The Forward Physics Monte Carlo

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Sakura meeting, 24-26 August 2009, Tokyo, Japan

Contents:

- MC description
- Diffraction at Tevatron/LHC
- Inclusive and exclusive diffraction in FPMC
- γ exchange in FPMC

Work done in collaboration with O. Kepka, V. Juranek, M. Boonekamp, M. Rangel

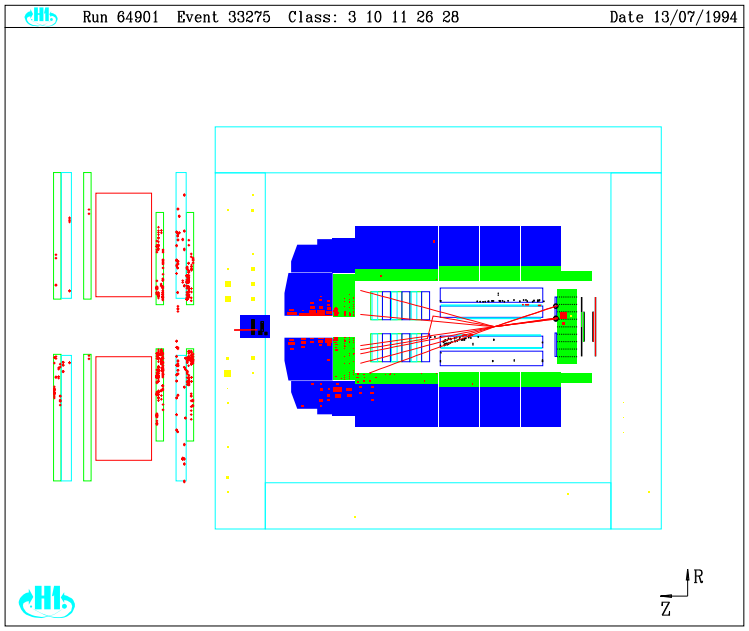
Forward Physics Monte Carlo: Included Processes

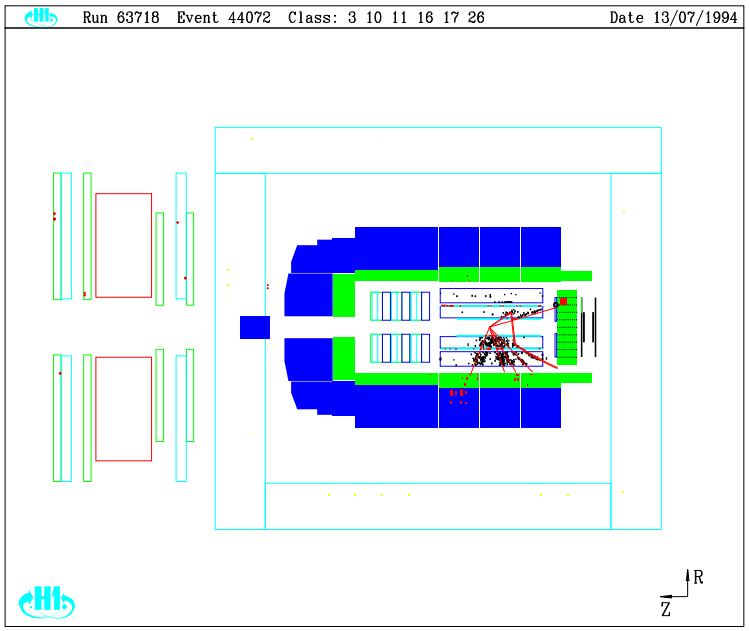
- Inclusive Diffraction: Single diffraction and double pomeron exchange at hadron colliders (Tevatron and LHC)
- Exclusive diffraction: Higgs, jet production (Durham model)
- QED processes: Photon induced processes to produce W pairs, anomalous couplings...
- Effect of additional soft interactions: survival probability, full treatment of soft corrections
- Proton dissociation corrections
- RHIC physics: nuclei interaction
- Interface with HERWIG: hard cross section calculation and hadronization effects

Forward Physics Monte Carlo

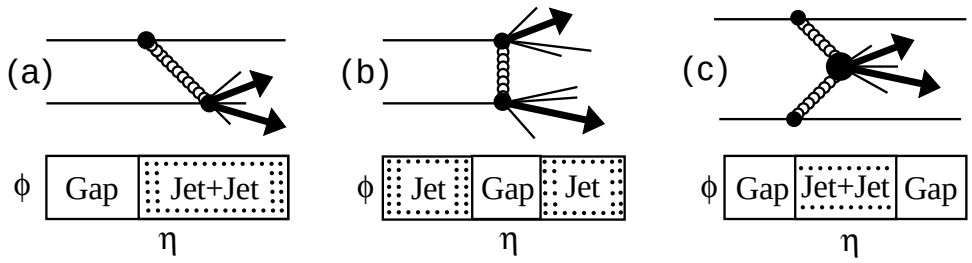
- Forward Physics Monte Carlo (FPMC): General program to produce diffractive events as well as photon exchanges (QED) at LHC, Tevatron
- FPMC interfaced with HERWIG for hadronisation, uses also HERWIG for calculation of hard matrix elements
- Main parameters:
  - TYPEPR: exclusive or inclusive
  - TYPINT: QED or QCD processes
  - NFLUX: flux selection
  - IPROC: type of process to be produced
  - MAXEV: number of events to be produced
  - PART1, PART2: type of beam 1 and 2 particles (proton, antiproton, nuclei...)
  - ECMS: center of mass energy
  - Different cuts on kinematics: PTMIN, PTMAX, YJMAX, YJMIN, XIMIN, XIMAX....
  - Specific parameters: Higgs mass, top mass, sparticle masses...

