

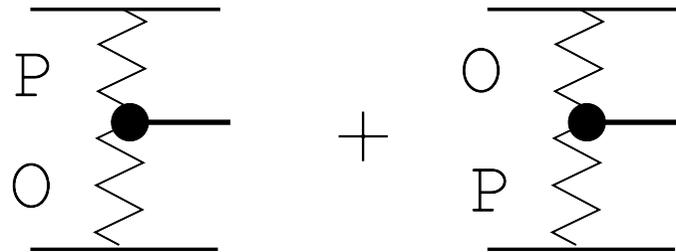
# Exclusive $J/\psi$ production in $pp$ and $p\bar{p}$ collisions and the QCD Odderon

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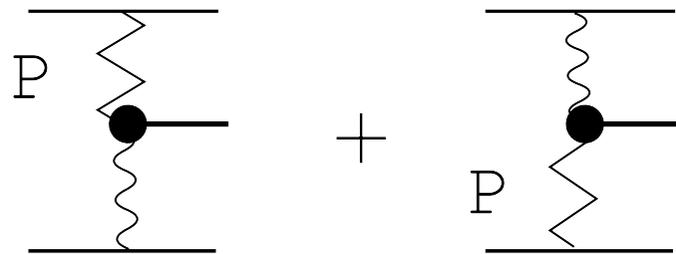
Low  $x$  Meeting - Lisbon 2006

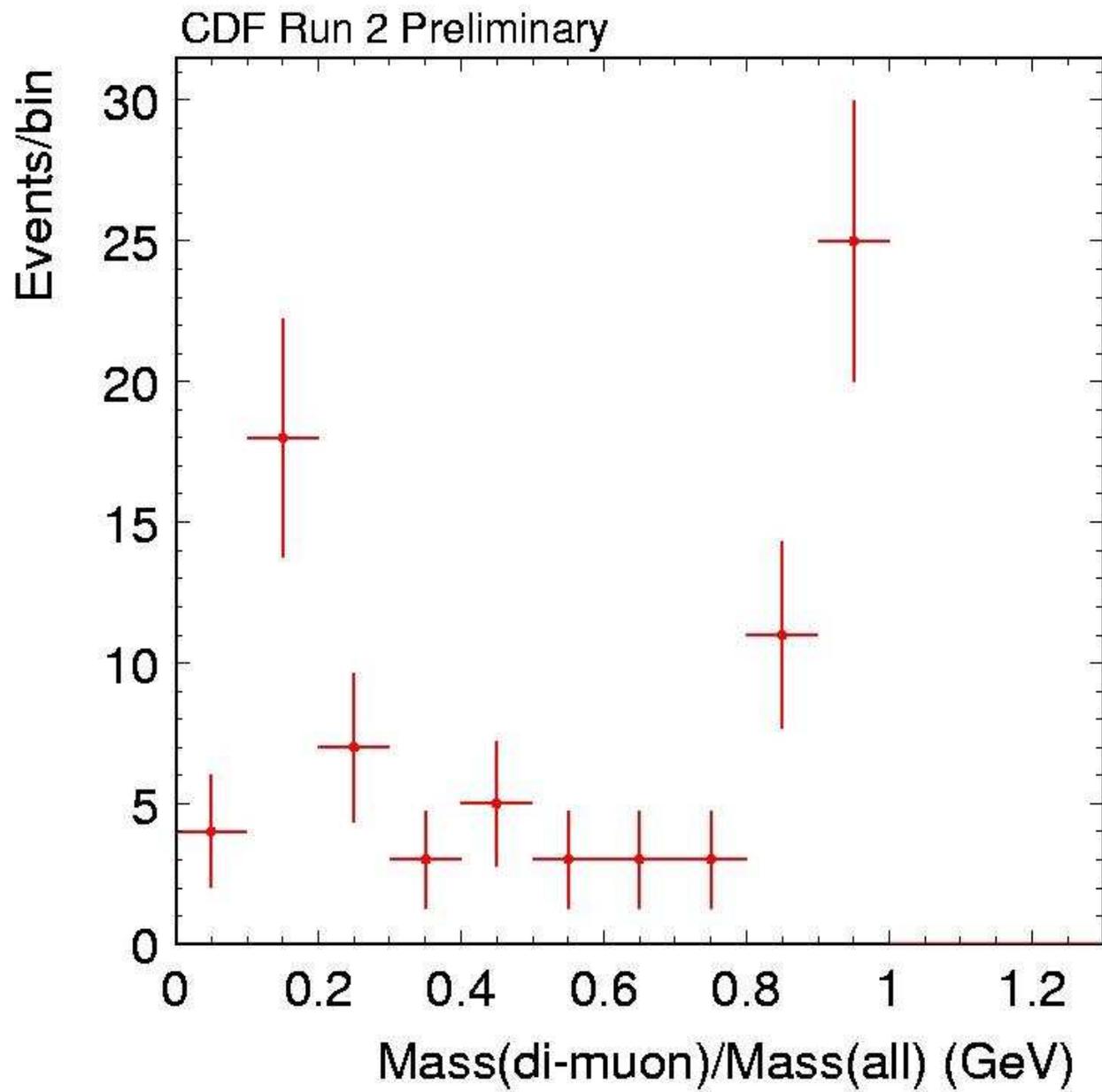
$J/\psi$  and Odderon are C odd, Pomeron is C even



