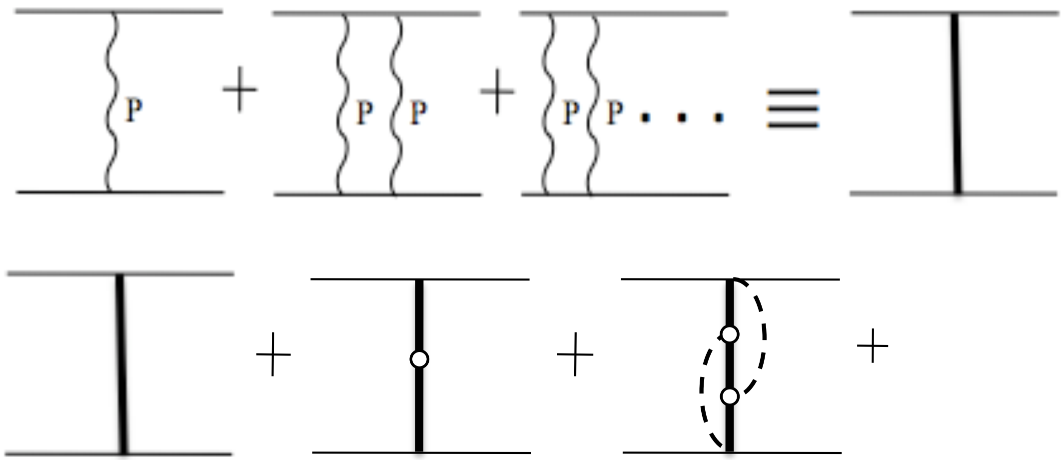


π-exchange is taken onto account based on OPER model

The motivation of writing different amplitudes for SD and DD (Ren. Pomeron)

Enhanced graphs and Pomeron intercept renormalization

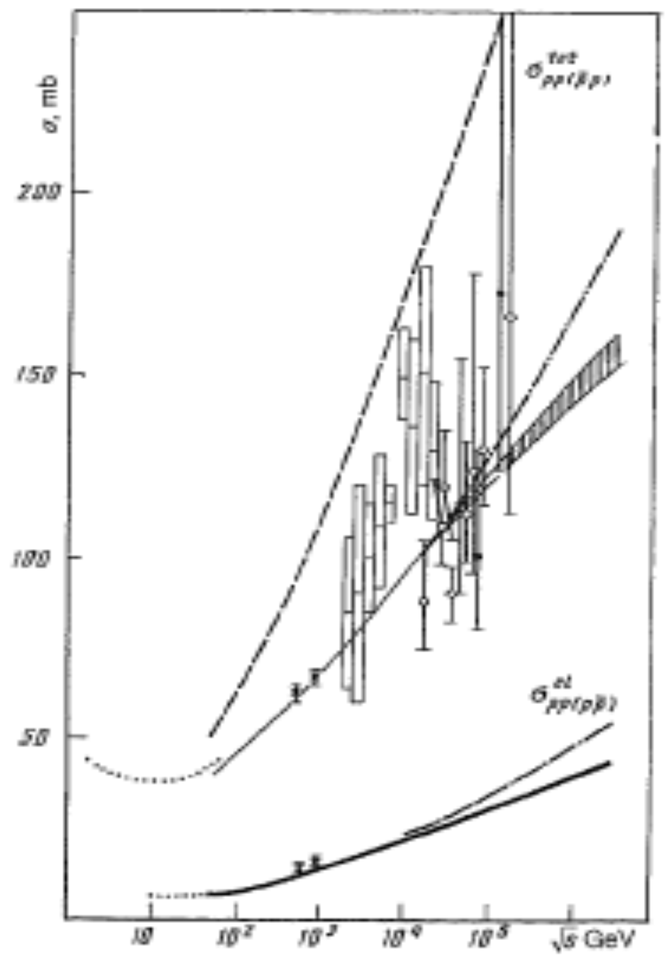
Dubovikov et al., Nucl. Phys. B123
Kopelovich and Lapidus, Sov. Phys. JETP 44
Dubovikov and Ter-Martirosyan, Nucl. Phys. B124
Kaidalov et al., Sov. J. N.P. 44



$$\Delta_{eff} = \Delta - 4\pi G_{PPP}$$

$\Delta = 0.2$ $\Delta_{eff} \approx 0.12$

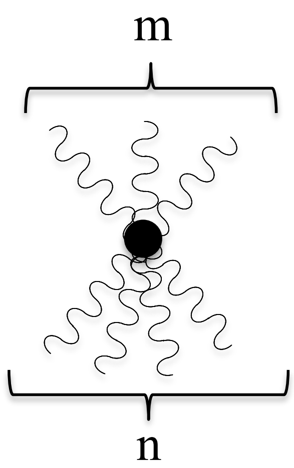
Kaidalov et al., Sov. J. N.P. **44**



The assumptions used for calculating "dressed" 3R vertices.

1. Eikonal approximation.

2. Eikonal-type structure for Transition of *n* Pometons into *m* Pomerons



$$\lambda^{m,n} = g_0 g^{m+n}$$

3. As a secondary Regge pole we consider *f*-trajectory. The conservation lows allow to assume the same pion dominance at transition with participation of *f*.

Extraction of parameters from experimental data

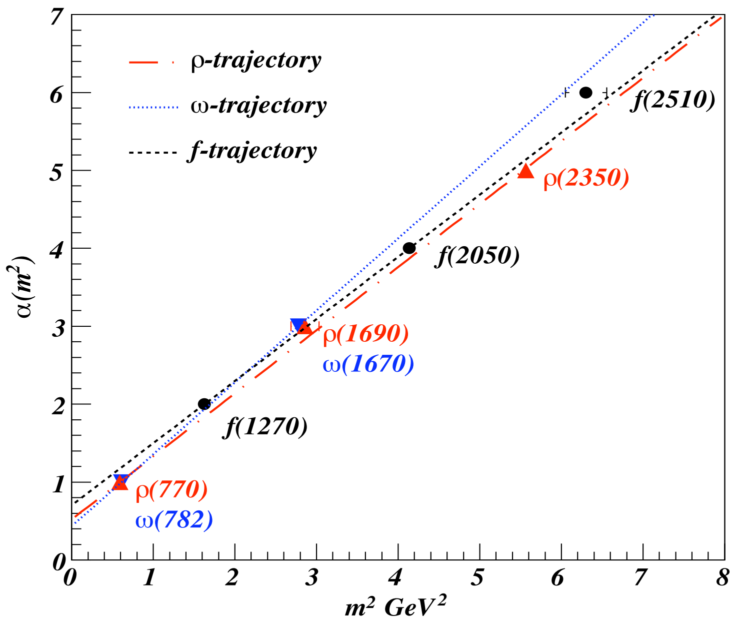
We have 18 free parameters. In order to be close to the reality they are fixed as follows.

1. Regge trajectory of the *f* meson: $\alpha_f(t) = \alpha_f + \alpha_f' t$. The parameters are defined from data on spin vs mass.

2. The residues of *f*-trajectory and the residues/trajectory of the Pomeron are found from fit to data on pp, ppbar and $p\pi^{\pm}$ total interaction and elastic scattering cross-section.