DIS and Diffractive event at HERA





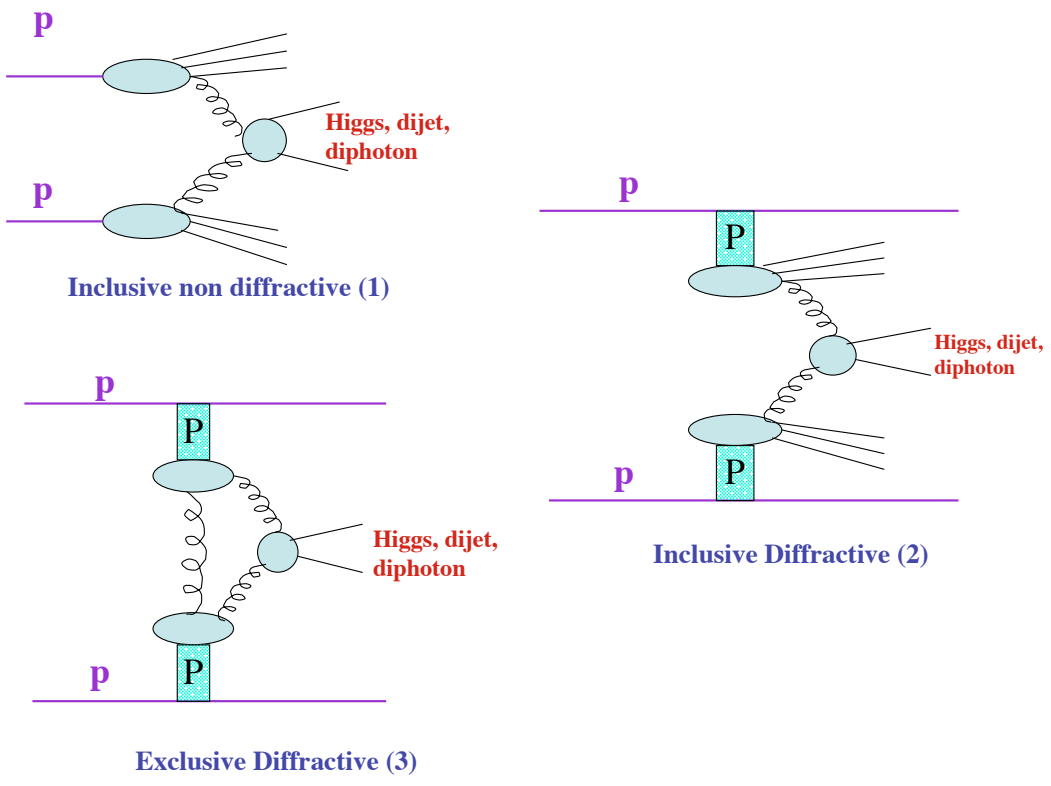
Diffraction at Tevatron/LHC



Kinematic variables

- t: 4-momentum transfer squared
- ξ_1, ξ_2: proton fractional momentum loss (momentum fraction of the proton carried by the pomeron)
- $\beta_{1,2} = x_{Bj,1,2}/\xi_{1,2}$: Bjorken-x of parton inside the pomeron
- Double diffraction: Introduced as a modification in HERWIG (see the talk by Florent)

Example of inclusive/exclusive diffraction



- All the energy is used to produce the Higgs (or the dijets), namely $xG \sim \delta$
- Possibility to reconstruct the Higgs boson properties from the tagged proton: System completely constrained
- See papers by Khoze, Martin, Ryskin; Boonekamp, Peschanski, Royon...

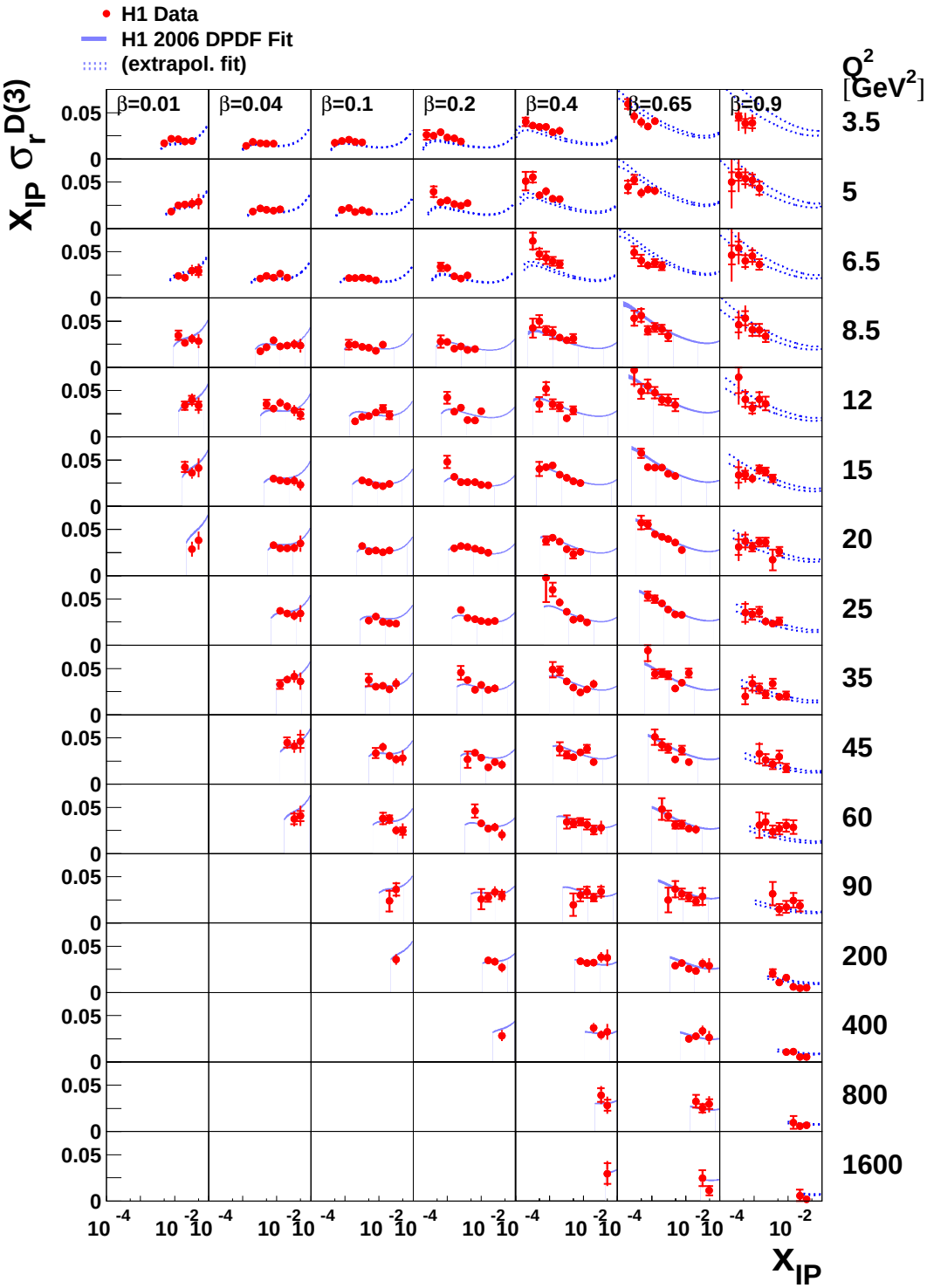
Measurement of the diffractive structure function F_2^D