$$\sigma_{tot} \leq 75 \text{ nb}$$

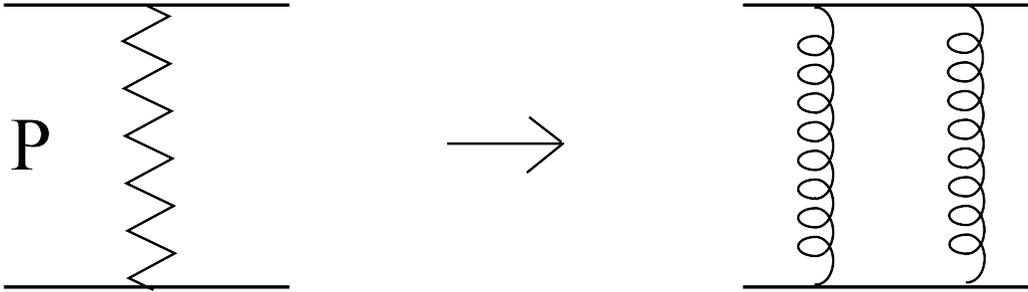
The photon pomeron fusion should be taken into account



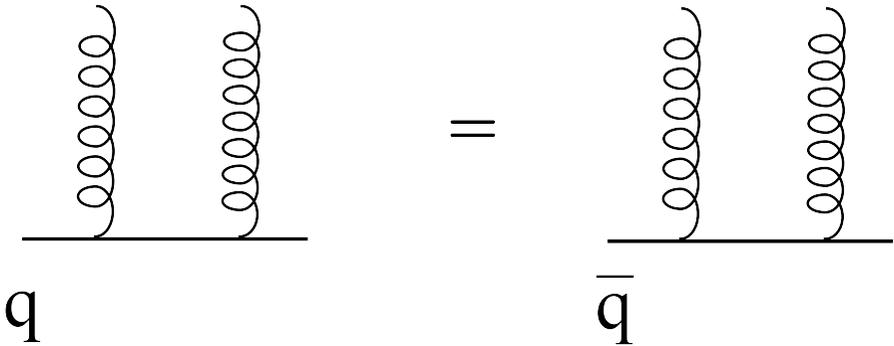


# The Pomeron

Vacuum quantum numbers  $\rightarrow$  colour neutral, **C even**

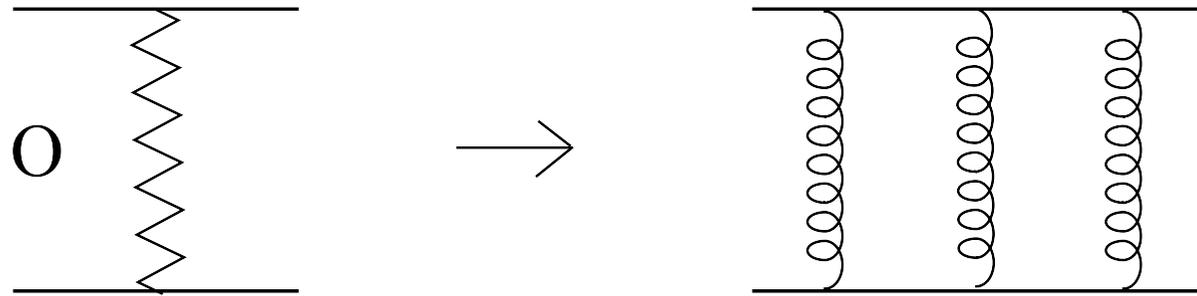


