CENTRAL EXCLUSIVE PRODUCTION:
VECTOR MESONS, DIJETS, HIGGS

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COLLABORATORS

Based on

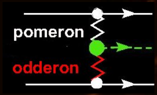
- A. Bzdak, L. Motyka, L. Szymanowski and J. R. C., "Exclusive J/psi and Upsilon hadroproduction and the QCD odderon," Phys. Rev. D **75** (2007) 094023 [arXiv:hep-ph/0702134].
- J. R. C., A. Dechambre, O. F. Hernández and I. P. Ivanov, "Central exclusive production of dijets at hadronic colliders," Eur. Phys. J. C **61** 369-390 (2009) [arXiv:0807.0600 [hep-ph]].

Outline

EXCLUSIVE PRODUCTION

Embedding of a hard process into pomeron exchange →

- no underlying event
- little background if sharp resonance and measurement of the hadronic energy
- discovery tool for new physics decaying into hadrons

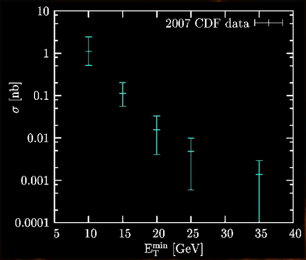


Production via odderon-pomeron fusion →

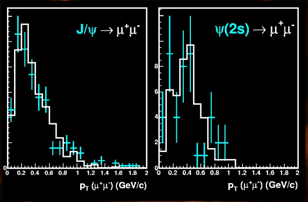
- discovery tool for the odderon

DATA: CDF RUN II

Exclusive dijets



Vector meson production



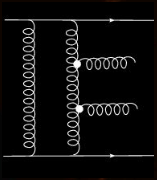
- E_T from 10 to 35 GeV
- $\sigma = 1$ nb to 1 pb
- M_{jj} up to 135 GeV $\approx M_H$

- $\left.\frac{d\sigma}{dy}\right|_{y=0}^{J/\psi} = (3.92 \pm 0.25 \pm 0.52)$ nb
- $\left.\frac{d\sigma}{dy}\right|_{y=0}^{\Psi(2s)} = (0.53 \pm 0.09 \pm 0.10)$ nb

BASIC INGREDIENTS: JETS

- Partonic singlet exchange:
  - $qq \to q + gg + q$
- Embed in hadrons:
  - $p\bar{p} \to p + gg + \bar{p}$
- Large vertex corrections
- Large screening corrections
- Make jets:
  - $p\bar{p} \to p + JJ + \bar{p}$

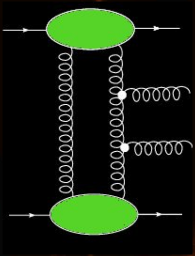
Collins-Berera



- fully calculable
- exact kinematics in $\perp$ plane
- $\sigma = \infty$ (IR divergence)

BASIC INGREDIENTS: JETS

Cheng-Wu, Soper-Gunion



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- regulates IR region
- changes the mass dependence
- $\sigma(E_T > 10\ \mathrm{GeV}) \approx 600$ nb

Basic ingredients: jets

- Partonic singlet exchange:
  - $qq \to q + gg + q$
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  - $p\bar{p} \to p + gg + \bar{p}$
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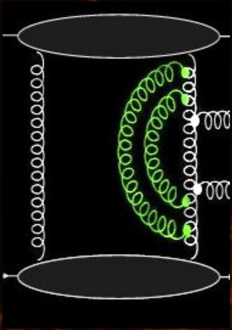
Diakonov-Dokshitzer-Trojan, Kaidalov-Khoze-Martin-Ryskin



- very large correction
- double logs fully known
- upper scale $\sim E_T$
- $\sigma(E_T > 10\ \mathrm{GeV}) \approx 25$ nb

BASIC INGREDIENTS: JETS

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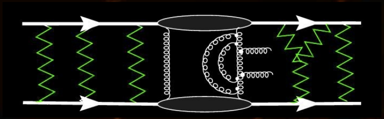
Bjorken



- under control if jet production at small distances
- otherwise depends on unitarisation scheme
- $\sigma(E_T > 10\ \mathrm{GeV}) \approx 3$ nb

BASIC INGREDIENTS: JETS

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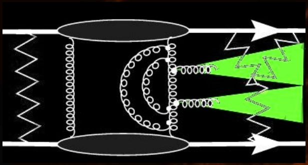
Kaidalov-Khoze-Martin-Ryskin, Salam

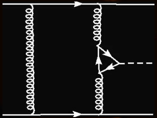


- several parametrisations
- $\sigma(E_T > 10\ \mathrm{GeV}) \approx 1$ nb

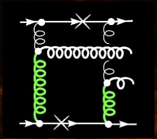
BASIC INGREDIENTS: HIGGS

- Partonic singlet exchange:
    - $qq \to q + H + q$
- Embed in hadrons:
    - $p\bar{p} \to p + gg + \bar{p}$
- Large vertex corrections
- Large screening corrections
- Background: direct $b\bar{b}$ production