- Measurement of the diffractive cross section using the rapidity gap selection over a wide kinematical domain in (x_P, β, Q^2)
- Definition of the reduced cross section:

$$\frac{d^3\sigma^D}{dx_P dQ^2 d\beta} = \frac{2\pi\alpha_{em}^2}{\beta Q^4}\left(1 - y + \frac{y^2}{2}\right)\sigma_r^D(x_P, Q^2, \beta)$$

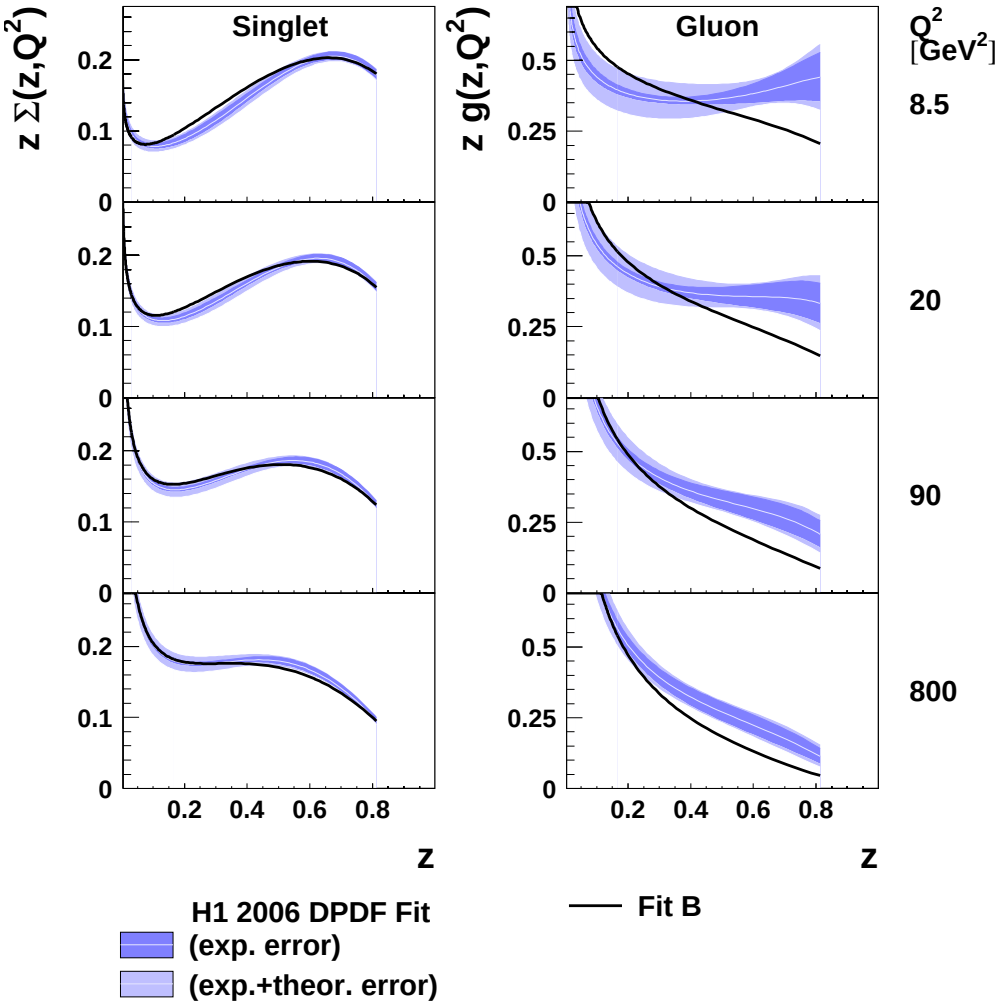
- As an example: H1 data

Measurement of the diffractive structure function F_2^D



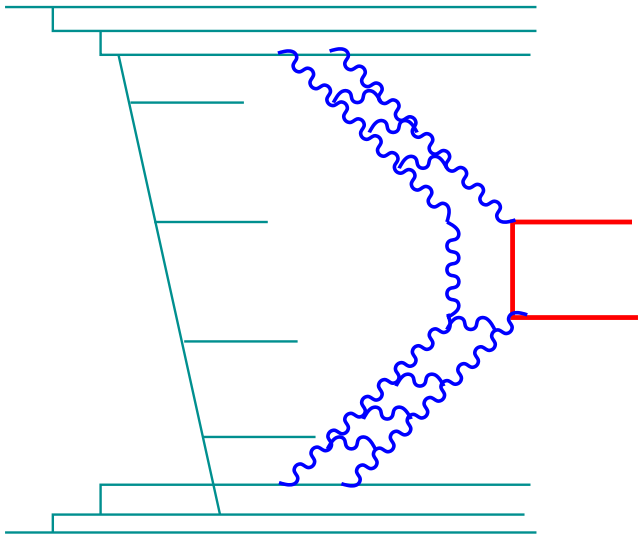
Parton densities in the pomeron (H1)

- Extraction of gluon and quarks densities in pomeron: gluon dominated