The Pomeron does not distinguish between particle and antiparticle



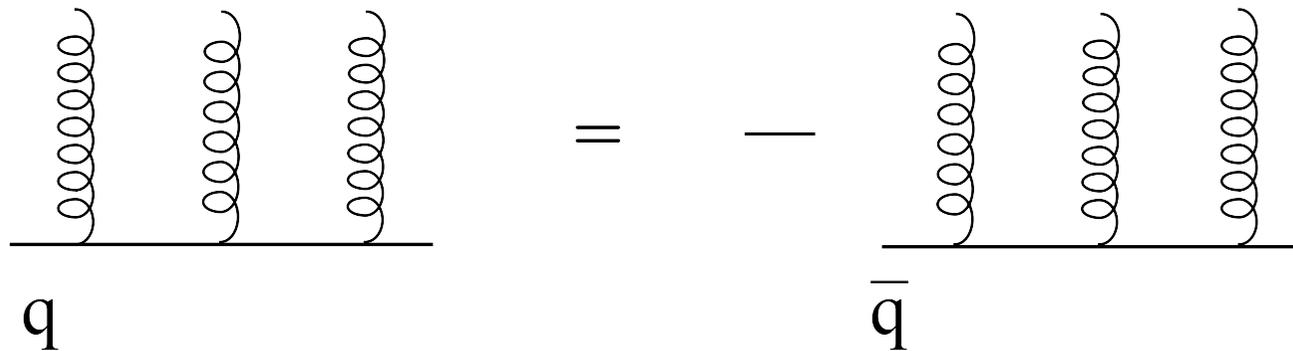
# The Odderon

Colour neutral, **C** odd



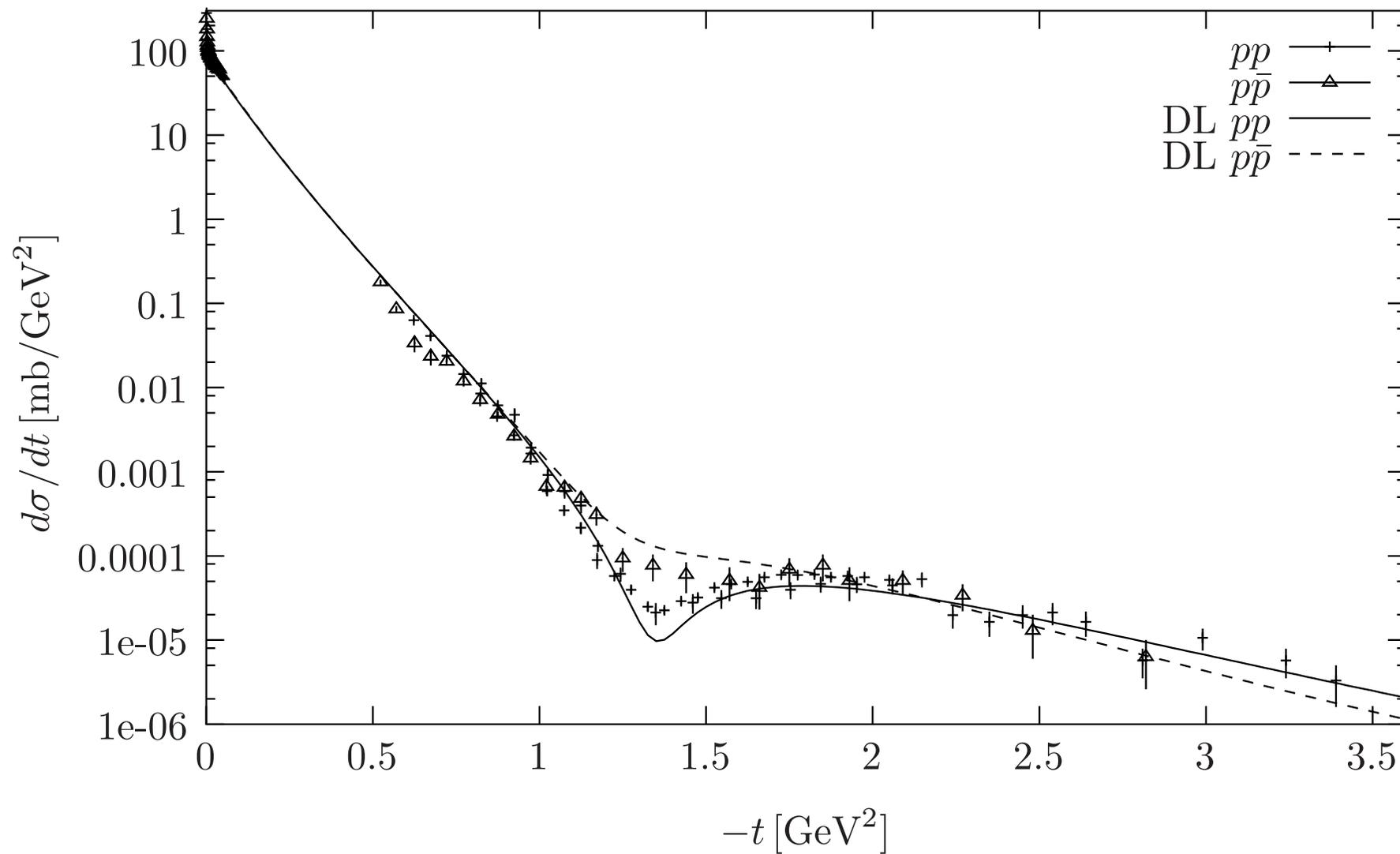
One would expect a suppression by a power of  $\alpha_s \Rightarrow O \lesssim P$