Bialas-Landshoff



similar to the dijet case as



is suppressed

BASIC INGREDIENTS: HIGGS

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- Large screening corrections
- Background: direct $b\bar{b}$ production

same as in dijet case $\to$ important to measure dijets at the LHC

Basic ingredients: Higgs

- Partonic singlet exchange:
  - $qq \to q + H + q$
- Embed in hadrons:
  - $p\bar{p} \to p + gg + \bar{p}$
- Large vertex corrections
- Large screening corrections
- Background: direct $b\bar{b}$ production

Kaidalov-Khoze-Martin-Ryskin

- double logs and single logs known
- scale 0.62 M_H

BASIC INGREDIENTS: HIGGS

- Partonic singlet exchange:
  - $qq \rightarrow q + H + q$
- Embed in hadrons:
  - $p\bar{p} \rightarrow p + gg + \bar{p}$
- Large vertex corrections
- Large screening corrections
- Background: direct $b\bar{b}$ production

similar to the dijet case

BASIC INGREDIENTS: HIGGS

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  - $qq \rightarrow q + H + q$
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- Large screening corrections
- Background: direct $b\bar{b}$ production

small if Higgs narrow

Basic ingredients: vector mesons

- Partonic singlet exchange:
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- Embed in hadrons:
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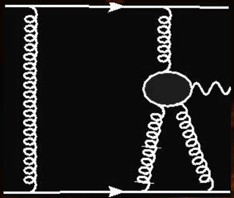
- Large screening corrections
- Background: photon-pomeron

Bzdak, Motyka, Szymanowski, Cudell



BASIC INGREDIENTS: VECTOR MESONS

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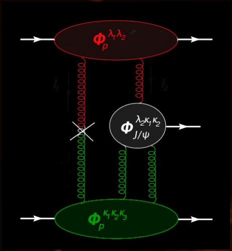

- pomeron side: same as in the dijet/higgs case
- odderon side: modelled by light-cone wave functions

Fukugita-Kwiecinski, Cudell-Nguyen

Basic ingredients: vector mesons

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similar to the dijet case

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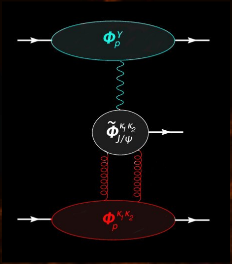
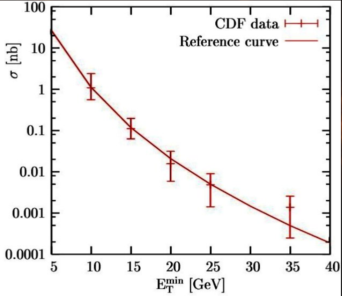


Results for CDF

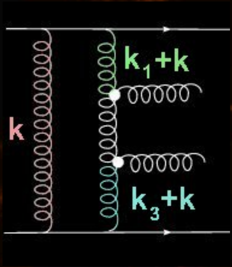
DIJETS

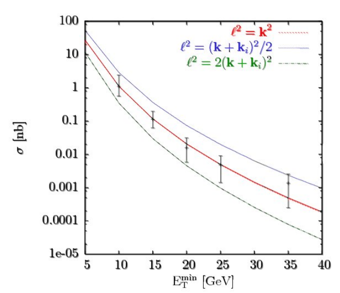
	parameter	value
hard	scale of α_S	s_{gg}
	$\Lambda^{(5)}_{QCD}$	200 MeV
Sudakov	scale of α_S	loop momentum
	$\sphericalangle$ ordering	yes
	terms	$\log^2 +$ log+constant
	lower scale	external off-shellness
	upper scale	$k_T^2/2$
impact factor	unitegrated gluon density	fitted to F_2
gap survival	$\langle S^2 \rangle$	15%
splash-out	$E_T^{jets}/E_T^{partons}$	0.8



DIJETS

Many curves go through the data!
For instance, change the lower scale in the Sudakov factor





HIGGS

$\sigma_H < 0.03$ fb

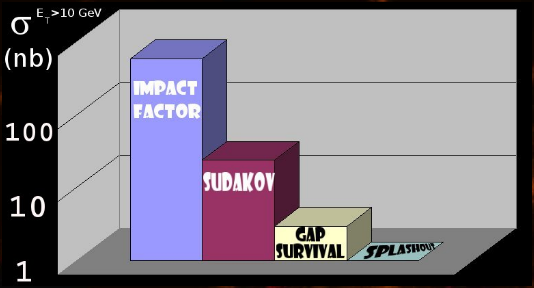
VECTOR MESONS

$d\sigma/dy\|_{y=0}$	J/ψ(nb)		Υ(pb)	
	odderon	photon	odderon	photon
Tevatron	0.3-5	0.7-9	0.7-15	0.8-9

Odderon/photon=

- 30-60% for J/Ψ
- 80-170% for Υ
- The J/Ψ and Ψ' data are consistent with photon exchange
- The odderon signal could be enhanced by a t cut

Huge correction factors

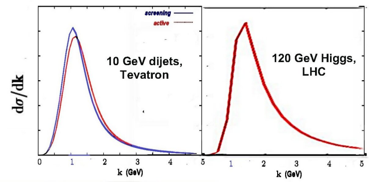


UNCERTAINTIES

parameter	uncertainty (highest/lowest)		
	Jets	Higgs	J/ψ
Sudakov	20	7	≈ 1
Impact factor	3	3	>3
Gap survival	3	3	3
Splash-out	2	-	-
Total	$\sim$200	$\sim$60	$\sim$10

GLUON MOMENTUM DISTRIBUTION

Only 30-50% of the cross section comes from the phase-space region with all off-shellnesses $>$ 1 GeV.