3. Triple-reggeon constants (G_{ijk}) are found from fit to data on high-mass diffraction dissociation data.

Secondary Rggeons



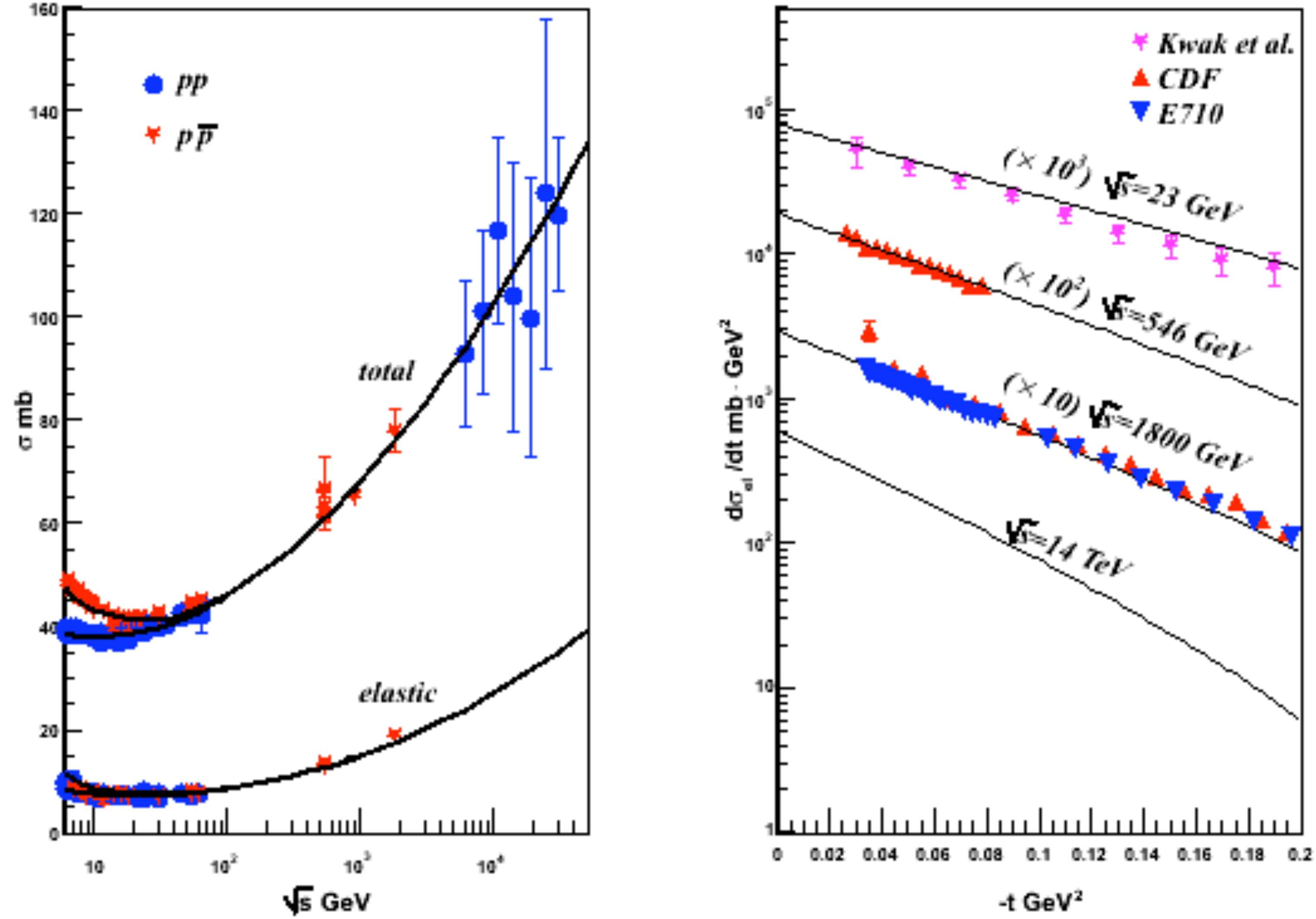
$$\alpha_i(t) = \alpha_i(0) + \alpha_i' \cdot t, \quad i = f, \rho, \omega.$$

$$\alpha_f(0) = 0.703 \pm 0.023 \quad \alpha_f' = 0.797 \pm 0.014 GeV^{-2}$$

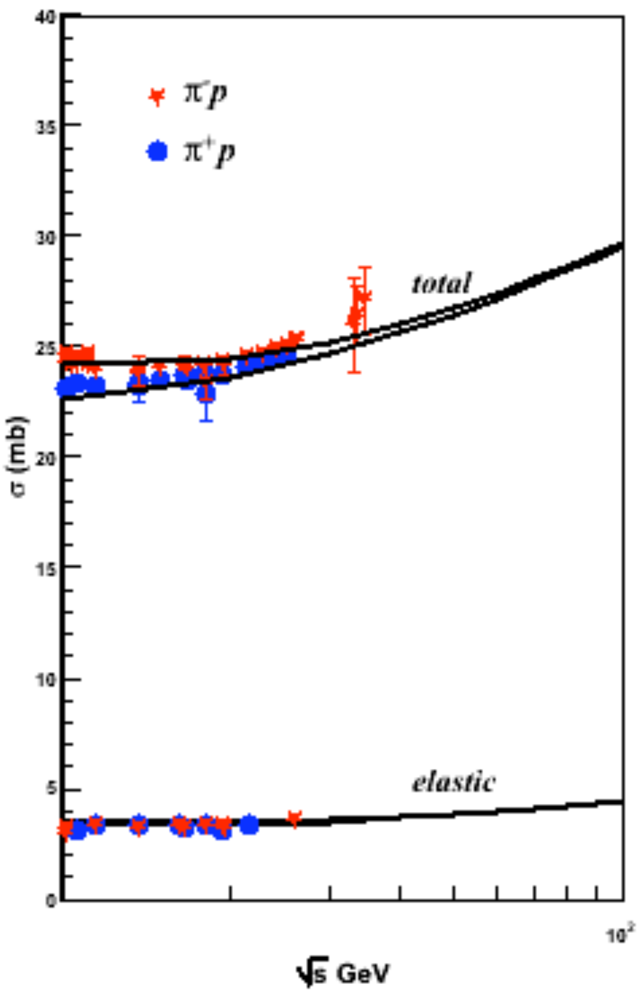
$$\alpha_\rho(0) = 0.522 \pm 0.009 \quad \alpha_\rho' = 0.809 \pm 0.015 GeV^{-2}$$

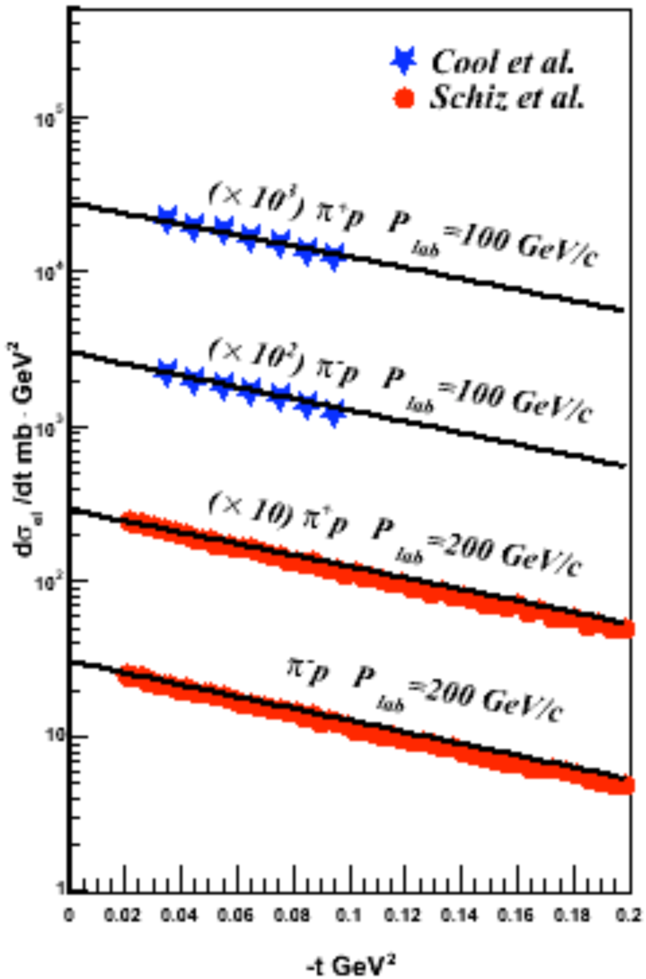
$$\alpha_\omega(0) = 0.435 \pm 0.033 \quad \alpha_\omega' = 0.923 \pm 0.054 GeV^{-2}$$