- Gluon density poorly constrained at high β (imposing $C_g = 0$ leads to a good fit as well, Fit B)
- Good description of final states

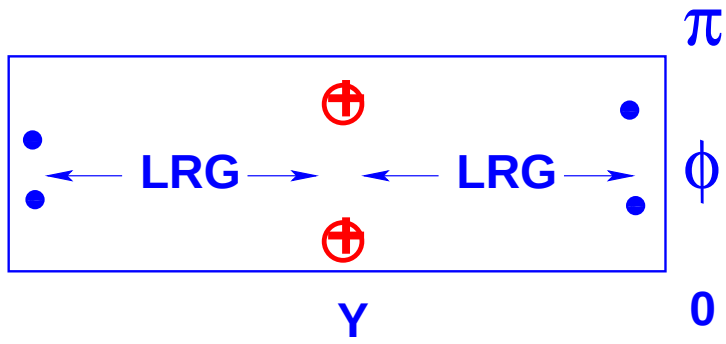


Factorisation at Tevatron?

- Is factorisation valid at Tevatron? Can we use the parton densities measured at HERA to use them at the Tevatron/LHC?
- Factorisation is not expected to hold: soft gluon exchanges in initial/final states
- Survival probability: Probability that there is no soft additional interaction, that the diffractive event is kept



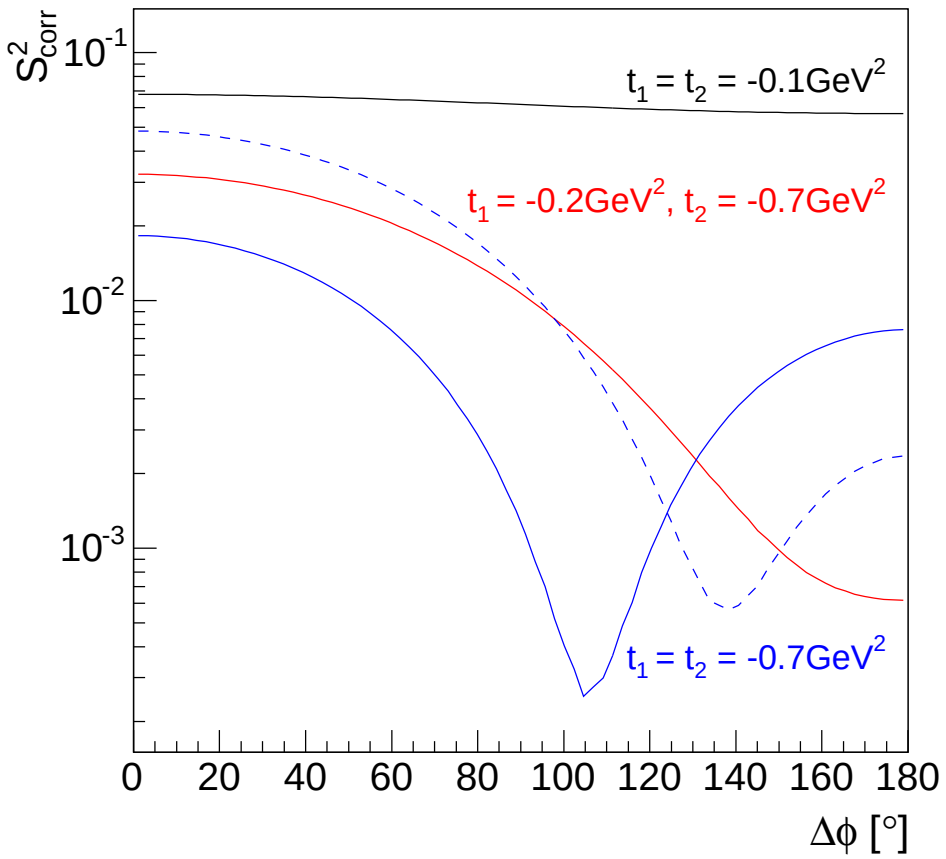
a)



b)