The Odderon distinguishes between particle and antiparticle



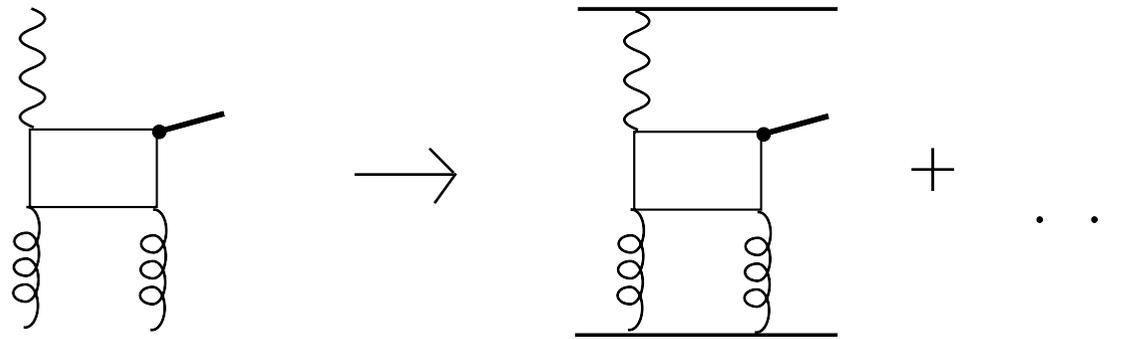
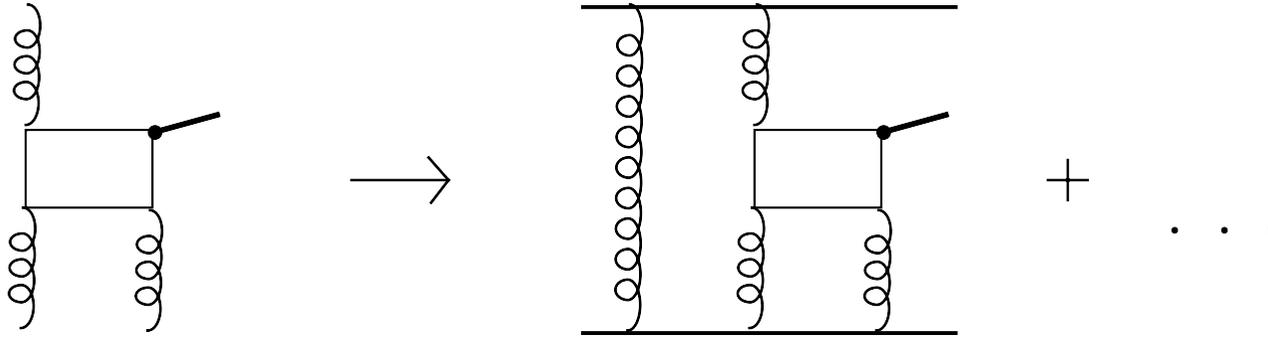