Fit to data on pp and $p\bar{p}$ total and elastic cross-section



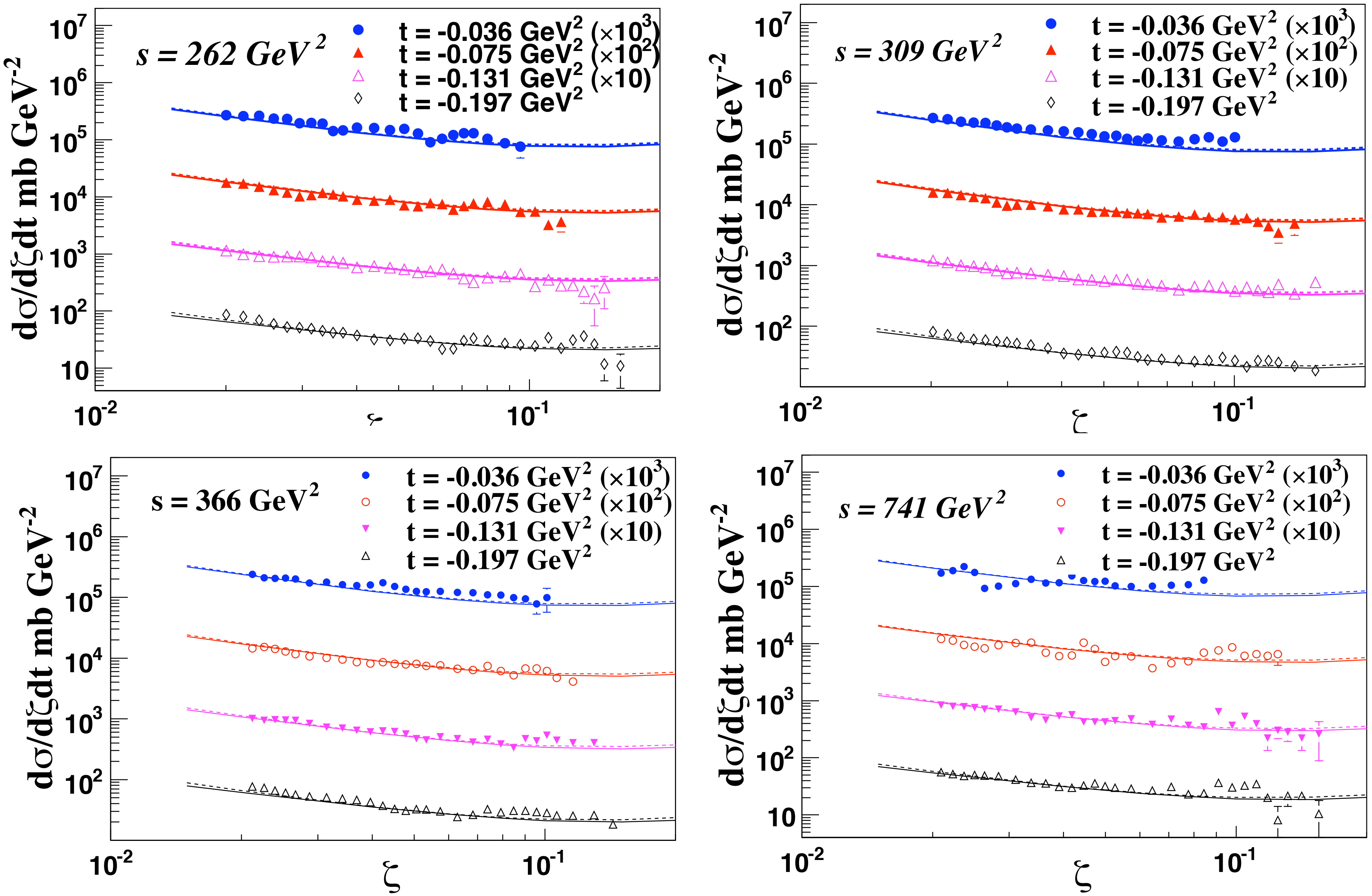
Fit to data on $\pi^{\pm}p$ total and elastic cross-section





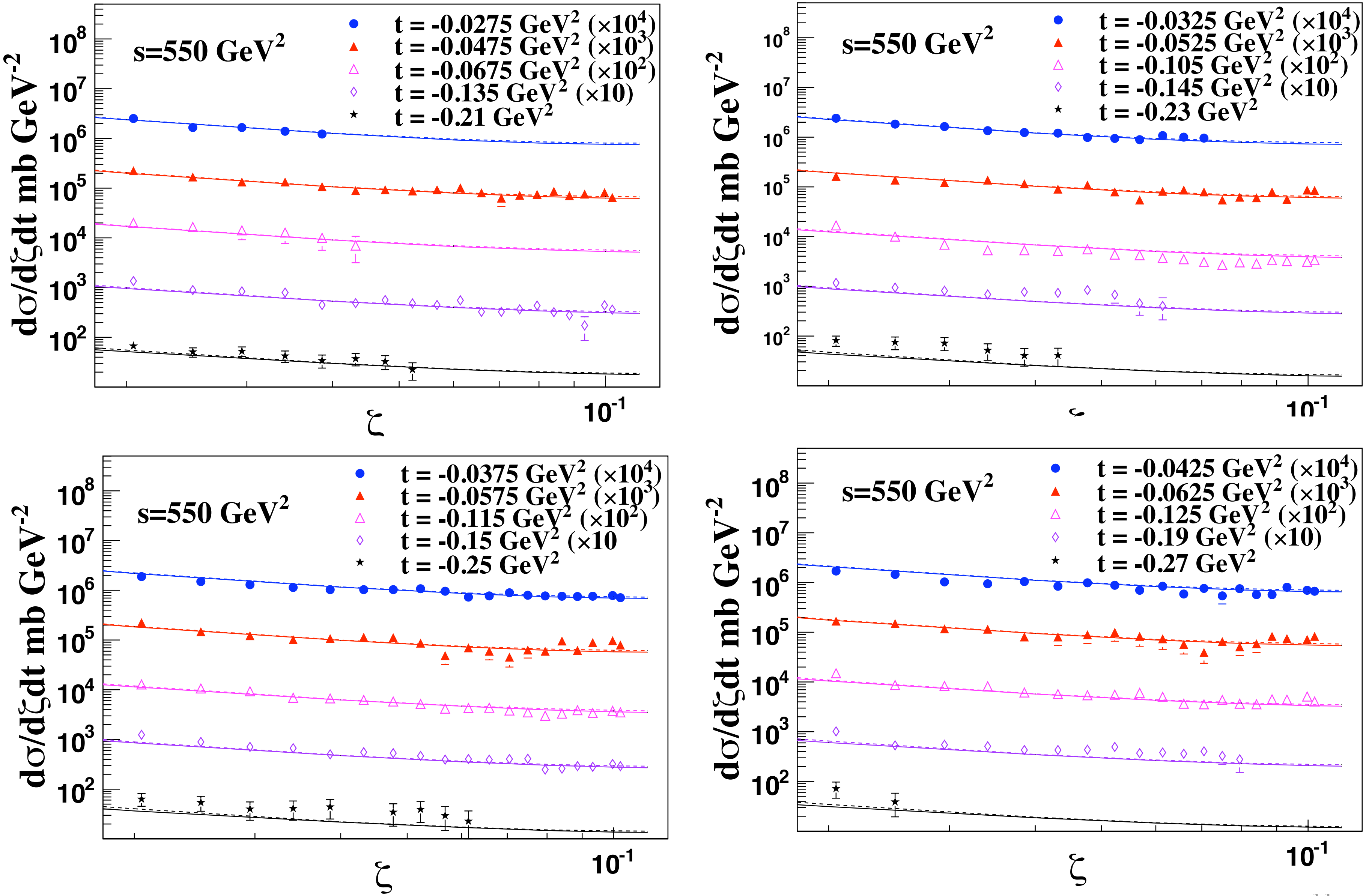
Fit to data on single diffraction dissociation

Data from Fermilab; Schamberger et al., Phys. Rev. **D17**

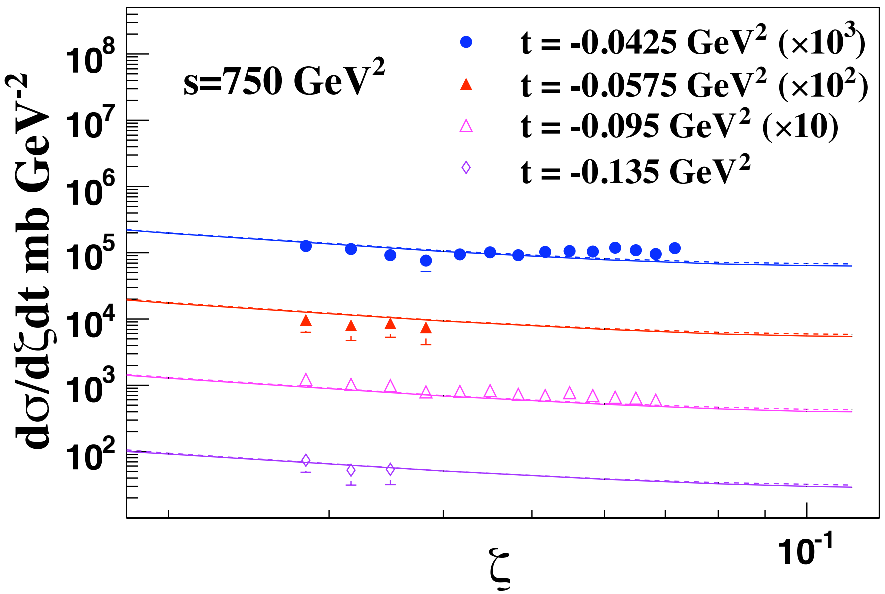


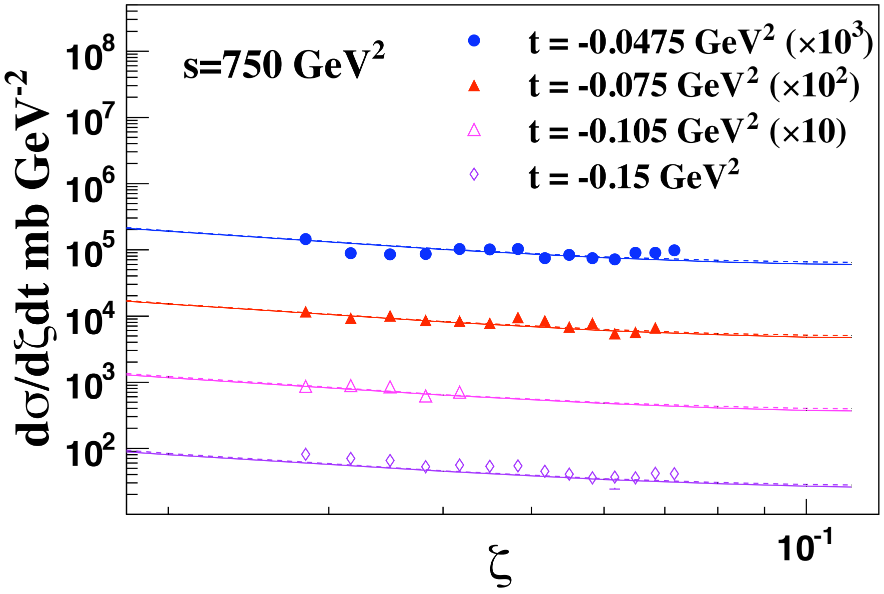
Fit to data on single diffraction dissociation