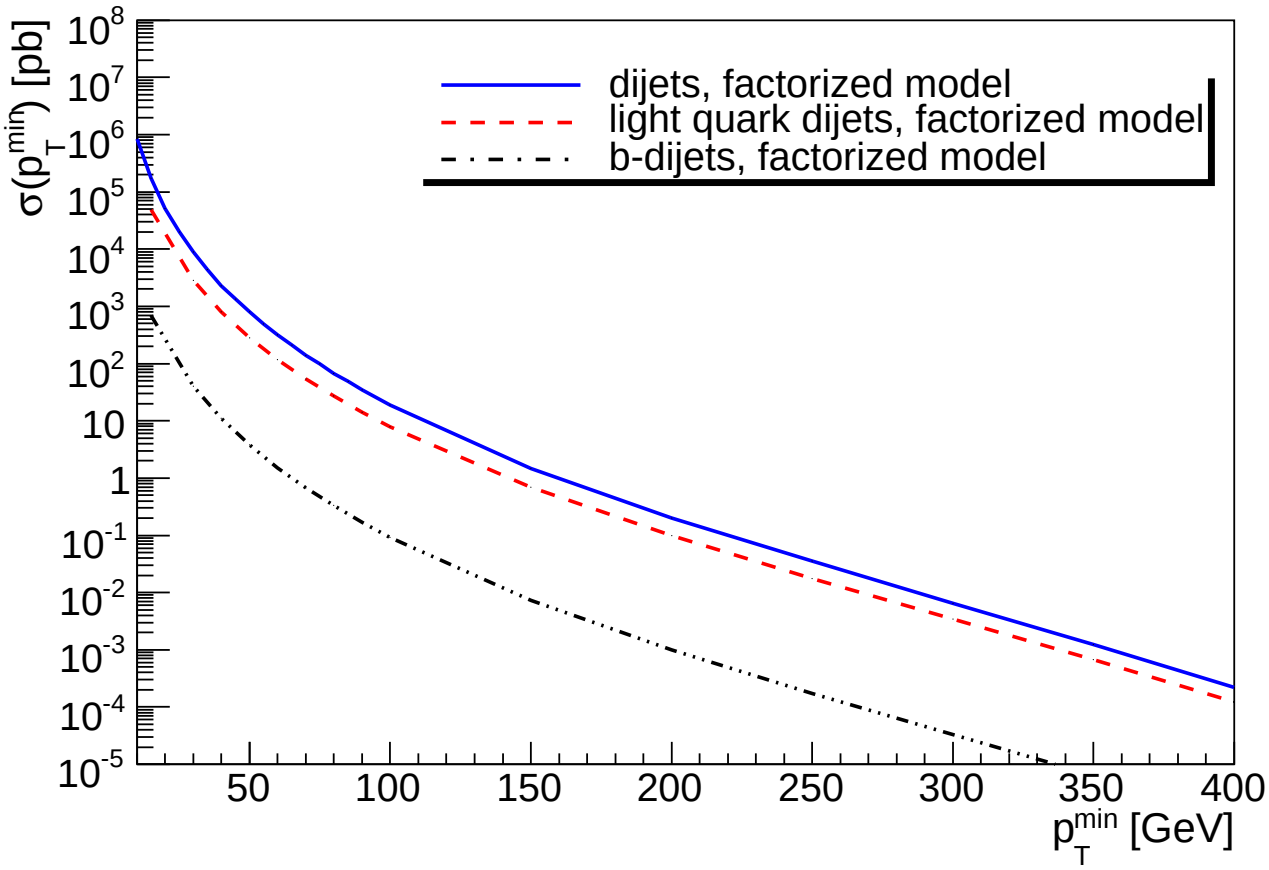
$\Delta\Phi$ dependence of survival probabilities

Survival probability strongly $\Delta\Phi$-dependent where $\Delta\Phi$ is the difference in azimuthal angles between p and $\bar{p}$



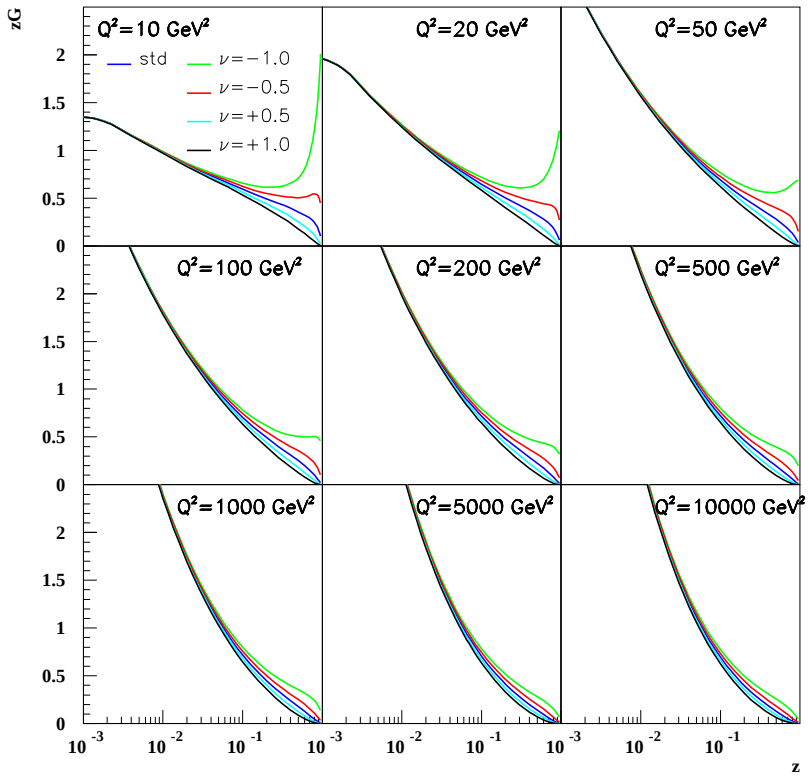
Inclusive diffraction: jet production

- Calculation of diffractive jet cross section: take the diffractive gluon from HERA, survival probability of 0.03, and predict jet cross section at LHC
- Assumption: survival probability is taken as a constant