The best but weak evidence for the Odderon - CERN ISR at  $\sqrt{s} = 53 \text{ GeV}$

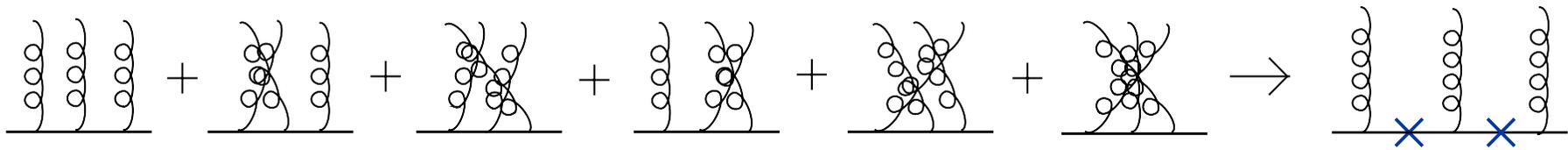
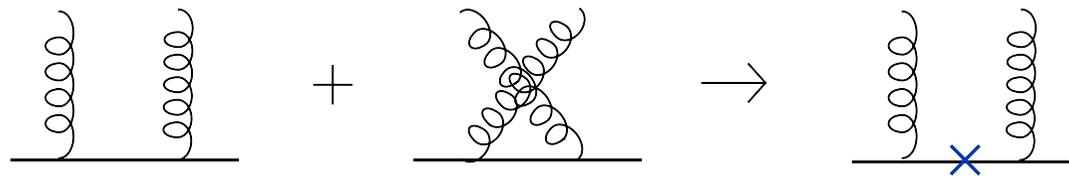
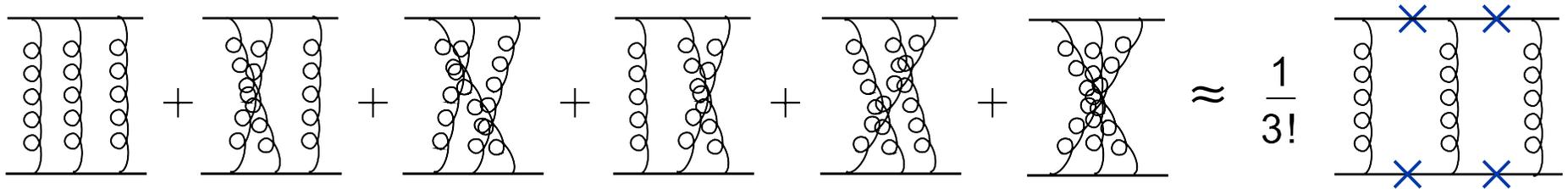
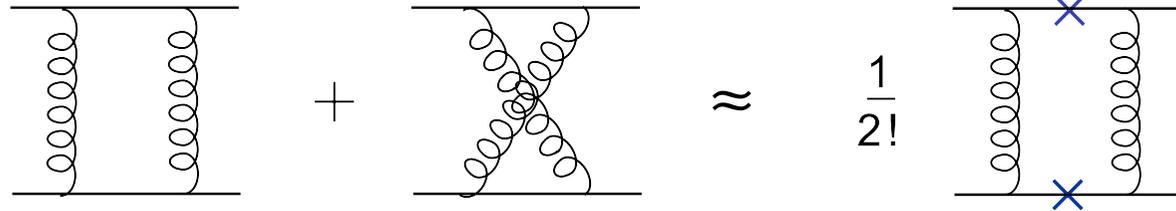