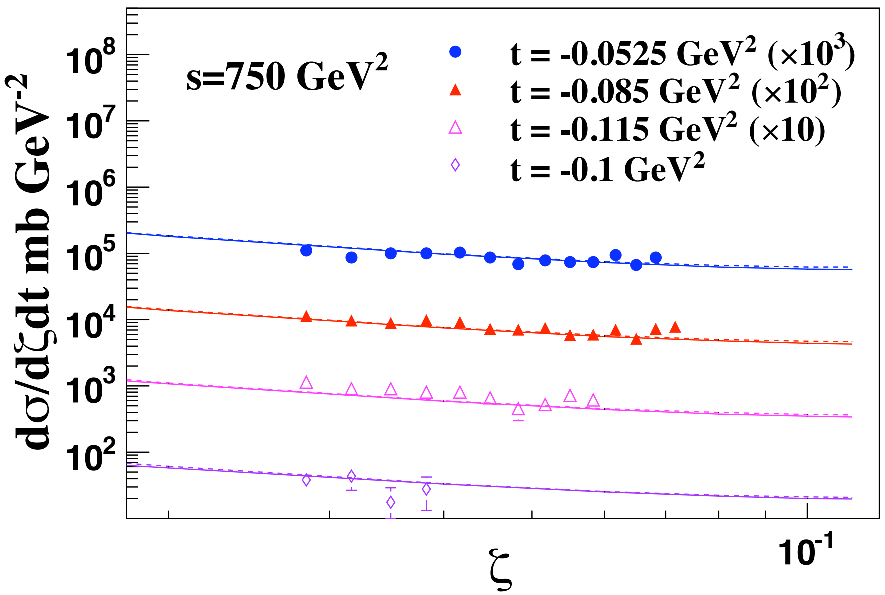
ISR data, Armitage et al. NP B194



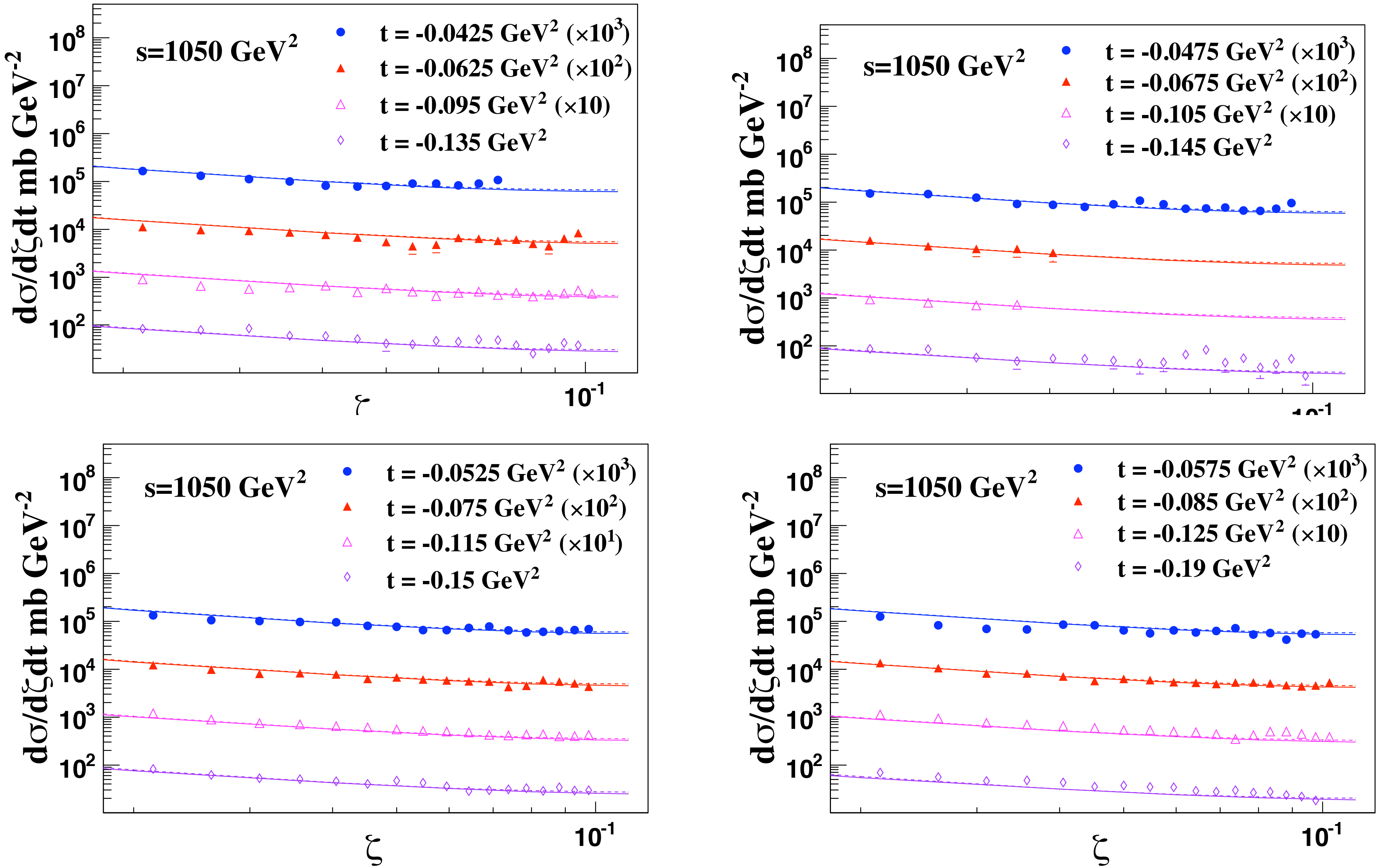
Fit to data on single diffraction dissociation