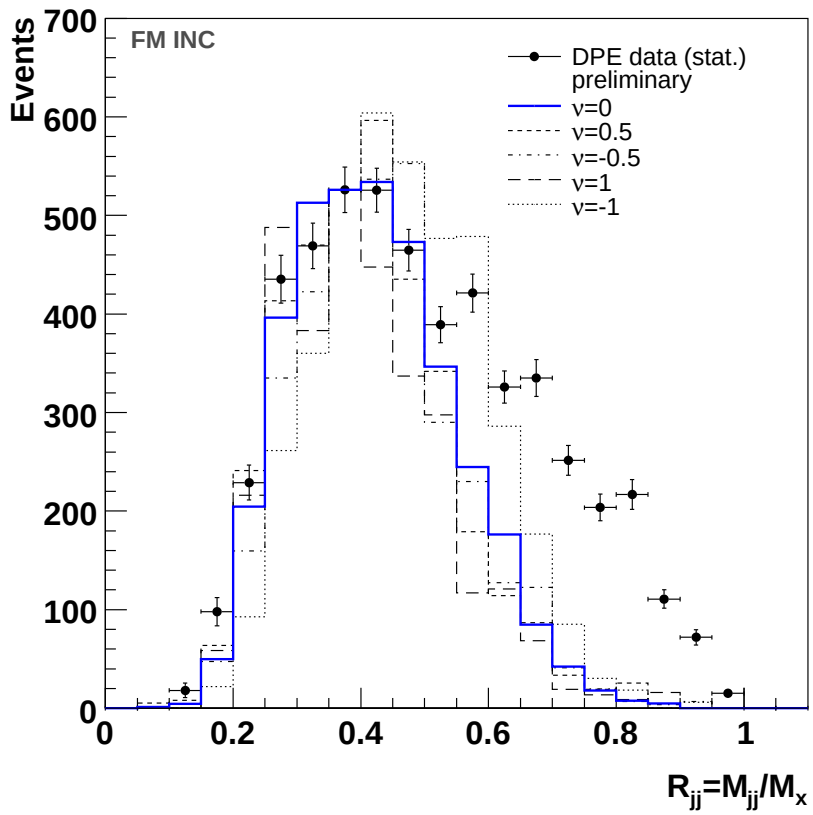
Looking for exclusive events: uncertainty on high β gluon

- Important to know the high β gluon since it is a contamination to exclusive events
- Experimentally, quasi-exclusive events indistinguishable from purely exclusive ones
- Uncertainty on gluon density at high β: multiply the gluon density by $(1-\beta)^{\nu}$ (fit: $\nu = 0.0 \pm 0.6$)