The calculation is tentative at best !

→use CDF data to constrain the predictions

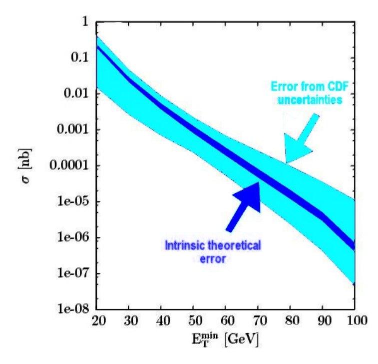
Results for the LHC

LHC DIJETS

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

- For typical cuts of FP420

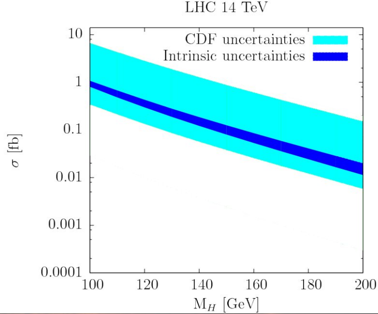
parameter	value
proton fractional momentum loss	0.002-0.02
jet rapidity	<1
mass of jet system	>50 GeV



LHC HIGGS

- For typical cuts of FP420

parameter	value
proton fractional momentum loss	0.002-0.02
Higgs rapidity	<1



Vector mesons

Worse than at the Tevatron!

$d\sigma/dy\|_{y=0}$	J/ψ(nb)		Υ(pb)	
	odderon	photon	odderon	photon
	0.3-4	2.4-27	1.7-21	5-55

Odderon/photon=

- 6-15% for J/Ψ
- 15-40% for Υ

CONCLUSIONS

NEW MYTHS	NEW REALITY
THE CALCULATION IS PERTURBATIVE	$k \approx 0.8 - 1.5$ GEV
THE UNCERTAINTIES OF THE CALCULATION ARE SMALL	FACTOR 10-200

importance of CDF data to test theoretical ideas

$\sigma_{Higgs} < 2$ fb for $M_H = 120$ GeV

σ_{jj} at the LHC could further constrain the Higgs cross section

odderon signal ≈15-40 % at LHC, 30-170 % at Tevatron, better in Υ

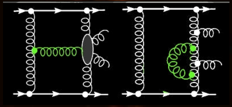
APPENDIX: EXTRA TRANSPARENCIES

EXAMPLE: SUDAKOV FORM FACTOR

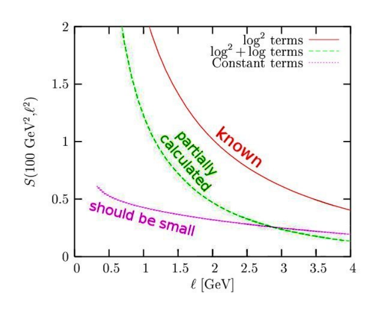
$$T(\mu^2,\ell^2) = \exp\left[-S(\mu^2,\ell^2)\right]\,, \quad S(\mu^2,\ell^2) = \int_{\ell^2}^{\mu^2} \frac{dq^2}{q^2}\frac{\alpha_s(q^2)}{2\pi}\int_0^{1-\Delta} dz\,[zP_{gg} + N_f P_{qg}]$$

Trick: virtual corrections $\sim$1-brehmstrahlung

- true for $\log^2$
- true for *some* log



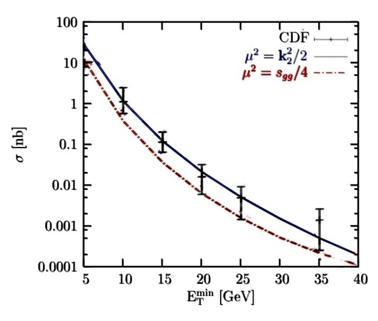
- not true for constant terms

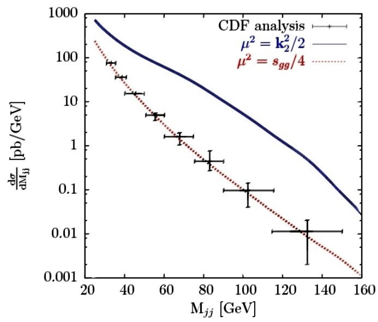


CONSEQUENCES

Two curves fitting the E_T distribution

can produce very different mass distributions





The ExHuMe Monte-Carlo used to analyse the data takes $\mu^2 = s_{gg}/2.62$.