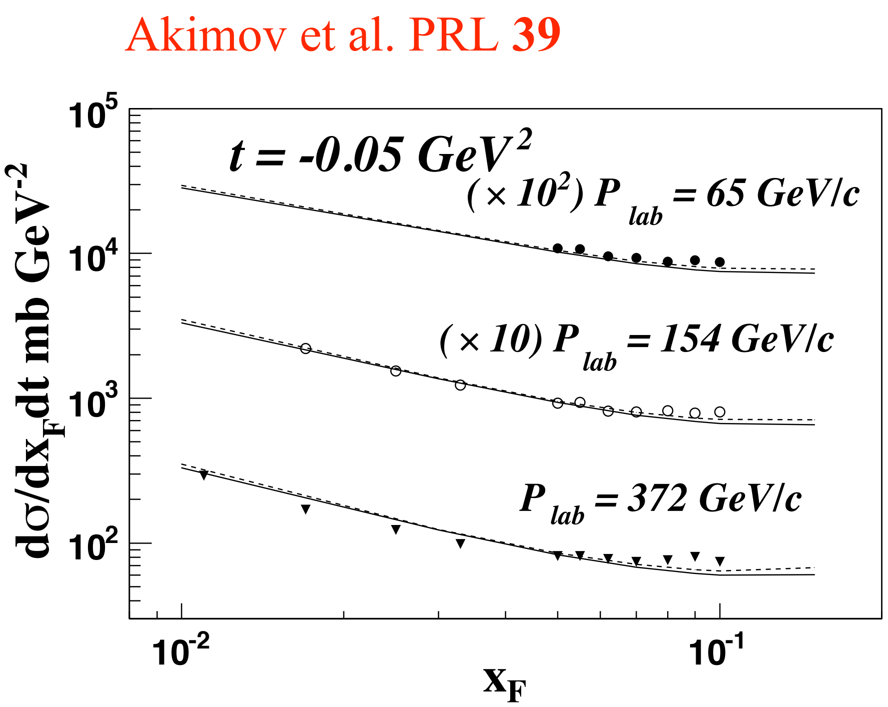


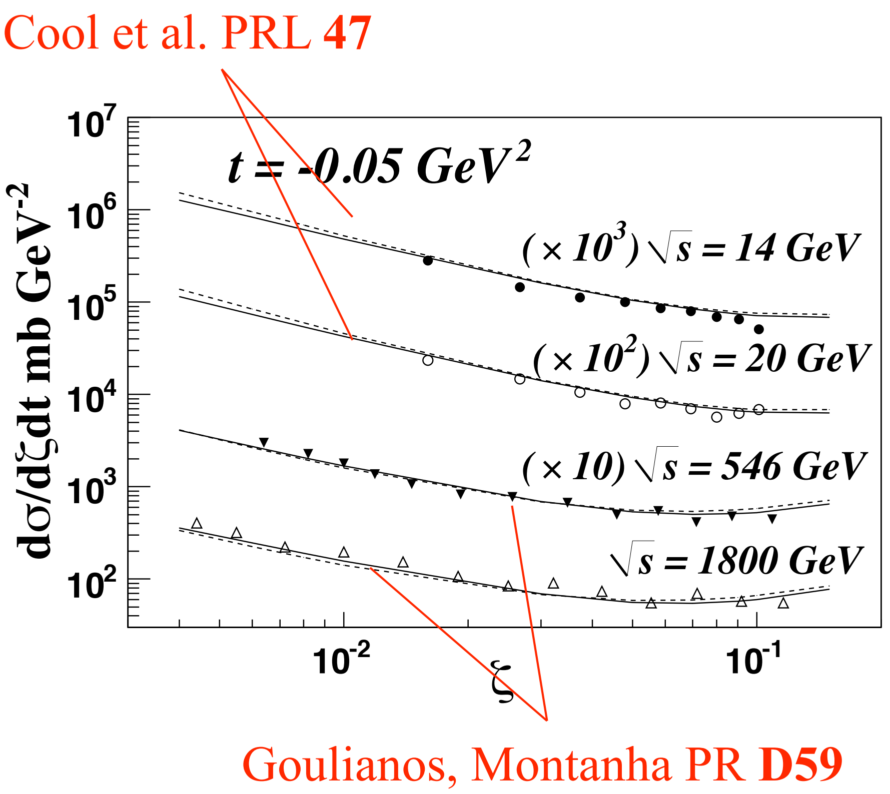
Fit to data on single diffraction dissociation



Fit to data on single diffraction dissociation

Data from Fermilab (fixed t)

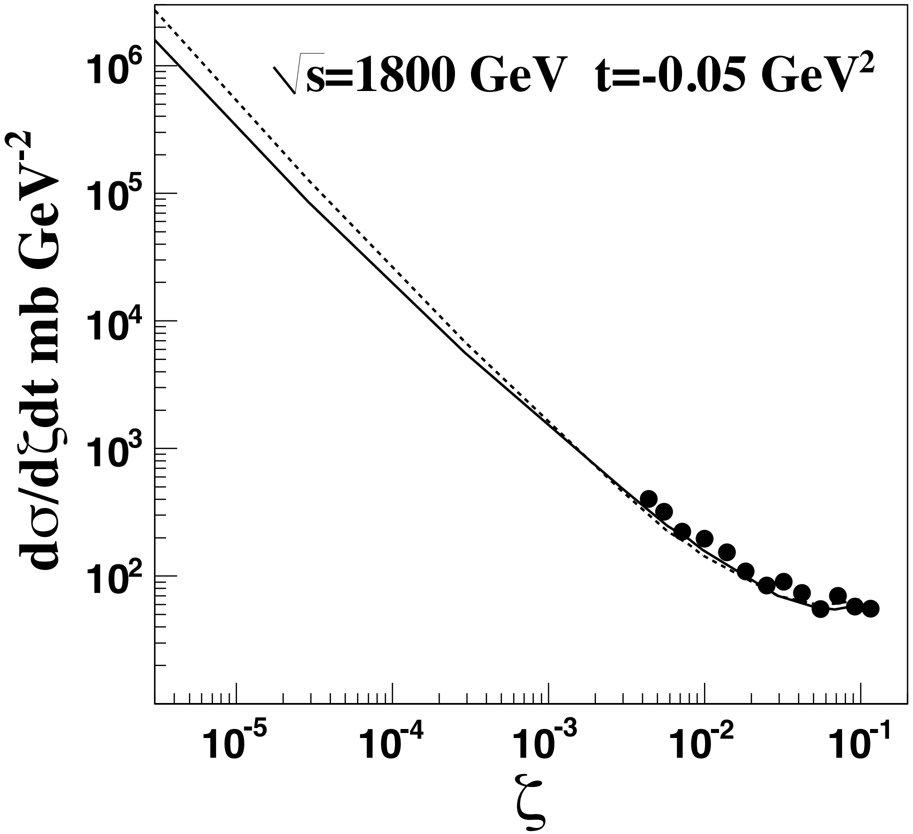


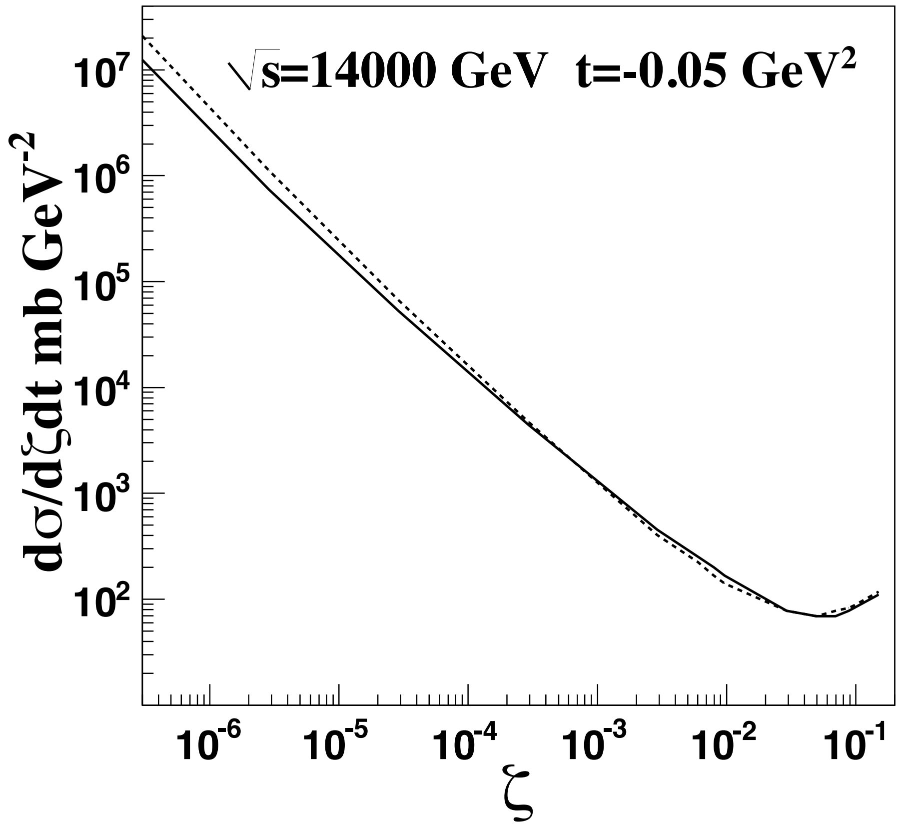


Triple-reggeon vertices (G_{ijk})

$G_{PPP} = 0.0098 \pm 0.0005\ GeV^2$	$G_{PPP} = 0.012\ GeV^2$
$G_{PPR} = 0.03 \pm 0.004\ GeV^2$	$G_{PPR} = 0.058\ GeV^2$
$G_{RRP} = 0.005 \pm 0.001\ GeV^2$	$G_{RRP} = 0.041\ GeV^2$
$G_{RRR} = 0.05 \pm 0.002\ GeV^2$	$G_{RRR} = 0.091\ GeV^2$
$G_{PRP} = 0.013 \pm 0.001\ GeV^2$	
$G_{PRR} = 0.033 \pm 0.005\ GeV^2$	