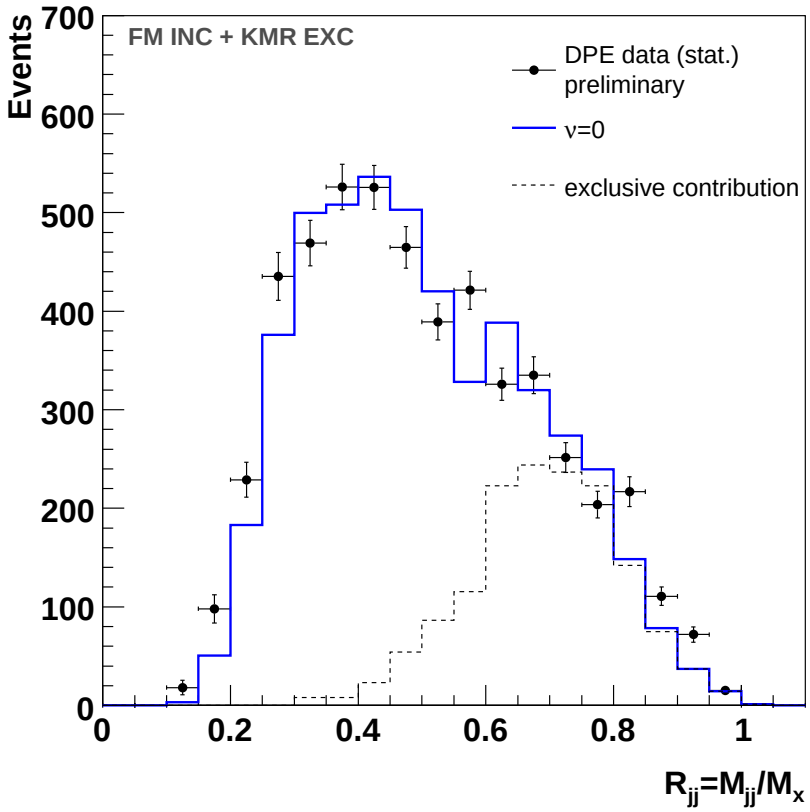
Dijet mass fraction measurement in CDF

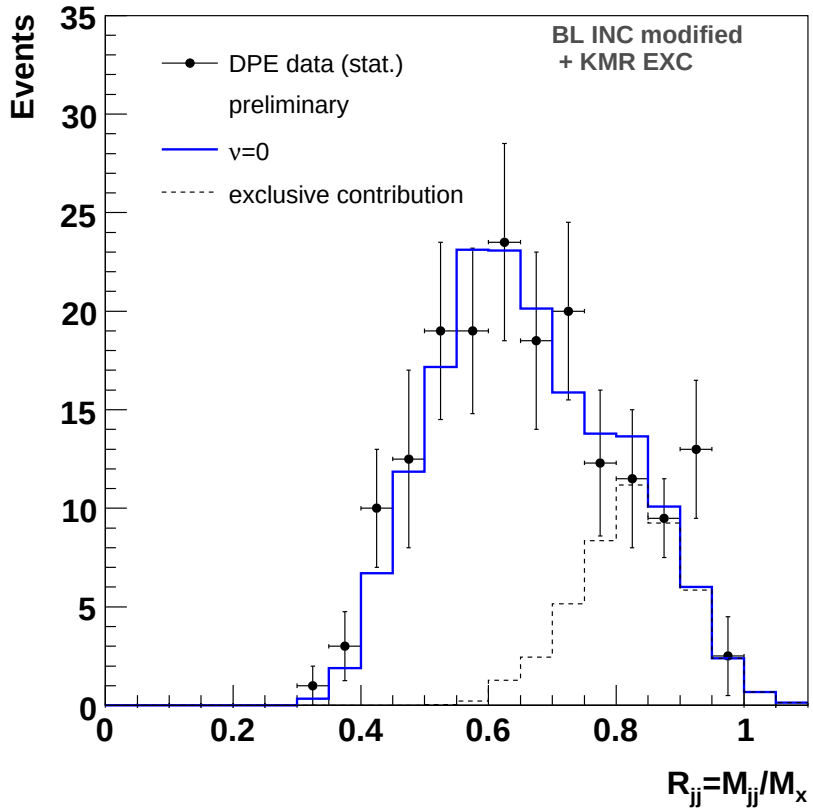
- Look for exclusive events (events where there is no pomeron remnants or when the full energy available is used to produce diffractively the high mass object)
- Select events with two jets only, one proton tagged in roman pot detector and a rapidity gap on the other side
- Predictions from inclusive diffraction models for Jet $p_T > 10$ GeV



Prediction from inclusive and exclusive diffraction

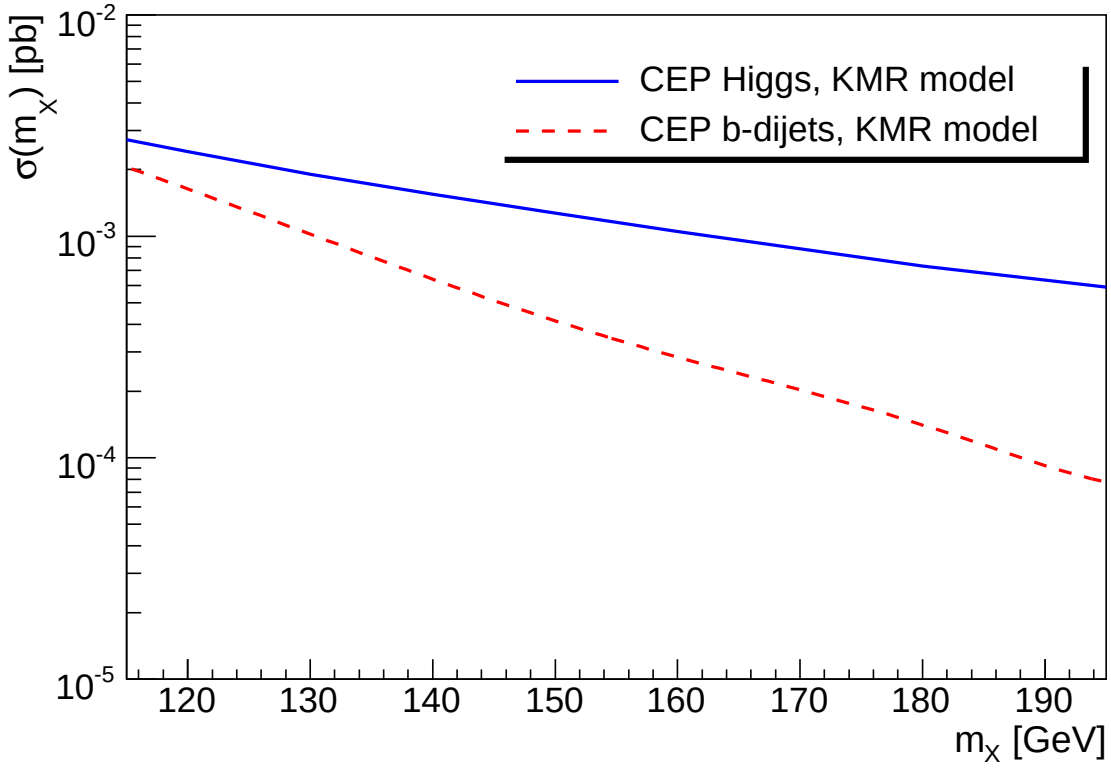
- Add the exclusive contribution (free relative normalisation between inclusive and exclusive contribution)
- Good agreement between measurement and predictions
- As an example: exclusive and inclusive models for $p_T > 10$ GeV and for $p_T > 25$ GeV
- See O. Kepka, C. Royon, Phys.Rev.D76 (2007) 034012; arXiv0706.1798