$J/\psi$  in perturbative QCD

$J/\psi$  is C odd (photon, gluon),  $M_{J/\psi} \approx 3 \text{ GeV}$



At high energies life is simpler

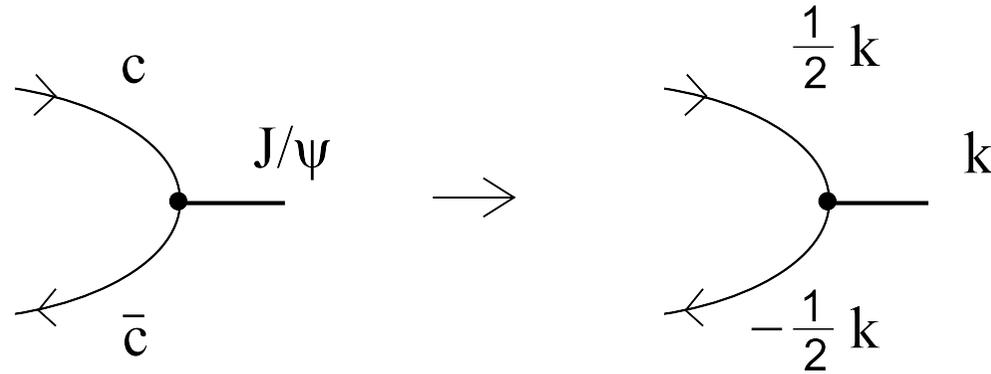


An amplitude (\*2!) for exclusive  $J/\psi$  production reads:

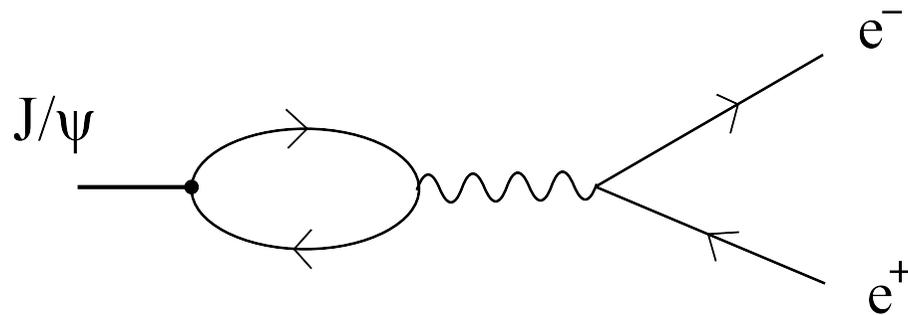
$$M \cdot 2! =$$

where:

It is enough to apply the collinear non-relativistic approximation

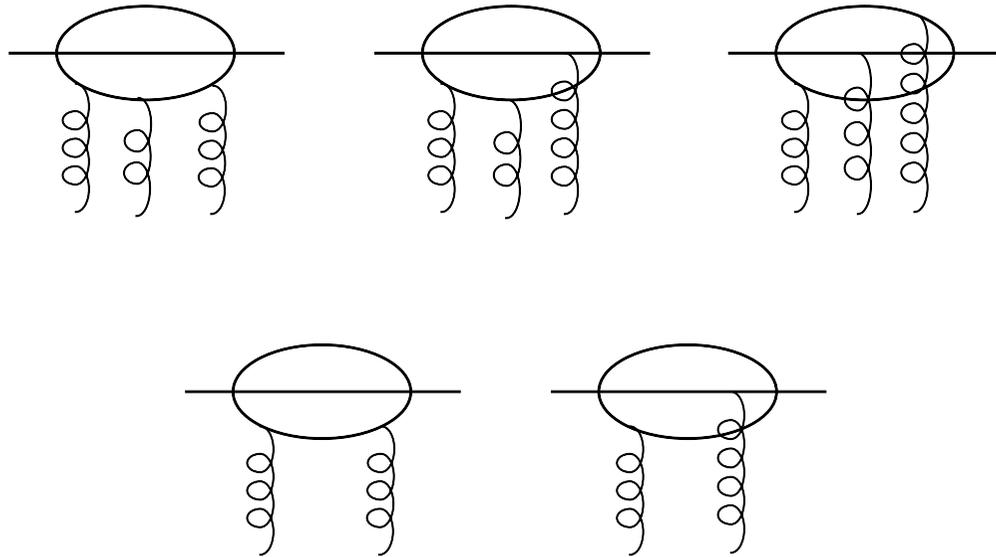


The coupling constant may be expressed in terms of the electronic width  $\Gamma_{e^-e^+}^{J/\psi}$  of  $J/\psi \longrightarrow e^-e^+$  decay

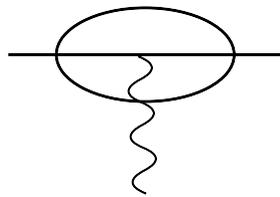


# The Fukugita-Kwiecinski's model

We consider the proton as a system of three valence quarks with totally antisymmetric wave function in the colour space



$\frac{G^2}{4\pi}$  originally  $\approx 1$  (possible  $\approx 0.3$ , Ewerz et al.)