Integrated SD and DD cross-sectoion

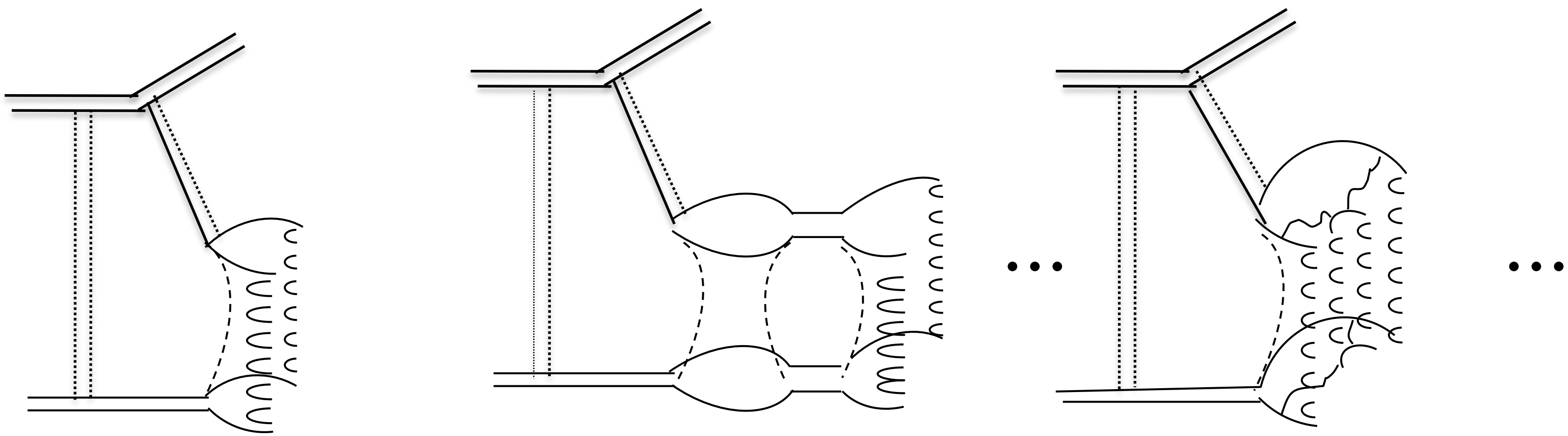




significantly different extrapolation to low masses (~40% at M=10 GeV/c^2).

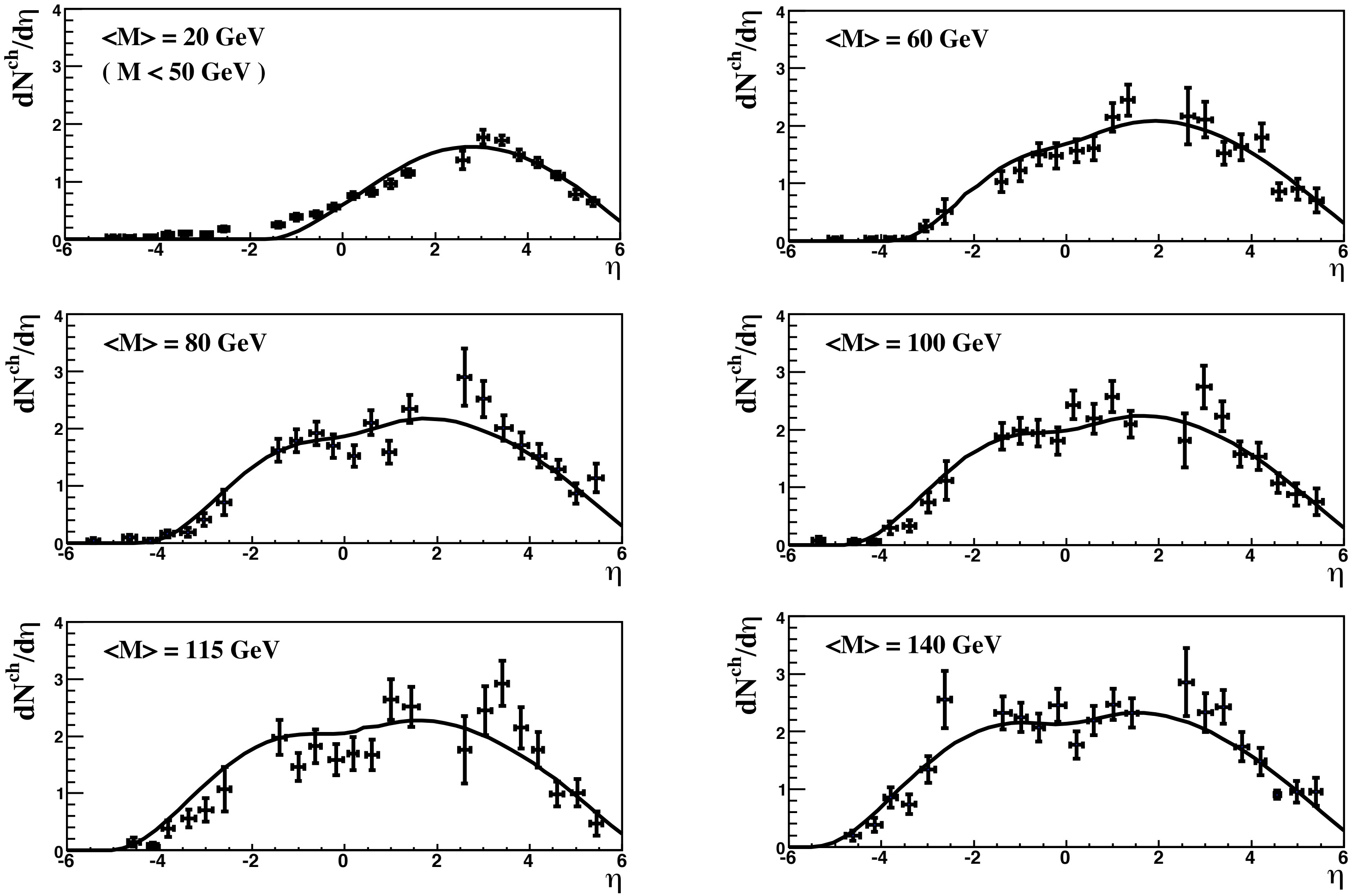
Spectra of particles produced in high-mass diffraction dissociation

The system of hadrons, produced in diffraction dissociation of a hadron can be considered as a non-diffractive interaction of a hadron with the qqbar system which is responsible for inelastic interaction of reggeons and/or pomerons.



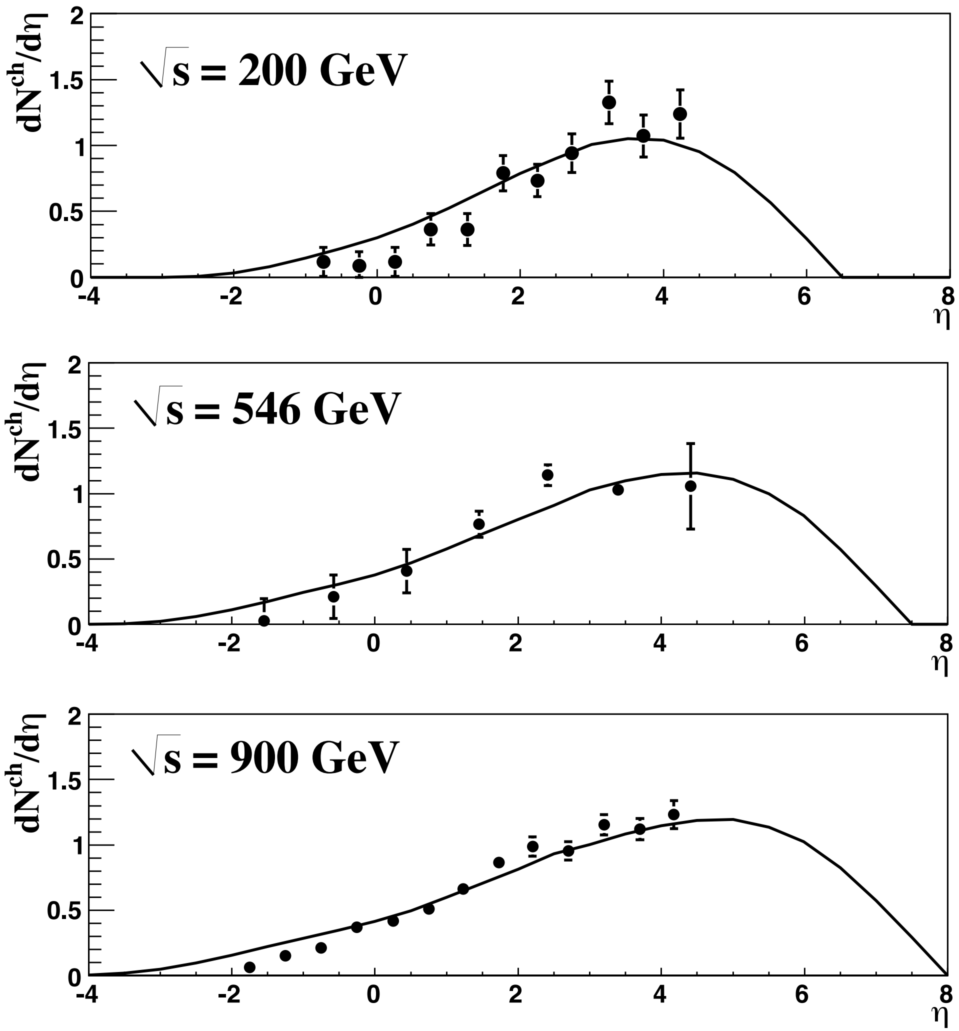
$N_{ch}/d\eta$ in **SD** events (1/2)

Description of UA4 data on charged particles pseudorapidty distribution in *ppbar* single-diffractive evens at √s = 546 GeV for different values of the diffractive mass.