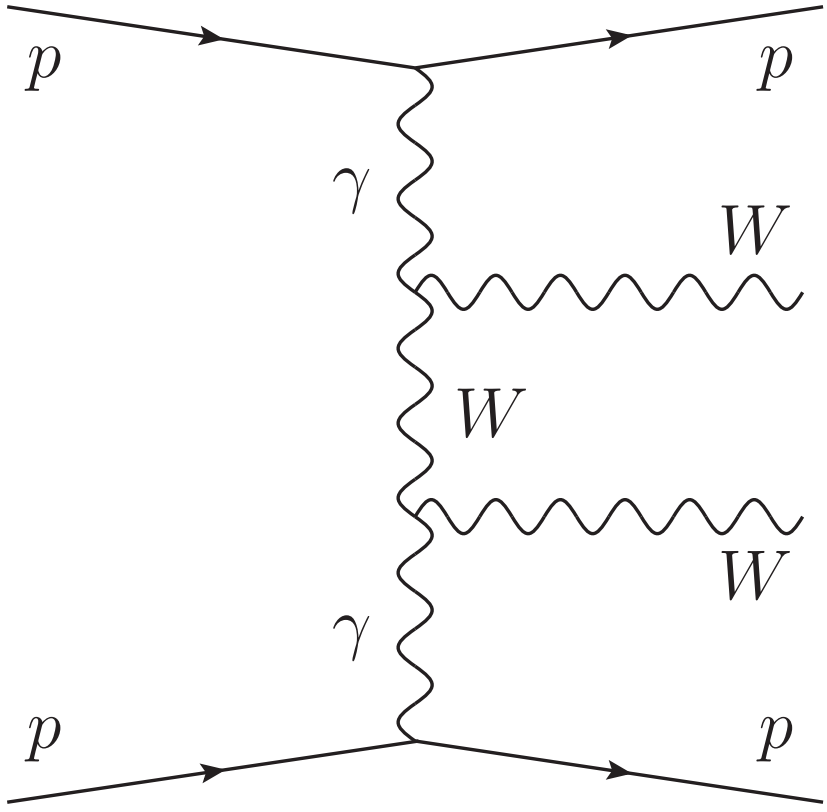


Exclusive Higgs production

Exclusive b dijet and Higgs production (Durham model)



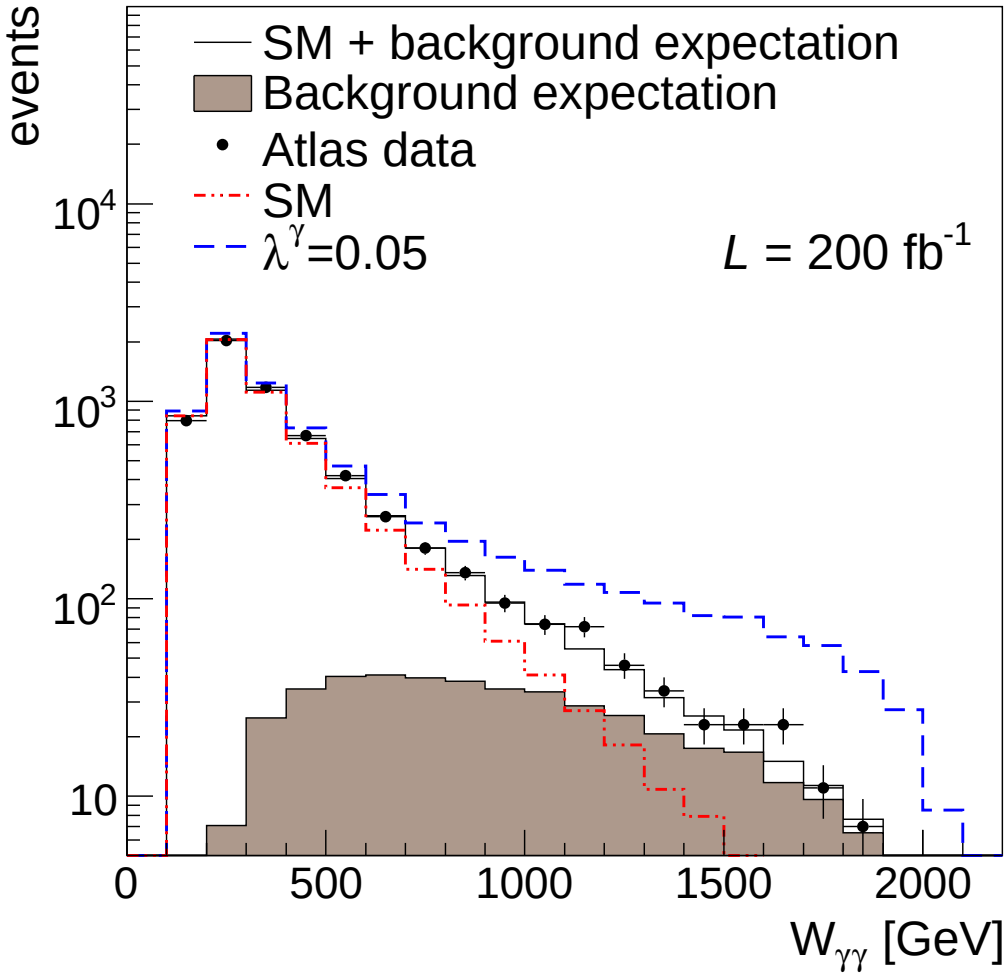
WW production at the LHC



- Study of the process: $pp \longrightarrow ppWW$
- Exclusive production of W pairs via photon exchange: QED process, cross section perfectly known
- Anomalous couplings introduced in FPMC
- See: O. Kepka, C. Royon, Phys. Rev. D 78 (2008) 073005

Reach on anomalous coupling

- Distribution of the $\gamma\gamma$ invariant mass $W_{\gamma\gamma}$:
- Specially interesting at high $W_{\gamma\gamma}$ where about 400 events are expected above 1 TeV for 200 fb^{-1}
- Many other interesting topics: quartic anomalous coupling, SUSY, top production...



Conclusion

- Forward Physics Monte Carlo available
- Manual to be available soon
- Allows to generate single diffraction, double pomeron exchange, exclusive diffraction, photon exchanges...
- Useful for LHC physics: ATLAS, CMS, ALICE