Gap survival factor  $S_{gap}^2$

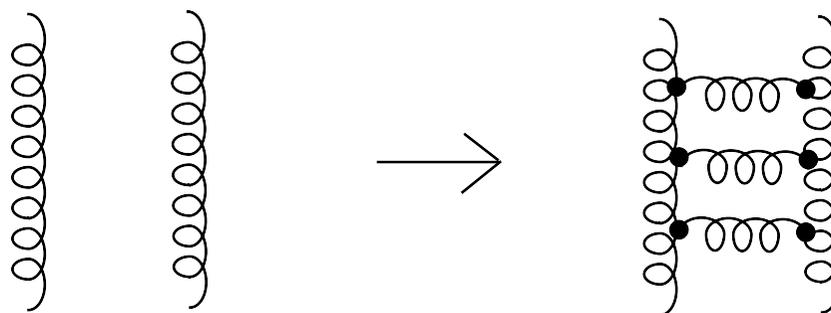
The probability of the gaps not to be populated by secondaries produced in the soft rescattering

Photon,  $S_{gap}^2 \approx 1$  (mainly from  $|t| \approx 10^{-4} - 10^{-2} \text{ GeV}^2$ )

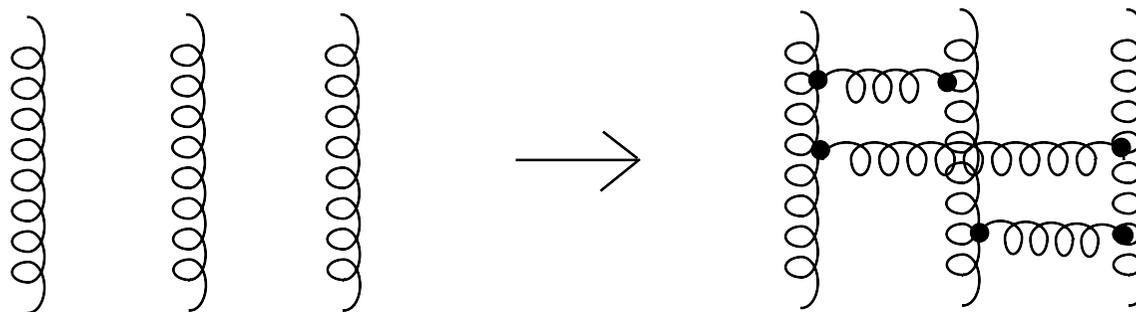
Odderon,  $S_{gap}^2 \approx 0.05$  for  $\sqrt{s} = 1.8 \text{ TeV}$  (KKMR,  $\chi_c$ )

BFKL evolution,  $s^0 \rightarrow s^\alpha$

For the Tevatron energy we expect enhancement by a factor  $\sim 3$



BKP evolution



# Preliminary results and summary

General remarks

$$\sigma_{pp} < \sigma_{p\bar{p}}$$

$\frac{d\sigma}{dy}$  weakly depends on the rapidity of the produced  $J/\psi$

Odderon and photon do not interfere

Our estimations for the Tevatron energy ( $p\bar{p}$ )

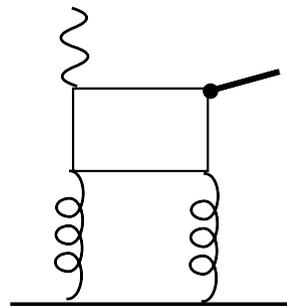
Photon:  $\frac{d\sigma}{dy}(y = 0) \approx 2.5 \text{ nb}$

Odderon:  $\frac{d\sigma}{dy}(y = 0) \approx 0.5 - 3 \text{ nb (coupling)}$

Photon's contribution may be well estimated in a model independent way from HERA data on  $\gamma p \rightarrow J/\psi p$



Weizsäcker-Williams



HERA

For the Tevatron  $\Rightarrow$  3 nb

For  $|t_1|, |t_2| > 0.25 \text{ GeV}^2$

The Pomeron-Odderon fusion decreases about 10 times

The Pomeron-photon fusion decreases about 200-500 times

Our recipe for the Odderon:

- take proton and antiproton
- collide them at very high energy
- switch off the light
- if you see something, it is the Odderon