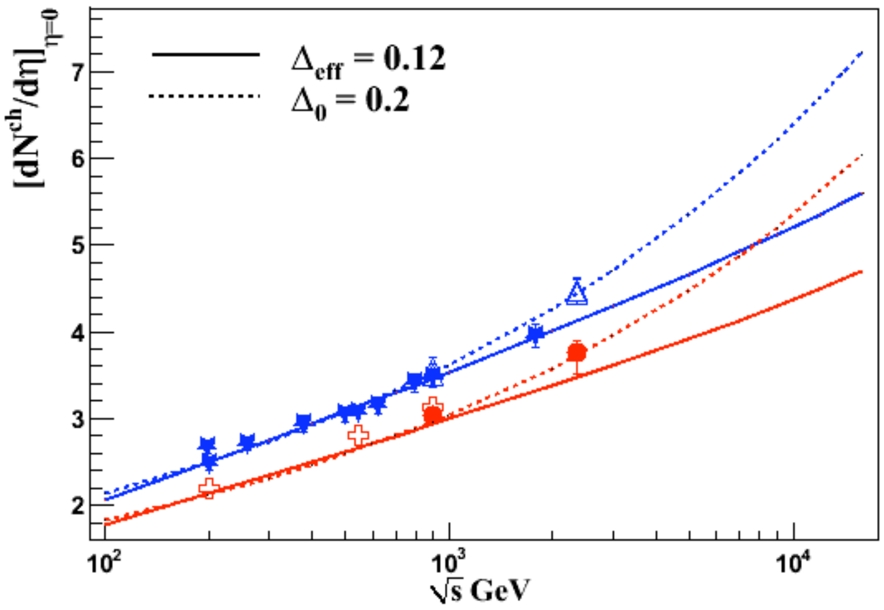
$N_{ch}/d\eta$ for SD events (2/2)

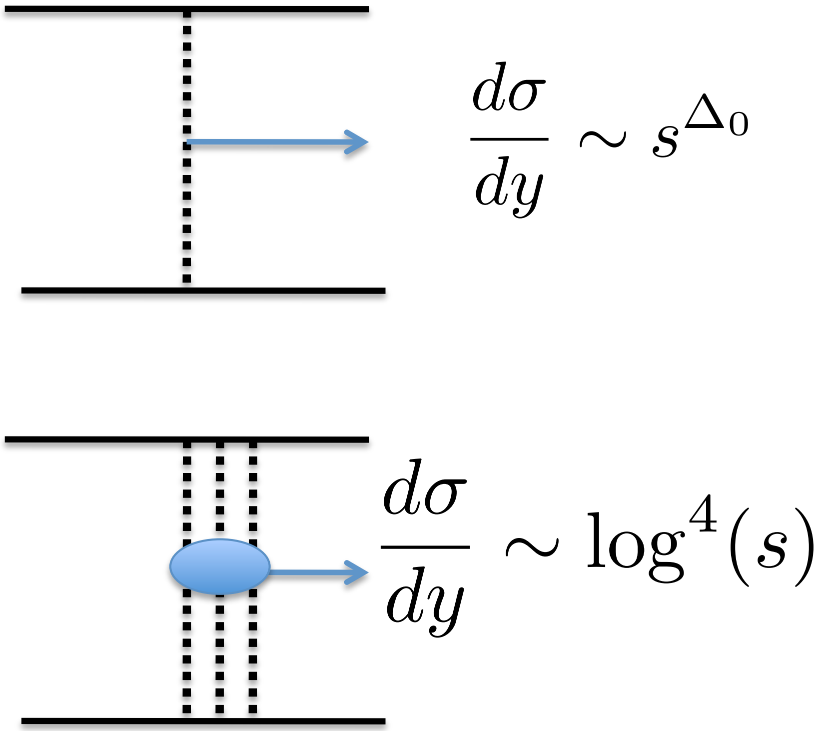
Description of UA5 data on charged particles pseudorapidity distribution in *ppbar* single-diffractive events. The indicated errors are statistical and the systematical errors are unknown.



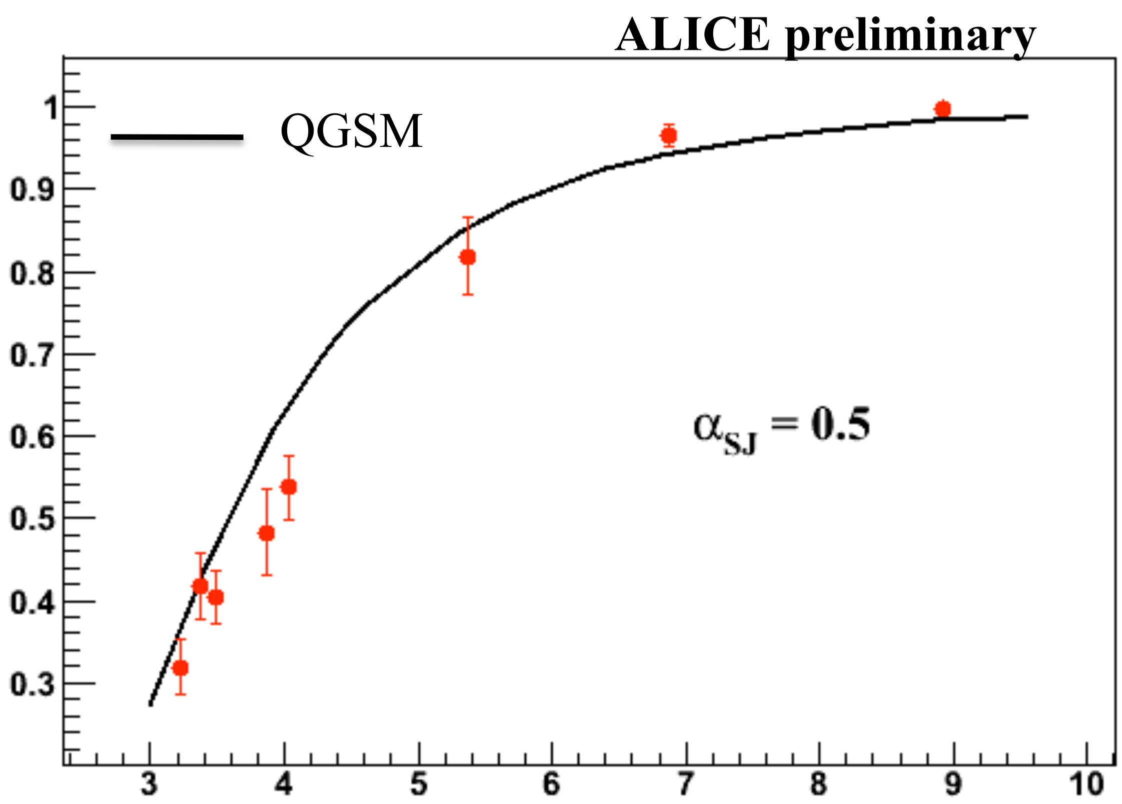
Integrated over all masses ($M^2/s \leq 0.05$)

$dN_{ch}/d\eta$ as a function of $\sqrt{s}$





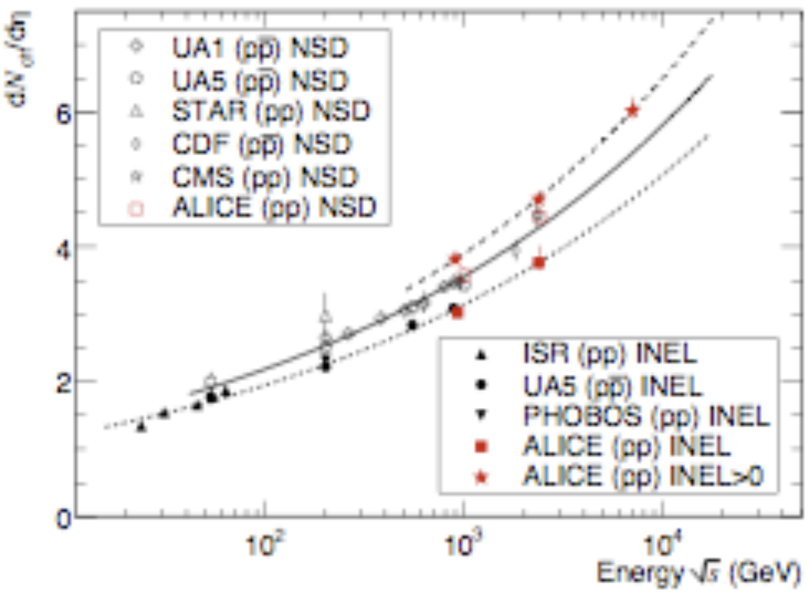
pbar/p ratio vs rapidity interval

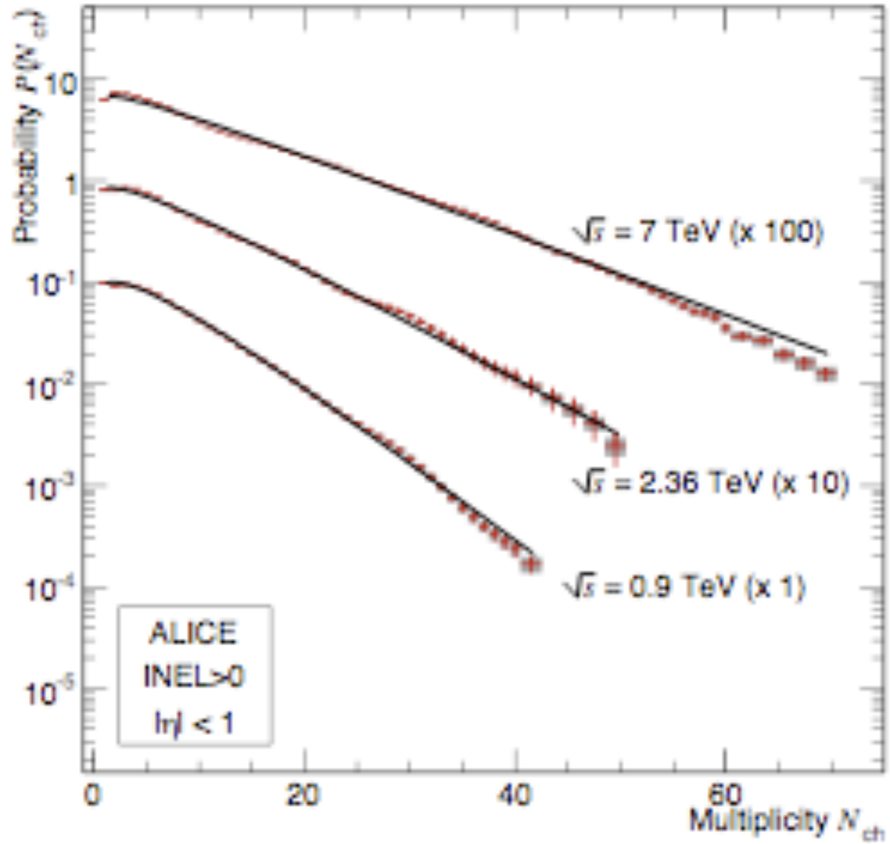


No room for reggeons with negative parity and $\alpha_R \approx \alpha_P$?

Charged-particle multiplicity measurement in proton-proton collisions at $\sqrt{s}$ = 7 TeV with ALICE at LHC.

arXiv:1004.3514





Summary

* We propose to describe soft single- and double- diffractive processes based on diagrams, where all possible eikonal-type corrections are taken into account in triple-reggeon and loop diagrams. This approach allows to describe data on diffractive pp and ppbar differential cross-sections in a wide energy range (from P_{lab} = 65 GeV/c to $\sqrt{s}$ = 1800 GeV) accessible by different accelerators of CERN and Fermilab. Available data on inclusive spectra of elastically scattered protons at single-diffractive interaction can be equivalently well described with and without accounting the interference terms. Nevertheless there is a deviation between these two scenarios at the extrapolation to low-masses and that is ~40% at masses of the diffracted system M=10 GeV/c^2.

•Incorporating this model with the Model of Quark-Gluon Strings, a good description of available SppS data on particles spectra in ppbar single-diffractive dissociation process is obtained in a parameter-free way.

•Contribution of enhanced diagram are important at LHC and looks like $\Delta_0 \approx 0.2$.

Appendix

One-pion exchange. The OPER model (1/2)

In the one-pion exchange approach the inclusive production of a hadron *c* in the fragmentation region of hadron *a* at interaction with hadron *b* is described by the diagram shown in Figure 21.

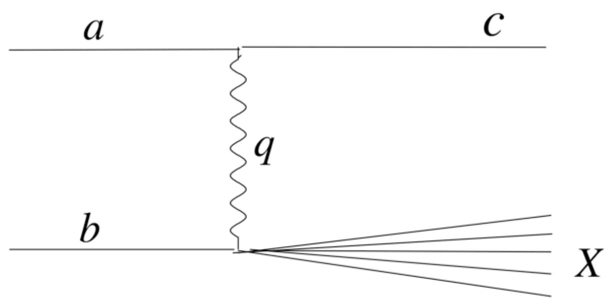


Figure 21: One-pion exchange diagram for the inclusive production of *c* in *ab* collisions.

According to the OPER-model, which was developed in ITEP [28], the invariant cross-section corresponding to this diagram has the form:

$$E_c \frac{d\sigma_{ab \to cX}}{d^3 p_c} = \frac{1}{16\pi^3} \frac{J_{\pi b}}{J_{ab}} V(t) |F_\pi(s, s_x, t)|^2 \sigma_{\pi b}^{tot}(s_x) \quad \text{(A.1)}$$

In (A.1), $V(t) = |M_{a\pi\text{->}c}|^2$ represents the square of the *acπ* vertex function (averaged over initial spin states), where the pion is off-mass-shell. $J_{ab} = \sqrt{(p_a p_b)^2 - m_a^2 m_b^2}$, $J_{\pi b} = \sqrt{(q p_b)^2 - m_\pi^2 m_b^2}$. p_a, p_b, p_c and q are the 4-momenta of the *a, b, c* and of the exchanged pion, respectively. $\sigma_{\pi b}^{tot}(s_X)$ is the on-mass-shell πb total cross-section at $\sqrt{s_X}$.

One-pion exchange. The OPER model (2/2)

The formfactor $F_\pi(s, s_X, t)$ describing off-mass-shell corrections has the following form

$$F_\pi(s, s_x, t) = exp\{\Lambda(t-\mu^2)\} \begin{cases} \frac{\pi}{2sin(\alpha_\pi(t)\pi/2)}, & |t| < |t_0|, \\ \frac{\pi}{2sin(\alpha_\pi(t_0)\pi/2)} exp\{R_2^2(t-t_0)\}, & |t| \geq |t_0|. \end{cases} \quad \text{(A2)}$$

$$\Lambda = R_1^2 + \alpha'_\pi ln\frac{s}{s_x}; \ \alpha_\pi(t) = \alpha'_\pi \cdot (t-\mu^2); \ \alpha'_\pi = 1\ GeV^{-2}.$$

μ is the pion mass. In the region of the threshold masses of πN-scattering ($s_X \leq 2$ GeV^2), where the P-wave production of Δ(1232)-resonance dominates, the amplitude is multiplied by the additional factor

$$f_\Delta(s_x, t) = \begin{cases} \frac{q_t}{q_0} exp\{R_3^2(t-\mu^2)\}, & |t| < |t_0|, \\ \frac{q_{t_0}}{q_0} exp\{R_3^2(t_0-\mu^2) + R_4^2(t-t_0)\}, & |t| \geq |t_0|. \end{cases} \quad \text{(A.3)}$$

where

$$q_t = Q(s_x, m_N^2, t), \ q_{t_0} = Q(s_x, m_N^2, t_0), \ q_0 = Q(s_x, m_N^2, \mu^2), \quad \text{(A.4)}$$
$$Q(x,y,z) = \sqrt{(x-y-z)^2 - 4yz}/2\sqrt{x}.$$

The nearness of the pion pole to the physical domain of scattering allows to fix the absolute normalisation of the cross-section at small $|t|$. The behavior at large values of $|t|$ is determined by the formfactor (A.2) and (A.3) which takes into account other exchanges, absorption corrections, etc. In this connection we must speak about an "effective" π-meson exchange, meaning a hadron system, whose interaction at small $|t|$ is well approximated by the pion exchange.
The parameters t_0 and R_i^2 are determined from fit to data and the following values are found

$$t_0 = -0.7\ GeV^2, \ R_1^2 = 0.3\ GeV^{-2}, \ R_2^2 = 0.74\ GeV^{-2}, \ R_3^2 = 2.75\ GeV^{-2}, \ R_4^2 = -1.3\ GeV^{-2}. \quad \text{(A.5)}$$

AGK cutting rules

In the language of Regge poles the multiparticle production processes are related to cut-Reggeon diagrams.

The basic results of AGK:

- There is one and only one cut-plane which separates the initial and final states of the scattering.
- Each cut-pomeron gives an extra factor of (−2) due to the discontinuity of the pomeron amplitude.
- Each un-cut pomeron obtains an extra factor of 2 since it can be placed on both sides of the cut-plane.